LumiCal pad design present understanding

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Outline

High statistics MC, Fast simulation

Design optimization (GEANT) :

1. Granularity and reconstruction algorithm (Log. Weighting).
2. Electronics channels (Maximum peak shower design).

Present understanding design (head on ILC, Crossing angle).

Method of counting Bhabha events

Summary

Fast Detector Simulation

Motivation :

High statistics is required to notice precision of : $\frac{\Delta L}{L} \cong 10^{-4}$
(Which is the precision goal of the ILC)

There is an analytic calculation (and approximation) : $\frac{\Delta L}{L} \approx \frac{2 * \Delta\theta}{\theta}$

Luminosity precision determination : $\frac{\Delta L}{L} = \frac{N_3 - N_2}{N_1 + N_2}$

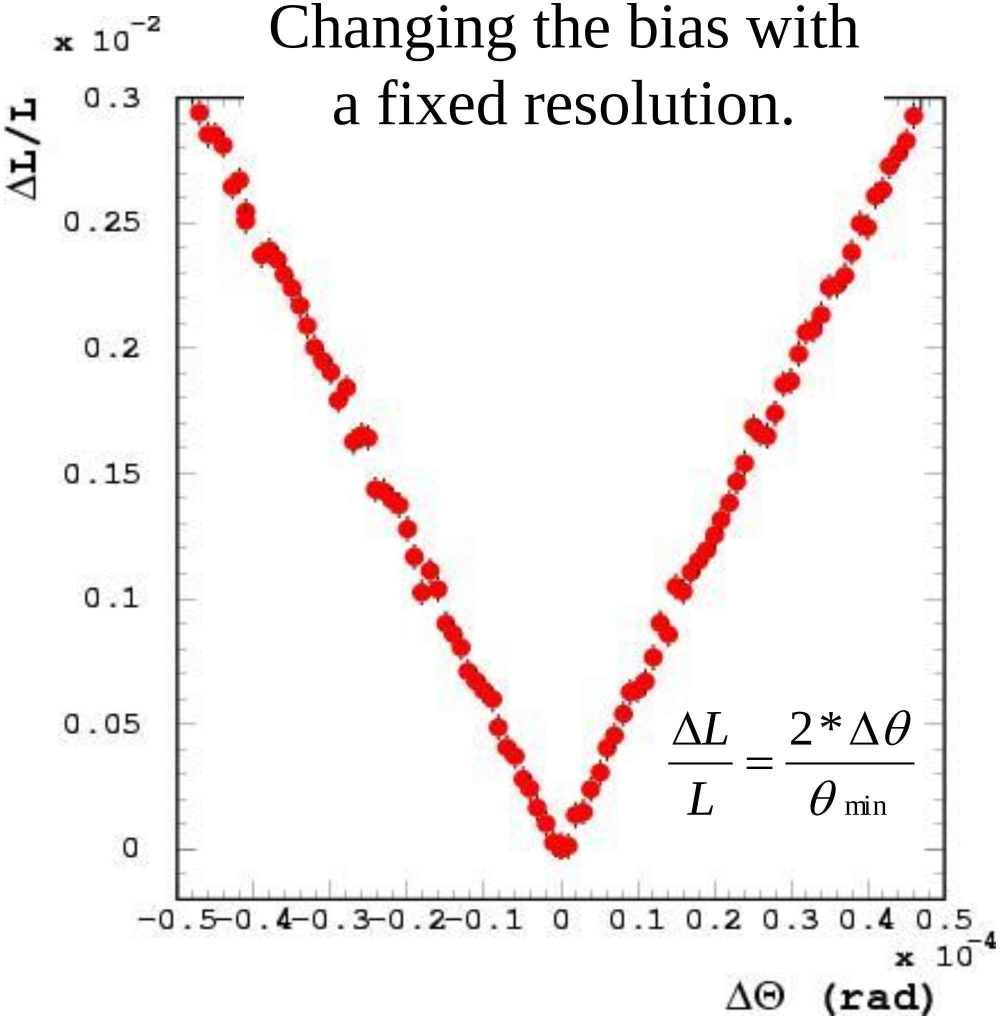
N_1 : Reconstructed and generated in acceptance region.

N_2 : Generated in acceptance region but reconstructed outside.

N_3 : Generated outside acceptance region but reconstructed inside.

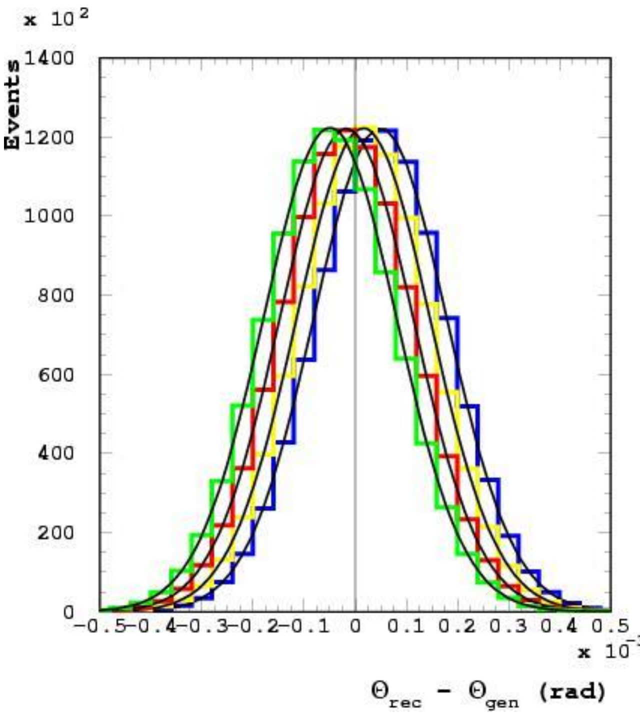
High Statistics Simulation

Changing the bias with a fixed resolution.



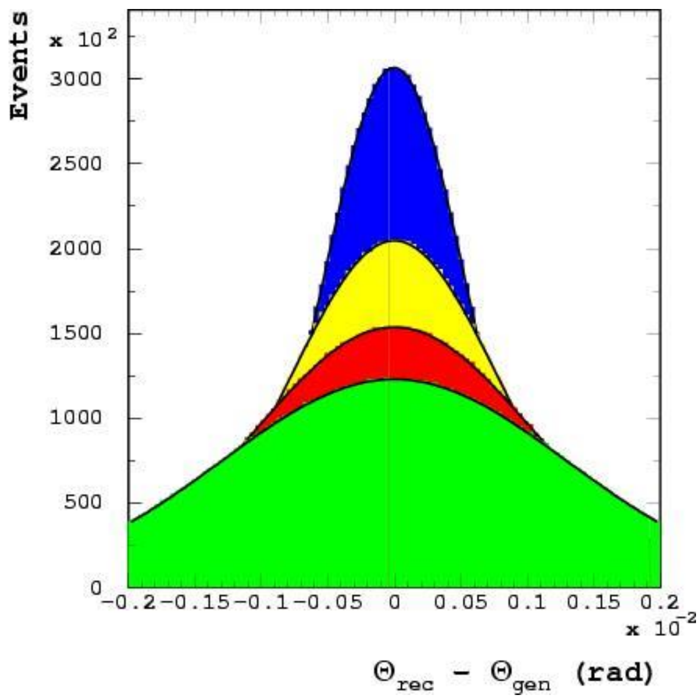
$$\frac{\Delta L}{L} = \frac{2 * \Delta\theta}{\theta_{\min}}$$

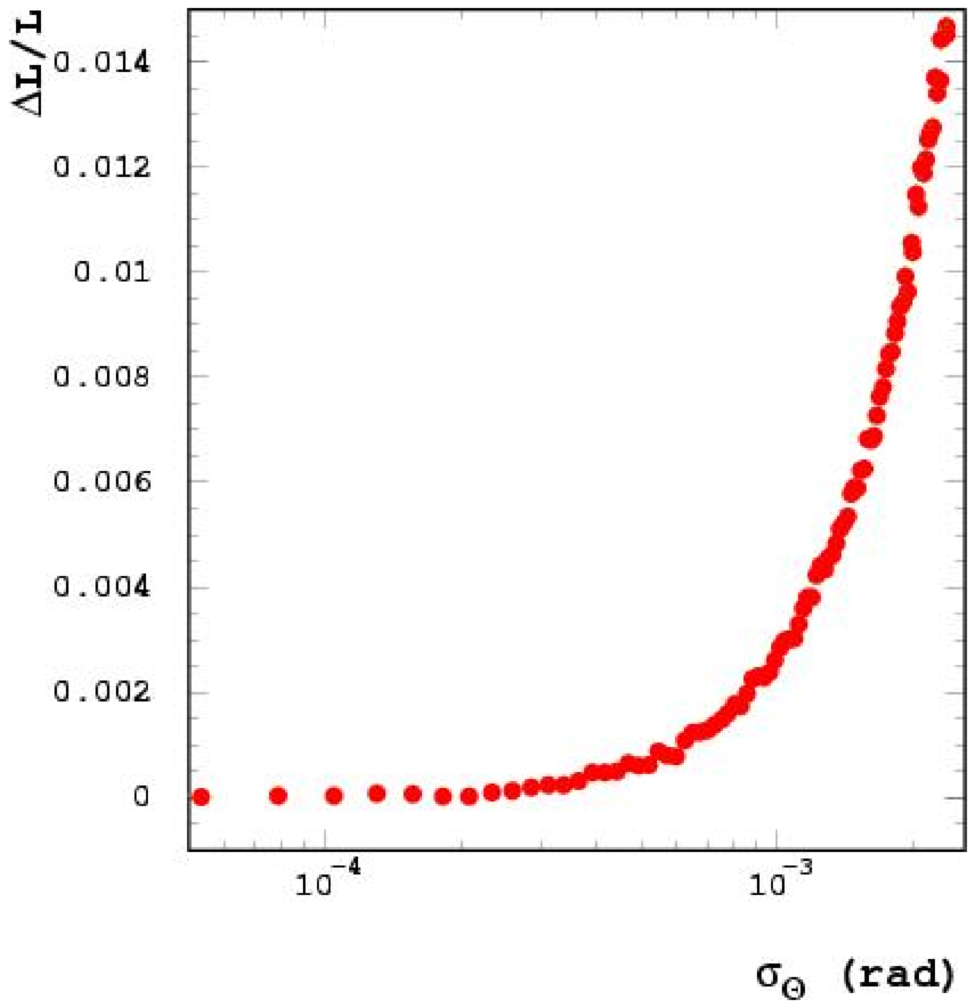
BHWIDE generated properties + smearing to simulate detector



High Statistics Simulation

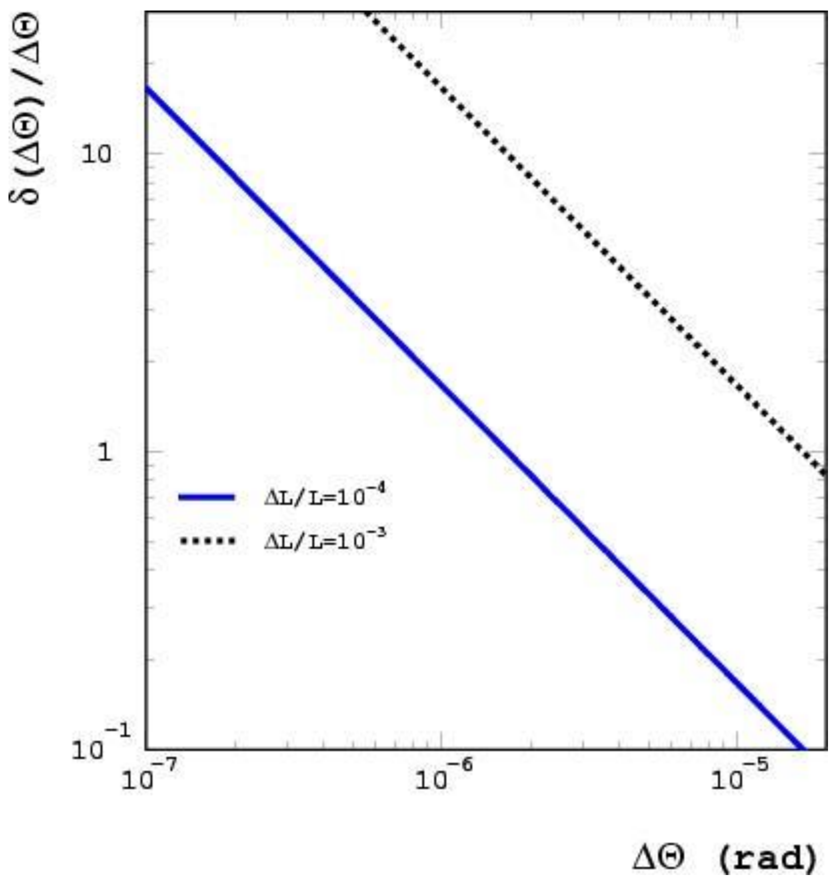
Changing the detector resolution with no bias

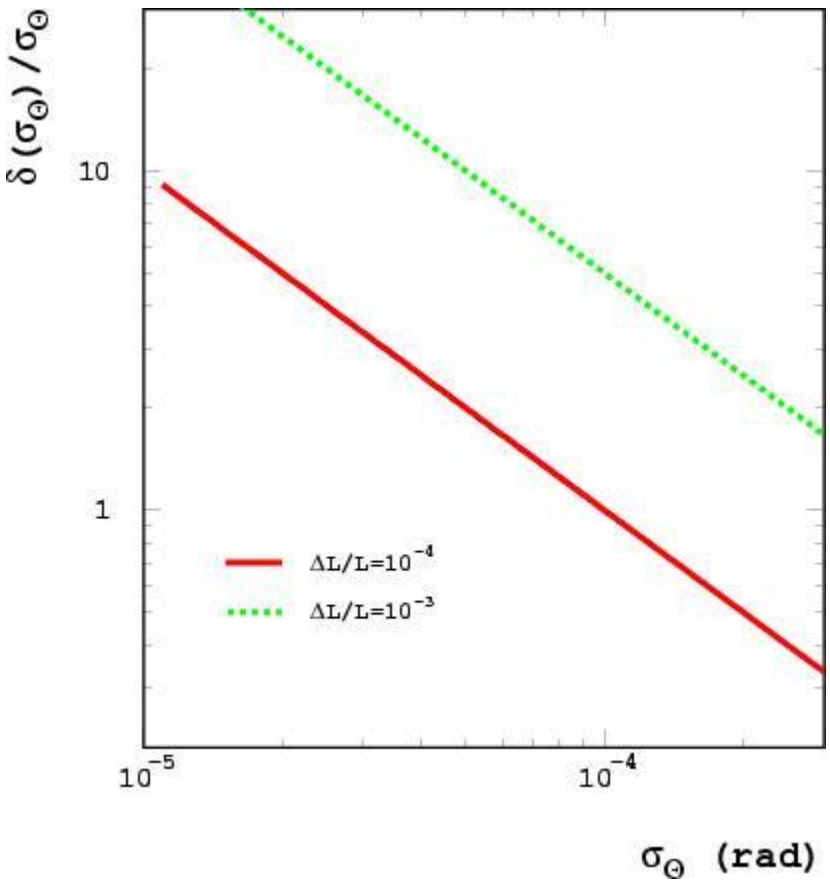




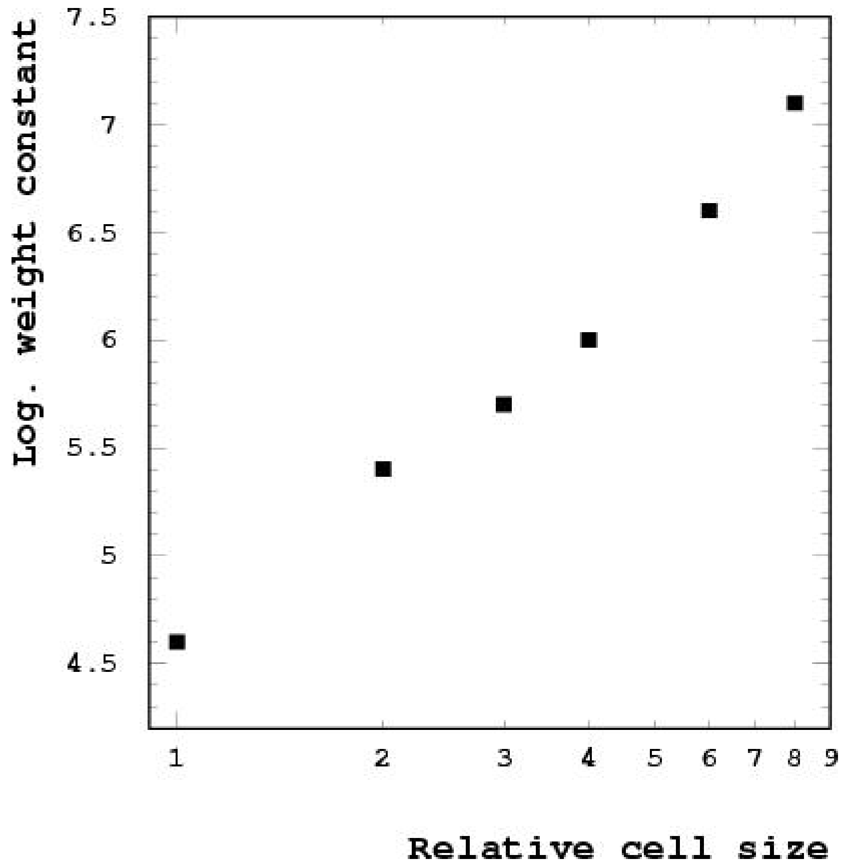
Data and MC

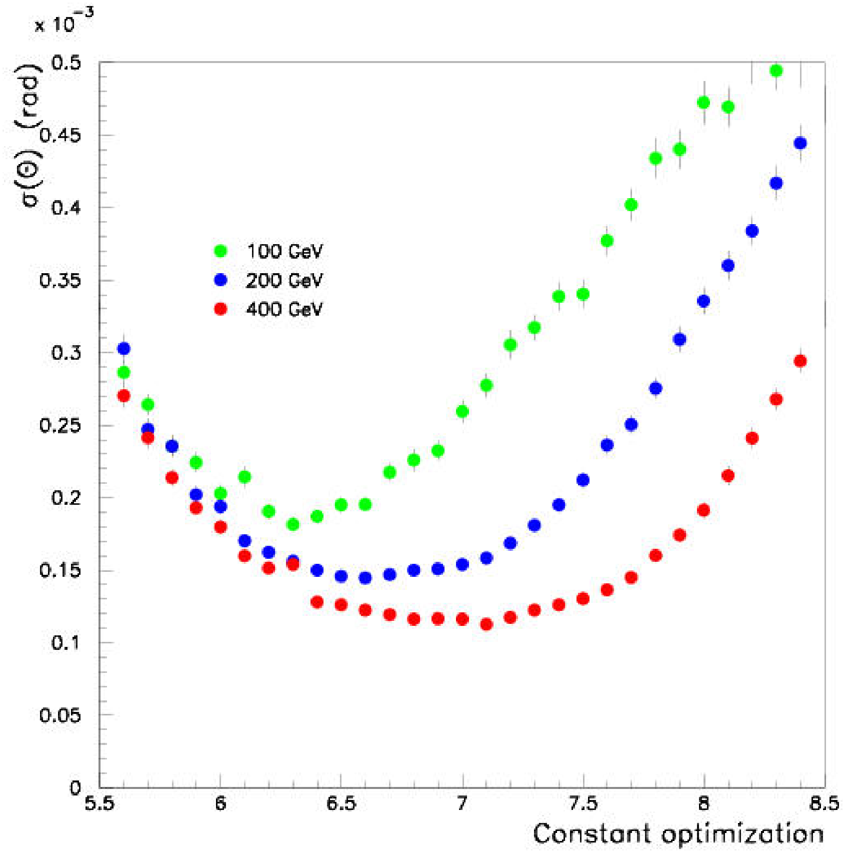
In real life we can include the detector performance (which is measured in test beam) into MC. The only question is: **How well should we know the detector performance ?**





Logarithmic Weighting



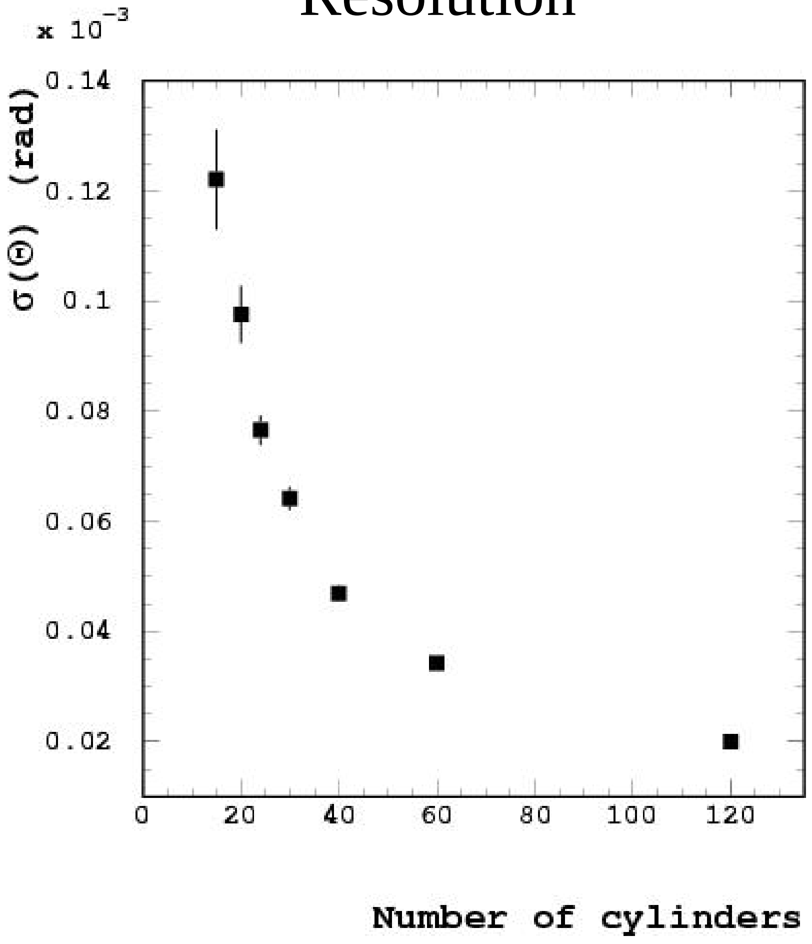


$$W_i = \max\{0, [const(E_{cell}) + \ln(\frac{E_i}{E_T})]\}$$

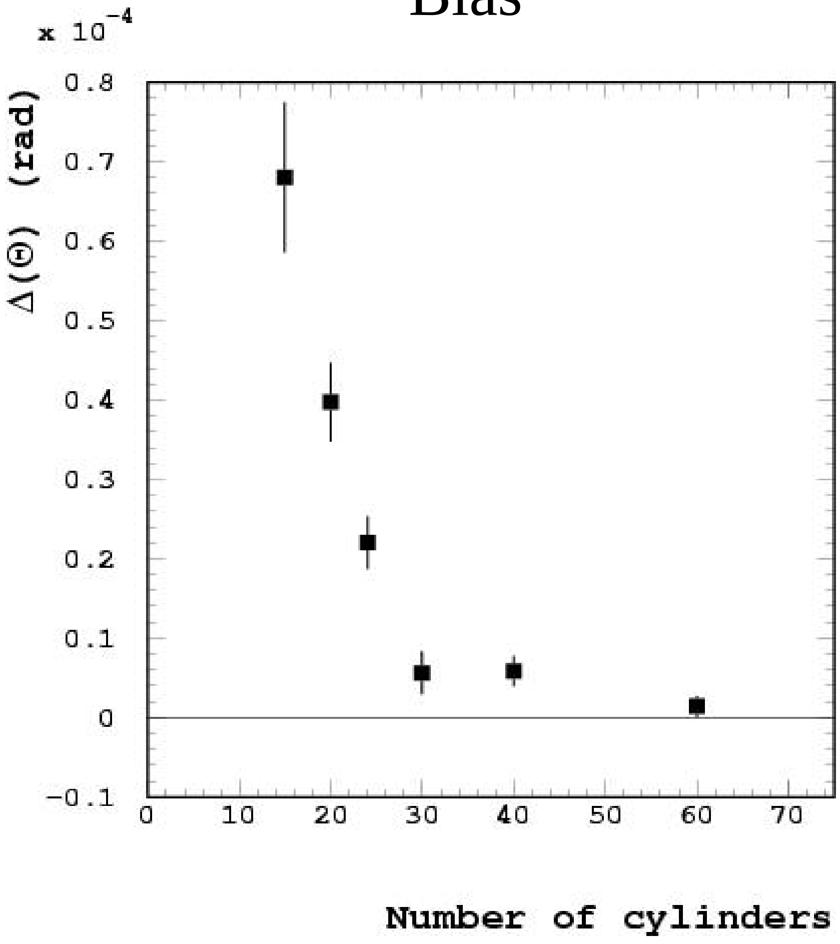
$$W_i = \max\{0, [const(E_{beam}) + \ln(\frac{E_i}{E_T})]\}$$

Granularity in theta, GEANT results

Resolution



Bias

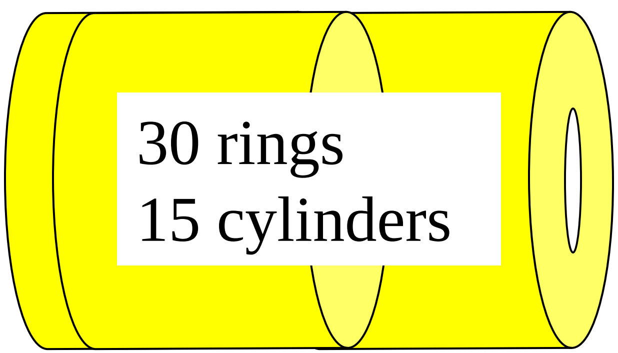


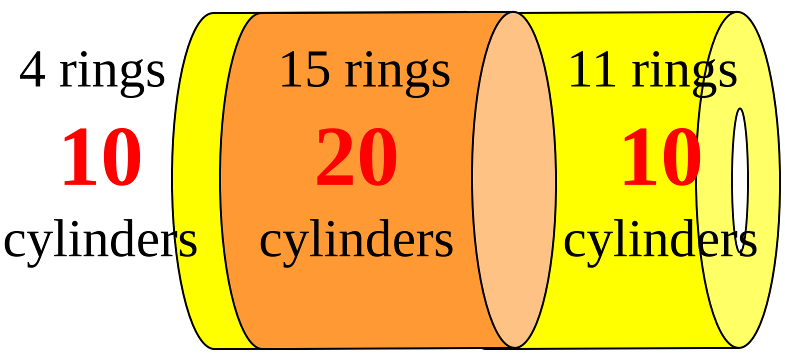
Maximum Peak Shower Design

Our basic detector is designed with

30 rings * **24** sectors * **15** cylinders = **10,800** channels

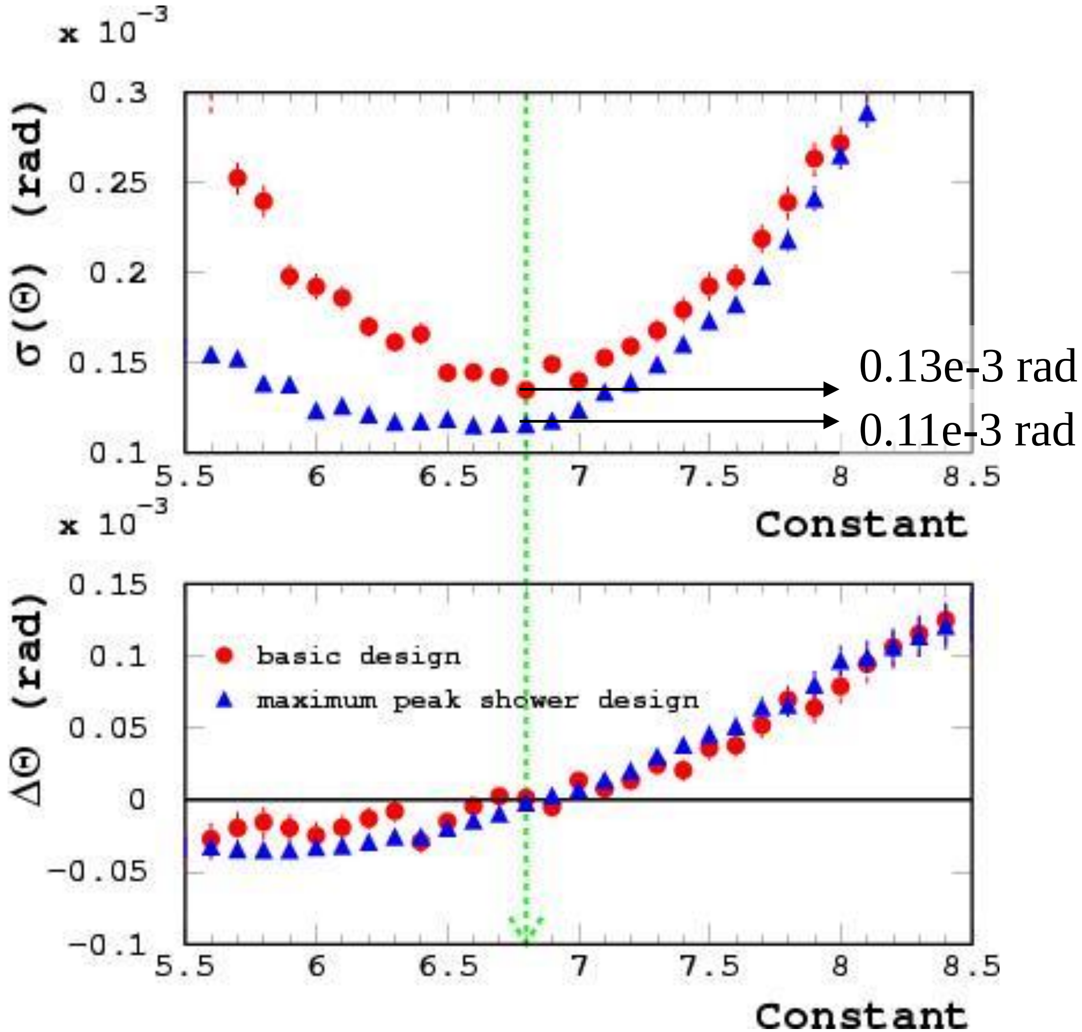
Do we use these channels in the most effective way ?





24 sectors * **15** rings * (10 cylinders + 20 cylinders) = **10,800** channels

Polar Reconstruction



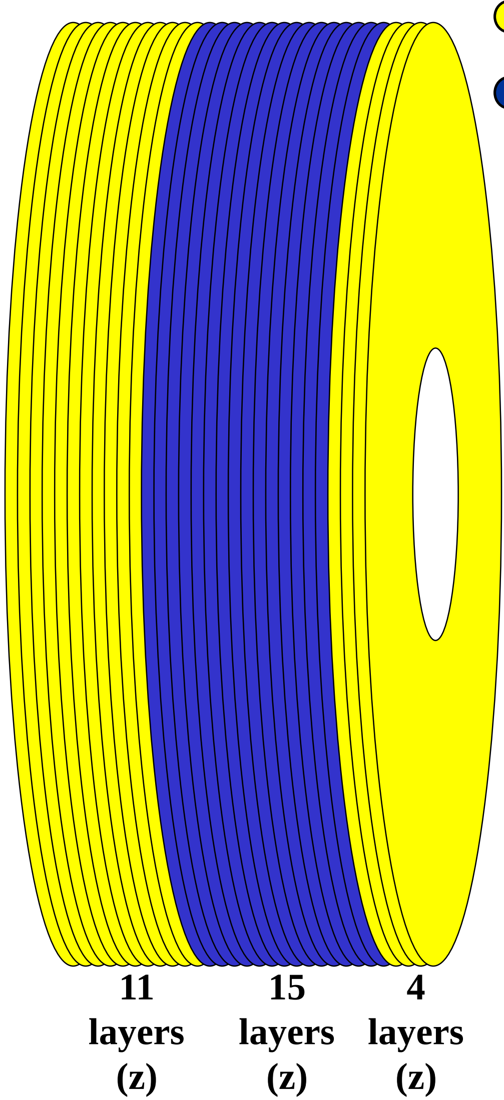
Maximum peak shower design

Basic Design

Angular resolution improvement without changing the number of channels

Other properties remain the same

Present Understanding (pad option)



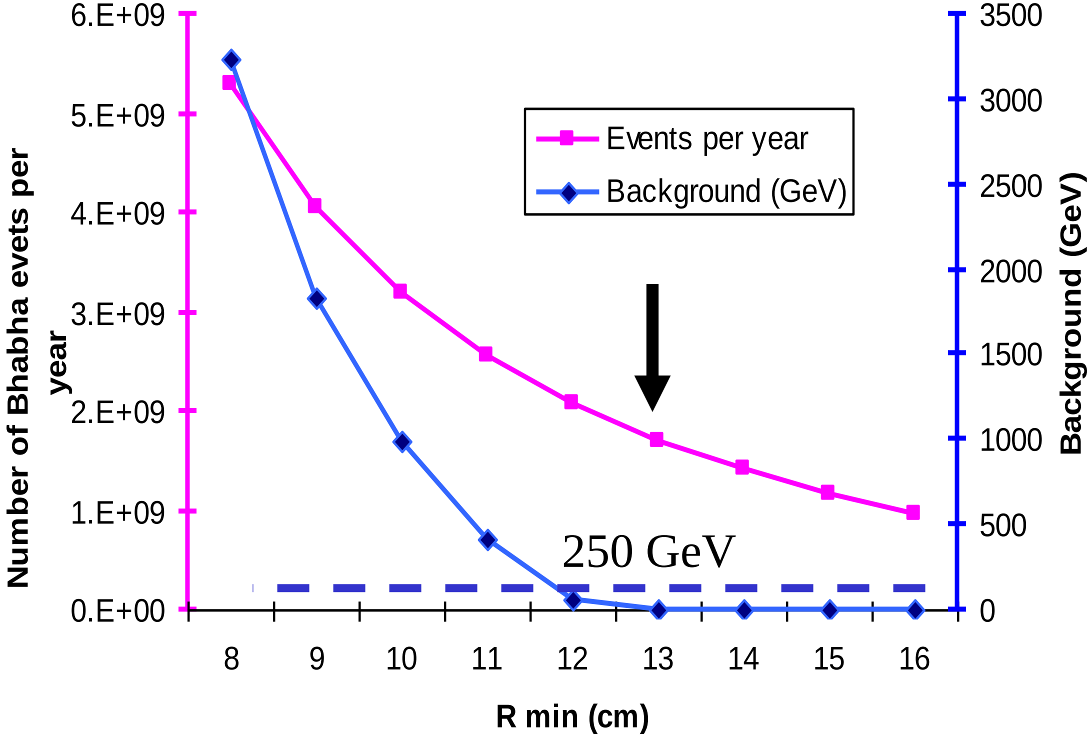
- (yellow) 10 cylinders (θ)
- (blue) 60 cylinders (θ)

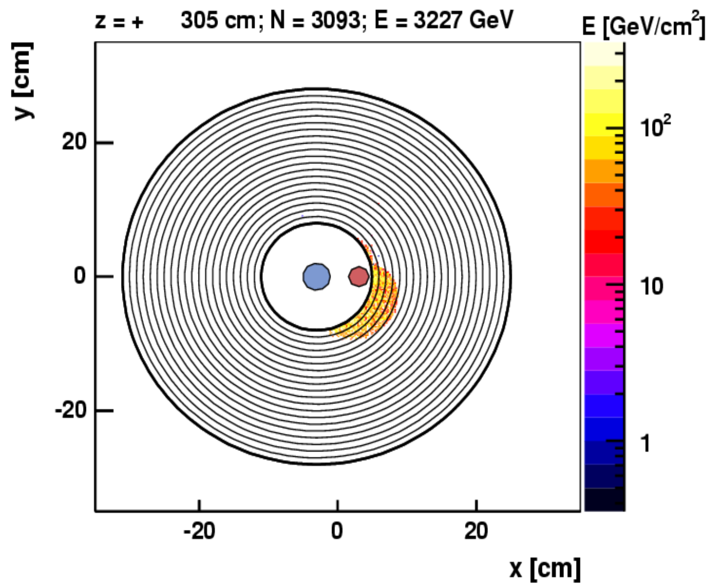
Based on optimizing theta measurement

Parameter	Opal	LumiCal
Distance from the IP	±2.5 m	±3.05 m
Sampling layers	19	30
Cylinders	32	60 (middle layers), 10 (first and last layers)
Sectors	32	24
Pitch in r (mm)	2.5	3.3 (middle layers), 20 (first and last layers)
Pitch in θ (rad)	0.001	0.001 (middle layers), 0.006 (first and last layers)
Pitch in ϕ (deg)	11.25	15
Pitch in z	1 X_0 2 X_0 (last 4 layers)	1 X_0
r_{min} (mm)	62	80
r_{max} (mm)	142	280
θ_{min} (mrad)	25	26
θ_{max} (mrad)	57	91
$Z_{max} - Z_{min}$ (cm)	14	20
Electronics channels in one detector arm	19,456	25,200

X- angle background

Beamstrahlung pair background





Christian Grah, DESY-Zuethen

Method of counting events

Maximum peak shower design and logarithmic weighting : working with a constant (Beam energy and cells size dependents) + applying differential weighting between the parts.

Applying tight acceptance cut on one detector arm.

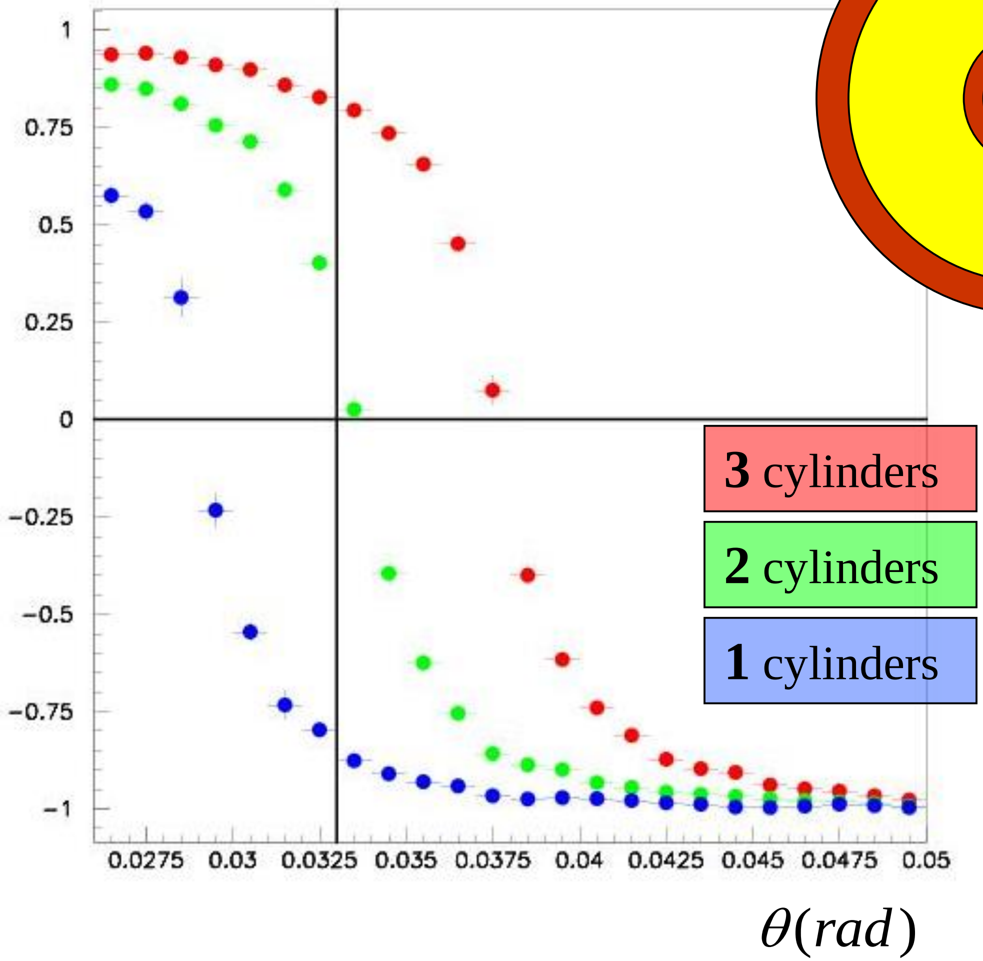
Applying a looser acceptance cut on the second detector arm.

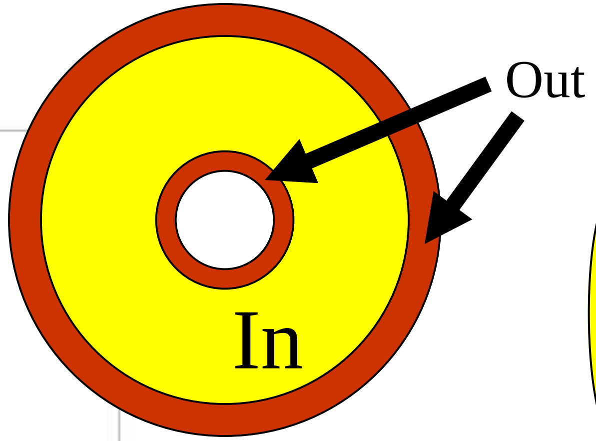
Count events which satisfy the back to back requirement using a band cut.

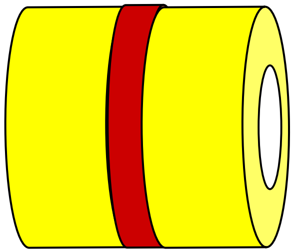
Repeat method for the other side of the detector and compare results.

Tight cut

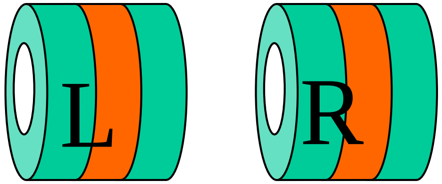
$$P = \frac{Eout-Ein}{Eout+Ein}$$

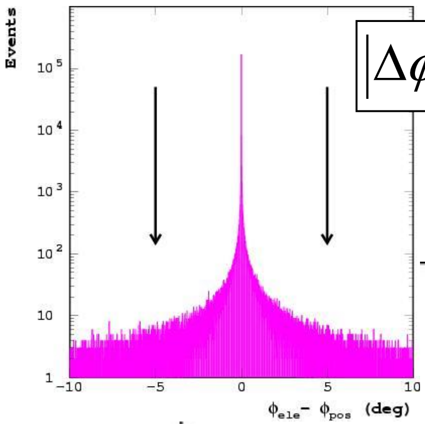




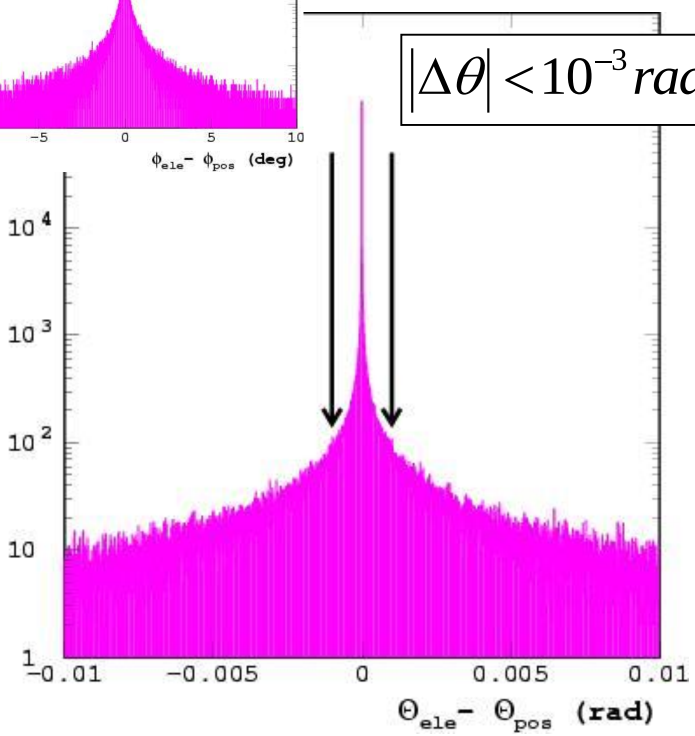


Forward-Backward Balance



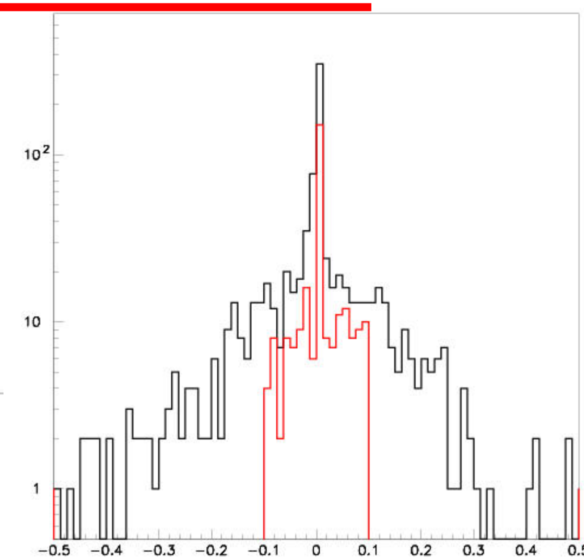


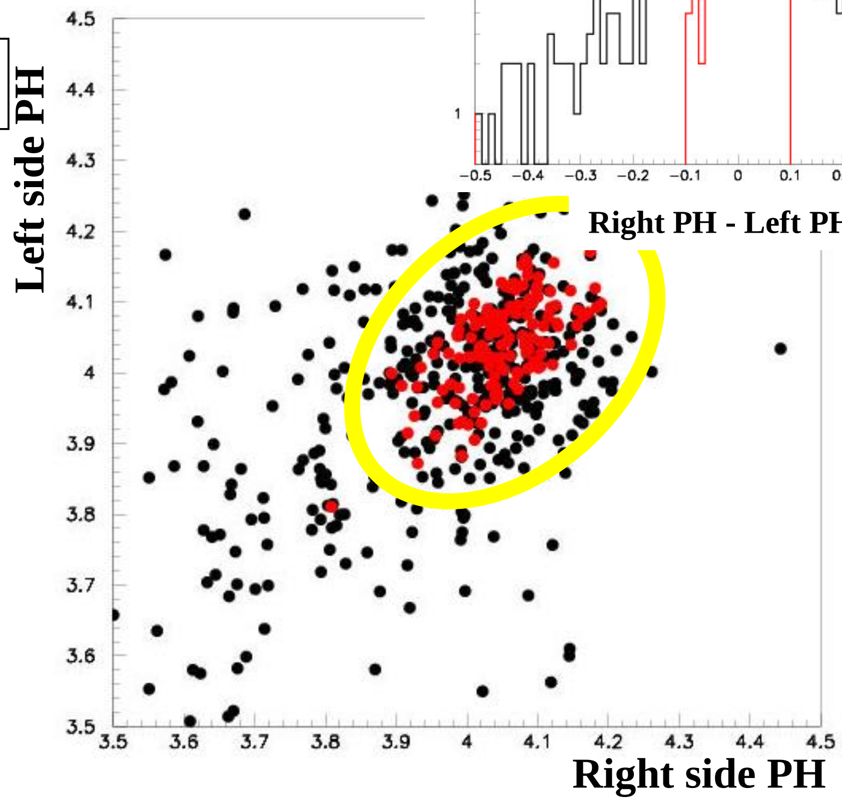
$|\Delta\phi| < 5\,\deg$



$|\Delta\theta| < 10^{-3}\,rad$

- Simulation distribution
- Distribution after acceptance and energy balance selection





Performance of present configuration

Parameter	Pad Performance
Energy resolution	25%
θ resolution	$3.5 * 10^{-5}$ (rad)
ϕ resolution	0.63 (deg)
$\Delta\theta$	$\sim 1.5 * 10^{-6}$ (rad)
Electronics channels	25,200 ~19,000 (X-angle)

With this performance the $\Delta L / L = 10^{-4}$ goal can be reached.

Next (and immediate) steps

Taking the present understanding design as a basis design for future simulation.

Understanding the criteria for identifying and selecting Bhabha event (maybe better detector resolutions are necessary).

Testing the crossing angle recommendation design in a crossing angle Bhabha scattering simulation which includes serpentine magnetic field.