Ion beam analysis at JSI

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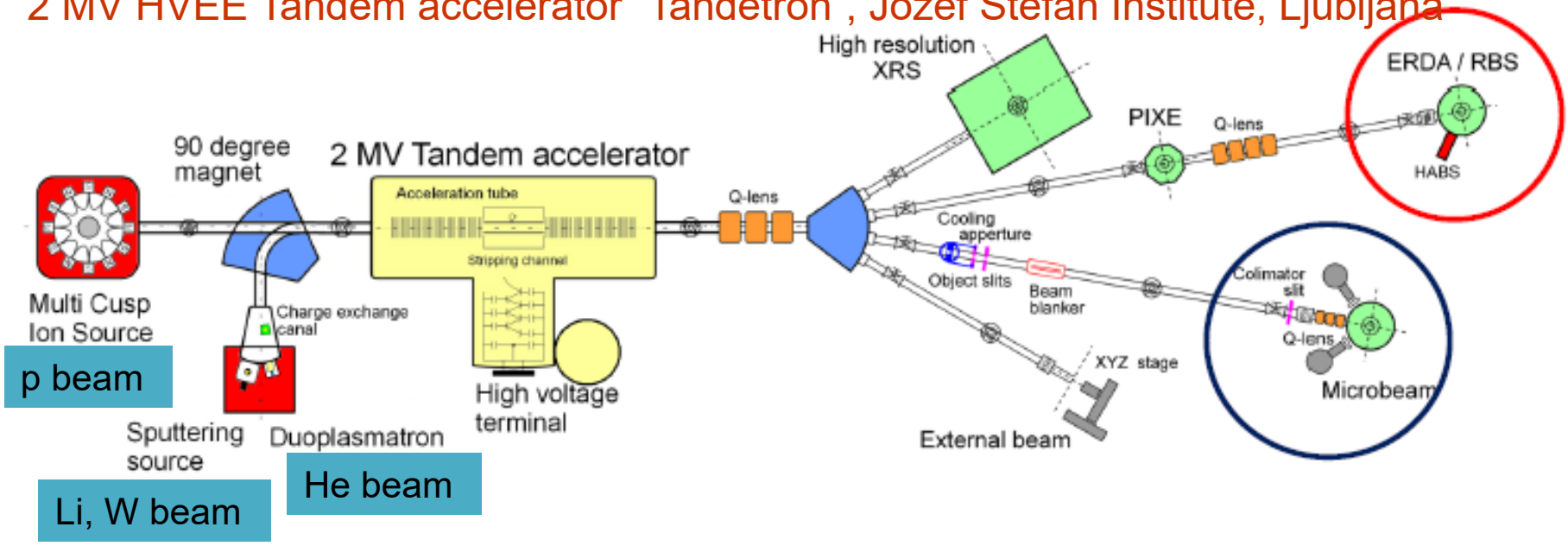
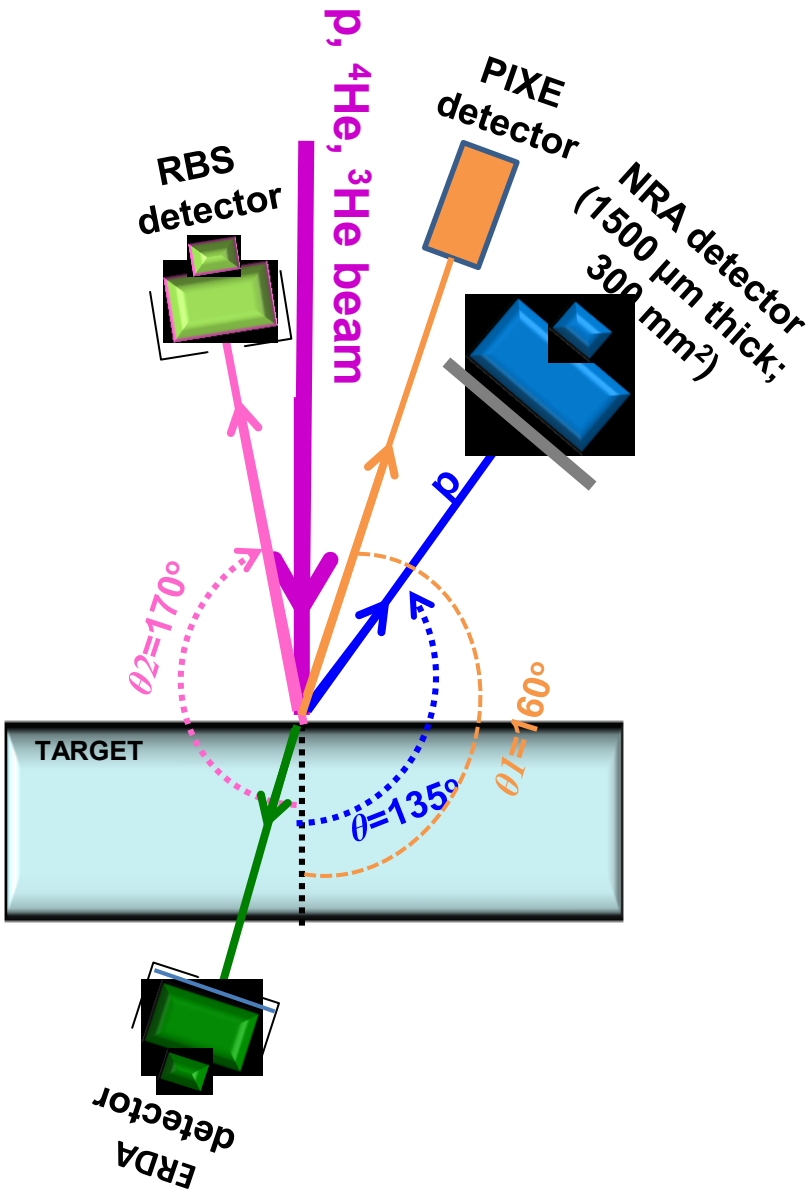
Ion beam studies at JSI - The accelerator

2 MV HVEE Tandem accelerator "Tandetron", Jozef Stefan Institute, Ljubljana



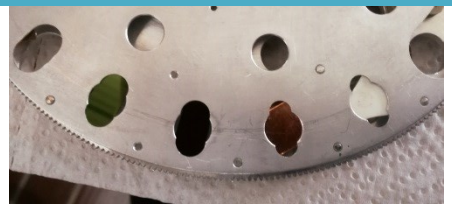
- Three ion sources for production of different ion beams: proton, He, heavier ions
- Broad beam NRA / RBS set for static and in situ D depth profile measurements and experiments
- Micro beam NRA / PIXE/ RBS for static post-mortem measurements.

Ion beam studies at JSI - The accelerator



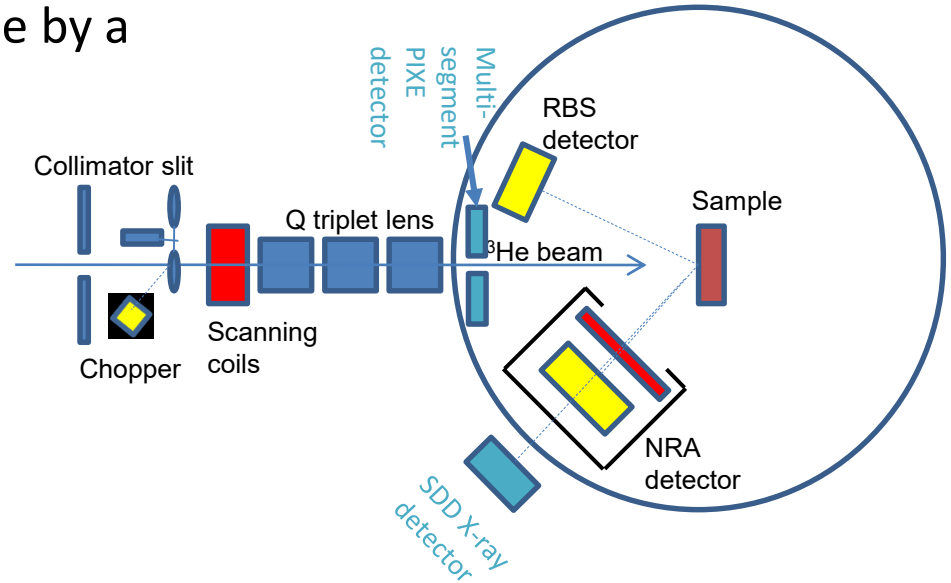
INSIBA chamber for broad beam analysis
NRA, RBS, ERDA, PIXE (new) analysis methods available

Classical analysis - 20 samples

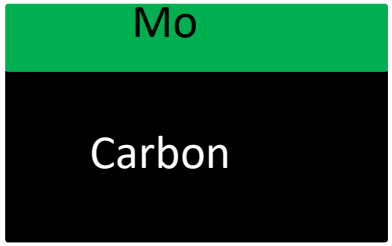


Microbeam station

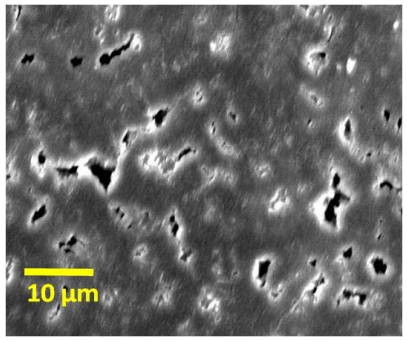
- Beam is focused by a triplet of quadrupole lenses and scanned over the sample by a scanning coils
- The ion dose is measured by a rotating chopper
- 4 detectors measuring simultaneously:
  - NRA (2000 µm thick SiLi (new) detector with 300 mm^2 active area)
  - RBS (300 µm thick PIPS detector with 50 mm^2 active area)
  - New SDD X-ray detectors for PIXE analysis
  - New multi-segment PIXE detector



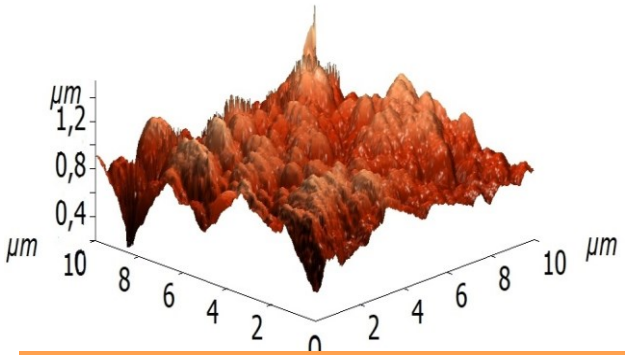
The project – influence of sputter yield on surface roughness



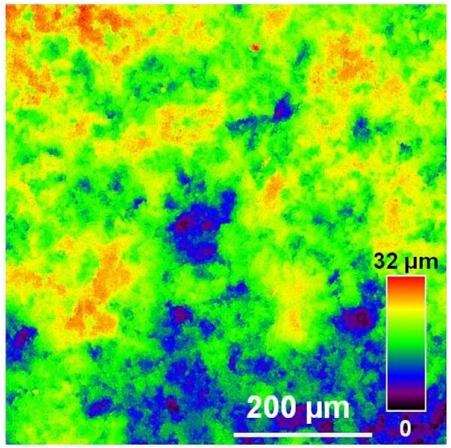
120 nm thick Mo films were deposited by pulsed laser deposition on mirror polished, plasma etched or sand blasted textured graphite substrates. The surfaces had surface roughness (Ra) from polished surfaces (Ra~ 5 nm) up to very rough surface (Ra~ 2-3 µm) with intermediate Ra~ 110 nm and Ra~ 280 nm.



SEM image of samples with Ra~ 5 nm. The observed holes are visible in black.



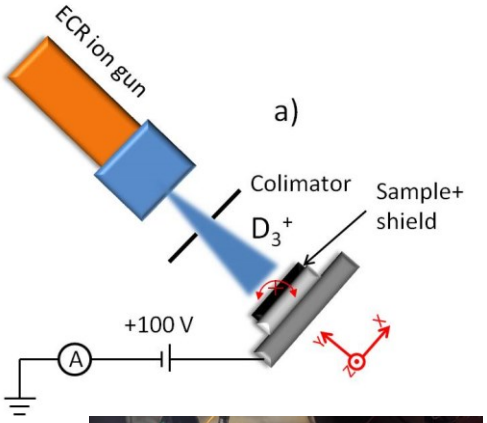
AFM image of samples with Ra~ 110 nm. This was used as direct input to SDTrimSP 3D.

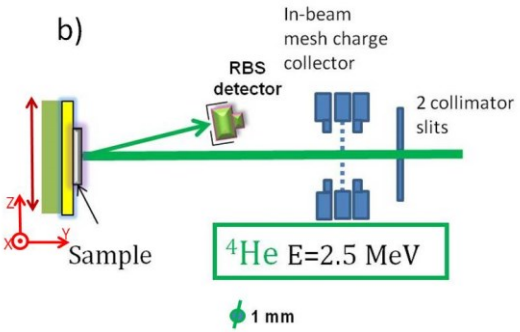


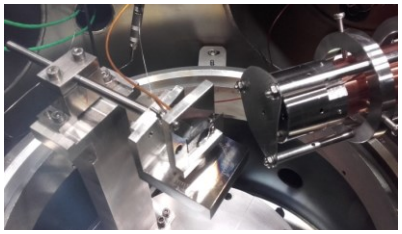
CLSM image of samples with Ra~ 2-3 µm. This was used as direct input to SDTrimSP 3D.

ISTP NanoLab POLITECNICO MILANO 1863 IPP Max-Planck-Institut für Plasmaphysik

Laboratory experiments

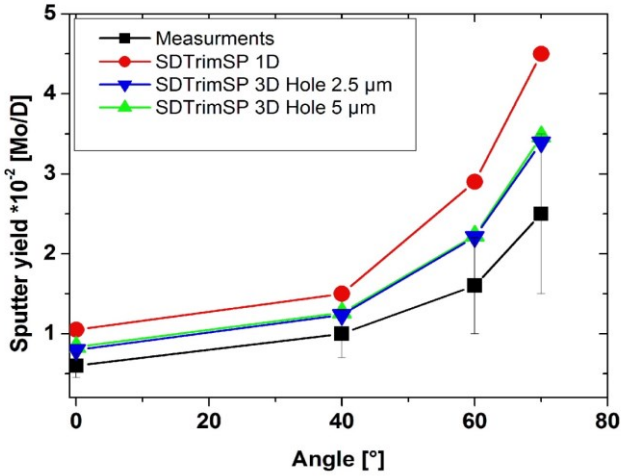


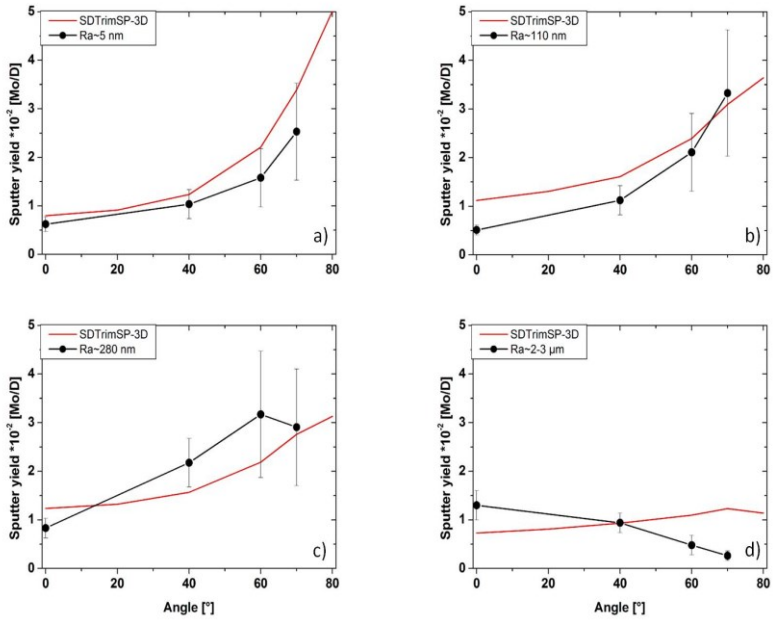




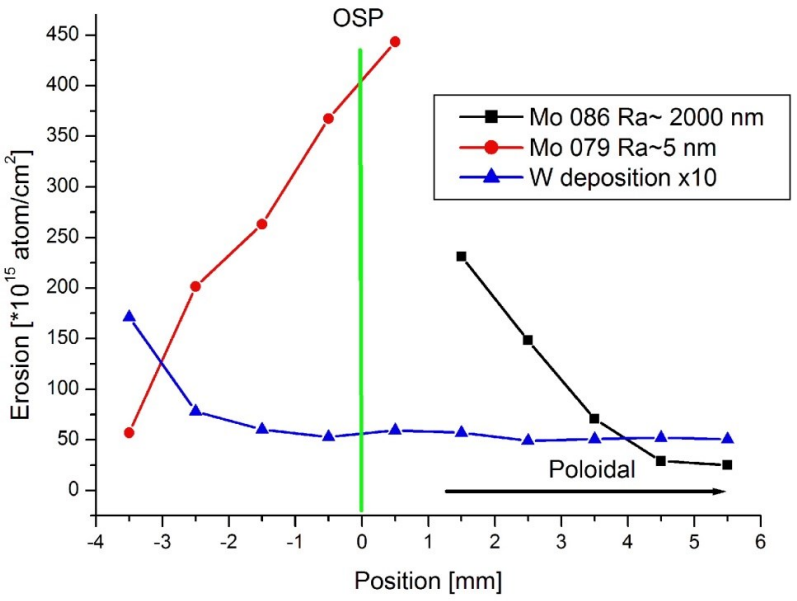
Samples irradiated by 1 keV/D ions

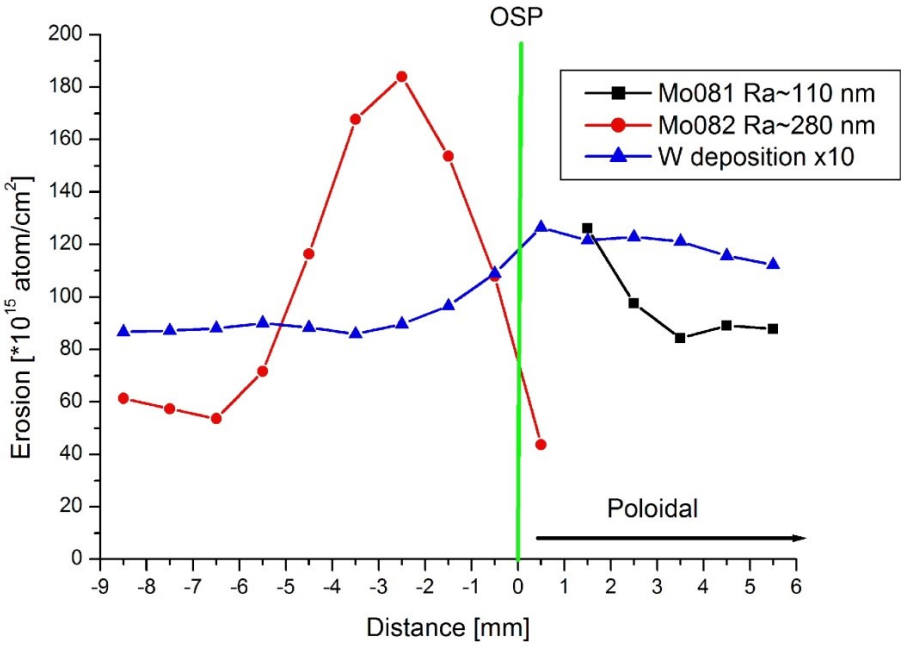
- At angles 0°, 40°, 60° and 70° between ion beam and surface of the sample.
- To determine sputter yield the thickness of Mo film was measured with RBS before and after the exposure to D ions.
- Paper accepted for publication in JNM





Sputter yield dependence on surface roughness - L-Mode experiment in AUG





- RBS analysis of sample exposed in AUG in 2019 is done.

- Obtained results are in agreement with the Lab results .

Sputter yield dependence on surface roughness - H-Mode experiment in AUG

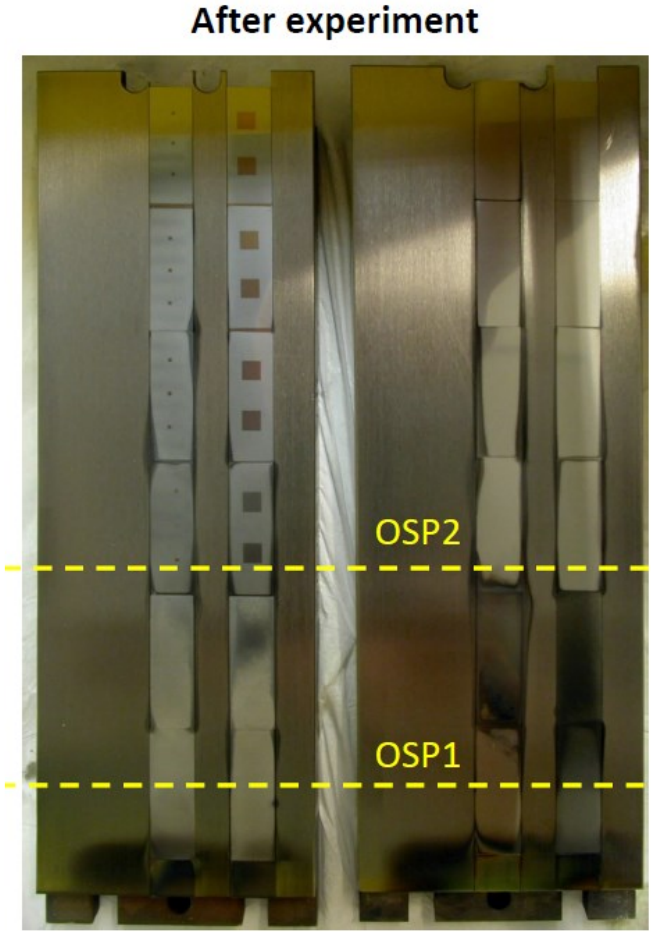
- **Experiment #3**: AUG H-mode experiment from 2020 with 2 different OSP positions – "small ELMs" Bt = 2.5 T, Ip = 0.6 MA
- **Left tile**: marker samples above OSP 2 and roughness samples between OSP1 and OSP2
- **Right tile**: Re- and Mo-coatings and roughness samples between OSP 1 and OSP 2

Actions for JSI – to do in 2021

From meeting on 18.2.2021

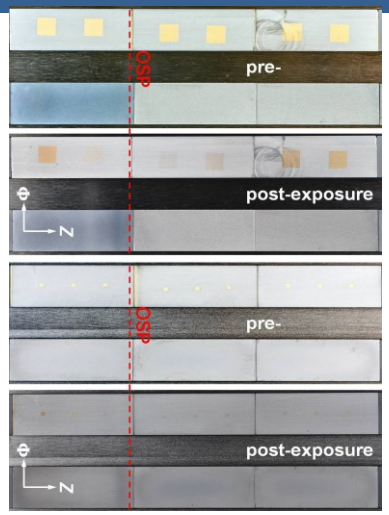
- Action on IPP to carry out broad-beam IBA and microscopy (no travelling possibilities before late summer at the earliest) → target mid-May
- Next step will be analyses at JSI → action on JSI to finish broad-beam measurements if better spatial resolution is needed and proceed to microbeam analyses – plan summer / autumn

✓ WEST samples analysed by PIXE and NRA – broad beam – spectra analysis needs to be done



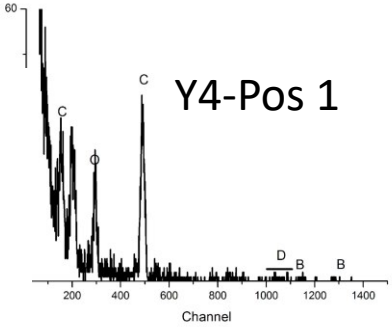
Microbeam analysis of AUG samples

- Analysis of impurity transport on Au marker samples exposed to L-mode D plasma in AUG.
- Measurements delayed due to substantial upgrades of JSI microbeam experimental end station.
- Upgrade to new data acquisition system, count rates up to 10 kHz.
- With new upgrades we expect to reduce the necessary measuring time for a factor of 5.
- Integration of Si(Li) detector for charged particles, NRA application.
- New multi-segment PIXE detector, with solid angle ~ 1 str.



Analysis performed on gap samples:

- MicroNRA analysis for B and C.
- MicroPIXE analysis for W, Mo, Au...
- SDD PIXE detector send for repair
  - no further analysis yet



Y4-Pos 1