SHiP Muon Test Beam
T10 area, CERN PS

(Technicians involved: Vincenzo, V. Cafaro, G. Papalino, F. Angeloni)

INFN-LNF, INFN Bologna, INR (Russia)
+ LAL Orsay (D. Breton for WaveCatcher/SAMPIC),
+ Barcelona ICCUB (S. Gomez and collaborators, FEE ASIC)

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The SHiP Muon System
Test beam goals

• The main objective of this test beam is to evaluate the timing performance and the detection efficiency of scintillator tiles for use in the SHiP Downstream Muon Detector.
  • Different Tile geometries
  • Different Tile coating
  • Different SiPM positions
  • Different readout electronics

• We also want to understand whether the SAMPIC digitizer is a workable solution for us
  • The sampling window is only 20 ns wide at 3.2 GS/s; is it enough?
  • Does reading each SiPM add any useful information for time measurement?
  • Is interpolation significantly better than a CFD? Is it more or less robust to outliers?
Prototypes prepared in Bologna & LNF

15x15x1 cm³ & 15x15x0.8 cm³
2 SIPM 3x3 mm² (Hamamatsu) placed on the corners

10x10x1 cm³ & 10x10x0.8 cm³
2 SIPM 3x3 mm² or 4x4 mm² (Hamamatsu) placed at the corners

7x7x0.6 cm³
4 SIPM 3x3 mm² (Hamamatsu) Placed along the long sides

10x20x1 cm³
6 SIPM 4x4 mm² (Hamamatsu) Placed along the long sides

Different tiles dimensions can be used in different muon stations to optimize performance versus cost.
Prototypes built in Bologna: details

- 150x150x10 mm³ tape wrapping
- 150x150x8 mm³ white painted
- SiPM on rigid end
- Amp on rigid pcb
- 100x100x8 mm³ white painted
- 100x100x10 mm³
### Preliminary - 10x20 cm$^2$ tile setup & SiPM

**Diagram:**
- A 10x20 cm$^2$ tile with dimensions indicating 5 cm width and 10 cm length.
- SiPM support & positioning detail (preliminary).

**Table: Parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>S14160/S14161-3050HS(-08)</th>
<th>S14160/S14161-4050HS(-06)</th>
<th>S14160/S14161-4050HS(-04)</th>
<th>S14160/S14161-6050HS(-04)</th>
<th>unit</th>
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<tr>
<td>Effective photosensitive area/channel</td>
<td>3.0 x 3.0</td>
<td>4.0 x 4.0</td>
<td>6.0 x 6.0</td>
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<td>mm$^2$</td>
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<td>Pixel pitch</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>µm</td>
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<tr>
<td>Number of pixels / channel</td>
<td>3531</td>
<td>6331</td>
<td>14331</td>
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<td>Geometrical fill factor</td>
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<td>Package</td>
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<td>Window refractive index</td>
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<td>Spectral response range</td>
<td>λ</td>
<td>270 to 900</td>
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<td>nm</td>
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<td>Peak sensitivity wavelength</td>
<td>λp</td>
<td>450</td>
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<td></td>
<td>nm</td>
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<tr>
<td>Photon detection efficiency at λp$^{\text{th}}$</td>
<td>PDE</td>
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<td>Break down Voltage</td>
<td>VBR</td>
<td>Typ. 37</td>
<td>VBR + 2.7</td>
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<td>V</td>
</tr>
<tr>
<td>Recommended operating voltage $^{\text{ref}}$</td>
<td>Vop</td>
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<td></td>
<td></td>
<td>V</td>
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<td>Vop variation between</td>
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<td>V</td>
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<tr>
<td>channels (+/-) in one array $^{\text{max.}}$</td>
<td>typ.</td>
<td></td>
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<tr>
<td>Dark current $^{\text{typ.}}$</td>
<td>0.6</td>
<td>1.1</td>
<td>2.5</td>
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<td>µA</td>
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<td>Crosstalk probability</td>
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<td>Terminal capacitance</td>
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<td>2000</td>
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<td>Temperature coefficient of recommended reverse voltage</td>
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</table>
Prototypes built in Frascati: details
Mechanical drawings of the tile 10x20 cm² with the ASIC housing (see later)
Prototypes built in Frascati: details

3D design and prototype of the tile 10x20 cm² with the ASIC housing (see later)

New MUSIC mini-board with MUSIC ASIC for analog readout of up to 8 SIPMs
Setup for test beam

Tiles under test
On table

Ribbon (+3 V, +54.6 V, amp out)

Patch panel
mcx

Leemo (54.6 V)

CAEN

SAMPIC

USB (1)

USB (2)

Veto

Beam

Fingers

Veto

AD8000

TTi PL601

Sala controllo

1 (Cherenkov) + 12 (tiles) + 2 (veto) + 2 (fingers) = 17 channels!!
Telescope for Beam Direction definition:

4 asole x il fissaggio

50 mm  42 mm

12 mm

30 x 30 mm²

52 mm

100 mm

G. Felici, F. Angeloni and A. Paoloni
Cherenkov for time reference

- Quarz crystal readout by a couple of 6x6 SiPMs:

- Expected resolution is dominated by the series of two SiPMs and electronics: about 100 ps (to be tested)
People at work
Currently happily taking data
(more results next meeting)