EPOS and HepMC

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Outline

- **Major problems**
  - **Centrality definition** (serious problem)
  - **Primary particle definition** (technical problem)
- **EPOS output**
  - **RootTree and HepMC**

Centrality definitions

Copied from my talk at the recent "Rivet" workshop:

- **Data should be data (and not partially theory), N_part etc are not measurable**
- **Glauber MC should not be mixed with data**
- **Everybody agrees ... BUT**

Looking into https://arxiv.org/pdf/1509.06727.pdf, providing a nice summary on centrality issues for PHENIX:

TABLE I. Summary of the data sets used in this analysis.

$\sqrt{s_{NN}}$ (GeV)	System	Year	N_{events}	Centrality	Trigger eff.
200	Au+Au	2002	270 k	BBC+ZDC	$93 \pm 3\%$
200	Au+Au	2004	133 M	BBC+ZDC	$93 \pm 3\%$
130	Au+Au	2000	160 k	BBC+ZDC	$93 \pm 3\%$
62.4	Au+Au	2004	20 M	BBC	$86 \pm 3\%$
62.4	Au+Au	2010	12 M	BBC	$86 \pm 3\%$
39	Au+Au	2010	132 M	BBC	$86 \pm 3\%$
27	Au+Au	2011	24.5 M	PC1	$86 \pm 3\%$
19.6	Au+Au	2011	6.3 M	PC1	$86 \pm 3\%$
14.5	Au+Au	2014	6.8 M	PC1	$85 \pm 3\%$
7.7	Au+Au	2010	803 k	RXNP	$75 \pm 3\%$
200	Cu+Cu	2005	558 M	BBC	$93 \pm 3\%$
62.4	Cu+Cu	2005	175 M	BBC	$88 \pm 3\%$
200	Cu+Au	2012	2.6 B	BBC	$93 \pm 3\%$
193	U+U	2012	317 M	BBC	$93 \pm 3\%$
200	^{3}He+Au	2014	1.6 B	BBC	$88 \pm 4\%$
200	d+Au	2008	1.4 B	BBC	$88 \pm 4\%$
200	p+p	2003	14.6 M	—	$54.8 \pm 5.3\%$

But it seems to be difficult (impossible?) to extract fully corrected distributions (=> not published)

So at this point not possible to compare simulation - data

But we must be sure that 10-20% means the same thing in the data and the simulation. How to do it?

Usually published : dn/dη vs N_part, the latter being based on some model of particle production, reality may be completely different => qualitative statements

- **Best solution: Provide fully corrected dN/dX if X is the centrality variable => quantitative statements**
- **Or for some basic quantity Y, like dn/d$\eta(0)$, provide**
  - **average of Y per 5% bins, and table with definitions of X and MB requirements,**
    - **to compare $\langle Y \rangle_{\text{bin}}$**
    - **or use $dn/d\eta(0)$ to select centrality**

Primary particle definitions

Ideally we want to see "primary particle" distributions (not coming from weak decays), but again, reality is different :

- In STAR (Phys.Rev.Lett. 92 (2004) 112301):
  pi, K feed-down corrected, p, ap not
- PHENIX (Phys.Rev.C 88 (2013) 024906, 2013):
  protons feed-down corrected, others not
- ALICE, CMS: Primary particles = feed-down corrected,
  not for ATLAS (see https://cds.cern.ch/record/2270008)

In addition, one may need to count
"particle Y from X decays"
(like electrons from HF decays), so

- **We should perform all decays**
- **store the complete decay chain via "vertex"**

or

- **No weak decays (leave it for Rivet)**

EPOS output: RootTree and HepMC

EPOS file header (possible problems for HepMC)

iversn = new int ; //EPOS version number

laproj = new int ; //atomic number projectile

maproj = new int ; //mass number projectile

latarg = new int ; //atomic number target

matarg = new int ; //mass number target

engy = new float ; //energy in the cms (need E_proj, E_targ)

nfull = new int ; //number of full events

nfreeze = new int ; //number of freeze outs per full event

EPOS event header

np = new int ; // number of particles

bim = new float ; // impact parameter

nhard = new int ; //number of parton-parton scatterings

npartproj = new int ; //number of projectile participants

nparttarg = new int ; //number of target participants

nspecp = new int ; //number of spectators protons

nspecn = new int ; //number of spectators neutrons

Remark: Participants and spectators refer to quatities computed "a la Glauber", for an EPOS event

EPOS event particles

px = new float [n]; // (same py,pz,e) four-momentum

x = new float [n]; // (same y,z,t) formation four-vector

id = new int [n]; // particle id

ist = new int [n]; // particle status

ior = new int [n]; // index of first parent

jor = new int [n]; // index of last parent

Parent-child relations (red = kept in HepMC)

Pomerons (status 30)
<=> partons (20)
<=> strings (29)

<=> core elements (7)
<=> core (hydro evolution)
<=> freeze out hadrons (3)

<=> corona elements (3)
= hadrons

hadronic cascade
no parent-child relations,
but we mark resonances whose children no not interact
(special status, allows to count $\phi \to KK$ etc)

final particles after cascade
<=> final weak decays (parents 1, children 0)

Additional list: All hadrons (3) + decay products
= EPOS without cascade
=> HepMC (with special status ?)