Linac4 Beam Characteristics

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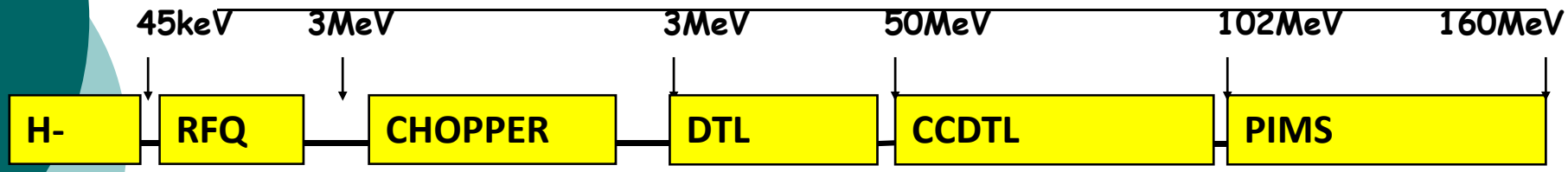
Nominal LINAC4 beam at the PSBooster

Generation of energy modulation

Tunability and uncertainties

Linac4 Layout



RF volume source (DESY) 45 kV 1.9m LEBT	Radio Frequency Quadrupole 352 MHz 3 m 1 Klystron 0.6 MW	Chopper 352 MHz 3.6 m 11 EMquad 3 cavities	Drift Tube Linac 352 MHz 18.7 m 3 tanks 3 klystrons 4 MW 111 PMQuad	Cell-Coupled Drift Tube Linac 352 MHz 25 m 21 tanks 7 klystrons 6.5 MW 24 EMQuads	Pi-Mode Structure 352 MHz 22 m 12 tanks 8 klystrons ~12 MW 12 EMQuads

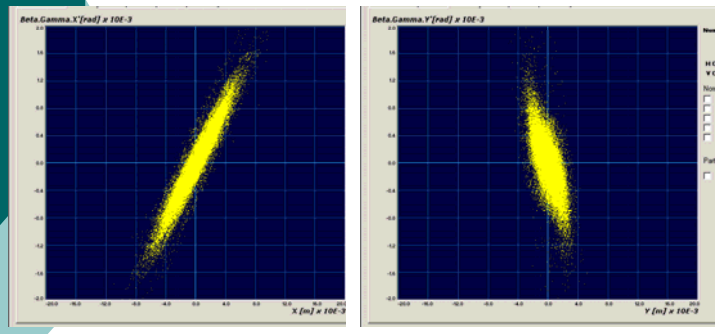
Total Linac4:
80 m,
19 klystrons

RF Duty cycle:
0.1% phase 1 (Linac4)
3-4% phase 2 (SPL)
(design: 10%)

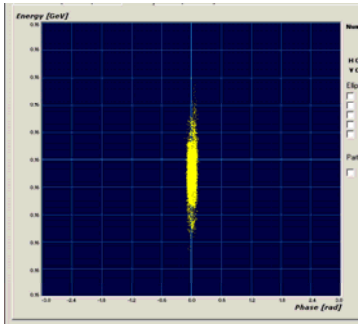
4 different structures,
(RFQ, DTL, CCDTL, PIMS)

Ion current: 40 mA (avg. in pulse), 65 mA (bunch)

Beam OUT of Linac4



Transverse phase space ,
scale: 20 mm X 2 mrad



Longitudinal phase space ,
scale 1 MeV X 180 deg at 352 MHz

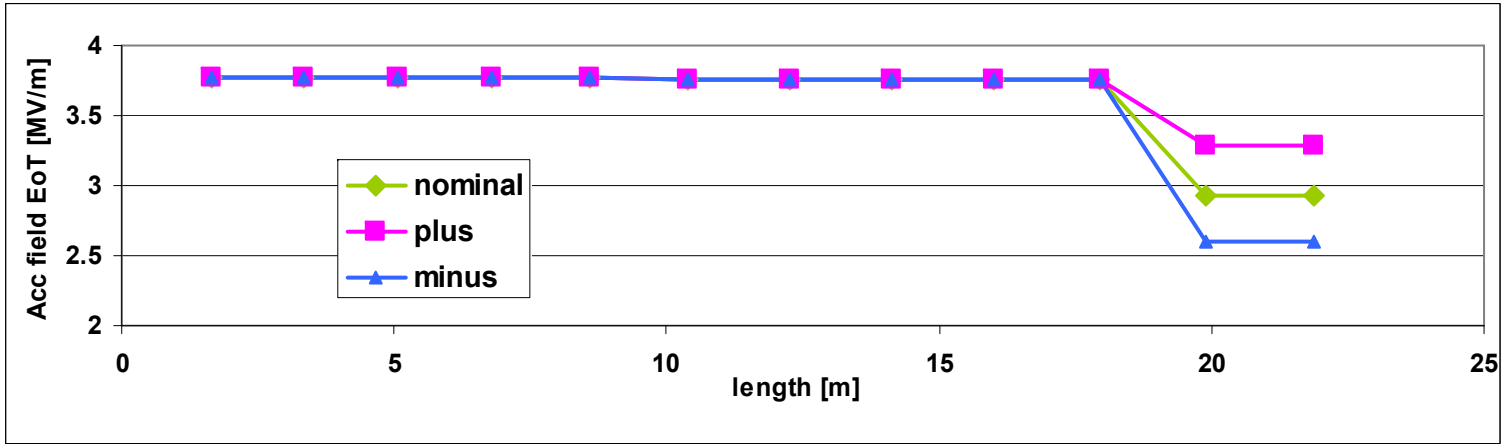
NB : betalambda = 440 mm ,
beam is 3 mm long

Beam pulse length = 400 µsec
Repetion rate = 1 Hz
Microbunch freq. = 352 MHz (2.8 nsec)
Current per microbunch = 65mA
Current per pulse = 40 mA (chopping)
Transverse emitt =0.35 µm
Energy = 159MeV (±1MeV modulation)
Energy spread rms = 80 keV
Energy jitter 1 σ = 78 keV (assuming 0.5deg 0.5% klystron stability)

Energy modulation

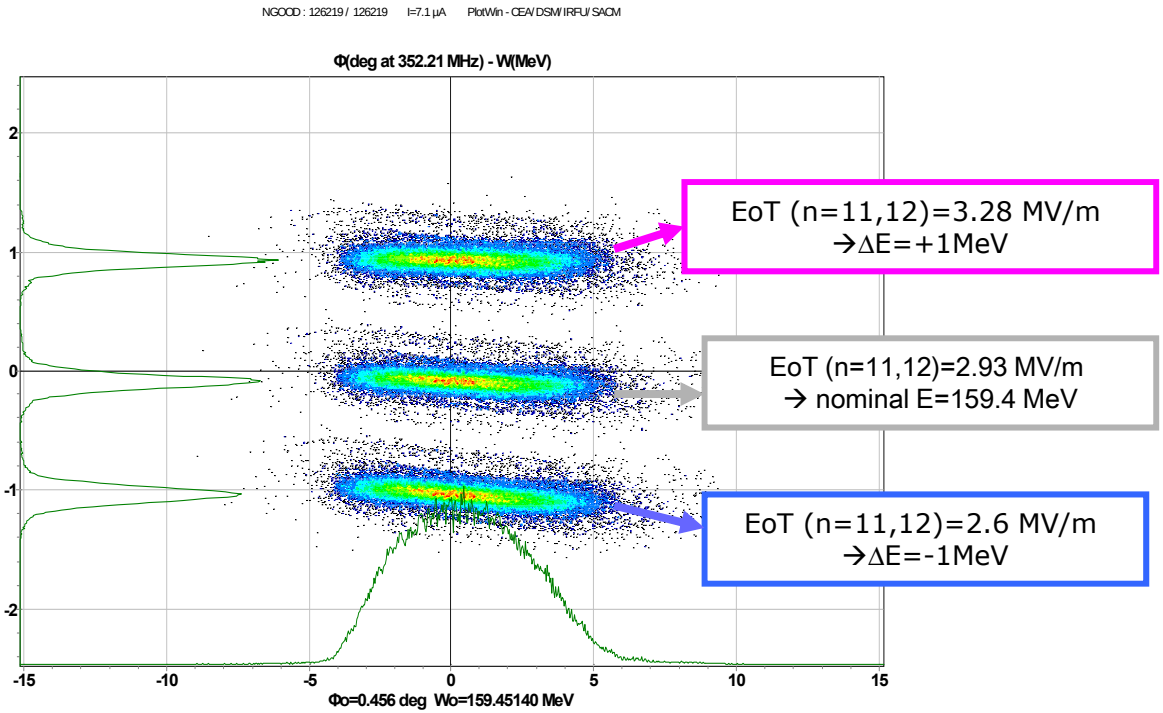
PSBooster asked for a linear energy variation over 10 + 10 μsec (20 turns) to better fit the 100 μsec pulse to the booster bucket

The field in the last two tanks of the PIMS is linearly increased /decreased from 2.6 to 3.28 MV/m over 20 μsec to vary the beam energy by ± 1MeV /160 MeV



Nominal field in the 1 tanks of the PIMS structure (100-160 MeV)

Energy modulation

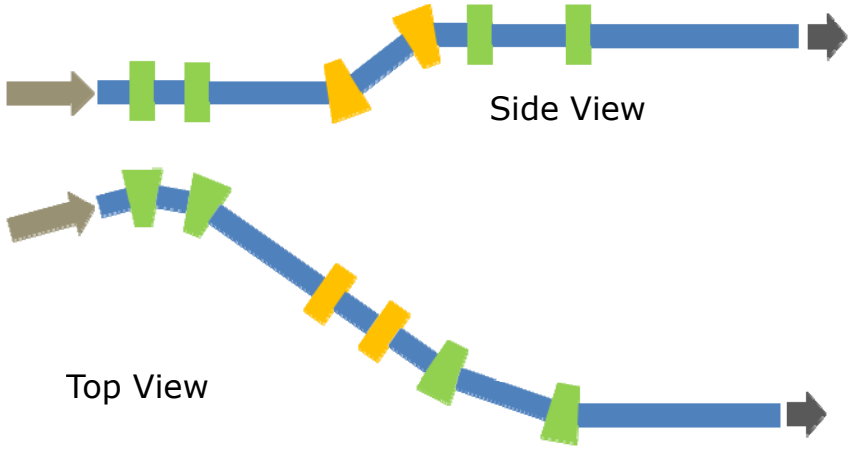


Longitudinal phase space at LINAC4 output for nominal and extreme setting of the last PIMS tank.

The beam transverse and longitudinal phase space is practically identical in the three cases

Transfer line to the booster

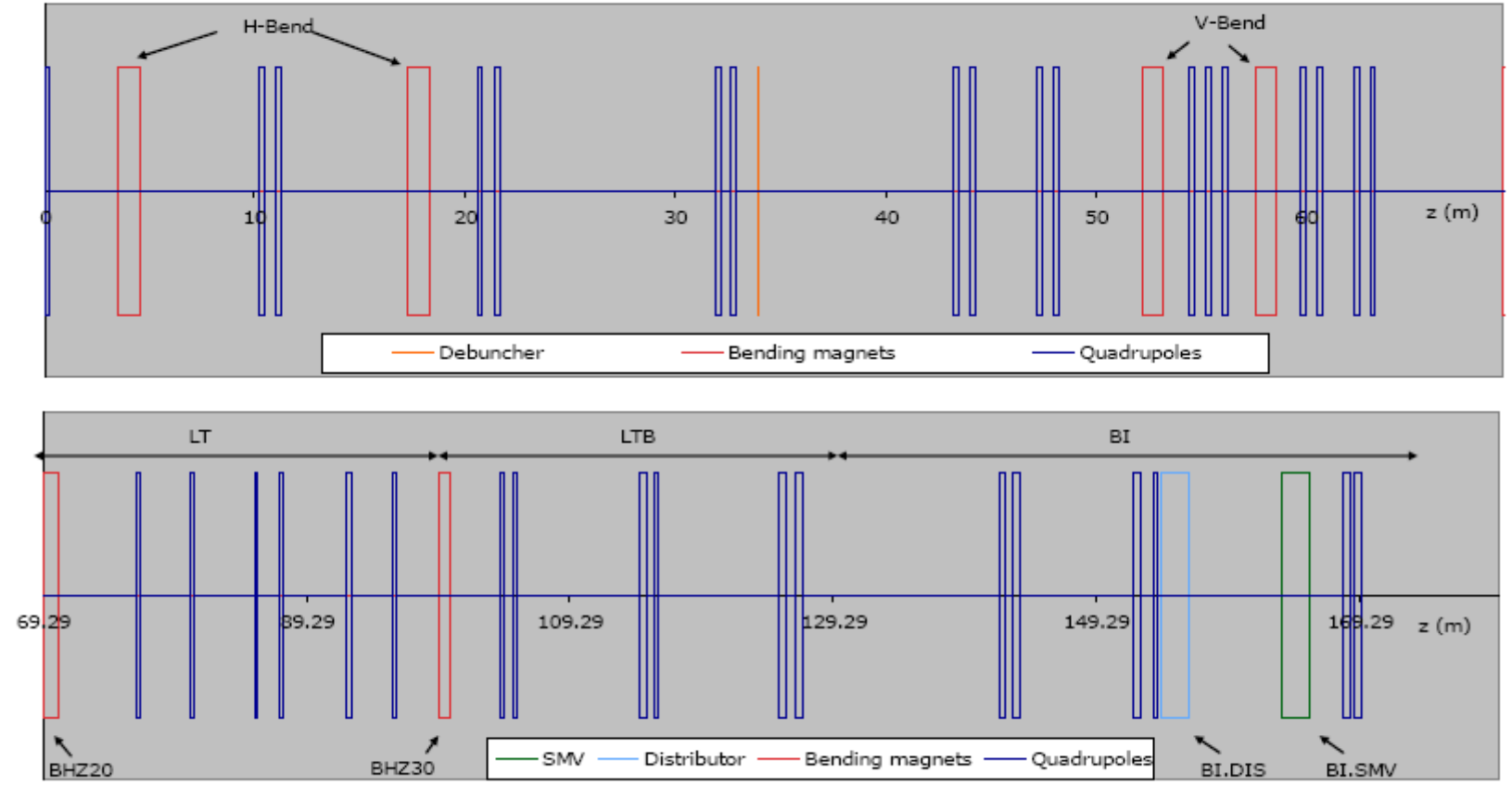
About 170 meter long
New part : 70 m , debuncher (0.7MV), 17 quads and 4 bends (35deg H, 28 deg V)
Existing line : 100 m, 18 quads and 2 bends (22 and 24deg), distribution system.



Beam dynamics Issues :

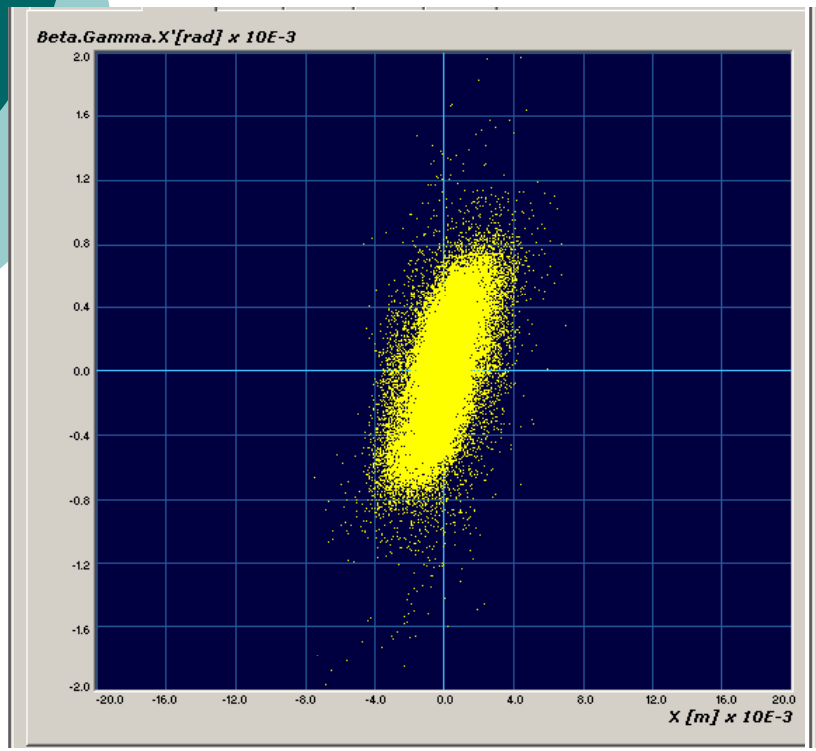
1) space charge with dispersion
2) uncompensated space charge forces (increase of energy spread)
3) limited aperture in distributor and septum (50 x 25 mm ; 15 X 34 mm)

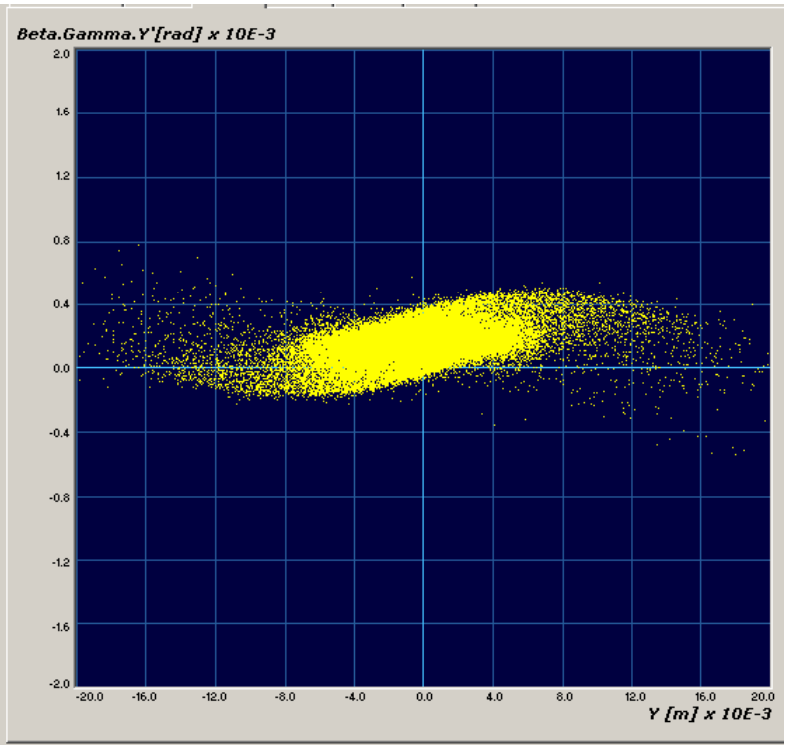
Transfer line to the booster



Nominal beam at the injection foil

Transverse Phase planes , scale 20 mm X 2 mrad

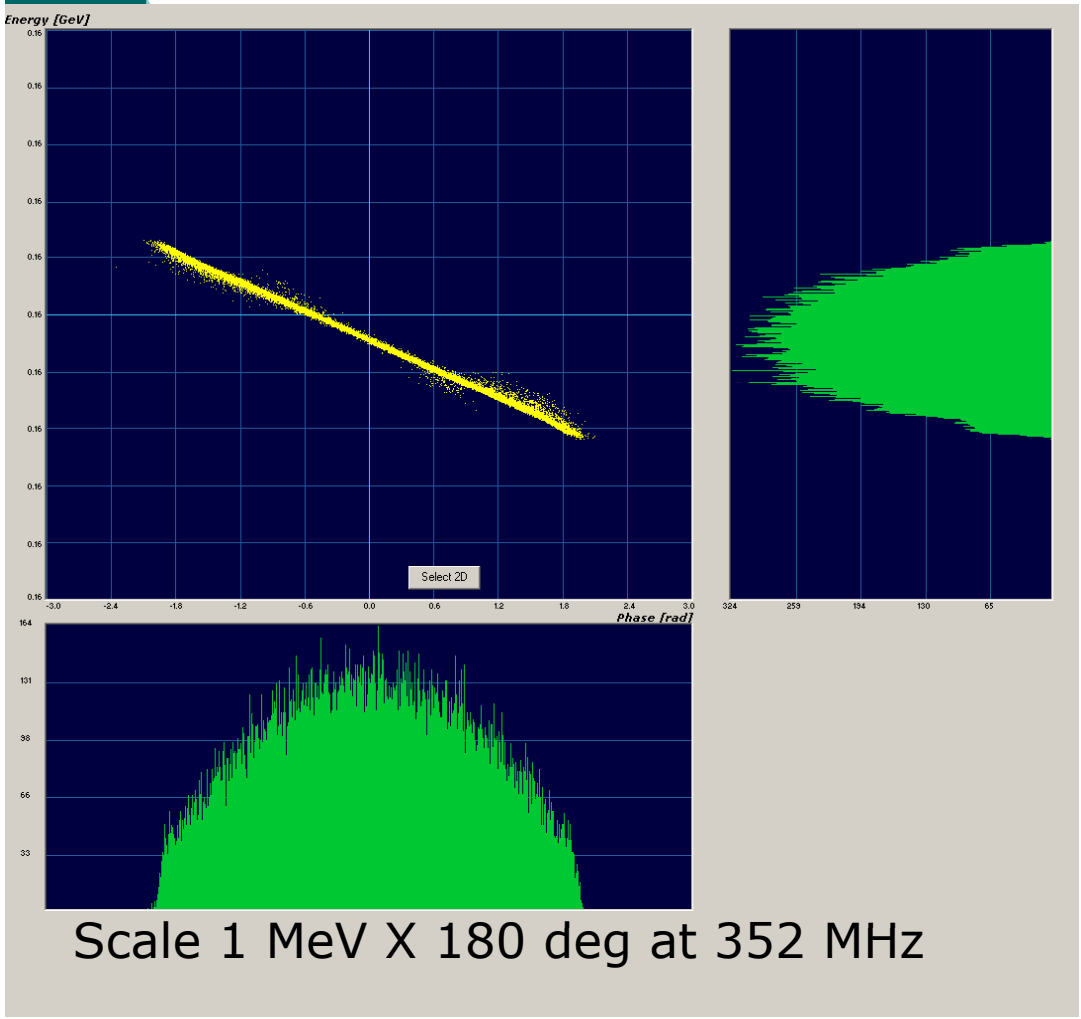




Alpha=-0.4
Beta = 3 m
Emittx =0.39 μm

Alpha=-0.8
Beta = 23 m
Emitty = 0.45 μm

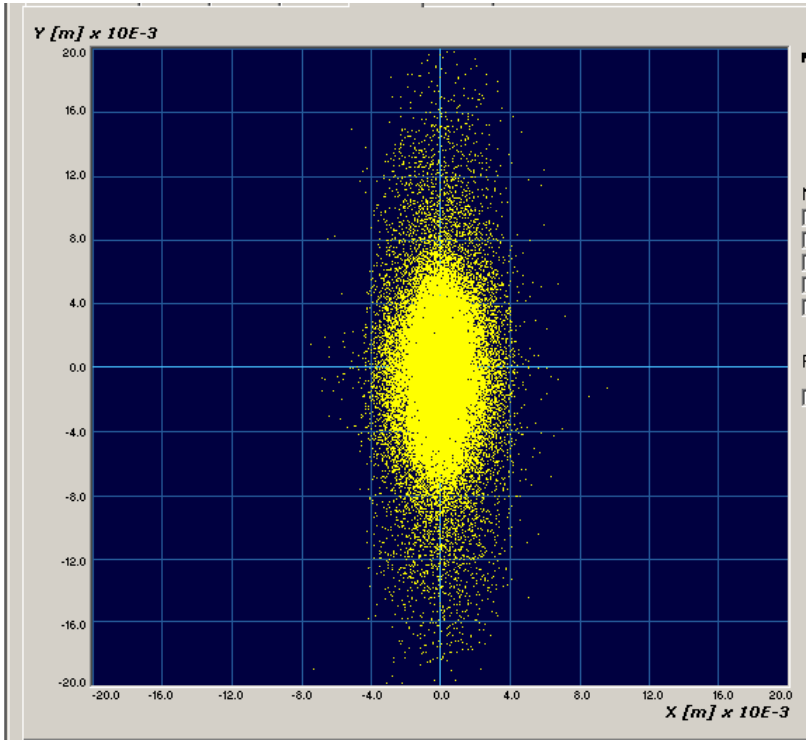
Longitudinal Plane at the injection foil



Scale 1 MeV X 180 deg at 352 MHz

Current per microbunch = 65mA
Current per pulse = 40 mA (chopping)
Transverse emitt =0.4 μm
Energy = 159MeV (±1MeV modulation)
Energy spread rms = 160 keV
Energy jitter 1σ = 20 keV

Nominal beam at the injection foil



scale : 20 mm X 20 mm

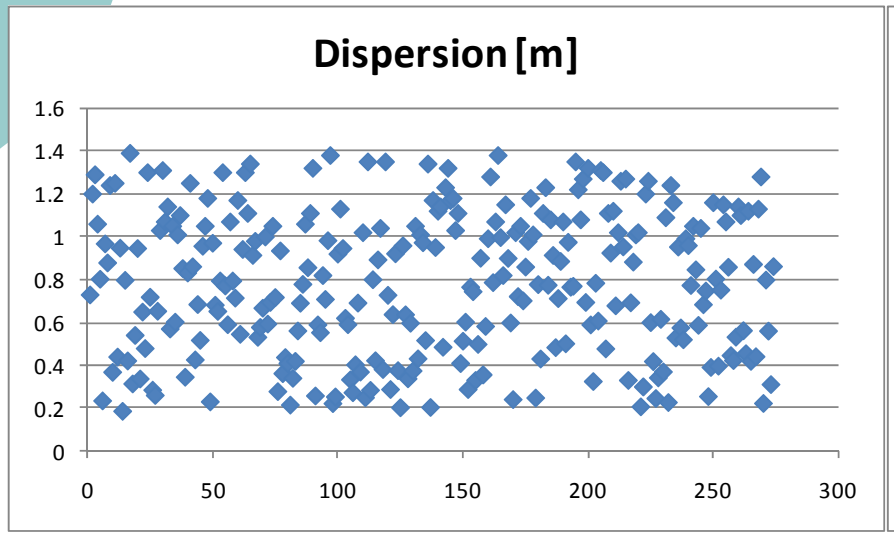
Beam transverse size rms = 1.4 x 4.3 mm

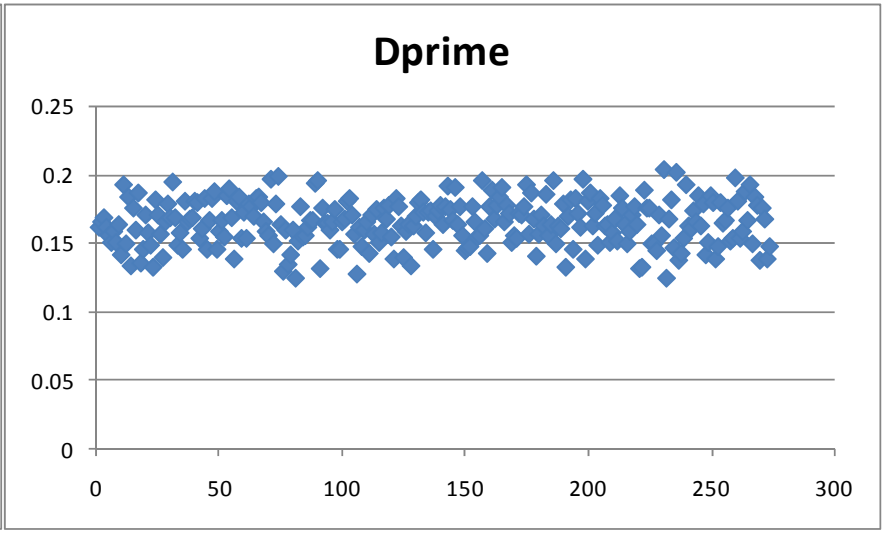
Dispersion = -1.4 m

Jitter in x position 1 σ = 0.1 mm

Tunability - Dispersion

Dispersion at BHZ40 (handover point) when varying QFN50 QDN55 QFN60 QDN65 QFW70 QDN75 by 10% Randomly around their nominal value



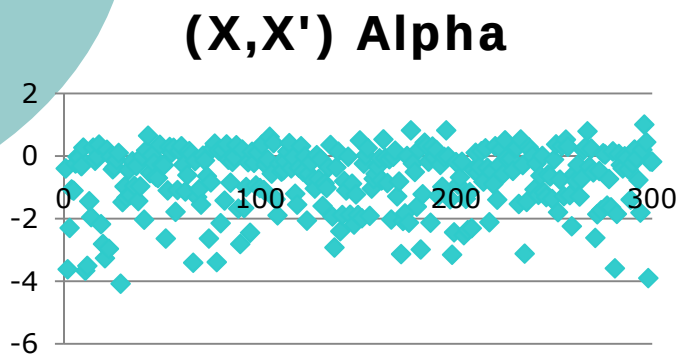


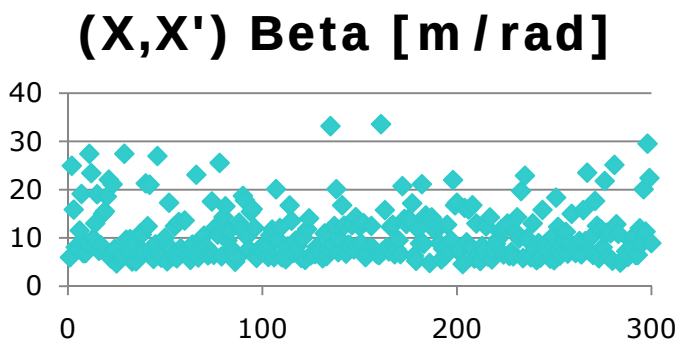
In all cases :

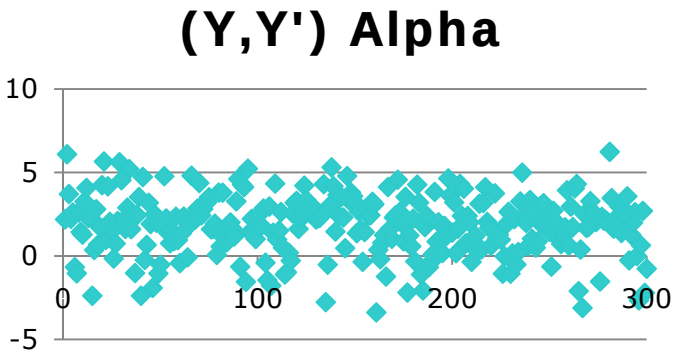
- Emittx,y increase is limited to 5%
- Full transmission

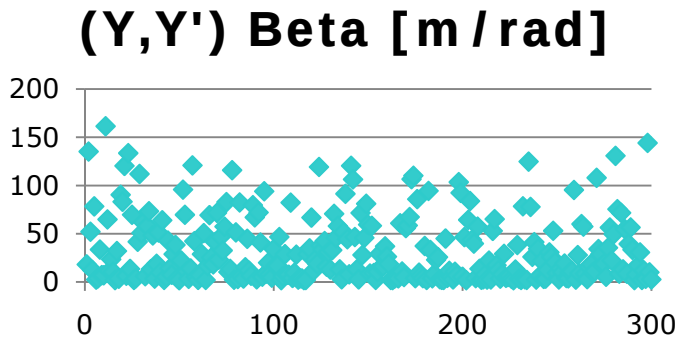
Tunability – alphas and betas

Transverse alphas and beta at BHZ40 (handover point) when varying QFN10 QDN20 QFW30 QDW40 QFW50 QDW60 by 10% Randomly around their nominal value









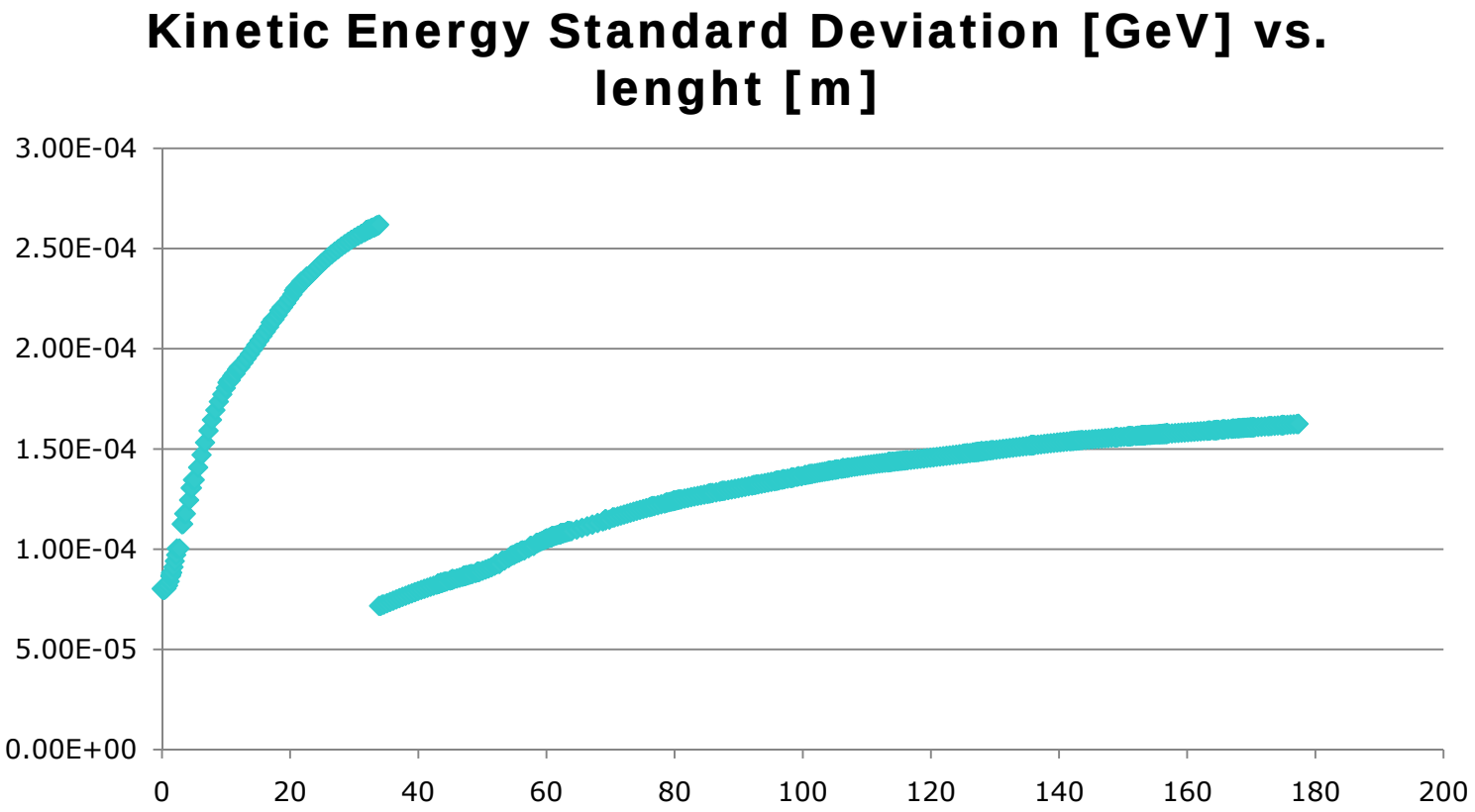
In all cases :

- Emittx,y are constant
- Full transmission
- Dispersion almost unchanged

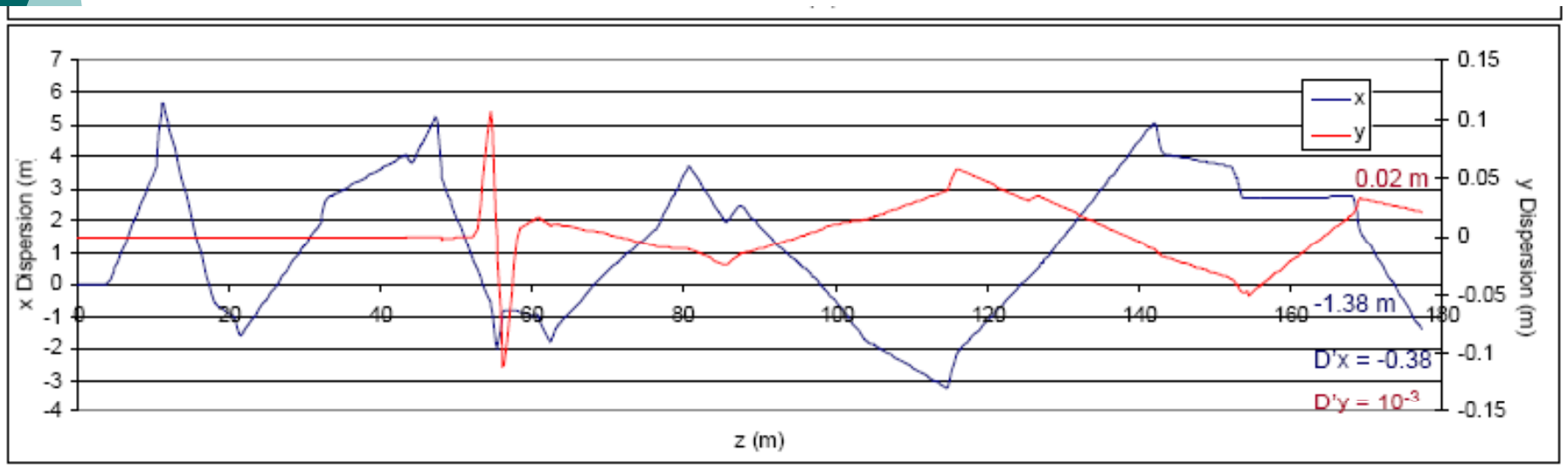
Conclusions

- The beam from LINAC4 can be successfully transported and matched to the PSB
- Optics parameters in the injection region can be tuned in a sufficiently (?) wide range
- A lower current, higher emittance and a higher energy jitter should be expected during initial operation.

Reserve-energy spread in TL



Reserve – dispersion in TL



Reserve-emittances in LINAC4