Elastic Recoil Detection Analysis of Fusion Reactor Wall Materials: Detector design and Applications

Petter Ström

Per Petersson, Marek Rubel

Department of Fusion Plasma Physics, School of Electrical Engineering, Royal Institute of Technology (KTH), Association VR, Stockholm, Sweden.

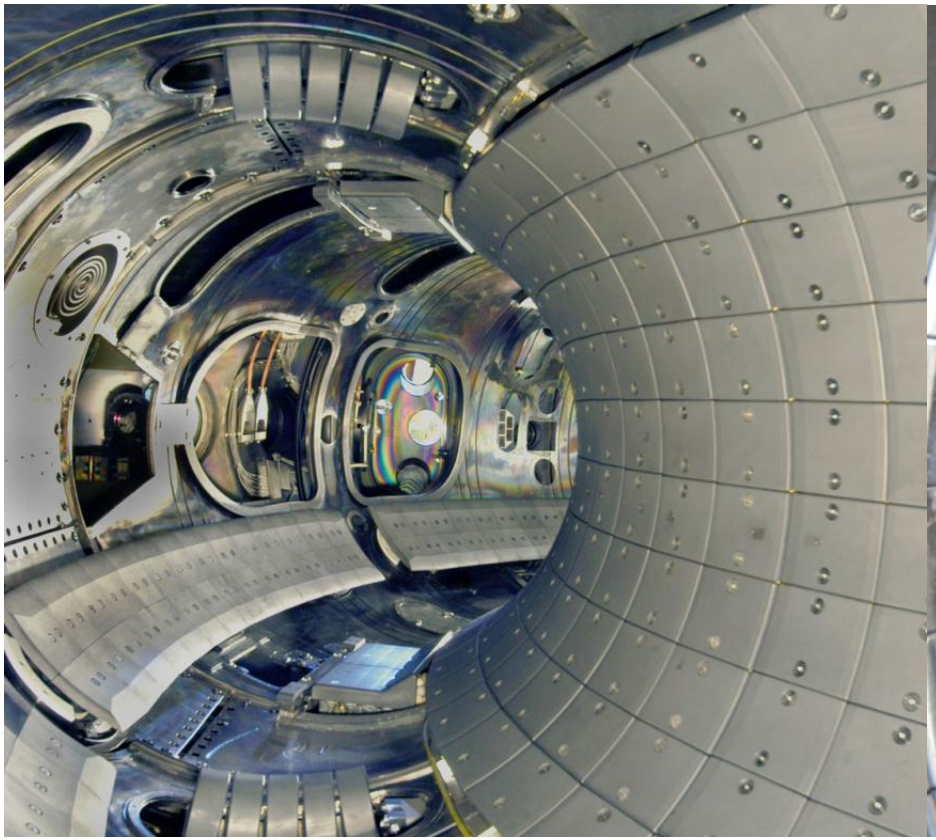
O U T L I N E

- ***Background: Plasma – Wall Interaction***
- ***Focus method: ToF-HIERDA***
- ***Detector design***

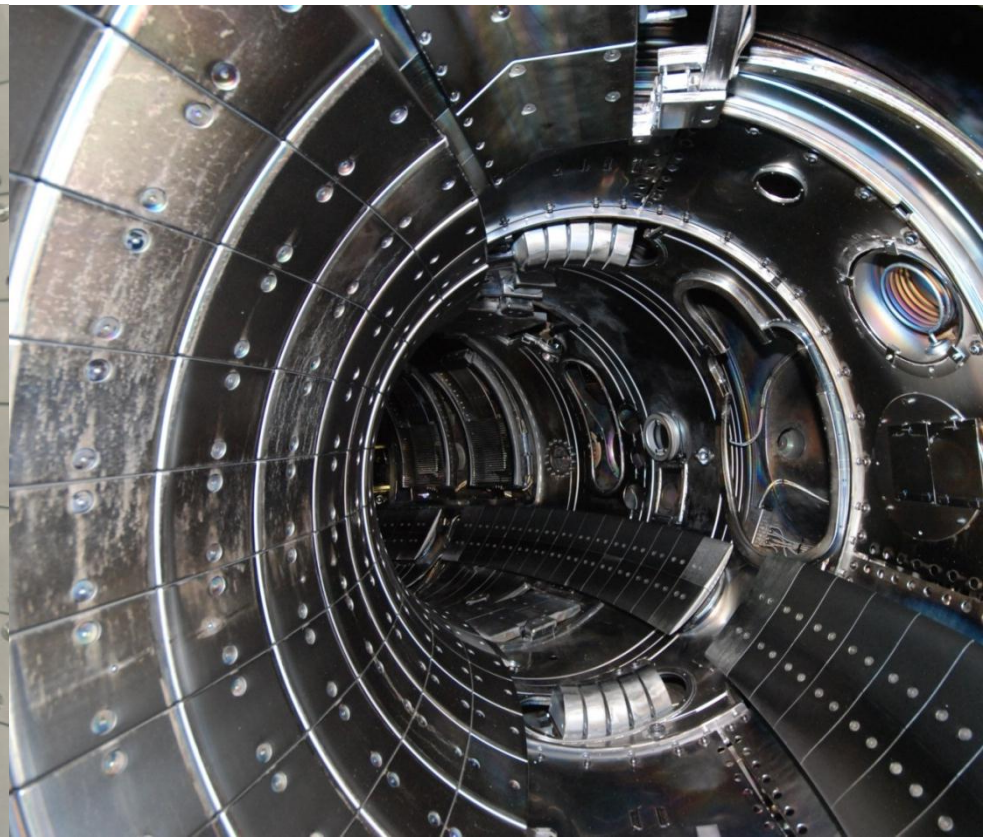
Background

TEXTOR tokamak (1982-2013), Forschungszentrum Jülich

New plasma facing components, 2003

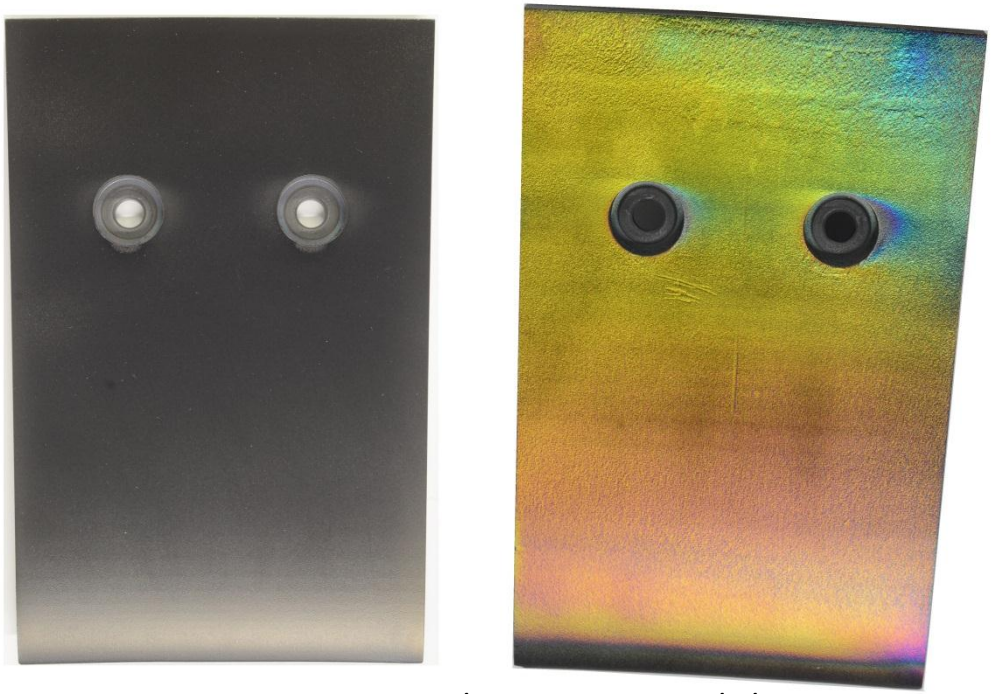


Typical condition after Experimental campaign



Images: Forschungszentrum Jülich

Plasma-wall interactions



Images: Harry Reimer, Forschungszentrum Jülich

Transport of particles and energy

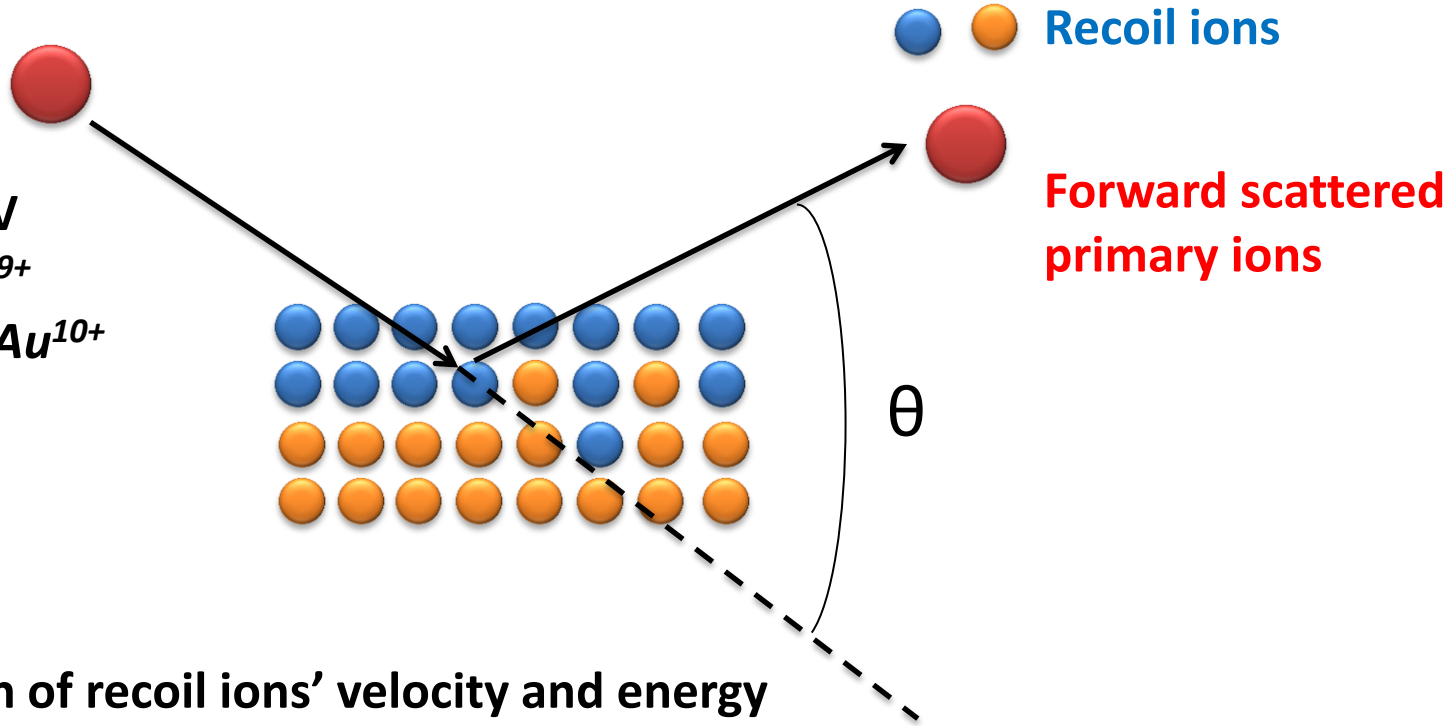
- **From plasma to wall**
- **From wall to plasma**

Material selection for PFCs affects plasma performance!

Assess material migration and fuel inventory!
In-situ/**Ex-situ** analysis

ToF-HIERDA

Time-of-Flight Heavy Ion Elastic Recoil Detection Analysis

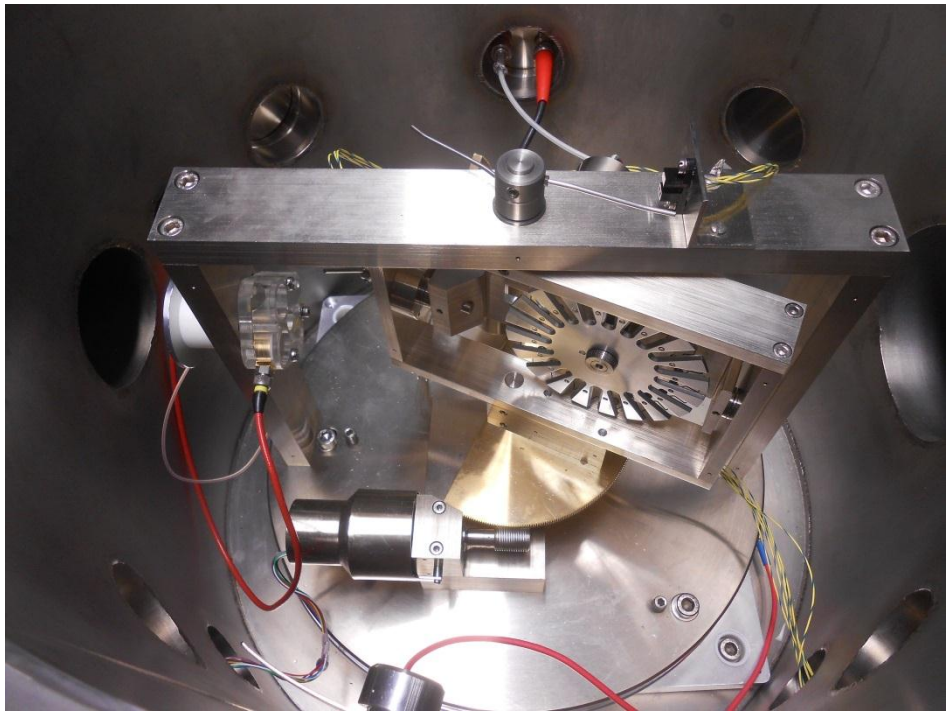


30 – 40 MeV
Iodine I^{7+} - I^{9+}
Gold Au^{7+} - Au^{10+}

- **Detection of recoil ions' velocity and energy**
- **Excellent resolution for light isotopes deposited on smooth surfaces**
- **Probing depth ≈ 1µm**

- **Problem: Forward scattered primary ions**

Experiment set-up



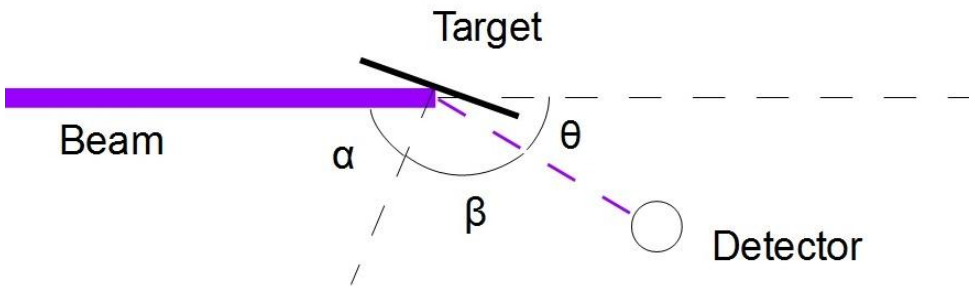
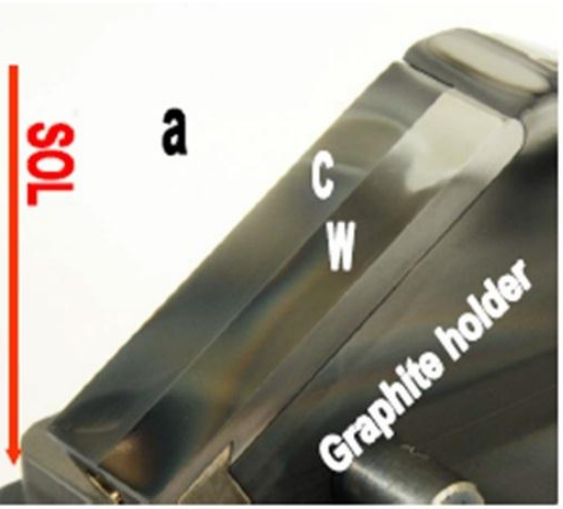
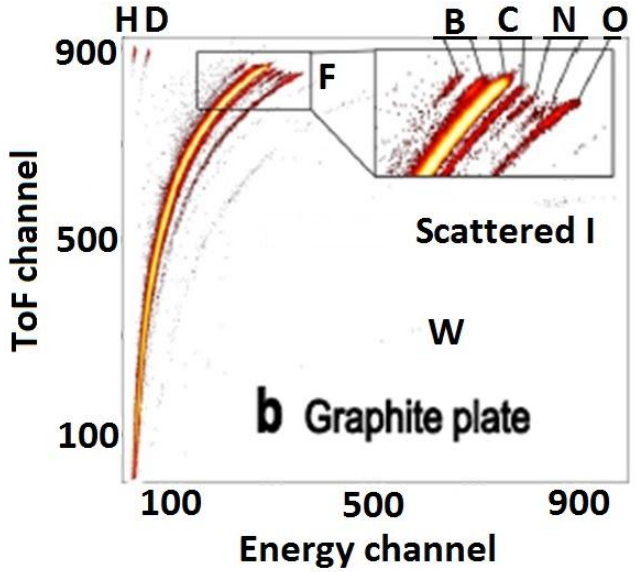
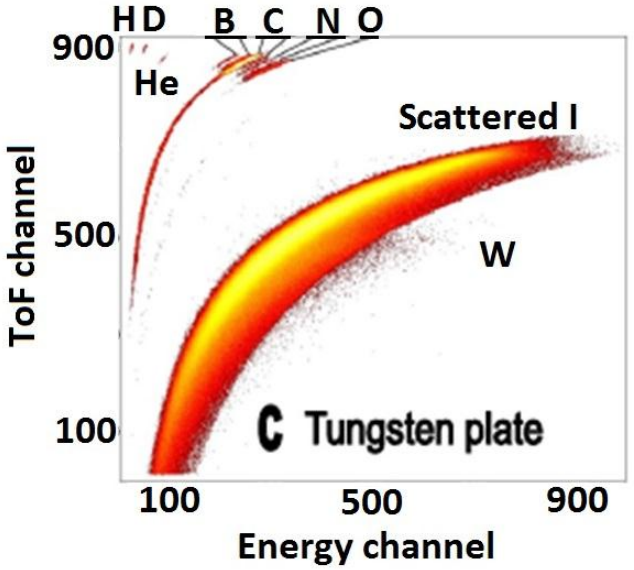


Illustration of the problem

HIERDA on carbon and tungsten plates from TEXTOR







Very good resolution for light elements, BUT

High iodine influx →

Deterioration of solid state semiconductor detector

Solution?

Detector: Gas Ionization Chamber

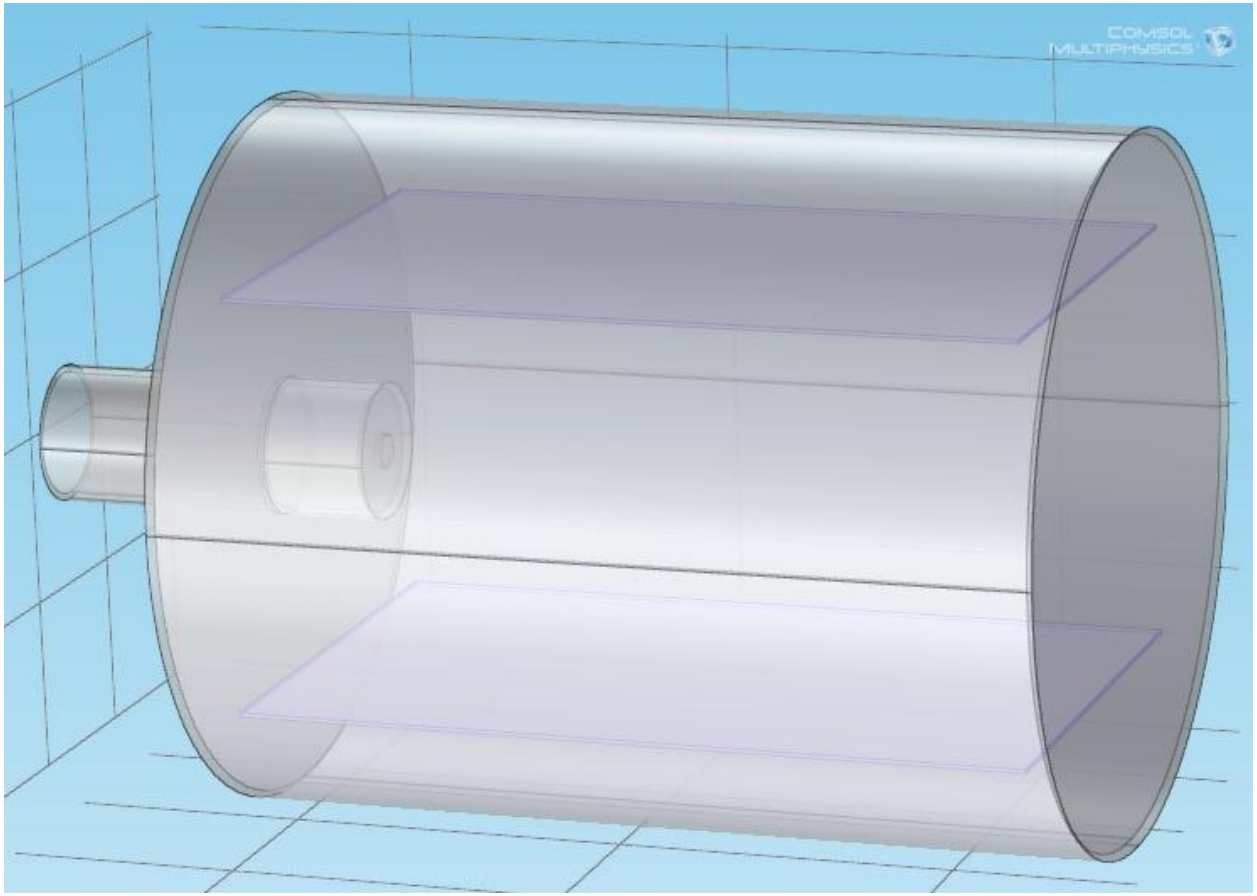


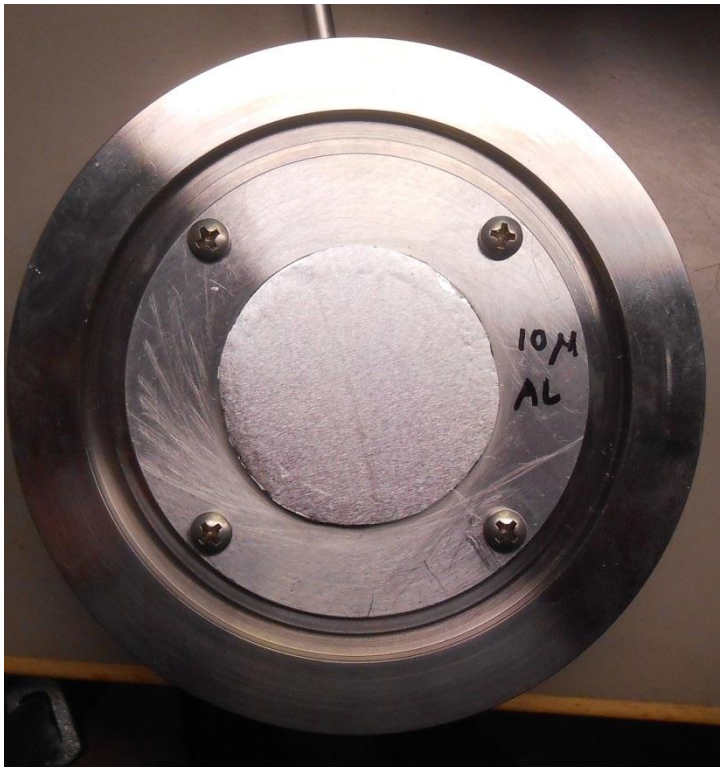
Image: Our simple detector model in COMSOL Multiphysics

Design parameters

- **Entry window**
- **Gas and pressure**
- **Detector geometry**
- **Voltages**

Window

10 µm Al



100 nm Si_3N_4

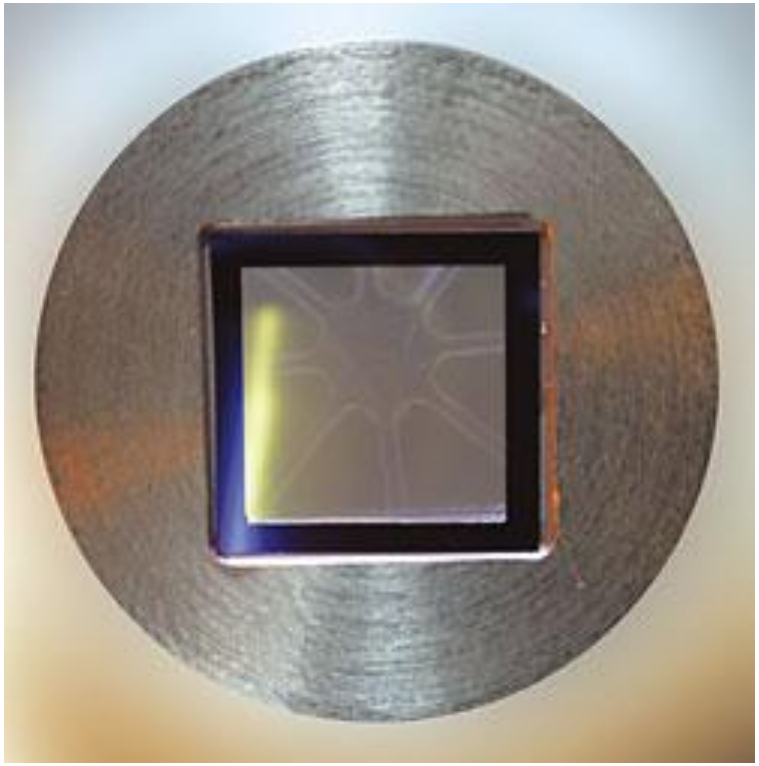
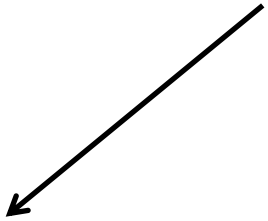
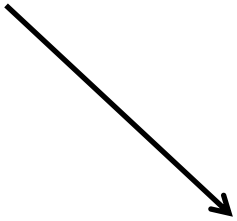


Image: Silson Ltd, membrane manufacturer
http://www.silson.com

Working gas and pressure

Aim: stop all incoming particles in detector volume





- **Preference:** high pressure
- **Drawback:** need thicker window

Compromise!

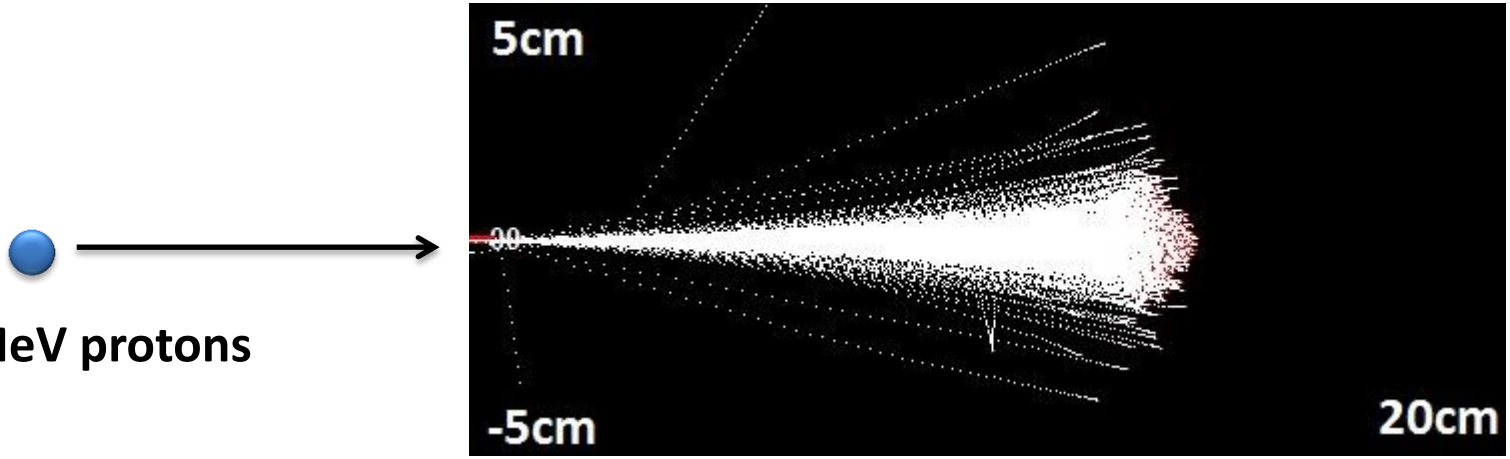
- Electronic stopping dominates
- Lots of electrons → advantage

Isobutane at 200 mbar!

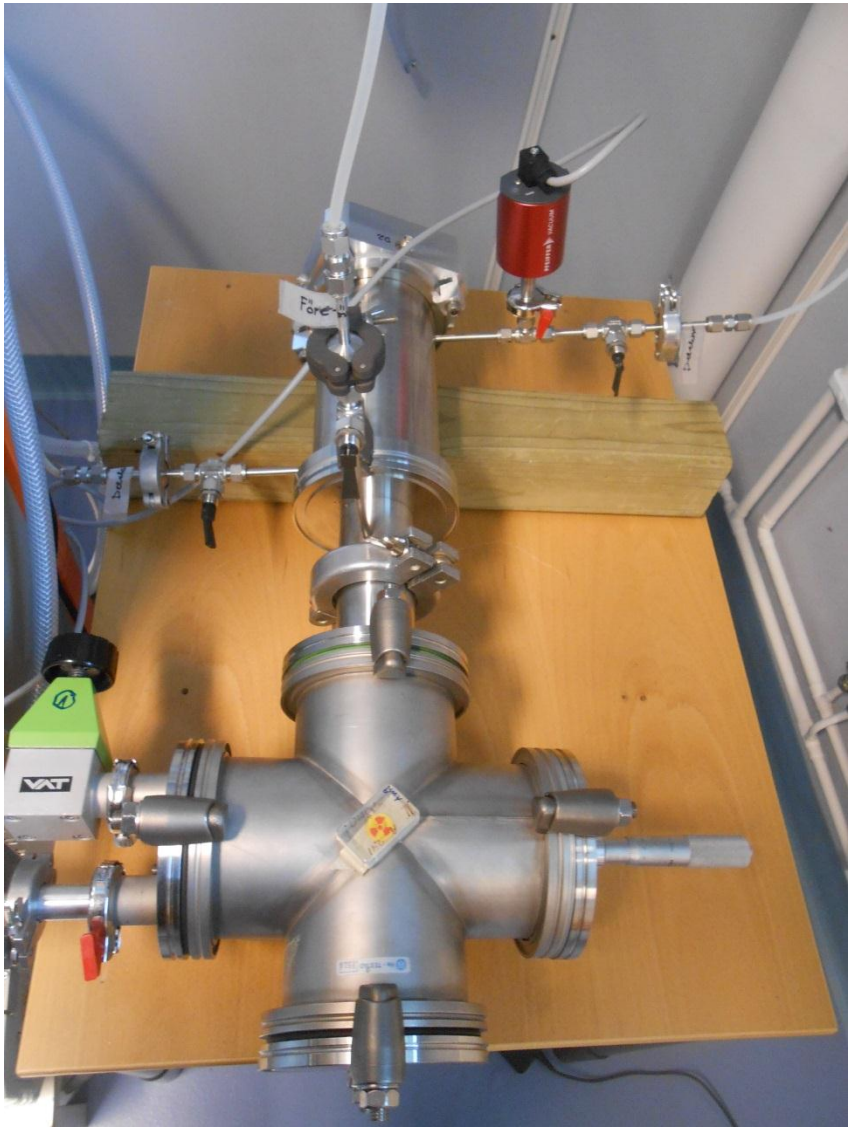
Geometry

- **Choose cylindrical detector (no unneccesary volume)**
- **Size: Large enough to stop all particles.**
  Radius 5cm, length 20cm

Trim calculation for 100 nm Si_3N_4 window and 200 mbar isobutane



Conclusion → Outlook

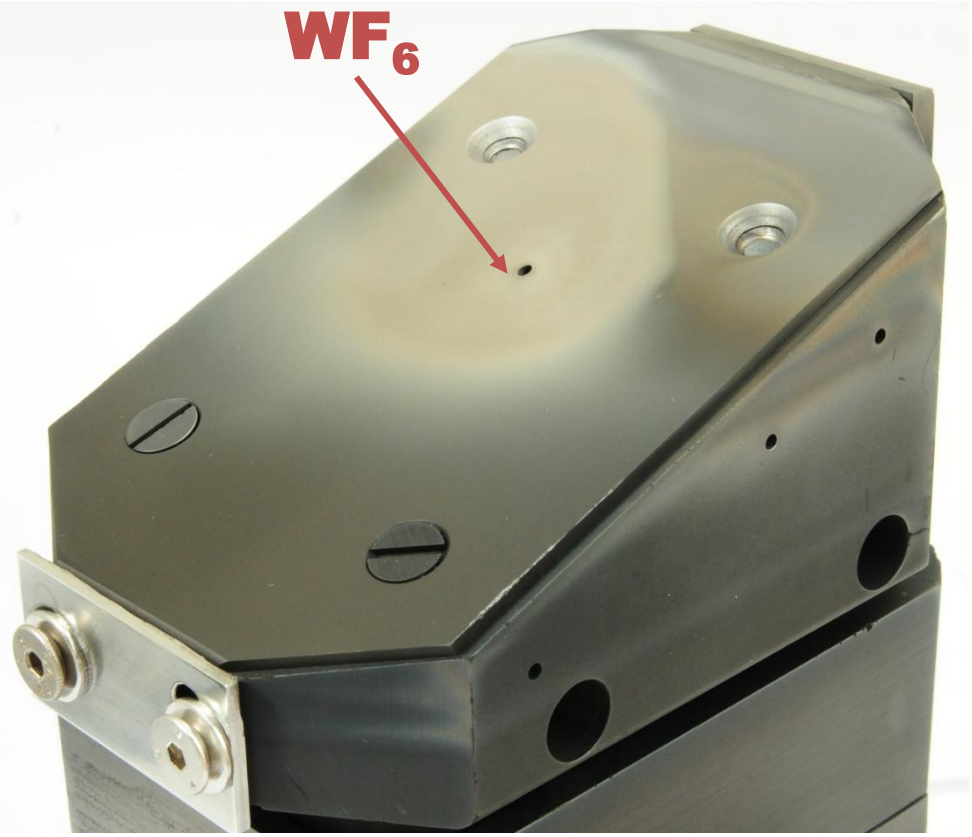


- **GIC feasible for HIERDA**
- **Design parameters fixed**
- **Detector tests underway**

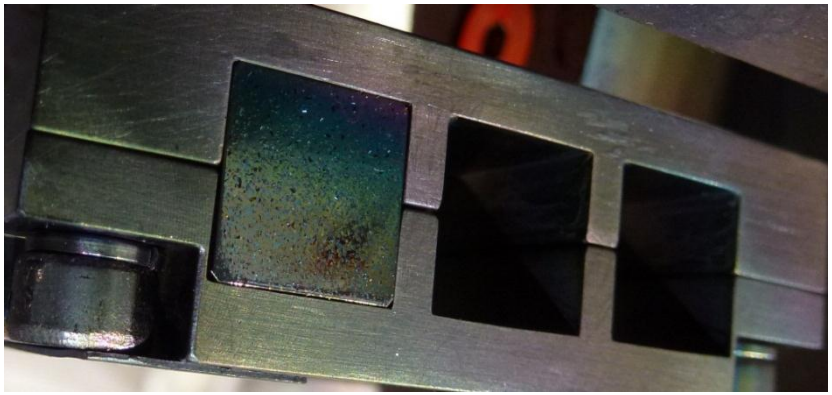
- **Study Be limiters and W divertor from JET-ILW**
- **Test limiters from TEXTOR**

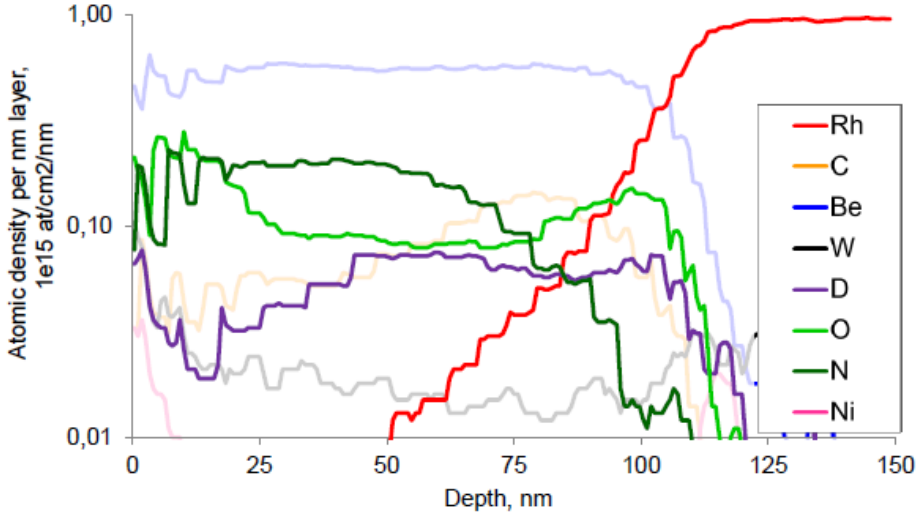
Applications

Tracer experiment with WF_6 and ^{15}N: Deposits on a test limiter from TEXTOR, Species: W, He, C, ^{14}N, ^{15}N, O, F



First Mirror Test at JET for ITER: Analysis of deposit on a test mirror





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