MDI at the XCC

Conventional Facilities, Machine Detector Interface Session, LCWS2024

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Machine Detector Interface at XCC

Accelerator Issues Related to Getting Four Particle Beams In and Out of IP Region

(1) Crossing angle and Aperture of final quad (given crossing angle choice, e^+, e^-, γ from primary & Compton IP's must pass through this aperture)

(2) L*, KB mirror length and location

(3) Shared vacuum pipe: point of entry of XFEL beam into e^- beampipe, passing of electron beam through KB mirror chamber

Detector issues due to backgrounds from e^+, e^-, γ produced at Compton IP's and primary IP:

(1) Vertex detector inner radius (incoherent e^+e^- pairs from primary IP - same situation as e^+e^- linear colliders)

(2) Beampipe X_0 (moderate soft X-ray flux from Compton IP's $|\cos\theta| < 0.95$)

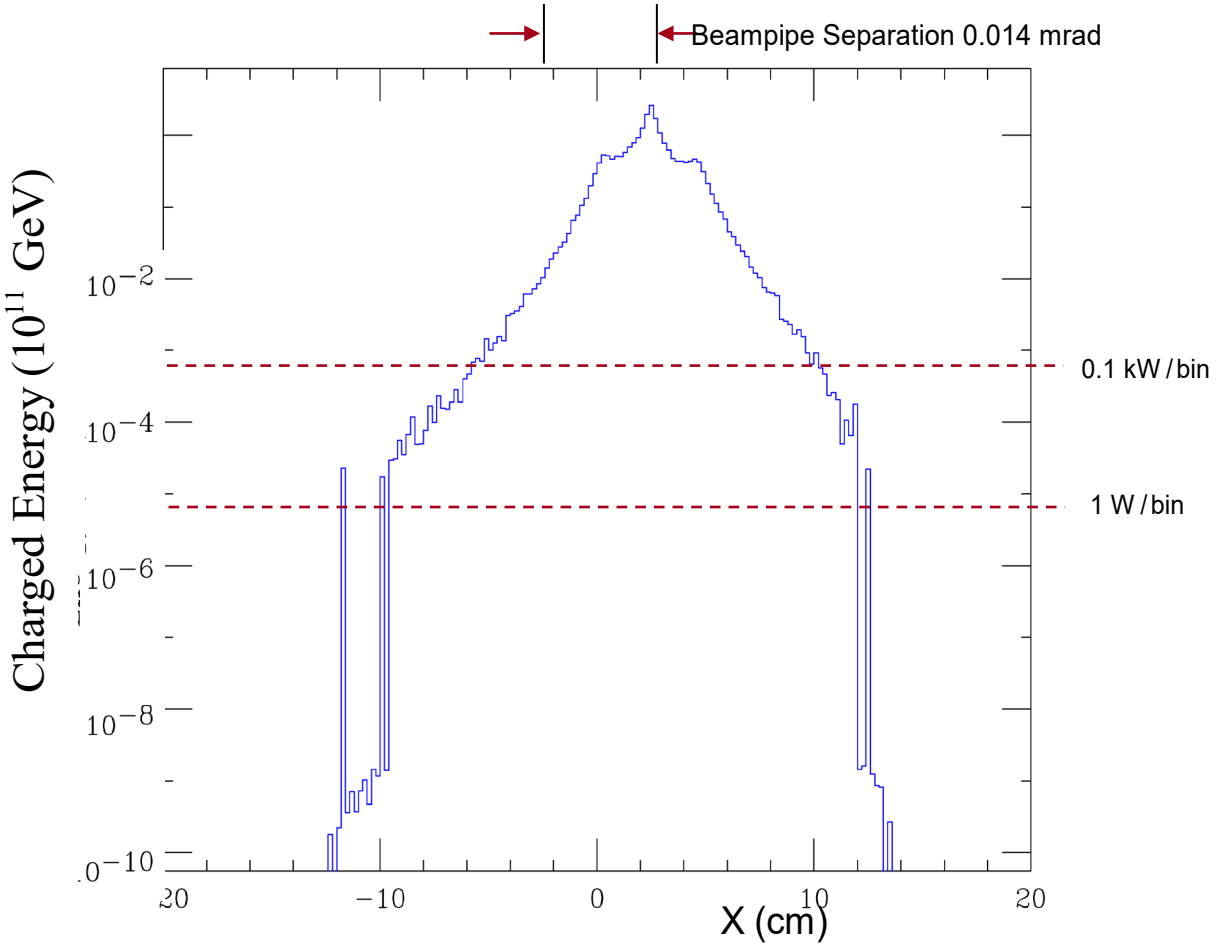
(3) Forward boundaries of the main tracker/calorimeter and solid angle coverage of forward detector (large hard X-ray flux from Compton IP's $|\cos\theta| > 0.95$)

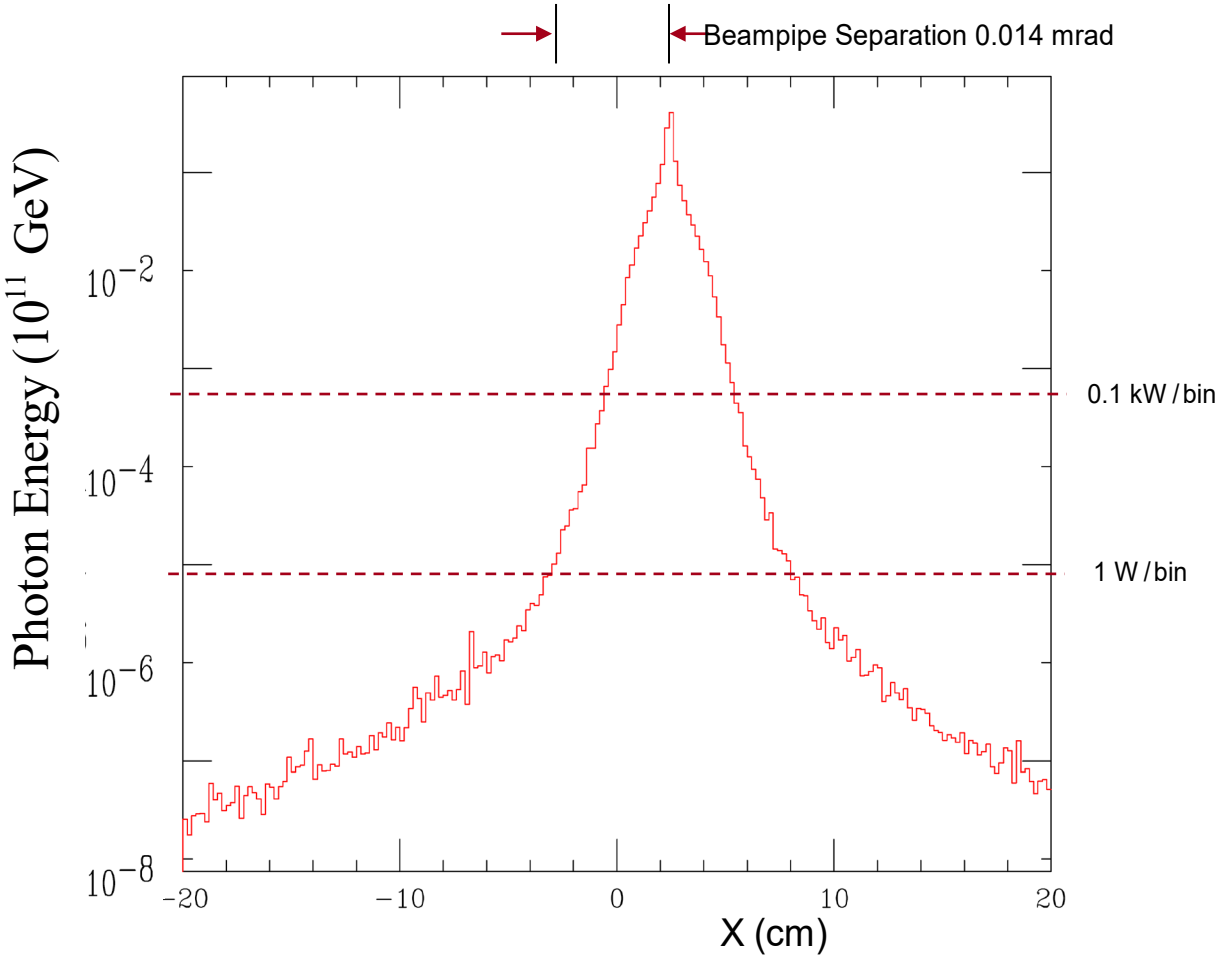
14 mrad Crossing Angle?

CAIN Simulation from IP to 3.5 m, Assume 5 T Solenoid

With, for example, 14 mrad crossing angle:

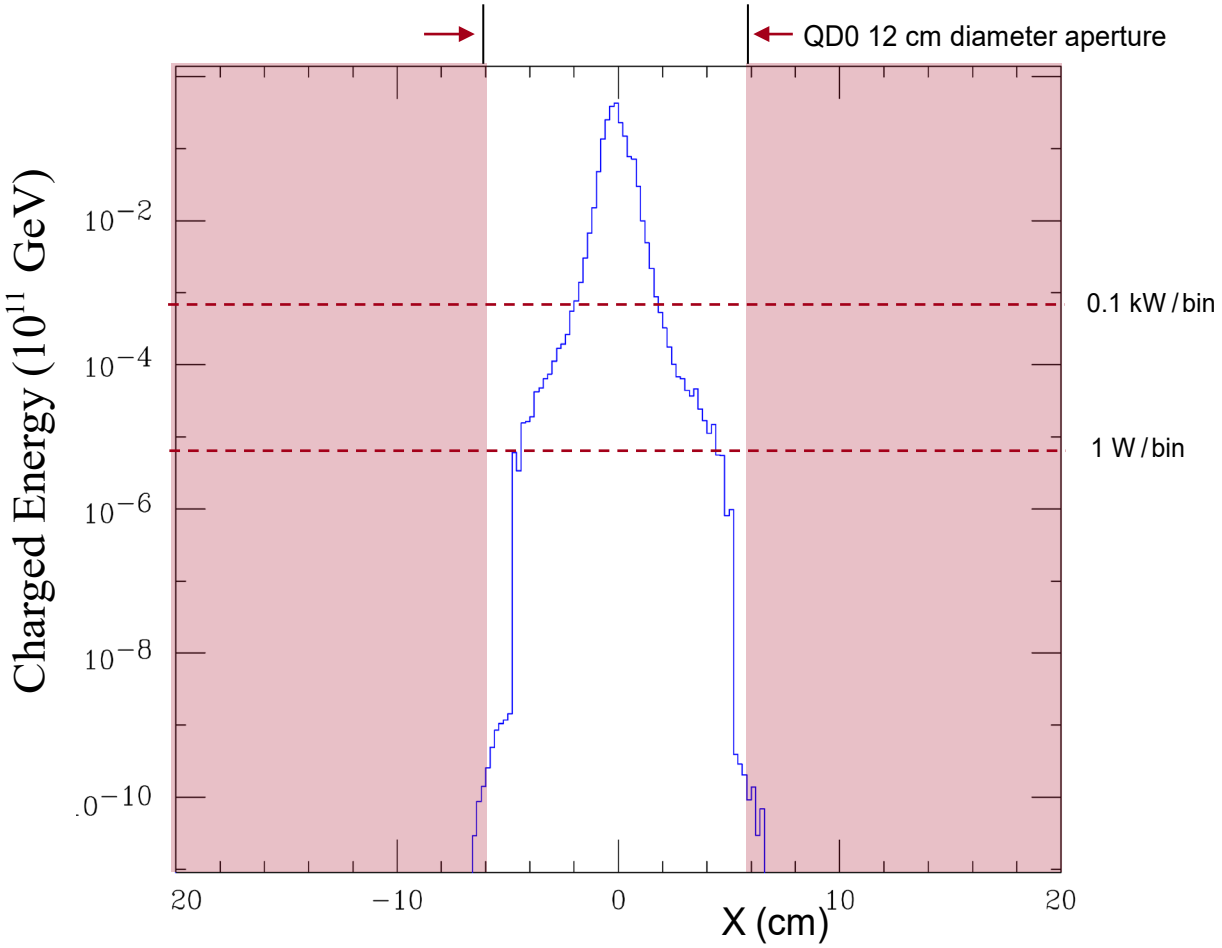
- Higgs rate down by factor of 6 w.r.t. head-on due to no γ beam crab crossing
- Charged particles spread out over much wider area due to beam-beam deflection of soft Compton IP electrons

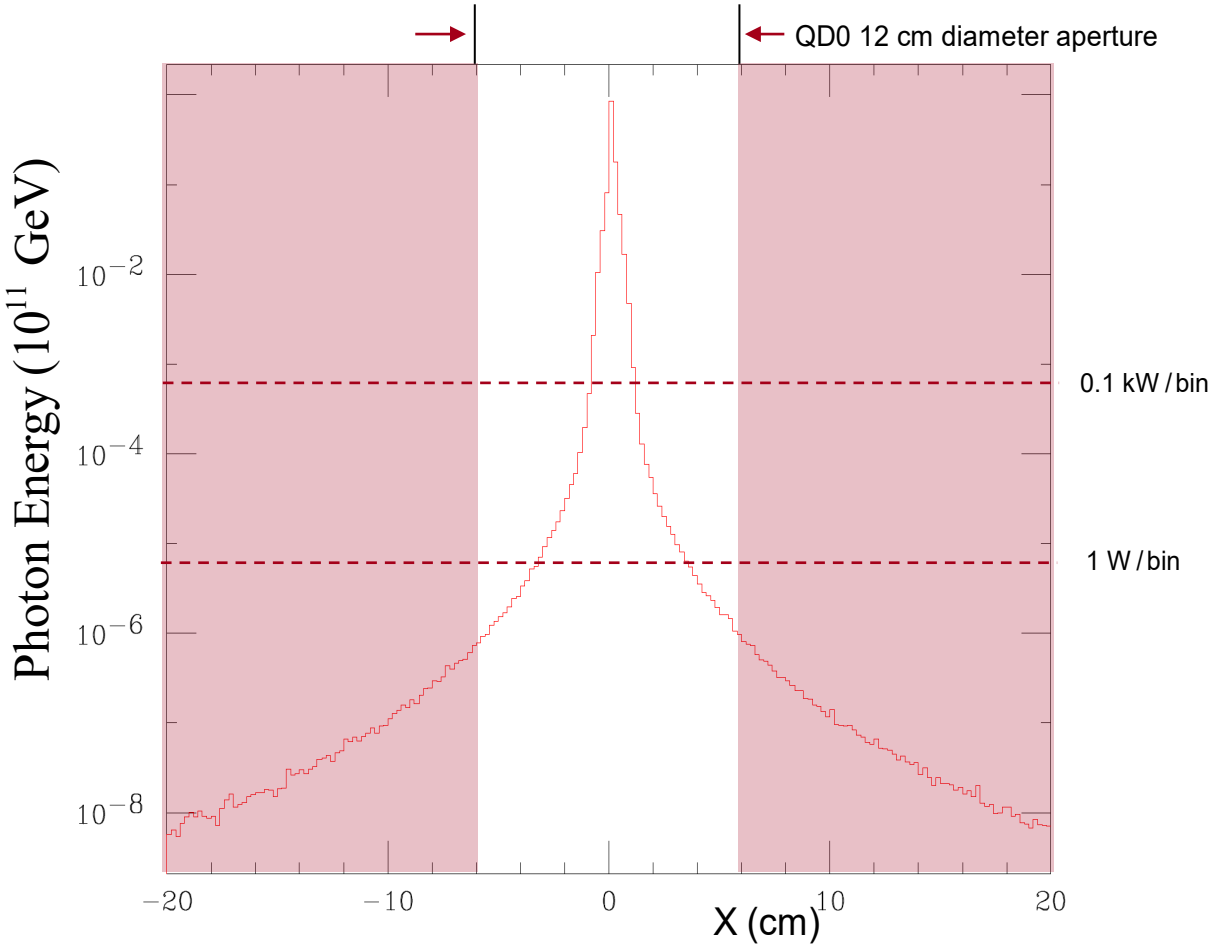




2 mrad crossing angle, L*=1.5 m

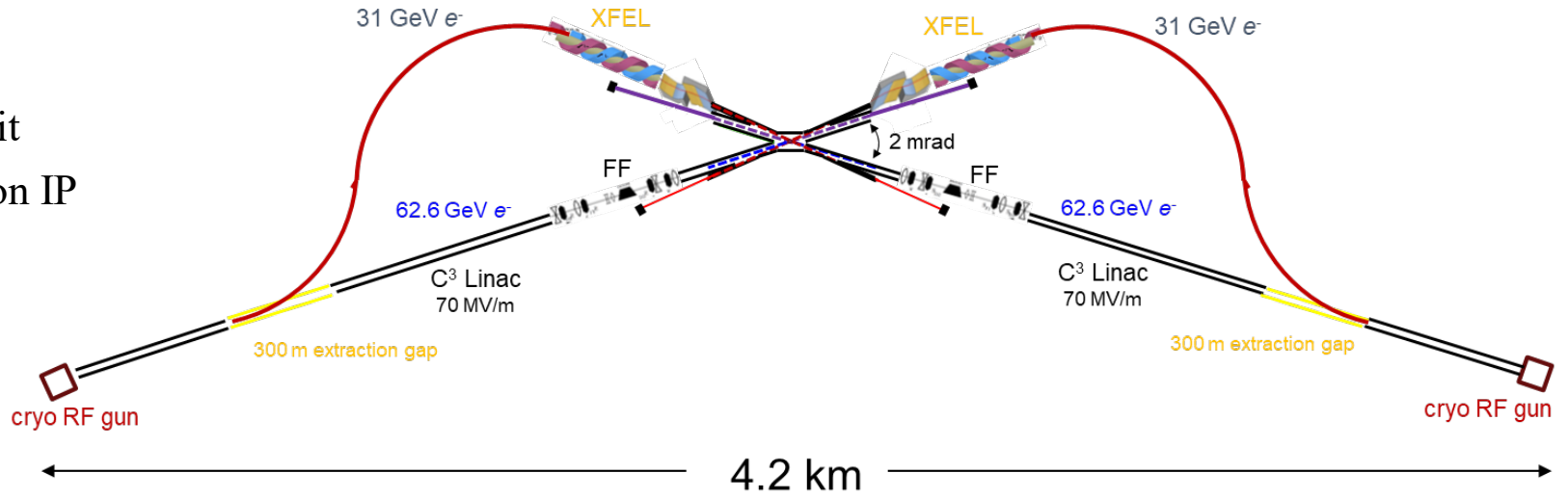
CAIN Simulation from IP to Face of Quad at L*=1.5 m, Assume 5 T Solenoid

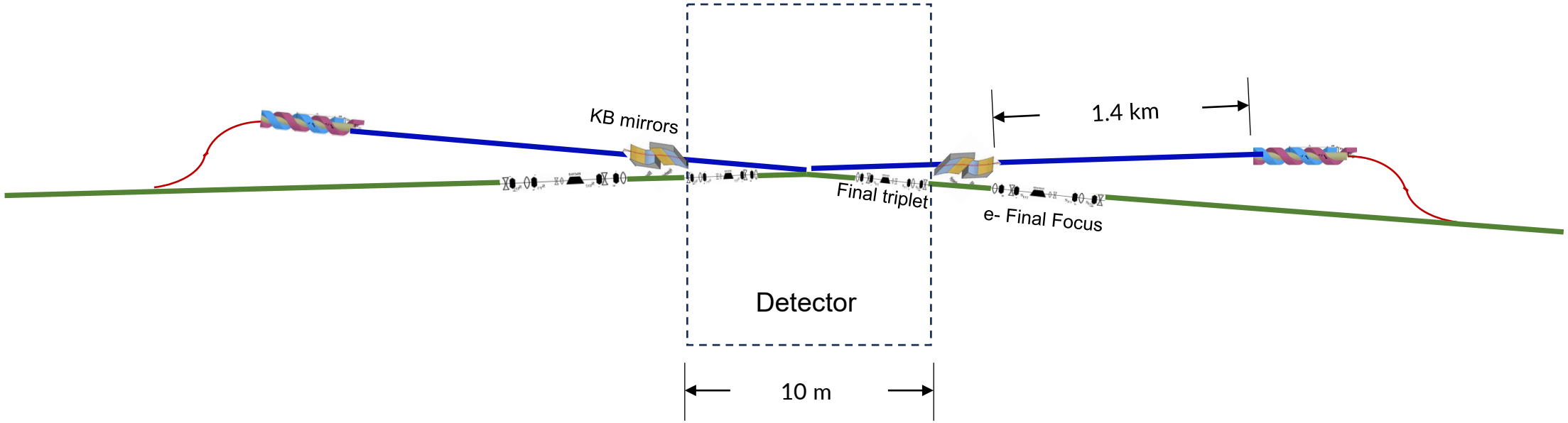


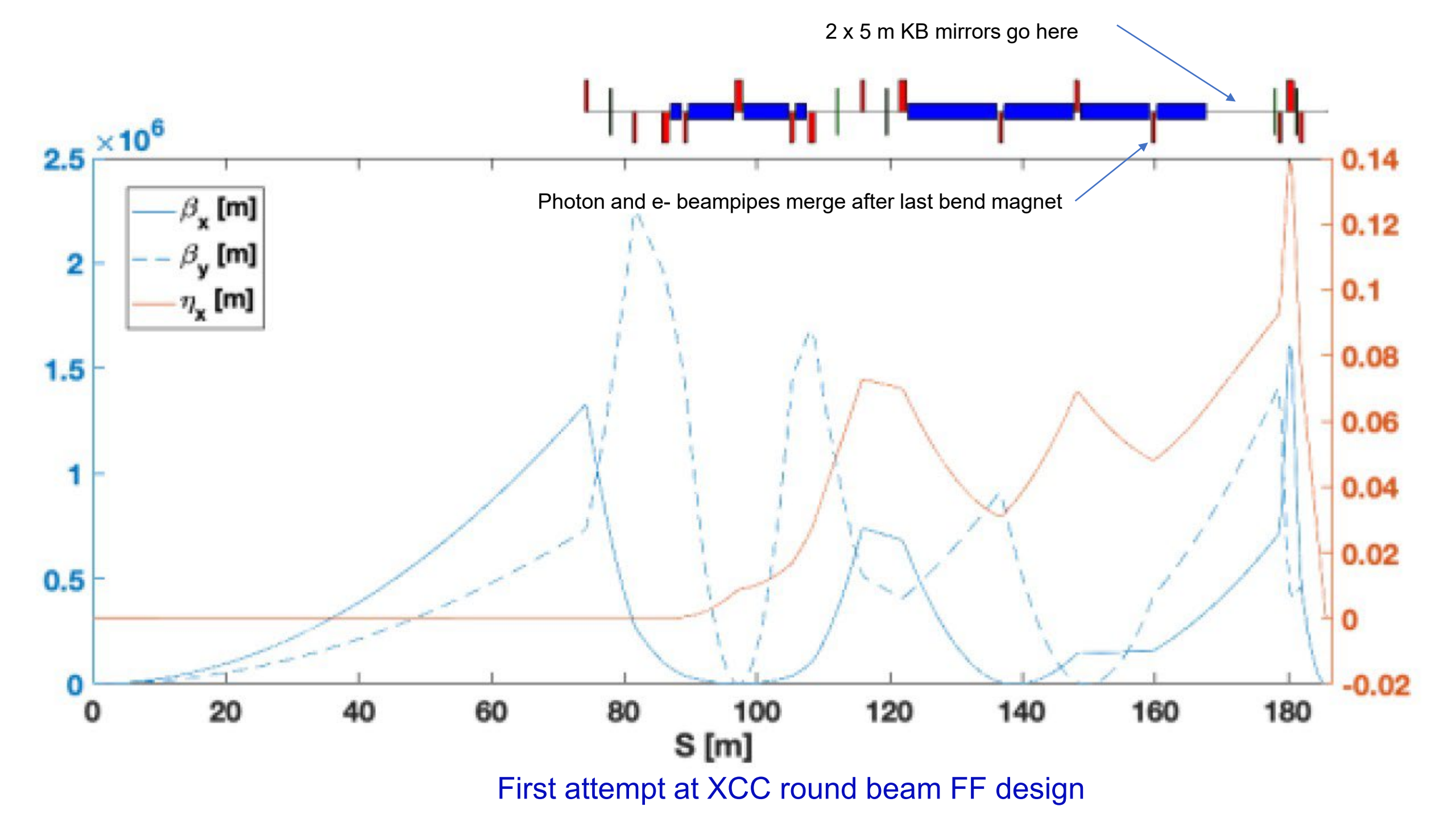


XCC Schematic with 1.4 km line between XFEL and KB mirrors

Demagnify 20 μm FWHM
XFEL beam at undulator exit
to 70 nm FWHM at Compton IP

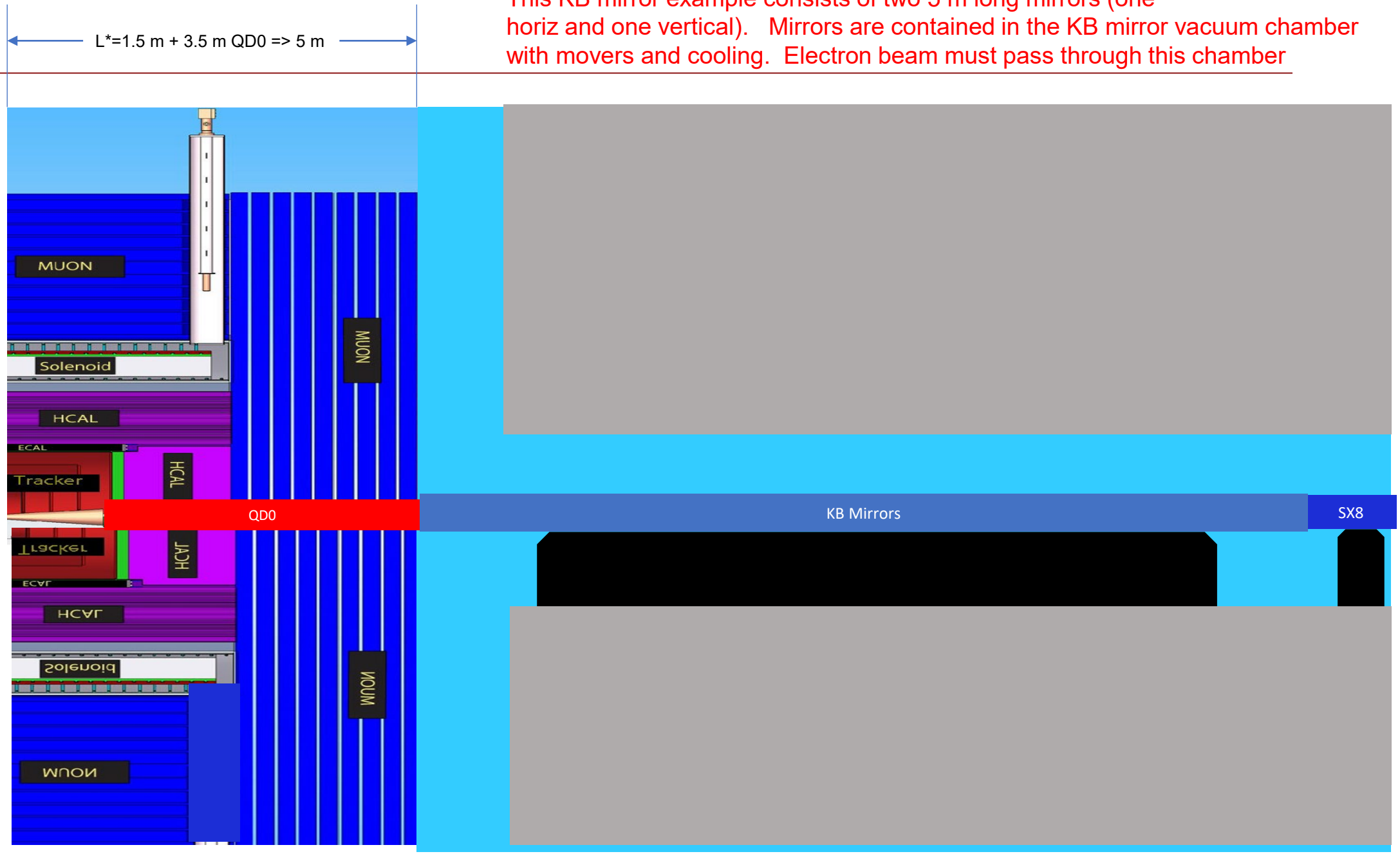




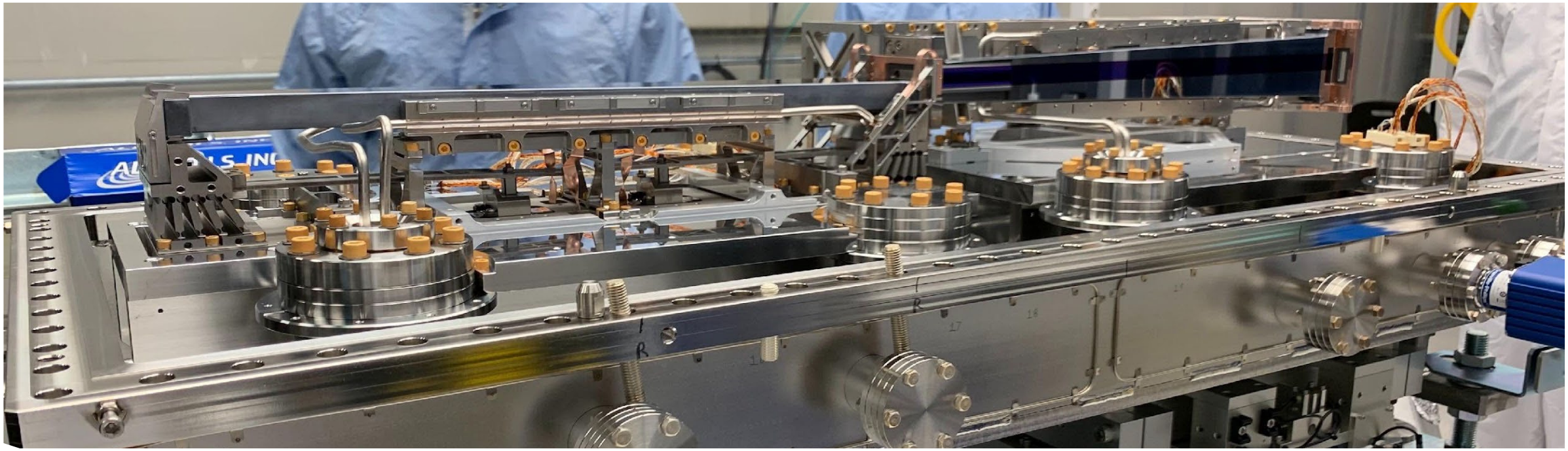


First attempt at XCC round beam FF design

Example beam layout of KB mirror and electron beam final triplet QD0.
This KB mirror example consists of two 5 m long mirrors (one horiz and one vertical). Mirrors are contained in the KB mirror vacuum chamber with movers and cooling. Electron beam must pass through this chamber



KB Mirror Chamber



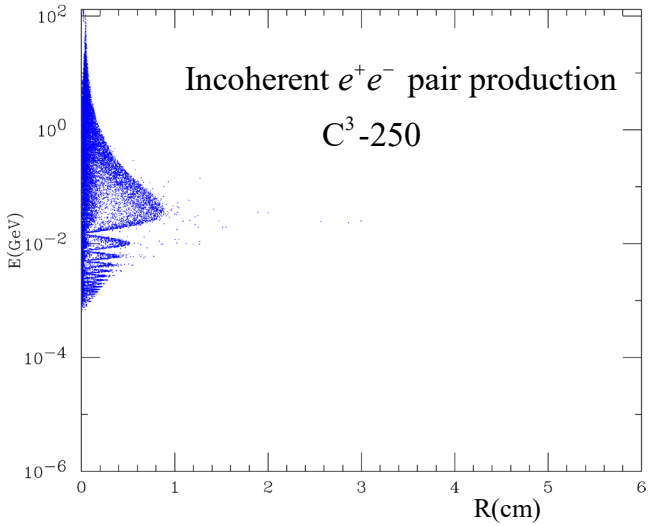
This KB mirror parameter table did not account for placement of mirrors outside detector. Substrate and focal lengths will actually be 2.5 times those shown here:

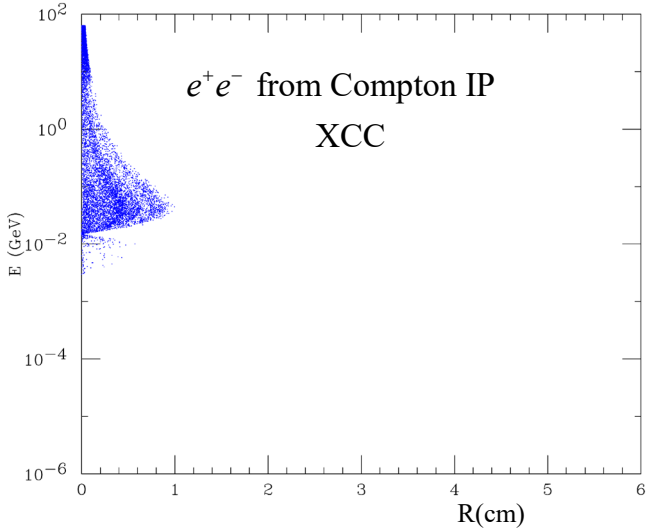
Focal Size (nm)	Photon Energy (eV)	Rayleigh Range (um)	RMS Source Size (um)	AOI (deg)	Max E w/ 10x SF (J)	Substrate Length (m)	Unfocused Beam Size (mm)	Source Distance (m)	Reflectivity	Focal Length (m)	IP Distance from Mirror (m)
50	1000	4.5	10	1.30	0.31	1.00	11.34	487	0.872	1.032	0.532
100	1000	18.2	10	0.90	0.68	1.50	11.78	505	0.926	2.144	1.394
50	2000	9.1	10	0.80	0.54	1.00	6.98	600	0.933	1.27	0.770
100	2000	36.4	10	0.60	1.05	1.40	7.33	629	0.967	2.668	1.968
50	2000	9.1	10	0.65	1.21	1.50	8.51	731	0.962	1.548	0.798
100	2000	36.4	10	0.50	2.14	2.00	8.73	750	0.976	3.176	2.176
40	4000	11.6	10	0.4	1.06	1.13	3.93	675	0.982	1.143	0.581
70	4000	35.7	10	0.3	2.40	1.50	3.93	675	0.992	2.001	1.251
40	4000	11.6	10	0.4	2.39	1.50	5.24	899	0.982	1.525	0.775
70	4000	35.7	10	0.3	4.27	2.00	5.24	899	0.992	2.668	1.668

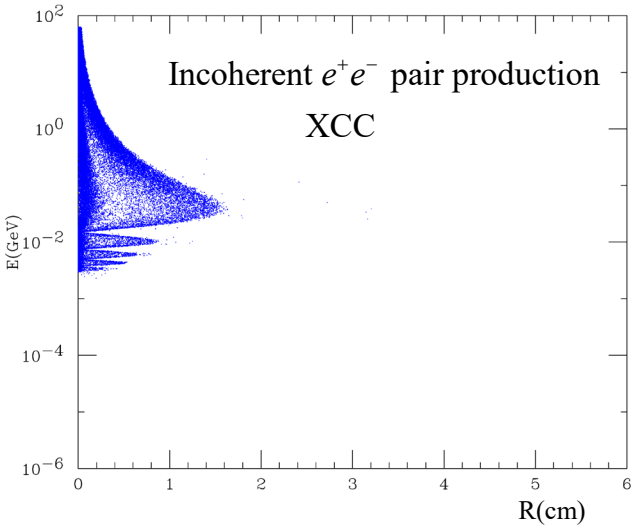
Vertex Detector Inner Radius

CAIN Simulation assuming 5 T Solenoid

$E(e^{\pm})$ vs. R at $z = 6.25$ cm

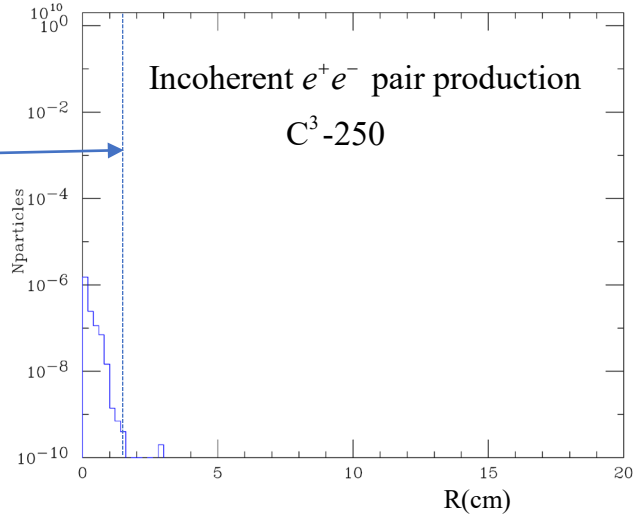




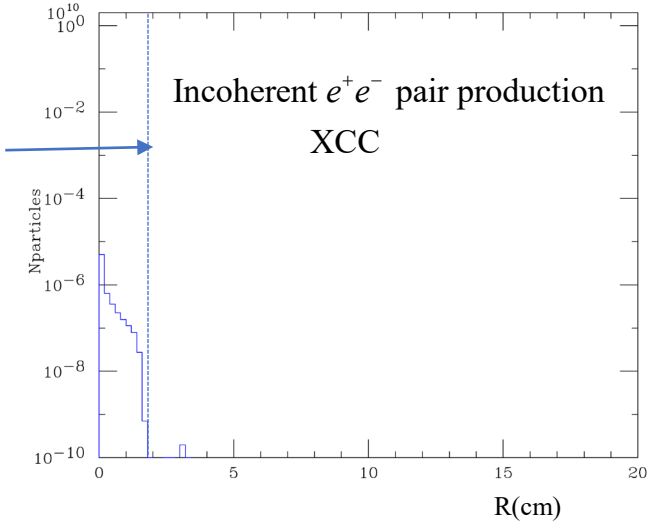


$N(e^{\pm})$ vs. R at $z = 6.25$ cm

SiD Vtx Inner Rad=1.5 cm



XCC Vtx Inner Rad=1.9 cm should be OK

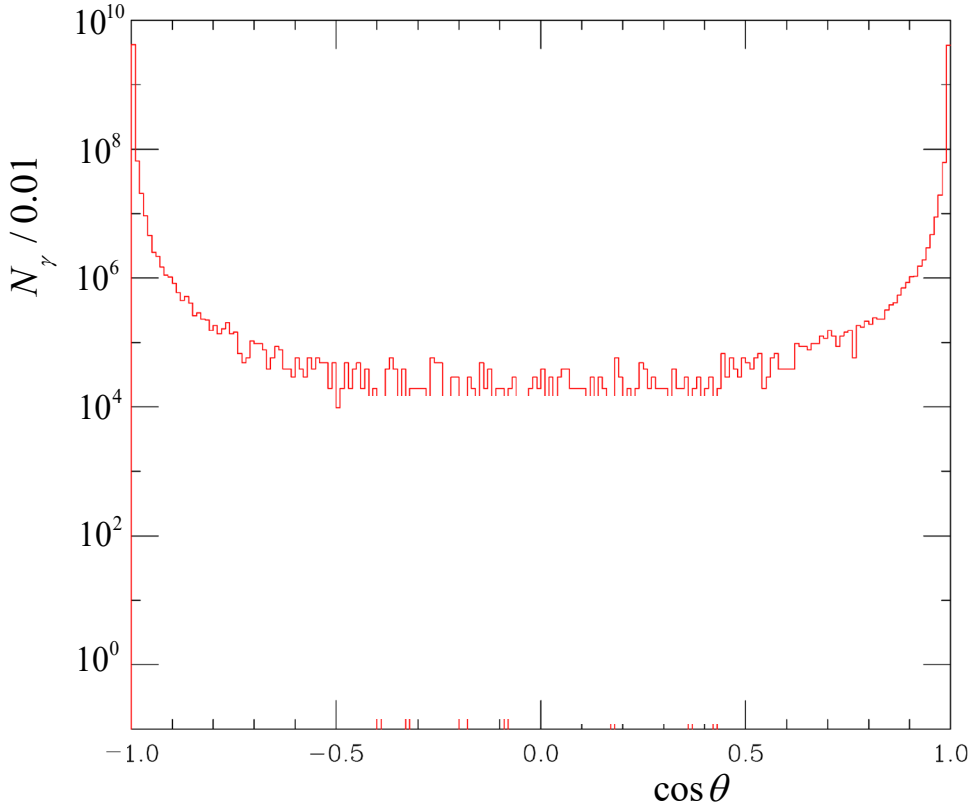


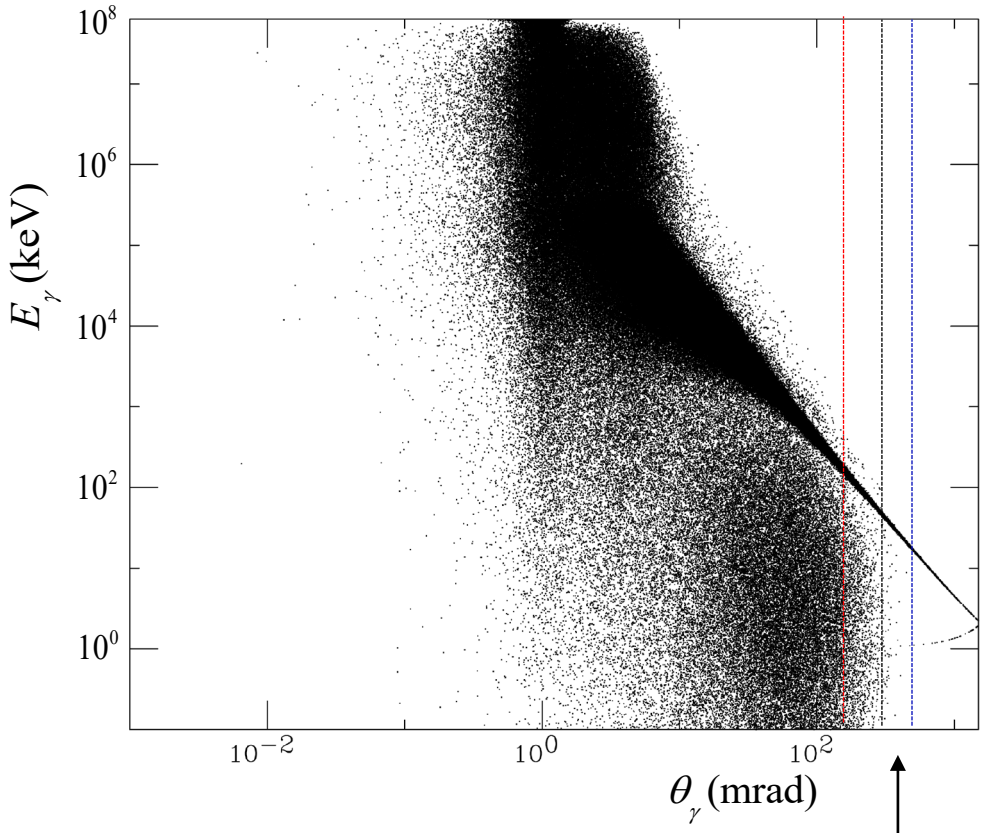
X-rays from Compton IP's

CAIN Simulation

Moderate flux of soft (few keV) X-rays in central region

Number and energy of Compton IP X-rays increases rapidly in the forward region





X-rays handled by adding 0.1% - 1.0% X_0 heavy element to Beampipe for $|\cos\theta| < 0.8$

Required absorber increases to 5.0% X_0 at $|\cos\theta| = 0.93$

Complicated design for $0.95 < |\cos\theta| < 0.99$; probably can't instrument for $|\cos\theta| > 0.99$

$|\cos\theta| = (0.99, 0.95, 0.90)$

Summary

Accelerator Issues Related to Getting Four Particle Beams In and Out of IP Region

(1) Crossing angle of 2 mrad and large aperture for final quad

(2) Short L*=1.5 is related to the final quad aperture issue. KB mirror must be located outside the detector due to stability issues. This leads to subtrates of length 5 m or more, much longer than current maximum 1.5 m substrates.

(3) XFEL beam can enter electron beampipe after the final dipole. In this design the e^- beam and γ beams will travel together through the last sextupole, the KB mirror chamber, and the FF triplet.

Detector issues due to backgrounds from e^+, e^-, γ produced at Compton IP's and primary IP:

(1) Vertex detector inner radius of 1.9 cm should be OK for incoherent e^+e^- pairs.

(2) X-ray flux from Compton IP's should be OK for $|\cos\theta| < 0.95$

(3) Forward boundaries of the main tracker/calorimeter and solid angle coverage of forward detector is an unsolved issue due to hard X-ray flux from Compton IP's $|\cos\theta| > 0.95$)

Many challenging, but very interesting , issues.