First Commissioning Experience with the Linac4 3 MeV front-end at CERN.

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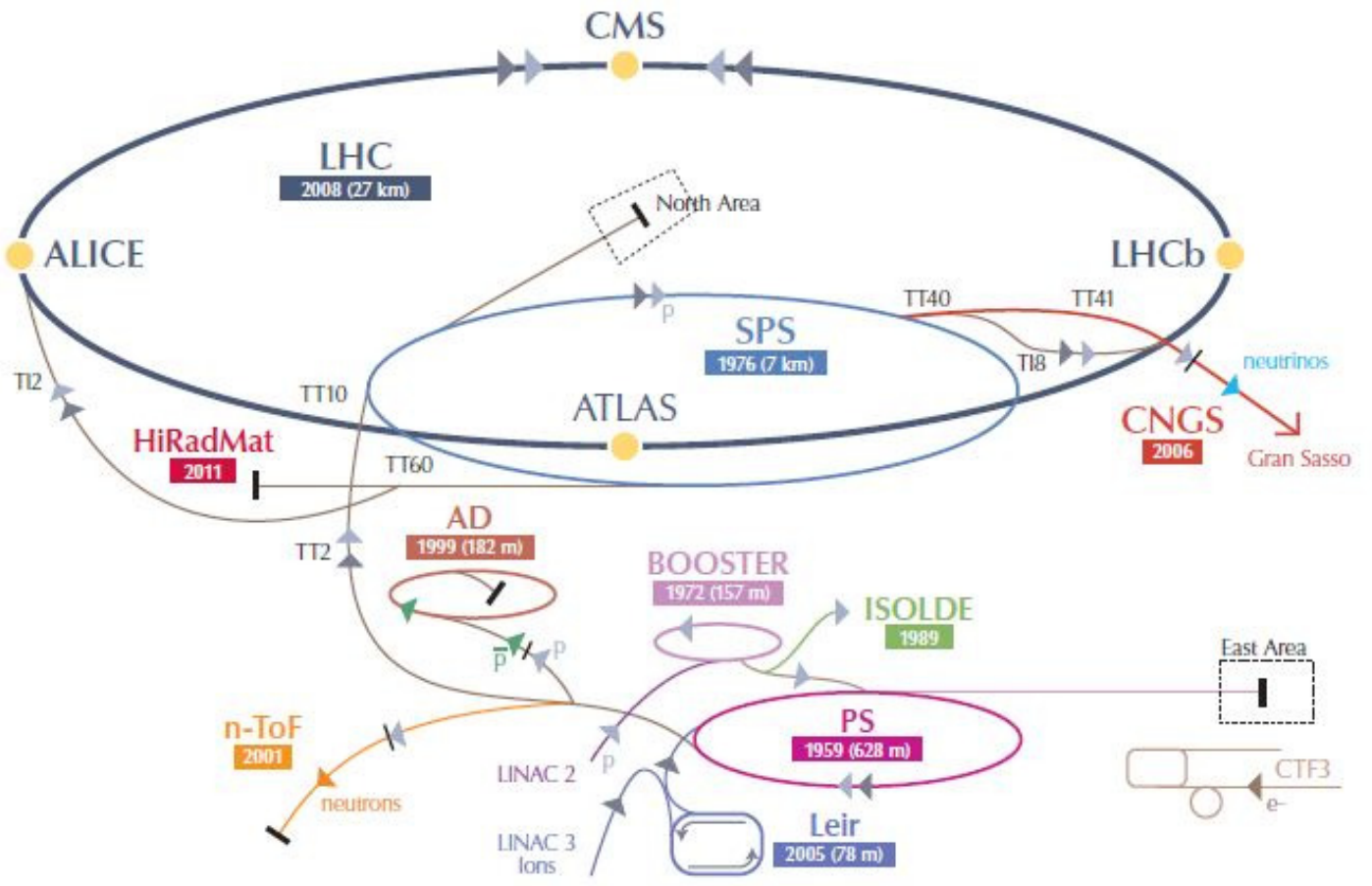
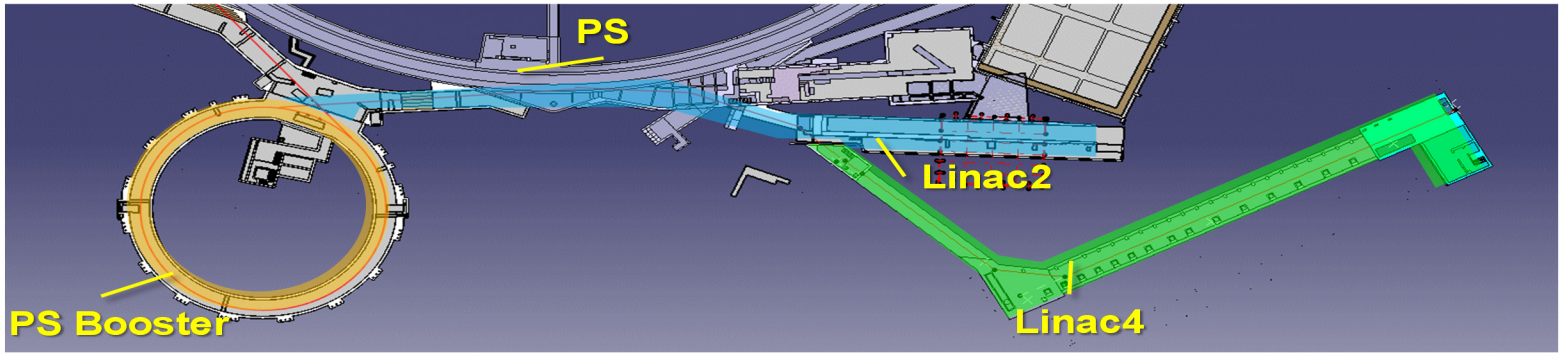
30 September 2013

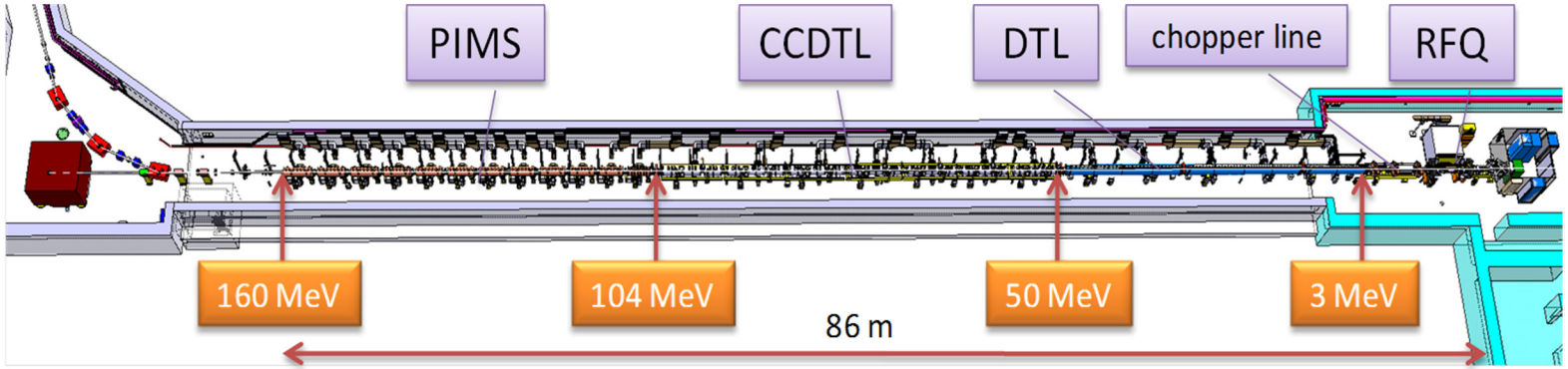
Linac4 : A new injector for the CERN proton complex



Replace the 50 MeV Proton Linac2 (1978)
160 MeV, H^- injection.

Linac4 : 160 MeV, H- accelerator



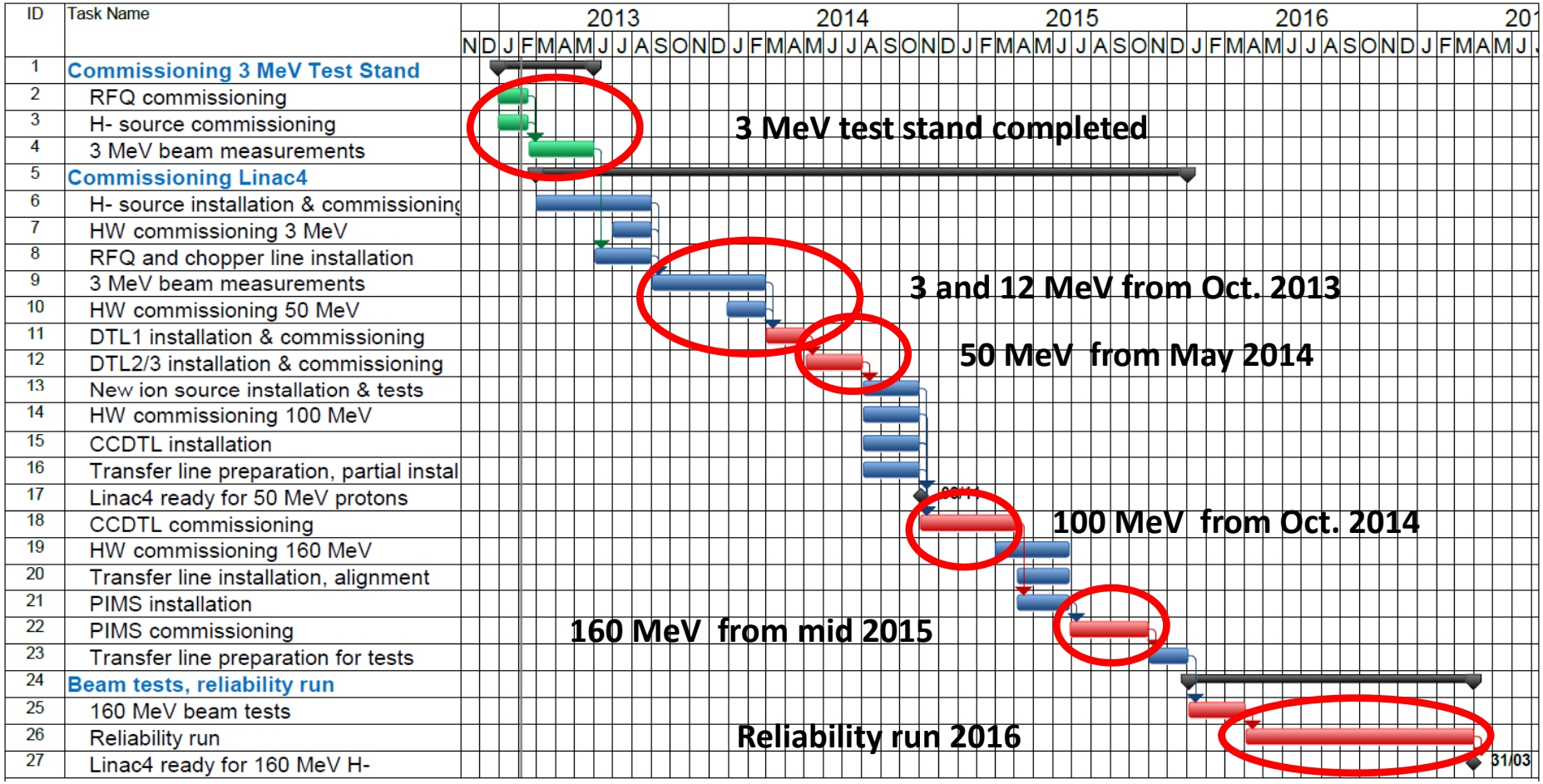


Design parameters : 65 mA, 352.2 MHz, 1.1 Hz, 400 µs.

The project is on track

General infrastructures and services completed.
DTL tank1 assembled – RF tuning starting soon.
DTL tanks 2&3 under assembly.
CCDTL : 7 modules delivered at CERN – RF measurements.
PIMS : 1st module ready for installation.
PIMS 2-12 : Delivery by end of 2014.

6 commissioning stages



First stage, completed !!!

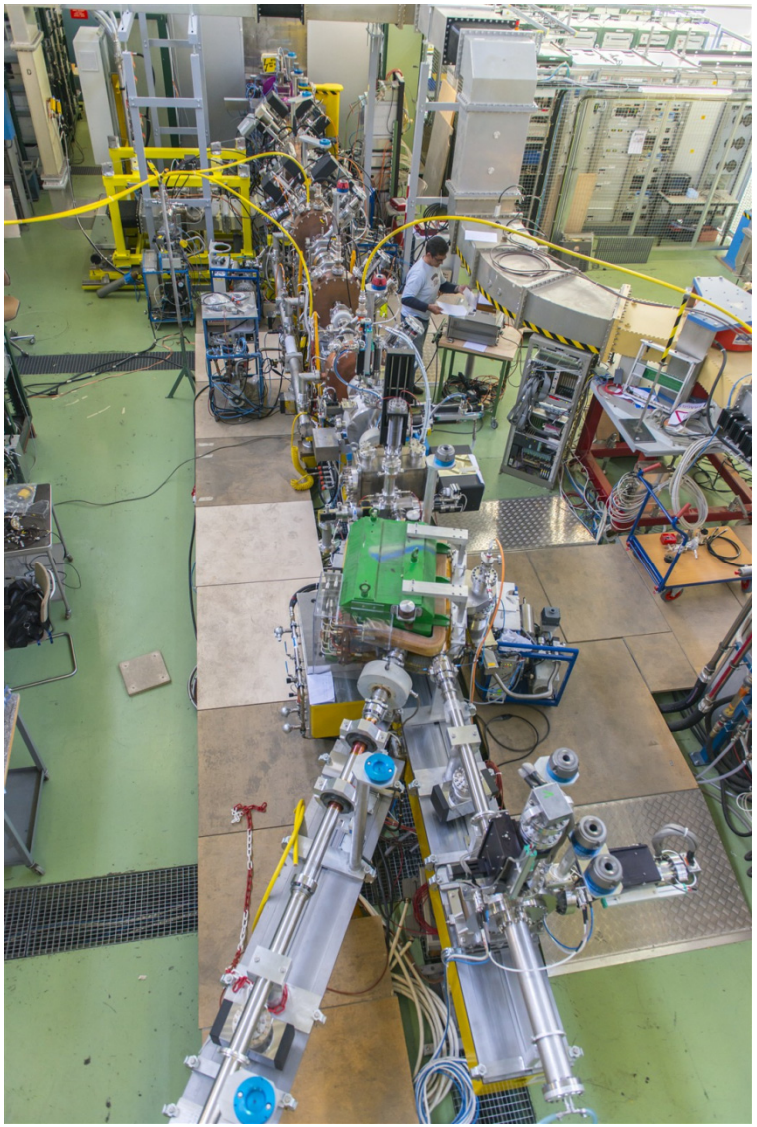
The 3 MeV test stand
Validate Source, LEBT, RFQ and Chopper-line

Source – 45 keV
LEBT
RFQ
MEBT
Diagnostic bench

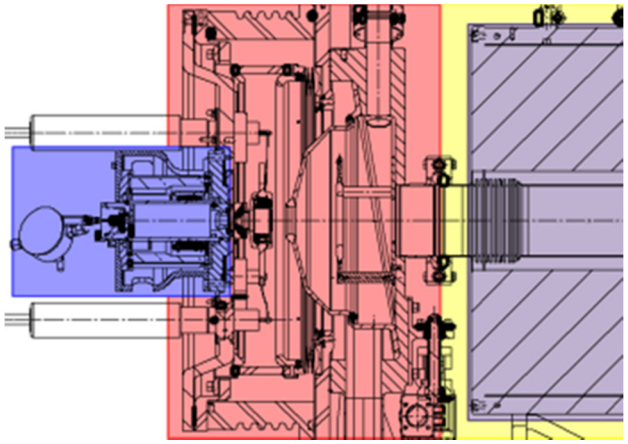
The low energy section is the most difficult part to master in a Linac:

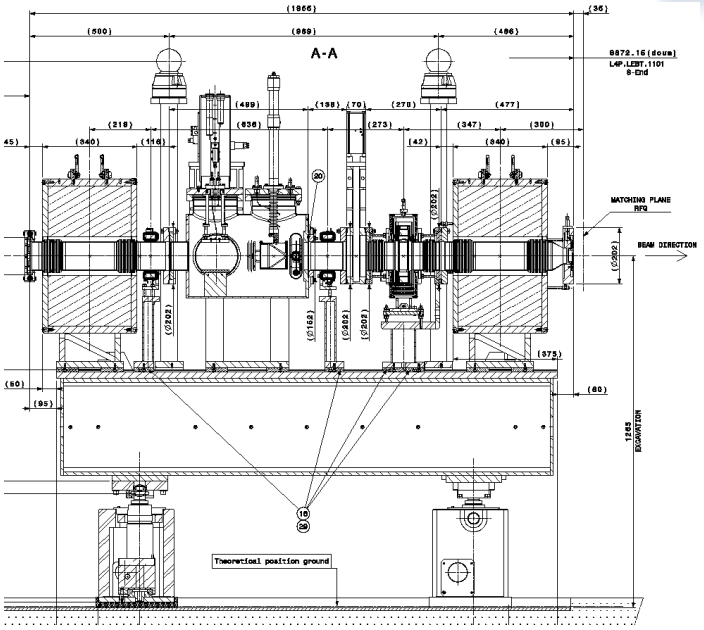
Space charge
Critical devices – RFQ and Chopper

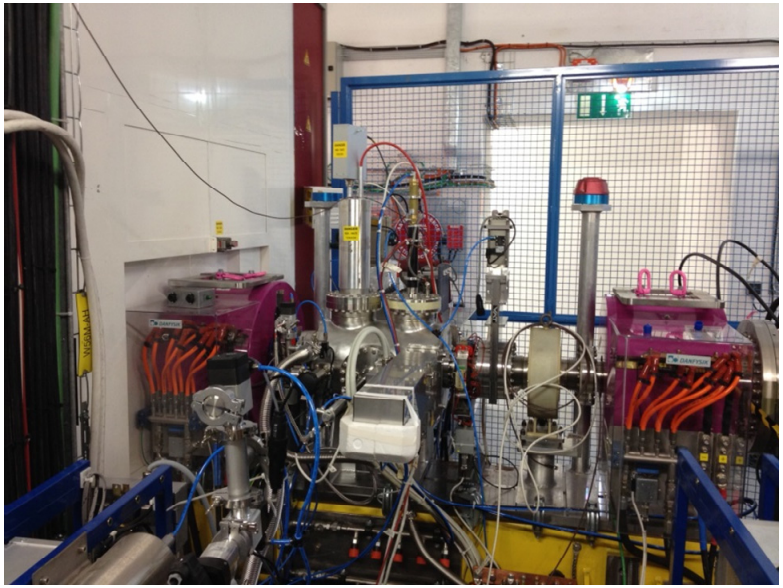
The measurements at the test stand took place during the first half of 2013.



Source and LEBT





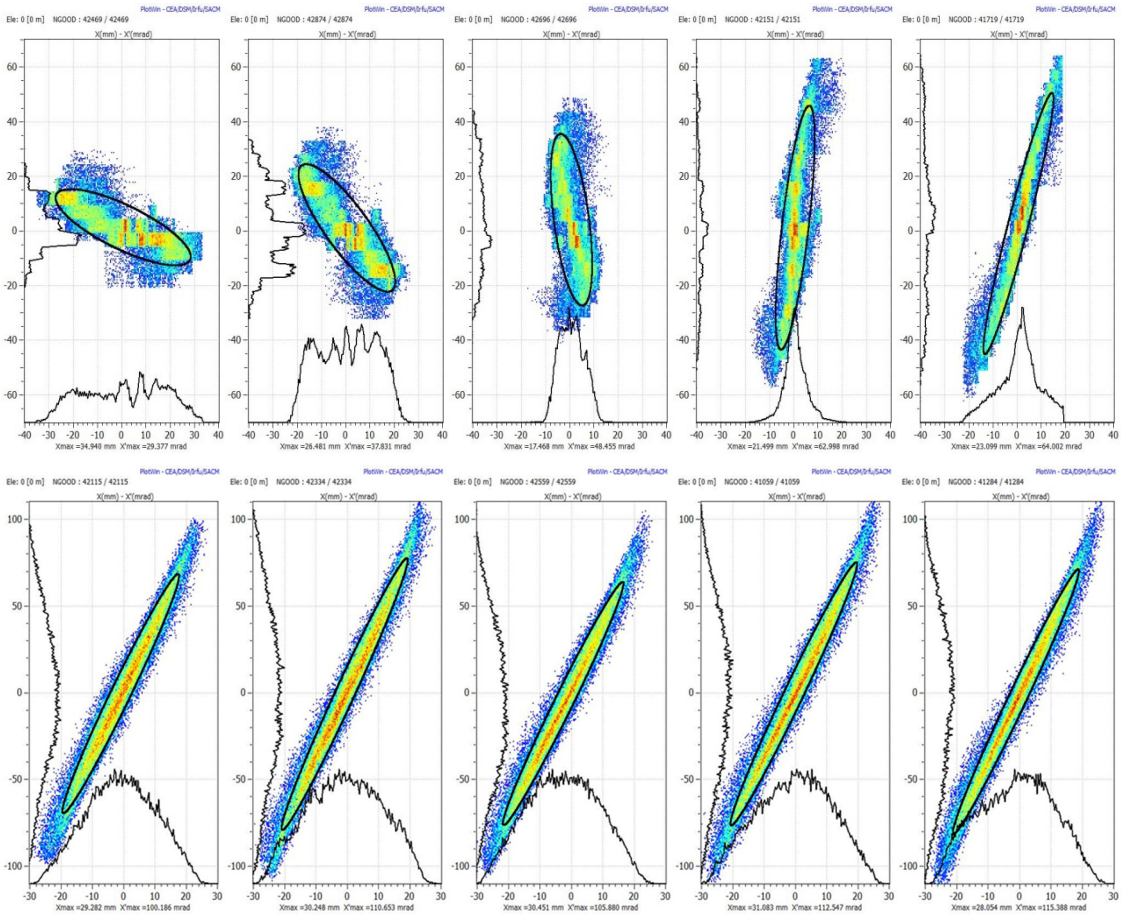


Preliminary version of the source
Plasma chamber and multi electrode extraction

LEBT : 2 solenoids and diagnostics

Transverse emittance from the source

Source | Sol | ε measurement | Sol



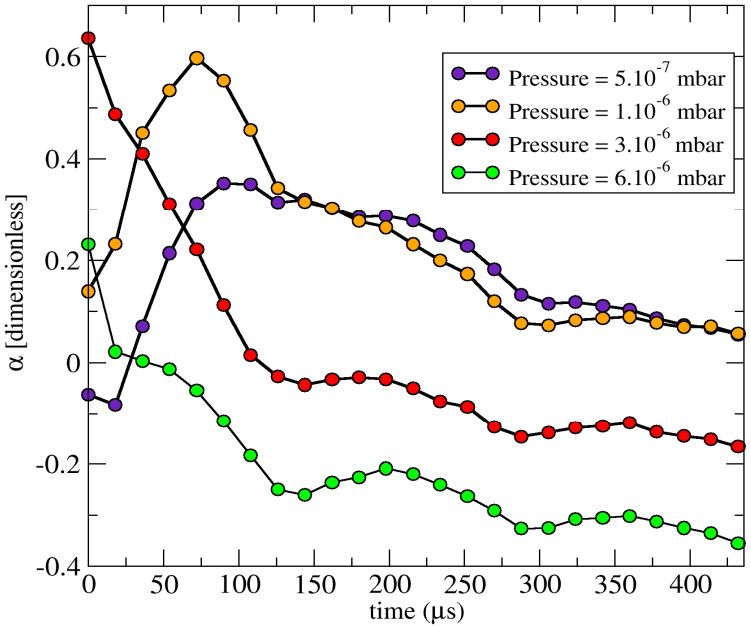
Transverse emittance measured for different solenoid settings.

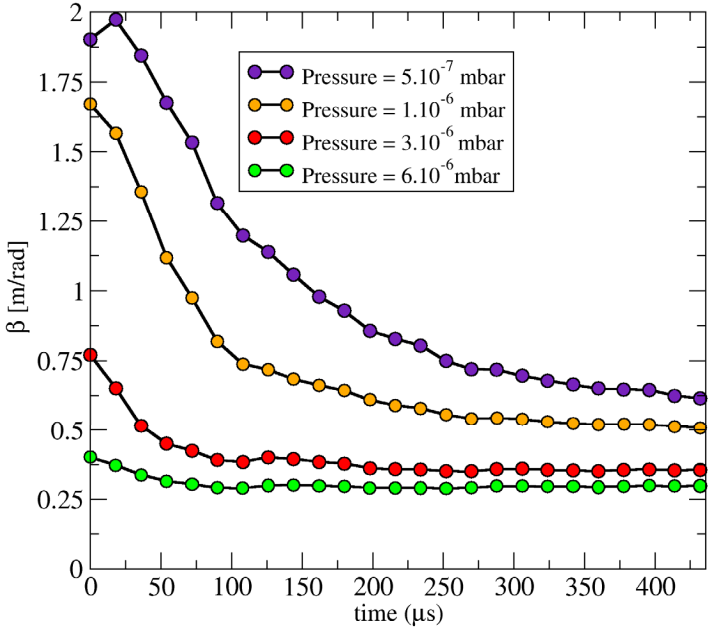
Beam reconstructed at source output and effective space charge estimate.

16-20 mA current
0.7-0.8 mm.mard

Space charge compensation in the LEBT

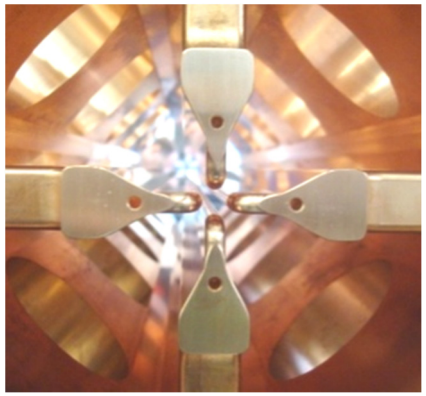
Space charge compensation : Effects of space charge can be reduced by secondary particles created from ionization of the residual gas.



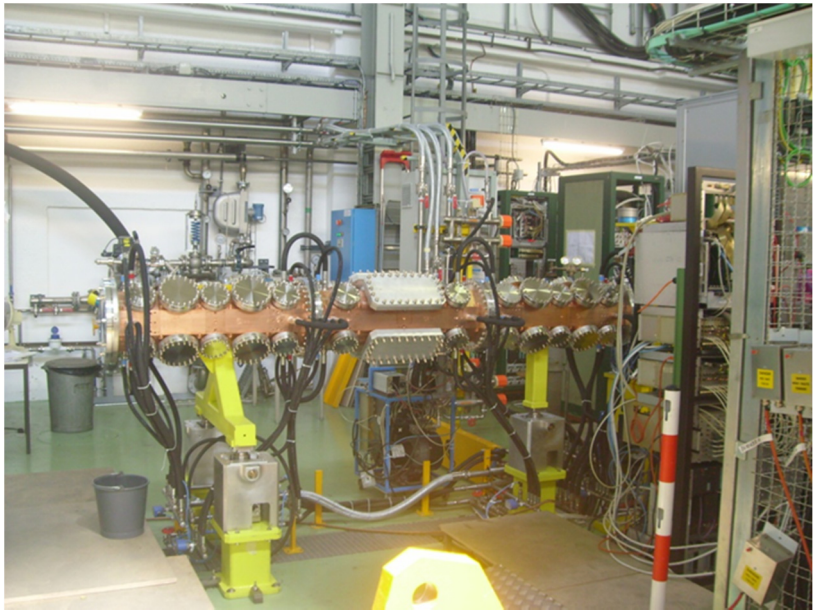


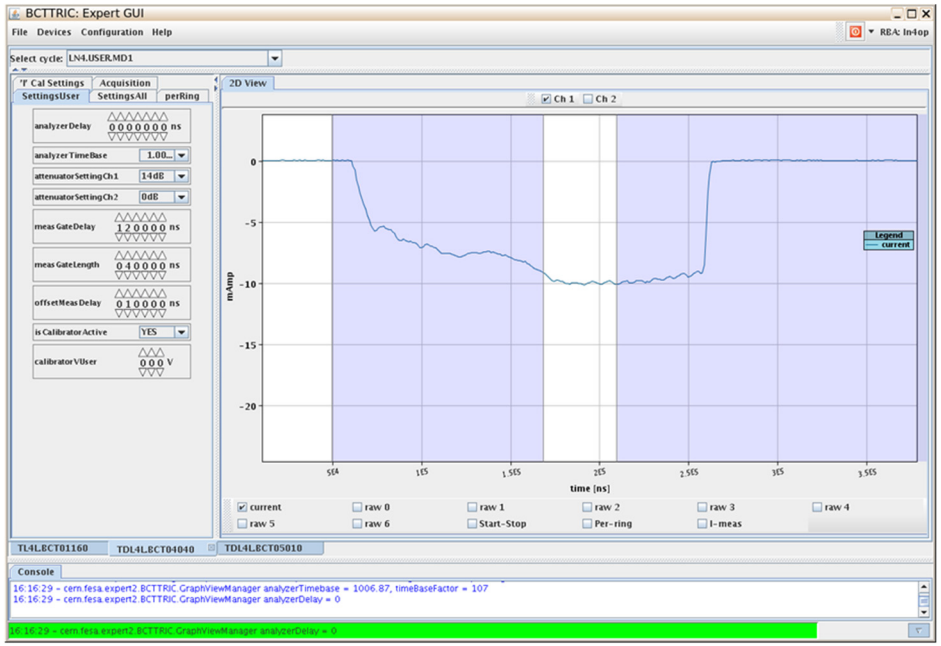
Influence of the pre-chopper still need to be measured

The Linac4 RFQ



4 vanes
352.2 MHz
3 m
Designed and manufactured at CERN





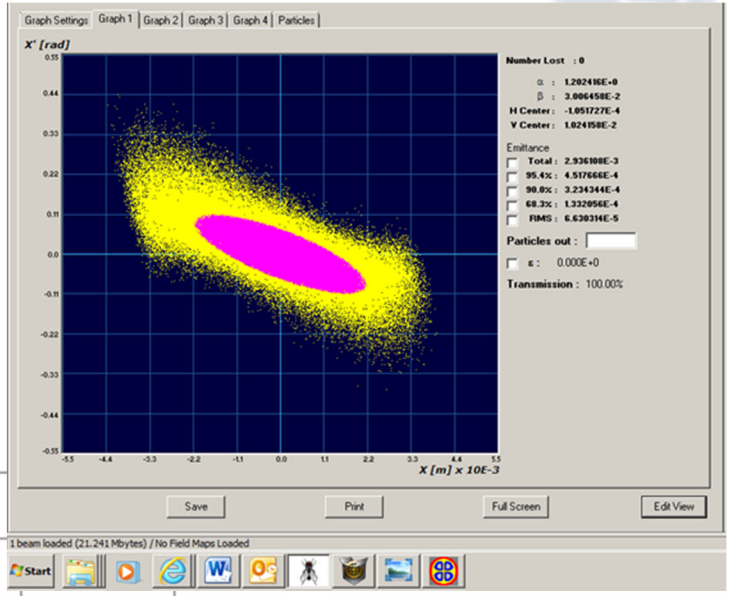
Wednesday 13/03/13 at 16h10
10mA H- accelerated to 3 MeV

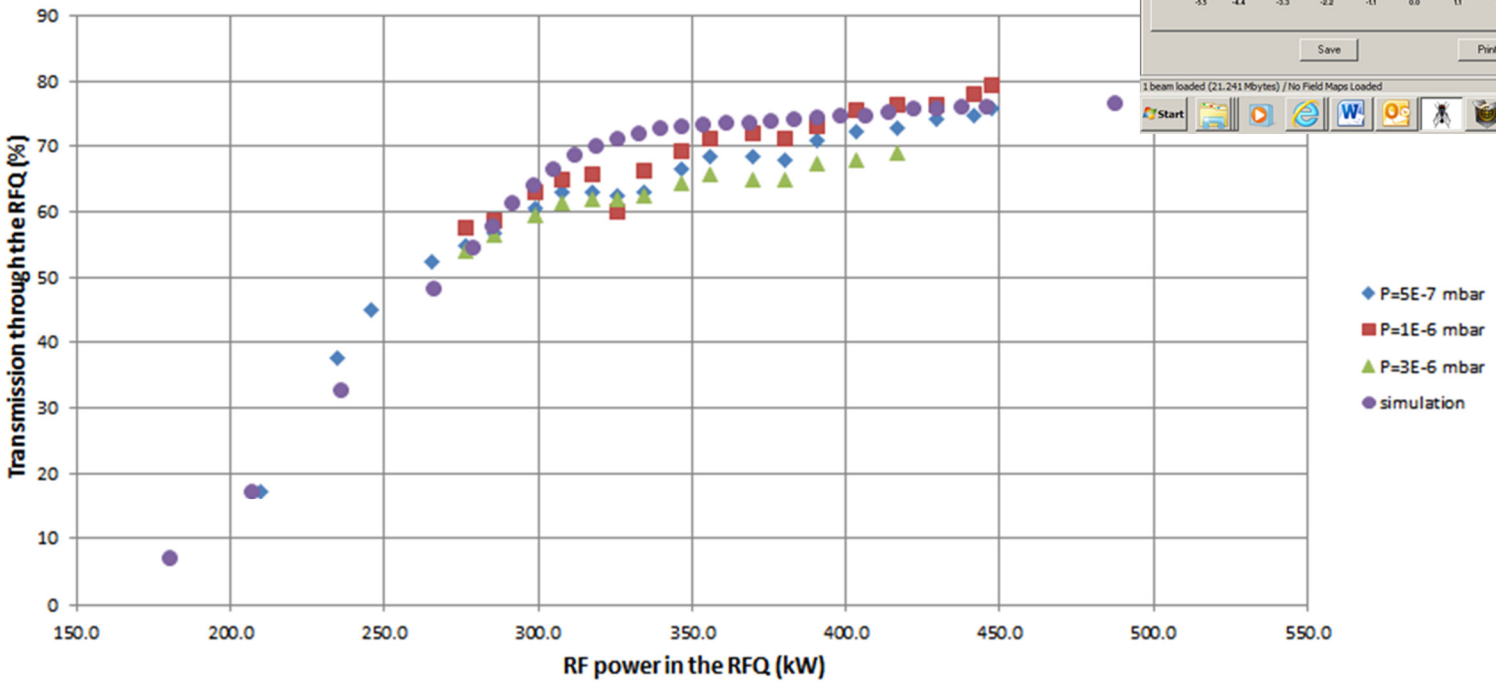
RFQ transmission as expected

RFQ simulated with Parmteq (LANL) and Toutatis (CEA).

Input beam distribution from the LEBT measurements.

The acceptance is smaller than the beam emittance at the test stand!



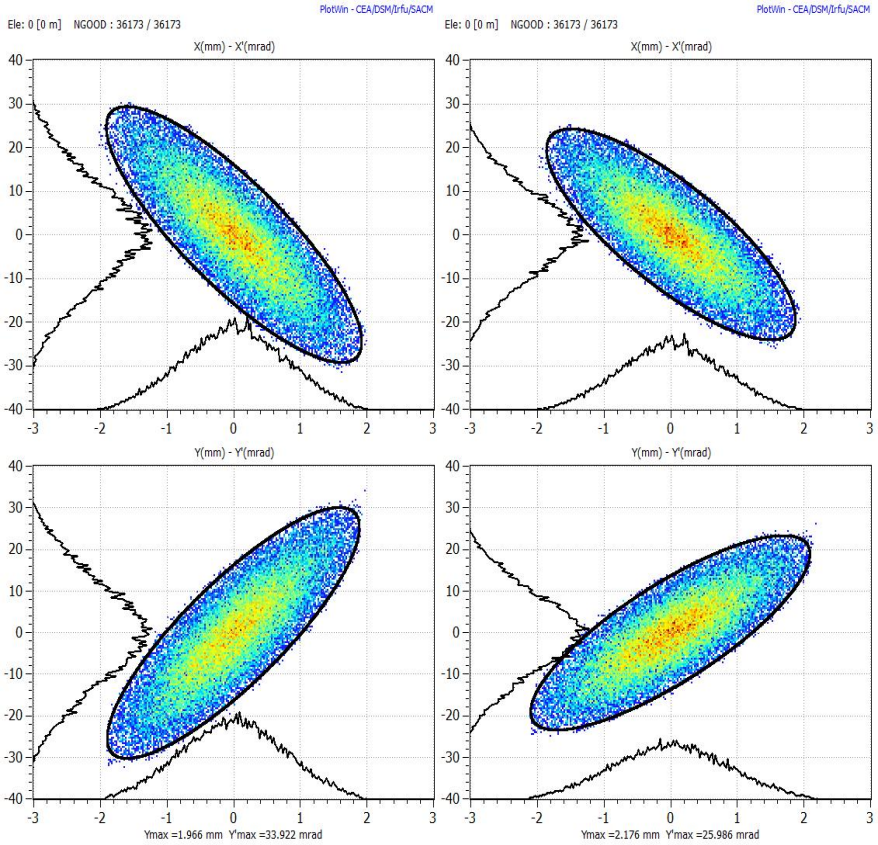


RFQ transverse emittance reconstruction

Transverse emittance was reconstructed using the 3 gradient method

Expected from simulations

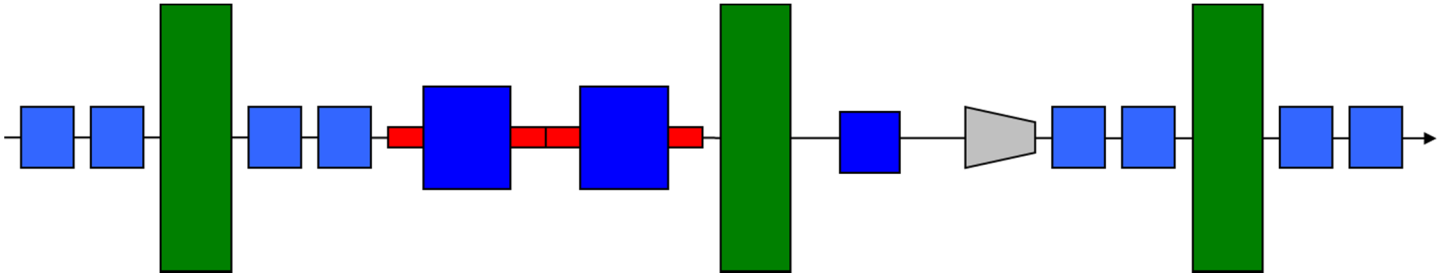
Reconstructed



	Expected	Recons.
α_x	1.54	1.35
β_x (mm/mrad)	0.12	0.13
ε_x (mm.mrad)	0.36	0.31
α_y	-1.56	-1.39
β_y (mm/mrad)	0.12	0.15
ε_y (mm.mrad)	0.37	0.34

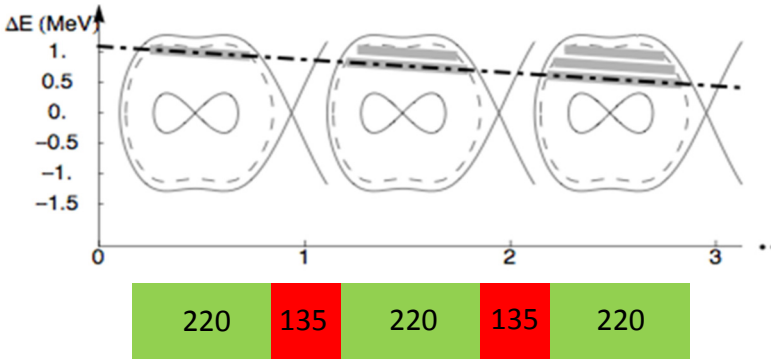
Measurements are very close to our expectations !

A fast chopper in the MEBT

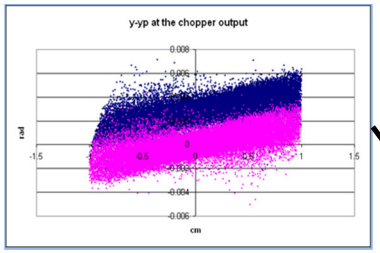


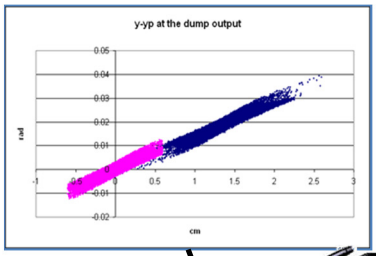
GREEN=BUNCHER
BLUE = QUADS
RED = CHOPPER
GREY = DUMP

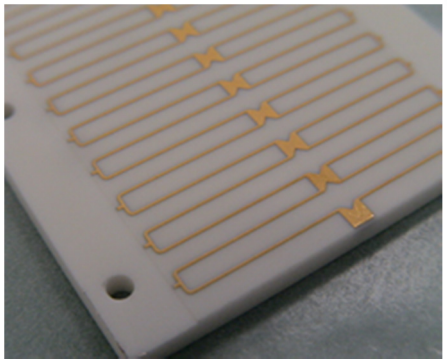
Linac4 at 352 MHz – PSB at 0.99 MHz
-> Remove 135 microbunches over 355

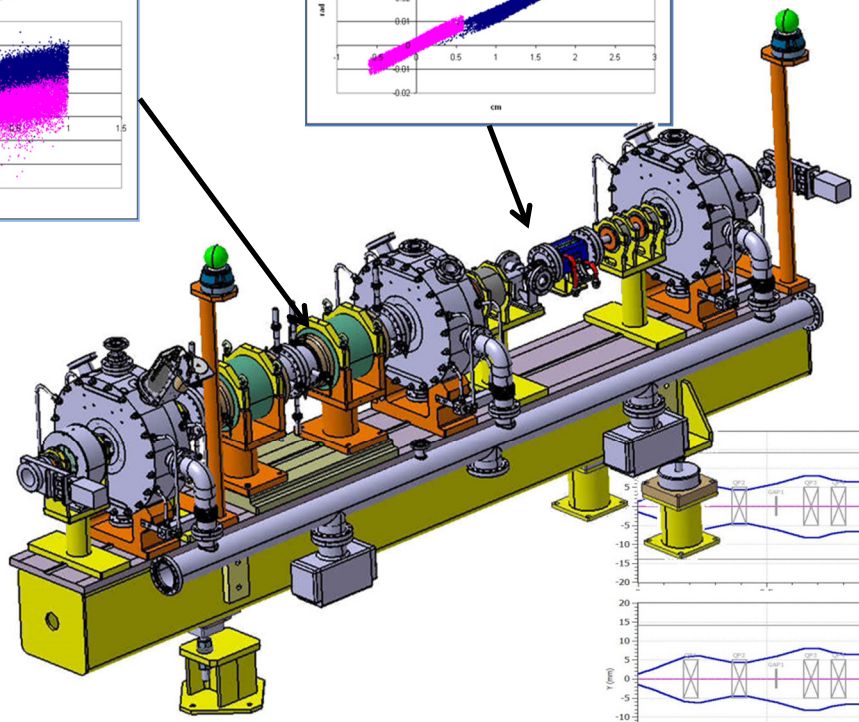


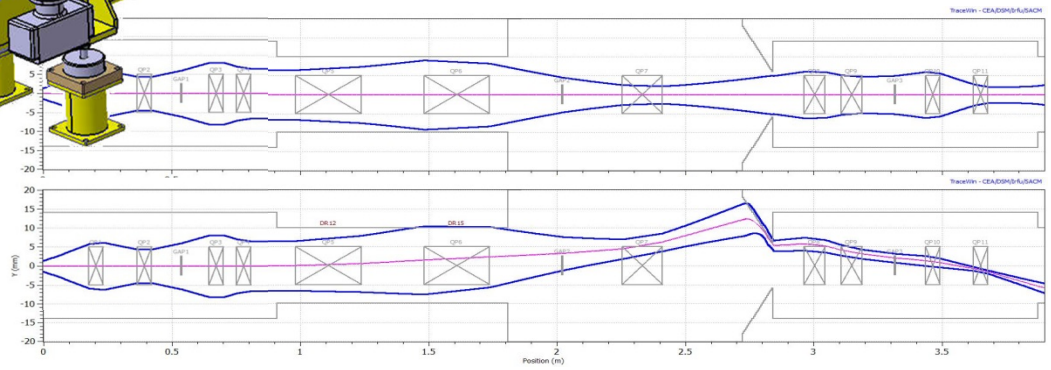
Chopper principle





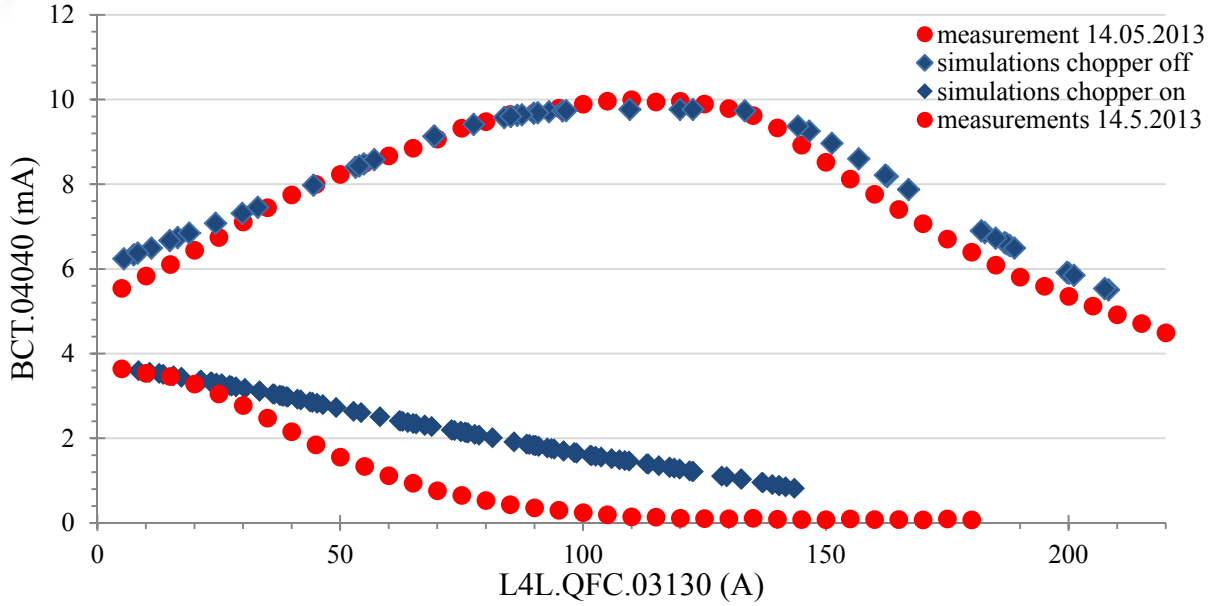




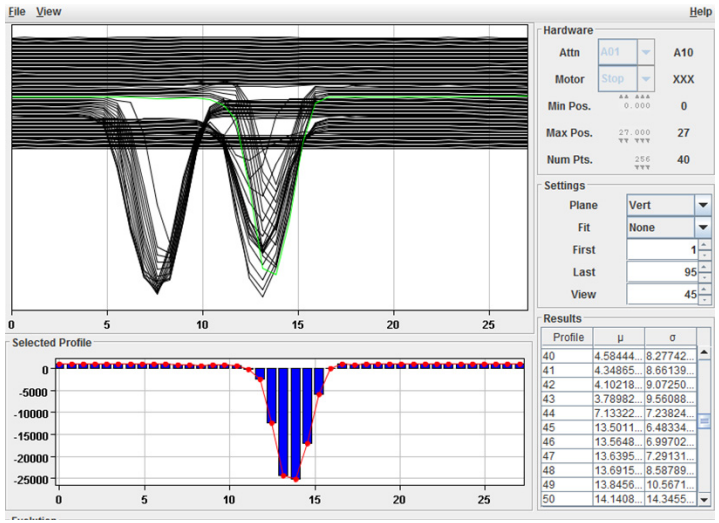


Micro-bunches are shifted in the phase space by a voltage applied between two plates.
Relatively low voltage to allow for short rise/fall time.
Shift transferred in the real space at the dump – Appropriate phase advance.

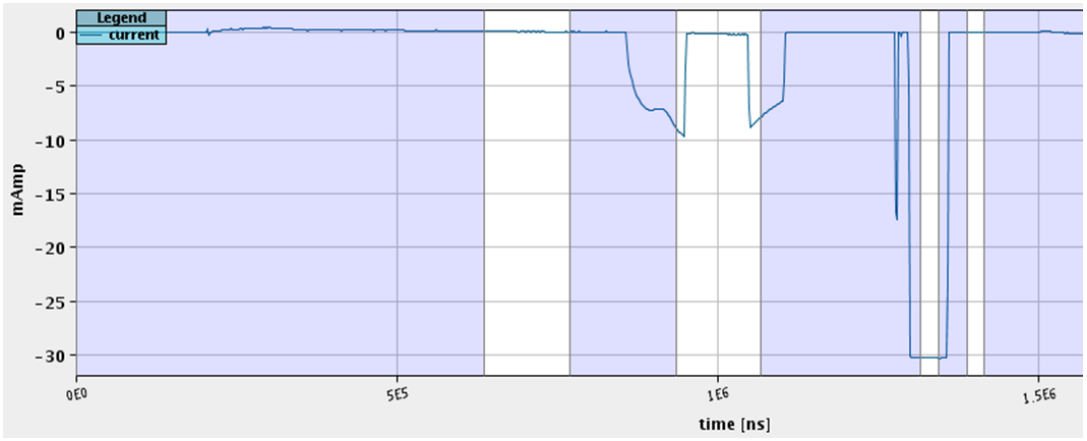
The chopper is working



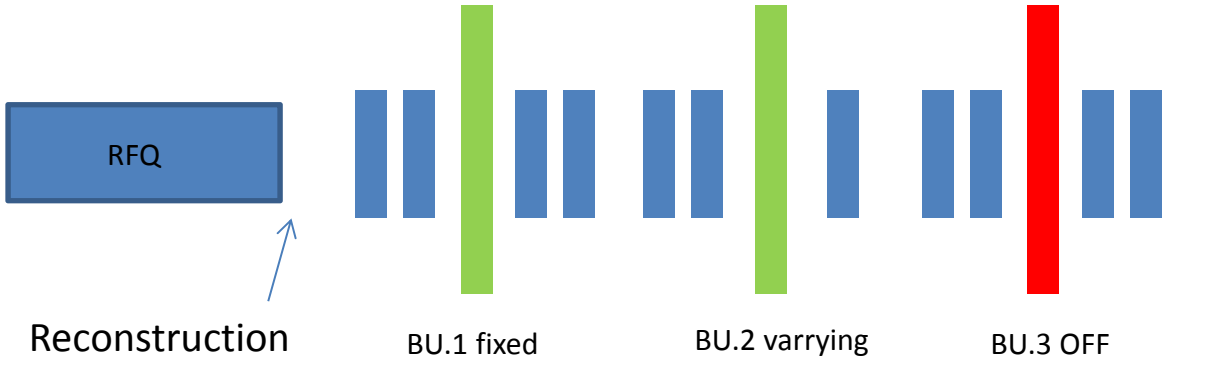
The chopper line dynamics is validated !

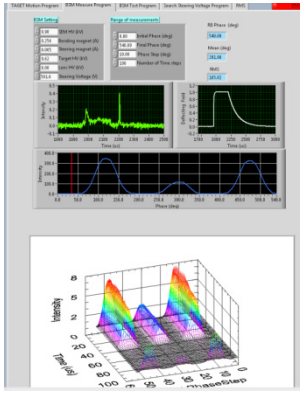


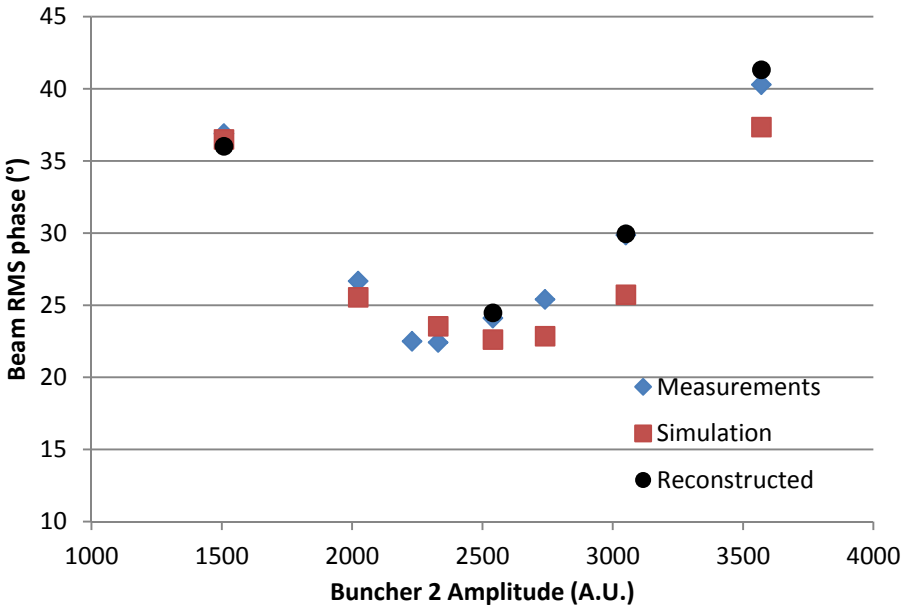
Fall and rise time < 10 ns !

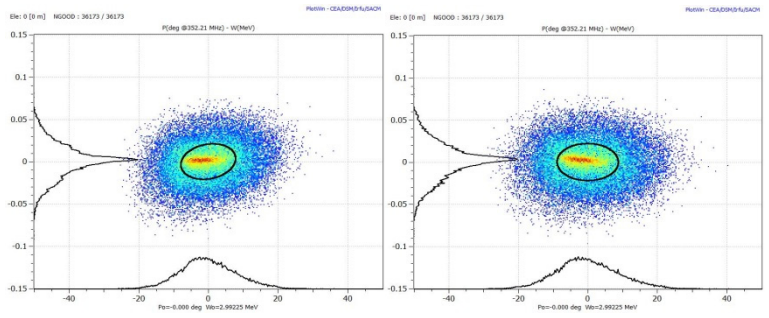


Longitudinal emittance reconstruction









	Expected	Recons.
ΔE (keV)	21	22
Δϕ (°)	7.8	8.8

3 MeV test stand is a success

Better understanding of the LEBT dynamics
RFQ as expected
100% chopper efficiency – 10 ns
Beam dynamics models and tracking codes validated
Commissioning strategy and measurements techniques are OK

Still 157 MeV to go…

3 MeV commissioning in the tunnel starting in 2 weeks

- Time resolved measurement of chopping on the ns scale
- Spectrometry / Time Of Flight
- Matching to DTL and 3rd buncher cavity

Beam commissioning interlaced with installation period until end 2015

Connection to PSB foreseen in 2017-18

Still a long …

… but quite straight way

Thank you for your attention

Questions ?