JÜLICH
FORSCHUNGSZENTRUM

# Development of Medical Radionuclides and Nuclear Data Measurement at the FZJ

**Ingo Spahn**

*Institut für Neurowissenschaften und Medizin (INM-5): Nuklearchemie*
*Forschungszentrum Jülich, D-52425 Jülich, Germany*

1st Research Coordination Meeting on *"Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production"* , Vienna, Austria, 3 – 7 December 2012

# *Forschungszentrum Jülich GmbH*

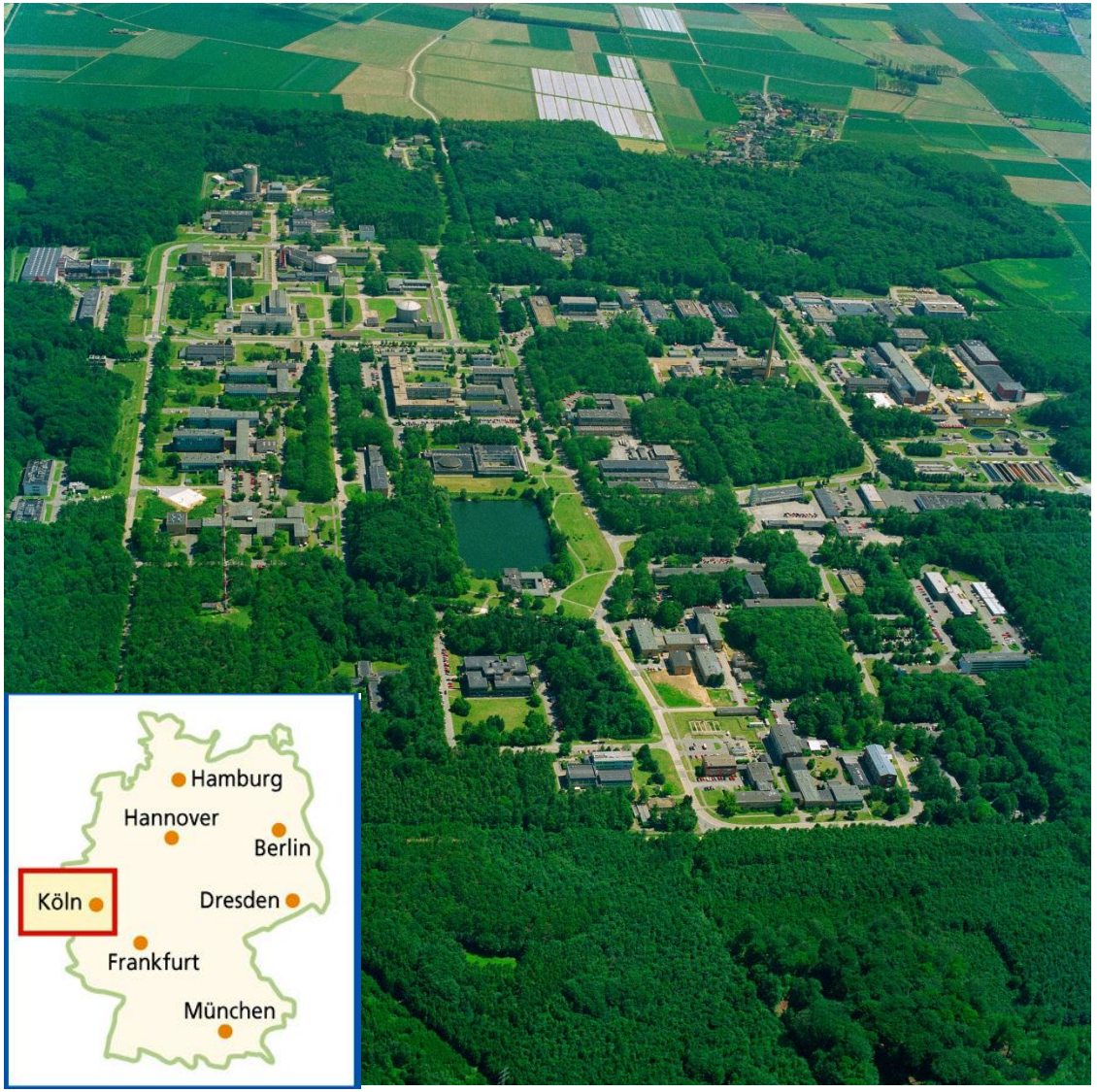
## Mission

*"We work towards comprehensive solutions for the grand challenges facing society in the future in the three fields of …"*

- Health,
- Energy and Environment
- Information Technology

5000 Employees

(1700 scientists)



# The Institute of Neurosciences and Medicine (INM-5): Nuclear Chemistry

## Mission (in catch words)

- Radionuclide development
- Development of radiopharmaceuticals
- Radiopharmaceutical Services
- Education

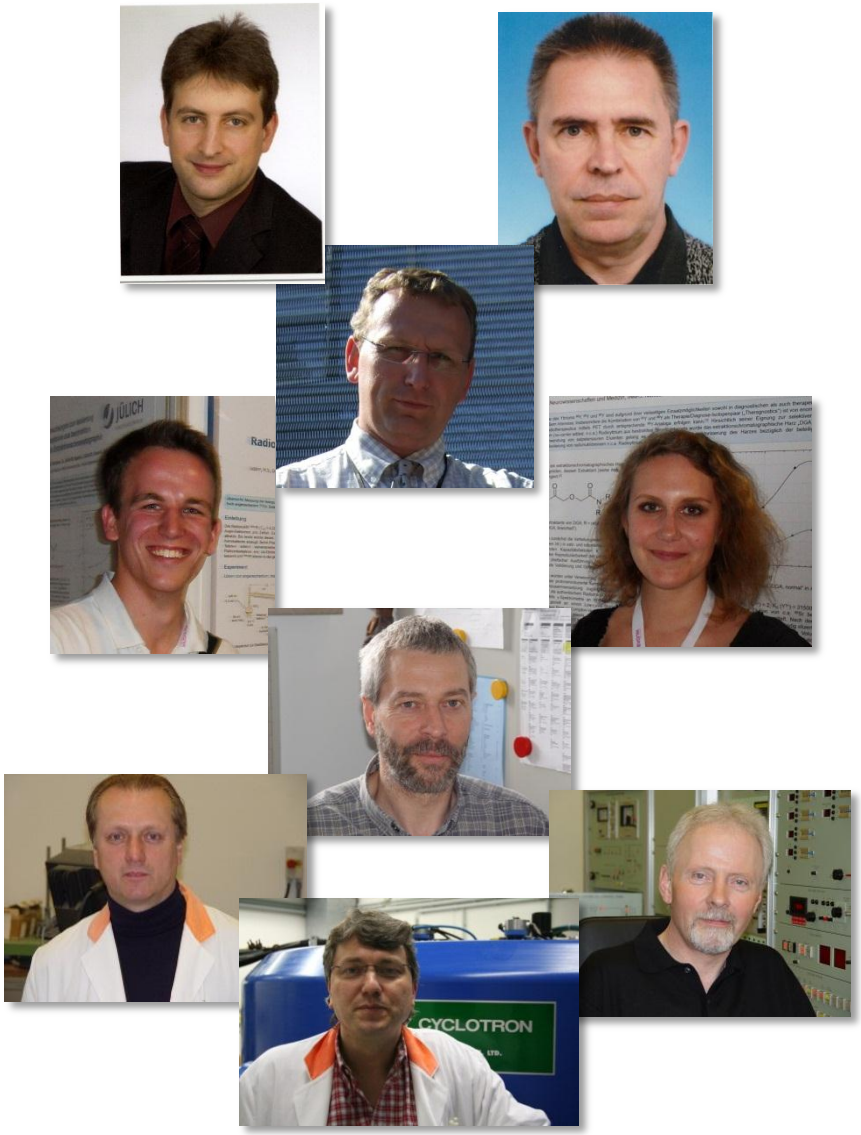
# Radionuclide Development at the INM-5

- Long tradition in radionuclide research.
- Very good reputation for development of radioisotopes for medical diagnosis and therapy as well as for measurement of nuclear data for radionuclide production.
  - ⇨ Pioneer work in the field of routine production of important PET- and SPECT-nuclides like F-18, I-123 and I-124.
- Since 1978 regular partner of the IAEA in CRPs and other projects. Prof. Qaim has been the initiator and leading person in all CRP's

# Development of Radionuclides

The “Radionuclide Group” working on

- Targets and target stations
- Nuclear data measurements
- Sample preparation
- Radiochemical separation procedures



# Research Personnel Involved in the Project

| | | |
|---|---|---|
| Ingo Spahn | - | Development of medical radionuclides |
| | | & |
| Bernhard Scholten | - | Investigation of charged particle monitor reactions |

| | | |
|---|---|---|
| Sebastian Kuhn | - | Investigation on the production of positron emitting radionuclides of scandium and titanium |
| Katharina Breunig | - | Studies on the production of radioisotopes of bromine and development of radiobrominated adenosine receptor ligands |

## Academic advisors

Prof. Dr. H.H. Coenen

Prof. Dr. Dr. h.c. mult. S. M. Qaim

# Accelerators for Radionuclide Development

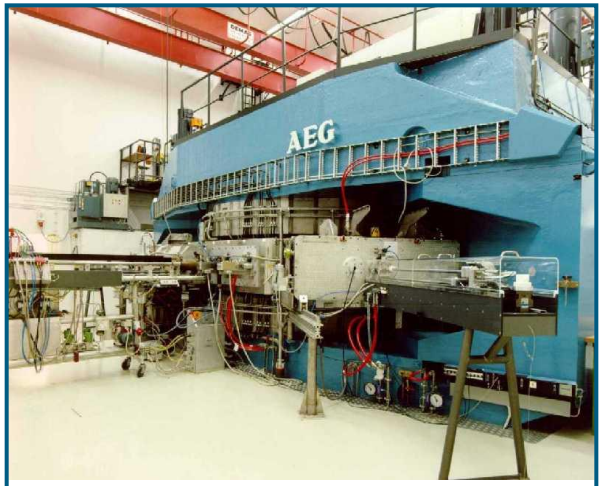
Compact Cyclotron
CV 28

Decommissioned and transferred to the KIPT in Ukraine

Baby Cyclotron
BC 1710

17 MeV $H^+$

(8 – 10 MeV $^2H^+$)

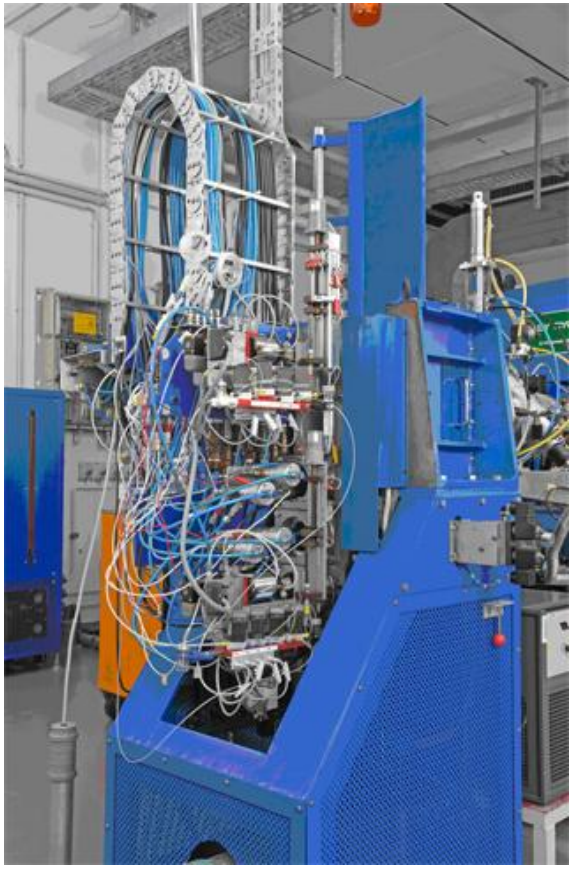



JULIC
Injector for COSY

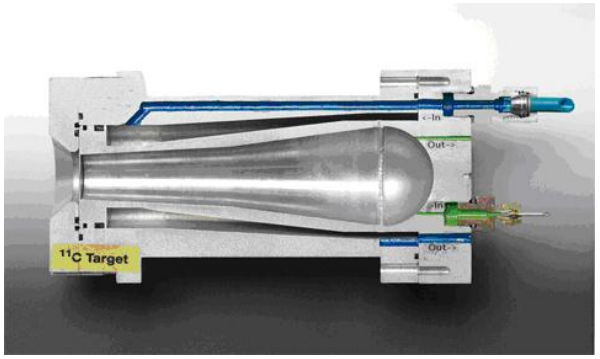
45 MeV $^1H^-$

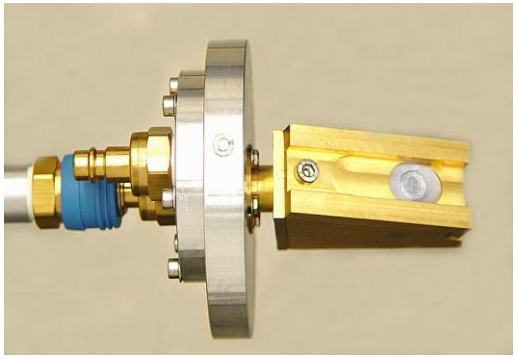
76 MeV $^2H^-$

# Radionuclide Development at the BC 1710



- Single beam-line with multi target station
- Irradiation of solid, liquid and gas targets
- Custom-built target holders and collimator for data measurements



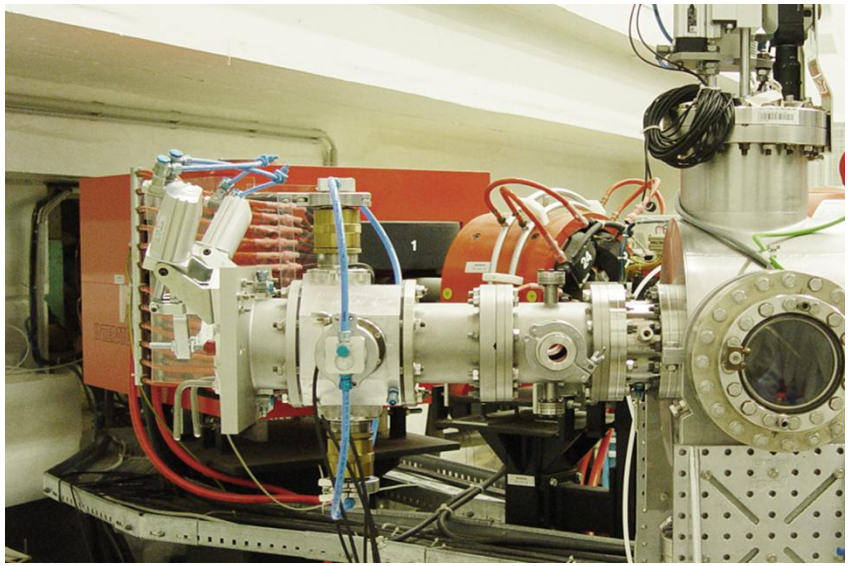



New solid target station for data measurements of non-standard PET nuclides and therapeutic radioisotopes was designed and constructed

# Irradiation at Injector of COSY (JULIC)

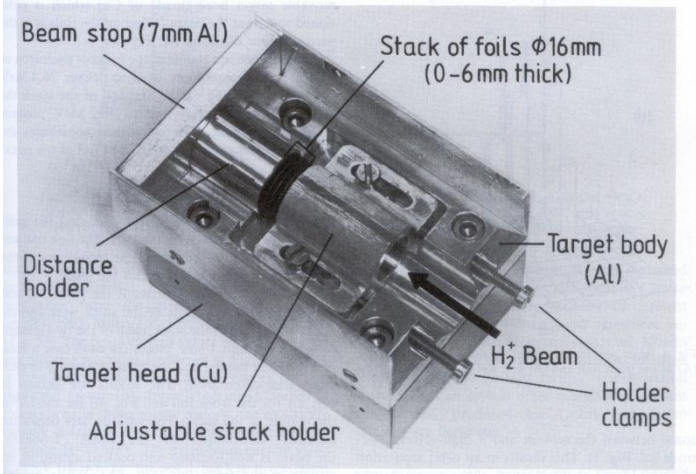
## External target station

- Adapter with water cooled 4 sector collimators
- Existing target systems for CV28 adapted to external beam line (stacked-foil target, gas-target, slanting target, etc.).



## Internal target system

- Water cooled stack holder
- Target-to-beam setup (no beam switching)
- Irradiation of thermally stable materials



# Nuclear Chemistry Facilities

**“hot chemistry” laboratories**

- Two hot zones of about 1500 $m^2$
- Radiochemical laboratories for handling of numerous radionuclides up to $10^7$-fold of permitted limit
- “Hot” mechanical and electrical workshops
- Equipment for performing inorganic and organic wet chemistry as well as gas phase chemistry

**Routinely applied radiochemical operations include**

- Dry distillation
- Ion-chromatography
- Solvent extraction
- Electroplating

# Analytical Equipment at the INM-5

**Chemical analysis**

- UV/VIS spectrometry
- Mass spectrometry
- Ion-chromatography
- NMR
- Microscopy and gravimetry

**Radioactivity measurement**

- Multiple HPGe-detectors
- Low-level $\gamma$-ray counting
- Low-level $\gamma\gamma$-coincidence
- X-ray counting
- “Instant Imager”

# Scientific Infrastructure at the FZJ

- Central Division for Chemical Analysis (ZCH)
- Central workshops
- Divisions for radiation safety and waste management
- Partner institutes with related research focus (lanthanide/actinide chemistry, material science)

# Proposed Project: Investigation of the PET-Isotopes $^{66}$Ga and $^{68}$Ga

Interesting positron emitters for medical diagnosis

| | Half-life | Positron energy |
|---|---|---|
| $^{66}$Ga | 9.49 h | 4.153 MeV |
| $^{68}$Ga | 67.63 min | 1.899 MeV |

- Cross section measurements using different projectiles and target materials
- Pure radiochemical separation of produced radiogallium (Shehata et al. J. Radioanal. Nucl. Chem. (2011) 288:887–893.)
- Preparation of thin samples for X-ray measurement
  - High-precision activity measurement preferably in co-operation with partner

# Investigation of the new PET-Isotopes $^{45}$Ti and $^{44}$Sc

New positron emitters for medical diagnosis

| | Half-life | Positron energy |
|---|---|---|
| $^{44m}$Sc | 58.6 h | -- |
| $^{44g}$Sc | 3.93 h | 1.474 MeV |
| $^{45}$Ti | 184.8 min | 1.040 MeV |

- Cross section measurements and determination of integral yields
- Pure radiochemical separation of produced radiogallium
- Preparation of thin samples for X-ray measurement
  - High-precision activity measurement preferably in co-operation with partner

# The “Novel” Positron Emitter $^{76}$Br

Longer-lived positron emitter with high chemical potential

| | Half-life | Positron energy |
|---|---|---|
| $^{76}$Br | 16.2 h | 3.382 MeV |

- Cross section measurements and determination of integral yields (Spahn et al., Radiochim. Acta **97**, 535–541 (2009).)
- Pure radiochemical separation of the product (Shehata et al., Radiochim. Acta **100**, 1–8 (2012).)
- Preparation of thin samples for X-ray measurement
  - High-precision activity measurement preferably in co-operation with partner

# Investigation of the PET-radionuclide $^{86}Y$

Interesting alternative to the SPECT-nuclide $^{90}Y$

| | Half-life | Positron energy |
|---|---|---|
| $^{86}Y$ | 14.7 h | 1.221 MeV |

- Cross section measurements and determination of integral yields; irradiation of enriched target material
  (Kettern et al., Radiochim. Acta (2002), 90(12), 845-849.)
- Pure radiochemical separation of the product
  (Kandil et al., J. Radioanal. Nucl. Chem. **279** (2009) 823–832.)
- Preparation of thin samples for measurement

# The new *IBA Cyclone 30XP*


Beam current up to 350 μA
(50 μA for α-beam)

Protons: 15 – 30 MeV

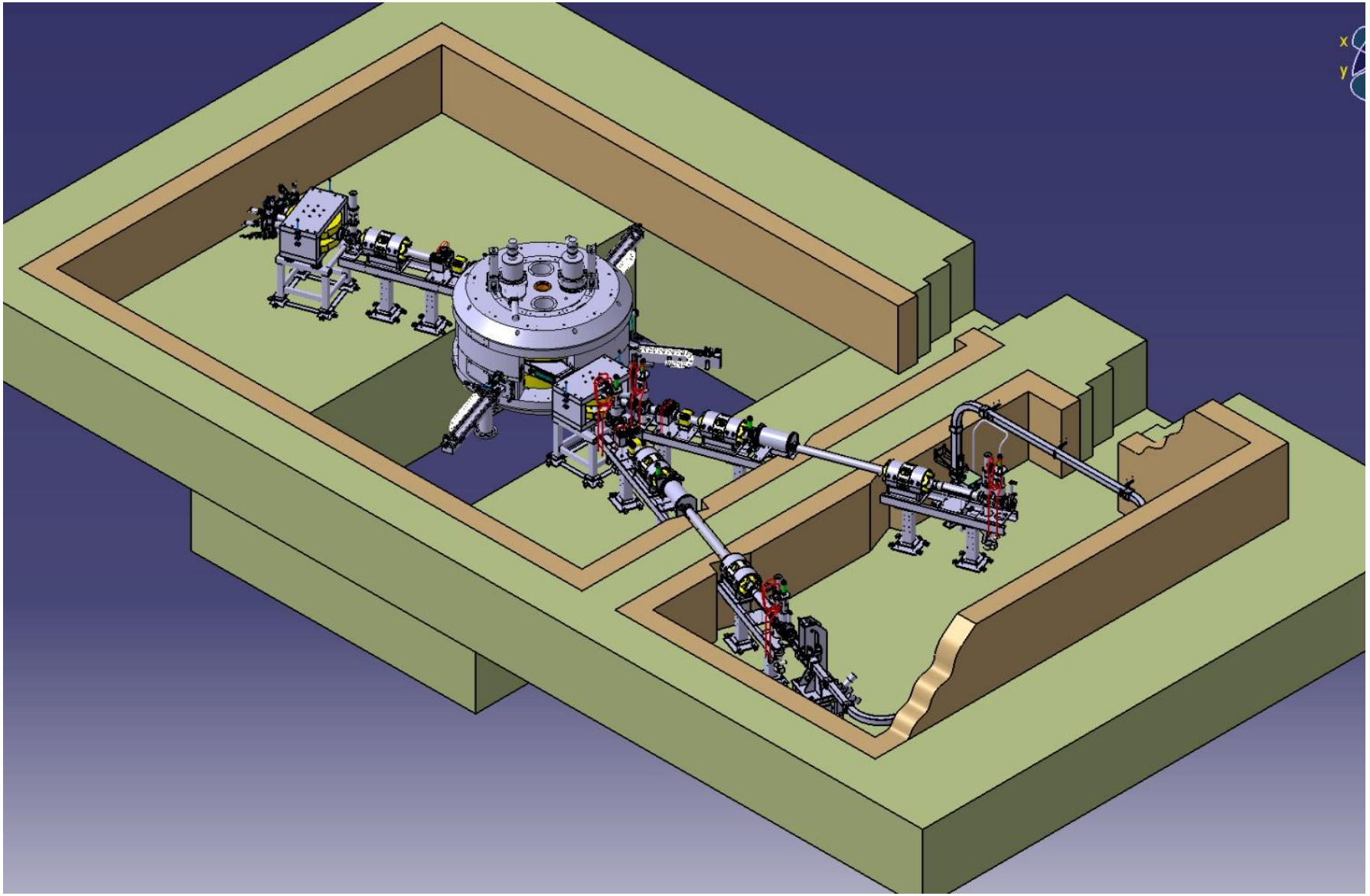
Deuterons: 7 – 15 MeV

α-particles: 30 MeV

⇨ Replacement of the cyclotrons CV 28 und BC 1710

⇨ Improvement of existing irradiation capacities

# Sketch of Cyclotron Vault and Target Stations



# Summary of Research Potential

- Preparation of targets for irradiation
- Irradiations with low energy protons (BC 1710) and intermediate energy deuterons and protons (JULIC)
- Radiochemical isolation und purification of radionuclides for in-house or external measurements

⇨ Positron emission probabilities and nuclear cross section determination

⇨ Determination of integral yields and TTY

⇨ Nuclear data evaluation in co-operation with international partners