Activities at INRNE Cyclotron Facility

- Project goals
- Lab specs
- Activities

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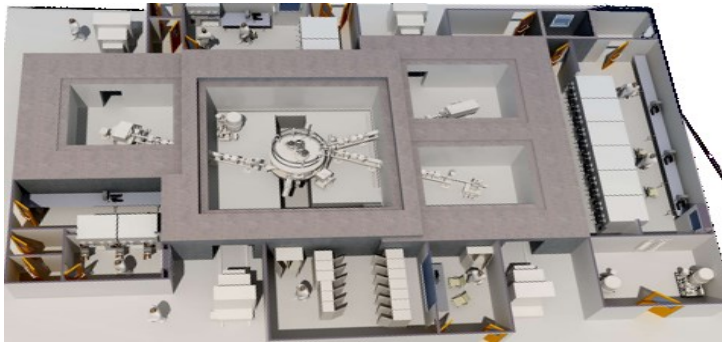
Goals of the project

- Locally produce radiopharmaceuticals in sufficient quantities
  - 18F-FDG imported from Austria and Hungary
  - aim for ^{18}F, ^{124}I, ^{64}Cu, $^{68}Ge/^{68}Ga$ for PET, ^{123}I, ^{111}In, ^{67}Ga, ^{99m}Tc for SPECT
- Short half-life of the radiopharmaceuticals
- Diagnostics of more patients
  - 4 x 2700 if locally producing isotopes
- Increased number of PET/CT and SPECT scanners
  - 2 more scanning centers being build
  - Currently state funding for only 2700 patients/year scanned
- Possibilities for R&D
  - nuclear spectroscopy
  - radiochemistry (^{99m}Tc) & radiobiology
  - archaeometry
  - etc.

Lab specs

- Accelerates negatively charged ions
- Energy range 15-24 MeV
- 400 μA total extracted proton beam current
- Extract 2 beams with different current
- 4 extraction lines (guaranteed 8Ci EOB activity of ^{18}F)

Define the building



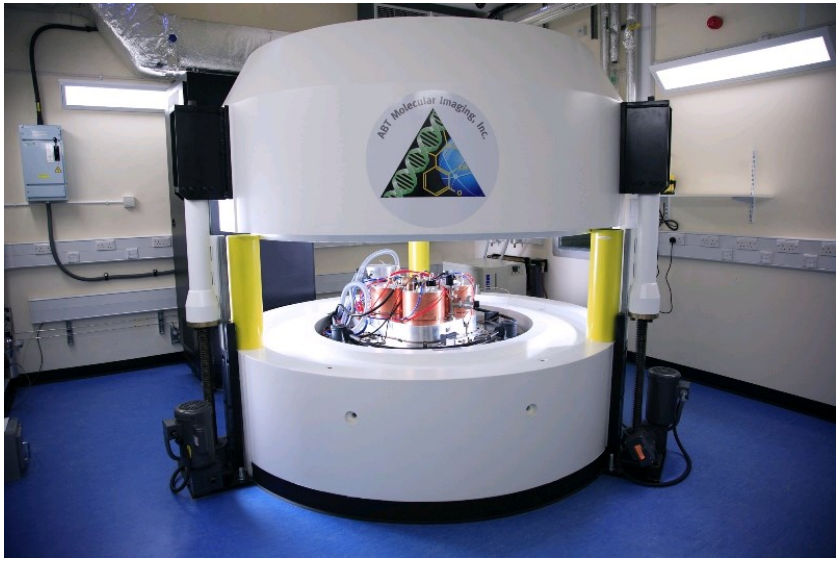
- 3-4 irradiation targets (2-3 for isotopes, 1 for physics)
  - Number of clean rooms
  - How to exhaust the residual air?
  - How to interlock the facility sections?
- Apparatus for PIXE, PIGE, RBS, Positron Spectroscopy, NAA, etc.

Activities

- Ongoing tender discussions
  - waiting for some law-regulated terms
- National Roadmap
  - according to EU regulations
  - like SPIRAL2 and ELI
- Applying for further funding
  - already running project with CIRCE @ IPHC-Strasbourg
  - already running project with University Hospital Varna
- Permissions to run a machine
  - estimated radioactive wastes
  - evaluated once in advance
  - compared to measured every year and 3-5 years

Activities with University Hospital

- 7.5 MeV, 2 μA machine, self-shielded, internal targetry (*ABT Biomarker Generator*)
- chemistry module enclosed
- producing single-doses of ^{18}F-FDP *"Dose on Demand"*
- running max 6h/day in 20 min runs (~20 mCi ^{18}F EOB activity)



- To estimate:
  - activation of components of the target volume
  - activation of surrounding area

In Almaty

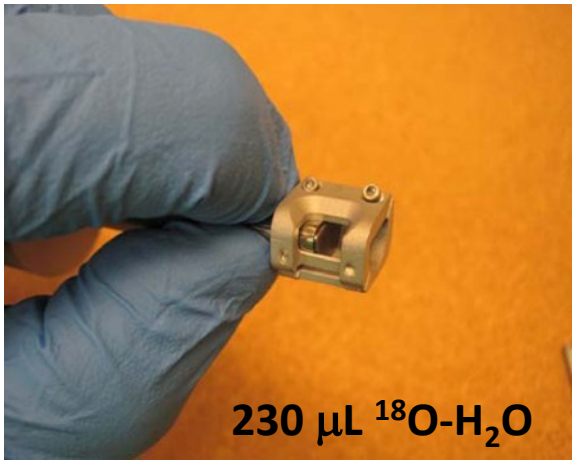
Brick walls?

Varna

Heavy concrete walls/floor/ceiling

with ^{10}B, ^{11}B

Activation of target



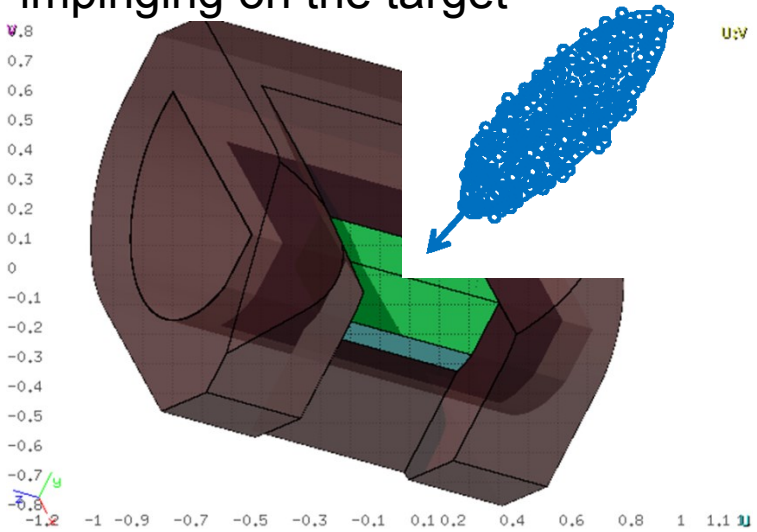
Handled manually each few months!

1. What's the beam energy reaching the ^{18}O-H_2O volume?
2. Is the simulated yield comparable to the produced one?
3. Isotopes in different target components
4. Neutron density out of target

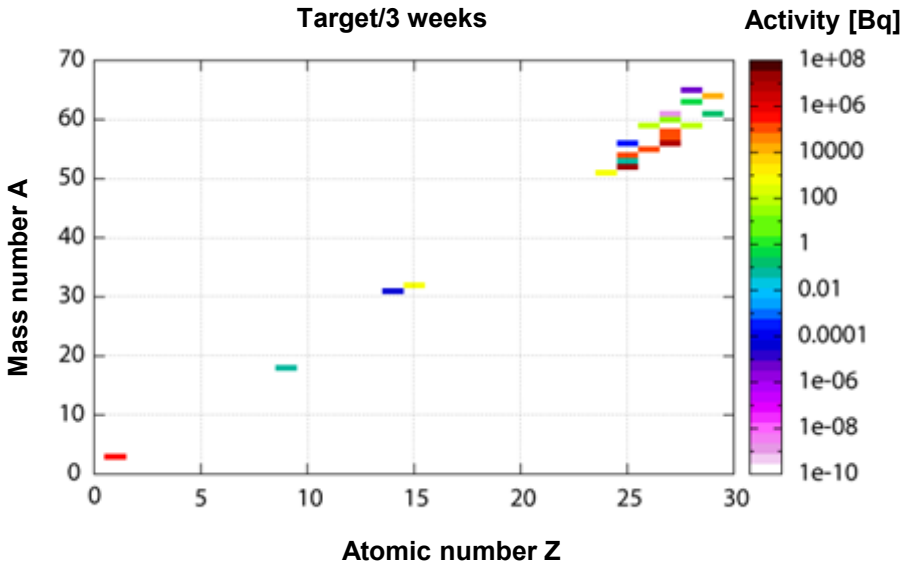
↓

To be used later for machine/vault irradiation

Proton beam (1.23e10 particles/s) impinging on the target

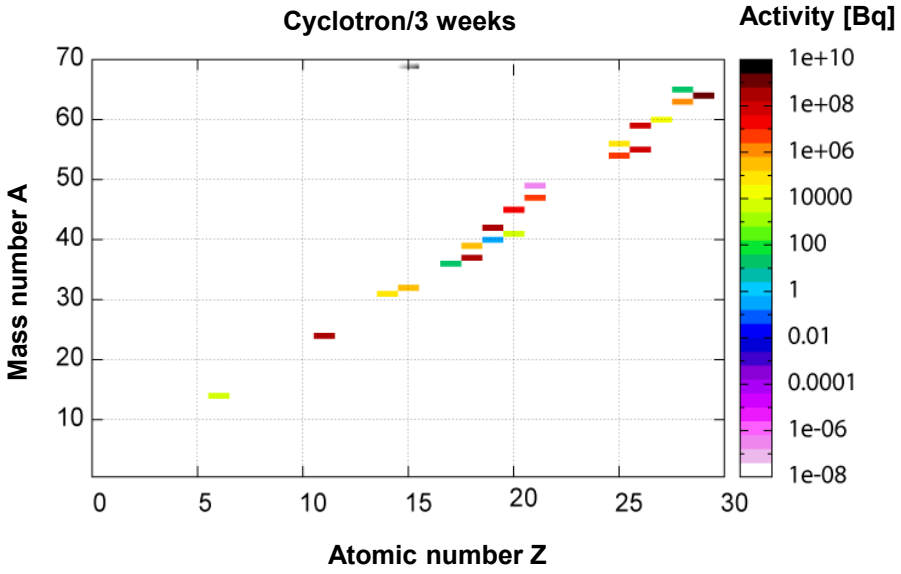


Activation of components



Long lived: Mn-54 (312 d), Co-57 (272 d),
Fe-55 (2.7 a),
Tc-97, Tc-98 (4E6 y)

Some of them seen in gamma spectroscopy done on site or by the producer.



Long lived: Ar-39 (269 a), Fe-55 soil under
Ni-63 (101 a), Fe-55
magnet/center
Ca-41 (1E5 a), Fe-55 in
borated concrete…

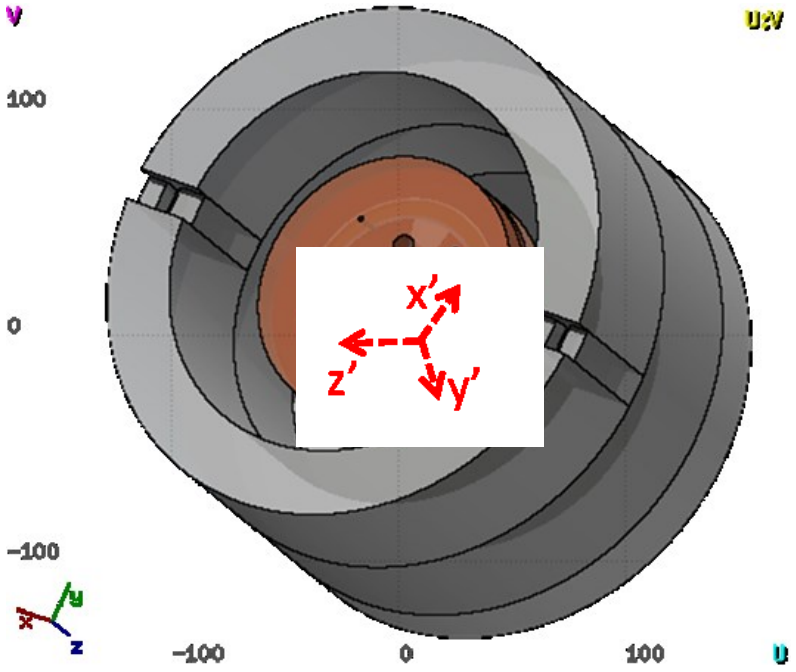
Machine irradiation

Step 1: target irradiation

→ some particle distribution in the frame of reference of the target with center (0., 0., 0.)

Step 2: machine irradiation

→ different center of the coordinate system



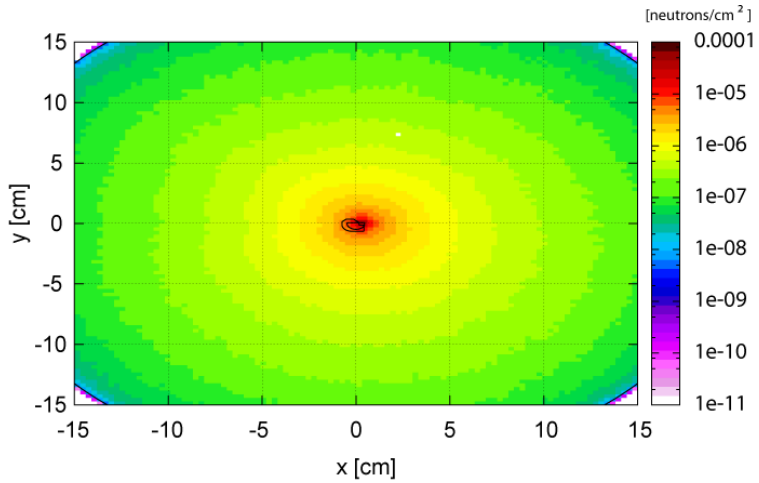
Each particle escaping the target volume needs to be "moved" to the position of the target within the cyclotron volume

i.e. the vector defining its position within the beam has to be translated in the coordinate system of the cyclotron, BUT the vector defining the momentum has to stay unchanged

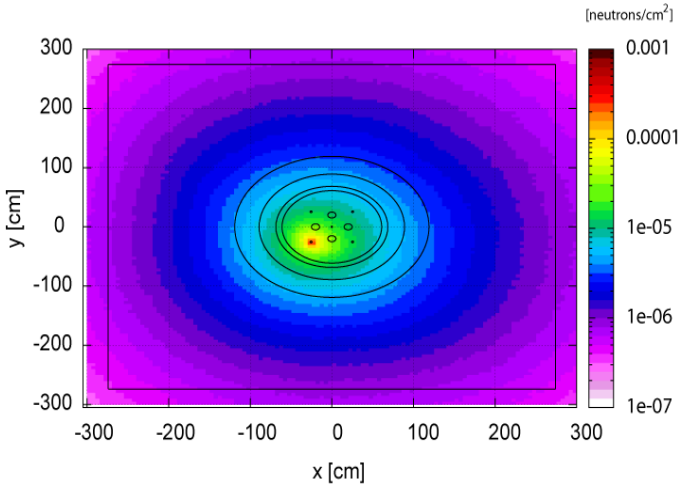
→ mostly neutrons

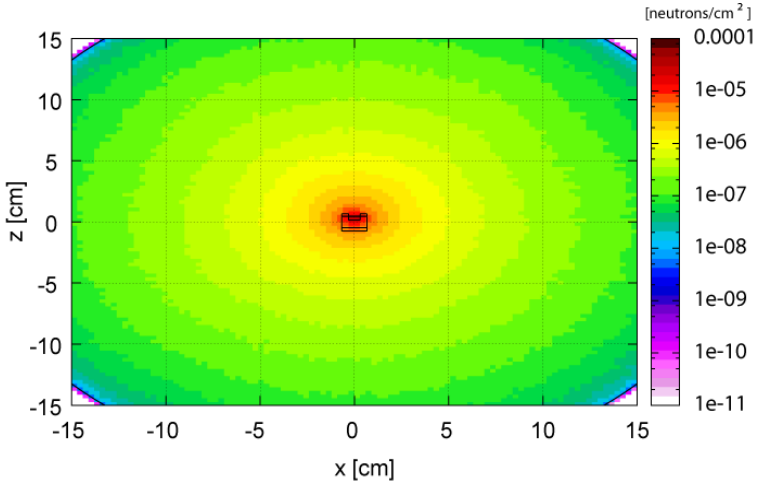
Neutron fluence

To be used for machine irradiation simulations.

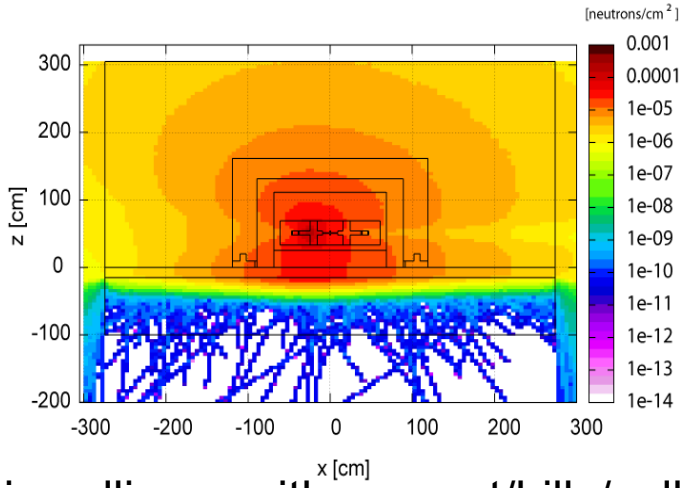


Isotropic distribution





Anisotropic distribution



Axis collinear with magnet/hills/valleys
→ iron → collimating effect

Future steps

- IPHC project related
  - targetry, n-source, shielding
- Funding still critical
- Develop concepts for positron and neutron sources