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HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Technische Universität Dresden

Fusion neutronics experiments with the intense DT neutron generator of TU Dresden

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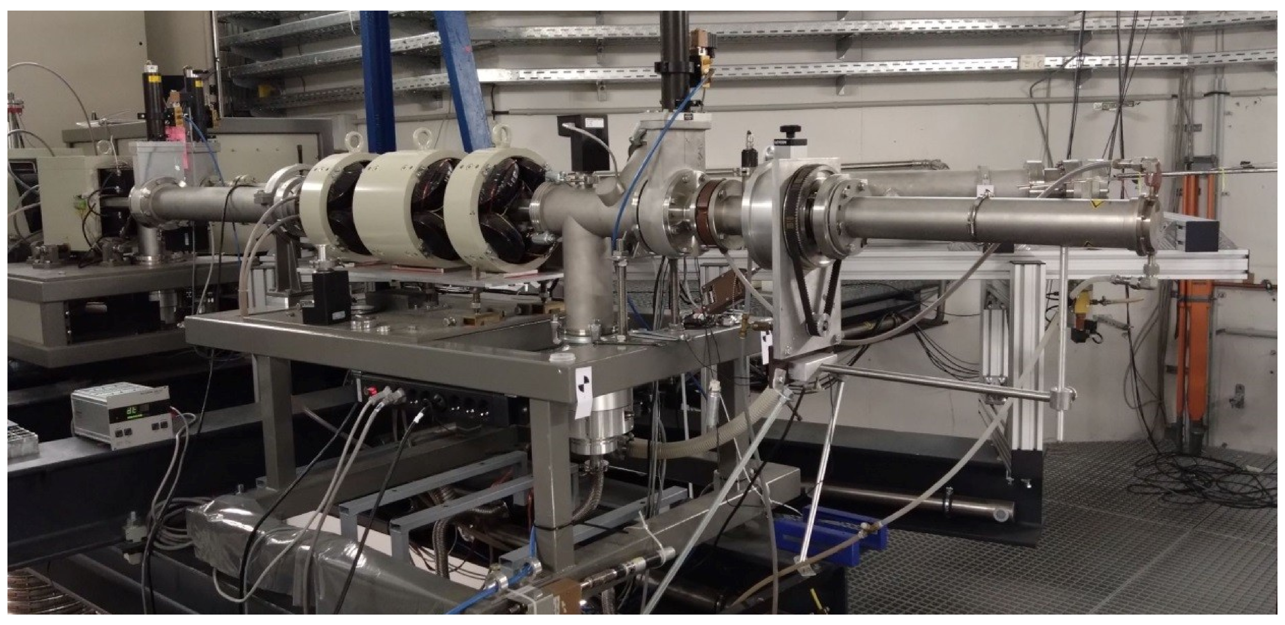
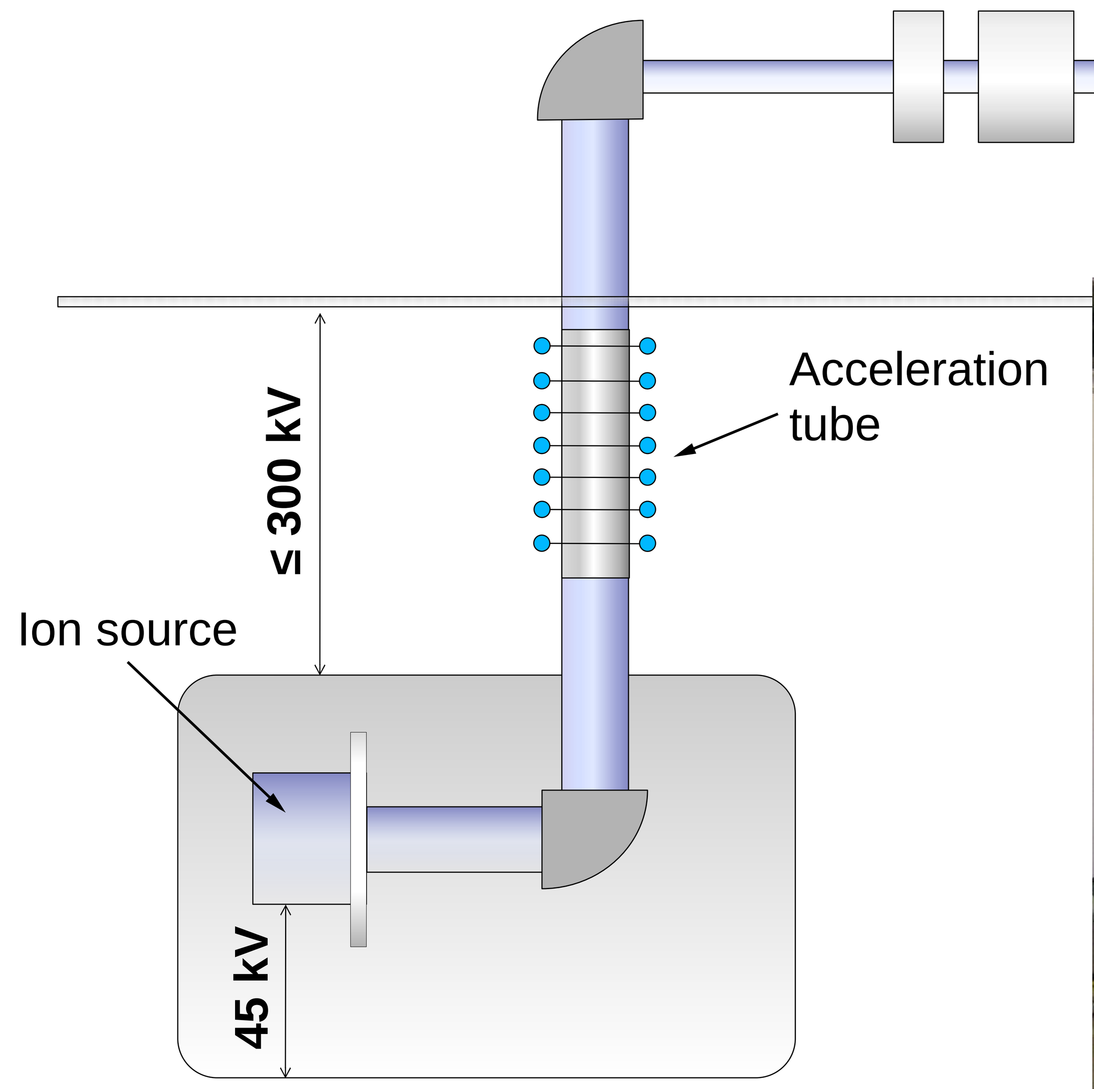
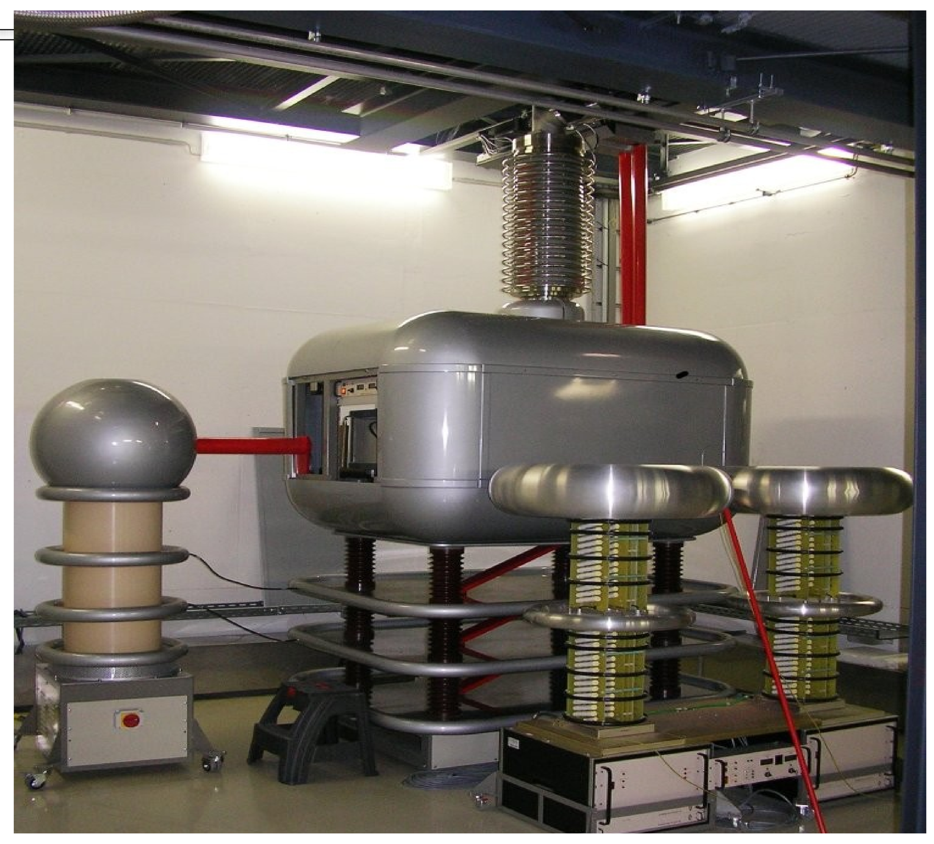
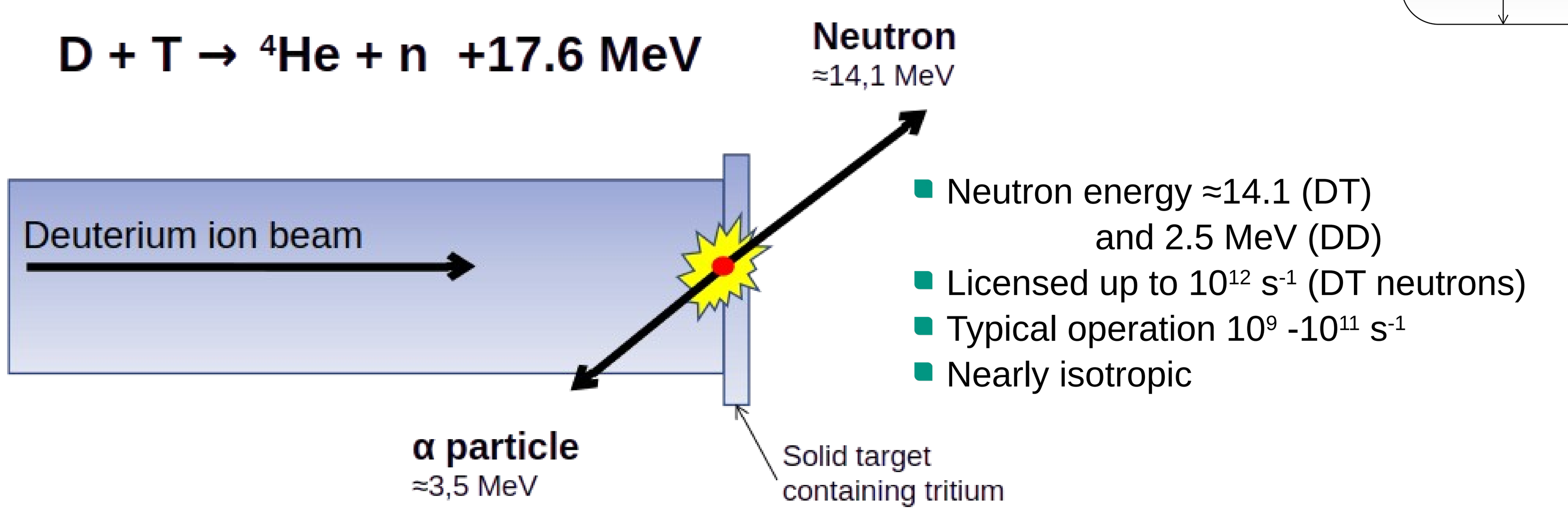
Deuterium-Tritium Neutron generator

- Accelerator with Greinacher multiplier (Cockroft-Walton)
- Continuous and pulsed mode (µs available, ns upgradeable)
- Maximum d-beam current 8...10 mA, energy up to 345 keV
- Target in center of room, distance to walls more than 4 m









- Neutron energy ≈14.1 (DT) and 2.5 MeV (DD)
- Licensed up to 10^{12} s^{-1} (DT neutrons)
- Typical operation 10^{9} -10^{11} s^{-1}
- Nearly isotropic

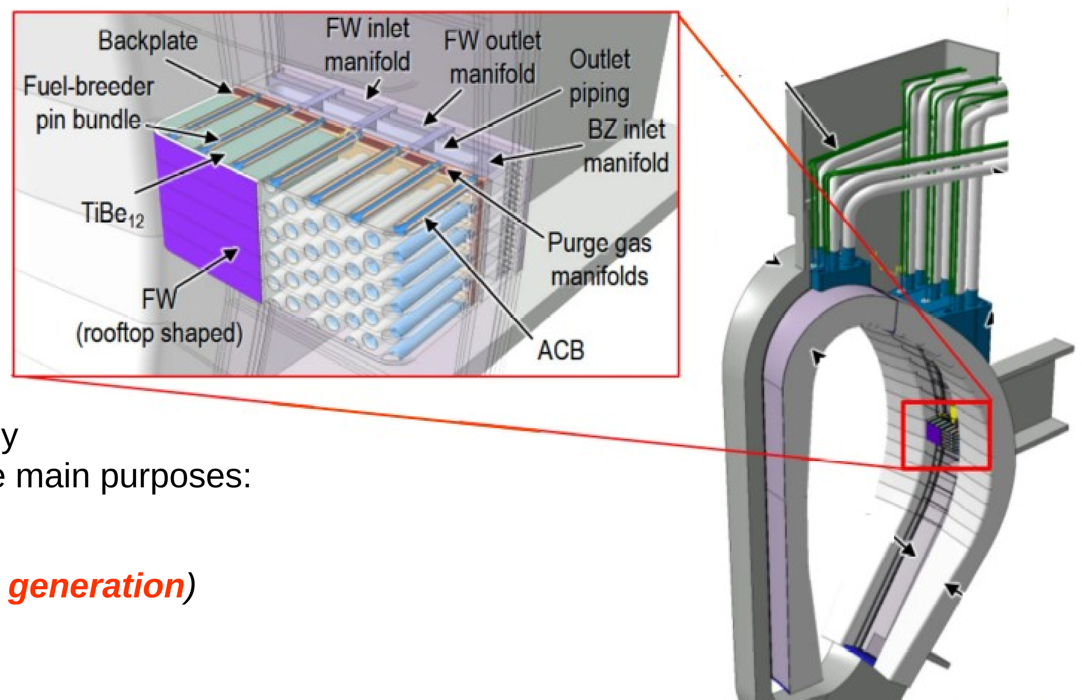
Applications to the development of nuclear fusion reactors

Neutron flux on First Wall

≲ 5*10^{14} cm^{-2} s^{-1}

$^{6}Li + n \rightarrow T + \alpha$

$^{7}Li + n \rightarrow T + \alpha + n$



Source: G. Zhou et.al., „The European DEMO Helium Cooled Pebble Bed BreedingBlanket: Design Status at the Conclusion of the Pre-Concept Design Phase", MDPI Energies 2023, 16(14), 5377"

DT fusion plasma surrounded by **breeding blanket** serving three main purposes:

- *Tritium production*
- *Energy conversion (→ **Heat generation**)*
- *Shielding*

Important nuclear parameters for fusion reactor blankets

Parameter	Required	Adressed by
Tritium breeding ratio	> 1.15	Local tritium production rate (TPR) in mockups
Nuclear heating	0.1-20 W cm^{-3}, depending on material and position	Energy deposition in mockups
Shielding capabilities	typically two orders of magnitude	Neutron/photon fluxes in and behind mockups
Material activation	Operation, maintenance, decommissioning, licensing	Sample irradiation and radioisotope production with AMS and NAA
Gas production	Maintenance procedures and life time, licensing	Sample irradiation and radioisotope production with AMS and NAA

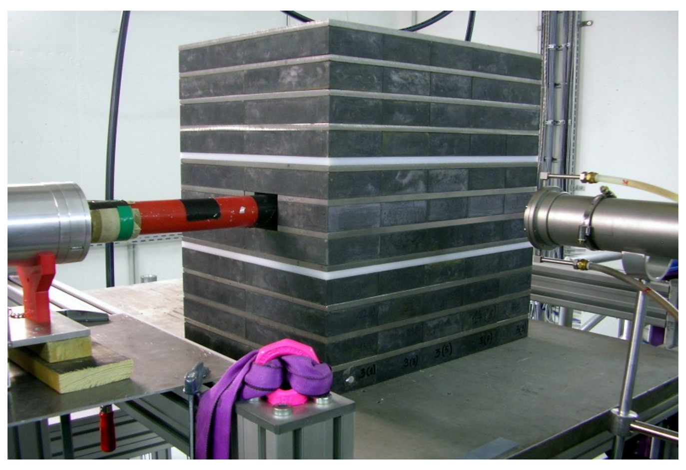
Usually combination of simplified experiments and simulation of experiments with state-of-the-art numerical modeling ⟹ **evaluation of:**

$$\frac{\textbf{Calculation +/- Uncertainty}}{\textbf{Experiment +/- Uncertainty}}$$

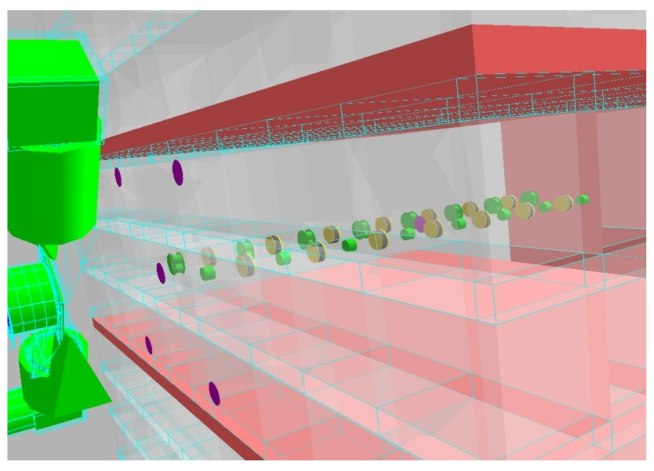
Dresden University of Technology Institute of Nuclear and Particle Physics Nuclear Physics Group

A.Klix et.al., The intensive DT neutron generator of TU Dresden, EPJ Web of Conferences 170, 02004 (2018)

HCLL Test Blanket Modul mockup experiment (TPR and shielding)

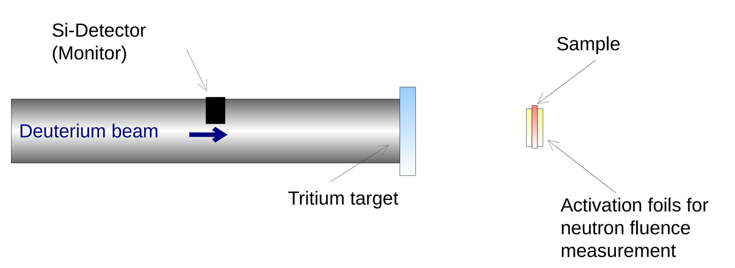


Neutron and γ-ray flux measurement

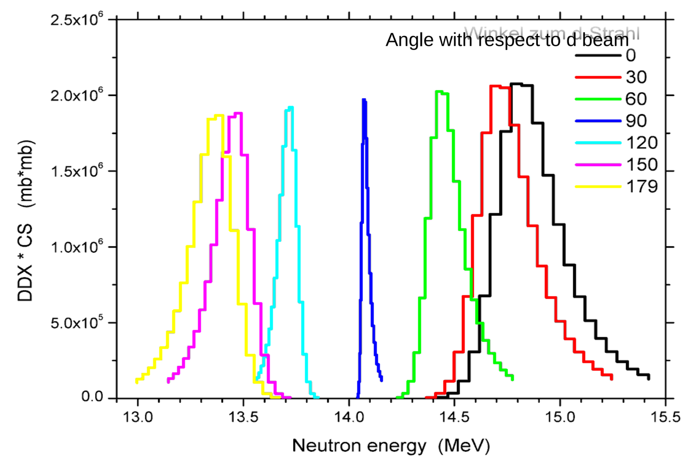


Tritium production rate with Li_2CO_3 pellets

Nuclear reaction cross section measurements

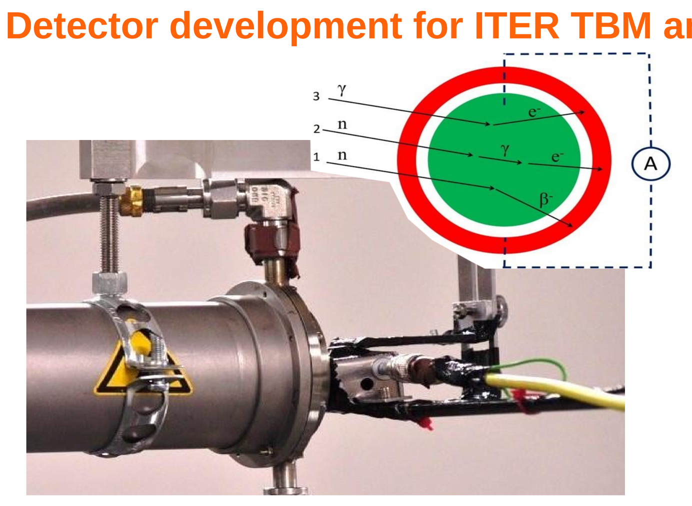


Small samples irradiated with DT neutrons Reaction products determined with AMS and gamma spectroscopy

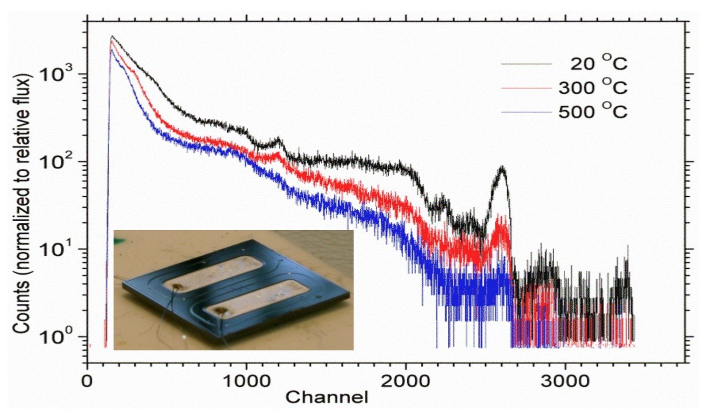


DT fusion neutron peak dependence from angle with deuteron beam

Detector development for ITER TBM and beyond



Self-powered (neutron) detectors for fast neutrons



SiC detector without neutron converter at temperatures up to 500 °C.

Future experimental plans and facility development

- Detailed breeding blanket mockup experiments
  - TPR measurement distributed in breeding zone, also off-axis
  - State-of-the-Art blanket materials such as lithium ceramics pebbles
  - Lithium-6 enrichment as in blanket designs (up to 90%)
- Nuclear cross section measurements for long-living products with low or no gamma activity – accelerator mass spectroscopy (AMS) facility at HZDR
- Substantial improvement of neutron source diagnostics
- Investigation into feasibilty of radiochemical measurements with ESR techniques (radiolysis and corrosion)

Obtaining experimental data to check (and validate) material property data bases, simulation codes and methods.