Neutronics experiments for validation of activation and neutron transport data for fusion application at the DT neutron generator of TU Dresden

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Outline

- Brief comments on history of the lab
- Context of the fusion-related experiments
- Recent blanket mock-up experiments
- Experiments for validation of activation cross sections

- New neutron laboratory of TUD was constructed in the early 2000s
- Successor of the neutron laboratory of TUD located in the city of Pirna-Copitz
- Neutron generator: DD operation since 2004,
  DT operation since 2005

Current utilization:

- ➔ For activation experiments relevant for double-beta decay (see A. Domula: HK 55.4, Thursday HG VI)
- ➔ Validation experiments for activation data libraries (EAF-2007, others) and neutron transport data libraries (JEFF, FENDL) in the frame of the European fusion program (EFDA / Fusion for Energy) (this talk)

Objective of the HCPB/HCLL neutronics mockup experiments

Important nuclear parameters for fusion reactor blankets

- Tritium production rate / Tritium breeding ratio
- Nuclear heating
- Shielding capabilities
- Material activation
- Gas production
- others

Neutronics calculations based on nuclear data libraries → Input for the physical design of the blanket (with iterations) →
- Physical design
- System operation
- Licensing
- Maintenance
- Decommissioning
- others

Data libraries require validation

→ **mock-ups irradiated in well-characterized DT neutron fields**

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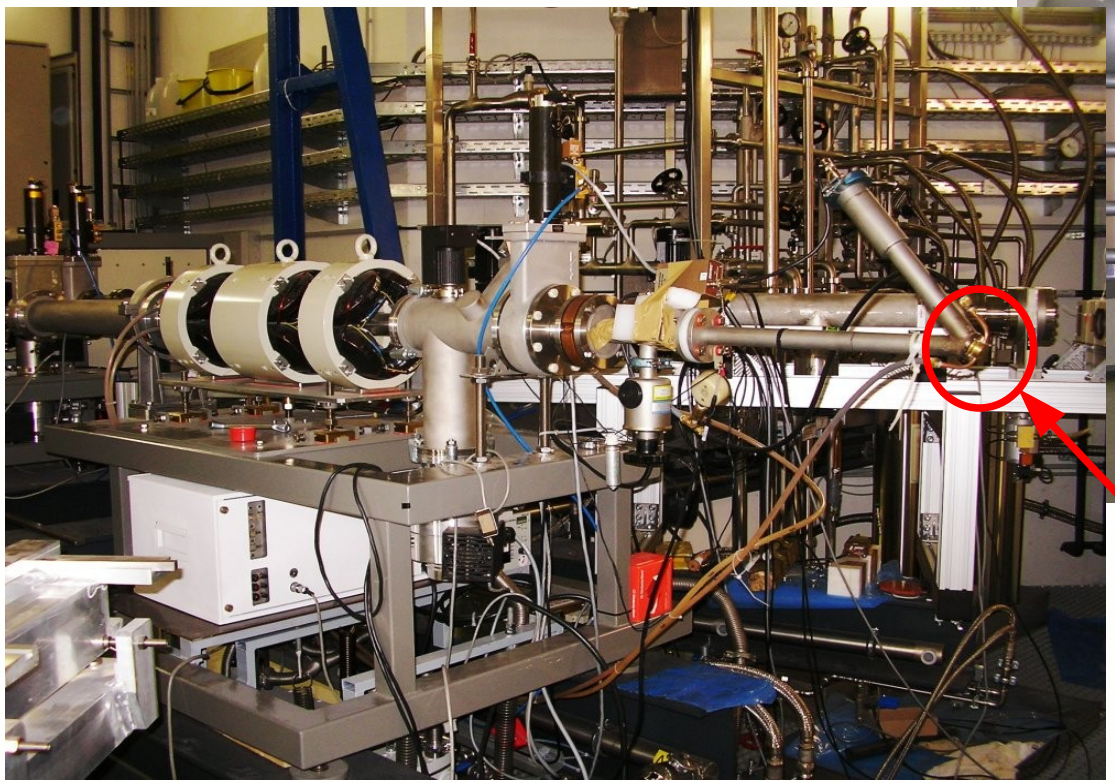
Neutron Generator TU Dresden

Accelerator: 300 kV, 10 mA

- up to 10^{12} n / s
- continuous or pulsed operation
- fixed and rotating T-Target



Targets:

Tritium: 3, 30, 250 Ci
Deuterium

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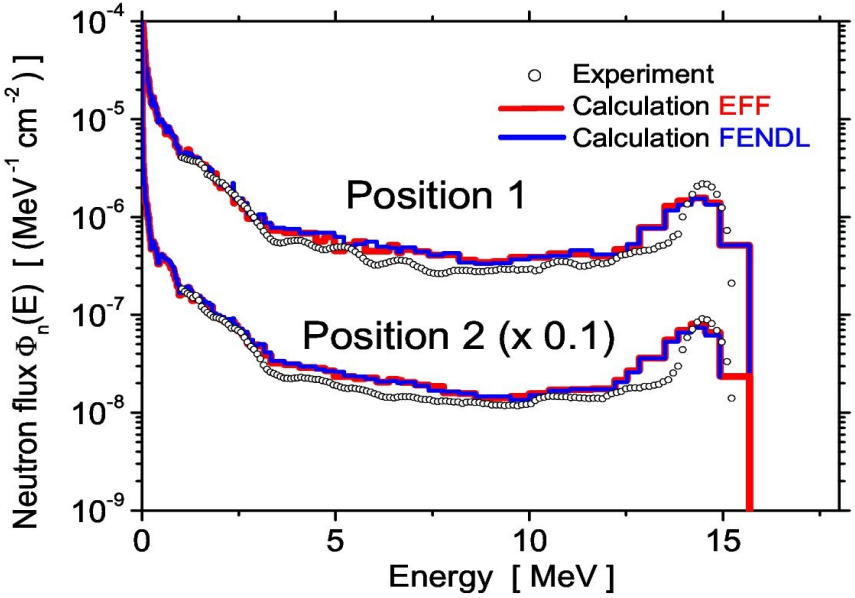
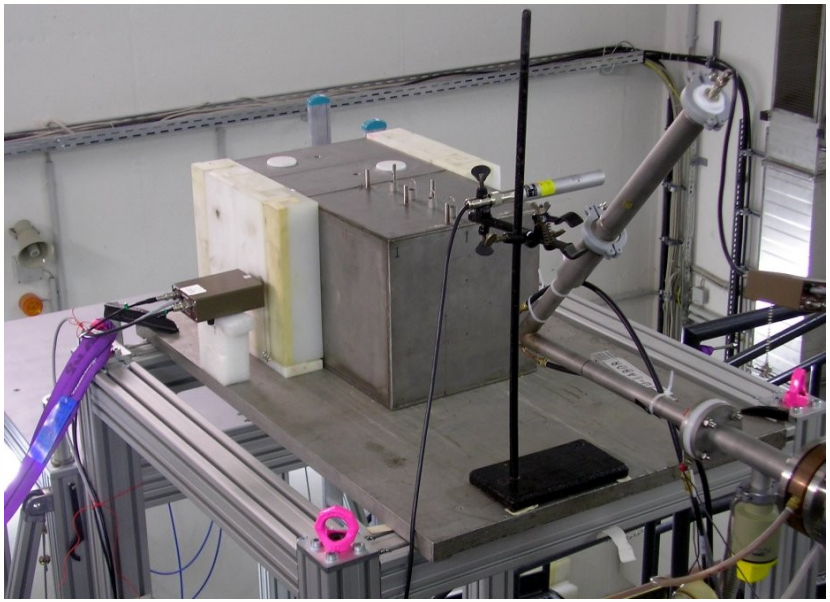
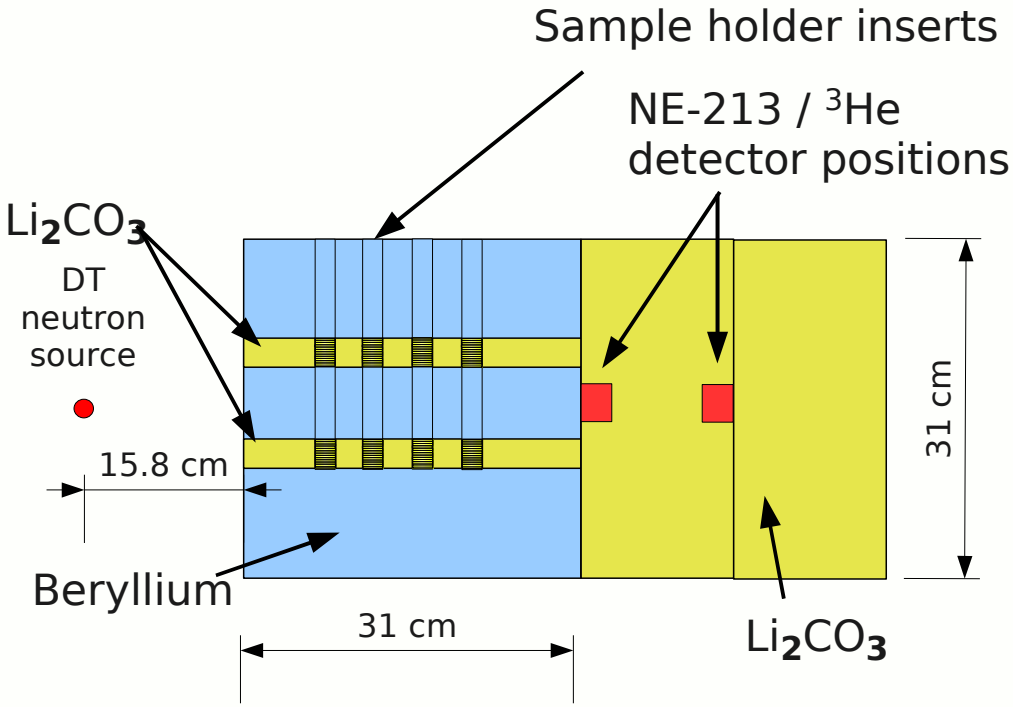
HCPB TBM mock-up experiment



Collaboration with
ENEA Frascati, FZ Karlsruhe,
TU Dresden, FNS/JAEA





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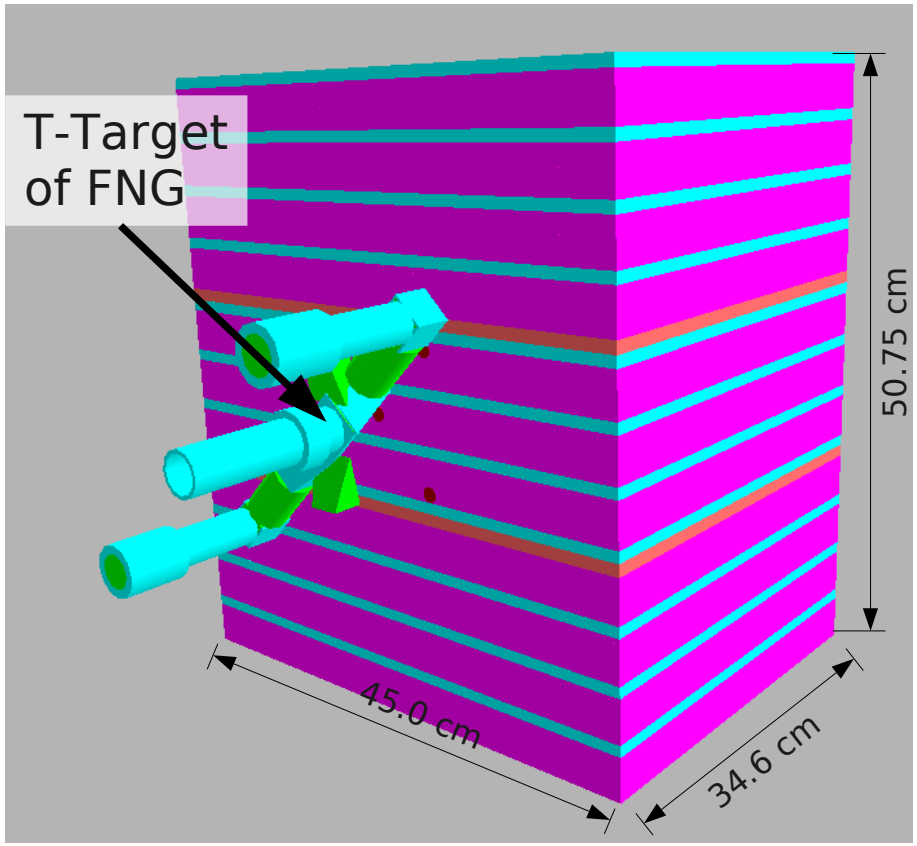
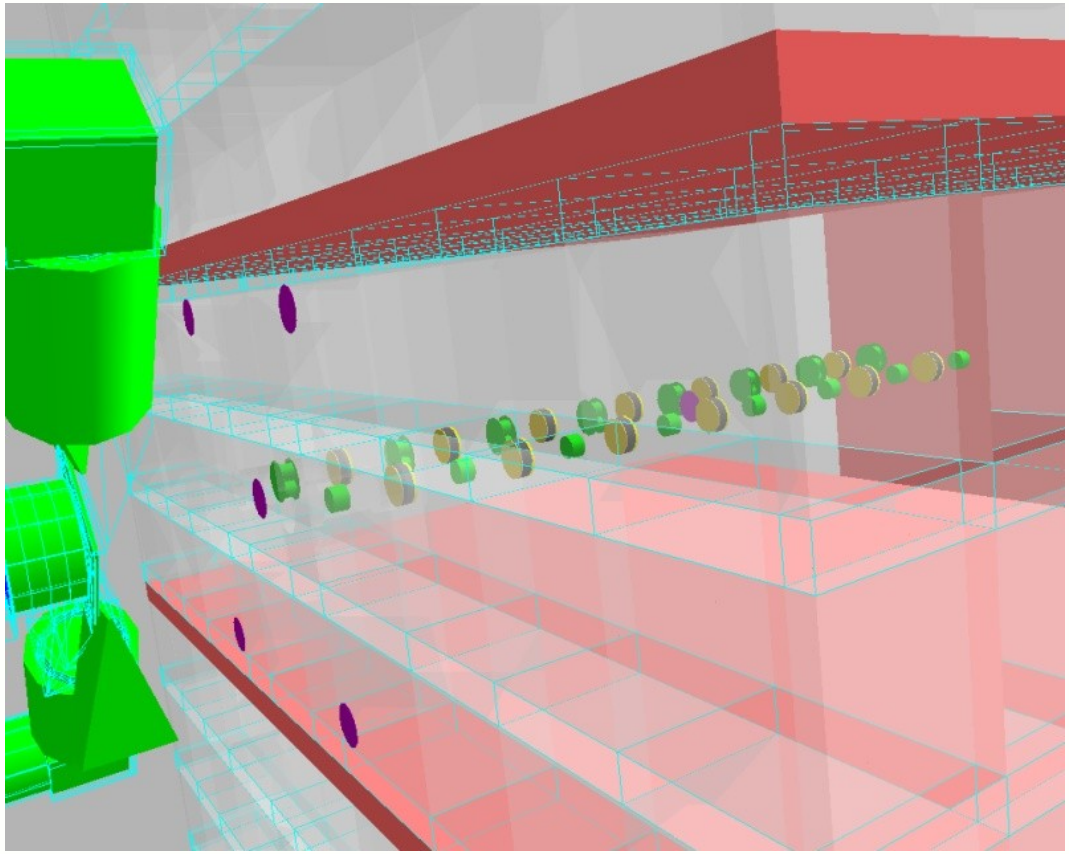
HCLL TBM mock-up experiment
Tritium production rate





Mock-up consists of layers of LiPb, Eurofer and polyethylene
Detectors placed along the axis of the mock-up

MCNP model: Detailed description of the neutron source and the detectors (Li_2CO_3 pellets and all LiF-TLD)

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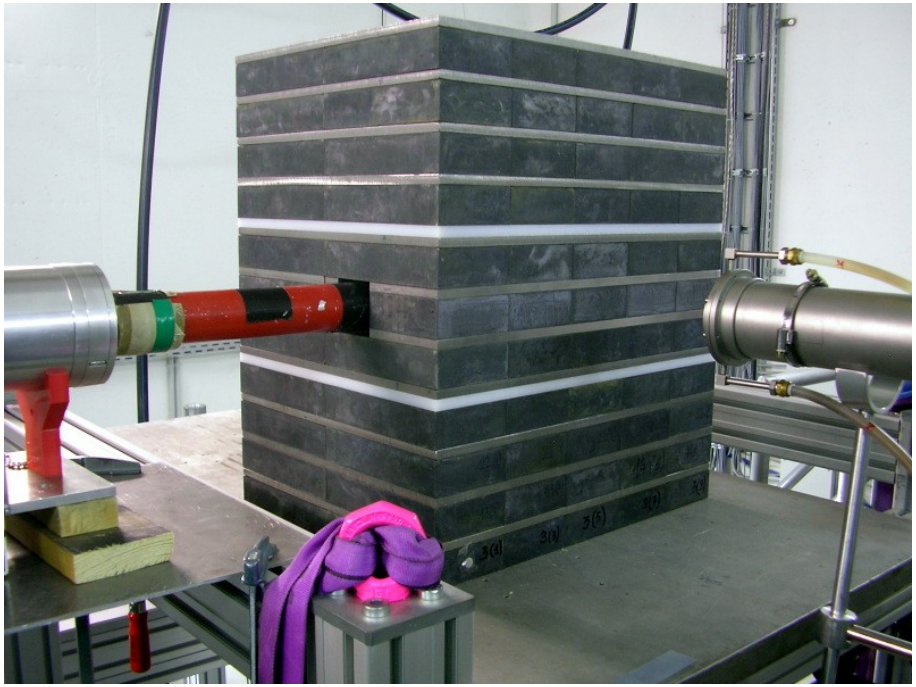
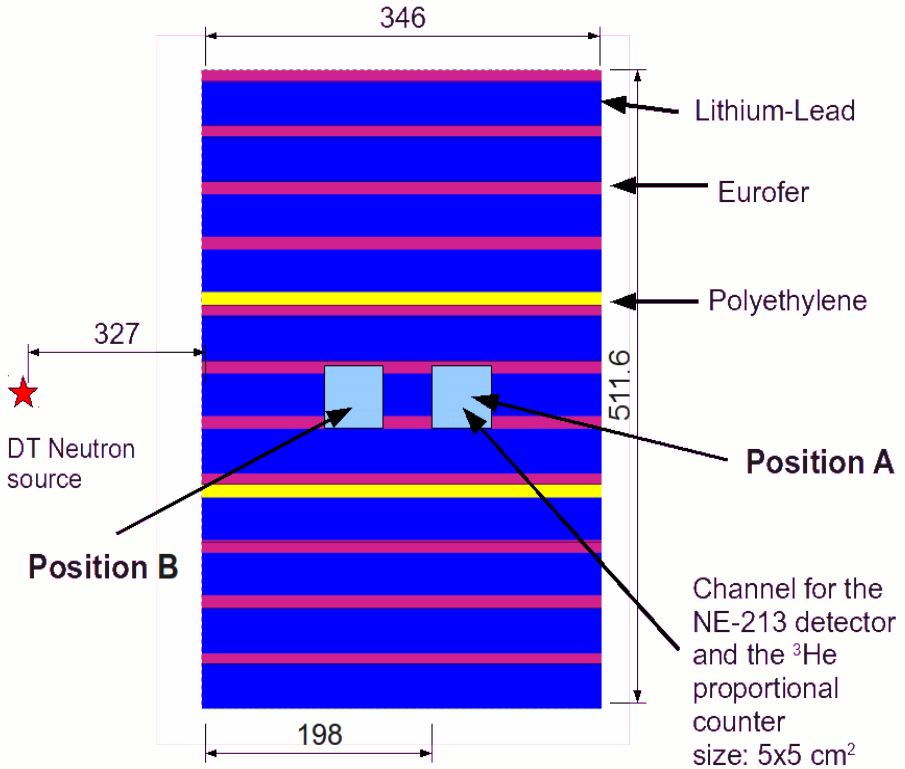
HCLL mock-up experiment:
Set-up for the measurement of fast neutron and gamma-ray fluxes





Left: NE-213 detector (1.5"x1.5 ")
Right: Ti-T target of neutron generator
Middle: Mock-up

Two measurement position have been used. Only one channel was present at a time.

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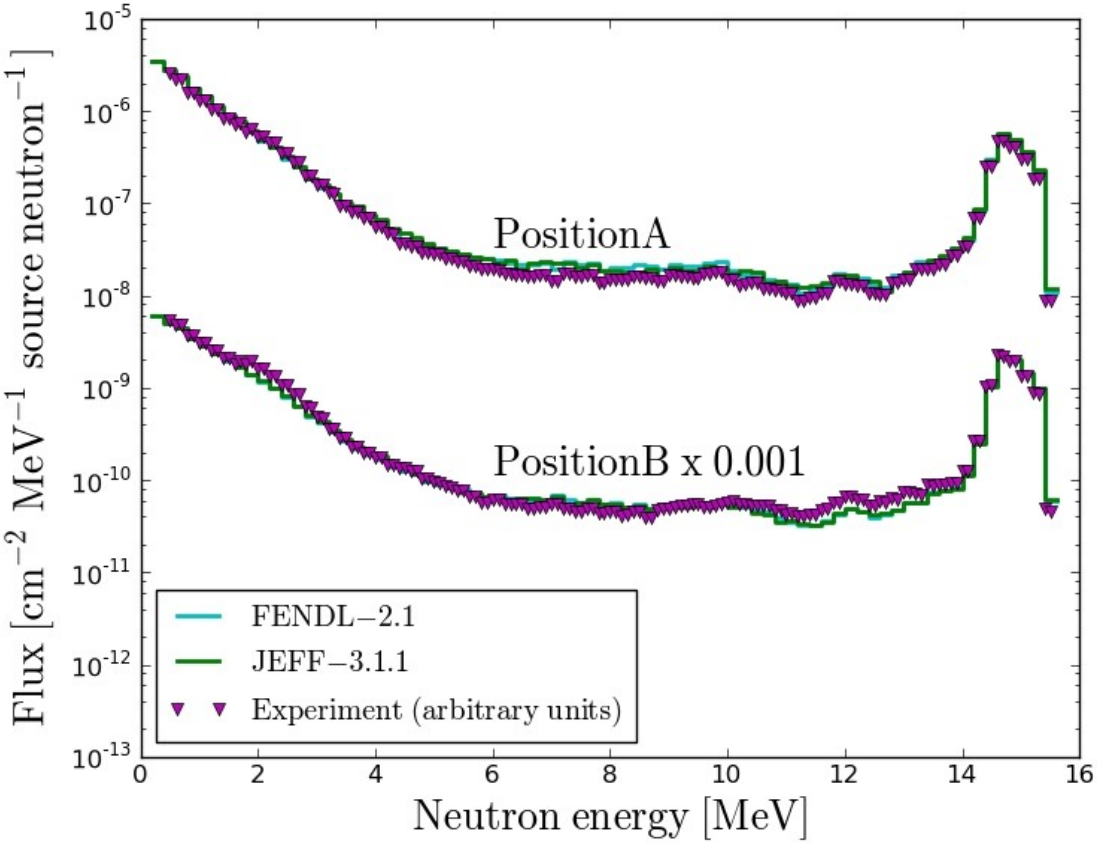
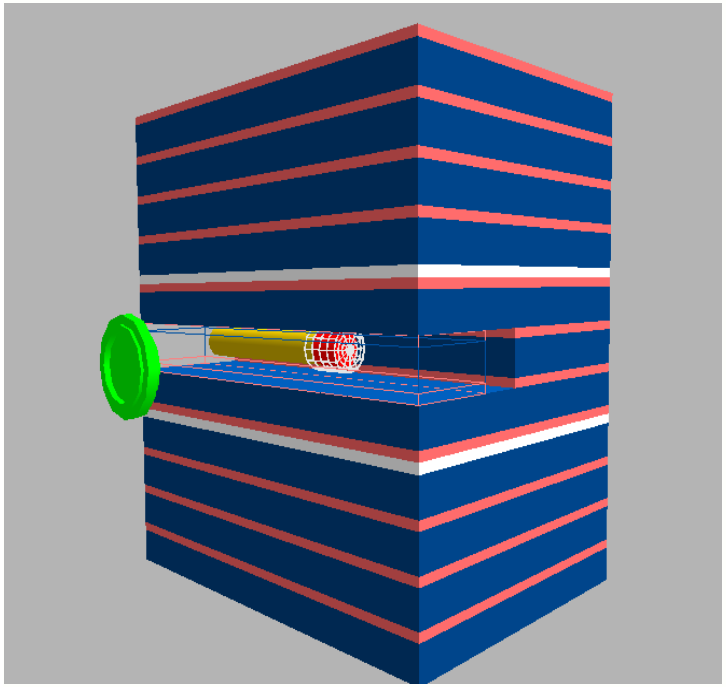
HCLL TBM mock-up experiment
Fast neutron flux spectra





Pulse height spectra recorded with the NE-213 detector
Unfolding with MAXED code, response matrix (validated at PTB)
Calculations with MCNP5 and JEFF-3.1.1 and FENDL-2.1
Normalization of unfolded spectra by fitting 14 MeV peak height

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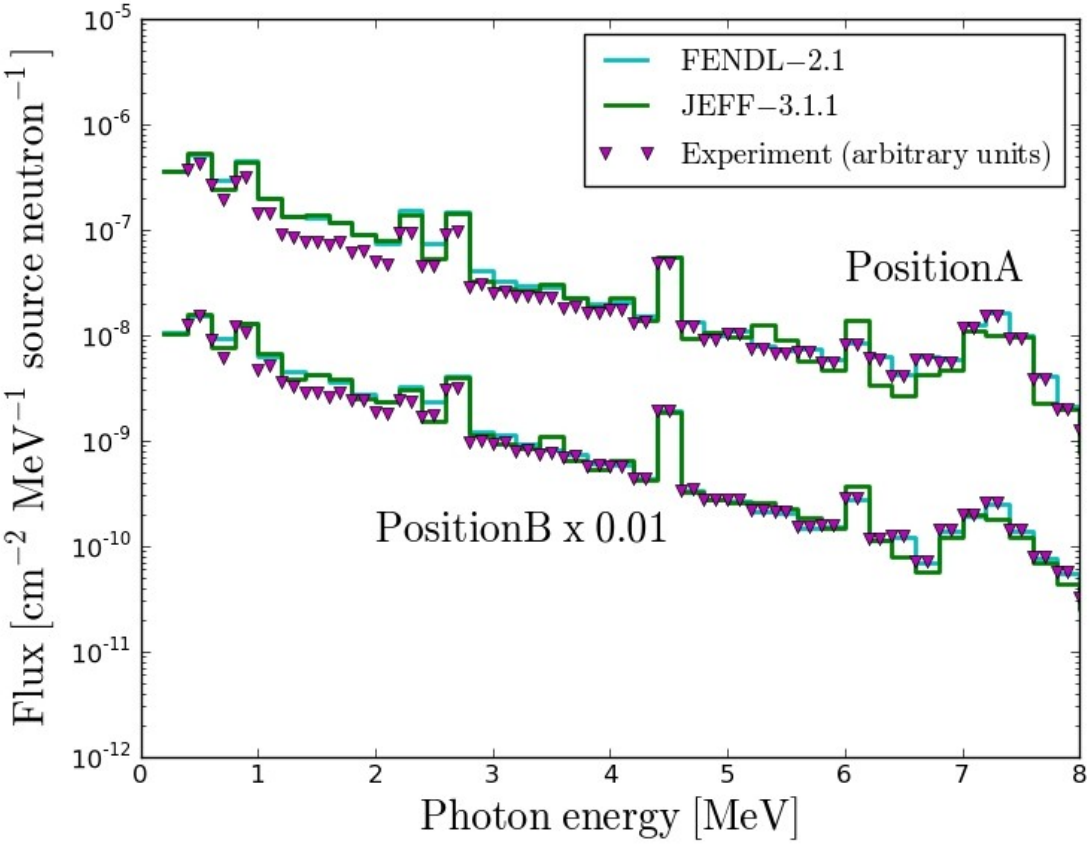
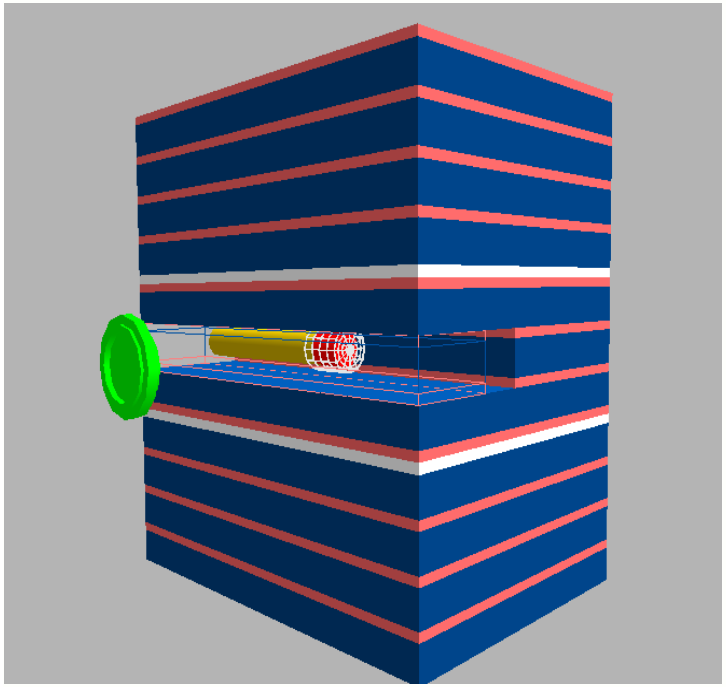
HCLL TBM mock-up experiment
Gamma-ray flux spectra





Pulse height spectra recorded with the NE-213 detector
Unfolding with MAXED code and response matrix
Calculations with MCNP5 and JEFF-3.1.1 and FENDL-2.1
Normalization from neutron spectrum

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Activation experiments for validation of EAF data
Here: Titanium

- Activation behavior of fusion reactor materials central topic for safety-related issues and decommissioning
- Most induced activation from slow neutrons (cross sections large) and fast neutrons (many open reaction channels)
- Assessment of induced activities usually based on inventory codes and activation data libraries

This work:

➔ Activation of **titanium** with **DT neutrons** and comparison with calculated values from **EASY-2007** (FISPACT and EAF-2007) for the isotopes contributing most to the contact dose rate

➔ Titanium contained in several materials in the blanket, for example Li_2TiO_3

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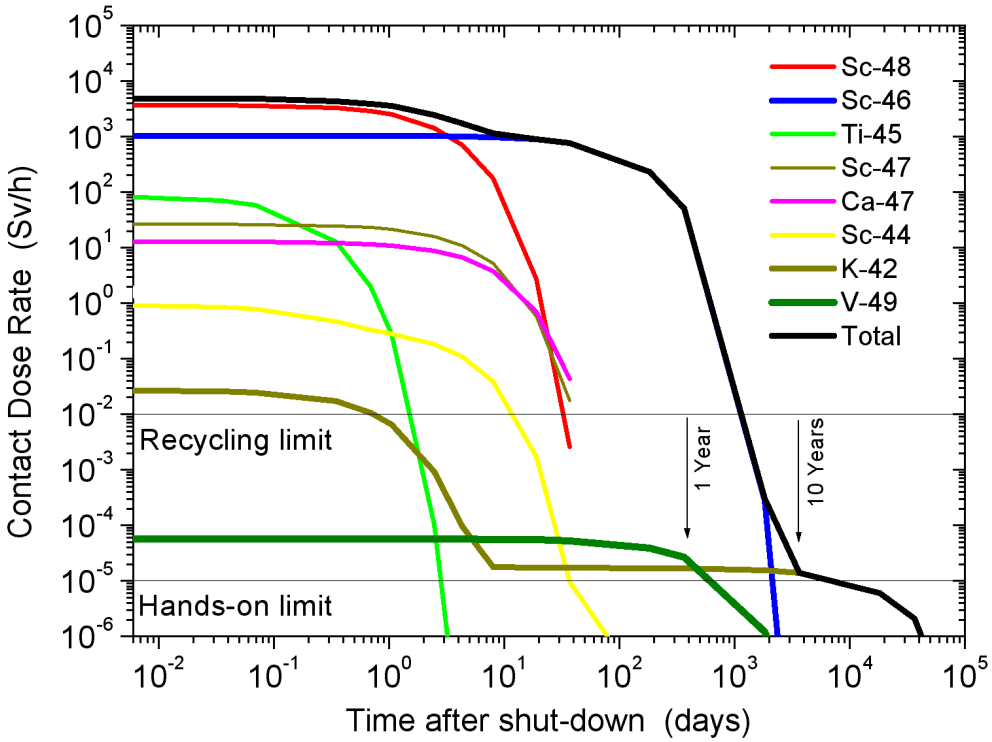
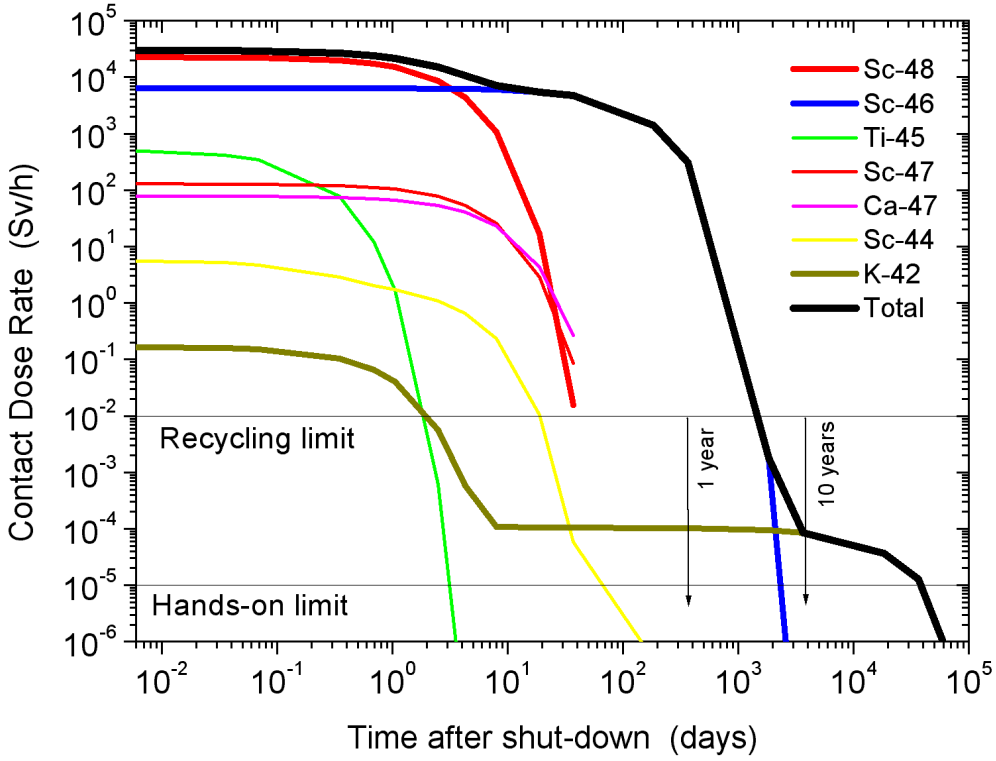
Activation experiments for validation of EAF data
Activation of Ti in reactor environment

- Calculation with FISPACT-2007 and EAF-2007
- Assuming 1 year of irradiation with 1 MW/m^2 wall load (primary neutrons)





Li_2TiO_3
important isotopes ^{48}Sc, ^{46}Sc, ^{42}K
recycling limit after about 3.2 yr
hands-on-limit after about 17.7 yr

Titanium only
important isotopes ^{48}Sc, ^{46}Sc, ^{42}K
recycling limit after about 4.4 yr
hands-on-limit after about 109 yr

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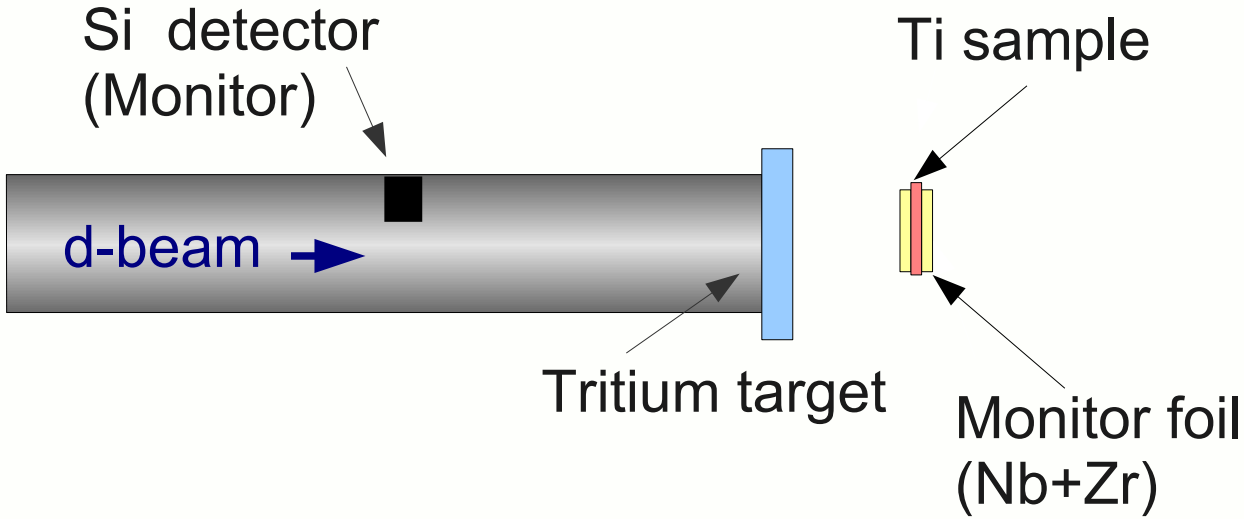
Activation experiments for validation of EAF data
Experimental conditions

Irradiation of Ti sample in fusion peak field of DT generator

Sample size:	1 cm^2 x 0.5 mm thick
Irradiation time:	**2.46 hrs**, fluence **$5.41*10^{11}$ n/cm^2**
Measurement:	γ-ray spectra at several times after irradiation with HPGe spectrometer

Set-up

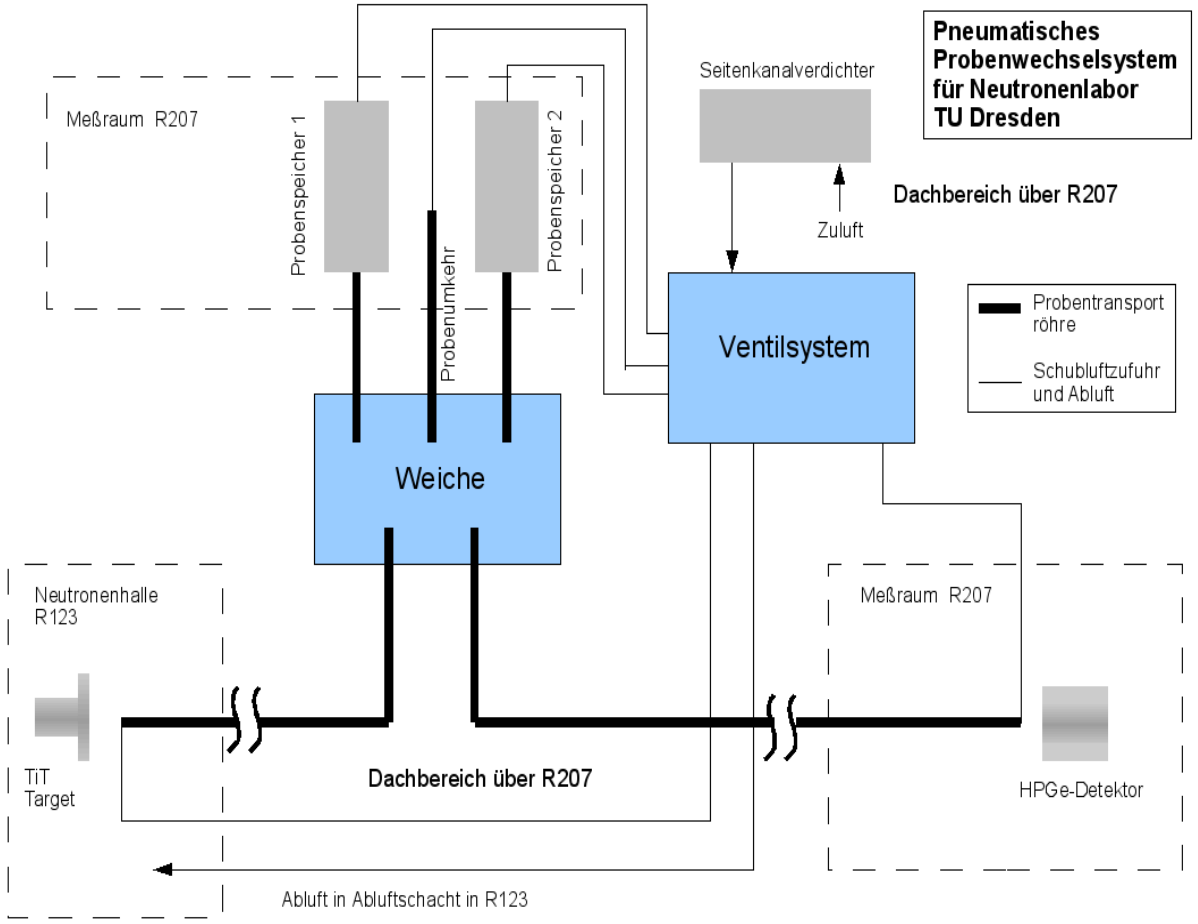


Preparation for experiments with Neutronics TBM in ITER

Detector development and testing

Neutron flux by dosimetry reactions

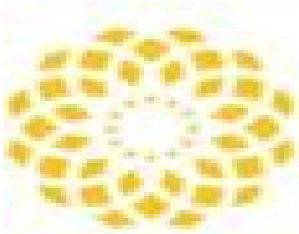
- selection of suitable sets of foils (short and long irradiation time)
- testing of gamma activation measurement regime
- practical demonstration of automated system



Status

- system is currently set up at TUD-NG
- investigation of suitable foil sets for different measurement regimes (i.e. 10..30 sec, entire pulse, several pulses) underway

Thank you very much for your attention!



FUSION FOR ENERGY

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