Future colliders

RECFA visit to Sweden - 16 May 2024

Rebeca Gonzalez Suarez (Uppsala University)

An eye on the future

Long-term perspectives

- The **uncontested main priorities** of the Swedish HEP community today are:
  - **the current LHC run, the success of the Phase-II upgrade, and the HL-LHC**
- Long-term plans are however a necessity
  - colliders take a long time and resources to build
- The Swedish community is enthusiastic about future collider work
- **We are active in different areas of development and planning of future colliders**
  - But there is no funding for these activities yet!

Linear collider work

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Compact Linear Collider (CLIC)

- The Swedish community has **good historic participation in linear colliders**
- From the **accelerator** side:
  - **Uppsala University** in CLIC (led by Maja Olvegård, Marek Jacewicz)
  - Extensive work developing novel acceleration methods for the **CLIC feasibility study** (Roger Ruber)
    - Building/operation of the two-beam test stand, part of the CLIC Test Facility 3 (CTF3)
    - Design of beam diagnostics systems for CTF3

Linear collider work

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Compact Linear Collider (CLIC)

- Currently:
  - Investigating **vacuum breakdown in high-gradient accelerating cavities**
    - Limiting factor for luminosity in colliders like CLIC
  - PhD student developing a **simulation framework for the drive beam complex**
    - Already used for beam performance studies.

code also useful for the muon collider study!

NIM A Vol 729, pp 546-553, 2013
NIM A Vol. 797, pp. 234-246, 2015
arXiv:2403.03198
J. Phys.: Conf. Ser. 2687 062027, 2024

Linear collider work

International Linear Collider (ILC)

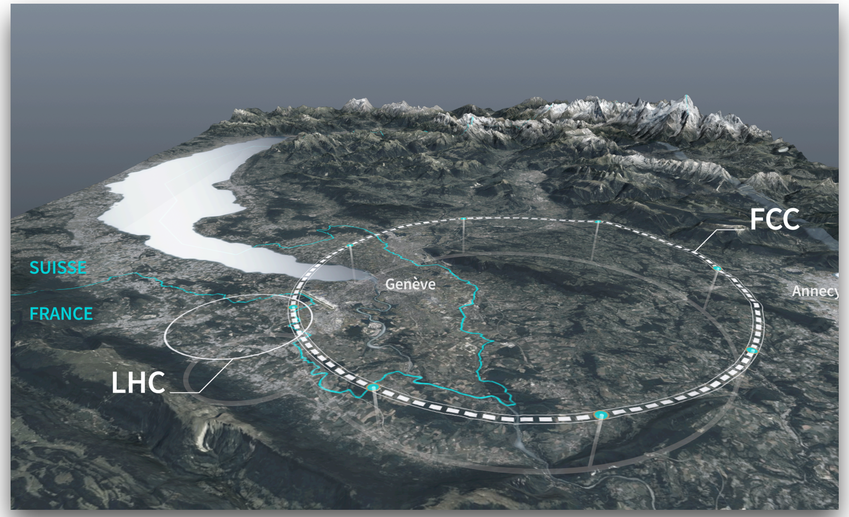
- From the **detector** side: **Lund University at ILC** (Leif Joensson, Anders Oskarsson)
  - Part of the LCTPC collaboration → working on a **tracking solution for the ILD** that involves s high resolution time projection chamber (TPC)
  - Partially funded by the EU (EUDET-, AIDA-, AIDA2020 projects)
  - Project led by DESY
- **No recent physics studies for either CLIC or ILC**
- **Linear collider activities ramping down**

The TPC is not only a linear collider solution, it is in fact considered as an option for FCC-ee
arXiv:2311.09181

Circular collider work

Future Circular Collider (FCC)

- **Work in FCC has been ramping up in the last few years**
  - Interest exists everywhere
  - **All universities eager to contribute**
- 1 fully signed MoU (Uppsala, early 2024)
- Mid term report: 4 Swedish authors (Uppsala and KTH)



- Last year, Vetenskapsrådet created a reference group to follow the FCC process and European Strategy Update:
  - **Sara Strandberg**, Lars Börjesson, Anders Karlhede, Lisbeth Olsson and **Mattias Marklund**

Uppsala

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FUTURE CIRCULAR COLLIDER

Physics, detector development

- **Institute contact:** Rebeca Gonzalez Suarez (Swedish national contact)
- Substantial work around **BSM options** in FCC-ee (long-lived particles)
  - **Convenership of BSM physics group**
  - **Related convener position in ECFA Higgs factories WG1**
- Postdoc partly funded to work on FCC (Giulia Ripellino)
- PhD student (Axel Gallén) partly FCC
- Visiting PhD student (Baibhab Pattnaik) from network grant
- Richard Brenner involved in detector development

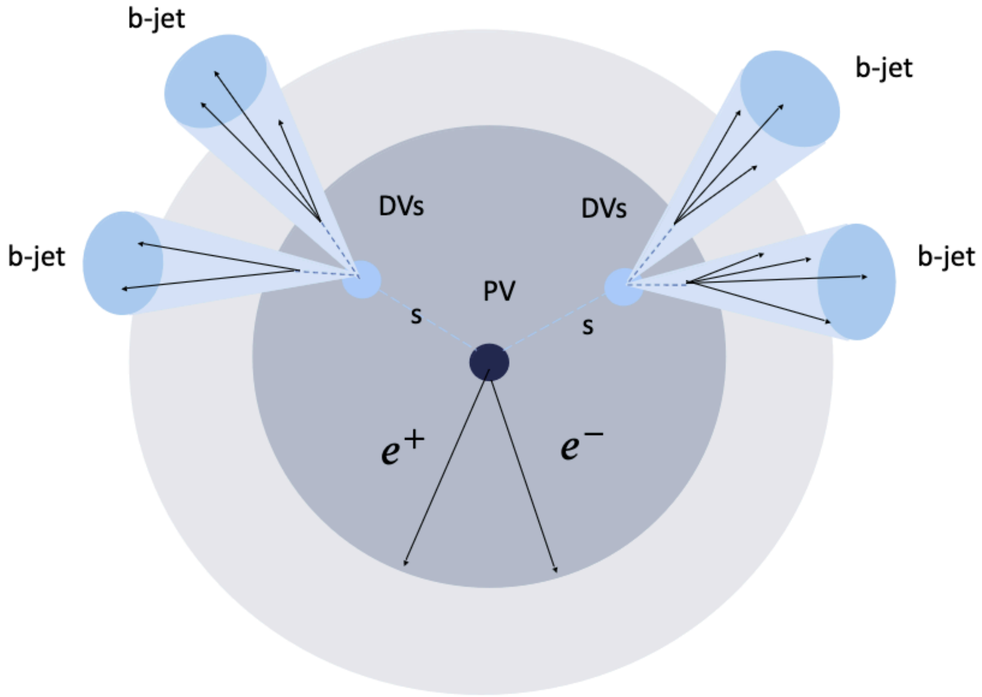
Recent papers:
arXiv:2401.07564
arXiv:2209.13128
arXiv:2203.08039
arXiv:2203.06520
arXiv:2203.05502
arXiv:2106.15459

Recent Master theses:
Rohini Sengupta
Lovisa Rygaard
Magdalena Vande Voorde

Uppsala University has a strong accelerator tradition and expertise. Intention to start contributing to FCC from that side too.

Physics

- **Institute contact:** Christian Ohm
  - **Sweden National contact for ECFA Detector R&D Roadmap**
- Interest in the group ramping up
  - Regarding future colliders the focus is only in FCC
- One PhD student (Magdalena Vande Voorde) already working on **exotic Higgs decays to LLPs**
  - Paper in collaboration with UU will come soon



Stockholm University

Physics, detector development

- **Institute contact:** Christophe Clément
- **Postdoc position to be announced before the summer**
- One master student already working
- Interest in detector layout studies and BSM Higgs sector physics with multiple neutral scalars

Aligns with Focus topics for the ECFA study on Higgs / Top / EW factories
arXiv:2401.07564

Lund University

Monte Carlo simulation

References:
arXiv1702.01329
arXiv:2203.11110

- **Institute contact:** Else Lytken
- No FCC activity at the moment but some MC related contributions:
  - Else + Torbjörn Sjöstrand provided input on parton radiation and fragmentation from LHC to FCC-ee
  - Snowmass contribution on event generators for HEP
- Additionally, the **ALICE group work on ALICE Si-tracking upgrades (ITS3/ALICE3) is also very relevant for FCC-ee**
  - very thin Si-technology (MAPS) being considered for FCC detector development

ESS

EUROPEAN SPALLATION SOURCE

FUTURE CIRCULAR COLLIDER

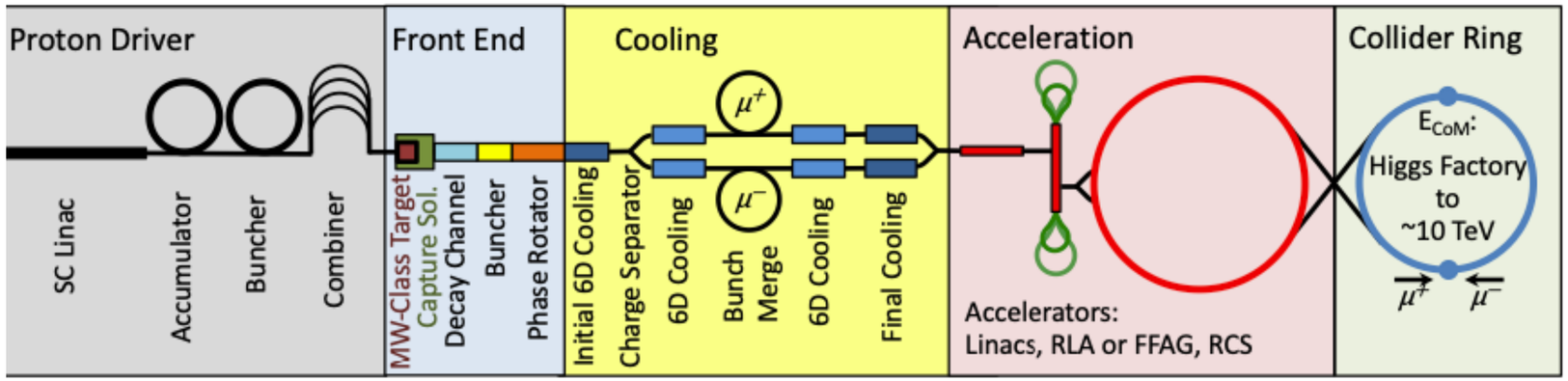
Accelerator development

- ESS is also a member of the FCC collaboration and FCC-ee
- **Contact:** Paolo Pierini
- Assembly and testing of FCC-ee Cryo Modules in the Superconducting Radio Frequency facility

Circular collider work

Muon collider

- **Uppsala** and **ESS** are part of the **European Consortium MuCol**
- ESS (Natalia Milas) is the lead institute and the coordinator of the **WP3 → the Proton Complex (or Proton Driver)**
- ESS and UU (Maja Olvegård, Vitaliy Goryashko) will design a proton accumulator and compressor to produce a proton beam that can generate a muon beam



ESS (3 physicists, a PhD student working partially on it and a postdoc 100% of the time)
UU (co-supervisors of the ESS postdoc)

Additional activities

From Lund in heavy ions / electron-ion colliders

- **Detector development**
  - Spin-off with involvement at the sPHENIX TPC at **Relativistic Heavy Ion Collider (RHIC) in BNL** (David Silvermyr)
  - May join EPIC at the **Electron-Ion Collider (EIC)** at BNL

no ongoing work yet

- **Monte Carlo work** (Else Lytken, Christian Bierlich, Torbjörn Sjöstrand)
  - Several developments in PYTHIA for future EIC collisions
  - MC validation studies

References:
arXiv:2112.12598

Community activities

Related to future colliders

- We did a **first FCC Nordic day** already in 2021:
  - https://indico.uu.se/event/872/
  - Well attended, should be followed up soon

Local discussions about FCC have also taken place informally

- **Young Nordic Future-Collider day** in connection with this meeting arranged by the ECR ECFA representatives (May 14)
  - https://indico.cern.ch/event/1373946 (Nordic activites talk)

Don’t miss Christina Dimitriadi’s talk later today [indico link]

- **Swedish FCC discussion** followed (same agenda) → decision: finding areas of national interest to better manage our resources
- Possible muon collider workshop being considered for a future time.

Summary

- Work is ongoing, involvement and interest rising everywhere in all areas
  - Accelerator and detector development and physics studies (from Monte Carlo to prospective studies)
  - **We expect it to grow even more after the Phase-II upgrade installation**
- **General interest in FCC in every institute at all levels, accelerator involvement in Muon collider**
  - Linear collider work existing but ramping down
- Future collider meeting and FCC discussion last Tuesday: [indico]
- Involvement of funding agencies in Sweden has started but:
  - **There is no national funding for future collider studies**, which makes starting projects complicated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