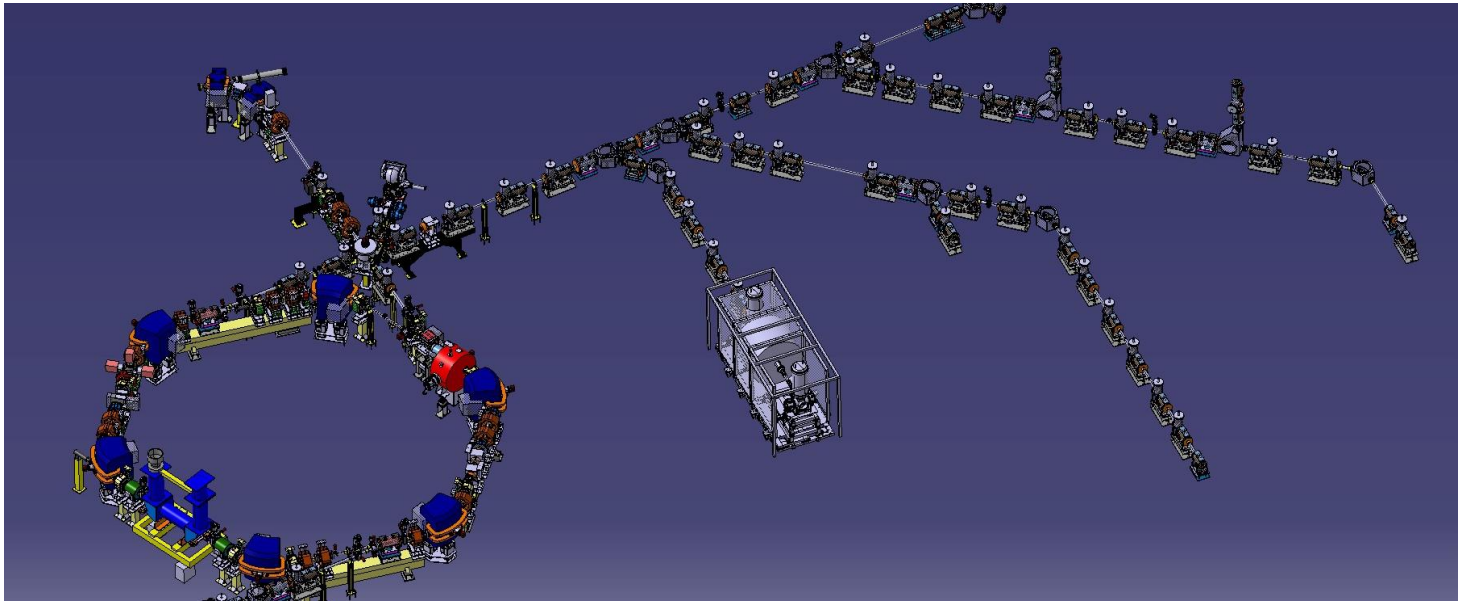
Status of ELENA

C. Carli on behalf of the AD/ELENA team(s)

ADUC, 30th October 2018

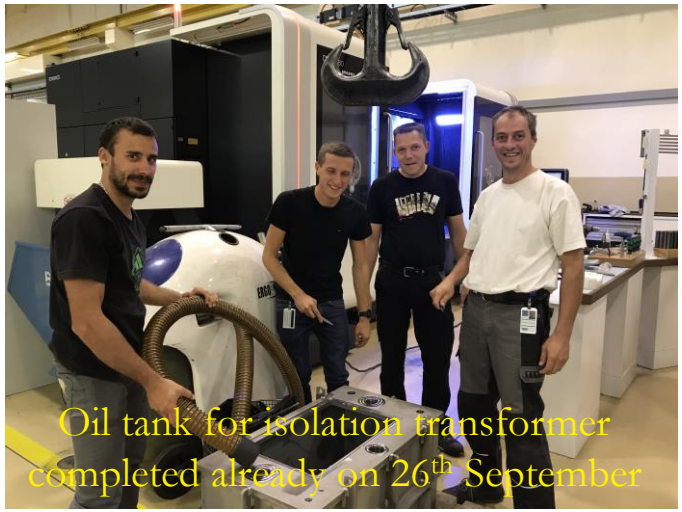


- Recent Results from Commissioning (selection of a few highlights)
- ELENA Commissioning Status
- Summary and Outlook

Recent Results from Commissioning

Efforts for a new isolation transformer using oil as insulator

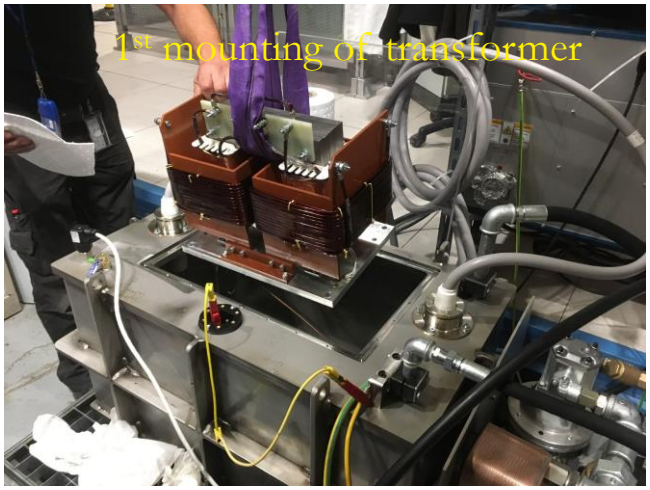
- Last (repaired) isolation transfo using solid insulator and operated at 85 kV failed on Friday 21st September
- Despite high priority by CERN groups for a transformer using oil, beam available only a few hours since



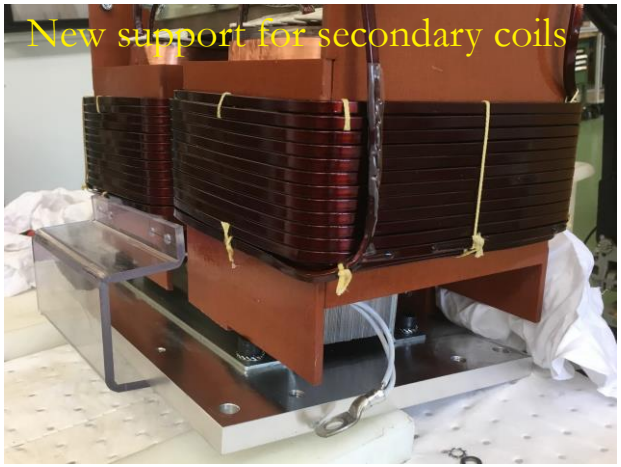
Oil tank for isolation transformer completed already on 26th September

Broken connector and new HV connection without connector

Thanks a lot for the high priority and efforts by several groups and many people



1st mounting of transformer



New support for secondary coils

Winding new secondary coil

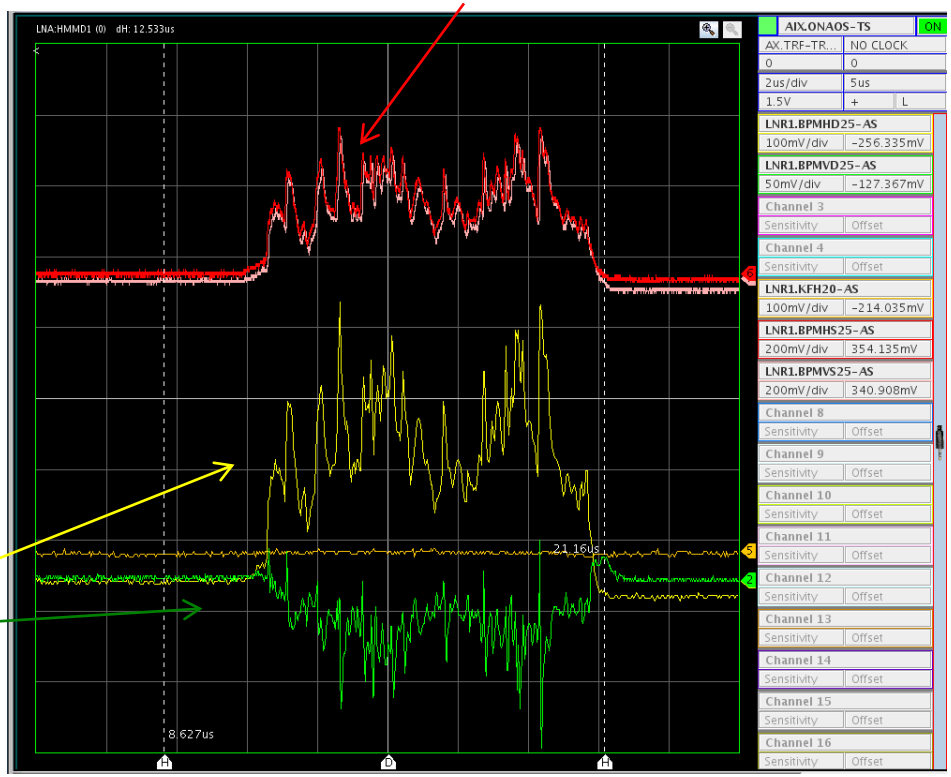
Recent Results from Commissioning

Observation of the beam from the source on a ring pick-up

- Observation of beam from source on first pick-up in ring
  - Steering without kicker (flat-top shorter than beam pulse from source) up to first ring pick-up
  - Higher deflection from septum and steering upstream
  - No beam must hit pick-up plates (delicate!)
  - Intensity fluctuations depend on source settings:
    probably caused by plasma fluctuations and may explain poor reproducibility observed
  - Source optimisation easier with these observations
  - Possibly, fluctuations may be reduced with longer rise times of the pulse

Investigations by D. Gamba

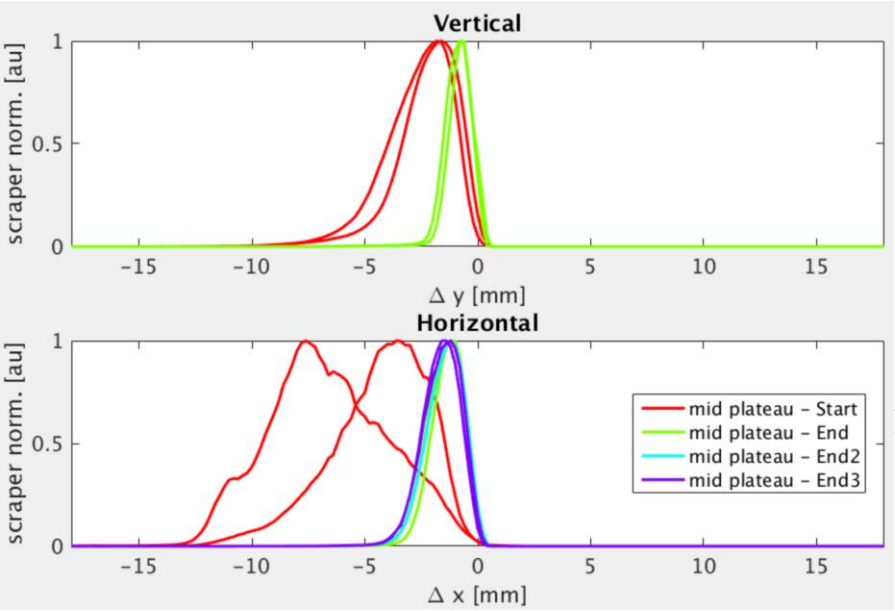
Pick-up sum signals showing (very likely intensity fluctuations, sometimes saturated)



Pick-up difference signals

Recent Results from Commissioning

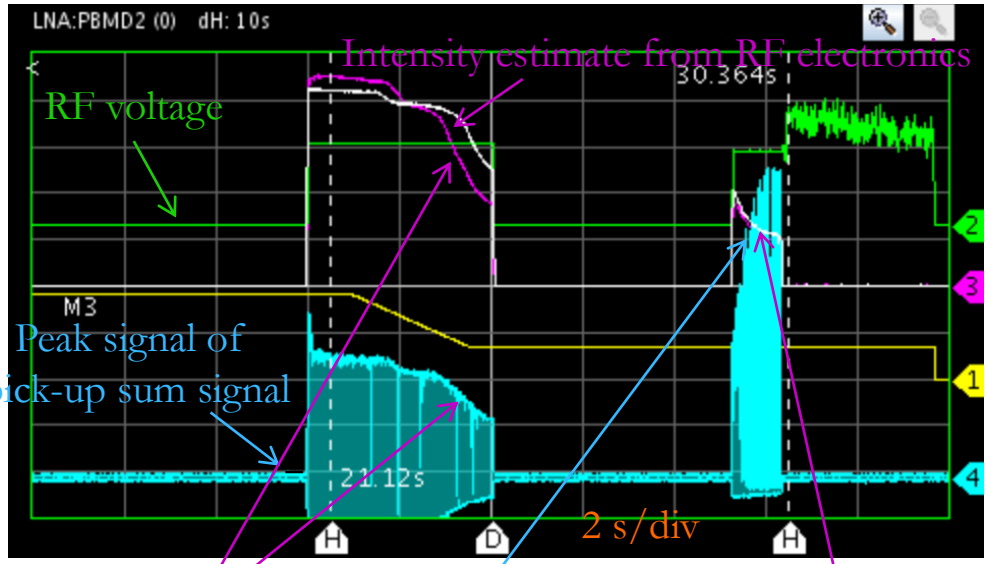
Observation along the cycle



- Measurements with a "scraper" at different times on the 35 MeV/c plateau
- Clear emittance reduction observed

- Only limited amount of time spent on systematic optimization of electron cooling (lack of time)

=> Margin for further improvements?

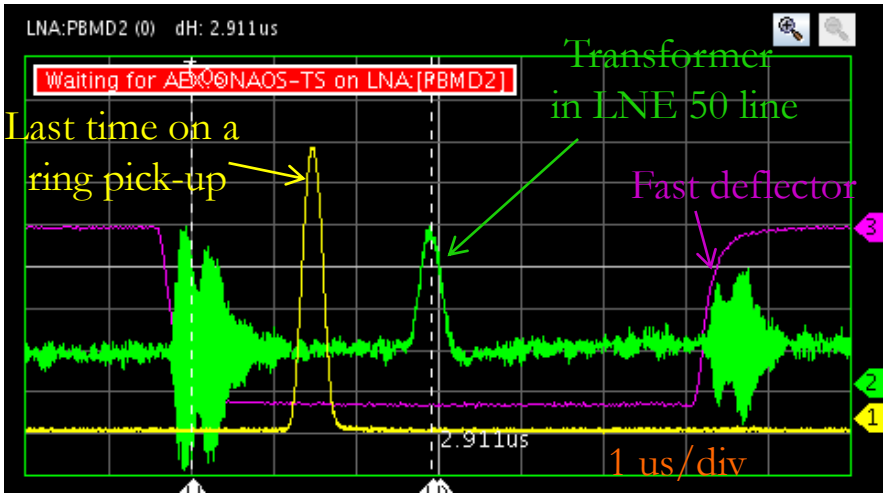


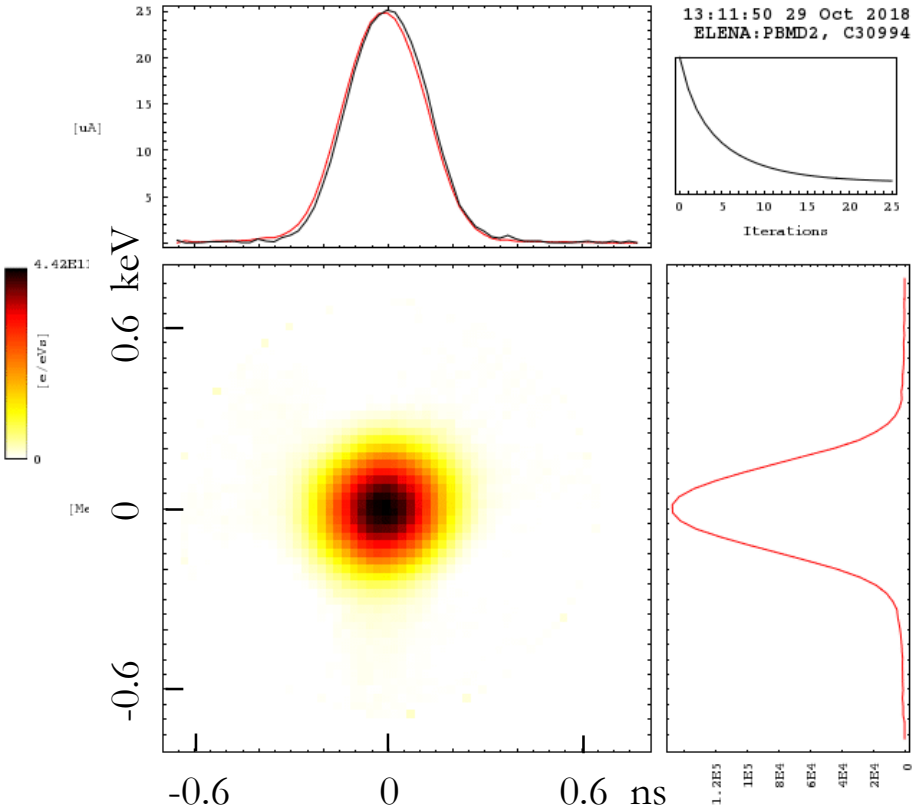
- Some signals along 2nd ramp and on the 100 keV plateau
- Typical situation during the last weeks

- Significant efforts to reduce the loss and situation improving slowly

Recent Results from Commissioning

Observation of antiproton beams at extraction





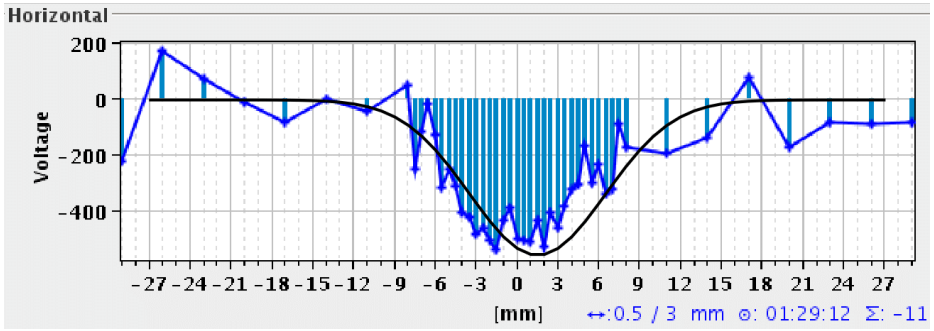
Reconstruction ("Tomography") of longitudinal phase space density distribution from bunch shapes acquired during about one synchrotron oscillation

- Bunches around extraction
  - More than .5 10^7 antiprotons seen very reproducibly in ring prior to ejection and in line
  - Possibly improved with better steering thanks to profile acquistions
  - Bunch lengths a bit long with U_{RF} = 32 V programmed on harmonics h = 1
  - Rms relative momentum spread of 0.68 10^{-3} from reconstruction about nominal (and possibly overestimated due to lower than expected RF voltage)

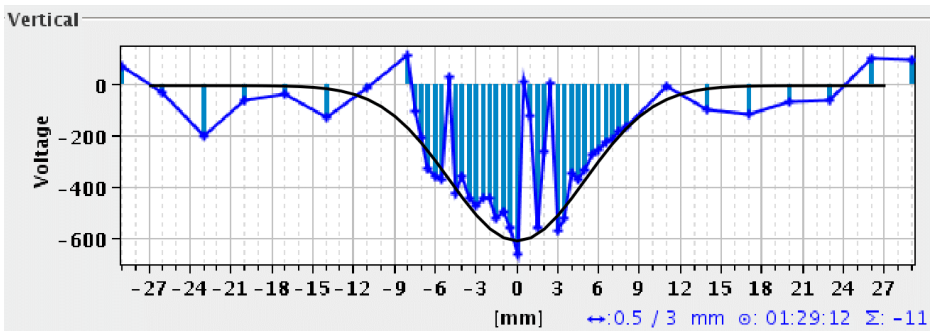
Recent Results from Commissioning

Observation of antiproton beams at extraction

- Profiles in the GBAR line



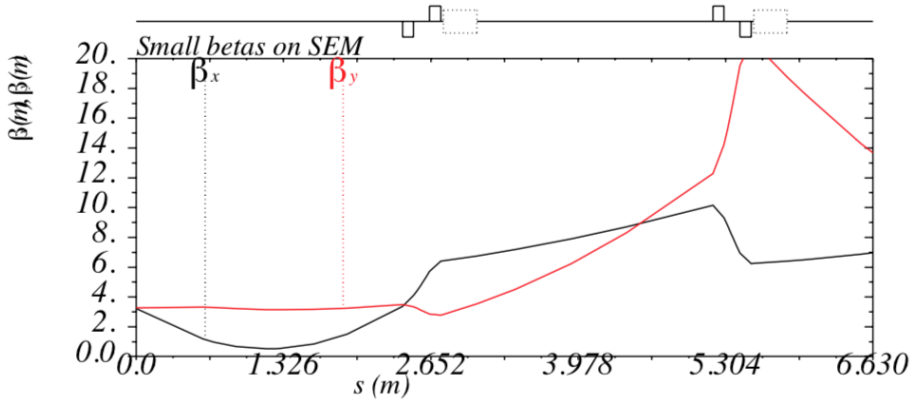
Gaussian fit by hand with σ_H = 4.5 mm



Gaussian fit by hand with σ_V = 5 mm

- Acquisitions with second monitor LNE.BSGWA.5060 in GBAR line

- Beam sizes with voltages of first two quads of line set to zero
  - β_H =6 m gives rms emittance ε_H = 3.3 um (slightly overestimated without taking dispersion into account)
  - β_V = 20 m gives rms emittance ε_V = 1.25 um

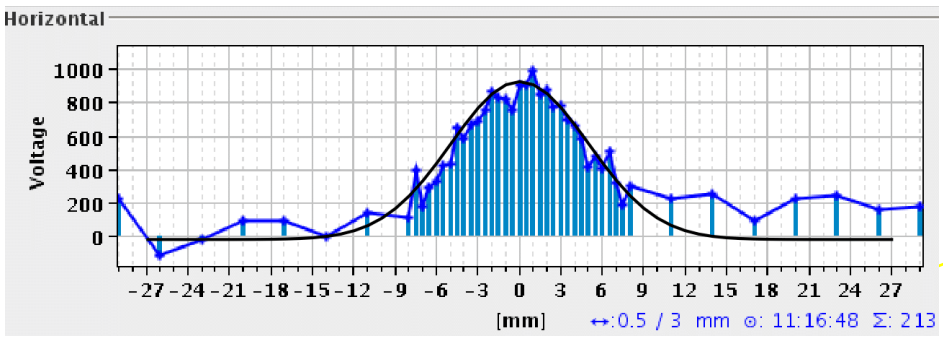


Betatron functions along LNE50 line with settings to provide beam to GBAR and ring optics updated to quad settings used in practice

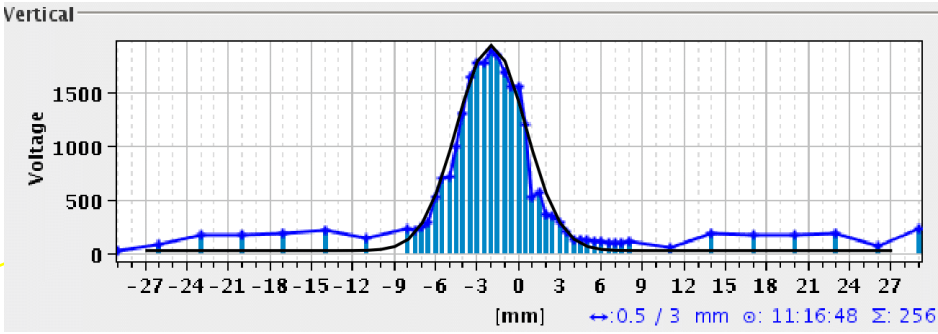
Recent Results from Commissioning

Observation of antiproton beams at extraction

- Profiles in the GBAR line



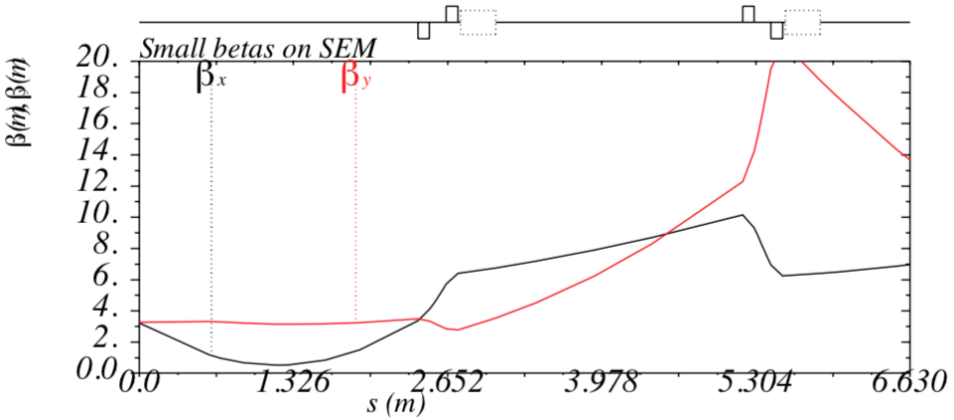
Gaussian fit by hand with σ_H = 5 mm



Gaussian fit by hand with σ_V = 2.5 mm

- Acquisitions with second monitor LNE.BSGWA.5020 in GBAR line

- Beam sizes with voltages of first two quads of line set to zero
  - β_H = 6 m gives rms emittance ε_H = 4.1 um (slightly overestimated without taking dispersion into account)
  - β_V = 4 m gives rms emittance ε_V = 1.5 um



ELENA Commissioning Status

- Aims defined at the beginning of 2018:
  - Continuation of Commissioning with electron cooler from April on
  - Get Confidence that machine works properly
    - Ideally demonstration of operational cycle to deliver 100 keV antiprotons
  - First beams for GBAR

- Achieved by and-October 2018:
  - Deceleration of antiprotons to 100 keV so far with modest efficiency (very reproducible)
    - Loss along 2nd ramp to 100 keV
    - >20 % of injected beam extracted
  - Clear emittance reduction in all three planes due to electron cooling (beneficial for deceleration)
  - Operation for GBAR
    - H^- and antiproton bunches with about nominal intensities
    - Emittance of antiproton bunches probably somewhat above nominal (factor <2 in transverse beam size)

- Status, issues, plans:
  - Less progress than expected at the beginning of the year, but evidence that conditions for experiments are improved
  - Progress slowed down by unavailability of beam from the AD and from the source
  - Open issues, studies to be done
    - Estimate Injection matching, loss along second ramp, blow-up due to RF noise, still very limited observations with prototype profile monitor for transfer lines

Summary and Outlook

- Significant ELENA Commissioning progress over the year despite various delays
  - Delay of restart due a vacuum leak of the cooler, unavailability of AD, issues with the ion source
  - In practice, most progress made with antiprotons, only during dedicated AD shifts (change of commissioning strategy)
  - Nominal antiproton cycle not (yet) available, single bunches (one per cycle) with characters "similar" to nominal bunches regularly sent to GBAR
- Plans for LS2
  - Installation of the transfer lines to the "old" experimental zone
  - Upgrades of the ion source for reliable generation of 100 keV proton and H^- beams
  - Review of status and possible improvements (ring optics, applications, instrumentation …)
  - Resume commissioning activities with beam from source in early summer 2020
    - Test of ring and electron cooling with protons
    - Commissioning of lines with H^- (beam intensity and quality of measured profiles?)
- Position of ELENA team on installation of lines to old experimental area
  - Enough observations to be confident that ELENA can improve the conditions for the experiments despite a fully operational antiproton cycle not (yet) available
  - Confidence in profile monitor availability thanks to a collaboration between Masaki Hori and BE/BI

=> Go on with the installation of the new lines (LS2 is the perfect moment for this activity)

=> Have 100 keV antiprotons for all experiments from 2021 on