Nuclear research infrastructure in Poland

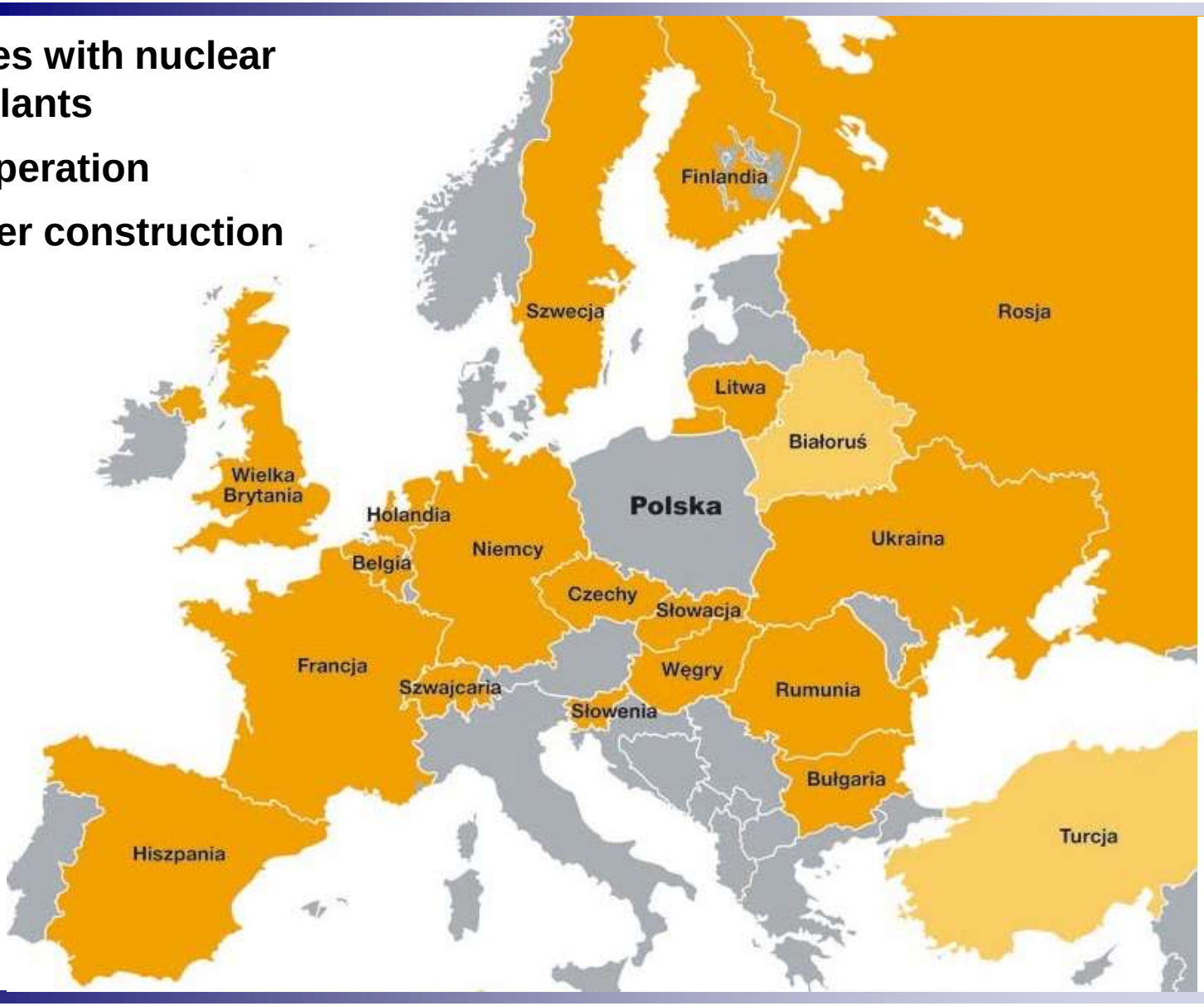
Reactor MARIA

Grzegorz Wrochna
National Centre for Nuclear Reserach
www.ncbj.gov.pl

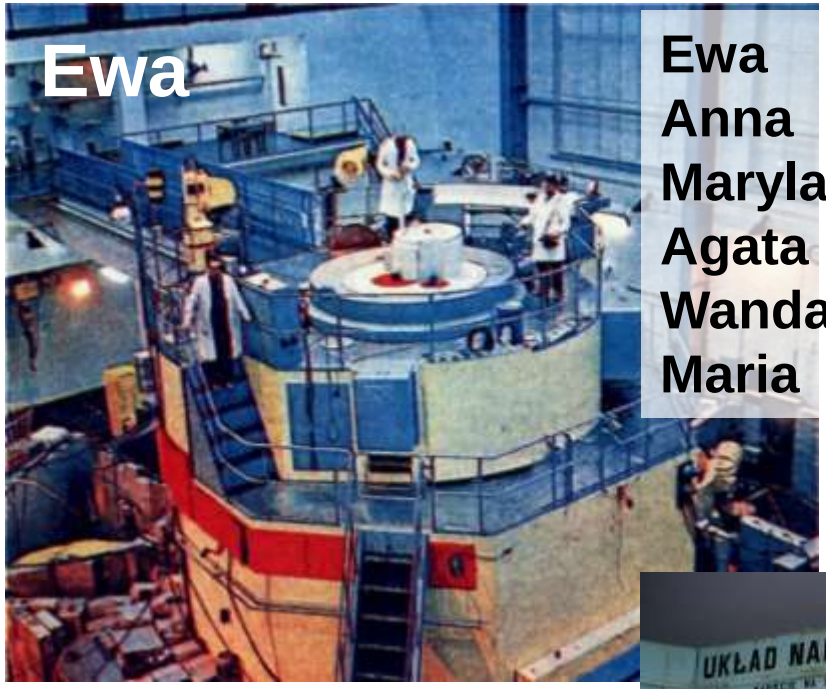
Poland: non-nuclear country?

Countries with nuclear power plants

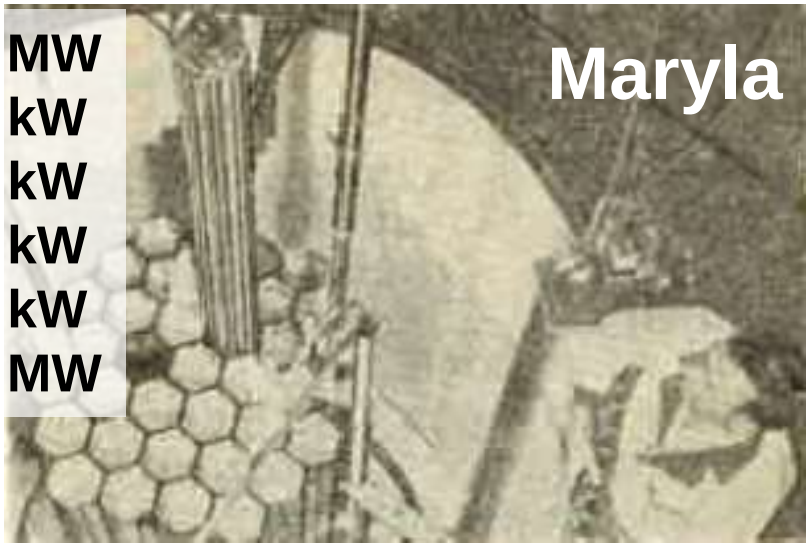
- **in operation**
- **under construction**

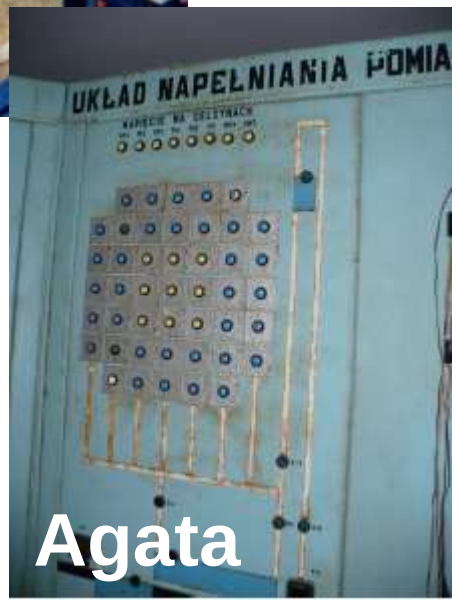


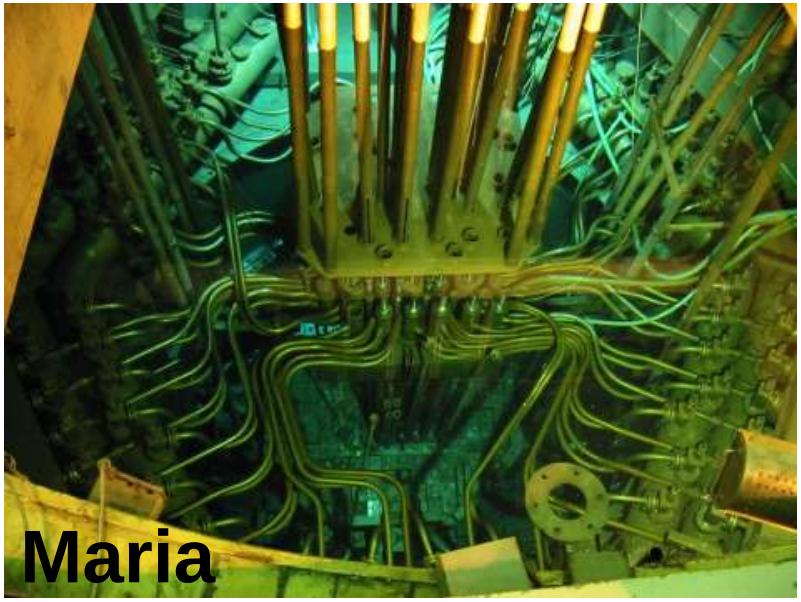
Poland: nuclear since 57 years



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 2024**

Program approved 28.01.2014:

Plan for the first unit:

- **2015 – technology choice**
- **2016 – request for permit**
- **2018 – licence issued**
- **2024 – in operation**

Some delay is expected

PGE

Polska Grupa Energetyczna

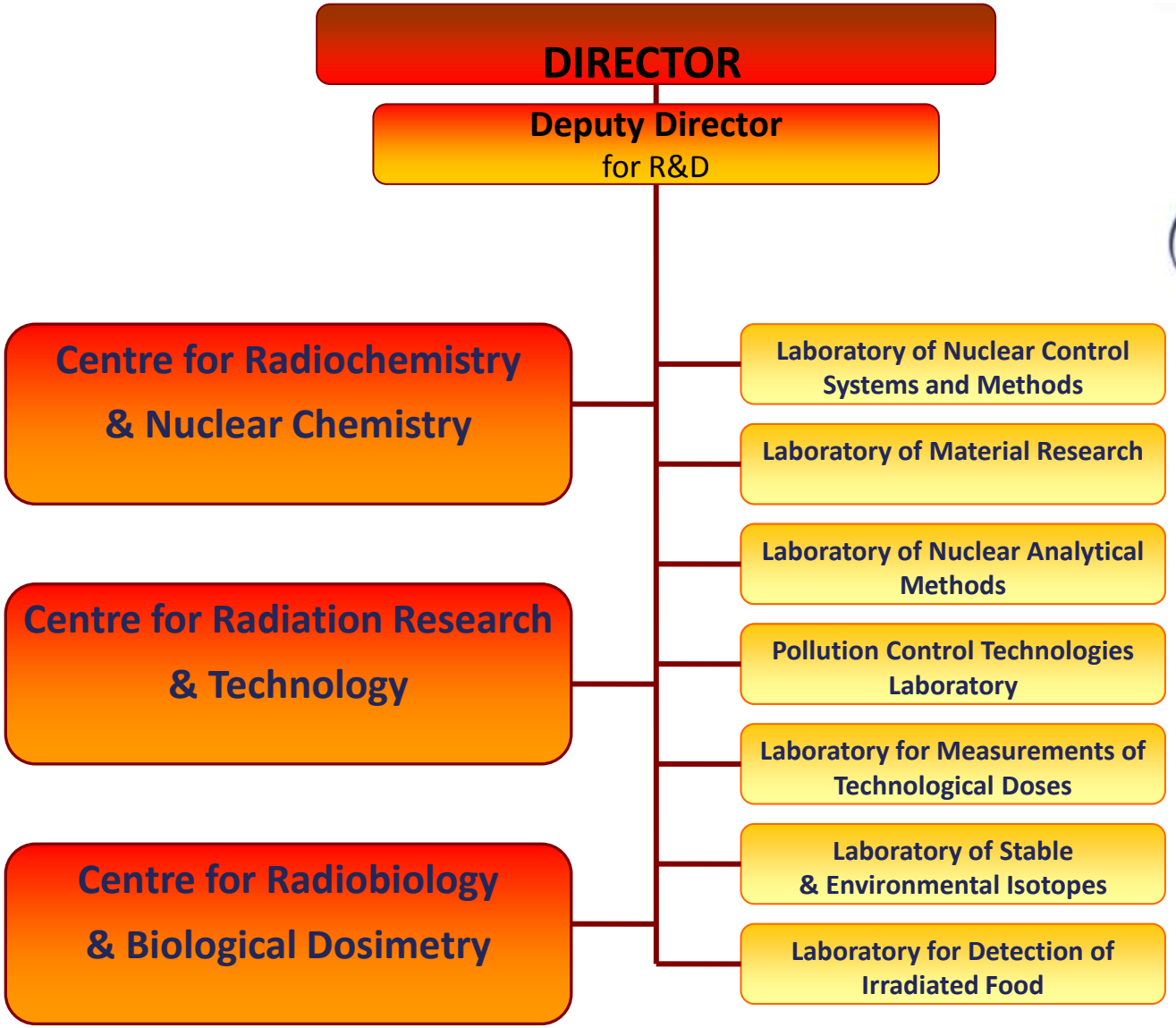
Polish nuclear institutes

Institute	site	staff	supervised	funded
National Centre for Nuclear Research (**NCBJ**)	Świerk, Warsaw	1073	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



ichtj

Staff

Total: 262

23 Prof.

50 PhDs.

80 MSs.

Institute of Nuclear Chemistry & Technology

Radiochemistry laboratories

Accelerators

National Centre for Nuclear Research

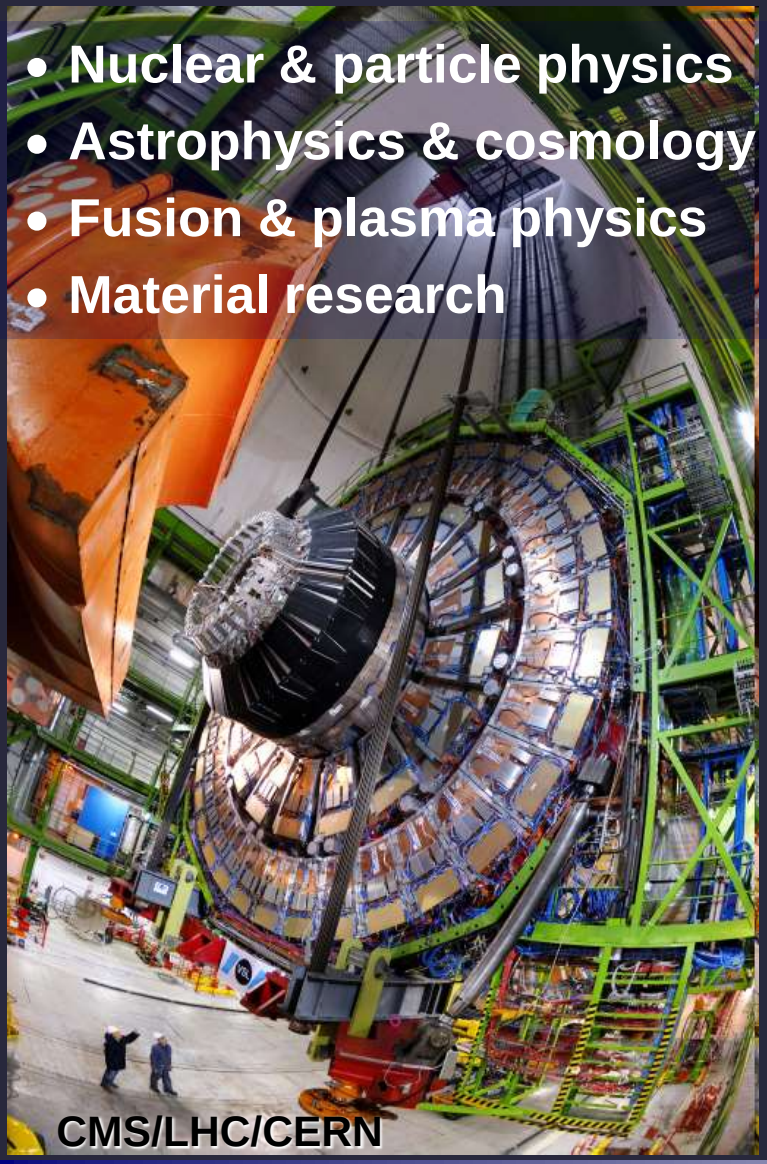
Nuclear Centre at Swierk
30 km from Warsaw

- The largest research institute in Poland
  - 1073 employees, inc. 56 prof. & 117 PhD
- Scientific achievements:
  - ~600 reviewed papers, 8200 quotations each year
  - Hirsh index = 115, $\Rightarrow$ 4th position in Poland
  - SCImago „Normalized Impact”:
    1st in Poland, 8th in region, 158th in the world
- Incomes:
  - statutory fund ~16%, grants/projects ~21%
  - commercial activities ~63%

www.ncbj.gov.pl

research ⇒ apparatus ⇒ products

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



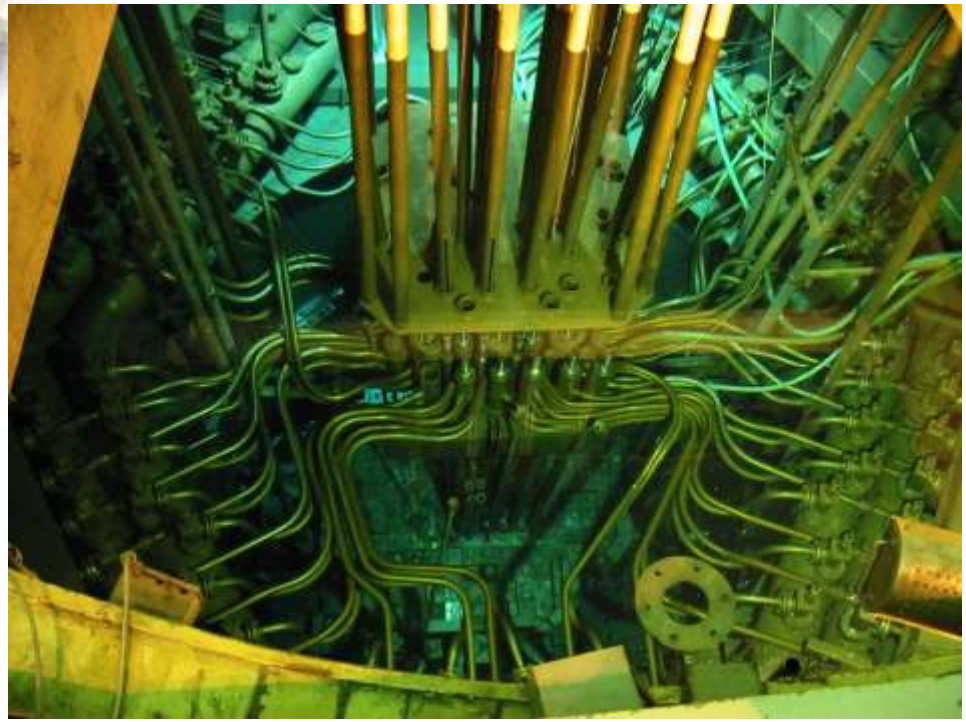
CMS/LHC/CERN

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
- ^{99}Mo for medical use - 20 weeks in 2013
- 1 week of Maria irradiation = 100 000 medical procedures

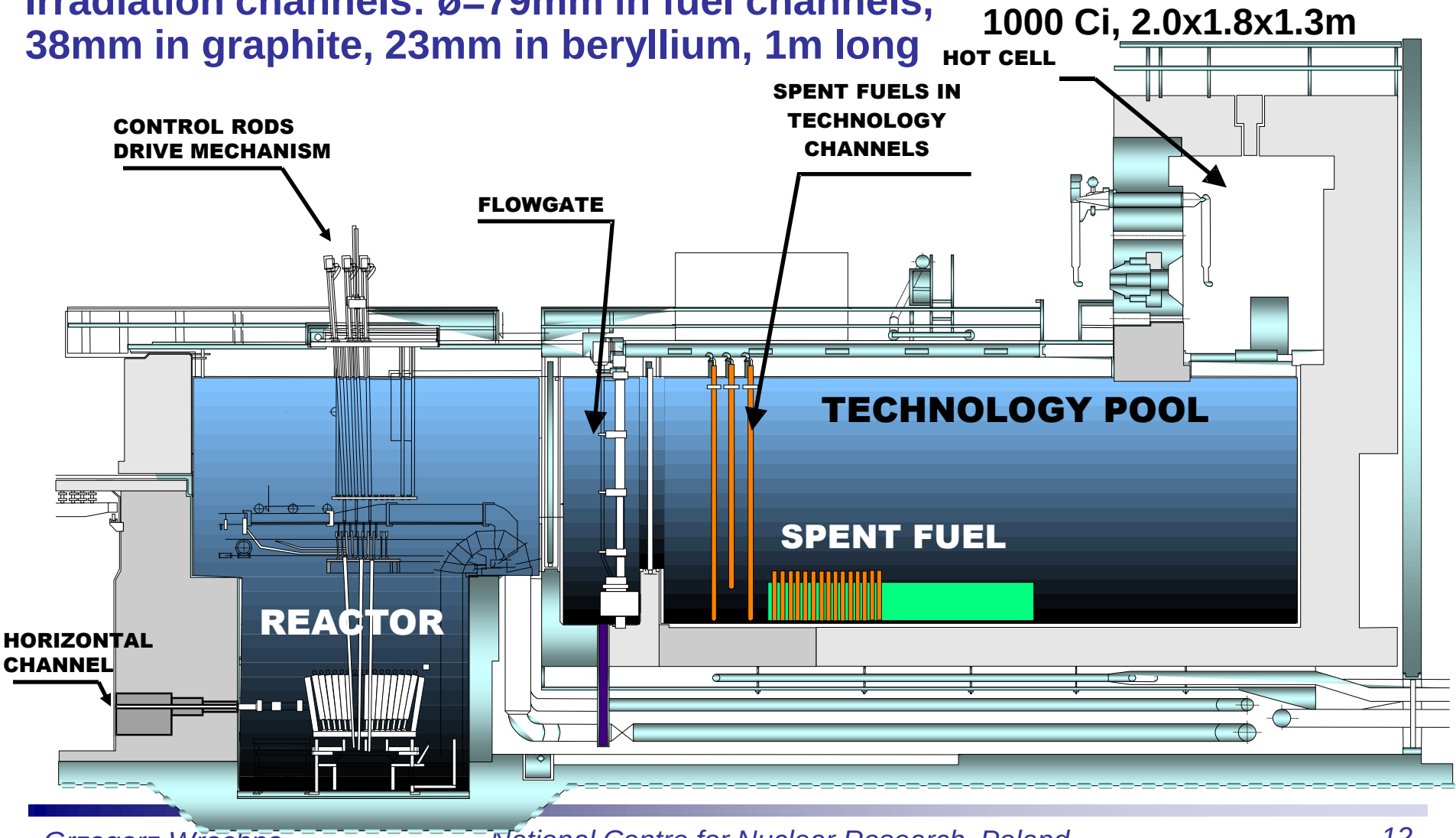


- built 1974, upgraded 1992
- pool type
- H_2O, Be moderated
- 30 MW thermal power
- neutron flux:
  - thermal $4 \cdot 10^{14}$ n/cm^{2}s
  - fast $2 \cdot 10^{14}$ n/cm^{2}s

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**

Project NLEJ (100 mln €)

- **MARIA reactor can work for many years**
  - **modular construction, modernised year by year**
- **Auxiliary equipment needs serious upgrade**
  - **neutron beams (spectrometers etc)**
  - **material analysis (tandem etc.)**
  - **…**

The project is called „NLEJ”:

National Laboratory for Nuclear Research

- **Status:**
  - **@ Polish Roadmap of Research Infrastructures**

POLATOM radioisotope centre

- Research on production methods and medical applications
- Production: ~80 products to 78 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

Radionuclide generators

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

Accessories for Nuclear Medicine Department

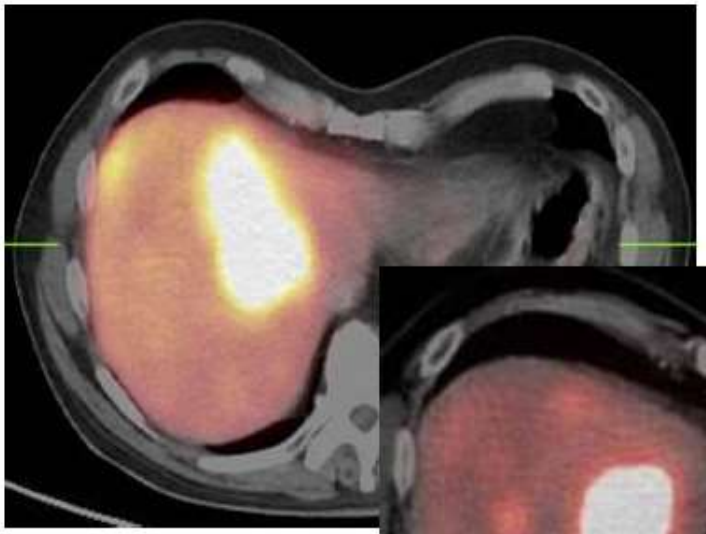
POLATOM

PRODUCTS FOR RESEARCH AND DEVELOPMENT

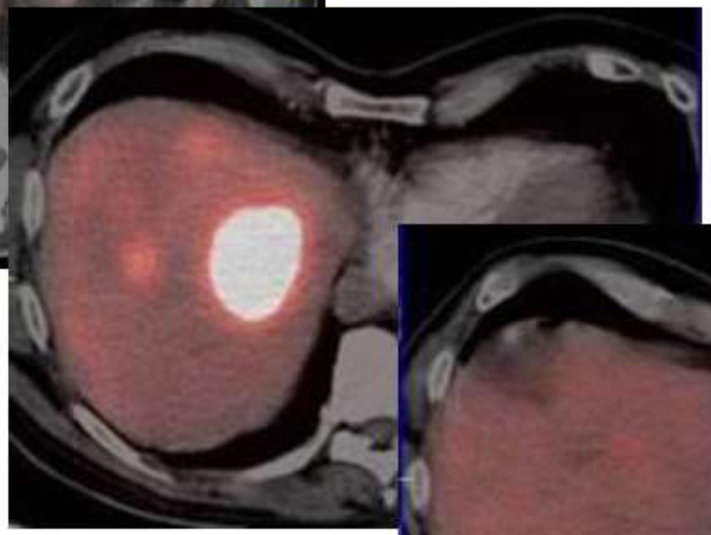
Radiochemicals reagents

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

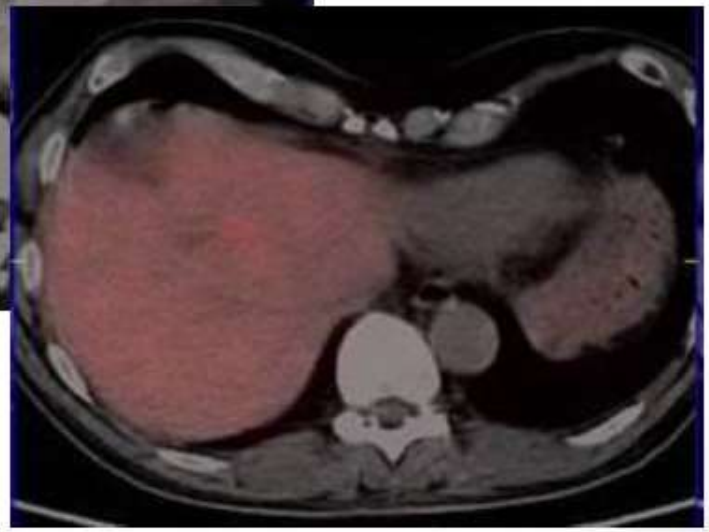
Itrapol (^{90}Y) & Lutapol (^{177}Lu)



2006



2007



2010

Pancreatic Neuroendocrine Liver Metastase five years post treatment with Somatostatin peptide analogue labelled with ^{90}Y (three cycles) and ^{177}Lu (one single treatment)

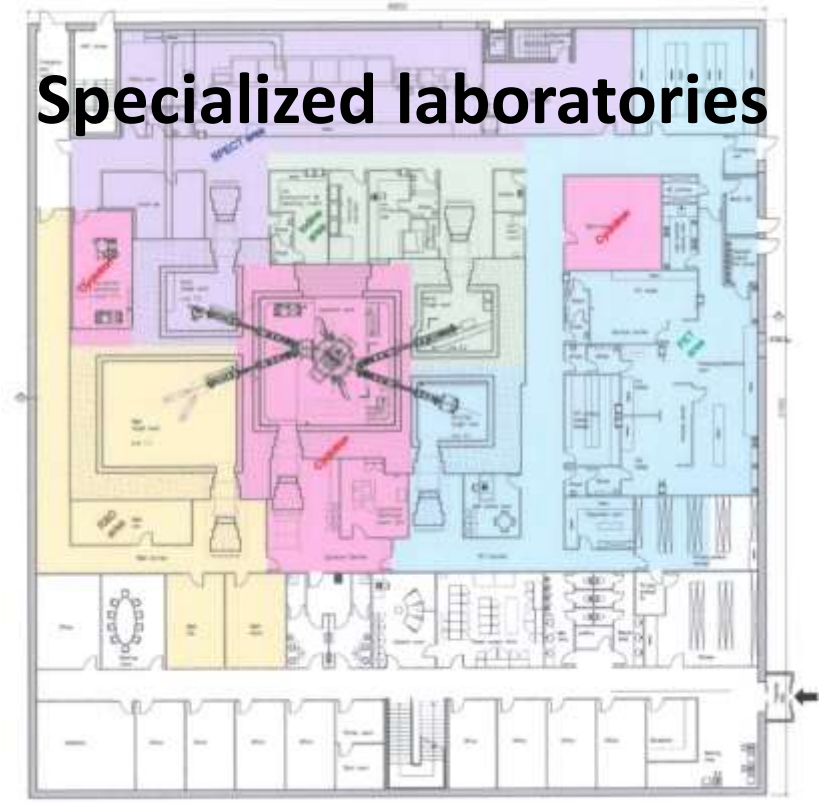
Prof. R. Baum - Bad Berka

9.2014 – first ever registration of ^{177}Lu medical product

Project CERAD (40 mln €)

Center of Design & Synthesis of Radiopharmaceuticals for Molecular Targeting

@ Polish RI Roadmap



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

Access to research infrastructures

- **Bilateral agreements**
  - **Cooperation with CEA:**
    - eg. gamma-heating experiment in MARIA for JHR
    - H2020: **POLARIC** proposal
- **Regional aliances**
  - **Visegrad-group (CZ, HU, SK, PL)**
    - Euratom: **VINCO** proposal
  - **Baltic countries (LT, LV, ET, PL, …)**
    - Euratom: **BRILLIANT** proposal
- **SNETP activities**
  - **Nuclear Cogeneration Industrial Initiative**
    - FP7: **NC2I-R** project coordinated by NCBJ

H2020 Teaming: POLARIC ⇒ NLEJ

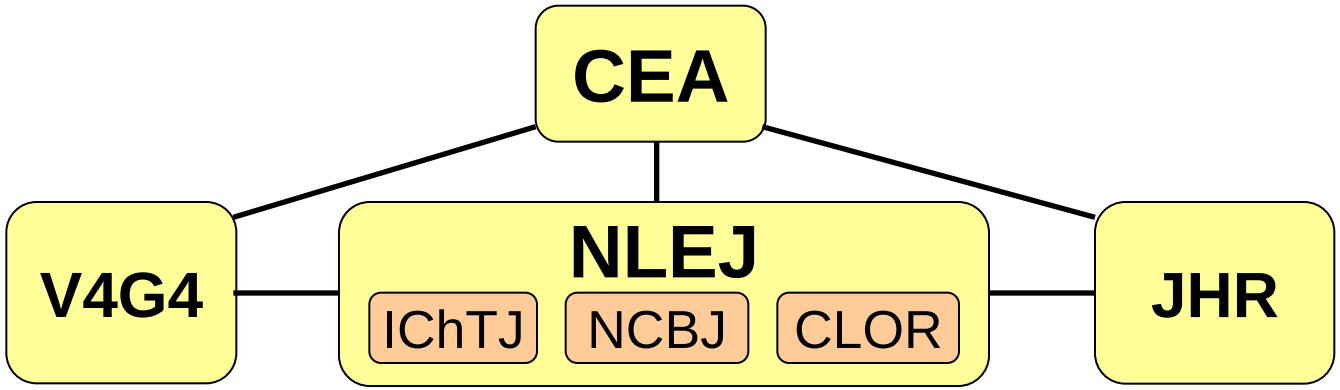
„Teaming" is an excellent tool

Polish nuclear institutes

- **to implement NLEJ**
- **to coordinate CLOR, IChTJ & NCBJ activities**
- **to facilitate cooperation with JHR & V4G4**
- **to strengthen collaboration with CEA**

POLish Atomic Research & Innovation Centre (POLARIC)

- **Deditated CEA-NCBJ MoU signed**
- **Dedicated CLOR-IChTJ-NCBJ MoU signed**
- **Proposal submitted to the „Teaming" call**



Visegrad-4 for Generation-4 reactors

V4G4

phase I

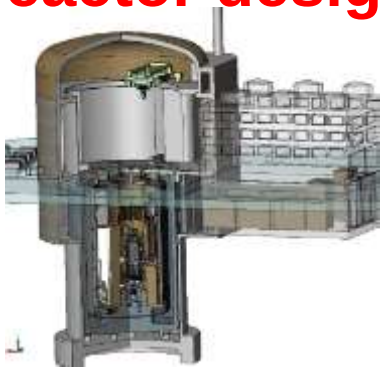
capacity building

know-how **infrastructure**

Allegro

phase II

reactor design



other projects

France: **Technology input**

Slovakia: **Reactor design & safety**

- safety concept, design basis, simulation and numerical analysis

Chech R: **Research laboratory on technology related experiments**

- thermophysics, aerodynamics, helium technology, reactor physics, etc.

Hungary: **Laboratory on the closed fuel cycle and fuel issues**

- PIE of ceramic fuels, separation of minor actinides, fuel fabrication, etc.

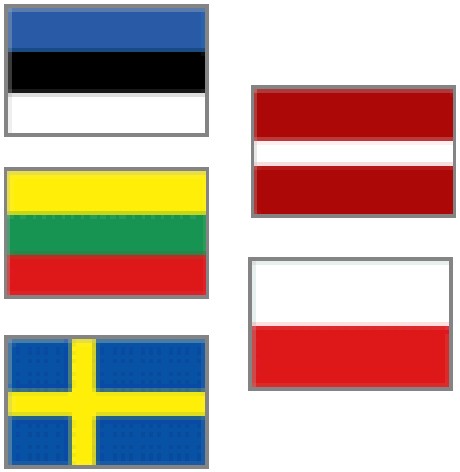
Poland: **Material research laboratory**

- irradiation by reactor & accelerators, structural & functional material analysis

BRILLIANT

Baltic Region Initiative for Long Lasting InnovAtive Nuclear Technologies

Estonia
Latvia
Lithuania
Poland
Sweden



Local problems:

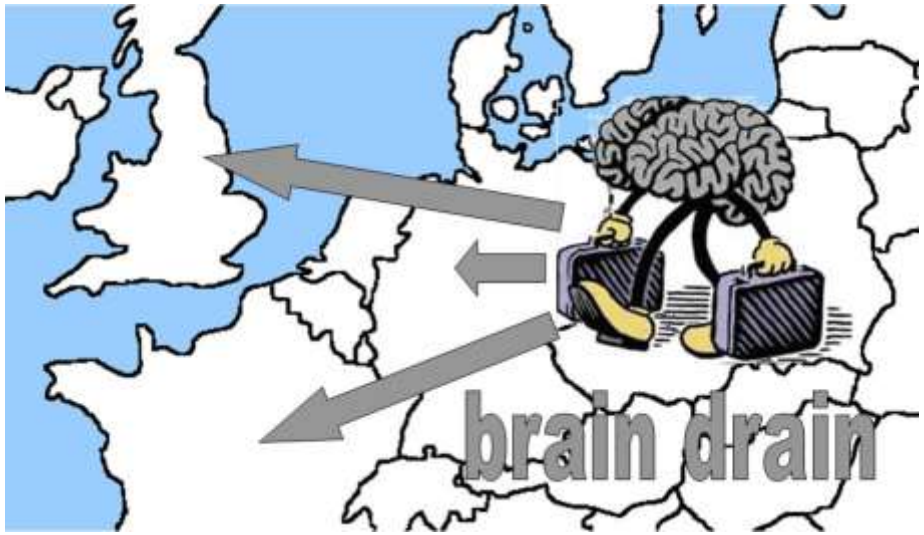
- Relatively small power systems & no justification for autonomous handling of nuclear wastes
- Basic technical level of heavy industry & diminishing number of qualified workers
- Poor nuclear research infrastru-cture & competence gap between old and new nuclear programs

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

EU and regional research infrastructures

- **System with large R.I. in only a few countries 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 have to reverse this trend**



The dream of Maria Skłodowska-Curie

is being realised by the MARIA reactor. Let's continue!

The nightmare of Maria Skłodowska-Curie

How to get funds
for research
on radiation
& its applications

We need more Marias!