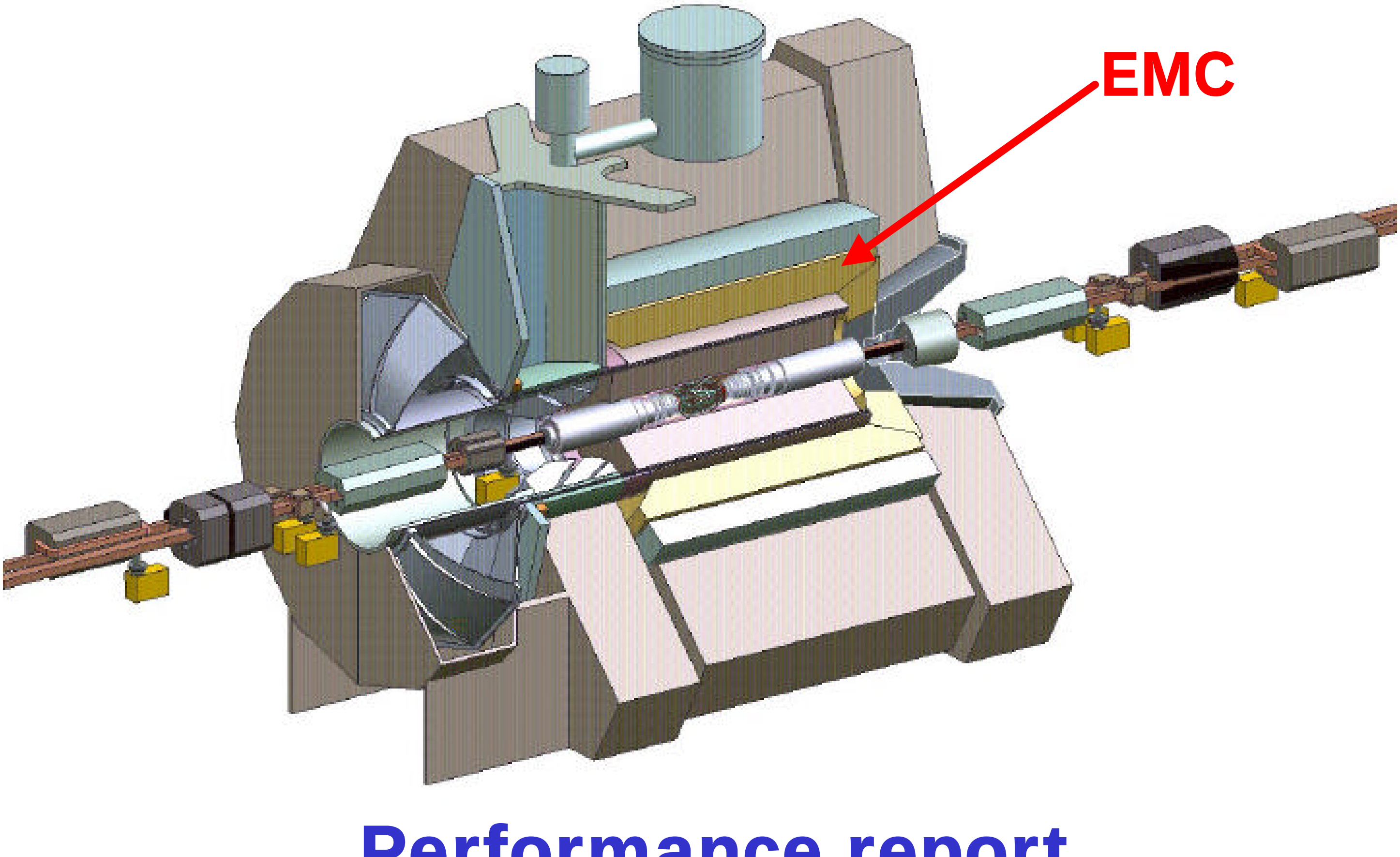
The BaBar Electromagnetic Calorimeter



Performance report

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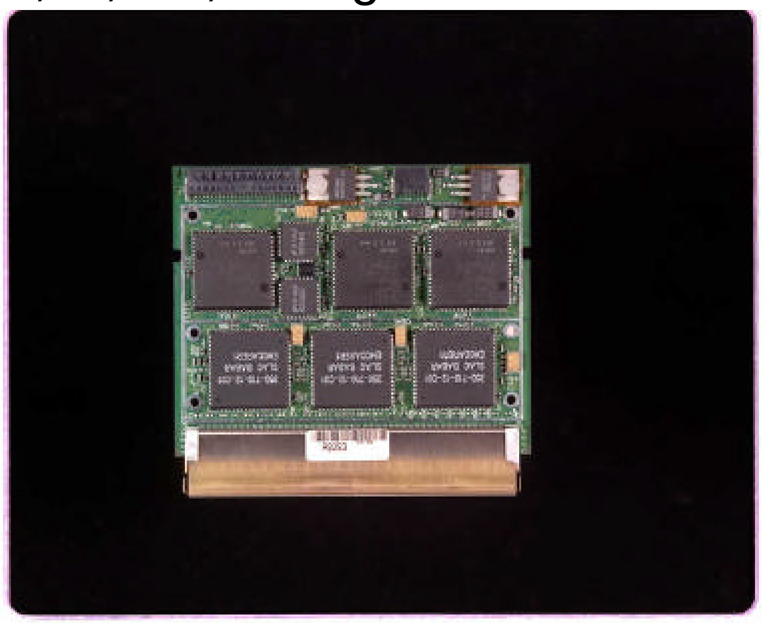
Requirements

- Physics:
  - Photons [20

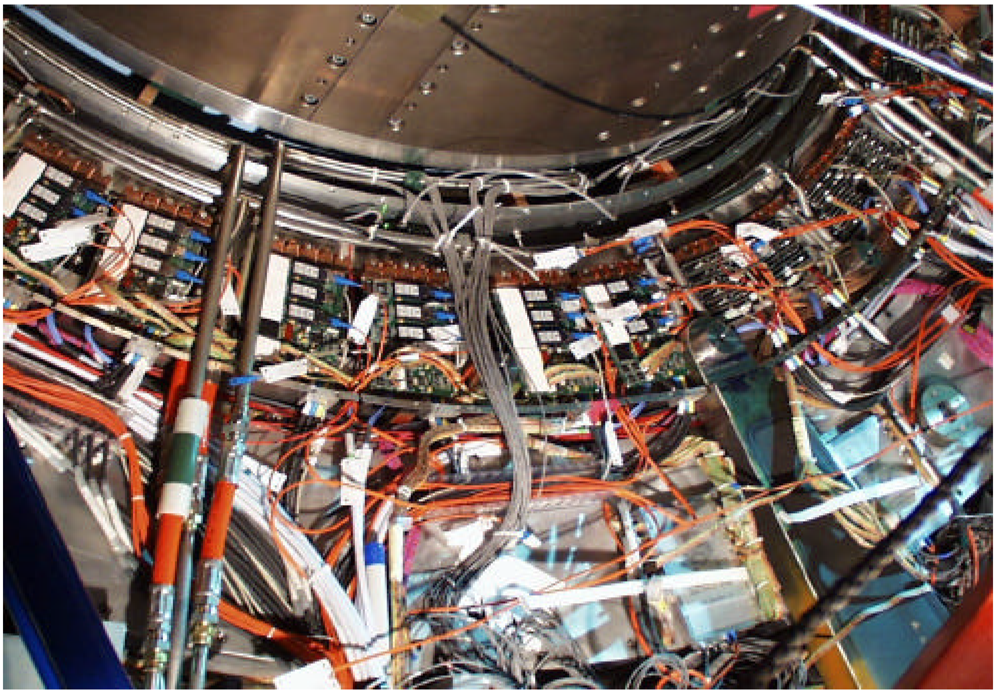
Readout Electronics

- 2 Photodiodes / crystal -> averaging
  - Hamamatsu S-2744-08: 2x1 cm2
  - Quantum Efficiency = 70%
- Need 18 bit dynamic range
  - Preamplifiers
    - **2 gains**
    - **0.4 μs shaping time (limit beam bkg)**
  - ADC board: 2 gains + 10 bits (mantissa)
    4 MHz ADC
    - x1,x4,x32,x256 gains

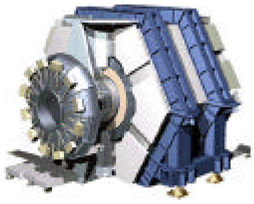


Picture Gallery

Crystals Installation



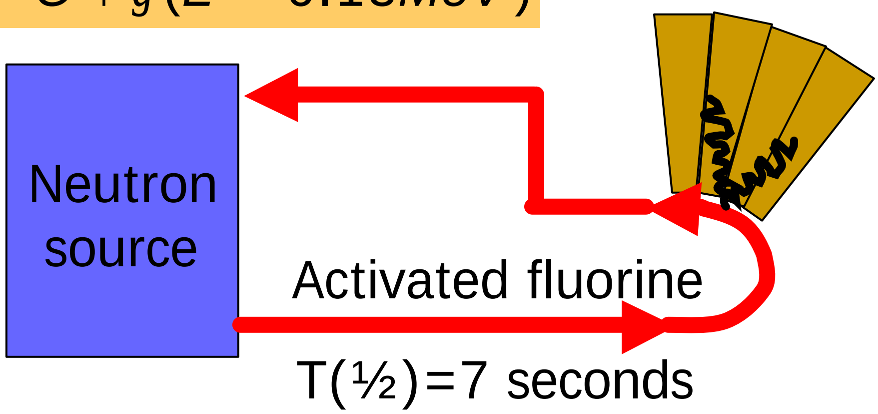
Front End Electronics
560 ADC boards
100 I/O boards

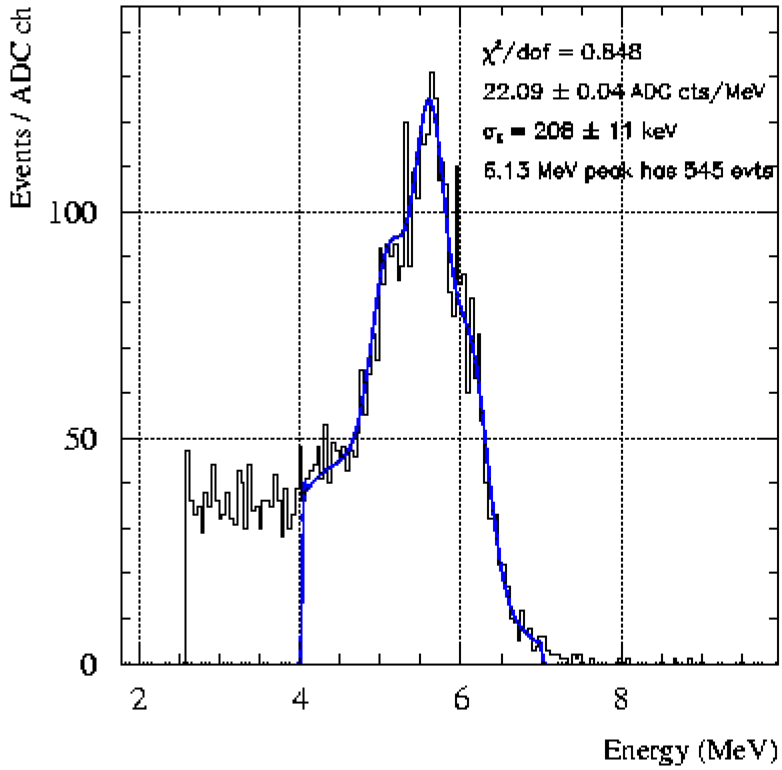


Radioactive Source Calibration

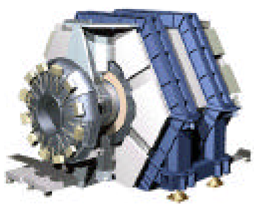
- **Single Crystal Calibration**

$$^{16}N \rightarrow {}^{16}O^{*} + b \rightarrow {}^{16}O + g\,(E = 6.13 MeV)$$

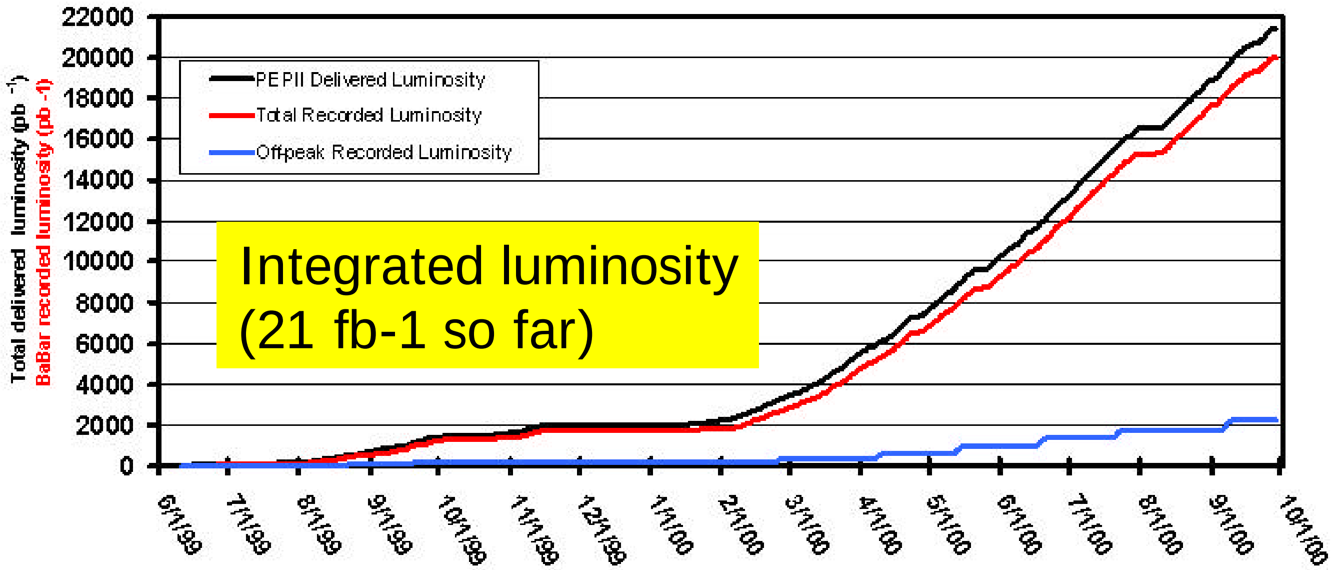


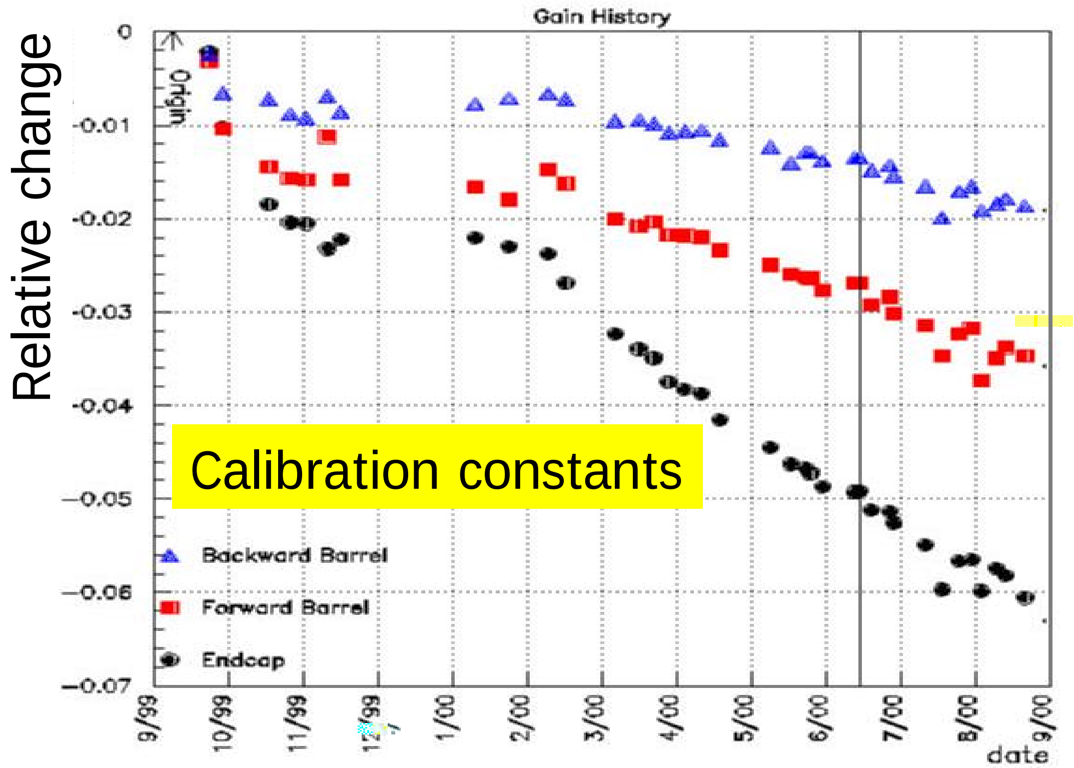


Accuracy:
0.35% / crystal
for a 30 min run



Radioactive Source Calibration



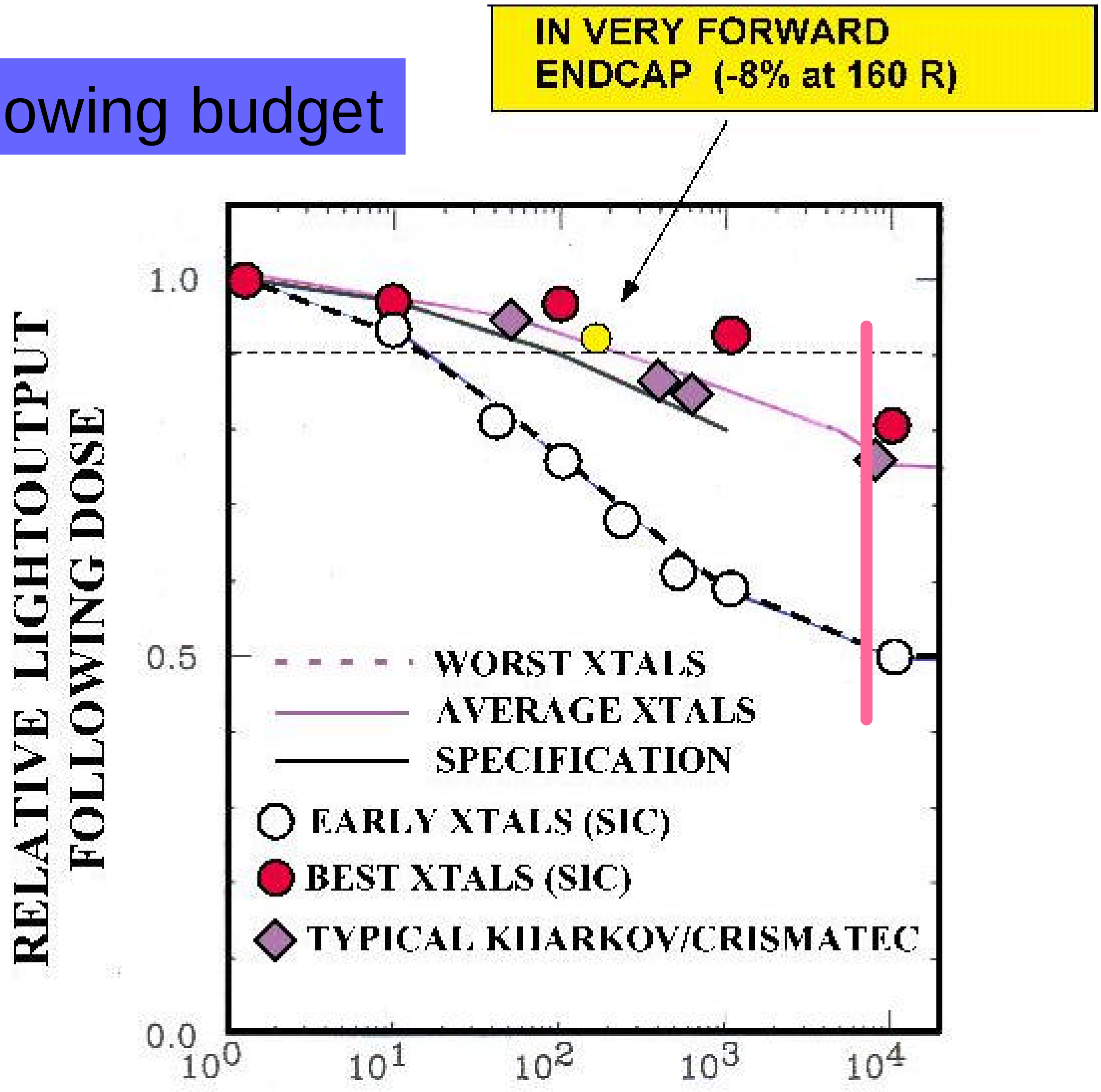


(Matt Weaver, Alex Olivas, Johannes Bauer)

Radiation Damage

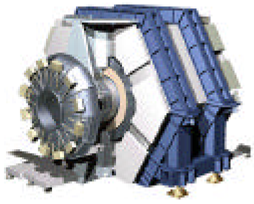
- Endcap dose so far = 160 Rad

Following budget



No uniformity problems

(Rafe Schindler)



BhaBha Calibration

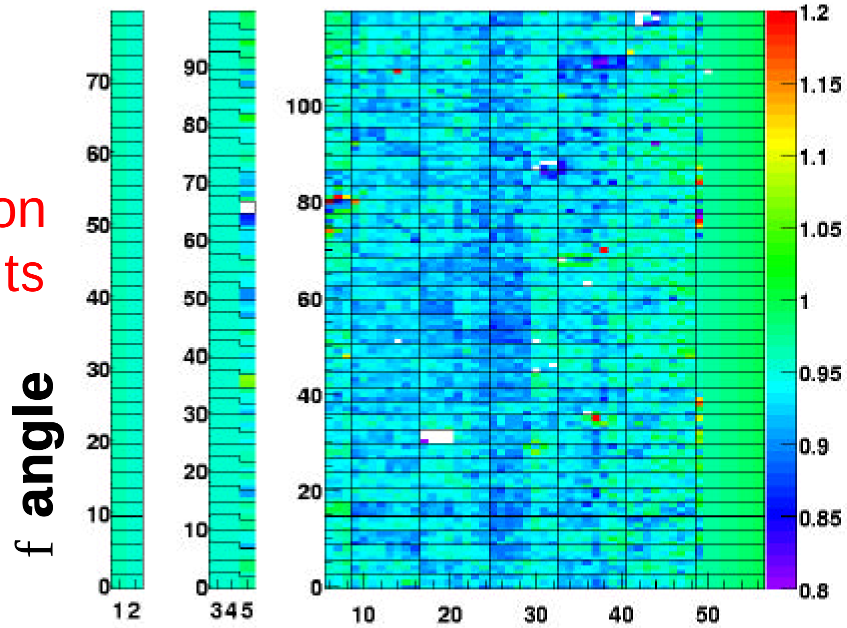
(Ralph Mueller-Pfefferkorn)

- High Energy calibration point

$$c^2 = \sum_k \sum_i (C_i e_i^k - E^k) / (s^k)^2$$

  – E(expected) = f(cosθ) + leakage corrections
  – Accumulate events and solve EQ by matrix inversion
  – 12H of data -> 200 hits /crystal -> 0.4 % stat error

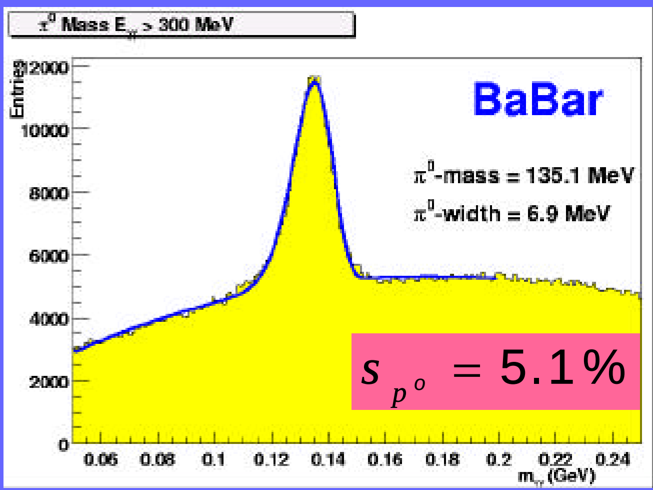
Calibration constants

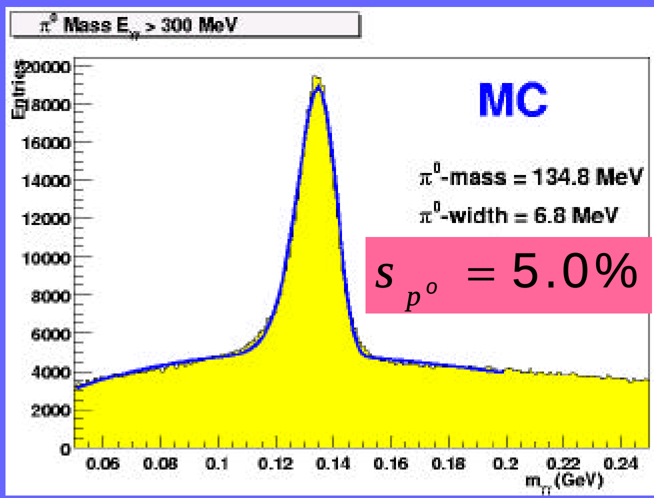


- Connecting the high and low points:

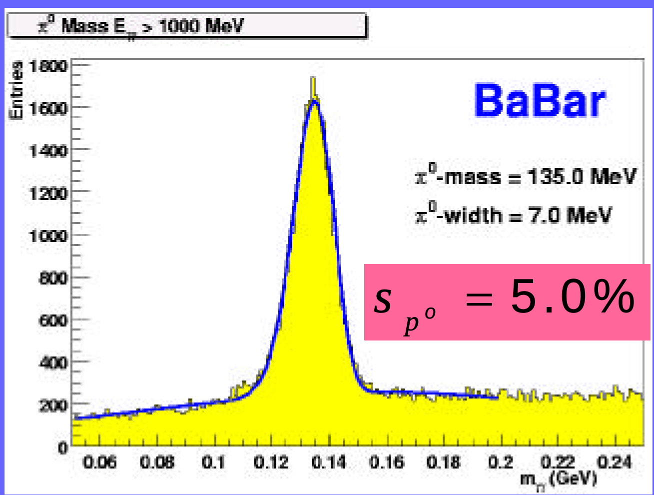
$$E_i^{cal} = E_i \times \left(\frac{\ln(E_i) - \ln(6.13)}{\ln(E^{BhaBha}) - \ln(6.13)} \times \left(C_i^{BhaBha} - C_i^{source}\right) + C_i^{source} \right)$$

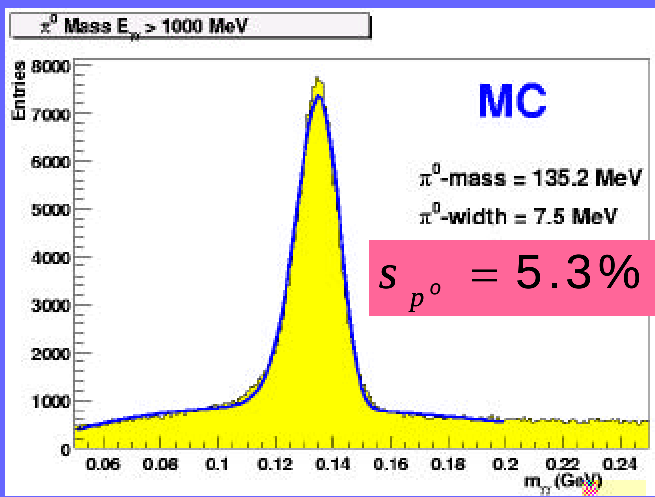
Performance: Pi0's





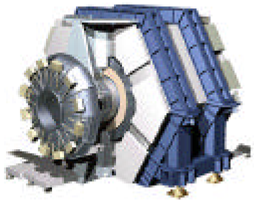
E(gg) > 300 MeV





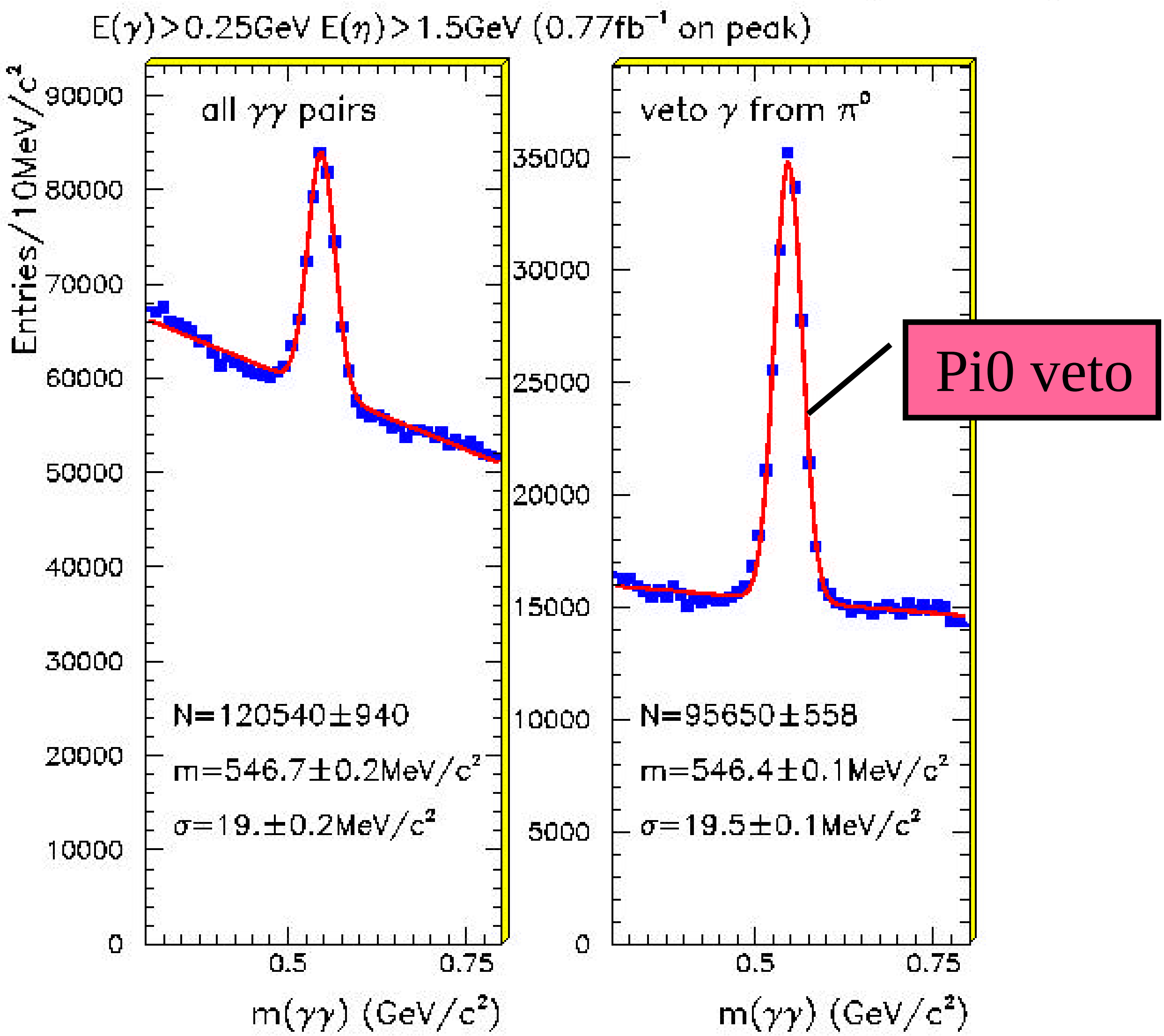
E(gg) > 1 GeV

- Simulation includes detailed electronics noise and real beam background mixing

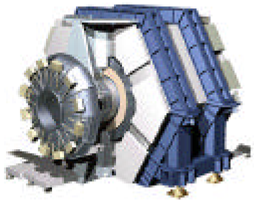


Performance: h

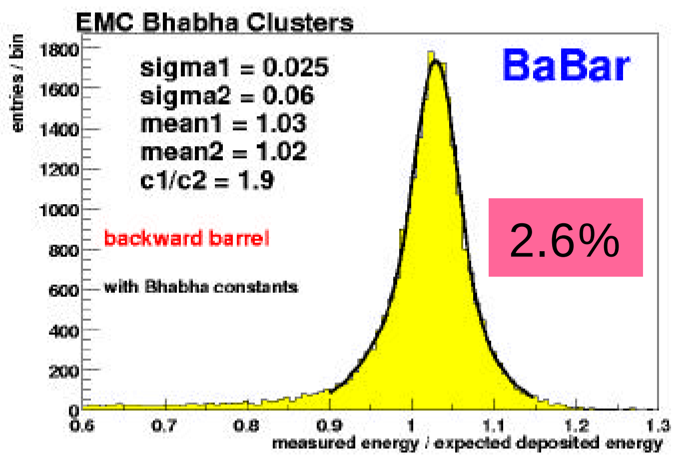
(J.P. Lees)

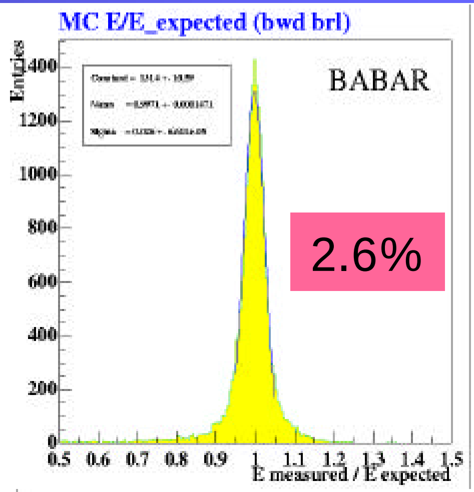


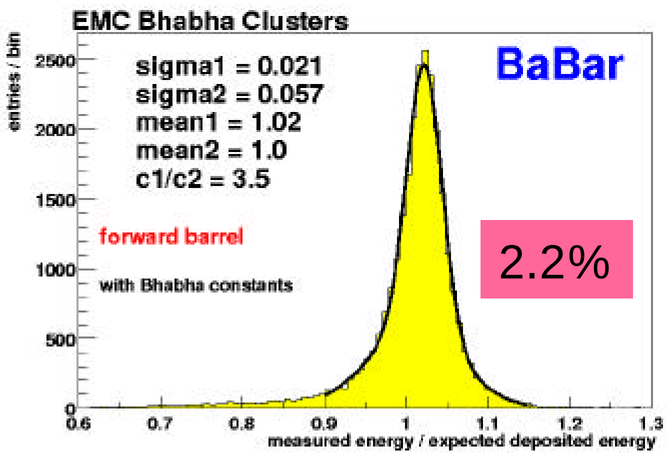
- Resolution = 3.5 % (E>1.5GeV)

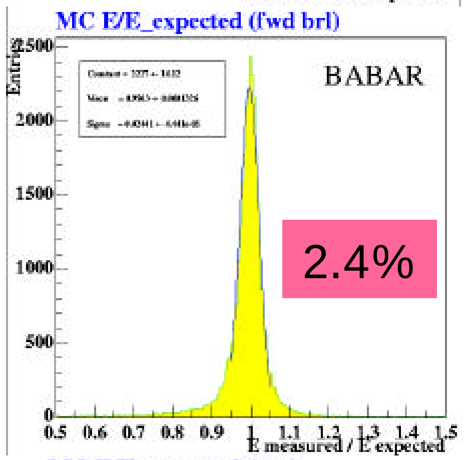


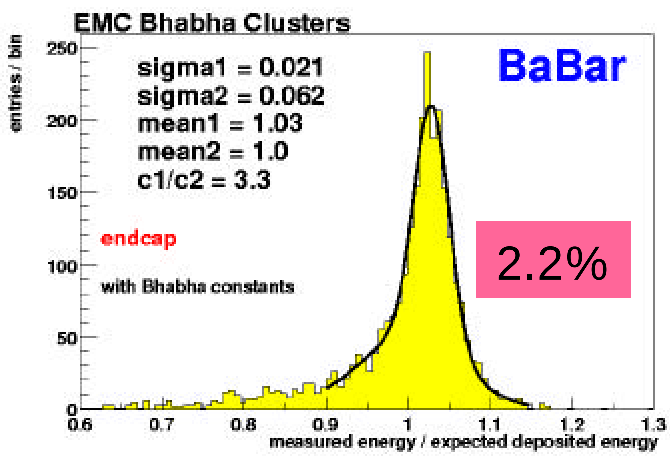
Performance: E/Eexp

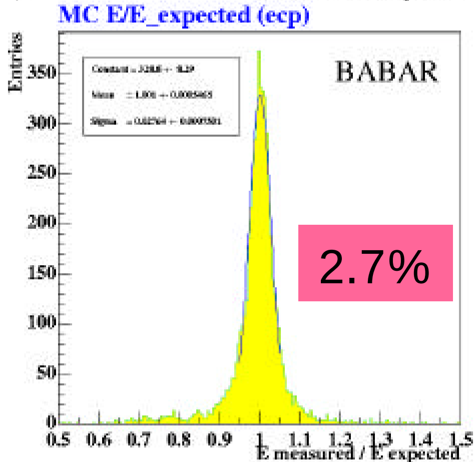


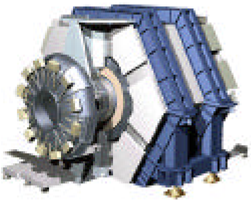










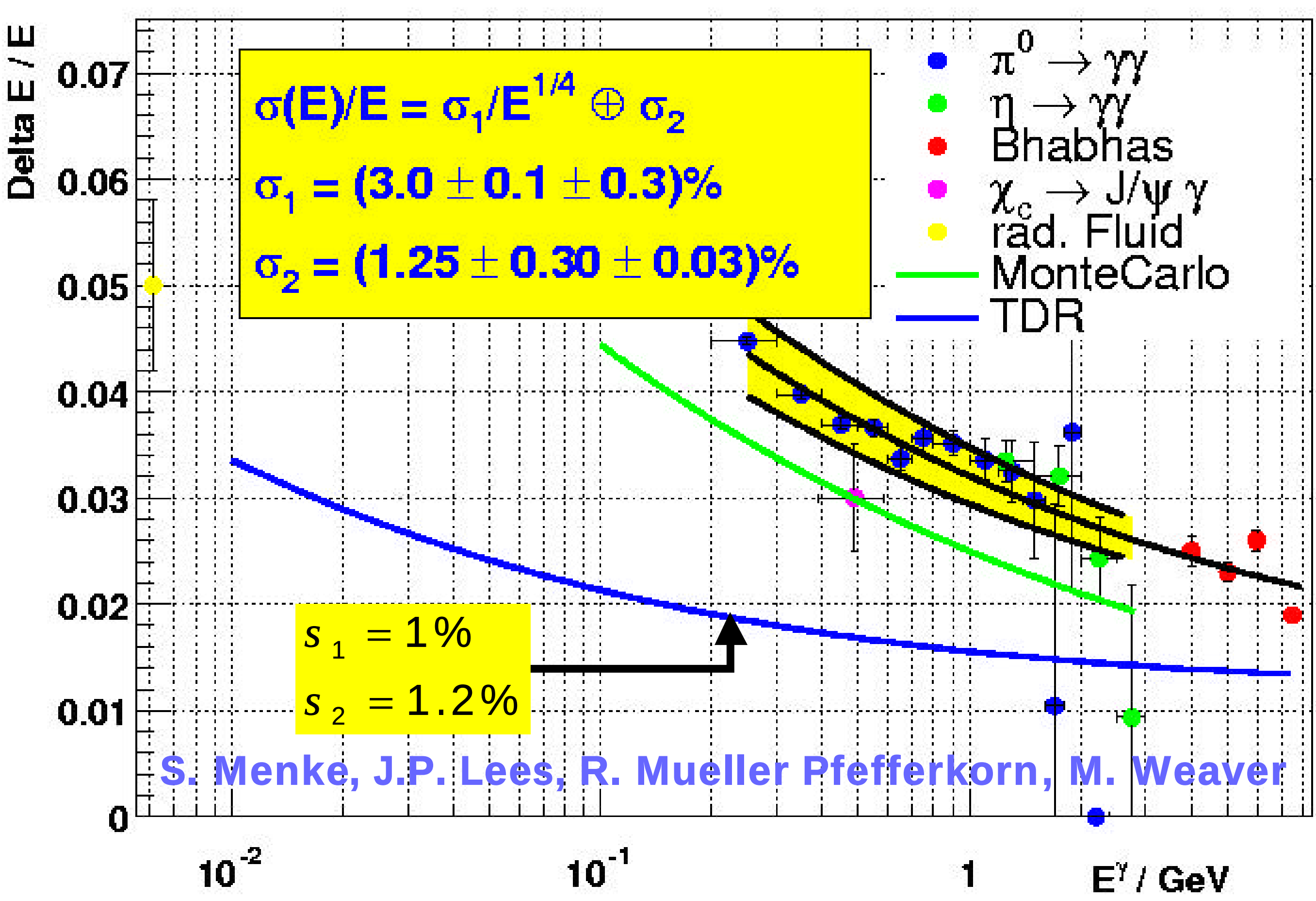


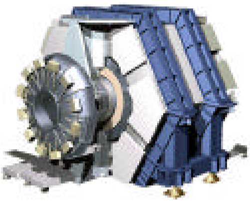
Energy Resolution

- Use symmetric Pi0 and eta + BhaBha
- Measure mass and width:

$$s = \sqrt{\frac{m^2}{2} \times \left(\frac{\Delta E}{E}\right)^2 + \frac{E^4 \sin^2 a}{m^2} (\Delta a)^2}$$

- Minimize $c^2 = \frac{\left(s_i^{meas} - s_i^{th}\right)^2}{\Delta s^2}$ to extract $\frac{\Delta E}{E}$ and Δa





Understanding resolution

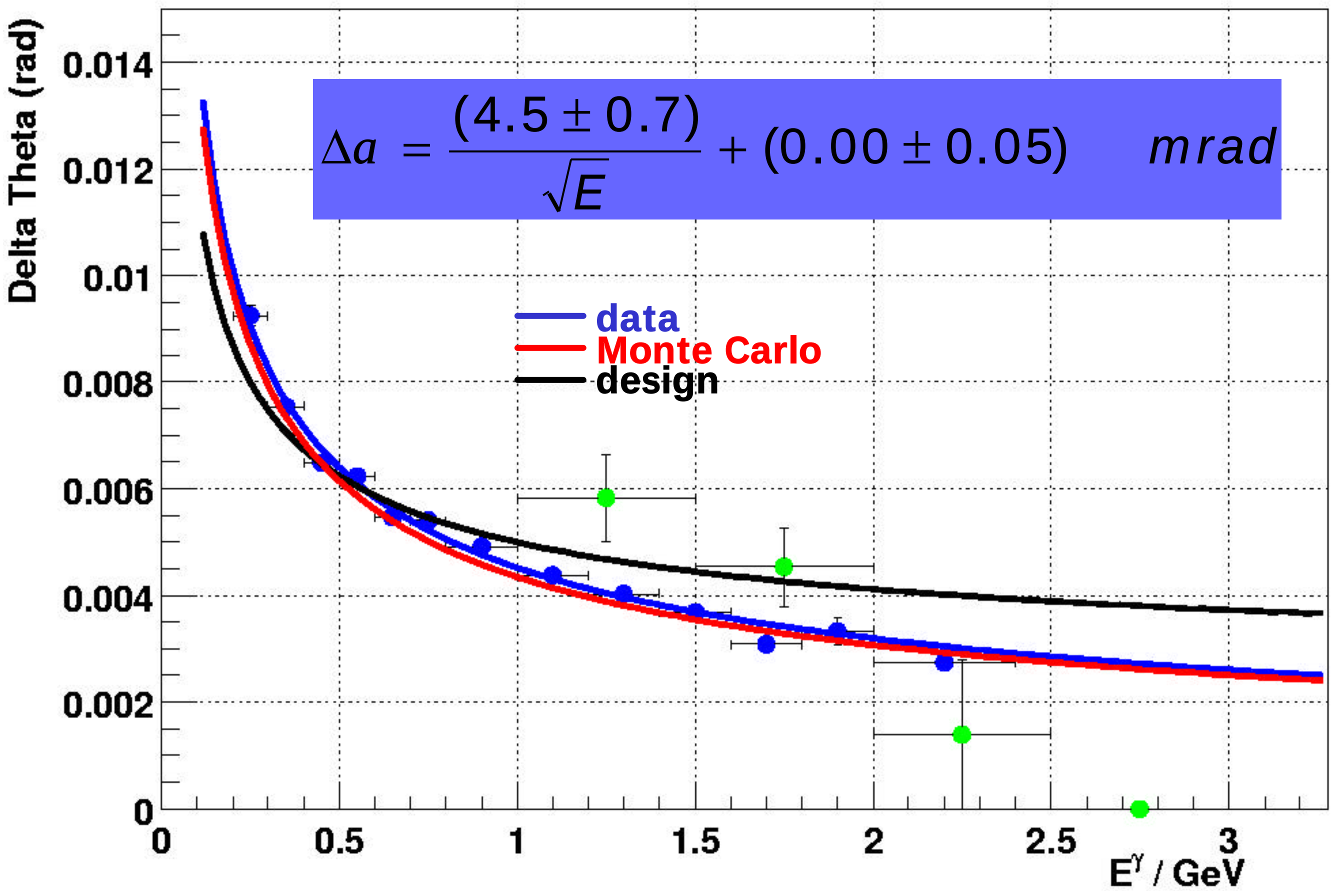
		$\frac{\sigma_E}{E}$ (%) at 100 MeV
	real data (π^0s, ηs)	5.5 ± 0.5
	MC no bkg (single γs)	4.5
Elex noise	MC no elec noise @ 90°	4
Elex noise	MC no sparsification	3.6
Elex noise	MC neighbor Ecut 1 MeV	3.2
Elex noise	MC Digi & neighbor Ecut 0.5 MeV	2.7
	TDR	2.2

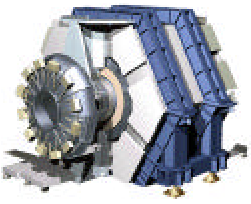
(Study by S. Menke and H. Marsiske)

- Things we can't improve:
  - material in front of EMC: 0.25->0.32Xo
  - material between crystal x1.3

Angular resolution

- Better than expected
  - use of logarithmic weighting of energy deposition to find centroid not used during design





Summary

- 1999-2000 run very successful
  - 21 fb-1 recorded
  - 2 dead crystals / 6580
  - radiation damage minimal
- Calibrations well understood
  - Radioactive source calibration is very precise (0.3% accuracy)
  - BhaBha calibration is being automated.
- Energy resolution

$$\frac{\Delta E}{E} = \frac{3\%}{E^{1/4}} + 1.25\%$$

And improving …