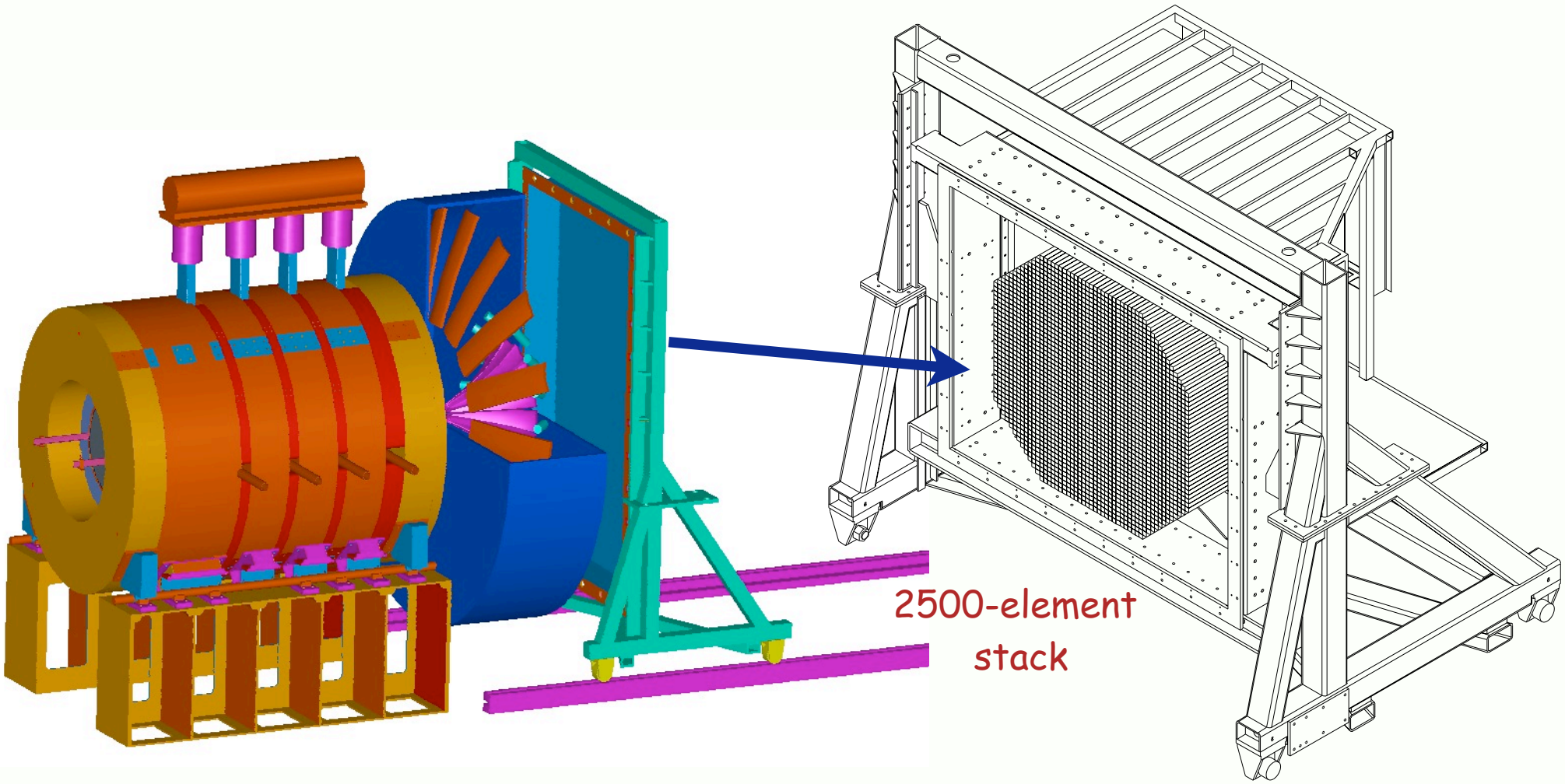
LGD in GlueX

Indiana/IHEP group constructed a 3000-element lead glass detector for E852 at BNL and a 700-element LGD for Radphi at JLab

E852: 18 GeV/c π beam GlueX: 9 GeV photon beam Radphi: 5 GeV photon beam



LGD Summary - 1

Purpose, Resolution Requirements, Description, Mass, Channel Count

The purpose of the LGD is to detect and measure the energy and position of photons from the decays of π^0, η and other mesons. LGD's of similar construction were used in experiments at Brookhaven (E852 - using a pion beam) and JLab (Radphi -using a photon beam). The energy resolution given by $\sigma(E)/E = 0.04 + 0.05/\sqrt{E}$ and transverse spatial resolution of 4 mm leads to a π^0 mass resolution of 10 MeV/c^2. The detector consists of 2500 lead glass blocks of dimensions $4 \times 4 \times 45$ cm^3 arranged in a nearly circular stack. The Cerenkov light from each block is viewed by a FEU-84-3 Russian phototube. The phototube bases are of a Cockcroft-Walton (CW) design. The phototubes are resigtered with respect to the glass using a cellular wall that includes soft-iron and μ-metal shielding. Since the LGD is the furthest downstream subsystem in the overall GlueX detector, the mass presented to particles is not an issue. The channel count is 2500.

GlueX groups built and operated a lead glass calorimeter in spectrometers for meson spectroscopy. Results presented in PRL, PRD and NIM. Issues of construction, magnetic shielding, digitization, monitoring, rates, triggering, photon reconstruction and final analysis have been dealt with in two experiments.

LGD Summary - 2

R&D Issues, Simulations, Monitoring and Other Considerations

The performance of the LGD has been described in two NIM publications for E852 experiment[1] and a a submitted NIM article for Radphi. An earlier version of the CW base is described in another NIM publication[2]. GlueX R&D has concentrated on construction of 100 prototype improved CW bases, evaluation of lead glass and FE-84-3 phototubes used in E852 and Radphi to determining suitability for use in GlueX and various curing techniques to repair radiation damage of lead glass. Simulations of detector response is based on extensive experience with E852 and Radphi data analysis. The monitoring system consists of a plastic scintillator sheet covering the up stream end of the glass stack and illuminated by fibers connected to a pulsed laser.

R&D is addressing issues of PMT ageing, radiation damage, magnetic shielding and simulations to understand hermeticity for the PWA.

LGD Summary - 3

Manpower, R&D and Production Schedules

The LGD is the responsibility of the groups from Indiana University and the Institute for High Energy Physics (IHEP) in Protvino, Russia. This manpower is adequate to complete remaining R&D in six months and to complete the detector construction (including CW bases) in two years from availability of funds.

Technology meets the rate and resolution requirements and capitalizes on the reconstruction and analysis experience from E852 and Radphi.

Lead Glass Experience

Nuclear Instruments and Methods in Physics Research A 332 (1993) 419–443
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

E852 - 1993

A study of two prototype lead glass electromagnetic calorimeters

ELSEVIER

Nuclear Instruments and Methods in Physics Research A 387 (1997) 377–394

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

E852 - 1997

A 3000 element lead-glass electromagnetic calorimeter

ELSEVIER

Nuclear Instruments and Methods in Physics Research A 414 (1998) 466–476

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

Radphi - 1998

A Cockcroft–Walton base for the FEU84-3 photomultiplier tube

in press (2004)

Studies of magnetic shielding for phototubes ☆

S. Denisov[a], J. Dickey[b], A. Dzierba[b,*], W. Gohn[b], R. Heinz[b], D. Howell[b], M. Mikels[b], D. O'Neill[b], V. Samoylenko[a], E. Scott[b], P. Smith[b], S. Teige[b]

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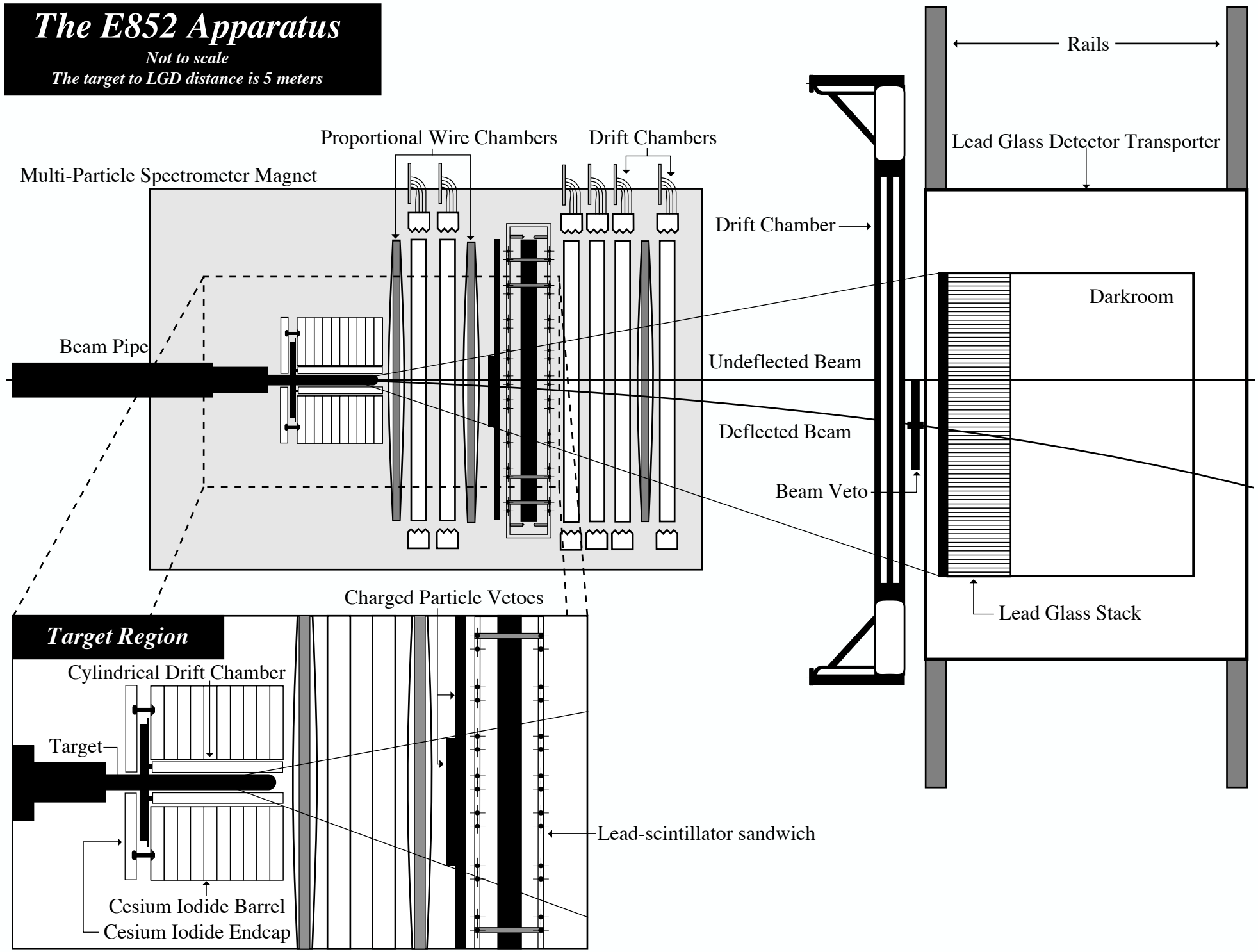
Received 8 April 2004; accepted 16 June 2004

submitted (2004)

The Radphi Detector

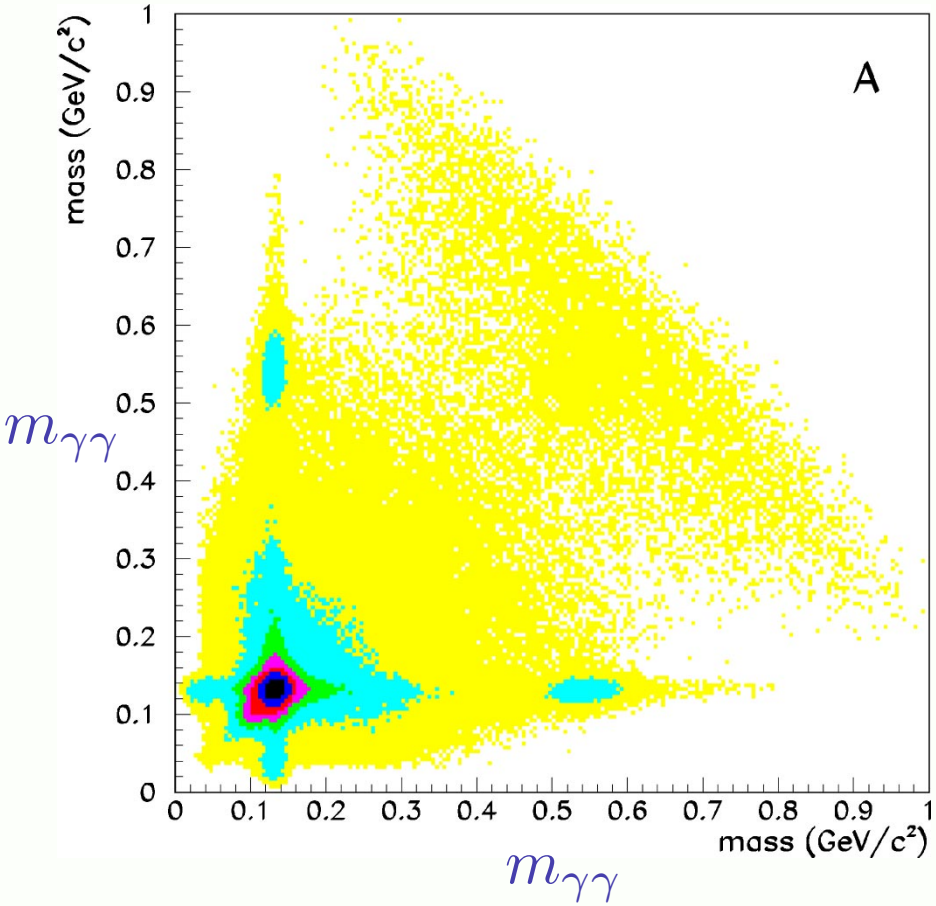

The E852 Apparatus
Not to scale
The target to LGD distance is 5 meters
Rails
Lead Glass Detector Transporter
Proportional Wire Chambers
Drift Chambers
Multi-Particle Spectrometer Magnet
Drift Chamber
Darkroom
Beam Pipe
Undeflected Beam
Deflected Beam
Beam Veto
Lead Glass Stack
Charged Particle Vetoes
Target Region
Cylindrical Drift Chamber
Target
Lead-scintillator sandwich
Cesium Iodide Barrel
Cesium Iodide Endcap

E852

$18\ GeV/c\ \pi^-$

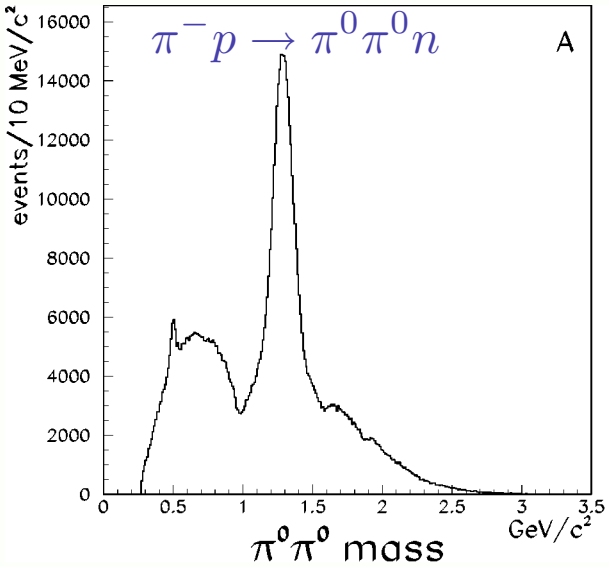
PWA for all neutrals

$\pi^- p \to 4\gamma n$



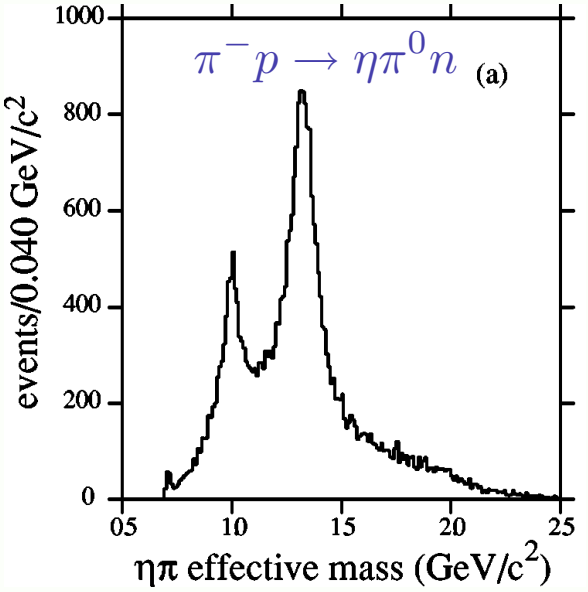
PHYSICAL REVIEW D, VOLUME 64, 072003

Partial wave analysis of the $\pi^0\pi^0$ system produced in $\pi^- p$ charge exchange collisions



PHYSICAL REVIEW D **67**, 094015 (2003)

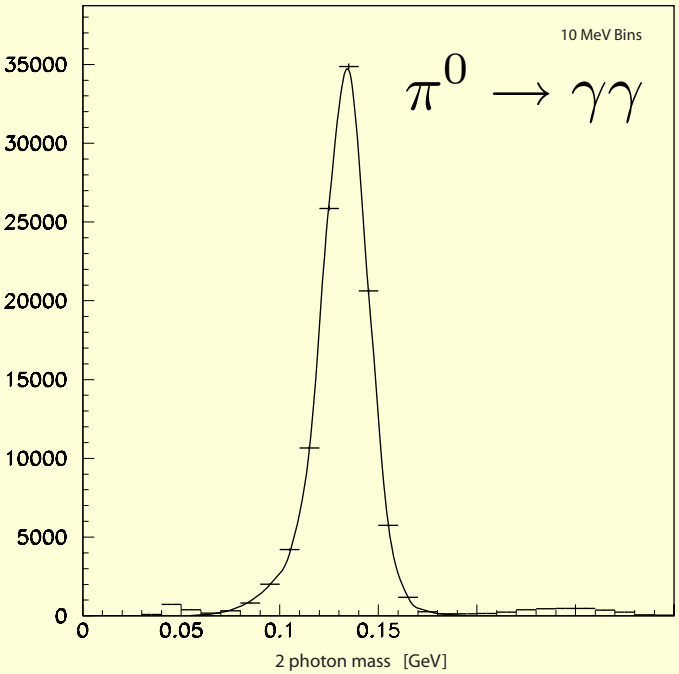
Study of the $\eta\pi^0$ spectrum and search for a $J^{PC}=1^{-+}$ exotic meson

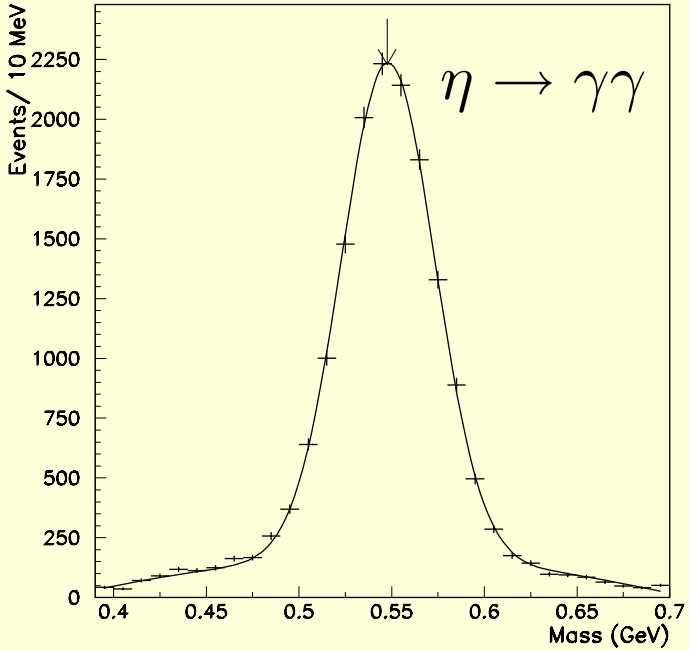


E852

$\pi^- p \to 4\gamma n$

$18\ GeV/c\ \pi^-$

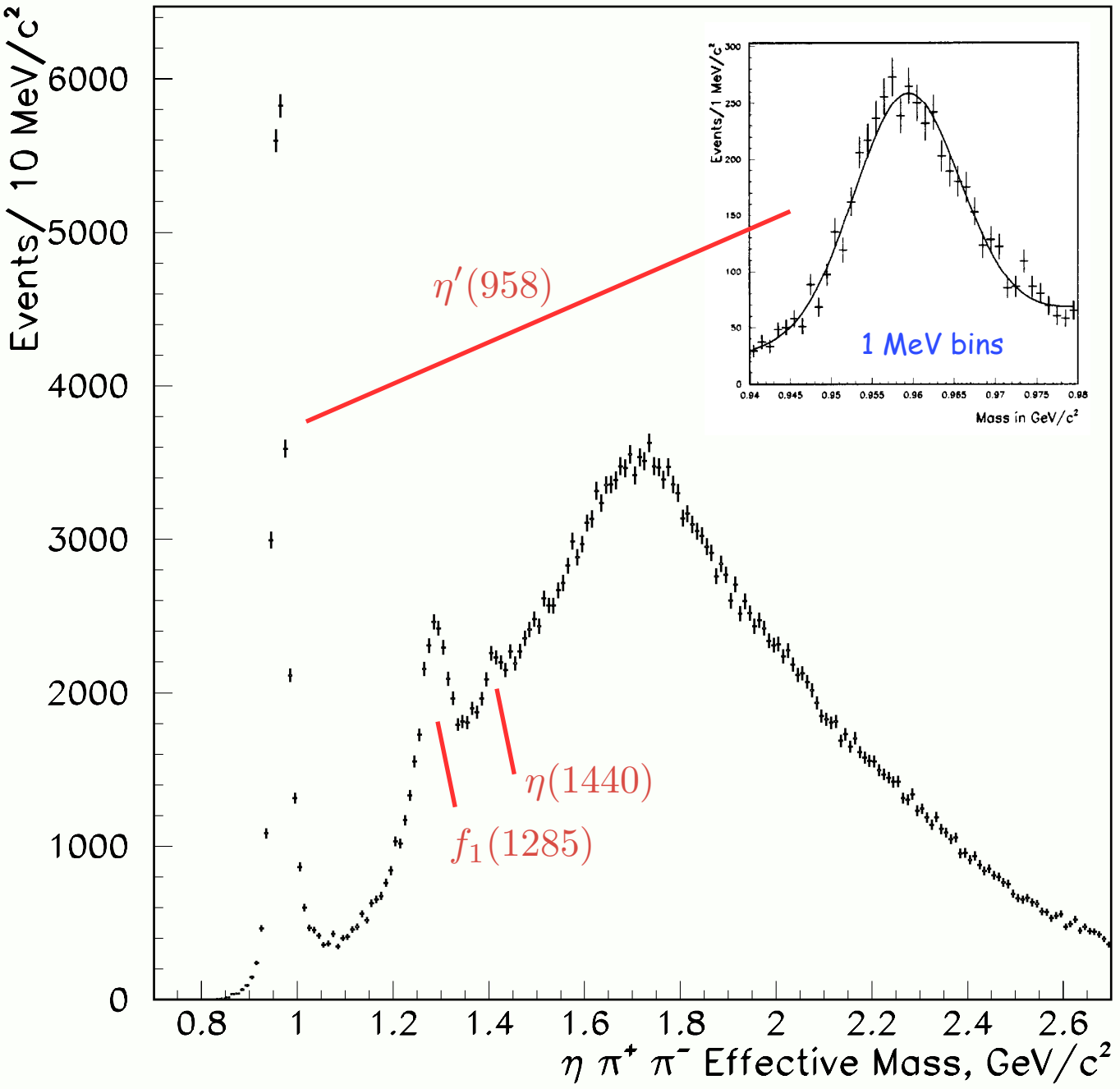




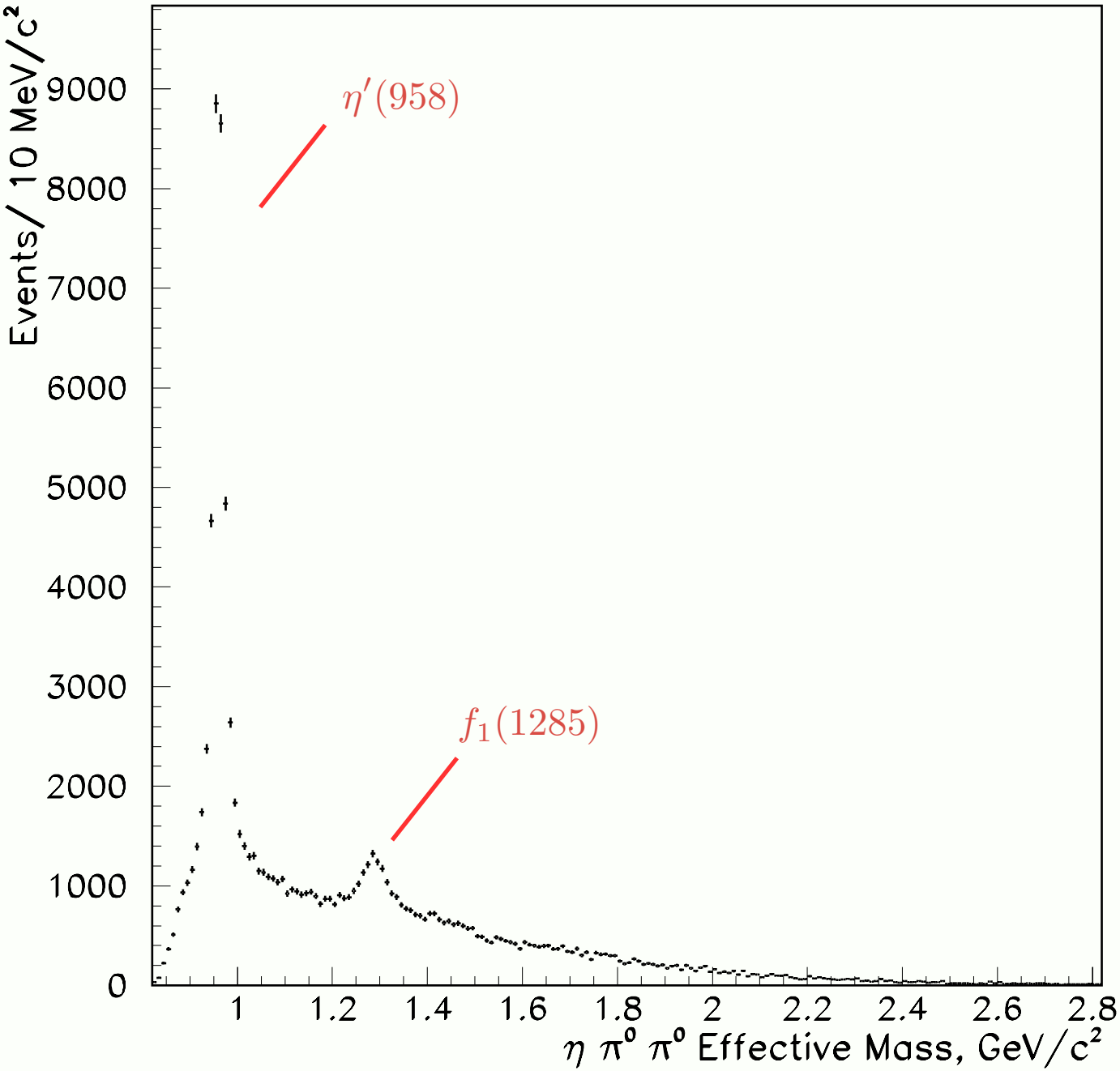
	E852		PDG	
Decay	Mass (MeV)	Width (MeV)	Mass (MeV)	Width(MeV)
$\pi^0 \to \gamma\gamma$	133.6 ± 0.1	10.6 ± 0.1	134.9	0
$\eta \to \gamma\gamma$	550.8 ± 0.5	25.0 ± 0.6	547.5	0
$f_2(1270) \to \pi^0\pi^0$	1278.7 ± 1.8	178.8 ± 4.5	1275 ± 5	185 ± 20
$a_2(1320) \to \eta\pi^0$	1314 ± 2	129 ± 6	1318.5 ± 1.6	103.4 ± 2.1
$a_0(980) \to \eta\pi^0$	989.6 ± 2.6	75.7 ± 10.7	982.4 ± 1.4	57 ± 11

Table 1: Masses and widths of well known resonances observed by E852 compared to the values provided by the Particle Data Group.

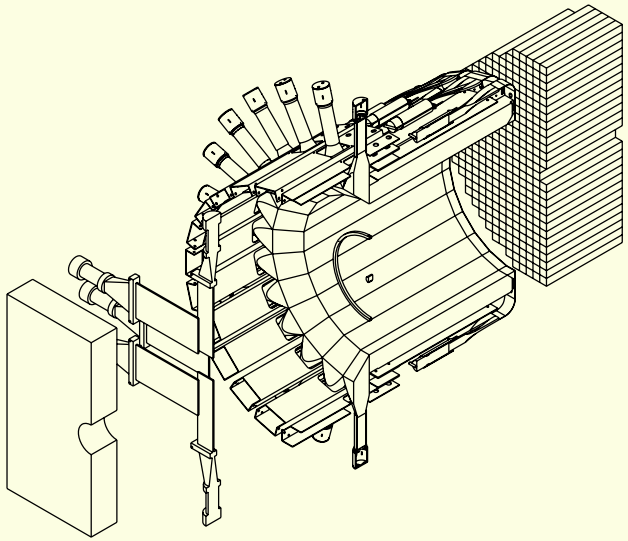
Photons + Charged Particles



Multi-photon states



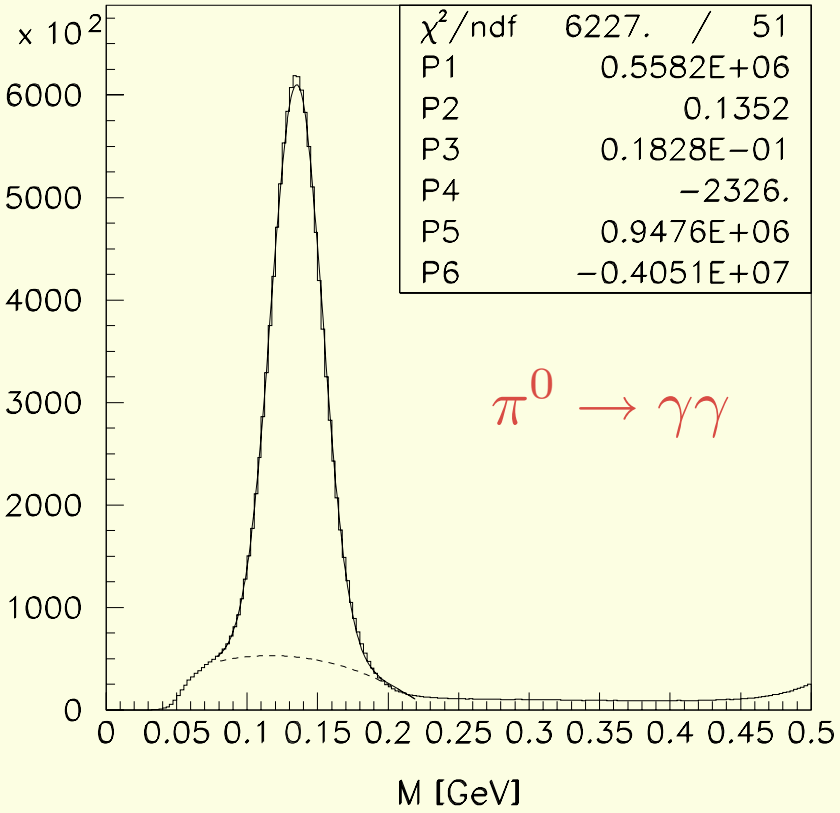
RADPHI

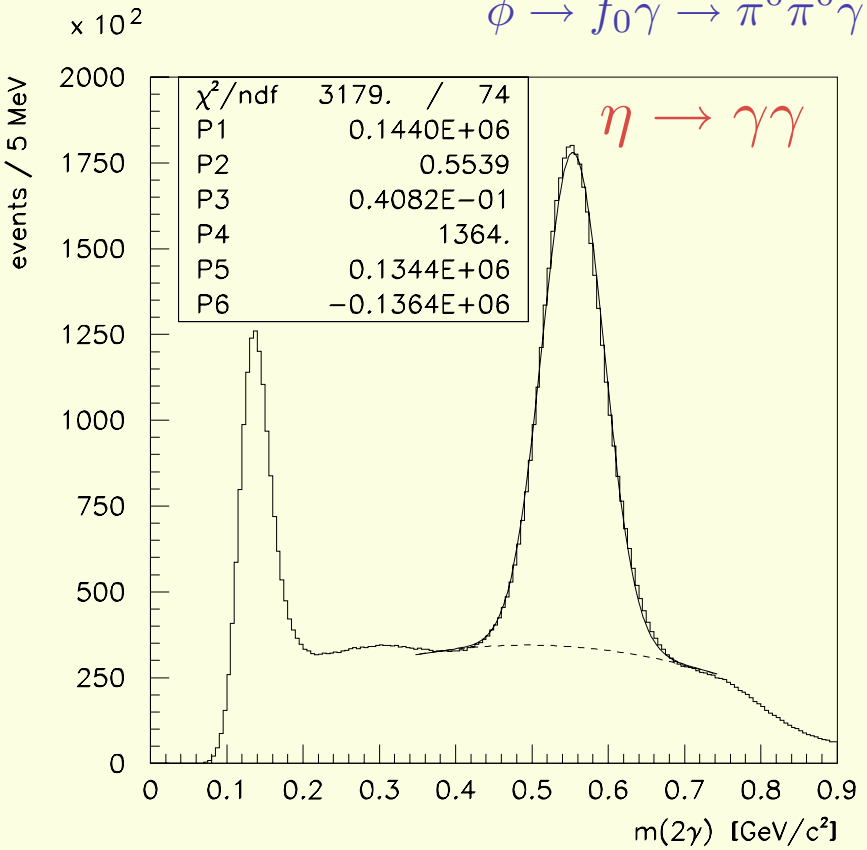


An experiment to search for rare radiative decays used 700 - element LGD in a bremsstrahlung photon beam with 5.5 GeV electrons

$$\gamma p \rightarrow \phi p$$

$$\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma$$
$$\phi \rightarrow f_0\gamma \rightarrow \pi^0\pi^0\gamma$$

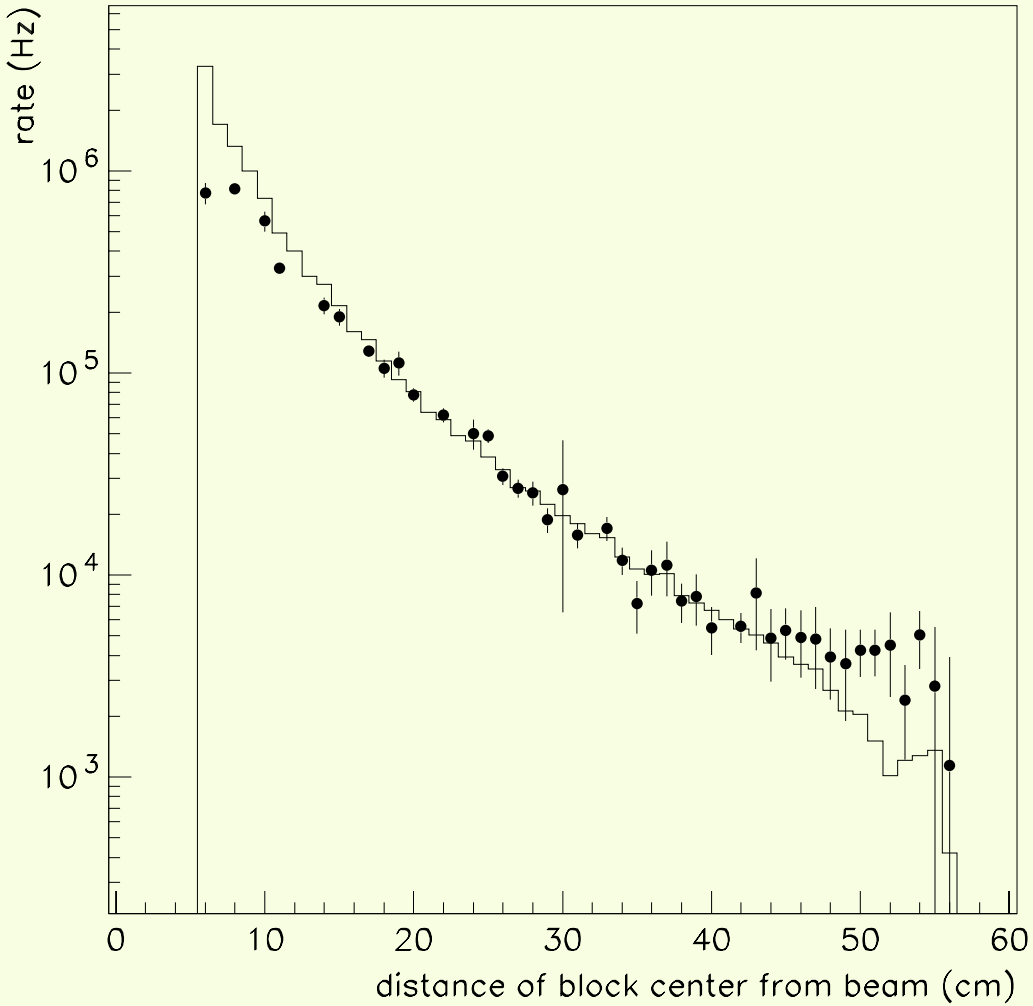




The parameters shown are the height (P1), mean (P2) and sigma (P3) of the Gaussian peak fitted to the data over a polynomial background described by parameters P4-P6.

RADPHI

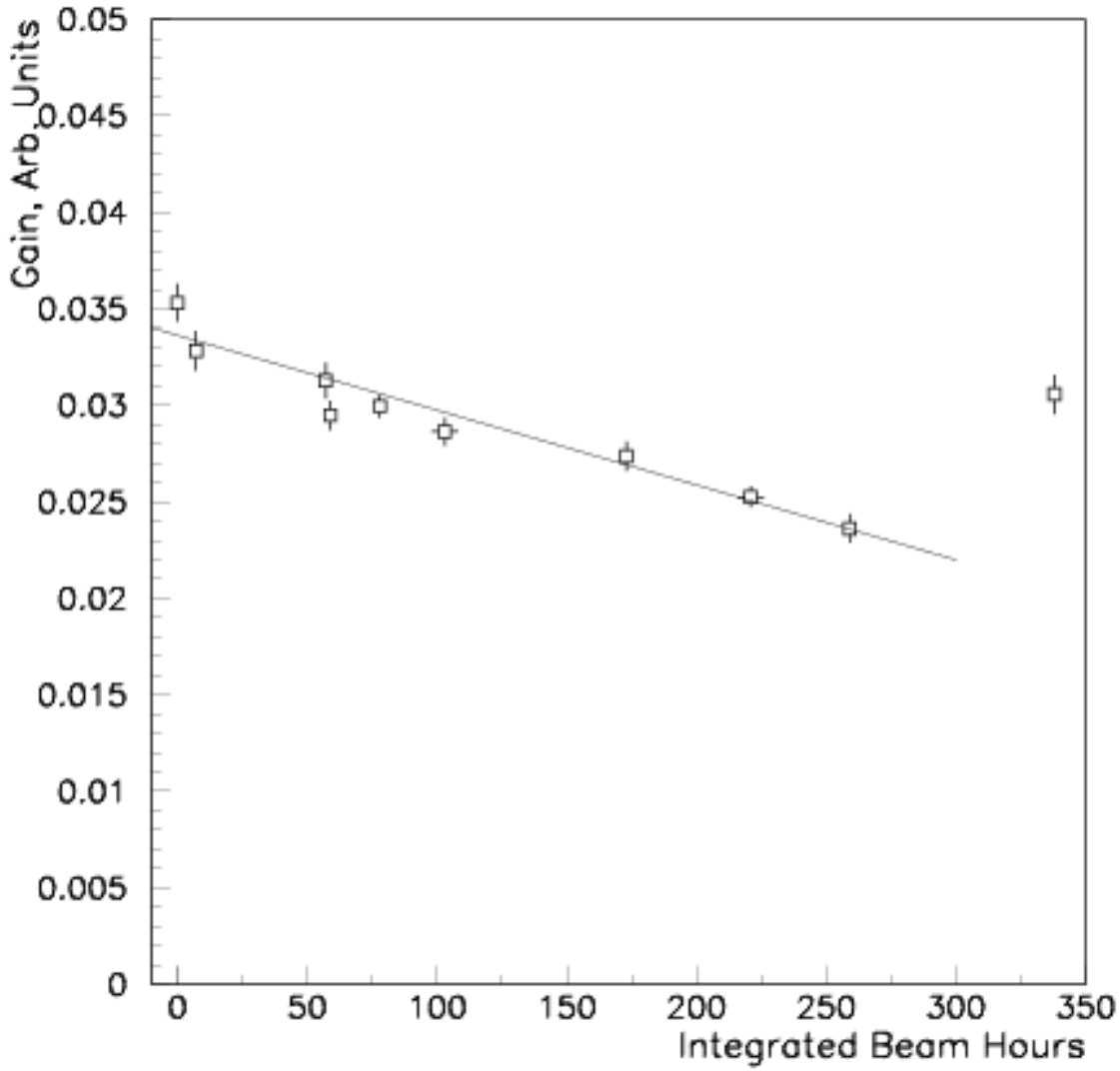
flux from e.m. backgrounds



Characteristics of unbiased flux observed in individual blocks in the LGD as a function of distance from the beam. The points are derived from data and the histograms from a Monte Carlo simulation of the electromagnetic background coming from the beam and target.

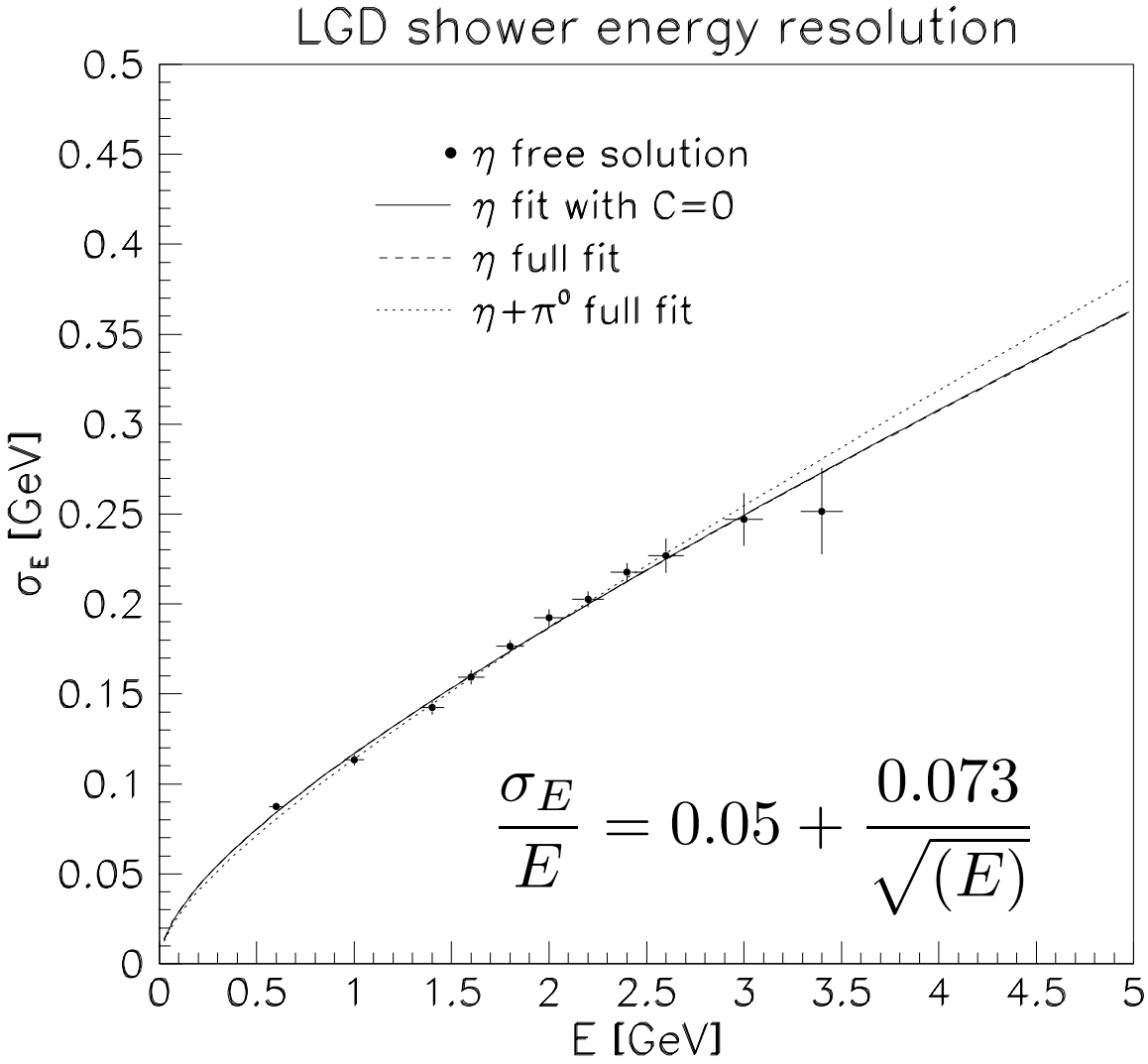
RADPHI

radiation damage



The effect of radiation damage on the central part of the detector. The last point shows the gain after an adjustment of the phototube high voltage.

RADPHI



using electrons at BNL: $\frac{\sigma_E}{E} = 0.01 + \frac{0.05}{\sqrt{(E)}}$

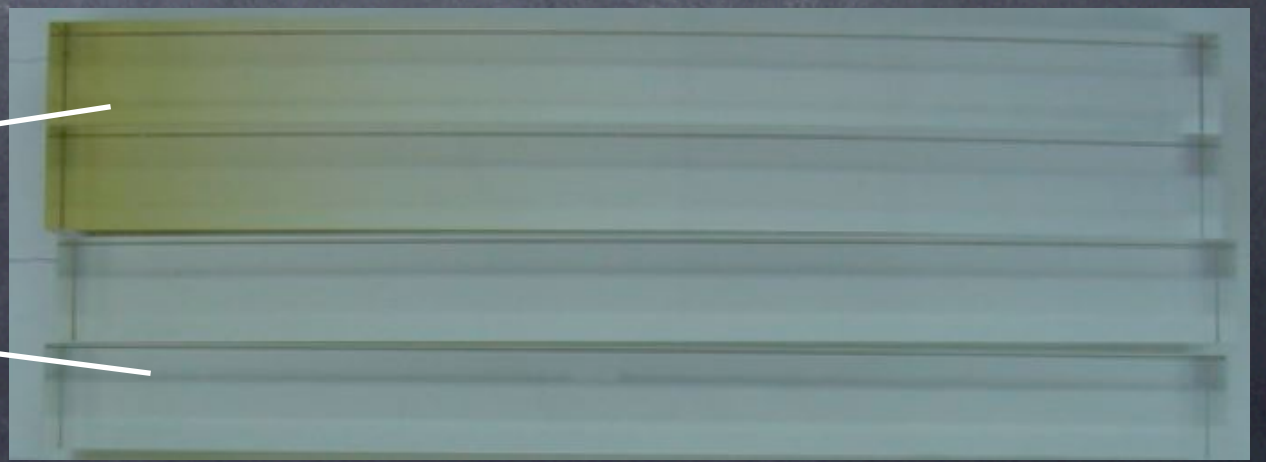
Evaluation of Glass

Transmission of each block measured

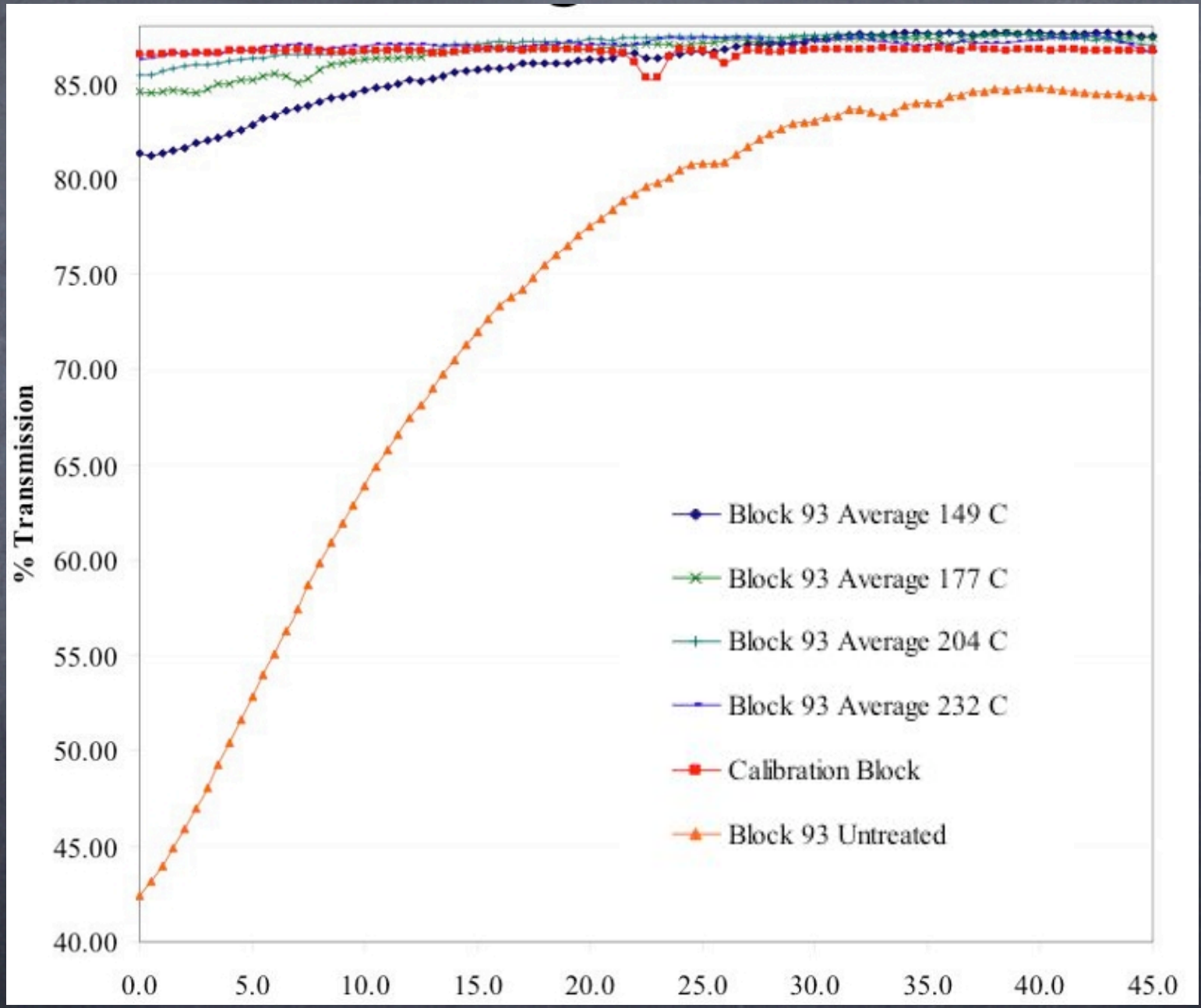
Spectrophotometer

radiation damage

heat curing



Damaged Blocks are Heat Treated



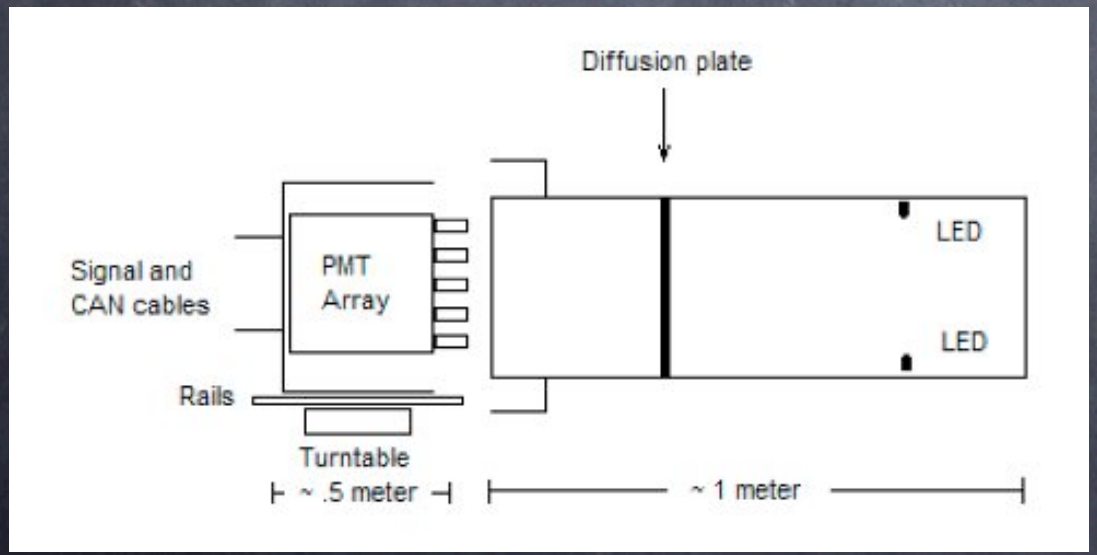
Phototube Evaluation

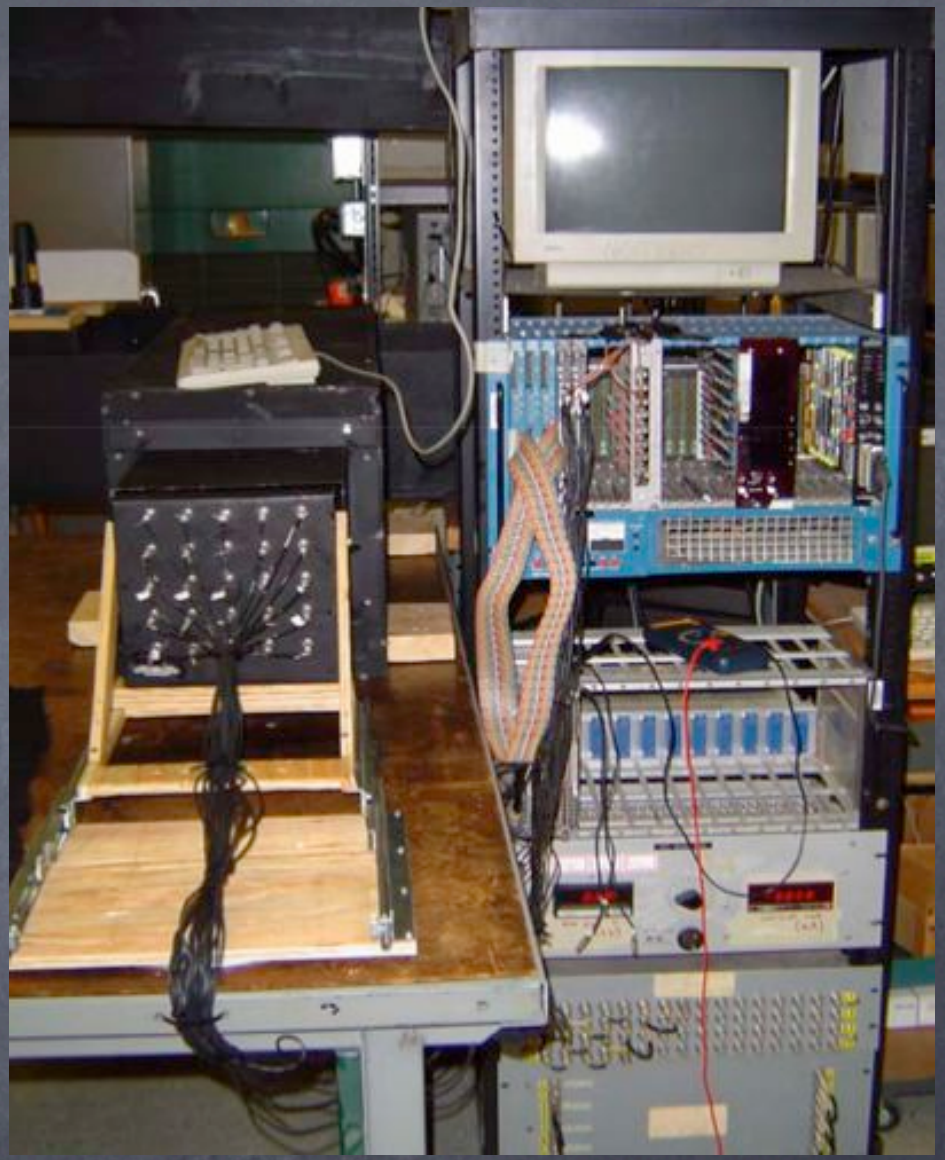
Measure/record:

- Plateau
- Dark noise rates
- Correlated noise

for each PMT

3000 PMT to be evaluated by end of 2004

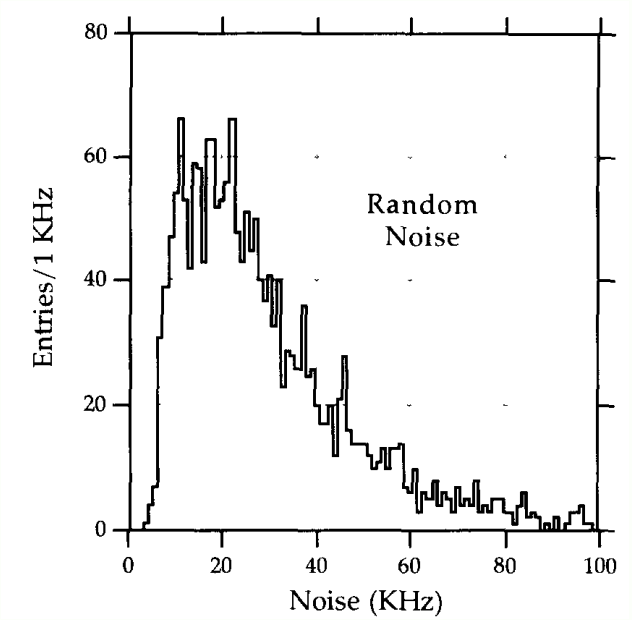


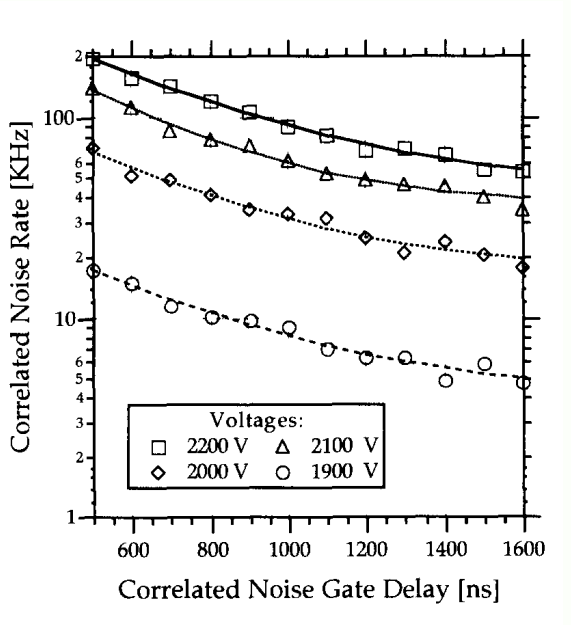


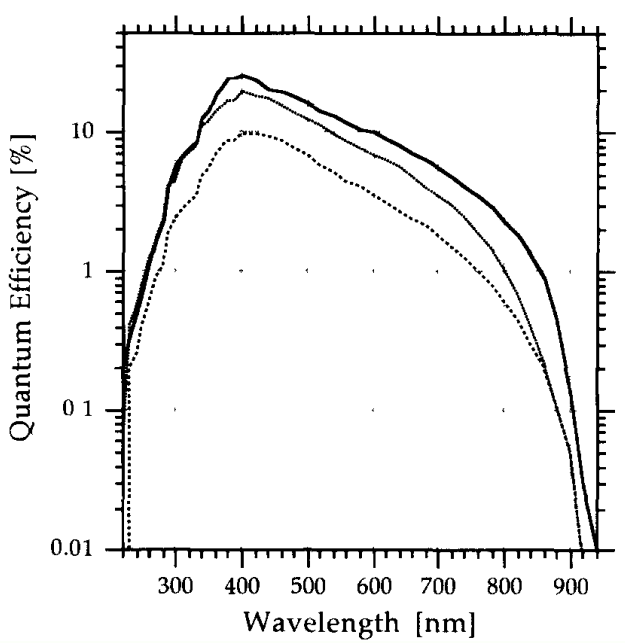
5 x 5 array

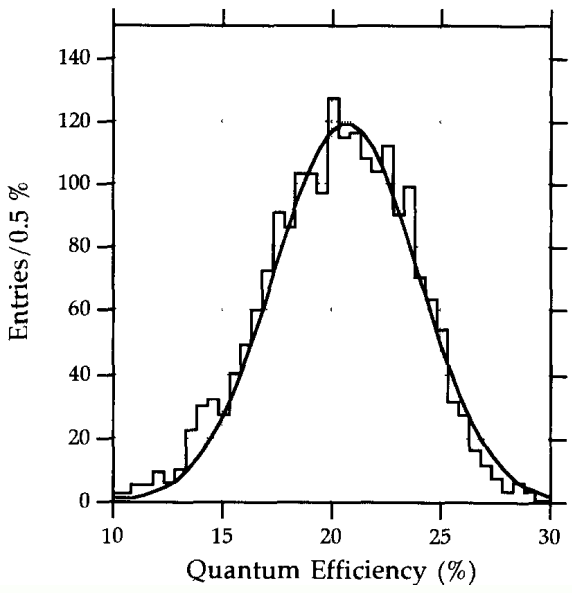
PMT Evaluation for E852

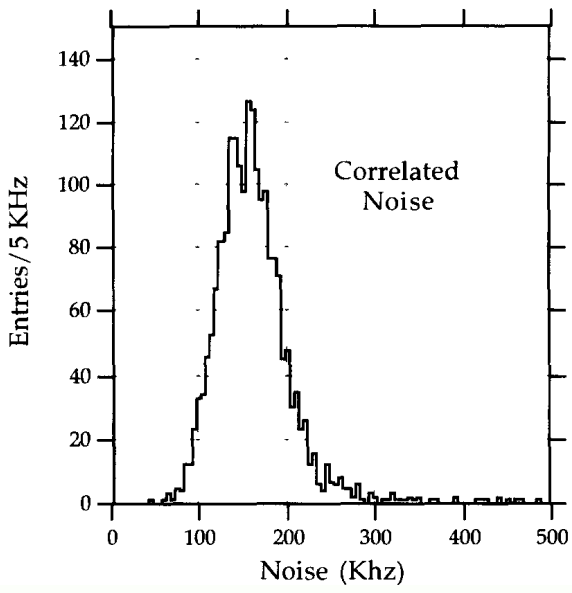
Carried out for 3500 FEU-84-3 in 1993





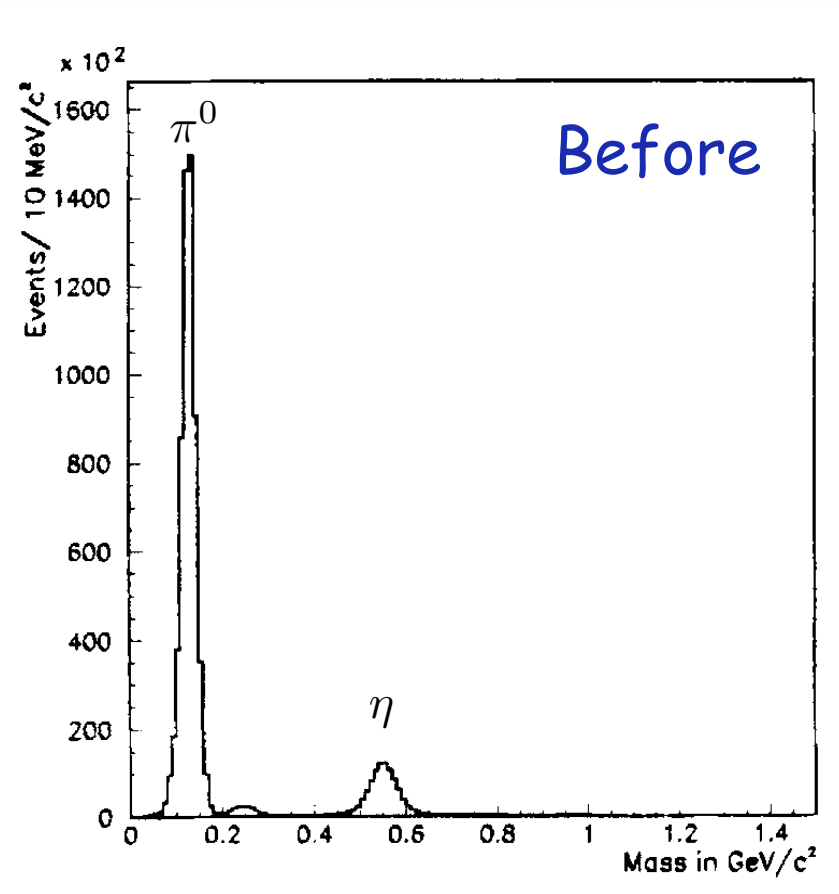




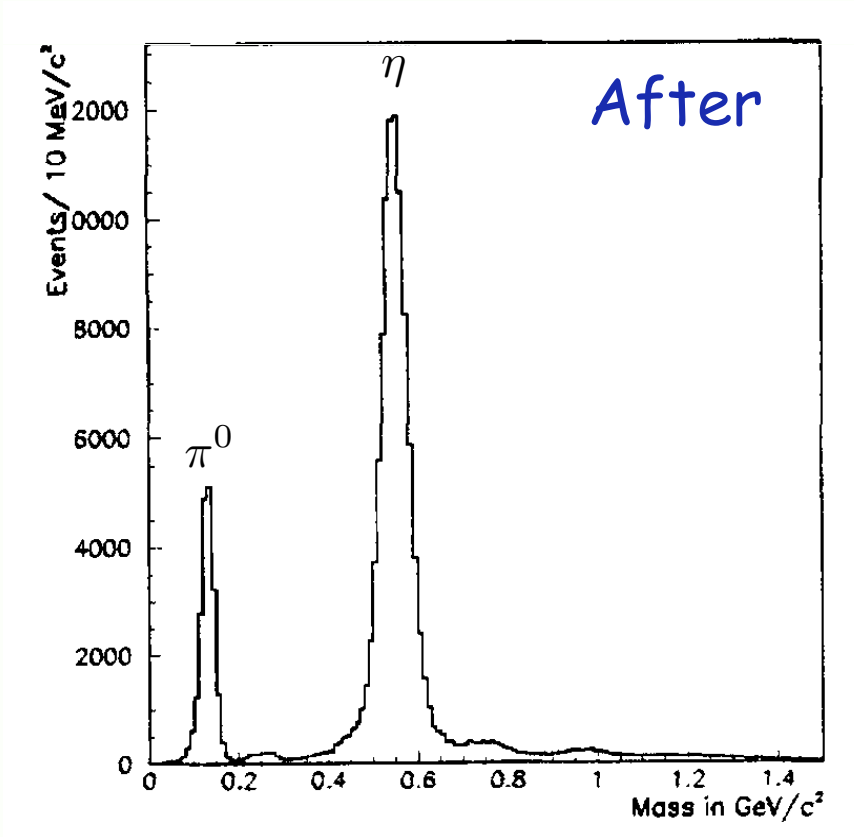


Trigger Processor

in E852 did an online calculation of effective mass of photons in the LGD and was used in the trigger



$m_{\gamma\gamma}$



$m_{\gamma\gamma}$