INFN R&D on SiPM Applications to ILC Calorimetry

Riccardo de Sangro
INFN - Laboratori Nazionali di Frascati

ILC-ECFA Workshop – Valencia 6th-10th November 2006

Outline

- Overview of other INFN SiPM R&D activities (incomplete & quick!)
- Present Proposal
  - Proponent Groups: Frascati, U. of Rome “La Sapienza” and INFN Rome
  - Proposed Activities

Other INFN Activities

- Present INFN R&D activity on SiPM is mainly dedicated to instrument-related technological developments (CSN-5)
  - FACTOR, V. Bonvicini et al., (Trieste/Udine/Catania) - SiPM for readout scintillating-fibers, development of readout electronics.
  - DASIPM2, G. Del Guerra et al., (Pisa, Bari, Bologna, Perugia, Trento) - medical applications (high resolution PET), space physics, HEP
- Good collaborative relations between INFN groups and the Italian producer of SiPM: ITC-IRST

Other INFN Activities

FACTOR

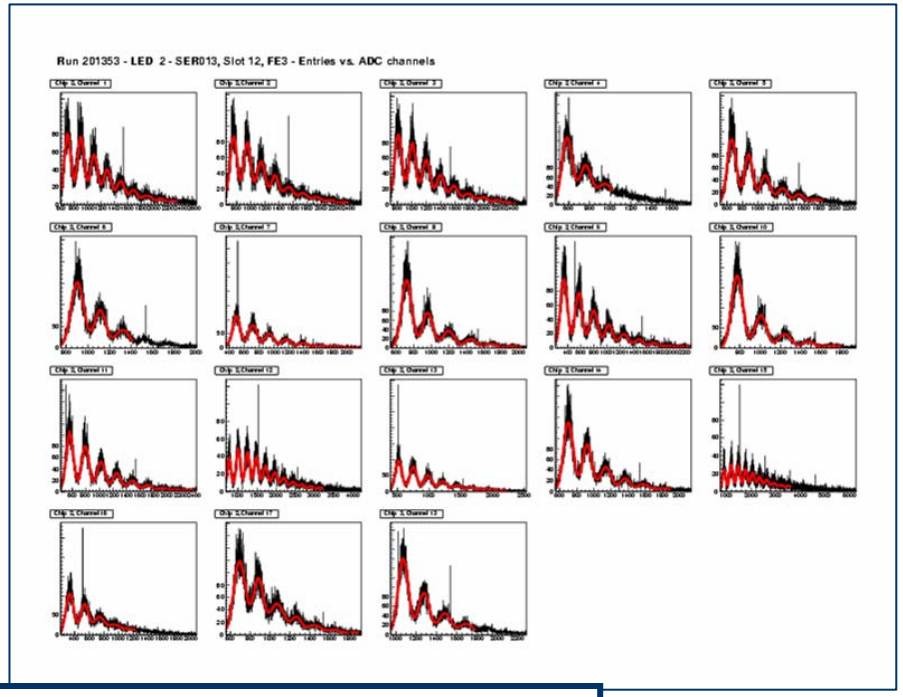
- Characterization and tests of SiPM produced by IRST as a function of temperature
- Applications to DREAM calorimeter
- See Penzo's talk

Other INFN Activities DASIPM2

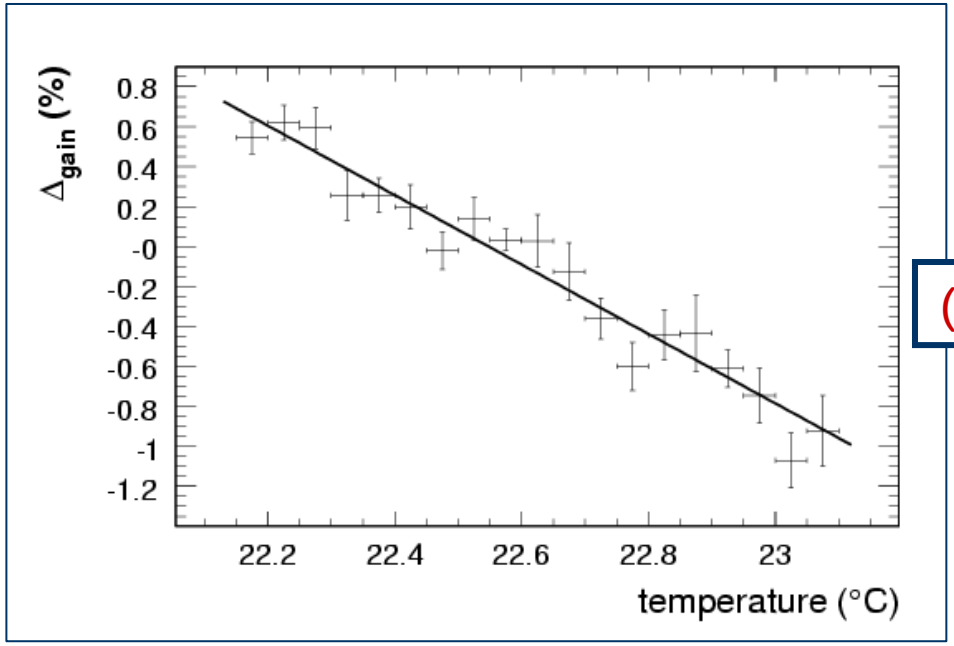
- Development, production and test of SiPM samples
- Current developments are:
  - Improve SiPM sensitivity to shorter wavelength region
  - Formation of 2D matrices of SiPM, that could be used as the basis of an imaging system
- Final goals are:
  - Realization of a high-resolution gamma camera for use in a next-generation Positron Emission Tomography (PET) system
  - TOF (Time of Flight) in space physics
- Possible future applications to HEP

SiPM for Calorimetry Open Issues

- High sensitivity of the gain to T and V_{bias} variations
  - Calibration
- Uniformity and quality of mass productions



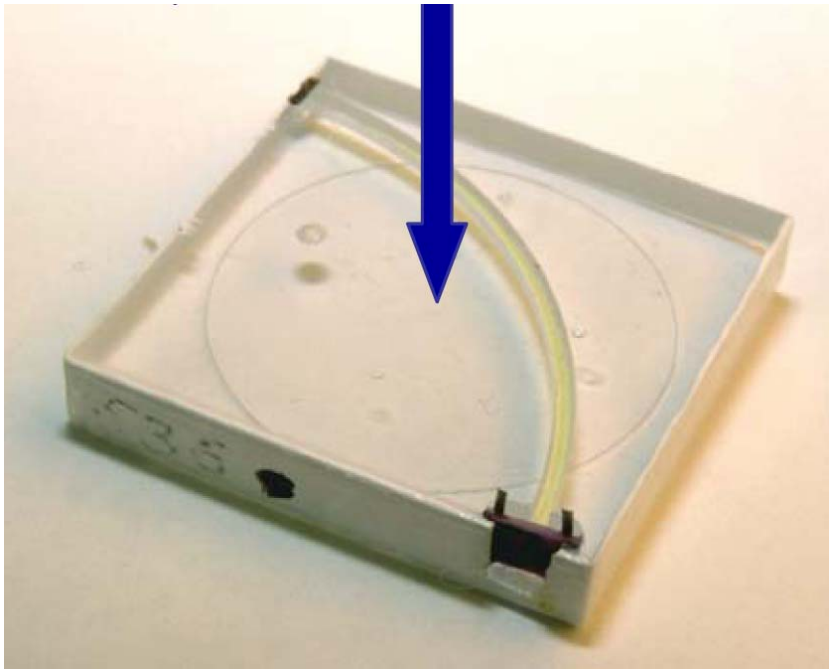
(E.Garutti, CALOR2006)



$$\frac{dG}{dV} \sim 2.5 \frac{\%}{0.1V}$$

$$\frac{dG}{dT} \sim -1.7 \pm 0.1 \frac{\%}{K}$$

SiPM for Calorimetry Open Issues



- Present solutions (HCAL) use WLS fibers to match SiPM sensitivity range with scintillator light WL
  - Find scintillators emmitting longer WL light
  - Develop SiPM with higher sensitivity at lower WL
- Optimization of the coupling of the SiPM to scintillator tiles in terms of light collection efficiency

P-ILC Calorimetry

- Our Proposal:
  - Study the application of SiPM to ILC calorimetry (and possibly m detection)
  - Collaborate with already ongoing efforts

- 2 years R&D program, part INFN's CSN1 P-ILC program coordinated by M. Caccia
  - This activity has been approved and funded from INFN CSN-1 last September and will start in 2007

Proponent Groups

- INFN – Laboratori Nazionali di Frascati
  - A. Calcaterra(*), R. de Sangro, G. Finocchiaro, P. Patteri, M. Piccolo, M. Rama
    - Present experiment Babar, built RPC μ detector (IFR), presently working on data analysis
    - Previously in SLD, built the WIC (hadron calorimeter and μ identifier) with Limited Streamer Tubes.
    - Recent work on RPC R&D applications for large area μ detectors (ILC), funded by INFN CSN-5
      - Glass RPC; Mechanically quenched RPC
  - People will contribute 30-40% of their time initially to this new effort

Proponent Groups

- University of Rome “La Sapienza”
  - C. Bosio, S. Gentile(*), E. Kuznetsova (INFN & Rome Univ.)
    - Present experiment ATLAS; previously in L3 with responsibility on physics analysis and calorimetric trigger, in AMS with the responsibility of the TRD control electronics, and in DELPHI hadronic calorimeter
  - D. Caputo (Electronics Engineering Dept – Roma Univ.)
  - G. Fortunato (Istituto Fotonica e Nanotecnologie del CNR, CNR)
  - People will contribute 30-50% of their time initially to this new effort

R&D Activities

- Comparative study of SiPM from different producers using a pulsed LED:
  - Crosstalk; Dynamic Range; Dark Noise
- Study newer SiPM whith higher sensitivity to blue light
- Study SiPM-Scintillator mechanical and optical coupling with and without WLS fibre, optimize geometry for light yield

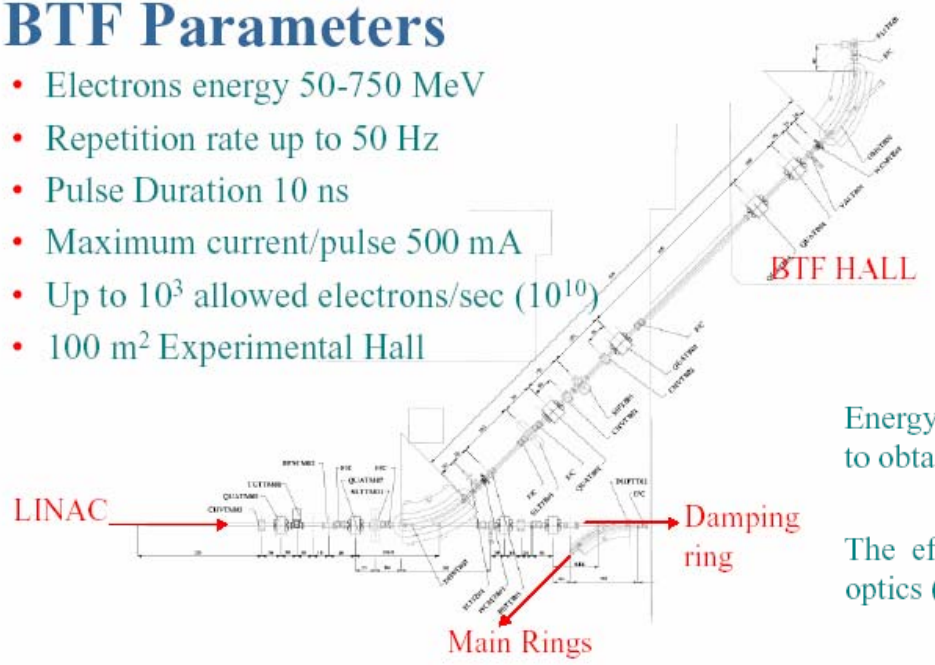
R&D Activities

- Realization of small prototypes using various SiPM matched to tiles made with different scintillator types with and without WLS
  - Measure charge spectra with cosmic rays as a function of T, V_{bias}
- Test different (SiPM + tile) prototypes at the Frascati Beam Test Facility to study:
  - Gain and linearity
  - Light collection efficiency
  - Time resolution
- Using the BTF all these studies can be performed in a timely way as a function of the impact point on the scintillator tile and for different track crossing multiplicities
  - Unique Facility!

The Frascati **T**est **B**eam **F**acility

BTF Parameters

- Electrons energy 50-750 MeV
- Repetition rate up to 50 Hz
- Pulse Duration 10 ns
- Maximum current/pulse 500 mA
- Up to 10^3 allowed electrons/sec (10^{10})
- 100 m^2 Experimental Hall

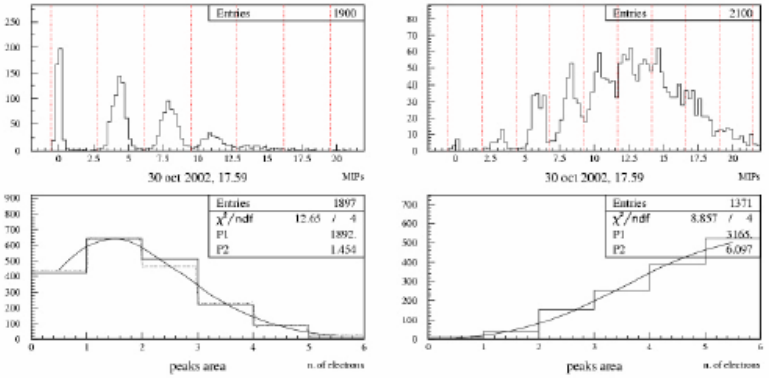


• The number of particle impinging on a detector can be tuned between 1 and 10^4 as well as the beam energy and size.
• New hardware allows running the BFT during normal DAFNE operations (>80-90% uptime)

Particle Multiplicity

Energy selector system and transport optics can be modulated in order to obtain the desired electron number distribution at different energies

The efficiency depends on energy and on the transport optics (the quadrupoles)



Good testing ground for different types of detectors (Calorimeters, RPC's...)

Further Possible Developments (2008)

- Evaluate applications to μ detector
  - i.e., different sensitive element geometry
- R&D on SiPM front end and DAQ elettronics

Conclusions

- We are looking forward to come back with exciting results!