Experience on Electron Linacs from NCBJ

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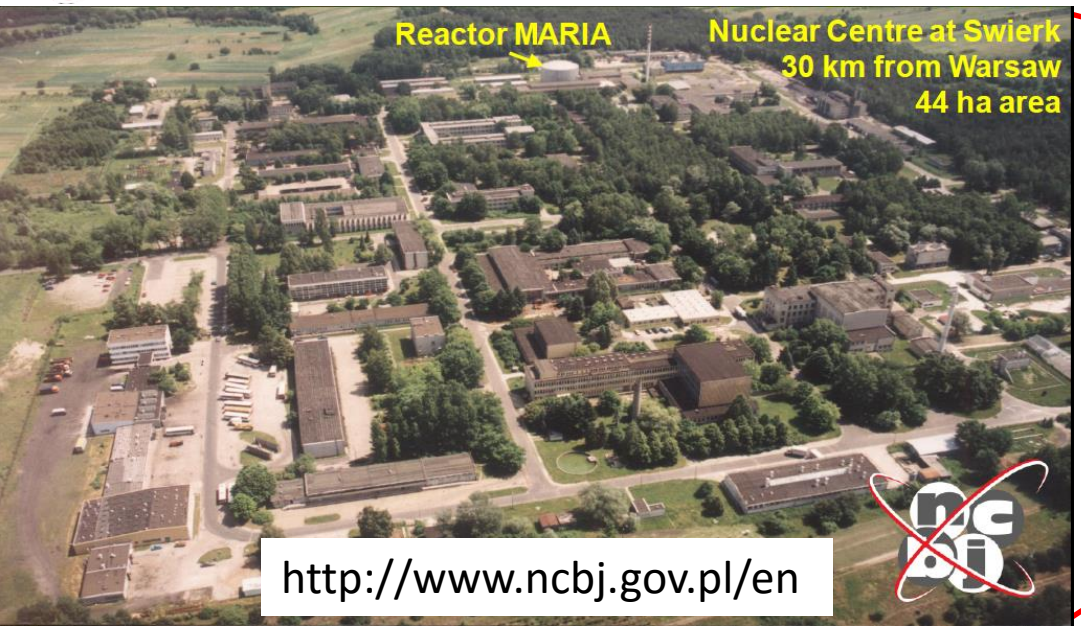
Abstract

National Centre for Nuclear Research (NCBJ) is the largest research institute in Poland and the host to the country' only nuclear reactor used for science and radiopharmaceuticals production. NCBJ has also a long tradition of developing and manufacturing particle accelerators including electron linacs. Current activities concentrate around development of accelerators for science (e.g., 9 MeV e- linac for the GBAR experiment or PIMS structures for LINAC4 at CERN), industry (mainly e- linacs for megavoltage X-ray radiography), security (dual energy accelerator for cargo screening) and medicine (with ongoing projects to develop a simple 6 MV Cobalt replacement unit and a novel, highly mobile accelerator for IOERT). Hardware developments are accompanied with research on new software as well as new efficient design methods, particularly in the area of electron beam forming systems [1]. This talk will present some of the NCBJ achievements, existing capabilities and ongoing R&D projects.

[1] P. Adrich, NIM A 817 (2016) 93–99; P. Adrich, NIM A 817 (2016) 100–108

National Centre for Nuclear Research Swierk, Poland

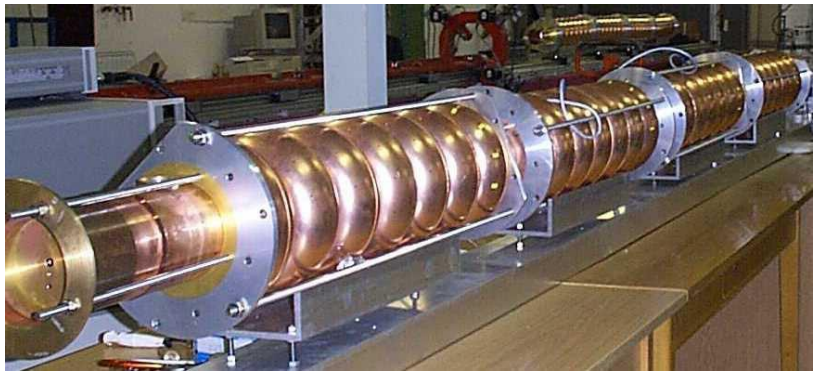


- ✓ Established in 1955
- ✓ The largest research institute in Poland (1000+ employees)
- ✓ Broad scope of fundamental and applied research in nuclear, high energy, plasma physics and material science
- ✓ Tradition of development and production of radiopharmaceuticals and medical equipment, including linear accelerators

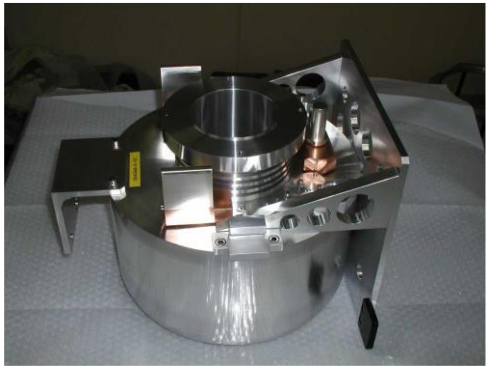
NCBJ at a glance – scientific collaborations

NCBJ contributes actively to many experiments at CERN and other leading laboratories:

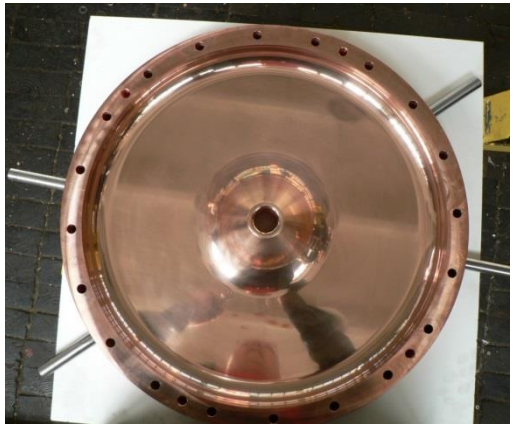
Isolde – target
CMS – RPC m-trigger
LHC-b – straw tubes, RASNIK, readout
ALICE – PHOS assembly & tests
Linac4 – proton buncher, PIMS
GBAR – electron linac



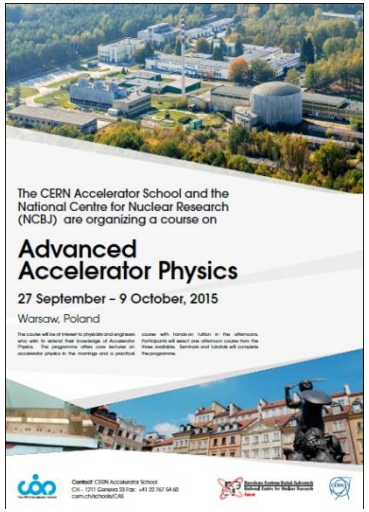
Prototype cavities 1.3 GHz for Tesla-FEL at DESY



Target for CERN's ISOLDE



First cavity for LINAC4@CERN manufactured at NCBJ



NCBJ at a glance – industrial electron linacs

Mobile linac for industrial radiography

Dual energy linac for industrial radiography (6/9 MV)

Early experience with medical linacs

Neptune10

Coline4

- Within framework of the National Cancer Programme (centrally planed, managed and financed). Since 1970s
- Neptune10 licensed from French company CGR/MeV
  - ~ 100 manufactured and sold (half exported; mostly to countries of the then Soviet bloc)
  - 6/9 MV photons (dose rate 200 cGy/min)
  - 6, 8, 10, 12 MeV electrons
  - Some were in operation until early 2000s (~20 years of continuous operation)
- Coline4 – own development
  - 4MV (Co-60 replacement)
  - Computer control
  - No MLC, No EPID
  - Multiple users in Poland (and Iran)
  - Very reliable and stable operation
- Programme terminated due to bankruptcy of socialistic/communistic economies of Poland and the Soviet Bloc countries (late 1980s, early 1990s).
- Market lost to foreign competitors

Renewed perspectives at NCBJ

Substantial investments following Poland's accession to the European Union (2004)

Upgraded machine shop
(CNC high precision turning and milling machines)

New computing cluster (ranked within world top500)

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Coline 6

Modern Co-60 replacement based on Coline 4 experience

- Aims at well balanced (quality/functionality/reliability/cost) solution for low and middle income countries
- Modern technology (but without the most sophisticated solutions)
- 6 MV single beam (magnetron powered)
- No therapeutic electron beams
- Therapeutic couch
- Essential control and therapy planning software (DICOM compatible)

Optional modules

- 80 leafs MLC (proprietary)
- IMRT (sliding window, step-and-shoot)
- MV Portal Imaging (no kV imaging)

Dual energy version (6/15 MV) and electrons under consideration

Ongoing commercialization in joint venture with UJP Praha (manufacturer of Co-60 units based in Czech Republic)

European Union
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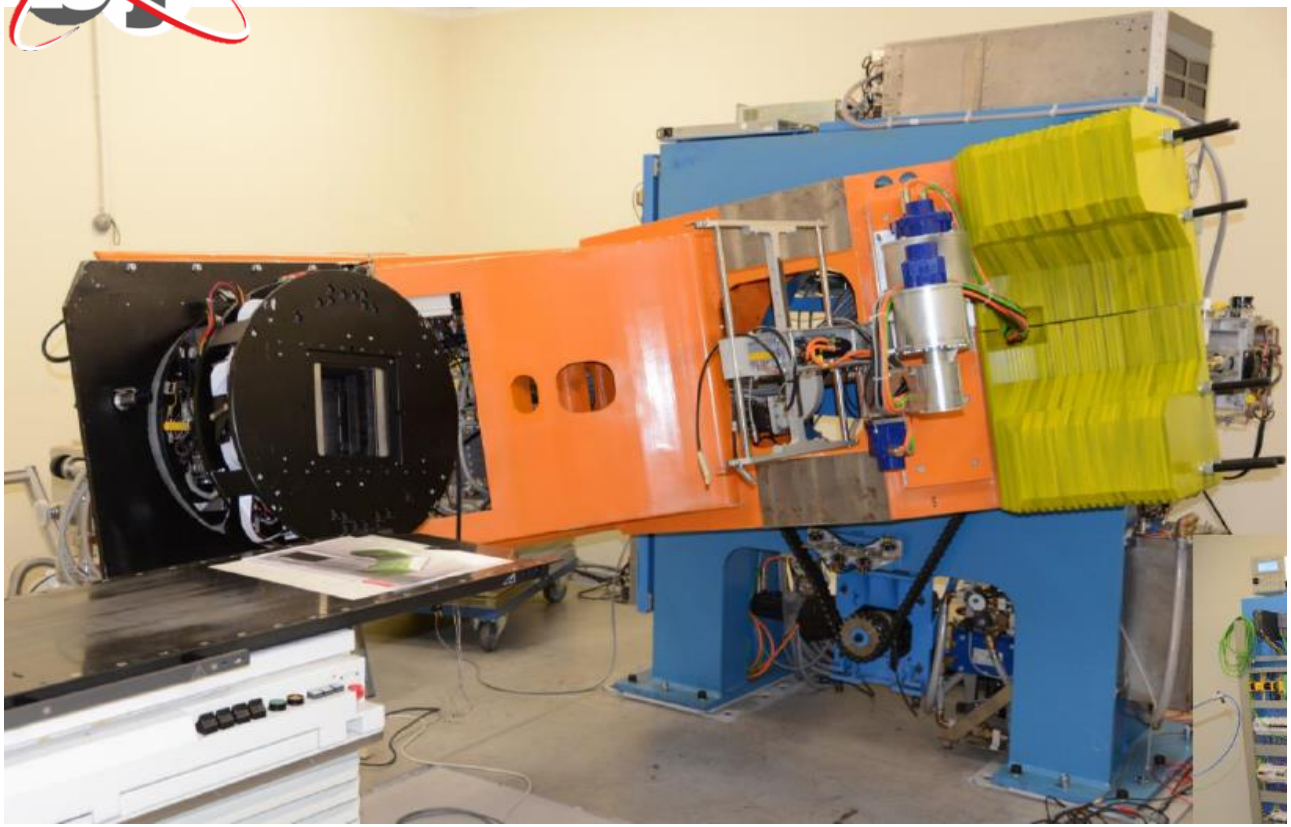
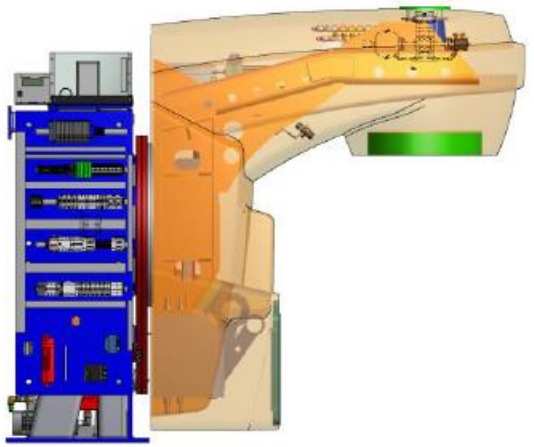
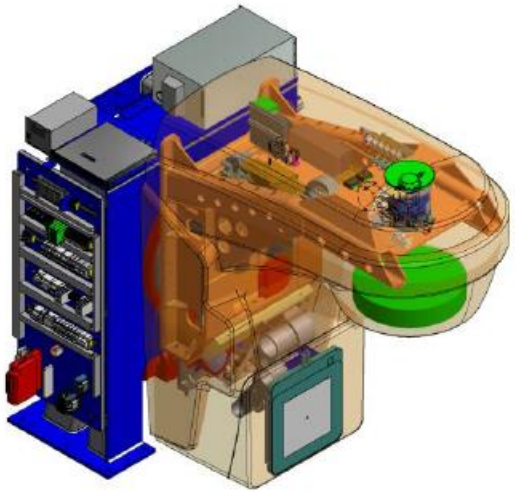
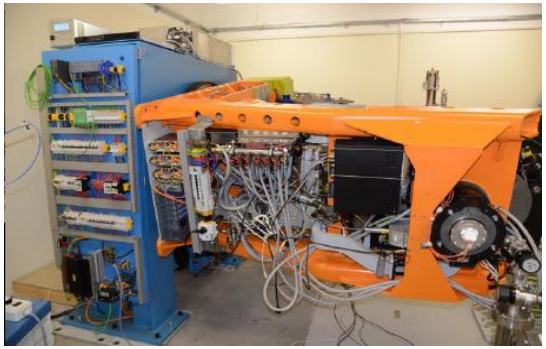
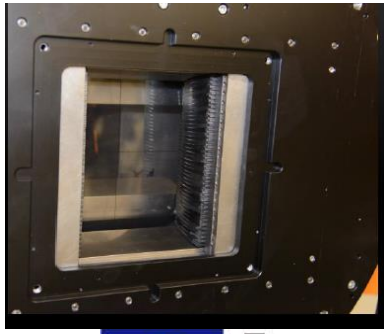
Coline 6











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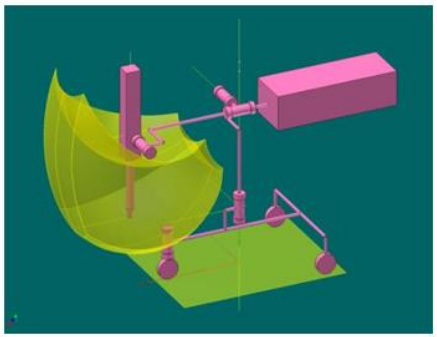
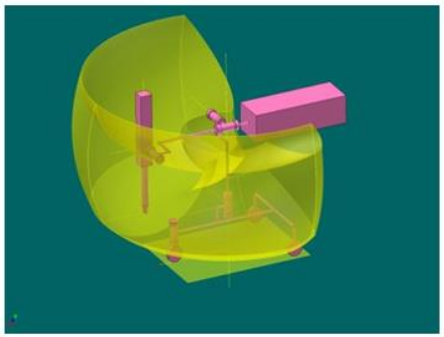
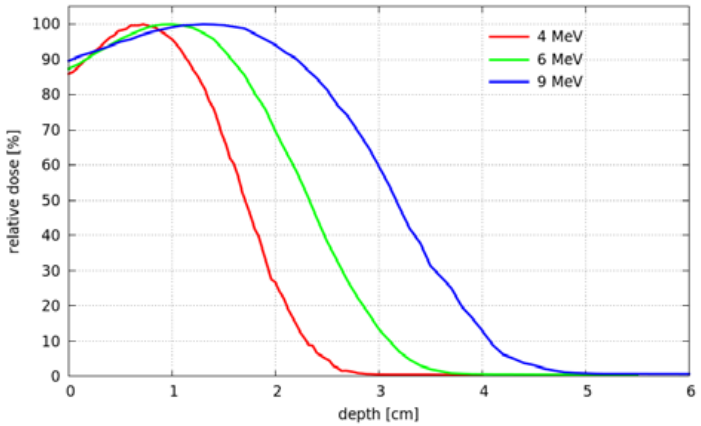
Mobile IOERT linac





- Novel design
- 4 – 12 MeV electron beams
- 5 – 12 cm circular fields
- 10 Gy/min
- Motorized platform
- Large working space
- Successful demonstrator unit
- Clinical prototype coming soon



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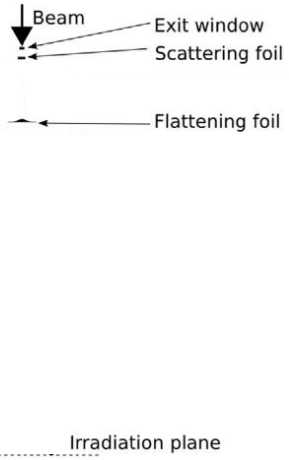
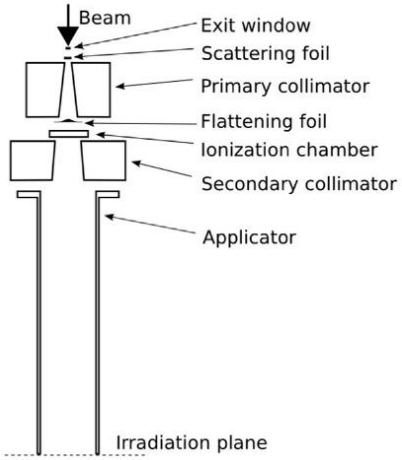
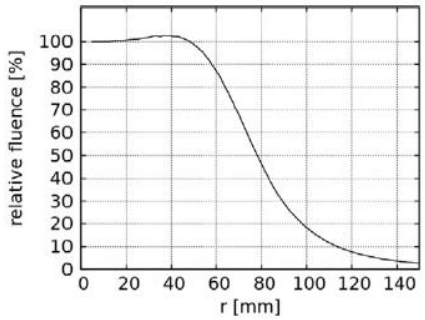
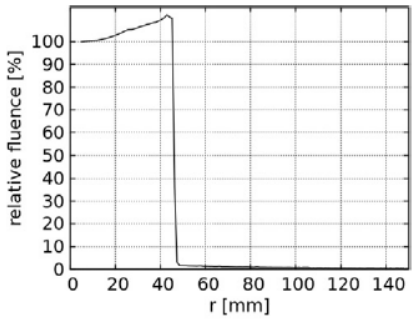
Novel method for designing electron beam forming systems

- Design methods not much improved since 1970s (reduced interest in electron therapy)
- Existing analytical models do not account for therapeutic beam interaction with collimating devices. Laborious corrections necessary (a lot of trial and error, *in silico*)





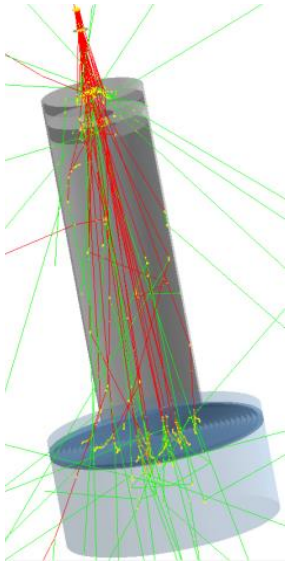


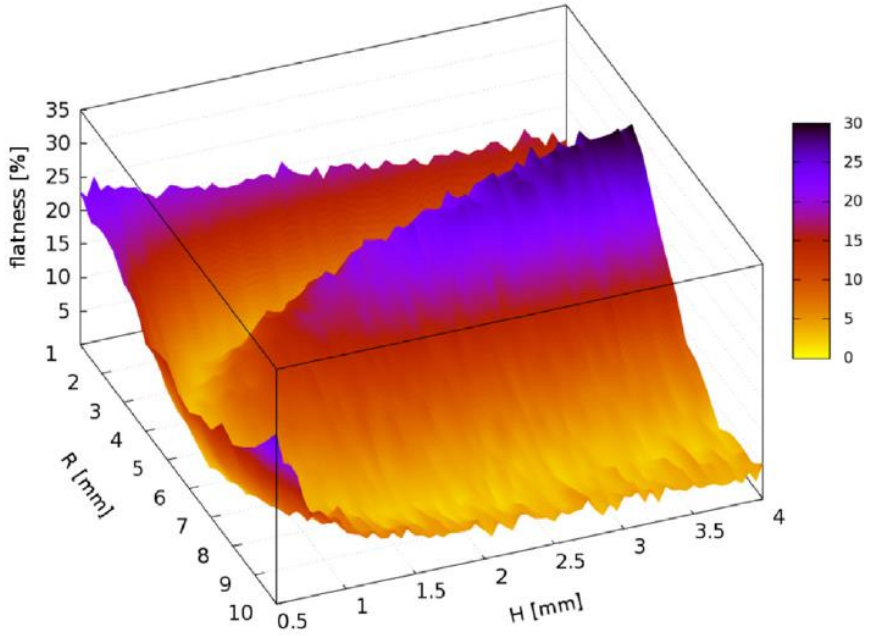


P. Adrich, *A new method for designing dual foil electron beam forming systems. I. Introduction, concept of the method*, NIM A 817 (2016) 93–99

Novel method for designing electron beam forming systems

- New design method based entirely on Monte Carlo calculations
- Complete, realistic geometry and physics
- Optimum system configuration from systematic, automatized scan of system performance under variation of its key parameters
- Highest quality and huge savings (days instead of months)





P. Adrich, *A new method for designing dual foil electron beam forming systems. II. Feasibility of practical implementation of the method*, NIM A 817 (2016) 100-108

Summary

NCBJ

- Design, prototyping, production capabilities (low volume)
- Seeking balance between technology sophistication, affordability, reliability, commercial viability (historically mixed experience)
- IOERT as a way to help alleviate RT equipment shortage
- New design methods to reduce costs while improving quality

Thank you for your attention!