Task 8.3.2
Large Area Scintillation Detectors

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INFN-Bologna (A.M.)
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INFN-Ferrara (Alessandro Saputi)
JGU - Mainz University (Lucia Masetti)
MPI for Physics (Frank Simon)

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Outline

- Most of our tasks were completed to fulfill Milestone M33 (Feb 2023):

«Design and test of scintillating tiles or strips with large active area suitable for large area detectors» to be achieved with *«Operational Testbenches»*

- Brief review of what was done for M33

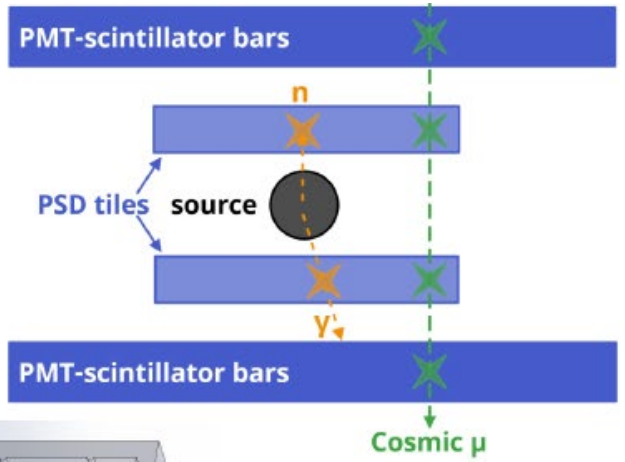
Update on 2023/2024 activities:

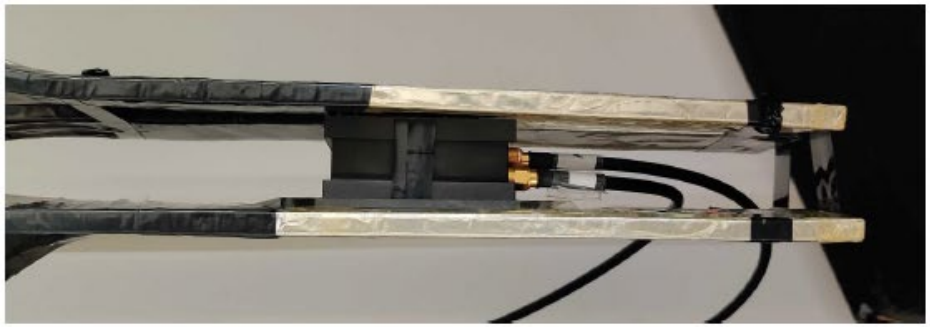
- MPI:
  - No updates since Frank Simon moved to KIT
- JGU (Mainz):
  - improved setup to study neutron/gamma separation of PSD (a la Calice)
  - PS strip with WLS/SiPM readout for ECAL of SHADOWS (proposed experiment for ECN3 area)
- INFN-Frascati, INFN-Ferrara, INFN-Bologna:
  - Measurement of muon flux for SHADOWS studies with 2 layers of scintillator tiles

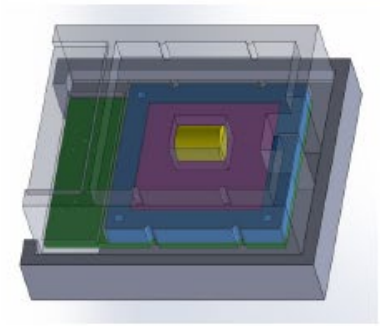
Update JGU

- Improved setup for neutron tagging:

- AmBe source emits gammas and neutrons in coincidence about 60% of the time
- Source surrounded by 2 PSD scintillator tiles (EJ-276G) read out by SiPMs
- **Possibility to tag coincidence signal as n + γ**
- Cosmic muon veto above and below

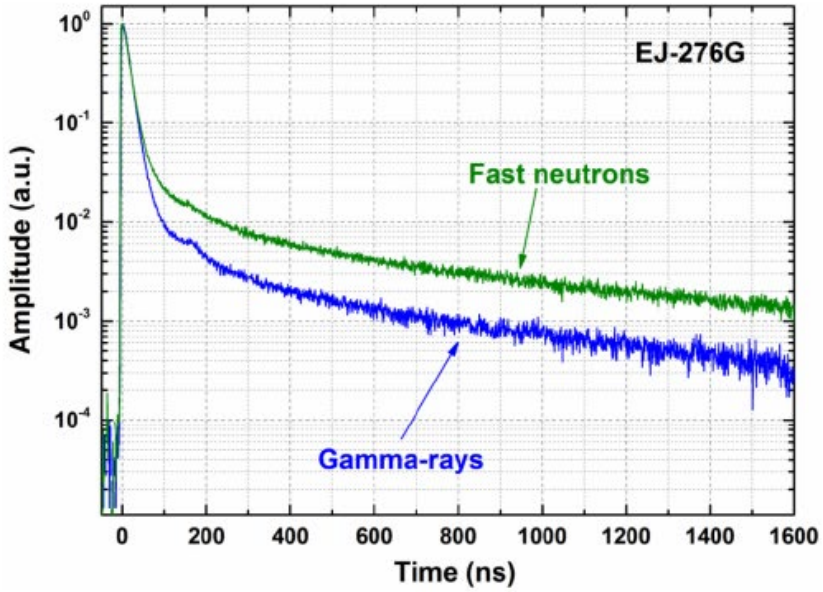


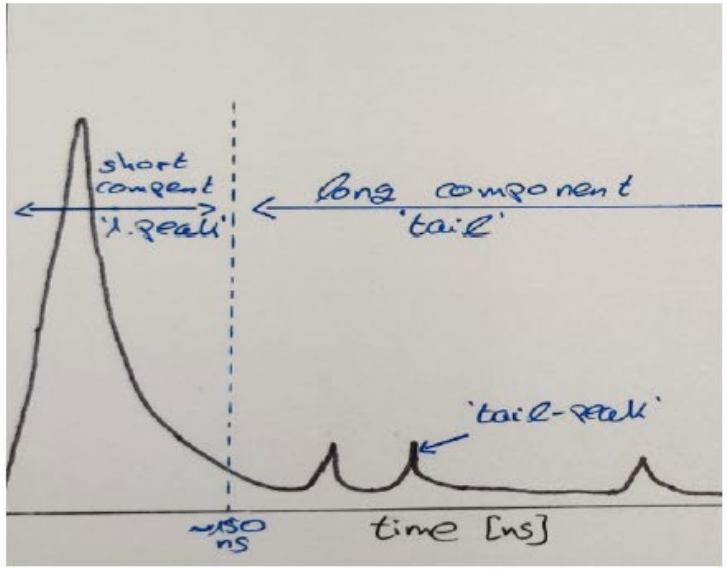




JGU – Mainz activities

- PSD analysis





Discriminating variables:

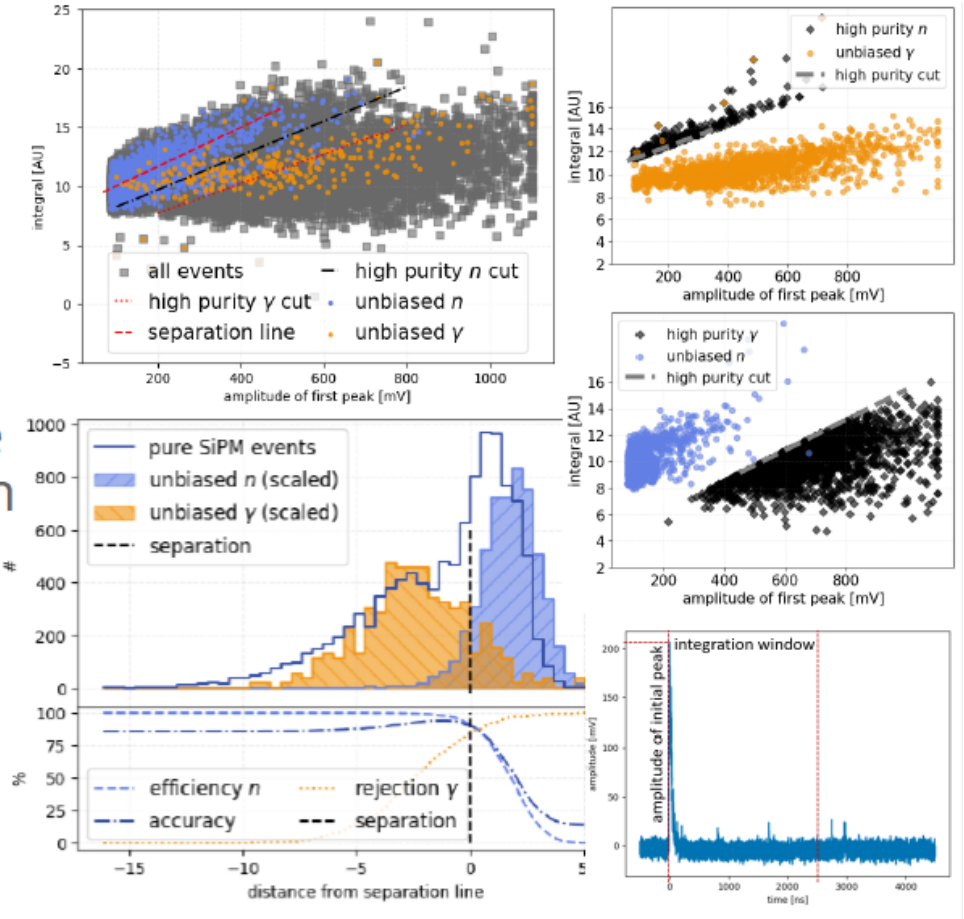
- Amplitude of first peak
- Number of tail-peaks

... and their **correlation**!

JGU update

- Separation power:

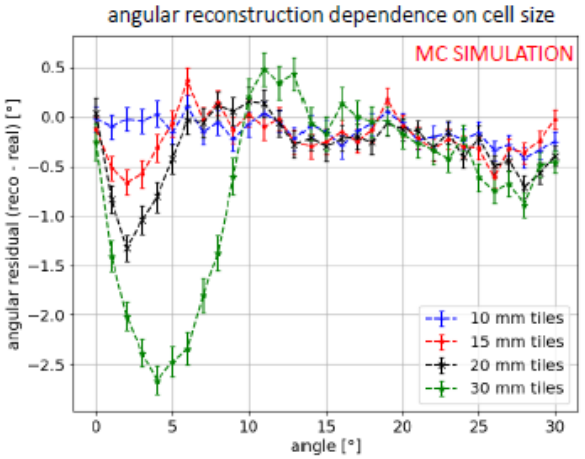
  - Integration window much larger than initial peak
  - 5 percentile cuts to determine unbiased gamma and neutron samples
  - Categorization by distance from separation line
  - 87% accuracy achievable with integrating readout

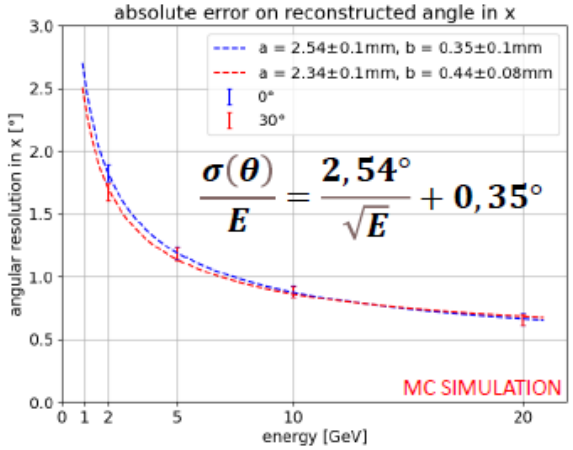


JGU update

- SHADOWS Electromagnetic Calorimeter:

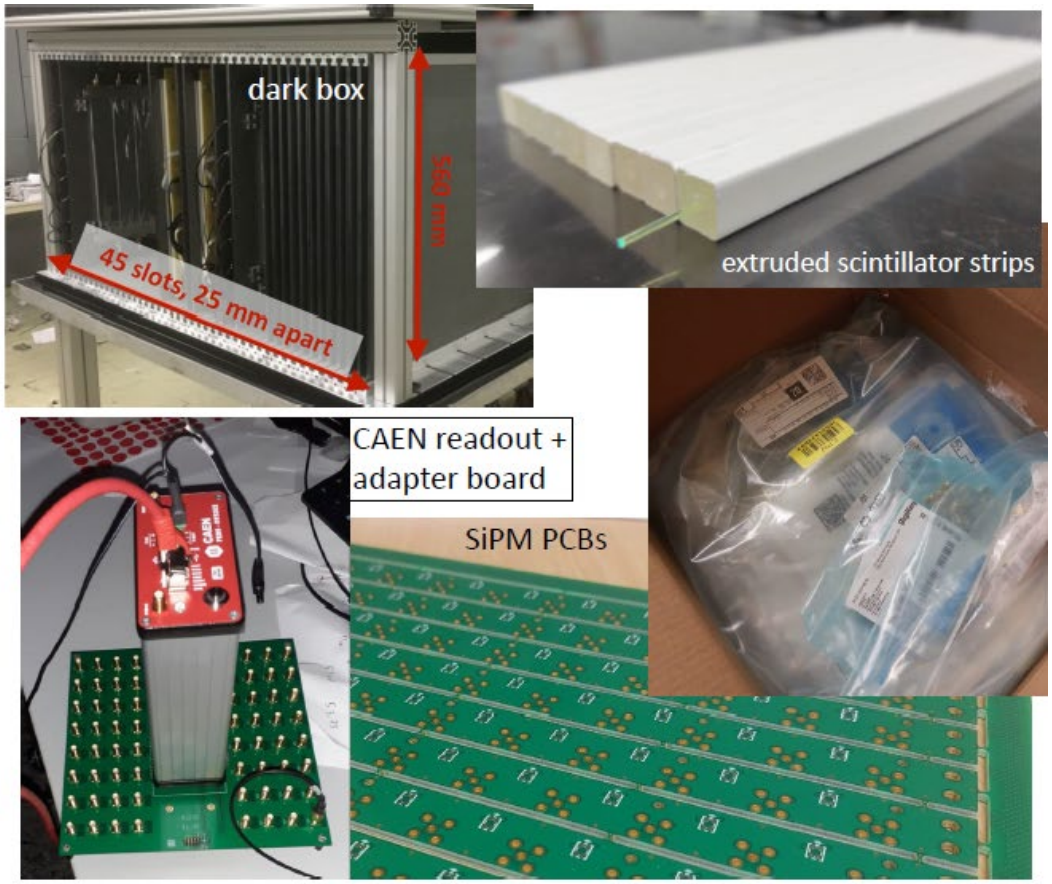
  - Iron + plastic scintillator sandwich ECAL
  - Outer dimensions 250x250x80cm³
  - 40 layers with $0.5X_0$ for shower containment
  - 1cm strips to achieve necessary angular resolution
  - Strips read out with fibers and SiPMs
  - 10.000 channels





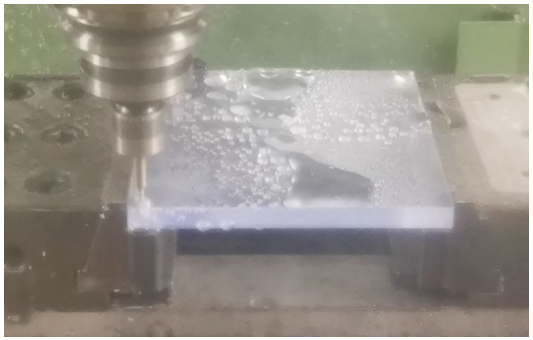
JGU update

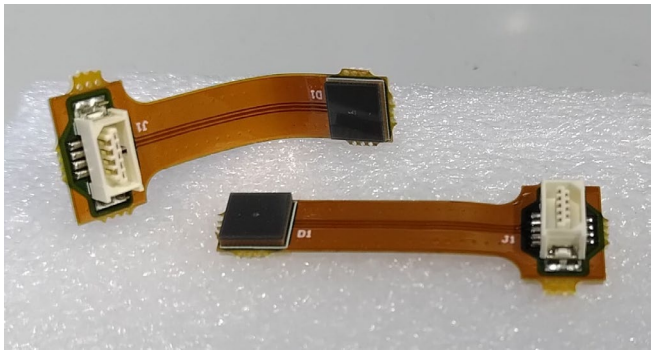
- Upcoming Prototype:
  - 11 layer prototype with 20x20cm² active area
  - 220 channels with fiber-to-SiPM readout
  - Test beam planned end of march at DESY
  - Main goal: verification of angular resolution
  - All parts except SiPMs arrived already

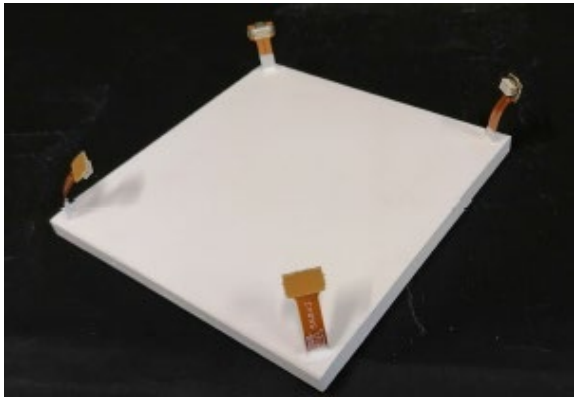


INFN activities

- Design and build a demonstrator consisting in a matrix of many tiles (3x5) and verify the **scalability** to large area detectors, while keeping position resolution O(cm) and timing resolution O(300 ps).

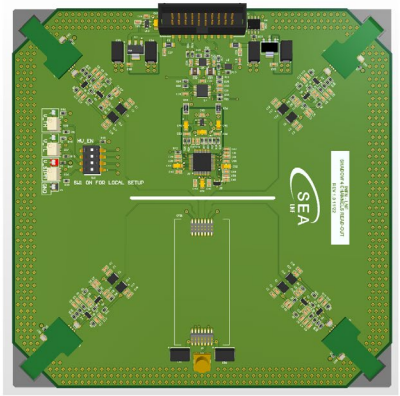


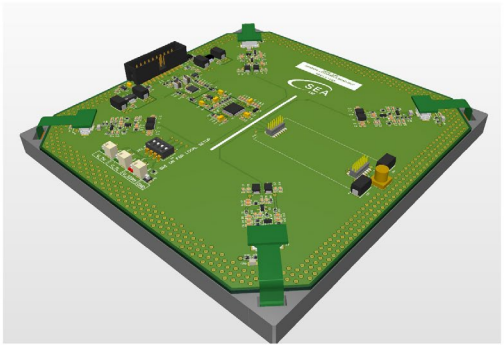


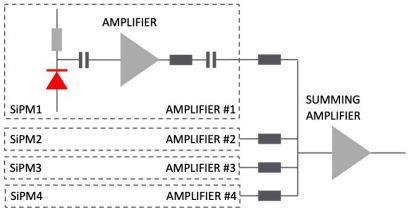


INFN activities

- Frontend electronics is integrated on a PCB placed on top of the tile
- Each SiPM is connected, through the Kapton flex cable, to its individual preamplifier
- The outputs of the 4 preamplifiers are summed.
- The outputs from the tile are:
  - Analog sum
  - Digital output from the comparison of analog sum with a configurable threshold

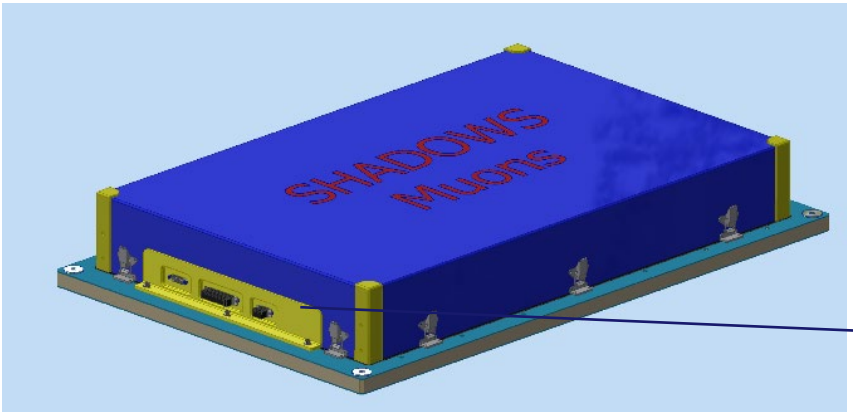


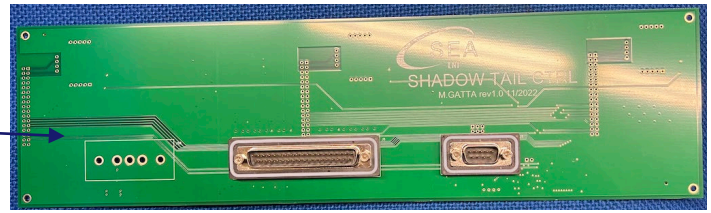




INFN activities

- Mechanical framework ready
  - Metallic cover for light tightness and Faraday cage
- All connections on a patch panel
- This unit can be replicated to cover large areas



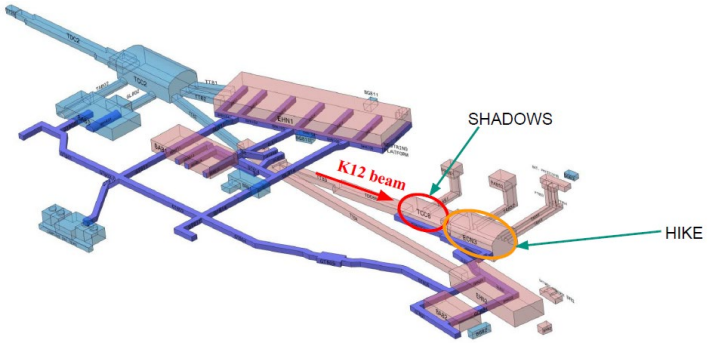


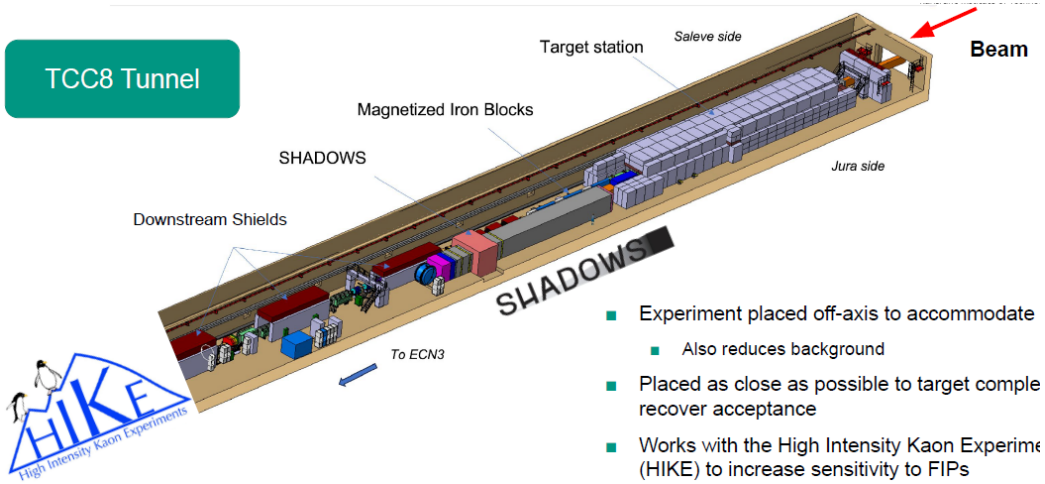
Update INFN

- Originally, our detector was conceived for the Muon Detector of the SHiP experiment

- Due to the uncertain future of SHiP proposal, a smaller scale experiment (SHADOWS) was proposed (by Gaia Lanfranchi) with same concept and located in the hall presently hosting NA62 (CERN, North Area, ECN3)

- The tile detector is suitable also for the Muon Detector of SHADOWS



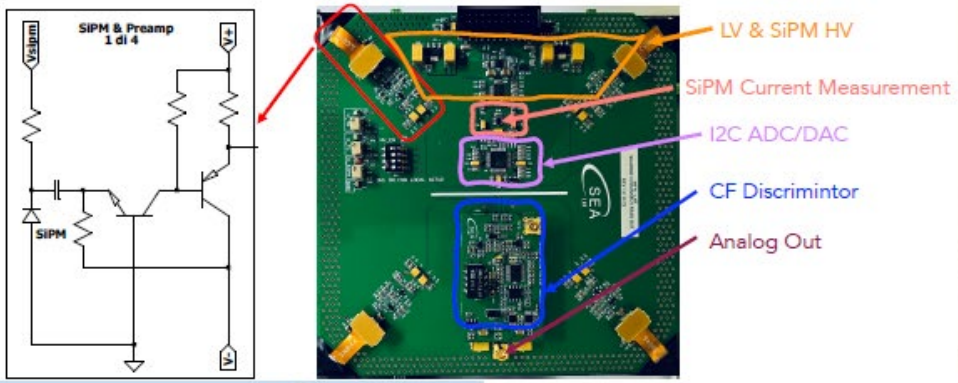


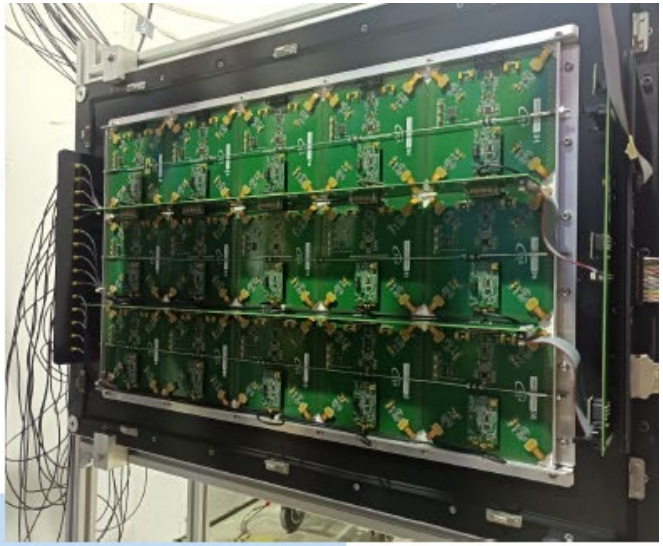
INFN update

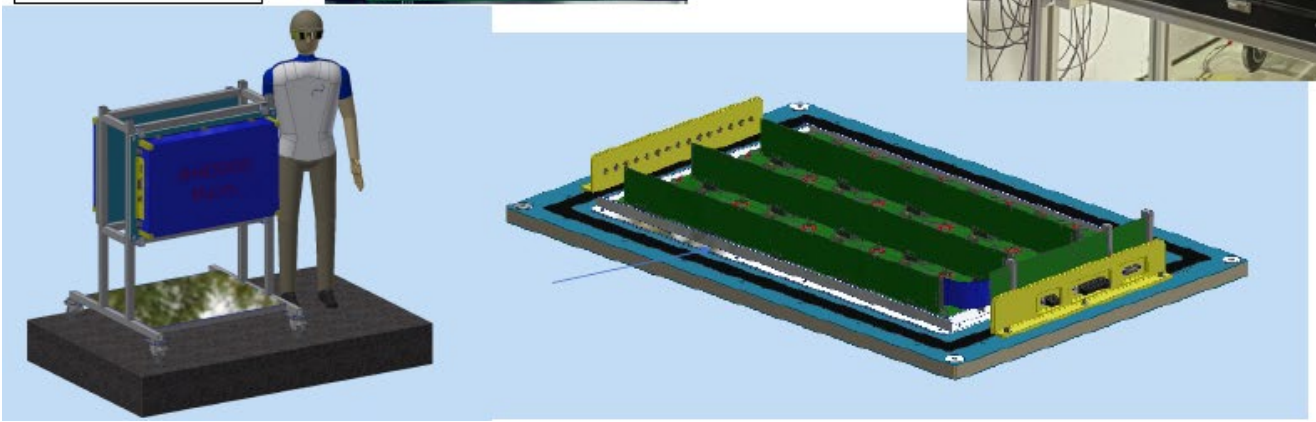
- Two detectors fully equipped were built:

INFN update

- Setup for muon flux measurement in the foreseen location for SHADOWS:

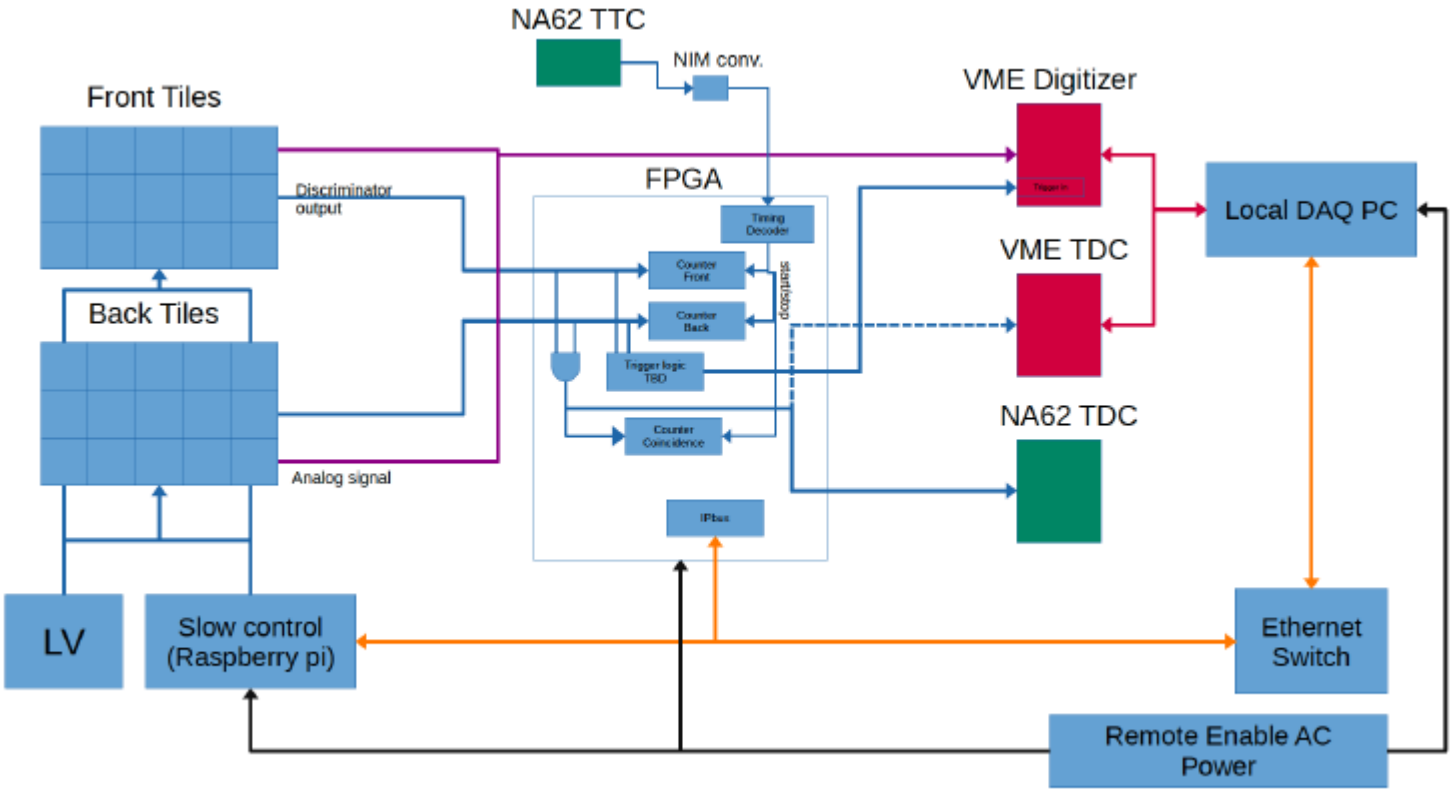




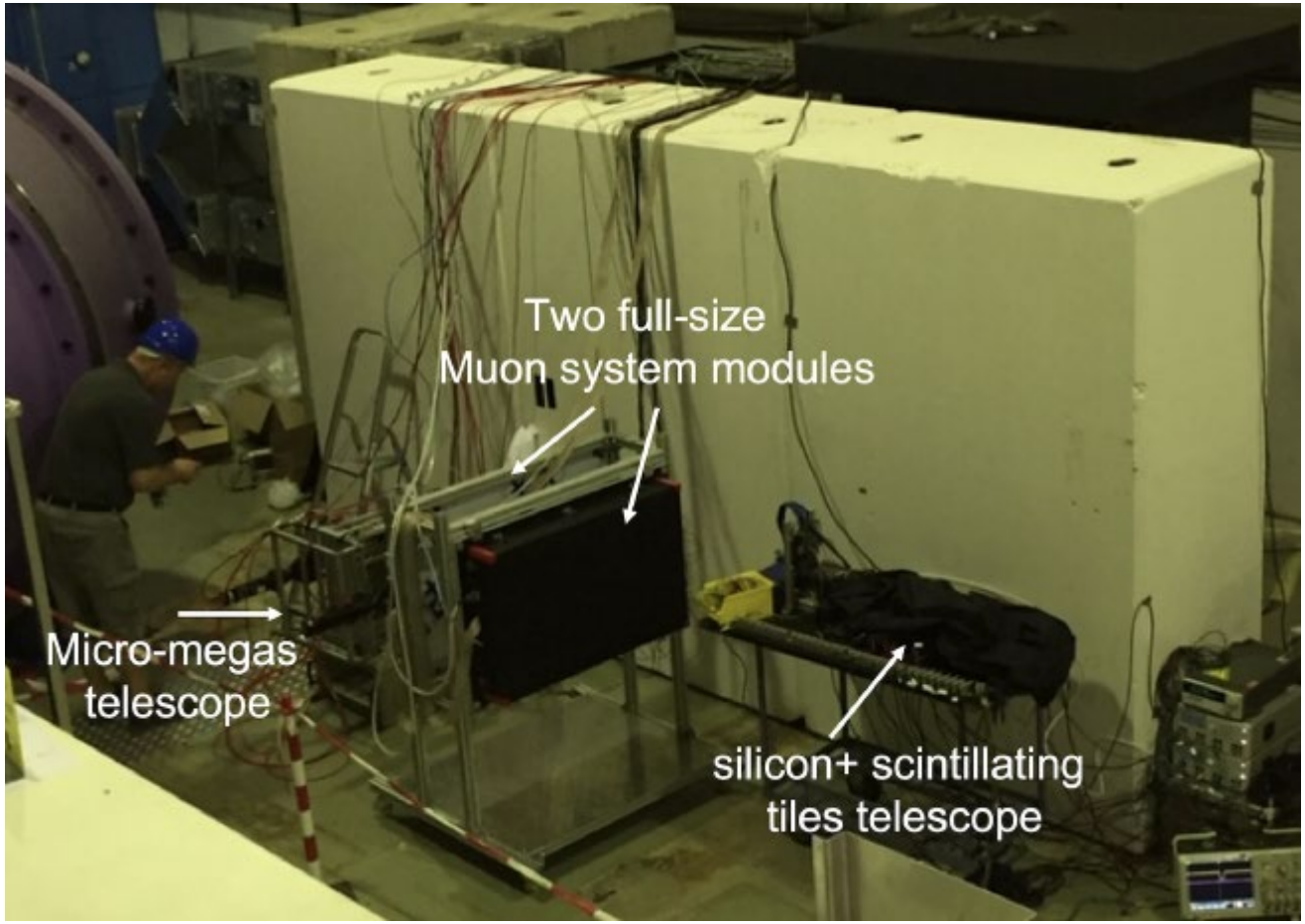


INFN update

- Full front-end and middle-end electronics was developed:



INFN update

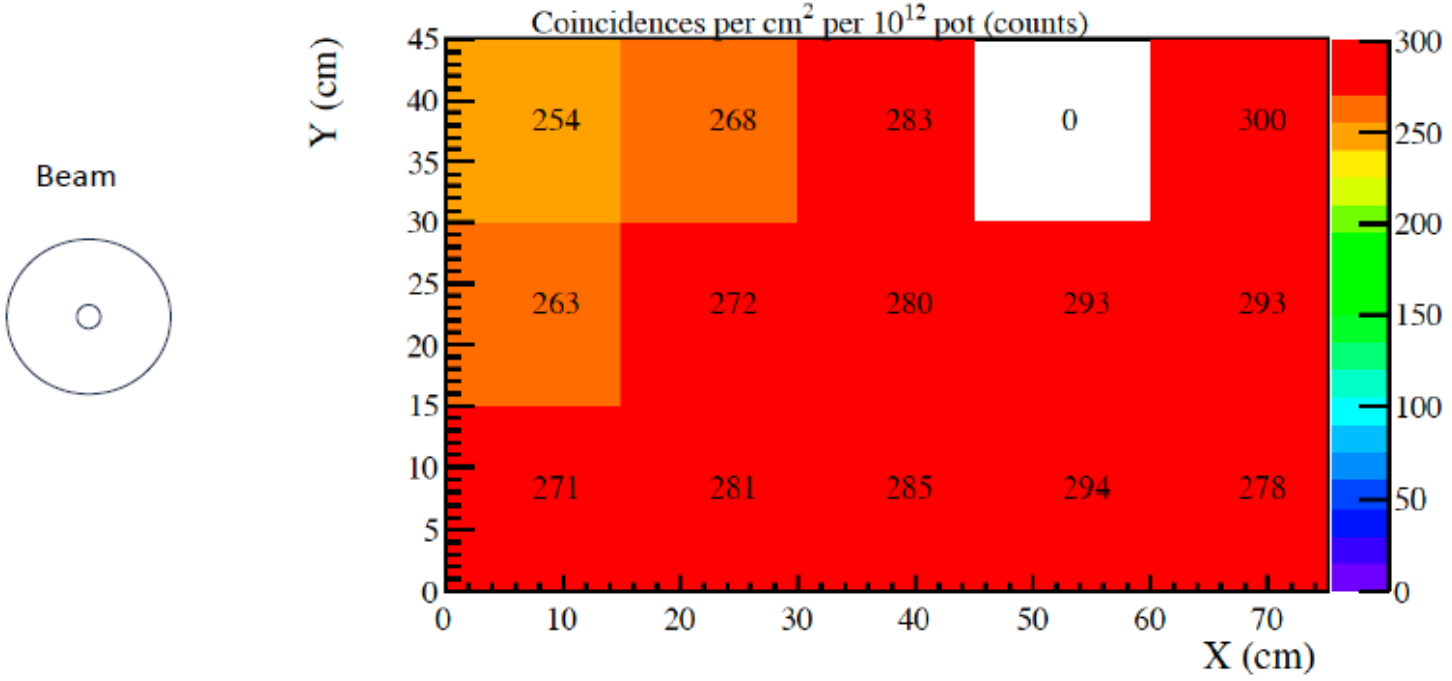

Two full-size
Muon system modules
Micro-megas
telescope
silicon+ scintillating
tiles telescope

INFN update

INFN update

- Preview of measured rates:

Modules illumination made by 15 pairs of coincidences (front-back)
once corrected for the spill intensity variations



Measured Rate: 250-300 counts/cm2/spill, increasing by increasing the distance from the beam