LHC Computing in Sweden

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High-level overview

Research and development: Open Source software

- ACTS: Common Tracking Software
- ARC: Grid middleware for distributed data analysis
- ARIADNE: Simulation of QCD radiation
- BALER: Data compression package
- CHIRON: Numerical solver for HEP
- COLORMATH: A package for color summed calculations
- DCACHE: Grid storage and archival system
- GEANT4: Detector simulation toolkit
- JEWEL: QGP-related simulations
- NEOS: ANN-based analysis of HEP data
- PYTHIA: Flagship particle physics event generator
- RIVET: Package for comparing data and simulations in HEP

Computing infrastructure (WLCG)

Swedish Tier2

DECOMMISSIONED in 2024

Sweden's contribution to the Nordic Tier1

Focus of this talk: WLCG

- Computing for LHC requires research and development
  - Lund has a long tradition of software development (e.g. Pythia)
  - Sweden established a national academic computing infrastructure (SNIC) in 2003
- Sweden started with LHC Grid R&D in 2000
  - Involved originally all Particle Physics groups (Lund, Stockholm and Uppsala) and all major computing centres in Sweden
  - Kick-started through a common Nordic project: NorduGrid
  - Was instrumental in creating SNIC
    - SNIC became NAISS in 2023, focus shifted to supercomputers (HPC)
- Primary goal: Nordic Tier1 centre for WLCG
  - Pledge support to ALICE and ATLAS (~6%)
- Unique situation: Nordic Tier1 is built from data centres in 4 different countries
  - Software challenge: created an own Grid middleware, the Advanced Resource Connector (ARC)
  - Political/financial challenge: created the Nordic e-Infrastructure Collaboration (NeIC)
    - NeIC evolved to host a range of non-physics activities

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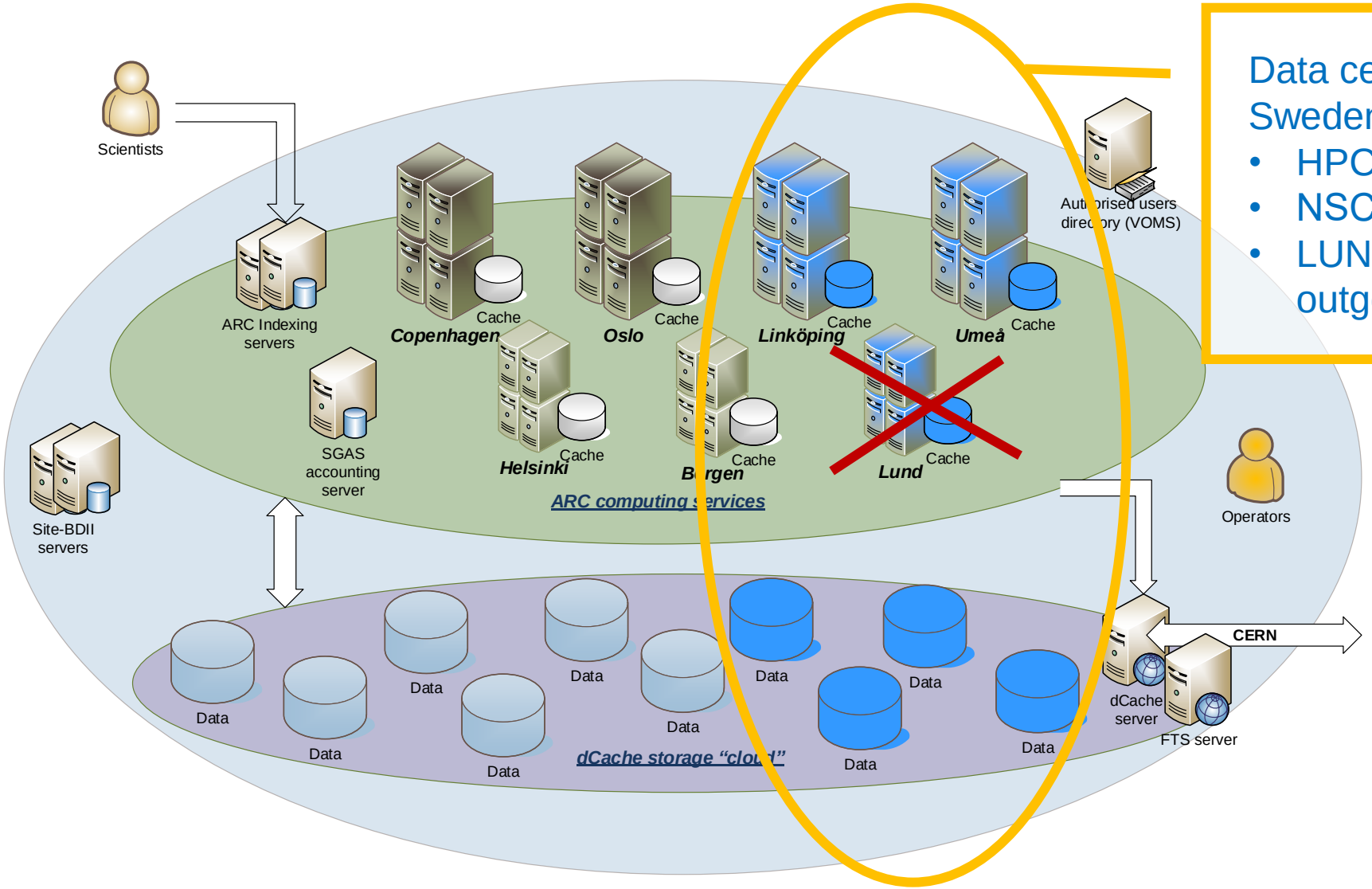
Nordic Tier1: an international center



Data centres in Sweden:

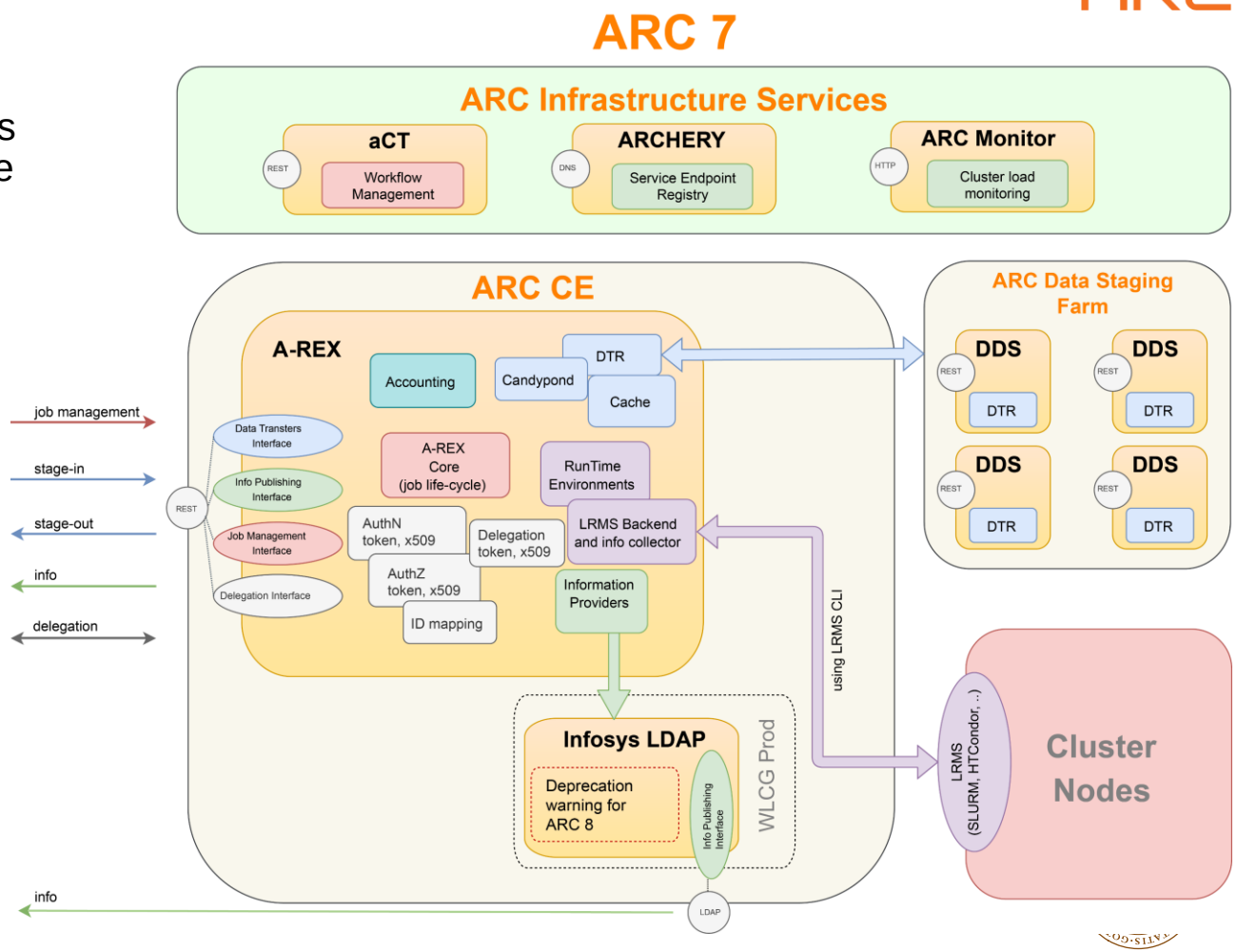
- HPC2N (Umeå)
- NSC (Linköping)
- LUNARC (Lund, outgoing)

Nordic Tier1 organisation

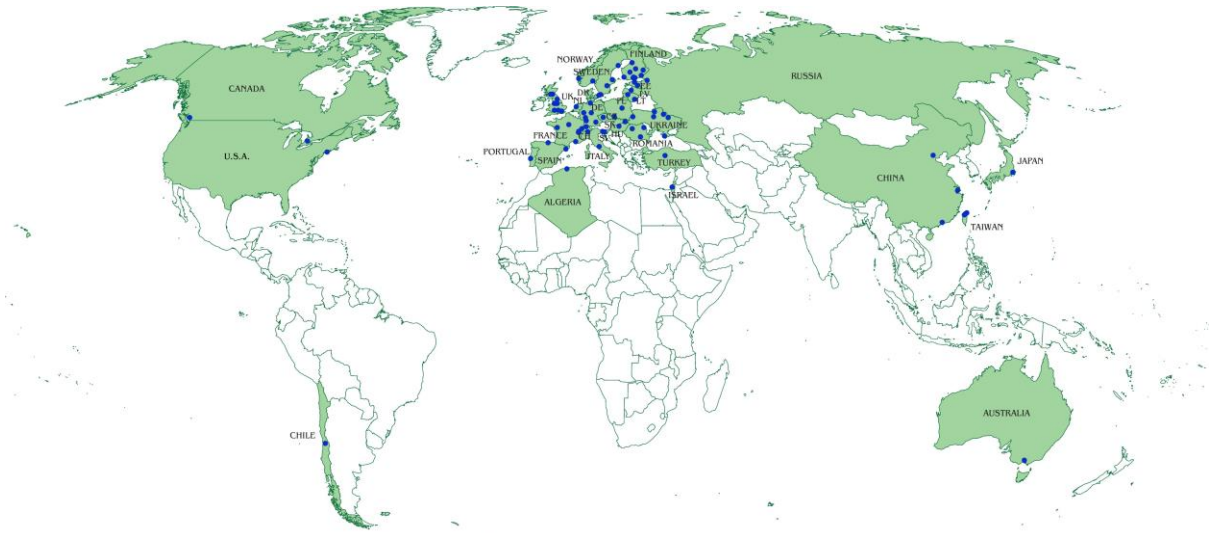
- In production since 2006
  - WLCG MoU signed by Sweden in 2008 (other contributing countries are Denmark, Finland and Norway)
  - Computing/storage resources are proportional to the respective national share at relevant LHC experiments
    - In Sweden, ALICE and ATLAS (no LHCb)
- Is operated since 2012 by the Nordic e-Infrastructure Collaboration (NeIC)
  - Funding via contributing countries
    - Each country contributes ~25%
    - Until 2024, had also co-funding from the Nordic Council of Ministers via NordForsk
- Tier1 staff: ~5.25 FTE (funded by NeIC), external experts: ~6 FTE (funded by national research programmes)
  - 1.25 FTE in software support (*ARC, dCache, SGAS*), the rest is in operations and management

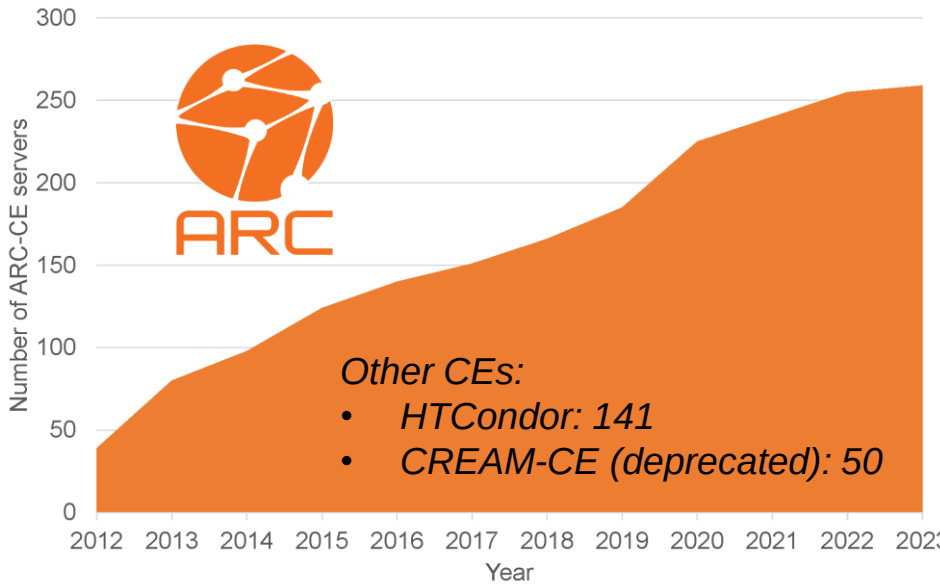
ARC Grid software

- Driven by the Nordic Tier1 and LHC needs
  - Common interface to supercomputer-class facilities
  - One of the most common Grid softwares worldwide now
- First release: 13th April 2004
- Current release: 6.19 (10 April 2024)
  - 81 releases so far
  - The major ARC 7 release is due this year
- 100 000+ lines of code
  - Free, Open Source Apache v2.0 license
- 46 past and present contributors
  - 11 in Sweden (5 active: 4 in Lund, 1 in Uppsala)
- Coordinated by the **NorduGrid Collaboration**
  - Not a project, hence no budget and no end-date



ARC usage worldwide





Developers in Sweden:

- *Lund University: Balázs Kónya, Florido Paganelli, Oxana Smirnova, Andrii Salnikov (now with MAX-IV)*
- *Uppsala University: Mattias Ellert*

Despite being the most used Grid Compute Element in WLCG, ARC has little financial support (0.5 FTE from Nordic Tier1, in Norway)

- 20 years-old software is of little interest for IT/CS
- HEP communities usually have no spare funds

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New trends

- Modern High Performance Computing (HPC) facilities have substantial GPU components
  - Hardware acceleration to parallelisable algorithms (e.g. in Machine Learning)
  - Some HEP algorithms (Fast Simulation, tracking) can benefit
  - Despite an effort aiming at using LUMI EuroHPC (largely *AMD MI250x* GPUs) for LHC, only a limited success has been achieved
    - Effort spent so far is not matched by the benefit
    - No adequate storage anyway
- Unclear to which extent we will be able to continue using generic supercomputing resources
  - It is probably cheaper to buy own “classic” hardware than to re-write all the experiment software
    - ARM processors may be promising, also energy-wise

Funding peculiarities

- In Sweden, infrastructure funding is separate from research funding
  - Infrastructure funds can‘t be re-allocated to e.g. PhD students or vice versa
  - In the latest round, Tier2 had to be dropped (along with other reductions)
    - Negligible on the WLCG scale, more important locally
- The overall trend is to consolidate computing power in massive exascale data centres
  - LHC computing is a corner case that is not accommodated
    - Need for long-term archival storage is unique
    - Parallelisation options for LHC tasks are very limited
  - No national/university HEP computing facility will exist in Sweden after 2024
    - Investments are consolidated in international facilities, like Tier1
- Software development and maintenance is still not seen as research
  - Even support from infrastructure grants is next to none

Recommendations from the last RECFA visit

- 2016 RECFA visit to Sweden (Lund, 20 May 2016), ECFA/Secr./16/1730:

> The grid computing effort organized through the Nordic Tier-1 (NDGF-T1) centre of the Worldwide LHC Computing Grid (WLGC) is a success story. In Sweden itself, the NDGF-T1 is the second-largest national research infrastructure after MAX IV. For the purpose of operating shared supercomputer-like facilities, Sweden's grid experts have developed special middleware known as ARC. This is another success story whereby ARC is already used by about 20% of the WLCG sites worldwide and usage is increasing. This achievement has put a heavy maintenance load on the existing team responsible for grid operations. The Committee recommends that adequate funding be provided to ensure that the existing achievements and expertise are preserved.

The recommendation was not possible to heed fully

Summary

- Sweden is an important contributor to the LHC computing
  - Successful operation of the Nordic Tier1
  - Development and support of the ARC middleware, the only surviving European Grid computing solution
  - Swedish computing experts are highly respected internationally
- We enjoy close and fruitful cooperation between researchers and computing resource operators in Sweden
- The global trend of consolidating computing power in few massive centers hits hard
  - HEP requirements are not prioritised
  - Funding for HEP-specific IT infrastructure decreases
- Software maintenance and development is not seen as research, not in Sweden, not globally
  - Funding and career path of developers is an issue for all Open Source software, even as famous as Pythia