Options for Dual-Readout Calorimetry in the 4th Concept

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

A. Penzo, INFN-Trieste
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 of 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


• 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

3.3mm
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 ~70 ns)
SiPM response to LED

Pulse charge spectrum from low-intensity light flashes (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

16 pe/MIP after full optical path

Run 020148
Tile test setup at Frascati

Erik Vallazza, Michela Prest
Fiber application study: Fiber Arrays

- **Fiber Array** mapped via a **Template** on a 16 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?

![Diagram showing fibers and scintillator with lead plates](image)
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 light yield with green WLS
- ~6 times more with blue scintillator light
Tile with SiPM on e beam