Instrumentation for HEP in Sweden

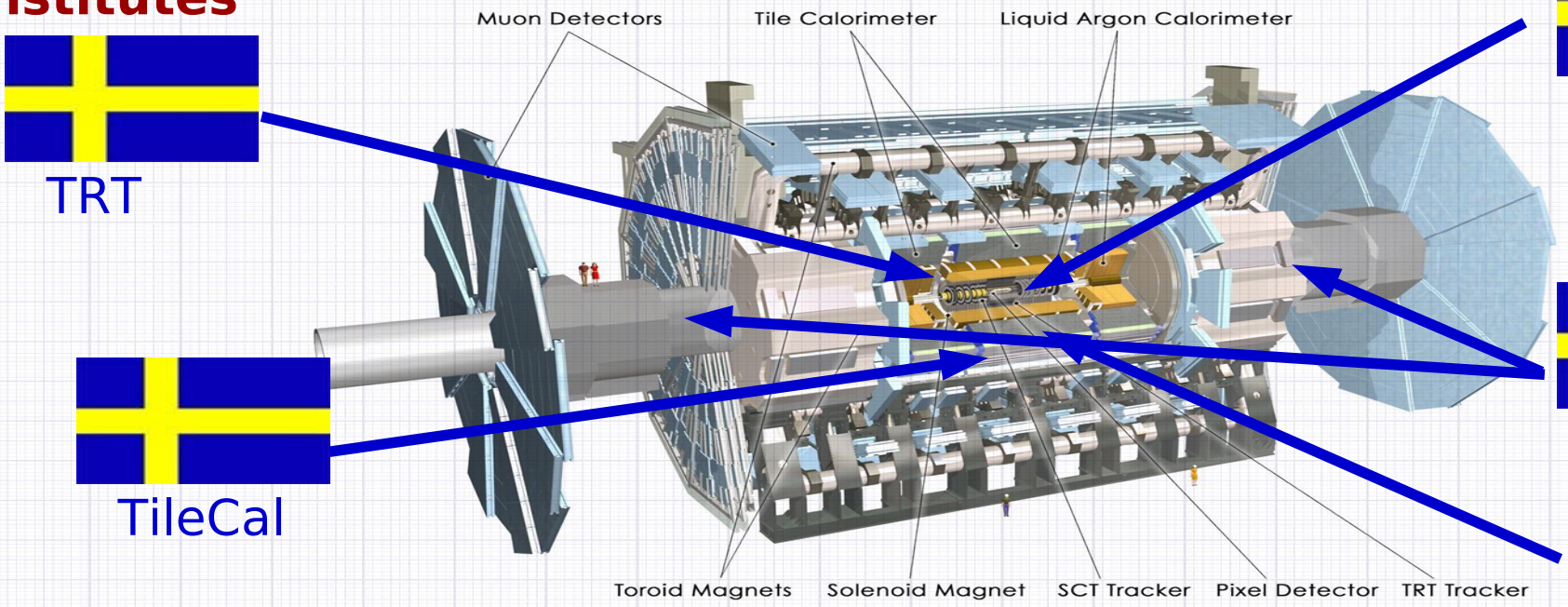
R. Brenner on the behalf of LHC-K

- Contributions to LHC
- Ongoing activities for HL-LHC
- Non LHC and R&D activities
- Funding and organisation
- Technology transfer - spin-off

Contributions to LHC

Contributions to the ATLAS detector

Infrastructure built and run by universities and research institutes



TRT

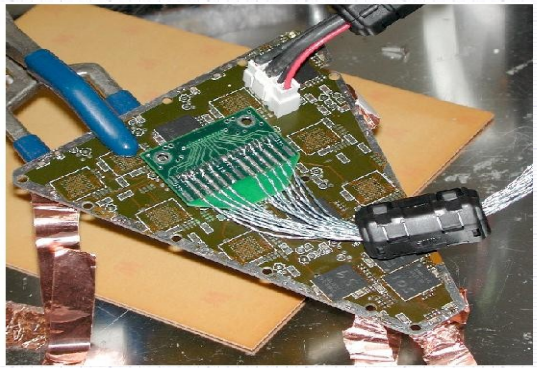
TileCal

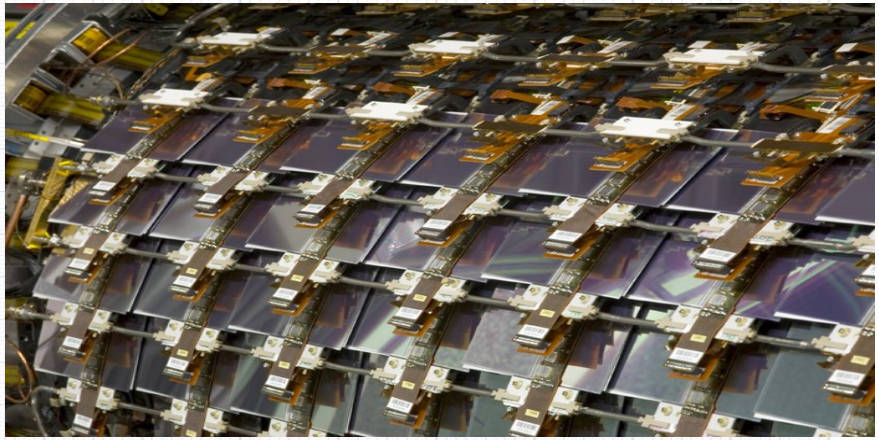
SCT

Lucid

LAr

Inner Detector





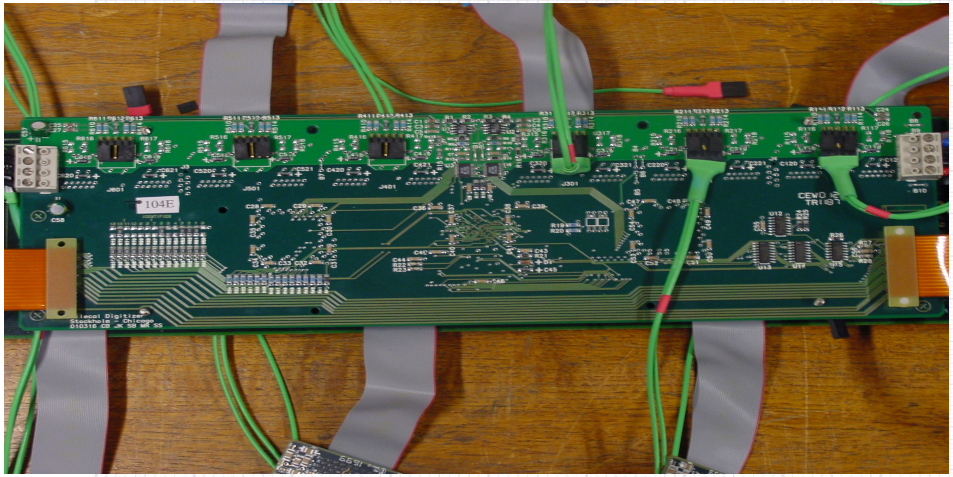
Lund – Transition Radiation Tracker:

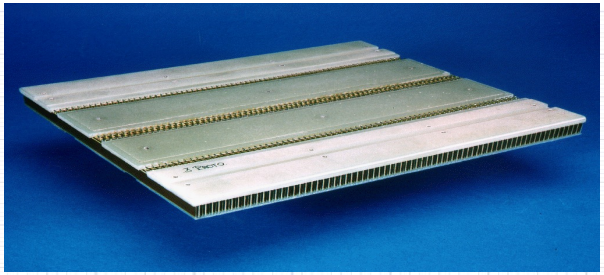
- Tension plates for barrel TRT
- Front-end electronics cards
- Digital integrated read-out circuit, DTMROC

Uppsala – SemiConductor Tracker:

- Production of 300 silicon micro-strip detector modules
- Environmental DCS and interlock system

Calorimeters





Stockholm – Tile Calorimeter:

- Production of front-end readout electronics
- Jet/energy sum processor system for L1 trigger

KTH – Liquid Argon Calorimeter:

- Production of electrodes for presampler
- Cables for optical read-out links and High Voltage supplies

Lund – Lucid:

- 16 photomultipliers (PMTs) attached to the beampipe support
- Quartz windows (pure SiO2)

KTH VETENSKAP OCH KONST

LUND UNIVERSITY

UNIVERSITET STOCKHOLMS

UPPSALA UNIVERSITET

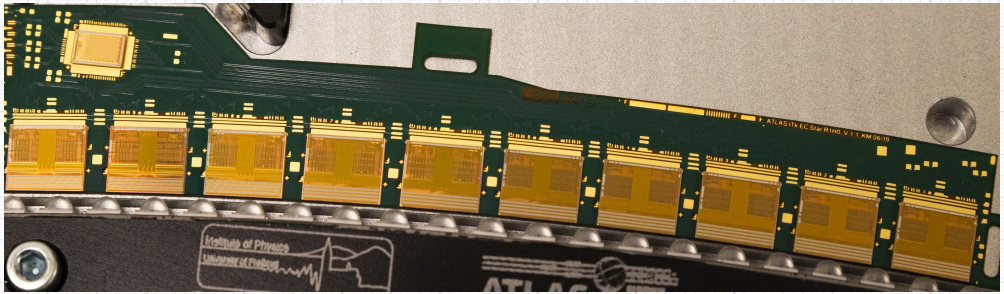
Ongoing activities for LHC phase 1 &2

Phase-II (LoI)

- New Inner Detector (ITK)
- New LAr front-end and back-end electronics
- New Tiles front-end and back-end electronics
- TDAQ upgrade
- TAS and shielding upgrade
- Various infrastructure upgrades
- Common activities (installation, safety, ...)
- New FCAL (if conditions require it)? → HGTD
- LAr HEC cold electronics consolidation (radiation hardness)?
- L1 track trigger
- Muon Barrel and Large Wheel system electronics upgrade?
- Forward detectors upgrade? - Lucid

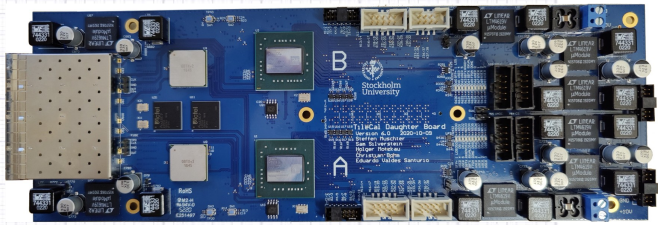
ITK

- Current tracker reaches end of life (Pixel, SCT and TRT) because of radiation damages and ageing. Replacement necessary regardless of increased luminosity.
- Lund and Uppsala contributes to the production in several areas
  - Assembly and testing of 50% of EndCap hybrids (~6000 units)
  - Thermal cycling of R1 & R3 modules
  - LV+HV PS specifications and procurement
- Sweden has in general small groups involved in instrumentation with limited in-house infrastructure → collaborate with industy
  - Assembly of EndCap hybrids done in collaboration with electronics producer NOTE (Norrtälje) starting in 2024
  - Hybrid burn-in and tests in Uppsala
  - Module burn-in & thermal cycling in Lund
  - Involve students (LU: 2 MS + 2BS, UU: 2 MS + 4 BS)
- Scandinavian production cluster involving Lund, Uppsala and NBI (Copenhagen)

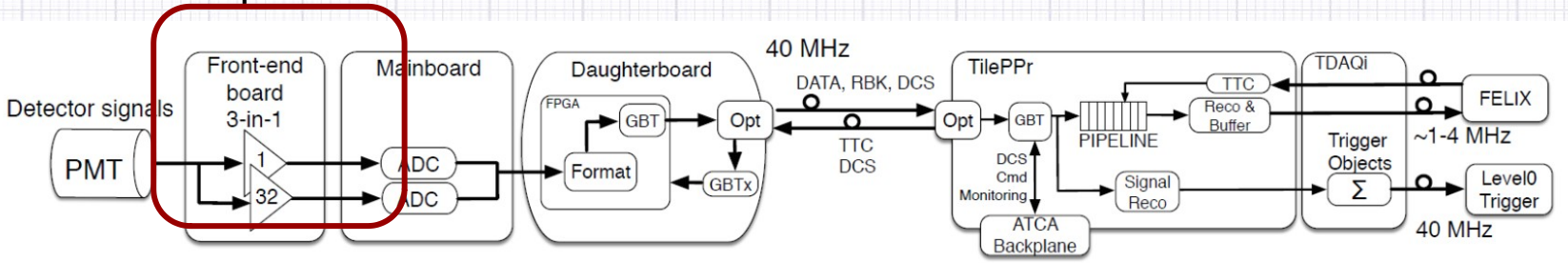


TileCal

- The readout electronics of the ATLAS hadronic calorimeter (TileCal) needs to be replaced in the Phase-II upgrade.
- Stockholm University is sole responsible for designing, manufacturing, testing and installing the approximately 1000 daughterboards.
- The daughterboards:
  - distribute the LHC synchronised clock signal
  - send configurations and control signals to the front-end chips
  - read out the digital data from all TileCal channels to the off-detector systems via multi-Gbps optical links.

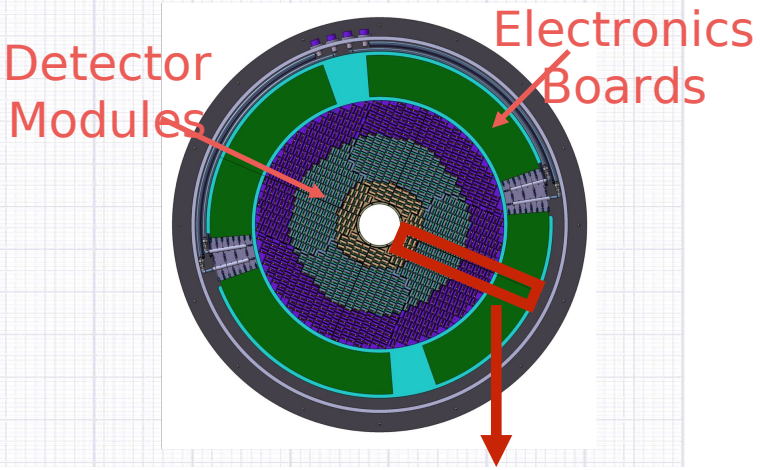


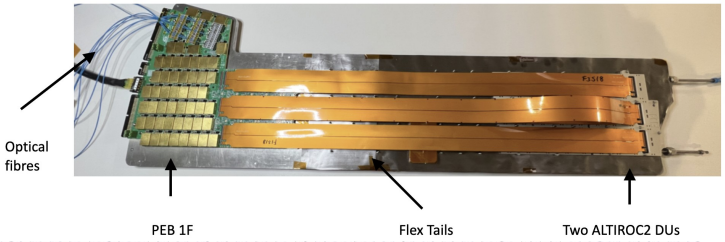
- Currently working towards Final Design Review.
- Production planned for 2025 and installation at CERN in 2026.



HGTD

- The High Granularity Detector is a new silicon detector to be installed.
  - Consists of 8,000 detector modules, arranged in 4 disks on either side of the ATLAS interaction point.
  - Measure timing of particles to 30 ps.
  - Measure luminosity.
- KTH group proposed the luminosity capability, and is responsible for this functionality. Also contribution to HV power supplies.

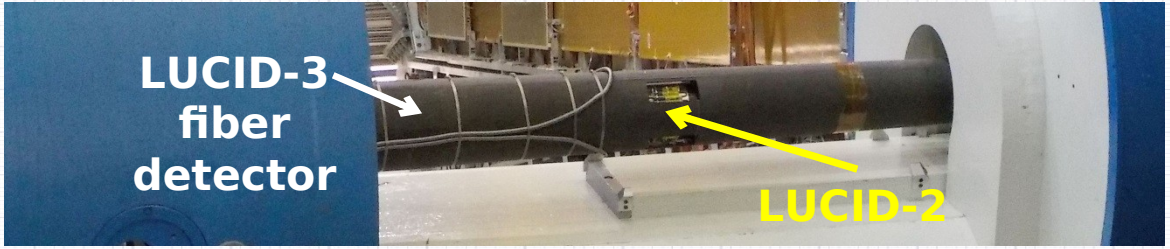




- Leadership roles:
  - Electronics coordinator 2019-2023.
  - Grounding and Shielding coordinator 2023.
  - Simulation, Performance and Physics coordinator 2019, 2021-now.
  - Luminosity, Data Acquisition and Controls Coordinator 2019-now.
  - Transitioning to production phase now, will require extensive presence at CERN for surface integration, quality control and data acquisition developments.
- HGTD Demonstrator (Detector slice)
  - Currently developing the DAQ and Luminosity software at the HGTD Demonstrator at CERN and at KTH.

Lucid

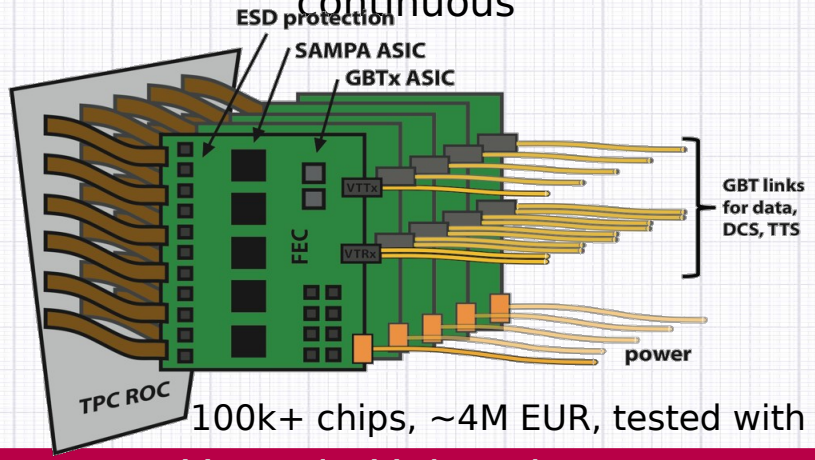
- LUCID is able to measure luminosity accurately over 5 orders of magnitude, from the very low luminosity in the tails of special beam-separation scans used to calibrate the detector, to the high luminosity in physics run.
- However, a too large acceptance gives saturation (signals in every bunch crossing) which can kill the measurement at the future High-Luminosity LHC (HL-LHC).
- A new detector has therefore been designed for the HL-LHC with smaller PMTs attached to the muon shielding instead of to the beampipe. A detectors using optical quartz fibers as Cherenkov medium has also been designed.
- Prototypes have been built of these new detectors and the data from them shows that the proposed designs will work at the very high luminosity at the HL-LHC.



LS2 (2019-2021) TPC Readout electronics : SAMPA

Lund major contributor to original ALICE TPC electronics for Run 1+2

- Smaller readout upgrade during LS1
- Major TPC upgrade during LS2 / New FE ASIC SAMPA (130 nm TSMC CMOS)
  - Positive or negative input, 32ch
  - Programmable conversion gains and peaking times
  - Readout modes: triggered or continuous



Lund SAMPA contributions:

- Physicist input to chip designers
- Testing and characterization of V1-V4/5 (2016-2020/2022)
- From oscilloscope level to DCS, DAQ & Analysis
- FEE for systems beam tests

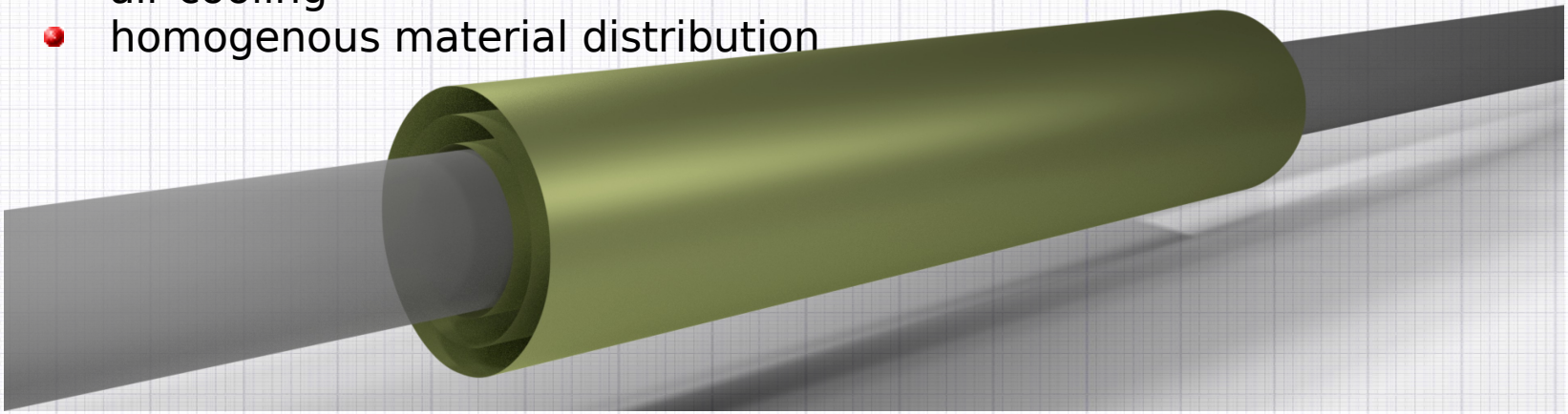
100k+ chips, ~4M EUR, tested with custom robotic setup at LU: https://youtu.be/3tnqPbMWzqQ

Alice

LS3 (2026-2028): ITS3 Specifications & Layout

Concept

- replace inner 3 layers of ITS2 with ITS3
- ~280 mm long sensor ASICs
- out of 300 mm long stitched (overlapping metal layers) wafers
- 20-40 µm thick (0.02-0.04% X/X0)
- ~20 x 20 µm2 pixel size
- bent shape with radius 18/24/30 mm
- carbon foam rib to hold ASICs in place
- air cooling
- homogenous material distribution



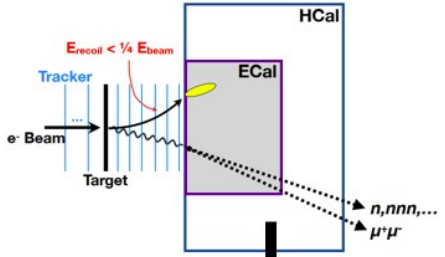
Lund is participating in characterizing/testing of large and small (“MOSS” and “babyMOSS”) ITS3 prototypes (technology also relevant for FCC-ee)

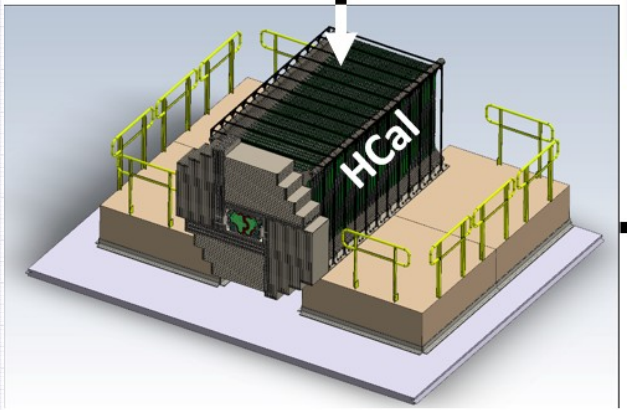
Non LHC and R&D activities

Essentially at all universities involve in HEP and NP experiments + Mid Sweden University which is involved in MEDIPIX

LDMX Light Dark Matter eXperiment

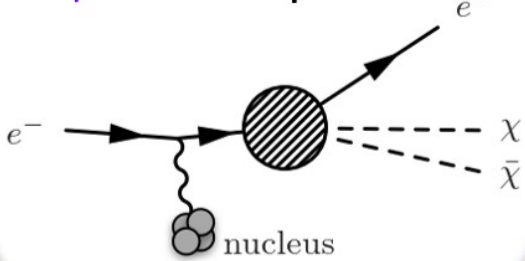
Signal in HCal means background



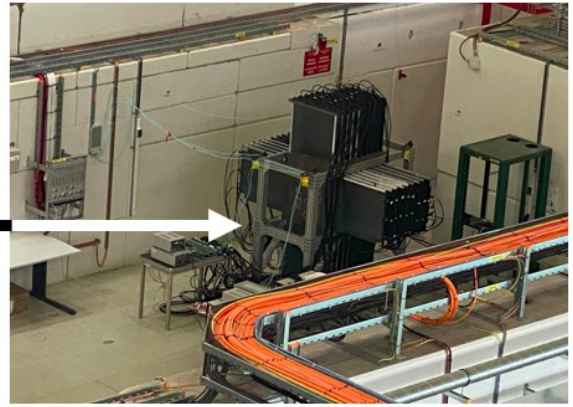


Importance of understanding downwards fluctuations in detector response

Search for DM production



HCal r/o electronics designed in Lund based on the CMS HGCROC

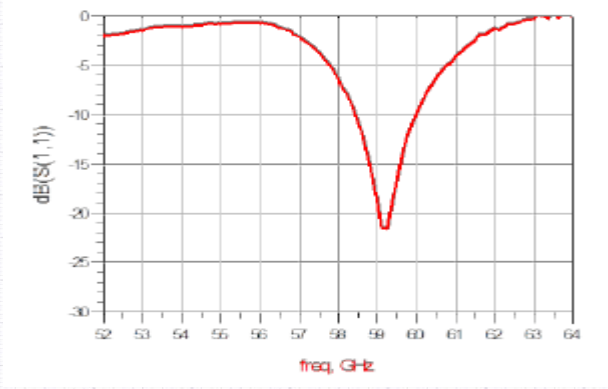


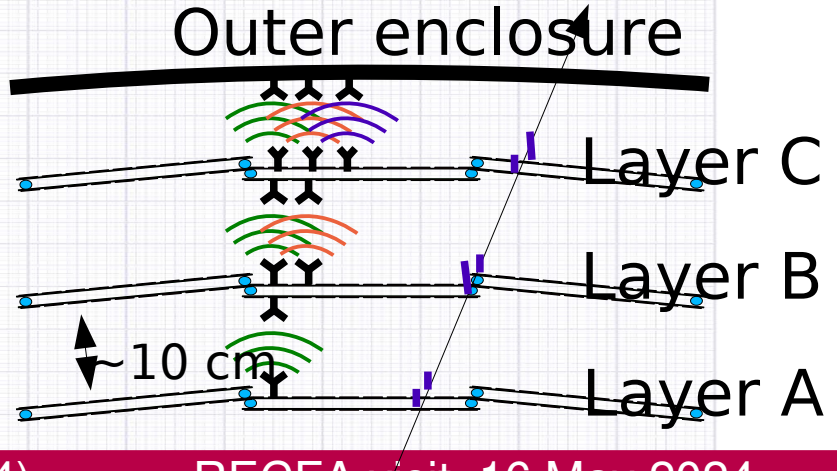
HCal prototype in the CERN East Area
Funded by the Crafoord foundation and the Physiographic Society in Lund

→ see astroparticle physics talk

Neuromorphic tracking

- Project in AIDA nova - WADPT
  - Aim to achieve GBT data transfer with wireless links to be used for neuromorphic track reconstruction (regional tracking)
  - Feature size of 60 GHz technology makes it well suited for tracking detectors.
  - Radiation tests show technology is radiation hard
  - Potentially large savings in material and services
  - Technology for ILC and FCC?
  - Demonstrator in production, to be completed in 2024





Funding and organisation

- Main source for funding research infrastructure is the Council for Research Infrastructure (RFI) at the Swedish Research Council (VR).
  - R&D funding for ATLAS & ALICE ~14 MSEK (2012-2017)
  - Investment money granted in 2015 for ATLAS upgrade ~ 44 MSEK (connected to fair share of CORE cost). An additional 12 MSEK was approved in 2023 to cover exchange rate losses. (Swedish currency has lost 50% w.r.t. SFR 2016 to 2023)
  - non-CORE funding granted in 2019 ~ 20 MSEK (pushed in RECFA letter)
  - Not possible to pay PhD students with infrastructure money → difficult to involve PhD student in detector work.
  - Decreasing number of engineers in groups because non stable funding for HW projects.
  - History: For building of current ATLAS & ALICE detectors VR contributed 84 MSEK and the private Knut and Alice Wallenberg foundation (KAW) 36 MSEK (CORE:non-CORE 1:1).

- Main research funding in Sweden go directly to universities.
  - Push from authorities to have universities fund infrastructure.
  - Universities are not well prepared to handle investment in infrastructure.

- RFI funding
  - Bi-yearly funding cycle and accepted project funded for 4-6 y
  - Funding works OK for operation but not for construction because longer duration and bigger uncertainty. RFI do not accept contingency in budget.
  - Split CORE /non-CORE is not well perceived
- Last RECFA visit recommendation:

> Since, as the Committee has learned, technology transfer works well in Sweden and a large number of Swedish companies are closely involved in particle detector projects, it might be worthwhile considering the formation of a national laboratory for instrumentation. Such a move could well turn out to be the most efficient way to promote the Swedish community's excellence in detector development and construction.

We are suggesting a Swedish National Accelerator and Instrumentation Laboratory in the ongoing inventory of needs done by RFI

- Big Science Sweden (ILO) is a good support to our CERN activities.

Swedish National Accelerator and Instrumentation Laboratory (SNAIL)

Sweden has no coordination of accelerator based research which has a negative effect on the field.

- Difficult for Sweden to contribute in international infrastructures.
- Difficult to keep technical competence
- Difficult for Universities to co-fund. instrumentation/infrastructure because split between many projects.
- Difficult to act on changes to cost and schedule.

SNAIL is an initiative to collect accelerator and instrumentation research (CERN, ESS, MAXIV, ILL, ESRF etc,) in one organisation

23 October 2023

New approach needed in Swedish research policy

An opinion piece signed by representatives of Lund and Uppsala universities and ESS was recently published in the Uppsala Nya Tidning newspaper.

Uppsala Nya Tidning

Lokalt Nyheter Sport Familj Åsikter Bostad E-tidning Kultur & Nöje

Svensk forskningspolitik måste uppdateras

Spin-off

- Sweden has no special organisation for technology transfer from big science. Universities are the main actors.
- Many companies in Sweden with connection to our field
  - Elekta – Radiotherapy, machines and dose planning etc.
  - Scanditronix – magnets
  - Scandidos, CRAD etc.- dosimetry
  - Scandinova - RF
  - Raysearch – Dose planning for radiotherpy
  - GE Medical – cyclotrons for radioisotopes (and PET)
  - X-counter, Mamea, Sectra, Beamocular etc – Imaging
- Various levels of interaction between research groups and companies.
  - Direct connection trough research eg Mats Danielsson at KTH.
  - Students eg trough projects, moving to industry and even shared industrial PhD positions.