Linac Extension Area (LEA) New Beamline

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Future LEA Experiments Workshop
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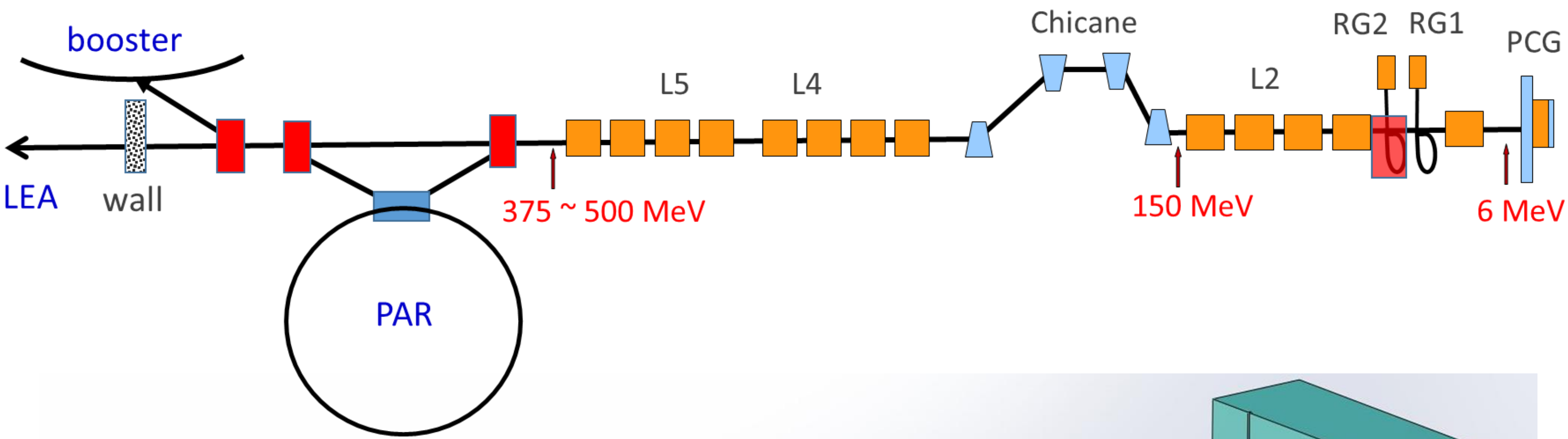
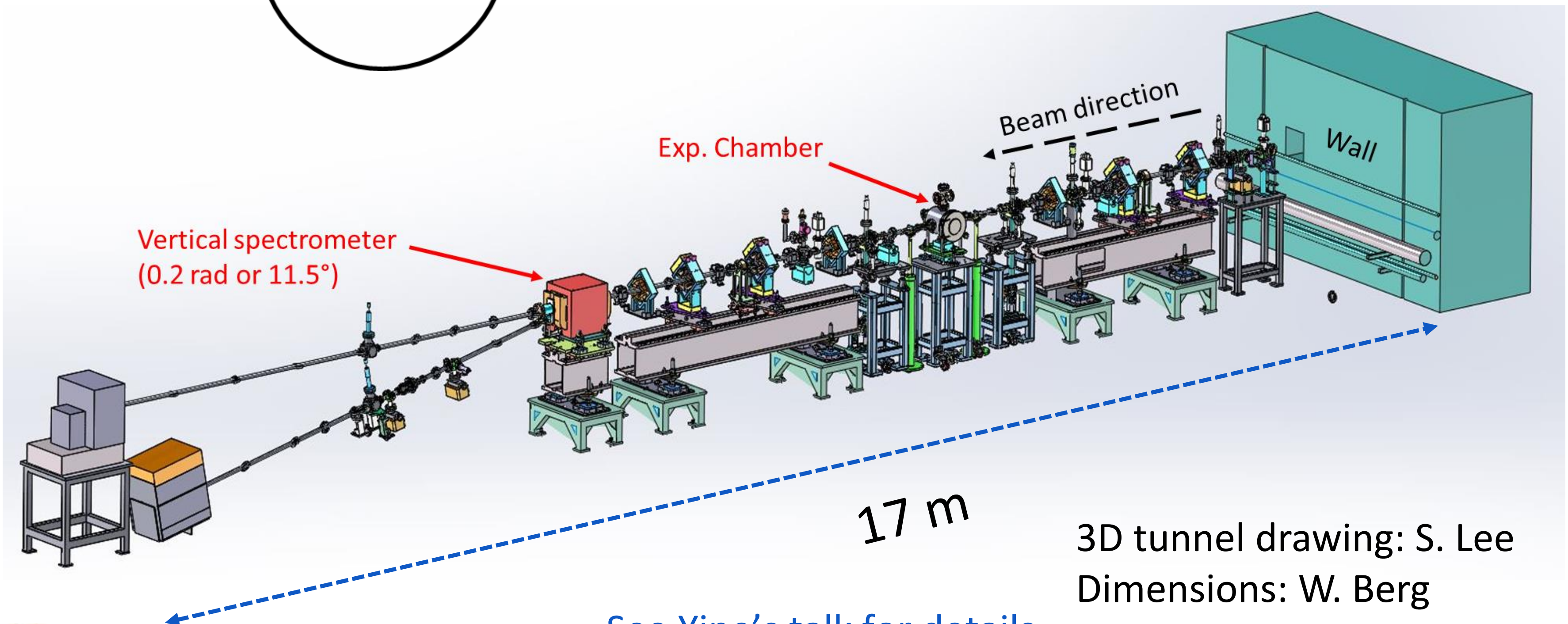
Content

- Overview: APS linac and LEA.
- Interleaving lattice.
- LEA new beamline.
- Wakefield application.
- S2E particle tracking simulation.

LEA: Linac Extension Area





3D tunnel drawing: S. Lee
Dimensions: W. Berg

See Yine's talk for details

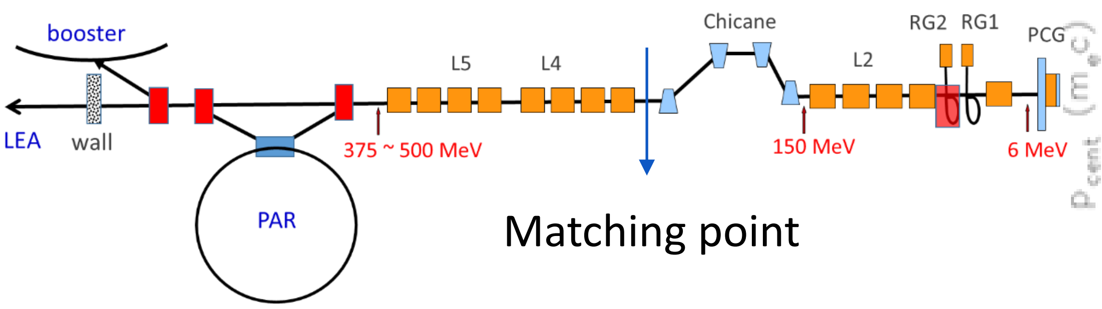
Consideration on interleaving lattice

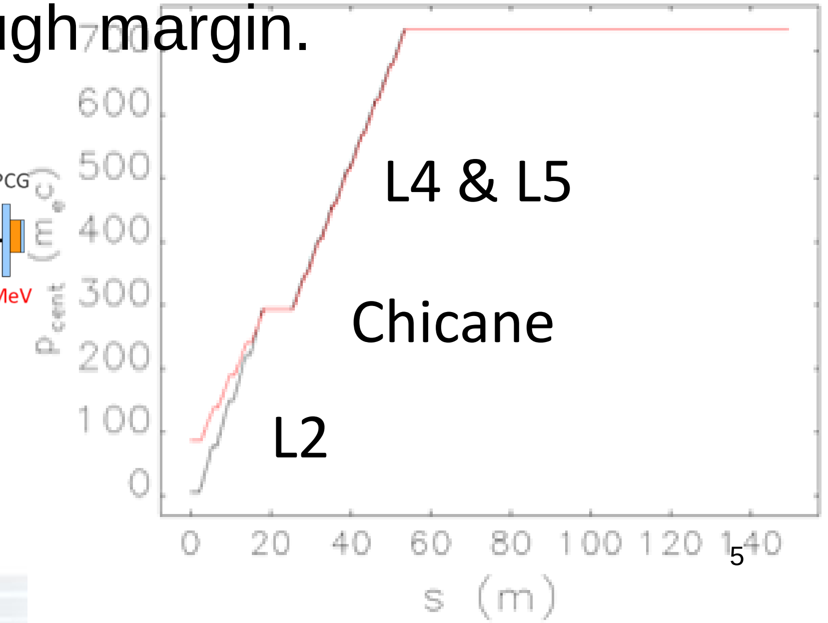
- Two different initial beams: different energy, emittance, charge, Twiss functions, etc.
- RG2 beam should be kept for the current transmission rate and injection efficiency.
- PCG beam should satisfy the required beam parameters for R&D.
- For both beam, small beta functions should be maintained.
- Same chicane parameter with operation condition but it can flexible.
  - RG2 beam: Crest phase @ L2
  - PCG beam: Depend on the required peak current.

See Yine's talk for details

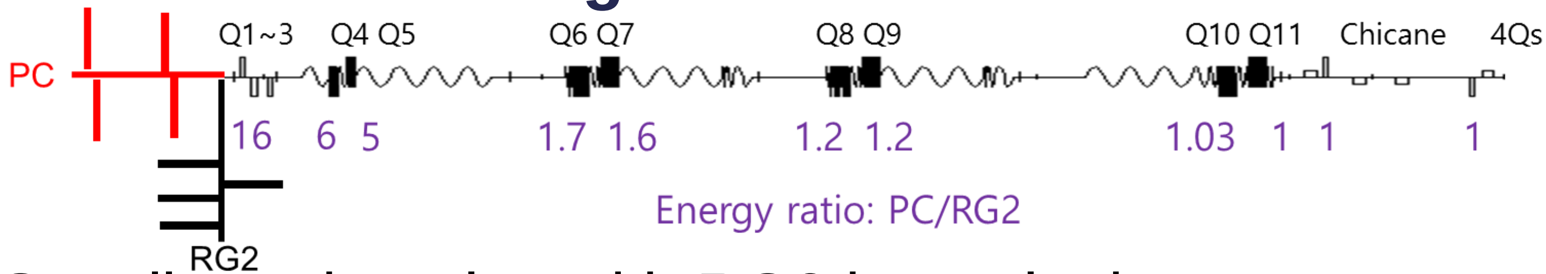
Longitudinal matching

- Set L4 and L5 on crest for maximum energy & small energy spread.
- Chicane system (flexible for application)
  - R56 = -65 mm with asymmetry chicane.
- L2 set
  - Voltage and phase can be switched.
  - RG2 beam: minimum energy spread.
  - PCG beam: flexible with enough margin.



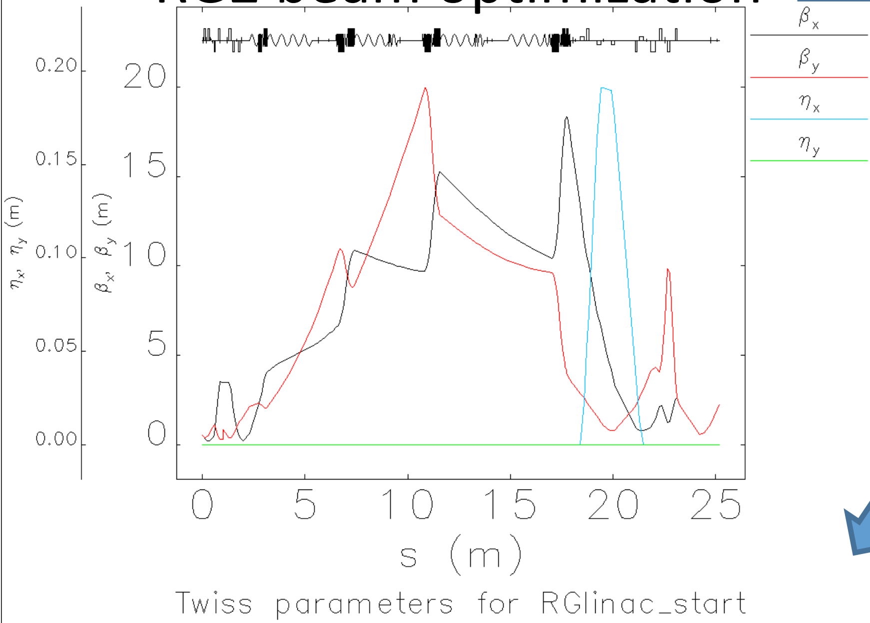


Transverse matching

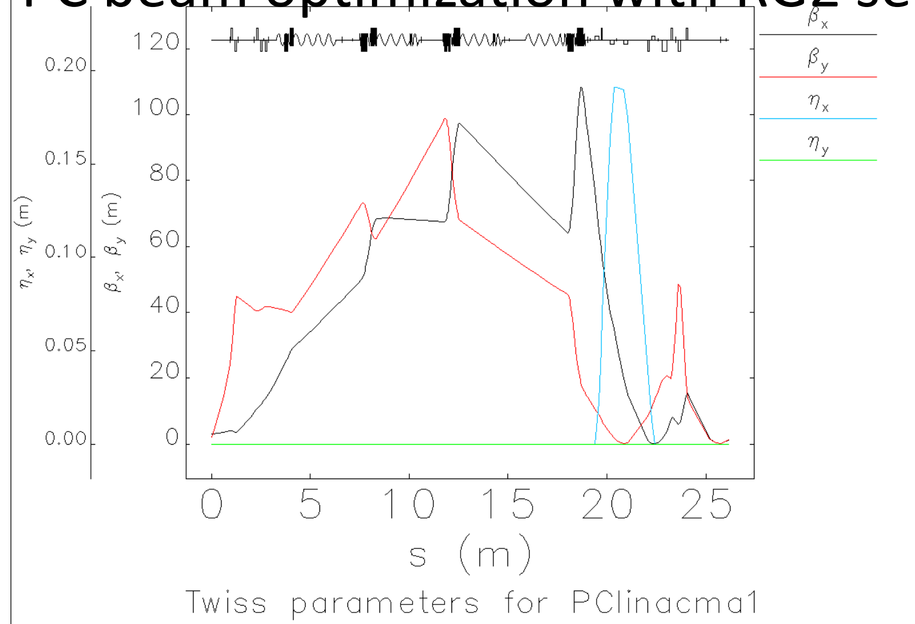


- Set all quadrupoles with RG2 beam lattice.
- Optimize four dedicated quadrupoles to keep low beta for PCG beam.
  - close Twiss functions with RG2 beam at matching point.
- Reduce CSR effect for PCG beam using Q11
  - betax = 0.8 m at the end of chicane.
- Optimize last four quadrupoles to realize matching condition for PCG beam.
  - downstream transmission and required Twiss functions.
- Optimize four dedicated quadrupoles for RG2 beam to make same Twiss function with PCG beam at matching point.

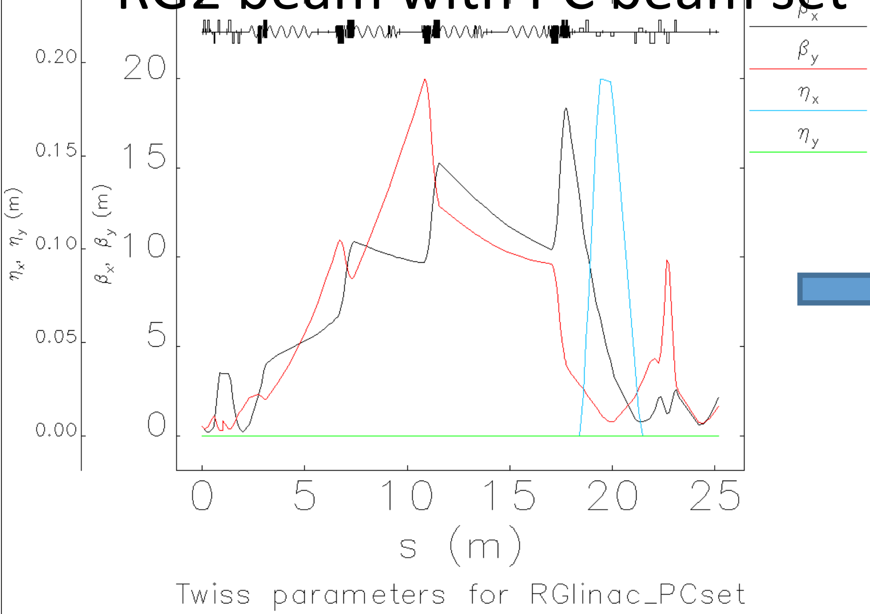
RG2 beam optimization



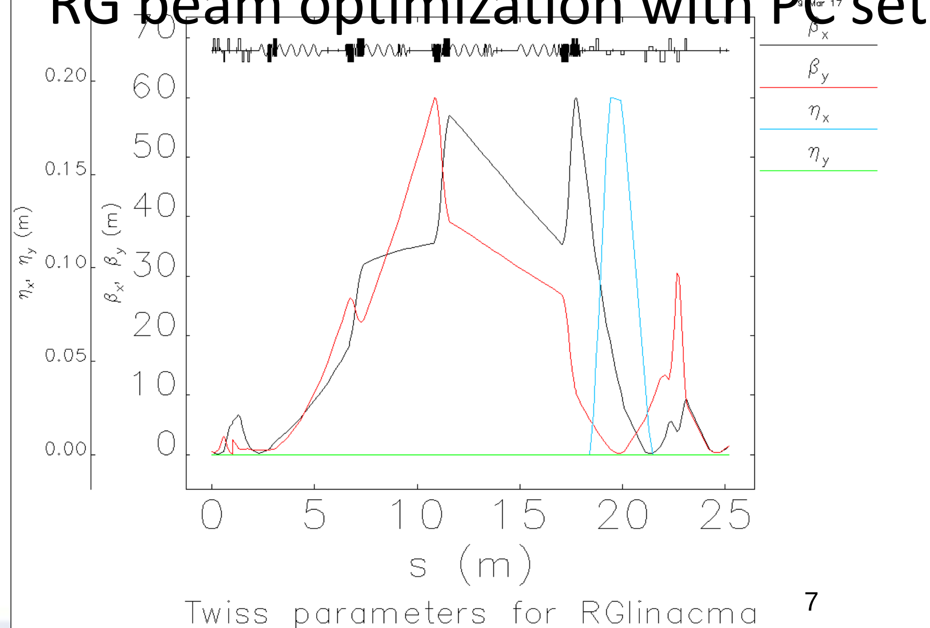
PC beam optimization with RG2 set



RG2 beam with PC beam set



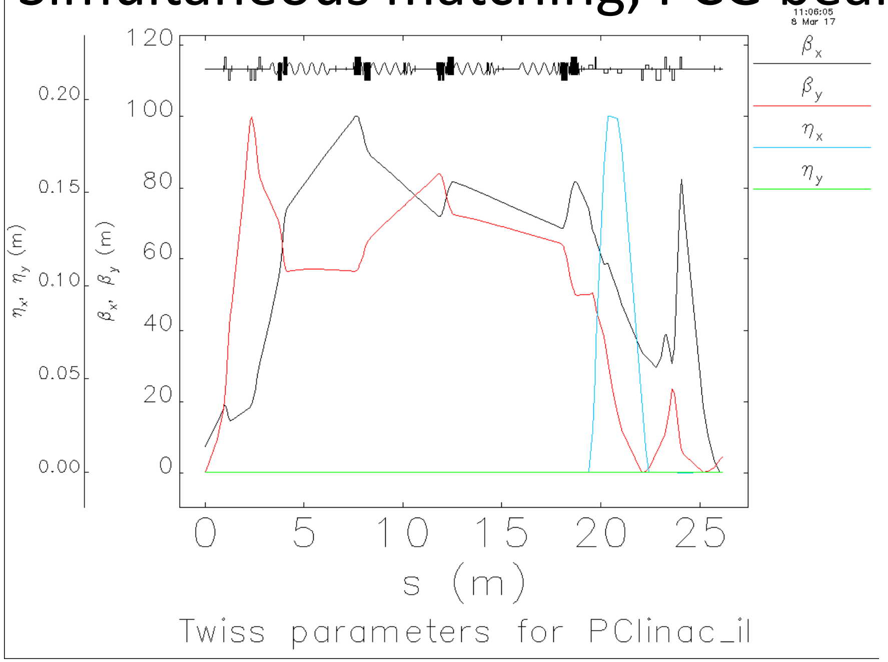
RG beam optimization with PC set



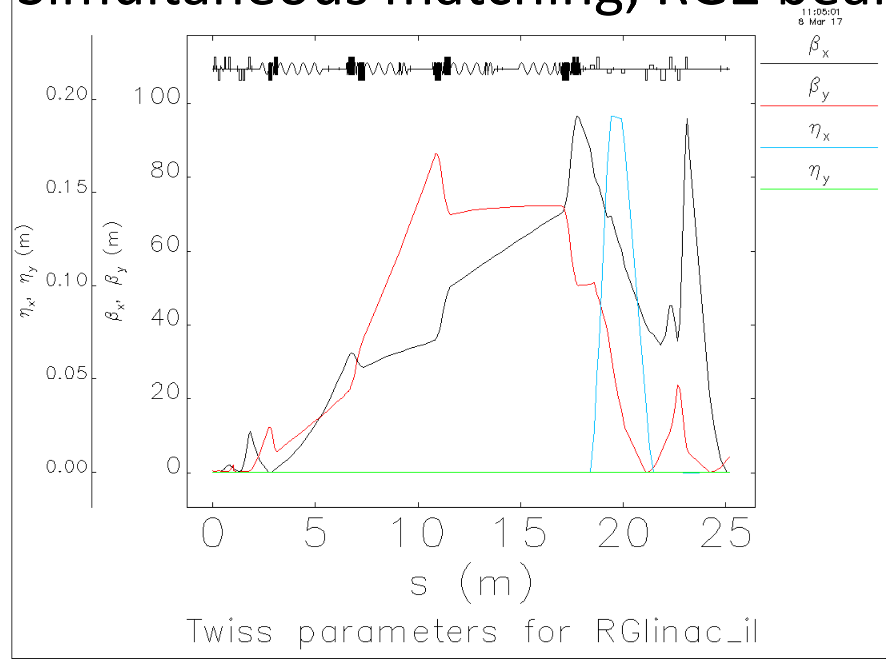
Alternative interleaving lattice

- Two beam simultaneous matching in Elegant.
- Same Twiss functions at matching point.
- Beta functions below 100 m.

Simultaneous matching, PCG beam

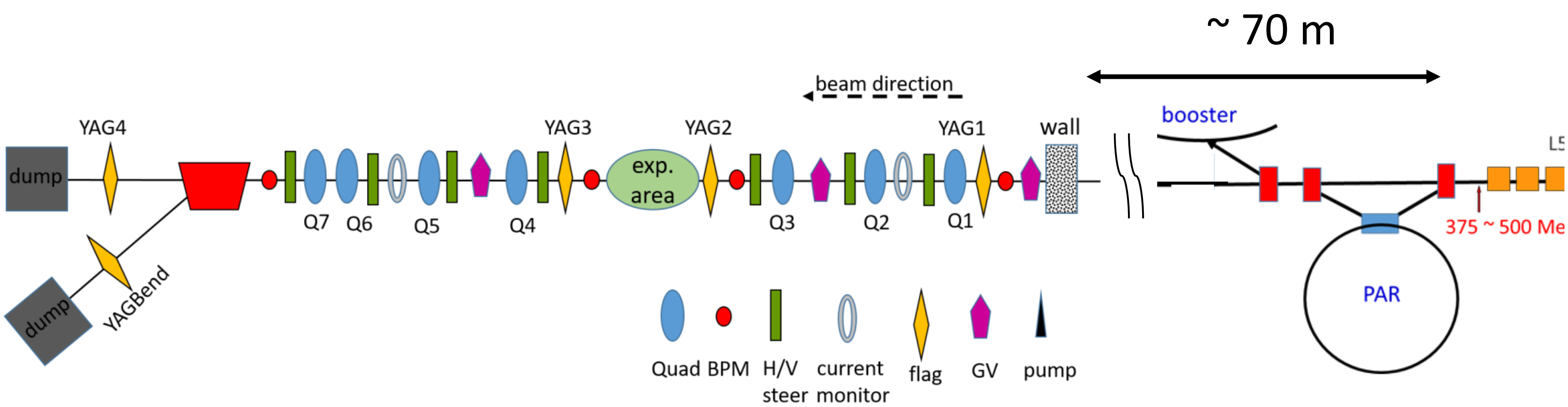


Simultaneous matching, RG2 beam



M. Borland gave idea and example for simultaneous matching.

LEA lattice design: Overview



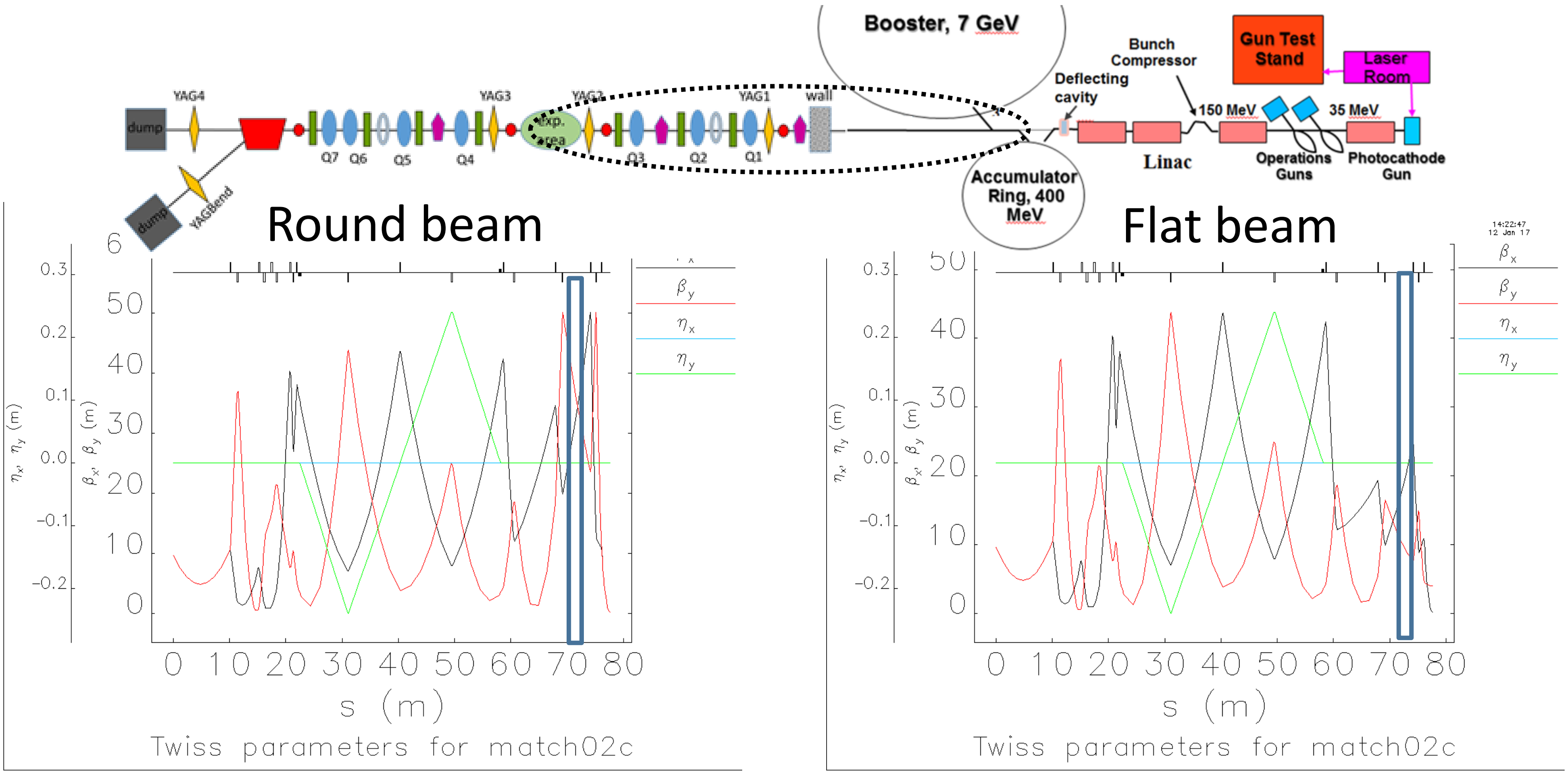
M. Borland set up the ELEGANT lattice optimization for LEA

- Provides flexible beam focusing at the center of experimental area. (from a round beam to a flat beam)
- Different vertical level with APS linac.
- One PS for Q3 and Q4.
- Vertical bending for spectrometer.

LEA lattice design: Experiment area

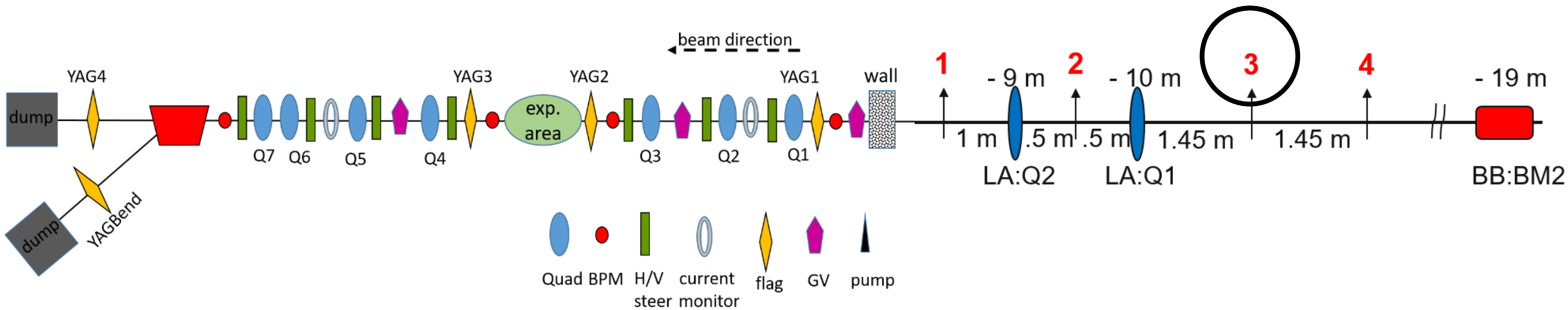
- High brightness photo-injector beam in LEA
  - Charge: 50 ~ 500 pC
  - Energy: Up to 500 MeV; Energy spread: 250 ~ 500 keV
  - Norm. Emittance: 0.5 ~ 1.5 μm
  - Bunch length: 100 ~ 1000 fs
  - Rep rate: up to 30 Hz
- 1.6 m free space for experiment.
- The first experiment
  - The testing of dielectric wakefield tubes: energy chirp and transverse kick.
  - Maximum energy resolution in vertical plane.
  - 90 degree horizontal betatron phase advance

LEA lattice design: Flexible beam

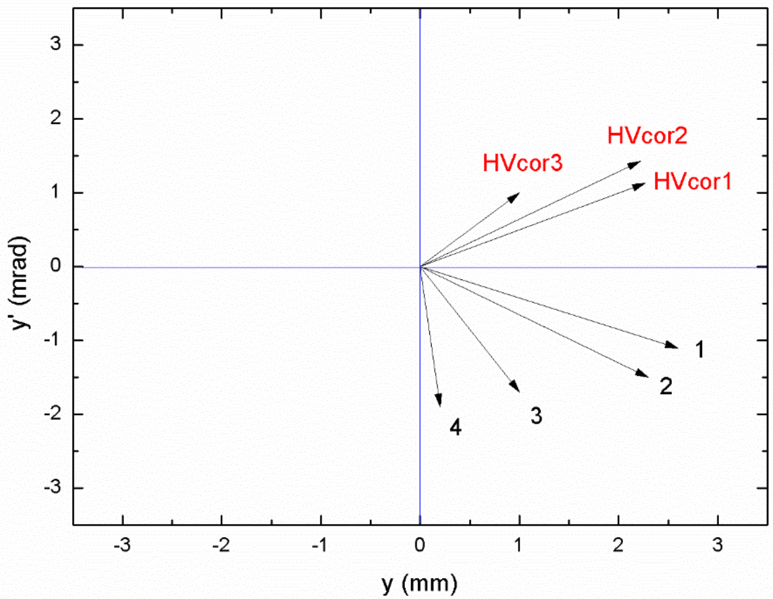


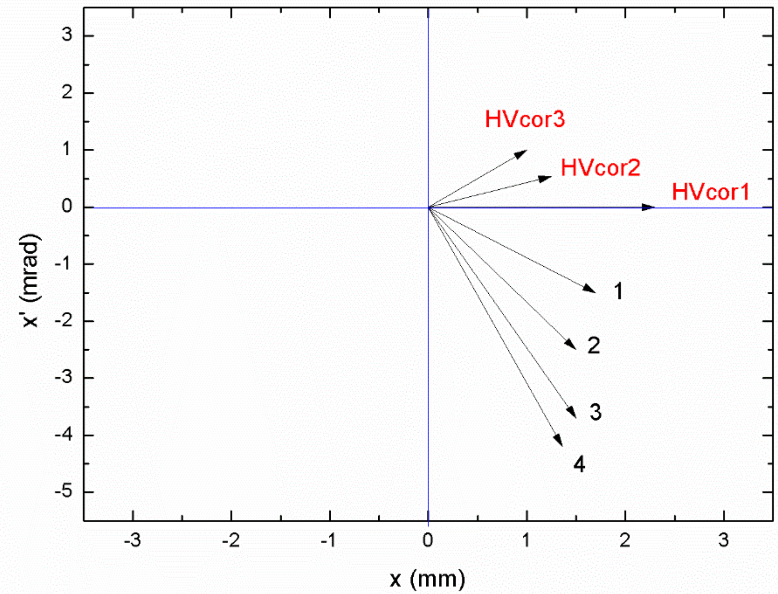
- Keep bet functions < 50 m.
- β_x/β_y: RB (0.2 m/0.2 m) and FB (0.2 m/4m).
- Vertical dispersion bump before LEA wall.

LEA lattice design: Trajectory control

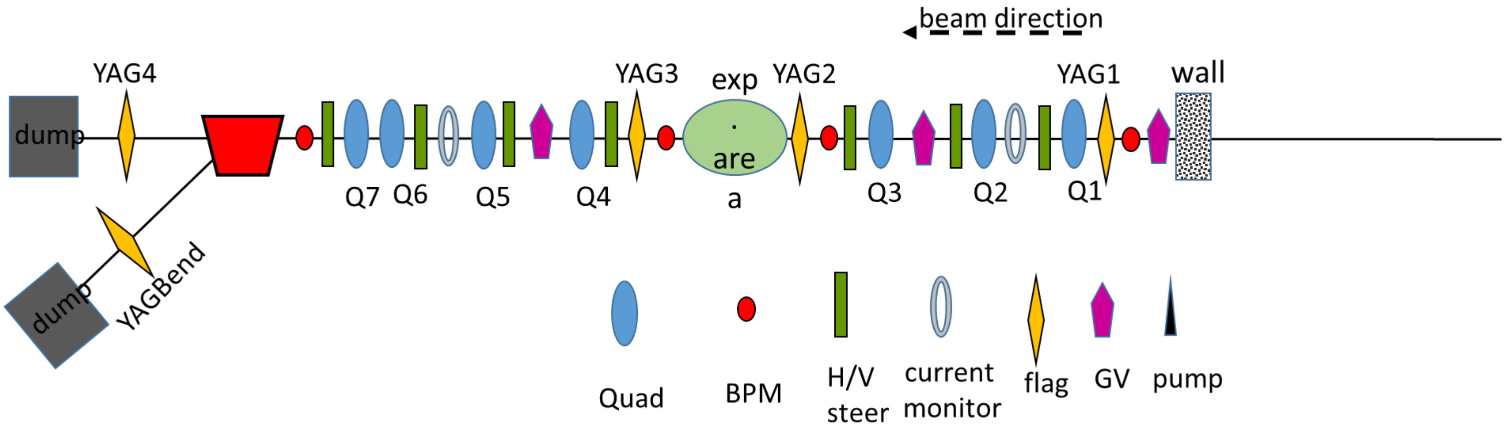


- Precise mechanical alignment with laser in experiment area.
- Trajectory control (offset and angle) in experiment area.





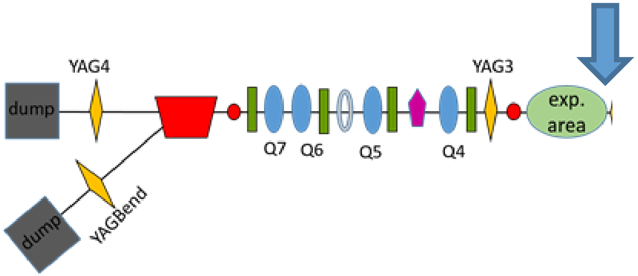
LEA lattice design: Diagnostics



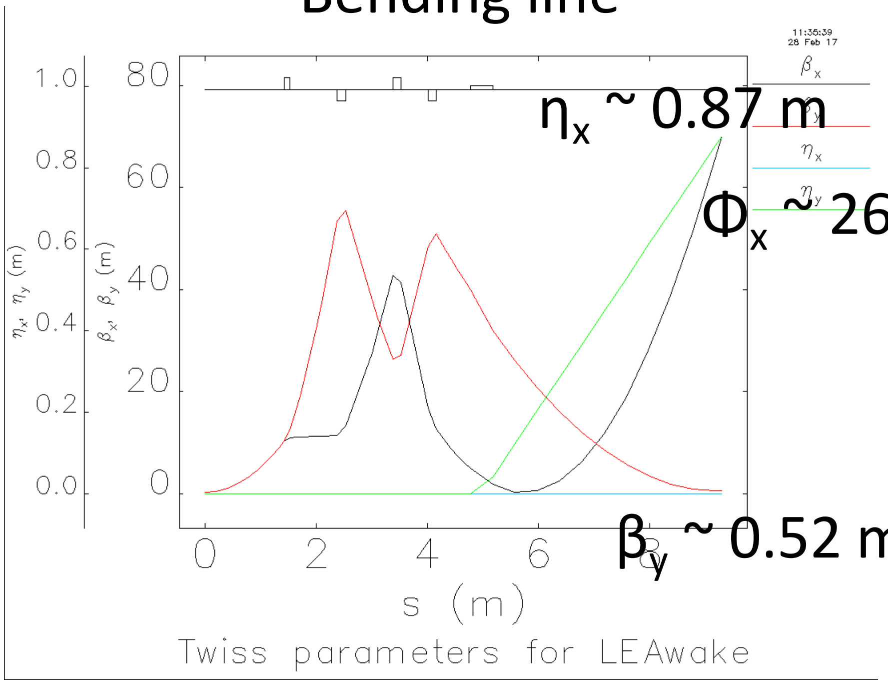
- 5 YAG screens
  - 2 upstream and 2 downstream of the experimental chamber
  - 1 downstream of the spectrometer dipole.
- 4 BPMs
- 2 current monitors
- 3 gate values and ~ 7 ion pumps

LEA lattice design: Spectrometer

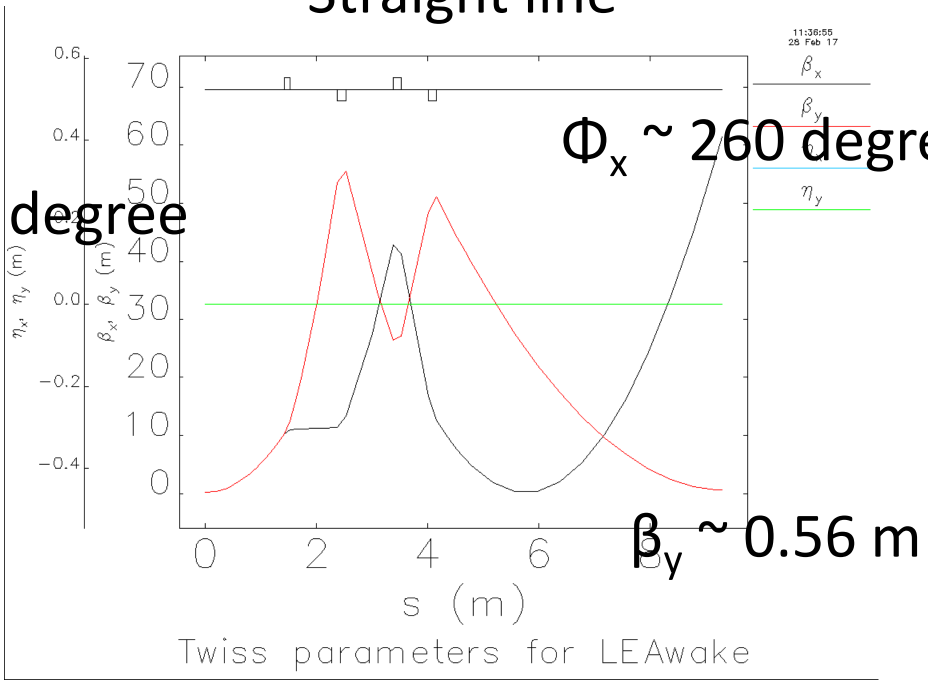
- Bending angle: fixed. (reuse)
- Maximum $D/\sqrt{\beta}$ in vertical plane.
- 90 degree horizontal phase advance.



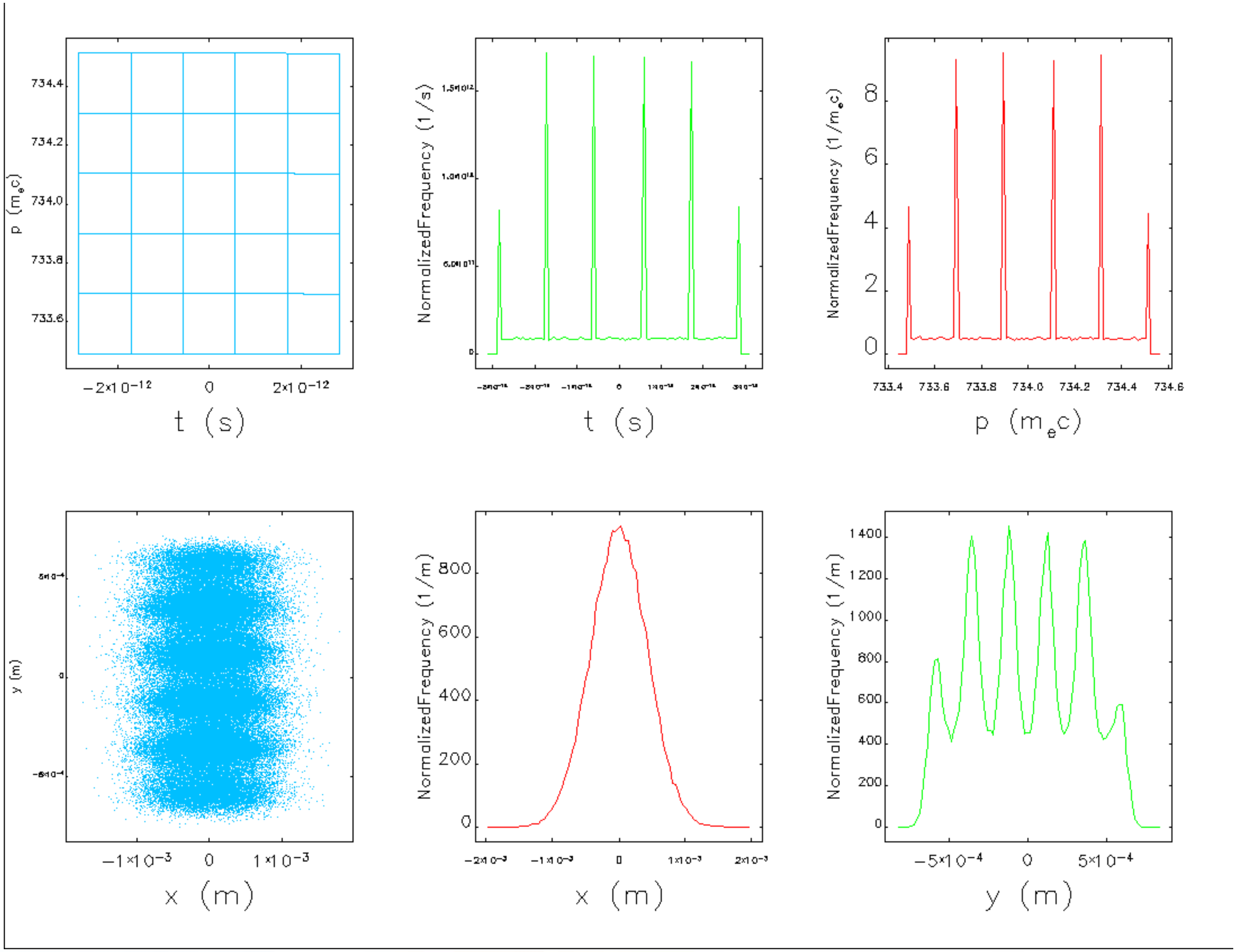
Bending line



Straight line

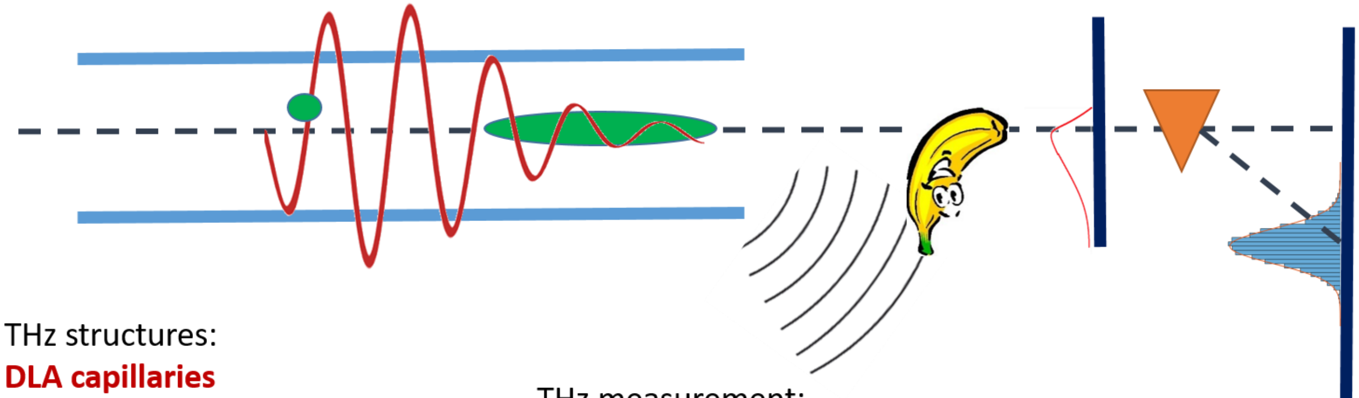


- Energy resolution.
  - Estimated energy resolution: < 2.7E-4 (< 100 keV)



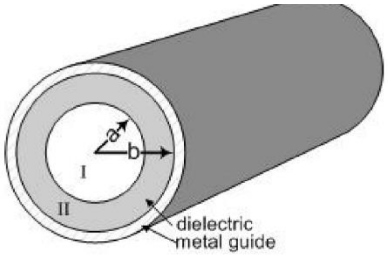
Wake field application

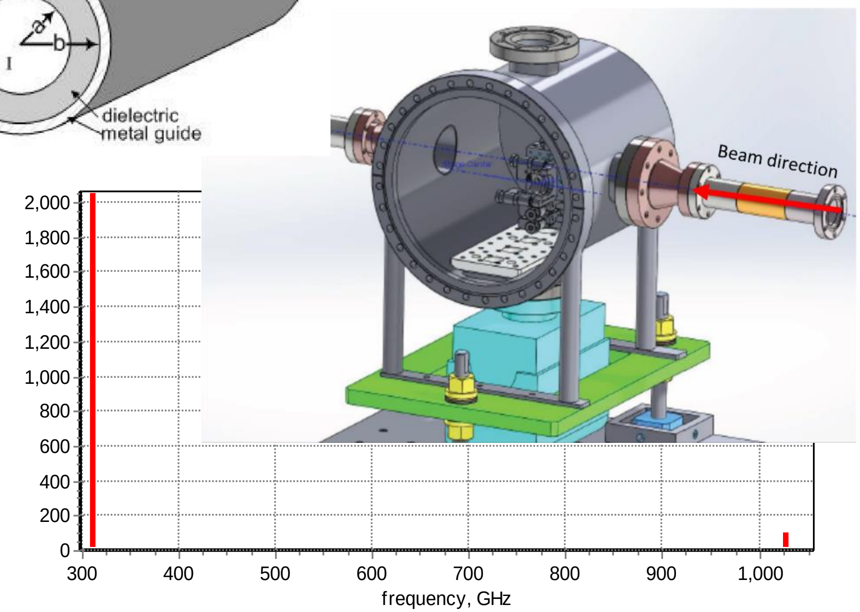
- Possible measurements review (S. Antipov)

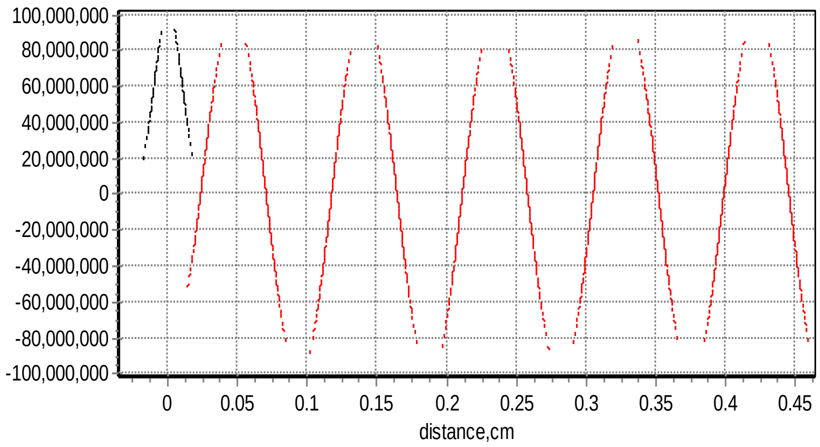


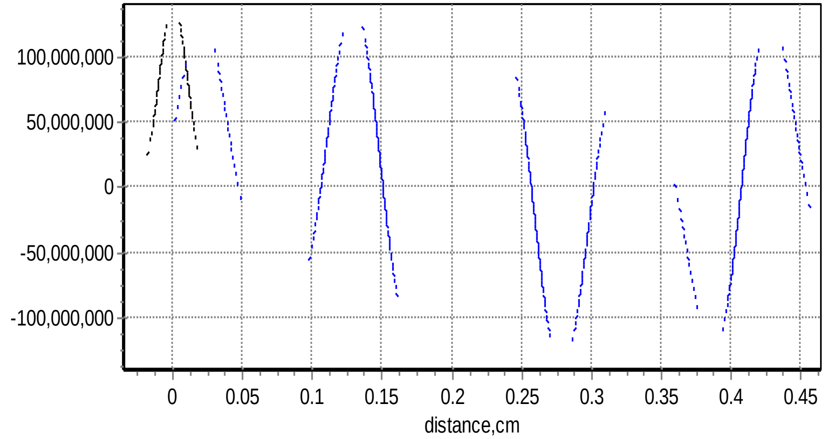
a= 0.4 mm, b = 0.5 mm and ε = 3.8

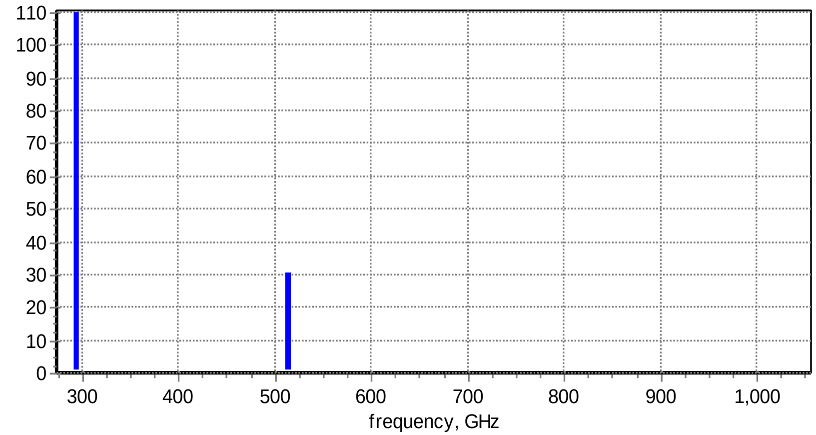
- Wakefield calculation
  - 100 um Gaussian beam





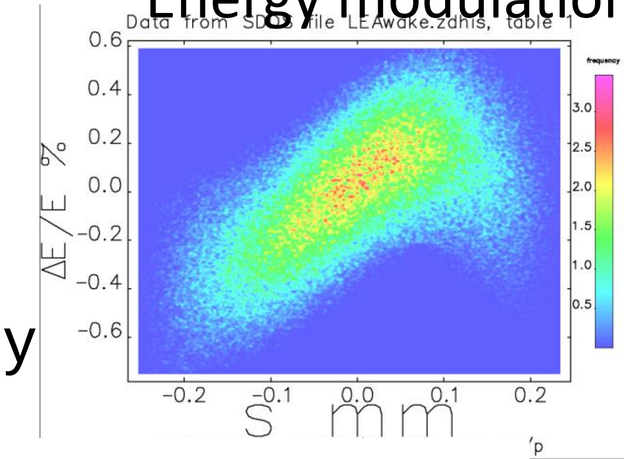




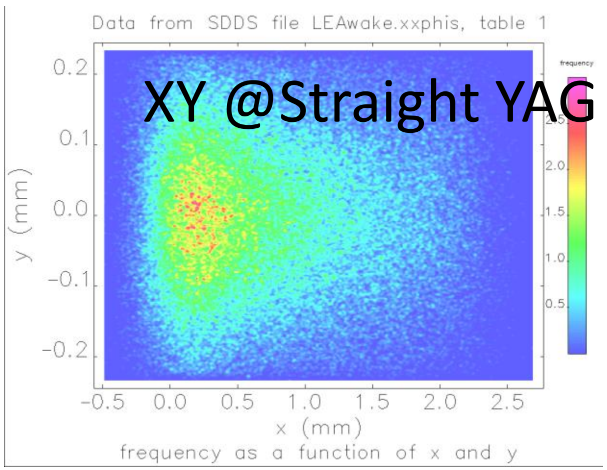


- Diagnostics for wakefield effect
  - 100 um Gaussian beam
  - Strip though x as well as y.
  - Longitudinal phase space tomography

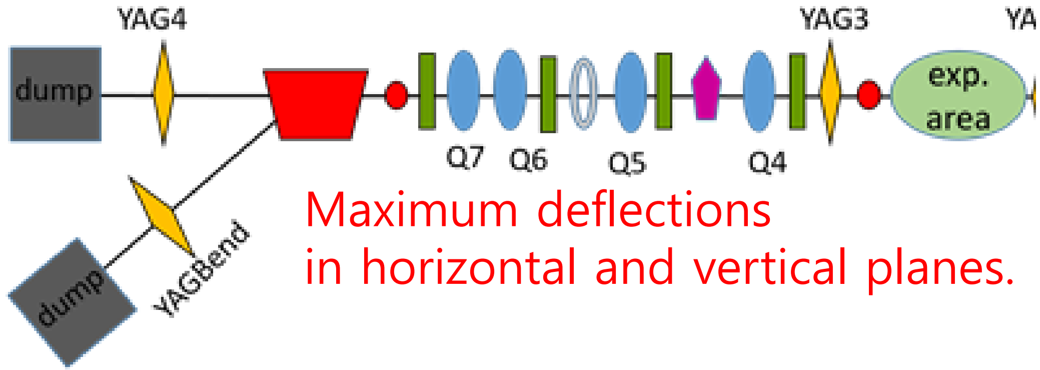
Energy modulation



XY @Straight YAG

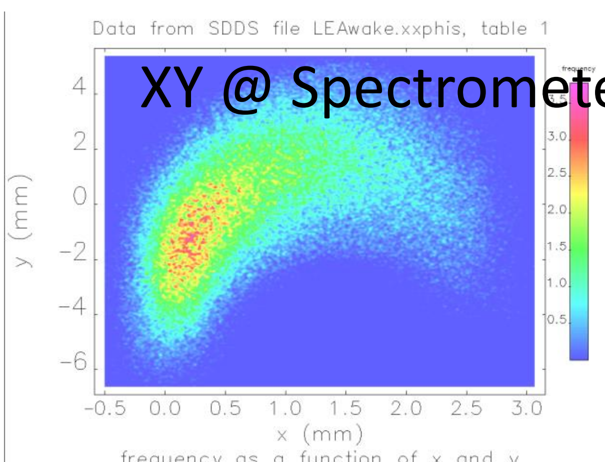


Max. 0.8 mrad kick

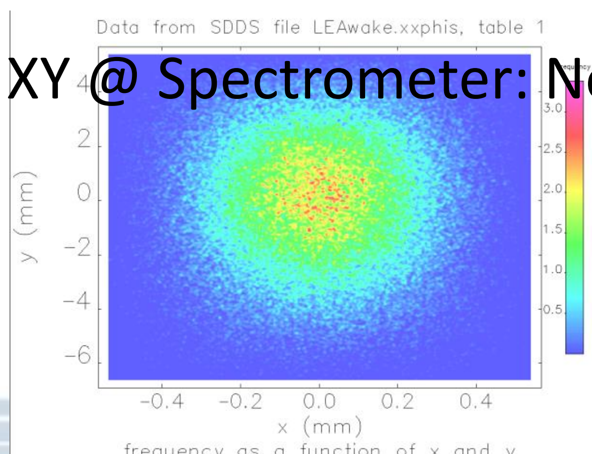


Maximum deflections in horizontal and vertical planes.

XY @ Spectrometer

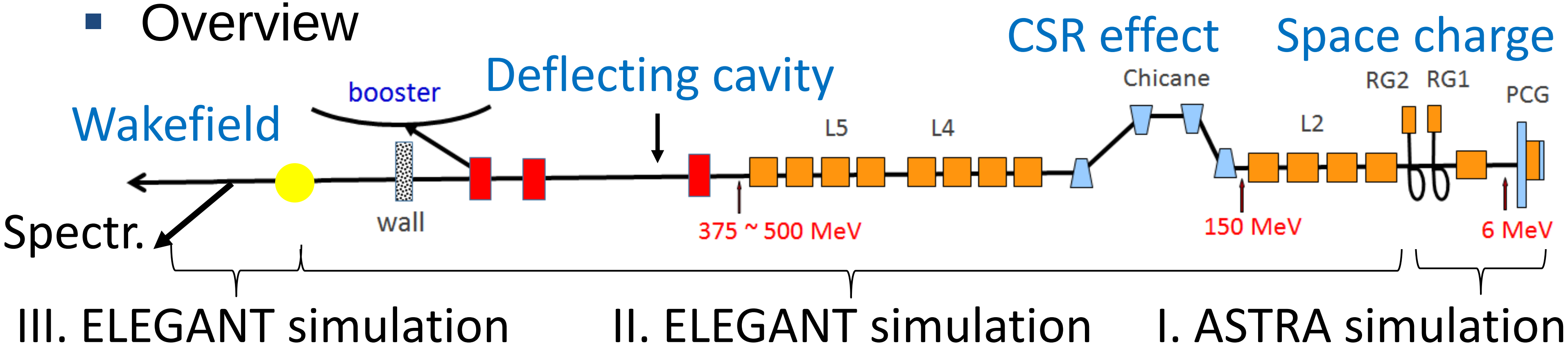


XY @ Spectrometer: No wake



S2E tracking: Overview

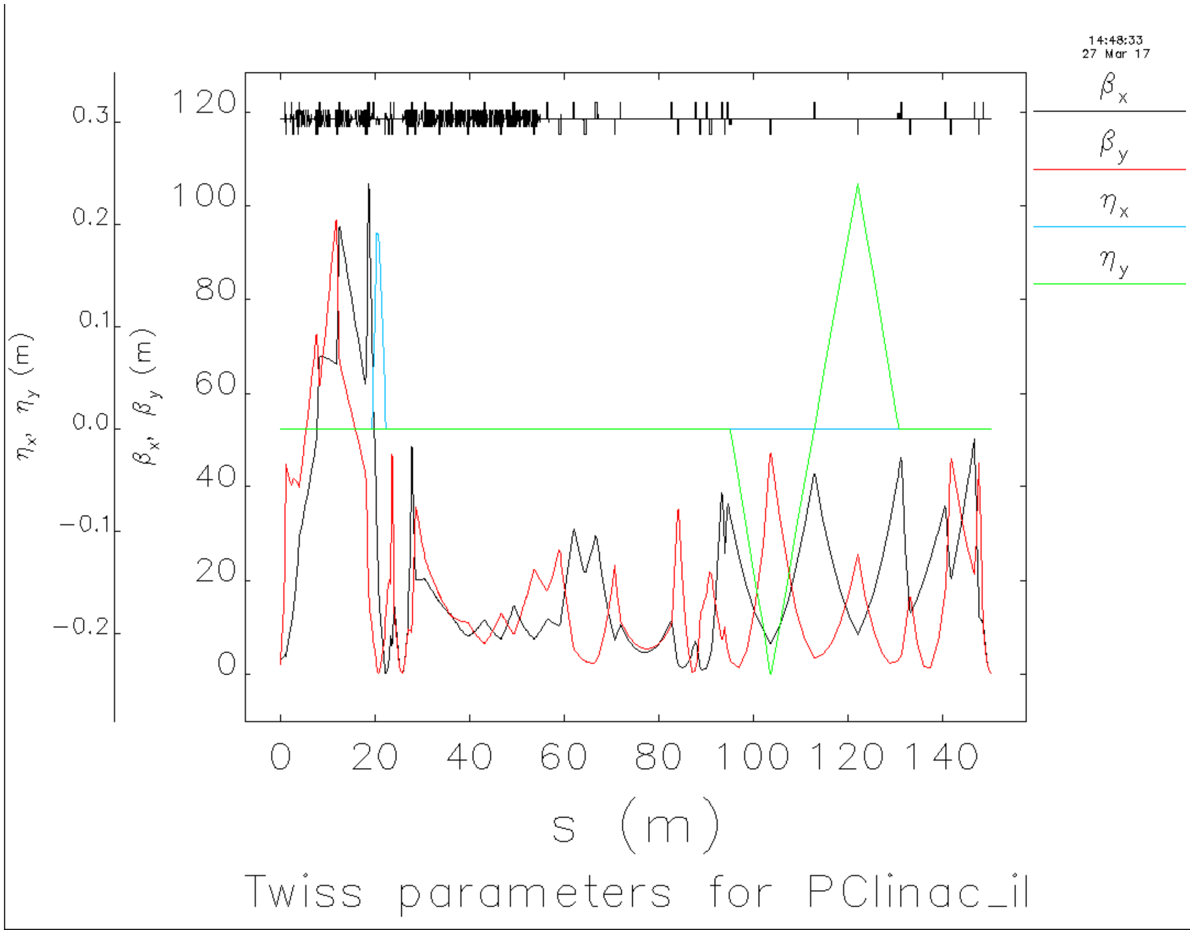
- Overview

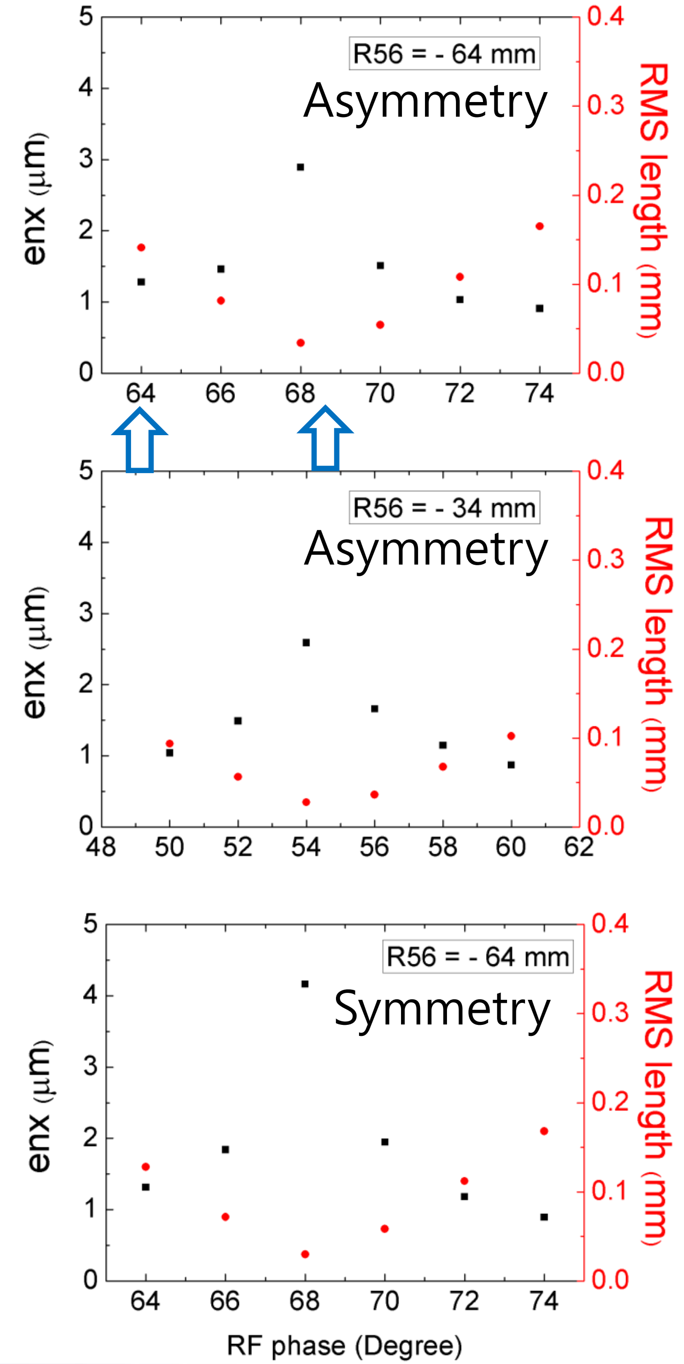


- Astra simulation
  - Before L2
  - Laser spot size: rms 0.4 mm
  - Maximum field in gun: 100 MV/m
  - 1 um normalized emittance with 300 pC
- Elegant simulation
  - From L2 to Spectrometer.
  - Interleaving lattice
  - All CSR effects included.
  - Wake field and deflecting cavity included.

S2E tracking: Twiss and CSR

- Parameter @ experiment region



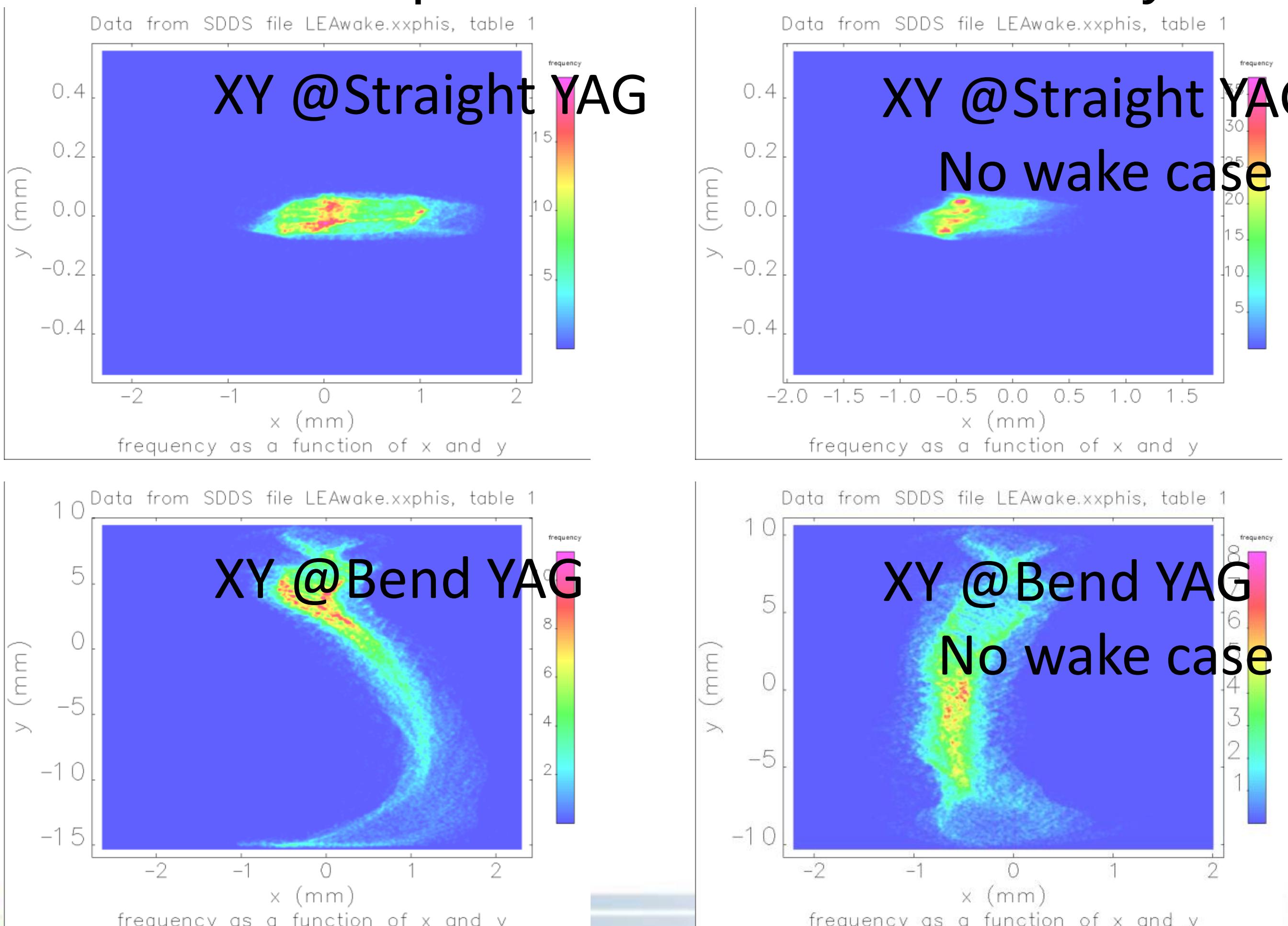


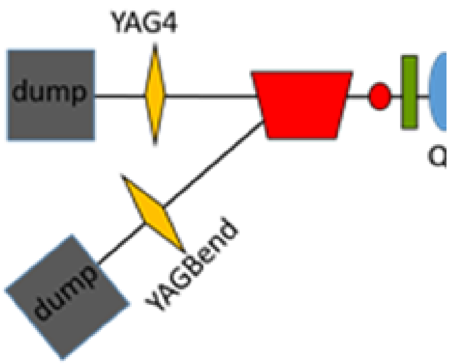
- Parameter @ experiment region

Parameter	High peak I mode	E chirp mode
Energy (MeV)	375	375
Charge (pC)	300	300
RMS bunch length (mm)	0.045	0.178
Nor. emittance x (um)	2.8	1.8
Nor. emittance y (um)	2.0	1.1
Nor. sliced emittance x (um)	1.0	1.0
Nor. sliced emittance y (um)	1.0	1.0
RMS energy spread (%)	0.5	0.5
Sliced energy spread (%)	-	0.01

S2E tracking: Wakefield application I

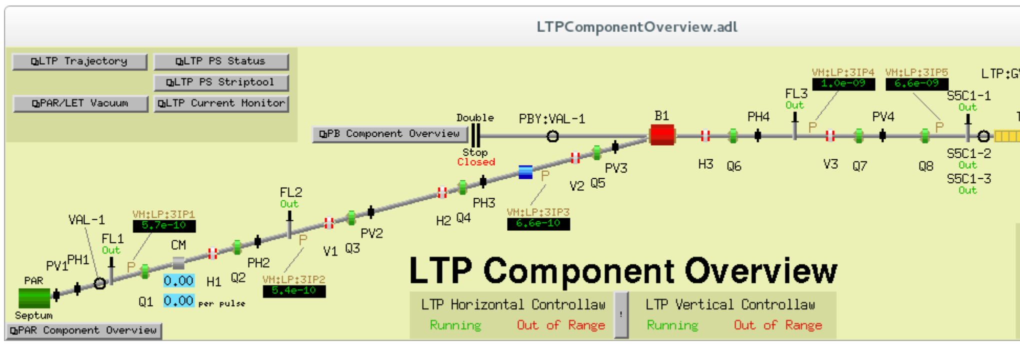
- Energy chirping due to wake structure
- Longitudinal tomography
  - L4 or L5 phase scan or x band cavity

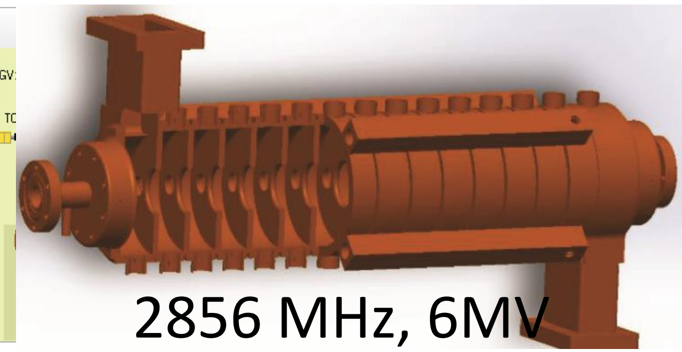




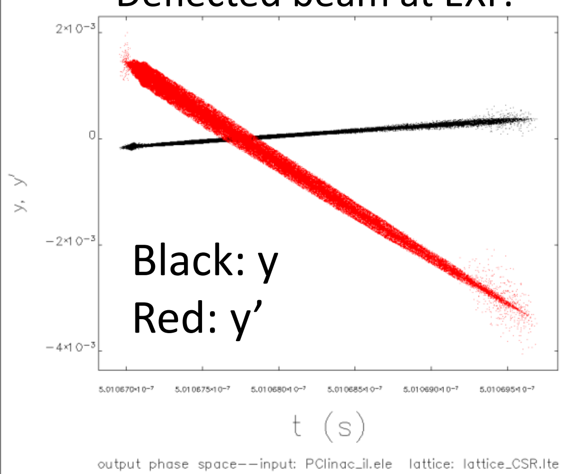
S2E tracking: Deflecting cavity

- Vertical deflecting cavity
  - To characterize the beam parameters from PC gun
  - We are trying to apply deflected beam at experiment area.

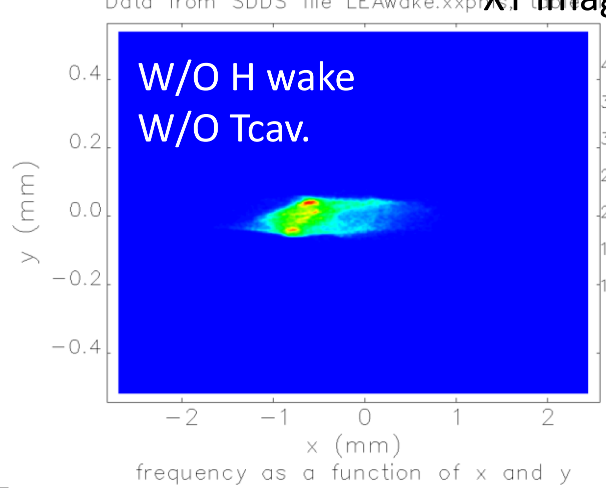


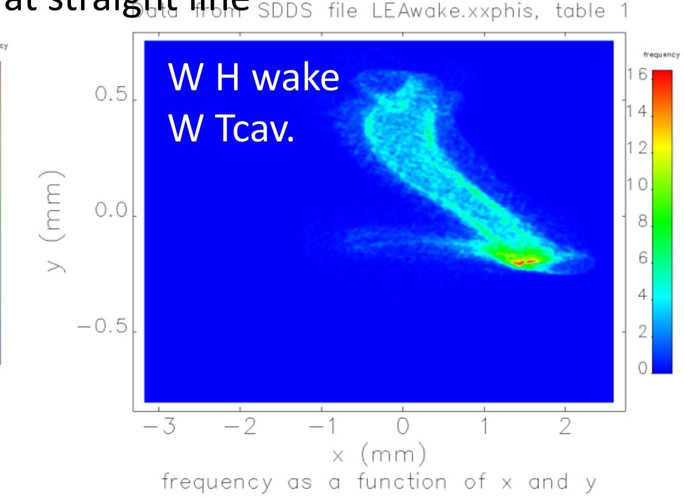


Deflected beam at EXP.



XY image at straight line





Summary

- Interleaving lattice design satisfy the requirements from both beams.
  => Demonstration though machine study.
- LEA beam line design was described
  => On engineering design stage
  => High energy resolution spectrometer
- Particle tracking though wake field structure was performed.
  => On development of wake field structure.
  => Longitudinal phase space was reconstructed in spectrometer.
- Based on committee comments, simulation studies are planned
  => Enumerating more possible experiments.
  => Improving spectrometer by increasing the bending angle.
  => Start to end jitter simulations.
- Simulation with x band cavity and deflecting cavity will be done
  for beam diagnostics (phase space tomography, slice characteristics).