Dual Readout: a step forwards a scalable solution

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on behalf of the IDEA Dual Readout group

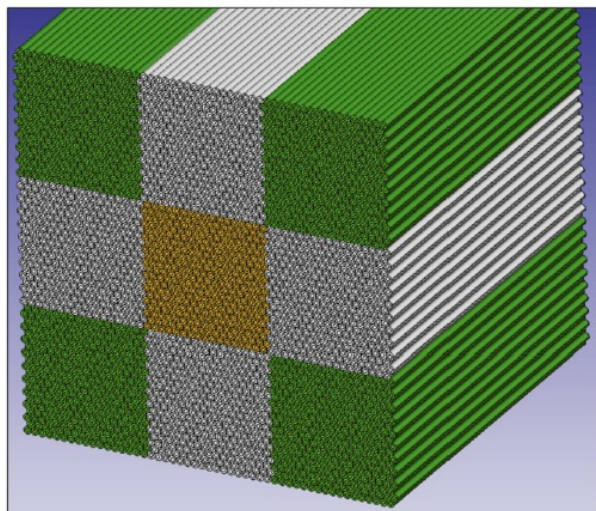Università dell'Insubria and INFN - Milano

Outlook

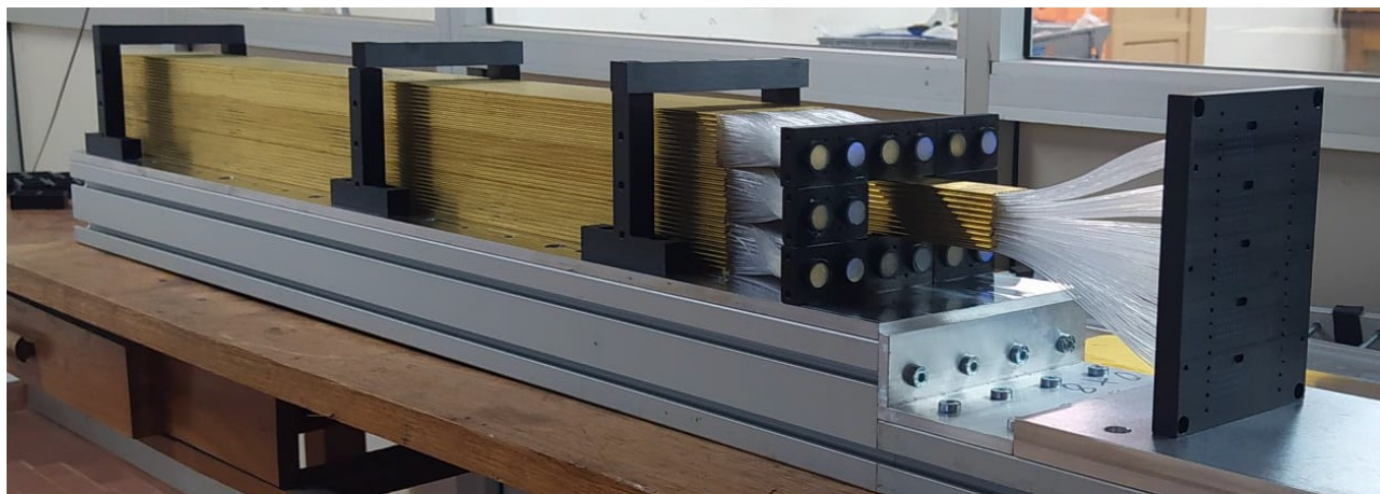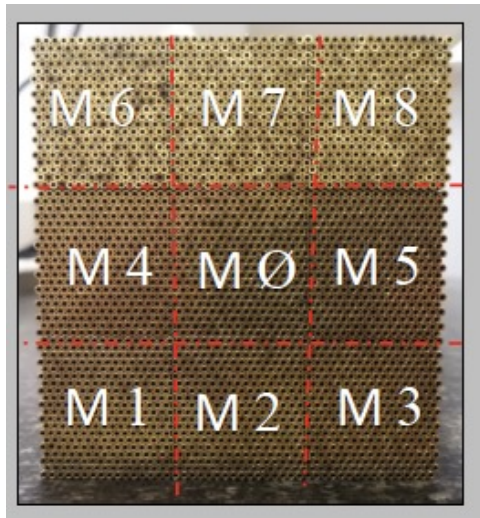❑ The 2021 test beam prototype

❑ The design of a scalable solution
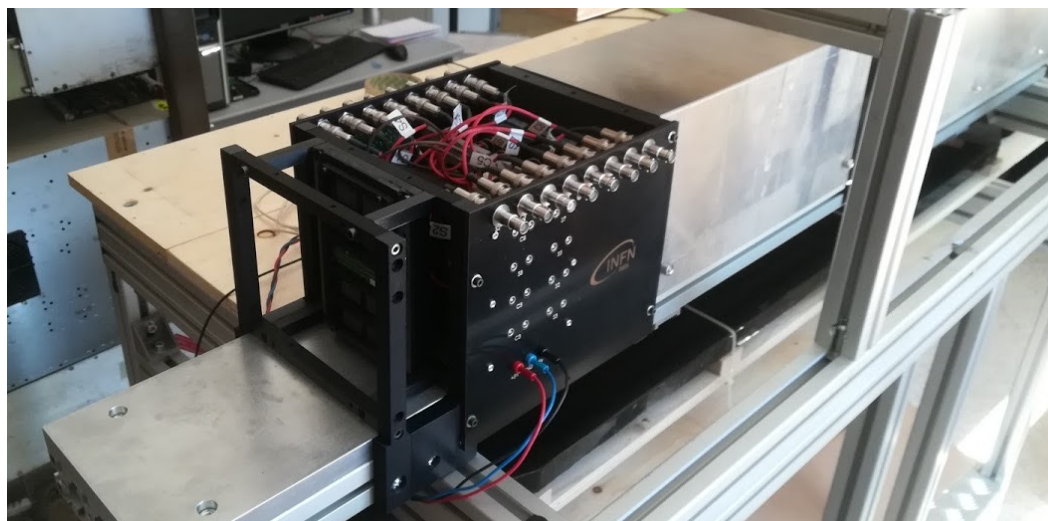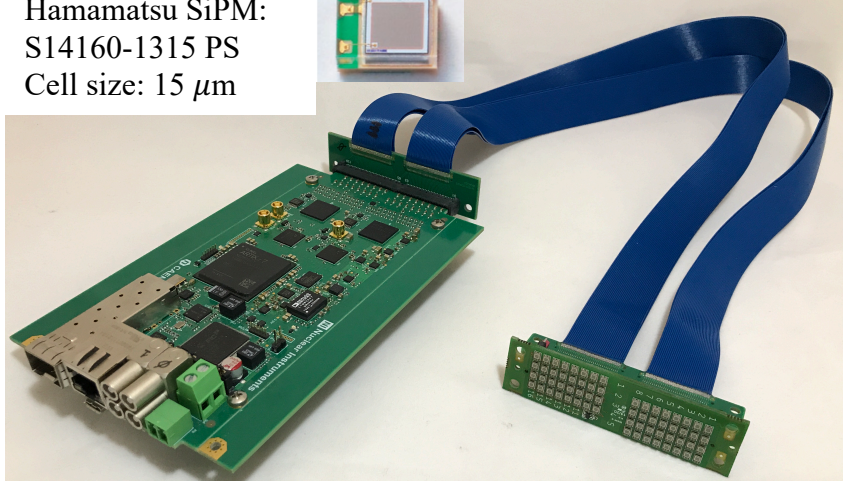
The 2021 test beam prototype

- ❑ **EM-prototype (10x10x100 cm^3)**
  - ❑ 9 modules made of 16 x 20 capillaries (160 C and 160 Sc)
  - ❑ Capillaries (brass): 2 mm outer diameter and 1.1 mm inner diameter

- ❑ **EM-prototype readout**
  - ❑ Each capillary of the central module is equipped with its own SiPM: highly granular readout
  - ❑ 8 surrounding modules equipped with PMTs (each module will use 1 PMT for C and 1 PMT for Sc fibres)
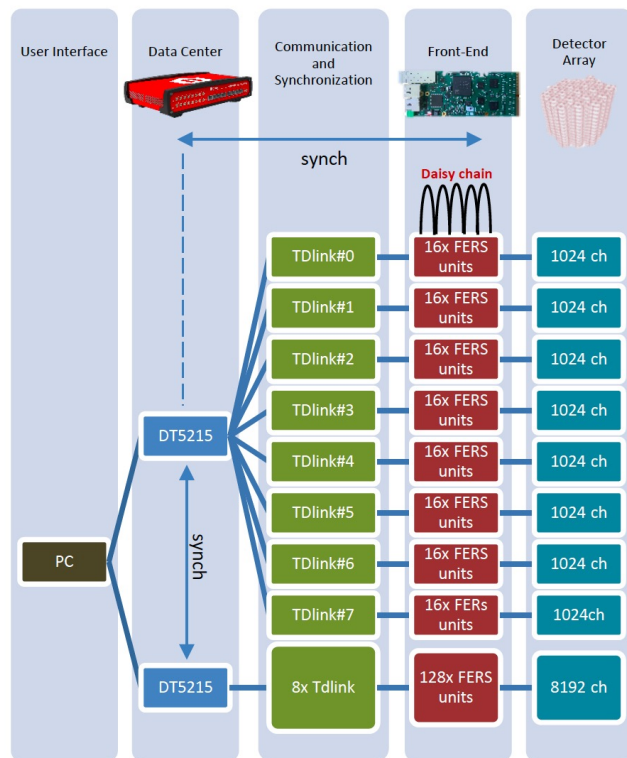
The 2021 test beam prototype
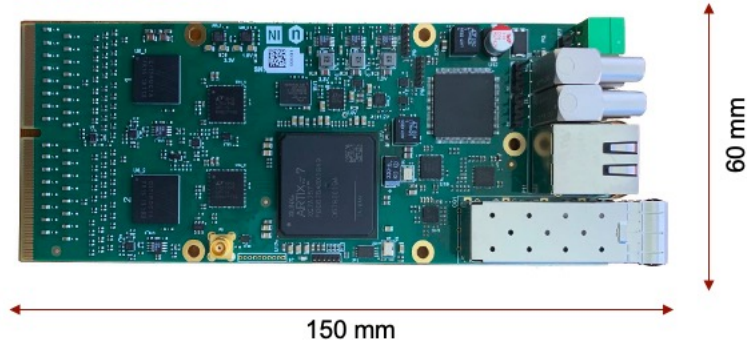

Hamamatsu SiPM:
S14160-1315 PS
Cell size: 15 μm

The 2021 test beam prototype: readout

❑ PMTs read out with QDC (V792AC) and TDC (V775N) modules from Caen

❑ The highly granular module (320 SiPMs) read out with the Caen FERS system (5200) using 5 readout boards (A5202)
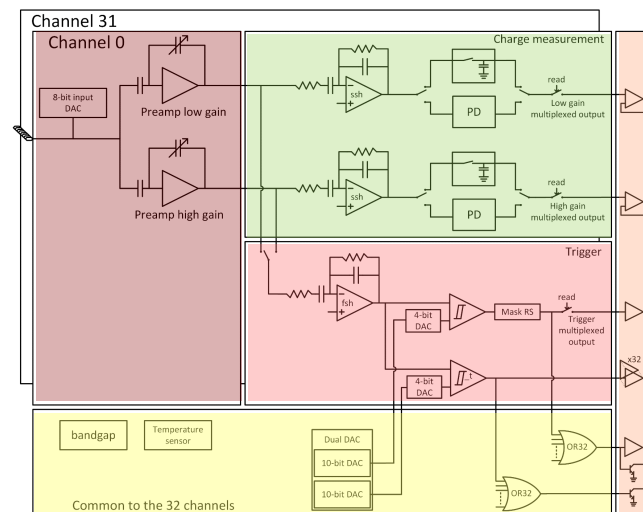

FERS: A5202

60 mm

150 mm

- Two Citiroc1A for reading out up to 64 SiPMs
- One (20 – 85V) HV power supply with temperature compensation
- Two 12-bit ADCs to measure the charge in all channels
- Timing measured with 64 TDCs implemented on FPGA (LSB = 500 ps)
- 2 High resolution TDCs (LSB = 50 ps)
- Optical link interface for readout (6.25 Gbit/s)

The impact of high granularity

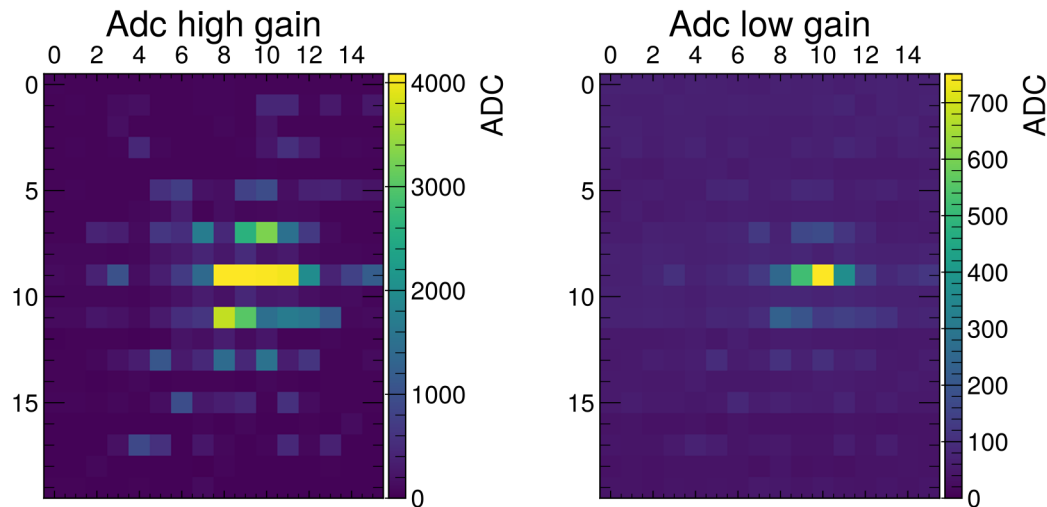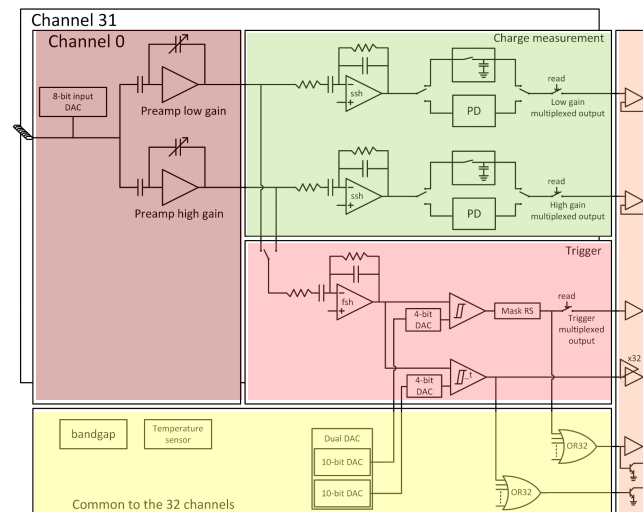☐ Beam @ 6GeV centred on the SiPM tower
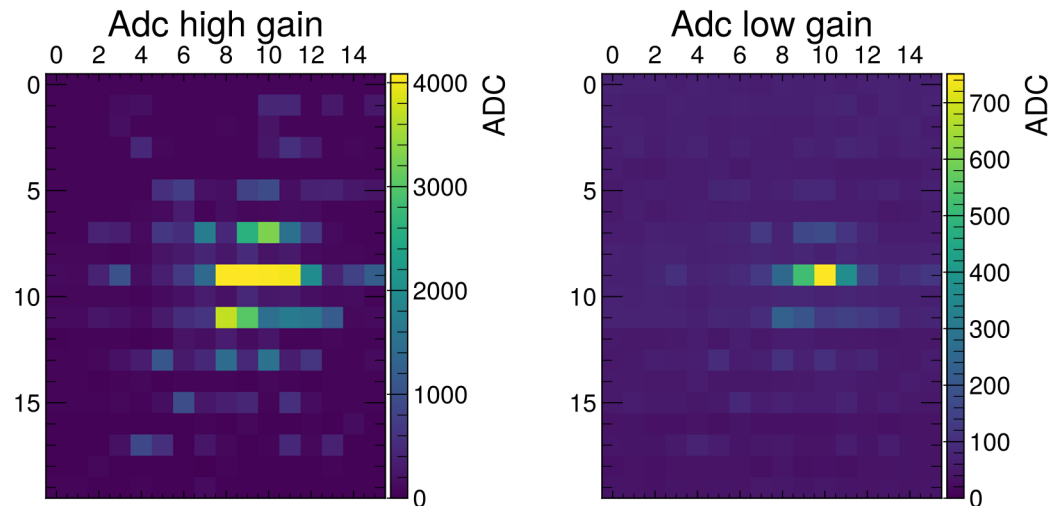
CITIROC 1A: block diagram

The impact of high granularity
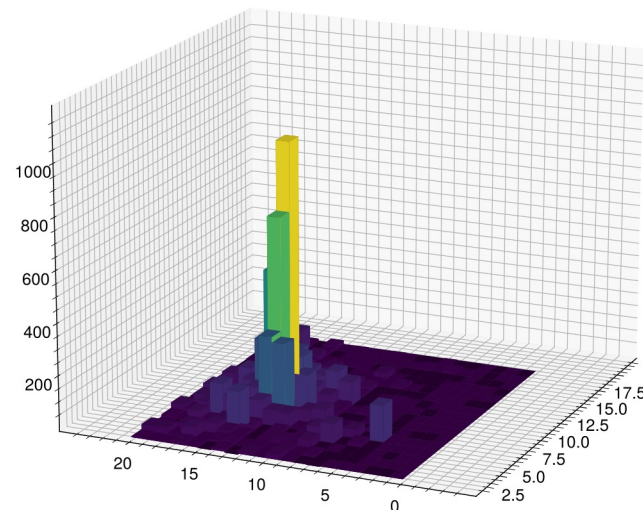
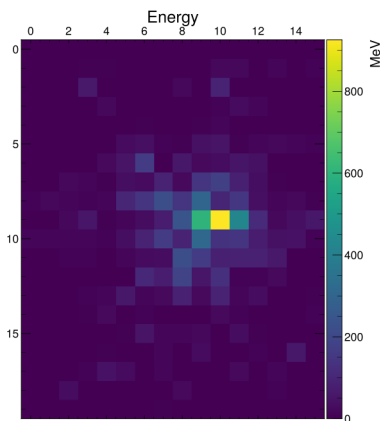❑ Beam @ 6GeV centred on the SiPM tower

Adc high gain

Adc low gain

CITIROC 1A: block diagram

❑ From raw data to merged and calibrated data
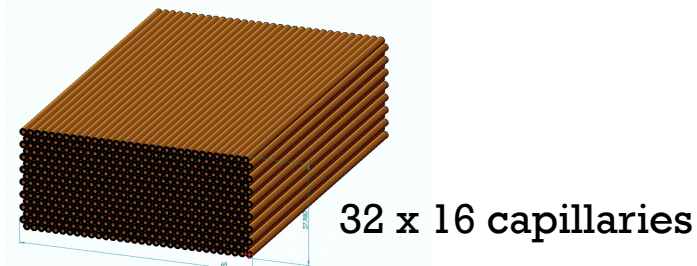
see G. Polesello's talk for the test beam results

Energy

The hadronic prototype

The Mini-Module

32 x 16 capillaries

The Module

10 Mini-modules
~ 13 x 13 x 250 cm^3
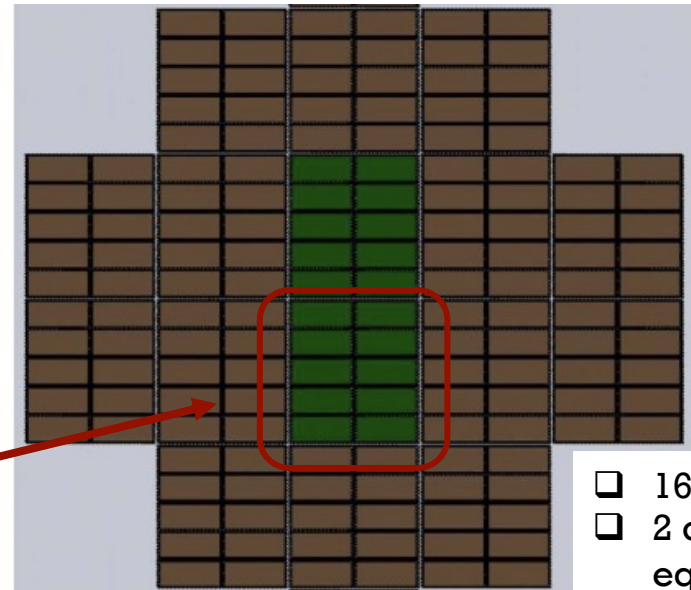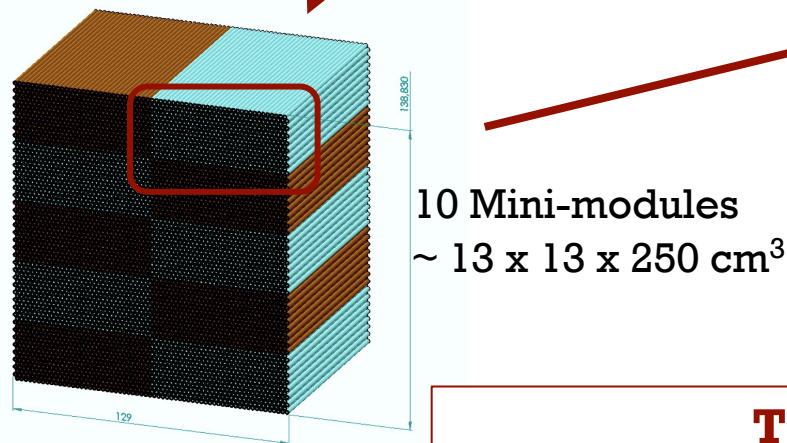
- 16 modules in total
- 2 central modules equipped with SiPMs
- 14 modules equipped with PMTs
- ~ 65 x 65 x 250 cm^3

The challenge:

We have 10240 SiPMs, fitting the back side of the detector, to be operated

The design of a scalable solution

- ❑ Challenging integration: there is almost no space
  - ❑ Sensor
  - ❑ Mechanical support
  - ❑ Cabling and readout to serve all channels
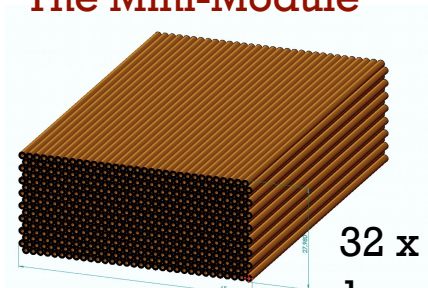
- ❑ Costs (only sensors and readout)
  - ❑ First goal: less than 10 euro per SiPM (is this reasonable?)
  - ❑ We need 160 FERS to operate 10240 SiPMs (same strategy used in the last test beam): do we have alternatives?

The challenge:

The Mini-Module

32 x 16 capillaries
1 capillary:
    2mm OD and 1.1mm ID

☐ 1 SiPM per Fiber: compact package

☐ SiPM with high Dyn-Range: $10\mu m$ pitch

☐ No contamination between Cherenkov
    and scintillating light

The design of a scalable solution: 1st design

The challenge:

The Mini-Module

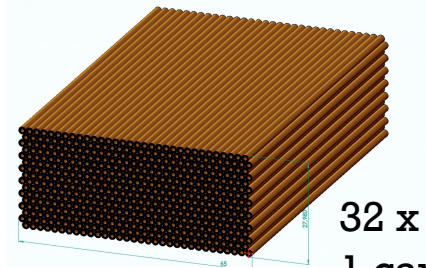**32 x 16 capillaries**
1 capillary:
    2mm OD and 1.1mm ID

- ❑ 1 SiPM per Fiber: compact package

- ❑ SiPM with high Dyn-Range: $10\mu m$ pitch

- ❑ No contamination between Cherenkov and scintillating light

Pair of FEE-boards joint togheter with the clips

Cherenkov light collection

Scintillating light collection

Absorber

FEE-board + SiPMs

Micro-connectors

Clips to hold the FEE-board in position

Cables

The design of a scalable solution: new sensor
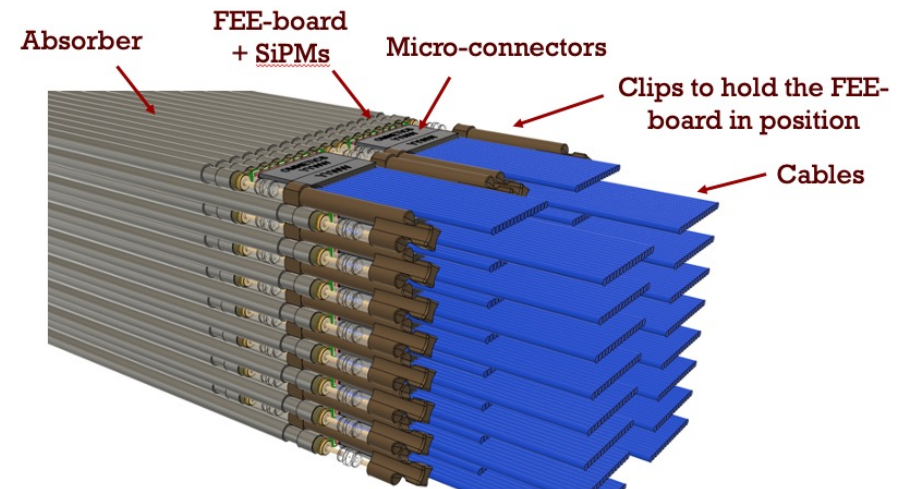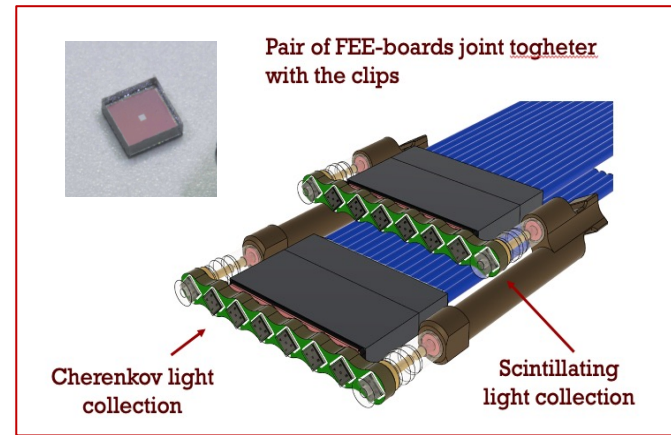
The challenge:

The Mini-Module
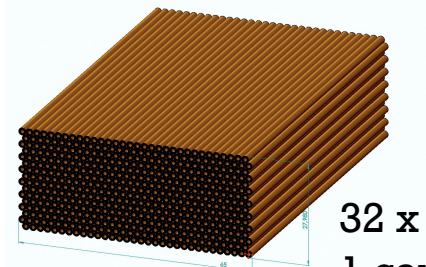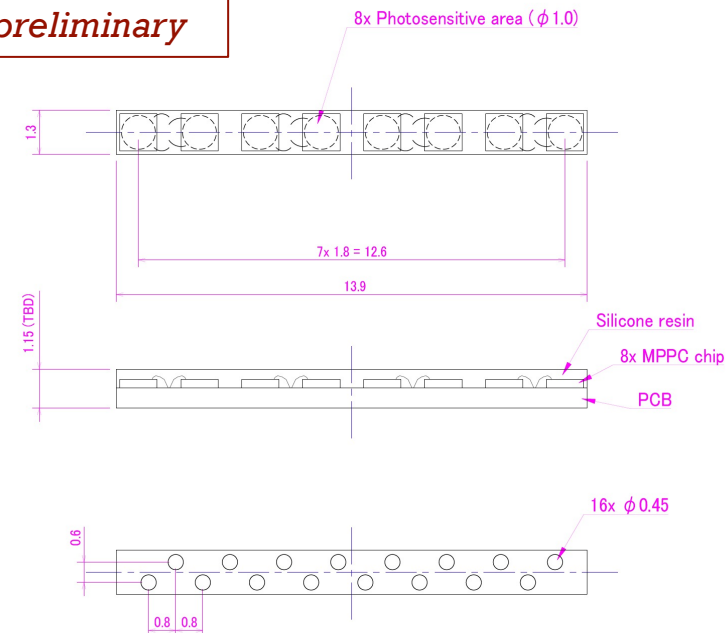

32 x 16 capillaries
1 capillary:
   2mm OD and 1.1mm ID

- 1 SiPM per Fiber: compact package

- SiPM with high Dyn-Range: $10\mu m$ pitch

- No contamination between Cherenkov and scintillating light
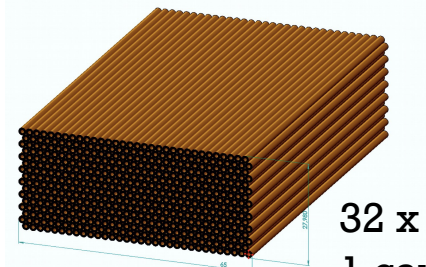
SiPM module from Hamamatsu

preliminary

8x Photosensitive area (ϕ 1.0)
1.3
7x 1.8 = 12.6
13.9
1.15 (TBD)
Silicone resin
8x MPPC chip
PCB
16x ϕ 0.45
0.6
0.8 0.8

- Custom designed module with 8 SiPMs (1x1mm²)

- Distance between SiPMs: 2mm (drawings to be modified)

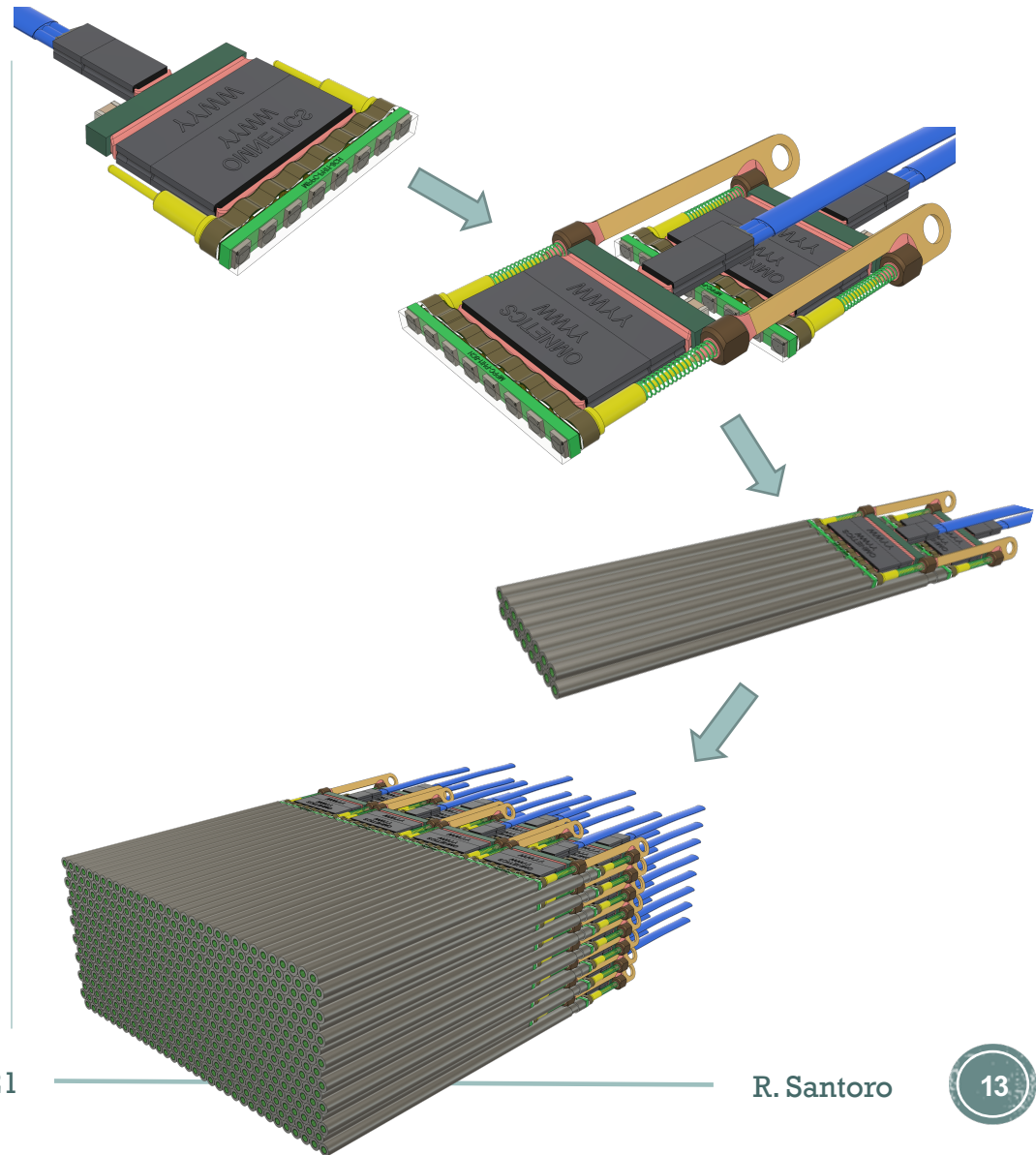- Two options: 10 and 15 μm pitch

The challenge:

The Mini-Module

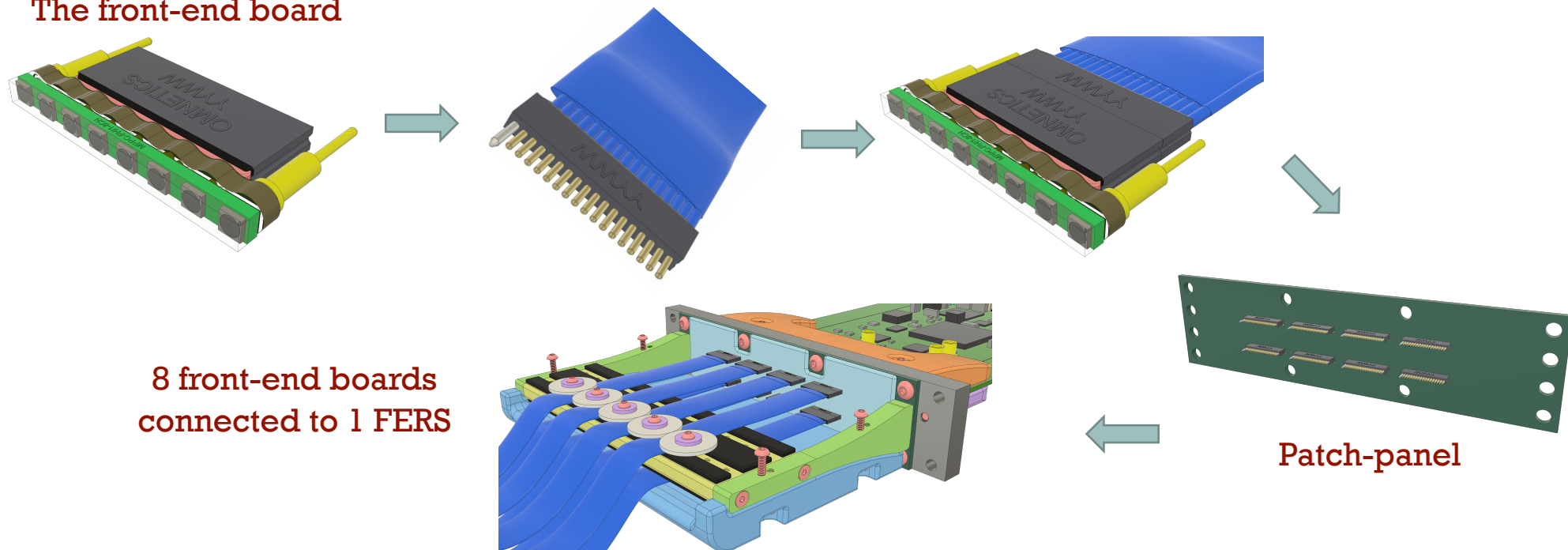32 x 16 capillaries
1 capillary:
  2mm OD and 1.1mm ID

- [ ] 1 SiPM per Fiber: compact package

- [ ] SiPM with high Dyn-Range: $10\mu m$ pitch

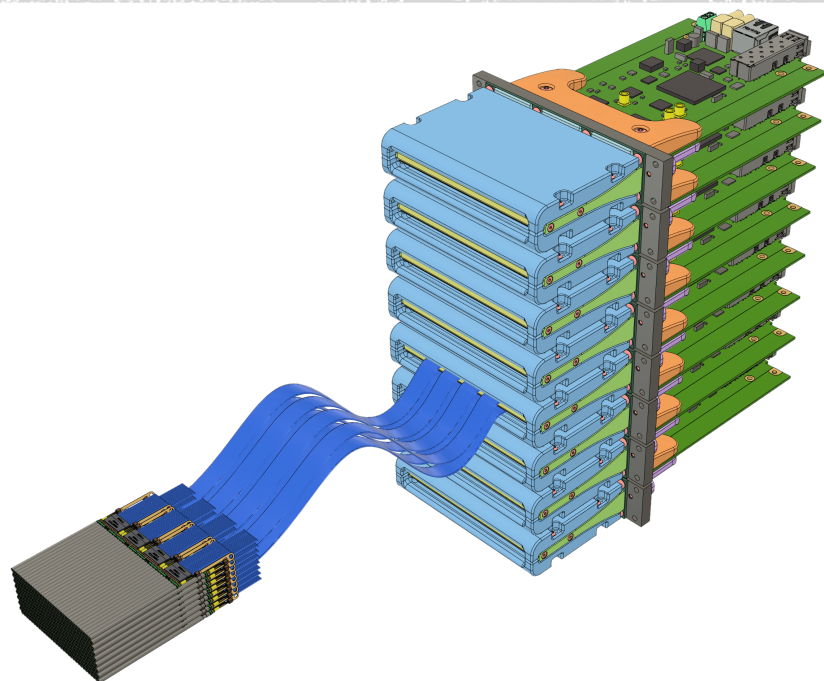- [ ] No contamination between Cherenkov and scintillating light

The front-end board

The front-end board

8 front-end boards
connected to 1 FERS

Patch-panel

Crucial for the commissioning phase

❑ Each SiPM can be qualified individually
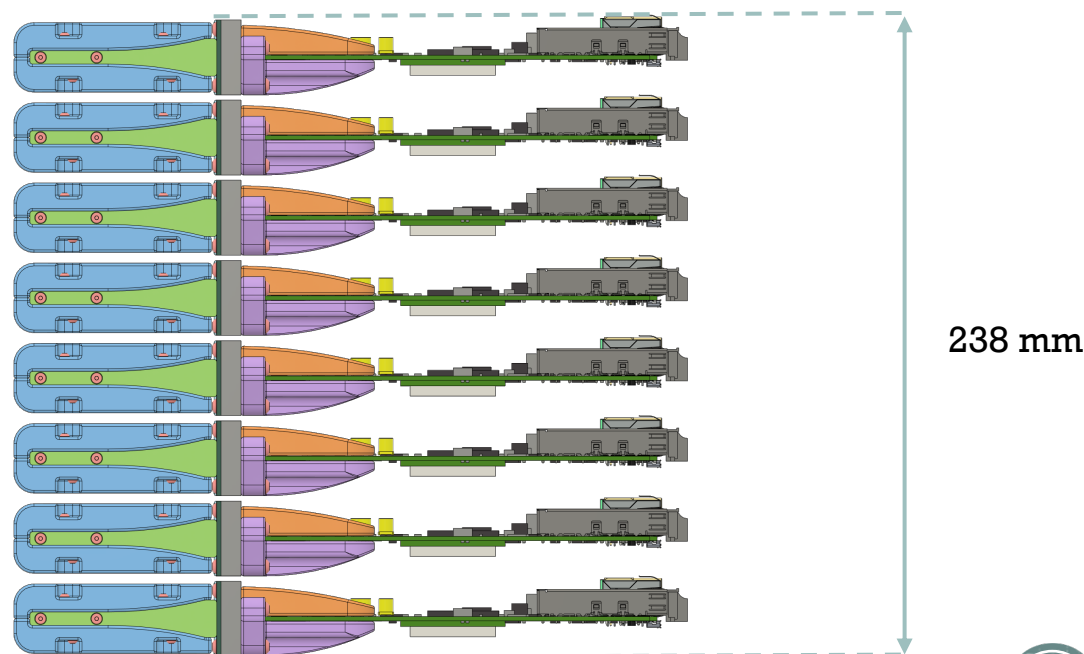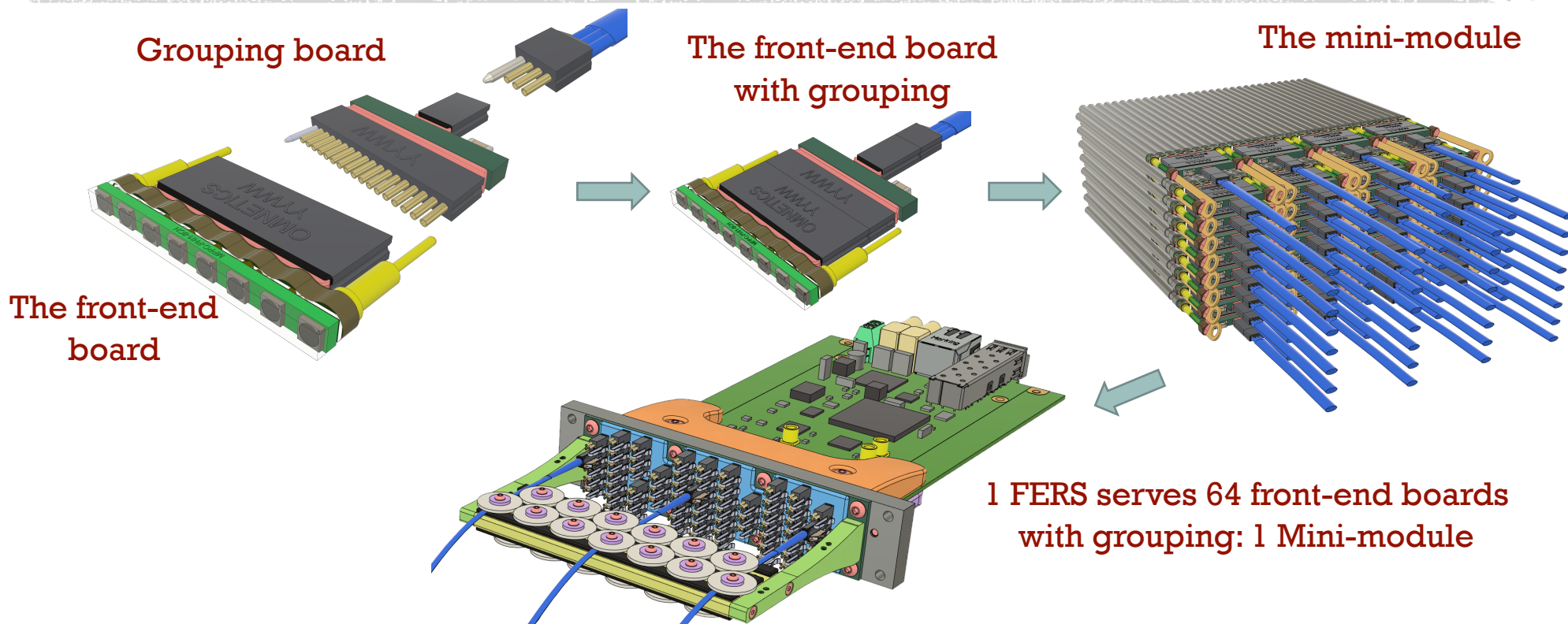
❑ 1 FERS allows to operate up to 64 SiPMs at the same time

Crucial for the commissioning phase

- ❑ 8 FERSs to readout 1 mini-module: not feasible for Hidra (20 mini-modules)

- ❑ Options to be considered only for system qualification or for specific measurements

28 mm

238 mm

Side view

Mini-module: the baseline solution

Grouping board

The front-end board
with grouping

The mini-module

The front-end
board

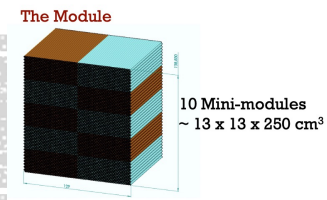1 FERS serves 64 front-end boards
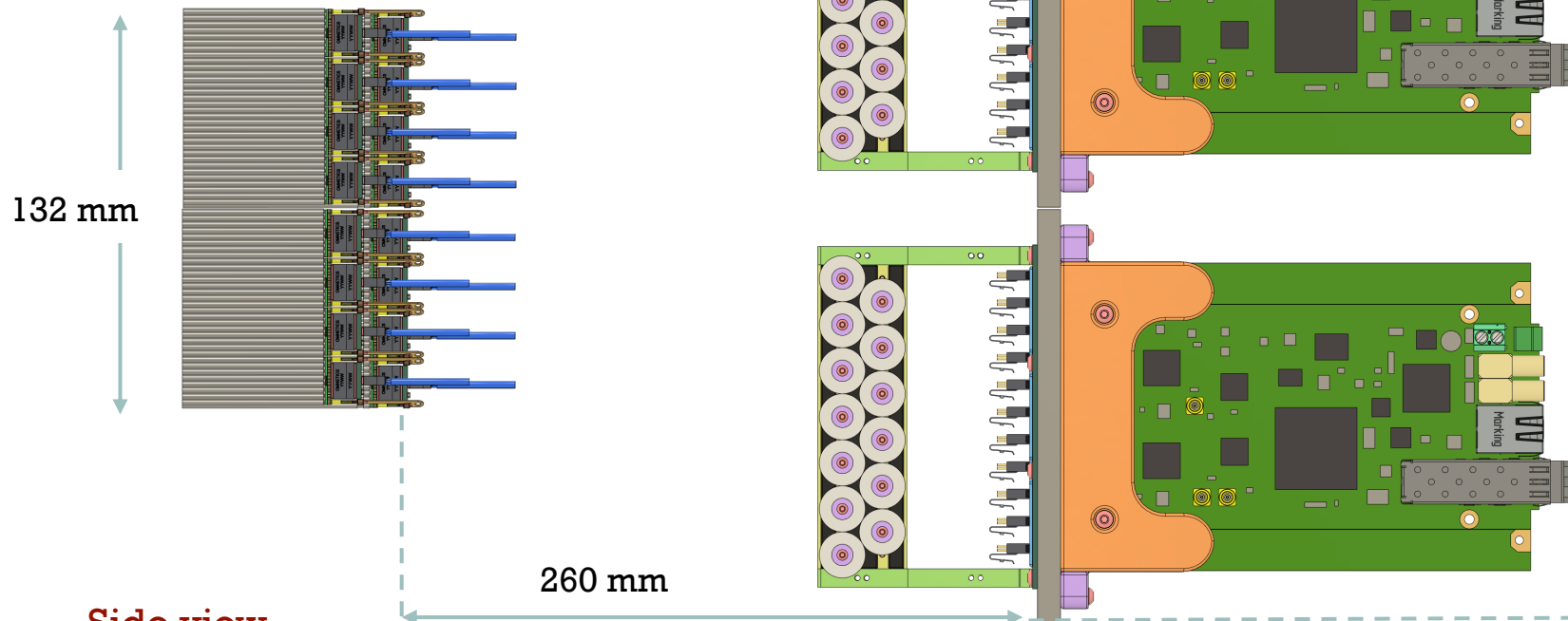with grouping: 1 Mini-module

Baseline solution

- ❑ Each bar of SiPMs will be operated at the same voltage

- ❑ The signals from 8 SiPMs is summed up in the grouping board

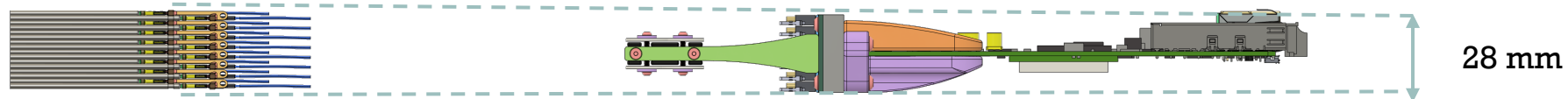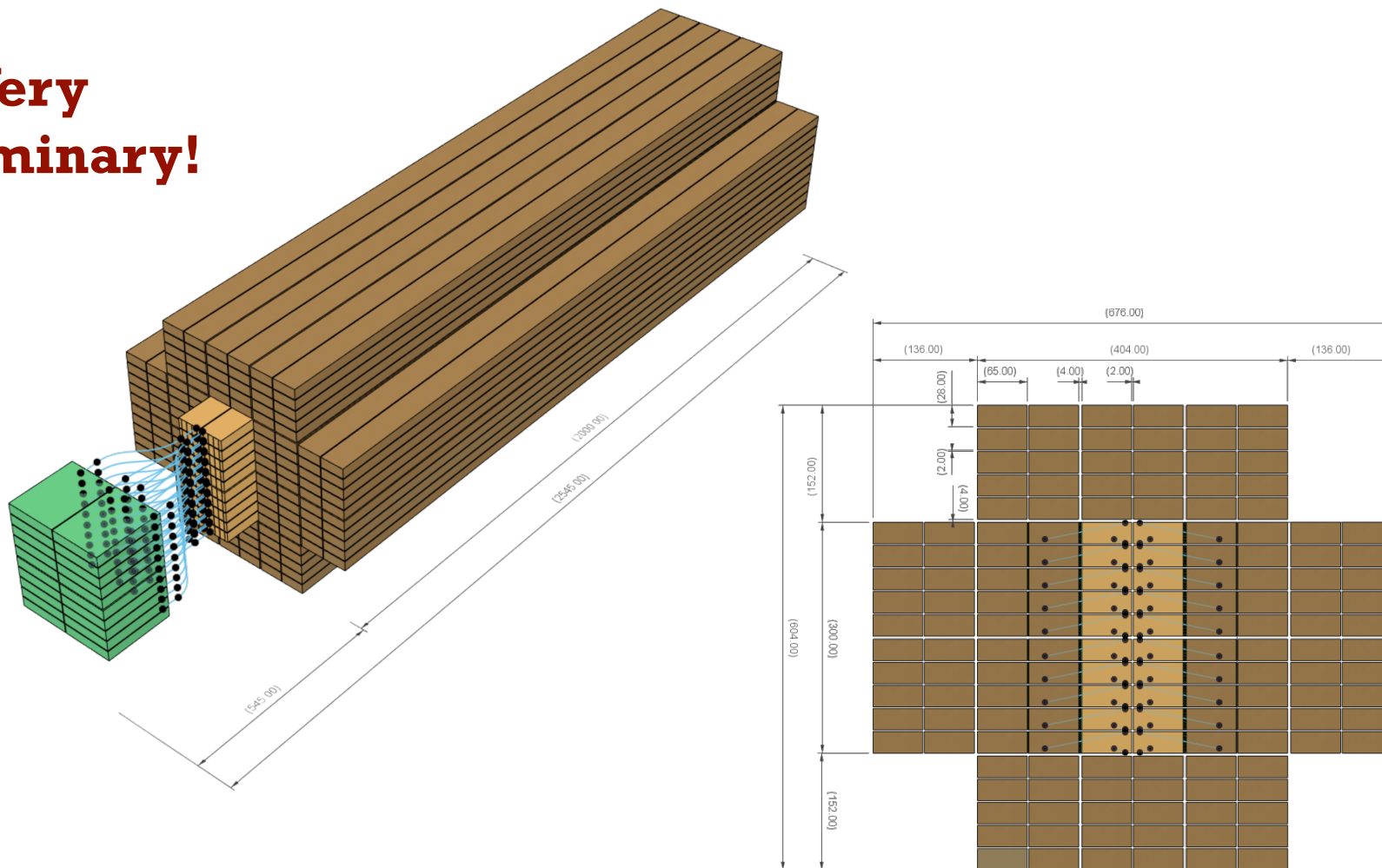# The module

10 Mini-modules ~ 13 x 13 x 250 cm³

Top view

132 mm

272 mm

260 mm

Side view

28 mm

Very preliminary!

Summary

❑ This year we built and qualified on beam an EM prototype which allowed:

   ❑ To test the assembling solution based on capillaries

   ❑ To qualify the new readout system for SiPMs

   ❑ To assess the EM performances (see next talk)

   ❑ To precisely tune the Montecarlo simulation (see next talk)

❑ The hadronic prototype is calling for new challenges. The proposed strategy allows

   ❑ To qualify individually the SiPMs before the installation

   ❑ To fit all SiPMs and readout board in the available space

   ❑ To reduce costs by using the grouping

Backup