# LumiCal with a Ø 20mm Racetrack pipe

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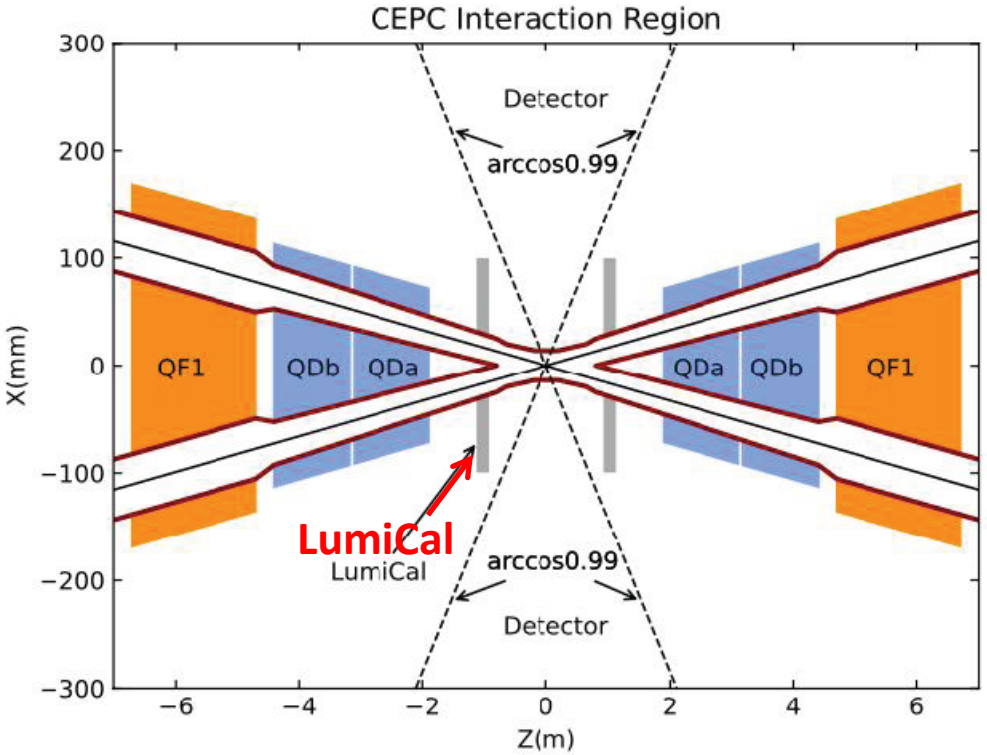
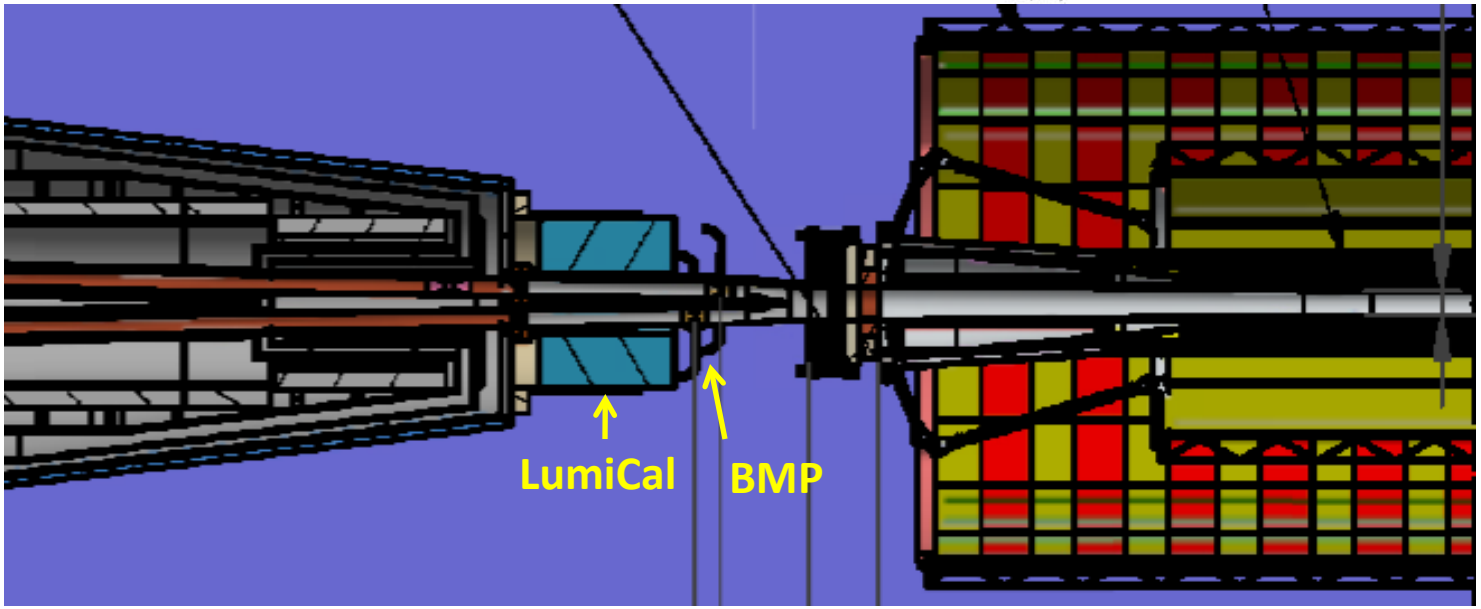
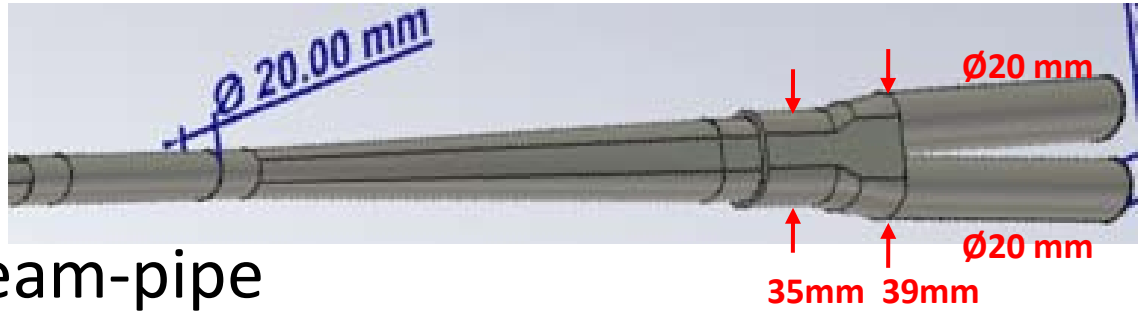



2020.05.24
11:00 indico.ihep.ac.cn/event/16509/

# Outline




- New **RaceTrack** beam-pipe

  IP Ø20 mm; *X splitting 20 – 35 – 39 mm*;
  *Y constant Ø20 mm to dual Ø20 mm pipes*

- **LumiCal option:**

  *lower theta acceptance*
  *against multiple scattering on $10^{-4}$ precision*

- **Bhabha cross section by BHlumi**

  boosted, beam crossing 33 mRad
  ***$\vartheta_{min}$ = 15 mRad ➔ σ(Bhabha) = 246 nb***

- **Event rate and occupancy**

  bunch crossing 32 ns, High-Lumi Z, L= $10^{36}$ /cm$^2$s

# Racetrack beampipe LumiCal

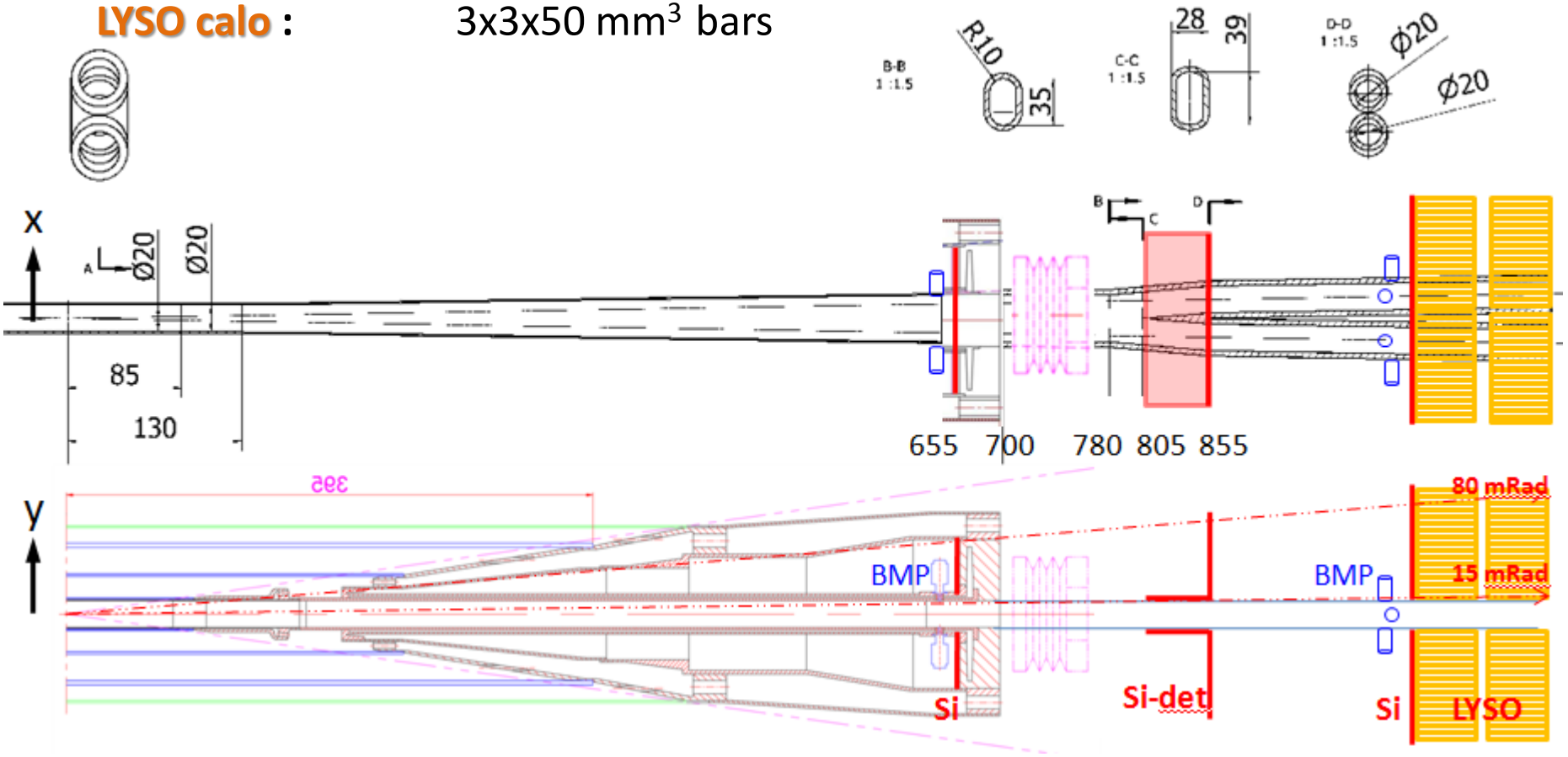
**33 mRad** beam-crossing, boost is horizontal, $e^{\pm}$ lost into beampipe

- beam-pipe flat surface y = ± 10 mm ← **the $\theta_{min}$ fiducial edge**
- Sandwich LumiCal modules $^{above}/_{below}$ |y|>10 mm

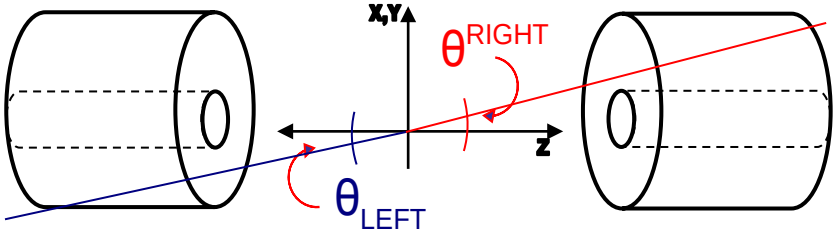
**Vertical Si-wafers** : $e^{\pm}$ theta tracking

**Flat Si-wafer** : minimal multiple scattering, **$\theta_{min}$ edge threshold detector**

**LYSO calo** : 3x3x50 $mm^3$ bars



# Bhabha Luminosity precision




Systematic error

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

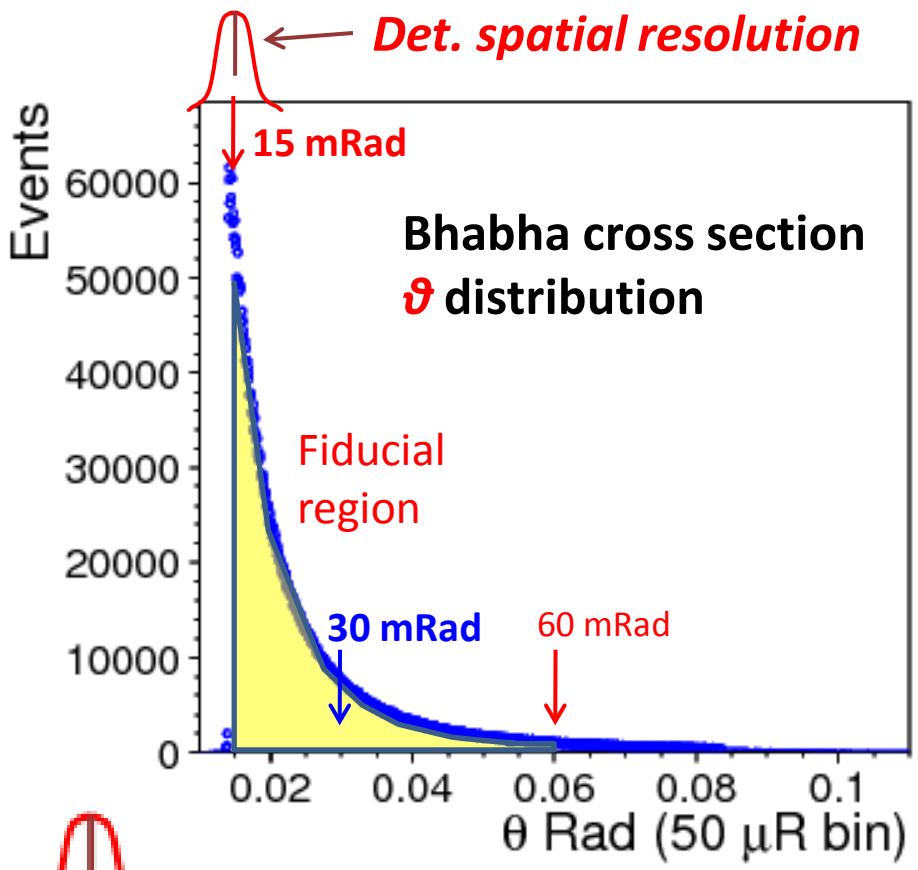
**for** $\delta L/L < 10^{-3}$

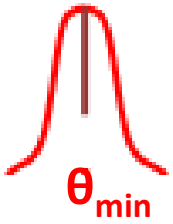
LumiCal at **z = ±1 m,** ➔ $\theta_{min}$ = 16 mRad

➔ $\delta\vartheta$ = 8 μRad e.q. dr = 8 μm

Error due to offset on ***Z*** position

➔ *1 mm on z* e.q. $dr = \delta \, Rx\vartheta$ = 16 μm



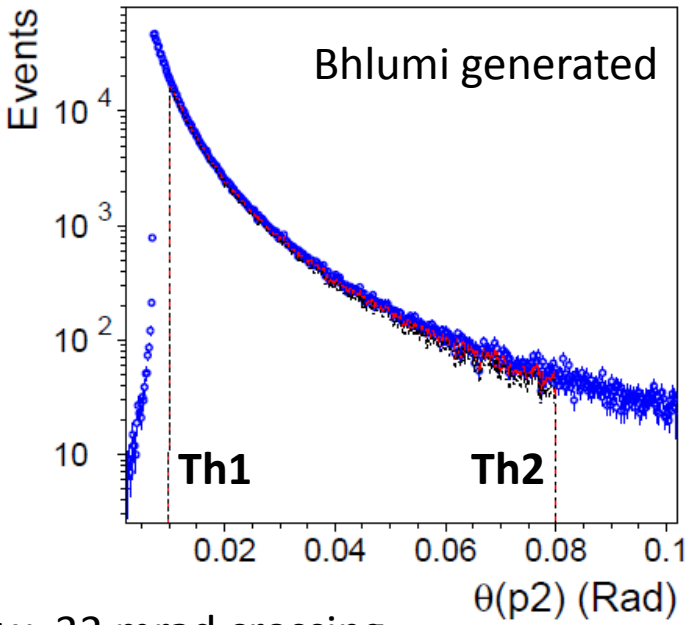

***LumiCal design goal:***

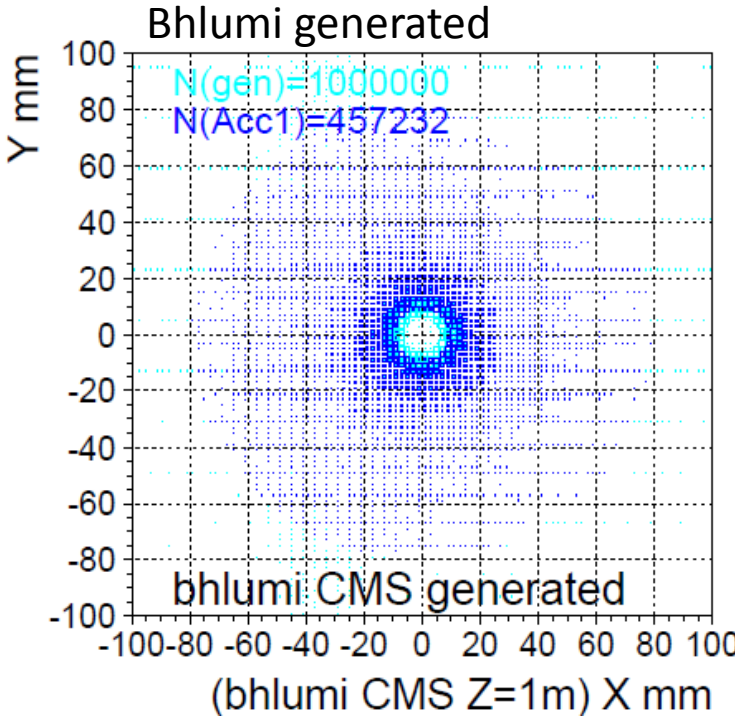
- *Spatial reso. narrow*
- *mean on* $\theta_{min}$ precision < ***1 μRad***

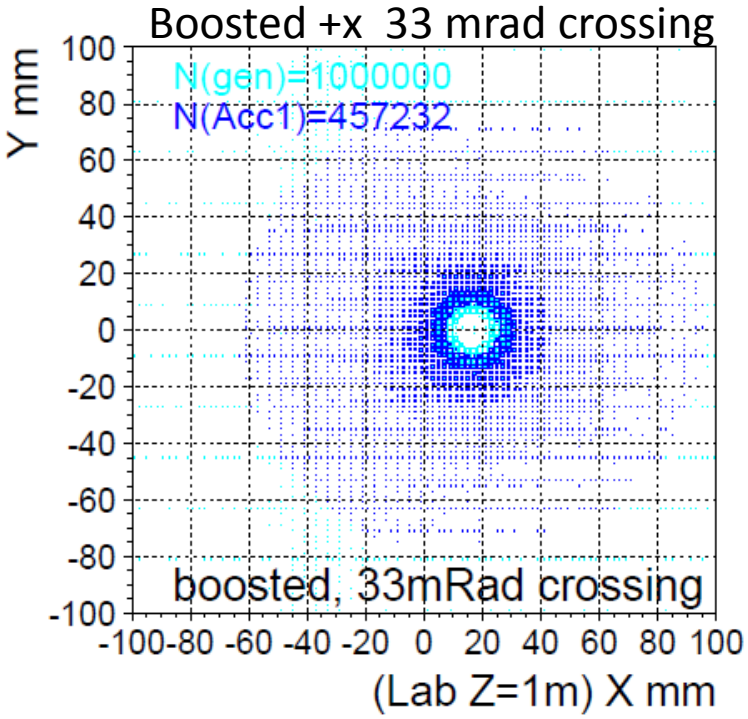
*offset of*
*the* ***mean on*** $\theta_{min}$
➔***LUMINOSITY error***

# BHLUMI QED calculation for Bhabha

1. Use Bhlumi paper parameters, x-checked
   $m_Z$=92. 3 GeV, Theta range : **Th1, Th2**
   **BARE1 X section:** Th1<$\theta_1$' and $\theta_2$'<Th2, s'> 0.5s
2. Boost +x for the 33 mRad e+,e- crossing
3. Count events in fiducial region, derive X-section

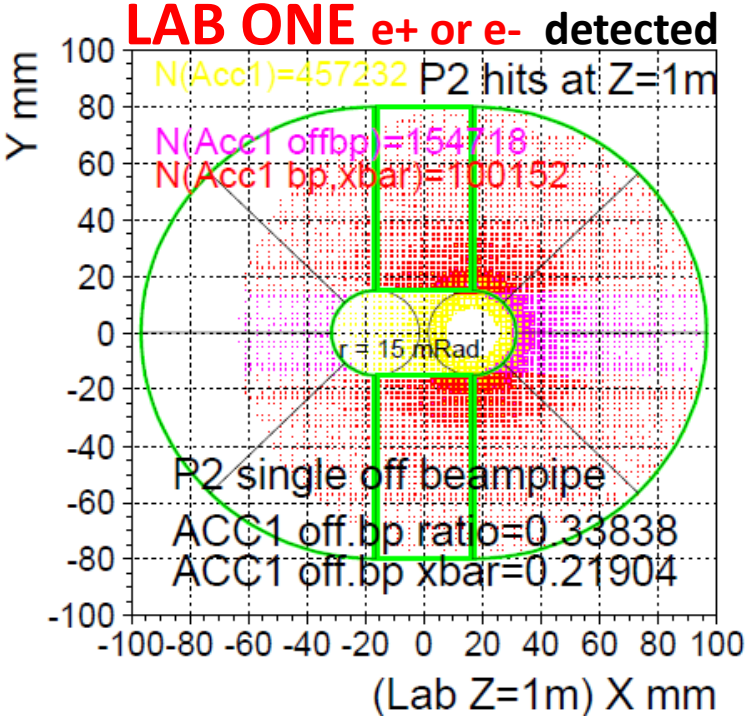


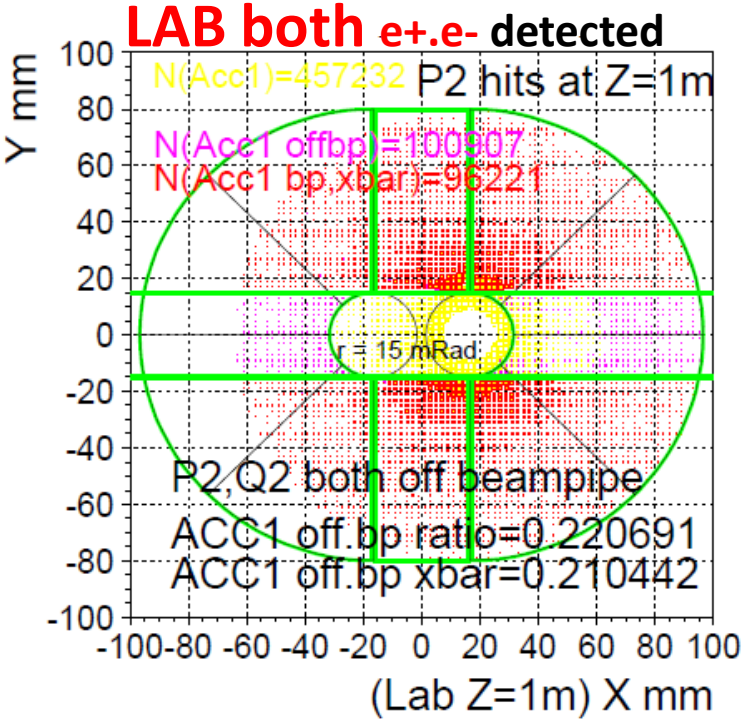



# BHlumi X-section, racetrack @CEPC

## *Bhabha electron distribution, one side on condition, one or both detected*




*RaceTrack @z=1m* r>15 mm, |y|>15 mm

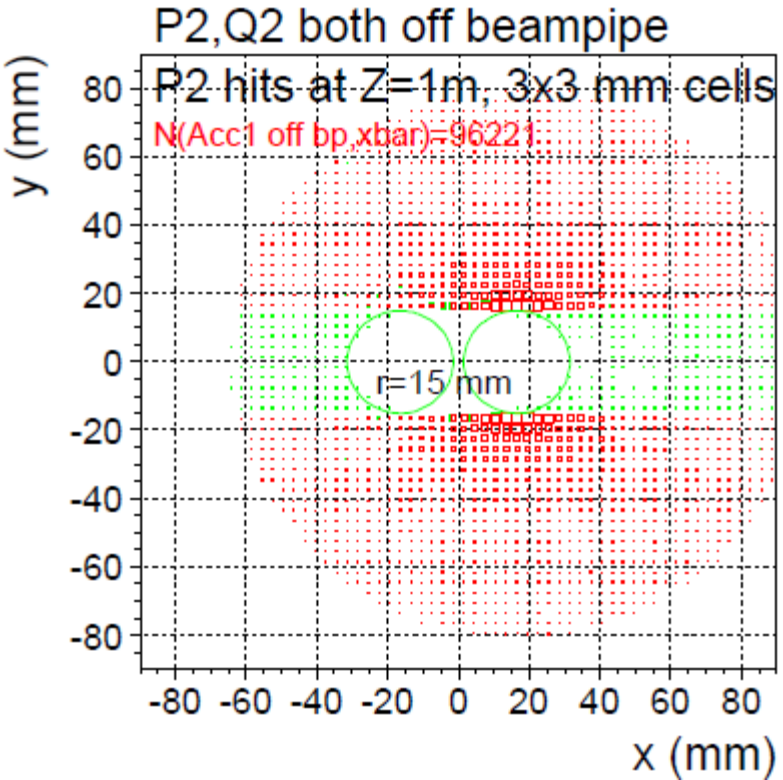
| CMS 10 ~ 80 mRad | | LAB ONE e+ or e- detected | | LAB both e+.e- detected | |
|---|---|---|---|---|---|
| BARE1 | | off r=15 RaceTrack | off r=15 RaceTrack \|y\|>15 | off r=15 RaceTrack | off r=15 RaceTrack \|y\|>15 |
| Nevents | 457232 | 154718 | 100152 | 100907 | 96221 |
| Xsec (nb) | 1168.3 | 395.3 | 255.9 | 257.8 | 245.9 |

# Bhabha event rate @High-Lumi Z

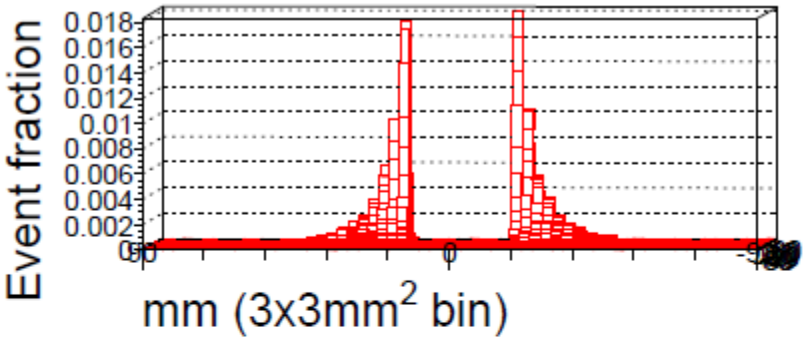
1. High-Lumi Z (2021 design) $L_{max}$/IP = **115 x $10^{34}$/cm$^2$s**
2. Bhabha both e+, e- detected, X-sec = **245.9 nb**
   **Event rate** = (246x$10^{-33}$) x (115 x $10^{34}$) /sec **= *280 kHz***
3. Event rate / 32ns bunch crossing = **0.009 events /b.c.**

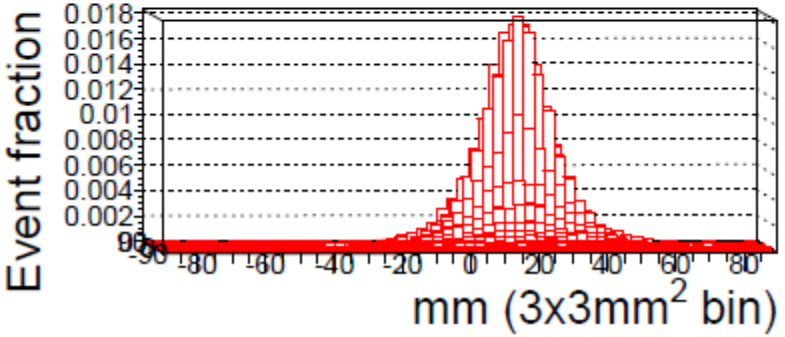
*c.f. LEP*
*L= 1x$10^{32}$*
*X-sec= 100nb*
*Rate= 10 Hz*

**Event distribution in 3x3 mm$^2$ cells**



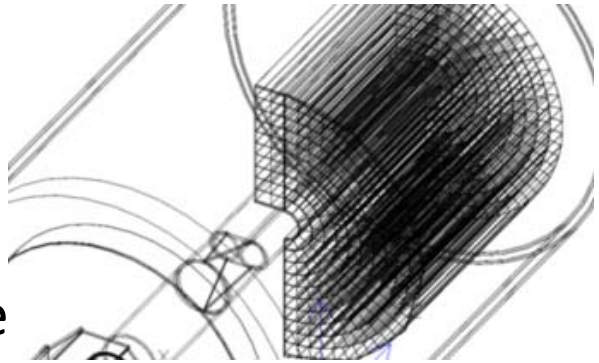

**Max event fraction/cell = 0.018**
**peaks at out-going pipe edge**



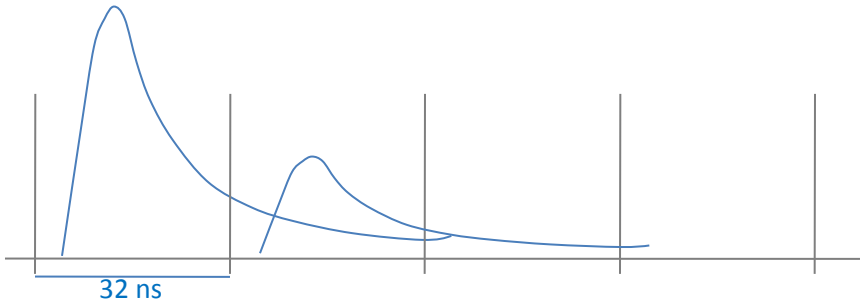
# Bhabha event pile up @High-Lumi Z

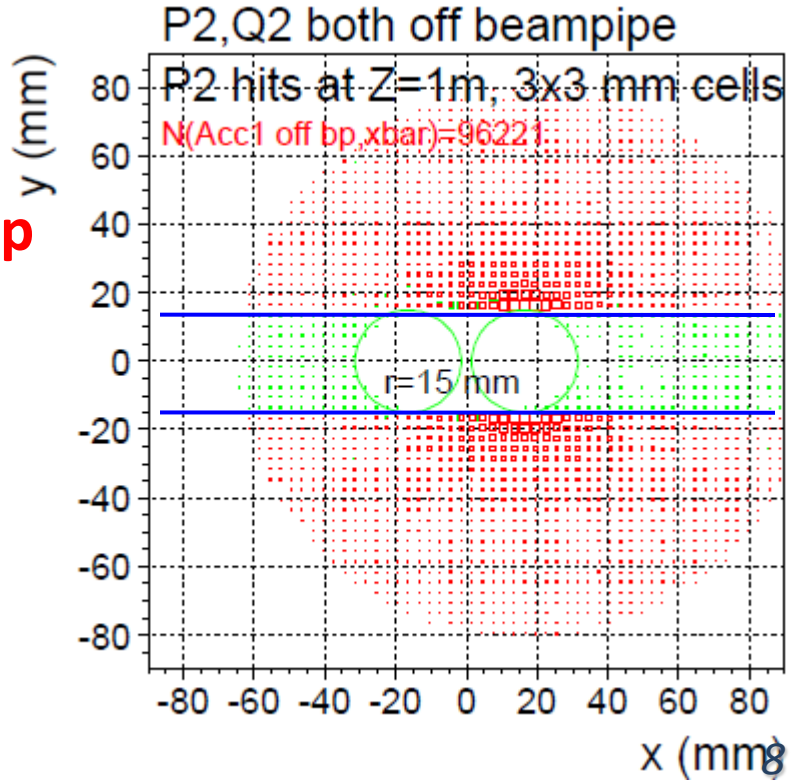
1. LYSO +SiPM segmentation:
   3x3x50 $mm^3$ bars along beampipe
2. 50 GeV electron shower in Ø10mm cone
3. Occupancy: overlapping near outgoing pipe
4. **Event pile-up:**
   **DAQ latency/32ns x .009 events**



**Shower clustering in LYSO cells**
**ADC type DAQ can not resolve pile-up**

LYSO signal overlap

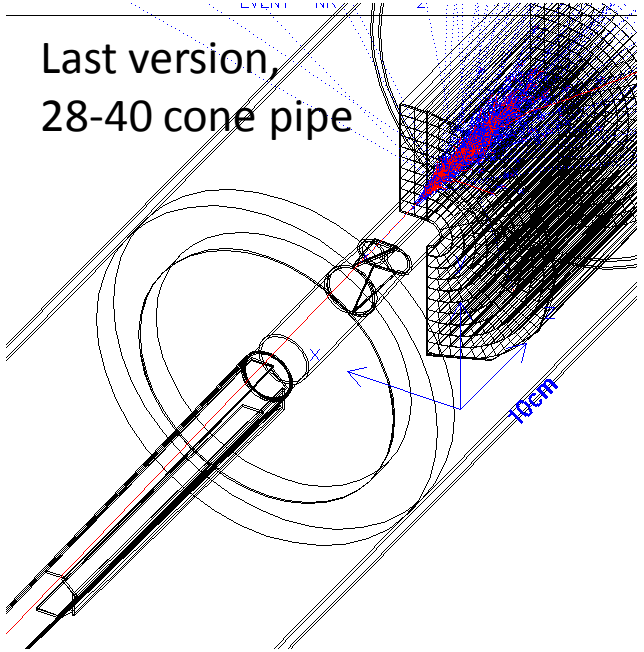


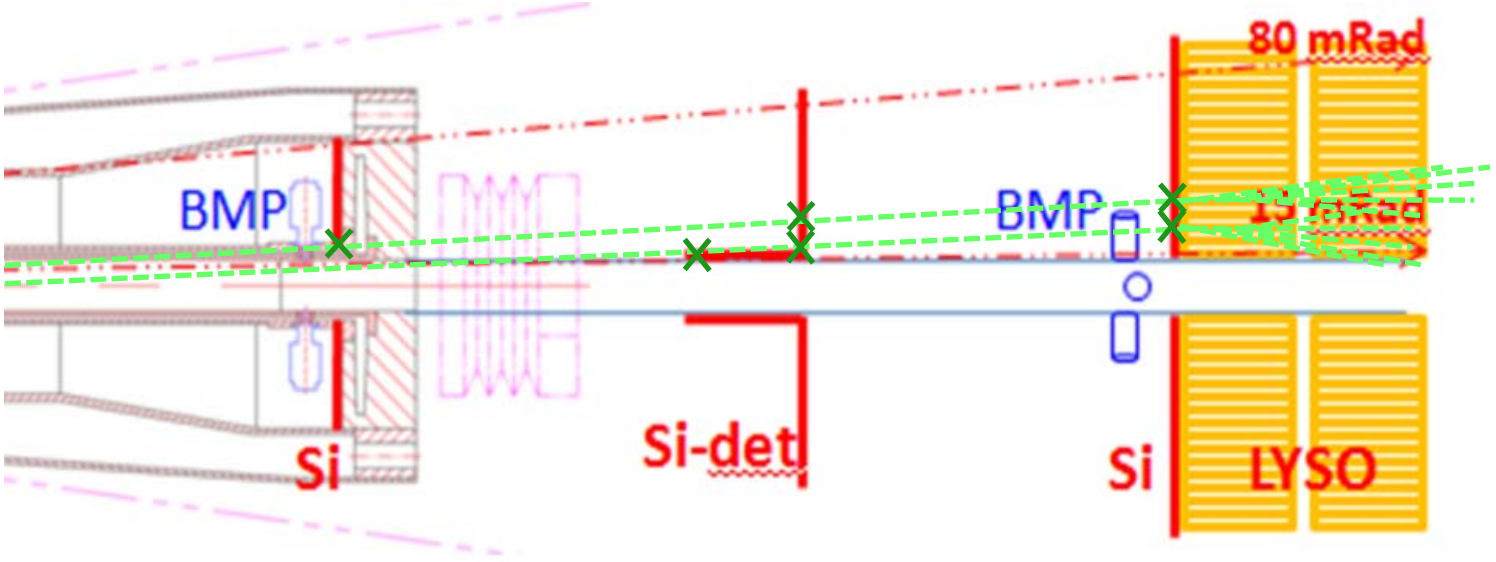



# Bhabha event pile up @High-Lumi Z

## Resolve electron pile-up

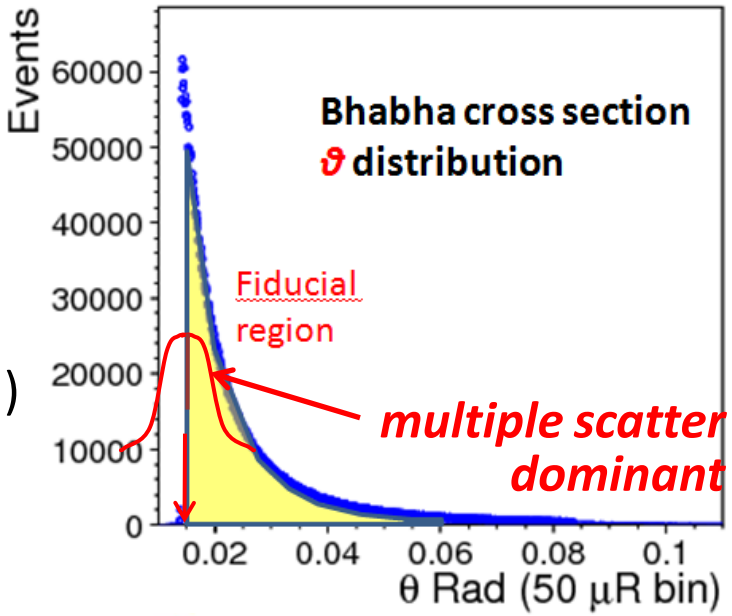
1) **LYSO sampling in time** to resolve signal of continuous bunches (in 32 ns)
2) **Si-strips/pads** in fine segmentation number of electrons arriving LYSO

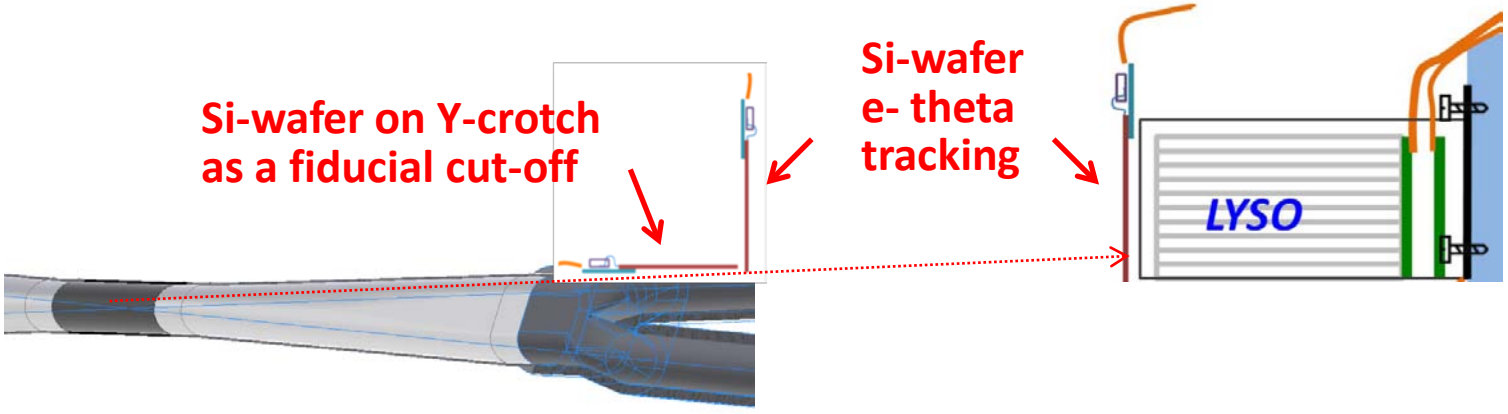


# Multiple scattering off Al beampipe

- ***50 GeV electron*** traversing Al-pipe 1mm
  traversing @ **15 mRad**
  dz = 1/tan(.015) = ***67 mm***
- **Multiple scattering effect dominates**
  the precision on fiducial $\theta_{min}$
  attach Si-wafer ***tight*** on beampipe
  detecting e- theta exiting beampipe
- **Si-wafer on beam-pipe Y-crotch**
  @θ = 15 mRad, 50mm Si-wafer (z=805-655mm)
  covers 1 mRad
  *expecting σ(Z) ~ 200 μm, σ(ϑ) ~ 20 μRad ??*
  ***further GEANT study required***



# Summary :

**LumiCal** on *Ø20* **–** *dual-Ø20 mm* **RaceTrack beampipe**

- **Bhabha cross-section** with both electrons detected in Lab frame of $\theta_{min}$ >15 mRad, |y|>15mm
  → X-section **= 246 nb**
  Bhabha event rate = 280 kHz
- **LumiCal simplified** *(detailed GEANT study to be followed)*
  - **Si-wafers** :
    for electron θ position, $\theta_{min}$ threshold ← ***$10^{-4}$ must***
  - **LYSO decks:**
    of 3x3x50 bars, DAQ on timing ← ***resolve pile-up***