A Shashlik e.m. Calorimeter with Longitudinal Segmentation for a Linear Collider experiment

CONTENTS

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

Requirements from L.C. Physics

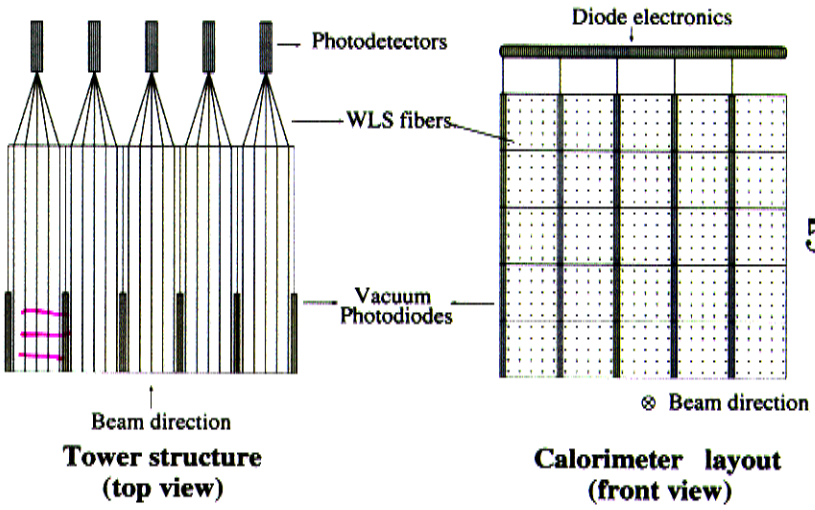
- **Jet energy reconstruction**
  disentangle showers (charged-neutral)
- **High granularity**
- **Longitudinal segmentation**
  e/π separation
- **Good resolution at High Energy ($\mathcal{O}(1\%)$)**
- **Working in high magnetic field**
- **Reasonable length ($25 \div 30 X_0$ in ~ 50 cm)**
- **Reasonable cost**

Shashlik Calorimeters

Shashlik

- Ligh collection via WLS fibers perpendicular to the Pb/sci tiles
- Compact, modular, easy to operate, no dead zones
- Longitudinal segmentation?

CALEIDO

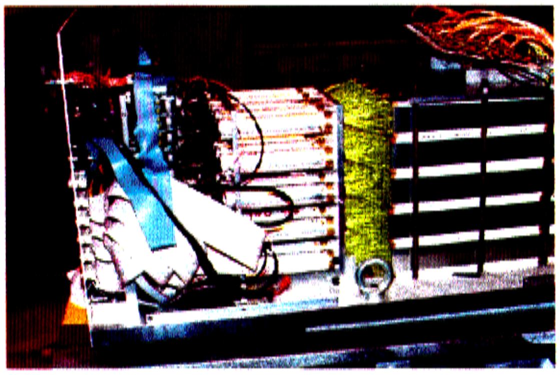


5×5 cm^2

- Study longitudinal segmentation options:
  - a) Insertion of thin vacuum photodiodes in the first X_0's
  - b) Use two scintillators with different time response

CALEIDO 1
published results [b]

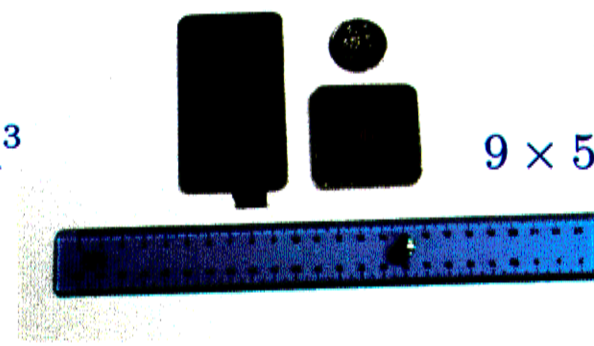
Vacuum Photodiodes in the first 8 (5) X_0



Tower: $5 \times 5 \times 28$ cm^3 5×5 WLS fibers

EMI

$9 \times 5 \times 0.5$ cm^3



Hamamatsu

$9 \times 5 \times 0.5$ cm^3

25 towers, 1 mm Pb + 1 mm scintillator sampling

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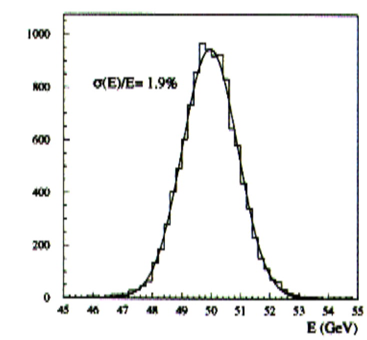
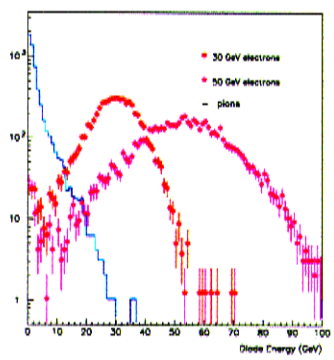
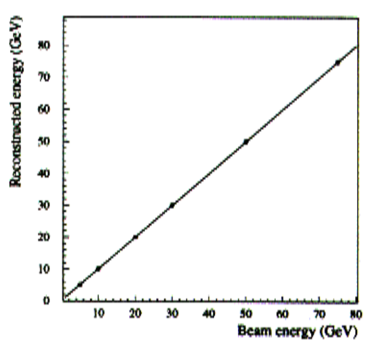
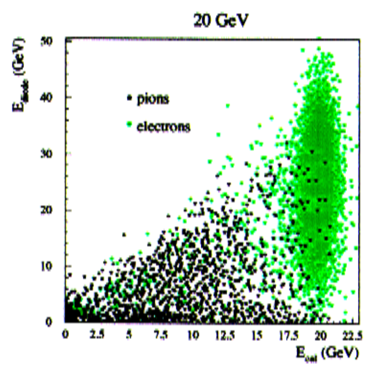
[b] N.I.M. **A432** (1999) 232

Results









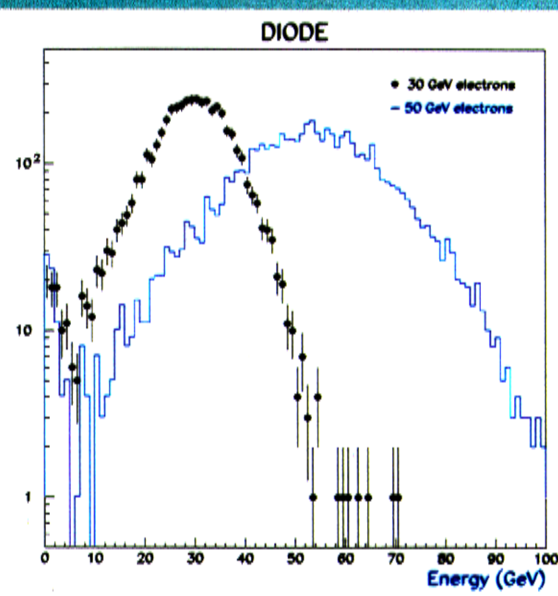
$$\frac{\sigma(E)}{E} = \sqrt{\left(\frac{9.6\%}{\sqrt{E}} + 0.5\%\right)^2 + \left(\frac{0.130}{E}\right)^2}$$

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

$e \div \pi$ separation: $\epsilon_\pi < 5 \times 10^{-4}$ (50 GeV)

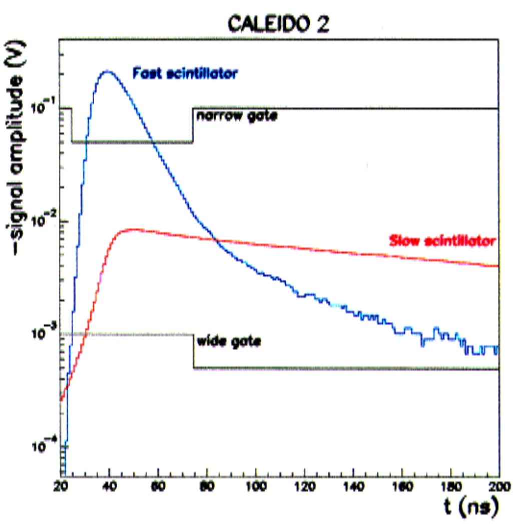
NEW

- $3 \times 5\ cm^2$ **Hamamatsu diode for** $3 \times 3\ cm^2$ **cells**



2 Scintillators with different time response

- First 5 X_0 with long τ scintillator
  same geometry, WLS fibers ....

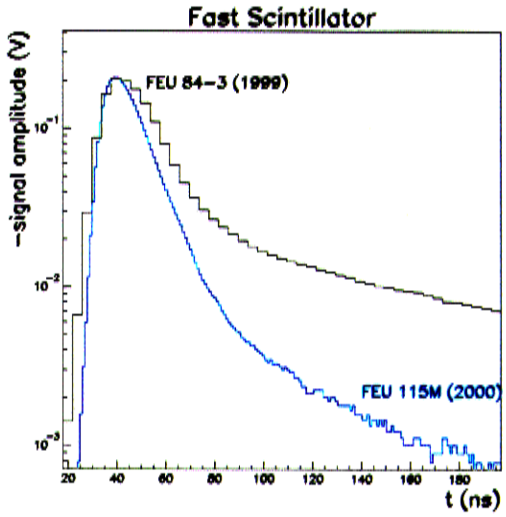


- Slow scint.: BC444 from Bicron $\tau \sim 250$ ns
- e/γ: early shw.$\Rightarrow$ high E_{slow} and E_{fast}
  hadrons: late shw. $\Rightarrow$ small E_{slow}
- 9 counters (3×3) with (fast) PM's
  FEU-84-3 FEU-115M
- RO: narrow and wide gate (50 and 150 ns)
- Q_n and Q_w mix the two components

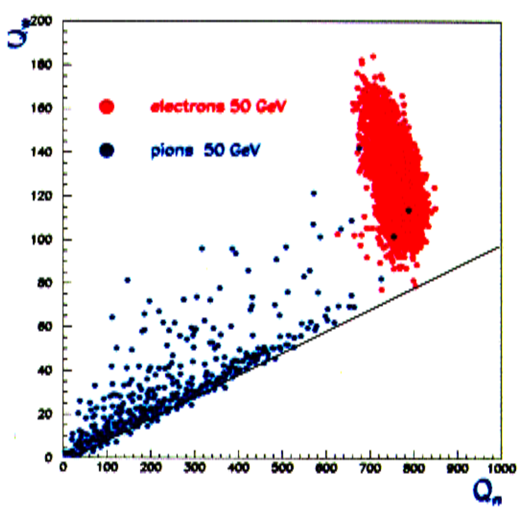
Shashlik

Fast component on the wide gate:

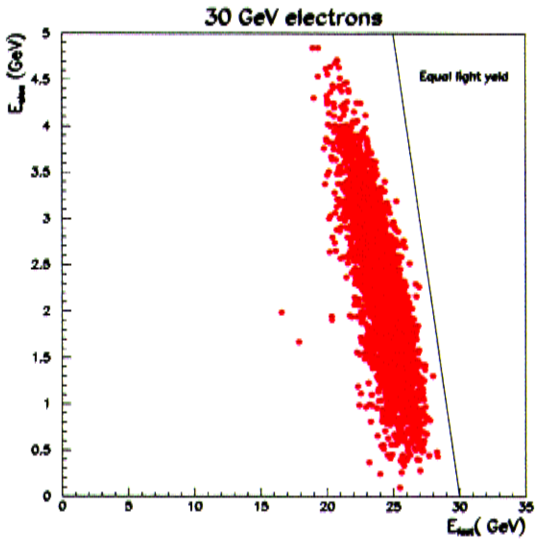
- gate width
- PM



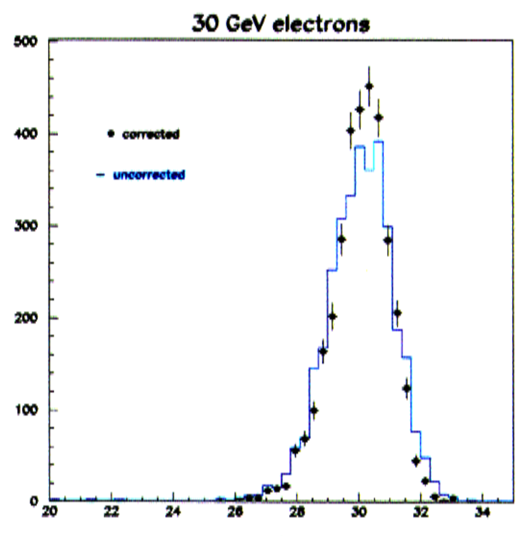
- Linear transformation: Q_w,Q_n $\rightarrow$$E_{slow}$,$E_{fast}$



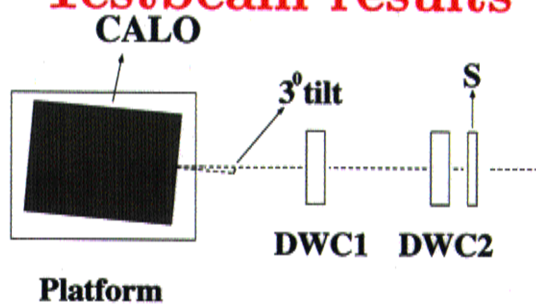
Different light yeld slow÷fast



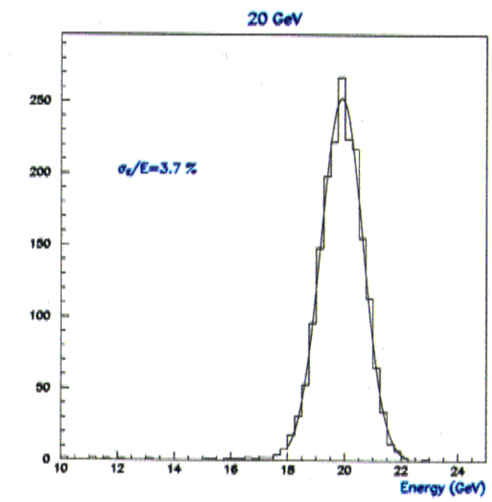
- correction allows to minimize the effect of shower longitudinal fluctuations

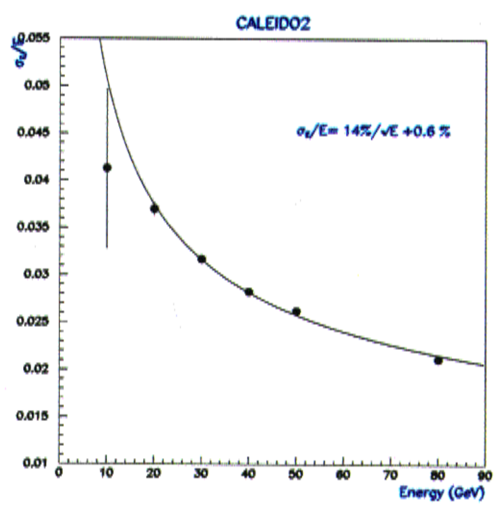


Testbeam results



- CERN X5 and H6 beams

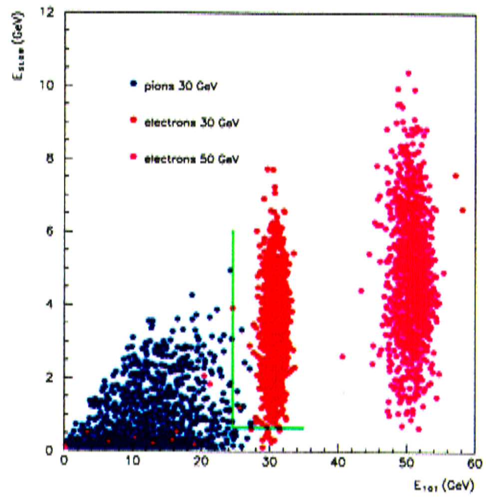


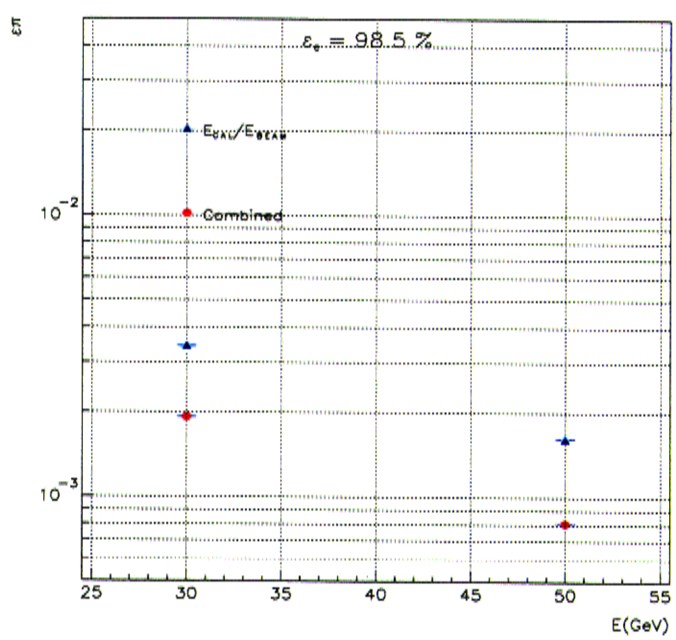


- Energy resolution (still preliminary):

$$\frac{\sigma(E)}{E} = \frac{14.2\%}{\sqrt{E}} + 0.6\%$$

e÷π separation (1999)

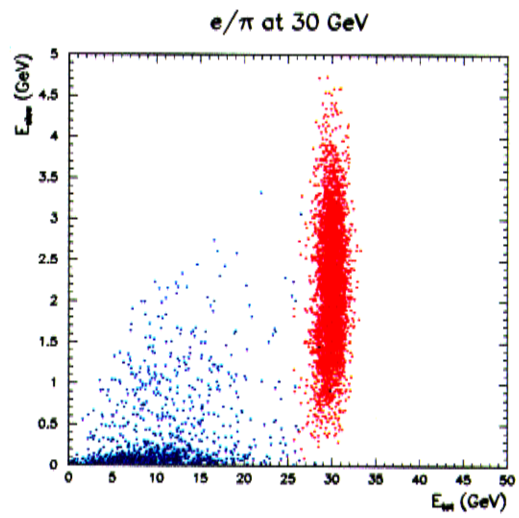


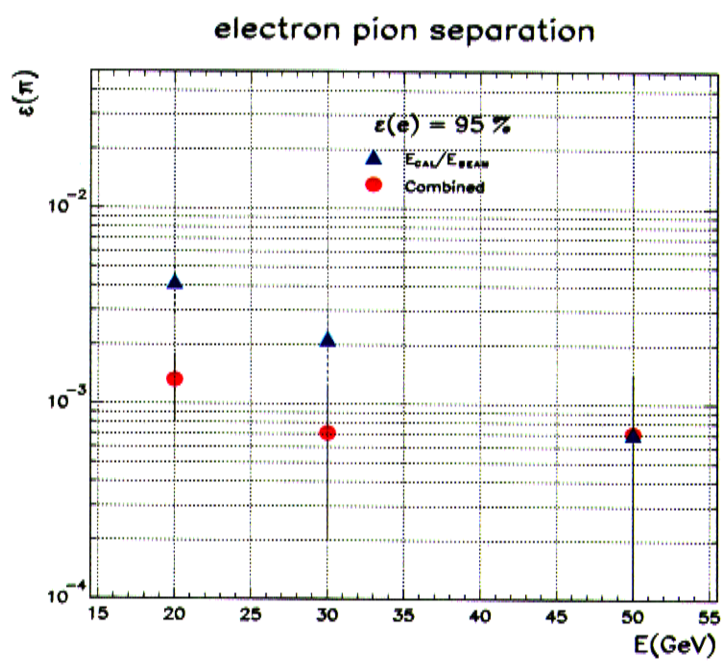


$\epsilon_\pi = 8 \times 10^{-4}$ for $\epsilon_e = 98.5\%$

$\epsilon_\pi < 5.6 \times 10^{-4}$ (95% C.L.) for $\epsilon_e = 95\%$

$e \div \pi$ separation (2000)





$\epsilon_\pi = 7 \times 10^{-4}$ for $\epsilon_e = 95\%$

Testbeam Summary

First prototype:

- Energy Resolution: $< \frac{10\%}{\sqrt{E}}$, $< 1\%$ c.t.
- e/π separation with lateral diode works: $< 5.0 \times 10^{-4}$ at 50 GeV
- Good Position Reconstruction
- No significative cracks

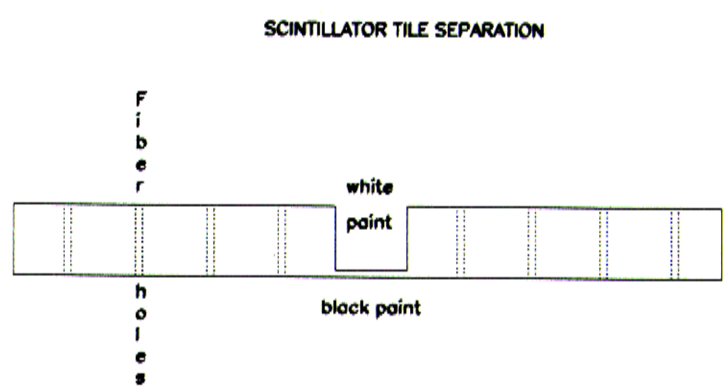
Second prototype:

- Energy Resolution: $< \frac{15\%}{\sqrt{E}}$, $< 1\%$ c.t.
- e/π separation with 2 decay time scint. works: $< 6.0 \times 10^{-4}$ at 50 GeV
- See prototype 1...
- Possibility for more compact mechanics

Both prototypes meet requirements!

Mechanical solution for a barrel E.M. calorimeter at TESLA LC

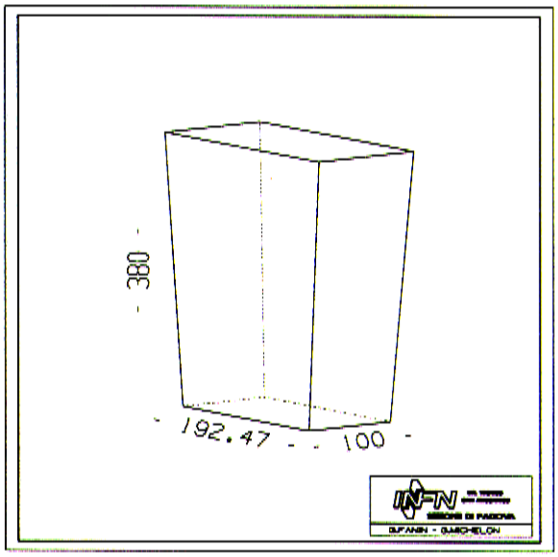
- The 2 τ prototype opens many solutions in addition to the cell-size structure
- Large ($20\ cm \times 10\ cm$) absorber plates with small ($3\ cm \times 3\ cm$) scintillator tiles
- Large ($20\ cm \times 10\ cm$) absorber plates with large scintillator tiles segmented



other solutions in LC note

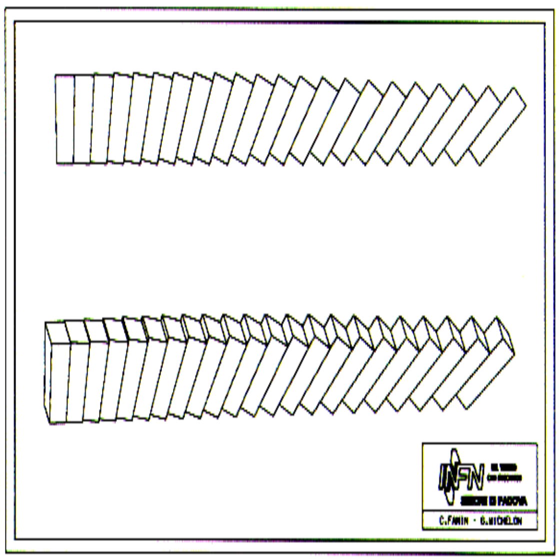
In both case Supermodule:

18 channels



21 S.modules

43344 channels



56 rows

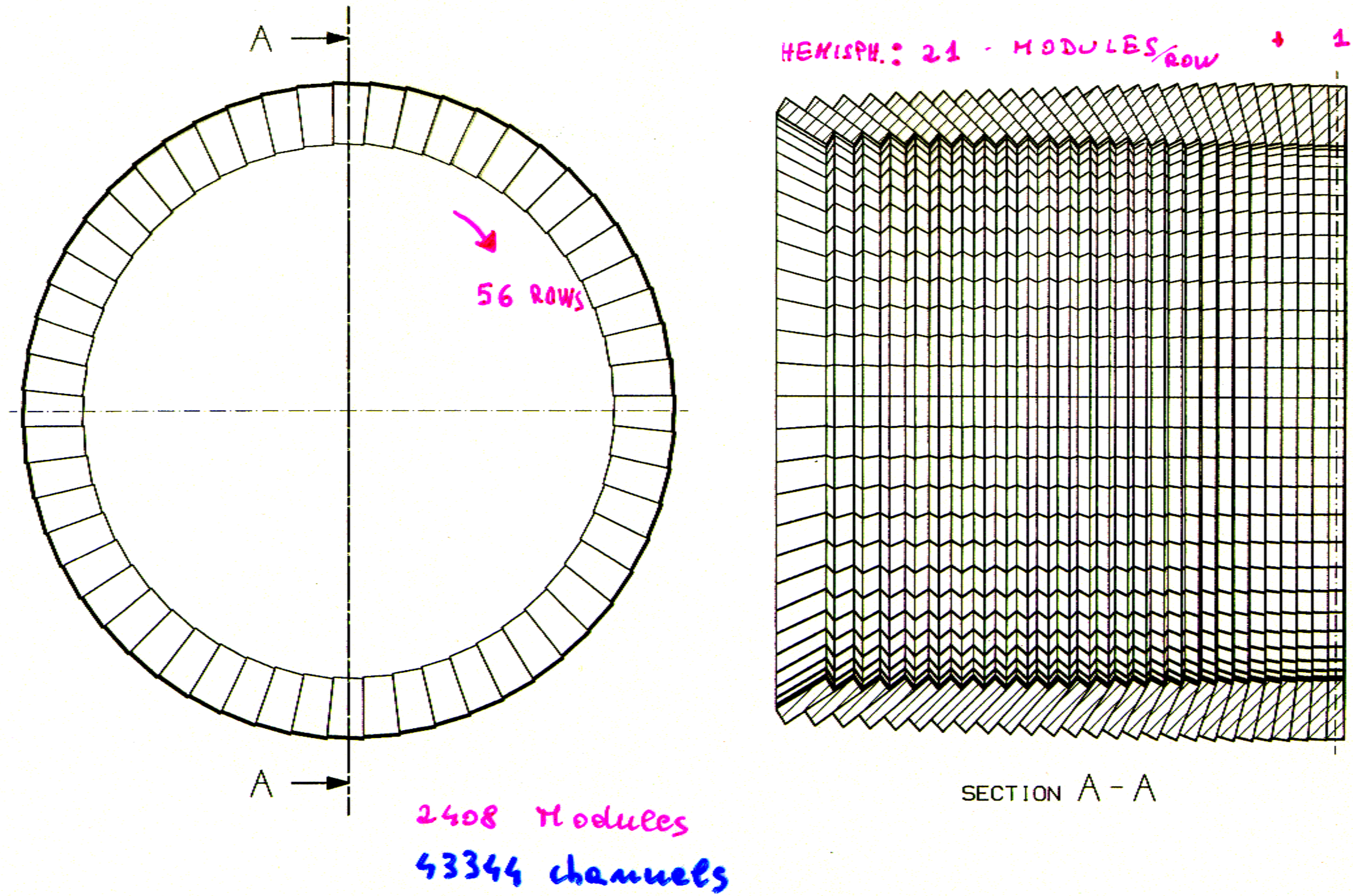
- **WLS fibers coupled to long clean fibers**
- **PM RO outside magnetic field**
- **Tungstene absorber (!?)**

Proposal to TESLA TDR

Conclusions

- Shashlik calorimeters with longitudinal segmentation are possible
- Two solutions successfully tested by CALEIDO
- New technique for channel separation under development
- Contribution to TESLA TDR $\sim$ available

Shashlik is a good candidate for an ElectoMagnetic Calorimenter at a future Linear Collider!


A
A
56 ROWS
HEMISPH.: 21 · MODULES/ROW + 1
SECTION A - A
2408 Modules
43344 channels