

ALICE Upgrade and Physics Topics (I)



Kenta Shigaki

(Hiroshima U. 広島大学)



4th Workshop on

Clustering as a Window on the Hierarchical Structure of Quantum Systems

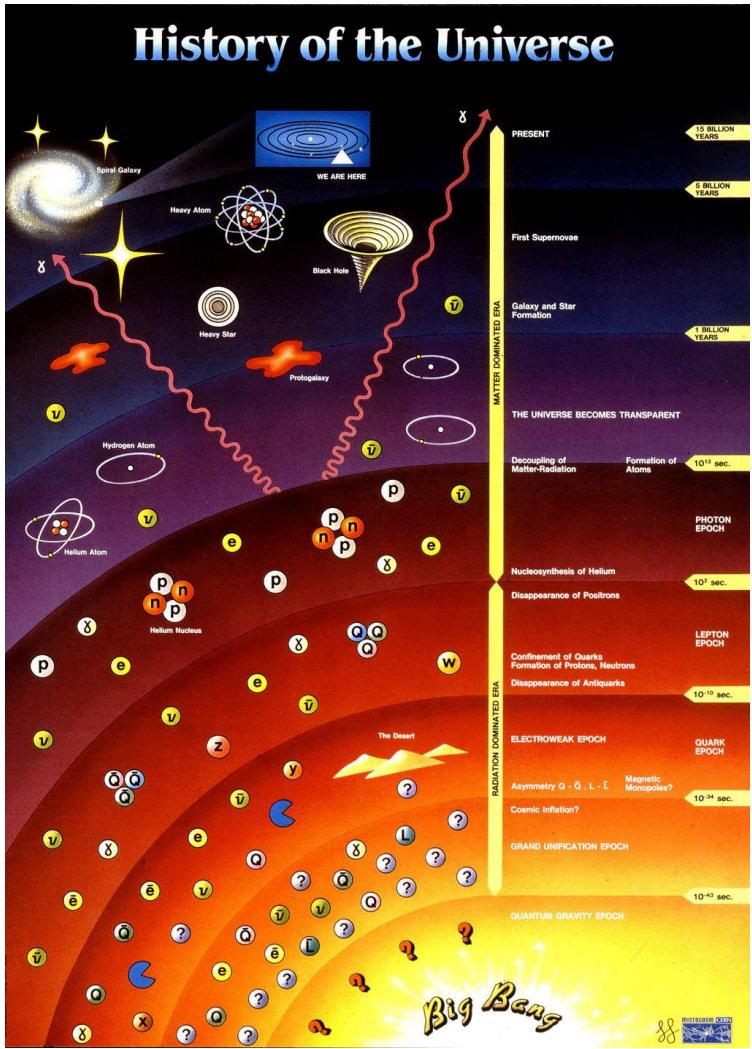
28 May 2020, Online

“A01” Presentation Plan



- ALICE Upgrade and Physics Topics (I) – K. Shigaki
 - ALICE and research group A01 overview
 - research group A01 status
 - muon forward tracker status and outlook
 - physics topic (1) – hadronization w/ charm
- ALICE Upgrade and Physics Topics (II) – T. Gunji
 - time projection chamber upgrade status and outlook
 - LHC/ALICE upgrades status
 - ALICE outlook and run plan
 - physics topic (2) – baryon, (anti-)nucleus

Quark and Hadron Hierarchies



14 by

this workshop

1 by

star/galaxy formation

10^{12} s

atom formation

10^2 s

nuclei synthesis

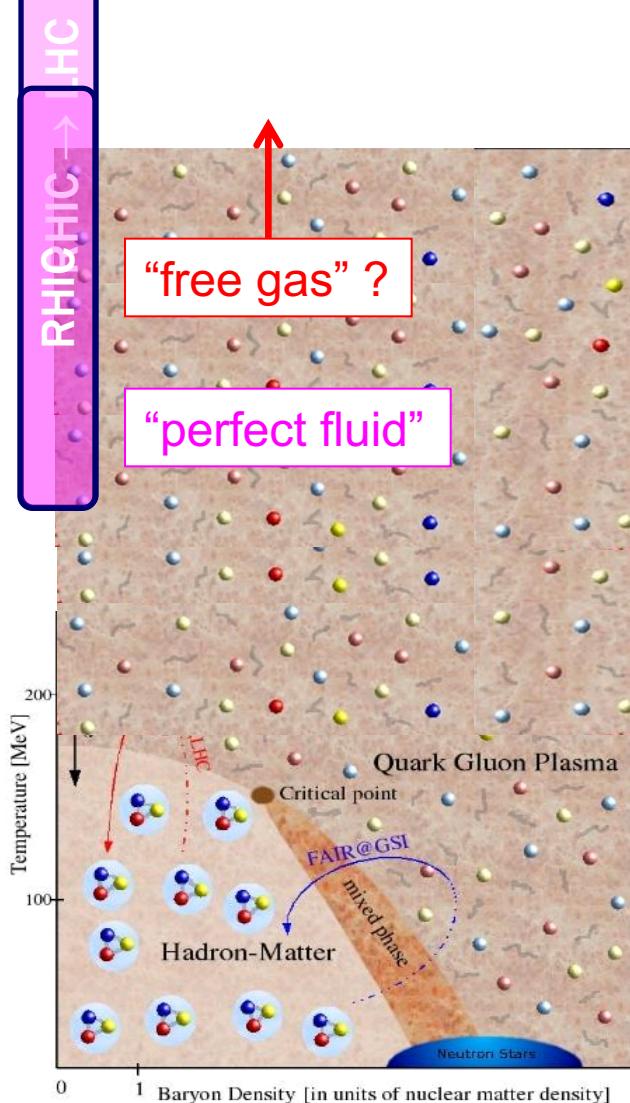
10^{-6} s

quark confinement
anti-quark annihilation
quark pair production

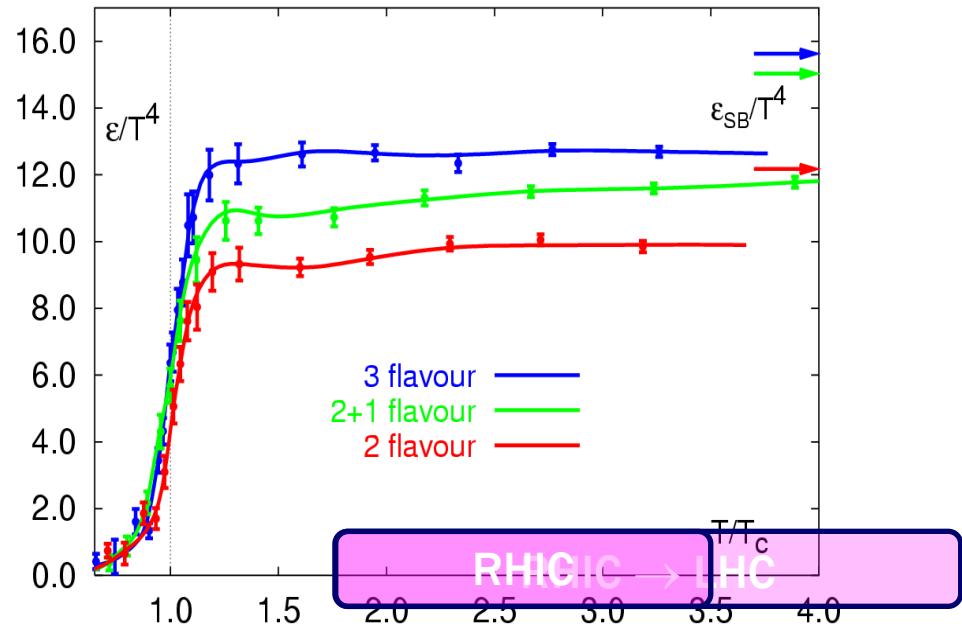
0.00 s

Big Bang

Boundary Re-Crossed in Early 2000's



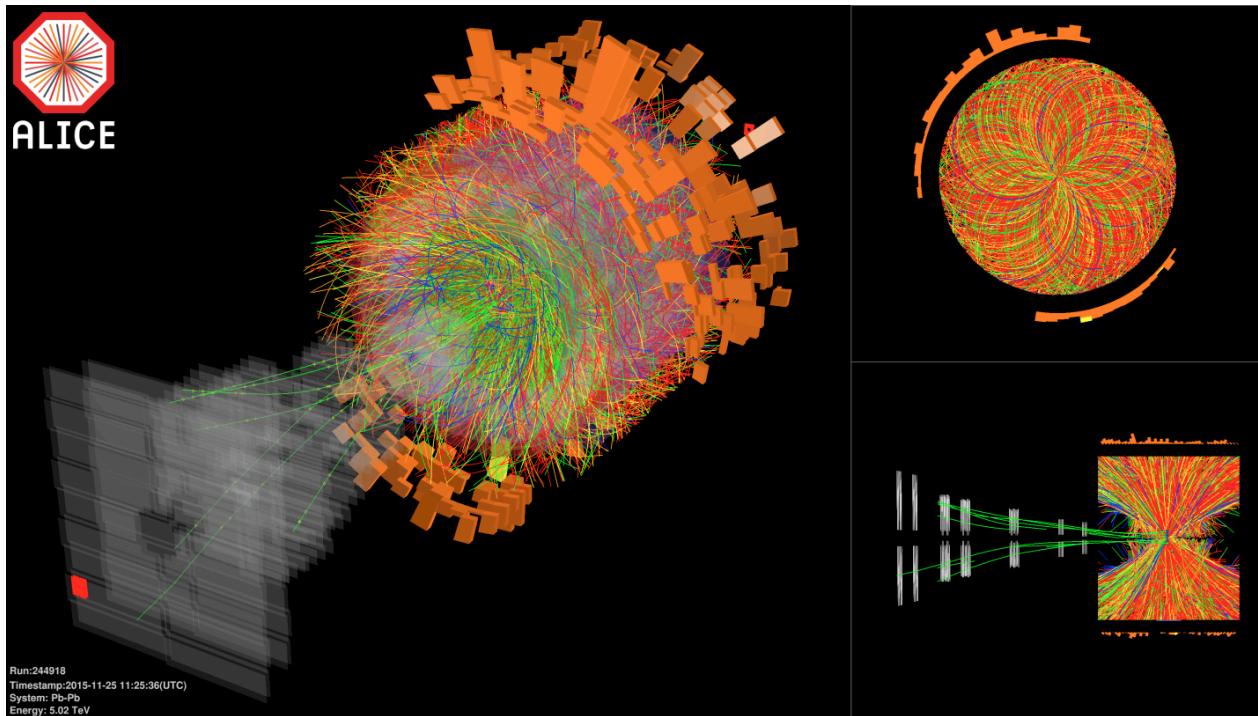
F. Karsch,
Lect. Notes Phys. 583, 209 (2002)



Most Energetic Heavy Ion Collisions



- 5.0 TeV per nucleon-nucleon pair at CERN LHC
 - 25 times higher than at BNL RHIC in U.S.A.



- design energy at 5.5 TeV in 2021(?)

A Large Ion Collider Experiment



- the nucleus-nucleus collision experiment at LHC
- 39 countries; 175 institutes; ~1,900 members

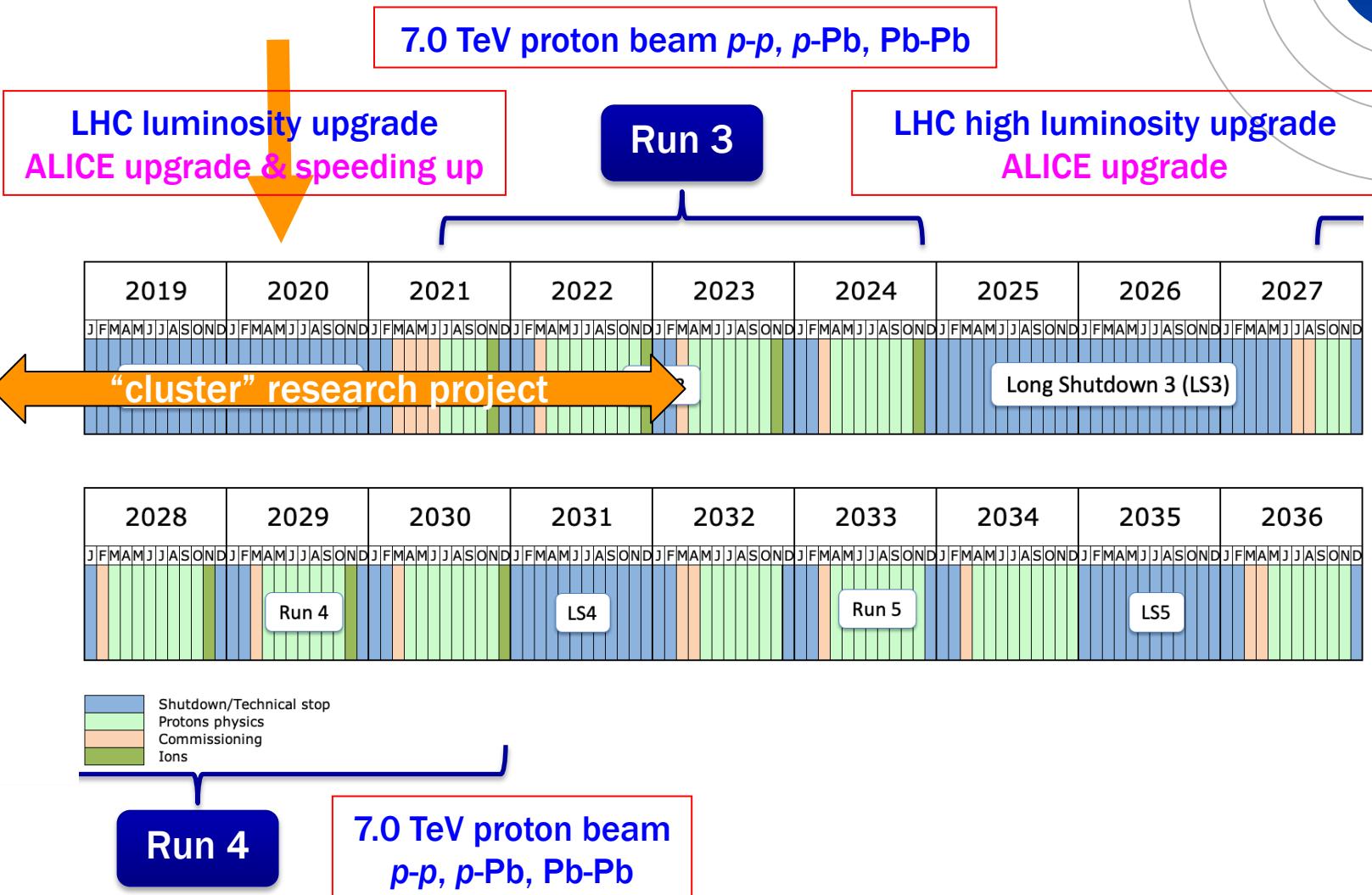


Research Project “A01” Members



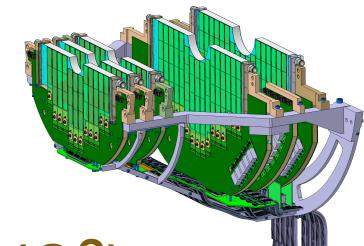
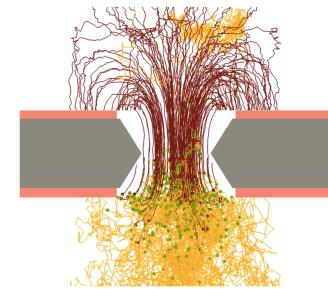
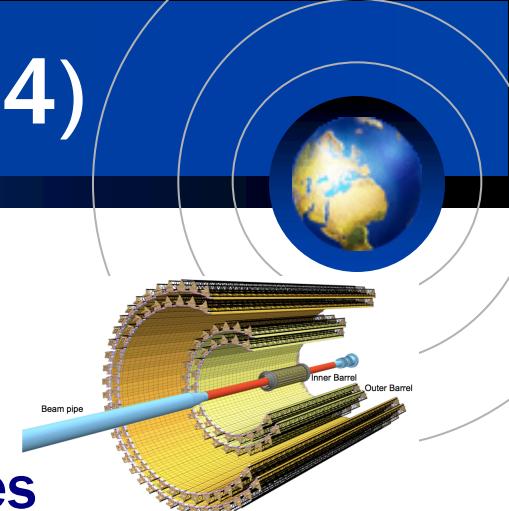
- principal investigator **Kenta SHIGAKI (Hiroshima)**
 - new forward tracking detector
- co-investigator **Hideki HAMAGAKI (Nagasaki IAS)**
 - data handling scheme upgrade
- co-investigator **Tatsuya CHUJO (Tsukuba)**
 - grid computing core facility
- co-investigator **Taku GUNJI (Tokyo)**
 - main tracking detector upgrade
- research collaborator **Maya SHIMOMURA (Nara Women's)**
 - conducting experiment, physics analysis

Where We Are at LHC



Upgrades for Run 3 (2021–2024)

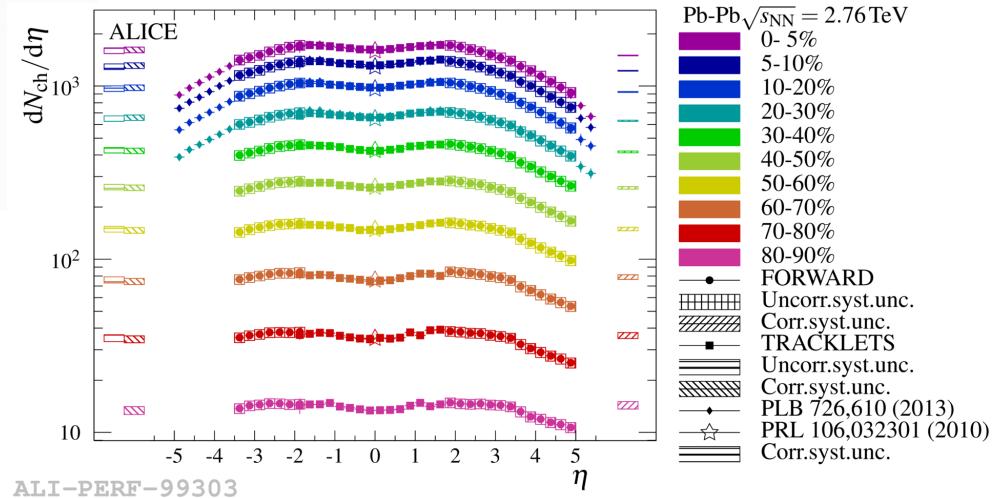
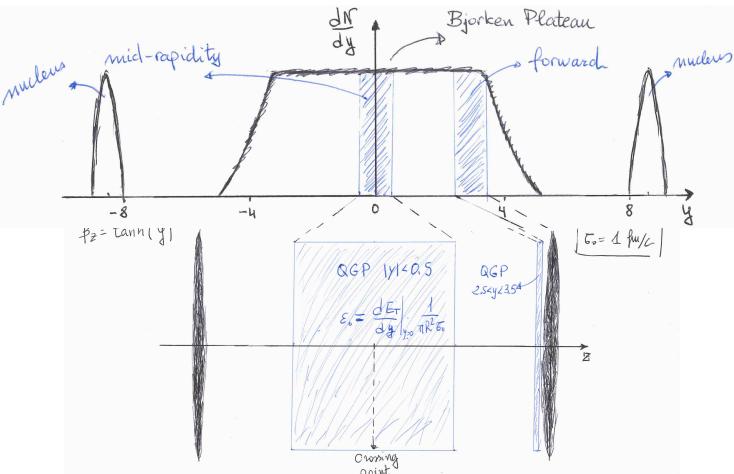
- new inner tracking system
 - 7 layers of MAPS silicon pixel detectors
 - precise measurement of displaced vertices
 - to separate charm/beauty mesons
- new TPC readout chambers
 - GEM technology with no gating grid
 - ~100 times higher data taking rate (50 kHz in Pb-Pb)
 - continuous readout without triggering
- Muon Forward Tracker (MFT)
- integrated online/offline data handling (O^2)



Aufheben of e + μ Measurements



- two interesting regimes of quark-gluon phase
 - exploration on QCD phase diagram

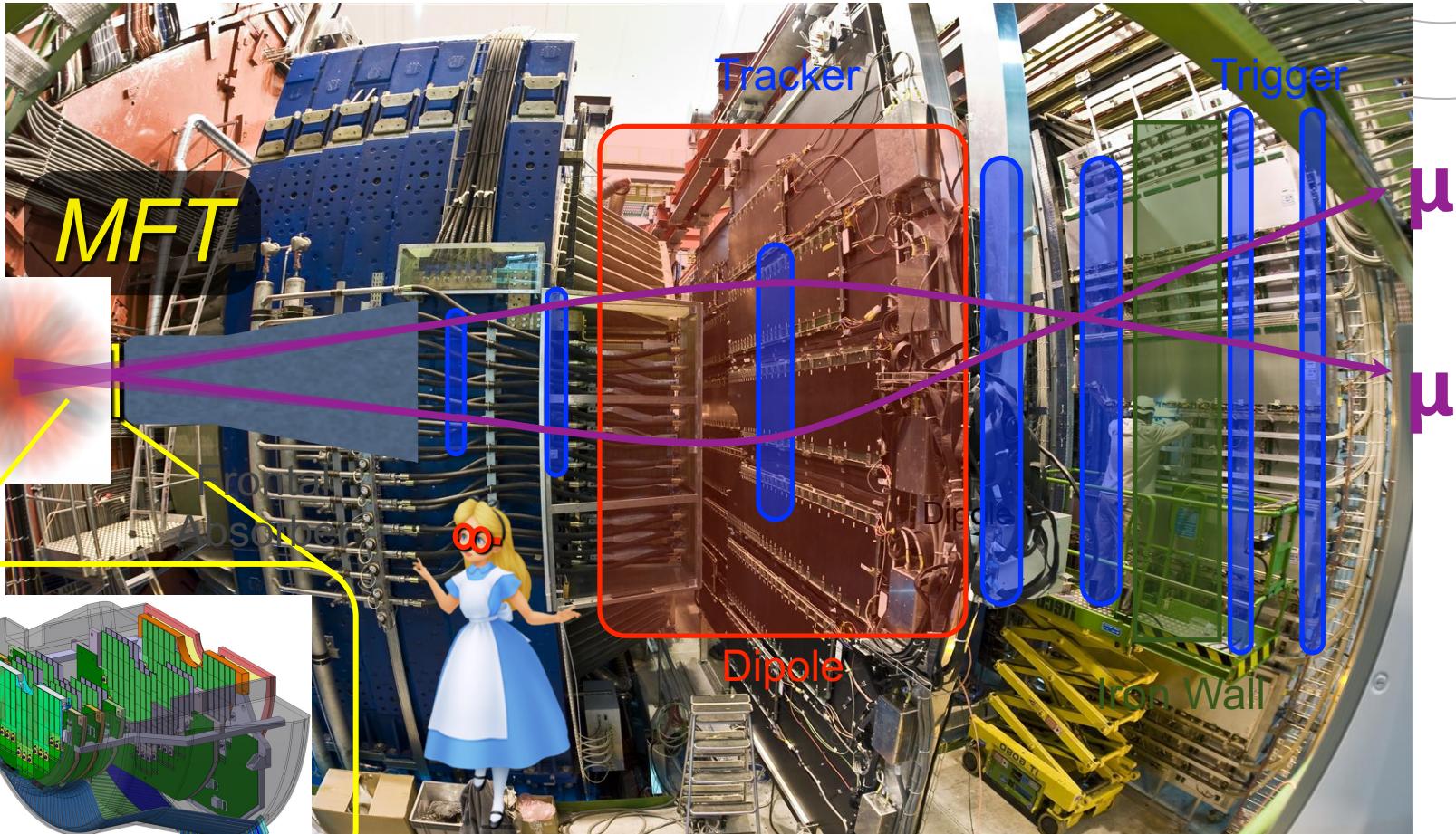


- new opportunity via muons at LHC (and above)
 - not too forward for “central” physics
 - technically forward enough for muon measurement

Muon Forward Tracker (2021-)



- precise vertex and invariant mass measurements



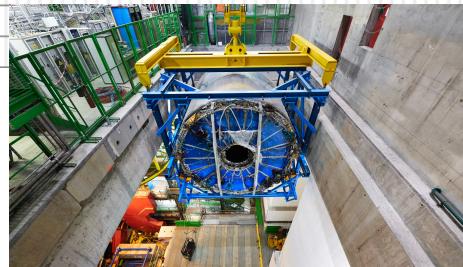
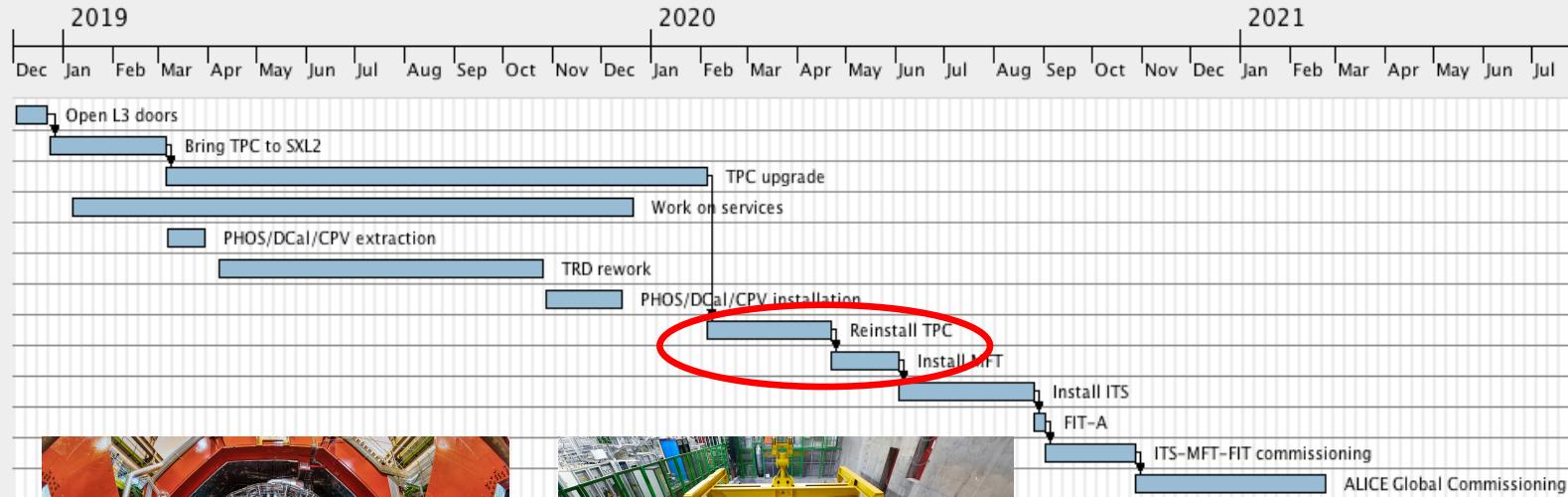
Upgrade Activities Halted (Resuming)



- detector components removed and ...



Begin date	End date	Duration
3/12/18	21/12/18	15
24/12/18	5/3/19	52
6/3/19	4/2/20	240
7/1/19	20/12/19	250
7/3/19	29/3/19	17
8/4/19	25/10/19	145
28/10/19	13/12/19	35
5/2/20	21/4/20	55
22/4/20	2/6/20	30
3/6/20	25/8/20	60
26/8/20	1/9/20	5
2/9/20	27/10/20	40
28/10/20	22/2/21	84



2020/05/28

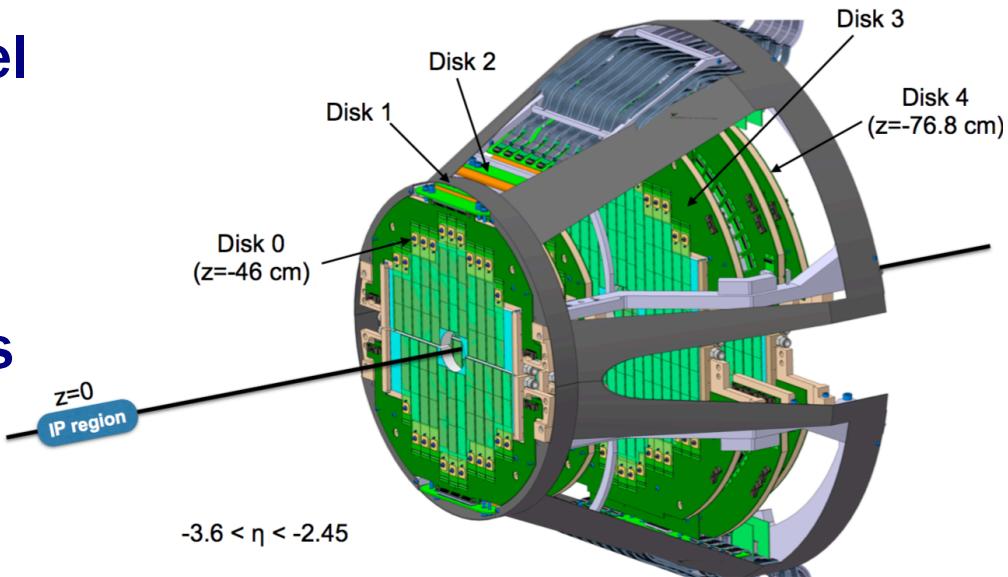
ALICE Upgrade and Physics Topics (I) – K. Shigaki

11/21



Muon Forward Tracker Design

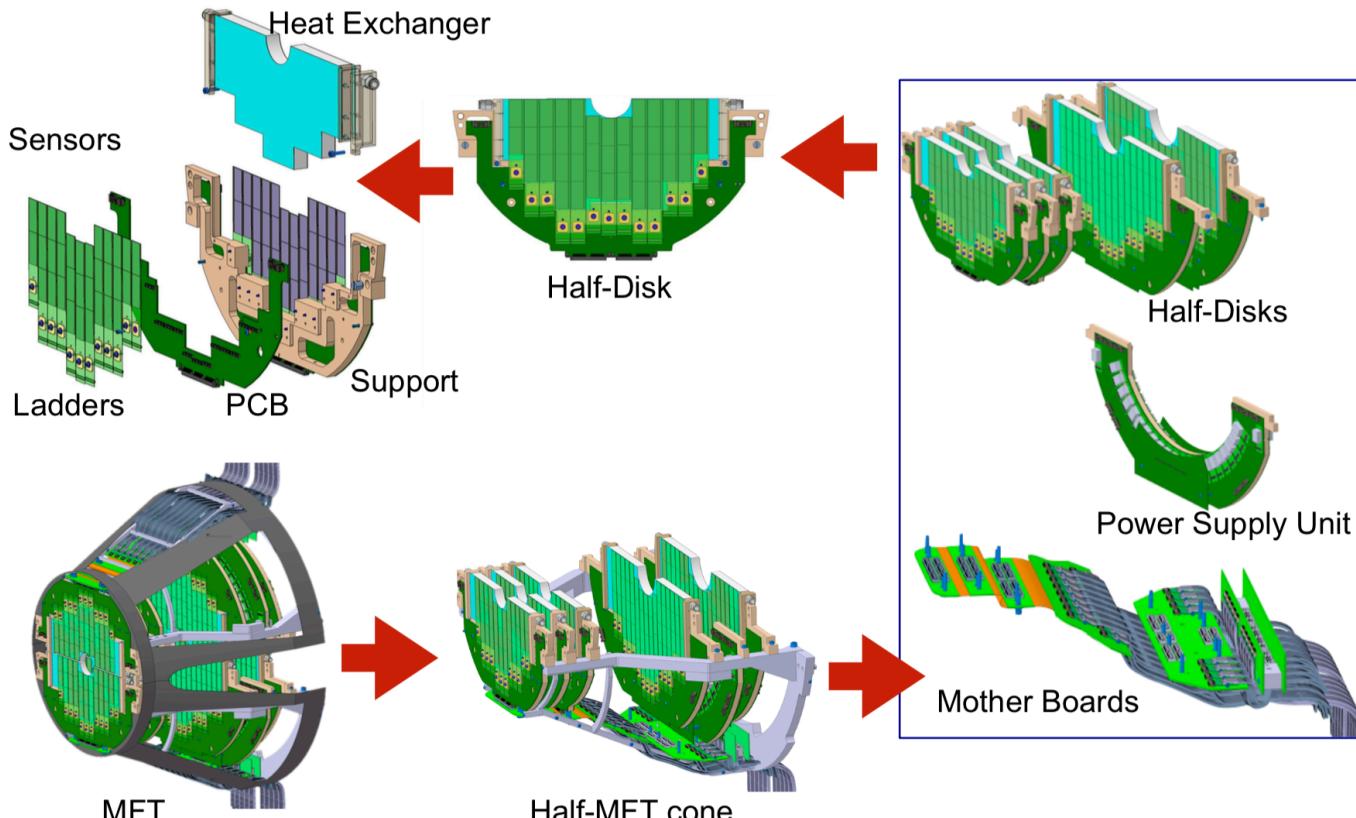
- $2.45 < -\eta < 3.6$
 - $-z = 460-768 \text{ mm}$
- 0.4 m^2 of MAPS silicon pixel sensors
 - $28 \mu\text{m} \times 28 \mu\text{m}$ pixel
 - $0.35\% X_0$ per layer
- 10 sensitive layers
 - 5 double sided disks
- precise vertexing capability for forward muons
- Pb-Pb $\sim 50 \text{ kHz}$, $p\text{-}p \sim 200 \text{ kHz}$



MFT Structure and Elements



- chip (936)/ladder (280)/zone (80)/half plane (20)
/half disk (10) + PS unit (2)/half MFT (2)/MFT (1)

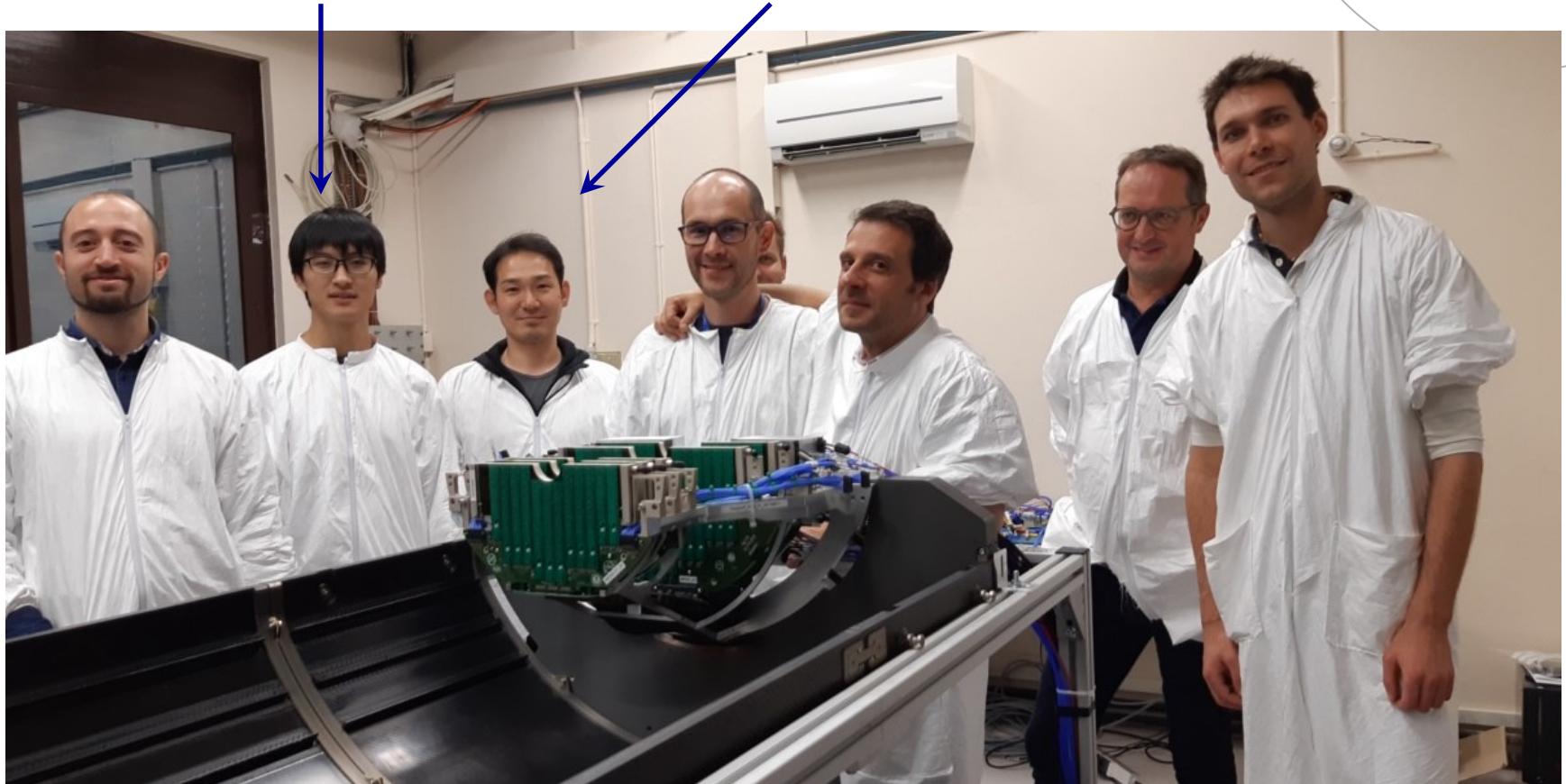


First Half MFT Assembly in 2019/10



Motomi Oya (HU grad. student)

Yorito Yamaguchi (HU)



Assembly Completed by 2020/03



- full MFT = top and bottom half MFT's
- control system led by Hiroshima team

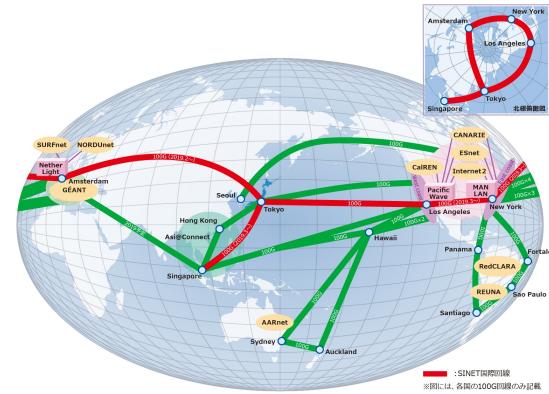
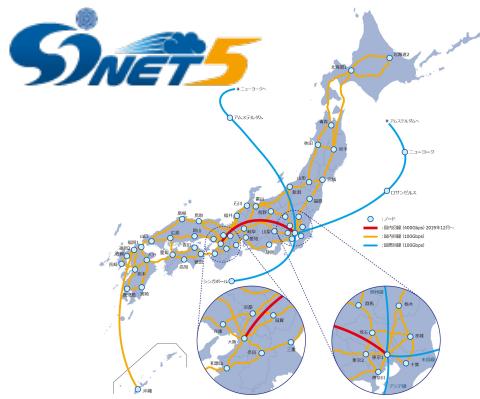


- activities at CERN now restarting
- installation into cavern hopefully in 2020/10

ALICE Computing Grid Activities



- resource allocation required to ALICE Japan
 - CPU 18 kHS06, storage 2.0 PB (as of 2020)
- enhancing Tsukuba T2
 - more worker nodes, storage, band width
 - 168 TB RAID added
 - 10 Gbps fiber connection to SINET5 via Hepnet-J

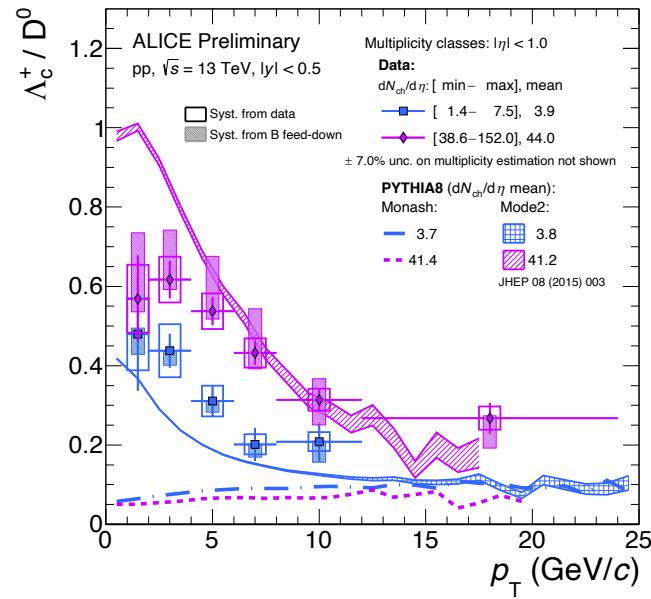
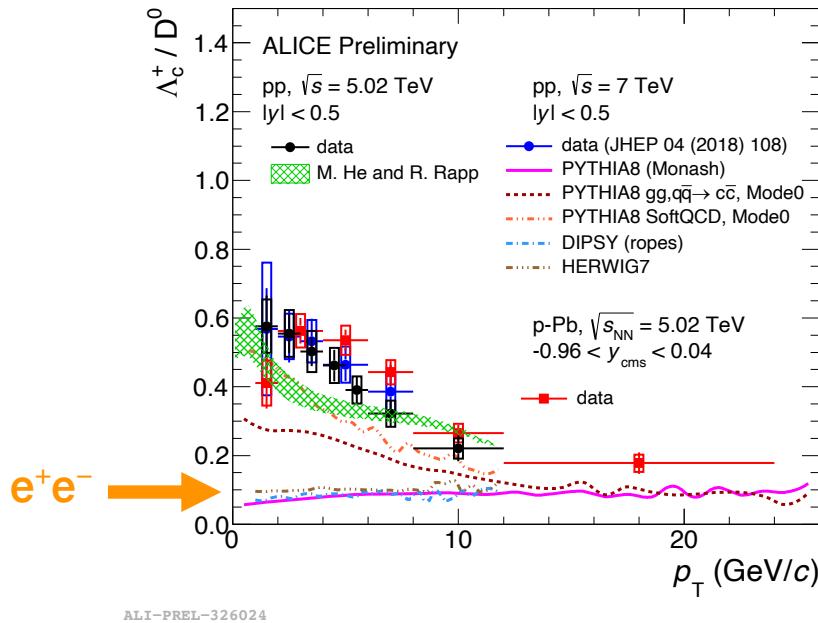


- reenabling Hiroshima T2 from temporary shutdown

Hadronization Probed with Charm

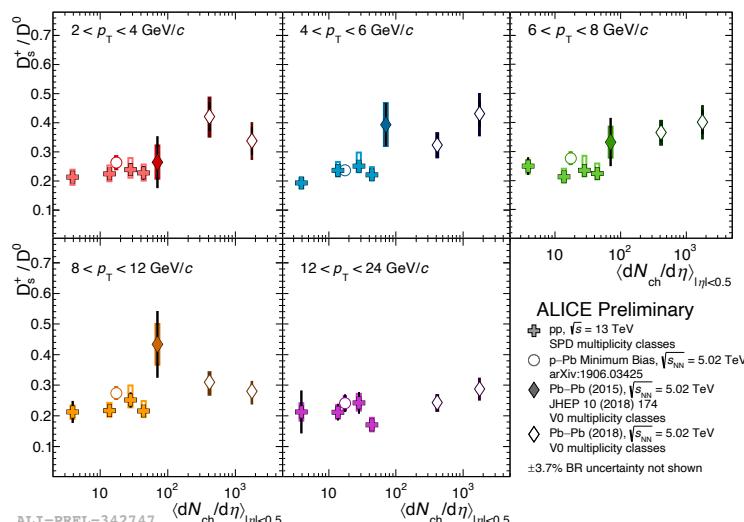
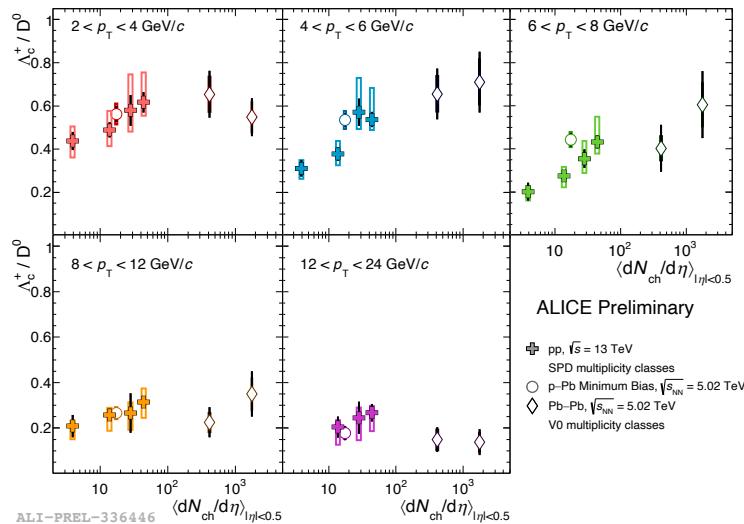
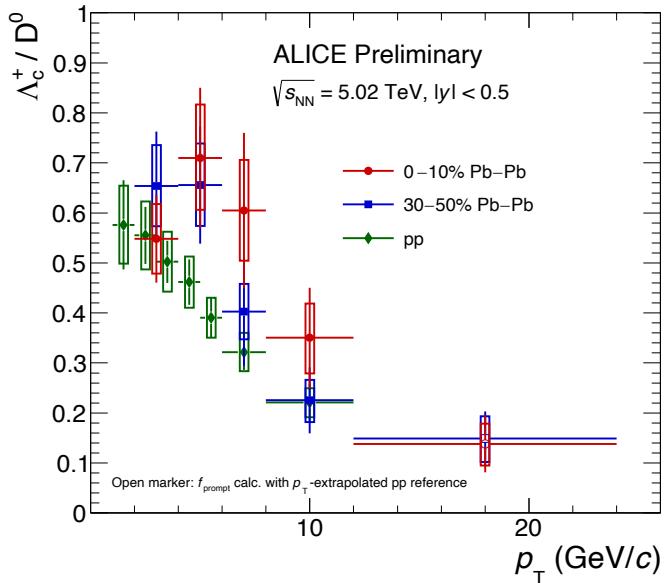


- baryon/meson ratio higher in pp, pA than e^+e^-
- seemingly non-universal fragmentation



- color reconnection?
- statistical hadronization model?

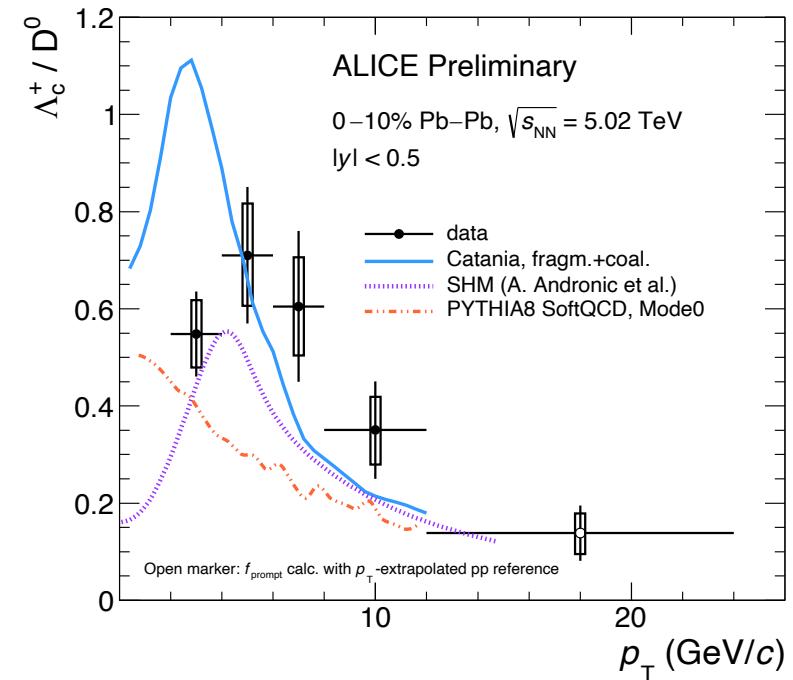
Baryon (+ Strangeness) Enhancement



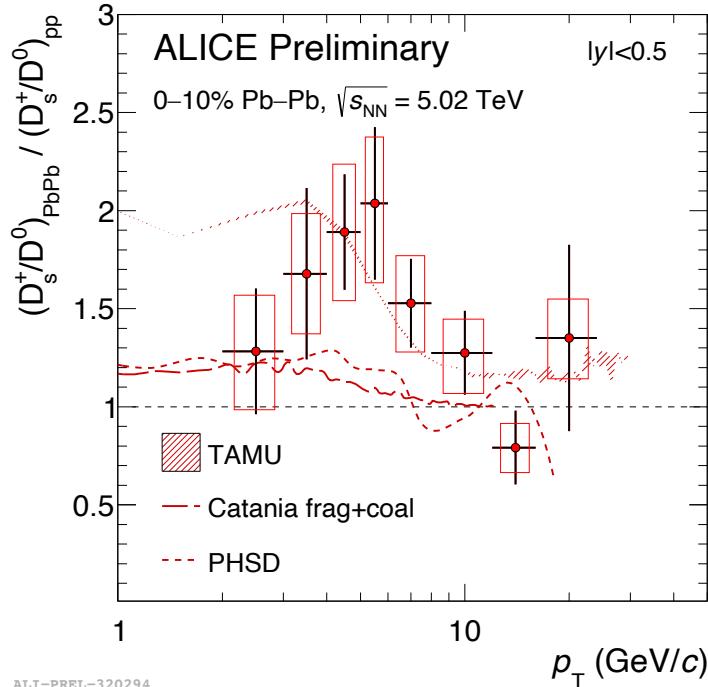
- consistent with coalescence in strangeness-rich medium

Comparison to Models

- consistently explained with:
 - fragmentation + coalescence
 - statistical hadronization model



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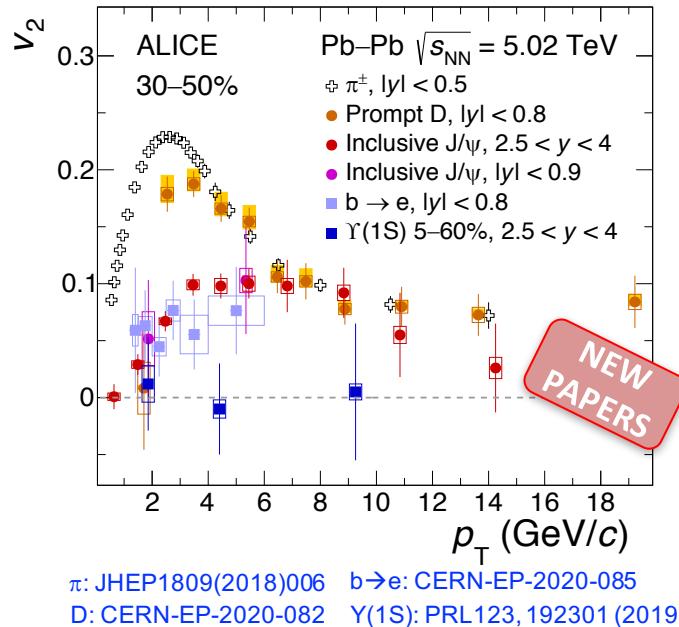


ALI-PREL-320294

Charm (and Beauty) Flow



- J/ψ (2 charms) < D (1 charm) < π (no charm)
- beauty < charm
- no indication with $\Upsilon(1S)$ (2 beauties)



- consistent with coalescence w/ mass hierarchy

(Interim) Summary and Remarks



- deconfined quarks: most fundamental hierarchy
 - only by high energy nucleus-nucleus collisions
- ALICE at LHC exploring quark physics frontier
- preparation toward upgraded runs (2021–)
 - x 100 higher rate for rare/hard-to-trigger phenomena
- well on track till COVID-19 pandemic
 - major Japanese contributions on MFT, TPC, CRU, etc.
 - mostly offline activities now; hopefully recovering
- finer harvests, e.g. charm/beauty, to come soon
 - unique laboratory for hadron physics as well