Operational Experience with the ELENA Ion Source

D. Gamba*, D. Aguglia, B. Lefort, C. Machado, F. Wenander,
CERN, Geneva 1217, Switzerland
R. Gebel, *Forschungszentrum Jülich GmbH, IKP-4, 52425 Jülich, Germany*

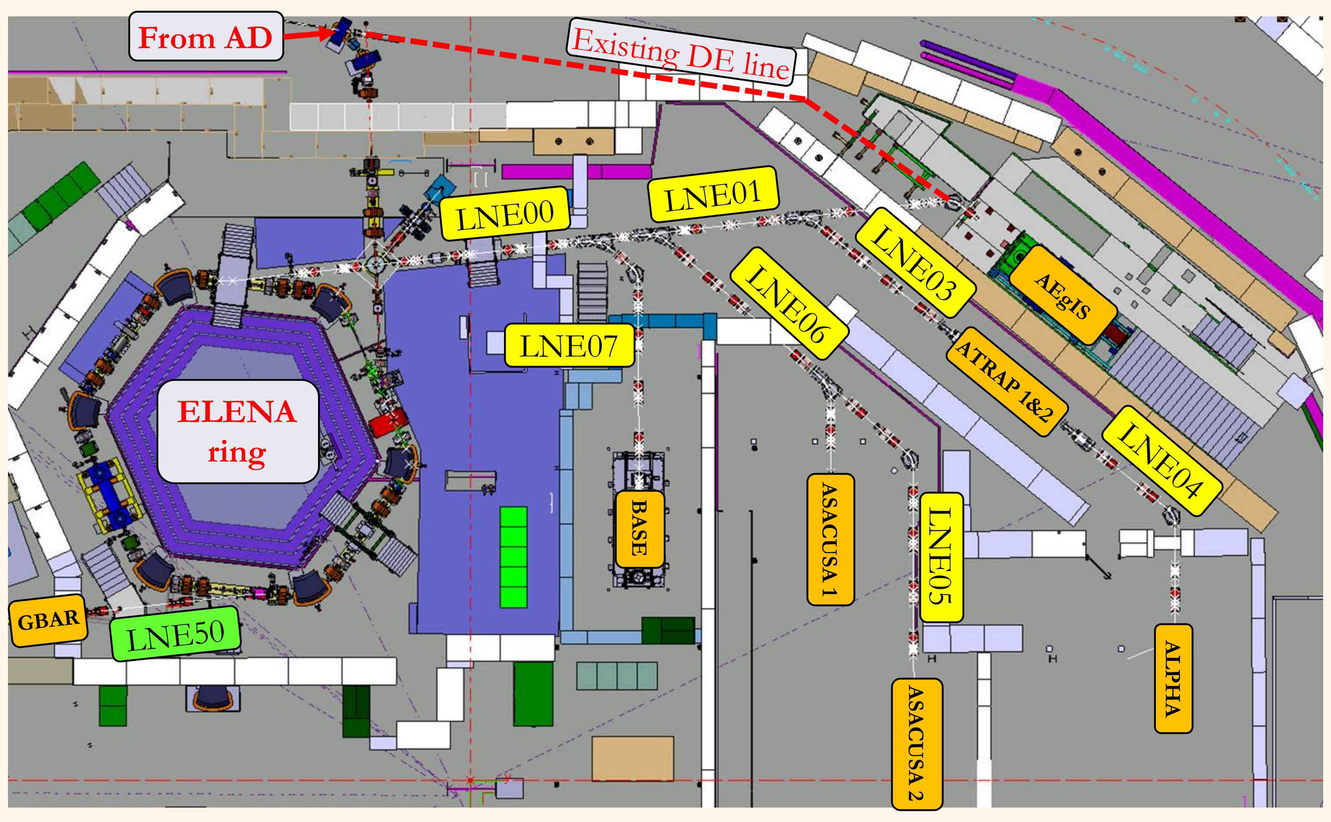
The Extra Low ENergy Antiproton facility

Aim: to extend the antimatter factory at CERN

- Further **decelerate** the 5.3 MeV **antiprotons** coming from the AD **down to 100 keV**
- **Increase experiment trapping efficiency** up to two order of magnitude

Timeline:

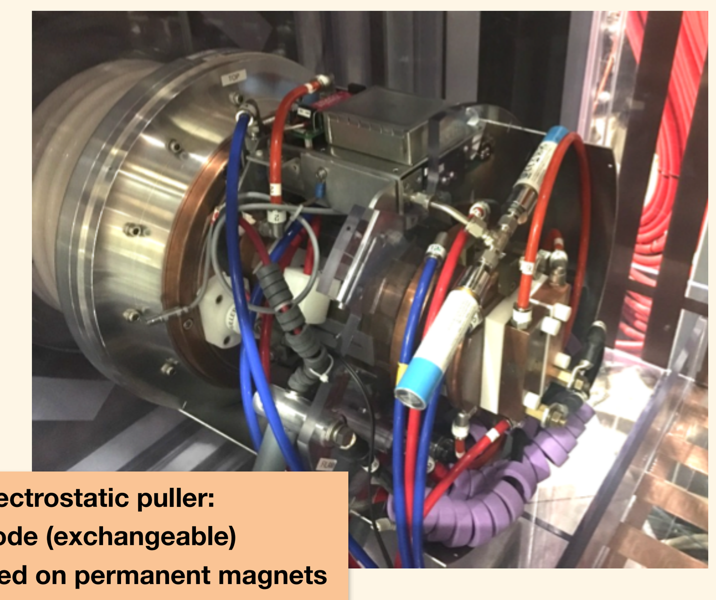
- **Approved** at CERN in June **2011**
- **First** H- **beam circulating** in the ring by end **2016**
- **First pbar beam** with **parameters relatively close to nominal** by end **2018**
- **Installation** of **electrostatic transfer lines** toward experiments **2019-2020**
- **Commissioning** of **transfer lines** with **H- 2020-2021**
- **pbar delivered** to **experiments** by mid **2021**

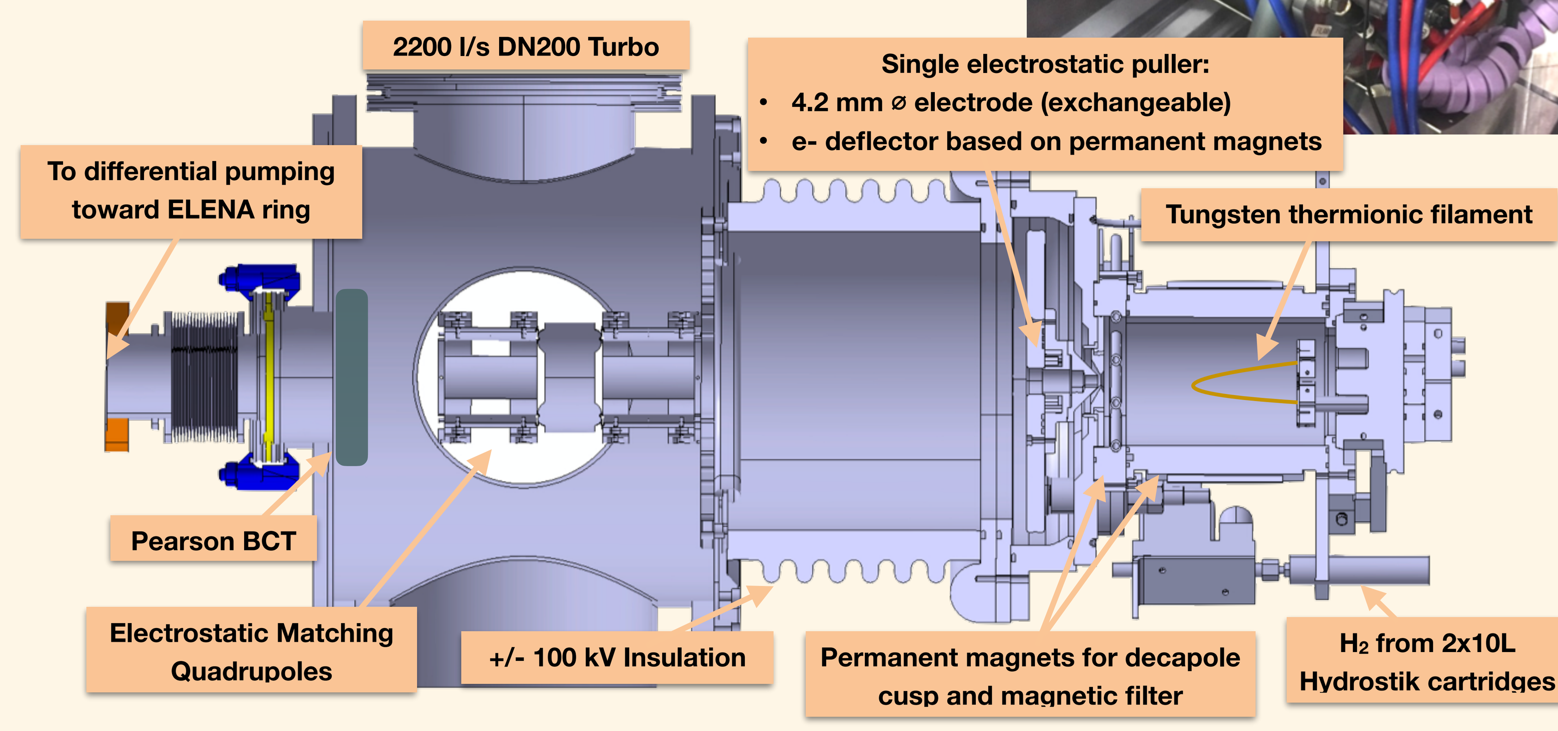


ELENA Ion Source: Parameters / Wish list

Aim: to mimic antiproton beam for ring and transfer line commissioning

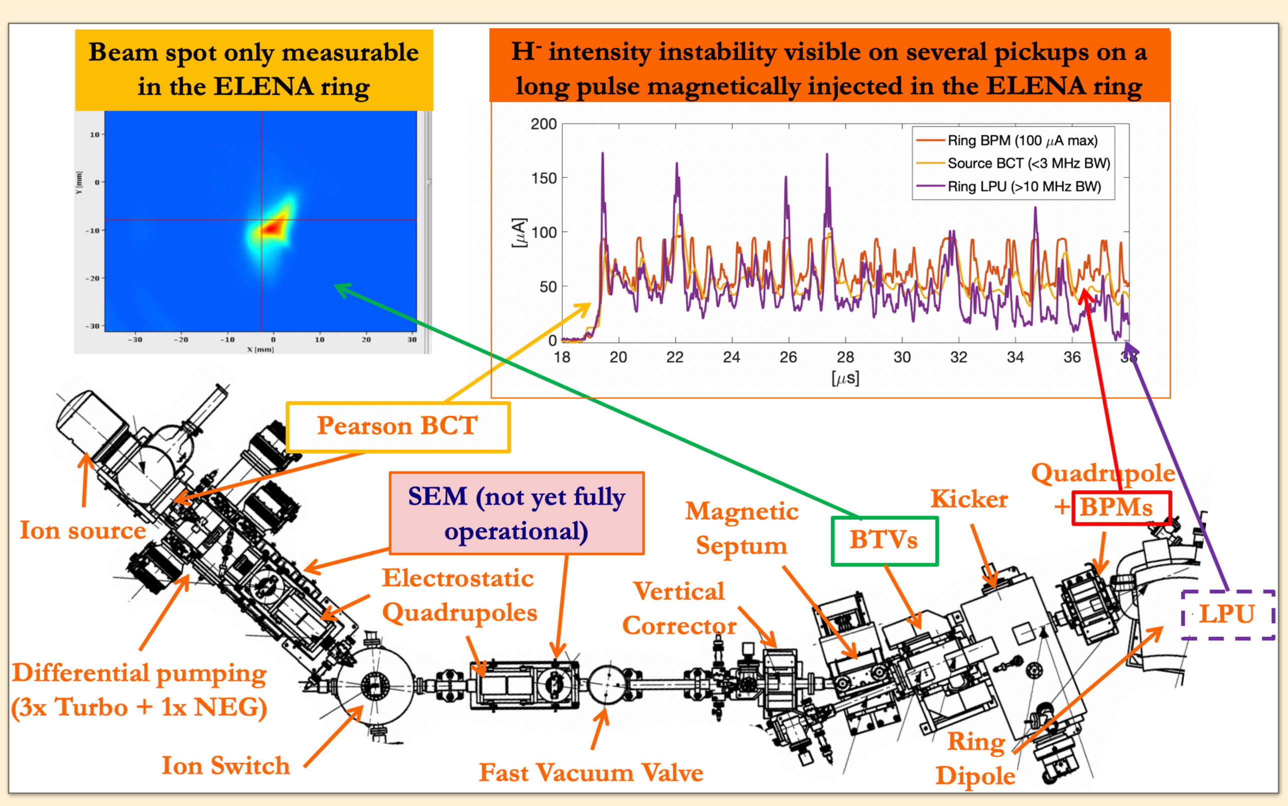
- **H^- and p beam pulses: ~100 uA amplitude, ~1 us length, 100 keV energy**
  - Note: **only <650 ns-long pulses injectable in ELENA ring by injection kicker**
- **r.m.s. physical emittance** of **~1 mm mrad**
- **Good shot-to-shot stability** and **repeatability:**
  - order of **a few % intensity** and **emittance**
  - order of **0.1%** or better **energy stability**
- **Low vacuum contamination**
  to preserve ~10^{-11} mbar in ELENA ring



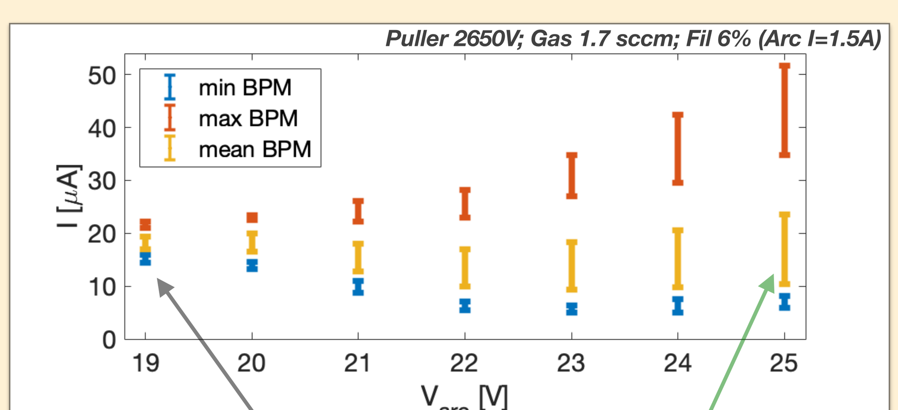


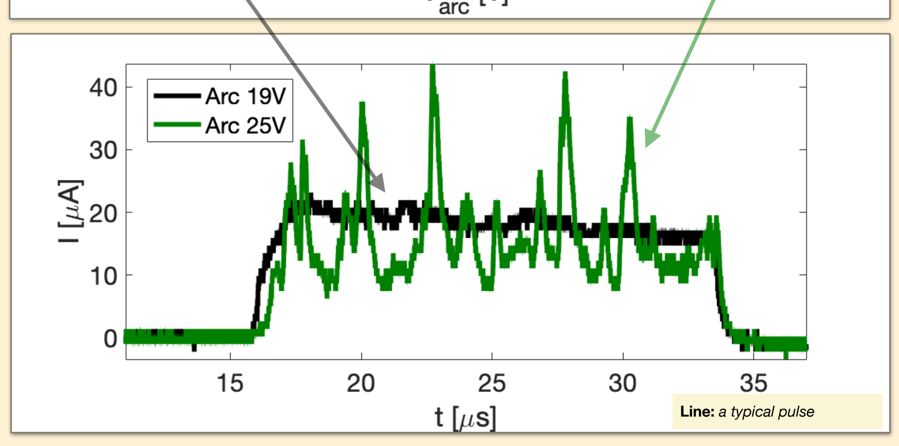
Based on a refurbished and upgraded **multi-cusp volume source** previously used at the COSY/Jülich injector cyclotron

Intra-pulse and shot-to-shot H^- intensity stability issue

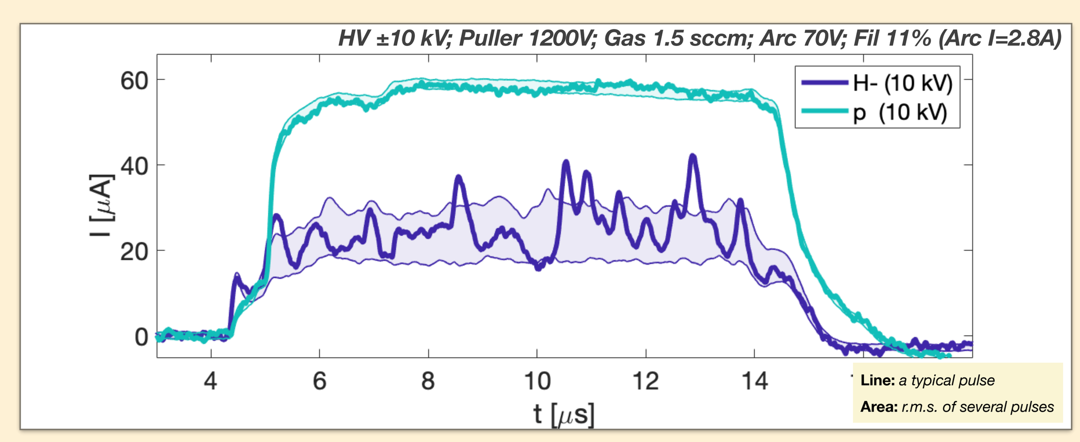


- Original setup had **poor instrumentation** also due to delays on SEM profile monitors, only now almost operational
- The original Pearson **BCT was not sensitive enough** to perform single shot acquisition due to background noise
- **BPMs** in the **ELENA ring first revealed this instability**, then confirmed with the **ring longitudinal pickup** (LPU) and finally also on the source **BCT thanks to ultra-low-noise amplifier** developed at CERN

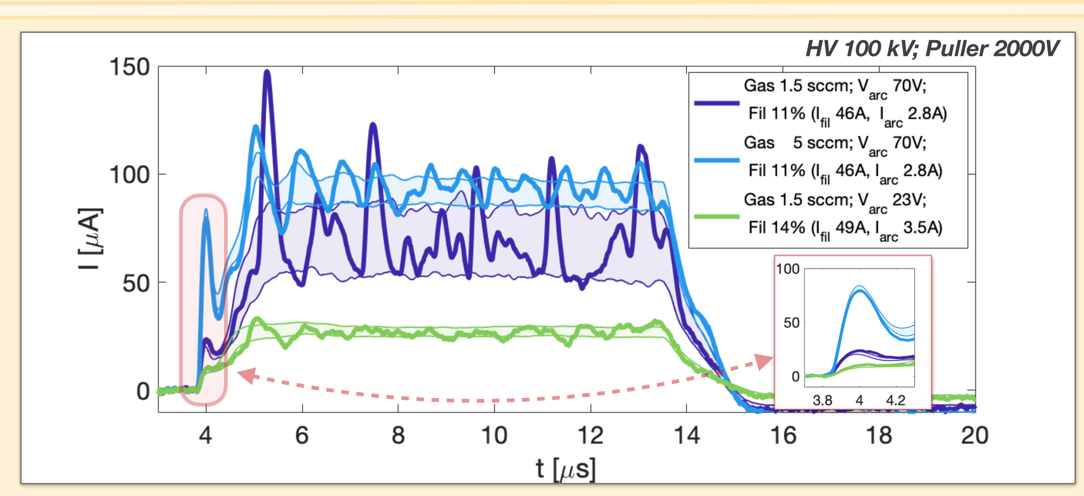




- Multi-parameter scan revealed that H^- pulse is **more stable for very low arc voltages** (at the limit of the plasma switching off), but it also provides **lower average intensity**
- During **first tests**, a **small increase** on **gas** pressure **did not seem beneficial**
  - No higher pressure were attempted not to **risk ring vacuum contamination**



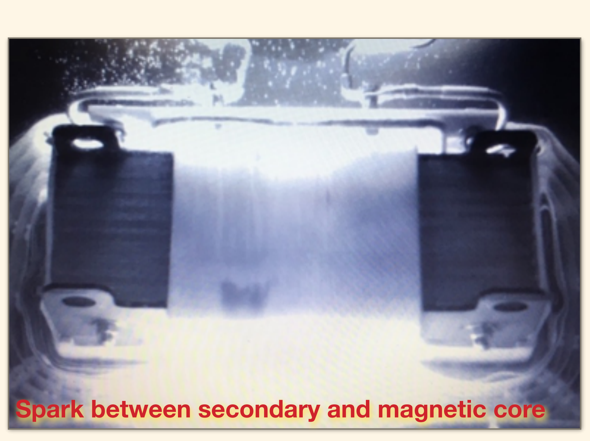
- Comparison between extracted **protons** and **H-** with the same plasma parameters **points toward** an **instability in the H^- formation process**



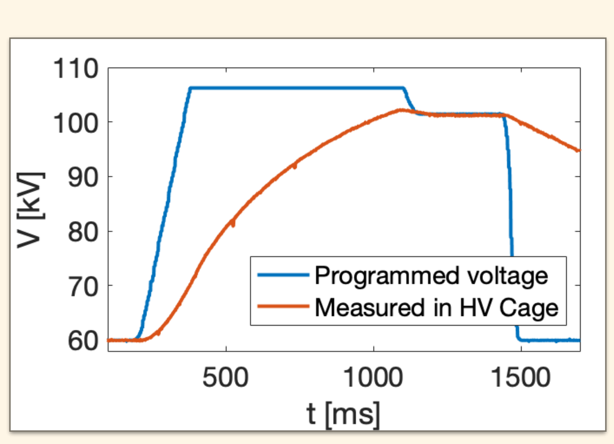
- Considerably **higher gas pressures** also seems to **cure the instability** while **preserving average intensity**
  - **Remarkably high stability** of the **first 400 ns peak**

HV Insulation Transformer Breakdowns

- **Designed** to run at **±100 kV DC,** with **400 Hz power supplies**
  - **No commercial solution** for a **reliable insulation transformer** (several breakdowns)
- **In-house** driven **development** may have **found a solution** (oil insulation, larger tank)
  - Also **updated** the **control system** to **work in pulsed mode** (no issues experienced)


Spark between secondary and magnetic core


Latest insulation transformer version



Recent Improvements and Future Plans

- **Added** and **improved several instruments** for online diagnostics
  - A **more sensitive** (x100) **BCT** after the source with the **possibility** to hold a **screen** for direct **beam spot characterisation** and **optimisation**
  - **Online** and **high bandwidth** measurement of **e^- current** dumped on the **puller**
  - Faraday **cage HV measurement** to allow for HV pulsed operation
  - **Vacuum leak test** of the source was performed showing no major issues
    - Estimated **plasma chamber pressure**: **4e-5/1.2e-3 mbar** for **0/1 sccm gas**
- **Beam quality** and **stability in the ring** with new settings **to be evaluated**
- Plans to **investigate if H^- production can be stabilised** in other ways:
  - Could a **different filament shape** be beneficial?
  - Is something wrong with the **magnetic configuration** of the magnetic filter?

NIBS 2020 online
7TH INTERNATIONAL SYMPOSIUM ON NEGATIVE IONS, BEAMS AND SOURCES — 1-11 SEPTEMBER 2020 — *DAVIDE.GAMBA@CERN.CH