Wrap-up of L4 2018 autumn run

Reliability and beam quality

JB Lallement for the L4 team

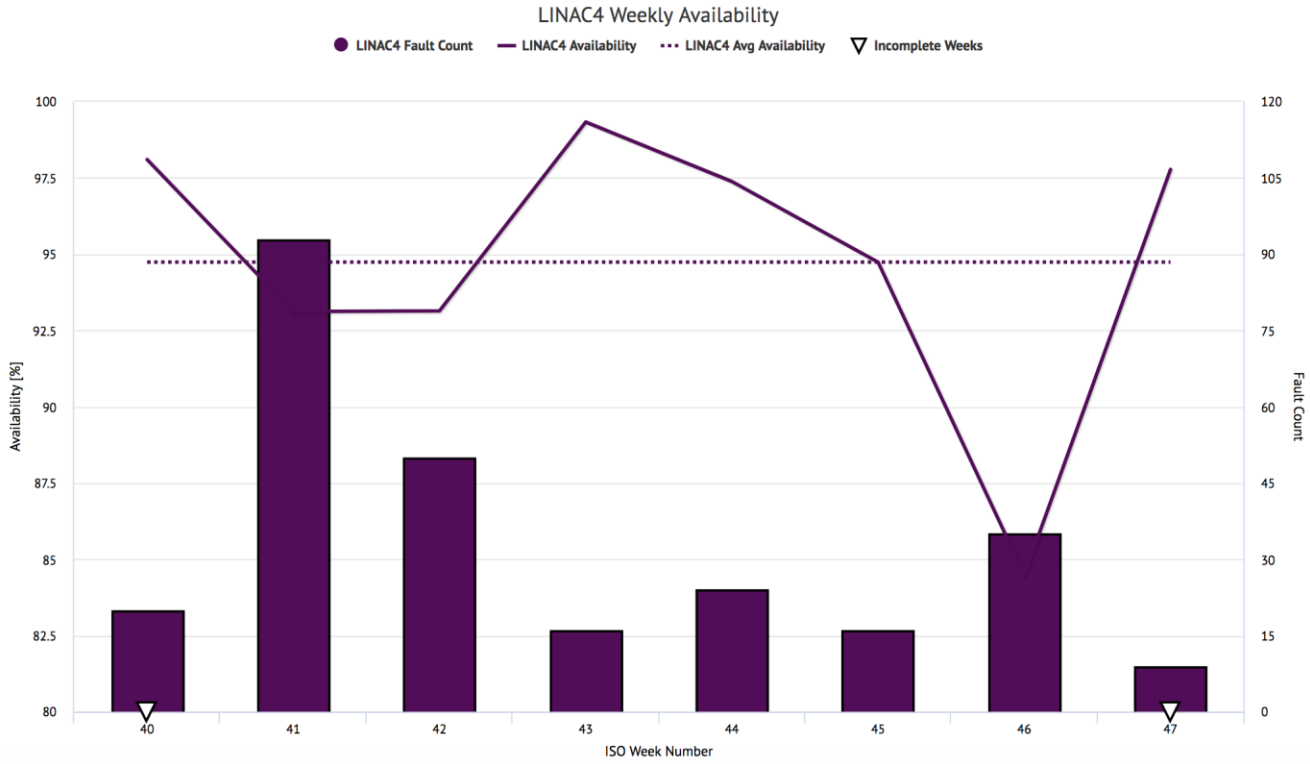
Coming after the battle, with material from Alessandra and Gian Piero

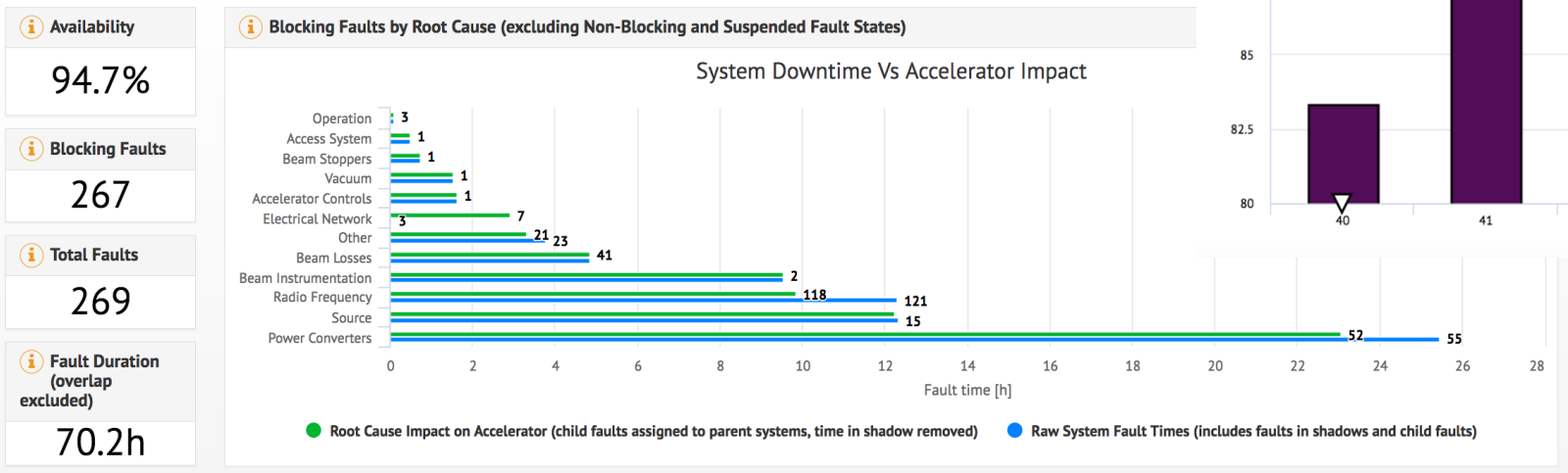
Pretty good reliability

- **Autumn run took place from early September to December.**
  - 1 month for machine restart and setting-up.
  - 2 months running 24/7 for stats and beam quality improvement.

- Quite few “new issues” discovered at the beginning
  - CCDTL/DTL tunners
  - RFQ trips.
- Source and FGC issues toward the end .

Overall, very good trend… under “operational” conditions.





Beam quality criteria

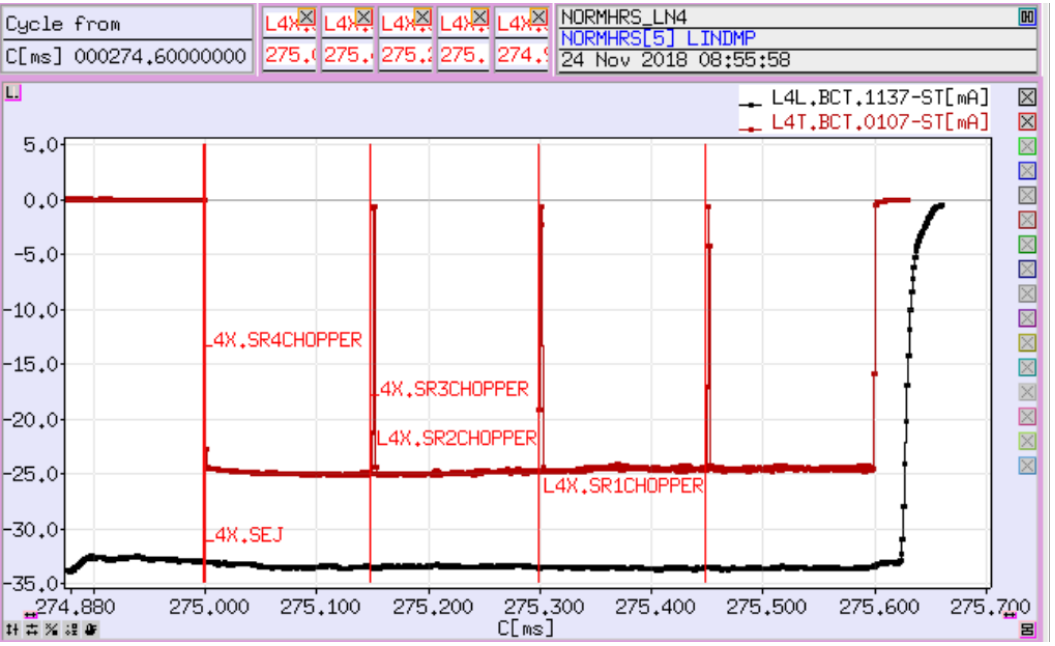
https://edms.cern.ch/ui/file/1898179/1.1/PSB-OP-EP-0001-10-10.pdf

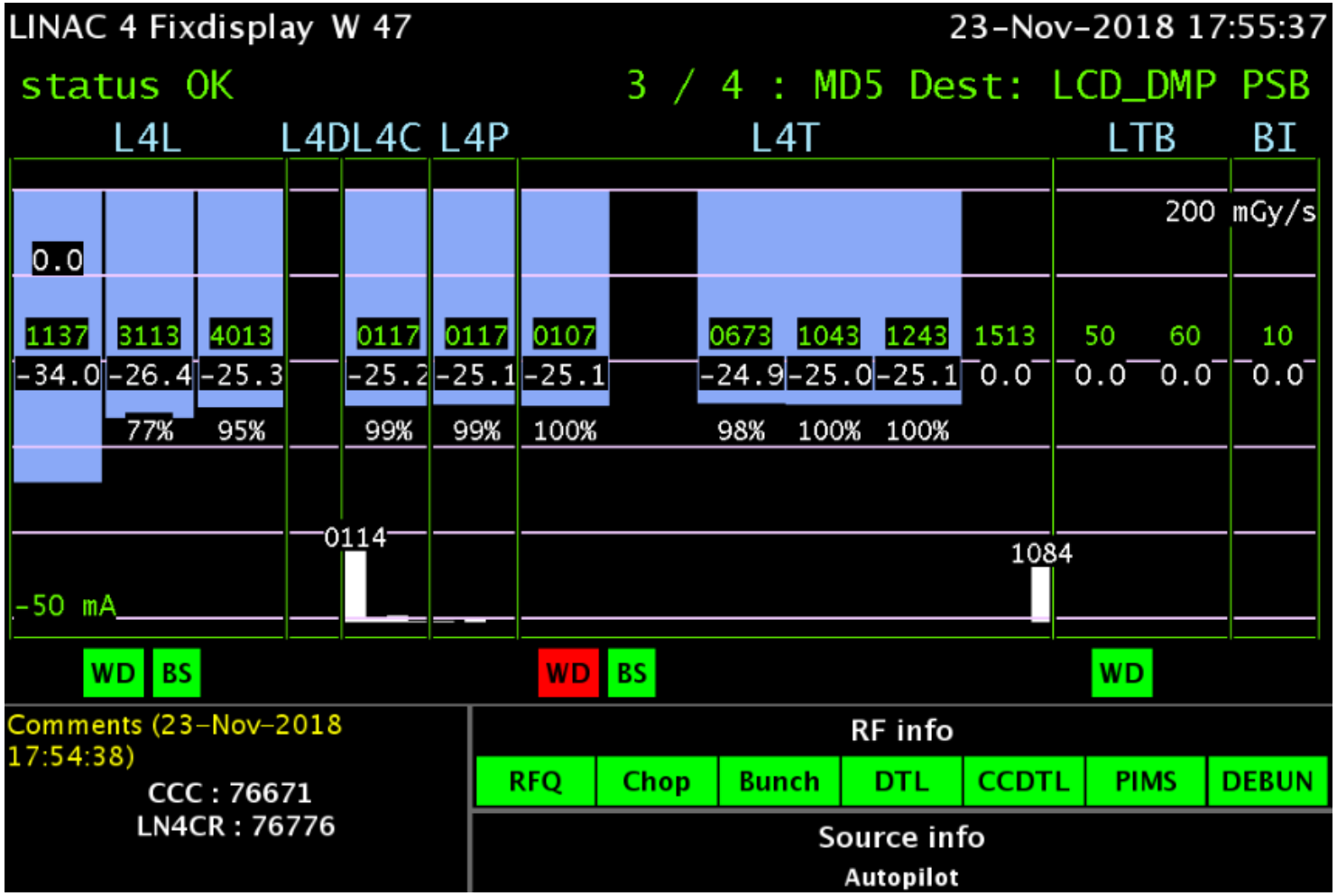
Linac4 beam requirements at PSB stripping foil location for 40 mA peak current.

Min. peak current (before chopping)	40 mA
Intensity flatness along the pulse for pulse lengths up to 160 μs	±2%
Intensity flatness along the pulse for pulse lengths >160 μs	±5%
Horizontal/vertical position variations along the pulse	±1 mm
Horizontal/vertical injection angle error	±<0.4 mrad
Current stability shot-by-shot	±2%
Normalized transverse emittances	≤0.4 mm mrad
Beam energy	160 MeV
Ppm energy spread	~80-450 (600) keV
Nominal chopper operation	See 7) 0.1% ex. factor
Energy painting	See 10) 2019

25 mA down the linac / Flatness in specs.

- **25 mA at 160 MeV with 600 us pulse.**
  - The 3 MeV fornt-end defines the current.
  - Knew that the source limit was 27 mA.
  - Far enough to produce all beam until LS3.
- **± 2% on short beams / ± 5% on long beams.**
  - Knobs to tailor the pulse were confirmed.
    - Pretty tricky !!!
  - Much better than for the last 40 years.





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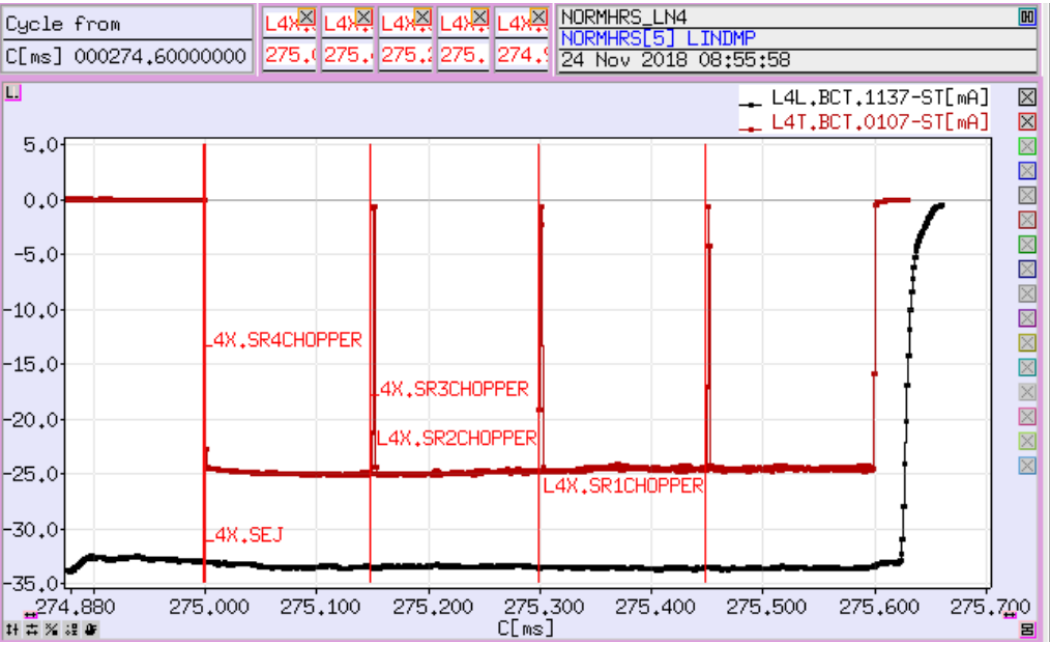
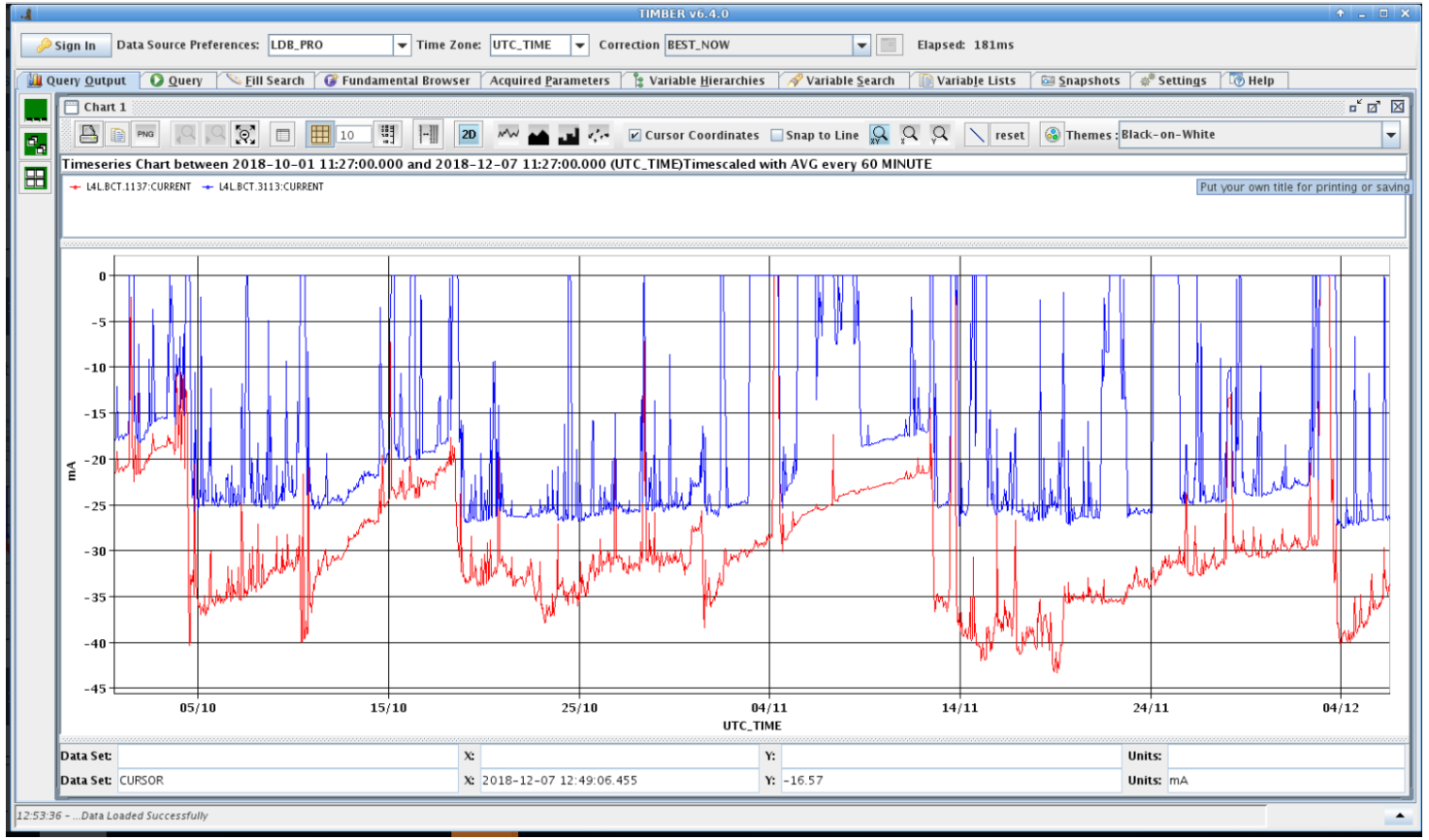
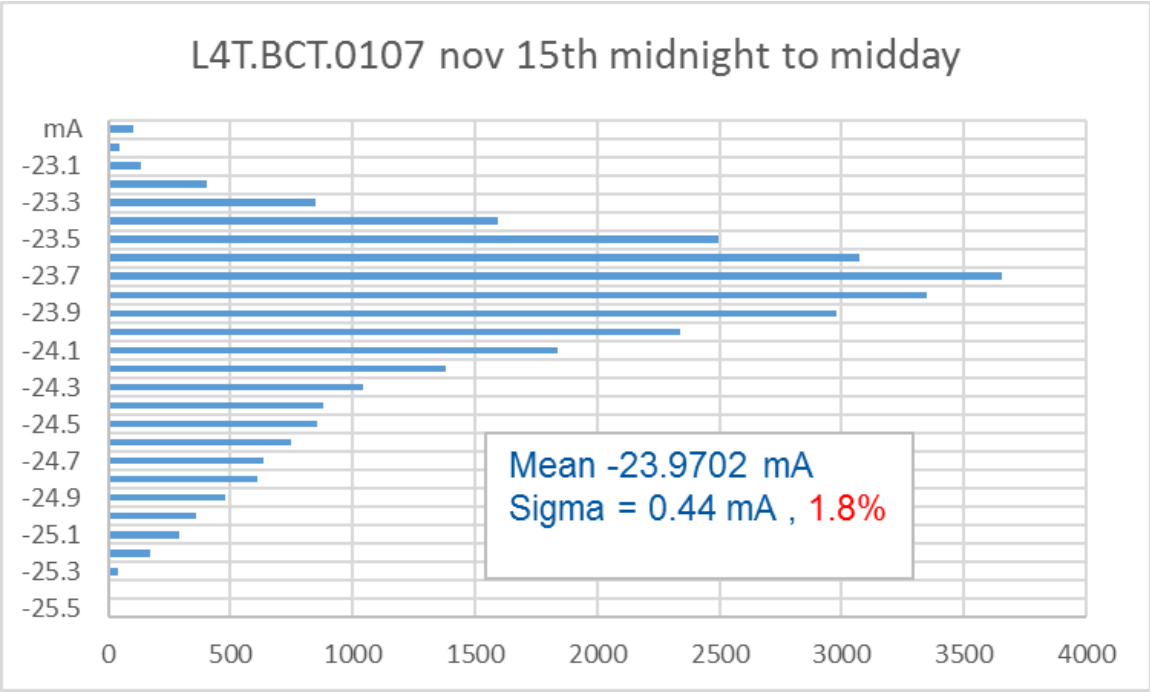


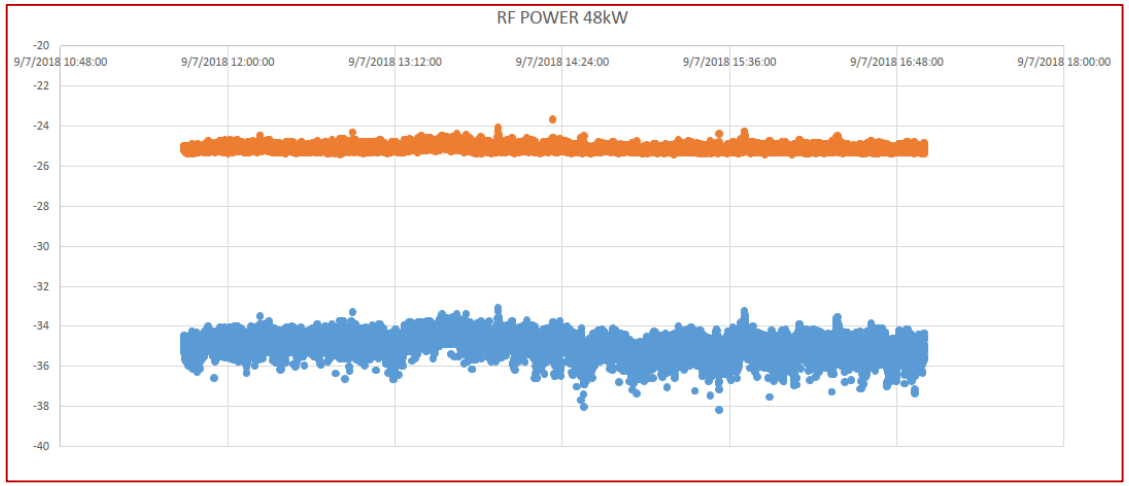


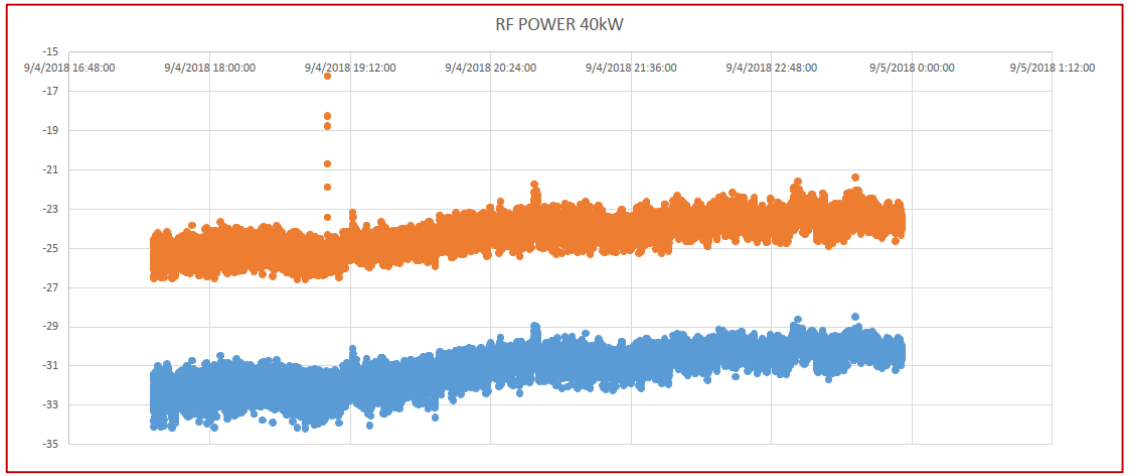
Shot to shot reproducibility

- **Shot to shot variation clearly depends on the source settings.**
  - Larger power on the source…
  - More current within the RFQ acceptance.
    - -> RFQ smoothing
  - Still better than for the last 40 years ;-)

- **The stability already defined at 3 MeV**

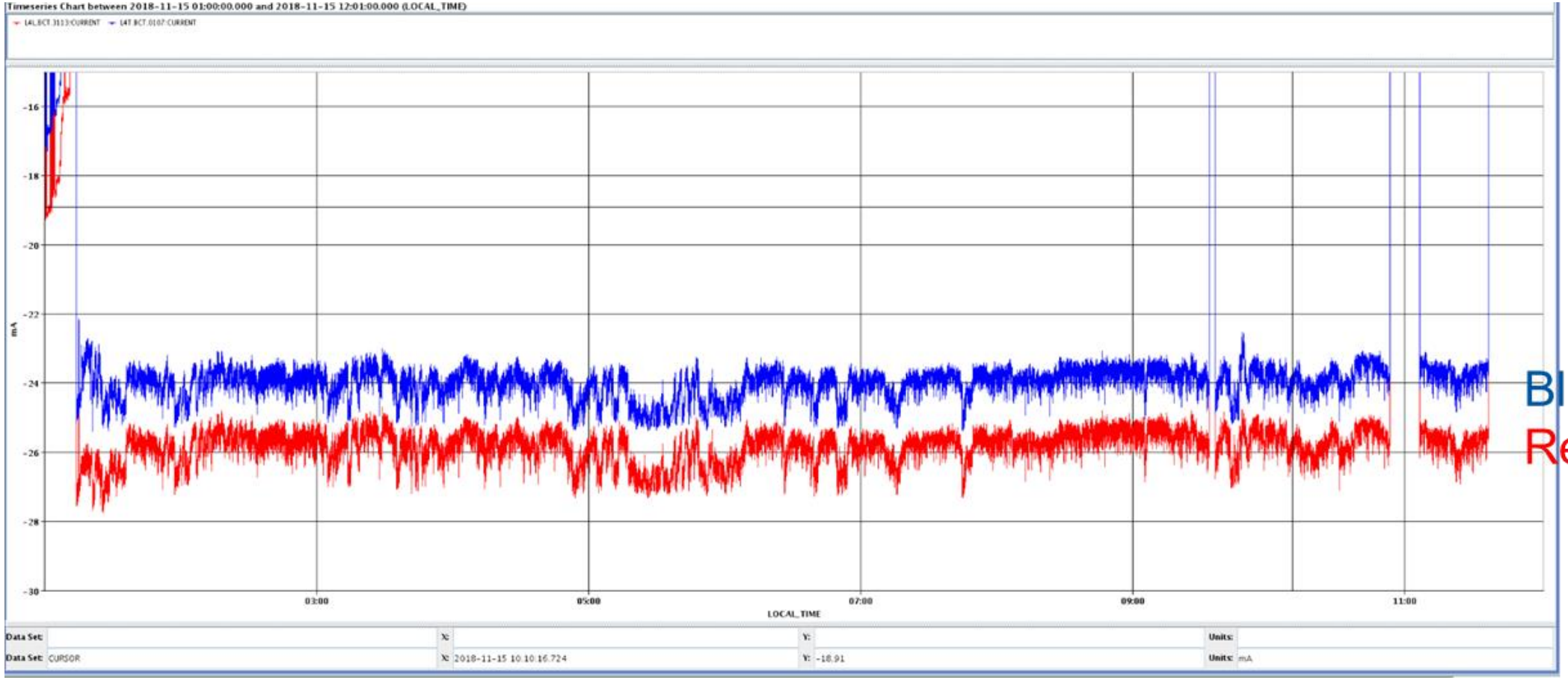






160 MeV is a perfect mirror of the 3 MeV

- **The stability already defined at 3 MeV**

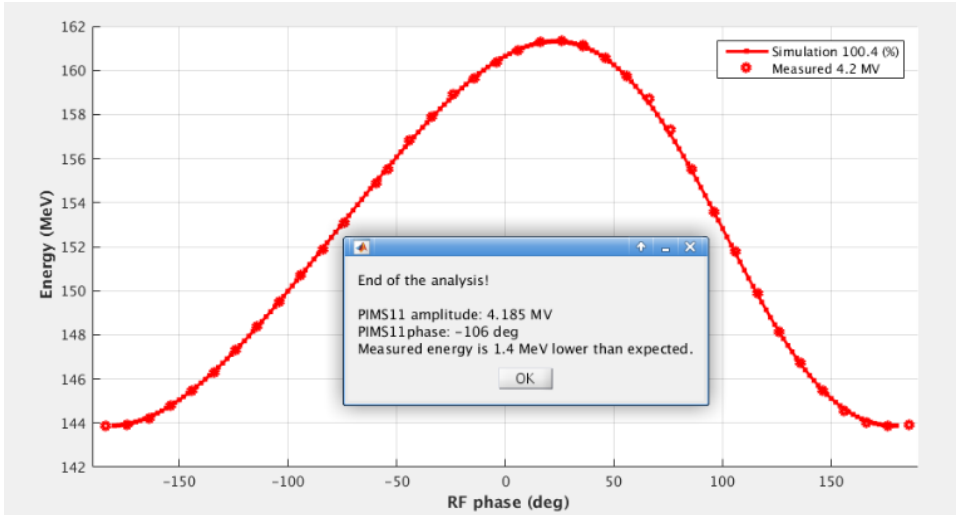


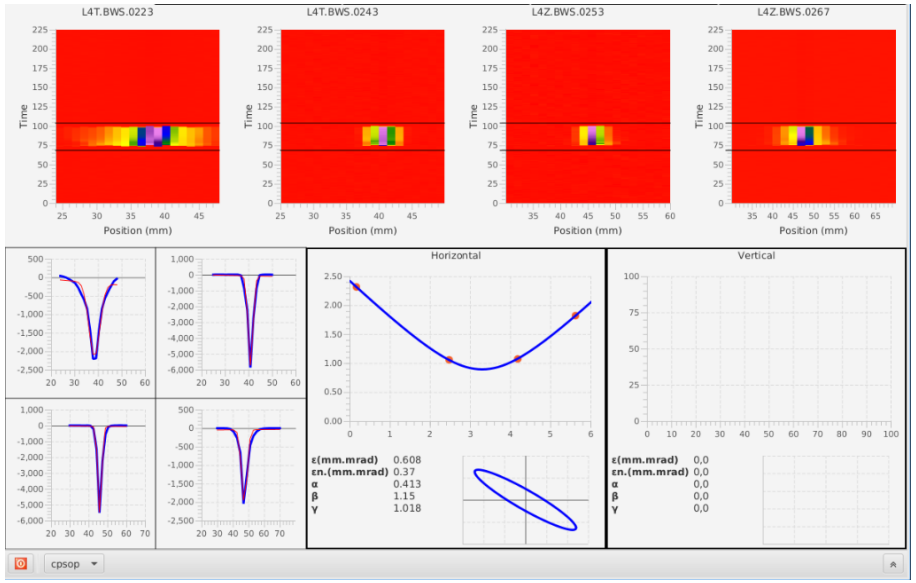
Blue 160MeV
Red 3MeV

160 MeV in 0.4 π.mm.mrad

- **Beam at 160.000 MeV ? ----** Certainly not. Only PSB can tell us.
  - But 160.7 ± 0.5 MeV: Yes
  - ToF pretty precise as relative measurement.
  - Beam goes thru the bends.
  - And longitudinal measurements are pretty clean.

- **Less than 0.4 π.mm.mrad ----** Certainly yes.
  - Acceptance limitation in the linac.
  - Transverse dynamics “frozen”.
  - Longitudinal dynamics with ToF….

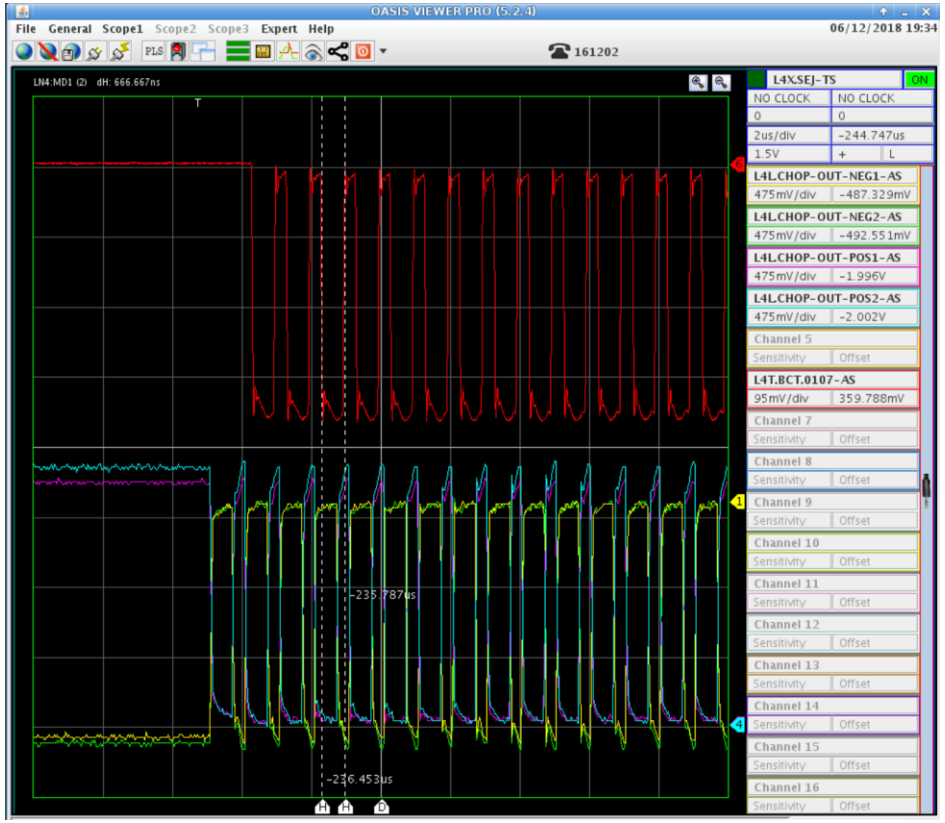




Beam chopping

- **Beam chopped at 99.9% ?**
  - Principle validated since 2013.
  - Not enough resolution on diagnostics:
    - Rise time of the chopping (not only the chopper).
    - Extinguish factor can be improved by optics.
  - Far enough to produce all beam until LS3.

- **BI working on BPMs to provide such a measurement during the LBE run.**



Zoom into start of Ring 4 with nominal chopping pattern; top: BCT in transfer line; bottom: output voltage (neg./pos.) of chopper plates.

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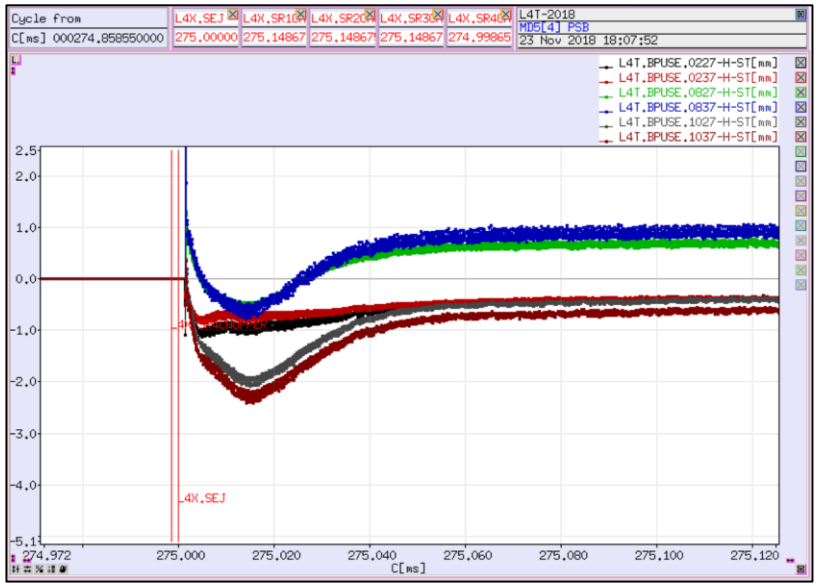
Some left for the LBE run, or later…

- **Position and angle stability along the pulse - ± 1mm - ± 0.4 mrad.**
  - If you get it in position, you get it in angle.
  - Transient beam loading has an influence on the beam position.
  - Dispersion is a real question:

    Keep these numbers in mind:

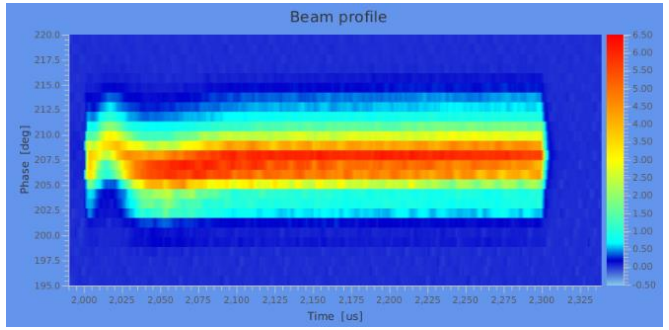
    ± 0.8 MeV -> ± 0.25 % dp/p -> ± 2.5 mm with 1 m dispersion !

  <u>LLRF and dispersion control</u>



- **Energy painting: ± 0.8 MeV.**
  - Real challenge is **debuncher control**.

- **PPM energy spread.**
  - Same conclusion as above !
  - At the end of the PIMS, the longitudinal beam parameters are the one we expect.



One paper, we have a very flexible machine. Flexibility brings complexity !