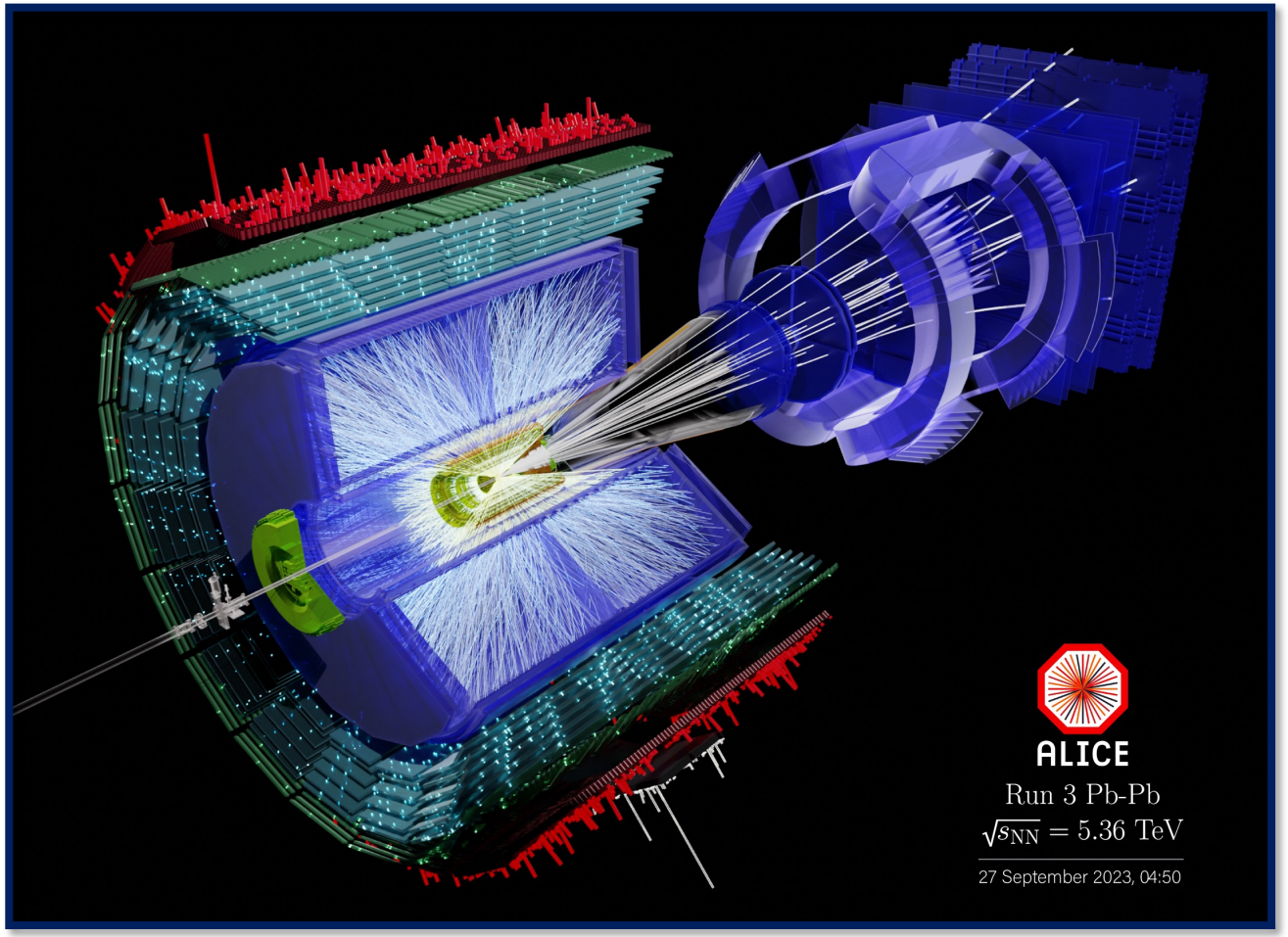
Postdoctoral Research position in Experimental Heavy-Ion Physics with ALICE at CERN-LHC

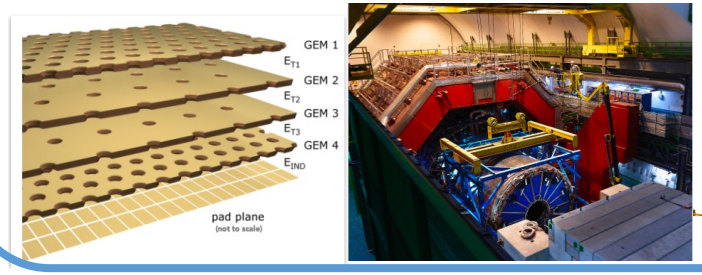


Sarah Porteboeuf Houssais
(sarah.porteboeuf@cern.ch)
Philippe Crochet
(philippe.crochet@cern.ch)

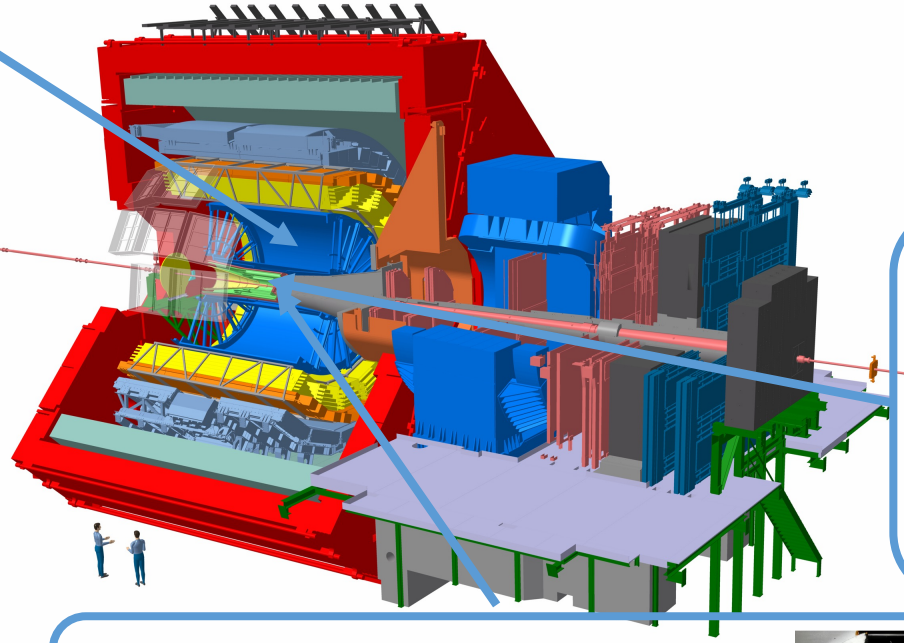
The ALICE experiment in Run 3

Time Projection Chamber (TPC)

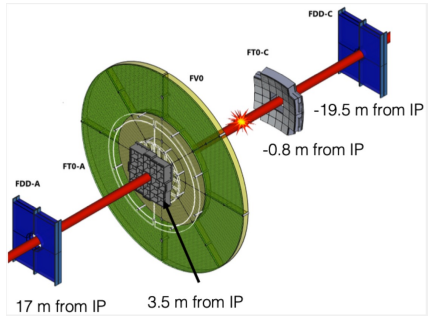
New readout chambers: from Multi Wire Proportinal Chamber (MWPC) to Gas Electron Multiplier (**GEM**)



Consolidation and readout upgrade of all subsystems

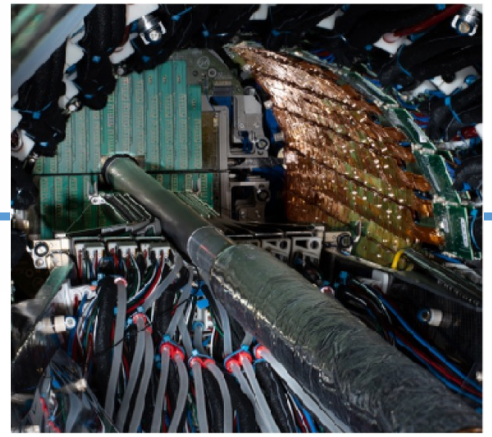


Fast Integration Trigger



Inner Tracking System (ITS 2)

3+2+2 cylindrical layer of MAPS (~ 10m^2)
Improved vertexing at high rate



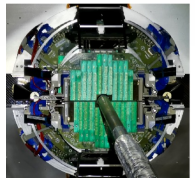
Integrated on-/off-line System

Continous Readout with First Level Processors (FLPs)
Event Processing Nodes (EPNs) for GPU-based Synchronous reconstruction

Online Data Compression

Muon Forward Tracker (MFT)

5 planes of MAPS
Forward vertexing for Muons

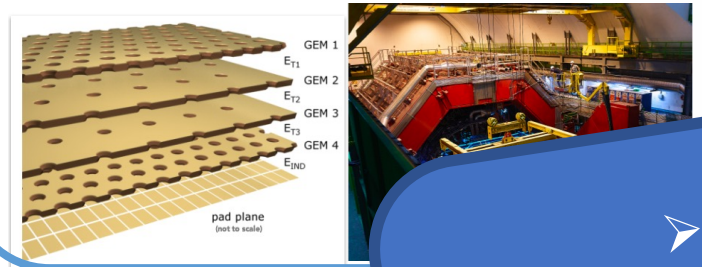


sarah.porteboeuf@cern.ch

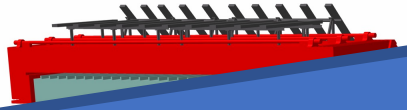
The ALICE experiment in Run 3

Time Projection Chamber (TPC)

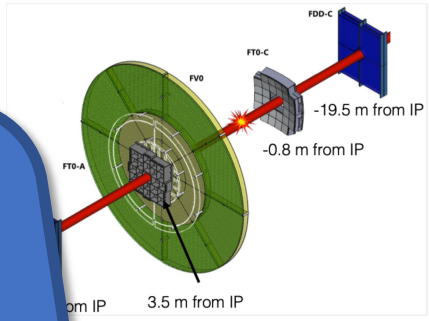
New readout chambers: from Multi Wire Proportinal Chamber (MWPC) to Gas Electron Multiplier (**GEM**)



Consolidation and readout upgrade of all subsystems



Fast Integration Trigger



- **Continuous readout** with Pb-Pb @ 50 kHz
- **Statistics** up to x50
- **Better vertexing** (central and forward)
- **Central-forward correlations**

ALICE step-in Precision Era

Integrated on-/off-l

Continous Readout wi

Processors (FLPs)

Event Processing Nodes

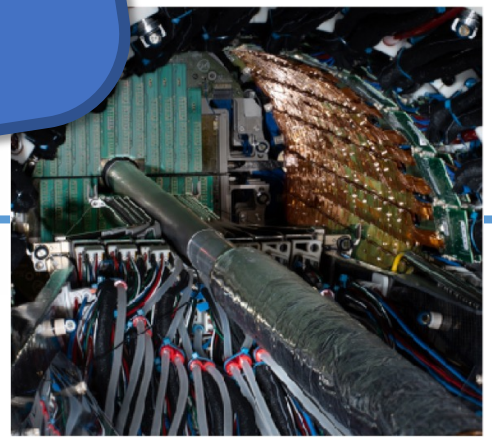
based Synchronous reco

Co pression

ng System (ITS 2)

cal layer of MAPS (~ 10m^2)

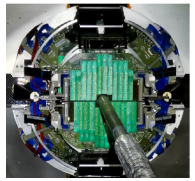
exing at high rate



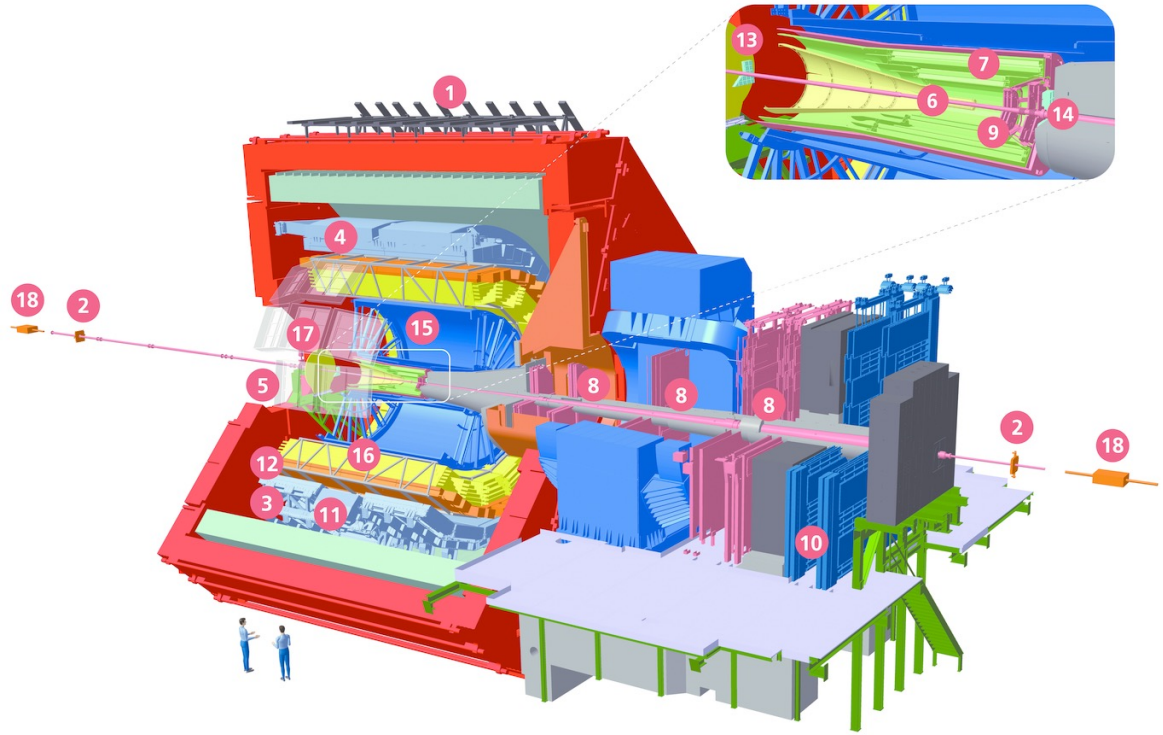
Muon Forward Tracker (MFT)

5 planes of MAPS

Forward vertexing for Muons



The Muon Forward Tracker

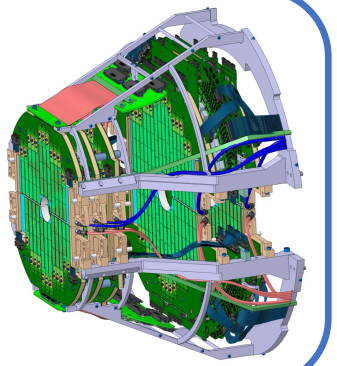


1. **ACORDE** | ALICE Cosmic Rays Detector
2. **AD** | ALICE Diffractive Detector
3. **DCal** | Di-jet Calorimeter
4. **EMCal** | Electromagnetic Calorimeter
5. **HMPID** | High Momentum Particle Identification Detector
6. **ITS-IB** | Inner Tracking System - Inner Barrel
7. **ITS-OB** | Inner Tracking System - Outer Barrel
8. **MCH** | Muon Tracking Chambers
9. **MFT** | Muon Forward Tracker
10. **MID** | Muon Identifier
11. **PHOS / CPV** | Photon Spectrometer
12. **TOF** | Time Of Flight
13. **T0+A** | Tzero + A
14. **T0+C** | Tzero + C
15. **TPC** | Time Projection Chamber
16. **TRD** | Transition Radiation Detector
17. **V0+** | Vzero + Detector
18. **ZDC** | Zero Degree Calorimeter

Continuous readout for all systems
(Common Readout Unit), for muons:

- **MCH** upgrade with SAMPA ASIC
- **MID** (upgrade of MTR) with FEERIC ASIC

- New detector: the **Muon Forward Tracker**
- Vertex tracker for the Muon Spectrometer, to be installed between the interaction point and the hadron absorber ($-3.6 < \eta < -2.5$)
- 920 silicon pixel sensors (0.4 m^2) in 280 ladders of 2 to 5 sensors each



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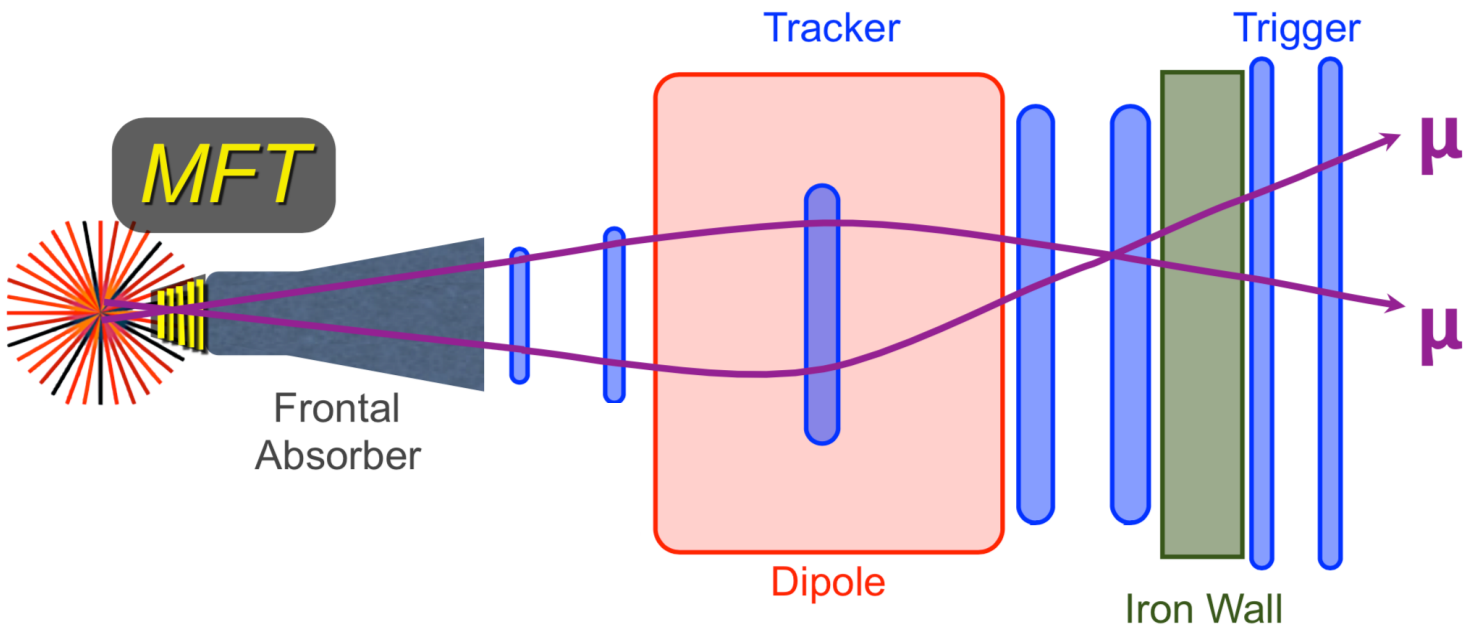
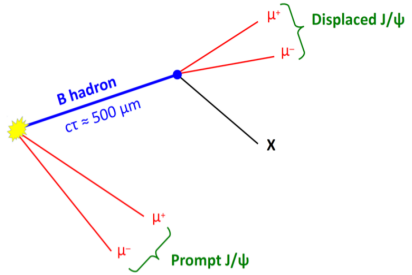
Muon measurement with ALICE at Run 3



- Muon tracks are extrapolated and **matched to the MFT clusters** before the absorber
- Gain vertexing capabilities

Muons with MFT in RUN 3

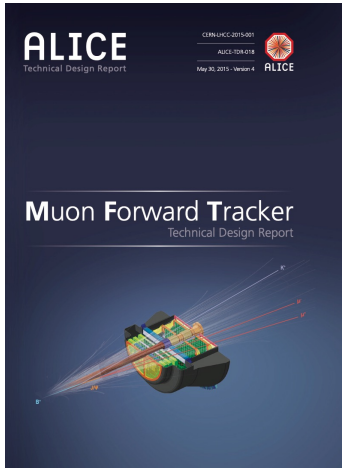
- **Increase of statistics (x10)** will reduce uncertainties and allow for multi-differential studies
  A large number of Runs 1+2 measurements will be significantly improved



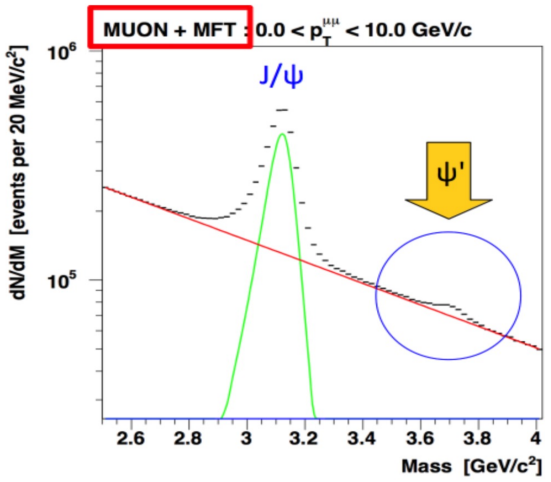
- **Open heavy flavours: separation of charm and beauty**
  Charm measurement down to p_T = 1 GeV/c in the single muon channel
  Beauty measurement down to p_T = 0 in the non-prompt J/ψ channel

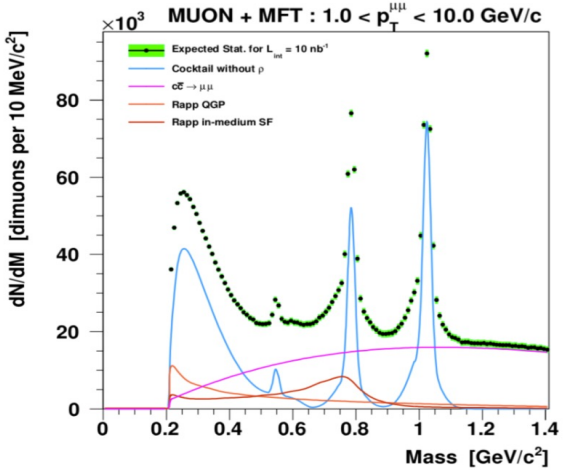
- **Prompt Charmonium production**
  Prompt/non-prompt J/ψ separation down to p_T = 0. Ψ(2S) measurement in central Pb-Pb collisions

- **Low-mass dimuons**
  Improved mass resolution for light resonances. Sensitivity to prompt continuum

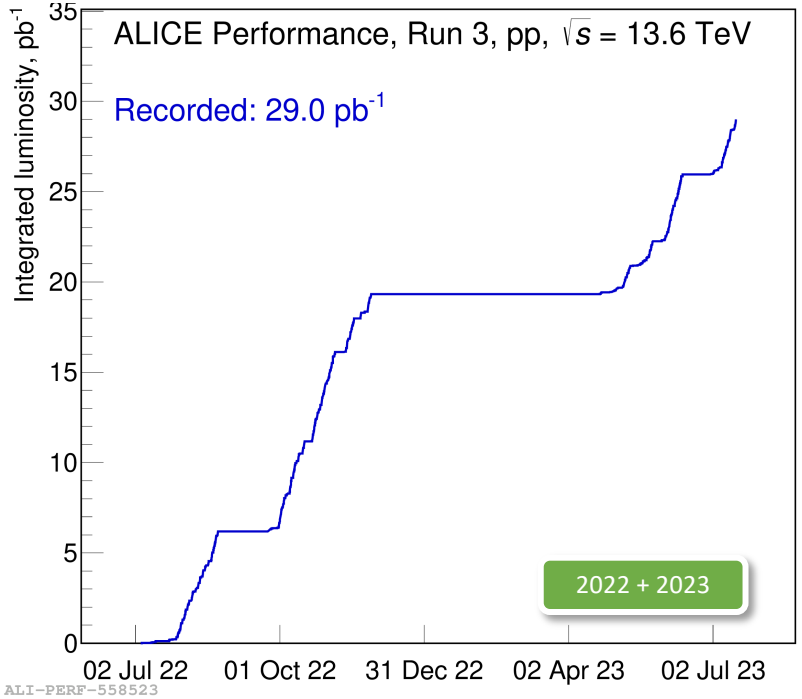


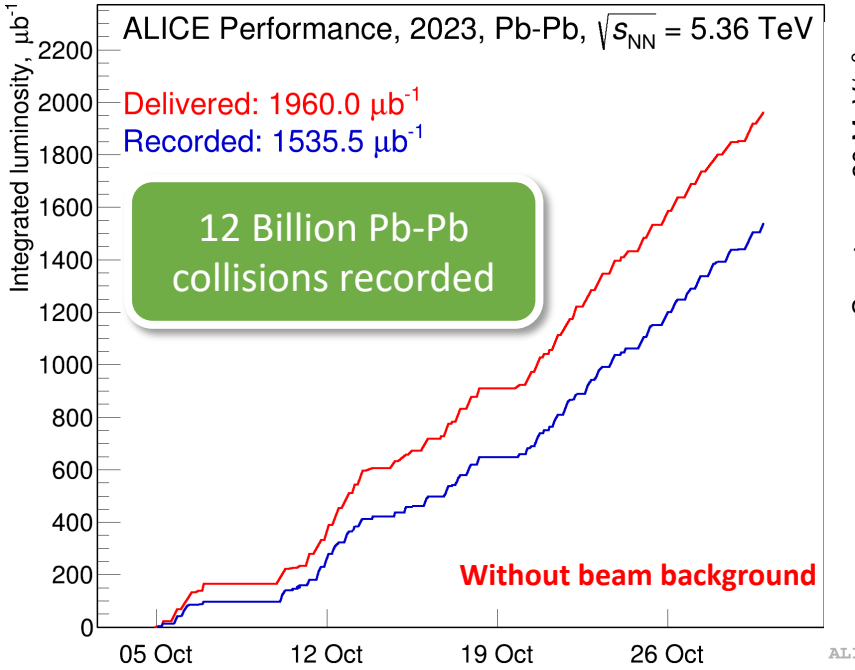
https://cds.cern.ch/record/1981898?ln=fr

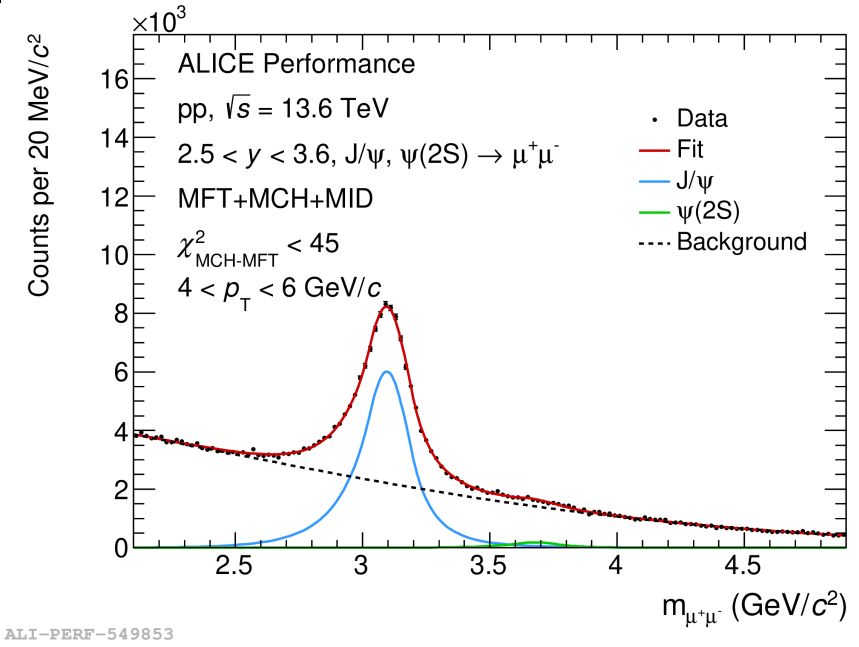




Unprecedent data sample for HI and QCD studies







Successful Pb-Pb run

- Collected sample much larger than RUN 1+2 (X40 MB sample)
- Delivered without background 1.96 nb^{-1} Represent 30% of total RUN 3 goal (6.5 nb^{-1})
- Challenge for muon matching in high multiplicity environment

The Post-doctoral project

Co-construction of the post-doctoral project with the candidate

- Physics analysis in the scope of quarkonium production studies in dense hadronic environment and take benefit of the large data sample collected by the ALICE experiment in proton-proton and Pb-Pb collisions during RUN 3. Exact subject to be defined with the candidate depending on his/her expertise and wish.
- Contribution to the software development of global muon physics related analyses. Global muons are muons with reconstructed components in the muon spectrometer and in the MFT.
- Leading role in the matching strategy between the MFT and the muon spectrometer, performance studies and analysis cut optimization related to global muons.
- Contribution to the experimental work of the ALICE operations and more specifically with the MFT project.
- The successful candidate is expected to rapidly take on scientific responsibilities in either area

Skills and profile

- Expert in relativistic heavy-ion collision physics, as demonstrated by a PhD in the field - Expert in object-oriented programming
- Previous experience in high-energy physics experiment at CERN
- Spoken and written scientific English
- Ability to work in a team and in a highly digital environment.

Contact us to discuss further your project !

Work environment : Auvergne region in France

- Post-doctoral project based at LPCA (Laboratoire de Physique Clermont Auvergne)
- Université Clermont Auvergne and CNRS (Centre National de la Recherche Scientifique)

- A nice campus in a exceptional natural environment

- At only 3h from CERN

Work environment : LPCA lab and ALICE group

Laboratoire de Physique Clermont Auvergne

- A mixed lab between CNRS and UCA
- ~ 150 staff members
- Members in 3 LHC experiments and theory
- A rich local scientific environment

Theory

Standard Model, QCD, Dark Matter, Beyond Standard Model, Field Theory

Physics for health and environment

Environment / Energy / Health

Universe and particle

Cosmology **SOLID** **COMET** **Future Collider**

ATLAS **LHCb** **CKMFitter**

ALICE

- 7 (teacher)-researchers
- PhD student
- long-standing expertise of the Muon Spectrometer, the Muon Forward Tracker and quarkonia measurements

What we offer ?

- 2 years (24 months) post-doctoral position
- Contract to start between 1st October to 31th December 2024
- Salary starting from 2905 euros monthly raw , depending on experience
- Holidays, maternity leave, sick leave following French laws
- Participation to national events and international conferences per group funding
- Regular trip to CERN for collaboration work and operational activities

How to Apply ?

- Only official applications through the CNRS website can be considered
  https://emploi.cnrs.fr/Offres/CDD/UMR6533-SARPOR-001/Default.aspx

- Applications include a CV and a motivation letter
  - Motivation letter should be enriched with your proposal regarding the analysis topic you are interested in

- At least 2 recommendation letters should be sent to
  - Philippe Crochet (philippe.crochet@cern.ch), ALICE LPCA group leader
  - Sarah Porteboeuf Houssais (sarah.porteboeuf@cern.ch), MFT project leader

- Selected candidates will be contacted for an oral interview

Contact us to discuss further your project !

Input for discussion

- the MFT TDR http://cds.cern.ch/record/1981898/files/?ln=fr

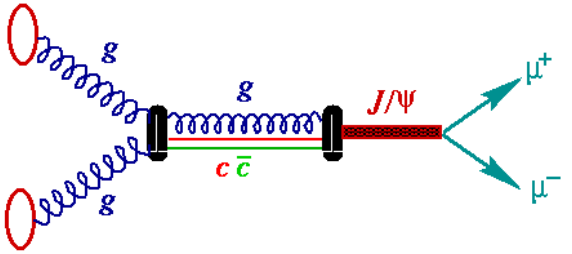
- Review on opportunities with quarkonia https://hal.science/hal-02097258v1

- series of Quarkonia as Tool conference series : https://indico.cern.ch/event/1324160/overview

sarah.porteboeuf@cern.ch

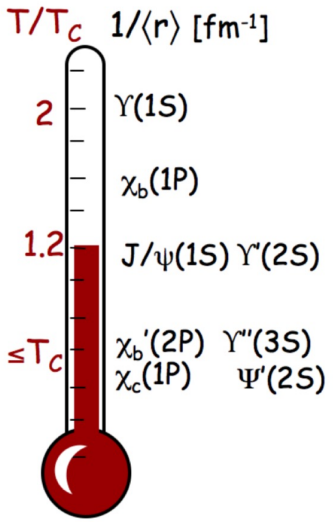
Quarkonia as QGP probe

- **Quarkonia**, bound states of charm and beauty quarks,
  - Charmonia ($c\bar{c}$): e.g. J/ψ and Ψ(2S)
  - Bottomonia ($b\bar{b}$): e.g. Υ(1S), Υ(2S) and Υ(3S)

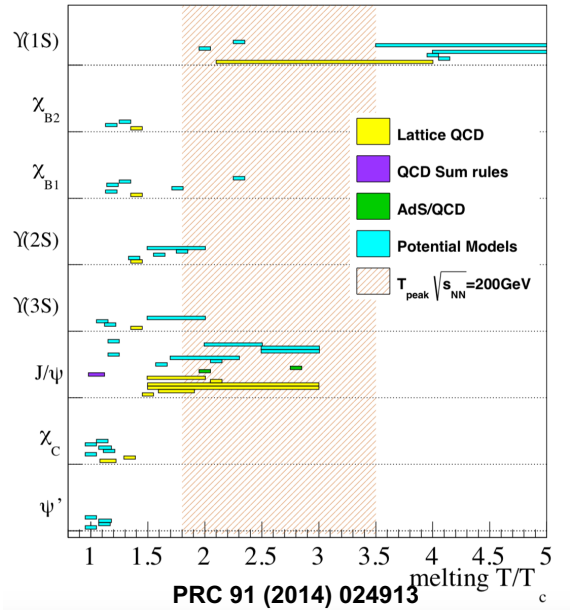


- Quarkonia, produced in first stage of AA collisions, experience the full QGP evolution:
  - **Quarkonium sequential suppression** via color screening [Matsui and Satz, PLB178 (1986) 416]
  - **Quarkonium regeneration**

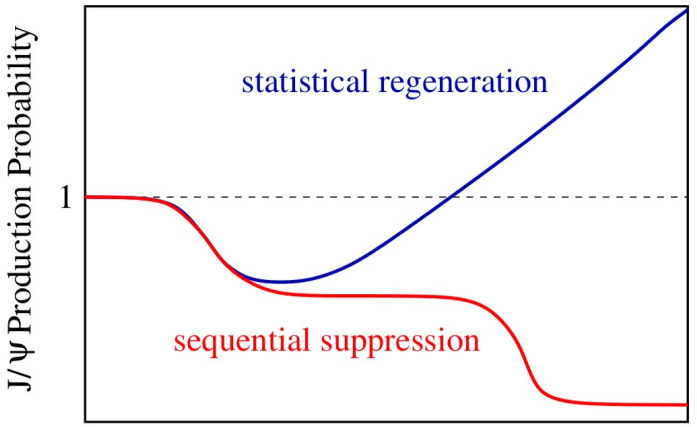
[Braun-Munzinger & Stachel, PLB 490 (2000) 196 ; Thews, Schroedter & Rafelski, PRC 65 (2001) 054905]



Eur Phys J C61 (2009) 705

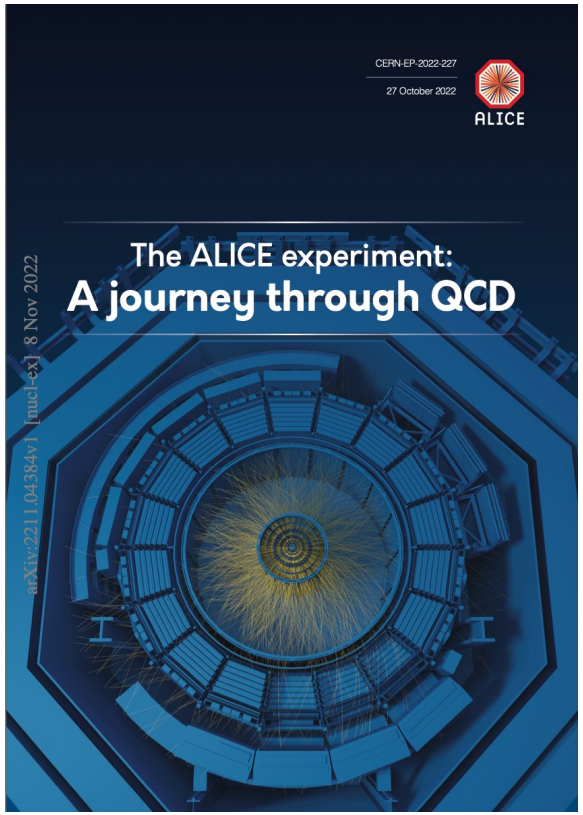


PRC 91 (2014) 024913



NPB 214 (2011) 3

Review of ALICE Run 1+2

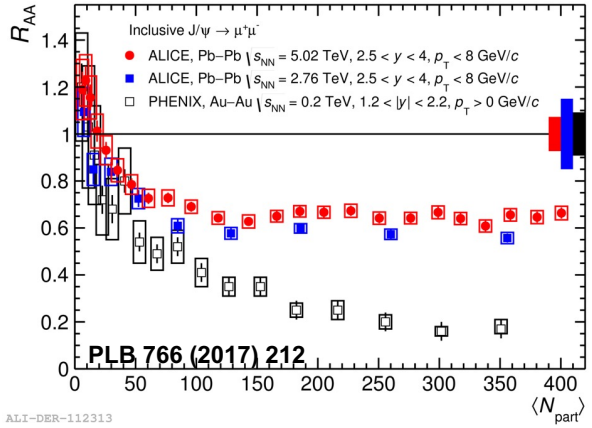


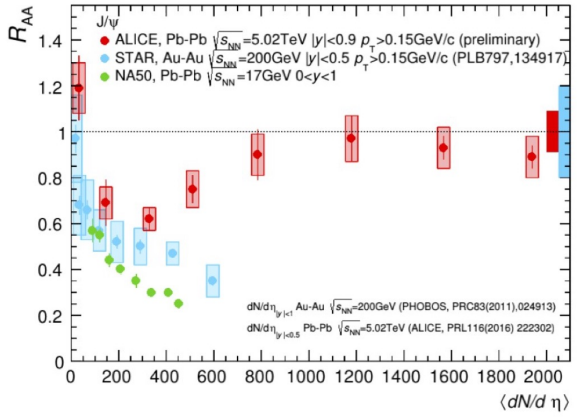
CERN-EP-2022-227 / arXiv:2211.04384

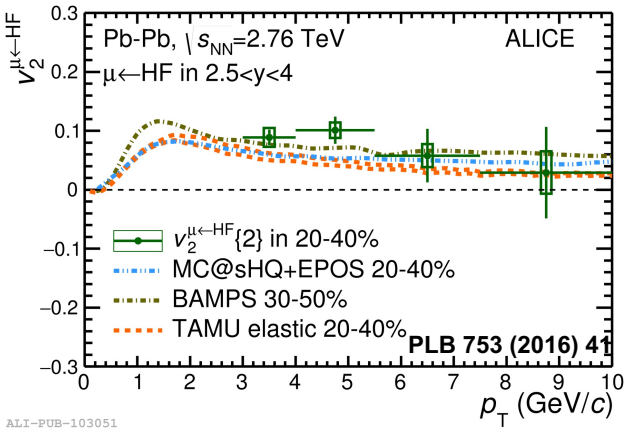
QGP physics with muons at Run 1+2

- **Muons are powerful tool to study QGP properties via a large set of probes**
  Quarkonia, Open Heavy Flavor, Dileptons, Vector bosons
  ALICE is well equipped with the muon spectrometer

- **LHC Runs 1 and 2 allowed a deep understanding of QGP with muons**
  J/ψ regeneration, path-length dependence of energy loss and participation of heavy quarks in the collective expansion

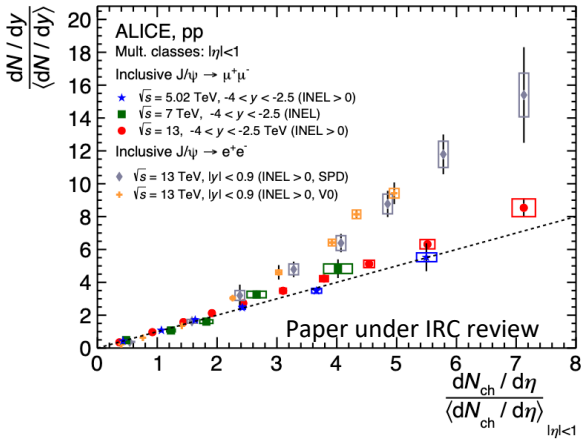


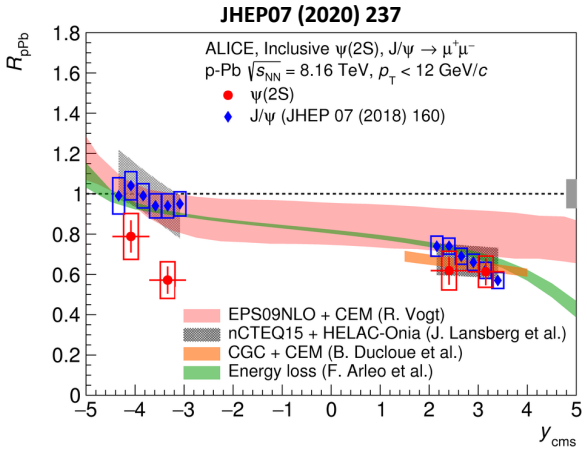


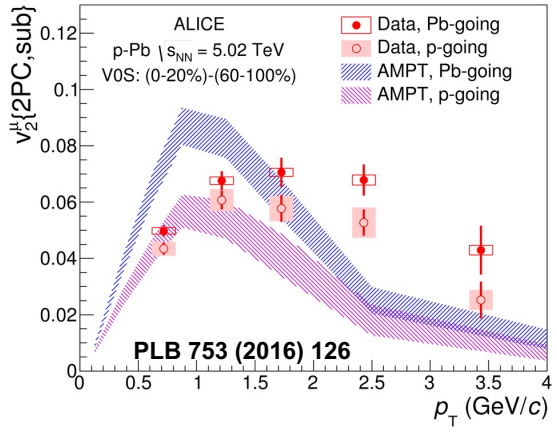


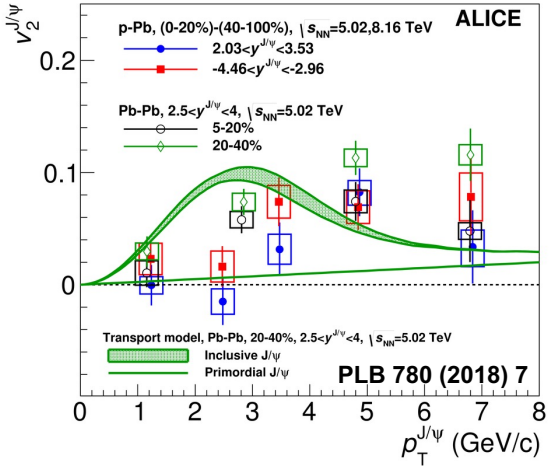
Muons contribute to small systems studies

- **LHC revealed unexpected features of high-multiplicity events in small systems**
  Questioning our understanding of initial vs. final state and emergence of collectivity
  Muon physics already contributes to this open questions







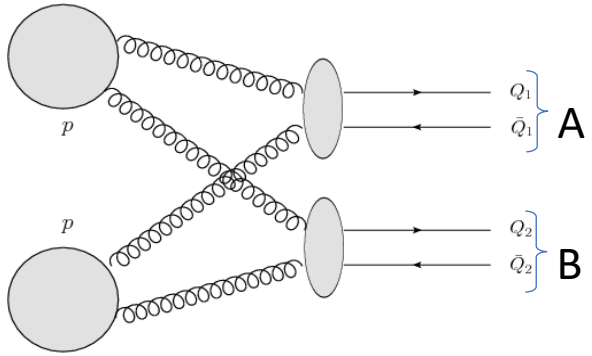


MFT opening possibilities for DPS

- DPS formalism 2 hard processes are independent (MPI) and factorize

$$\sigma_{DPS}^{AB} = \frac{m}{2}\frac{\sigma_{SPS}^{A}\sigma_{SPS}^{B}}{\sigma_{eff}}$$

m=2 when A and B are distinguishable
m=1 when indistinguishable
σ_{eff} universality in question



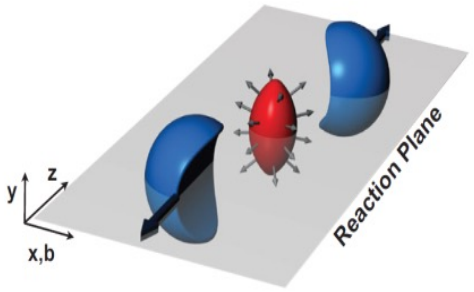
- Linked between MPI formalism and nucleon structure
- Potential signals with 4 leptons: J/ψ + J/ψ J/ψ + Υ, J/ψ + W, J/ψ +Z, Υ + Υ
- J/ψ + D mesons, measured by LHCb with D in the hadronic channel
- Require to investigate physics potential and feasibility with ALICE in Run 3 conditions: with muons only, with muons + electrons, with muons + hadronic channels

PRD 90 (2014) 111101 , JHEP 1409 (2014) 094, JHEP 10 (2016) 063 , PRL 116 (2016) 082002, EPJC 77 (2017) 76, JHEP 06 (2017) 047, JHEP 10 (2017) 068, JHEP 05 (2017) 013

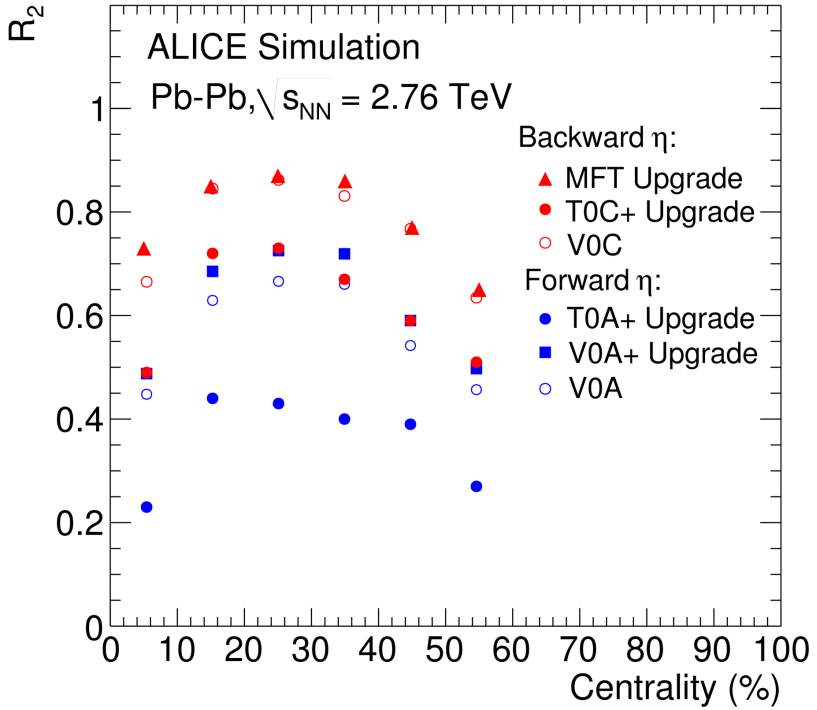
- Possibilities should be enhanced by the continuous readout
  The MFT will specifically improve the signal/background for channels where the signal is composed of prompt muons. First study by D. Stocco and P. Bartalini

MFT opening possibilities as multiplicity estimator

- **In addition to muon tracks, MFT will measure unidentified tracks**
- **Clear benefit for study of hard-soft correlations**, like quarkonia vs. multiplicity, with a multiplicity estimator in the acceptance of the hard probes
- Reaction plane measurement

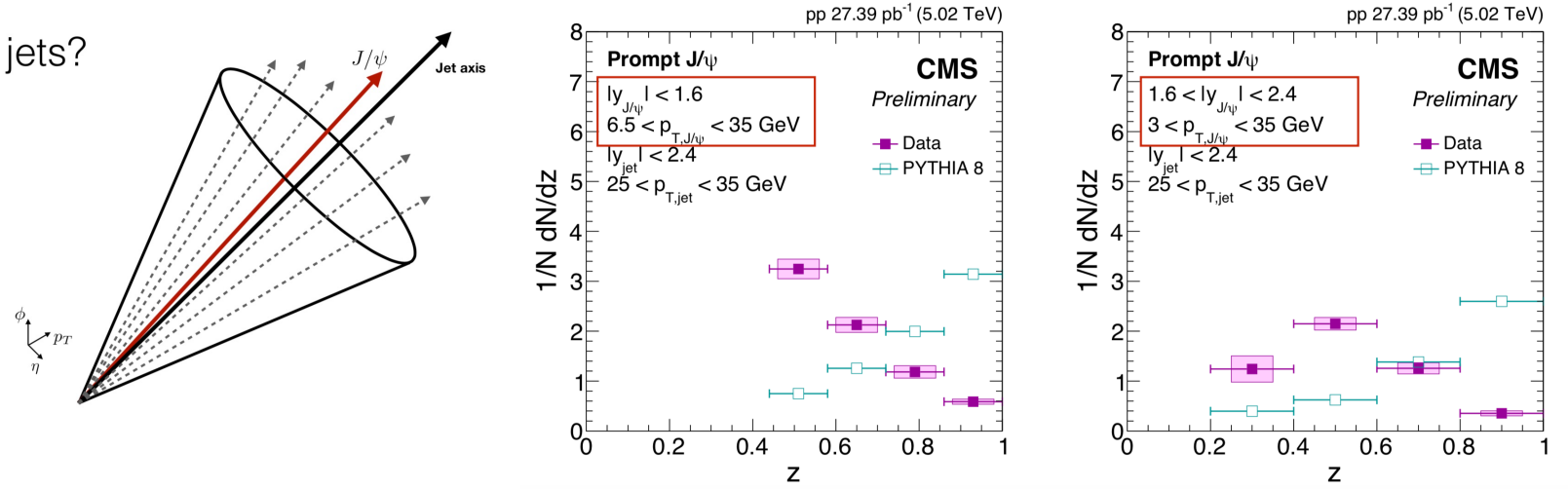


- **Excellent reaction plane resolution with the MFT**, thanks to its high-granularity and the possibility to perform a standalone tracking



MFT opening possibilities for quarkonium in dense hadronic environment

- Quarkonium production are not yet understood and no theoretical knowledge about quarkonium fragmentation function, poor implementation in MC event generators
- **A key measurement is quarkonia in jet**, see workshop *Quarkonia as Tools*
  https://indico.cern.ch/event/745939/
- First measurements from CMS: J/ψ less isolated in data than in PYTHIA 8

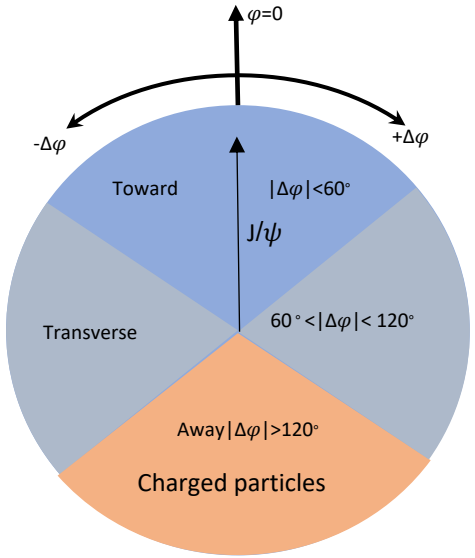


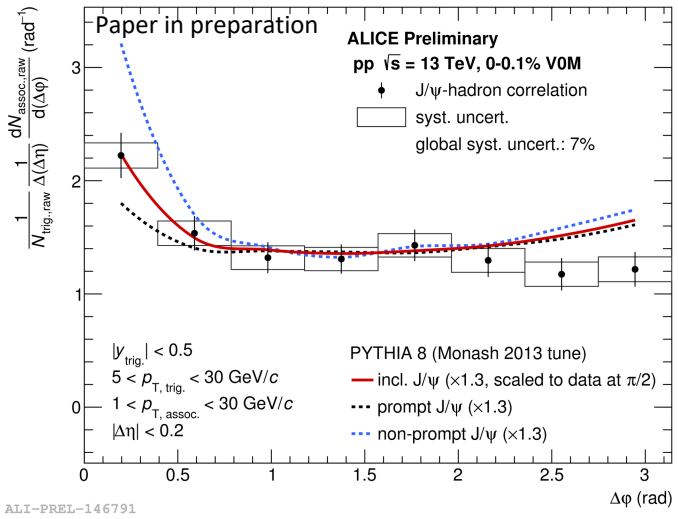
- Also : *Study of J/ψ meson production inside jets in pp collisions at $\sqrt{s}$=8 TeV* **PLB 804 (2020) 135409**
- **Feasibility to be investigated with Muon Spectrometer + MFT ?**

MFT opening possibilities for correlations studies

- LHC results point to a **need of a full tomography of the final state**, understanding links between the underlying event/bulk/soft part and hard components

- **Underlying event studies with "muon" as leading particle**





- **Opportunities to be investigated** in the muon channel **with the MFT** as a vertexer and a multiplicity estimator