First discussion on luminosity requirements and run schedule

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with inputs from WG5 conveners and topic coordinators

Present baseline lumi requirements and schedule

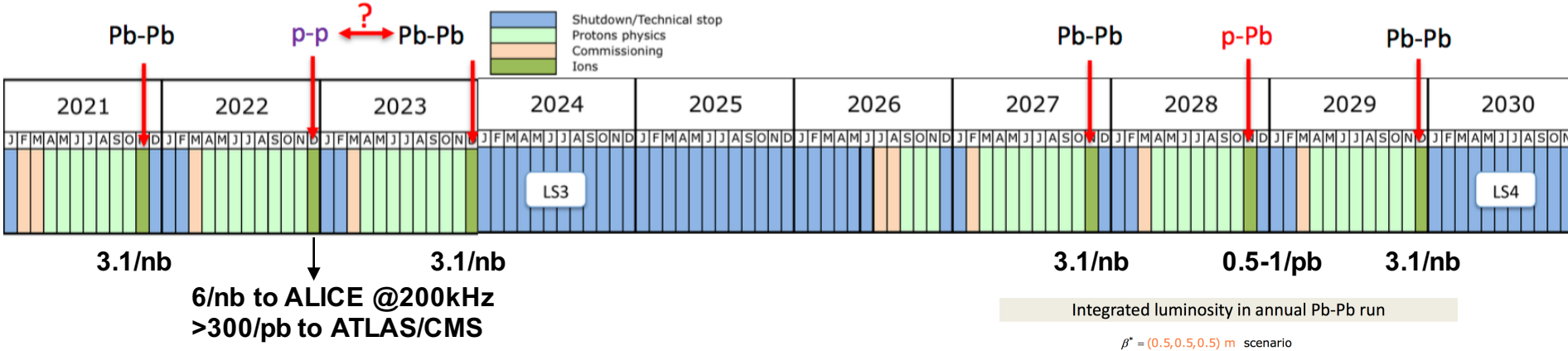
- ALICE L_{int} requirements (Upgrade LOI):
  - Pb-Pb: 10/nb @0.5T + 3/nb @0.2T
  - pp 5.5 TeV: 6/pb (4e11 events)
  - p-Pb: 50/nb
  - pp 14 TeV: introduced in 2015 (O^2 TDR)
- ATLAS/CMS:
  - Pb-Pb: 10/nb
  - pp 5.5 TeV: 300/pb (equivalent NN lumi of 10/nb Pb-Pb)
  - p-Pb: no lumi limitations
- LHCb:
  - Committed to participate in all runs, but no specific lumi requests up to now

Year	System	$\sqrt{s_{NN}}$ (TeV)	L_{int} pp: (pb^{-1}) p–Pb: (nb^{-1}) Pb–Pb: (nb^{-1})	$N_{collisions}$
2021	pp	14	0.4	$2.7 \cdot 10^{10}$
	Pb–Pb	5.5	2.85	$2.3 \cdot 10^{10}$
2022	pp	14	0.4	$2.7 \cdot 10^{10}$
	Pb–Pb	5.5	2.85 **0.2T**	$2.3 \cdot 10^{10}$
2023	pp	14	0.4	$2.7 \cdot 10^{10}$
	pp	5.5	6	$4 \cdot 10^{11}$
2027	pp	14	0.4	$2.7 \cdot 10^{10}$
	Pb–Pb	5.5	2.85	$2.3 \cdot 10^{10}$
2028	pp	14	0.4	$2.7 \cdot 10^{10}$
	Pb–Pb	5.5	1.4	$1.1 \cdot 10^{10}$
	p–Pb	8.8	50	10^{11}
2029	pp	14	0.4	$2.7 \cdot 10^{10}$
	Pb–Pb	5.5	2.85	$2.3 \cdot 10^{10}$

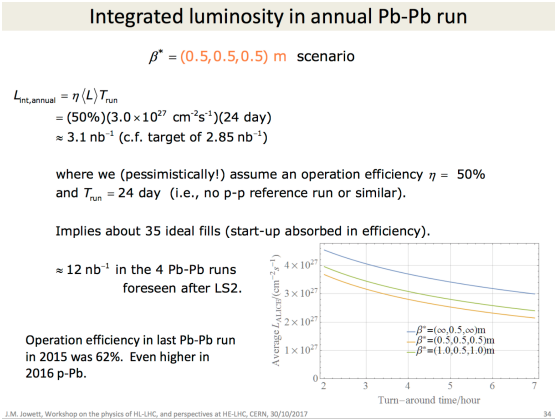
Updated (years) from ALICE O^2 TDR, CERN-LHCC-2015-006

LHC baseline schedule

- Baseline schedule, based on ALICE LOI, presented by J. Jowett at October WS
  https://indico.cern.ch/event/647676/contributions/2721134/attachments/1548951/2432673/HL-HE-LHC_physics_Jowett_30Oct2017.pdf



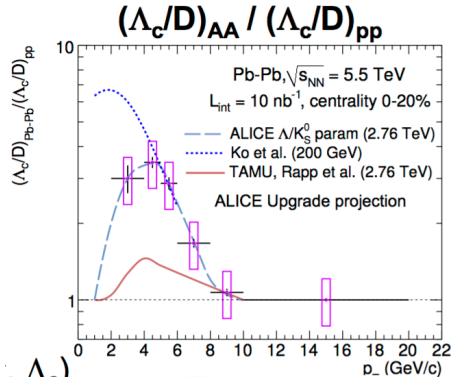
Pb-Pb:
β* = (0.5,0.5,0.5) m scenario (nominal)
50% LHC efficiency, 24 days runs
→ 12.4/nb in 4 runs

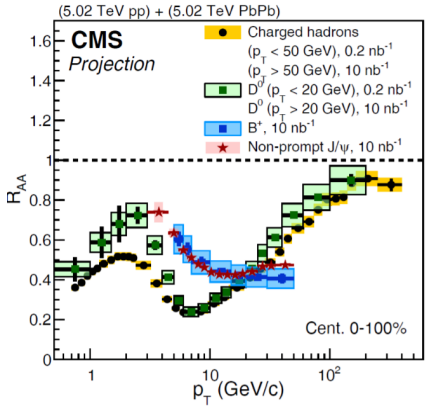


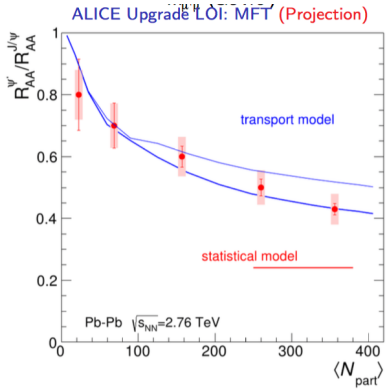
A fresh look at L_{int} requirements: Pb-Pb

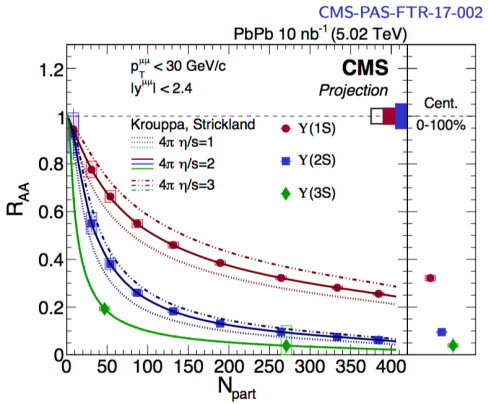
- The initial requirements are confirmed/assumed: 13/nb
  - **Heavy flavour:** 10/nb with ALICE at full field → Λ_c and Λ_b down to p_T of about 2-3 GeV/c; B-meson (+ non-prompt D and J/ψ) R_{AA} and v_2 down to p_T=0 with ALICE and CMS
  - **Quarkonia:** 10/nb → ψ(2S) R_{AA}, J/ψ v_2 down to p_T=0; Υ(2S) R_{AA} vs cent. <10%, first Υ(3S) R_{AA} in min. bias
  - **Jets:** 10/nb with ALICE at full field → e.g. D-jet FF; 10/nb with ATLAS/CMS → e.g. Z-jet momentum imbalance vs Z p_T (to be quantified), jet R_{AA} at 1 TeV with ~10% unc
  - **Light nuclei:** 10/nb with ALICE at full field → e.g. $^4_\Lambda$He (signif~5) and $^4_\Lambda$H (signif~10)
  - **Thermal radiation:** 3/nb with ALICE at low field → di-electron inverse slope with ~10% unc and v_2 with ~0.01 unc
  - **Flow:** 10/nb with ALICE at full field → D meson charge-dep v_1 with 3% unc on slope
  - …

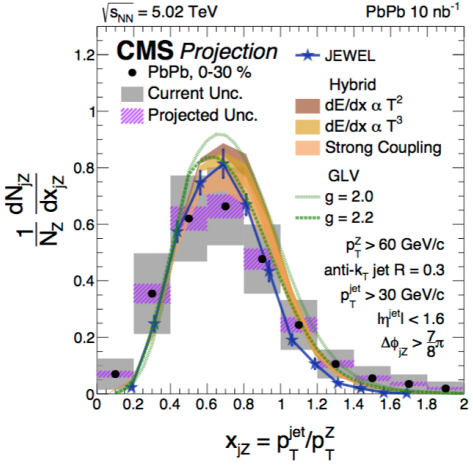
A fresh look at L_{int} requirements: Pb-Pb - plots

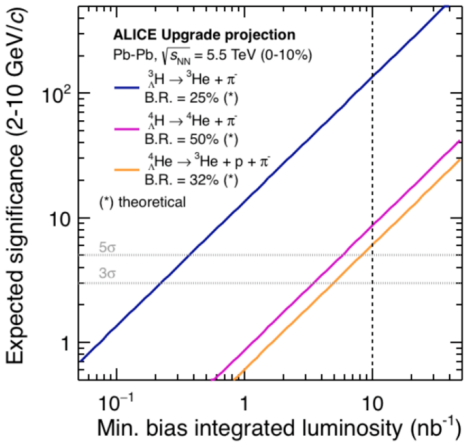


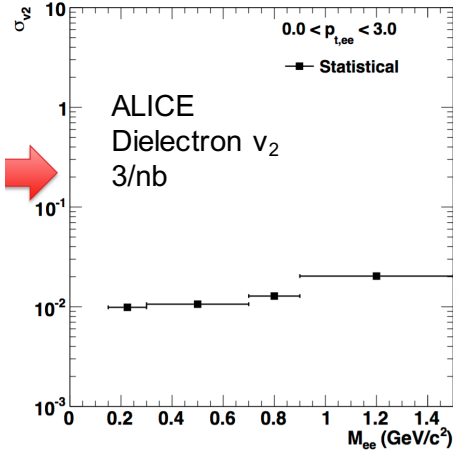


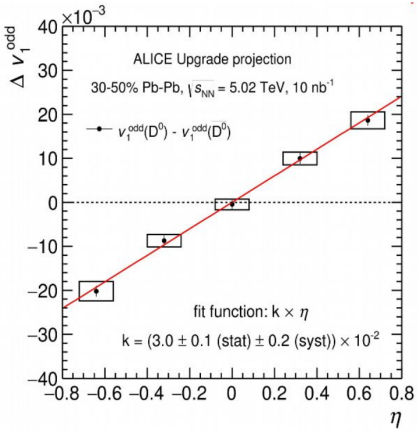










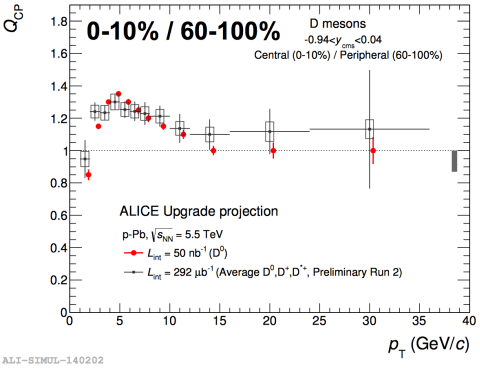


A fresh look at L_{int} requirements: p-Pb

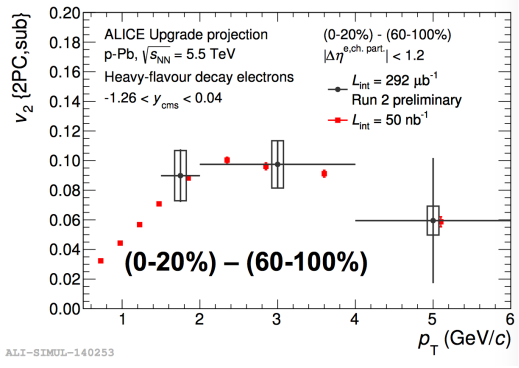
- The initial requirements are increased to ~1/pb for ALICE/ATLAS/CMS, ~0.5/pb for LHCb
  - **Heavy flavour:** 50/nb (same as LOI) for ALICE D meson R_{pA}, Q_{CP}, v_2
  - **Quarkonia:** 0.5-1/pb → J/ψ v_2, v_3 down to p_T=0 in p-Pb and Pb-p
  - **UPC, nPDFs:** 1-2/pb for ATLAS/CMS → reduce by ~30-50% nPDF unc at high Q^2 with top, dijets, W fwd/bkwd; 0.5/pb for LHCb → Drell-Yan measurement (plots in the prep.)
  - **Jets:** 1-2/pb with ALICE/ATLAS/CMS → search for energy loss in p-Pb (support plot?)
  - **Light nuclei:** >0.1/pb → N_{ch}-dependence of ^{3}He
  - **Thermal radiation and dileptons:** 50/nb → potential observation of thermal radiation with Rapp prediction, more detailed study ongoing; ~1/pb for ALICE for low-mass dark photon search?
  - …
- ALICE looking into possibility to run at ~1 MHz → 0.5-1/pb per month

A fresh look at L_{int} requirements: p-Pb - plots

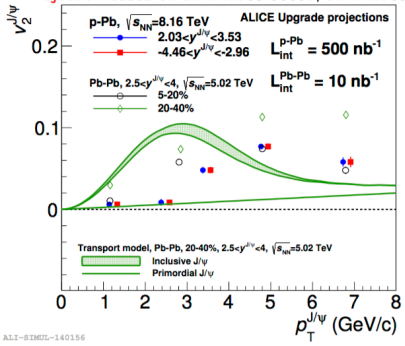
D mesons

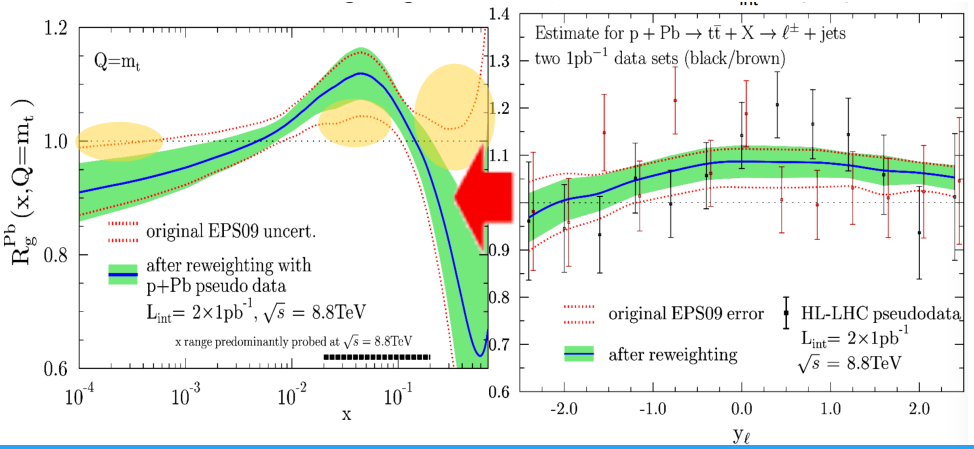


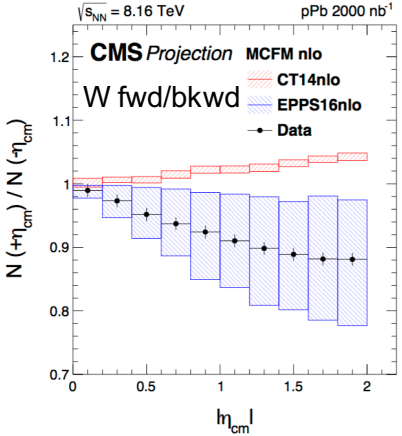
HF electron- hadron correlations



Projection based on arXiv:1709.06807, arXiv:1709.05260







p-Pb energy and timing

- 5.5 or 8.8 TeV?
  - 8.8 TeV optimal for most measurements: larger cross sections, N_{ch}, lumi, lower Bjorken-x
    - However, needs a dedicated pp reference run at 8.8 TeV (L_{int} requirements to be quantified). Could be a few days for ATLAS/CMS/LHCb. Takes longer for ALICE, but maybe lower L_{int} requirements?
  - 5.5 TeV has the advantage of having the same pp reference as Pb-Pb

- Timing:
  - Physics potential of p-Pb favours having a p-Pb run in Run-3
  - A second run in Run-4 would benefit from extended tracker acceptance for ATLAS/CMS (up to eta=4), for multi-particle correlations; in addition: possible FoCal in ALICE

New on the table

- pp 14 TeV data at low μ
  - Opens opportunity of large overlap between pp and PbPb, see talk by Jan Fiete
  - Requirement by all experiments of 200/pb with HM (and diffr.) triggers in Run-3 (2021-22-23)
    - ALICE μ~0.01 (negligible pileup)
    - ATLAS/CMS μ~1-2 (pileup under control), also benefit W measurements for PDF constraints (info from WG1)
  - May have impact on ATLAS/CMS overall running plan and LHC filling scheme (ALICE)
  - Feasibility in ALICE has now been verified (~1 MHz int. rate + trigger and "HLT" selection)
- Lighter nuclei collisions (e.g. Ar-Ar or Ca-Ca)
  - Extended discussion at June WS (Zvi coordinating)
- p-O for cosmic-ray generators tuning
  - See talks by H. Dembinski at previous WG5 meetings
  - Ongoing discussions on quantitative improvement wrt pp-pPb interpolation
  - Required lumi: ~0.2/nb (100M events), ~1 week including setup

Summing up (provisional)

- **Pb-Pb (confirmed)**: 13/nb (timing not discussed yet)
- **pp 5.5 TeV (confirmed)**: 6/pb ALICE, 300/pb ATLAS/CMS (timing not discussed yet)
- **p-Pb (updated)**: 0.5/pb ALICE/LHCb, 1-2/pb ATLAS/CMS
  - (also) in Run-3?
  - 8.8 TeV preferred for most topics, but likely needs dedicated pp reference
- **pp 14 TeV (updated)**: 200/pb in Run-3 at low(er) μ
- **New to be discussed: lighter ions, p-O**

To be continued ….

EXTRA SLIDES