THOR

THe HORizontal Reflectometer

INSTRUMENT PROPOSAL

IKON 9-2013

M. Strobl

Instrument Division

ESS AB

EUROPEAN SPALLATION SOURCE

Contributing WU in NR WP

Table 4: Work Package breakdown structure for Instrument Concepts

anag. IC1	**SANS IC2**	**Reflectometry IC3**	**Macromol. Diffraction IC4**	**Single Crystal Diffraction IC5**	**Powder Diffraction IC6**	**Materials Engin. Diffraction IC7**	**Imaging IC8**	**Direc Spect**
	Conventional SANS Full DU for fast conv. ext. q-range SANS, 29 PM, SD004DE/a	Horizontal Reflectometer Full DU for wide q and add-ons, 23 PM, SD003DE/a	Macromol. Diff. Full DU, potent. farm SD036ESS	Magn. Single Crystal Diffractom. Full DU SD060ESS	Wide Band Powder Diffraction Full DU, wfm, gen. purp., 23 PM, SD005DE/a	Engineering Diffraction SPEED full DU plus prototyping tests, 57 PM, SD005DE/b	Multi Purp. HR Imaging Full DU in close collab. with CH, dark-field, Bragg edge, polarized 68 PM, SD006DE	Cold Spect Full DU, hig pol. ca SD
	GISANS Full DU, potent.	Vertical Magnetism			Multi Purp. Extreme	CEED Full DU, tests, PM,	Larmor Label. Full DU, TOF DF imaging	Bisp Ch

Activities on that concept started already in Ven (and earlier) became German WU

Main contributions:

D. Nekrassov, M. Trapp, K. Lieutenant, J.-F. Moulin

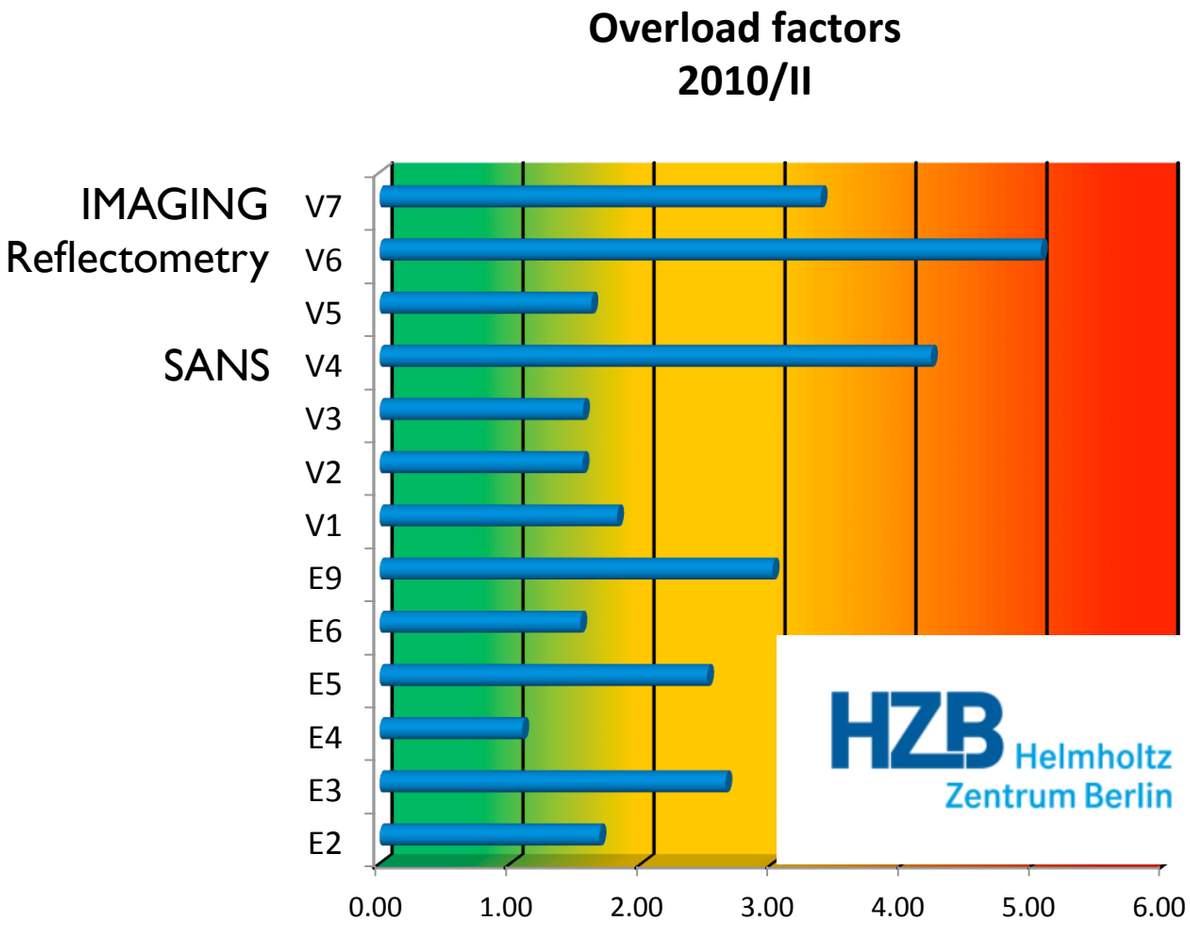
R. Steitz, M. Strobl

published:

arxiv:physics.ins-det/1309.6215

General simulations, in-house supporting simulations, interface moderator-beam extraction, McStas SD022DK, 5

THOR - User demand



3

D17, SuperADAM, Figaro

Science & Technology I ISIS

4

SURF, CRISP, INTER, Offspec, PolREF

FRM II

5

N-REX+, MARIA, REFSANS, MIRA, TREFF

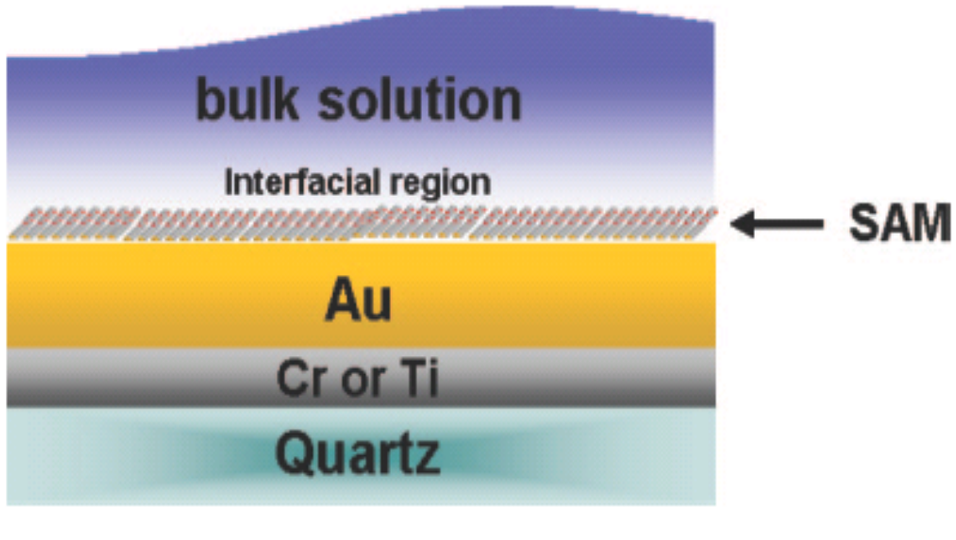
NIST National Institute of Standards and Technology U.S. Department of Commerce

3

NG1, NG7, AND/R

THOR - Science case

High Q - monolayers

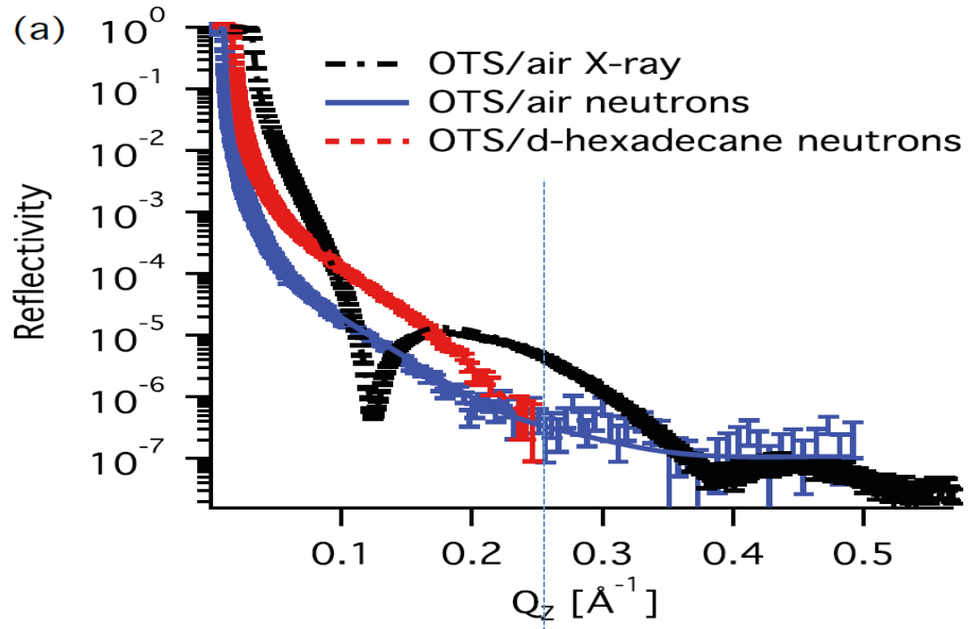


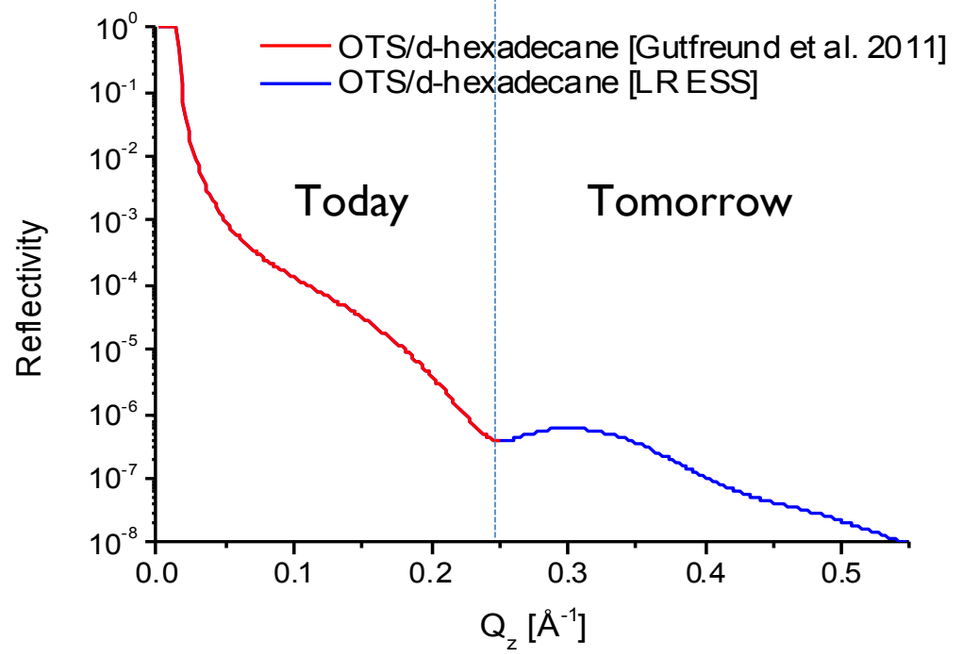
M. Skoda et al.,
Langmuir **2009,** *25,* 4056

P. Gutfreund, et al.,
J. Chem. Phys. **2011,** *134*, 064711:

Silicon/**OTS**/liquid including roughness

d_{OTS} = 25Å





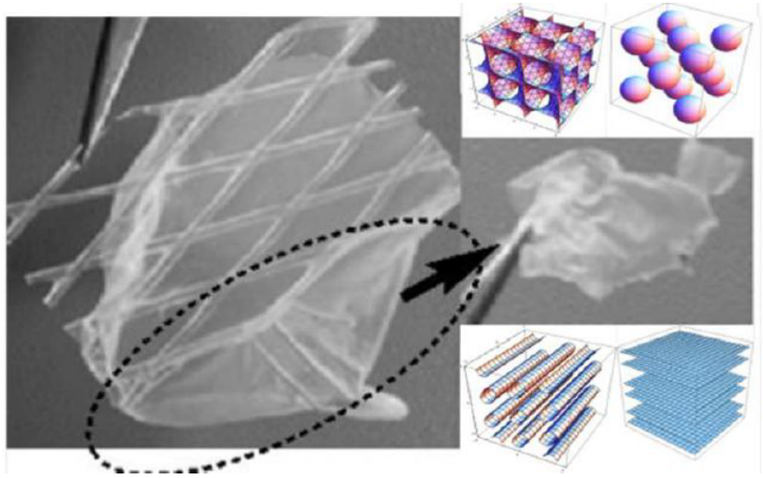
Unambiguous determination of thickness, i.e. decoupling of d and SLD

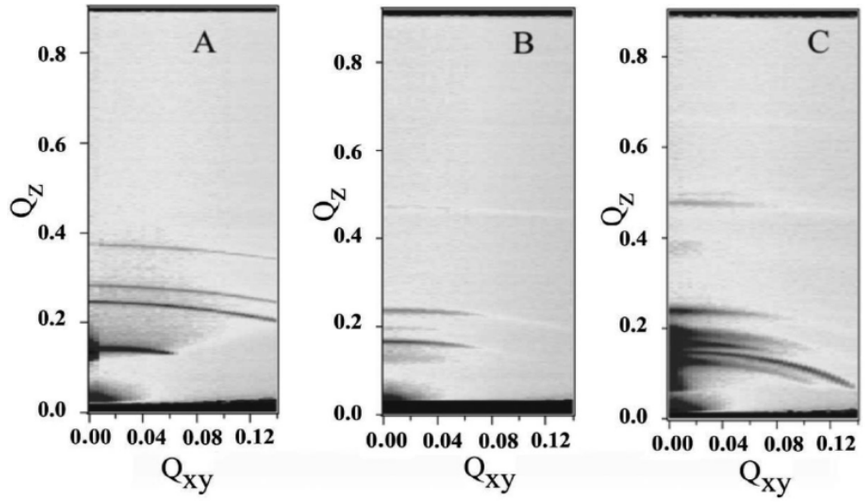
THOR - Science case

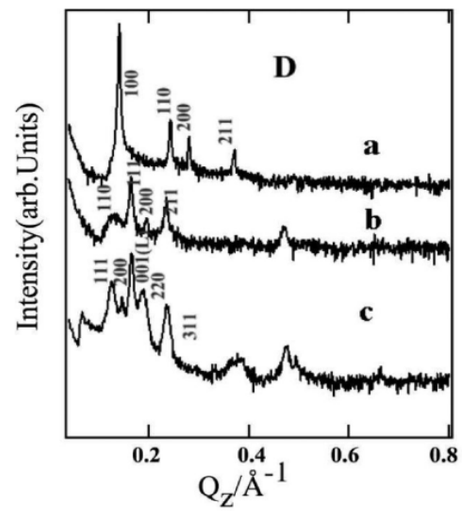
High resolution – hierarchical structures

Today: Limited to X-rays at air/liquid interface

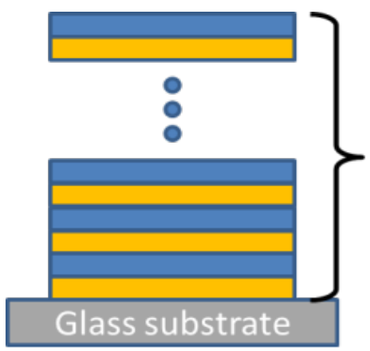
Yang, B.; Holdaway, J. A.; Edler, K. J., Robust Ordered Cubic Mesostructured Polymer/Silica Composite Films Grown at the Air/Water Interface. *Langmuir* **2013,** *29*, 4148:



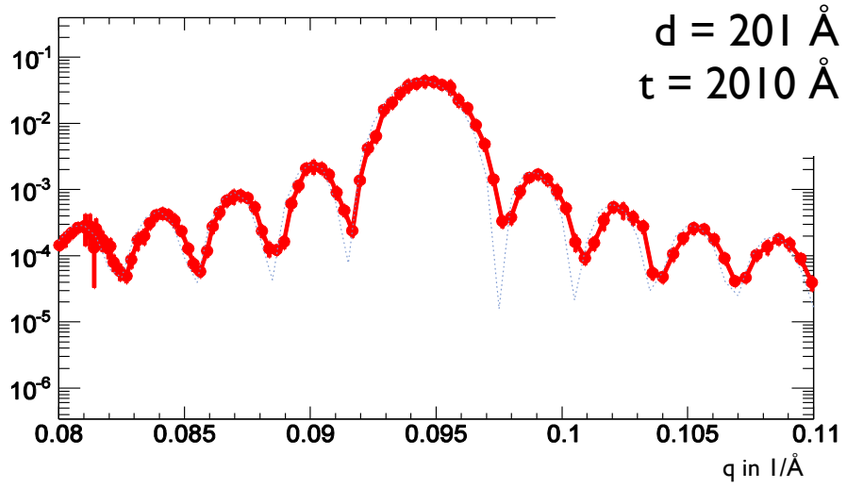


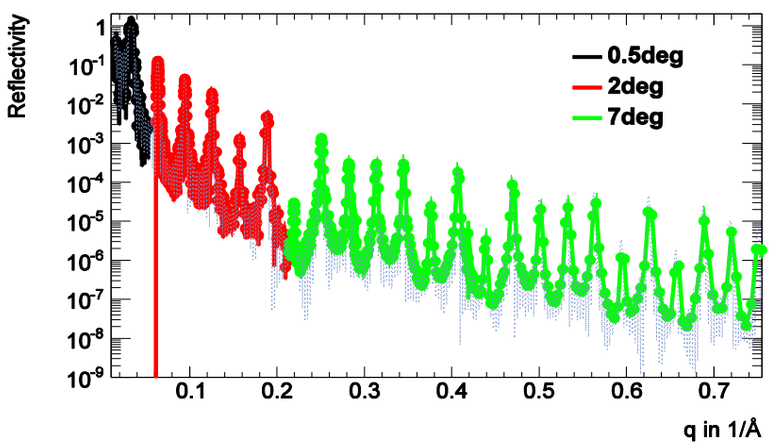


Tomorrow**: Neutrons** at air/solid, air/liquid and **solid/liquid** interfaces



$[Ni/Ti]_{10}$/glass



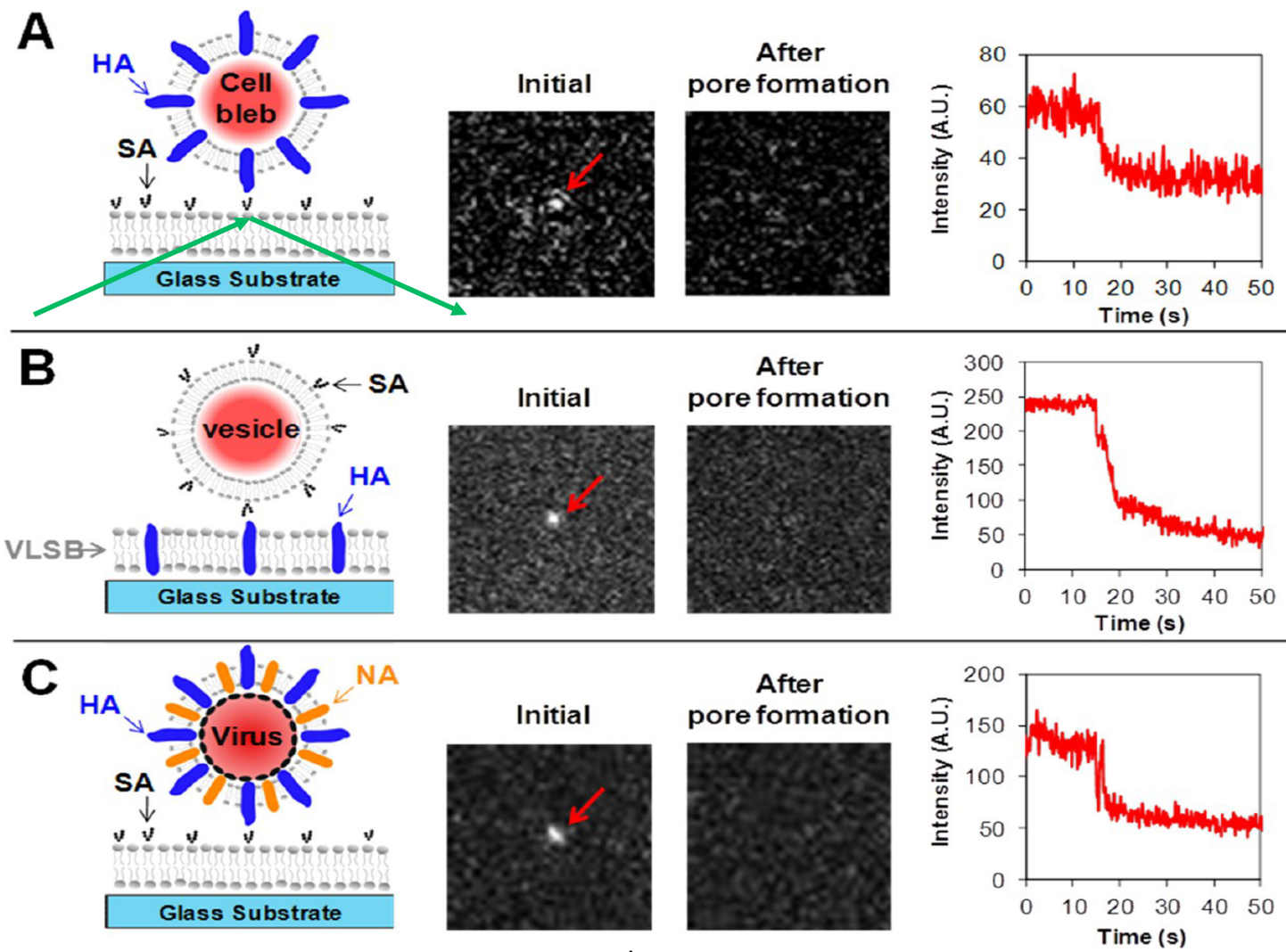


THOR - Science case

High flux – kinetics of self-assembly

Costello, D. A.; Hsia, C. Y.; Millet, J. K.; Porri, T.; Daniel, S., Membrane Fusion-Competent Virus-Like Proteoliposomes and Proteinaceous Supported Bilayers Made Directly from Cell Plasma Membranes. *Langmuir* **2013,** *29*, 6409:

Today



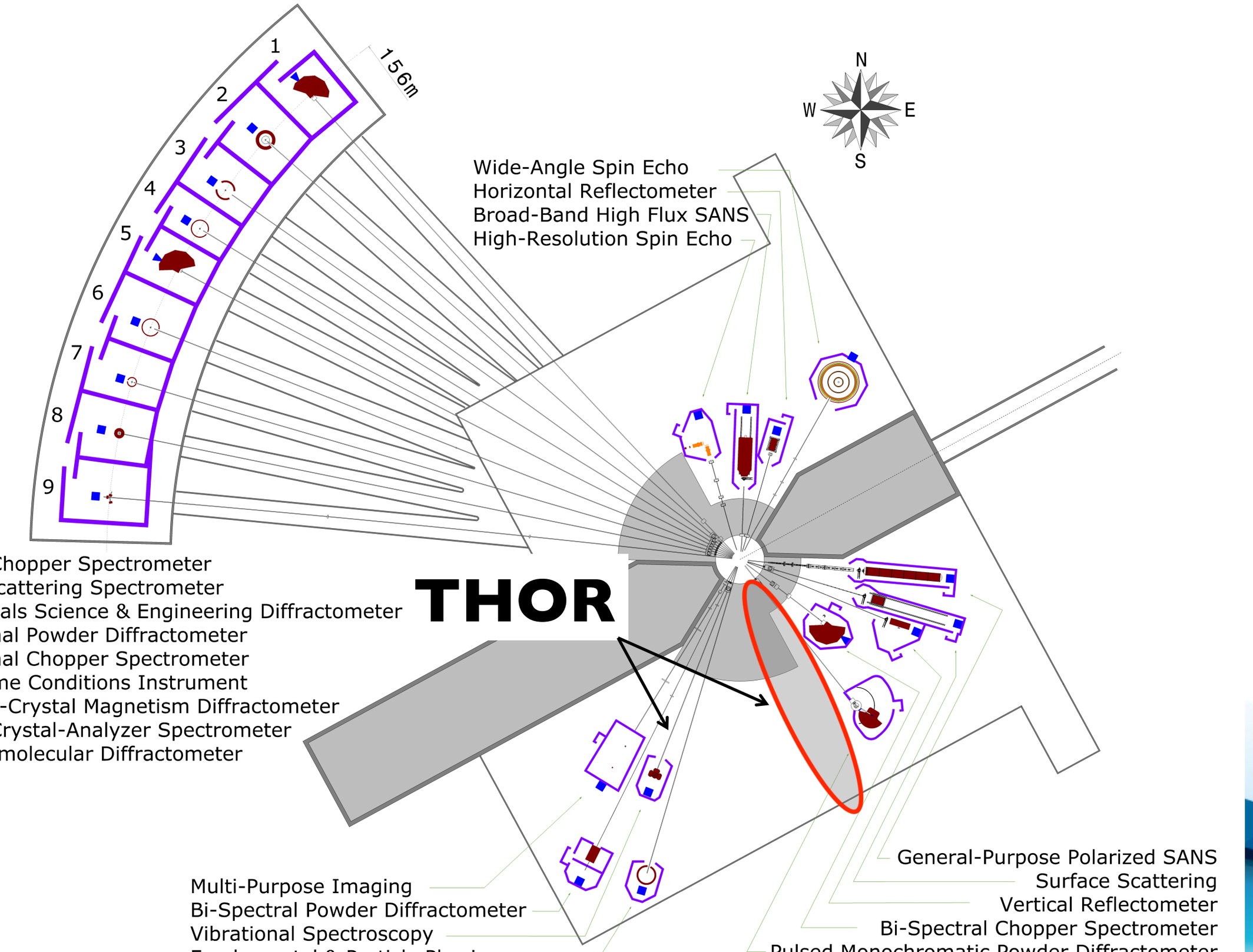
micrometer

Tomorrow

Information on virus like supported bilayer (VLSB)
kinetics of **virus-host interactions on Nanoscale**
by **NR & GISANS & d-Proteins**

Spatial resolution:
$Q_{z,max}$ = 0.7 Å^{-1}
ΔQ_y = 7e-4 Å^{-1}
Temporal resolution:
t_{int} = sub-sec

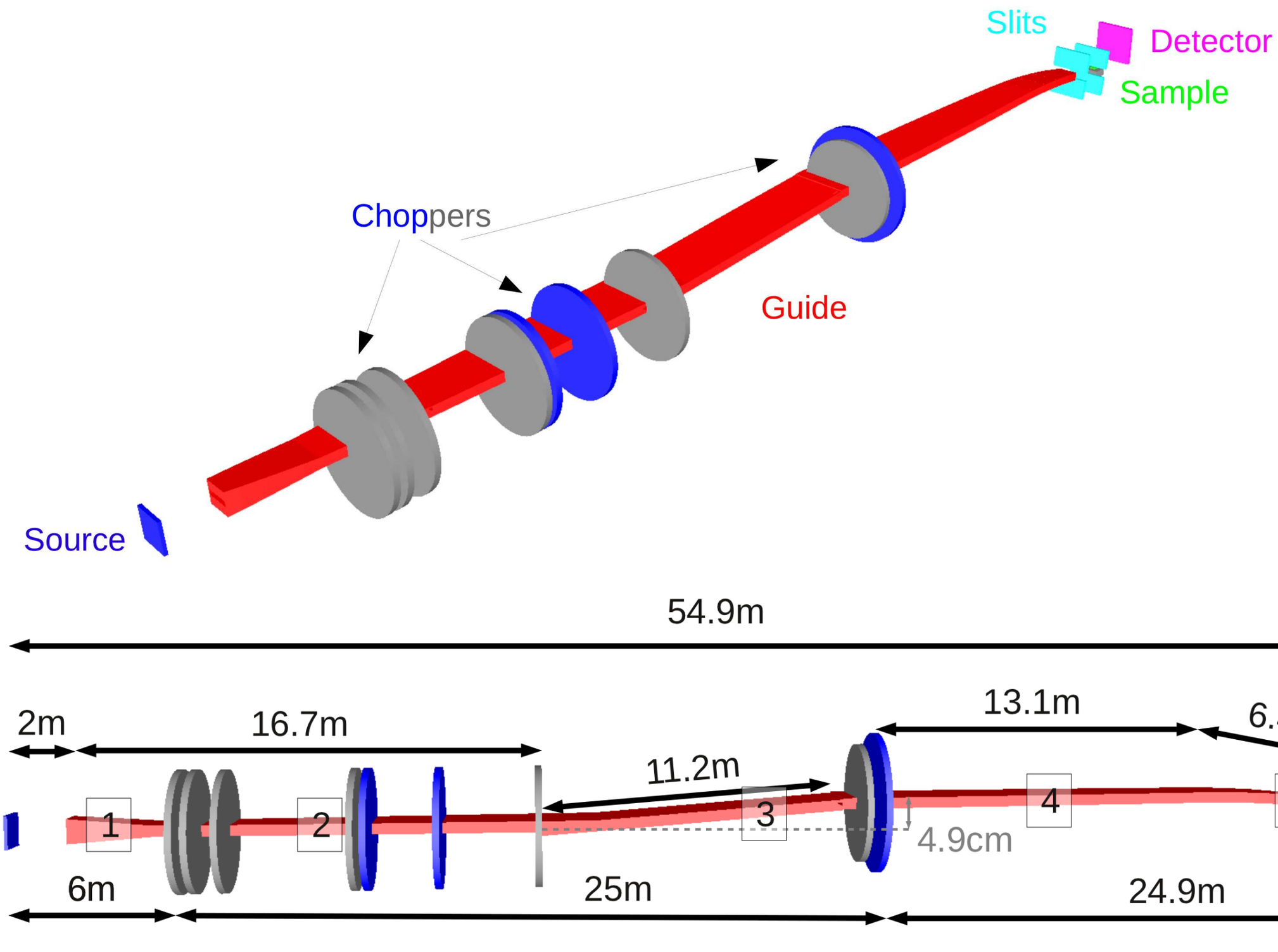
THOR - ESS Instrumentation



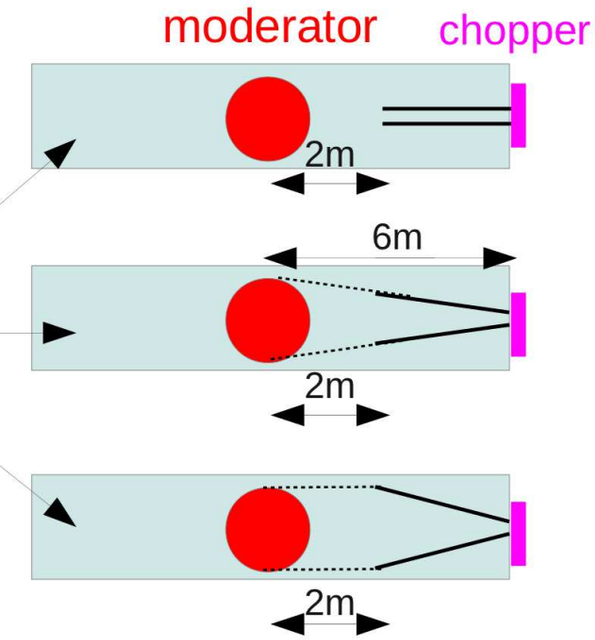
1. Cold Chopper Spectrometer
2. Backscattering Spectrometer
3. Materials Science & Engineering Diffractometer
4. Thermal Powder Diffractometer
5. Thermal Chopper Spectrometer
6. Extreme Conditions Instrument
7. Single-Crystal Magnetism Diffractometer
8. Cold Crystal-Analyzer Spectrometer
9. Macromolecular Diffractometer

THOR

THe HORizontal Reflectometer



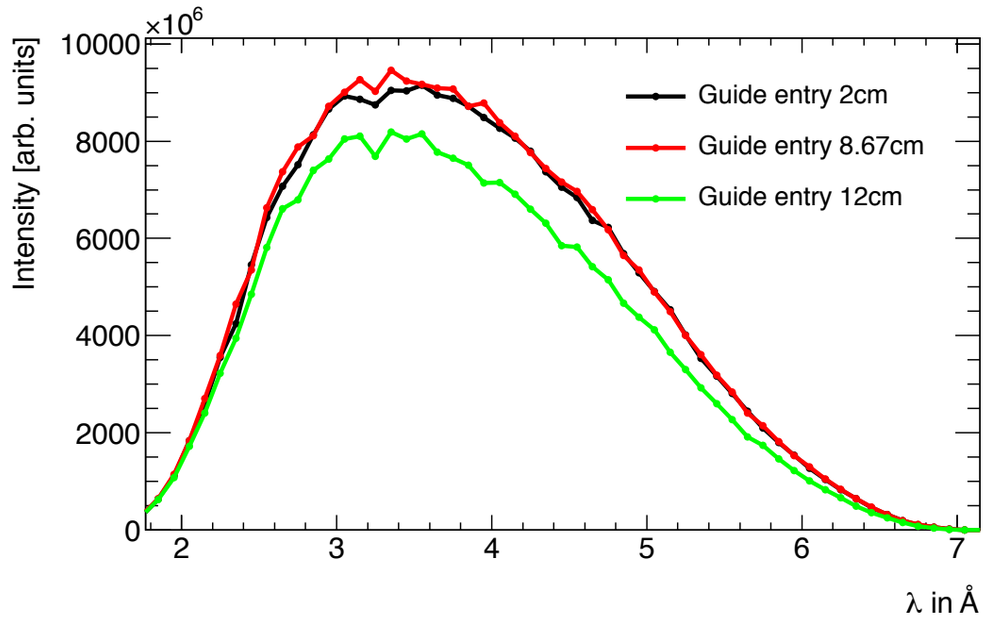
THOR - extraction



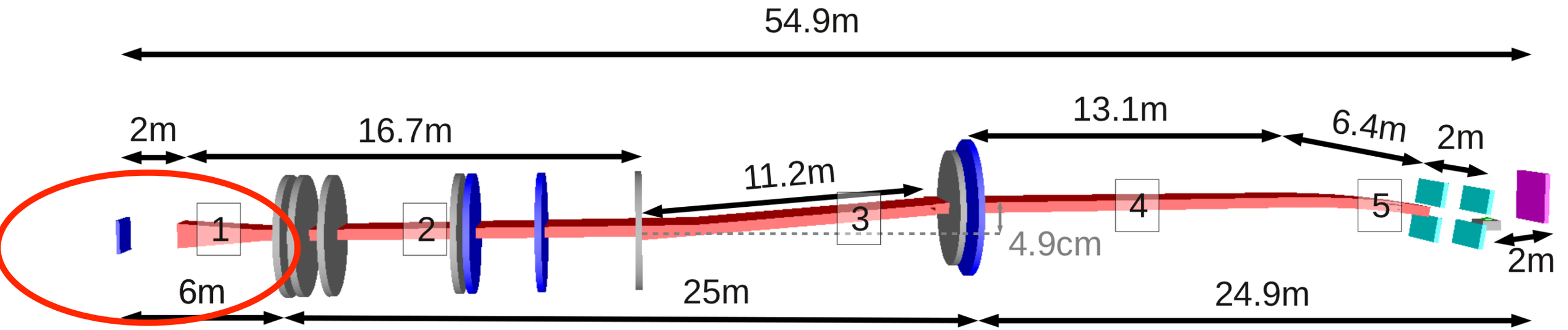
1) Constant height: 2cm

2) Looking at entire moderator, max height 8.67cm

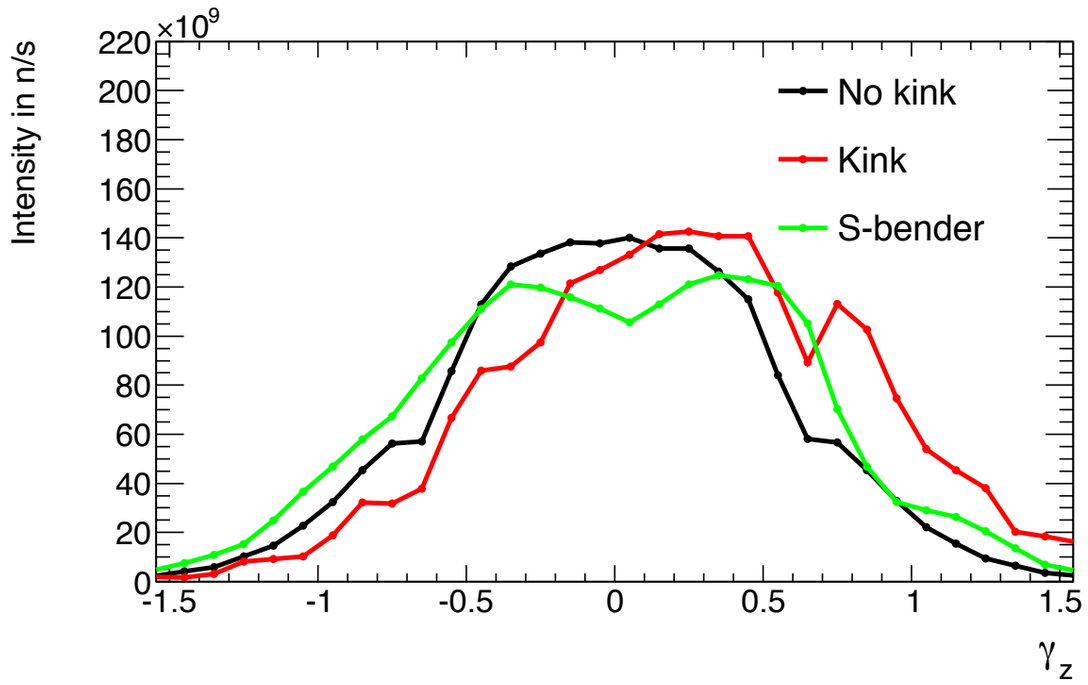
3) Guide entrance as large as the moderator, max height 12cm

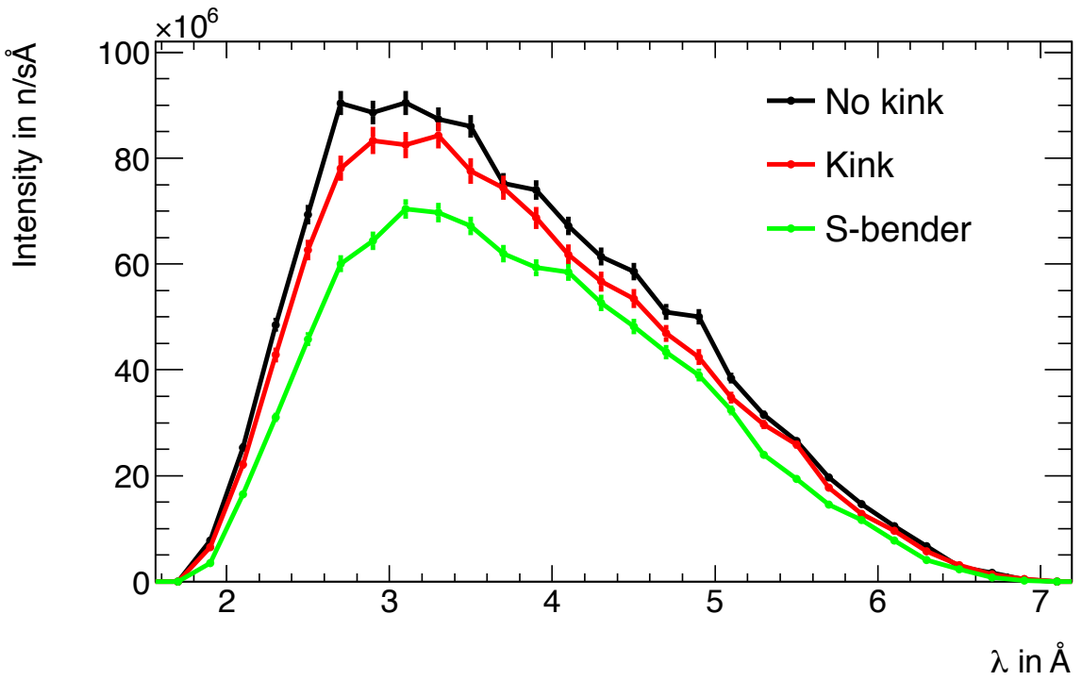


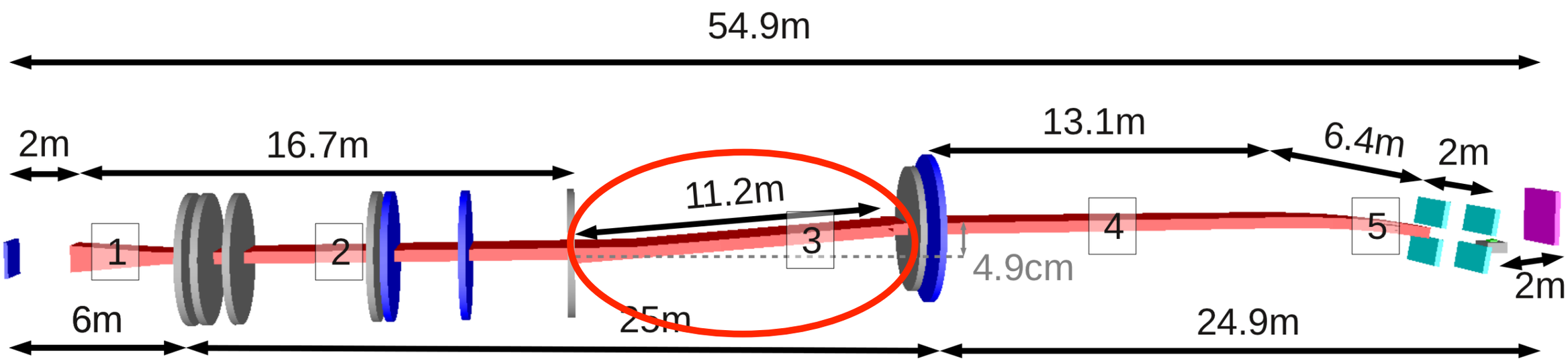
Would obviously benefit from pancake moderator solution!



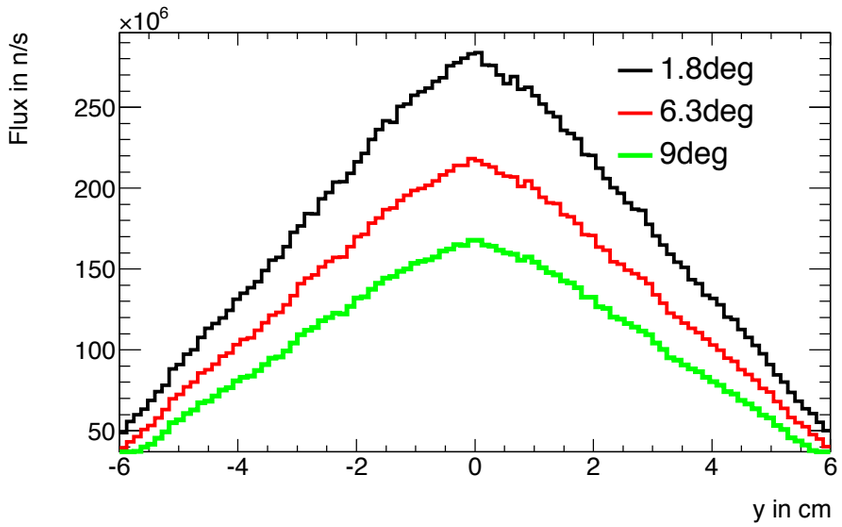
THOR – loosing line of sight (twice)



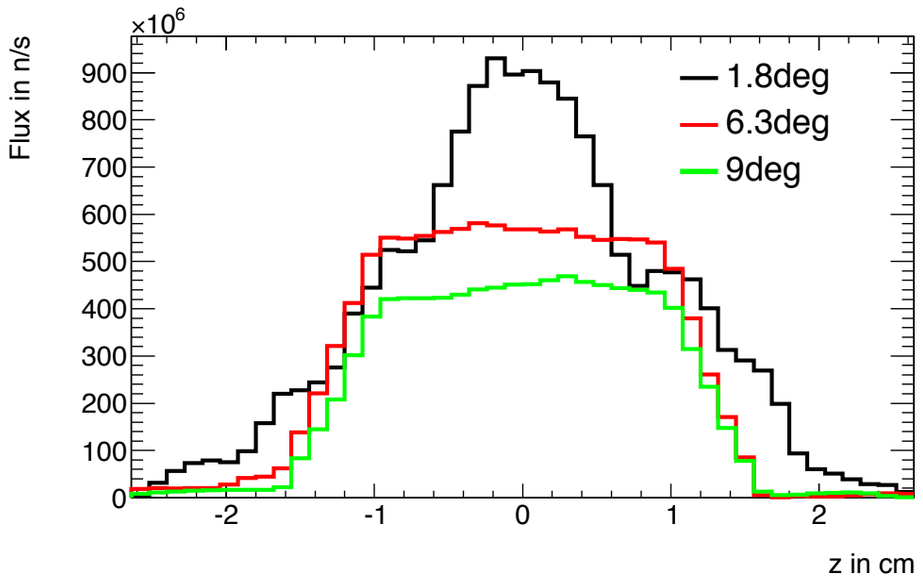




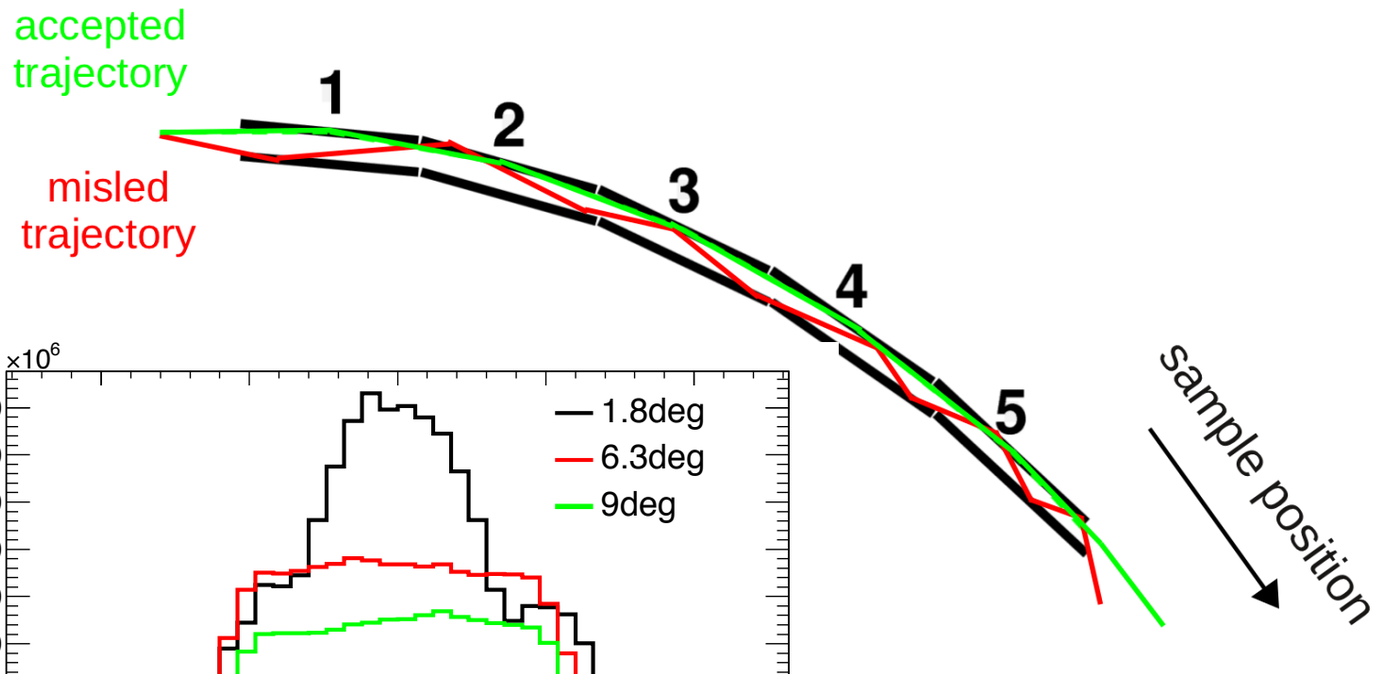
THOR – bending on sample

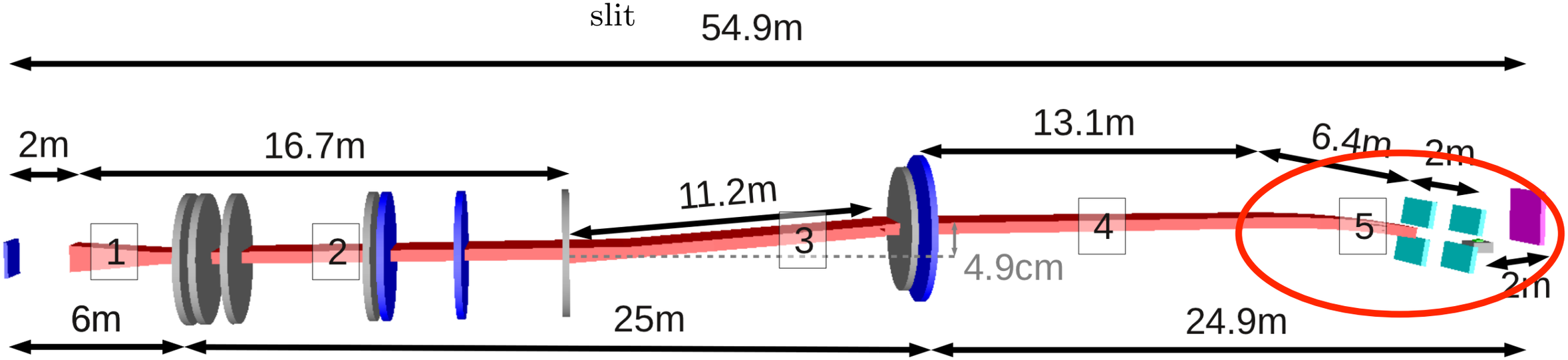


(a) Horizontal beam profile at footprint slit



(b) Vertical beam profile at footprint slit

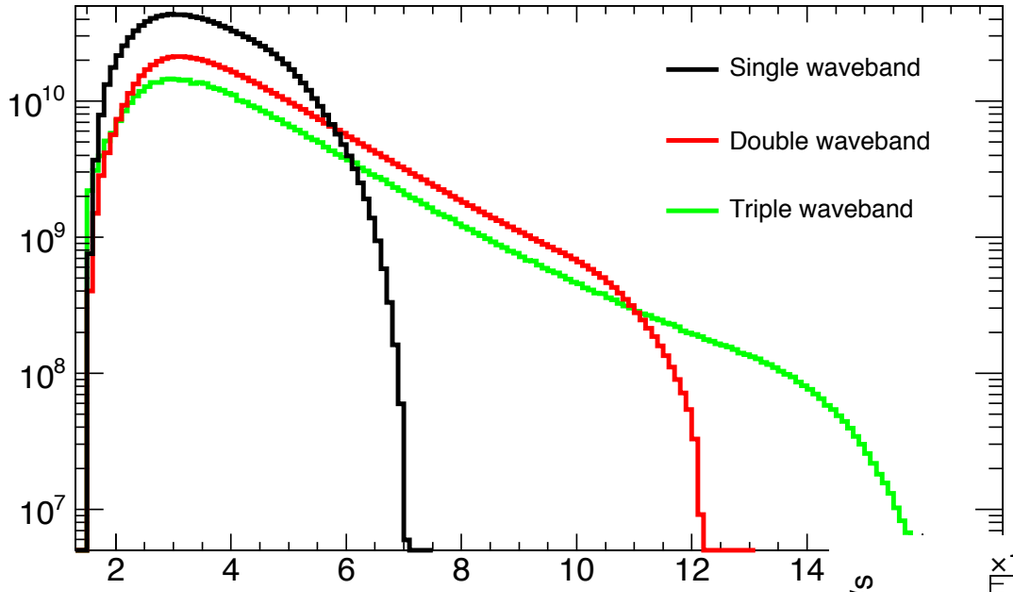




THOR – choppers & resolution modes

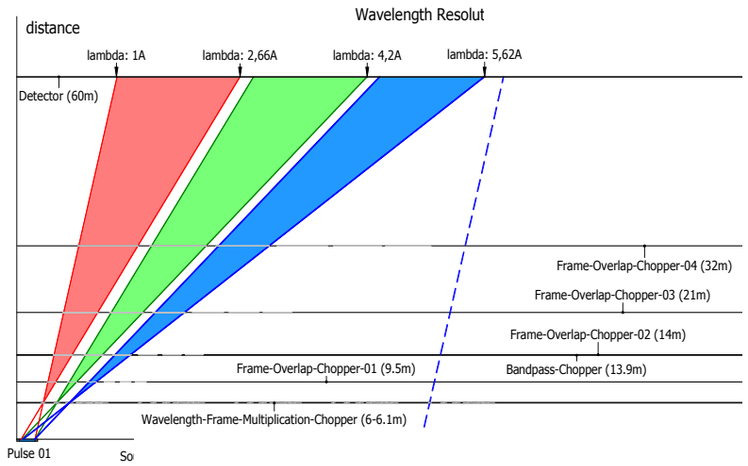
Flexible bandwidth & flexible band position Allows resolution adaptation

10% - 5%



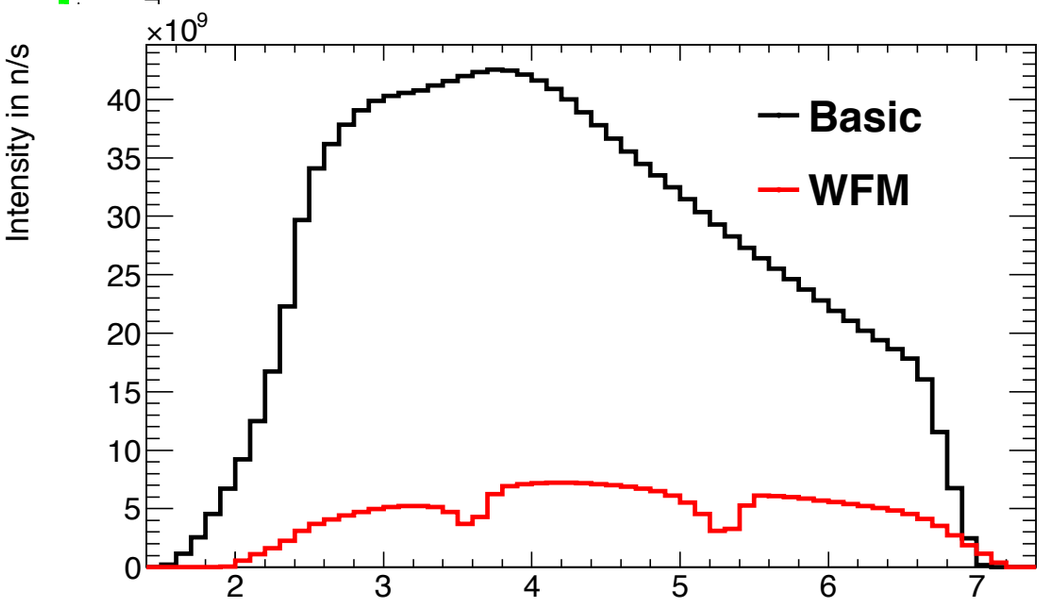
(a)Single frame

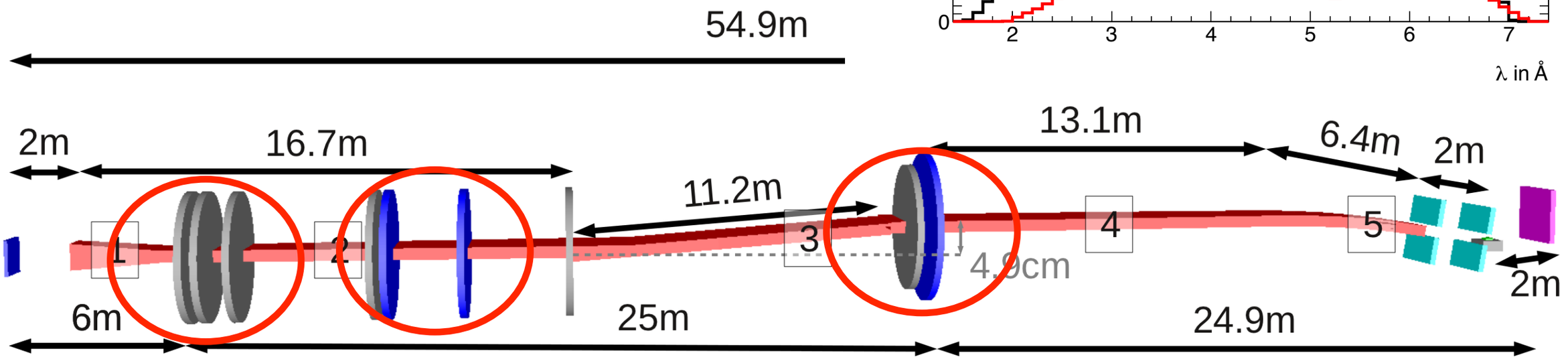
b)Pulse suppession



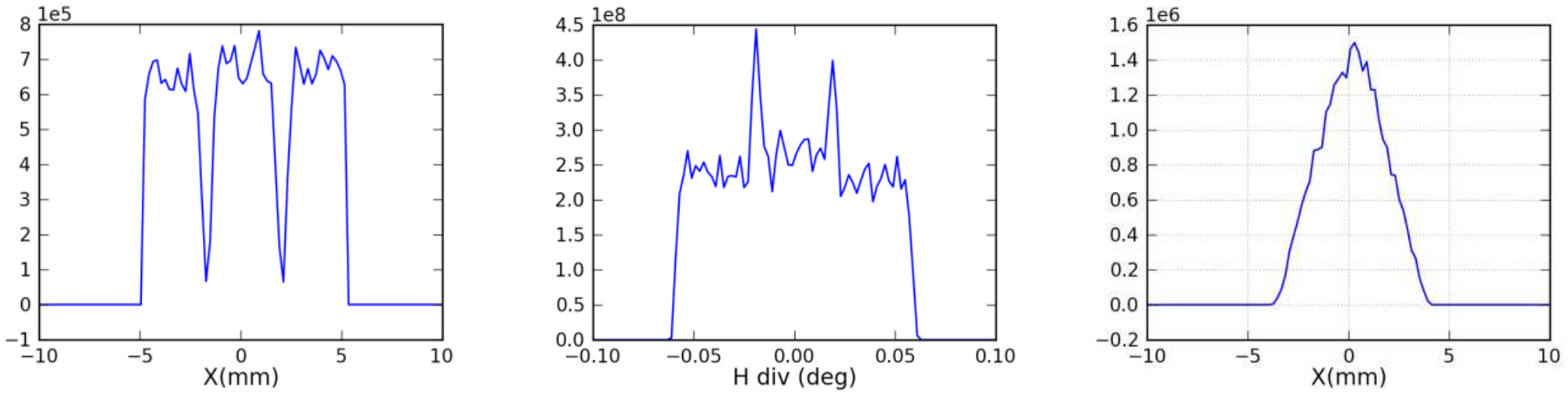
(c) High res

0.5%-2%



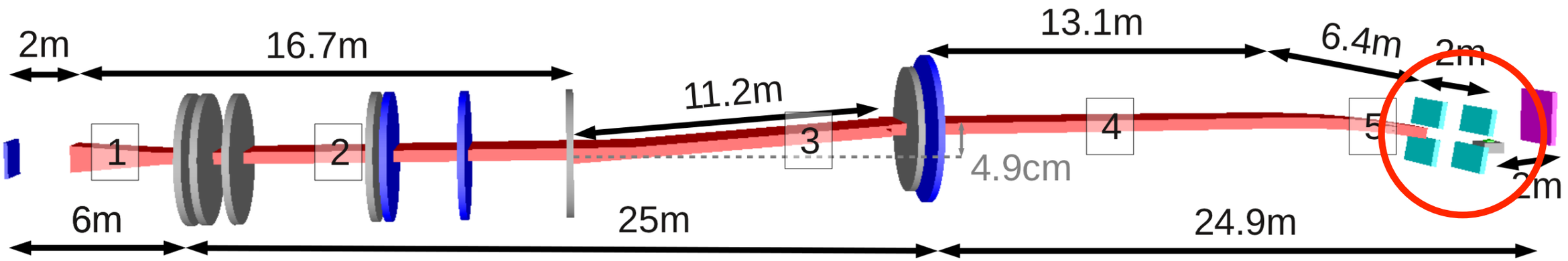


THOR – add-on user options OffSpec/GISANS/hard matter



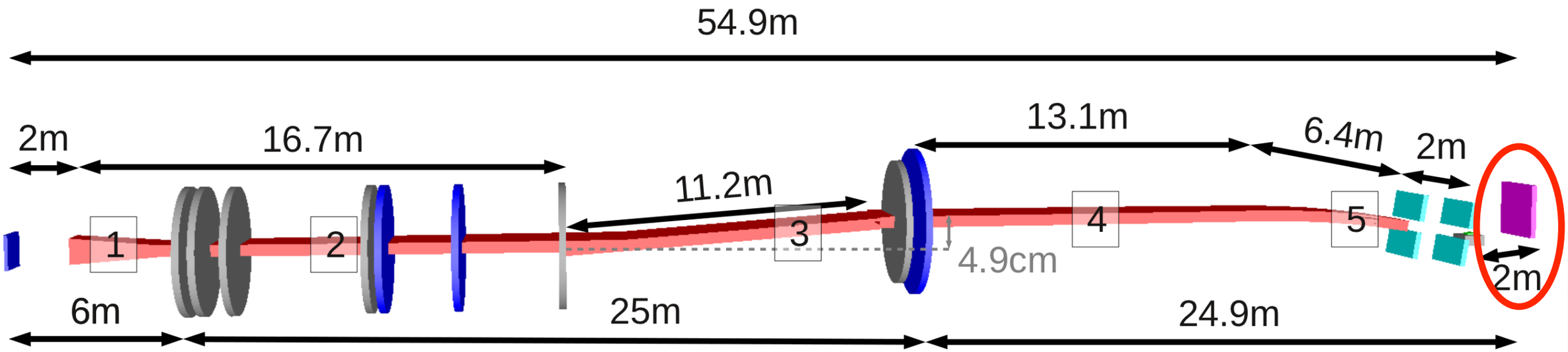
(a) (b) (c)

Figure 13: Illustration of expected (a) intensity distribution in the horizontal plane at collimator exit, (b) horizontal divergence (full beam) at sample position, (c) profile of the beam at the detector position.

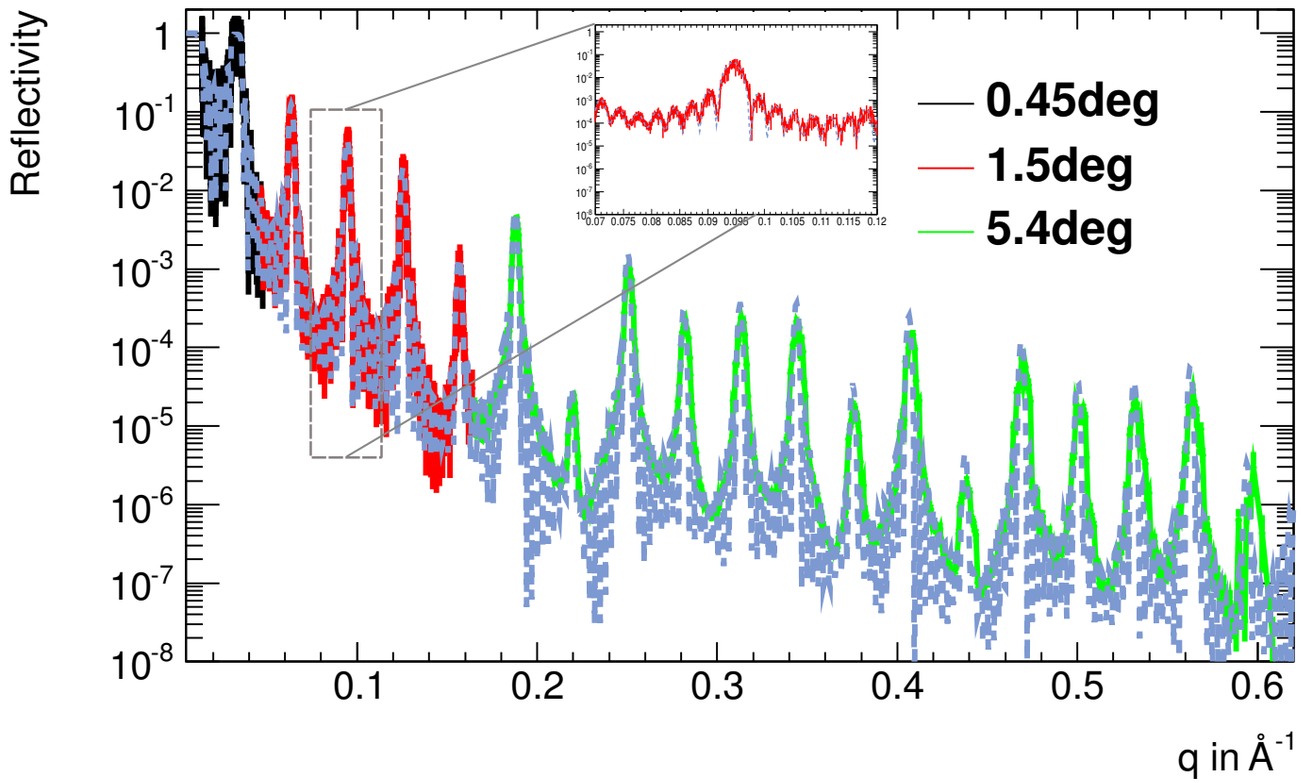


THOR – detection

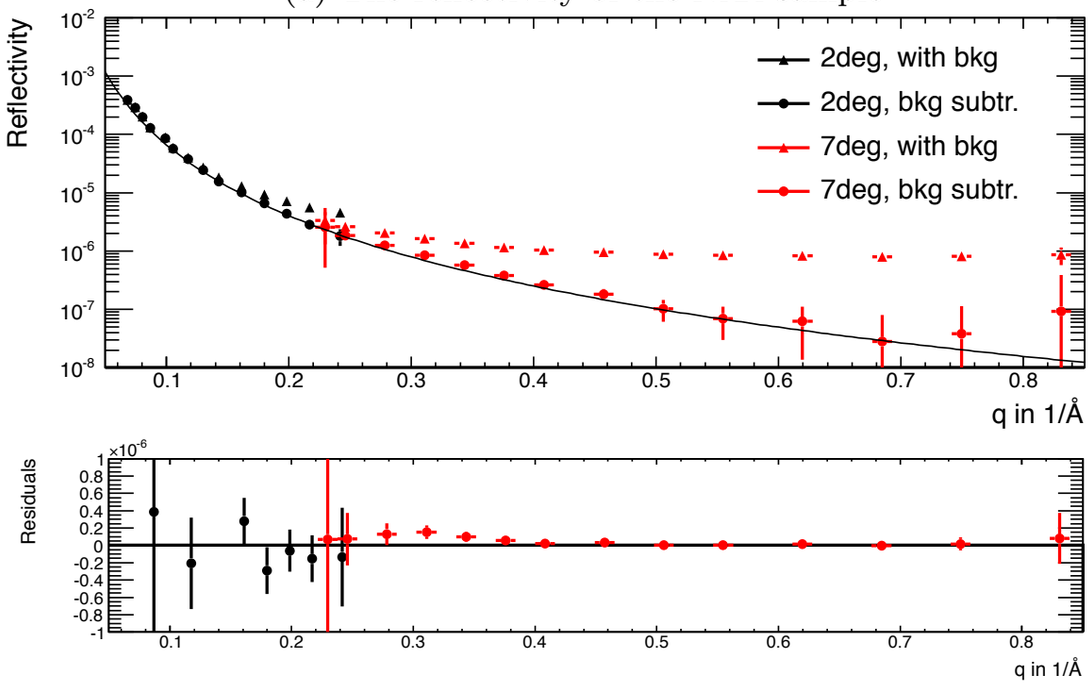
High flux mode a serious task for detector group (or is e.g. DENEX He3 sufficient)
for high resolution (required when significant off spec intensities)
HZG detector development can be a feasible option
(tests planned at ESS testbeamline)

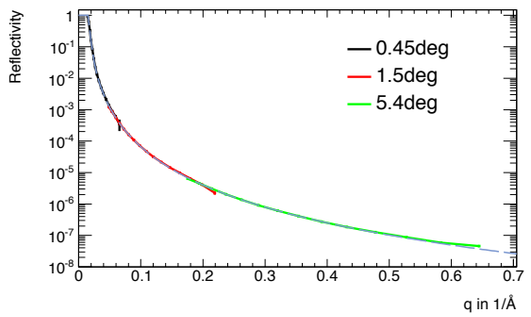


THOR – performance

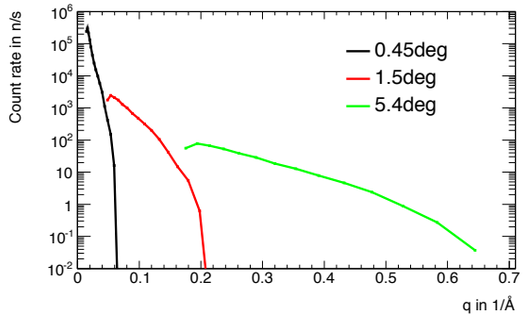


(a) The reflectivity of the NiTi sample

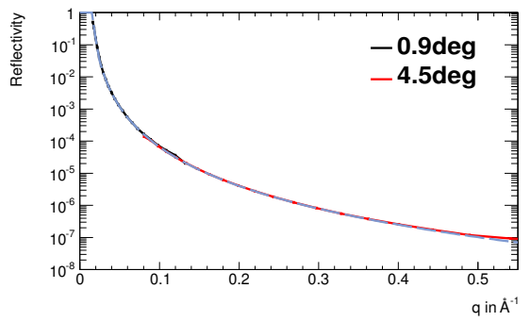




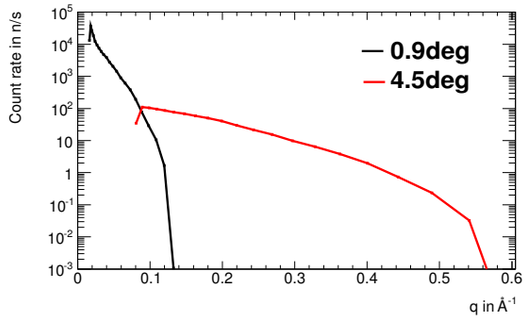
(a) Reflectivity of a D_2O surface measured with the single waveband



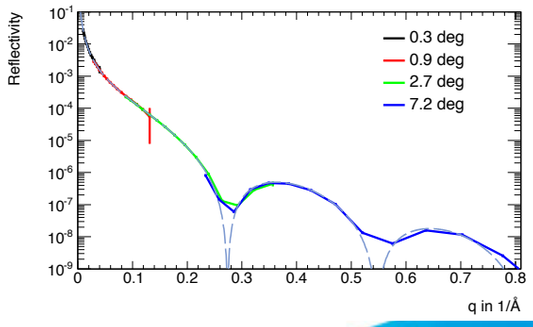
(b) Count rate achieved on a D_2O surface with the single waveband



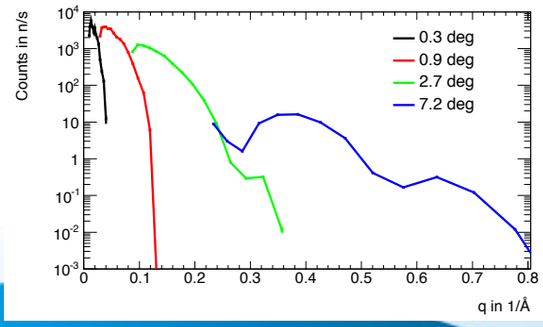
(c) Reflectivity of a D_2O surface measured with the double waveband



(d) Count rate achieved on a D_2O surface with the double waveband



(e) Reflectivity of a Langmuir layer on null reflecting water measured with the single waveband



(f) Count rate achieved on a Langmuir layer surface with the single waveband

THOR - Costing

THOR			cost estimate kEuro
	Conventional Infrastructure		160
	Extraction		100
	Guide / Optics		2700
	Choppers		1500
	Shielding		3020
	Sample Area and Sample Environment		1200
	Detector(s)		500
	Special Parts		760
	Electrical Engineering		240
	Computing		50
	SUM		**10330**
	Manpower*		**3000**

THOR - Minimum risk

- Principal world-leading operation does not rely on any complex technical installation.

- State-of-the-art technology/methodology

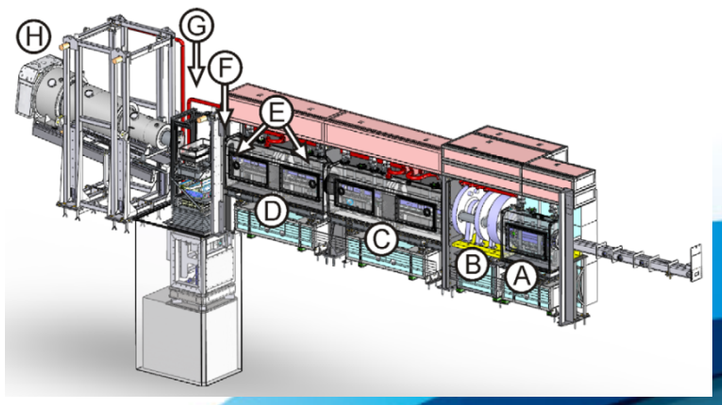
- Flexible resolution and performance even without WFM in place

- Works also without beam bending (except free liquids)

• Sample translation stage (z)

Figaro: 500 + 32 mm

THOR: ≤ 2 x Figaro



Campbell et al., Eur. Phys. J. Plus (2011) **126**: 107

EUROPEAN SPALLATION SOURCE

Summary

THOR is an all-round instrument

Soft/hard matter, large range, high res, low res, medium res, θ/2θ, θ/θ, small samples, big samples, offspec, GISANS

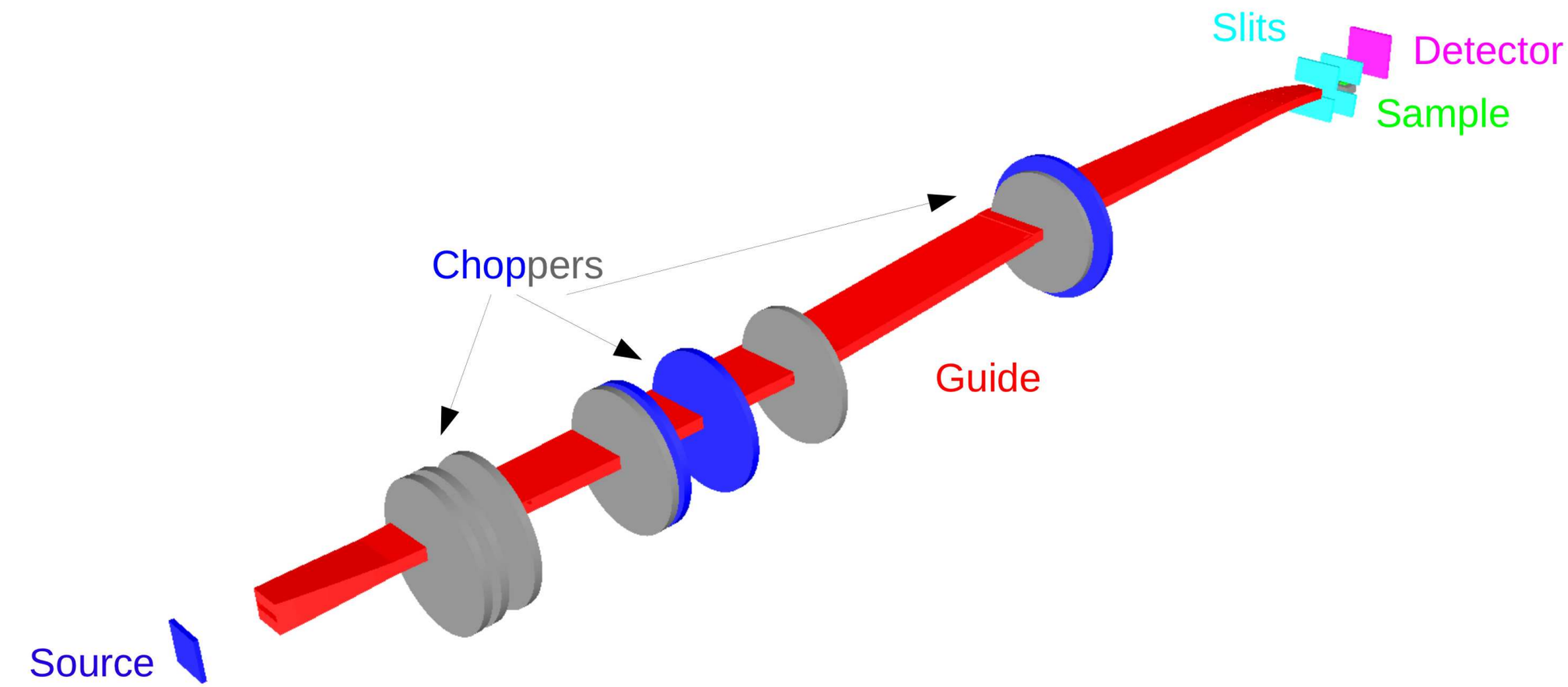
focusing on our strengths

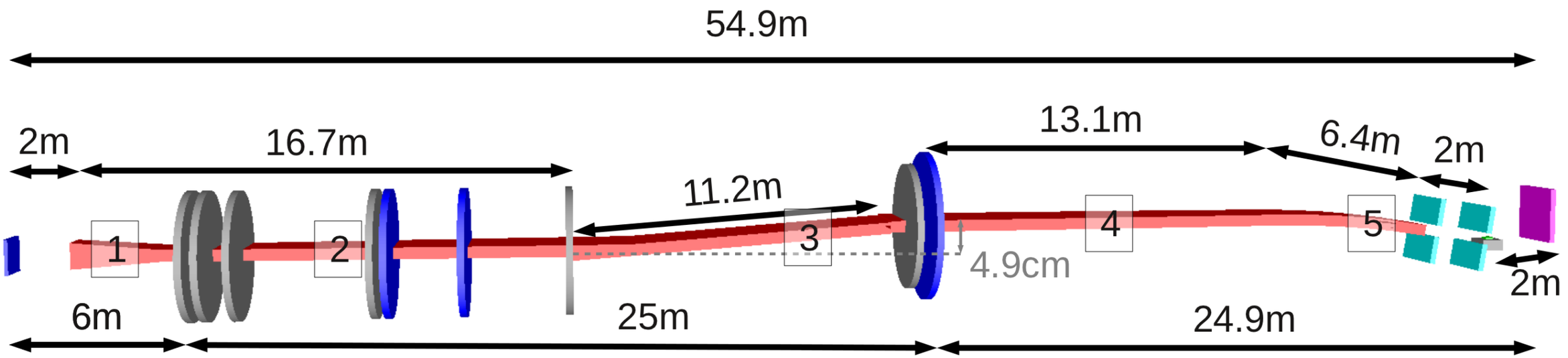
flexible, high flux, small samples, spectral range

but based on state-of-the-art technological solutions!

THOR

~~THe~~ THird HORizontal Reflectometer





Thank you !

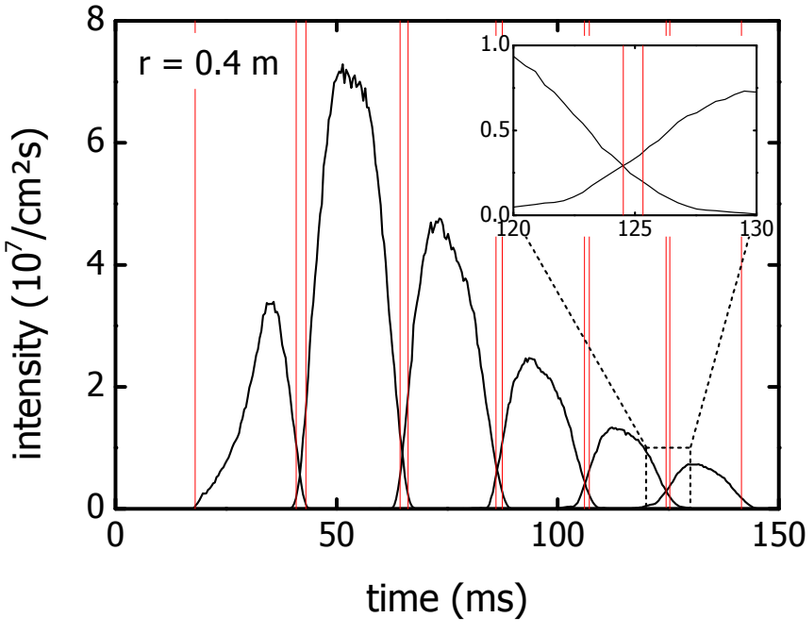
EUROPEAN SPALLATION SOURCE

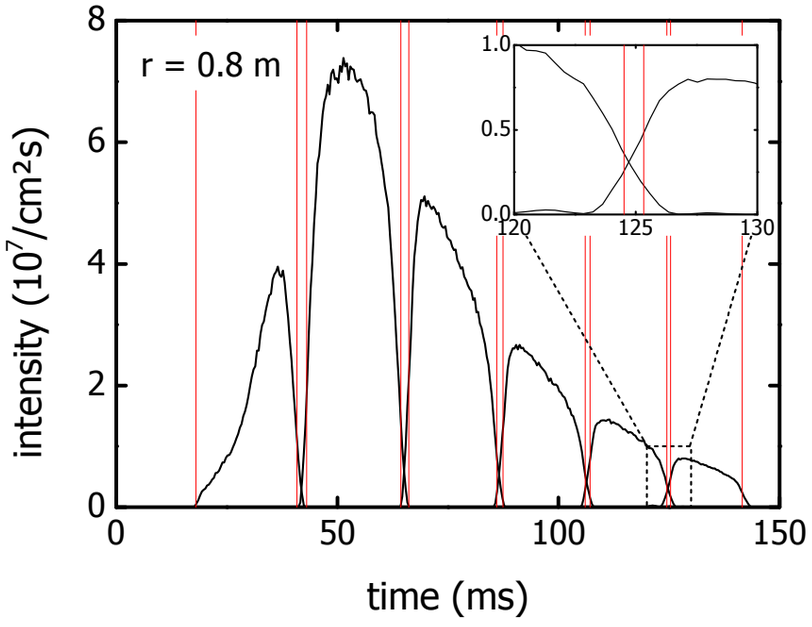
M. Strobl

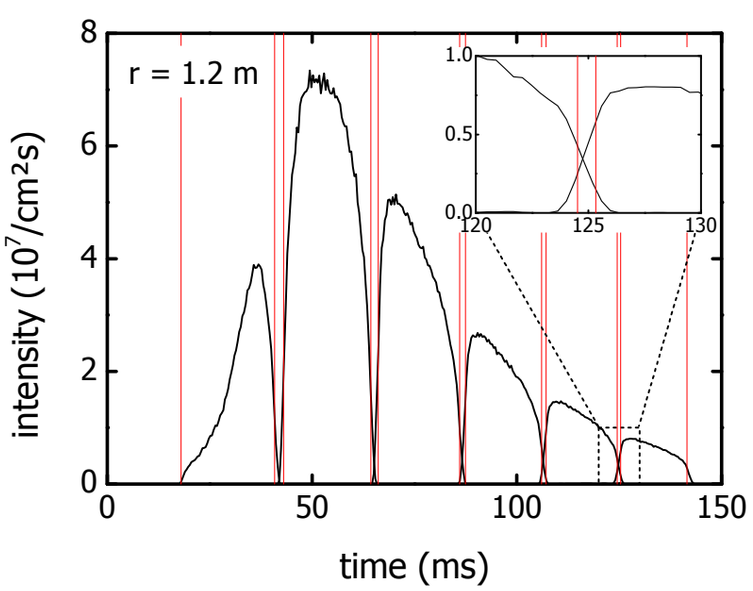
Instrument Division

ESS AB

Chopper diameters







chopper system - risk

Lieber Markus,

Wir haben hier die Email diskutiert, prinzipiell erscheint uns alles gut machbar und ohne technische Schwierigkeiten.

Meine Kostenschätzung hat für das ganze System 1,260 k€ ergeben. Diese Kostenschätzung ist inoffiziell und erhebt keinen Anspruch auf Gültigkeit.

Ich denke, die Kostenschätzung ist relativ genau (+/- 10%), falls sich aus der späteren Spezifikation nicht
noch spezielle Anforderungen ergeben..

Bei Bedarf würde ich auch ein offizielles Angebot machen.

Berno Spiegelhalder

Astrium GmbH