

EXP9 - Beschleunigerphysik

Simple Accelerator for Learning Optics and the Manipulation of Electrons

SALOME

Motivation

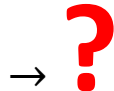
Particle accelerators **indispensable** for **fundamental research**, **medicine** and **industry**.

Large variety of possible **applications**:

- ☐ **colliders** for high energy physics,
- ☐ photon science (3rd and 4th generation **light sources**),
- ☐ **medical imaging**, radiation **therapy**,
- ☐ **industry**: market size ~ **\$USD 3 Billion** in 2022, anticipated to **rise rapidly**

⇒ **Higher requirements to the academical education of the future accelerator physicists**

- ☐ good theoretical background
 - starts in **B.Sc.**(e.g., **Proseminar Beschleuniger, Physik V**)
 - continues in **M.Sc.** (**Accelerator I, Accelerator II**)
- ☐ AND **practical experience** in the operation of the modern machines



EXP9 - Beschleunigerphysik

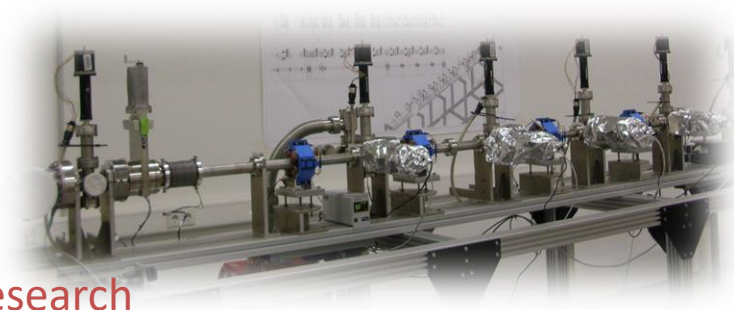
Aim of the experiment

- ☐ Provide a **platform** to **learn** and to extend knowledge of the **basics of accelerator physics**,
- ☐ stand-alone machine - **students** are **free to operate** the device without disturbing the normal accelerator operations at DESY ,
- ☐ Experiments on both **introductory** and **advanced level** of the accelerator physics course,
- ☐ Introduce **theoretical concepts** and **experimental methods** used in daily accelerator operation, e.g., **trace space, linear optics, betatron oscillations, emittance**...,...
- ☐ Perform state of the art **beam-manipulation** techniques, **measurements** and **data analysis**.

EXP9 - Beschleunigerphysik

Experimental setup

- Built in close **collaboration** with **DESY**.
 - Using DESY-know-how, maintained by DESY
 - Using **same control system** as DESY-accelerators
- ⇒ The **same "look and feel"** as **accelerators used in the research**



- Students can learn (and see) how various **accelerator hardware** and **sub-systems** operate
- Have possibility to learn how **accelerator diagnostics** work
- Learn to deal with **modern accelerator control** system
- Have possibility to **estimate, discuss** and **correct** impact of different **systematic effects** (power supply noise, misalignments, higher order magnetic multipoles, nonlinearities)
- **May play and experiment with machine settings**

Data processing and analysis

- 1) **Initial data processing**: diagnostics using YAG-screens → CCD images (**raw data**)
 - Learn about **image processing** (video system developed by DESY)
 - Discuss **resolution**, impact of **intensity digitization**, electronic noise,...
 - Learn how to **remove systematic effects**
- 2) **Parameter estimation**: fit data to **linear** and **nonlinear models** to extract e.g., beam energy, Twiss-parameters, trace-space correlations, emittance, ..., ...
 - either use provided codes (it is **discussed** line-by-line **what the code does**)
 - or write your own (~50% choose this, usually PYTHON)
- 3) **Error propagation**: **statistical lectures** (SL) proved **very useful**
 - directly compare SL-slides with models used to identify correct error propagation law
 - discuss covariance matrix of measured data
 - calculate covariance matrix of estimated parameters (use provided or own code)

EXP9 - Beschleunigerphysik

Summary

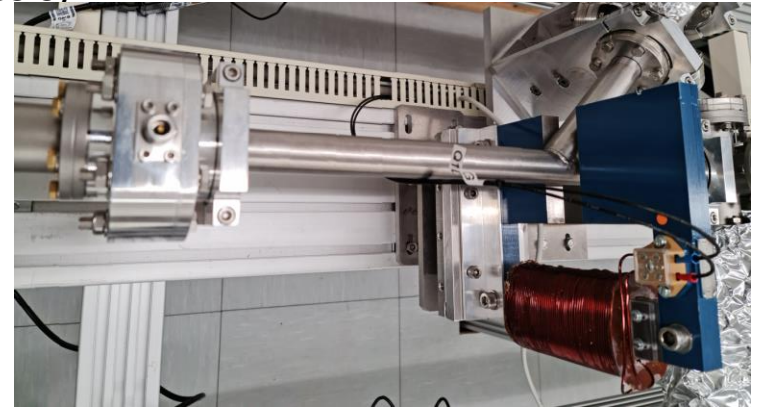
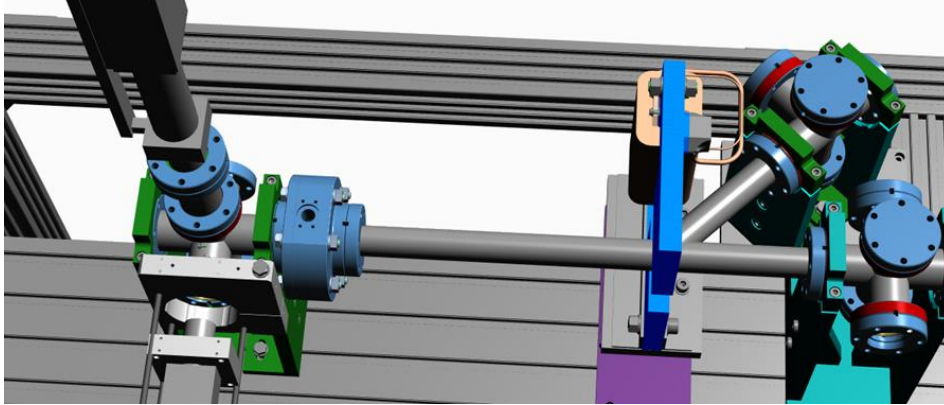
- Students get **introduced** to basics of **accelerator physics and technology**,
- Gain **hands-on experience** on a 'real' accelerator,
- Learn to measure important beam parameters, with same methods and techniques used at **modern research facilities**.

There is more to the story

EXP9 is often a **starting point of a scientific career**. Many students after this FP-experiment choose to do a **bachelor-, master- and PhD thesis** in the field of accelerator physics (many examples available)

Outlook

- ❑ **Towards time-resolved experiments:** a buncher cavity developed (bachelor's thesis), installed and being commissioned (master's thesis)



- ❑ New experiment
“Cavities: deeper insight in the phenomenon of physical resonances”
Can be offered starting WISE23/24