

New Educational Projects of JINR for University Students

Yu. Panebrattsev



Joint Institute for Nuclear Research

Basic Physical Facilities



**Neutron fast pulsed
reactor – IBR-2**



Accelerators of heavy ions



**Accelerator of relativistic
nuclei – Nuclotron**



ИБР-2. Laboratory of Neutron Physics

Physical start-up of IBR-2

In JINR a new reactor with a design power of 4 MW under the name IBR-2 was constructed by 1977. The physical start-up was in 1978 and the official operation began in February 1984.



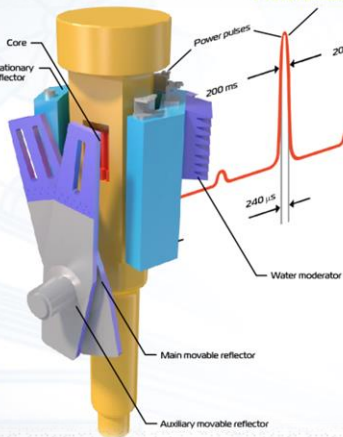
Figure 10. Celebration in the reactor control room as the first self-sustained chain reaction was achieved on November 30, 1977



- 1955 Idea of IBR
- 1960 Start-up of the first self-sustained chain reaction in the world pulsed neutron reactor
- 1964 Creation of the first pulsed booster
- 1969 Start-up of the IBR-30 with the injector LUE-40
- 1977 Physical start-up of IBR-2
- 1984 IBR-2 first power
- 2004 New movable reflector
- 2006 IBR-2 modernization
- 2010 Physical and pulsed start-up of the

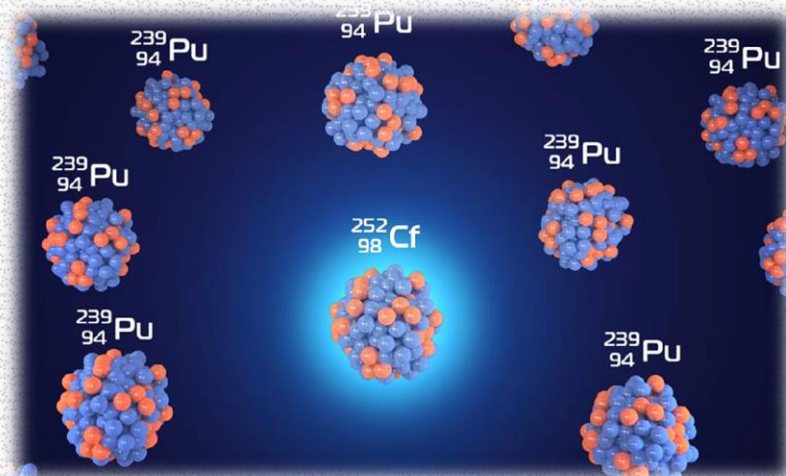


Parameters of IBR-2M



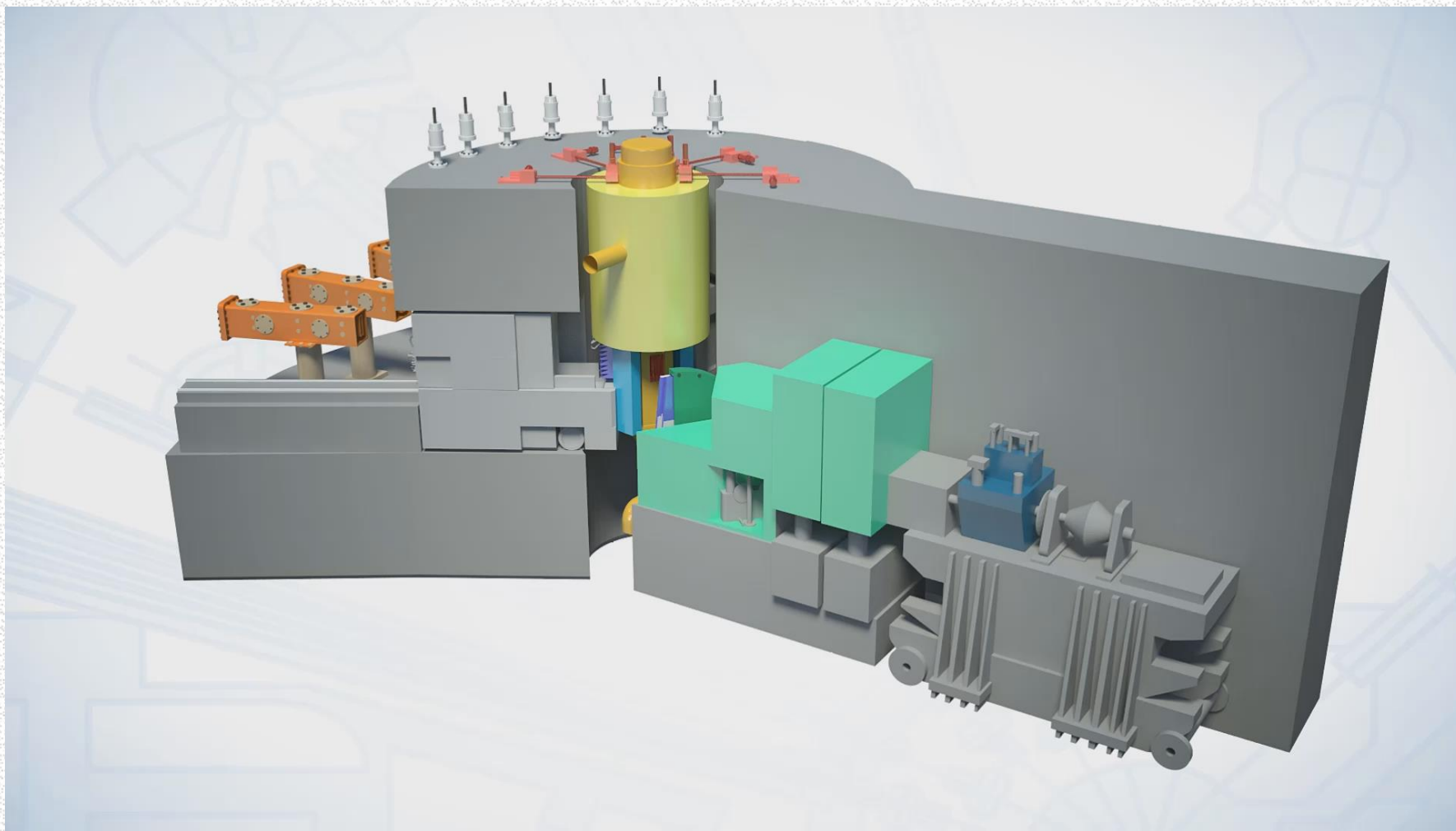
Average power, MW	2
Burst power, MW	1850
Fuel	PuO ₂
Number of fuel assemblies	69
Maximum burnup, %	9
Pulse repetition rate, Hz	5; 10
Pulse half-width, μ s:	
fast neutrons	240
thermal neutrons	320
Rotation rate, rev/min:	
main reflector	600
auxiliary reflector	300
MMR and AMR material	nickel + steel
MR service life, hours	55000
Background, %	7.5
Thermal neutron flux density from the surface of the moderator*:	
time average	$\sim 10^{11}$ n/cm ² ·s
burst maximum	$\sim 10^{16}$ n/cm ² ·s

* More precise data on the thermal neutron flux density after the modernization will be available when the reactor operates at full power.



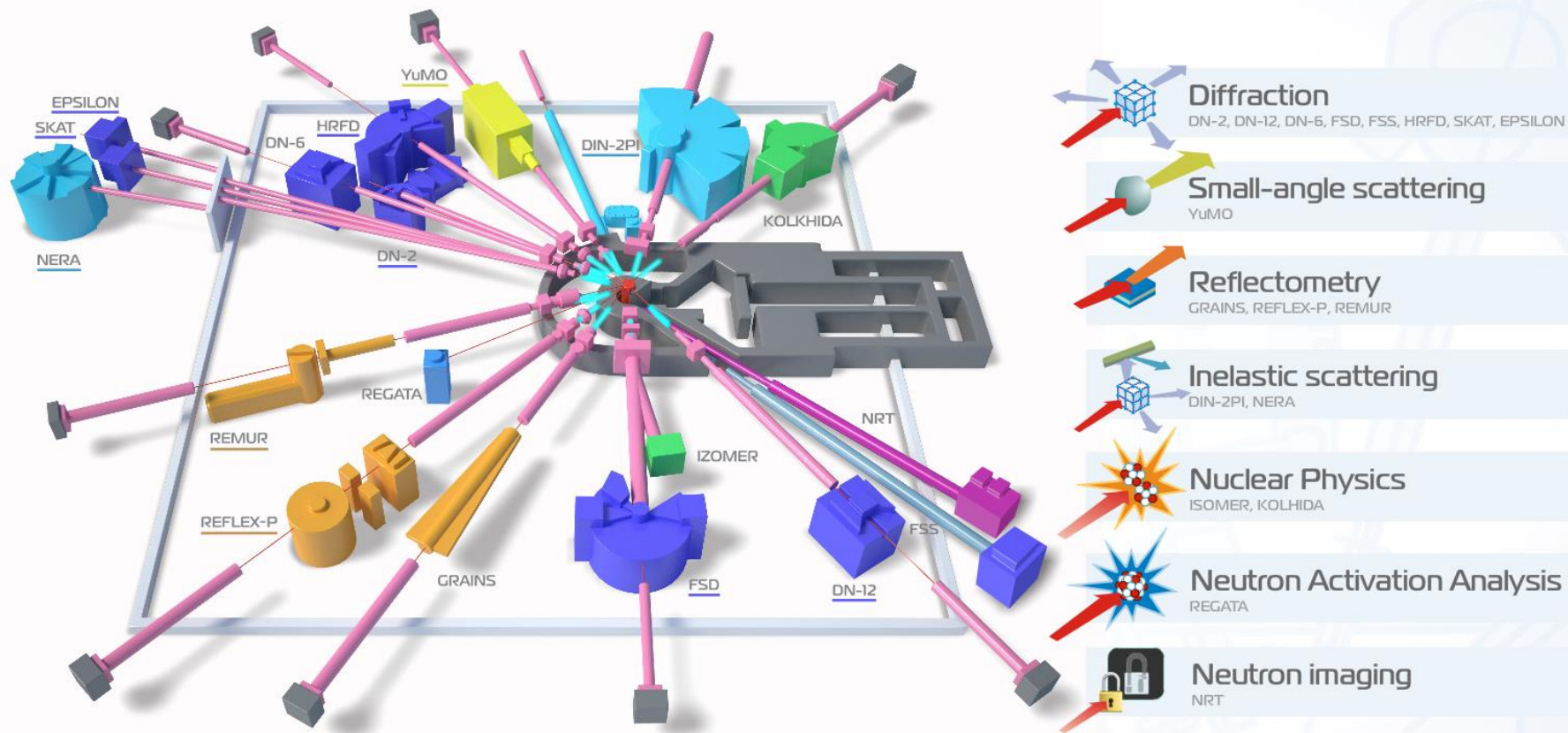


ИБР-2. Лаборатория нейтронной физики



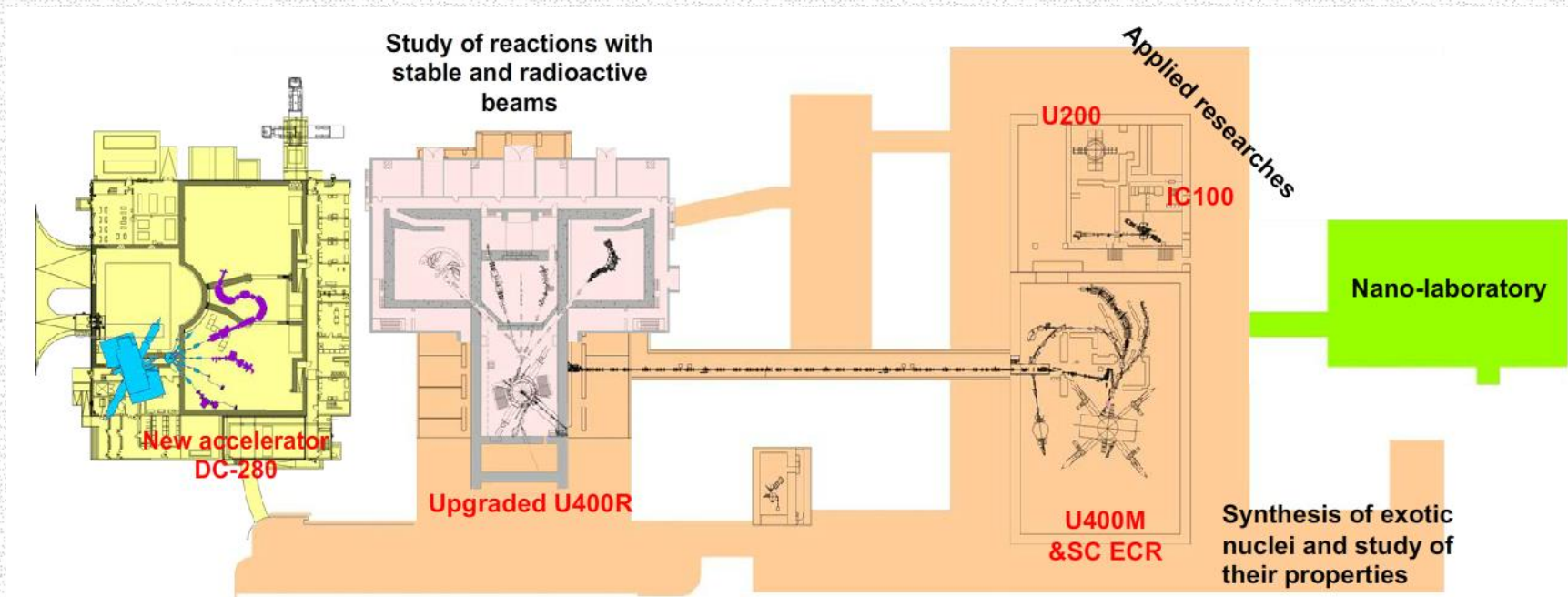
Frank Laboratory of Neutron Physics JINR

Experimental facilities



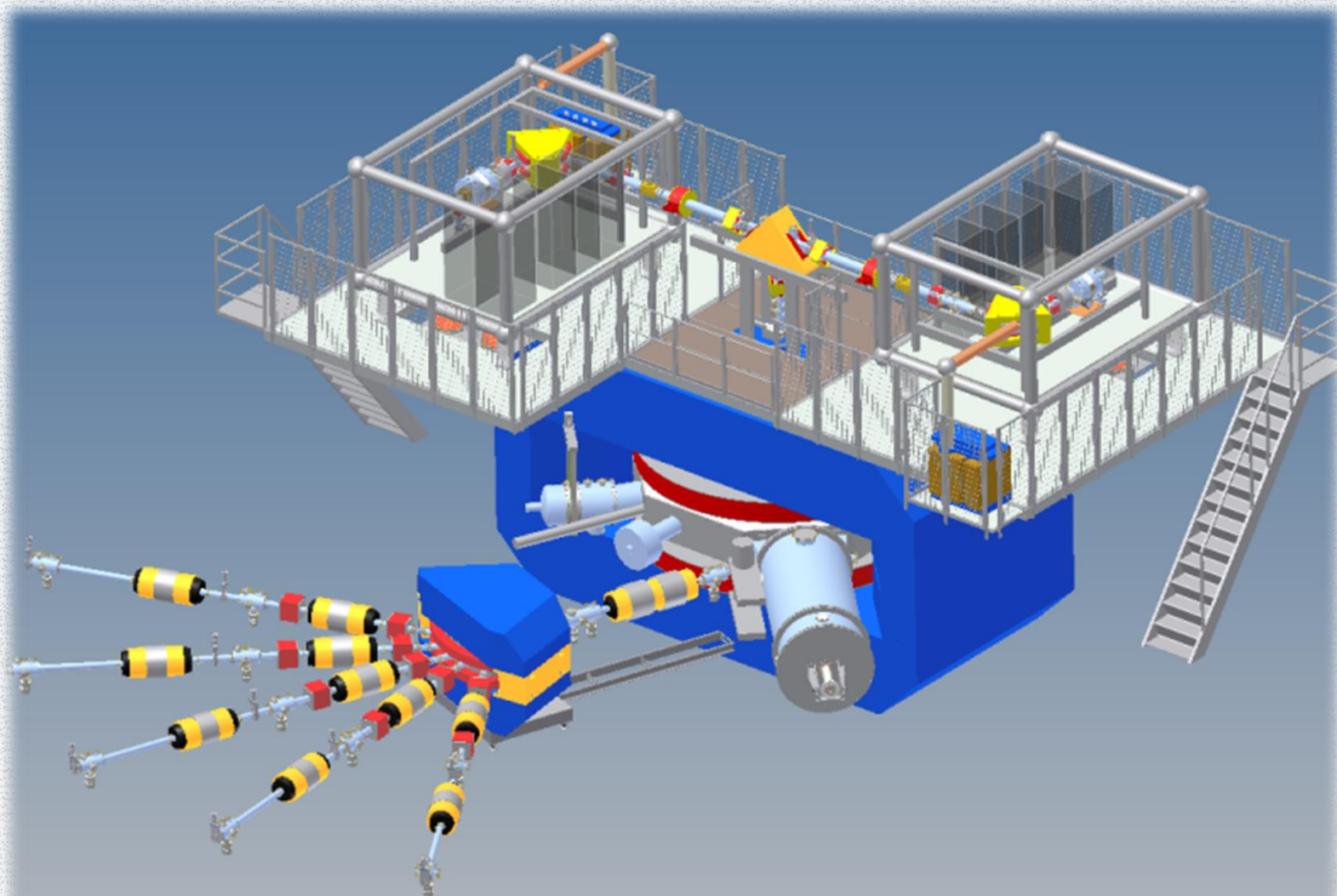


SHE Factory – Фабрика сверхтяжёлых элементов.



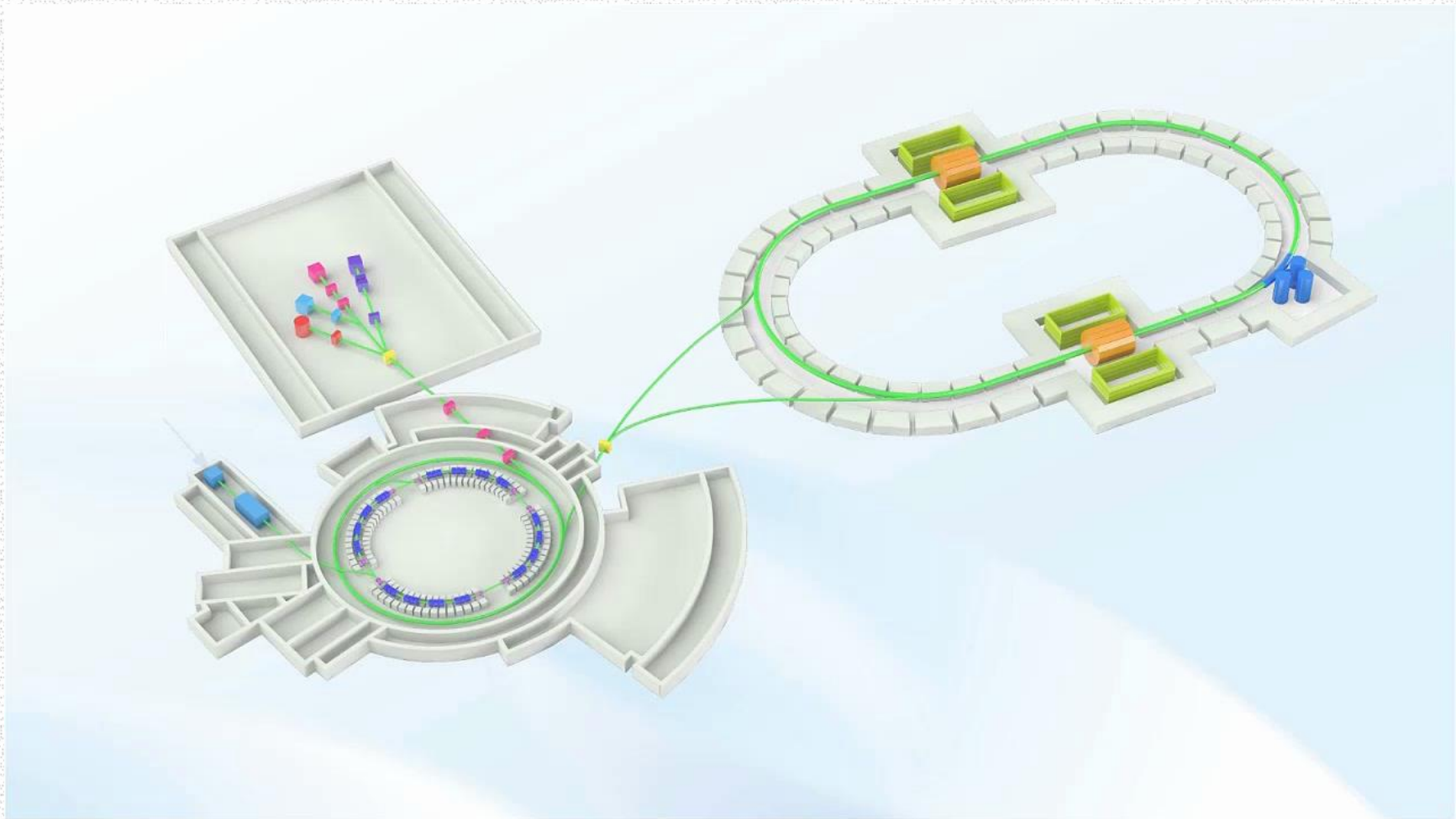


SHE Factory – Фабрика сверхтяжёлых элементов.



Новый ускоритель ДЦ-280

NICA/MPD - Laboratory of High Energy Physics



Educational Project for STAR and NICA/MPD Experiments



Joint Institute for Nuclear Research



The goals of the project

- To attract new students to this exciting field of research and the inclusion of results of experimental studies in the educational process.
- To provide students from various universities of new educational resources appropriated to their level of education about various modern experiments, facilities and international collaborations.
- To create community of students from different countries and universities interested in working on this area of science, will form a community of learners and teachers.



Nuclear Science and Technology

Scientists, Teachers and Students Global Community

Target Group

1. University students of Physics departments
2. Undergraduate students
3. Bachelors and Masters of Physics
4. Science teachers



The screenshot shows the top section of a website. On the left is the logo for 'Nuclear Science and Technology', which consists of two overlapping circles, one red and one black. To the right of the logo is the text 'Nuclear Science and Technology' in a bold font, and below it, 'Scientists, Teachers and Students Global Community' in a smaller font. In the top right corner, there are three links: 'About', 'Board', and 'Contact', each in red text. Below the header is a world map with several yellow dots indicating locations. To the right of the map is a search area with the text 'Use live search to find any experiment or institution you need or use 'All' parameter to display all objects.' Below this text are three search options: a dropdown menu for 'Choose field of science' with the text 'Choose field of science...' and a downward arrow; a dropdown menu for 'Choose Institution' with the text 'All' and a downward arrow; and a text input field with the placeholder text 'Text...'.

TOPICS

- ❑ General information
- ❑ Scientific Highlights
- ❑ Detectors subsystems
- ❑ Instruments and methods for data analysis
- ❑ Trigger system
- ❑ Control Room
- ❑ Virtual labs based on real experimental data
- ❑ Analysis Infrastructure. Tools for beginners.
- ❑ Contact Information for Students



The STAR Collaboration published in Physical Review Letters, [Phys. Rev. Lett. 114, 022301 \(2015\)](#), the first high statistics measurement of $\Lambda\Lambda$ correlation function in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV and it is also highlighted as PRL editors' suggestion. This research pioneered the venue of using RHIC as a hyperon factory to investigate hyperon-hyperon interactions. The STAR measurement can provide precious data for the understanding of hyperon-hyperon interaction which is an important input to various baryon-baryon interaction potential model as well as for the study of equation of state for neutron stars. The $\Lambda\Lambda$ interaction is also closely related to the existence of the H dibaryon, one of the most searched for exotic hadrons in nuclear collisions.

Official website: www.star.bnl.gov

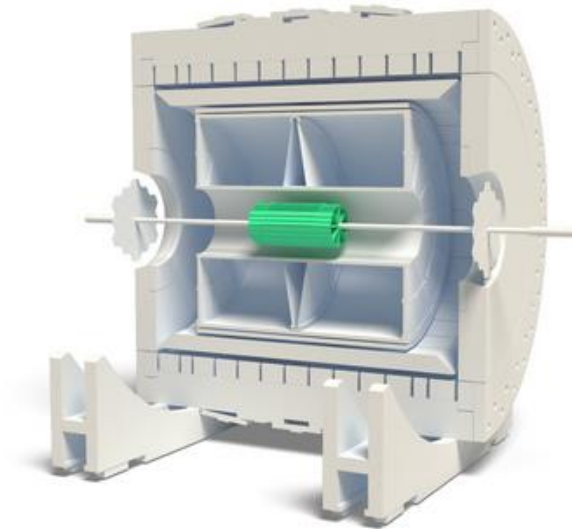
STAR Detectors Subsystems



STAR Detectors Subsystems

STAR Detector

HIDE MENU



- ▶ All systems
- Magnet
- BEMC
- TOF
- TPC
- ▶ **HFT**
- SSD
- IST
- PXL
- BBC
- MTD

General info Technical info Operating principle Photos

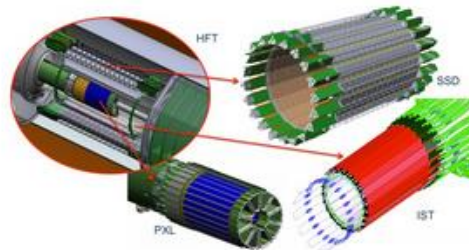


Fig.1 HFT parts

Sub detector	r (cm)	Sensitive units	$\sigma_{(r-\phi)}$ (μm)	σ_z (μm)	X/X_0 (%)
Silicon Strip Detector	22	2 side strips with 95 μm pitch	20	740	1
Intermediate Silicon Tracker	14	600 μm \times 0.6 cm strips	170	1800	<1.5
PIXEL	2.5/8	18 μm pixel pitch	12	12	0.4/layer

Trigger System

Trigger system

Event Triggering (educational model)

The STAR Trigger System (manual)

The Solenoidal Tracker at RHIC (STAR) is designed to detect charged and neutral particles produced in relativistic heavy ion collisions. The majority of the STAR data is provided by relatively slow detectors: TPC, SVT, FTPC, EMC. The trigger system must look at every RHIC crossing and decide whether or not to accept that event and initiate recording the data.

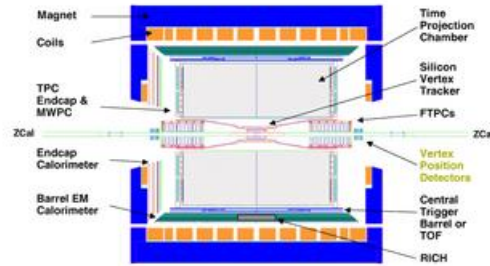


Figure 1. The STAR detector

TRIGGER DETECTORS

A schematic diagram of all the trigger detectors showing how they fit together in the STAR system.

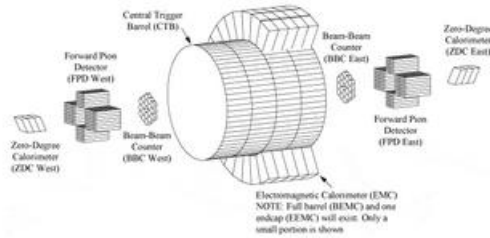
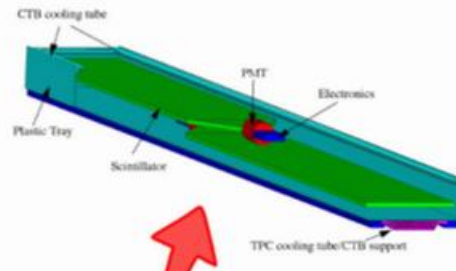


Figure 2. A schematic diagram of all the trigger detectors

- CTB (Central Trigger Barrel) – The Central Trigger Barrel consists of 240 scintillator slats arranged around the TPC. Each slat is viewed by one PMT. The CTB covers a region from -1 to $+1$ in h and 0 to $2p$ in f . It measures charged multiplicity in this region of phase space.

Central Trigger Barrel





Analysis Infrastructure. Tools for beginners



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STAR Experiment

- [General information](#)
- [Scientific Highlights](#)
- [STAR detectors subsystems](#)
- [Instruments and methods for data analysis](#)
- [Trigger system](#)
- [Control Room](#)
- [Virtual labs based on real experimental data](#)
- [STAR Analysis Infrastructure](#)
- [Contact Information for Students](#)

HIDE MENU

STAR Analysis Infrastructure. Tools for beginners

["Introduction to STAR software and makers"](#), Leszek Kosarzewski, Warsaw University of Technology (PDF )

The STAR detector tracks thousands of particles (see Fig.1) produced in Au + Au, U + U, Cu + Cu and polarized p + p collisions. While STAR collects physics data, there are always large volumes of accompanying meta-data to track, store and analyze. The STAR detector is composed of over two dozen subsystems operating in concert while RHIC provides colliding beams. Hundreds of scientists and engineers are watching the data-taking process and tuning detector performance by checking meta-data streams produced by detector components. To ease the procedure of collection, analysis and review of that meta-data, STAR software group created an MQ-based MIRA framework.

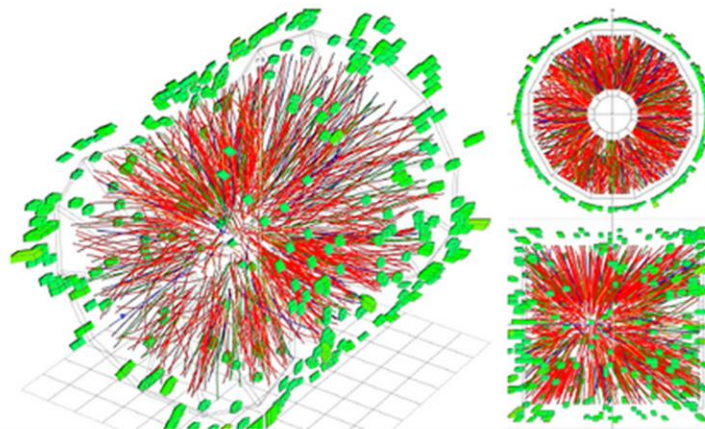


Fig. 1. STAR U + U event at energy 193 GeV per nucleon



Analysis Infrastructure. Tools for beginners.

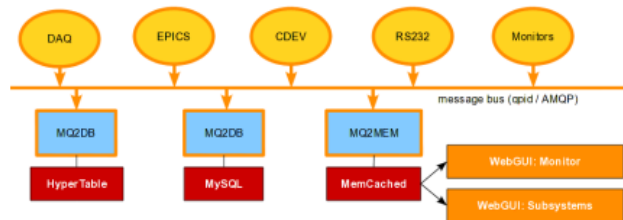
Online Meta-data Collection and Monitoring Framework for the STAR Experiment at RHIC

D Arkhipkin, J Lauret, W Betts and G Van Buren
Physics Department, Brookhaven National Laboratory, Upton, NY 11973-5000 USA
E-mail: arkhipkin@bnl.gov, jlauret@bnl.gov, wbetts@bnl.gov, gene@bnl.gov

Abstract. The STAR Experiment further exploits scalable message-oriented model principles to achieve a high level of control over online data streams. In this paper we present an AMQP-powered Message Interface and Reliable Architecture framework (MIRA), which allows STAR to orchestrate the activities of Meta-data Collection, Monitoring, Online QA and several Run-Time and Data Acquisition system components in a very efficient manner. The very nature of the reliable message bus suggests parallel usage of multiple independent storage mechanisms for our meta-data. We describe our experience with a robust data-taking setup employing MySQL- and HyperTable-based archivers for meta-data processing. In addition, MIRA has an AJAX-enabled web GUI, which allows real-time visualisation of online process flow and detector subsystem states, and doubles as a sophisticated alarm system when combined with complex event processing engines like Esper, Borealis or Cayuga. The performance data and our planned path forward are based on our experience during the 2011-2012 running of STAR.

1. Introduction

An acronym for the Solenoidal Tracker At RHIC (Relativistic Heavy Ion Collider), STAR [1] tracks thousands of particles produced in Au+Au, U+U, Cu+Cu, and polarized p+p collisions. While STAR collects physics data, there are always large volumes of accompanying meta-data to track, store and analyze.



Introduction to STAR software and makers

Leszek Kosarzewski

Warsaw University of Technology

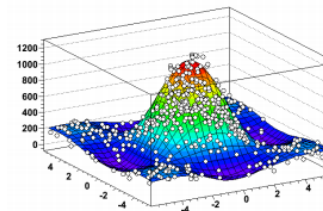
STAR software - Basics

STAR software

Most of STAR software is based on libraries of ROOT data analysis framework.

- ROOT is widely used in Heavy Ion and High Energy Physics community
- STAR ROOT libraries contain classes specific to STAR:
 - Detector geometry classes
 - Event data
 - Specific makers
 - Database classes
- Look for information and class description on the ROOT webpage.

Minuit fit result on the Graph2DErrors points



ROOT webpage

<https://root.cern.ch/drupal/>

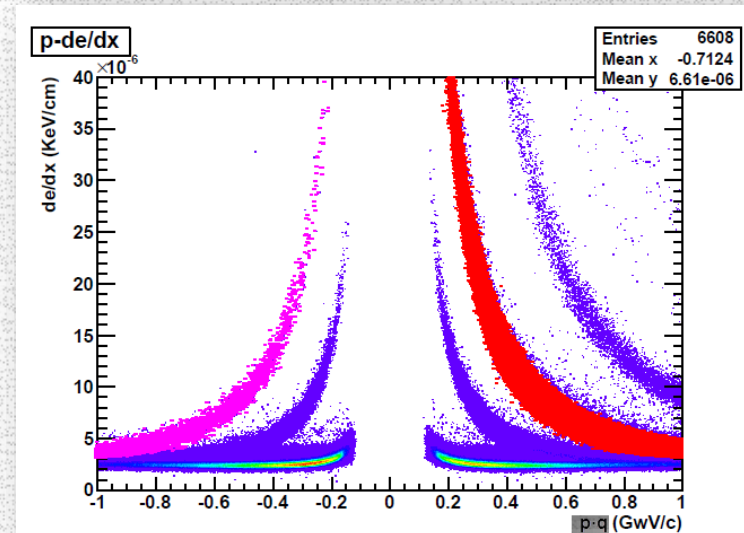
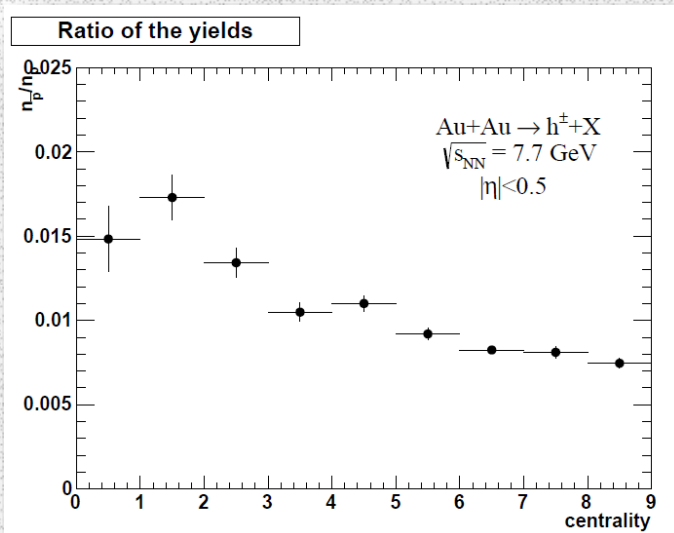
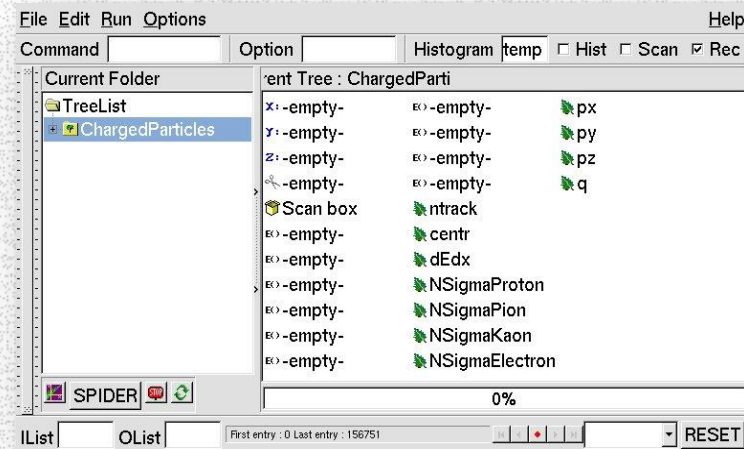
Listing 1 : To run STAR ROOT

```
root4star
```

Practicum on Real Experimental Data

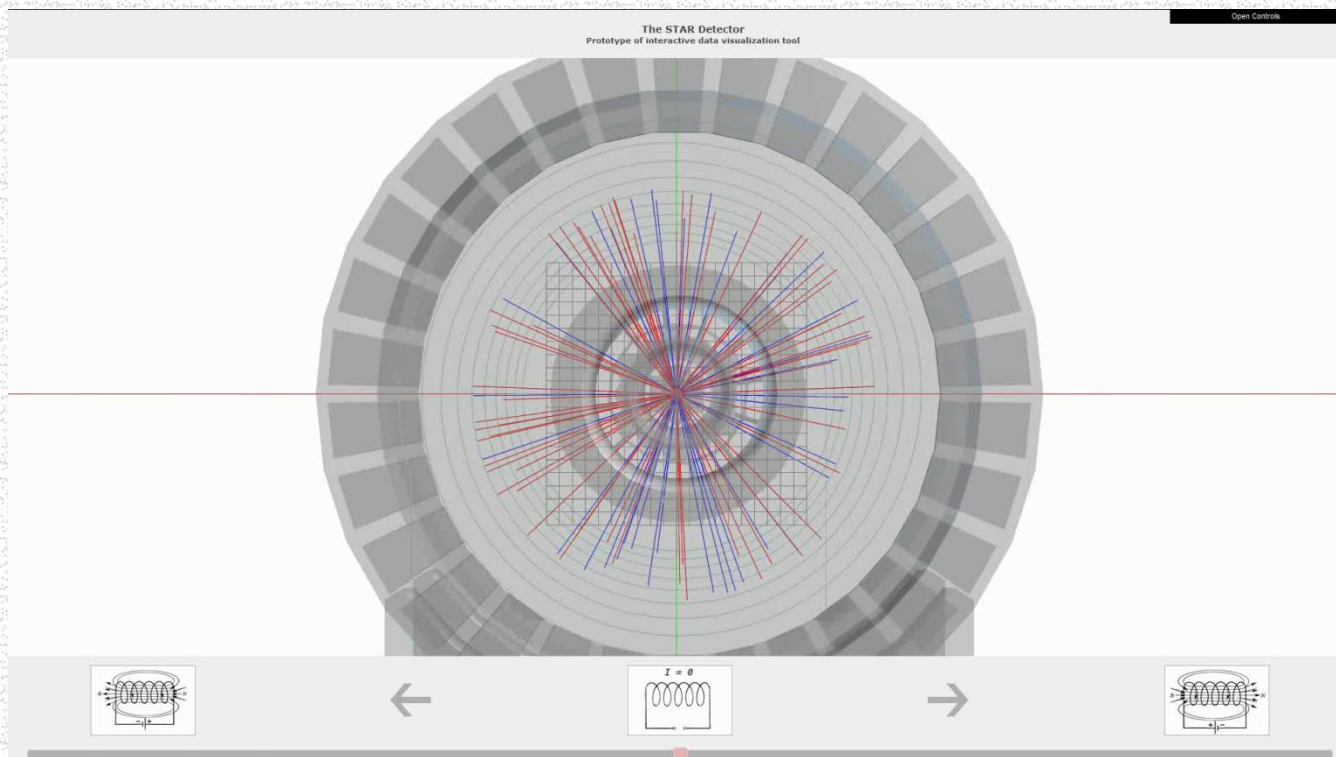
Virtual labs based on real experimental data: “Measurement of proton and antiproton yields in the central collisions at RHIC energies”

- Real data
- Physical task
- PicoDST
- Algorithm
- Results
- Analysis
- Conclusions



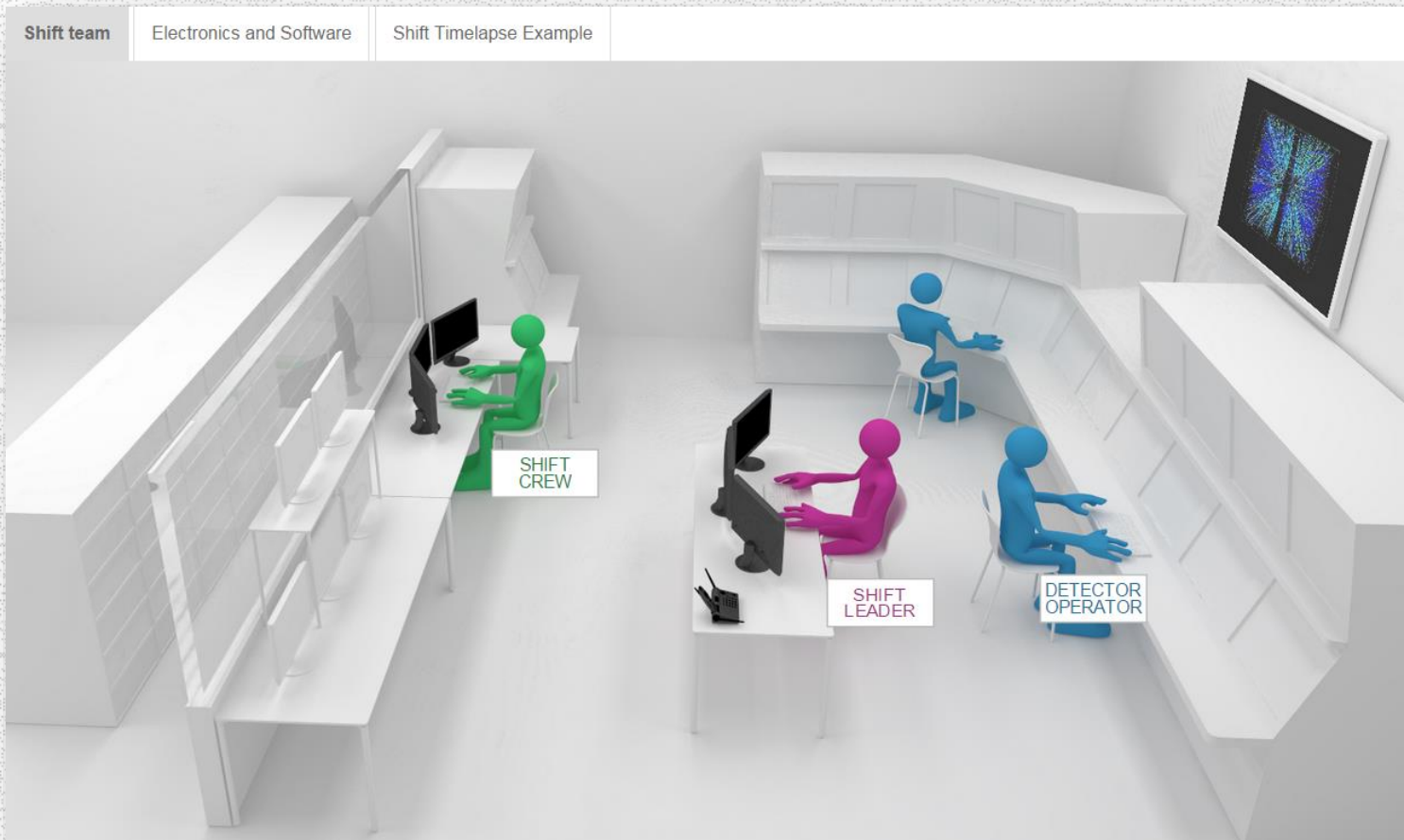
Practicum on Real Experimental Data

- Currently a lab used experimental data on the gold-gold collisions at different energies from 7.7 to 200 GeV to study production of antiprotons at RHIC collider is realized.
- As instrument for the complex study of events it is developed the module to visualize events using interactive 3-D graphics



Control Room

Purpose: students, future STAR shift members. Interactive information system of the STAR control room and the shift team. Includes the detailed description of the team member roles, duties, instructions, trainings and practical exercises; description about electronics and software.




Control Room



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Use live search to find any experiment or institution you need or use 'All' parameter to display all objects.

Choose field of science
Relativistic Heavy Ions

Choose Institution
Choose Institution...

Or type the keyword
Text...


Search results

▶ BNL, USA ▶ CERN, Switzerland ▶ GSI, Germany ▶ JINR, Russia

Board

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 STAR Experiment STAR related community	Topics: 0 Posts: 0	No posts	

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WHO IS ONLINE

In total there is 1 user online :: 0 registered, 0 hidden and 1 guest (based on users active over the past 5 minutes)
Most users ever online was 2 on Thu May 14, 2015 6:55 am

Registered users: No registered users
Legend: *Administrators*, *Global moderators*

BIRTHDAYS

No birthdays today



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Scientists, Teachers and Students Global Community

<http://NSWW.org>



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

Hardware-Software Complex “Virtual Laboratory of Nuclear Fission”

The goal of the Project

The goal of the project is the integration of technological elements of modern science into the educational process, carrying out labs based on combination of real equipment, virtual and online laboratory research using data obtained from the existing physical facilities.

Light Ions Spectrometer

- As a first step we have chosen an actual scientific problem – the study of spontaneous fission using the spectrometer LIS from Flerov Laboratory of Nuclear Reactions, JINR



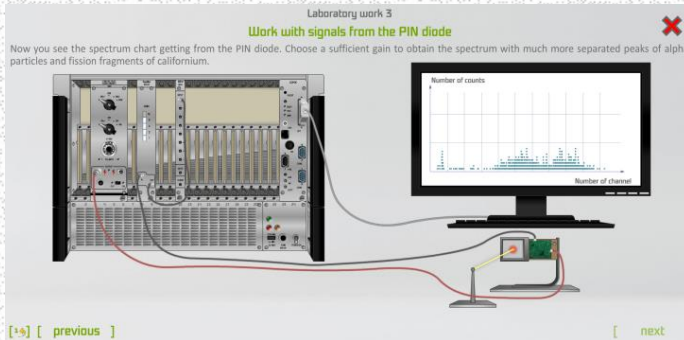
LIS setup with timestamp detectors based on MCP

The project is comprised of three educational levels:

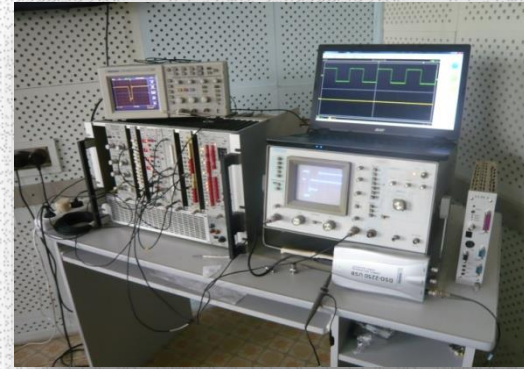
- ***Elementary level.*** A typical target group at this level are high school students, science teachers, undergraduate students and participants of summer practices.
- ***Basic level.*** The goal at this level is to study various types of radiation detectors, nuclear electronics & DAQ and some important methods of experimental data processing.
- ***Advanced level.*** A typical target group at this level are students who plan to prepare their bachelor and master theses based on the measurements at the LISSA project. This level may be useful as a training before independent work as experimentalists in nuclear physics.

Practicum types

- Virtual labs



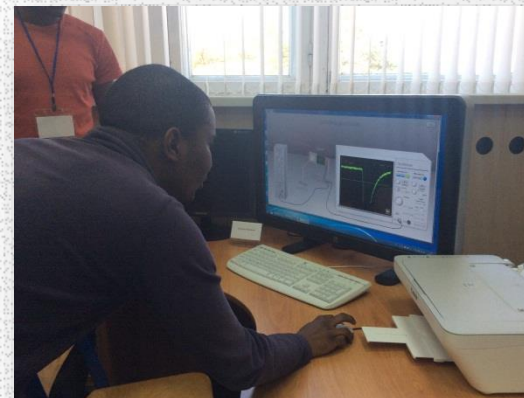
- Real equipment



- Remote labs

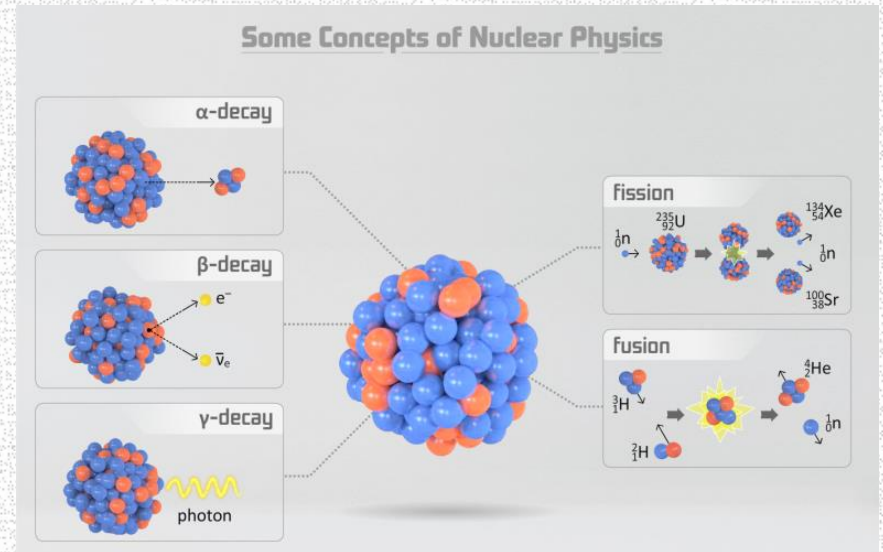


- LabView

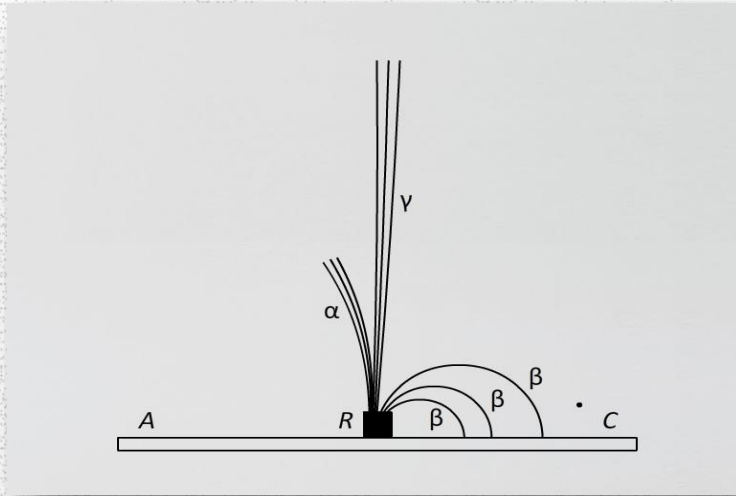


Part 1. Some Concepts of Nuclear Physics

1. Introduction
2. Proton-Neutron Nuclear Model
3. Mass – Energy – Momentum
4. Nuclear Energy: Fusion and Fission
5. Radioactivity:
6. Alpha Decay
7. Beta Decay
8. Gamma Decay
9. Spontaneous Fission
10. Radioactive Decay Law
11. Quiz
12. Exercises



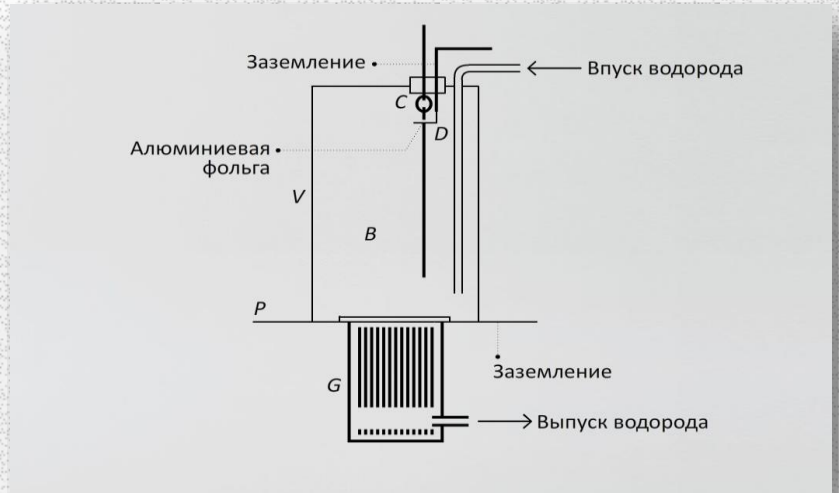
Exercises for experimentalists



Some Concepts of Nuclear Physics

3/20. Radioactive materials are studied in a magnetic field.
Move nameplates to the corresponding rays.


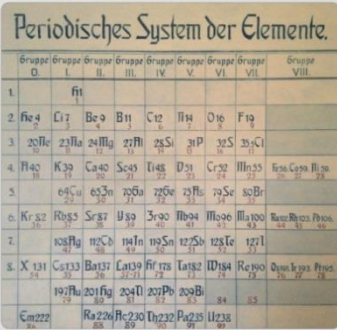

A diagram showing a radioactive source in a U-shaped magnetic field with South (S) and North (N) poles. Three rays are shown emerging from the source: a blue ray (alpha), a green ray (beta), and a yellow ray (gamma). A legend on the right shows three nameplates: a blue circle for α -rays, a green circle for β -rays, and a yellow circle for γ -rays.



Part 2. How to Measure Radioactivity

1. Introduction
2. Radioactive Sources
3. Interaction of Radiation with Matter
4. Radiation Detectors:
 - Gas-Filled Detectors
 - Scintillation Detectors
 - PIN Diodes
 - Detectors Based on Microchannel Plates
5. Measurement of Radioactivity
6. Quiz
7. Practicum

How to Measure Radioactivity



Periodisches System der Elemente.

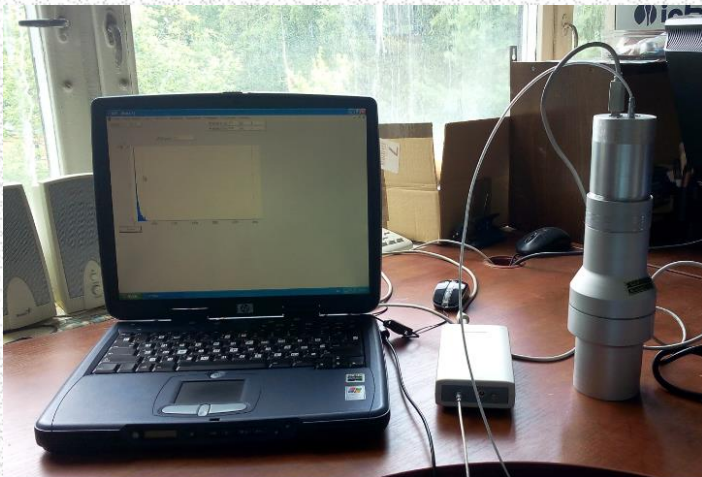
Gruppe	Gruppe	Gruppe	Gruppe	Gruppe	Gruppe	Gruppe	Gruppe	Gruppe
0	I	II	III	IV	V	VI	VII	VIII
1	H 1							
2	He 4	Li 7	Be 9	B 11	C 12	N 14	O 16	F 19
3	Ne 20	Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35,5
4	Ar 40	K 39	Ca 40	Sc 45	Ti 48	V 51	Cr 52	Mn 55
5	Kr 84	Rb 85,5	Sr 88	Y 89	Zr 91	Nb 93	Mo 96	Tc 98
6	Xe 136	Cs 133	Ba 137	La 139	Hf 178	Ta 182	W 184	Re 187
7	Rn 222	Po 210	At 210	Rn 222	Po 210	At 210	Rn 222	Po 210
8	Xe 136	Cs 133	Ba 137	La 139	Hf 178	Ta 182	W 184	Re 187
9	Rn 222	Po 210	At 210	Rn 222	Po 210	At 210	Rn 222	Po 210
10	Ra 226	Ac 227	Th 232	Pa 231	U 238	Np 237	Pu 244	Am 243

Practicum



Skills:

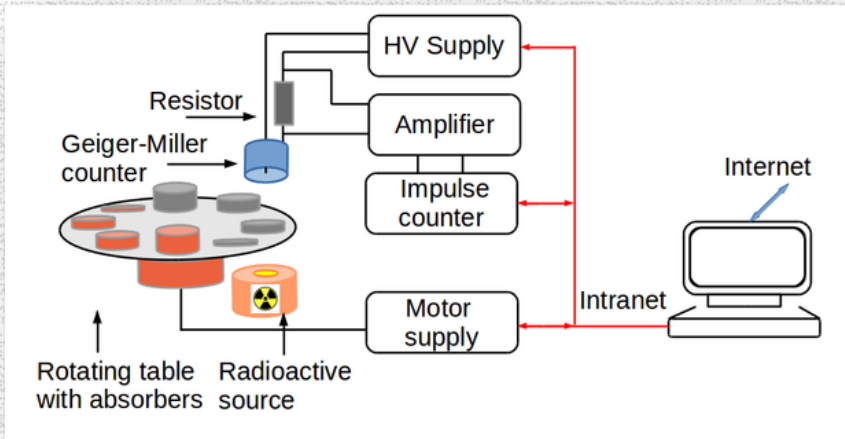
1. Work with oscilloscopes and pulse generators
2. Work with scintillation detectors (NaI, CsI, plastic)
3. Measurements and spectrum analysis
4. Coincidence method and registration of cosmic particles



Remote labs



WARSAW UNIVERSITY OF TECHNOLOGY

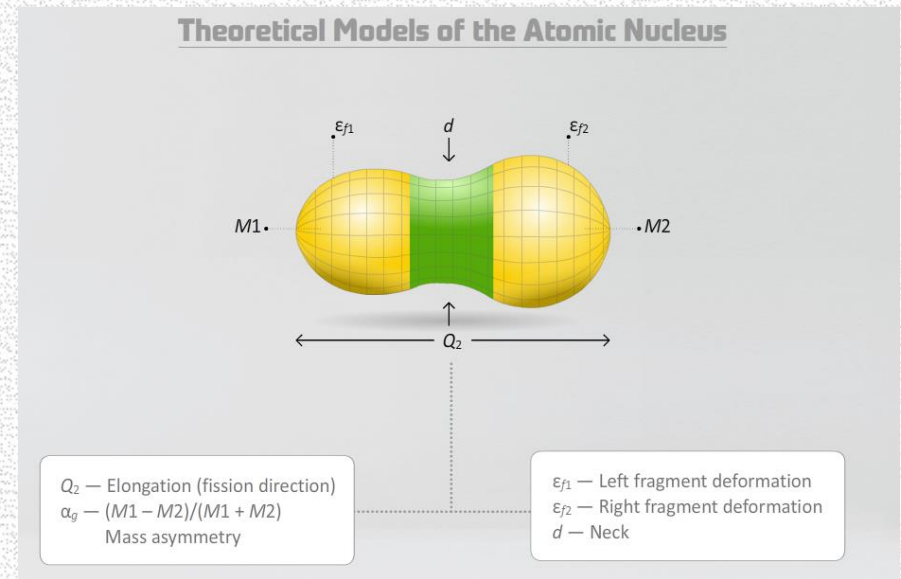


In collaboration with the Warsaw University of Technology the remote lab for studying of attenuation of gamma radiation was implemented.



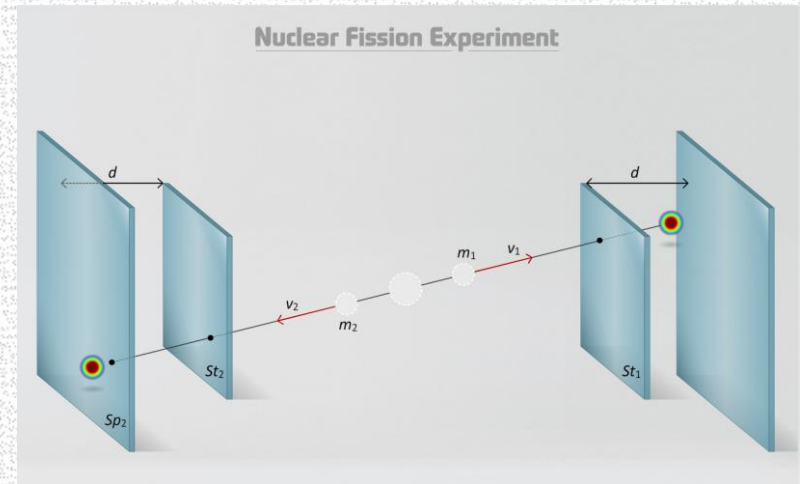
Part 3. Theoretical Models of the Atomic Nucleus

1. Introduction
2. Nuclear Models
3. Quantum Mechanics in Nuclei
4. Fission and Quantum Tunneling
5. Basic Regularities of Spontaneous Fission
6. Collinear Cluster Tri-Partition (CCT)
7. Quiz
8. Exercises



Part 4. How to Measure Nuclear Fission

1. Introduction
2. Physics of Binary Fission
3. Methods of Detection of Fission Fragments
4. Energy Measurements of Fission Fragments
5. Time Measurements of Fission Fragments
6. Quiz
7. Practicum



Part 5. Light Ions Spectrometer – Measurements

1. Physical Motivation
2. LIS Setup
3. Electronics of the LIS Setup
4. Block Diagram and Data Acquisition System
5. CAMAC Practicum
6. PIN Diode Calibration
7. Time of Flight Calibration
8. LIS Manual



Light Ions Spectrometer – Practicum

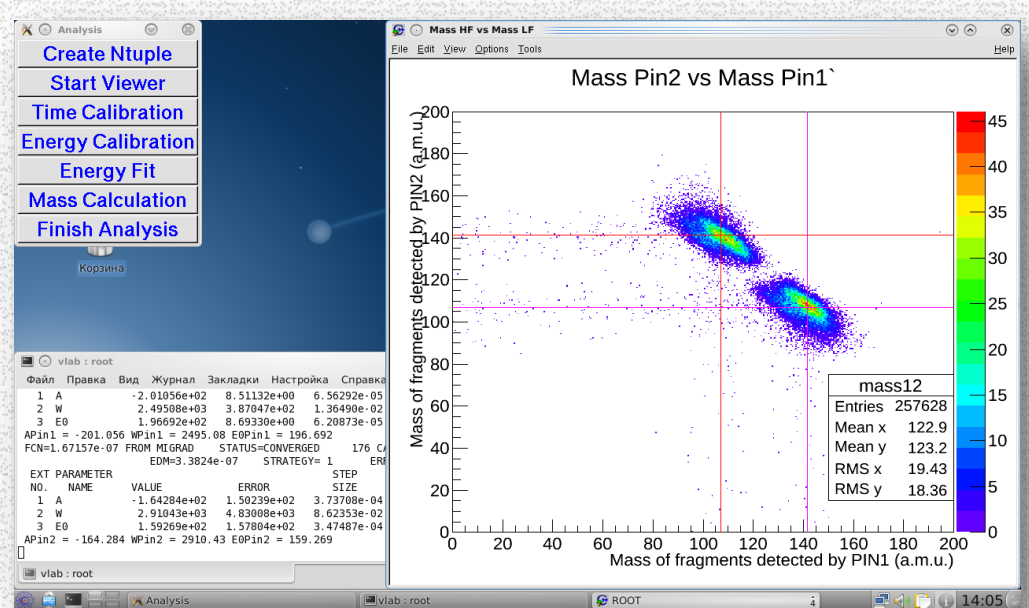


Skills:

1. Vacuum system preparation
2. Measurements of PIN diode signals from the alpha source
3. Measurements of thin foil thickness and Bragg's peak obtaining

Part 6. Light Ions Spectrometer – Data Analysis

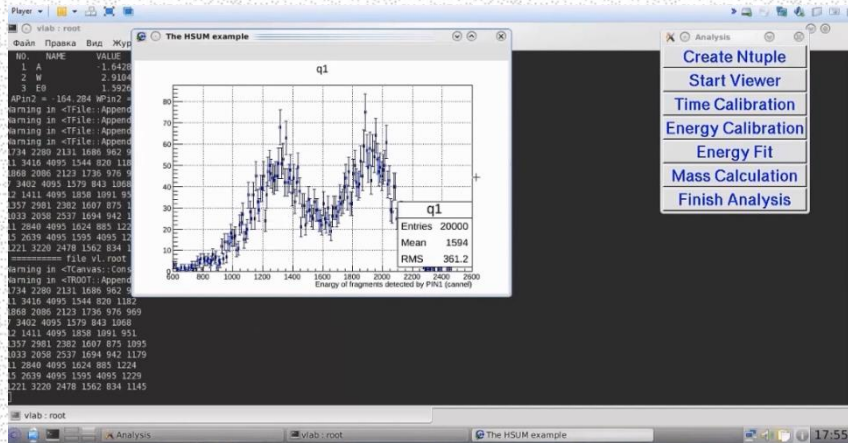
1. Introduction
2. Data Viewer
3. Time and Energy Calibration
4. Energy and Mass Fit
5. Exercises
6. ROOT Manual
7. ROOT Practicum



Data analysis – ROOT Practicum



Data analysis from LIS setup



1. Analysis of data obtained from LIS setup using ROOT

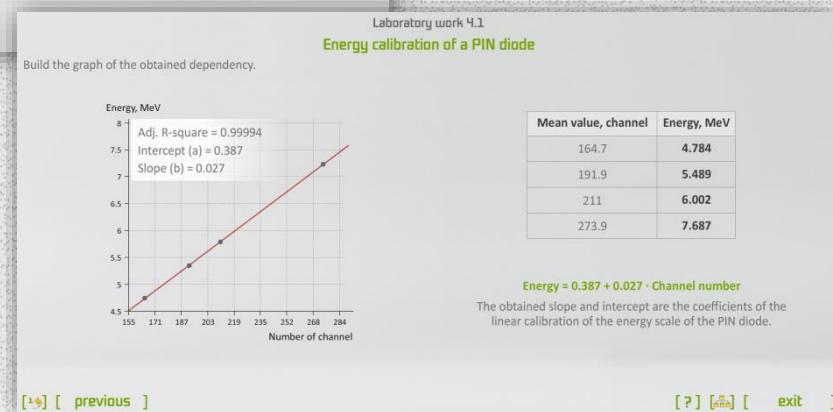
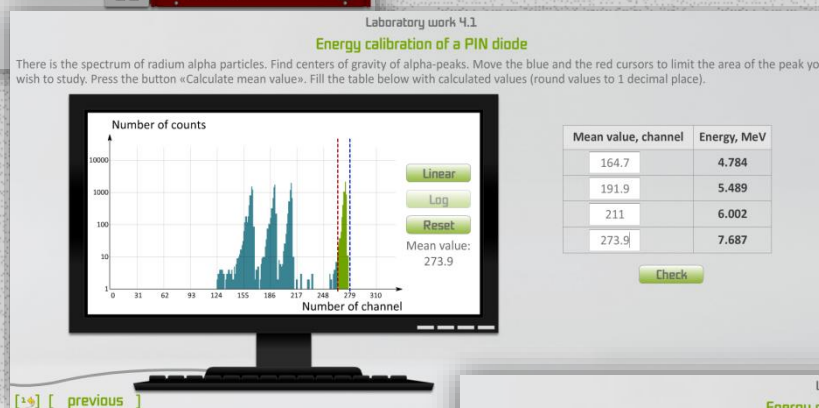
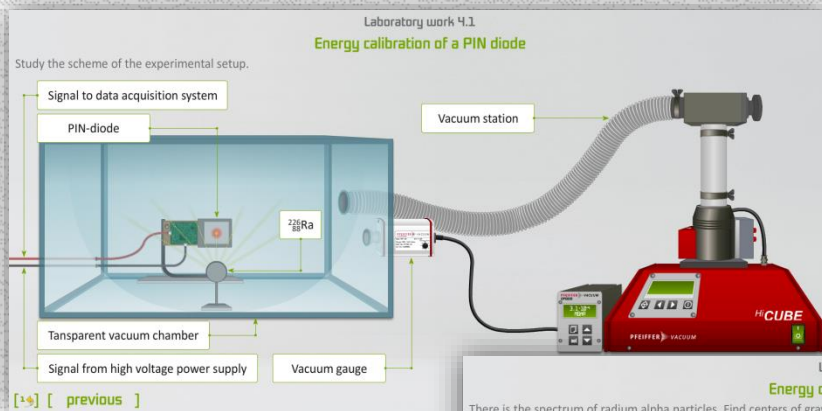


2. Data analysis of signals from 5 GS/s Switched Capacitor Digitizer



«Virtual laboratory of spontaneous fission»

Калибровка PIN-детектора



- Изучение спектра от радия-226
- Выбор коэффициента усиления сигнала
- Построение калибровочного графика



«Virtual laboratory of spontaneous fission»

Измерение энергий частиц от калифорния-252 и измерение толщины источника

Laboratory work 4.2
Measurement of radiation energies and thickness of ^{252}Cf -source

Set the same amplification that you used for the PIN diode calibration in the previous laboratory work.

WELL DONE!

[+] [previous]

Laboratory work 4.2
Measurement of radiation energies and thickness of ^{252}Cf -source

Define the centers of gravity of:
– the alpha particle peak of californium-252, ... >>>

Number of counts

Number of channel

Linear
Log
Reset

Mean value:
269.885

Name	Mean value, channel
Alpha particles of californium-252	214.179
Alpha particles of radium-226 with the highest energy	269.885

Check

[+] [previous] [?] [?] [next]

- Измерение энергетического спектра 252-калифорния
- Расчет потерь энергии альфа-частиц радия в источнике калифорния
- Расчет толщины источника калифорния

Laboratory work 4.2
Measurement of radiation energies and thickness of ^{252}Cf -source

Define the centers of gravity of fission fragments of californium-252 (round values to 3 decimal place). For this purpose it is recommended to choose the scale of the axis so that you will see only ... >>>

Number of counts

Number of channel

Linear
Log
Reset

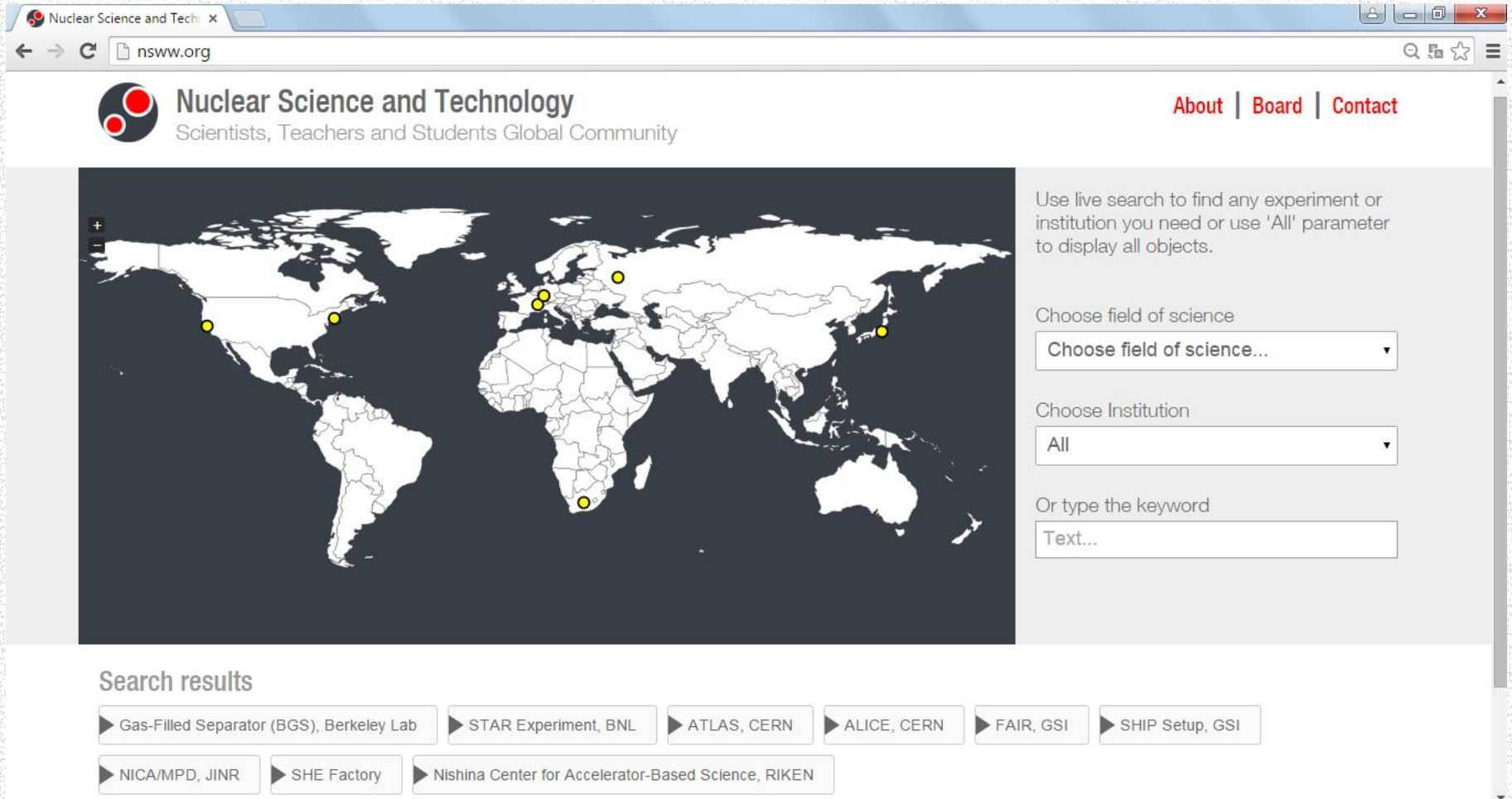
Mean value:
2424.17

Name	Mean value, channel
Light fragment (LF)	3419.259
Heavy fragment (HF)	2424.17

Check

[+] [previous] [?] [?] [next]

Nuclear Science and Technology Community



The screenshot shows a web browser window with the URL nsww.org. The page header includes the logo for Nuclear Science and Technology, which consists of two overlapping circles (one red, one black) with a white dot in the center. The text next to the logo reads "Nuclear Science and Technology" and "Scientists, Teachers and Students Global Community". In the top right corner, there are links for "About", "Board", and "Contact".

The main content area features a world map on the left with several yellow location markers. To the right of the map is a search section with the following text: "Use live search to find any experiment or institution you need or use 'All' parameter to display all objects." Below this text are two dropdown menus: "Choose field of science" (with a dropdown arrow) and "Choose Institution" (with "All" selected and a dropdown arrow). Below the dropdowns is a text input field with the placeholder "Text...".

At the bottom of the page, under the heading "Search results", there is a horizontal list of buttons, each with a right-pointing arrow and text: "Gas-Filled Separator (BGS), Berkeley Lab", "STAR Experiment, BNL", "ATLAS, CERN", "ALICE, CERN", "FAIR, GSI", "SHIP Setup, GSI", "NICA/MPD, JINR", "SHE Factory", and "Nishina Center for Accelerator-Based Science, RIKEN".

nsww.org

Massive Open Online Courses

coursera

edX



National Research Nuclear University MEPhI

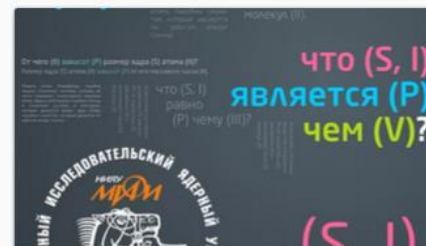
National Research Nuclear University "MEPhI" is one of the most recognized technical universities in Russia. It is the only research nuclear university in Russia. The aim of the university existence is preparing the specialists for nuclear industry, science, information technology and other high-tech sectors of Russian economy. National Research Nuclear University "MEPhI" implements postgraduate professional education curricula (PhD and postdoctoral level), carries out fundamental and applied scientific research in high-priority fields of science and technologies. Among MEPhI graduates are Nobel Prize winners, members of the Russian Academy of Sciences, and winners of national prizes. Its professors and alumni have made major contributions to various fields of theoretical and experimental physics, mathematics, cybernetics, and computer sciences.



Физика как глобальный проект
По требованию



Элементы атомной и ядерной физики
По требованию



Создание научно-технического текста
По требованию

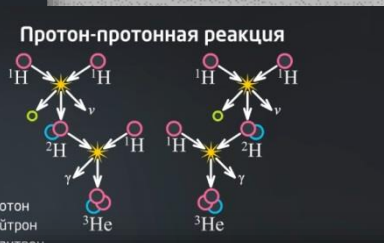
- **Создание научно-технического текста**
Для иностранных студентов в России
Запуск курса: 12 октября 2015 года
- **Элементы атомной и ядерной физики**
Для бакалавров
Запуск курса: 30 ноября 2015 года
- **Физика как глобальный проект**
Физика для всех
Запуск курса: 20 декабря 2015 года



Элементы атомной и ядерной физики

Принцип действия гамма-ножа

Радиоактивный кобальт
Гамма лучи
Шлем
Цель



1 стади
2 стади

Радиационные пояса Земли

Солнечный ветер
Радиационные пояса

Радиационные пояса Земли — области магнитосферы, в которых накапливаются высокоэнергичные заряженные частицы.

Физика как глобальный проект

Преподаватели



Ольчак Андрей Станиславович

Доцент

Кафедра общей физики

Темы

- Физика от Аристотеля до Ньютона. Основные принципы и подходы глобального проекта "Физика"
- Обобщённая механика. Первая полноценная успешная теория
- Конкретная механика. "Нет ничего практичнее хорошей теории"
- От механики к тепловым явлениям
- Статистическая физика. Как Бог играет в кости?
- Поля и волны. Откуда у природы берутся силы?
- Квантовая физика. Новая физика 20-го века
- Физика высоких энергий. Так как же всё-таки устроен этот мир?

Thank you!