Draft of the Programme of the Veksler and Baldin Laboratory of High Energies for Next 7 Years

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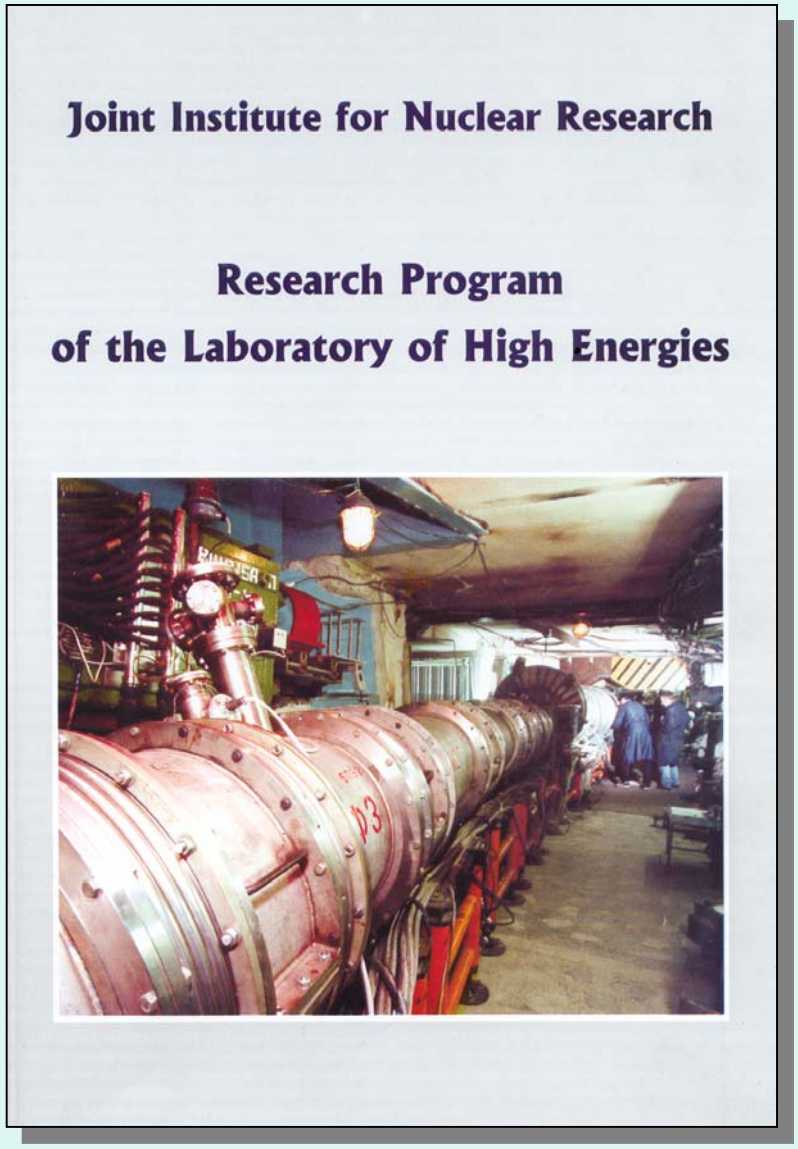
Report at the 92nd Session of the JINR Scientific Council

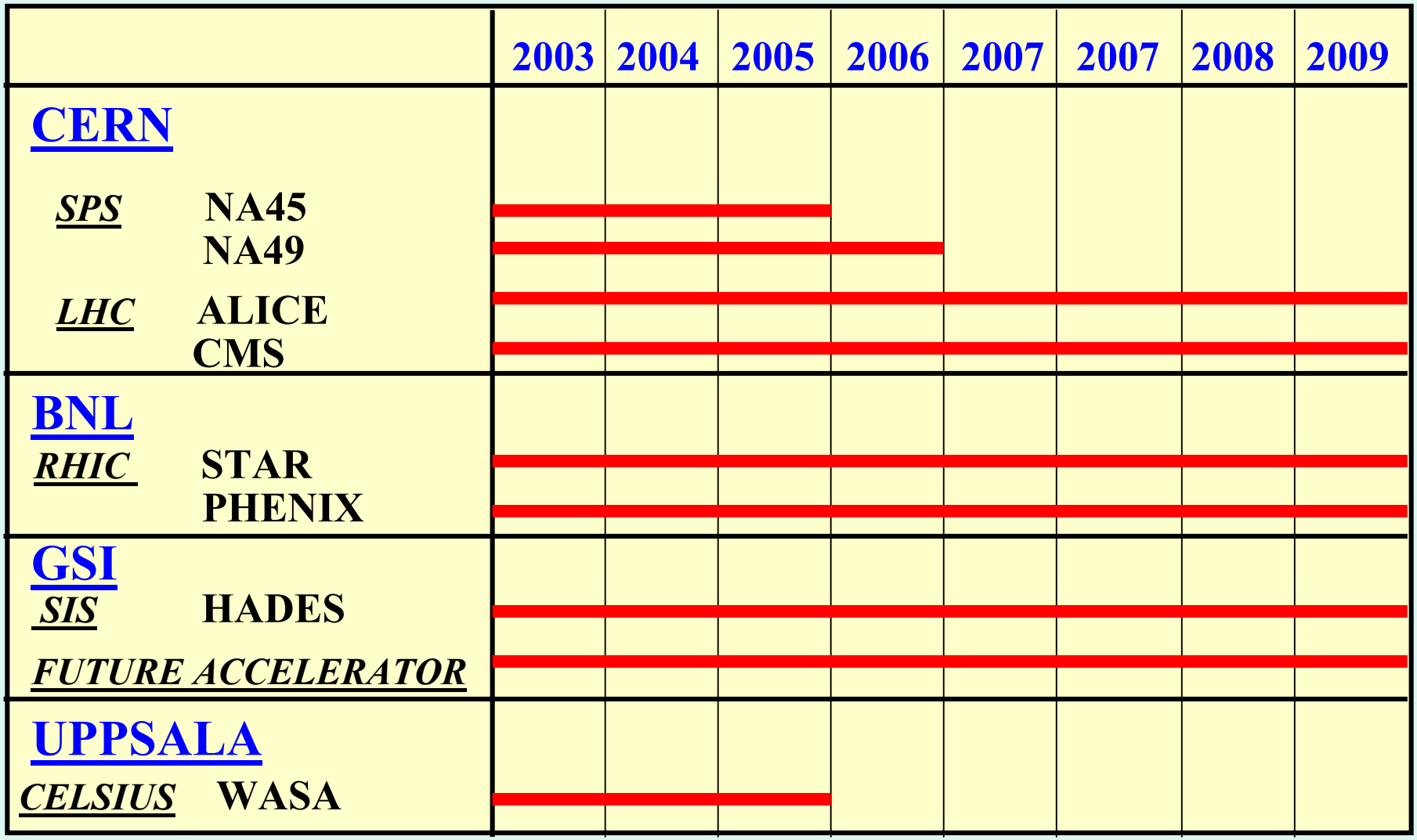
6 June 2002

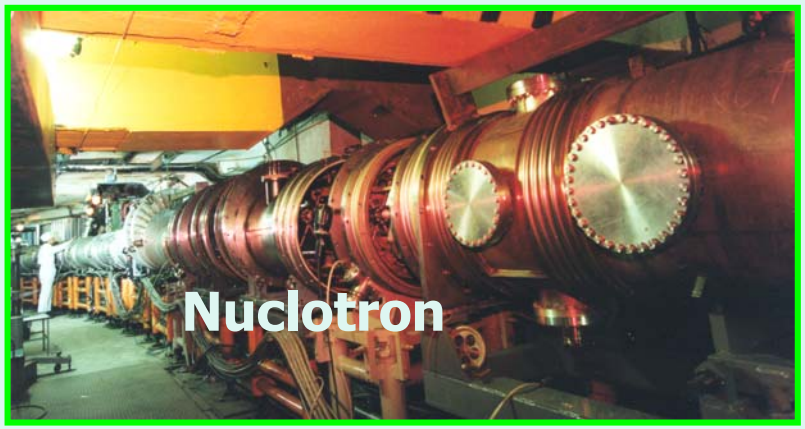
- **Physics research at the Nuclotron**
- **Research in the other scientific centers**
- **Development of the accelerator complex**

Physics research at the Nuclotron



Research in the other scientific centers





Experiments with relativistic nuclei

Experiments with polarized beams

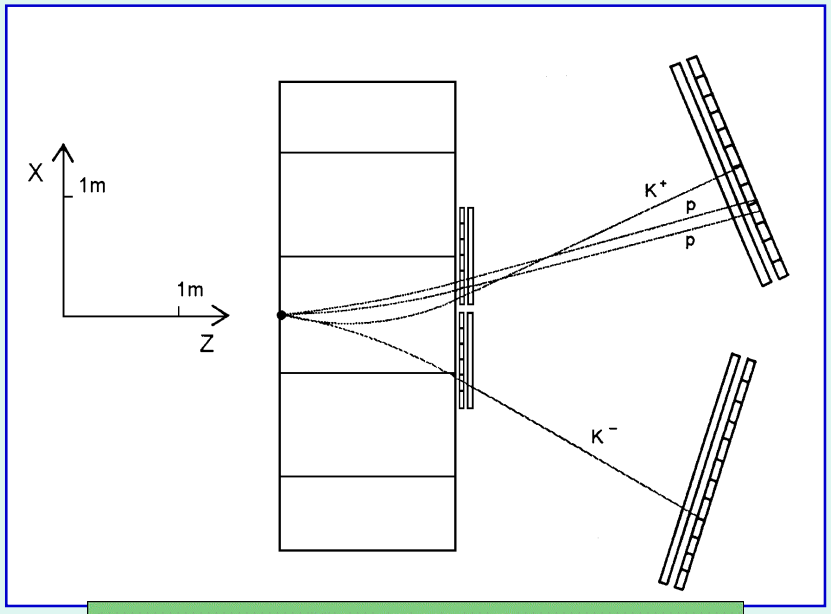
Applied investigations

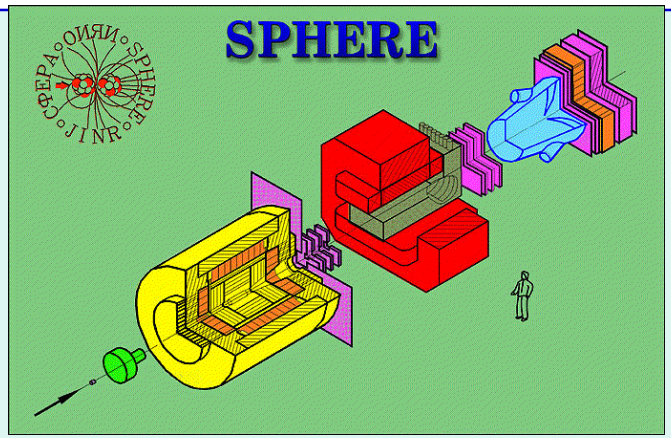
Experiments with relativistic nuclei

- Nucleon structure
- Nuclear structure
- Medium effects on particle production
- Modification of nuclear matter
- Hypernuclei and η nuclei

Experiments with relativistic nuclei

- **Nucleon structure**





NIS project

Polarized nucleon strangeness

The planned results are:

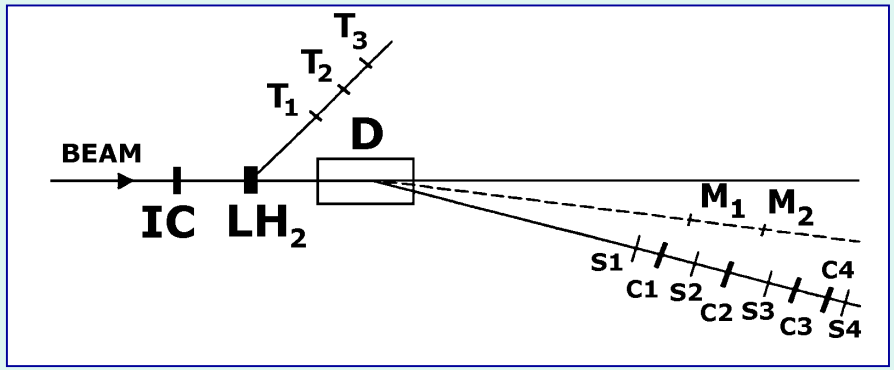
Ratio of ϕ and ω meson production cross sections near their thresholds in *pp* interaction and the comparison on the cross sections for *pp* and *np* interactions under similar kinematical conditions

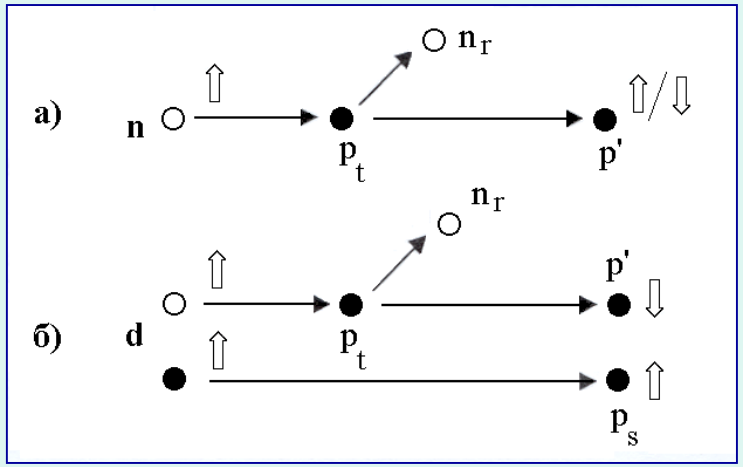
SUCH EXPERIMENT IS POSSIBLE IN THE FORESEEN FUTURE ONLY AT NUCLOTRON !

Experiments with relativistic nuclei

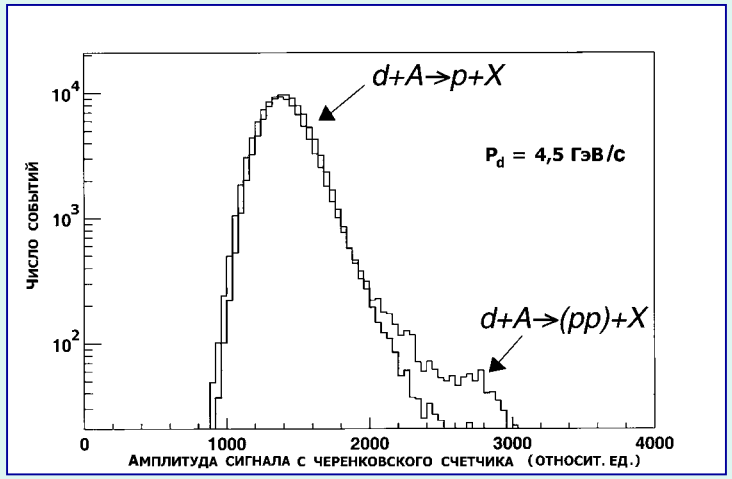
- **Nucleon structure**

STRELA project



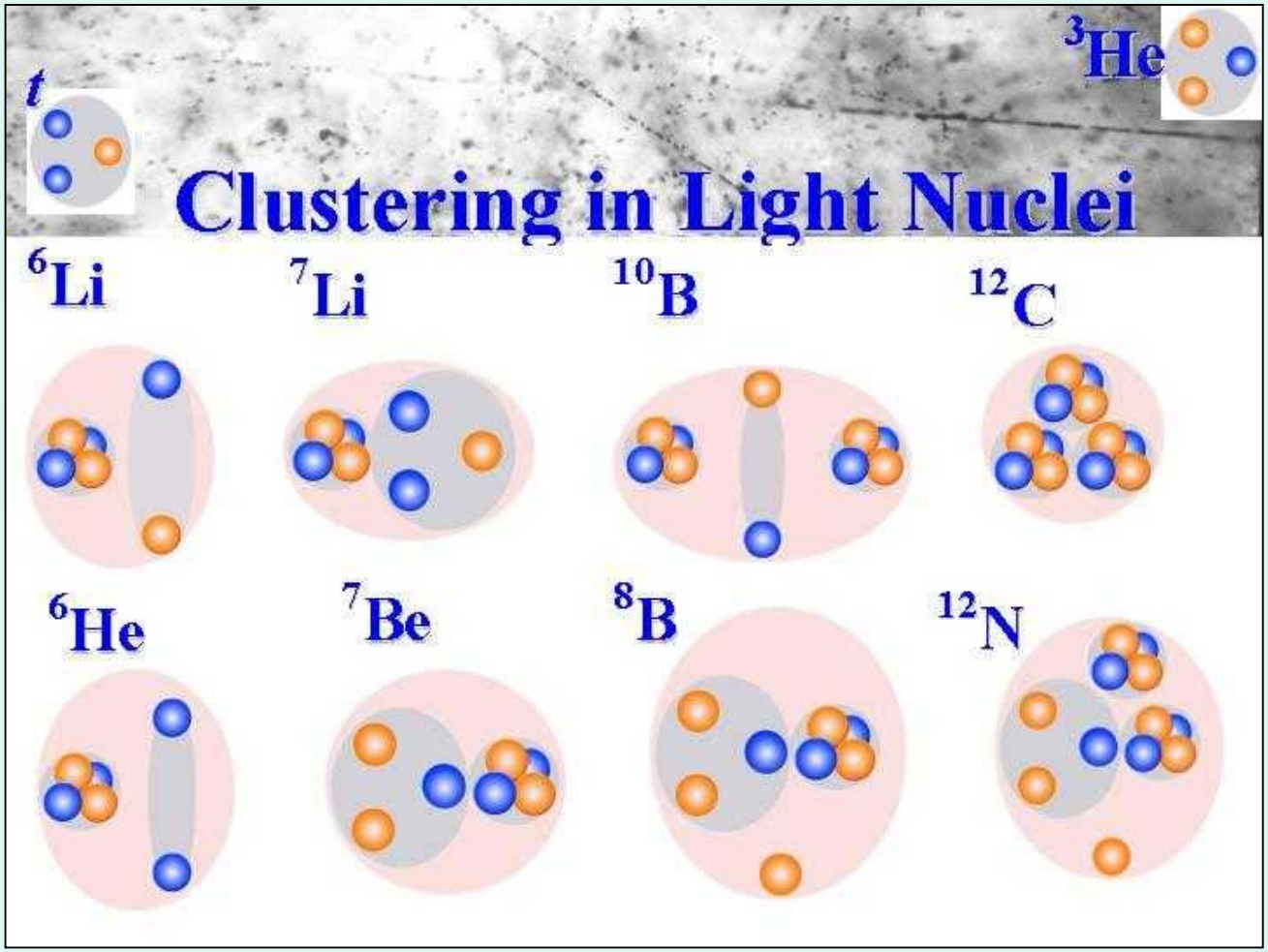


Study of the spin-dependent component of the nucleon scattering amplitude in the charge-exchange process *np→pn* in a deuteron beam extracted from the Nuclotron



Experiments with relativistic nuclei

- **Nuclear structure**



BECQUEREL project

Experiments with relativistic nuclei

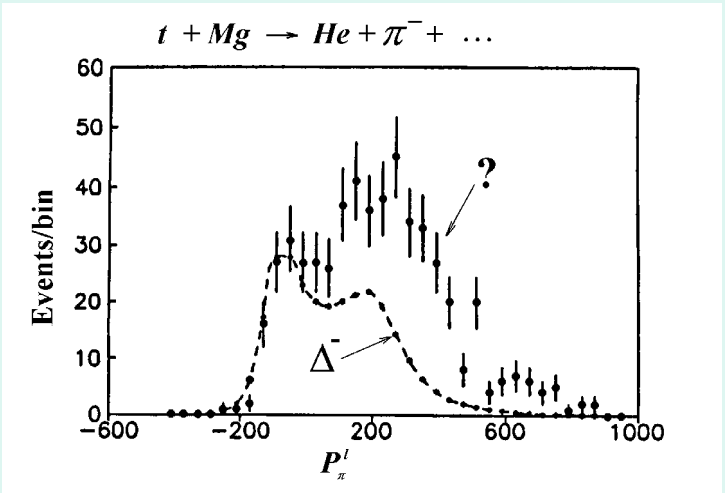
- **Medium effects on particle production**

Delta-isobars in nuclei

DELTA project (INR)

SMS project (MSU)
(Leading particles)

GIBS project



Experiments with relativistic nuclei

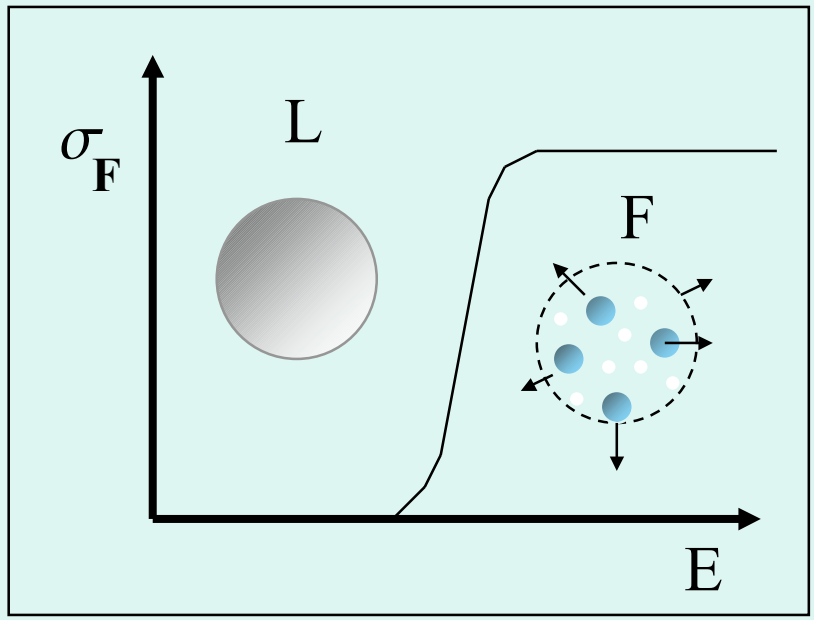
- **Modification of nuclear matter**

FAZA project (DLNP)

- **Hot nuclei**
- **Termal mulifragmentation**
- **Liquid-Fog Phase Transition**

Tc = (20±2) MeV !!!

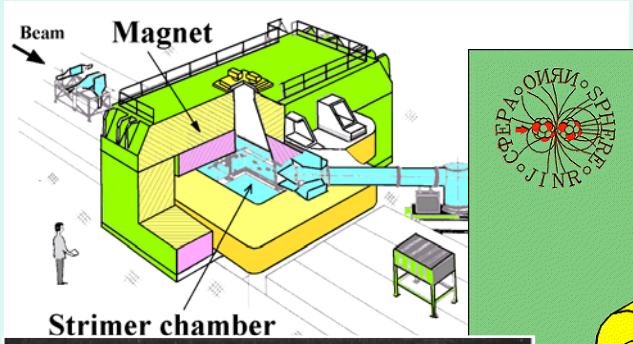
(Tc = (6.7±0.2) MeV, Morettol et al. ??)

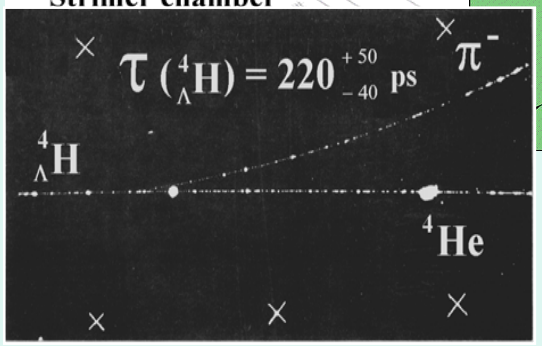


Experiments with relativistic nuclei

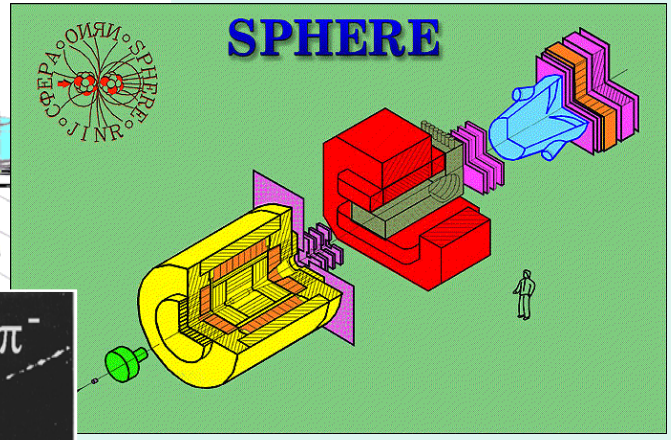
• Hypernuclei

GIBS project



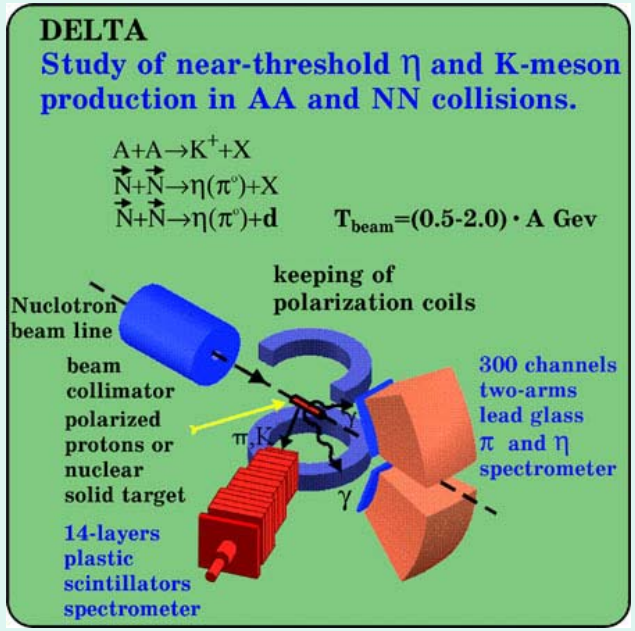


SPHERE project



• η nuclei

DELTA project (INR)

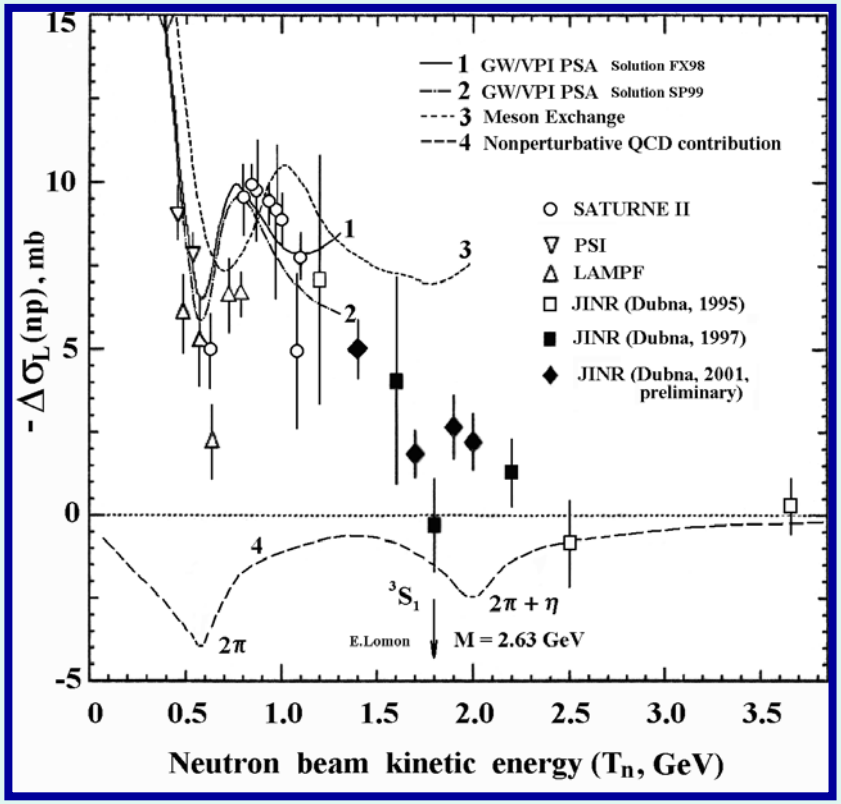


Experiments with polarized beams

- **Spin structure of the *np* forward scattering amplitude**
- **Spin deuteron structure at short distances**
- **Spin structure of the three nucleon systems**

Experiments with polarized beams

- **Spin structure of the *np* forward scattering amplitude**



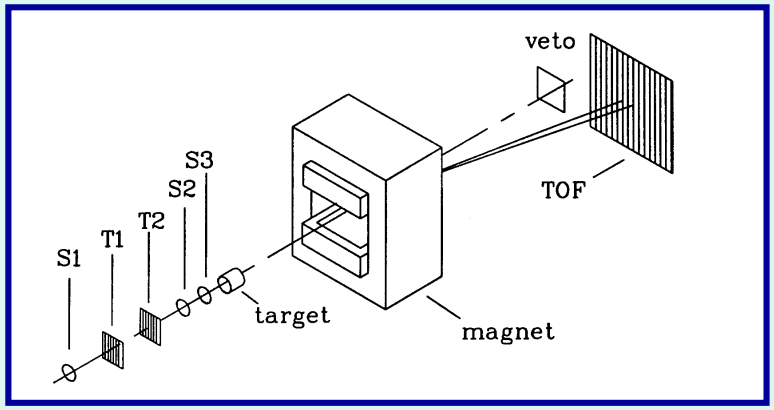
DELTA-SIMA project

→ $\Delta\sigma_T(np)$

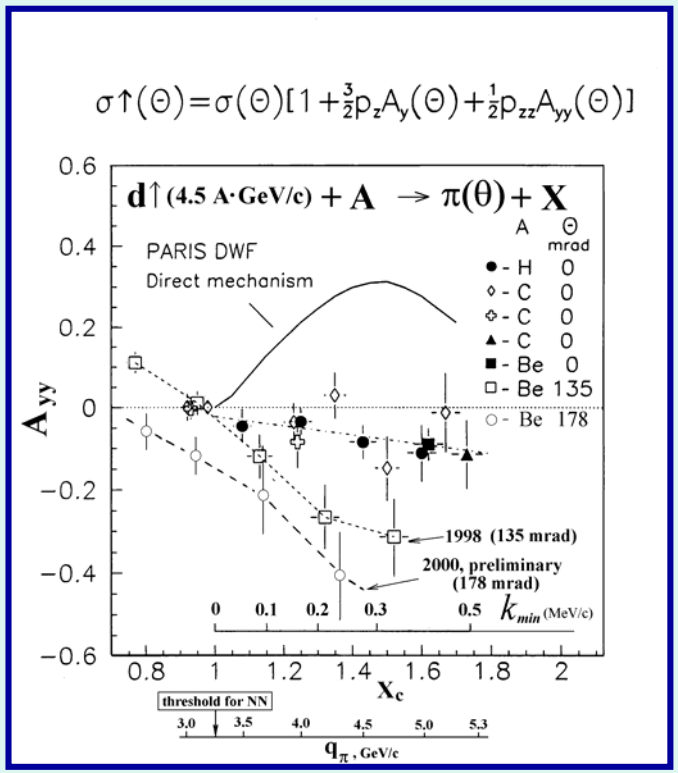
Experiments with polarized beams

- **Spin deuteron structure at short distances**

SCAN-2 project



PIKASO project



Experiments with polarized beams

- **Spin structure of the three nucleon systems**

LNS project

pHe3 project

Light Nuclei Structure investigations at LHE and RIKEN

$$d\uparrow + {}^{3}He\uparrow \rightarrow {}^{4}He + p$$

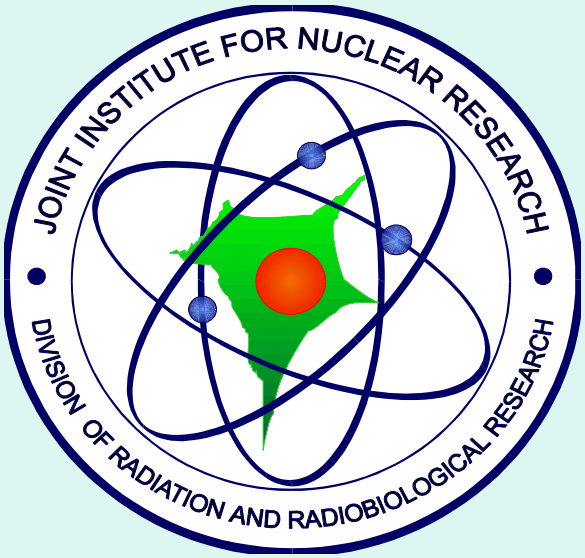
$$E_d = 1.0 - 1.75\ GeV$$

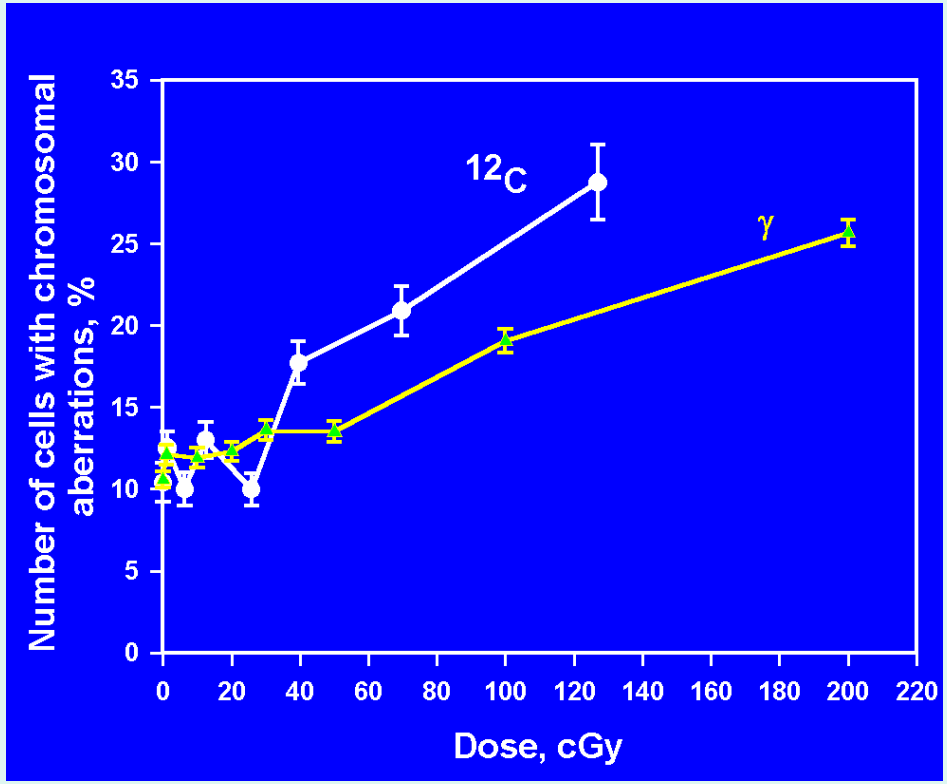
Applied research

- **Radiobiology and space biomedicine**
- **The impact of nuclear beams on the microelectronic components**
- **The transmutation of radioactive waste**
- **Accelerator driven energy production**

Applied research

- **Radiobiology and space biomedicine**

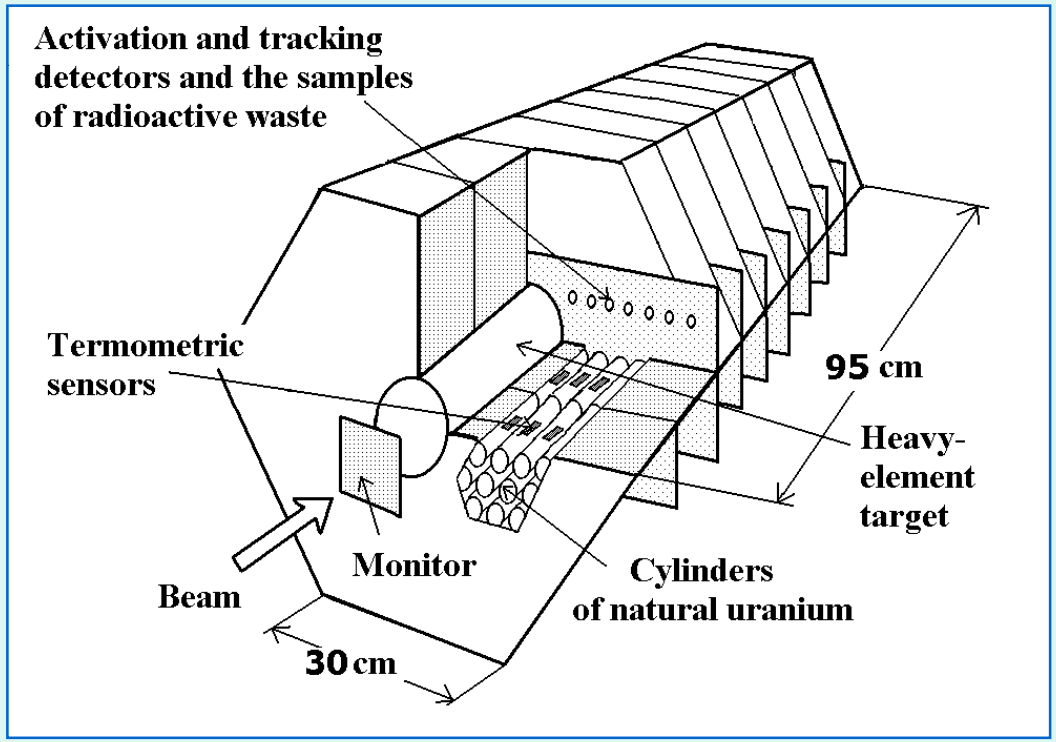




Applied research

- The transmutation of radioactive waste
- Accelerator driven energy production

Energy + Transmutation project



NUCLOTRON – Users' Facility

Australia:
The University of Sidney

Belarus:
The Institute of Radiative Physical-Chemical Problems of NASB, The Academy of Scientific and Engineering Complex 'SOSNY', (Minsk) …

Bulgaria:
Institute for Nuclear Research and Nuclear Energy of BAS, University of Chemical Technology and Metallurgy (UCTM) (Sofia) …

Czech Republic:
Nuclear Physics Institute (Řež), Charles University, Czech Technical University (Prague) …

Greece:
Aristotle University of Thessaloniki (Thessaloniki)

Italy:
Istituto Nazionale di Fisica Nucleare. Sezione di Firenze (Florence) …

Germany:
Technishe Hochschule Darmstadt – Institut für Kernphysik (Darmstadt), Universität (Siegen, Karlsruhe), Philipps-Universität Marburg (Marburg), Forschungszentrum Jűlich GmbH (Jűlich) …

Mongolia:
Institute of Physics and Technology of MAS, National University of Mongolia (Ulaanbaatar)

JINR:
LHE, DLNP, LPP, LIT, BLTP, FLNP, DRRR

Slovak Republic:
Institute of Experimental Physics, P.J. Šafárik University (Kosiče), Institute of Physics SAS, Comenius University (Bratislava) …

Poland:
Niewodniczanski Institute of Nuclear Physics (Cracow), The Andrzej Soltan Institute for Nuclear Studies (Otwock, Warsaw) …

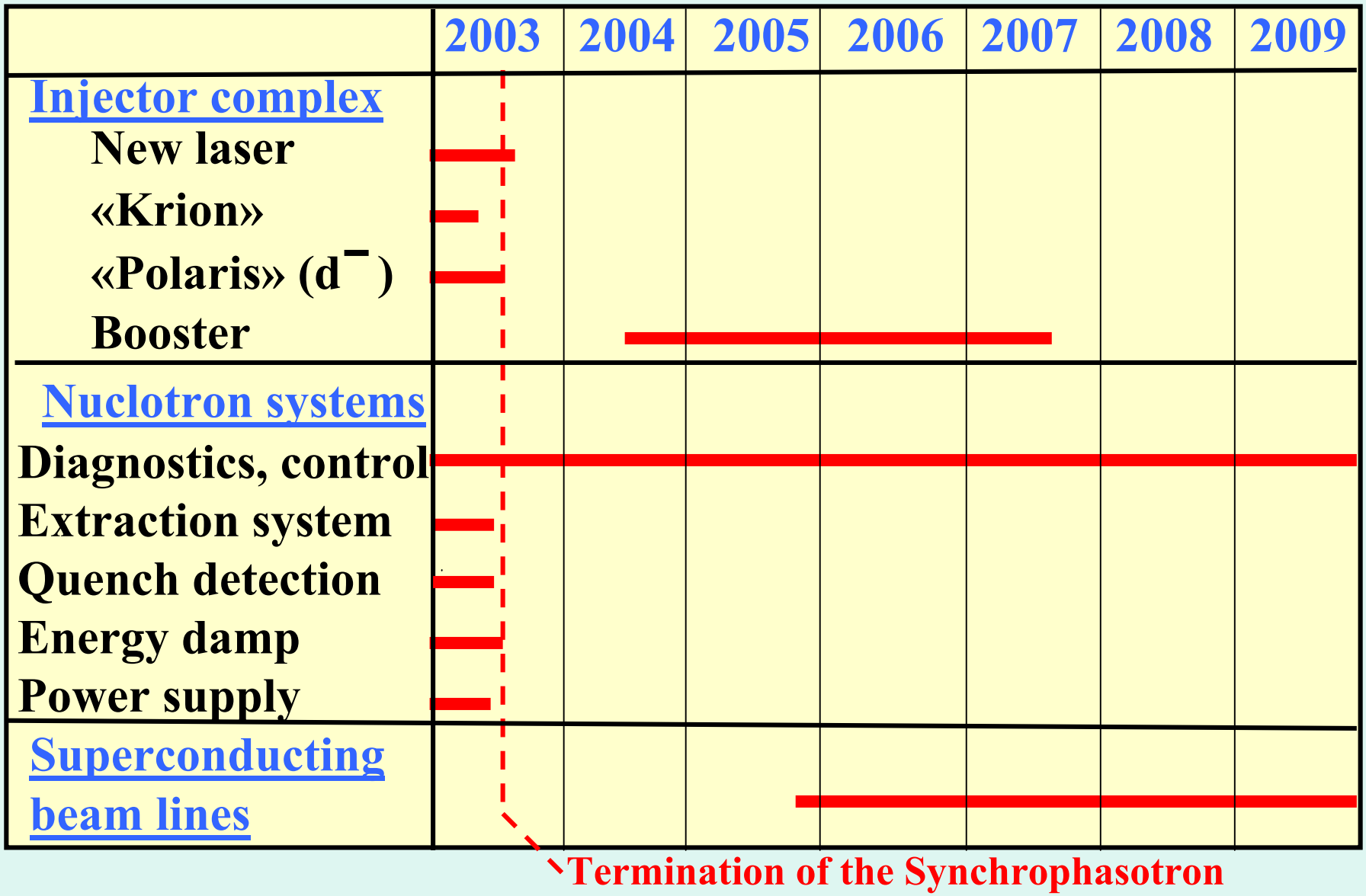
Russia:
Institute for Nuclear Research of RAS (Troitsk), Lebedev Physical Institute of RAS (FIAN), Skobeltsyn Research Institute of Nuclear Physics at the Moscow State University, Russian Nuclear Research Institute of Experimental Physics (Sarov), Institute of Atomic Energy (Obninsk) …

And Other Scintific Centers

Development of the accelerator complex

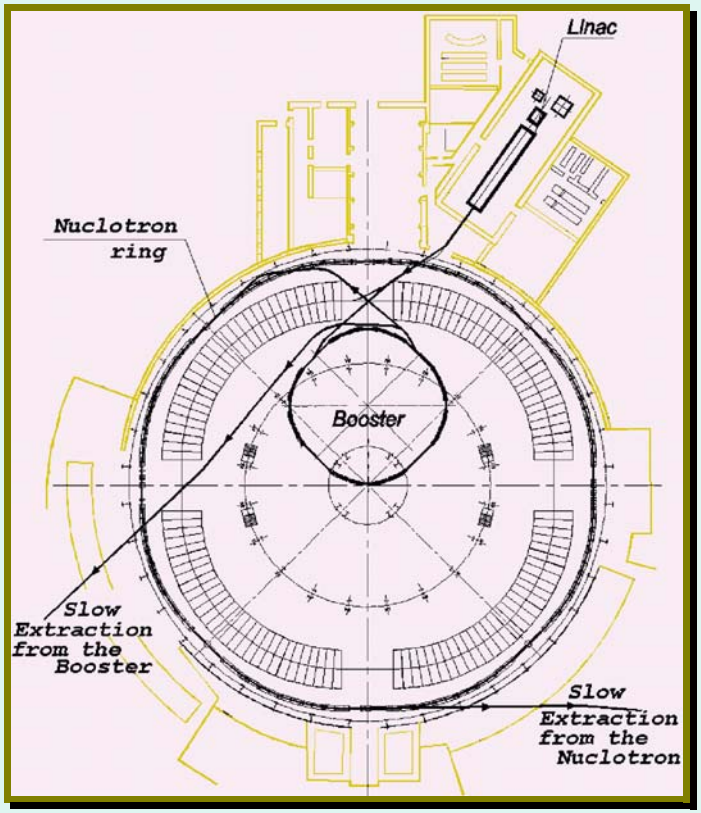
- **Nuclotron development**
- **Superconductive beam lines**
- Cyclotron C14
- Collider 6 + 6 A·GeV ???

Nuclotron development



Booster

DEVELOPMENT OF THE LHE ACCELERATOR FACILITY



MAIN PARAMETERS

	NUCLOTRON	BOOSTER
Peak energy, GeV/u	6	0,25
Repetition rate, Hz	0.5-1	1(3)
Magnetic field, T	2	1.2
Aperture, v × h, cm^2	5.5 × 11.0	10 × 16
Circumference, m	251.5	83.8
Operating temp., K	4.5	4.5/80
Stored energy, MJ	2.35	0.5
Cold mass, t	80	2.5/20
Number of dipoles	96	32
Number of quadr.	64	24

BOOSTER OF THE NUCLOTRON

- FAST CYCLING (f=1Hz) SUPERCONDUCTING 250 MeV/u SYNCHROTRON AIMED TO REACH THE LIMITING BEAM INTENSITIES AT THE ACCELERATOR COMPLEX OF LHE JINR

- THE BOOSTER RING 84 m IN PERIMETER IS PLACED INSIDE THE SYNCHROPHASOTRON BUILDING AT THE GROUND FLOR. THE MEDIAN PLANES OF THE BOOSTER AND NUCLOTRON ARE AT THE SAME LEVEL

- MULITURN INJECTION INTO THE BOOSTER AND ELECTRON COOLING OF STORED BEAM ARE PROVIDED.

- BOTH AS FAST AND SLOW RESONANCE BEAM EXTRACTION MODES FROM THE BOOSTER WILL BE REALISED.

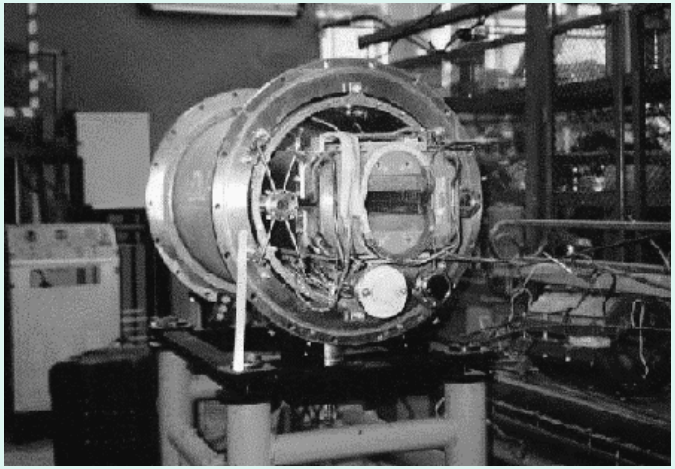
- ADVANCED TECHNOLOGY OF SUPERCONDUCTING MAGNETIC SYSTEM OF THE BOOSTER MAKES IT POSSIBLE:
  - MINIMIZATION OF COOLING AND ELECTRIC POWER
  - SAVE MATERIALS (SUPERCONDUCTOR, COOPER, STEINLESS STEAL ETC.)

- EXPERIENCE OF THE NUCLOTRON DESIGN IS USED

Superconductive beam lines

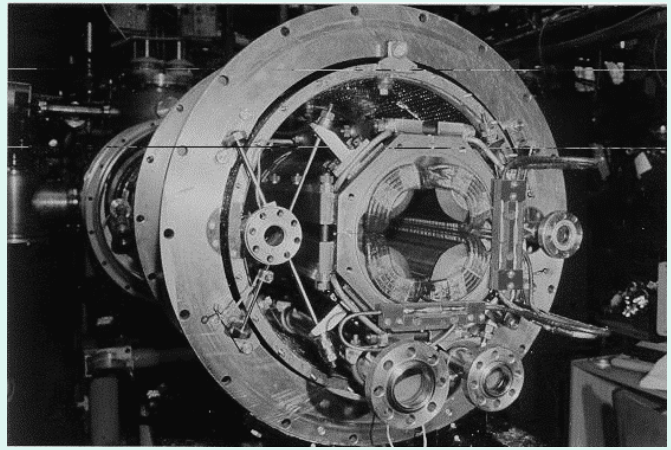
Now: 8 – 13 MW ➡ Superconductive ~280 kW

Nuclotron type magnets



Banding magnets

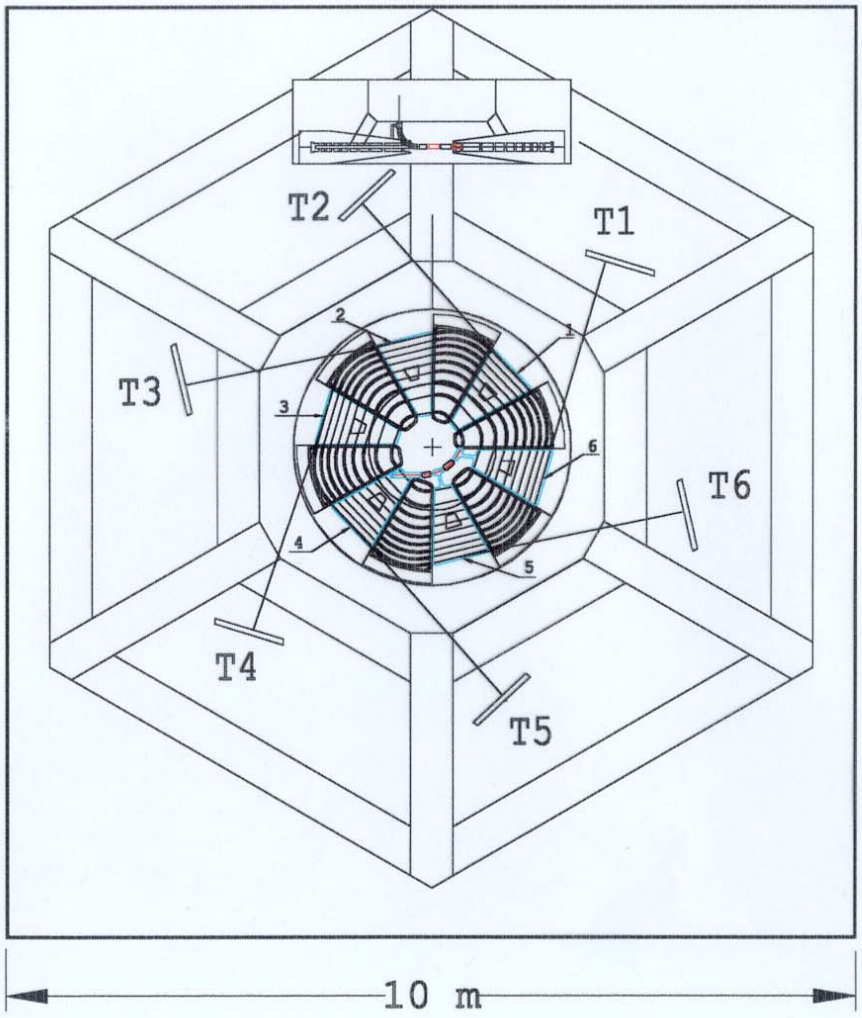
Aperture	120x80mm
Yoke Length	1400mm
Maximal induction	2,0 T
Current	200A



Quadrupole magnets

Aperture	150 mm
Yoke Length	1000 mm
Maximal gradient	30 T/m
Current	200A

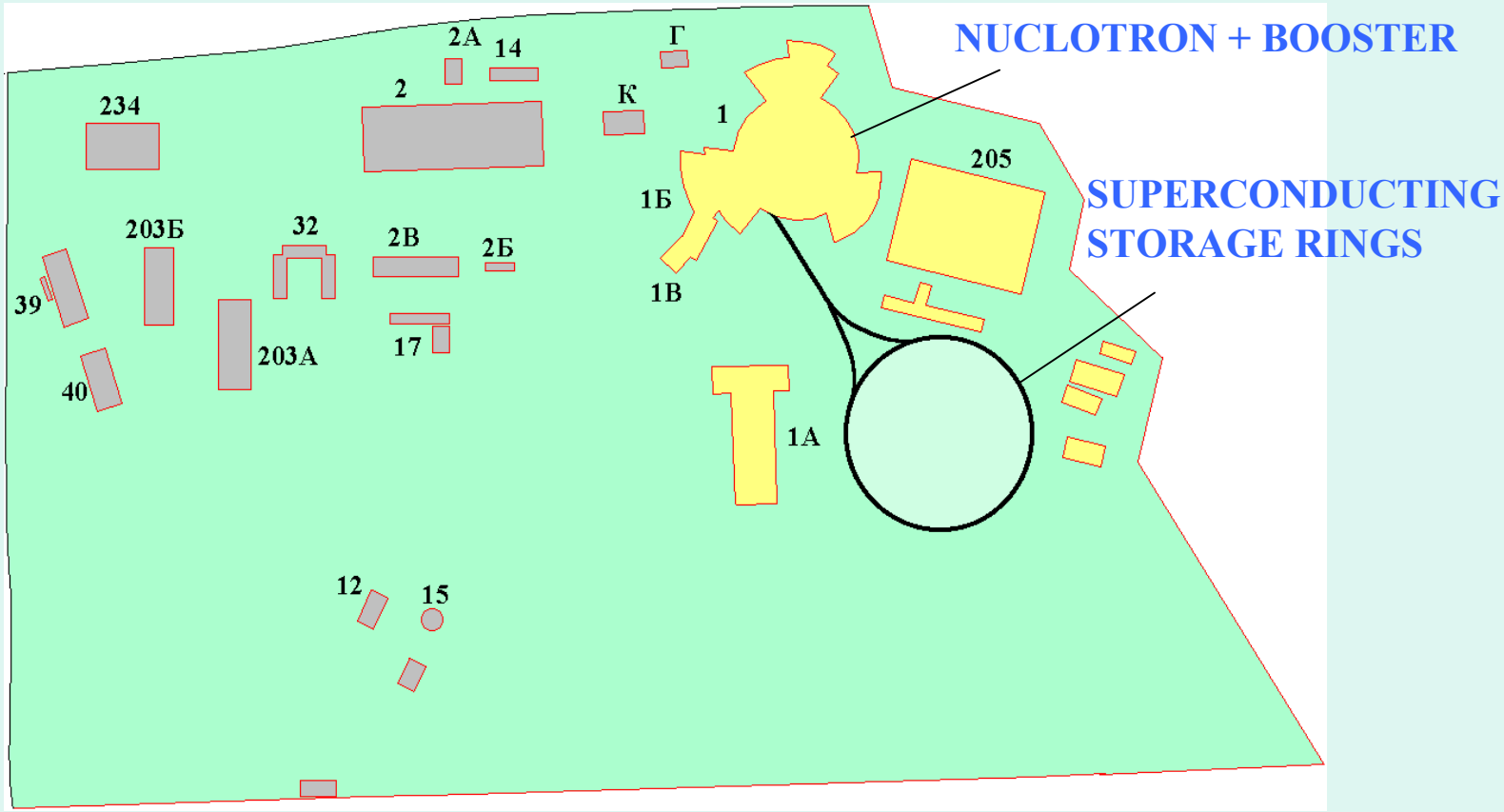
Cyclotron C14



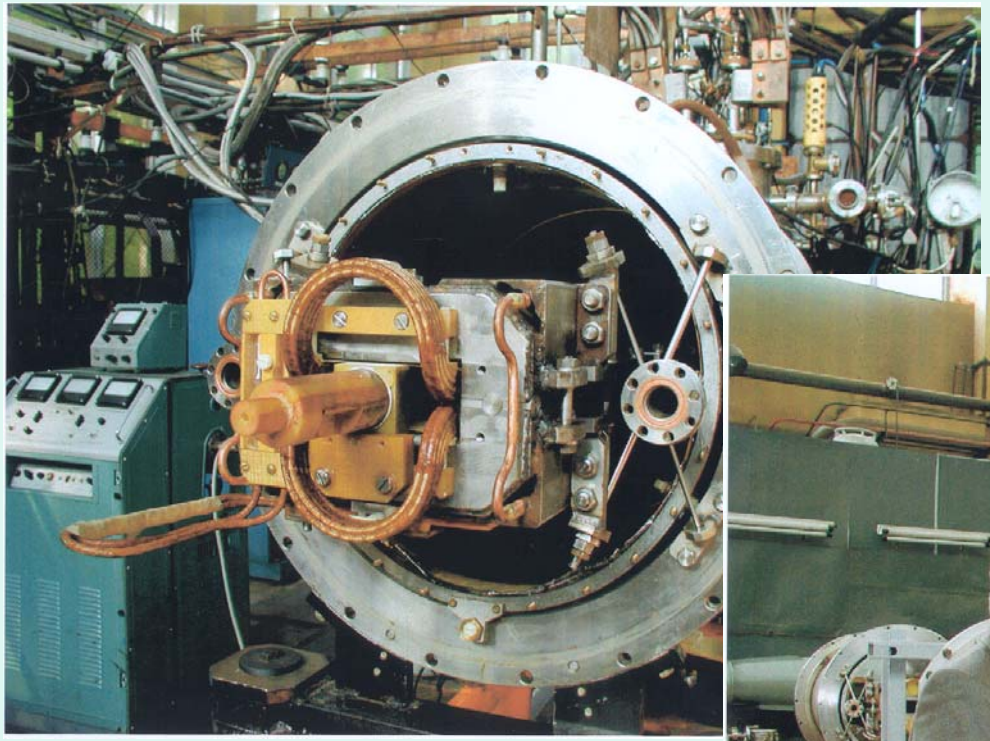
CYCLOTRON C-14 SETUP

External beam number	6
Beam intensity, mA	9=6x1.5
Proton energy, MeV	14
Magnetic field, T	0.77
Final radius, m	1.32
Coil current, A	950
Coil power, kW	17.0
Copper weight, kg	164
Steel weight, t	10.0
Number of dees	6
Frequebcy, MHz	34.77
Dee tension, kV	125
Hf power, kW	15
Outside cavety dia, m	3.2
Cavity weight, t	1.85
Number of deflectors	5

Collider 6 + 6 A·GeV



R&D for GSI future accelerator



Topics of the 1-st priority (budget)

Topic	2003	2004	2005	2006	2007	2008	2009
03-1-0979-92/2006 (Accelerator Complex)	300	300	300	300	300	300	300
03-0-0941-91/2003 (Spin Effects)	90	90	90	90	96	101	106
03-1-0983-92/2006 (4π-geometry)	251	266	291	286	316	316	323
03-1-1011-95/2002 (STAR, NA45, DISK)	140	150	150	150	150	150	150
03-1-1020-95/2002 (HADES)	80	90	90	100	100	100	100
03-1-0001-2000/2005 (ALICE)	140	140	140	140	140	140	140
03-1-1010-99/2002 (MARUSYA)	80	80	80	80	80	80	80
02-7-1044-2002/2002 (NIS)	50	25	25	25			
Total (k$)	1131	1141	1166	1176	1182	1187	1199

Conclusions

- The relevant programme of physics research will realize by international collaborations at the Nuclotron
- The collaboration with other research centers is also important for developing of LHE physical research programme
- It is planned to upgrade the Nuclotron and create on its territory a user center for relativistic nuclear physics and applied research using relativistic ions with the energy of few GeV per nucleon