XLS start-2-end Simulations
S-Band Based Injector

Edu Marin[1], R. Munoz Horta[1]
emarin@cells.es

[1]CELLS, Barcelona, Spain

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WP6: Beam Dynamics

Injector Road Map, INFN

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Inputs

- User's Input
- New Module Configurations
- Injector Distribution (S-Band)

XLS New Design

- Twiss Functions
- 6-D Tracking Results

Monte-Carlo Studies

- Tuning Framework
- Tuning Results

Conclusions

XLS Requirements

Lattice Constraints

User's Input:

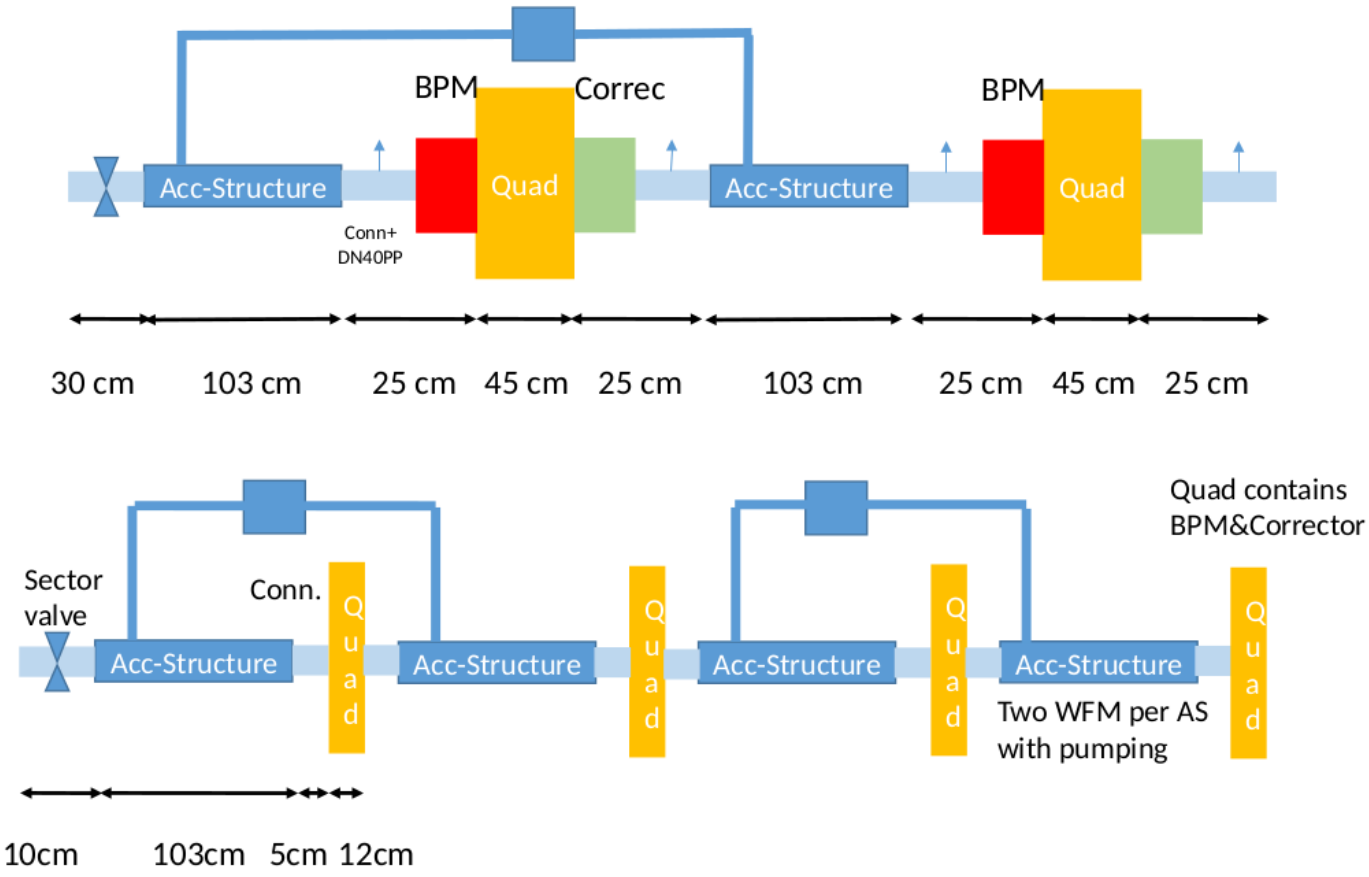
- Design a lattice which delivers e^{-} *beams* with peak currents of 5 *kA*
- Beam energy @*L2* ranging from 2.75 *GeV* to 5.5 *GeV*

- Acc. Structures will run at high and low gradients
  - high gradient **HG= 65** MeV/m
  - low gradient **LG= 20** MeV/m

From beam dynamics (consensus):

- Beam energy at exit of L0 should be 300 *MeV*
- Beam energy at exit of L1 should be 1 *GeV*

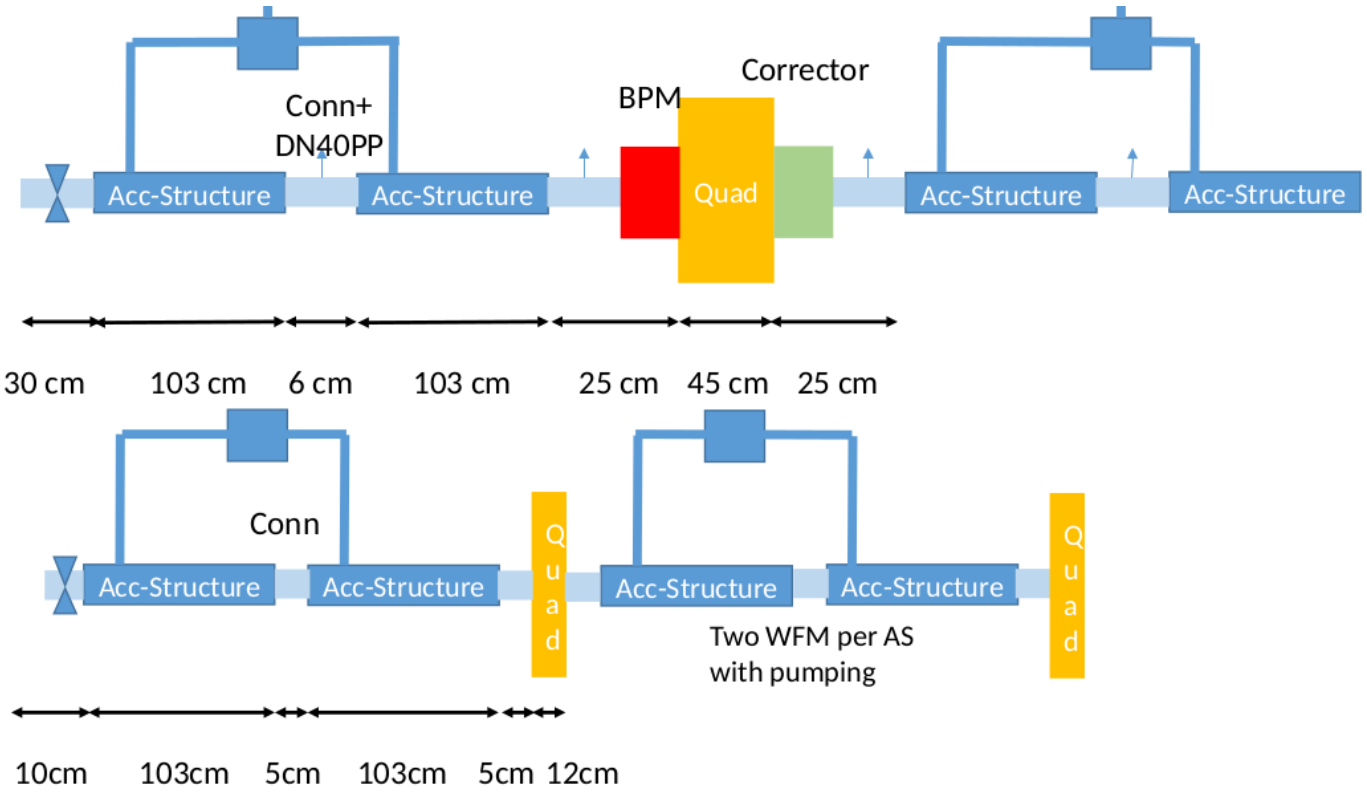
L1 New Module Configuration



RF Fill Factor increased from 42% to 71%*

** Provided by M. Aichelar*

L2 New Module Configuration

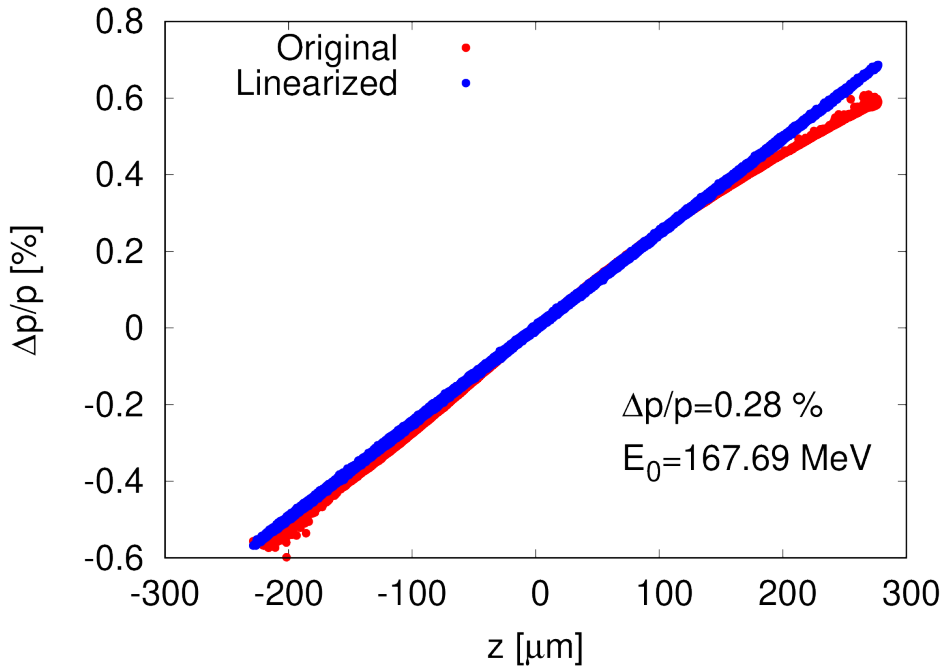


RF Fill Factor increased from 53% to 76%*

* *Provided by M. Aichelar*

S-Band Injector*

- Injector Operation Mode: Velocity Bunching
- Output Energy: 168 MeV
- Normalized Energy Spread: 0.28%
- $\# e^-$ ≈31 k
- Bunch Charge: 75 pC



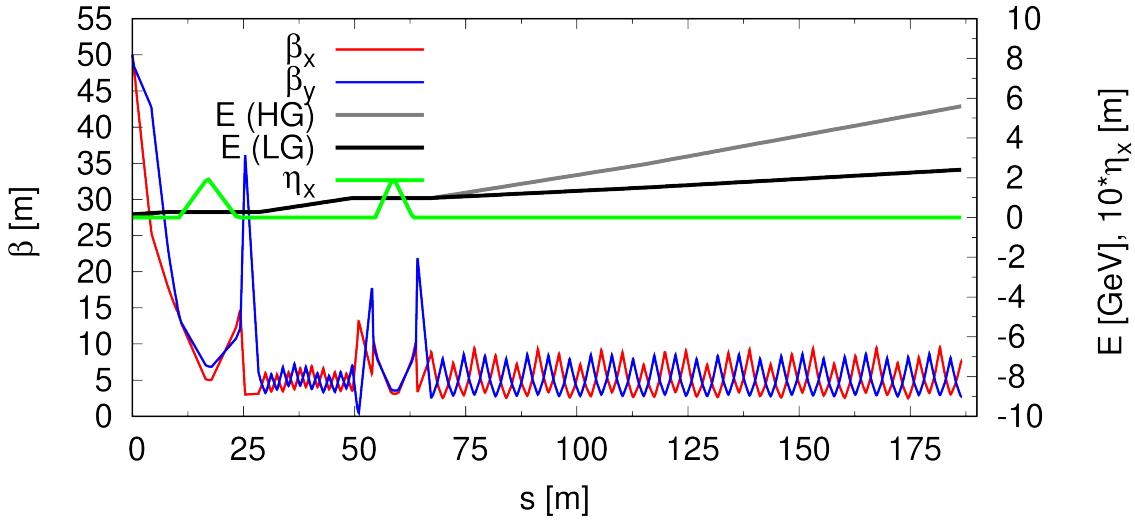
- Twiss parameters
  $\beta_{x,y}$ = 50 m
  $\alpha_{x,y}$ = 2.0
- Emittances
  $\gamma\epsilon_{x,y}$ = 0.21 μm
- Bunch length
  σ_z = 113 μm

*provided by A. Giribono

XLS New Design

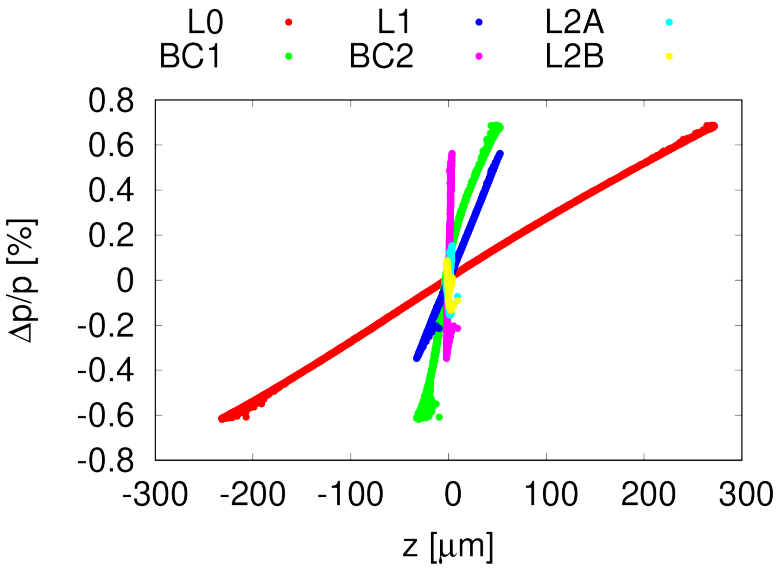
Twiss Functions

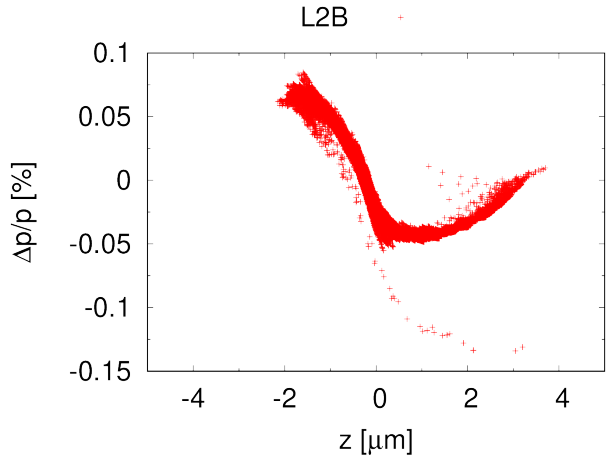
- 2x (4-dipole chicane)
  - angle (BC1): 3.0 deg
  - angle (BC2): 2.1 deg
- L2 is split in 2 sections:
  - L2A Phase: 30 deg
  - L2B Phase: 0 deg
- Length: 186.5 m
- 8 bends, 166 Quads, 119 Cavs
- Max Energy:
  - LG-mode: 2.75 *GeV*
    HG-mode: 5.6 *GeV*



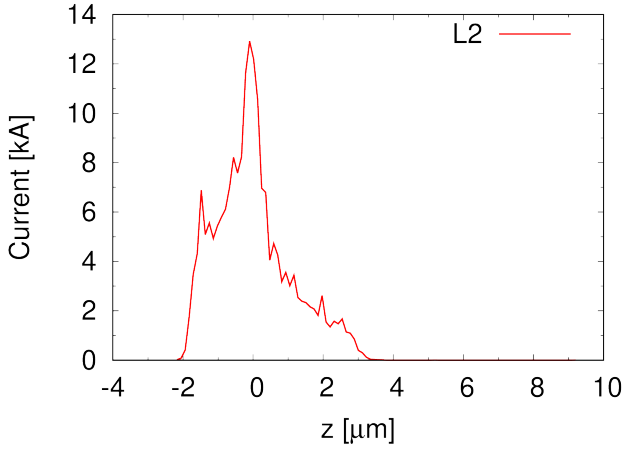
Lattice available at https://gitlab.cern.ch/XLS-Git/WP6

6-D Tracking Results





- σ_z = 1.0 μm (rms)
  1.8 μm (fwhm)
- $\epsilon_{x,y}$ (rms) = 0.2 μm
- $\Delta p/p < 0.04$ %



Monte-Carlo Studies

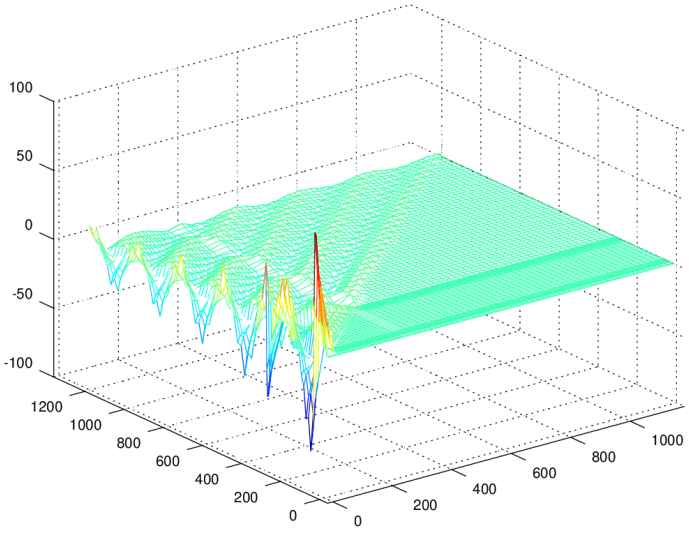
Tuning Study Framework

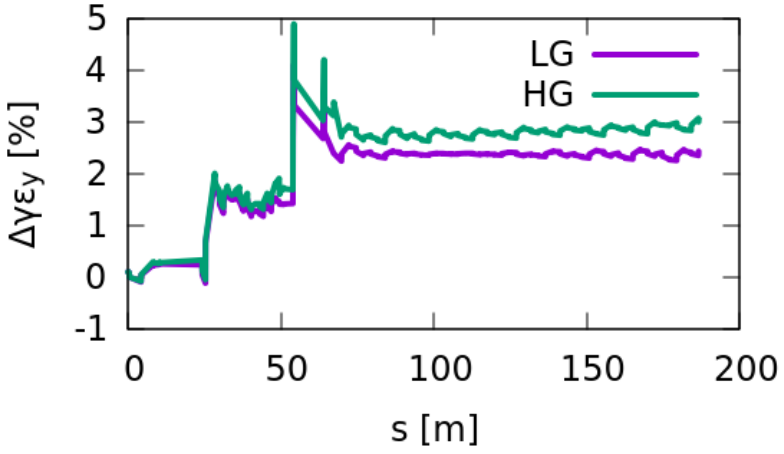
- 40 machines with different imperfections are generated
- Imperfections are randomly assigned following a Gaussian distribution
- Quads transversely misaligned (100 μm)
- Cavities transversely misaligned (100 μm)
- Cavities transversely tilted (140 μrad)
- BPM resolution : 5 μm

Tuning Results

We have obtained the WFS response matrix

and applied the WFS correction algorithm





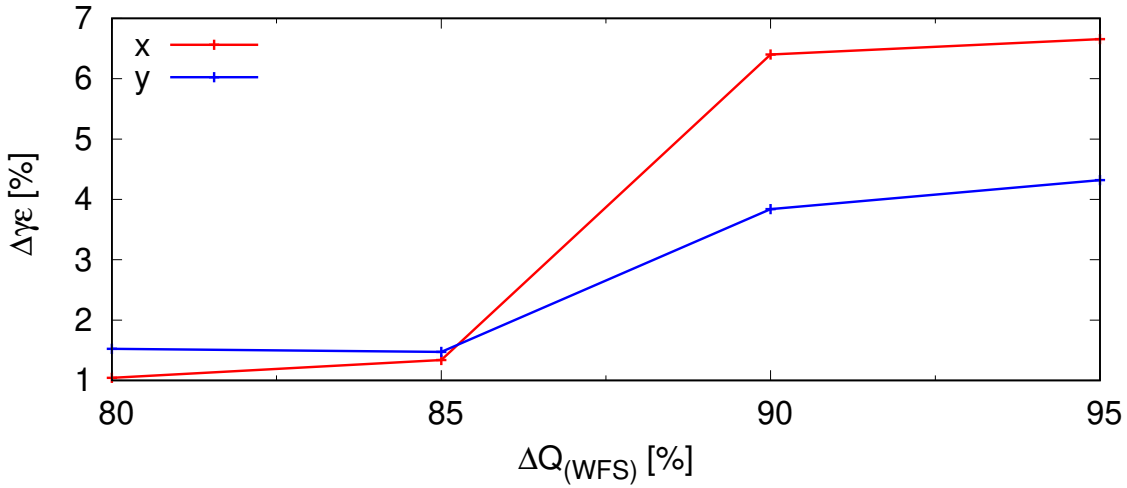
The algorithm can fully recover the initial emittance

HG : $< \Delta\epsilon_{x,y}^{(f)} > / \epsilon_{x,y}^{(i)} \leq 4\%$

LG : $< \Delta\epsilon_{x,y}^{(f)} > / \epsilon_{x,y}^{(i)} \leq 3\%$

Tuning Results

- Tuning Parameters Optimization
  - Charge variation



- To be done
  - Correction weights (1-2-1, DFS, WFS)
  - Phase variation of individual cavities (DFS)

Conclusions

New XLS lattice has been obtained using the new module configurations

- Using the latest S-band distribution in v.b. mode
- User input (variable energy from 1 to 5.5 *GeV*)
- Still room for optimization...

Monte-Carlo studies initiated

- only static transverse alignment imperfections
- WFS successfully recovers the initial emittance

Future Steps

- Evaluate the impact of CSR into our current models
- Additional imperfections (?)