Options for Dual-Readout Calorimetry in the 4th Concept

LCWS2007

Calorimetry

DESY, June 1, 2007

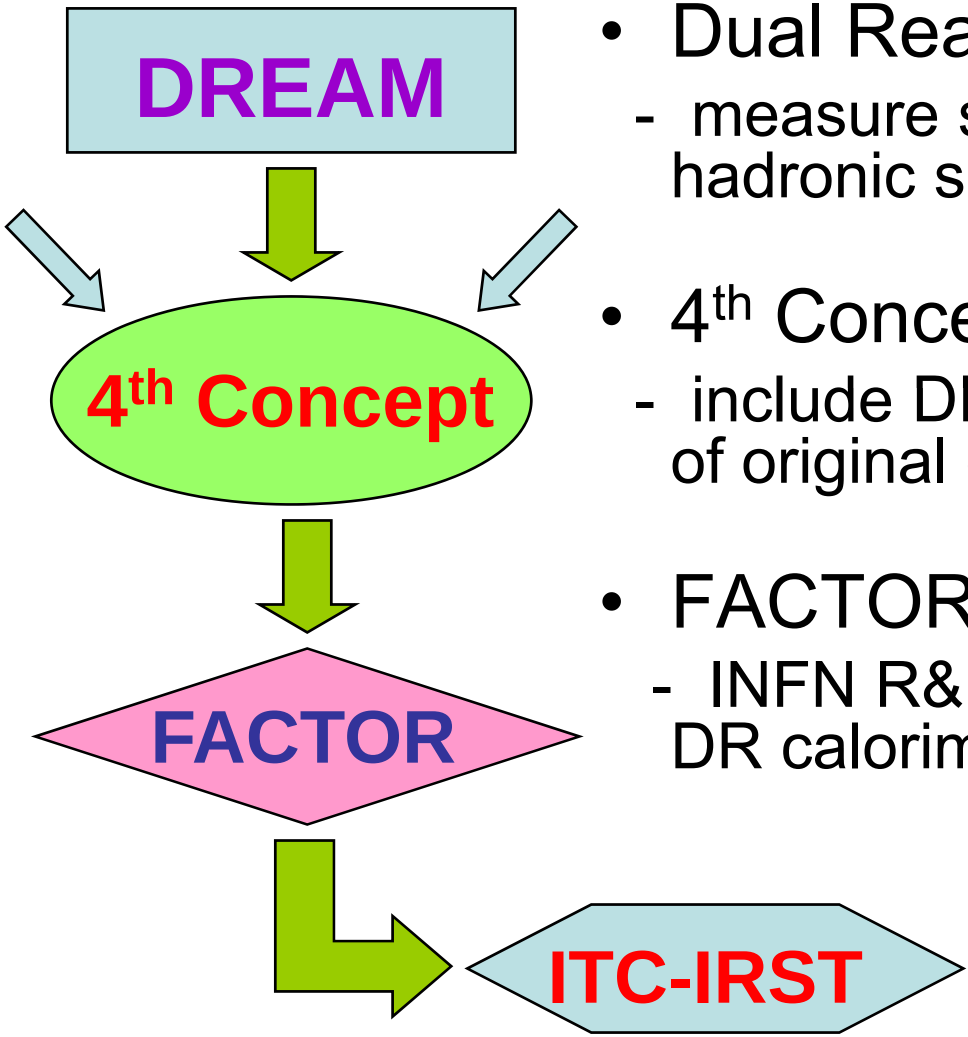
* (Light-Emitting) **Active Media**
* (Photon-Sensing) **Detectors**
* (Time-Domain) **Signal Processing**

Istituto Nazionale di Fisica Nucleare
INFN
Sezione di Trieste

A. Penzo, INFN-Trieste

DREAM 4 ILC

How does all this come together?



- Dual Readout (DR) Calorimetry
  - measure separately EM fraction of hadronic showers and slow neutrons
- 4th Conceptual Detector
  - include DR calorimetry in spectrometer of original design (dual solenoid)
- FACTOR (Trieste-Udine-Messina)
  - INFN R&D project on technology for DR calorimetry (SiPM, fibers, etc)

ITC(*)-IRST (Trento) public research and technology inst. since 1994 working on the development and production of semiconductor devices

(*) Now **Fondazione Bruno Kessler**

ITC-IRST (Trento)

ITC (Now Fondazione Bruno Kessler) – IRST is a public research and technology Institute, working since 1994 on the development and on the production od semiconductor devices for research and applications. It has a fully equipped Microfabrication Laboratory in which silicon devices are built.

- Ion Implanter
- Furnaces
- Litho (Mask Aligner)
- Dry&Wet Etching
- Sputtering &Evaporator
- On line inspection
- Dicing

Main activities:

- TCAD simulation,CAD design
- Fabrication
- Certification

FACTOR: INFN R&D Project

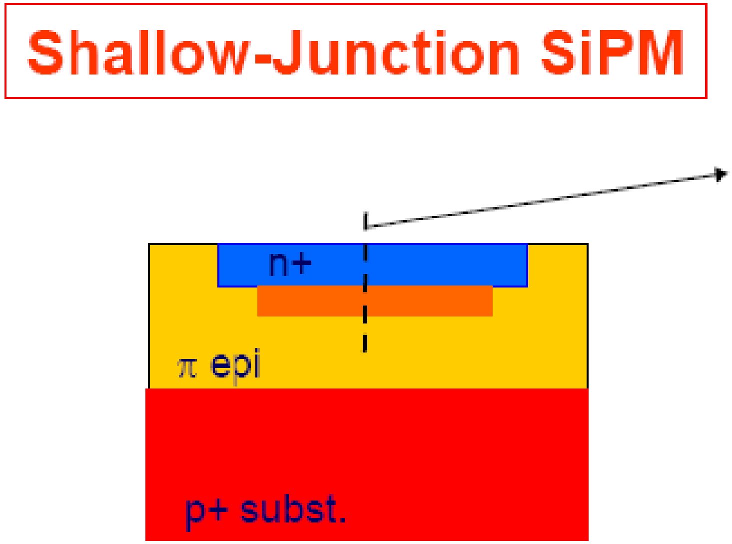
- 3 Teams: Messina (5), Trieste (7), Udine (4)
  (Walter Bonvicini et al.)

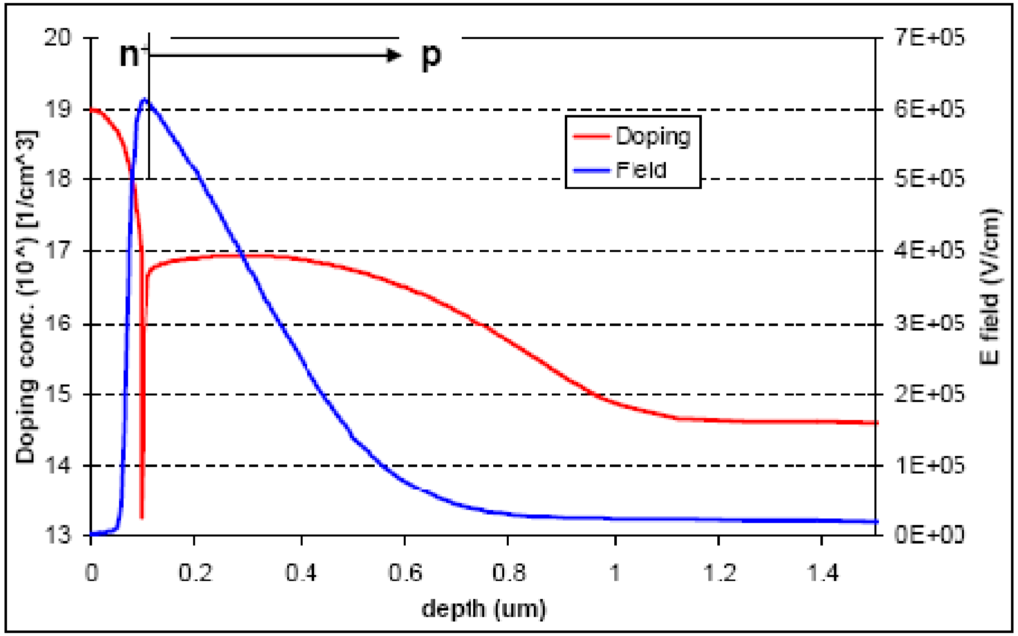
- Tasks:
  - Studies and development of crystals, Cerenkov radiators, neutron sensitive scintillators
  - Design (in collaboration with IRST) of SiPM, with properties optimized for DR calorimetry, and their evaluation
  - Evaluation and design of “pulse shape” sensitive fast electronics

- Schedule: 2006-2007 Studies, R&D, prototypes
  2008 Full scale tests

IRST Technology

C. Piemonte "A new Silicon Photomultiplier structure for blue light detection" NIM A568 (2006) 224
C.Piemonte et al. "Characterization of the first prototypes of Silicon Photomultiplier fabricated at ITC-IRST" IEEE Trans. Nucl. Science 54 (2007) 1

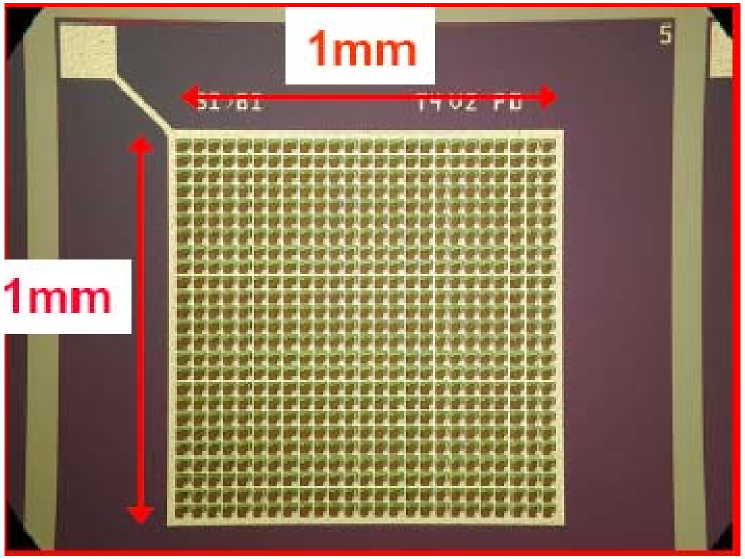




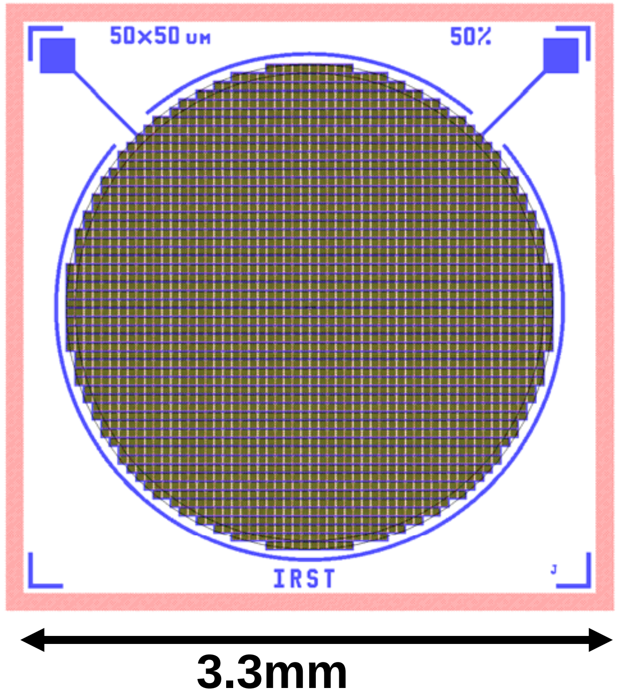
- 1) Substrate: p-type epitaxial
- 2) Very thin n+ layer
- 3) Quenching resistance made of doped polysilicon
- 4) Anti-reflective coating optimized for λ~420nm

IRST detector structure

Basic SiPM geometry:
- 25x25 cells
- cell size: 40x40μm2



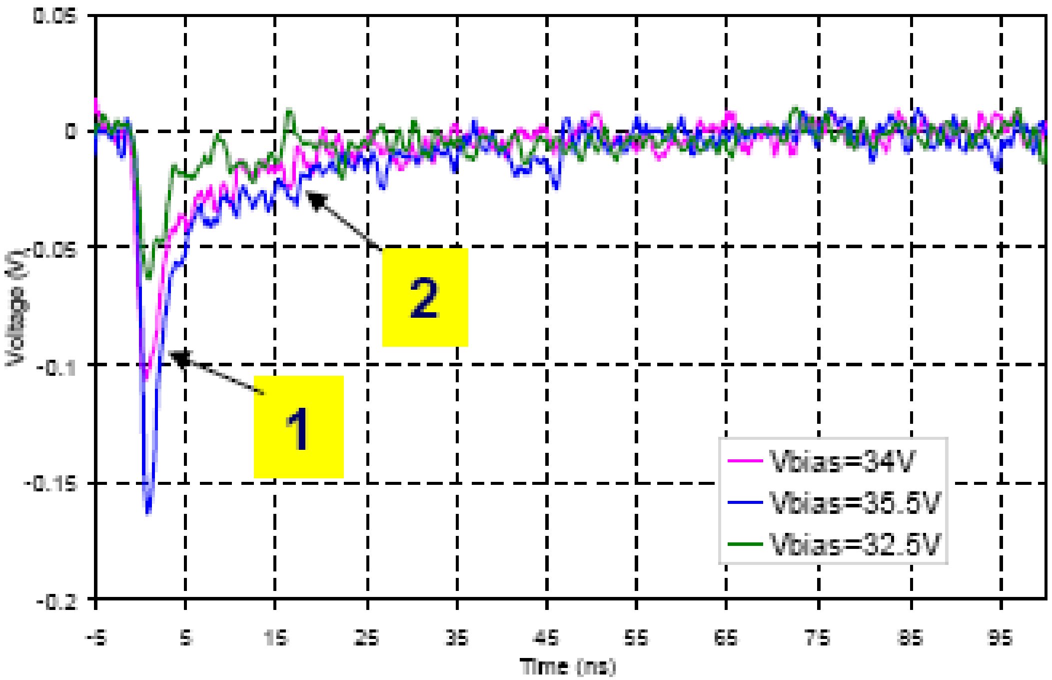
IRST new design
Delivery of prototypes in 2007



SiPM signal shape

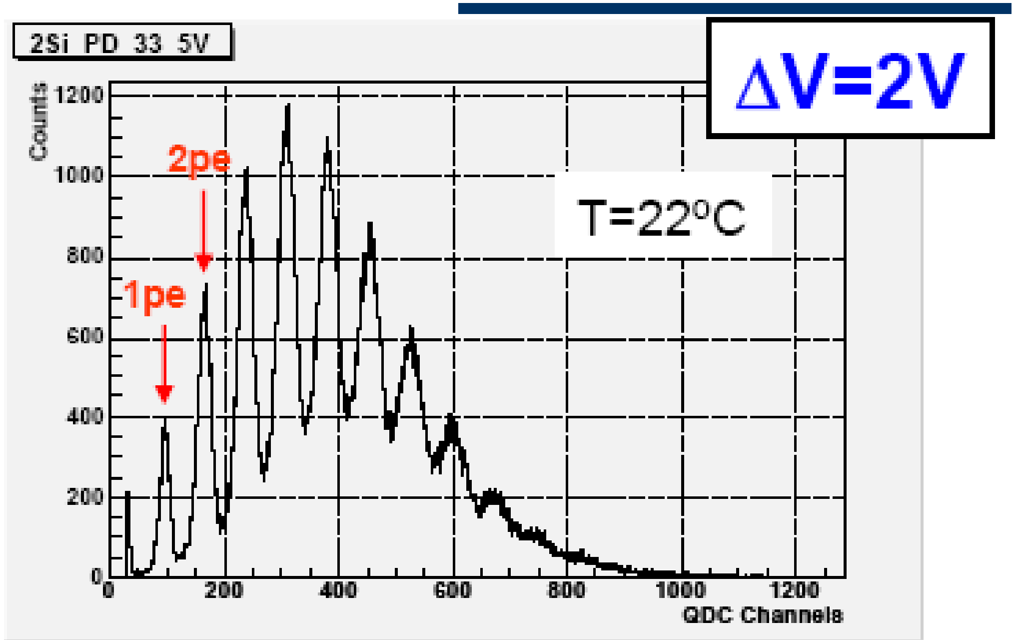
- The signal presents 2 components:

1. Avalanche current reproduced at the output by parasitic capacitor
2. slow component due to the recharge of the diode capacitance (Recovery time ~70ns)



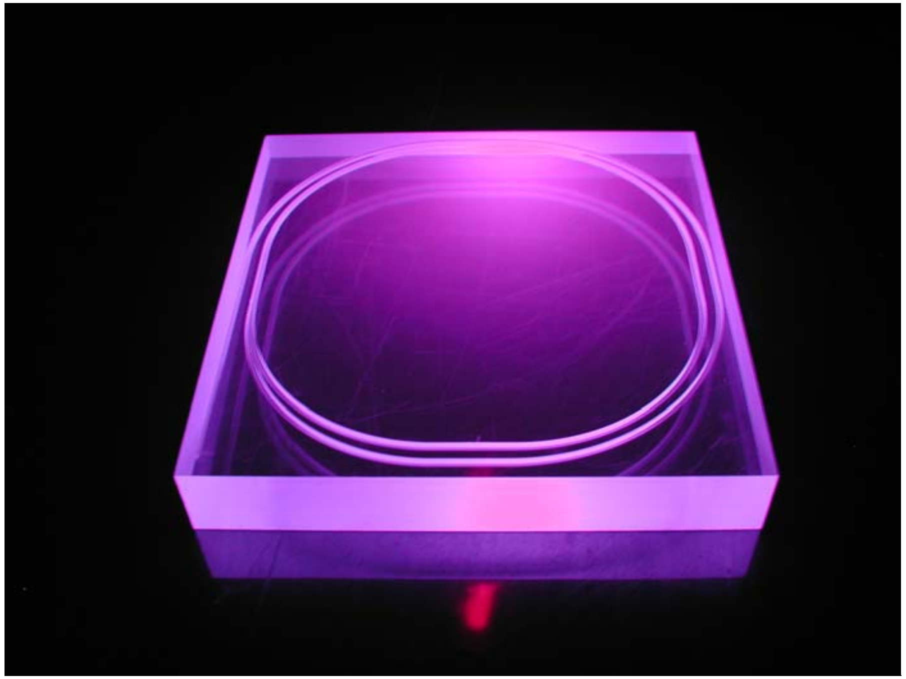
SiPM response to LED

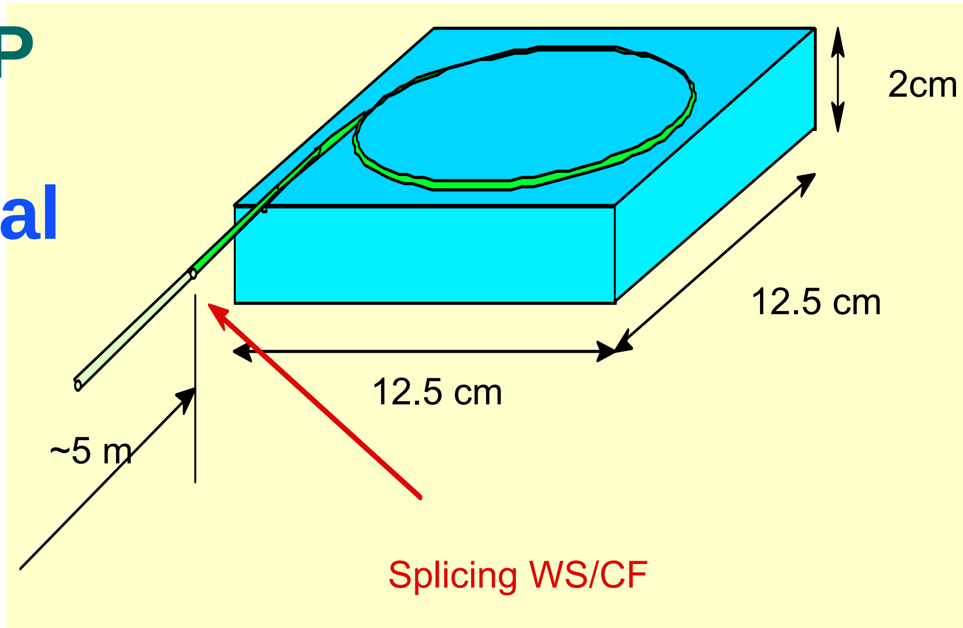
Pulse charge spectrum from low-intensity light flashs (blue LED)



Tiles used for Ts/Ud tests

- **Dubna scintillator + keyhole/double-spiral groove + 3M super-reflector**
- **Kuraray fiber achieved 37 pe/MIP without optical glue, 44 pe/MIP with glue.**
- **Lose x3-4 along optical path to PMT (attenuation+splice+ connector)**





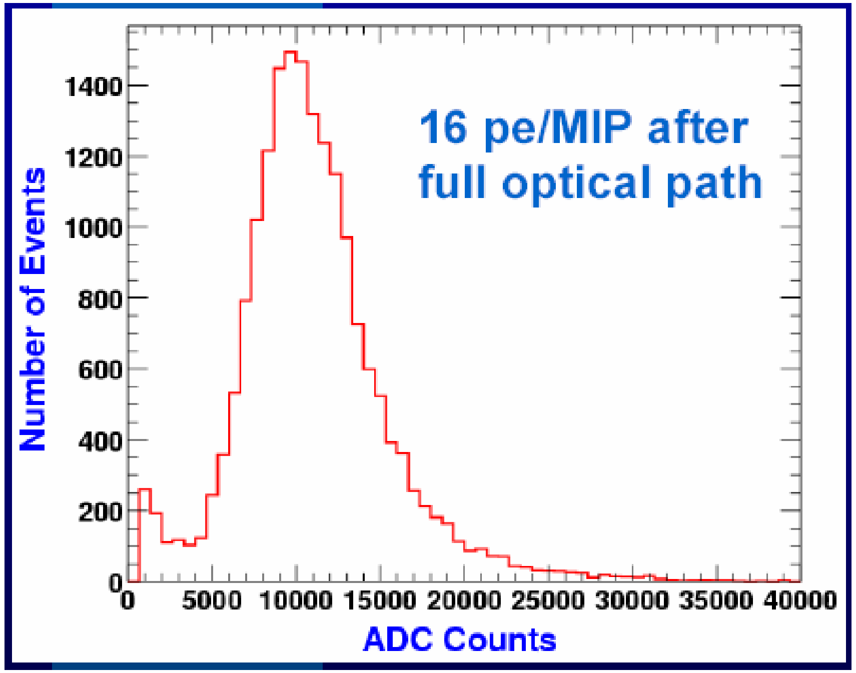
Performance (MIP)

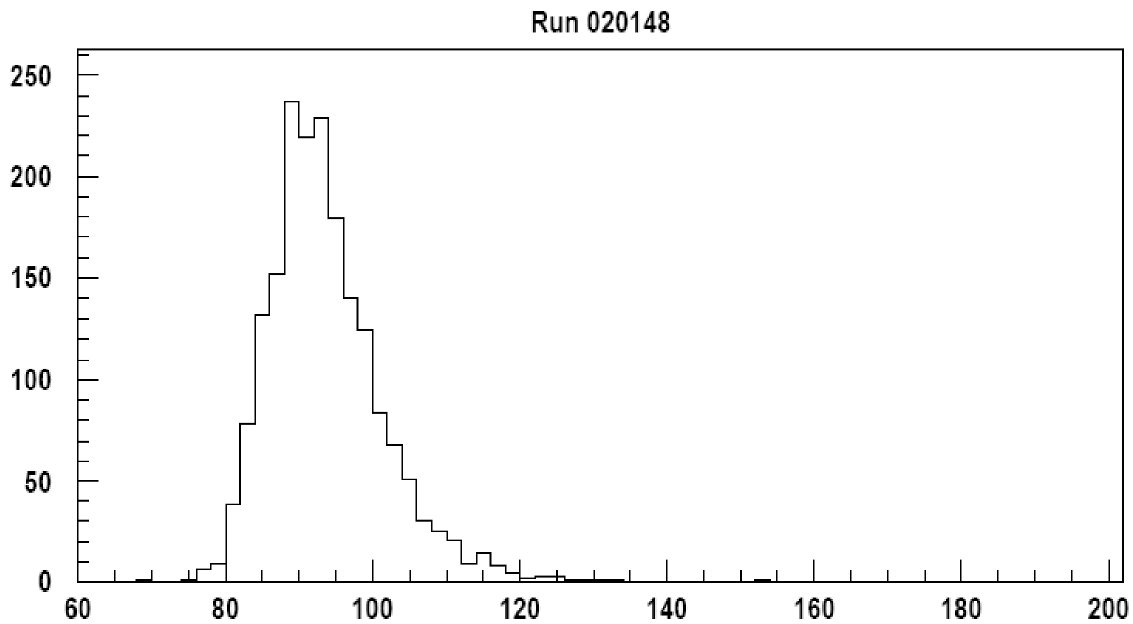
with

PMT

and

SiPM



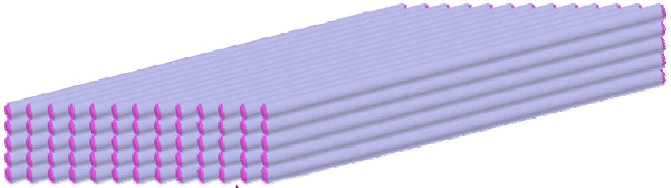


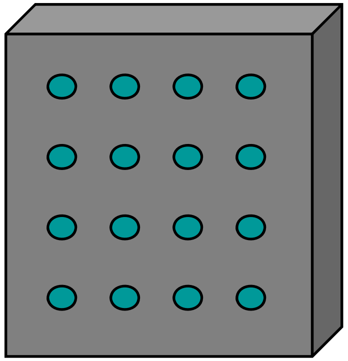
Tile test setup at Frascati

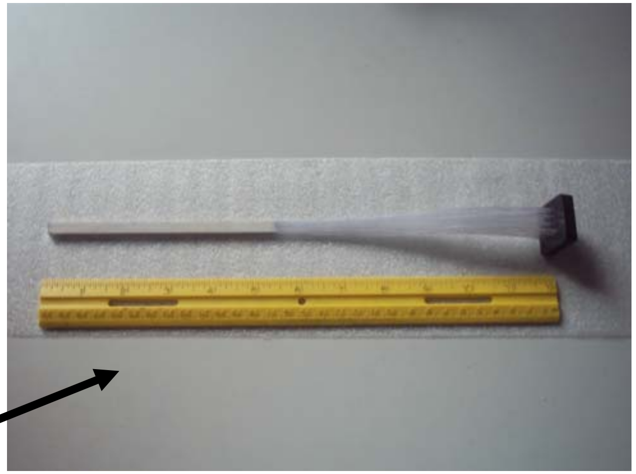
Erik Vallazza, Michela Prest

Fiber application study: Fiber Arrays

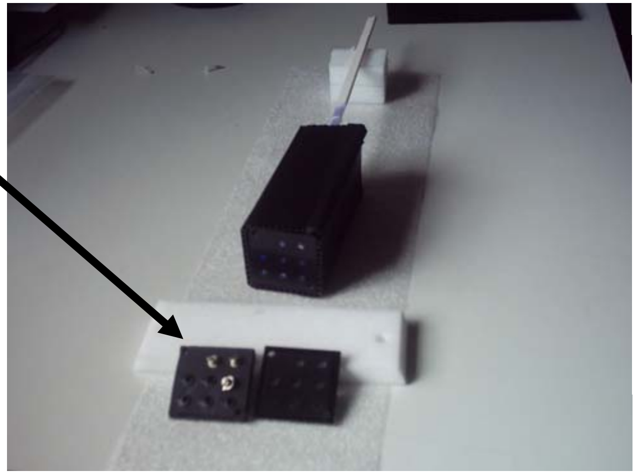
[5 layers of 0.5 mm diameter Fibers]







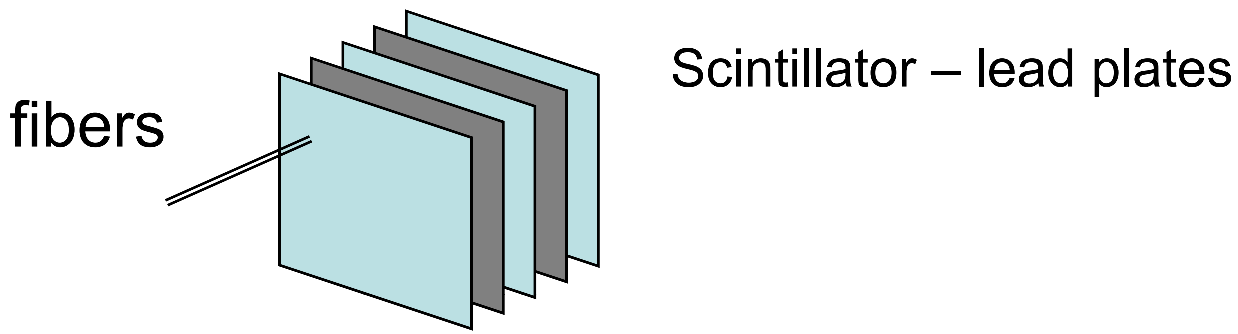
- **Fiber Array** mapped via a **Template** on a16 channel multi-anode photomultiplier H6568
- A second **Fiber Array** equipped with **SiPM** (8 channels, each corresponding to 2 of the adjacent channels of MAPMT)



The 2 arrays are accurately superimposed and aligned in a PS test beam (T11)

Interim Summary…

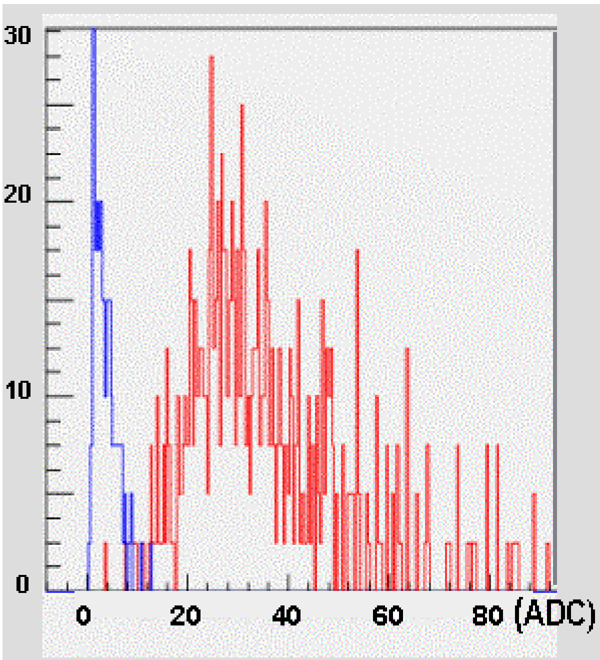
- SiPM interesting, still in evolution, improve linearity
- Look for other photodetectors to survive high B field
- Extensive R&D and tests
- Materials and structure for active media
- Fast-slow discrimination
- Many ways to compensating dual-readout (DR)?
- How about a "shashlik" configuration?



Spare Slides

- Photo-converter for B = 3.5 T. The usual suspects: SiPM, HPD,
- special B-resistant PMTs, microchannel plate PMs.

MIP distributions



- Hamamatsu blue-sensitive SiPMs
- 400 pixels on $1mm^2$, moderate crosstalk
- 2-3x more lightyield with green WLS

~6 times more with blue scintillator light

Tile with SiPM on e beam