Possible subject: "Positron source for the FCC-ee"
Design and optimization studies of the FCC-ee positron source with the proof-of-principle experiment at PSI

Établissement: Université Paris-Saclay
École doctorale: Particules, Hadrons, Énergie et Noyau : Instrumentation, Imagerie, Cosmos et Simulation
Spécialité: physique des accélérateurs
Unité de recherche: Laboratoire de Physique des deux Infinis Irène Joliot-Curie
Encadrement de la thèse: Iryna Chaikovska (IJCLab)
Co-Encadrant: P. Craievich/ H. Braun (PSI, Switzerland)
Financement: already granted by the IN2P3/CNRS

Profile and skills required: master's degree in physics. Preferably prior experience in one of the following fields: accelerator physics and technology, particle interaction with matter, programming (C++, ROOT, python, matlab), optimization methods.

Description

Positron sources are essential to the future e^+e^- / $\mu^+\mu^-$ collider projects (ILC, CLIC, SuperKEKB, FCC-ee, LEMMA, etc.) with challenging critical requirements of high-beam intensity and low emittance necessary to achieve high luminosity.

In a conventional positron source, positrons are produced by high energy electrons passing through a target, then the low-momentum population exiting the target is captured and accelerated in a capture section to the required energy needed. This scheme has been used for all circular e^+e^- colliders (ADA, ACO, DCI, SPEAR, ADONE, VEPP, LEP, KEKB, SuperKEKB, PEP-II) and also for the first linear collider SLC. In the conventional positron-generation system, a possible scheme to increase the positron intensity is to increase the incident electron beam power (intensity and/or energy). However, the allowable heat load as well as the thermo-mechanical stresses in the target severely limit the allowable beam power of the incident electrons.

Within this framework, recent investigations led to a hybrid scheme based upon a relatively new kind of positron source, one that uses an intense photon production by high energy (some GeV) electrons channelled along a crystal axis (i.e. channelling radiation). Thus, electrons propagating in the crystal at glancing angles to the axis can be channelled or quasi-channelled with consequent emission of a large number of soft photons due to the collective action of a large number of nuclei along the axes. Several experiments at CERN and KEK, including a proof-of-principle experiment in Orsay, have been performed to investigate such a possibility. They have shown very promising results for the enhancement of the positron yield. Further studies demonstrated a possibility of reducing significantly the energy deposition in the target, if compared to the conventional one. This led to a concept of the hybrid scheme, which has been adopted by CLIC as a baseline for the unpolarized positron source.

A candidate is expected to join the positron source activity at IJCLab to work on the design and optimization of the FCC-ee positron source. This group has a longstanding

expertise in positron sources acquired through numerous studies and realizations that concerned fixed target experiments with positrons, positron sources for storage rings (ACO, DCI and SuperACO), and studies for e+e- circular (LEP, SuperB) and linear colliders (CLIC, ILC). The work is ongoing now on the positron injector for the FCC-ee project. The FCC-ee is a high-luminosity, high-precision circular collider to be constructed in a new 100 km tunnel in the Geneva area. It is part of the Future Circular Collider design study at CERN, and would be the first step towards the long-term goal of a 100 TeV proton-proton collider. The physics case is well established and the FCC-ee operation is foreseen at 91 GeV (Z-pole), 160 GeV (W pair production threshold), 240 GeV (Higgs resonance) and 350 GeV (t-tbar threshold). Positron injector is one of the key elements of the FCC-ee requiring special attention due to the large 6D production emittance and important thermal load in the production target.

The research work within the PhD program will involve all aspects of the positron source design: different positron production schemes taking into account the thermo-mechanical constraints imposed by the target material; several options of the positron accelerating-capture system and injection into the Damping Ring. Eventually, the start-to-end simulations and optimization studies will allow arriving to an optimized and realistic design of the positron injector capable to deliver the FCC-ee design parameters. In this framework, a positron source demonstrator for novel target and capture system using the 6 GeV linac of the SwissFEL facility at PSI will be realized to validate the proposed concept. Therefore, a co-supervision of the PhD candidate with the PSI is proposed. This project is performed in close collaboration with CERN, PSI and also may involve exchanges with KEK.

Contact: Iryna CHAIKOVSKA (iryna.chaikovska@ijclab.in2p3.fr)

Laboratoire de Physique des 2 Infinis Irène Joliot-Curie (IJCLab)
CNRS / UMR 9012
Pôle Physique des accélérateurs
Bât. 209a, bureau 115
91405 Orsay
Tél: 01.64.46.83.28

M2 Internship

Subject: "Positron source conceptual design: generation and primary capture"

Établissement: Université Paris-Saclay
Unité de recherche: Laboratoire de Physique des deux Infinis Irène Joliot-Curie
Encadrement: Iryna Chaikovska (IJCLab)

During the internship, the student will get acquainted with the physics and design of the positron sources used for the particle accelerators, considered as one of the key element of the future collider projects (ILC, CLIC, FCC-ee). In this context, the different schemes of the positron generation will be investigated. In particular, the main focus will be on the positron collection system. It is installed downstream the production target and consists of the matching device ensuring the strong solenoidal field after the target followed by the several accelerating structures imbedded in the DC solenoid field to accelerate the positrons up to a few hundreds of MeV. The main constraints to increase the positron source intensity given by the target and capture section reliability will be highlighted.
The student will study and deepen his/her knowledge of the particle interaction with matter and beam dynamics in electromagnetic fields.

This internship can be followed by a PhD thesis fully funded by the IN2P3/CNRS on this thematic. The financial support is already granted.

R. Chehab, "Positron sources", LAL-RT-89-02, CERN-1989- 005.105, 1989.