LumiCal preparation

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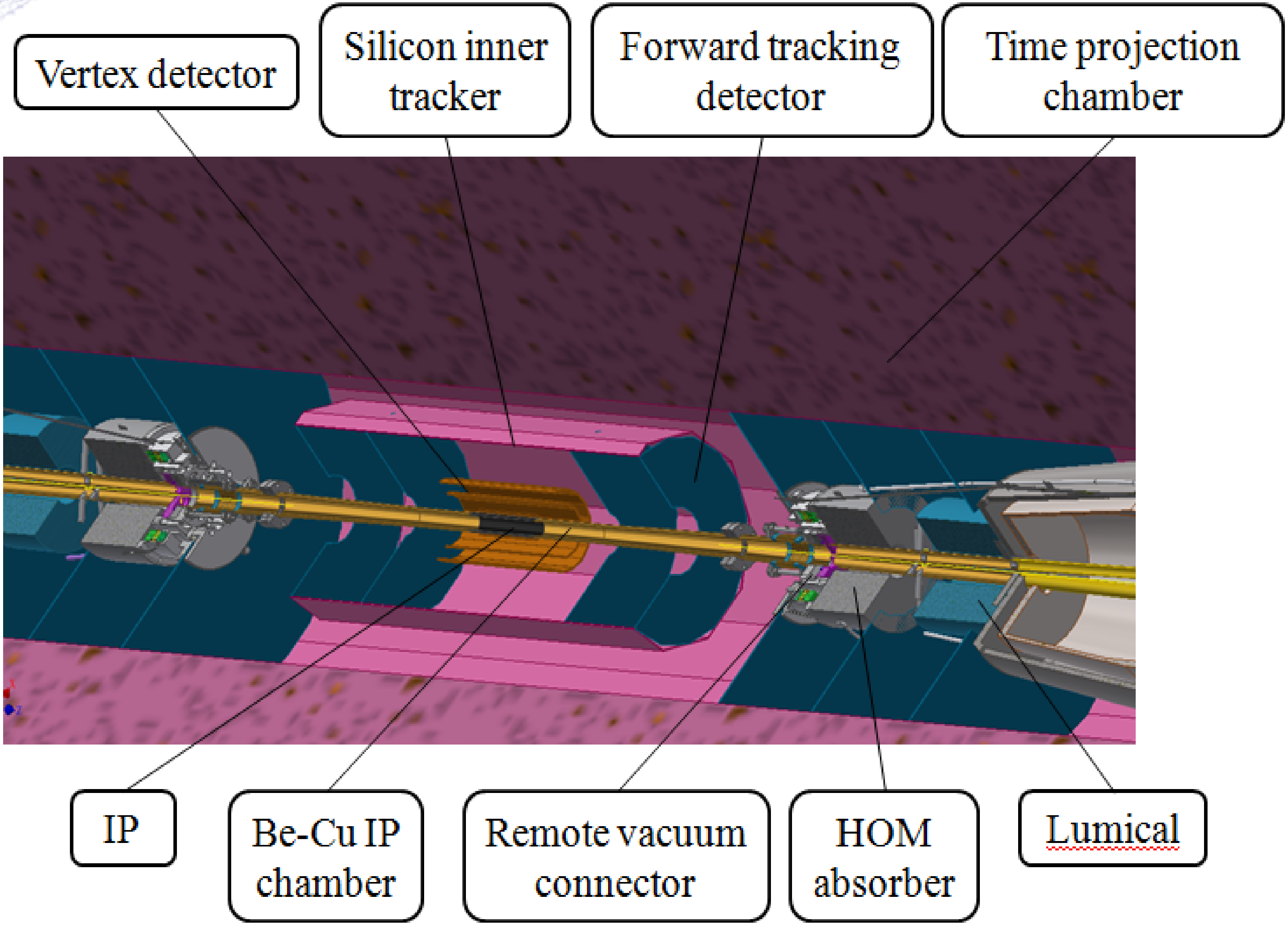
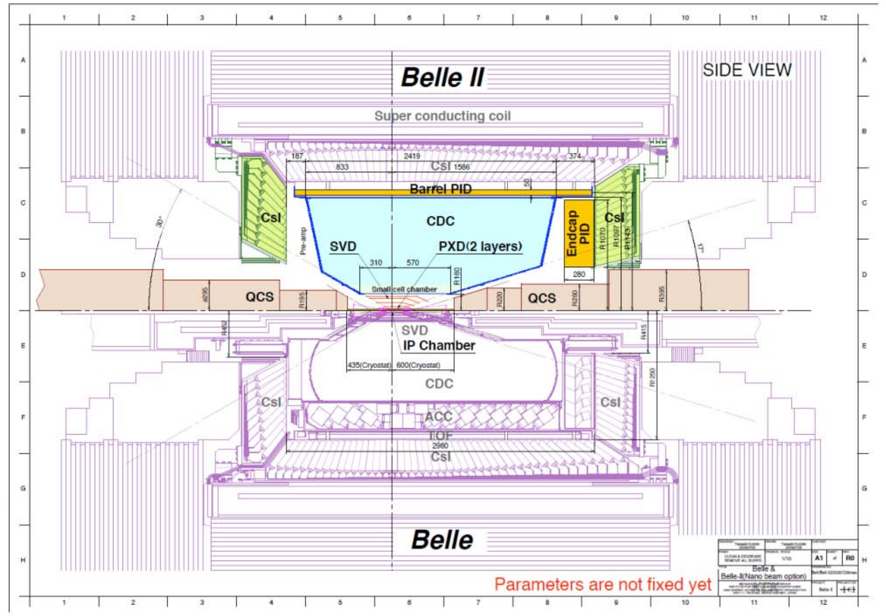
- **Parameters of CDR**
- **New beam pipe design**
  proposal:
  before ring lockup-fringe @ z= 500 mm
  layers of precision Si-W of up to 2X_0
  for Bhabha electron theta, e/γ ID
- **MDI, interface to tracker, endcap**

Layout of MDI

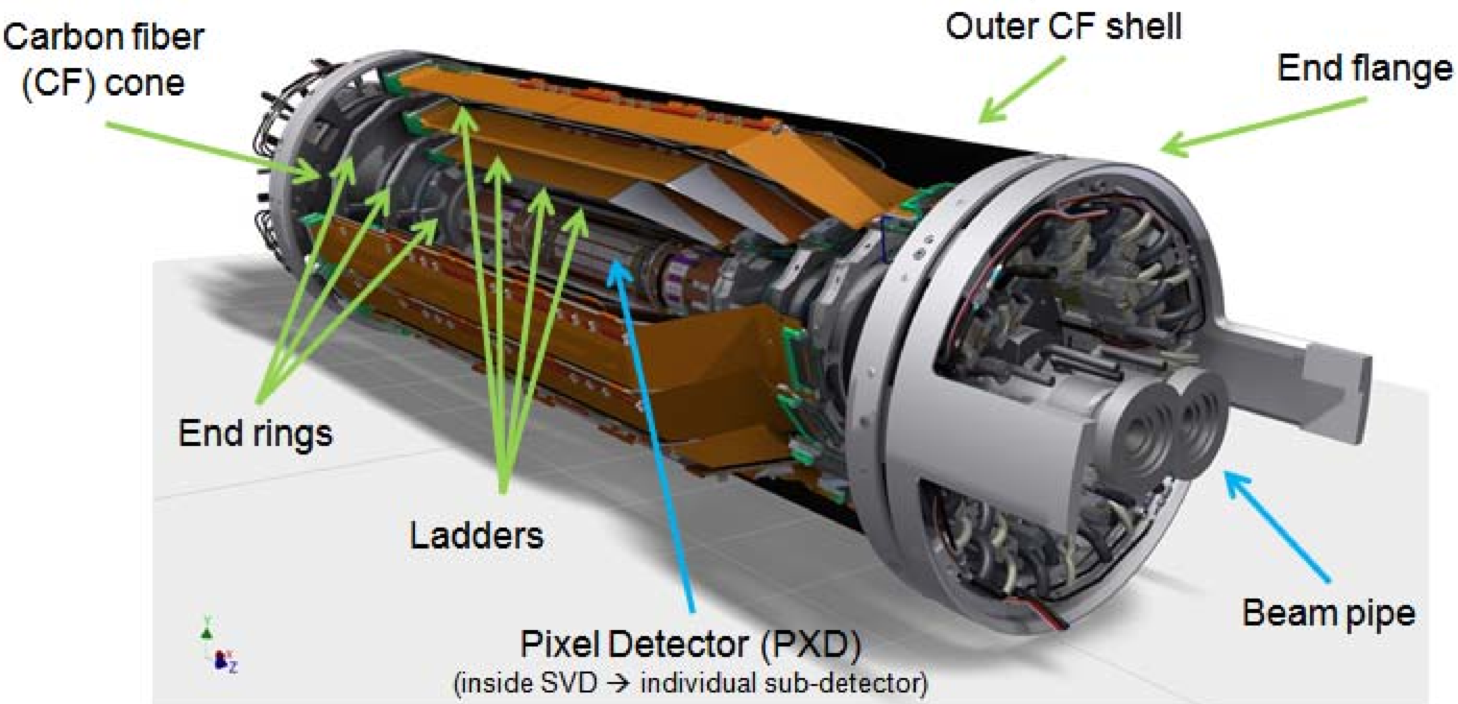
Haijing Wang
March 11, 2019, IHEP



Belle II silicon



Belle II Silicon Vertex



Forward, LumiCal physics

- Bhabha $e^+e^-(\gamma)$ pairs
- SM radiative, e.g. Zγ, Zγγ
- two-photon physics
  e.g. ee → eeμμ, eeqq
- **Beam monitoring**

Forward instrumentation

Silicon tracker end-cap

fine pitch strip, < 5 μm resolution

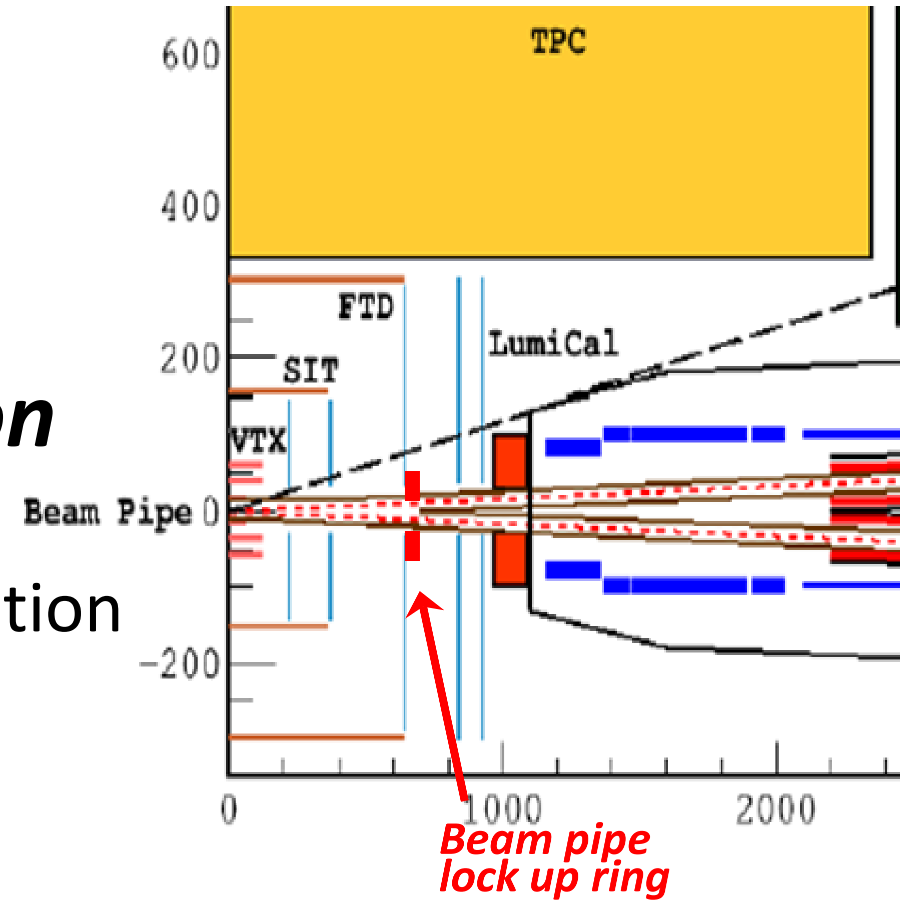
θ reaching beam pipe

to <30 mRad for σ_{Bha}> 50 nb

LumiCal behind MDI

front layer = preshower

e, γ separation, < 1 mm resolution

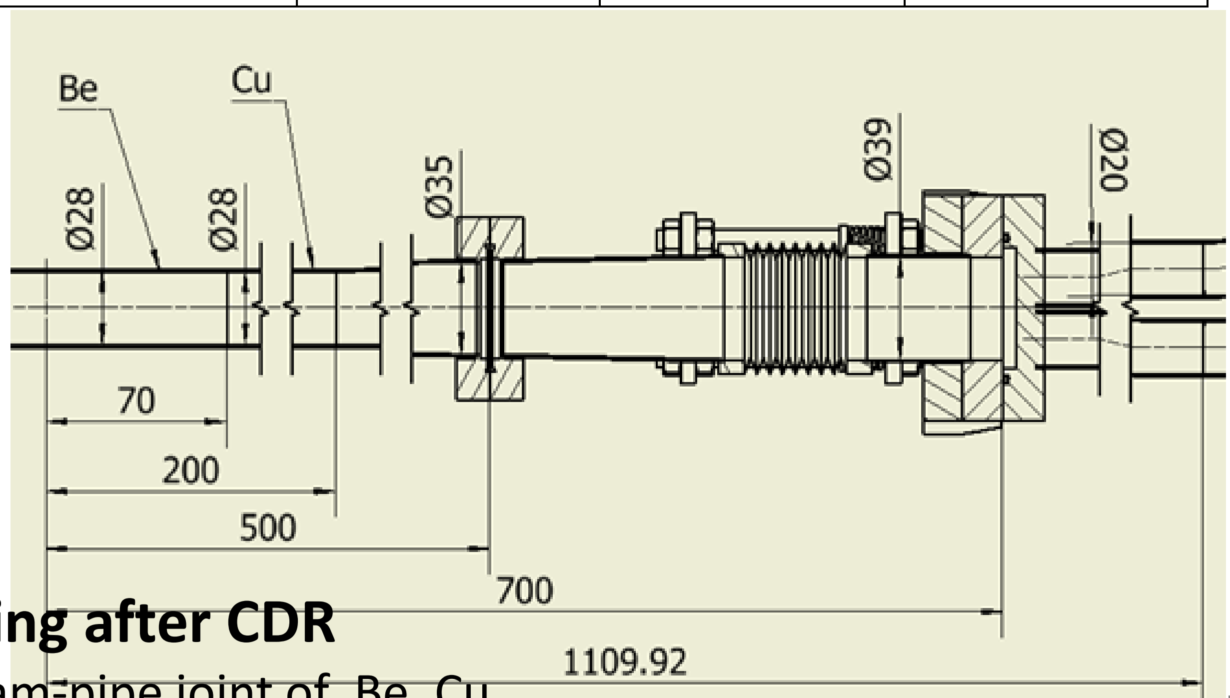


Geant implementing new GEOM

1. Be 的長度為 140mm，Z 範圍-70~70mm。

2. 以 IP 單側為例，Be 管及銅管的尺寸見下表及附圖，真空管相對於 IP 對稱。

材料	Z 範圍（mm）	內直徑（mm）	備註
Be	0~70	28	直管
Copper	70~200	28	直管
	200~500	28~35	錐管
	500~700	35~39	錐管，包含波紋管



Beam pipe drawing after CDR

Assuming a tube beam-pipe joint of Be, Cu

Electron Traversing 2mm Cu pipe ➔ very “THICK” in forward direction

Geant implementing new GEOM

Material thickness

traversing 2mm thick Cu beam pipe

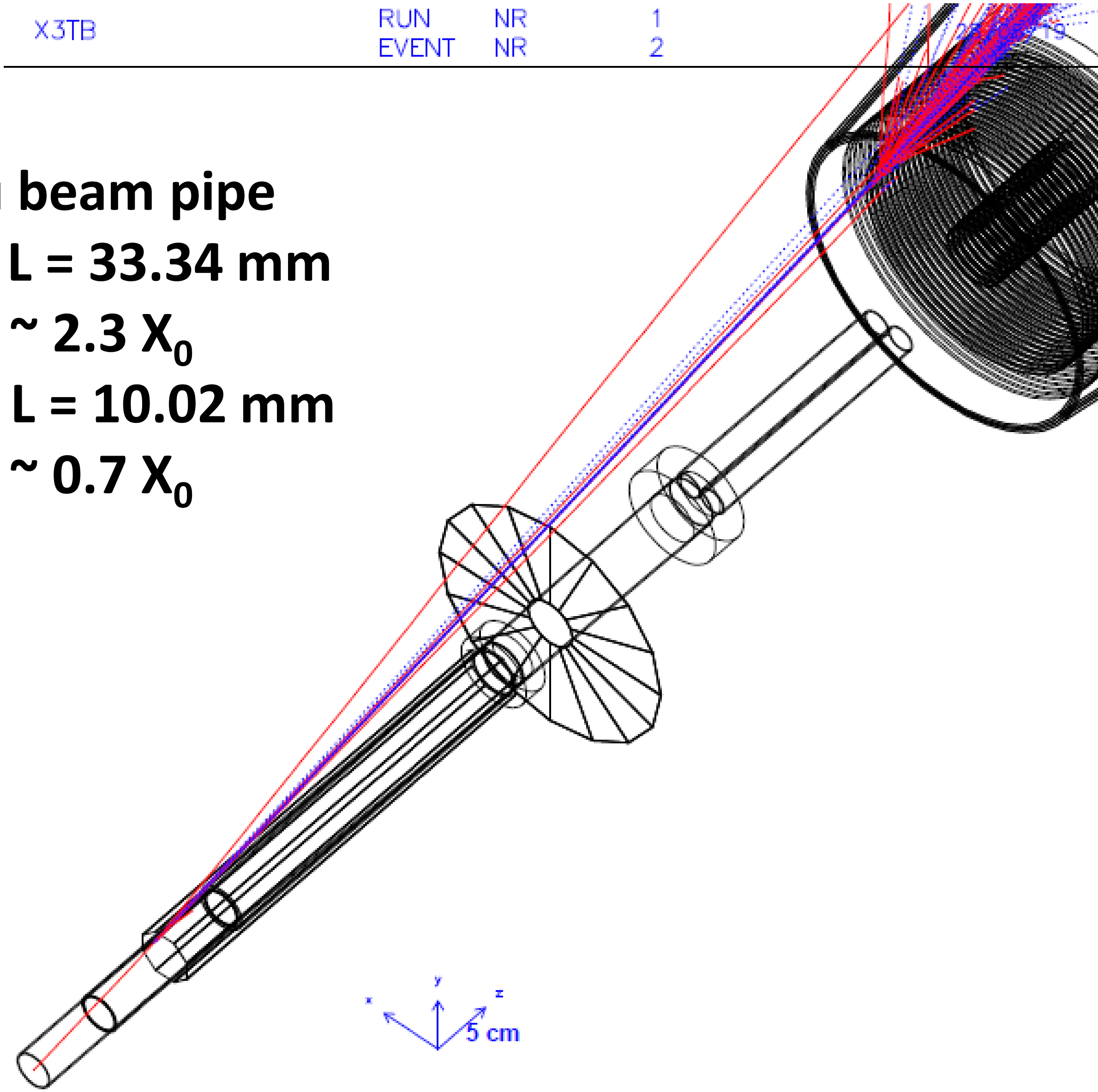
2mm/L = sin (30mRad) **L = 33.34 mm**

~ 2.3 X_0

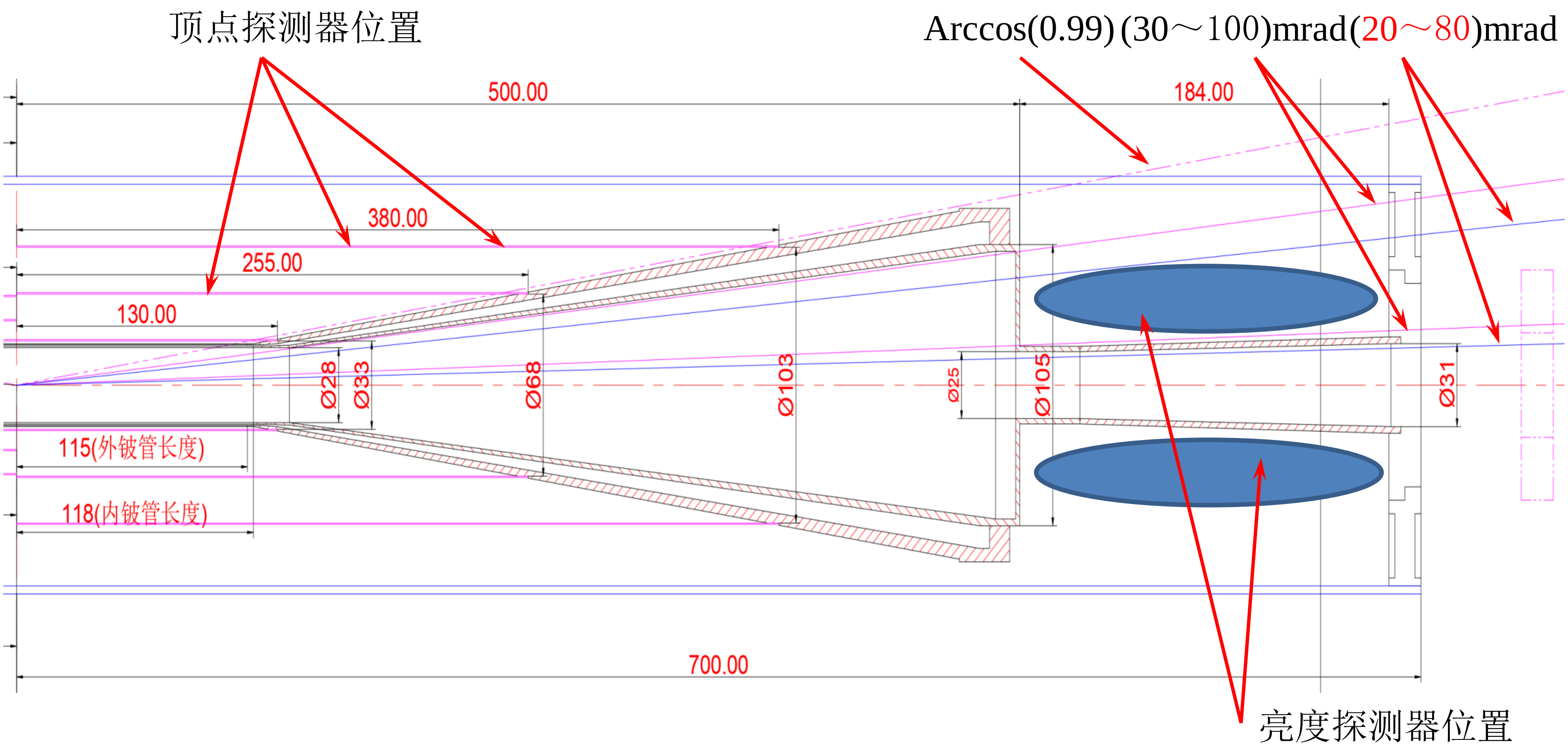
2mm/L = sin (100mRad) **L = 10.02 mm**

~ 0.7 X_0

X_0(Cu) = 1.44 cm



亮度探测器放置束流管内方案



内铍管厚度: 0.50
外皮管厚度: 0.35
内外铍管间隙: 0.5
冷却介质:1号电火花油

说明:
1.Ø25和Ø31是根据白莎的计算，最小束流管孔径
2.亮度探测器对应管道为单层管(无冷却)，
需根据计算确定184mm 是否满足温度要求

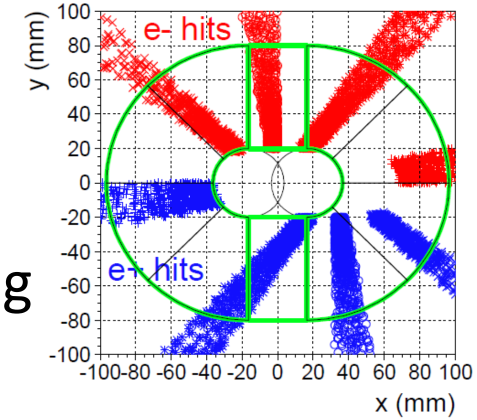
Lumical construction

- Q-pole magnet front, z = ± **1000 mm**
- On PIXEL tube, new design z = ± **500 mm**

Weight of Si-W LumiCal

at z = ± 1m

- a circular W layer, $1X_0$, of radius=100 mm
  3.14x10cm^{2}x.35cm x 19.3 = 2000 g
- a rectangular 10cm x3.3cm x.35cm x19.3 = 220 g
- **a W layer = 2.5 kg** , a 25 layer detector = **62 kg**



at z = ± 0.500 mm, r=50 mm (θ= 100 mRad)

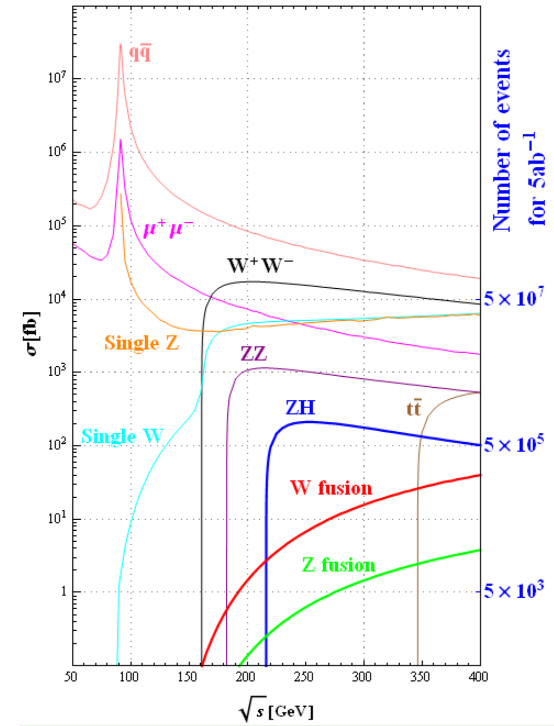
- a circular W layer, **$1X_0$,** of radius=50 mm
  3.14x5cm^{2}x.35cm x 19.3 = **0.53 kg**
- max radius to outer support tube, r= 70 mm weight = 1 kg

Tungsten density 19.3 g/cm^3

Radiation length 3.5 mm

Luminosity measurement

- Z lineshape, $e^+e^- \rightarrow Z \rightarrow q\bar{q}$
  is dominant, ***σ = 41 nb***
- Luminosity is by counting
  Bhabha, $e^+e^- \rightarrow e^+e^-$ elastics scattering



Counting Bhabha in a fiducial θ region

$\delta L/L \sim 2\, \delta\vartheta/\vartheta_{min}$

$\boldsymbol{\delta L/L < 10^{-3}}$ at **z = ±1 m**

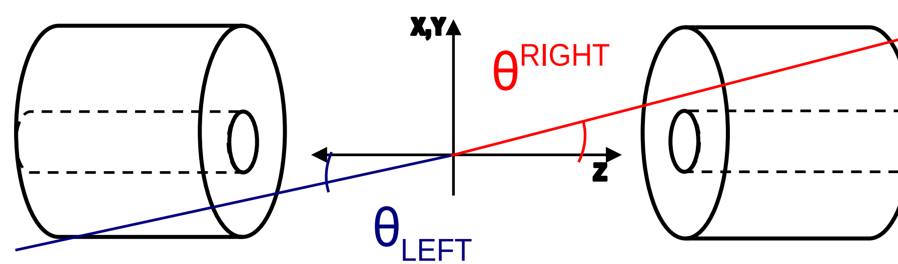
$$\mathcal{L} = \frac{1}{\varepsilon}\frac{N_{acc}}{\sigma^{vis}} \qquad \sigma = \frac{16\pi\alpha^2}{s}\cdot\left(\frac{1}{\theta_{min}^2} - \frac{1}{\theta_{max}^2}\right)$$

θ_{min} = **20 mRad**

→ $\delta\vartheta = 10\ \mu Rad$ or ***dr = 10 μm***

offset on Z

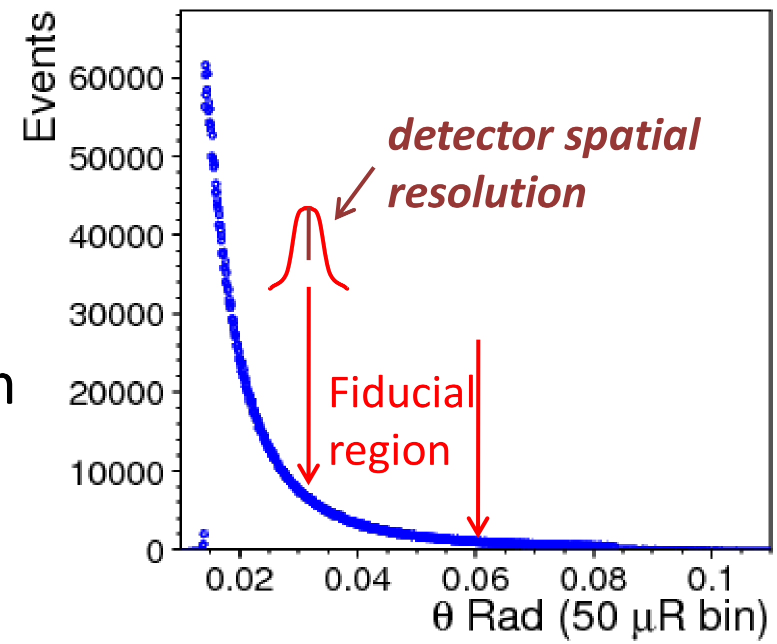
→ *1 mm on z* or ***dr = δzxϑ = 20 μm***



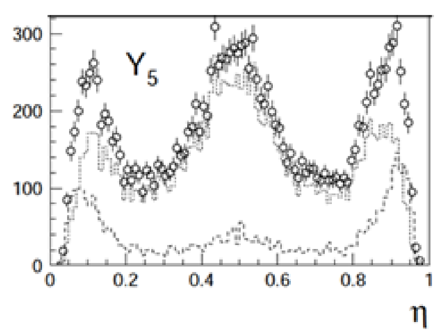
LumiCal precision with Si strips

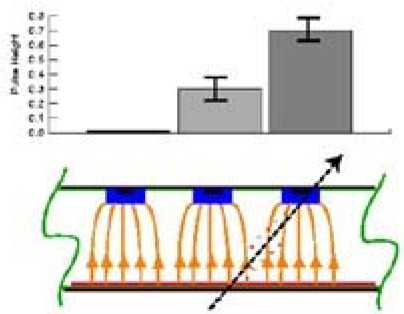
Precision is dominated by
at the fiducial θ_{min}
→ offset on the mean of **θ** at edge
→ **δ**N in event counting

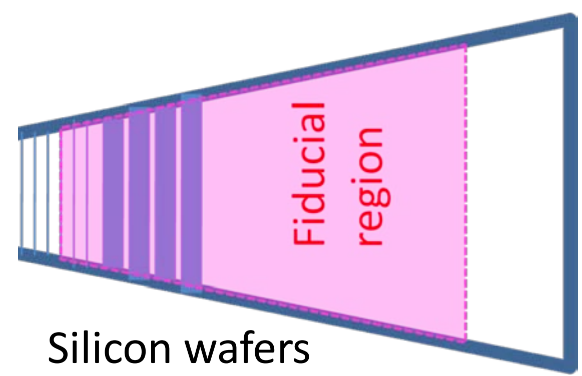
Fine pitch strips (50 um pitch) σ ~ 5µm
calibrate the σ shape
→ **Error on mean can reach zero**



$$\eta = \frac{Q_r}{Q_r + Q_l},$$



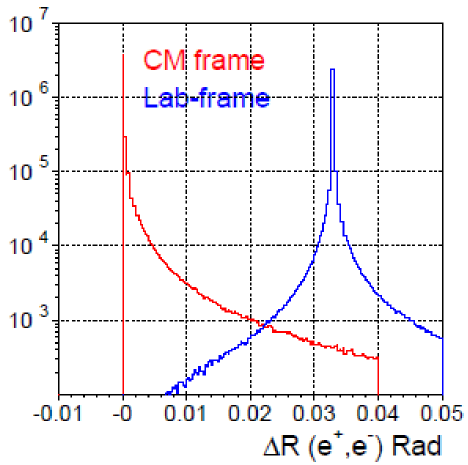


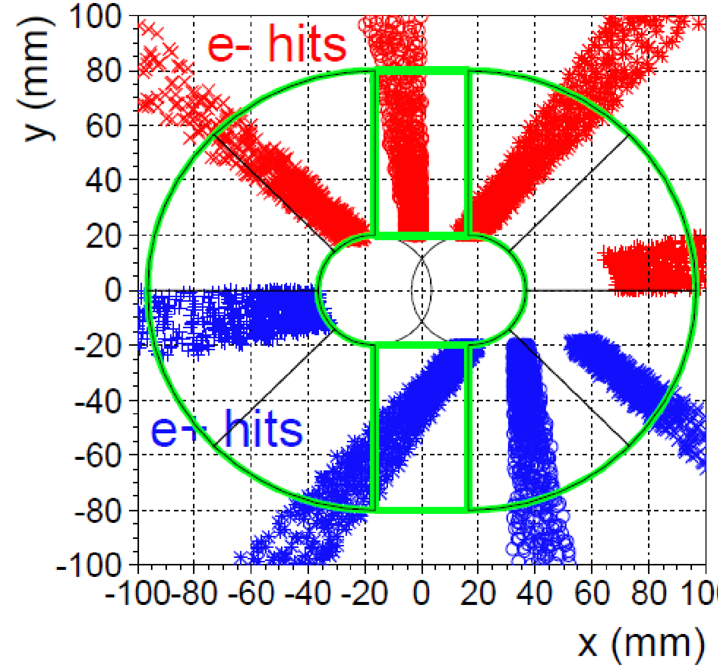


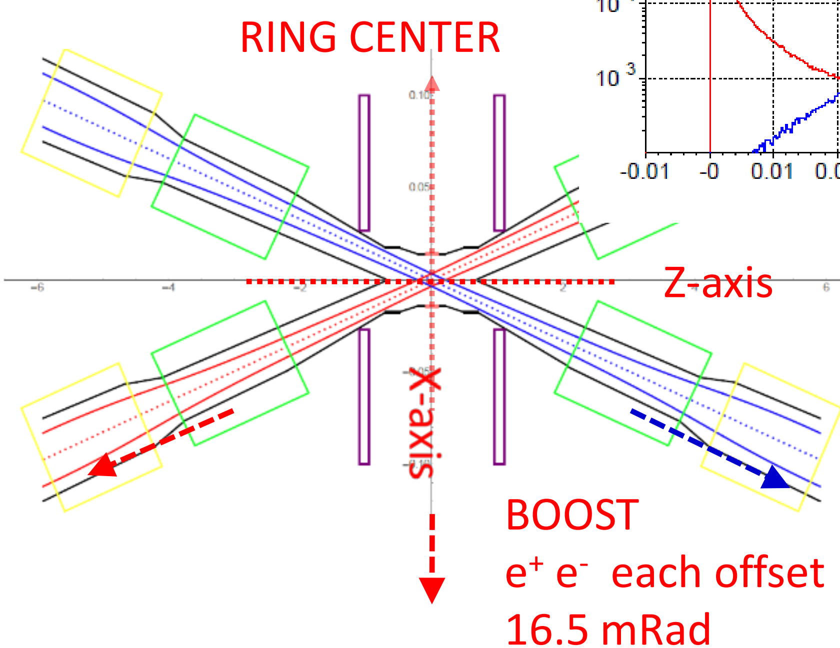
Silicon wafers of micro-strips

Bhabha measurement

- **Each EM shower > 1/2 E_{beam}**
- **Electron-positron back-to-back**
  (symmetric to out-going beam pipe)







Beam crossing: 33 mRad

→ Boost off ring center (+x axis)
→ offset 16.5 mRad maximum
(electrons on x-z plane)

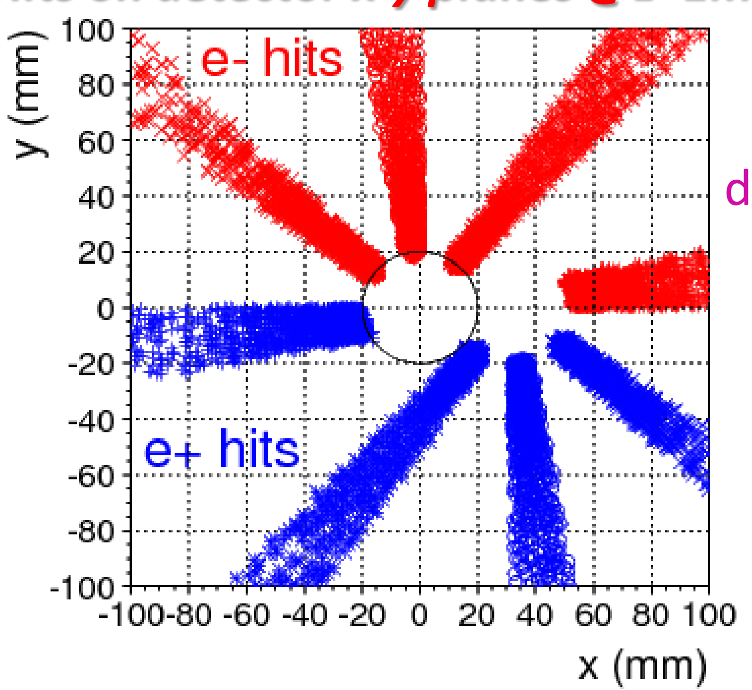
Boosted Bhabha

- Shift of LO Bhabha, (e^+e^-, no γ) on r-ϕ plane
- assuming e^+, e^- detected in ***fiducial of >20 mm @ z= 1 m***
- plotted in bands (every 45 deg in ϕ)
- event loss ***163 nb → 98 nb***

→ loss is SIGNIFICANT
→ LumiCal wants a small inner r,
→ in OVAL shape if feasible

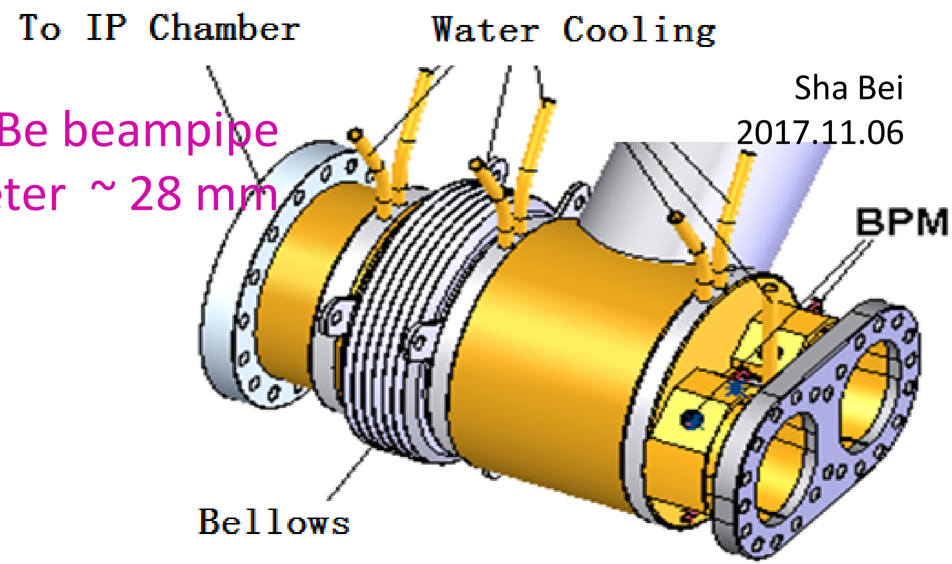
Redo this calculation
For a circular
@ Z= ± 500 mm

Hits on detector x-y planes @z=1m



Be beampipe
diameter ~ 28 mm

Sha Bei
2017.11.06



LumiCal
Inner R = 28.5 mm

LumiCal shower leakage

- **GEANT3 of a lateral shower testbeam***

  agree on charged multiplicity, lateral dist.

- **Si-W sandwich**

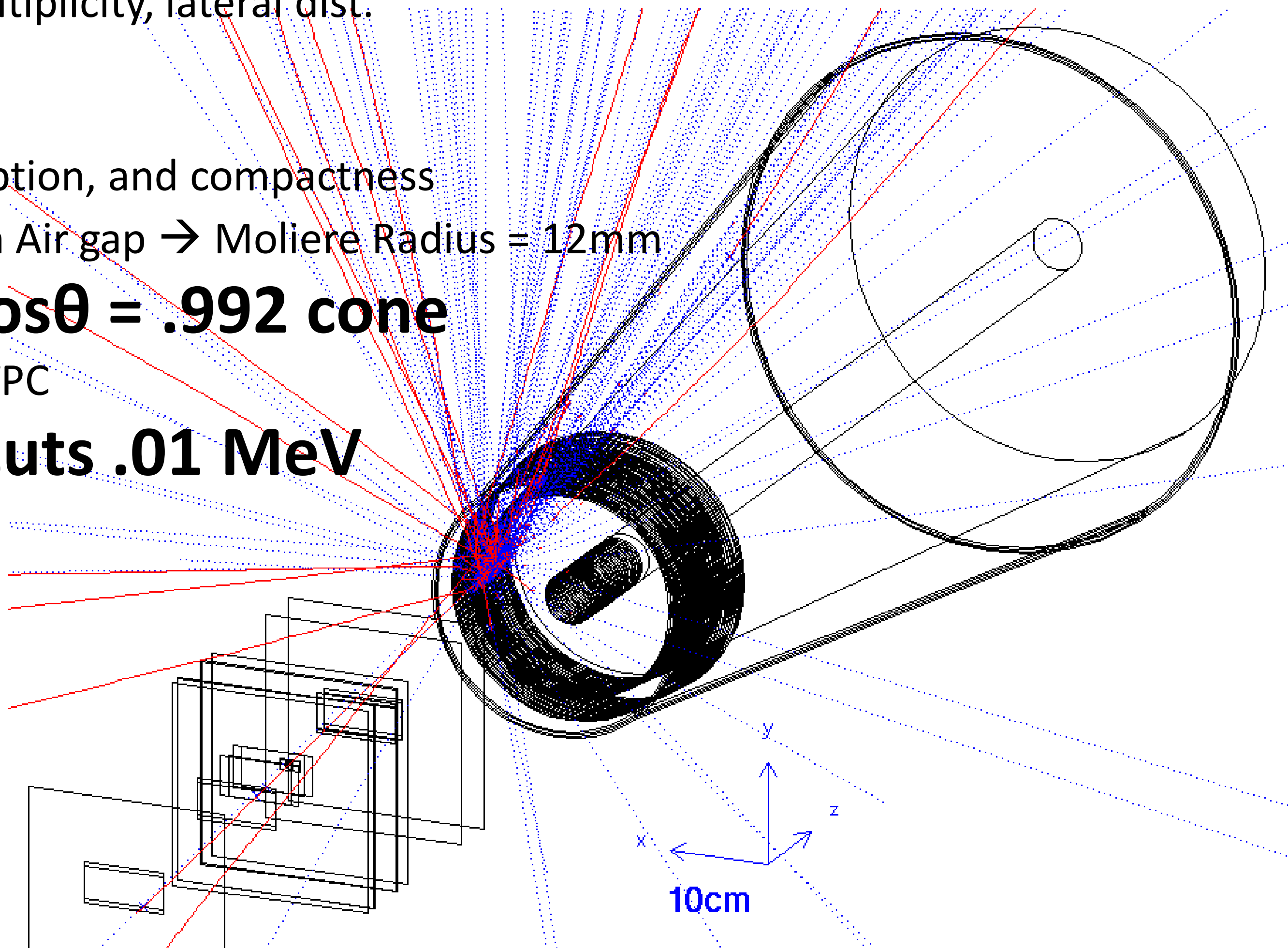
  better shower description, and compactness

  W $1X_0$(3.5mm) + 1mm Air gap → Moliere Radius = 12mm

- **Mockup of a cosθ = .992 cone**

  detecting leakage to TPC

- **Mininum e/γ cuts .01 MeV**

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C============
c    ( CUTGAM,CUTELE,CUTNEU,CUTHAD,CUTMUO, BCUTE,BCUTM, DCUTE)
CUTS   .00001   .00001   .01     .01     .01    .0001  .0001   .0002
c
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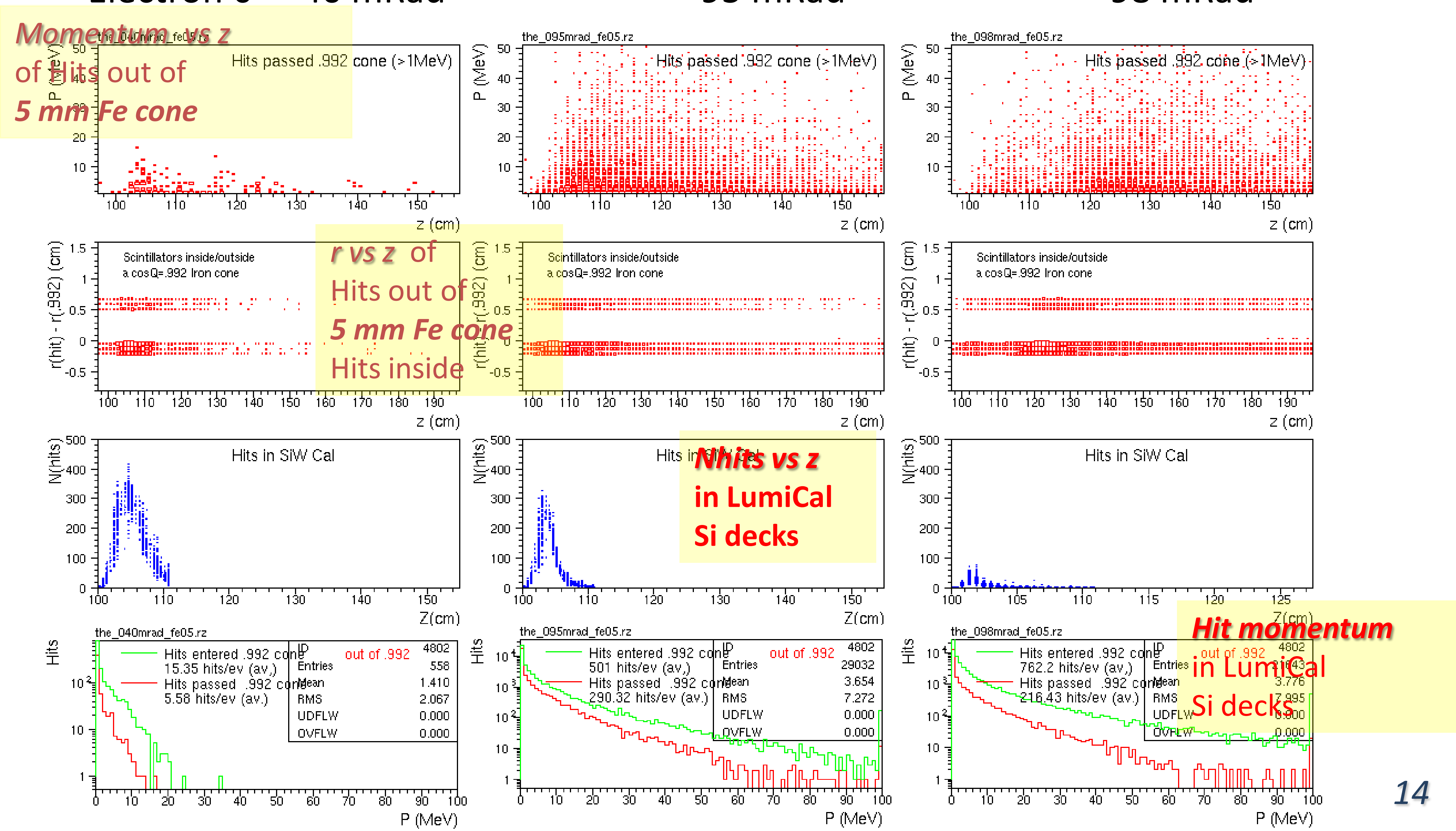
* NIM A 388 (1997) 135.

"TUBE" LumiCal shower leak distribution

50 GeV electron shower, reaching the outer Fe cone (5mm) at θ=.992

Electron θ= 40 mRad 95 mRad 98 mRad

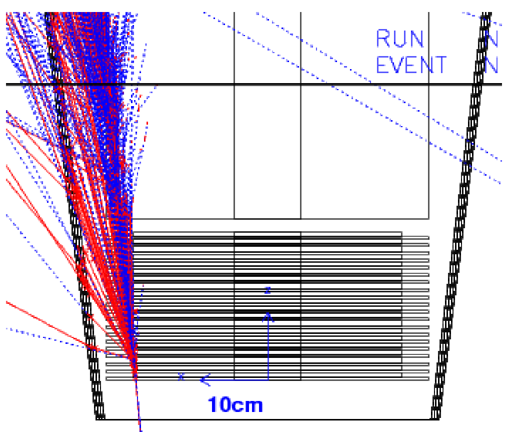


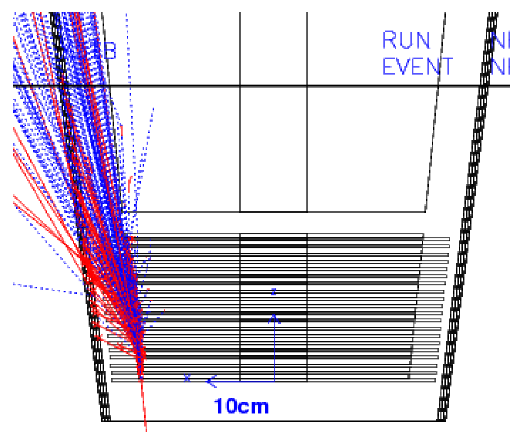
125GeV electron shower leak vs theta

Simulate 125 GeV electron from IP at fixed theta

Shower leakage are mostly low energy < 100 MeV particles

125 GeV electron	average events enter/pass 5 mm Fe cone at 0.992 Rad	
electron θ (mRad)	TUBE LumiCal N(enter) /N(pass)	CONE LumiCal N(enter) /N(pass)
40	38.0 / 16.0	35.8 / 14.7
90	1028 / 399	434 / 19 7
95	2389 / 720	937 / 382
98	1718 / 473	2176 / 725
99	1102 / 273	3306 / 915





To do

- **Si layer at Z = 500 m behind "Cone pipe"**
  ϕ 31, r= 15.5 mm ➔ calculate X sec (θ>30 mrad)
  cut-off horizontal (x-axis) for mechanical support
- **Estimate shower leakage**
  e.g., a "$2X_0$ preshower LumiCal"