Объединенный институт ядерных исследований

Joint Institute for Nuclear Research

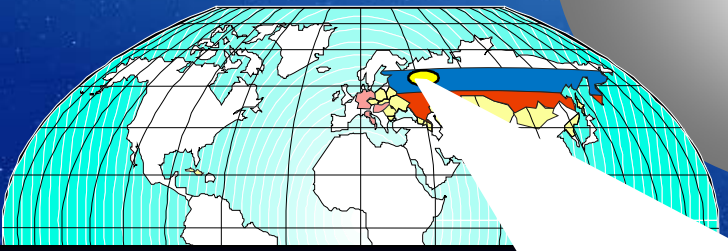
Международная межправительственная организация

International Intergovernmental Organization

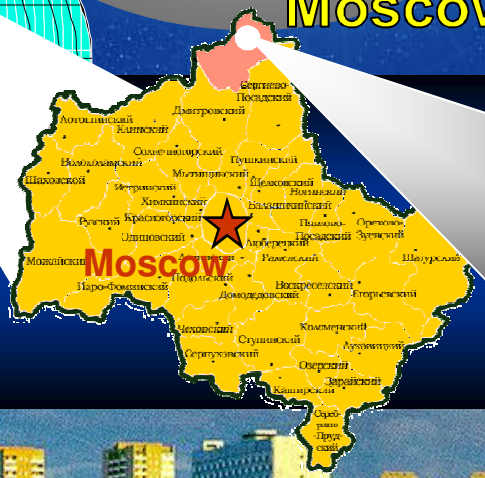
Разработка «дорожной карты» по развитию ОИЯИ на 10-15 лет – «дорожная карт
ОИЯИ имеет целый арсенал базовых и экспериментальных установок. Здесь разработаны уникальные методики э
ОИЯИ справедливо называют школой высшей квалификации. За пятьдесят лет сформировалась обширная образовател
Фундаментальные исследования, проводимые в ОИЯИ, имеют такие важные приложения, как обеспечение наземного те
Важным направлением в концепции развития ОИЯИ поэтому является формирование развитого инновационного пояса
Подробная информация об ОИЯИ доступна на сайте Института: www.jinr.ru
Спасибо

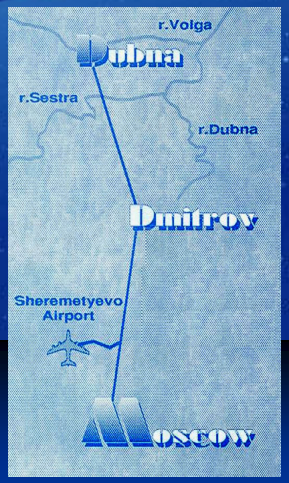
Сотрудничество ОИЯИ — ЦЕРН

Russia



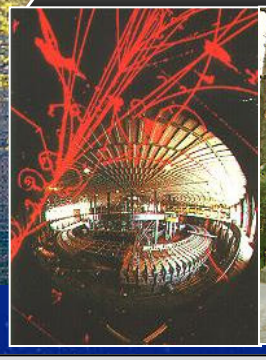
Moscow Region



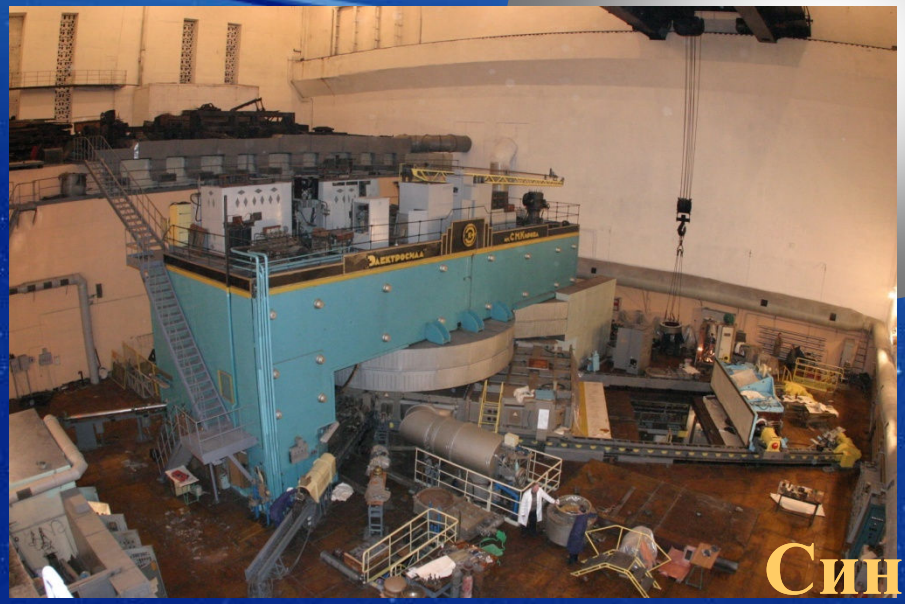


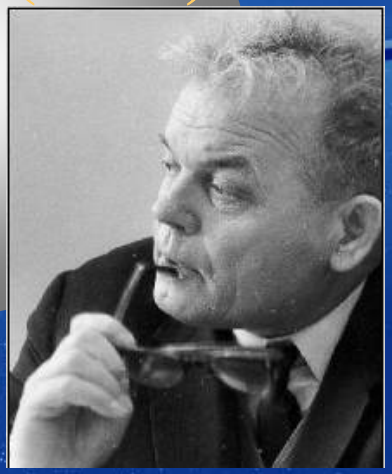
Dubna

JINR



Синхроциклотрон 680 МэВ (1949)





M.Meshcheryakov

Синхрофазотрон 10 ГэВ (1957)

V.Veksler

JOINT INSTITUTE for NUCLEAR RESEARCH
International Intergovernmental Organization

1956


Albania


Bulgaria


China


Czechoslovakia


GDR


Hungary


D.P.R.Korea


Mongolia


Poland

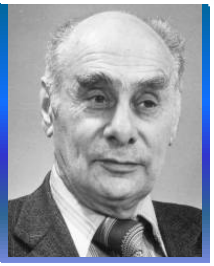

Romania


USSR


Vietnam

The agreement on the establishment of JINR was signed on 26 March 1956 in Moscow

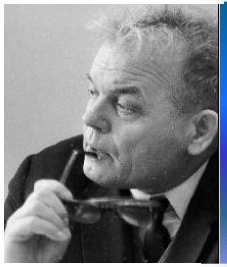
Founders



G.Flerov

V.Veksler

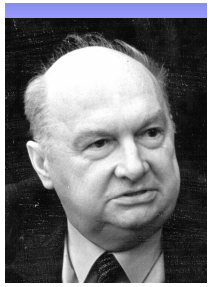
I.Frank



M.Meshcheryakov

V.Dzhelepov

N.Bogoliubov,
D.Blokhintsev



A.Baldin

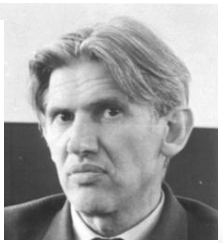
L.Infeld

B.Pontecorvo

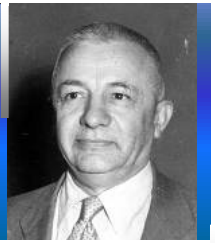
H.Hulubei

Wang Ganchang

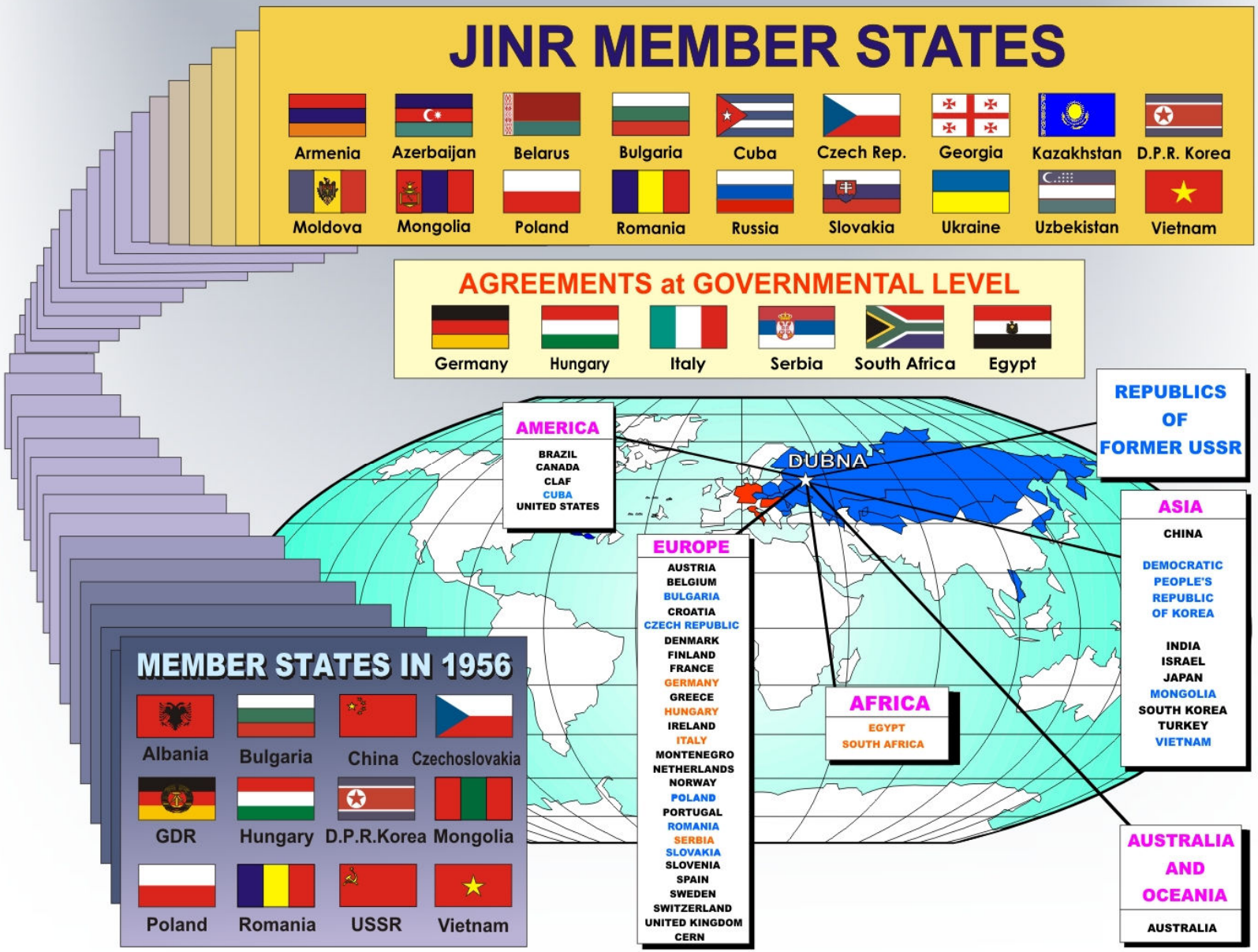
H.Niewodniczanski



L.Janossy



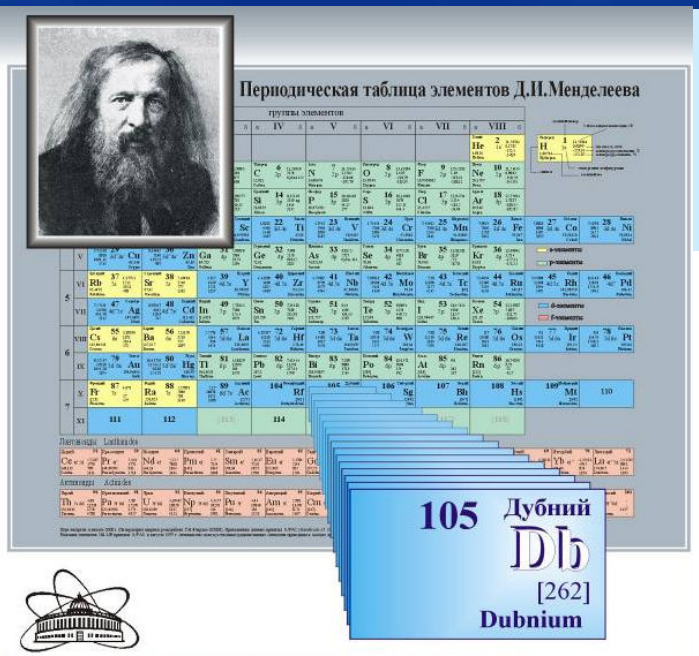
G.Najakov

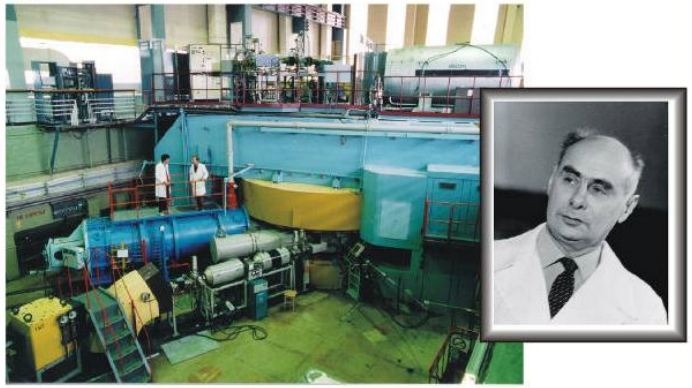


Collaboration with > 700 institutions from 60 countries

Discoveries

JOINT INSTITUTE for NUCLEAR RESEARCH





- **46 prestigious academic and state awards, and prizes of Russia, Bulgaria, Georgia, Romania, Czech Republic, Uzbekistan and other countries.**

More than 40 discoveries, including:

- 1959 – nonradiative transitions in mesoatoms
- 1960 – antisigma-minus hyperon
- 1963 – element 102
- 1972 – postradiative regeneration of cells
- 1973 – quark counting rule
- 1975 – phenomenon of slow neutron confinement
- 1988 – regularity of resonant formation of muonic molecules in deuterium
- 1999-2005 – elements 114, 116, 118, 115 and 113
- 2006-2009 – chemical identification of superheavy elements

Three Pillars of JINR

I.

Great experience and world-wide recognized traditions of scientific schools:

- more than 40 discoveries
- 46 prestigious academic and state awards of Member States and other countries

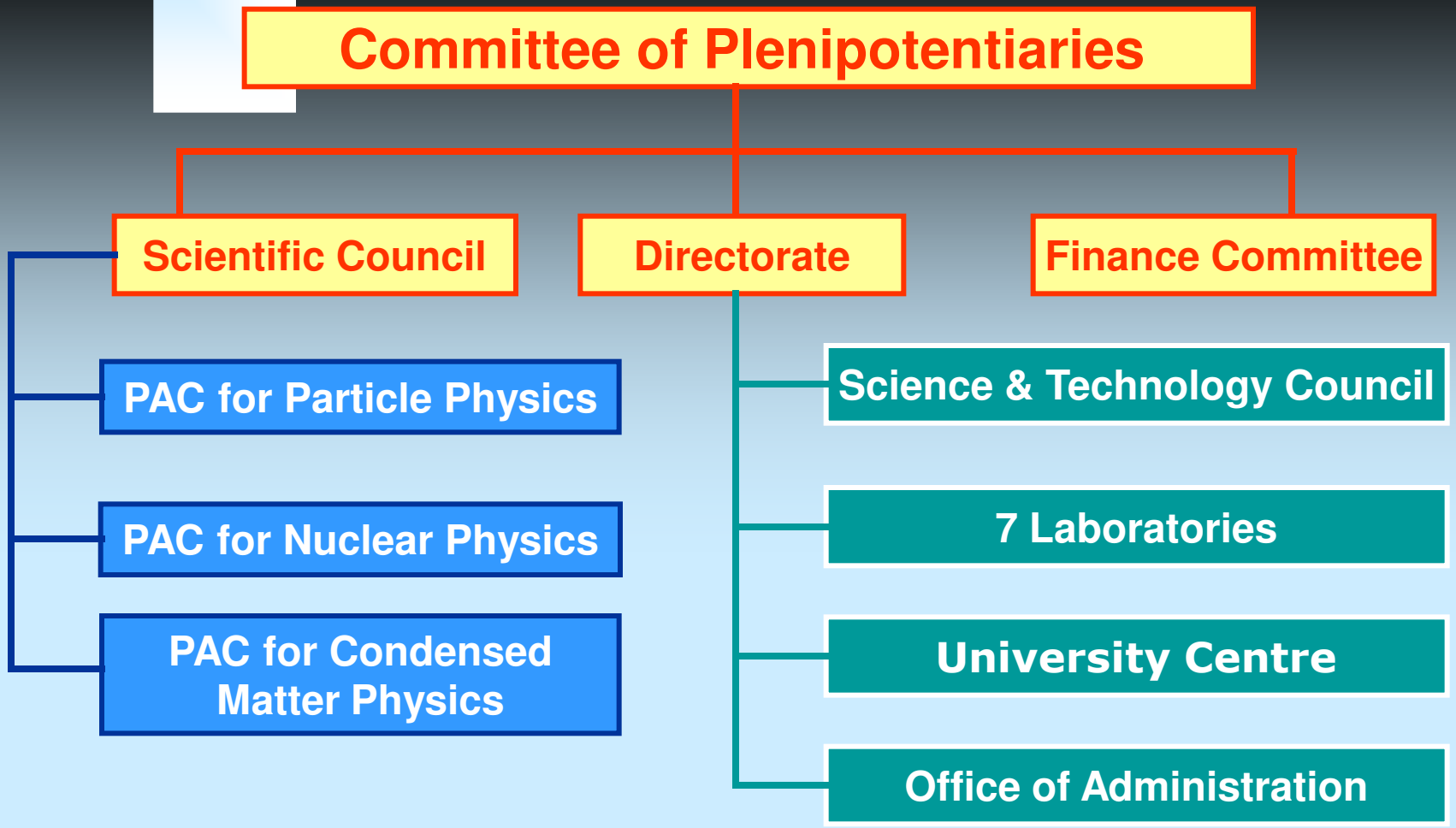
Large and unique park of basic facilities for fundamental and applied research:

- various types of particle accelerators
- high flux pulsed reactor

Status of an international intergovernmental organization:

- JINR was established through the Convention signed on 26 March 1956 by eleven founding States and registered with the United Nations on 1 Feb. 1957
- Russian Federal Law on Ratification of "The Agreement between the Government of the RF and JINR on the Location and Terms of Activity of JINR in the Russian Federation" (January 2000)
- broad international cooperation – more than 700 institutions located in 60 countries

Governing Bodies & Structure



J I N R

D u b n a

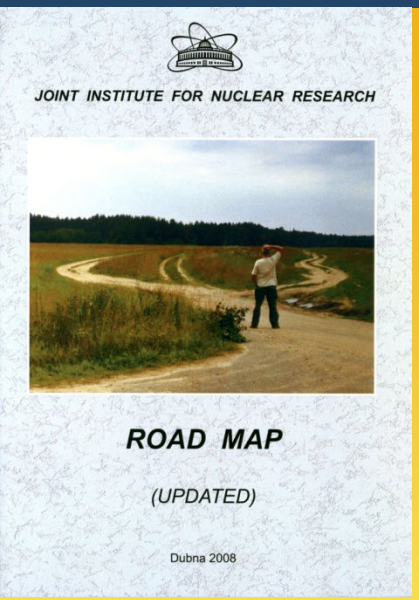
JINR in figures

JINR's staff members ~ 5500
researchers ~ 1300
including from the Member States ~ 500
(but Russia)

Doctors and PhD ~ 1000

JINR's Science Policy

II.



- 7-Year Programme: '2003 – 2009'
  '2010 – 2016' (in preparation)
- Road Map (2006-2017)

http://wwwinfo.jinr.ru/Road_Map_2008-2017.htm

JINR should develop its role as a world leader in certain research domains!

Fundamental Science

Innovation belt

Education programme

Special Economic Zone "Dubna"
Public-Private-Partnership

UC, DIAS-TH
International Univ. "Dubna"

JINR's ROAD MAP

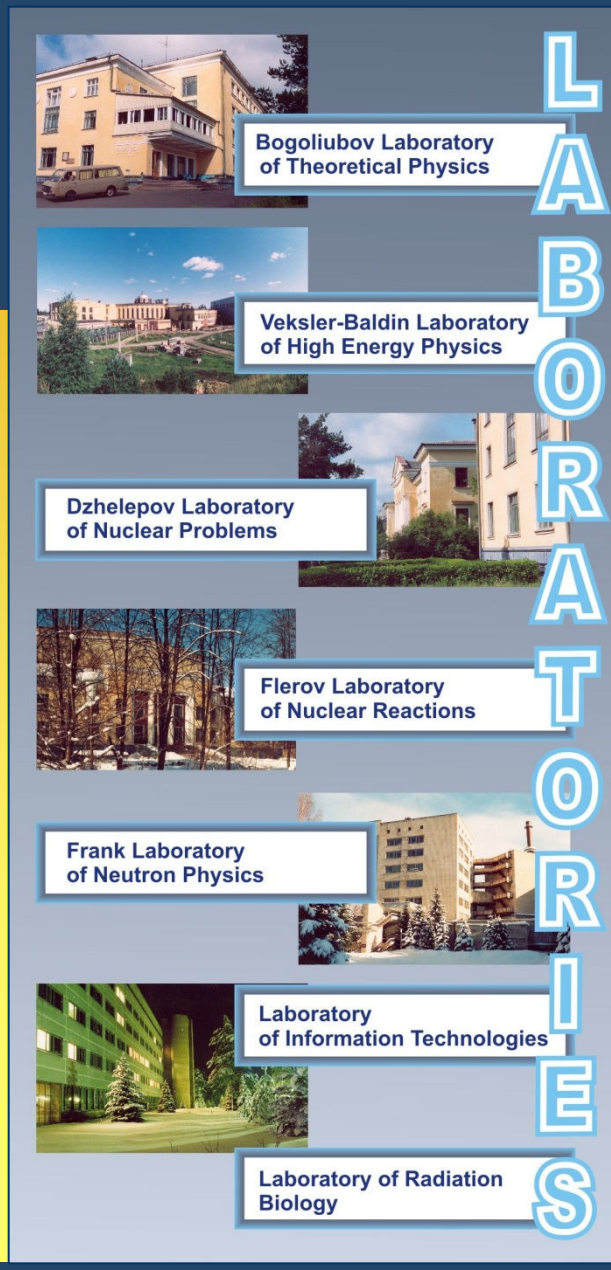
II.

Basic Scientific Directions

- High Energy Physics
- Nuclear Physics
- Condensed Matter Physics

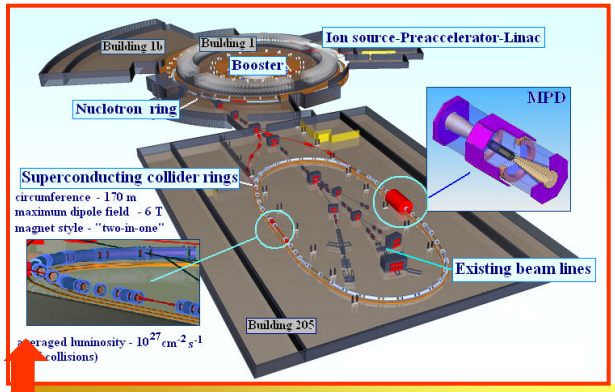
Main Supporting Activities:

- Theory of PP, NP, CMP
- Networking and computing
- Physics instruments and methods
- Training of young staff



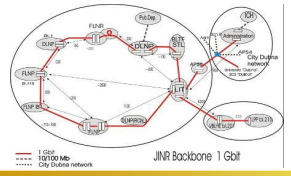
Upgrade of JINR Basic Facilities

II.

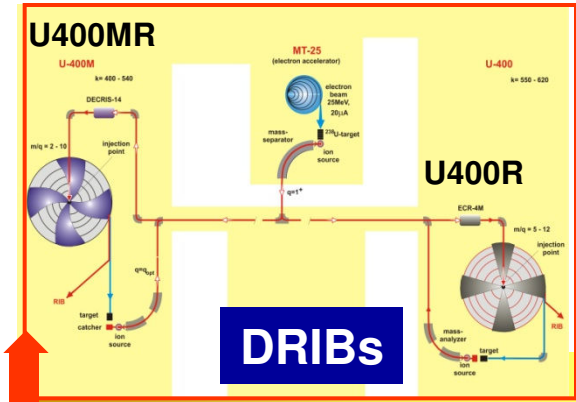


Upgraded Nuclotron-M
(2009 – 2010)
+
NICA (2013-2014)

Telecommunication channels:
20 Gbps – 2009
800 Gbps – 2016

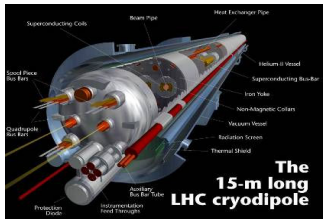


JINR networks:
- GRID technology
- improvement of computer links with Member States (2010-2016)



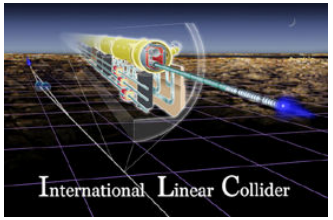
DRIBs II – (2009-2010)
DRIBs III – (2011-2015)

Participating in LHC, RHIC, TEVATRON…
In future: FAIR, ILC …



LHC-2008

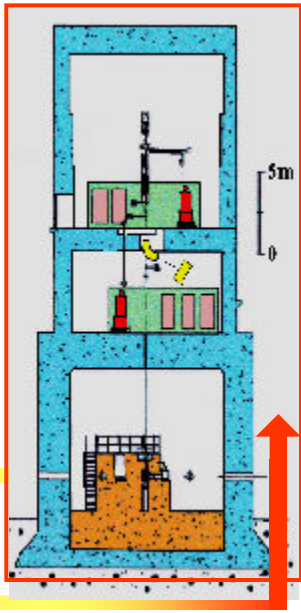
FAIR-2015

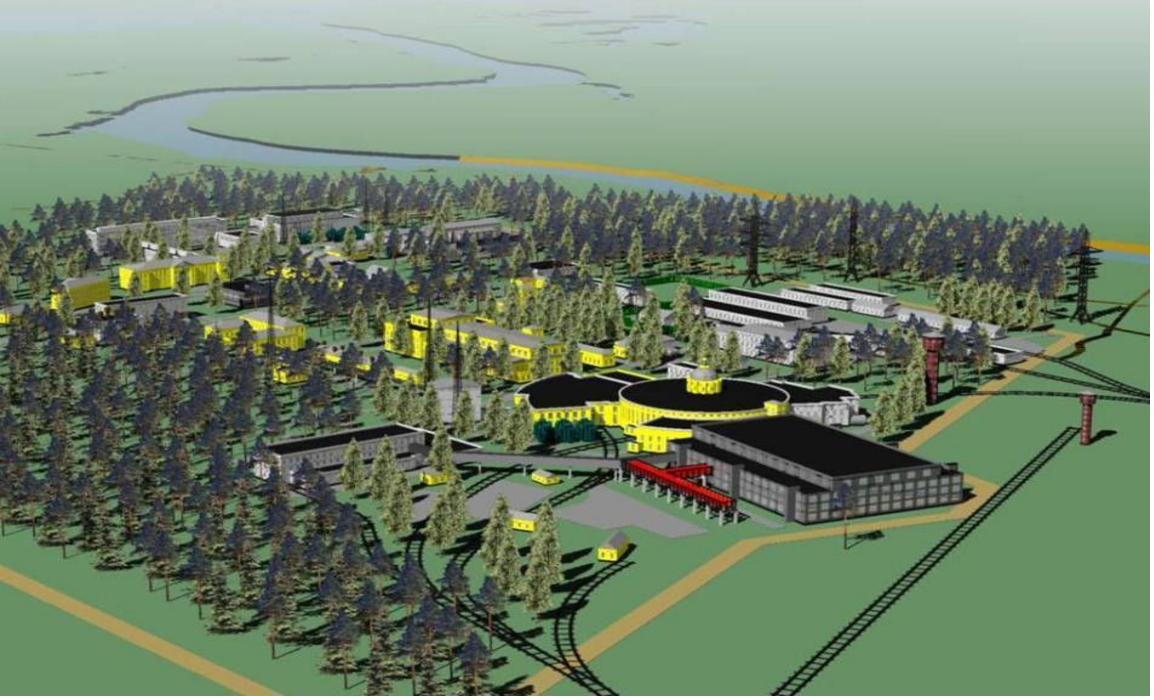


ILC – after 2020 (?)

New reactor IBR-2M – 2010
Complex of modern neutron spectrometers (2011-2016)

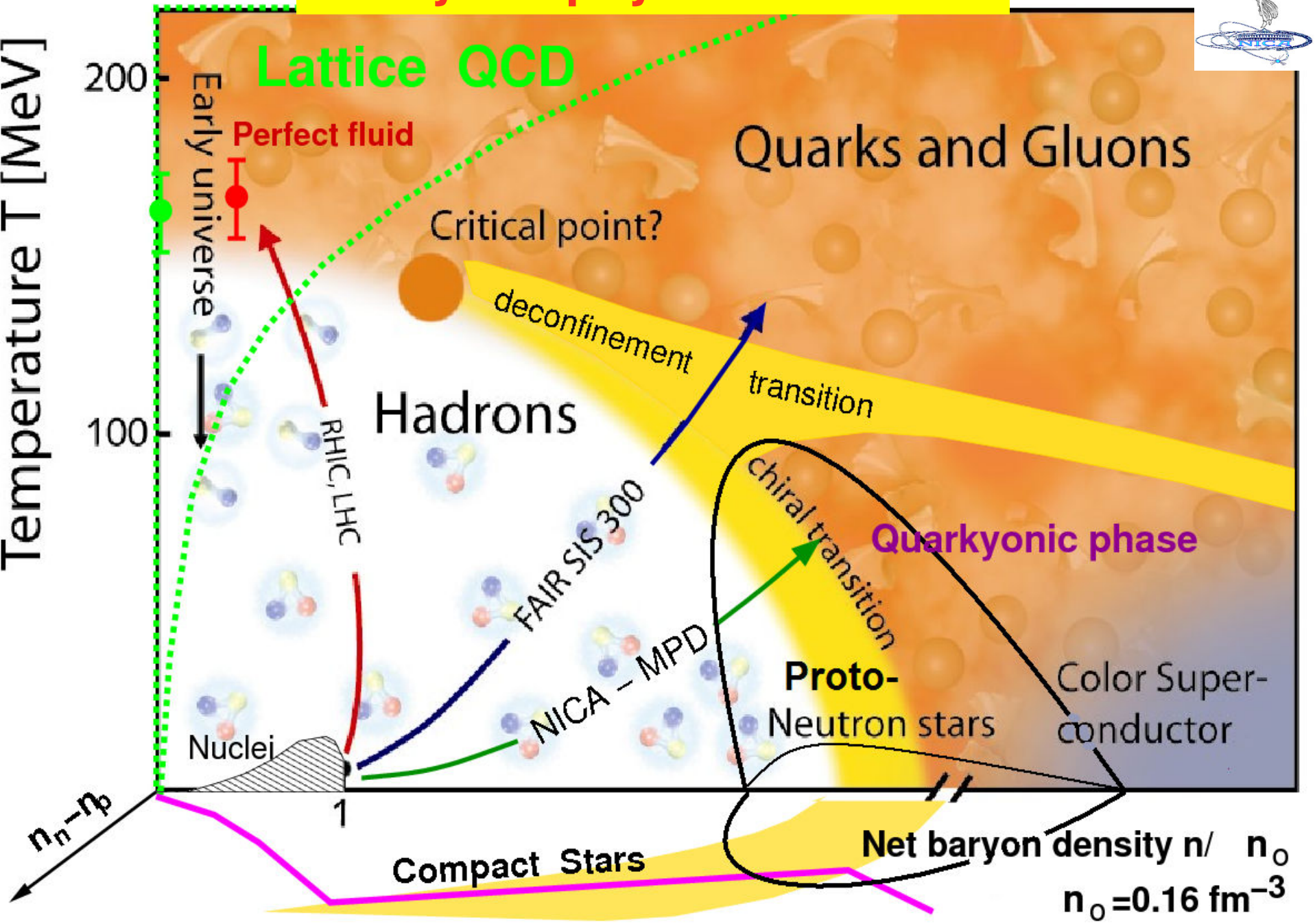
IREN-I
2008



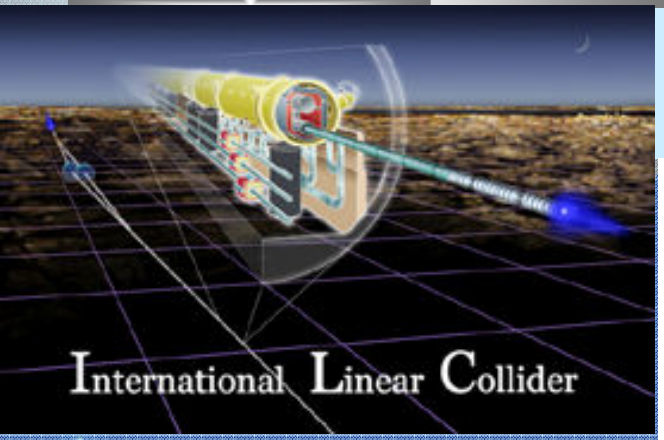


NICA general layout

Heavy ion physics at NICA



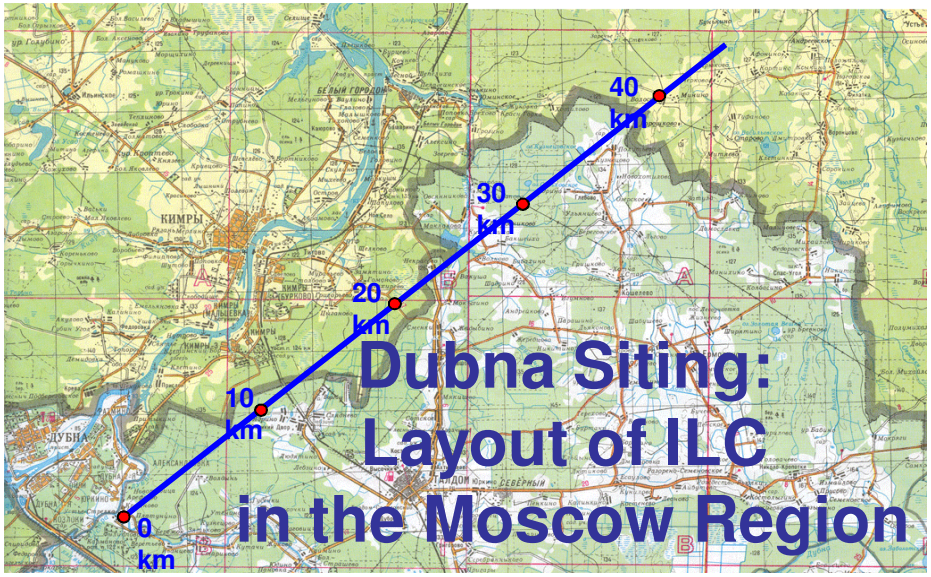
International Linear Collider



The activities at JINR on Physics and Detector for ILC are underway and will be continued in order to provide JINR's visible participation in this ambitious project.

Challenging tasks

- Factory of the Higgs boson
- Supersymmetry
- Dark matter, dark energy
- …



A vitally important task is attracting young people from all the Member States to science

EDUCATIONAL PROGRAMME

JINR UNIVERSITY CENTRE

More than 300 students and postgraduates from Member States are trained at the UC

Chairs: MSU | MIPT | MEPI | MIREA | others

JINR is a school of excellence for the Member States!

"Dubna" International University

DIAS - TH

Dubna International Advanced School on Theoretical Physics

The UC offers graduate programmes in the fields of:

- Elementary Particle Physics
- Nuclear Physics
- Theoretical Physics
- Condensed Matter Physics
- Technical Physics
- Radiobiology

General Information

Special Economic Zones

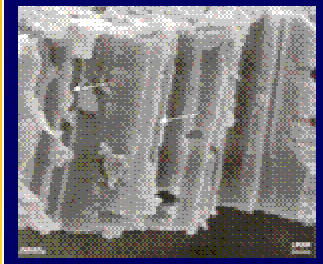
II.

The Special Economic Zone in Dubna, Moscow region

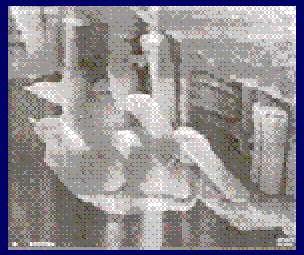
SEZ main specialization

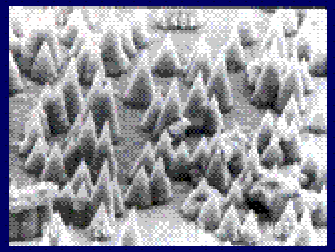
II.

Nanotechnologies

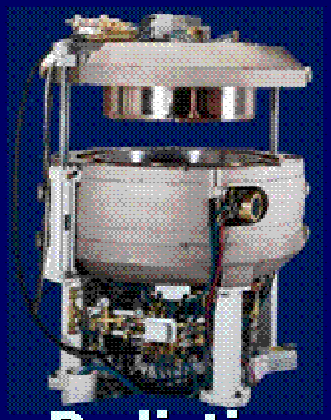


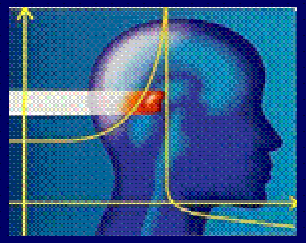
COPPER MICROTUBES





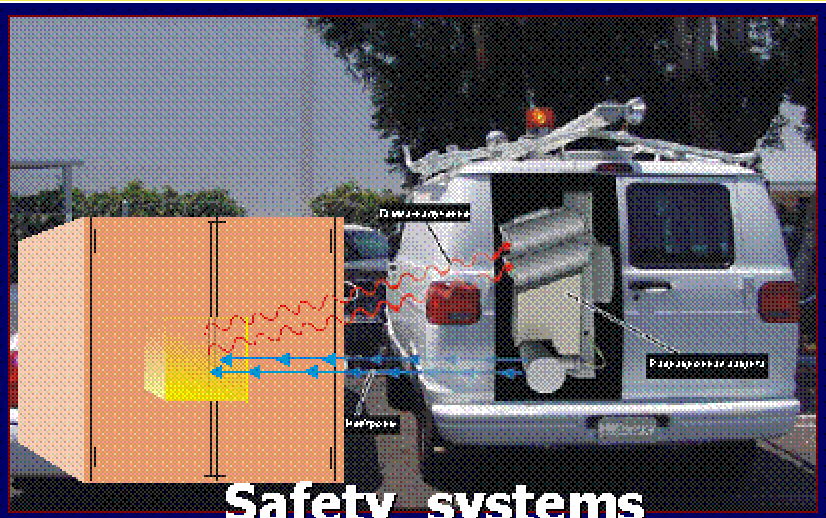
METALLIC NEEDLES





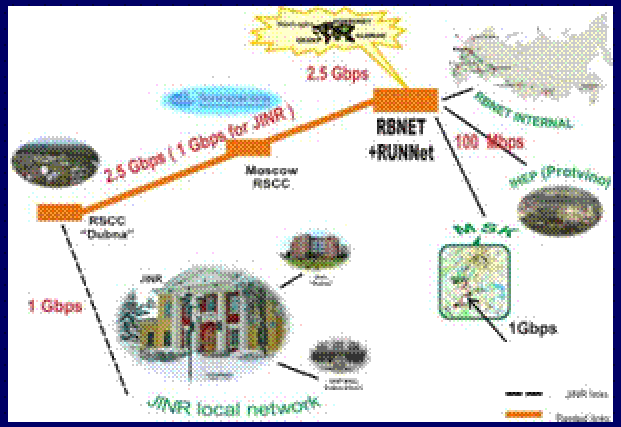
Hadron therapy

Radiation medicine



Safety systems

IT and Telecommunication



President D. Medvedev Visits JINR on 18 April 2008

II.

President D. Medvedev noted the importance of the future realization of two large-scale projects proposed by JINR: establishment at Dubna of a Centre for Radiation Medicine and of an International Innovation Centre for Nanotechnology (IINC).

Cooperation with CERN

The history of cooperation between CERN and JINR spans over 45 years.

CERN is JINR's main partner in Particle Physics.

Dubna physicists are widely involved in more than 20 CERN projects, including 3 LHC experiments

1963, JINR, Dubna
CERN Director-General
Prof. V.Weisskopf,
Prof. V.Dzhelepov and
Prof. B.Pontecorvo

2004, CERN Director-General
Dr R.Aymar in Dubna

1971, Dubna
CERN Director-General
Prof. W.Jentschke
and JINR Director
Prof. N.Bogoliubov

NA4 – the First JINR-CERN Experiment

BCDMS
NA4 Collaboration

Bologna

CERN

Dubna

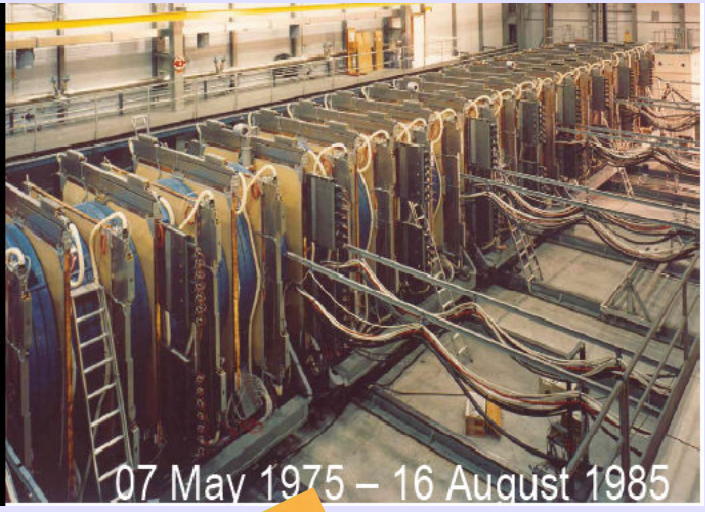
Munich

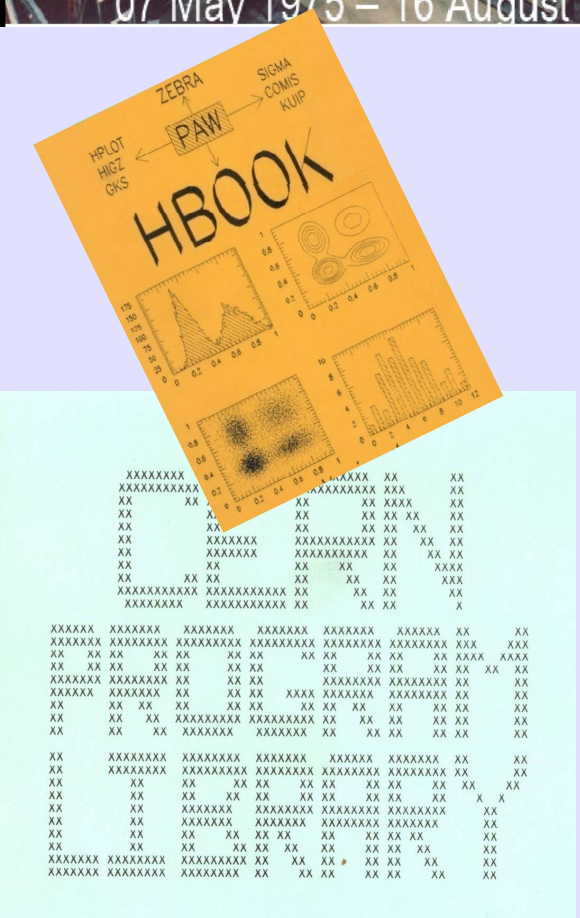
Saclay

Co-operation with CERN at SPS

JINR Dubna contribution to NA4 - 30 %

Chambers were delivered by IL-76 military aircraft





Первый совместный эксперимент с ЦЕРН – NA4 стал новым этапом сотрудничества и в области программного обеспечения.

В соавторстве с сотрудниками ЦЕРНа созданы пакеты программ для статистической обработки данных и динамического взаимодействия с функциональными программами. Разработаны распределённые системы для статистического анализа информации.

- (Brun R., Ivanchenko I., Palazzi P. HBOOK – histogramming, fitting and data presentation package. JINR,D10,11-11264,Dubna,1978; R. Brun, I. Ivanchencko, and P. Palazzi. *HBOOK users guide (Version 3), Program Library Y250 and DD/77/9*. CERN, 1977.
- Эта новая среда программирования, рассчитанная на широкий круг пользователей, радикально изменила технологическую основу систем обработки и анализа экспериментальных данных.
- В соответствии с соглашением с ЦЕРН специалисты ЛВТА/ЛИТ обеспечивают адаптацию и поддержку программного обеспечения ЦЕРН для операционных систем, используемых в ОИЯИ (LINUX, WINDOWS и т.д.).

Main BCDMS results

-Structure functions

$$F_2^p(x,Q^2), F_x^d(x,Q^2), F_2^c(x,Q^2)$$

have been measured with high precision (~1%) which is not exceeded up to now in the corresponding kinematic region

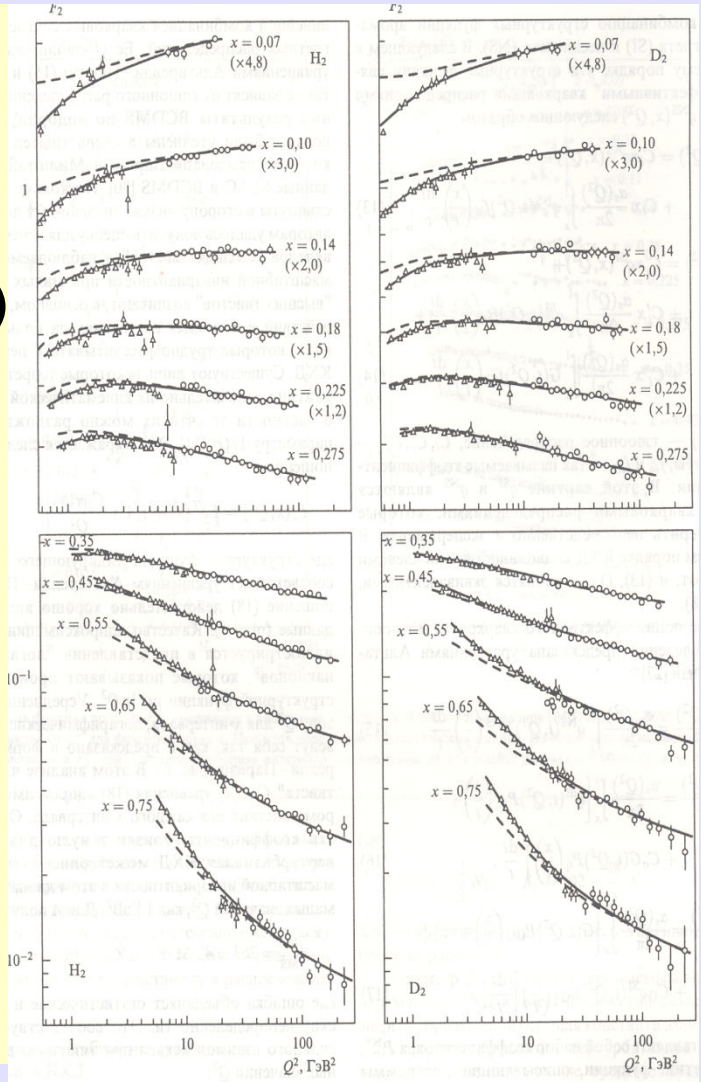
- Q^2 behaviour of F_2 is in agreement with QCD.

Parameter : Λ_{QCD}= 263±42 MeV

Corresponding to:

$$\alpha_s\left(M_Z^2\right) = 0{,}113 \pm 0{,}003(\text{exp.}) \pm 0{,}004(theor.)$$

(most precisely measured)



COmmon Muon and Proton Apparatus for Structure and Spectroscopy

COMPASS: эксперимент NA58

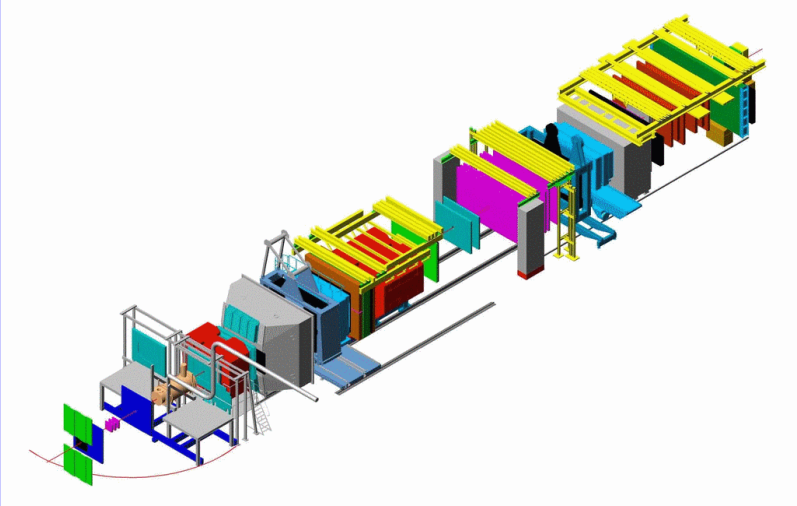
Участвует ~230 физиков из 11 стран

Чехия, Финляндия, Франция, Германия, Индия, Израиль, Италия, Япония, Польша, Португалия, Россия

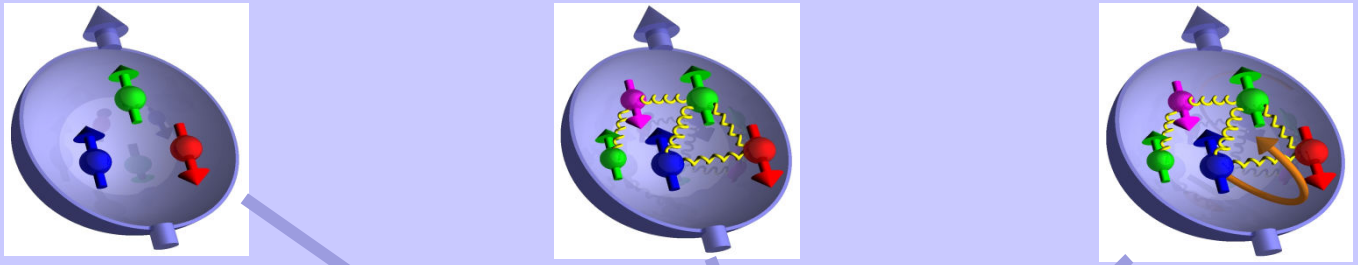
- **«Спиновый кризис»**

  Исследования процесса глубоко неупругого рассеяния поляризованных μ на протонной и дейтронной поляризованной мишенях при энергии **160** ГэВ/с.

- **Программа исследований с пучками** π, **K** , **p** при энергии **190** ГэВ/с **K**



Как образуется спин нуклона



$$S_N = \frac{1}{2} = \frac{1}{2}\,\Delta\Sigma + \Delta G + L_q + L_g$$

Наивная модель:

$\Delta\Sigma = \Delta u_v + \Delta d_v = 1$

Полная картина :

- $\Delta\Sigma = \Delta u + \Delta d + \Delta s$ (for q and $\bar{q}$)
- ΔG
- орбитальный угловой момент

ОИЯИ на LEP

- **1989-2000 гг. - Проведение совместных экспериментов на коллайдере LEP в ЦЕРН.**

Основные результаты:

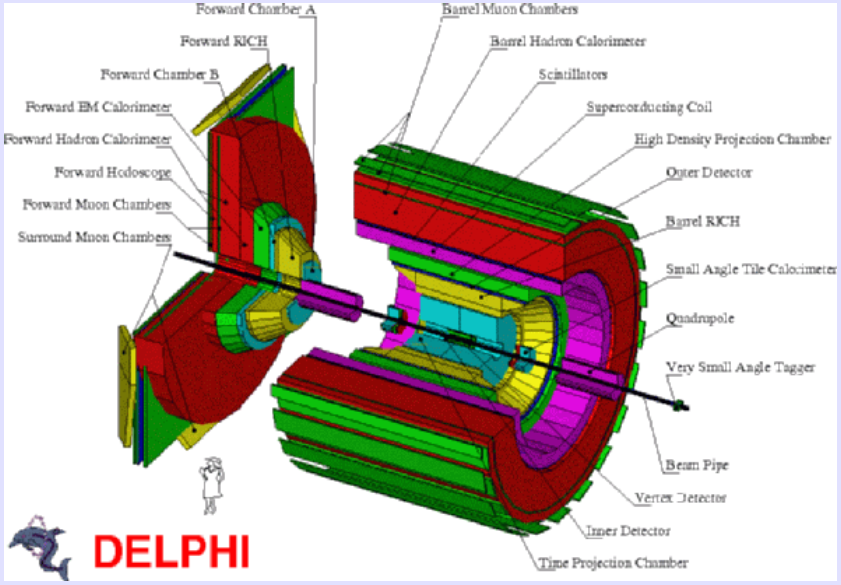
✓определение числа поколений фундаментальных фермионов,

✓ наблюдение зависимости констант взаимодействий от шкалы энергии процессов,

✓точное измерение масс и констант взаимодействия Z- и W-бозонов,

✓ экспериментальное подтверждение существования трех-глюонной вершины и многие другие.

ОИЯИ на LEP – эксперимент ДЭЛФИ

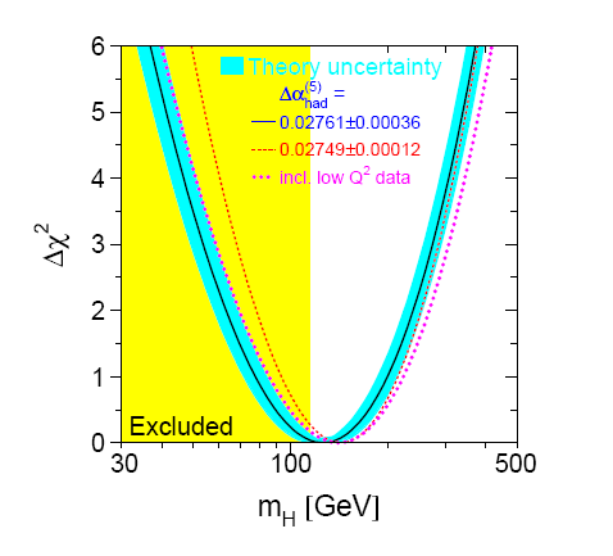


Вклад :

✓Создание адронного калориметра;

✓ Создание дополнительных мюонных камер;

✓Обработка данных эксперимента.

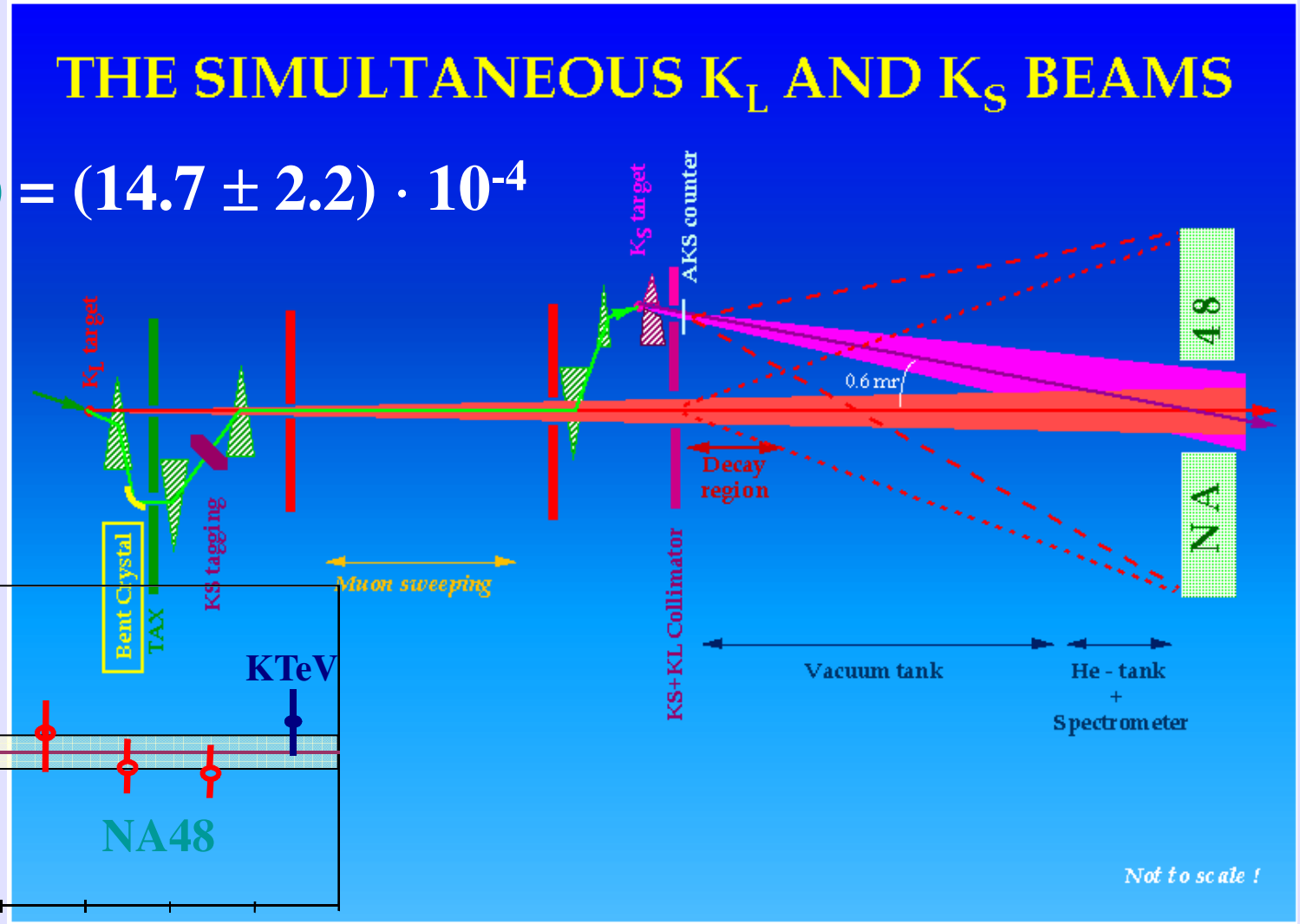


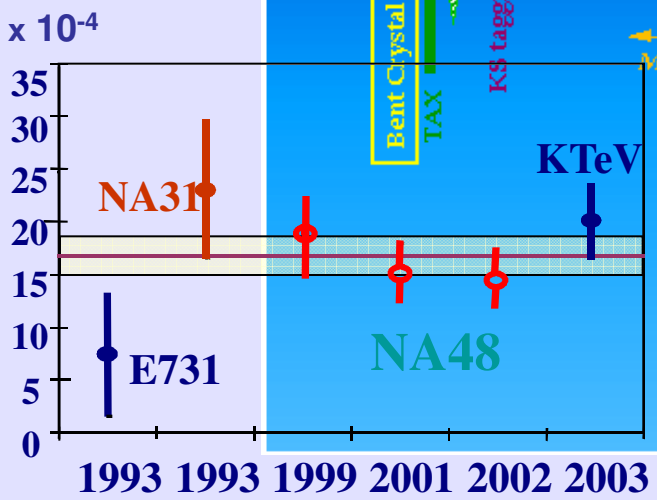
Полученные физические результаты:

- дополнили наши представления об элементарных частицах и их взаимодействиях;
- наметили пути дальнейших исследований в Стандартной Модели, физике КХД, физике двухфотонных взаимодействий и других областях.
- Предсказания на массу еще не открытого бозона Хиггса

Direct CP violation in NA48

$Re(\varepsilon'/\varepsilon) = (14.7 \pm 2.2) \cdot 10^{-4}$





NA48/2 (spokesperson Prof. V.Kekelidze, JINR)

II.

Two major parameters - *a0* and *a2* of pi-pi scattering lengths have been extracted with an unprecedented experimental precision of few percents.

This result is highlighted at CERN as experimental achievement in 2008

Measurement of pi-pi sc. length in two processes

- *Cusp :* $a_0 = 0.224 \pm 0.004 \pm 0.011_{theor.}$
- *Ke4 (FF phases):* $a_0 = 0.220 \pm 0.008$

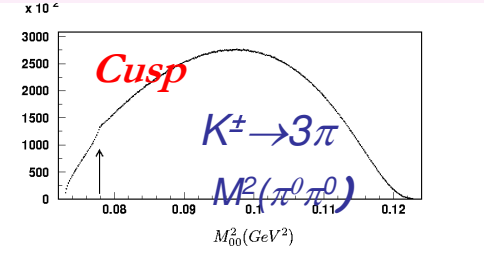
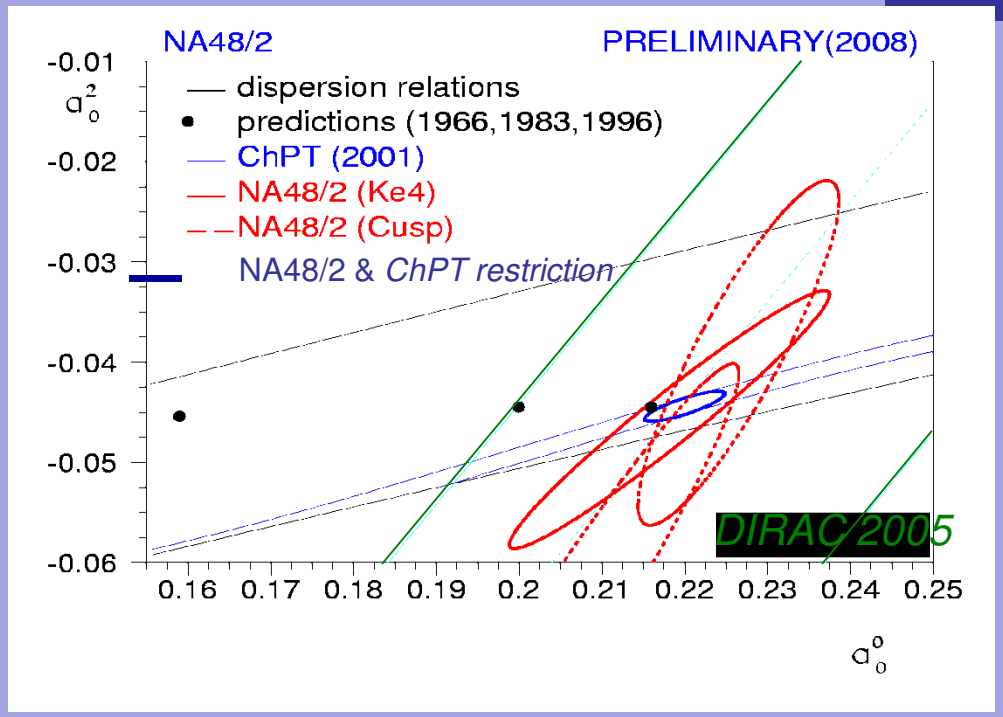
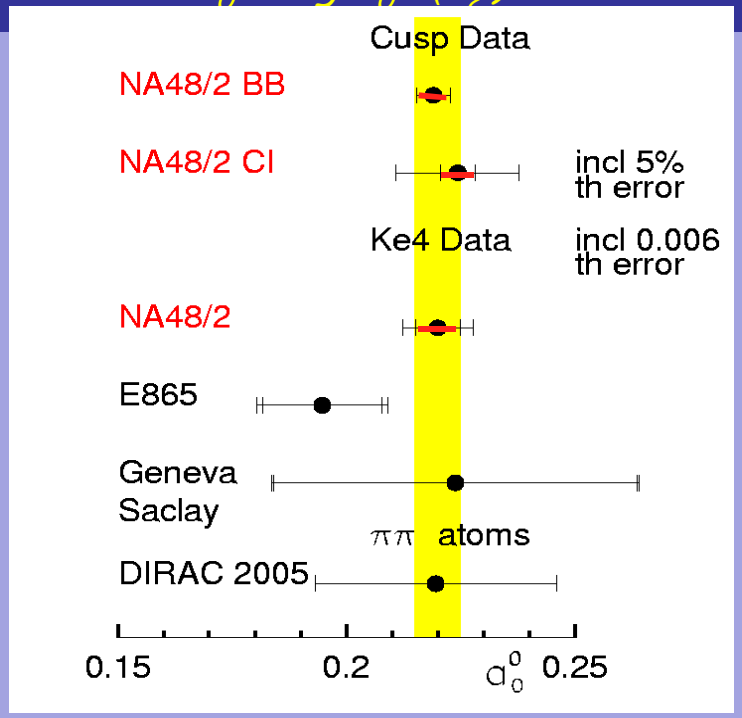


Рис. 1: Distribution of the $\pi^0\pi^0$ invariant mass squared in $K^{\pm} \to \pi^{\pm}\pi^0\pi^0$ decays for NA48/2 experimental data

measurements of a_0 & a_2

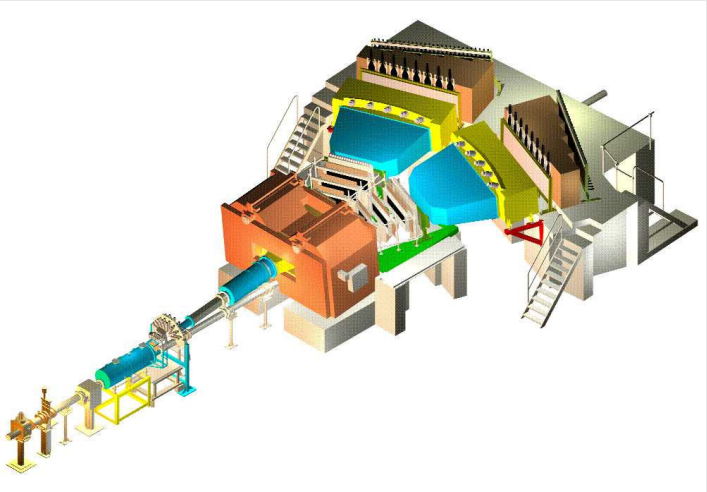


measurement of a_0 using a_0=f(a_2) from ChPT



ОИЯИ в ЦЕРНе: другие эксперименты

Эксперимент DIRAC

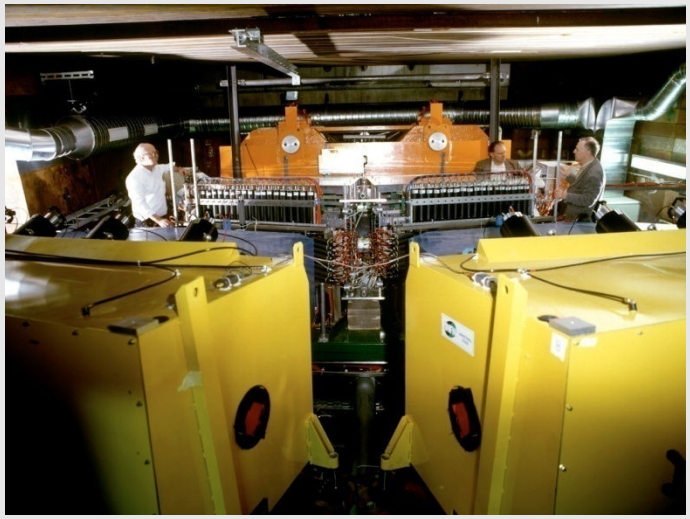


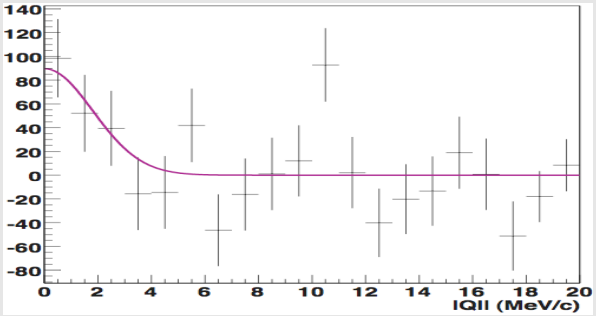
Цель: измерения времени жизни атомов $\pi^+\pi^-$, π^+K^- и π^-K^+ для проверки прецизионных предсказаний низкоэнергетичной КХД

Ожидаемые результаты:

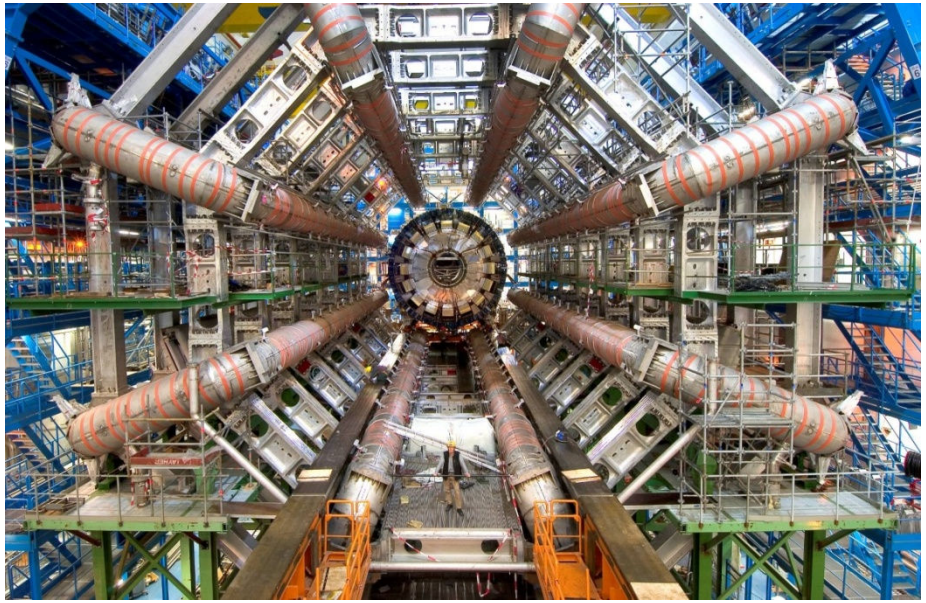
✓Улучшение точности измерения времени жизни атомов $\pi^+\pi^-$ до 6%;

✓Наблюдение атомов, состоящих из π^+K^- и π^-K^+ мезонов





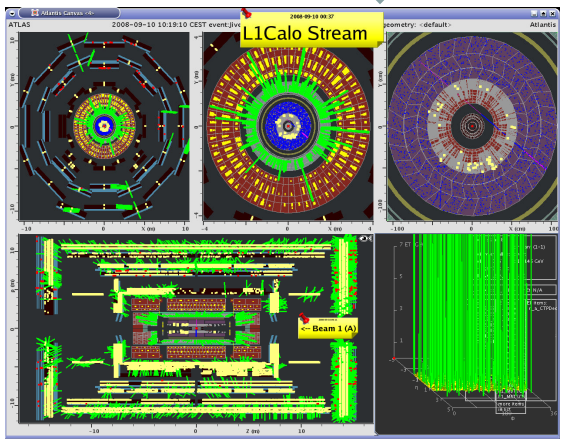
LHC: ATLAS DETECTOR



The experiment was ready for the LHC start-up in September 2008

All JINR's obligations to ATLAS were successfully fulfilled

The very first beam-splash event from the LHC in ATLAS on 10:19, 10th September 2008



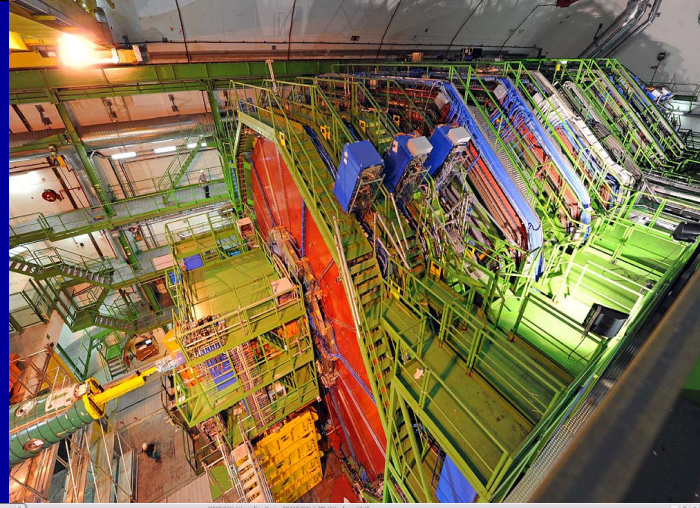
The most important contributions of JINR to the ATLAS detector are:

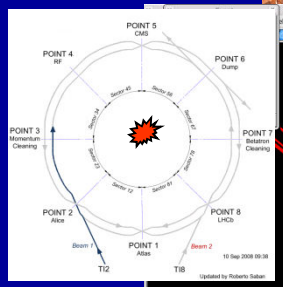
- ***Muon system (MDT chambers)***
- ***Tile Calorimeter***
- ***Hadronic End Cap LAr Calorimeter***
- ***Transition Radiation Tracker***
- ***Development of the Data Acquisition***
- ***Calorimetry software***
- ***Magnet system assembly***

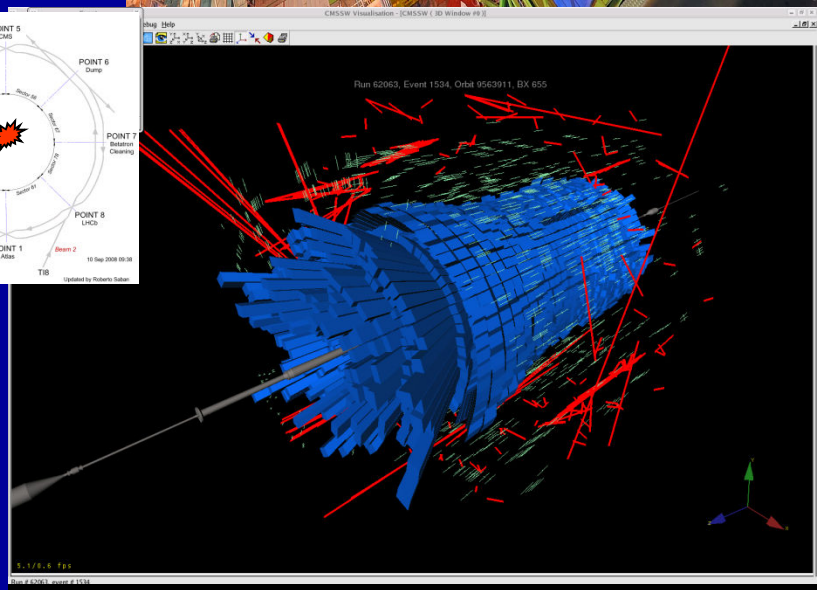
The JINR-ATLAS team now is fully concentrated on the awaited LHC physics

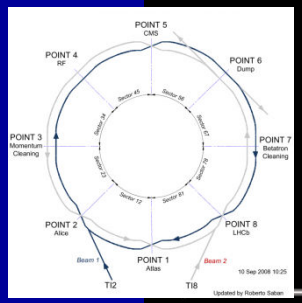
LHC: CMS Detector

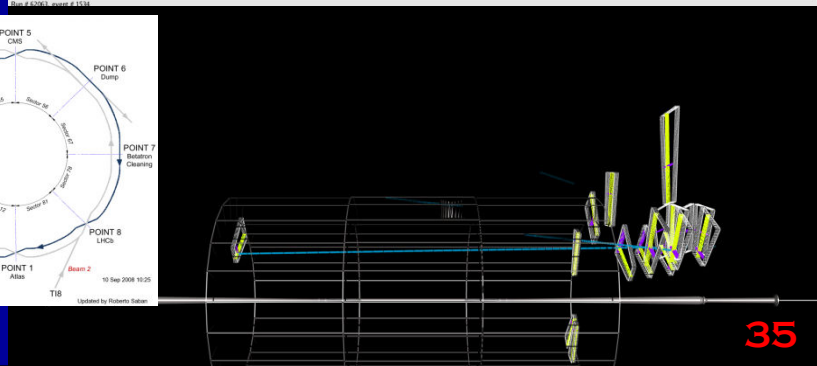
- *Inner Endcaps including endcap hadron calorimeter HE and Forward Muon Station ME1/1 of full JINR responsibility demonstrated an efficient operation*
  - *with beam dumped on collimator (on top) First Beam-Induced events in hadron calorimeters seen at CMS*
  - *and beam halo (bottom) in endcap muon system*





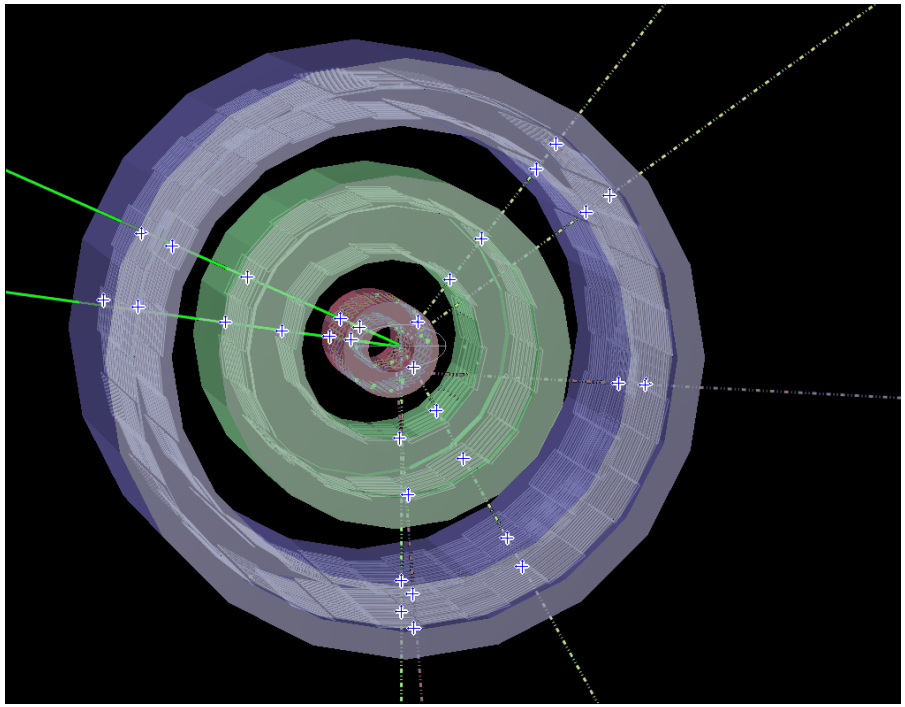






Detectors of full JINR responsibility are ready for data-taking

LHC: ALICE DETECTOR



Interaction of the proton beam with residual gas detected by ALICE Inner Tracking System during the start-up of the LHC

JINR obligations to the construction of the ALICE detector (a very large dipole magnet, drift chambers, lead tungstate crystals) have been fulfilled.

The first data on proton-proton collisions, expected in 2009-2010 will be analyzed at JINR via ALICE-GRID.

Physics goals: vector meson production (ω, ρ, ϕ), femtoscopy (particle correlations), heavy quarkonia production (J/Ψ – and ϒ - families).

Science Bringing Nations Together

European School on High-Energy Physics
Joint CERN-JINR schools since 1970

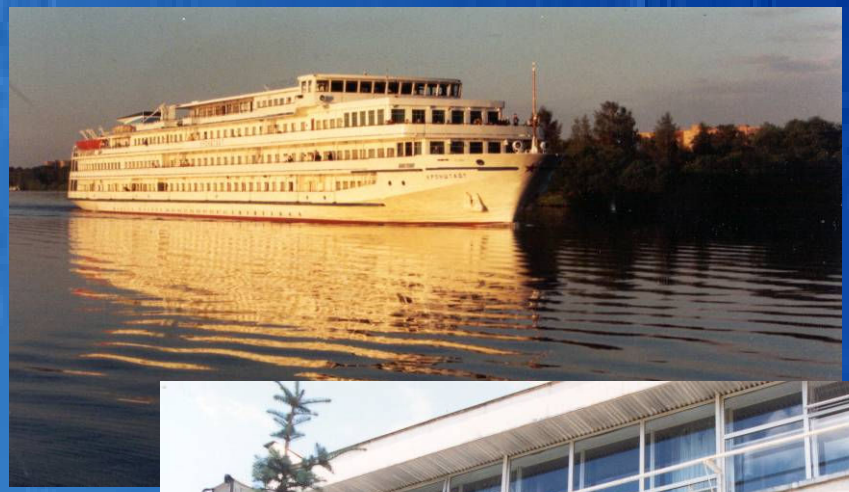
Tsakhkadzor, Armenia
24 August – 6 September 2003

Sant Feliu de Guíxols, Spain
May 30 - June 12, 2004

Following discussions between the Directors-General of CERN and of JINR, it was agreed that CERN should organize the 1970 School in collaboration with JINR in Finland, which at that time was not a Member State of either CERN or of JINR.

In 1971, JINR organized a School in Bulgaria in collaboration with CERN, following which it was decided to hold joint CERN – JINR Schools.

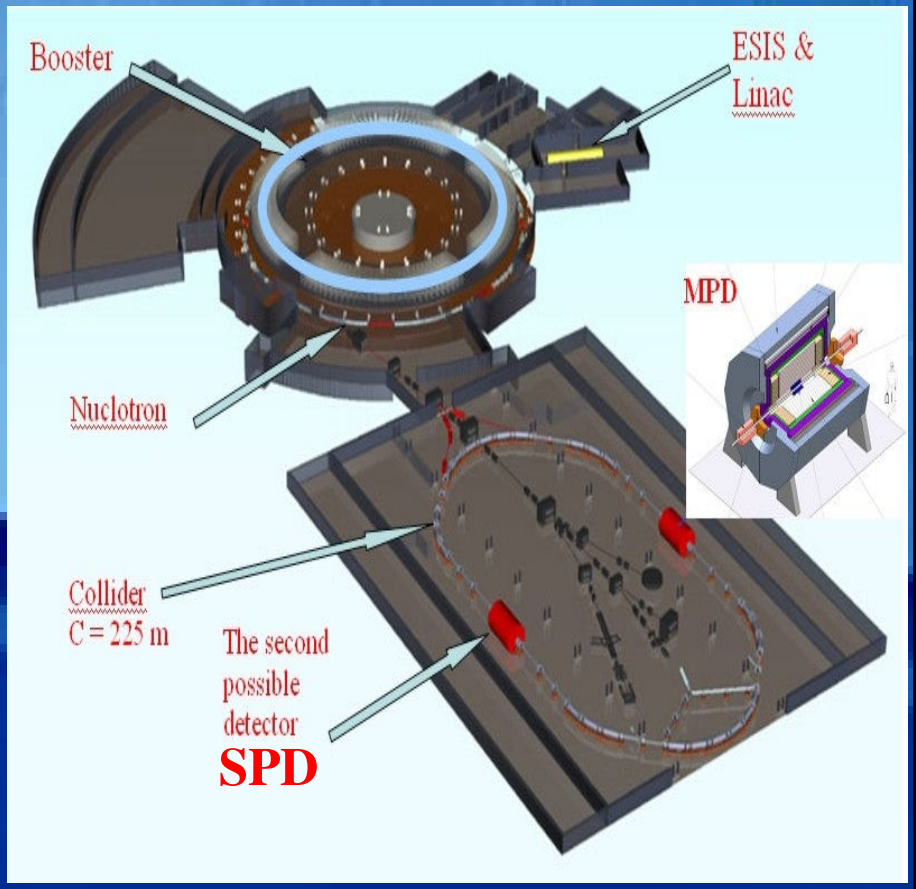
Welcome to JINR (Dubna)



NICA/MPD tentative list of observables

- Anti-proton to proton ratio
- Baryon to meson ratios
- Charged particle directed flow
- Charged particle elliptic flow
- DCC searches
- Elliptic flow for identified charged hadrons & photons
- Femtoscopy of identical particles
- Femtoscopy of $K\pi$, $\Xi\pi$, $\Omega\pi$, etc
- Fluctuations of particle ratios, esp. K/π, p/π
- Fluctuations of $\langle p_T \rangle$, $\langle v_2 \rangle$, photon multiplicity, etc
- Hyperons and light hypernuclei
- Invariant mass and p_T distributions of leptons
- Longe-range forward-backward correlations
- Net-proton and net charge kurtosis
- Nuclear modification factor
- Production of light nuclei and antinuclei
- Standard femtoscopy source parametrs
- Strong parity violation
- Triggered azimuthal correlations
- Untriggered pair correlation in $\Delta\varphi$ and $\Delta\eta$
- Yields of strange particles

NICA complex parameters



Circumference	m	225
Number of collision points		2
Beta function in the collision point	m	0.5
Rms momentum spread		0.001
Rms bunch length	m	0.3
Number of ions in the bunch		10^9
Number of bunches		15
Incoherent tune shift		0.05
Rms beam emittance at 1 GeV/u / at 3.5 GeV/u	π mm mrad	3.8 / 0.26
Luminosity per one interaction point at 1 GeV/u at 3.5 GeV/u	$cm^{-2}s^{-1}$	$6.6\cdot10^{25}$ $1.1\cdot10^{27}$

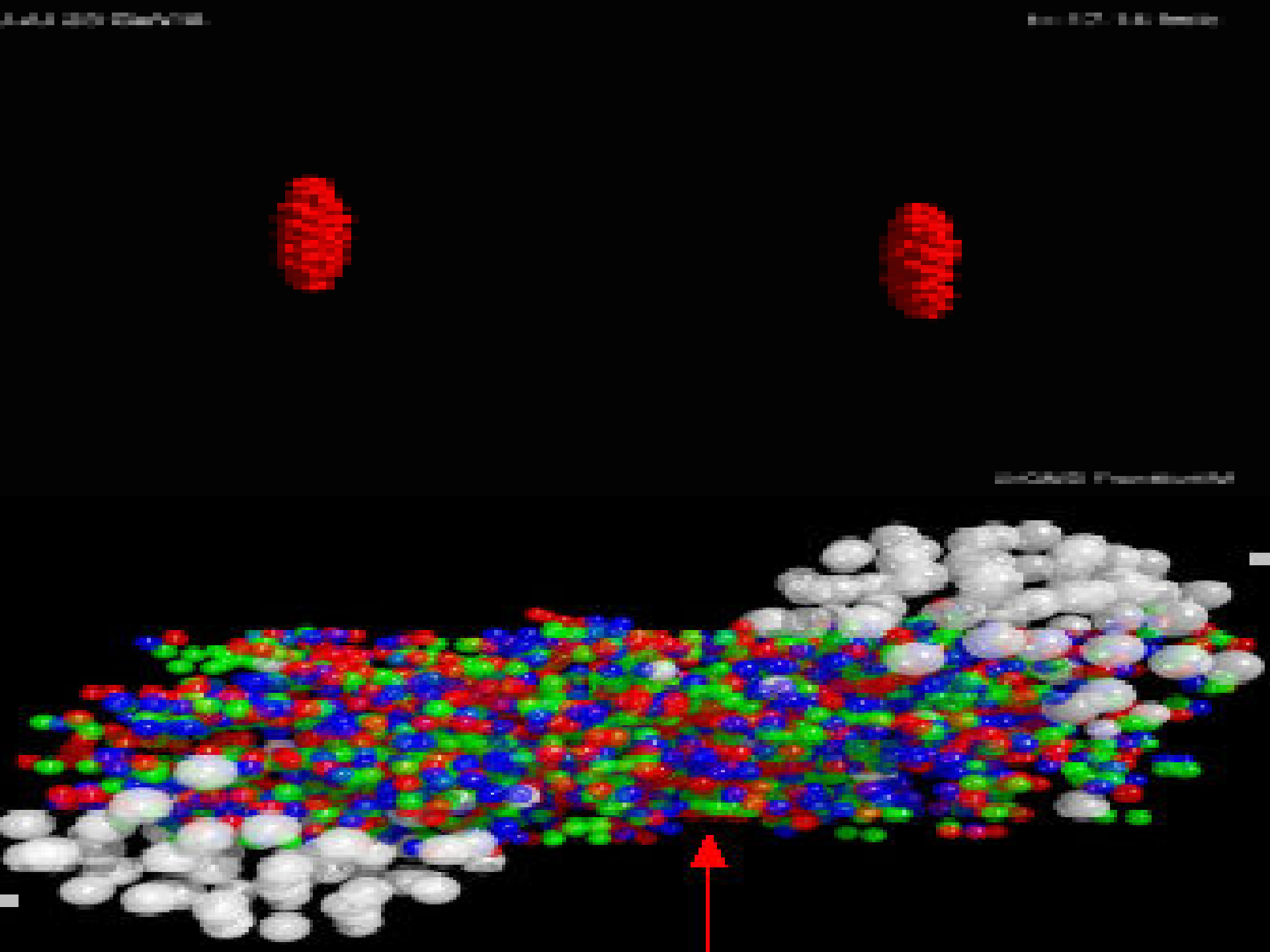
High Energy Physics

Nuclotron is a superconducting synchrotron for heavy ions

(has been operating since 1993).

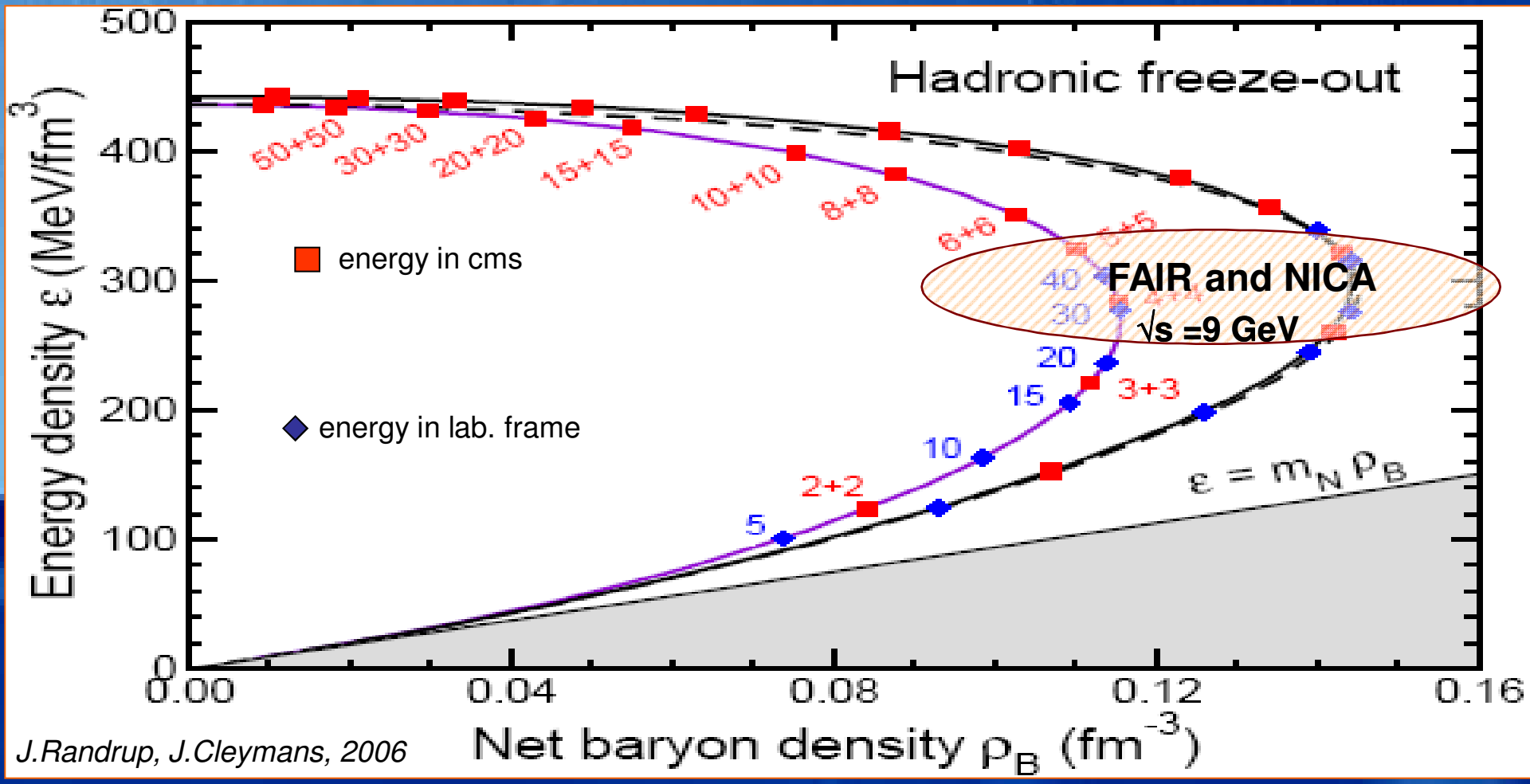
The main home facility (today): Nuclotron complex of VBLHEP (upgrade till 2010).

Future plan: creation of NICA/MPD – Nuclotron-Based Ion Collider Facility and Multipurpose Detector (2014).



High baryonic densities

II.



J.Randrup, J.Cleymans, 2006

Maximal baryonic densities on freeze-out curve! ⇨ High densities on interaction stage!?

The NICA Project Milestones

- **Stage 1: years 2007 – 2009**

- Upgrate and Development of the Nuclotron facility

– Preparation of Technical Design Report of the NICA and MPD

– Start prototyping of the MPD and NICA elements

- **Stage 2: years 2008 – 2012**

– Design and Construction of NICA and MPD

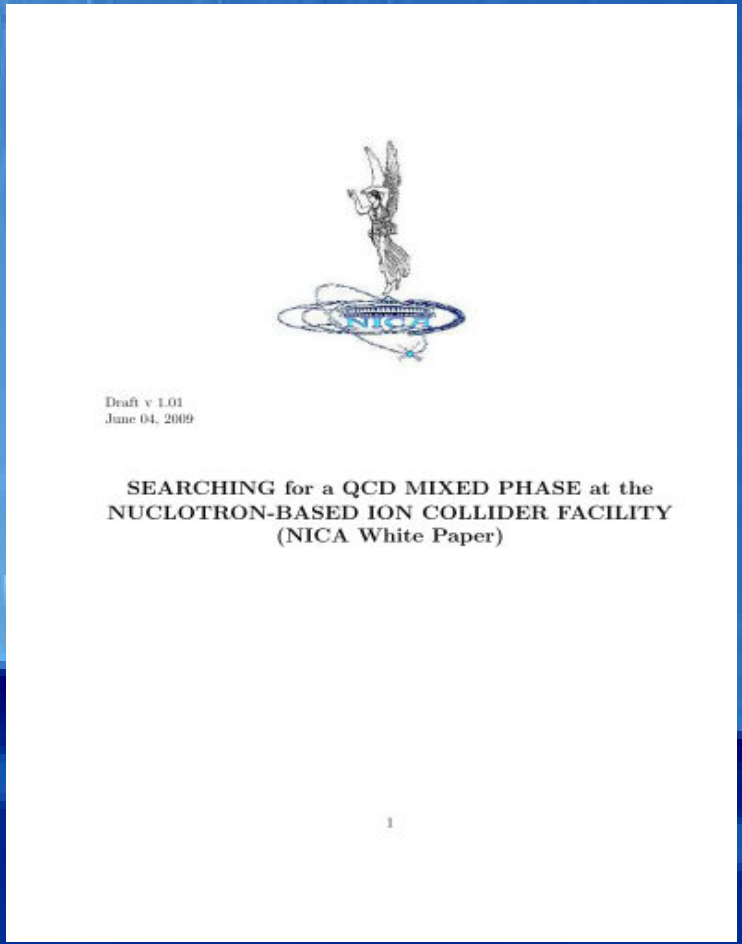
- **Stage 3: years 2010 – 2013**

– Assembling

- **Stage 4: year 2013 - 2014**

– Commissioning

Progress towards a White Paper on the NICA/MPD


Draft v 1.01
June 04, 2009

SEARCHING for a QCD MIXED PHASE at the NUCLOTRON-BASED ION COLLIDER FACILITY (NICA White Paper)

1

Editorial board:
D. Blaschke
D. Kharzeev
A. Sissakian
A. Sorin
O. Teryaev
V. Toneev
I. Tserruya

31 research centres in 15 countries (including 8 JINR Member States).

http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome

Computing

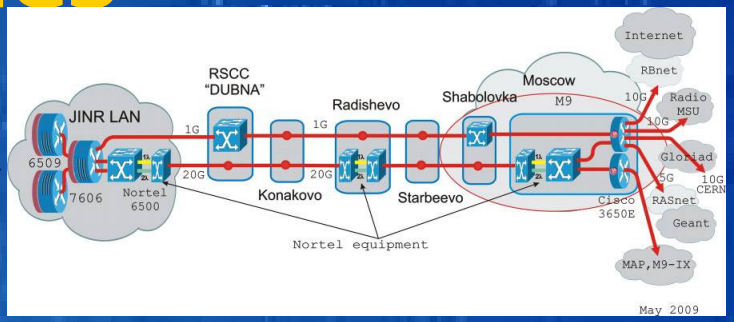
LIT: telecommunication, networking,
and computing infrastructure

LHC experiments
CERN, European and
US GRID programs

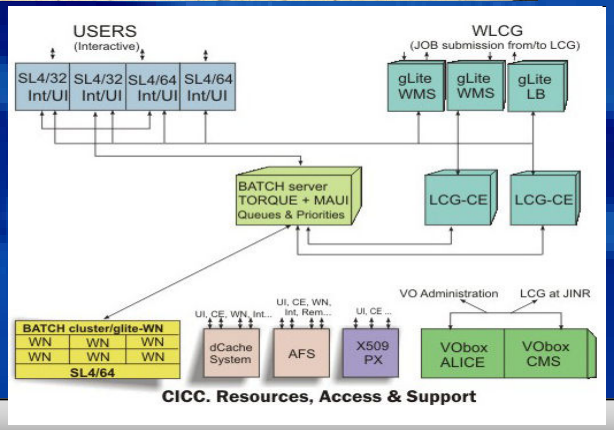
The home made implementations of open software,
CERN Projects: COMPASS-II, NA62
NICA/MPD/SPD
projects at FAIR complex,
International Linear Collider (ILC)

Laboratory of Information Technologies

- The high-speed 20 Gbps telecommunication data link Dubna – Moscow was installed. The availability of the applied technologies and state-of-art networking equipment will be used for further extension of the channel capacity up to 800 Gbps.



- The LIT plans to increase the Central Information and Computing Complex (CICC) performance up to 2300 KSI2K and the data storage up to 500 TB have been completed. The optimization of the network infrastructure of the JINR CICC was performed.

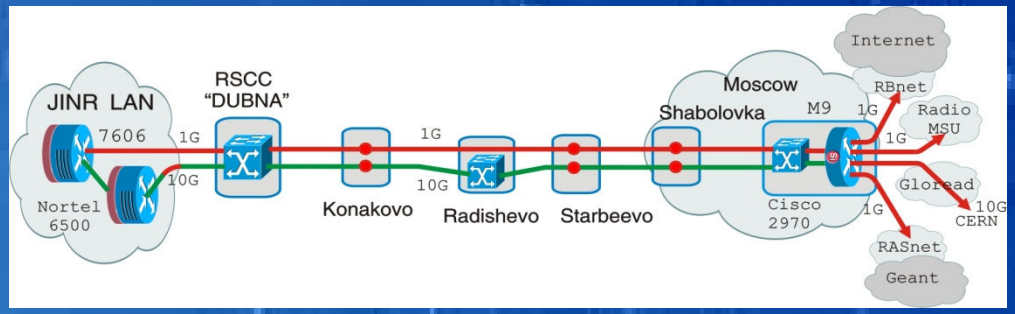


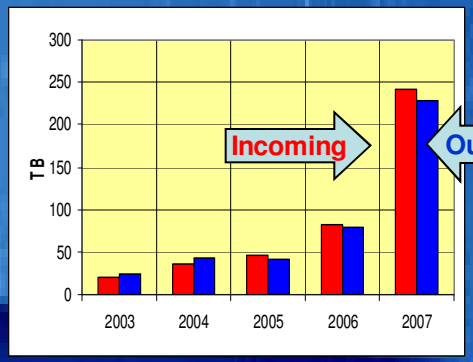
- The JINR CICC Grid-infrastructure testing in frame of the preparation of real data processing for LHC experiments is in progress.

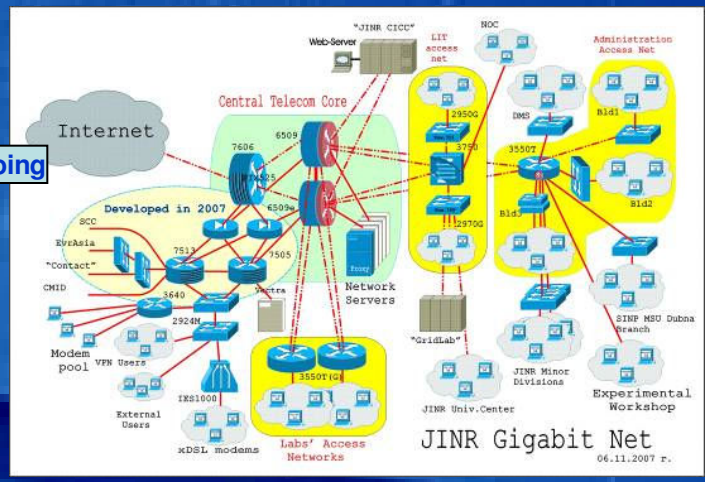
LHC experiments support

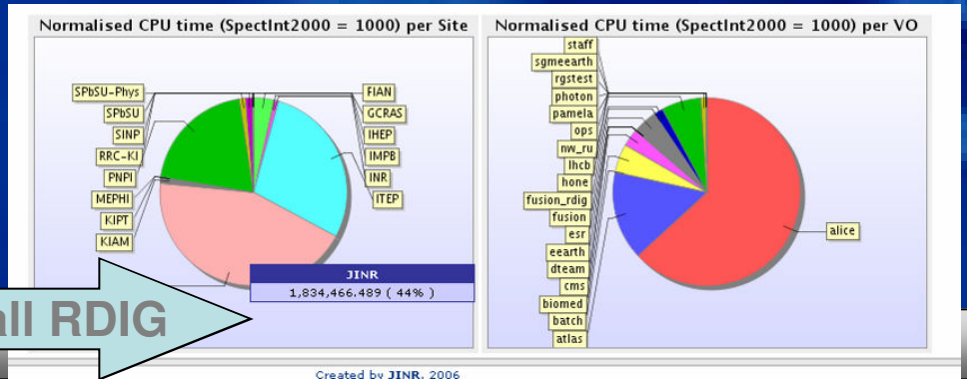
- Networking
- Computer power
- Data storage
- Software installation and maintenance
- Mathematical support

Grid – solution for LHC and other research



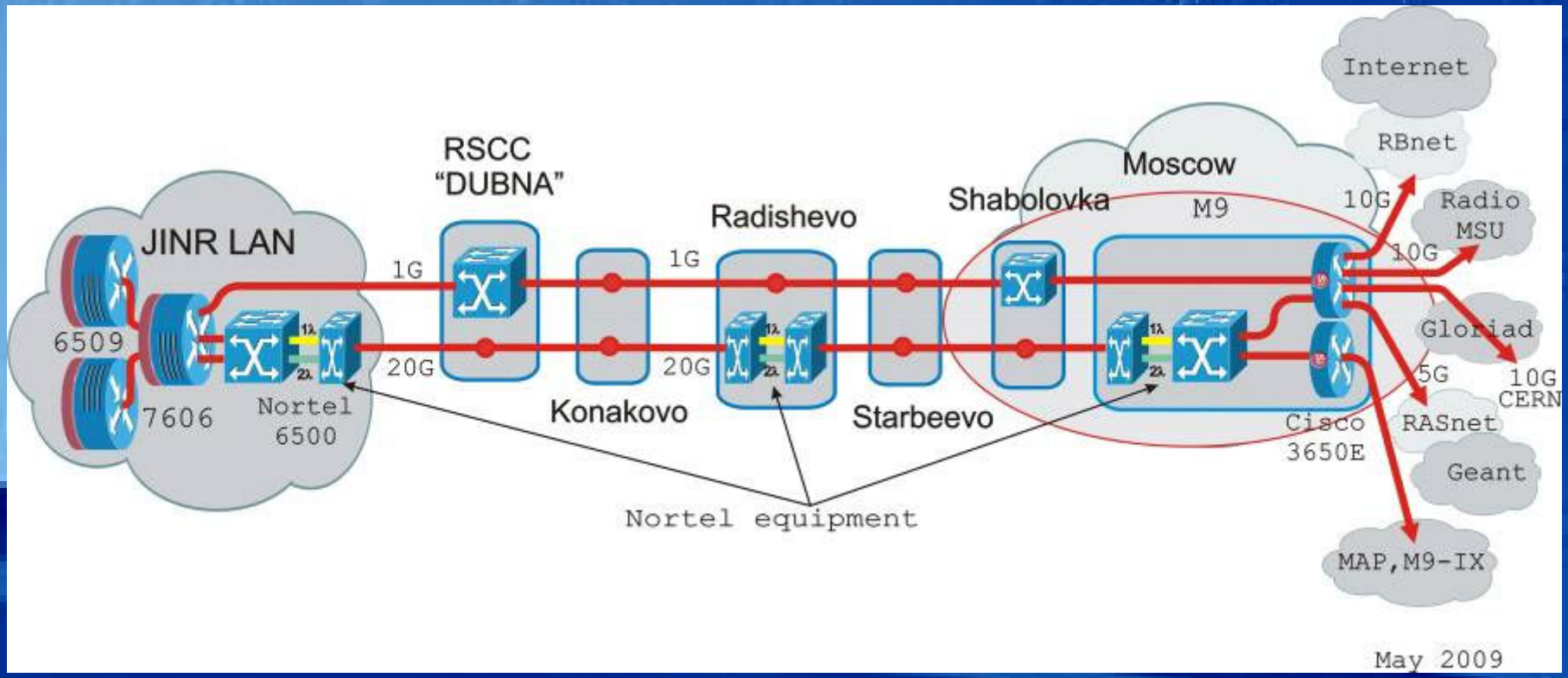






JINR – 44% of all RDIG

11 JUNE 2009
«Presentation of the new telecommunication channel JINR-Moscow and of the JINR Grid-segment»



Collaboration with RSCC, RIPN, MSK-IX, JET Infosystems, Nortel

Russian Satellite Communications Company
Federal State Unitary Enterprise

RIPN Russian Institute for Public Networks

MSK IX Московский Internet Exchange

EDUCATIONAL PROGRAMME
JINR University Centre: 1997-2008

- The number of students preparing their graduation diplomas at JINR has increased 9 times
- 7 new JINR-based university chairs have been opened
- more than 150 Master's theses are prepared each year
- creation of student laboratories began in 2005
- 174 people have completed the PhD programme at JINR
- International student practice in the JINR fields of research has been held since 2004
- Weekly classes (practicum) for secondary schools have been functioning since 2002
- 760 people have completed programs of training specialists for equipment operating and received their qualifications.

COMPASS : HADRON SPIN STRUCTURE

The main goals of the 2010-2016 experiment are:

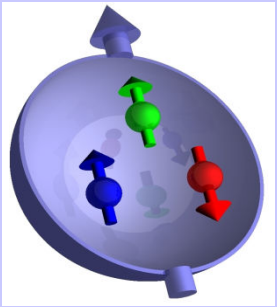
measurement of exclusive processes with the aim of obtaining data on Generalized Parton Distributions;

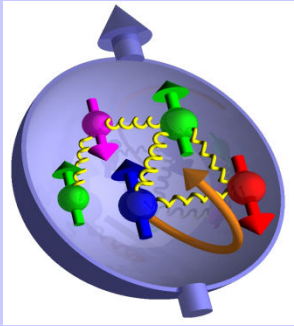
measurement of the MMTDY processes;

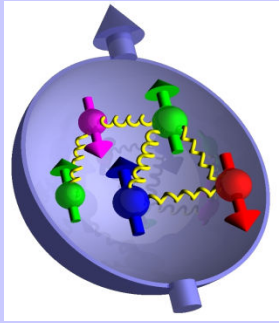
study of the transverse structure of the nucleon;

continued study of the longitudinal spin structure of the nucleon ($\Delta G/G$, parton distribution functions etc.);

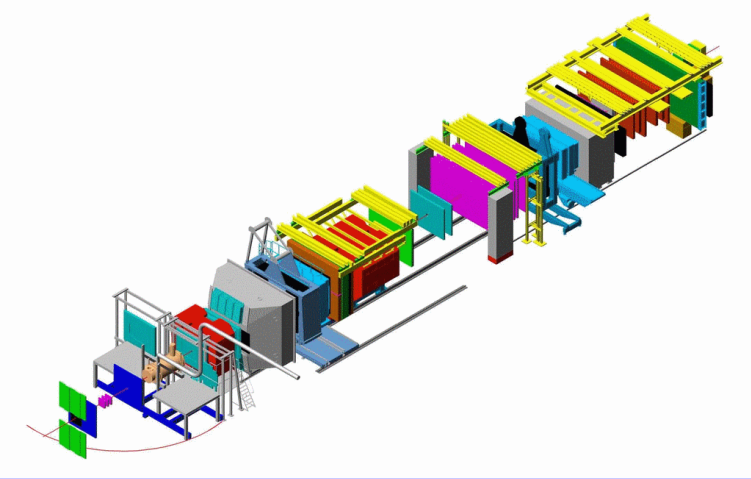
study of the doubly charmed baryons.

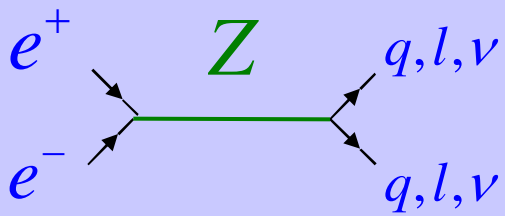






$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_z \rangle$$





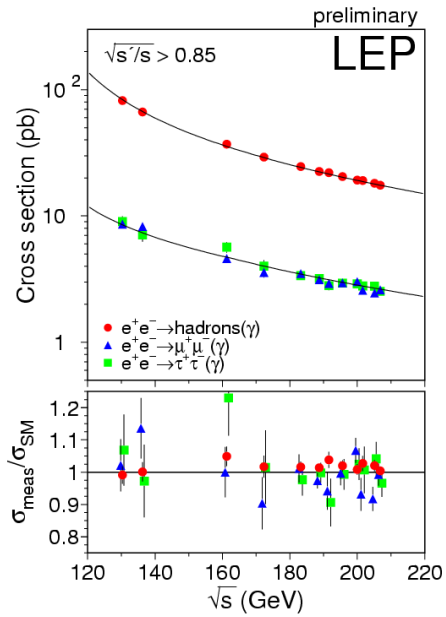
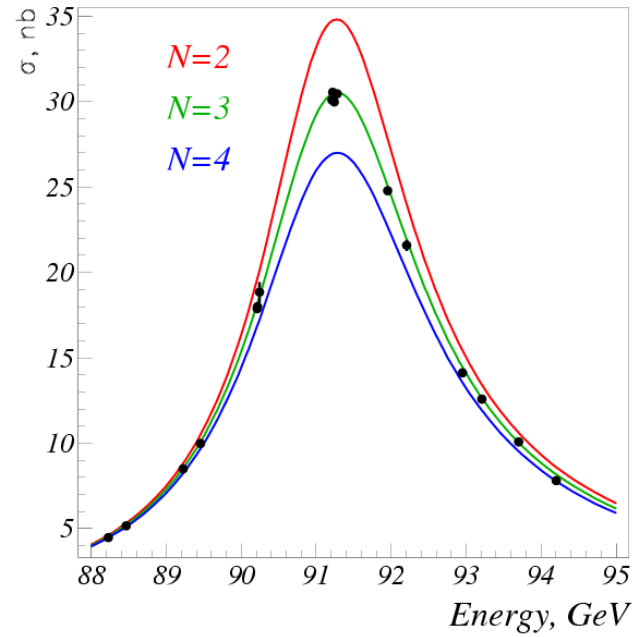


Figure 8.2: Preliminary combined LEP results on the cross-sections for $q\bar{q}$, $\mu^+\mu^-$ and $\tau^+\tau^-$ final states, as a function of centre-of-mass energy. The expectations of the SM, computed with ZFITTER [84], are shown as curves. The lower plot shows the ratio of the data divided by the SM.

37

ELECTROWEAK PHYSICS



(N is no. of light - wrt M_Z - neutrinos)

The main aim of LEP from the start

12

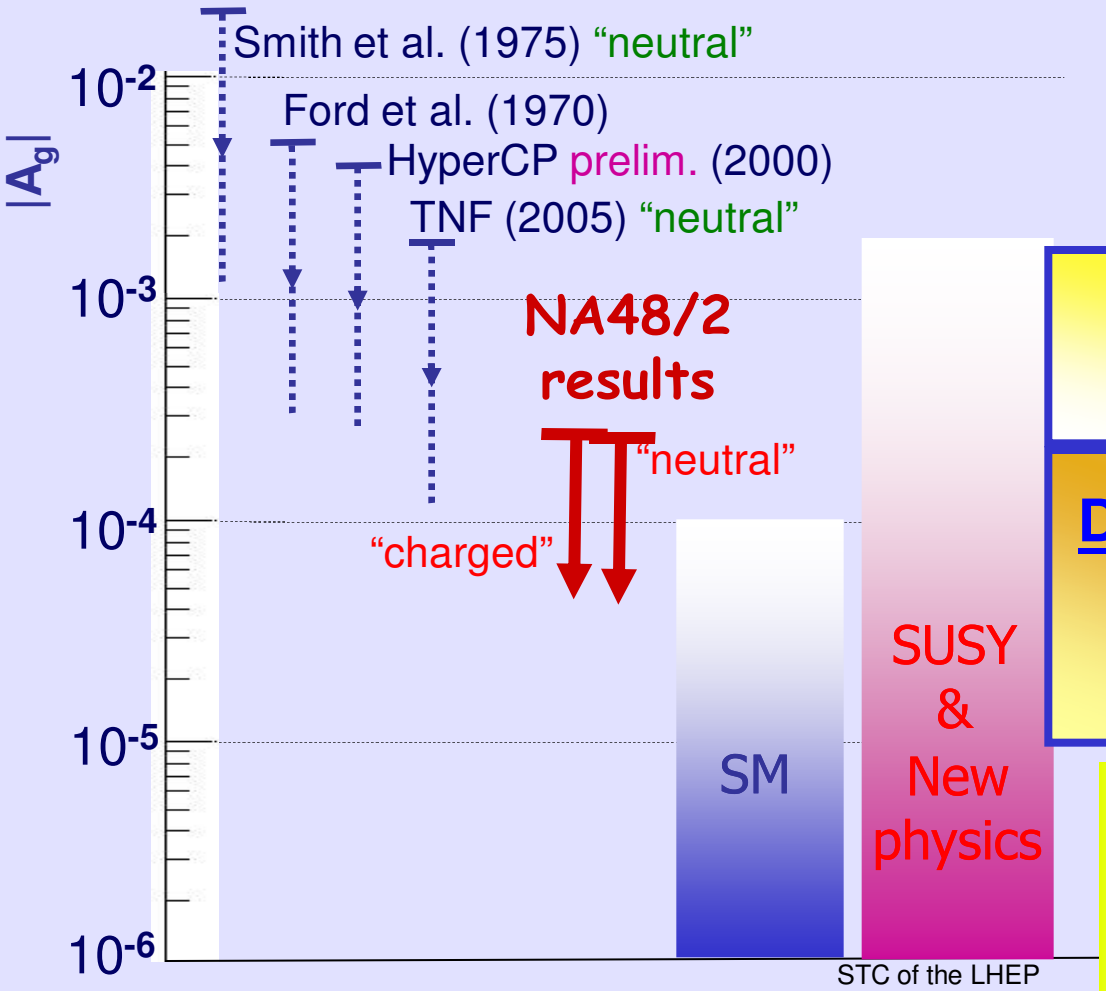
$$\sigma(e^+e^- \to hadrons) = \frac{12\pi\,\Gamma(Z \to ee)\Gamma(Z \to hadrons)}{(E^2 - M_Z^2)^2 + M_Z^2\Gamma_Z^2}$$

NA48/2: Search for the direct CP-violation in charged kaon decays

Two decay modes:

$BR(K^{\pm} \to \pi^{\pm} \pi^{+} \pi^{-}) = 5.57\%$ ("charged") $3.11 \cdot 10^{9}$ events

$BR(K^{\pm} \to \pi^{\pm} \pi^{0} \pi^{0}) = 1.73\%$ ("neutral") $9.13 \cdot 10^{7}$ events



Kaon rest frame:

$u = 2m_K \cdot (m_K/3 - E_{odd})/m_\pi^2$;

$v = 2m_K \cdot (E_1 - E_2)/m_\pi^2$.

Matrix element:

$|M(u,v)|^2 \sim 1 + gu + hu^2 + kv^2$

Direct CP-violating quantity: the slope asymmetry

$A_g = (g_+ - g_-)/(g_+ + g_-) \neq 0$

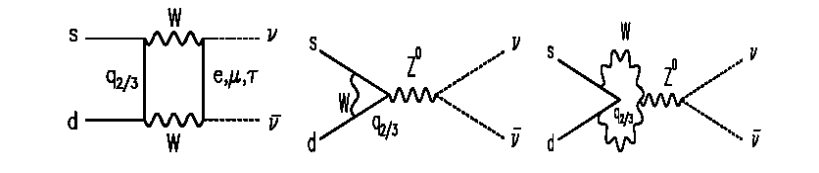
NA48/2 final results:

A_g (charged) $= (-1.5 \pm 2.2) \cdot 10^{-4}$

A_g (neutral) $= (1.8 \pm 1.8) \cdot 10^{-4}$

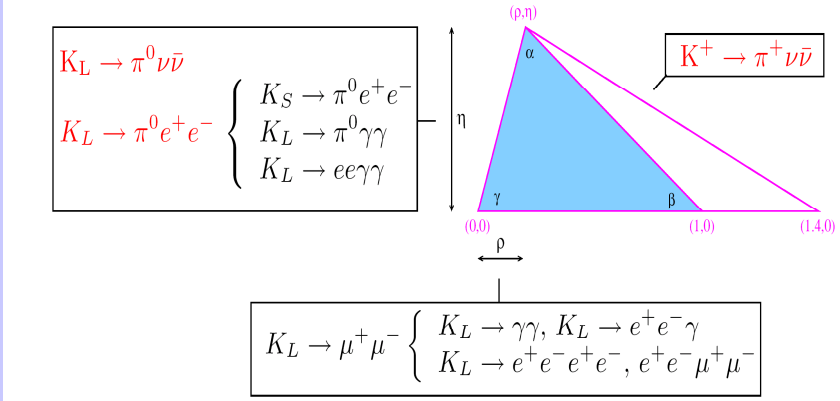
The $K^+ \to \pi^+ \nu\bar{\nu}$ decays: a clean test of SM

- Flavor Changing Neutral Current loop process: s→d coupling and highest CKM suppression



- Very clean theoretically: short distance contributions dominate in the matrix element; hadronic matrix element can be related to measured quantities ($K^+ \to \pi^0 e^+ \nu$).

Golden modes



SM predictions (uncertainties from CKM elements):

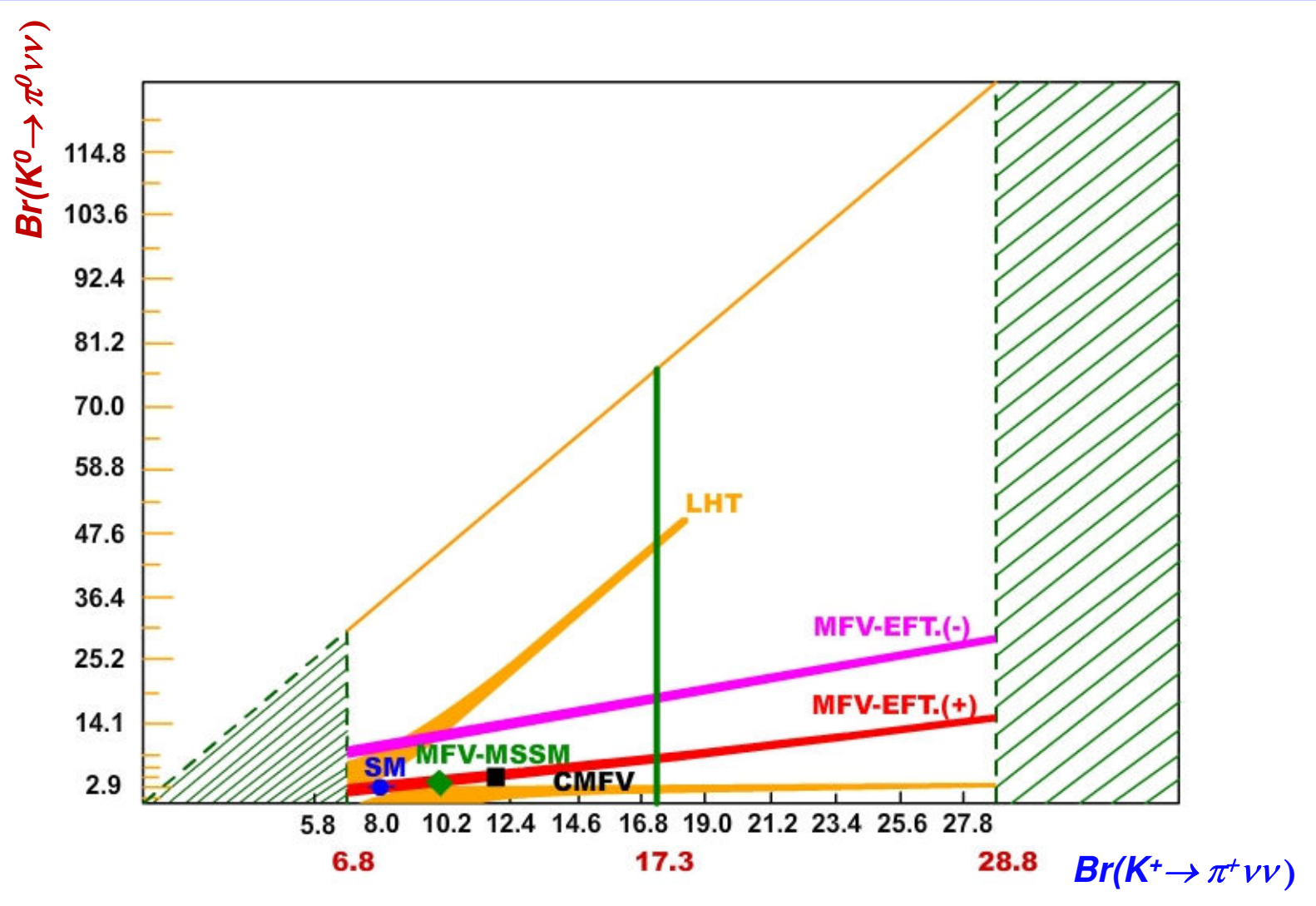
$BR(K^+ \to \pi^+ \nu\nu) \approx (1.6\times10^{-5})|V_{cb}|^4[sh^2+(r_c-r)^2] \to (8.0 \pm 1.1)\times10^{-11}$

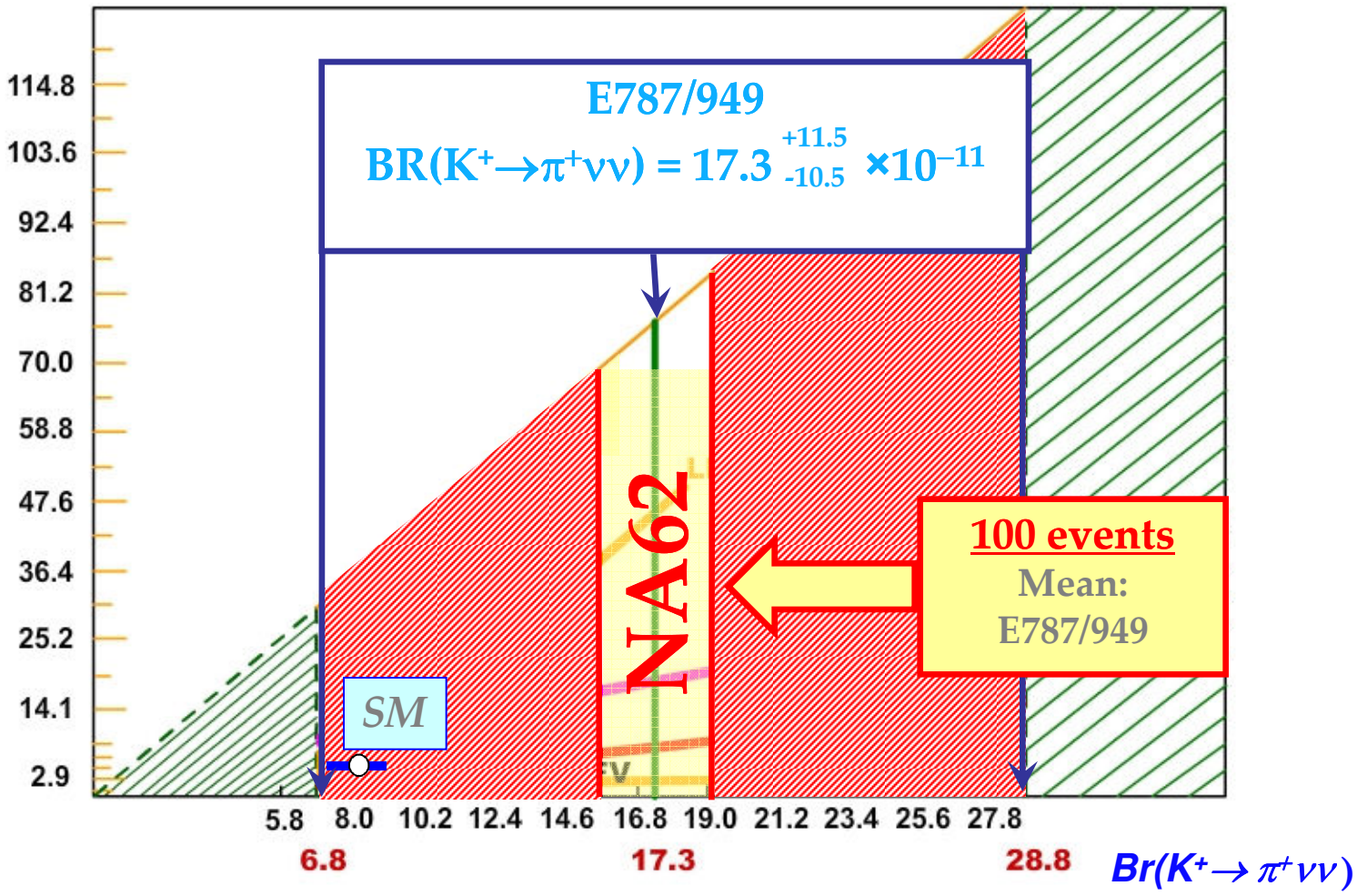
$BR(K_L \to \pi^0 \nu\nu) \approx (7.6\times10^{-5})|V_{cb}|^4 h^2 \to (3.0 \pm 0.6)\times10^{-11}$

Unique in K and B physics and extremely sensitive to New Physics

Present measurement (E787/949): $BR(K^+ \to \pi^+ \nu\nu) = 17.3\ ^{+11.5}_{-10.5} \times 10^{-11}$
(2008 - 6 events)

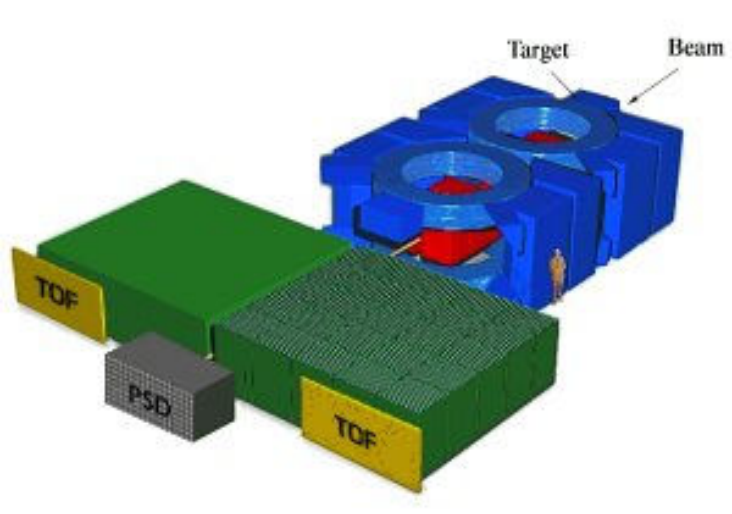
Effects of new physics on $K \to \pi \nu \bar{\nu}$ decays

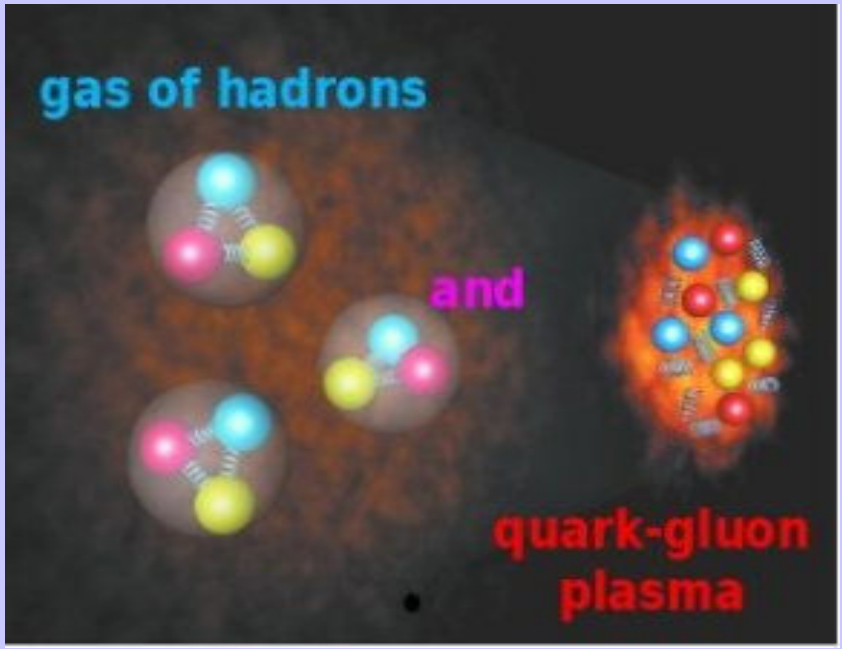



E787/949
BR(K+→π+νν) = 17.3 +11.5 -10.5 ×10−11
114.8
103.6
92.4
81.2
70.0
58.8
47.6
36.4
25.2
14.1
2.9
SM
NA62
100 events
Mean:
E787/949
5.8 8.0 10.2 12.4 14.6 16.8 19.0 21.2 23.4 25.6 27.8
6.8
17.3
28.8
Br(K+→ π+ νν)

NA61 : Interaction of Nuclei at 20-158 GeV

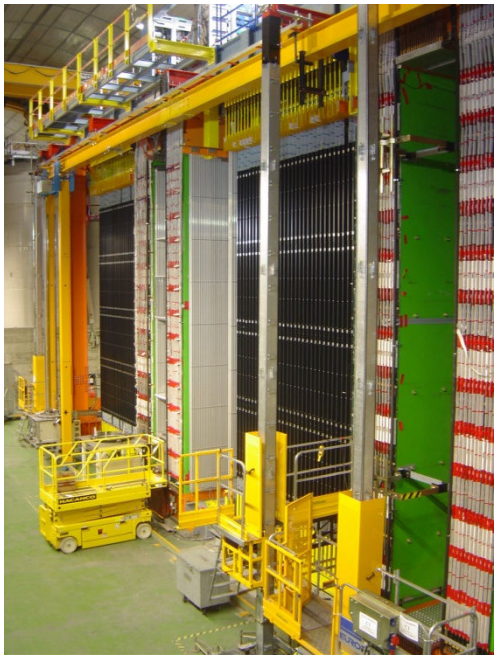
- continues a series of experiments at the NA49
- interactions of nuclei of various size (A) at the energies 20-158 GeV/n
- phase transition from hadron matter to quark-gluon plasma and mixed phase
- hadron production for neutrino and cosmic ray experiments
- JINR team will participate in this program for the period preceding the start-up of the NICA accelerator complex.

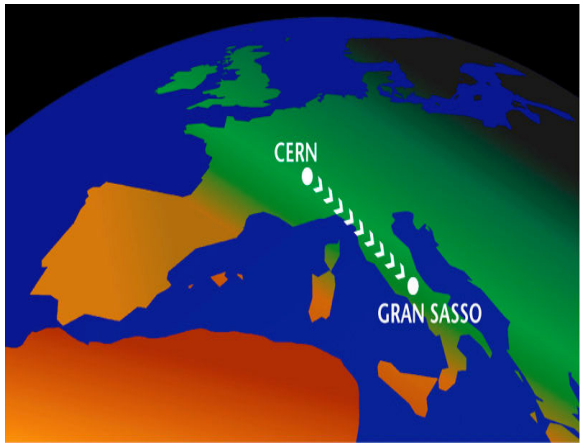


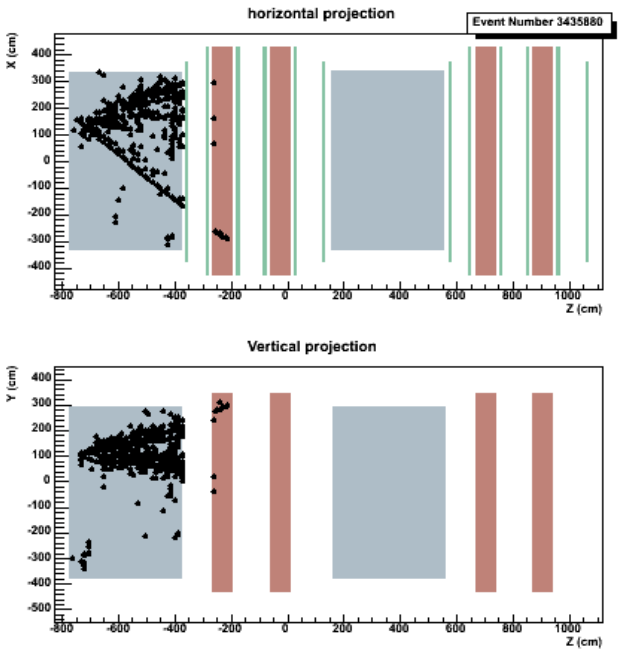


ОИЯИ в ЦЕРНе: другие эксперименты

Эксперимент OPERA – потомок эксперимента NOMAD





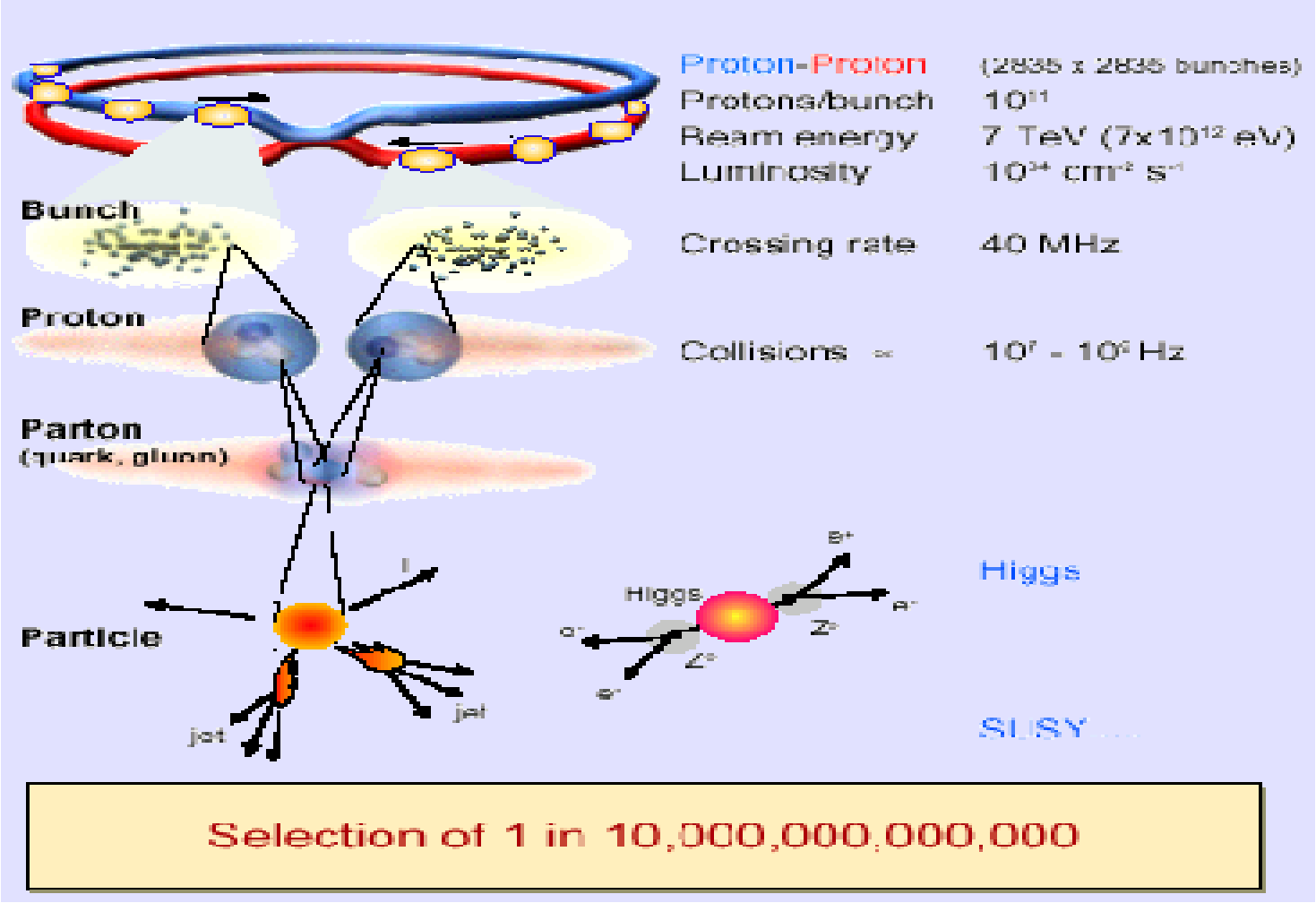


Первые нейтринные события, зарегистрированные детектором OPERA

2008 г.– установка собрана (1.8x10^{19} блоков системы целеуказания)

2009 г. и далее – набор данных в течении 5 лет (2.5x10^{20} блоков системы целеуказания)

ОИЯИ на LHC



Цель – «поймать» бозон Хиггса

Главная надежда – ускоритель LHC

LHC Damper

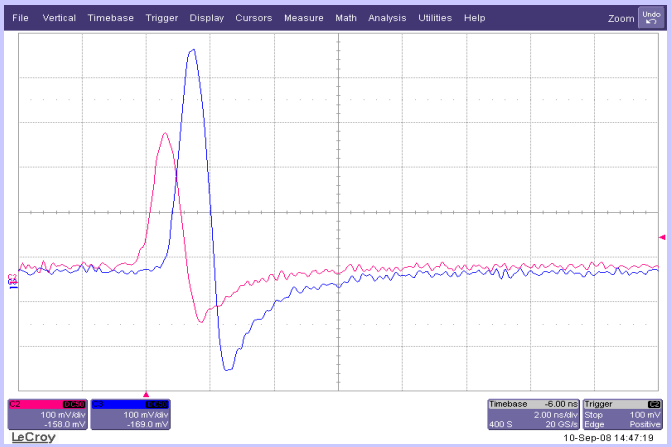
Hardware commissioning:

- all the required extensive tests were completed; the design specifications have all been met

Beam commissioning:

- *16 kickers (JINR) & front-electronics (CERN) were successfully checked for the first LHC beams*
- *tune measurements were the first operational option for the LHC Damper*

The CERN Control Centre of the LHC.
7 September 2008.



Signals from the LHC Damper pick-up for first shot of beam 2.
10 September 2008.