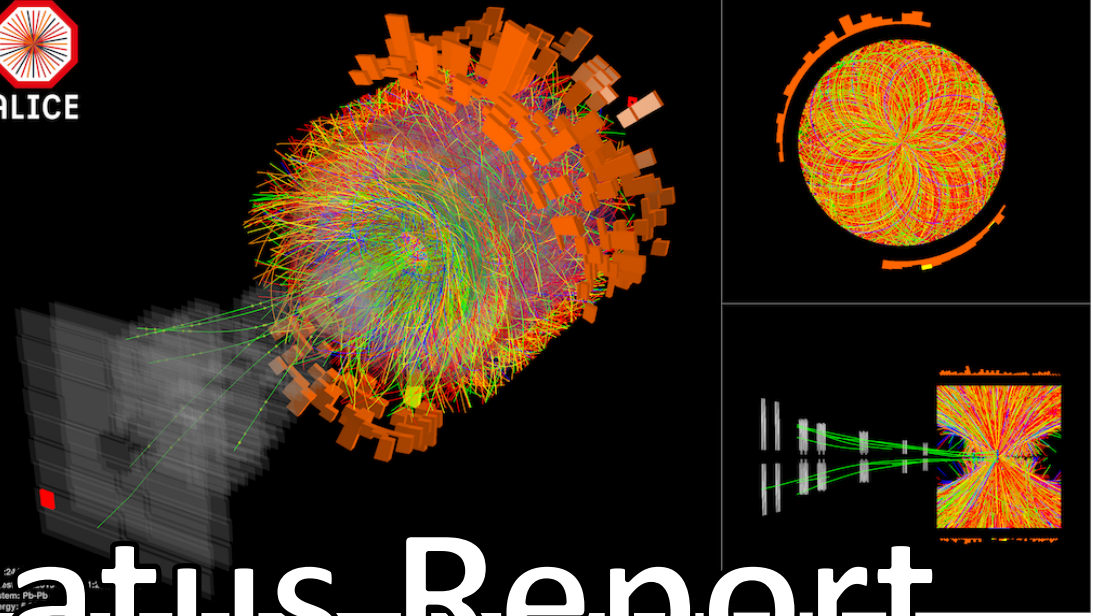




ALICE

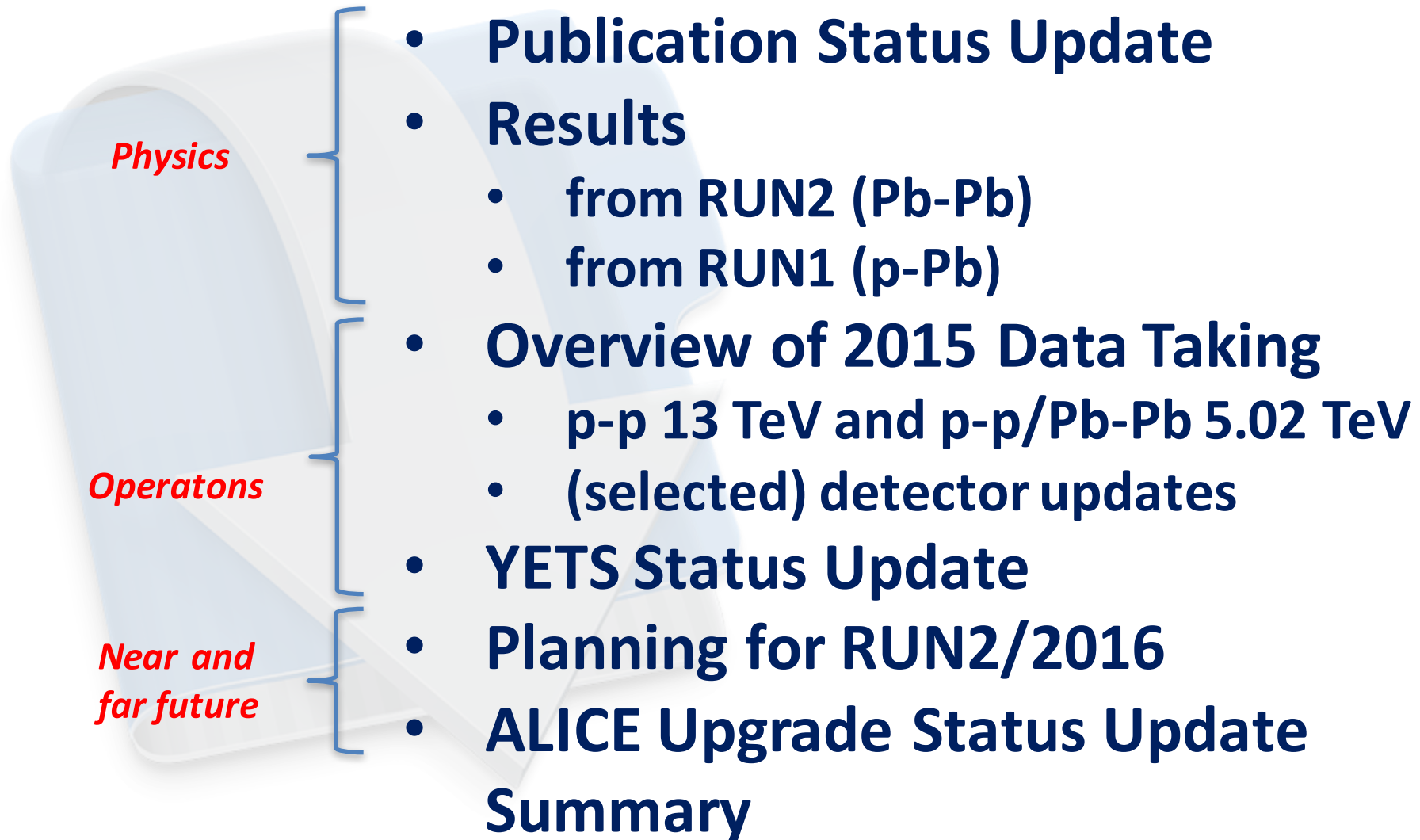


Status Report

ALICE

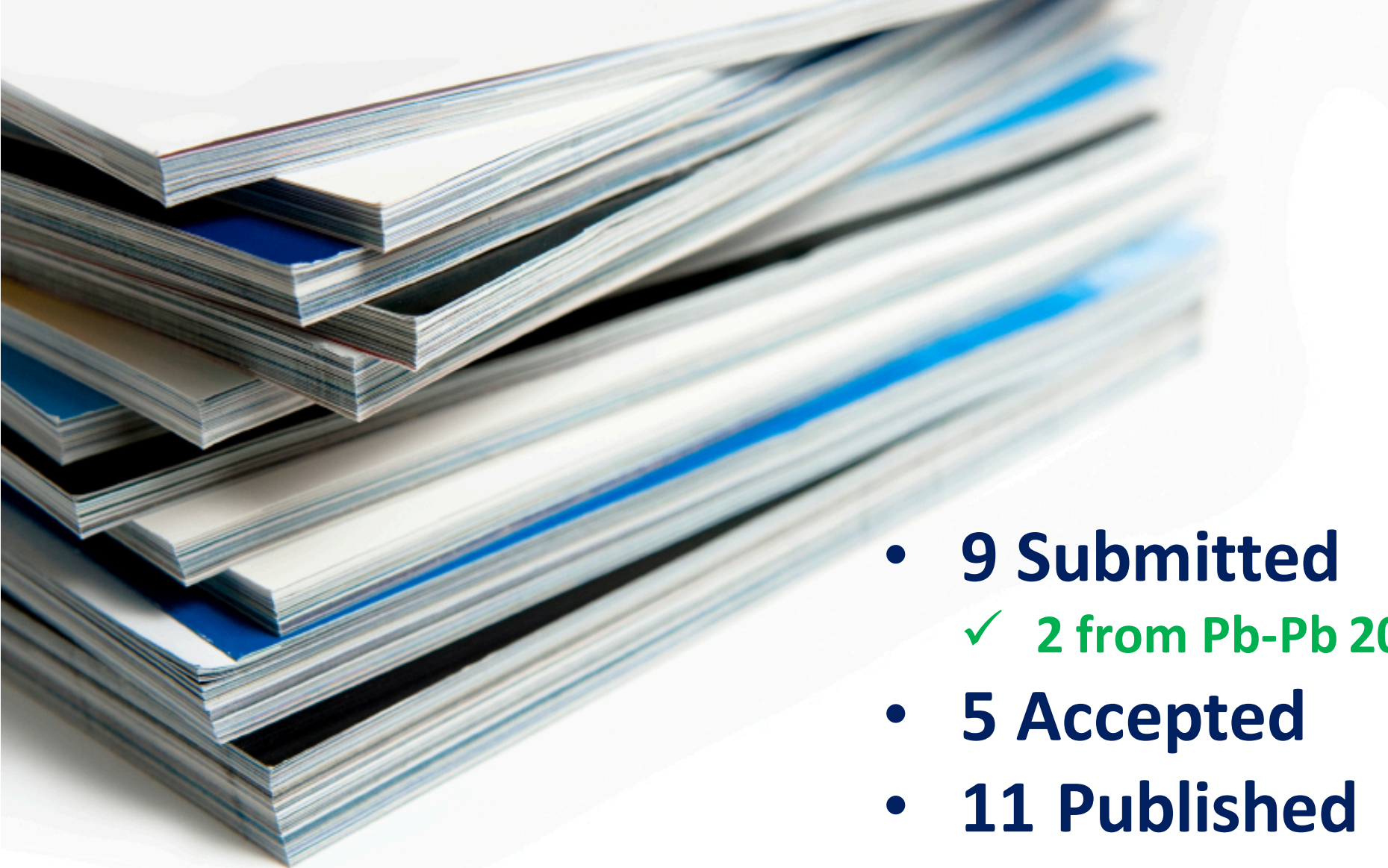
Federico Ronchetti
on behalf of the ALICE Collaboration

125th LHCC Open Session – CERN



Publications Status Update

A Large Ion Collider Experiment



- **9 Submitted**
 - ✓ **2 from Pb-Pb 2015**
- **5 Accepted**
- **11 Published**

9 Submitted Articles (since last LHCC, Dec 2nd 2015)

A Large Ion Collider Experiment

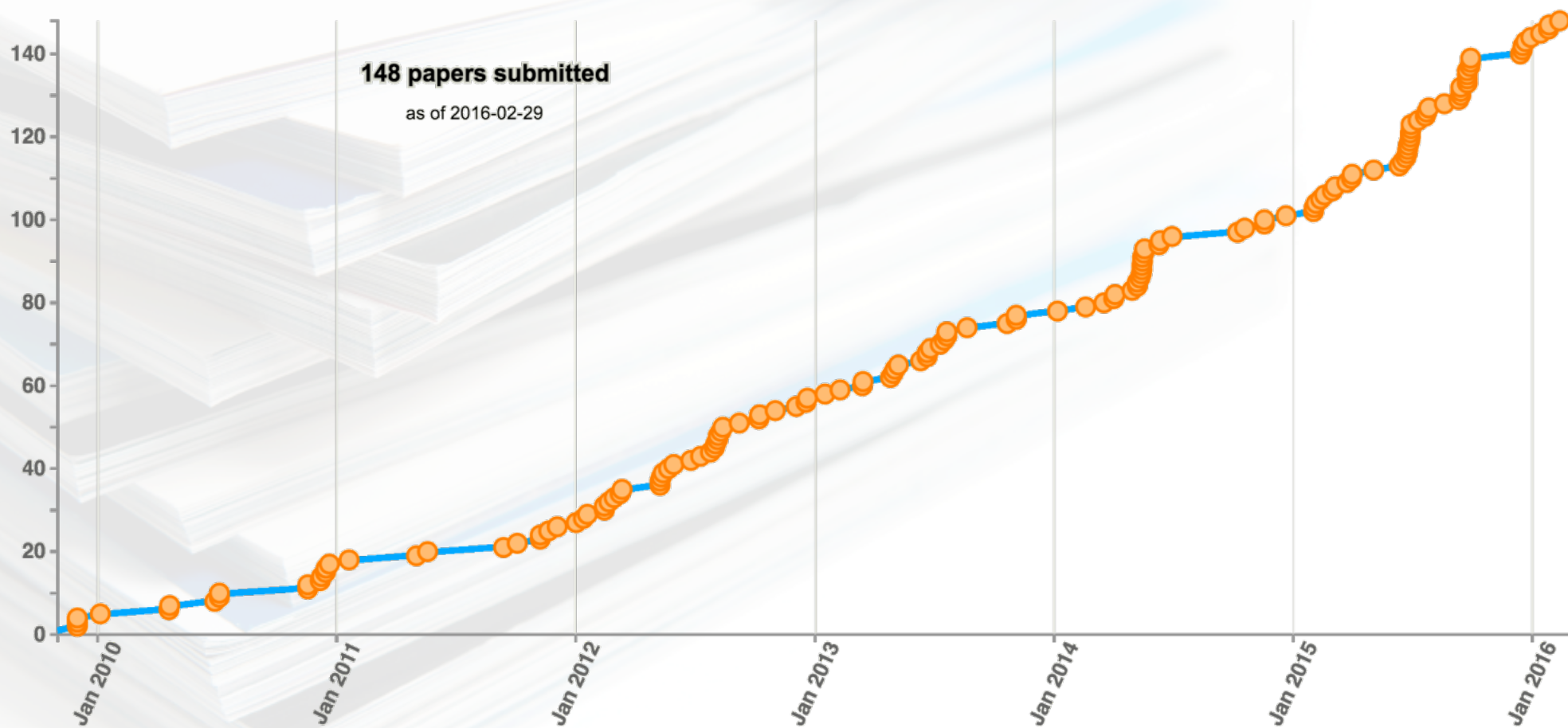


ALICE
EPJ+

PERFORMANCE	Particle identification in ALICE: a Bayesian approach → arXiv:1602.01392 [physics.data-an]	
FLOW (2)	Anisotropic flow of charged particles in Pb-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1602.01119 [nucl-ex]	PRL
	Charge-dependent flow and the search for the Chiral Magnetic Wave in Pb-Pb collisions at $v_{sNN} = 2.76$ TeV → arXiv:1512.05739 [nucl-ex]	PRC
CORRELATIONS	Multi-pion Bose-Einstein correlations in pp, p-Pb, and Pb-Pb collisions at the LHC → arXiv:1512.08902 [nucl-ex]	PRC
	Production of $K^*(892)^0$ and $\phi(1020)$ in p-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1601.07868 [nucl-ex]	EPJC
LIGHT FLAVOR (4)	Multiplicity dependence of charged pion, kaon, and (anti)proton production at large transverse momentum in p-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1601.03658 [nucl-ex]	PLB
	Multi-strange baryon production in p-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1512.07227 [nucl-ex]	PLB
	Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1512.06104 [nucl-ex]	PRL
HEAVY FLAVOR	Measurement of D meson production versus multiplicity in p-Pb collisions at $v_{sNN} = 5.02$ TeV → arXiv:1602.07240 [nucl-ex]	JHEP

ALICE Articles Timeline: 148 Submitted

A Large Ion Collider Experiment



148 papers submitted
as of 2016-02-29

5 Accepted Articles (since last LHCC, Dec 2nd 2015)

A Large Ion Collider Experiment



<i>CORRELATIONS</i>	Multiplicity and transverse momentum evolution of charge-dependent correlations in pp, p-Pb, and Pb-Pb collisions at the LHC	EPJ C
<i>LIGHT FLAVOR</i>	Production of light nuclei and anti-nuclei in pp and Pb-Pb collisions at LHC energies	PR C
	Measurement of D_s^+ production and nuclear modification factor in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	J.HEP
<i>HEAVY FLAVOR</i> (3)	Measurement of electrons from heavy-flavour hadron decays in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV	PL B
	Transverse momentum dependence of D-meson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	J.HEP

11 Published Articles (since last LHCC, Dec 2nd 2015)

A Large Ion Collider Experiment



<i>FLOW</i>	Elliptic flow of muons from heavy-flavour hadron decays at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PL B 753
	Centrality dependence of pion freeze-out radii in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PR C 93
<i>CORRELATIONS</i> (3)	Forward-central two-particle correlations in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV	PL B 753
	One-dimensional pion, kaon, and proton femtoscopy in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PR C 92
<i>JETS</i>	Azimuthal anisotropy of charged jet production in $\sqrt{s_{NN}} = 2.76$ TeV Pb-Pb collisions	PL B753
<i>GAMMA</i>	Direct photon production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PL B 754
	Centrality evolution of the charged-particle pseudorapidity density over a broad pseudorapidity range in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PL B 754
<i>LIGHT FLAVOR</i> (3)	Pseudorapidity and transverse-momentum distributions of charged particles in proton-proton collisions at $\sqrt{s_{NN}} = 13$ TeV	PL B 753
	Search for weakly decaying Λ_n and $\Lambda\Lambda$ exotic bound states in central Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV	PL B 752
<i>QUARKONIA</i>	Centrality dependence of inclusive J/Ψ production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV	JHEP 11
<i>COSMIC RAYS</i>	Study of cosmic ray events with high muon multiplicity using the ALICE detector at the CERN Large Hadron Collider	JCAP 1601

Pb-Pb $\sqrt{s_{NN}} = 5.02$ TeV

Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV \rightarrow arXiv:1512.06104 [nucl-ex]

PRL

Anisotropic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV \rightarrow arXiv:1602.01119 [nucl-ex]

PRL

Charged Particle Multiplicity: Pb-Pb @ 5.02 TeV

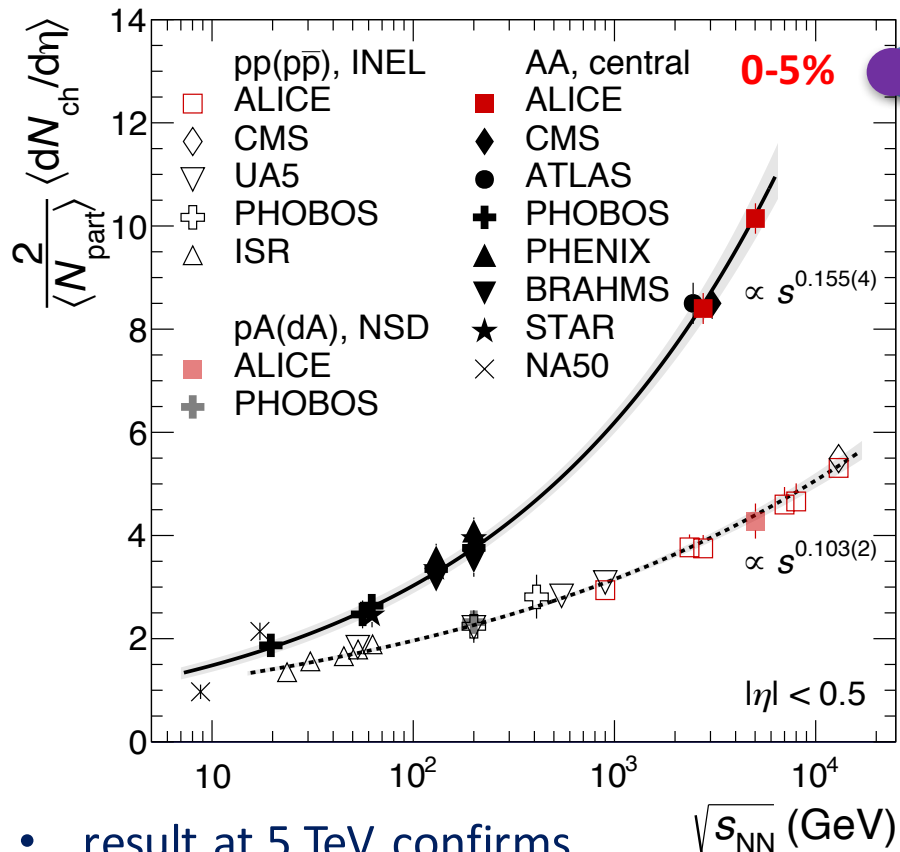
A Large Ion Collider Experiment



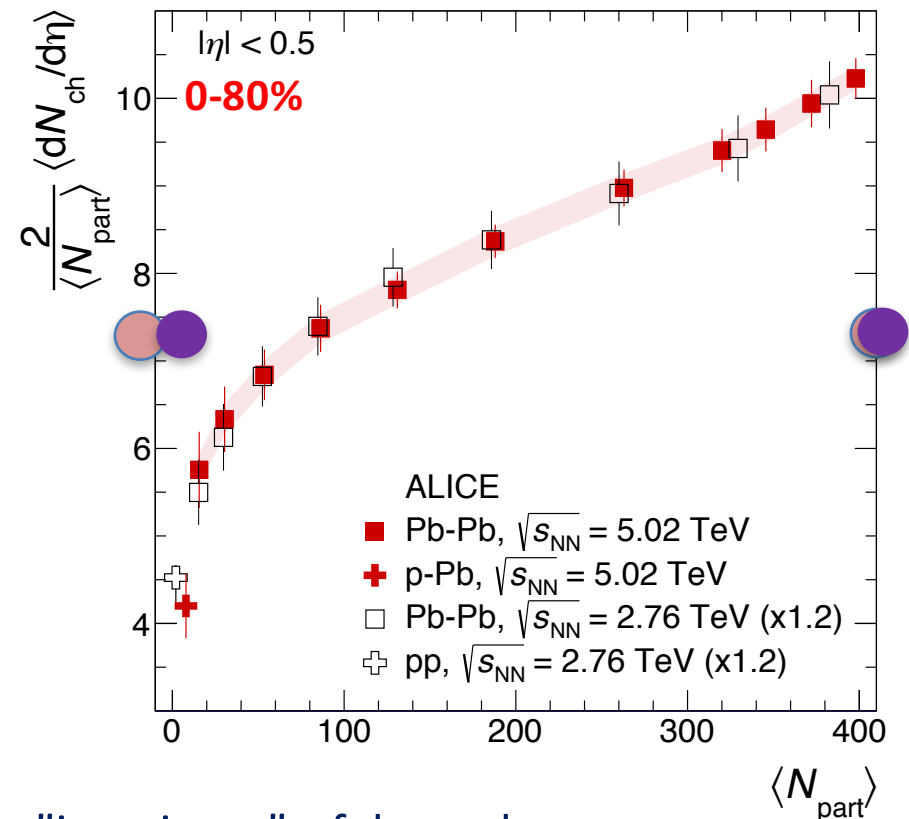
ALICE

Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV \rightarrow arXiv:1512.06104 [nucl-ex]

Key input for simulations and models



- result at 5 TeV confirms trend established by lower energy data
- strong rise in Pb-Pb is not solely related to the multiple collisions



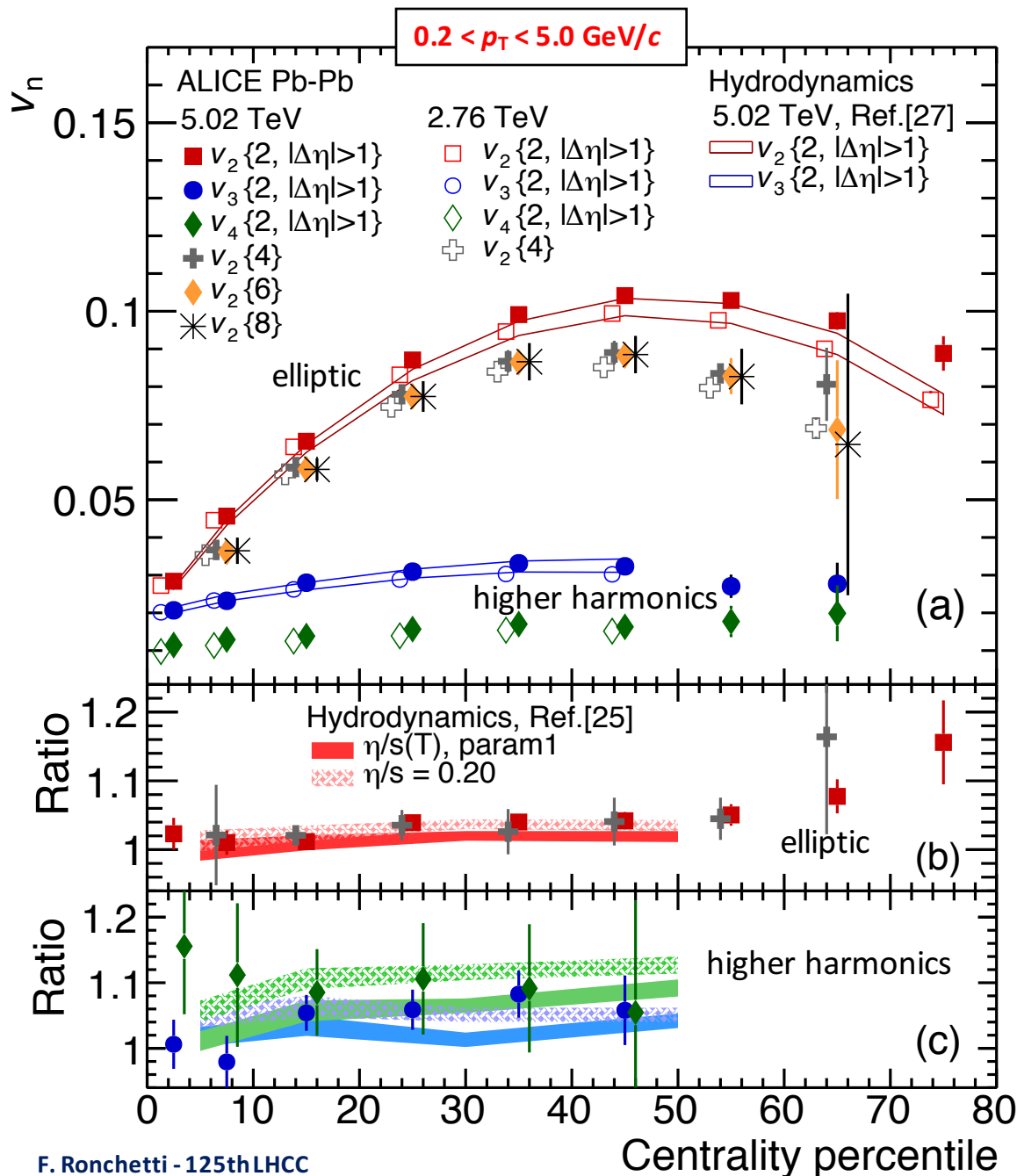
- "invariance" of dependence from centrality with respect to energy
- smooth trend towards value measured in minimum bias p-p and p-Pb collisions

Anisotropic Flow in Pb-Pb @ 5.02 TeV

A Large Ion Collider Experiment

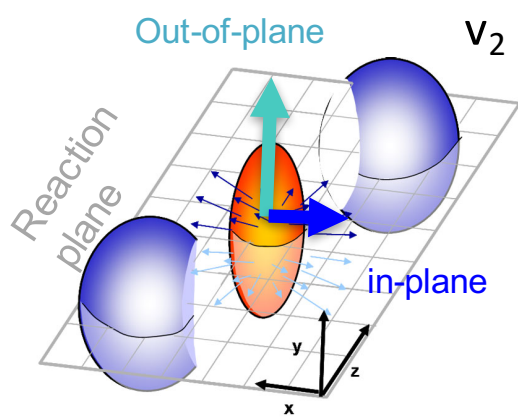


ALICE



Anisotropic flow of charged particles
In Pb-Pb collisions at $v_{NN} = 5.02 \text{ TeV}$
 → arXiv:1602.01119 [nucl-ex]

$$\frac{dN}{d\varphi} \propto 1 + 2 \sum_{n=1}^{\infty} v_n \cos[n(\varphi - \Psi_n)]$$



Anisotropic flow: measure of the momentum anisotropy of the final state particles.

- Sensitive to**
- Initial collision geometry
 - Transport mechanism

p-Pb $\sqrt{s_{NN}} = 5.02$ TeV

Multiplicity dependence of charged pion, kaon, and (anti)proton production at large transverse momentum in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

PLB

→ [arXiv:1601.03658](https://arxiv.org/abs/1601.03658) [nucl-ex]

Production of $K^*(892)^0$ and $\phi(1020)$ in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

EPJC

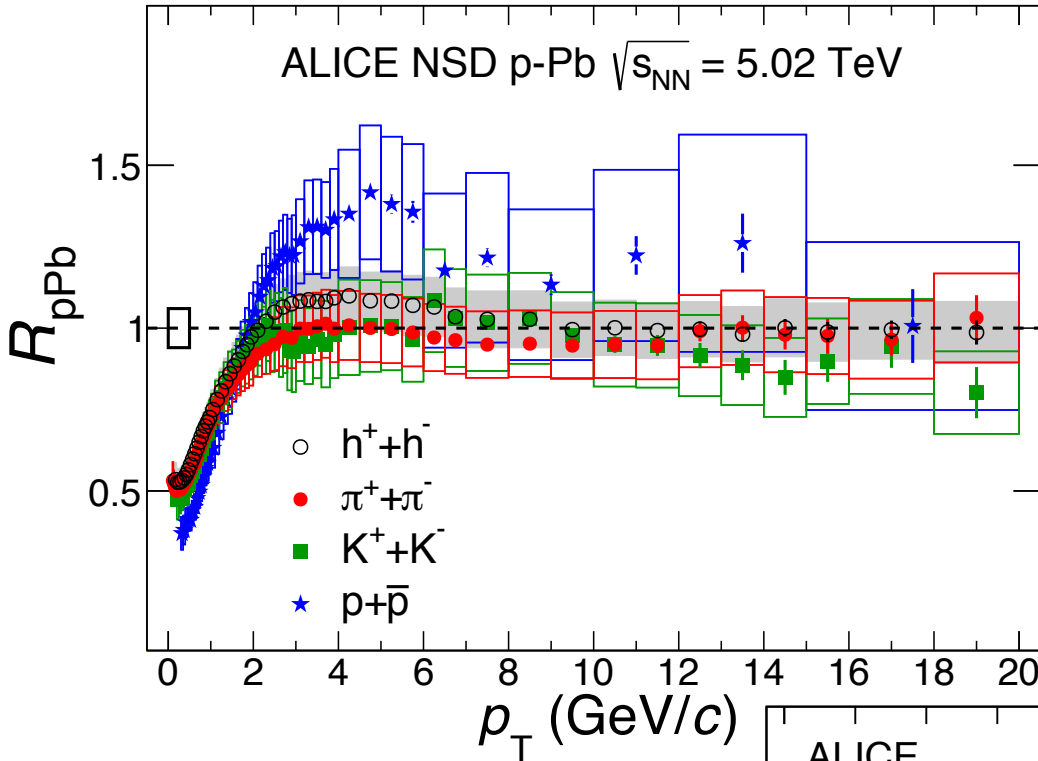
→ [arXiv:1601.07868](https://arxiv.org/abs/1601.07868) [nucl-ex]

Multiplicity of π^\pm , K^\pm , p in p-Pb 5.02 TeV

A Large Ion Collider Experiment



ALICE

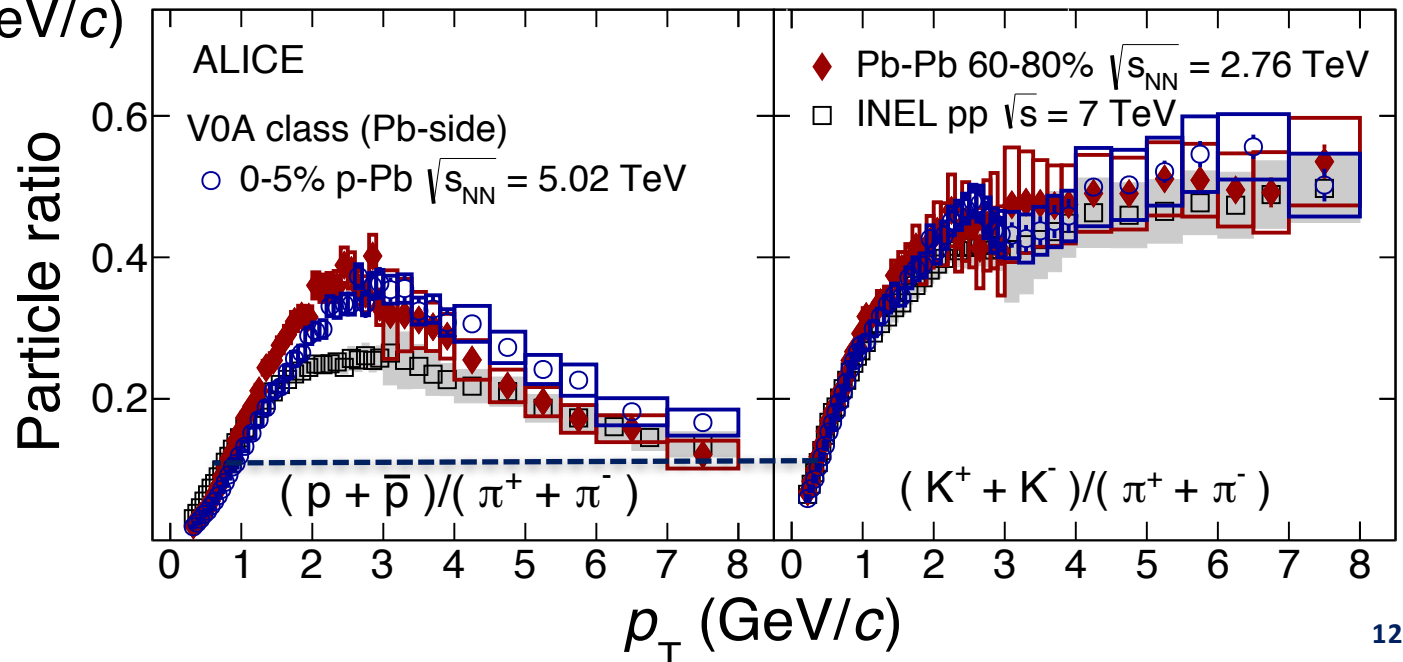


Multiplicity dependence of charged p , K , and (anti) proton production at large p_T in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

→ arXiv:1601.03658 [nucl-ex]

- (anti)p nuclear modification factor shows a Cronin-like increment
- π and K show little or no nuclear modification

- p/π ratio increases at intermediate and high p_T with the event multiplicity.

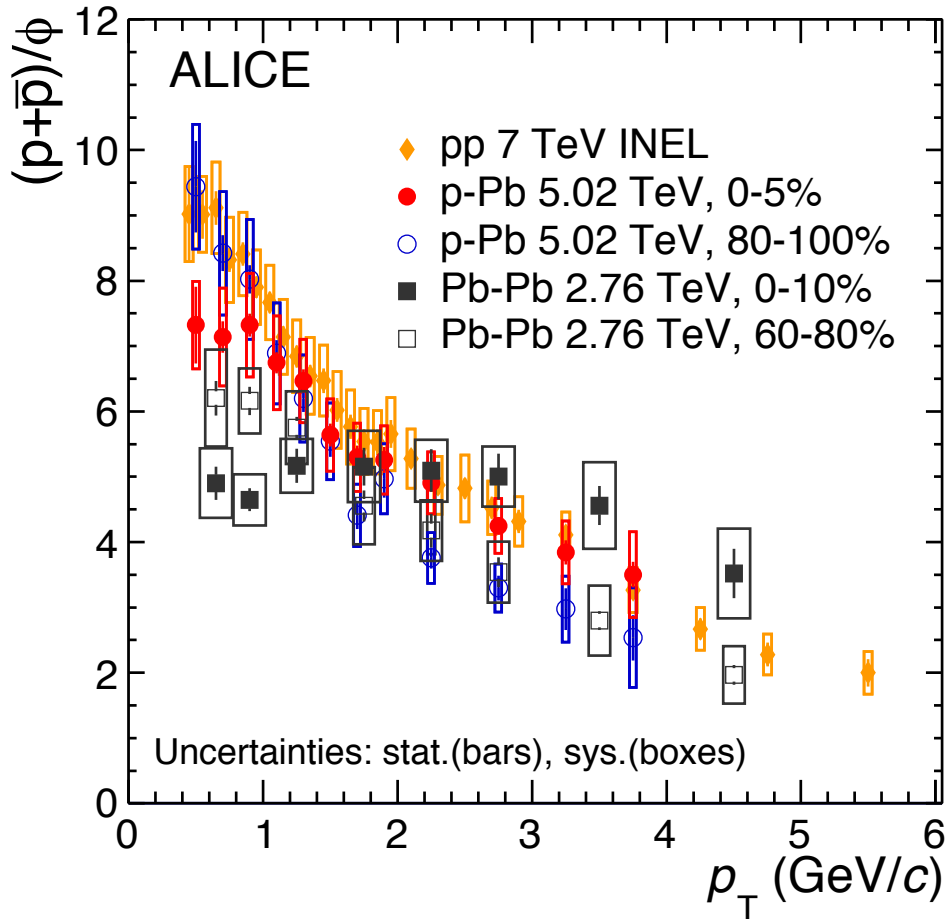


Production of $K^*(892)^0$, $\phi(1020)$ in p-Pb 5.02 TeV

A Large Ion Collider Experiment



ALICE

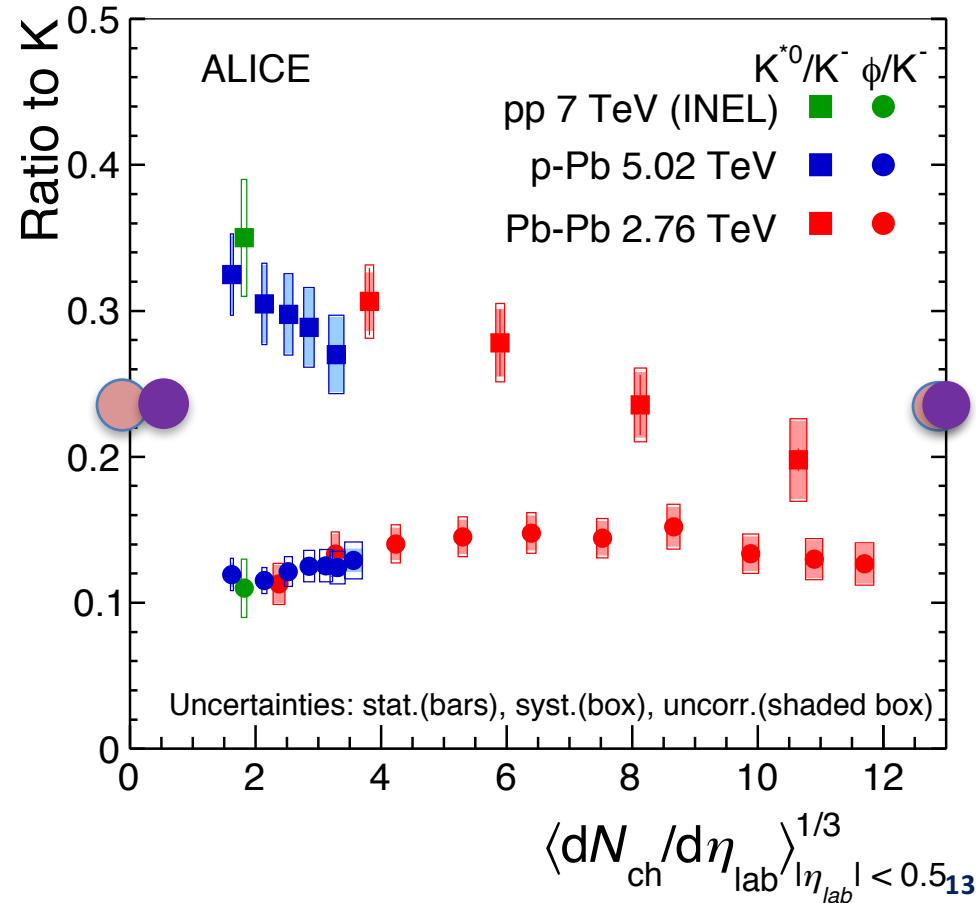


- ϕ/K^- not suppressed in in Pb-Pb
- x10 shorter lived K^{0*} is suppressed in Pb-Pb (re-scattering of decay products)
- Hint of suppression seen also in p-Pb

Production of $K^*(892)^0$ and $\phi(1020)$ in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
 → arXiv:1601.07868 [nucl-ex]

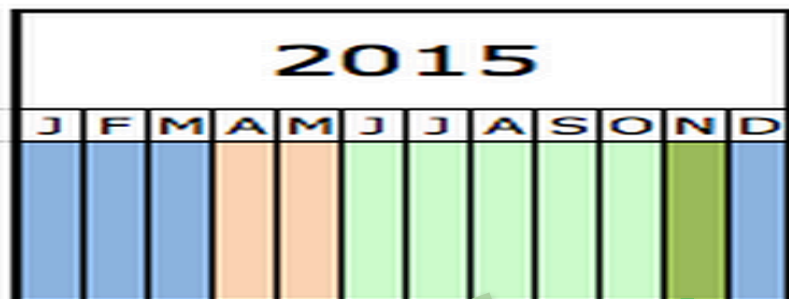
Mass ordering observed in central Pb-Pb collisions: similar mass → similar p_T

- Hydrodynamic behavior

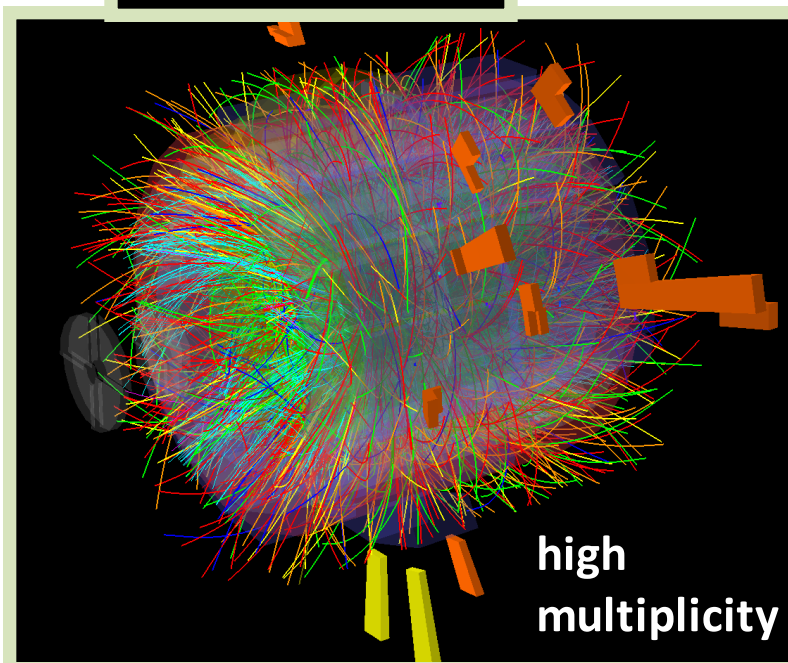


Overview of 2015 Operations

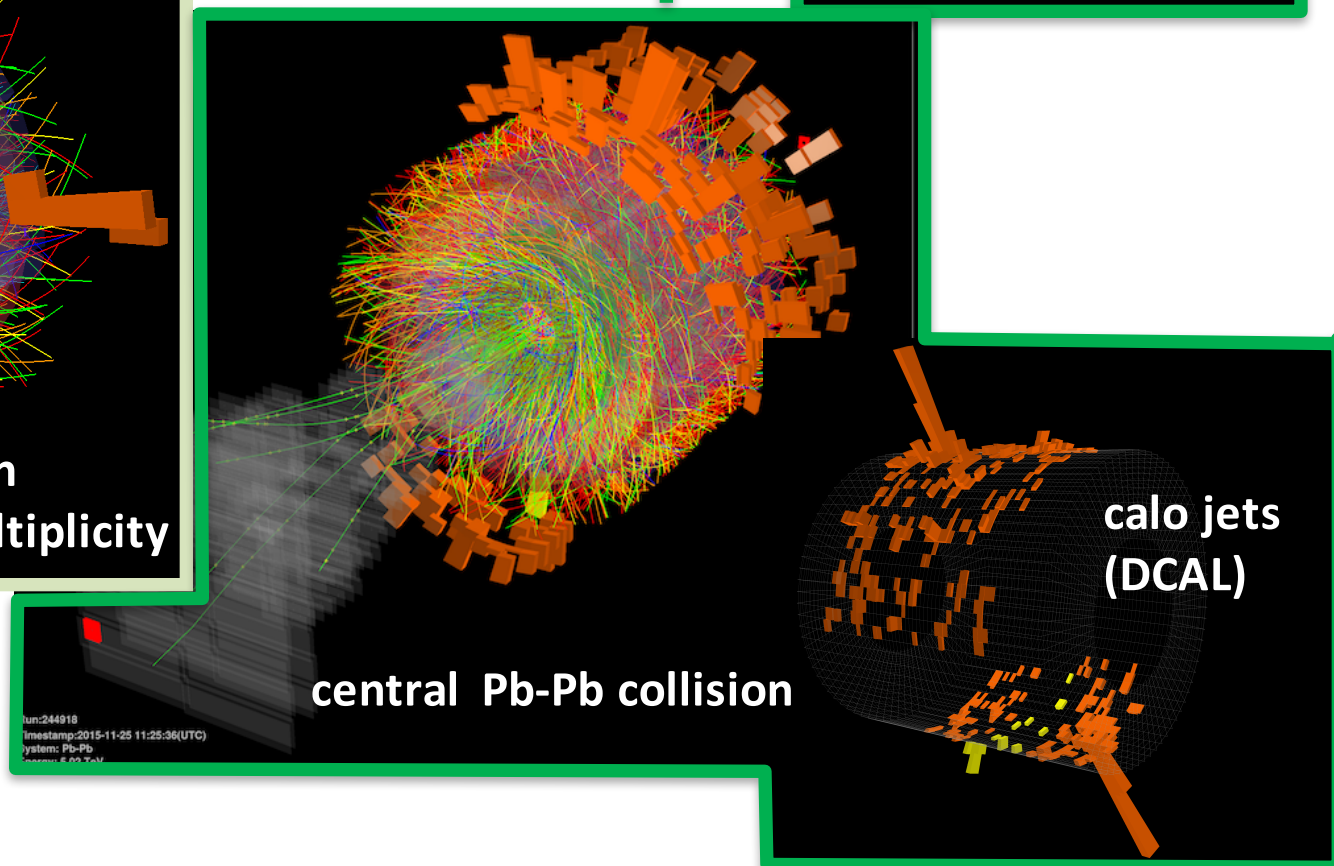
A Large Ion Collider Experiment



p-p @ 13 TeV

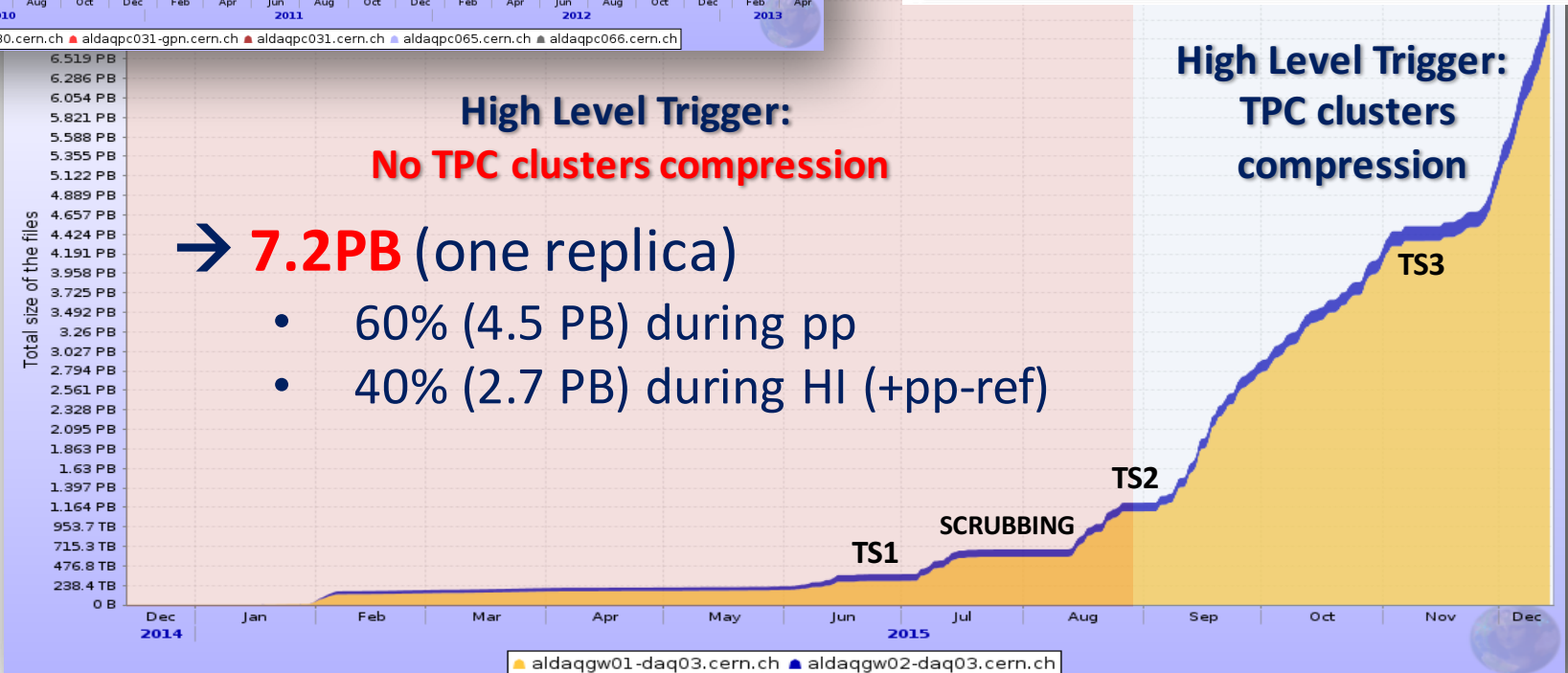
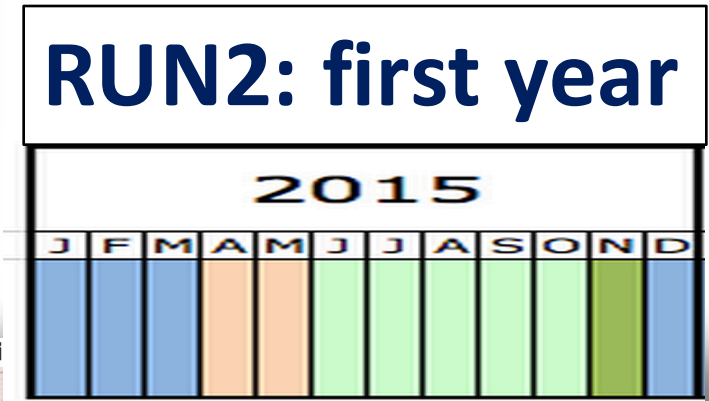
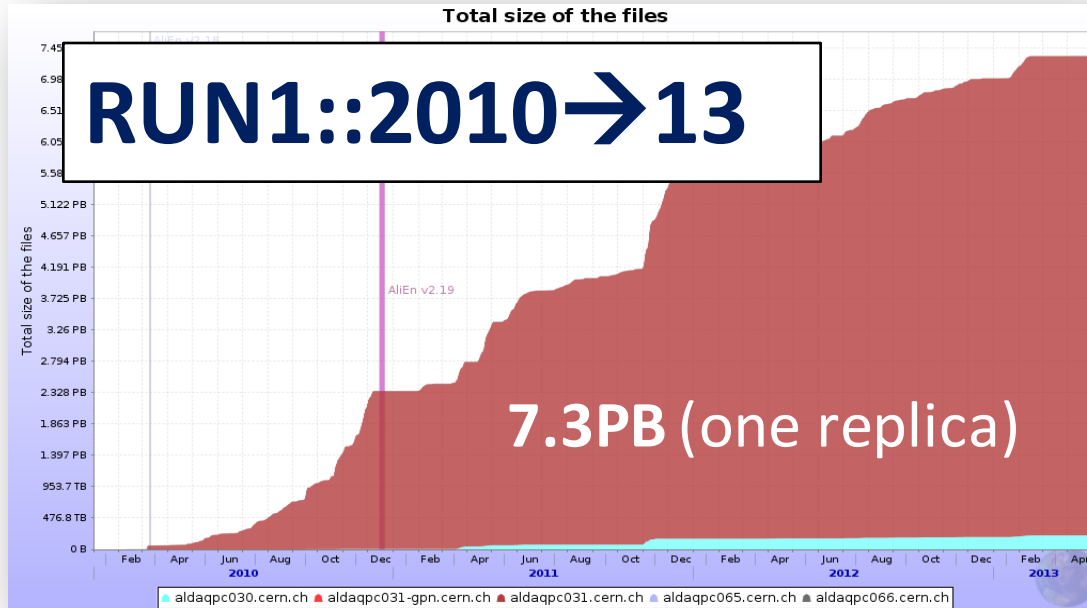


Pb-Pb @ 5.02 TeV



ALICE Data Taking Profile: RUN2 vs RUN1

A Large Ion Collider Experiment



Overview of p-p Data Taking at 13 TeV

A Large Ion Collider Experiment

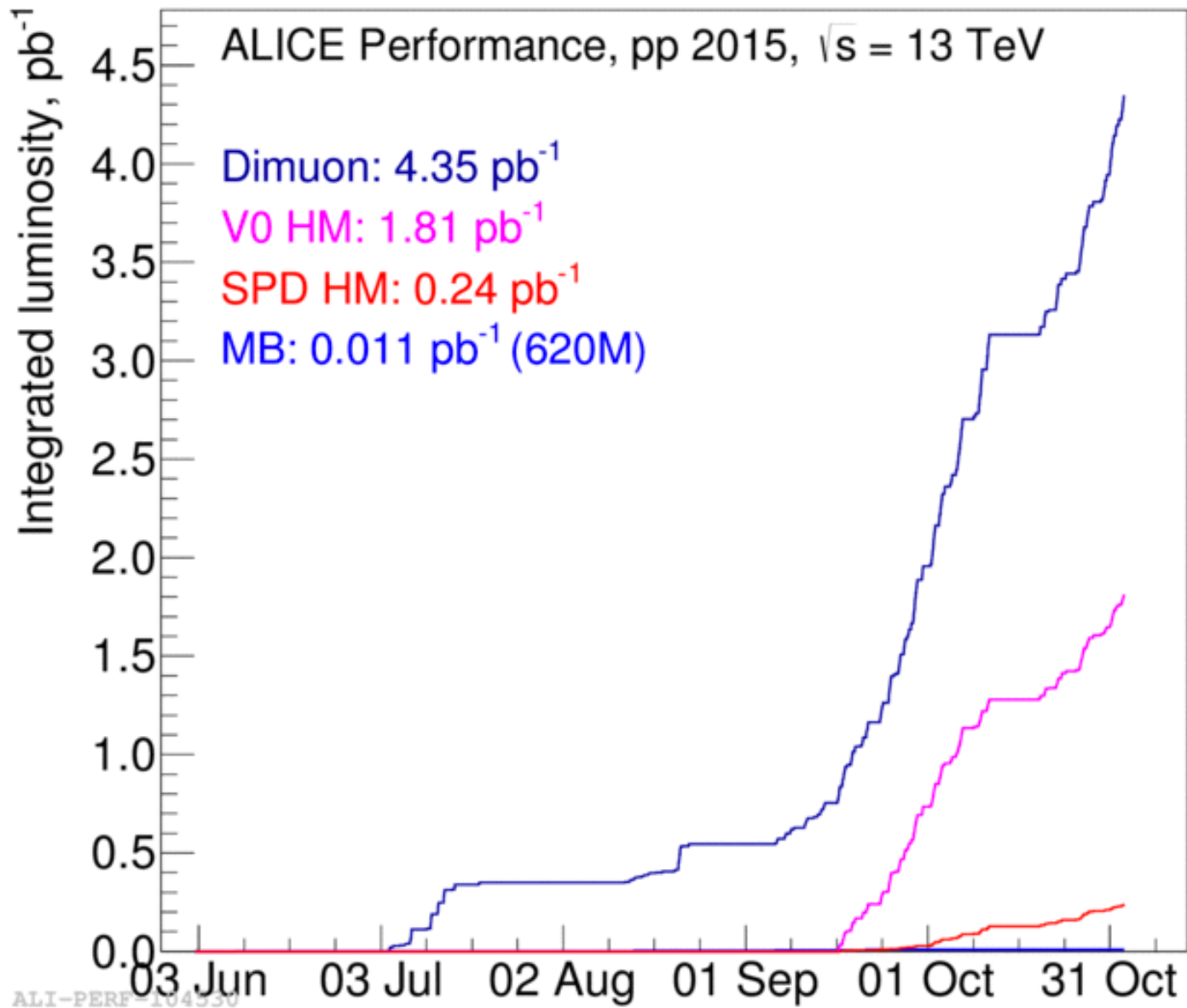


LHC restart (INDIV)

- diffractive data taking: collected **165 ME**

50ns and 25ns trains

- Instantaneous luminosity **up to 5 Hz/ub**
- Campaign for **minimum bias** and **rare triggers** at low pile up (μ)

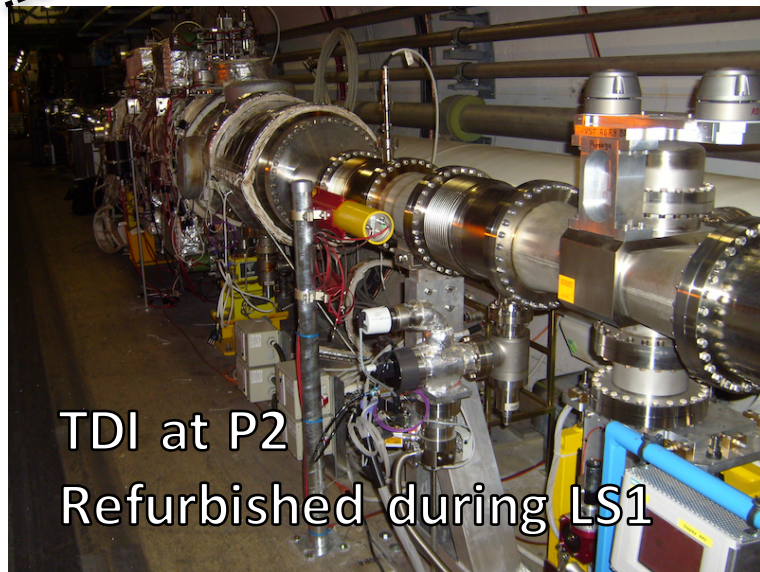
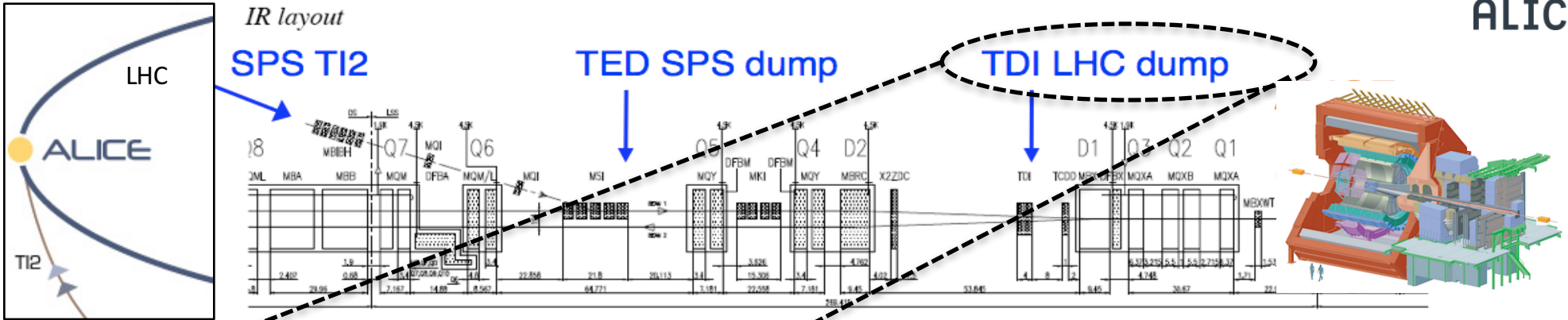


25 ns Trains: Beam Induced Background

A Large Ion Collider Experiment



ALICE

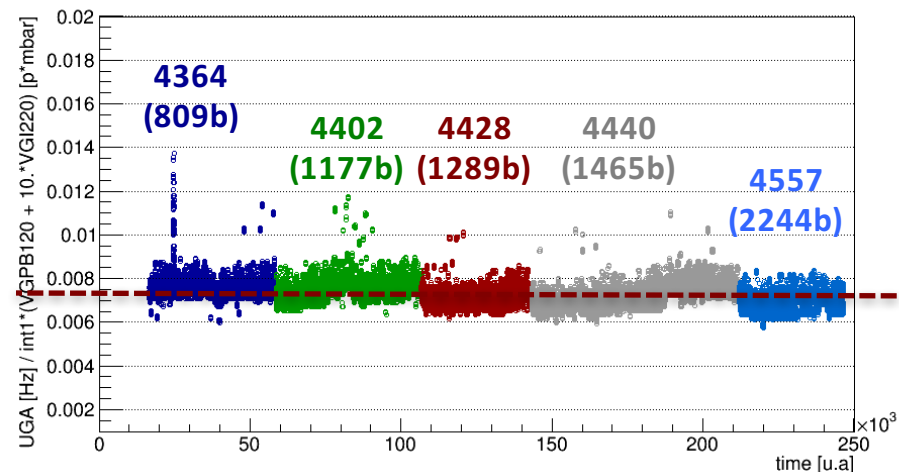


TDI at P2
Refurbished during LS1

Average pressure in straight section

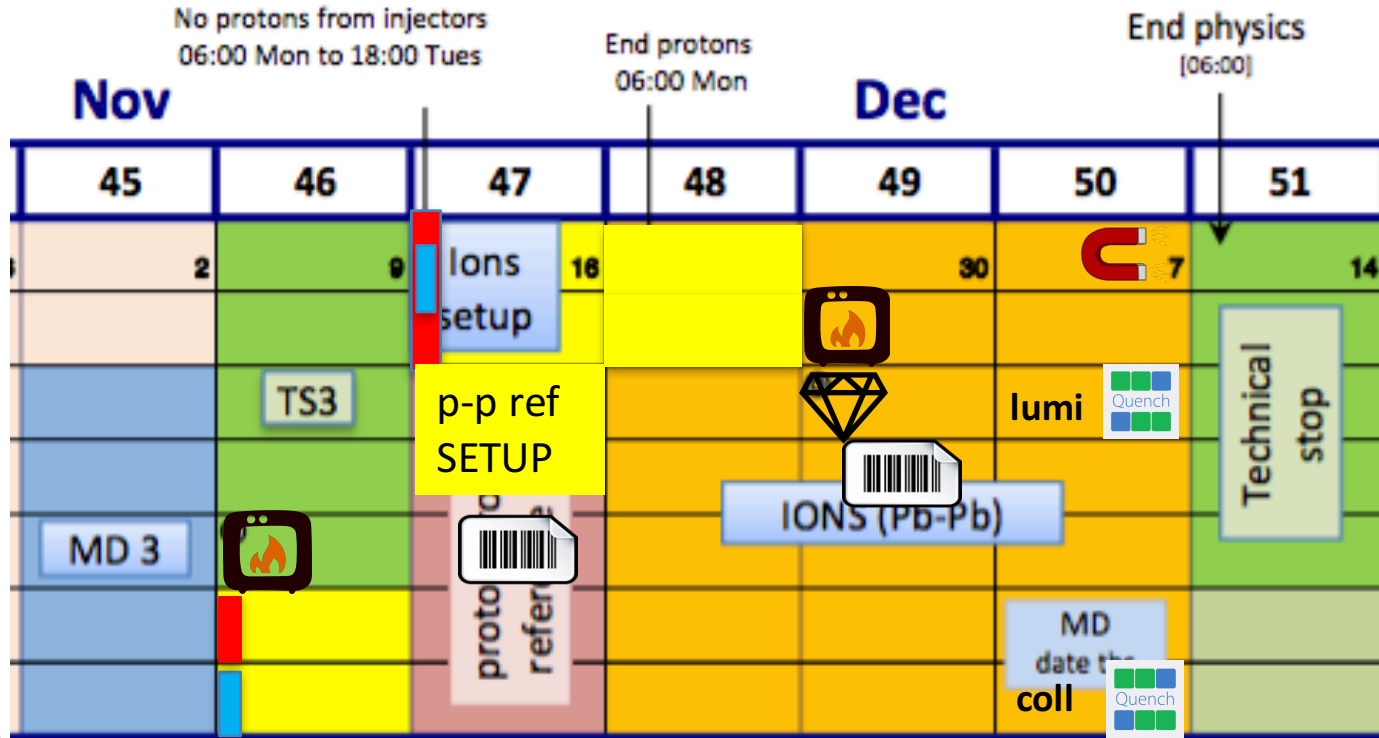
- **2012 Stable Beams**
1380b: $\sim 3E-8$ mbar
 - **2015 2244b: $\sim 4E-9$ mbar**
- $\sim x10$ improvement

Pressure-normalized background is flat: background correlated only to beam-gas events



HI 2015: Ultra-Packed Schedule

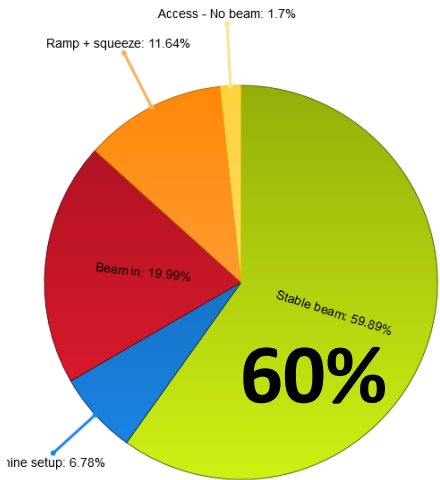
A Large Ion Collider Experiment



Proton Cycle
2.51 TeV

Ion Cycle
6.37Z TeV

Stable beam Machine setup Beam in Ramp + squeeze Access - No beam



Machine development

Special physics runs (indicative - schedule to be established)

Pb oven re-fill

vdM scan

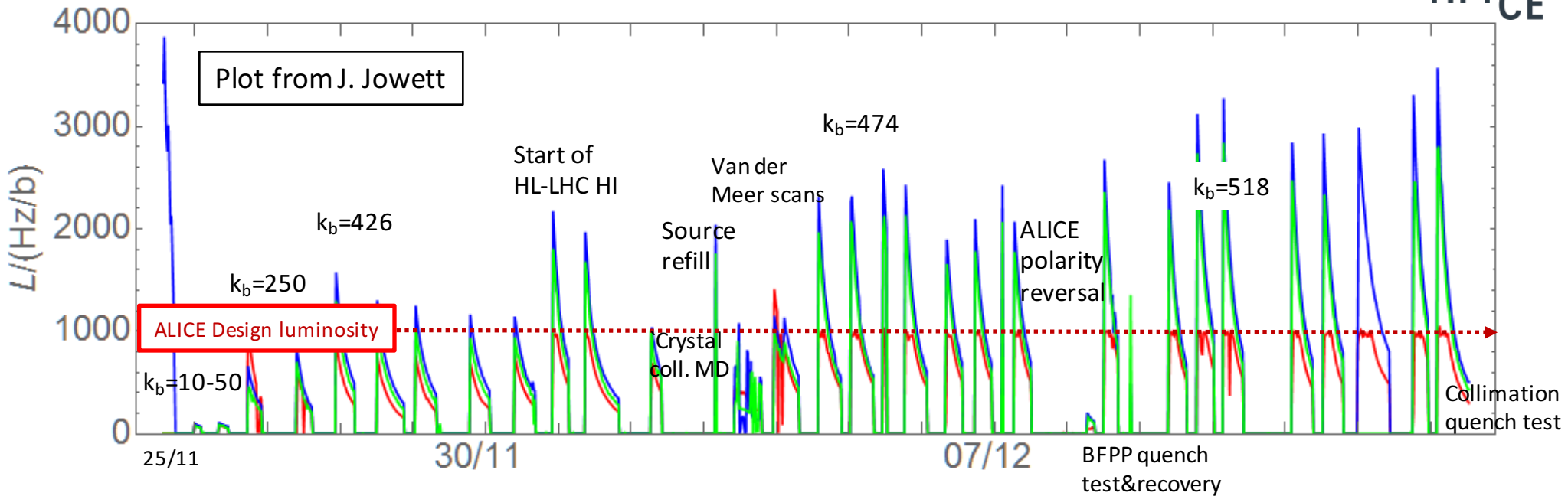
ALICE polarity flip

Crystal collimation MD

Quench tests

LHC Lumi Production in HI

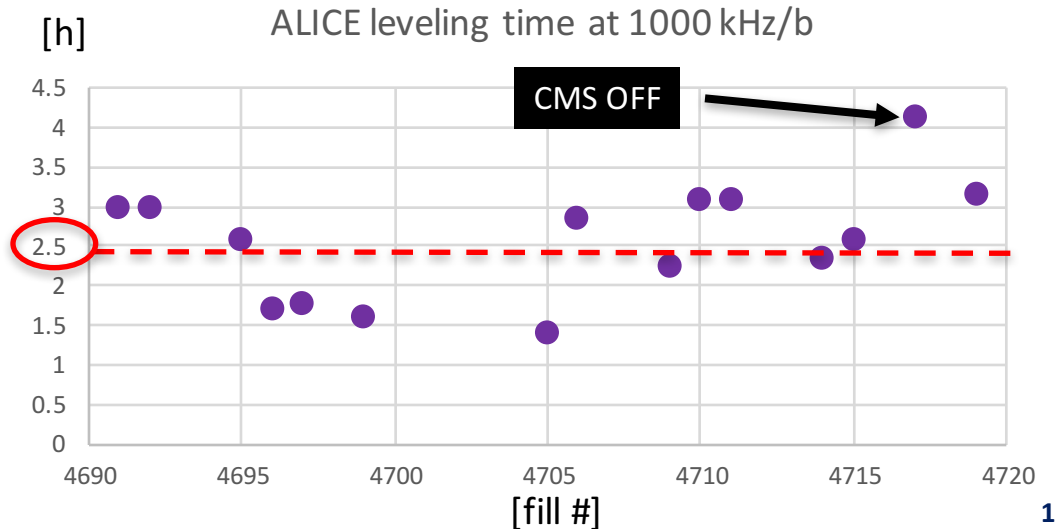
A Large Ion Collider Experiment



Excellent LHC availability. ALICE average levelling time: 2.46 h

Ramp up steps

Bunch Spacing	Bunches per ring	IP 1/5	IP 2	IP 8
100_150ns	518Pb_516Pb	492	444	24_22inj
100_225ns	426Pb_424Pb	400	362	24_19inj
100_225ns	250Pb_250Pb	216	236	24_11inj
100_225ns	250Pb_250Pb	216	236	24_11inj
100_225ns	51Pb_51Pb	33	18	16_4inj
100_225ns	51Pb_51Pb	33	18	16_4inj
Single	10Pb_5	6	2	10inj

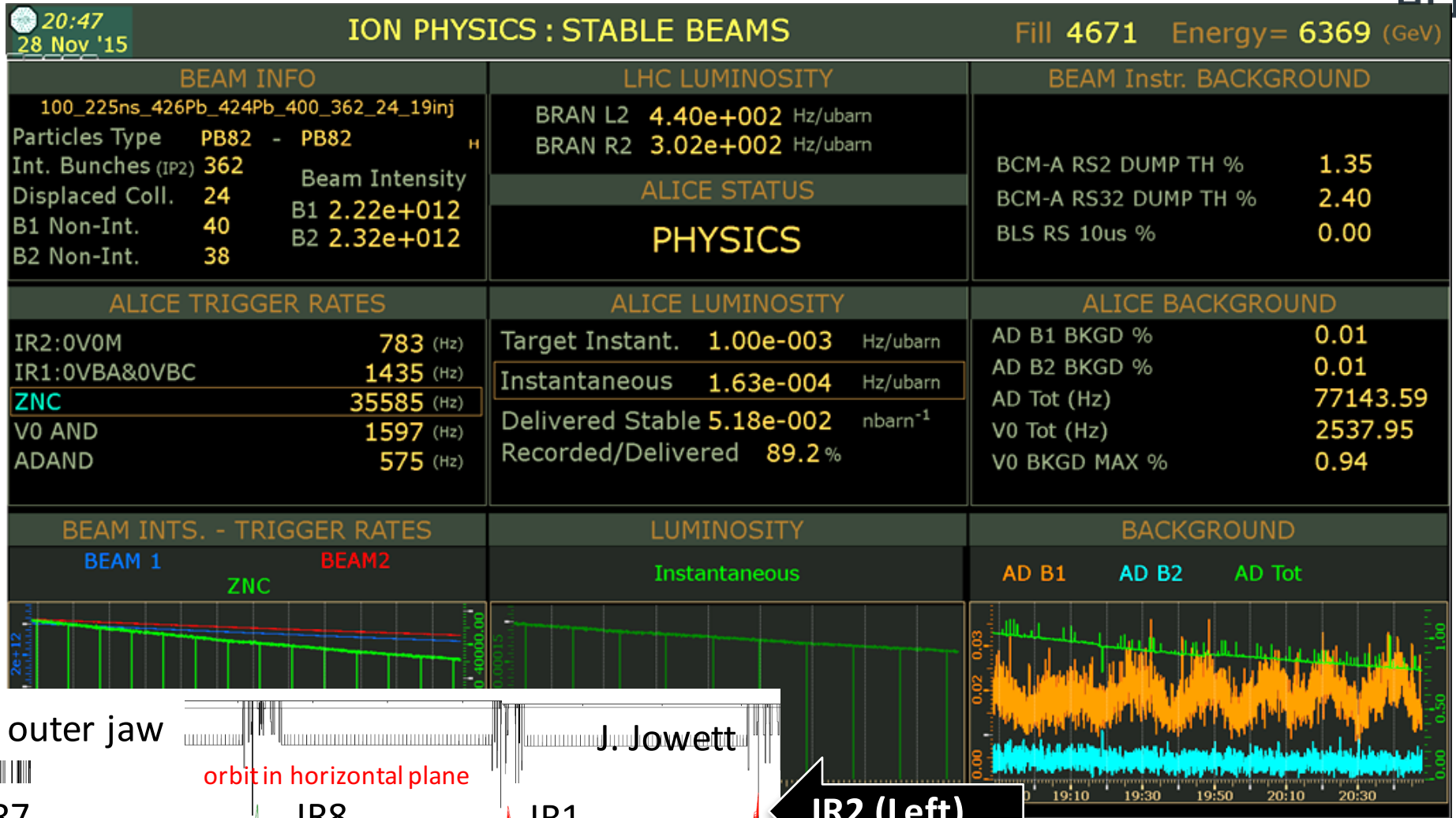


Background: EMD in IR7 TCP, Losses on IR2 TCT, ZDC



A Large Ion Collider Experiment

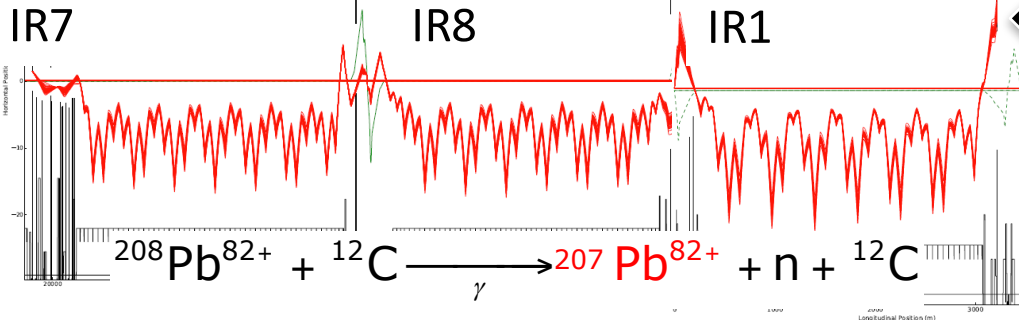
ALICE



TCP outer jaw

J. Jowett

orbit in horizontal plane



Note: LHC performed studies to prevent the problem in the future.

Example of ALICE Pb-Pb Running at 1 kHz/b

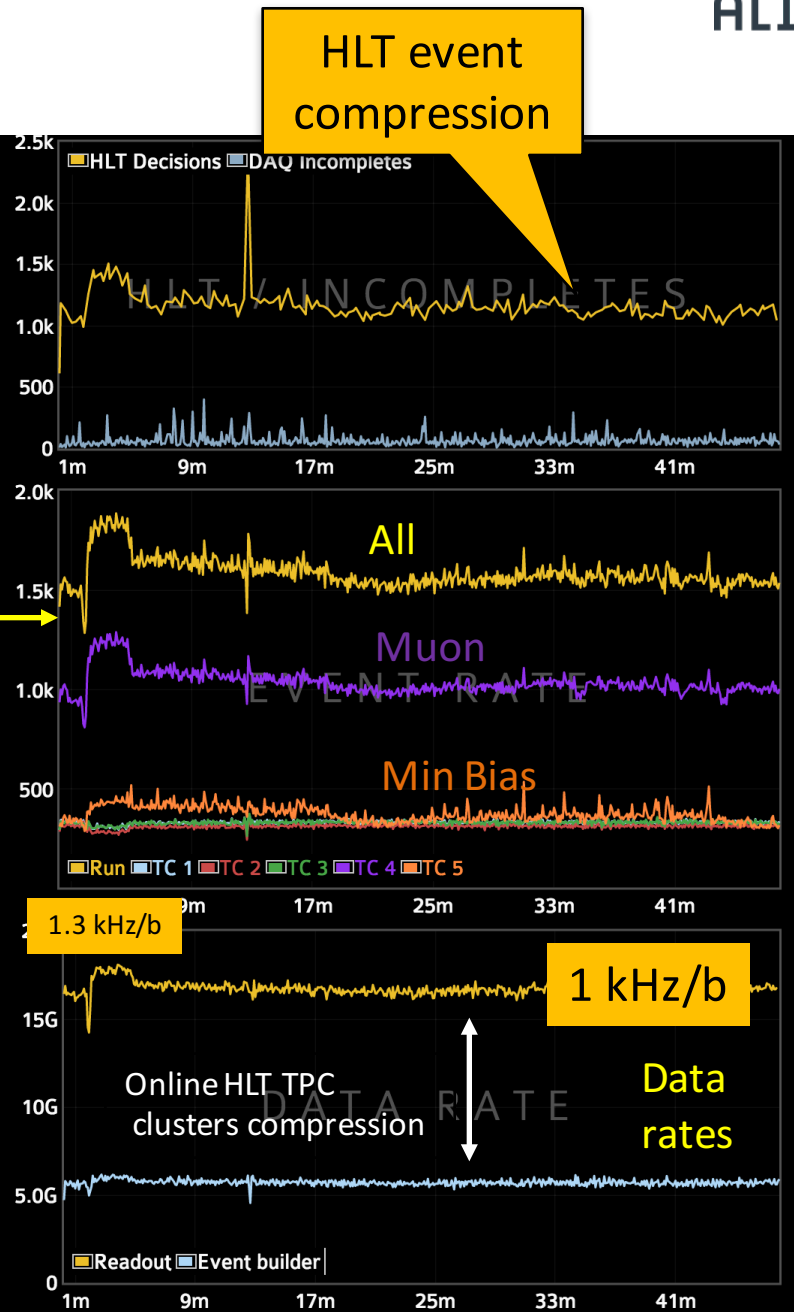
A Large Ion Collider Experiment



Sub-detectors running

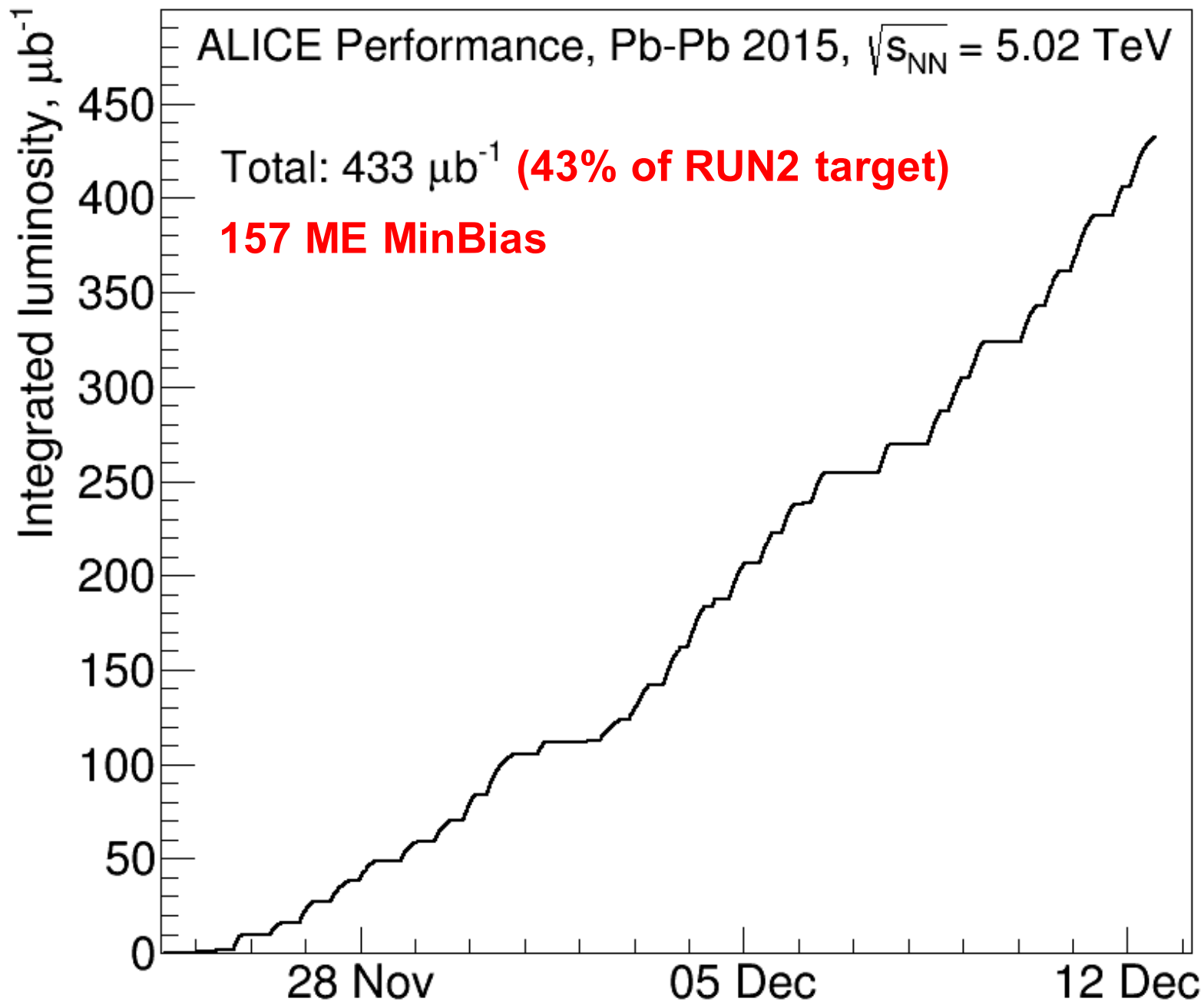
Concurrent trigger sets

Calib	Bsy	Bck	Name	RUN	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8
	-	-		4.5M	940k	884k	938k	3m	1.1m	-	-	-
	-	-	ACO	-	-	-	-	-	-	-	-	-
21:23	PED	-	AD0	✓	✓	✓	✓	✓	✓	-	-	-
21:45	PED	-	CPV	✓	✓	✓	✓	-	-	-	-	-
	-	-	EMC	✓	✓	✓	✓	-	-	-	-	-
	-	-	FMD	✓	✓	✓	✓	-	-	-	-	-
21:24	CAL	-	HMP	✓	✓	✓	✓	-	-	-	-	-
16:33	CAL	-	MTR	✓	-	-	-	✓	○	-	-	-
21:52	PED	-	MCH	✓	-	-	-	✓	-	-	-	-
	-	-	PHS	✓	✓	✓	✓	-	-	-	-	-
21:44	PED	-	PMD	-	-	-	-	-	-	-	-	-
21:51	INJ	-	SDD	✓	✓	✓	✓	-	-	-	-	-
	-	-	SPD	✓	✓	✓	✓	✓	✓	-	-	-
21:26	PED	-	SSD	✓	✓	✓	✓	-	-	-	-	-
	-	-	T00	✓	✓	✓	✓	✓	✓	-	-	-
21:23	NOI	-	TOF	✓	✓	✓	✓	-	✓	-	-	-
19:19	LAS	-	TPC	✓	✓	✓	✓	-	-	-	-	-
	-	-	TRD	✓	✓	✓	-	-	-	-	-	-
	-	-	TRI	✓	✓	✓	✓	✓	✓	-	-	-
	-	-	TST	-	-	-	-	-	-	-	-	-
	-	-	V00	✓	✓	✓	✓	✓	✓	-	-	-
21:27	SPE	-	ZDC	✓	✓	✓	✓	✓	✓	-	-	-
	-	-	HLT	-	-	-	-	-	-	-	-	-



2015 Pb-Pb Run at 5.02 TeV

A Large Ion Collider Experiment

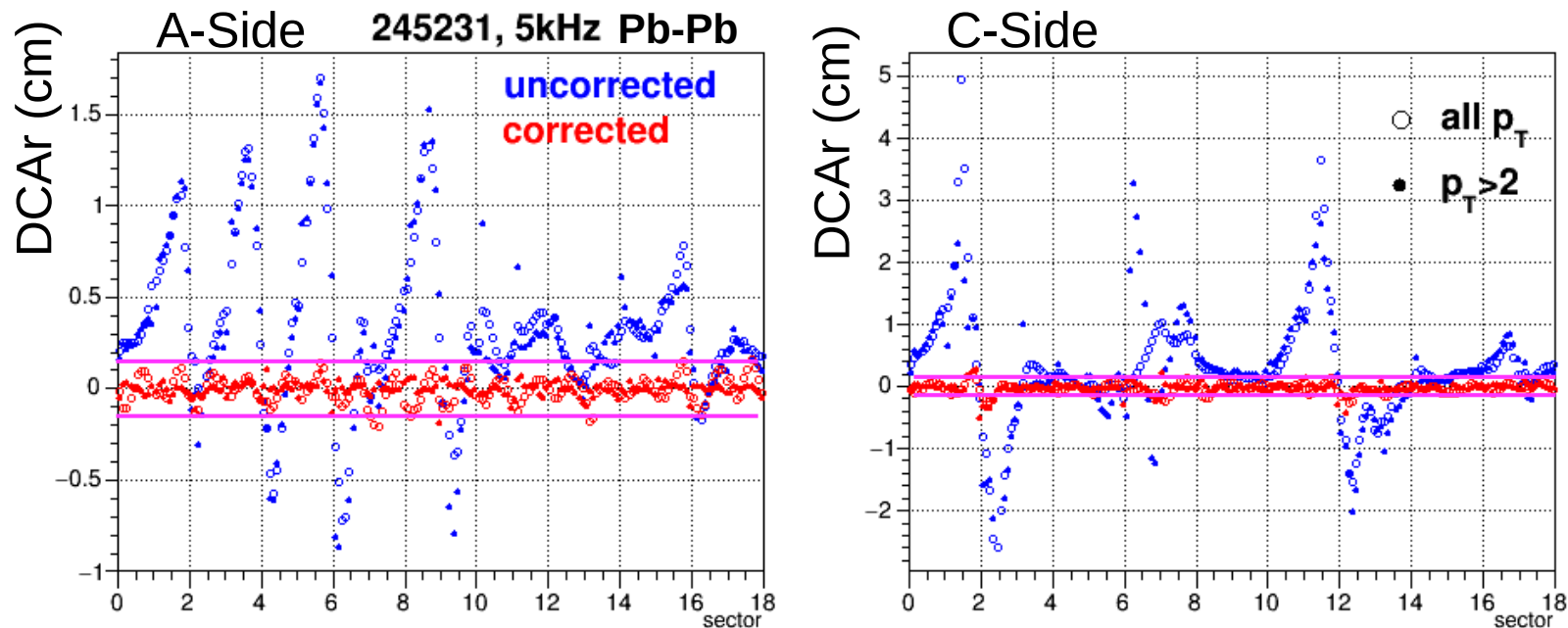
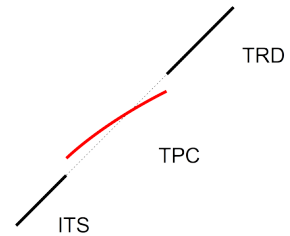


TPC Calibration

A Large Ion Collider Experiment



- Gas was changed from Ne:CO₂ to Ar:CO₂ (90:10)
- Space charge distortions in the bulk of acceptance as expected
- Excessive space charge distortions observed at IROC chamber edges and a few specific OROC points.
- RUN3-like correction procedure (TPC to ITS+TRD track interpolation) to correct distortions down to the intrinsic single track resolution developed and deployed in calibration.



Start of data reconstruction: week 10 (underway)

EMCAL/DCAL Performance

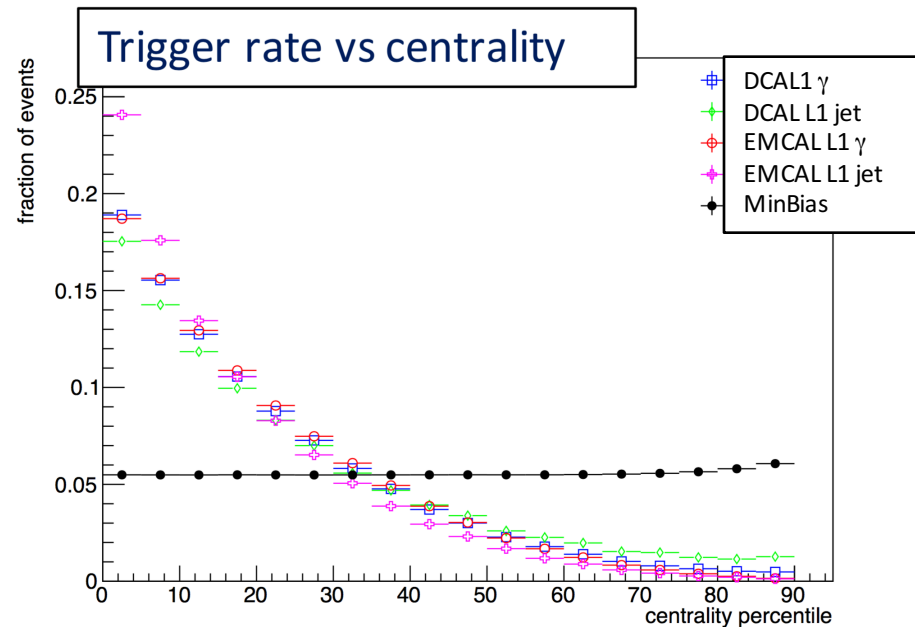
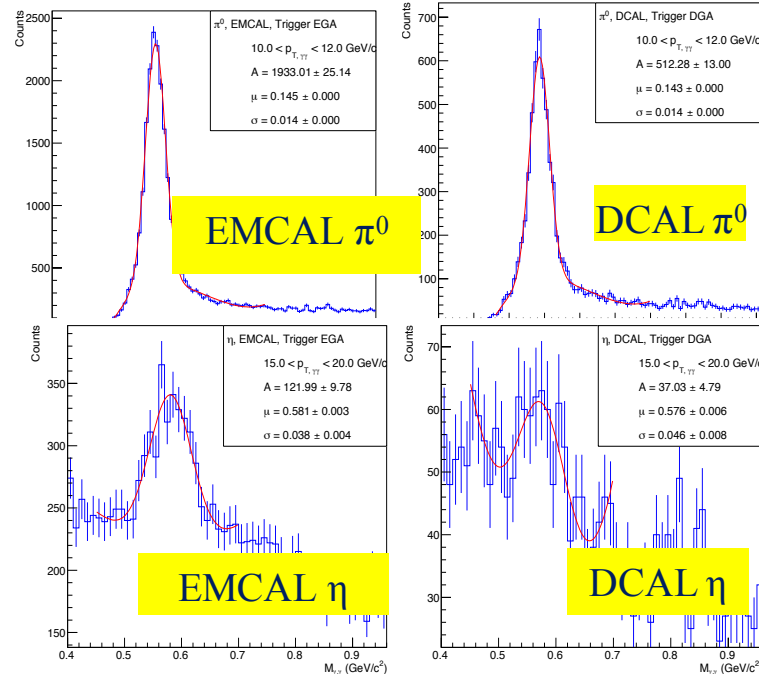
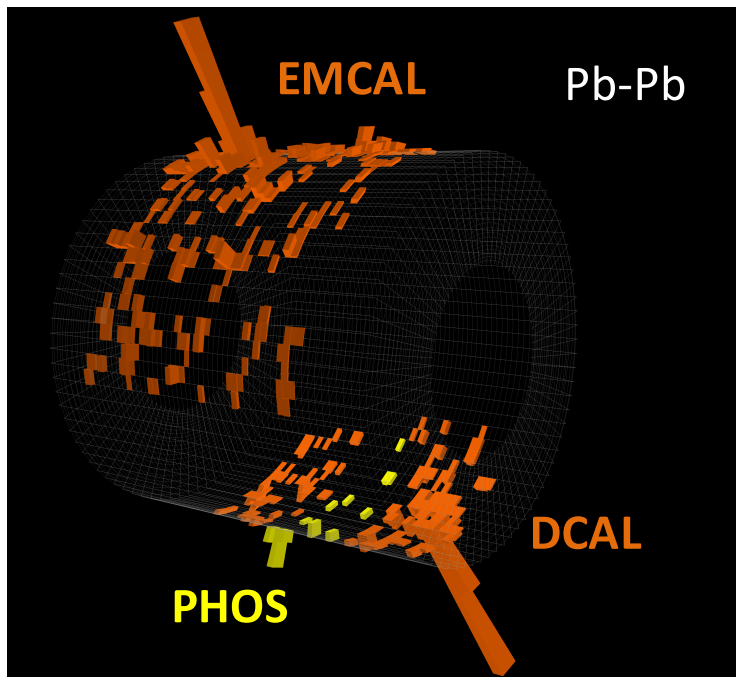
A Large Ion Collider Experiment



ALICE

DCAL installed in LS1

- EMCAL, DCAL (and PHOS) readout and trigger electronics upgraded in LS1
- Development of readout and trigger firmware
- Calibration with beam
- Validation of L0 and L1 triggers

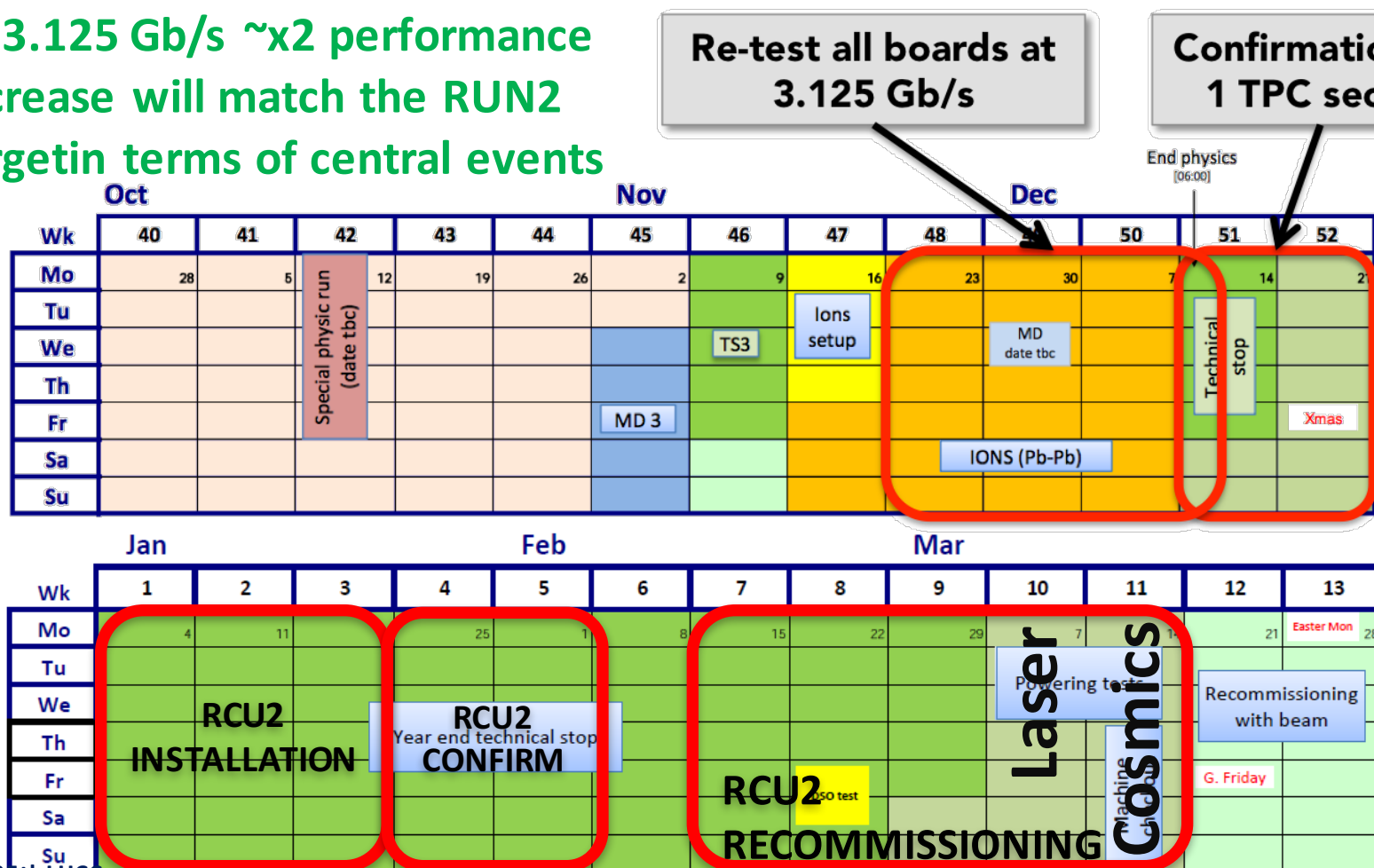


YETS Status Update: RCU2 Installation



A Large Ion Collider Experiment

- Radiation tolerant FPGA
- Increase performance by x2.6 by bus parallelization and higher link speed.
- System proved to be is fully stable at 3.125 Gb/s (hundreds of TB transferred in situ no errors)
- At 3.125 Gb/s ~x2 performance increase will match the RUN2 target in terms of central events

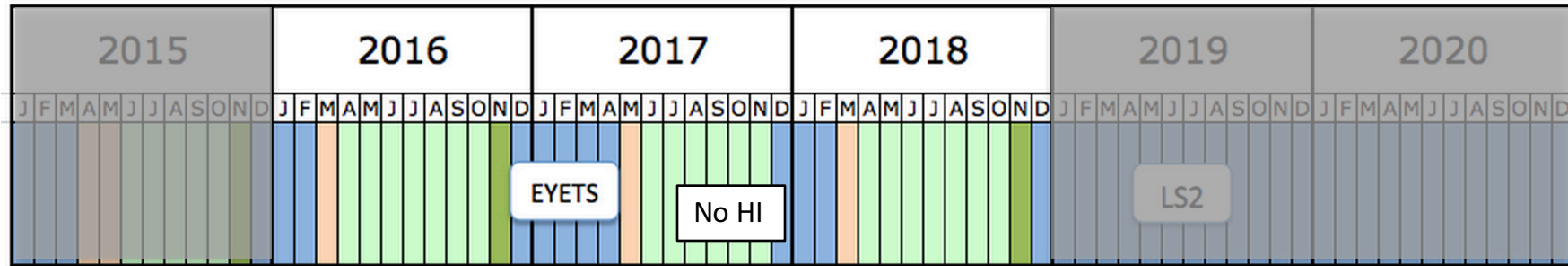


RUN2 Overview (from ALICE Perspective)



ALICE

Large Ion Collider Experiment



Year	System	E [TeV]	Lumi [$\text{cm}^{-2}\text{s}^{-1}$]	Rate [kHz]	Time
2015	pp	13	5×10^{30}	300	14w
	Pb-Pb	5.02	1×10^{27}	8	3w
	pp-ref	5.02	1×10^{30}	50	4d
2016	p-p	13	5×10^{30}	300	28w
	p-Pb	5.02(8.16)	$1 \times 10^{28} + 1 \times 10^{29}$	20(mB)/200	4w
2017	p-p	13	5×10^{30}	300	24w
	pp-ref(?)	5.02	1×10^{30}	50	7d
2018	p-p	13	5×10^{30}	300	28w
	Pb-Pb	5.02	1×10^{27}	8	4w
	pp-ref(?)	5.02	1×10^{30}	50	7d

- **InstLumi: 5 Hz/ub (300 kHz) at pile-up (μ) ~ 1-2%**
Preliminary trigger scenario
 - Central barrel: **Minimum Bias**
 - **High multiplicity** triggers
 - **jet** and **quarkonia** (TRD, Transition Radiation Detector):
 - **Calorimeters: L1 γ** and **jet** (low/high thresholds EMCAL/DCAL/PHOS)
 - **diffractive double-gap** trigger (AD)
 - **single** and **di-muon** triggers at **low-pT** (1 GeV/c) and **high-pT** (4.2 GeV/c)
 - Muon bundles **physics**: 4-fold coincidence cosmic trigger (ACORDE)
 - **β^* 2.4 km run: ALICE in parasitic data taking (at her own β^* of 10m)**
 - in p-p 2016/7/8 aim to **flip the dipole** and solenoid **polarity between fills** (using 25ns trains, **no extra flips planned**)
 - Use external h.c. angle 200 μ r
 - dipole angle effect in the shade of ext. h.c. (no extra loss maps after flip)

RUN2: p-p Reference at 5.02 TeV

A Large Ion Collider Experiment



In RUN2 ALICE aims at **1/nb intlumi** of Pb-Pb at 5.02 TeV

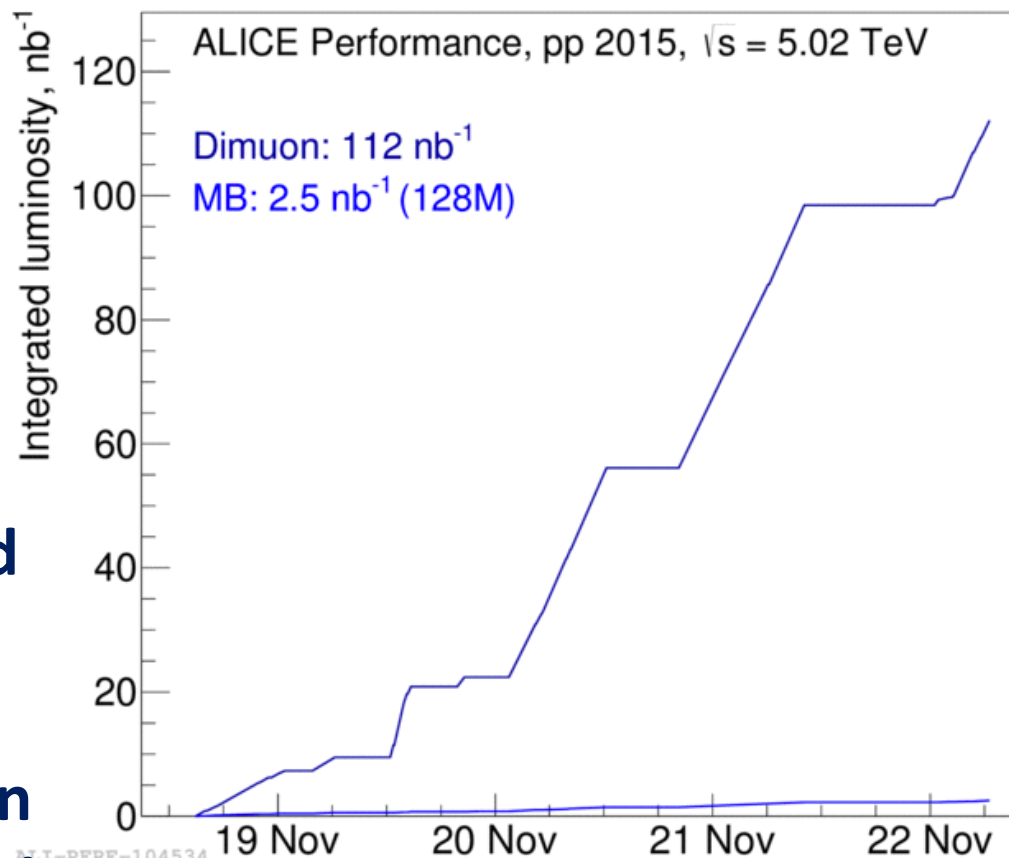
- **~1000M MinBias for direct reference (same energy) at low p_T**
- to be collected at low PU ($\mu \sim 1-5\%$)

➤ **Uncertainty on observables as R_{AA} at low p_T is dominated by statistical uncertainty on reference data.**

- In 2015 **collected 130M**.
~ 800M still to be collected in 2 weeks over 2017/18

- **ALICE view: pp-ref not taken from the 4 weeks of the HI time.**

- **Not necessarily attached to the HI block of the year**



2016 Heavy Ion Run: p-Pb

A Large Ion Collider Experiment



ALICE desires to have p-p and p-Pb reference **at the same energy**: 5.02 TeV (p-Pb as direct reference for Pb-Pb).

COMPROMISE SCENARIO (LPC)

4 weeks of p-Pb

- ~ 9d (3 setup) @ 5.02 TeV (6d net)
- minimum bias leveled at $1E28 \text{ Hz/cm}^2$
- No species reversal
- Target MinBias statistics: **1000M events**
- PU of 0.5% O(300b)

Low burn-off
Very long fills (20+h)

- 17d (6 setup +1 LHCf) @ 8.16 TeV (11d net)
- Target: 20 /nb of rare triggers at $1E29 \text{ Hz/cm}^2$
- **β^* and colliding bunches TBD**
- species reversal: YES (10+10) /nb

Hi burn-off
Short fills (5h)

- 1 vdM scan
- pp-ref taken in 2017/18 (p-p)



“RUN2 for RUN3”: tests at high interaction rate

MUON ARM (Chambers and Trigger)

- pp ~ 3 MHz \rightarrow 42 Hz/ub (84% of equivalent 50 kHz Pb-Pb)
- **Good MCH HV stability** with respect to RUN2 rates

TPC/TRD/TOF/ITS (Central Barrel)

- pp 0.9 MHz \rightarrow 14 Hz/ub: **stable response.**

Status of main upgrade items

- Approval process of ALICE upgrade **concluded in 2015**
- Final prototype of ITS Pixel chip (ALPIDE) being evaluated
- EDR for ITS staves in April 2016
- EDR for TPC GEMs and chamber mechanics **done (11/15).**
Final prototypes and PRR being prepared.
- **T0/FIT (ALICE lumi-meter) prototype installed at P2**

Physics Output (since last LHCC)

- **9 papers submitted**, 5 accepted and 11 published
- Reconstruction of the 2015 Pb-Pb data started

Operations

- **Successful detector restart** after LS1 installations (TRD, DCAL)
- Beam induced background in p-p **improved substantially**
- **Good running efficiency in p-p** (4.5 PB collected)
- **Successful p-p reference and Pb-Pb runs**
with good running efficiency (~90%, 2.7 PB collected)
- TPC distortions correction procedure **implemented and working**
- **New TPC readout RCU2 installed** and tested during the EYETS

ALICE ready for 2016 data taking

Backup

A Large Ion Collider Experiment



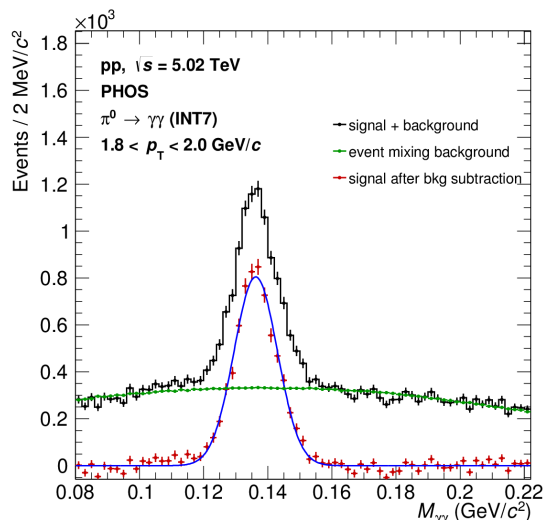
ALICE

PHOS/CPV Performance

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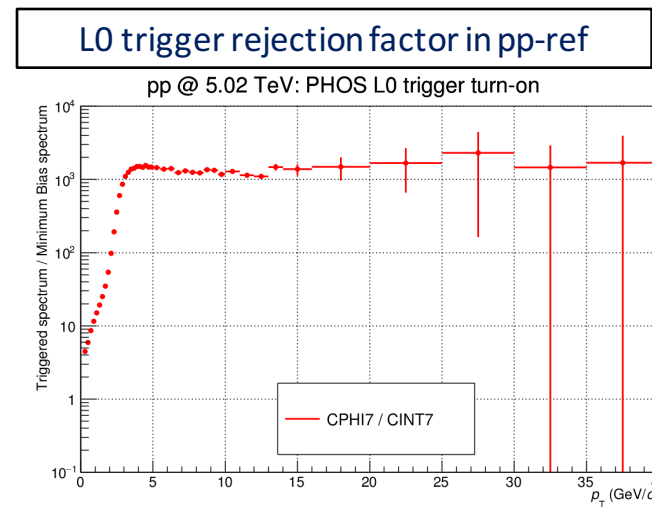


L0 trigger deployed in pp-ref run. Physics data taking with L0 threshold 3 GeV: 0.5M events triggered by CPHI7 in CALOFAST cluster with PHOS, EMCAL, CPV, VZERO, SPD, T0.



L0 trigger enhances spectra at high p_T . Accumulated statistics allows one to T measure spectra:

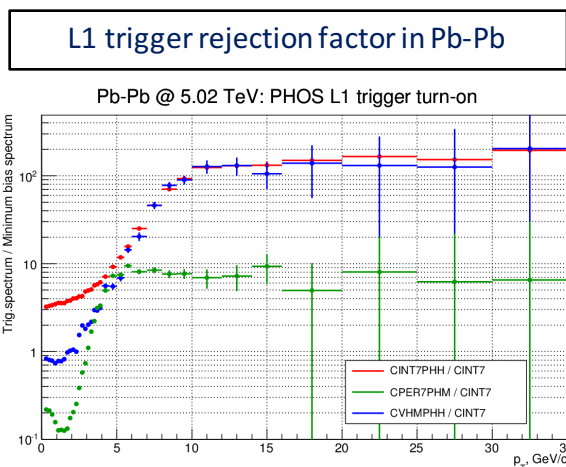
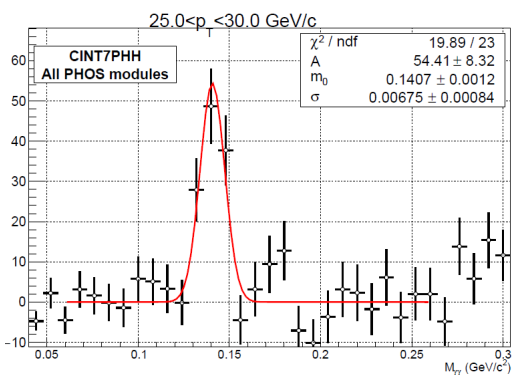
π^0 up to $p_T = 40$ GeV/c
 η up to $p_T = 12$ GeV/c
 T



L1 trigger deployed in Pb-Pb run. PHOS L1 configuration:

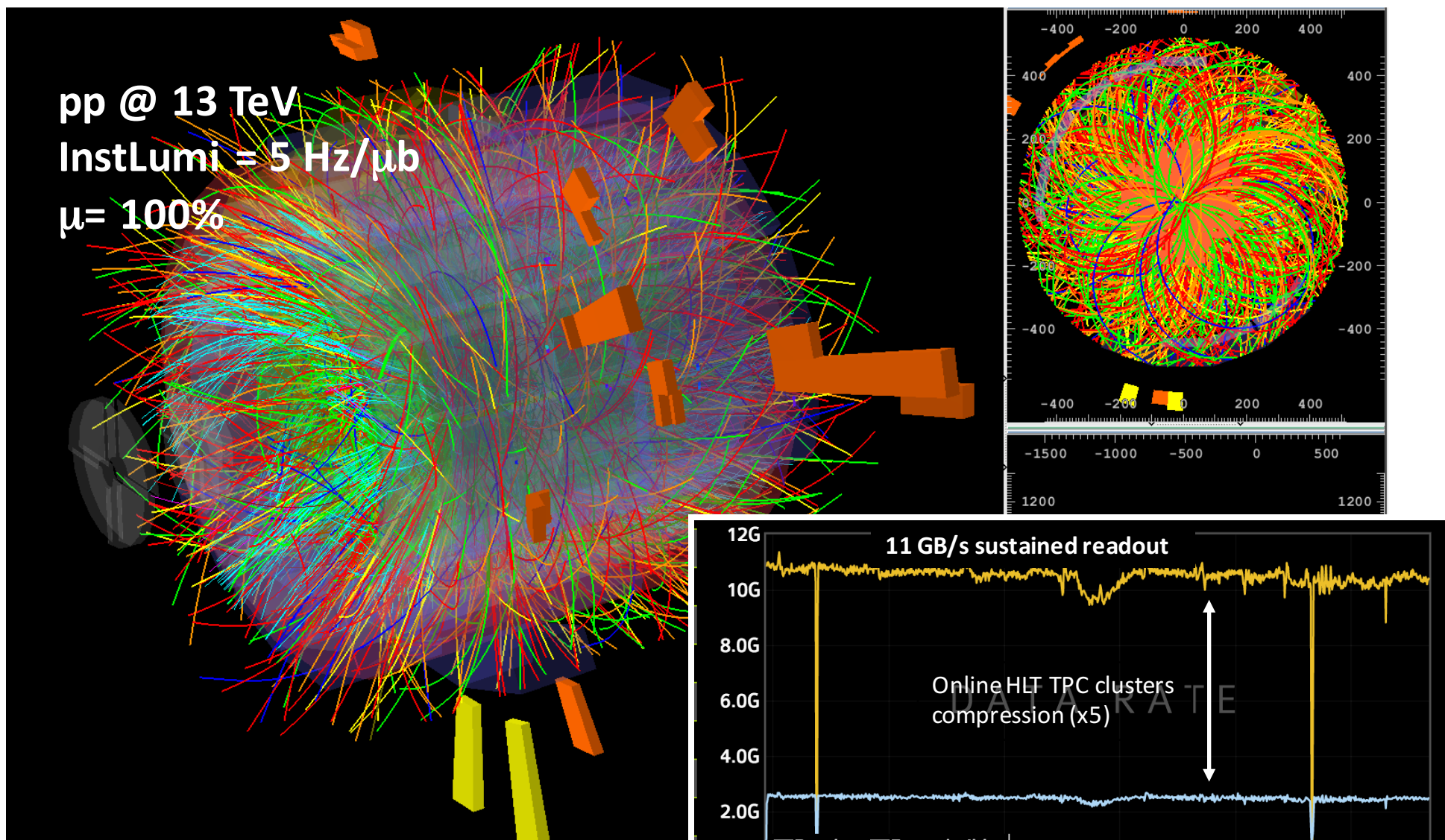
- + CINT7PHH: Gamma trigger with threshold 8 GeV & CINT7
- + CPER7PHM: Gamma trigger with threshold 4 GeV & CPER7

CPV is designed for photon ID in PHOS. **Stable operation since June.**



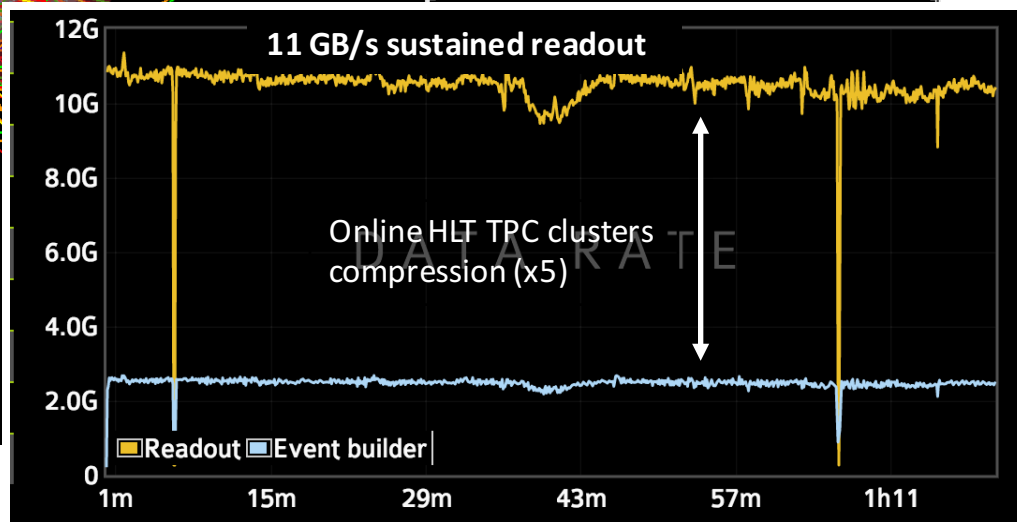
High Multiplicity p-p @ 13 TeV

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3 GByte/s sustained output to

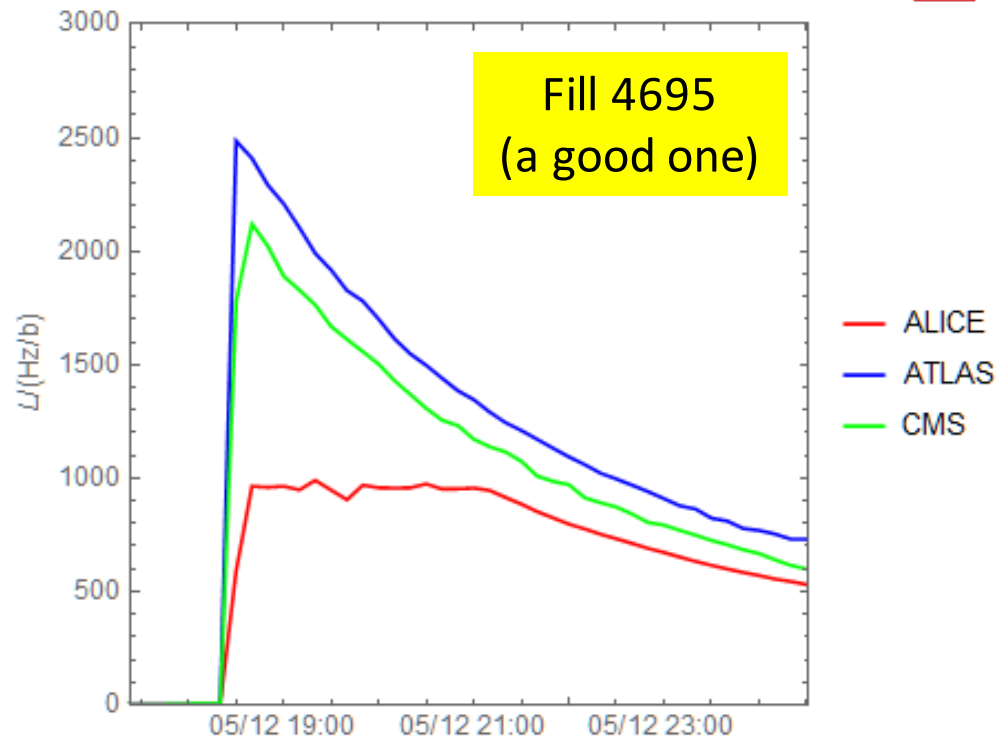
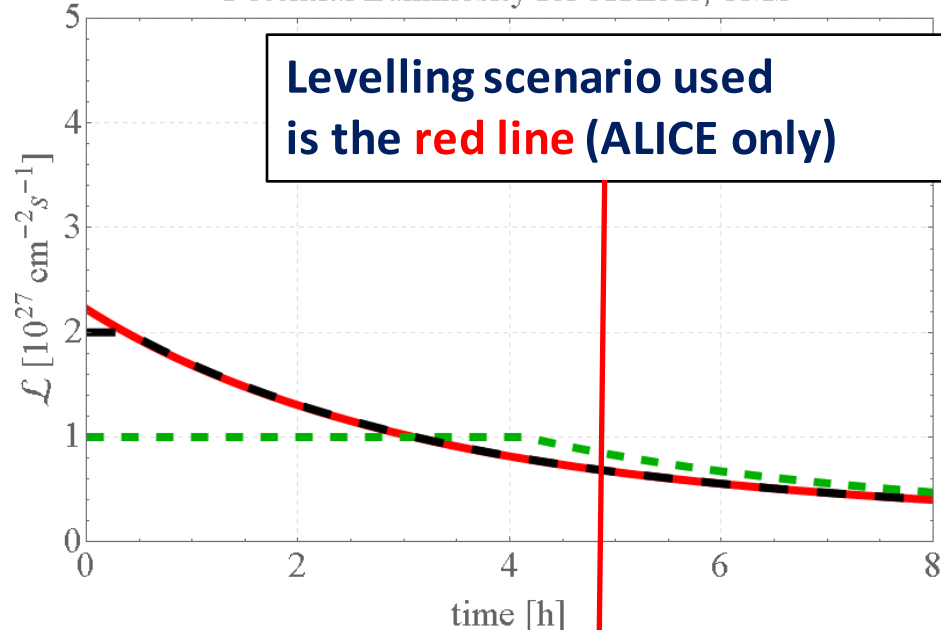
disk storage after compression. **2016/7/8 ~x2 with TPC RCU2**



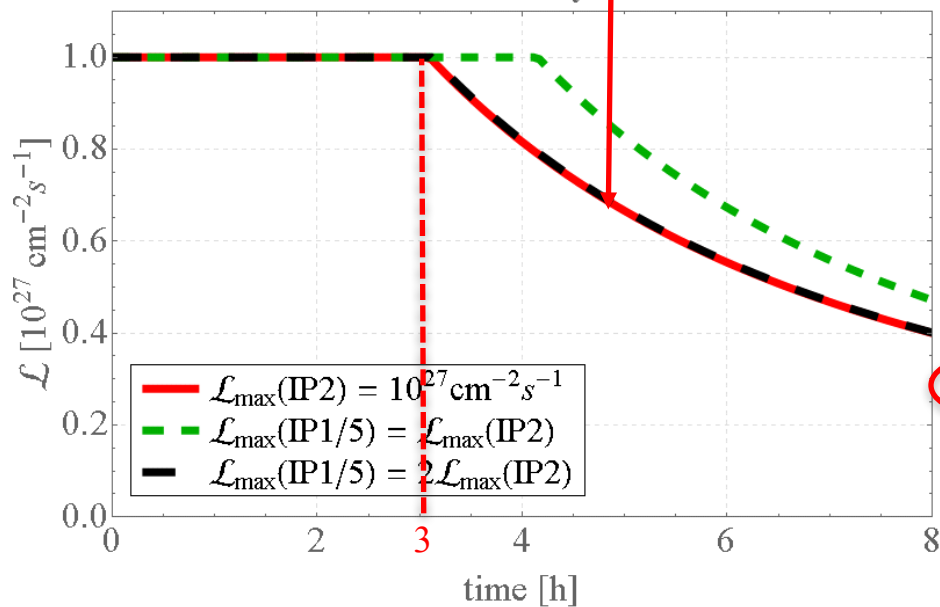
Luminosity Evolution: Prediction vs Reality



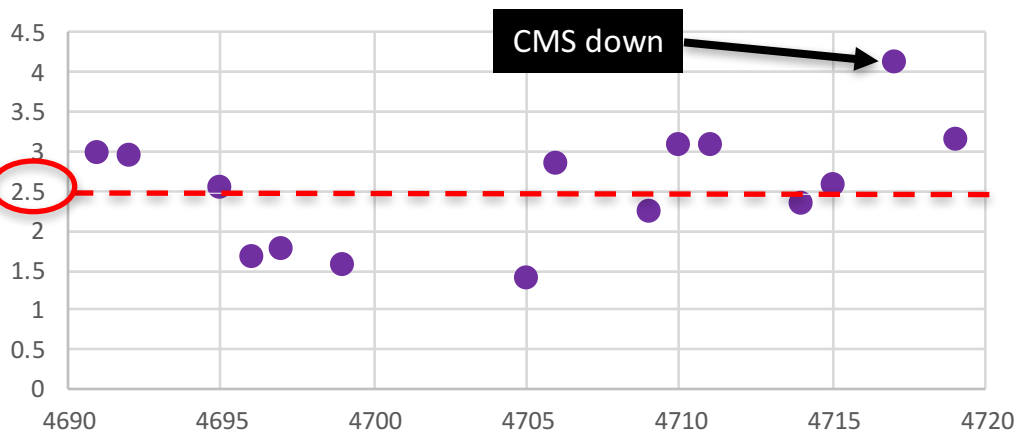
Potential Luminosity for ATLAS/CMS



Potential Luminosity for ALICE



ALICE leveling time at 1000 kHz/b



Simulation without LHCb (Michaela Schaumann)

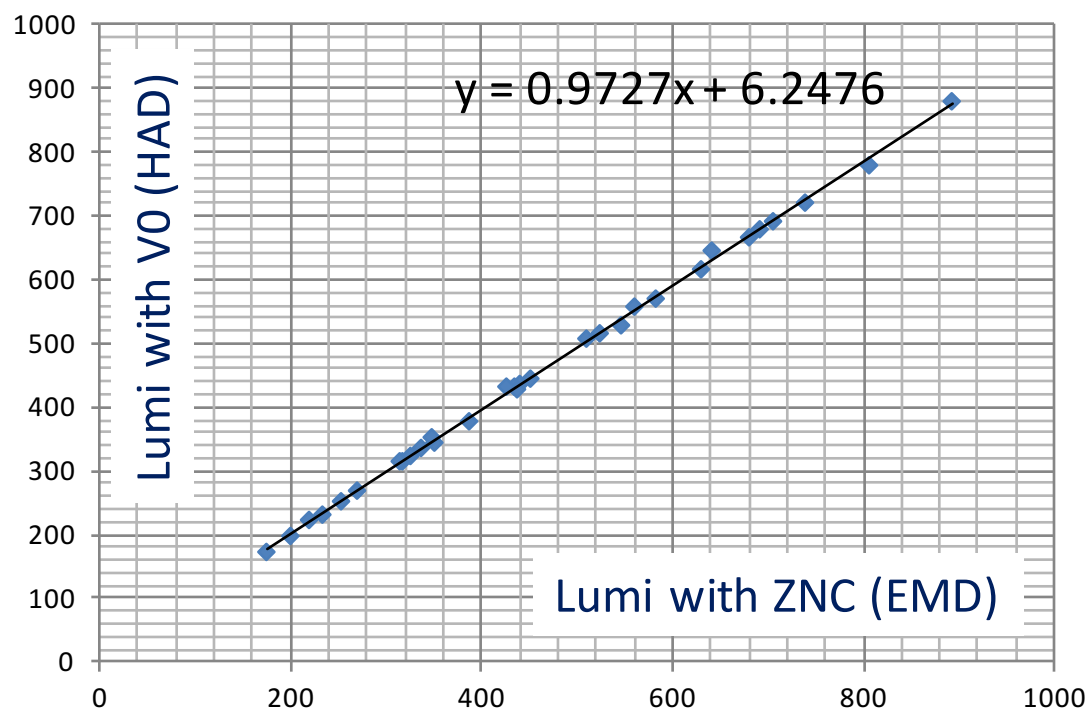
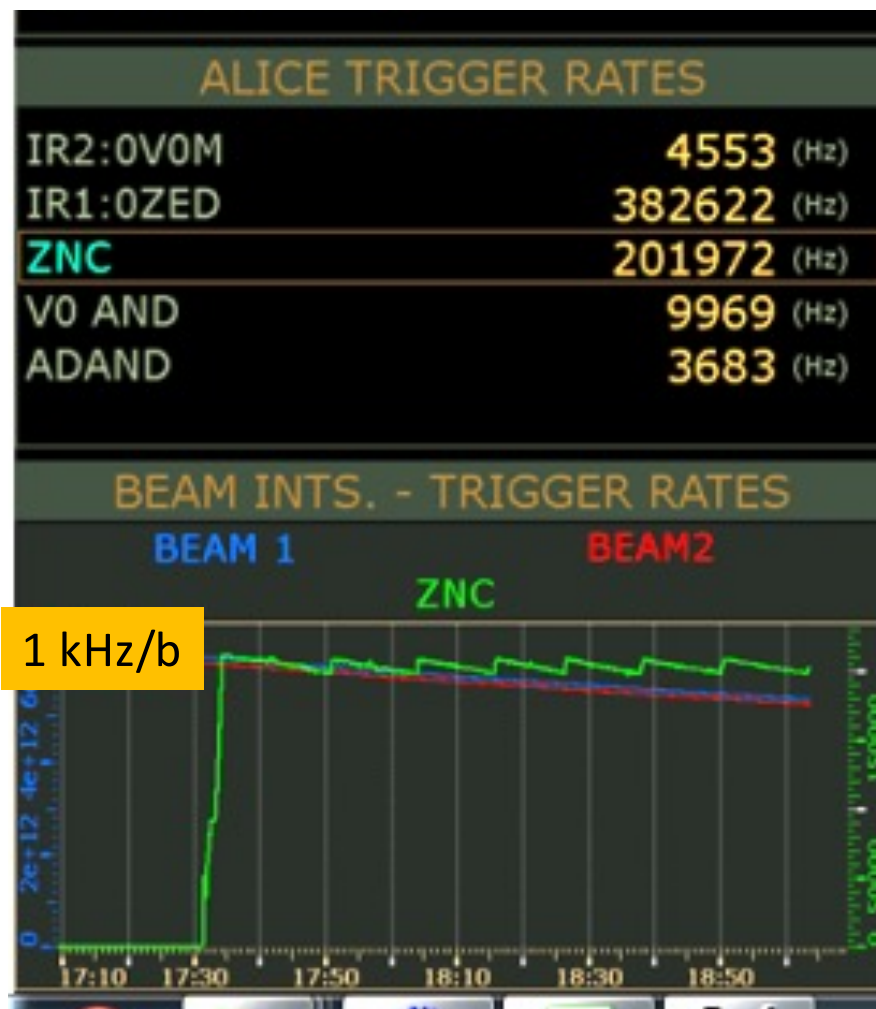
ALICE Luminosity Normalization

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The ZDC (Right of IR2) was used for luminosity reference:

- **ZNC – neutron ZDC fired:** $\sigma = 213$ b (RELDIS prediction at 5 TeV)
- **V0(0-60% centrality):** $\sigma = 7.7$ b x 0.6 = 4.6 b (assuming 7.7 b hadronic)



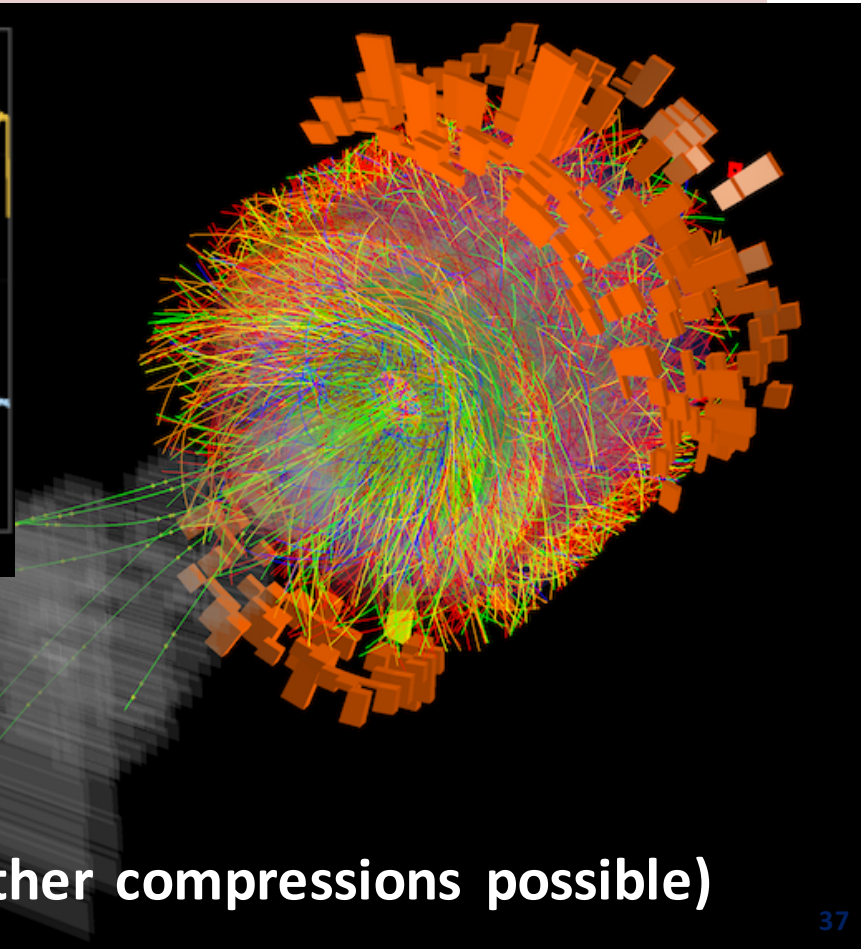
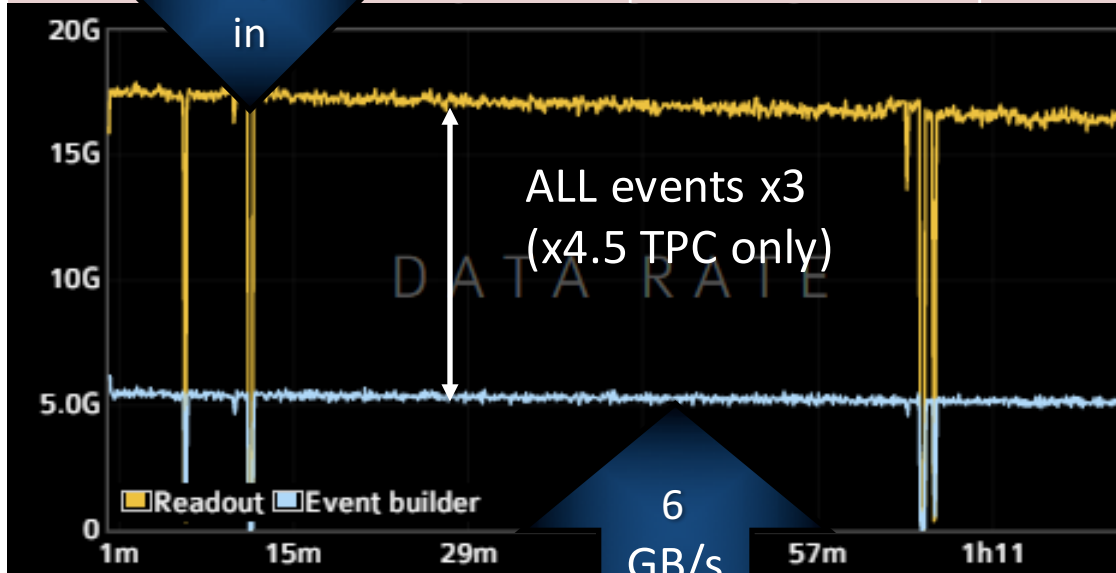
Excellent agreements between rates coming from different detectors sensitive to different processes

Pb-Pb 2015: Detail of ALICE Data Taking Profile



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Beam	# of Physics runs	Physics readout	Physics recorded
pp	4050	12.5 PB	5.3 G events, 4.5 PB, 1.1 TB/run
HI	388	9.3 PB	0.6 G events, 2.6 PB, 6.7 TB/run
Total	4438	21.8 PB	5.9 G events, 7.1 PB Run 1 (2010-2013): 7.4 PB



Data Rates with old (RUN1) TPC readout
 TPC RCU2 operational in 2016

→ **new target rate after HLT: 10 GB/s** (further compressions possible)

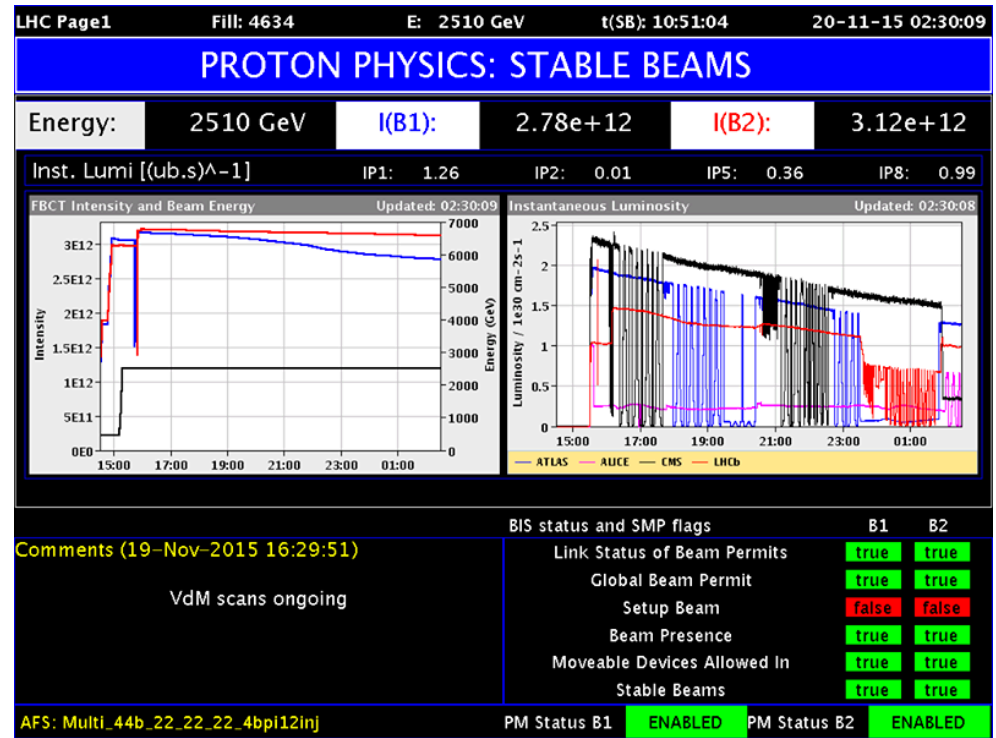
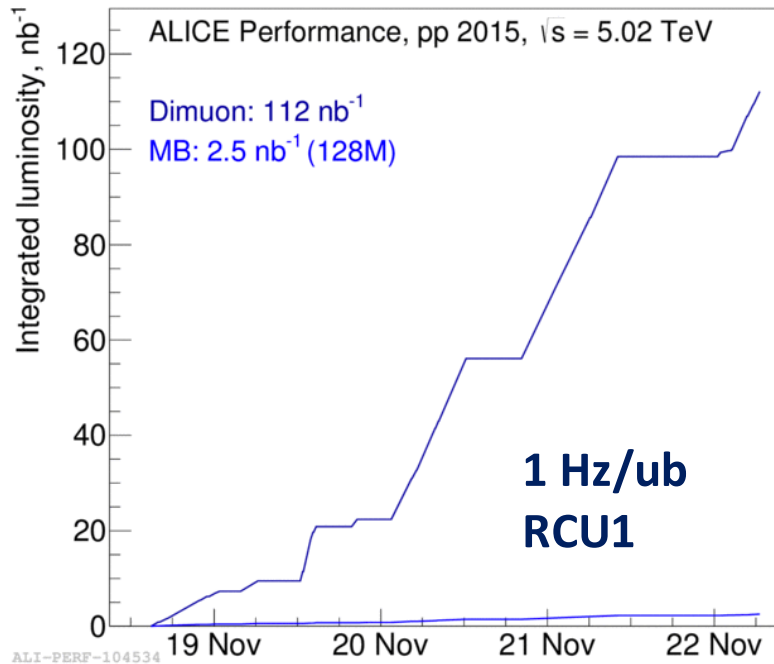
2015: p-p Reference at 5.02 TeV

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ALICE

7 days (3 setup, 4 running)
little contingency

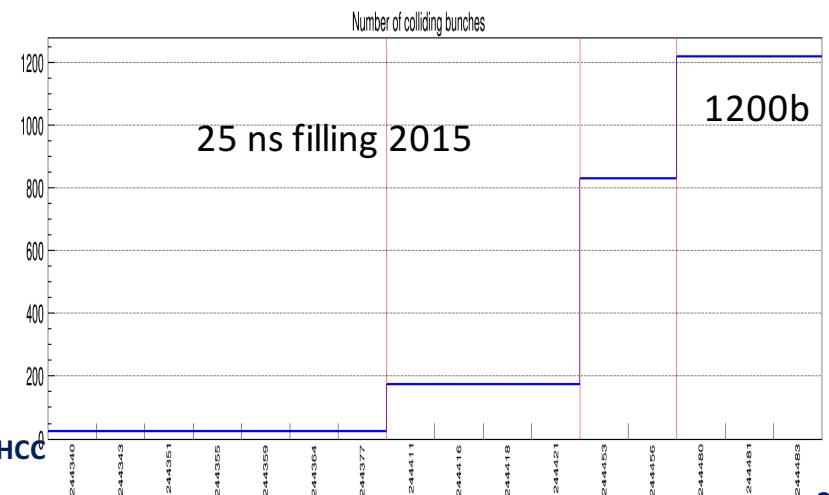


2016/17/18:

847 M events still to be collected in 2 additional weeks

- not taken from the 4 weeks of HI time
- PU (μ) of the order of 1-5%
- Not necessarily attached/close to the HI block or in the same year or in two separate periods

F. Ronchetti - 125th LHC



RUN2 TPC Readout Upgrade (RCU2)

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RCU2 installed

- First Commissioning successful
- FW Update done (week 8)
- Ready for “black laser data” and cosmic runs

Mar

7	8	9	10	11	12	13
15	22	29	7	14	21	Easter Mon 28
			Powering test		Recommissioning with beam	
	DSO test		Laser		Cosmics checkout	
					G. Friday	

