Calorimeters' system Status and Plans

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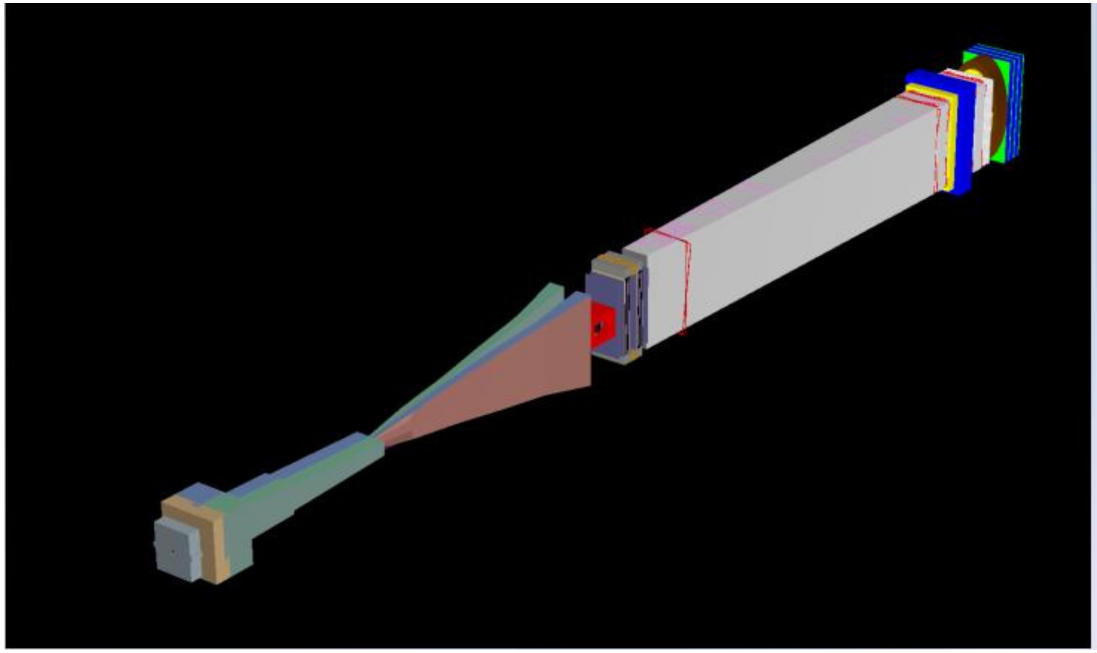
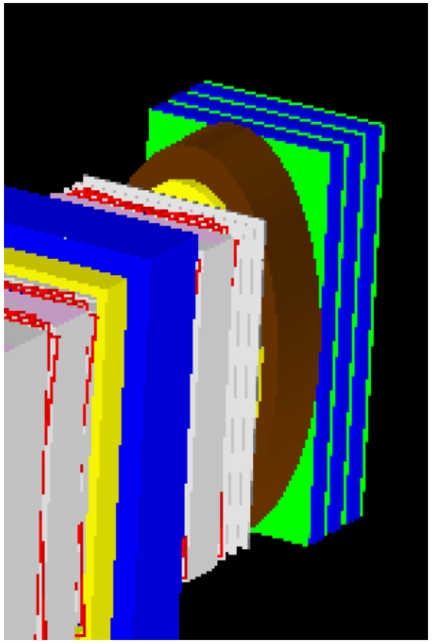
Outline

- Status
  - Current software status and upgrades
- Ideas on new designs
  - Preshower
  - Digital calorimetry
- Summary

Tuning with SHiP geo

- Rectangular vessel → rectangular calo





- For backward compatibility, Calos are simply extended to cover a rectangular area: shashlik modules everywhere (baseline option)
- With «optimal» cluster position reconstruction

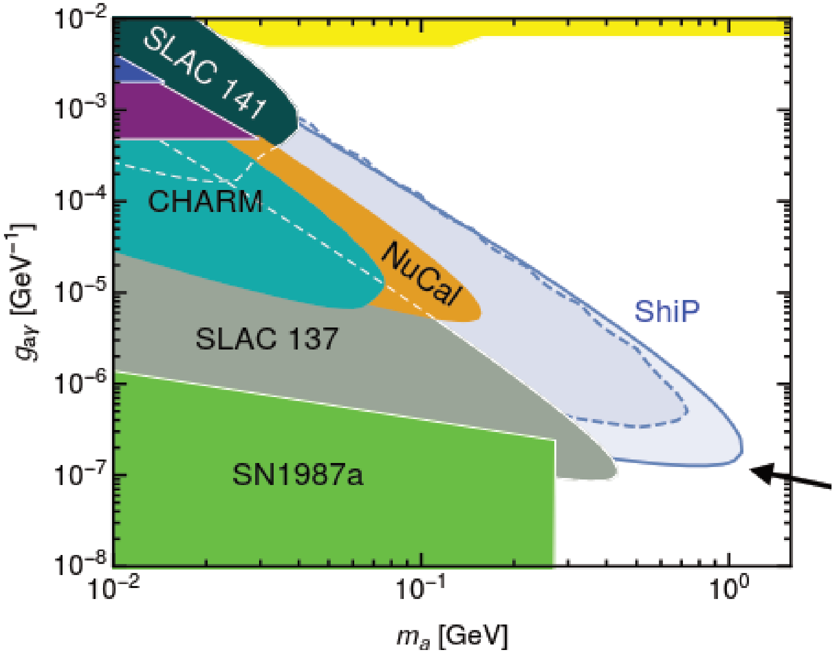
Ideas on new designs

- Driving wishes
  - Reduce overall costs
  - Balance between cost and performances
  - Enlarge the physics reach of calos

- Constraints/requirements
  - Which performance do we really need/want?
  - Energy resolution? Spatial resolution? Longitudinal segmentation? Shower directions? Particle identification capabilities?

All neutral channel(s)

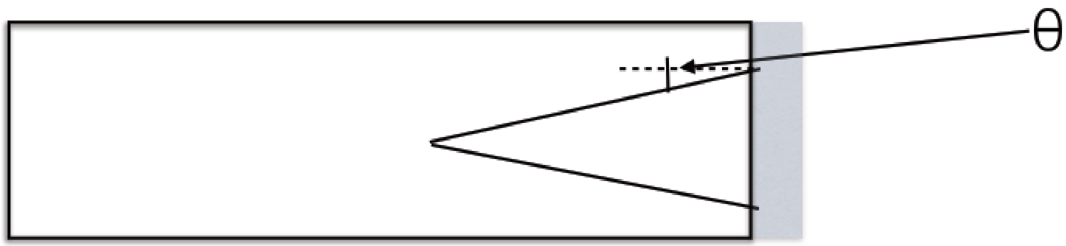
- Axial Like Particles → $\gamma\gamma$



W. Bonivento

First indications are promising … need a detailed simulation to check the feasibility with a realistic detector. Need a complete system: preshower or new calo, and full reconstruction.

Sample results

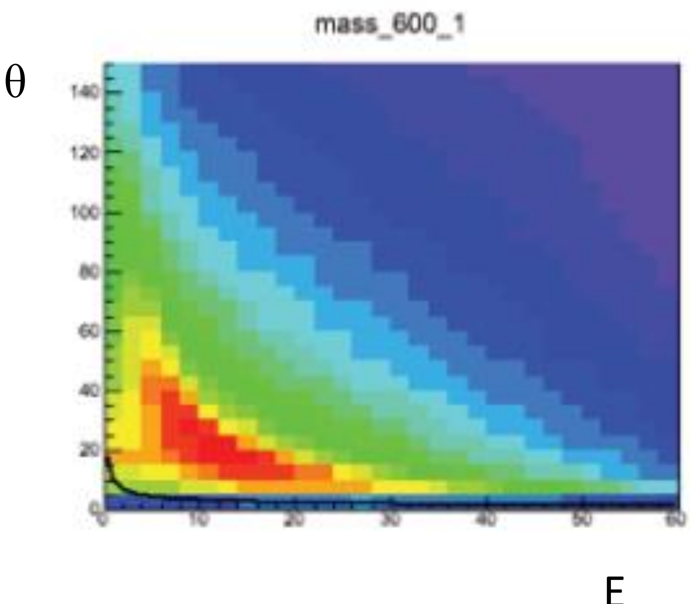


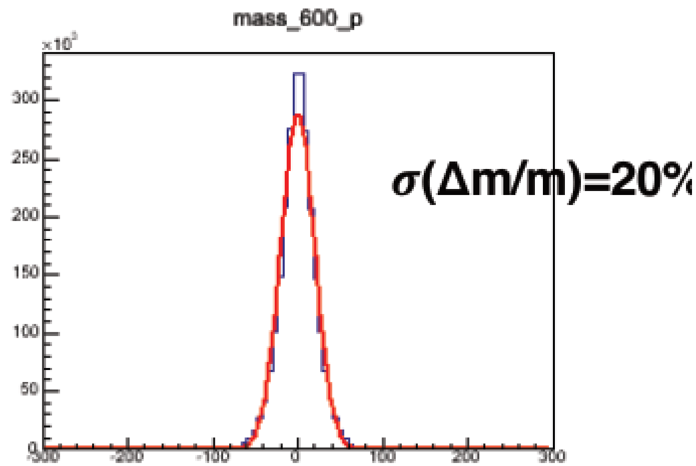
Expected resolutions:

$$\frac{\sigma_E}{E} = \frac{10\%}{\sqrt{E}} \oplus 1\%$$

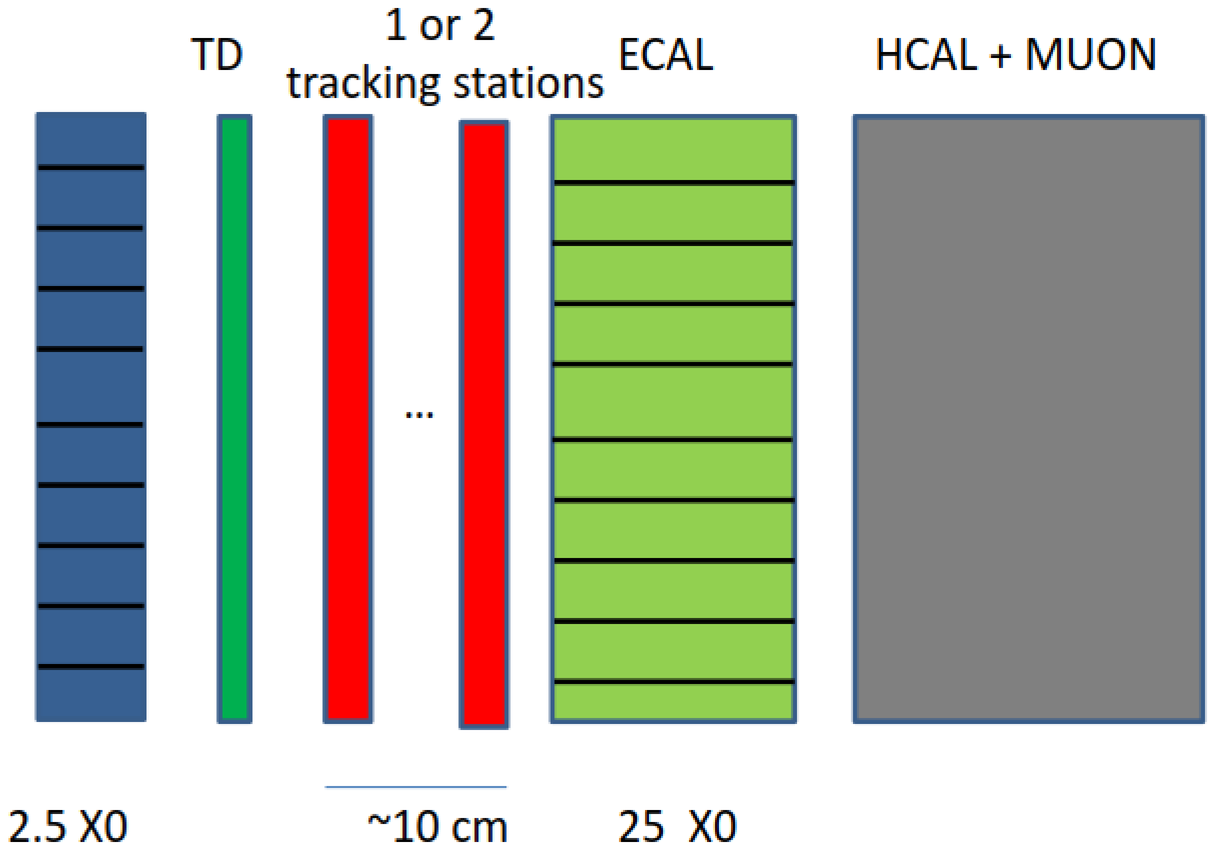
$$\sigma_{x,y} = \frac{1.35cm}{\sqrt{E}} \oplus 0.28cm$$

$$\sigma_\theta = \frac{10mrad}{\sqrt{E}}$$





A possible set-up with preshower



σ x,y	TP	100 μm	20*20 cm2
σ t	TP		
σ q	10 bits		

J. Chauveau

Side remarks

- Preshower or not, most of the costs come from using the shashlik technology
  - Tuned for high occupancy environments (hadronic colliders)
  - Very nice energy resolution and spatial resolutions (order of a fraction of cell size)
- In SHiP:
  - No requirements on occupancy (small:3-4 signals on calo per event)
  - Energy requirement might not be so crucial; provided that PID can keep efficiency and rejection power →algorithm dependent

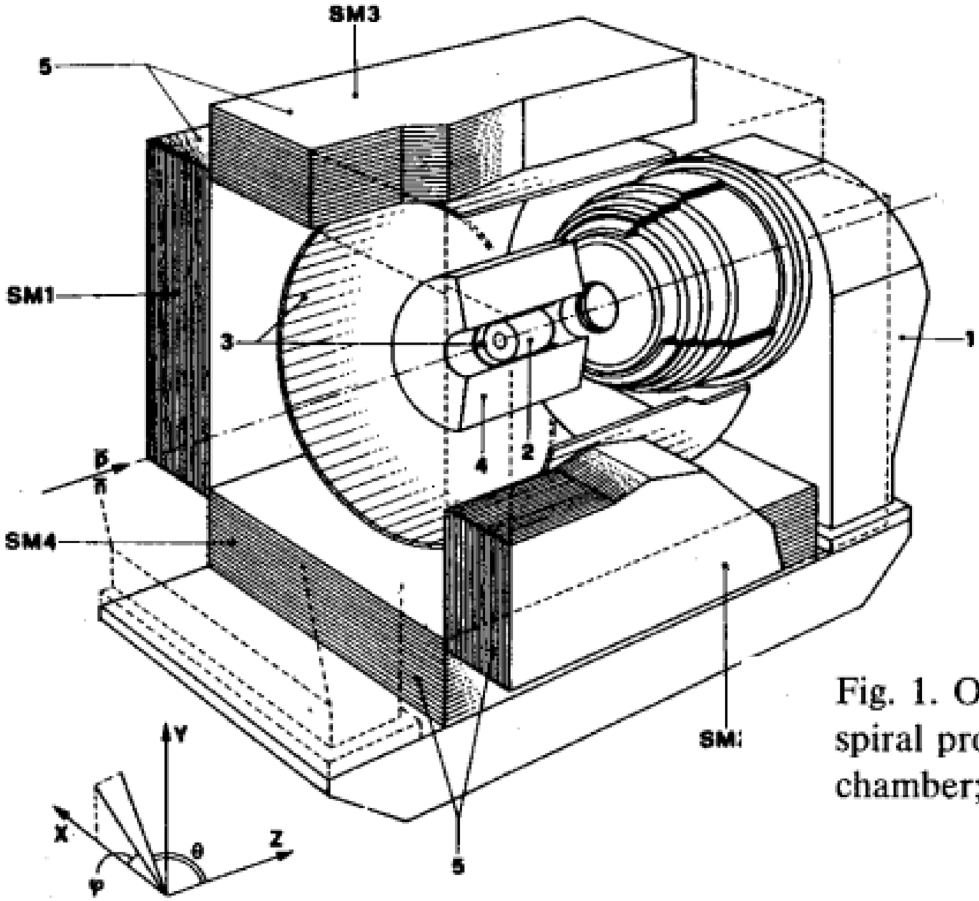
Digital calorimetry

- Some examples on Hadron digital calorimetry
  - DHCAL – Calice collaboration (R&D)
    - Sensors: RPCs, Micromegas (but also other sensors tested)

- Few examples on EM digital calorimetry:
  - HARGD (used)
    - Sensors: electrodes on Limited Streamer Tubes
  - TeraPixel Active Calorimeter (R&D)
    - Sensors: MAPS

OBELIX experiment PS201   (1990-96)

- Devoted to proton-antiproton annihilation at rest (in gas or LH2)
- Gamma energies below 2 GeV



4 Calorimeter modules:

Dimensions:

4 m x 3 m x 80 cm

Fig. 1. OBELIX spectrometer: 1: open axial field magnet; 2: spiral projection chamber; 3: time-of-fligth system; 4: jet drift chamber; 5: electromagnetic calorimeter (SM1–4: left, right, top and bottom SMs).

Calorimeter HARGD

- High Angural Resolution Gamma Detector
- Accuracy on shower direction much more interesting than accuracy on energy

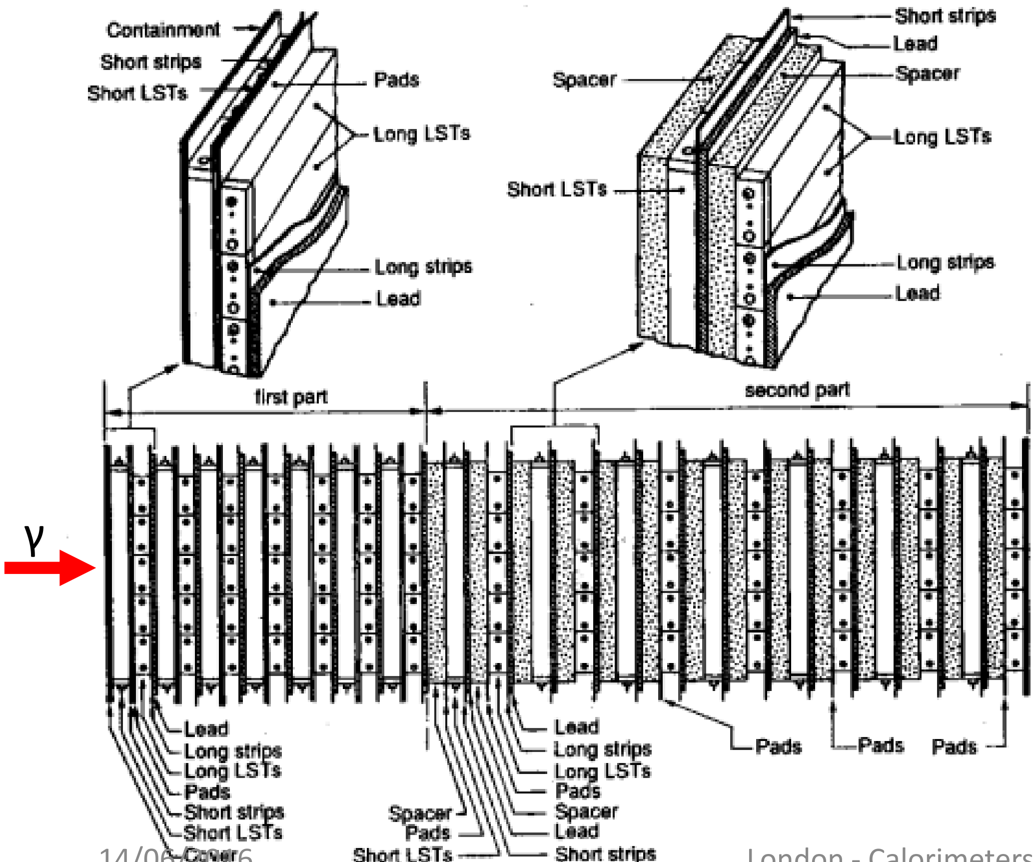
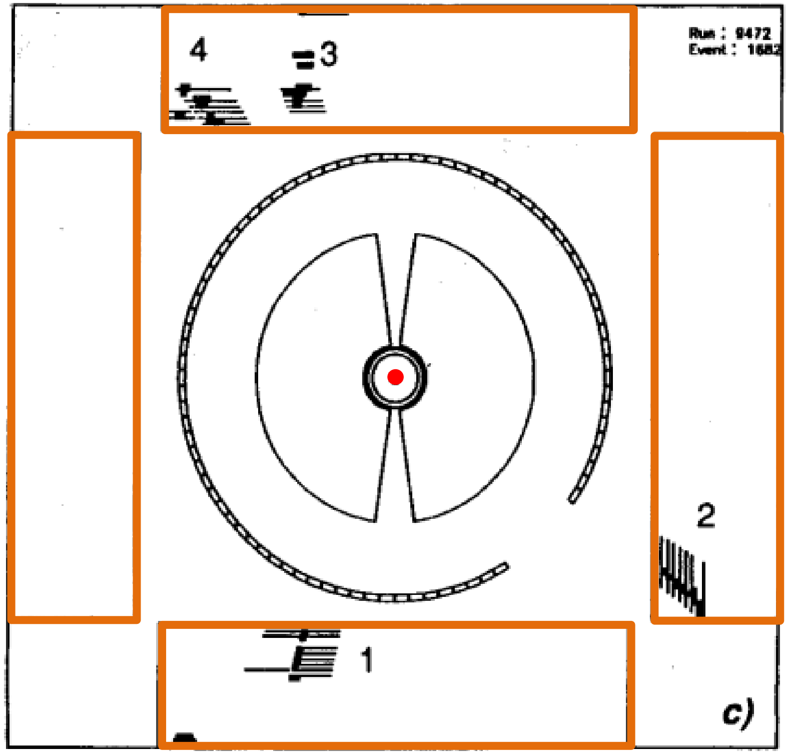


Fig. 2. Electromagnetic calorimeter stratigraphy.

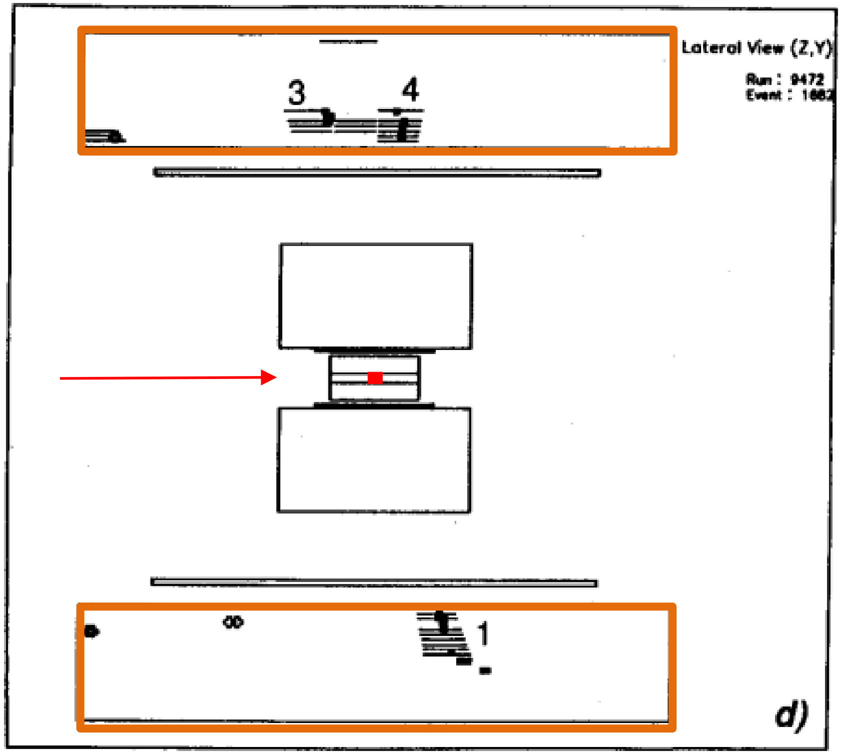
- Sampling calorimeter.
- Converter: lead
- Active: Limited streamer tubes (1cm pitch)
- Dual reading: on strips and on pads
- Digital: hit/not hit
- 10 Xo
- Spatial accuracy below 3 mm (-> 2 mrad)

'90s event display

Front view
(beam entering in the center)



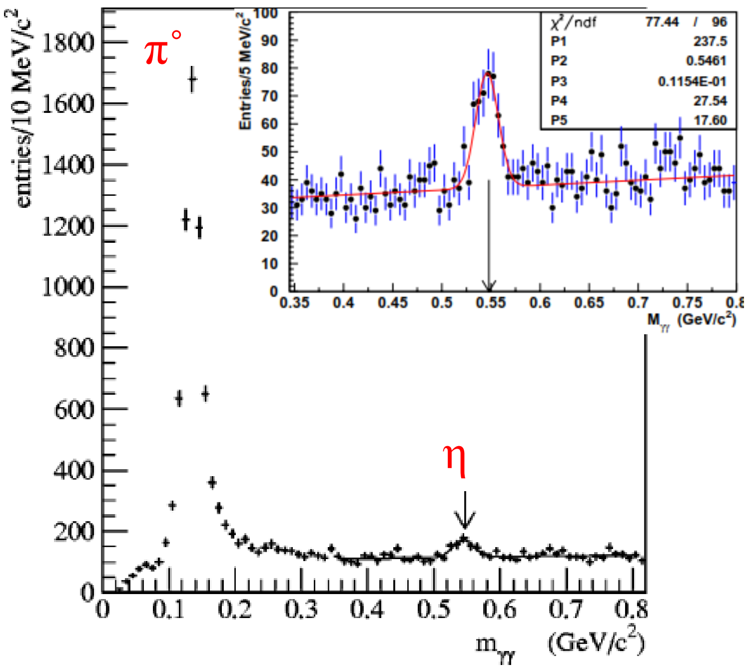
Lateral view
(beam entering from the left)



Some results

All neutrals:

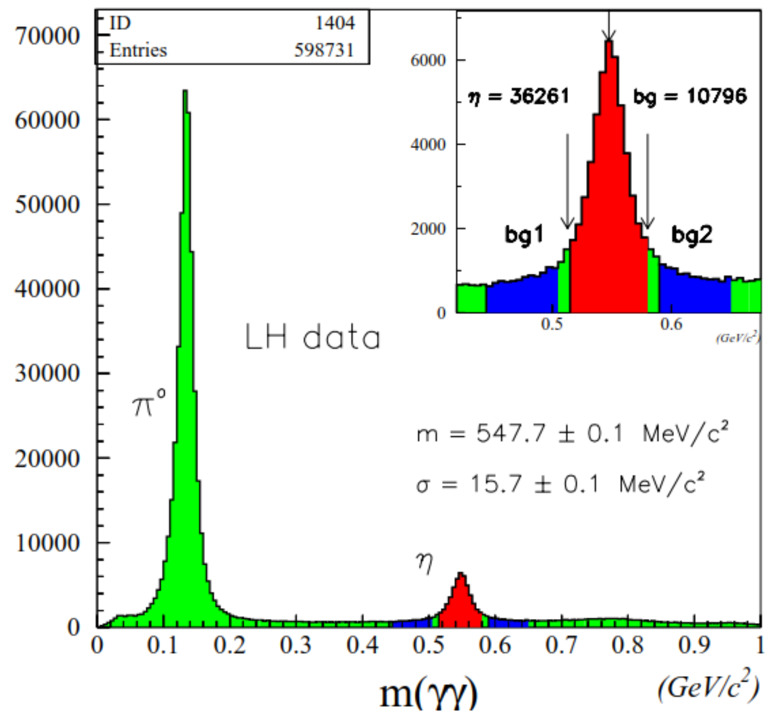
$$\bar{p}p \to \pi^o X\,(X \to \gamma\gamma;\quad X = \pi^o, \eta)$$



$$\sigma(m_{\pi^o}) = 10MeV,\quad \sigma(m_\eta) = 12MeV$$

Two prongs

$$\bar{p}p \to \pi^+\pi^- X\,(X \to \gamma\gamma;\quad X = \pi^o, \eta)$$



$$\sigma(m_{\pi^o}) = 10MeV,\quad \sigma(m_\eta) = 16MeV$$

Electronics

- Very simple: just digital (0/1) on strips and pads
- All strips in a plane connected to form long shift registers.
- One effective DAQ channel per instrumented plane;
- LST dead time (local) about 2 us.

- Pad electrodes used for triggering (and to resolve ambiguities)

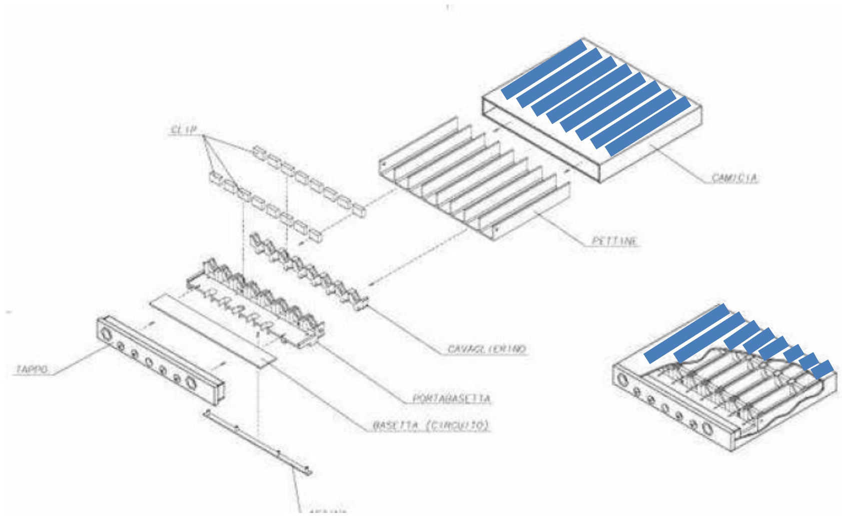
Ideas reusable for SHiP calo?

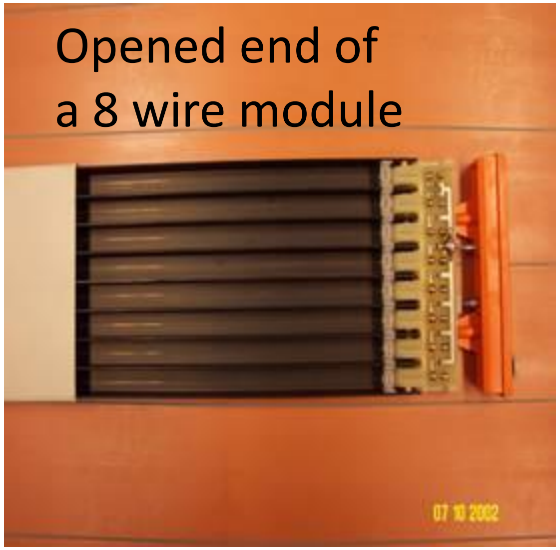
- Still sampling (low cost), with lateral reading
- Ideal for low occupancy experiment
- Active material 7-10 m long (feasible with tubes); handling is another problem
- Need to increase the Xo since the energies are higher
- Lateral sampling can provide more information for PID and for gamma directions
- Energy resolution will suffer for sure.

  How much can we afford?
- We can use segmented strips (2.5 m long ?)
- We can have pad electrodes for triggering
- One active layer can be analog and of a different technology (scintillators?) for other purposes (timing)

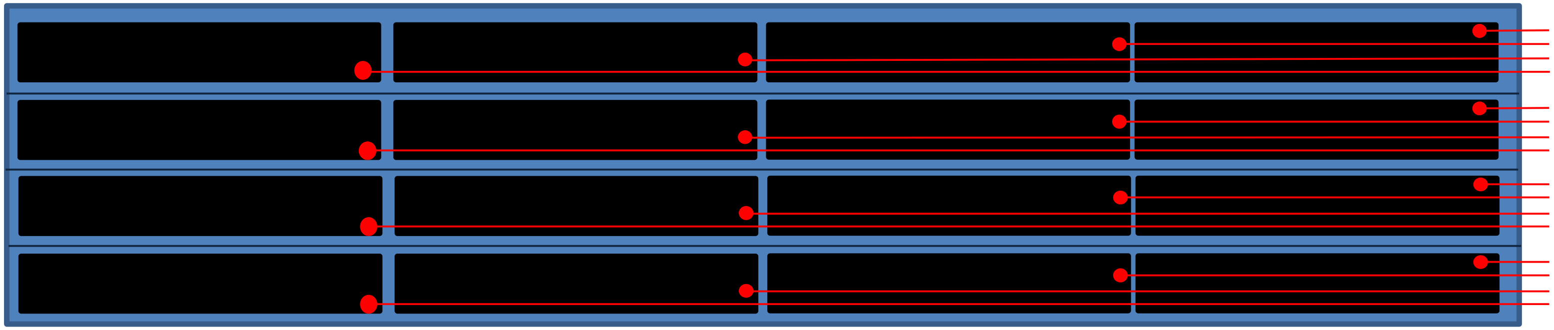
Readout idea

8 wire module read on wires or on electrodes





4 wire module read by 4 electrodes per wire: 16 channels



BoE calculations

- 20 Xo, 30 active layers, 1 cm tube pitch
- 10 x 5 m^2 to cover →40-50 m^2 per layer

  -> 22500 single tube channels

    ->2k or 5k tube modules

  →can be approx 70 k digital channels

  →30 shift registers to read + pad channels

Pro and cons

- Pro:
  - Simplification in design, sensors and electronics
  - Longitudinal shower observable
  - Shower direction available; better PID (?)
  - Costs (?)
    (Guesswork: might be lower. To be evaluated more precisel\y)

- Cons:
  - Gas handling (?); different detector
  - Worsening of energy resolution
    (no numbers yet)
  - No time information
  - No high rates (not a problem)

Plans

- Have an integrated simulation to test these ideas;
- Provide a «simple» reconstruction
- Test different detector types and read-out principles
  - LST (cheap, long response times),
  - RPC (cheap, fast detector),
  - Scintillation bars (expensive, very fast)

  - Analog readout: featurefull, expensive
    → higher accuracy; better performance
  - Digital readout: no time; no overlaps; cheap!
    → lower accuracy

Summary

- There are several areas where ideas, suggestions and actual contributions are really welcomed.

- New collaborators wishing to contribute in any calo area are welcomed
  – Software/reconstruction
  – Detector design & further optimization

Please do not be shy!

Back up

References

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  Nuclear Inst. and Methods in Physics Research, A **325**(3): 417-428
- Bargiotti, M., A. Bertin, et al. (2002).
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