Nuclear research infrastructure in Poland

Reactor MARIA

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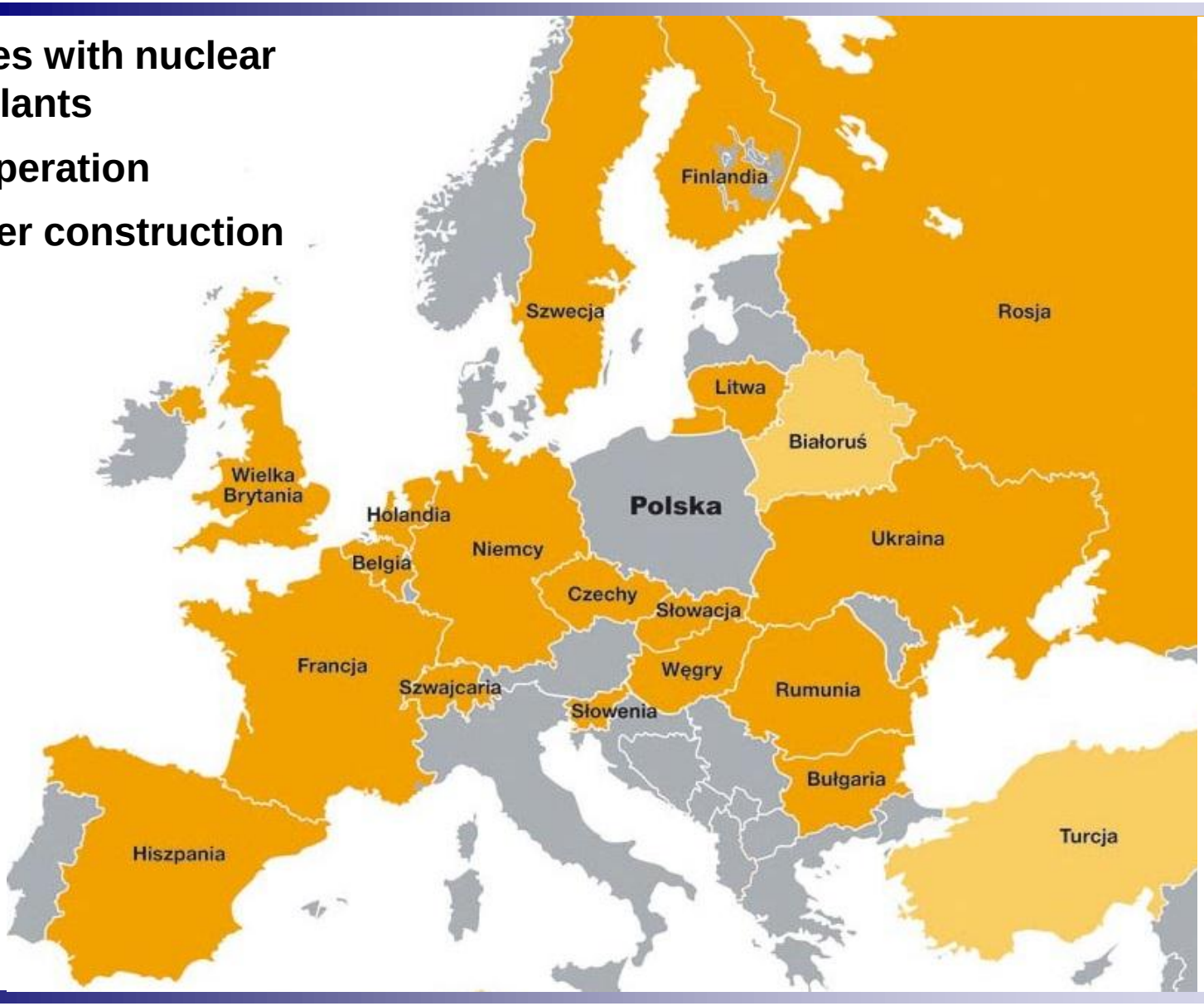
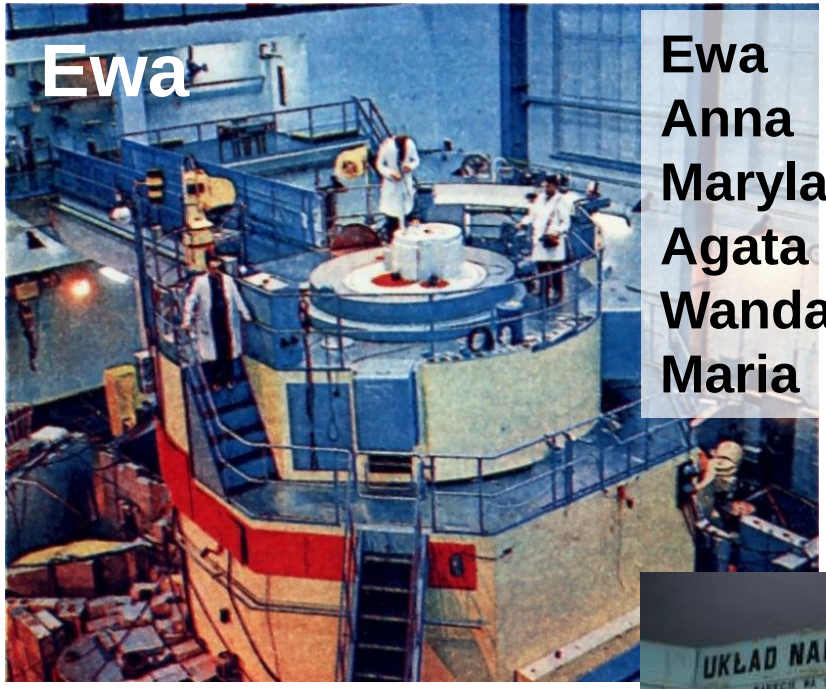
Poland: non-nuclear country?

Countries with nuclear power plants

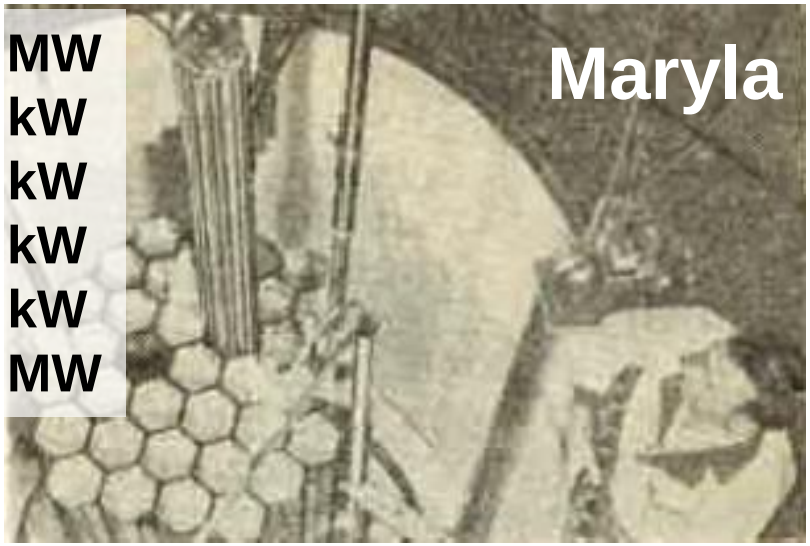
- in operation
- under construction

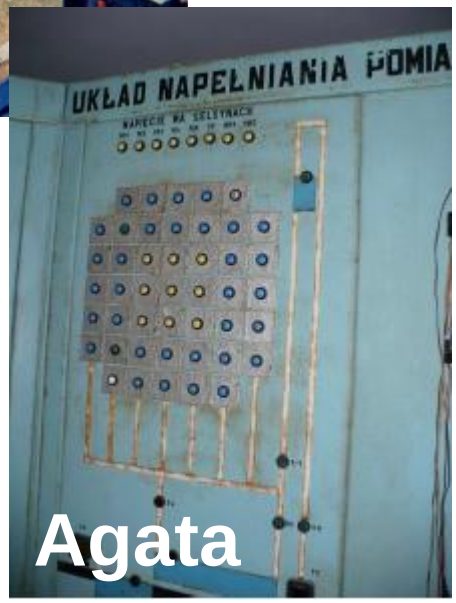


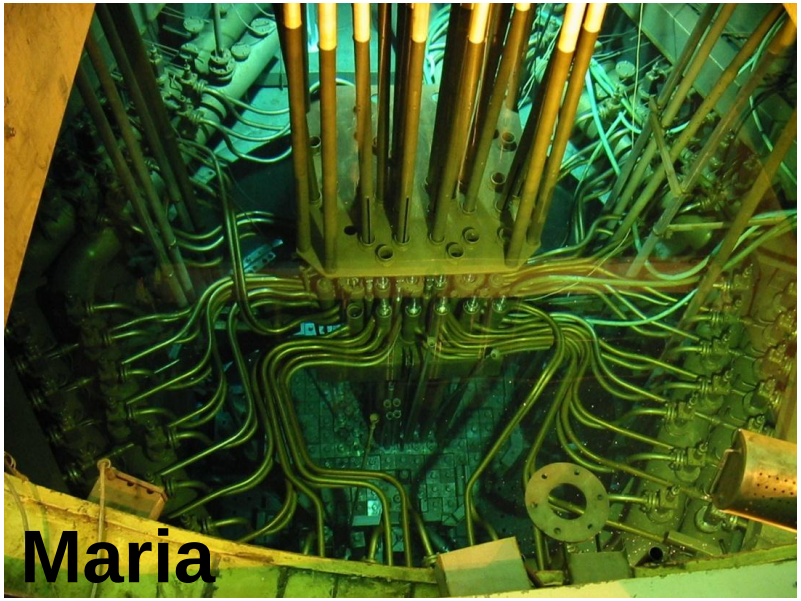
Poland: nuclear for 57 years



Ewa	1958	2 MW
Anna	1963	10 kW
Maryla	1963	100 kW
Agata	1973	10 kW
Wanda	1985	100 kW
Maria	1974	30 MW

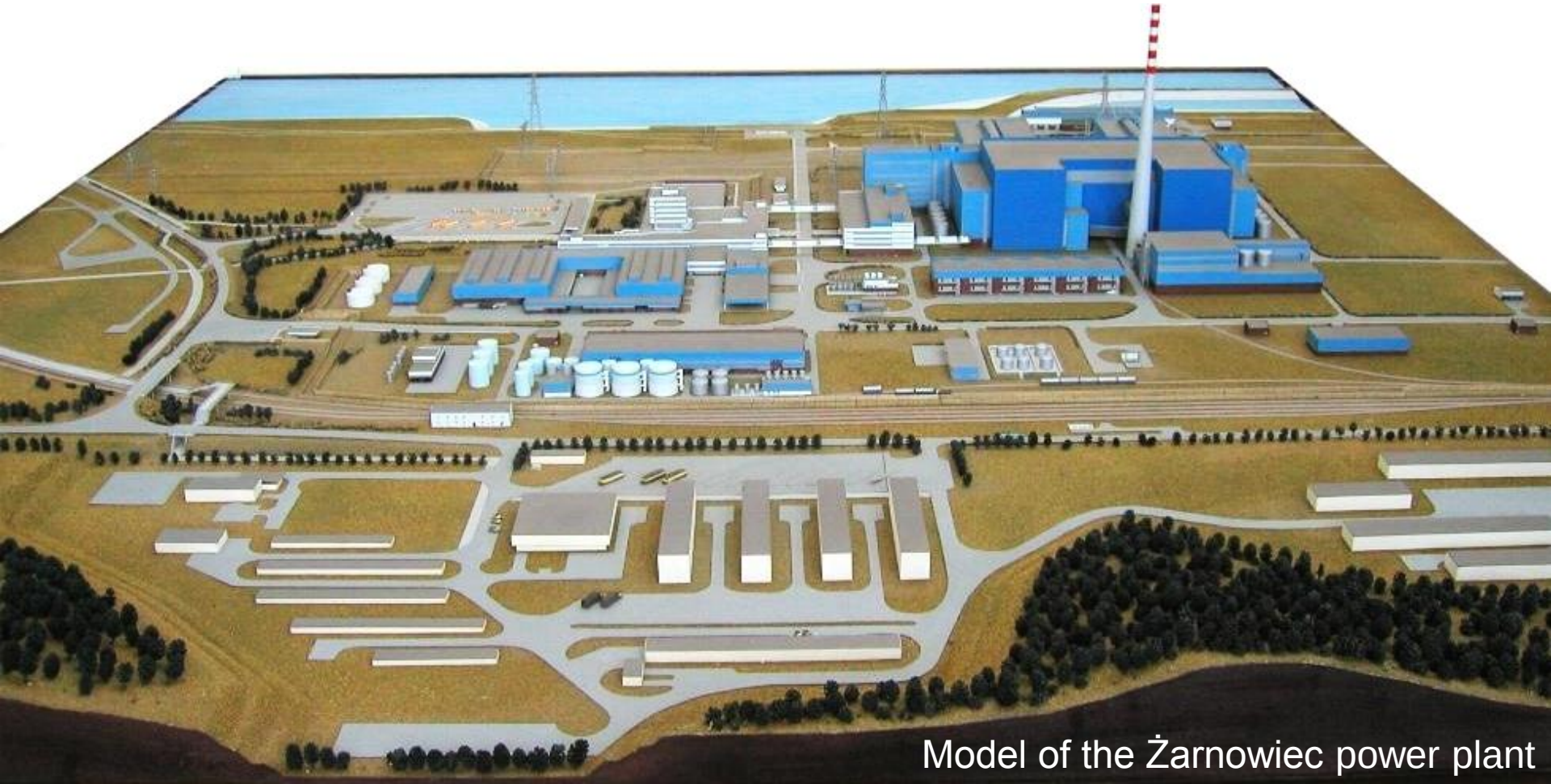






Polish Nuclear Power Programme

- **The first attempt ~1970: VVR400 in Żarnowiec**
- **Abandoned after constructing 44% of the plant**



Model of the Żarnowiec power plant

Polish Nuclear Power Programme

Decision taken 13.01.2009:

- **PGE indicated as the first investor**
  - **largest Polish energy company**
- **2 plants, 3000 MW each, by 2030**
  - **the first unit by 2020, now delayed to 2025**

Program approved 28.01.2014:

Plan for the first unit:

- **2016 – technology choice**
- **2017 – request for permit**
- **2019 – licence issued**
- **2025 – in operation**

Some delay is expected

PGE

Polska Grupa Energetyczna

Polish nuclear institutes

Institute	site	staff	supervised	funded
National Centre for Nuclear Research (**NCBJ**)	Świerk, Warsaw	1114	Ministry of Economy	Ministry of Science & Higher Education
Inst. of Nuclear Chemistry & Technology (**IChTJ**)	Warsaw	262		
Central Lab. for Radiological Protection (**CLOR**)	Warsaw	53		
Institute for Plasma Physics & Laser Microfusion (**IFPiLM**)	Warsaw	81		
Institute of Nuclear Physics (**IFJ**) Polish Academy of Sciences	Cracow	486	Ministry of Science & Higher Education	

Universities with some nuclear research and education:

- AGH Technical University in Cracow,
- Warsaw University of Technology, University of Warsaw,
- Technical University in Gdańsk, Silesian University of Technology,
- Wrocław Technical University, + …

Institute of Nuclear Chemistry & Technology

Radiochemistry laboratories

Accelerators

Institute of Nuclear Physics, Cracow

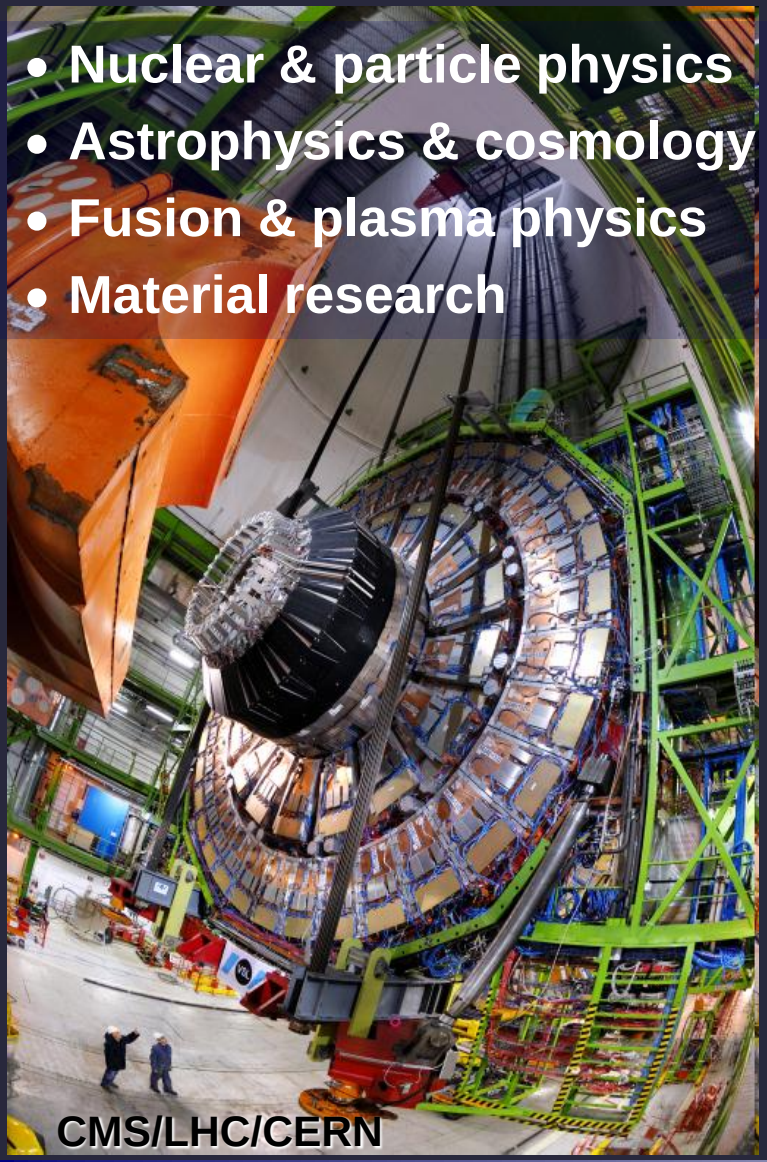
230 MeV proton cyclotron for research & proton therapy

National Centre for Nuclear Research

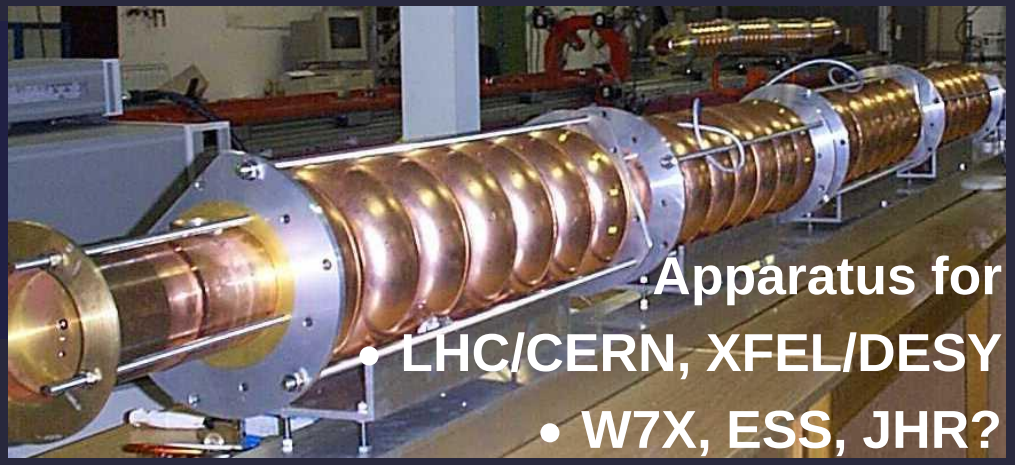
www.ncbj.gov.pl

research ⇒ apparatus ⇒ products

- Nuclear & particle physics
- Astrophysics & cosmology
- Fusion & plasma physics
- Material research



CMS/LHC/CERN

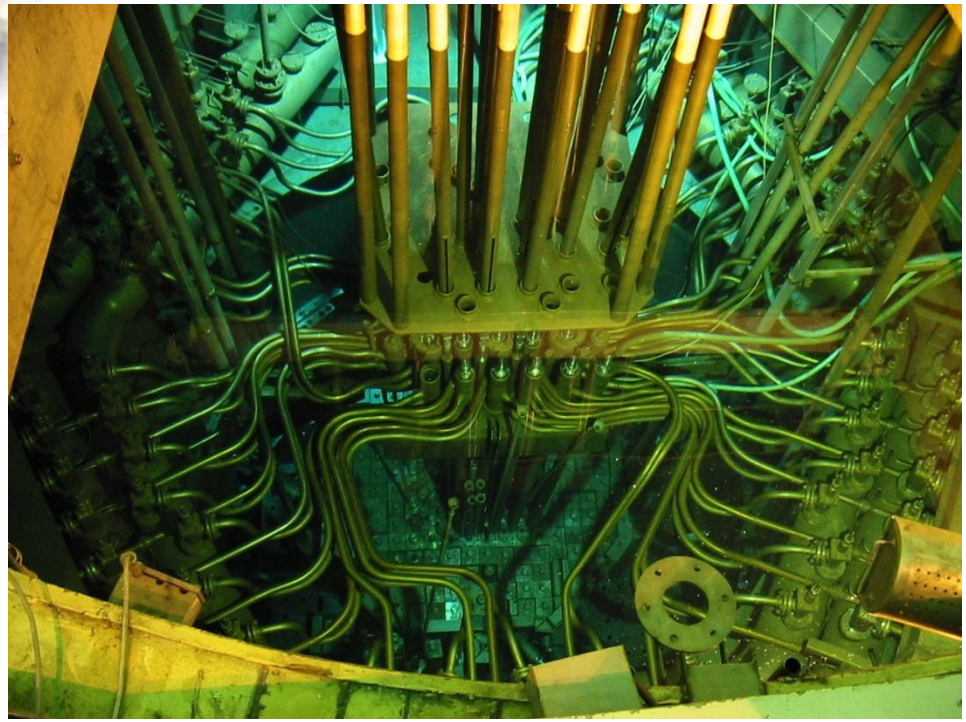


Apparatus for
- LHC/CERN, XFEL/DESY
- W7X, ESS, JHR?

Accelerator & detectors for
- healthcare, industry, security

Research reactor MARIA at Świerk

- neutron beam research, material irradiation, radioisotope production+R&D
- ^{99}Mo for medical use - 20 weeks in 2013
- 1 week of Maria irradiation = 100 000 medical procedures

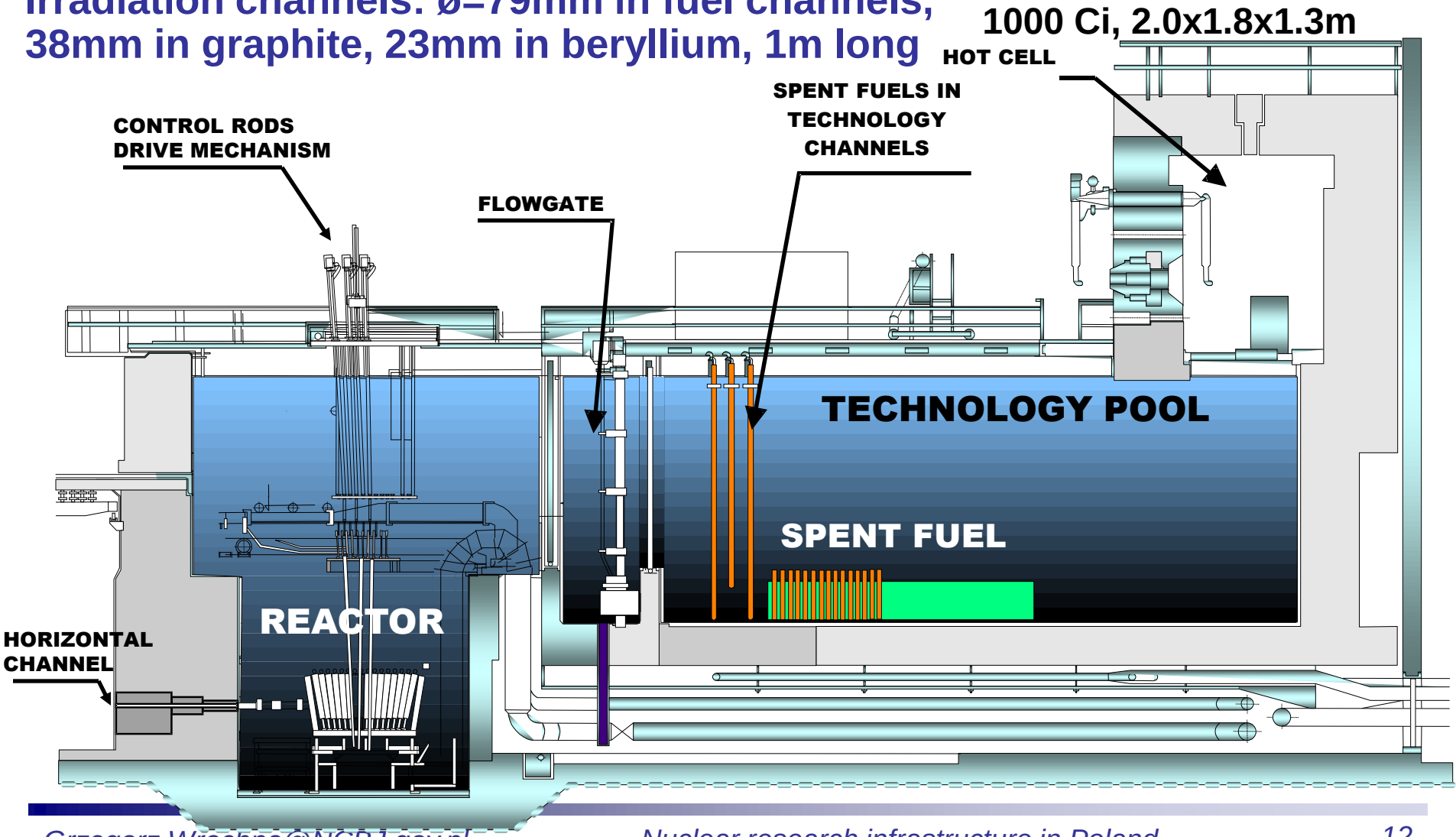


- built 1974, upgraded 1992
- pool type
- H_2O, Be moderated
- 30 MW thermal power
- neutron flux:
  - thermal $4 \cdot 10^{14}$ n/cm^{2}s
  - fast $3 \cdot 10^{13}$ n/cm^{2}s

Maria research reactor

Each channel is individually connected to the primary cooling circuit

Irradiation channels: ø=79mm in fuel channels, 38mm in graphite, 23mm in beryllium, 1m long

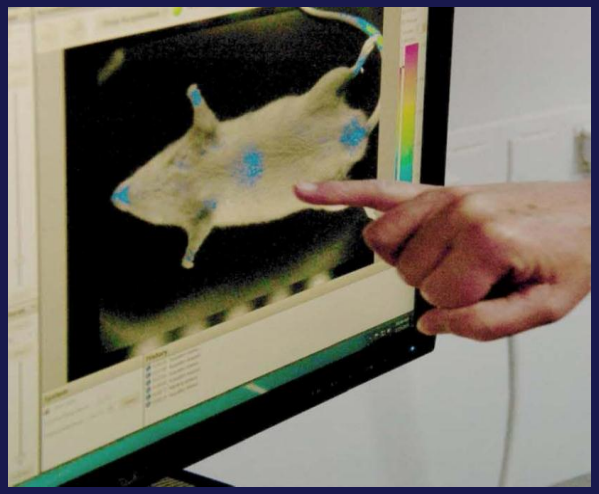


Material Testing Laboratory

- **Hot cells, mechanical tests, structural analysis**

POLATOM radioisotope centre

- Research on production methods and medical applications
- Production: ~80 products to 80 countries



Lab for preclinical tests with animals

Radioisotope products of NCBJ

PRODUCTS FOR NUCLEAR MEDICINE

Radiopharmaceuticals for diagnostic and therapy

- MIBG – ^{131}I for diagnostic use
- MIBG – ^{131}I for therapeutic use
- MIBG – ^{123}I for injection
- Sodium iodide, $^{Na\ 131}I$ for injection
- Sodium iodide, $^{Na\ 131}I$ capsules for diagnostics
- Sodium iodide, $^{Na\ 131}I$ capsules for therapy
- Sodium orthophosphate, $Na_2H^{32}PO_4$ for injection
- Hipuran – ^{131}I for injection
- Strontium chloride, $^{89}SrCl_2$

Kits for labelling with ^{99m}Tc

- PoltechColloid, 0,17 mg
- PoltechDMSA, 1 mg
- PoltechDTPA, 13,25 mg
- PoltechMBrIDA, 20 mg
- PoltechMDP, 5 mg
- PoltechMIBI, 1 mg
- PoltechRBC, 14,40 mg
- ^{99m}Tc-Tektrotyd

Radiochemicals (pharmaceutical grade)

- Sodium chromate, $Na_2{}^{51}CrO_4$ for injection
- $^{64}CuCl_2$ as cupric (II) chloride
- ^{59}Fe as Iron (III) citrate, $FeC_6H_5O_7$
- ^{51}Cr as ^{51}Cr-EDTA for injection

Precursors for labelling

- LutaPol
- ItraPol

^{177}Lu, ^{90}Y

Radionuclide generators

- $^{99}Mo/^{99m}Tc$ generator
- $^{188}W/^{188}Re$ generator

Accessories for Nuclear Medicine Department

POLATOM

PRODUCTS FOR RESEARCH AND DEVELOPMENT

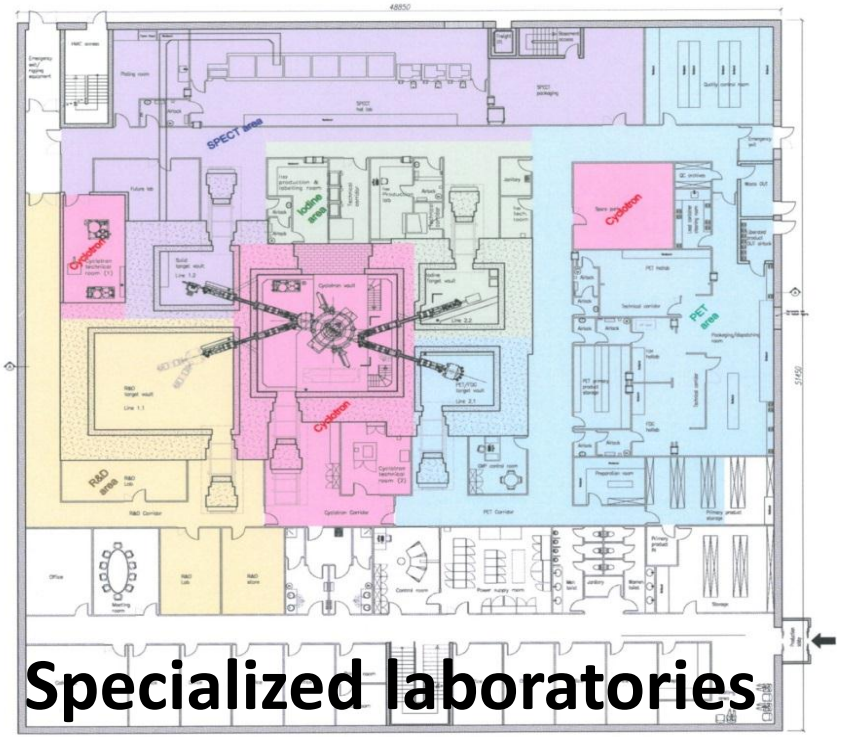
Radiochemicals reagents

Antimony ^{124}Sb
Arsenic ^{76}As
Barium ^{131}Ba
Barium ^{133}Ba
Bromine ^{82}Br
Cadium ^{109}Cd
Cadium ^{115m}CD
Caesium ^{131}Cs
Caesium ^{134}Cs
Caesium ^{137}Cs
Calcium ^{45}Ca
Chromium ^{51}Cr
Cobalt ^{58}Co
Cobalt ^{60}Co
Copper ^{64}Cu
Europium ^{152}Eu
Europium $^{152+154}Eu$
Gold ^{198}Au
Holmium ^{166}Ho
Iodine ^{131}I
Indium ^{114m}In
Iridium ^{192}Ir
Iron ^{55}Fe
Iron ^{59}Fe
Lanthanum ^{140}La
Lutetium ^{177}Lu
Neodymium ^{147}Nd
Phosphorus ^{32}P
Rhenium ^{186}Re
Rubidium ^{86}RB
Samarium ^{153}Sm
Scandium ^{46}Sc
Selenium ^{75}Se
Silver ^{110m}Ag
Sodium ^{24}Na
Strontium ^{85}Sr
Strontium ^{89}Sr
Strontium ^{90}Sr
Sulphur ^{35}S
Terbium ^{160}Tb
Thallium ^{204}Tl
Thulium ^{170}Tm
Tin ^{113}Sn

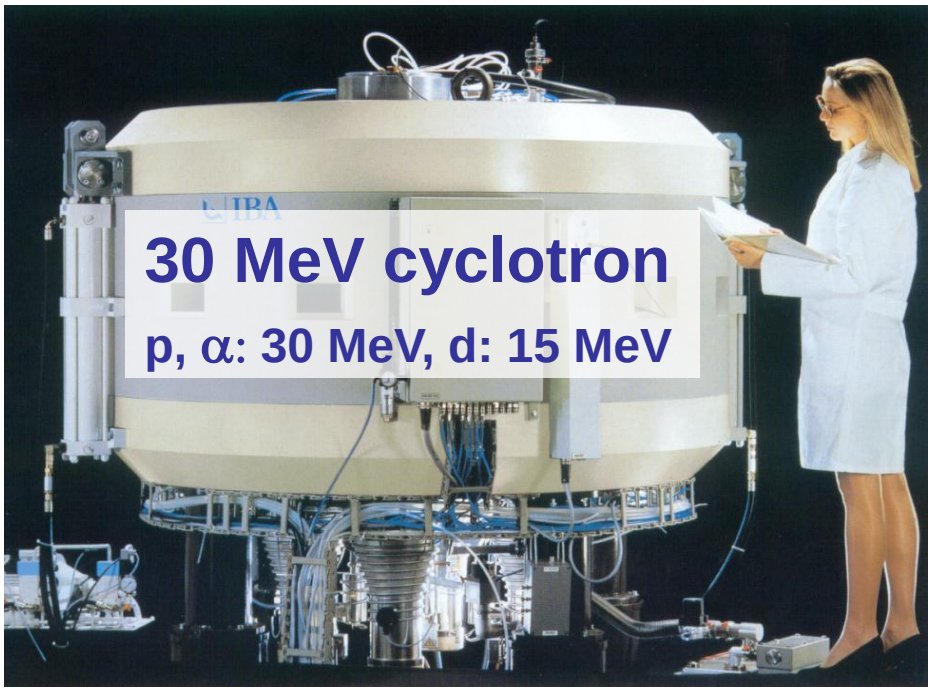
Project CERAD (40 mln €)

Center of Design & Synthesis of Radiopharmaceuticals for Molecular Targeting

@ Polish RI Roadmap, applying for structural funds



Specialized laboratories



30 MeV cyclotron

p, α: 30 MeV, d: 15 MeV

Widdening the range of radionuclides:

^{11}C, ^{13}N, ^{15}O, ^{18}F, ^{22}Na, ^{44}Sc, ^{47}Sc, ^{74}As, ^{64}Cu, ^{67}Cu, ^{67}Ga, ^{68}Ge, ^{81}Rb, ^{82}Sr, ^{86}Y, ^{89}Zr, ^{94m}Tc, ^{99m}Tc, ^{109}Cd, ^{111}In, ^{123}I, ^{124}I, ^{201}Tl, ^{211}At, ^{225}Ac

Novel imaging techniques:

Multimodality scanners, chemical synthesis and biochemical laboratories

Financing nuclear R&D infrastructure

- **NCBJ incomes** (2014): **50 M€**
  - **13%: Ministry of Science**
  - **2%: Ministry of Economy**
  - **22%: grants (PL+EU+US)**
  - **63%: commercial** (radioisotopes, accelerators
- **IChTJ ~10M€, IFJ ~40 M€** (more grants, less commertial)
- Hardly enough to maintain existing infrastructure

- **New infrastructure only from EU structural funds**
  - **35+20 M€ - IFJ Cracow 230 MeV cyclotron+gantry**
  - **24 M€ - NCBJ computing centre (500 TFLOPS, 4PB)**
  - **10 M€ - IChTJ laboratories**

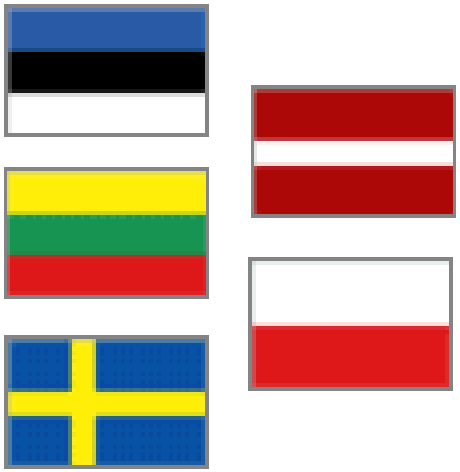
Access to research infrastructures

- **Bilateral agreements**
  - **Cooperation with CEA: Osiris → Maria → JHR**
    - γ-heating, Be ageing, Melodi(?) experiments in Maria
    - H2020: **POLARIC** proposal (to be resubmitted in 2017)
  - **HZB BER-II n spectro-,diffractometers moving to Maria**
- **Regional aliances**
  - **Visegrad-group (CZ, HU, SK, PL)** – see Hungarian pres.
    - Euratom: **VINCO** project (coordinated by NCBJ)
  - **Baltic countries (LT, LV, ET, PL, SE)**
    - Euratom: **BRILLIANT** project
- **SNETP activities**
  - **Nuclear Cogeneration Industrial Initiative**
    - Euratom: **NC2I-R** project (coordinated by NCBJ)

BRILLIANT

Baltic Region Initiative for Long Lasting InnovAtive Nuclear Technologies

Estonia
Latvia
Lithuania
Poland
Sweden



Local problems:

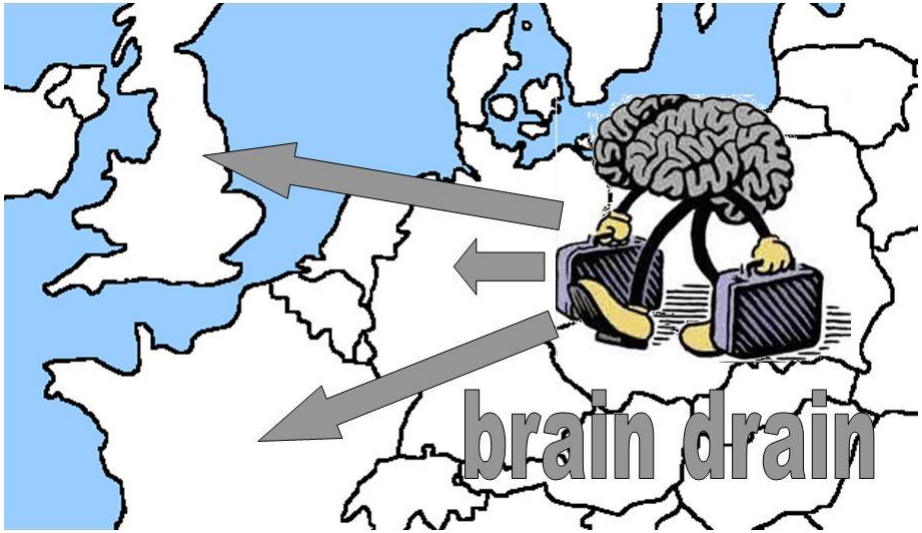
- Relatively small power systems & no justification for autonomous handling of nuclear wastes
- Basic technical level of heavy industry & diminishing number of qualified workers
- Poor nuclear research infrastru-cture & competence gap between old and new nuclear programs

Towards regional solutions:

- Analysis of electric power systems
- Regional cooperation on nuclear waste and fuel cycle
- Macroeconomic impact of nuclear programs
- Nuclear R&D capacity building

Large & small research infrastructures

- **System with large R.I. in only a few countries** (ESFRI only) **is not sustainable**
- **Researchers from other countries must have possibility to make careers & educate new generations at home**
- **Otherwise, it is just brain-drain. We must reverse it!**



- **Small (0-10 MW) reactors necessary for research, education, training and developing safety culture!**