STOPPED NUCLEONS IN CONFIGURATION SPACE

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IN STANDARD MODELS OF PARTICLE PRODUCTION AT HIGH ENERGY, THE PROJECTILE SLOWS DOWN AFTER COLLISION BY EMITTING PARTICLES AND THUS LOOSING ENERGY.

EXAMPLE:
IN THE LUND MODEL THE PROJECTILE EXCHANGES COLOUR WITH THE TARGET AND CREATES A STRING WHICH SLOWS IT DOWN AT THE RATE GIVEN BY STRING TENSION $\sigma \approx 1$GeV/fm. STRING BREAKS (MANY TIMES) AND PRODUCES PARTICLES.

SIMPLE OBSERVATION

THIS PICTURE IMPLIES THAT A PROJECTILE WHICH SLOWED DOWN TO C.M. RAPIDITY CLOSE TO ZERO, IS NOT SITTING $z \approx 0$ BUT RATHER AT $z \approx E/\sigma$; $E = \frac{1}{2}\sqrt{s}$ IS THE INITIAL C.M. ENERGY OF THE NUCLEON.

THUS, IN A pp COLLISION 10+10 GeV, NUCLEONS IN THE CENTRAL RAPIDITY REGION ARE LOCATED ABOUT 10 fm APART FROM THE CENTRE!

QUALITATIVELY, SIMILAR ARGUMENTS ARE VALID ALSO IN THE WOUNDED NUCLEON MODEL AND IN THE WOUNDED QUARK (OR DIQUARK) MODELS (ONLY THE VALUE OF σ CHANGES).

CONSEQUENCES

THERE ARE TWO IMPORTANT QUALITATIVE CONSEQUENCES IF THIS OBSERVATION:

(i) LARGE NET BARYON DENSITY DIFFICULT TO ACHIEVE.
Since the nucleons which stopped at $y \approx 0$ are located far from the point $z = 0$, they do not overlap in configuration space and thus do not produce the expected high net baryon density.

(ii) STOPPING NUCLEONS DO NOT EQUILIBRATE
As the quark-gluon plasma is expected to be produced at the centre (both in rapidity and in the position along the z-axis) the stopped nucleons do not interact effectively with the plasma (because they are sitting at the place where there is no plasma).

SPACE-TIME PICTURE

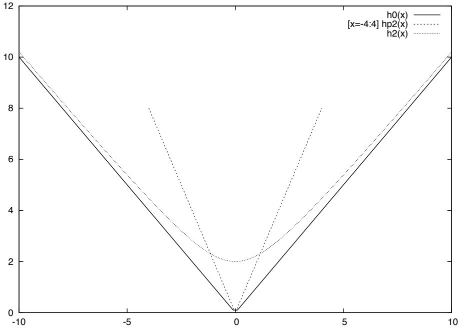

Figure: Space-time picture of particle production at very high energy

LOWERING THE ENERGY

THE PRESENTED QUALITATIVE ARGUMENT REFERS TO HIGH-ENERGIES.

Is it relevant for the Beam Energy Scan program at RHIC?

CONSIDER A NUCLEON WHICH STOPPED AT C.M. RAPIDITY $y = y_p$. **THEN ITS ENERGY IS** $E_p = M_\perp \cosh y_p$, **AND THUS ITS POSITION** z_p **IS**

$$z_p = z_c + (E - E_p)/\sigma = z_c + (E - M_\perp \cosh y_p)/\sigma \tag{1}$$

WHERE z_c **IS THE COLLISION POINT, AND** $E = \frac{1}{2}\sqrt{s}$.

TO OBTAIN DISTRIBUTION OF z_p **ONE HAS TO AVERAGE OVER COLLISION POINTS AND RAPIDITIES OF THE OBSERVED NUCLEONS.**
THE RESULTS ARE SHOWN IN THE NEXT TWO SLIDES.

THE DISTRIBUTION OF NUCLEONS IN z

$\sigma = 1$ GeV/fm (WOUNDED NUCLEON MODEL)
$R_A = 6.5$ fm

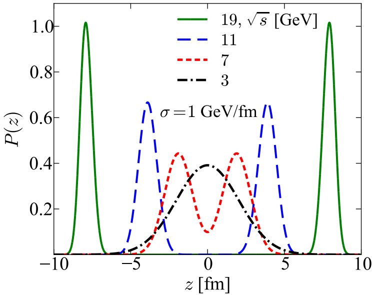

Figure: The distribution of the position along the z axis of the nucleons with $|y| \leq 1$. averaged over the collision points. $\sigma = 1$ GeV/fm.

THE DISTRIBUTION OF NUCLEONS IN z

$\sigma = 3$ GeV/fm (WOUNDED QUARK MODEL)
$R_A = 6.5$ fm

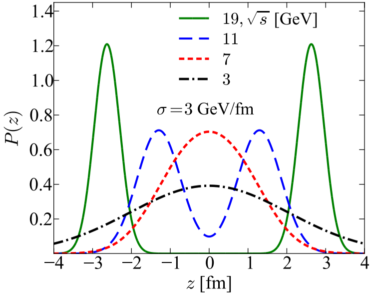

Figure: The distribution of the position along the z axis of the nucleons with $|y| \leq 1$. $\sigma = 3$ GeV/fm.

SUMMARY

1. AT HIGH ENERGIES, THE NUCLEONS LOCATED IN THE CENTRAL RAPIDITY REGION ARE WIDELY SEPARATED IN CONFIGURATION SPACE AND THUS ARE UNLIKELY TO PRODUCE A HIGH NET-BARYON DENSITY.
2. WHEN EXTRAPOLATED TO LOW ENERGIES (AS THOSE RELEVANT FOR THE BES PROGRAM), THIS ARGUMENT INDICATES THAT THE PROBLEM MAY BE PRESENT ALREADY ABOVE $\sqrt{s} = 8$ GeV.

WARNINGS

1. The main point of this semi-quantitative study is to call attention to the importance of the configuration space distribution of the final state particles in discussions of the statistical properties of the system produced in heavy ion collisions.
2. Although extrapolation of models which were verified at high energies to the energies relevant for the BES program may be questioned (as other mechanisms of energy loss could be effective there), we feel that this investigation provides good arguments for further studies of the configuration space distributions of the produced particles.
3. Note: This study does not address the important question of *how many nucleons actually stop at* $y \approx 0$**, since it is** *not relevant* **for discussion of the distribution of nucleons in configuration space. Answering this question would require more information about details of the process of energy loss.**