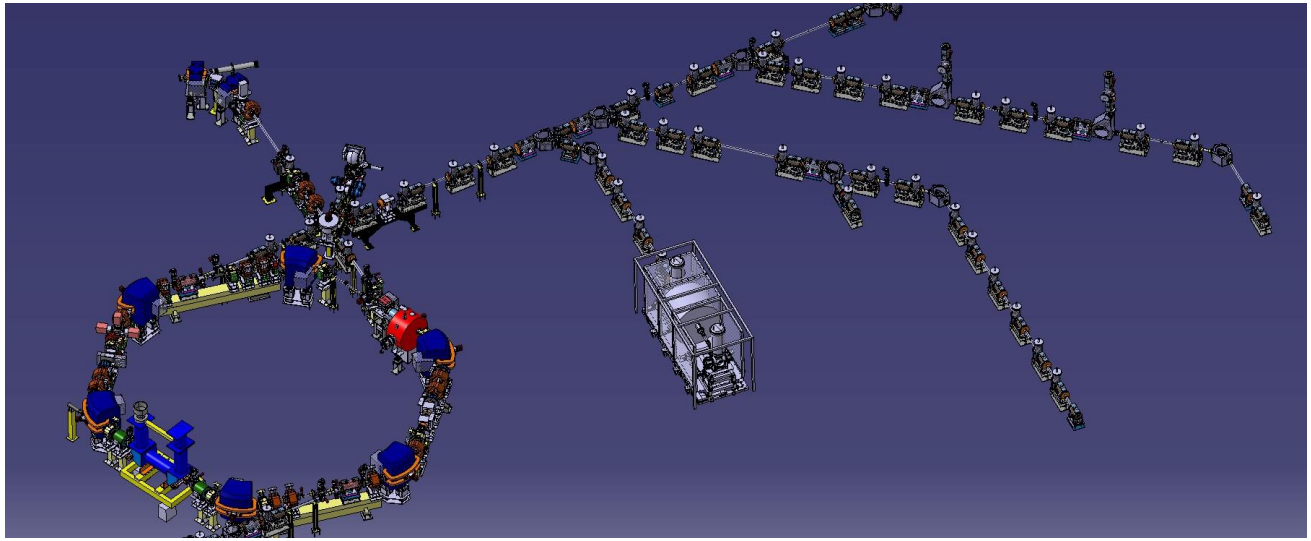
Progress on ELENA development 2019 and plans for 2020

C. Carli on behalf of the ELENA Team

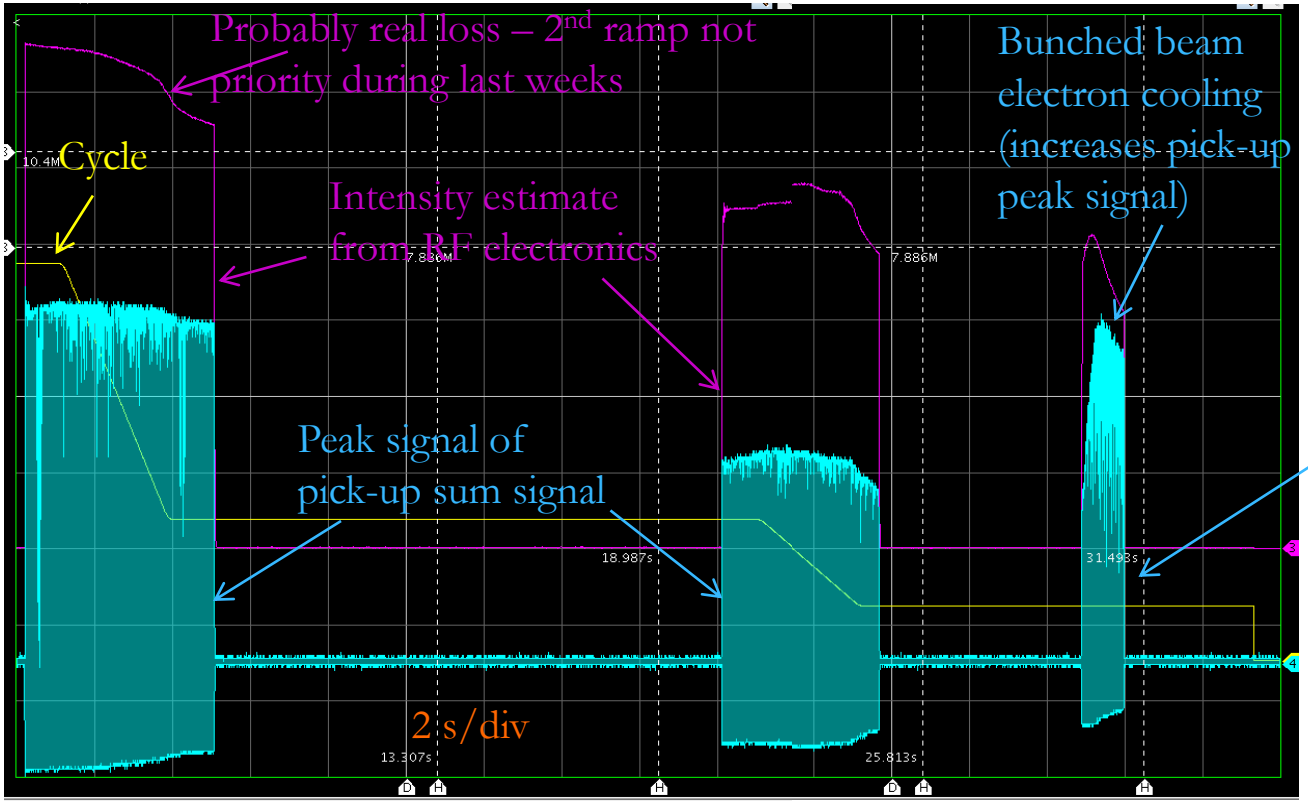
AD Users Committee, 10th December 2019



- Situation about a year ago
- Installation of transfer lines
- Source and Isolation Transformer
- Issues with Tune Kicker Repair
- Electron Cooler
- Profile Monitors
- Analysis of Observations
- Plans for 2020 and beyond
- Summary and Outlook

Situation about a Year ago

- Finally promising results from commissioning with beam
  - Not yet nominal beam parameters (in particular larger transverse emittances)
  - Most progress made with antiprotons and not, as expected, with H^- from source
  - Performance a clear improvement for experiments and potential for further improvements



Whole ELENA cycle with beam (combining two acquisitions, 2nd with slightly higher intensity)

- Decision to go ahead with installation of lines formally agreed at ADUC on 30th October 2018

Situation about a Year ago

From an extended ECC meeting on 7th March (https://indico.cern.ch/event/803767/)

First Ideas on Activities with Beam in LS2 (Input for a Discussion and instead of Conclusions)

- Aims of possible tests in 2019 - mainly preparation of transfer line commissioning in 2020
  - Demonstration of reliable source operation at 100 keV with upgraded isolation transformer
  - Investigations on intensity fluctuation along pulse: requires line to ring for observation on 1st ring pick-up (can one increase the pick-up saturation level for this pick-up?)
  - Increase of intensity from source (sufficient intensity of extracted bunches for line commissioning possibly with scraping to adjust emittances)?
  - H^- injection matching (BTV after septum and possibly observation in SEMs)
  - Probably not possible (but would be of interest!): injection tests to optimize efficiency (even without RF), tests with beam on SEM in GBAR line

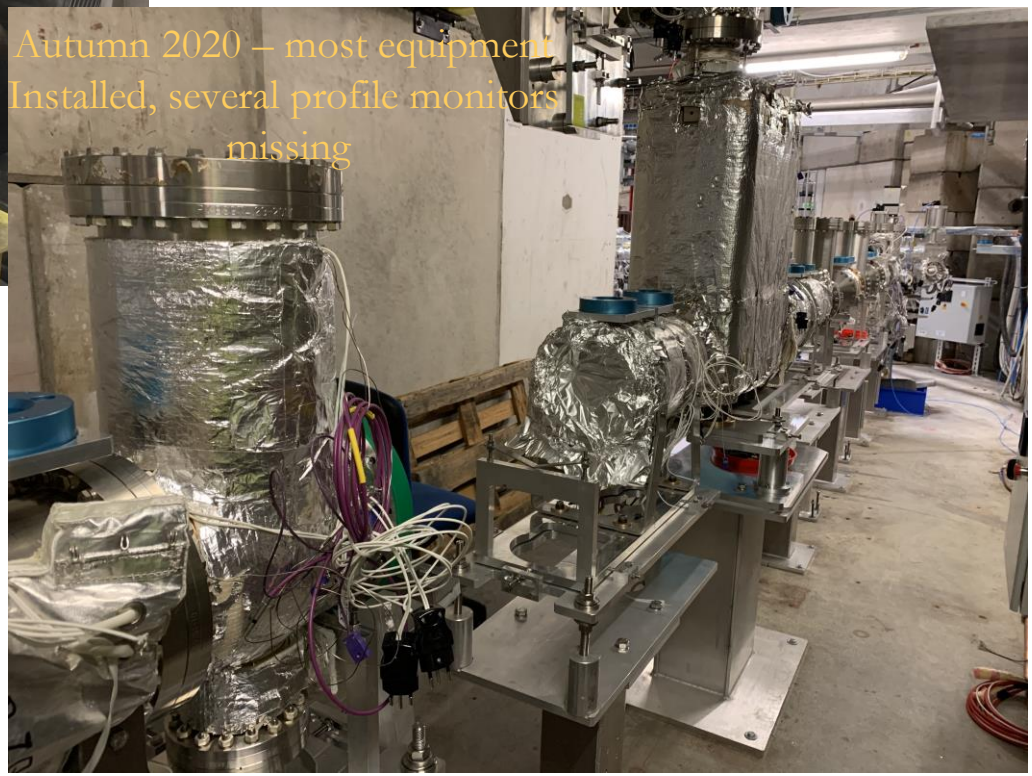
Test period in autumn? (plus earlier tests with source alone at 85 kV)

- Aims for 2020
  - Commissioning of transfer lines to experiments in "old" experimental zone with H^-
    - Profile monitors mandatory!!
    - Requires sufficient intensity H^- within appropriate transverse emittances
    - Show control of beam along lines and arrival with expected characteristics at the last monitor
    - Magnetic stray fields and shielding: plans for investigations and, possibly ?
  - Possible other tests with H^- and/or proton beams from source?
    - Electron cooling with protons or H^-
    - Lattice control and understanding, (loss on ramp at low energy?) …
    - Acceleration, deceleration ...

Installation of transfer lines

Beginning of 2020 with magnets still installed

For all details, see dedicated presentation by Francois



Autumn 2020 – most equipment Installed, several profile monitors missing

- Main activity this year
- Progressing well in spring
- Some delay in autumn,

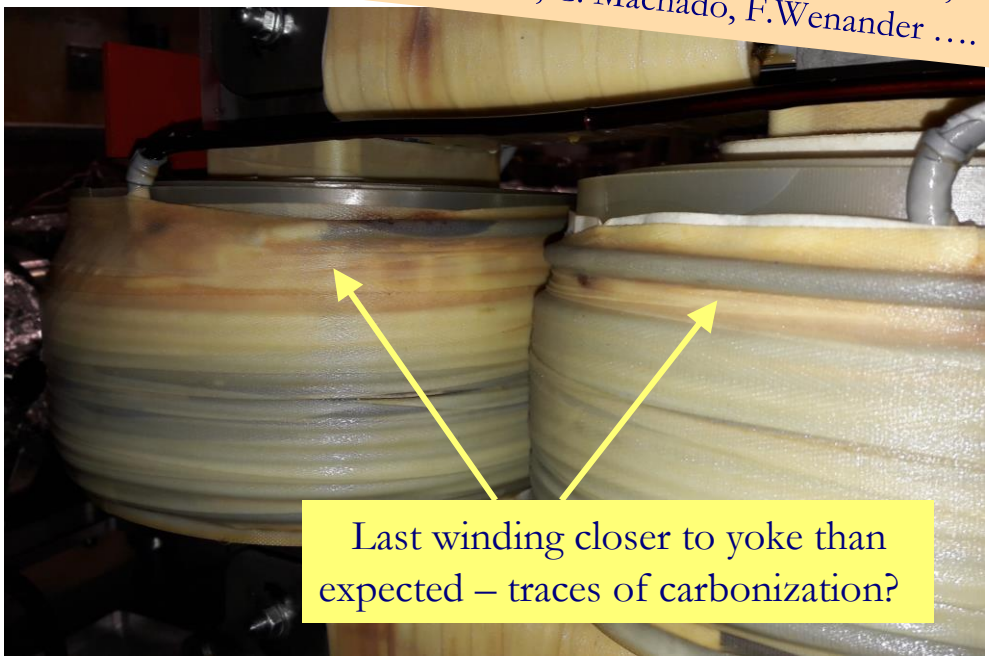
=> installation of many profile monitors and most bake-outs moved to 2020

Source and Insulation Transformer

Many contributions by D. Aguglia, D. Gamba, R. Gebel, B. Lefort, C. Machado, F.Wenander ….

Two more iterations with an insulation transformer in an oil bath

- Beginning of summer:
  - New isolation transformer (design by company following CERN instructions)
  - After first good results, sparks again (probably between secondary and yoke)
  - Issue with last two windings of secondary
  - Pulsing the HV shown to work to generate 100 keV H^- and used for profile monitor tests
- Since last week
  - Another transformer arrived and installed
  - Used already this week to generate beam in DC mode foreseen (recommendation by CERN experts), HV pulsing as back-up in case of troubles

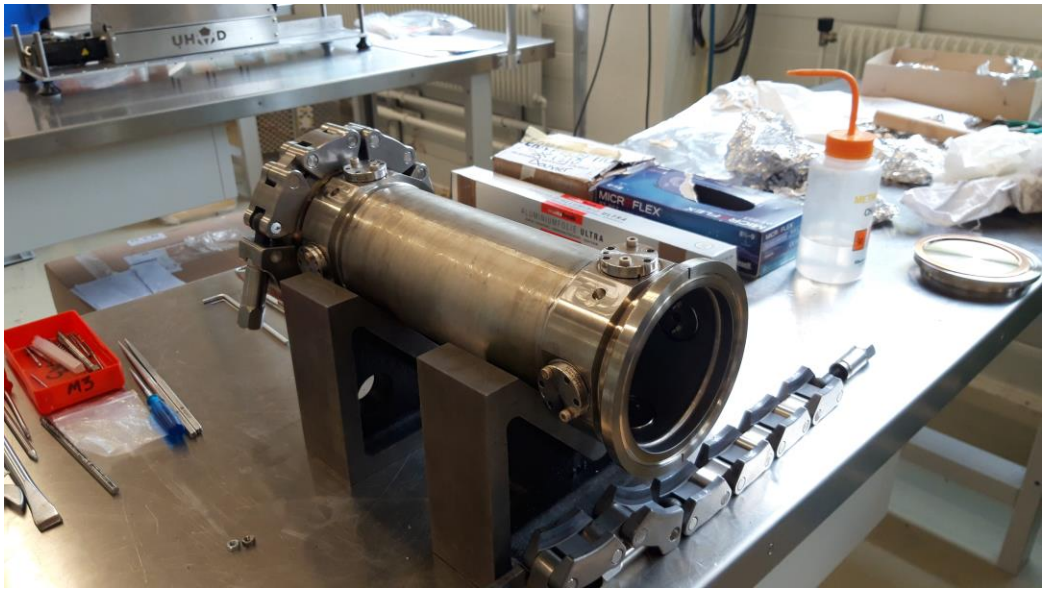


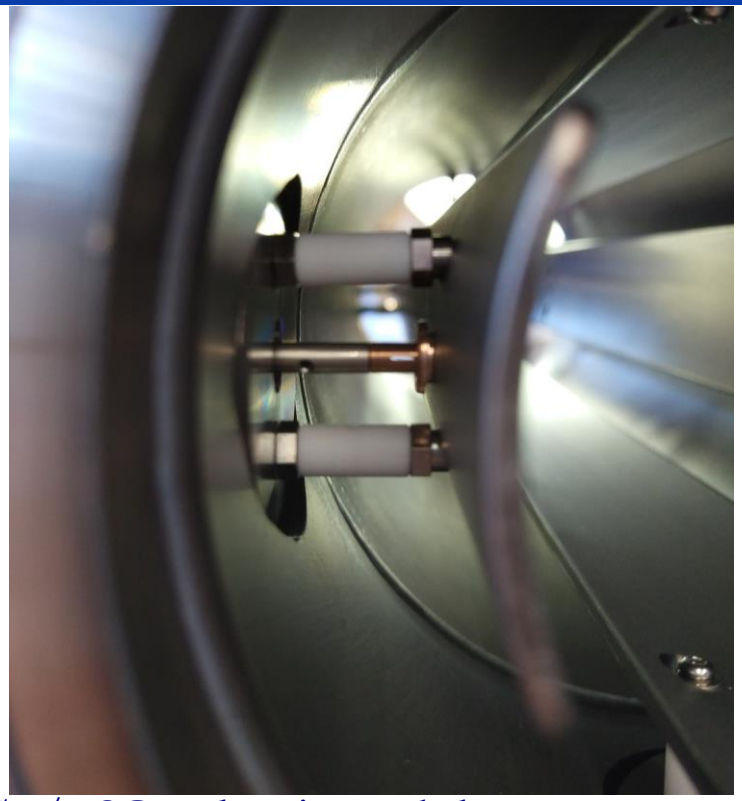
Many studies, improvements and important findings on the ion source

- Fluctuations along pulse from source seen last year confirmed
- Studies on increase of beam current and fluctuations along pulse with different source settings

For all details, see dedicated presentation by Davide

Issues with Tune Kicker Repair

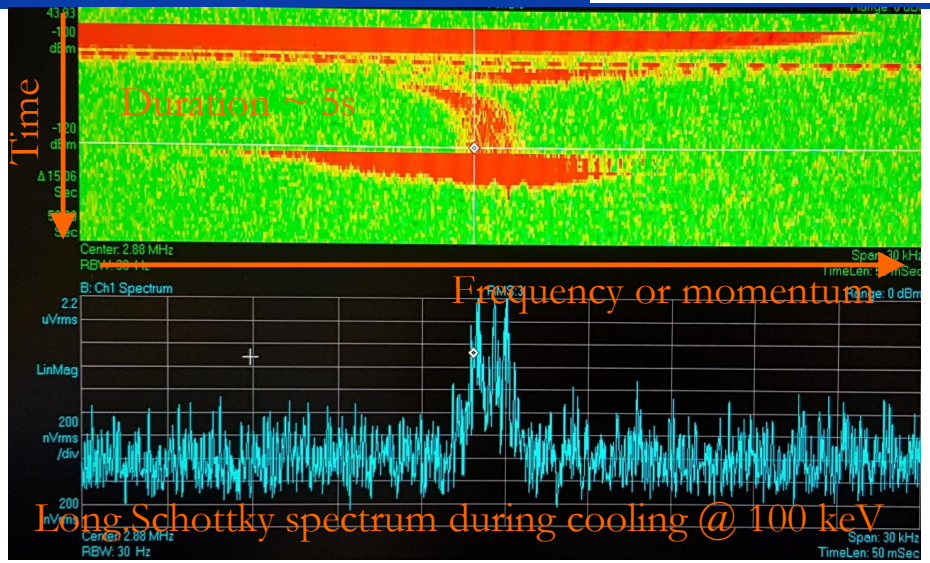




- Taken out for repair to replace electrode supports (one electrode had detached from support)
  - Incident (tap broken & stuck in threaded hole)
- More series repair required (collaboration BE/BI, TE/VSC and main workshop
  - Removal of piece and re-welding
  - Was known to be risky for NEGs, pollution by hydrocarbons identified in vacuum acceptance tests
- Repair, installation and bake-out completed since last Friday
  - Ring closed and available again, but without RF system for RP
  - Tune kicker finally available earlier than replacement chamber prepared in parallel!

Electron Cooler

- Recap: Cooling in all three planes and at both energies observed in 2018
  - Fundamental to show that ELENA is an improvement for experiments
  - Lack of time for thorough (empirical) optimizations (more effort than expected required for magnetic cycle)
  - Potential for performance improvements (compared to 2018 results)



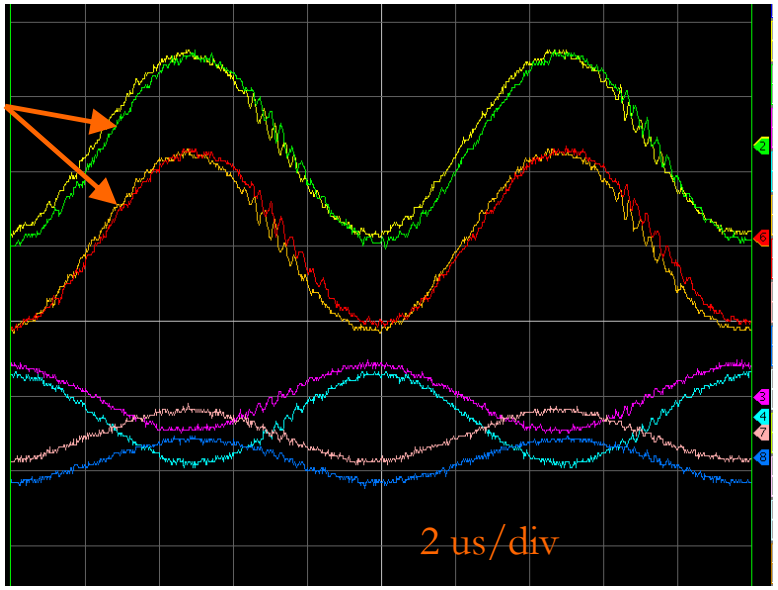
- Electron position measurement implemented during 2019
  - Modulation of electron beam
  - Electron beam position from ratio between sum and difference signals

=>Beam position of circulating beam and electrons measured with same PU

=>More efficient alignment (position and angle) of circulating pbars w.r.t. electron beam from next restart on

PU sum signals with electron beam modulation - all four (two planes at two locations) signals similar

PU difference signals

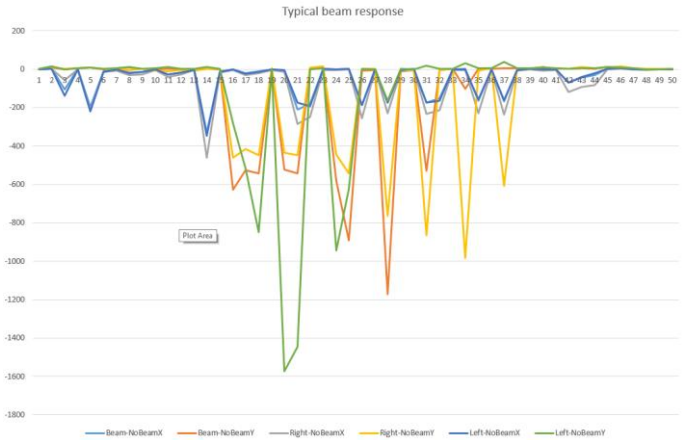


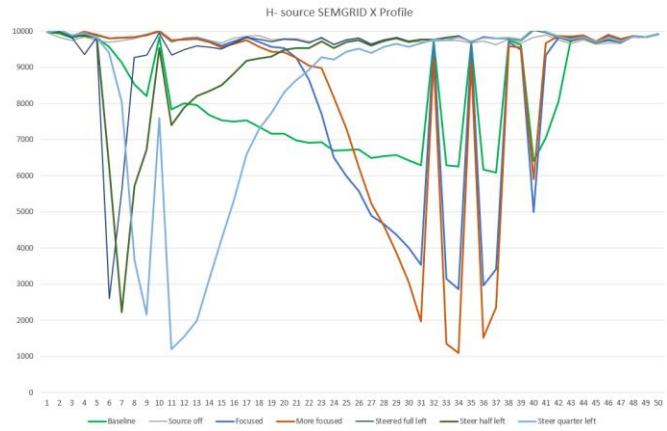
Profile Monitors for Lines

- Recap:
  - Technically very interesting and impressive in-kind contribution
  - More and more taken over by BE/BI
    - Starting with the mounting of the monitors,
    - Recently contributions to to electronics, revision of FPGA code, tests with beam, …

See dedicated presentation by Mark

- Tests with beam using the second but last front-end electronics prototype



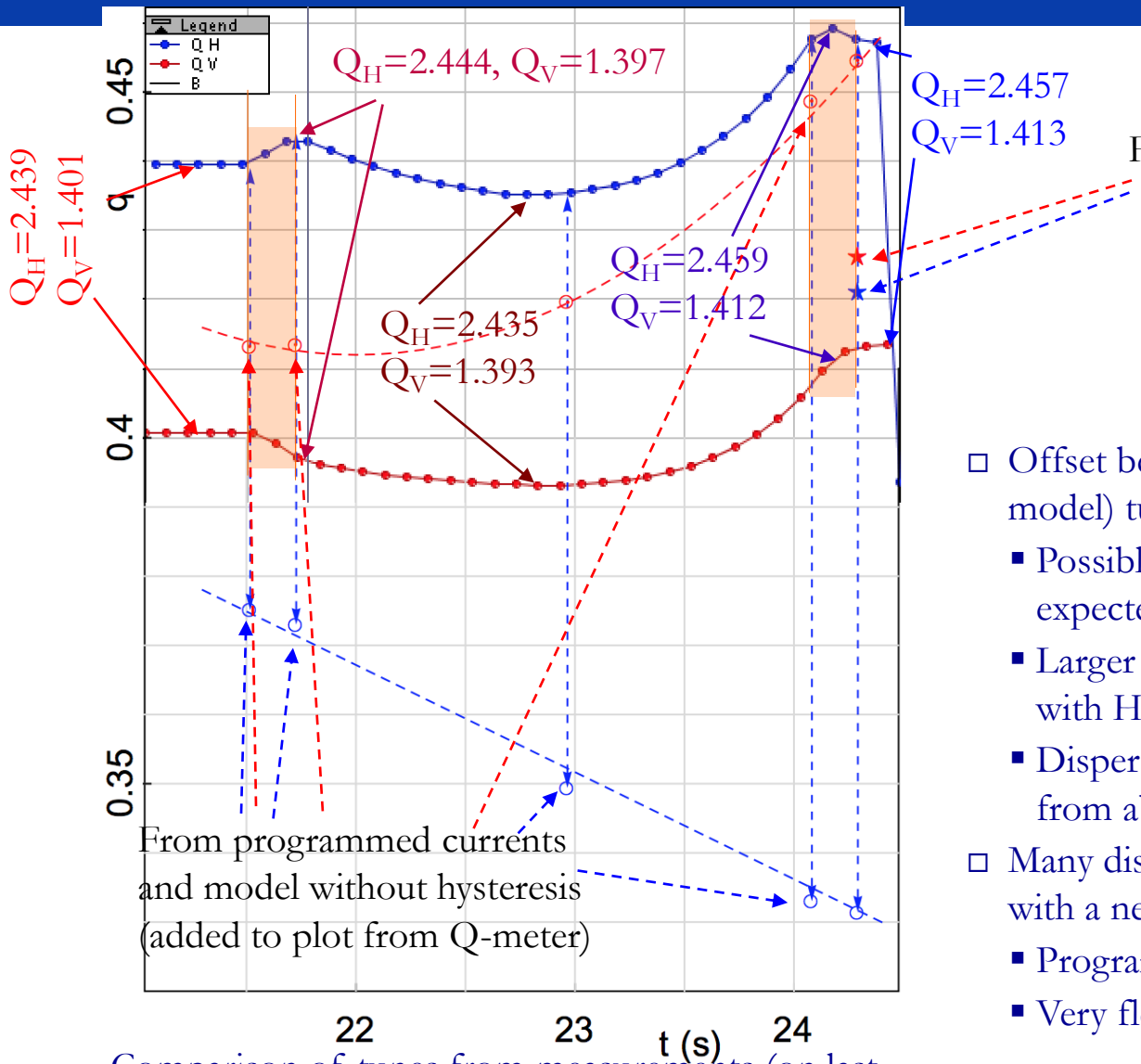


Expertise to use and program electronics now in BE/BI ☺

Example of profiles measured (on a monitor in the line from the source to the ring)

  - Signal generated by beam (effect of steering, beam on/off, quads settings seen)
  - Many missing channels for monitor in GBAR and two monitors in source to ring lines
  - Two monitors in GBAR have few missing channels (similar to last year)
- Still a lot of work to be done: completion and installation of monitors, test of last prototype front-end electronics, electronics mass productions, missing channel issue, testing of installed monitors

Analysis of observations and improvements of tools



Comparison of tunes from measurements (on last beam day by Laurette) with expectations from currents

- Offset between measured and expected (from model) tunes increase along 2nd ramp
  - Possibly due to hysteresis (even though expected hysteresis not sufficient)?
  - Larger effect at 100 keV than seen in 2016 with H^- coherent injection oscillations
  - Dispersion from model increases as well from about 1m to about 1.7 m …
- Many discussions on magnetic cycle editing with a new program available
  - Programming directly tunes
  - Very flexible!

Plans for 2020 and beyond

- Plans for 2020
  - January to March: cabling campaign - other activities (bake-outs, tests with beam) unlikely
  - April to June: bake outs (TE/VSC manpower needed) and cable connections
    - Compatible with tests with beam of source, injection … (probably no RF at most/all of the time)
  - July until end of year: transfer line commissioning with H^-
    - Details to be worked out (extended ELENA Commissioning Committee meeting again?)
    - Profile monitors mandatory (review of situation by March)!!
    - Show control of beam along lines and arrival with expected characteristics at the last monitor
    - Sufficient H^- intensity within appropriate emittances (studies on increase of current from source)
    - Magnetic stray fields and shielding: investigations and, if needed, implementation of shielding
    - Optional depending on progress: other tests to better understand machine optics and cooling
- Beyond 2020 (dates from 1st version of LHC injector schedule 2021)
  - Restart of ELENA with H^- ions on 1st February
    - Depending on progress made in 2020, completion of commissioning of lines, acceleration/deceleration,
  - AD production beam on target on 22nd March
    - Commissioning of new target and AD re-commissioning after a long shutdown
  - Antiproton beam to ELENA on 19th April
  - Start of physics with 100 keV antiprotons from ELENA on 10th May

Discussions on schedule for 2021 starting => dates preliminary

Summary and Outlook

- Aims for 2019: preparation of transfer line commissioning in 2020
  - Most installation work for transfer lines done, some delays due to, amongst others, profile monitors
    - Most bake-outs delayed to next year
  - Two more iterations of isolation transformer in oil bath – solid solution implemented (?)
  - Less tests with beam due to various issues (mainly isolation transformer and tune kicker)
    - Nevertheless interesting observations on source (fluctuations, intensity, …) and profile monitors
    - Still some hope for studies this week (injection matching, few turns in ring … profile monitor …)
- Aims for 2020
  - Completion of preparations for transfer line commissioning (cabling, bake-outs ..)
  - Commissioning of transfer lines to experiments in "old" experimental zone with H^-
    - Profile monitors mandatory!!
    - Show control of beam along lines and arrival with expected characteristics at the last monitor
    - Magnetic stray fields and shielding: plans for investigations and, possibly ?
  - Possible other tests with H^- and/or proton beams from source?
    - Electron cooling with protons or H^-
    - Lattice control and understanding, (loss on ramp at low energy?) …
    - Acceleration, deceleration ...
- First 100 keV antiprotons from ELENA for experiments expected in May 2021