Design Considerations and Optics Solutions for the New SMATCH Section

Christopher Behrens*, Velizar Miltchev*
and Christopher Gerth

Deutsches Elektronen-Synchrotron (DESY), Uni Hamburg (UHH)

Beam Dynamics Seminar
15. June 2009

Outline

FLASH Upgrade 2009

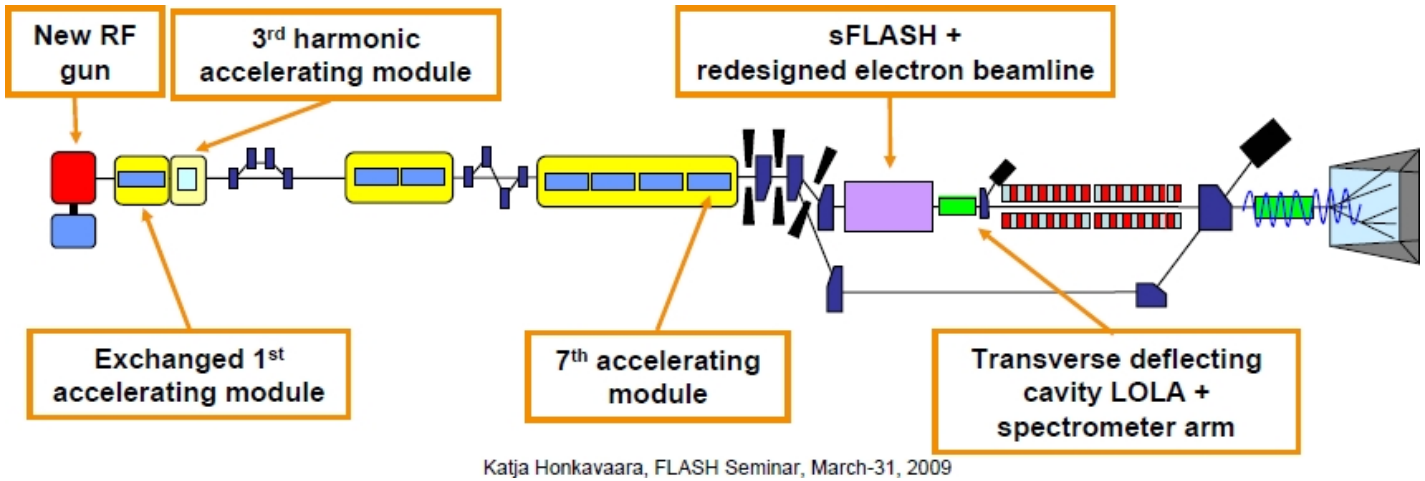


Figure: Main modifications of FLASH in 2009

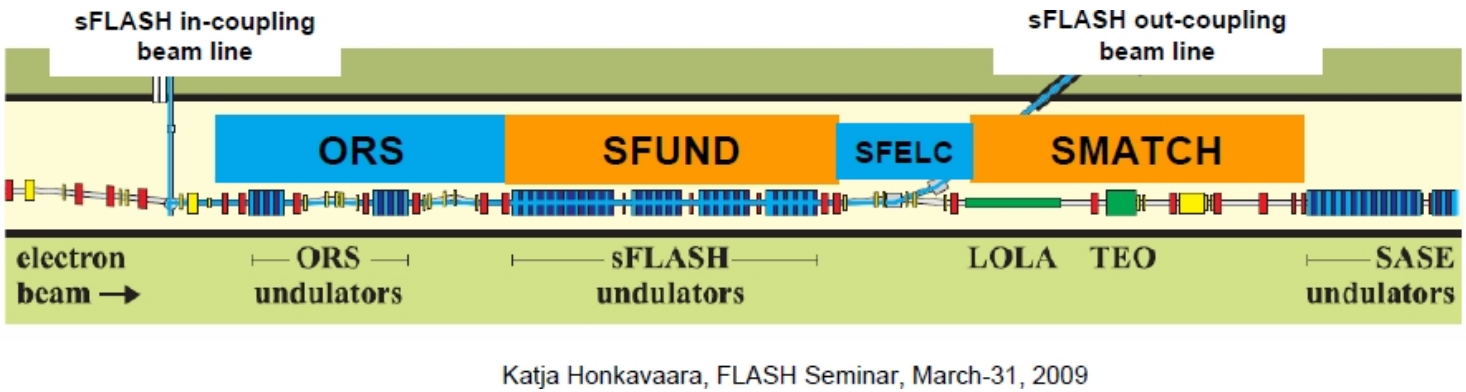


Figure: sFLASH project with new beam line sections

SMATCH and SDUMP

Features and Goals of SMATCH/SDUMP

- Movement of the RF-Deflector "LOLA" in front of the FEL-Undulators.
- Magnetic energy spectrometer (MES) beam line for longitudinal phase space measurements. $\rightarrow$ SDUMP
- Optics design for parasitic "LOLA" operation with high longitudinal resolution.

General Requirements

- The design of a flexible lattice. $\Rightarrow$ Twiss parameters at undulator entrance have to be accomplished for all options and energies.
- Keeping the quadrupoles strengths and beta functions in reasonable ranges. $|k| < 3\ \mathrm{m}^{-2}$ and $\beta < 30\ \mathrm{m}$
- A consistent design including magnets, standard diagnostics and dedicated experiments (e.g. TEO, LOLA, THz spectroscopy etc.).

Longitudinal Resolution (SMATCH)

- $y(s) = y_\beta(s) + S_y(s) \cdot \zeta$ "$S(s)$: Shear function of the RF-Deflector"
- $\sigma_\zeta \gtrapprox \dfrac{\sqrt{\epsilon_N} \cdot pc}{\sqrt{\beta_y(s_0)} \cdot \sin(\Delta\Phi_y) \cdot eV_0 k} \sim \dfrac{1}{\sqrt{\beta_y(s_0)} \cdot \sin(\Delta\Phi_y)}$

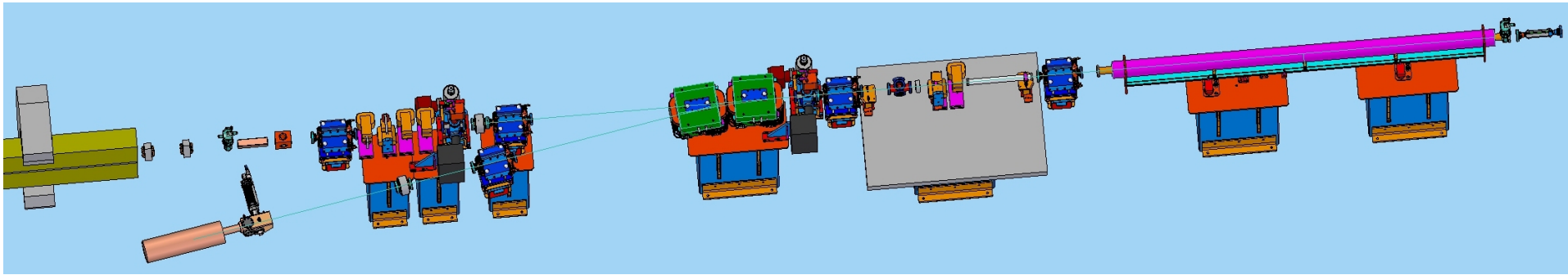
Energy Resolution (SDUMP)

- $x(s) = x_\beta(s) + D_x(s) \cdot \delta$ "$D(s)$: Dispersion function of the MES"
- $\sigma_\delta \gtrapprox \sqrt{\epsilon_N} \cdot \dfrac{\sqrt{\beta_x(s_1)}}{D_x(s_1)} \sim \dfrac{\sqrt{\beta_x(s_1)}}{D_x(s_1)}$

Set of Optics

- 3 different energies: 445 MeV, 700 MeV and 1000 MeV
- 3 different options: V1, V4 and V7 (from Nina and Vladimir)
- 2 sFLASH undulators options: opened or closed (natural focusing)

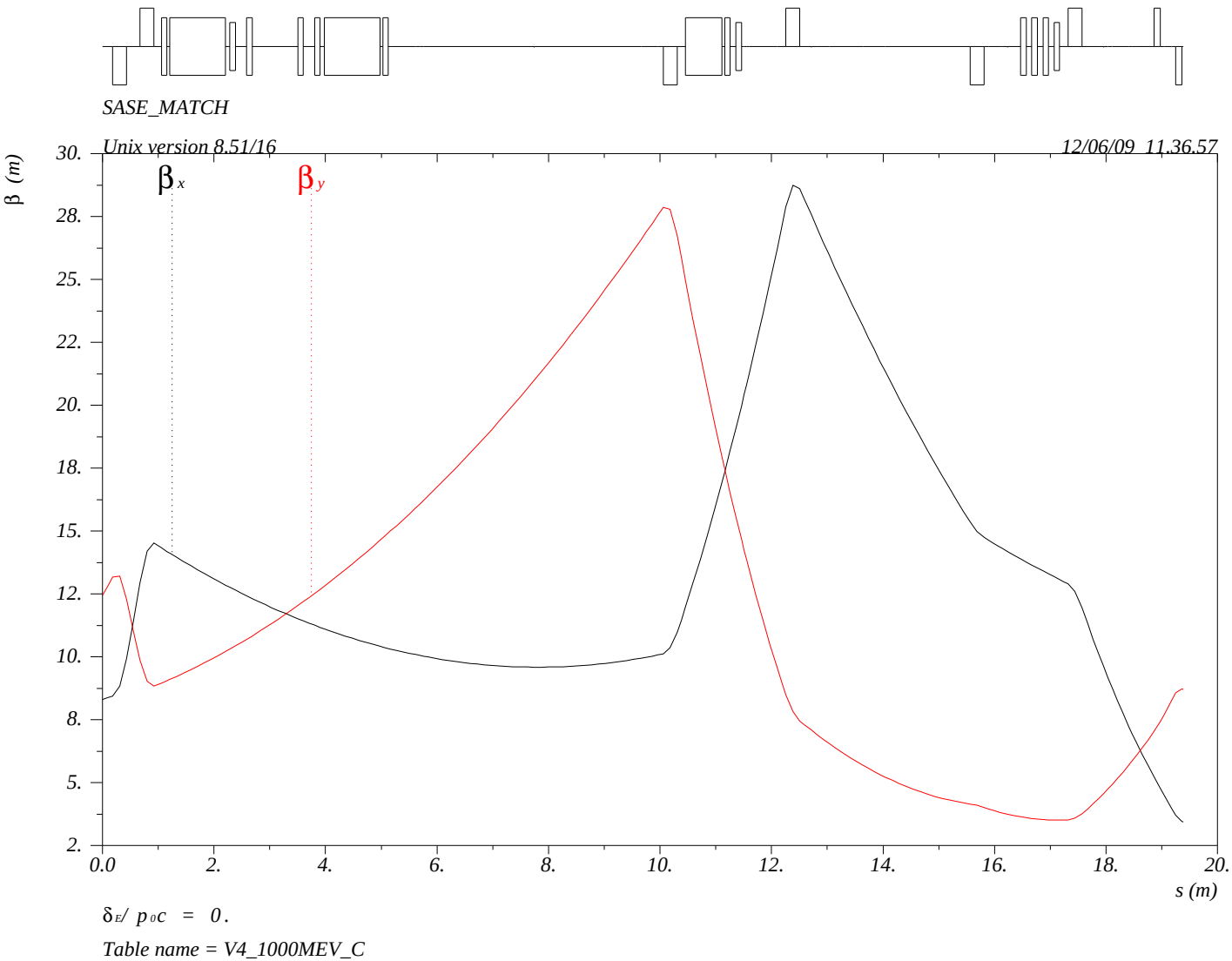
The SMATCH/SDUMP Lattice



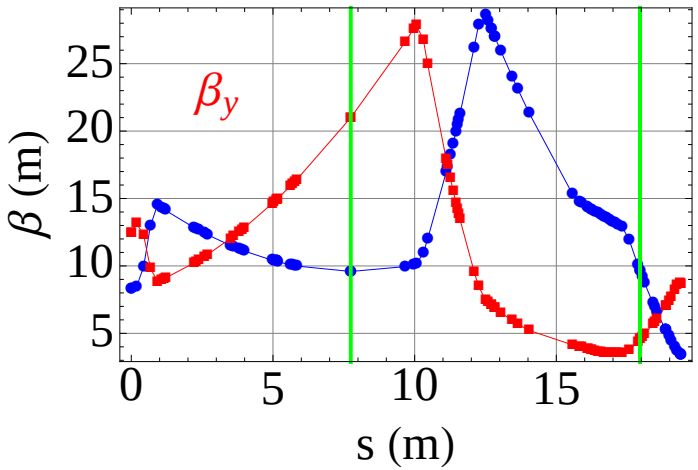
Lattice Components

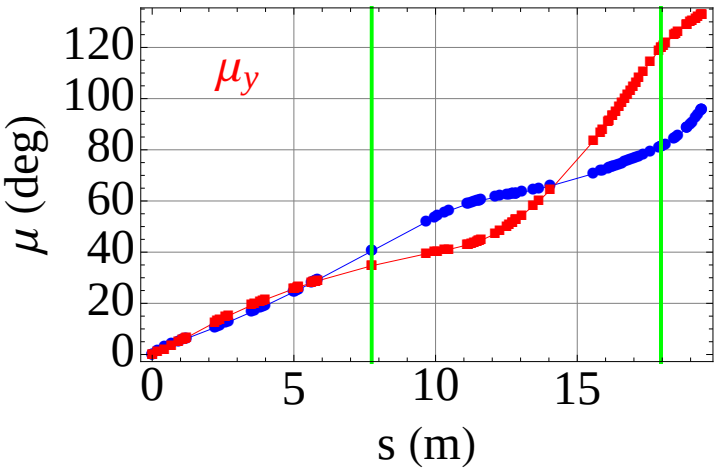
- 9 quadrupoles for matching of the desired Twiss functions: 6 in SMATCH, 2 upstream of "LOLA" and 1 in SDUMP
- 6 steerers: 2 units for vertical/horizontal steering (SASE steerers) and 1 unit for beam dumping (Killer steerers)
- 2 dipole magnets for generation of dispersion
- 1 fast kicker magnet for diagnostics with off-axis screens

Example: 1000 MeV, V4 and sFLASH Undulators Closed



Example: 1000 MeV, V4 and sFLASH Undulators Closed





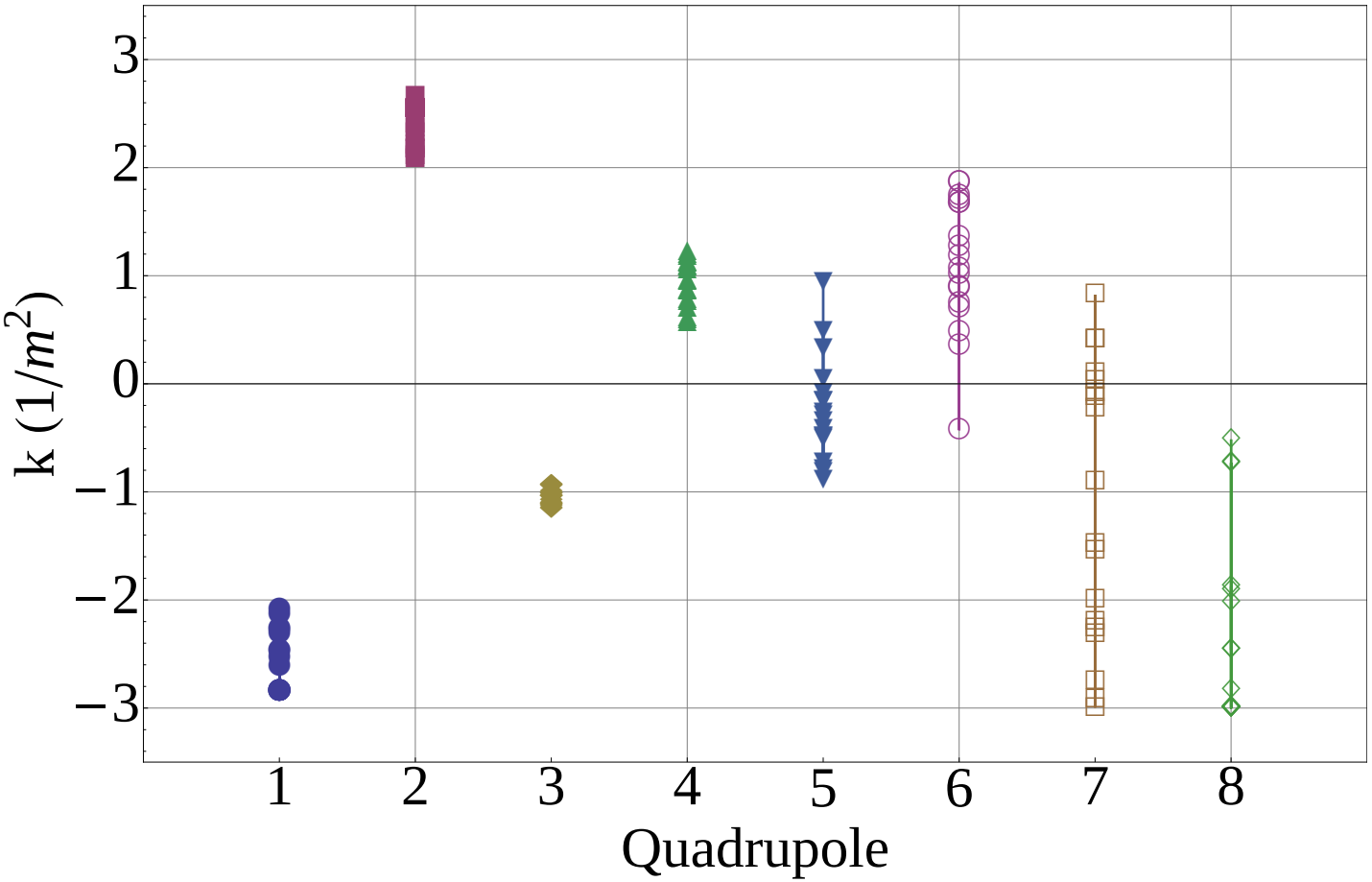
Example: $\epsilon_N = 2\ \mu\mathrm{m}$

- longitudinal resolution $\sigma_\zeta \approx 19$ fs
- phase advance $\Delta\Phi_y \approx 85°$

"LOLA" Performance for All Optics

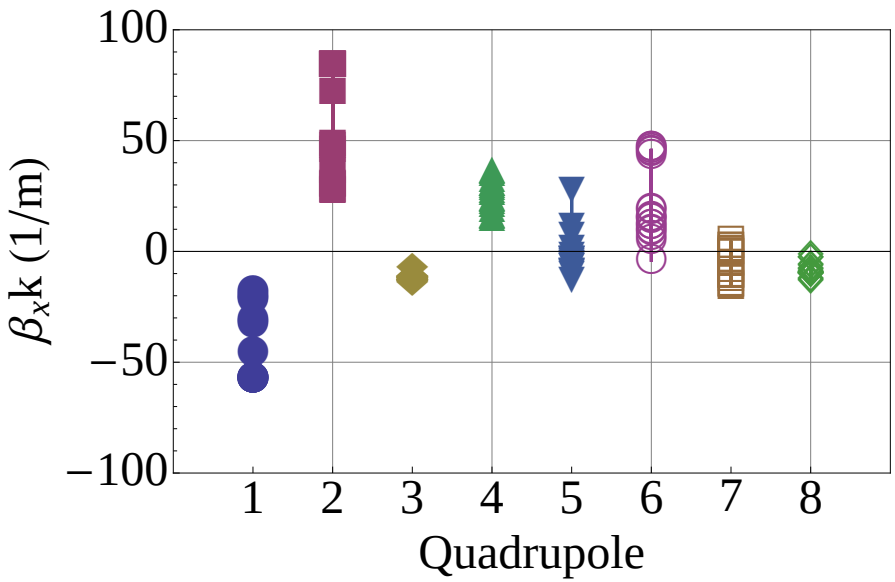
- longitudinal resolution $10\ \mathrm{fs} < \sigma_\zeta < 20\ \mathrm{fs}$
- phase advance $80° < \Delta\Phi_y < 100°$

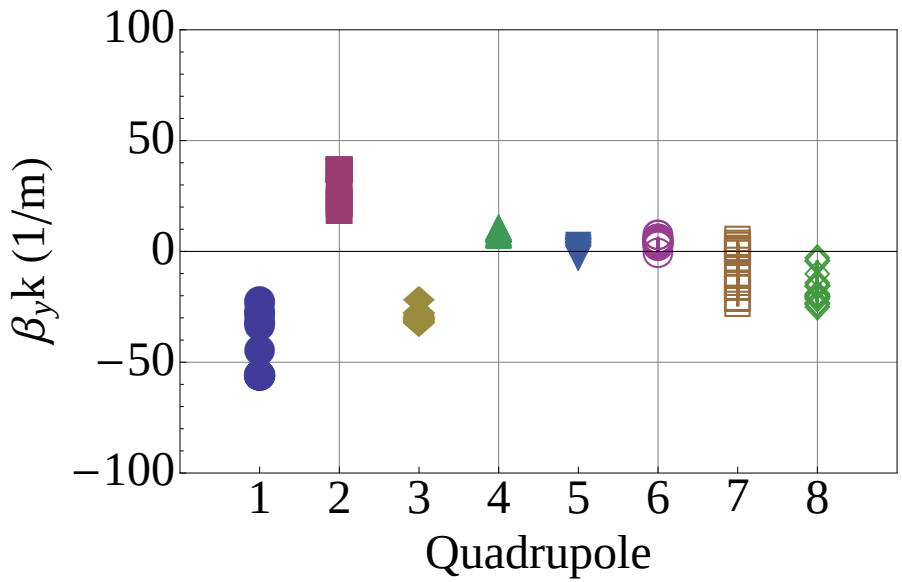
Quadrupole Strengths k for All optics and Quadrupoles



The last two quadrupoles (TQG's) in front of the FEL-undulators are necessary for matching. They are currently switched off.

"Sensitivity" of Individual Quadrupoles (βk-value)





The sensitivity of individual quadrupoles errors are less dominant in front of the FEL-undulators (small beta functions).

Interim Summary

Achievements

- Lattice of SMATCH and SDUMP defined and proved by engineers.
- Optics for parasitic "LOLA" measurements with high longitudinal resolution.
- All optics conditions accomplished (different energy and options including sFLASH undulators).
- Steering performance is sufficient [Velizar Miltchev].

Final Remarks

- merge the optics fragments (e.g. SMATCH and sFLASH) into one reference file, which is managed and optimised by experts
- take care of $75^\circ < \Delta\Phi_y < 105^\circ$ and $\beta_y > 15\ \mathrm{m}$
- keep in mind that the TQG's are required
  $\Rightarrow$ check and provide usability

445 MeV and Option V4

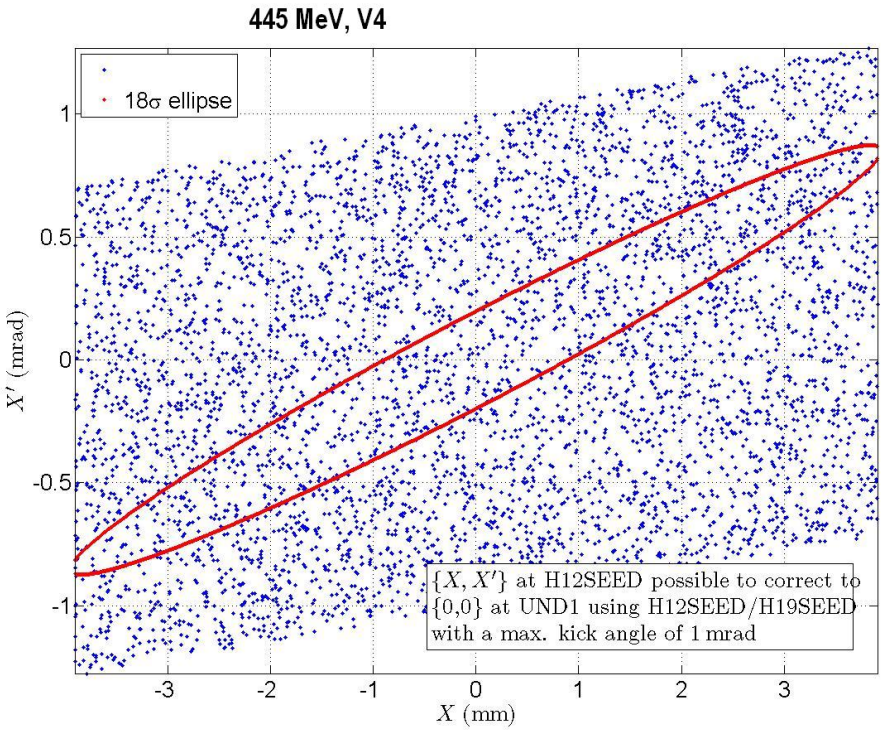


Figure: Horizontal Phase Space

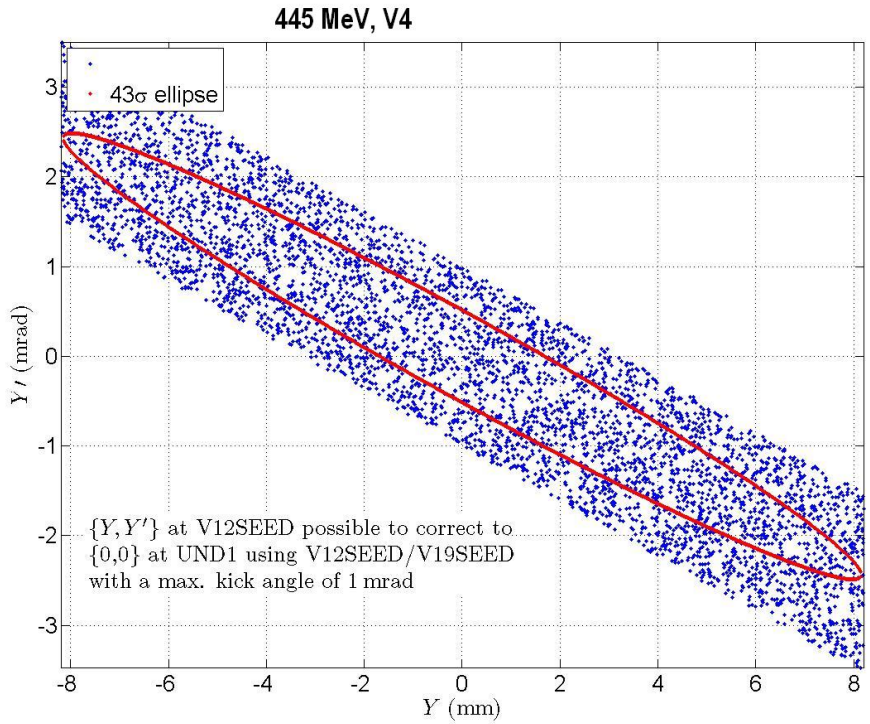


Figure: Vertical Phase Space

700 MeV and Option V4

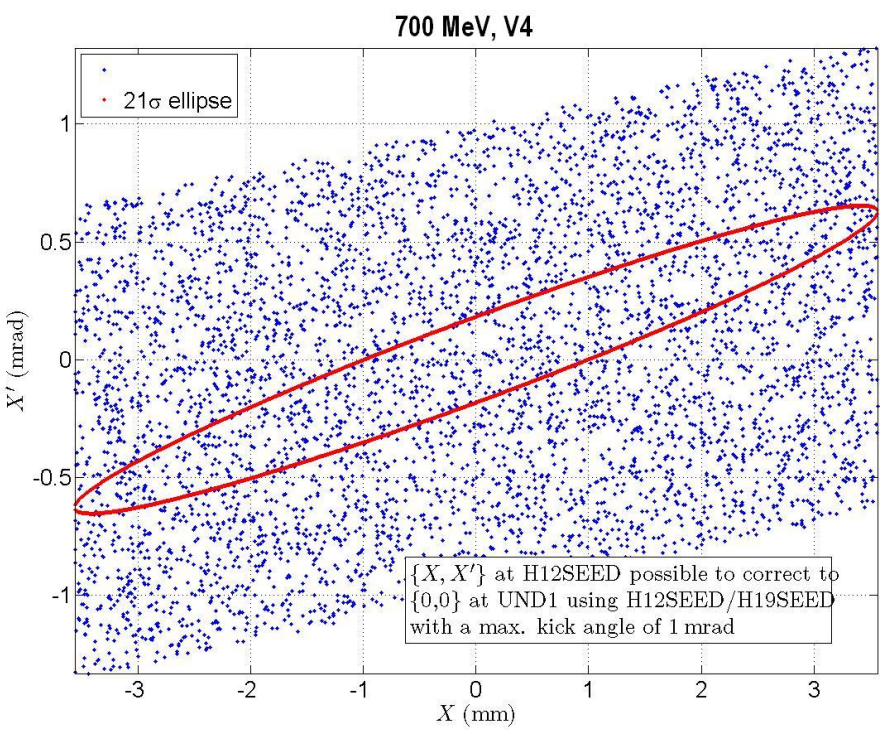


Figure: Horizontal Phase Space

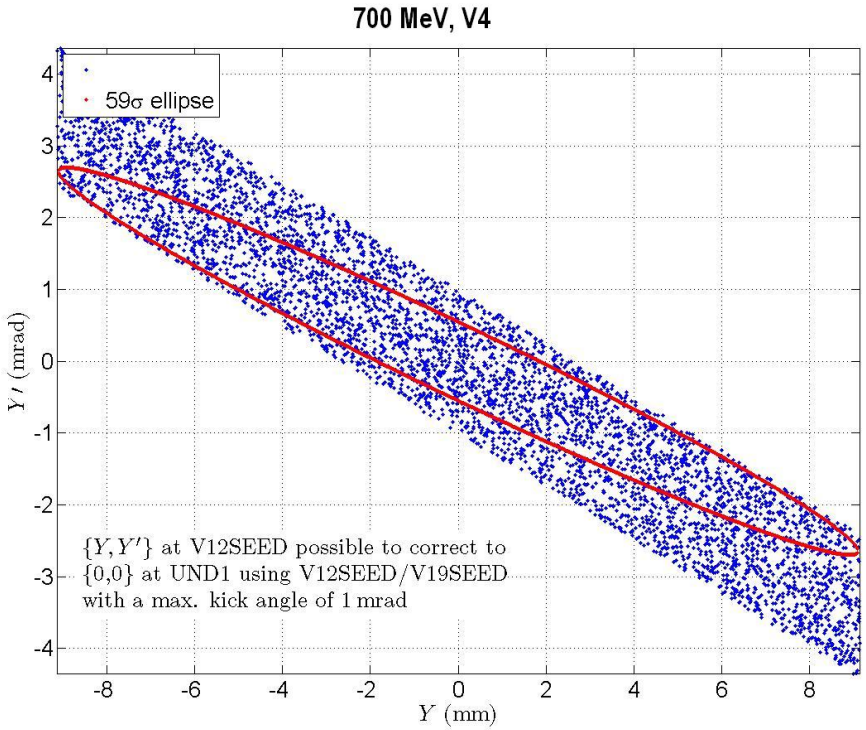


Figure: Vertical Phase Space

1000 MeV and Option V4

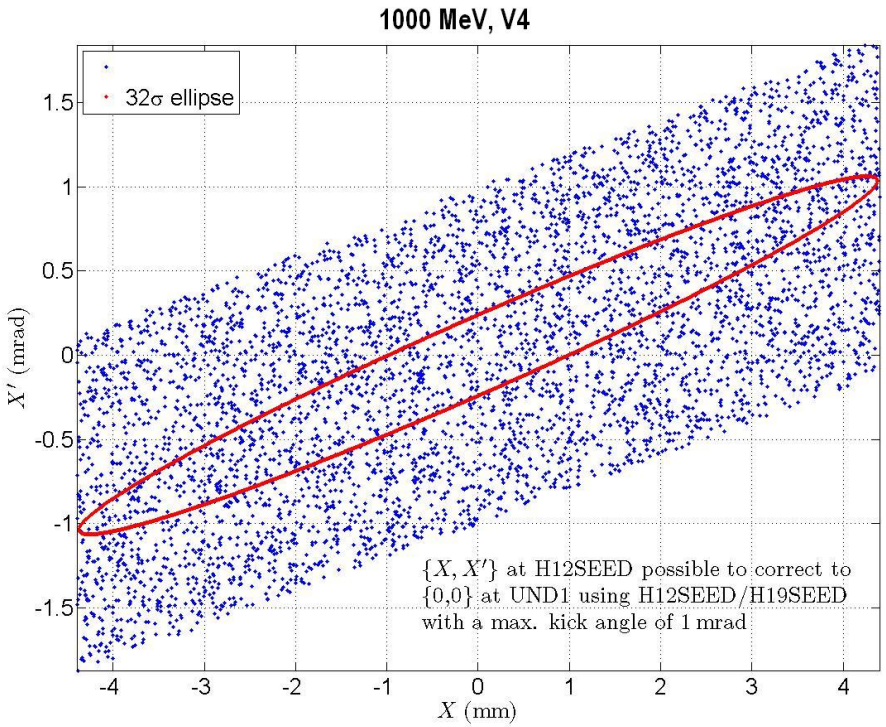


Figure: Horizontal Phase Space

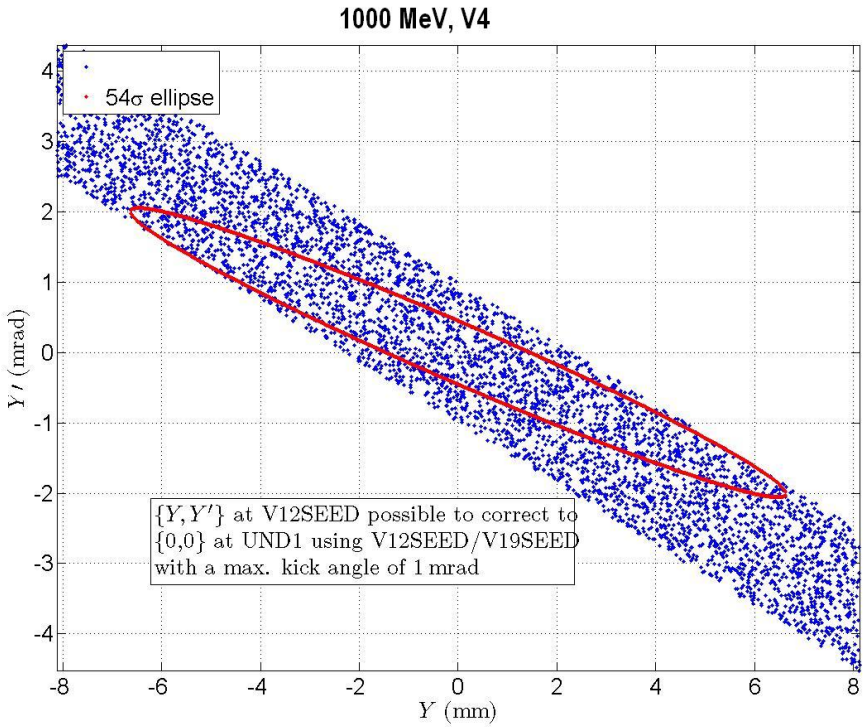


Figure: Vertical Phase Space