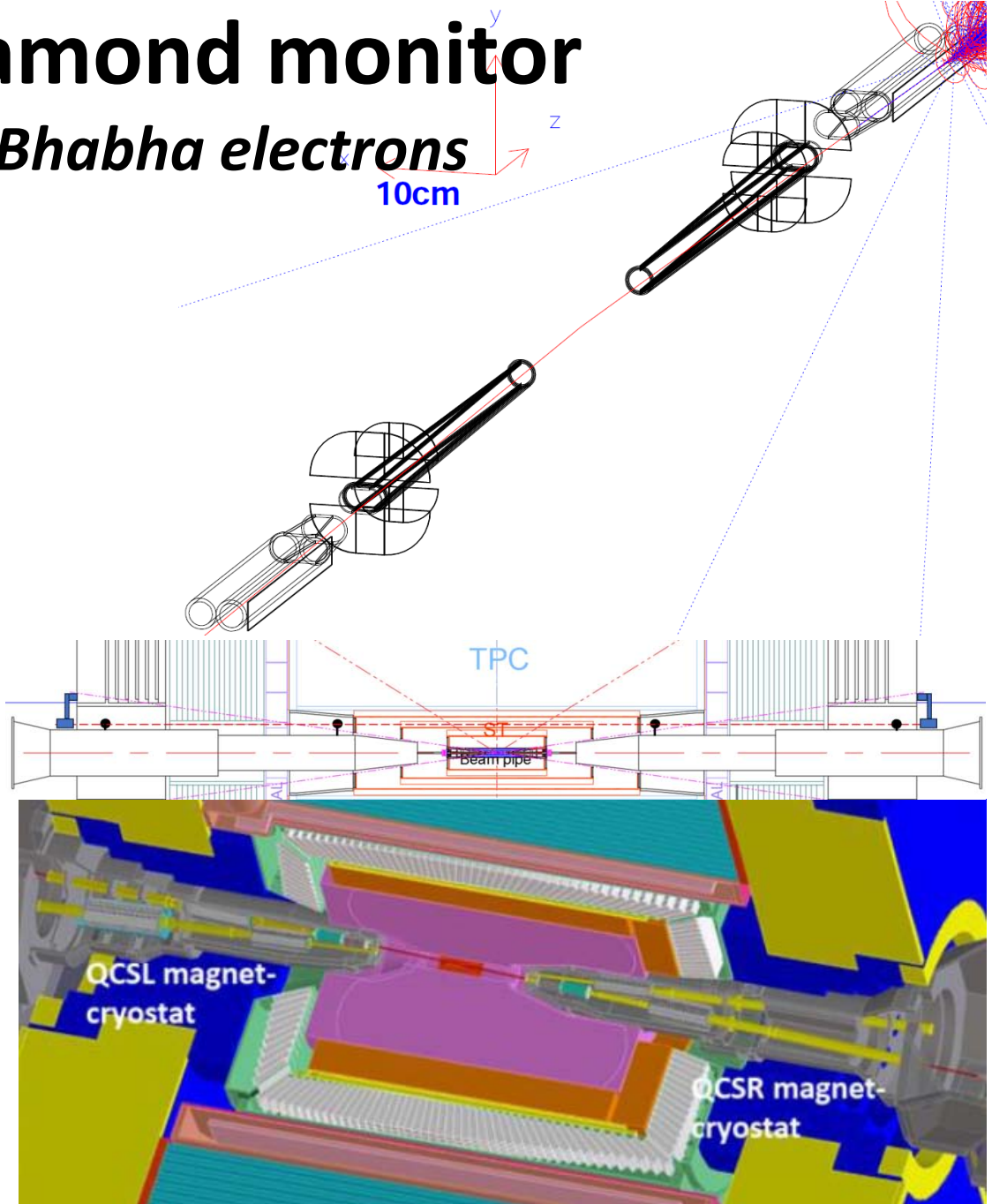
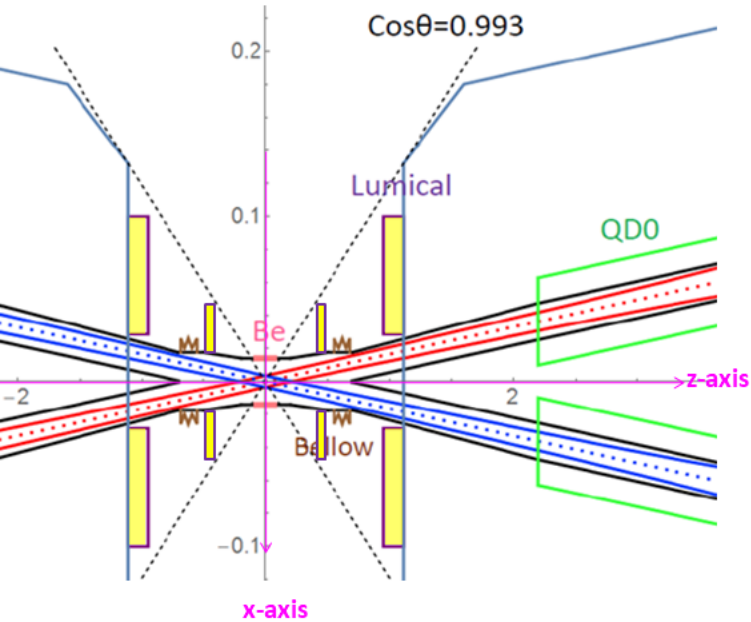


Fast LumiCal diamond monitor

detecting far-forward Bhabha electrons

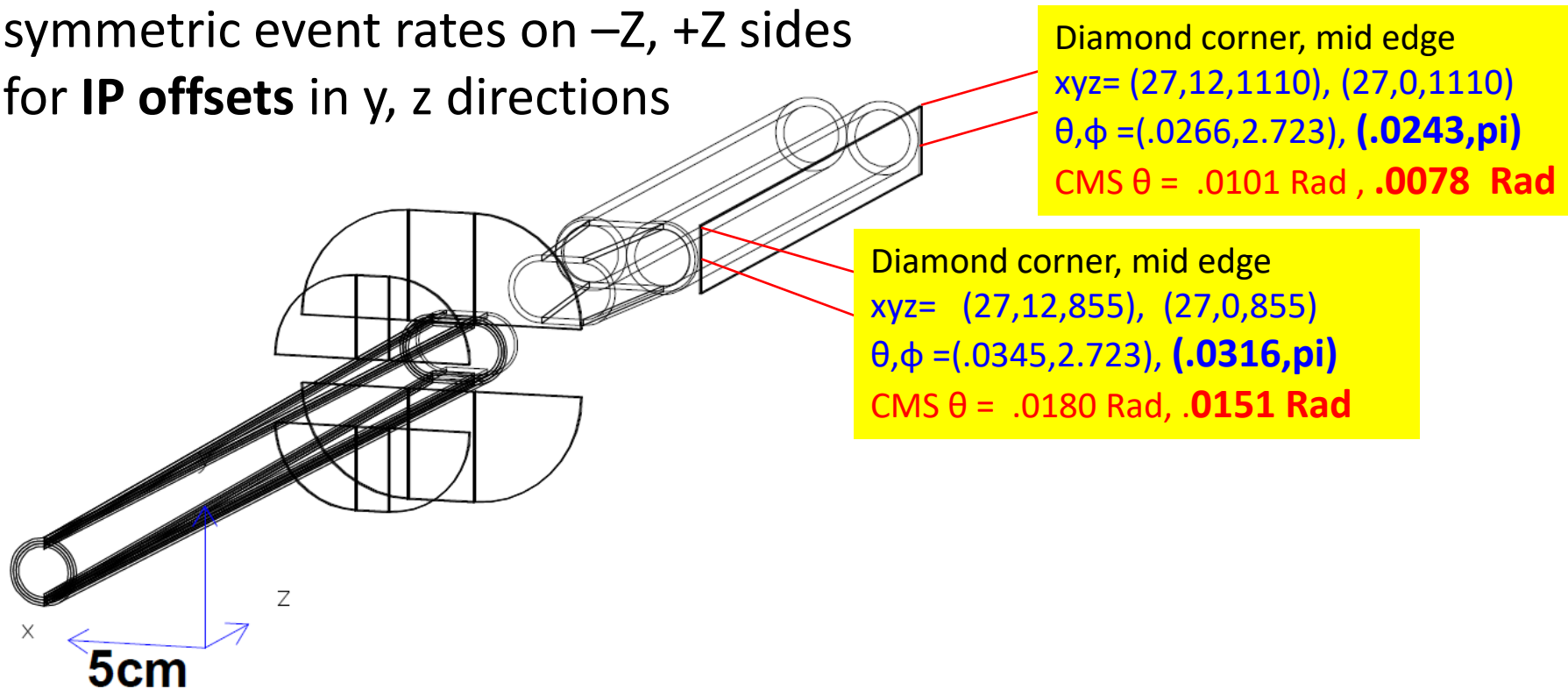
2024.09.14

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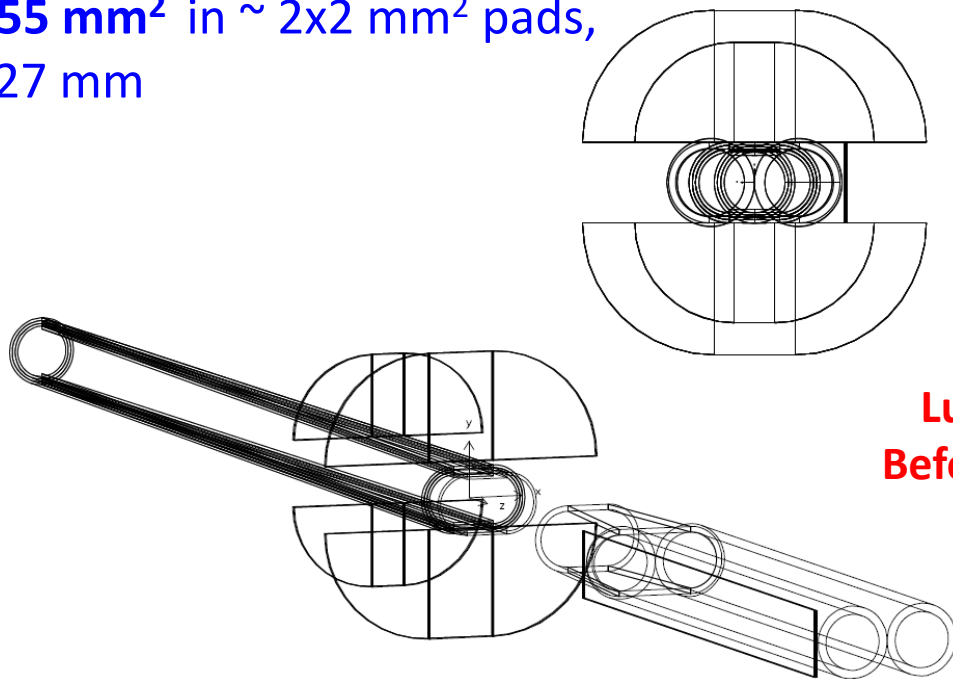
Lumical far-forward diamond monitor

- detecting scattered **electrons of Bhabha** e^+e^- collisions
 ~ 10 mRad (CMS frame) boosted by **33 mRad beam crossing**
on x-axis (CMS+16.5mRad to lab frame) $\vartheta_{CMS} = 15.1 \sim 7.8$ mRad
- front of Quadrupole $|z|=855\sim 1110$ mm $\vartheta_{Lab} = 31.6 \sim 24.3$ mRad
diamond slab by the side of beam-pipe
- Beam monitoring
symmetric event rates on $-Z, +Z$ sides
for **IP offsets** in y, z directions

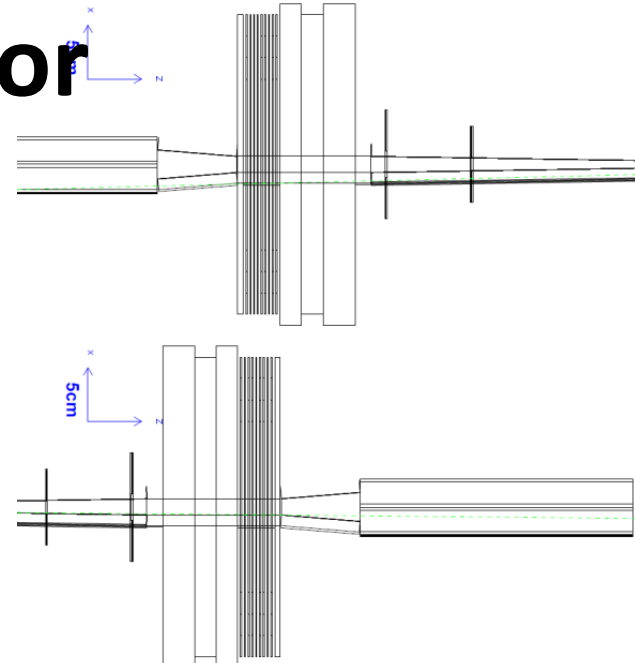
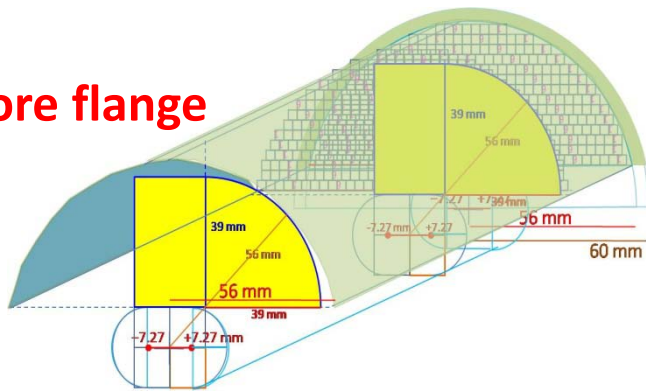


Lumical far-forward monitor

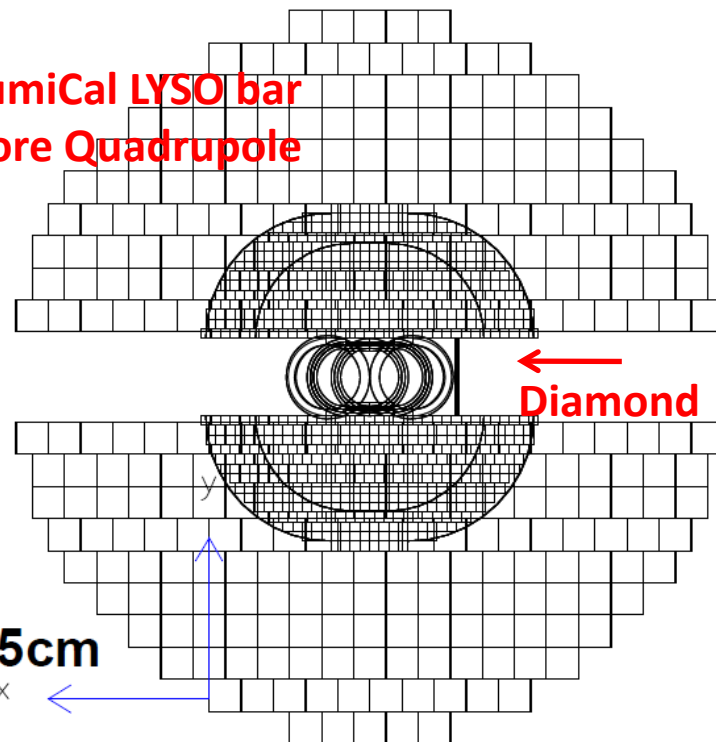
- **Dual-pipe** as absorber, Cu inner $\varnothing 10$, 3mm thick
 $X_c = \pm 13$ mm $|Z| = 855 \sim 1110$ mm
- **Diamond slab** as sampler, 400 μ m thick
 24×255 mm² in $\sim 2 \times 2$ mm² pads,
 $X_c = -27$ mm



LumiCal before flange



**LumiCal LYSO bar
Before Quadrupole**

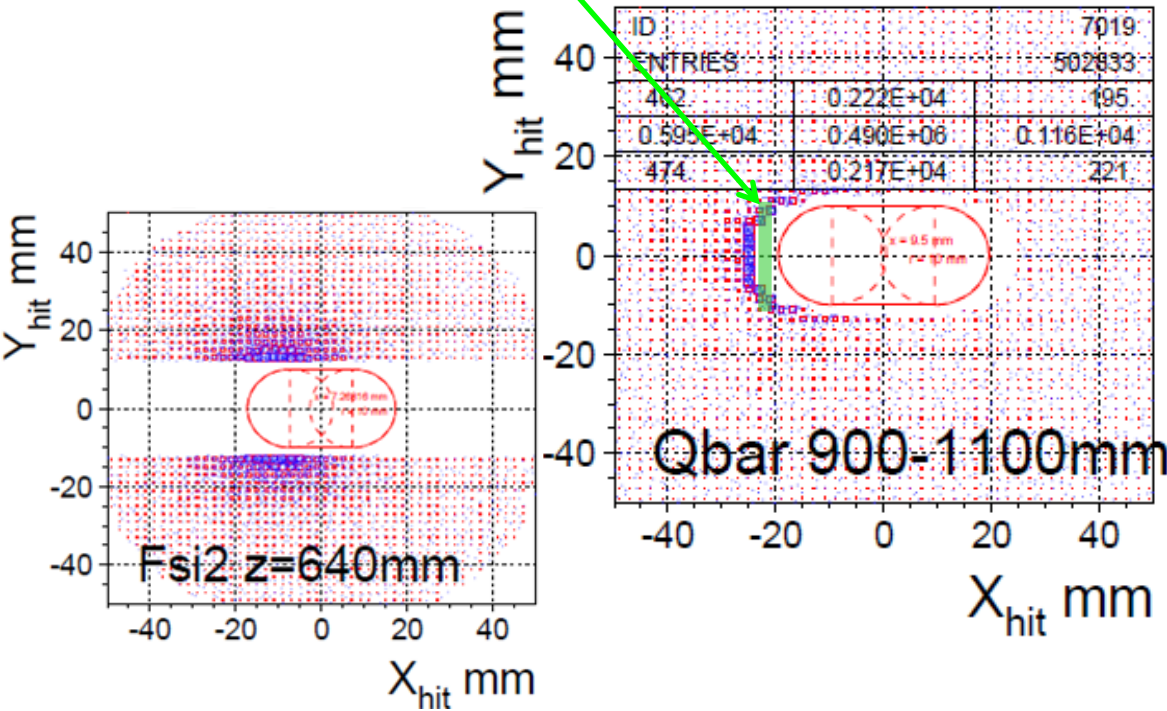


X-section, event rate @CEPC

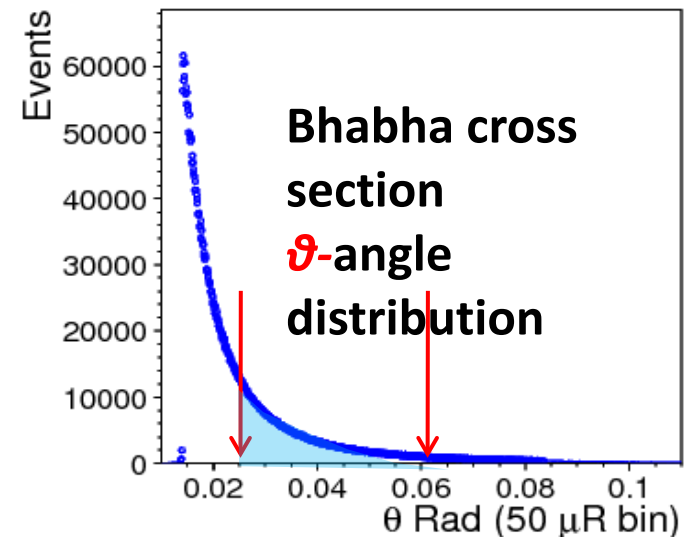
Diamond slab covering 8~15 mRad
 X-sec order of ~100 nb

Event rate @Z, $L=1 \times 10^{36}/\text{cm}^2\text{s}$

$= (100 \times 10^{-33}) \times (1 \times 10^{36}) / \text{s} = \sim 100 \text{ kHz}$



$$\sigma = \frac{16\pi\alpha^2}{s} \left(\frac{1}{\theta_{min}^2} - \frac{1}{\theta_{max}^2} \right)$$



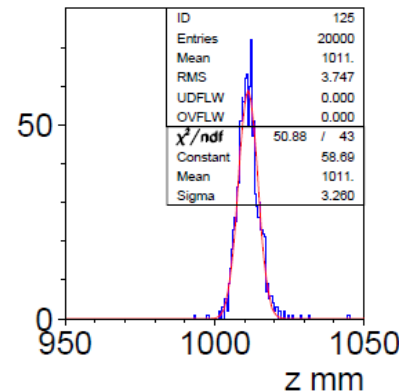
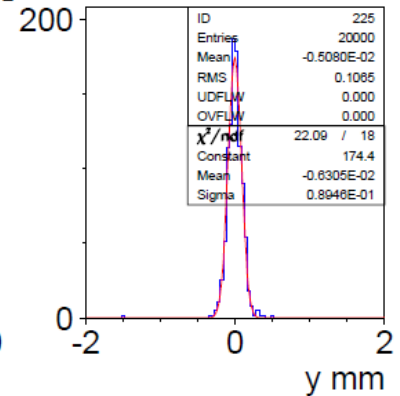
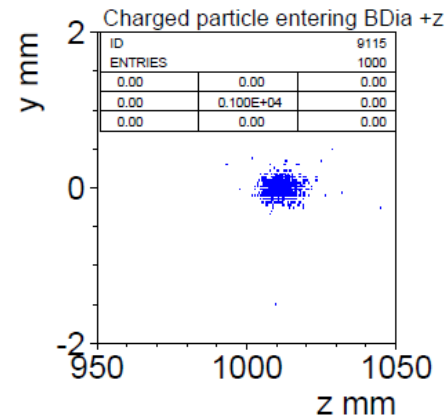
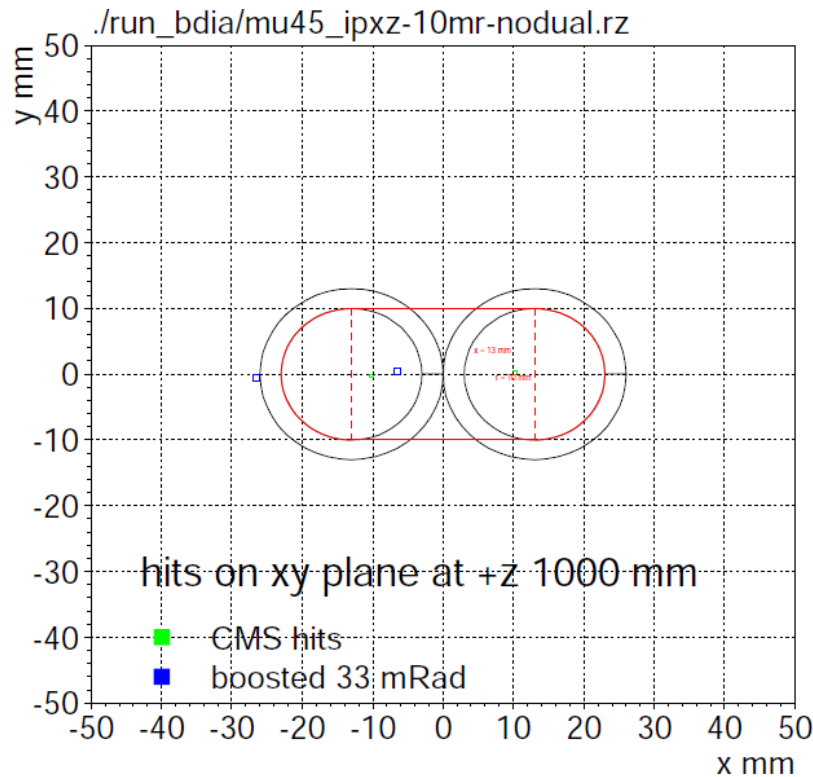
at Z = 1000 mm LAB frame e^+ , e^- detected

LAB ONE e^+ or e^- detected		LAB both e^+ , e^- detected	
lab $\theta > 15 \text{ mRad}$	$\theta > 15 \text{ mR}$ & $ y > 15 \text{ mm}$	lab $\theta > 15 \text{ mRad}$	$\theta > 15 \text{ mR}$ & $ y > 15 \text{ mm}$
395.3 nb	255.9 nb	257.8 nb	245.9 nb

50 GeV muon on far-forward diamond

- Shoot muon at CMS 10 mRad
- Boosted by 33 mRad beam crossing
- GEANT on 3mm Cu pipe wall multiple scattering

Multiple Scattering $\sigma_z = 3.3 \text{ mm}$ $\sigma_y = 0.089 \text{ mm}$
 $\sigma_\theta = 0.085 \text{ mRad}$ $\sigma_\phi = 3.8 \text{ mRad}$

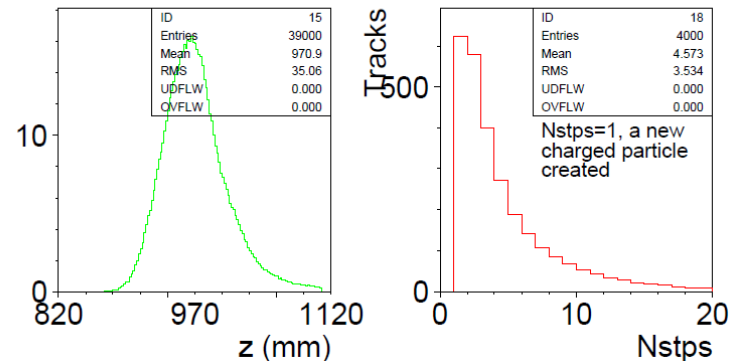
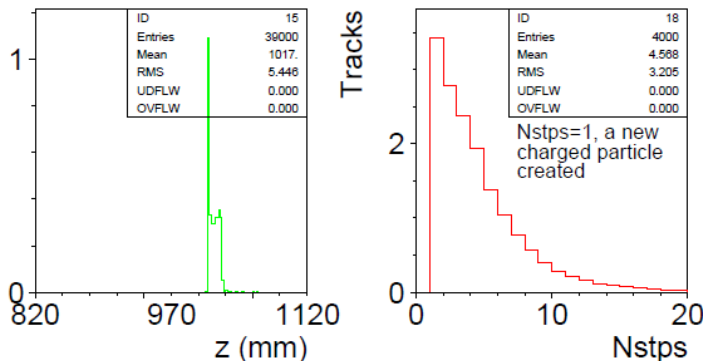
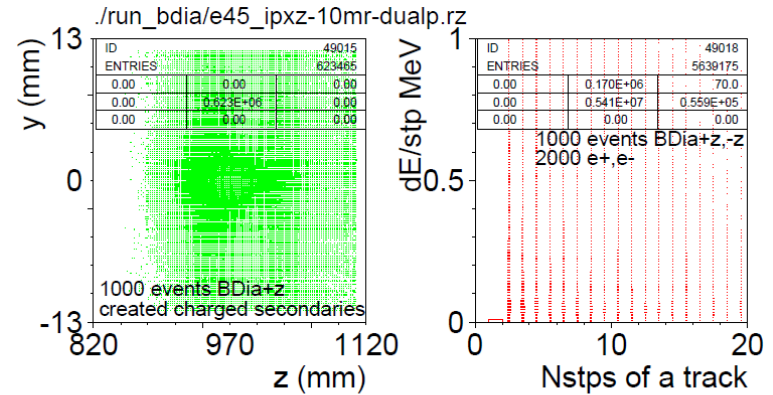
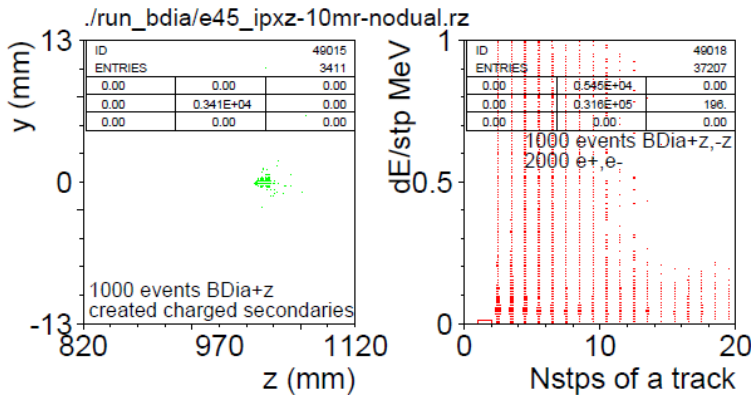


50 GeV electron shower on diamond

- Shoot electrons at CMS **10 mRad**, beam crossing boosted
- GEANT with/without 3mm Cu pipe
- Examine dE/step of charged tracks (>100keV) in diamond

w.o. Cu pipe,
ch. Multiplicity in diamond = 3.4

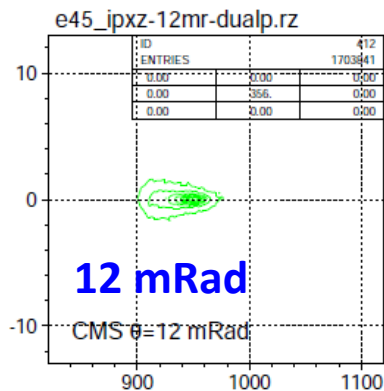
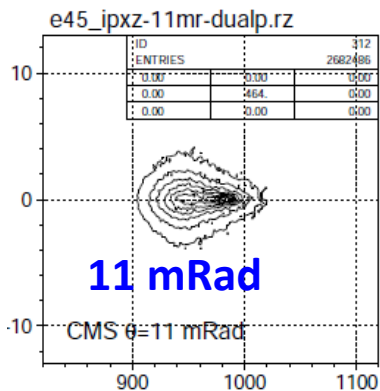
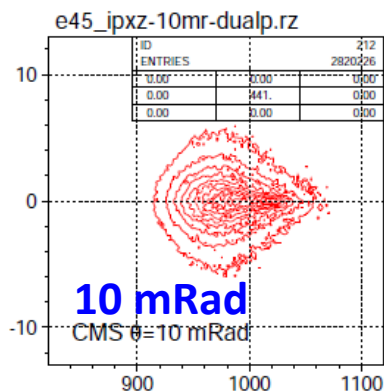
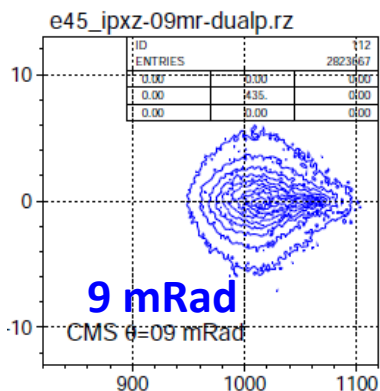
w. 3mm Cu pipe, @26.5 mRad
ch. Multiplicity Cu+diamond = 620
Shower spread in z: $\sigma_z = 30$ mm



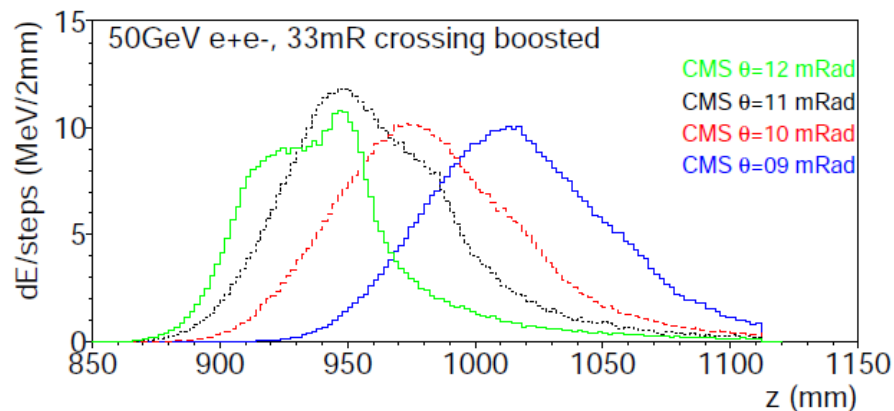
Electron θ vs shower spread on diamond

- Shoot electrons at CMS **9 ~ 12 mRad**, beam-crossing boosted
- dE/step deposits of charged tracks (>100keV) in diamond

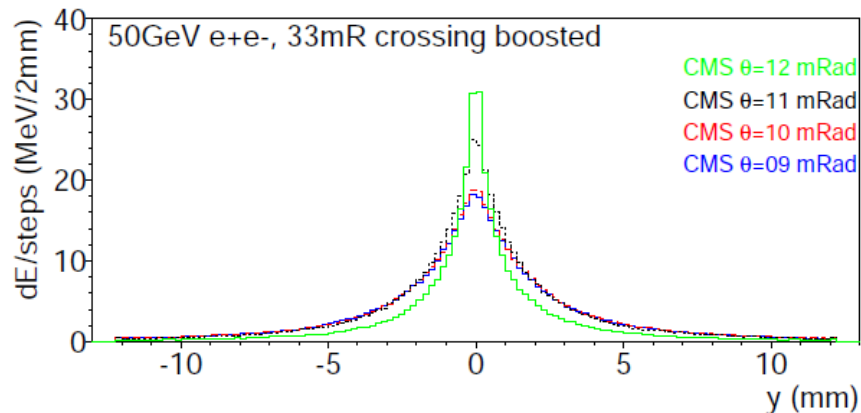
dE/steps in y-z diamond slab on +z side



dE/steps in z profile



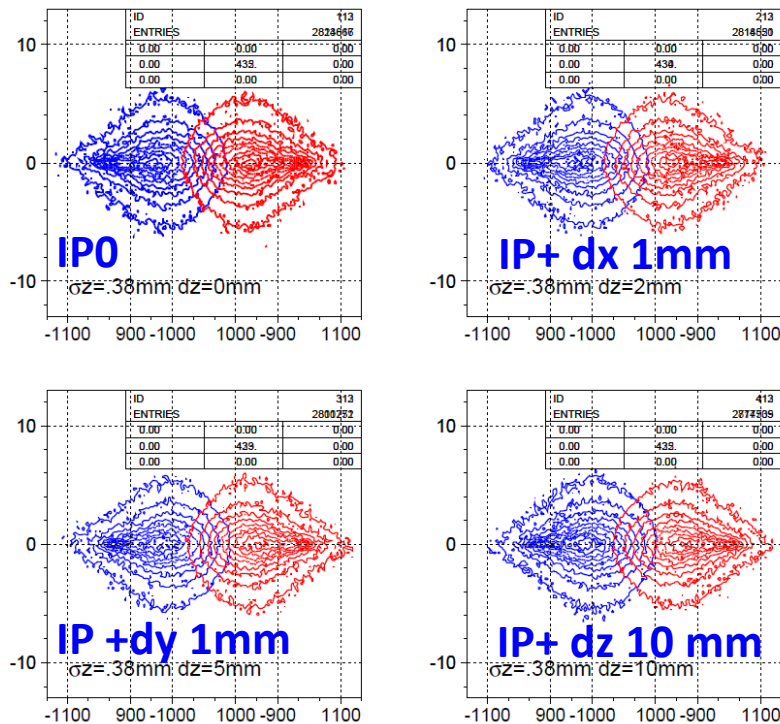
dE/steps in y profile



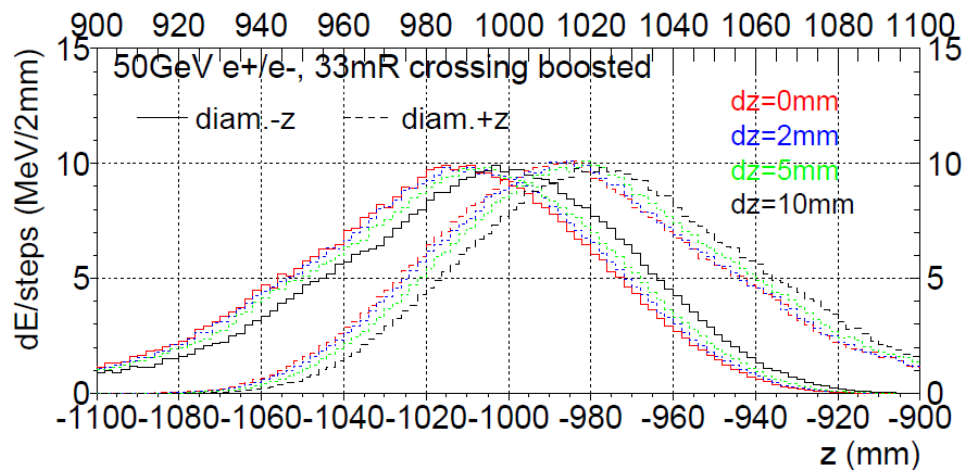
IP offsets in z, asymmetric on diamonds

- IP offsets in z, electrons at CMS 9 mRad, beam-crossing boosted
- dE/step deposits of charged tracks (>100keV) in diamond

dE/steps in y-z diamond slab
on +z side



-z/+z shower profiles offsets
toward the dz at equal magnitude

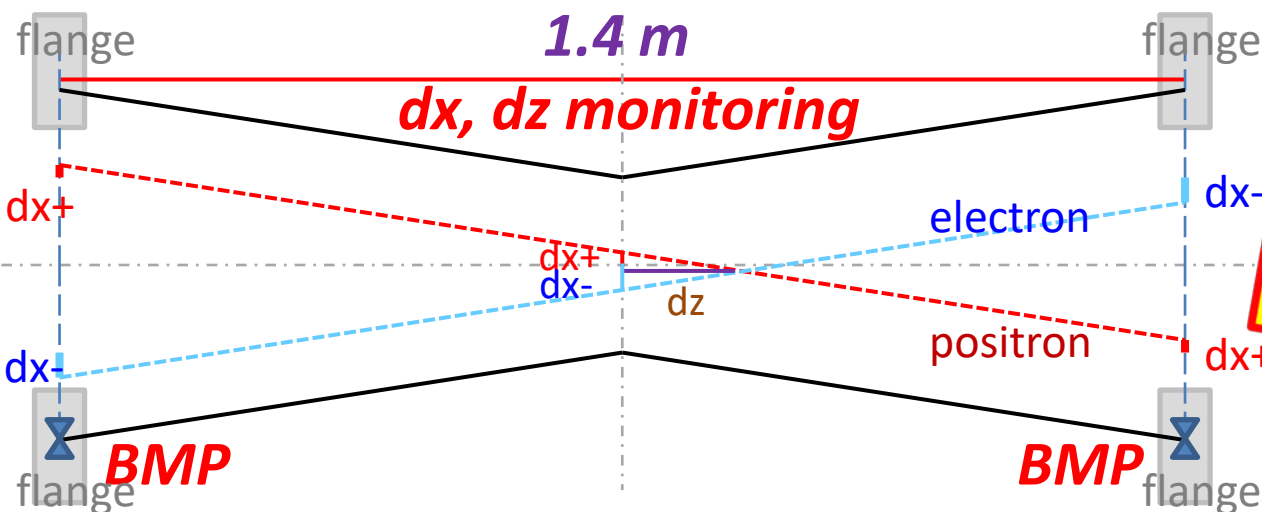
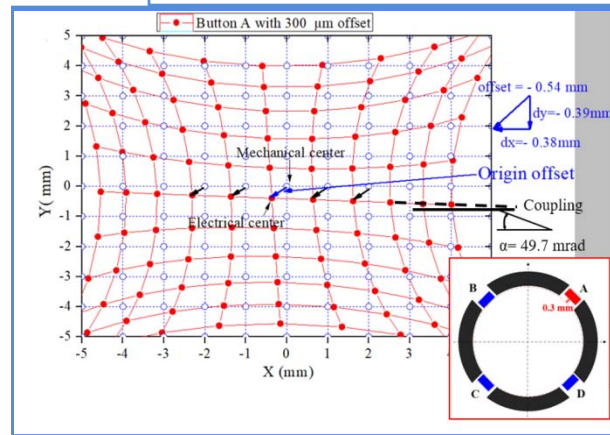
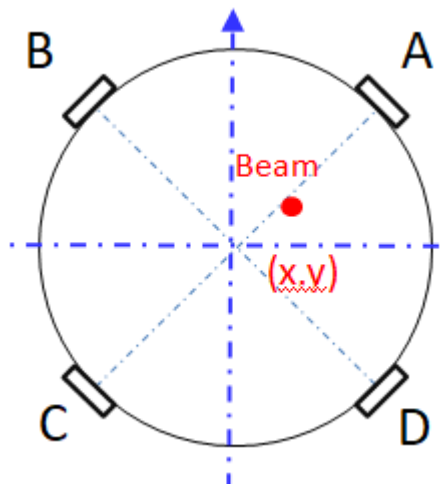
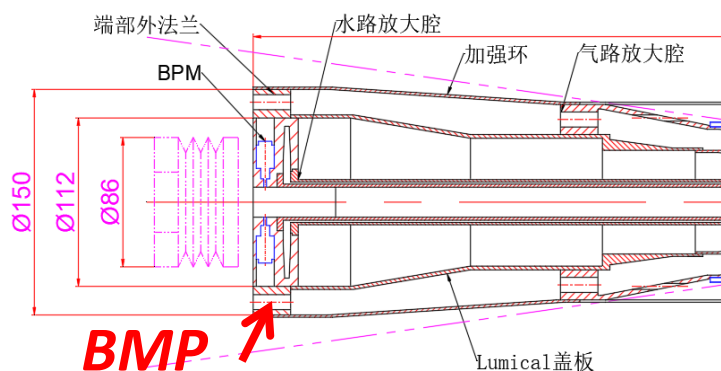


LumiCal survey/monitoring, Beam position

Survey monitoring

- Beam monitoring Probe **BPM**, on beam line crossing IP
- Position monitoring, Flange $dx, dy \sim 1 \mu m$, $dz \sim 50 \mu m$

CEPC WS2023, J. He



LumiCal 挑战
 监测位置
 1. 法蓝 $dx, dy 1 \mu m$,
 $dz 50 \mu m$
 2. 电子束流 $dx, dy 1 \mu m$

Discussion

- **Fast LumiCal diamond monitor**
|z| = 855~1110, lowest θ detectig Bhabha at CMS 8 mRad
- **Detect one-sided Bhabha electrons**
shower profile threshold/slope position = electron θ
- **Fast luminosity in θ**
by event rates on $-z/+z$ diamonds, by pattern on pads
- **Beam steering**
electron ~ 0.1 mRad resolution,
IP dy 0.1mm, dz 1mm resolutions