

Muon Forward Tracker

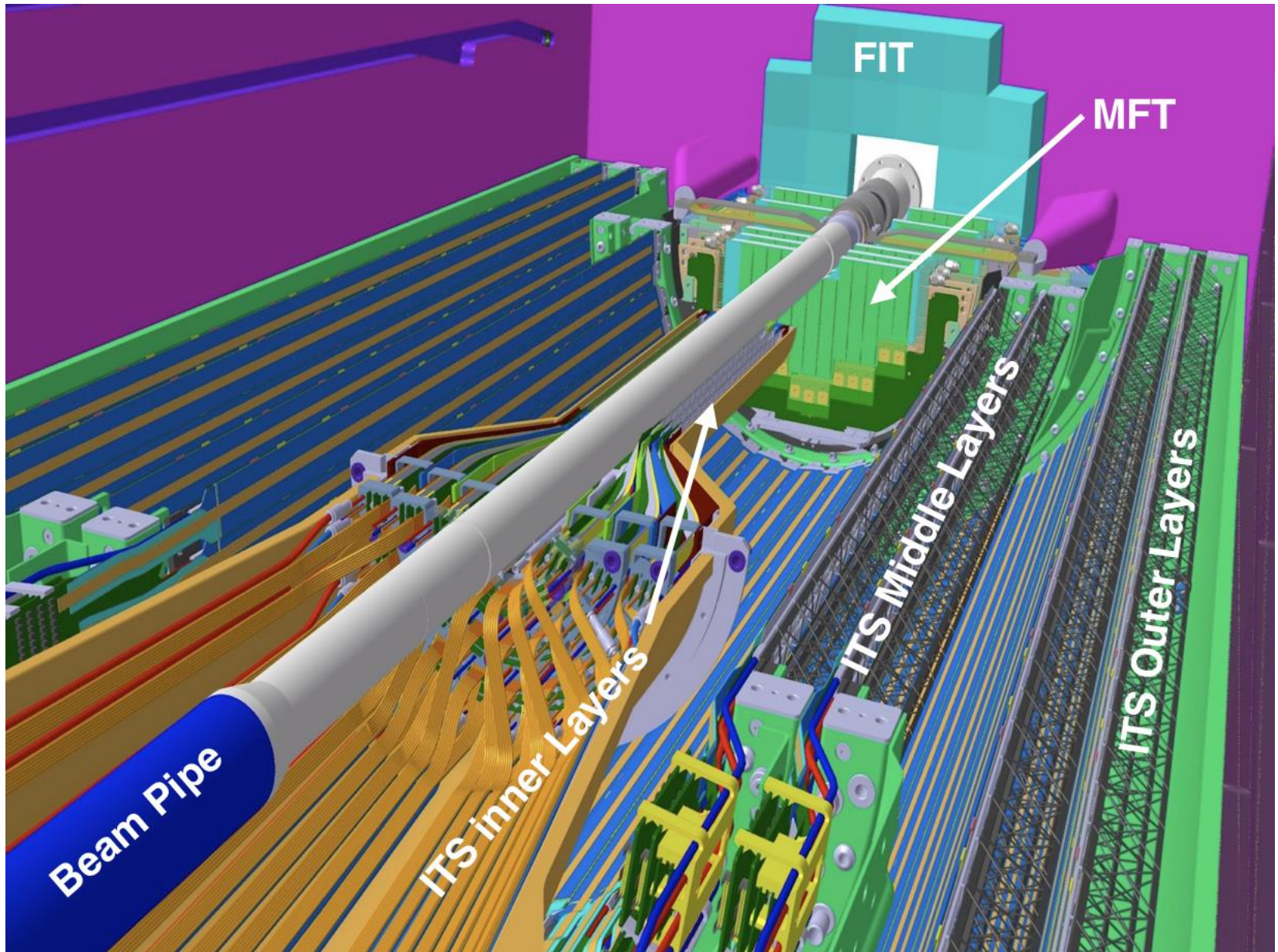
Status report

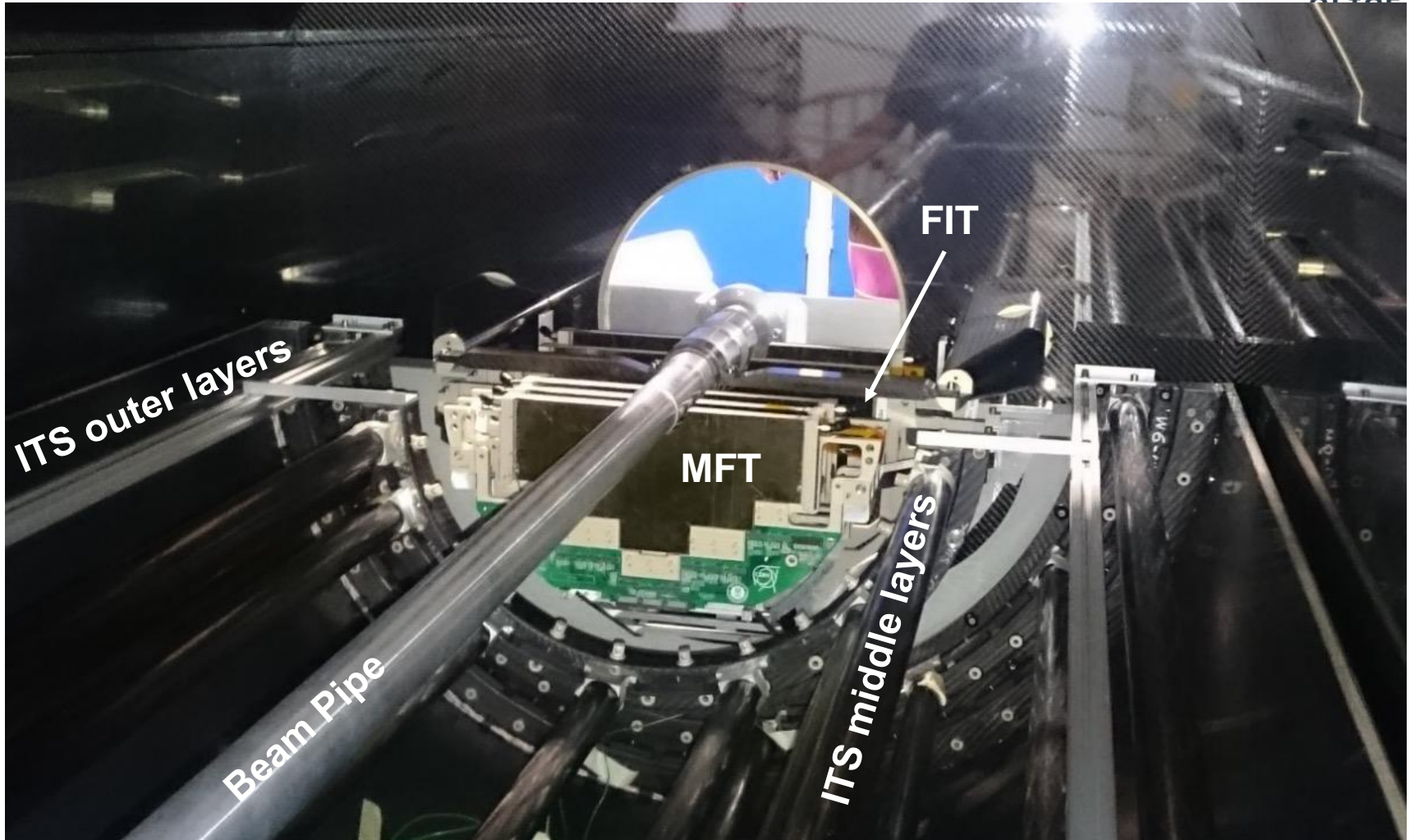
Raphael TIEULENT – IP2I Lyon

LHCC in-depth review meeting

September 9th 2019

MFT





MFT layout

936 ALPIDE Silicon pixel sensors (0.4 m^2) on 280 ladders of 2 to 5 sensors

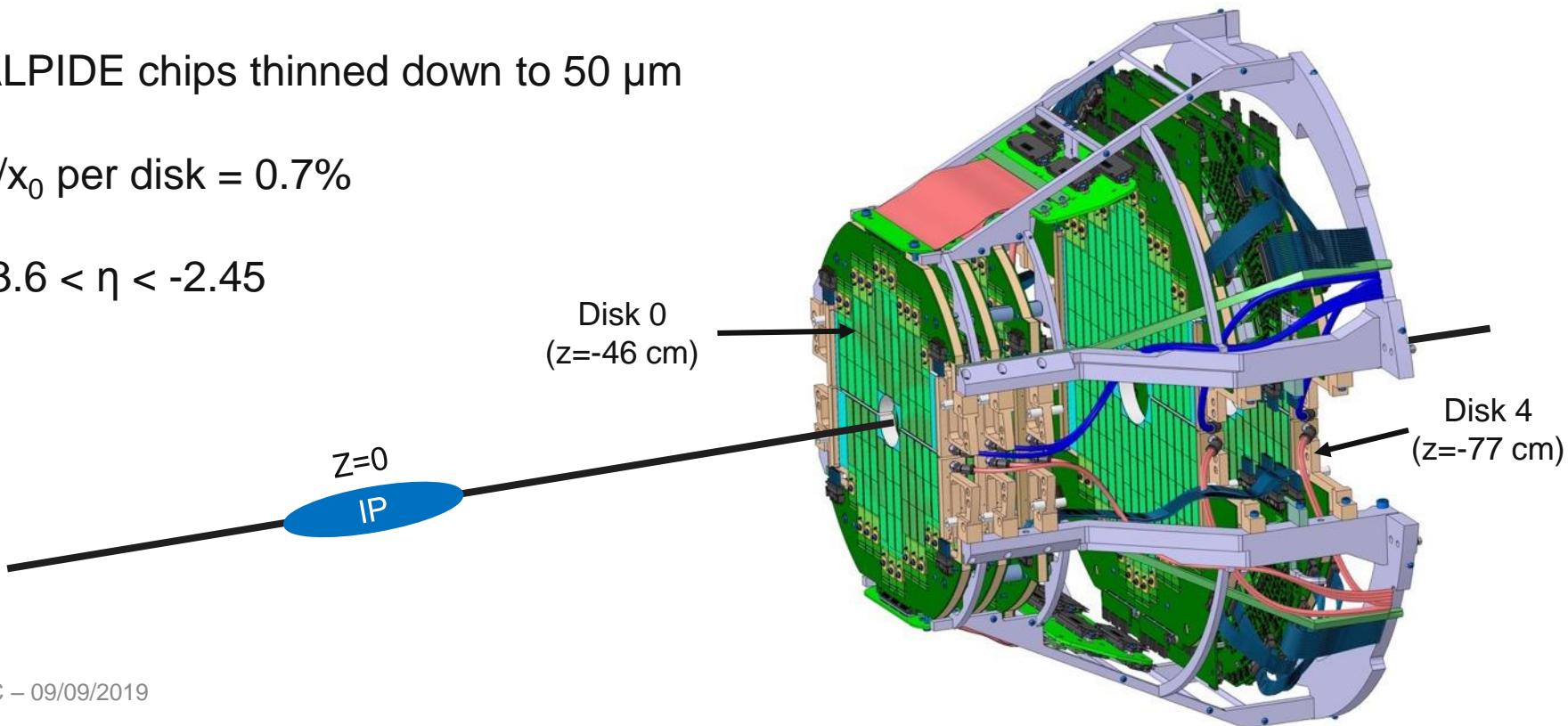
Sensor size = $15 \times 30 \text{ mm}^2$; Pixel pitch = $29 \times 27 \text{ } \mu\text{m}^2$

5 Disks with 2 detection planes each

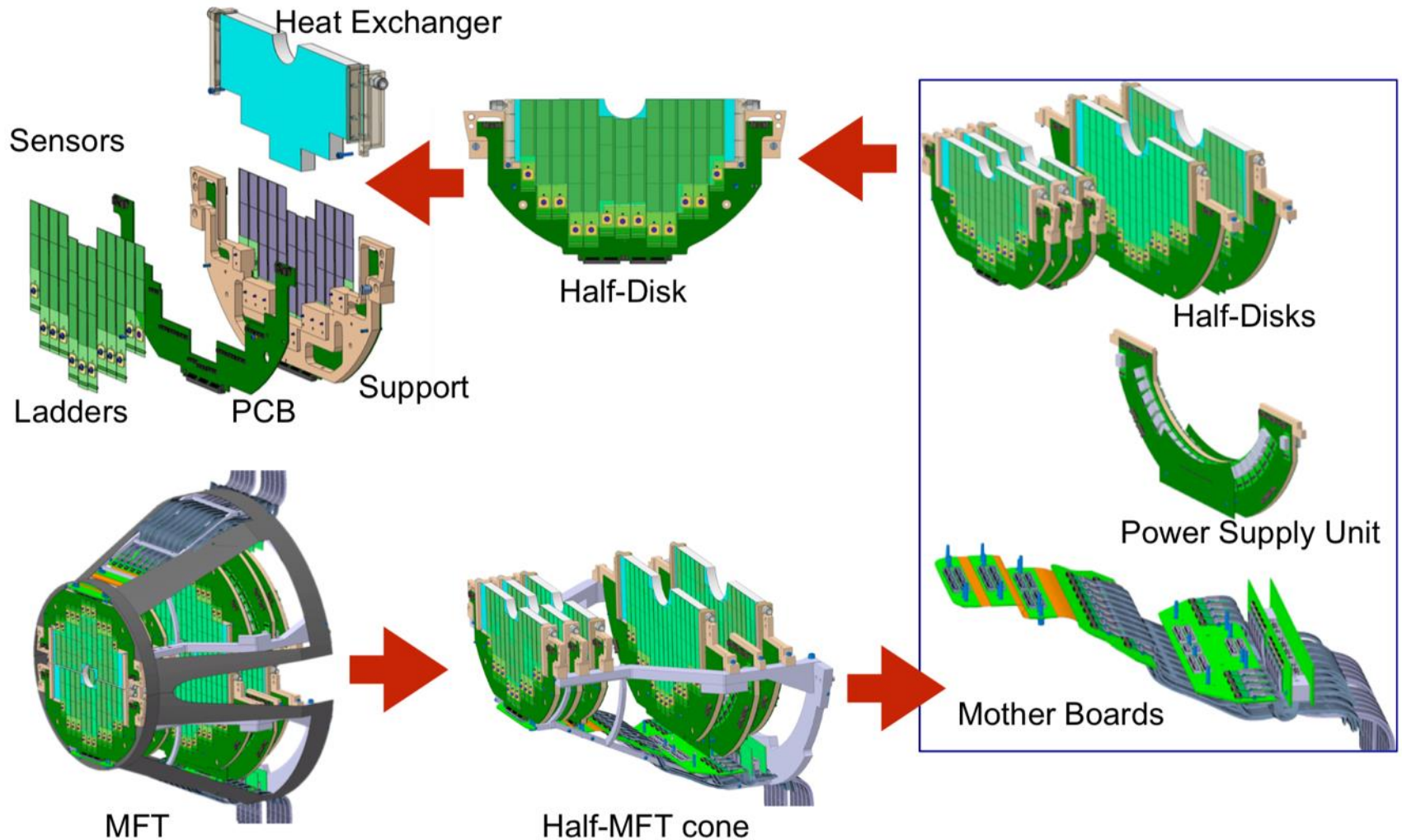
ALPIDE chips thinned down to $50 \text{ } \mu\text{m}$

x/x_0 per disk = 0.7%

$-3.6 < \eta < -2.45$

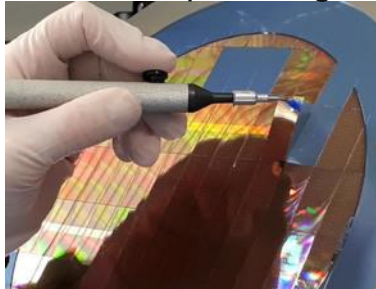


MFT layout



MFT disk production in a nutshell

Chip Picking

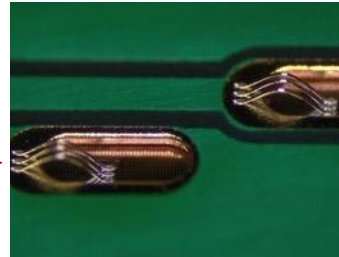


Chip testing

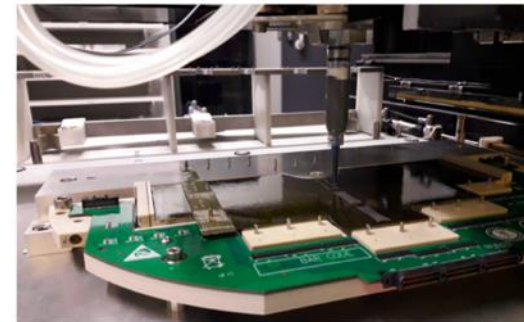


PROBE CARD

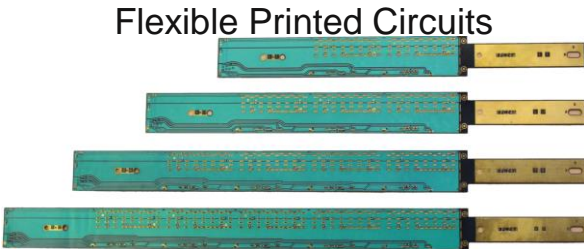
Wire Bonding



Ladder gluing on the disk



Flexible Printed Circuits



Disk support



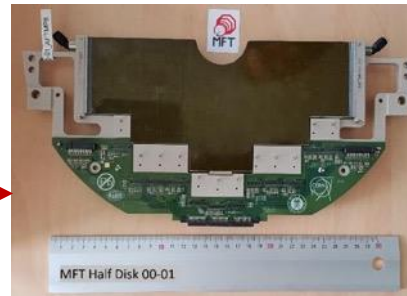
Heat Exchanger



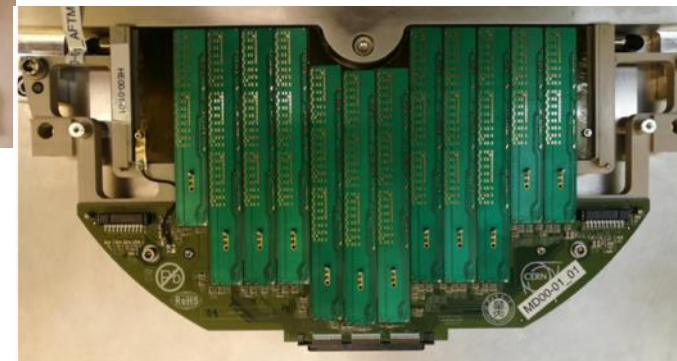
Disk PCB



Mechanical disk

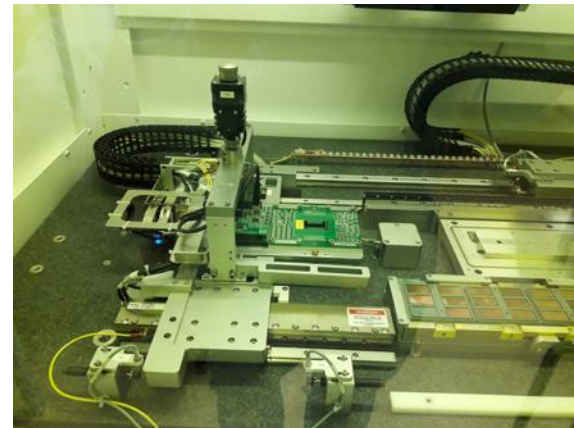
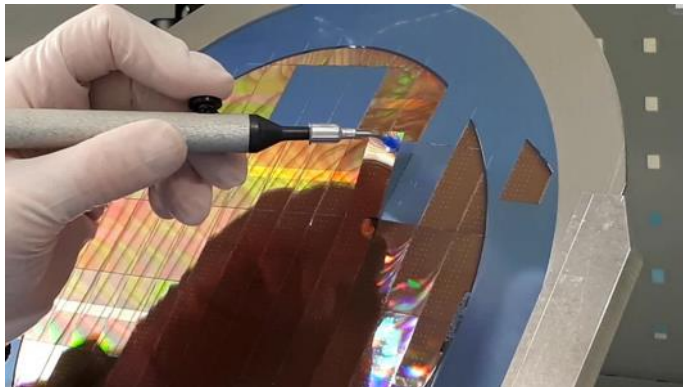


LHCC – 09/09/2019



Chip

- ALPIDE production finished: 100 wafers
- MFT team had to take over the chip picking and testing from ITS
- MFT-ALPIDE chip picking and testing ongoing (at CERN DSF)
 - 2 lots fully picked and tested
 - Third lot to be received in September
 - Highly time consuming task
 - Non-permanent person hired by CNRS-IN2P3, based at CERN for 18 months (until august 2020)
- Throughput (pick, clean, visual inspection, test): 4 wafers/week



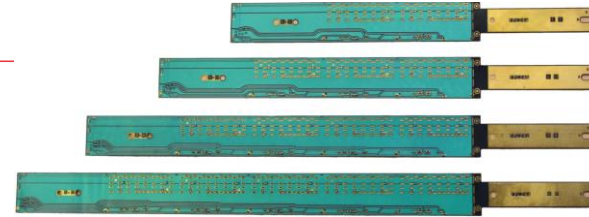
Ladder Production

FPC production

- Chips are interconnected to a Aluminum Flexible Printed Circuit (FPC)
- Produced at CERN in batches of 4 foils

Batch 1, 2	FPC R&D
Batch 3	Pre-production, SMD 1 μ F
Batch 4	Used for production
Batch 5	Used for production
Batch 6	Used for production
Batch 7	In-use for ladder production
Batch 8	In-use for ladder production
Batch 9	In production (SMD component soldering)
Batch 10	In production (FPC cutting)
Batch 11, 12, 13, 14	Under thermal treatment

- Expert at CERN contract ended in August ; knowledge transfer done
- FPC quality to be closely monitored for the last batches



Ladder Production

HIC production status



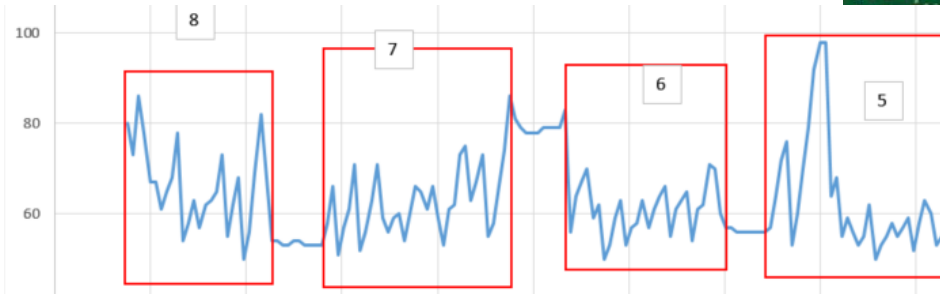
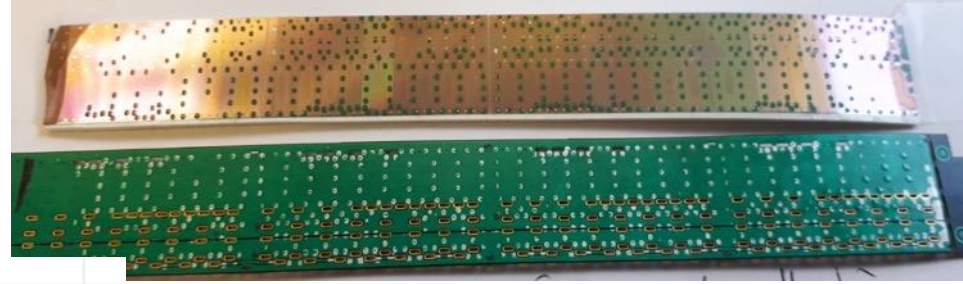
- Production throughput: 10 ladders/week (max: 13 ladders produced in a week)
 - Status: 70% of ladder total production (290/420 HICs)
 - HIC production to be completed by December (end of second ½ MFT + spares)
- Production yield of 90%
 - Very stable assembly operation
 - Fast and high quality response from bonding lab
- Ladder qualification
 - Service task for ladder qualification (3 PhD students + 1 summer student)
 - Ladders qualified on average 48h after bonding: constant and efficient throughput



Ladder Production

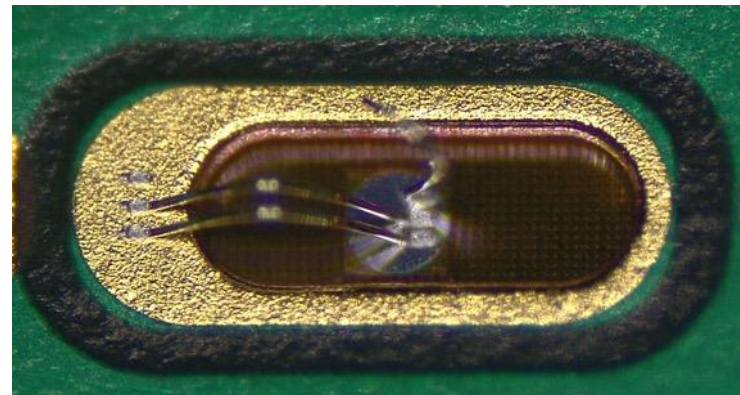
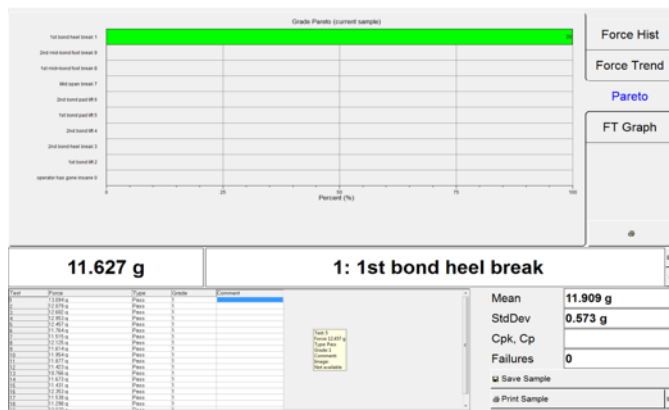
Production quality check

- Peel test on selected ladders



Peel force varies from 60 to 90 g

- Pull test on wire bonds



Pull force varies from 10 to 14 g

Ladder production

Qualification

- Qualification protocol
 - Smoke test
 - FIFO scan (slow control)
 - Digital scan (digital circuitry test)
 - Threshold adjustment (analog circuitry test + threshold equalization)
 - Noise occupancy
 - Eye diagram (output signal strength and stability test)
- "Gold+Silver quality" yield: 82%

Alpide Testing

Actions

MFT HIC Qualification

MFT HIC

scan	status
1 Fifo Scan	Done (in 33 sec)
2 Digital Scan BB 0	Done (in 12 sec)
3 Threshold Scan 3.0 V	Done (in 36 sec)
4 Tune VCASN Scan 3.0 V	Done (in 56 sec)
5 Tune JTHR Scan 3.0 V	Done (in 44 sec)
6 Threshold Scan 3.0 V	Done (in 4 min)
7 Noise Occupancy 3.0 V	Done (in 30 sec)

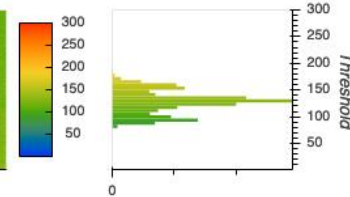
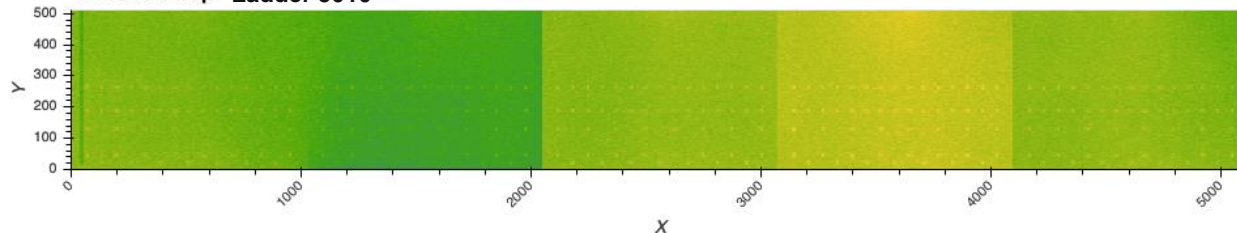
MFT Upgrade HIC qualification

MFT

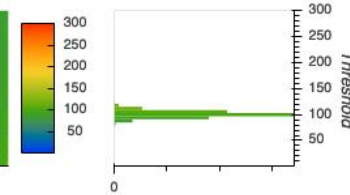
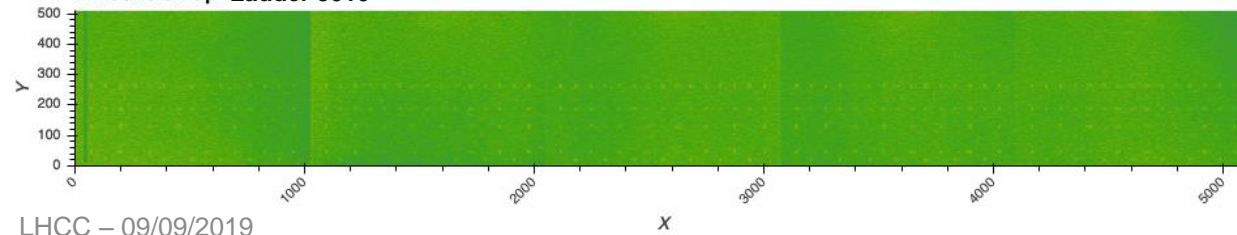
MFT HIC

Chip4 Chip5 Chip6 Chip7 Chip8

ThresholdMap Ladder 5010



ThresholdMap Ladder 5010



Threshold adjustment

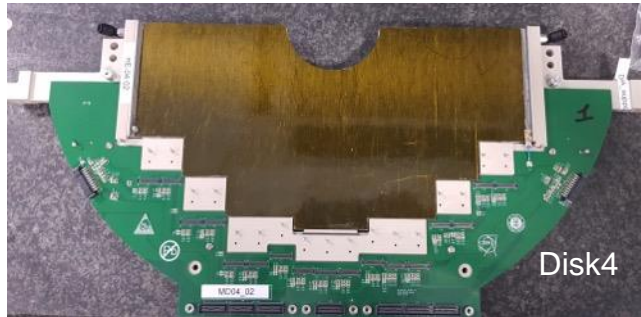
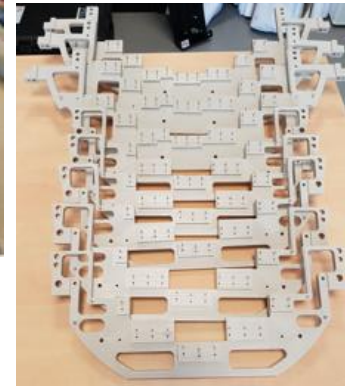
MFT – Disk production

- Heat Exchanger, Disk Support & PCB
 - Production finished
- Qualification
 - Procedure fully operational including X-Ray tomography and cooling test



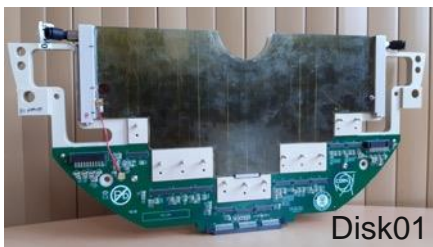
Heat exchangers

Disk supports

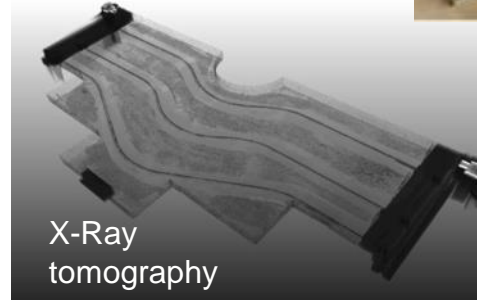


Disk4

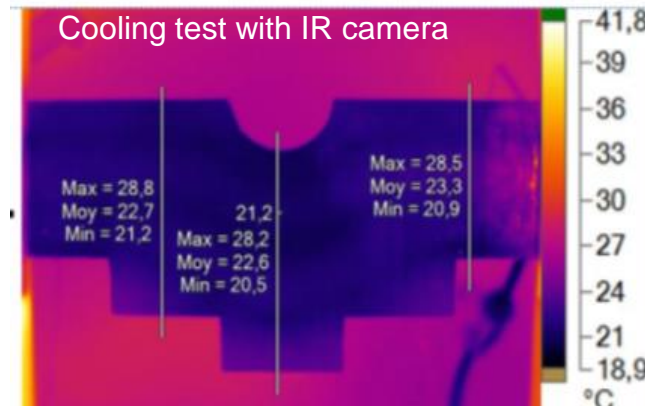
Mechanical disks ready for ladder gluing



Disk01



X-Ray tomography

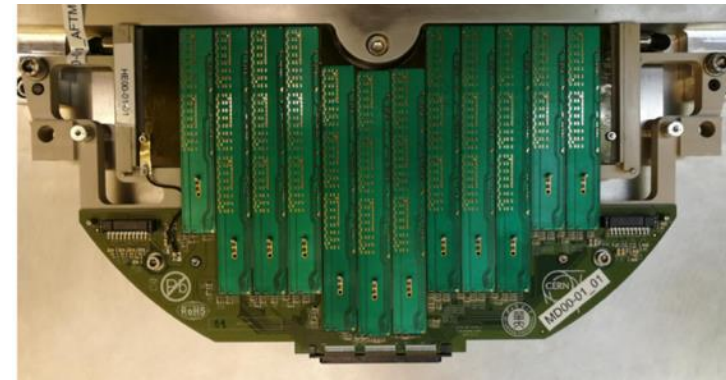
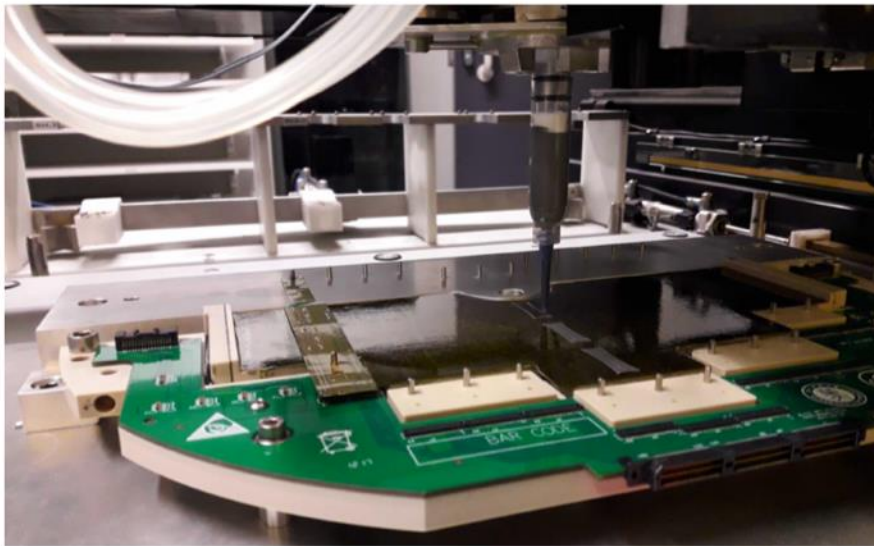


Disk PCBs

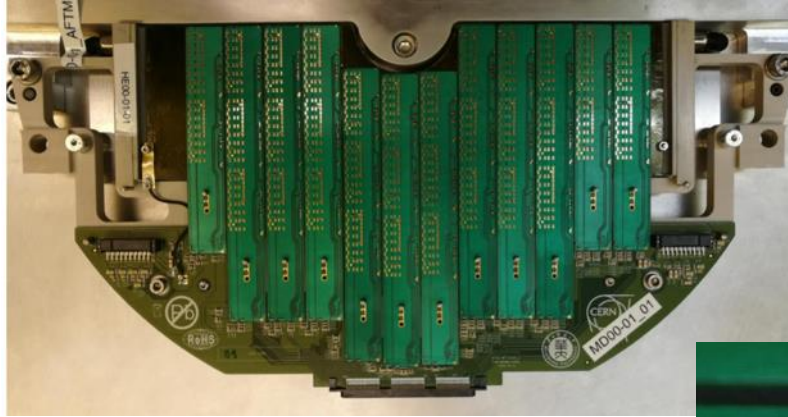


Disk Production

- Assembly procedure using automatic glue dispenser
- Gluing time = 2 days / disk (1 day per face)
- Ladders are tested after positioning on the disk to ensure no damage to the ladder in the process



Disk Production



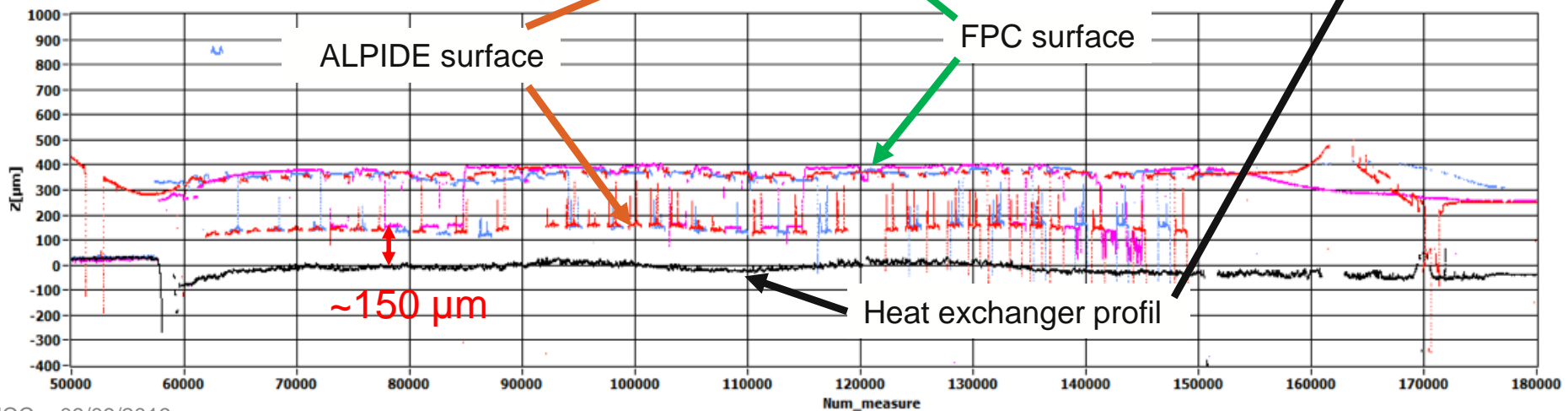
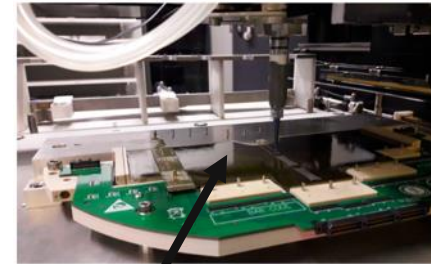
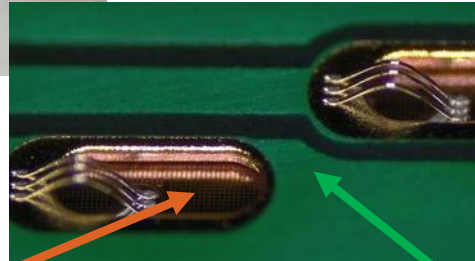
2 disks 0/1

1 disk 2

1 disk 3

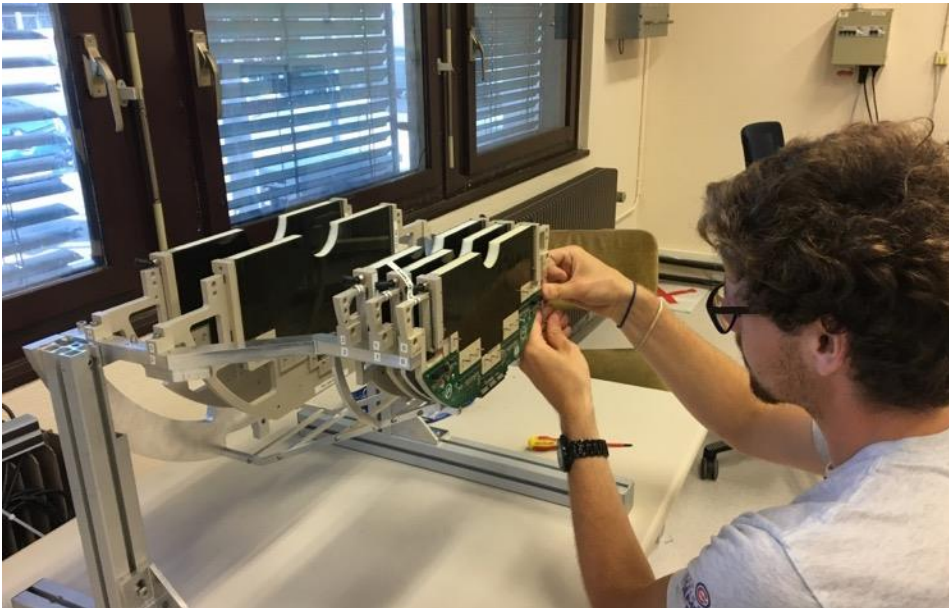
Produced

Glue thickness measured for each ladder (~100 μm)

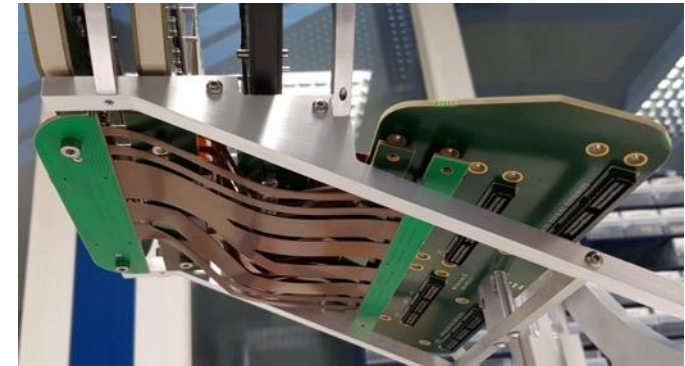


Cone

- Cone mechanics produced, assembled and tested
 - Successful Mother Boards integration
- Power Supply Unit
 - PCB in production: delivery end of September
 - Mechanics produced



Mother Board integration test

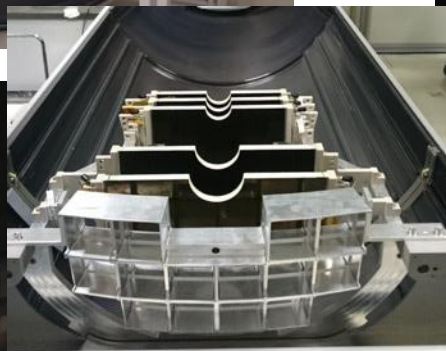
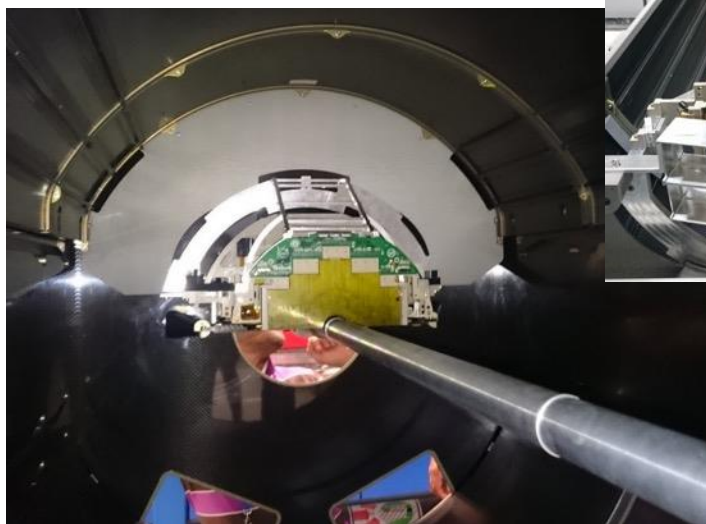
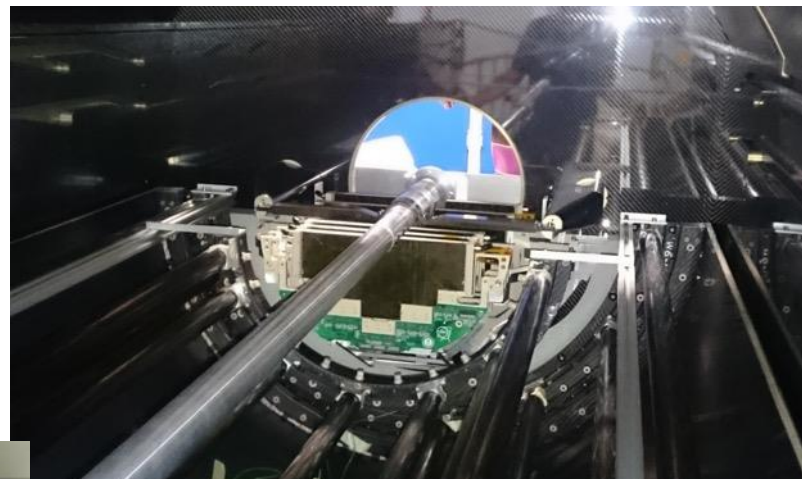
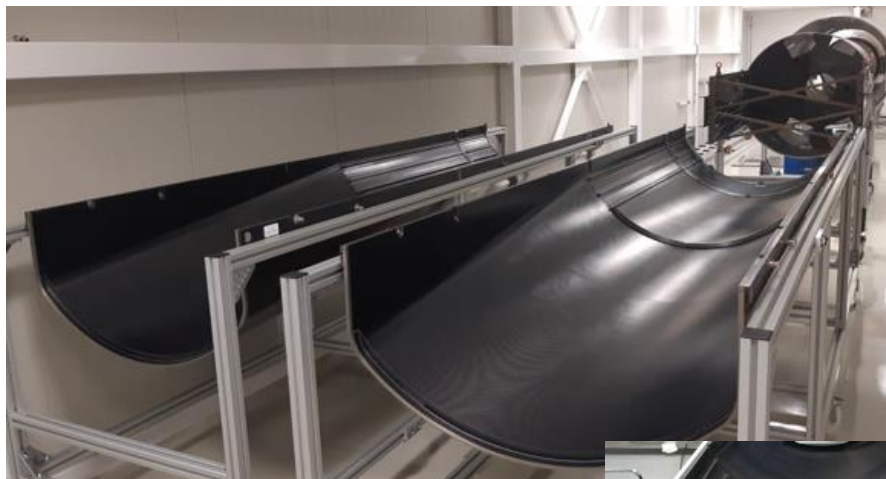


PSU Support



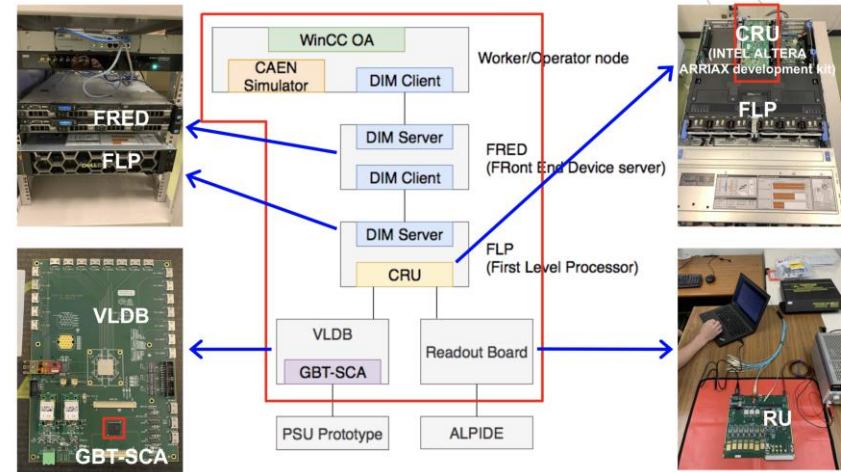
Barrel

- Successful insertion test in ITS cage with
 - * MFT mechanical cone, FIT, beam pipe, ITS middle and outer barrels



Services & Detector Control System

- DCS Test bench @ Hiroshima
 - Development ongoing using VLDB/CRU/FLP/ALF/FRED/WinCC chain
 - RUv2 added to the test bench
 - SW/HW interlocks scheme frozen
- Cooling plant
 - Produced and tested with final disks
 - Cooling pipes pulling on-going
- LV Power
 - Power supply Procurement finished
 - Setup on-going
 - Cables & patch panels installation on-going



LV Power supply



Cooling plant

Readout

- Production
 - Mother Board production finished
 - e-link Data cable production finished
 - RU production and test finished (88 units)
 - 11 CRU received and installed
 - Fibers production done
 - Racks and crates procured

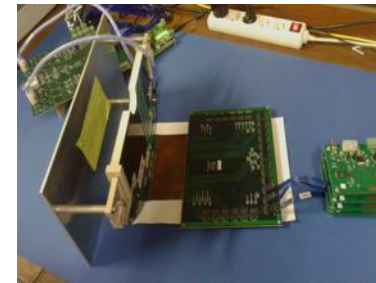
- Full scale setup
 - Using final production elements
 - BER measurements in PRBS mode at 1.2 Gbs
 - 170 hours without errors; BER = $5 \cdot 10^{-15}$



e-link data cables



Full Scale setup



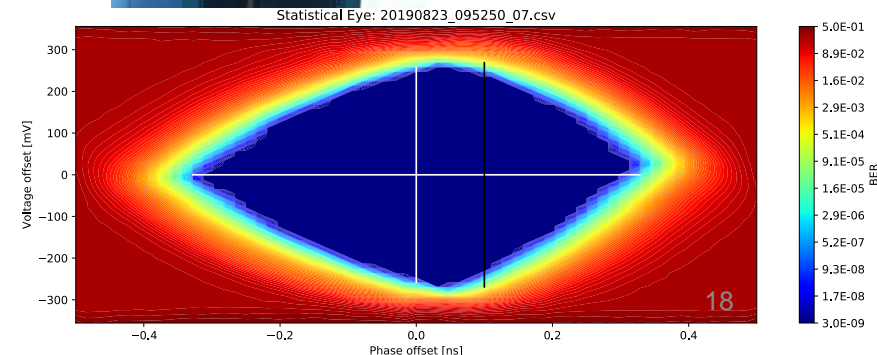
8m data cable



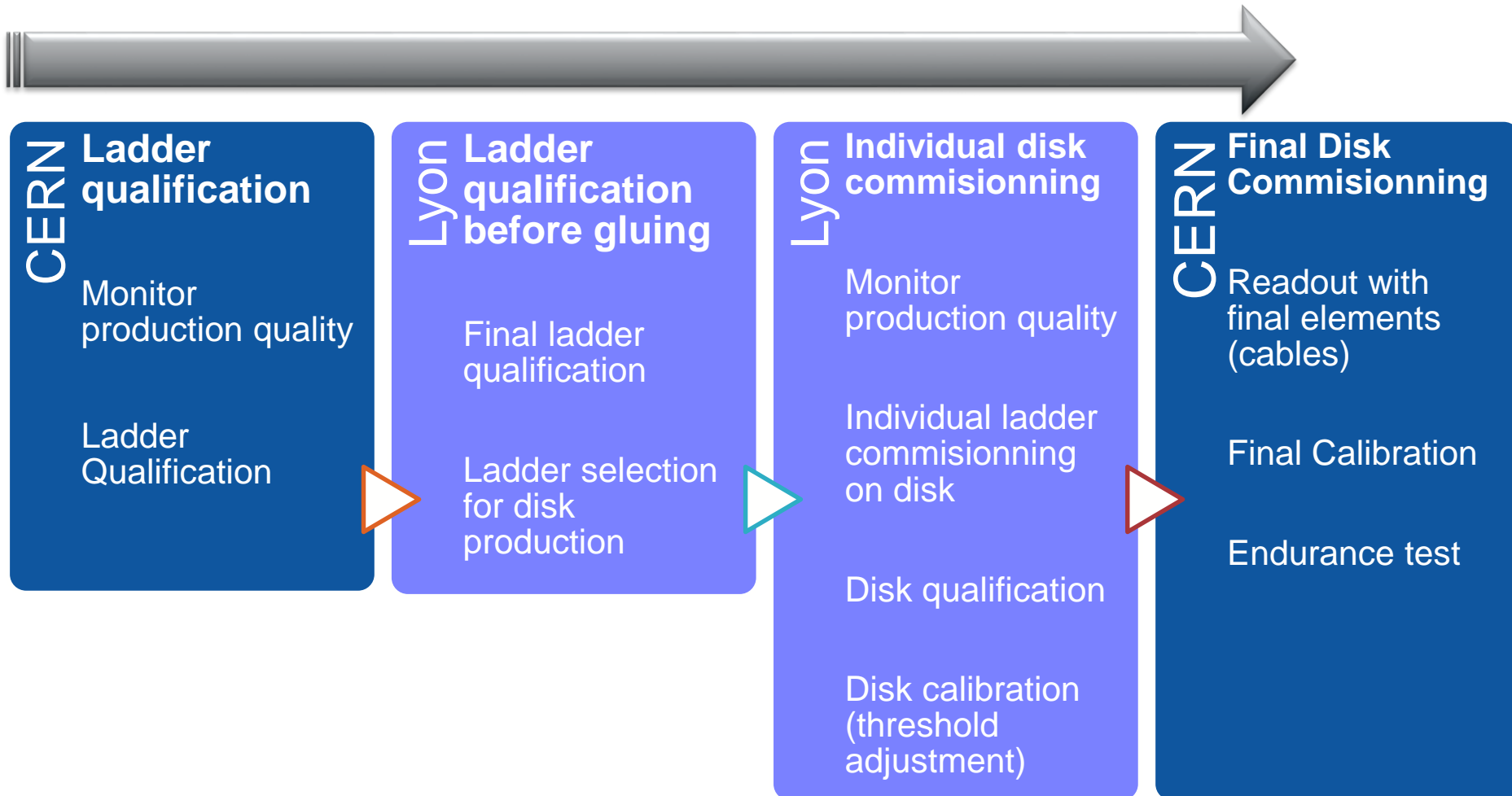
Readout Unit

3 FLPs + 6 CRUs

Fibers to CRU

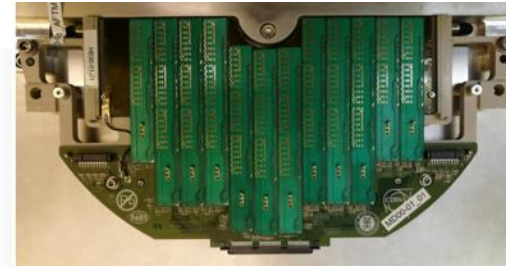
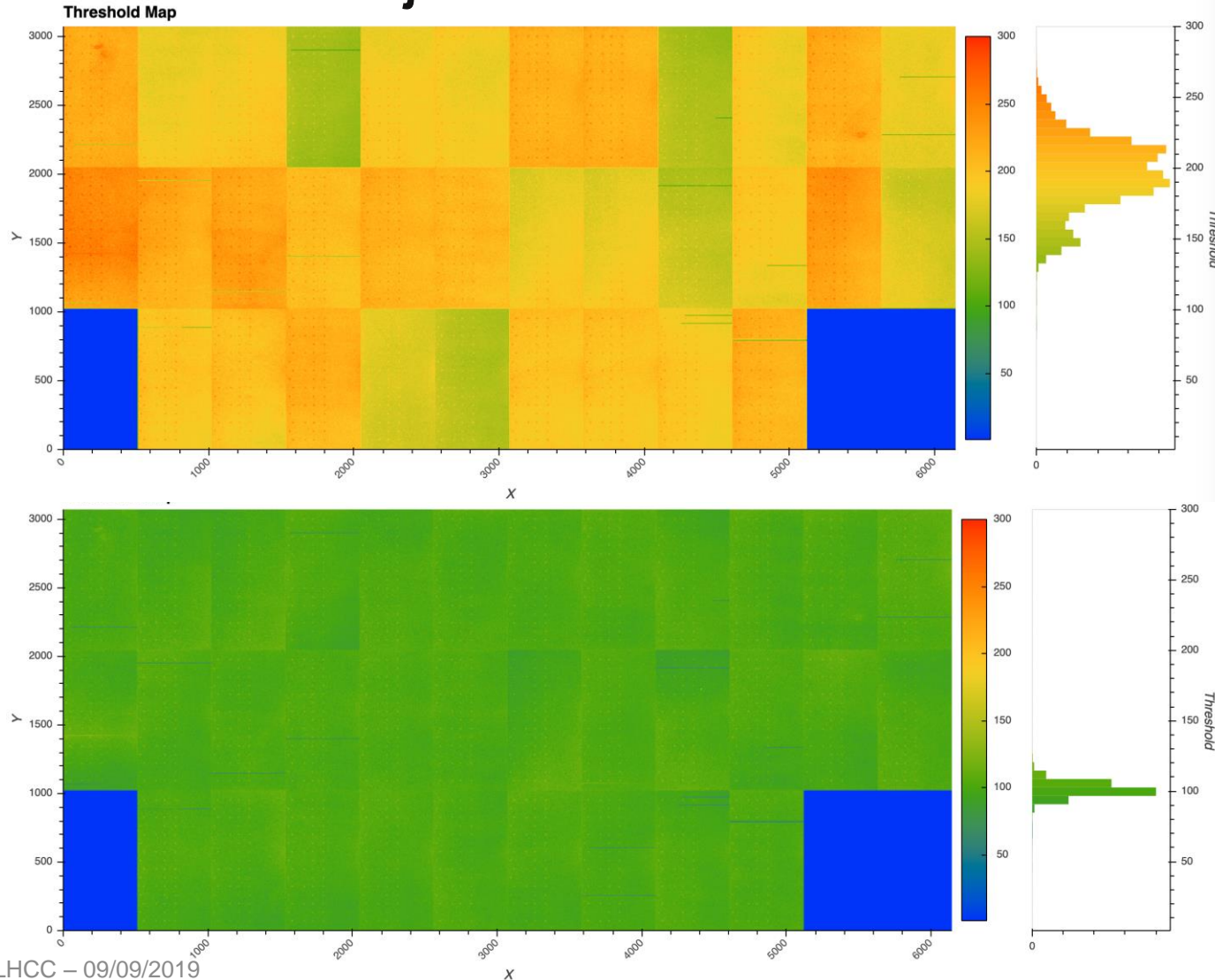


Commissioning strategy



Commissioning

Threshold adjustment



Adjust ALPIDE parameters to have an uniform gain



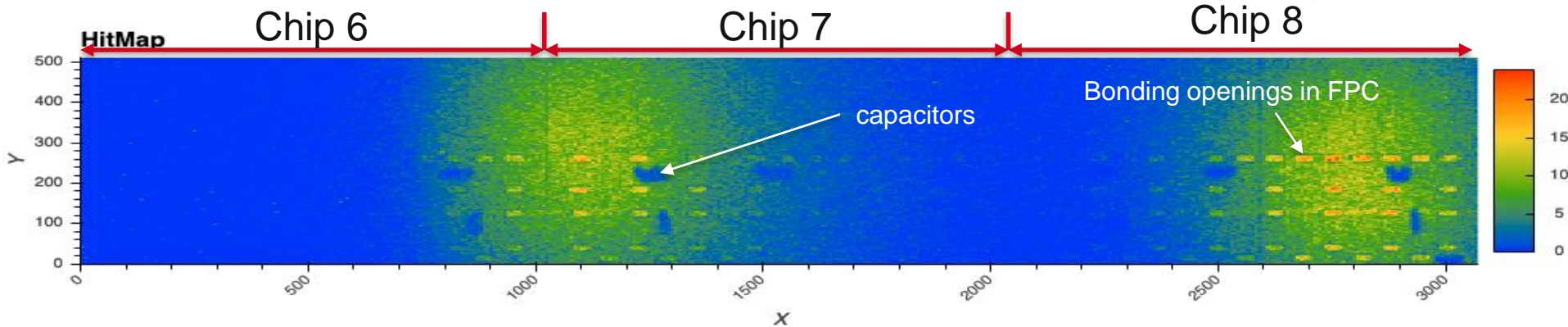
Threshold adjustment

Keep parameters in DB

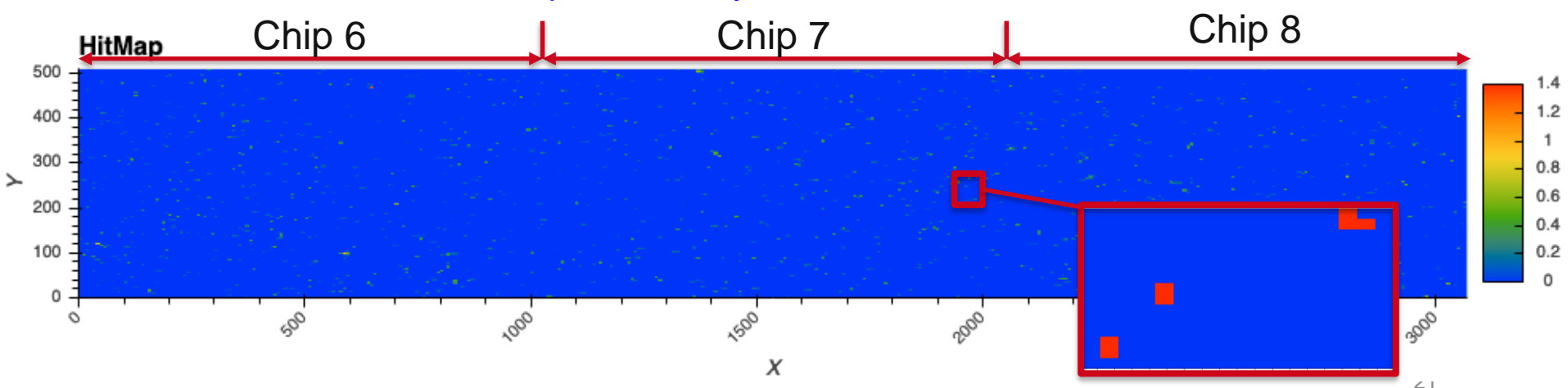
Commissioning

Sr-90 source and cosmics run

Two Sr-90 sources on top of one ladder (2h runs ~5 M hits) – Efficiency study



Cosmics run – cluster size/pattern study



Commissioning

- Clean Room in bldg. 581 ready for final commissioning
- Equipped to test $\frac{1}{2}$ MFT
 - Cooling
 - Power
 - Readout

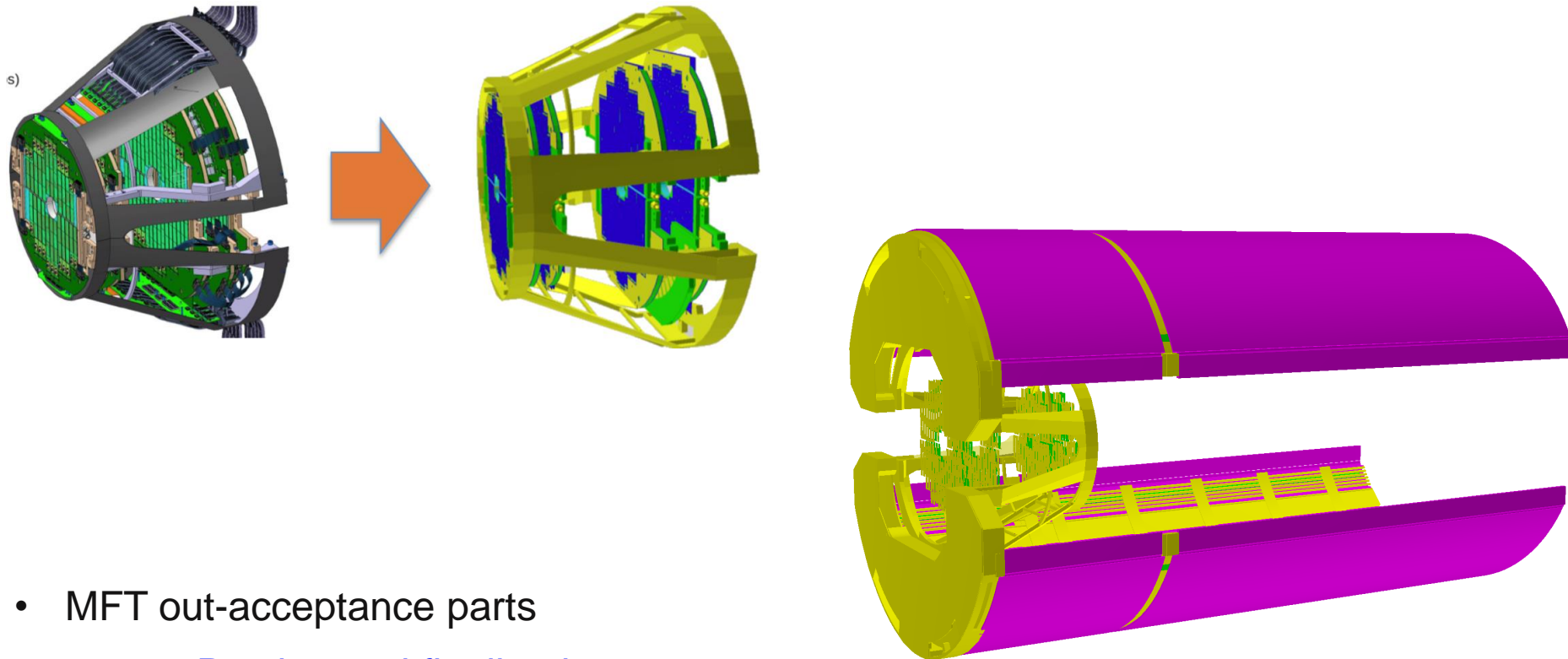


Room before refurbishing



Simulation & Reconstruction in O2

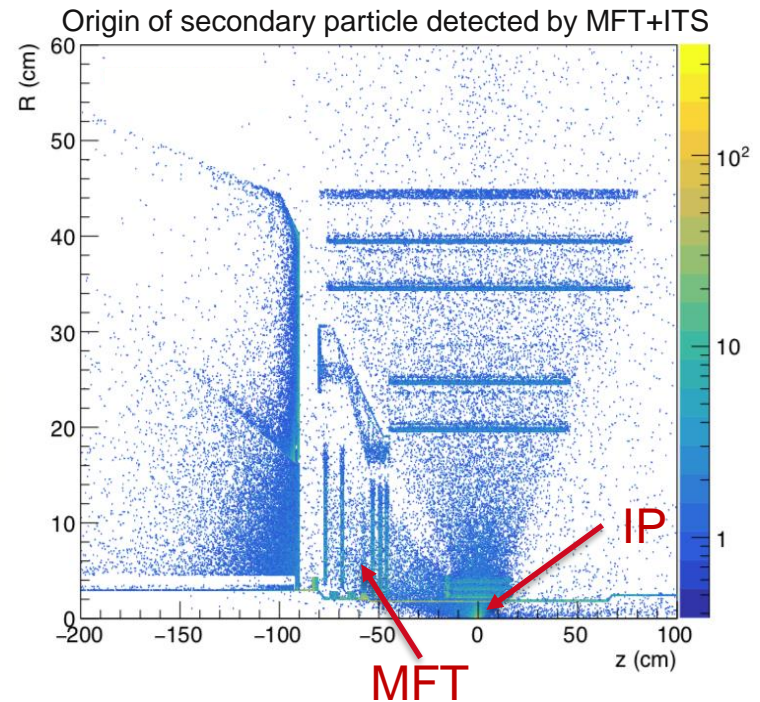
- MFT Detector geometry fully implemented



- MFT out-acceptance parts
 - Patch panel finalized
 - Barrel and services finalized for the part in central barrel acceptance
 - Overlaps with ITS and TPC being checked

Simulation & Reconstruction in O2

- Event simulation & Reconstruction using ALICE - O2
 - Digitalization → done
 - Clusterization → done
 - Standalone tracking → done
- For Commissioning and real data taking
 - MFT chip /RU mapping implemented
 - Data quality control development on-going
 - Detector Calibration tasks (calibration runs, i.e. threshold map)
 - Data Monitoring tasks (physics runs, i.e. hit map)



Planning

