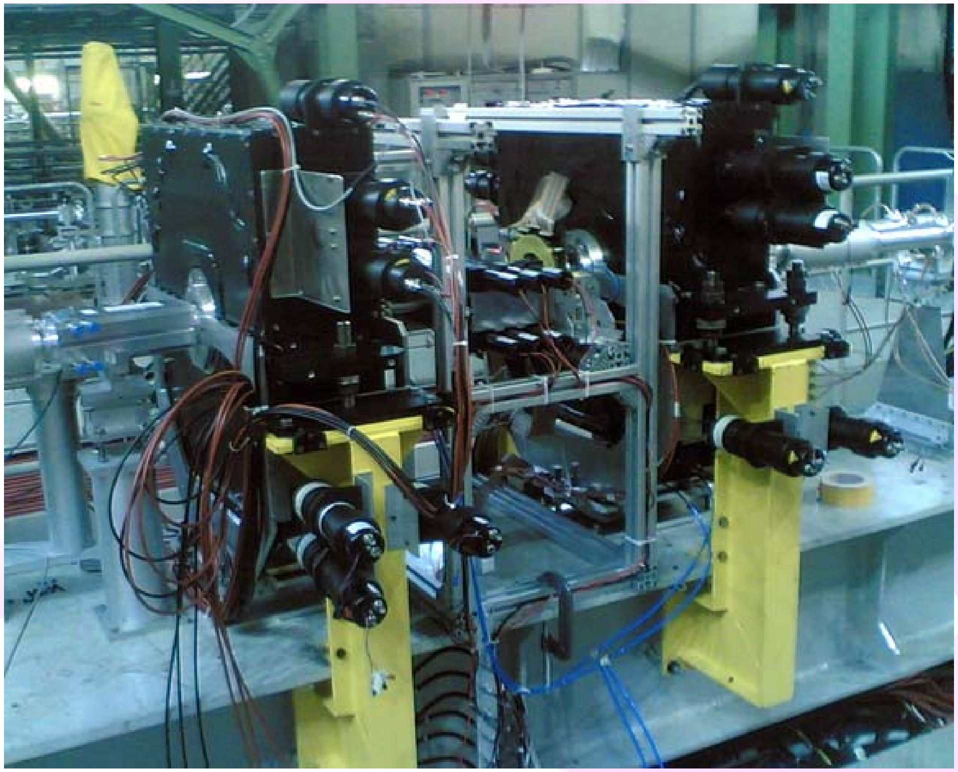
Calorimeter for absolute luminosity at upgraded DAΦNE



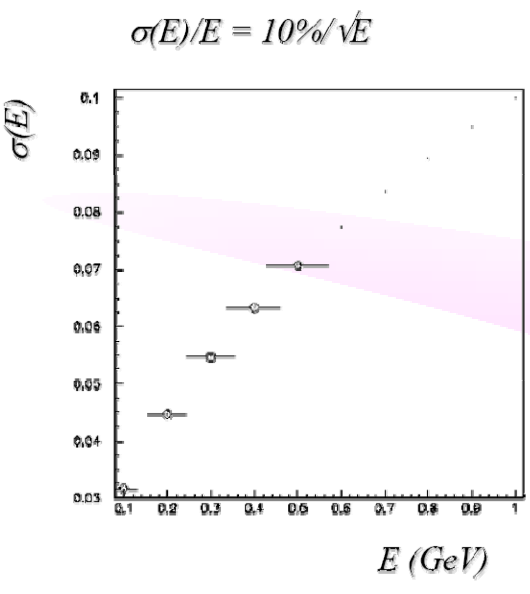
P. Branchini, 30 May 2008

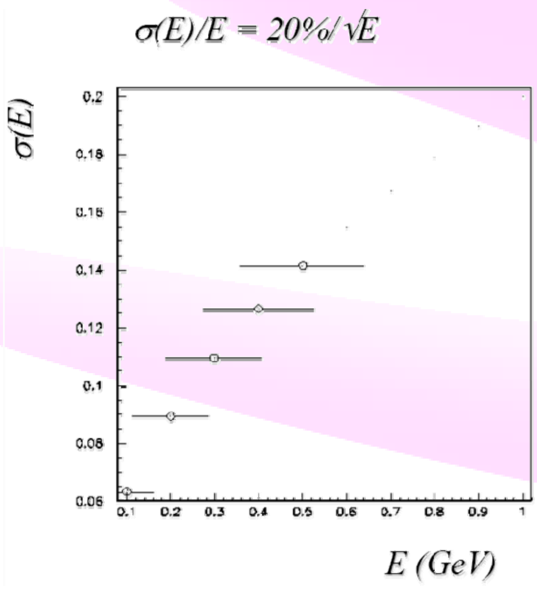
LumiCalo requirements:

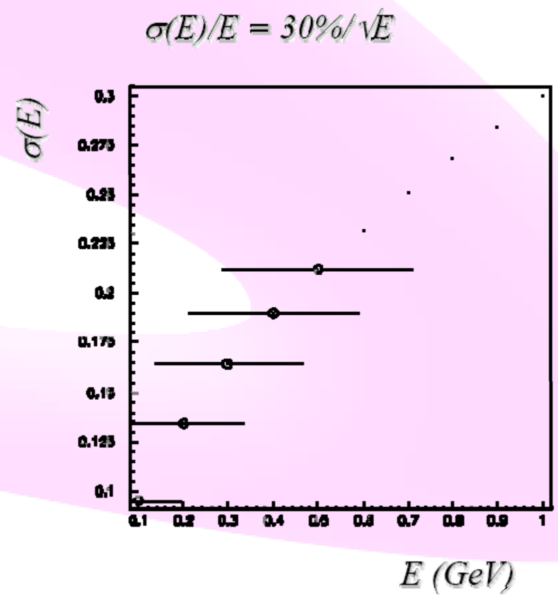
- *It should be able to clearly identify Bhabha events.*
- *It should provide time and energy information.*
- *It should be a self triggering device.*
- *It should be cheap.*

LumiCalo design: resolution

Back in Jan. 2007 we were discussing the kind of energy resolution that we would have desired, in order to separate Bhabha events with a cut on energy, e.g. at half energy of a Bhabha: ***250 MeV****.*
We established then a target resolution of about ***$\sigma(E)/E \sim 15\%/\sqrt{E}$***



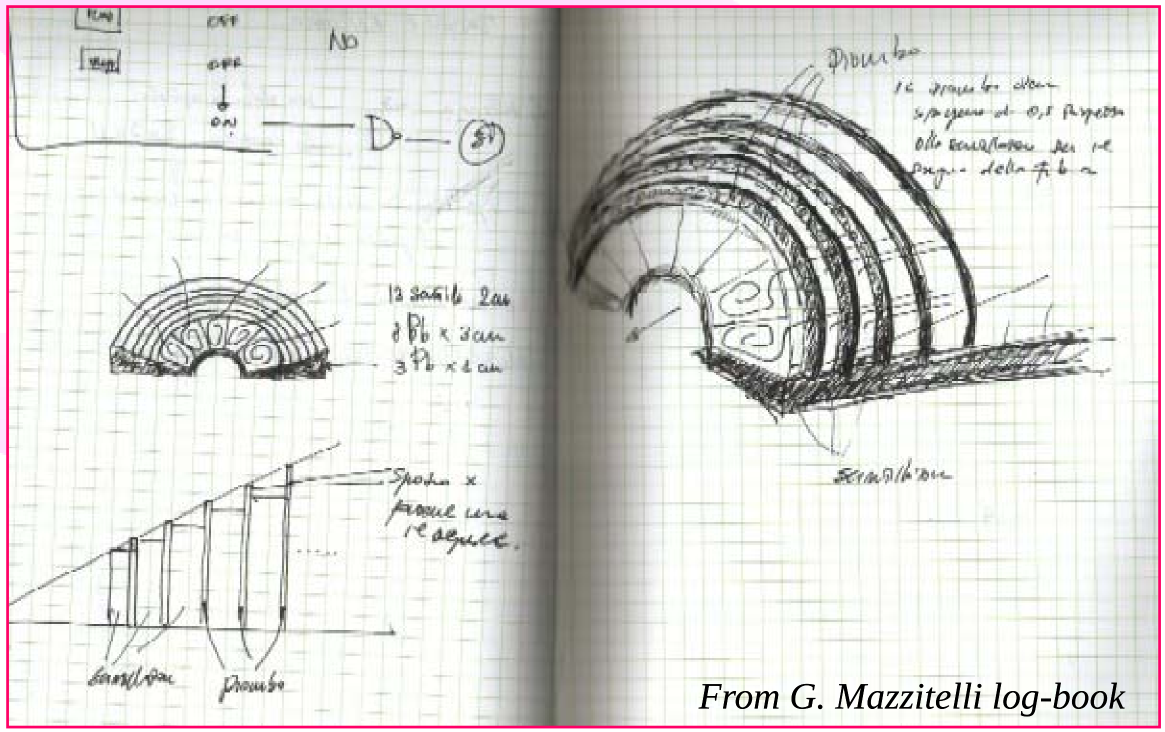




First design

Considerations that have driven the very first design of our calorimeters:

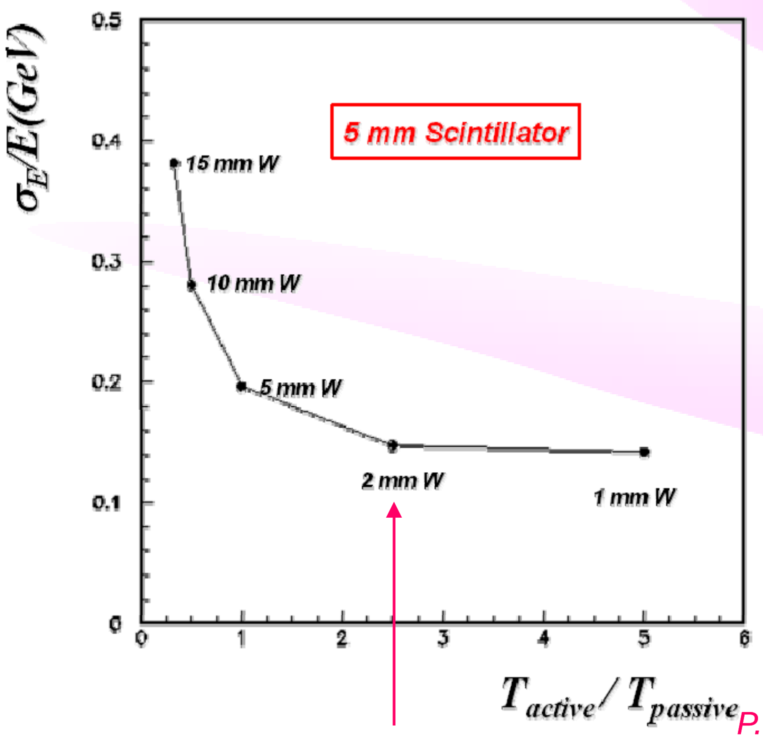
- *ring shaped around the interaction region*
- *well defined acceptance, especially in θ and at lower angles*
- *extend to minimum radius [quadrupole] and maximum θ [Siddharta]*
- *good ϕ coverage to maximize rate [for fast feedback]*
- *four half-rings, two on each side of the IP for simple back-to-back trigger logic*
- *$\sigma(E)/E$ ~ 20% at 510 MeV*

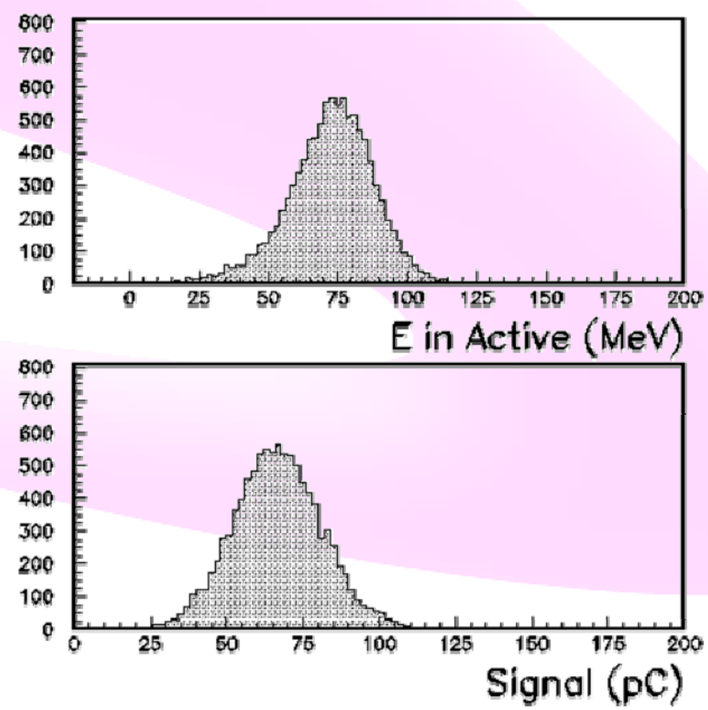


From G. Mazzitelli log-book

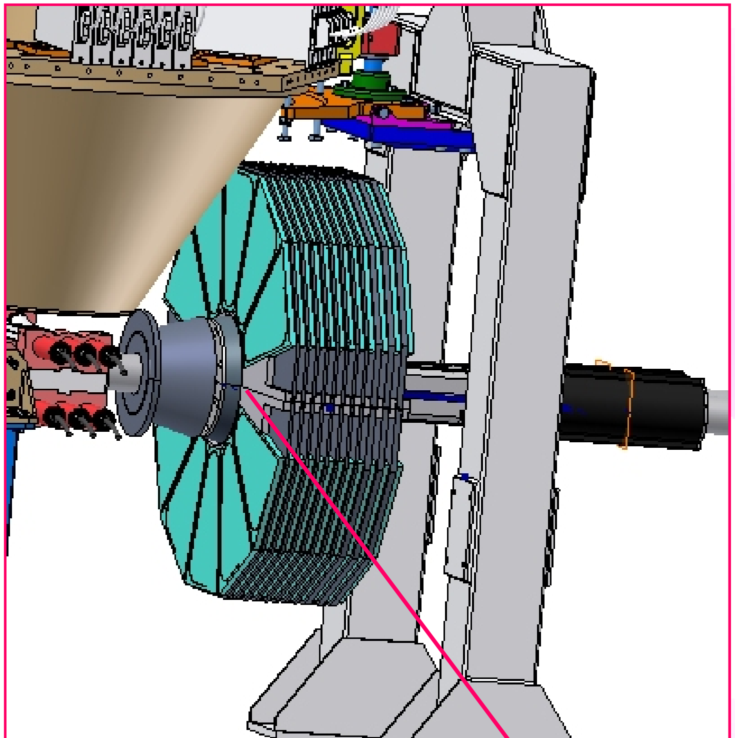
LumiCalo design: segmentation

- *Excluded the all-crystals solution, both for practical and budget reasons;*
- *Given the limitations on the total depth due to the presence of Siddharta and of the quadrupoles, we have optimized the sampling fraction of our calorimeter*
- *In the end, we used lead in place of tungsten mainly for budget reasons*





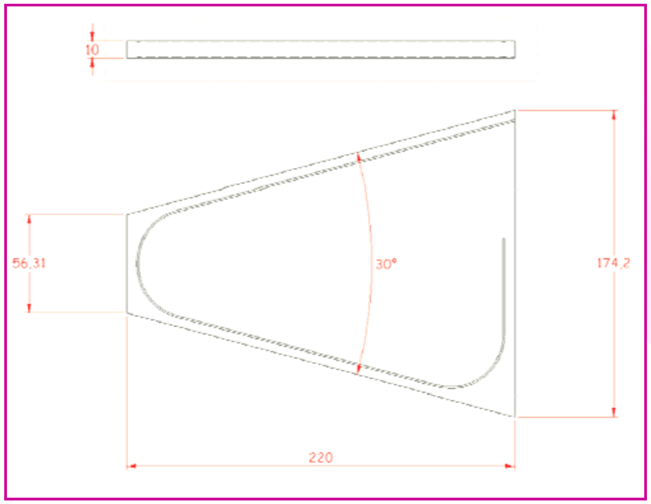
Final design



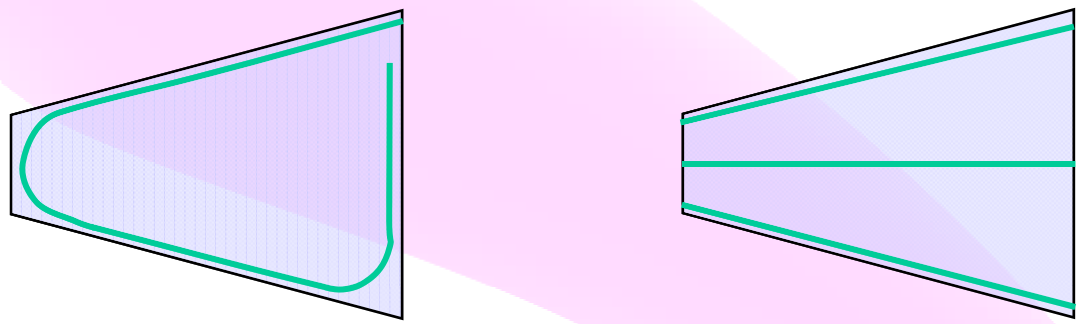
- *Longitudinal segmentation has been optimized keeping in mind that the total* ***available depth*** *is the length of the quadrupole* ***≈20 cm***
- *11 absorber plates + 12 samplings:*
  - *8×0.5 cm + 3×1 cm lead ≈12.5 X_0 should ensure* ***sufficient shower containment***
  - *12×1 cm scintillator*
  - ***2:1 active:passive ratio*** *should ensure* ***≈15%/√E(GeV) resolution***
- *Lateral segmentation dictated by the need of keeping a* ***reasonable number of channels*** *and to have some degree of freedom in defining the acceptance*

We decided to instrument only 10 out of 12 sectors, keeping out the ϕ=0º-180º plane, since we were expecting larger backgrounds from there

LumiCalo design: WLS fibers



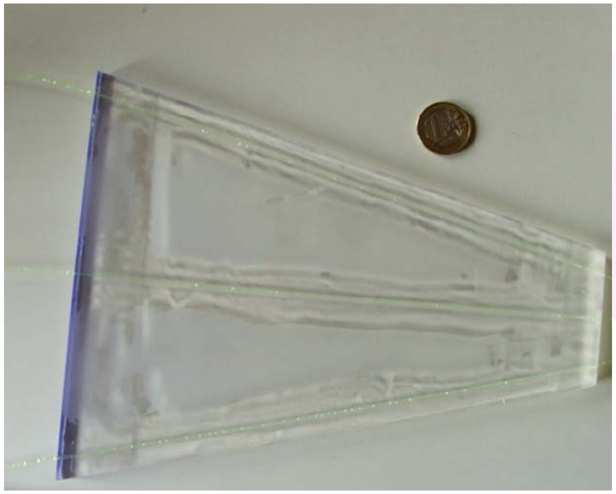
Finalized design of tiles: Feb. 2007.
We have chosen Protvino scintillator:
IHEP SC-307, 30 ph.el./MeV nominal light yield

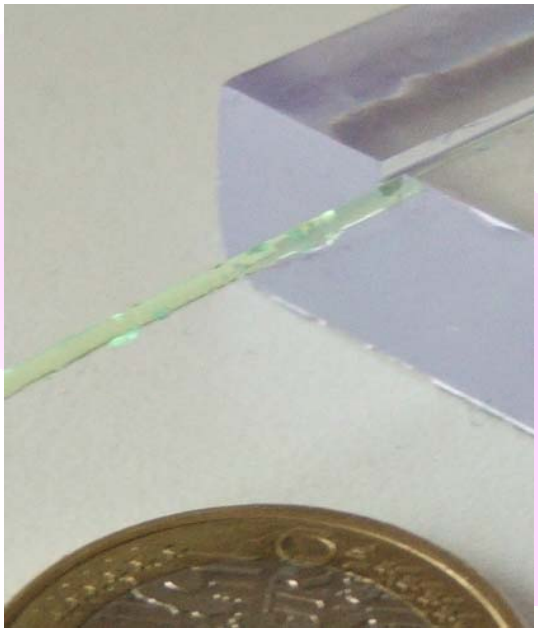


First design for wavelength-shifting fiber readout, sigma-shaped, changed to ***three longitudinal fibers*** *with the advantage of:*

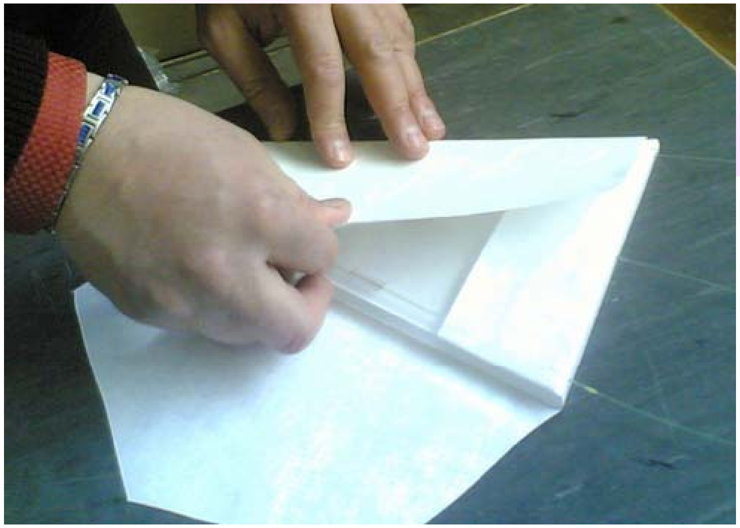
- *Simpler production of tiles with linear grooves*
- *Same or better light collection: shorter fibers, better collection by middle fiber*
- *Divide light from one tile on three fibers: less sensitivity to broken fibers*

Tiles and WLS fibers





***Groove** designed for optimal matching with 1.0 mm fibers 2 mm depth, 1.1 mm diameter*

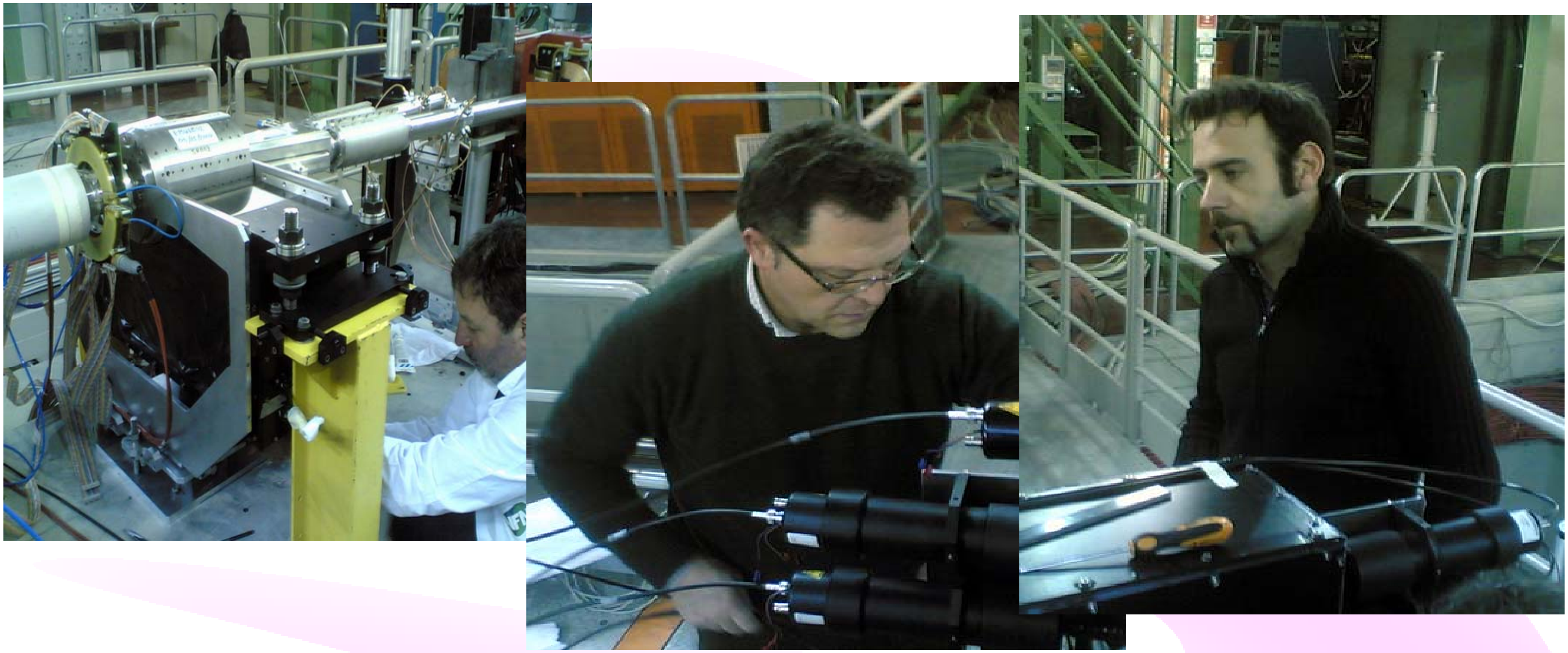


Each tile wrapped with Dupont Tyvek^{TM} sheet to improve light collection

CaloLumi construction

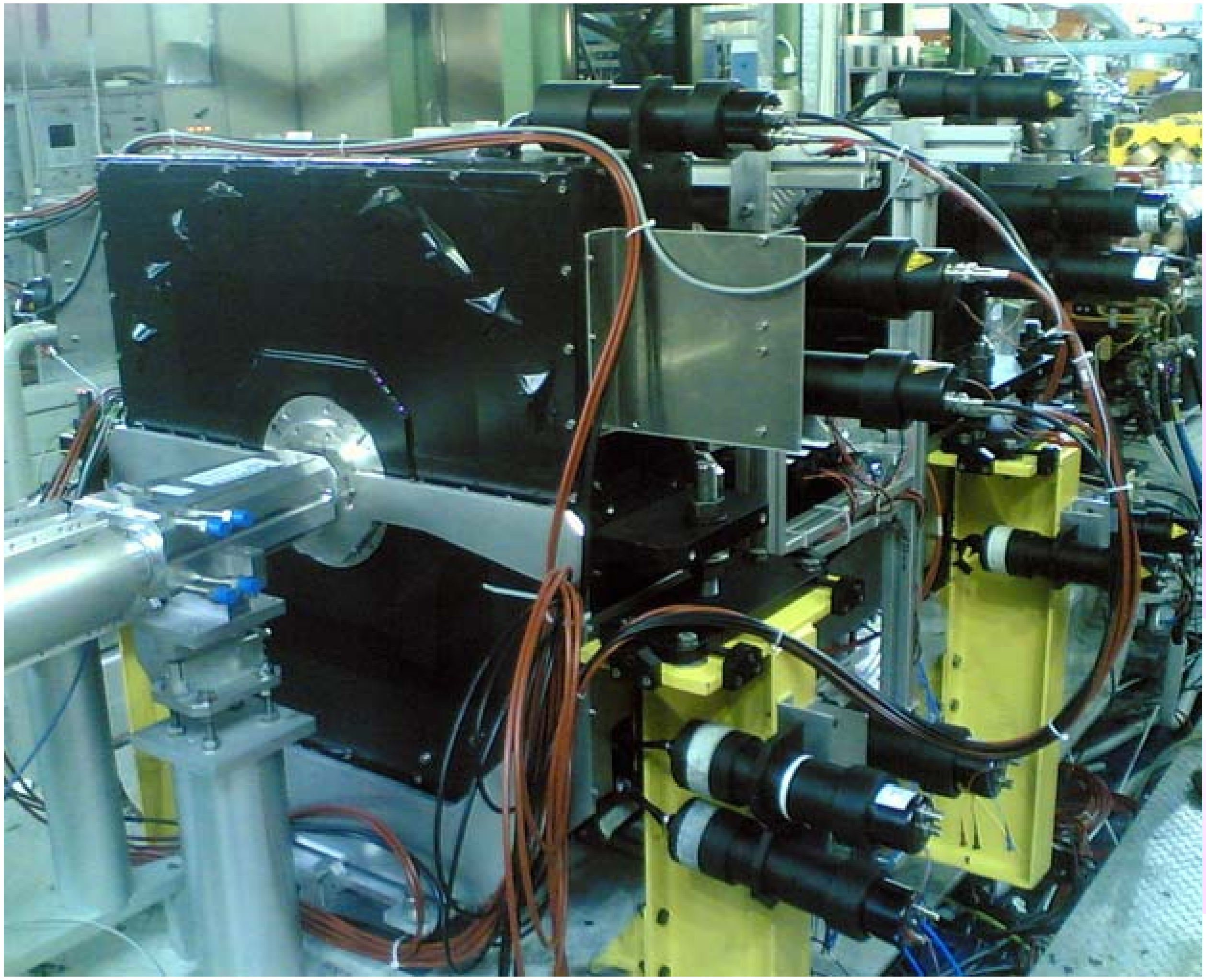
The mechanical structure and all the details have been realized by the Frascati workshop many thanks to: Luciano Iannotti, Vittorio Romano and G. Sensolini.

CaloLumi installation

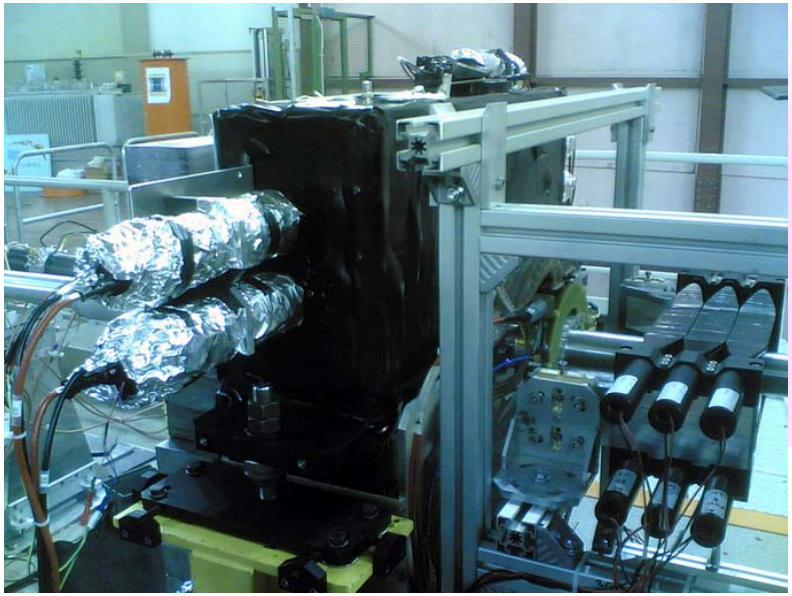


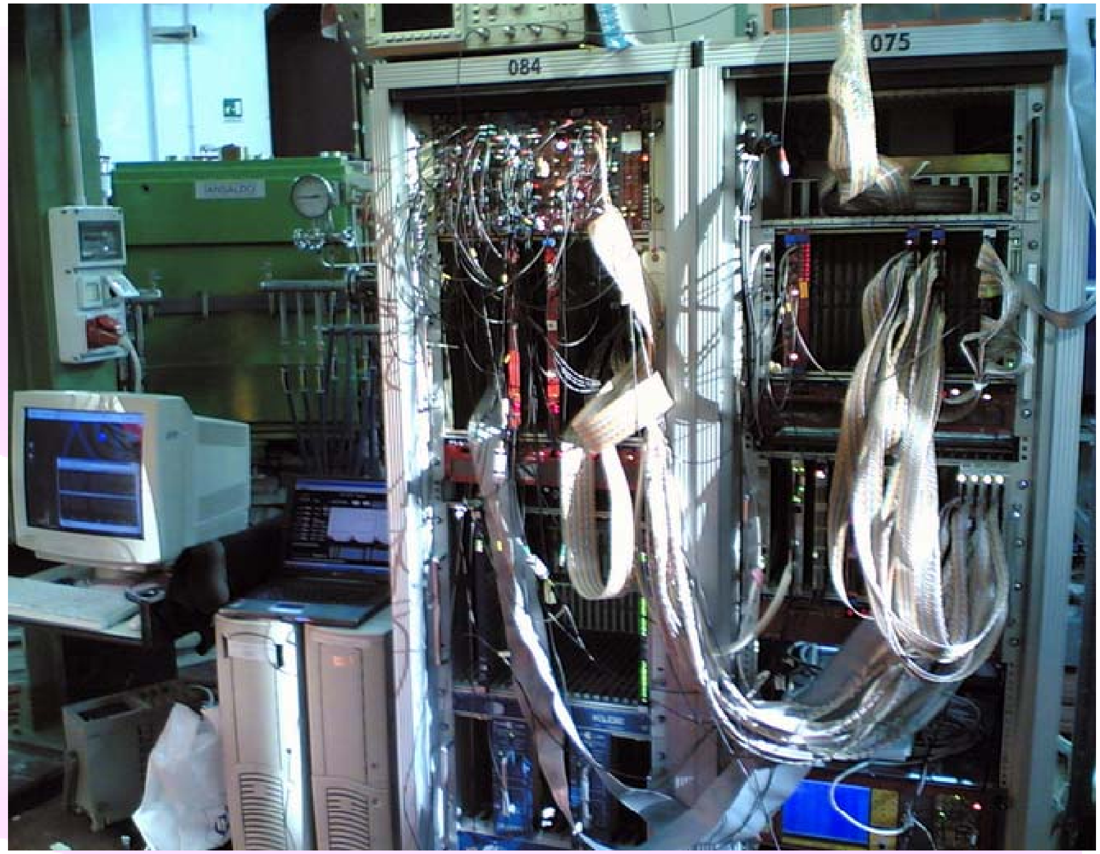
Cables and all connections for front-end electronics have been realized by Oscar Coiro and Claudio Mencarelli

CaloLumi installed



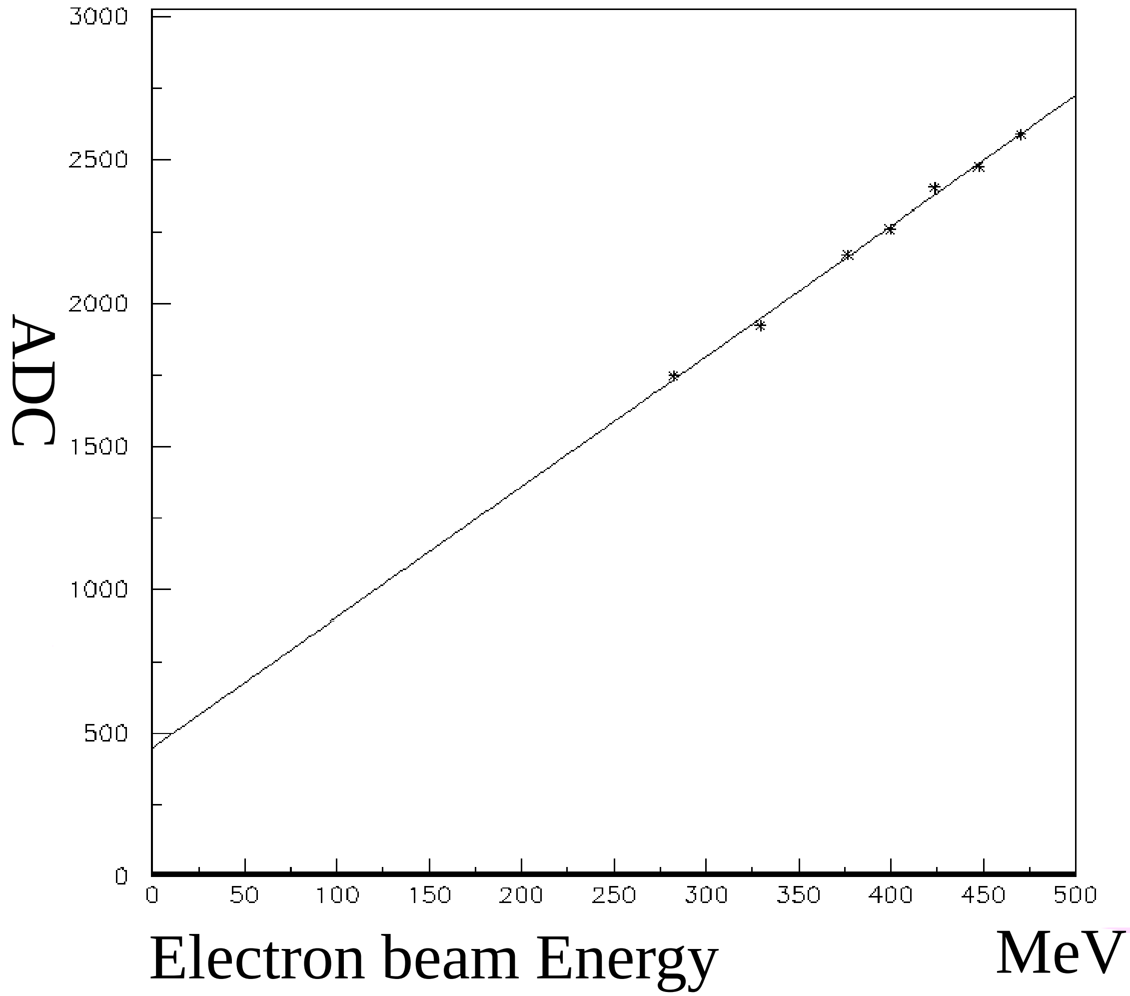
CaloLumi DAQ





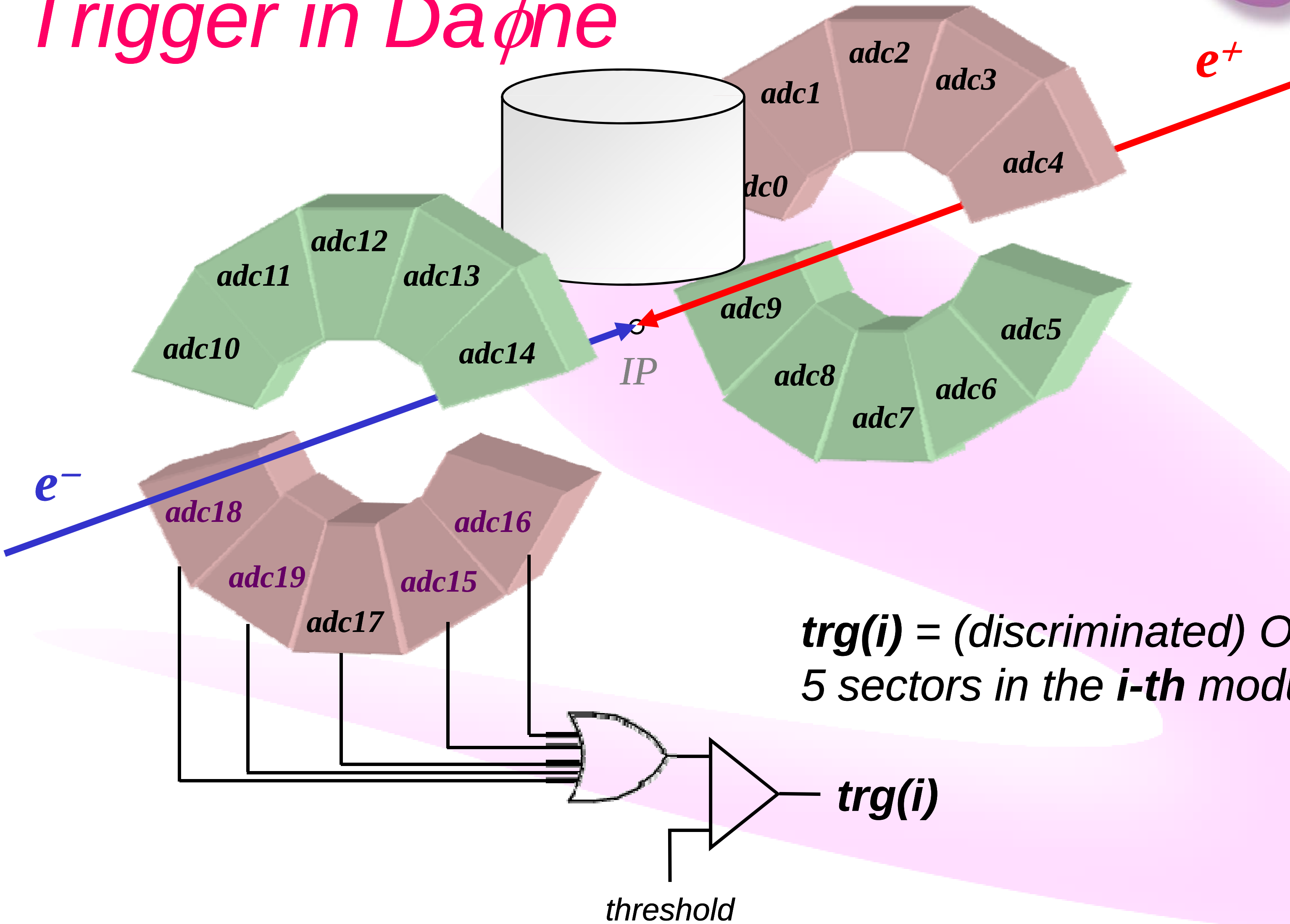
The DAQ is based on the KLOE system. The analog signal is split, we acquire charge and time and we also use the signal from the pmts to assert the trigger.

Linearity



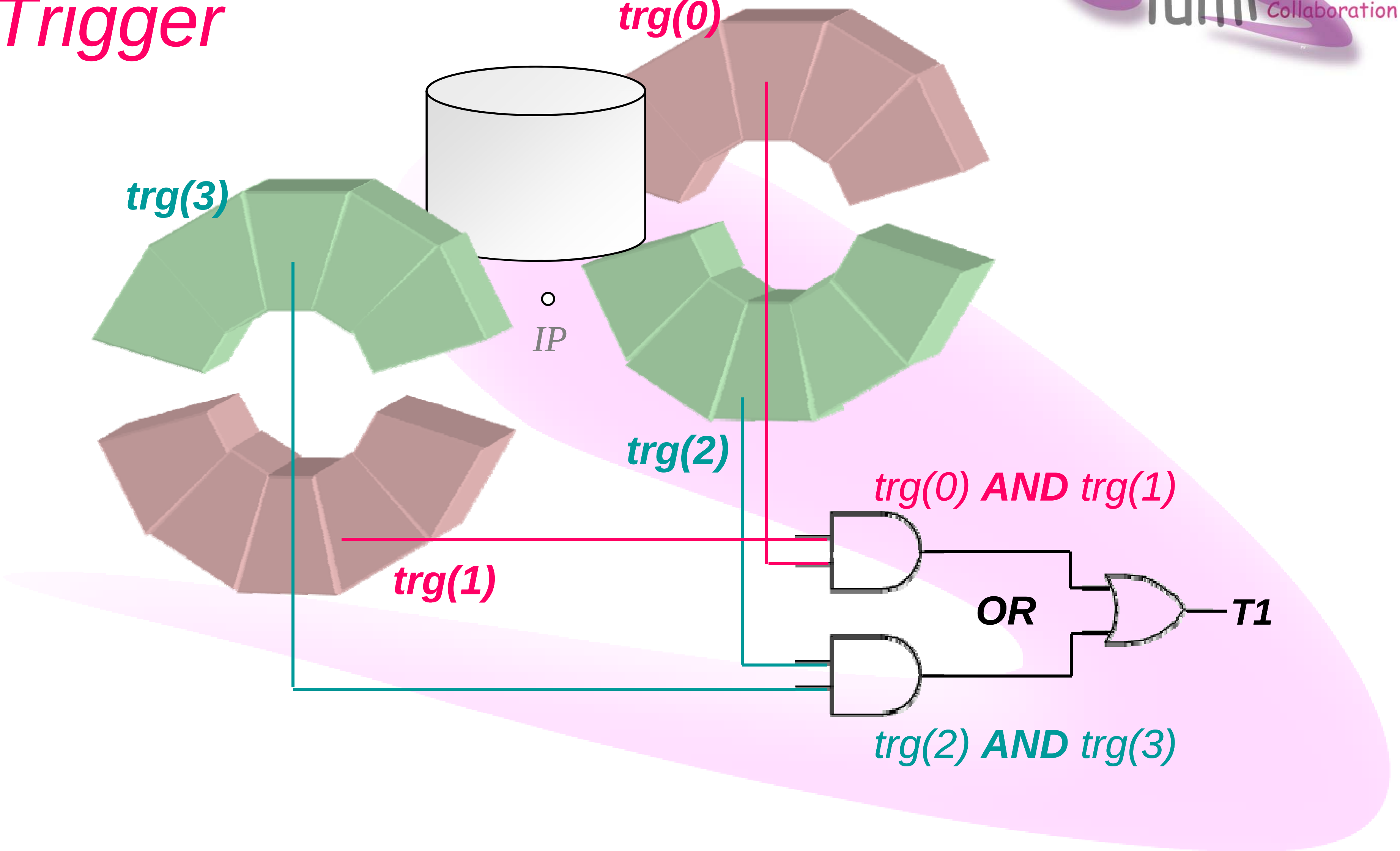
Module 0 btf calibration results.
The trigger asserted used the rf signal from the linac.
Energy resolution was in agreement with MC estimates.

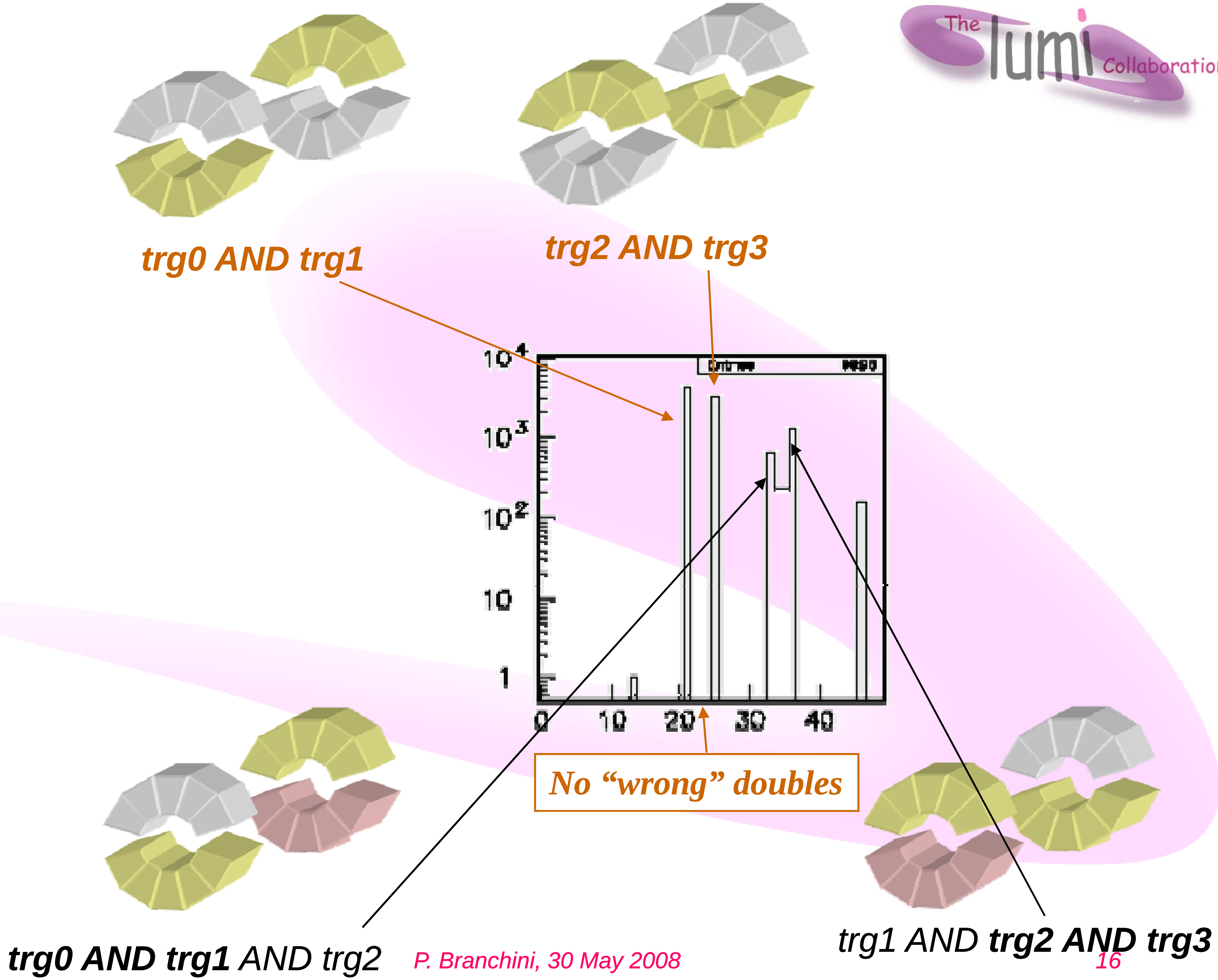
Trigger in Daϕne



trg(i) *= (discriminated) OR of the 5 sectors in the* ***i-th*** *module*

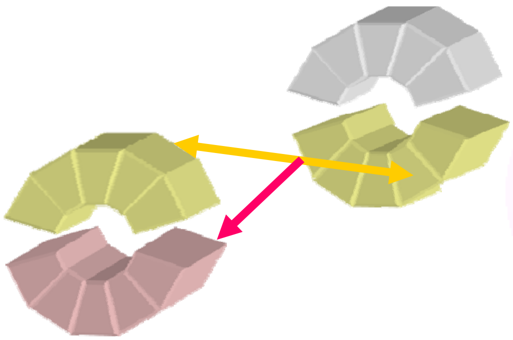
Trigger



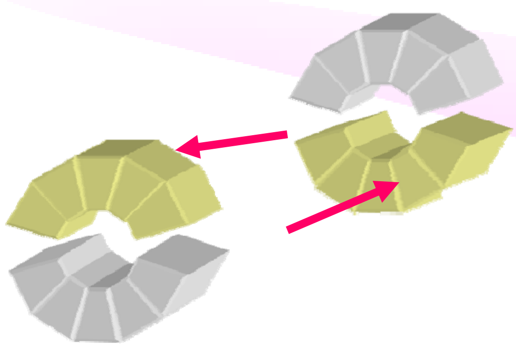


trg0 AND trg1
trg2 AND trg3
10^4
10^3
10^2
10
1
0
10
20
30
40
No “wrong” doubles
trg0 AND trg1 AND trg2
trg1 AND trg2 AND trg3

Background



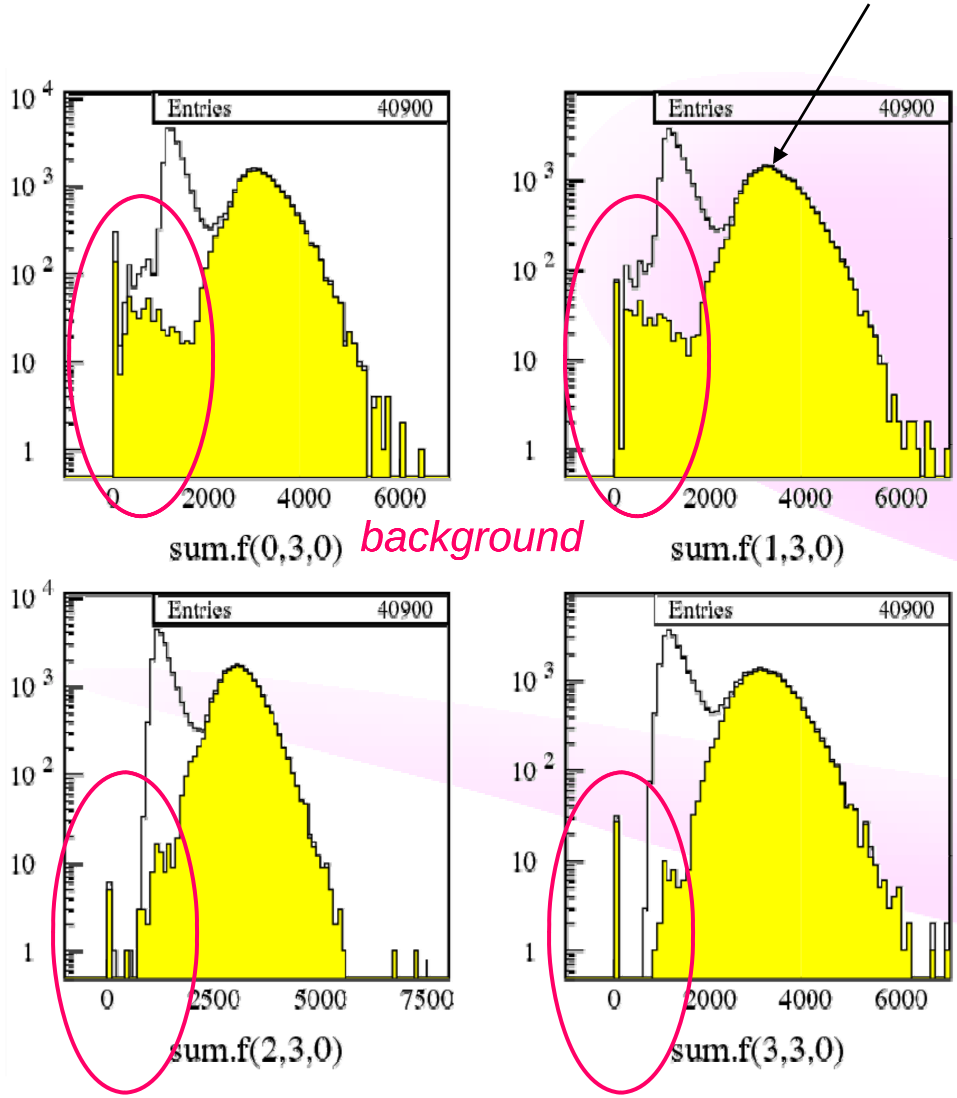
We can have energy deposits over threshold in another module, in addition to the couple of triggering modules: this gives us the "triples"



We expect a similar level of events with no Bhabha, but with ***two*** *"spurious" deposits, giving a fake coincidence*

Background

Bhabha peak



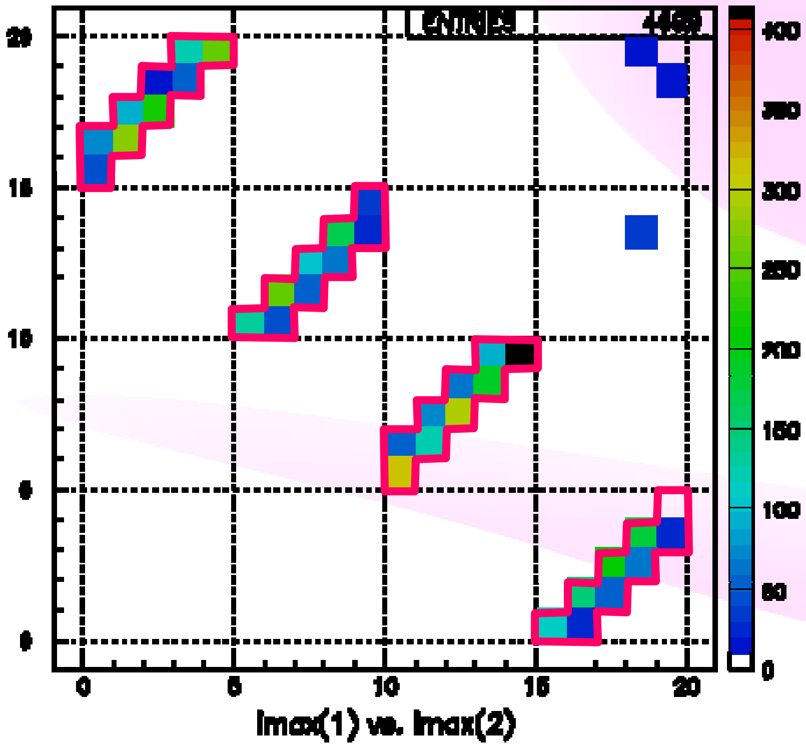
$$\sum_{i=0,\ldots,4}(ADC_i - \langle PED \rangle_i)$$

*Indeed **not all** the triggering events look like Bhabha events…*

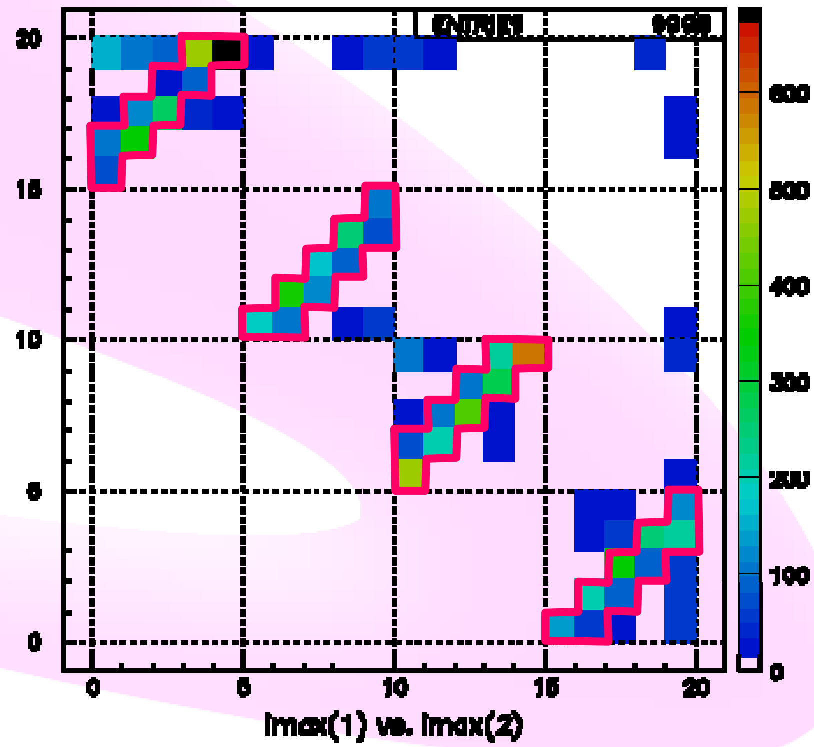
Background topology

imax(1) = sector with most energy
imax(2) = 2nd most energetic sector

Diagonals=back-to-back sectors + neighbor



1+1 bunches

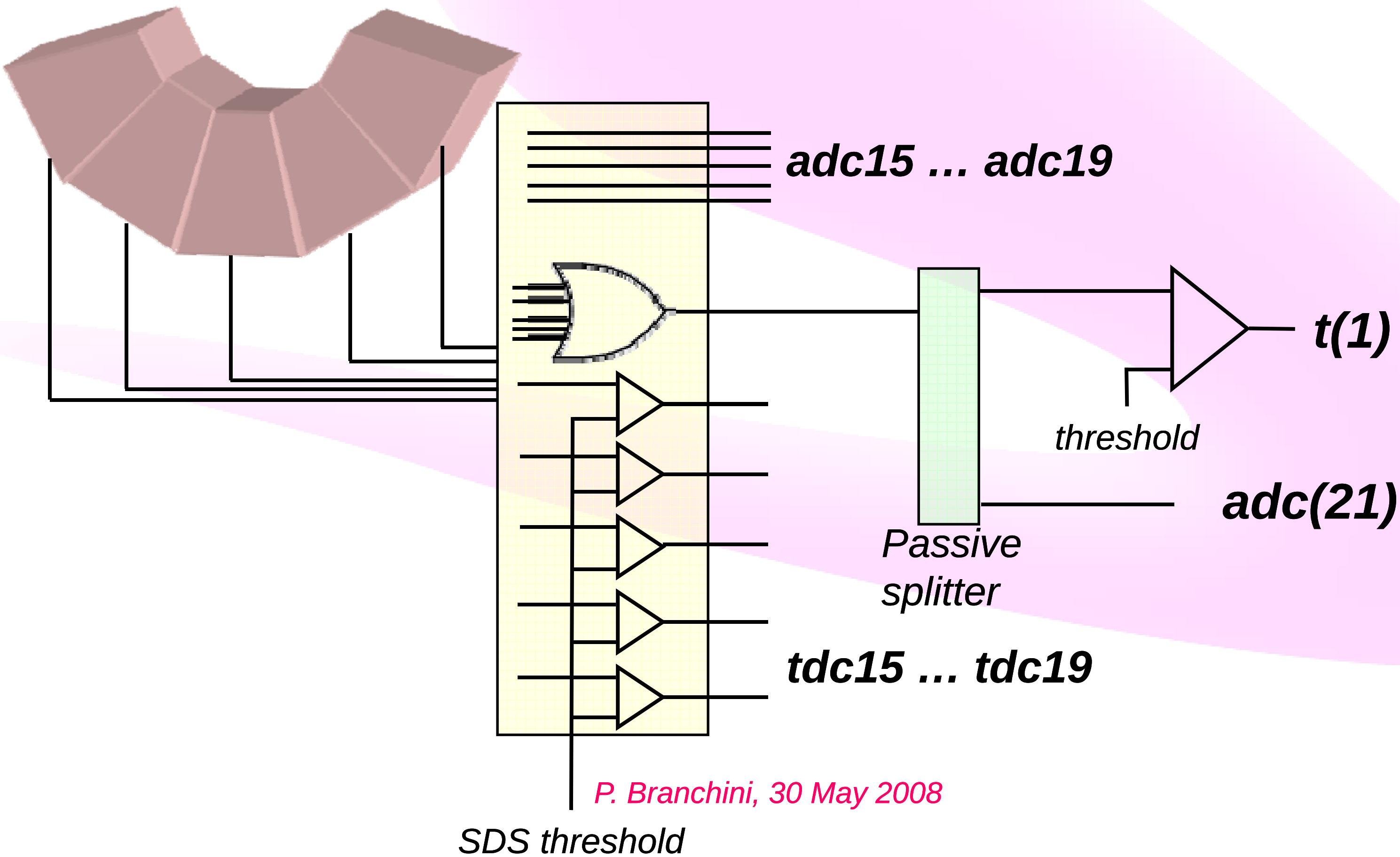


100+100 bunches

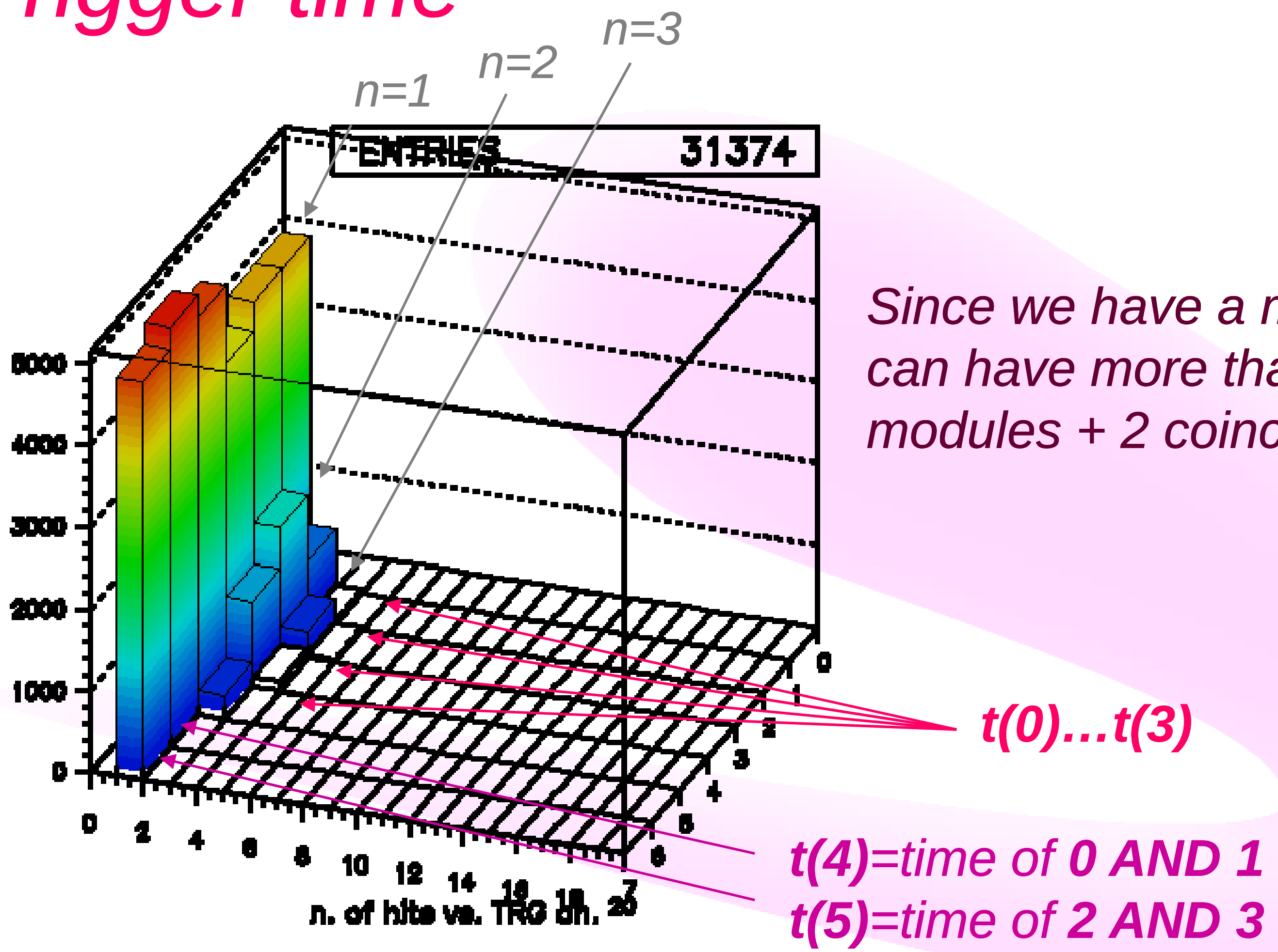
Time

Let's give a look at the time information:

- *Time of single sectors is available*
- *We can also use the time of analog sum of the five sectors in **each** of the 4 modules*



Trigger time

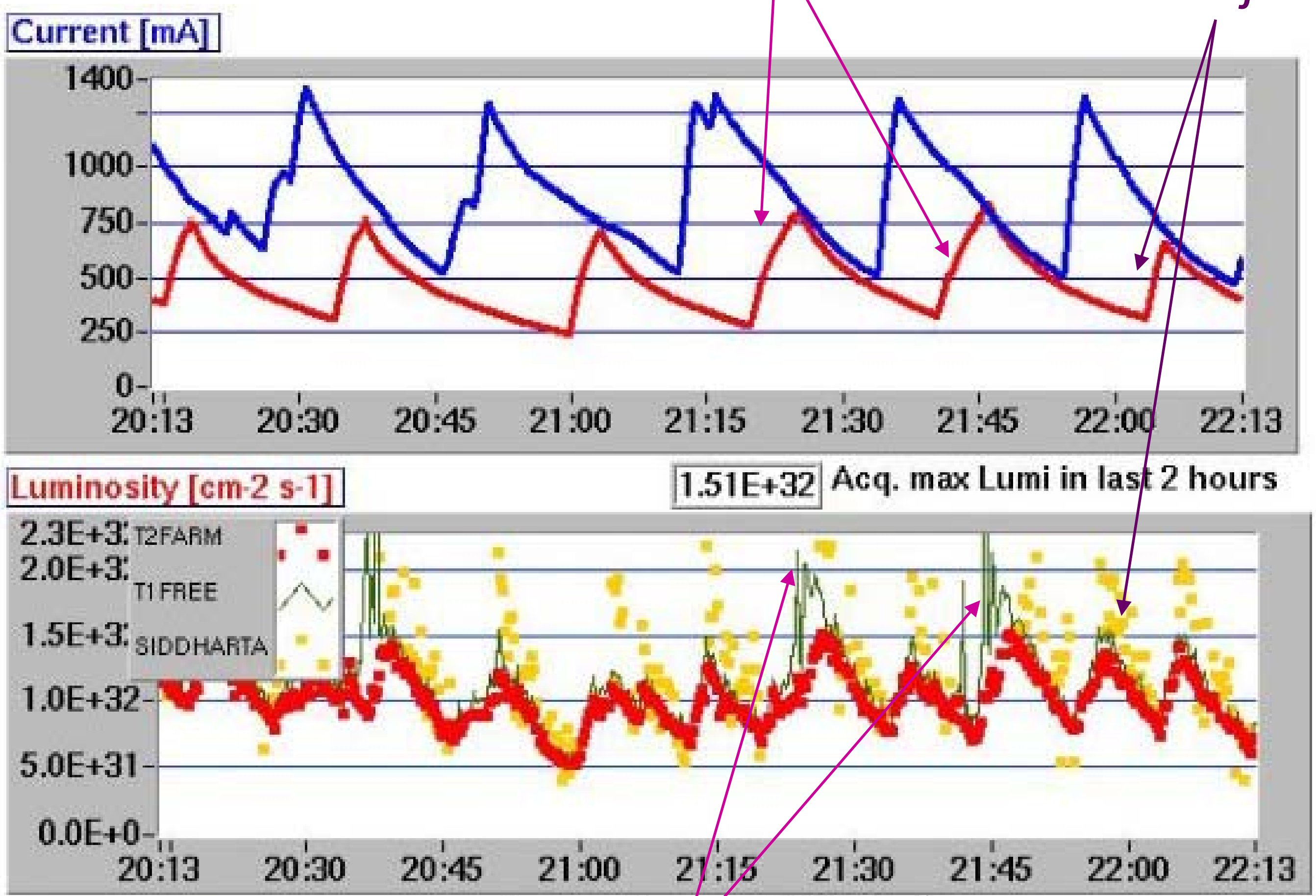


Since we have a multi-hit TDC, we can have more than 1 hit for the 4 modules + 2 coincidences

*Choose the **largest time** [the one closest to the COMMON STOP]*

Bad e^+ injections

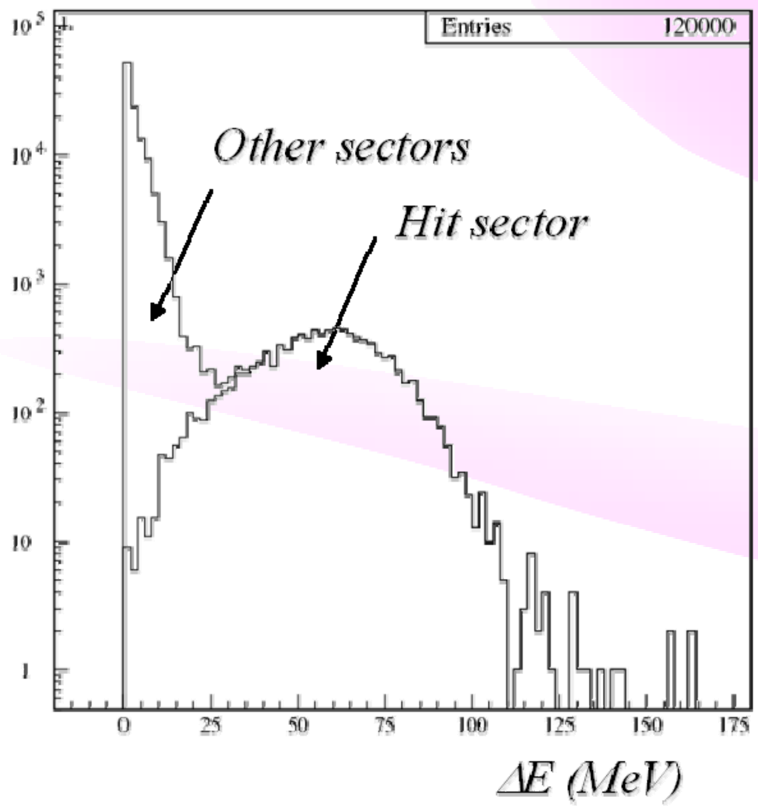
Good e^+ injection



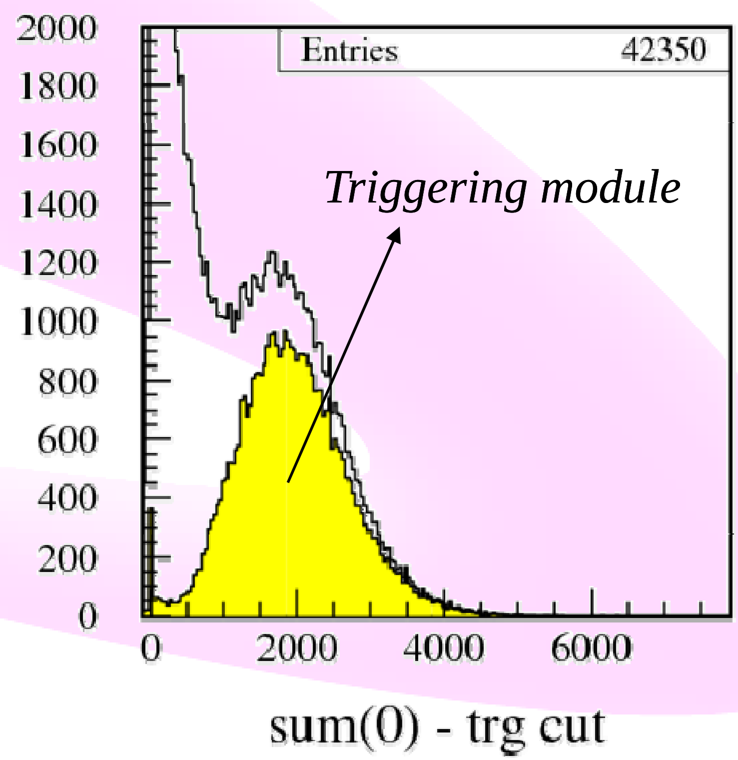
Bad e^+ injections

Energy deposit

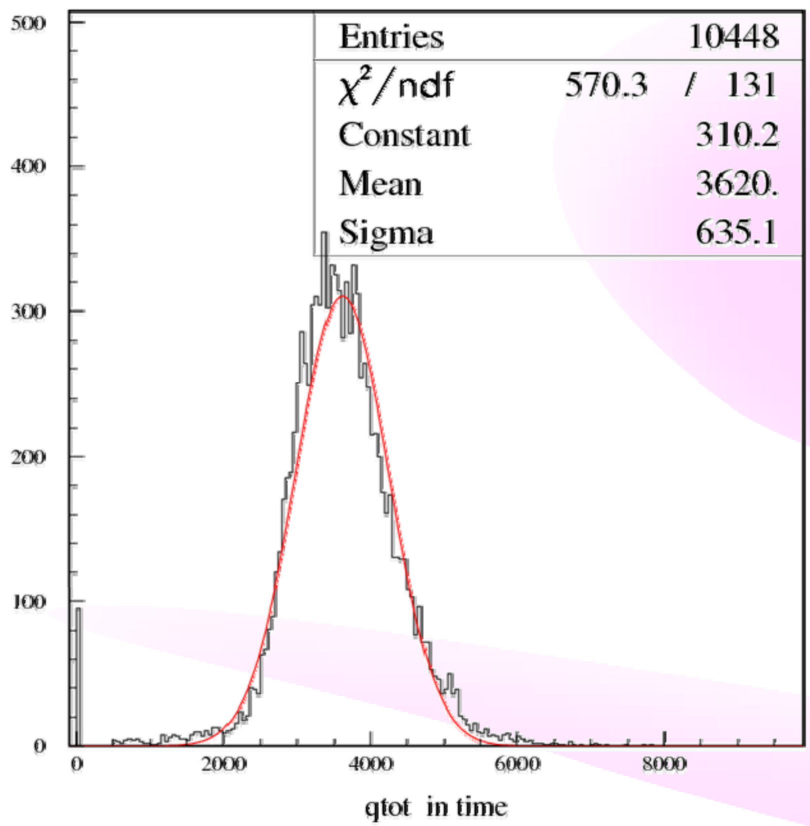
Feb. 2007 first Monte Carlo, 1 e-, 510 MeV



Sum of 1 calo module, after pedestal subtraction



Energy resolution



Measured resolution with Bhabha events: 17.5% at 510 MeV, which translates to ***12.4%/√E(GeV)***

Conclusions

- *The main **design specifications** seem to be met in a very satisfactory way…*
- *The construction and installation of the detector modules was **quick** and **very effective**, thanks to the contribution of many technicians of the Div. Acc. and Div. Ric.*
- *Luminosity delivered online, on the basis of our Monte Carlo acceptance, with good accuracy.*