MULTI-MODULAR MODEL FOR SIMULATING RELATIVISTIC HEAVY ION COLLISIONS

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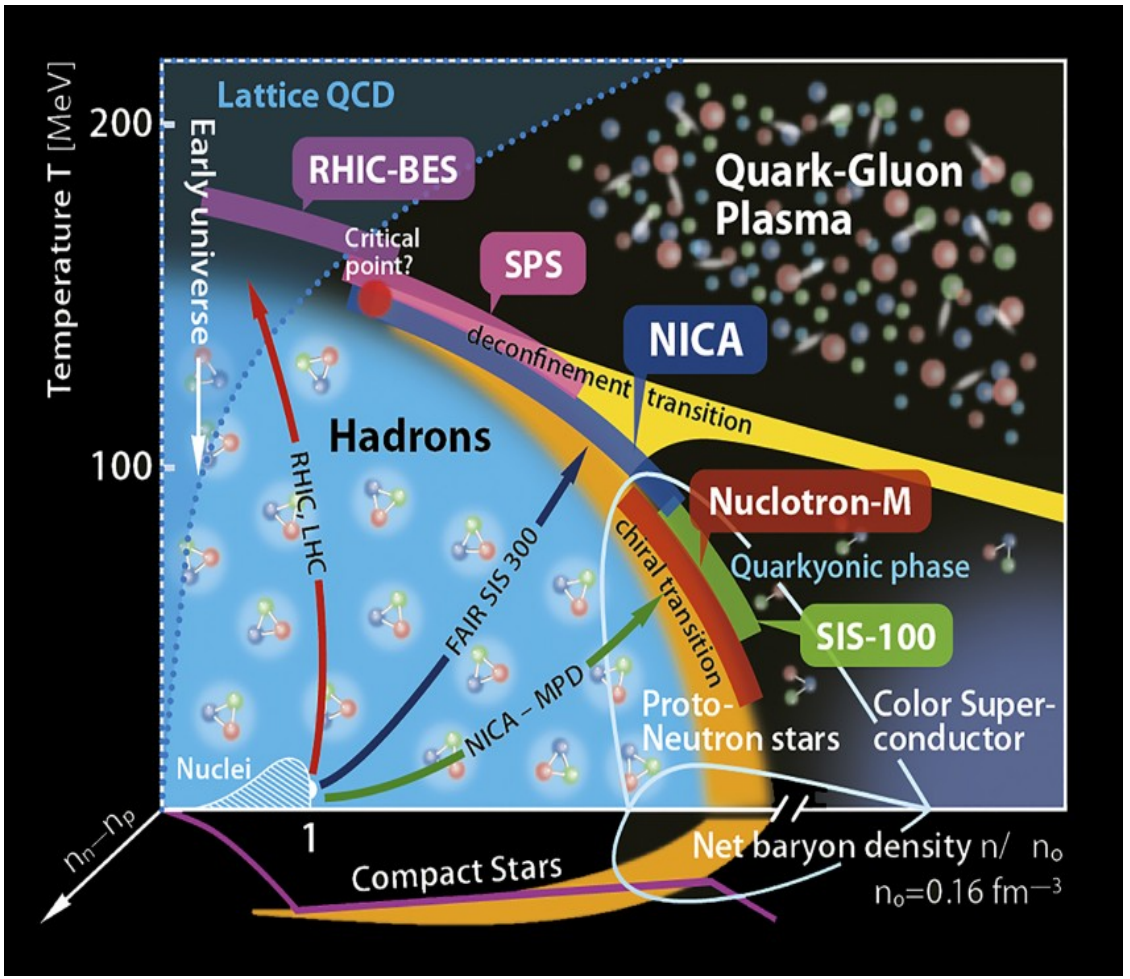
ICCUB
Institut de Ciències del Cosmos

OUTLINE

- MOTIVATIONS
- DIFFERENT STAGES OF A RELATIVISTIC HEAVY ION COLLISION
- PARTICLIZATION PROCESS
- FREEZE-OUT HYPERSURFACE

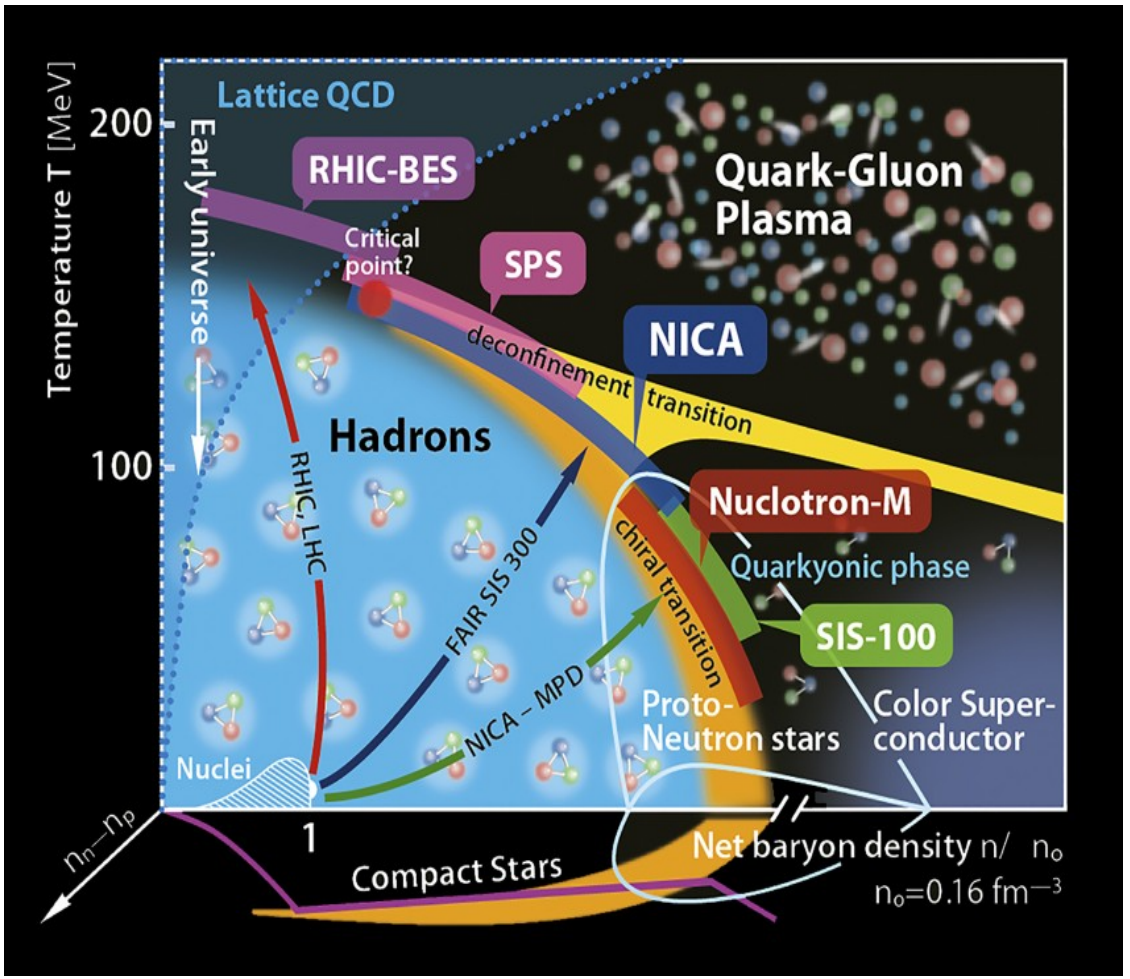
MOTIVATIONS



MOTIVATIONS

- STUDY THE PROPERTIES OF THE STRONGLY INTERACTING MATTER AT EXTREME TEMPERATURES AND DENSITIES

  RHIC (BNL) AND LHC (CERN) FACILITIES



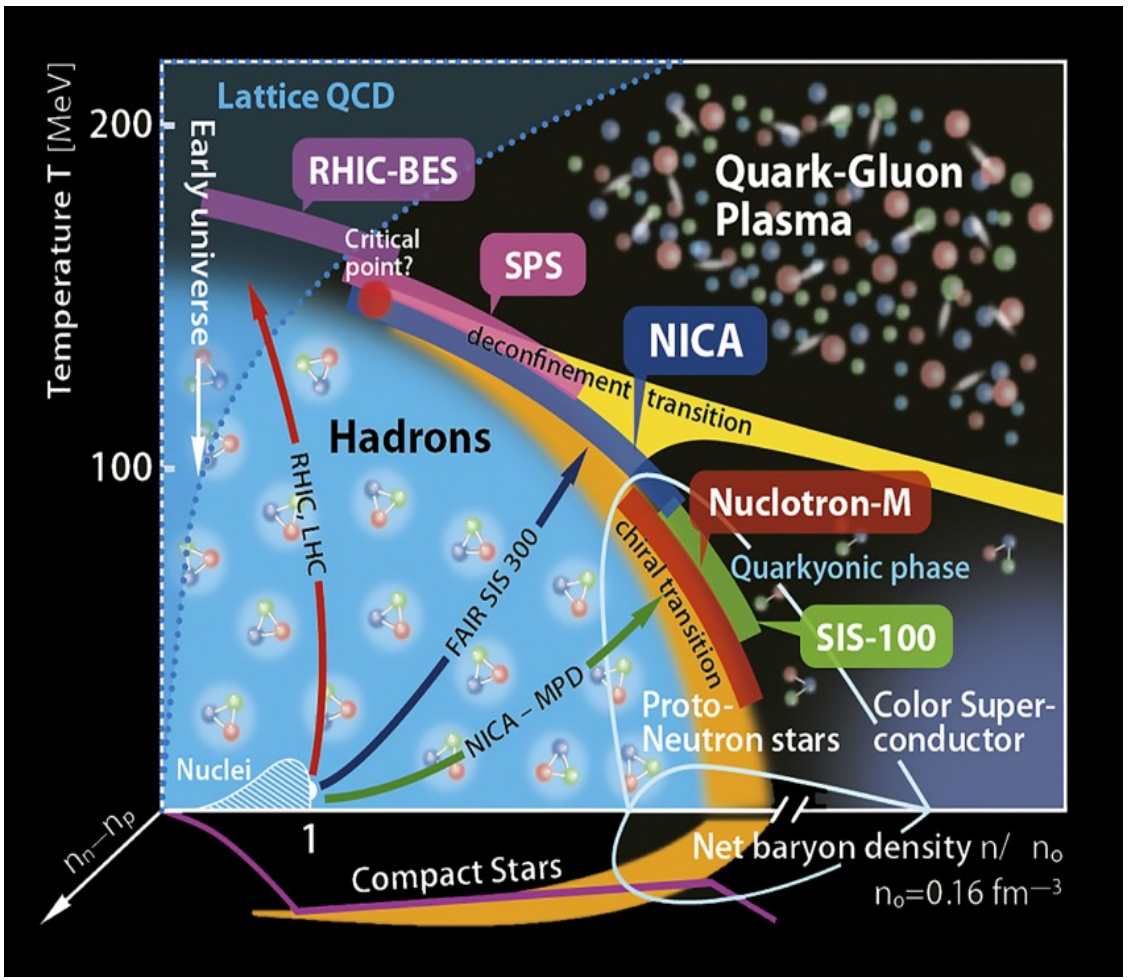
MOTIVATIONS

- STUDY THE PROPERTIES OF THE STRONGLY INTERACTING MATTER AT EXTREME TEMPERATURES AND DENSITIES

  RHIC (BNL) AND LHC (CERN) FACILITIES

- EXPLORE THE PHASE DIAGRAM OF QCD AND FIND SIGNS OF THE EXISTENCE AND LOCATION OF A POSSIBLE CRITICAL END POINT:

  NA49 AND NA61-SHINE EXPERIMENTS AT CERN-SPS, STAR AND PHENIX EXPERIMENTS AT RHIC, FAIR AND NICA



RHICs SEEN AS A MULTISTAGE DYNAMICS SYSTEM

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- INITIAL STAGE OR PRE-EQUILIBRIUM STAGE (MODULE I)

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- FINAL STAGE AND OBSERVABLES (MODULE III)

RHICs SEEN AS A MULTISTAGE DYNAMICS SYSTEM

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  1) COLOR GLASS CONDENSATE (Ann.Rev.Nucl.Part.Sci.60 (2010) 463)

  2) GLISSANDO (Comput.Phys.Commun.180 (2009) 69)

  3) ESRM (Nucl. Phys. A 712 (2002) 167) **V. Magas**

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- **FINAL STAGE AND OBSERVABLES (MODULE III)**

  Freeze OUT or Particlezation+Hadron cascade

  1) UrQMD (Prog.Part.Nucl.Phys.41:255-369,1998; arXiv:nucl-th/9803035v2)

  2) SMASH (Phys. Rev. C 94, 054905 (2016)) **Larissa Bravina; Evgeny Zabrodin; Iurii Karpenko**

INITIAL STAGE

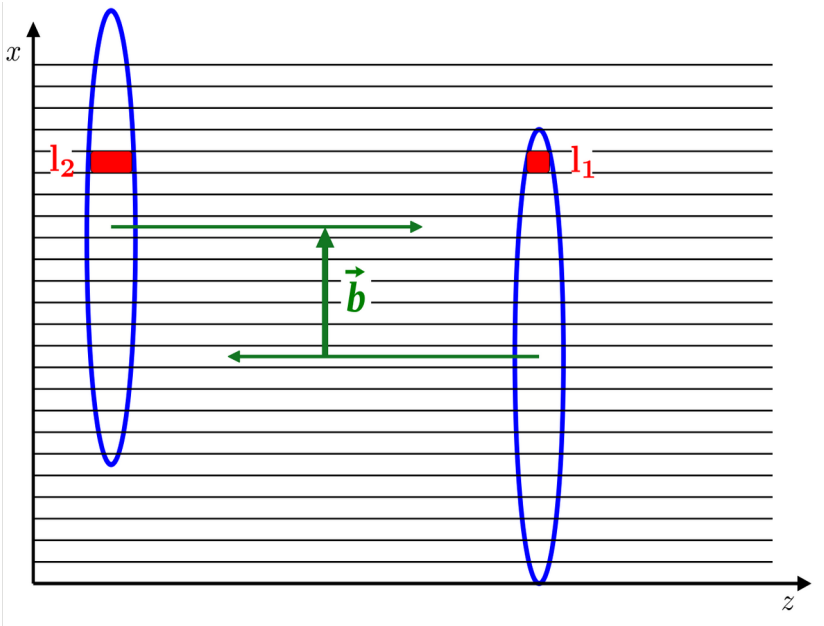
GENERALIZED EFFECTIVE STRING ROPE MODEL
(Phys. Rev. C 107, 034915)

(EFFECTIVE STRING ROPE MODEL (Nucl. Phys. A 712 (2002) 167-204)

+

GLAUBER MONTE CARLO APPROACH (Annual Review of Nuclear and Particle Science Vol. 71:315-344))[13]

ESRM REVIEW (Nucl. Phys. A 712 (2002) 167-204)



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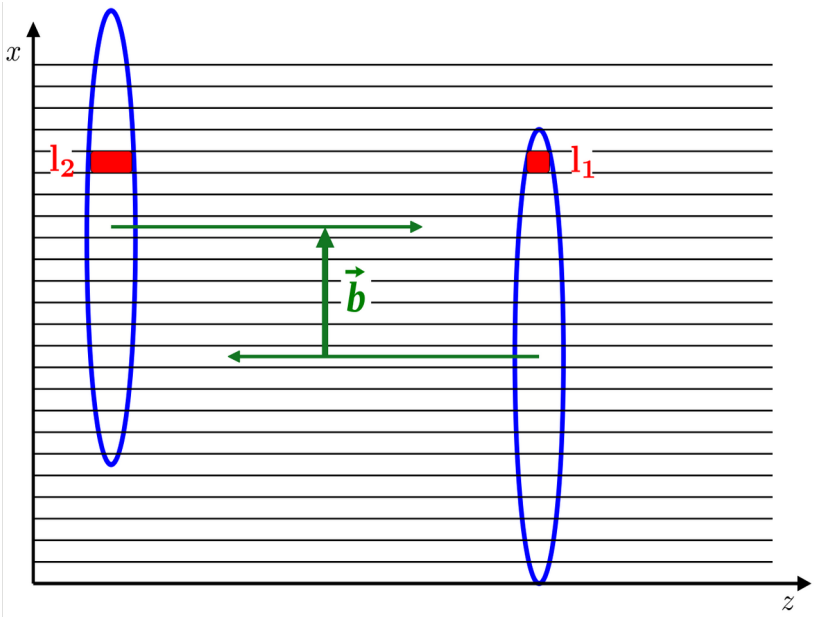

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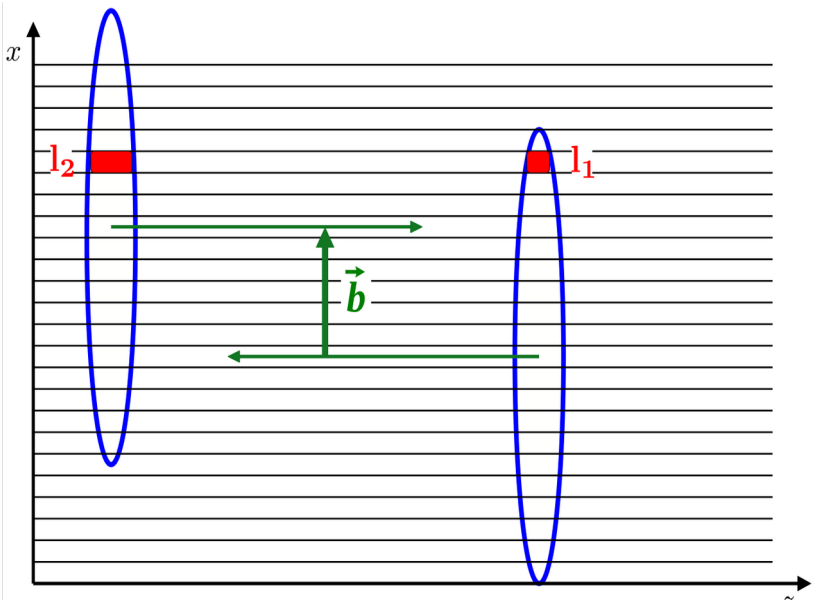
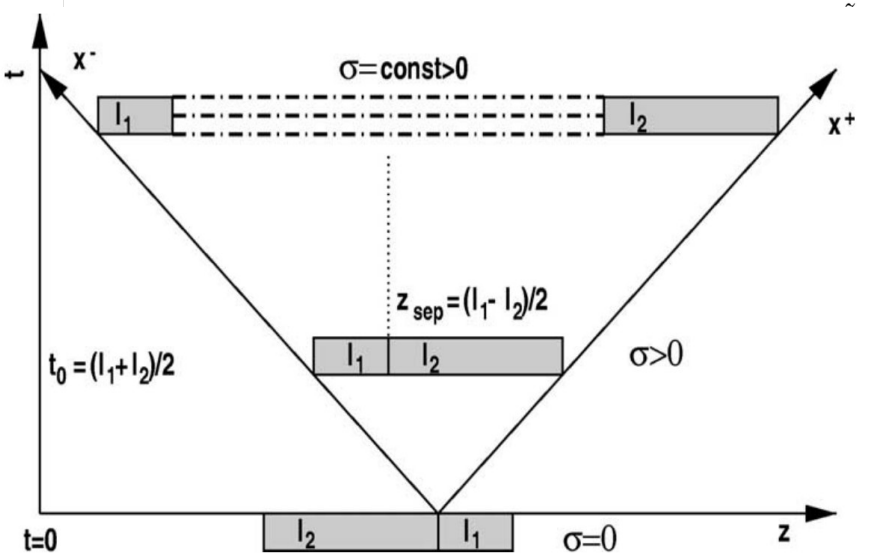
1) STREAK+STREAK COLLISIONS
2) COMPLETE TRANSPARENCY





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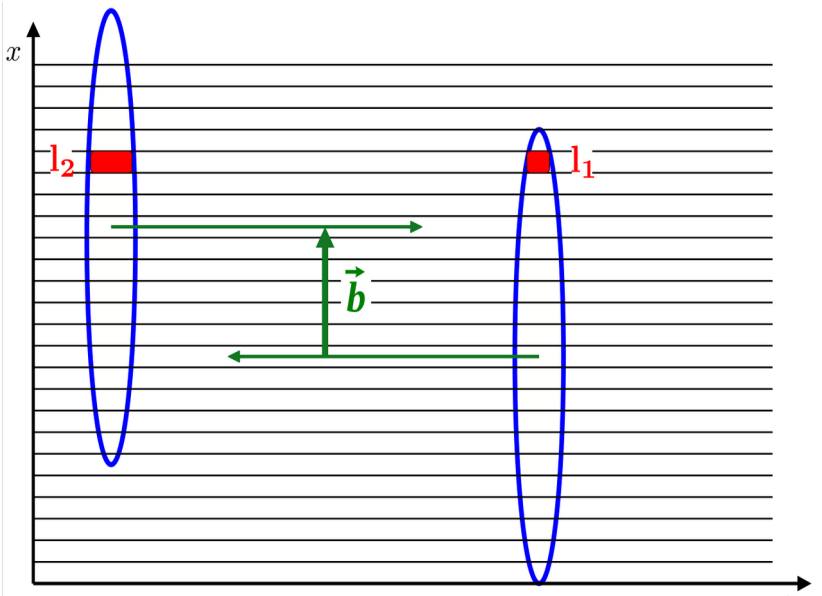
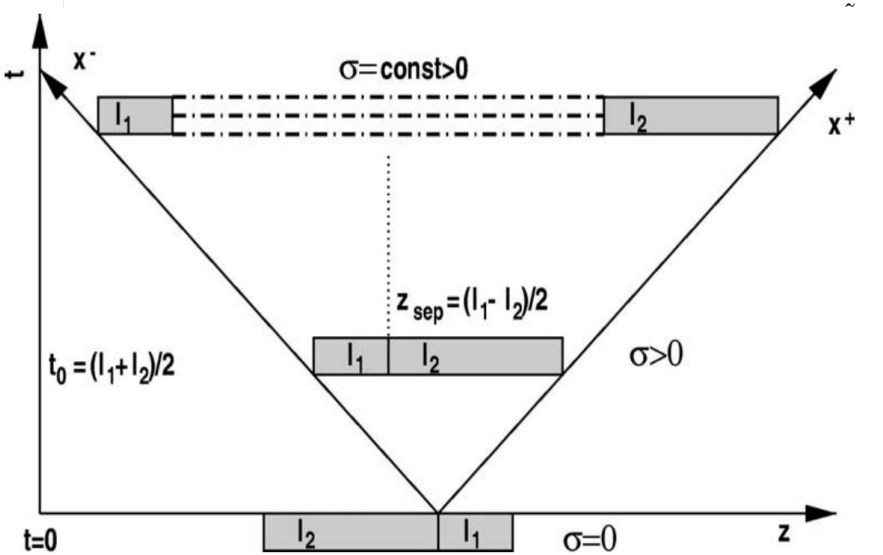
3) ONE DIMENSIONAL, UNIFORM CHROMO-ELECTRIC FIELD OF CONSTANT CROSS SECTION





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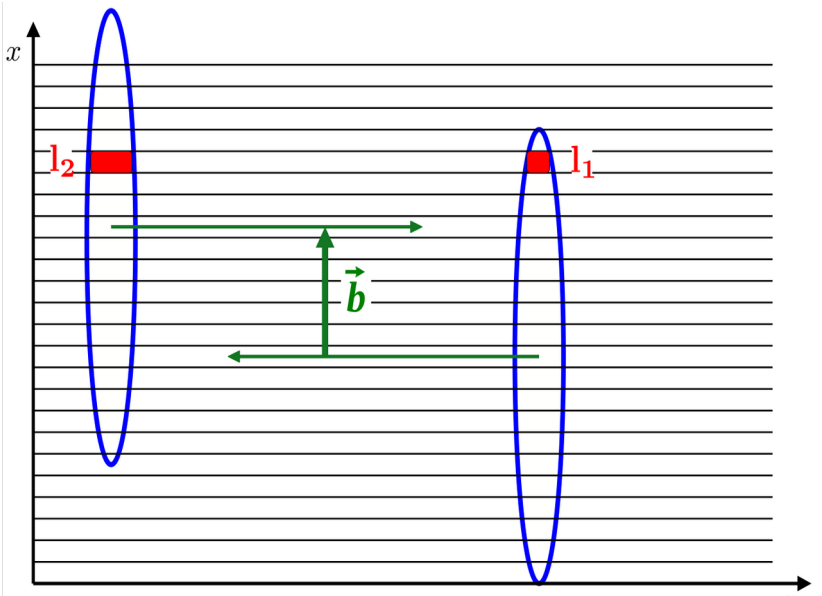
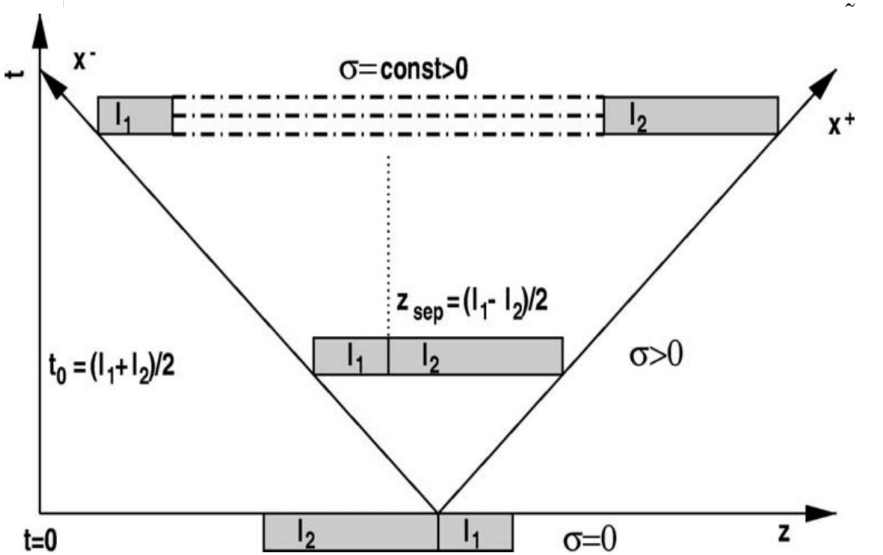
4) BARYON RECOIL ARISES FROM THE ACCELERATION OF PARTONS IN AN EFFECTIVE FIELD





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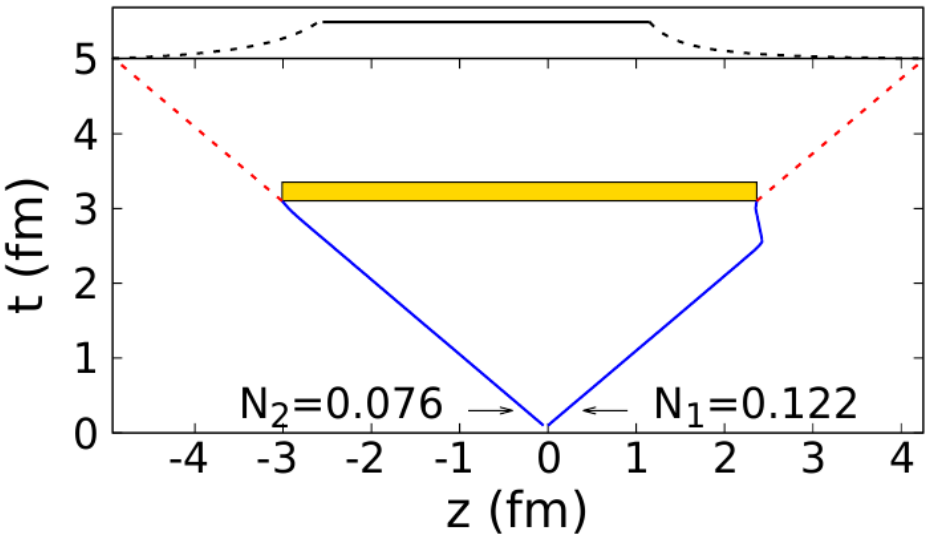

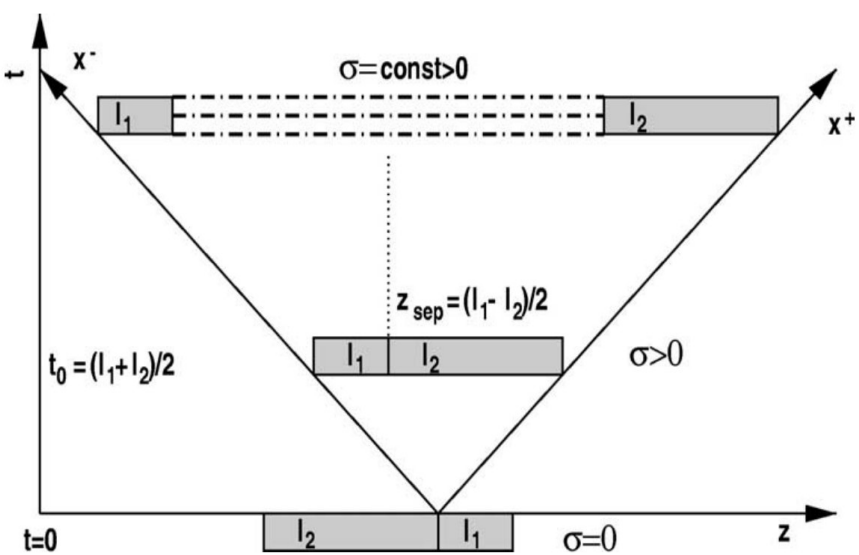

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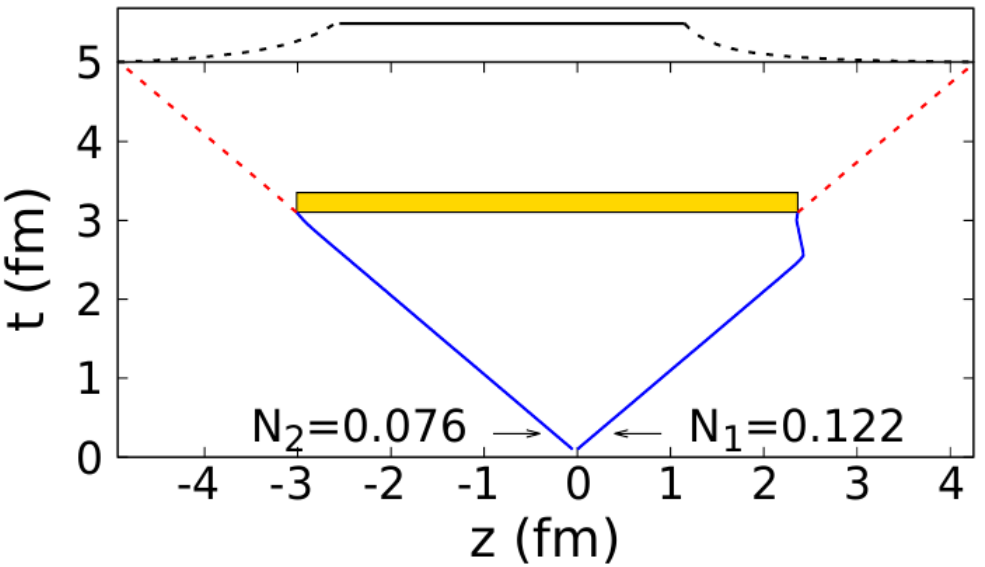
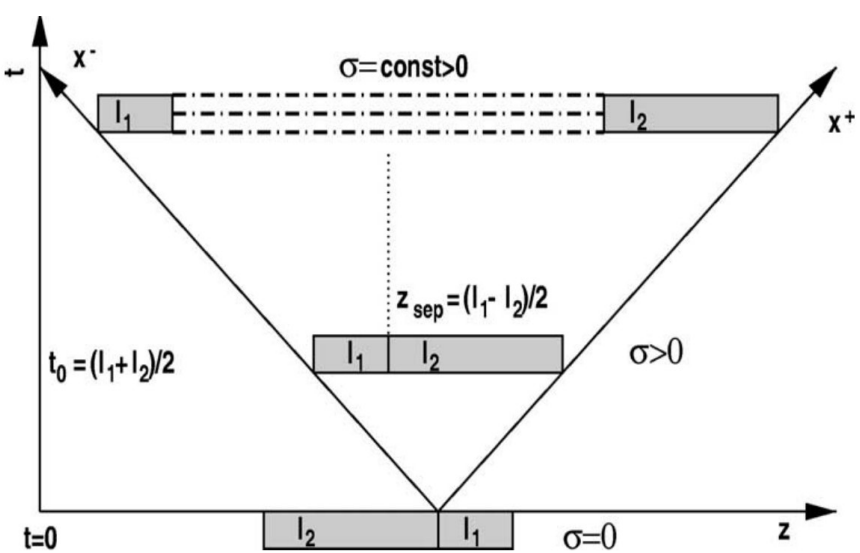
6) EXPANSION OF FINAL STREAK





GENERATING GEOMETRICAL FLUCTUATIONS

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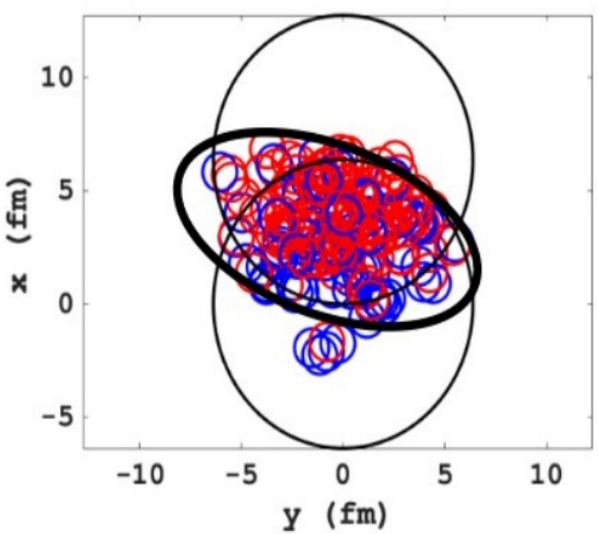
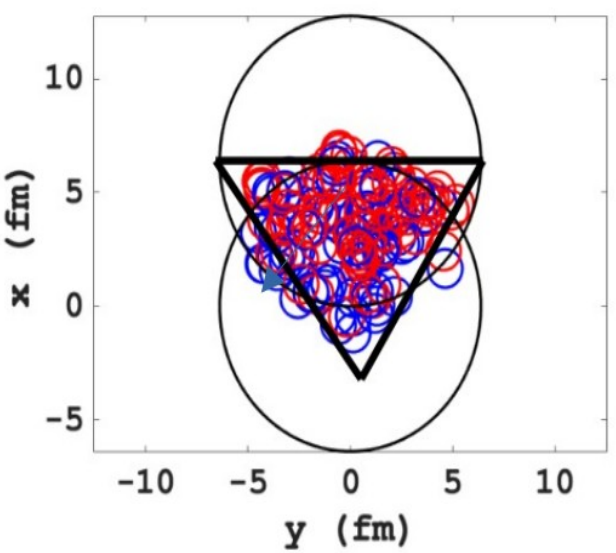
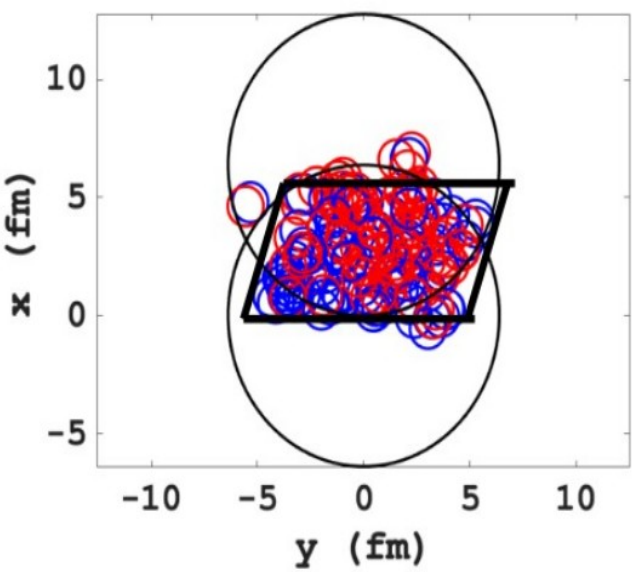
$$\rho_{WS}(x,y,z) = \frac{\rho_0}{1 + e^{\frac{\sqrt{(x-x_0)^2+(y-y_0)^2+(z-z_0)^2}-r}{a}}}$$



Elliptic geometry



Triangular geometry



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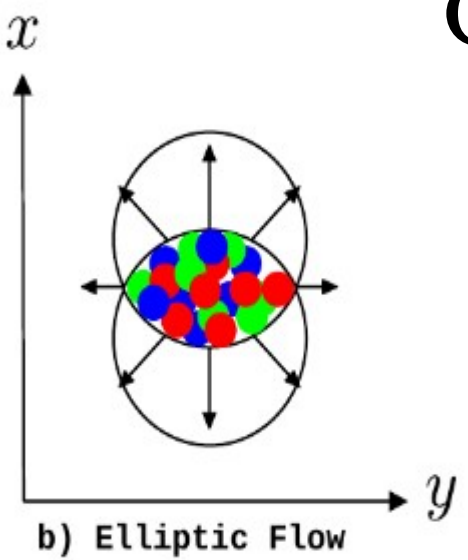

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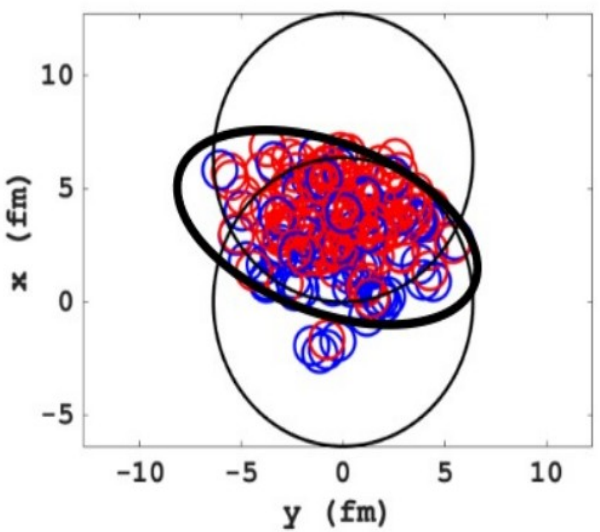

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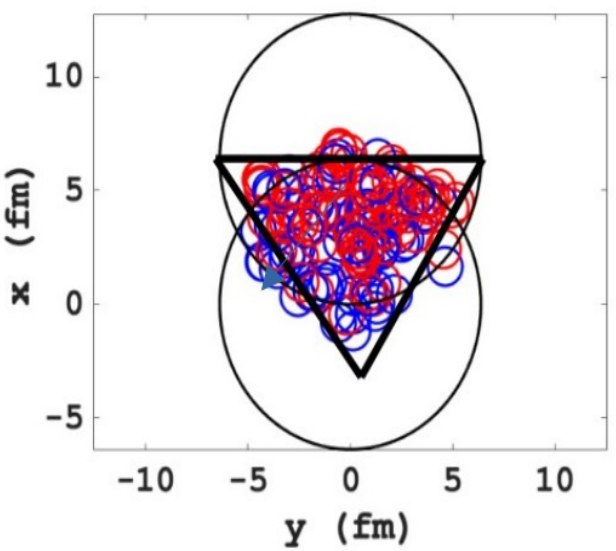

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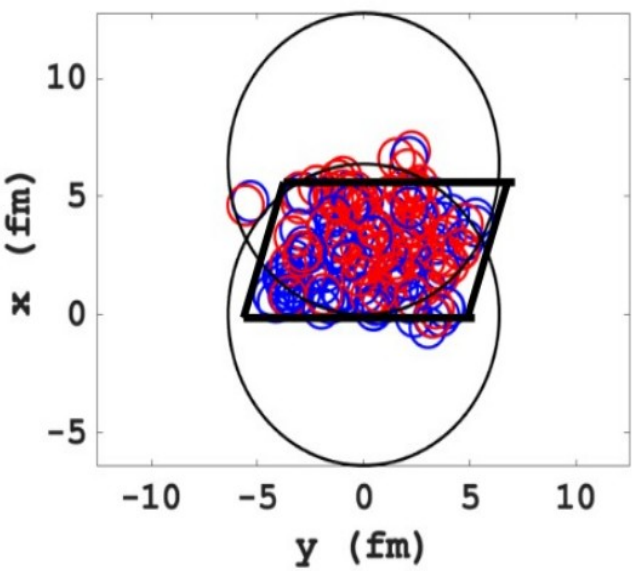

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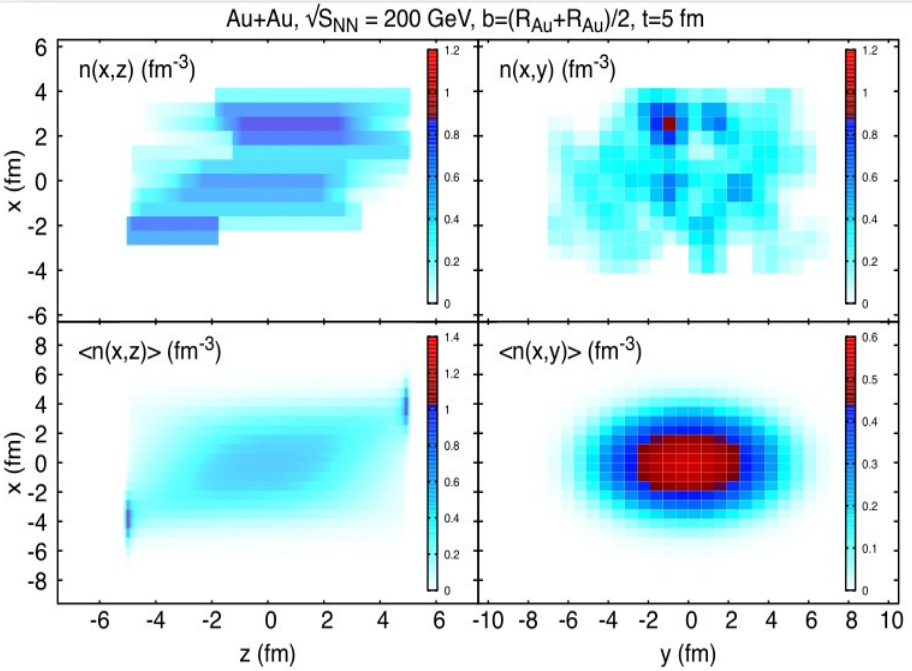

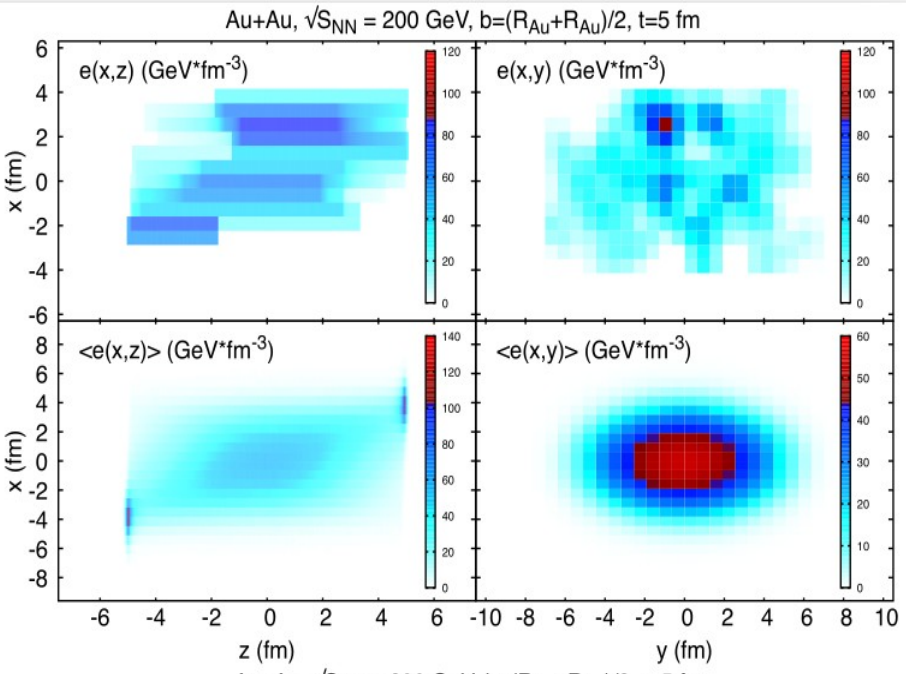

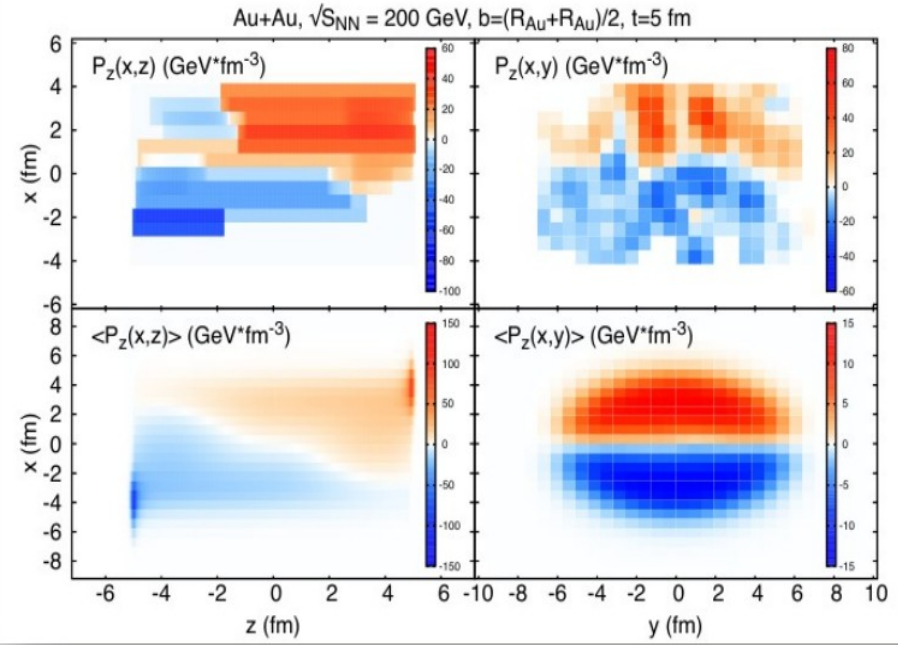

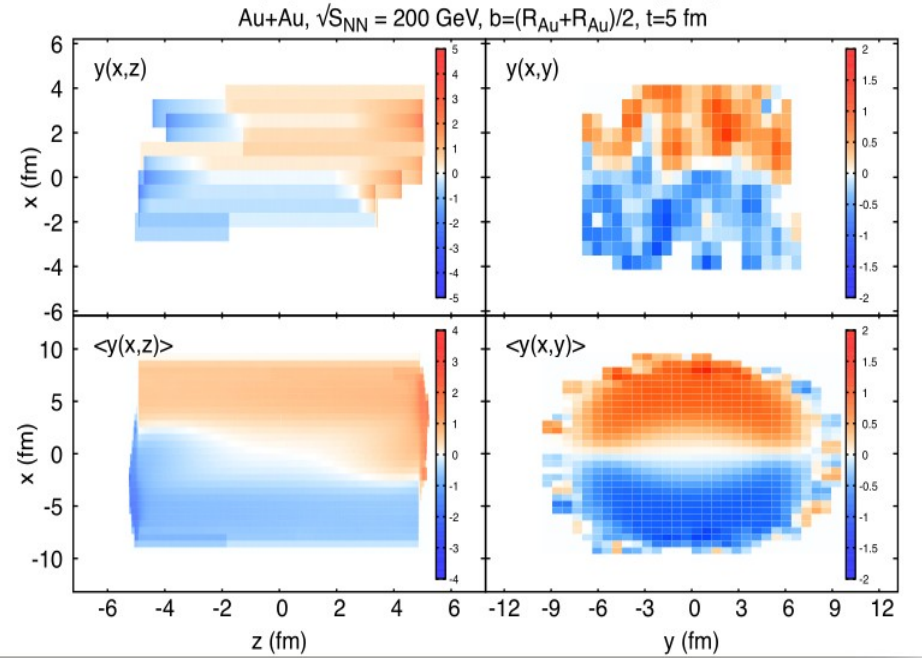

PRC 107 (2023) 034915

INTERMEDIATE STAGE

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3D RELATIVISTIC IDEAL HYDRODYNAMICS CODE

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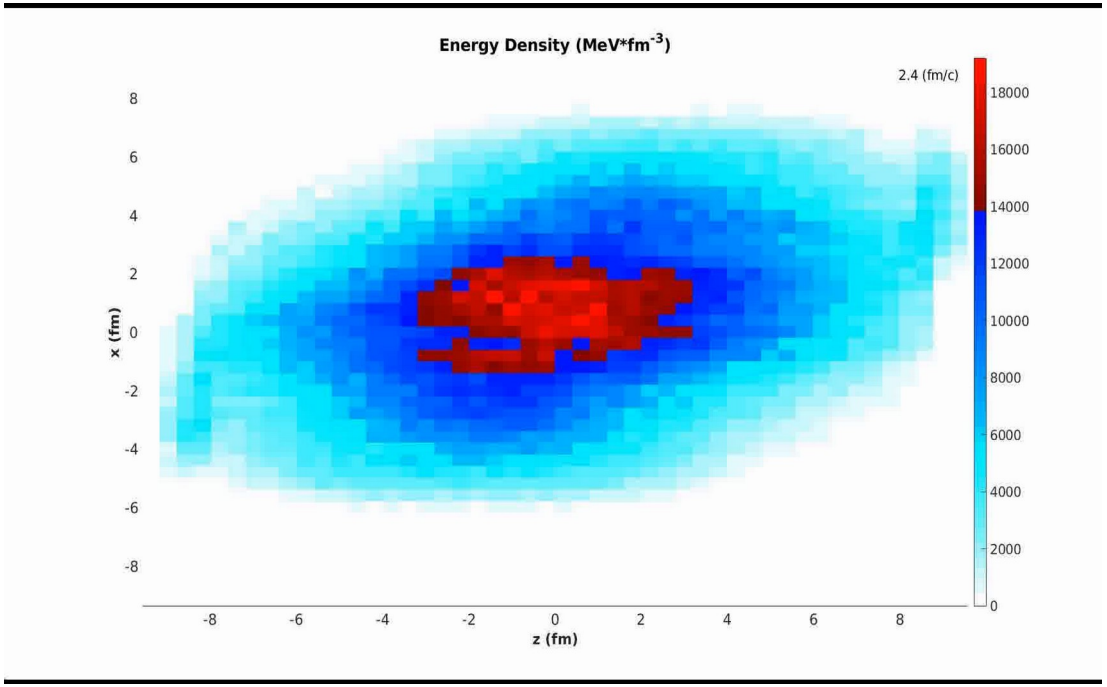
SYMMETRIC INITIAL STAGE $\rightarrow$ FLUCTUATING INITIAL STAGE

INTERMEDIATE STAGE

3D RELATIVISTIC IDEAL HYDRODYNAMICS CODE

SYMMETRIC INITIAL STAGE → FLUCTUATING INITIAL STAGE



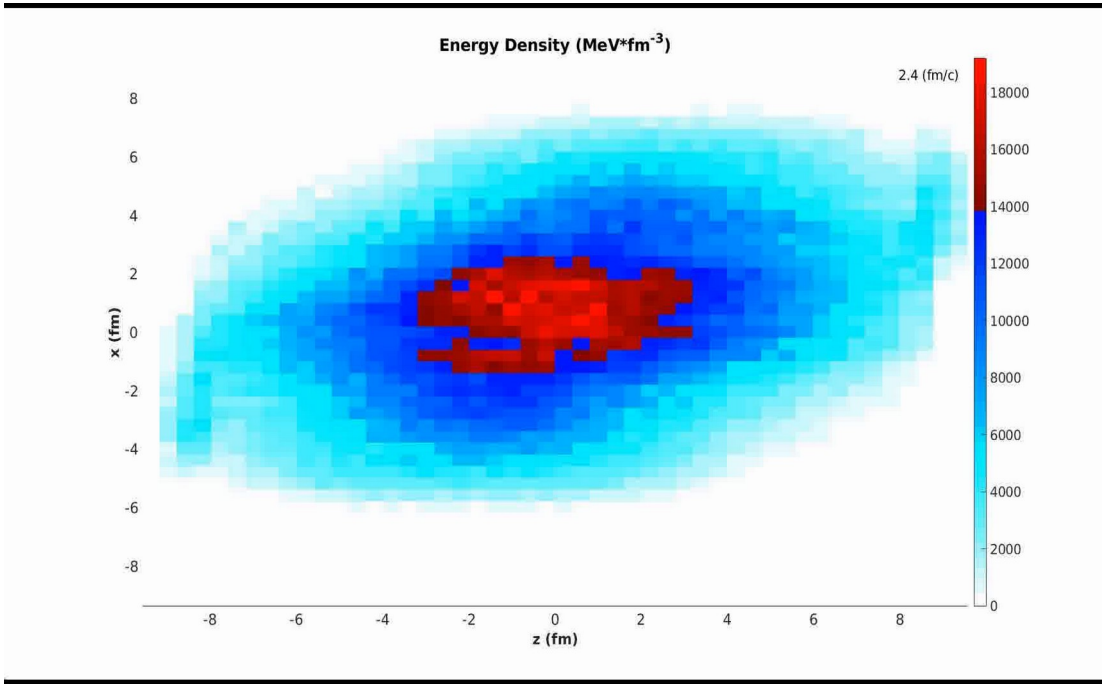
Au+Au @ RHIC $b = 0.5 * (R_{Au} + R_{Au})$ 100 EVENTS

INTERMEDIATE STAGE

3D RELATIVISTIC IDEAL HYDRODYNAMICS CODE

SYMMETRIC INITIAL STAGE → FLUCTUATING INITIAL STAGE

t=const FO HYPERSURFACE



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- COOPER-FRYE PROCEDURE FOR CALCULATING PARTICLE DISTRIBUTIONS

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  CONSTRUCT A 3D-HYPERSURFACE AT CONSTANT ENERGY OR TEMPERATURE IN 4D-SPACE

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  CONSTRUCT A 3D-HYPERSURFACE AT CONSTANT ENERGY OR TEMPERATURE IN 4D-SPACE → CORNELIUS ALGORITHM (P. Huovinen and H. Petersen, arXiv:1206.3371)

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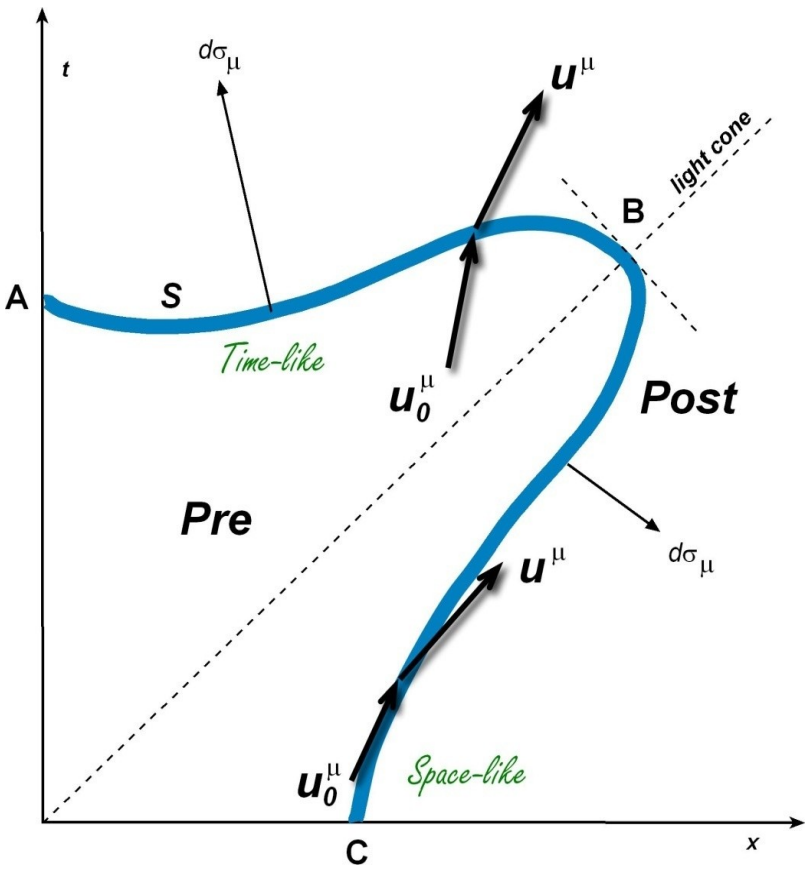

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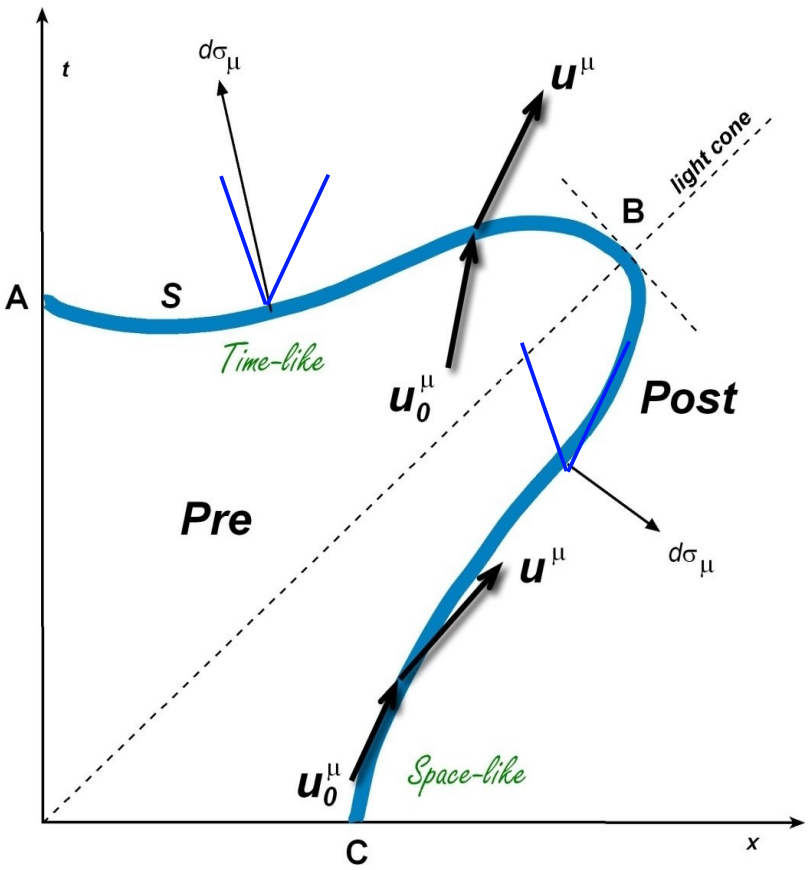
  HYPERSURFACE WITH TIME-LIKE AND SPACE-LIKE SURFACE ELEMENTS !!!



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  POSITIVE FLOW: $d\sigma_\mu u^\mu > 0$

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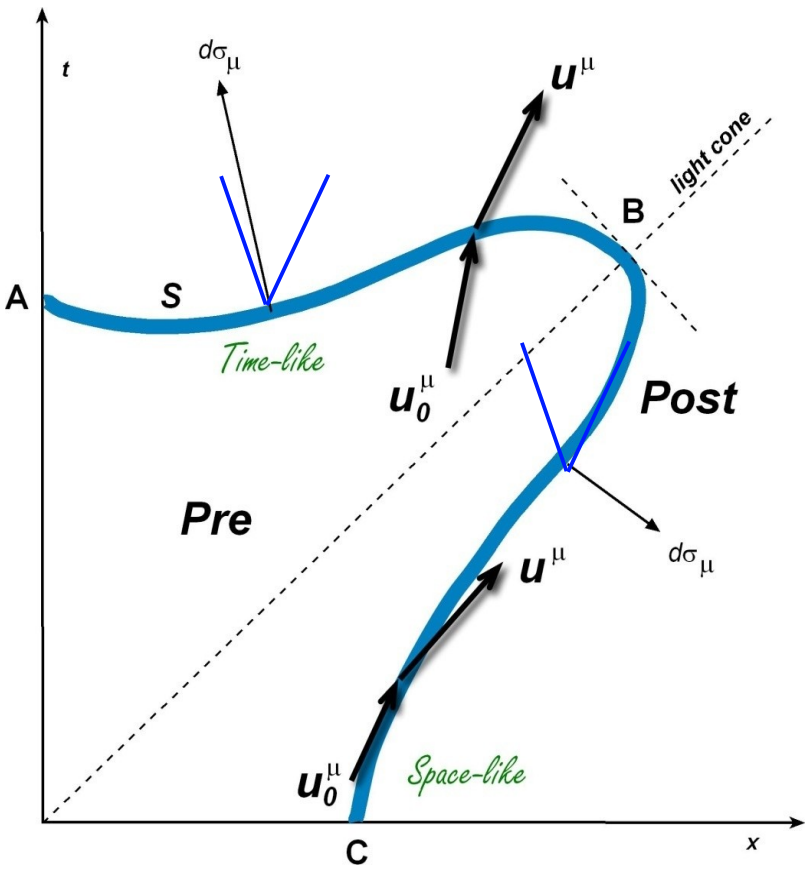

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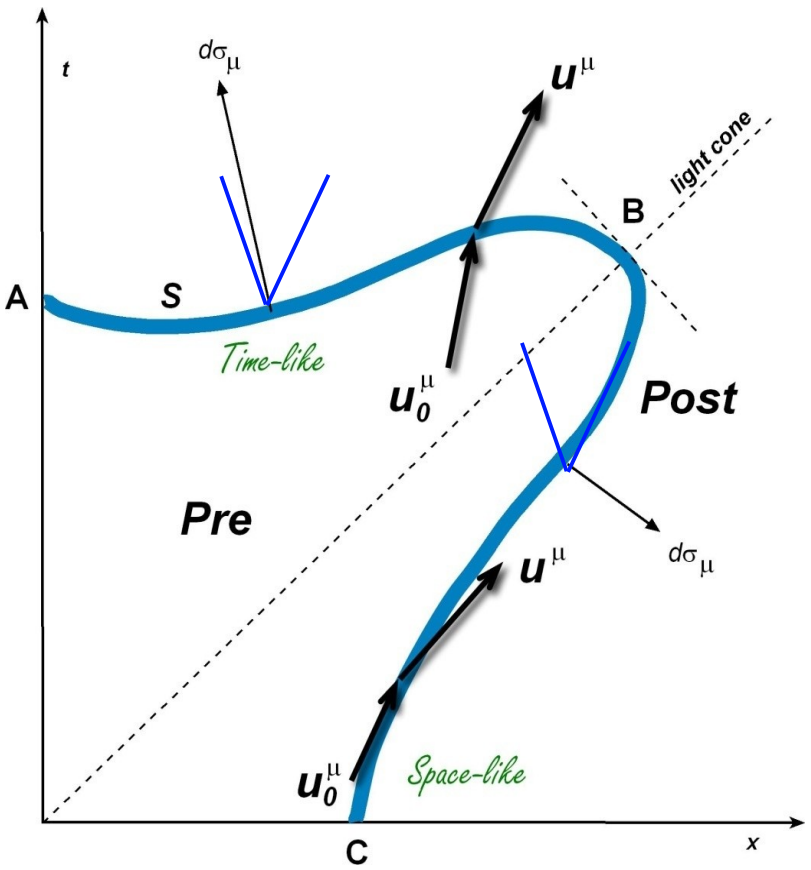

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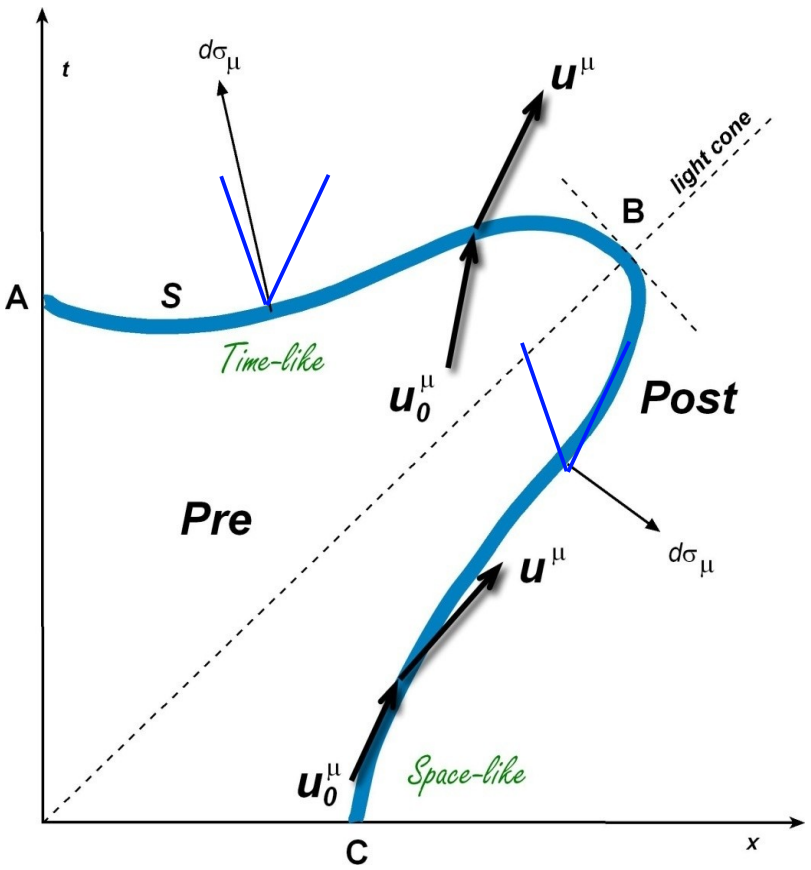
$$N = \int_\sigma \mathrm{d}\sigma_\mu j^\mu(x) = \int_\sigma \mathrm{d}\sigma_\mu \int \frac{\mathrm{d}^3p}{E}\, p^\mu f(x,p)$$



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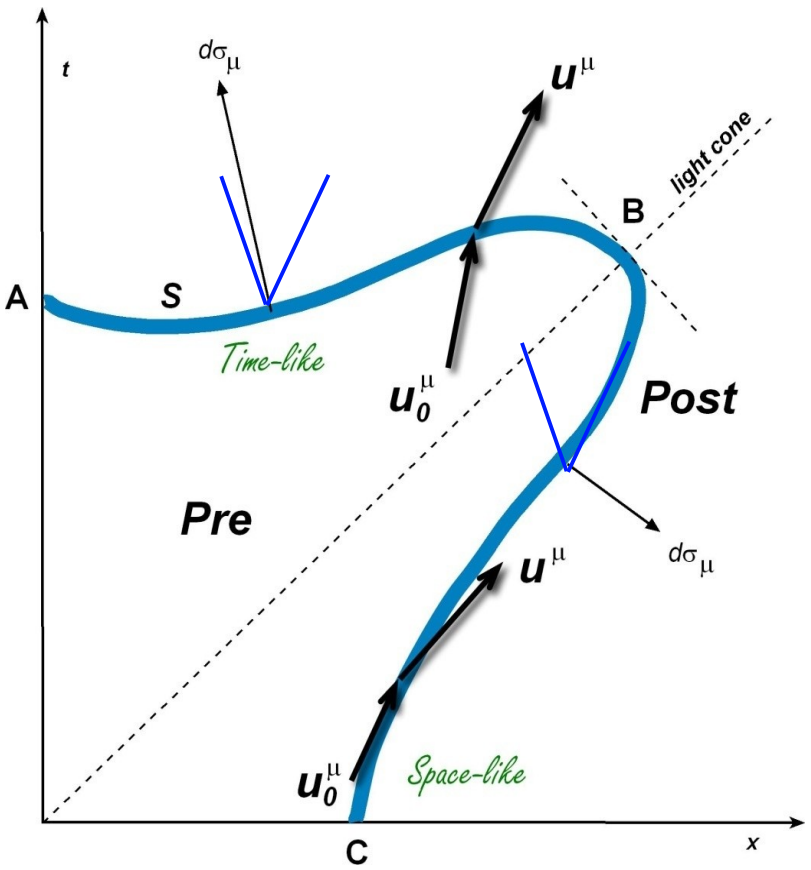
$$T^{\mu\nu}_{pre} = T^{\mu\nu}_{pos} \qquad T^{hydro} = T^{HG}$$
$$N^{\mu}_{pre} = N^{\mu}_{pos} \qquad \mu^{hydro} = \mu^{HG}$$
$$\vec{v}^{hydro} = \vec{v}^{HG}$$



Ideal gas of QUARs & Gluons (Bag model) → EFFECTIVE CHIRAL HADRON-QUARK EoS (J Steinheimer et al 2011 J. Phys. G: Nucl. Part. Phys. 38 035001, http://arxiv.org/abs/1009.5239v2)

HADRONIC AFTERBURNER EVOLUTION

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  3) AT HIGH ENERGIES AND CHARGE DENSITIES $2 \rightarrow n$ SCATTERING PROCESS ARE TAKEN INTO ACCOUNT BY STRING FORMATION AND FRAGMENTATION

OUTLOOK

- IMPLEMENT CORNELIUS ALGORITHM and Monte-Carlo particlization
- RUN SMASH
- High statistics is need! $\rightarrow$ Large output files
- CALCULATE OBSERVABLES: FLOWS, POLARIZATION OF Λ PARTICLES, PARTICLE SPECTRA...
- CONTRAST RESULTS WITH EXPERIMENTAL DATA

THANKS!!!