CALEIDO COLLABORATION[a] : Shashlik Calorimeter Prototypes for a LC

- **Requirements from TESLA C.D.R.**

- **CALEIDO 1 (1998 Prototype)**

- **Published 1998 test results**

CALEIDO 2 (1999 Prototype)

- **Further developments**

[a] Bologna, CERN, Lund, Milan, Padua, Serpukov

Requirements from TESLA C.D.R.

- **High granularity**

- **Good resolution at High Energy** ($\mathcal{O}(1\%)$)

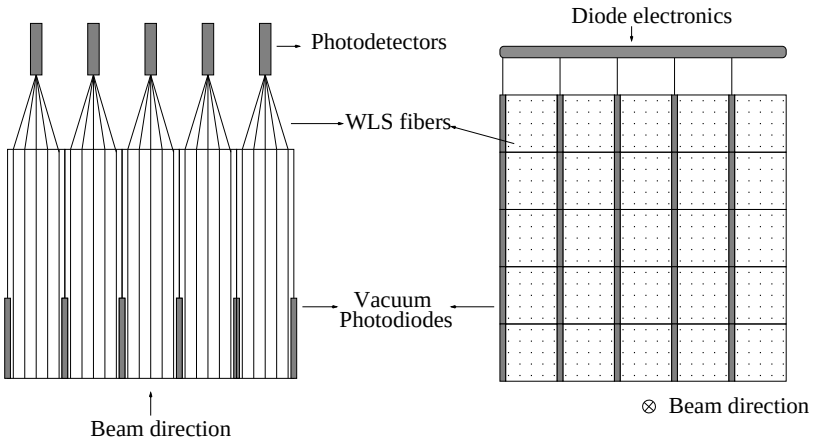
- **Longitudinal segmentation**
  e/π separation,γ direction reconstruction

- **Working in high magnetic field**

- **Reasonable length** ($\mathbf{25 \div 30 X_0 \sim 50}$ **cm**)

- **Reasonable cost**

Shashlik Calorimeters



Tower structure (top view) **Calorimeter layout (front view)**

- Light collection via WLS fibers perpendicular to the Pb/sci tiles

- Compact, modular, easy to operate, no dead zones

- Longitudinal segmentation?

CALEIDO

- Study longitudinal segmentation options:

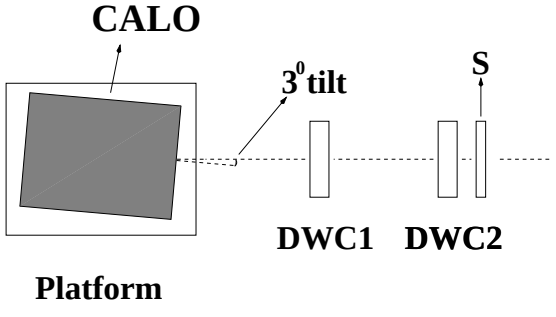
- **a) Insertion of vacuum photodiodes in the first 8 X_0**
- **b) Use two scintillators with different time response**

CALEIDO 1

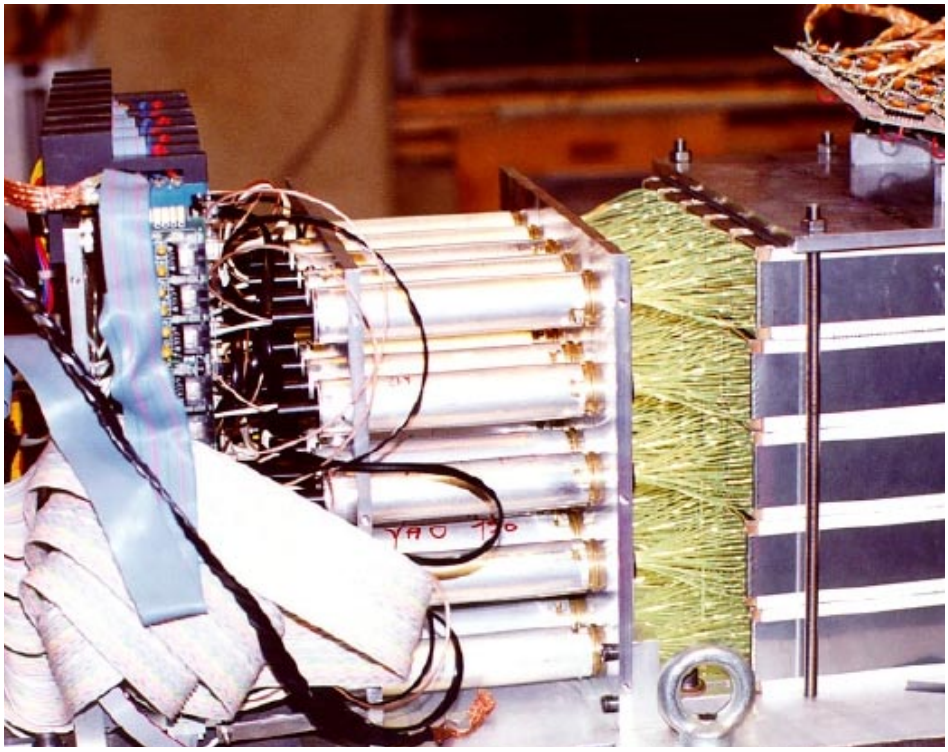
- 5×5 towers (produced in Serpukov):
  - $5 \times 5 \times 36$ cm^3 (~ 25 X$_0$)
  - 1 mm Pb 1 mm scint.
  - 5×5 WLS longitudinal fibers:
    Bicron BCF20 (! scintillating !)
    Kuraray Y11
  - back read-out: Phototetrodes/Apd
  - Longitudinal segmentation from lateral vacuum Photodiodes ~ 10 cm $\sim$ 8X$_0$

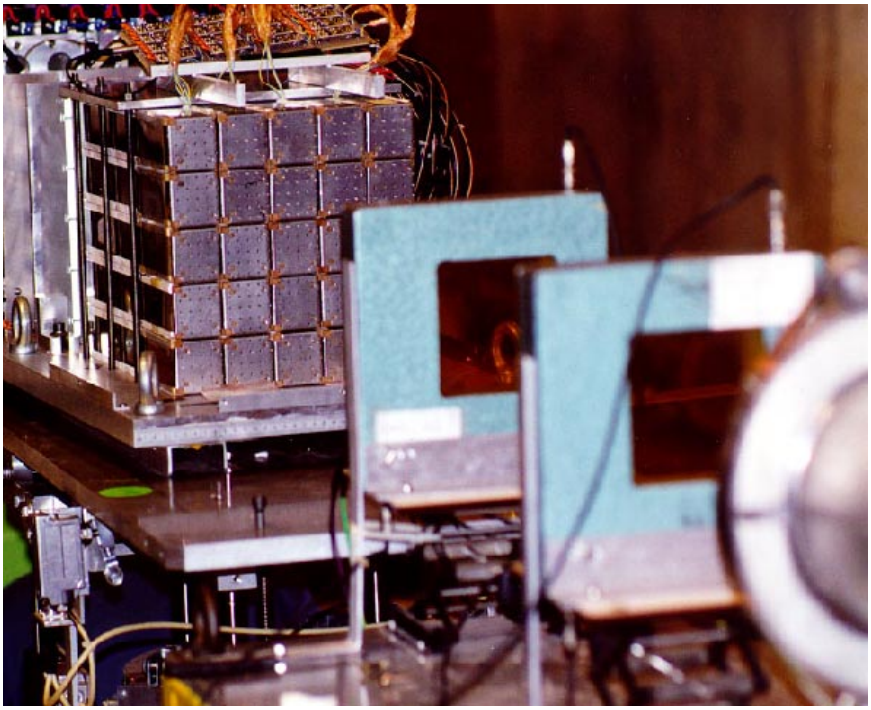
- Same electronic chain as in DELPHI detectors (FEMC and STIC)

- Tested at CERN X5 beam



CALEIDO 1 (1998 prototype)





Vacuum Photodiodes

	EMI	Hamamatsu
Sensitive area	28.9 cm^2	10.9 cm^2
Thickness	5.0 mm	5.1 mm
Working bias	-10 V	-20 V
Capacitance	250 pF	17 pF
e.noise	$\sim$ 1200 MeV	$\sim$ 900 MeV

Published test results

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN–EP/98–200
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An electromagnetic shashlik calorimeter with longitudinal segmentation

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Abstract

A novel technique for longitudinal segmentation of shashlik calorimeters has been tested in the CERN West Area beam facility. A 25 tower e.m. calorimeter has been built with vacuum photodiodes inserted in the first 8 radiation lengths to sample the initial development of the shower. Results concerning energy resolution, impact point reconstruction and e/π separation are reported.

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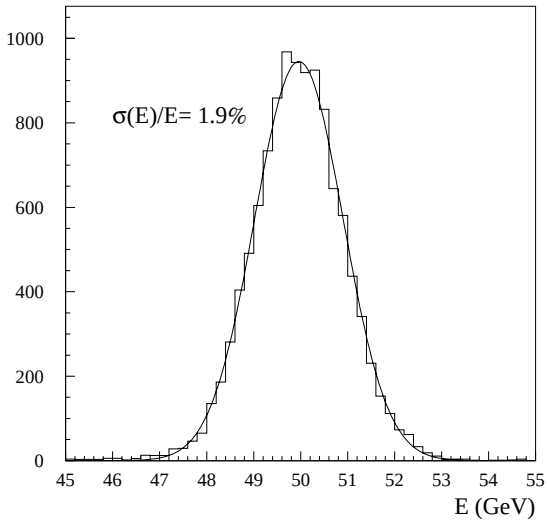
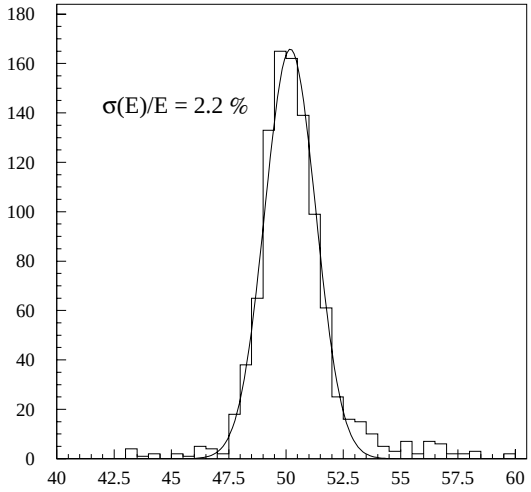
- **Energy Resolution**
- **Shower Impact Reconstruction**
- **Diode response and e/π separation**

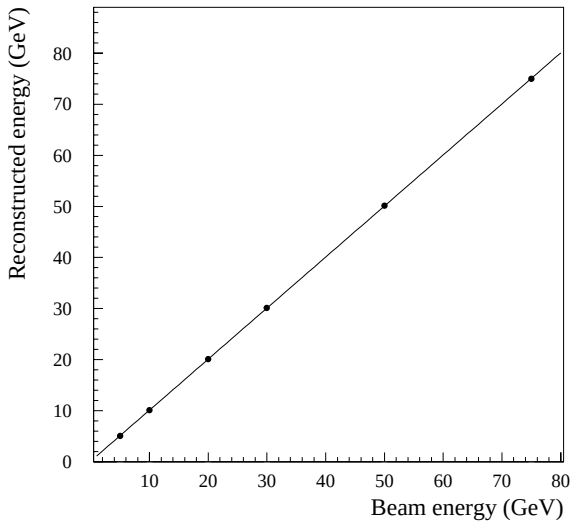
Energy Resolution

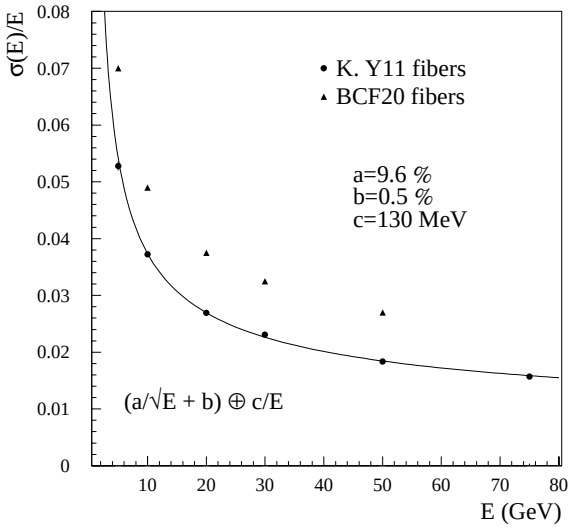
Tetrode



APD







$$\frac{\sigma(E)}{E} = \sqrt{\left(\frac{9.6\%}{\sqrt{E}} + 0.5\%\right)^2 + \left(\frac{0.130}{E}\right)^2}$$

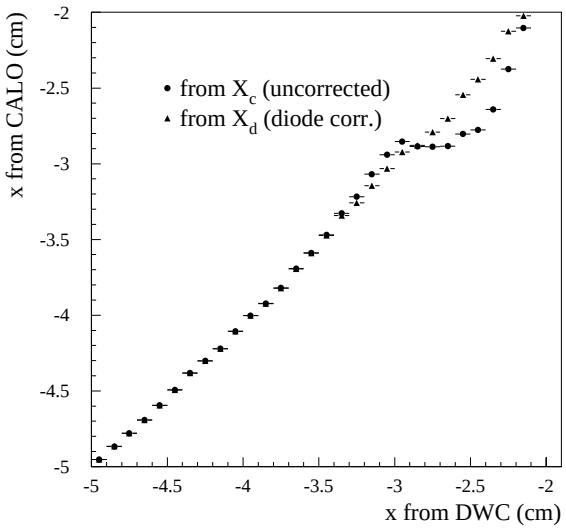
Shower impact reconstruction

- **The impact from modified barycenter:**

$$X_b = 2 \sum_i iE_i / \sum_i E_i$$

$$X_c = b \ \mathbf{arcsinh}\left(\frac{X_b}{} \ \mathbf{sinh}\ \delta\right)$$

- **corrected using the Diode energy :**

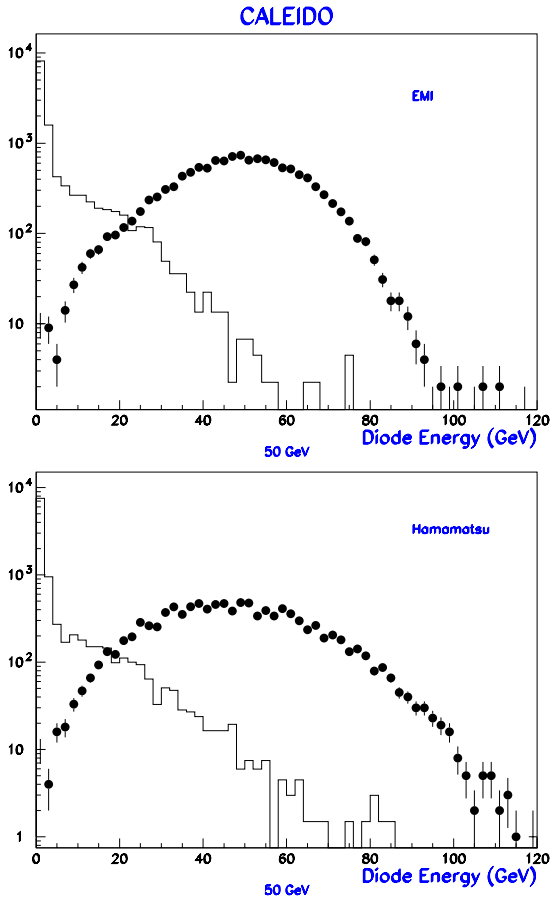


$$\sigma_X\ (E) \ = \ \sqrt{\left(\frac{0.9}{\sqrt{E}}\right)^2 + (0.1)^2}\ \mathbf{cm.}$$

Diode response

- **Widths dominated by fluctuations in shower development**

e^- ● , π ⊓

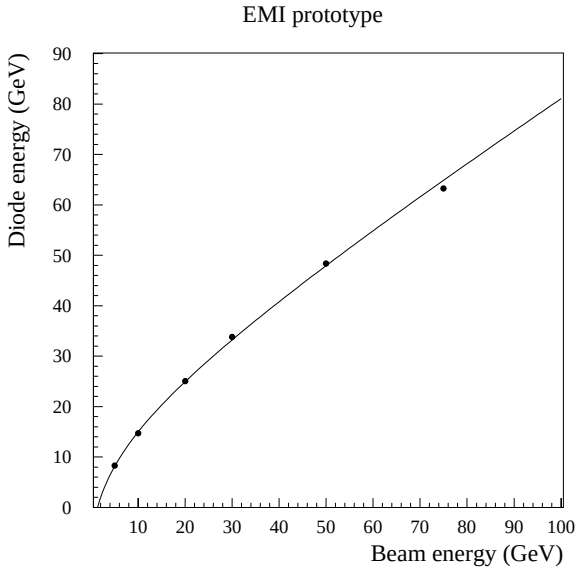


- **Hamamatsu diode ($< 5\ X_0$):**
  - **Larger fluctuations**
  - **Smaller noise**

Diode response

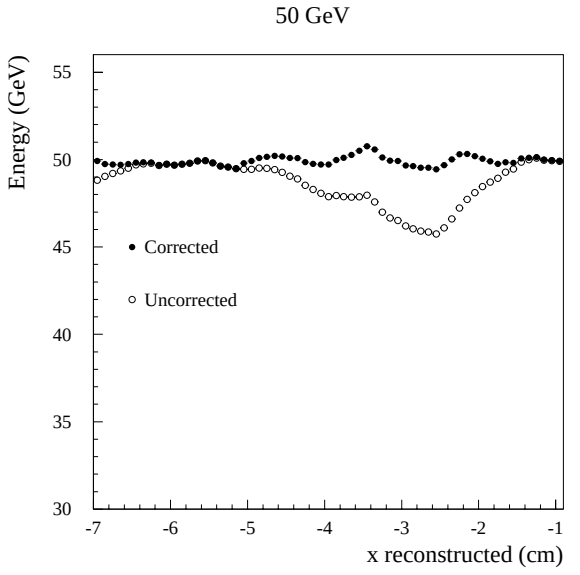
- **Energy response not linear**

(e.m. showers not contained in 8 X_0)



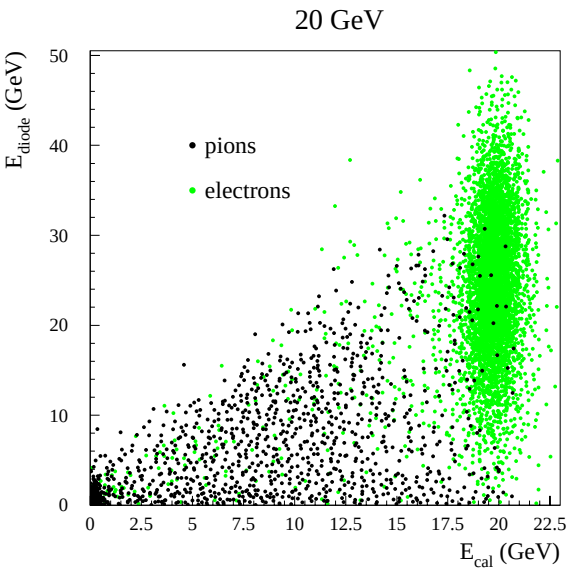
- **Crack effect can be corrected!**

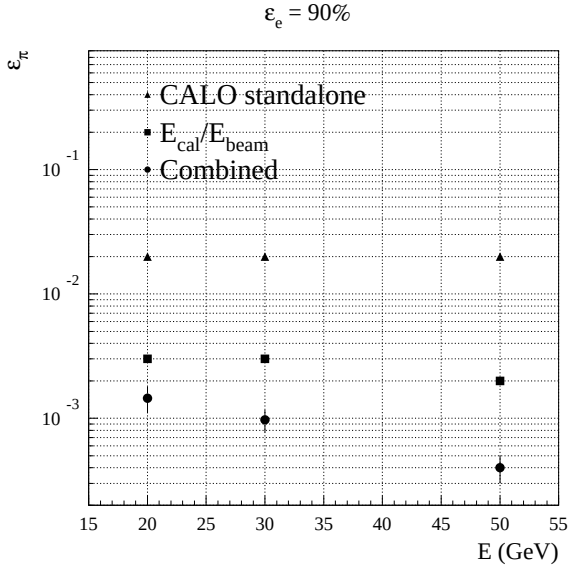
Total Energy vs position



e/π separation

- separation obtained from:
  - Total Energy (E/p)
  - Diode energy
  - Lateral development of the shower





$\epsilon_\pi = (4.0 \pm 1.5) \times 10^{-4}$ for $\epsilon_e = 90\%$

Test Summary

- **Energy Resolution:** $< \frac{10\%}{\sqrt{E}}$, $< 1\%$ **c.t.**

- **Good Position Reconstruction**

- e/π **separation with lateral diode works:** $< 4.0 \times 10^{-4}$ **at 50 GeV**

- **No significative cracks**

- **Non Uniformity** $< 1.5\%$ **with Y11 fibers**

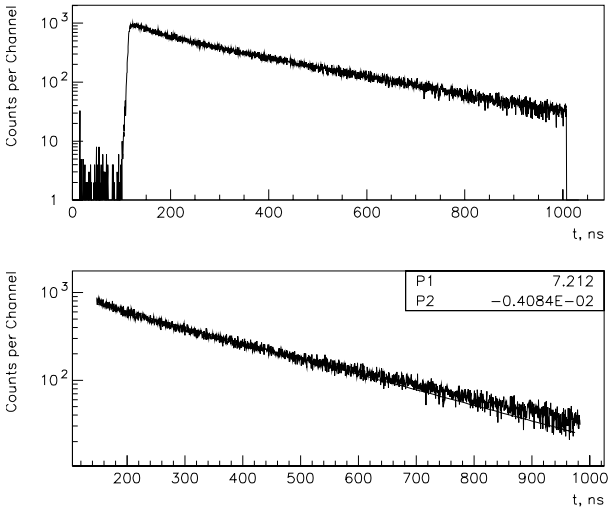
- **APD readout tested (to be optimized)**

First prototype meets requirements!

CALEIDO 2

- **First 5 X_0 equipped with BC-444 scint.**

$\tau \sim 250$ ns[a]



- **P.M. readout + TDC for test beam**

- **June + September Tests at X7 (CERN)**

[a] Serpukov measurements

Further developments

- **CALEIDO 1:**

  - **- Two diodes per tower (3 segmentations)**

  - **- Reduce the granularity to $3 \times 3\ cm^2$**

- **CALEIDO 2:**

  - **- Dense scintillator**

  - **- Large Pb plates (i.e. $25 \times 25\ cm^2$) with optically separated scint. tiles**

- **Tungsten absorber**