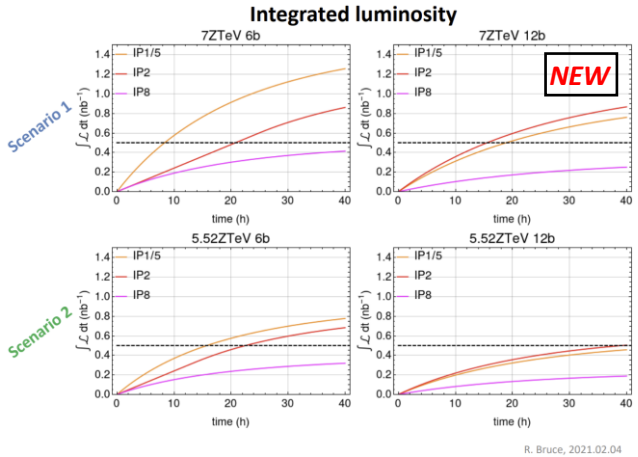
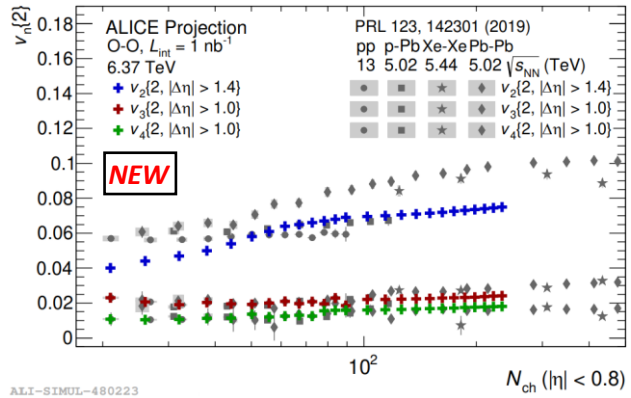
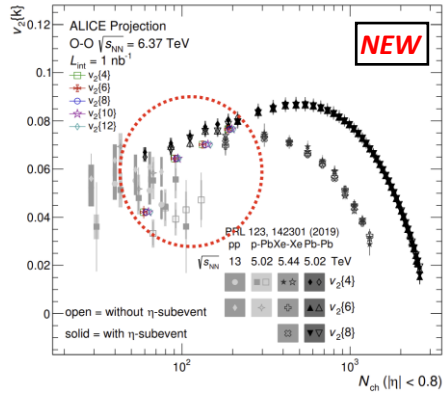
Workshop Summary Discussion

Jasmine Brewer, Aleksas Mazeliauskas and Wilke van der Schee

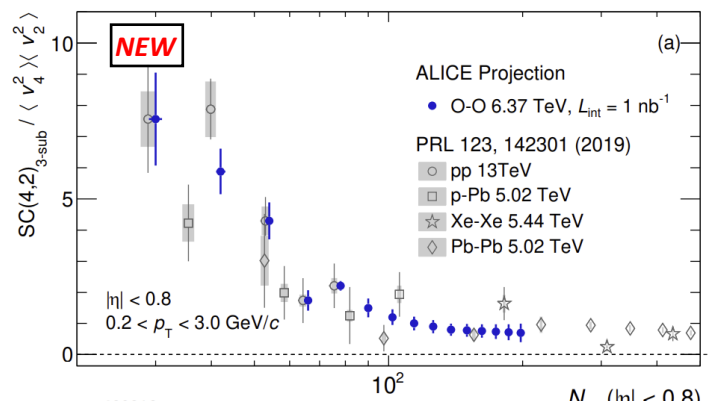


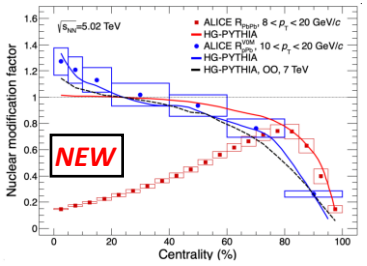
R. Bruce, 2021.02.04

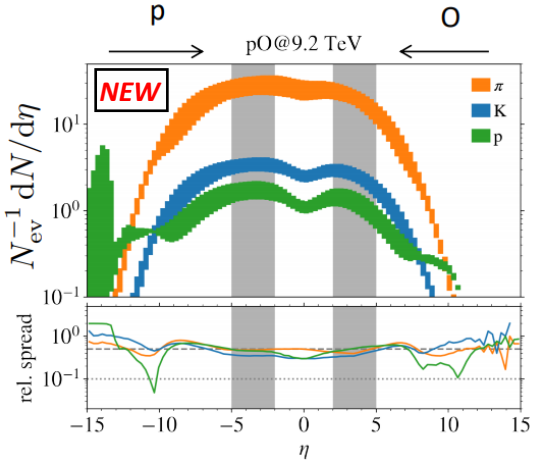


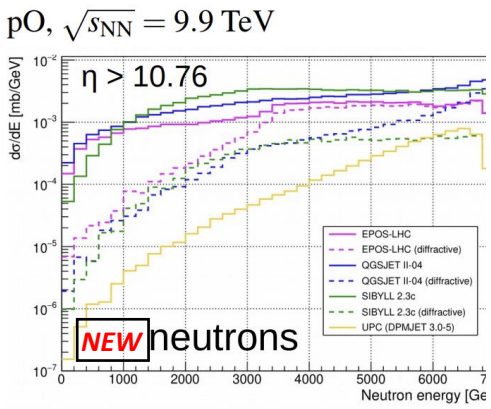


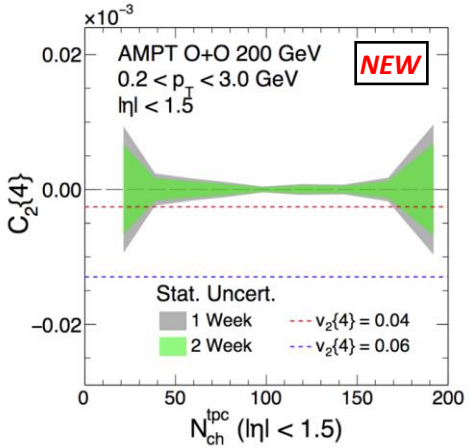
Using Pb-Pb data (60-80%)
Typical σ_{sys}: ~3%

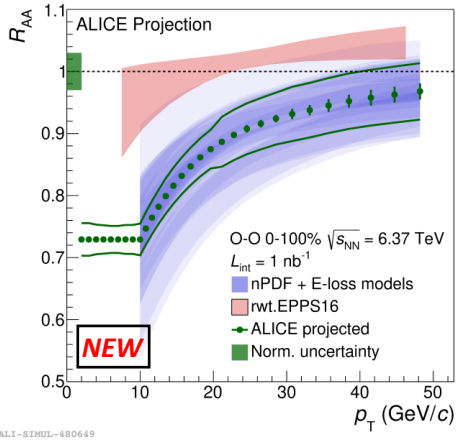


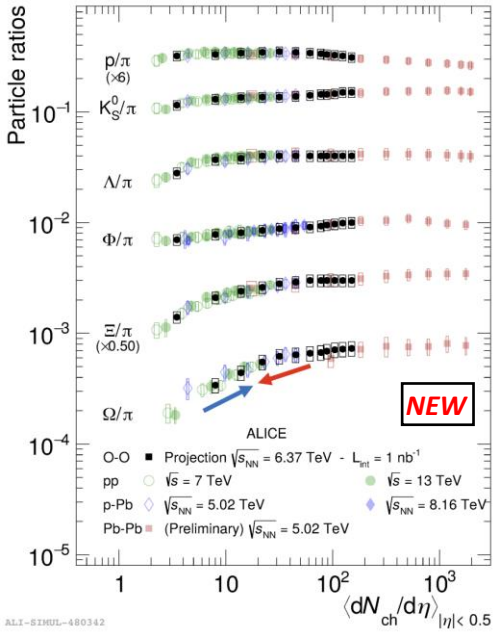


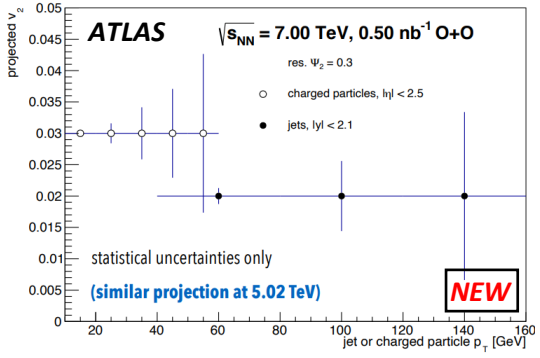


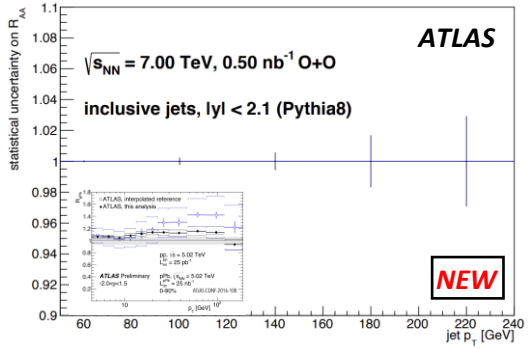


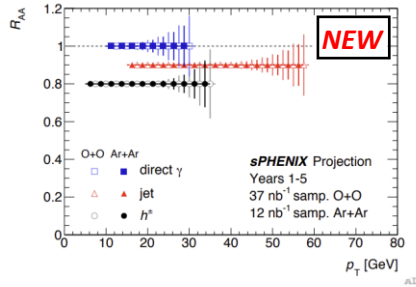


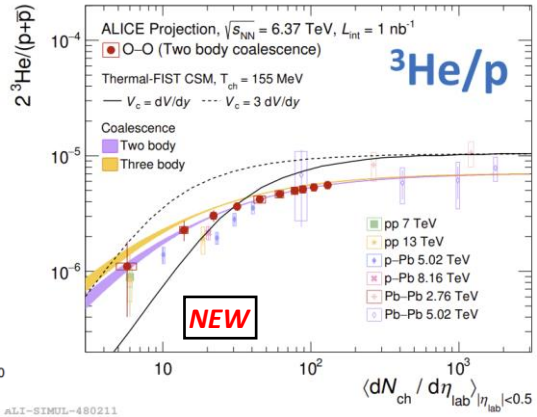


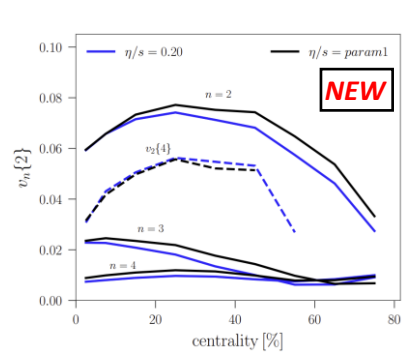


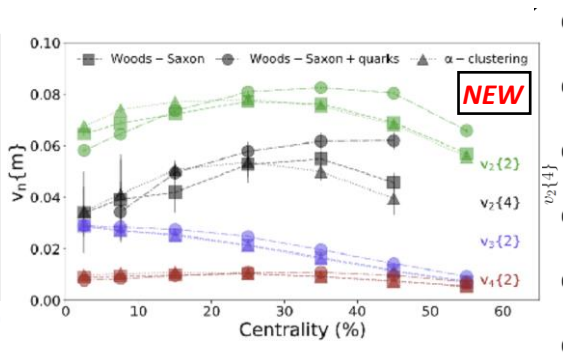


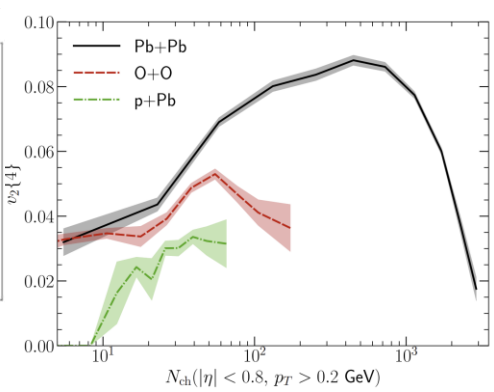


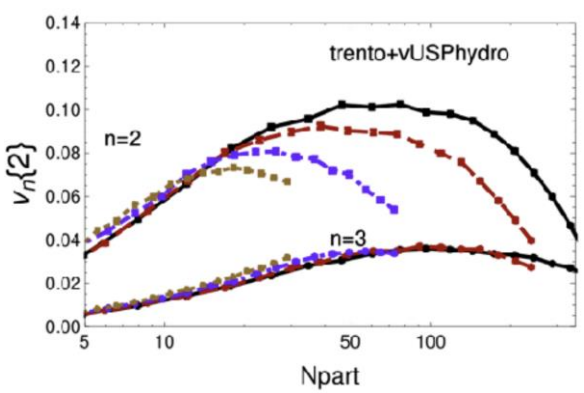


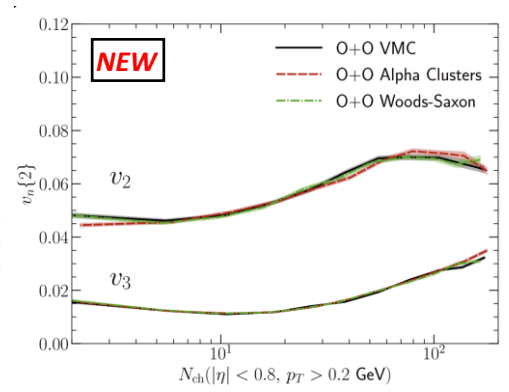


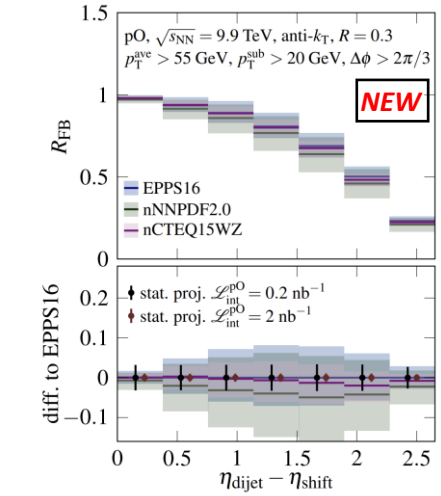

$\eta/s = 0.20$
$\eta/s = param1$
NEW
$n = 2$
$v_2\{4\}$
$n = 3$
$n = 4$
$v_n\{2\}$
centrality [%]

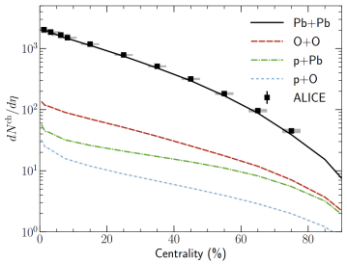

Woods – Saxon
Woods – Saxon + quarks
α – clustering
NEW
$v_n\{m\}$
$v_2\{2\}$
$v_2\{4\}$
$v_3\{2\}$
$v_4\{2\}$
Centrality (%)

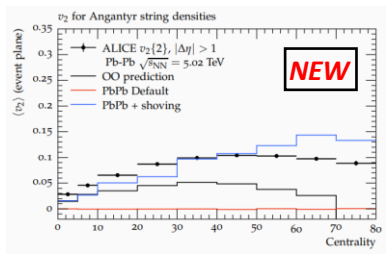

Pb+Pb
O+O
p+Pb
$v_2\{4\}$
$N_{ch}(|\eta| < 0.8,\ p_T > 0.2$ GeV)

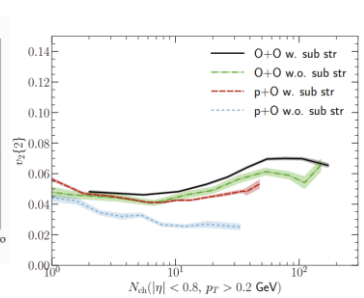

trento+vUSPhydro
n=2
n=3
$v_n\{2\}$
Npart

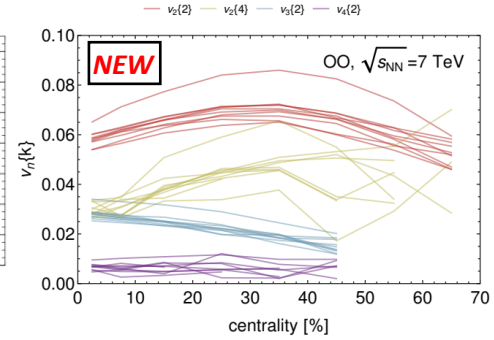

NEW
O+O VMC
O+O Alpha Clusters
O+O Woods-Saxon
v_2
v_3
$v_n\{2\}$
$N_{ch}(|\eta| < 0.8,\ p_T > 0.2$ GeV)

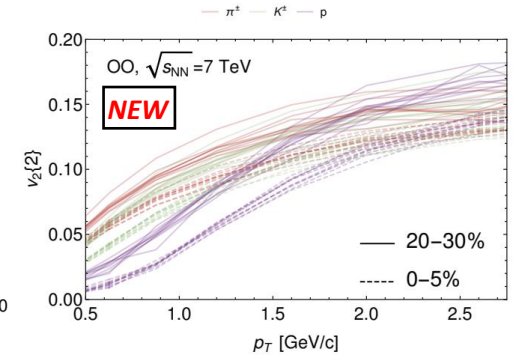

pO, $\sqrt{s_{NN}} = 9.9$ TeV, anti-k_T, $R = 0.3$
$p_T^{ave} > 55$ GeV, $p_T^{sub} > 20$ GeV, $\Delta\phi > 2\pi/3$
NEW
R_{FB}
EPPS16
nNNPDF2.0
nCTEQ15WZ
stat. proj. $\mathscr{L}_{int}^{pO} = 0.2$ nb^{-1}
stat. proj. $\mathscr{L}_{int}^{pO} = 2$ nb^{-1}
diff. to EPPS16
$\eta_{dijet} - \eta_{shift}$

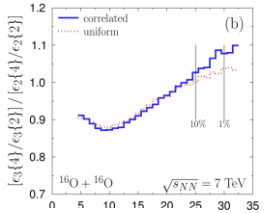

Pb+Pb
O+O
p+Pb
p+O
ALICE
$dN^{ch}/d\eta$
Centrality (%)

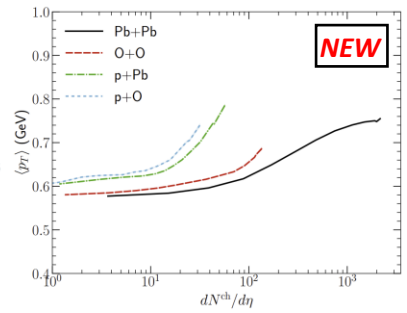

v_2 for Angantyr string densities
ALICE $v_2\{2\}, |\Delta\eta| > 1$
Pb-Pb $\sqrt{s_{NN}} = 5.02$ TeV
OO prediction
PbPb Default
PbPb + shoving
NEW
$\langle v_2 \rangle$ (event plane)
$v_2\{2\}$
Centrality

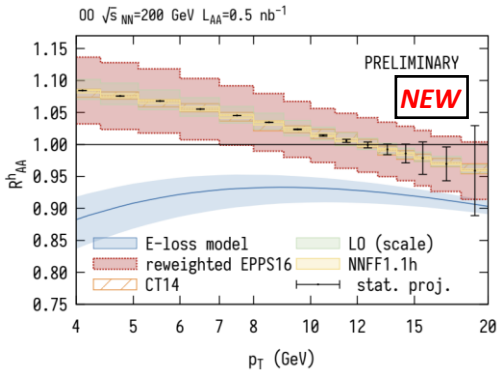

O+O w. sub str
O+O w.o. sub str
p+O w. sub str
p+O w.o. sub str
$N_{ch}(|\eta| < 0.8,\ p_T > 0.2$ GeV)

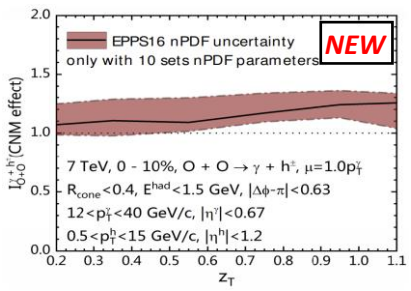

$v_2\{2\}$ $v_2\{4\}$ $v_3\{2\}$ $v_4\{2\}$
NEW
OO, $\sqrt{s_{NN}}$ =7 TeV
$v_n\{k\}$
centrality [%]

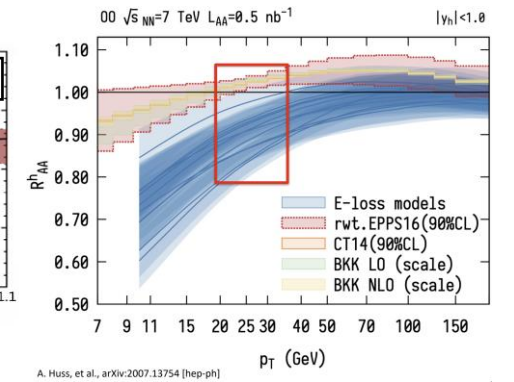

$\pi^\pm$ $K^\pm$ p
OO, $\sqrt{s_{NN}}$ =7 TeV
NEW
$v_2\{2\}$
20–30%
0–5%
p_T [GeV/c]

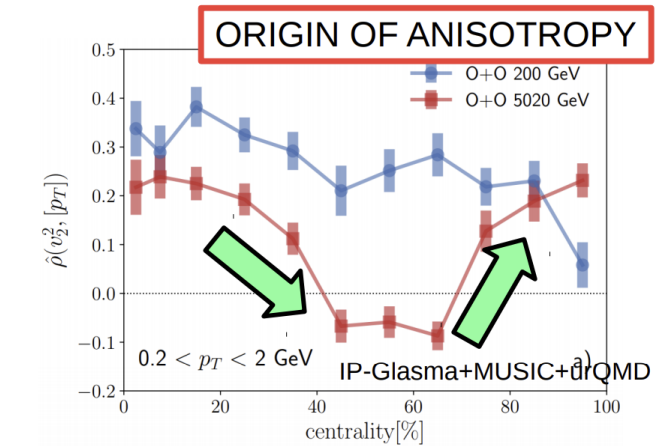

correlated
uniform
(b)
$[v_3\{4\}/v_3\{2\}]/[v_2\{4\}/v_2\{2\}]$
$^{16}O + ^{16}O$
$\sqrt{s_{NN}} = 7$ TeV

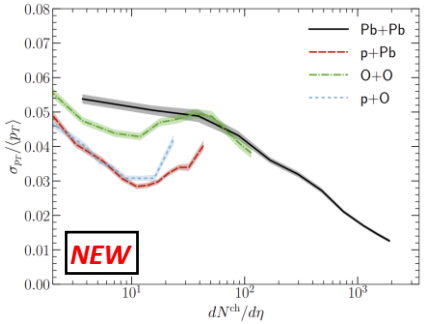

Pb+Pb
O+O
p+Pb
p+O
NEW
$\langle p_T \rangle$ (GeV)
$dN^{ch}/d\eta$

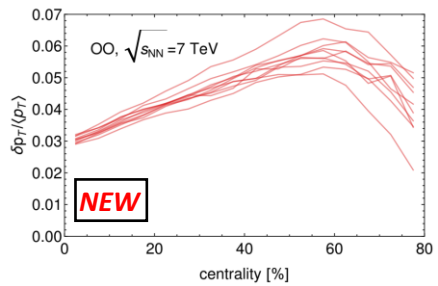

OO $\sqrt{s}_{NN}$=200 GeV L_{AA}=0.5 nb^{-1}
PRELIMINARY
NEW
R^h_{AA}
E-loss model
reweighted EPPS16
CT14
LO (scale)
NNFF1.1h
stat. proj.
p_T (GeV)

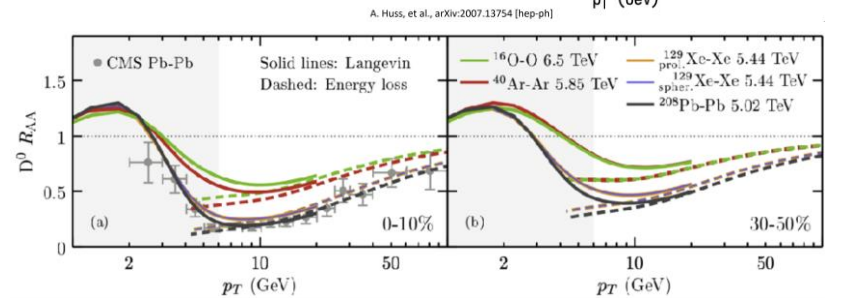

EPPS16 nPDF uncertainty
only with 10 sets nPDF parameters
NEW
$I^{\gamma+h^-}_{O+O}$(CNM effect)
7 TeV, 0 - 10%, O + O → γ + h$^-$, μ=1.0p_T^γ
R_{cone}<0.4, E^{had}<1.5 GeV, $|\Delta\phi_{\gamma\pi}|$<0.63
12<p_T^γ<40 GeV/c, $|\eta^\gamma|$<0.67
0.5<p_T^h<15 GeV/c, $|\eta^h|$<1.2
z_T


OO $\sqrt{s}_{NN}$=7 TeV L_{AA}=0.5 nb^{-1}
$|y_h|$<1.0
R^h_{AA}
E-loss models
rwt.EPPS16(90%CL)
CT14(90%CL)
BKK LO (scale)
BKK NLO (scale)
p_T (GeV)


ORIGIN OF ANISOTROPY
O+O 200 GeV
O+O 5020 GeV
$\hat{\rho}(v_2^2, [p_T])$
$0.2 < p_T < 2$ GeV
IP-Glasma+MUSIC+UrQMD
centrality[%]


Pb+Pb
p+Pb
O+O
p+O
NEW
$\sigma_{p_T}/\langle p_T \rangle$
$dN^{ch}/d\eta$


OO, $\sqrt{s_{NN}}$ =7 TeV
NEW
$\delta p_T/\langle p_T \rangle$
centrality [%]


A. Huss, et al., arXiv:2007.13754 [hep-ph]
CMS Pb-Pb
Solid lines: Langevin
Dashed: Energy loss
^{16}O-O 6.5 TeV
^{40}Ar-Ar 5.85 TeV
^{129}Xe-Xe 5.44 TeV
^{129}Xe-Xe 5.44 TeV
^{208}Pb-Pb 5.02 TeV
D^0 R_{AA}
(a)
0-10%
(b)
30-50%
p_T (GeV)
p_T (GeV)

Optimal center-of-mass energy for pO / OO

Maximum energy	**Same $\sqrt{s_{NN}}$ as PbPb / pPb**
7 TeV OO / 9.9 TeV pO	5.52 TeV OO / 8.79 TeV pO
1.5 higher luminosity	2-3 extra days tuning / system
pp reference?	Re-use pp reference from PbPb, pPb

Van der Meer scan: 2 hr/exp (1.5-3% accuracy)

Can pp reference be reliably interpolated? Which observables?

Quark-gluon plasma in OO?

- OO "sweet spot" between pPb and PbPb (but hotter and smaller than PbPb at same multiplicity).
- Extensive hydro model predictions – going beyond?
- Accurate flow measurements (up to $v_2\{12\}$, $N_{ch} < 100$).
- Change of sign in v_2-p_T correlation in peripheral OO?
- Geometry control in OO:
  - Any sensitivity to alpha clustering?
  - Subnucleonic fluctuations (> than PbPb, < pPb).

What can be ruled out with OO data?

Energy loss in OO?

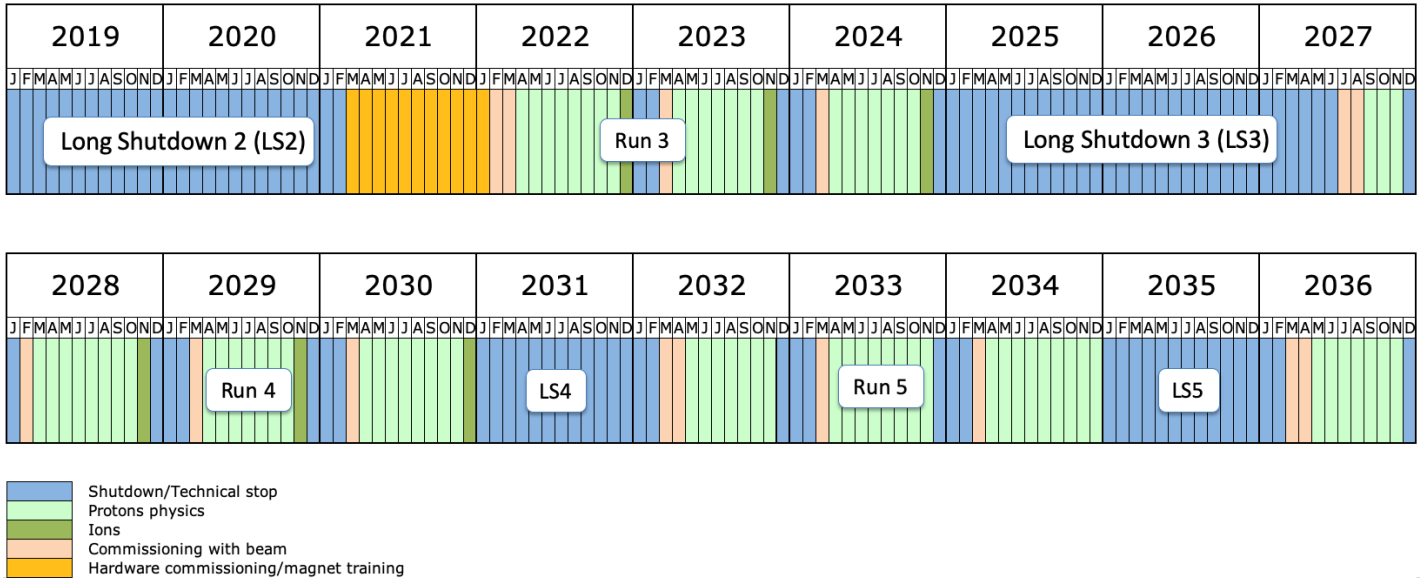
- Small signal expected: uncertainties of theory baseline (nPDFs) is crucial.
- No oxygen data in nPDF fits. Constraints from dijet R_{FB}, and R_{pO} in pO without reference?
- Experimental projections for hard probes (R_{AA}, high-p_T v_2, h-jet).
- Need for theory developments on integrated soft and hard modelling.

What energy loss signal can be detected (without pp reference) and with which observables (MB / centrality, inclusive, semi-inclusive)?

pO and cosmic rays

- LHCb and LHCf probe relevant forward regions for cosmic rays and Pierre Auger.
- Significant luminosity for fixed target with various systems in SMOG2 (OO, PbO and many more).
- Unique opportunity window (LHCf can only take data in Run 3).

What impact will pO have on CR shower interpretation?



For reference

Single-Beam Energy (GeV/nucleon)	$\sqrt{s_{NN}}$ (GeV)	Run Time	Species	Events (MinBias)	Priority
3.85	7.7	11-20 weeks	Au+Au	100 M	1
3.85	3 (FXT)	3 days	Au+Au	300 M	2
44.5	9.2 (FXT)	0.5 days	Au+Au	50 M	2
70	11.5 (FXT)	0.5 days	Au+Au	50 M	2
100	13.7 (FXT)	0.5 days	Au+Au	50 M	2
100	200	1 week	O+O	400 M 200 M (central)	3
8.35	17.1	2.5 weeks	Au+Au	250 M	3
3.85	3 (FXT)	3 weeks	Au+Au	2 B	3

E_{beam} / Z	$\sqrt{s_{NN}}$(pp)	$\sqrt{s_{NN}}$(PbPb)	$\sqrt{s_{NN}}$(XeXe)	$\sqrt{s_{NN}}$(OO)	$\sqrt{s_{NN}}$(pPb)	$\sqrt{s_{NN}}$(pO)	Year
2.51	5.02						2015, 2017
2.76	5.52						?
3.19	6.37						?
3.5	7						?
4					5.02		2012, 13,16
5.02				5.02			??
5.52				5.52			??
6.37		5.02		6.37	8.00	9.00	2015,18, Run 3,4?
6.5			5.44		8.16		2017, 2016
7		5.52		7.00	8.79	9.90	Run 3,4?

OLD

Year	Systems, $\sqrt{s_{NN}}$	Time	L_{int}
2021	Pb–Pb 5.5 TeV	3 weeks	2.3 nb^{-1}
	pp 5.5 TeV	1 week	3 pb^{-1} (ALICE), 300 pb^{-1} (ATLAS, CMS), 25 pb^{-1} (LHCb)
2022	Pb–Pb 5.5 TeV	5 weeks	3.9 nb^{-1}
	O–O, p–O	1 week	500 μb^{-1} and 200 μb^{-1}
2023	p–Pb 8.8 TeV	3 weeks	0.6 pb^{-1} (ATLAS, CMS), 0.3 pb^{-1} (ALICE, LHCb)
	pp 8.8 TeV	few days	1.5 pb^{-1} (ALICE), 100 pb^{-1} (ATLAS, CMS, LHCb)
2027	Pb–Pb 5.5 TeV	5 weeks	3.8 nb^{-1}
	pp 5.5 TeV	1 week	3 pb^{-1} (ALICE), 300 pb^{-1} (ATLAS, CMS), 25 pb^{-1} (LHCb)
2028	p–Pb 8.8 TeV	3 weeks	0.6 pb^{-1} (ATLAS, CMS), 0.3 pb^{-1} (ALICE, LHCb)
	pp 8.8 TeV	few days	1.5 pb^{-1} (ALICE), 100 pb^{-1} (ATLAS, CMS, LHCb)
2029	Pb–Pb 5.5 TeV	4 weeks	3 nb^{-1}
Run-5	Intermediate AA	11 weeks	e.g. Ar–Ar 3–9 pb^{-1} (optimal species to be defined)
	pp reference	1 week	