Linac4 commissioning

Transverse emittance measurement strategy

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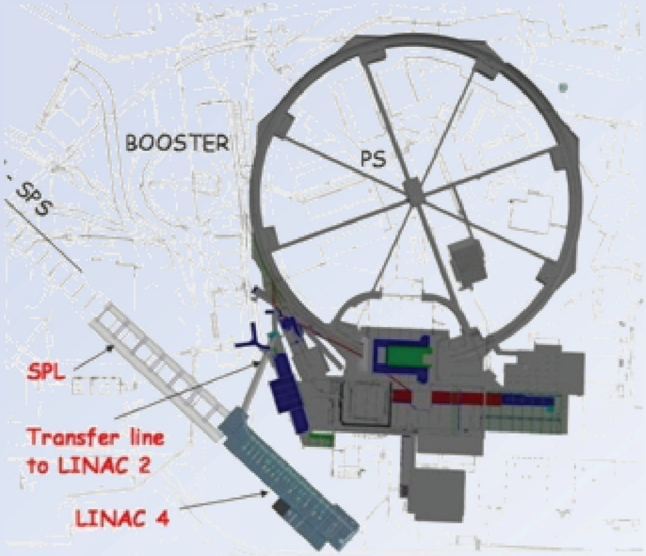
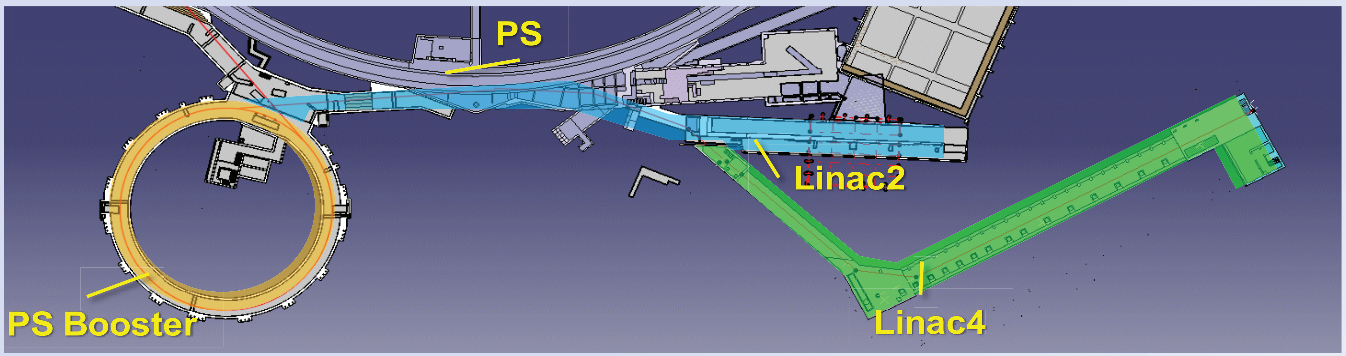
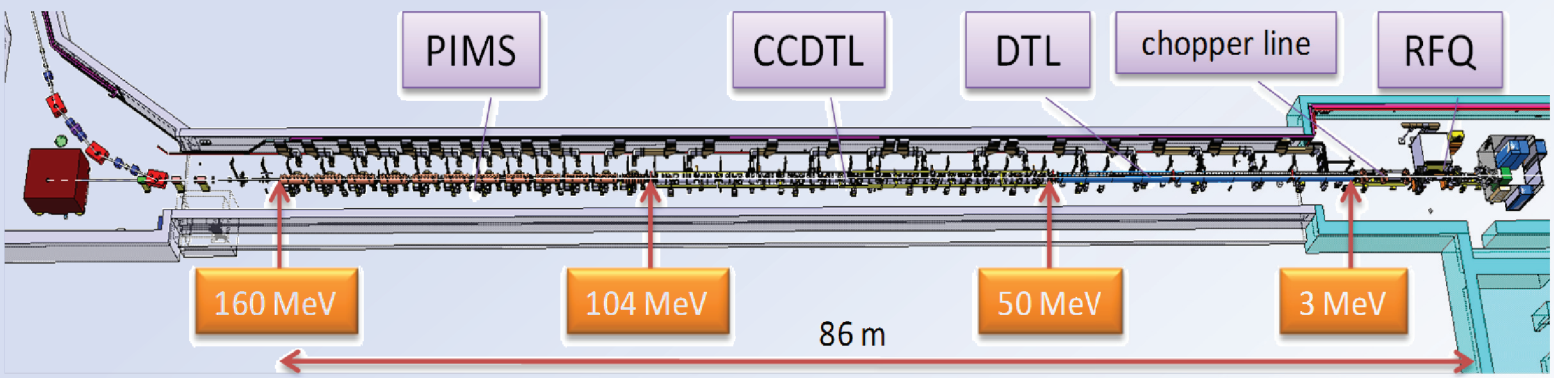


Linac4 Layout

- A new 160 MeV H^- ion linac, injector of PS Booster.

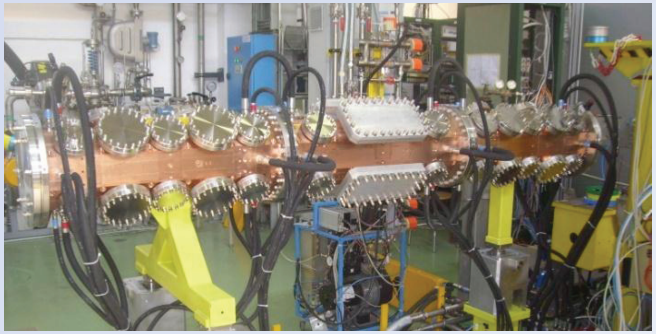


65 mA
352.2 MHz
1.1 Hz
400 μs



Linac4 present status

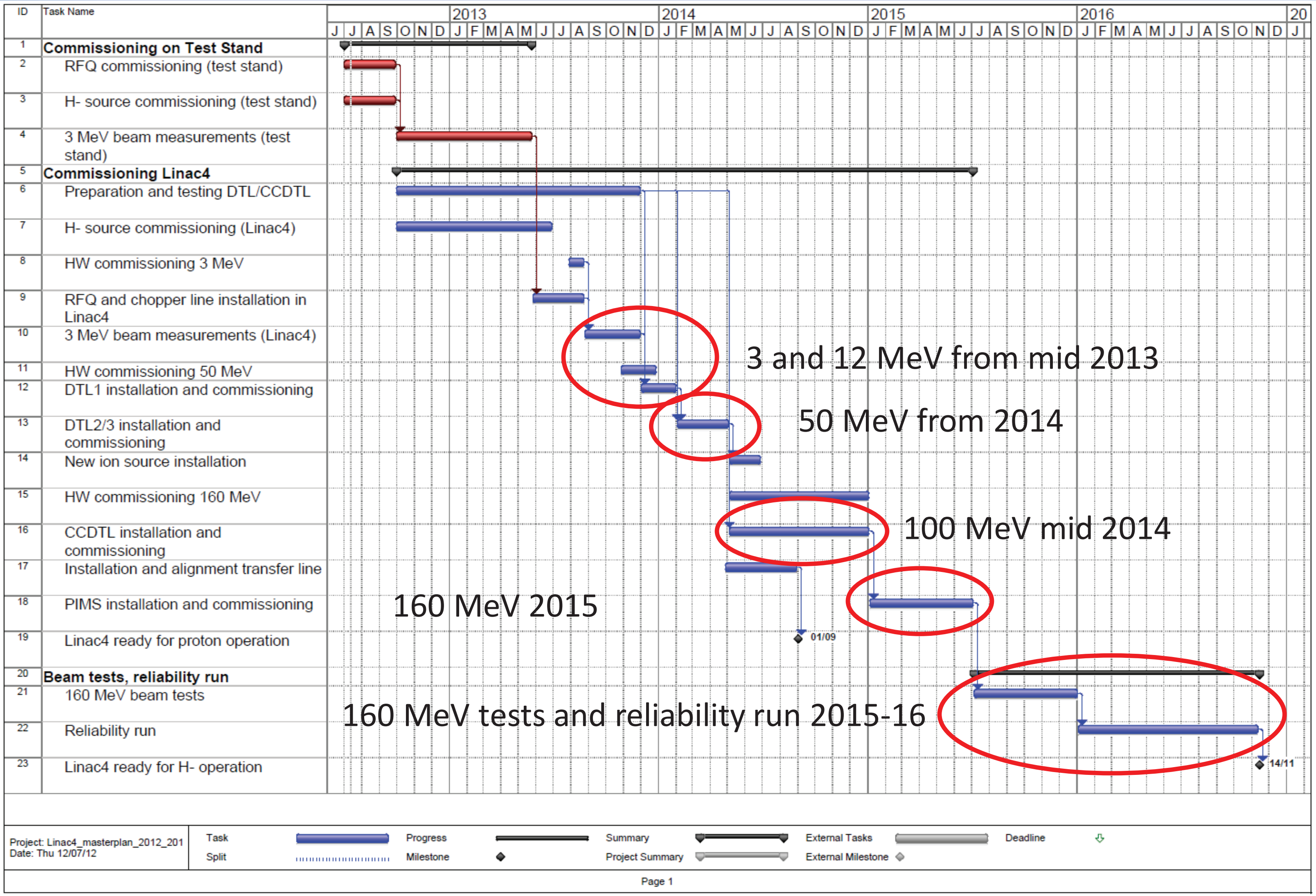
- H- source presently under commissioning.
- RFQ delivered, RF bead-pulls performed.
- DTL, Tank1 assembled.
- First CCDTL modules delivered in October.
- PIMS modules ready from next year.
- Tunnel ready for machine installation.



Linac4 commissioning plans

- Commissioning will start next year and will be divided into 6 stages
  - Stage1: 3MeV test stand. Commissioning of the source, LEBT, RFQ and MEBT in the PS south hall.
  - Stage2: Re-commissioning of the 3MeV line in the tunnel.
  - Stage3: First DTL tank (12 MeV).
  - Stage4: DTL tank 2&3 (50 MeV).
  - Stage5: CCDTL (100 MeV).
  - Stage6: PIMS (160 MeV).

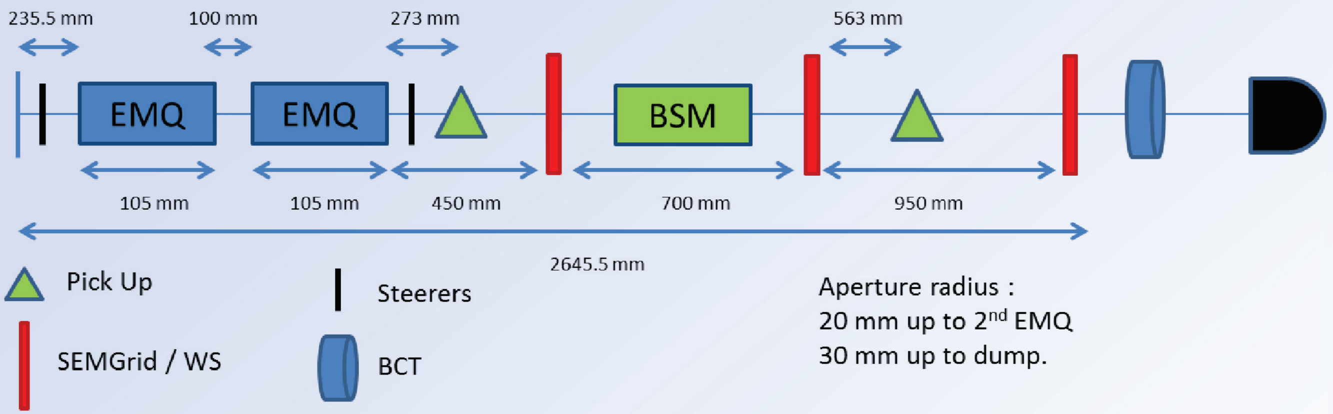
Commissioning Planning



Emittance measurement

- Low energies, up to 12 MeV
  - Low penetration depth
  - Low activation
  - ➢ Use of an emittance-meter : Slit-Grid

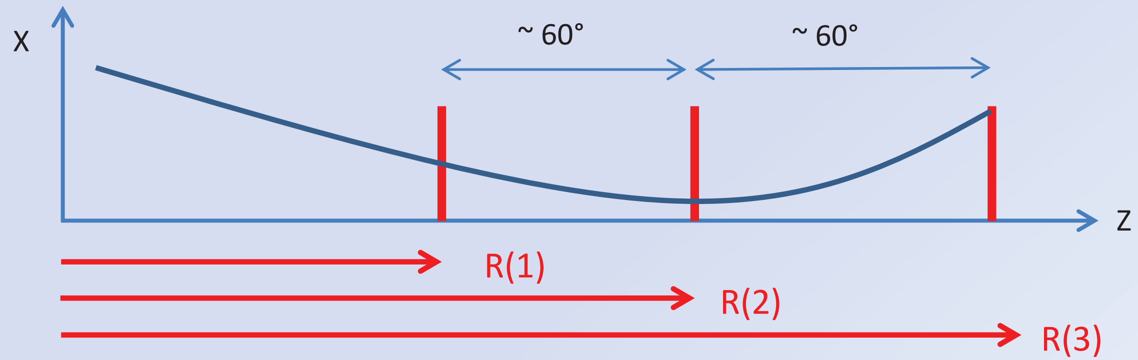
- High energies, 30, 50, 100 and 160 MeV
  - Three monitor method
  - Space charge to be taken into account…

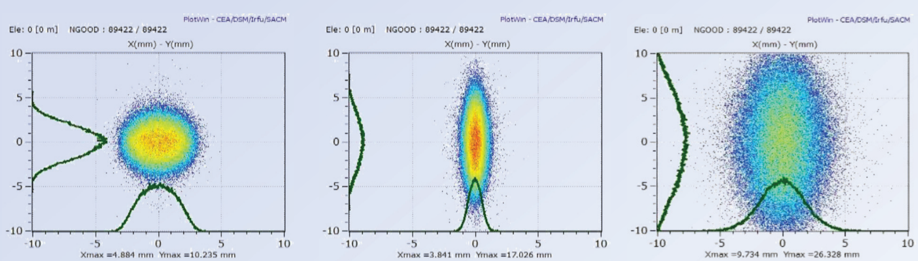


The « Forward Method »

- 1[st] step: No space charge included, the classical 3 monitor method

$$\sigma = \begin{pmatrix} x_m^2 & x_e x_m' \\ x_e' x_m & {x_m'}^2 \end{pmatrix} = \epsilon \begin{pmatrix} \beta & -\alpha \\ -\alpha & \gamma \end{pmatrix} \qquad R = \begin{pmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{pmatrix} \qquad \sigma(L) = R * \sigma(0) * R^T$$





$$x_{monitor1}^2 = \sigma_{11}(1) = R_{11}^2(1)\epsilon\beta - 2R_{11}(1)R_{22}(1)\epsilon\alpha + R_{12}^2(1)\epsilon\gamma$$

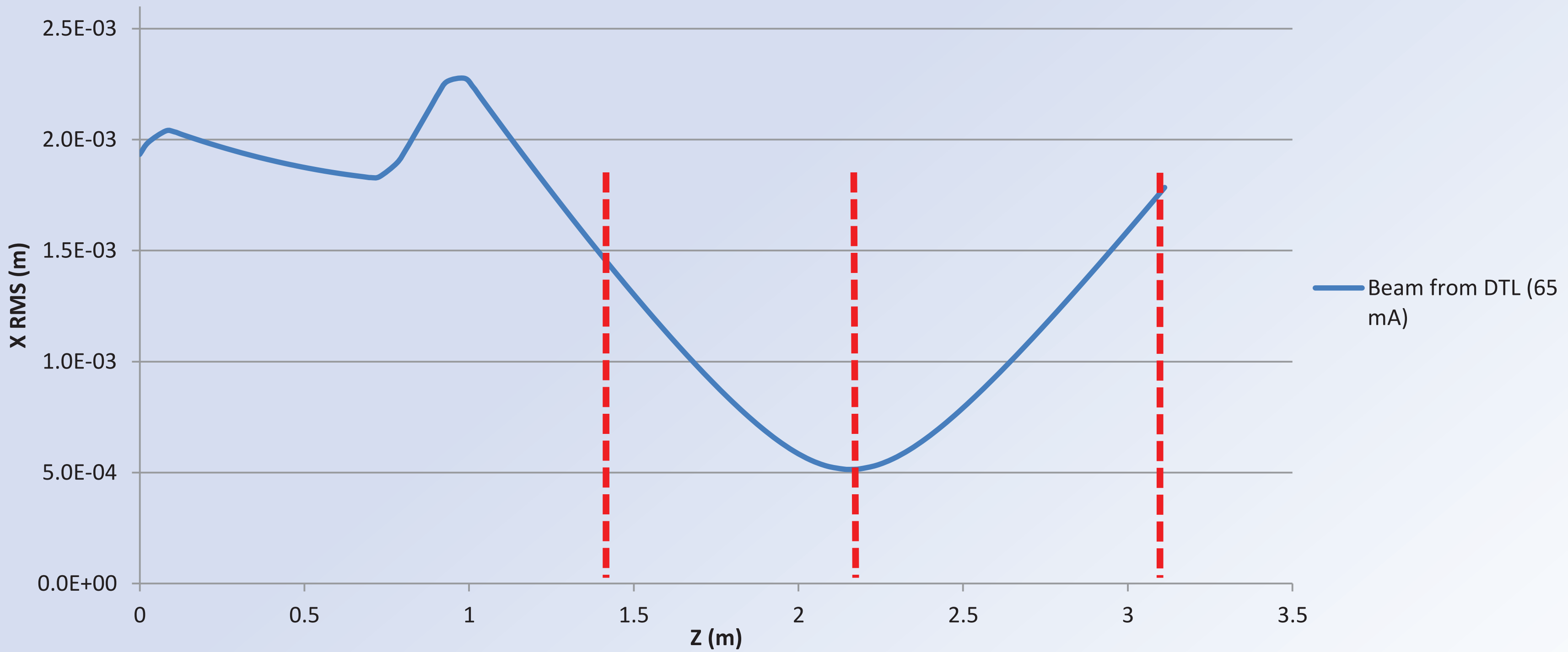
$$x_{monitor2}^2 = \sigma_{11}(2) = R_{11}^2(2)\epsilon\beta - 2R_{11}(2)R_{22}(2)\epsilon\alpha + R_{12}^2(2)\epsilon\gamma$$

$$x_{monitor3}^2 = \sigma_{11}(3) = R_{11}^2(3)\epsilon\beta - 2R_{11}(3)R_{22}(3)\epsilon\alpha + R_{12}^2(3)\epsilon\gamma$$

The « Forward Method »

- 1st step: No space charge included, the classical 3 monitor method

@ DTL output, 50 MeV.



The « Forward Method »

- 1st step: No space charge included, the classical 3 monitor method

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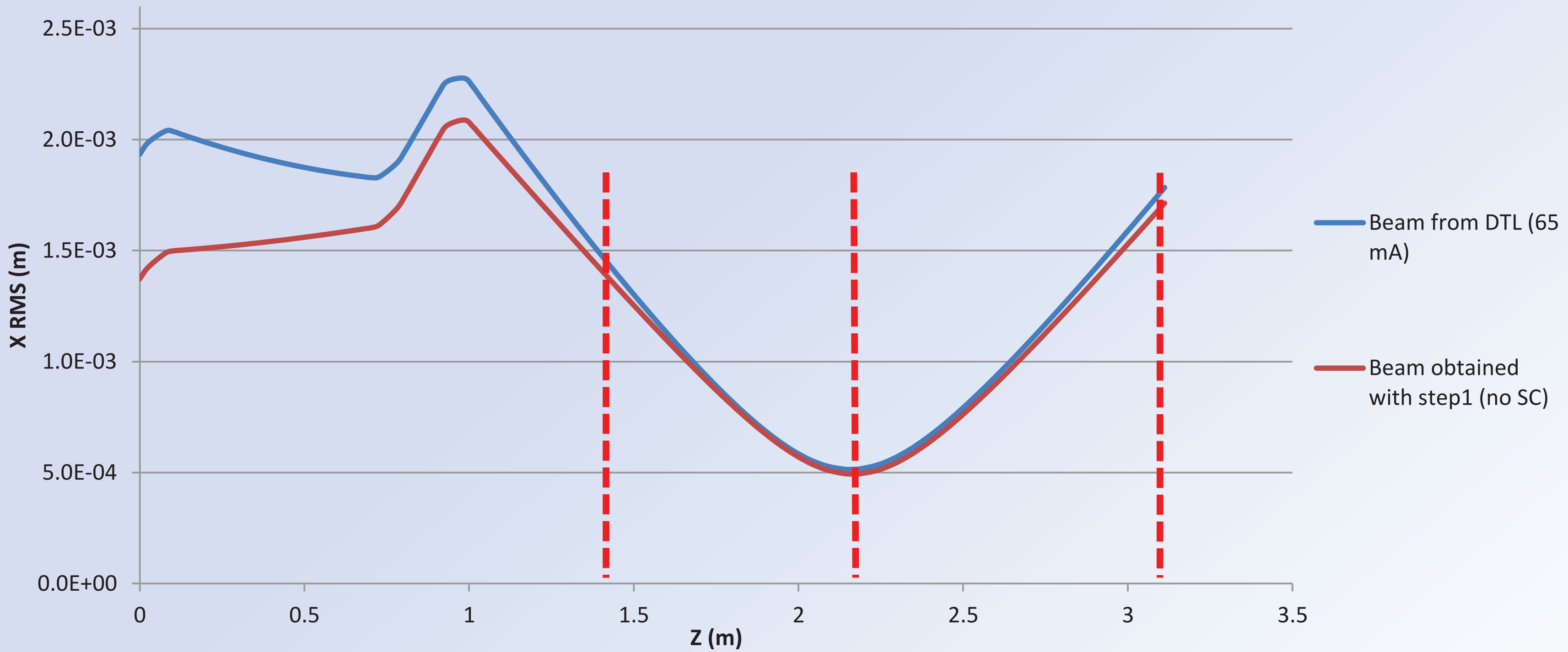
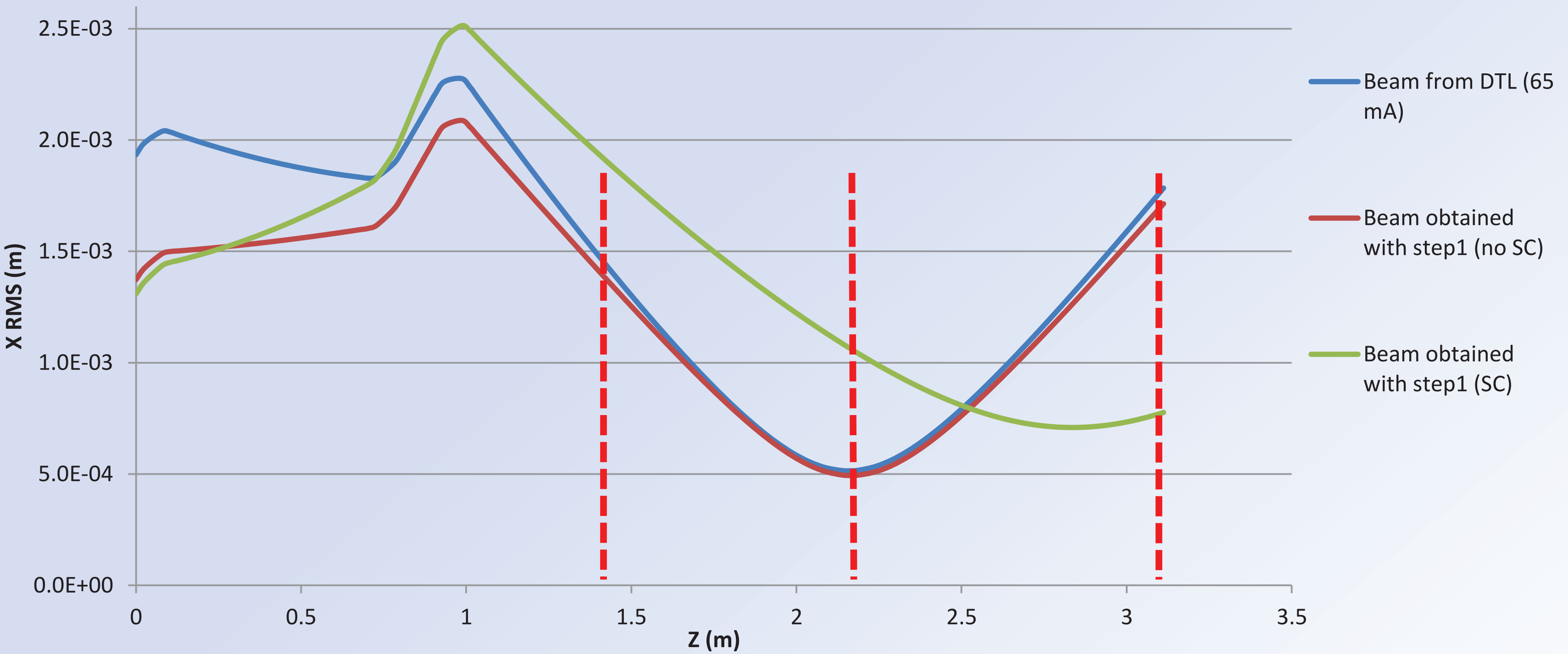


The « Forward Method »

- 1st step: No space charge included, the classical 3 monitor method

@ DTL output, 50 MeV.

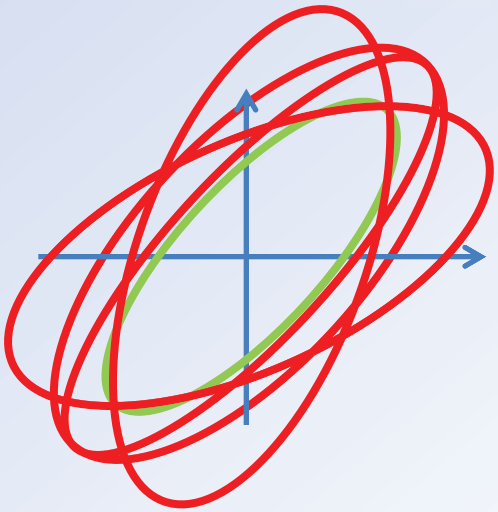


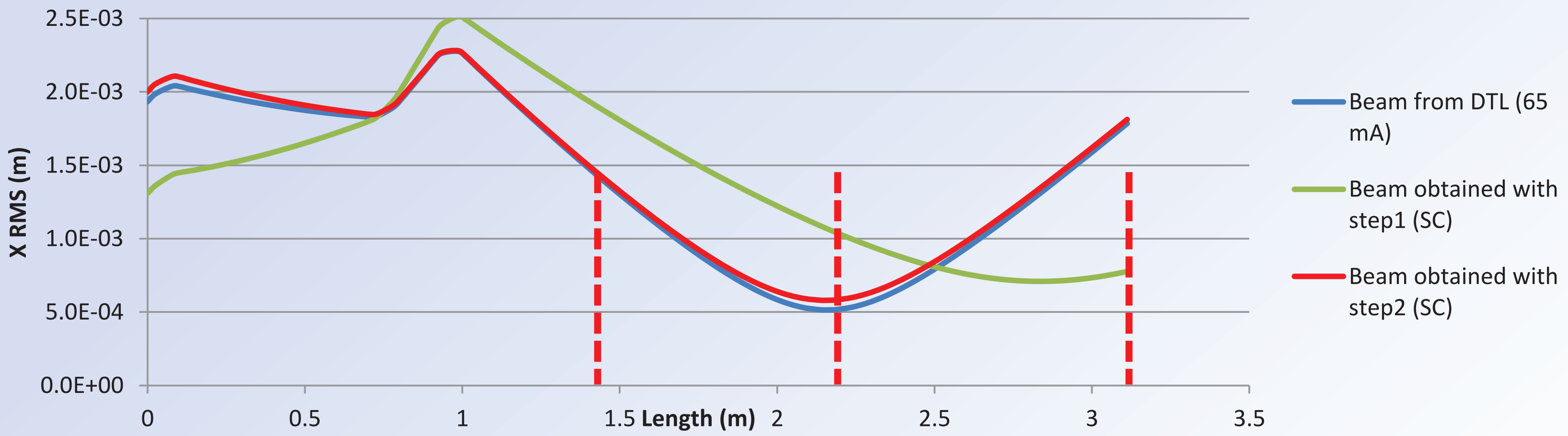
Need to include space charge forces in the calculation !!!

The « Forward Method »

- 2^{nd} step, Including space charge, iterative process with particle tracking code.

- Generate a beam distribution file for a multiparticle tracking code, with parameters found at step 1.
- Assume a longitudinal distribution (simulations and BSM).
- Launch a series of statistical runs of the measurement line by varying the beam input transverse parameters (α, β, ϵ) at each run.
- At each run, simulated beam size at the monitor locations is compared to measured values to get a convergence criteria.

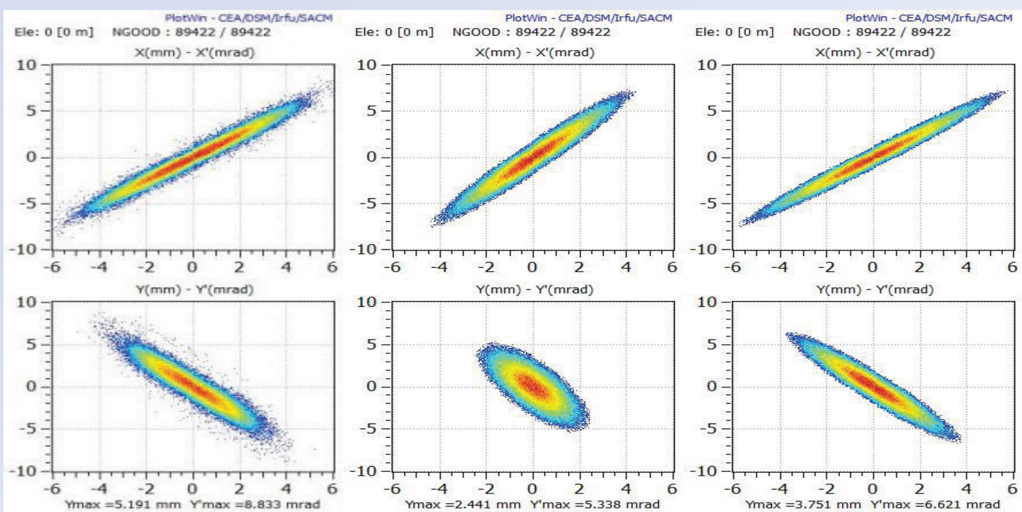




The « Forward Method »

- DTL emittance reconstruction at 50 MeV.

Twiss parmeters	From beam distribution	3 monitors method No space charge	Forward method
α_x	-5.51	-3.67	-5.61
β_x (mm/mrad)	4.38	2.22	4.57
ϵ_x Norm. rms. (mm.mrad)	0.28	0.30	0.29
α_y	2.77	1.03	2.95
β_y (mm/mrad)	1.69	0.66	1.78
ϵ_y Norm. rms. (mm.mrad)	0.29	0.32	0.29



Summary

- We have developed and validated a method for the transverse emittance reconstruction in a space charge dominated regime that we will apply during the Linac4 commissioning.

- The method is based on multiparticle tracking codes and its key point is the generation of the beam distribution in the 3 phase spaces.

- Constraints are :
  - 3 monitor measurement conditions.
  - Knowledge of the longitudinal plane distribution.
  - Choice of the transverse distribution types.