ALICE
From RUN 2 to RUN 3 and beyond

Sarah Porteboeuf Houssais for ALICE-France

Conseil Scientifique IN2P3 – 06/02/2023
Outline

- Why to study the Quark-Gluon Plasma?
- What we learned from RUN 2?
- What are the plans for RUN 3?
- What was done to prepare for RUN 3 challenges?
- What are the plans for RUN 4?
- What we expect from the ALICE-France community at the horizon of RUN 4?
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Collective behavior with charm and beauty

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

If quarkonium are regenerated, they acquire collective properties of the expanding medium \( v_2 > 0 \)

Unambiguous observation of non-zero \( J/\psi \) \( v_2 \)

At high \( p_T \), stronger effect than expected: possible path-length dependence effect

At low and intermediate \( p_T \): \( v_n(J/\psi) < v_n(D) < v_n(h) \)

Also
Jet azimuthal anisotropy, submitted to PRL arXiv:2110.15852
\( \eta \) meson in Pb-Pb EPJC 78 (2018) 559 and pp EPJC 81 (2021) 772

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QGP droplets in p-Pb and pp?

- Ambiguous results for probes directly related to a possible formed hot medium
- No sign of in-medium interaction with energy loss within the current experimental precision
- Role of initial state, saturation, final state, hadronization, fluctuations under investigation

Also azimuthal anisotropy of jet particles in p-Pb and Pb-Pb submitted to PRL single-$\mu$ azimuthal anisotropy to be submitted to PLB

J/ψ – hadron correlations in pp to be submitted to JHEP

Quarkonium inclusive production submitted to EPJC arXiv:2109.15240

Jet cross section in pp PRD 100, 092004 (2019)
RUN 3

- Better probe QGP with heavy flavor quarks
- Study hadronic collision scaling quantity from pp to Pb-Pb and onset of collectivity in hadronic collisions

- Improve vertexing capabilities in the central barrel allowing better reconstruction of primary and secondary vertices
  - Better rejection of background
  - Better reconstruction of decay chain, especially at low $p_T$

- Charmonia and Open heavy flavors: separation of charm and beauty
  - Prompt Charmonium production
    Prompt/non-prompt $J/\psi$ separation down to $p_T = 0$. $\psi(2S)$ measurement in central Pb-Pb collisions
  - In the HF sector
    Charm and Beauty measurement down to $p_T = 1\text{ GeV}/c$ in the single muon channel
    Beauty measurement down to $p_T = 0$ in the non-prompt $J/\psi$ channel

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

- Open possibilities for central-forward correlation of many probes

- Increase statistics by a factor 10 (muons) to 50 (central barrel)
RUN 3 challenges

RUN 1
2009-2013

pp 7 TeV, pPb, Pb-Pb

RUN 2
2015-2018

pp 13 TeV, pPb, Xe-Xe Pb-Pb

RUN 3
2022-2025

pp 13.6 TeV, pO, O-O, pPb,Pb-Pb

RUN 4
2029-2032

pp, pPb, Pb-Pb

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A Large Ion Collider Experiment

RUN 3 challenges

Total integrated Luminosity RUN 1+2

Pb-Pb: 1.5 nb⁻¹ in ALICE
2.54 nb⁻¹ in ATLAS/CMS, 0.26 nb⁻¹ in LHCb

p-Pb: 75 nb⁻¹ in ALICE
≈220 nb⁻¹ in ATLAS/CMS, 36 nb⁻¹ in LHCb

In ALICE, Pb-Pb: interaction rate ~8 kHz with trigger event → Readout ≈ 1 kHz

Target Luminosity RUN 3+4

Pb-Pb: 13 nb⁻¹ in ALICE/ATLAS/CMS,
2 nb⁻¹ in LHCb

p-Pb: 0.5 pb⁻¹ in ALICE
1 pb⁻¹ in ATLAS/CMS, 0.2 pb⁻¹ in LHCb

In ALICE, Pb-Pb: interaction rate 50 kHz, continuous readout
Statistics from x10 to x50 depending on probe
Online data reconstruction
RUN 3 plan adaptation

- **In 2022 major events impacting LHC operation**
  - LHC cryo issue, LHC stopped 4 weeks, 3 weeks of data taking lost (1 week shadowed by planned Technical Stop)
  - War in Ukraine and Energy crisis in Europe: 2022 operation stopped 2 weeks earlier for energy saving

- **RUN 3 plan adapted**
  - 2022 devoted to pp data taking
  - HI run postponed to 2023 with extended running time: 5 weeks instead of 4
RUN 3 plan adaptation

- Detailed RUN 3 plan under discussion
  - 20% reduction of running time every year as a baseline
  - Several scenarios under discussion

- p-Pb in 2024 as initially planned
- 2 Pb-Pb period extended to 5 weeks
- 3w p-Pb in 2025, after completion of the PbPb program
- 4w Pb-Pb in 2024 and 2025
- p-Pb postpone to RUN 4
To ensure the PbPb plans

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RUN 3 plan adaptation

- Thanks to reduce set-up times and higher performances of the machine in longer run
- ALICE integrated luminosity target remains
  - 2023 Pb-Pb: target $L_{\text{int}}^{\text{Pb-Pb}} = 3.25 \text{ nb}^{-1}$
  - Target Pb-Pb lumi for Run 3: $L_{\text{int}}^{\text{Pb-Pb}} = 6.5 \text{ nb}^{-1}$
  - If achieved in 2023+2024: run p-Pb in 2025 with $L_{\text{int}}^{\text{p-Pb}} = 150 \text{ nb}^{-1}$

Considerations on performance

- Estimated performance has large uncertainties
  - Especially from machine availability and beam parameters in collision

- Depending on scenario, estimate about
  - 2.7-3.6 nb$^{-1}$ at ALICE
    - Goal by experiment: 3.25 nb$^{-1}$
  - 2.4-3.2 nb$^{-1}$ at ATLAS/CMS
    - Goal by experiment: 3 nb$^{-1}$
  - 0.3-0.5 nb$^{-1}$ at LHCb
    - Goal by experiment: 0.4 nb$^{-1}$

- The goals set by the experiments are challenging and ambitious
  - Could be feasible, but also clear risk that we cannot reach the goals for some or all experiments
  - If we do not reach the 2023 goal, could compensate by doing Pb-Pb instead of p-Pb
  - If we have 4 ion runs in Run 4, it will be easier to reach the overall Run3 + Run 4 goal

- 3-5% loss in integrated luminosity at 6.37 Z TeV
A Large Ion Collider Experiment

RUN 3 challenges

RUN 1
2009-2013

RUN 2
2015-2018

RUN 3
2022-2025

RUN 4
2029-2032

LS1

LS2

LS3

pp 7 TeV, pPb, Pb-Pb

pp 13 TeV, pPb, Xe-Xe Pb-Pb

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continuous readout
Statistics from x10 to x50 depending on probe
Online data reconstruction

ALICE 2 is a new experiment!

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ALICE 2 – Upgrades for RUN 3

Time Projection Chamber (TPC)
New readout chambers: from Multi Wire Proportional Chamber (MWPC) to Gas Electron Multiplier (GEM)

Integrated on-/off-line System
Continous Readout with First Level Processors (FLPs), O2-CRU
Event Processing Nodes (EPNs) for GPU-based Synchronous reconstruction

Consolidation and readout upgrade of all subsystems with Common Readout Unit (CRU)
- MCH upgrade with SAMPA ASIC
- MID (upgrade of MTR) with FEERIC ASIC

Fast Integration Trigger

Online Data Compression

Muon Forward Tracker (MFT)
5 double planes of MAPS
Forward vertexing for Muons

Inner Tracking System (ITS 2)
7 cylindrical layer of MAPS (~ 10m²)
Improved vertexing at high rate

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A Large Ion Collider Experiment

MUON CHAMBER - MCH

- 5 tracking stations (2x5 Multi-Wire Proportional Chambers)
- complemented with an absorber system

- Redesign of Readout electronic with DualSampa cards

- Rejuvenation of high/low voltages (quadrant opening and cleaning)

- Successfully Installed, cabled and integrated

- Software
  - Simulation
  - Simulation & Reconstruction
  - Calibration

- Commissioning finalised, successful data taking at 500 kHz pp interaction rate

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MUON IDENTIFIER - MID

- 72 Resistive Plate Chambers (RPCs) in 2 stations of 2 planes
- total surface ~150 m²
- 21k readout channels.

- Upgrade of Front-End electronic with amplification (FEERIC) to prevent ageing:
  - Design
  - Production
  - Installation
  - Distribution of the thresholds via wireless systems

- Upgrade of readout electronics, slow control, detector simulation

- Software
  - reconstruction
  - QC

- Commissioning finalized, successful data taking at 500 kHz pp interaction rate

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MUON FORWARD TRACKER - MFT

- Vertex tracker for the Muon Spectrometer, installed between the interaction point and the hadron absorber (-3.6 < η < -2.5)
- 920 ALPIDE silicon pixel sensors (0.4 m²) in 280 ladders of 2 to 5 sensors each (same sensor as ITS2)

**Hardware and Services**
- Ladder assembly
- Cooling system
- Power Supply Unit
- Readout System and Firmware
- Slow Control (ALF-FRED)

**Installation and commissioning**

**Software**
- Geometry
- Reconstruction
- Tracking
- MCH-MFT matching

**Commissioning finalized**, successful data taking at 500 kHz pp interaction rate

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INN1ER TRACKING SYSTEM 2 – ITS2

- **Monolithic active sensors** (MAPS) called ALPIDE, integrating both pixel sensor and read-out electronics in a single device.

- **7 coaxial layers to cover** $|\eta| < 1.3$ divided into 2 groups:
  - the 3 internal layers installed closest to the beam pipe
  - 4 outer layers

- **Successfully installed**, cabled and integrated in May 2021.

- **Commissioning finalized**, successful data taking at 500 kHz pp interaction rate
  - Online reconstruction and data compression
  - Tracking and dedicated QC
  - Performance studies with comparison to Monte Carlo
  - Alignment

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ALICE 2 pp Data Taking 2022

- Physics data taking at 500 kHz
  - Online data compression of a factor 18
  - Commissioning and validation of all components
  - Preparation of Physics

- Preparation of Pb-Pb program
  - 1 MHz (pp ref run)
  - Intensity scan up to 4 MHz in pp (equivalent track load of Pb-Pb 50 KHz)

![Delivered Luminosity 2022](image)
ALICE 2 pp Data Taking 2022

- 2022 pp data under reconstruction on EPN Farm (Event Processing Node) and the Grid
- Performance study and analysis preparation ongoing

Work In Progress

A Large Ion Collider Experiment

21
ALICE 2 Commissioning Pb-Pb test beam

- 2 fills at top energy 5.36 TeV
- Machine commission slip stacking and crystal cleaning
- All ALICE 15 detectors in the data taking
- Online calibrations and reconstruction (including most central events)
- 3.68 pb\(^{-1}\) of data recorded (Compressed and Raw Time Frame)

Input data rate

<table>
<thead>
<tr>
<th>Readout</th>
<th>StiffBuilder</th>
<th>DPL In</th>
<th>DPL Out</th>
<th>StiffBuilder In</th>
<th>StiffBuilder Out</th>
<th>TIBuilder In</th>
<th>TIBuilder Out</th>
<th>DPL In</th>
<th>CTF Writer</th>
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<td>95.0 GB/s</td>
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<td>93.5 GB/s</td>
<td>868 MB/s</td>
<td>90.4 GB/s</td>
</tr>
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</table>

1.1 M MB Events

Stable processing during 8h30

PID TPC
ALICE 2.1 – Upgrades for RUN 4

**FoCal**
- FoCal-E, Si-W high granular elem. calorimeter
- FoCal-H, Cu-fibre hadronic calorimeter

**ITS 3**
- B- & c-strange mesons+baryons: $B^0_s, \Lambda_b^0, \Lambda_C^+, \Xi_C^0, \Xi_C^+$
- **Heavy-flavour vertexing at low $p_T$** with prompt $\Lambda_C^+, Ds^+, \Xi_C$
- By reducing the material budget and getting closer to IP
- Inner-most tracking layers to be replaced by ultra-thin, wafer-scale bent MAPS

**Small-x complementary to LHCb and EIC**

**Fixed Target**
- Proposal for a retractable fixed target
- Target position $z \sim 4.8$ m on A side
- Use of bent crystals
- Conceptual design and perf. studies
- ANR JCJC by L. Massacrier
- Continuation of integration studies by ALICE Technical Coordination not supported by ALICE MB

Presented at Conseil Scientifique IN2P3
27/10/22
Projet de participation à une jouvence de l’expérience ALICE

CERN-LHCC-2020-009
VI.1 – ITS3 project: state of the art 2022-10

- Beam tests of bent ALPIDE chips (arXiv:2105.13000)
- Beam tests with μITS3
- Construction of SuperALPIDE, ongoing (i.e. ITS2 chip 50-μm thick, 180-nm technology)

Mechanical integration, cooling test

C. from 180-nm CMOS technology to 65-nm (Tower foundry): MLR1
  i) charge collection, ok!
  ii) ε > 99%
  iii) rad hard, ok!

D. 1D Stitching: wafer-scale "chip" (=1.4x26 cm²), thinned (< 40 μm)

V.1 – ITS3 project: milestones

4 Engineering Runs (ER), all in 65-nm technology, "no production phase only R&D":

1. MLR1 tape out (2020-12):
   - 60 chips of 1.5x1.5 mm², (analog + digital blocks) + 3 prototypes: APTS, CE65, DPTS
   - Main goals:
     - Learn technology features of 65-nm node
     - Characterize charge collection (cluster, timing, ...) and detection eff. (>99%)
     - Validate radiation hardness

2. ER1 tape out (2021-11):
   - stitching 1D (+ assess yields by the foundry)
   - sensors MOSS and MOST, with 18 and 22.5 μm pixel pitches
     - Technical Design Report, TDR (2023-10) – i) bending MAPS, ii) 65-nm MAPS, iii) stitching –

3. ER2 tape out (2024-02):
   - prototype with full functionalities (power, readout, ...) ITS3-like

4. ER3 tape out (2025-06):
   - final "production"

Presented by A. Maire at CS IN2P3 27/10/22 Projet de participation à une jouvence de l’expérience ALICE
https://indico.in2p3.fr/event/28308/
ALICE-France (IN2P3) community

- O(100) physicists in the French QGP community
- + Engineers and technicians
- ALICE-IN2P3 permanent physicists = 34
- QGP-France annual meeting
- High level of implication and recognition in the ALICE Collaboration
  - Projects : ITS2, MCH, MID, MFT, O2
  - Implied at many levels of the collaboration
    - Spokesperson office
    - Management Board
    - Physics Board
    - Technical Board
    - Conference committee
    - Run coordination
    - Scientific coordination
      - Physics Coordination
      - Physics Working Group
      - Physics Analysis Group

<table>
<thead>
<tr>
<th>Level of responsibility</th>
<th>2021</th>
<th>2022</th>
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<tbody>
<tr>
<td>L1</td>
<td>4</td>
<td>3</td>
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<tr>
<td>L2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>L3</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

- Linked to the GDR QCD
- Linked to the SFP Division Nucléaire and Division Champs et particules

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Conclusions

- **Important physics results** for the comprehension of QGP physics have emerged during RUN 2 data analysis with strong leading role from the French community.

- **Successful upgrade** conducted during LS2 in preparation for RUN 3
  - Leading role in major ALICE projects MCH, MID, MFT, ITS2
  - Upgrade in time despite worldwide situation (Covid pandemic)

- **Successful installation and integration** into the global ALICE data taking

- **Preparation of RUN 3 physics analysis** ongoing

- **Engagement of the French community until end of RUN 4**
  - Maintenance and operations of ITS2, MCH, MID, MFT, O2-CRU
  - Exploitation of physics data through data analysis

- **Preparation of LS3/LS4 and upgrades upon IN2P3 approval**
Thanks to the ALICE-France community for the help in preparing the slides!
And more specifically to
Antonin, Antonio, Boris, Christophe, Cvetan, Cynthia, Diego, Marie, Nicole, Philippe, Xavier
ALICE-France for RUN 3 and RUN 4

Person–power anticipated evolution
Permanent only (not including post-doc, PhD and emeritus)
Including known retirements and thematic changes
No permanent recruitment taken into account

<table>
<thead>
<tr>
<th>Team</th>
<th>“M&amp;OA” (2022)</th>
<th>Due service work FTE/year (2022)</th>
<th>Main detector activities in Runs 3 (+ Run 4)</th>
<th>“M&amp;OA” (projected end Run 3, 2026)</th>
<th>“M&amp;OA” (projected early Run 4, 2029)</th>
</tr>
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<tbody>
<tr>
<td>IJClab Orsay</td>
<td>4 + 1</td>
<td>5</td>
<td>MCH, O²</td>
<td>4 + 1</td>
<td>5</td>
</tr>
<tr>
<td>IPHC Strasbourg</td>
<td>5 + 1</td>
<td>6</td>
<td>ITS2 (+ ITS3)</td>
<td>4 + 1</td>
<td>5</td>
</tr>
<tr>
<td>IP2I Lyon</td>
<td>3 + 0</td>
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<td>MFT (+ ITS3)</td>
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<td>4</td>
<td>readout, DPG (+ ITS3)</td>
<td>2 + 2</td>
<td>4</td>
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<tr>
<td>Subatech Nantes</td>
<td>7 + 2</td>
<td>9</td>
<td>MID, MCH, MFT</td>
<td>4 + 2</td>
<td>6</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>23 + 11</strong></td>
<td><strong>34</strong></td>
<td></td>
<td><strong>18 + 11</strong></td>
<td><strong>16 + 9</strong></td>
</tr>
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</table>

1. Ensure the maintenance and operations of all projects handled by French teams

2. Exploit the full physics output

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Studying the Quark-Gluon Plasma

Quark-Gluon Plasma (QGP) is a deconfined state of quarks and gluons (asymptotic freedom regime) predicted by QCD and studied in high-energy heavy-ion collisions


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Historical approach for QGP studies

- pp collisions were considered as the vacuum reference
- p-A collisions are a control experiment to estimate cold matter effects
- AA collisions are described by a (geometrical) Glauber model defining the number of participants and the number of binary collisions ($N_{\text{coll}}$) for a given impact parameter $b$

- Emblematic observables for hard and soft probes

**Nuclear modification factor**

\[
R_{\text{AA}} = \frac{dN_{\text{AA}}/dp_T}{<N_{\text{coll}}>/x dN_{\text{pp}}/dp_T}
\]

**Elliptic flow**

Initial spatial anisotropy transferred into a momentum anisotropy of particles

\[
\frac{dN}{d\phi} \propto 1 + 2 \sum_{n=1}^{\infty} v_n \cos(n(\phi - \Psi_n))
\]
Characterizing the medium

Nuclear modification factor

\[ R_{AA} = \frac{dN_{AA}/dP_T}{<N_{coll}> \times dN_{pp}/dP_T} \]

Normalization by the number of collision \((N_{coll})\)

Measurement in AA

Some probe sensitive to the nuclear environment: cold matter effect (pA)

Suppression

Hard probes

Interact with the medium

Measurement in AA

\[ N_{coll} \]

\[ N_{pp} \]
Characterizing the medium

Nuclear modification factor

$$R_{AA} = \frac{dN_{AA}/dP_T}{<N_{coll}> \times dN_{pp}/dP_T}$$

Measurement in AA

Suppression

$$\beta_{1A} = \text{superposition of } N_{pp}$$

Some probe sensitive to the nuclear environment: cold matter effect ($pA$)

$$R_{\text{AA}}$$

Normalization by the number of collision ($N_{coll}$)

Same measurement in min-bias pp

$$\frac{dN_{AA}}{dP_T}$$

Measurement in AA

$$\frac{dN_{pp}}{dP_T}$$

$P_T$ bins

$N_{coll}$

$N_{pp}$

$P_T$

$N_{AA}$

$N_{PP}$

$P_T$

$N_{coll}$

$N_{AA}$

$N_{PP}$

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Isolated photons extend $x_T$ world coverage and confirm $n = 4.5$ scaling: same production mechanism.

Significant deviations from the free-nucleon PDF predictions, up to 3.5$\sigma$. Correspond to the shadowing region of the nuclear modifications at low Bjorken-$x$.

The calculations using nuclear PDFs describe the yield measured in Pb–Pb collisions.
Searching new scaling paradigm in pp and p-Pb

- Differential study of hard probe production as a function of charged particle multiplicity
  - Probability to produce the hard process scales with the mean multiplicity
  - The production is independent of the underlying event
- Similar behavior measured for all probes
  - Close to linear when the hard probe is measured in the forward-\(y\) and multiplicity in central-\(y\) region
  - Deviation from linearity when both are measured in central-\(y\) region

\[
\frac{dN_{\text{Hard}}}{dy} \quad \left\langle \frac{dN_{\text{Hard}}}{dy} \right\rangle
\]

The correlation is more complex due to hadronisation in final state, saturation effects, hardness of the probe.
monolithic active pixel sensor chip (MAPS), called ALPIDE, integrating both pixel sensor and read-out electronics in a single device

- p-type substrate with a thin, high-resistivity epitaxial layer (see diagram) in a 180 nm CMOS process provided by Tower Semiconductor

- includes a 512 x 1024 matrix of 29.24 x 26.88 mm² pixel cells, together with analogue biasing, control, readout and interfaces
Stable 500 KHz running was achieved with further optimisation of:

- The Common Readout Unit (CRU) FirmWare (FW) to prevent from data corruption
- The ReadOut process configuration with better memory buffers allocation
- The Data Distribution software and its shared Memory Management
COLLECTED 13.6 TeV DATA until end of August

Delivered integrated luminosity 9.4 pb\(^{-1}\)

Statistics collected used for asynchronous reconstruction

Ongoing:

- **Allocation of EPN resources for Async Reconstruction**: started async pool of 20 nodes.
- Use the LHC downtime to allocate more nodes (not needed by COSMIC runs) and to automate the management

sarah.porteboeuf@clermont.in2p3.fr
Publications

- Total de 401 publications soumises
  avec 41 publications soumises en 1 an
    (49 publications soumises pour 2020–21)
    (46 publications soumises pour 2019–20)
    (32 publications soumises pour 2018–19)
  - 13 (11) renommées
  - 35 (33) célèbres
  - 74 (68) réputées
- “pics” corrélés avec QM, SQM et ICHEP 2022
  (QM en avril à Cracovie, SQM en juin à Pusan et ICHEP en juillet à Bologne)
- 13 sur 29 publications avec au moins un collaborateur/trice français/e dans le “Paper Committee” ou l’“Internal Review Committee”
  (en général restreint à 3 personnes)
# The 2023 Draft LHC Schedule in Numbers

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration [days]</th>
<th>Ratio [%]</th>
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<tbody>
<tr>
<td>Beam Commissioning &amp; Intensity ramp-up</td>
<td>47</td>
<td>21.7</td>
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<tr>
<td>Scrubbing</td>
<td>2</td>
<td>0.9</td>
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<tr>
<td>25 ns physics (&gt;1200 bunches)</td>
<td>97</td>
<td>44.7</td>
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<tr>
<td>Special physics runs (incl. setting-up)</td>
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<td>3.2</td>
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<tr>
<td>Pb-Pb ions &amp; p-p ref. setting-up</td>
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<td>2.8</td>
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<tr>
<td>Pb-Pb ions physics &amp; p-p ref. run</td>
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<td>14.7</td>
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<tr>
<td>Technical stop</td>
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<td>3.7</td>
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<tr>
<td>Technical stop recovery</td>
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<tr>
<td>Machine Development blocks (incl. floating MDs)</td>
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<td>7.4</td>
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# 2023

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<td>16</td>
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<td>Control System admin, days</td>
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First Stable beams
Collisions with 1200 bunches
End of 2023 Run: Monday 30th October
Pb-Pb TEST (USING PROTON CYCLE)

Tentative Plan (36h)

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• **Commissioning → 6h**
  • Proton cycle: 6.8 Z TeV (5.36 TeV) 😊
  • $\beta^* = 10$ m in IP2 😞
  • Slip-stacking tests at injection → 2h
  • Crystal collimation test → 12h

• **Stable Beams → 16h → 2 fills**
  • ALICE Magnets +/- polarity → small angles
  • **First fill: Individual bunches**
    • Half-crossing angle in IP2 = -72(int) + 172(ext) = +100 ur
    • Validation of new position of TCLIA collimator right of IP2 and ZDC operation
  • **Second fill: 50 ns slip stacked trains**
    • Half crossing angle at IP2 = -72(int) + 128(ext) = +56 ur
**Pb-Pb: ALICE OPERATION**

**Final set-up for Pb-Pb:**

- FT0 Calibration + FDD mezzanine cards installed
- ZDC Operation and calibration as luminometer
- ALL detectors ON and in readout
- LHC Interface for lumi publication

---

**Amplitude of ZNC signal**

1 neutron, 2.68 TeV

1n peak resolution ~ 15% (20-21% in Run 1-2)
En prévision du LS3: FoCal-E

- Calorimètre EM en région avant avec lecture Si-W de haute granularité
- Dédié à la mesure de photons directs en région avant

- Démonstrateur FoCal-E PAD
- Construction d’un prototype (1/5 du module final) en collaboration avec le C4Pi
- Tests sous faisceau au CERN (PS & SPS) avec readout O2 (CRU)
En prévision du LS3: **Fixed Target**

- Dispositif de fonctionnement en Cible Fixe non polarisée
- **Proposed layout for ALICE with bent crystal**
  - Beam splitting thanks to a bent crystal
  - LHC collimation studies done for ALICE with proton beam, started with Pb beam
  - Coupled to a retractable solid target in front of ALICE

- Aim at an installation in LS3 (2026-2027)

- Probe high-x gluon, antiquark and heavy-quark content in the nucleon and nucleus

- Provide inputs for astrophysics (charm and antiproton production)

- Study the nuclear matter properties in heavy-ion collisions towards large rapidity
En prévision du LS3: Fixed Target

**Target design and integration**
- Target position: ~5 m from IP2 with material budget outside of FoCal acceptance
- Conceptual design of the target system performed
- Mechanical integration within ALICE ongoing

**Physics performance in pW at 115 GeV**
- Tracking performance of the central barrel with displaced vertex for charged particles D and Λ
- PID performance ongoing
  
  Towards a Lol (2022)

**Next studies**
- Vacuum and impedance integration, machine protection studies

ANR JCJC 2022 (Laure Massacrier): 2 years postdoc (performance studies), 1 IE (2 years) for vacuum studies, 1 AI (1 year) for impedance studies, material and missions