Tail-catcher Muon-tracker for the CALICE Beam Tests.

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Outline

- What is TCMT? Who are building TCMT?
- TCMT stack: design, main components, optics.
- Calibration, monitoring system and common readout with AHCAL.
- The first cassette: cosmic ray spectra and beam test at DESY.
- Possible optical separation of a cell in a modular design for ILC detector.
- Summary.

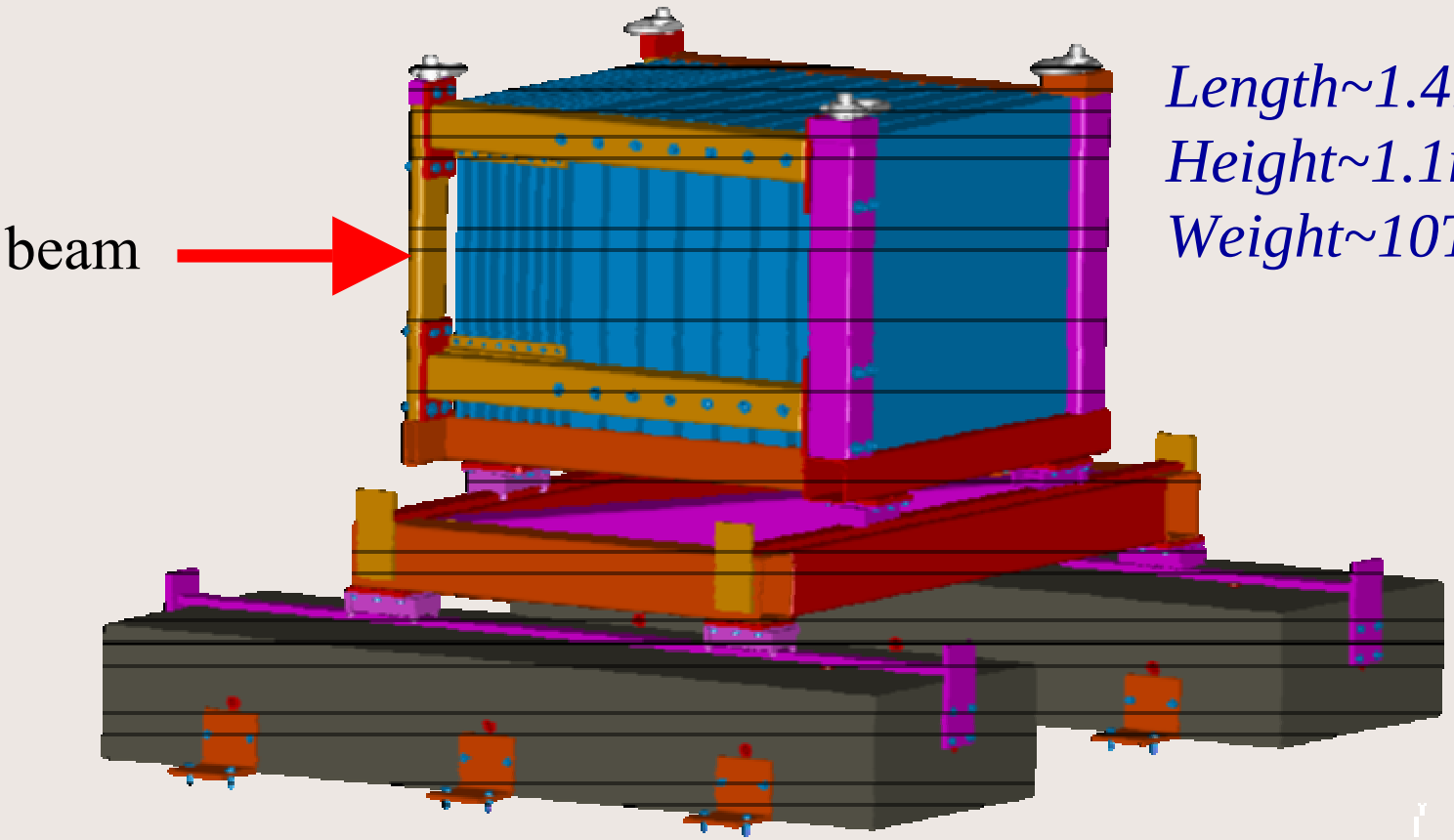
Introduction

- As a precision instrument for the ILCD, calorimeter is essential to get a jet energy resolution $\sigma/E \sim 30\% /\sqrt{E}$.
- A complete calorimeter system includes an integrated tail-catcher and muon system to be located behind the ECAL and HCAL.

Introduction II

- A US-European group is pursuing the construction of about a cubic meter sized scintillator-steel device which will serve as a **t**ail-**c**atcher and **m**uon **t**racker (TCMT) and so has a fine and a coarse section.
  - *The construction of the TCMT is being pursued by DESY and NIU with Fermilab contributions*.

A Scintillator-steel Design for the Tail-catcher Muon-tracker



Length~1.4m
Height~1.1m
Weight~10T

TCMT Major Parts

- **As an passive media** there will be 16 layers of steel. 8 fine (2cm) and 8 coarse (10cm) plates arrange in a stack.
- **As an active media** there will be 16 cassettes with extruded scintillator strips (in alternating x-y orientation), WLS fibers, and SiPM as readout.

Goals for the TCMT Beam Test

- For calorimeter:

1. *A detailed measurement of the hadron shower tail for a MC simulation validation,*
2. *Valuable insights into hadronic shower leakage,*
3. *A punch-through from thin calorimeter,*
4. *The impact of the coil in correcting the leakage.*

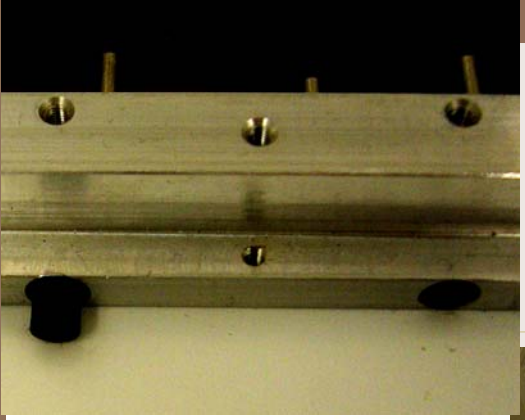
- For muon system:

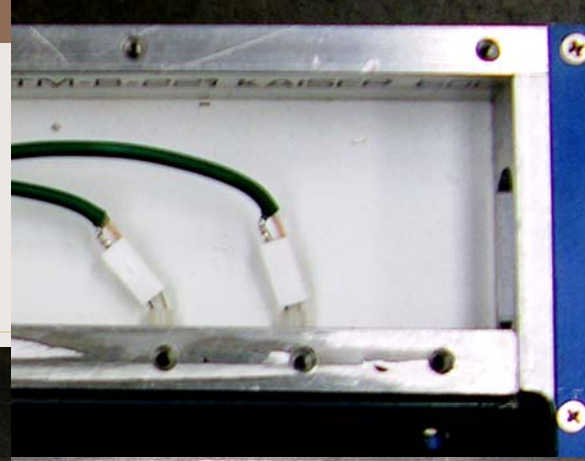
1. *A prototype of muon tracking,*
2. *A muon identification within the particle flow reconstruction framework.*

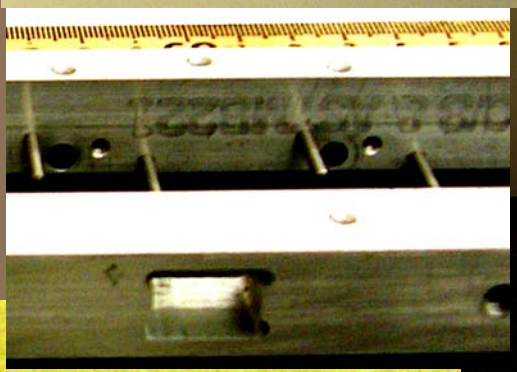
Optical Part Includes:

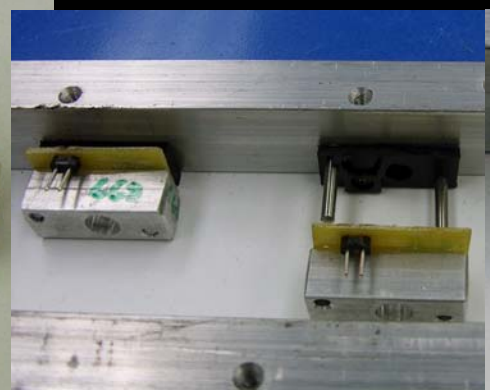
1. NICADD extruded scintillating strips (101cm long, 10cm wide, 5mm thick) with separation groove and co-extruded holes; edges painted with EJ-510 reflective coating. (QC done)
2. Kuraray Y11, 1.2mm OD, 1033mm long, multiclad, WLS fibers (not glued); polished, with UV epoxy protected mirrored end. (QC done)
3. Reflective materials: VM2000, Tyvek.
4. Photo detector: SiPM (from MEPhI&PULSAR) with square 1mm^2 active area (one sensor per 5cm strip).

TCMT Cassette

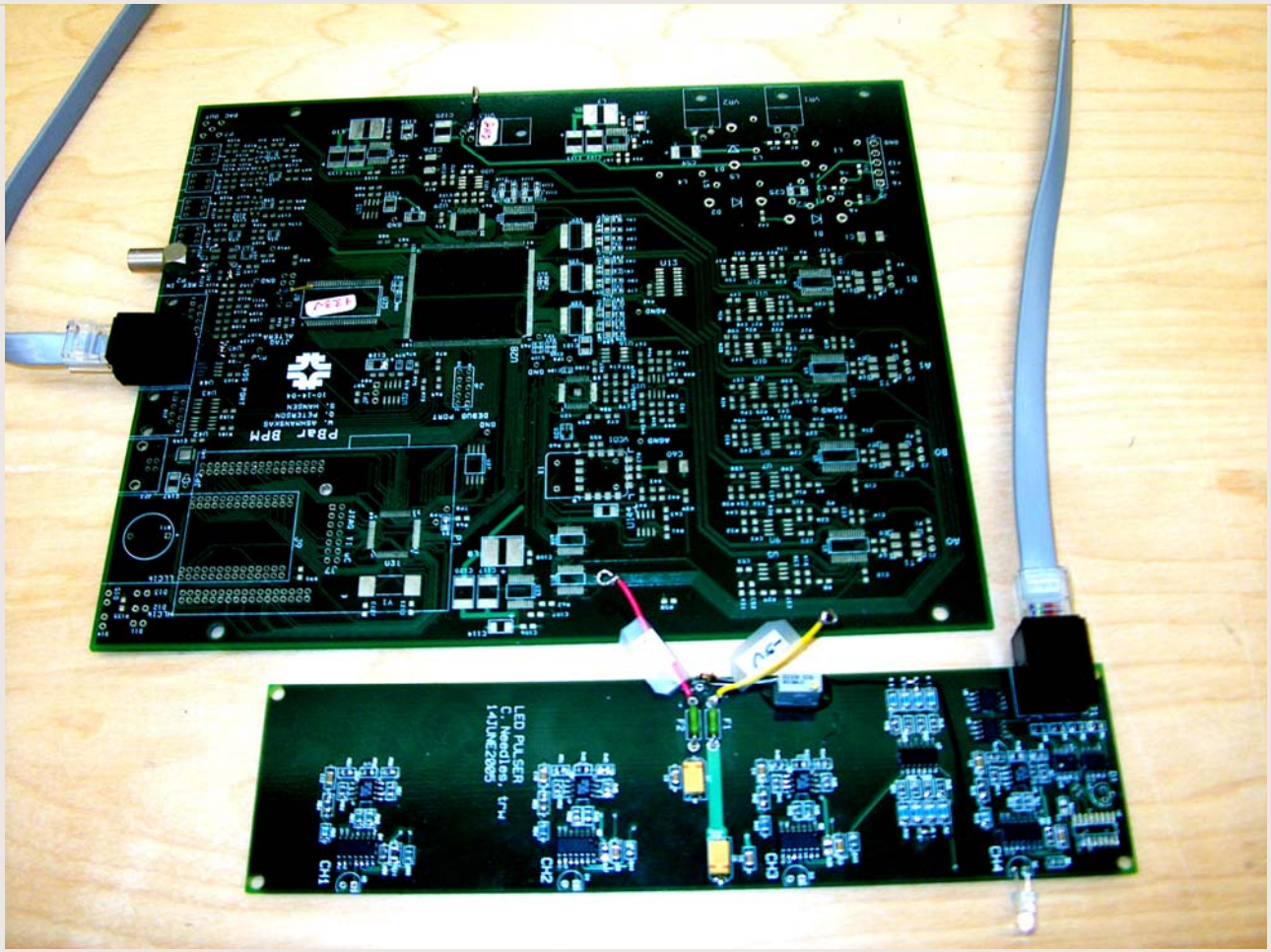




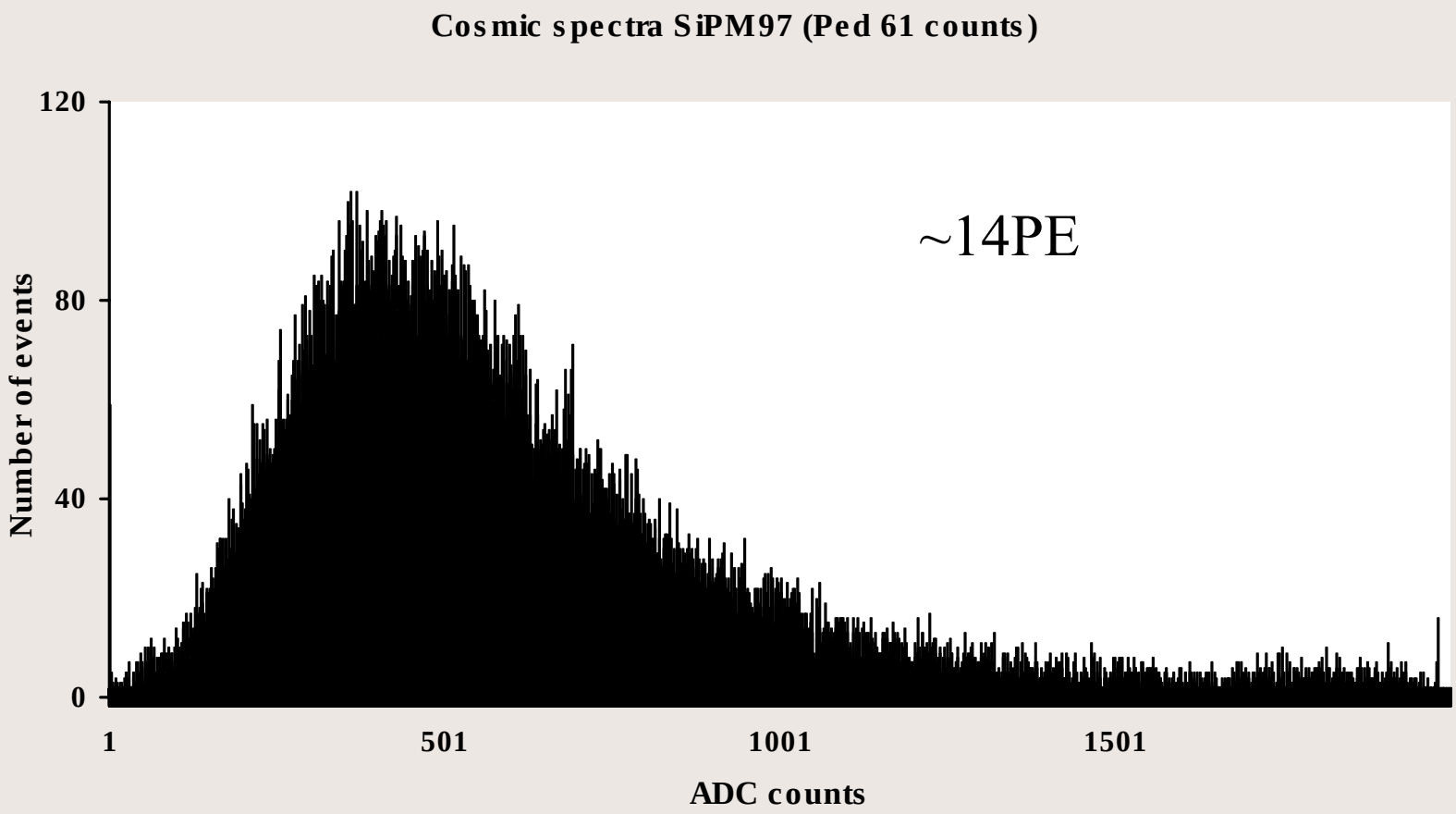




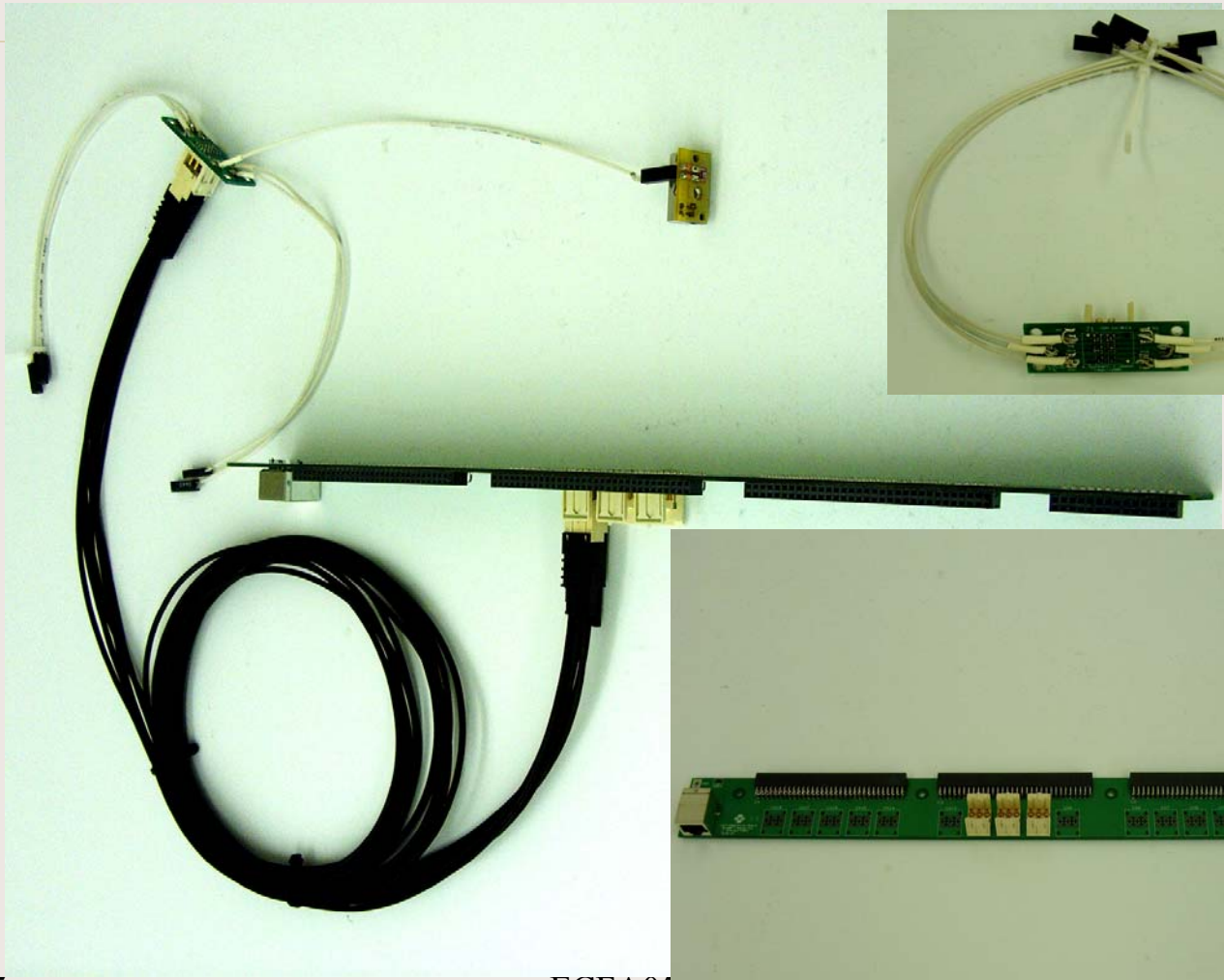
Calibration and Monitoring



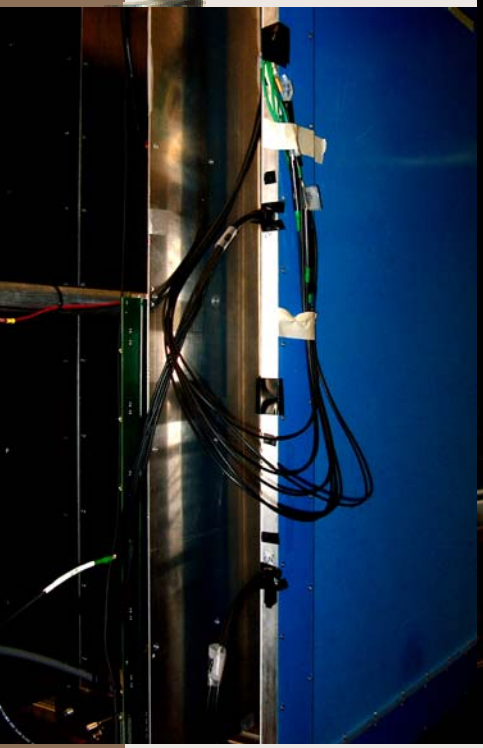
The First Cassette Commissioning

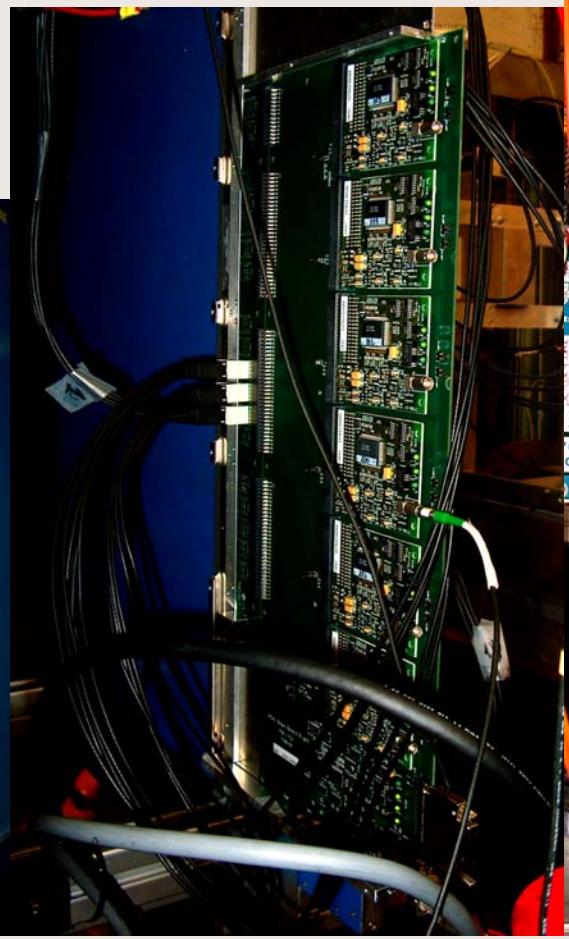


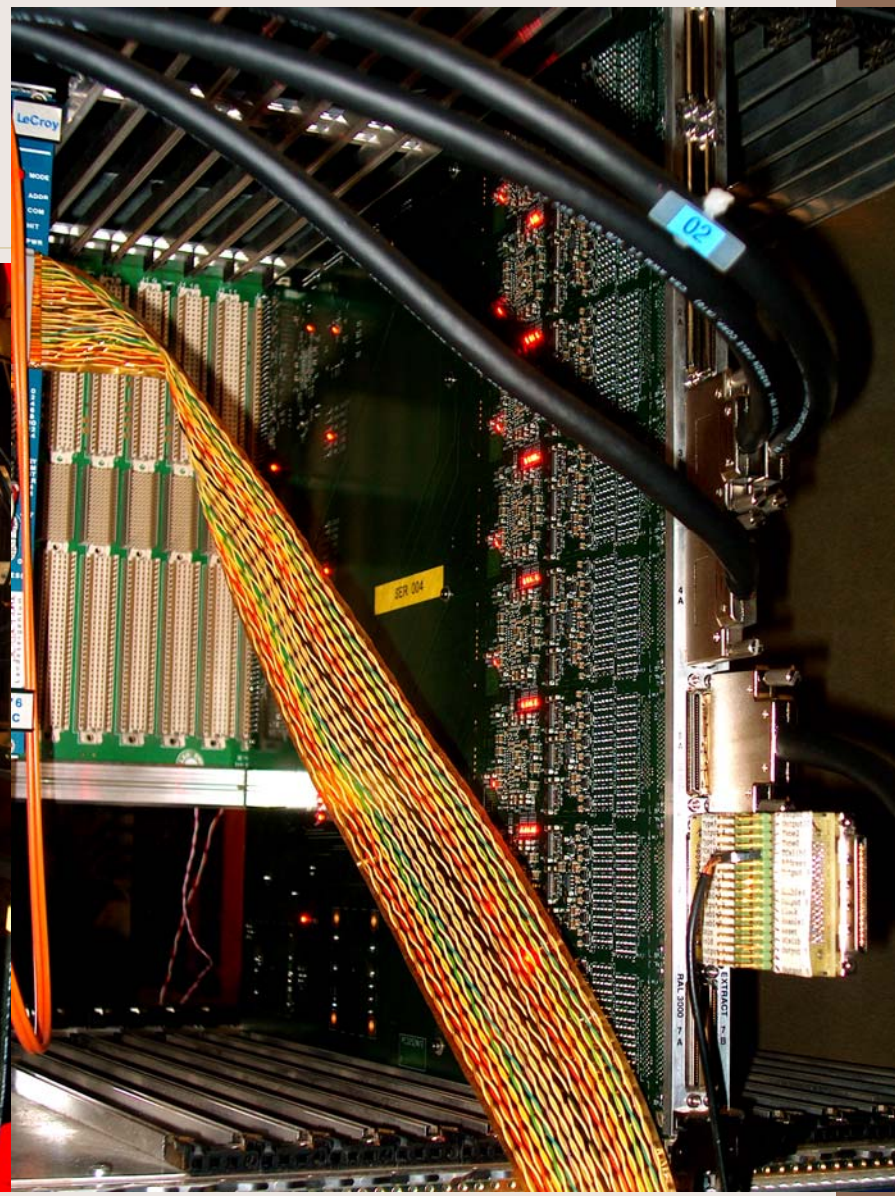
Cable, Connectors, and Adaptor Board for Common Readout with AHCAL



Connected





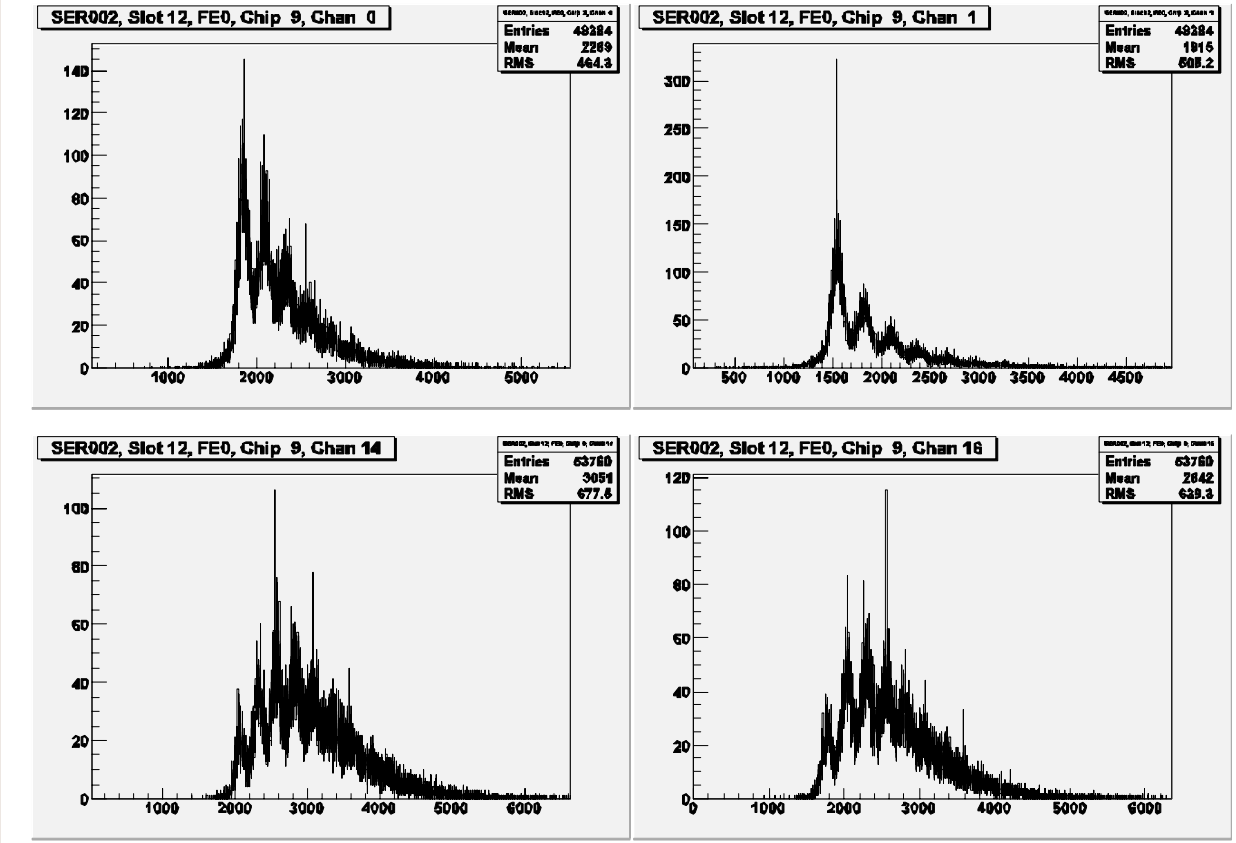


Primary Goal

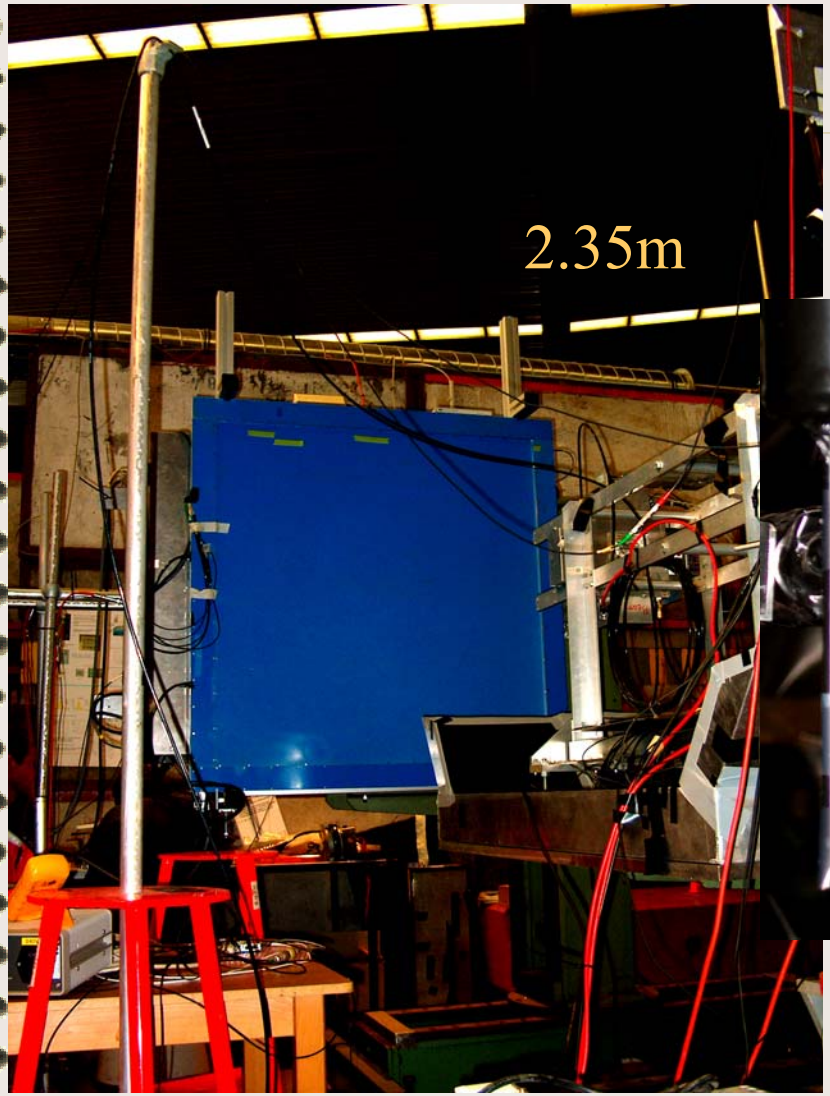
- Integrate the TCMT into the HCAL electronics and DAQ chain

- *The individual biases on the SiPM were set through the DAQ and pedestals and LED spectra for all 18 channels were successfully read out*

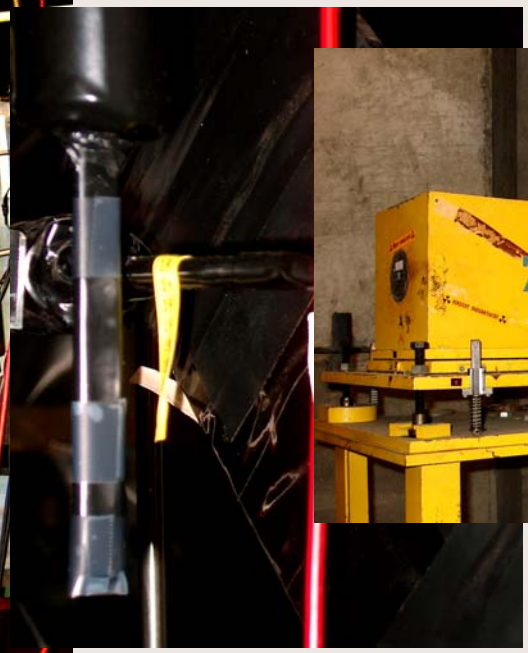
The Primary Goal has been Achieved

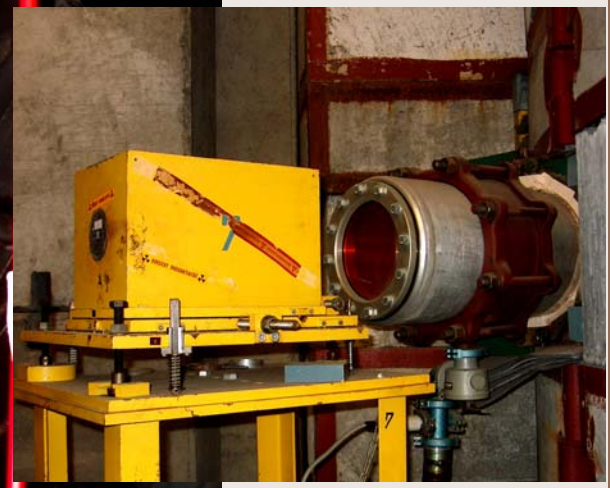


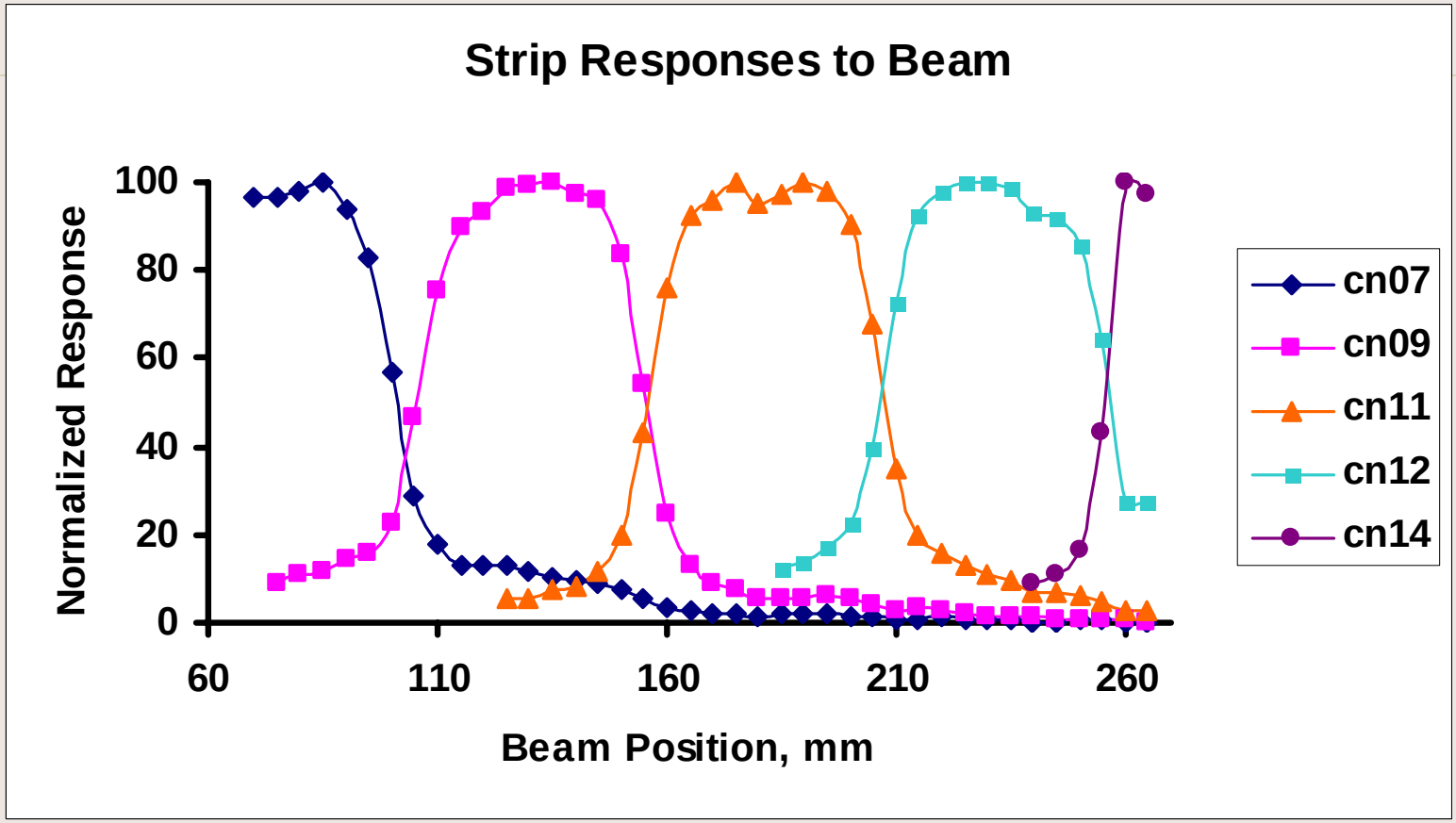
DESY Beam Test



6.75m






Strip Responses to Beam
Normalized Response
100
80
60
40
20
0
60
110
160
210
260
Beam Position, mm
cn07
cn09
cn11
cn12
cn14

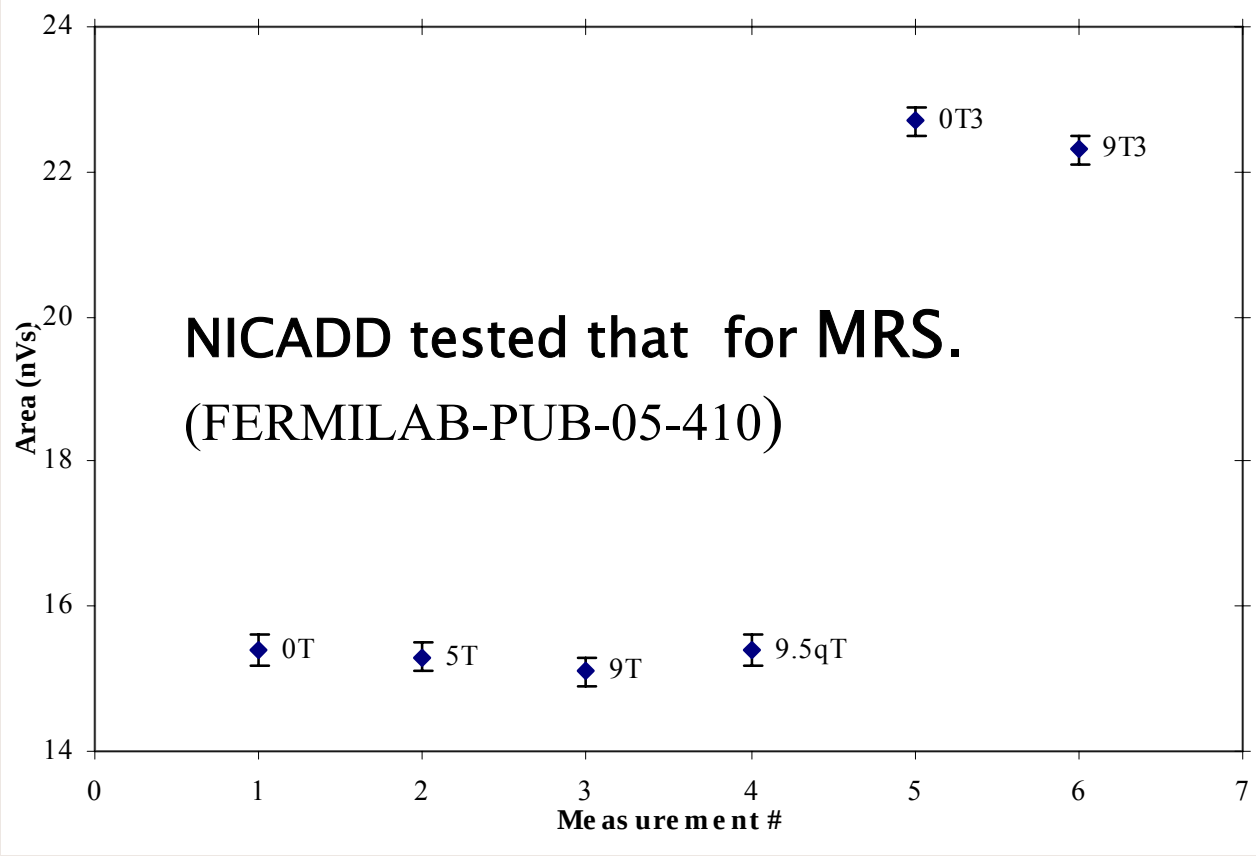
2006 Beam Tests of Hadronic Calorimeter Including TCMT

- Energy scans with single pion and proton responses (1-60 GeV).
- Incident angle scans (3 angles at 2 energies).
- Calibration runs (with defocused muons).
  - Muon responses (3-20 GeV).

- *TCMT making excellent progress.*
- *Should be ready for beam tests.*

(awaiting arrival of full SiPM)

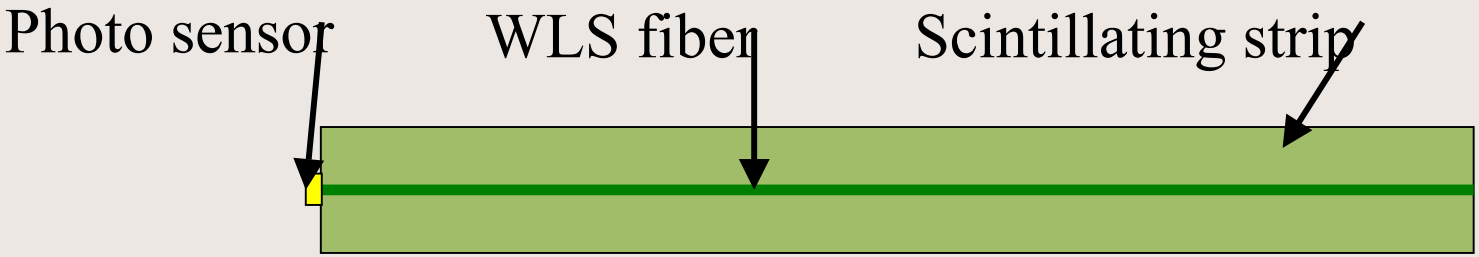
Silicon Photo Detector Insensitivity to Magnetic Field up to **9T**



New Activity in Silicon Photo Detector Implementation

- An active element technique based on a **narrow scintillating strips** with dimensions about 10mm width and 20cm length was tested and proved for GLD-Calorimeter.
- A wavelength-shifting (WLS) optical fiber **with one photo sensor per strip** was used as readout.

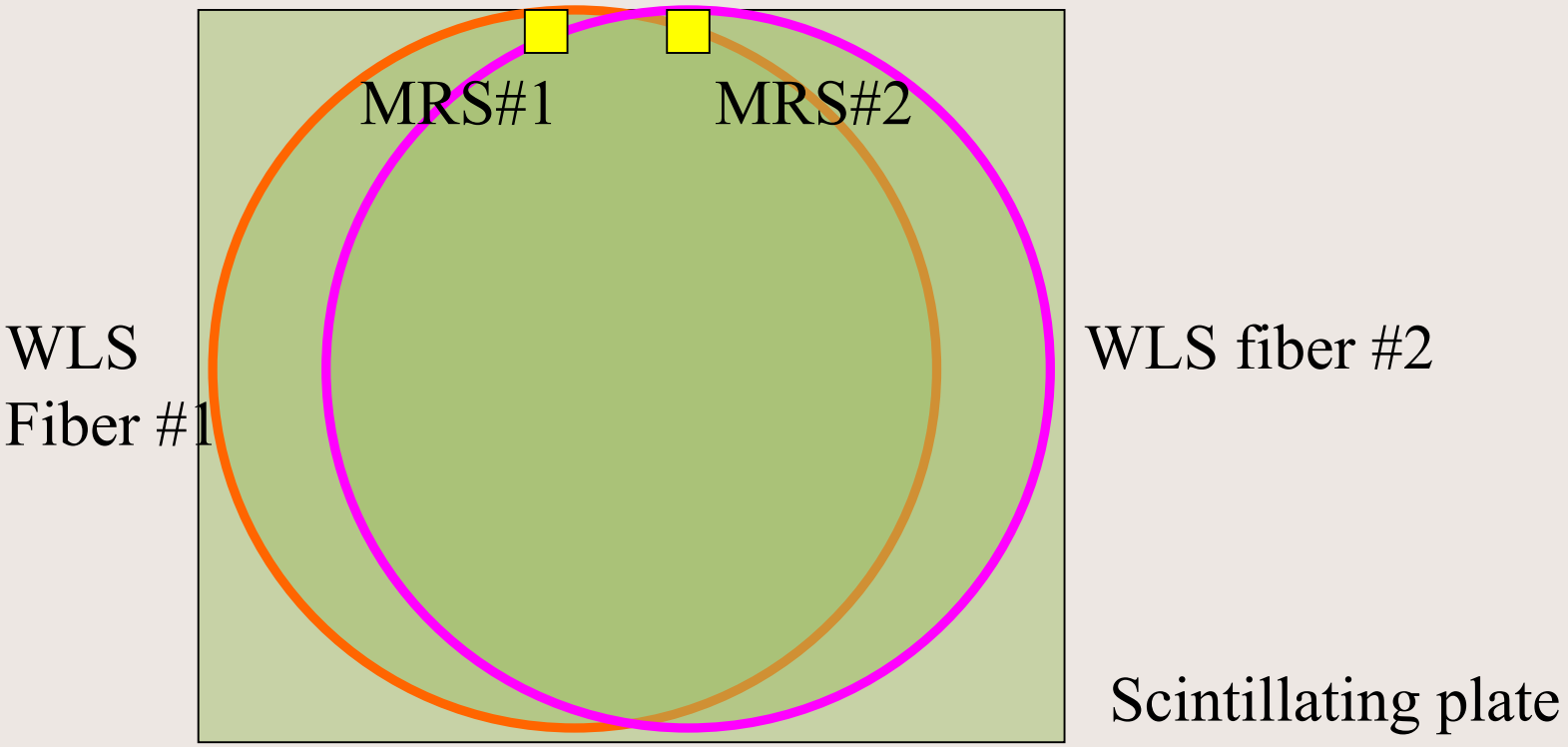
  [T.Takeshita talk at Snowmass 2005]



How to Reduce Influence of the Intrinsic Noise?

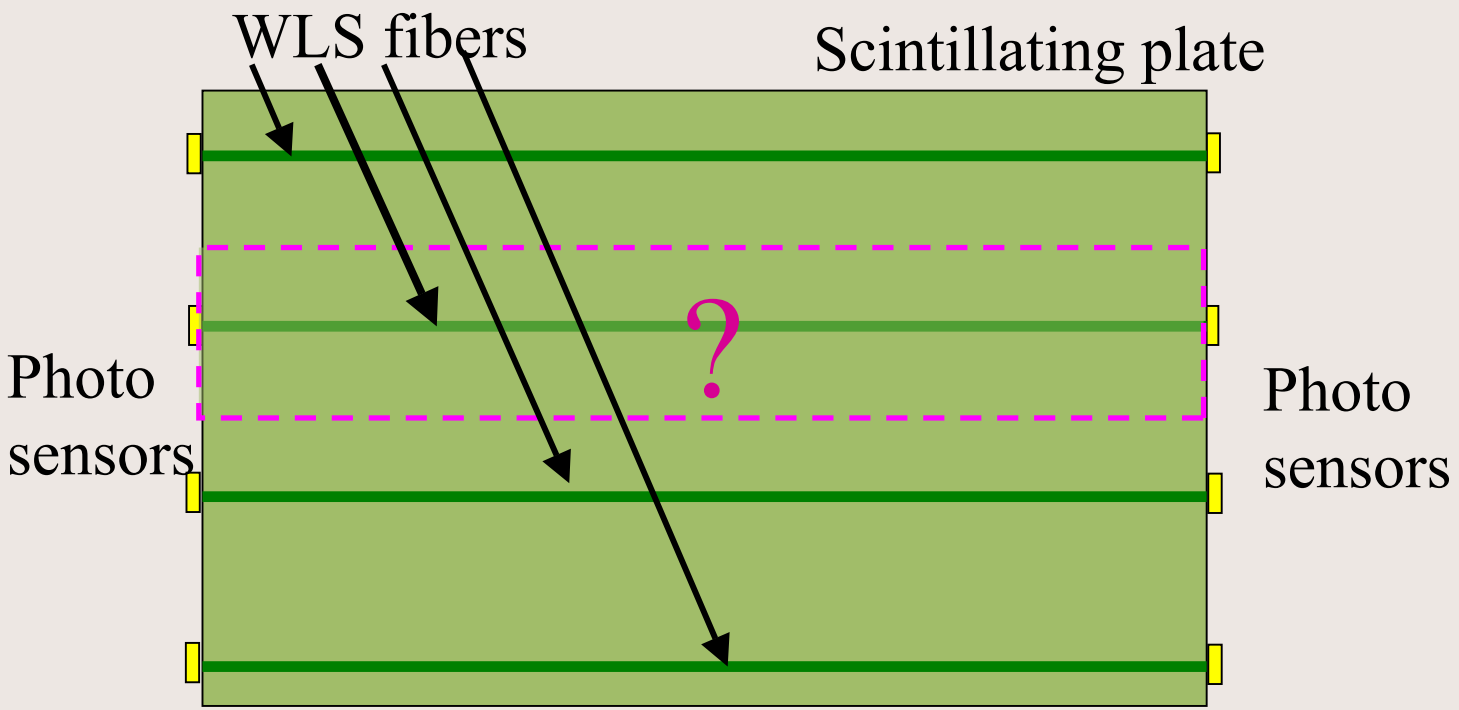
- **A scintillation counter** (150x150x**10**mm^3) for the START detector used a coincidence (gate ~20ns) of **two MRSs** connected to **two WLS fibers**.
- This approach combined with a high threshold (at least 3 PE) in each channel killed the influence of the MRS intrinsic noise on the detector performance. [A.Akindinov et al.].

One Scintillator with Two Fibers and Two MRS.



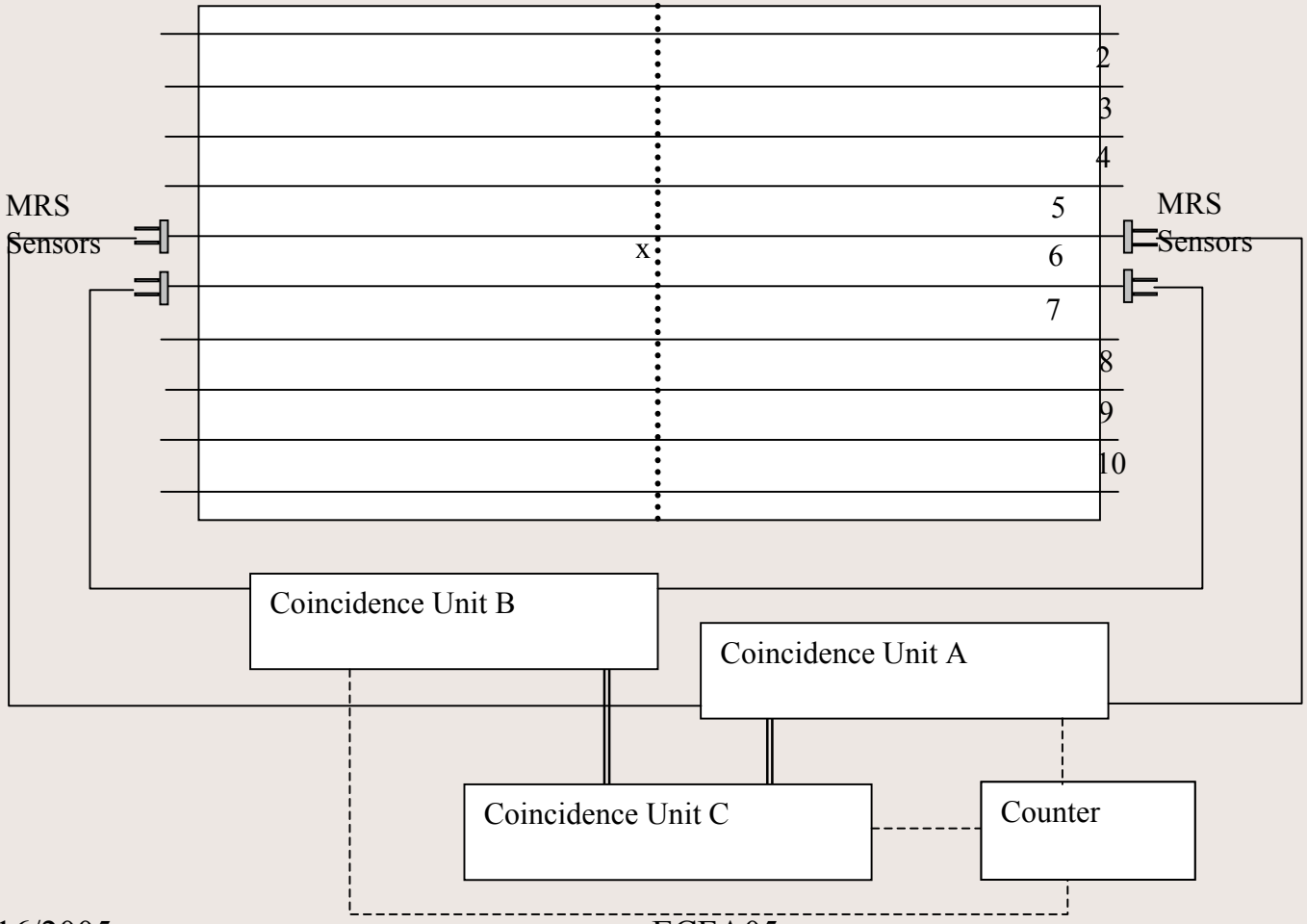
Two MRS Per Fiber Without Glue

(5mm Thick,10mm Width, 20cm Length):

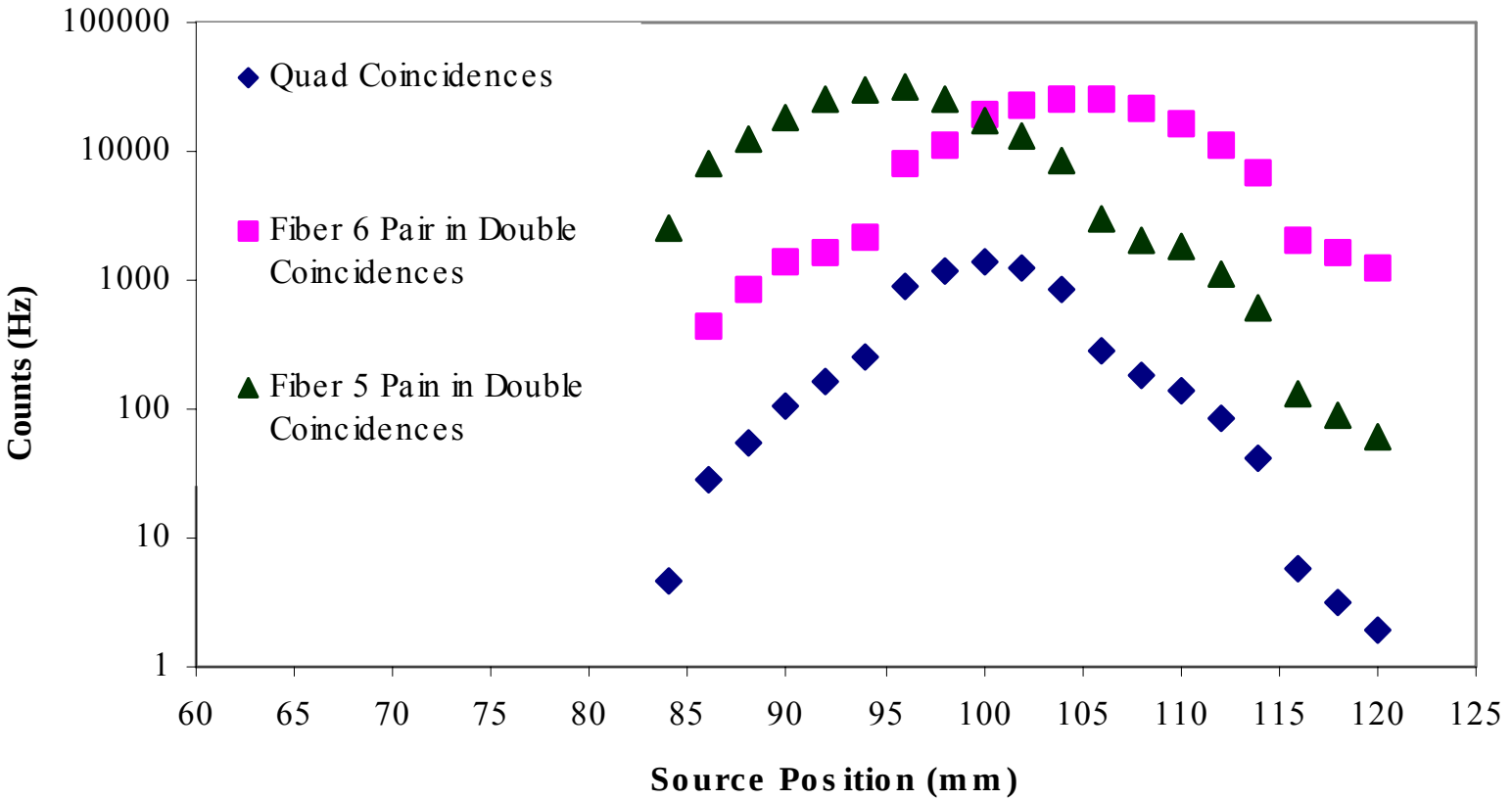


Sr-90 Rate Test Schematic

(10cm Width, 20cm Length, with 10 WLS Fibers):



Result of the Rate Tests



Summary

- Coincidence between neighboring WLS fiber signals provides a ***good optical separation of a cell in a modular design.*** (FERMILAB-PUB-05-387)
- The test, performed with machining grooves, indicates that extruded scintillating **strip** with co-extruded **holes**, separation **grooves**, and **reflector** full covered can be a good ***design element.***
- This choice promises technical improvements, simplification in optics & on board electronics, and cost savings for a scintillator based ILCD.