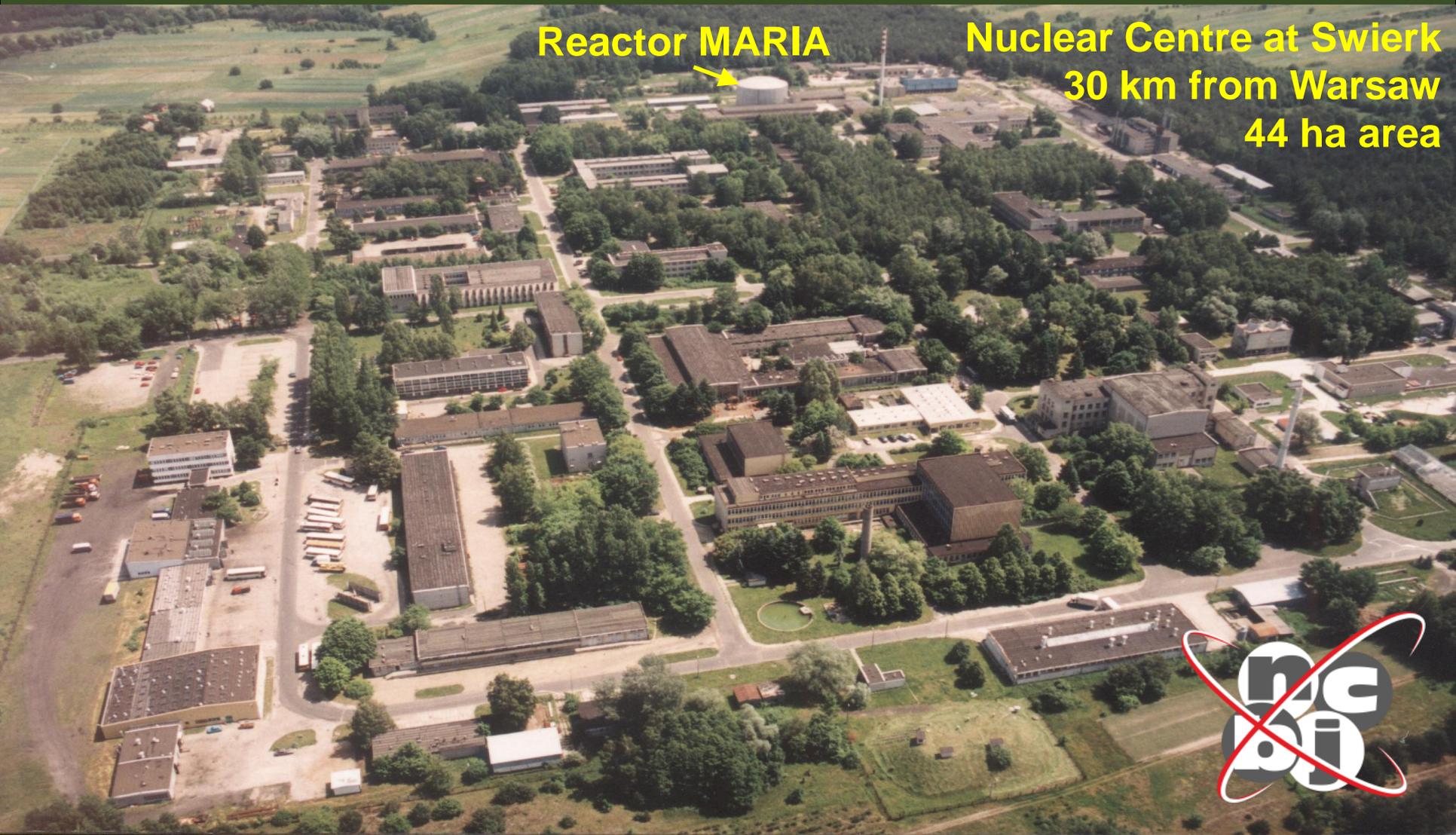


# *Accelerator R&D and construction at the National Centre for Nuclear Research*



**Reactor MARIA**



**Nuclear Centre at Swierk  
30 km from Warsaw  
44 ha area**



**Grzegorz.Wrochna@ncbj.gov.pl**

**www.ncbj.gov.pl**



# National Centre for Nuclear Research

- **The largest research institute in Poland**
  - Created 1.9.2011 by merging two institutes @ Świerk
  - 1073 employees, inc. 56 prof. & 117 PhD
- **Scientific achievements:**
  - ~320 reviewed papers, 5000 quotations each year
  - Hirsh index = 103,  $\Rightarrow$  7<sup>th</sup> position in Poland
- **Incomes: ~20 M€ (2011)**
  - statutory fund 4 M€, grants/projects 7 M€
  - commercial activities 9 M€
- **Technical infrastructure**
  - ~40 ha green field, 72 000 m<sup>2</sup> routes & squares
  - networks: electricity 65 km, telecom 172 km
  - water pipelines 32 km, tanks 1900 m<sup>3</sup>



# National Centre for Nuclear Research

**Scientific Council**

**Director**  
*Grzegorz Wrochna*

## RESEARCH SECTOR

**Scientific Director**  
*Ewa Rondio*

**Deputy for Research Infrastructure**  
*Krzysztof Wieteska*

**Director of DEJ**  
*Grzegorz Krzysztozek*

**Nuclear Energy  
Department**

MARIA Reactor

**Director DBP**  
*Grzegorz Wilk*

**Department of  
Fundamental  
Research**

**Director of DFM**  
*Jacek Jagielski*

**Material  
Physics  
Department**

Material Research  
Laboratory

**Director of DTJ**  
*Agnieszka Syntfeld-Kazuch*

**Department of  
Nuclear Techni-  
ques & Equipment**

Division of Nuclear  
Equipment HITEC

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Director supervised units

**Scientific Secretary**  
*Krzysztof Kurek*

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& Education**

**Deputy for Nucl. Safety  
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Radioisotope Centre  
POLATOM

**Administrative &  
Technical Deputy**  
*Marek Juszczyk*

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Division of Transport

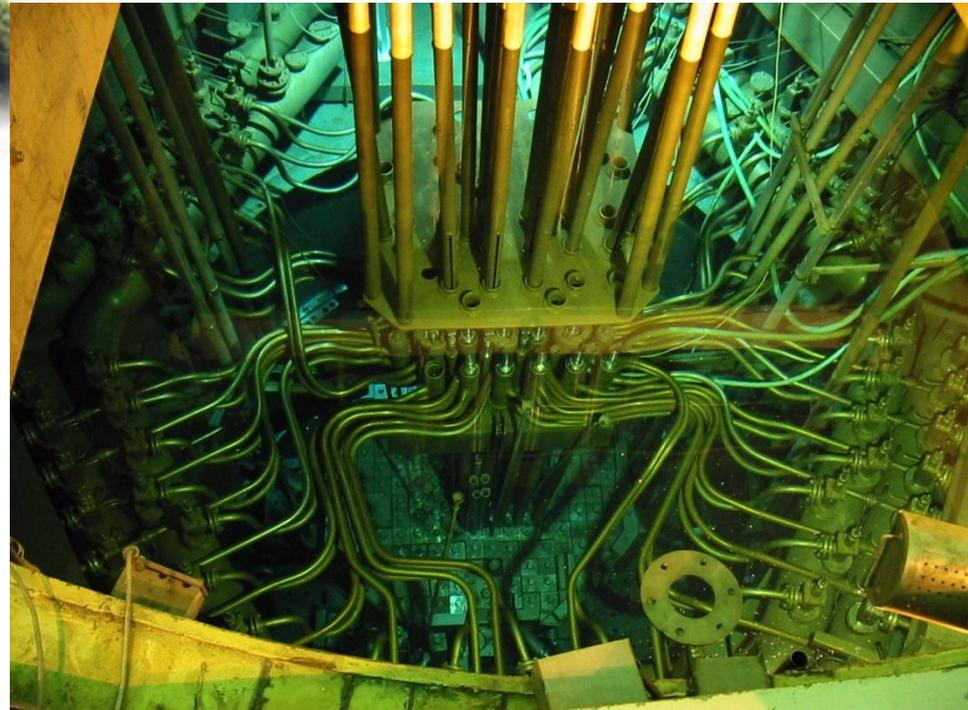


# Research reactor *MARIA* at Swierk



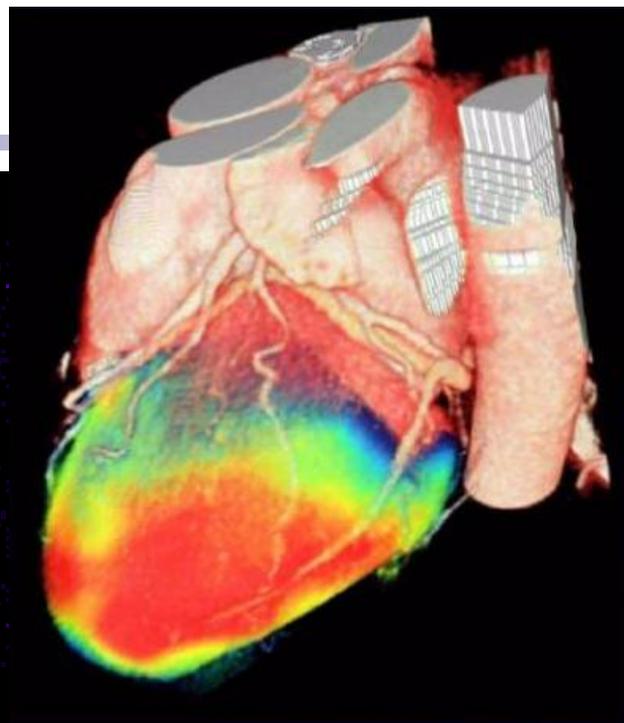
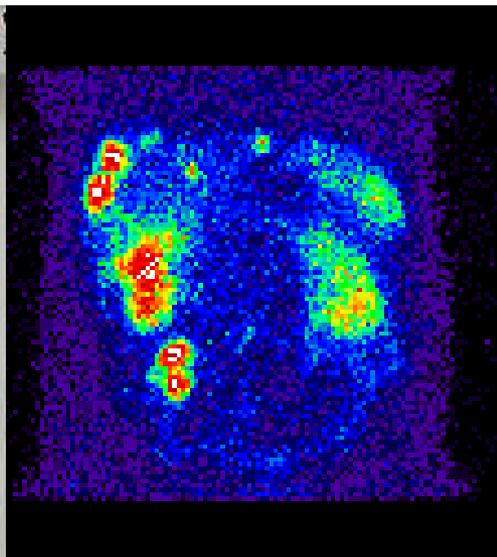
- built 1974, upgrade 1992
- neutron beam research, activation analysis, isotope production:  
 **$^{99}\text{Mo}$  for medical use**

- pool type
- $\text{H}_2\text{O}$ , Be moderated
- 30 MW thermal power
- neutron flux:
  - thermal  $4 \cdot 10^{14}$  n/cm<sup>2</sup>s
  - fast  $2 \cdot 10^{14}$  n/cm<sup>2</sup>s





# Radioisotope Centre



## Development of new technologies and manufacturing:

- radioactive isotopes & isotope radioactive sources
- chemical compounds marked with radioisotopes
- **plans for dedicated cyclotron 30-70 MeV**

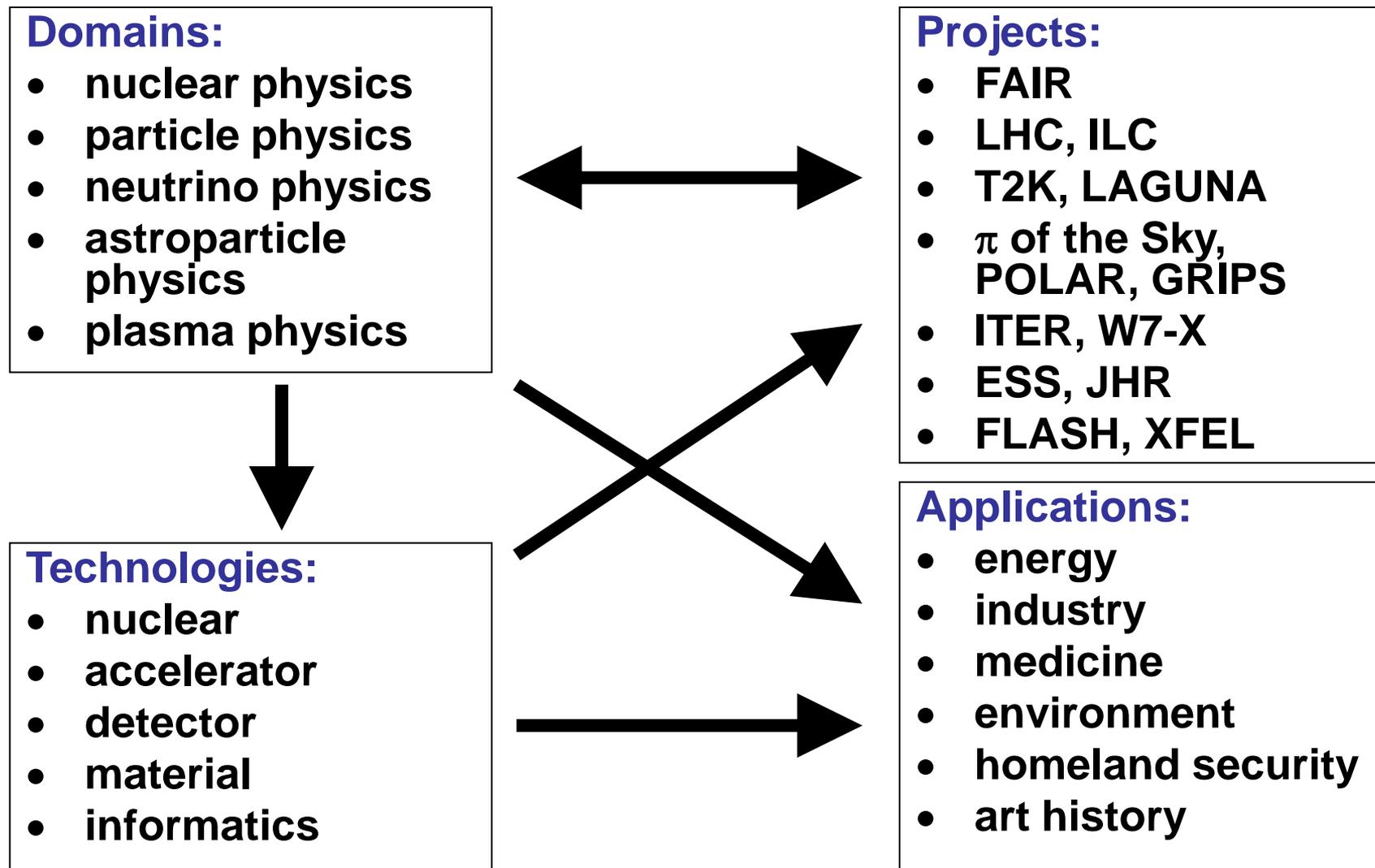
## Applications:

- medicine
- industry
- science





# Basic and applied research





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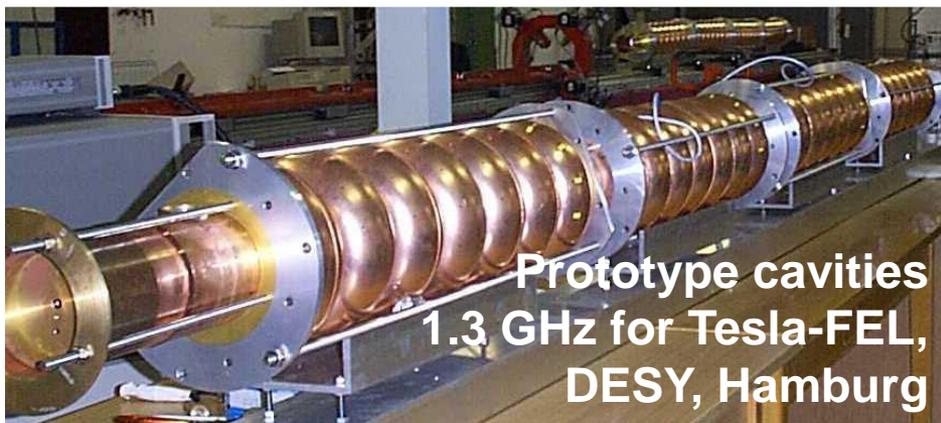


# NCBJ for large research infrastructures

Name <i>site</i>	Const- ruction	Cost	Contribution		
			Poland	NCBJ	
European-XFEL <i>DESY Hamburg</i>	2010- 2014	1,0 G€	27 M€	6 M€	accelerator components
Linac4 dla LHC <i>CERN Genewa</i>	2008- 2014		-	1 M€	p-buncher, $\pi$ -mode structures PIMS
Stellarator W7-X <i>Greifswald</i>	2011- 2014	2,0 G€	6 M€	4,5 M€	neutral beam injection components
FAIR <i>Darmstadt</i>	2012- 2017	4,4 G€	24 M€	~1 M€	detector components
European Spallation Source (ESS) <i>Lund</i>	2008- 2025	1,5 G€	?	?	accelerator components, radiation calculation, ...
Jules Horowitz Reactor (JHR) <i>Cadarache</i>	2012- 2014	0,5 G€	10 M€?	5 M€?	hot cell to measure gas composition
Eksperyment GBAR <i>CERN Genewa</i>	2012- 2016		-	~1,2 M€	e <sup>-</sup> accelerator construction



# Components for large experiments



Prototype cavities  
1.3 GHz for Tesla-FEL,  
DESY, Hamburg



Target for experiment  
Isolde, CERN, Geneva



Proton buncher  
LHC, CERN



Linac4 PIMS  
LHC, CERN



# Accelerators for industry and medicine



- **Sterylisation**
- **Radioteraphy**
- **Radiography**



## Inspection of

- bridges spans
- welds
- frames
- pressure pipes
- castings
- containers
- elements made of steel





# ***Lillyput 3 for nondestructive inspection***

- **Stationary and mobile configuration**
  - **X-ray head with integrated modulator and inner cooling system**
  - **Computer controlled**
  - **Photon energy 6 & 9 MV**
  - **Maksimum dose rate  
20 Gy/min \*  
(10x10 cm<sup>2</sup> field in 1 m distance from target)**
- \* Without flattening filter**





# Lillyput 3 – mobile version





# *COLINE linear accelerators for radiotherapy*

- **Used in standard and conformal radiotherapy**
- **Several models: energy from 4 to 20 MeV**
- **Digitally controlled**
- **Compact and reliable design**
- **With optional multileaf collimator and electronic portal imaging system**
- **Ready to connect to therapeutic line**





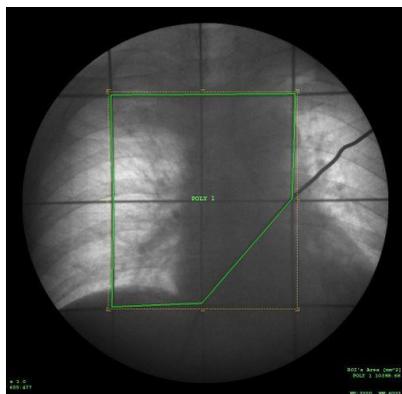
# Not only accelerators

## All components for treatment:

- Treatment Planning Systems
- X-ray simulators
- Therapeutic tables
- Mould-room equipment
- Protecting doors, shielding ...



High  
Technology  
Center





# Accelerator R&D and construction

## Division of accelerator physics and technology

- lead by Dr Sławomir Wronka
- 25 employees



## Division of Nuclear Equipment HITEC

- lead by Dr Paweł Krawczyk
- 108 employees





# Machines at HITEC Świerk

2008



2009



## **Project „accelerators and detectors”:**

- **Cargo inspection:**

- X-ray radiography
- dual energy accelerator
- neutron radiography

- **Radiotherapy:**

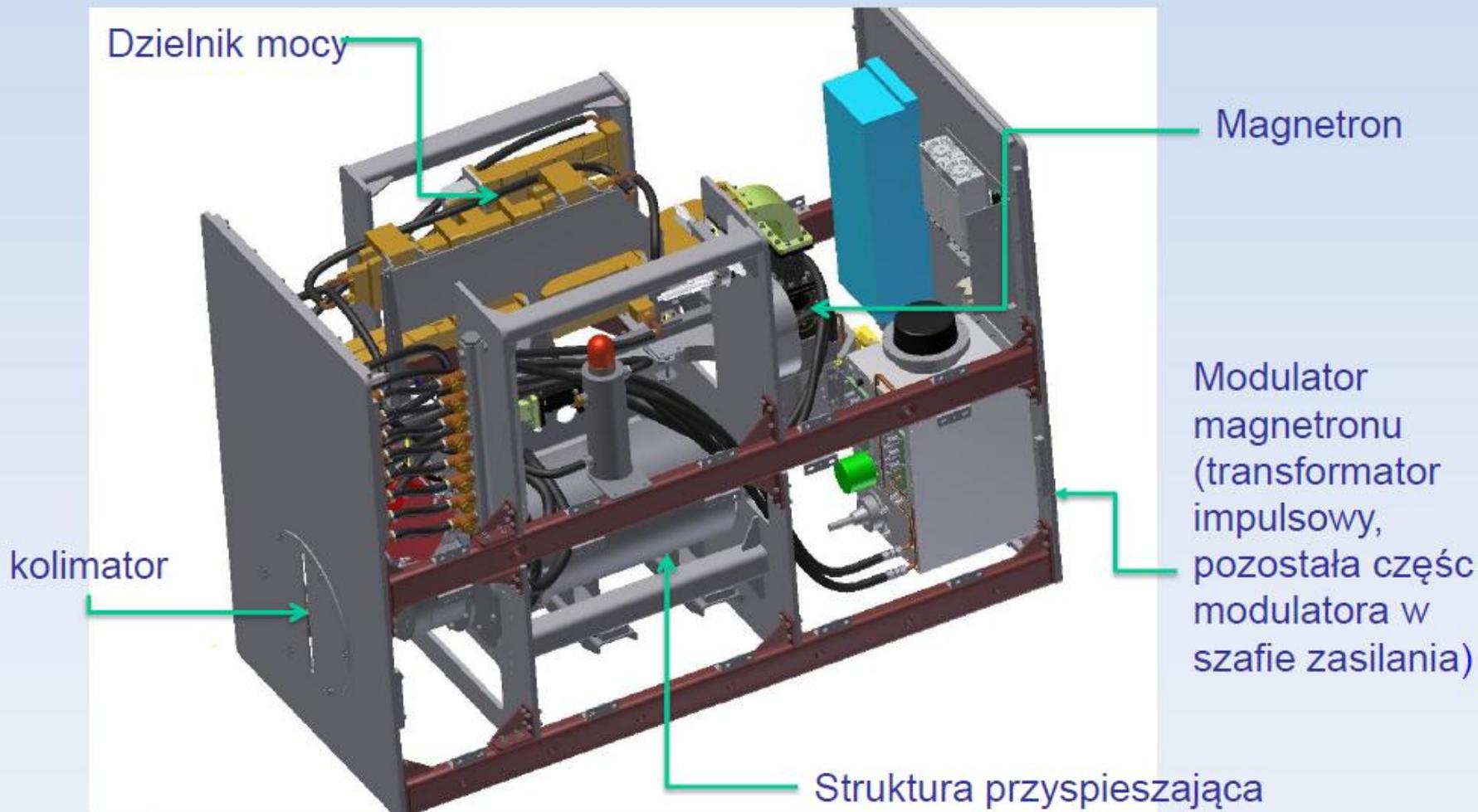
- NALR – low energy X-ray tube accelerator
- IORT – intra-operative radiation therapy
- Hadvanced radiotherapy accelerator



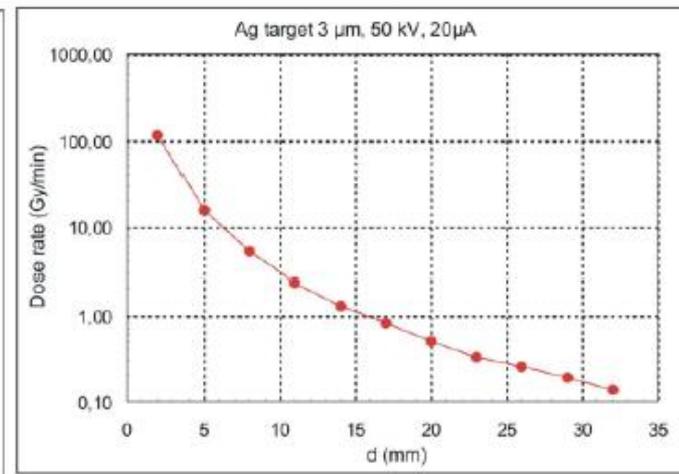
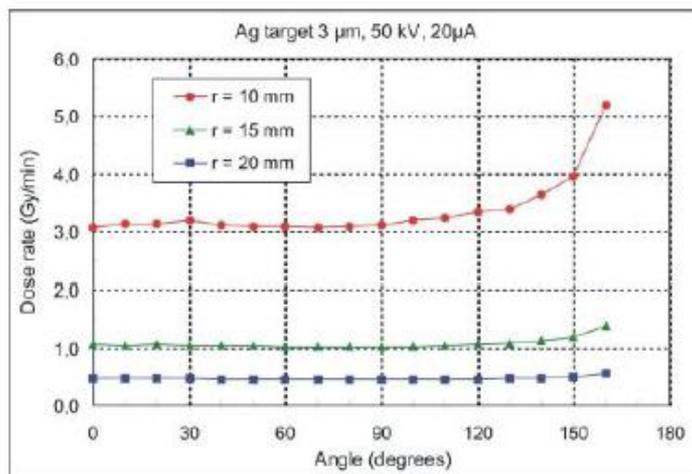
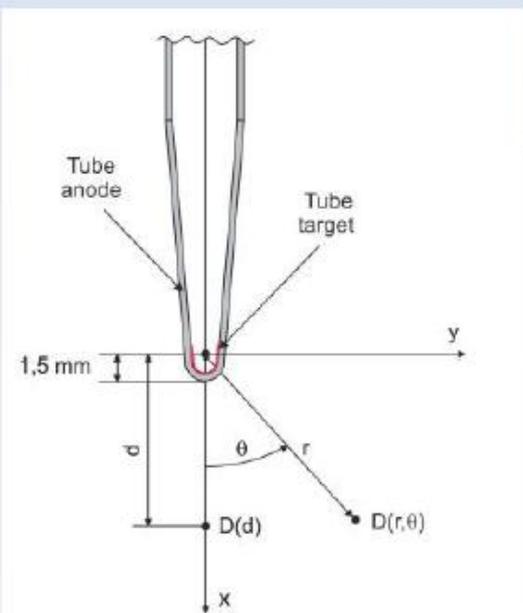
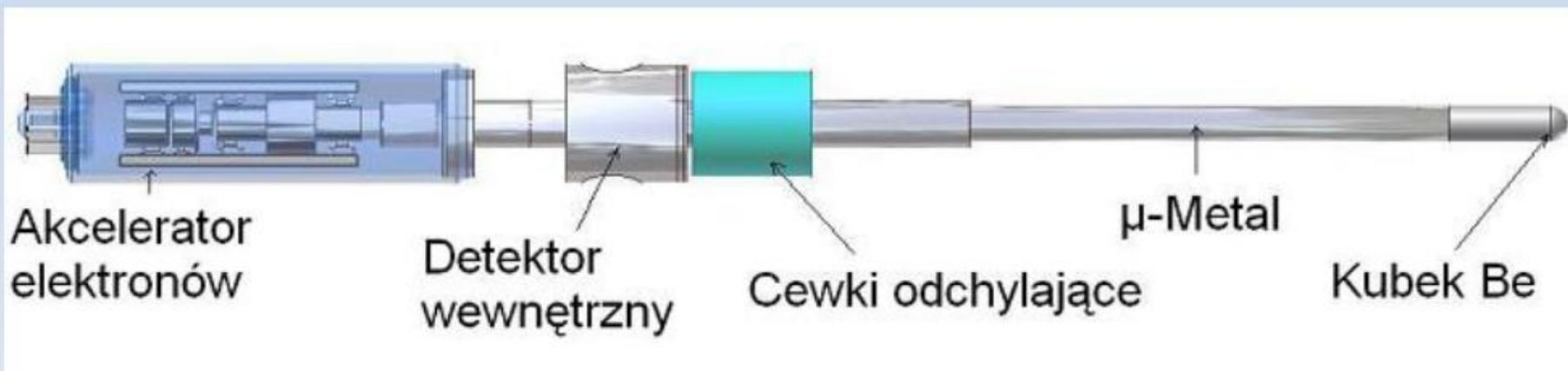


# Dual energy (6/9 MeV) accelerator

## Ogólny widok akceleratora dwuenergetycznego



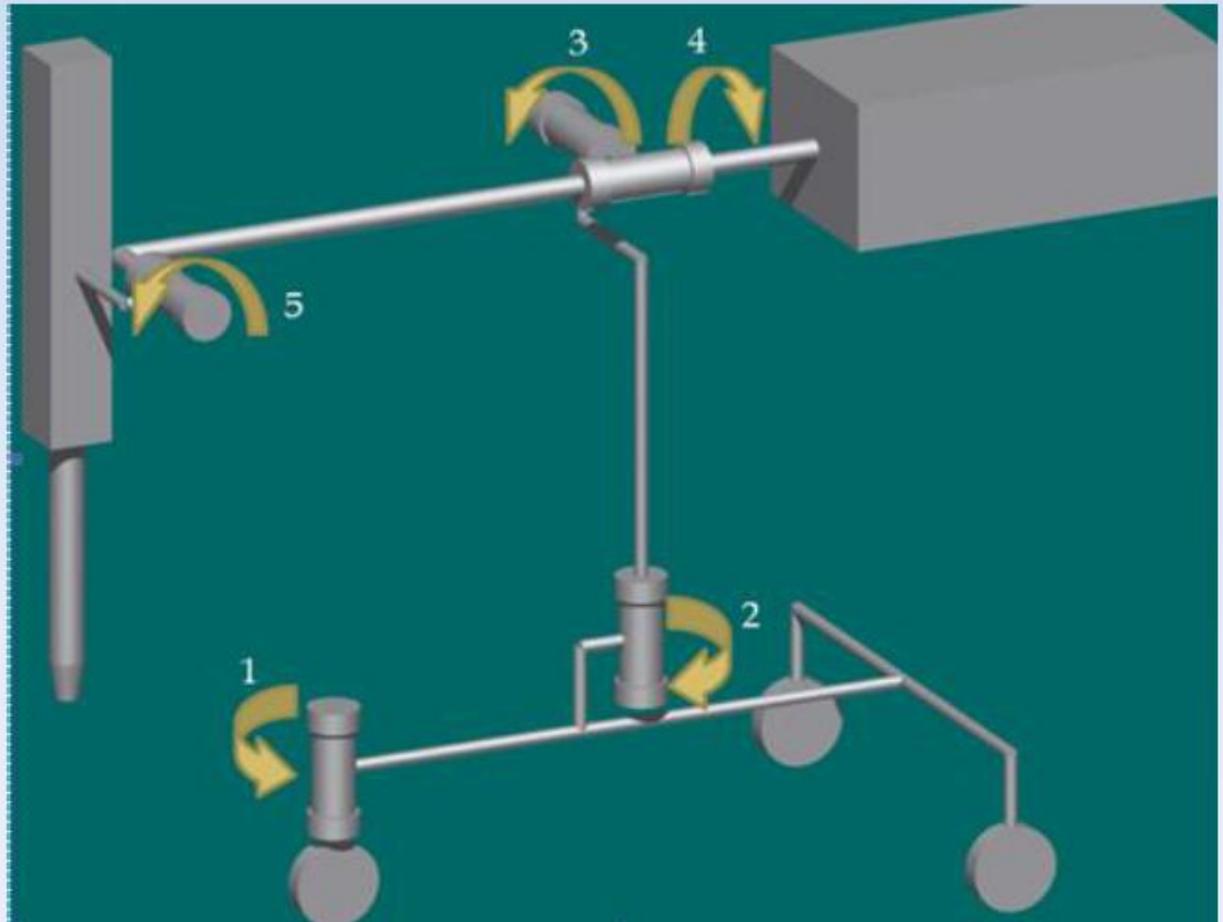
# Głowica systemu NALR (Inline PN50)



Obliczenia Monte-Carlo dla lampy rentgenowskiej NALR

# Akcelerator śródoperacyjny

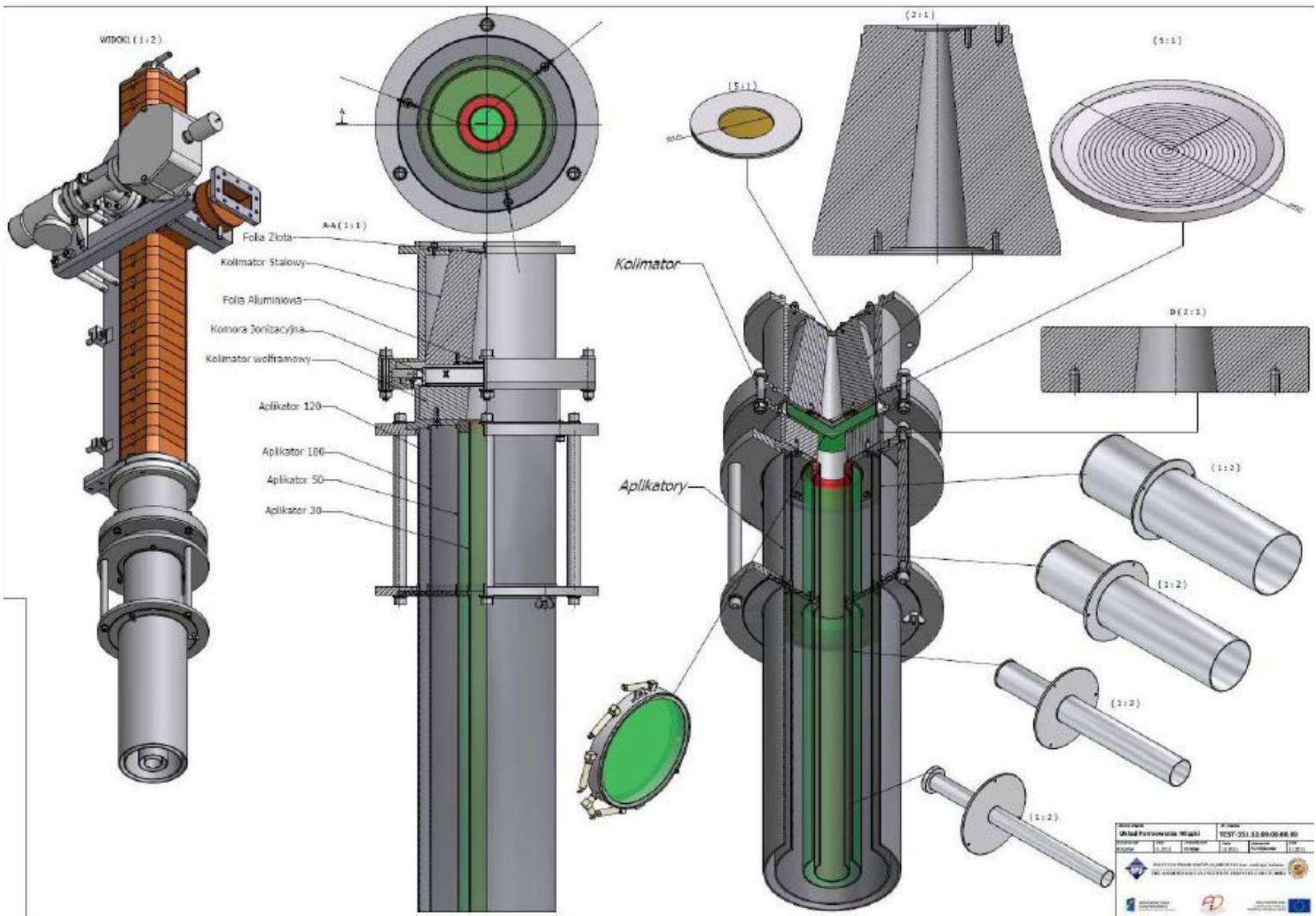
- elektrony
- zakres energii 4 – 12 MeV
- pola o średnicach od 4 do 12 cm
- także aplikatory o kształtach niecylicydrycznych
- wybór sposobu dokowania aplikatorów („soft” lub „hard”)



Schemat kinematyczny akceleratora śródoperacyjnego



# Head of intra-operative accelerator





# Advanced radiotherapy accelerator

- $e^-$  4-22 MeV
- $\gamma$  6-18 MeV
- X-ray CT intergated
- Multi-leaf collimator





# National Centre for Nuclear Research

- Nuclear technologies for medicine and industry

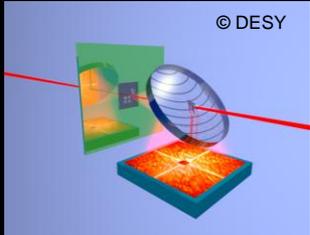


- **Interface between research and industry**
  - office & lab space, administrative & social support
- **Specialised in particle accelerators & detectors**
  - vacuum, cryogenic & magnet technologies



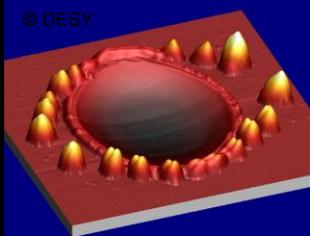
# Free Electron Laser @ Świerk

4<sup>th</sup> generation light source driven by electron accelerator



© DESY

**3D-imaging:**  
molecules  
& nano-  
structures



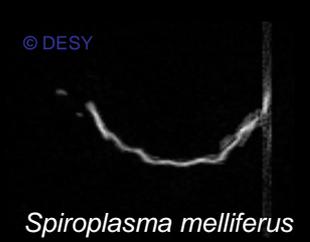
© DESY

**Material studies:**  
dense plasma  
properties



© DESY

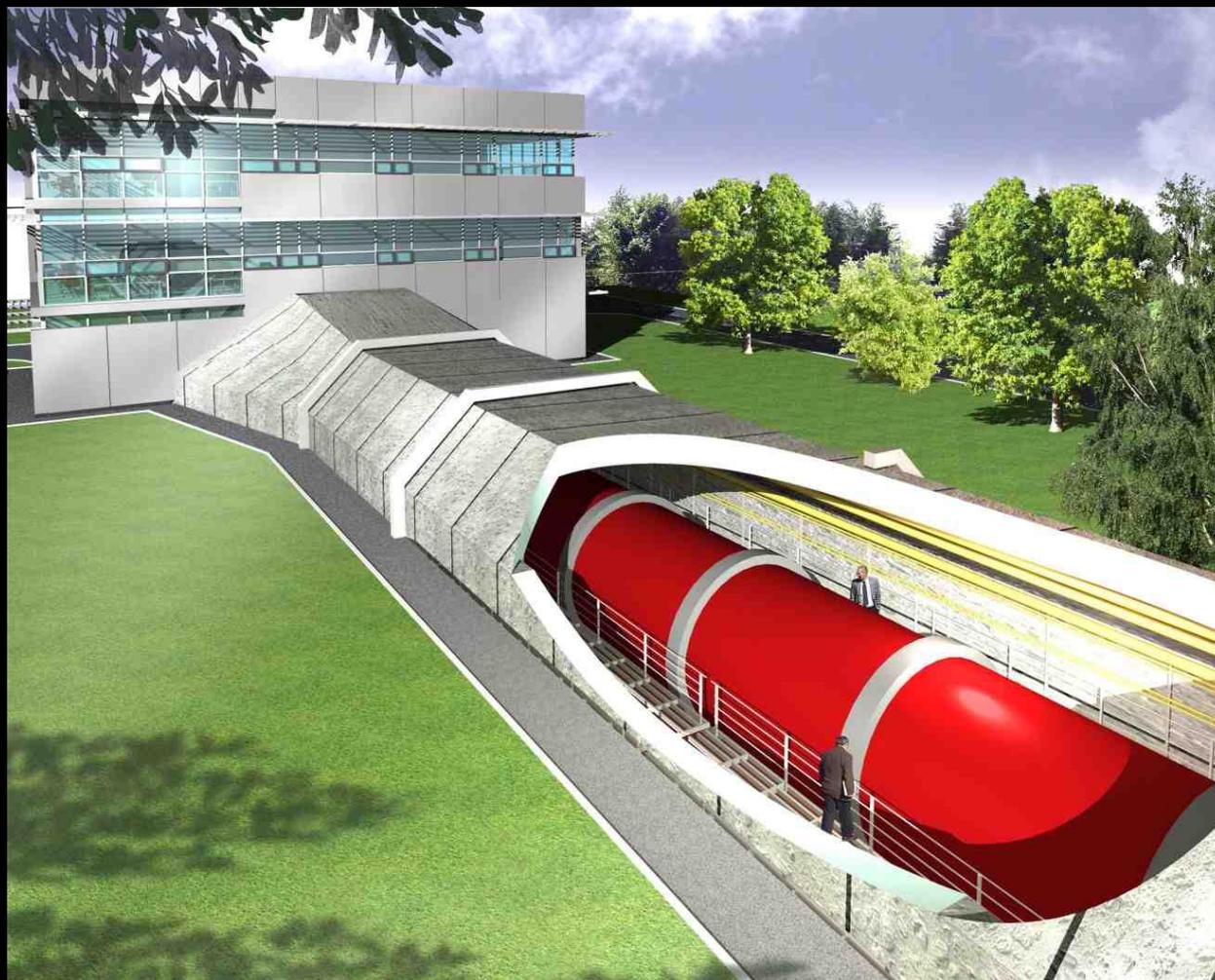
**Novel technologies:**  
surface  
modification



© DESY

**Live sciences:**  
biological cell  
imaging

*Spiroplasma melliferus*



Continuous e<sup>-</sup> beam E → **600 MeV**  
Radiation wavelength: **THz** → **UV 9 nm**  
Pulse length: **< 100 fs**

Beam power (peak): **0.22 GW**  
Length: up to **400 m**  
Cost: **100 M€**



# POLFEL technical details

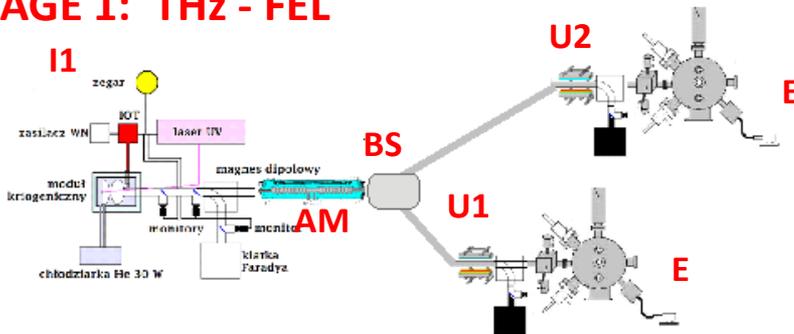
## POLFEL schedule:

- 0:** SC Injector + tunnelling + experimental hall + cryogenics
- 1a:** THz-FEL with U1 & 1 exp. station
- 1b:** +U2 & 2<sup>nd</sup> exp. station
- 2a:** XUV-FEL + experimental station
- 2b:** Supporting magnetic & nuclear labs, next experimental stations

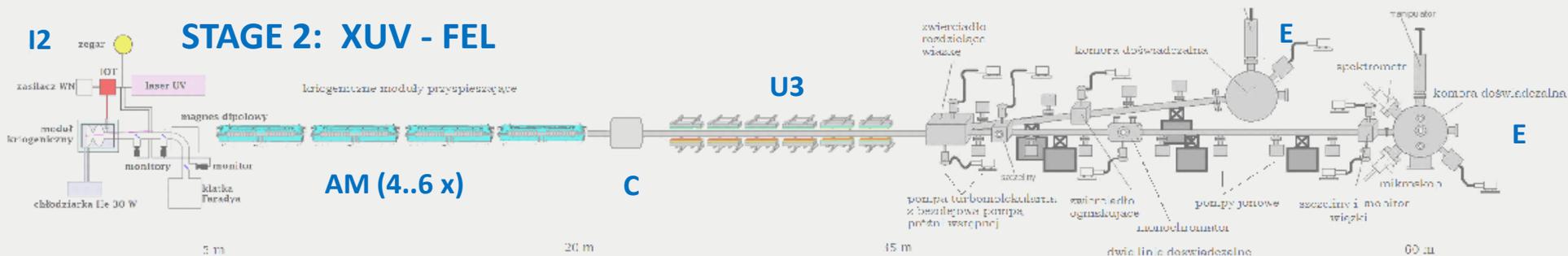
## POLFEL characteristics:

	Stage 1	Stage 2
Source	THz-FEL	XUV-FEL
E-beam energy:	5 – 50 MeV	> 800 MeV
Accelerating field frequency:	1,3 GHz	1.3 GHz
Modes of operation:	Pulsed and CW	Pulsed and CW
Repetition rate of UV laser initiating the photoemission from SC photocathode:	50 kHz	100 kHz
Radiation wavelength:	6 – 1000 $\mu\text{m}$	< 10 nm
Peak power:	0.8 kW	0,2 GW
Pulse energy:	50 $\mu\text{J}$	> 10 $\mu\text{J}$
Pulse width:	1 ps	10 fs
Average power:	250 W	> 10 W
Total length:	25 m	230 – 280 m

## STAGE 1: THz - FEL



## STAGE 2: XUV - FEL





# Conclusion on accelerator R&D @ NCBJ

We deal with

- low budget
- old infrastructure
- generation gap

but ...



# we can do miracles!