Summer Student Projects Submission 2025

Thursday 23 January 2025 - Thursday 20 February 2025

Book of Abstracts

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Automated report generation in LaTeX for experimental data

Authors: Nazanin Samadi[1]; Kathryn Spiers[2]; Hans-Christian Wille[3]

[1] *DESY*

[2] *FS-PETRA-S (FS-PET-S Fachgruppe P25)*

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We are seeking a motivated summer student to join the P25 beamline team at PETRA III. The selected student will develop a software tool in Python that automates the generation of experimental reports in LaTeX after data processing. The software tool integrates with the beamline's data processing workflow, enabling efficient documentation of results with figures, tables, and text summaries.
This project is an excellent opportunity to gain hands-on experience in scientific computing, data processing, and report automation in a cutting-edge and diverse research environment.
Experience in Python is required and familiarity with LaTeX would be beneficial.

Group:

FS-PETRA-S

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Experience in Python is required and familiarity with LaTeX would be beneficial.

DESY Site:

Hamburg

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Design and build an X-ray microscope

Authors: Nazanin Samadi[1]; Kathryn Spiers[2]; Hans-Christian Wille[3]

[1] *DESY*

[2] *FS-PETRA-S (FS-PET-S Fachgruppe P25)*

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We are seeking a motivated summer student to join the P25 beamline team at PETRA III. The project focuses on the design and construction of an X-ray microscope that will be used for wavefront characterization at the P25 beamline of PETRA III. This microscope will serve as a high-precision diagnostic tool for evaluating X-ray optics.
The student will contribute to the design, assembly, and commissioning of the microscope, working on optical alignment, and experimental tests. Key tasks include design of the microscope framework and structural components, optical alignment, sensitivity analysis of the system, and experimental testing. The project will provide hands-on experience with synchrotron beamline instrumentation, X-ray optics, and wavefront reconstruction.
Candidates with a background in physics, engineering, or a related field, with an interest in optics, imaging, and experimental research are encouraged to apply. Prior experience with CAD software is beneficial but not required. This position offers a unique opportunity to contribute to cutting-edge

synchrotron science while developing technical skills in a dynamic and diverse research environment.

Group:

FS-PETRA-S

Project Category:

A4. Development of experimental techniques

Special Qualifications:

Candidates with a background in physics, engineering, or a related field, with an interest in optics, imaging, and experimental research are encouraged to apply. Prior experience with CAD software is beneficial but not required.

DESY Site:

Hamburg

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Tensor networks in machine learning

Author: Takis Angelides[1]

[1] *CQTA (Centre f. Quantum Techno. a. Application)*

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This project will introduce the basics of tensor networks and provide an opportunity to apply them to machine learning models through hands-on coding.

Tensor networks in machine learning is a new and exciting area of research with significant applications for the future of science, technology, and humanity. For example, tensor networks can greatly enhance the efficiency of large language models, such as ChatGPT, by reducing the computational complexity of training these models, making them more accessible and scalable. Additionally, in climate change applications, tensor networks are well-suited to model complex environmental systems, enabling more accurate predictions and simulations with lower resource demands.

Beyond machine learning, tensor networks also have diverse reach in quantum computing, fluid dynamics, condensed matter, quantum many-body physics, data compression, signal processing, and many more, further demonstrating their wide spectrum of applications.

Group:

CQTA

Project Category:

B5. Computing

Special Qualifications:

Programming knowledge in Python, Julia, or other.
Linear algebra.
Machine learning.

DESY Site:

Zeuthen

4

Variable and extended emission from gamma-ray binaries observed with VERITAS

Author: Gernot Maier[1]

Co-authors: Eshita Joshi [1]; Tobias Kai Kleiner [2]

[1] *DESY*

[2] *Z_CTA (Cherenkov Telescope Array)*

Corresponding Authors: gernot.maier@desy.de, tobias.kleiner@desy.de, eshita.joshi@desy.de

This project focuses on analyzing the time variability of gamma-ray binaries across multiple timescales and investigating possible extended emission from stellar winds. The study will utilize a large dataset of observations from the VERITAS telescope to characterize variability patterns and search for spatially extended gamma-ray emission associated with these systems.

Group:

Z_CTA / Z_VERITAS

Project Category:

C1. Astroparticle physics analysis and observations

Special Qualifications:

Enthusiasm.

DESY Site:

Zeuthen

5

ATLAS ITk strip detector - developments on the end-cap system test

Author: Jan-Hendrik Arling[1]

Co-authors: Konstantin Mauer [2]; Lennart Huth [1]; Sergio Diez Cornell [2]

[1] *DESY*

[2] *ATLAS (ATLAS Upgrade)*

Corresponding Authors: sergio.diez.cornell@desy.de, konstantin.mauer@desy.de, lennart.huth@desy.de, jan-hendrik.arling@desy.de

The ATLAS detector is one of the four LHC experiments and will be upgraded for the upcoming high luminosity runs. For that, a new all-silicon tracking detector, the Inner Tracker (ITk), is being built right now. At DESY, the so-called system test for the end-cap system is being developed and serves as the main testbench for the whole detector concept.

Within the summer student project, the student will have the opportunity to work on this unique setup and can get involved in topics like detector readout, cooling, powering and control systems. During this work, several test measurements will be conducted, analysed and evaluated in view of the designated detector operation. This involves hands-on work in the big clean room facilities, but also programming in terms of automation and analysis of the taken datasets

Group:

FH-ATLAS

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

Silicon detectors, Python, electronics (basics)

DESY Site:

Hamburg

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Electric current induced by blazar-induced pair beams in homogeneous IGMF

Author: Mahmoud S.A. Alawashra[1]

Co-author: Robert Brose [1]

[1] *Z_THAT (Theoretische Astroteilchenphysik)*

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This project aims to estimate the current driven by the blazar-induced pair beams deflecting in homogenous intergalactic magnetic fields. The propagation of those very-high-energy gamma rays from Blazars over cosmological distances has been a topic of extensive theoretical and observational investigations, as it offers a unique probe into the intergalactic medium (IGM).

TeV gamma rays interact with the extragalactic background light (EBL), producing focused beams of electron-positron pairs. These pairs can be deflected by intergalactic magnetic fields (IGMF) suppressing their observed electromagnetic emission by inverse Compton scattering on the cosmic microwave background (CMB) photons.

When the correlation length of the intergalactic magnetic field is larger than the pairs' cooling length. The electrons and positrons go in opposite directions and could induce an electric field in between that drives an electric current in the IGM. The student will use their undergraduate electromagnetic theory knowledge to estimate this current and compare its generated magnetic field with the IGM homogenous one.

Group:

THAT

Project Category:

C3. Theory of astroparticle physics

Special Qualifications:

Undergraduate electromagnetic theory
Basic programming (any language)

DESY Site:

Zeuthen

7

Optimization of twin electron bunch dynamics for PWFA

Authors: Matthias Scholz[1]; Tianyun Long[2]; Ye Lining Chen[1]

[1] *MXL (XFEL)*

[2] *MPA2 (Beam-Driven Plasma Accelerators)*

Corresponding Authors: ye.lining.chen@desy.de, tianyun.long@desy.de, matthias.scholz@desy.de

optimizing the dynamics of twin electron bunches in the photoinjector, surfing in the same radio-frequency (RF) bucket of the electron gun and downstream accelerating modules, is of crucial importance for potential plasma wake-field acceleration experiments at the European XFEL in the future. The topic is practically challenging due to the optimization of multiple beam and machine operation parameters aimed for specifically required twin bunch configuration and thus the resulting longitudinal phase spaces. Such a technical goal could not be straightforwardly achieved using existing beam dynamics codes and consequently adding complexities to practical machine tuning.

A suitable candidate should carry out dedicated studies first using existing and well-justified beam dynamics code (e.g. ASTRA), and then develop a new scheme / interface for twin-bunch optimization using a preferable programming language (such as python, C++ or Matlab) based on advanced schemes (e.g. Bayesian optimization). Such an enhanced tool should serve the goal for twin bunch optimization in the simulations and provide useful guidance for optimizing the twin bunch beam dynamics in the XFEL injector experimentally.

Group:

MXL

Project Category:

B3. Research on accelerators

Special Qualifications:

1. prior experience in programming (Python, C++ or Matlab) and/or beam dynamics in the photoinjector;
2. self-motivation to achieve research goals and willing to cooperate

DESY Site:

Hamburg

8

Simulations of the Monolithic Active Pixel Sensors for the Octopus Project

Authors: Anastasiia Velyka[1]; Gianpiero Vignola[1]

[1] *DESY*

Corresponding Authors: gianpiero.vignola@desy.de, anastasiia.velyka@desy.de

The Optimized CMOS Technology for Precision in Ultra-thin Silicon (Octopus) Project aims to develop sensors for the vertex detector for future lepton colliders. As an intermediate step, the project also focuses on developing high-resolution sensors for

beam telescopes at DESY and CERN, with less stringent power and timing requirements, but focusing on achieving 3 µm position resolution.
As part of the Work Package 1: Simulation, research is being conducted to optimize sensor layouts and dimensions and better understand sensor performance. Building on extensive evaluations of n-blanket and n-gap layouts, further improvements in sensor design in the scope of the deep n-implant shape and size are under investigation.
A summer student will contribute by developing and running TCAD and Allpix^2 simulations, as well as analyzing the results. The student will gain hands-on experience with TCAD static simulations and high-statistics Monte Carlo simulations, both of which are essential for optimizing sensor designs and improving overall performance.
Preferred skills include familiarity with Linux, Python, C++, and basic detector physics.

Group:

FH-ATLAS

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

Preferred skills include familiarity with Linux, Python, C++, and basic detector physics.

DESY Site:

Hamburg

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Laboratory Characterization Monolithic Active Pixel Sensors Prototypes

Authors: Larissa Mendes[1]; Sara Ruiz Daza[2]

[1] *ATLAS (ATLAS-Experiment)*

[2] *DESY (Deutsches Elektronen Synchrotron)*

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Future lepton and electron-ion collider concepts rely heavily on silicon sensors as primary tracking devices. Therefore, it is necessary to explore cost-effective silicon sensor technologies that maintain high performance. The Tangerine Project at DESY actively investigates monolithic active pixel sensors (MAPS), developed using 65 nm CMOS imaging technology.

A key objective of the group is to build expertise in these technologies by participating in all stages of sensor development from simulation and design to prototype characterisation. One of the sensors under study is the H2M (Hybrid-to-Monolithic), a fully integrated chip that ports a hybrid pixel detector architecture into a monolithic sensor. Another test chip, DESY-ER1, shares the same analog pixel front-end as H2M but provides direct access to the analog amplifier output. This feature allows for a more detailed understanding of the sensor's behaviour and underlying technology.

The summer student will gain hands-on experience testing these detectors and conducting characterisation measurements on one or both chips, depending on project needs. Key activities include electrical characterisation, equalisation, energy calibration, and optimisation of operational parameters. These steps are crucial for understanding detector performance and preparing for test beam campaigns.

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

No prior experience with these specific detectors is required, basics in Linux, Python or C++, and Unix shell. Nice to have: lab/silicon experience, ROOT basics.

DESY Site:

Hamburg

Group:

FH-ATLAS

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Test Beam Data Analysis and Calibration of APTS Prototypes Developed in 65 nm CMOS Imaging Technology

Authors: Finn King[1]; Gianpiero Vignola[2]

[1] *DESY (Deutsches Elektronen Synchrotron)*

[2] *DESY*

Corresponding Authors: finn.feindt@desy.de, gianpiero.vignola@desy.de

Vertex detectors play a crucial role in tracking systems for high-energy physics experiments, primarily relying on silicon pixel sensors to identify charged particles. The latest advancements in Monolithic Active Pixel Sensors (MAPS), developed using a 65 nm CMOS imaging process, enable higher circuit densities, allowing for smaller pixel sizes and more complex integrated electronics. These sensors provide a cost-effective, lightweight solution with low power consumption, making them well-suited for future lepton colliders.

Within the Tangerine project, several MAPS prototypes in 65 nm CMOS technology are being studied. Among these is the Analog Pixel Test Structure (APTS), a test structure developed at CERN within the context of the ALICE Inner Tracking System upgrade (ITS3). Prototypes with different pitches and sensor layouts are under investigation at DESY, and several test-beam and laboratory measurement campaigns have been conducted on the samples in recent months.

The student will be involved in the analysis of test-beam data and the charge calibration in the laboratory of some APTS prototypes. The results of these measurements will contribute to the understanding of the sensor performance and will be used to validate simulations carried out within the research group.

Group:

FH-ATLAS

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

Prior experience with hardware, lab data analysis, Python or C++, and Unix shell is welcome but not required. Interest in laboratory work and/or test beam data analysis is required.

DESY Site:

Hamburg

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Measuring photon-induced dilepton pairs in proton collisions

Authors: Daniel Werner[1]; Lydia Beresford[1]; Weronika Stanek-Maslouska[1]

[1] *ATLAS (ATLAS-Experiment)*

Corresponding Authors: daniel.werner@desy.de, lydia.beresford@desy.de, weronika.stanek@desy.de

A fundamental process in quantum electrodynamics is the production of pairs of leptons emerging from collisions between high energy photons. At the LHC we can produce this process in the laboratory by exploiting the LHC as a photon collider. The electromagnetic field surrounding LHC protons act as a cloud of high energy virtual photons. When LHC protons narrowly miss one another collisions between their surrounding photons can occur, reaching photon-photon energies up to the TeV scale.

The $\gamma\gamma \rightarrow \mu\mu$ process was measured by the ATLAS experiment in 2018 using 3.2 fb^{-1} of data [1], however, a much larger dataset is now available. Differential measurements of this process are limited by data statistics, motivating measurement of this process with a larger dataset.

In this project we will study the $\gamma\gamma \rightarrow \mu\mu$ process. Simulated data will be used to select such events and to assess the potential yields which could be achieved. Time permitting, first steps towards a measurement of this process will be made by investigating 'unfolding'procedures to correct for detector effects.

[1] https://www.sciencedirect.com/science/article/pii/S0370269317310201

Group:

FH-ATLAS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Any experience with bash shells, Python, C++ and ROOT would be advantageous

DESY Site:

Hamburg

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Flavour Tagging Studies in GN3 with the ATLAS Experiment

Authors: Krisztian Peters[1]; Neelam Kumari[2]

[1] *ATLAS (ATLAS Beyond Standard Model)*

[2] *ATLAS (ATLAS SM and Beyond)*

Corresponding Authors: krisztian.peters@desy.de, neelam.kumari@desy.de

The identification of jets containing b-hadrons (b-jets) plays a crucial role in the physics program of the ATLAS experiment. This project will focus on improving and evaluating the next iteration of b-tagging algorithms, GN3, and using the FTAG tools currently used in ATLAS. The student will explore quark/gluon tagging with the GN3 tagger, assessing its performance and optimisation strategies. The project will also involve comparing overall GN3 performance with the previous flavour tagging algorithm (GN2) across various simulated event samples. This project provides an excellent

opportunity for hands-on experience with machine learning training, data analysis, and detector physics.

Group:

FH-ATLAS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Python, Basic particle-physics knowledge

DESY Site:

Hamburg

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Run 3 Forward Electron Energy Calibration in ATLAS

Authors: Linghua Guo[1]; Ludovica Aperio Bella[2]

[1] *ATLAS (ATLAS-Experiment)*

[2] *ATLAS (ATLAS SM and Beyond)*

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Detecting and identifying electrons in the forward region (|eta| > 2.5 outside the ATLAS tracker acceptance) it is an unique feature of the ATLAS experiment. Precise energy calibration of those electrons is essential for many physics analyses, particularly in measurements related to the electroweak mixing angle. Accurate calibration ensures consistency between data and Monte Carlo (MC) simulations, improving the overall precision of key electroweak observables.

The student will gain an understanding of electron reconstruction in the forward region of ATLAS and the methods used to calibrate their energy response. Our group has played a leading role in forward electron calibration during Run 2, where a multivariate analysis (MVA)-based method was developed to predict electron energy and a dedicated calibration procedure was implemented to align the response between data and MC. For Run 3, the student will apply the existing Run 2 MVA-based calibration approach to new data, ensuring its validity and performance in the updated detector and data-taking conditions. Building upon this foundation, the student will contribute to the calibration of forward electrons in Run 3, which will be an integral part of the ATLAS electron and photon (egamma) calibration recommendations for Run3. This project provides an opportunity to work on a key aspect of ATLAS calibration, gaining hands-on experience with data analysis, machine learning techniques, and the calibration framework used in high-energy physics experiments.

Group:

FH-ATLAS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Programming Languages, Statistical Test

DESY Site:

Hamburg

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A new electromagnetic calorimeter for BabyIAXO to search for axions from solar fusion and supernova explosions

Authors: Axel Lindner[1]; Jose Alejandro Rubiera Gimeno[2]; Daniel Heuchel[3]; Maximilian Felix Caspar[4]; Louis Helary[5]

[1] *ALPS (ALPS _ Any Light Particle Search)*
[2] *ALPS*
[3] *DESY*
[4] *ATLAS (ATLAS-Experiment)*
[5] *DESY - FTX*

Corresponding Authors: louis.helary@desy.de, maximilian.caspar@desy.de, daniel.heuchel@desy.de, jose.rubiera.gimeno@desy.de, axel.lindner@desy.de

BabyIAXO is a future experiment located at DESY to search for the dark luminosity of our Sun: hypothetical very lightweight and extremely feebly interacting new particles like the axion. Such bosons are perfect candidates to also explain the dark matter in our Universe. This project is embedded in a study to further expand the science case of BabyIAXO. By adding a new electromagnetic calorimeter, BabyIAXO might become also sensitive to 5.5 MeV axions produced by the solar fusion processes and $\mathcal{O}(100\,\mathrm{MeV})$ axions from nearby supernova explosions.

The successful applicant will contribute to the designs of possible calorimeter solutions focusing on:

- The optimization of the acceptance for gamma rays resulting from the interaction of the axions with BabyIAXO's magnetic field taking into account geometric constrains (e.g., space constraints, detector positioning).
- Exploring potential detector types and materials.

The student will become familiar with Monte Carlo tools to simulate the transport of radiation in matter such as Geant4 and OpenGATE, which are standard tools in particle physics. The study might include also very new concepts like chromatic calorimetry.

To gain some experience in laboratory work, it could be possible in addition to contribute to the commissioning, calibration and background measurements of X-ray detectors for BabyIAXO (depending on the schedule of the test-bench installation).

Group:

FH-ALPS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

- Good knowledge of Python programming. C++ knowledge or experience with ROOT is a plus.
- Good command of the English language.
- Ability to summarize and present the outcome of your work in a structured manner.

DESY Site:

Hamburg

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Anomaly Detection in dCache Storage System

Authors: Kilian Schwarz[1]; Tigran Mkrtchyan[2]

[1] *IT (IT Scientific Computing)*

[2] *DESY-IT, Scientific Computing*

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The dCache project provides open-source software that is deployed worldwide to meet the increasingly demanding requirements of scientific storage. It offers a multifaceted approach to support various use cases using the same storage infrastructure, which includes high-throughput data ingestion, data sharing over wide area networks, efficient access from HPC clusters, and long-term data persistence on tertiary storage.

DESY-IT operates multiple dCache instances that generate gigabytes of log files each day. These log files contain information about data access and operations, which can be utilized to identify misbehavior by malicious users or system failures.

This project aims to explore possibilities to automate the processing of dCache log data and implement techniques for uncovering unusual patterns in system operations by applying state-of-the-art machine learning methods to detect anomalies effectively.

Prerequisites:
- Python programming skills
- Familiarity with Jupiter Notebooks, NumPy, Pandas and Kafka
- Fundamental knowledge of machine learning concepts is beneficial but not required
• Experience with Linux OS is a plus

Group:

IT

Project Category:

B5. Computing

Special Qualifications:

Prerequisites: - Python programming skills - Familiarity with Jupiter Notebooks, NumPy, Pandas and Kafka - Fundamental knowledge of machine learning concepts is beneficial but not required • Experience with Linux OS is a plus

DESY Site:

Hamburg

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PaNET adoption at DESY.

Authors: Alexander Paul Millar[1]; Kilian Schwarz[2]; Melanie Nentwich[3]

[1] *IT (Research and Innovation in Scientific Co)*

[2] *IT (IT Scientific Computing)*

[3] *None*

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Since the first use of photons and neutrons as probes, the Photon and Neutron (PaN) community has been developing an ever increasing portfolio of experimental techniques. These different techniques bear similarities to each other by exploiting similar experimental physical processes, using similar experimental probes, having similar functional dependencies, or having similar purposes. This creates a complex structure of techniques that is best organised as an ontology, with persistent identifiers for each technique: the Photon and Neutron Experimental Technique (PaNET) ontology. The initial purpose of PaNET is to help find open datasets, additionally it is also being used in other contexts.
You would be working on developing web-based applications that are based on semantic web technologies (e.g., SPARQL), extending and enhancing PaNET itself, facilitating the adoption of PaNET at DESY, and helping building bridges between PaNET and other technologies.

Group:

IT

Project Category:

B5. Computing

DESY Site:

Hamburg

Special Qualifications:

Requirements: Experience with programming and git
Beneficial: knowledge of semantic web technology, knowledge of HTML and web-based technologies, functional programming.

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Direct DOI Dataset Access

Authors: Alexander Paul Millar[1]; Kilian Schwarz[2]; Melanie Nentwich[3]

[1] *IT (Research and Innovation in Scientific Co)*

[2] *IT (IT Scientific Computing)*

[3] *None*

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Associating datasets with persistent identifiers (a globally unique ID) is crucial for ensuring that research outputs are available for open science and comply with the FAIR principles (Findable, Accessible, Interoperable, and Reusable). This enhances the value of the data and it also allows other people to recreate existing work, or to use the data in new and novel research.

Currently, several platforms and institutes offer the possibility to store data with a DOI, a type of persistent identifier. However, no standard exists that allows a machine to access or download the data from a DOI. Repositories typically either have no way to download data automatically, or have adopted some proprietary solution. With no widely deployed standard, any support for accessing or downloading data from a DOI can only be incomplete.

You would be working on this task, for which a solution has already been proposed, based on existing approaches in other contexts (HTTP content-negotiation, and a dataset description language). You would implement a proof-of-concept code, based on the design, that will demonstrate that the approach can work. This will involve a mixture of modifying existing production software and developing new code to build a demonstration of the benefits of this approach.

Group:

IT

Project Category:

B5. Computing

DESY Site:

Hamburg

Special Qualifications:

Requirements: Experience with programming and git

Beneficial: network protocols and HTTP in particular, knowledge of golang, experience with filesystems and FUSE.

18

Precision in New Physics searches at future electron-positron and muon colliders

Authors: Juergen Reuter[1]; Krzysztof Mekala[2]; Maximilian Loeschner[2]; Panagiotis Stylianou[2]

[1] *DESY*

[2] *T (Phenomenology)*

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Future colliders (electron-positron colliders like CEPC, CLIC, FCC-ee, ILC, muon colliders MuC, and hadron colliders FCC-hh) are being designed to tackle several riddles in modern particle physics: dark matter, missing CP violation, neutrino masses, the origin of the flavor structure and electroweak symmetry breaking. To determine their physics potential, precise predictions for new physics signals and known-physics backgrounds are needed. The project aims at the study of precision prediction of new physics signals for SM effective field theory (SMEFT) for FCC-ee/ILC and MuC together with their Standard Model backgrounds using modern multi-purpose Monte Carlo event generators, specifically in multi-Higgs and associated Higgs production channels. The project allows to learn next-to-leading order QCD and electroweak corrections, QED and electroweak lepton PDFs, simulation of beam shapes like beam spread and event selection on infrared-safe inclusive observables. Also, loop-induced processes will be investigated.

Group:

T

Project Category:

B4. Theory of elementary particles

Special Qualifications:

Quantum Mechanics I+II, Particle Physics basics, ideally a quantum field theory course

DESY Site:

Hamburg

19

Precision investigations of Higgs couplings and applications for collider phenomenology

Authors: Alain Verduras Schaeidt[1]; Felix Egle[1]; Francisco Manuel Arco Garcia[1]; Georg Weiglein[1]; Johannes Braathen[1]

[1] *T (Phenomenology)*

Corresponding Authors: alain.verduras@desy.de, felix.egle@desy.de, johannes.braathen@desy.de, georg.weiglein@desy.de, francisco.arco@desy.de

After the discovery at the CERN Large Hadron Collider of a Higgs boson with a mass of about 125 GeV, the structure of the Higgs sector and the actual form of the Higgs potential still remain to a large extent uncharted. In this project, we will explore extended Higgs sectors, which could for instance be suitable for providing a possible candidate for dark matter and for explaining the matter-antimatter asymmetry of the Universe. Predictions for relevant couplings of the Higgs boson and their phenomenological applications, in particular in the context of processes at current and future colliders, will be investigated.

Group:

T

Project Category:

B4. Theory of elementary particles

Special Qualifications:

DESY Site:

Hamburg

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Tests of SiPM-on-Tile modules for the CMS HGCAL

Author: Katja Krueger[1]

Co-authors: Antoine Laudrain [2]; Mathias Reinecke [3]

[1] *DESY (FTX Fachgruppe DTA)*

[2] *DESY*

[3] *FE (FEB Analog Electronik)*

Corresponding Authors: mathias.reinecke@desy.de, katja.krueger@desy.de, antoine.laudrain@desy.de

Our group works on the development of highly granular hadronic calorimeters based on small scintillator tiles read out by Silicon Photomultipliers (SiPMs). This "SiPM-on-tile"technology will be used for the upgrade of the calorimeter endcap of the CMS detector for HL-LHC, the High Granularity Calorimeter (HGCAL). An important ingredient for these calorimeters is the readout electronics, which is fully integrated into the detector layers.

We have started to build the first active elements that will be installed in the CMS detector, and the production will ramp up during this year. The active elements will be tested and characterised at DESY before they are sent on to be integrated into the HGCAL. The tests comprise basic electronics tests in the lab, tests in a climate chamber at -30 degree C and tests with particles (cosmic muons and particle beams).

The student is supposed to contribute to the tests and to the analysis of the results.

Group:

FH-FTX-DTA

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

enjoy working with hardware and electronics; prior experience is an advantage, but not necessary

DESY Site:

Hamburg

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Belle II data analysis

Author: Daniel Pitzl[1]

[1] *DESY FH/Belle II*

Corresponding Author: daniel.pitzl@desy.de

The Belle II experiment at the asymmetric B-Factory SKB at KEK in Japan has been accumulating electron-positron annihilation data since 2019.
Several opportunities for data analysis are open in the DESY Belle II group. We focus on rare B decays, precision tau physics, charm physics as well as more detector related studies with the pixel detector. The exact topic will be defined by taking to the student's interest and knowledge into account. Analyses are done on ROOT files either directly in C++ or using a Python interface to the standard Belle II analysis framework.

Group:

FH/Bellle II

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

DESY Site:

Hamburg

22

Invertable normalising flows for calorimeter simulation

Author: Henry Day-Hall[1]

Co-author: Frank Gaede [1]

[1] *FTX (FTX Fachgruppe SFT)*

Corresponding Authors: frank.gaede@desy.de, henry.day-hall@desy.de

The FTX-SFT group develops software tools and algorithms for HEP with aiming at experiments at future colliders, such as the planed FCCee or the ILC. One focus of the group is investigating the use of machine learning algorithms for fast detector simulation as well as reconstruction.

One of the rare features of normalising flows is that in principle they are invertible. That is, it is computationally tractable to run the transformation in either direction. In this project, a normalising flow architecture that has demonstrated success in the forward direction will be rewritten with tools that allow for inversion. This normalising flow is used to model the expected number of hits in each layer, given an incident energy and shower direction. If it could be inverted, then it would be able to calculate the likely hood of a given energy from a distribution of clusters. This method can be compared to traditional algorithms for estimating the incident particle energy. This project will compare reconstruction from an inverted normalising flow to traditional reconstruction methods.

Group:

FTX-SFT

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

python

DESY Site:

Hamburg

23

Instrumentation development for medical applications using Silicon Photomultipliers

Authors: Priscilla Pani[1]; Vlad Dumitru Berlea[2]

[1] *DESY*

[2] *None*

Corresponding Authors: priscilla.pani@cern.ch, vlad.berlea@desy.de

We are actively developing an instrumentation solution involving Silicon Photomultipliers and different scintillation materials in order to detect very low activity natural isotopes. The application aims to further the field of medical physics, bringing a cheap alternative to expensive imaging techniques such as MRIs. As part of our team you, together with a supervisor would be responsible with designing your own experiment and the data acquisition and analysis tools needed to extract physics results.

Group:

DET_Z

Project Category:

A1. Solid-state physics and nanoscience

Special Qualifications:

Python language knowledge
Basic Solid State Physics knowledge

DESY Site:

Zeuthen

24

Reconstruction of tau decays at Future Collider Experiments using Multivariate Methods and Machine Learning

Author: Bryan Bliewert[1]

Co-authors: Jenny List [2]; Julie Torndal [2]

[1] *FTX (FTX Fachgruppe SLB)*

[2] *DESY*

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The physics programs at lepton and future colliders offer diverse prospects for precision studies due to clean experimental environments. However, many challenges in the reconstruction remain. One of them is the reconstruction of tau leptons. The goal of this project is to develop MVA- or ML-based methods to identify and accurately reconstruct hadronic and leptonic tau decays. A possible application and benchmark is the Higgs self-coupling analysis at the ILD detector, where improvements to tau identification could increase the sensitivity in a variety of channels and decay modes.

Group:

FH-FTX

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Proficiency in programming in either Python or C++ are greatly beneficial.

DESY Site:

Hamburg

25

Physics Performance Studies of the International Large Detector at the FCC-ee

Author: Victor Laurenz Schwan[1]

Co-author: Jenny List [2]

[1] *FTX (FTX Fachgruppe SLB)*

[2] *DESY*

Corresponding Authors: jenny.list@desy.de, victor.laurenz.schwan@desy.de

The ILD detector concept has originally been developed for the International Linear Collider. Detailed simulations gauged against the performance of prototype components have shown that ILD in its ILC incarnation is ideally suited to pursue the physics program of a linear Higgs factory as well as of a higher energy e+e− collider. Recently, the ILD collaboration has started to investigate how the detector concept would need to be modified to operate successfully in the experimental environment of a circular Higgs factory like for instance FCC-ee. In particular, the interaction region, or machine-detector interface (MDI), requires substantial changes to make room for accelerator elements and to withstand backgrounds. Finally, the measurement precision and accuracy of this adapted model is to be studied.

Intern Role Description:

- support the efforts of designing a FCC-ee compatible version of the ILD detector concept
- co-development of a software framework for the systematic investigation of the effects of various underground processes in detectors
- evaluating the impact of different detector design options on physics studies
- possibly, improvement of track reconstruction software in modular detector concepts and facilitation of plug-and-play studies for future detectors
- possibly, co-development of a software framework for analyzing tracking performance in detectors

Group:

FH-FTX-SLB

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

- experience in data analysis using Python or ROOT/C++
- experience with Unix, git, python and C++ of advantage

DESY Site:

Hamburg

26

Improving Belle II Simulation for Rare B Meson Decays

Author: Sebastiano Raiz[1]

Co-author: Niharika Rout [2]

[1] *BELLE (BELLE II Experiment)*

[2] *(BELLE (BELLE II Experiment))*

Corresponding Authors: sebastiano.raiz@desy.de, niharika.rout@desy.de

The Standard Model (SM) describes elementary particles and their interactions but may be part of a more general theory. The Belle II experiment tests the SM by studying B meson decays, particularly those with missing energy, which are sensitive to new physics.

A recent Belle II result on $B \to K\nu\bar{\nu}$ shows a deviation from the SM, increasing interest in similar decays. At DESY, an analysis of $B^0 \to \rho^0(\to \pi^+\pi^-)\nu\bar{\nu}$ is underway, where precise simulation is crucial. A key challenge is background from $a_1(1260) \to \pi\pi$, which mimics ρ^0 but has poorly known properties.

This project focuses on improving Belle II simulation by studying $a_1(1260)$ decays using control samples and real data. The student will reconstruct and identify these decays, reducing systematic uncertainties in the analysis. Basic Python knowledge is required.

Group:

FH-BELLE

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Basic Python knowledge

DESY Site:

Hamburg

27

Radio Antennas and their properties

Authors: Anna Nelles[1]; Enrique Huesca Santiago[1]

[1] *Z-RAD (RADIO)*

Corresponding Authors: anna.nelles@desy.de, enrique.huesca.santiago@desy.de

Work on a future outreach project with antennas (also hardware).

Group:

Z-Radio

Project Category:

C2. Instrumentation for astroparticle physics

Special Qualifications:

DESY Site:

Zeuthen

29

Making GHz Frame-Rate Movies of Plasma Accelerator Devices

Author: Stephan Wesch[1]

Co-author: Jonathan Christopher Wood [2]

[1] *DESY-FTX-AST*

[2] *MPA (Beam-Driven Plasma Accelerators)*

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When two short electron bunches, separated in time by a few hundred femtoseconds, are focussed in to a plasma the space-charge force of the leading bunch expels plasma electrons from its vicinity. This creates accelerating and focussing electric fields for the trailing bunch with GV/m strengths, at least an order of magnitude greater than radiofrequency accelerators. Plasma accelerators therefore hold great promise to dramatically reduce the size and cost of future electron accelerators, providing a route to increased access to accelerator facilities and reduced environmental impact [1-5].

A key upcoming challenge for plasma accelerators is to raise their repetition rate from the current state of the art of 1-10 Hz to levels required for Collider or Free Electron Laser facilities, which is typically of order 10 kHz, or even 1 MHz. The first concrete steps towards this goal are currently being made as part of the FLASHForward experiment at DESY [6]. In order to produce the same accelerated beam properties every time the density profile of the plasma target must be kept the same, which is no easy challenge when both the drive bunch and the electric pulse used to create the plasma each deliver of order 100 J/m^3/us average power densities into the plasma source. Due to the rapid evolution of high energy density systems, diagnostics are required on the significantly sub-microsecond level.

This project will contribute to understanding the energy dissipation process from the plasma creation by using an ICCD camera to take nanosecond-gated images of the plasma evolution in the capillary to build up a GHz frame-rate movie of the plasma evolution. By spectrally filtering the light coming from the plasma, the behavior of trace elements used for density and temperature analysis can be mapped out, contributing to a fuller understanding of the plasma source. If time allows, the project could be extended to studying the effects of modifications to the plasma source design, which could be rapidly prototyped using 3D printing. Finally, a recently demonstrated statistical method could be attempted to provide high-time-resolution movies without the need for expensive cameras [7], making it suitable for implementation into the accelerator environment at FLASHForward.

Bibliography
[1] T. Tajima and J. M. Dawson, Laser electron accelerator, Phys. Rev. Lett. 43, 267 (1979).
[2] P. Chen et al., Phys. Rev. Lett. 54, 693 (1985).
[3] M. Litos et al., Nature 515, 92–95 (2014).
[4] C. A. Lindstrøm et al., Phys. Rev. Lett. 126, 014801 (2021).
[5] B. Foster et al., New J. Phys. 25 093037 (2023)
[6] https://mpl.desy.de/ffwd/
[7] V. Lee et al., Phys. Plasmas 31, 013104 (2024)

Group:

FH-FTX-AST

Project Category:

B3. Research on accelerators

Special Qualifications:

This is an experimental-based project. Some lab experience would be advantageous. Skills in data analysis in a language such as Python or MATLAB will be required.

DESY Site:

Hamburg

30

Decay-mode independent searches for new Higgs-like scalar at a future e+e- collider

Author: Maria Teresa Nunez Pardo De Vera[1]

Co-authors: Carl Mikael Berggren [2]; Jenny List [3]

[1] *FH-FTX/FS-EC*

[2] *FTX (FTX Fachgruppe SLB)*

[3] *DESY*

Corresponding Authors: maria-teresa.nunez-pardo-de-vera@desy.de, mikael.berggren@desy.de, jenny.list@desy.de

Many BSM models predict the existency of Higgs-like scalars. Future e+e- colliders are specially suited for searching these scalars, for instance in associated production with a Z boson. The most model-independent
search is based on the recoil of the scalar against the Z boson. This project will determine the sensitivity of a e+e- linear collider at center-of-mass energy 550 GeV to these new scalars, extending a study recently done at 250 GeV to higher scalar masses. The search will be based on a detailed simulation of the
International Large Detector (ILD) originally proposed for the ILC.

Group:

FH-FTX

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Good programming skills, mainly cpp and python, some knowledge of root adventageous.
Interest in physics prospects of future colliders.

DESY Site:

Hamburg

31

Sensitivity studies of rare B+ —> K+ tau+ tau- decays at Belle II

Author: Niharika Rout[1]

[1] *BELLE (BELLE Gruppe)*

Corresponding Author: niharika.rout@desy.de

The Standard Model (SM) of particle physics describes elementary particles and their interactions, but may be an effective theory incorporated into a more general framework at higher energies. Searching for physics beyond the SM is a key goal, pursued through direct high-energy searches and precision indirect measurements.

The Belle II experiment, situated at KEK, Japan, probes the SM by analysing meson and lepton decays from electron-positron collisions at 10.58 GeV energy, focusing on indirect search of non-SM physics. One such decay, \(B^+ \to K^+ \tau^+ \tau^- \), is sensitive for our search but challenging to detect due to the presence of neutrinos in the final states. In this project, we will analyse Belle II simulation data to search for this decay and set up the framework to reject the 10^9 times background events compared to the signal \(B^+ \to K^+ \tau^+ \tau^- \) events. Students will learn data analysis, Monte Carlo (MC) simulation, machine learning techniques, and statistical methods for high-energy physics. Prior knowledge of Python programming is required.

Group:

FH-BELLE

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

DESY Site:

Hamburg

32

Beam-Based THz Source for Users at the European XFEL

Authors: Francois Lemery[1]; Karel Camille A Peetermans[1]

[1] *MXL (XFEL)*

Corresponding Authors: karel.peetermans@desy.de, francois.lemery@desy.de

STERN (Superradiant THz radiation generation) is a project funded by the European XFEL to develop and provide a high-power terahertz source to enable pump-probe science with the existing high-power X-ray beam. This evasive region of the electromagnetic spectrum has a wide range of applications facilitating the exploration of life and matter science. STERN will use both diffraction targets and waveguides to generate broad- and narrowband radiation. The summer student will have several responsibilities including the production of novel high-frequency waveguides using atomic-layer deposition and the development of an experiment to characterize the waveguides. The student will have the option of working with high-power lasers and should be comfortable with some coding language like python. Furthermore, the student will assist in the assembly of the vacuum beamline for radiation transport as well as the vacuum chamber that will host the experiment itself.

Group:

MXL

Project Category:

B3. Research on accelerators

Special Qualifications:

DESY Site:

Hamburg

33

Simulation for a target experiment in the PRIMA facility with high intensity electron beams

Author: Dohun Kim[1]

Co-authors: Marcel Stanitzki [1]; Sven Ackermann [2]

[1] *FTX (FTX Fachgruppe TBT)*

[2] *FTX (FTX Fachgruppe AST)*

Corresponding Authors: marcel.stanitzki@desy.de, dohun.kim@desy.de, sven.ackermann@desy.de

The PRIMA (Primary-Beam Test Area) facility is located in the R-Weg, the former transport beam line from the DESY II synchrotron to the DORIS storage ring. PRIMA is a high-intensity electron beam facility that has been proposed for testing detectors and devices with much higher particle fluxes than the ones possible at the existing beamlines of the DESY II Test Beam Facility. Also sensor irradiation and fixed-target experiments are possible at this new beamline.
After parasitically extracting electron beams for the DESY II Test Beam Facility by creating Bremsstrahlung and using this to create electrons, the main beam of the DESY II synchrotron is currently dumped during test beam operation. The PRIMA facility upcycles these beams, using them for high-intensity experiments.
Recently, interest rose to create a muon beam for tomography. To carry out fixed target experiments in PRIMA, as for the above example generating muons with a tungsten target, it is also necessary to determine the radiation background from the target during and directly after irradiation and to establish when the radiation emitted by the activated materials falls to a safe level.
FLUKA is a Monte Carlo framework for simulating the interaction and transport of particles in materials including material activation. It is commonly used for studying the radiation background, the properties of shielding materials and particle generation through interactions with the target materials.
Using this simulation tool, the summer student will study the radiation background of the target during and after beam irradiation to investigate how the generated background can be shielded with suitable materials. In addition, thestudent will establish the rate at which the desired particles, typically muons and pions, are produced and how the choice of shielding changes the angular distribution of the created muon and pion beam.

Group:

FTX-TBT

Project Category:

B2. Development of experimental equipment (hardware-oriented)

Special Qualifications:

DESY Site:

Hamburg

34

Fast and efficient orbit response matrix measurement: A simulation study for PETRA IV

Author: Sajjad Hussain Mirza[1]

[1] *DESY (MSK)*

Corresponding Author: sajjad.hussain.mirza@desy.de

PETRA IV's large-scale storage ring will include 790 Beam Position Monitors (BPMs) and 560 fast corrector magnets, making traditional orbit response matrix (ORM) measurements inefficient. This summer student project focuses on deploying and testing in simulation a faster ORM measurement technique by simultaneously exciting corrector magnets with variable frequencies.

Group:

MSK

Project Category:

B3. Research on accelerators

Special Qualifications:

Programming Skills (Matlab)

DESY Site:

Hamburg

36

4D phase space coupling studies with the symmetric RF coupler

Author: Christopher James Richard[1]

[1] *Z_PITZ (Betrieb und Forschung)*

Corresponding Author: christopher.richard@desy.de

The student will re-analyze measured phase space scans using the virtual pepper pot method to quantify the x-y beam coupling from gun 5.2 with the symmetric rf coupler. The results will be compared to measurements from previous guns (gun 5.1 or earlier) which used an asymmetric rf coupler.

Group:

PITZ

Project Category:

B3. Research on accelerators

Special Qualifications:

DESY Site:

Zeuthen

38

Simulations for TW level, attosecond X-Rays pulses

Author: Marc Guetg[1]

Co-author: Filippo Sottocorona [1]

[1] *MXL (XFEL)*

Corresponding Authors: marc.guetg@desy.de, filippo.sottocorona@desy.de

Atto-second pulse generation is a major research direction for x-ray FELs worldwide. EuXFEL is currently undertaking a large simulation and engineering investigation as to asses eSASE as a way to generate the short pulses. The summer student will have the opportunity to learn the basics of the FEL process and the required training to perform simulations with the 3D simulation code GENESIS. This allows them to be part of the effort to generate Terawatt-level attosecond pulses in the hard x-ray regime.

Group:

MXL

Project Category:

B3. Research on accelerators

Special Qualifications:

DESY Site:

Hamburg

39

Modeling Drifts with Parameter-Varying Response Matrix Utilizing Existing Data of European XFEL

Author: Bindu Sharan[1]

Co-author: Marie Kristin Czwalinna [2]

[1] *MSK (Strahlkontrollen)*

[2] *DESY, MSK*

Corresponding Authors: bindu.sharan@desy.de, marie.kristin.czwalinna@desy.de

At the free-electron laser EuXFEL several separate, slow feedback control loops are used for long-term stabilisation of the electron bunch parameters. This study aims to investigate and model the characteristics of residual drifts in the feedback system in order to evaluate its closed-loop behaviour. The final goal is to develop a new design for a generalised global controller.

Group:

MSK-SDiag

Project Category:

B3. Research on accelerators

Special Qualifications:

DESY Site:

Hamburg

40

Research Facilities 2.0 - Sustainable Computing

Authors: Dwayne Isaac Patrick Laurence Spiteri[1]; Kilian Schwarz[1]; Martin Gasthuber[1]

[1] *IT (IT Scientific Computing)*

Corresponding Authors: kilian.schwarz@desy.de, martin.gasthuber@desy.de, dwayne.spiteri@desy.de

The EU funded project Research Facilities 2.0 has the aim to make large scientific infrastructures and institutes more sustainable.
Within the project green and sustainable concepts for the computing infrastructures at DESY for scientific data storage and data analysis are being developed. This not only happens in close collaboration among the various IT teams, but also within other DESY groups and other research infrastructures in Germany.

In this context the sustainability potentials of different computing strategies can be tested such as:
- the use of servers based on different architectures (ARM / RISV-V / AMD)
- the analysis of different machine specs in terms of efficiency in power and work done
- server based power reduction options as for instance frequency reduction.
- options to investigate power reduction options for storage and/or network (especially InfiniBand).
- strategies for running work differently to avoid times where power generation is dirtier

Students with more experience in software development can potentially contribute to an initial concept of a digital twin of the computing infrastructure at DESY.

Group:

IT

Project Category:

B5. Computing

DESY Site:

Hamburg

Special Qualifications:

comfortability with a UNIX terminal/commands, some prior coding experience

41

Enhancing the development of scientific software with Large Language Models

Authors: Andreas Haupt[1]; Dmitriy Kostunin[2]; Kilian Schwarz[3]

[1] *Z_DV (Datenverarbeitung)*

[2] *DESY Zeuthen*

[3] *IT (IT Scientific Computing)*

Corresponding Authors: andreas.haupt@desy.de, dmitriy.kostunin@desy.de, kilian.schwarz@desy.de

The project focuses on developing AI agents based on instruction-tuned large language models (LLMs) that can leverage existing documentation and codebases, understand contextual information, interact with external APIs, and communicate with users in natural language. The student will integrate these capabilities into the Cherenkov Telescope Array Observatory pipelines for both operations and offline data analysis. The project objectives include the embedding of relevant knowledge bases, implementing the required interfaces, and assessing the effectiveness of retrieval-augmented generation.

Group:

Z_DV

Project Category:

B5. Computing

Special Qualifications:

good Python programming skills; basic knowledge on large-language models, experience with their prompting

DESY Site:

Zeuthen

42

Research Software for DNA Methylation Analyses

Authors: Kilian Schwarz[1]; Yannis Schumann[2]

[1] *IT (IT Scientific Computing)*

[2] *IT (Informationstechnik)*

Corresponding Authors: kilian.schwarz@desy.de, yannis.schumann@desy.de

DNA methylation analyses represent one of the most prevalent techniques for genome-wide epigenetic characterizations e.g., for diagnoses of brain tumors. Only few companies offer the techniques and services to perform these analyses and they typically store the results in proprietary file formats, opaque to researchers. Despite significant efforts in reverse-engineering the structure of these files, there is no library for compiled languages that offers read/write access for all relevant sections.
We are looking for a summer student who will contribute to our toolkit for efficient analysis of DNA methylation data by pursuing one or multiple of the following goals:
• refactoring our Rust-based idat-crate for read/write operations to support further organisms (especially mouse-genome)
• extending our CI/CD pipeline (adding integration tests, integration with crates.io)
• writing and extending the documentation of the considered file formats

Group:

IT

Project Category:

B5. Computing

Special Qualifications:

The successful applicant should have at least beginner's experience with a statically typed programming language (e.g., C, C++, Rust, Java⋯) and should be interested in interdisciplinary work.

DESY Site:

Hamburg

44

Analysis of Strong-Field QED Data from FACET-II for the LUXE Experiment

Author: Luke Hendriks[1]

Co-authors: Antonios Athanassiadis [2]; Jenny List [3]

[1] *FTX (FTX Fachgruppe SLB)*

[2] *DESY - FTX*

[3] *DESY*

Corresponding Authors: jenny.list@desy.de, luke.hendriks@desy.de, antonios.athanassiadis@desy.de

The LUXE (Laser Und XFEL Experiment) collaboration aims to study quantum electrodynamics (QED) in strong electromagnetic fields, so called strong-field QED. These strong fields can make QED interactions non-perturbative. LUXE aims to reach this non-perturbative regime by colliding high energy electrons with a high intensity laser. In preparation for LUXE, a prototype of a high-rate electron detection system underwent testing at the FACET-II facility at SLAC National Accelerator Laboratory. During these tests the detector prototype also measured non-perturbative laser-electron interactions. This summer student project will focus on the analysis of FACET-II test beam data and the corresponding detector simulations, contributing to the technical preparation of the LUXE experiment at DESY.

Group:

FH-FTX

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Preferably some experience with Python and/or C++ or other programming languages, but the project could be adjusted for someone without programming experience, as long as they are willing to learn it.

DESY Site:

Hamburg

46

Exploring multi-wavelength correlation between maps using TeV, X-ray and radio observations

Authors: Emma Maria de Ona Wilhelmi[1]; Robert Daniel Parsons[2]; Sylvia J. Zhu[1]; Tim Lukas Holch[1]

[1] *Z_HESS (High Energy Steroscopic System)*

[2] *Z_GA (Gammaastronomie)*

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This project focuses on analyzing Multi-Wavelength (MWL) data across different energy bands, including TeV, X-rays, and radio, to explore and quantify statistical correlations between different datasets. By utilizing advanced statistical tools and techniques, we aim to investigate the interdependencies and potential physical non-thermal processes linking the emissions observed at different wavelengths. The project will involve processing observational data, applying correlation methods, and evaluating the strength and significance of these relationships. This project offers hands-on experience in data analysis, statistical methods, and multi-wavelength astronomy, while fostering the development of critical research skills in the field of high-energy astrophysics.

Group:

GAMMA

Project Category:

C1. Astroparticle physics analysis and observations

Special Qualifications:

DESY Site:

Zeuthen

47

Applications on Quantum-inspired Convolutional Neural Networks

Author: Hala Siddig Mohamed Elhag[1]

[1] *CQTA (Centre f. Quantum Techno. a. Application)*

Corresponding Author: hala.elhag@desy.de

Quantum Convolutional Neural Networks (QCNNs) have emerged in recent years as a promising tool in the field of quantum machine learning. Numerous studies have demonstrated that QCNNs can achieve improved accuracy compared to their classical CNN counterparts in various tasks. However, it has recently been shown that QCNNs, when applied to classical data, are classically simulable, raising questions about their quantum advantage in such contexts. Nevertheless, QCNNs still remain a viable architecture for a wide range of applications, particularly in scenarios where their quantum properties can be effectively leveraged.

Group:

CQTA

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

DESY Site:

Zeuthen

48

Modeling particle acceleration in the remnant of SN1987A

Authors: Qiqi Jiang[1]; Robert Brose[2]

Co-author: Mahmoud S.A. Alawashra [2]

[1] *THAT*

[2] *Z_THAT (Theoretische Astroteilchenphysik)*

Corresponding Authors: mahmoud.al-awashra@desy.de, robert.brose@desy.de, qiqi.jiang@desy.de

Supernova remnants are still the best candidates for for the origin of the majority of the Galactic cosmic-rays - the charged particles, that constantly bombard Earth from outer space. Despite the fact that our understanding of the acceleration process that energizes this cosmic-rays greatly improved since it first proposal in the middle of the last century, many details of the acceleration process are still poorly understood.

The remnant of the first detected Supernova in 1987 - SN 1987A - occurred in the large Magellanic cloud and was the closest Supernova to Earth in the last five centuries. As a consequence, its remnant is one of the best-observed objects in astronomical history. Despite all efforts, so far, no gamma-ray emission has been detected form SN 987A, which would be indicative of the particle acceleration happening in the object.

The aim of the project is to use state-of-the-art models for the medium around the progenitor-star of the explosion, to model the evolution of the shock-fronts in the object, the particle acceleration and ultimately the particles' emission. It will be a first attempt to model the acceleration in a peudo-3d model, assuming piecewise spherical symmetry, producing high-resolution emission maps in different wavelengths of the thermal and non-thermal emission that can be compared to rich observational dataset of this object.

Group:

THAT

Project Category:

C3. Theory of astroparticle physics

Special Qualifications:

Experience with python would be highly beneficial

DESY Site:

Zeuthen

49

Calibration or Simulation studies for the detection of astrophysical neutrinos with IceCube

Author: Markus Ackermann[1]

[1] *Z_ICE (IceCube+NG)*

Corresponding Author: markus.ackermann@desy.de

This project will encompass a small study on IceCube simulation or calibriation data to improve analysis performance or reduce systematic uncertainties.

Project Category:

C1. Astroparticle physics analysis and observations

Special Qualifications:

Experience in python programing

DESY Site:

Zeuthen

Group:

NEUTRINO

50

CTA SST Camera Backplane characterization tests

Author: Gianluca Giavitto[1]

[1] *Z_EL (Elektronik)*

Corresponding Author: gianluca.giavitto@desy.de

The goal of the project is to develop the tests to characterize the functionality of the Backplane of the SST camera.

The functionality to be tested includes:
- event timestamping
- data delivery
- trigger formation

Furthermore the tests will be used for quality control purposes, so they will need to be extensive and have full coverage of the backplane hardware (i.e. repeated for all channels and combinations).

This project will consist in a phase of learning about the SST camera hardware and the backplane in particular, the setting up the lab equipment, writing the software and performing the data analysis of the test results.

Group:

GAMMA

Project Category:

C2. Instrumentation for astroparticle physics

Special Qualifications:

DESY Site:

Zeuthen

52

Determination of fundamental standard model parameters using CMS data

Authors: Mikel Mendizabal Morentin[1]; Roman Kogler[2]

[1] *DESY*

[2] *DESY FH, CMS*

Corresponding Authors: roman.kogler@desy.de, mikel.mendizabal.morentin@desy.de

Global simultaneous fit to CMS data on jets, top quark production and fb asymmetry from Z boson decays together with HERA data. Extract alpha_s. m_t, sin_theta_w, EFT. Data and theory have been prepared for x

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

No special qualifications

DESY Site:

Hamburg

53

Studying the Higgs Boson production in association with top-quarks and decaying into a b-quark pair with CMS Run 3 data

Authors: Daina Leyva Pernia[1]; Danyer Perez Adan[2]; Maria Aldaya Martin[1]; Matin Torkian[1]

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[2] *RWTH Aachen*

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The measurement of the top-Higgs coupling is a crucial probe for testing the validity of the Standard Model. One direct way to explore this coupling is through the top-associated Higgs boson production process (ttH). On the other hand, the Higgs decay into a pair of bottom quarks (Hbb) features the largest branching fraction among all possible channels and thus offers a great incentive to scrutinize this process. This project contributes to the ongoing analysis of the ttHbb process with CMS Run 3 data, with an emphasis on several key improvements:

• The transition towards more data-driven methods for improved background description.

• The application of advanced Machine Learning (ML) techniques for more accurate jet-parton assignment and event categorization.

The student will gain an in-depth understanding of the analysis workflows at CMS and will contribute to the development of the ttHbb analysis. They will explore the potential kinematic reconstruction of the signal events when both W bosons emerging from the top quark pair decay to a (anti-)lepton and a (anti-)neutrino.

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Python

DESY Site:

Hamburg

54

Search for Higgs-pair production in the CMS experiment at the LHC

Authors: Rainer Mankel[1]; Suman Chatterjee[2]

[1] *DESY*

[2] *CMS (CMS Fachgruppe HIGGS)*

Corresponding Authors: suman.chatterjee@desy.de, rainer.mankel@desy.de

Run 3 data, look for HH -> 4b
ML techniques for s/b discrimination
and b tagging

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

C++ and/or Python, ROOT preferred but not necessary

DESY Site:

Hamburg

55

Search for BSM Neutral Higgs boson decaying into a pair of tau leptons using a columnar analysis framework

Authors: Alexei Raspereza[1]; Aliya Nigamova[2]; Jacopo Malvaso[3]

[1] *DESY*

[2] *University of Hamburg*

[3] *CMS (CMS Fachgruppe HIGGS)*

Corresponding Authors: aliya.nigamova@desy.de, jacopo.malvaso@desy.de, rasp@mail.desy.de

Training of ML tools and optimization of analysis sensitivity.
Developing analysis tools to search for signatures of BSM physics in BSM H-> tau tau

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Good knowledge of Python

DESY Site:

Hamburg

56

Long-lived particles at the FCC-ee

Authors: Freya Blekman[1]; Jeremi Niedziela[2]; Juliette Alimena[3]; Lovisa Rygaard[3]

[1] *DESY/University of Hamburg*
[2] *DESY*
[3] *CMS (CMS Fachgruppe Searches)*

Corresponding Authors: juliette.alimena@desy.de, lovisa.rygaard@desy.de, freya.blekman@desy.de, jeremi.niedziela@desy.de

FCC-ee sensitivity studies to LLPs.
Long-lived ALP - can we see them?
Supervisors will be J. Alimena and L. Rygaard.

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Linux and C++/Python. Experience with ROOT is a plus

DESY Site:

Hamburg

57

Searching for new Long lived particles using a dedicated detector simulation

Authors: Andreas Hinzmann[1]; Lucia Coll Saravia[1]

[1] *CMS (CMS Fachgruppe Searches)*

Corresponding Authors: lucia.ximena.coll.saravia@desy.de, andreas.hinzmann@desy.de

PUCP ToyDetector C++ simulation with Pythia8 and Fastjet
Rerun simulation and do statistical data analsysis as well
as a search for a new heavy neutrino

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Preferably C++ (MG5 and Pythia 8 knowledge welcome)

DESY Site:

Hamburg

58

Searching for Cosmologially-motivated Dark Showers at the LHC

Authors: Dominic Stafford[1]; Freya Blekman[2]

[1] *CMS (CMS Fachgruppe Searches)*

[2] *DESY/University of Hamburg*

Corresponding Authors: freya.blekman@desy.de, dominic.stafford@desy.de

Generate MC samples, investigate sensitive variables

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Strong physics background, experience in data analysis, MC generation, and in particular, C++

DESY Site:

Hamburg

59

Analysis of CERN Open Data Integration of ATLAS research-0-level Open Data into Higgs–>4 Lepton analysis example

Author: Achim Geiser[1]

[1] *CMS (CMS Fachgruppe QCD)*

Corresponding Author: achim.geiser@desy.de

Open data analysis

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Basic ROOT and C++ or Python, as well as particle physics

DESY Site:

Hamburg

60

Automation of tracker alignment workflows for the CMS experiment

Authors: Lakshmi Priya Nair[1]; Tomas Kello[None]

[1] *CMS (CMS Fachgruppe HIGGS)*

Corresponding Authors: lakshmi.priya.sreelatha.pramod@desy.de, tomas.kello@cern.ch

Automation of workflows for HL-LHC Runs 4 and 5.

Project will be co-supervised by Tomas Kello from remote.

Group:

FH-CMS

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Python and shell

DESY Site:

Hamburg

61

Measuring Proton Structure Functions with xFitter

Authors: Alexander Glazov[1]; Oleksandr Zenaiev[2]

[1] *DESY*

[2] *Hamburg University*

Corresponding Authors: alexander.glazov@desy.de, oleksandr.zenaiev@desy.de

The structure of the proton is governed by quantum chromodynamics (QCD), a non-Abelian gauge theory that exhibits striking variations across different momentum scales. Understanding this structure requires precise measurements and theoretical modeling. In this project, a summer student will use xFitter, a tool for performing QCD fits to experimental data, to analyze the proton's parton distribution functions (PDFs). The study will focus on recently introduced theoretical models and their impact on PDF extraction. Fits will be performed using deep inelastic scattering (DIS) data from HERA electron-proton collider, with a particular emphasis on their implications for precision measurements at the Large Hadron Collider (LHC) and studies of ultra-high-energy cosmic neutrino interactions.

Group:

FH-Belle II

Project Category:

B1. Physics data analysis and performance (software-oriented)

Special Qualifications:

Basic programming and familiarity with statistical analysis techniques

DESY Site:

Hamburg

62

Preliminary design considerations for Helmholtz coils at the PITZ RF photogun

Authors: Matthias Gross[1]; Mikhail Krasilnikov[1]

[1] *DESY*

Corresponding Authors: mikhail.krasilnikov@desy.de, matthias.gross@desy.de

Description: The student will investigate the space constraints around the PITZ RF gun to develop Helmholtz air coils to compensate for the vertical and horizontal components of the earth's magnetic field (residual magnetic field in the tunnel). Two pairs of coils around the cavity of the gun should be able to generate a static homogeneous magnetic field of ~50 uT along the cavity axis. Simulations of the static magnetic field should also consider the number of wire windings in conjunction with the available power supply capability, and an estimate of the wire heating has to be done. Optionally, residual magnetic field measurements with a Hall probe could be done.

Group:

PITZ

Project Category:

B3. Research on accelerators

Special Qualifications:

DESY Site:

Zeuthen

63

Studying the neutrino-blazar connection with public data from the IceCube Neutrino Observatory

Author: Massimiliano Lincetto[1]

[1] *Z_GA (Gammaastronomie)*

Corresponding Author: massimiliano.lincetto@desy.de

Astrophysical neutrinos, produced in the interaction of accelerated ions with particles or radiation fields, are a key messenger for understanding the origin of ultra-high-energy cosmic rays. However, the sources of astrophysical neutrinos are, for the most part, still unknown. Blazars, active galactic nuclei with relativistic jets pointed towards Earth, are among the most powerful cosmic accelerators in the Universe and promising candidate sources for both neutrinos and cosmic rays. In this project, you will analyse public data from the IceCube Neutrino Observatory, gaining experience with maximum likelihood methods used in the search for neutrino point sources. The work will be aimed to study the hypothesis of blazars being sources of astrophysical neutrinos.

Group:

GAMMA

Project Category:

C3. Theory of astroparticle physics

Special Qualifications:

DESY Site:

Zeuthen

64

Non-relativistic top quarks at the LHC

Author: Katharina Behr[1]

[1] *ATLAS (Fingerprint of the Vacuum)*

Corresponding Author: katharina.behr@desy.de

Collision events resulting in a top and an anti-top quark ($t\bar{t}$) provide a sensitive probe of phenomena beyond the Standard Model, such as additional neutral Higgs bosons or axion-like particles. Moreover, they provide an ideal test bed to study quantum phenomena, such as spin entanglement, at the TeV scale and in a system of fundamental quarks. Recently, special attention has been drawn to top quarks close to the kinematic threshold for $t\bar{t}$ production ($m_{t\bar{t}} \sim 2m_t$), where the top quarks carry only a very small Lorentz boost and their dynamics can be described by non-relativistic QCD. In this region, the $t\bar{t}$ system is not only maximally entangled but may also form a –so far only hypothetical

–quasi-bound state, which it may be possible to observe with the current LHC datasets. Current reconstruction mechanism for top quarks are not optimised for this kinematic region where typically one of the top quarks is not on-shell. Improved reconstruction algorithms are needed for precision measurements and searches for new phenomena close to the kinematic threshold.

In this project, we will investigate the use of different ML techniques (DNNs, transformers) to improve the reconstruction accuracy –and hence resolution of kinematic variables of interest –close to the kinematic threshold. The performance will be measured in simulated $t\bar{t}$ events and compared to that of established reconstruction algorithms optimised for the full kinematic regime.

Special Qualifications:

Python

DESY Site:

Hamburg

Group:

FH-ATLAS

Project Category:

B1. Physics data analysis and performance (software-oriented)

65

Phenomenology of Energy Correlators Measured on Boosted Top Quarks

Author: Aditya Pathak[1]

[1] *DESY*

Corresponding Author: aditya.pathak@desy.de

Energy Energy Correlators (EECs) are a class of collider observables that characterize the hadronic energy flux by measuring energy weighted angular correlations. They have recently gained a significant interest as tools for precision measurements. In particular, EECs, when measured on boosted top quark jets, can yield an elegant probe for the top quark mass. The project will involve exploring the phenomenology of EECs and their application for top mass measurements using the tools of Monte Carlo simulations. Prerequisites include knowledge of quantum field theory, QCD, as well as good software skills.

Group:

T

Project Category:

B4. Theory of elementary particles

Special Qualifications:

Knowledge of C++/Python, Basics of quantum field theory, QCD

DESY Site:

Hamburg

66

Enhancing Accelerator Diagnostics: Real-Time ML-Driven Image Analysis

Authors: Frank Mayet[1]; Sergey Tomin[1]

[1] *MXL (XFEL)*

Corresponding Authors: sergey.tomin@desy.de, frank.mayet@desy.de

Accurate beam image analysis is a cornerstone of accelerator diagnostics. A critical challenge in this domain is the reliable identification of regions of interest (ROI), especially when electron beam parameters change significantly—often causing traditional algorithms to falter. This proposal aims to investigate whether machine learning techniques can significantly enhance the accuracy and robustness of ROI detection in quasi real-time. The project will involve developing, training, and evaluating ML models tailored for online image analysis, with the goal of boosting diagnostic performance.

Group:

MXL

Project Category:

B3. Research on accelerators

Special Qualifications:

computing, machine learning, python

DESY Site:

Hamburg

67

Development of 3D printed nozzles for time-resolved serial crystallography

Author: Sasa Bajt[None]

Corresponding Author: sasa.bajt@desy.de

Protein microcrystals can be delivered into an x-ray beam produced by an X-ray free electron laser or synchrotron via liquid jets. Such jets can be created by gas virtual dynamic nozzles (GDVNs) to achieve fast, micron diameter jets. The project is aimed to further development and study of a device fabricated with 3D printing for the application in serial crystallography. It will include design and 3D printing of nozzles with the state-of-the-art 3D printer; device assembly in the nozzle lab and jetting tests.

Group:

FS-ML

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

68

Observation of the development and propagation of instabilities in laser compressed matter

Author: Cornelius Strohm[1]

[1] *DESY Photon Science*

Corresponding Author: cornelius.strohm@desy.de

N/A

Group:

FS-HIBEF

Project Category:

A1. Solid-state physics and nanoscience

Special Qualifications:

DESY Site:

Hamburg

69

Non-equilibrium heating of a plasma to million-Kelvin temperature

Authors: Sang-Kil Son[1]; Zoltan Jurek[2]

[1] *CFEL-DESY*

[2] *FS-CFEL-3 (Forschung mit Photonen Theorie)*

Corresponding Authors: sangkil.son@cfel.de, zoltan.jurek@desy.de

Intense x-ray pulses from x-ray free-electron lasers (XFELs) can produce matter at extreme conditions. This can be used to gain insight on stellar and planetary interiors or on high-energy density plasmas in inertial confinement fusion. Because of the ultrashort pulse duration, XFEL-produced plasmas are initially out of equilibrium, and the ensuing thermalization dynamics are not well understood. Recently, an experiment conducted at the European XFEL demonstrated that a neon plasma was formed by an XFEL pulse with an electron temperature approaching 1 keV, corresponding to about 1 million Kelvin. The DESY summer student working on this project will have the opportunity to learn the basics of x-ray-matter interactions and plasma physics. The student will become familiar with the XATOM and XMDYN codes developed at DESY. These codes allow the student to perform non-equilibrium simulations of neon plasma formation, in order to explore how to reach such extreme temperatures and to determine the time scale on which thermalization between electrons and ions unfolds.

Group:

FS-CFEL-3

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

70

Cross-correlating Major Luminescence Pressure Standards for Diamond Anvil Cell Experiments at Low Temperatures

Author: Konstantin Glazyrin[1]

[1] *FS-PETRA-D (FS-PET-D Fachgruppe P02.2)*

Corresponding Author: konstantin.glazyrin@desy.de

The diamond anvil cell is a well-established high-pressure technique that enables studies of small material samples at pressures exceeding multiple megabars. It is widely used for investigating strongly correlated systems, particularly at moderate pressures below 50 GPa and low temperatures.
While luminescence standards for pressure determination are well understood under ambient and high-temperature conditions, low-temperature studies rely primarily on Cr^{3+}-doped Al_2O_3, which has limitations and conflicting calibration curves. This project will cross-correlate four luminescence-based pressure standards—Sm:YAG, $SrBrO_4$, Cr:Al_2O_3, and the novel AlB_4O_6N. The resulting insights will improve reproducibility and comparability in high-pressure, low-temperature experiments, but in particular in the fields of solid state physics.

Group:

FS-PETRA-D

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

71

Instrumentation development for the polarized luminescence measurements at P66, PETRA III

Authors: Aleksandr Kataev[1]; Aleksei Kotlov[2]; Oksana Chukova[2]; Yevheniia Smortsova[2]

[1] *FS-PETRA-S*

[2] *FS-PETRA-S (FS-PET-S Fachgruppe P66(Time-r-lumi.))*

Corresponding Authors: yevheniia.smortsova@desy.de, aleksei.kotlov@desy.de, aleksandr.kataev@desy.de, oksana.chukova@desy.de

P66 time-resolved vacuum-ultraviolet spectroscopy beamline started its operation in autumn 2021 and is devoted to the study of the electronic structure of the wide-bandgap luminescent materials. Circularly-polarized luminescence (CPL) is emitted by the chiral enantiopure (no inversion centre) materials and is an interesting fundamental process, structural relationship of which that is not yet completely understood. The CPL measurement scheme at P66 is realized using a quarter-wave plate and a linear film analyzer.
The aim of the project is the design, production and programming of a new motorized stage supporting the quarter wave plate.

Group:

FS-PETRA-S

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

72

Time-resolved luminescence spectroscopy of wide bandgap oxide nanocrystals

Authors: Aleksandr Kataev[1]; Aleksei Kotlov[2]; Oksana Chukova[2]; Yevheniia Smortsova[2]

[1] *FS-PETRA-S*

[2] *FS-PETRA-S (FS-PET-S Fachgruppe P66(Time-r-lumi.))*

Corresponding Authors: oksana.chukova@desy.de, aleksei.kotlov@desy.de, yevheniia.smortsova@desy.de, aleksandr.kataev@desy.de

Possibility of luminescence excitation with VUV and XUV photons is very important, sometimes critically important for study of widebandgap materials especially if they are developed for high energy applications. Luminescence spectroscopy plays a crucial role include material characterization, biomedical imaging, sensing and lightening techniques, wide bandgap materials engineering. Luminescence study can provide insights into the structural properties of materials, helping researchers understand the arrangement of atoms and molecules. It is sensitive to defects and impurities in materials, making it a valuable tool for identifying and characterizing structural imperfections. Such excitation can be optimally realized with application of the pulsed synchrotron light sources devoted to material science needs like PETRA III at Deutsches Elektronen-Synchrotron (DESY). The PETRA III P66 Time resolved luminescence spectroscopy (TRLS) beamline at DESY is a unique facility specifically designed to study the luminescence phenomena of various materials as a function of photon energy and time with excitation by pulsed synchrotron radiation.
We propose to concentrate in this project the area of scientific interest on luminescence spectroscopy of wide bandgap oxide nanocrystals as there are stable materials with high resistivity to effects of external factors those are widely used in optoelectronics.

Group:

FS-PETRA-S

Project Category:

A1. Solid-state physics and nanoscience

Special Qualifications:

DESY Site:

Hamburg

73

Expand the View of the X-Ray Tomograph ENCI

Authors: Andreas Schropp[1]; Philipp Paetzold[2]

[1] *FS-PETRA (PETRA III)*

[2] *FS-PS (Photon Science)*

Corresponding Authors: andreas.schropp@desy.de, philipp.paetzold@desy.de

The portable CT device ENCI, developed by the FS-PETRA group in close collaboration with the Excellence Cluster "Understanding Written Artefacts" at the University of Hamburg, has already been successfully deployed in renowned institutions such as the Louvre and the Museum of Anatolian Civilizations. In these settings, it has revealed the hidden messages of 4000-year-old cuneiform tablets.
Now that the device has returned to DESY, the next phase of development aims to optimize the investigation of larger specimens. These objects currently pose challenges as they do not fit entirely within the Field of View (FOV). To effectively capture their details, more complex scanning methods are required, either through multiple scans or a helical scan trajectory. While initial ideas and approaches have been proposed, there remains significant potential for further development and refinement. Participants will need basic coding skills in Python to contribute effectively.
This project offers summer students a unique opportunity to contribute to the advancement of ENCI and get introduced to the topic of tomography. Due to the user-friendly interface and straightforward handling, students will have the chance to independently carry out data acquisition on clay tablet replicas or even on their own samples, making for a truly enriching experience.

Group:

FS-PETRA

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

74

Tomography alignment automation

Author: Ken Vidar Falch[1]

[1] *FS-PETRA-S (FS-PET-S Fachgruppe P06)*

Corresponding Author: ken.vidar.falch@desy.de

One of the routine experiments at the P06 scanning microscopy beamline is tomography. Tomography is a 3D imaging technique where a 3-dimensional image of a sample is constructed from a series 2D images taken from different angles. For this, the sample is mechanically rotated, as well as translated in the focused x-ray beam. A critical preparatory step is the alignment of the sample and rotation axis so that the sample is always in frame during rotation. While a simple task in principle, it is a process prone to human error. More often than not, this is a time consuming process, which depending on circumstances can even take multiple hours. P06 would like to automate its tomography alignment procedure as much as reasonably possible. Starting with coarse alignment based on visible light microscopes, and eventually progressing down to the sub micron alignment precision needed to place small crystal grains into the axis of rotation.

Group:

FS-PETRA-S (P06)

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

75

Setting-up a Yb:YLF femtosecond laser oscillator

Author: Marcus Seidel[1]

[1] *FS-LA (High-Power Laser Sources)*

Corresponding Author: marcus.seidel@desy.de

Femtosecond lasers have found a wide variety of applications in science and industry. For example, they are used for recording ultrafast molecular movies and for high-precision materials processing. The aim of the summer project is to set-up a femtosecond laser oscillator based on the active material Yb:YLF, which offers exceptional power and energy scalability when cooled to cryogenic temperatures [1]. The project will provide theoretical and practical knowledge in laser engineering and femtosecond optics. Topics include resonator design, passive mode locking, and dispersion control. Previous work [2,3] can be used as a guideline for the experiments. The student will work in state-of-the-art ultrafast laser laboratories and will have access to all necessary diagnostic tools to characterize the developed light sources. The project results can later be used to build a laser amplifier chain.

[1] Demirbas et al., Optics Letters 46, 3865 (2021). [https://doi.org/10.1364/OL.430651]
[2] Coluccelli et al., Optics Express 16, 2922 (2008). [https://doi.org/10.1364/OE.16.002922]
[3] Demirbas et al., Optics Letters 47, 933 (2022). [https://doi.org/10.1364/OL.450706]

Group:

FS-LA

Project Category:

A5. Lasers and optics

Special Qualifications:

DESY Site:

Hamburg

76

Fast diffraction data heuristics for real-time data processing

Authors: Anton Barty[1]; Thomas White[2]

[1] *FS-SC (Scientific computing)*

[2] *FS-SC*

Corresponding Authors: thomas.white@desy.de, anton.barty@desy.de

This project aims to develop fast methods that can be used for rapidly recognising valid crystallographic diffraction patterns in our real-time data processing system. The new methods will be incorporated in software deployed at facilities around the world.

Group:

FS-SC

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

77

Development of an optical chopper for a compact FTIR instrument

Authors: Rui Pan[1]; Seung-gi Gang[1]

[1] *FS-FLASH-B (FLASH Photon Beamlines and Optics)*

Corresponding Authors: seung-gi.gang@desy.de, rui.pan@desy.de

The student will design, test, and validate a new setup for a compact optical chopper that will later be a part of the FTIR setup for FEL characterization and material analysis. The project involves 3D modeling, python programming, basic electronics and work with optomechanical systems. Depending on the progress of the project, this chopper will be used for absorption/transmission measurements of materials in a broadband spectral range.

Group:

FS-FL-B

Project Category:

A5. Lasers and optics

Special Qualifications:

DESY Site:

Hamburg

78

Automatization of SFX data analysis for high-throughput structural dynamics

Author: Dominik Oberthuer[1]

[1] *HH_FS_CFEL-1 (Fachgruppe SFX)*

Corresponding Author: dominik.oberthuer@cfel.de

N/A

Group:

FS-CFEL-1-SFX

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

79

Scanning X-ray Diffraction Microscopy of Unconventional Non-Cubic Gold Microcrystallite

Author: Chaitali Sow[1]

[1] *FS-PETRA (PETRA III)*

Corresponding Author: chaitali.sow@desy.de

Bulk gold usually crystallizes in face-centered cubic crystal structure. Recently, we have stabilized Au microcrystallites in unconventional body-centered orthorhombic and body-centered tetragonal (together referred to as bc(o,t)) lattices. These bc(o,t) microcrystallites exhibit excellent catalytic properties and nobler behavior in aqua regia and mercury, in clear contrast to the celebrated properties of the conventional Au. Quantifying the presence of strain within individual crystallite is important for understanding their growth. For this, scanning X-ray diffraction microscopy of a single gold microcrystallite has been done at P06 beamline. Currently, we are analyzing the generated data. The project student can take part in the analysis of the diffraction data and understand the strain distribution within the microcrystallite body.

Group:

FS-PETRA

Project Category:

A1. Solid-state physics and nanoscience

Special Qualifications:

DESY Site:

Hamburg

80

Sampling Requirements for X-ray Ptychography

Author: Mansi Butola[1]

[1] *FS-CFEL-1 (Forschung mit Photonen Experimente 1)*

Corresponding Author: mansi.butola@desy.de

The student will develop a formal analysis the optimal experimental parameters in the method of ptychography, in which many coherent X-ray diffraction patterns or holograms are recorded from an object and combined to recover a high-resolution image.

Group:

FS-CFEL-1

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

81

A Unified Deep Learning Approach for Denoising and Flat Field Correction in Near-Field Holographic Imaging

Author: Vahid Rahmani[1]

[1] *FS-PETRA (PETRA III)*

Corresponding Author: vahid.rahmani@desy.de

Background and Motivation:

In Near-field holography effective denoising and flat field correction are critical for accurate image reconstruction. Traditionally, flat field correction relies on principal component analysis (PCA), which computes the PCA components from a series of images without objects and subtracts the PCA representation from the images with objects. While effective, PCA is a linear method and may not fully capture the complex variations in holographic imaging conditions.
Recent advances in deep learning have demonstrated the ability of neural networks to extract rich, nonlinear feature spaces from data. These feature spaces can serve multi-purpose roles, including denoising and flat field correction. This project proposes a unified approach that leverages the feature space of a denoising deep learning model not only for noise removal but also as a replacement for PCA components in flat field correction. By using the same model for both tasks, the proposed method aims to enhance the accuracy and robustness of the correction process while simplifying the overall framework.

Significance and Impact:

This project has the potential to significantly advance the field of holographic imaging by introducing a deep learning-based alternative to PCA for flat field correction. The proposed method can improve image quality, facilitate more accurate scientific analyses, and pave the way for broader adoption of machine learning techniques in optical imaging. The outcomes of this research can benefit applications in biomedical imaging, material science, and other fields that rely on holographic imaging techniques.

Strengths of the Idea:

1. Combining Denoising and Flat Field Correction: Leveraging the same feature space for both tasks is efficient and reduces the need for separate models or processes.
2. Deep Learning Over PCA: PCA is linear, while deep learning can model nonlinear, complex variations, which are more representative of real-world imaging conditions.
3. Feasibility in Six Weeks: Since the denoising model is already developed, the project focuses on optimizing and adapting its feature space, making the scope manageable within the timeline.
4. Scientific Impact: A more robust flat field correction method using deep learning can significantly improve image quality, making it highly impactful for fields like biomedical imaging and materials science.

Group:

FS-PETRA / CXNS

Project Category:

A6. Theory and computing

Special Qualifications:

programming, machine learning

DESY Site:

Hamburg

82

Modeling of Scanning X-ray Microscopy using a MEMS-activated scanning mirror

Author: Martin Seyrich[1]

[1] *FS-PETRA-BO (Beamline Optics Simulation)*

Corresponding Author: martin.seyrich@desy.de

In X-ray Scanning Microscopy techniques, the sample is conventionally scanned through the X-ray beam. However, for very fast measurements and sample systems contained in heavy in-situ environments, this approach is limited by the mechanics of the scanning stage.

It is therefore desirable to develop a microscope that scans the X-ray beam over a stationary sample. One problem in such a system is that X-ray mirrors introduce distortions of the wavefront, changing with the reflection angle of the mirror. This results in changes of the beam shape during the scanning motion. This is particularly relevant in coherent scanning microscopy (ptychography).

The student will work with first experimental data to retrieve the shape error of the mirror and produce a forward model of the imaging process using a scanning mirror.

Group:

FS-PETRA-BO

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

83

Simulation of molecular dynamics in reaction microscopes

Author: Ulrike Fruehling[1]

[1] *FS-FLASH-O (FLASH Scientific User Operation)*

Corresponding Author: ulrike.fruehling@desy.de

At the free-electron laser in Hamburg (FLASH) a reaction microscope (REMI) is used to study the dynamics of atoms and small molecules following photoexcitation. With this setup, the momenta of charged fragments (ions and electrons) are measured in coincidence, allowing for detailed insights into molecular states and geometries.

We use a Python program to simulate the trajectories of the charged particles and predict the expected detector images in the REMI. Within this project this code will be further developed to include also the simulation of molecular geometry changes on the experimental outcome. The project offers a great opportunity to learn about atomic and molecular physics experiments at FELs, advanced experimental techniques and gain experience in Python programming.

Group:

FS-FL-O

Project Category:

A4. Development of experimental techniques

Special Qualifications:

Python

DESY Site:

Hamburg

84

Automation of Liquid Flat-Jet Characterization for X-ray Free-Electron Laser Experiments

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[1] *FS-PS-FCP*

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This project aims to develop an automated system for real-time characterization of water flat-jets using MATLAB or LabVIEW. The goal is to create a user-friendly graphical user interface (GUI) that allows for one-click characterization, enabling efficient and accurate measurements of flat-jet dimensions (250 x 500 μm2 area and sub-μm thickness) from laser interference fringe patterns during experimental campaigns. The project will integrate the GUI with the experimental setup for real-time analysis, tested under vacuum conditions, to optimize the system for accuracy and reliability. The outcome of the project will include a fully functional GUI for automated vacuum running flat-jet characterization during beamtime at the X-ray Free-Electron Laser. Currently, we have the capability to measure the flat-jet thickness using phase shift data from an interferometer using MATLAB programing software. The existing diagnostics software package is needed to be further developed.

Group:

FS-PS-FCP

Project Category:

A4. Development of experimental techniques

Special Qualifications:

Matlab

DESY Site:

Hamburg

85

Machine-learning-based analysis of interface evolution during spray coating

Author: Stephan Roth[1]

[1] *FS-SMA (Sustainable Materials)*

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In modern thin film technology, spray coating plays a crucial role in fabricating flexible electronics and photovoltaics. The complex interface and multilayer structure are deduced by surface-sensitive

scattering methods [1]. Spray coating was applied to create functional layers, from novel latex colloids to complex biomaterials templates [2,3]. There is a strong need to go beyond a one-dimensional analysis and to investigate the use of simulation-based analysis. The real-space structure is modeled (size and distribution of the nanostructures in three dimensions), the scattering pattern is calculated and compared to the experimental data. Hence, the goal of this project is to simulate the scattering pattern based on established algorithms and based on our results recently obtained [2,3,4]. The project includes image analysis, machine learning, supercomputing, as well as establishing reliable and feedback fitting routines. The simulations will be compared to previously acquired data [2,3,4]. Ultimately, the project participates in establishing a digital twin of the real experiments.

Literature:
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[2] J. Engström, C. J. Brett, V. Körstgens, P. Müller-Buschbaum, W. Ohm, E. Malmström, and S. V. Roth: "Core–Shell Nanoparticle Interface and Wetting Properties", Adv. Funct. Mater. 30, 1907720 (2020)
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Group:

FS-SMA

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

86

Machine-learning supported shaping of laser pulses in a control loop

Authors: Hsuan-Chun Yao[1]; Tim Laarmann[2]

[1] *FS-PS (Photon Science)*

[2] *FS-PS (FS-PS Fachgruppe FCP)*

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The central goal is the implementation of a neural network based self-learning loop, which connects advanced laser technology, an optimization algorithm, and an experimental feedback signal. The showcase example is the machine-learning supported compression of a femtosecond laser pulse to its Fourier limit, which is the lower limit for the pulse duration that can be technically realized for a given optical spectrum of the pulse. The corresponding experimental realization is the maximization of laser-frequency up-conversion, i.e. second-harmonic generation in a nonlinear optical crystal. The higher the recorded second-harmonic output signal is that serves as the feedback for the algorithm, the shorter the initial laser pulse is that interacts with the crystal. The optimization algorithm controls the pulse shaper hardware and proposes a new pulse that gives rise to another output signal, until convergence is reached. The summer student will join the team of experienced scientist working on the project to characterize convergence of optimal control algorithm with respect to the number of free variables, steering parameters and noise resilience.

Group:

FS-PS-FCP

Project Category:

A5. Lasers and optics

Special Qualifications:

Programming experience

DESY Site:

Hamburg

87

Upgrading an x-ray attosecond pump-probe beamline with an active stabilization interferometer

Authors: Aurelien Sanchez[1]; Kate Robertson[1]

[1] *FS-ATTO*

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Are you curious about how atoms and electrons move on the fastest timescales imaginable? Join the Attosecond Science Group (https://atto.cfel.de) at the Center for Free-Electron Laser Science (CFEL), where we create and harness ultrashort laser pulses with durations in the attosecond (1 as = 10^{-18} s) and few-femtosecond (1 fs = 10^{-15} s) range. These pulses allow us to observe and manipulate ultrafast dynamics in systems ranging from bio-relevant molecules to clusters and nanoscale materials. By exploring these fundamental processes, we aim to deepen our understanding of the earliest steps in photochemistry and pave the way for potential control over these ultrafast reactions.
What You'll Do:
In this project, you'll gain hands-on experience with experimental techniques designed for time-resolved ultrafast experiments on the femtosecond and attosecond timescales. A key aspect of these experiments is ensuring the beamline's stability for long-duration scans. You will:
• Build an interferometer using a leakage of the IR main driving field in both arms of our in-vacuum beamline.
• Develop methods to stabilize the beamline, ensuring precise alignment and timing control for extended data collection.
• Apply programming skills to automate the system and maintain temporal overlap of both beams with attosecond precision.
This project offers an exciting opportunity to work on both the hardware and software aspects of ultrafast laser experiments, contributing directly to the enhancement of cutting-edge pump-probe techniques.
Who Should Apply:
We welcome motivated master's students with a background in physics, optics, engineering, or related fields. Familiarity with interferometry, laser systems, or vacuum technology is an advantage. Additionally, programming experience (e.g., Python, LabVIEW, or similar) will be valuable for automating the stabilization system. Most importantly, we're looking for students with a passion for experimental research and a desire to work at the forefront of ultrafast science.

Group:

FS-ATTO

Project Category:

A5. Lasers and optics

Special Qualifications:

DESY Site:

Hamburg

88

Ultrathin liquid jet systems for probing electronic and vibrational coherences in solution

Authors: Oliviero Cannelli[1]; Sabine Rockenstein[1]

[1] *FS-ATTO (Attosecond Science and Technology)*

Corresponding Authors: oliviero.cannelli@desy.de, sabine.rockenstein@cfel.de

Are you curious about how atoms and electrons move on the fastest timescales imaginable? Join the Attosecond Science Group (https://atto.cfel.de) at the Center for Free-Electron Laser Science (CFEL), where we create and harness ultrashort laser pulses with durations in the attosecond (1 as = 10^{-18} s) and few-femtosecond (1 fs = 10^{-15} s) range. These pulses allow us to observe and manipulate ultrafast dynamics in systems ranging from bio-relevant molecules to clusters and nanoscale materials. By exploring these fundamental processes, we aim to deepen our understanding of the earliest steps in photochemistry and pave the way for potential control over these ultrafast reactions.
What You'll Do:
In this project, you'll be involved in cutting-edge research focused on creating and probing coherent wavepacket dynamics in molecular systems. A key challenge in performing these measurements in solution phase at extreme timescales is the development of ultrathin flat jets capable of operating in vacuum environments. You will gain hands-on experience with:
• Preparing and handling chemical solutions for ultrafast experiments.
• Working with vacuum chambers and turbomolecular pumps to maintain precise experimental conditions.
• Utilizing advanced liquid jet technologies, including microsheet nozzles, extraction systems, and recirculation setups for stable jet operation.
• Performing preliminary pump-probe measurements at few femtosecond time scales in solution phase
This project offers a unique opportunity to work at the intersection of ultrafast laser science and fluid dynamics, developing both experimental skills and an understanding of complex molecular processes in solution.
Who Should Apply:
We welcome motivated students with a background in physics, physical chemistry, chemical engineering, or related fields. Experience with fluid dynamics, vacuum systems, or laser-based experiments is a plus, but not essential. A strong interest in experimental research and a willingness to engage with interdisciplinary challenges are the most important qualifications!

Group:

FS-ATTO

Project Category:

A2. Molecular sciences

Special Qualifications:

DESY Site:

Hamburg

89

Resonant dispersive wave development for advanced optical pump/soft X-ray probe investigations

Authors: Agata Azzolin[1]; Linda Oberti[2]

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[2] *FS-ATTO*

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Are you curious about how atoms and electrons move on the fastest timescales imaginable? Join the Attosecond Science Group (https://atto.cfel.de) at the Center for Free-Electron Laser Science (CFEL), where we create and harness ultrashort laser pulses with durations in the attosecond (1 as = 10^{-18} s) and few-femtosecond (1 fs = 10^{-15} s) range. These pulses allow us to observe and manipulate ultrafast dynamics in systems ranging from bio-relevant molecules to clusters and nanoscale materials. By exploring these fundamental processes, we aim to deepen our understanding of the earliest steps in photochemistry and pave the way for potential control over these ultrafast reactions.
What You'll Do:
As part of this project, you'll gain hands-on experience in cutting-edge experimental techniques used in ultrafast laser science. You will:
• Learn methods for compressing and converting laser pulses from the near-infrared to the ultraviolet spectrum.
• Work with state-of-the-art technology, including resonant dispersive wave emission, to generate tunable ultrashort laser pulses.
• Get involved in building optical setups, characterizing pulse durations, collecting data, and analyzing results.
• Possibly use these pulses in our soft X-ray pump-probe setup to investigate ultrafast processes at the atomic and molecular level.
This project offers an exciting opportunity to immerse yourself in an active research environment, develop valuable laboratory skills, and contribute to experiments at the forefront of ultrafast science.
Who Should Apply:
We welcome motivated master's students with a background in physics, optics, physical chemistry, or related fields. Prior experience with lasers or optics is a plus but not required—enthusiasm for experimental work and a desire to explore the ultrafast world are the most important qualifications!

Group:

FS-ATTO

Project Category:

A5. Lasers and optics

Special Qualifications:

DESY Site:

Hamburg

90

Modeling and analyzing resonant x-ray scattering from solids irradiated by XFEL pulses

Authors: Andrei Benediktovitch[1]; Tae Kyu Choi[2]

[1] *FS-TUX (Theoretical ultrafast X-ray science)*

[2] *FS-TUX*

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The experiments at X-ray Free Electron Lasers (XFEL) enable to study matter at unique conditions. To fully exploit this potential, new methods must be developed to extract information that is not accessible with other x-ray sources. Within the project, students will have the opportunity to work with recent XFEL experimental data on resonant x-ray scattering from crystalline samples. Depending on their interests, the project can focus on theoretical modeling of the scattering signals, data analysis, or a combination of both.

Group:

FS-TUX

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

91

Optimizing the photon energy for strain tensor tomography

Author: Peter Modregger[1]

[1] *FS-PETRA*

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Strain tensor tomography constitutes a recently emerging x-ray powder diffraction method that aims at retrieving the six spatially resolved strain tensor components. Tomographic reconstruction is performed by iterative gradient descent, which can suffer from badly conditioned inversion. However, the utilized photon energy impact reconstruction quality in two opposing ways: Lowering photon energy increases the Bragg angles, which stabalizes reconstruction. But at the same time transmission through the sample is decreased, which increases noise. Thus, an optimum must exists and it is the task of the student to find this optimal photon energy with the help of numerical simulations and experimental data analysis performed in python.

Group:

FS-PETRA

Project Category:

A4. Development of experimental techniques

Special Qualifications:

Python

DESY Site:

Hamburg

92

Precision characterization of supercooled liquids

Author: Claudia Goy[1]

[1] *FS-SMP (Spectroscopy of molecular processes)*

Corresponding Author: claudia.goy@desy.de

Students learn about methods to investigate the structure and dynamics of systems such as complex liquids and glasses such as small-angle X-ray scattering (SAXS) using coherent X-ray beams, X-ray photon correlation spectroscopy (XPCS) and X-ray cross-correlation analysis (XCCA). In addition, they synthesise colloidal samples in our chemistry lab. Hands-on experiments using laser scattering set-ups on self-synthesised colloidal systems and analysing and interpreting the obtained data allows both to train their programming skills as well as critical discussion of experimental results.

Student 1:
Work on a Raman spectroscopy setup for temperature dependent characterization of liquid samples. The core of the project is to set up a temperature calibration for different capillaries using melting point characterization of different reference liquids.
Optional: The project will be extended to acquiring temperature dependent Raman spectra of different relevant liquid samples from mildly supercooled to ambient conditions, that will in future be also subject to investigations using synchrotron and FELs.

Student 2:
Optical characterization of different liquid jets with 10-50µm initial diameter; Characterization of the Rayleigh breakup length for different flow velocities.
Optional: Characterization of the jets using Raman spectroscopy to study temperature dependent properties of the molecular vibrations.

Group:

FS-SMP

Project Category:

A3. Soft-matter sciences

Special Qualifications:

DESY Site:

Hamburg

93

Sono-Photonic Interferometry

Author: Yannick Schroedel[1]

[1] *FS-PRI (Photonics Research and Development)*

Corresponding Author: yannick.schroedel@desy.de

Gas-phase sono-photonics is an emerging field in photonics where light with potentially extreme parameters is controlled by interaction with intense ultrasound waves in gaseous media like ambient air. However, there are no common ways to quantitatively measure three dimensional sound fields, which is a requirement for future sono-photonic schemes.
This summer student project combines numerical research and initial practical implementation of a device that reconstructs 3D sound pressure fields using interferometric and machine learning techniques.

Group:

FS-PRI

Project Category:

A5. Lasers and optics

Special Qualifications:

DESY Site:

Hamburg

94

Understanding Temporal Landscapes of Photoinduced Structural changes in Polycyclic Aromatic Hydrocarbon (PAHs) dyads by pump-probe spectroscopy and photocrystallography

Author: Krishnayan Basuroy[1]

[1] *FS-SCS (Strukturdynamik Chemischer Systeme)*

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The internship will be an opportunity offered by the FS-SCS group in the photon science division of DESY. The FS-SCS group is mostly invested in investigating energy conversion and structural changes in molecules during chemical reactions, using different pump-probe techniques. The group is well known for studying the time-dependent electronic and spatial behaviors of the molecules under external stimuli such as light photons, heat, pressure, etc. in real time. We continue to pursue the elusive "molecular movie methods"in the fields related to time-resolved and ultrafast X-ray physics, which include various types of ultrafast X-ray and optical spectroscopy techniques as well as high-resolution ultrafast X-ray diffraction and scattering methodologies. Our study helps to shed light on how different processes that take place at different time scales in the event of a photo-induced chemical reaction, in solids or solutions, are correlated. The results also help us to understand how much of the structural changes are local and how much of the structural dynamics is distributed through inter-atomic or inter-molecular interactions, in the system. We also spend a lot of time researching on designing the pump-probe experiments need for investigating the temporal landscapes in the structure of complex matters during the course of a chemical or biochemical reaction.

The polycyclic aromatic hydrocarbons (PAHs) such as pyrene- or anthracene-based systems are known to form complex structures through the formation of excimers, charge transfer states, triplets, etc. upon photoexcitation. However, photoinduced reactions in the context of PAHs in molecular dyad crystals have not been studied in great details, especially, when intermolecular interactions are overwhelming. For example, the excimer formation by intermolecular non-covalent interactions is not studied much in the context of pyrene and N, N'-dimethylaniline (DMA) -containing dyads, where electron-rich DMA is connected to relatively electron-poor, pyrene. Due to its planar structure, pyrene or DMA is already known to be susceptible to ⊠···⊠ stacking, essential for excimer formation. The need for functionalizing pyrene comes from the idea of overcoming the excimer formation by ⊠···⊠ stacking. Nonetheless, several examples of excimer-induced enhanced emission (EIEE) have been reported, which encourages excimer formations to be well utilized in designing multifunctional optoelectronic materials.

In the present project, the intern will go through a series of pyrene-bridge-DMA and anthracene-bridge-DMA dyads where different kinds of bridging groups are covalently connecting the electron rich DMA to pyrene or anthracene. There are already single crystals for several molecules available. The single crystal X-ray diffraction measurements using the single crystal X-ray diffractometer available in the group would allow the intern to investigate the intermolecular interaction patterns in the crystals. He/she will be also able to process the time-resolved spectroscopic and (if time permits) some pump-probe photocrystallographic datasets collected at synchrotron facilities for some of these molecules, to process and understand the dynamics of different photoinduced reactions in

different media. For the same project, the intern may also get involved in setting up crystallization for some of these molecules. The training will help him/her to understand the geometry and logistics of these experiments. How different software packages or programming codes are used to process these datasets. The student will also gain hands-on experience in steady-state optical spectroscopic and single-crystal X-ray diffraction measurements. Moreover, the student will gain important knowledge on how to combine spectroscopy and crystallography while deciphering the temporal landscapes of stimuli responsive reactions. The opportunity will provide a firsthand learning experience to an undergraduate student with a physics/chemistry or related background, to go through the cutting-edge experimental and theoretical techniques that involve our research at the FS-SCS. We believe the experience will be quite helpful for the students aspiring for a future in the field of scientific research, academia, or industry.

Group:

FS-SCS

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

95

Synthesis, characterisation and application of neutral and ionic metal-organic frameworks

Author: Jose Velazquez Garcia[1]

[1] *FS-SCS (Strukturdynamik Chemischer Systeme)*

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Metal-organic frameworks (MOFs) are modular porous materials synthesized from metal cluster nodes and organic linkers that connect these nodes. These materials have been an object of extensive study for the past two decades, since their ultrahigh porosity (up to 90% free volume) and enormous internal surface areas (extending beyond 6000 m^2/g) make them interesting for potential applications in clean energy, most significantly as storage media for gases such as hydrogen and carbon dioxide. Additional applications in thin-films devices, catalysis, and biomedical imaging are increasingly gaining importance owing to incorporation of new functionalities by varying both the organic and inorganic components of MOFs structures.
Two of the most important features of MOFs is the versatility and flexibility in their synthesis, enabling the creation of MOF-type materials incorporating multiple ligands. The synthesis of mixed ligand MOFs holds immense significance, particularly in the realm of heterogeneous catalysis. In our ongoing project, we have successfully developed around 20 novel 2D MOFs and 5 ionic MOFs (iMOFs), utilising trimesic acid and imidazole derivatives. However, the synthesis process requires further refinement, and the comprehensive characterization of these compounds remains a challenging task.
In this project, the students will help us to improve and/or scale the synthesis of both types of MOFs. Additionally, they will characterise the product of the synthesis by single crystal XRD, FTIR, and UV-vis. Finally, we will perform the ionic exchange in the iMOFs, using ionic drugs.

Group:

FS-SCS

Project Category:

A2. Molecular sciences

Special Qualifications:

DESY Site:

Hamburg

96

Advanced motion control for multidimensional trajectory movements for photon science instrumentation

Authors: Linus Pithan[1]; Tobias Spitzbart-Silberer[2]

[1] *FS-EC (Experimente Control)*

[2] *FS-EC (FS-EC Fachgruppe Electronic)*

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While preparing for the bright future with the fourth generation lightsource PETRA IV on the DESY campus we already test and evaluate strategical ingredients for next generation experiment control hard- and software.
The here proposed project focusses on motion control and the potential development of a motion control test bench with real hardware involving stepper motors and piezo drives. Depending on the candidate's preferences there are two options. This could become a python focused project to transfer an existing (ESRF developed) software stack to the test bench setup and study how to parametrize complex trajectories and to assure position-based triggering of detectors in continuous scans. A second option would be to work "closer to hardware", by studying different device integration strategies into larger setups e.g. relying on TANGO, EtherCAT and CANopen. In any case this is an interesting and challenging instrumentation project just at the between hard- and software in the field of experiment controls and automation.

Group:

FS-EC

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

97

Development of the TEMPUS detector

Authors: Jonathan Correa[1]; Stefanie Jack[1]

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TEMPUS is a versatile pixel detector based on the Timepix4 chip. It offers two operating modes - conventional photon counting, or precise timestamping of individual photons - and is particularly suited to experiments at synchrotrons requiring extreme time resolution."More information you find here:
https://photon-science.desy.de/research/technical_groups/detectors/projects/tempus/index_eng.html

Group:

FS-DS

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

98

Numerical Simulation and Analytical Study of Efficient Weakly Nonlinear Plasma Wakefield Injector for PETRA IV and Plasma Wakefield Collider

Author: Vasyl Maslov[1]

[1] *MPA1 (Plasma Theory and Simulations)*

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Our group studies high-efficiency acceleration of charged particle beams in the plasma wakefield experimentally and by numerical simulation (see 1-[9]). The most impressive experimental results 1 until now in electron accelerating by a wakefield, excited in a plasma, have been achieved using capillary-generated plasma. Plasma-wakefield acceleration provides high accelerating gradients [1,10], promises compact accelerators of high-brightness and high-energy electron beams. Applications of plasma-wakefield accelerators, in particular, particle free-electron lasers (see [11]) and colliders demand low energy spread beams, their small emittance, high current of accelerated bunches, large transformer ratio and high-efficiency operation. Achievement of these requires plateau formation on both the accelerating field for witness-bunch and the decelerating fields for driver-bunch. As it is known plateau formation is possible by controlled beam loading with careful shaping current profile and beam charge selection. We will demonstrate by numerical simulation by PIC code such optimal beam loading in a weakly nonlinear electron-driven plasma accelerators. Beams for plasma accelerator are prepared with RF linear accelerator with high beam quality.
In the blowout regime the hose instability can appear [12]. Earlier investigations [13]-[14] show that the instability is essentially suppressed if the focusing force is inhomogeneous along the bubble, and radial inhomogeneity can be additional effect. The problem of the instability can be solved in weakly nonlinear regime. In weakly nonlinear regime throughout the areas of the driver and witness bunches the focusing force is inhomogeneous. Radial inhomogeneity of residual plasma electron distribution also leads to bunch stabilization. We will present results of analytical investigation and numerical simulation of hose instability suppression in plasma wakefield accelerator driven by electron bunch in the weakly nonlinear regime.

Another problem for which the usage of the weakly nonlinear regime will be useful is that for the transition between the accelerating cells, the injection of witness requires placing it in the maximum of the accelerating field of the bubble with plateau formation, and in the case of a weakly nonlinear regime this will be achieved.

Specific areas of interest are:
- optimal beam loading for the self-consistent distributions of a decelerating wakefield of plateau type for a driver-bunch and an accelerating wakefield of plateau type for a witness-bunch during all time of acceleration in the weakly nonlinear regime;
- control of optimal field shape (by loading effect), accelerating electron bunch in plasma wakefield in the weakly nonlinear regime;
- obtaining long electron witness-bunch of good quality (due to loading effect) in plasma wakefield accelerator at high transformer ratio in the weakly nonlinear regime.

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Group:

MPA

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg

99

Imaging ultrafast shock waves propagated in Si wavers after optical laser pump using streaking diffraction signals

Author: Angel Rodriguez-Fernandez[1]

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To develop new schemes for ultrafast laser manufacturing it is key to understand the temporal deformations in materials when illuminated by femtosecond optical lasers. To understand these first instances, the development of new techniques is crucial to retrieve the change in materials shortly after the laser impact. Several femtosecond optical laser pump - X-ray probe experiment have been performed at the MID instrument of European XFEL using different kinds of X-ray imaging techniques. During this summer project, the student will investigate new tools to analyze the pump-probe signals collected in experiments at MID. The student will learn about techniques to analyses

the already collected data and develop new tools in collaboration with members of the MID team and external collaborations.

Group:

XFEL_E1_MID

Project Category:

A4. Development of experimental techniques

Special Qualifications:

DESY Site:

Hamburg

100

Investigation of dynamics in colloidal systems by dynamic light scattering

Authors: Joerg Hallmann[1]; Johannes Moeller[1]

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The MID instrument at the European XFEL performs coherent X-ray scattering experiments in material science of hard and soft condensed matter. The summer student project includes the synthesis of nanoparticle suspensions, as well as their characterization using a dynamic light scattering (DLS) setup in MID's laboratory.
In the first part, standard colloidal samples of gold or silica nano-particles are investigated. The data analysis of the temporal laser light fluctuations reveals the nano-particle size, size-distribution, as well as the dependency of the dynamics on the temperature and other solution parameters. The second part focusses on the synthesis of monodisperse silica nano-particles using the Stöber synthesis. Finally, the synthesized particles will be characterized with respect to their size and size distribution and compared to the commercial standards.

Group:

XFEL_E1_MID

Project Category:

A3. Soft-matter sciences

Special Qualifications:

DESY Site:

Hamburg

101

Processing and Analysis of X-ray Diffraction Images to Assess Crystal Quality for X-ray Optics Applications at EuXFEL

Author: Kelin Tasca[1]

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The X-Ray Optics (XRO) Group is engaged in characterizing the crystalline quality of silicon and diamond materials to ensure the optimal performance of devices such as monochromators and spectrometers at the European X-ray Free Electron Laser (EuXFEL). A primary technique used for characterization is the combination of X-ray diffraction and topography to identify defects and quantify crystalline quality. The technique, known as Rocking Curve Imaging (RCI), involves the digital collection, processing, and analysis of a series of X-ray diffraction images using X-ray Dynamical Diffraction Theory to evaluate crystal quality. The image processing involves reading, numerically analyzing, and visualizing results from hundreds of images. A fundamental aspect of RCI is the peak shape analysis, which includes evaluating the width, intensity, and position of peaks in the diffraction profile of each pixel across the image series, allowing for the creation of spatial maps for visualization of the crystal quality and determination of its suitability for X-ray optics. To optimize data interpretation, this process can be significantly enhanced with a dedicated computational code capable of handling large data files while integrating basic image processing with profile analysis.

Goal
The goal of this project is to develop a Python code that can process RCI images, analyze the rocking curves, plot the peaks, and represent the results in spatial maps. Additionally, the processing should enable contrast enhancement, cropping, and selection of regions of interest of both raw images and resulting maps to improve visualization and interactivity.

Activities
- Basic learning of X-ray diffraction
- Code development
- Discussions with researchers
- Beamline visit at PETRA
- Potential participation in a beamtime

Group:

XFEL_DO_ID_XRO

Project Category:

A6. Theory and computing

Special Qualifications:

DESY Site:

Hamburg