ILC Baseline BDS Collimation Depth Calculations

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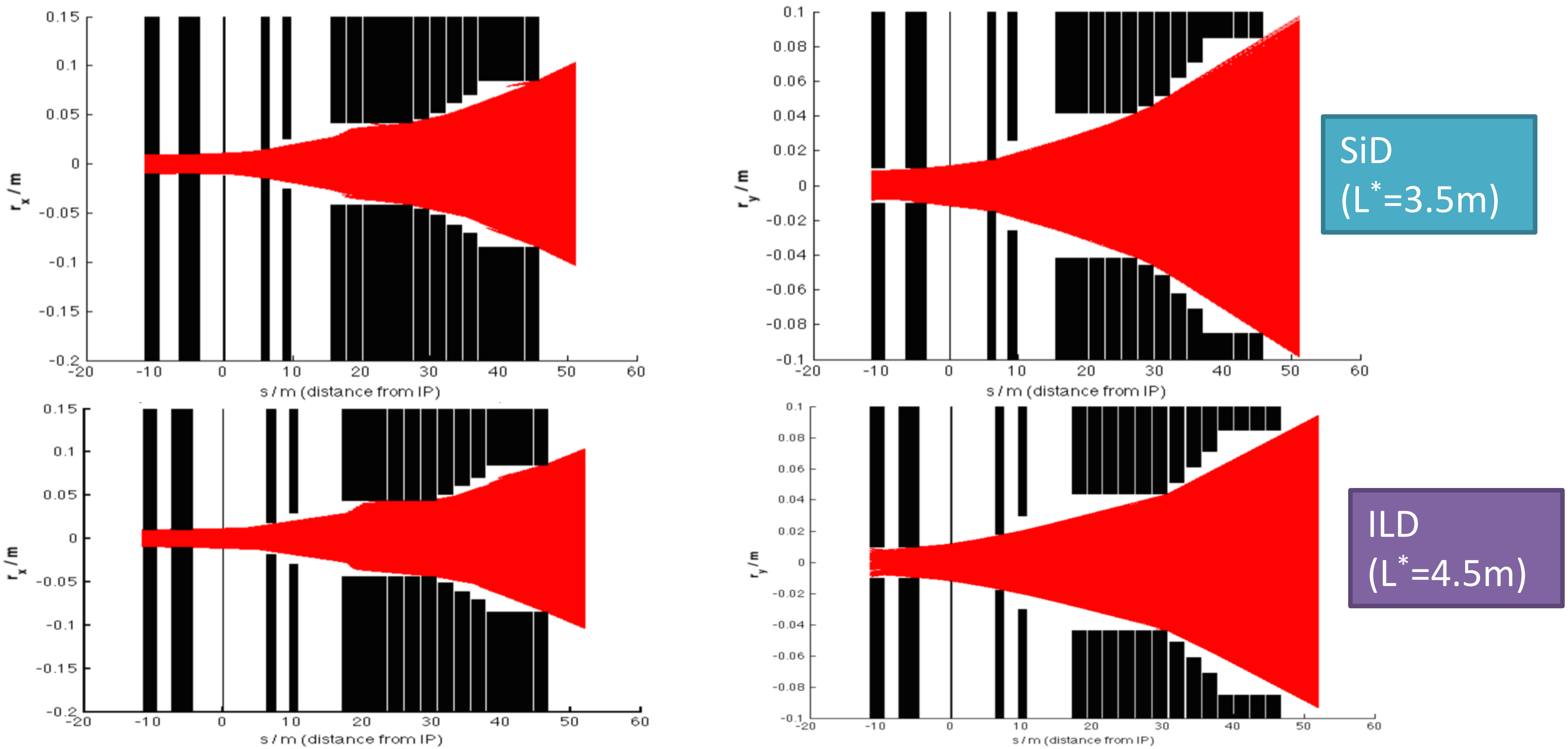
August 21, 2014

Overview

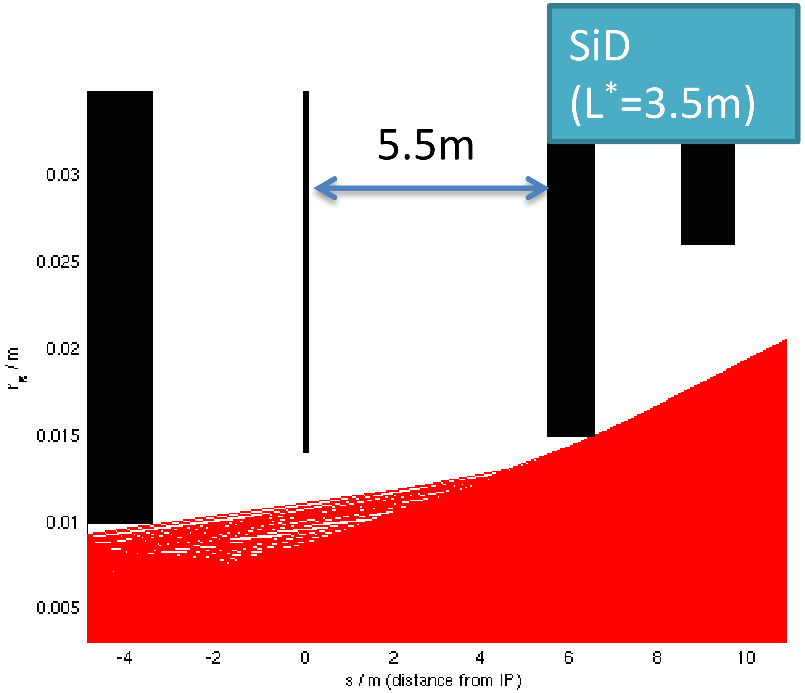
- Calculate collimation apertures based on no SR photons hitting IR region (QF1 -> IP+50m)
  - 3.5m (5.5m DL) L*
  - 4.5m (6.3m DL) L*
  - TDR Baseline (500 GeV CME)
- Tracking-based calculation (Lucretia) to include non-linear field elements (FD sextupoles, octupoles).

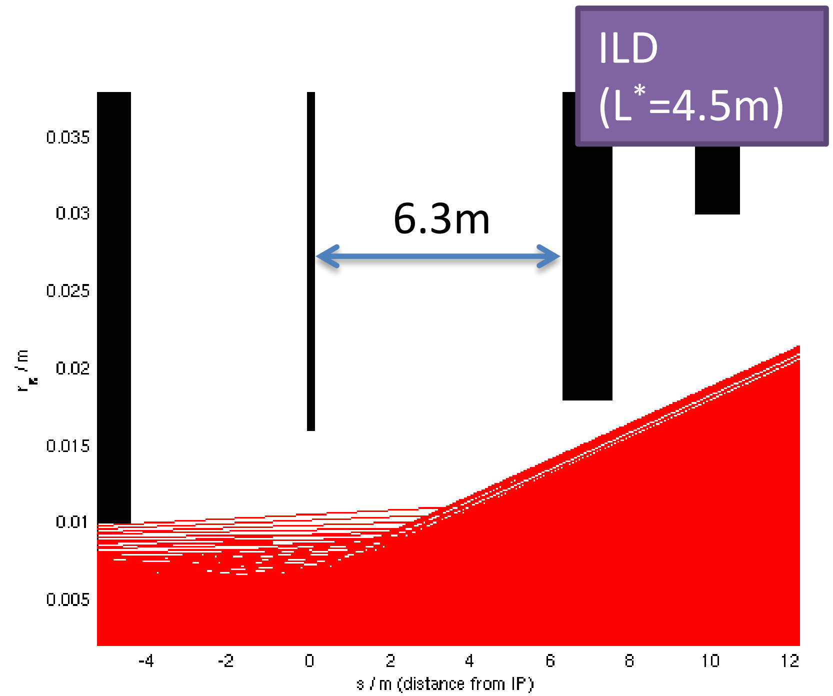
SR Radiation in IR Region



- SR from particles covering all QF1 phase-space
  - Rays not hitting apertures shown
- Aperture @ IP = 14mm (SiD), 16mm (ILD) radius inner vertex detector layer (L=125mm)

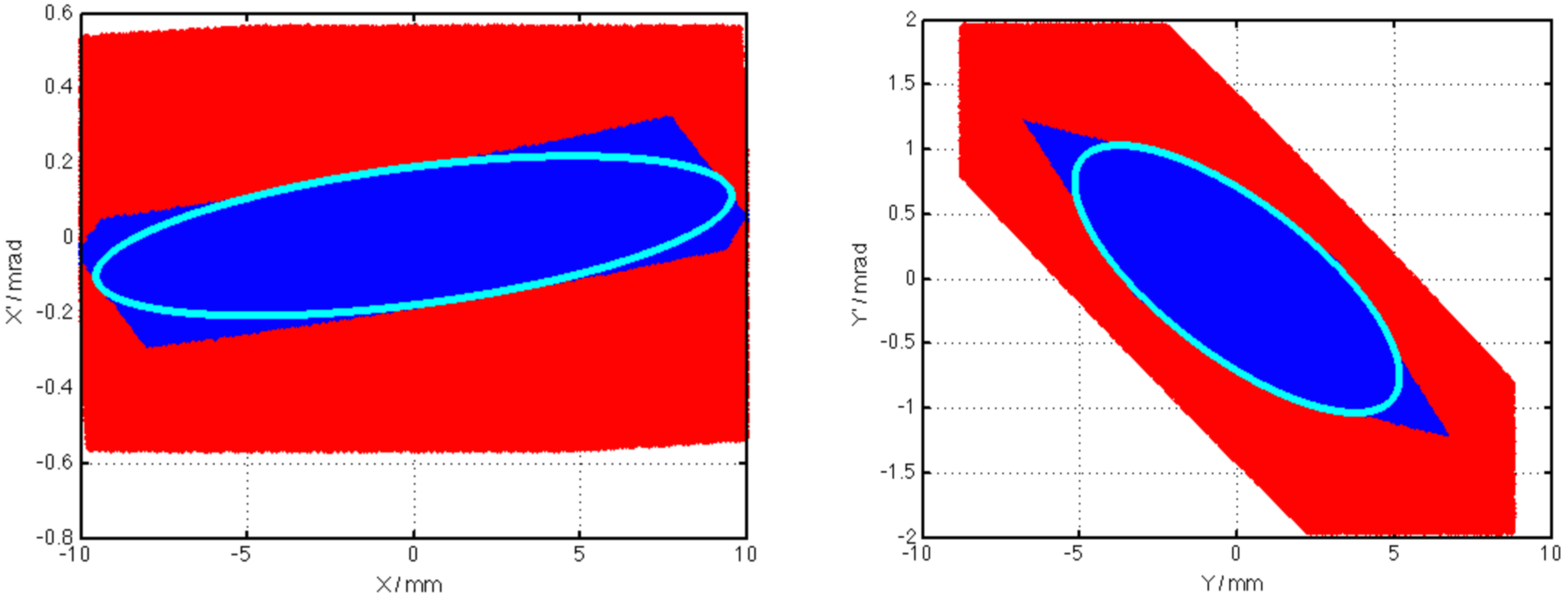
3.5m vs. 4.5m L* IR Geometry





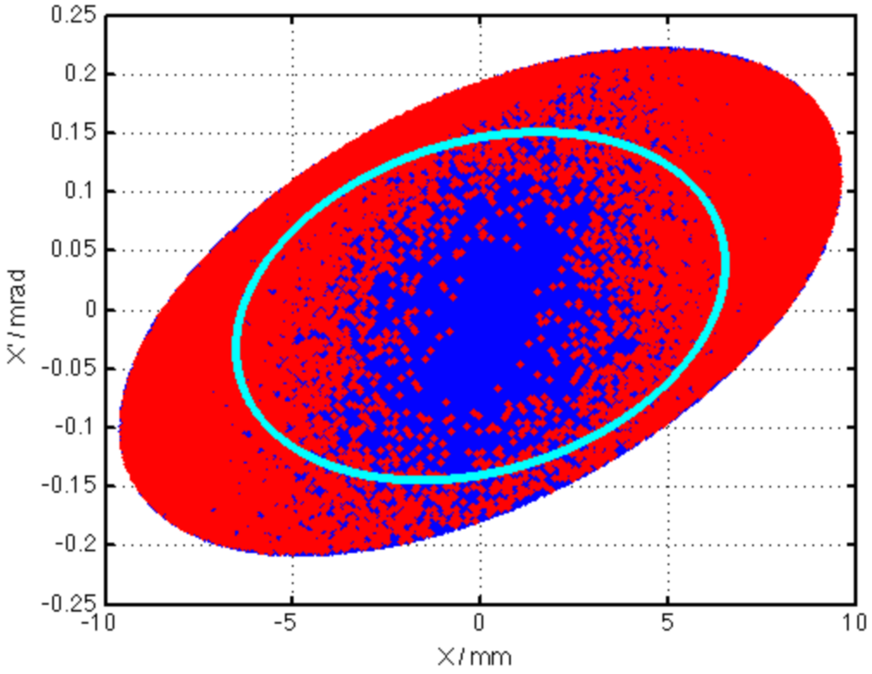
- Difference in detector and extraction system design for 2 IR's
  - No simple scaling for collimation depth

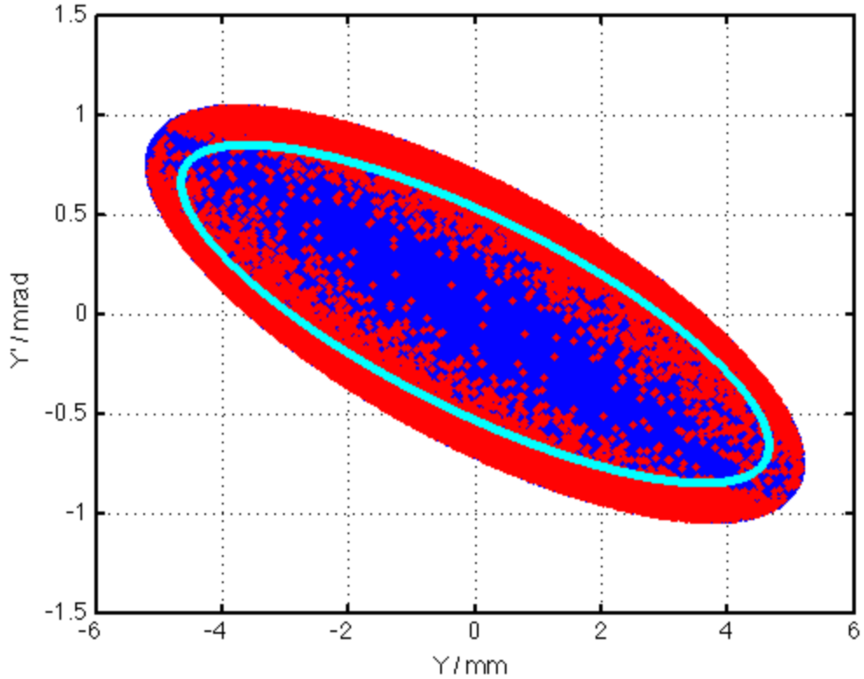
2D Particle Phase Space @ QF1 Entrance *(L^*=3.5m)*



- 1e6 Macro-particles, uniform random distribution in 2D phase-space.
- Red tags particles generating SR photon hits in IR. Blue OK. Ellipse fit to define SR aperture.
  - Missing particles in above plots = collimated by IR magnet apertures.

4D Particle Phase Space @ QF1 Entrance *(L^*=3.5m)*

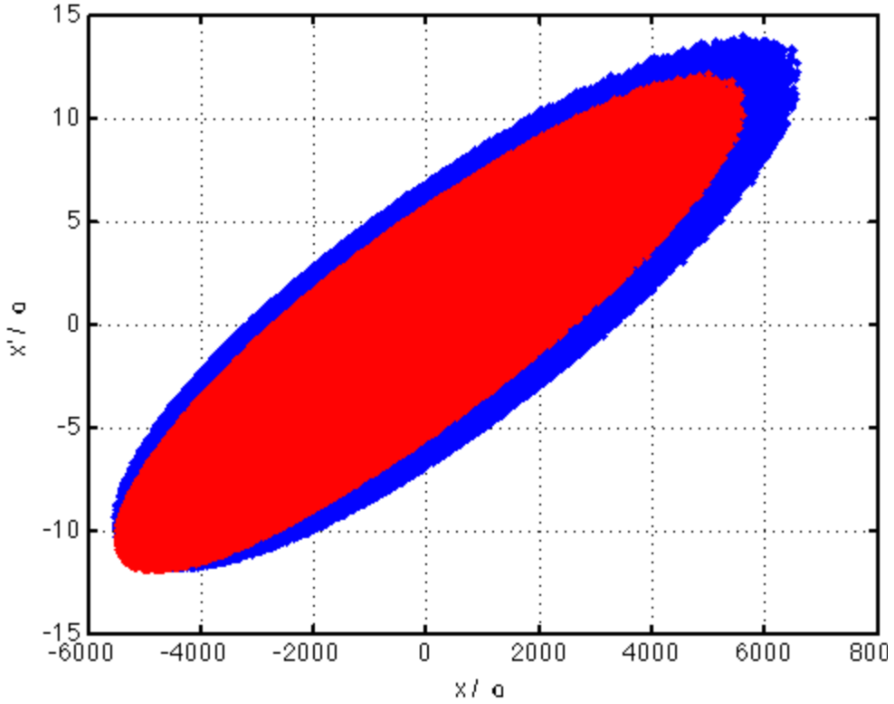


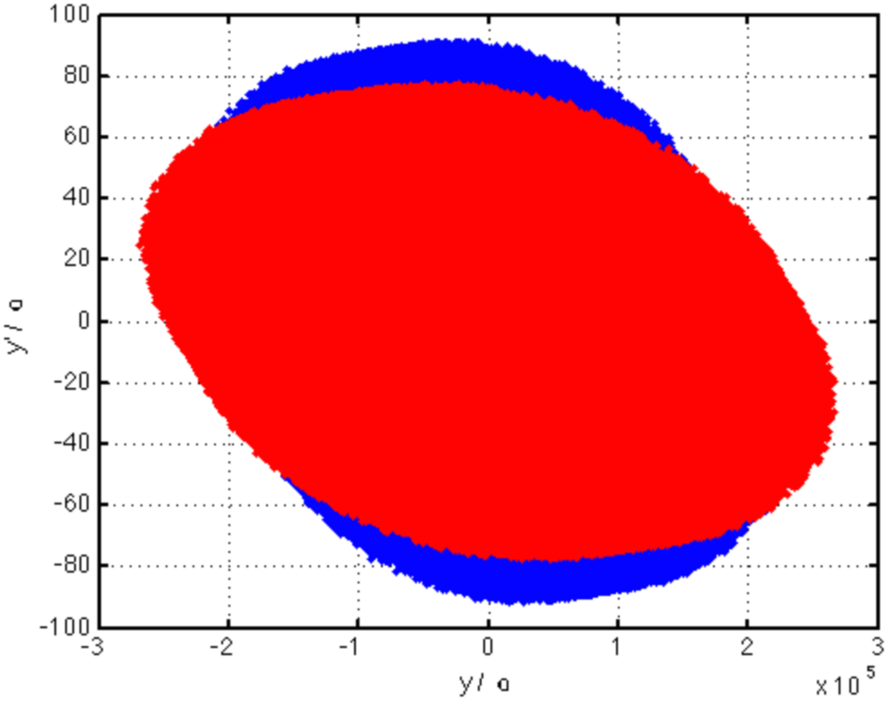


- Generate initial phase-space from previous plots.
- Additional hit particles present due to x-y correlations.
- Use minimizer to find simultaneous x and y phase space ellipse apertures which ensure no IR SR photon hits (cyan ellipses).

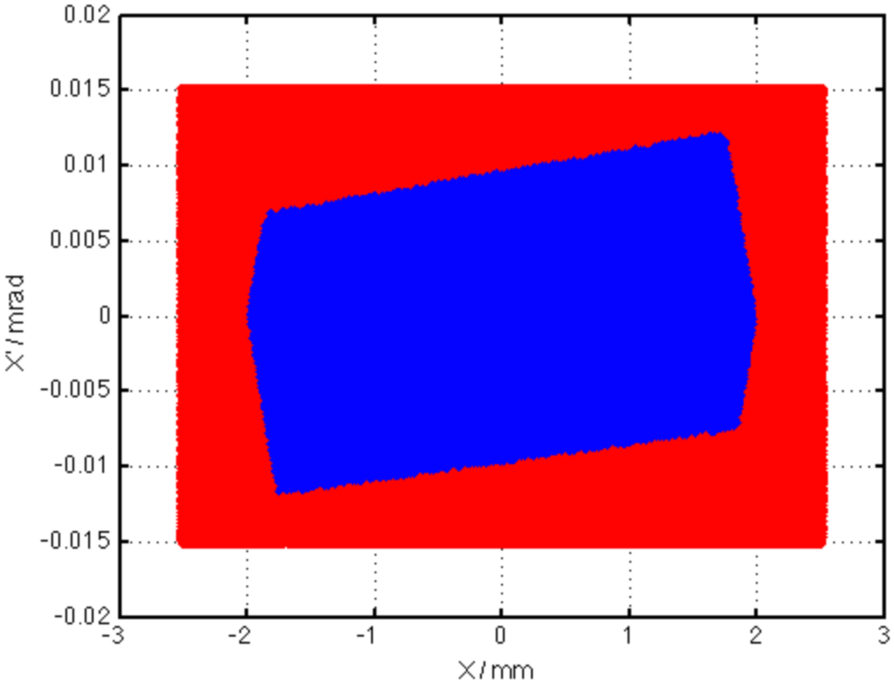
Allowed Particle Apertures @ IP

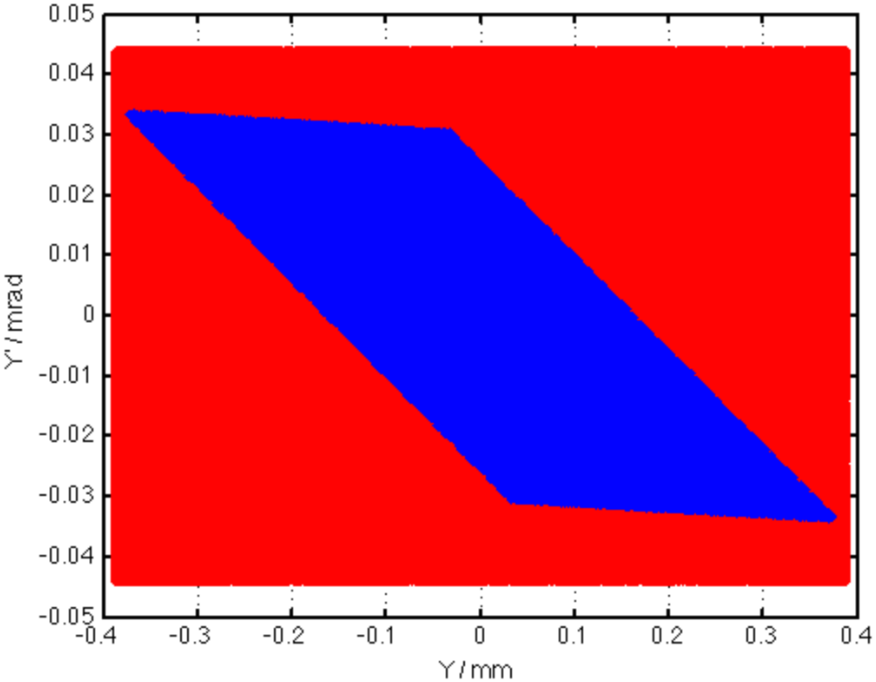
L^* = **3.5m** , **4.5m**





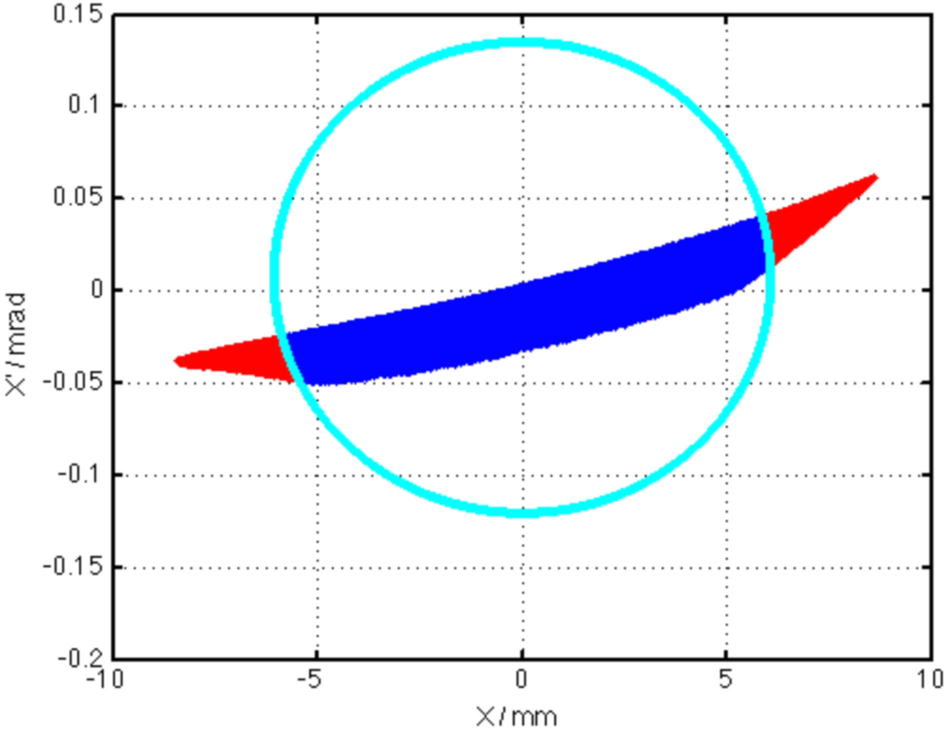
Phase Space Tracking SP1 -> QF1 *(L^*=3.5m)*

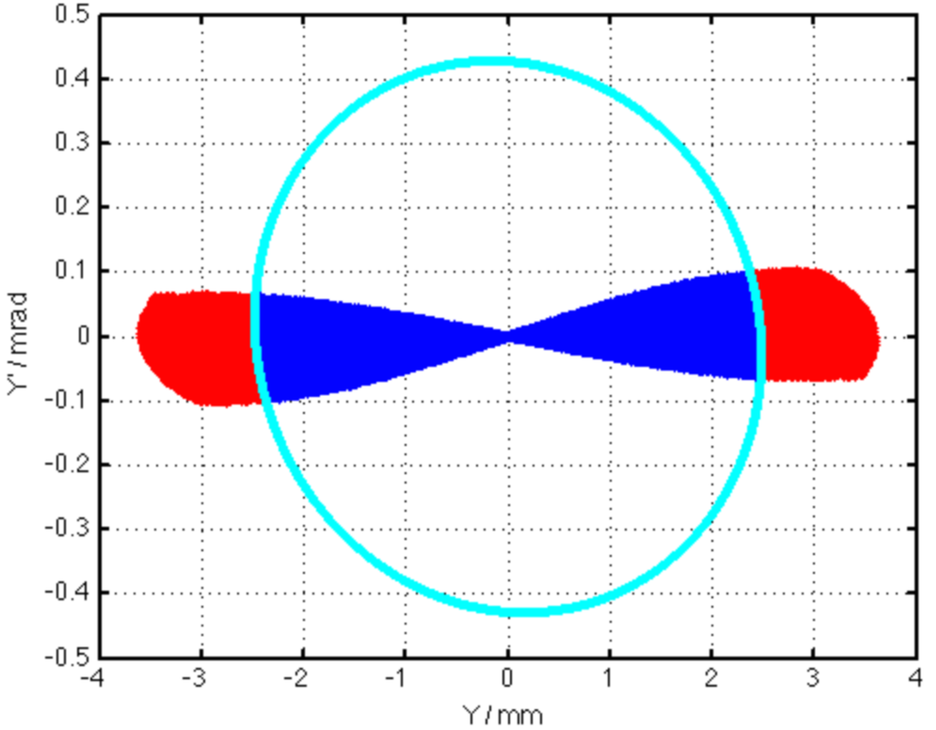




- Track 4D phase space from entrance SP1 spoiler to QF1 magnet entrance.
  - Blue shows particles with clear transmission to QF1
  - Red shows particles collimated by magnet apertures (all spoiler apertures deactivated)

Phase Space @ QF1 Entrance *(L^*=3.5m)*





- Particles tracked from SP1 and not hitting magnet aperture
  - Blue = No SR hits in IR
  - Red = SR hits aperture in IR
  - Cyan ellipse = SR aperture @ QF1 from previous calculation
- Set betatron collimation apertures to cut red particles that generate SR hits in IR

Betatron Spoiler Apertures

Name	L^*=3.5m		L^*=4.5m		Existing Lattice	
	X / mm ($N\sigma_x$)	Y / mm ($N\sigma_y$)	X / mm ($N\sigma_x$)	Y / mm ($N\sigma_x$)	X / mm ($N\sigma_x$)	Y / mm ($N\sigma_y$)
SP1	-	-	-	-	0.3 (15)	0.25 (250)
SP2	-	-	1.24 (11)	0.2 (24)	0.3 (2.7)	0.2 (24)
SP3	-	-	0.5 (25)	0.22 (219)	0.3 (15)	0.25 (250)
SP4	-	-	0.59 (5.4)	0.22 (26)	0.3 (2.7)	0.2 (24)
SP5	-	-	-	-	0.42 (11)	0.25 (250)

- "-" = no collimation needed at this location to prevent IR SR hits.
  - (L*=3.5m optics completely shielded by magnet apertures)
- Tightest aperture: SP2/SP4 (X)
  - *2.7σ = 0.7% Beam loss = 36kW for existing lattice*
- TDR calls for 1-2E-5 main beam loss => 4.3σ tightest collimation aperture. (Max with all muon spoiler space filled = 1E-3 beam loss => 3.3σ)
  - **Tightest L*=4.5m aperture = SP4 = 5.4σ**

Summary and Next Steps

- Collimation apertures calculated for baseline optics for both L* configurations based on SR hits in IR.
  - 3.5m L* optics completely shielded by magnet apertures
  - 4.5m L* optics requires loose collimation (24σ tightest collimation aperture)
- Next job: calculate collimation efficiency, iterate collimator settings requirement and calculate muon suppression requirements.
- Possible refinements for SR calculations:
  - Include perturbation of colliding beam
  - IR solenoid field
  - Higher-order QED field calculations?