Notes on possible physical experiments at SPD&BM@N

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Nuclotron-NICA energy range:

- Rare nontrivial fluctuations in ordinary nuclear matter (fluctons)
- Phase transitions at high $\mu$ and low (or moderate) $T$
- The properties of new states of matter (cold and dense baryonic matter)
- Exotic structures (diquarks, …)
- Hadronization in nuclear matter
in contrast to hot nuclear matter created in multiply high energy collisions cold and dense baryonic matter probably cannot be prepared without fluctuation →
- not needed very high initial energy
- not needed heavy nuclear (A₁,A₂:1÷50)

BM@N: 2.5<√S_{NN}<4GeV; SPD:4<√S_{NN}<13GeV
Cold&dense matter study: 2.5<√S_{NN}<6GeV
Fluctons

Where we stand:

- Fluctons exist (it is not trivial high momentum component)

What would be possible next steps:

- Correlations with cumulative trigger - flucton properties
- From few nucleons fluctons to cold and dense matter
Flucton-Flucton interactions

$\pi, \gamma, \gamma (\pi^0), \ldots$ high $p_t$

$A_1 \rightarrow A_2$

Fluctons

Dense baryon system

$\sqrt{S_{FF}}$ up to 50GeV

$B_1, \ldots, B_N$
<table>
<thead>
<tr>
<th>Bosonic system</th>
<th>Fermionic system</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma, \pi, K^+, \rho$</td>
<td>$\rho, n, \Lambda, \Sigma^{+0}$, exotic</td>
</tr>
</tbody>
</table>
Motivation:

1) $\gamma, \pi$ trigger – max. baryonic density

- Lightest bosons provide access to maximum possible density – minimum energy for bosonic system and maximum number of baryons in fermionic system (FLINT: $N_1+N_2 > 5$)
### Motivation:

2) Kinematical cooling

<table>
<thead>
<tr>
<th>CC, UrQMD, 10^5 ev.</th>
<th>2AGeV</th>
<th>3AGeV</th>
<th>4AGeV</th>
<th>10AGeV</th>
<th>30AGeV</th>
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<tr>
<td>K^-</td>
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<td>918</td>
<td>11516</td>
<td>51639</td>
</tr>
</tbody>
</table>

[Image of graph showing invariant mass distribution]
Motivation:

3) K trigger - strange degrees of freedom

• For cold matter “strangeness” is “small parameter” → as an example: slight excess of neutrons in dense and cold matter could be transformed into large value of $\Sigma^-/\Sigma^+$ ratio:

\[
n/p > 1 : 2n^+ \Sigma^+ \rightarrow 2p^+ \Sigma^- ; \frac{\Sigma^-}{\Sigma^+} \gg 1
\]
Motivation:

4) Polarized dd interaction - spin degrees of freedom

• In the cold and dense nuclear matter all degrees of freedom are important, including spin and isospin one → the state of matter depends not only on temperature and density but also on spin and isospin

• One can expect an increasing of vector meson fraction in mesonic system and trend to spinless baryonic cold matter
"cold" → (δp → 0), "dense" → (δx → 0), but cold and dense matter must be in accordance with Pauli blocking → bosonisation of constituents could be a solution and diquark is probable candidate for important constituent.
Diquark-
nontrivial $\Sigma/\Lambda$ ratio,
an increasing probability of an exotic, ...

$E \geq 1\text{GeV (no FSI)}$

Model baryon=quark+diquark:
“diquark: $I=S=1$ or $0$."

И.Ю.Кобзарев, Б.В.Мартемьянов, М.Г.Щепкин
УФН 162, вып.4,1992,стр.1-41(in Russian)
(Quark-Diquark Systematics of Baryons)
...independent of detailed information about the interaction used to describe quark-quark scattering.

The result is most easily seen when looking at Eqs. (A.1) in [arxiv.org](https://arxiv.org/pdf/1705.03988.pdf). There you will see that the isospin=0 Lambda contains two different arrangements of diquark correlations. However, the simple [ud] configuration is forbidden in the isospin=1 Sigma^0, which only contains [us]d+[ds]u. To be explicit, here are the flavour wave function components:

Lambda ...
[ud]s, [us]d-[ds]u, {us}d-{ds}u

Sigma^0 ...
[us]d+[ds]u, {us}d+{ds}u

Dynamics determines the relative strength of each term within a given baryon. As you note below, depending on the assumed reaction mechanism, this difference in diquark content could affect the Lambda/Sigma production ratio in AA collisions.
Thanks for the attention!