Z–pole event pileup estimation

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1   Bhabha events on LYSO cells ($3x3mm^2$)

   pile-up rate ~$1x10^{-4}$ at low-θ edge

2   Z lineshape   Z → qq

   pile-up rate (4π coverage)   ~$1x10^{-3}$

➔ *Resolve BCID, inner ECAL layers,*

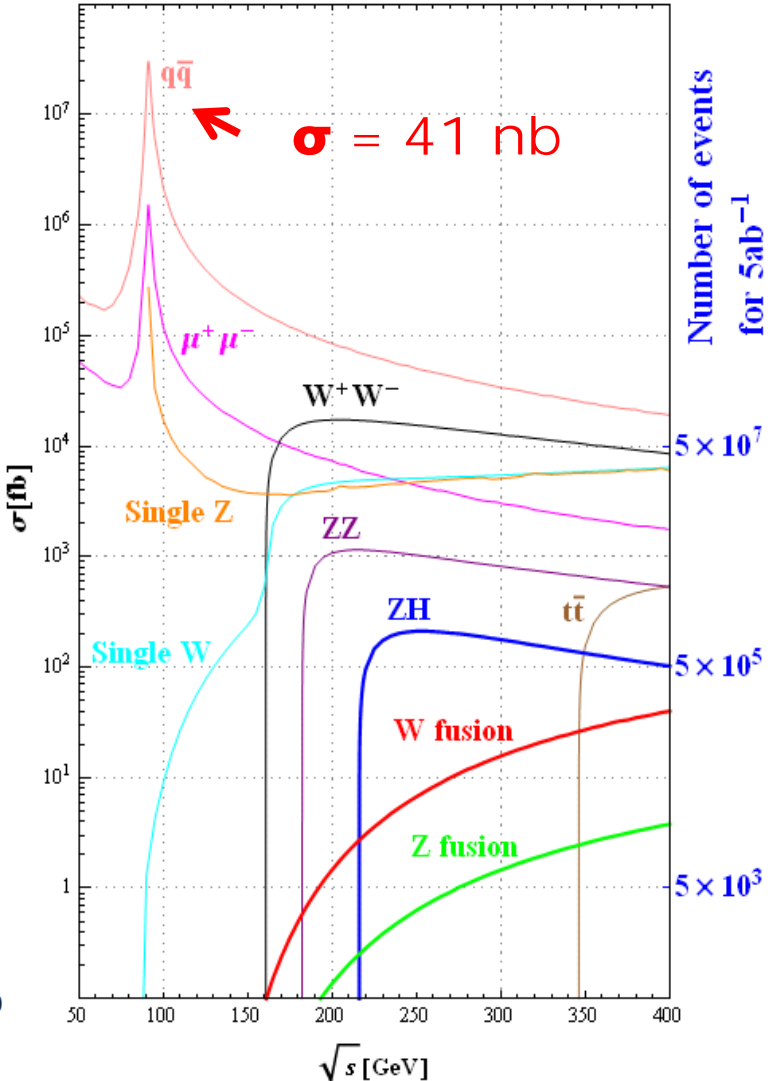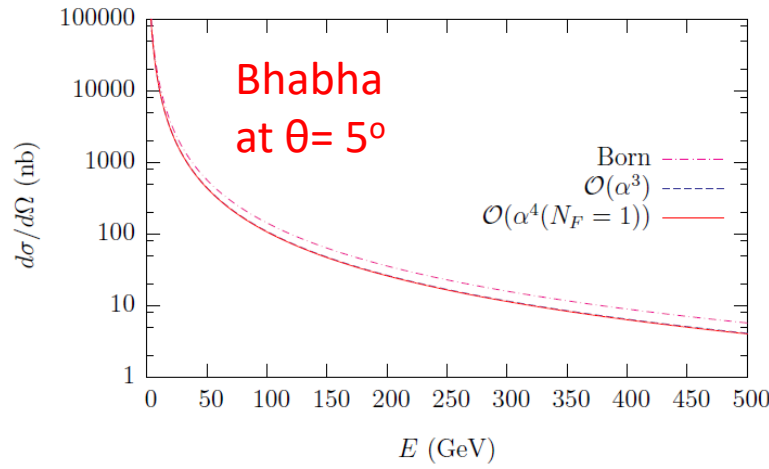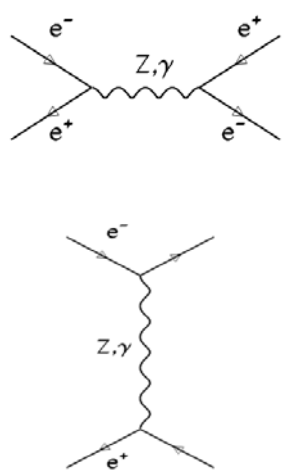   *SiPM do High-gain + 3-bit (8 levels) comparator*

Cross-section

- **Z-lineshape**

  $e^+e^- \rightarrow Z \rightarrow q\bar{q}$

- **Luminosity by Bhabha**

  $e^+e^- \rightarrow e^+e^-$

$$\mathcal{L} = \frac{1}{\varepsilon}\frac{N_{\text{acc}}}{\sigma^{\text{vis}}} \quad \sigma = \frac{16\pi\alpha^2}{s}\cdot\left(\frac{1}{\theta_{min}^2} - \frac{1}{\theta_{max}^2}\right)$$
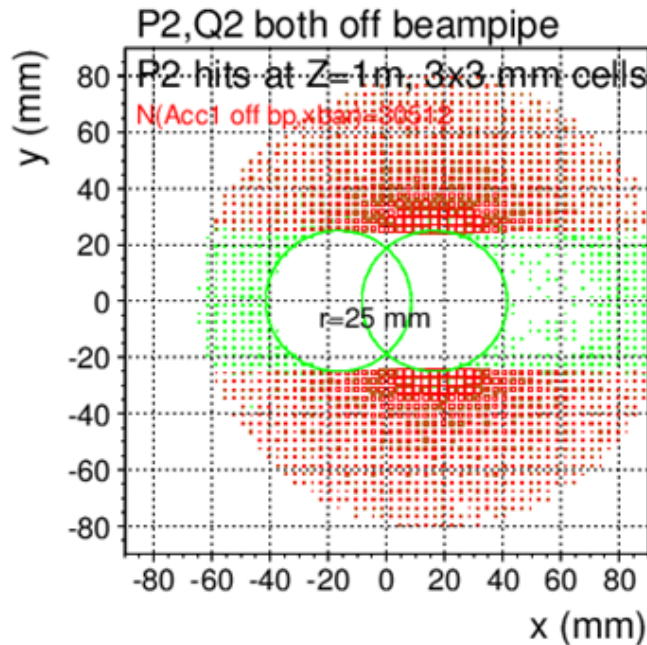
σ = 41 nb

Bhabha
at θ= 5°

Born ———
$\mathcal{O}(\alpha^3)$ ------
$\mathcal{O}(\alpha^4(N_F = 1))$ ———

hep-ph/0411321 NPB 716 (2005) 280

BHLUMI X-section, racetrack @CEPC

Acceptance @z=1m r>25 mm, |y|>25 mm

e^+, e^- back-to-back
Symmetric to
out-going pipe center

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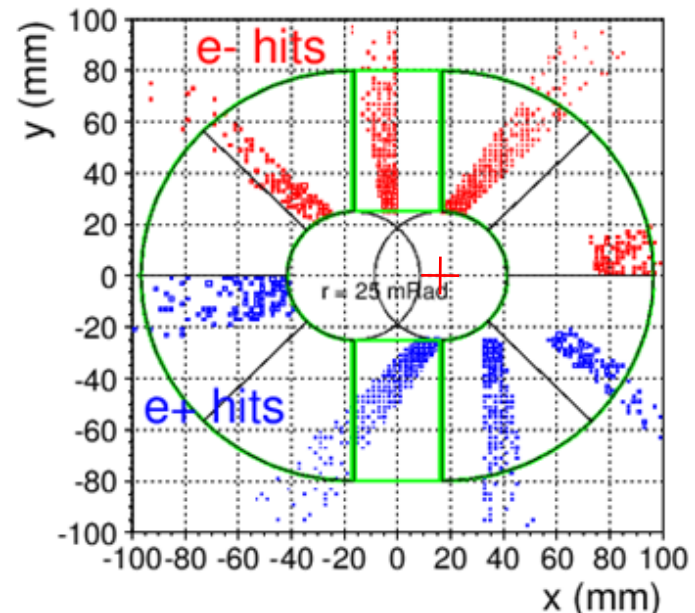
at Z = 1000 mm

LAB ONE e^+ or e^- detected		LAB both e^+, e^- detected	
θ>15 mRad	θ>15mR & |y|>15mm	θ>15 mRad	θ>15mR & |y|>15mm
395.3	255.9	257.8	245.9
θ>25 mRad	θ>25mR & |y|>25mm	θ>25 mRad	θ>15mR & |y|>25mm
133.5 nb	81.8 nb	85.4 nb	78.0 nb
θ>30 mRad	θ>30mR & |y|>30mm	θ>30 mRad	θ>30mR & |y|>30mm
87.2	51.8	54.9	49.1

Systematics against $\delta L/L \sim 10^{-4}$

● **$\delta N/N \sim 10^{-4}$ in fiducial ϑ window**

1. **Det. Position offset**
2. **Multi. Scattering, det. Resolution B-field helix**
3. **Rad. Bhabha, preshower offset**

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

$\delta L/L < 10^{-4}$ for $\theta_{min} = 20$ mRad

→ **$\delta\vartheta = 1\mu Rad$ dr=1μm @ z=1m**

Si-strip detector
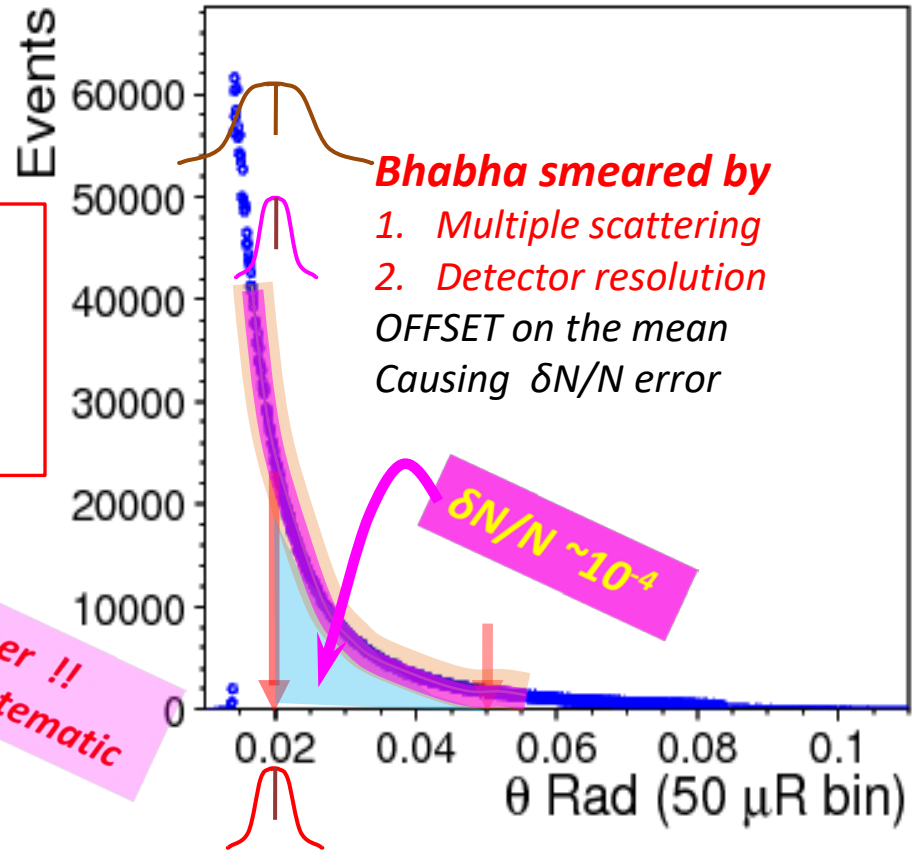fiducial edge = central line between two strips
Multi.Scattering → events flow in/out Fiducial
+ geo error   → *event counting error*
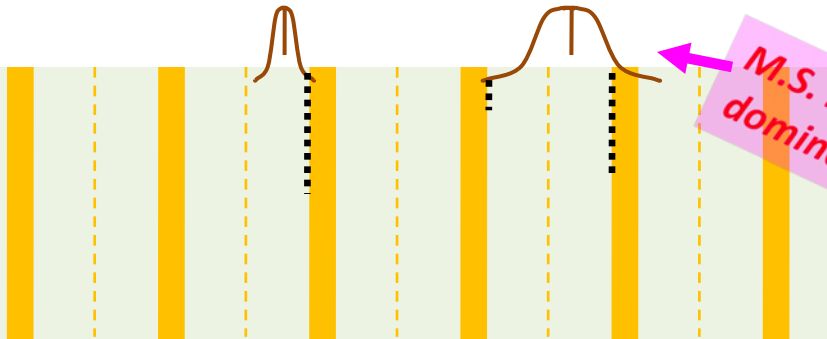
Bhabha smeared by
1. *Multiple scattering*
2. *Detector resolution*
OFFSET on the mean
Causing $\delta N/N$ error

$\delta N/N \sim 10^{-4}$

M.S. non-liner !!
dominant systematic

Events

60000
50000
40000
30000
20000
10000
0

0.02   0.04   0.06   0.08   0.1
θ Rad (50 μR bin)

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Bhabha pile-up rate @High-Lumi Z

1. High-Lumi Z (2021 design) L_{max}/IP = **115 x 10³⁴/cm²s**
2. Bhabha both ***e⁺, e⁻*** detected, X-sec = **246 nb**
   Event rate = (246x10⁻³³) x (115 x 10³⁴) /sec **= 115 kHz**
3. Event rate / 25 ns bunch crossing = **0.003 events /b.c.**
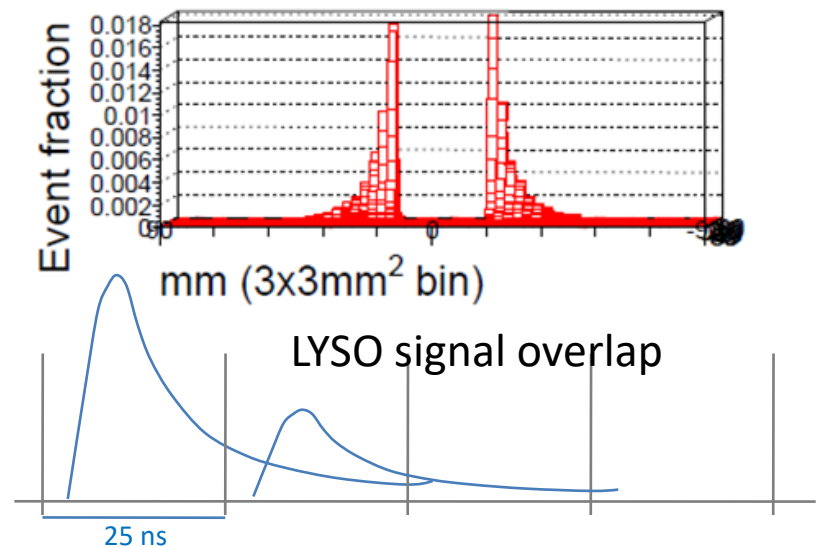4. **Pile-up: next b.c., @adjacent cell in peak region**

   Pile-up Fraction = 0.018*6cells/2sides = **0.054**

   Pile-up event rate = 0.003*0.054 = **1.6 x 10⁻⁴**   **in 3x3 mm² cells**

c.f. LEP
L= 1x10³²
X-sec= 100nb
Rate= 10 Hz

50 GeV e- shower in 3x3 mm² cells
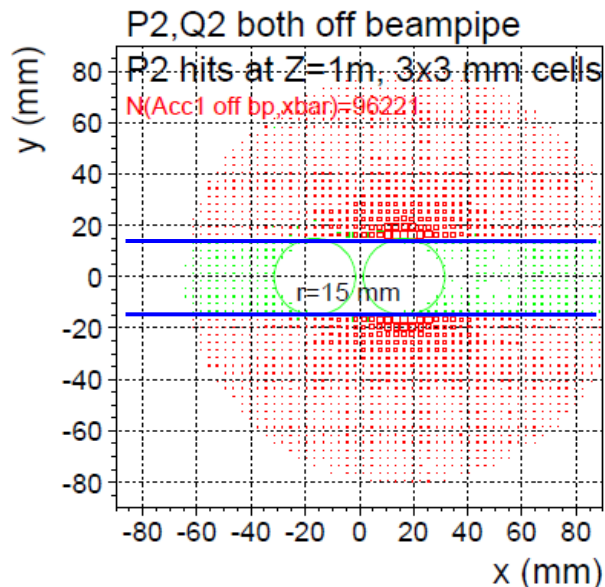
event fraction /(cell of 3x3mm²)
maximum at beampipe edge = 0.018

LYSO signal overlap

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Bhabha pile-up rate @High-Lumi Z

1. High-Lumi Z (2021 design) L_{max}/IP = **115 x 10^{34}/cm²s**

2. **Z $\rightarrow$ q$\bar{q}$** , X-sec = **41 nb**

   Event rate = (41x10^{-33}) x (115 x 10^{34}) /sec = *47 kHz*

   bunch cross = 40 MHz

3. Event rate / 25 ns bunch crossing = **0.001 events /b.c.**

4. **next b.c. having a Z $\rightarrow$ q$\bar{q}$**

   Pile-up rate 4π coverage ~ 1x 10^{-3}

if BCID not identified
- **pileup of two 2-jets ➜ 4-jet**
- **rare decay precision ~1x 10^{-3}**

25 ns

LEP: e⁺e⁻ → Z→ q$\bar{q}$→hadrons