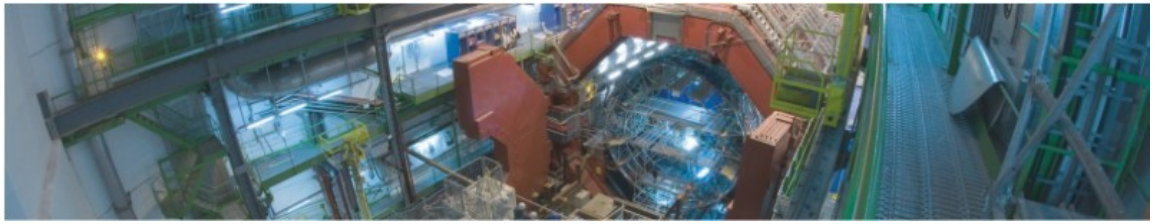
Antonin MAIRE, for the ALICE Collaboration (PAG-MC)
Thurs, 14 Nov. 2024 – **LHC MC WG**

Indico.cern.ch:1471395
https://lpcc.web.cern.ch/content/monte-carlo-wg

LHC Monte Carlo WG: kickoff meeting

ALICE perspectives

alidist *github* *lxplus* *alisw* *github.io* *LCG* *gitlab* *AliRivet* *CVMFS* *jenkins* *rivet.sh* *Pythia8* *EPOS4* *Herwig7*



Outline

I . ALICE context of data taking

- real-data taking strategy
- CPU performances by MC generators (*Examples of EPOS4, Pythia8*)

(II. existing PHENOmenal meetings)

III. ALICE topics for LHC MC WG

I.1 – Context foreword : ALICE data collection strategy

ALICE focus = on low p_T and/soft physics ($0 < p_T <$ 2-10 GeV/c, typically)
→ ALICE targets *physics of bulk*
(≈ QCD various expressions in the overall context of the event)
over *physics of rarity*
(≈ intrinsic properties of a given particle/rare process)

Consequence : difficult to enhance signals of a given physics process
without distorting the QCD context of the event

→ **Data**:
ALICE$_2$ in Run 3+ = strategy of data collection based on **continuous** readout (≈ triggerless),
i.e. huge samples of Min. Bias data
(ex: 2023 pp $\sqrt{s_{NN}}$ =13.6 TeV ≈ [9.5 pb^{-1} ↔ 760. 10^9 events] recorded
2024 pp $\sqrt{s_{NN}}$ =13.6 TeV ≈ [53.1 pb^{-1} ↔ 4248. 10^9 events] recorded
2023 Pb-Pb $\sqrt{s_{NN}}$ = 5.36 TeV ≈ [1535 μb^{-1} ↔ 12. 10^9 events] recorded
(NB : *recorded* ... *i.e.* not only delivered and inspected...)
(See LHCC open sessions, 155th, Sept 2023 +156th, Nov 2023 + 160th, Nov 2024)

→ **Simulations**:
default option = in correspondence, i.e. plain simulation of complete **inelastic** collisions

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I.2 – Context : Pythia8 "performances"

Core Intel i7-12800H / 32 GB RAM

MC	version	Pythia8 config param.					System	$\sqrt{s_{NN}}$	"Centrality"	Evt counts	CPU time	CPU.evt^{-1}	HEPmc size
		Base	SoftQCD	Parton Level	Angantyr	Hadron Level					duration	s.evt^{-1}	plain kB.evt^{-1}
Pythia8	v8304-alice1-13	Monash 2013	all	MPI+CR	-	*off*	**pp**	13 TeV	MinBias	1.00E+04	00h 00min 31s	0,003	81,94
		Monash 2013	all	MPI+CR	-	Rescatter	**pp**	13 TeV	MinBias	1.00E+04	00h 00min 47s	0,005	111,20
		CR Mode 2	all	MPI+CR	-	*off*	**pp**	13 TeV	MinBias	1.00E+04	00h 00min 30s	0,003	79,74
		CR Mode 2	all	MPI+CR	-	Rescatter	**pp**	13 TeV	MinBias	1.00E+04	00h 00min 46s	0,005	111,19
		Monash + Rope	all	MPI+CR	-	*off*	**pp**	13 TeV	MinBias	1.00E+04	00h 01min 09s	0,007	90,84
		Monash + Rope	all	MPI+CR	-	Rescatter	**pp**	13 TeV	MinBias	2.00E+04	00h 02min 51s	0,009	118,52
		Monash + Rope + Shoving	all	MPI+CR	-	*off*	**pp**	13 TeV	MinBias	1.00E+04	00h 01min 17s	0,008	102,93
		Monash + Rope + Shoving	all	MPI+CR	-	Rescatter	**pp**	13 TeV	MinBias	1.00E+04	00h 01min 38s	0,010	133,06
											duration	s.evt^{-1}	kB.evt^{-1}
Pythia8	v8304-alice1-13	Monash 2013	all	MPI	Glissando	*off*	**Pb-Pb**	5.02 TeV	MinBias	1.00E+03	00h 08min 53s	0,533	7 238,22
		Monash 2013	all	MPI	Glissando	Rescatter	**Pb-Pb**	5.02 TeV	MinBias	2.00E+01	00h 53min 12s	159,600	33 146,78

Some physics options:

- Colour Reconnection, in
- With Colour Junctions ? (i.e. *CR mode 2, Skands, arXiv:1505.01681*)
- With Rope hadronisation ? (*arxiv:1412.6259*)
- With Rope hadronisation + Rope shoving ? (*arXiv:1710.09725*)
- Late-hadronic interactions allowed or not ? (*arXiv:2005.05658*)

https://pythia.org//latest-manual/Welcome.html

I.3 – Context : EPOS4 "performances"

Core Intel i7-12800H / 32 GB RAM

MC	version	EPOS4 config param.					System	$\sqrt{s_{NN}}$	"Centrality"	Evt counts	CPU time	CPU.evt^{-1}	HEPmc size
		Ninicon	core	hydro	EoS	hacas							plain
											duration	s.evt^{-1}	kB.evt^{-1}
EPOS4	v4.0.0-alice3	1	full	hlle	x3ff	full	**pp**	13 TeV	MinBias	1.00E+02	01h 38min 30s	59,100	24,82
		1	PFE	*off*	*off*	full	pp	13 TeV	MinBias	1.00E+03	00h 03min 06s	0,186	21,94
		1	PFE	*off*	*off*	*off*	pp	13 TeV	MinBias	1.00E+03	00h 01min 24s	0,084	21,23
		1	*off*	*off*	*off*	*off*	pp	13 TeV	MinBias	1.00E+03	00h 00min 26s	0,026	29,44
											duration	s.evt^{-1}	kB.evt^{-1}
EPOS4	v4.0.0-alice3	1	full	hlle	x3ff	full	**Pb-Pb**	5.02 TeV	MinBias	2.00E+00	00h 17min 40s	530,000	2 223,01
		1	full	hlle	x3ff	full	Pb-Pb	5.02 TeV	0-5%	2.00E+00	00h 39min 26s	1 183,000	5 771,44
		1	PFE	*off*	*off*	full	Pb-Pb	5.02 TeV	MinBias	1.00E+02	01h 30min 52s	54,520	1 399,83
		1	PFE	*off*	*off*	full	Pb-Pb	5.02 TeV	0-5%	1.00E+02	11h 38min 05s	418,850	5 832,04

Some physics options:

- Full hydrodynamics ? (core)
- Or parametrised hydrodynamics ? (PFE)
- Late-hadronic interactions allowed or not ? (hacas)

https://klaus.pages.in2p3.fr/epos4/physics/papers

II.1 – (Parenthesis) : what exists for exchanging in ALICE

∃ dedicated open meetings between ALICE collaboration + MC phenomenologists
= PHENOmenal meetings,
~runs since oct. 2020, 19 meetings,
100% Zoom
typically during ALICE mini-weeks

- Philosophy:
  one set of ALICE results presented by ALICE,
  a special light shed by 1-2 MC theorists
  < 2h-long meeting
- Organisers:
  - Valentina Zaccolo, Trieste
  - Christian Bierlich, Lund

- Indico category : https://indico.cern.ch/category/8420/ + GoogleDoc list of agendas
- E-groups: alice-phenomenal

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III.0 – Topics : non-exhaustive list

1. Integration of the MC generators in the software of various LHC collaborations:
   Collab-made **installation** Vs SFT under CVMFS ?

2. **MC validation** via MCplots, for pp physics first ?

3. From *Rivet* for Heavy-Ion systems to ***MCplots*** for **Heavy-Ion systems**

4. **PDF** and nPDF

5. **Tuning** of MC event generators

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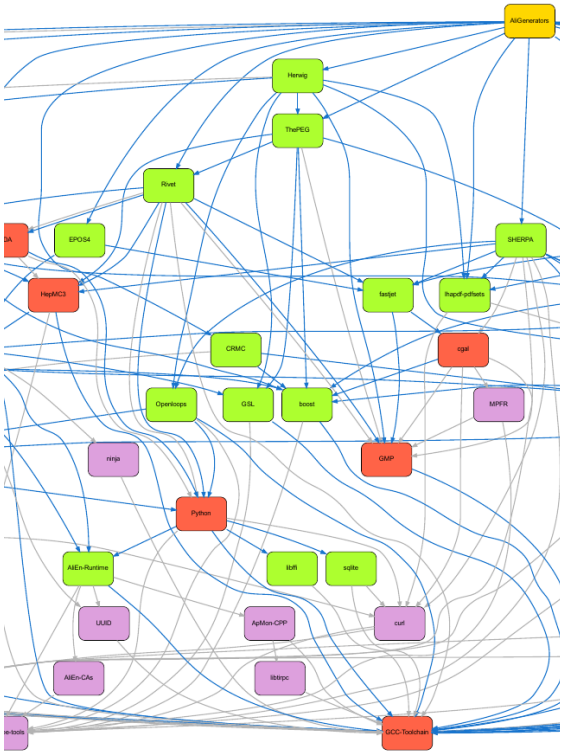
III.1 – Topics : MC-generator installations

- Integration of the MC generators in the various collaborations
  Collab-made installation Vs SFT under CVMFS ?

(Dealing with :
  - compilation,
  - (inter)dependences among packages
  - and central deployment for execution...)



LHC Situation ?

- ALICE = Standalone, no use of SFT LCG compilations
- ATLAS = use of LCG compiled code !
- CMS = Standalone, no use of LCG compilations
- LHCb = mix, SFT LCG + local builds

III.2 – Topics : MCplots as validation tool

- MC validation via MCplots, for pp physics first ?

→ Pure-MC analyses, as benchmark — Rivet: **ok!** / MCplots: **ok!**
(compare reference MC with new release MC)
for validation of MC with Mcplots: *http://mcplots.cern.ch/?query=allvalidations*

For ALICE, that could be:
identified hadron production = f(p_T, y, event activity),
incl/excl feed-down

→ multiple-run analyses: — Rivet: **ok!** / MCplots: ∅ **?**
. multiple √s and ratios among colliding energies
(e.g. pp 5.36 TeV Vs pp 13.6 TeV)

→ multiple-job analyses: — Rivet: **ok!** / MCplots: ∅ **?**
large MC dataset needed for validation (often >10^8-10^9)
i.e. multiple jobs to manage with MCplots (LHC@home)

https://cds.cern.ch/record/2904943 ATL-PHYS-PUB-2024-013

III.3 – Topics : MCplots in AA ...

- MC validation via MCplots, for pp physics first ?

- From Rivet for Heavy-Ion systems to MCplots for Heavy-Ion systems

→ multiple-run analyses: Rivet: **ok!** / MCplots: ∅ **?**

. • multiple $\sqrt{s}$ and ratios among colliding energies

\+

• multiple systems (pp, p-Pb, Xe-Xe, Pb-Pb, next year p-O, O-O) and ratios among systems

.

• calibration (e.g. centrality) and then analysis

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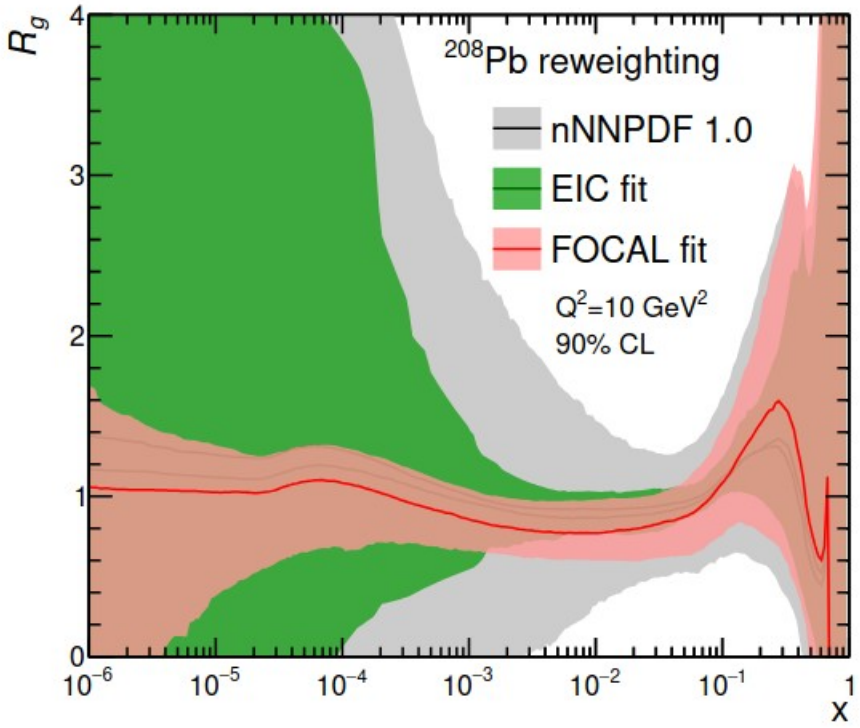
III.4 – Topics : PDF

PDF and nuclear PDF constraints by LHC

To come :

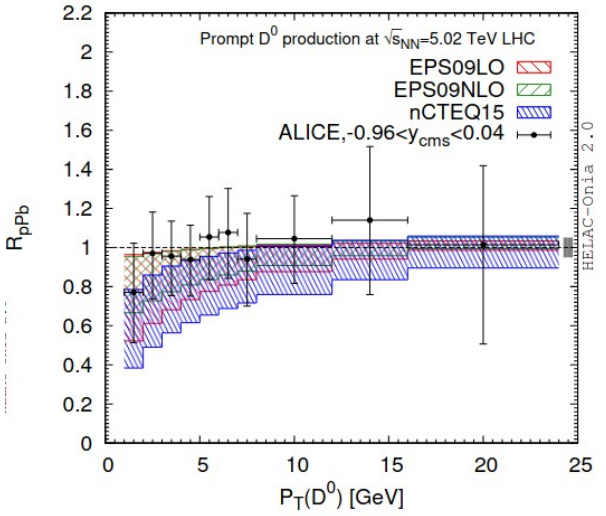
- FoCal single-arm calorimeters
  (= E.m. calo with [Si+W] + Hadronic calo)
  at forward rapidities [3.4 < η < 5.8],
  in LHC Run 4 (≥ 2030)
  ⟶ access to gluon (n)PDF, at very low x (< 10^{-5})
  via direct-γ detection



Nuclear modification of gluon PDF in ^{208}Pb
(FoCal, LoI Fig.41)

In the meantime, already things to do ?

Ex: [D°, η_C, J/ψ, Υ(nS)] meson production in pp, p-Pb
measured by 1. LHCb + 2. Others LHC
⟶ nPDF constraint



HELAC-Onia arXiv:1610.05382

III.5 – Topics : MC tuning

- Tuning
(Nascent effort in ALICE...)

- Professor Vs Apprentice ?

. • Any **good practice** or no go ? (experience in ATLAS, CMS, ... + MC authors)
e.g. definition of uncertainties ? Agreed protocol to derive them ?

.

- **benchmark set** of Rivet analyses to be default core results to be reproduced ?

- ∃ physical **burning** questions that we may want to address in common ?

III.5 – Topics : MC tuning

Example of addressed question :

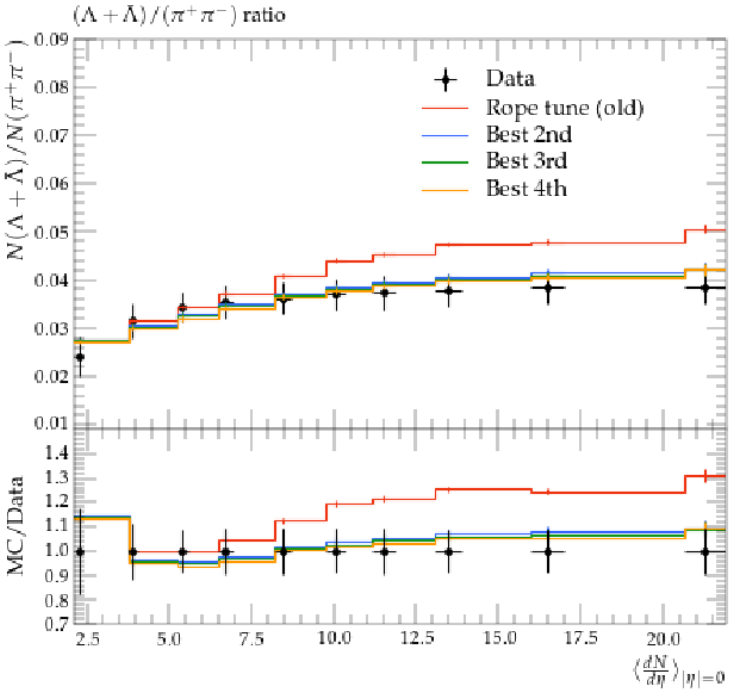
baryon production, for different valence quark flavours

Two recent works performed recently with Pythia8 (summer 2024)

1. Tuning of rope hadronisat° model (using Professor2)

Focus ≈ identified light-flavour hadrons,
incl. strangeness, in pp
e.g. $p/\pi^{\pm}$, $\Lambda/\pi^{\pm}$ = f($dN_{ch}/d\eta$ multiplicity, p_T)

Basis: Pythia8 with Ropes
. 6 Pythia parameters
. exchange with Christian Bierlich on Ropes



III.5 – Topics : MC tuning

Example of addressed question :

baryon production, for different valence quark flavours

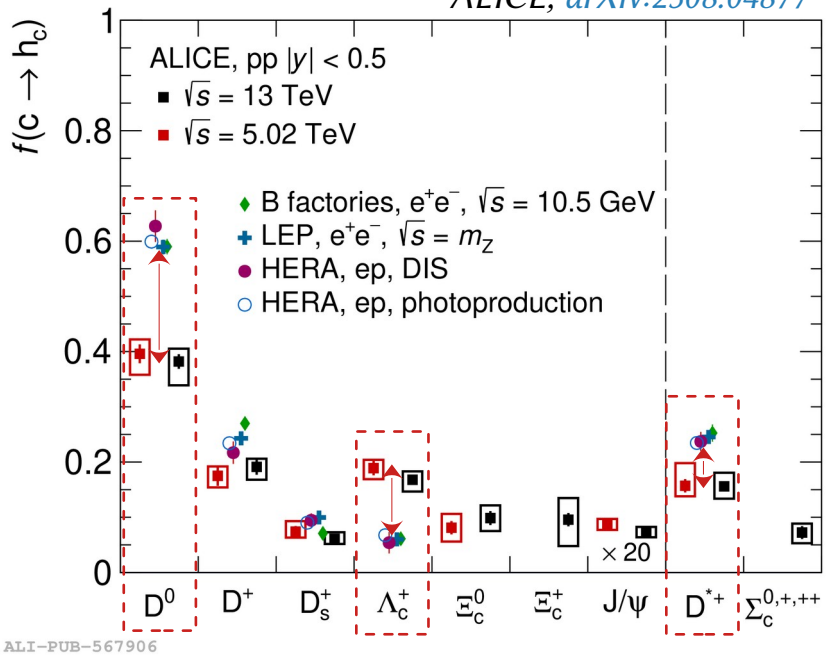
Two recent works performed recently with Pythia8 (summer 2024)

2. Tuning of enhanced CR tune Mode 2 (using Apprentice)

Focus ≈ identified charm hadrons,
and notably charm baryons, in pp
e.g. Λ_c^+/D° production = f(p_T)

Basis : Pythia8 CR Mode2 (*arXiv:1505.01681*)
. 2 Pythia parameters
. exchange with Andy Buckley on Apprentice,
. exchange with Peter Skands on Junctions

ALICE, arXiv:2308.04877



– The end –

III.6 – Topics : GPU usage for MC generation ?

Any GPU usage for MC ?
- ∃ farm of GPU in ALICE (Event Processing Nodes, EPN)
  and farm of FPGA (First-Level Processors, FLP)

⟶ heavily use for our online reconstruction of real data (continuous readout)

But so far not much for MC generations...