CANAM
Center of Accelerators and Nuclear Analytical Methods

@

Nuclear Physics Institute of the CAS

Jan Dobeš

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Center of Accelerators and Nuclear Analytical Methods

Nuclear Physics Institute of the CAS
public research institution

The Czech Academy of Sciences

www.ujf.cas.cz

major Czech institution in nuclear physics field

~ 290 employees (220 FTE) **~ 100 scientists (80 FTE)** **~ 30 PhD student**

annual budget 8.5 MEUR
(50% institutional support CAS, 50% targeted support)

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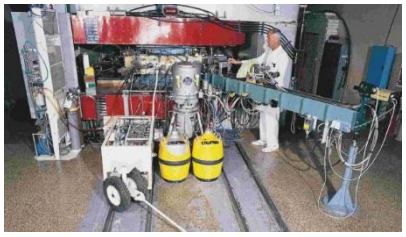
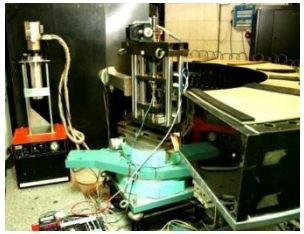
mission

- **basis research in nuclear physics and related disciplines**
- **use of nuclear physics methods in interdisciplinary scientific and research areas**

- **participation in large-scale international projects (ALICE, STAR, HADES, CBM, KATRIN, ESS, SPIRAL-2)**
- **employment of home facilities and equipment**



CANAM Center of Accelerators and Nuclear Analytical Methods

- a multipurpose research platform
- tools based on ion-beams and neutrons
- internal synergies
- multidisciplinary character

- open access
- cooperation in ESFRI facilities
- in Large-scale integrating projects

Laboratory of Cyclotron and Fast Neutron Generators (LC & FNG)

Operating cyclotrons
Isochronous cycl. U-120M
Recently purchased TR-24

Laboratory of Tandetron (LT)

Operating an accelerator
Tandetron 4130 MC

Neutron Physics Laboratory (NPL)

Providing facilities at the reactor LVR-15

~90 persons (48 FTE)

~ 30 scientists (10 FTE)

~ 7 PhD students

annual budget 2.1 MEUR
(31% institutional, 69% targeted support)
only operation and investments of infrastructure

- 58 research infrastructures approved by MEYS
- operational costs funded by the MEYS
- investment costs - European Structural and Investment Funds

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

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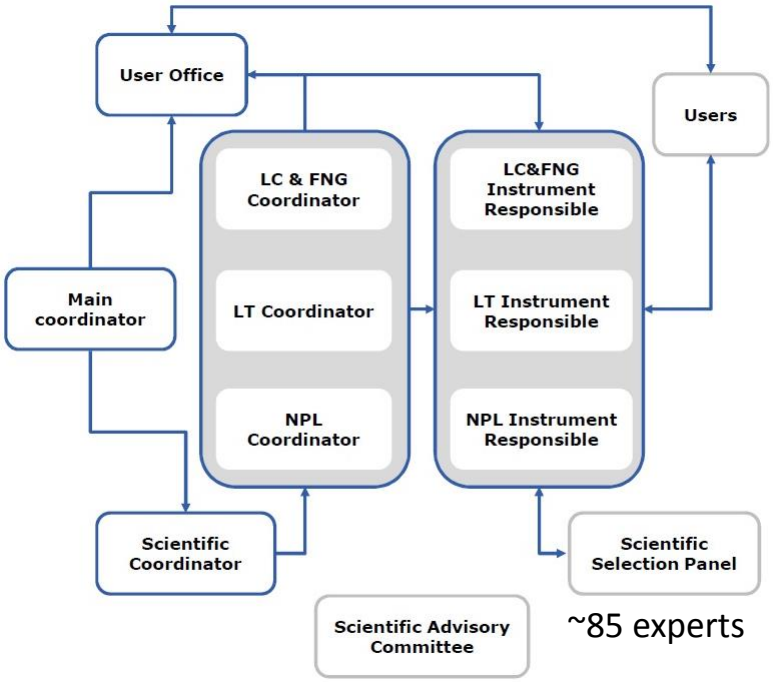
CANAM – open access



open access procedure

proposals via Users Portal

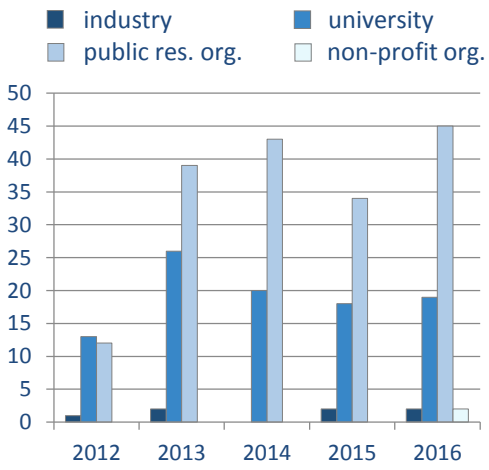
reviewed by 2 experts from SSF

technical feasibility by IR

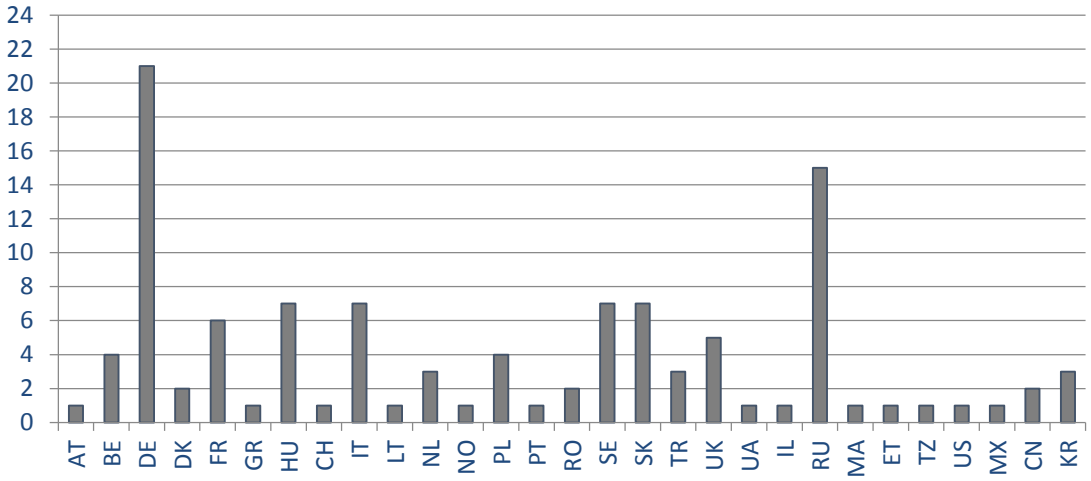
start in the middle of 2012

CANAM user community

- **user community (2012 – 2016):**
  users (proposers and co-proposers of experiments) – 776 from abroad – 259
  accesses (experiments performed) – 278 (CZ – 167, ERA – 86, others – 25)



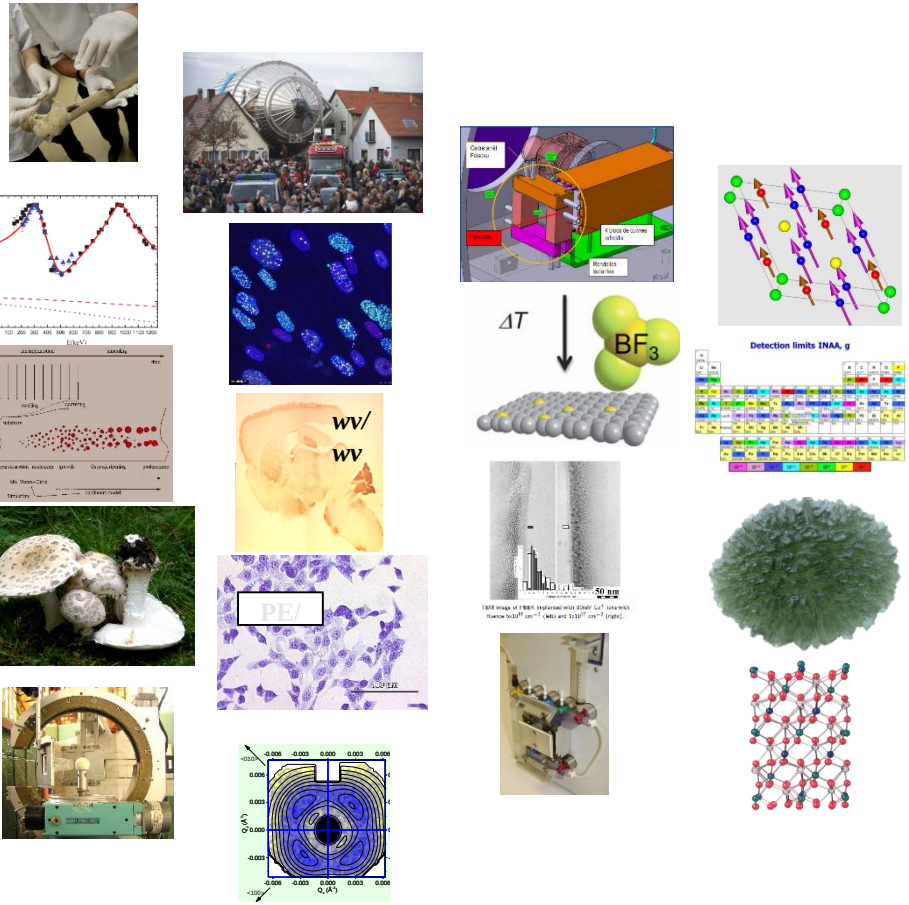
Accesses by year

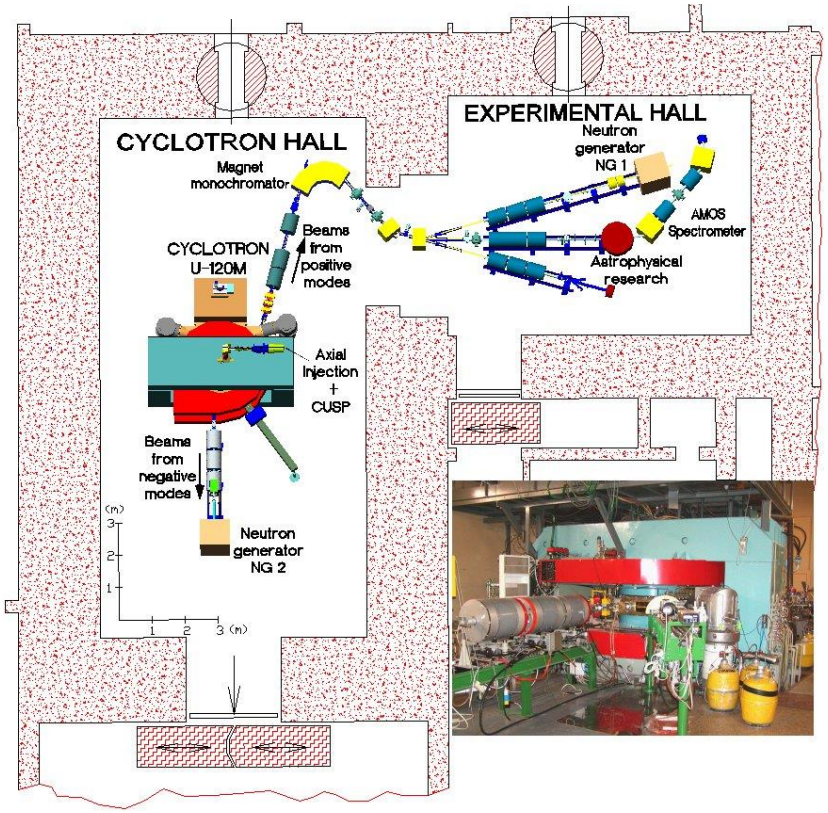


Accesses by country

in 2012 - 2015 164 publications in impacted journals concerned with 22 scientific disciplines

Archaeology, anthropology, ethnology
Elementary particle theory and high energy physics
Nuclear, atomic and molecular physics, accelerators
Optics, masers and lasers
Plasma physics and discharge through gases
Solid-state physics and magnetism
Astronomy and celestial mechanics, astrophysics
Biophysics
Inorganic chemistry
Analytical chemistry, separation
Organic chemistry
 Macromolecular chemistry
 Biochemistry
 Physical chemistry and theoretical chemistry
 Electrochemistry
Nuclear and quantum chemistry, photochemistry
Geochemistry
Pollution and air control
Genetics and molecular biology
Microbiology, virology
Botany
Biotechnology and bionics
Food industry
Electronics and optoelectronics
Sensors, detecting elements, measurement and regulation
Composite materials
 Other materials
 Corrosion and material surfaces
Fatigue and fracture mechanics





isochronous machine with K=40

Ions	Energy [MeV]	Max. current [μA]
H^+	6–25	5
H^-/H^+	6–37	50–30
D^+	12–20	5
D^-/D^+	11–20	35–20
$^3He^{+2}$	18–52	2
$^4He^{+2}$ (α)	24–38	5

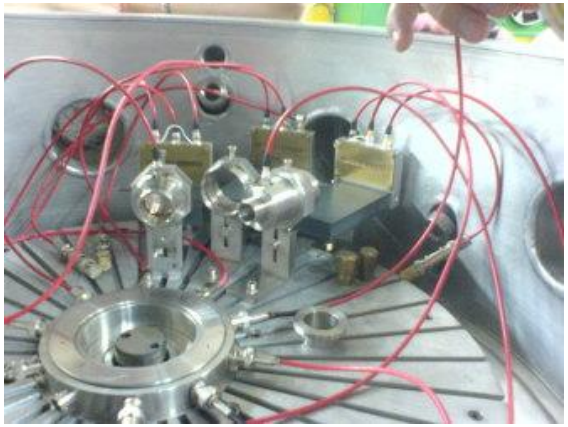
+ ions $\Delta E/E \sim 5.10^{-4}$

indirect methods

Trojan Horse Method

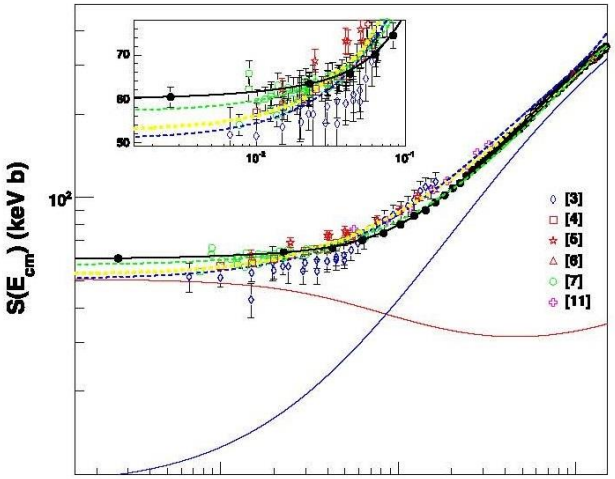
$d + d \rightarrow p + t \longrightarrow {}^{2}H\,({}^{3}He, p\,{}^{3}H)\,{}^{1}H$

$d + d \rightarrow n + {}^{3}He \longrightarrow {}^{2}H\,({}^{3}He, n\,{}^{3}He)\,{}^{1}H$



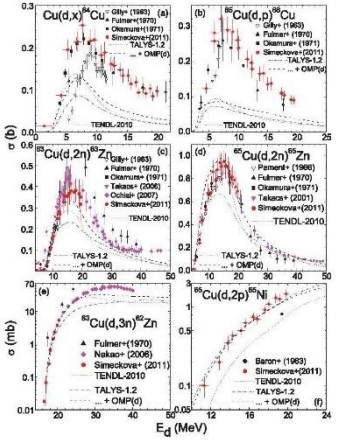
Asymptotic Normalization Coefficients method

$^{15}N(p, \gamma)^{16}O \longrightarrow {}^{15}N(^{3}He, d)^{16}O$



activation cross sections
d + construction materials
E_d = 4 – 20 MeV
requested by IFMIF
(International Fusion Irradiation Facility)

d + $^{63, 65}$Cu



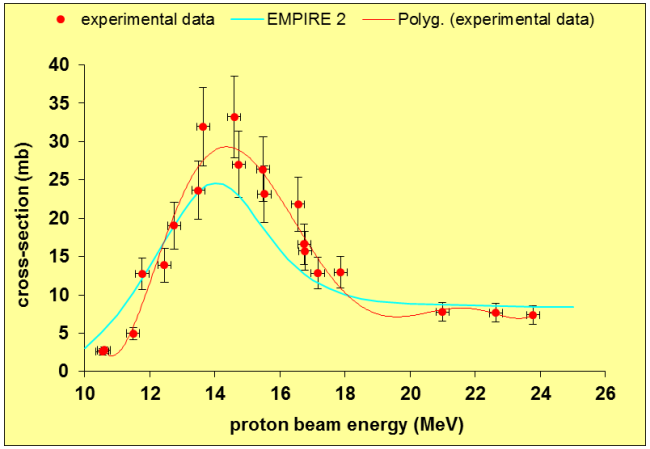
excitation functions for radioisotope production activities of NPI Radiopharmacy Dpt.

production routes to ^{230}U
novel therapeutic nuclide for targeted α therapy

(i) p + ^{232}Th → ^{230}Pa +3n → ^{230}U + β^- (8.4 %)

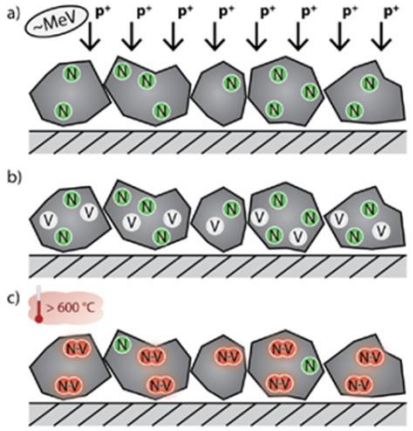
(ii) p + ^{231}Pa → ^{230}U +2n

thick – target yields (i) and (ii) similar



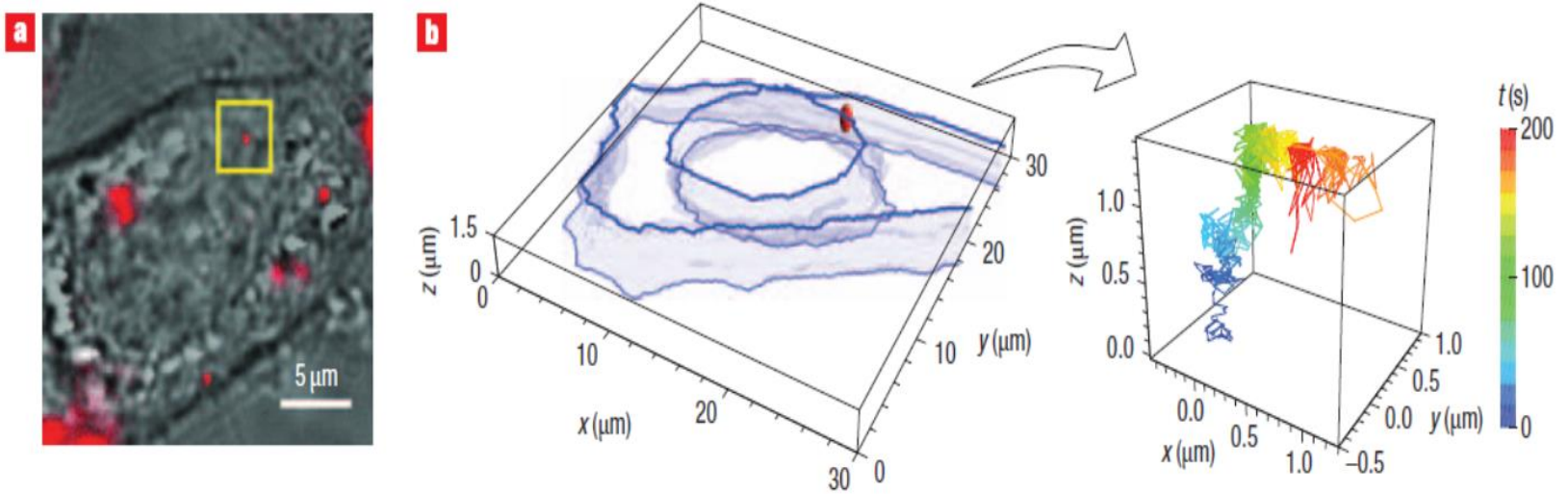
fission channel contribution

Nanodiamond: biocompatible carbon nanomaterial (Ib HPHT)
powder or aqueous solution, variable size ranging from ~ 5 nm

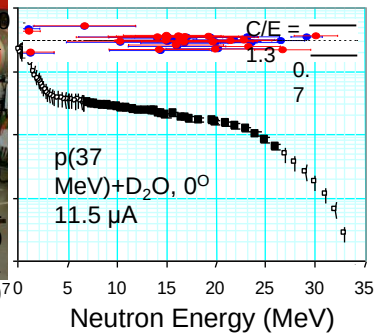


after irradiation and annealing
fluorescence nitrogen-vacancy (NV) centers formed

bioimaging, biolabeling, substitution of quantum dots, single particle tracking etc.



Fast Neutron Generators @ U-120M

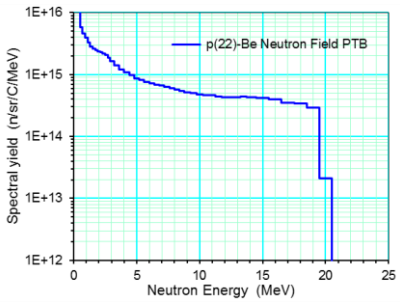


High-power broad-spectrum neutron generator

$p + D_2O$ E_p= 37 MeV

integral flux up to 10^{11} cm^{-2} s^{-1}

IFMIF like white spectrum with a mean energy of 14 MeV and extension up to 32 MeV

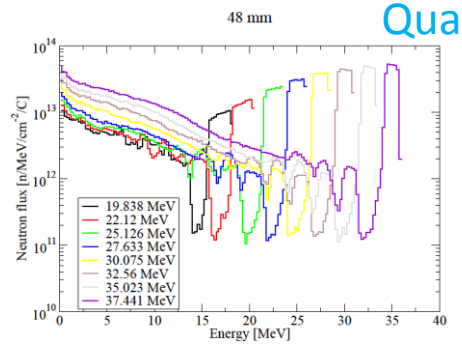


Variable-energy broad-spectrum neutron generator

d+Be E_p= 10 – 37 MeV E_d= 8 – 20 MeV

integral flux: up to 10^{11} /sr/s

mean energy: 4 - 12 MeV



Quasi-monoenergetic neutron generator

$p+^7Li$ E_p= 20 – 37 MeV

peak energy: up to 36 MeV

neutron flux density in the QMN peak:

up to 10^9 $n/cm^2/s$

neutronics data

neutron data above 15-20 MeV needed for fusion and ADTT programs

FNG involved in projects

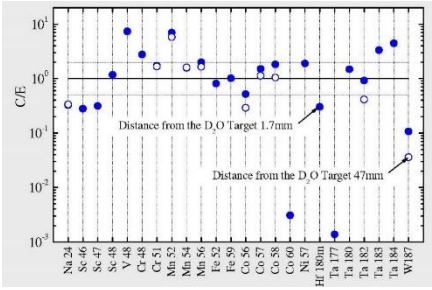
FUSION FOR ENERGY

IAEA

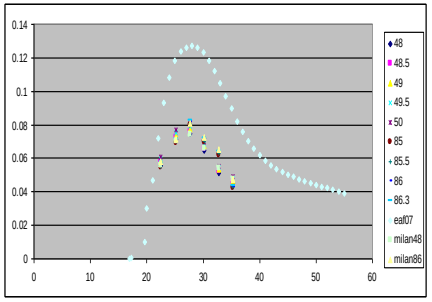
CHANDA SOLVING CHALLENGES IN NUCLEAR DATA FOR THE SAFETY OF EUROPEAN NUCLEAR FACILITIES

SEVENTH FRAMEWORK PROGRAMME

activation of EUROFER in IFMIF like spectrum



$^{93}Nb(n,3n)^{91m}Nb$

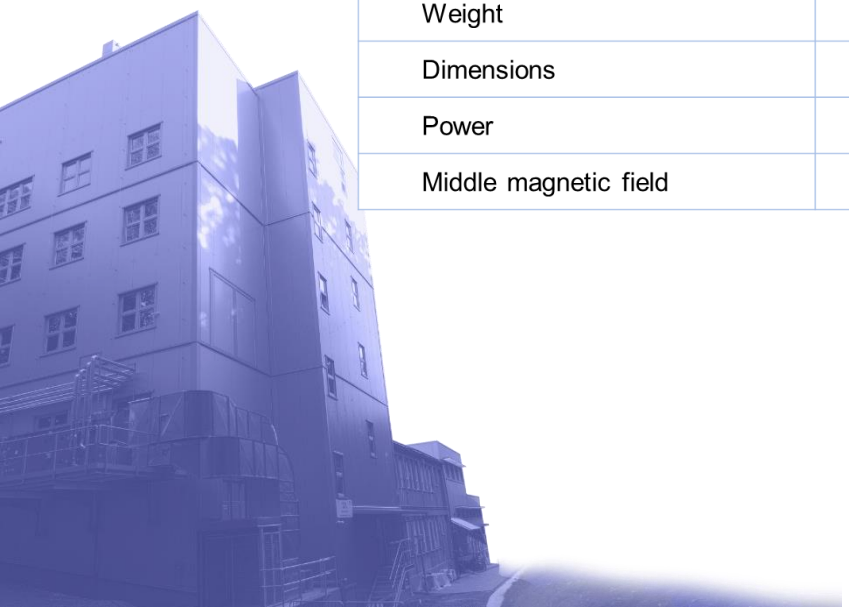


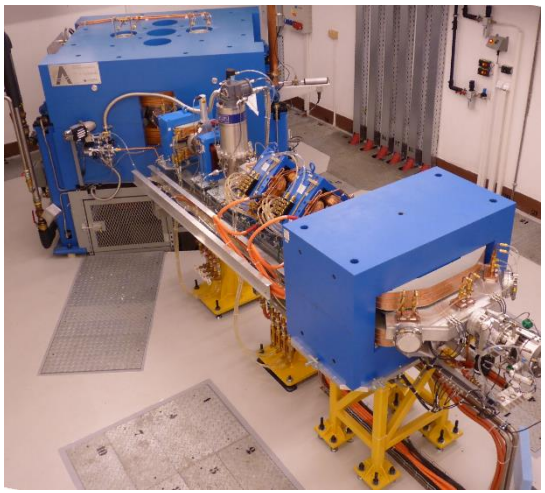
detector and electronics tests

ATLAS & LHC ALICE & LHC CBM @ FAIR

2013 – 2015 investment (CAS, MEYS, NPI)

TR 24 – Advanced Cyclotron System Inc. (Canada)	
Proton energy range	18–24 MeV
Max. proton beam current	300 μA
Acceleration frequency	85 MHz
Acceleration voltage	50 kV
H^- Ion source	Multi-CUSP
Simultaneous beams	2
Weight	25 t
Dimensions	1.8×1.8×2.5 m
Power	180 kW
Middle magnetic field	1.4 T

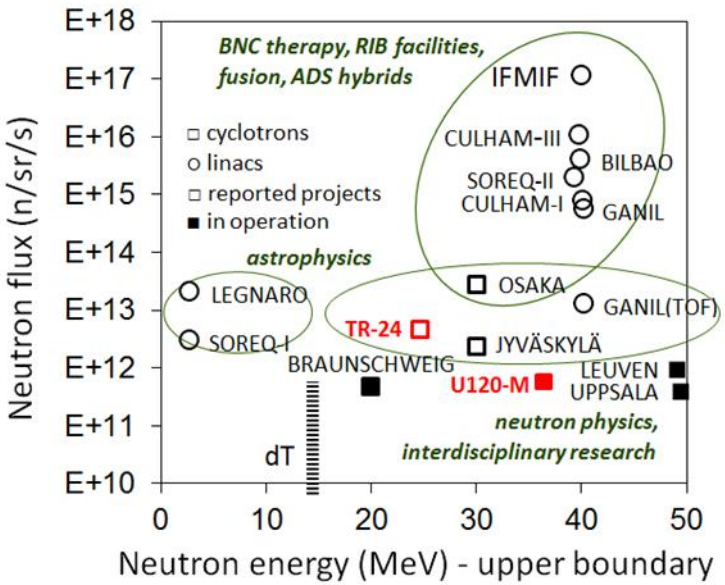


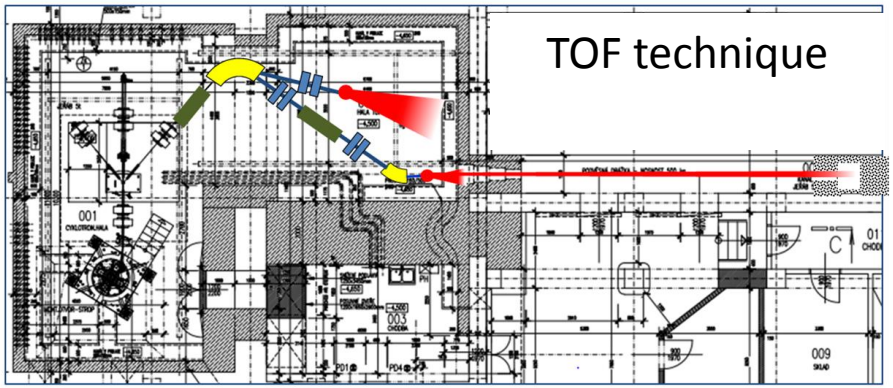


Research program associated with

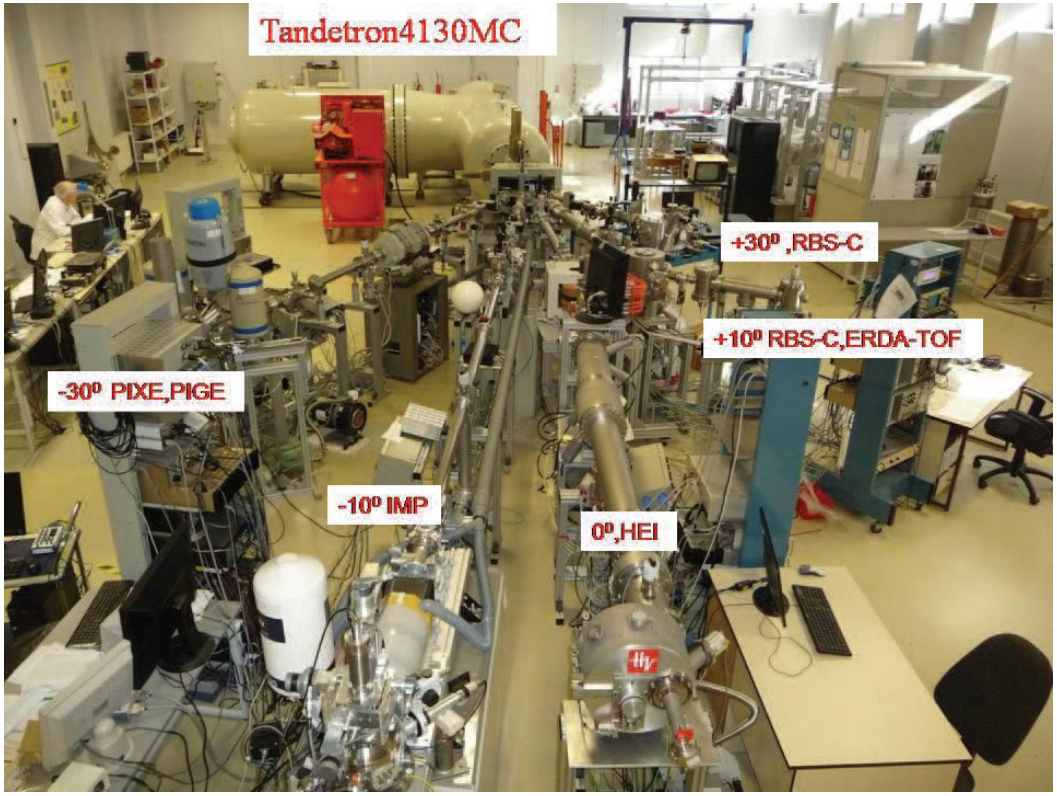
- generation of high fluxes of fast neutrons:
  - nuclear data for new fusion-fission and advanced fission systems
  - neutron radiation tests of electronic or diagnostic components

- production of novel medical radionuclides
  - theranostics ^{64}Cu, ^{68}Ga,…
  - ^{99m}Tc via (p,2n) reaction as an alternative to reactor-produced generator ^{99}Mo/^{99m}Tc





LT Tandetron 4130 MC



terminal voltage 200 kV - 3 MV

duoplasmatron ion source

sputter ion source

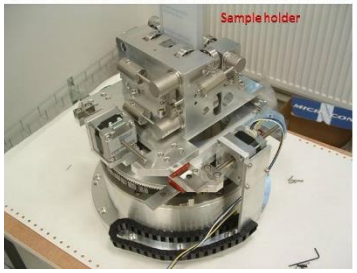
ions H – Au

ion energies 400 keV – 24 MeV

ion currents nA - uA

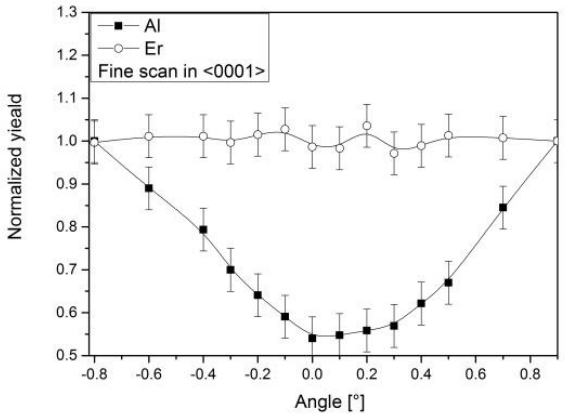
nano- and micro-structured systems
- preparation
- modification
- complex characterization

multi-analytical chamber

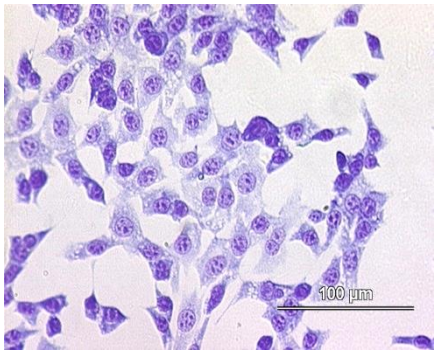


high-energy ion implantation

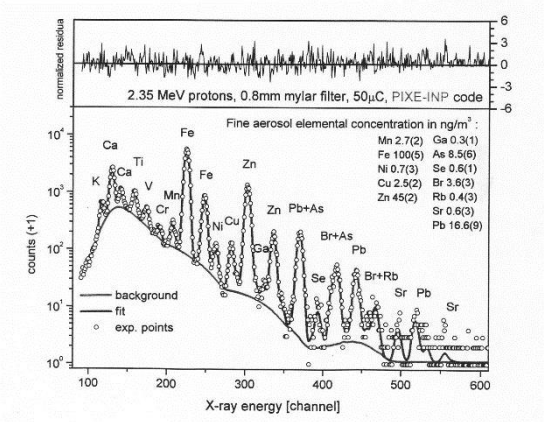
RBS-C optical waveguides
Er implanted in sapphire (Al_2O_3)



polymer bio-materials
PE irradiated by O ions



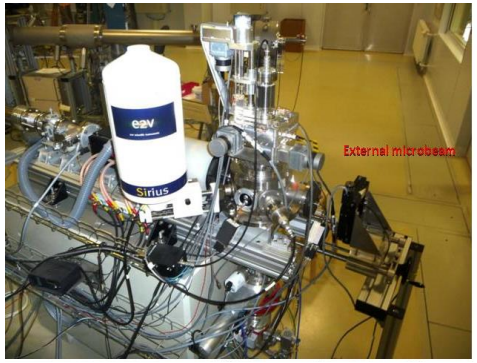
PIXE multi -elemental analyses
atmospheric aerosols

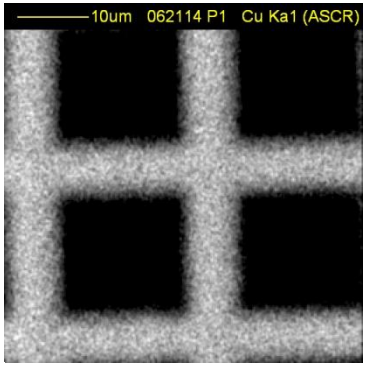


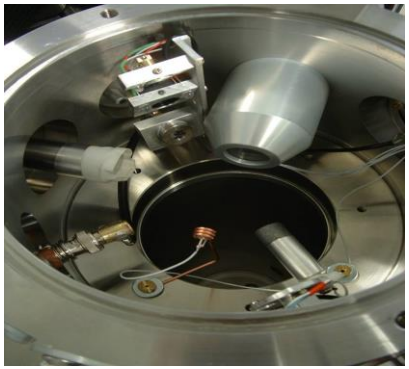
- 10° line

Ion Micro-beam

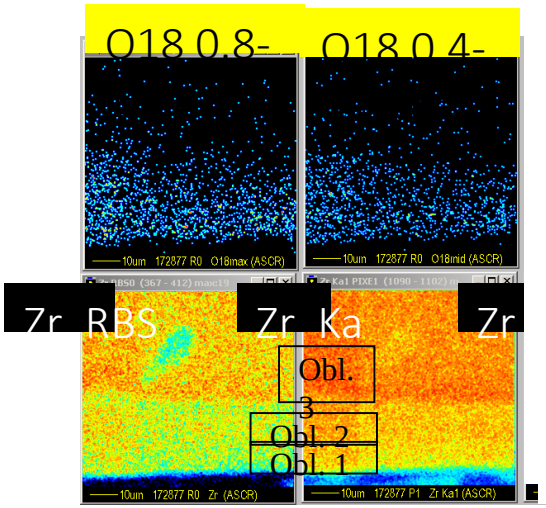
PIXE RBS PESA



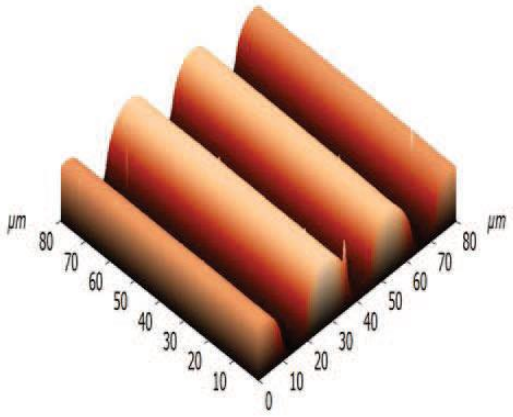


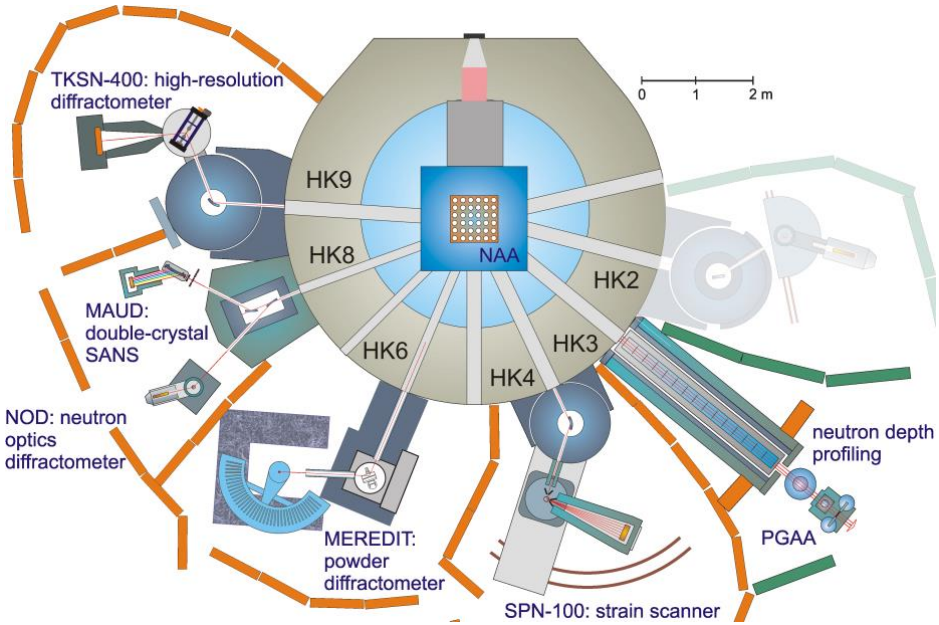


3D elemental mapping
oxidation study of Zr alloys

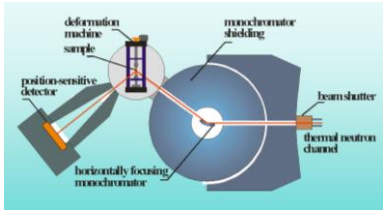
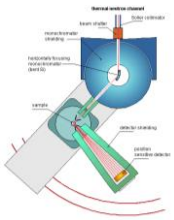
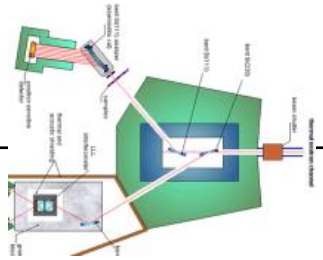
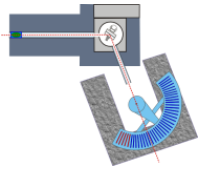


heavy ion micromachining
optical microcomponents

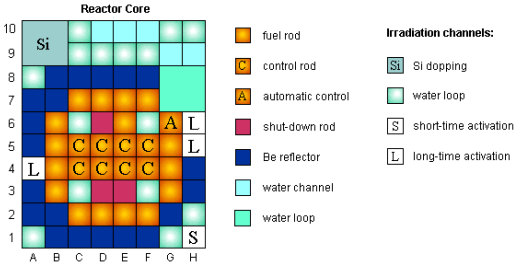




LVR-15 research reactor
operated by the Research Centrum Řež, Ltd.
thermal power 10 MW
max. flux 10^{14} n/s/cm^2

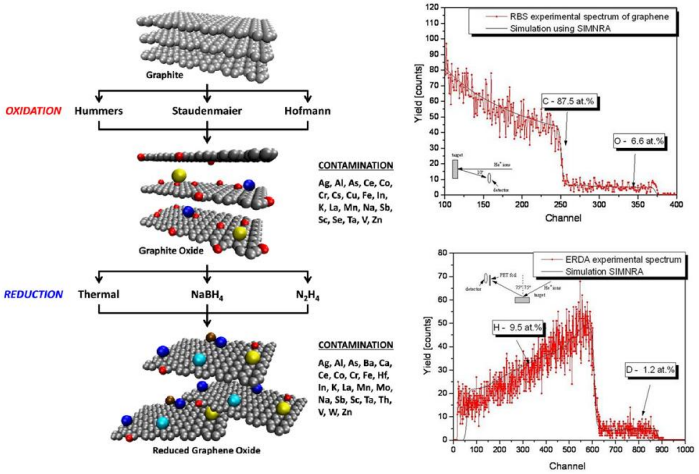
TKSN-400 	**High-resolution diffractometer**: microstrains in polycrystals, in-situ thermo-mechanical processing, phase transformations in alloys (steels, SMA etc.)
SPN-100 	**Diffractometer for macrostrain scanning** of polycrystalline materials (welds, materials after processing)
MAUD 	**Double crystal small-angle neutron scattering**: microstructural studies (precipitation in alloys, porosity in ceramics)
NOD	**Neutron optics diffractometer** for tests of neutron optics and imaging
MEREDIT 	**Medium resolution powder diffractometer**: standard diffraction experiments; experiments with sophisticated sample environment (T, deformation)

Neutron Activation Analysis:
low-level elemental characterization - biology, biomedicine, environment, geology, archaeometry



synthesis of graphene

different oxidation and reduction steps introduce varying types and amounts of elements into the graphene materials



Was Tycho Brahe poisoned by Hg?

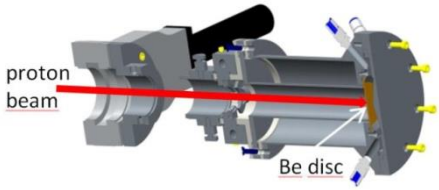
NAA and μ-PIXE analyses of hair samples

CANAM most important plans

Installations and methodological development:

2017 – 2019

- high-intensity neutron source at TR-24
- n-TOF method, modernization of the detection system at FNG
- upgrade LT - ion microprobe and external analytical end-stage
- upgrade NPL - supermirror neutron guide

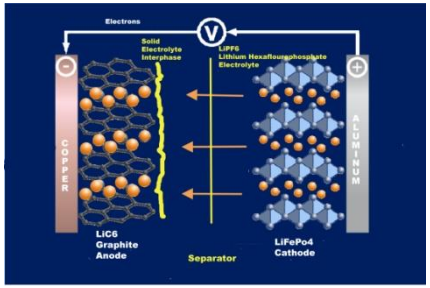


2020 and beyond:

- TR-24 - dual beam regime, neutron lines with TOF
- Accelerator Mass Spectrometry (AMS)

Research:

- nuclear data for basic and applied tasks
- nano-structured materials for optoelectronics
- lithium ion batteries
- materials research



canam.ujf.cas.cz

is looking forward to continuing collaboration with and proposals from **TALYS/TENDL community**

Thank you for attention

EUROPEAN UNION
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