PUNCH2.0 Use Cases: key4HEP based workflows for future colliders (FCC, ILC, CPEC, ...)

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Motivation

▶ Particle Physics is currently in a phase where *worldwide* new lartge-scale projects are being envisaged or already being decided upon

▶ These will shape the field for the next 50 years

▶ Up to now: no formal collaborations, physics studies just picking up

▶ One common framework for simulation, reconstruction and analysis already in place: The `key4HEP` environment

▶ Large demand in the community for easy starting points for students

▶ Ideal starting point for PUNCH2.0 to entering and co-shaping a field
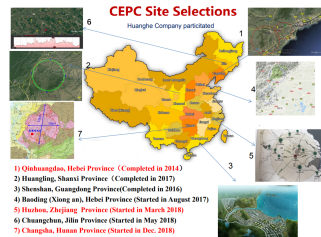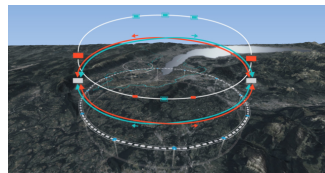
Statement by the German Particle Physics Community
as Input to the Update of the European Strategy
for Particle Physics

March 17, 2025

The German community supports the FCC-ee as the next flagship project at CERN with highest priority. The German community will be fully committed to engage in all aspects of this project. Its realization requires the timely development of a solid and affordable financial plan by CERN.

3.2 Future Collider Flagship project at CERN

While we expect significant progress on physics results at HL-LHC and Belle II and other experiments, **important fundamental questions will remain open, which cannot be answered without a future large collider project.**

To maintain Europe's international competitiveness in science and technology, CERN's leading role after the successful completion of the high-luminosity LHC program must be ensured through **the timely realization of a future collider flagship project at CERN.** Such a project will require a very strong commitment of the particle physics community in all relevant areas, namely detector and accelerator development as well as construction, computing, data science, and artificial intelligence. Theoretical developments are indispensable for its success. The project must have the ambition to be innovative while at the same time achieving the highest standards in sustainability.

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3.2.1 Higgs factories

An e^+e^- collider, which explores the Higgs, top and electroweak sector, will open up a new window to address our open questions with unprecedented precision. Such **a Higgs factory remains the highest priority of the German community.**

The German community assesses the physics performance (and future options) of the FCC-ee and of linear e^+e^- colliders with a centre-of-mass energy of up to 550 GeV (LC550) in the following way:

– For electroweak measurements at the Z pole and at the WW threshold the FCC-ee provides the best accuracy due to its extremely high luminosity.

– Both circular and linear Higgs factories provide an excellent potential to measure the Higgs coupling to SM particles at very high precision. A FCC-ee run at the Higgs mass could give access to the Higgs coupling to electrons. At the LC550 the trilinear Higgs self-coupling can be measured directly in Higgs pair production.

– Through an energy scan at the top-quark pair production threshold the top-quark mass can be measured to excellent precision at the FCC-ee and at linear colliders. Better sensitivity to deviations from the SM is achieved at higher energies, however.

– For both circular and linear e^+e^- colliders the sensitivity to beyond-SM (BSM) physics is complementary to the LHC BSM searches. At lower energies light resonances can be probed directly and precision measurements allow indirect sensitivity to heavy new physics. The sensitivity to BSM physics increases with energy and luminosity.

– The clean environment and extremely high luminosity at the FCC-ee enable high precision tests of QCD. In addition, its flavour program is complementary to the measurements at existing flavour experiments.

– Regarding future options, the tunnel built for the circular e^+e^- collider can be reused for a high-energy hadron collider. Linear e^+e^- colliders on the other hand can be upgraded to higher centre-of-mass energies and be used as a photon-photon collider.

PUNCH
N F D I

What we should answer

- ▶ What is in this box?
- ▶ What are the 3 main deliverables / milestones?
- ▶ Approx. resource requirements?
- ▶ involved / interested / necessary institutions?
- ▶ Community coverage - i.e. who is potentially left behind?
- ▶ Gap analysis - are these the right boxes?

Answers to questions

- ▶ **What is in this box?**
  - ▶ Work on example workflows for FCCee/ILC/CEPC/FCChh(?)/...
  - ▶ Work on seamless integraton between Portal, Platform, Registry/Catalogue, S4P, C4P and if necessary AAI
  - ▶ *Make complex workflows useable on the PUNCH infrastructure*
  - ▶ Overall: About a 50/50 split
  - ▶ List of components covered with *specific* contributions from the graphics: Workflows, Catalogues/Registry, (Portal, Platform, DRP)
  - ▶ List of compopnents which are touched by the work on this use case: AAI, S4P, C4P

- ▶ **What are the 3 main deliverables / milestones?**
  - ▶ Event Generation/Simulation/Reconstruction as a fully reuseable and automatized workflow on the SDP
  - ▶ User Analysis as a fully reuseable and automatized workflow on the SDP
  - ▶ Publication of Future Collider Aalyses as an interactive document on the SDP
  - ▶ Overall: Establish PUNCH technologies for FAIR infrastructure/services and analyses in the FutureColliders world

Answers to questions

▶ **Approx. resource requirements?**
  ▶ Minimum 2 institutes
  ▶ Real requirements: absolute minumum 2 positions **per institute** (can be one 1 postdoc, 1 2/3 positions for a PhD student, full time and duration)

▶ **involved / interested / necessary institutions?**
  ▶ Directly involved: DESY, UBo
  ▶ Necessay partner: CERN
  ▶ Other partners welcome

Answers to questions

- **Community coverage - i.e. who is potentially left behind?**
    - We think that the progress on PUNCH infrastructure pushed forward by this use case benefits everybody who works on sequential workflows, that can be interactive or batch jobs.
    - The underlying goal is to draw a large community towards PUNCH, create a future for PUNCH technology beyond PUNCH itself, and make the PUNCH SDP working seamlessly and in the most integrated way
    - If someone **only** needs one individual component of anything, then this is not the workflow for them. That's OK, we think.
- **Gap analysis - are these the right boxes?**
    - We think that "Catalogue" and "Registry" should not be separate
    - We think that the Portal should be on there