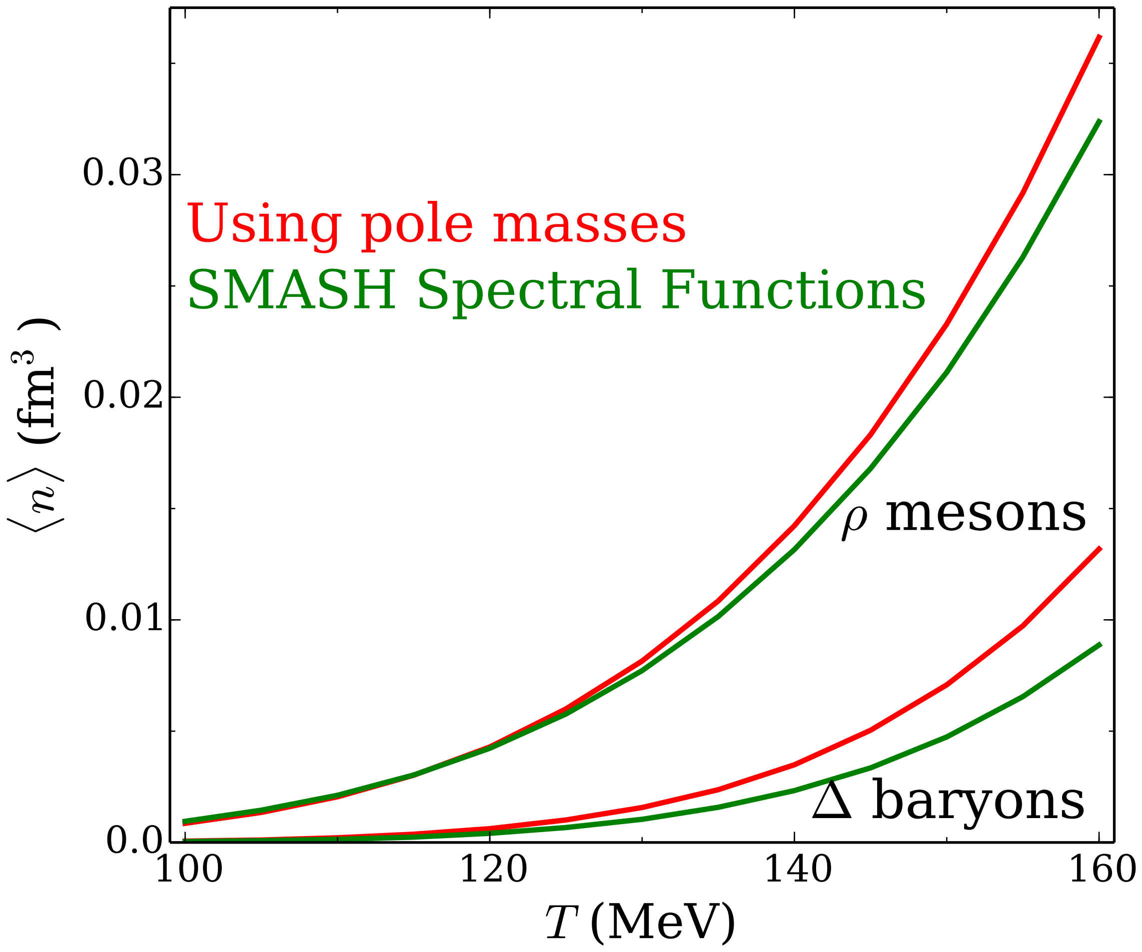
Hadron dynamics summary

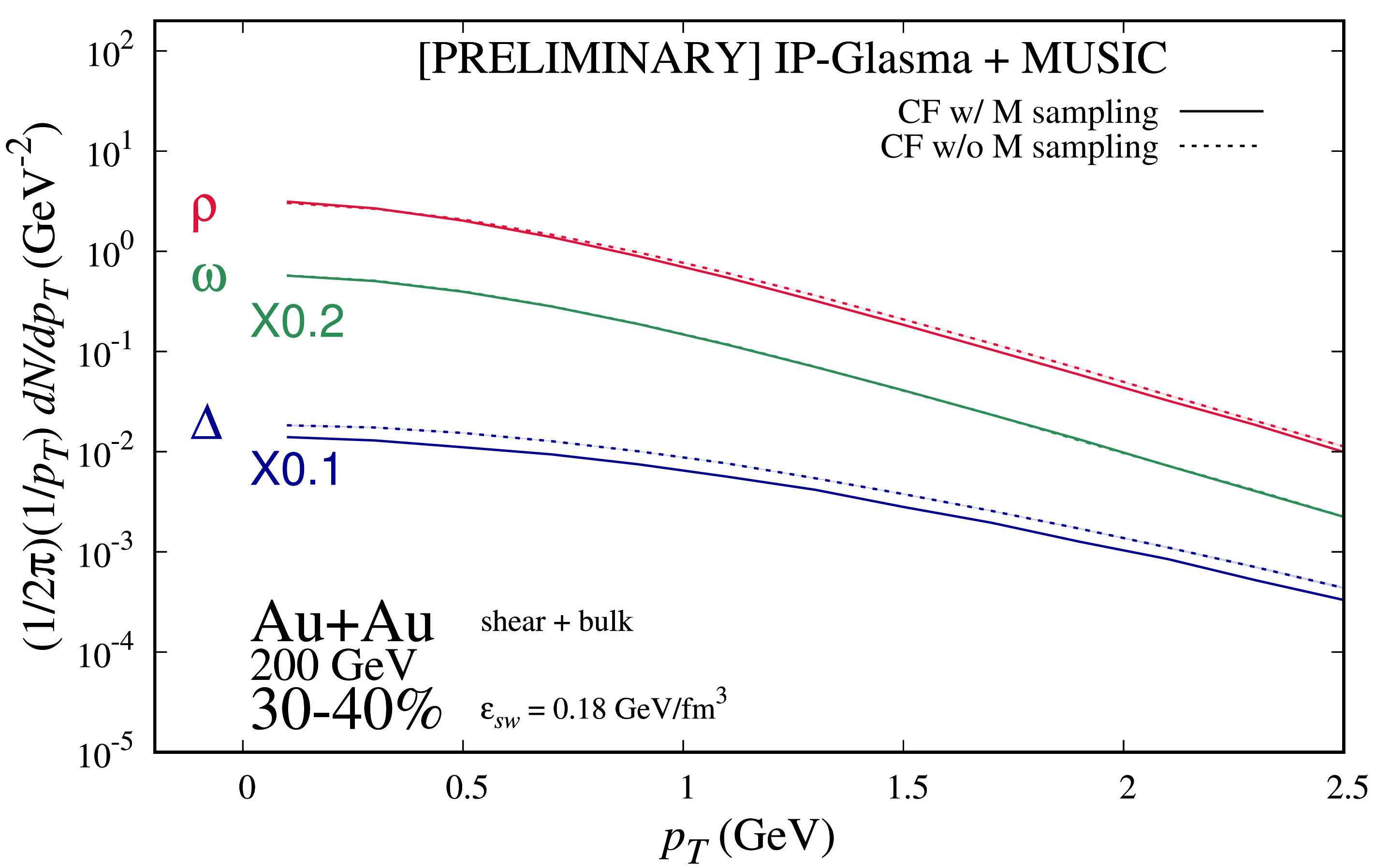
- Transform hydro field into particles (particlization)
  - talks by Sangwook, Maneesha, Maneesha, Shuzhe
- Hadron transport including mean field
  - talk by Agnieszka
- Data fitting

Particlization

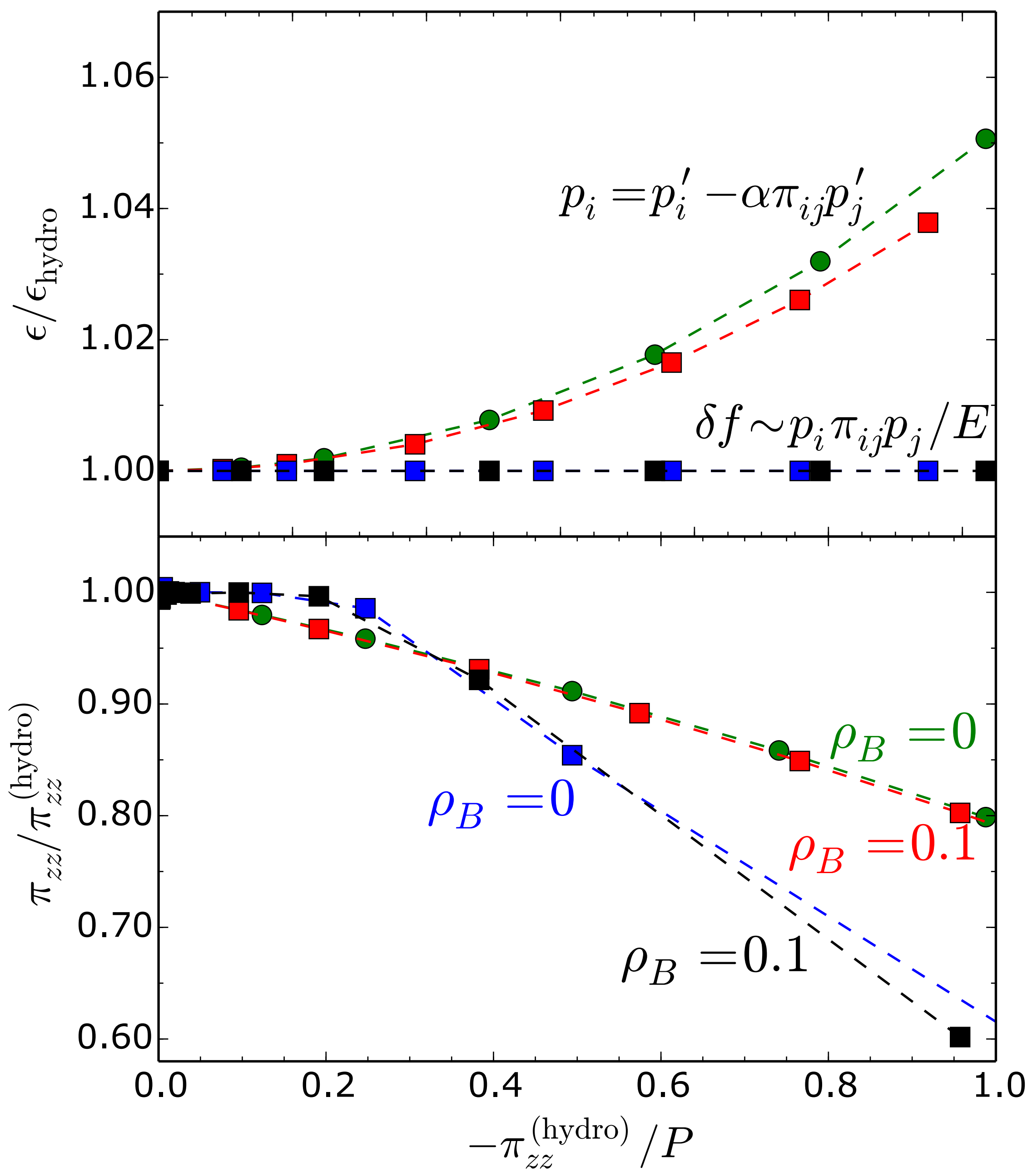
- General:
  - Account for details such as viscous corrections and spectral shapes etc
    - Shapes are done, and viscous corrections for shear viscosity
- Fluctuations, correlations:
  - Poisson sampling generates additional fluctuations and washes out correlations
    - Micro-canonical sample (Dima)
      - Sampling is done and works, patches still need more conceptual input
    - Sampling (2,3,4,…) particle correlations (Maneesha)
      - two particle correlation function at “freeze out” available, particlization to be done

Spectral shapes





Viscous corrections (shear)



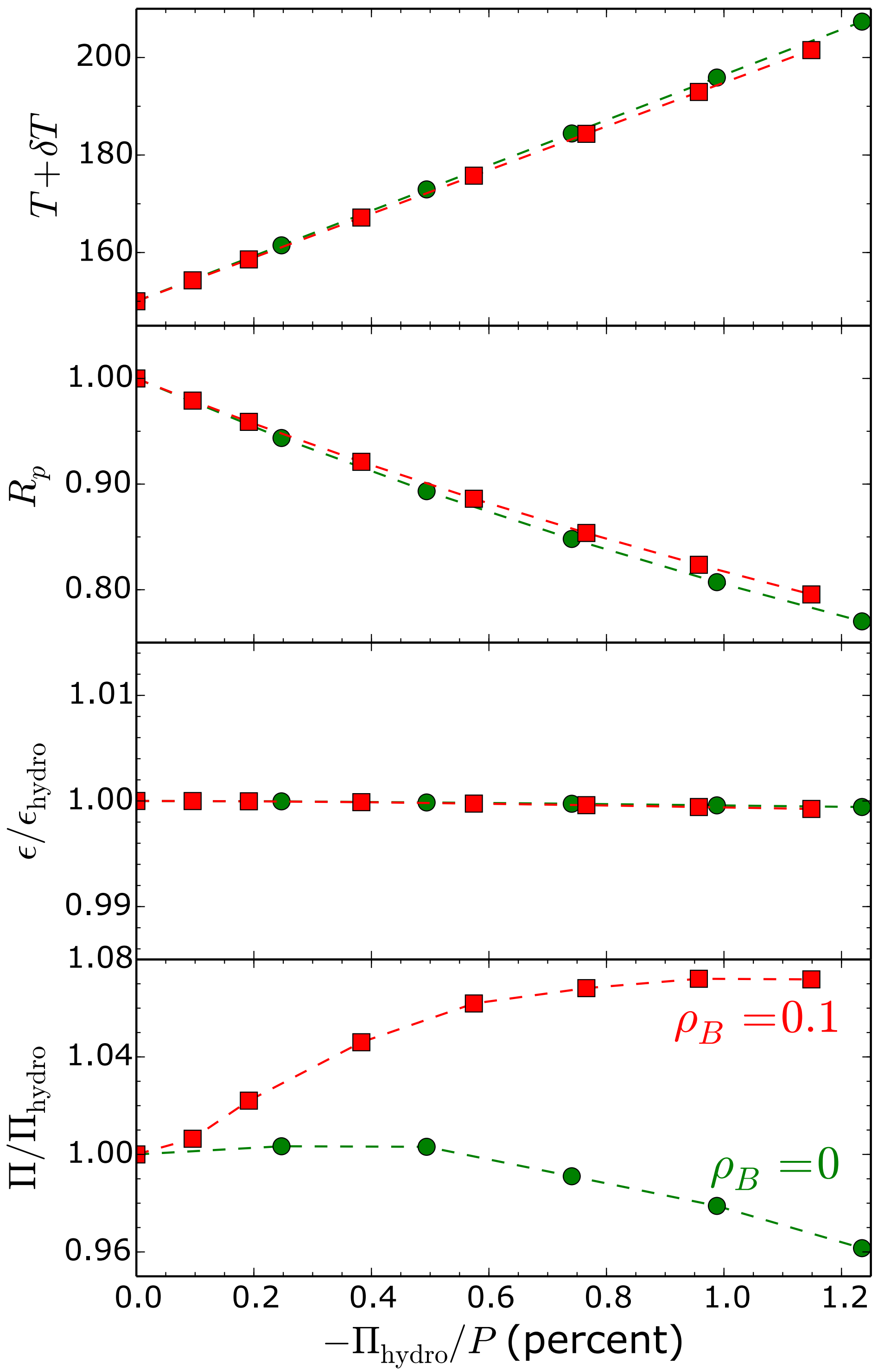
$$p_i = (\delta_{ij} + \alpha\pi_{ij})p_j'$$

red and green

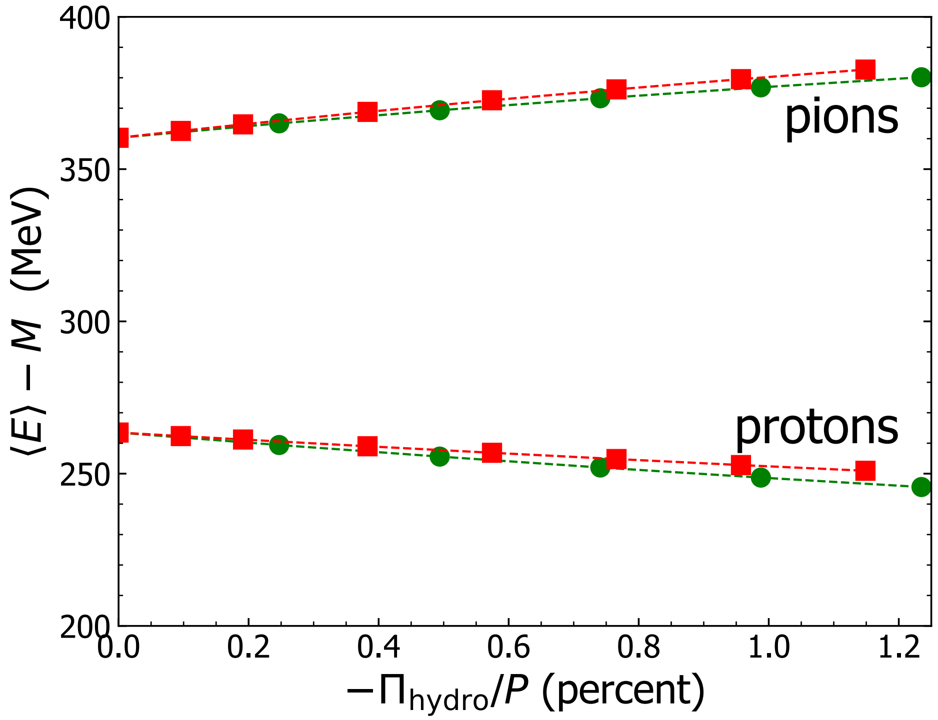
$$f(p) = f_0(p) + \alpha\pi_{ij}\frac{p_i p_j}{E}$$

black and blue

Viscous correction (bulk)



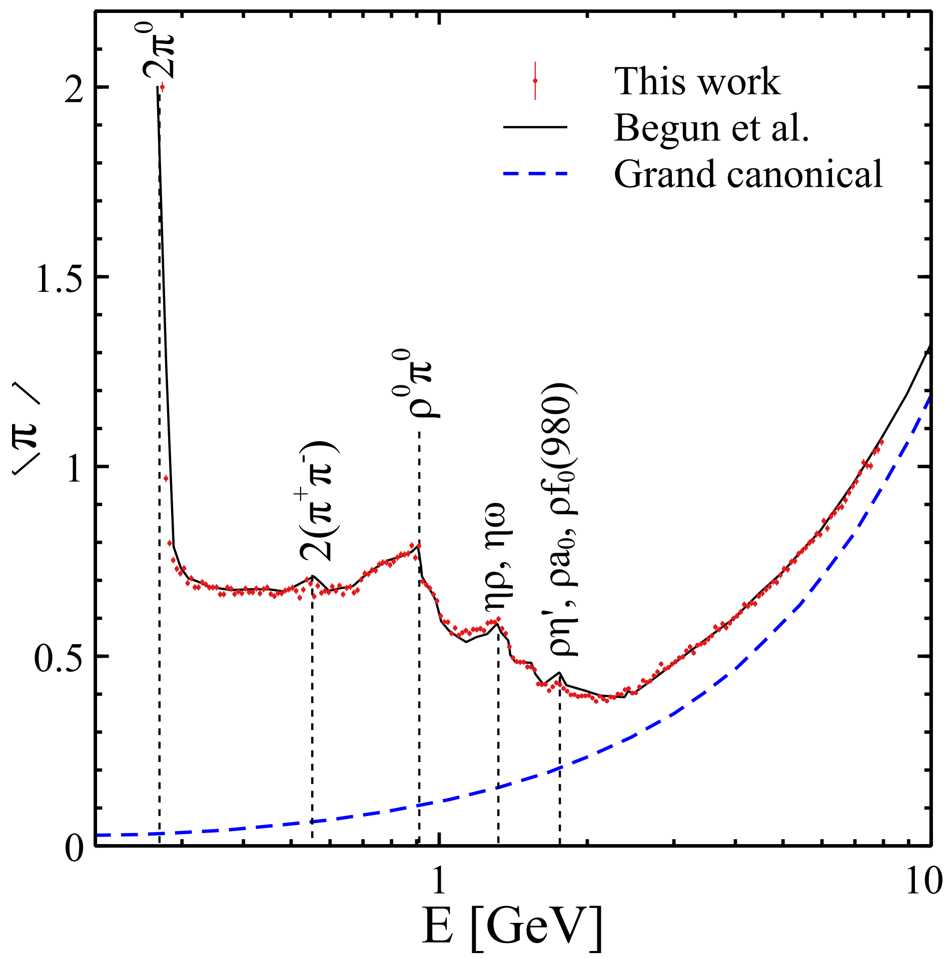
$$p_i = (1 + \alpha \Pi_{i,i}) p_i'$$

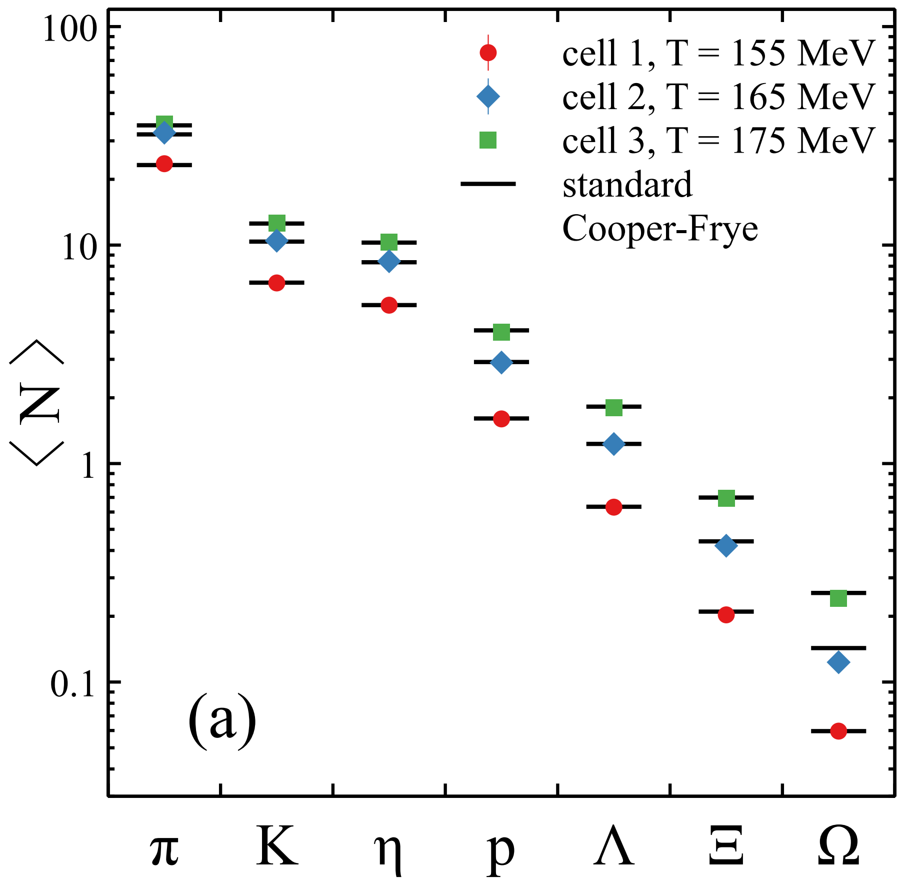


Micro Canonical Sampling

- Main motivation: Stochastic hydro
  - All (including thermal) fluctuations are provided by ensemble of stochastic hydro events
  - Need to map the “local” values of ALL conserved charges into kinetic theory for each member of the stochastic hydro ensemble.
  - added benefit: small systems, global conservation for non-stochastic hydro
- Patches: Forced upon us since computational cells have <<1 particles
  - No need for classical fluids.
  - Coarse grains computational grid into physical grid
  - Open question: How to chose the patch “size”
    - Fixed energy: Intuitive, but may “interfere” with stochastic fluctuations
    - Any good ideas and suggestions are welcome

Micro Canonical(+) Sampling

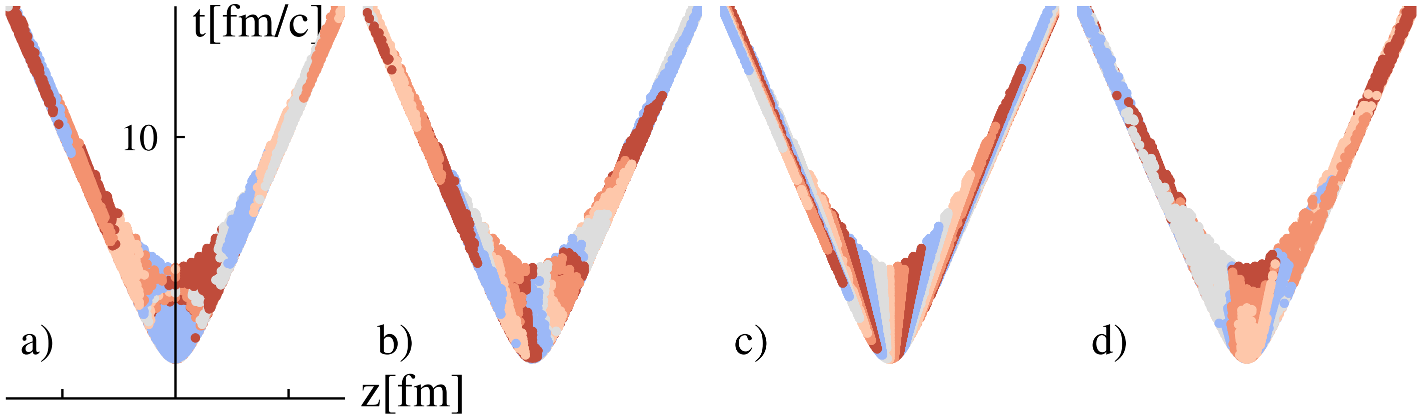


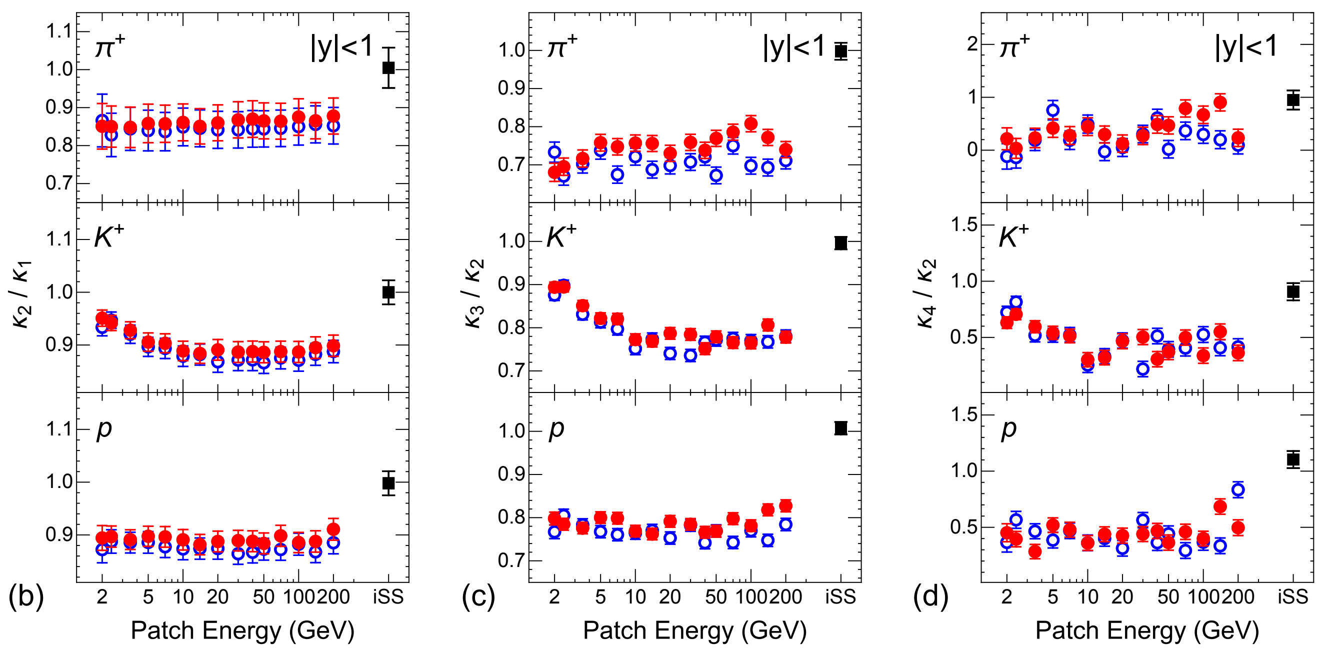


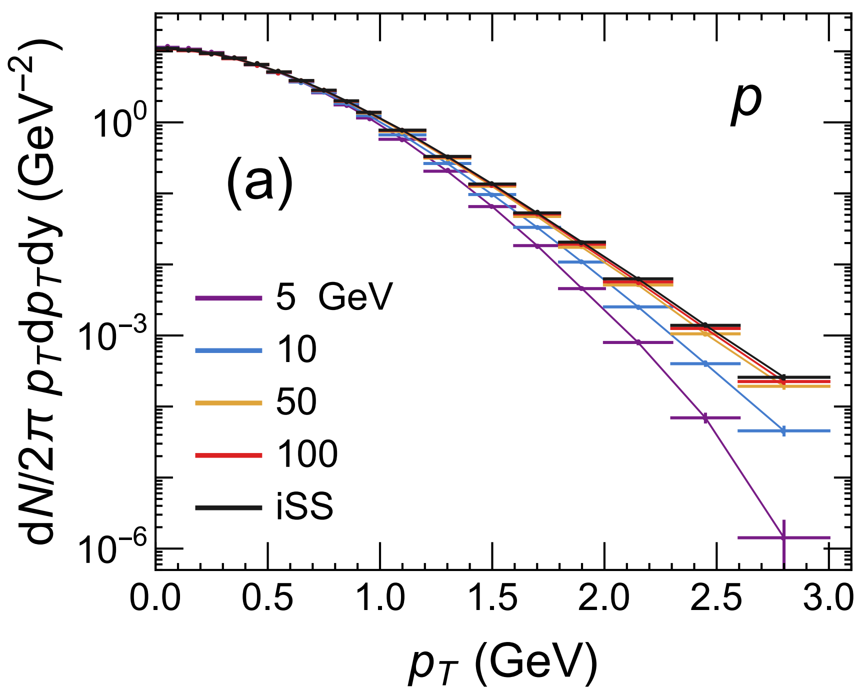
It works!
And is sufficiently fast

Able to account for (energy) density variation within patch if so desired

Micro-canonical sampling: Patching



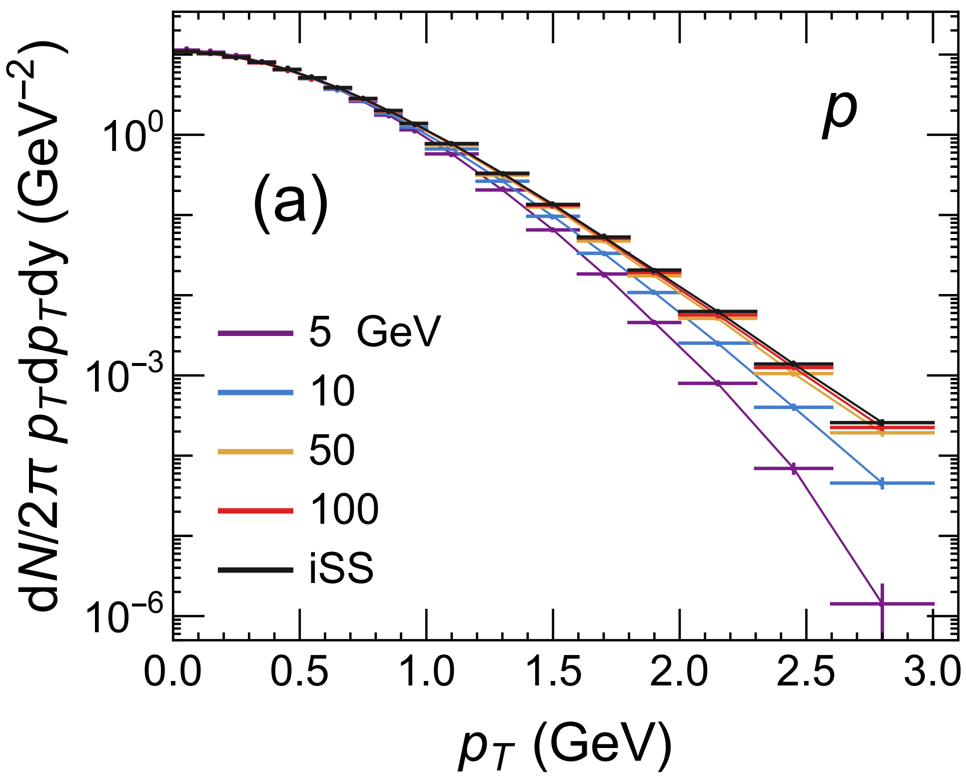




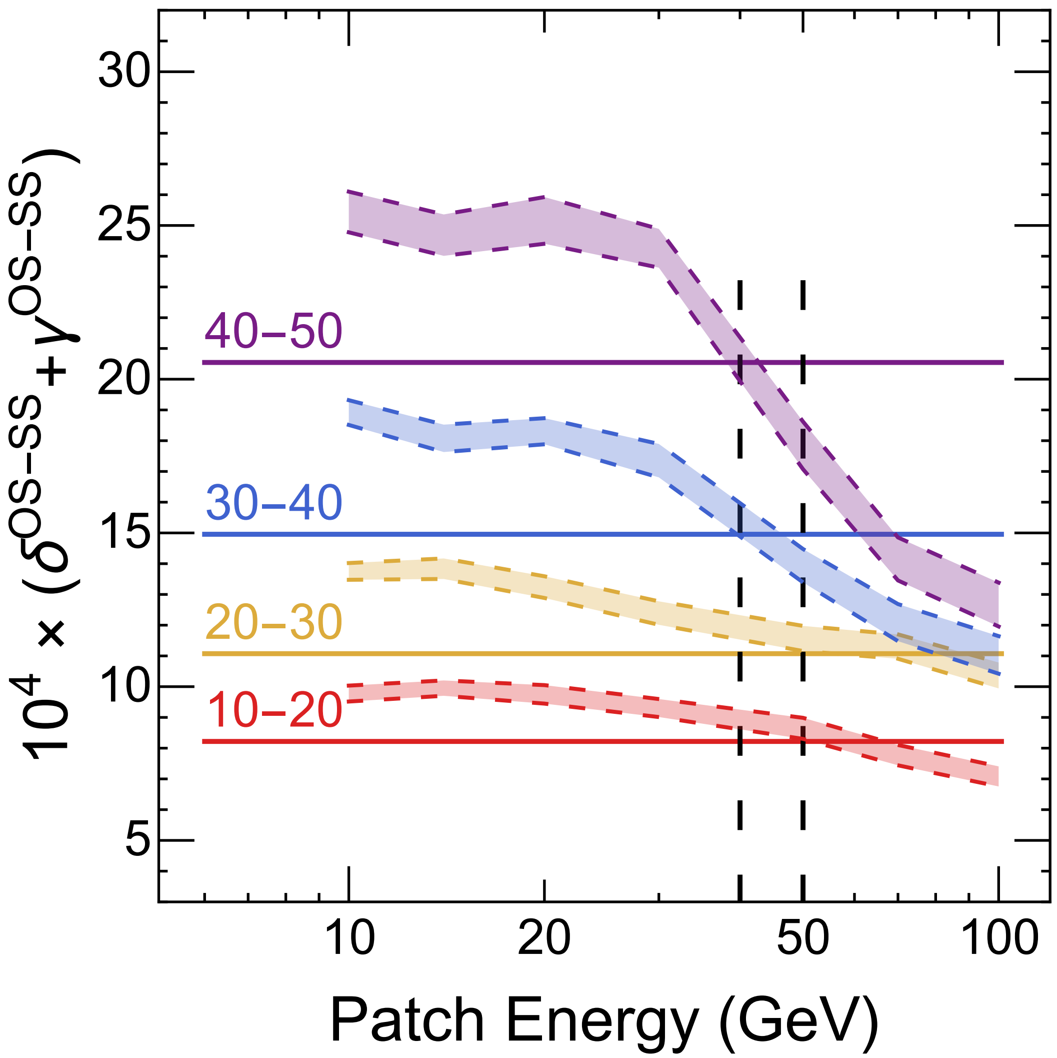
Effects of patch algorithm are present but tolerable

Kinematic constraints will be softened in stochastic hydro…

Patches



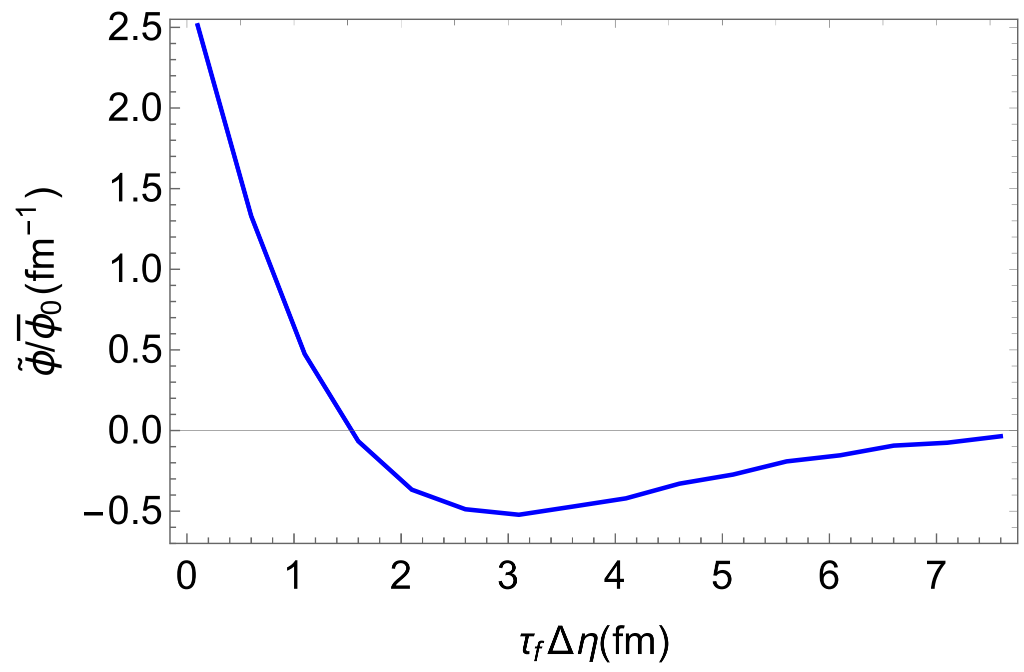
Kinematic constraints will be softened in stochastic hydro…

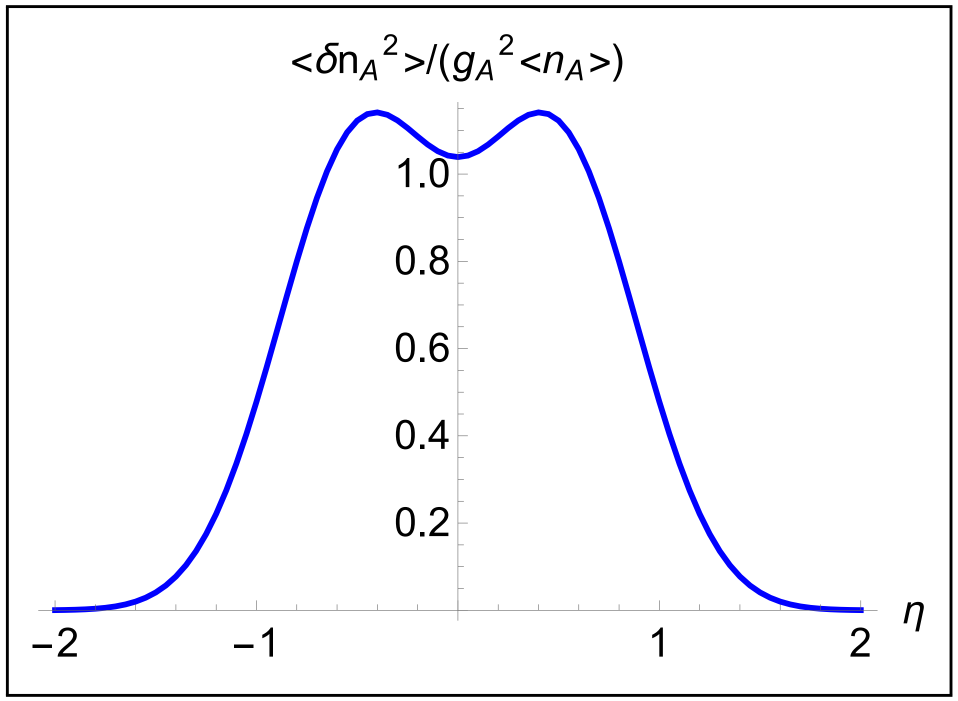


Eventually constrain by data

Hydro+

- Correlation function on the hyper surface
- first result for two particle correlation
- may inform the choice of patch size
- No particles yet



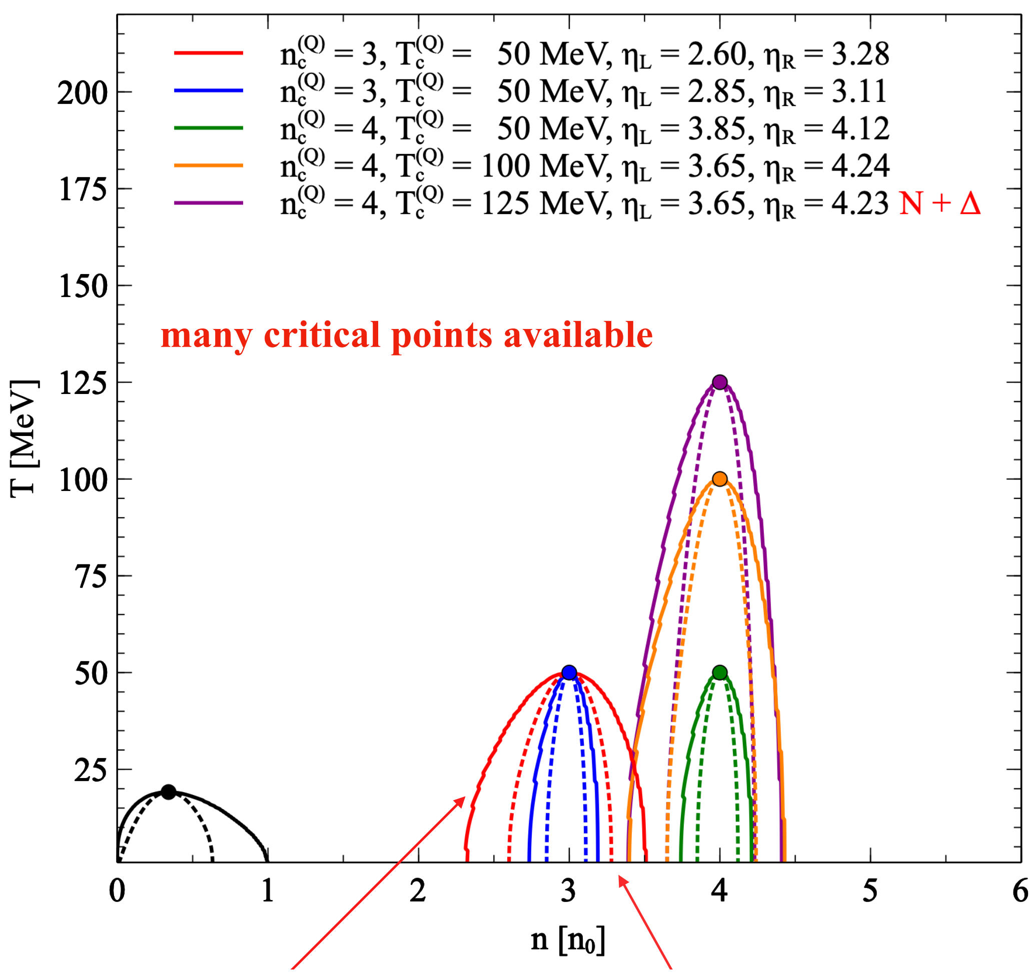


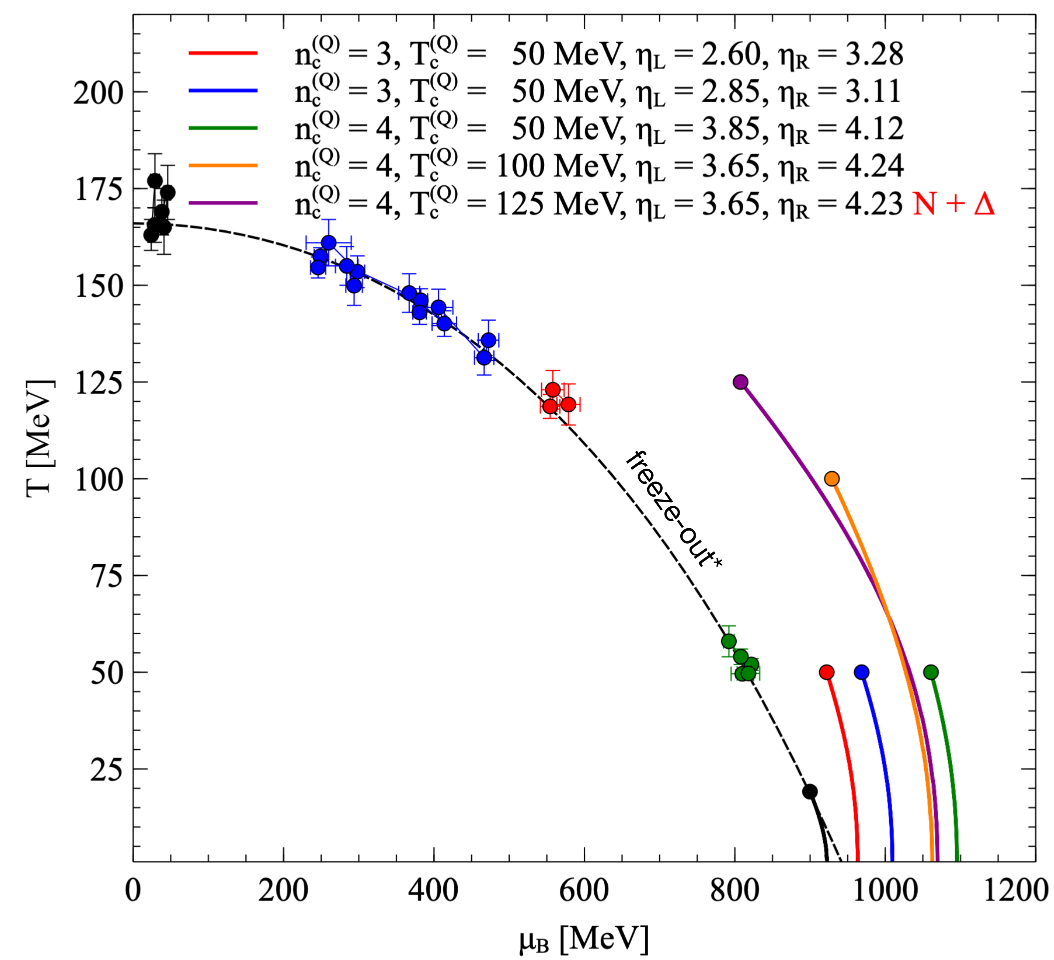
Hadronic Transport

- Include mean field to be able to match EOS on the hadronic side
  - develop flexible mean field (DFT) Hamiltonian
  - implement in Smash

Mean field

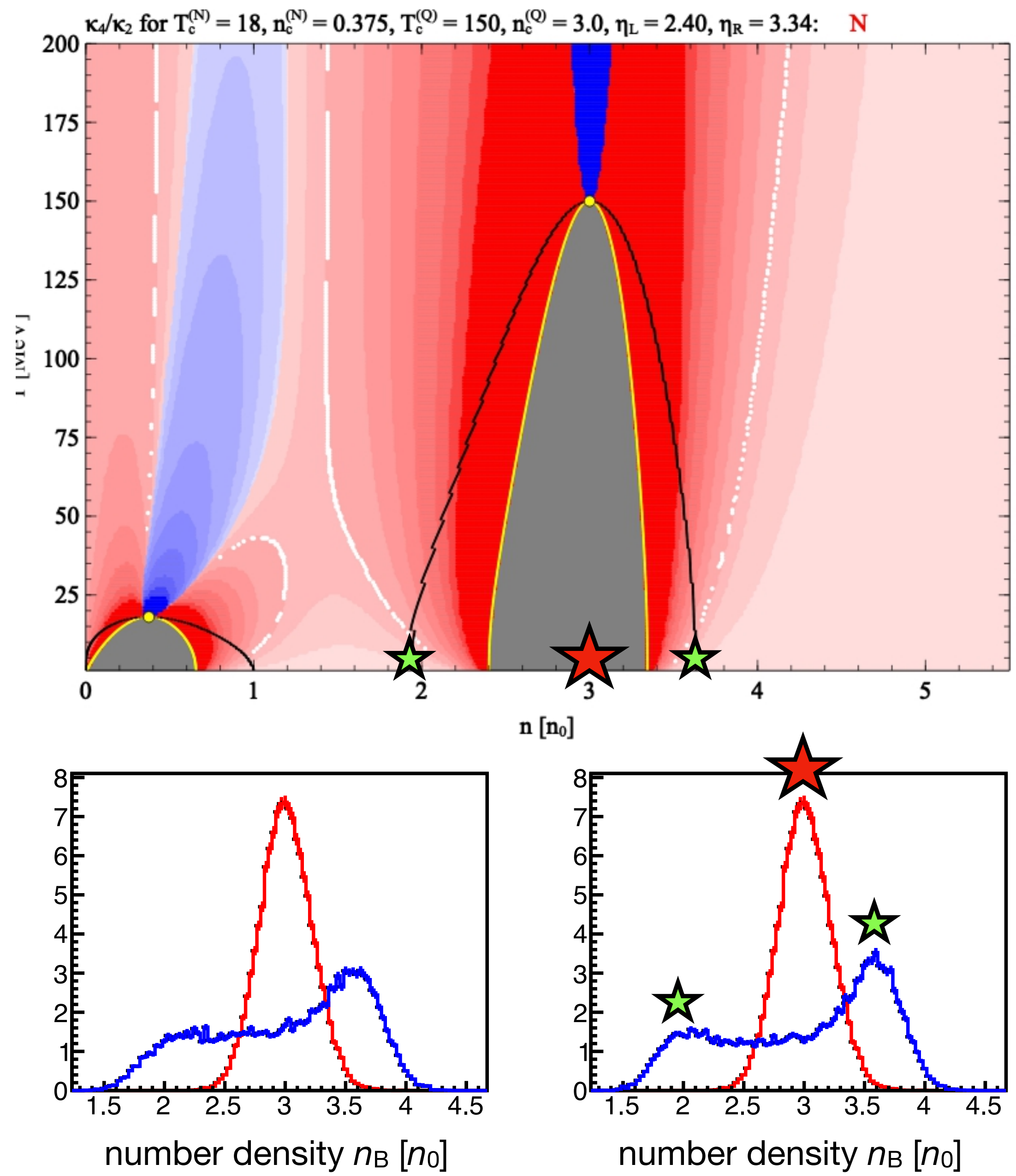
$$\mathcal{E} = \mathcal{E}[f_{\mathbf{p}}] = \int \frac{d^3p}{(2\pi)^3}\, \epsilon_{kin}\, f_{\mathbf{p}} \; + \; \sum_{i=1}^{N} C_i \left(j_\mu j^\mu\right)^{\frac{b_i}{2}-1} \left[j^0 j^0 - g^{00} \left(\frac{b_i - 1}{b_i} \right) j_\lambda j^\lambda \right]$$





Mean field in smash

- Implementation of vector mean field complete
  - conserves energy and momentum
- Shows expected behavior in box
- Ready for prime time



Where are we

- Particlization algorithms in good shape
- Patches need some physics input
- Semi flexible mean field available
- Implemented and tested in SMASH

To Do

- Better understand the patch “size”
  - use data
  - would be very helpful to have some kind of stochastic hydro to “play” with
- Extend mean field to include scalar interaction
  - proved more flexibility
  - requires additional work on the SMASH side
- Data Fitting
  - Need parameterization of initial state
    - Nice progress reported by Bjoern
  - Need to get going