

“The ALICE Muon Forward Tracker project: status and expected performances”

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ALICE experiment at forward rapidities

ALICE (LHC- CERN)

- ❖ Study the Quark-Gluon Plasma (QGP)
- ❖ Collisions : pp, pPb, PbPb

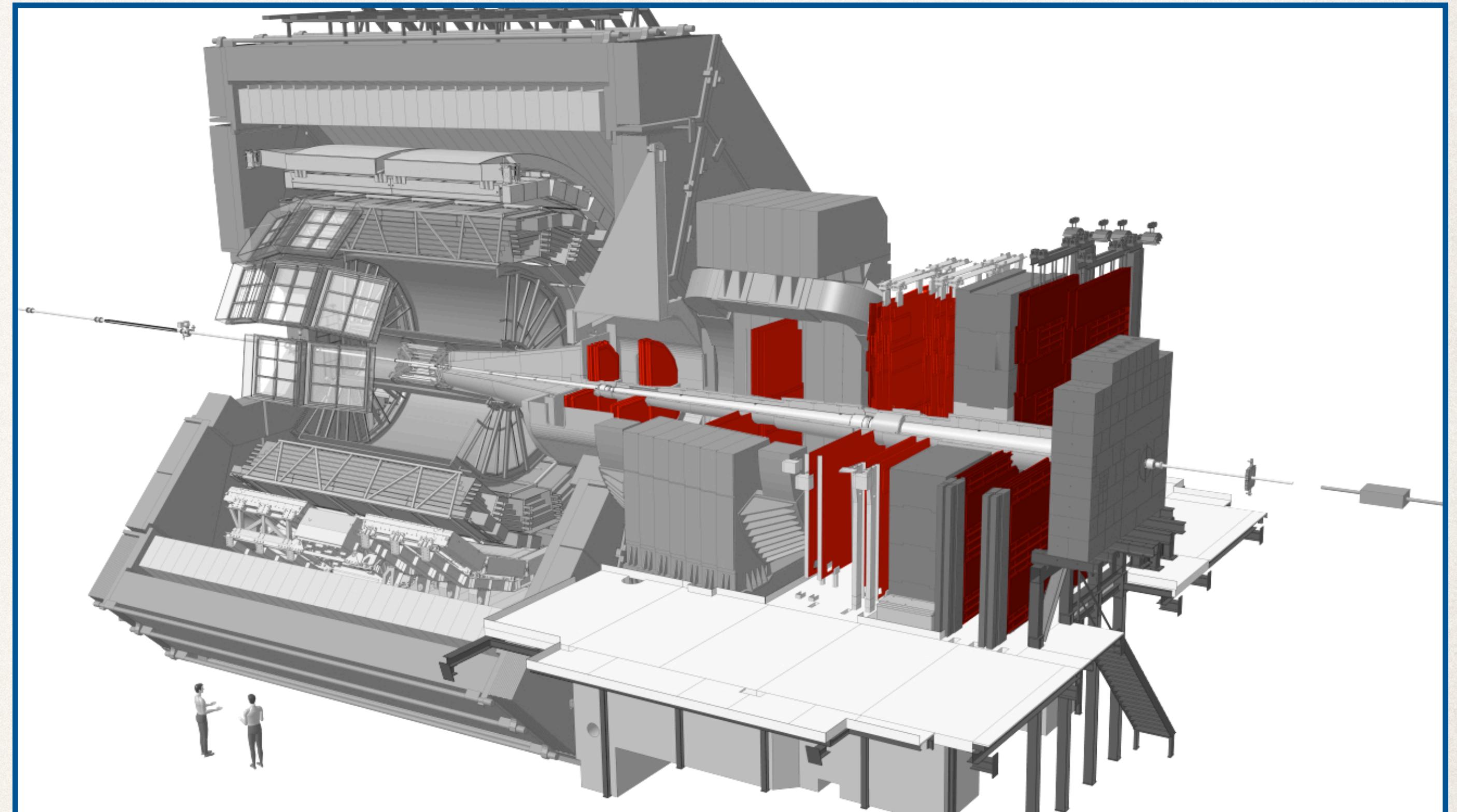
Forward Rapidity

Muon Spectrometer composed by an absorber wall and muon chambers :

$$2.5 < y < 4.0$$

Heavy flavours and quarkonia

- ❖ Probing QGP medium;
- ❖ Measuring beauty production;
- ❖ Evaluation of the $c\bar{c}$ recombination



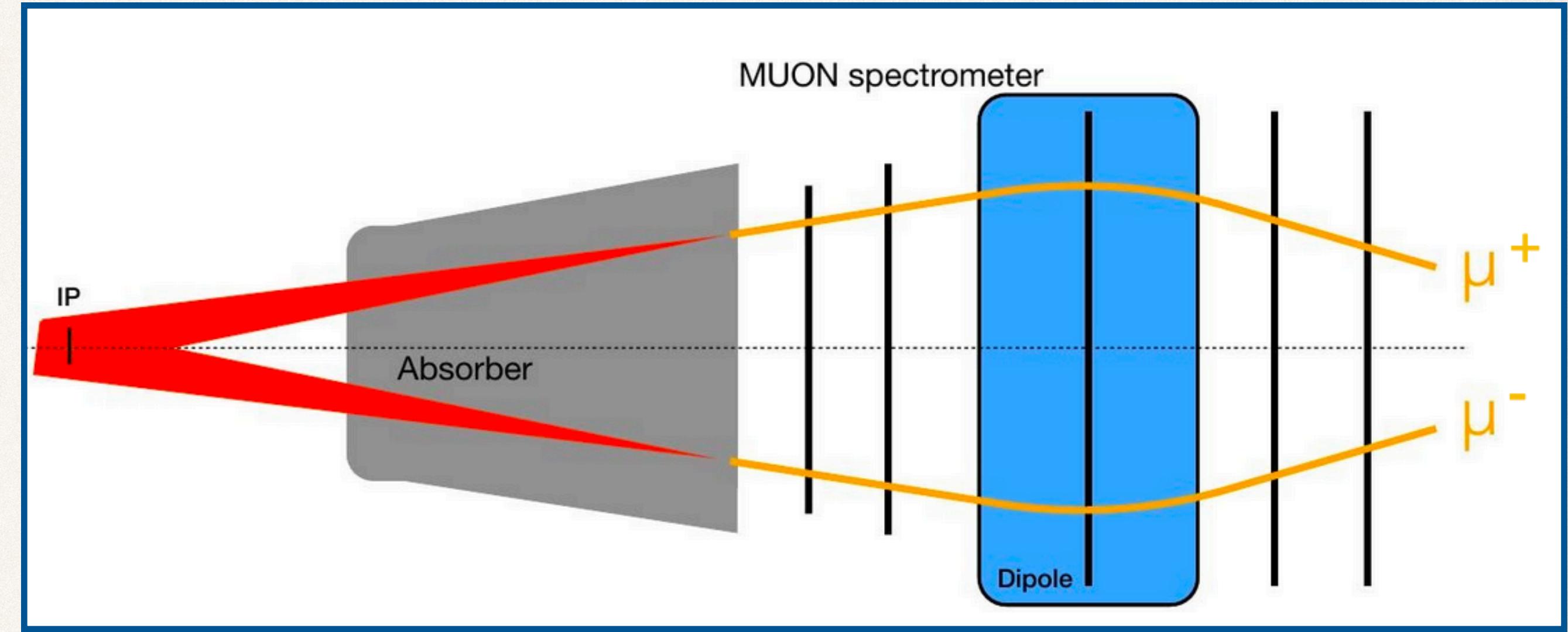
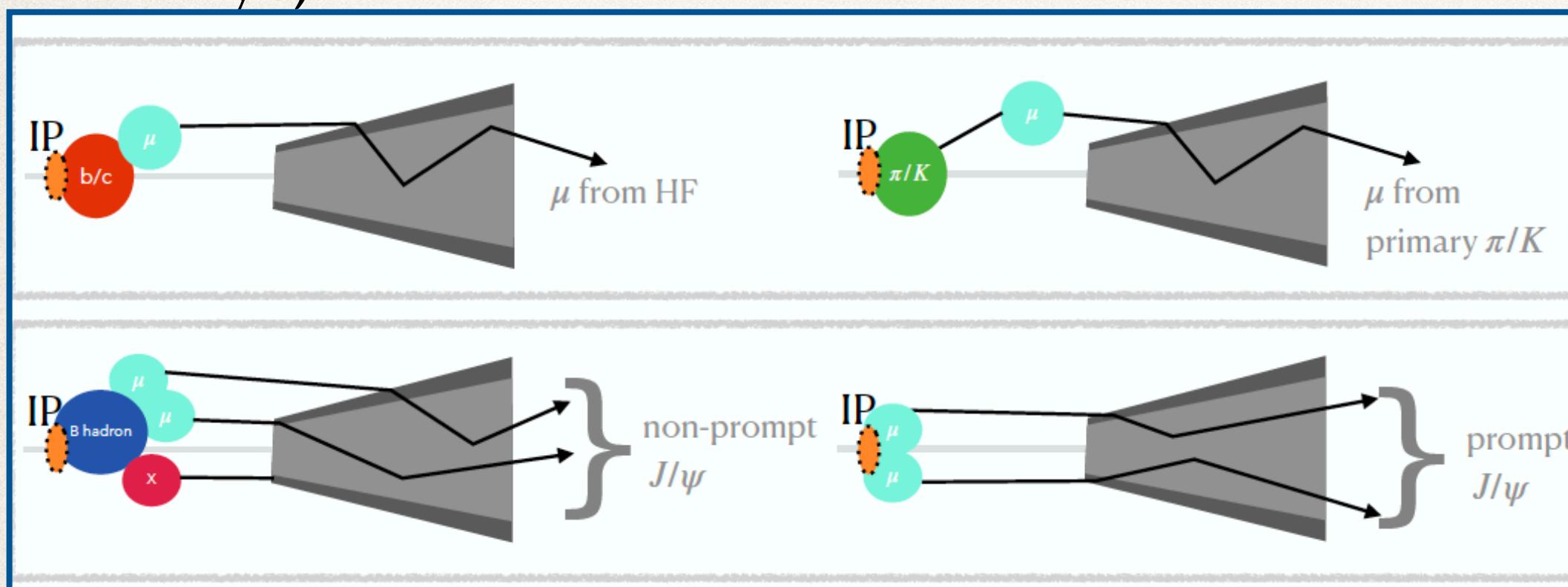
The Muon Spectrometer limitations

Charm/beauty separation :

- ❖ Determination of the muon production vertex is impossible;
- ❖ Limited mass resolution for resonances.

Background :

- ❖ High background coming from π and K meson decays;



⇒ Poor spatial resolution around the IP region

⇒ Need of a high spatial resolution tracker in front of the muon absorber

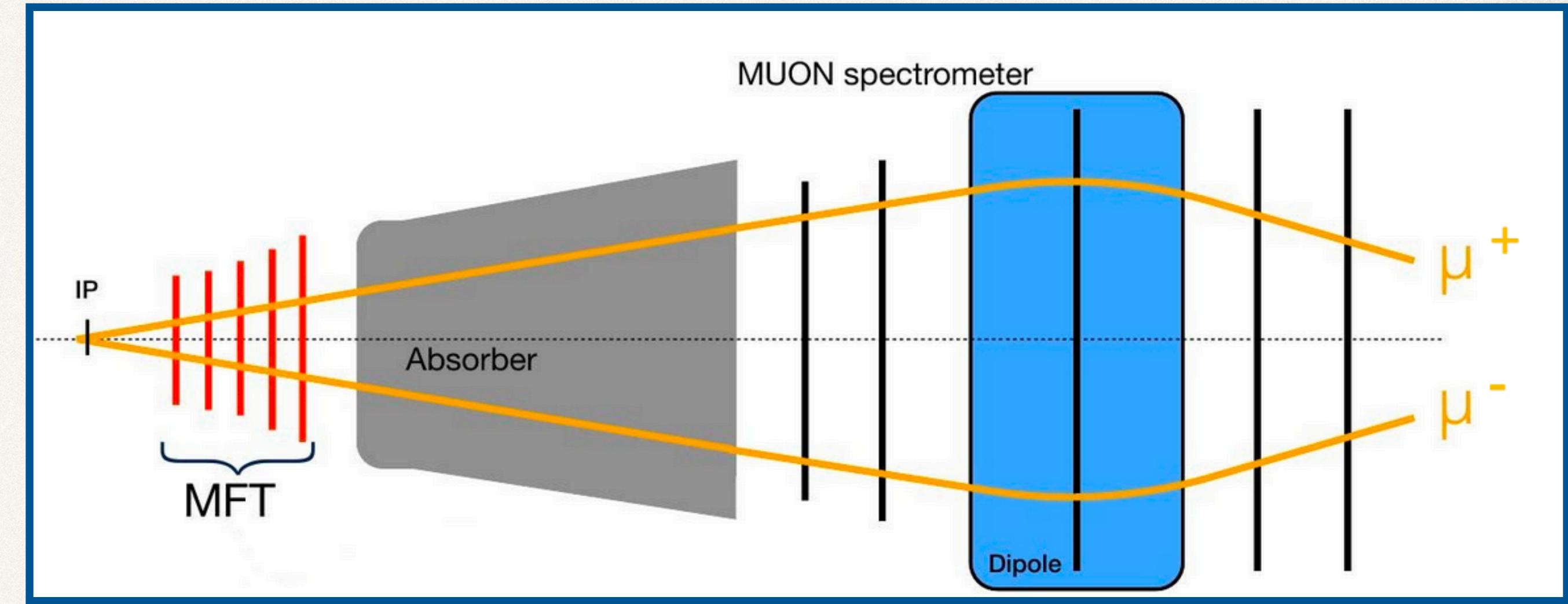
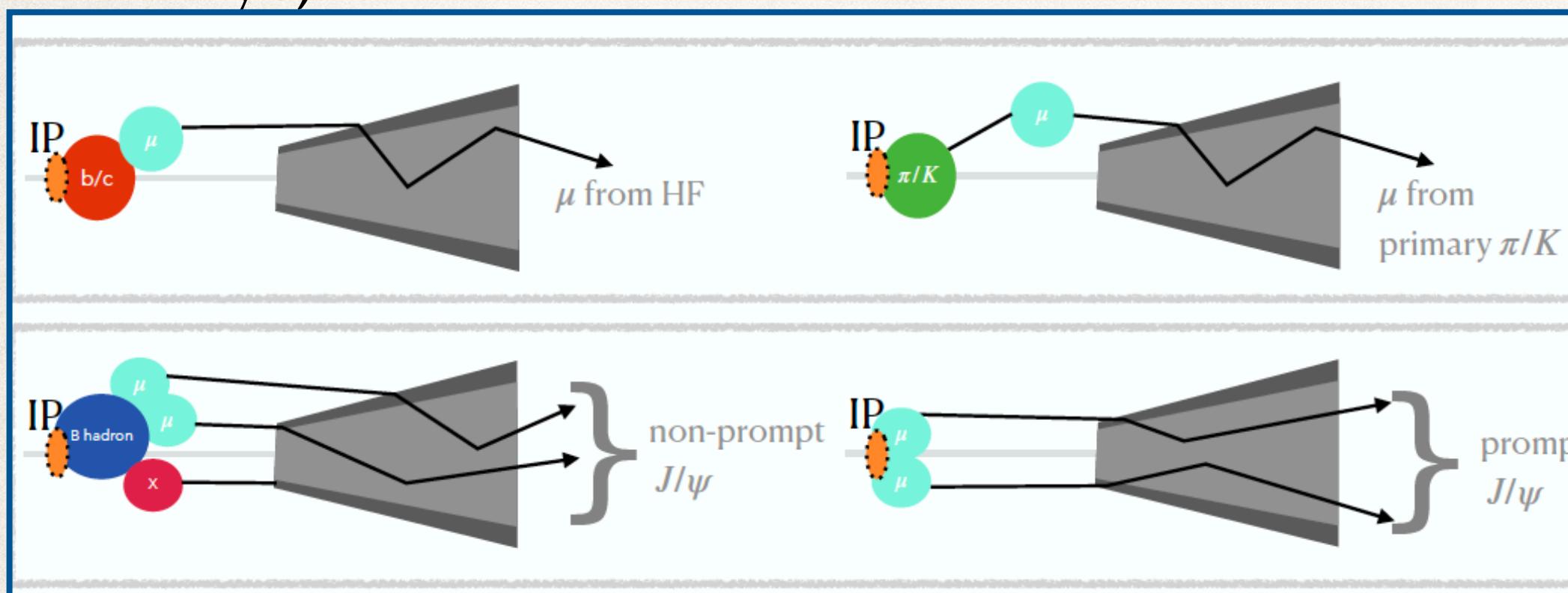
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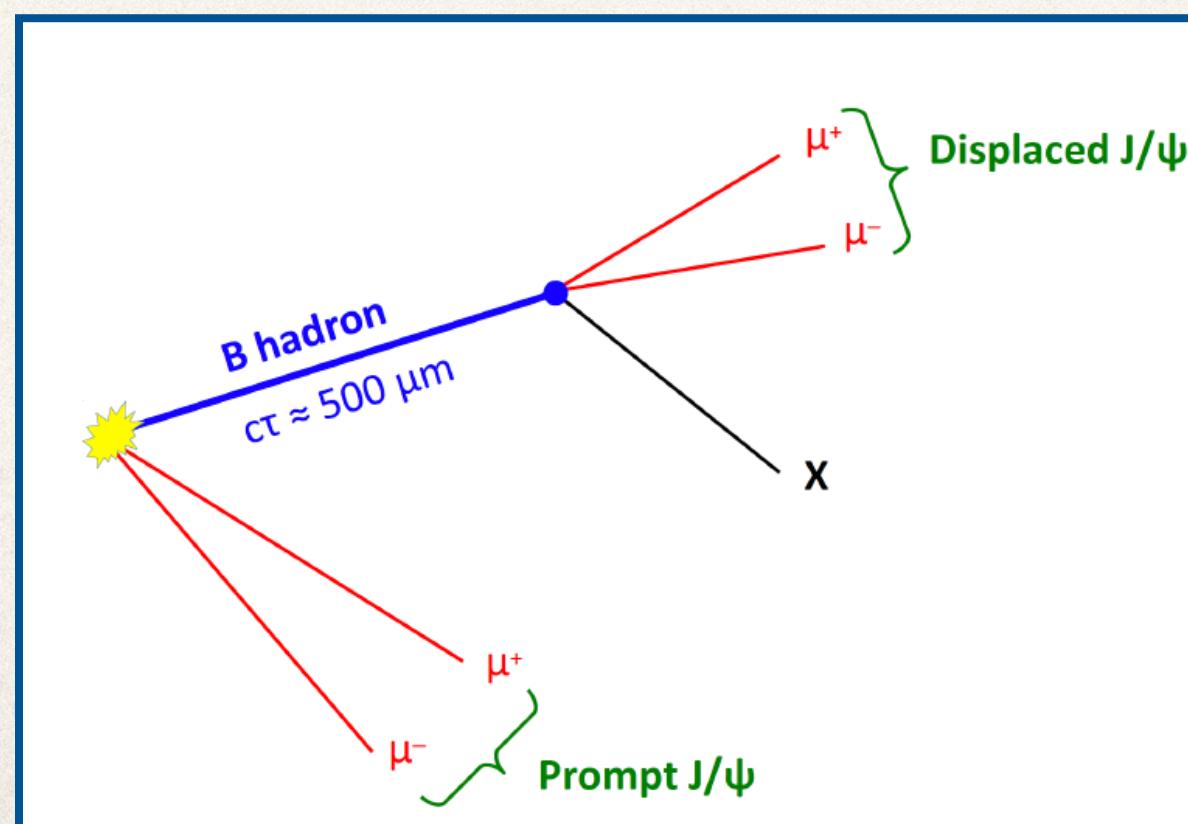
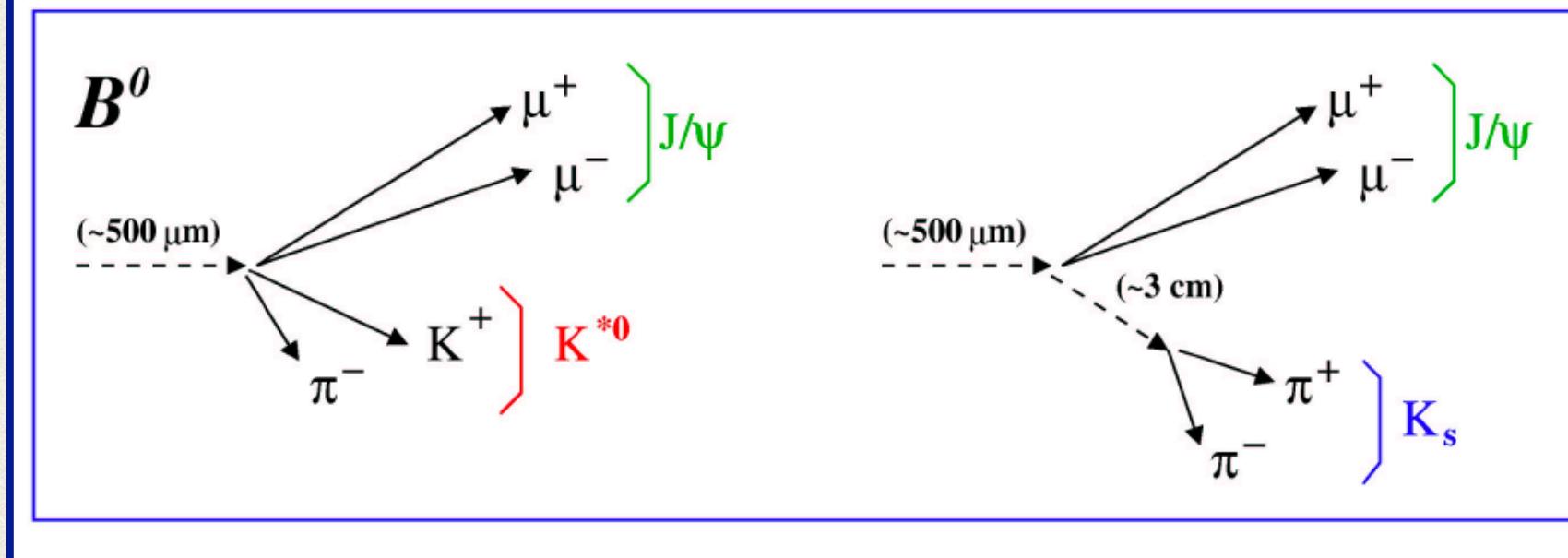
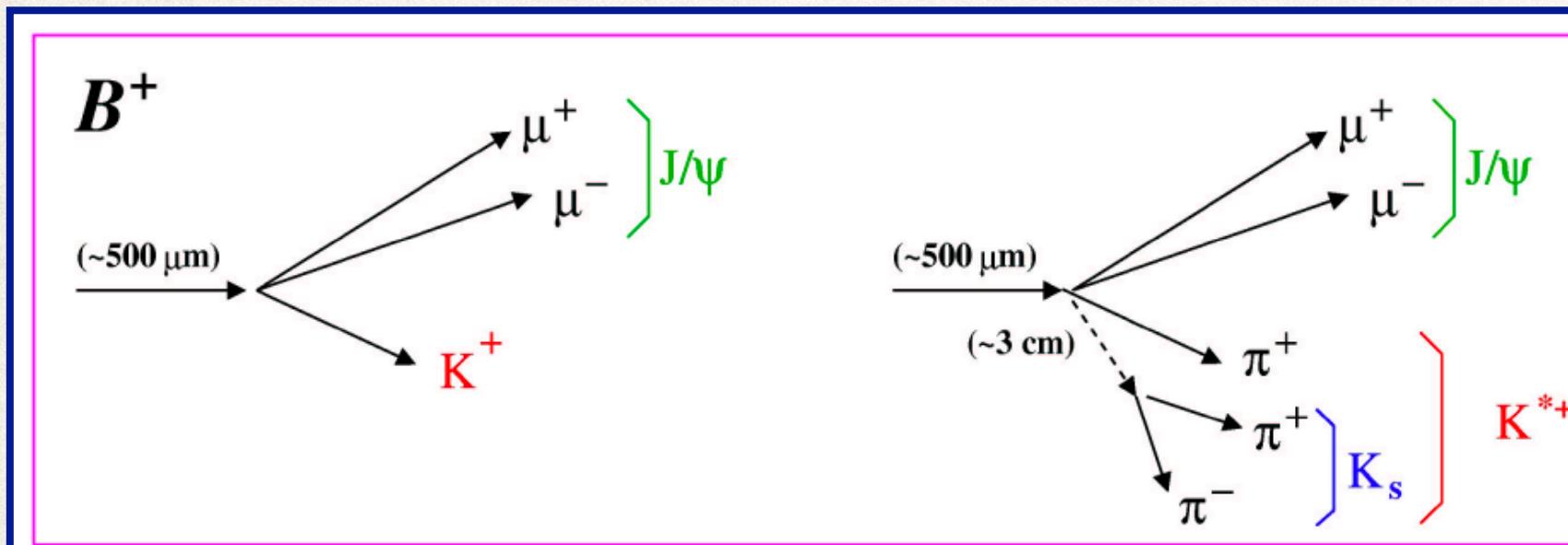
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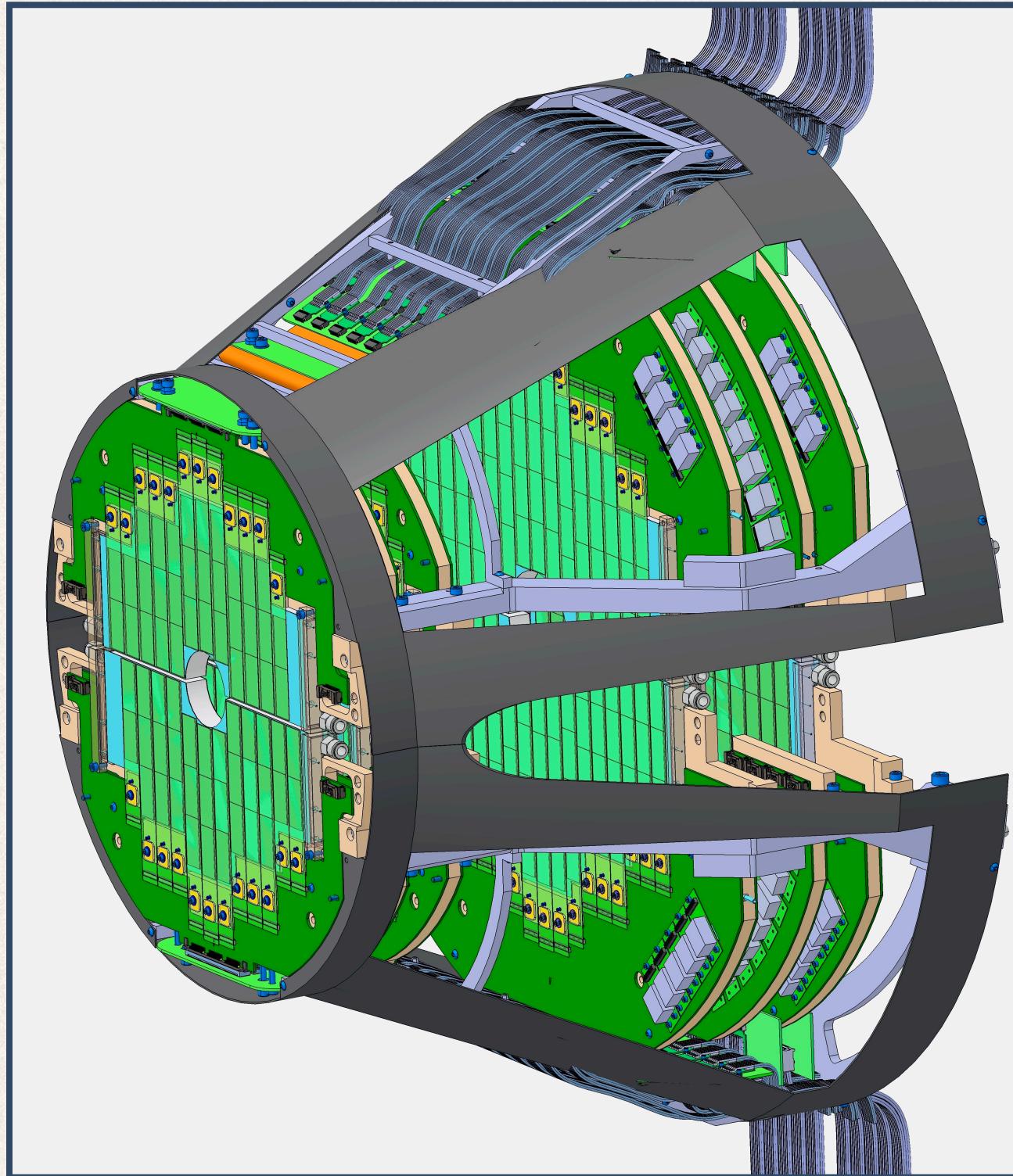
Muon Forward Tracker (MFT) (1)



Physics objectives

- ✿ Precise determination of production vertex:
 ⇒ Charm/beauty separations resolution is better than 100 μm ;
 ⇒ Track matching with Muon Spectrometer.
- ✿ Heavy flavours :
 ⇒ Less background expected : **low p_T** awaited.
- ✿ Charmonia :
 ⇒ S/B extraction of the $\psi(2S)$ signal improvement;
 ⇒ Access to the charmonia **non prompt fraction**.
- ✿ Low mass dimuons :
 ⇒ Better dimuon opening angle resolution : **better mass resolution**.

Muon Forward Tracker (MFT) (2)



Physical characteristics

- ❖ Position :
 - ⇒ Beam pipe and Muon Spectrometer on pseudo-rapidity ($-4 < \eta < -2.5$) ;
 - ⇒ Pb-Pb rate 50kHz & p-p rate 200kHz : **fast electronic read-out needed.**
- ❖ Occupancy less than 1hit / mm² :
 - ⇒ hit resolution at the level of 5μm (pixel size $\simeq 28\mu\text{m}$) noise rate $< 10^{-5}$.
- ❖ Low material budget per disk :
 - ⇒ 0.7% X_0 .
- ❖ Disk positions :
 - ⇒ First disk closest to the IP: **$z=-460\text{mm}$** ;
 - ⇒ Last disk closest to the absorber: **$z=-768\text{mm}$** .

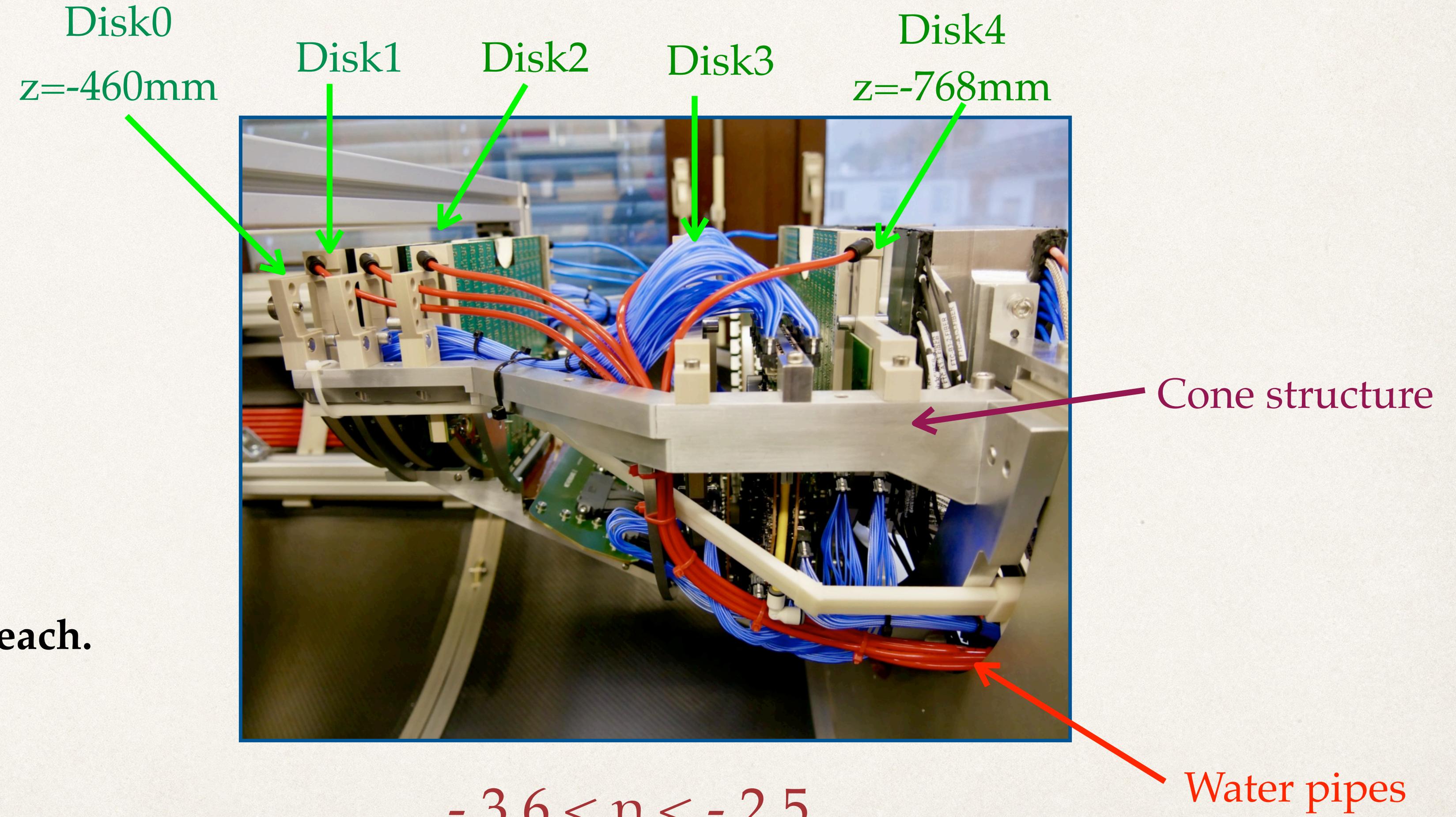
MFT in a nutshell

Small vertex detector;

Composed by 936 active sensors;

Placed in ALICE's inner barrel;

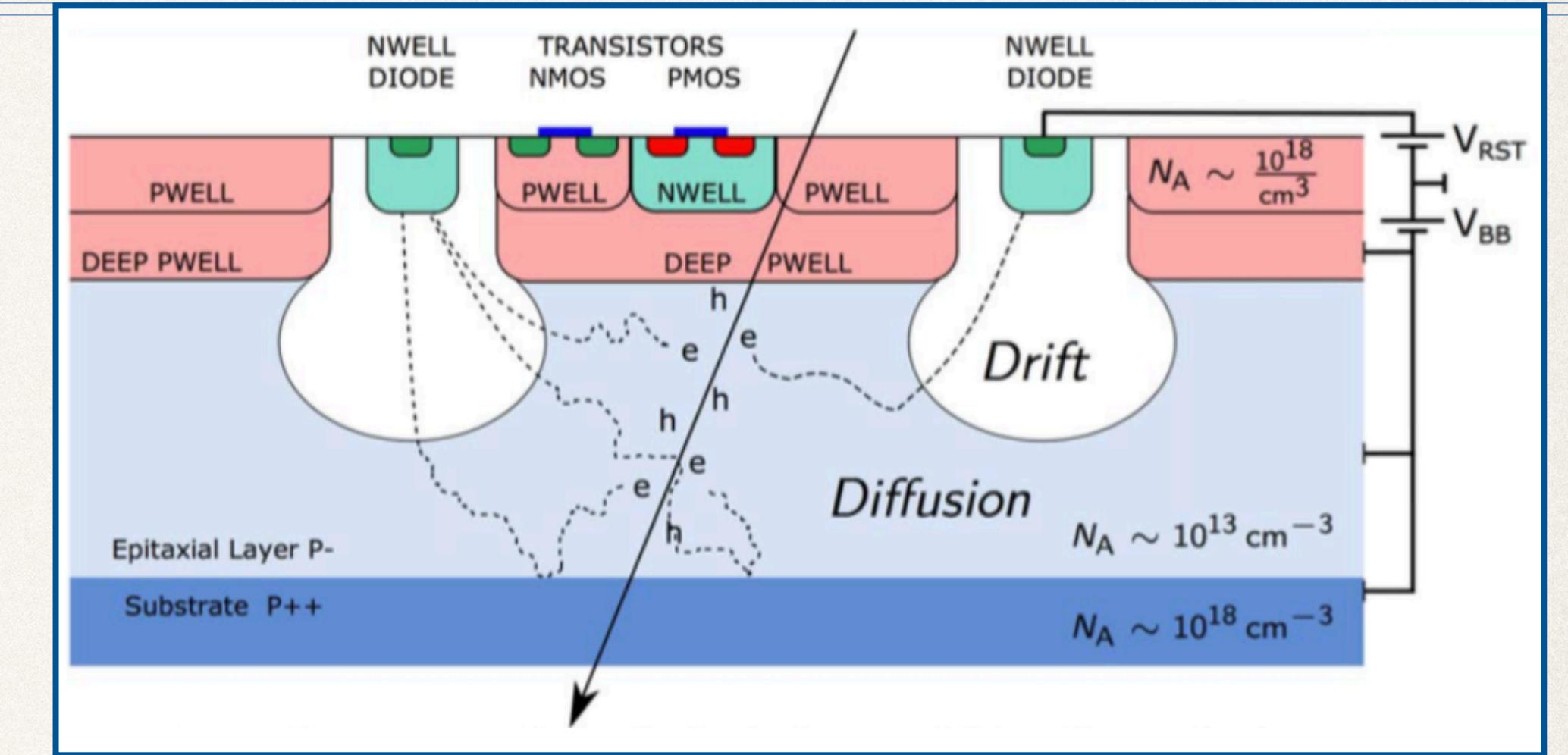
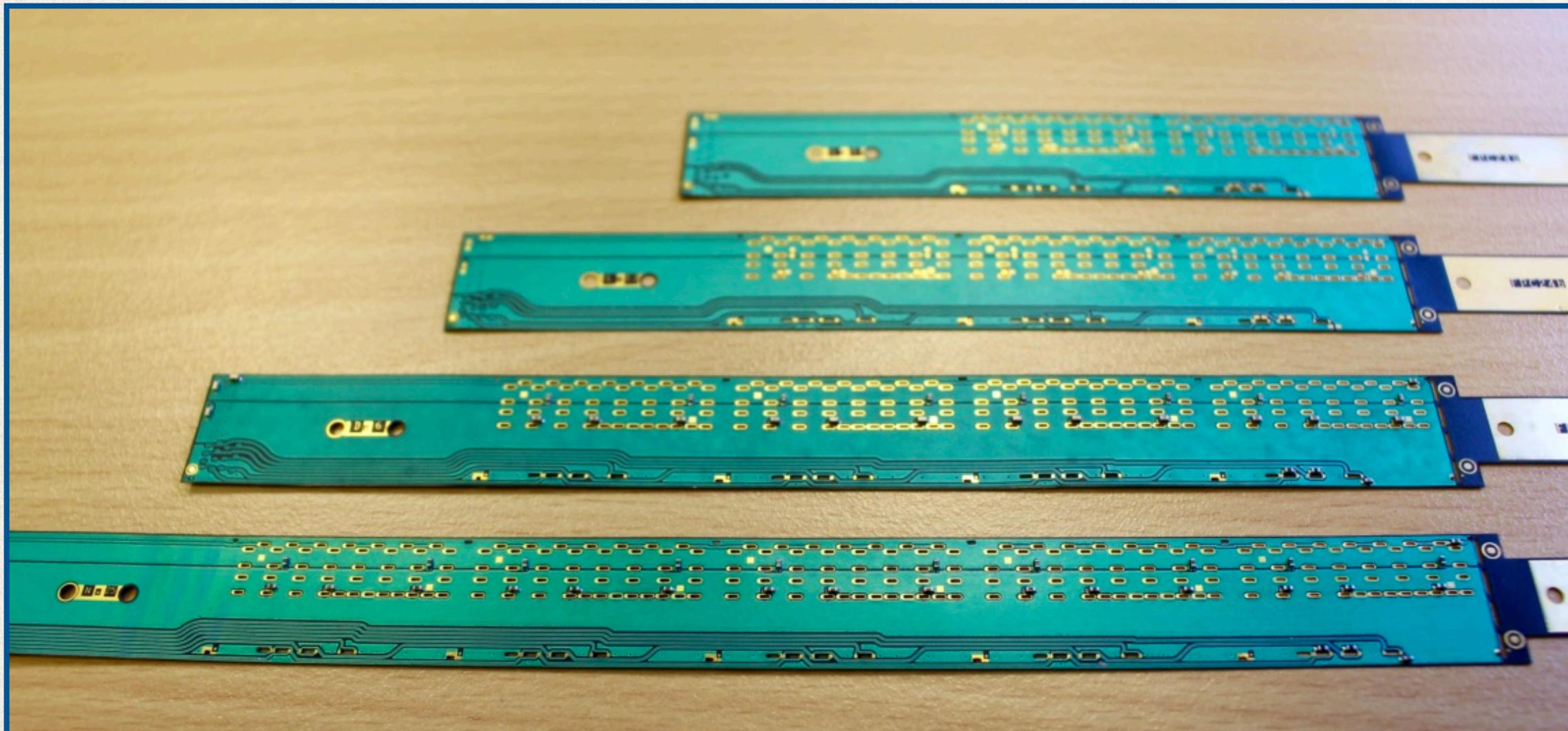
10 Half-Disks, 2 detection planes each.



MFT Sensors and Ladders

Sensor specifications

- » ALPIDE Sensor size: 15mm x 30mm x 50 μm ;
- » Pixel size: $26.88 \times 29.24 \mu\text{m}^2 \rightarrow 524,288$ pixels / sensor;
- » Integration time about 4 μs ;
- » Low power consumption: < 50mW / cm²;



MFT Ladders

- » 4 types (2, 3, 4 and 5 sensors);
- » Power distribution: Analog, Digital and Back Bias;
- » Slow control and readout lines.

Detector components and geometry (1)

MFT Disks

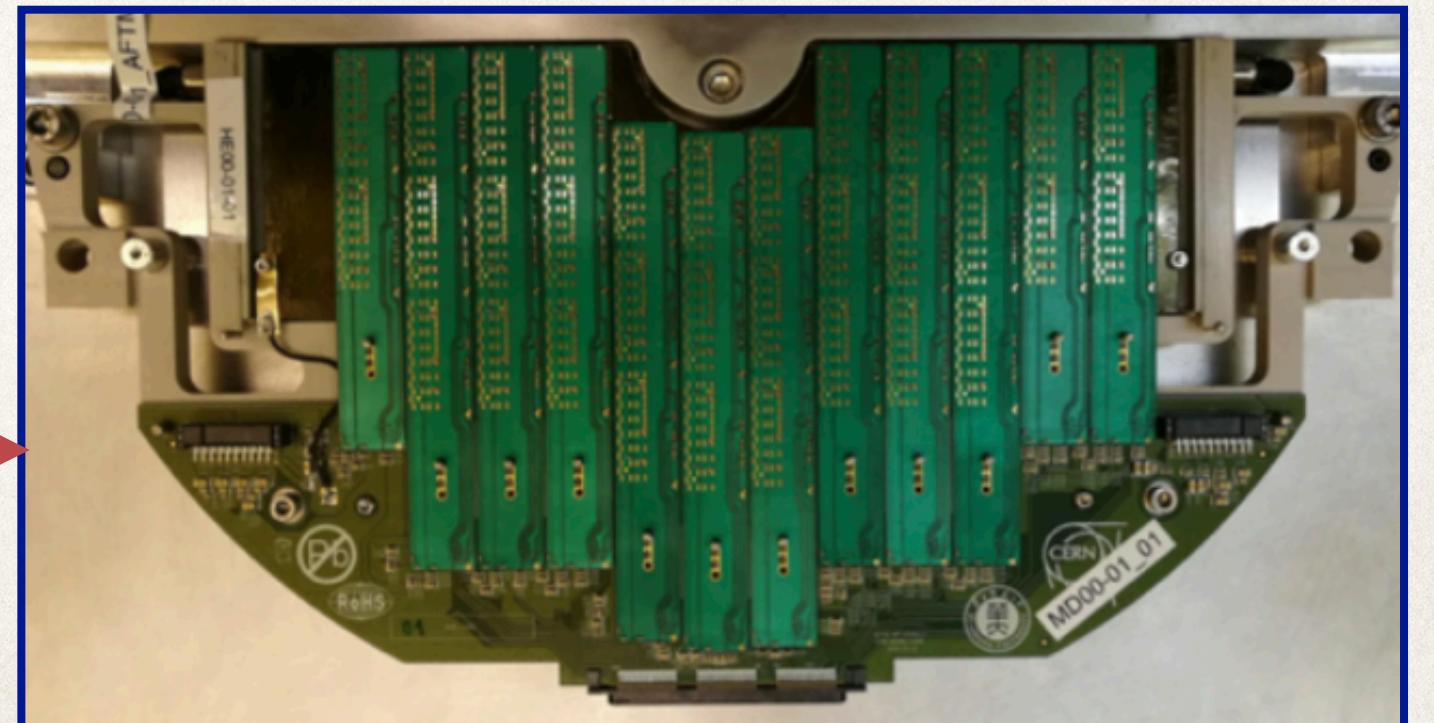
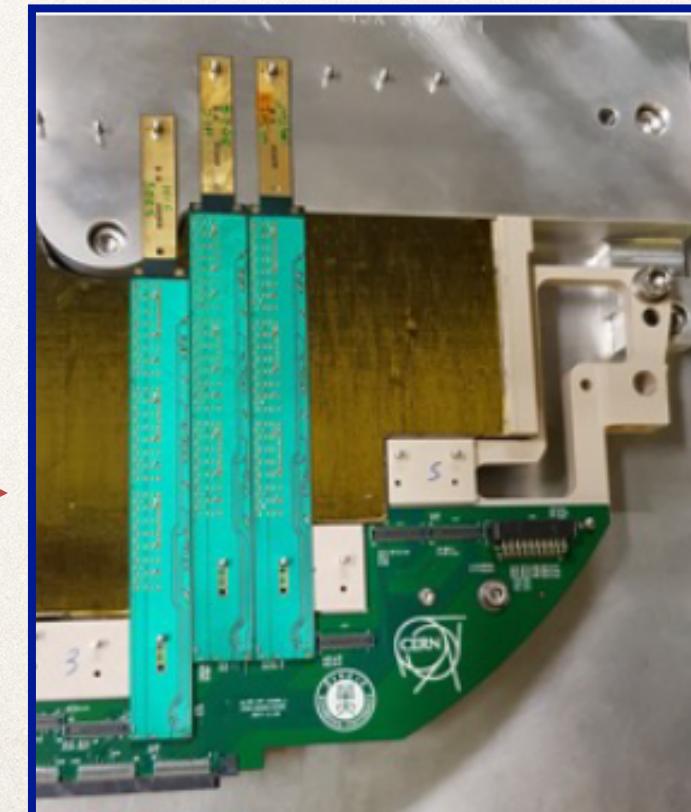
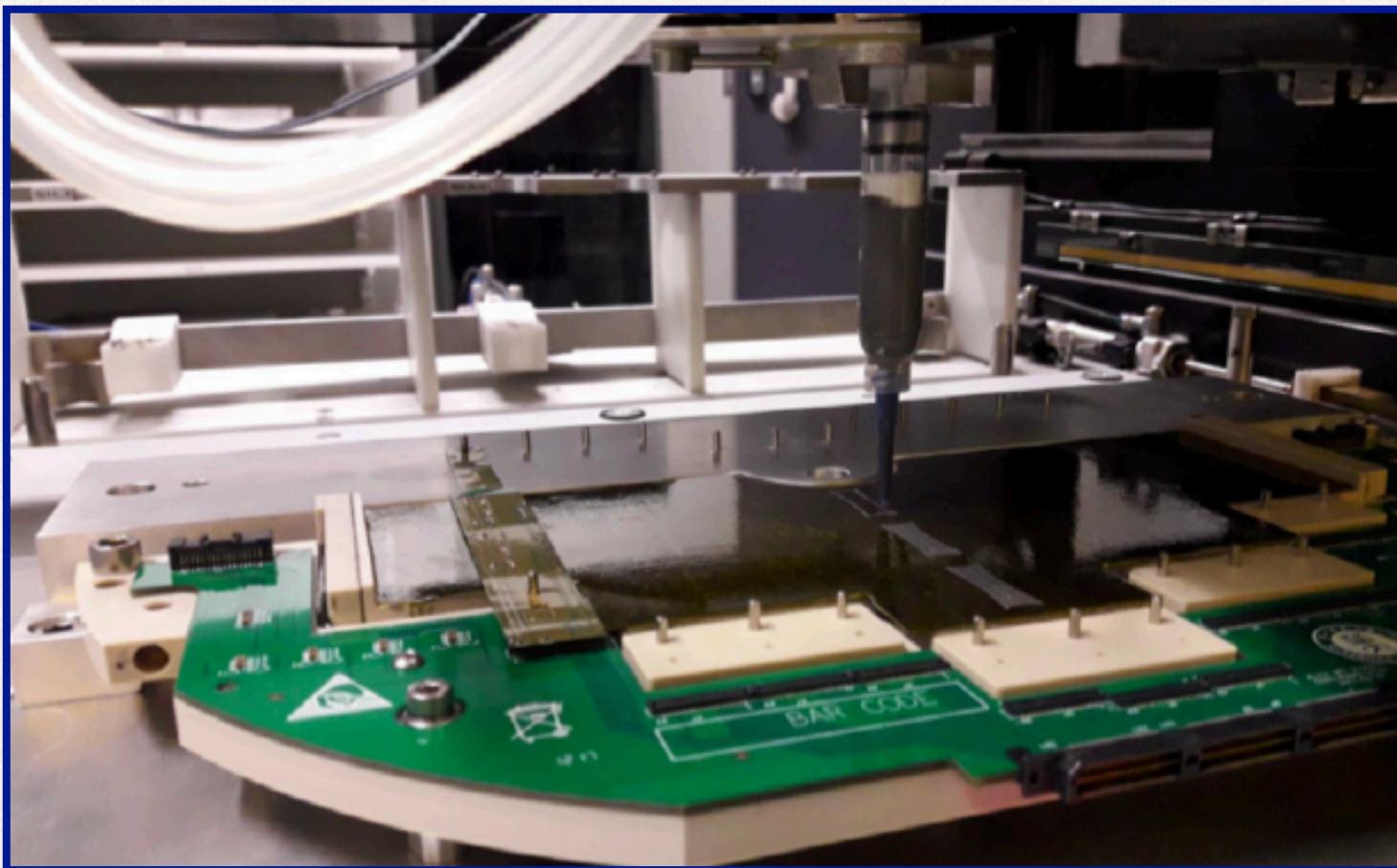
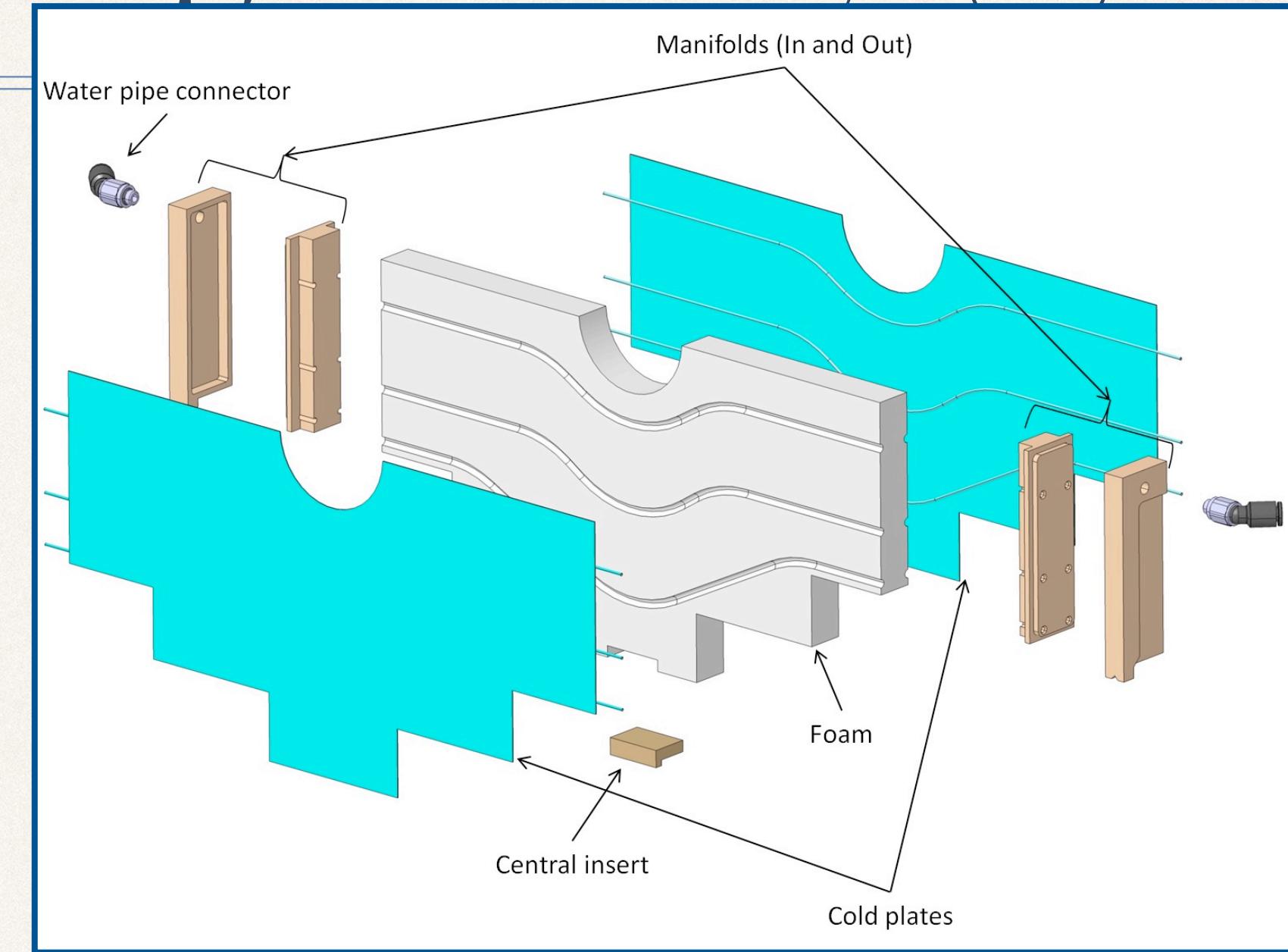
Components :

- » 2 PCBs with power connectors;
- » Heat-exchanger;
- » Disk Support.

Ladders glued on the heat-exchanger surface;

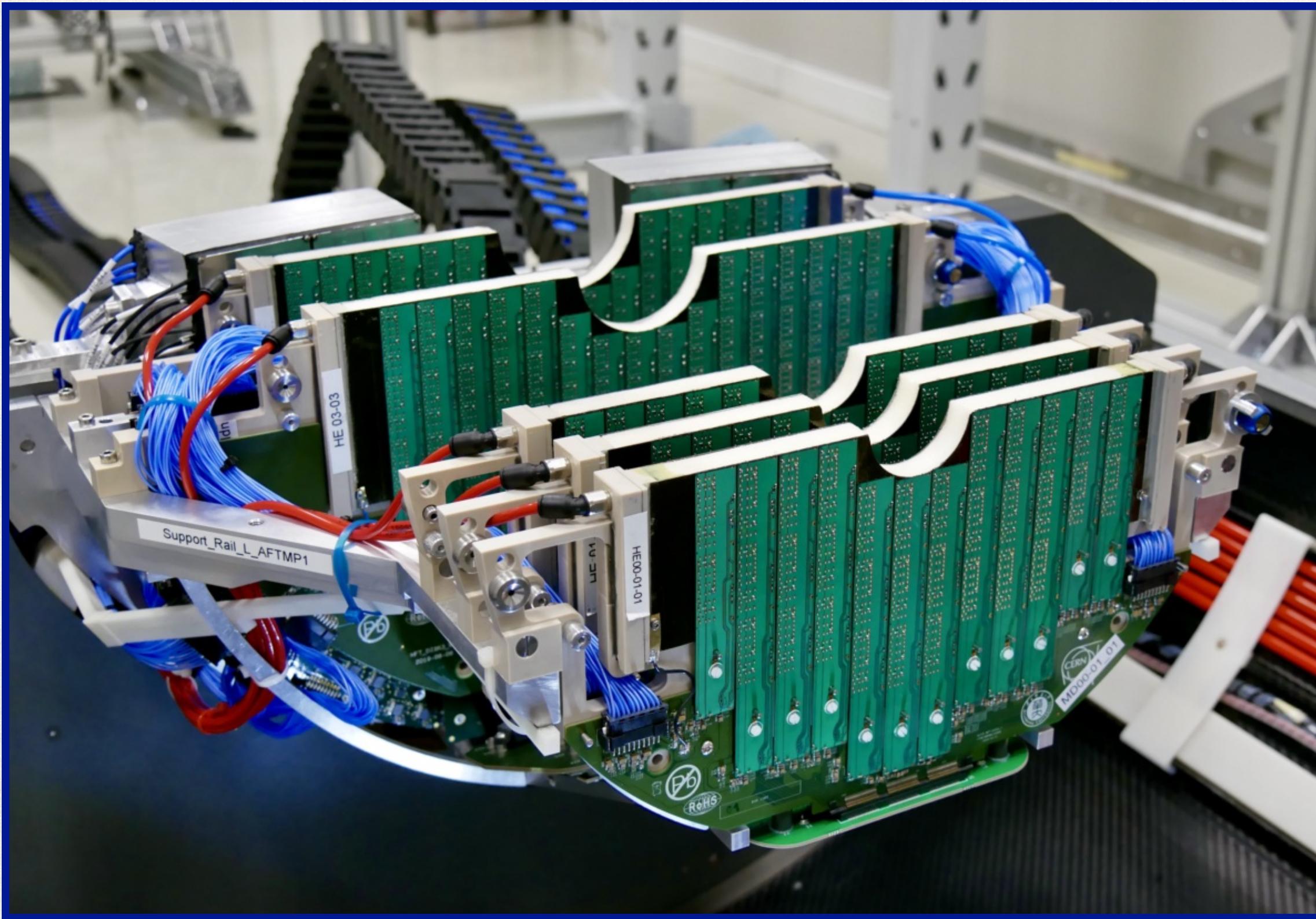
Glue disposed of in a **spiral shape**;

All sensors tested and them positions measured.



Detector components and geometry (2)

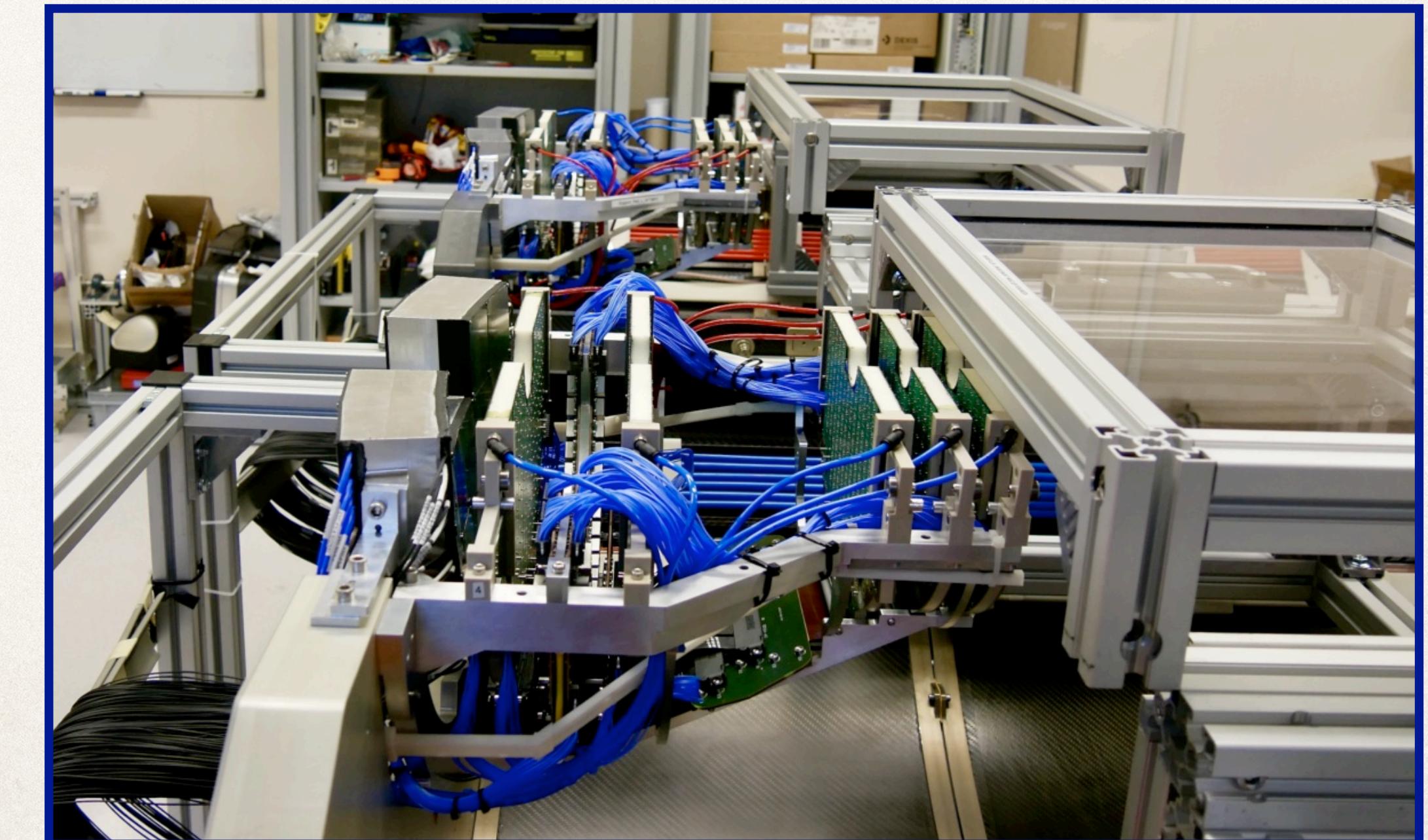
MFT Mechanical Structure



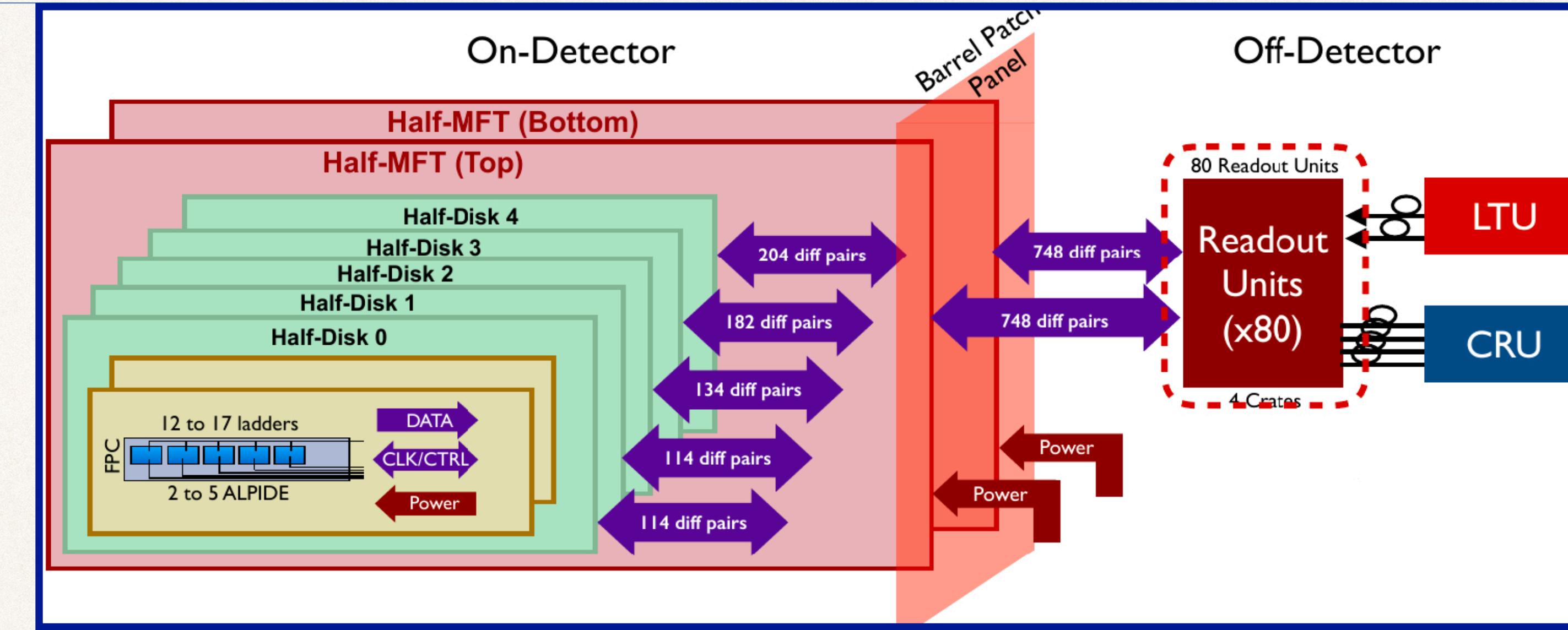
Cone structure in aluminum

Functionalities :

- » Support Disks, Power Supply Unit and Mother-Boards;
- » Routing cables and pipes (power, readout, cooling).

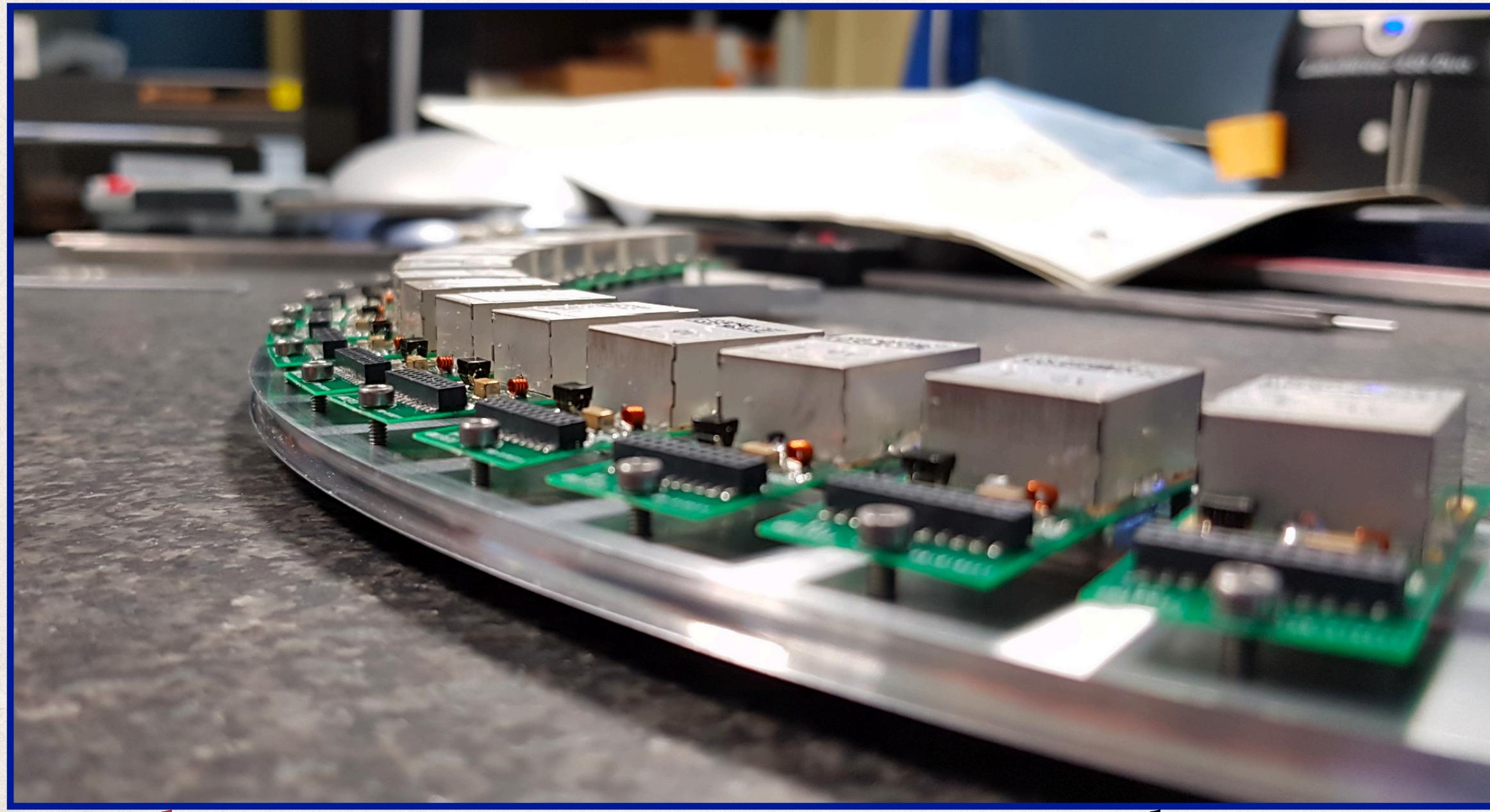


Readout Structure



- ❖ Between 132 and 272 high-speed data signals (1.2 Gb / s) per disk;
- ❖ Between 96 and 136 clock and slow control signals per disk;
- ❖ Total of 1496 Twinax cables for read-out and control arranged in FireFly cables;
- ❖ 80 Readout Units (concentrator boards) ~ 6 m away, where TID about ~ 1 krad;
- ❖ 10 Common Readout Units + 1 for Power Supply Unit control → 6 Readout computer node.

Power Supply Unit

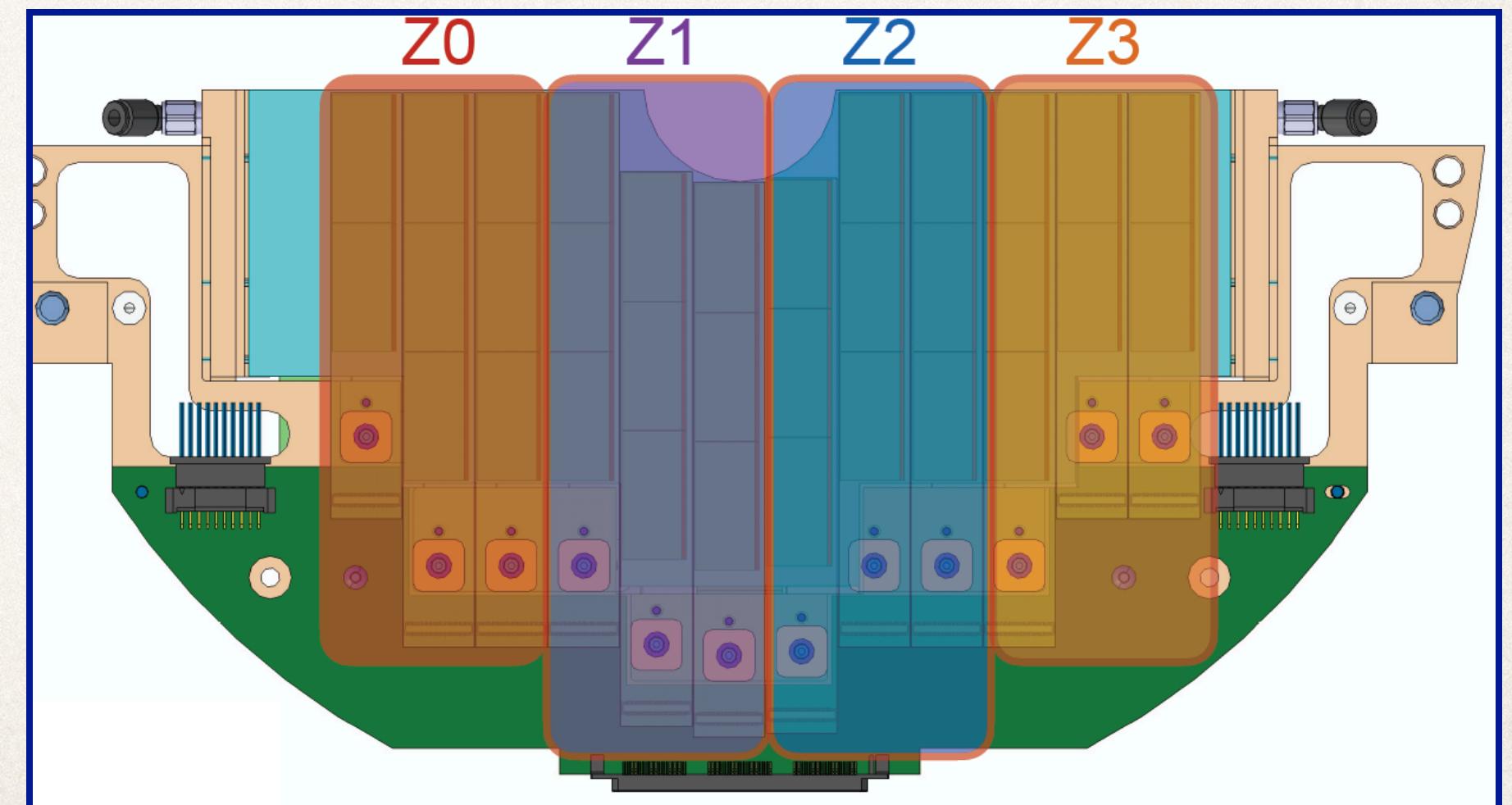


- » **Latch-up detection:** Overcurrent \Rightarrow switch-off completely 1 zone;
- » Inside the cone but outside acceptance;
- » **4 PSU:** 1 for 5 Half-Disks surfaces.
- » **Local power generation from DCDC Converters.**

27th May 2021

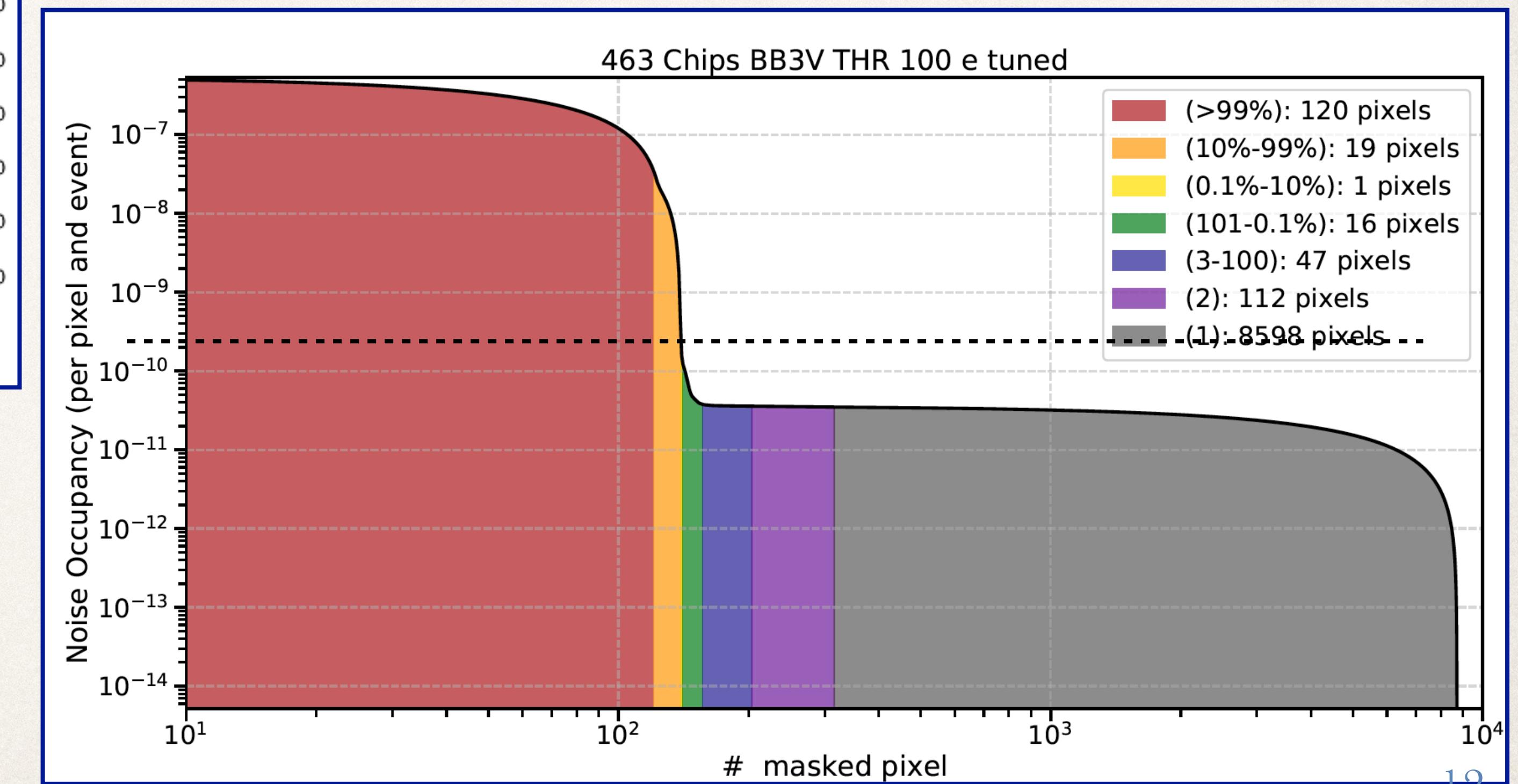
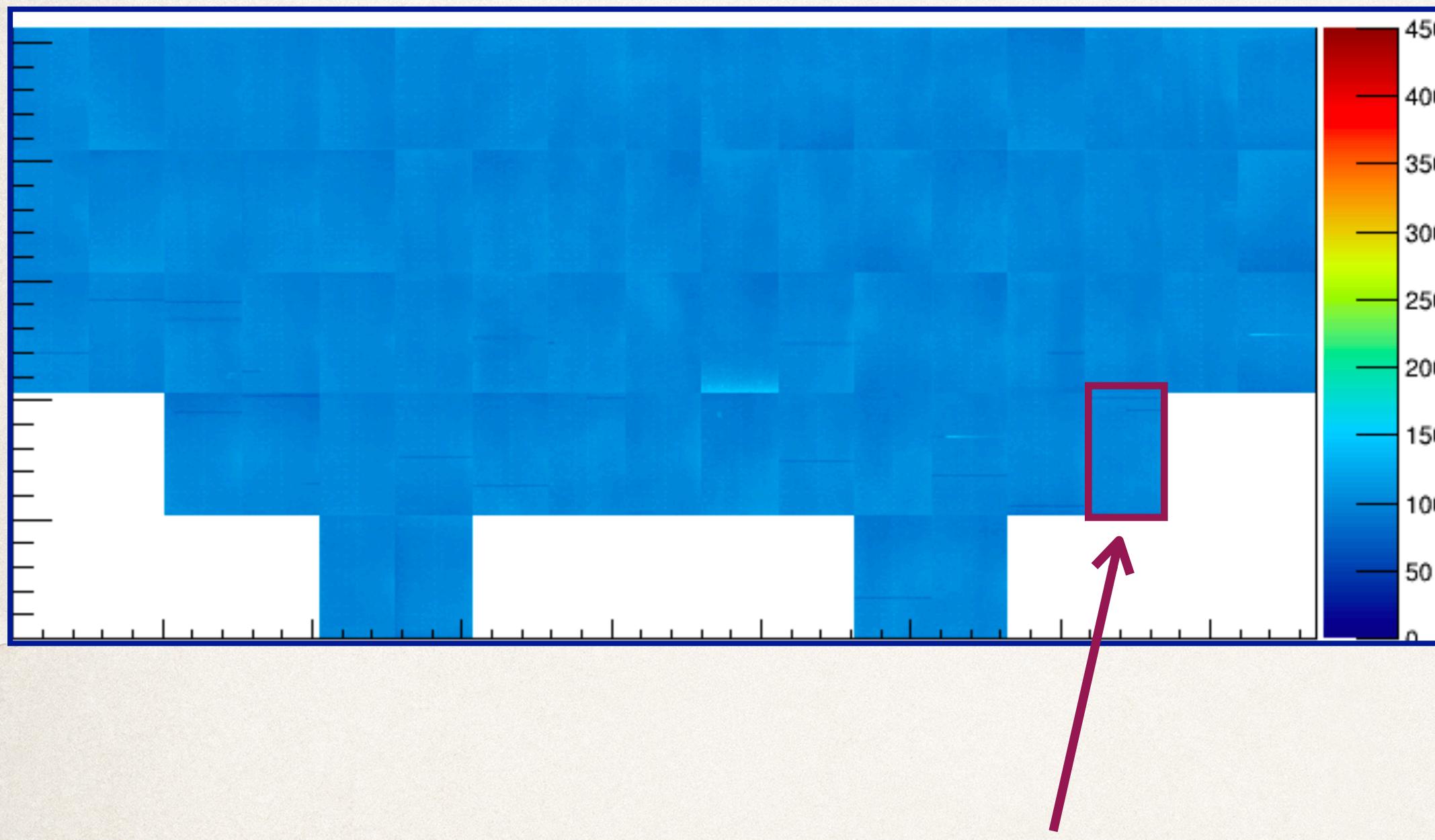
MFT Power Supply

- » $P \approx 350$ W for full MFT Powering (without services);
- » Three types of voltage : **Analog** (1.8V), **Digital** (1.8 V), **Back Bias** (0 V or -3 V);
- » Powering sensors zone by zone (4 zones in each Half-Disk Face).

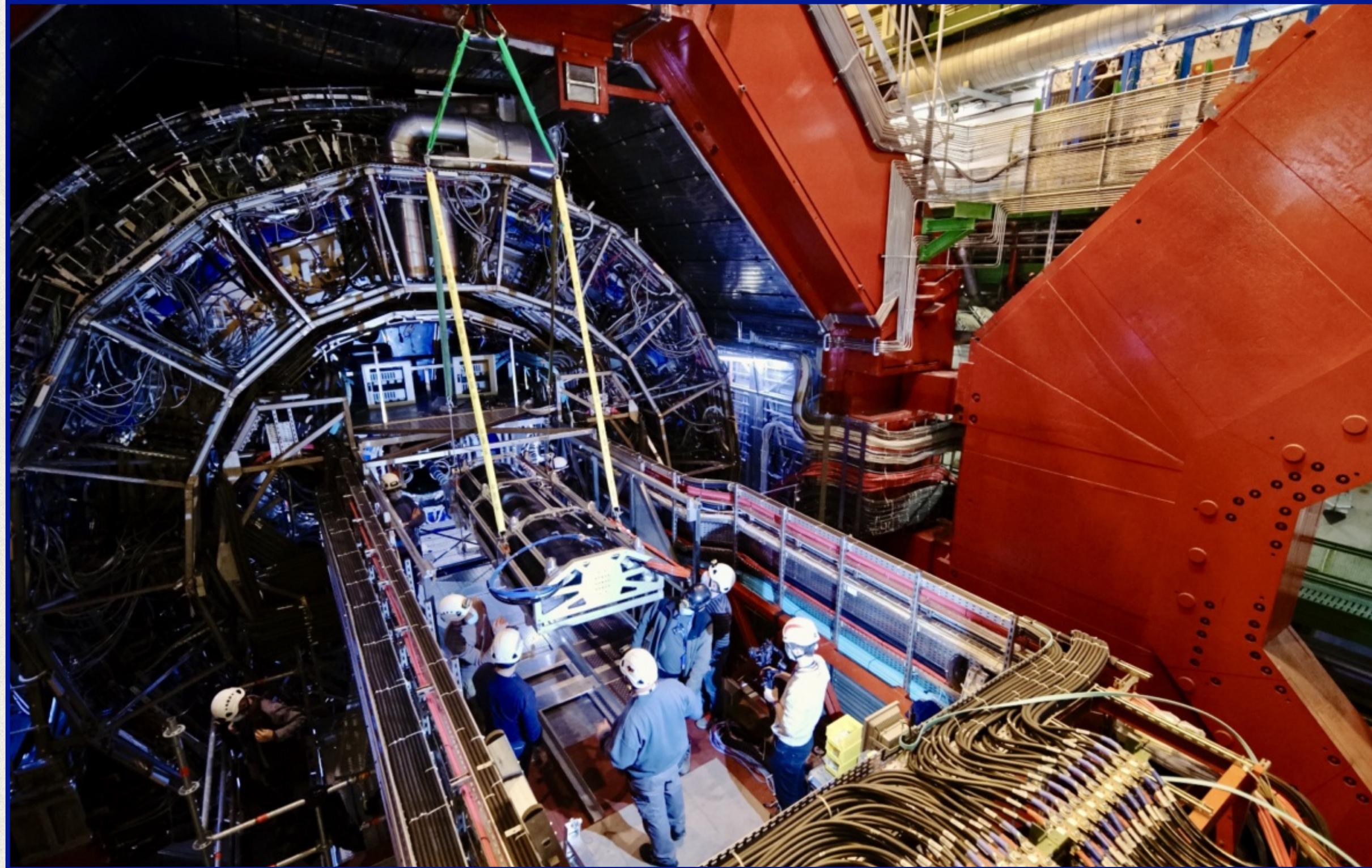


Surface commissioning

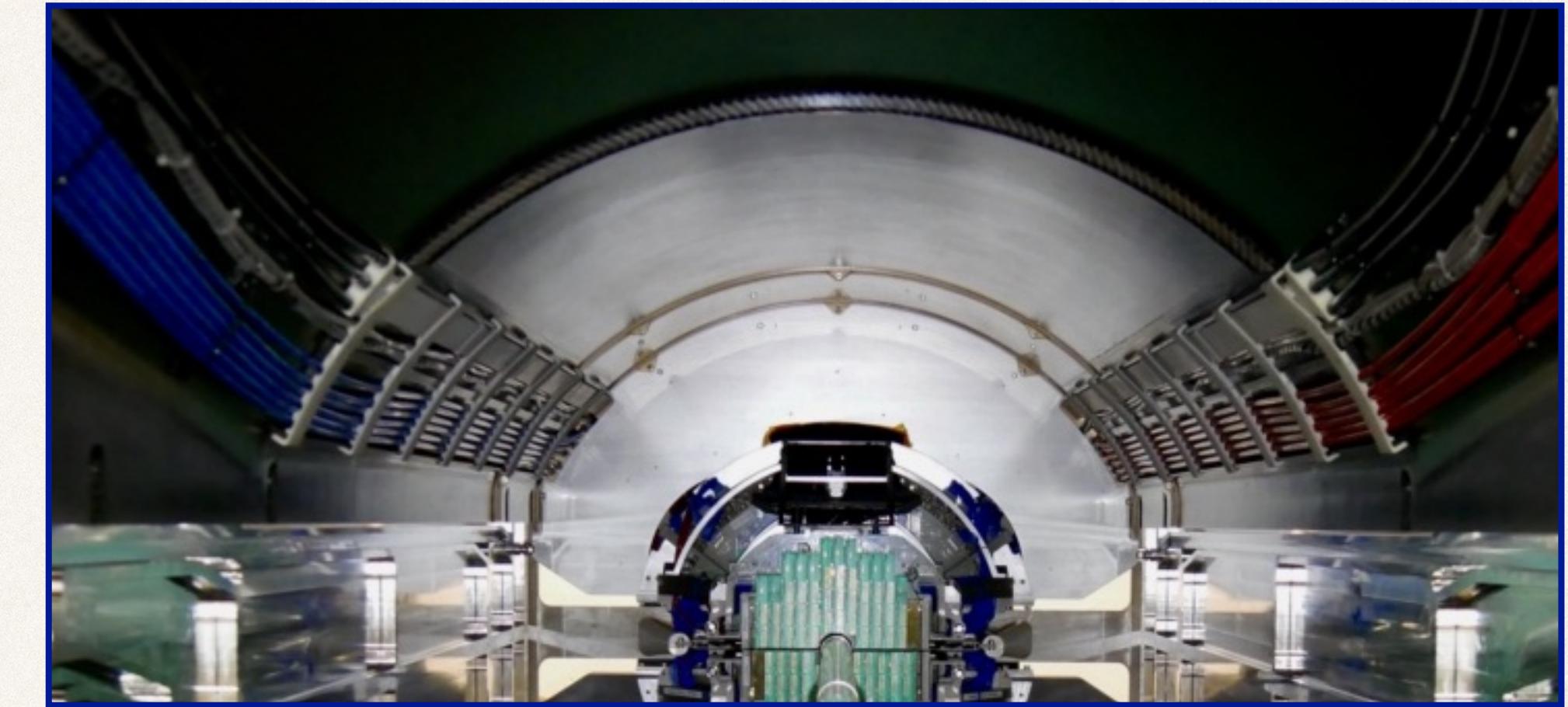
- » The two barrels of the MFT were built and assembled ;
- » Operating parameters optimisation :
 - Few pixels masked to reach Noise $< 10^{-10}$
 - Thresholds equalised (around 100 e⁻)



Installation in ALICE cavern



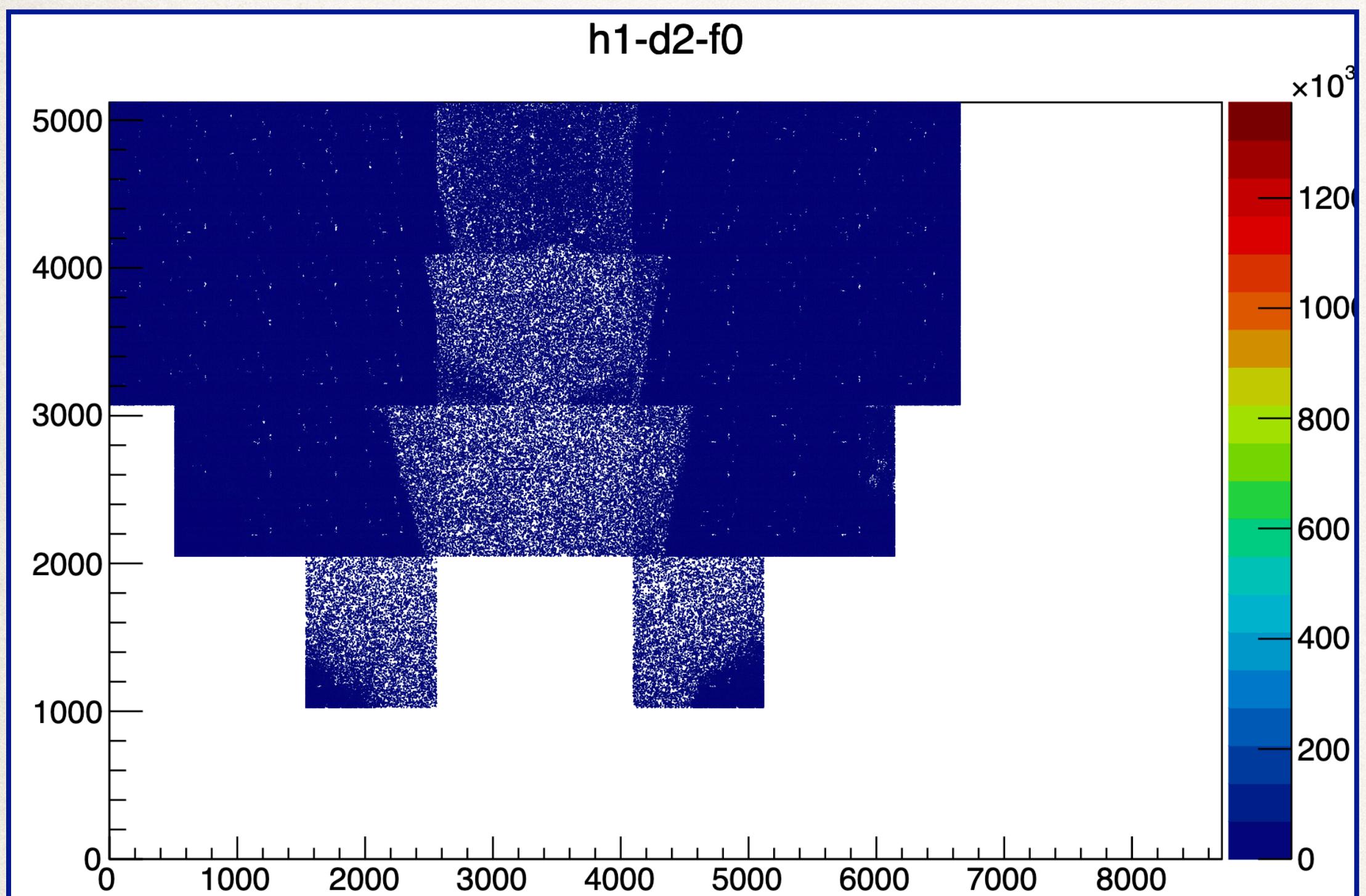
The two MFT barrels installed in ALICE cavern
in the **first week of December 2020**



Integration into ALICE central systems (DCS, DAQ)
Starting from January 2021

First results and perspectives

X-Rays Beam March 2021



27th May 2021

During the global ALICE commissioning (until the end of the year) :

- » Noise in cavern;
- » Pb-Pb pattern.

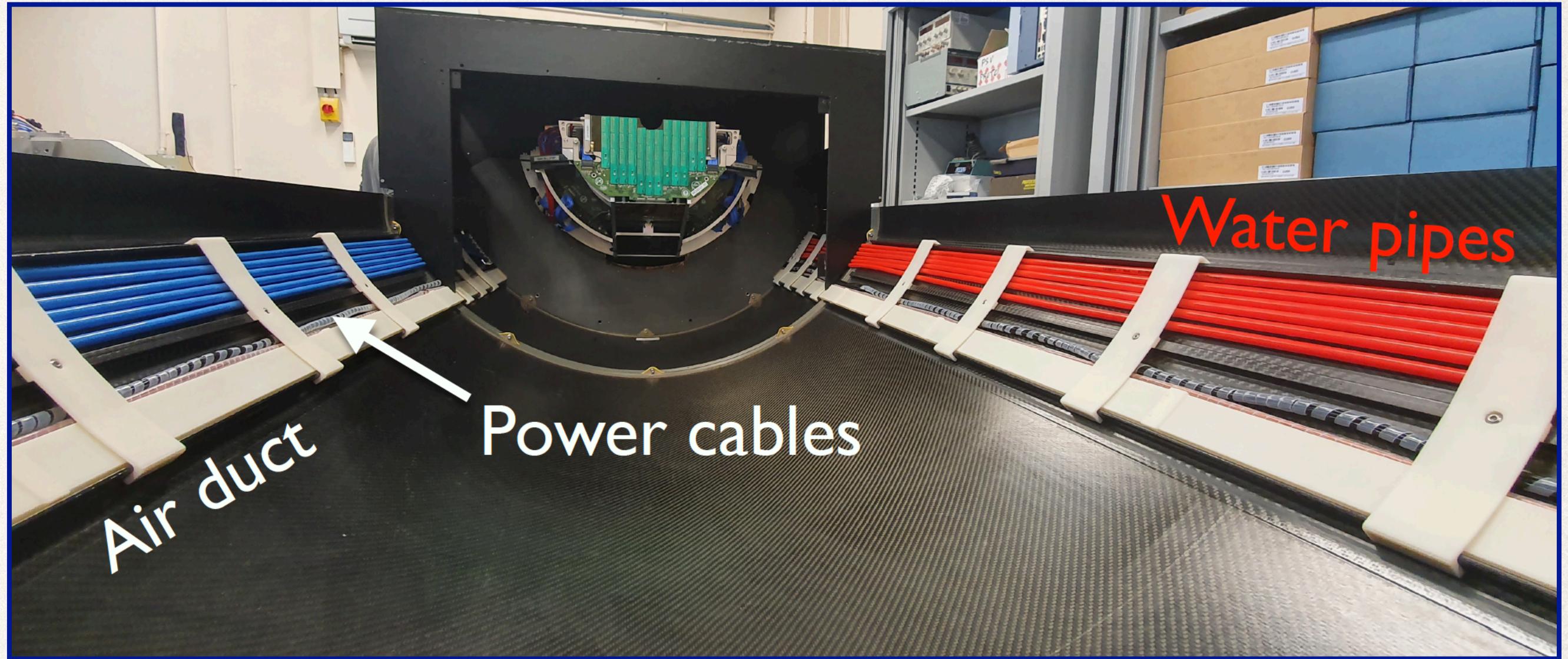
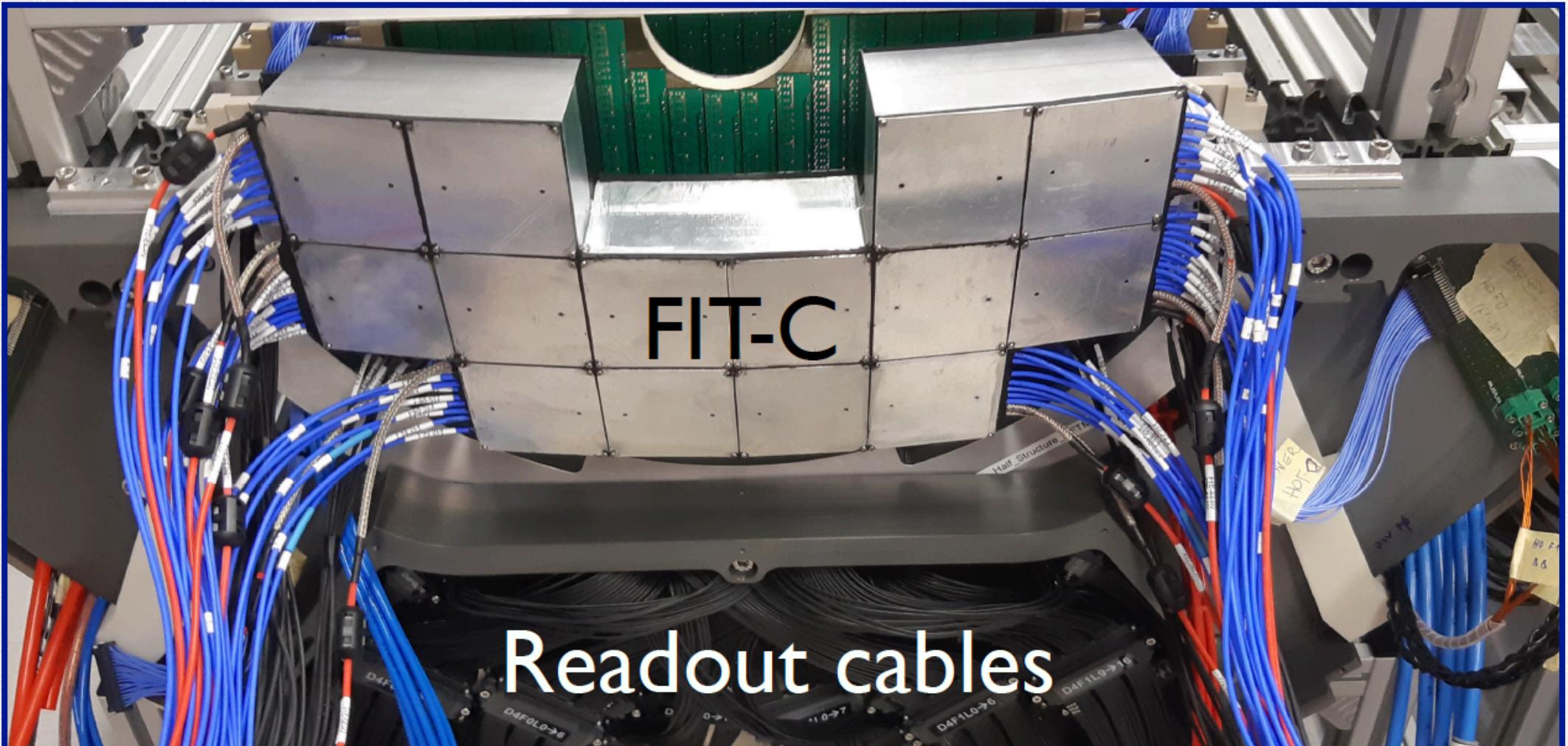
First pp collisions (March 2022) and first PbPb collisions (November 2022).



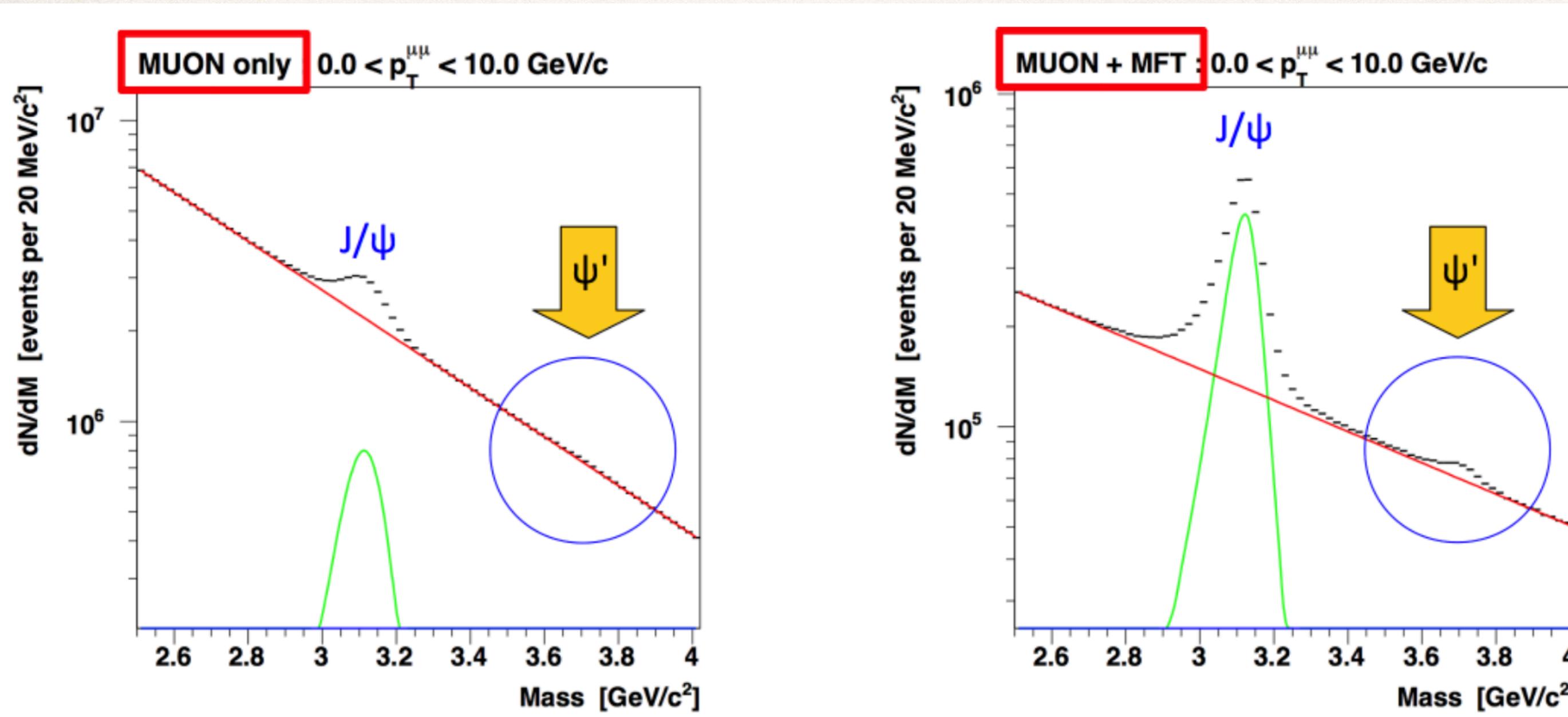
Backup Slides

MFT Barrel

- » MFT Cones fixed to their composite carbon barrels;
- » Cooling, power, and readout cables inside;
- » Integration of the Fast Interaction Trigger detector.



Excepted performances



$\Psi(2S)$ S/B improved by a factor 6-7, visible even in central Pb-Pb collisions

