

Updates for Angantyr for hadron-ion collisions

Pythia week 2024

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Goals

- Extend Angatyr to handle hadron-nucleus collisions where $h = \pi, K, \rho, \omega, \dots$
- Allow for event-by-event energy variation
- Allow for variation of hadron species during generation

Enable simulations for

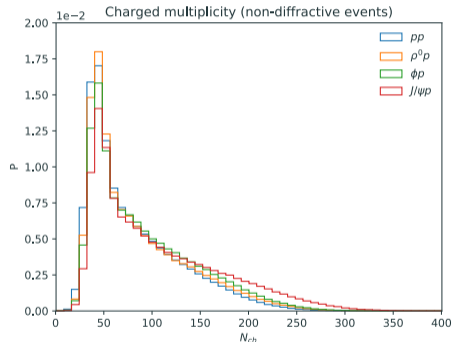
- Particle showers in atmosphere from high-energy cosmic rays
- Hadronic component of photon-ion collisions
 - Photoproduction with an ion target (EIC)
 - Ultraperipheral collisions at the LHC

Starting point

- Work by Marius and Torbjörn for hadron-proton collisions
- PDFs for a generic hadron (SU21)
- Cross section parametrizations from SaS for various beam configurations

Required developments

- Cross section fluctuations for asymmetric beam configuration
- Initialization for varying collision energy and beam type



Default Angantyr

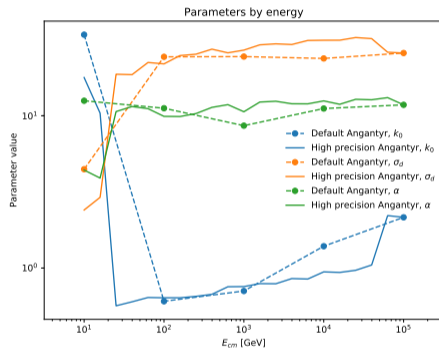
- A three-parameter model (k_0, σ_0, α) for cross section fluctuations, assume symmetric (nucleon-nucleon) collision, included in 8.311
- Initialized at fixed energy, usually ~ 20 generations enough

Updated model

- New collision models `HeavyIon:CollisionModel = 4,5` implemented, Separate parameters for each beam (six in total)
 - Requires ~ 1000 generations for similar fit quality, hours of computing time
 - Very similar results as with the default symmetric model
 - \Rightarrow Default model sufficient for now

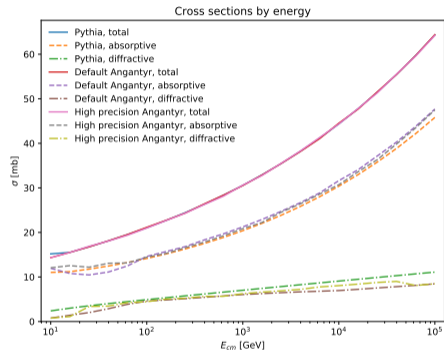
Parameter interpolation

- Initialize fluctuations at fixed points
- Interpolate between the points
- Parameters fairly stable for $E_{\text{cm}} \gtrsim 50$ GeV for ρ -proton



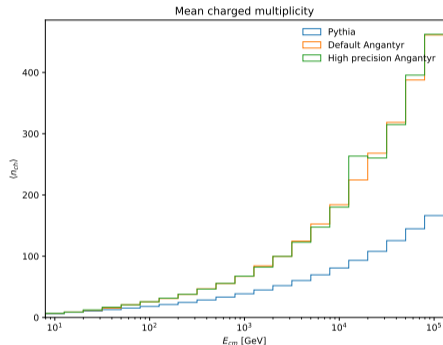
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- Very similar cross sections
- Also multiplicities but some difference with native Pythia
- Included in 8.311



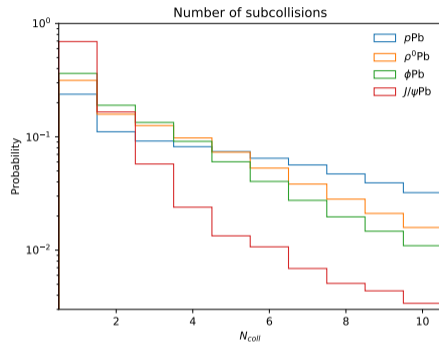
Hadron-ion collisions

Multiplicity driven by

- Number of subcollisions
- Number of MPIs in each subcollision

We find

- Less subcollisions with mesons



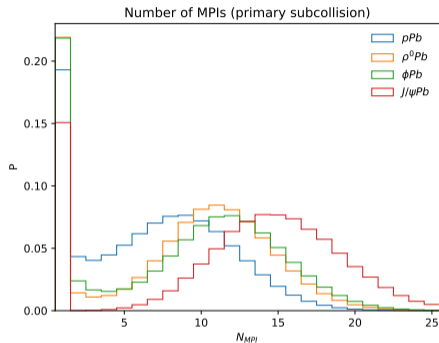
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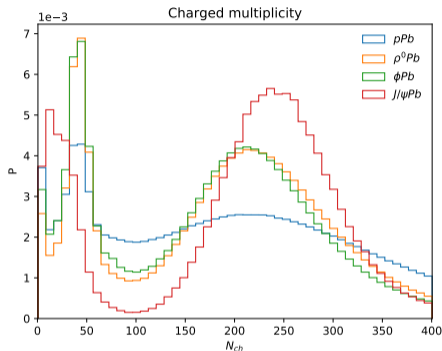
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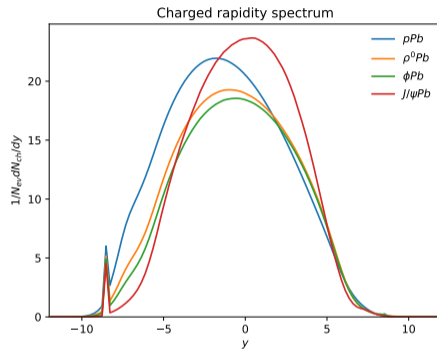
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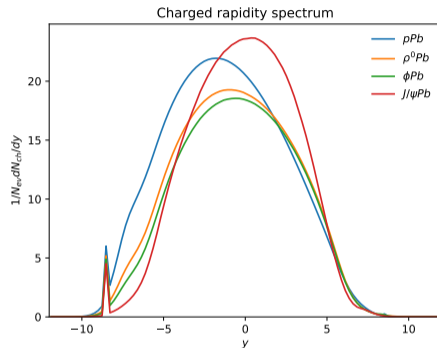
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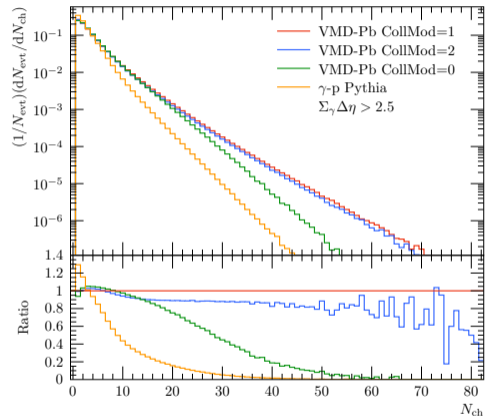
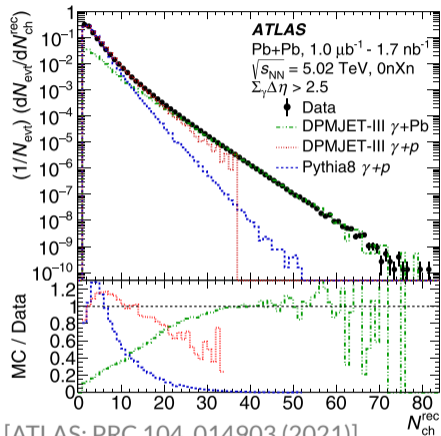
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- A merge request in place for varying hadron beam type together with the energy

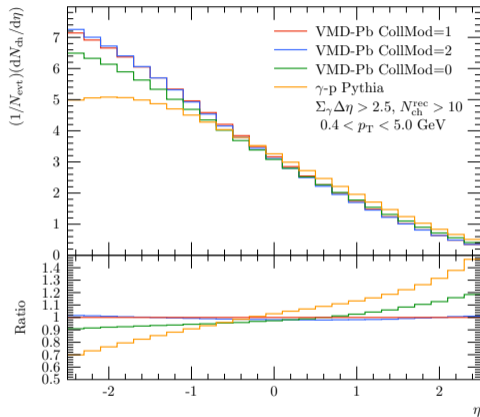
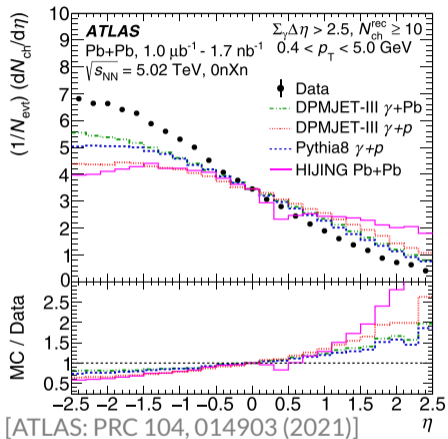
Comparison with data for γ +A using VMD



[ATLAS: PRC 104, 014903 (2021)]

- ATLAS data not corrected for efficiency, estimated with $N_{\text{ch}}^{\text{rec}} \approx 0.8 \cdot N_{\text{ch}}$
- Relative increase in multiplicity well in line with the VMD-Pb setup
- Seems that a fluctuating model needed to match data

Comparison with data for γ +A using VMD



- Multiplicity cut adjusted according to the limited efficiency
- More results and details on Thursday's seminar