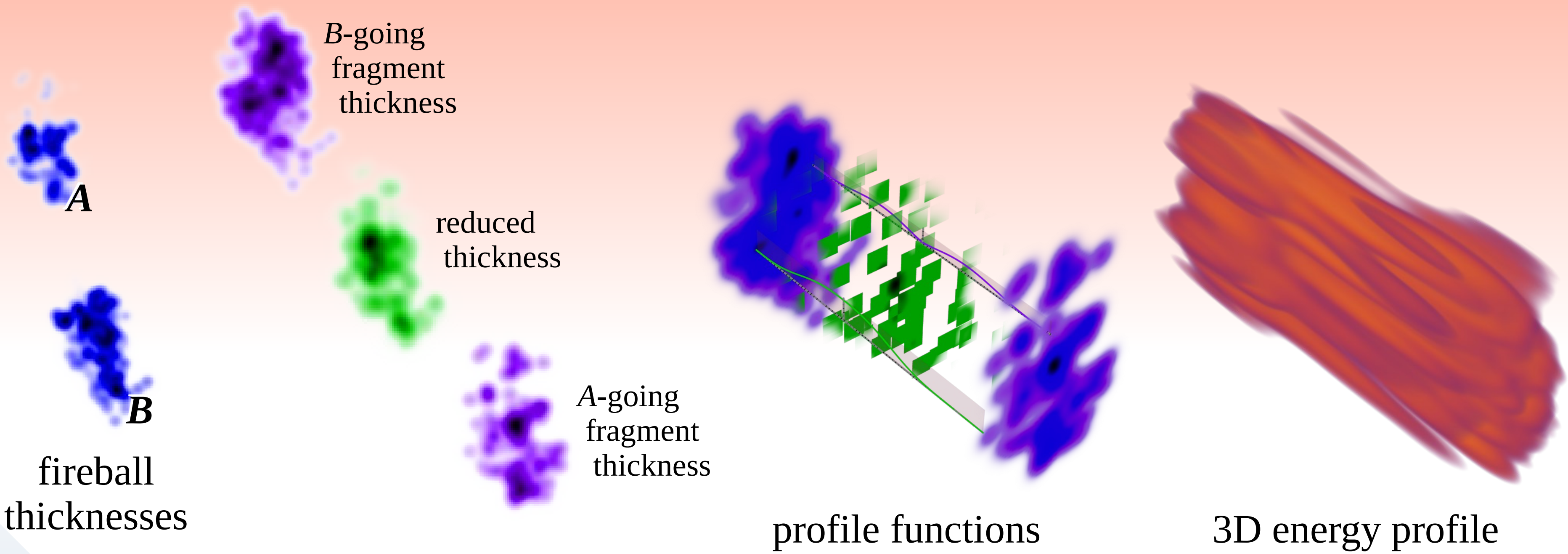
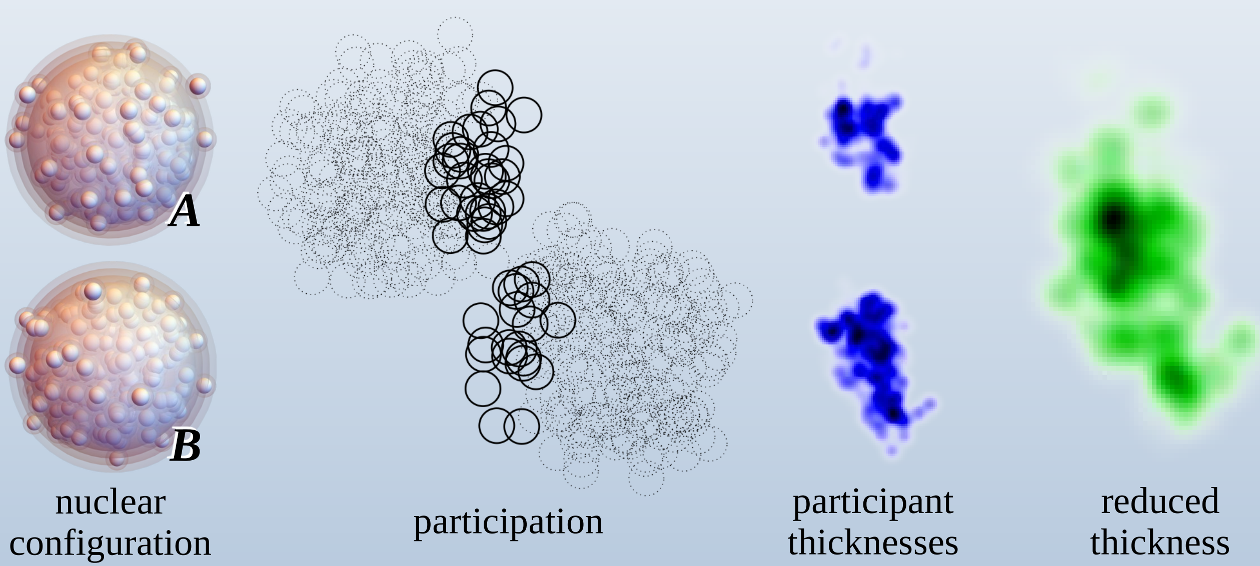
T$_R$ENTo-3D



T$_R$ENTo (2D)



Phys. Rev. C 92 (2015) 011901, 1412.4708; Phys. Rev. C 101 (2020) 024911, 1808.02106

First Results for the New T$_R$ENTo-3D Initial-Conditions Ansatz

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On behalf of:
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TRENTo-3D

We assume a **central fireball** and two **fragmentation regions**, with profile functions:

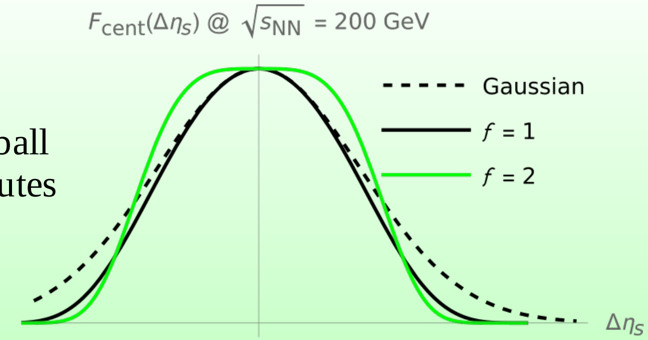
$$F_{\text{cent}}(\Delta\eta_s) = \exp\left\{\left(\frac{-\Delta\eta_s^2}{2\eta_{s,\max}}\right)^f\right\}\times\left(1-\left(\frac{\Delta\eta_s}{\eta_{s,\max}}\right)^4\right)^4 \quad \text{and} \quad F_{\text{frag}}(x) = (-\ln x)^\alpha x^{\beta+1}\exp\left(\frac{-2k_{\text{T,min}}}{x\sqrt{s_{NN}}}\right)$$

Central Fireball

- Gaussian-like profile function with flatness parameter f:
- On average, N–N participant pair deposits fraction $\langle x_{\text{loss}}\rangle$ of energy into fireball
- Event by event, each constituent (subnucleonic degree of freedom) contributes an independent fraction x_{loss} of its energy to fireball, distributed as:

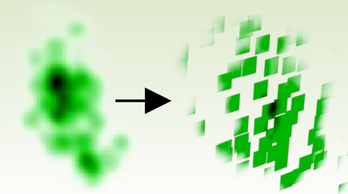
$$x_{\text{loss}} \sim \text{Beta}\{\langle x_{\text{loss}}\rangle K,\ (1-\langle x_{\text{loss}}\rangle)K\}$$

with mean $\langle x_{\text{loss}}\rangle$ and fluctuation parameter K



$\Delta\eta_s = \eta_s - \eta_{s,cm}$, with center of central fireball $\eta_{s,cm}$ varying over $\boldsymbol{x}_{\text{T}}$ with fireball thicknesses:

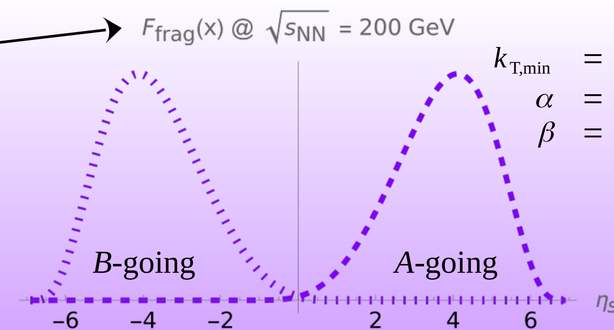
$$P^\mu_{\text{cm}}(\vec{x}_{\text{T}}) = \left((T_A(\vec{x}_{\text{T}})+T_B(\vec{x}_{\text{T}}))\frac{\sqrt{s_{NN}}}{2},\ \hat{z}(T_A(\vec{x}_{\text{T}})-T_B(\vec{x}_{\text{T}}))\sqrt{\frac{s_{NN}}{4}-m_p^2}\right), \quad \eta_{s,cm} = \text{asinh}\left(p_{cm}\,/\,\sqrt{P^\mu_{cm}P^{cm}_\mu}\right)$$



Fragmentation Regions

$$x = \exp(-\eta_{s,\text{beam}} \pm \eta_s)$$

- Form inspired by limiting fragmentation hypothesis[1] and PDFs[2]
- Constituents deposit fraction (1 - x_{loss}) of energy into fragments
- **Conservation of energy**: all participant energy is accounted for



$k_{\text{T,min}}$ = 0.25 GeV
α = 4.0
β = 0.4

[1] Benecke *et al.*, Phys. Rev. 188, 2159 (1969)
[2] Bass, Müller, Srivastava, Phys. Rev. Lett. 91 (2003) 052302, nucl-th/0212103

TRENTo-3D

We assume a **central fireball** and two **fragmentation regions**, with profile functions:

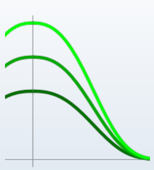
$$F_{\text{cent}}(\Delta\eta_s) = \exp\left\{\left(\frac{-\Delta\eta_s^2}{2\,\eta_{s,\max}}\right)^f\right\}\times\left(1-\left(\frac{\Delta\eta_s}{\eta_{s,\max}}\right)^4\right)^4 \quad \text{and} \quad F_{\text{frag}}(x) = (-\ln x)^{\alpha}\,x^{\beta+1}\exp\left(\frac{-2\,k_{\text{T,min}}}{x\sqrt{s_{NN}}}\right)$$

$$\varepsilon(\vec{x}_{\text{T}},\eta_s) = N_{\text{Trento}}\sqrt{T_A(\vec{x}_{\text{T}})T_B(\vec{x}_{\text{T}})}\,F_{\text{cent}}(\eta_s-\eta_{s,cm}(\vec{x}_{\text{T}})) + \frac{k_{\text{T,min}}}{\int_{k_{\text{T,min}}/\sqrt{s_{NN}}}^{1} dx\,F_{\text{frag}}(x)}\times \left\{F_A(\vec{x}_{\text{T}})F_{\text{frag}}(\exp(-\eta_{s,\max}+\eta_s)) + F_B(\vec{x}_{\text{T}})F_{\text{frag}}(\exp(-\eta_{s,\max}-\eta_s))\right\}$$

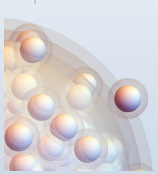
(TRENTo $p = 0$)

Model parameters

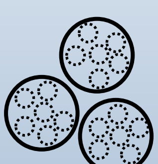
Fluctuation (k)



Fireball normalization (N_{Trento})

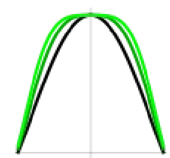


Nucleon width (w)

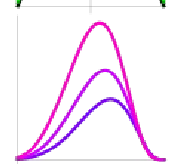


Constituent width (v)

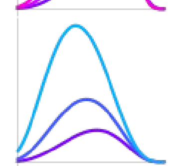
Constituent number (n_c)



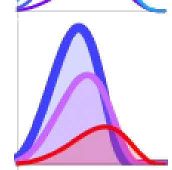
Flatness (f)



Fragmentation shape α



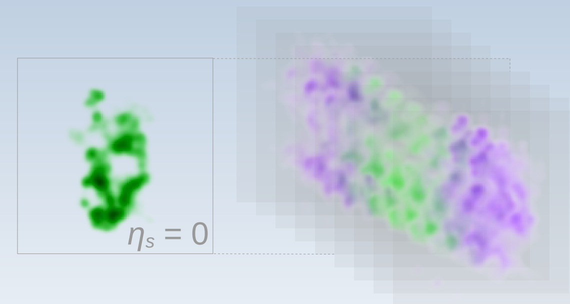
Fragmentation shape β

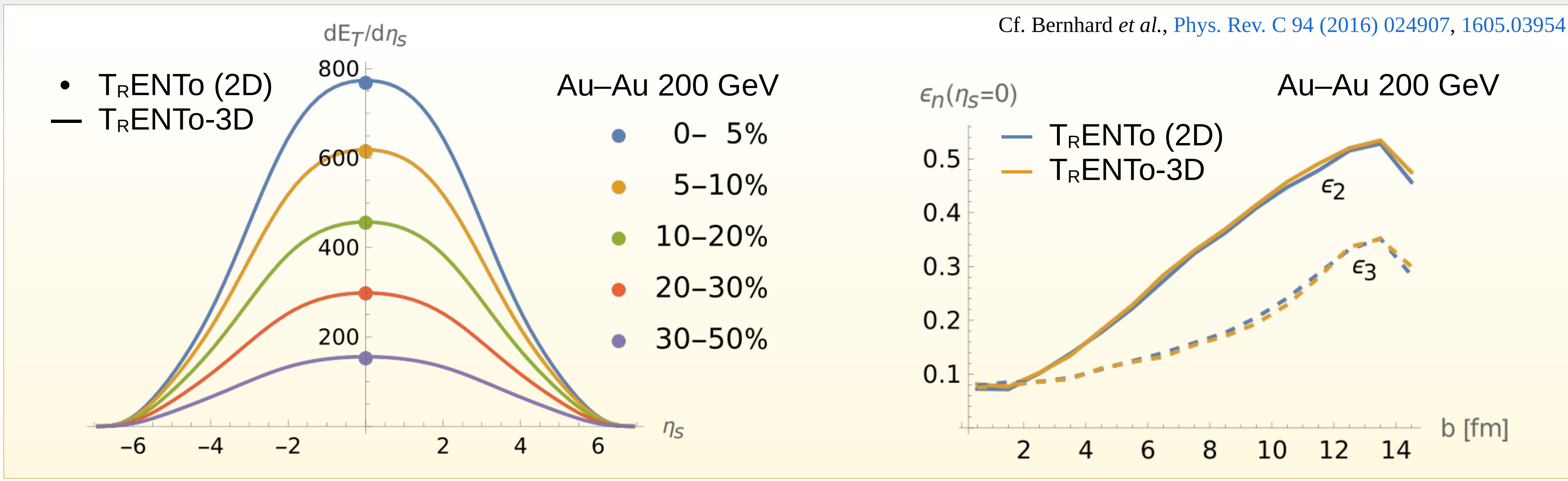


Typical parton transverse momentum scale ($k_{\text{T,min}}$)

Analysis

Confirming that TRENTo-3D matches 2D TRENTo at midrapidity:*

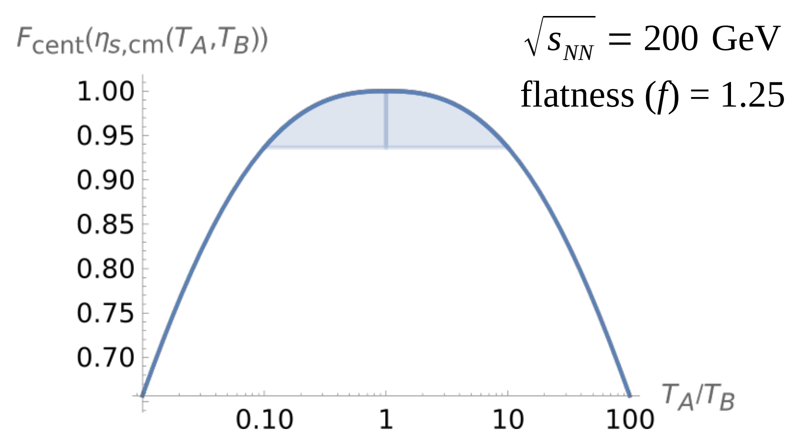




Cf. Bernhard *et al.*, Phys. Rev. C 94 (2016) 024907, 1605.03954

* Some considerations:

- TRENTo-3D's N_{Trento} is $\times\, 1/\langle x_{\text{loss}}\rangle = 1.43$ here because its fireball–fragment fluctuation beta distribution has a **mean of** $\langle \mathbf{x}_{\textbf{loss}}\rangle$, whereas TRENTo (2D) fluctuates participants by a gamma distribution with **mean 1**
- TRENTo-3D's **central fireball profile** applies at midrapidity wherever $\eta_{s,cm}(\mathbf{x}_{\mathrm{T}}) \neq 0$, but in large symmetric systems it **can be neglected**:

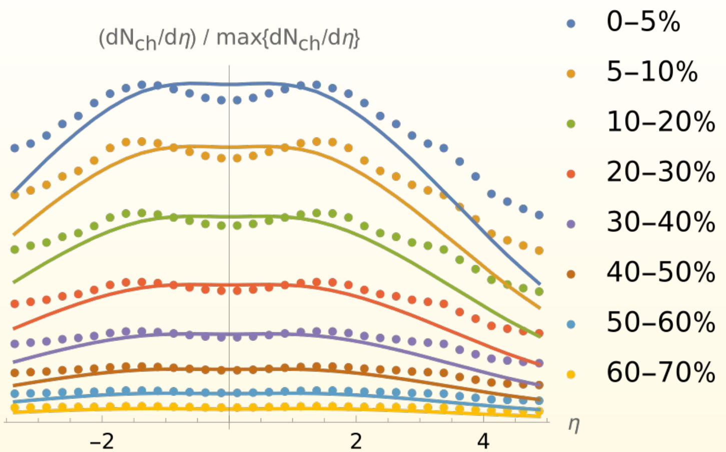


Analysis

- To connect TRENTo-3D with experiment, we use a linearized (1+1)D hydrodynamic code (“LH”) and Cooper–Frye with a transverse-Gaussian assumption (“CF”)
- No hadronic transport/decays—instead, we normalize data sets to peak at unity
- Simultaneously fitting to three experimental data sets:

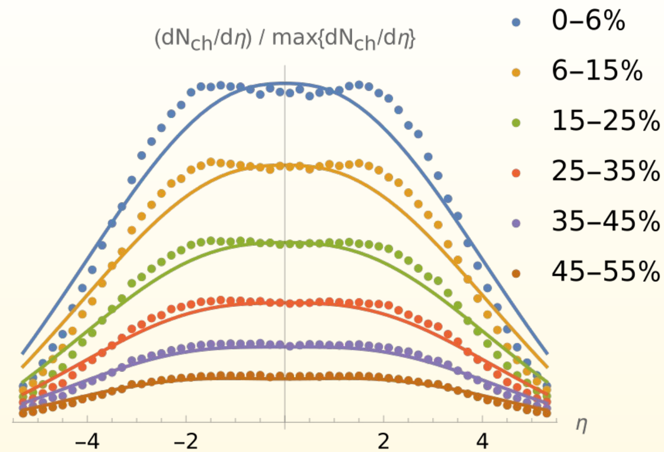
• Experiment
— T$_R$ENTo-3D → LH → CF

Pb–Pb 5.02 TeV



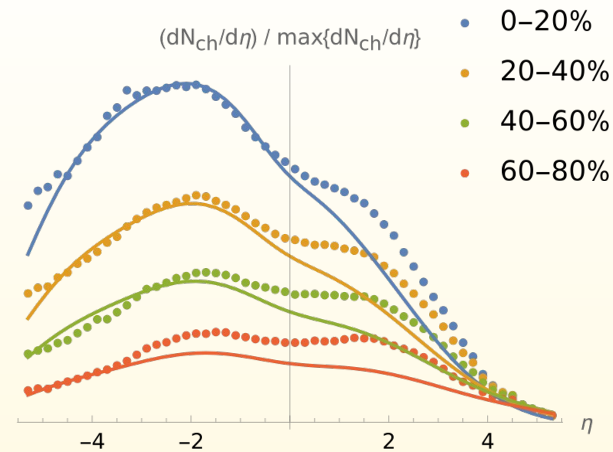
ALICE, Phys. Lett. B 772 (2017) 567-577, 1612.08966

Au–Au 200 GeV



PHOBOS, Phys. Rev. Lett 91 (2003) 052303, nucl-ex/0210015

***d*–Au 200 GeV**



PHOBOS, Phys. Rev. C 72 (2005) 031901, nucl-ex/0409021

- Parameter values used above:
  w = 0.41 [fm] v = 0.19 [fm] n_c = 9.39 f = 1.34 α = 3.41 β = 0.20
  $N_{200\ \mathrm{GeV}}$ = 3.52 $N_{5.02\ \mathrm{TeV}}$ = 14.7 k = 0.11 $k_{T,\min}$ = 0.22 [GeV] τ_0 (LH) = 1.48 [fm/c]
- Calibration is ongoing: more systems and energies
- Parametrization seems to challenge Bayesian parameter estimation, may need revision