ECAL: test of module performance

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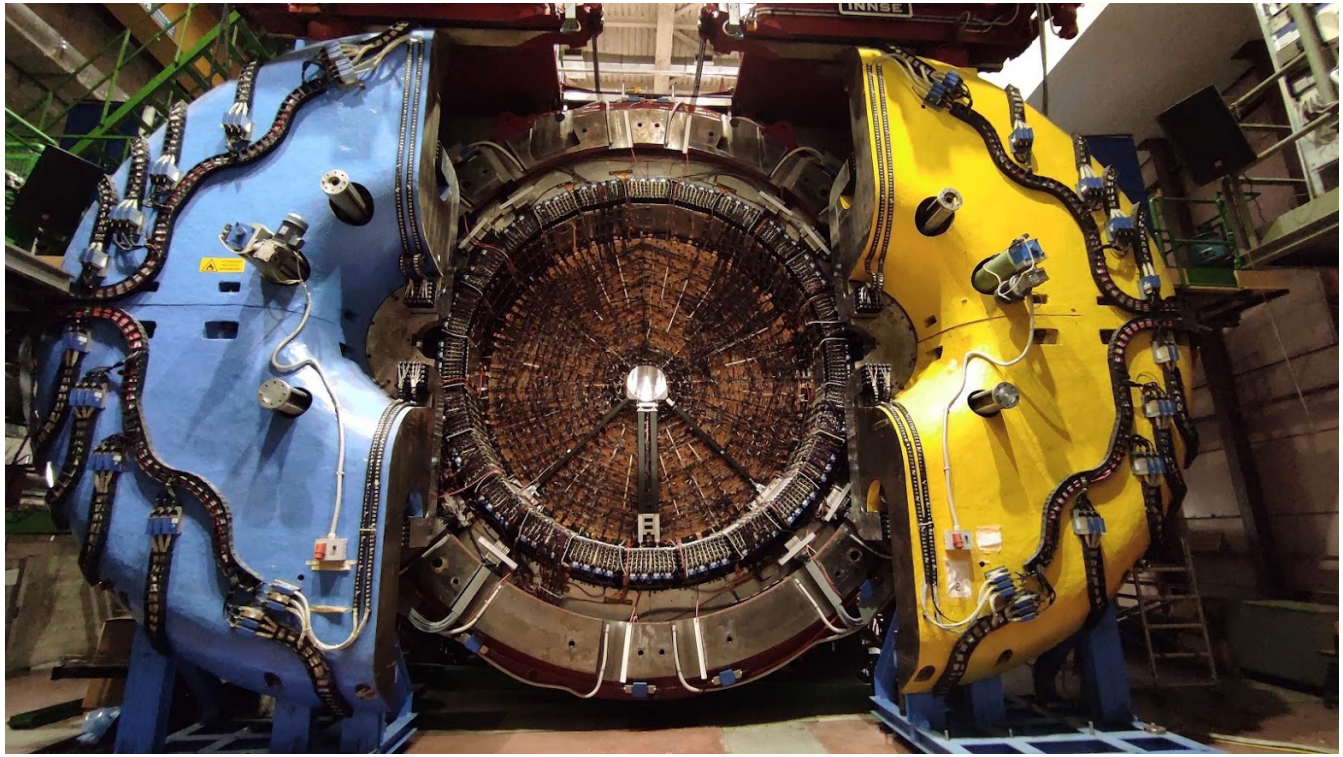


Meeting DUNE-Italia – Ferrara, 28-30 Ottobre 2024

ECAL module consolidation and test

see Fabrizio's talk

Consolidation
- Gluing of delaminated parts
- Replace light-guides protections
- Wrap with new Aluminum-Fiberglass tape

Operational Test
- test basic performance with cosmics rays
- test of new FEE prototypes (comparison with old KLOE electronics)

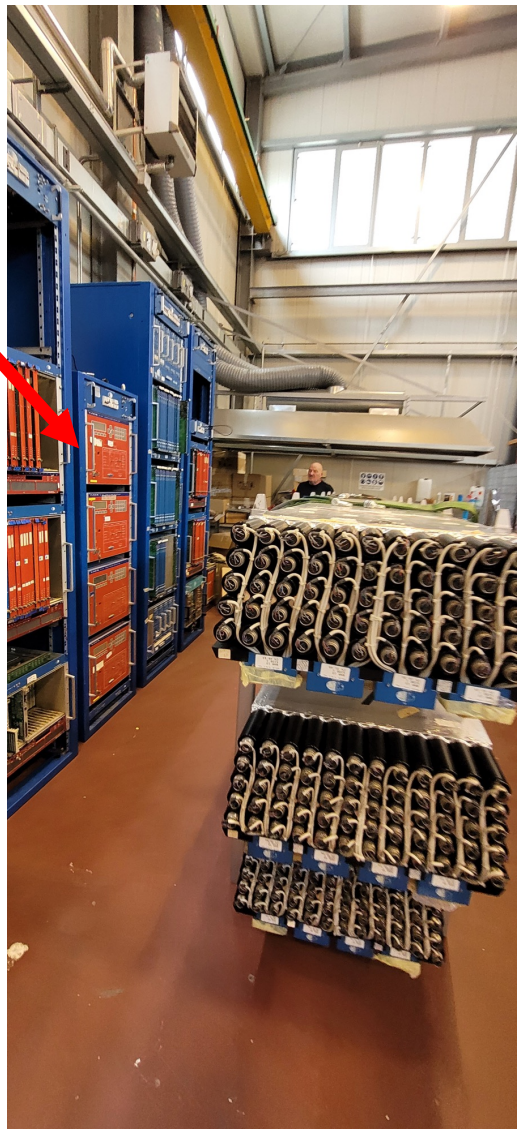
24 Modules are stored each on its own support that will be used also for the transportation
An experimental area is being set up for Consolidation and Operational test of the modules

ECAL signal+HV cables
15+15 m long
in 12 storage boxes

ECAL test at LNF

We plan to test two barrel modules at the same time; (60+60)x2=240 channels

Test area



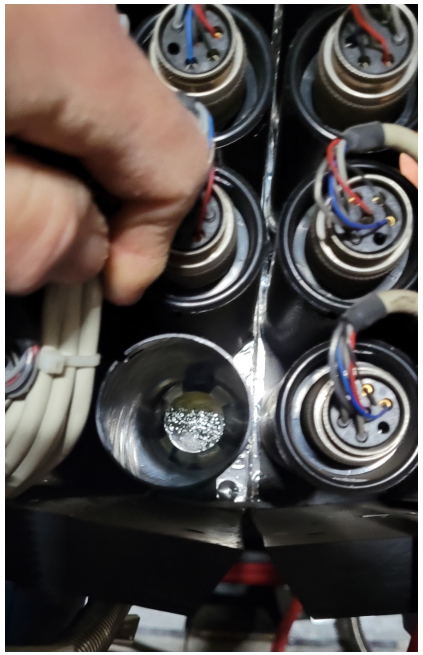
Refurbishment area

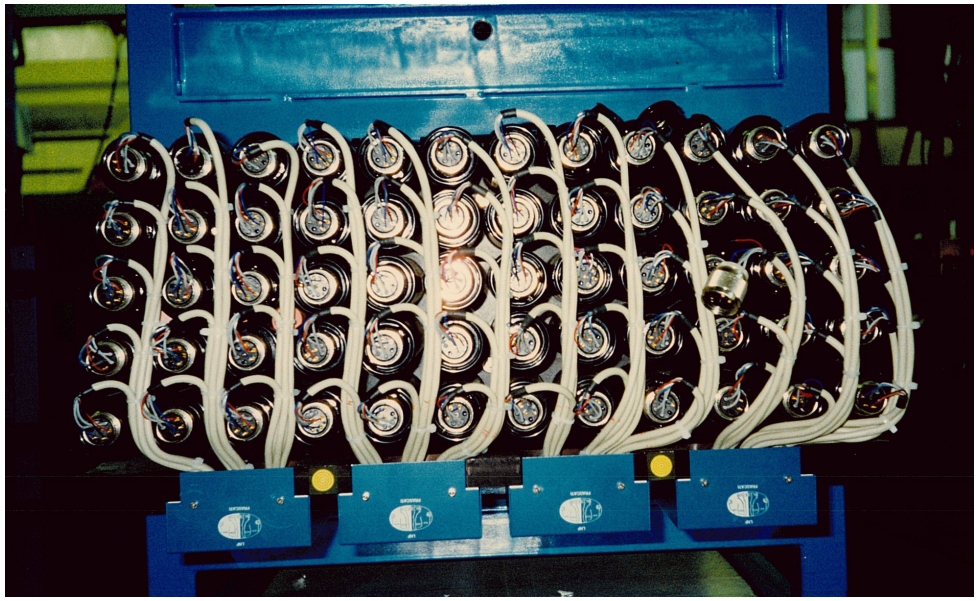
(In total test+refurbishment ~85 mq in bld.57)

ECAL test at LNF

PMTs will be dismounted, light guides cleaned, new optical gel applied, and PMT re-mounted.

ECAL module refurbishment and test





Bicron optical gel BC-630

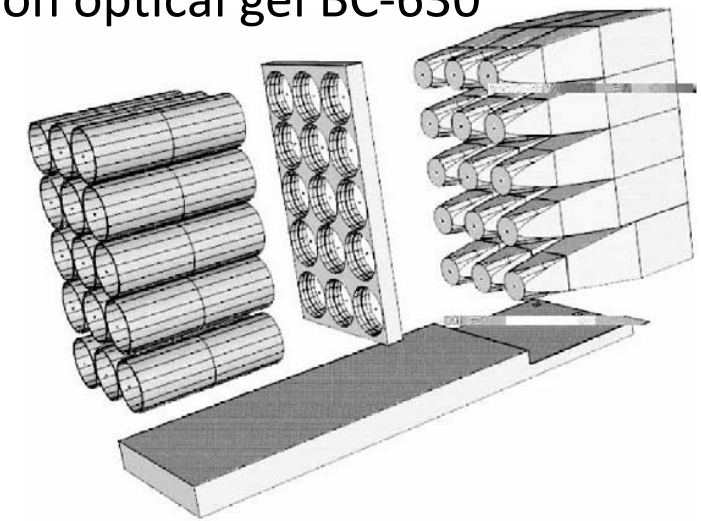


Fig. 4. Exploded view of the PM box.

ECAL test at LNF

For the ECAL module test the KLOE electronics will be reused

VME bridge

trigger distributor
NIM modules for trigger logic

CAEN HV power supply

KLOE ADC CAEN VX559 (30 ch.) 8 boards
KLOE TDC CAEN VX569 (30 ch.) 8 boards

KLOE Low Voltage power supply (380~V)
+/-6V (2x 300W) => PMT preamp, FEE etc.
+/- 5.2 (2x 280W) => digital circuitry

KLOE SDS 8 boards: spllitter + discriminators on 30 ch./board
common tunable threshold(low+hign thr.)

ECAL: procurement of HV and LV power supply

HV

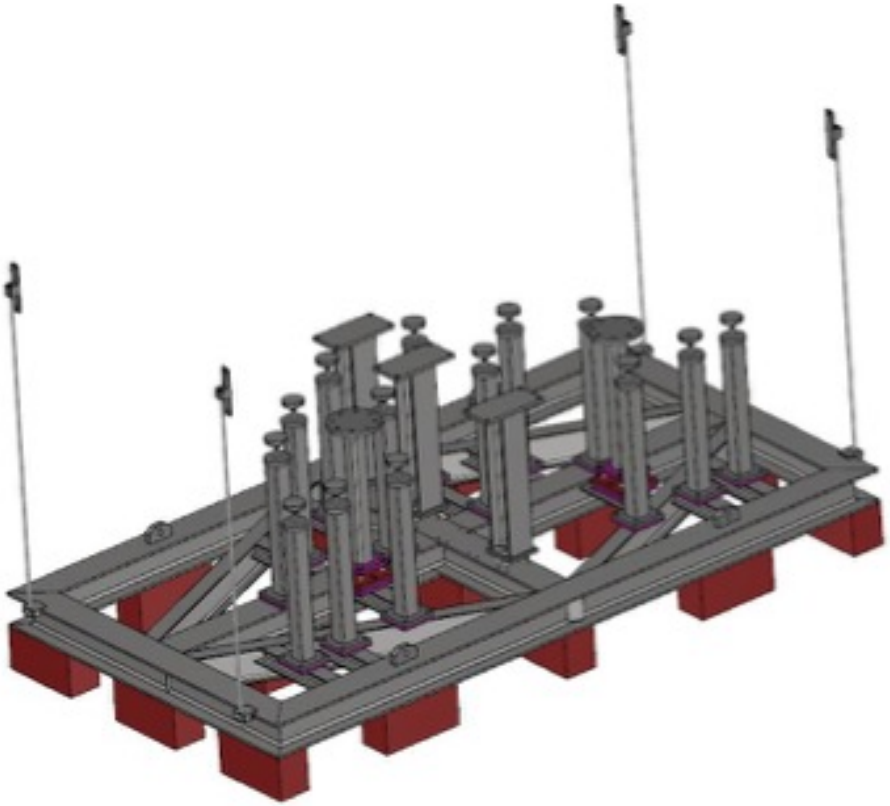
LV

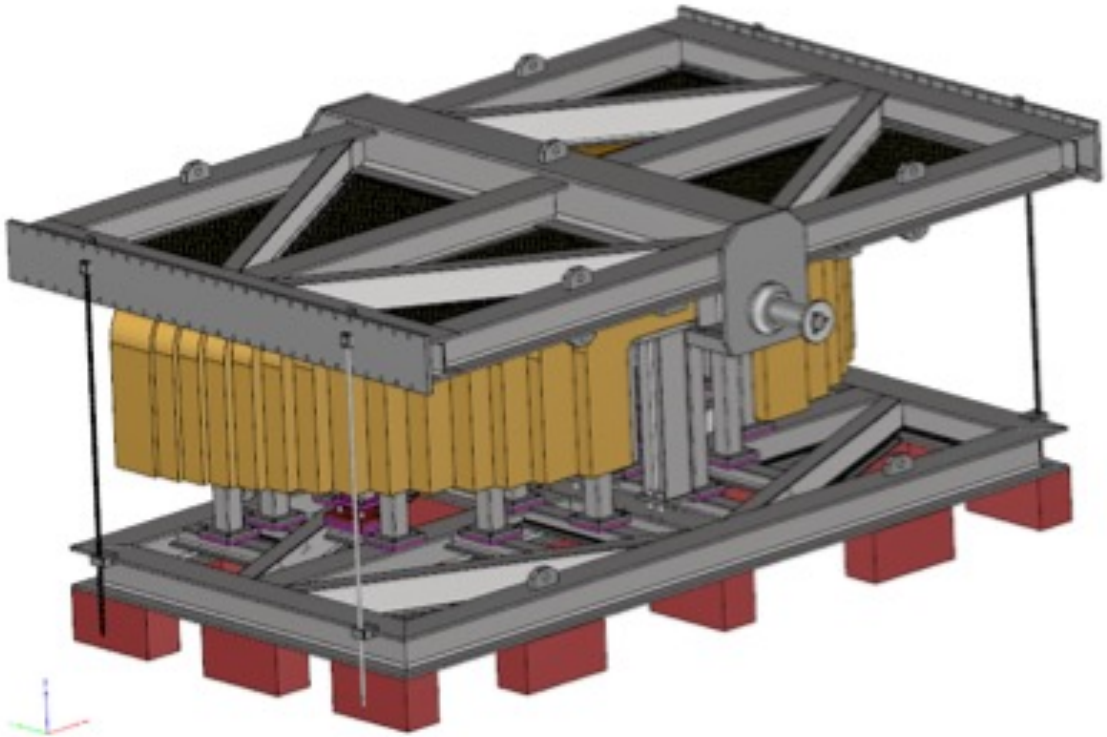
CAEN
n° 102 board A7030P (48 ch.) H.V. channels +3 KV 1 mA (1.5 W) - Multipin Conn. common floating
n° 7 Sistem SY4527B Universal Multichannel Power Supply System - BASIC 600W
n° 7 Power supply booster A4533 - 1200W

n° 10+2 spare board A25251 8 full floating channels 8V/12A

Mapping of present HV cables 5x12ch on 48 ch. modularity not trivial (to be studied also for LV)
=> under study to minimize cost (custom connectors or patch panel)

ECAL test at LNF: End-cap modules



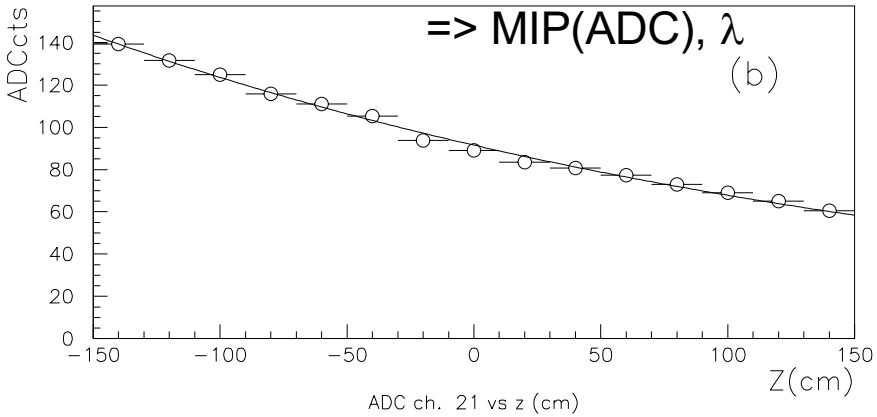


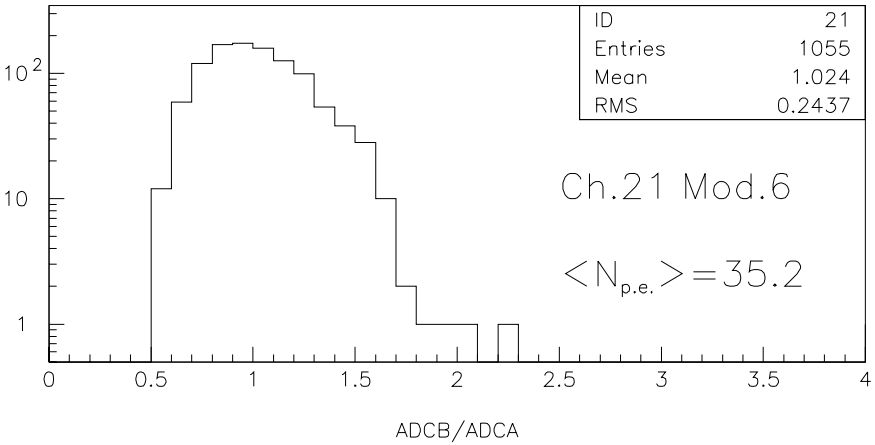
Design of supports for handling and transportation of each half End-cap.

ECAL test with cosmic rays

- 4-5 DAYS OF FULL DATA TAKING (WHOLE MODULE AND ALL CELLS EXPOSED TO COSMIC RAYS)
  => TRIGGER – SOME OPTIONS
- 1-2 DAYS FOR PMT MOUNTING/DISMOUNTING AND MODULE HANDLING
- => 1 WEEK PER BARREL MODULE FOR TEST
- DATA TAKING COULD GO IN PARALLEL FOR TWO MODULES

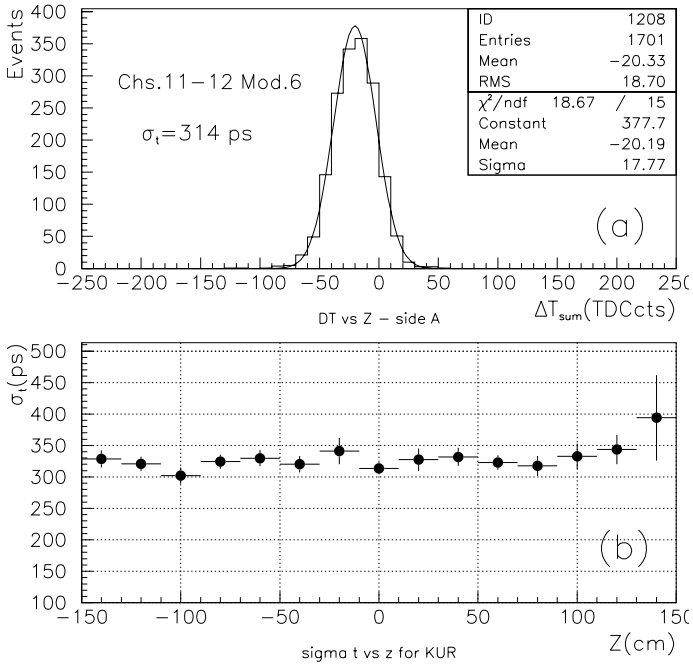
ECAL test with cosmic rays





$$\frac{R.M.S.(r_{AB})}{< r_{AB} >} = \sqrt{\frac{2}{N_{p.e.}}}$$

r_{AB} = ratio Q_A/Q_B for particles impinging at the module center.



$$\Delta T_A = T_A(i) - T_A(i+1)$$
$$\Delta T_B = T_B(i) - T_B(i+1)$$
$$\Delta T_{sum} = \frac{T(i)_A + T(i)_B}{2} - \frac{T(i+1)_A + T(i+1)_B}{2} = \frac{\Delta T_A + \Delta T_B}{2}$$

for vertical muons to reduce spread of time of flight between consecutive cells.

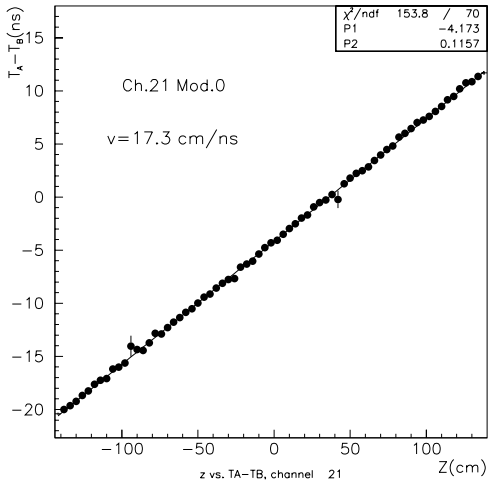
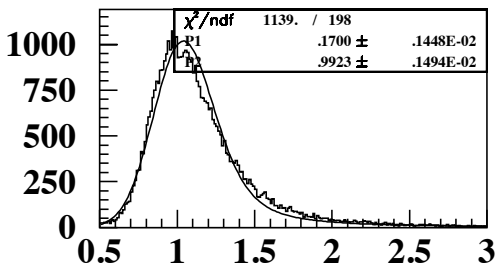


Figure 5: (a) Example of distribution of ΔT_{sum} for a couple of Kuraray elements around $Z = 0$. (b) Dependence of σ_t on Z.

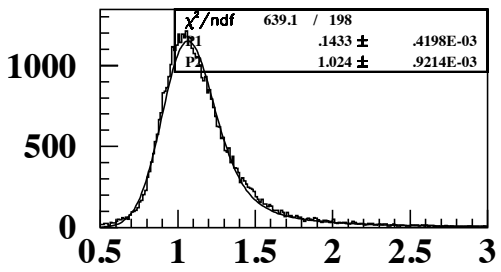
ECAL test with cosmic rays

Parameter	Mod. 0/01	Mod. 3/01	Mod. 6/01	Mod. 6/02	Mod. 8/02	Mod.12/02
λ Kur.(cm)	354 ± 9	430 ± 10	435 ± 9	428 ± 8	431 ± 6	444 ± 6
λ PHT (cm)	234 ± 4	294 ± 5	309 ± 4	306 ± 5	325 ± 5	351 ± 5
MIP (ADC cts) Kur.	78.3 ± 2.9	94.2 ± 3.5	108.3 ± 3.5	95.3 ± 3.1	99.3 ± 5.0	99.1 ± 6.0
MIP (ADC cts) PHT	56.6 ± 1.5	87.4 ± 2.3	102.4 ± 2.9	88.4 ± 1.9	89.8 ± 4.6	95.7 ± 6.0
$N_{p.e.}$ Kur.	24.3 ± 1.3	28.6 ± 0.8	32.0 ± 0.8	35.0 ± 0.7	34.8 ± 1.0	37.6 ± 0.8
$N_{p.e.}$ PHT	18.8 ± 0.5	26.9 ± 0.5	29.9 ± 0.6	31.3 ± 0.6	32.1 ± 0.5	33.3 ± 0.8
$\sigma_t(ps)$ Kur.	385 ± 5	367 ± 11	359 ± 11	313 ± 9	327 ± 12	334 ± 15
$\sigma_t(ps)$ PHT	532 ± 14	423 ± 26	399 ± 11	346 ± 5	321 ± 15	325 ± 7
$\sigma_Z(cm)$ Kur.	6.21 ± 0.10	6.38 ± 0.13	5.88 ± 0.12	5.21 ± 0.08	5.17 ± 0.10	5.37 ± 0.16
$\sigma_Z(cm)$ PHT	8.50 ± 0.16	6.90 ± 0.10	6.39 ± 0.10	5.97 ± 0.18	5.18 ± 0.21	5.03 ± 0.09

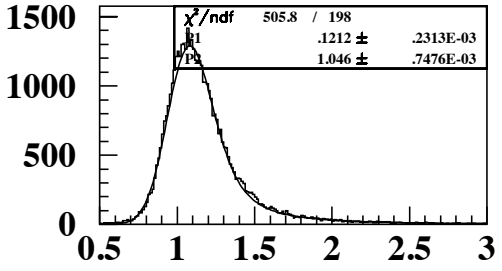
ECAL test with cosmic rays: energy resolution



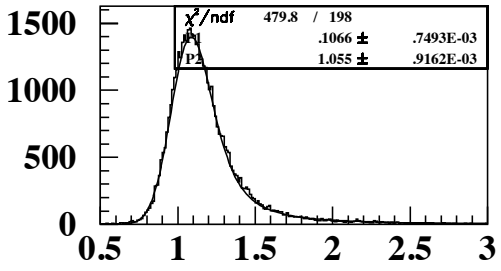
Layer 1



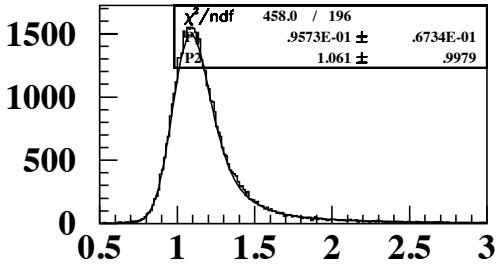
Layers 1-2



Layers 1-3



Layers 1-4



Layers 1-5

$$f(E) = A \cdot \int_0^{\infty} dE'\, L\left(\frac{(E' - E_0)}{\Delta_0}\right) g\left(\frac{(E' - E)}{\sigma_E}\right)$$

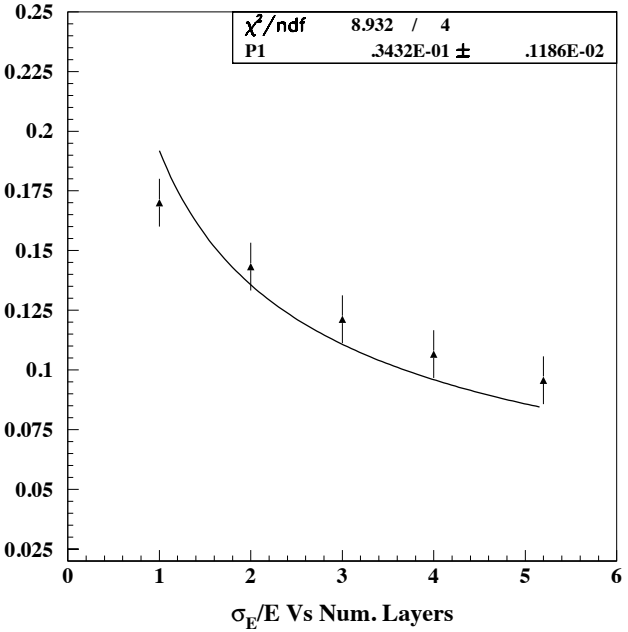
L(x) = Landau distribution

A = normalization factor

E_0 = most probable amount of energy released

Δ_0 = proportional to the Landau width

$\sigma_E(E)$ = energy resolution



ECAL test at FNAL

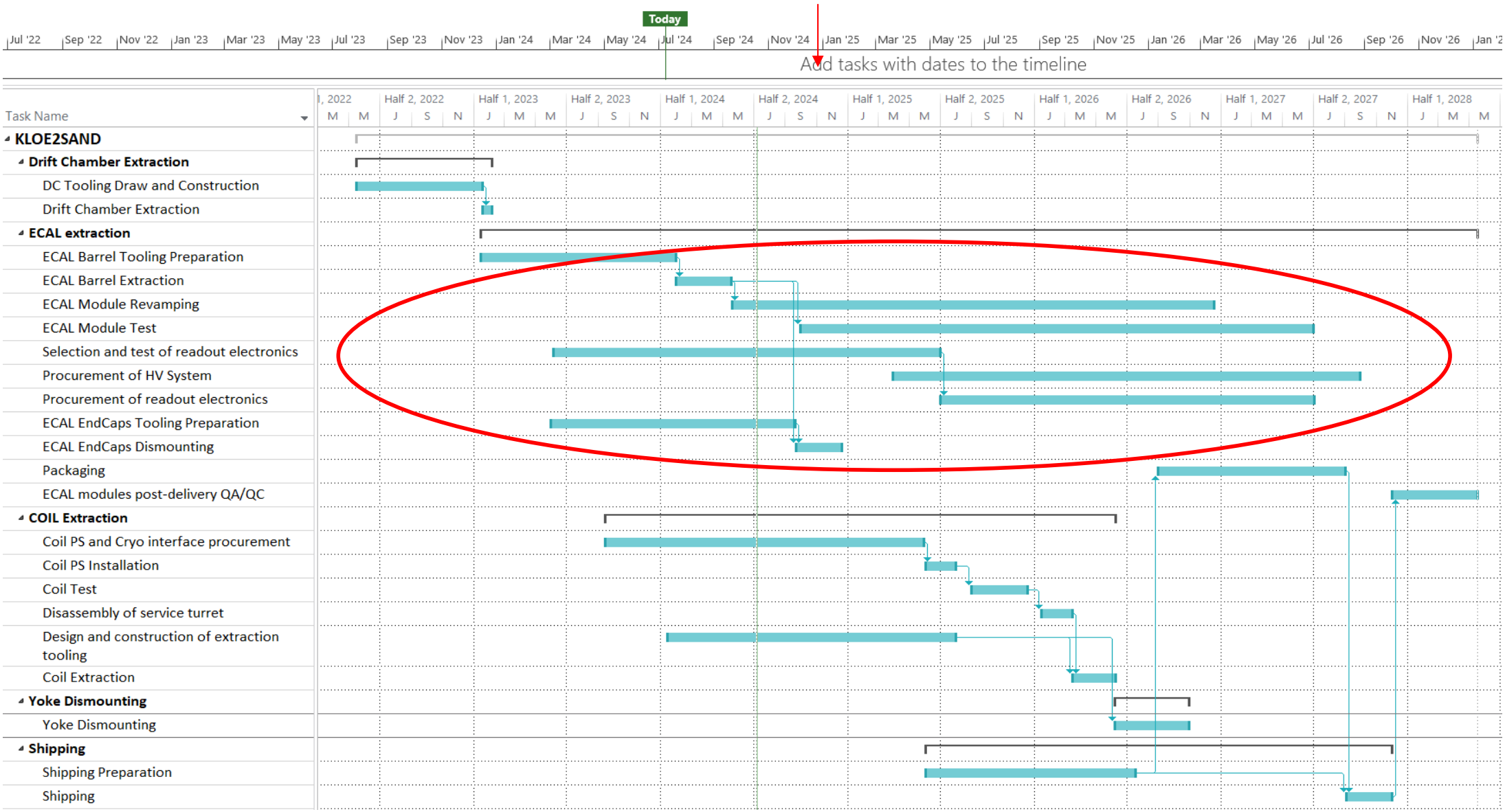
Upon arrival at Fermilab, ECAL modules will be stored in a proper area for barrel and equipped with a crane of 5 t maximum load for handling barrel modules, and 15-20 t for handling Endcap modules. A controlled temperature environment is required in the storage and test area of ECAL modules, avoiding thermal stresses and keeping temperature changes within about $\pm 10^{o}$C along the whole period.

The quality assurance (QA) and quality control (QC) operation will be performed repeating the tests on each module done at LNF. In particular, after re-installation of PMTs (shipped separately) in the ECAL modules, the ECAL module performance in terms of light yield, energy and time resolution using cosmic rays will be measured and checked again at a cosmic ray test stand, with the same equipment used at LNF, before installation in the SAND detector.

Storage area for barrel modules: ~50 m^2
Storage area for end-cap modules: ~60 m^2
Test area: 50-100 m^2 depending on the parallelization degree of the operations

spare slides

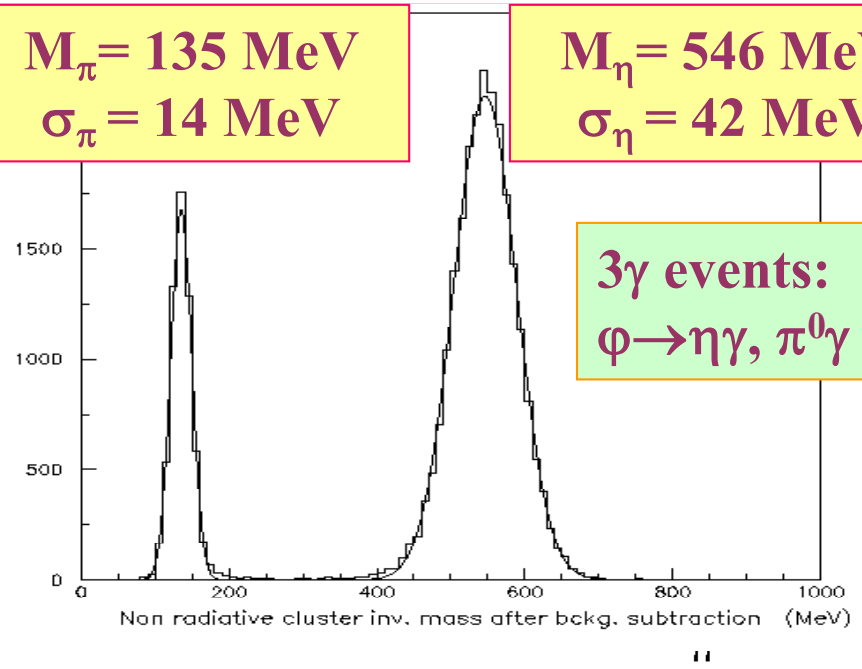
KLOE-to-SAND Project Time Schedule



Examples of mass reconstruction in KLOE

M_π= 135 MeV
σ_π = 14 MeV

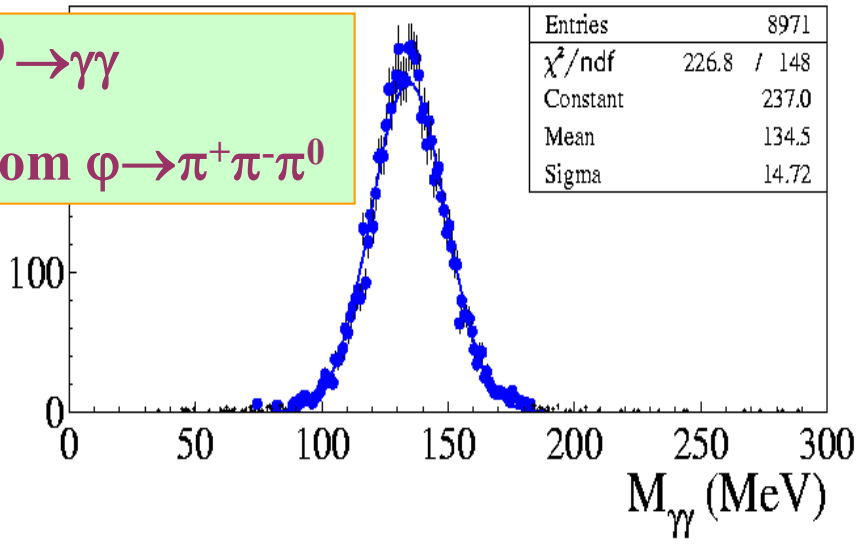
M_η= 546 MeV
σ_η = 42 MeV



3γ events:
φ→ηγ, $\pi^0\gamma$

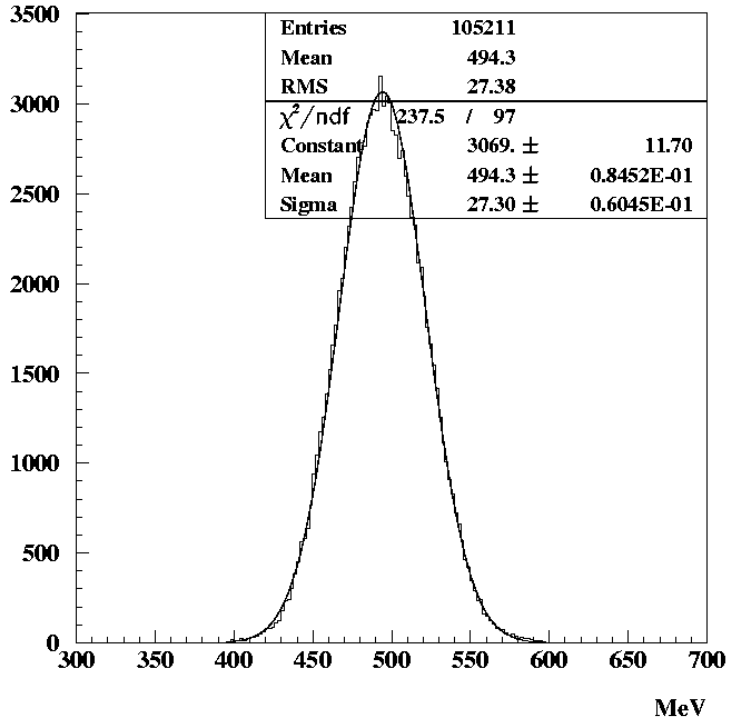
$\pi^0 \rightarrow \gamma\gamma$

from $\varphi \rightarrow \pi^+\pi^-\pi^0$



$K_s \rightarrow \pi^0 \pi^0$

M_K= 494 MeV
σ_K = 27 MeV



Mass reconstruction within 1%with PDG. Resolutions are in good agreement with MC expectation.