Mid-term report : Sweden

D. Milstead

Description of activities with a focus on

(i) following up points raised at the 2016 RECFA visit (ii) core ECFA activities.

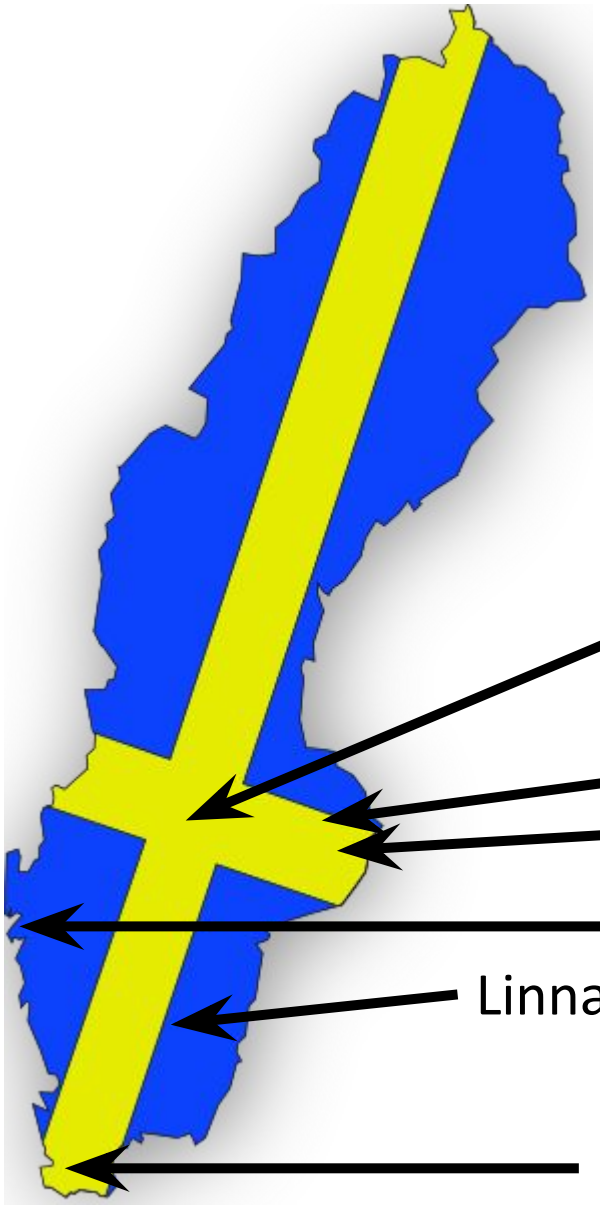
- Institutes
- Theory
- LHC
- Accelerator
- Grid
- Outside and beyond the LHC

Funding

- Swedish Research Council (VR)
  - Project grants (4 years)
    - PhD students/senior salary costs
    - Postdocs
    - Travel
  - Starting grants for young researchers
  - Research Infrastructure (RFI)
    - CERN, FAIR …
- Wallenberg Foundation
  - Private foundation
  - Large investments
  - Wallenberg scholars, Wallenberg Academy Fellows, Wallenberg Research Projects
- Horizon 2020
  - Individual grants
  - MSCA actions for graduate schools/fellows

Particle-physics related research in Sweden

LHC (ATLAS, ALICE), Isolde,
accelerator development (incl. CLIC), future collider experiment design & physics
Cosmo/astroparticle physics,
Neutrino physics, Low energy particle physics, Theory



Karlstad (KU)

Uppsala (UU)

Stockholm (SU, KTH)

Göteborg (GU, CTH)

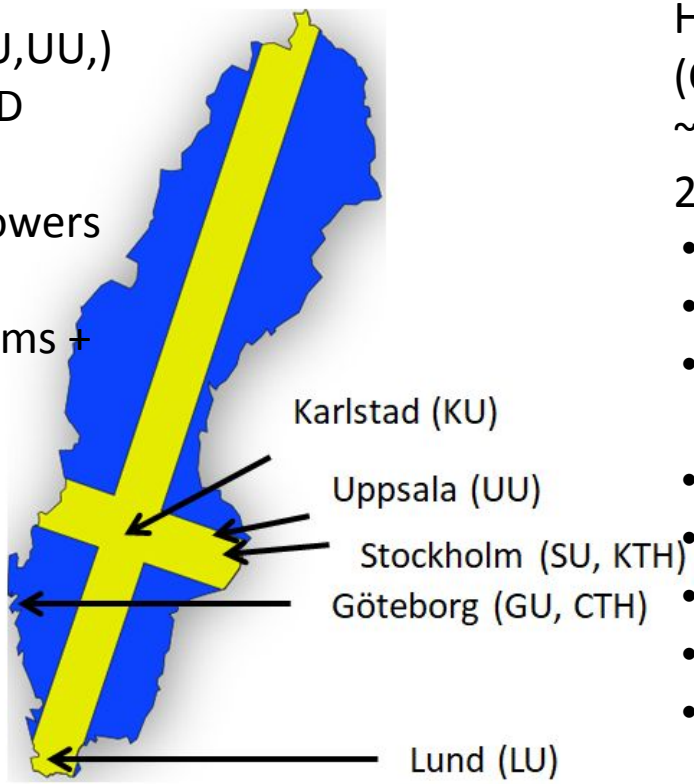
Linnaeus (LnU)

Lund (LU), European Spallation Source (International lab)

Theory

Theory+pheno (CTH,KTH, LU, SU,UU,)
~18 faculty+16 postdoc + 15 PhD

- Standard Model pheno
- Event generators/parton showers
- Soft and pQCD
- QCD dynamics of small systems + HI
- BSM model-building
- Low energy hadron physics
- Neutrino physics
- Dark matter (collider)



High energy physics- theory (CTH, KU,SU,UU)
~ 30 seniors + 41 postdocs + 28 PhD students

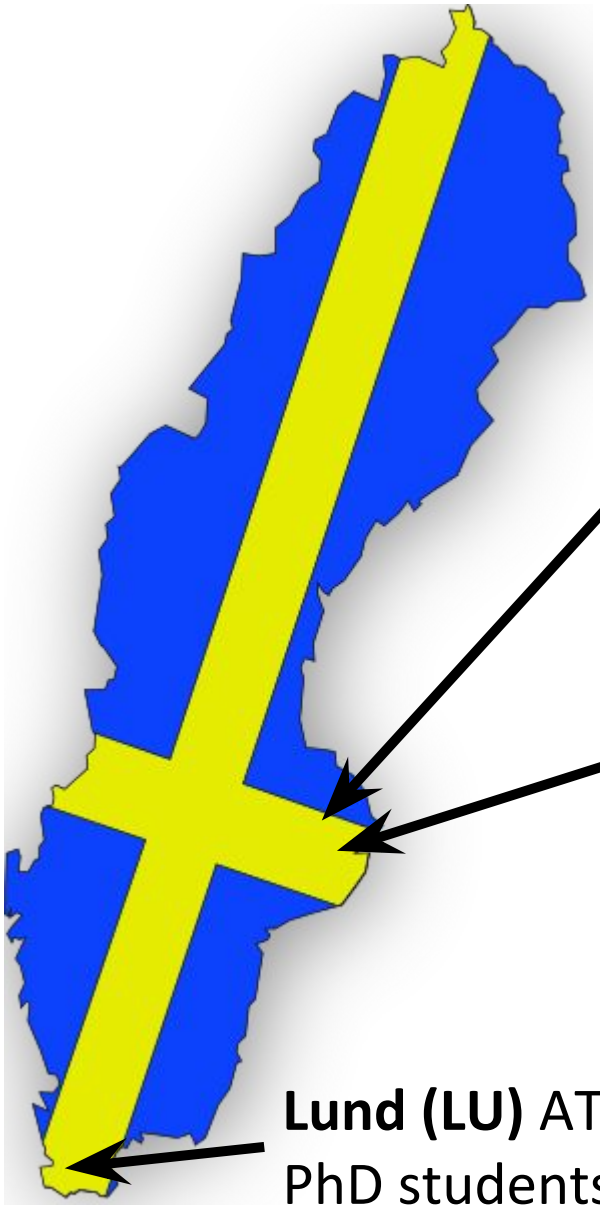
- String theory, M-theory
- Event dimensions
- Mathematical aspects of QFT
- Integrable models
- Black-hole models
- Quantum systems
- Quantum gravity
- SUSY, holography

Cosmo+astro theory+pheno (CTH, SU)
~10 faculty + 9 postdoc + 5 PhD

- Dark matter, dark energy
- Cosmic ray astrophysics
- Gravitational waves
- Cosmology

Natural synergies where appropriate where but no special effort to bridge formal theory and pheno.

LHC in Sweden



Uppsala (UU)
ATLAS: 5 faculty, 1 researcher, 1 postdoc, 5 PhD students

Stockholm (SU)
ATLAS: 6 faculty, 4 postdocs, 9 PhD students

KTH
ATLAS: 2 faculty, 1 researcher, 3 postdocs, 2 PhD students

Lund (LU) ATLAS: 7 faculty, 2 postdocs, 2 researcher/staff, 7 PhD students, ALICE: 3 faculty, 1 postdoc, 4 PhD students

LHC Experiments – Phase 2 upgrades

Lund, Stockholm, KTH and Uppsala

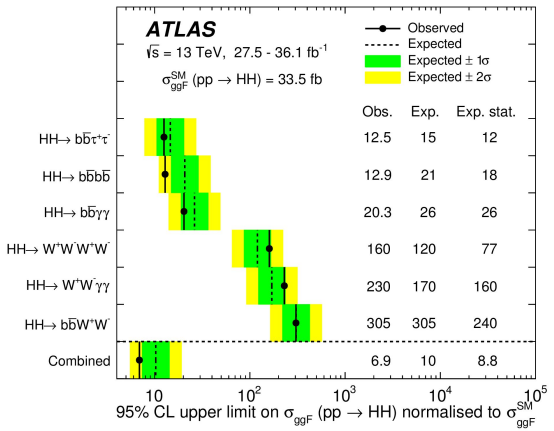
Phase 2

- ITK (LU,UU): Form Scandinavian cluster together with Copenhagen and Oslo. Production of EC detector hybrids and modules (R1 and R3) in collaboration with Swedish industry.
- TileCal (SU): Replace most exposed photomultipliers. Replace and redesign readout electronics (DaughterBoards)⟶ fully digital, using full granularity
- HGTD (KTH): Overall design and performance studies for TDR. Electronics and readout system for precise luminosity determination.
- HTT (UU): Parts of the Pattern Recognition Mezzanine and development of alternatives to Associative Memory ASIC.

Lund Uni

Novel ultra-thin upgrade of the inner-most tracker layers of ALICE (0.05% X_0 per layer, circular-shaped Si sensors).

Full exploitation of upgrades ⟶ evidence of di-Higgs production possible at HL-LHC
(all LHC-Sweden institutes are involved in these measurements)



Funding HL-LHC Commitments

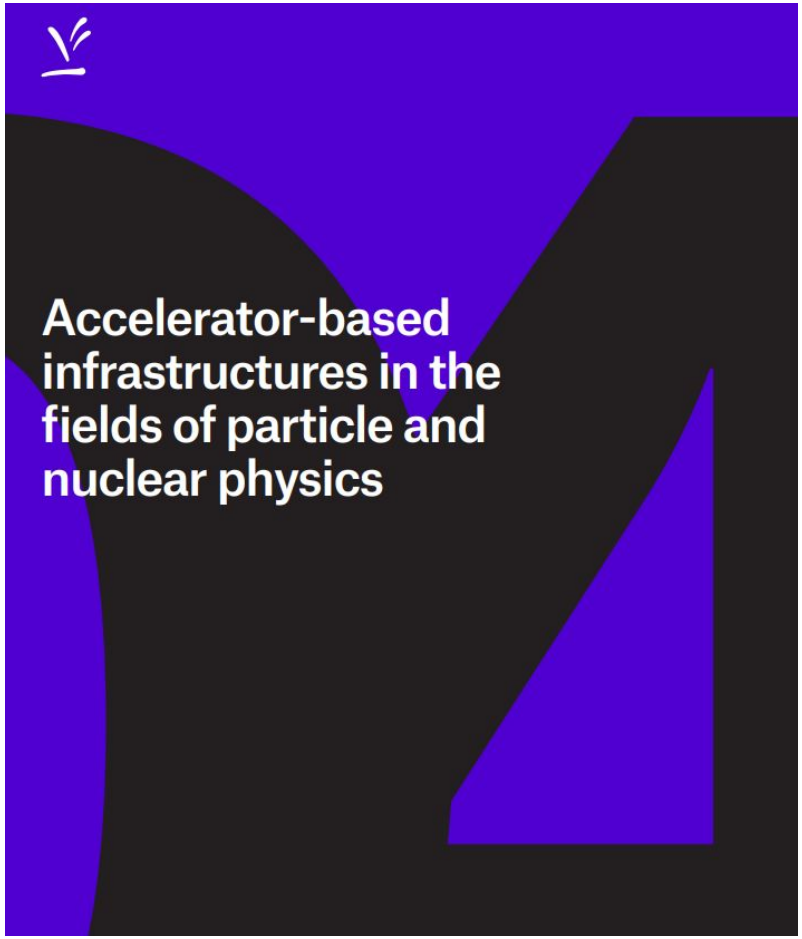
- At the time of the RECFA visit (2016) the CORE funding for Phase 2 upgrade was secured but non-CORE funding was missing. The groups have now received non-CORE funding until 2023.
- The non-CORE funding covers production costs but no money for academics needed to run the project.
  - This money has in the past been granted from Scientific Research Council for Natural and Engineering Sciences (VR)
  - This support has not materialized in recent years → hinders exploitation of infrastructure/operation investments
- The association between infrastructure funding and funding for exploitation/operation is weak.
  - Also an issue for related fields requiring large infrastructure investments.

Recommendations of VR report in particle/nuclear physics

- Bring up to discussion the possibility to transfer the treaty-bound membership fees to the Ministry of Education and Research
- For long-term funding and planning, initiate a dialogue between RFI, the Scientific Council for Natural and Engineering Sciences (NT, also a part of the Swedish Research Council), and the Swedish universities involved in the research (e.g. through URFI, the University infrastructure reference group).
- Investments made in terms of membership fees and in-kind deliveries need to be utilised.

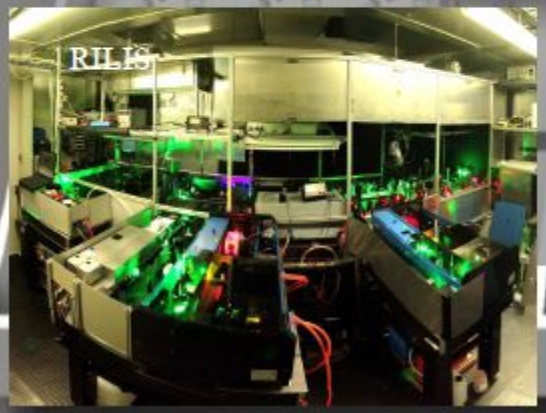
Discussion started between CERN, Swedish council delegates, VR to find ways to address the issue of Swedish exploitation of CERN which, in particular, is visible in all employment/fellow/student categories. The work started in autumn 2019 and the follow-up meeting planned in 2020 was cancelled because of COVID.

- Link to report



Sweden at ISOLDE

- **Physics with radioactive ion beams**: pure nuclear physics for exotic nuclear systems, nuclear astrophysics, fundamental physics, atomic physics, medical physics, solid state physics.
- Most recent development: world unique capability to post-accelerate exotic beams over the full chart up to ca 10 MeV/u with **HIE-ISOLDE.**
- Membership via common infrastructure grant in collaboration between four university groups: **Lund, Chalmers, Gothenburg U, Uppsala.**
- Sweden is **founding member of ISOLDE** and has a long standing history of physicists running experiments at ISOLDE and doing technical development for the facility.
- Major Swedish contributions (KAW) to **laser ion source, charge breeder and new post-accelerator** (Scandinavian collaboration within EU program).
- Latest Swedish collaboration is a project with the **FREIA laboratory** in Uppsala to develop **beam sharing** between high and low energy experiments using one primary target.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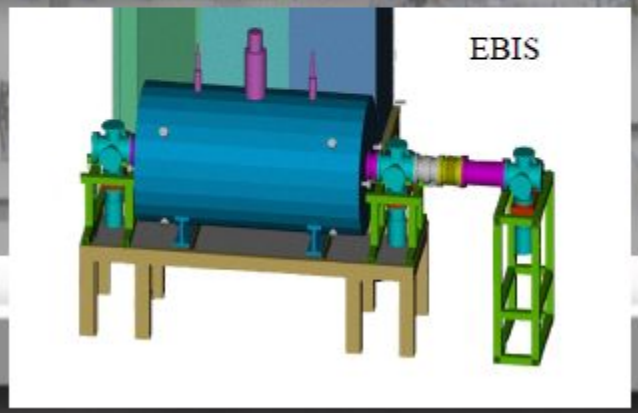

EBIS


HIE-ISOLDE SC cavities

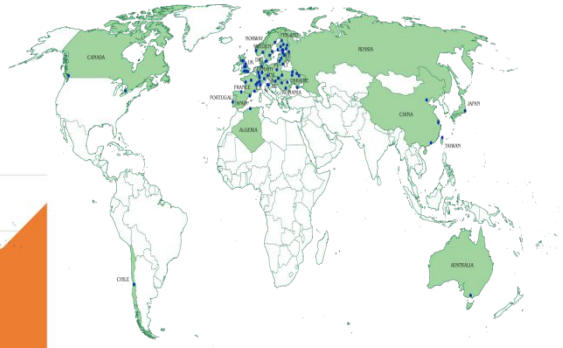
Accelerator Activities in Sweden

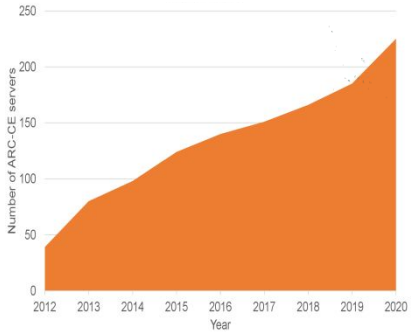
- **MAX IV Laboratory**
  - accelerators in full (daily) operation, 10 beam lines in operation, 6 beam lines under construction
  - conceptual design study for soft X-ray FEL extension to be completed in 2021 (collaboration with universities of Lund, Uppsala, Stockholm, KTH), then seek funding
- **FREIA Laboratory**
  - test stands for superconducting cavities, cryomodules in operation; commissioning magnet test stand
  - tested prototype ESS & HL-LHC cavities, ESS cryomodule; start testing ESS series (spoke) cryomodules
  - studies of solid-state RF amplifiers, RF/vacuum breakdown in CLIC cavities and at cryogenic temperature
  - conceptual design study for ESSnuSB to be completed in 2021 (international collaboration, EU-funded)
  - collaborations with industry to develop superconducting magnets and cryostats (for HL-LHC)
- **ESS ERIC**: International organization, so not included for Sweden
  - BUT needs to establish a regional technical eco-system which can support operation and upgrades
  - HOW to organize use of ESS competence and infrastructure for other projects outside its mission?
- **National coordination** for developing accelerator science and training accelerator physicist
  - discussions ongoing but no action taken: still facing the same obstacles of lack of coordination and funding
  - **this hampers all development work and (in-kind) contributions by Swedish groups**

Computing: NDGF Tier1 and ARC

- Nordic data grid facility Tier1 is now hosted by the Nordic e-Infrastructure Collaboration (NeIC) and is funded through HEP grants in Nordic countries
  - Key personnel from Sweden: NDGF director (M. Wadenstein), CERN Liaison (O. Smirnova), project manager (M. Barth), several operators
- ARC from 2021 will become the only European Grid middleware for computing, will be deployed in most countries
  - No sustained funding was possible to obtain since 2013 neither from EU nor from Nordic countries or HEP communities
  - Best-effort support with intermittent help from NeIC
  - Key personnel from Sweden: technical coordinator (B. Konya), distributions expert (M. Ellert), several developers

ARC usage around the world

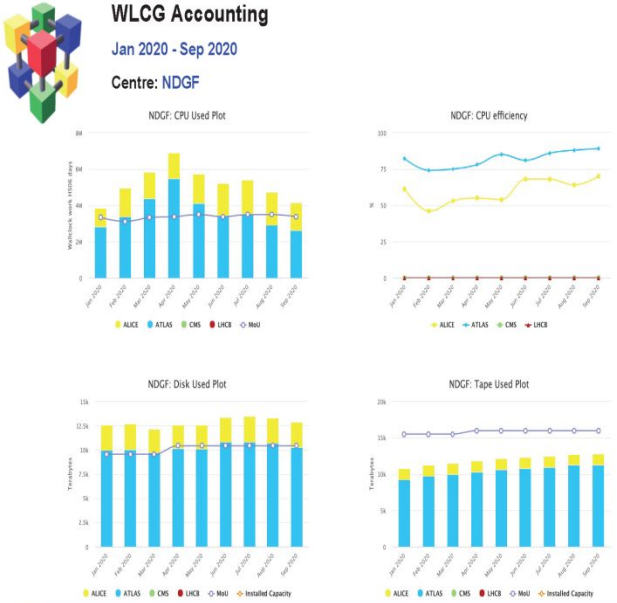




NORDUGRID
Grid Solution for Wide Area Computing and Data Handling

ARC Releases

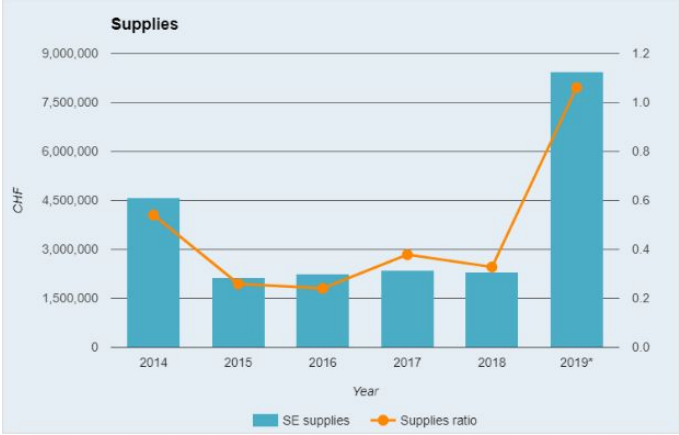
ARC release nr.	Release date	ARC tag(*)
6.8.1	October 8, 2020	6.8.1
6.8	October 8, 2020	6.8.0
6.7	July 2, 2020	6.7.0
6.6	April 27, 2020	6.6.0
6.5	February 14, 2020	6.5.0
6.4.1	December 2, 2019	6.4.1
6.4	November 15, 2019	6.4.0
6.3	October 16, 2019	6.3.0
6.2	August 30, 2019	6.2.0
6.1	June 27, 2019	6.1.0
6.0	May 29, 2019	6.0.0
15.03u20	March 18, 2019	5.4.4



NDGF Tier1 performance in 2020

Industrial links and cross-field collaborations

- Big Science Sweden was founded to serve as a link between Swedish industry and the Big Science research facilities in which Sweden is a member.
  - The 2020 edition of Big Science Suppliers and Partners Guide includes many particle physics activities
  - A positive development was seen in supplies to CERN in 2019.
- Swedish researchers involvement & coordination of cross-field initiatives, e.g.
  - EuCAPT, The European Consortium for Astroparticle Theory
  - iDMEu, dark matter initiative within the Joint ECFA/NuPECC/Appec Activities (JENAA)
  - High Energy Physics Software Foundation (HSF), ESCAPE Project



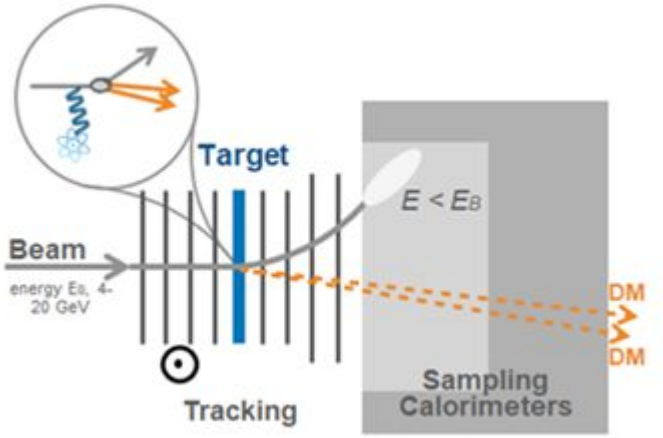
iDMEu
initiative for Dark Matter in Europe and beyond

EuCAPT

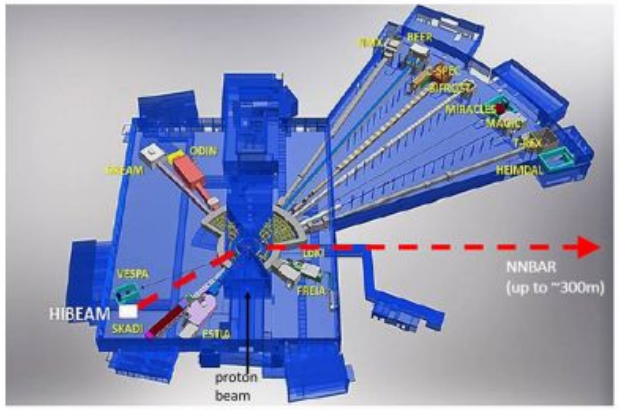
HSF
HEP Software Foundation

Outside and beyond the LHC

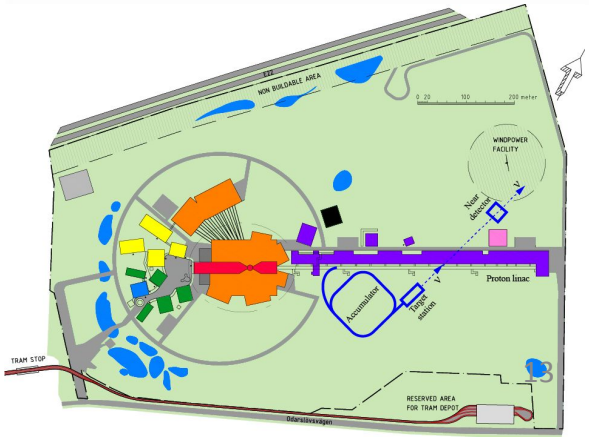
- LDMX
  - Fixed target missing momentum experiment with primary e- beam 4&8 GeV at SLAC, potentially 20 GeV at CERN
  - Dark matter in MeV-GeV mass with unprecedented sensitivity
  - Supported by KAW, VR, Crafoord Stiftelsen, Kungliga Fysiografiska Sällskapet Lund, L'Oreal-Unesco for Women in Science
  - 7 US institutes + LU



- HIBEAM/NNBAR
  - Search for baryon number violation via neutron conversions to sterile neutrons and/or antineutrons
  - Search at ESS with fundamental physics beamline
  - Up to 1000 x improvement in sensitivity
  - Supported by VR and H2020 Infrastructure Design (HighNESS)
  - 26 institutes, 8 countries + SU, CTH, UU, LU
  - Proceedings towards CDR



- ESSnuSB
  - Search and precision measurement of leptonic CP violation
  - Uses ESS 5 MW linac to generate uniquely intense neutrino beam to measure the 3 times enhanced CPV signal at the second ν oscillation maximum
  - Supported by EU H2020 and COST Action
  - 16 institutes in 10 countries, including UU, LU, KTH and LTU in Sweden
  - Started January 18, will publish CDR in December 2021 and TDR in 2025
  - Study started of the use of the ESS linac for νSTORM, νFACTORY, μCollider



- SHIP
  - Beam dump experiment
  - Hidden sector, exotic neutral leptons
- FCC
  - Early involvement in accelerator/experiment design
  - Initiatives starting
- Muon collider - initiative starting

Synergies in physics problems and technology across these projects

SEKTIONEN FÖR ASTRO- OCH PARTIKELFYSIK

Bild från vårens internationella mästarklasser i Lund då deltagarna i slutet av dagen diskuterade och samarbetade med grupper som gjort samma övning i Frankrike, Italien, Storbritannien, Tjeckien och forskare på plats på CERN.

Detta tillfälle sammanföll med den av FN instiftade Internationella Dagen för Kvinnor och Flickor inom Vetenskap (http://www.un.org/en/events/women-and-girls-in-science-day/), och leddes av kvinnliga forskare för att visa att de utgör en viktig del av forskningsfältet.

"Pröva på" forskning i partikelfysik

Varje år arrangerar grupper av forskare aktiva inom såväl ATLAS- och ALICE-experimenten vid CERN en dag då gymnasieelever får prova på hur det är att forska inom ex-

samma övning under dagen för att kombinera sina resultat. Efter att ha diskuterat sina resultat med forskare på CERN fick eleverna chans att fråga om deras jobb och hur de hamnat där. Övriga aktivite-

från KTH och Stockholms universitet. Chalmers arrangerade regelbundet internationella mästarklasser fram till 2016, och de vill gärna fortsätta traditionen och välkomnar lokala gymnasieskolor att ta kontakt om de är intresserade.

International Particle Physics Outreach Group (IPPOG) har organiserat mästarklasser i partikelfysik sedan 2005, och sedan 2017 även med det speciella syftet att uppmuntra fler flickor och kvinnor att välja naturvetenskapliga utbildningar och prova på forskningsaktiviteter.

Outreach - IPPOG

Sweden is a member of IPPOG

J. Strandberg (KTH) - IPPOG Representative

Swedish institutes are active in IPPOG Masterclasses:
High school students become "particle physicists for a day"

- Masterclasses are held twice a year, once for the International Day of Girls and Women in Science (mostly led by women researchers)
- Local media resonance for particle physics masterclasses also leads to interviews/visibility for Master's and PhD students helping out

The Swedish Particle and Astroparticle Physics board is discussing outreach funding: no national sources of funding to cover e.g. IPPOG participation fees or delegate travel

- this is an issue, as we are benefitting from IPPOG resources to educate the general public and to attract high school students to physics degrees

Summary

Wide range of particle physics activities in Sweden with LHC at the core

- Deep engagement in operations and upgrade
- Involvement in physics and synergistic activities

Expansion towards future accelerator & other particle physics experiments

Some issues:

- Partial disconnect between infrastructure support and operation/exploitation support
- International outreach support funding
- Sustainable funding issue for Nordic Data Grid Facility

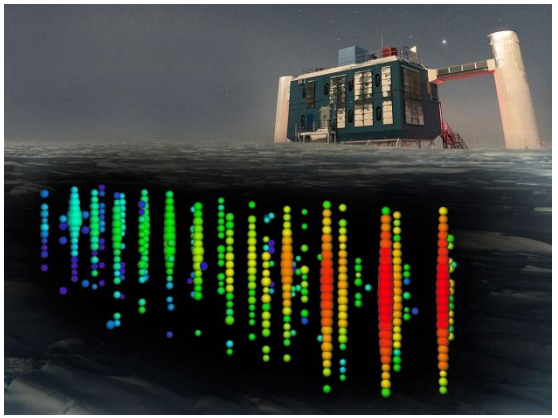
National coordination would benefit accelerator and instrumentation.
Outreach still lacks a dedicated funding line.

ATLAS operation, DQ and performance

- Detector operation
  - LAr cal (KTH)
  - LUCID (LU)
  - SCT (UU)
  - TRT (LU)
  - TileCal (SU)
- Trigger
  - Jet (LU)
  - L1 calo (SU)
- Object performance
  - Jet performance (LU, SU)
  - b-tagging (SU)
  - Fake tau, tau validation (UU)
- Computing (LU, UU)
- Data preparation
  - Luminosity (KTH, SU,LU)
  - DQ (ALL)

Interesting particle physics-related activities covered largely by NuPECC and APPEC

IceCube Neutrino Observatory (SU, UU)



High-energy nu alert – association with blazar galaxy (2018).

Proceeding toward IceCube-Upgrade in 2023:

nu_tau measurement – test unitarity of mixing matrix.

XENON Experiment Dark Matter Search (SU)

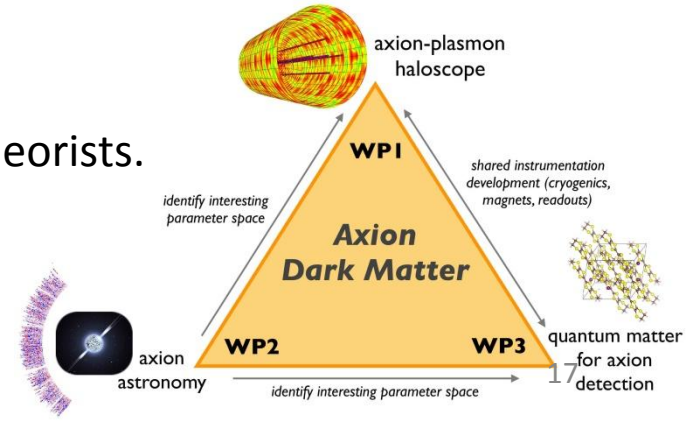
1 Ton results (June 2020): Excess of electron recoil events.

Proceeding toward XENONnT (5.9 tons).

AxionDM – new VR research environment (SU)

Particle, cosmology, & cond. matter experimentalists and theorists.

Developing axion-plasmon haloscope.



Outreach in Sweden and internationally

Many different local outreach initiatives in addition to Masterclasses, e.g.:

- Talks to the general public (e.g. in libraries and schools)
- Local events: Forskarfredag (Research Friday), Culture night, international Researchers Night
- Science days/career fairs within individual institutes
- Activities within our own experiments (e.g. guided tours, open days)
- Additionally, one of our permanent researchers has been elected next outreach coordinator of the ATLAS experiment R. Gonzalez Suarez (UU)

Since dark matter is a big research topic in Sweden, our researchers are involved in Dark Matter Day activities. Some examples from the past:

R. Gonzalez Suarez (UU) - Soapbox Science

C. Ohm (KTH) - Dark Matter Day ATLAS talk

C. Doglioni (LU) - Dark Matter Day Live @ CERN