Status and prospects for the Antimatter Factory at CERN

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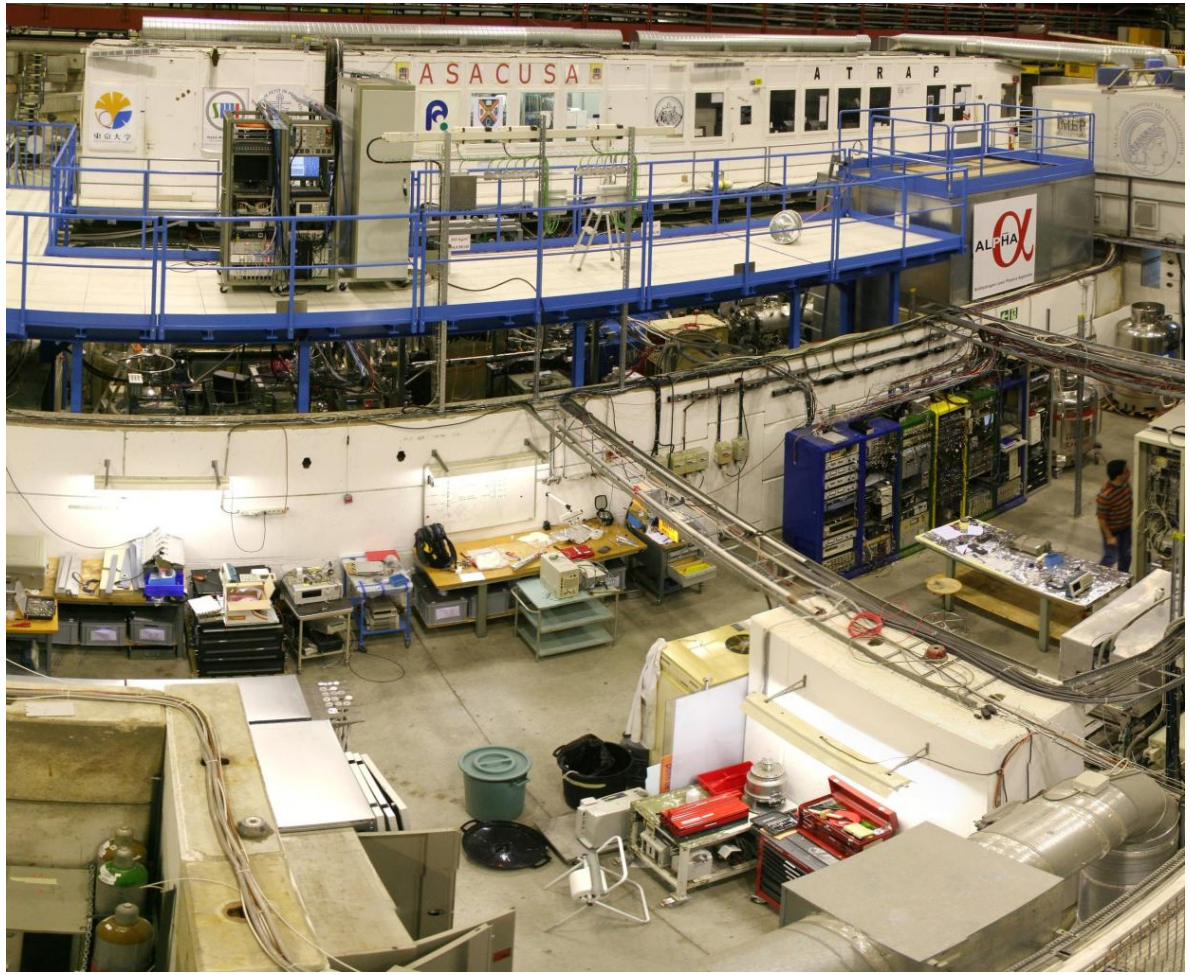
A Bit of History I

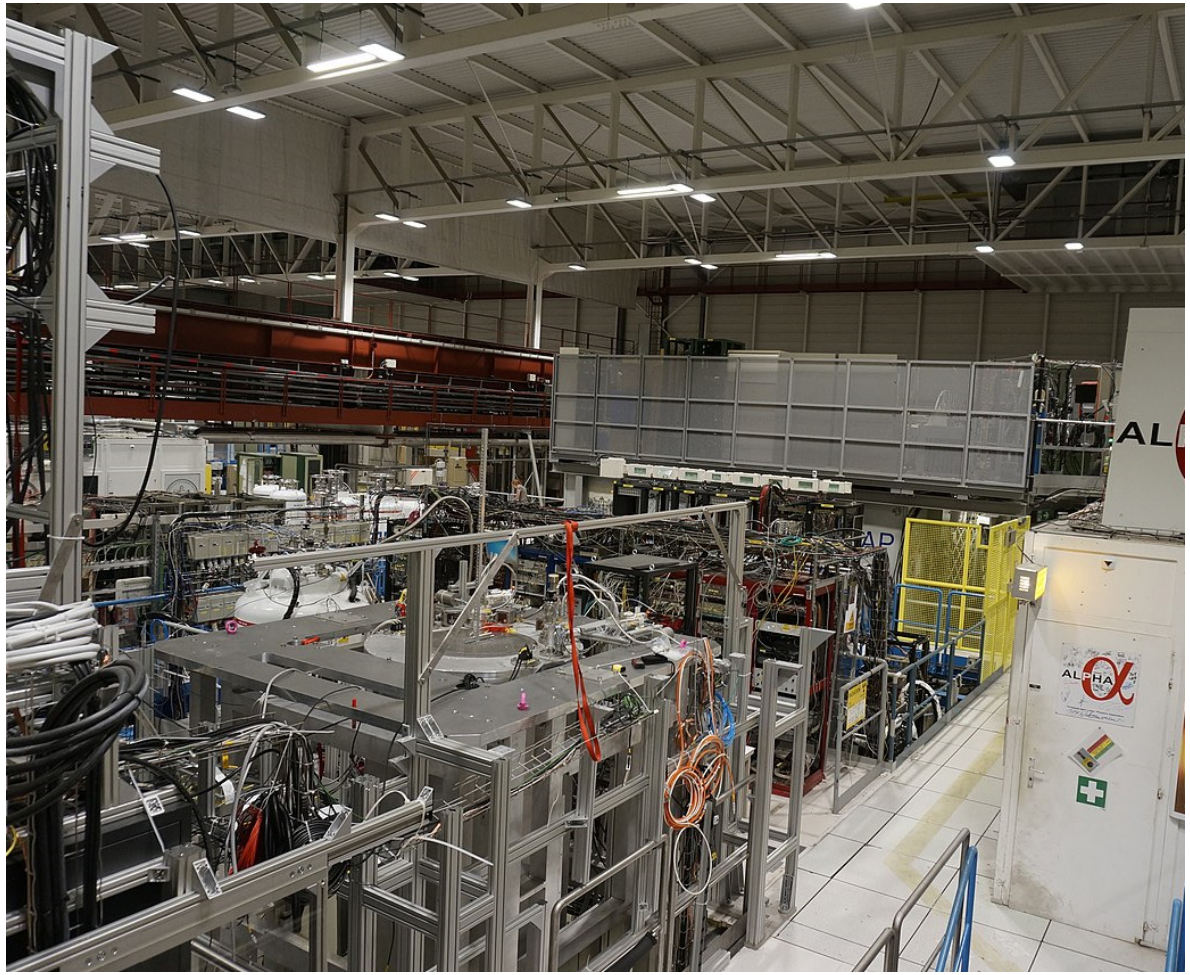
- **The Antiproton Decelerator (AD) started delivering beam for physics in 2000.**
  - AD parameters: Injection at 3.57 GeV/c, 4 cooling flat-tops -2 x Stoichastic Cooling 2 x e-cooling
  - Ejection at 100 MeV/c (5.3 MeV), ~150 ns pulse, cycle time ~120 sec.
  - Ejection approx.. 20 million pbars
  - The short expected life time and cost savings meant the AD was built on the cheap, re-using old magnets, vacuum systems, power converters, etc.- mostly from the AA/AC

- **Originally it was approved for operation up until 2006**
- **This was extended in 2002 to operation up until 2009**
- **etc.**
- **In 2009 the AD was approved for operation until 2016**
- **Some funds for making the AD**



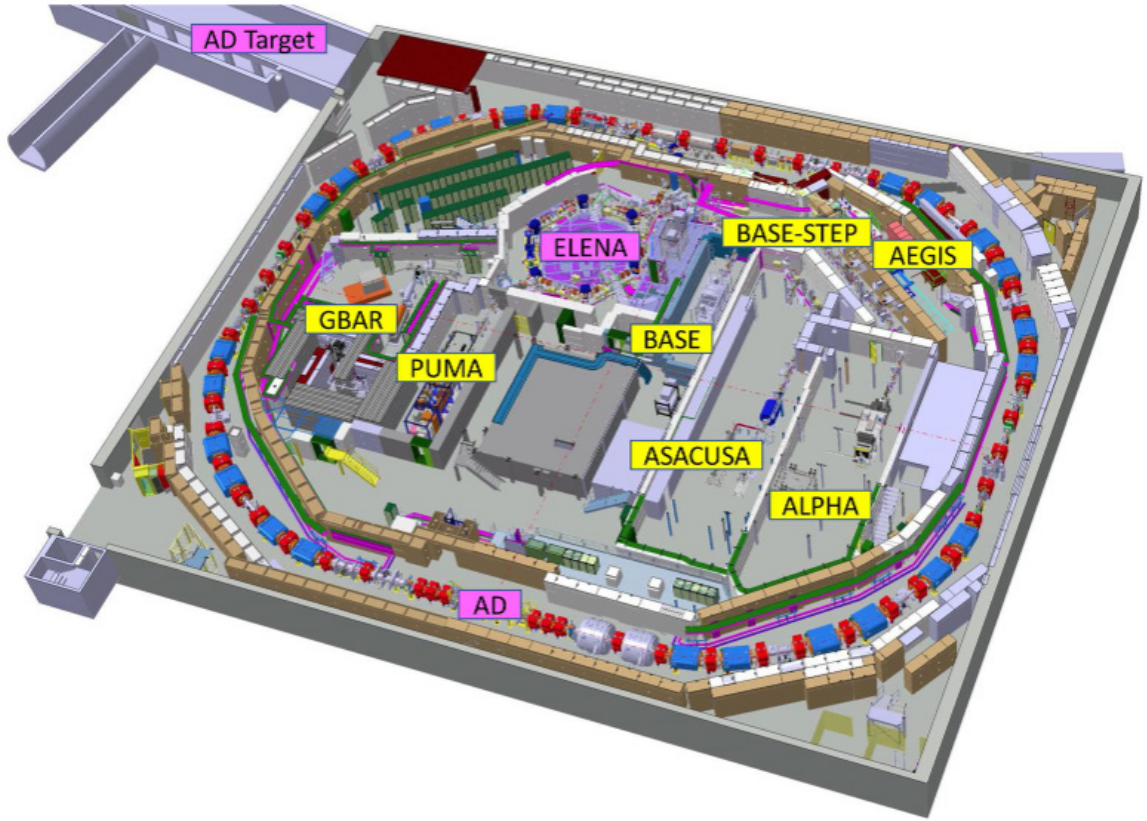
A Bit of History II

- In 2011 the CERN Council approved the construction of Extra Low ENergy Antiproton ring (ELENA) with the aim to further reduce the extraction energy down to 100 keV and thus increase the number of useful antiprotons for the experiments by a factor of up to 100!
- With ELENA being built, the AD had to be extended since without the AD there can be no ELENA.
- AD now approved to run until ~2040 – Modernization and consolidation of the AD to make it into a modern machine necessary.



ELENA impact on operation?

- **Energy reduced from 5.3 MeV to 100 keV**
- Collisions with rest-gas go up exponentially as energy goes down – hence ELENA *must have a very good vacuum!*
- Space charge effects increase with reduced energy – hence the beam is split into four bunches.
- The time spacing between the four bunches means no experiment can capture more than one of the bunches.
- ELENA shoots four bunches to four different experiments. Switching between experiments not possible with magnetic extraction lines – new electrostatic lines from ELENA to the experiments were installed during LS2.



More ELENA impact

- All experiments can get beam all the time. 24-7! Before max three experiments could take beam in one week and only during their shifts.
- Experiments typically trapped ~50 000 of pbars from AD when receivind a shot of about 30 million pbars.
- Now they trap ~ >1 million out of 8-10 million pbar in each of the 4 bunches of deliverable per cycle of the AD.
- During LS2 electrostatic extraction lines were installed and commissioned using H- beam from a local source.
- Post-LS2 ELENA now standard operation. Most experiments have developed some automatic systems to avoid having to run shifts 24h/day.

AD Consolidation and upgrades – PS beam

Before 2022 AD was getting 4 p bunches from the PS

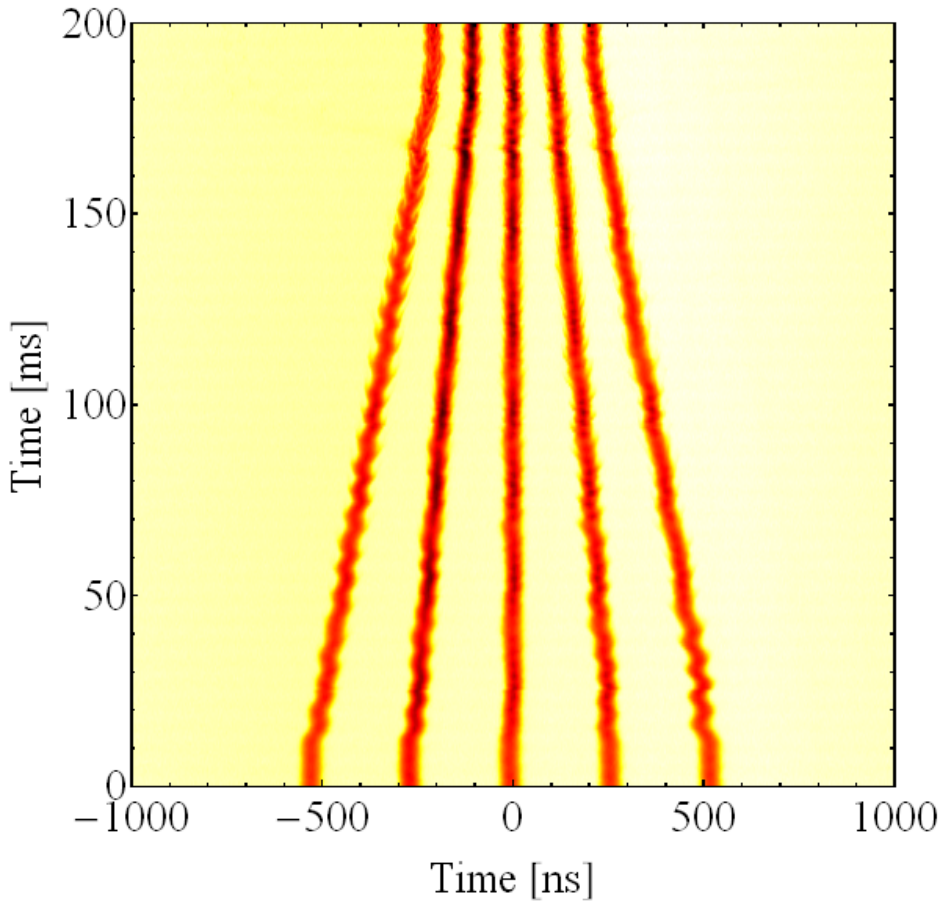
5 p bunches back in operation since 2022 (restart after LS2

- they **were available at AC times**

Tests in the PS indicated proton intensities of up to 2.1e13 possible

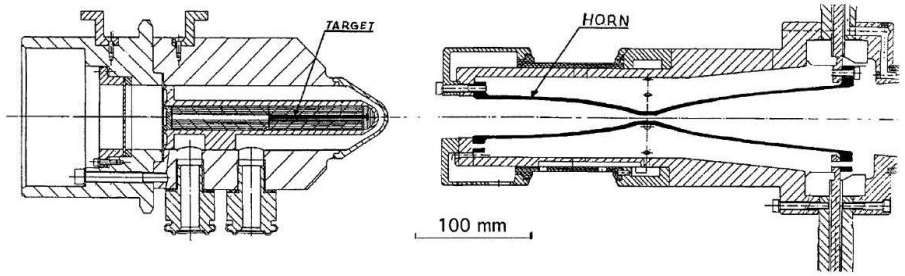
- **Slowly increasing toward this value in operation**

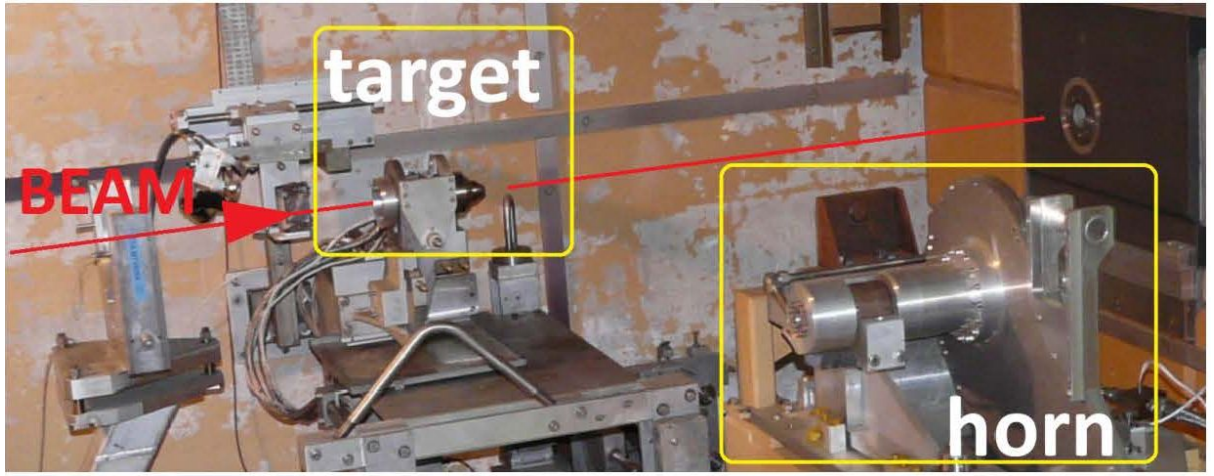
10% p lost during transmission in FTA



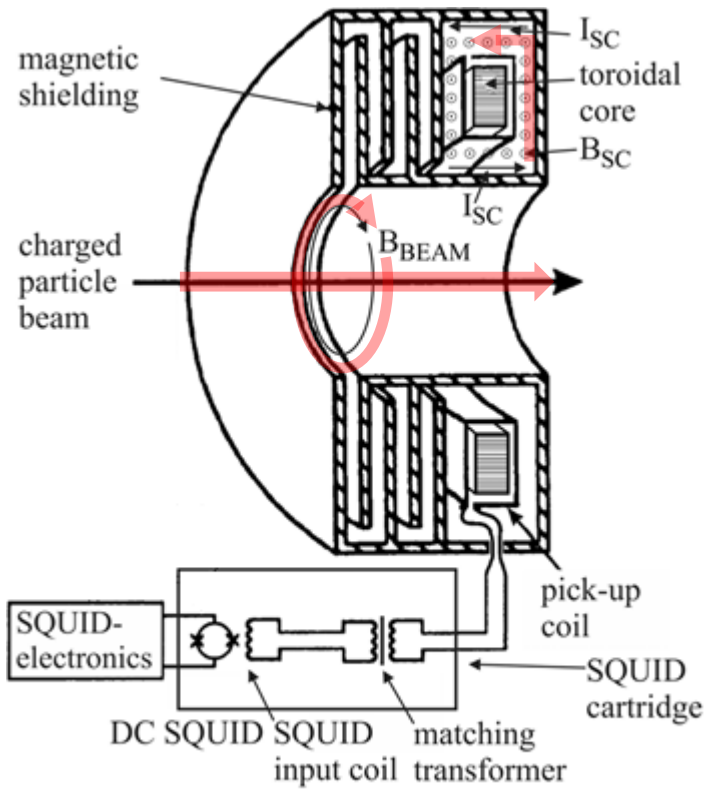
AD Target renovation and upgrade

- AD Target had remained largely untouched during AD era.
- It was designed for the AA/AC injectors for the proton – antiproton operation of the SPS in the 80's.
- Therefore, designed for proton beam every 2.4 sec.
- Water cooled.
- Good design – just worked – loss of expertise!
- During LS2 new target arrangement installed.
- Air cooled. Two last magnets before target now permanent magnets





Cryogenic Current Comparator



Working principle

- Field $\mathbf{B_{BEAM,}}$ induced by beam current, generates screening currents $\mathbf{I_{SC}}$ in the meander-shaped superconductive shielding

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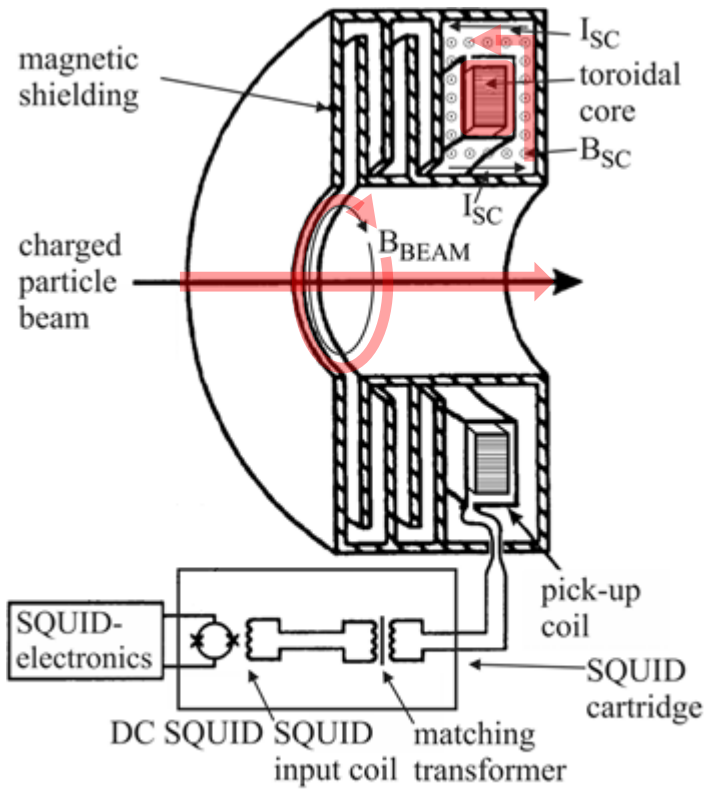

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- Field $\mathbf{B_{BEAM,}}$ induced by beam current, generates screening currents $\mathbf{I_{SC}}$ in the meander-shaped superconductive shielding
- $\mathbf{I_{SC}}$ in turn generates $\mathbf{B_{SC}}$ which couples to the single-turn toroidal pickup coil with a ferromagnetic core.

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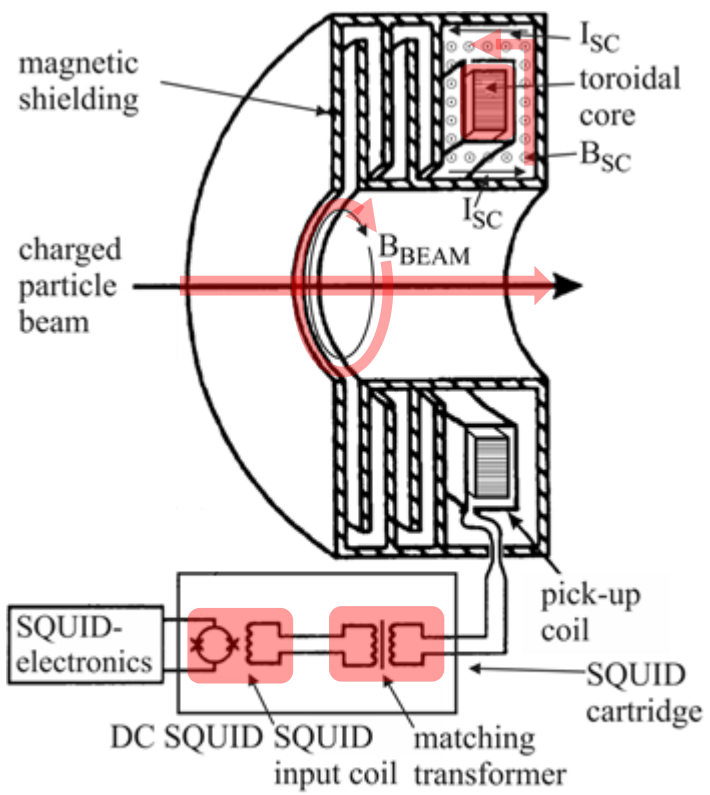

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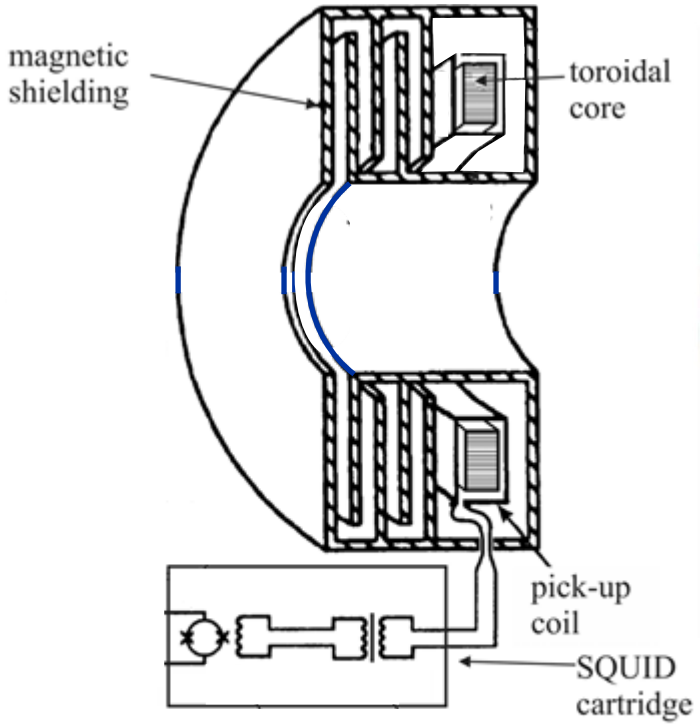
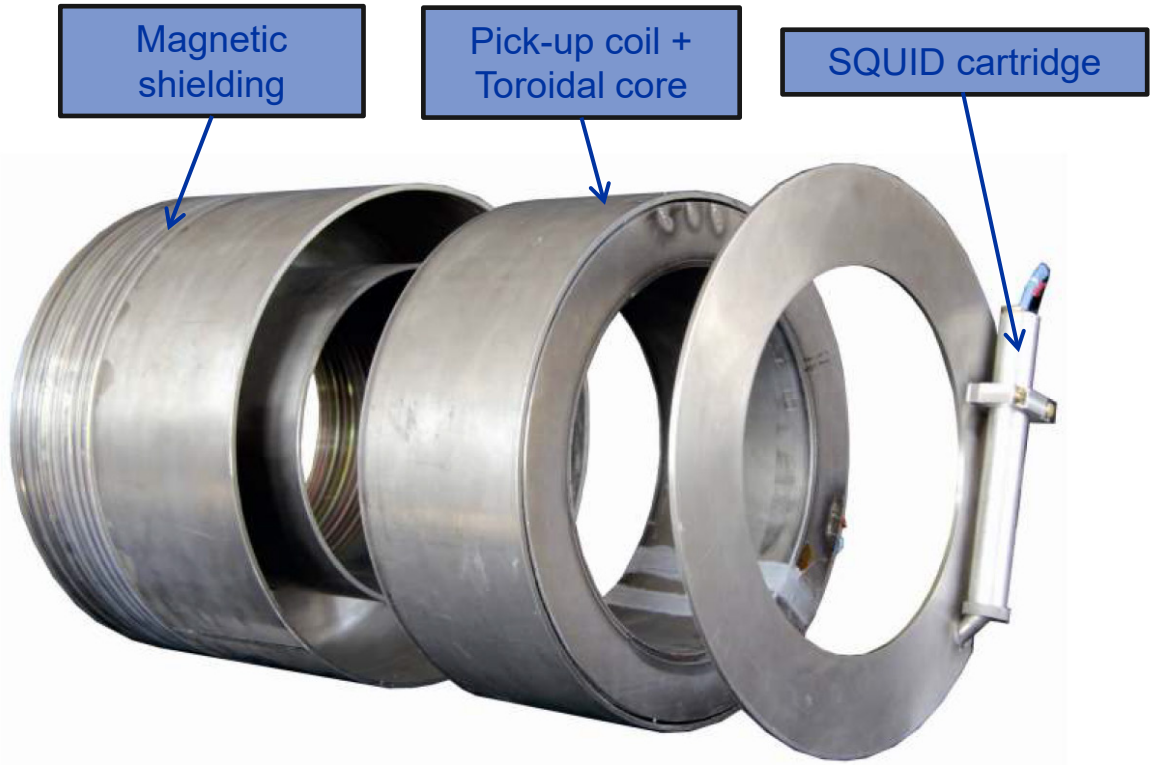
- $\mathbf{I_{SC}}$ in turn generates $\mathbf{B_{SC}}$ which couples to the single-turn toroidal pickup coil with a ferromagnetic core.
- The current in the pickup coil is coupled to the dc-SQUID through the **SC flux transformer**.

Superconducting flux transformer couples DC magnetic fields

BCCCA – Cryogenic Current Comparator





Prototype built by GSI for FAIR
On loan at CERN, finally purchased

Superconducting material : Niobium
Core material : Nanoperm

New AD Electron Cooler being designed and built

- Current AD electron cooler built 1976-77.
- Magnetic systems supplied by Thrige-Titan in Odense, Denmark.
- Built very few magnets and definitely none after ~1980
- Company ceased to exist around 2000.

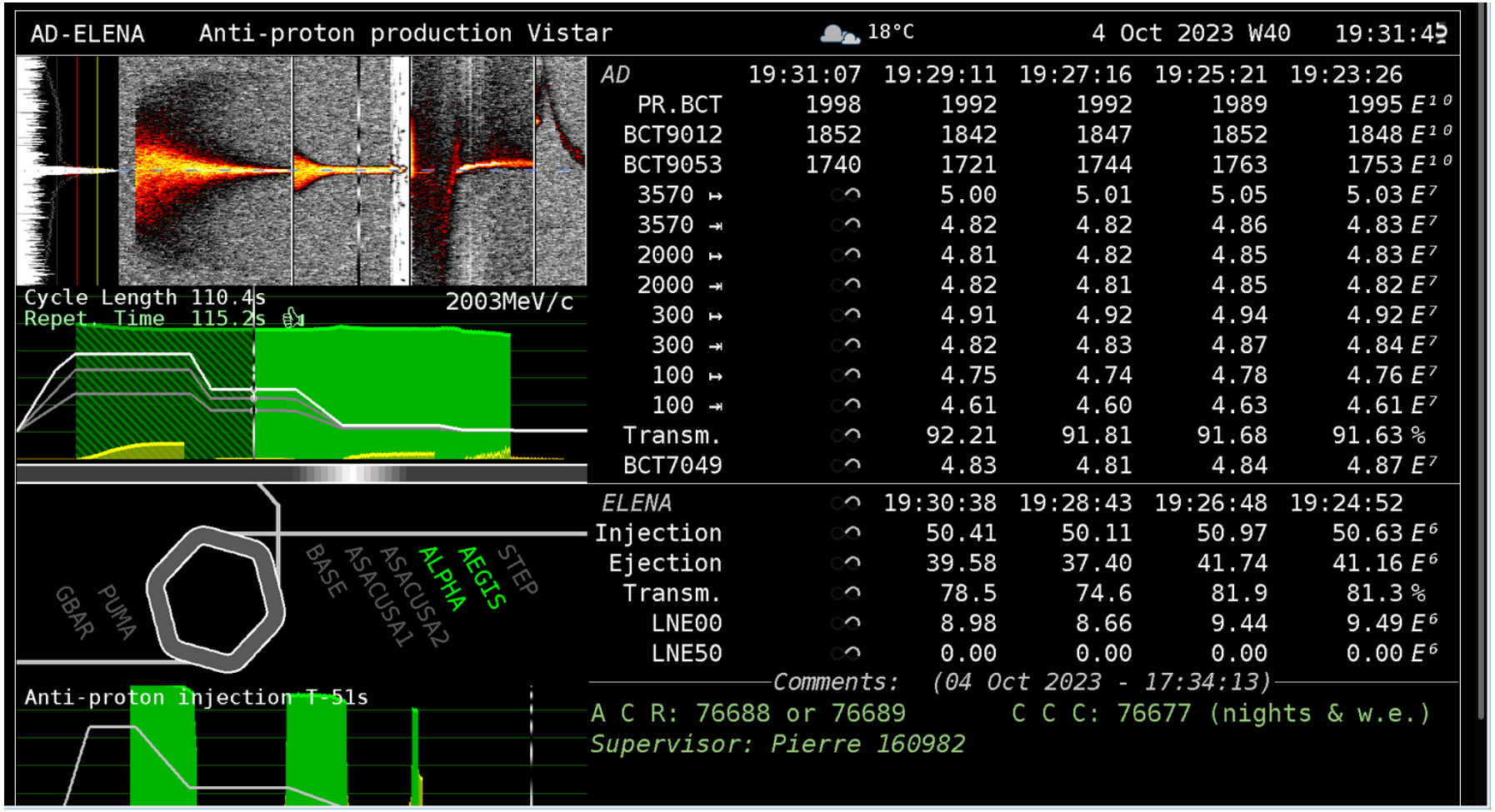
- How many new ideas and improvements in electron cooler design and operation in 50 years??

- See A. Rossi presentation from Monday morning

Other AD consolidation

- Vacuum systems
- Control systems
- Magnets – re-used and not originally built to cycle
- Power converters – some of current power converters >40 years old
- RF systems – ‘New’ Finemet Cavity C02
- Ventilation
- Cooling tower

New AD/ELENA Vistar with much more information



- Breaking records every week!:
  - up to 5.2e7 injected in AD
  - above to 4.8e7 extracted from AD
  - up to 9.5e6 per bunch extracted to LNE00

….. And the experiments make progress!

Thank you !

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