



ALICE Muon Spectrometer upgrade and commissioning for the LHC Run 3

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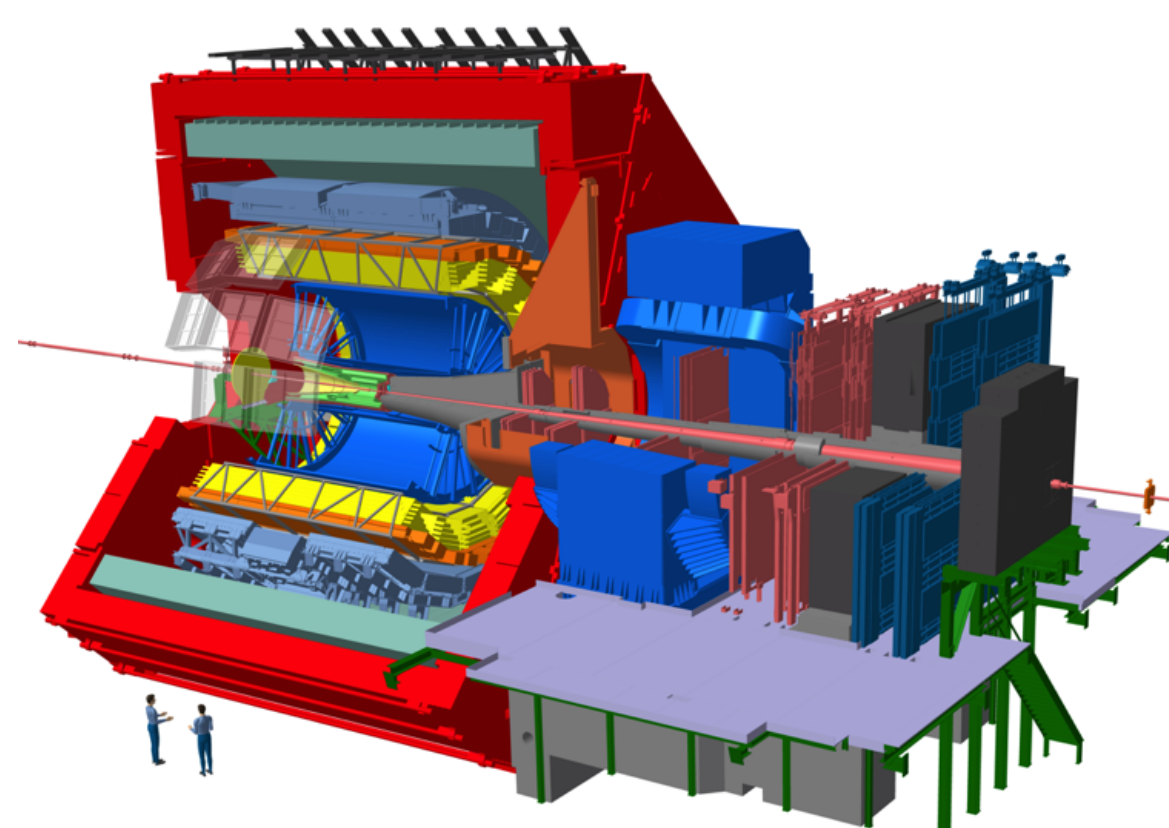


ALICE

1) Introduction

- A Large Ion Collider Experiment (ALICE) at the CERN Large Hadron Collider (LHC) is the experiment specifically designed to study the Quark-Gluon Plasma (QGP) in heavy-ion collisions
- During the long shutdown 2 of LHC, ALICE achieved a major upgrade of its apparatus:

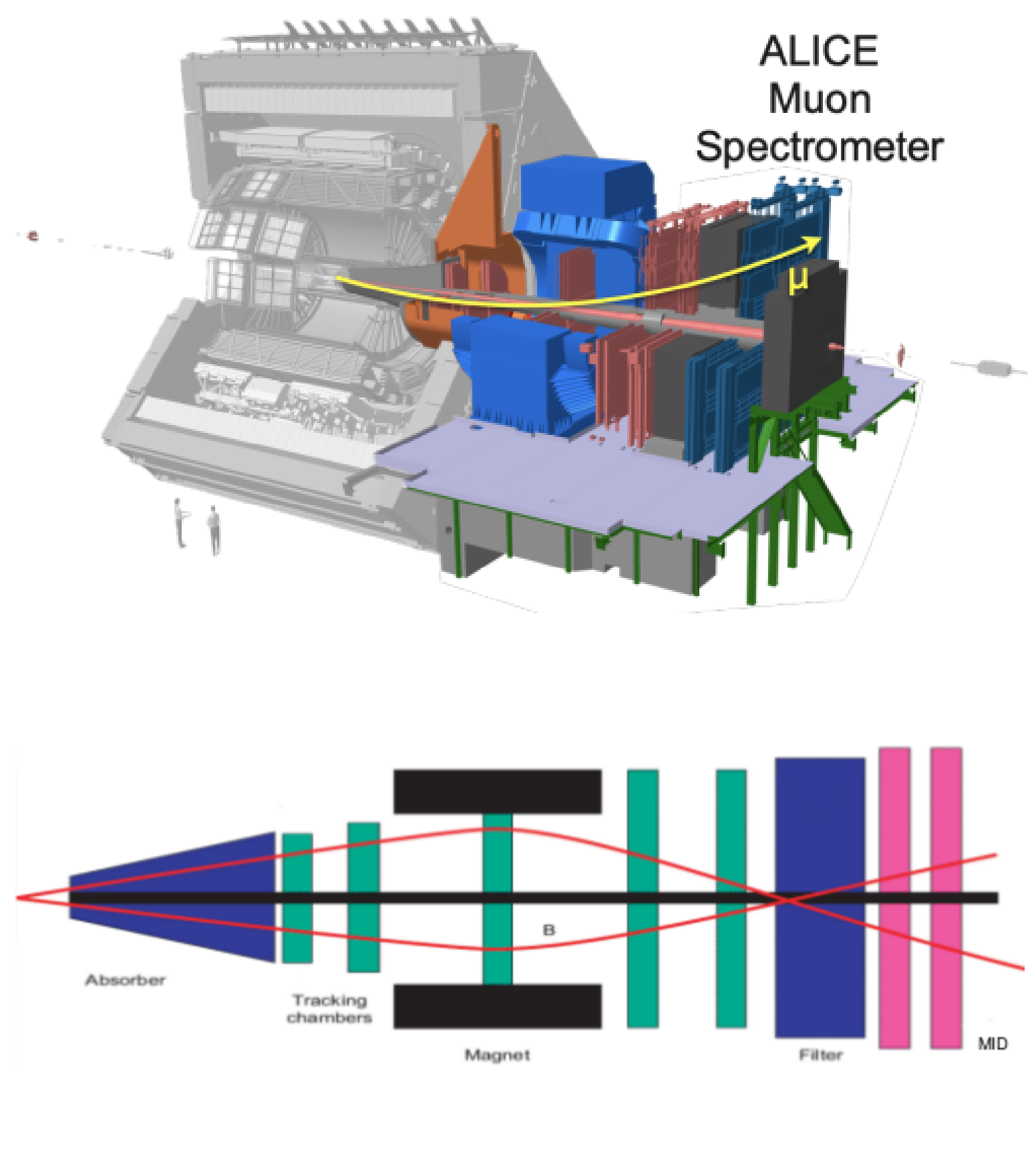
- ▶ to cope with the increased collision rate foreseen for Run 3
- ▶ to allow a new ambitious program of high-precision measurements



2) ALICE Muon Spectrometer (MS)

- Covers the pseudorapidity range $2.5 < \eta < 4$.
Made up of:

- ▶ **Absorbers**: front absorber, filter iron wall
- ▶ **Muon Chambers (MCH)**, 5 stations of 2 planes of Cathode Pad Chambers (CPC)
- ▶ **Muon Identifier (MID)**, 2 stations of 2 planes of Resistive Plate Chambers (RPC)



- Current muon physics topics:

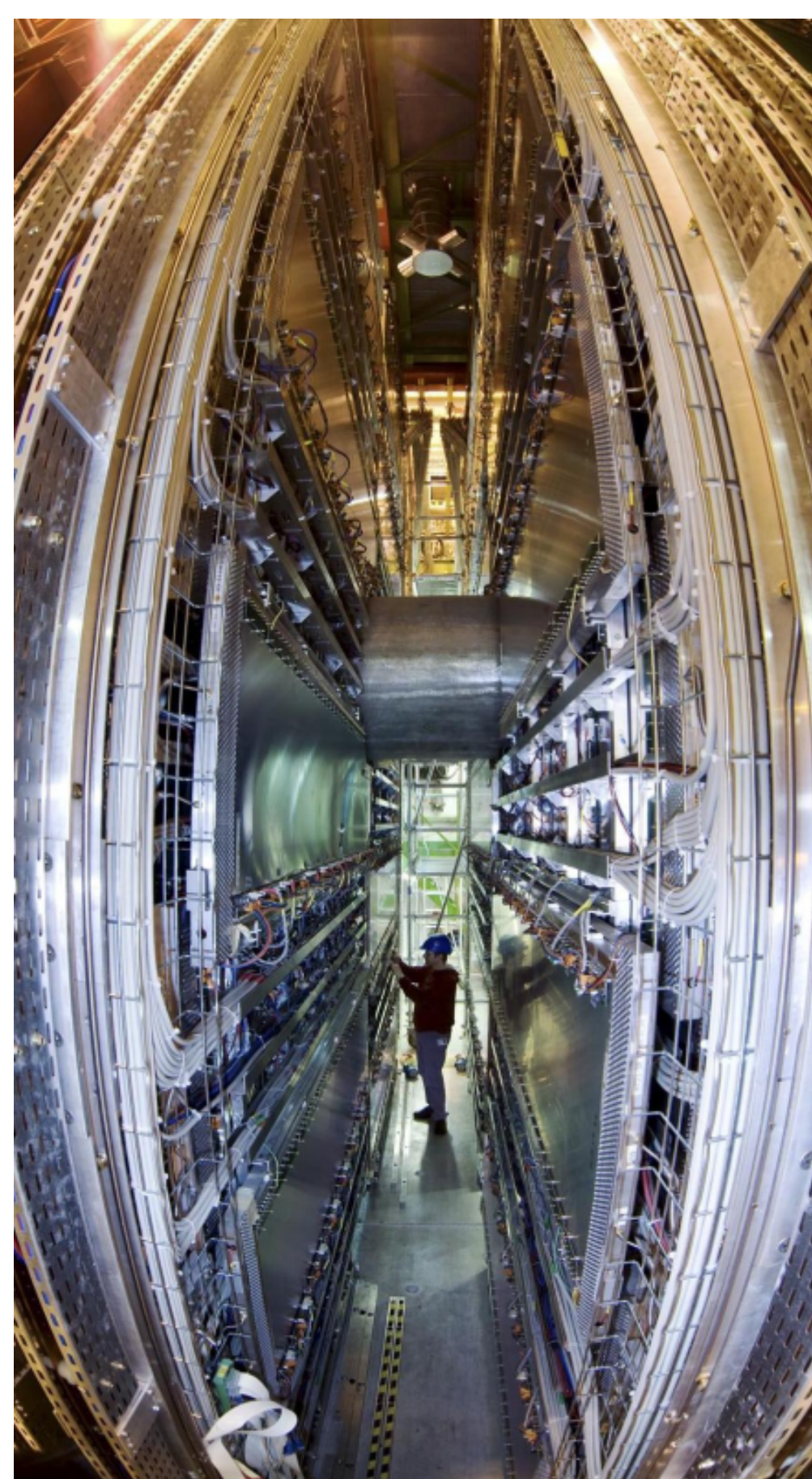
- ▶ quarkonia production
- ▶ open heavy flavors
- ▶ low mass dimuons
- ▶ single muons and dimuons from W^\pm/Z^0

3) MS upgrade motivations

- Determine the muon production vertex
→ before the upgrade, no disentanglement of open charm and open beauty production
→ separate prompt and non-prompt J/ψ
→ reduce background from non-prompt sources (presently there are significant statistical uncertainties in single muon and dimuon analysis due to background coming from combinatorial π/K)
→ improved mass resolution for light neutral resonances
- faster read-out needed to cope with the expected interaction rates in Pb-Pb collisions for Run 3 (50 kHz)

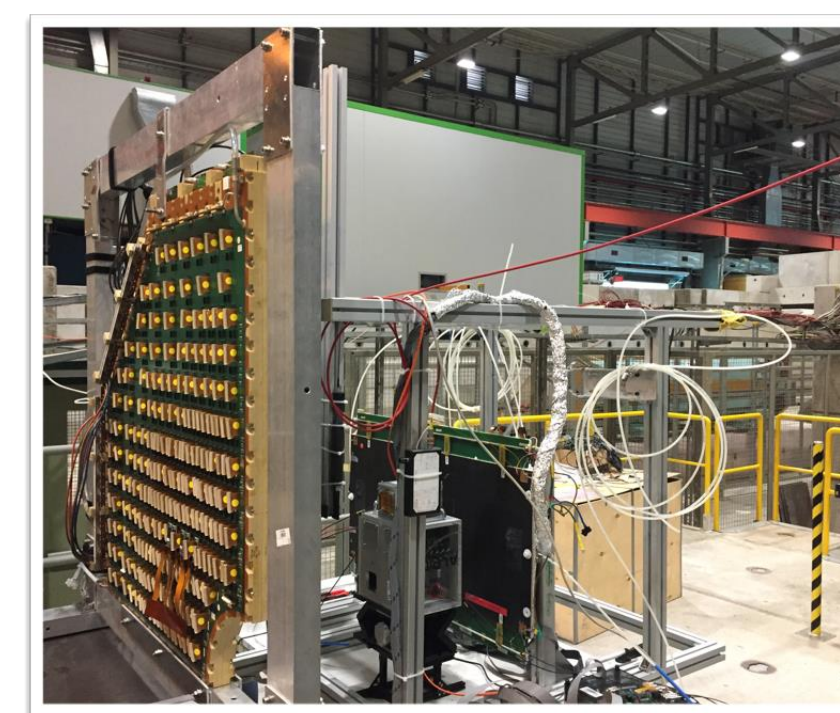
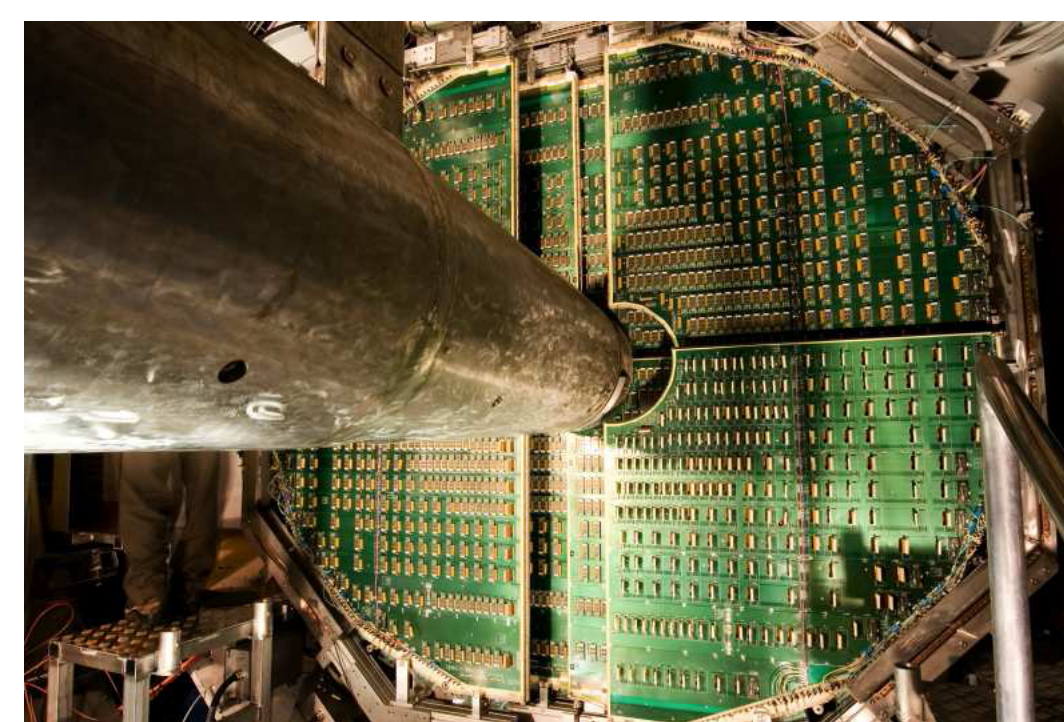
4) Muon Identification System (MID)

- 72 Resistive Plate Chambers (RPCs) arranged in 4 planes with 21k readout channels
- from Run 3 the RPCs will operate in continuous readout mode
→ this required an upgrade of the read-out electronics, which is now completed
- to cope with the increased counting rate and reduce aging effects the RPCs will be operated at a low-gain avalanche mode thanks to a new front-end electronics (FEERIC ASIC) which include a pre-amplification stage
→ one RPC in ALICE cavern equipped with FEERIC cards during Run 2 showed similar efficiency w.r.t. the other RPCs



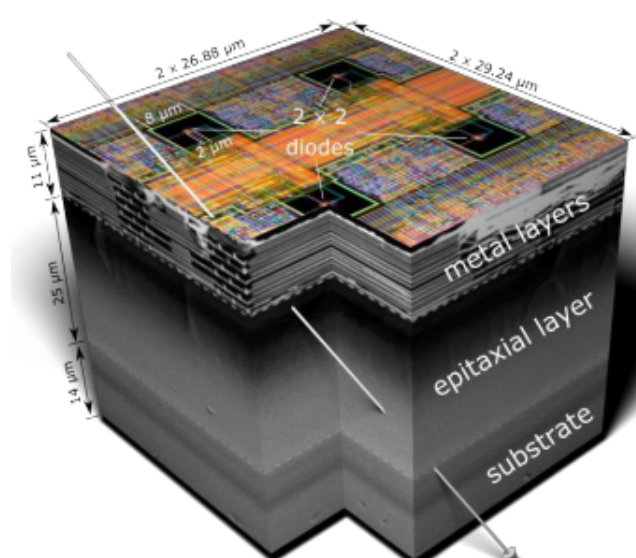
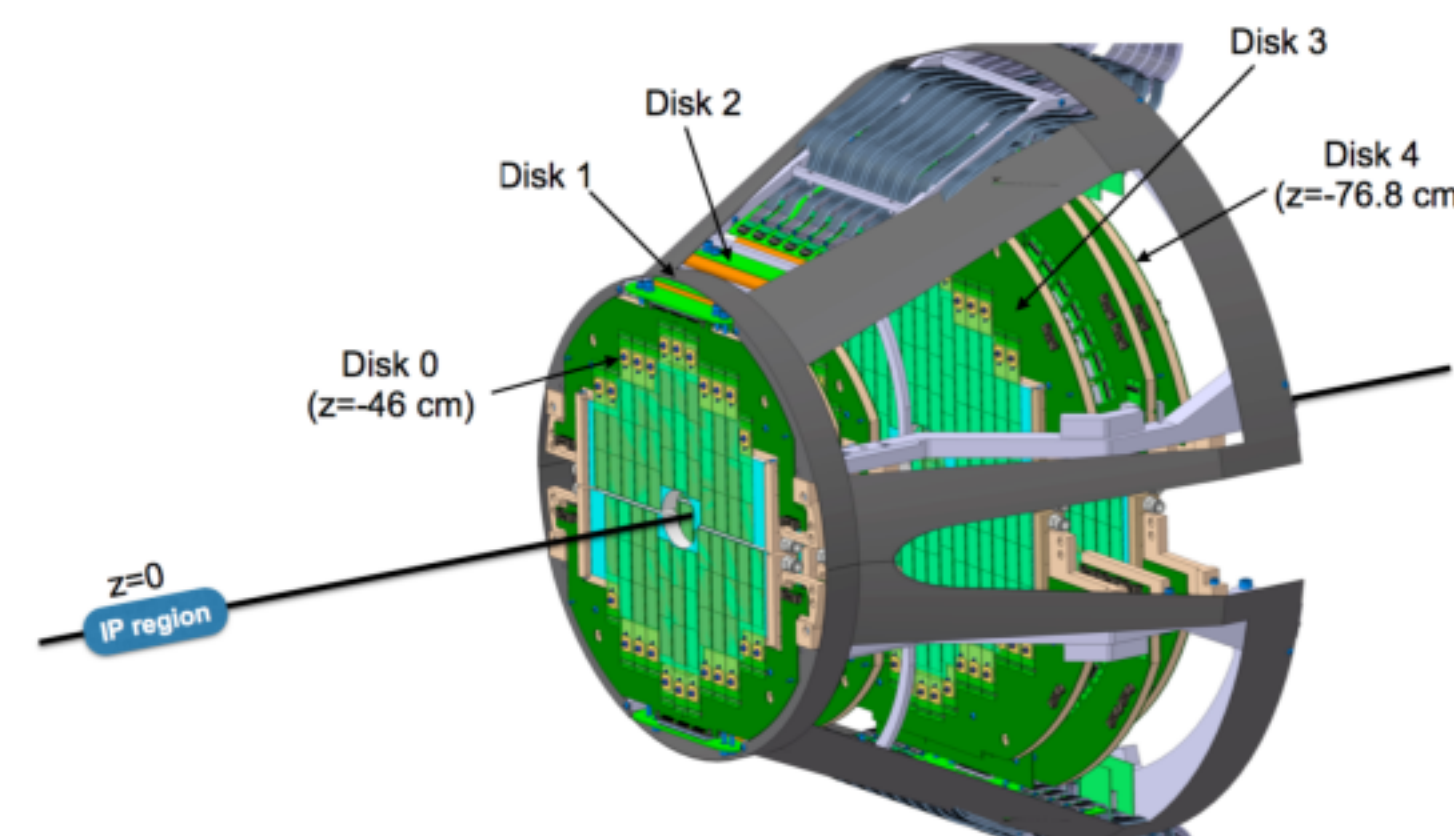
5) Muon Chambers (MCH)

- Tracking chambers based on Cathode Pad Chambers grouped in 10 planes with 1.1 million readout channels; spatial resolution $\sim 100 \mu\text{m}$
- new front-end electronics FEE and new read-out chain
 - ▶ FE chip – SAMPA
 - ▶ FE board hosting two SAMPA chips – Dual Sampa (DS)
 - ▶ Concentrator board with GBT links protocol taking data from several DS – SOLAR
 - ▶ Common Readout Unit (CRU)
- Full chain successfully tested in test beam in 2017 at CERN SPS



6) Muon Forward Tracker (MFT) design

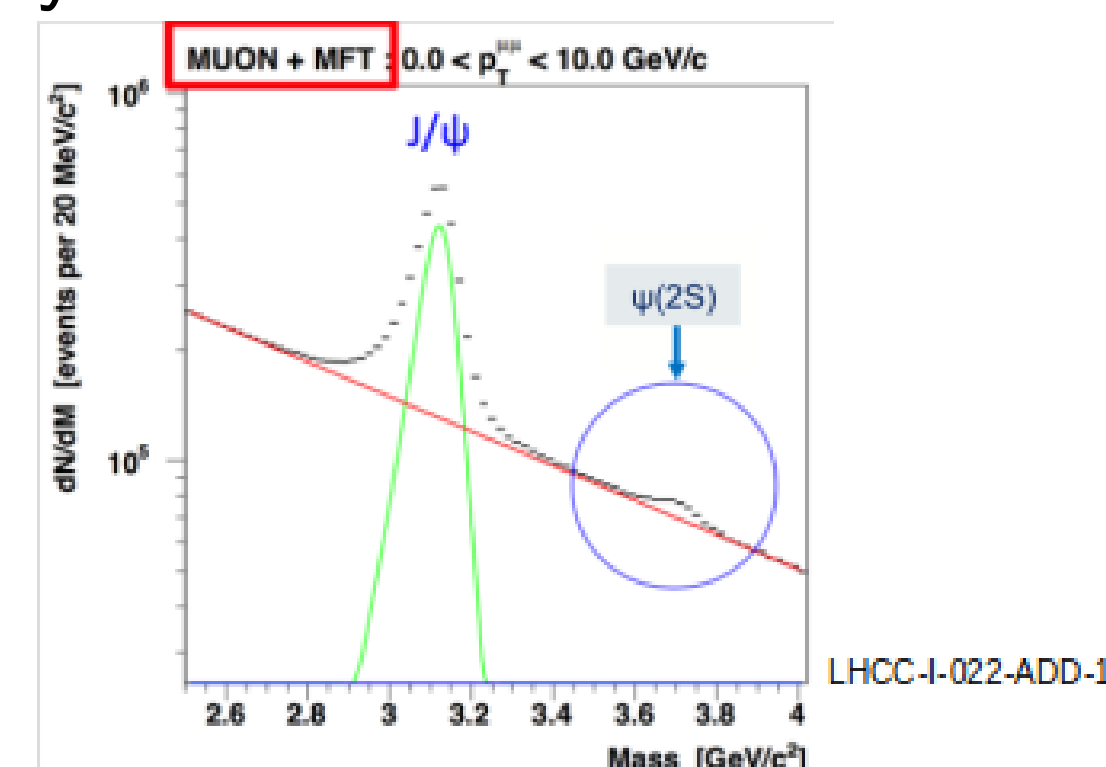
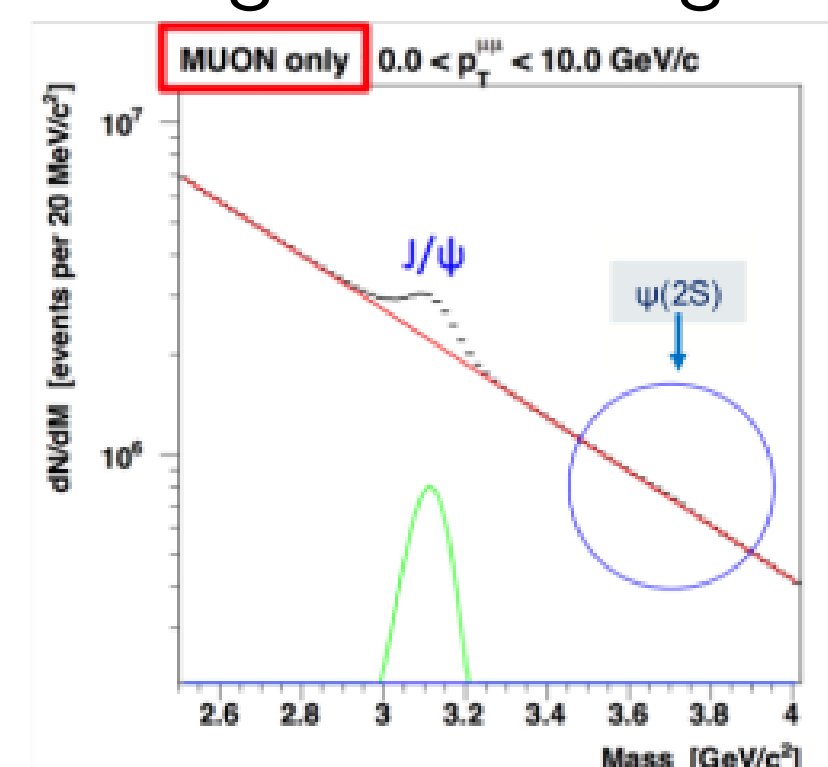
- New Pixel Tracker at forward rapidity: **Muon Forward Tracker (MFT)**
 - ▶ pseudorapidity range $2.5 < \eta < 3.6$, installed before the hadron absorber
 - ▶ 936 ALPIDE Silicon pixel sensors (0.4 m^2), based on Monolithic Active Pixel Sensors (MAPS). Sensor size $15 \times 30 \text{ mm}^2$; Pixel size $27 \mu\text{m} \times 29 \mu\text{m}$; 512×1024 pixel matrix; spatial resolution better than $5 \mu\text{m}$
 - ▶ cone structure formed by ten half disks. Each half-disk consists of structures called ladders which host the ALPIDE chips (280 ladders of 2 to 5 sensors).



→ MFT installed in ALICE since Jan '21, now under commissioning

7) Physics measurements with the MFT

- improve vertexing and tracking capabilities → matching between extrapolated muon tracks coming from the MCH after the absorber with MFT tracks before the absorber
- separation between prompt and non-prompt J/ψ down to 0 p_T , by measuring the pseudo-proper decay time associated to the secondary vertex
- reduce the uncertainties on the $\psi(2S)$ measurements in the Pb-Pb collisions, improving the signal-to-background by a factor of 5-6



- improving low-mass dimuon measurement by reducing the combinatorial background from the semi-muonic decays from kaons and pions and by improving the mass resolution, thanks to the precise measurement of the opening angle of muon pairs

8) Conclusions

- MCH and MID have been upgraded with new FEE to cope with the higher interaction rates in Run 3
- MFT will significantly improve the muon physics program for Run 3
- ALPIDE chips used by the MFT (and ITS) are a result of an intense R&D program and all of them have already been installed
- all the components for the MS data readout chain have successfully been tested and installed

References

- 1 ALICE Collaboration, The ALICE experiment at the CERN LHC, JINST 3, S08002 (2008).
- 2 ALICE Collaboration, Letter of Intent for the Upgrade of the ALICE Experiment, CERN-LHCC-2012-012, LHCC-I-022, 2012.
- 3 ALICE Collaboration, Addendum of the Letter Of Intent for the Upgrade of the ALICE Experiment: The Muon Forward Tracker, CERN-LHCC-2013-014, LHCC-I-022-ADD-1, 2013.