Improved Luminosity Measurement in L_3

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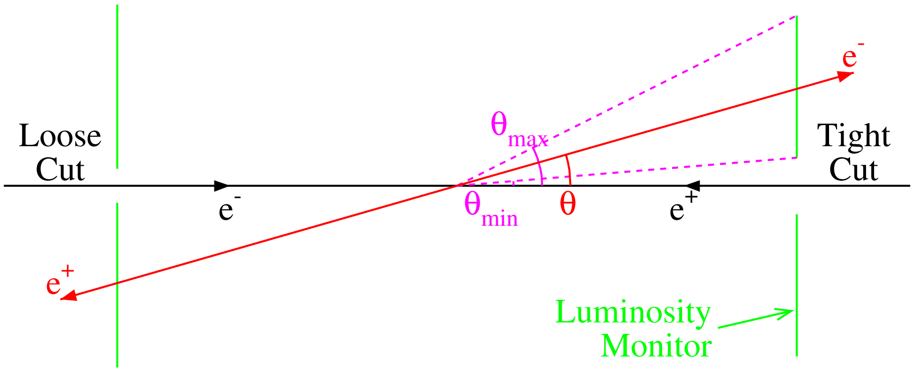
- Introduction
- The L_3 Silicon LUminosity Monitor (SLUM)
- Event Selection
- Geometrical Alignment
- Luminosity and Systematic Errors
- Hadronic Z Lineshape

Luminosity Measurement:



$$\sigma_{\text{bhabha}} \propto \frac{1}{\vartheta^2_{\min}} - \frac{1}{\vartheta^2_{\max}}$$

- **Define a precisely known fiducial volume**
- **Detect all Bhabhas inside the volume**

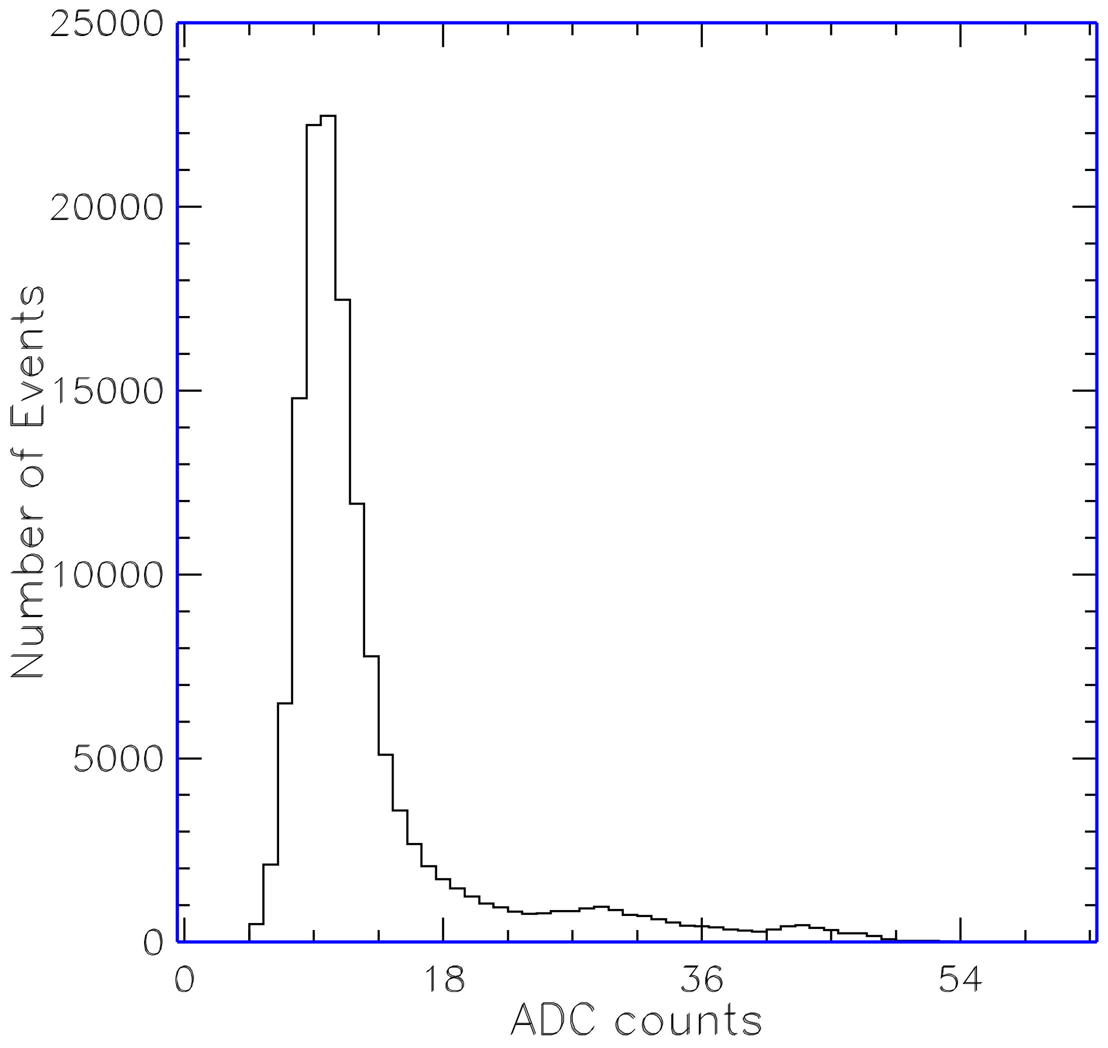
Silicon Detector Characteristics:

- **Very sharp boundaries between strips: 1-2 μm**
- **Precise geometry: $<$30 μm**
- **Fine granularity: 0.5 mm radial strips**
- **Planar detector: easy $R \rightarrow \vartheta$ conversion**

Run Summary:

- SLUM was installed in 1992-1993 shutdown
- Succesfully operated the whole year
- Collected 3 million Bhabhas $\Rightarrow \mathcal{L} = 33\mathrm{pb}^{-1}$

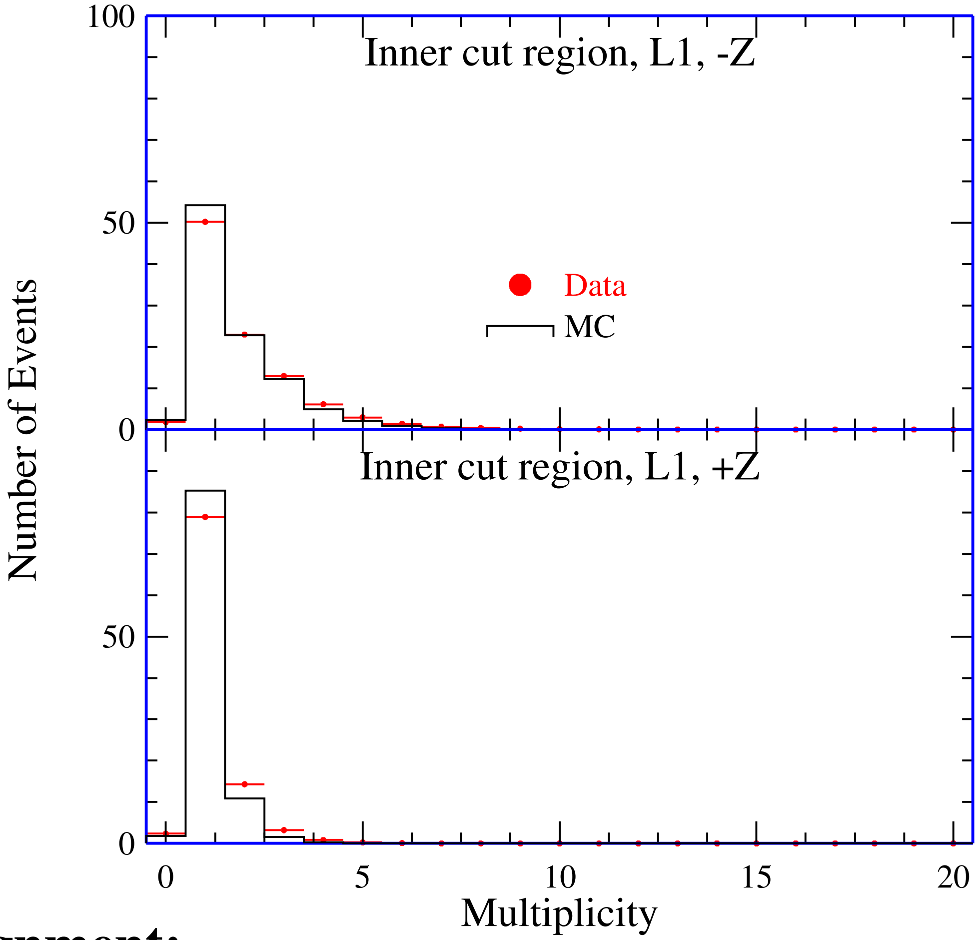
Average pulse height spectrum



Signal over noise ratio: $\Rightarrow S/N = 10/0.7 = 14$

Silicon Multiplicity

Multiplicity distribution on +Z and -Z



Hit assignment:

- **If $N_{sil} = 0$: Use the BGO information**
- **If $N_{sil} = 1$: Use the silicon strip hit**
- **If $N_{sil} > 1$:**
  - **average**
  - **random assignement**
  - **multiple hit algorithm (under study)**

$\Rightarrow$ Introduce no biases!

Event Selection:

- **Energy requirement:**

$$E_1 > 0.8 \cdot E_{\mathrm{beam}}$$
$$E_2 > 0.4 \cdot E_{\mathrm{beam}}$$

- **Window Requirement:**
  Form a window around the BGO cluster:

$$\Delta R = \pm 5 \text{ mm}$$
$$\Delta\phi = \pm 2.5^o$$

- **Asymmetric fiducial volume cut:**

$$32 \text{ mrad} < \vartheta < 54 \text{ mrad}$$
$$|\phi - 90^o| > 11.25^o \text{ and } |\phi - 270^o| > 11.25^o$$

  No cut on other side.

- **Coplanarity requirement:**

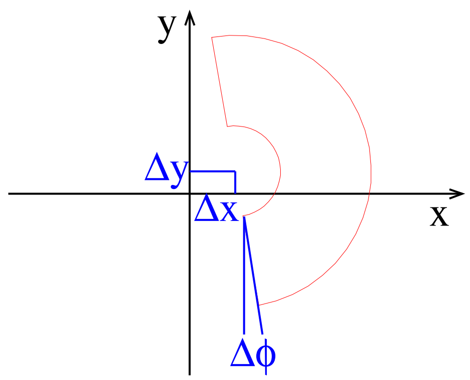
$$|\Delta\phi - 180^o| < 10^o$$

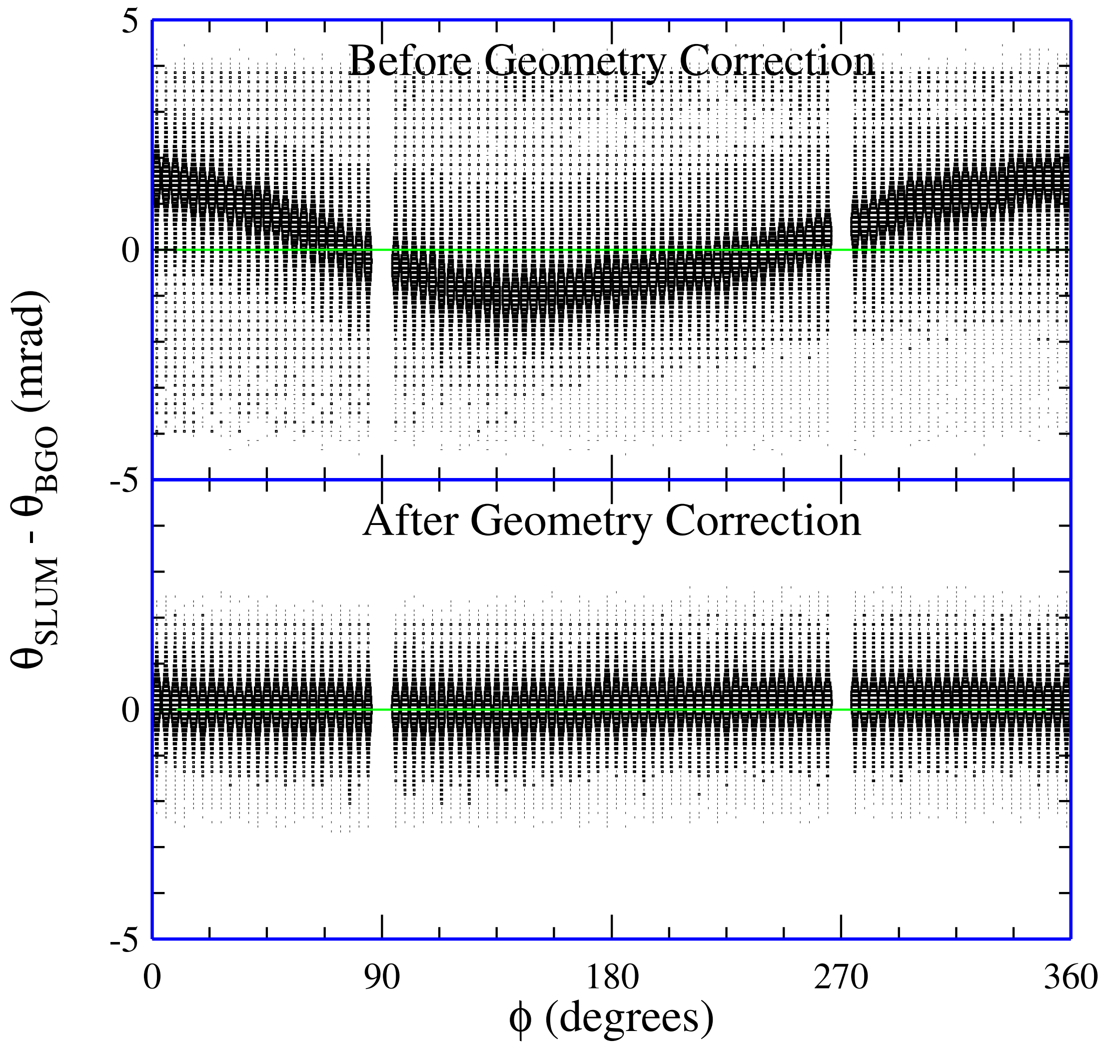
Luminosity:

$$\mathcal{L} = \frac{1}{2}\frac{N_{-z} + N_{+z}}{\sigma_{\mathrm{bhabha}}}$$

Aligning BGO and SLUM

Fit the position of each BGO half detector with respect to SLUM

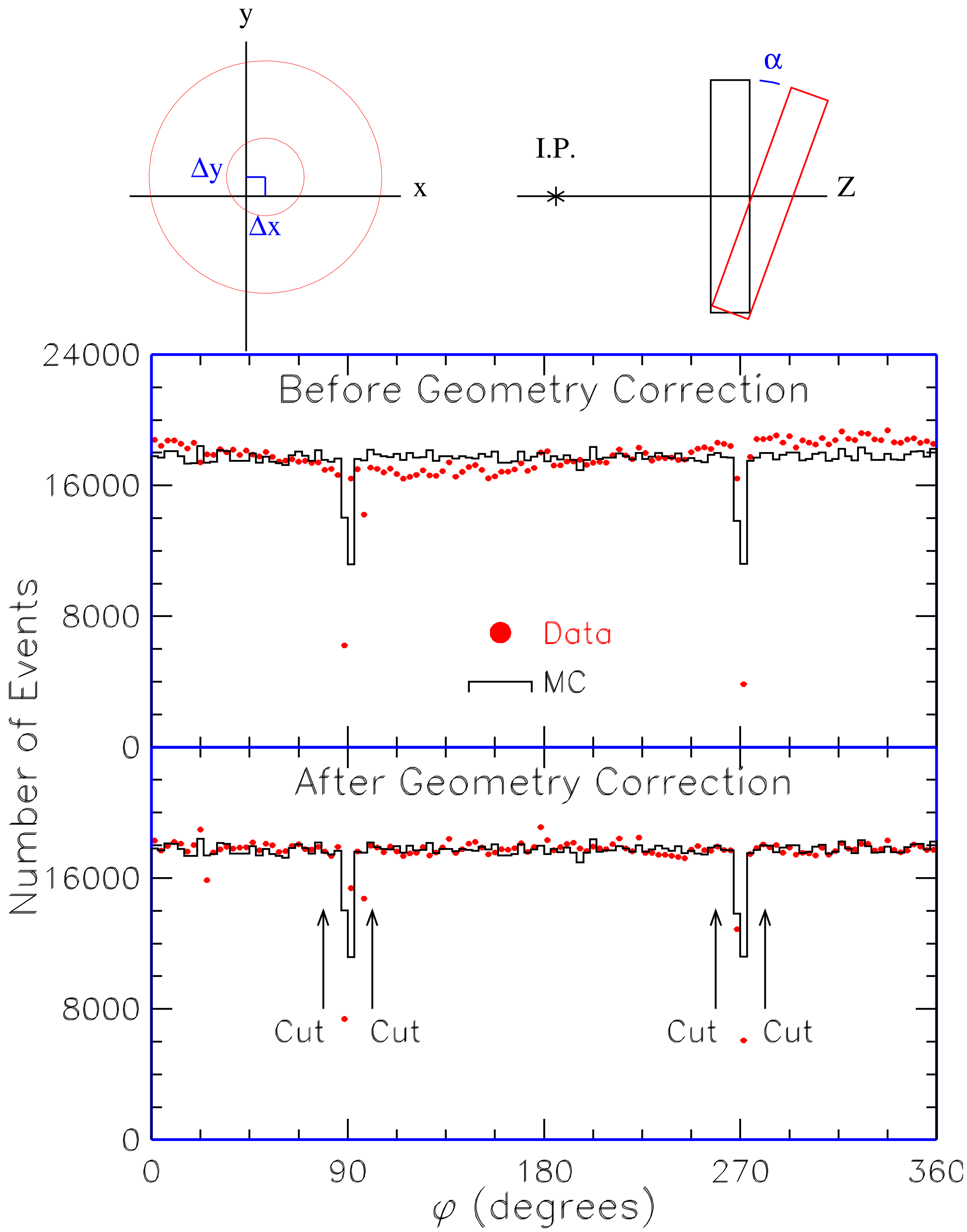




⇒ Precision Δx, Δy, $\Delta\phi \approx$ 0.1 mm

Aligning to the beam axis

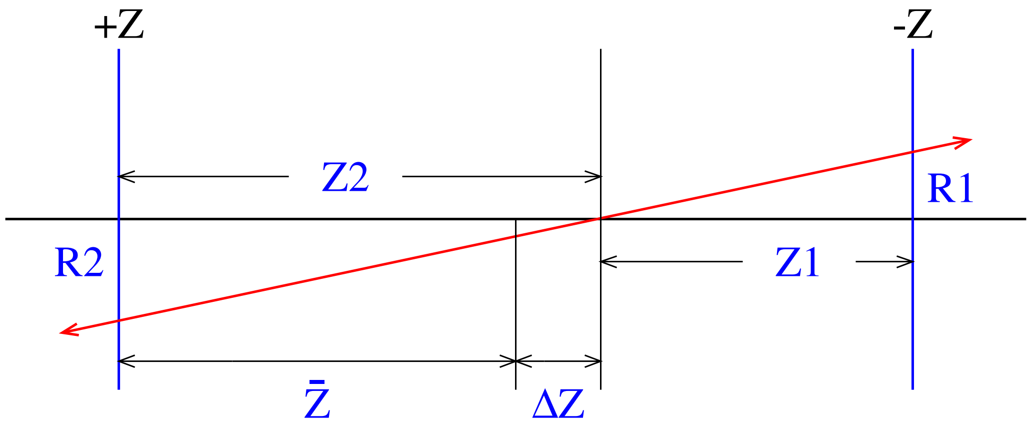
Fit the SLUM position and rotation with respect to beam



⇒ Precision Δx, Δy, α_x, $\alpha_y \approx 0.1$ mm

The position along the beam

Fit the z-position of the detectors

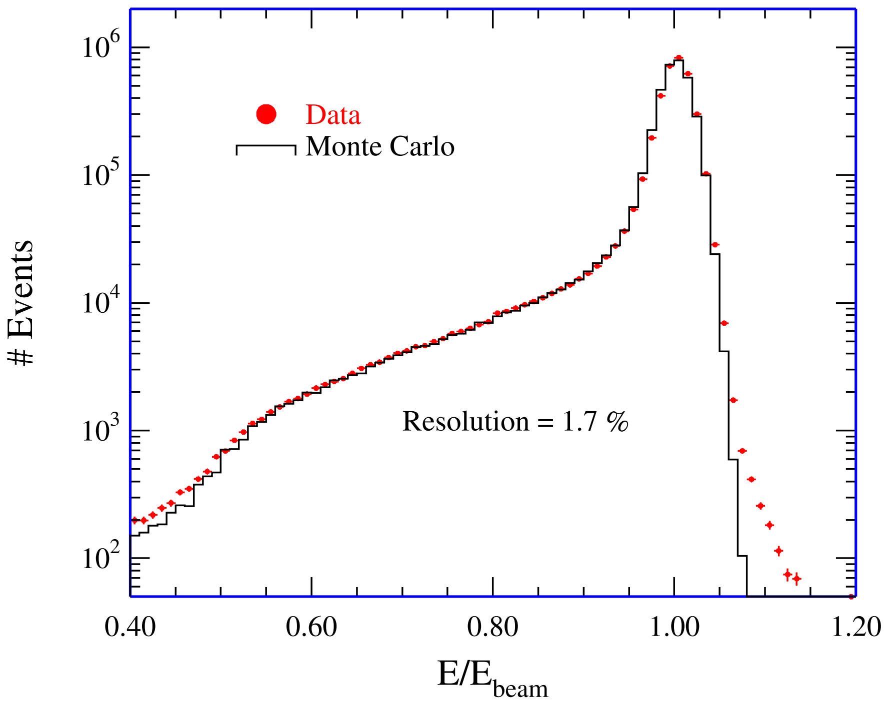


$$\Delta_Z = \frac{R1 - R2}{R1 + R2} \cdot \overline{Z}$$

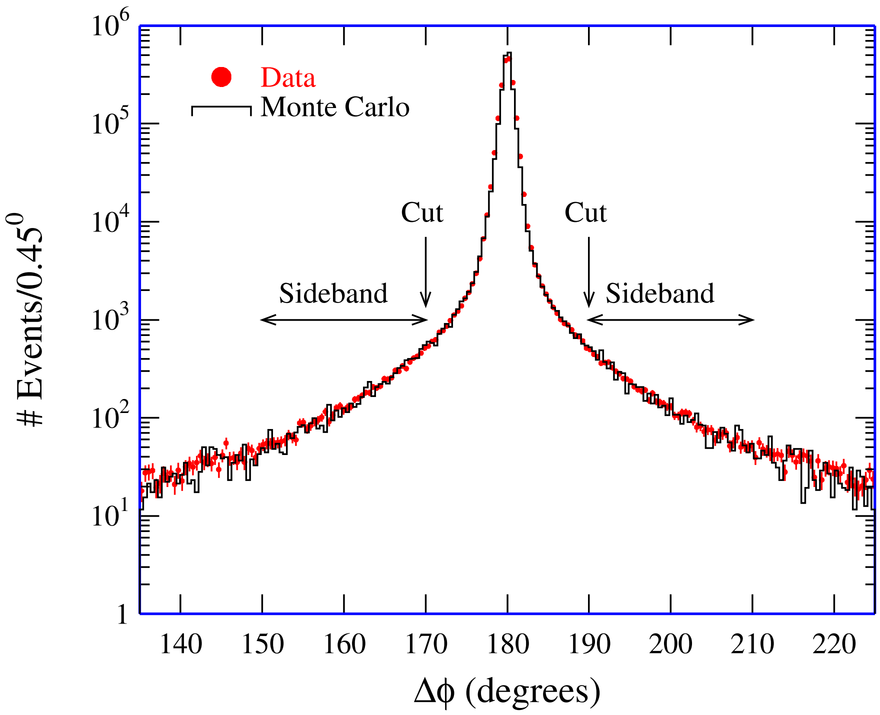
- **Survey gives the total distance between the detectors at +z and -z.**
  $\Rightarrow$ z-dist = 5301.5 mm $\pm$ 1.6mm
- **Fit the relative Z-position of the vertex using the back-to-back Bhabha events.**
  $\Rightarrow$ Δ_z = -2.5 mm $\pm$ 0.2 mm

Distributions

Energy distribution

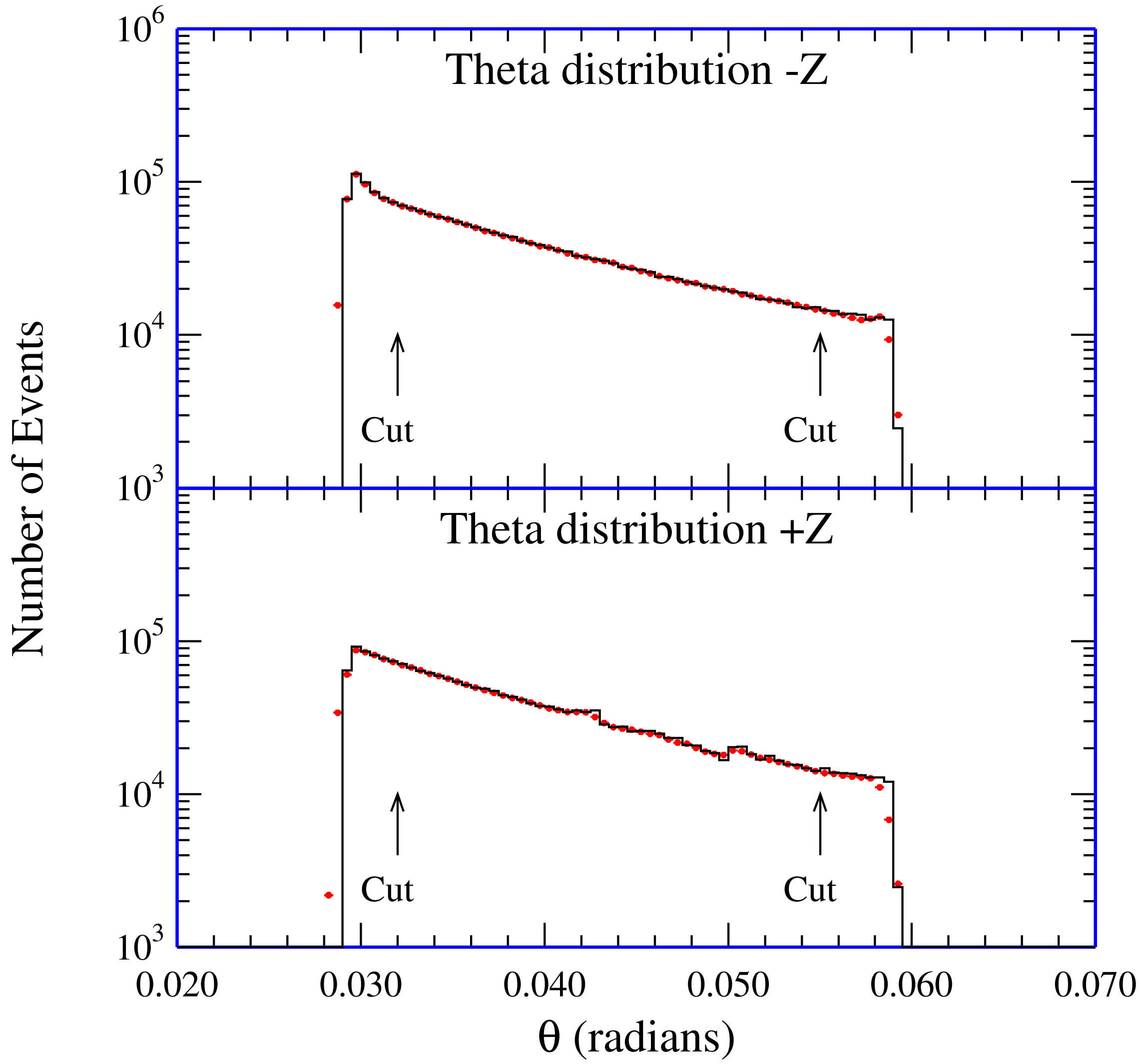


Acoplanarity distribution



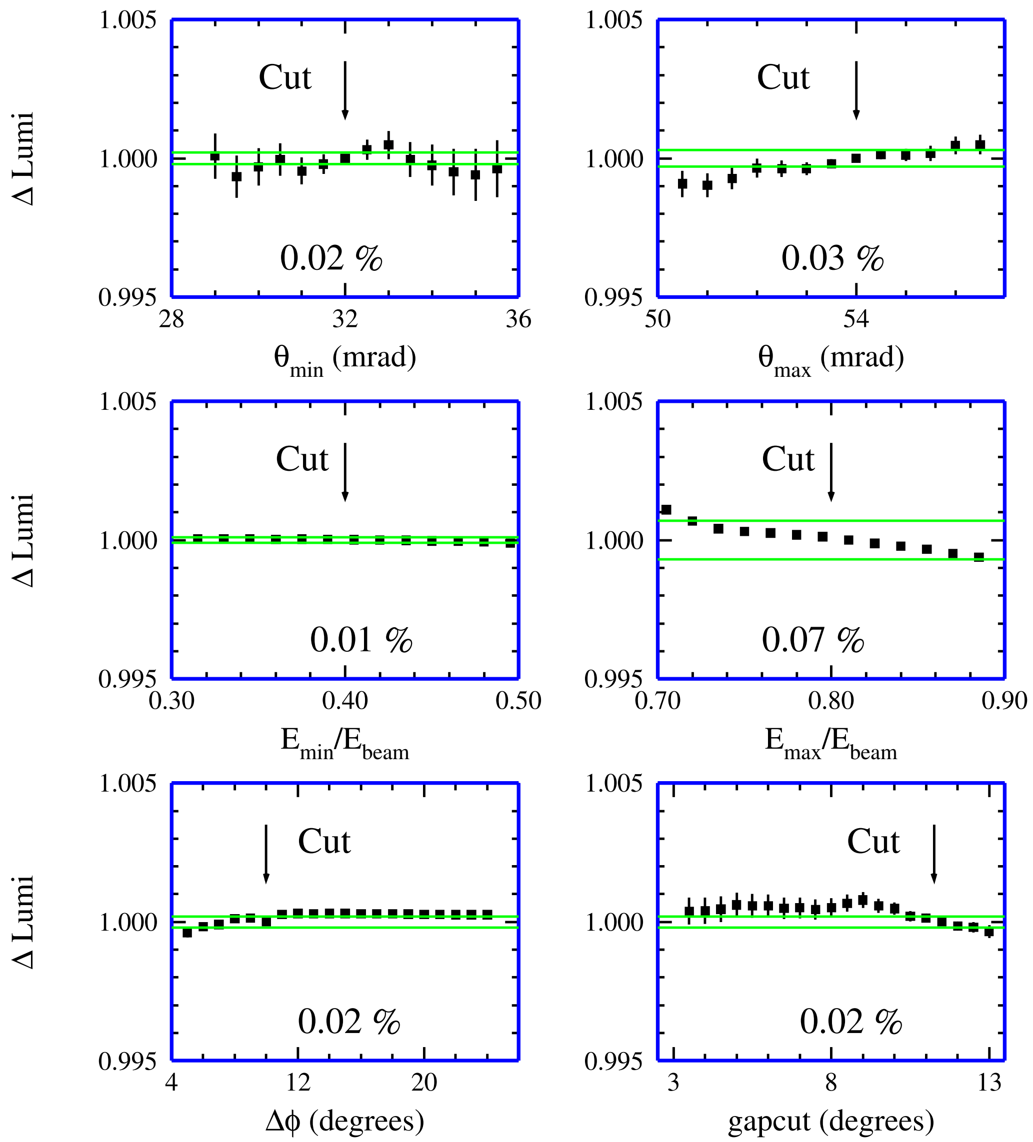
Event Selection

Polar angle distribution



Event selection systematics

Change in Lumi as function of cut parameters:



Total event selection error: $\Delta\mathcal{L} = 0.09\%$

Systematic Errors

Geometry:

Survey precision	6 μm	$\Rightarrow$0.015 %
Wafer to wafer RMS	7 μm	$\Rightarrow$0.017 %
Temperature effects	10 μm	$\Rightarrow$0.024 %
Z-distance	1.6 mm	$\Rightarrow$0.060 %
Total geometry		$\Rightarrow$ 0.07 %

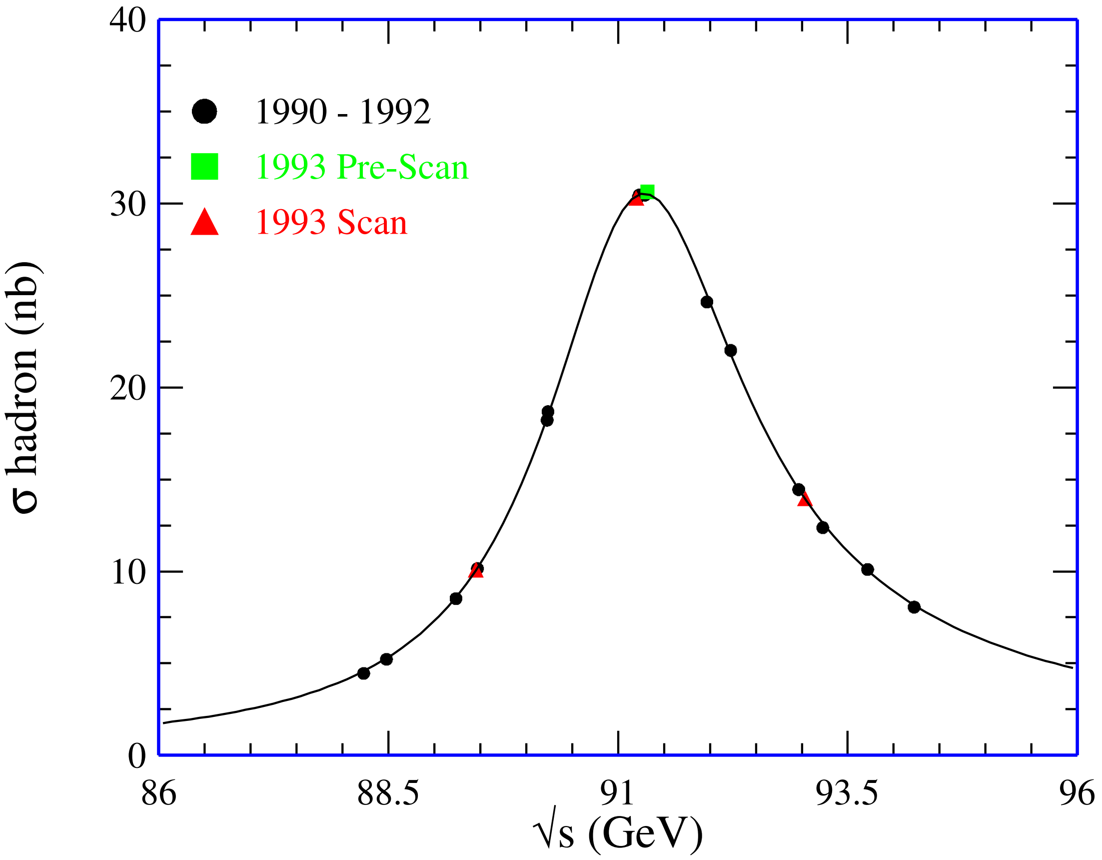
Total Systematic Error:

Source	BGO Error (%)	SLUM Error (%)
Trigger	Negligible	Negligible
Event Selection	0.3	0.09
Background Subt.	Negligible	Negligible
Geometry	0.4	0.07
Total Exp	0.5	0.12
MC Statistics	0.10	0.10
Theory	0.25	0.25
Total	0.6	0.30

Statistical Error 1993 = 0.06 %

Hadronic Z Lineshape

Hadron cross section:



L_3 (1990 - 1992) data:

$$\sigma^0_{\mathrm{had}} = 41.42 \pm 0.26 \text{ nb}$$

L_3 (1990 - 1993) data (Preliminary):

$$\sigma^0_{\mathrm{had}} = 41.41 \pm 0.15 \text{ nb}$$

Summary

- **SLUM has been running reliably all through 1993: Collected $3 \cdot 10^6$ Bhabhas**
- **The geometry of the detector was measured before and after the run and agreement within survey precision was found.**
- **The experimental systematic error has been reduced from 0.5 % (BGO) to 0.12 % (SLUM)**
  (The design precision was 0.2%)
- **Present limiting factor on luminosity precision is systematic error assigned to theory.**
- **The better luminosity measurement substantially improves the precision on N_ν measurement**