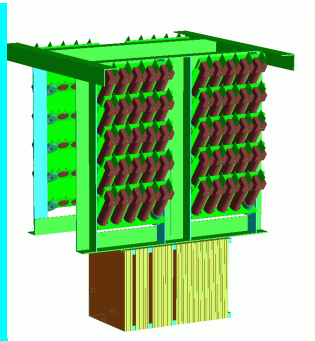
LCcal*: a Calorimeter prototype for future Linear Colliders



TALK SUMMARY

- **Design principles**
- **Prototype description**
- **Construction details**
- **Test Beam results**
- **Conclusions and Future plans**

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Design principles

From the LC Physics requirements:

- high granularity,(Energy Flow)
- σ_E O$(10\%/\sqrt{E} + 1\%)$
- longitudinal segment. (e/π) separation
- working in magnetic field
- high density (25-30 X_0 in $\sim$ 50 cm)

Tesla TDR solutions:

- **Si W**
- **Shashlik (thanks to CALEIDO)**

Alternatives:

- **Cristals**
- **Fully compensating Ecal+Hcal**

Proposed solution:

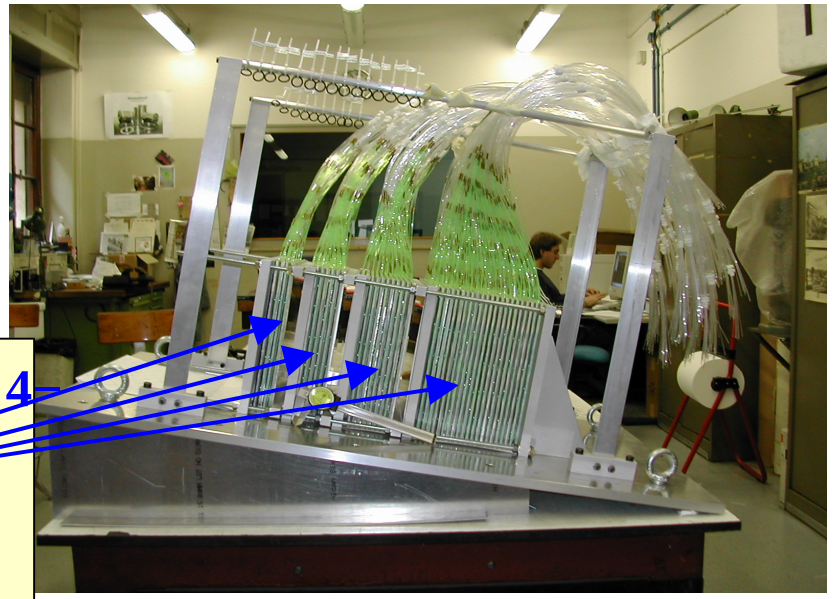
Keep SiW advantages (flat geometry, high granularity)

Erec. not from Si but from Scintillator−WLS fibers

Reduce (factor >10) the number of channels

Detector Assembling:

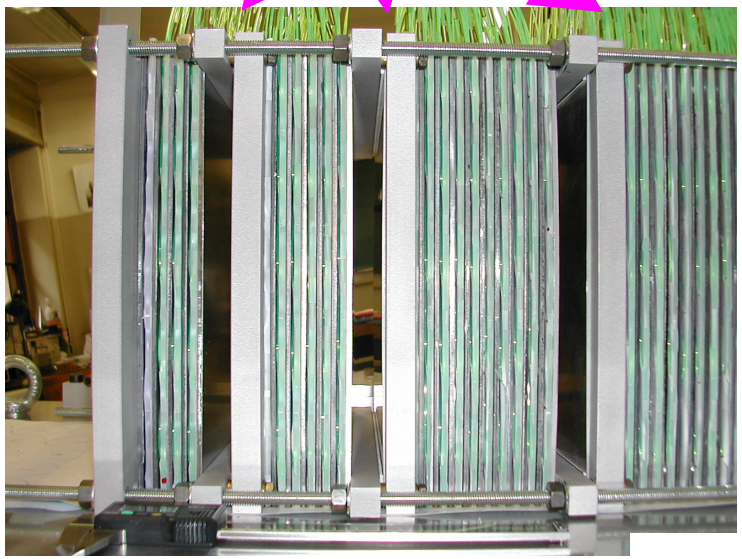
45 Layers calorimeter prototype completely built in 2002

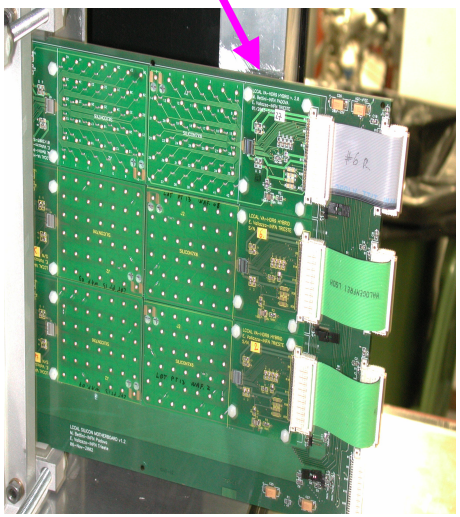


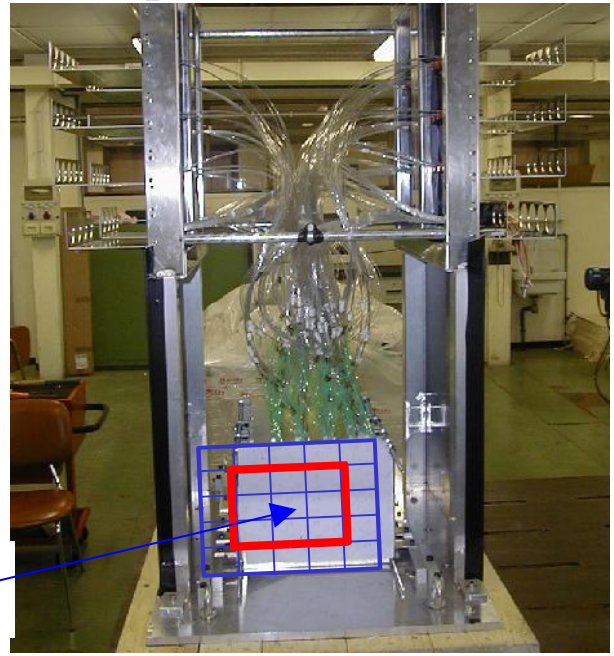
Fibres grouped into 25x4 bundles making a 4-fold longitudinal segmentation.

Slots for the insertion of the 3 Si pad planes (Motherboard)

Mechanical support for Photomultipliers





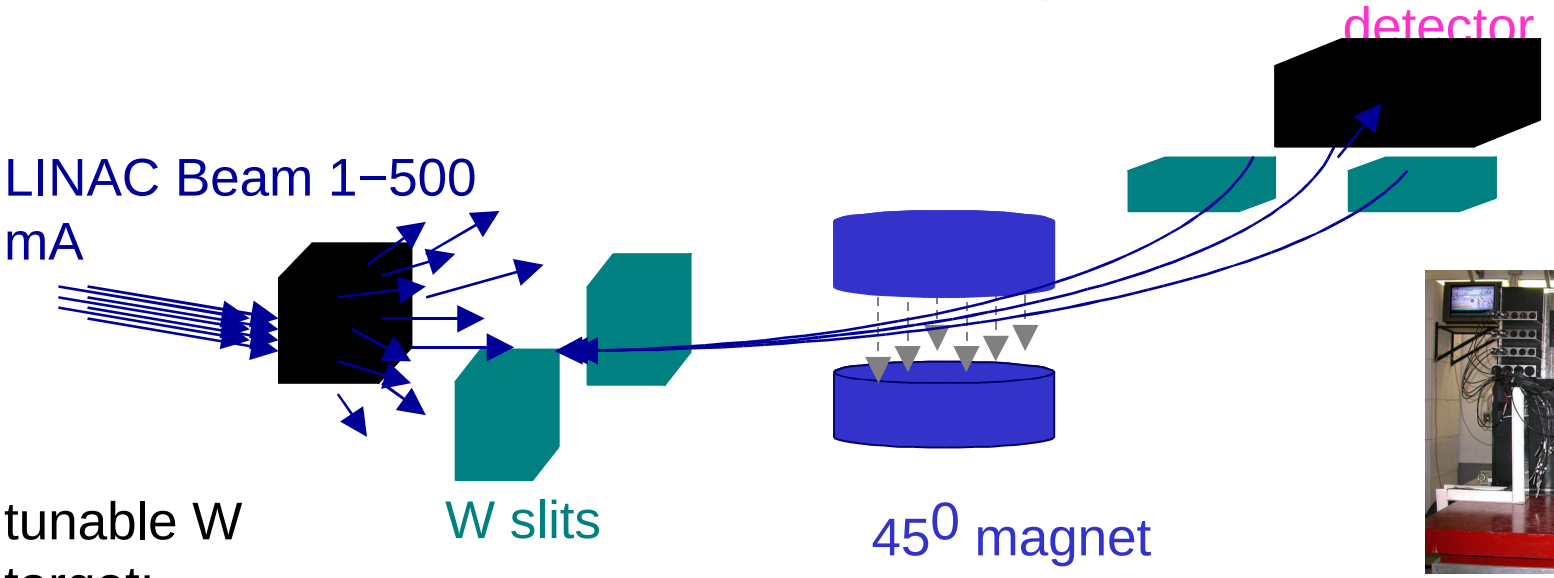


in the 3x3 central cells

Test beam activity

after a 2002 pre test with the 1st layer only (2.1 X_0) at CERN

- **two runs at Frascati Beam Test Facility (n × 50 – 750 MeV)**

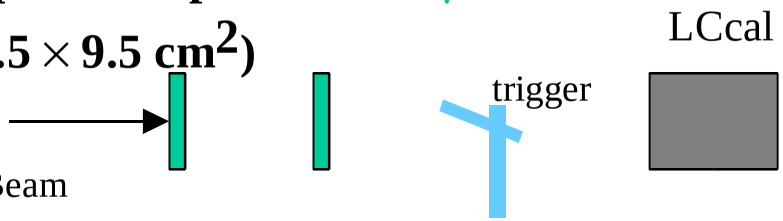


it is possible to tune the multeplicity.....

- **run at CERN SPS H6 beam line (e/π 5 – 150 GeV)**

All tests: two beam position monitors (telescope) put in front of the calorimeter.

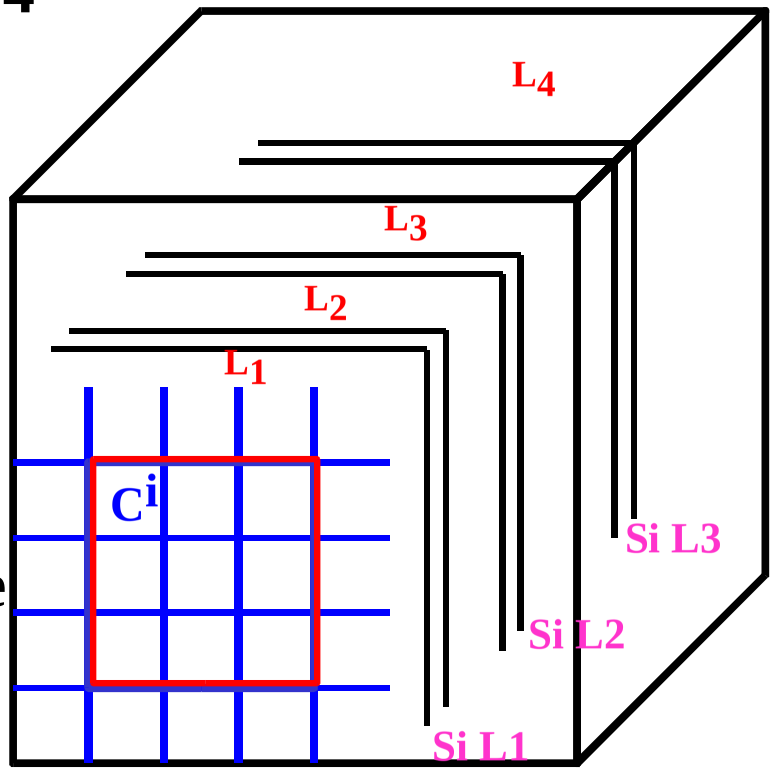
- **Each detector consisting of 400×400 x–y Si strips with a pitch of 240 μm**
- **They cover the central area of the prototype (9.5 × 9.5 cm^2)**



Test beam activity : detector calibration

define 'cell' as the calibrated sum of the 4 longitudinal layers on the same lateral position: $C^i = b^i \Sigma_{j=1,4} a_j L^i_j$

(4−1+9+16 parameters)



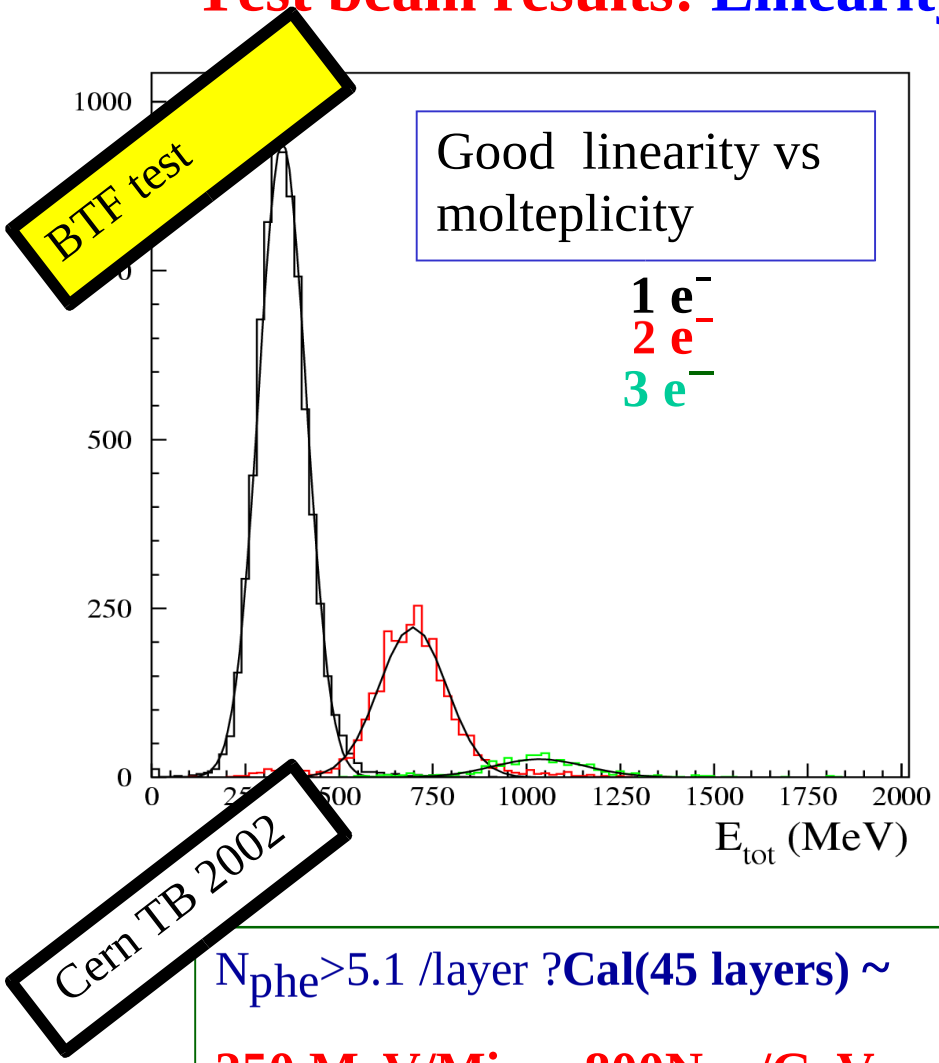
process in two steps:

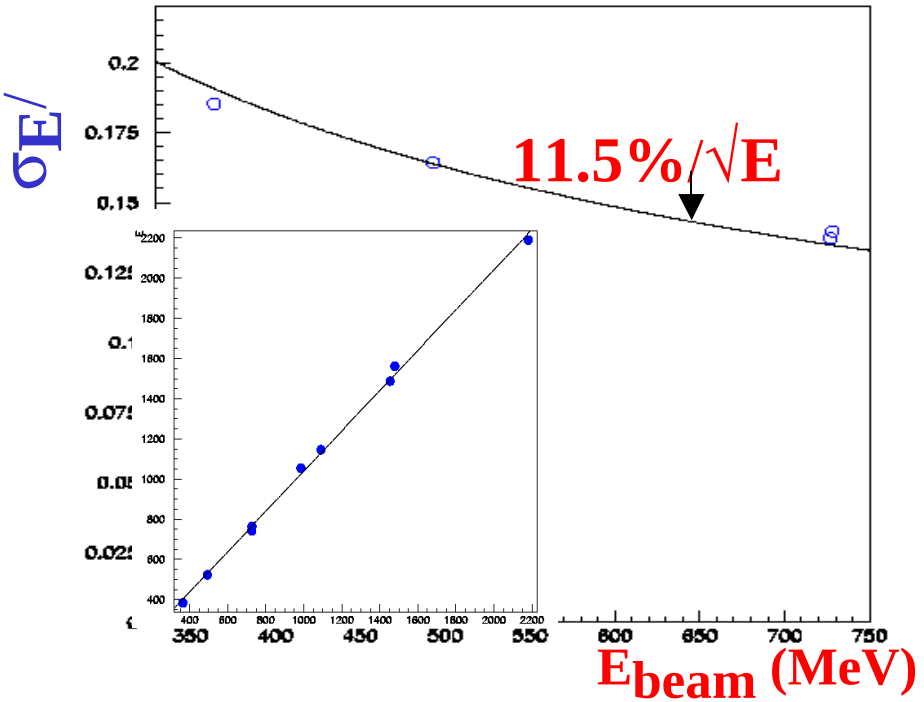
- **equalise the layer response at the same incoming energy** $L^i_j = b^k/b^i \, L^k_j$
- **minimise the Energy spread on the sum of 9 cells**

(iterative process)

a_j | **min. width** $E_{cal} = \Sigma_{n=1,9} C^n$

Test beam results: Linearity and Energy Resolution





N_{phe}>5.1 /layer ?**Cal(45 layers) ~**

250 MeV/Mip ~ 800Npe/GeV

OK also @ BTF (E ~500 MeV)

1. Photoelectron statistics **negligble**
2. Stocastic Term **11.5% as in MC**

- Light disuniformity **<<10%** Effects on resolution to be measured at **SPS (August 2003)**→

Test beam results: Linearity and Energy Resolution

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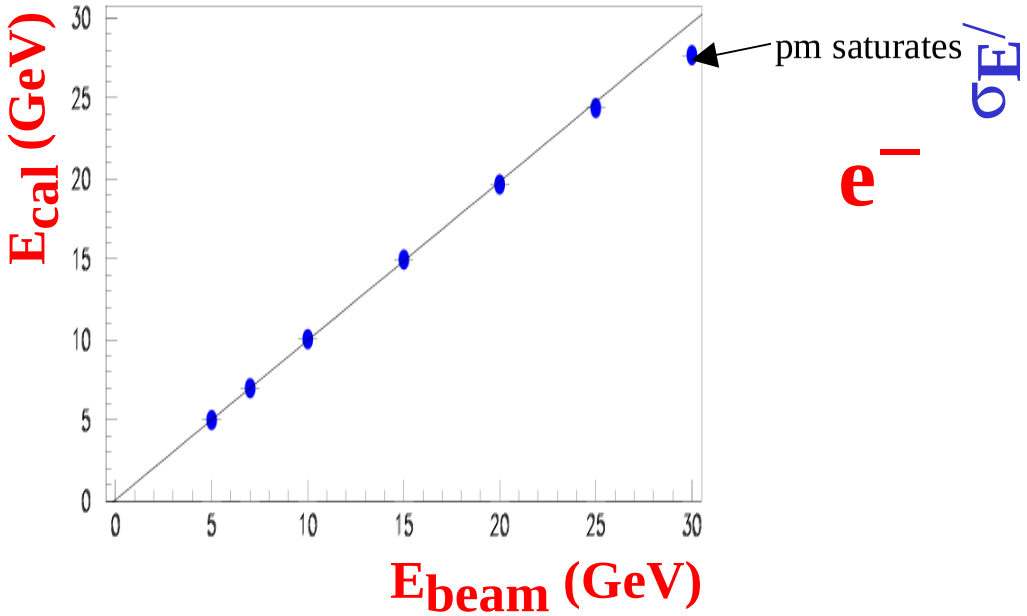
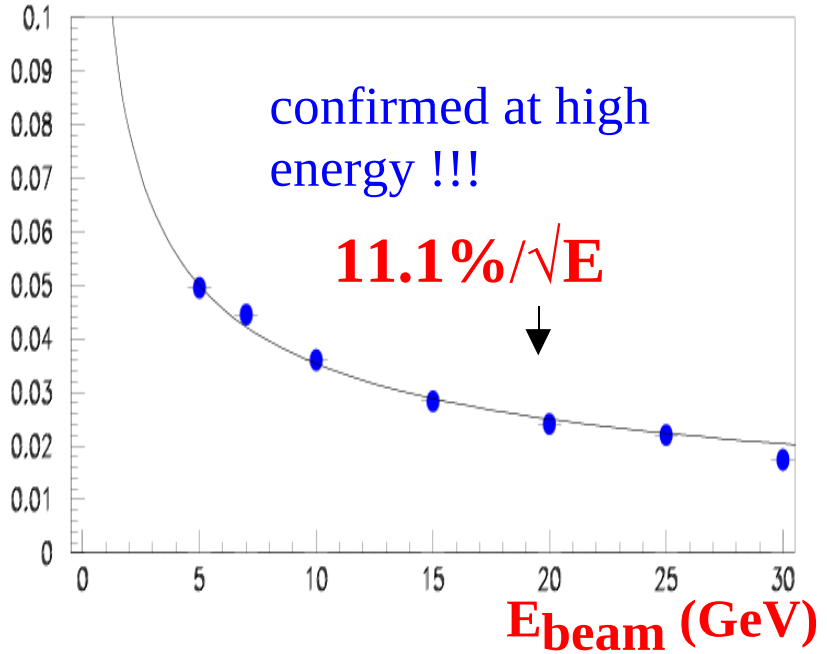
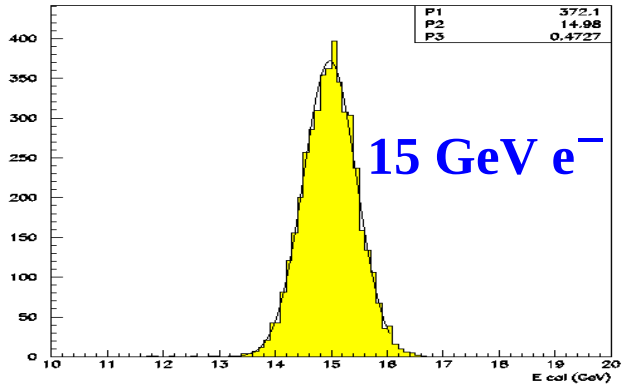
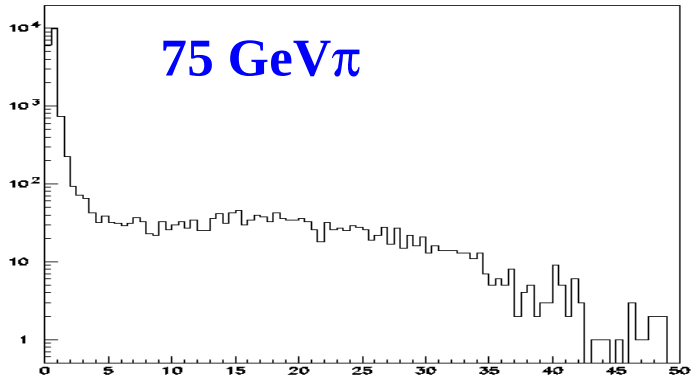


e^-







Test beam results: Si pad detector (Signal/Noise Ratio)

$$\mathrm{ENC} = A + \frac{B}{pF} \approx 1000\,e^- +$$

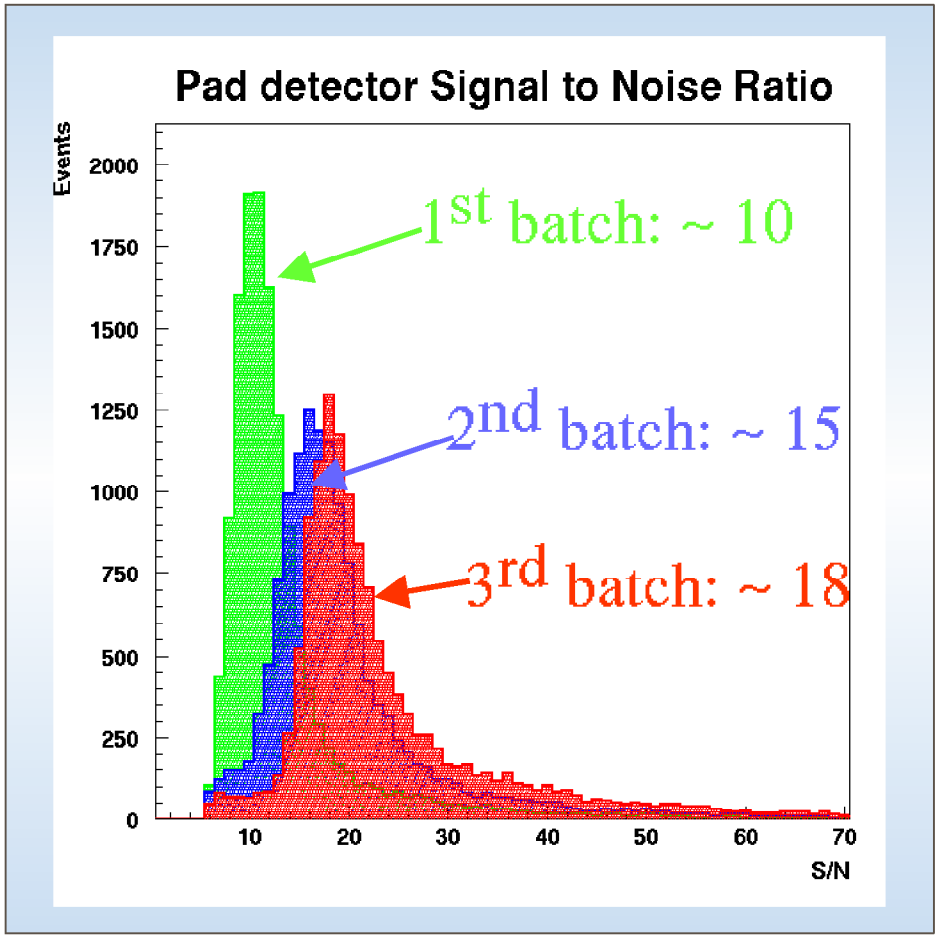
$$\mathrm{ENC} = \frac{e}{q}\sqrt{\frac{qI_l T_p}{4}} \approx 30\,e^- +$$

$$\mathrm{ENC} = \frac{e}{q}\sqrt{\frac{T_p k_B T}{2R}} \approx 230\,e^- =$$

$$1260\ e^-$$

Mips: 80 $e^-/\mu m$

→ Theoretical*
SNR ~ 20



*Value obtained for detector of the 3rd batch

Test beam results: Si pad detector (Position Meas.)

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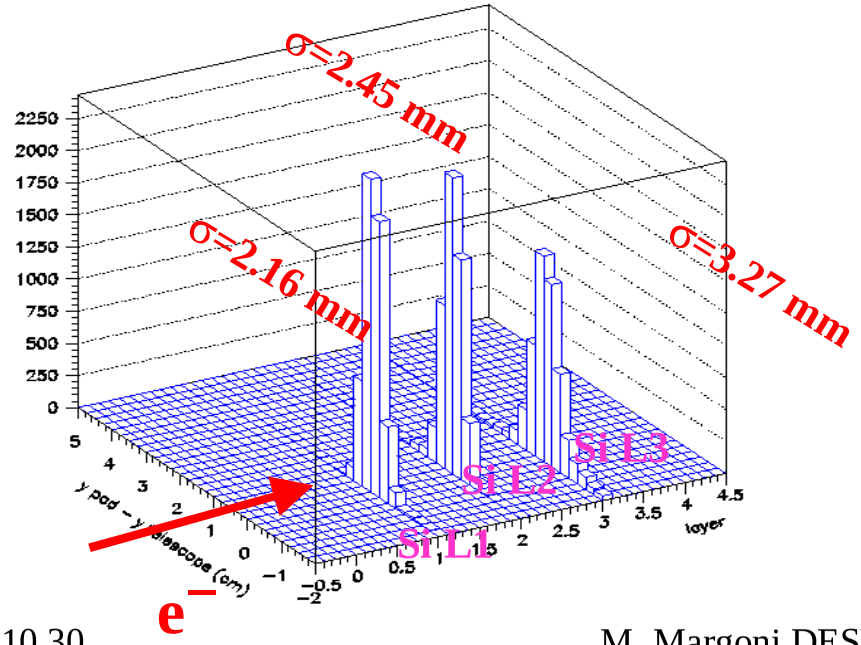
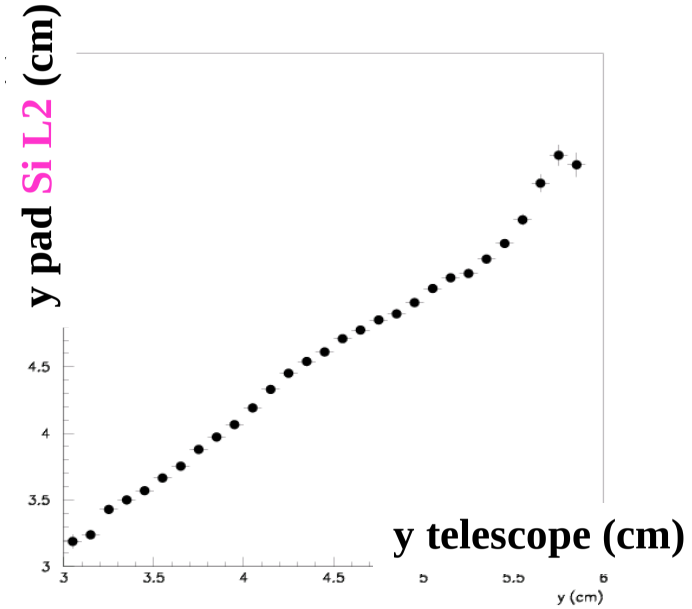
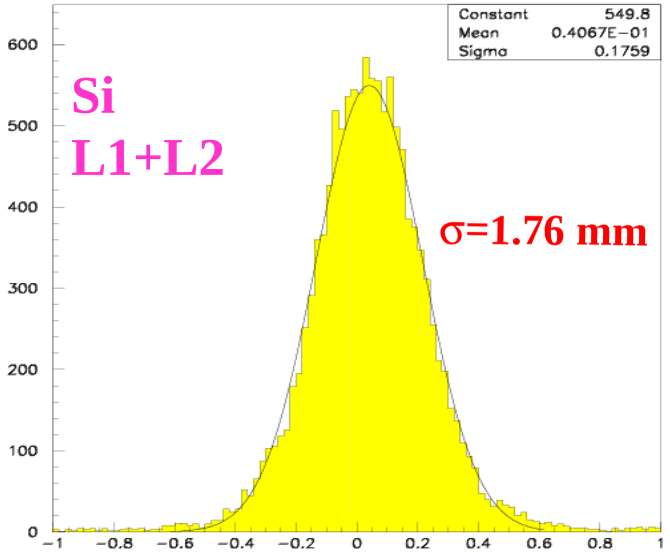
30 GeV electrons





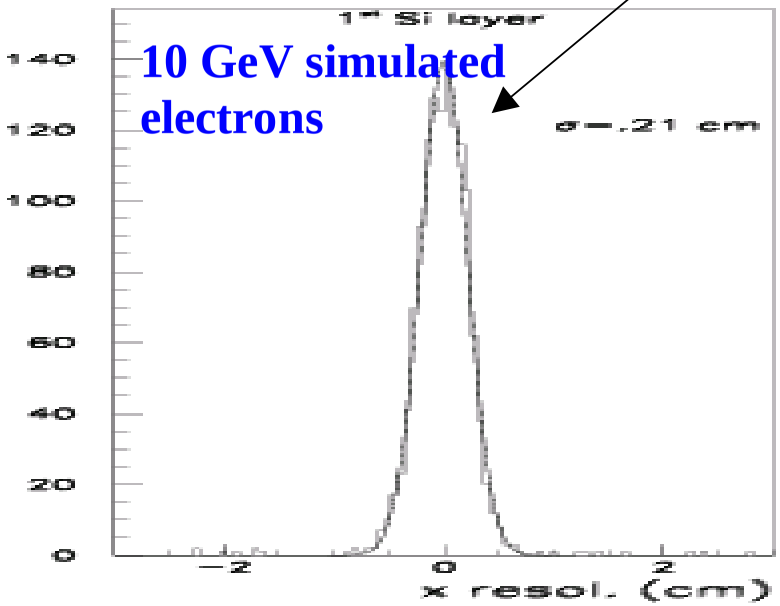


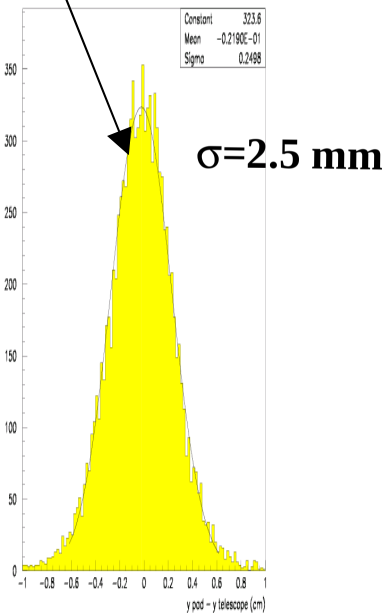
Test beam results: Si pad detector (Position Meas.)

PRELIMINARY analysis: pad noise subtraction not optimised

Position resolution ~ 2.5mm not far from Monte Carlo

10 GeV electrons





Test beam results: uniformity in (light) Energy response

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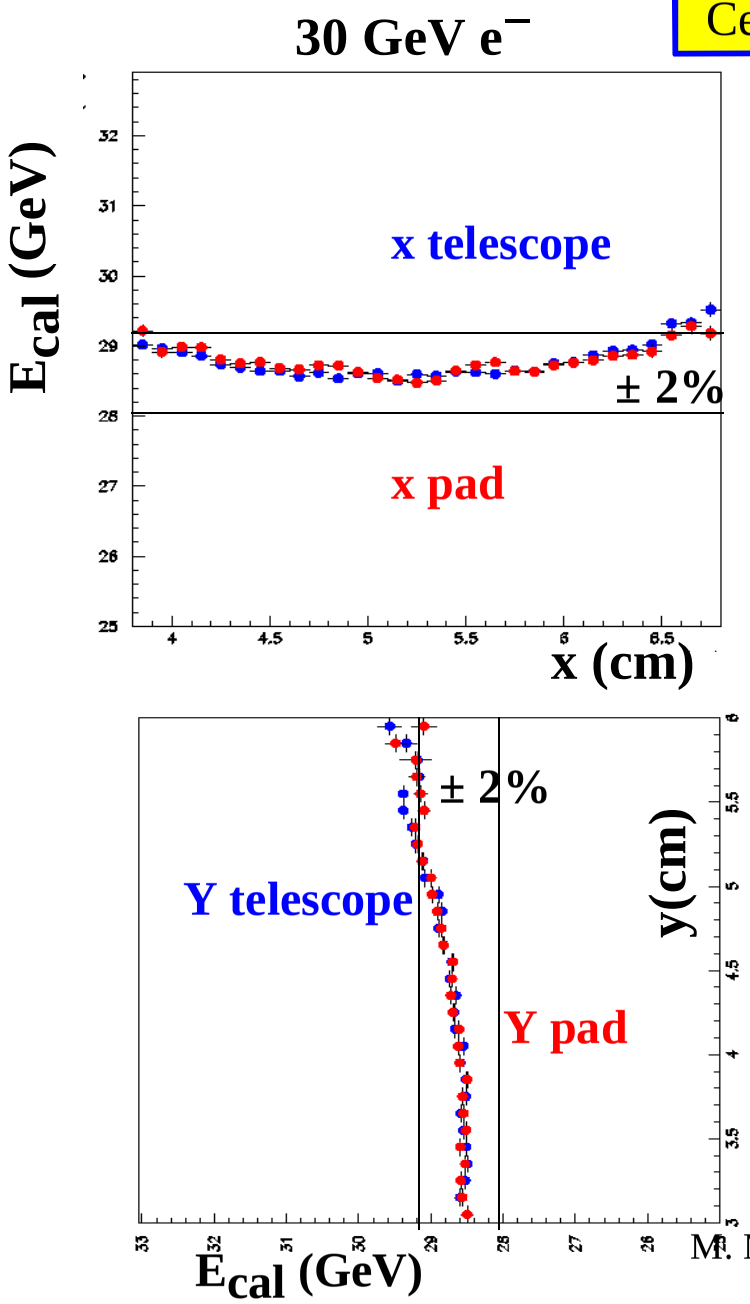
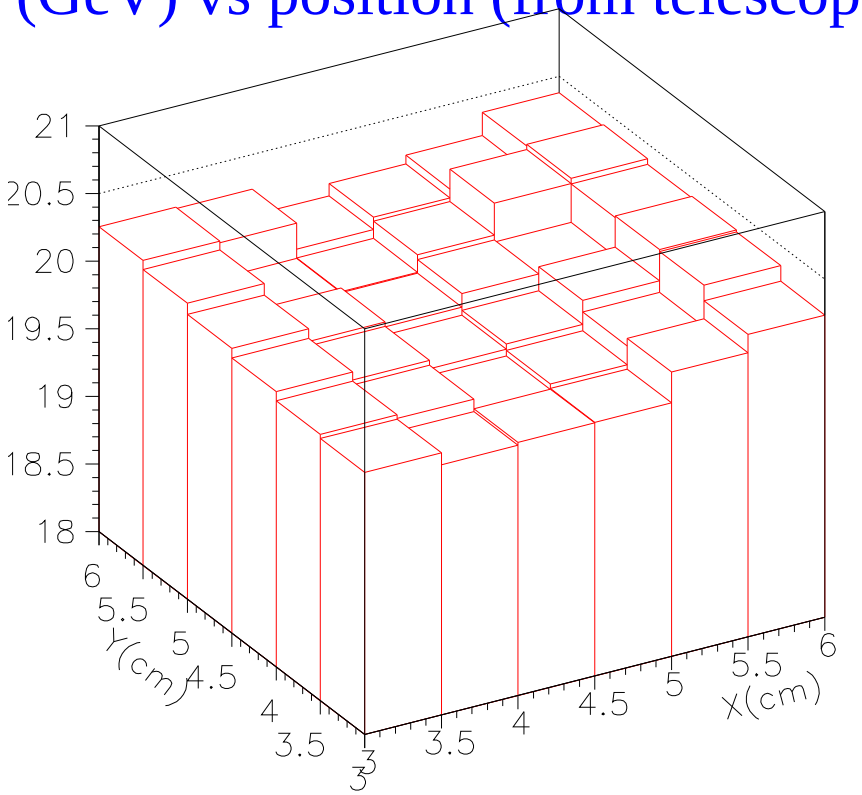


disuniformity < 2%

correction from pad reconstruction can be applied!

E_{cal} (GeV) vs position (from telescope)



Test beam results: (e/π rejection)

the redundancy of the information on the linear/lateral shower development makes the rejection very easy

(difficult to quantify below 10^{-3} due to beam contamination)

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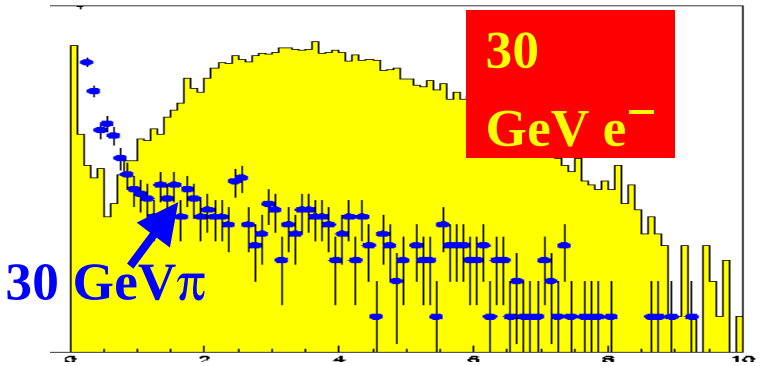
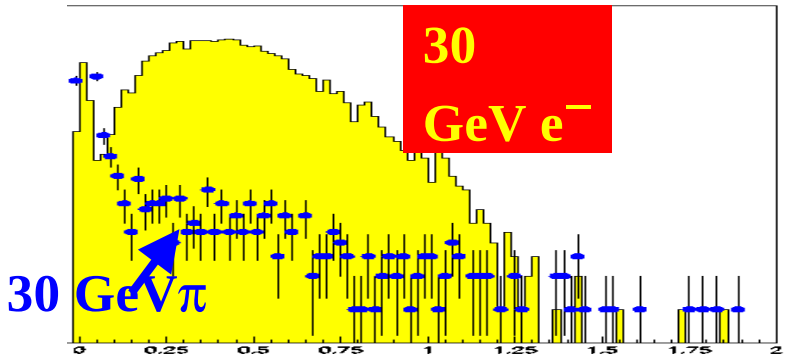
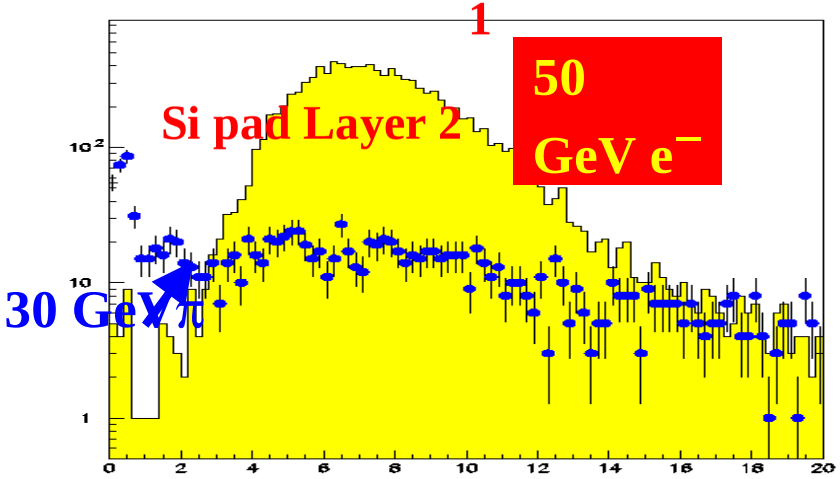
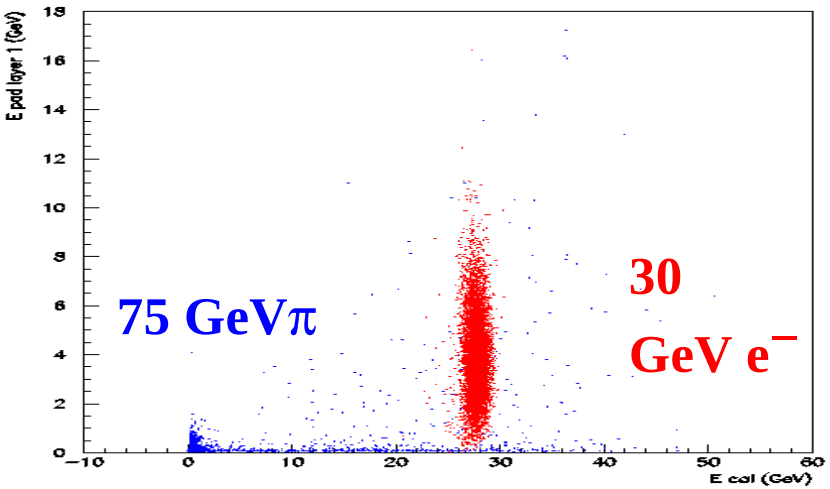


E Si pad Layer 1



E cal Layer 1





shower "variance": $\Sigma_i r_i^2 E_i / \Sigma_i E_i$

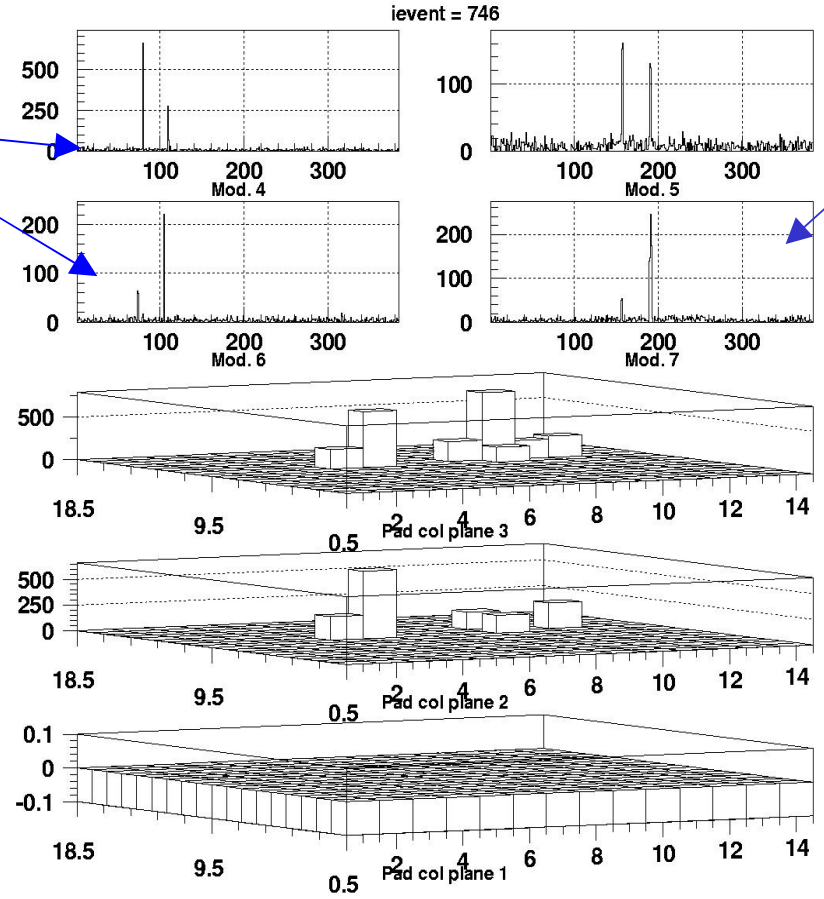
Test beam results: Si Pad two particle separation

exhaustive analysis not fully accomplished

Two electrons with energy 750 MeV

X silicon chambers

Y silicon chambers



BTF test

First layer

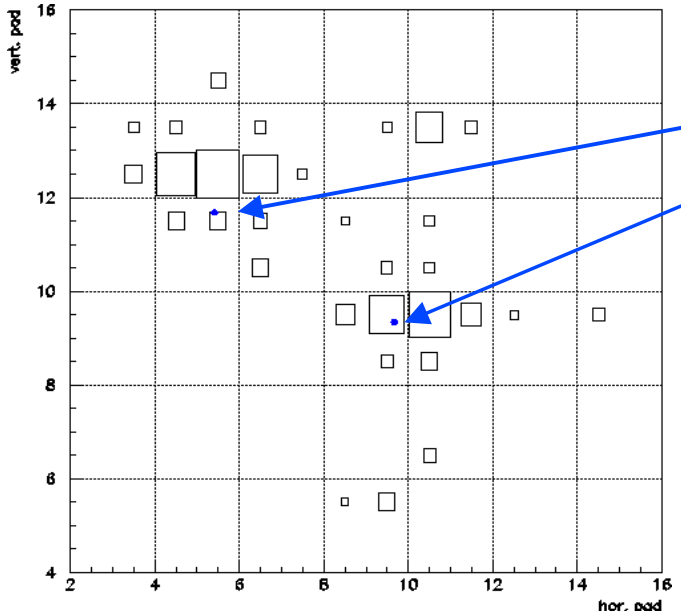
Second layer

Third layer

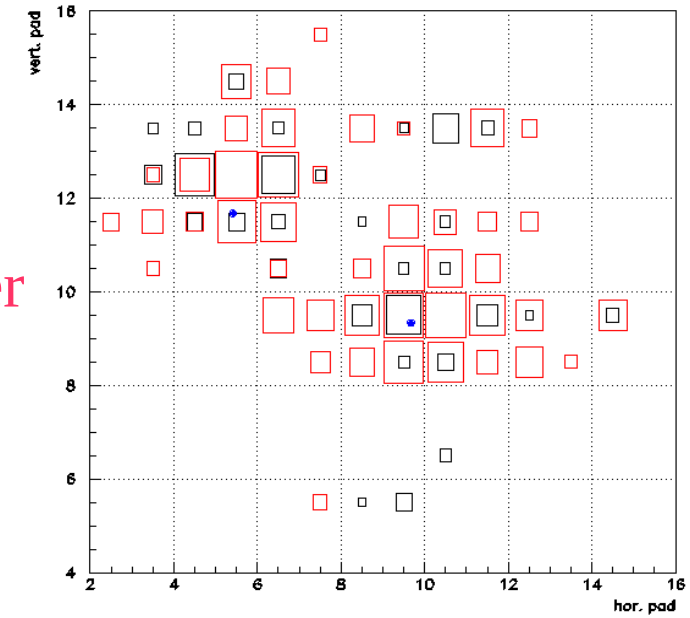
NB: not fully equipped+ problematic channels

Test beam results: Si Pad two particle separation

First Layer



Second Layer



Silicon Chambers

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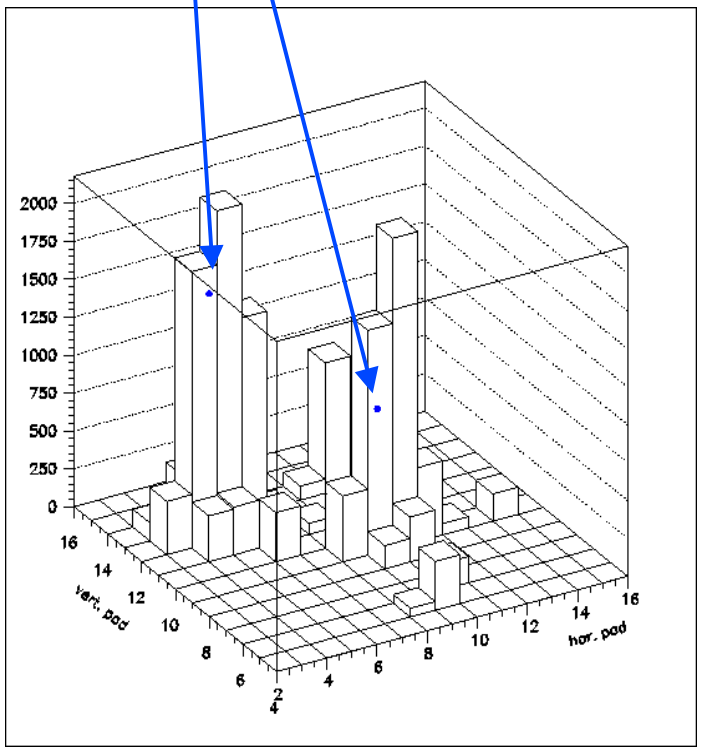

Conclusions and Future plans

- **A calorimeter prototype with the proposed technique has been built and fully tested. All the results are preliminary.**
- **Energy and position resolution as expected: σ_E/E ~11.−11.5% /√E, σ_{pos} ~2 mm (@ 30 GeV)**
- **Light uniformity acceptable.**
- **e/π rejection very good ($<10^{-3}$).**
- **Two particle separation results coming soon.**
- **Next steps: include a calorimeter made following this technique into the general LC simulation and Pattern recognition.**
- **Combined test with Hcal (?)**
- **Planned W absorber too expensive w.r.t. Current fundings...**