Subtask 8.4.2:

Development of highly granular dual-readout fibre-sampling calorimeter

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On behalf of the IDEA dual-readout calorimeter group

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761.

Outline

- Status report on the ongoing activities to build the demonstrator
- Test beam plans and more

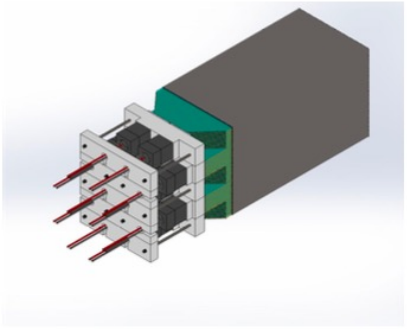
Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D8.4	Construction and qualification with beam of 10×10 cm^2, 2 m long, prototypes	WP8	22 - INFN	Demonstrator	Public	46

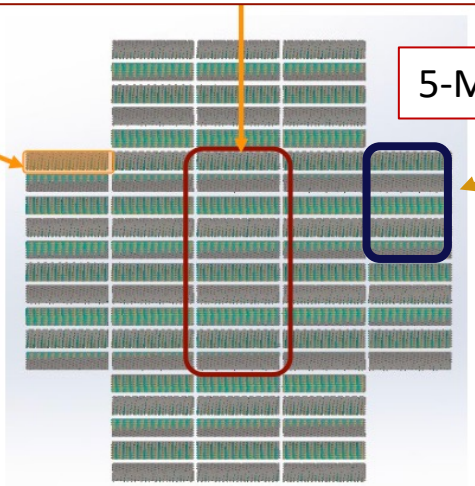
New geometry of the HiDRa detector

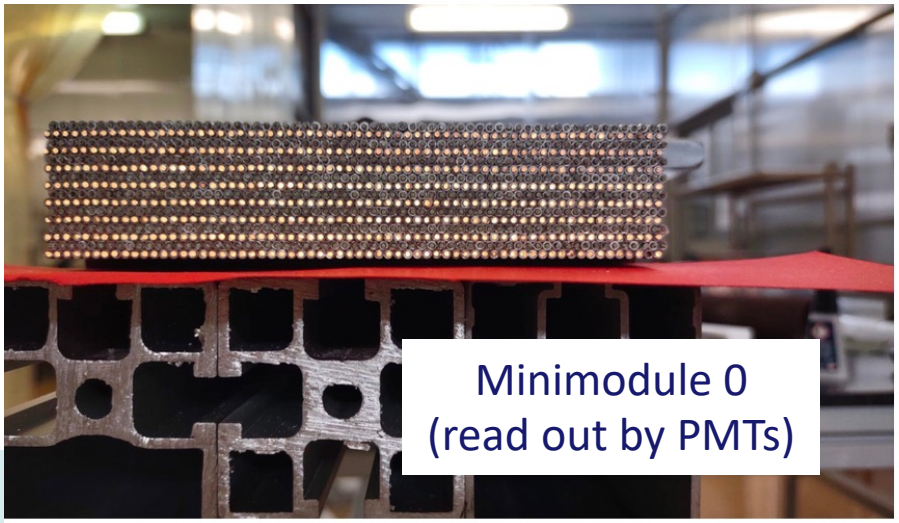
Outer shell: Each minimodule is read out by 2 PMTs (1 for Cherenkov and 1 for scintillation)

High granularity core: fibres individually read out by SiPMs

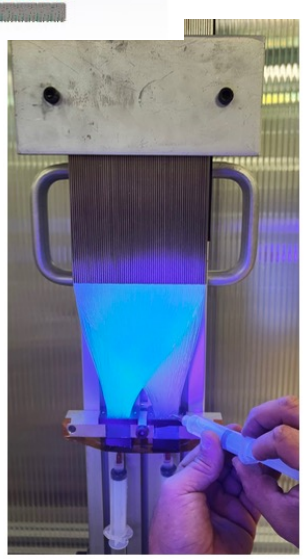
5-Minimodules = 1 Module







Minimodule 0
(read out by PMTs)



Material procurement and assembly program

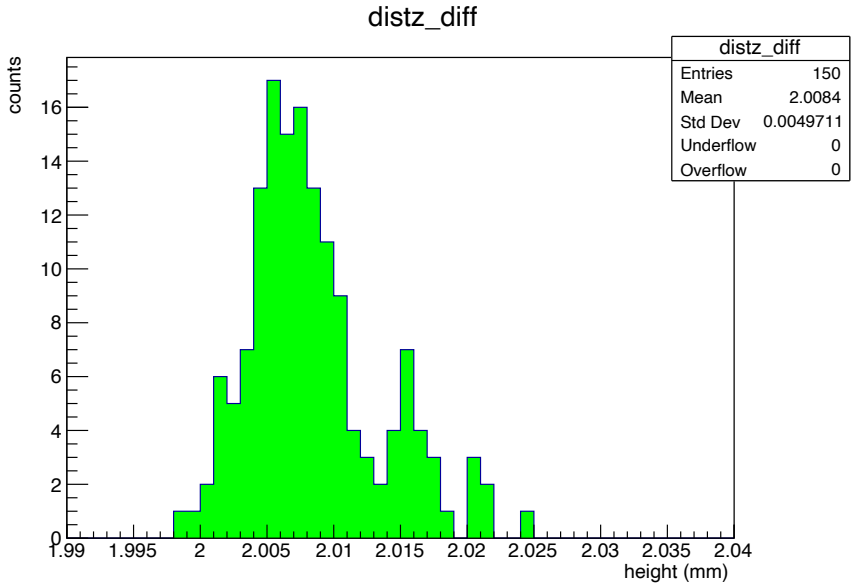
- Capillary tubes: arrived
- Cherenkov fibres: arrived
- Scintillating fibres: 7 batches arrived -> next, 1 batch/month
- PMTs: 100/140 available (others to be ordered in 2024)
- SiPMs: order - completed (delivery time delayed -> will be estimated soon)
- High granularity readout boards: 10/20 available (others to be ordered in 2024)

- Assembly (net) time for one minimodule
  - Gluing: half a day
  - Mechanics QAQC procedure: half a day
  - Threading the fibres: 2 days

} Partially in parallel -> foreseen two minimodules/week

- 18 minimodules completed

QAQC on components



Sampling measurements of tube outer diameter

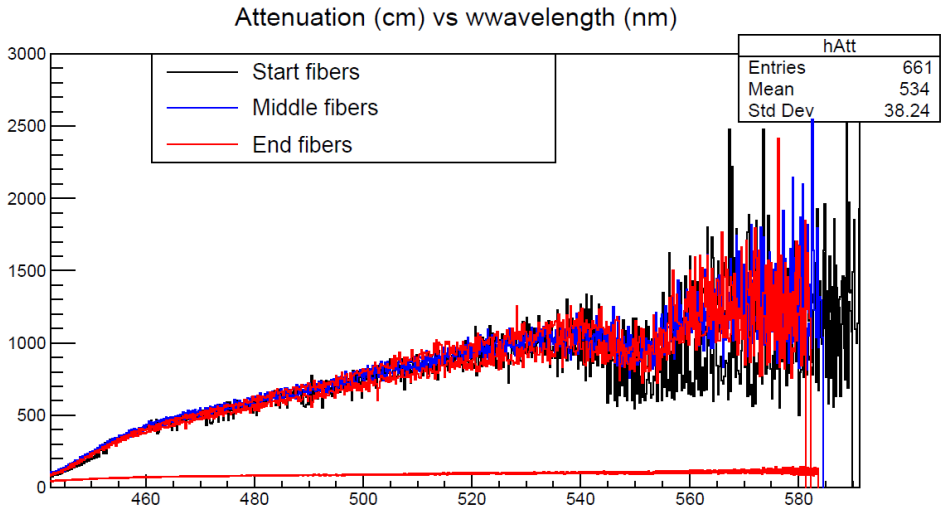
Other checks:

- Straightness
- Inner diameter (pass/fail test)
- length

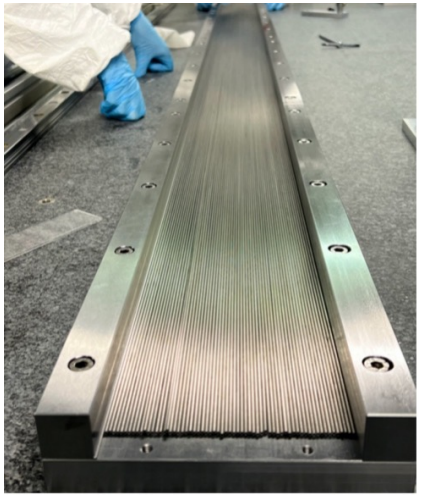
Rejected: 5-10 % (preliminary estimate)
Mainly because of poor straightness

Scintillating fibres: sampling measurements of attenuation length

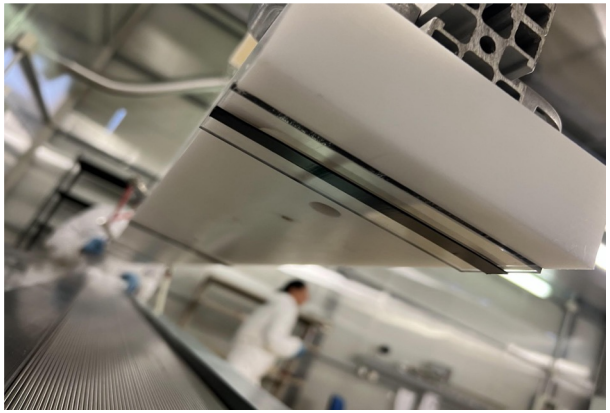
Rejected: 5-10 % (preliminary estimate)
Because of anomalous attenuation length, air bubbles and damage during handling



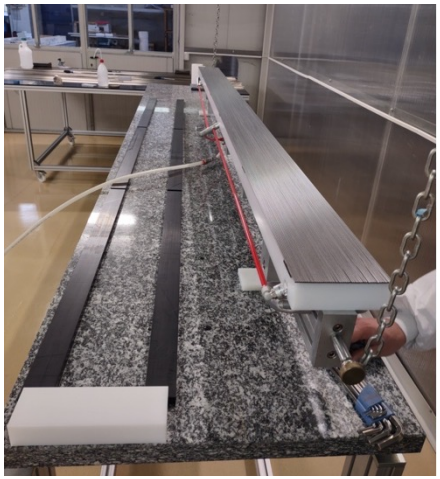
Construction technique for the minimodule

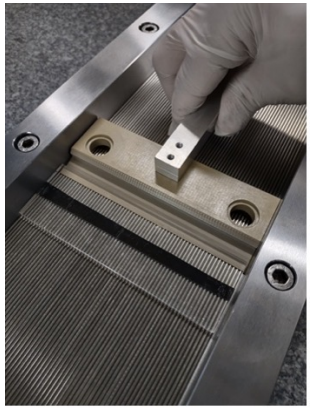


Assembly reference structure anchored to the granite table with the 1st layer of tubes in place



Vacuum + double-sided tape for tube handling



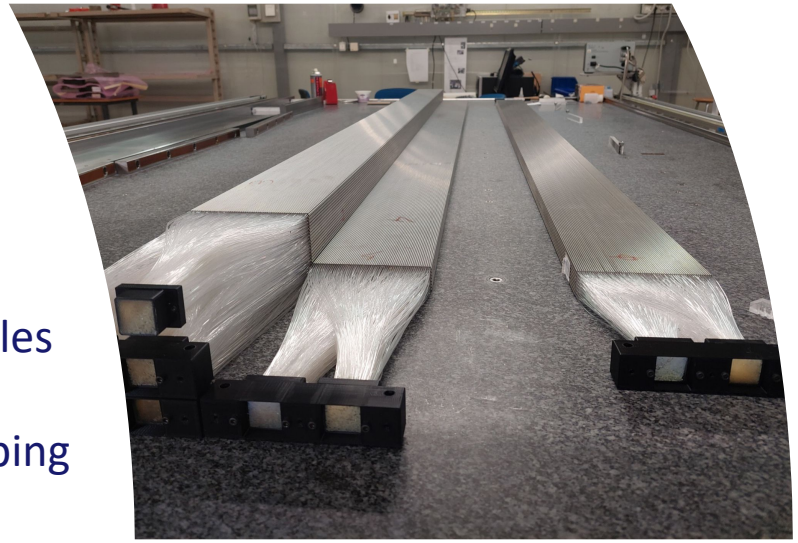


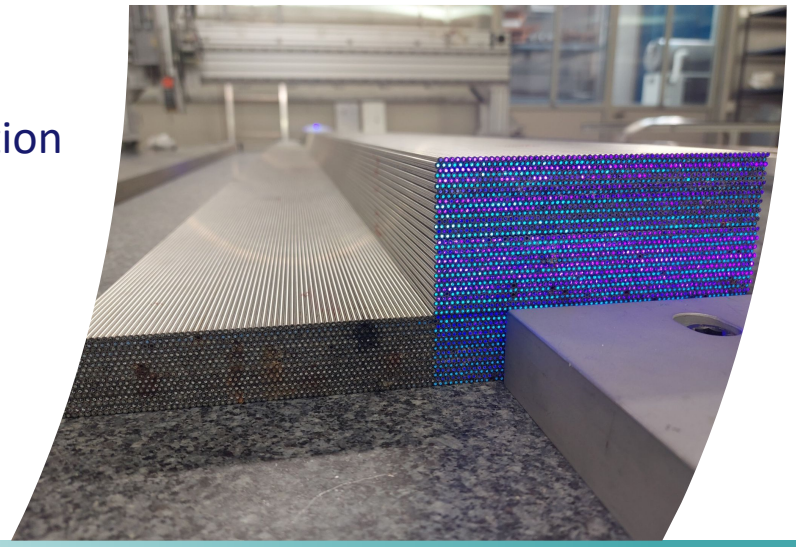
Glue dispensing and tube alignment and positioning

Construction technique for the minimodule

- Measurement of modules planarity
- Fibre loading and grouping
- Preparation for PMT coupling

- next to come: qualification with the PMT

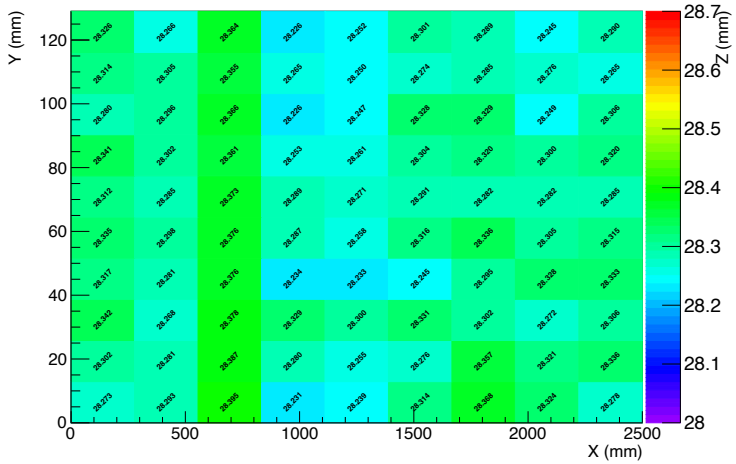




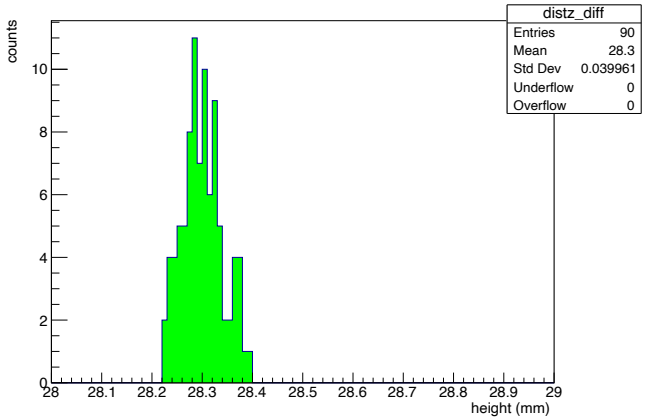
Semi-automatic system for planarity QAQC

Typical Result for a minimodule

9 measurements along the tubes (x-axis) and 10 measurements across the minimodule surface (y-axis)



Measurements distribution



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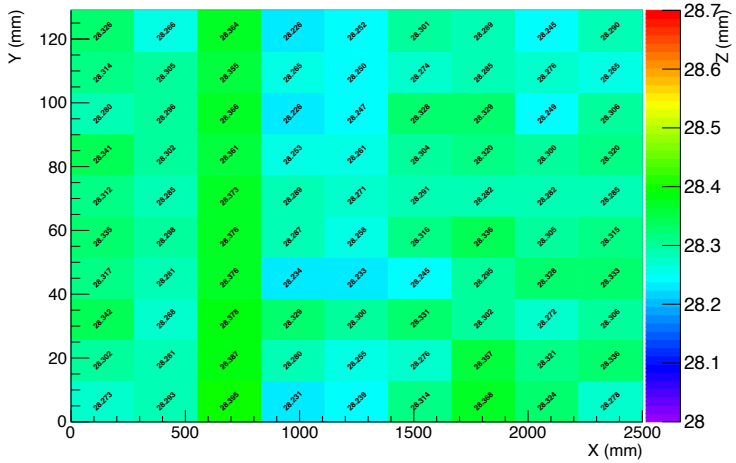
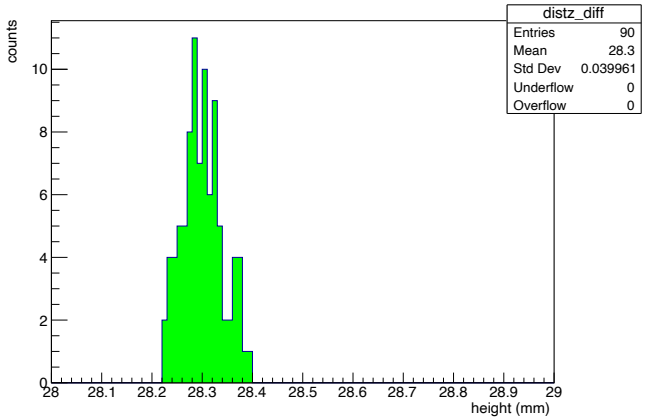
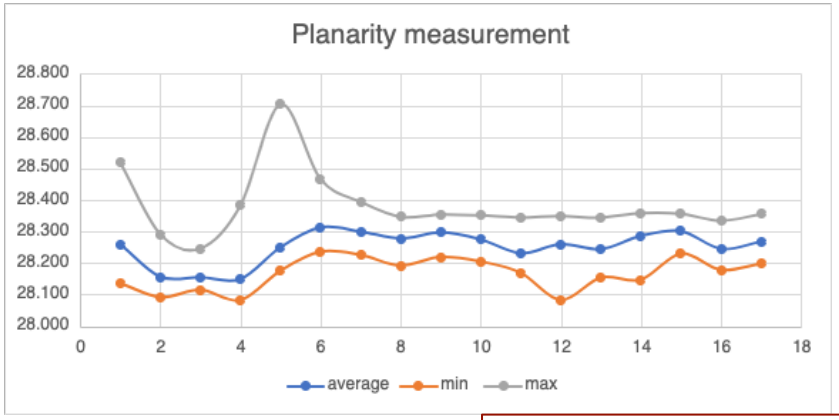
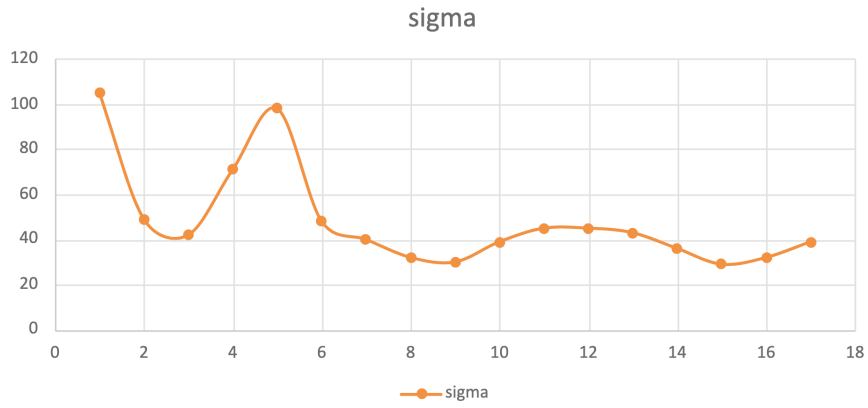


Measurements distribution



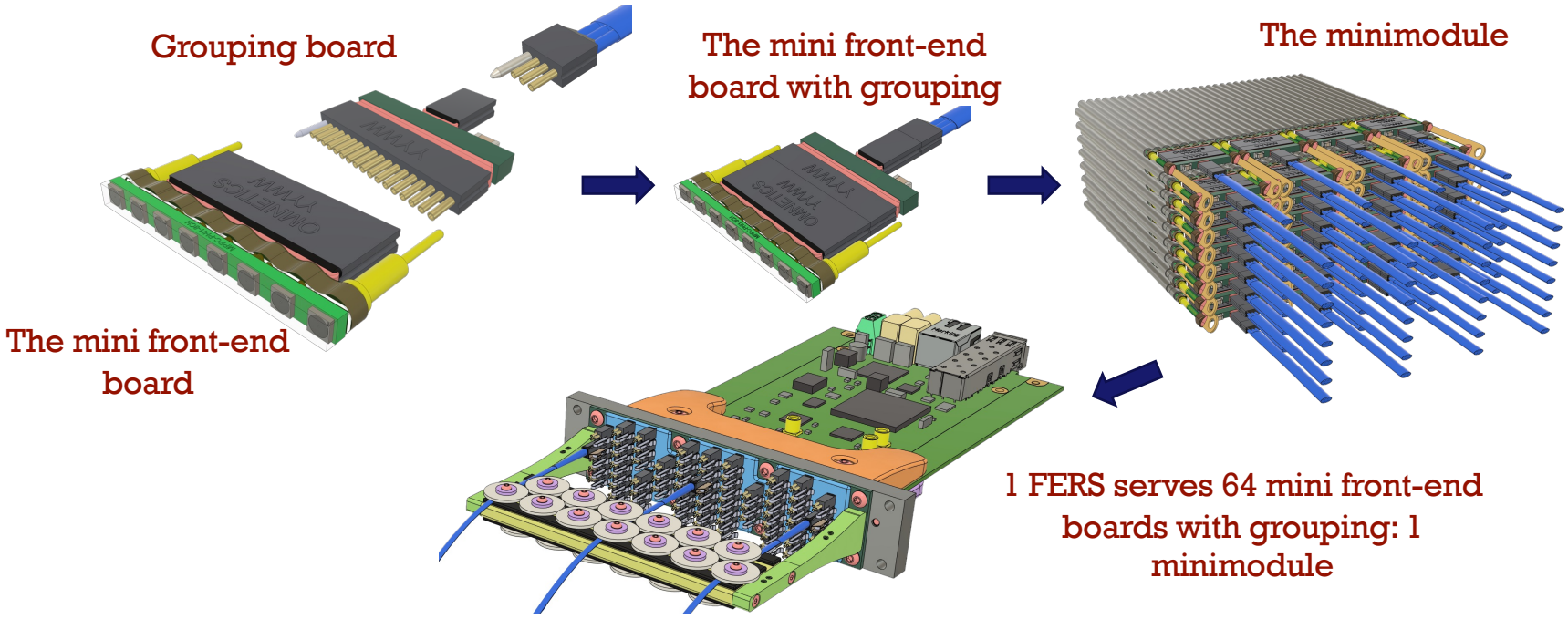




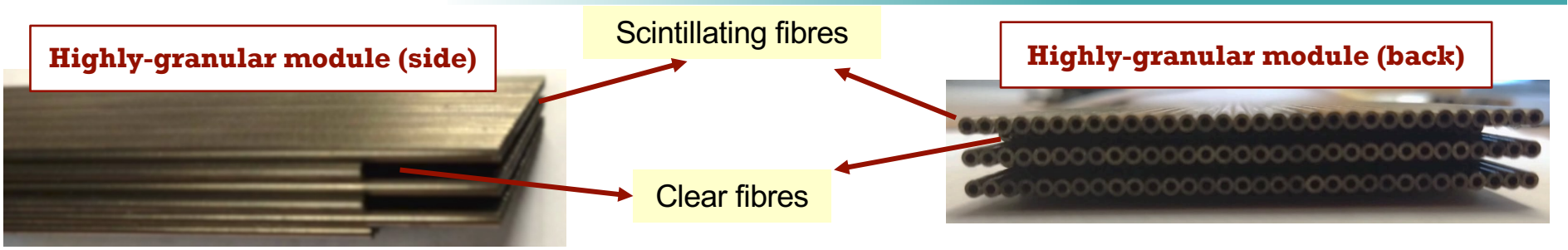
Summary from all mini-modules assembled so far

Highly granular module in short

The original design

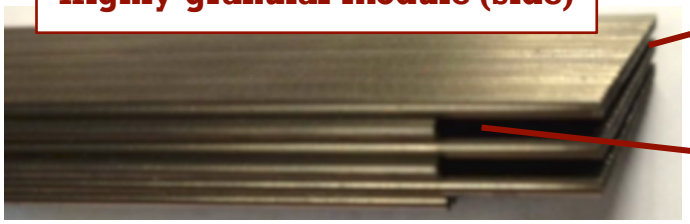


Mechanical integration and cabling



Mechanical integration and cabling

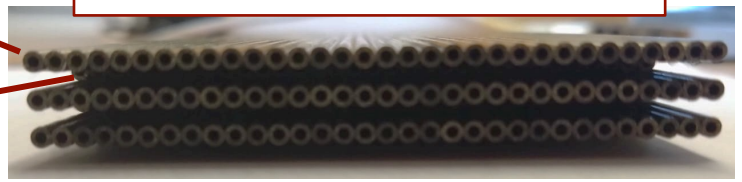
Highly-granular module (side)



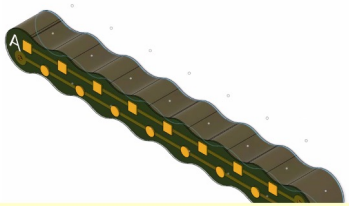
Scintillating fibres

Clear fibres

Highly-granular module (back)

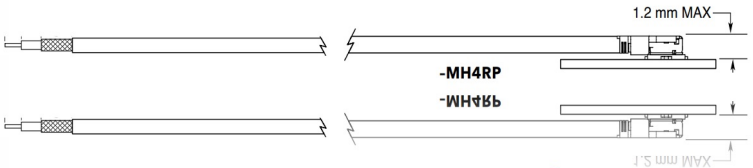


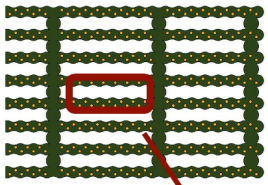
mini FE-board with integrated grouping (8 SiPMs)



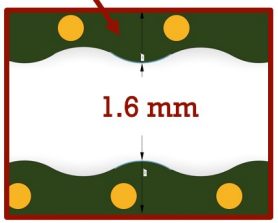
SiPM bar mounted on the front and two-pin cable on the back

MH081: shielded micro-coax RF cables from Samtec





connectors fitting into the PCB holes



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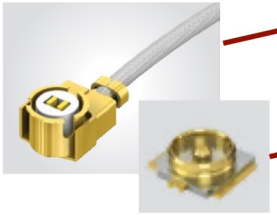
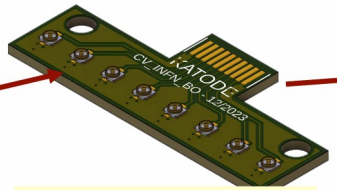
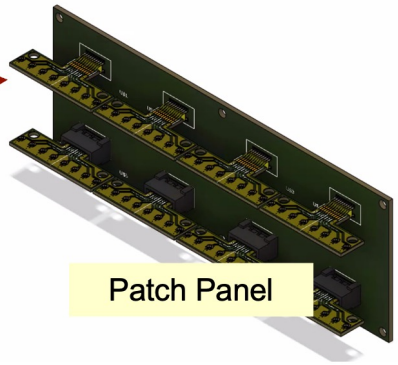




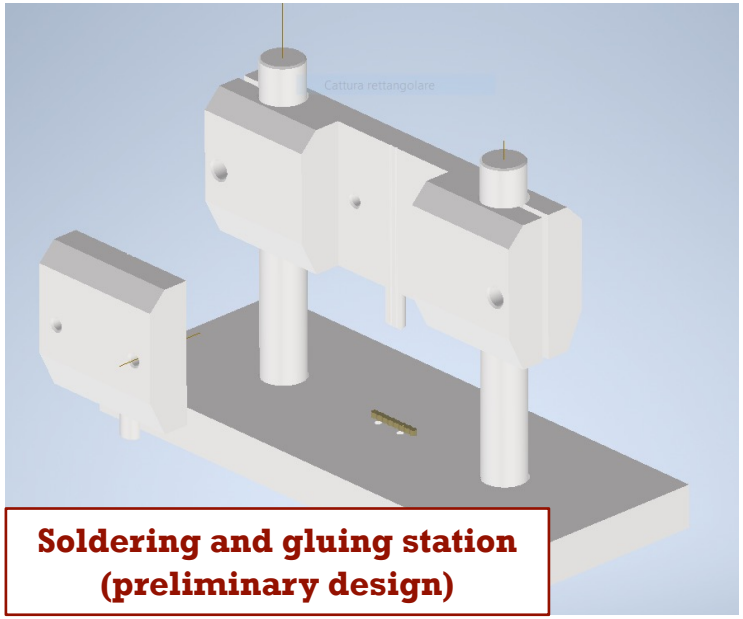
Bridge board: serves 8 SiPM-bars



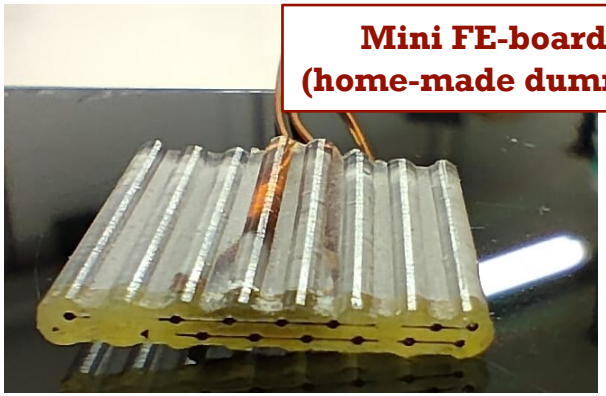
Patch Panel

A5202-Board: serves half-minimodule

Integration studies with dummy components

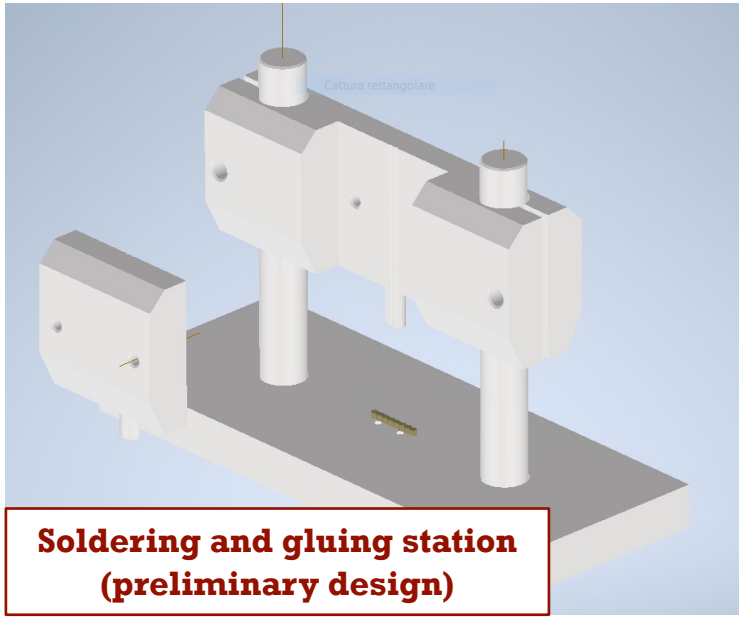


Soldering and gluing station (preliminary design)



Mini FE-board (home-made dummy)

Integration studies with dummy components



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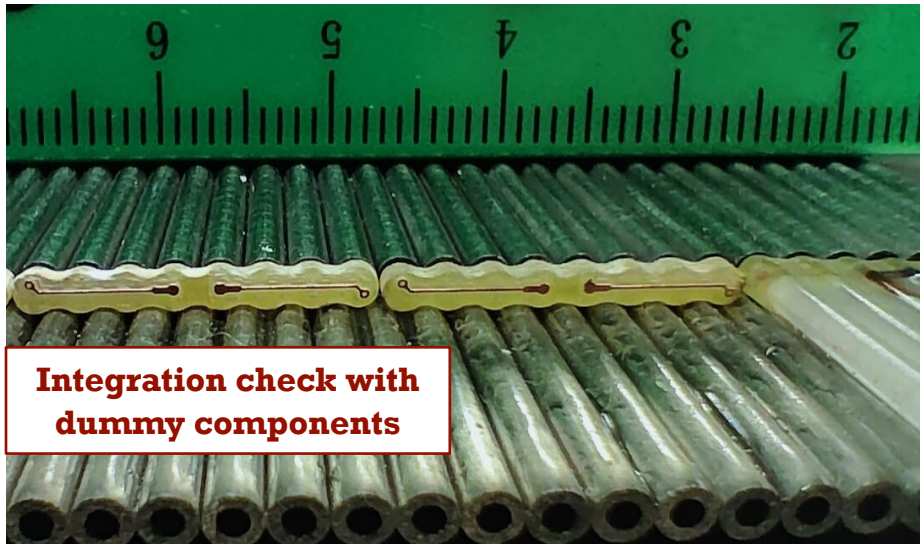
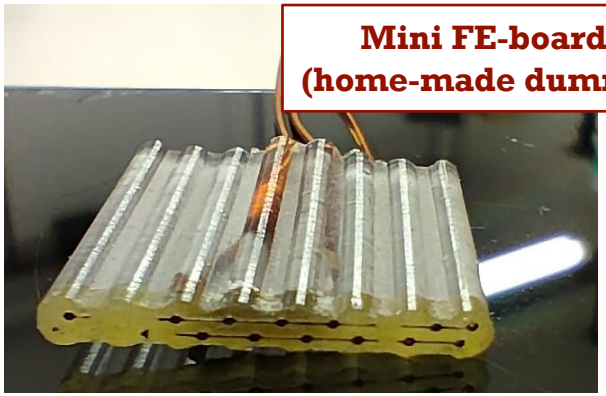


Integration check with dummy components



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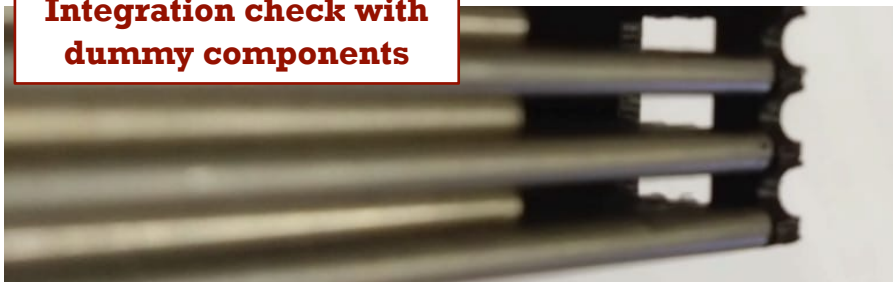
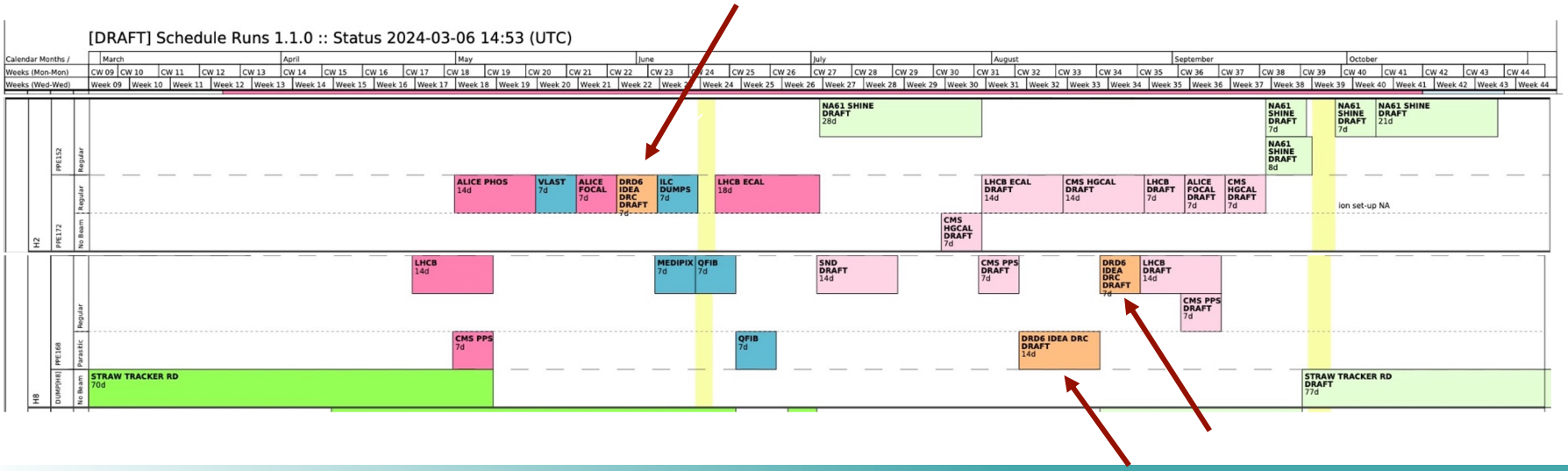


Integration check with dummy components

Test beam activities

- 4 weeks allocated (1 week in H2, 2+1 weeks in H8)
  - https://ps-sps-coordination.web.cern.ch/ps-sps-coordination/schedules/ps/2024/v1.1.0/schedule_runs_v110_20240306_all.pdf
- Beam time will be shared internally based on the scientific program, hardware available and deadlines with funding agencies
  - Three main groups (DRD6-WP3, Task 3.3.1).
  - Details on the activities can be found here: https://indico.cern.ch/event/1386879/
- Schedule is still preliminary: there are two weeks with two groups running parasitic without a main user (to be fixed)



Activity of interest (DRD4 – WP4.1)

Activity program

- Development of a technology platform for digital SiPMs in applications to dual-readout calorimetry - activity extending over a 3-4 year span
- Involving some of the groups participating in DRD4, with possible contributions from other Italian groups - proposal to be presented to INFN at the beginning of Summer
- Characterization of the ASAP110LF test chip developed in a 110 nm CMOS technology, including different SPAD arrays with different features (passive and active quenching, different active area, structures for investigating timing properties and ionizing radiation tolerance) and mini-SiPMs
  - DCR, breakdown voltage, afterpulsing, electrical and optical cross-talk, also as a function of the temperature
  - QE and PDP/PDE
  - Time resolution
- Investigation of the cumulative damage from ionizing radiation (X-ray) and from atomic dislocation in the substrate (neutrons, protons)

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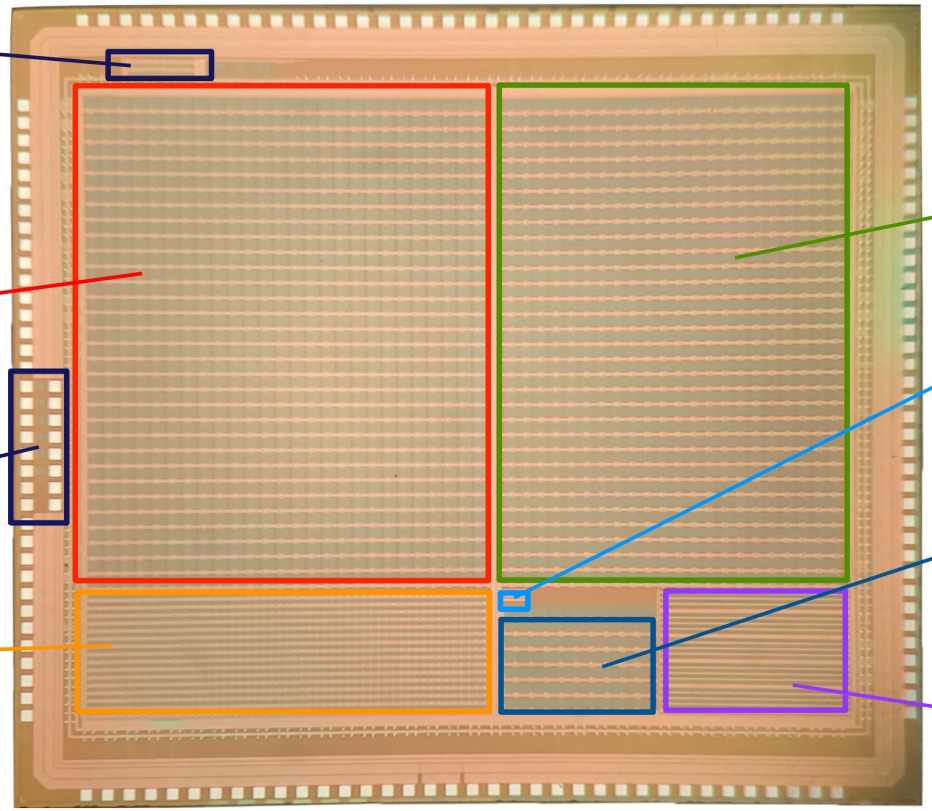
Activity of interest (DRD4 – WP4.1)

ASAP110LF chip – a technology characterization platform



ECFA DRD4 WP4.1 Solid State Photon Detectors Meeting – February 26, 2024

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Lodovico Ratti et. al. (INFN), from "Introductory meeting of the DRD4 WP4.1" 25/02/2024

Activity of interest (DRD4 – WP4.1)

Activity program

- Development of small scale prototypes of CMOS SiPMs consisting of about 1000 SPADs with 15-20 um pitch
  - for the readout, both a fully digital and a mixed analog and digital approach will be explored – best compromise between detection efficiency (fill factor) and functional density
  - on sensor electronics to be provided with event detection, counting, thresholding and time stamping capabilities, possibly together with the ability to follow the time evolution of the light pulses – reconstruction of the longitudinal shower and discrimination between Cherenkov and scintillation signals
  - specific structures included to test the chip functionalities
- Development of a demonstrator chip including 8 SiPMs, each with a 1 mm^2 area
  - inter-SiPM region used for integrating most of the electronics, to minimize the impact on the fill-factor
  - characterization to be performed in the lab and possibly in a beam test
- Possible extension to other applications with the involvement of other groups

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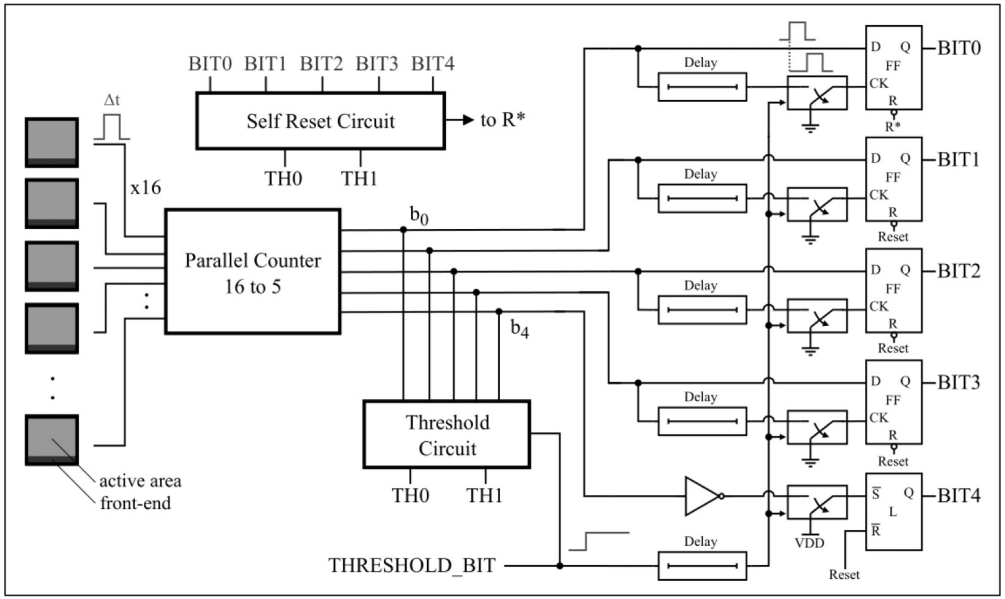
Thank you for your attention

backup

Mini-SiPM with parallel counter

- The SiPM contains **16 SPADs**, arranged in a 4x4 array, and a processing circuit.
- The 16-bit input **parallel counter** provides in **real time** the number of simultaneously triggered SPADs.
- The count result is fed to the memory elements through an **auto-triggering mechanism**, which filters out spurious glitches coming from the counter.
- A **SOT** logic has been implemented.
- A **noise rejection feedback network (NRFN)** has been designed to filter out individual dark pulses.



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