Hands-on Pythia 8.3 features: Particle production with Angantyr

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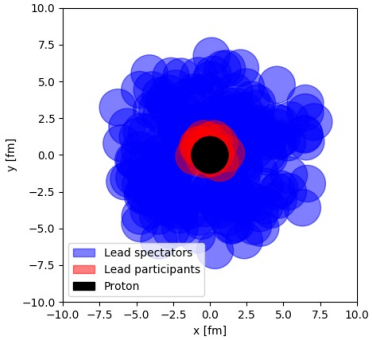
Angantyr: Overview

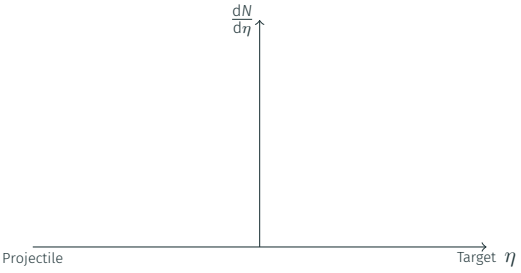
The extension of the PYTHIA MPI model for heavy ion collisions.

1. A Glauber model determines which nucleons will interact (be *wounded*). Own total cross section model, automatic fits to SaS.
2. Sub-collisions can either be *absorptive* or *diffractive*. The absorptive ones are the tricky part.
3. Signal processes etc. can be specified as usual.



Tell me more about absorptive collisions...

- Emission $F(\eta)$ per wounded nucleon
  $\rightarrow \frac{\mathrm{d}N}{\mathrm{d}\eta} = n_t F(\eta) + n_p F(-\eta)$.
- $F(\eta)$ modelled with even gaps in rapidity, as diffraction.
- Tuned to reproduce pp in the $n_t = n_p = 1$ case.
- No tunable parameters for AA – though some freedom in choices along the way.



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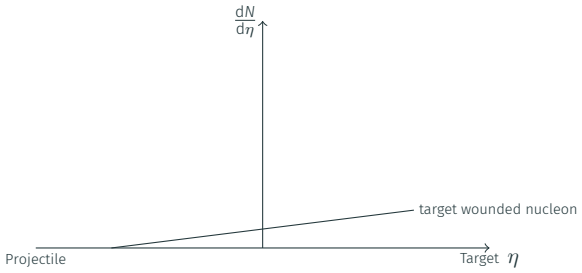

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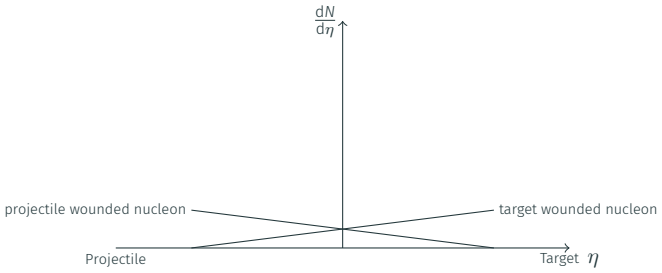

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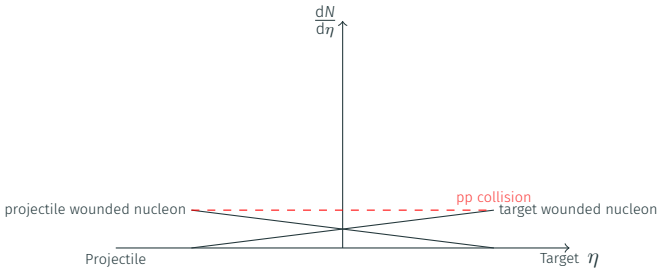

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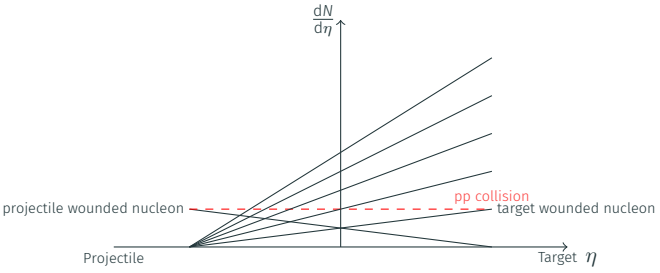

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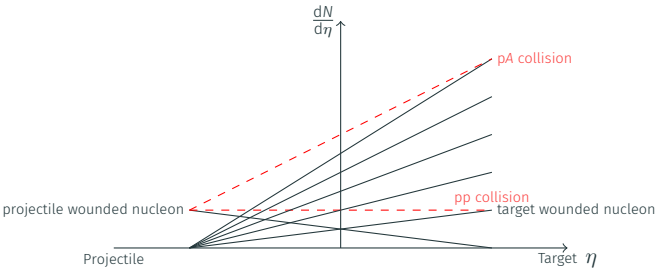

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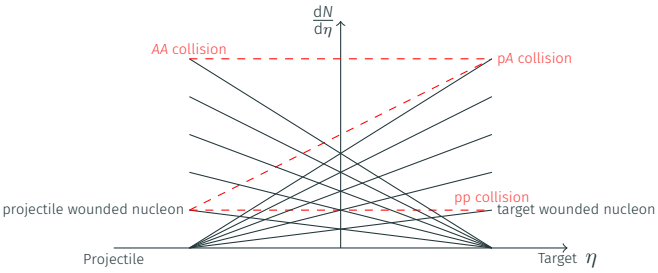
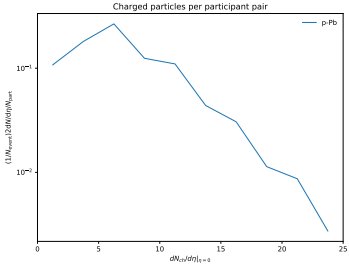
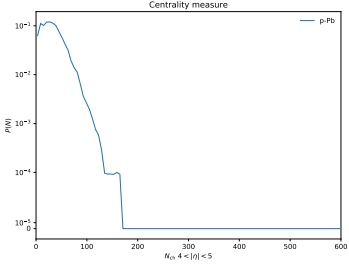


Exercise I: Multiplicity in p-Pb collisions at LHC

- Use provided `test70.cc` to generate p-Pb collisions at LHC energies.
- Add a figure with charged multiplicity at mid-eta scaled by the number of absorptive and diffractive wounded nucleon pairs.
- The number of wounded nucleons are part of the `HIInfo` object. See `main113.cc` for inspiration.
- Study the first part of the output in terminal.
  - How well are the cross sections reproduced?
- Plot the distributions using the generated Python code.

Expected result:

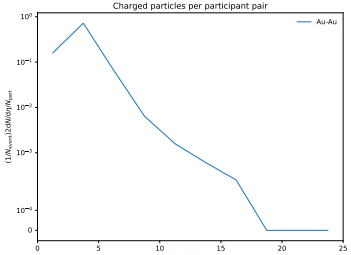


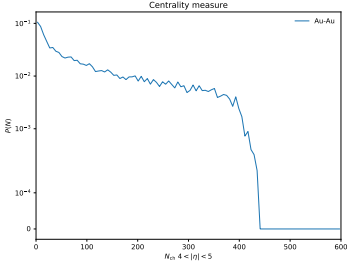


Exercise II: Au-Au collisions at RHIC

- Generate the same figures for Au-Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV.
- (Bonus: Make an additional histogram plotting the number of participant nucleons.)
- Some things to consider:
  - Changing beam type and energy – find help in the online manual.
  - The cross sections change from 5 TeV to 200 GeV. How to make sure that this is taken care of? Hint: study the output.

Expected result:

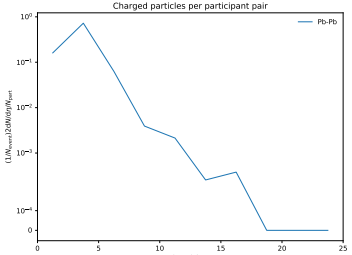


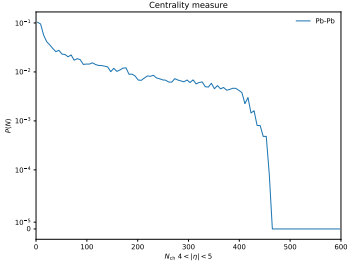


Exercise III: Pb-Pb collisions

- Generate the same figures for Pb-Pb collisions at $\sqrt{s_{NN}} = 200$ GeV.
  - What happens to the two multiplicity figures when changing beam types?
  - If you generated the bonus plot, compare its behaviour to the centrality measure.
  - Why is there a difference in top plot from AA to pA collisions? (careful, trick question!)
  - Generating 10k events will take time. Consider reducing the number, and just calculate averages.

Expected result:





Bonus: Centrality dependence

- If you need more to do, you can try to contruct observables like they do in heavy ion experiments.
- All observables are binned versus percentiles of the “centrality observable”.
- Contruct two histograms with total multiplicity, one for 0-10% most central, one for 10-20%.
- The best way is a two-pass, where you generate the centrality observable first, use it to calculate cuts, and then run again.
- This procedure is automated in Rivet (see next slide).

Bonus: Expected results

- Taken from the Rivet analyses: `ATLAS_PBPB_CENTRALITY`, `ALICE_2013_I1225979` and `ALICE_2016_I1394676`.
- Study the Rivet documentation for specific instructions.