Particle Physics in Poland

Mid-term report for ECFA

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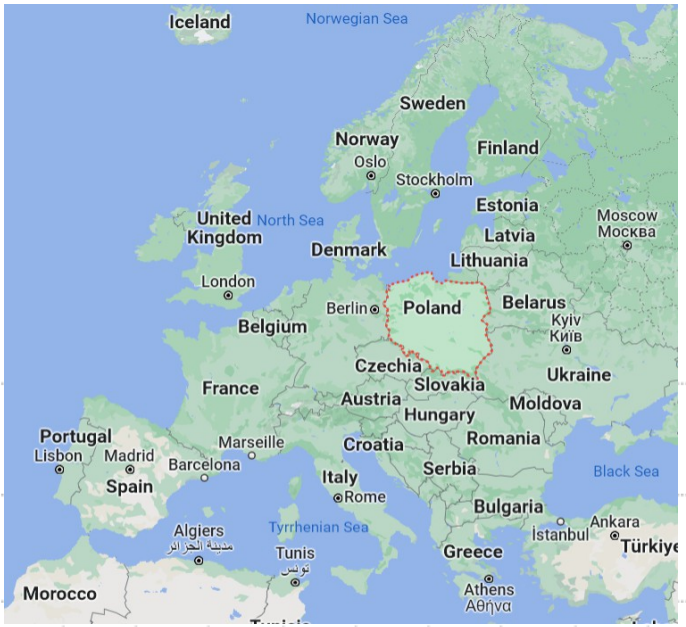
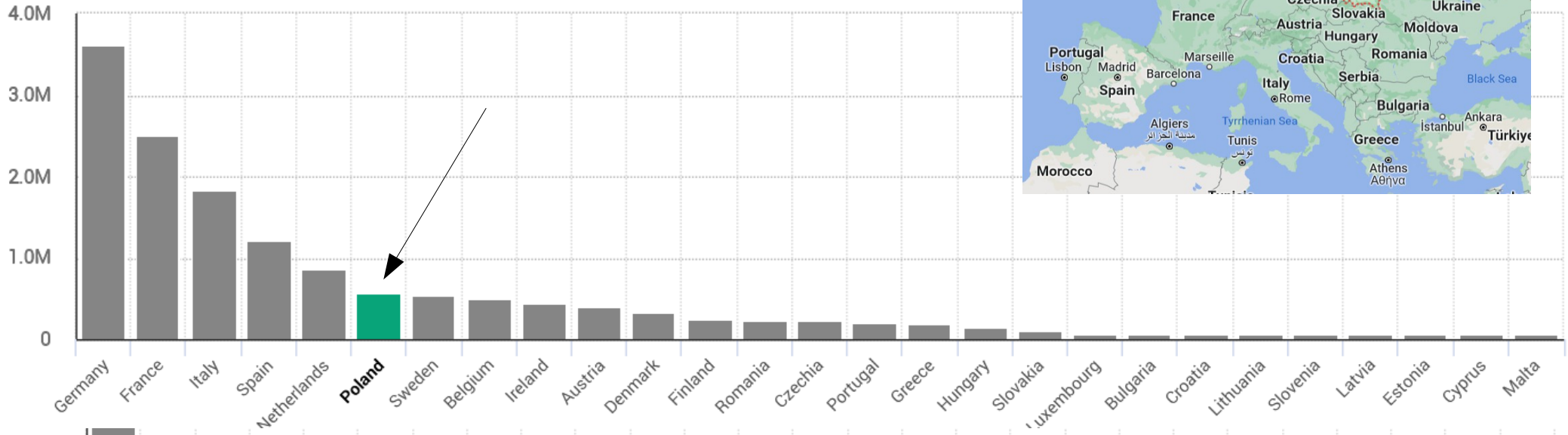
CERN, November 16th 2023

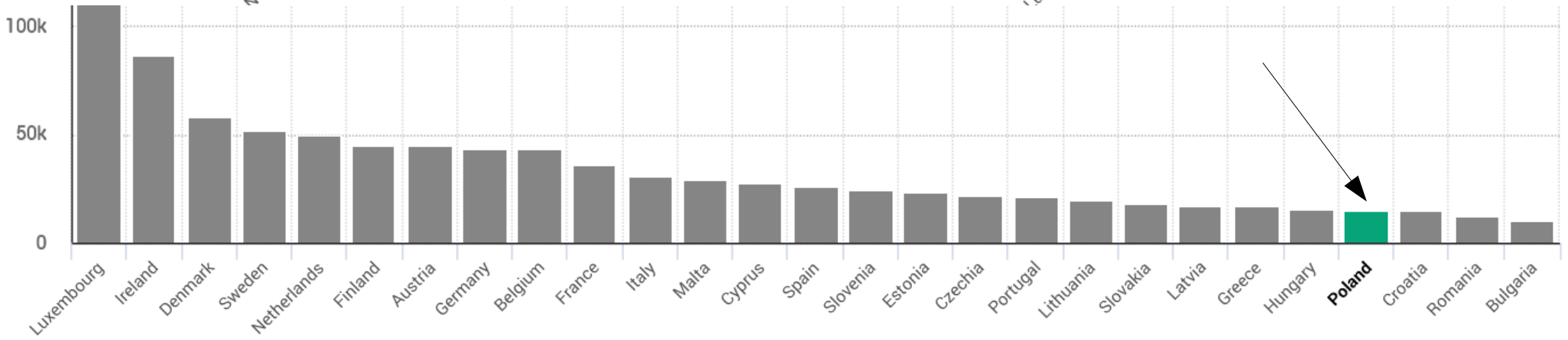
Poland – general information

- **2021**: population 37.84 mln, area 311,9k km^2
- **GDP** 574.4 10^9 EUR
  (+5,9% wrt 2020) → 6th in EU,
  15 050 EUR per capita → 24th in EU



in millions

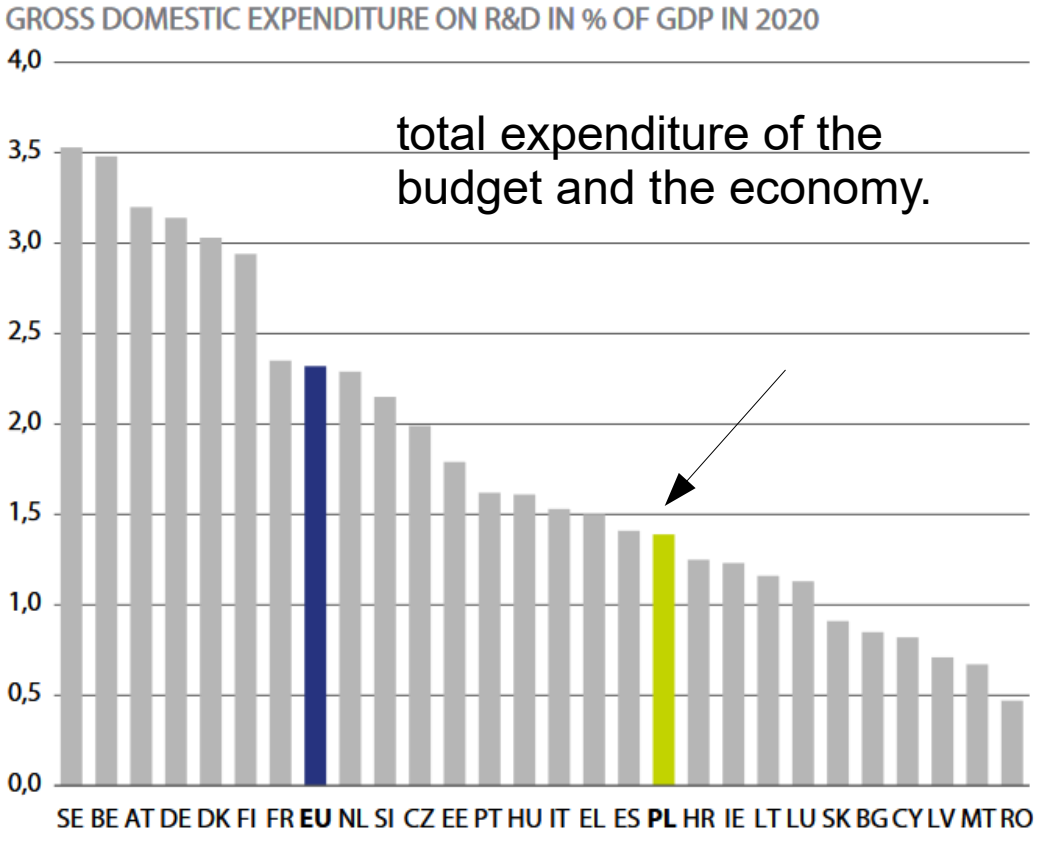


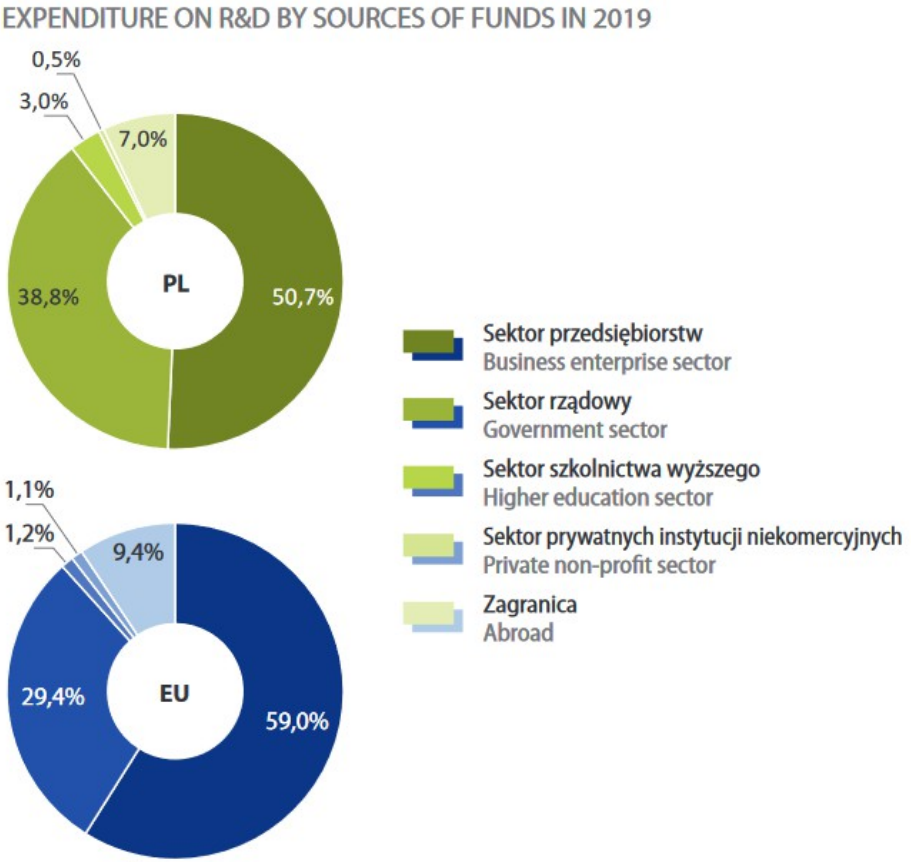


Plots taken from „Poland in the European Union” by Statistics Poland, Warsaw 2022 and Eurostat

Funding of R&D

- **1.4%** GDP spending on Research & Development
- **Ministry of Education and Science** - contributions to the international research infrastructures and participation of Polish scientific teams in these infrastructures
- public funding agencies
  - **National Science Centre** (NCN) - fundamental or basic research
  - **National Centre for Research and Development** (NCBiR) - technology innovations in order to strengthen domestic industry
  - **National Agency for Academic Exchange** (NAWA)

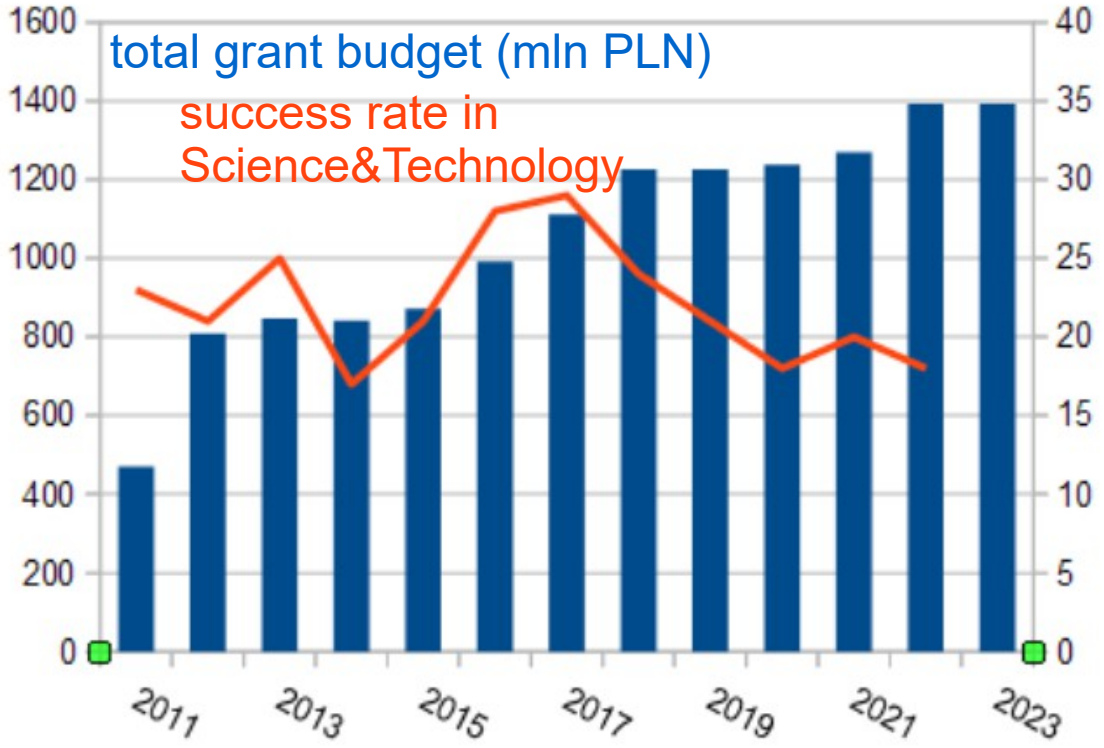




NCN

- grants available for scientists at different stages of career
  - special grants for cooperation with scientists from foreign countries
- 2018-2022: the grant budget higher by 13%,
  total requested sum increased by ~59% (from 5.4 bn PLN to 8.6 bn)
  - a rapid increase in the **cost intensity** of a single project

  → resulting in **decreasing success rate**



HEP in Poland

UMK: N. Copernicus University
UŁ: University of Łódź

USz: U. of Szczecin
UZG: U. of Zielona Góra

UB: University of Białystok

UW: University of Warsaw
PW: Warsaw U. of Technology
NCBJ: National Centre for Nuclear Research
CAMK: N.Copernicus Astronomical Centre, **AstroCENT**
CBK: Space Research Center
IM: Institute of Mathematics PAS

UWr: U. of Wrocław
UŚ: U. of Silesia

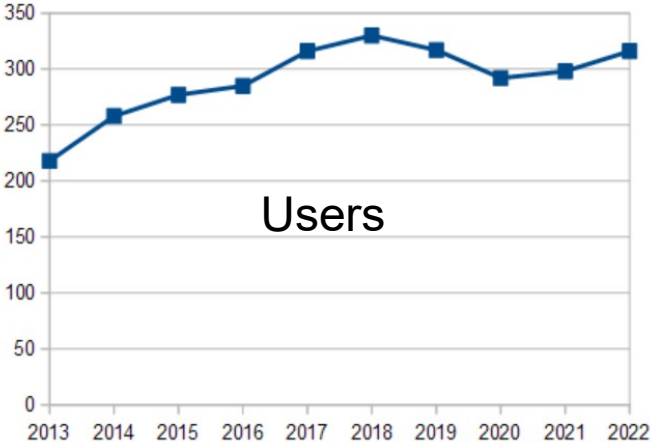
AGH: U. of Science and Technology
UJ: Jagiellonian University
PK: Cracow U. of Technology
IFJ: Institute of Nuclear Physics PAS

UJK: Jan Kochanowski U.
UMCS: M. Curie-Skłodowska U,

Poland in CERN

- Poland is Member State of CERN since July 1, 1991
- Polish groups took an active part in all phases of experiments, often from the beginning
  - Number of Institutes: **30**
  - Number of Authors: **228**
  - Users: **305**, Staff members: **91**

Source: Greybook



- Contribution to the CERN budget: **~3%** (~36 M CHF in 2023)
  - return on staff selections: **1.21**
  - return on fellows selections: **2.61**
  - industrial return factor: **0.74** → among poorly balanced countries
    - seminars, webinars, industry days organized for Polish companies

2022

  - one of largest contracts (2022): KrioSystem sp. z o.o. will supply cryogenic distribution line for the HL-LHC
    - two new helium distribution line will be connected to the helium refrigerators to distribute the cooling power to the new HL-LHC magnets and crab cavities installed at P1 and P5.
    - the contract includes design, installation, commissioning, and testing at CERN.

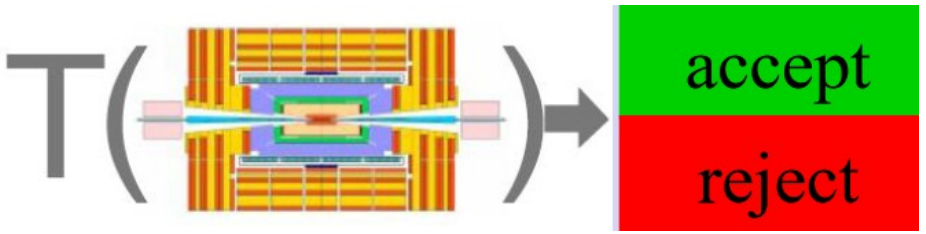
CMS

Groups:
UW, NCBJ, PW; AGH

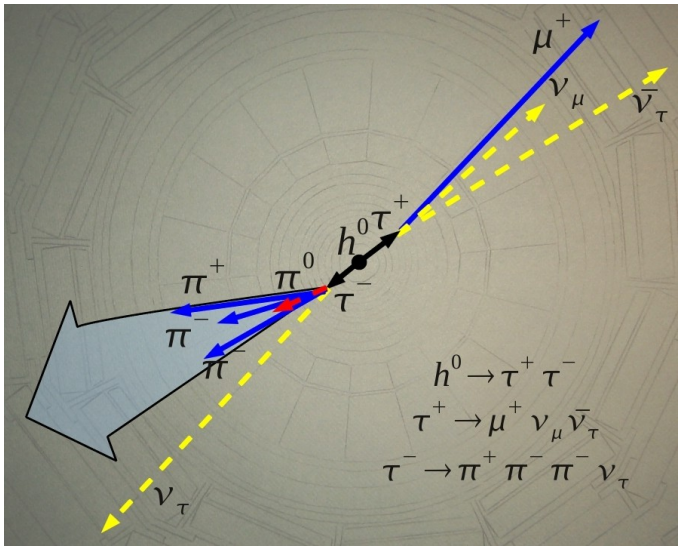
People: 17 staff, 1 post-doc, 4 PhD students, 4 engineers, 9 MSc students

Contributions to hardware and software
- design and construction of the **RPC readout** and components of the **L1 Trigger**
- maintanance and support of the OMFT trigger
- modernisation of trigger
- **Upgrade**: trigger algorithms (with machine learning) and firmware (inc. new techniques)
- development of **tau** reconstruction and indentification algorithms
- development of reconstruction and analysis of **forward** protons

Funding
Funding until 2026, intention to apply for further funding to participate in LHC Phase-II program



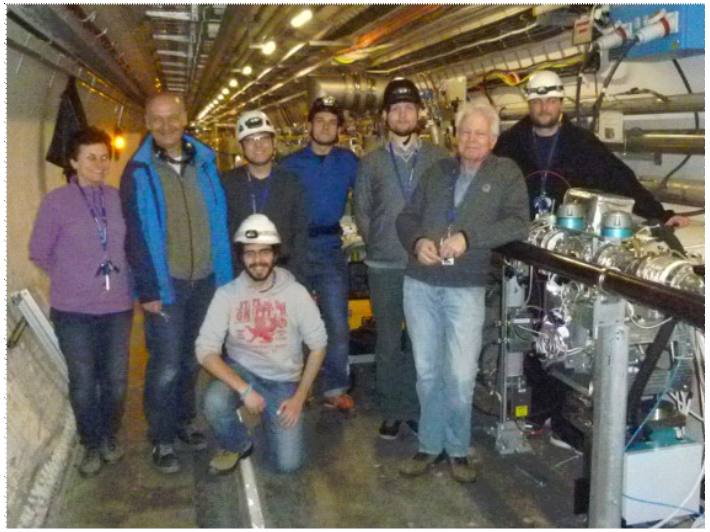
Physics studies
- tau: Higgs and displaced leptons
- Vector Boson Scattering – Standard Moder testing
- search for exotic long-lived massive charged particles
- Forward Physics



ATLAS

Groups: only from Cracow: IFJ, AGH, associated UJ, PK - Upgrade only

People: 34 physicists, 21 PhD+MSc students, 11 engineers (18 women, 9 foreigners)



Contributions to hardware and software:

- Design, construction, and maintenance of SCT, TRT, AFP, ALFA, and ZDC detectors.
- Maintenance and development of TDAQ
- Involvement in the detector upgrade for HL LHC
  - construction of the new Inner Tracker, preparation of DAQ and systems for detector control

- full engagement in the ATLAS physics exploration, directly participating in the **leading analyses**
  - Standard Model precision measurements
  - forward physics
  - searches for the extended scalar sector,
  - heavy ions
- Important management **responsibilities**
  - TRT and ARP Project Leaders;
  - Coordination of: ARP DCS, DAQ and Software, ITk Strip Power Supplies, Trigger MinBias/FWD Signature; EF Tracking L4 Manager;
  - Convenorships of physics and performance groups.

Funding

two large grants from the Ministry of Education and Science

- M&O grant till end of 2026: (~1.2 MPLN/250 kCHF per year)
- additional financing for Upgrade activities: previous project finished (2018-2023), proposal for new project submitted

beneficiary of 13 NCN, NAWA, and H2020 grants.

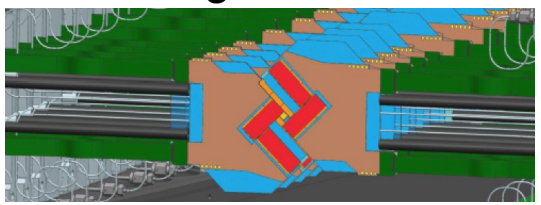
LHCb

Institutions from Warsaw (NCBJ) and Cracow (IFJ, AGH, PK)

People: 26 physicists, 12 PhD students, 11 engineers, 2 MSc students (8 women, 7 foreigners)

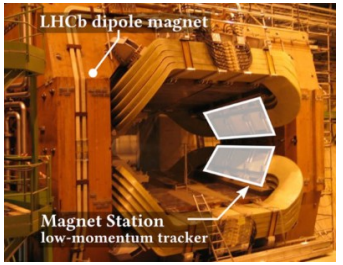
Upgrade 1 involvement

- Upstream Tracker: ASIC design
- Vertex Detector (VELO): cooling, radiation damage, calibration s/w



- RICH: contribution to ASIC chip design (Claro), Rich full simulation and PID performance monitoring

Real Time Analysis



- reconstruction algorithms: primary vertex, short tracks
- on-line monitoring of primary vertex performance
- Long-lived tracking algorithm
- central scripts for performance monitoring

Upgrade 2 plans

- Magnet Stations, Muon Stations
- Detector design and production (mechanical support, electronics cooling)
- Design of ASIC chip
- VELO : Novel radiation hard silicon structures, 4D tracking algorithms
- SciFi contribution (option to Muon Stations):

Physics studies

- **CP and CPT violation** in charm and beauty decays
- **Rare** semileptonic and hadronic **decays**
- Baryon and lepton violation decays
- Search for tetraquarks in $B \rightarrow J/\psi K\pi$
- B-jets, bb cross-section
- Bose-Einstein corelations
- Exclusive vector meson production

Computing

- Tier-2 Data center, to be commissioned as Tier-1 Nov2023
- contribution to development of distributed analysis software (DIRAC)
- development of central software architecture

Funding

- M&O grant till end of 2026
- upgrade grant for Cracow groups
- several NCN grants

ALICE

Consortium ALICE-PL:
PW, NCBJ; IFJ, AGH

People: 27 scientists and 15 PhD students

Detector development, calibrations, maintenance and operation

- Time Projection Chambers and Photon Spectrometer since 1993 (calibration, electronics)
- Fast Interaction Trigger since 2019 (electronics, simulations)

(~1.6 MCHF contribution to TPC, PHOS and FIT)

LS3 modernization

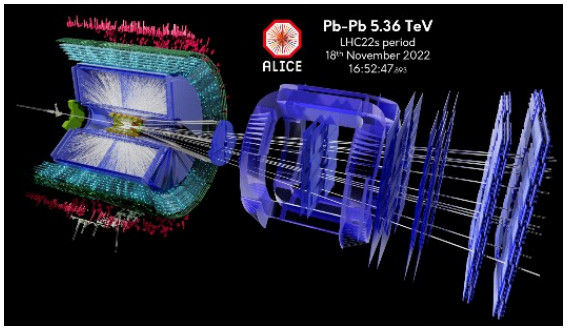
- PHOS and FIT electronics and development
- construction of FoCal forward calorimeter since 2022 (mechanics & cooling).

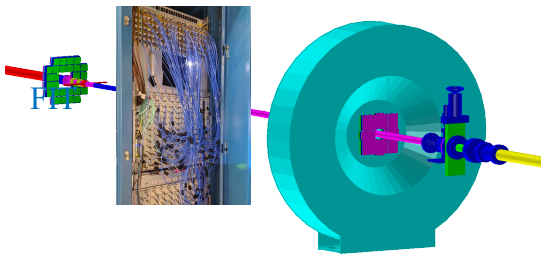
Interest in LS4 modernization

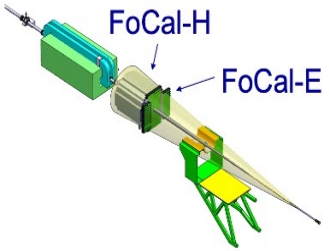
- luminosity monitoring and fast triggering.

Funding

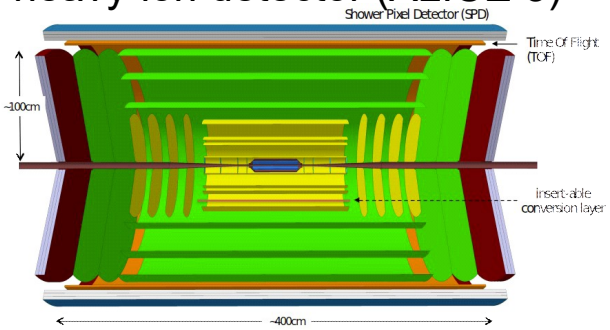
- Ministry od Education and Science (M&O, IDUB→PW)
- grants from National Science Centre (NCN)
- applied for funding for LS3 modernization from the Ministry of Education and Science







LS4: Future heavy-ion detector (ALICE 3)



Physics analyses

- Femtoscopy and angular correlations
- Open charm measurements
- ML for particle identification

NA61/SHINE

Groups: UJK; UW, PW, NCBJ; UJ, IFJ, AGH; UŚ, UWr

People: ~63 ← the strongest participation of Poles in a single CERN collaboration (30%)

Detector upgrade completed in 2022 (cost of 2.0M CHF covered by funding agencies).
The data rate increased by a factor of 10-20. More than 200M events were collected in both 2022 and 2023.
Plans for LS4 (2026-2027): Detector upgrade with the cost of 1-2M CHF

- Reconstruction, calibration, DRS system, DAQ

Analysis

- CP search via fluctuations and correlations in p+p and A+A collisions
- Properties of the onset of deconfinement via analysis of spectra and yields
- EM effects in non-central A+A
- Open charm measurements
- Reference data for T2K: spectra from p+C and p+T2K replica target

Positions:

- deputy spokesperson
- upgrade coordinator, deputy upgrade coordinator
- EXSO (experminatal safety officer)
- deputy analysis coordinator
- PBC QCD representative, PBC Beam representative,

Funding
NA61/SHINE Common fund - cover by Ministry grant till 2024

Other CERN experiments

Antihydrogen and precision spectroscopy of exotic atoms at **AD/ELENA**

The participation to the **AEgIS** experiment of Polish institutes is coordinated by the Consortium AEGIS-PL with the following participating institutions: UMK, IFJ PAN, UJ, PW (20 persons)

Pursued Physics program with involvement of Polish institutes:

- Pulsed antihydrogen beam via charge exchange reaction 2023-2025
- Positronium spectroscopy 2023-2028
- Antiprotonic atoms synthesis and spectroscopy phase I 2023 – 2027
- Antiprotonic atoms synthesis and spectroscopy phase II 2028 – 2032
- Antiprotonic molecules and other systems 2033 – 2038

GBAR – NCBJ, 5 persons

- desing and production of linear electron accelerator

- **COMPASS** and **AMBER**
  - NCBJ, PW, UW, ~12 persons (5)
    - SciFi detectors design, construction and operation
    - front-end electornics for ECAL0
    - upgrade of CEDAR detectors
    - Drell-Yan and Deeply Virtual Compton Scattering analysis
- Extensive and long-tem exploitation of **ISOLDE** infrastructure
  - AGH, UW, IFJ, NCBJ, UŁ, UAM, PP (Poznań) = 55 persons
- **MuonE**: IFJ, AGH - ~4 persons
  - detector layout and technology, reconstruction
- **CLICdp**: UW, UJ, AGH
  - physics studies, FCAL and pixel detectors R&D
- TOTEM, nTOF

BELLE II and BES III

BELLE II experiment at SuperKEKB e+e- collider at luminosity frontier, tuned to Y(4s) mass

Groups: IFJ

People: 3 physicists, 2 PhD students, 1 engineer

Contributions

- SVD: slow-control, integration of read-out with DAQ, software development
- magnetic field measurements
- pixel detectors: R&D, protection system and low voltage system

Funding

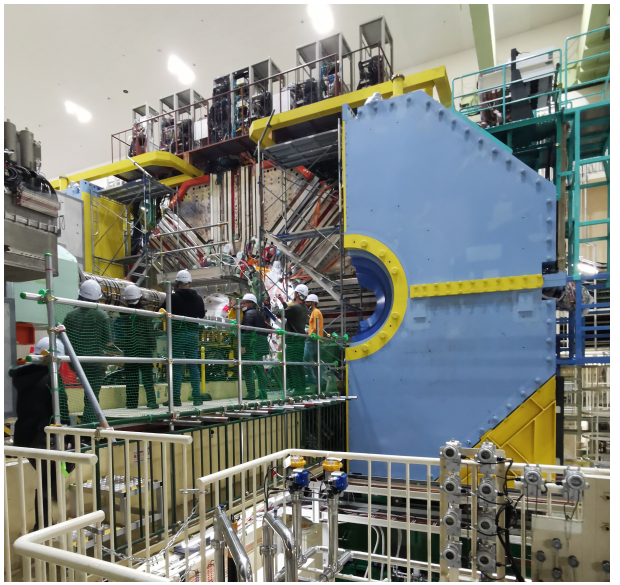
- H2020 MCSA mobility grant
- grant from Ministry finished last year

Topics:

- B decays with missing energy
- Inclusive measurements
- Charm spectroscopy
- B decay tagging methods

Positions:

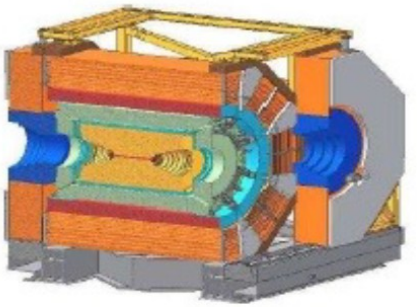
- Speakers Committee, Executive Board, Financial Board, Offline SVD software coordinator



BES III

at BEPCII e+e- collider, with center-of-mass energy 3.78 GeV

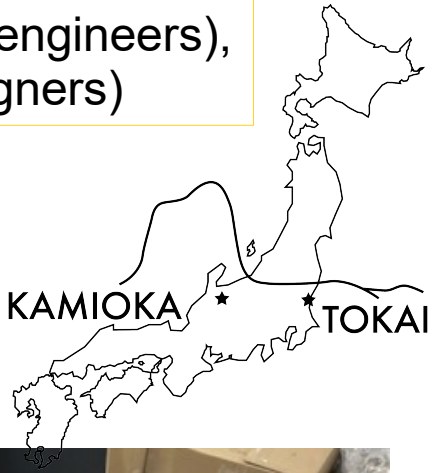
- small group from NCBJ:
- leader, 2 post-docs, 1 PhD student
- CP violation in decays of (anti)hyperons and eta mesons



T2K, Super-K and Hyper-K

T2K (**SK**): NCBJ, UW, PW, IFJ, UŚ, UWr
HK: as above + AGH, UJ

People: T2K: 22 staff (16 physicists, 6 engineers), 8 PhD students (8+1 women, 2+4 foreigners)



T2K operation and upgrade
- care for FGD subdetector
- calibration of SK (reflectivity, cosmic muons)
- for ND280 upgrade: TPC mechanical support and testing equipment for MicroMegas

HK R&D and construction (inc. WCTE)
- read-out electronics
- multiPMTs design and assembly
- design and construction of LINAC for calibration

Contributions to analysis:
- systematic uncertainties estimation
- oscillation analyses: new inputs to T2K OA, T2K-NOvA joint fit, SK tau appearance analysis
- cross section measurements in ND280
- development of oscillation fitter based on Markov Chain MC
- development of NuWro generator

Positions
- T2K: PubBoard, ASG, ND280 Upgrade Integration (previously also EC, ND280 NuMu, ND280 G4)
- HK: EB, Electronics convener, PubBoard, Speakers Board

Funding
- ministerial grant for T2K operation
- ministerial grant for HK R&D and construction
- 4 smaller grants from NCN for positions and travels
- 2 H2020 MCSA mobility grants

Other neutrino experiments

High energy neutrinos

- **P-ONE experiment**
  - 1 staff, 1engineer, 2 PhD students, (expected soon +1 postdoc,+ 1 PhD student)
  - NCN grant till 2028
  - adaptation of laser calibration system for P-ONE (formerly designed for Baikal)
  - - Development of fast simulation of photons propagation in water
  - - STRAW calibration data analysis
  - - GEANT4 detector simulations
- **KM3NeT**
  - dedicated grant finished, seeking for possibility to continue the involvement
  - 1 PhD thesis currently in review

Low energy neutrinos, 0vββ and Dark Matter

- **Borexino**
- **GERDA, LEGEND**
- **DarkSide**
- UJ Cracow – 3 physicists
- experts at background reduction techniques
  - received the Polish Minister of Education and Science Awards for Significant Achievements in Scientific Activity for their work on Borexino.

- Individual contributions to **DUNE**
  - UW, UWr

Electron Ion Collider

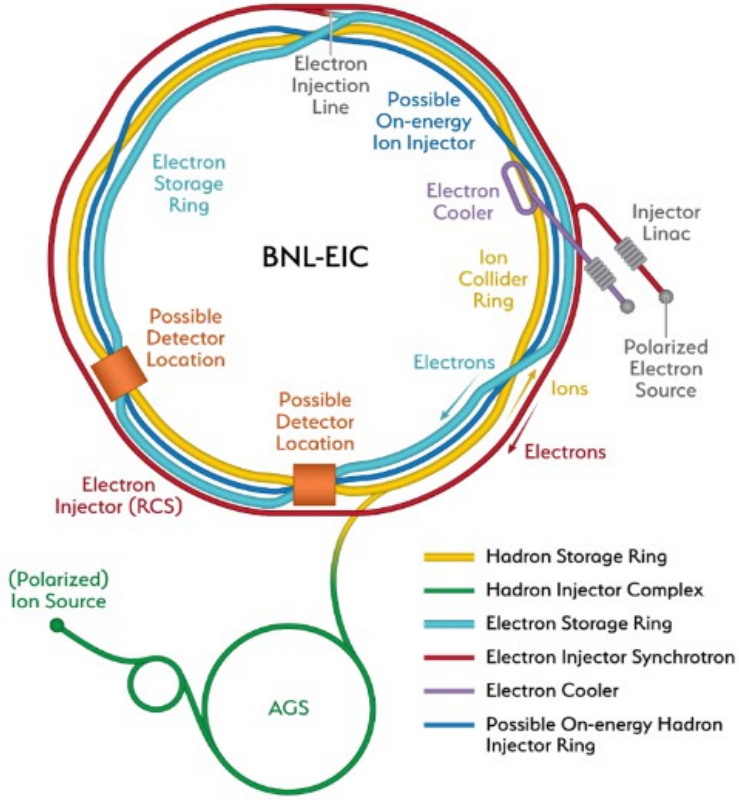
New generation QCD facility being built in BNL – the major investment of US in particle physics
Poland has expressed a strong interest in the project. The latter will be definitely pursued in synergy with CERN, especially a.f.a. accelerator technology is concerned

Polish EIC consortium:
AGH, IFJ, NCBJ, PK, PW, UJ, URz, UW
(27 interested people)

- Polish group has engaged in the theoretical research related to a variety of topics to be studied at EIC
- development of both the accelerator and the detectors.

- organisation of seminars and schools promoting EIC subject and the Polish involvement, e.g.: 61st Cracow School of Theoretical Physics, Epiphany'23 in Cracow

- organisation of EIC Users Group meeting in Warsaw (June 2023)
https://indico.cern.ch/e/EICUG2023



Funding
application for funding in progress
several NCN grants

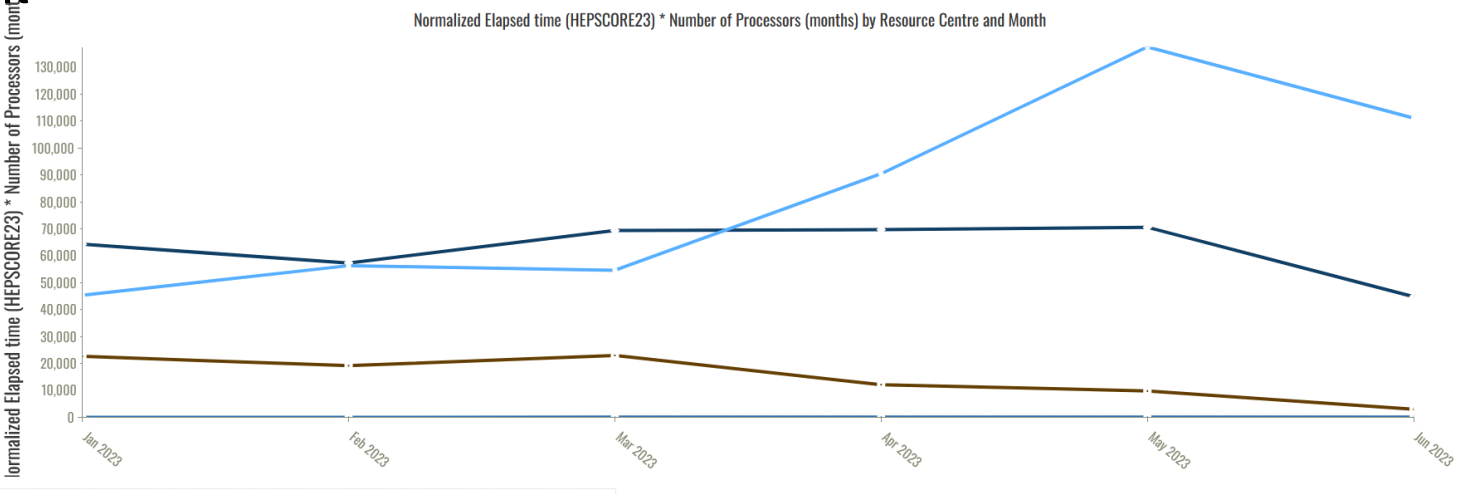
Theory

- Broad spectrum:
  - **Standard Model** - precision calculations for EW and QCD processes, heavy ions, analytical and numerical tools, Monte Carlo generators (Herwig, KKMC, Phokhara, Tauola, …) for LHC and future colliders
  - **BSM** in flavour (leptons, quarks) physics, discrete symmetries, model building
  - **Electroweak breaking and nature of the Higgs sector**: GUT, SUSY, composite higgs, higgs-less models, multi-higgs models, conformal models
  - **UV completion**: strings, string pheno, strongly coupled gauge sectors, extra dimensions (RS, deconstruction), effective field theories
  - **Dualities**: AdS/CFT and its applications to nonequilibrium properties of strongly coupled plasma, relevant for the experimental RHIC/LHC heavy-ion experiments
  - **Cosmology and particle astrophysics**: inflation and dark matter, primordial fluctuations, dark energy, phase transitions (EW baryogenesis), gravitational waves, extensions of Einstein Gravity, non-standard Big Bang cosmologies

UW (2 groups) 31 staff+14 PhD st. (4 women, 20 foreigners) 15 grants for 23 MPLN	**NCBJ** 18 staff+7 PhD st. (4 women, 14 foreigners) grants for 15.6 M PLN	**UJ** (2 groups) 14 staff+8 PhD st. (2 women, 11 foreigners) grants for 13 MPLN	**IFJ** (2 groups) 16 staff+7 PhD st. (1 women, 8 foreigners) 6 grants for 8.5 MPLN
UŚ 6 staff+4 PhD st. (1 women, 2 foreigners) grants for 1.5 MPLN	**UJK** 9 staff+4 PhD st. (2 women, 8 foreigners) grants for 1.5 MPLN	**UWr** (2 groups) 16 staff+6 PhD st. (4 women, 6 foreigners) 10 grants for 7.9 MPLN	+ USz, UMCS

Computing

- Polish WLCG Agreement (2021) signed by:
  - Akademickie Centrum Komputerowe **CYFRONET** AGH, Kraków
  - Narodowe Centrum Badań Jądrowych (**NCBJ**), Świerk
  - Poznańskie Centrum Superkomputerowo-Sieciowe ICHB PAN (**PCSS**), Poznań
- Commitments to experiments:
  - **ALICE**: PCSS (T2)
  - **ATLAS**: ACK Cyfronet (T2)
  - **CMS**: NCBJ and ACK Cyfronet (T2)
  - **LHCb**: NCBJ (proto T1)
- Good fulfillment of obligations
  - **CPU** – often more delivered than pledged
  - **Storage** – more difficult to achieve pledges
- Financial issues
  - increased costs of electricity
  - no dedicated funds for CERN experiments computing



RECFA visit recommendations in 2019

- *Developing a **clear funding path for pure detector R&D projects** is essential: It is important to make sure, however, that the funding opportunities for pure detector R&D projects do not fall between the cracks of the system. […] The potential is high, but a clear funding path for detector R&D seems to be missing.*
- No significant progress has been made

- *It is essential that **CERN activities feature clearly on the Polish roadmap**, as they do on the ESFRI roadmaps. When the mechanisms introduced following this reform have been implemented, it would give us great pleasure to see **additional steps taken to increase the fraction of the Polish GDP devoted to research**, which, at around 1% today, is perceived to be too low. In general, **funding is not abundant.***
- Polish Roadmap for Research Infrastructures established and „is to become the basis for the investment policy of the Ministry of Science and Higher Education in the coming years, however it is worth underlining that placing a research infrastructure project on the Roadmap **does not automatically imply** the financial commitment of the Ministry."
- includes: Cherenkov Telescope Array, Virgo, ESS, E-XFEL and PolFEL, FAIR, Spiral2, Hyper-Kamiokande, Particle Physics Research with the CERN Infrastructure (all activities, including future colliders and computing)

https://www.gov.pl/attachment/b3cc211e-39d5-4de1-a914-5796bc5944a4

cont.

- ***Additional guidance*** *for Polish researchers applying for EU grants would be welcome. The possibility of a* ***reward system****, potentially involving matching funds, could be considered for successful applications.*
  - no systemic support
  - some rewards from the ministry exist: additions to salaries, additions to mobility grants
- *A more profound* ***integration of particle physics topics into the curricula of Bachelor's education*** *could attract more Master's students, ultimately enabling Polish research groups in particle physics to take on more PhD students*
  - individual effort at universities
- *The Committee feels, however, that a* ***national network to exchange best practices and co-organise activities*** *would further strengthen the outreach effort. It might get more researchers on board and be a portal to attract funding in order to sustain concerted outreach efforts*
  - no significant progress has been made in creating an official structure

- there are recommendations in 2019 RECFA letter which are not yet addressed
  - in the meantime: COVID-19 pandemic, war in Ukraine...
  - recently, there were elections in Poland, the change of the government is possible