PAUL SCHERRER INSTITUT

neutron imaging & activation group ©

BOA – imaging option

experiences in 2012

demands for 2013

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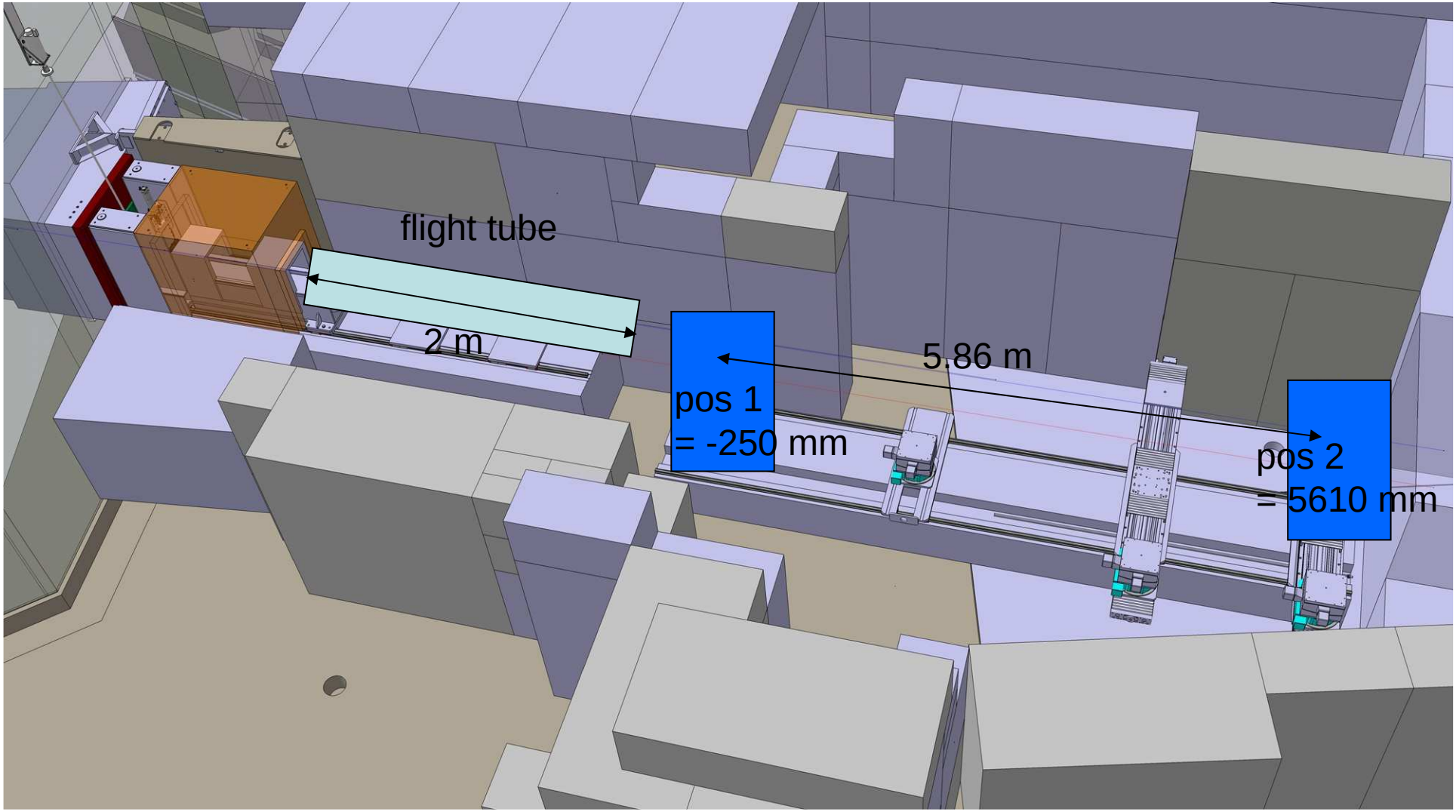
OUTLINE

- topics for NI @ BOA
- results in 2012
- problems and experiences
- options for improvements
- request for beam time in 2013

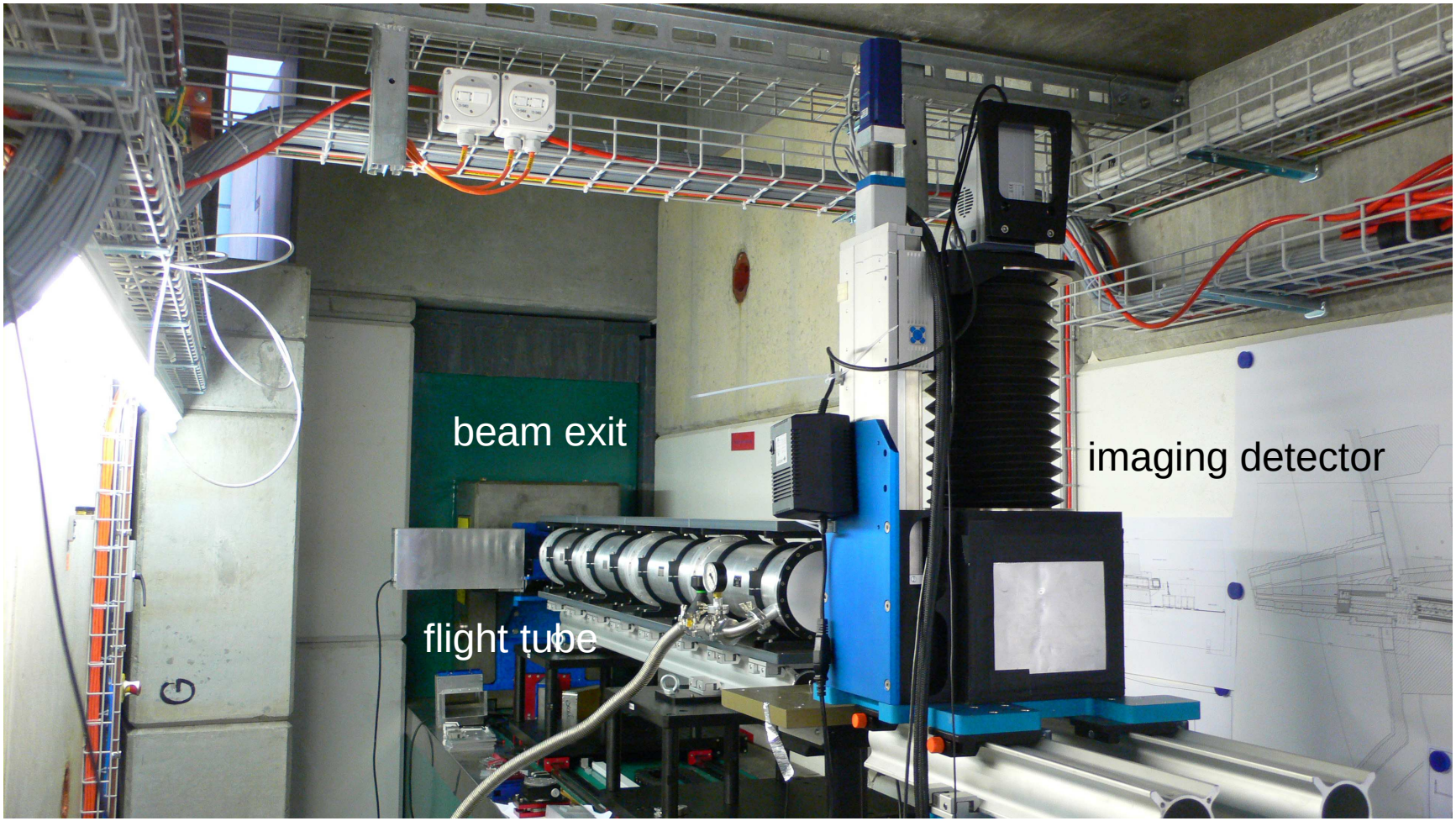
topics for neutron imaging at BOA

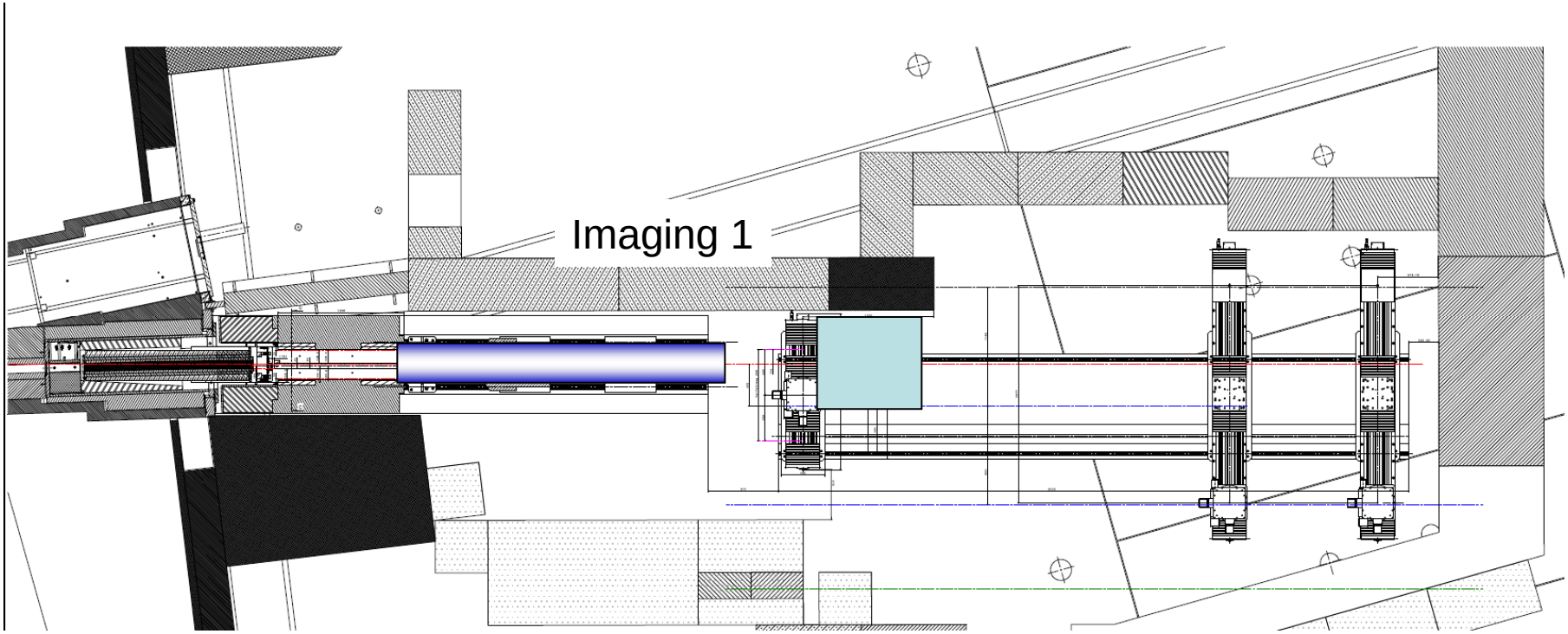
- polarized neutron imaging (ESS – IKON – WP)
- Tomography with high performance (sensitivity, contrast, speed, resolution, …)
- energy selective imaging (double crystal mono-chromatizer) – *PhD S. Peetermans*
- best quantification: scattering suppression in the absorption range
- phase-contrast imaging and edge enhancement by refraction
- Test of components for the n-microscope

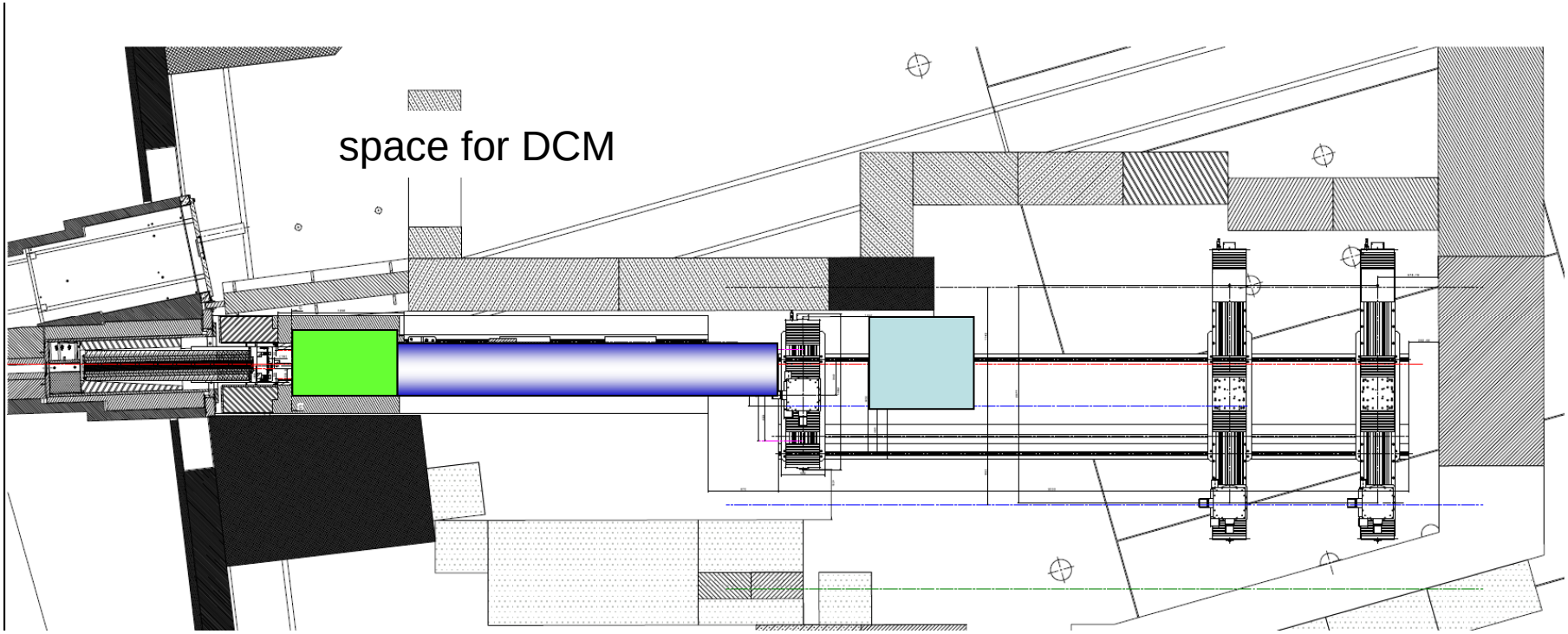
BOA layout

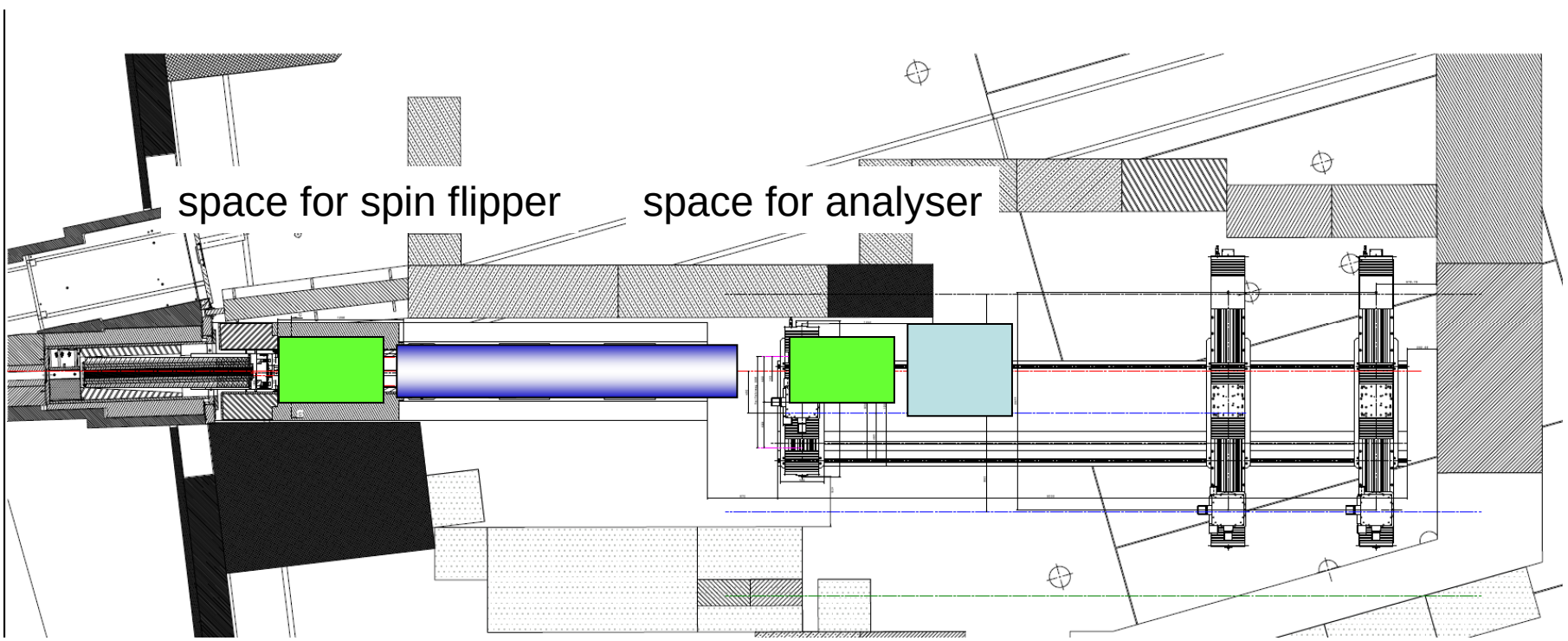


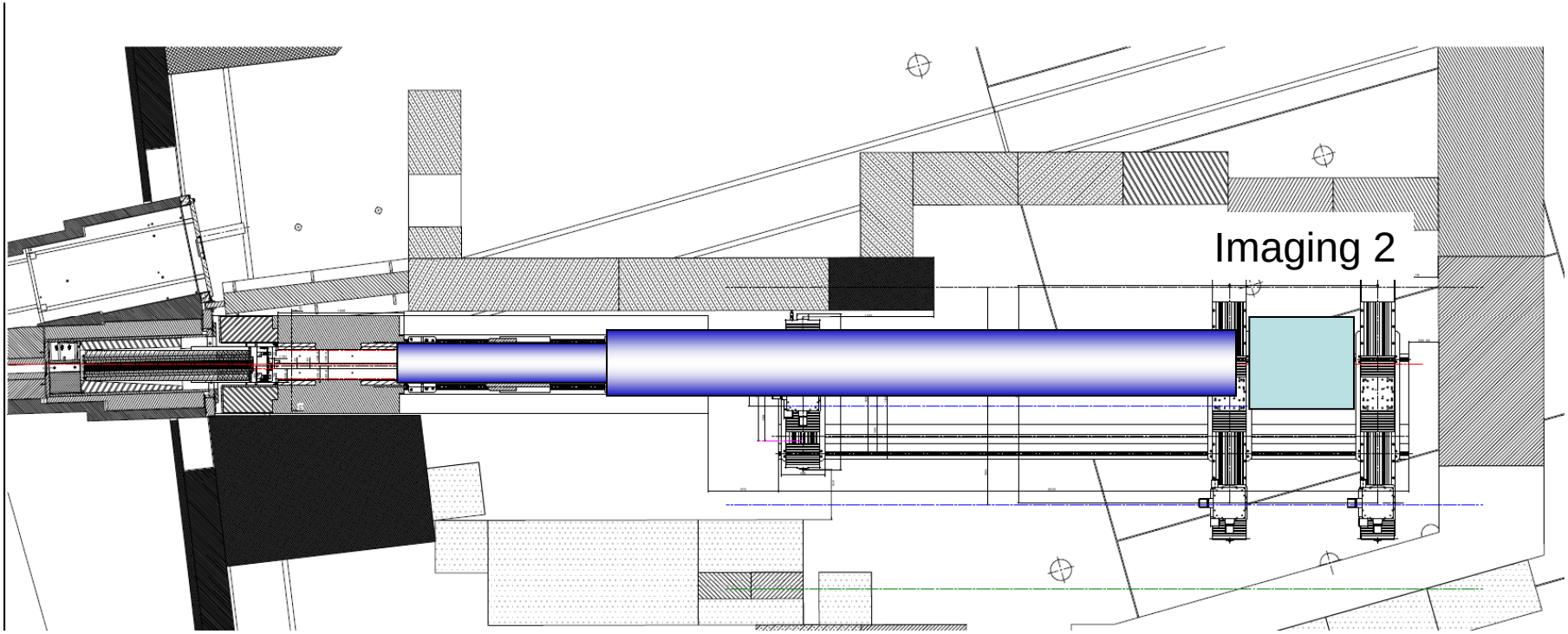
The neutron imaging setup at BOA - position 1 -




Imaging 1


space for DCM


space for spin flipper
space for analyser



not used in 2012

Beam time request NIAG in 2012

Person	Thema	Dauer	Bemerkung
S. Peetermans	Doppel-Kristall-Monochromator Test u. Inbetr.	1 Woche	gemeinsam mit LDM
S. Peetermans	Doppel-Kristall-Monochromator Nutzung	1 Woche	
A. Kaestner	Imaging mit Pol.Neutronen	1 Woche	gemeinsam mit M. Schulz, TUM
P. Boillat	Test von Brennstoffzellen	2 Wochen	
F. Piegsa	Imaging mit Pol.Neutronen	1 Woche	gemeinsam mit C. Grünzweig
E. Lehmann	Implementierung Micro-Tomography	2 Wochen	
E. Lehmann	Phasenkontrastmessungen	1 Woche	
	gesamt	9 Wochen	

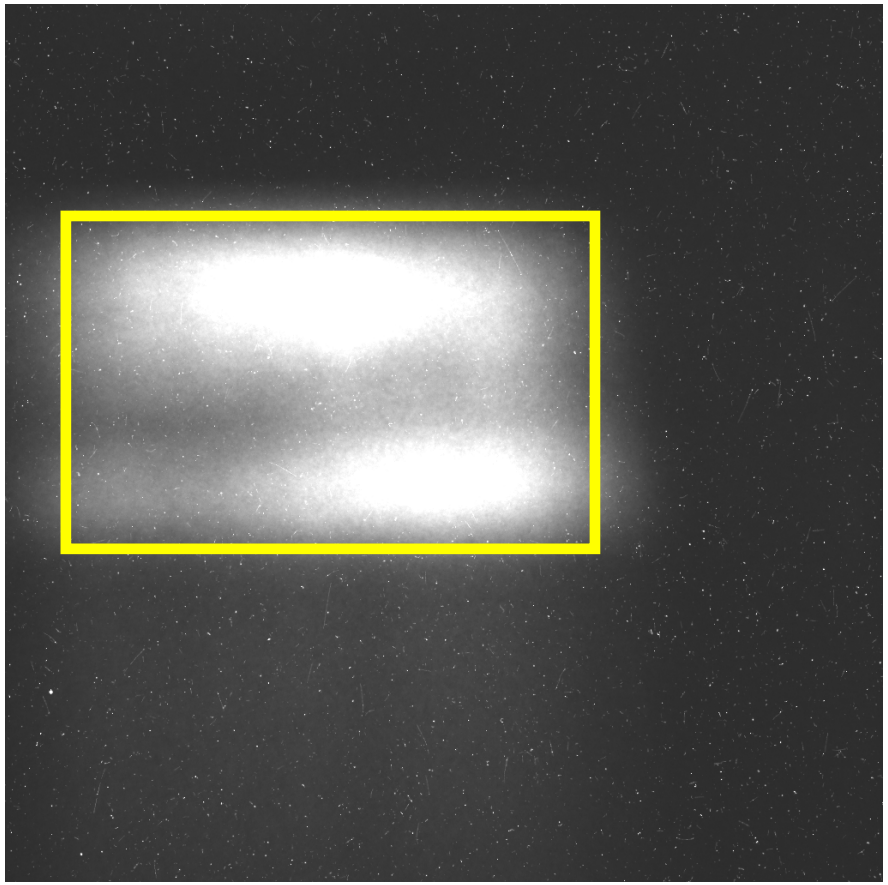
actually: 3 weeks allocated for NI, only 2 weeks were useful
1 week shared with A. Tremsin (detector development)

NI studies in 2012

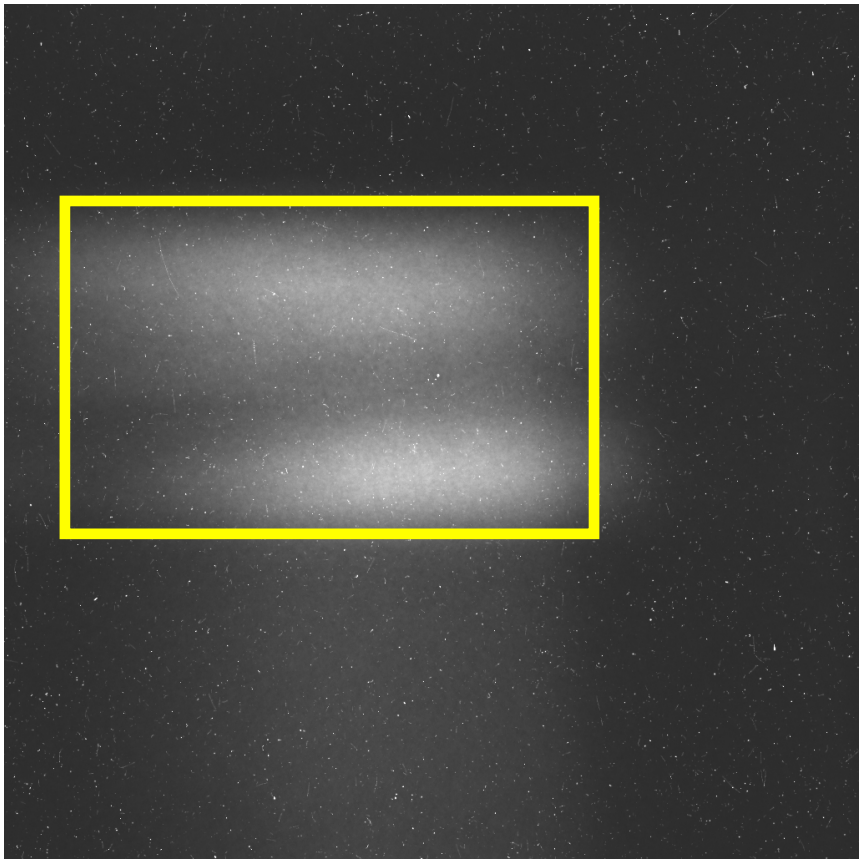
- **D**ouble **C**rystal **M**onochromatizer test (with T. Panzner)
- TOF (M. Morgano)
- Diffractive imaging with side detector setup (S. Peetermans)
- polarised neutron imaging (M. Morgano, A. Tremsin)
- energy selective tomography (M. Morgano)
- quantification (P. Vontobel, E. Lehmann)

DCM: Field of view „Open beams“

3 Å

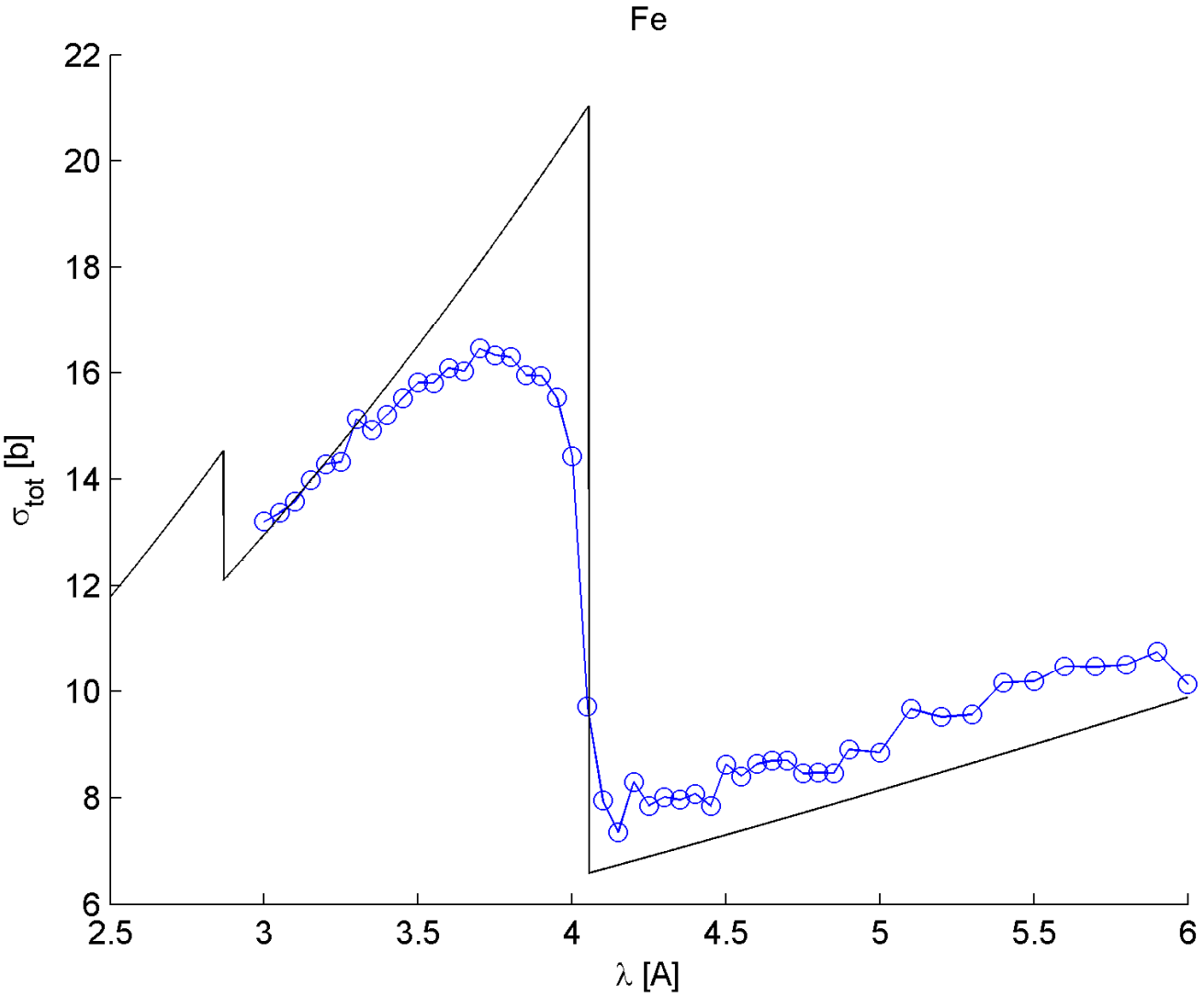


5 Å

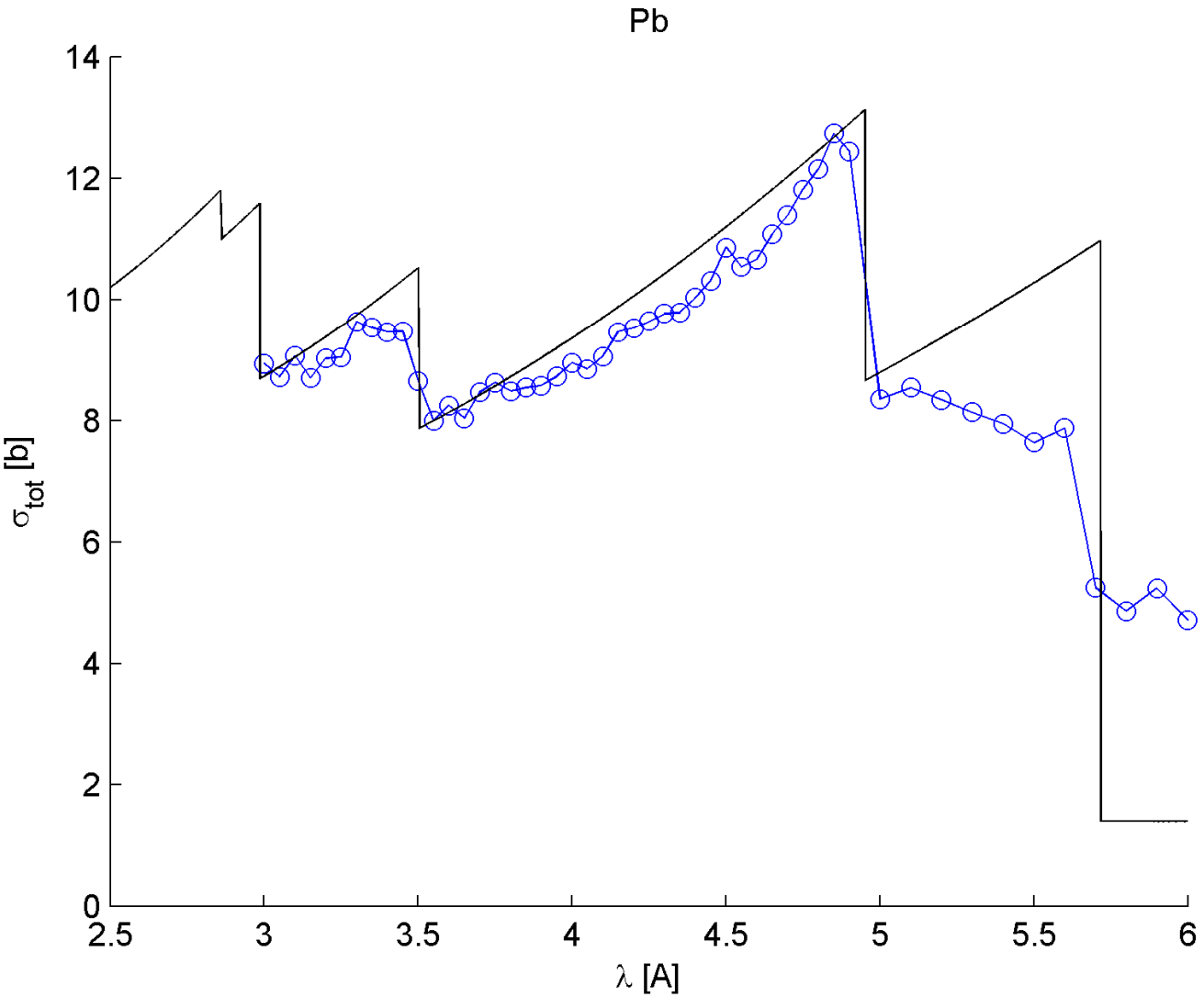


Size of the rectangle: about 3x5 cm2

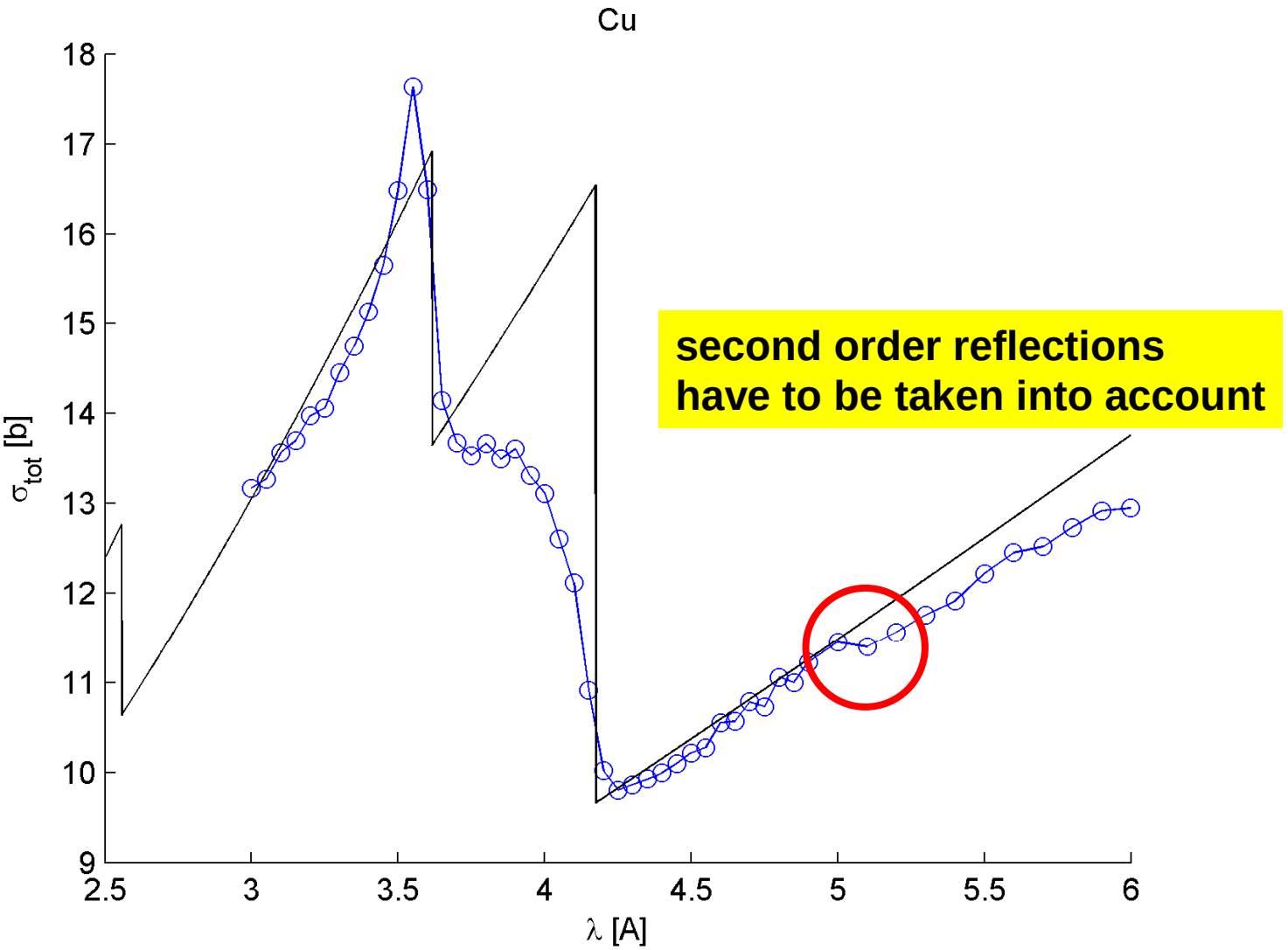
Bragg Edges - Iron



Bragg edges - lead



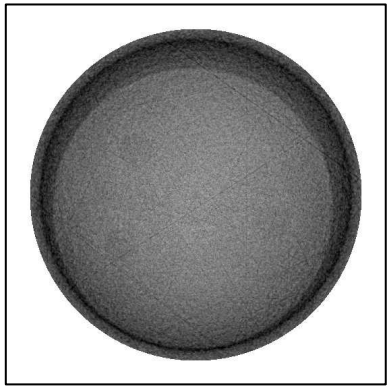
Bragg edges - copper



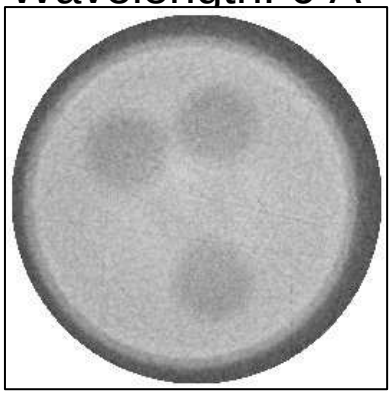
DCM: Mono-energetic tomography

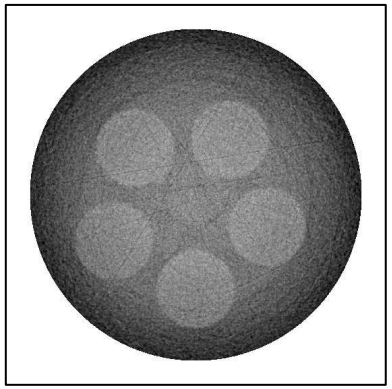
Reconstructed slices from a monochromatic tomography of two tests object: Cu cylinder with Al rods in it and Al cylinder with Cu rods in it. Size about 3 cm

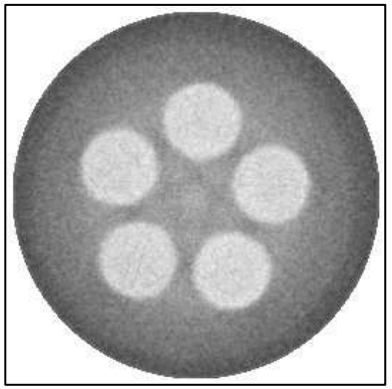
Wavelength: 3 Å



Wavelength: 6 Å







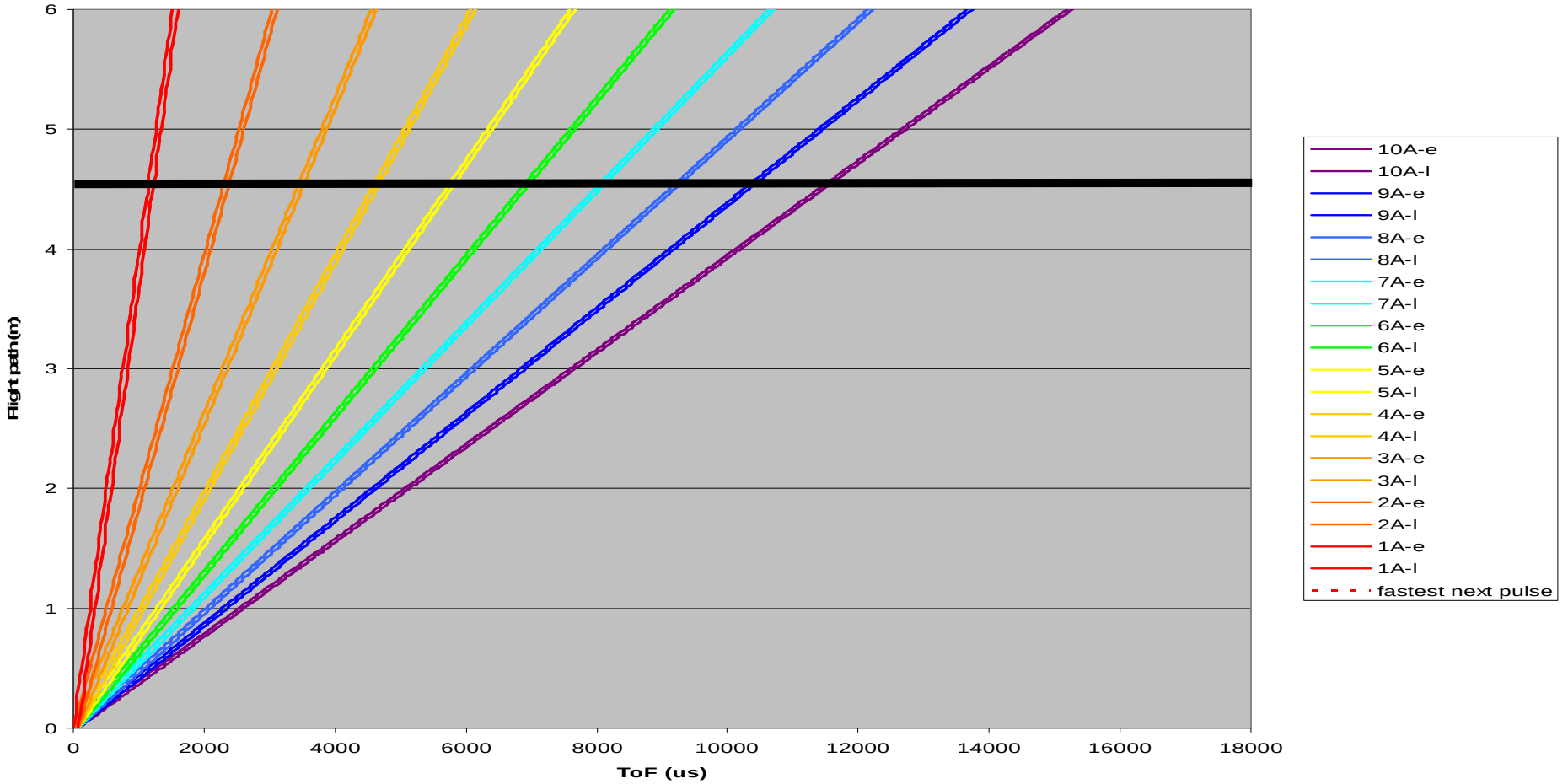
DCM conclusions

- technique maybe better than TESI @ ICON
- second order reflections have to be studied by TOF (and suppressed: 3rd crystal?)
- stable and fast alignment system needed
- new crystals for performance increase

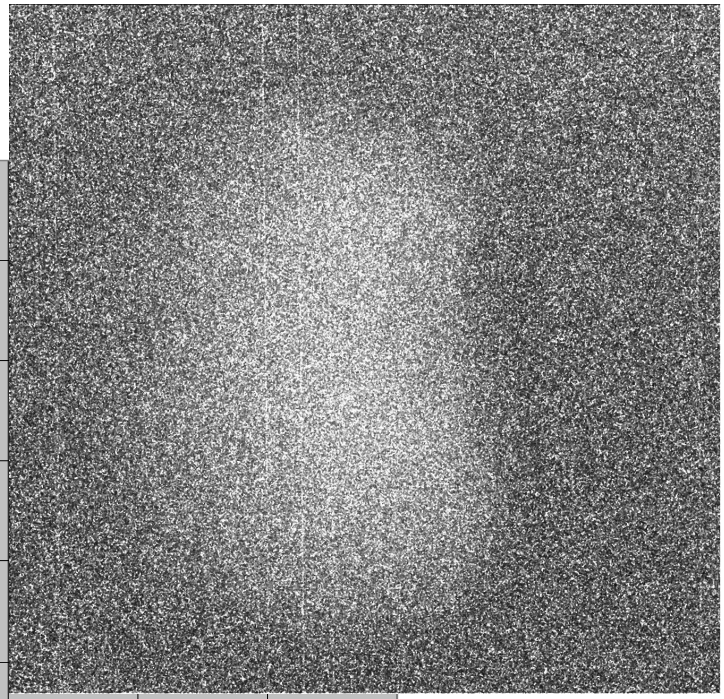
TOF @ BOA

- Chopper (20 Hz, 1mm and 30 mm slit)
- triggered and intensified CCD (PI max)
- stacking of images on-chip
- detector test for ESS imaging beam line

ToF measurements at BOA

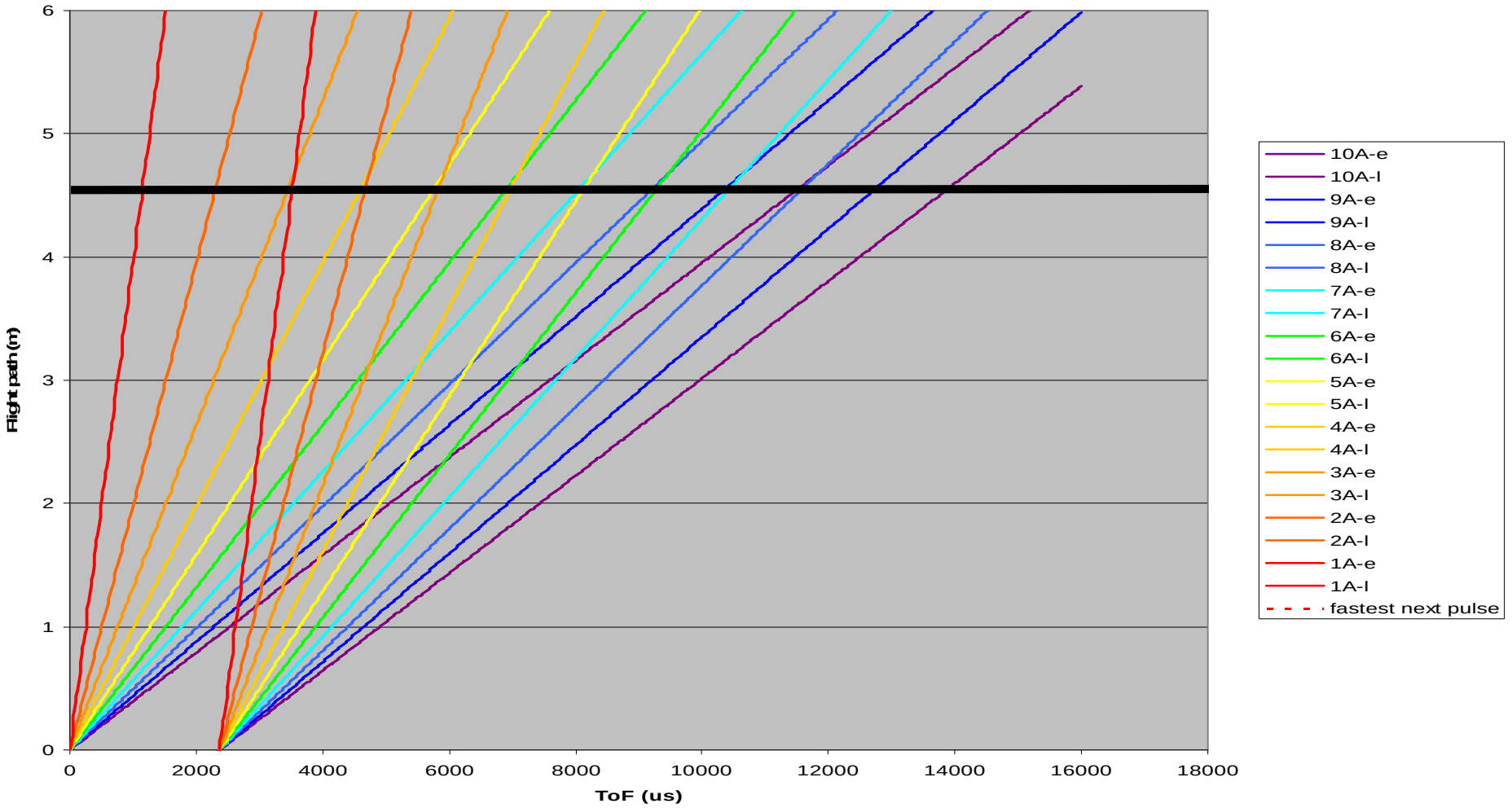


BOA spectrum

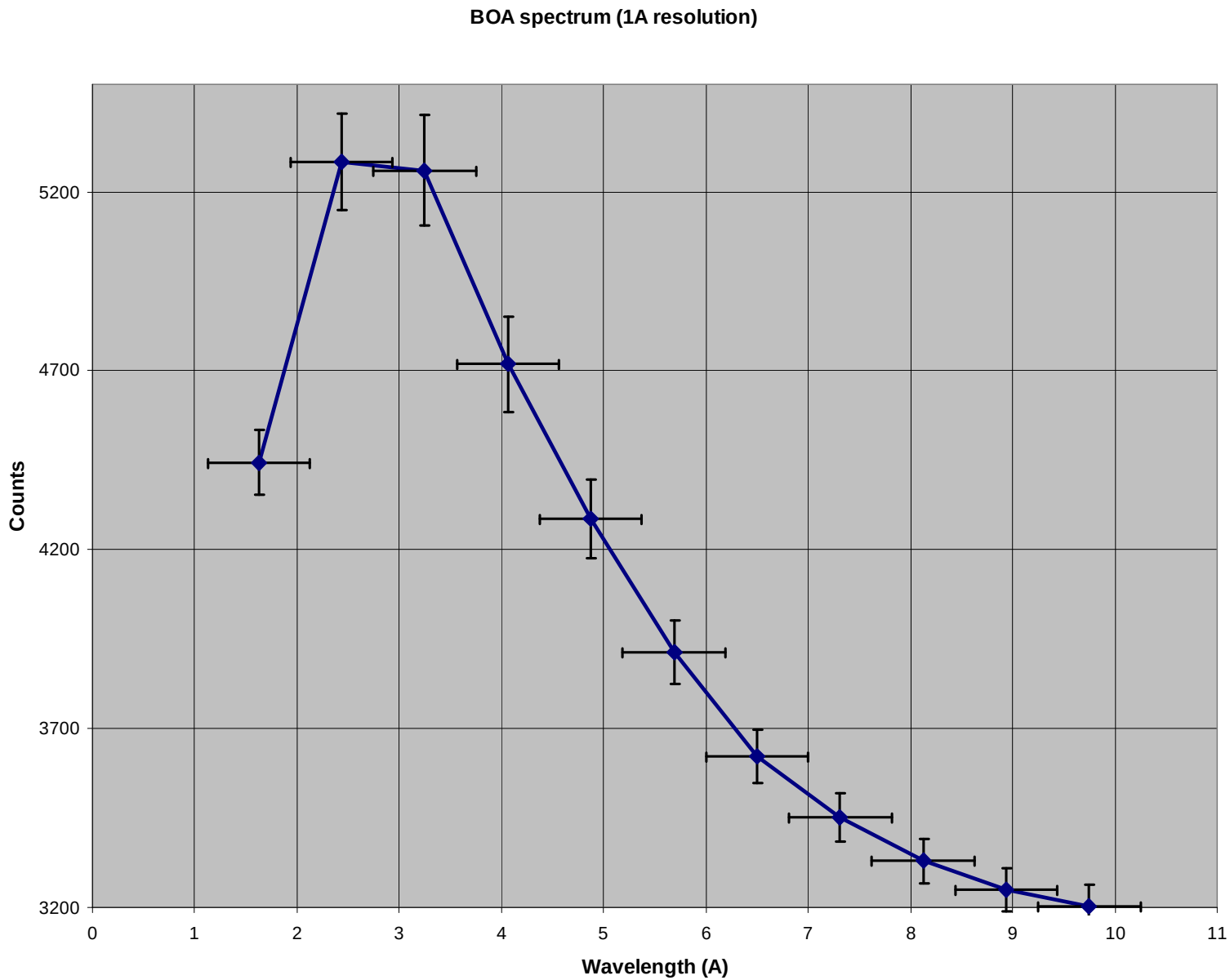


BOA spectrum v.2

- Slit width 30mm, time bin = 1ms
- Spectrum with coarse resolution (1A)



BOA spectrum



Problems with this setup (at BOA)

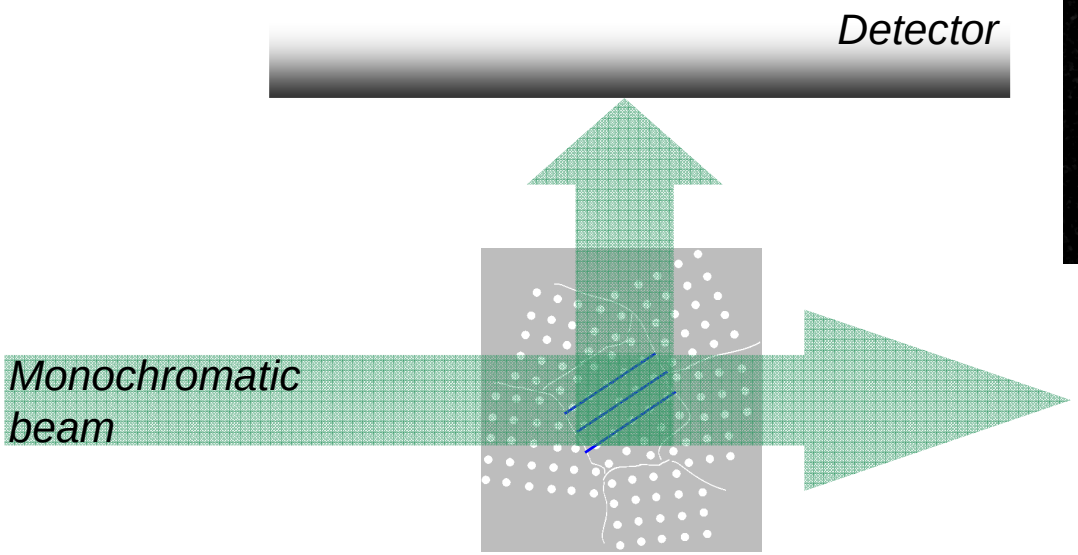
- Choice of only 2 blades with slits of 1mm or 30mm.
- 1 mm slit is too small. To achieve a nice DR you need an exposure time of around 4 seconds. The slit's aperture time is just 80 us at 20 Hz. This requires the accumulation of 50000 images that, at 20 Hz, takes almost 45 minutes per image. Not very practical.
- 30 mm slit is too big. Its aperture time is more than 2 ms (at 20 Hz) which induces a lot of contamination in the spectrum and a poor energy resolution.

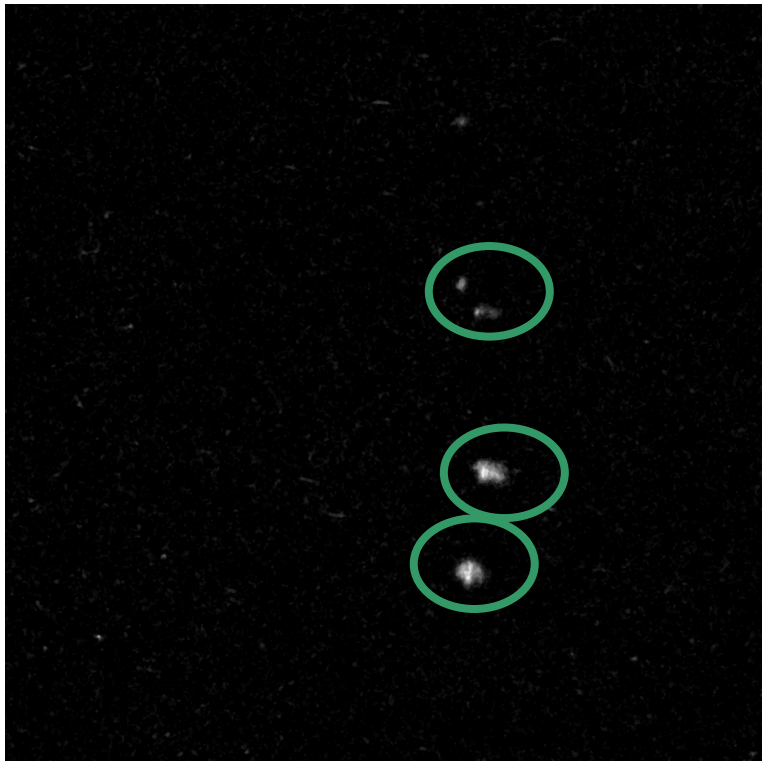
- The frequency of the chopper is not enough.

Diffractive imaging setup

BOA well suited:

- Double crystal monochromator (though λ/2…)
- Flexible automatized camera positioning angle around sample (>< DDS@ICON)

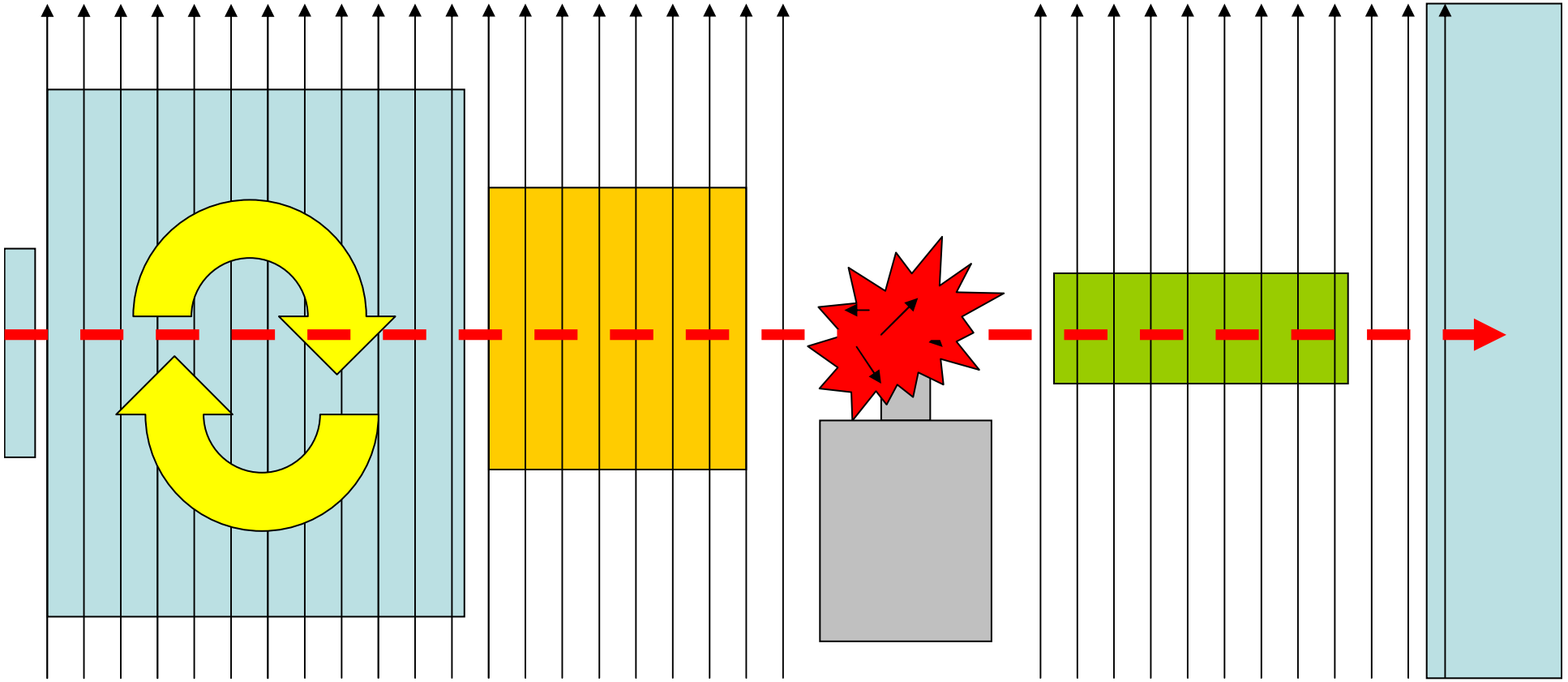




Coarse grained Aluminium sample:
detector at 90°, 2.87A

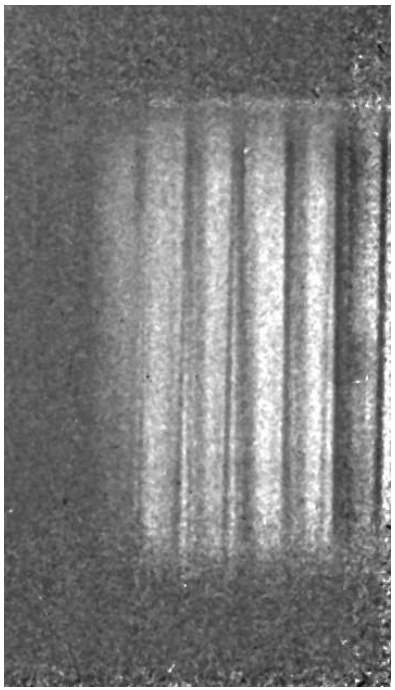
Polarization imaging setup

- Guiding field along the beam path
- Spin flipper
- Double crystal monochromator (optional)
- Sample holder (outside the guiding field, but not too far)
- Analyzer (we have used two of them)
- Camera/Pixellated detector

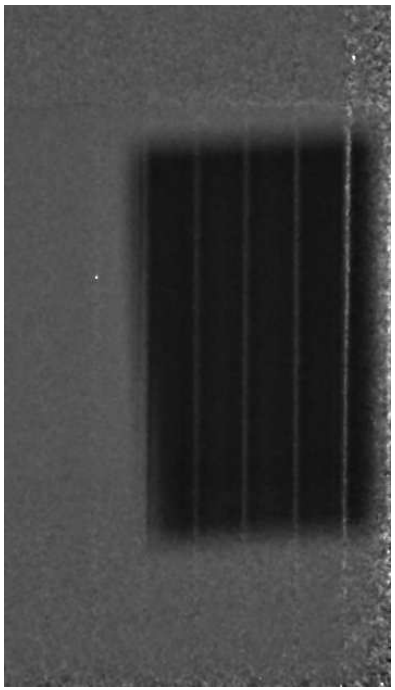

Spin flipper
DCM
sample
analyzer
CCD

Images of a weak magnet in the beam

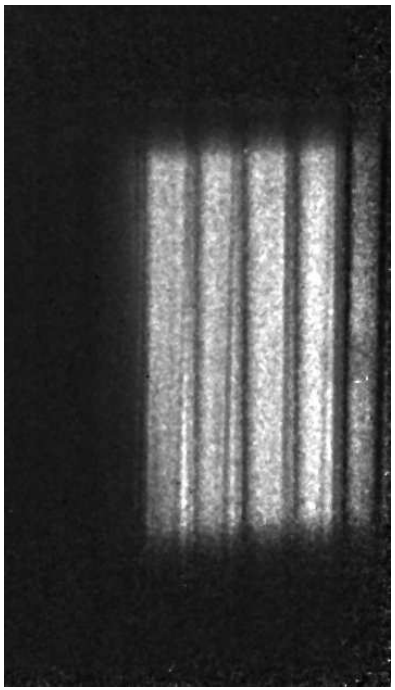
Flipper OFF



Flipper ON



OFF/ON

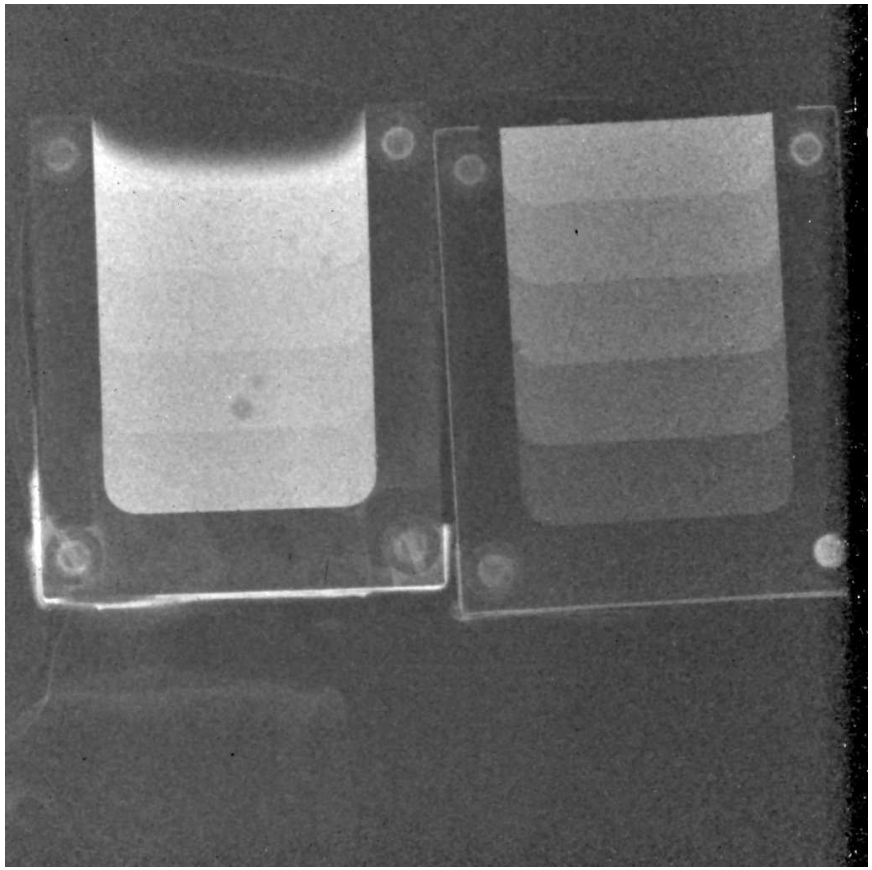


Water content quantification

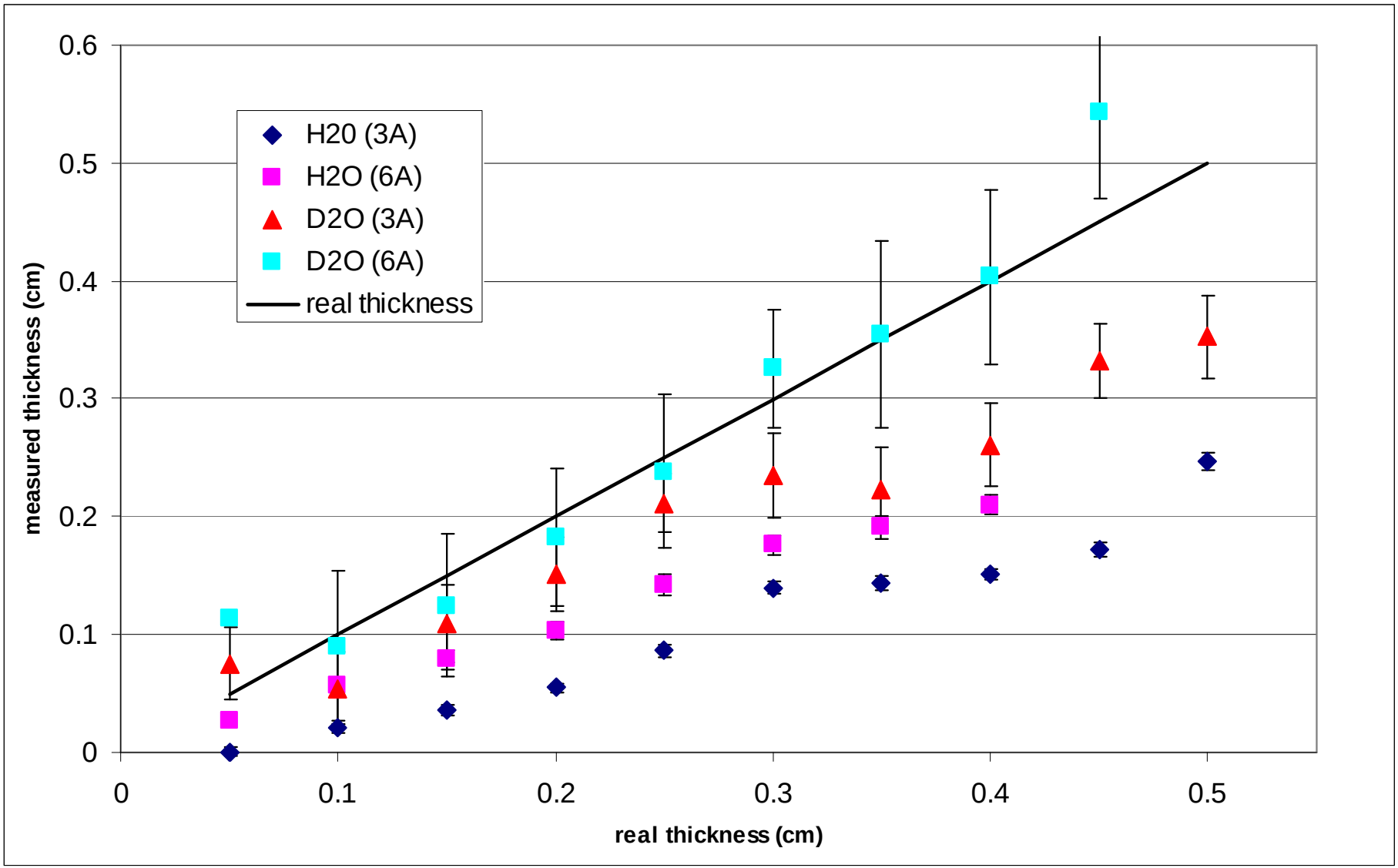
Step-wedge filled with D2O and H2O

Steps of 0.5 mm

Measured at 3 and 6 A



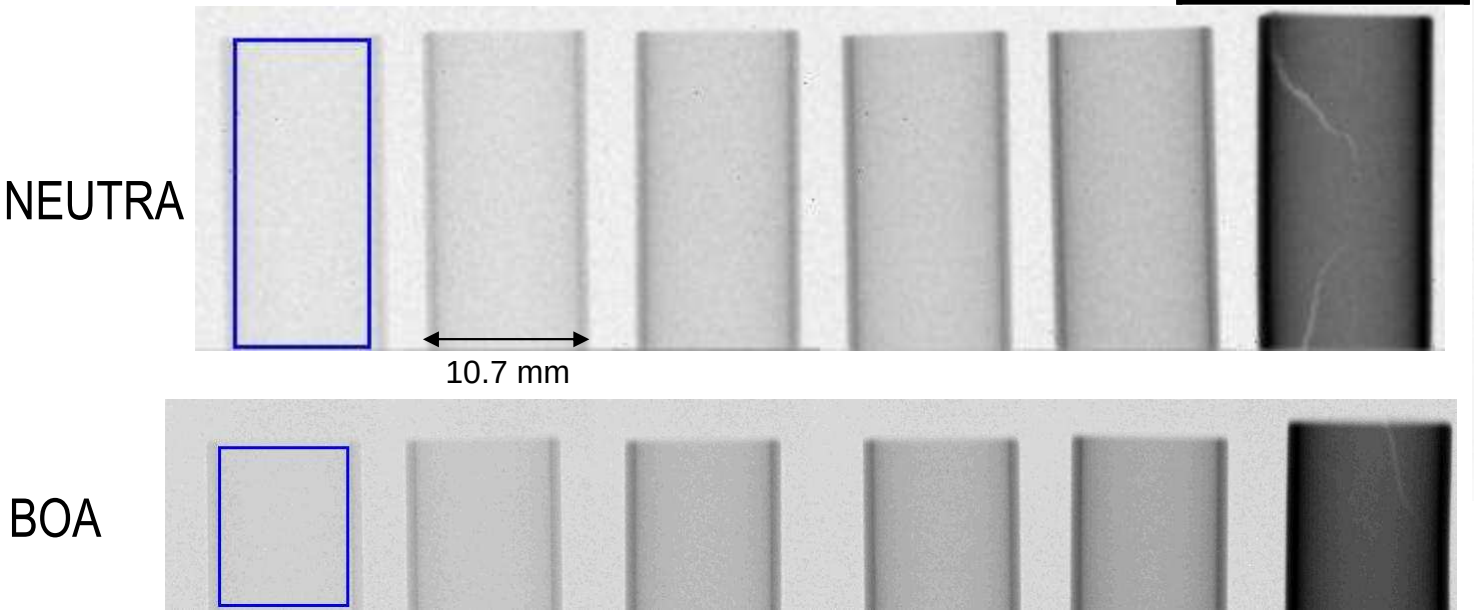
Water content quantification

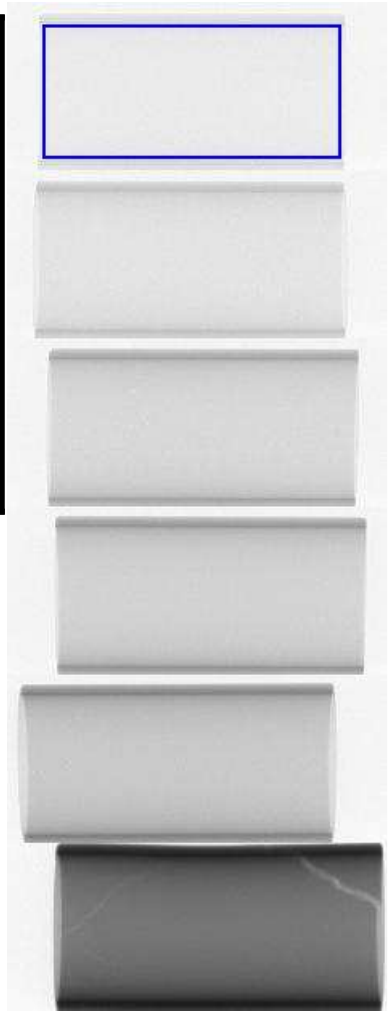


Hüllrohrproben: Zircaloy-4 mit definierter Wasserstoffbeladung

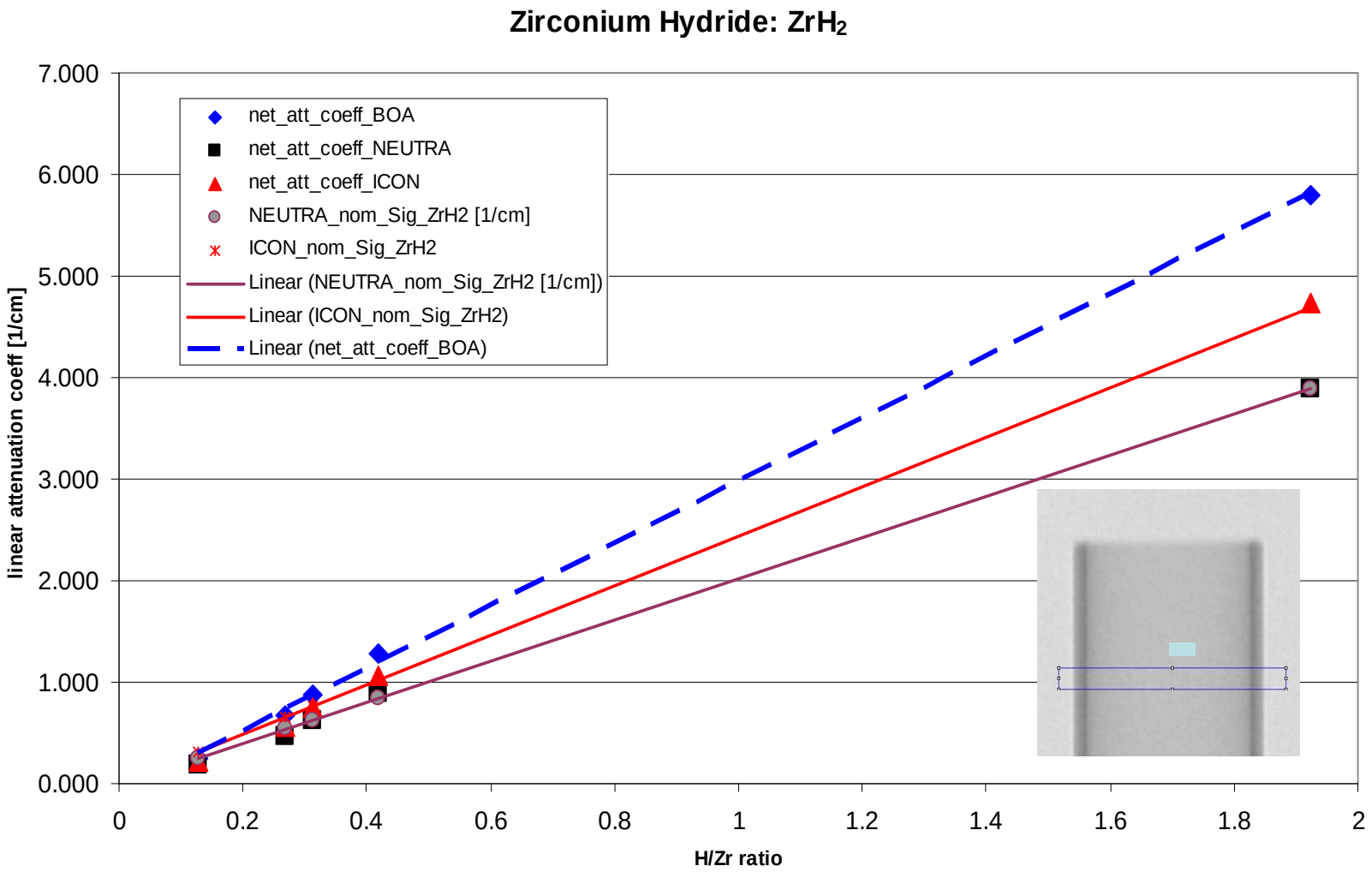
- Mirco Grosse, KIT hat eine Serie von 6 Referenz-Hüllrohrproben (von LWR Brennstäben) mit definierter Wasserstoffbeladung hergestellt. Research topic: **Hydrogen distribution in nuclear fuel cladding materials tested under LOCA conditions**
- **Aufgabe: Untersuche die Sensitivität von Neutronen-transmissionsmessungen zur Wasserstoff-gehaltsbestimmung an den 3 NR Strahllinien NEUTRA, ICON und BOA mit ihrem thermischen bzw kalten Neutronenspektrum.**

Probe	H/Zr ratio
8	0
9	0.127
10	0.268
11	0.312
12	0.418
13	1.924





Abschwächungskoeffizient aus radialem Profil



Request for knowledge about BOA properties

- neutron intensity
- neutron spectrum
- homogeneity
- polarization
- useful FOV under various conditions
- collimation options

Request for improved infrastructure

- better crystals for DCM
- faster DCM alignment
- translation stage close to the detector
- optimized analyzer (NIAG task)
- table/mounting for flight tube
- horizontal collimation
- higher reliability

→*better communication about system status*

→*we like to contribute more …*

Demand for beam time 2013

- Polarized neutron imaging (MM34): at least 2 weeks
- Energy selective imaging (PT34) with DCM: 2 weeks
- Double detector setup tests (PT34): 1 week
- High sensitivity H detection (BP56) (i.e. fuel cell, fuel cladd.): 1 week
- Scintillator development (TP34): can probably be done sparsely
- IF focusing guide must be tested: at least 1 week
- Refractive edge enhancement studies under BOA conditions (LE34)
- Tomography performance study at BOA (KN34): 1 week.
- **Minimum: 5 weeks**