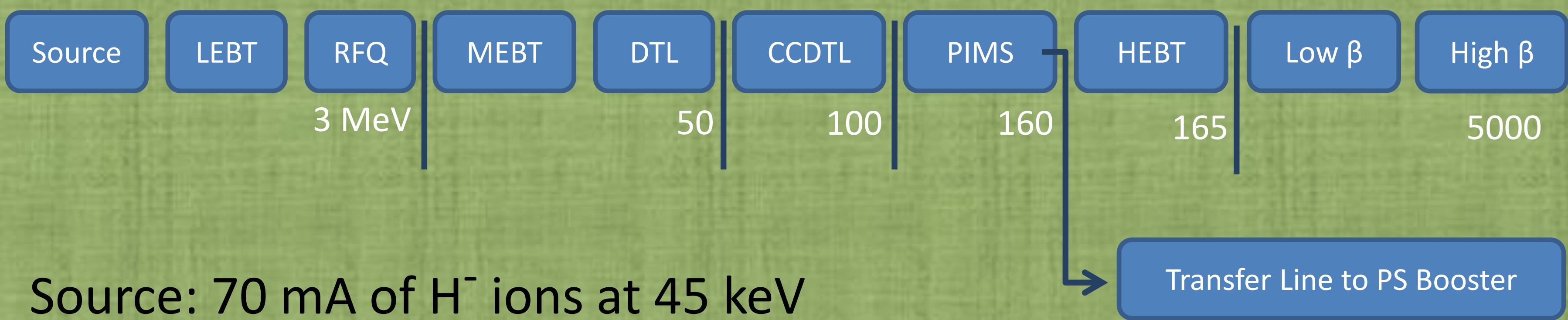
From Linac4 to SPL

Mohammad ESHRAQI 3rd SPL Collaboration meeting CERN 12-11-2009

LINAC4 plus SPL layout



Source: 70 mA of H^- ions at 45 keV

RFQ: 65 mA, 352.2 MHz

DTL: Three tanks (FFDD+FD)

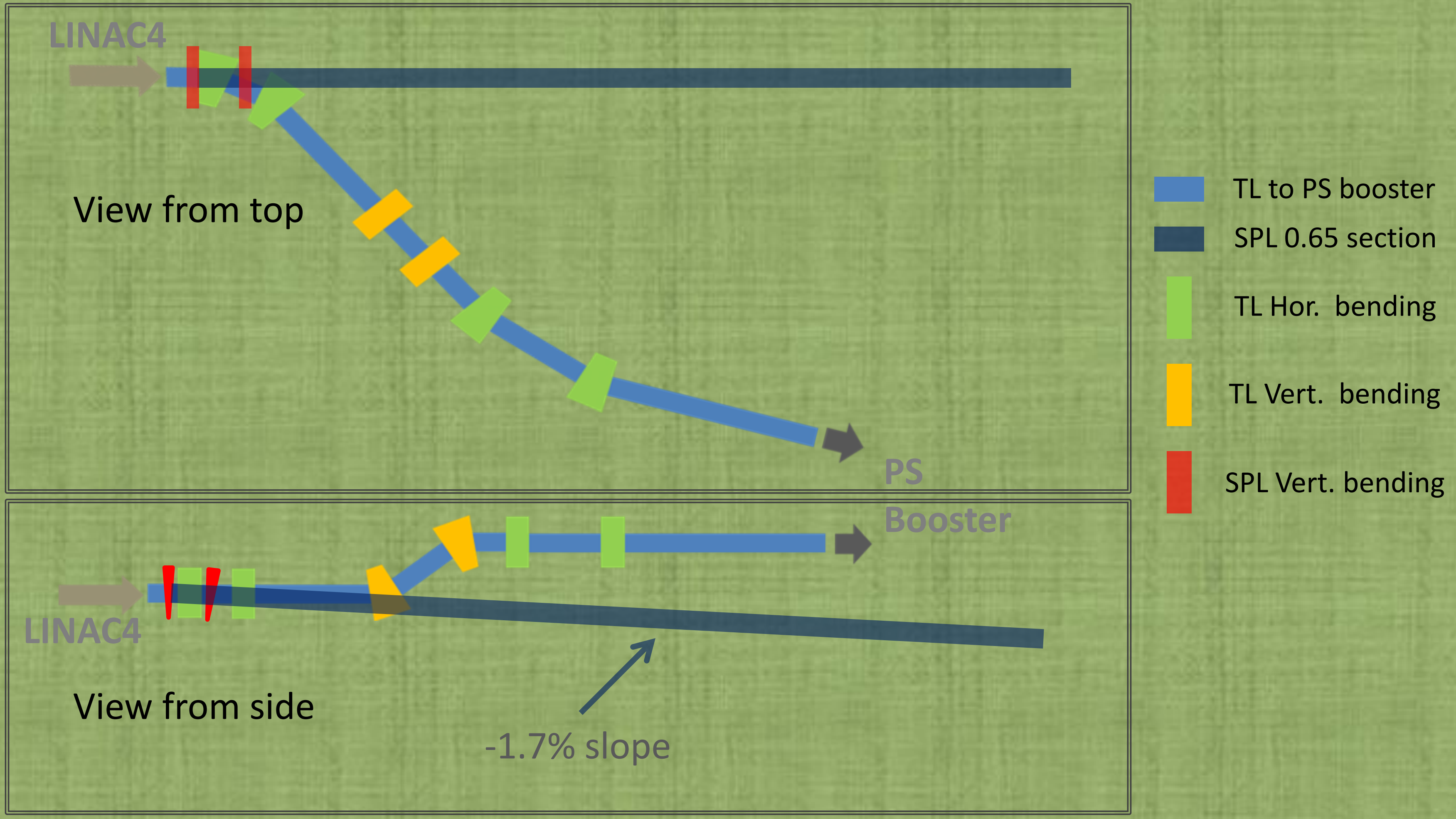
CCDTL: 7 Tanks (FD)

PIMS: 12 Tanks (FD)

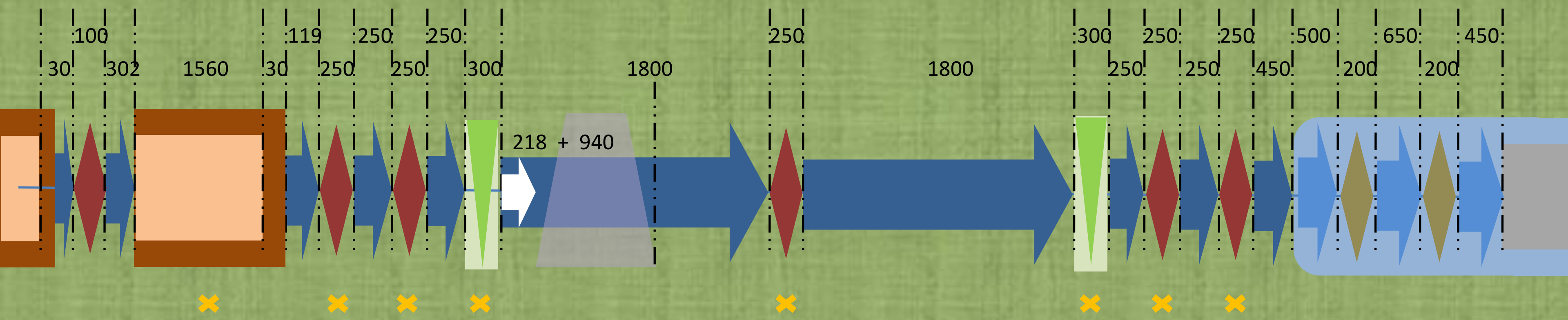
HEBT: 1 Tank, an achromatic vertical bend

Elliptical: Two generations of elliptical cavities, geometric betas of 0.65 and 1. (Doublets , or singlets) 704.4MHz

LINAC4 and SPL



HEBT schematic layout



Drift space

Quadrupole

Vertical Bending (0.85 degrees down) (SPL)

Horizontal Bending (35 degrees right) (PS Booster TL)

Not present in L4-PSB transfer-line

Achromatic bend

Length [300mm] (radius of curvature 41 m) of the magnets is chosen such that it does not strip the H^- beam.

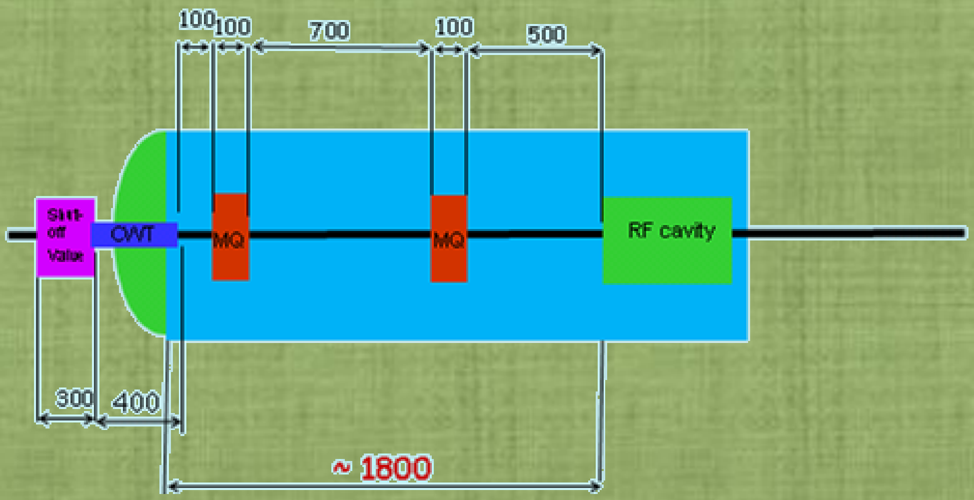
$df/ds = (f.B/A_1).exp[-A_2/(\beta.\gamma.c.B)]$,
where B is the magnetic field in Tesla, A_1 (2.47E-6 V.s/m) and A_2 (4.49E9 V/m) are constants, and c is the speed of light.

The achromatic vertical bend between LINAC4 and SPL is designed to house the beam collimators each around (less) than 1.5 meters. Phase advance from center of first drift to the center of the second drift is ~80 degrees.

Warm-Cold transition

The first beta = 0.65 cryo-module needs a special design which:

- Integrates valve box
- Integrates shorter doublet. 150 in simulations, *restricted by stripping.*

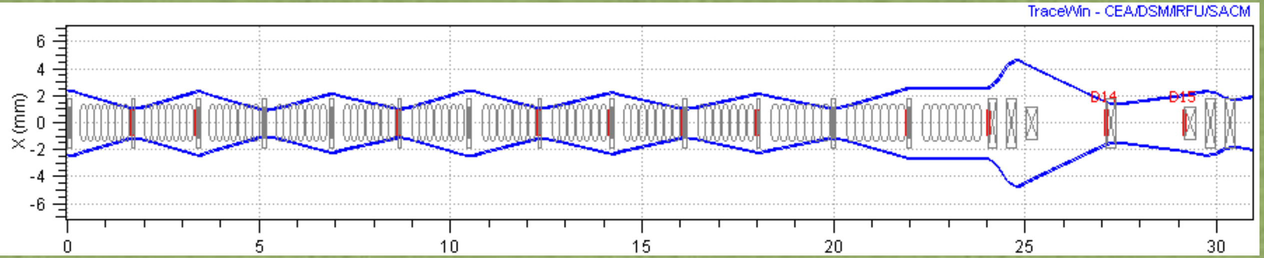


This 1.8 m is needed for integration of cryogenic equipment, valves, phase separators, instrumentation, …

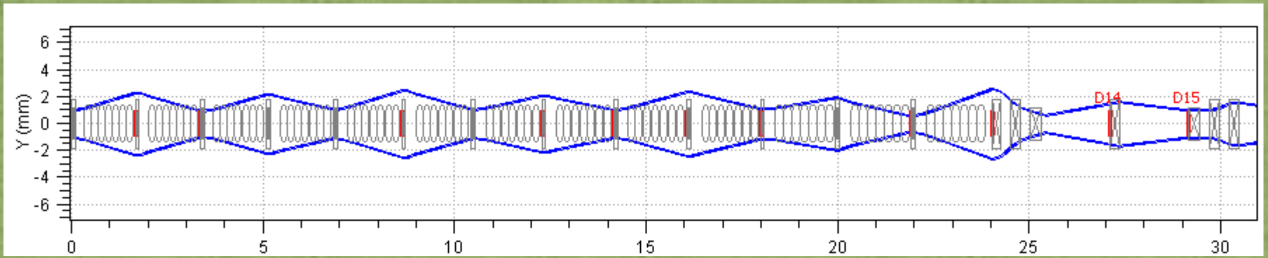
Courtesy of V. Parma

Beam envelopes

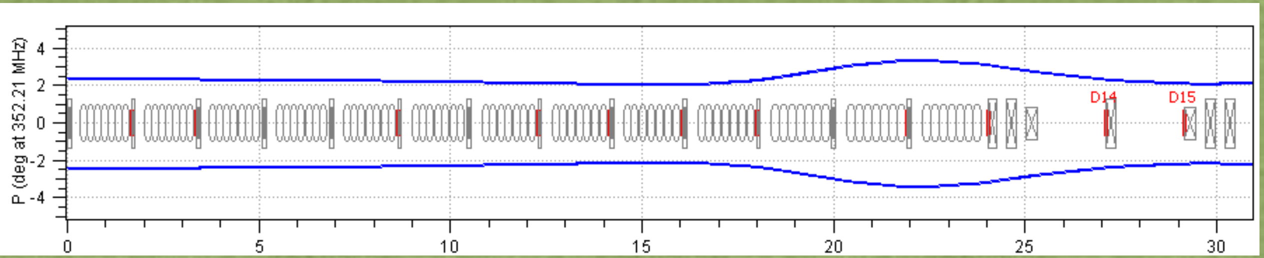
Radius in X (horizontal)



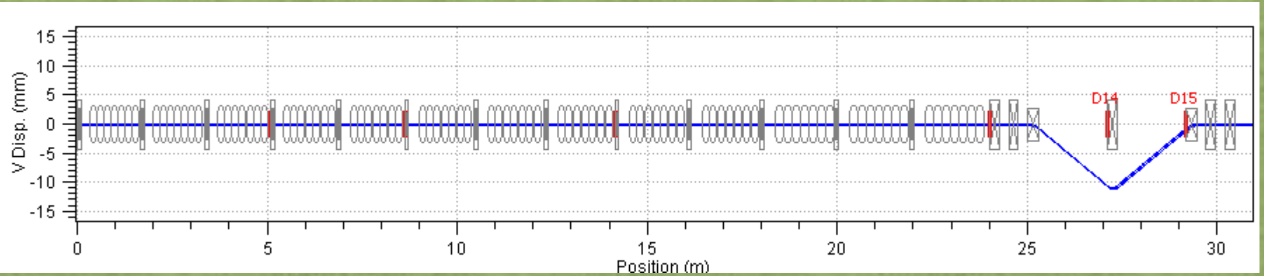
Radius in Y (vertical)



Phase spread

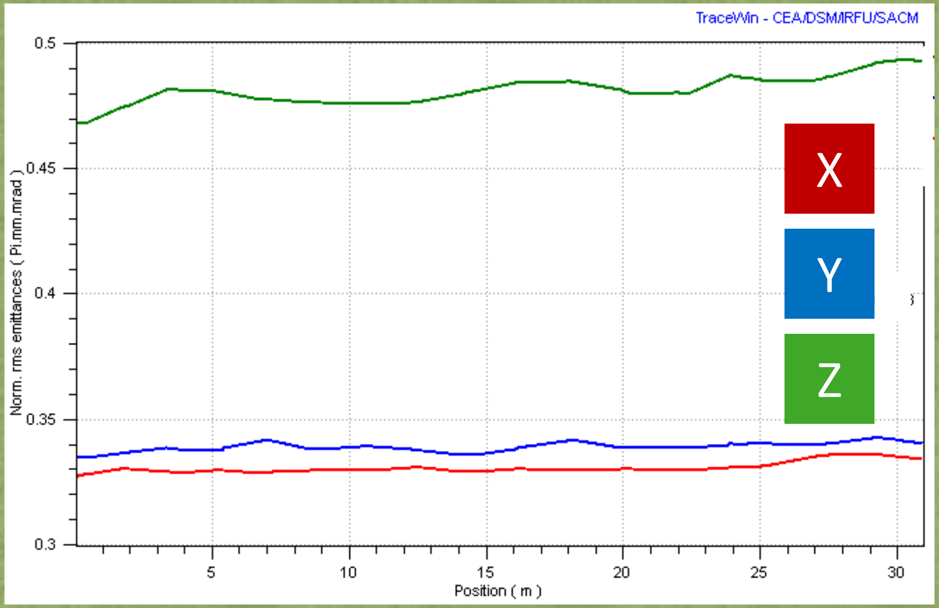


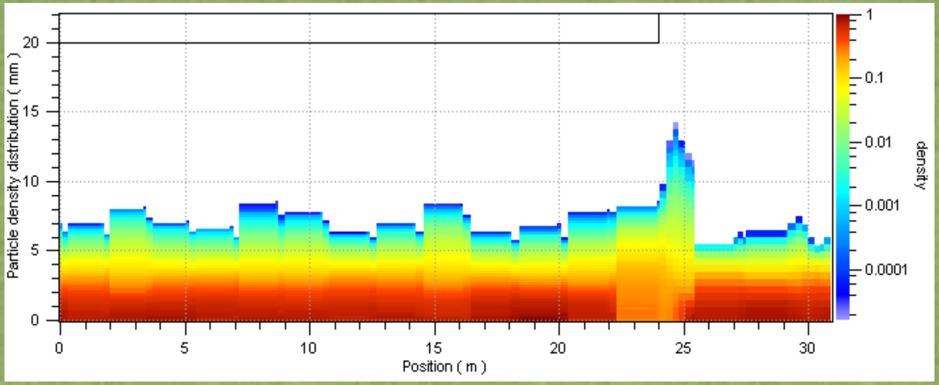
Vertical dispersion



Beam emittance and density

	X	Y	Z
Initial ε (π.mm.mrad)	0.328	0.334	0.468
Final ε (π.mm.mrad)	0.334	0.337	0.493
Δε/ε %	2.00	1.73	5.34



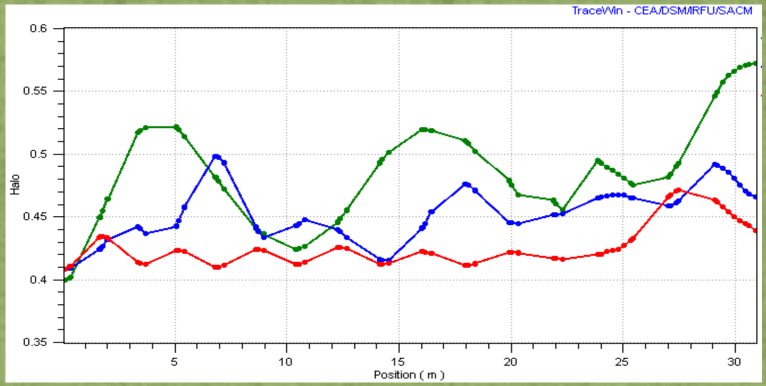


Maximum beam radius at the second quad of doublet right after the extra PIMS module

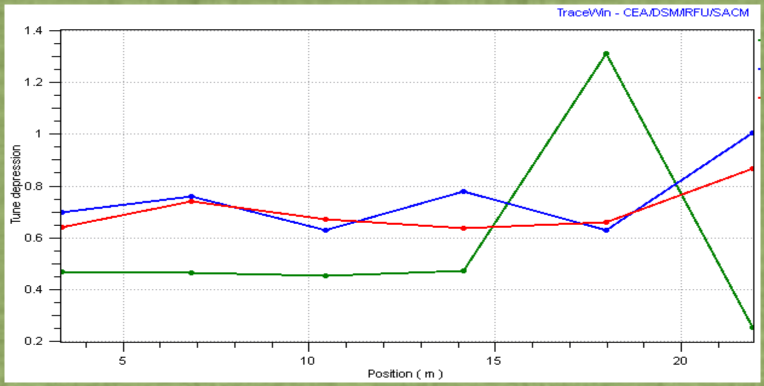
Beam dynamics

sLHC

Halo parameter



Tune depression

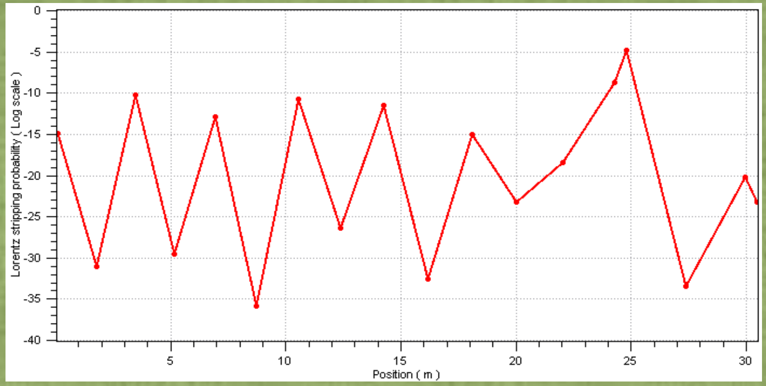


X

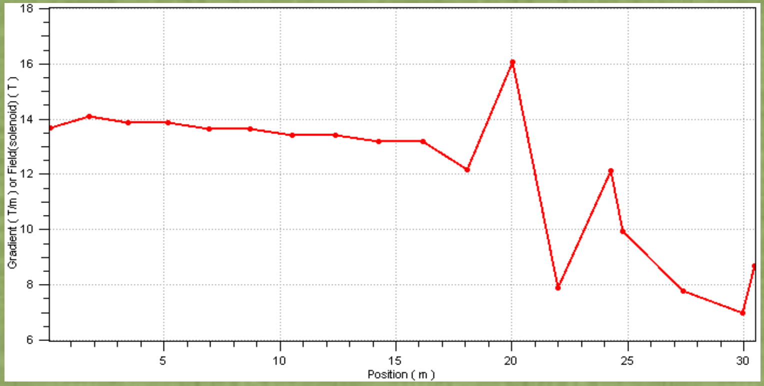
Y

Z

Lorentz stripping probability



Quadrupole gradient (T/m)



Erpør Studies I

For the robustness study of the HEBT, a set of statistical runs were performed including the PIMS.
Error consisted of:

- 0.3 mm, 0.3 mrad uniform error as input beam jitter
- 0.1 mm Gaussian misalignment error on quadrupoles
- 0.5% gradient error on quadrupoles
- + 0.5% error on dipole field error for the study of dispersion

A correction system of integrated steerers inside quadrupoles plus BPMs correct the beam center position.

Erpør Studies II

There were no losses in the simulations.

With respect to the nominal runs, the emittances at the injection point to SPL were

	$\Delta\varepsilon_x$	$\Delta\varepsilon_y$	$\Delta\varepsilon_z$
(Ave±3σ)	0.01±0.83%	0.02±0.38%	0.02±0.43%

Beam jitter, with correction at SPL injection

	X (mm)	Y (mm)	X' (mrad)	Y' (mrad)
(Ave±3σ)	0.1±0.01	0.1±0	0.04±0.12	-0.07±0.2

Erpør Studies III

Dispersion at SPL injection.

In Nominal HEBT $D_V = D'_V = 0$

Ave ± 3σ	Error just on Quads, w or w/o steerers	Just Bending field error	Error on Quads and Bends
D (mm)	-0.01 ± 0.32	1.50E-4 ± 2.17E-4	0 ± 0.34
D’ (mrad)	0 ± 0.11	6.11E-5 ± 2.13E-5	0 ± 0.11

For a dispersive bend D = -39.8 mm, and D’ = 13.0 mrad.

Conclusion

It is possible to deliver beam to PS booster during SPL commissioning.

An achromatic non-stripping bend is deigned for LINAC4-SPL integration.

Beam quality does not degrade in the line due to errors.

Dispersion due to the quadrupole gradient error is more important than the effect due to the error on the dipole field.