Referee answers.

1. **Question.**

   The proposal, as a whole, is fragmentary and vague. The physics case is not elaborated in due detail. The main results obtained by the FASA team are listed, but a general picture of the phenomena studied and the physics context where this picture fits is missing.

   Answer.

   The aim of the Project is to study the properties of hot nuclei (with an excitation energy of more than 3 MeV per nucleon). Hot nucleus, expanding due to thermal pressure, falls into the region of phase instability (spinodal region). As a result of density fluctuations, a homogeneous nuclear system disintegrates into an ensemble consisting of fragments and nucleons. The process is interpreted as a "liquid-gas" phase transition occurring at a temperature 5-7 MeV.

   The reaction mechanism is composed of three steps. The first step is the energy deposition step, when energetic nucleons and pions are emitted and the nuclear remnant is excited. This step is considered using the intranuclear cascade model (INC). We use the Dubna version of the INC to get the distribution of the nuclear remnants in charge, mass, and excitation energy. The second step is expansion driven by the thermal pressure in the hot remnant, which is described in the spirit of the Expanding Emitting Source model (EES). This process results in reducing the excitation energy. The final stage we describe by using the Statistical Model of Multifragmentation (SMM). Within this model the probabilities of different decay channels of the excited remnant are proportional to their statistical weights. The volume of the system from which the emission of fragments occurs determines the Coulomb energy of the system.

Experiments on the relativistic beams of the Nuclotron accelerator using 4π-FASA device will provide information on the spinodal state of nuclear matter. The relevance of research is doubtless, because we are talking about the experimental study of nuclei with extreme excitation energy (comparable to the total binding energy of the nucleus). The Project will answer key questions about the time scale of fragment emission (there is a sequential emission of fragments or simultaneous breakup of the system), about degree of thermalization of the system before the breakup, and about radial flow.

2. **Question.**

   On the methodical side almost nothing is presented. Just a picture of the apparatus and one dE-E plot are displayed without clear explanations. Work characteristics of the detectors and data about the performance of the set-up are missing. Even the measurement principles – what is measured, how it is measured and with what precision – are not given.

   Answer.

   We have increased the description of the methodical side set-up. What is measured, how it is measured and precisions are given in objectives of the Project.

3. **Question.**

   In addition, despite the scarce information given in the proposal, I think that most of the planned measurements could be performed with the BM@N set-up.

   Answer.

   The thresholds of the BM@N detector system are so large that this set-up can register particles with energies 1000 times more energetic than it does FASA detector system. Thus, standard geometry on BM@N installation does not allow perform experiments that are performed on the FASA set-up.

The BM@N team may try to perform these experiments in inverse kinematic. In this case, BM@N needs a gold beam with intensity 10^9 particles per spill, hydrogen and deuterium target, and new high angular resolution detector placed near beam pipe to provide the precision of the IMF relative angles measurements of about 10^{-3}. I think that the later conditions will not be able to be fulfilled on the BM@N device in the near future.

4. **Question.**

   The requested cash resource not big. Besides travel money, the rest is aimed at replacement of the CAMAC based FEE and DAQ by a VME based ones. There is no justification why this is needed. Event rates, reading times, dead time introduced by DAQ and its throughput, etc. – nothing is given.

   Answer.

   FASA device uses ADC and QDC made in standard VME, which have dual port memory that can store up to 32 events. Recording takes place in the "event-by-event" via VME standard at event rates 15 events/s. Reading time of one event is 35 μs. Dead time introduced by DAQ is 41 μs. Throughput - 10 MB/s. In this Project, we plan move to a VME standard our trigger system, which is now implemented via CAMAC blocks of 15 years old. VME has a higher degree of integration. Constructions made in the VME standard (compare to the CAMAC standard) has compact form factor and channel density, more reliable, the price of one channel (and therefore the price of whole construction) is less.

5. **Question.**

   The accelerator resources asked for are also modest and again they are asked without any detail concerning the type of the light ions, beam energy and intensity, etc.

   Answer.

   The Project requests accelerator resources for 2020 and 2021 years. It is planned to study a radial flow with beam energy from

1 GeV/nucl. to 4-4.5 GeV/nucl. for alpha and carbon beams. It is planned to measure the source velocity and lifetime of the system on the beams of these energies. To obtain these experimental values with percentage accuracy we will need to collect 10^6 events for each measurement. 50 hours of acceleration time with beam intensity of 10^9 particles per spill give us one million events. Thus, we will need following accelerator resources:

2020 – Experiments using alpha beam:

50 hours: 4 GeV energy, intensity more than 10^9 particles per Spill;

50 hours: 10 GeV energy, intensity more than 10^9 particles per Spill;

50 hours: 16 GeV energy, intensity more than 10^9 particles per Spill;

2021 – Experiments using carbon beam:

50 hours: 10 GeV energy, intensity more than 10^9 particles per Spill;

50 hours: 30 GeV energy, intensity more than 10^9 particles per Spill;

50 hours: 48 GeV energy, intensity more than 10^9 particles per spill;

6. **Question.**

The manpower, in terms of percentage of time expected to be devoted to the Project by the people involved, is not given.

Answer.

The manpower, in terms of percentage of time expected to be devoted to the project by the people involved:

S.P. Avdeyev	100%
H.Yu. Abramyan	30%
A.S. Botvina	30%
W. Karcz	100%

V.V. Kirakosyan	50%
L.V. Karnushina	70%
E.M. Kozulin	50%
A.G. Litvinenko	30%
E. Norbeck	30%
V.F. Peresedov	30%
P.A. Rukoyatkin	30%
V.I. Stegaylov	50%
O.V. Strekalovsky	30%