



The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences

www.ifj.edu.pl



World University Rankings 2024

Discover the world's top 2000 universities



Place 753 (3.6%)

Prof. Tadeusz Lesiak
Director General

General Information about IFJ PAN



• Personnel: **560**; Prof. **31**, Assoc. Prof. **58**, Ph.D. **103**, engineers **117**

• Scientific Divisions:

- Division of Particle and Astroparticle Physics
- Division of Nuclear Physics and Strong Interactions
- Division of Condensed Matter Physics
- Division of Theoretical Physics
- Division of Interdisciplinary Research
- Division of Applications of Physics

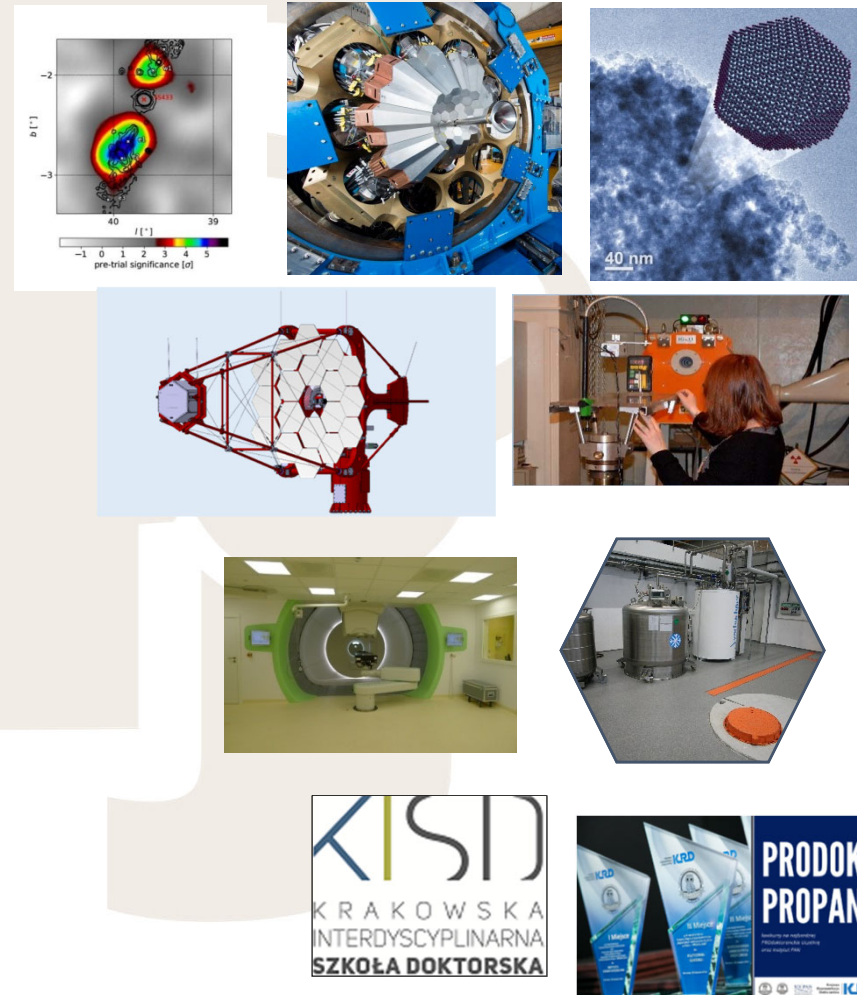
• Researcher Departments:

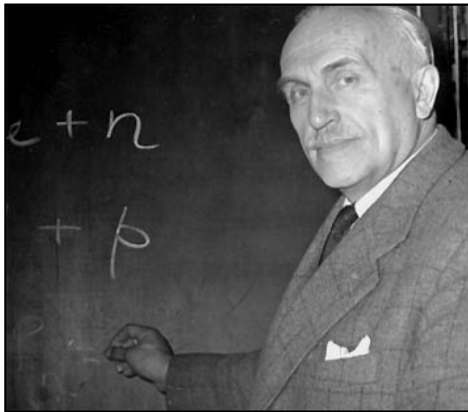
- Cyclotron Centre Bronowice
- Division of Scientific Equipment and Infrastructure Construction
- Four accredited laboratories

• Education:

- International Ph.D. Studies
- Interdisciplinary Doctoral Studies
- Kraków Interdisciplinary Doctoral School

• Scientific output: **> 650** publications annually





(Fot. Archiwum of the IFJ PAN)

- **1955** – foundation of the IFJ – as a branch of the Institute of Nuclear Research – Prof. Henryk Niewodniczański (1900-1968)
- **1960** – IFJ as a standalone unit
- **1970** – Particle physics enters – Prof. Marian Mięśowicz (1907-1992)
- **1988** – IFJ gets the name of its patron – Henryk Niewodniczański
- **2003** – IFJ gets the status of a research institute of Polish Academy of Sciences





Projects coordinated by the IFJ PAN

1. CCB – Cyclotron Center Bronowice (development, next phase)
2. Centrum of Engineering of Cryogenic Materials
3. ESS – European Spallation Source
4. SPIRAL2
5. Research in particle physics at CERN

Projects with IFJ PAN as a partner, correlated with the national contribution to ESFRI:

1. E-XFEL – Free Electron Laser
2. ELI – Extreme Light Infrastructure
3. CTA – Cherenkov Telescope Array
4. FAIR – Facility for Antiproton and Ion Research
5. ESRF – European Synchrotron Radiation Facility

Division of Particle and Astroparticle Physics (NO1)



1. The ATLAS experiment

- physics analyses of proton-proton (tau physics) and heavy ion collisions
- design, construction and maintenance of SCT, TRT, AFP, ALFA and ZDC detectors, ITk for HL-LHC



2. The LHCb experiment

- physics analyses ($b \rightarrow s$, CKM γ , spectroscopy) and RTA (Real Time Analysis), on-line event reconstruction and selection, monitoring
- involvement in RICH, scintillator based trackers (Magnet Stations, Sci-Fi for Upgrade II), interests in calorimeters



3. The Belle II experiment

- physics analyses (B decays with missing energy)
- Development of electronics for SVT



4. Cosmic Ray Research

- **project Pierre Auger** – construction and data analysis
- **project Cosmic-Ray Extremely Distributed Observatory (CREDO)** search for cosmic ray ensembles spread over very large surfaces using smartphones (“citizen science”)



5. Neutrino studies

- **T2K** – neutrino oscillation studies; upgrade of BD200 subdetector
- **P-ONE** – search for UHE neutrinos of astrophysical origin (under construction)



6. High energy Gamma-Ray Astrophysics

- **H.E.S.S.** (High-Energy Stereoscopic System) experiment
- **HAWC** (High Altitude Water Cherenkov) experiment
- Cherenkov Telescope Array (**CTA**) observatory (under construction)



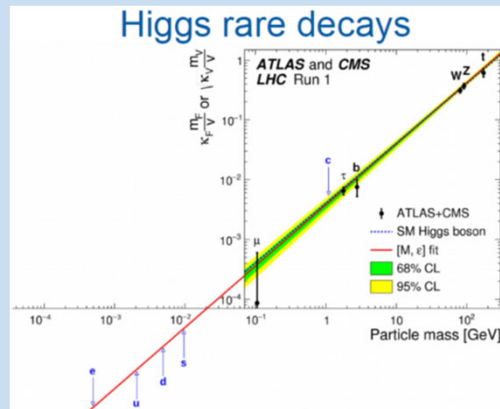
7. Involvement in other projects

- preparation of **MUonE** experiment at CERN
- Preparation of **ATHENA** experiment at future Elektron Ion Collider (EIC)
- Physics feasibility studies for future accelerators (mainly **FCC**)
- development of “Cloud Computing” and GRID computing infrastructures

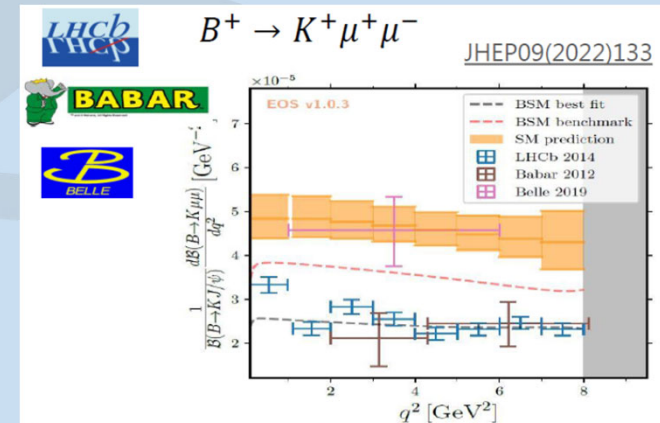




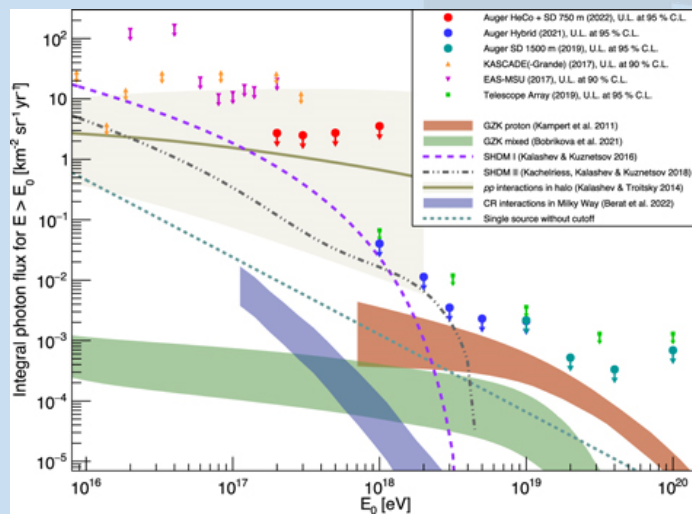
Standard Model (SM) Couplings (ATLAS)



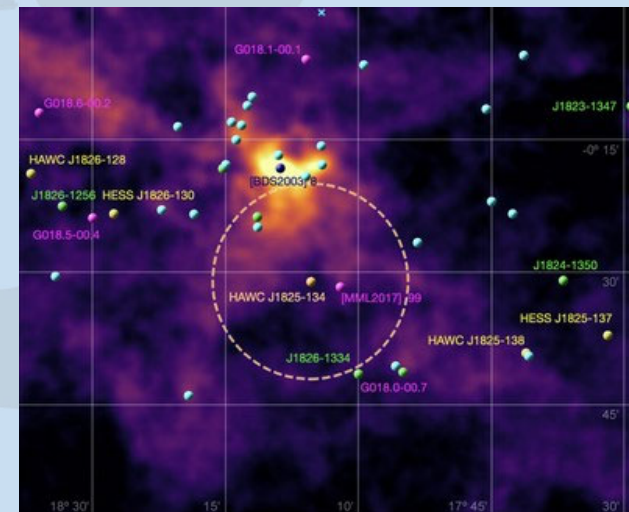
Search for deviation from the SM in $b \rightarrow s$ transitions (LHCb)



Energy spectrum of UHE cosmic rays (Pierre Auger)



Cosmic accelerators seen in UHE photons (HAWC)





➤ Major expts:

- AGATA
- PARIS
- ALICE
- NA61/SHINE
- neutron EDM
- ...

➤ International cooperation:

- IJCLAB Orsay
- GANIL Caen
- LNL INFN Legnaro
- Milano University,
- GSI Darmstadt
- FZ Julich
- RIKEN Japan

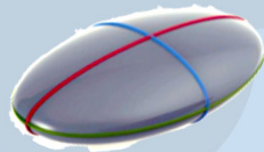
➤ Local research program at Cyclotron Center Bronowice IFJ PAN

➔ next slide

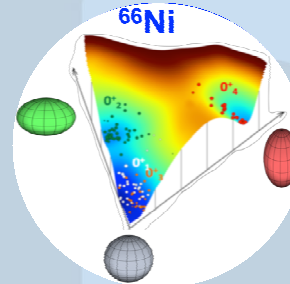
Staff: about **45** people

Results: about **140** publications/yr

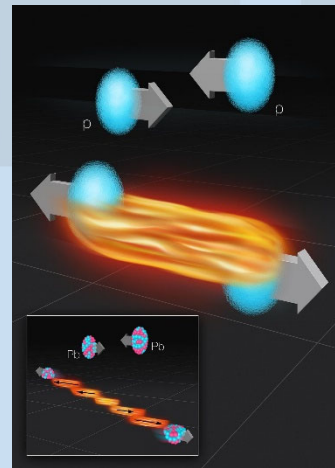
Superdeformed and triaxial states in Ca-42



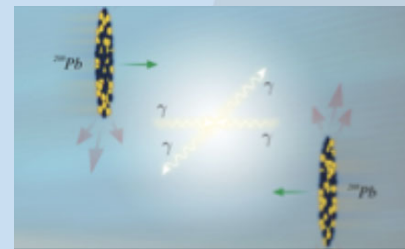
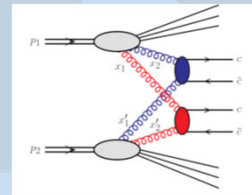
Identification of shape isomers in Ni-66 and Ni-64



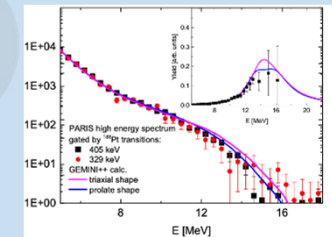
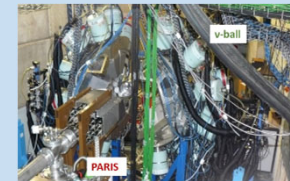
Fire streaks model of nuclei and proton collisions



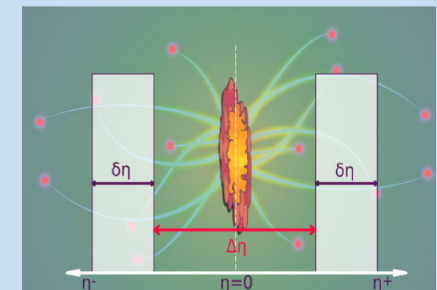
„Light-on-light” scattering in HE ultraperipheral nucleus-nucleus collisions



PARIS
– coordinated by the IFJ PAN



Long range forward-backward correlation in UHE nucleus-nucleus collisions @ ALICE

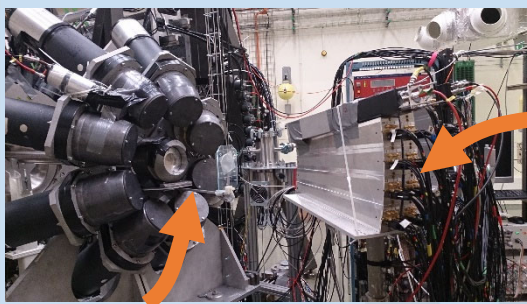


Fundamental Research at the Cyclotron Center Bronowice



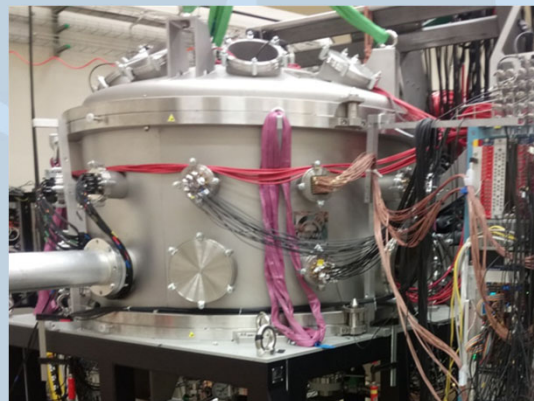
Proton beam (230 MeV) from the Proteus-235 Cyclotron at the Cyclotron Centre Bronowice

Studies of resonance excitations of nuclei

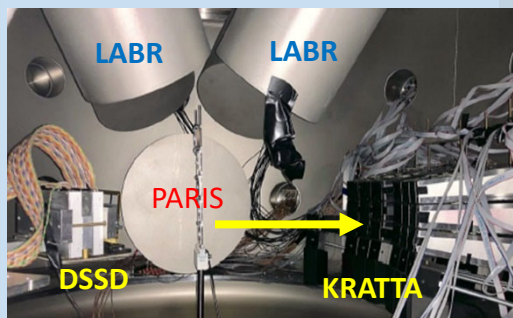


detector HECTOR
Measurements of gammas)

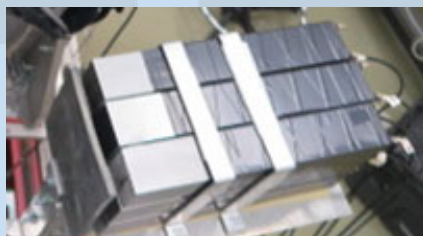
Detector KRATTA
Measurement of proton's
inelastic scattering



„Big” scattering chamber



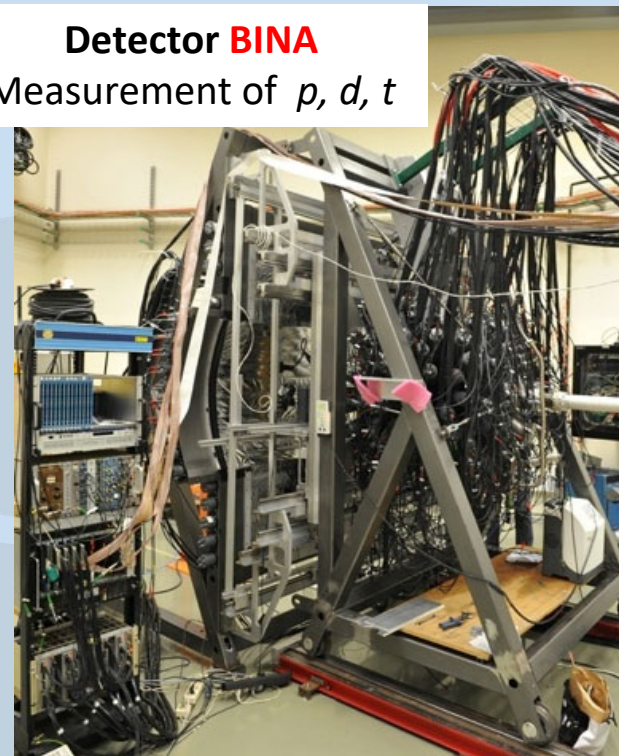
Detectors inside
the scattering chamber



PARIS and LaBr3
high-energy γ -ray array

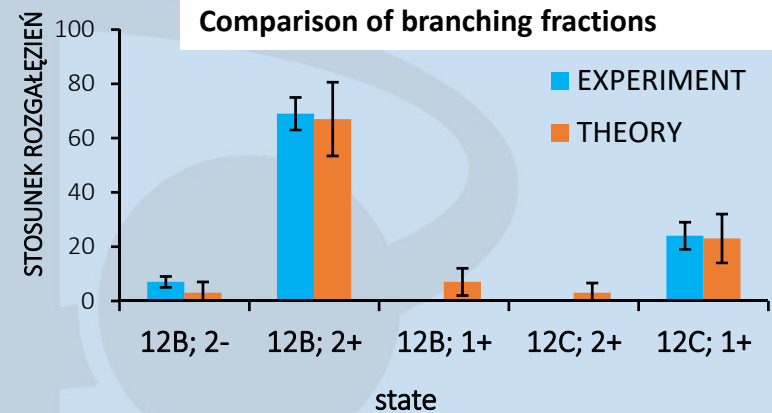
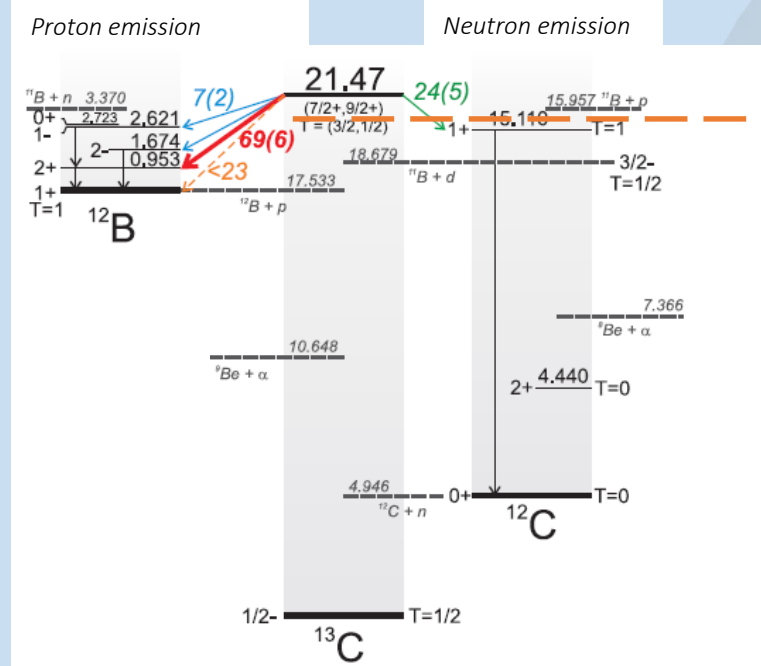
Studies of triple nucleon dynamics

Detector BINA
Measurement of p, d, t

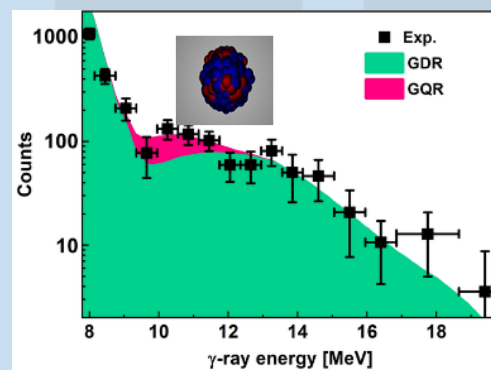




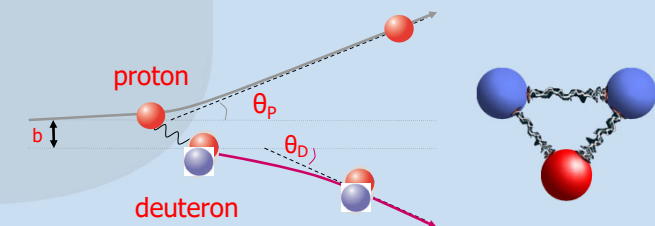
The decay of the 21.47-MeV stretched resonance in C-13



Observation of the isoscalar giant quadrupole resonance in its gamma decay to Pb-208



Studies of 3-body nuclear forces



Measurement of neutrons produced in the deuteron break-up induced by protons

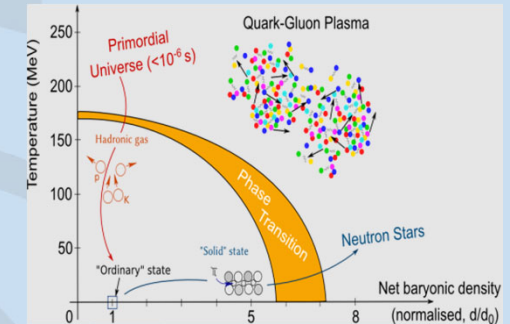
➤ Major studies

Staff: about **34** people

Results: about **60** publications/yr

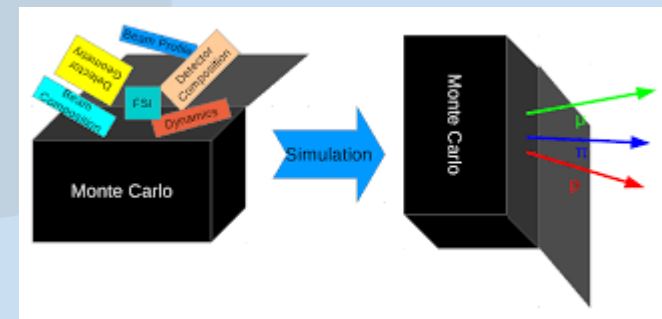
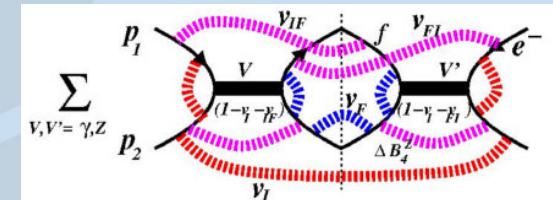
Theory of structure of matter

- Studies of q-g plasma created in heavy ion collisions: hydrodynamical description, early thermalization, plasma polarisation
- Studies of parton distribution functions of nucleon and their QCD evolution: GPDs, quasi PDFs, double PDFs, TMDs
- Phenomenological analyses of high precision rare and semi-leptonic B and D decay data from LHCb and Belle II
- Sonification of data recording and analysis for cosmic rays under the CREDO project



Particle Theory

- Construction of nuclear parton distribution functions and their application to LHC physics and future colliders
- Participation in nCTEQ collaboration
- Forward and low x physics. Construction of general framework for NLO calculations; predictions for future upgrades of LHC
- Search for saturation effects
- Monte Carlo development for FCC and LHC
- Calculations of N3LO within SCET for LHC precision phenomenology
- Jet quenching in heavy ion physics. Monte Carlo simulations cross section calculations
- Entanglement entropy at high energies



Applied research at the AIC-144 60 MeV proton cyclotron

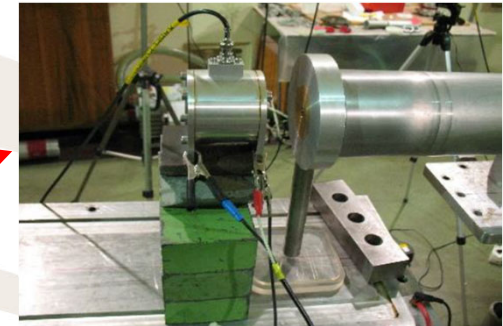


Eye line for precise irradiation

- dose rate: 0.001 – 1 Gy/min
- beam field size: ≤ 40 mm;
- Typical flux: $10e8 - 10e9$ p/cm²·s;

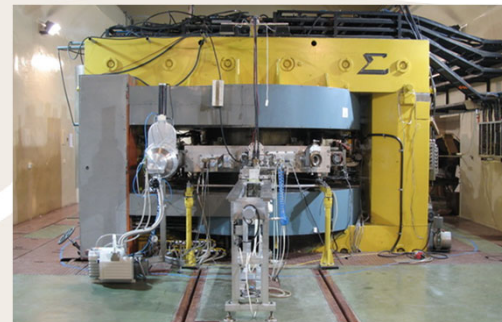
Line for isotope production

- proton current: < 100 nA;



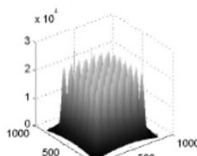
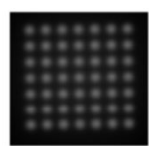
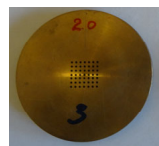
Experimental room: high beam intensity

- proton current: 2 nA – 100 nA;
- Dose rate up to 50 Gy/s
- irradiation field $d < 12$ cm;



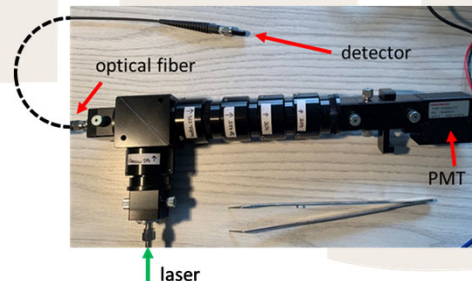
AIC-144 Cyclotron

- energy 60 MeV; RF 26,26 MHz;
- beam current 80 nA

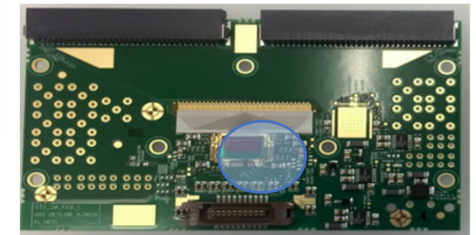


Proton grid therapy – to reduce side effect of treatment

Staff: **10** people



Testing of detectors and dosimeters



Testing of electronics for space flights

Cyclotron Centre Bronowice (CCB)



Construction 2010-2015;
the 1st patient: Oct. 2016

- **1193** patients finished irradiation in gantries
- **371** ocular patients with eye melanoma

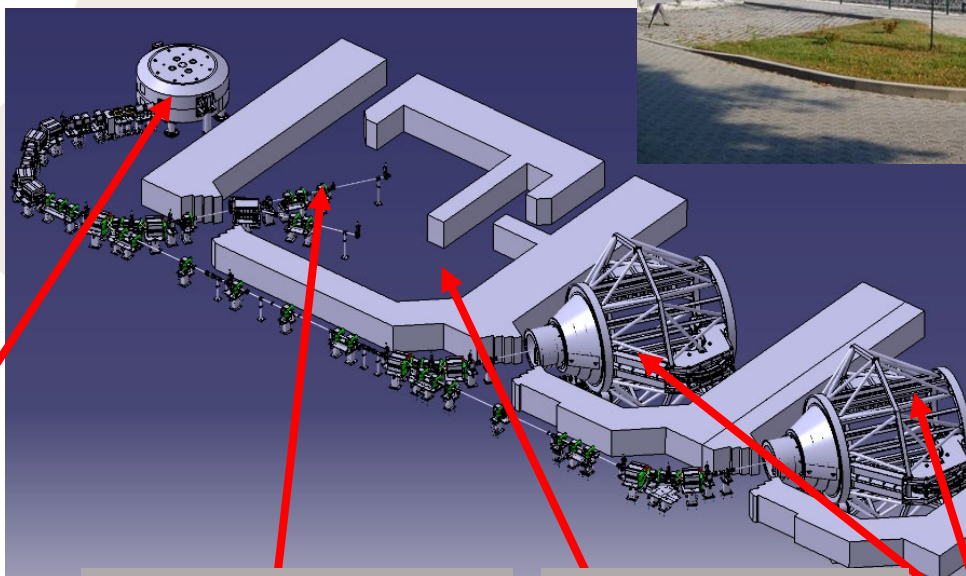
(by June 2024)



AIC-144 cyclotron

Start of operation :
2005-2010
Treatment of first
patient with eye
melanoma

Proteus-235
cyclotron IBA



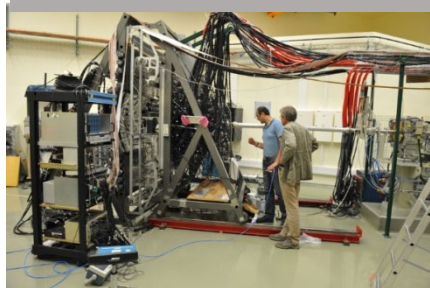
Staff: about
60 people

Two dedicated
scanning gantries



70-230 MeV, $I_{\text{beam}} = 1-500 \text{ nA}$

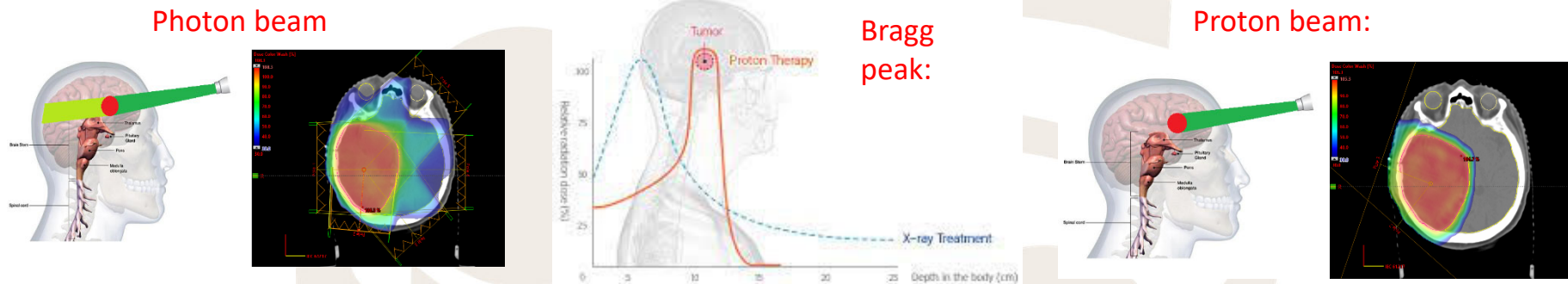
Experimental Hall



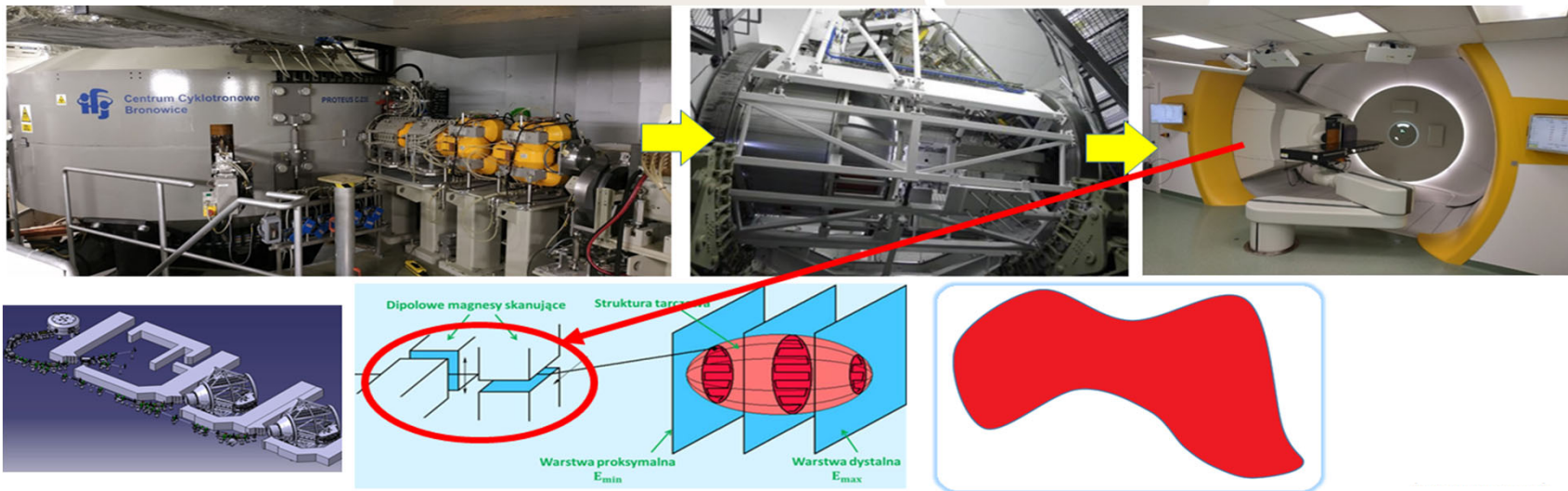
Eye treatment



Physics properties of protons allow for uniform dose distribution inside the tumour; at the same time the surrounded tissues and organs are not irradiated



These advantages strenghtens exploitation of the Pencil Beam Scanning:



Division of Scientific Equipment and Infrastructure Construction (DAI)



- Constructions of **big external research infrastructures** AND **development of local research base** (cryogenics, vacuum, precise mechanics, quality aspects, tests of magnets, RF systems installations and tests,...)

➤ Cooperation with:



Experience example	FTE
E-XFEL – DESY, Hamburg, Niemcy	~165
ITER – Cadarache, France	~15
LHC – Long Shutdown 2	~47
European Spallation Source (ESS) – Lund, Sweden	~130



Klystrons used at ESS



XFEL cryomodules

Last decade engagements: 536 FTE
Income ~30 M EUR

Scientific Results:
about 10 publications/yr

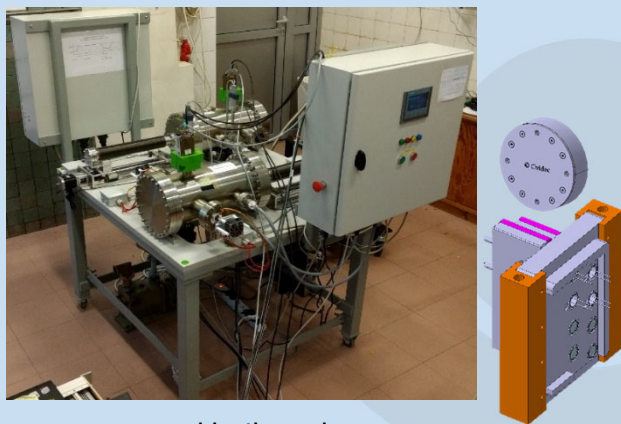
Staff:
specialist/engineer/technician: 40
Phd/assoc. prof./prof.: 5

Division of Scientific Equipment and Infrastructure Construction (DAI)



Tests for ITER

(feedthrough, diamod detectors)

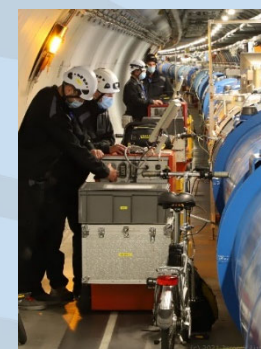


Test stand built at the IFJ PAN

Installation of SIS100 (GSI)



Contribution to LHC



QC for interconnections of LHC magnets



Dedicated measuring apparatus built at the IFJ PAN

Surface Scintillator Detector (SSD) for Pierre Auger

225 pieces



Batch of 15 SSDs ready to move to Argentina

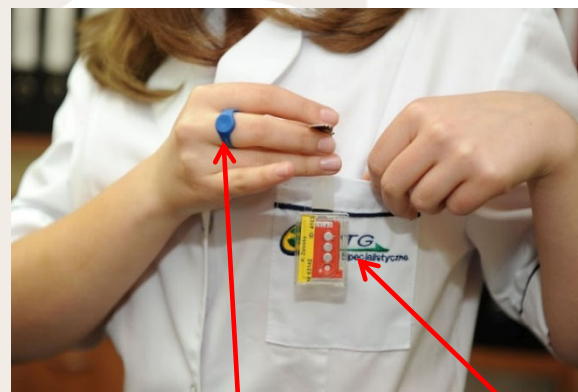
Local infrastructure: test stand for S.C. wires and magnets



Under commissioning

Laboratory of Individual and Environmental Dosimetry (LADIS)

- ❖ Measurements of individual and environmental doses by thermoluminescence method
- ❖ **210 000** measurements annually
- ❖ **11 000** institutions in Poland and Europe
- ❖ **50 000** radiation workers/measurement points under dosimetric supervision
- ❖ **730** installations of Roentgen radiography under supervision
- ❖ **Work in progress: implementation of the 1st in Poland Optically Stimulated Luminescence (OSL) system, based on BeO detectors**



0,07mm
skin dosimetry
Hp(0,07) w mSv

For measurements
on 3 mm depth in
tissue (for eye-
lens) Hp(3) w mSv



10 mm depth for the whole body
dosimetry of deep organs
Hp(10) w mSv

Laboratory of Calibration of Radiation Protection Instruments

- ❖ Calibration of up to **2300/yr** survey meters (g-rays)
- ❖ Calibration of **240/yr** survey meters (a, b surface emission)
- ❖ **150/yr** calibrations of passive dosimeters





Krakov School of Interdisciplinary PhD Studies (established in 2019)

- I. The Henryk Niewodniczański Institute of Nuclear Physics PAN - **coordinator**
- II. Jerzy Haber Institute of Catalysis and Surface Chemistry PAN
- III. Jerzy Maj Institute of Pharmacology PAN
- IV. Mineral and Energy Economy Research Institute PAN
- V. Strata Mechanics Research Institute PAN
- VI. Institute of Metallurgy and Materials Science PAN

- VII. Faculty of Materials Science and Ceramics AGH
- VIII. Faculty of Physics and Applied Computer Science AGH



Theoretical and experimental research work is carried out in the following directions:

- Particle physics and astrophysics
- Nuclear physics and strong interactions
- Solid state physics
- Interdisciplinary research:
 - medical physics,
 - physics in biological systems,
 - radiation protection,
 - environmental protection,
 - new energy sources.

~130 PhD students (20% of non-Poles)

Outreach Activities

– Promotion and Education in Science



Małopolska Researchers' Night



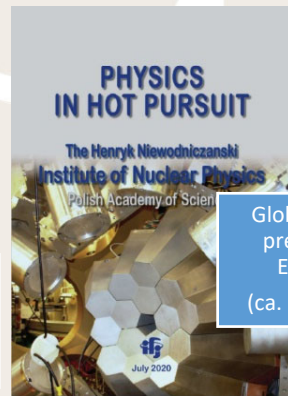
"Physics Couch" discussion series



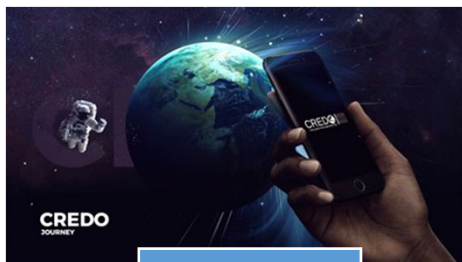
Shows "Fascinating Physics" for children and teenagers



Musical spectacle "At the intersection of two infinities"



Global scientific press service: EurekAlert (ca. 15 per year)



"Particle Hunters" contest with the CREDO Detector application



Children's Day at IFJ PAN



- Festival of Science and Art in Krakow
- Scientific Picnic of the Polish Radio and Copernicus Science Centre
- Scientific Picnic of the Polish Academy of Sciences
- Visits of high school students to laboratories at IFJ PAN
- IFJ PAN Open Day for students
- Małopolski Festival of Innovation
- QuickPhysX and QuizFiz contests
- Silesian Science Festival in Katowice
- Particle Physics Summer Student Program at IFJ PAN
- Int. Masterclasses - Hands on Particle Physics for high school students
- Making popular science movies on research carried out at IFJ PAN
- Activity in social media: Facebook, Twitter and YouTube



THANK YOU FOR YOUR ATTENTION