Two TMPs breakdown:

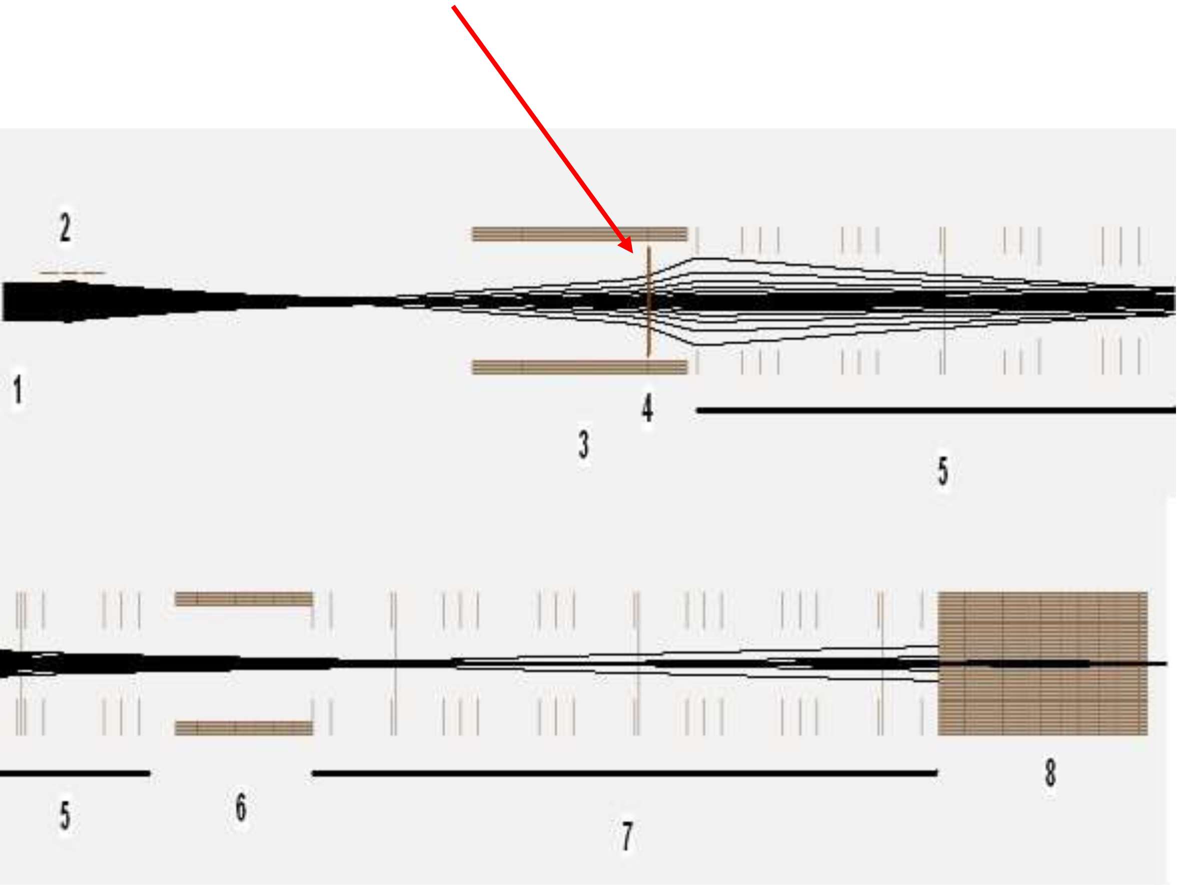
1. Atmospheric pressure at foreline
2. Unknown reason

Rb migrating from the source to extraction (or glass tube) area causing instabilities and sparking. Solution: through cleanning of ion source

Belt worn out after
~20000 working hours

Some upgrades to the optics of EN:
LE improvement - gridded lens addition

Grided lens (4) in addition to einzel lens (2) acts as zoom-lens

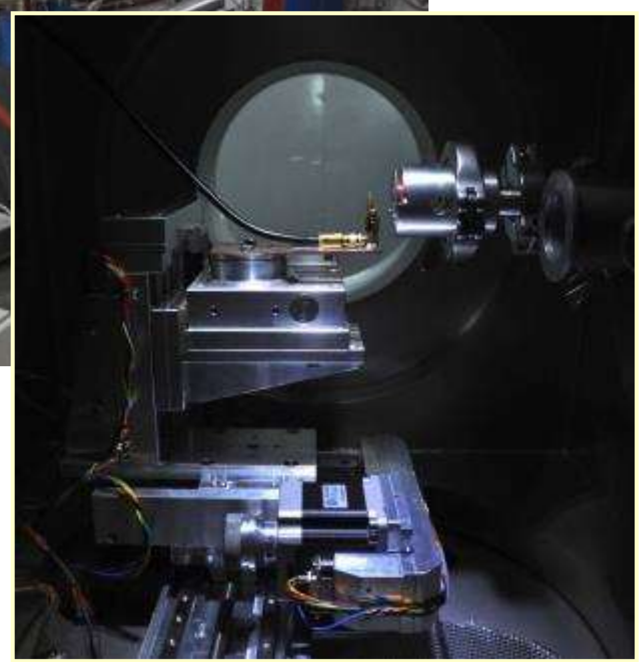


IAEA BEAM LINE
Since 1996.

Used up to 20 days/year by:

- IAEA staff (different projects)
- IAEA trainees (TC projects)
- Training courses

Beam line upgraded in 2012., by addition of irradiation chamber for detector testing.
In 2016, original IAEA chamber is replaced by dual beam irradiation including microbeam



DiFU
Dedicated Dual-ion Irradiation Facility for Fusion Materials

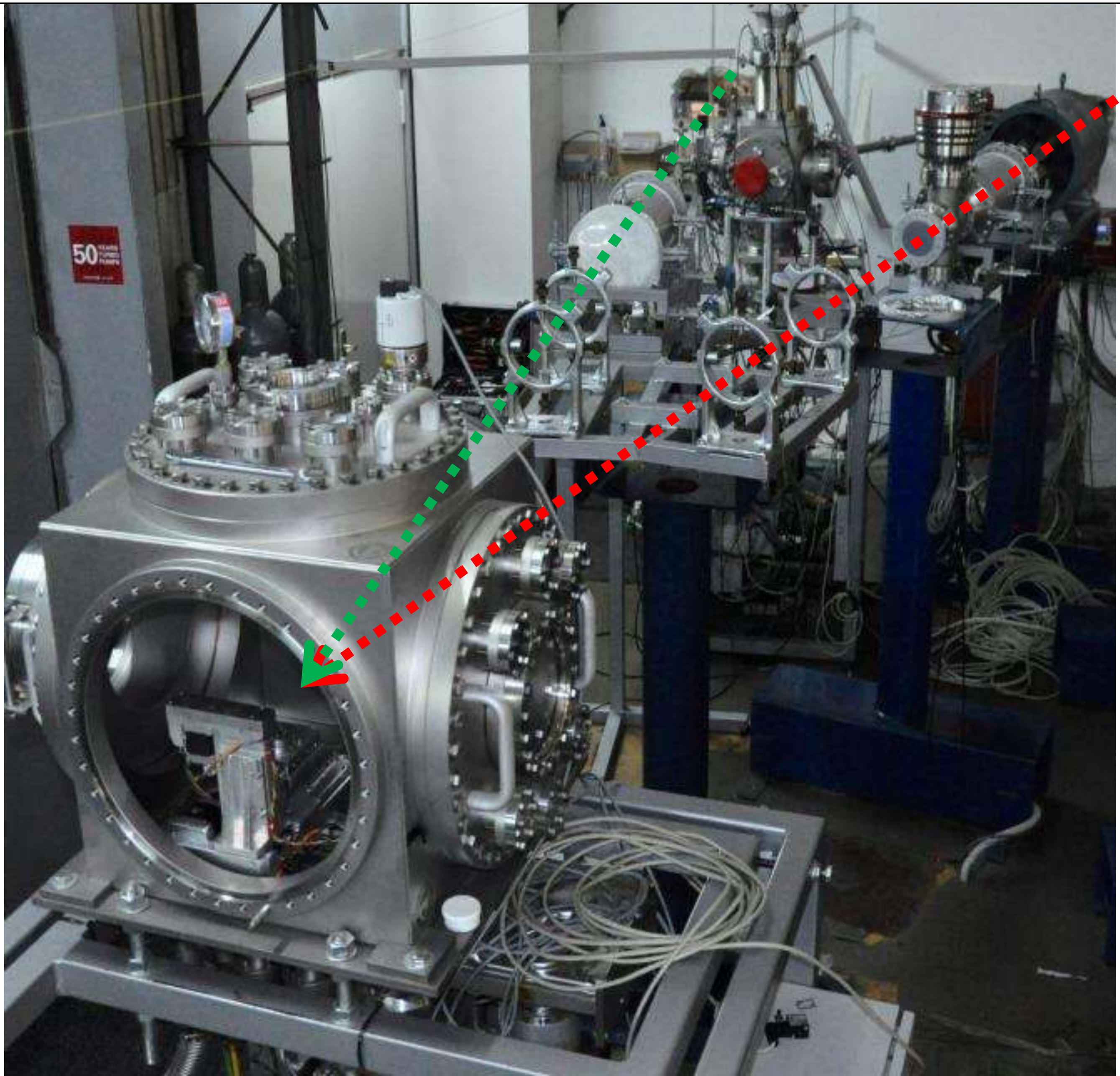
RBI and Croatian fusion Reserach Unit (CRU)

In

European Fusion Programme – H2020 project EUROfusion
WorkPackage Fusion Materials (WPMAT)
- ***SP Ion and Neutron Irradiation***

a) Irradiation of samples by single-beam and dual-beam of ions on area from 5x5 to 30x30 mm^2
b) Electrostatic ion beam scanning, with high scanning frequency; flexible scanning area, pattern and frequency
c) Homogenuous damage profiles in depth by adjusting of ion energy using beam degraders with rotating foils and/or varying of ion beams' energies
d) Indirect ion beam profile/ion beam flux measurement using Micro-FCs;
e) Sample positioning using XYZΘ manipulator;
f) Heating of sample and control of sample's temperature by IR camera and set of thermocouples;
g) Gas-jet injection in front of irradiated area at the sample, if required;
h) High vacuum (< 1 10^{-7} mbar) using turbo-molecular pump, with ion pump added, to reduce creation of hydrocarbons at irradiated area of the sample.

Ion beam lines for DiFU station after precision alignment of components (June 2016)



Expected heavy ion beam currents at DiFU station

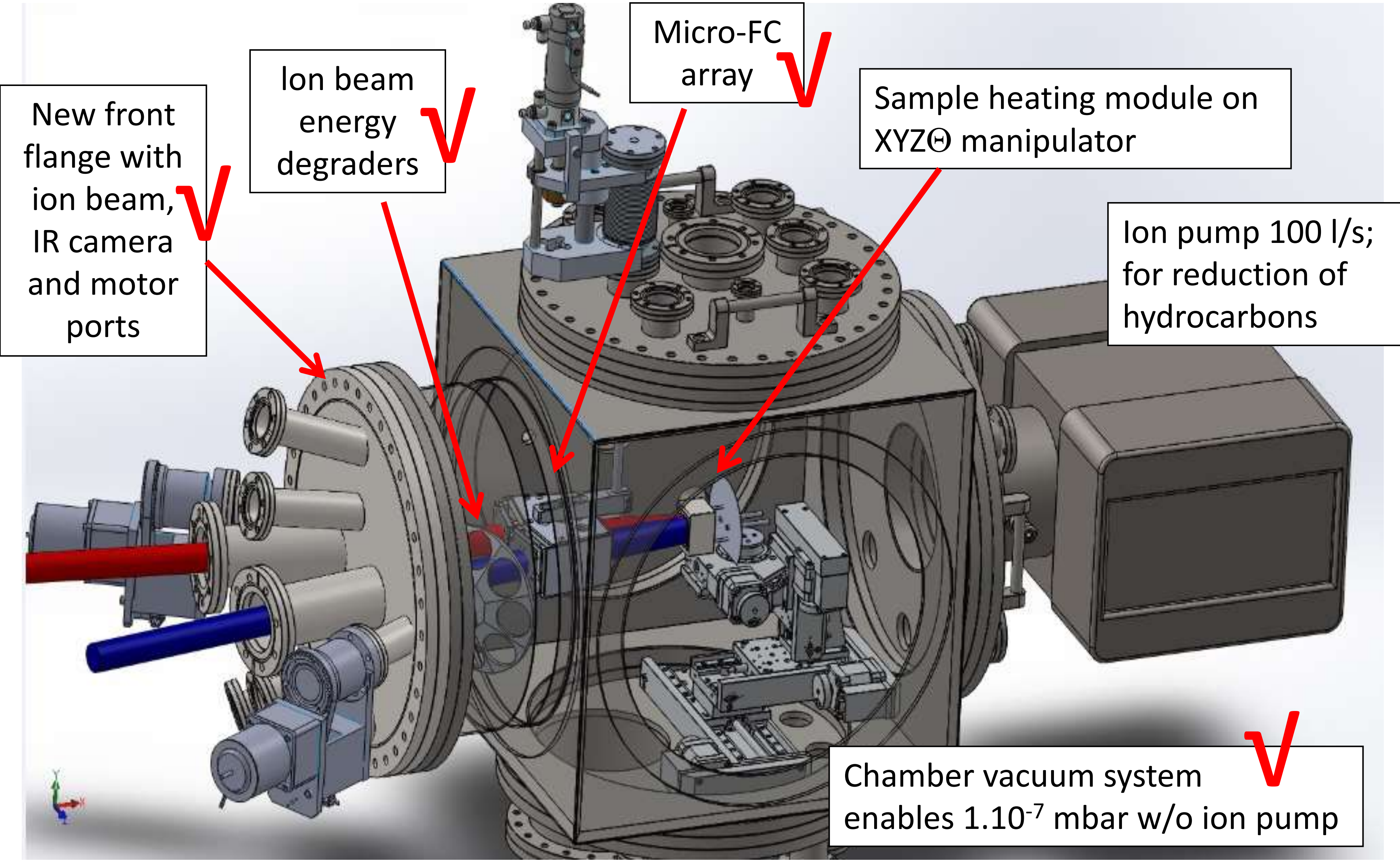
Ion	Z	M	Ion Energy (MeV)	Neg. Ion Current (nA)	Ion charge +Q	Ion Rigidity M E /Q²	Termin. Voltage (MV)	Ionizat. Probab. %	Stripper MS Transmiss. %	Total Transmiss. %	Expected Ion Current (nA) In 6 mm Ø area
W	74	184	10	500	5	73.6	1.667	5.741	0.264	0.015	0.4
W	74	184	20	500	6	102.2	3.5	4.441	0.594	0.026	0.8
W	74	184	30	500	8	86.2	3.33	1.161	0.885	0.014	0.6
W	74	184	40	500	9	90.8	4.0	0.856	1.234	0.011	0.5
Fe	26	56	10	500	3	62.2	2.5	24.054	2.833	0.681	10
Fe	26	56	20	500	4	40	4.0	18.721	7.094	1.328	26
Fe	26	56	30	500	6	46.6	4.286	3.943	7.971	0.314	9
Fe	26	56	40	500	8	35	4.444	0.421	8.892	0.037	1.5
Cu	29	63	10	5000	3	70	2.5	23.210	2.307	0.553	80
Cu	29	63	20	5000	4	78.7	4	18.320	5.877	1.077	215
Cu	29	63	30	5000	6	52.5	4.286	4.111	6.687	0.275	82
Cu	29	63	40	5000	8	39.3	4.444	0.559	7.109	0.040	16

~20 nA

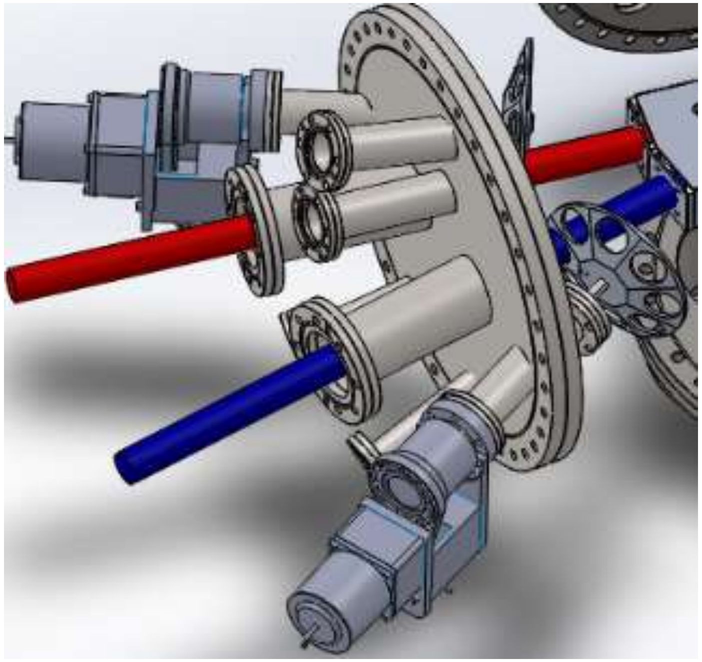
~12 nA

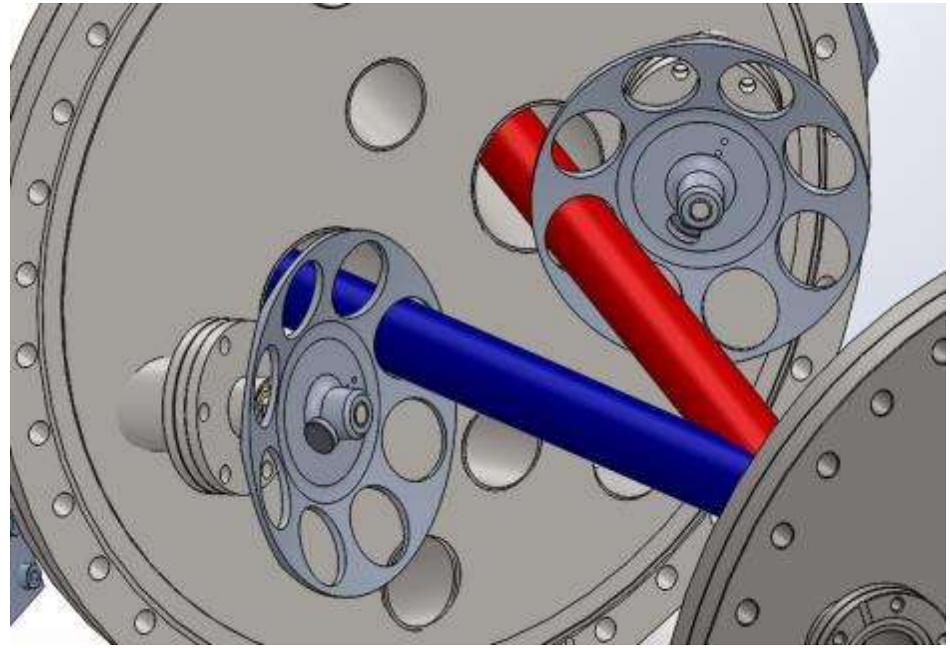
Measured in 10 mm Ø area in front of DiFU chamber ;
more trials are necessary with varying of Fe cathode, stripper gas density and ion optics

Modifications of irradiation chamber for DiFU station



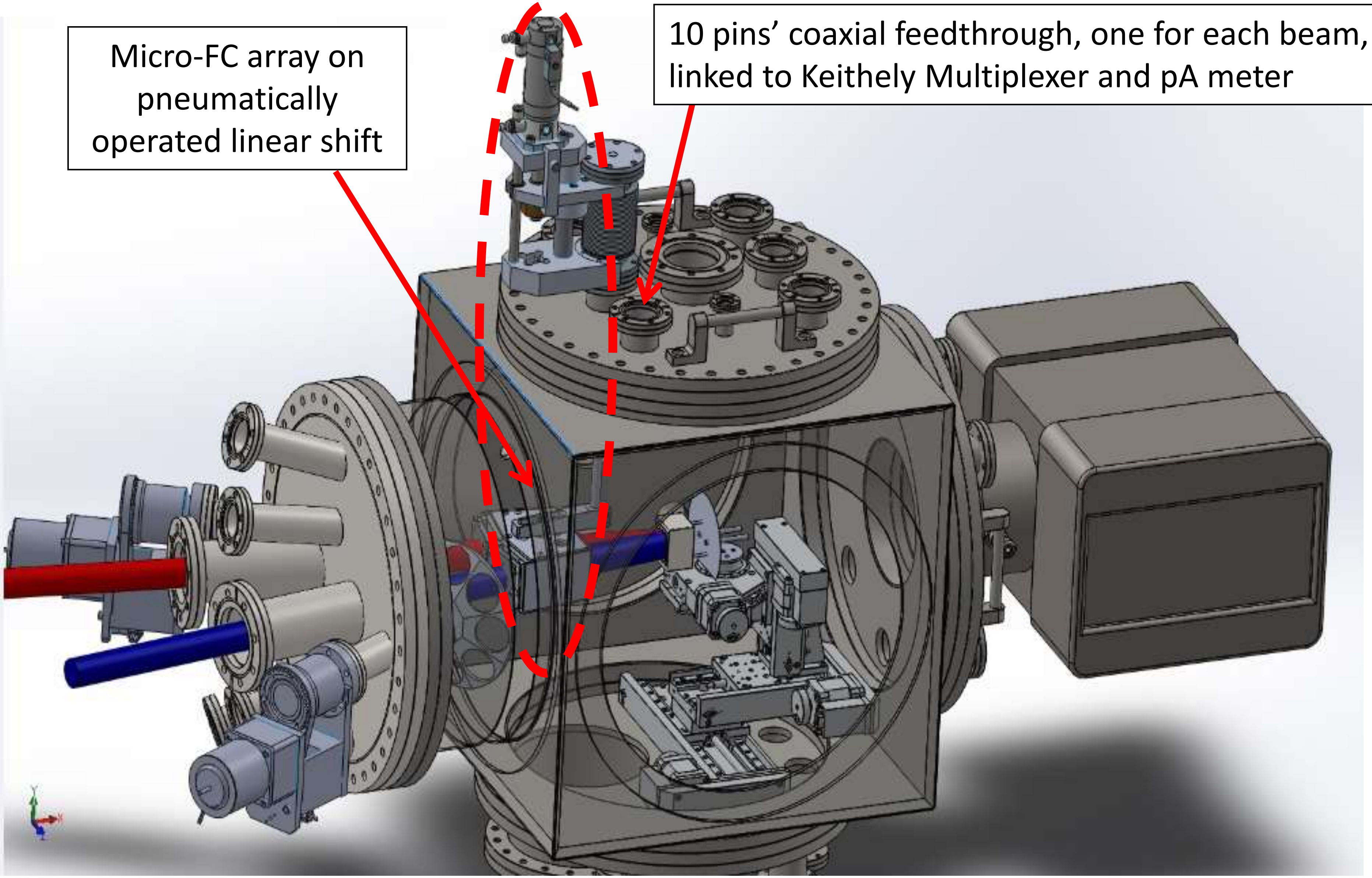
Rotational ion beam energy degraders at DiFu station



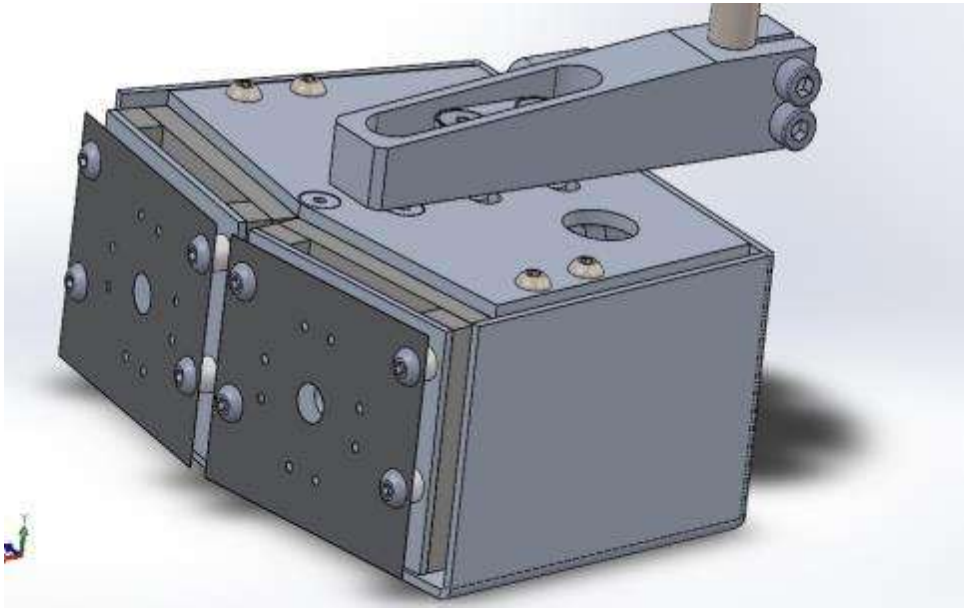


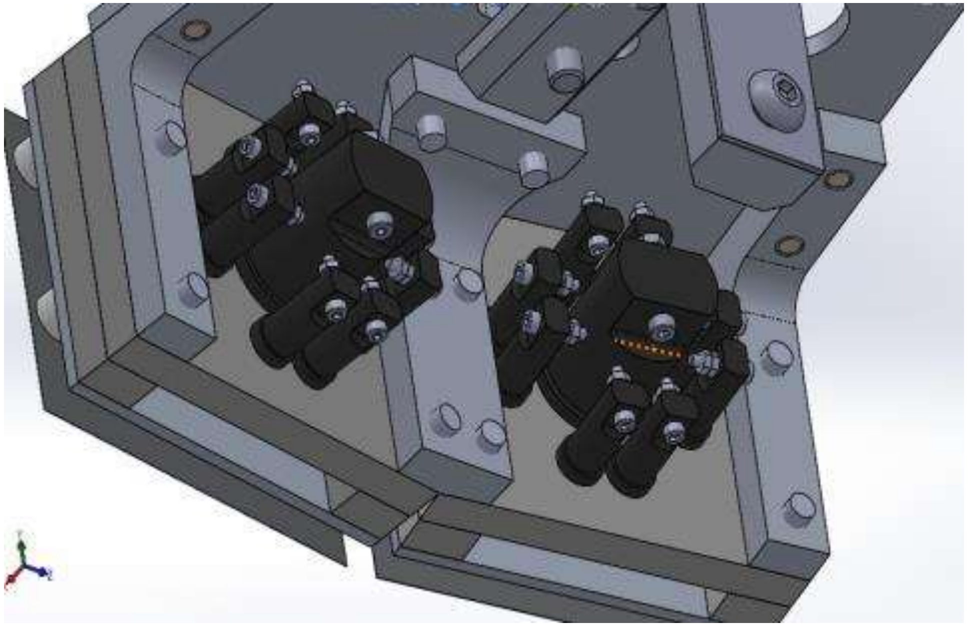
- Degraders shaped as 8-side pyramids, made of single Al block – good heat sink
- 1 empty + 7 foil-covered positions;
- Holes for foils of 35 mm diameter; foils 250 mm from sample surface
- Degraders fixed to rotating shaft & at 20^0 to the respective ion beam.

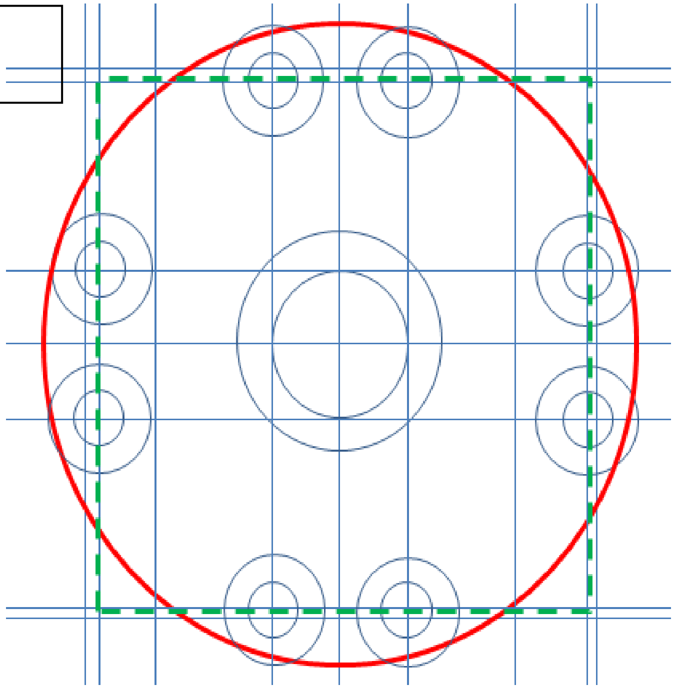
Micro-FC Array for ion flux monitoring



Micro-FC Array for ion flux monitoring





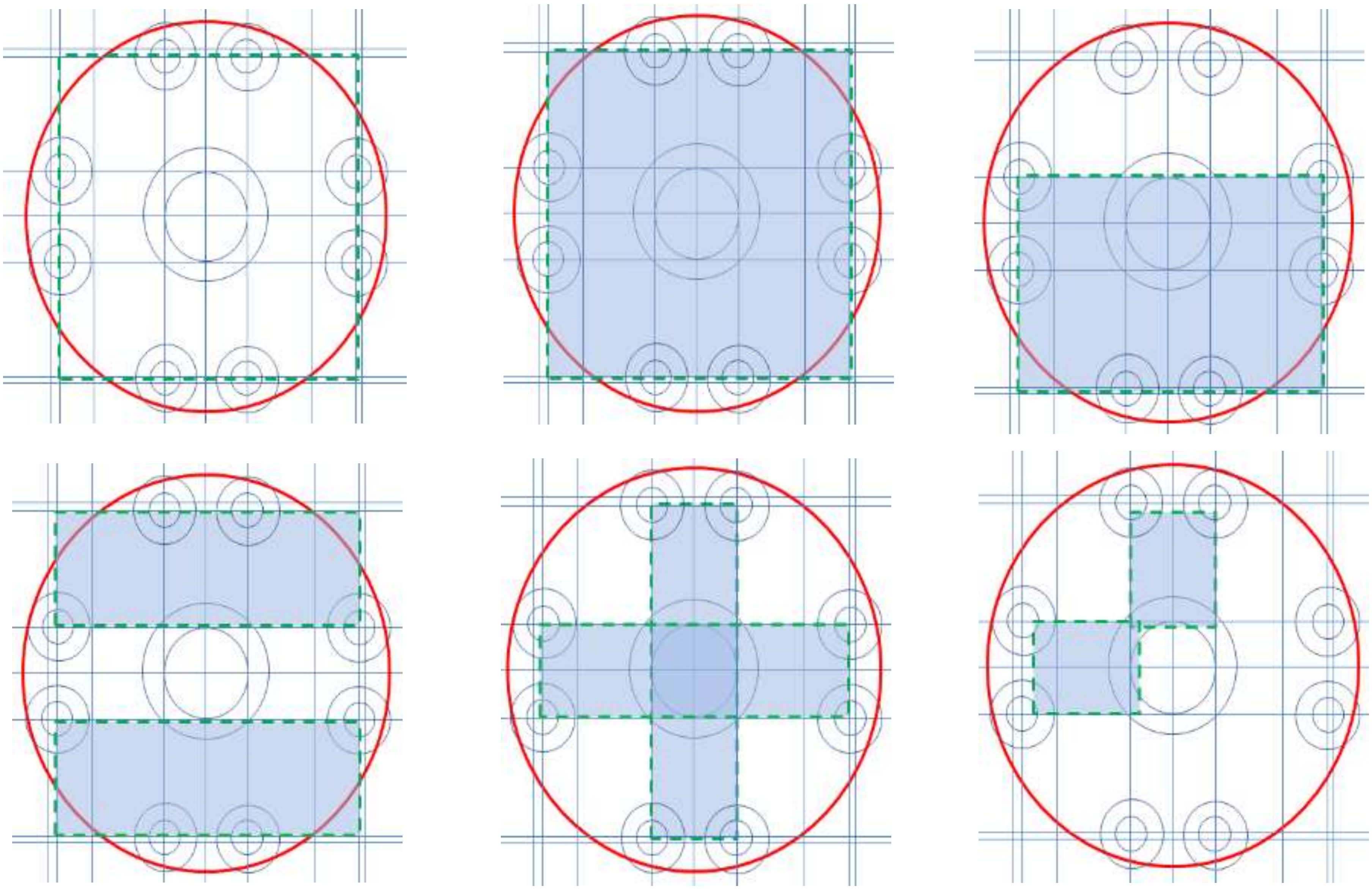


Planned configuration:

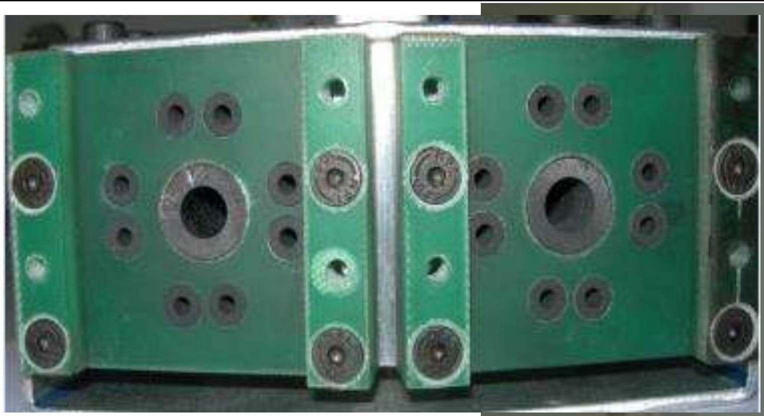
- Circle diameter 35 mm = size of Al foils at degrader; Dotted line 30x30 mm
- Central FC Ø8mm + 8 x FCs Ø3mm
- Multiplexer & pA meter for sequential ion flux measurement (30s in each 30 min)

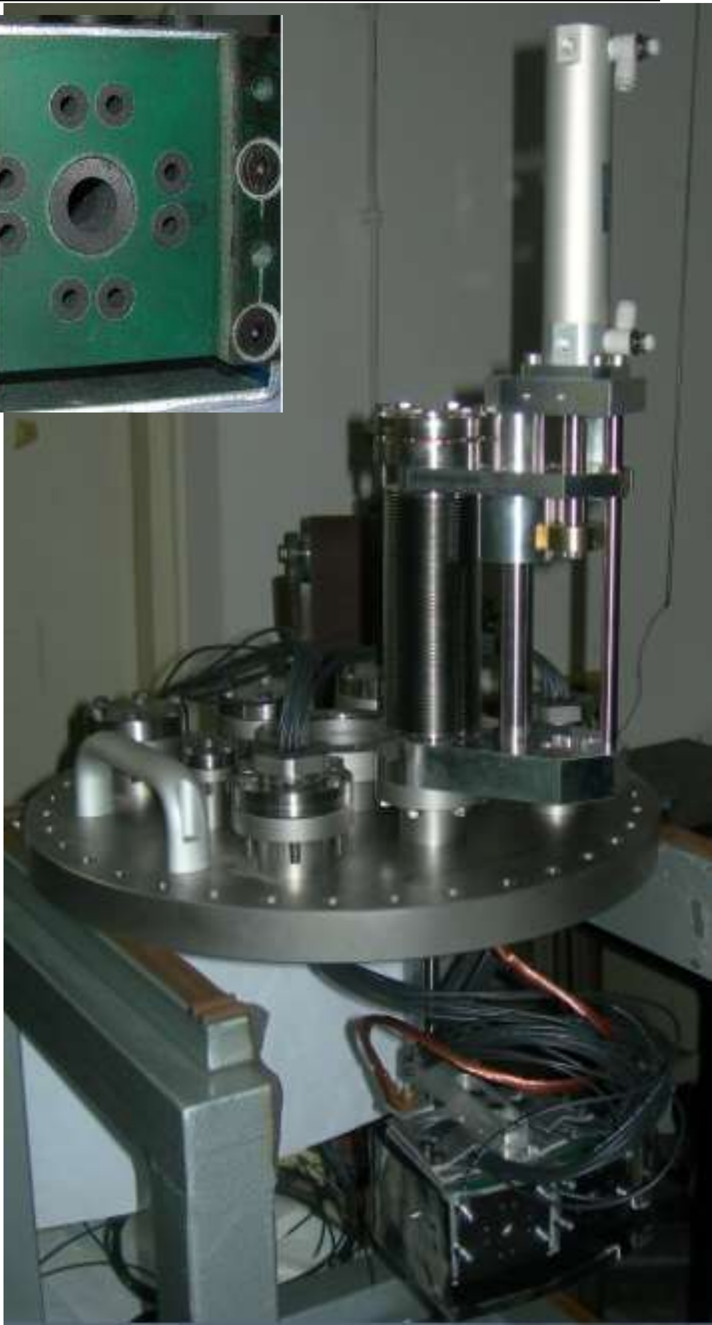
- Hardware and software developed for microbeam scanning enables pattern

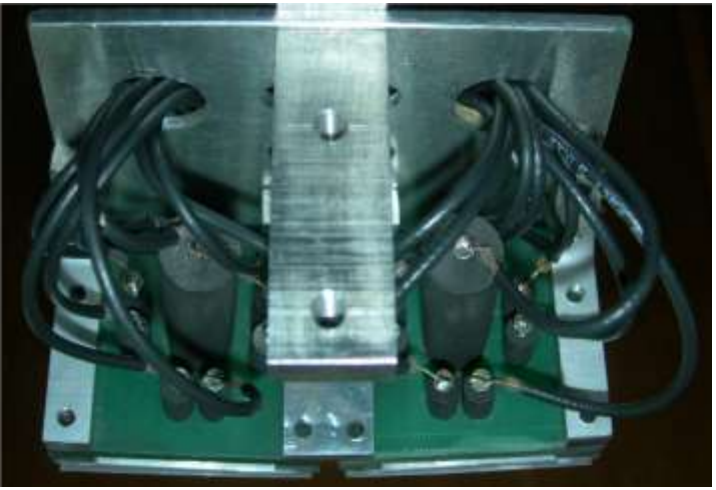
Various scanning areas monitored by Micro-FC array

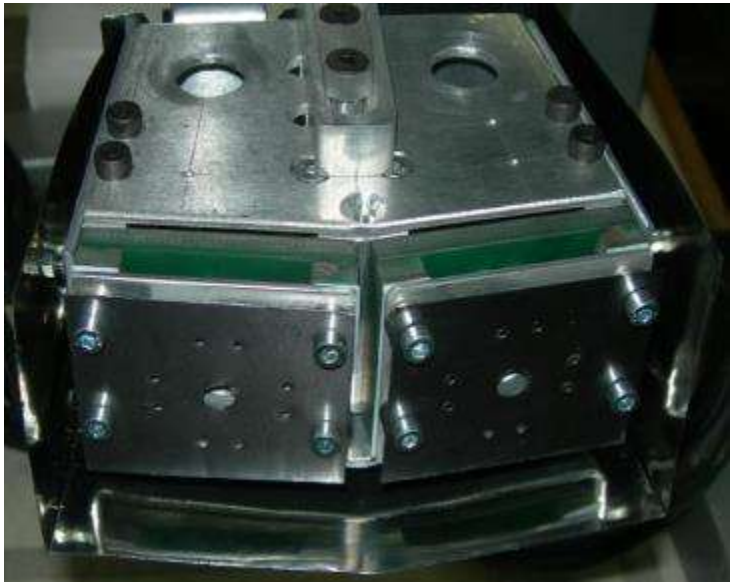


Micro-Faraday Cup Array for monitoring of ion flux

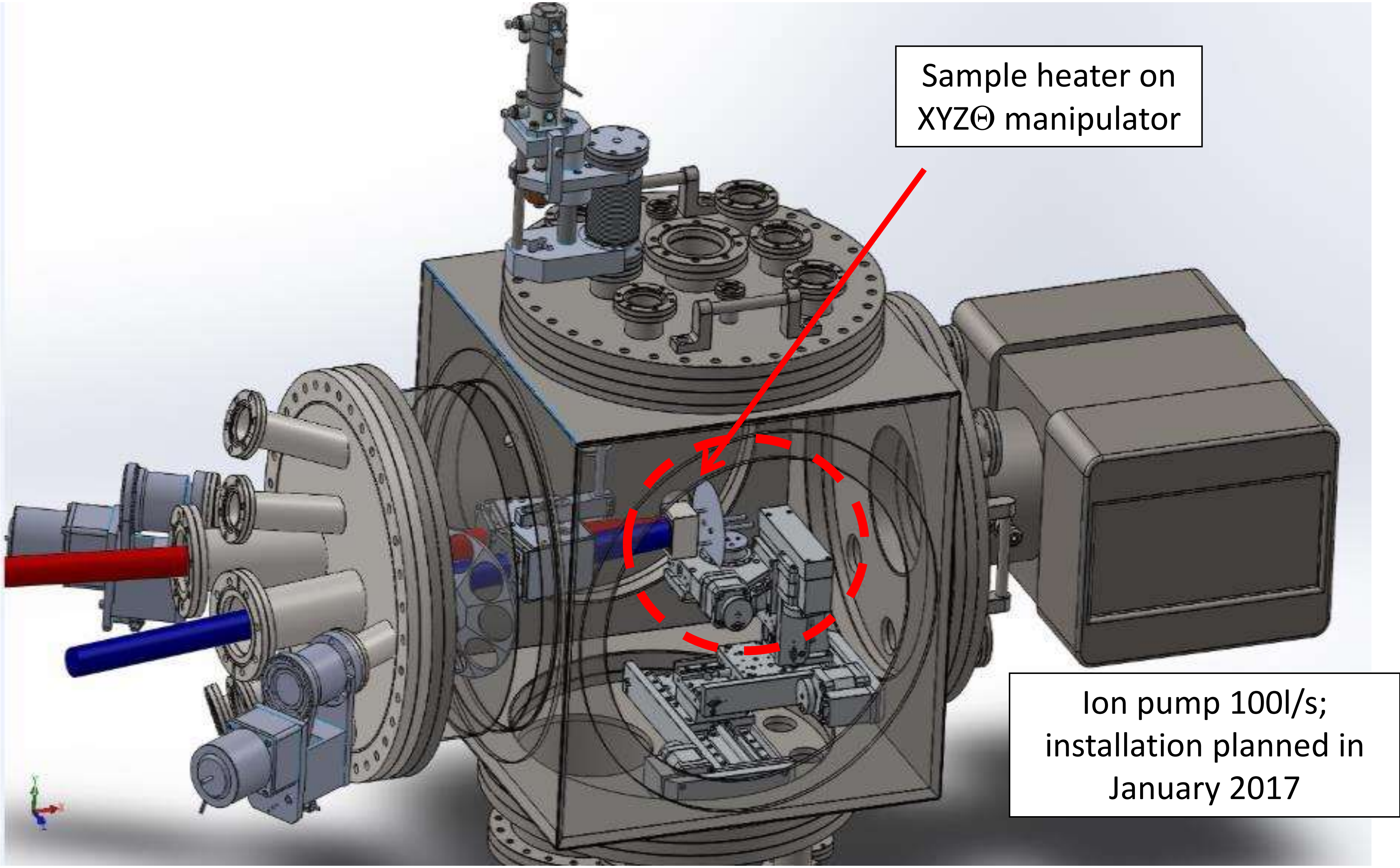






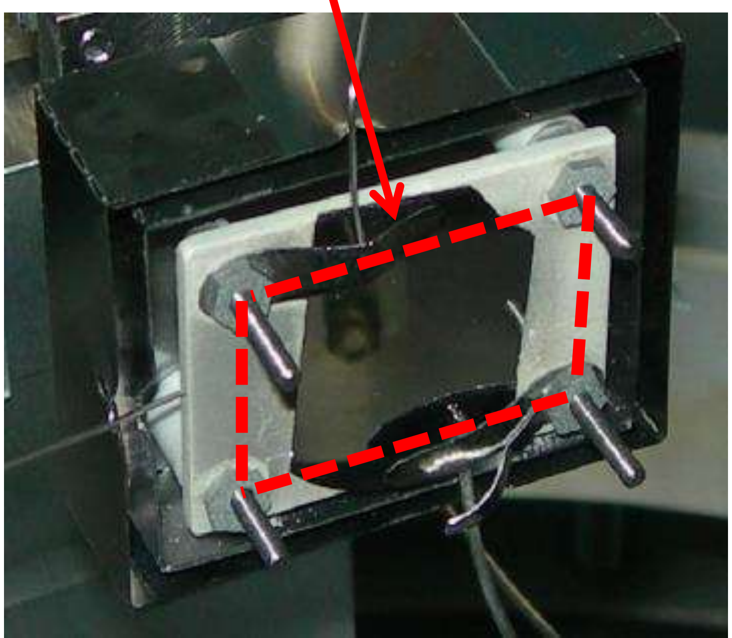


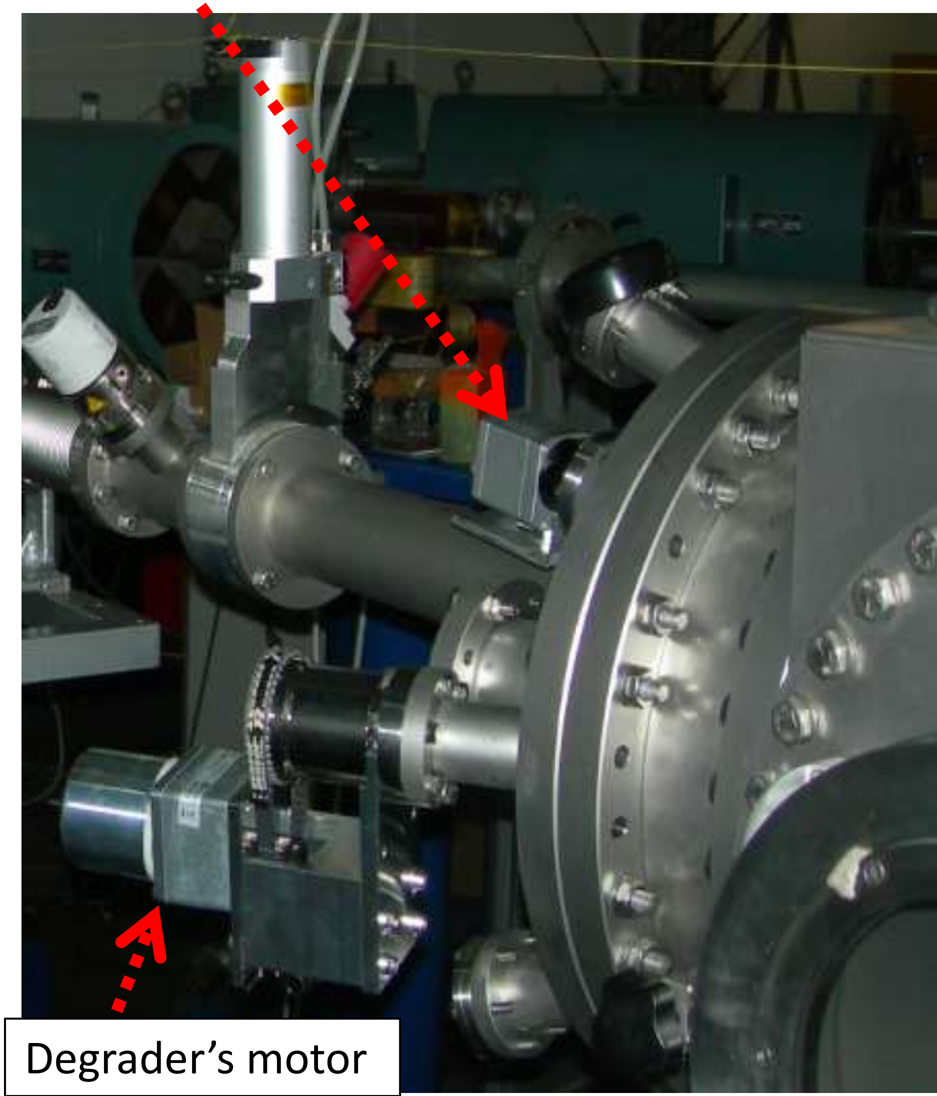
Sample heater on XYZΘ manipulator



Optris PI Infra Red Camera on ZnSe (uncoated) viewport;
-20 to 900°C measurement temperature range; 75 mK resolution
Up to 120 Hz real time video recording
640x480 pixels; position resolution 0.4 mm

Installation of 3 K-type thermocouples
at sample and TECTRA ohmic heater
Max. operating temp: ~ 700 ^{0}C
Low volume & rapid cooling
Heating area 35x25 mm





Degrader’s motor

Possible further upgrades:

- Ohmic heater with larger area: 50 x 75 mm; and/or
- IR quartz lamp heating of sample
- Active cooling of the sample
- FC-array on front frame – to avoid inserting of Micro-FC array
- Microscopy of irradiated samples
- Detectors for on-line IBA of irradiated samples
- Etc....

Key principles:

- Prolonged irradiation with low currents
- Flexibility of experimental conditions
- Tailoring of the setup according to customers' needs & ideas

Manchester (UK), Rosendorf (DE), Saclay (FR), Zagreb (HR)

Multi-ion beam facilities in EU

THANK YOU FOR ATTENTION!