R. Woracek, T. Hofmann, M. Bulat, M. Sales, K. Habicht, K. Andersen, M. Strobl,
The testbeamline of the \European Spallation Source – instrumentation development and wavelength frame multiplication, Nuclear Instruments and Methods in Physics Research Section A, 949, (2016)

EUROPEAN
SPALLATION
SOURCE

The ESS Testbeamline (V20) at HZB

Robin Woracek

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&
Instrument Scientist at V20

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www.europeanspallationsource.se

ERICE, July/05/2017

How to stay awake…

How I got here…

- Mechanical Engineer (Automotive Industry)
- Fulbright scholarship 2006 (Ms) -> The University of Tennessee, Knoxville (UTK)
- PhD at UTK (2009-2014) in collaboration with HZB+ORNL: **Neutron Imaging & Engineering Diffraction**
- Since February 2015 at ESS, responsible for V20
- My interest: Apply these new 'adventurous' techniques to relevant samples… and make these methods better and useful for everyone ☺

AGENDA

- **Overview V20:**
  - Introduction
  - Chopper System
  - Beam Characteristics
  - Layout
  - Available Detector Systems
- Platform for ESS Integrations
- Example Applications
- SEMSANS in practice at V20

Motivation & Background

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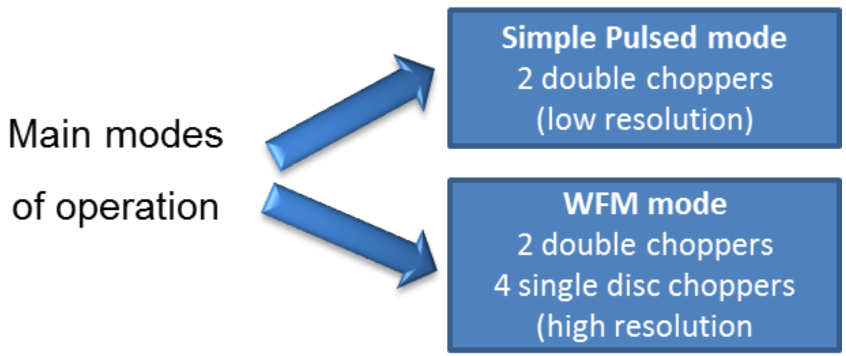
Dedicated test instrument for ESS:

1) Experimental test case for "Long pulse"-instrumentation with FLEXIBLE SETUP
2) Develop/establish procedures and data reduction before ESS
3) Dedicate time to develop new methods
4) Green field site: Testing and integration of components

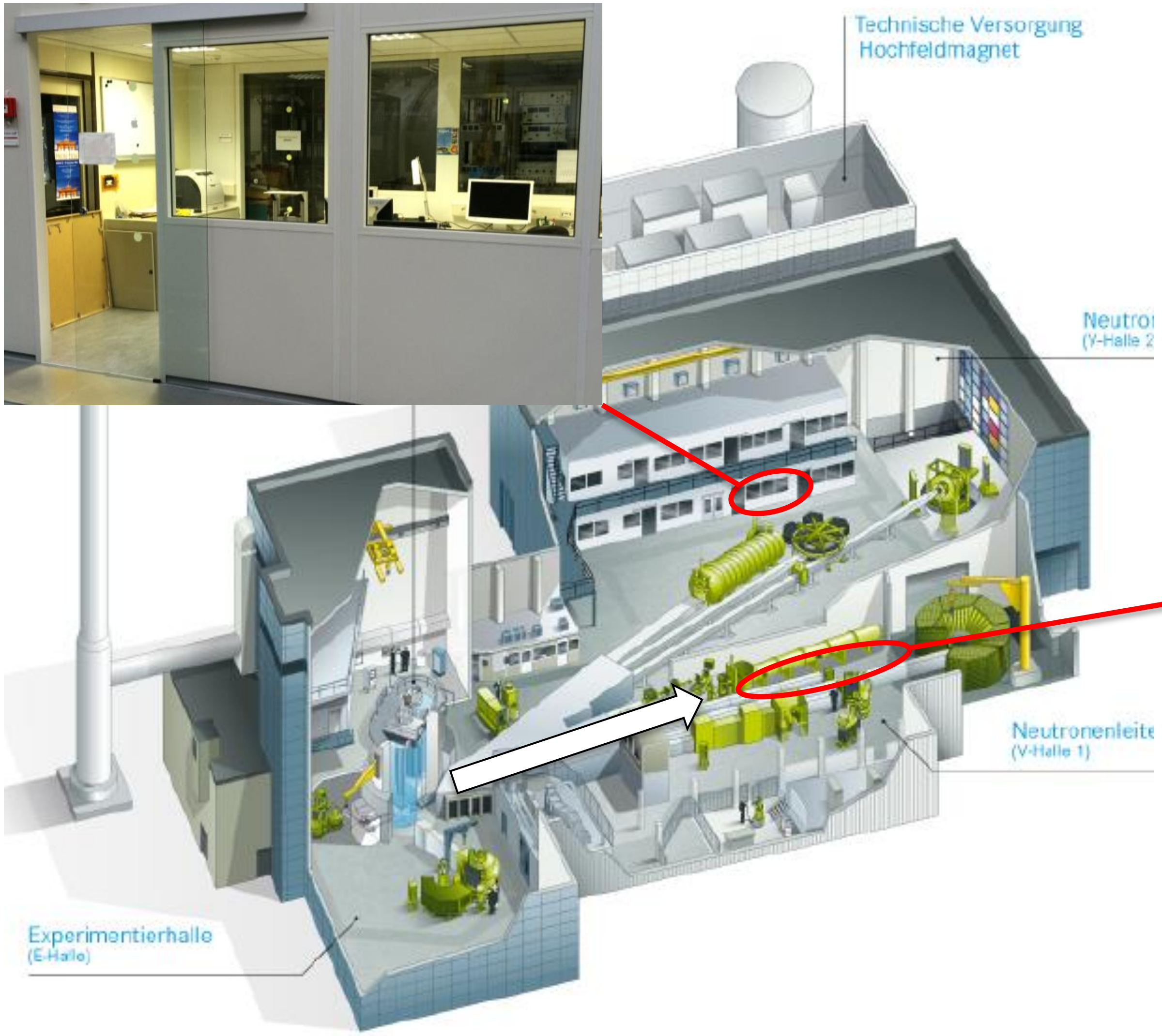
- Choppers provide the **ESS pulse structure** (14Hz, 2.86ms)
- Additional **pulse shaping choppers** provide Wavelength Frame Multiplication (WFM) option



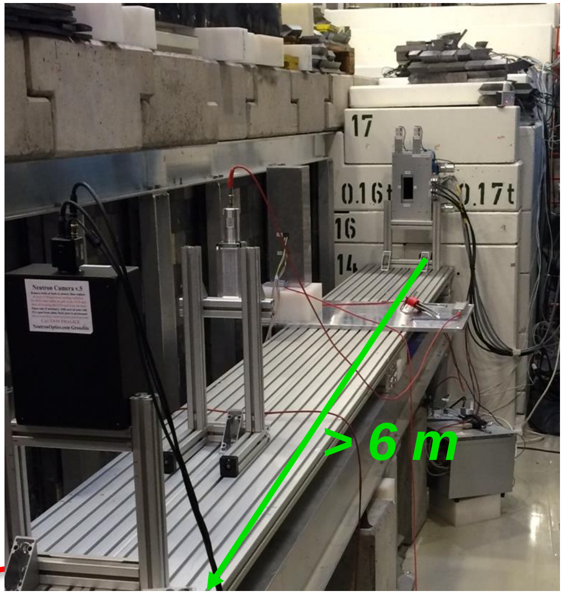
ESS Test Beamline (V20) at HZB

ESS Test Beamline (V20) at HZB

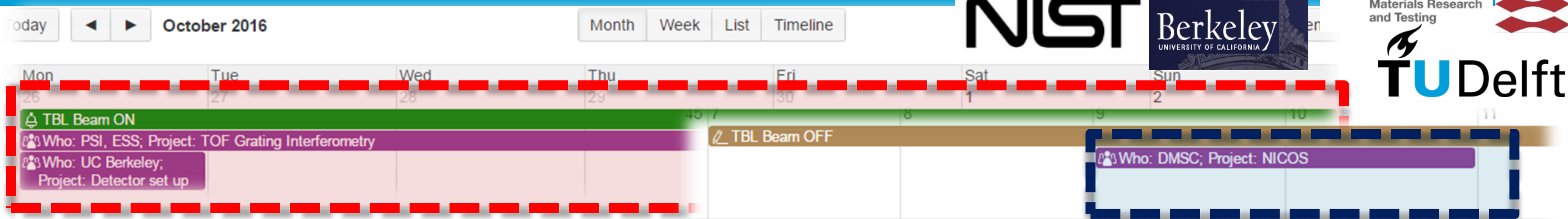
Control Room



Beamline



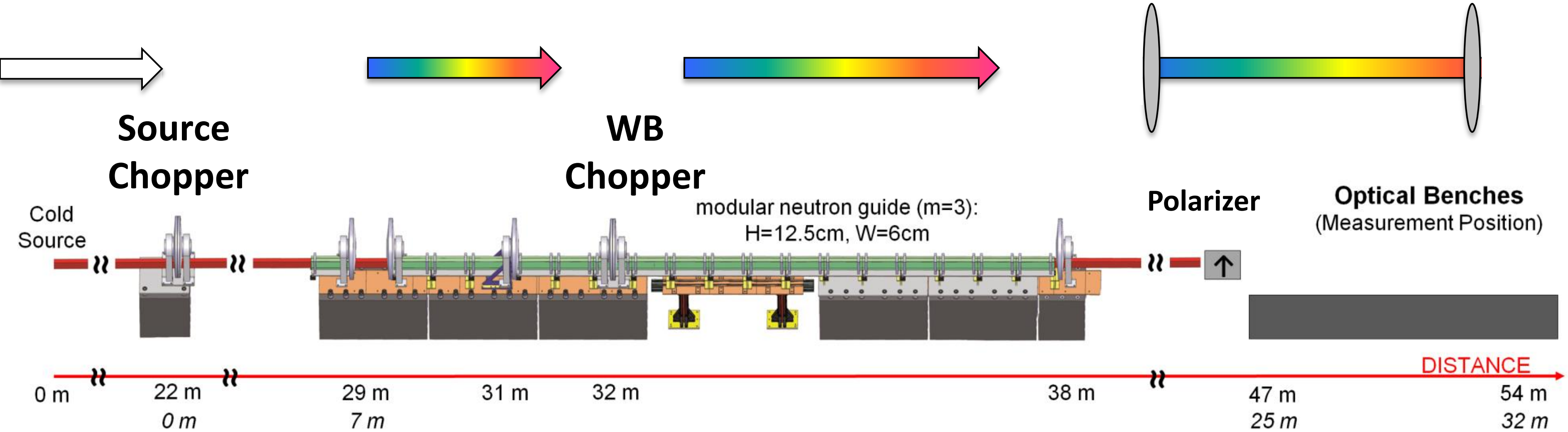
Typical Users & Activities at V20

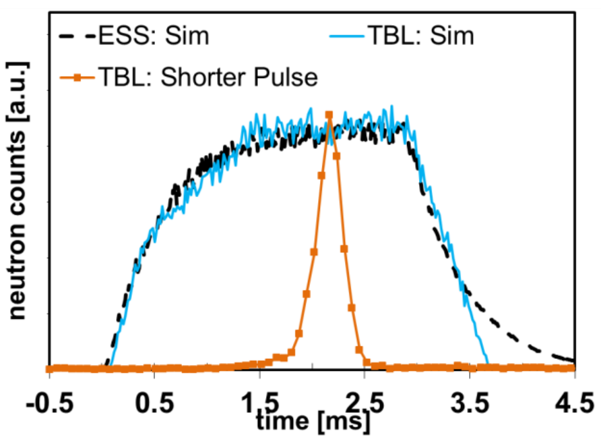


- Method development
- Integration of control software
  - Tested by users
- Applications using Imaging + Diffraction in WFM mode
- Planning for integration of ESS infrastructure
- Tests of neutronic components
- Integration of ^{3}He PSD detector for use at V20
- Tests of detectors for ESS instruments

- ESS neutron instrument division
- ESS technical groups + DMSC
- ESS in-kind partners
- **Scientific collaborators. YOU?**

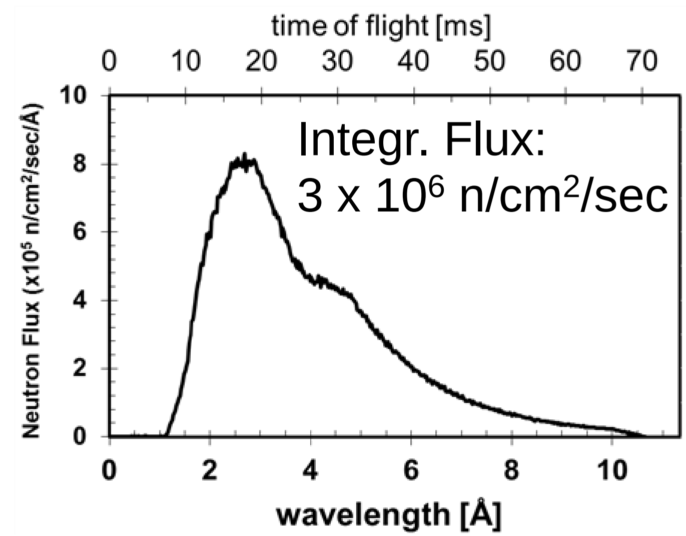
Chopper System: Simple Pulsed Mode





Flexibility!

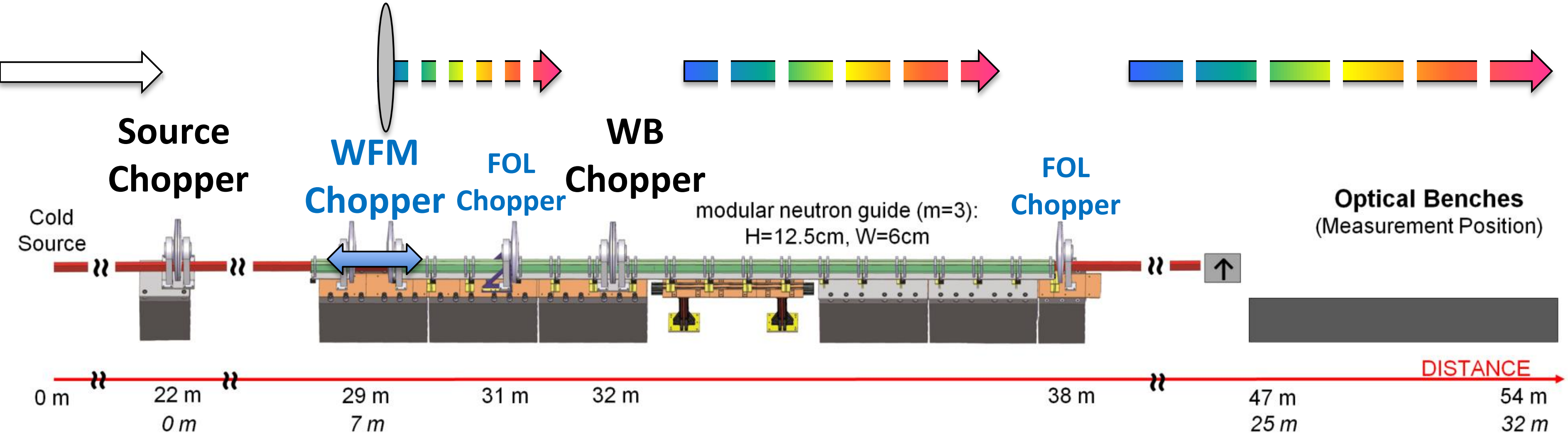
→ *Vitess & McStas model*

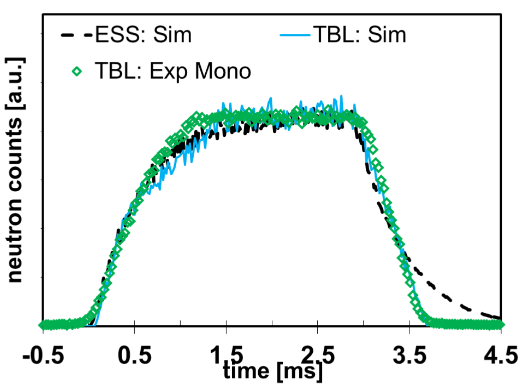


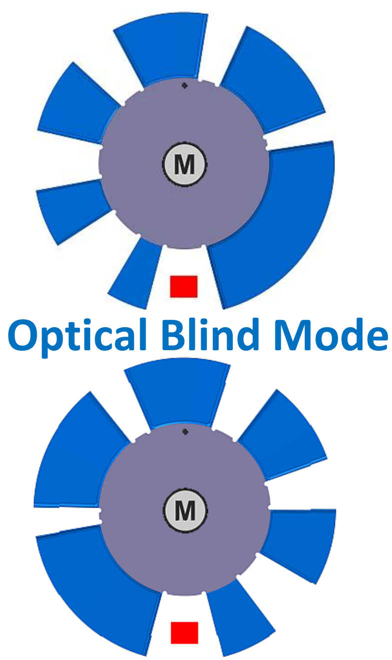
Repetition: variable

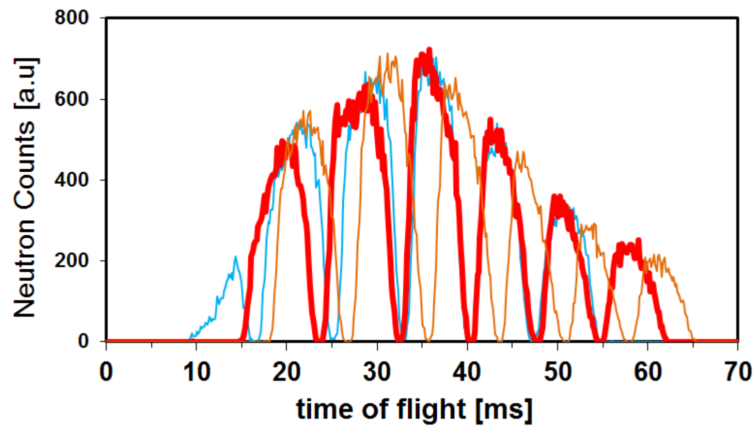
Wavelength resolutions: 0.7%-3%

Chopper System: WFM Mode





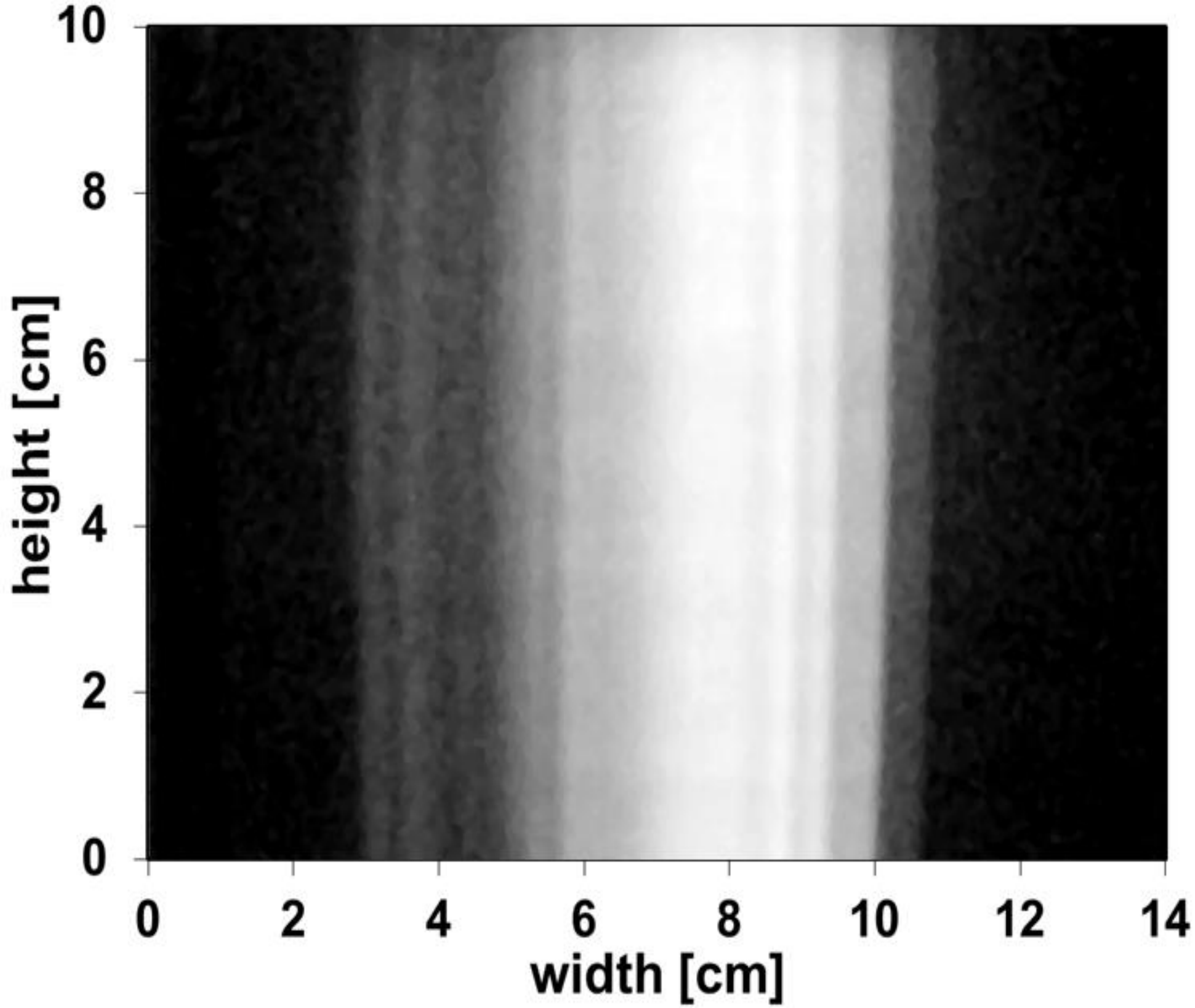




Tunable (but constant)
Wavelength resolutions: 0.5%-2%

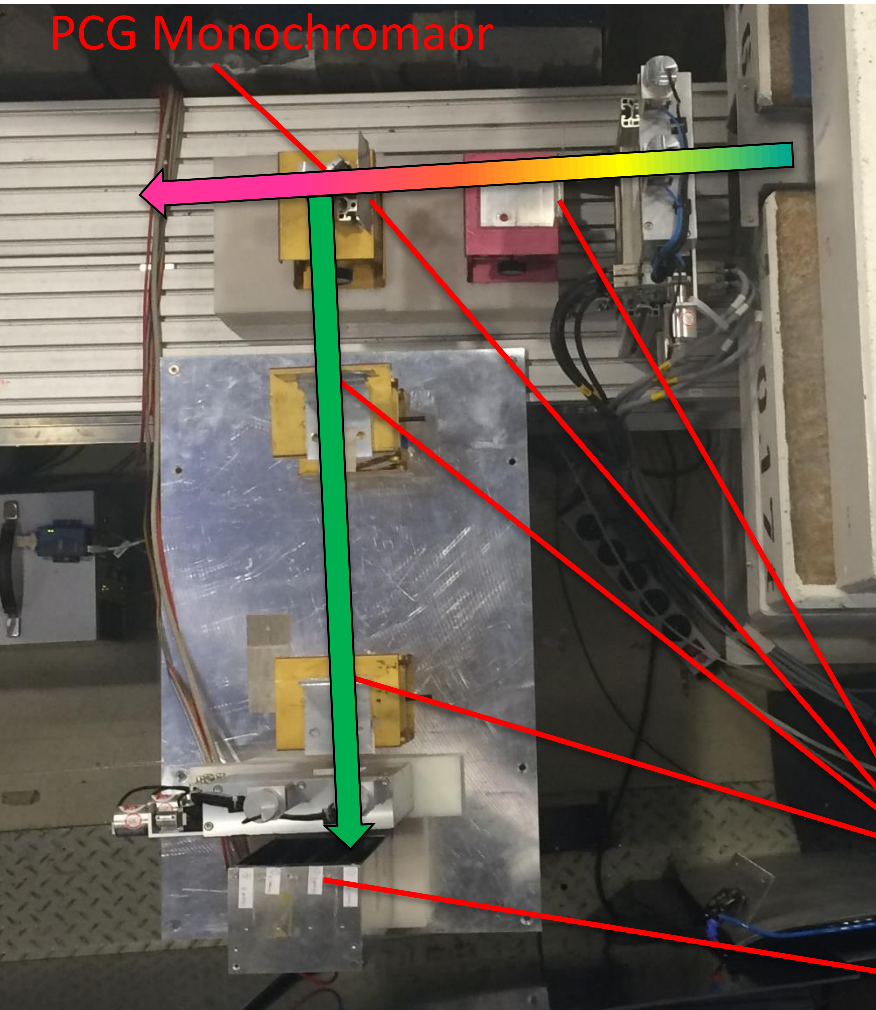
Some characteristics

- Beam size and end of shielding



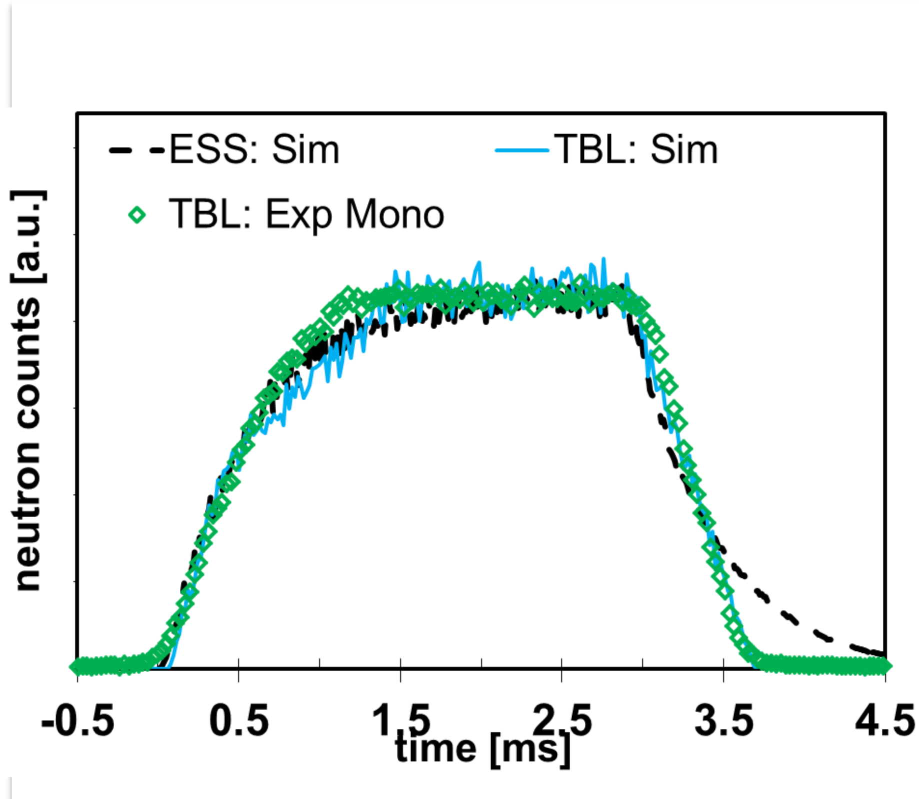
Some characteristics

- Pulse shape



Gd Pinholes (10mm)

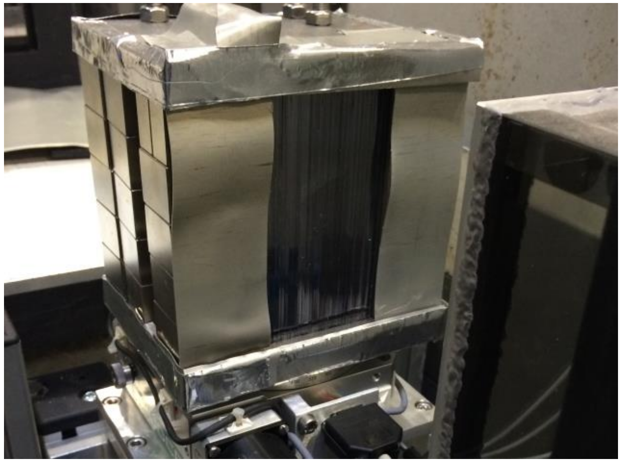
^{3}He Detector (4tubes)

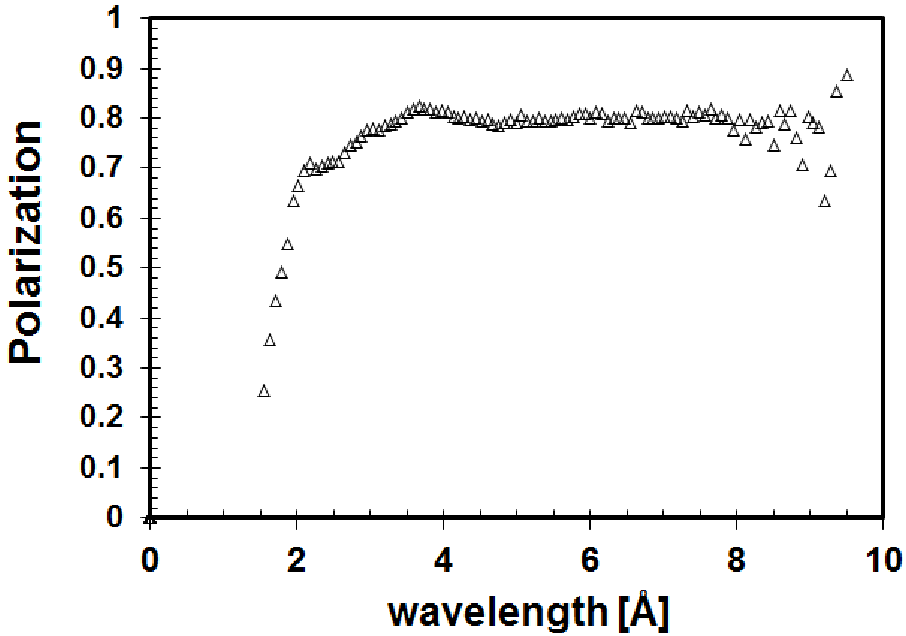


Some characteristics

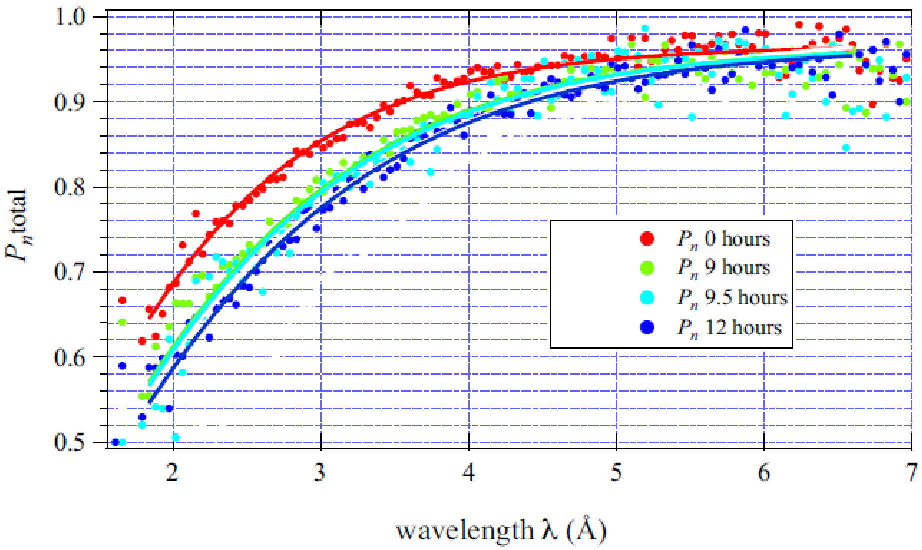
- Polarizing S-bender (Fe-Si)
- Can be moved in-out remotely
- Area: 60 mm x 125 mm
- Weighted polarization (4.9 Å) 98.7%

- Polarization after 3m guide field, spin flipper, analyzer



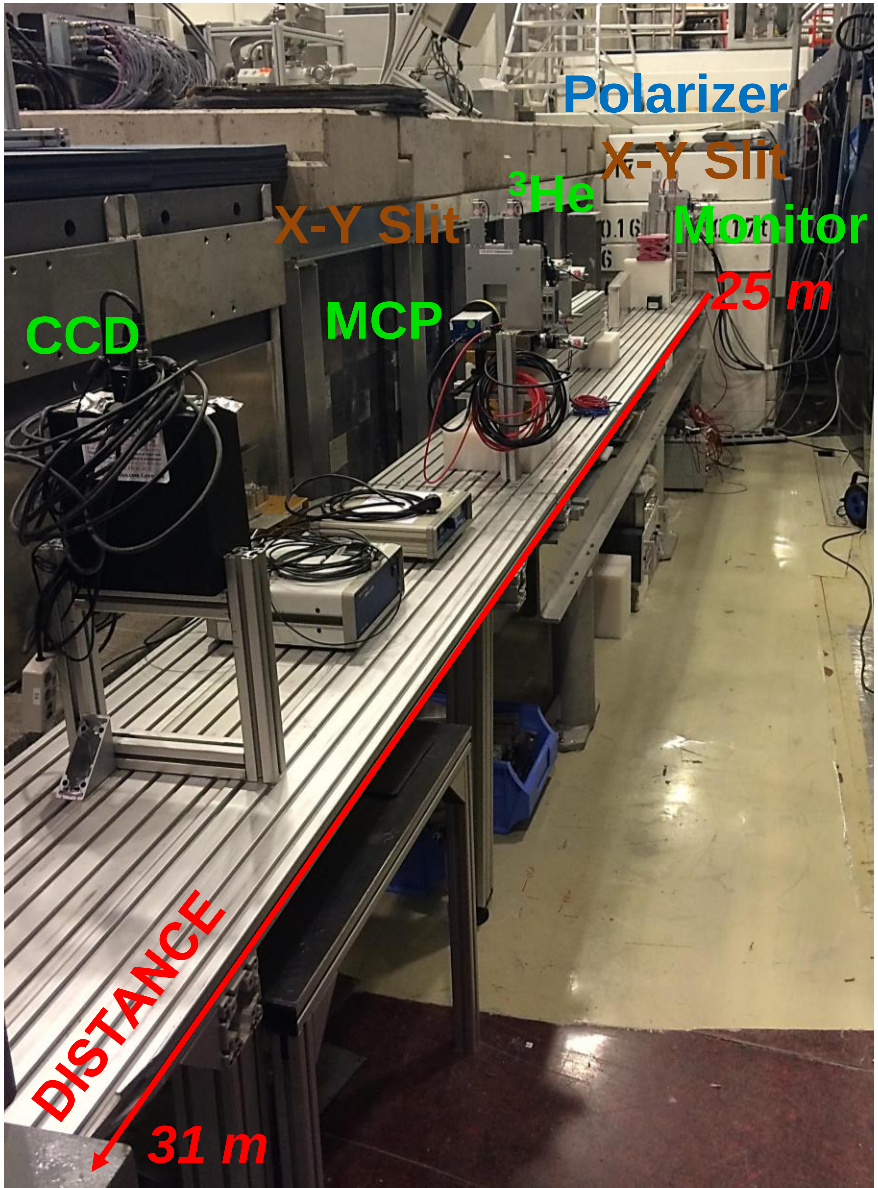


- ^3He analyzer -> estimate an incident polarization of > 97% for all wavelengths

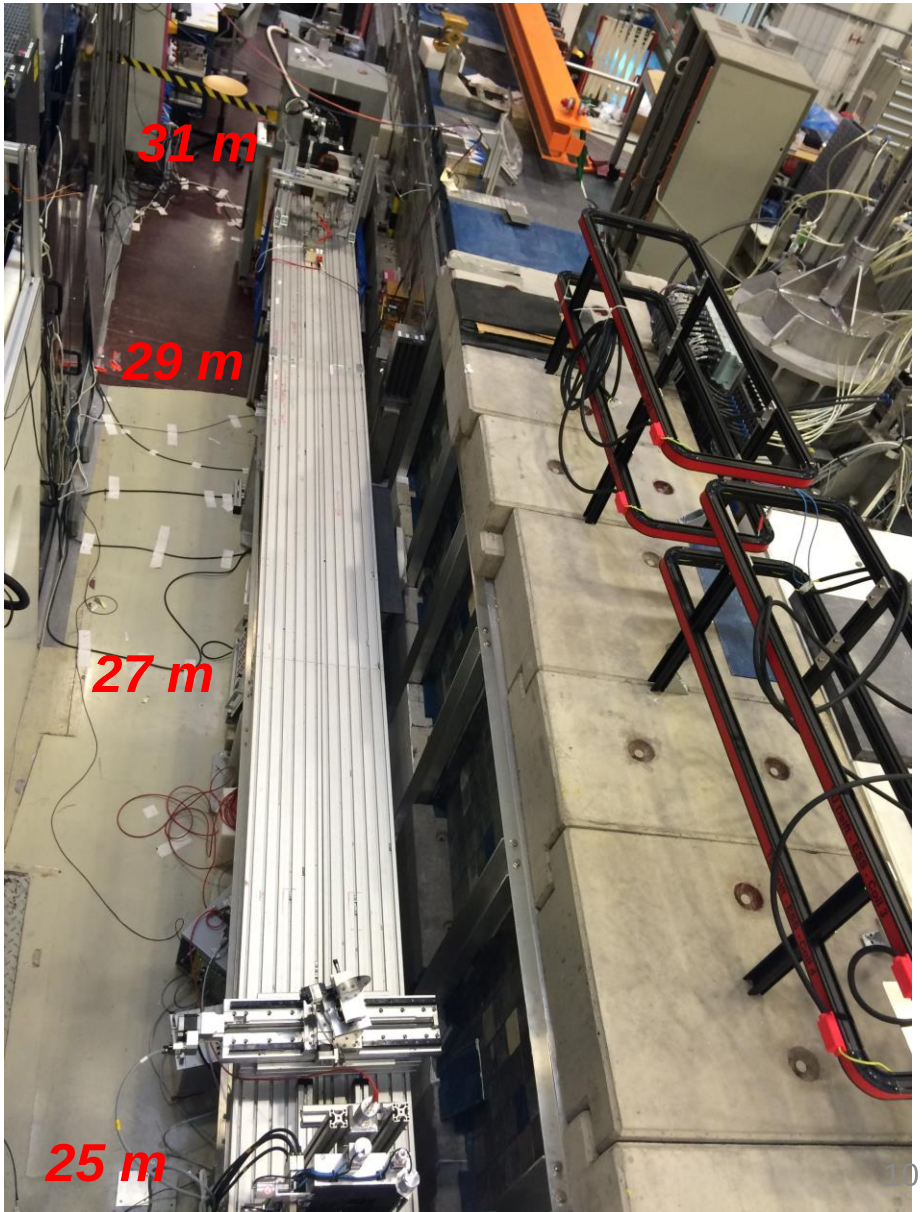


Babcock, E., et al., 2017, "Recent on-beam tests of wide angle neutron polarization analysis with a 3He spin filter: Magic PASTIS on V20"

Layout



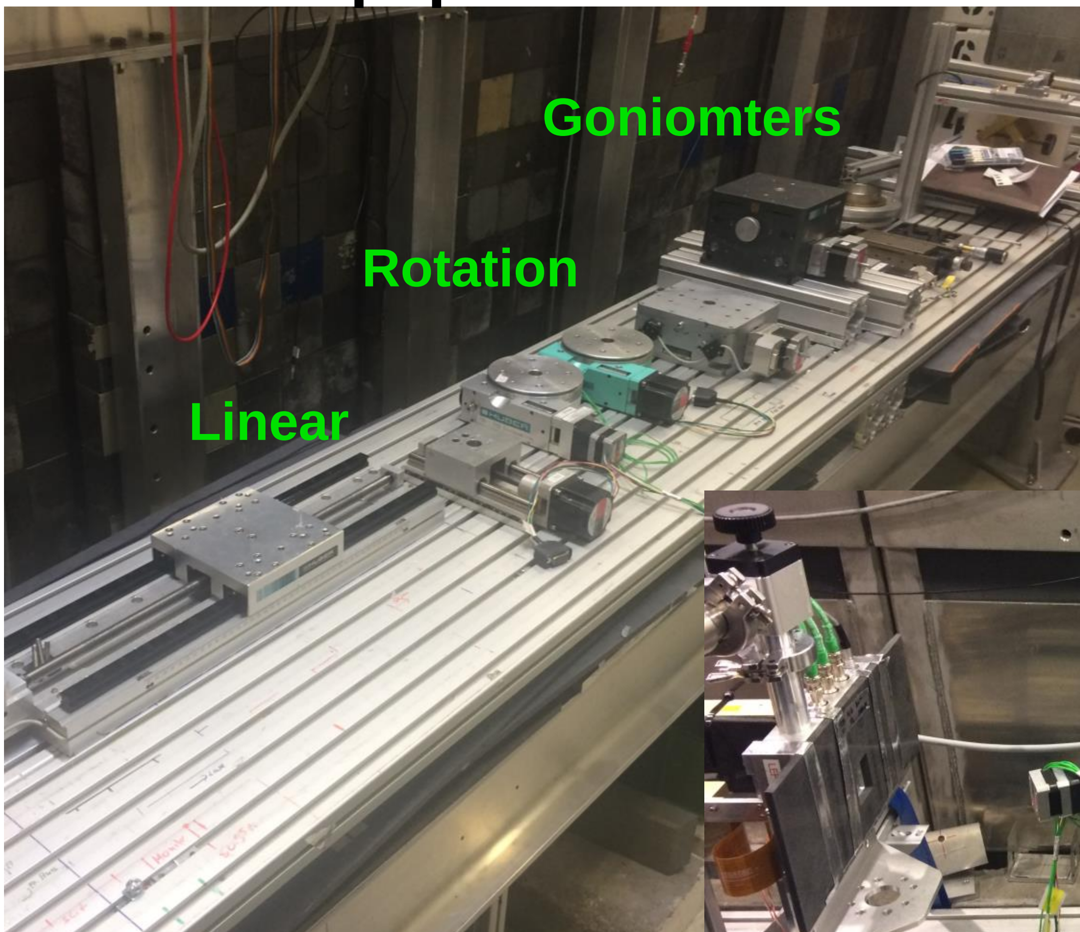
Polarizer
X-Y Slit
³He
X-Y Slit
Monitor
25 m
MCP
CCD
DISTANCE
31 m

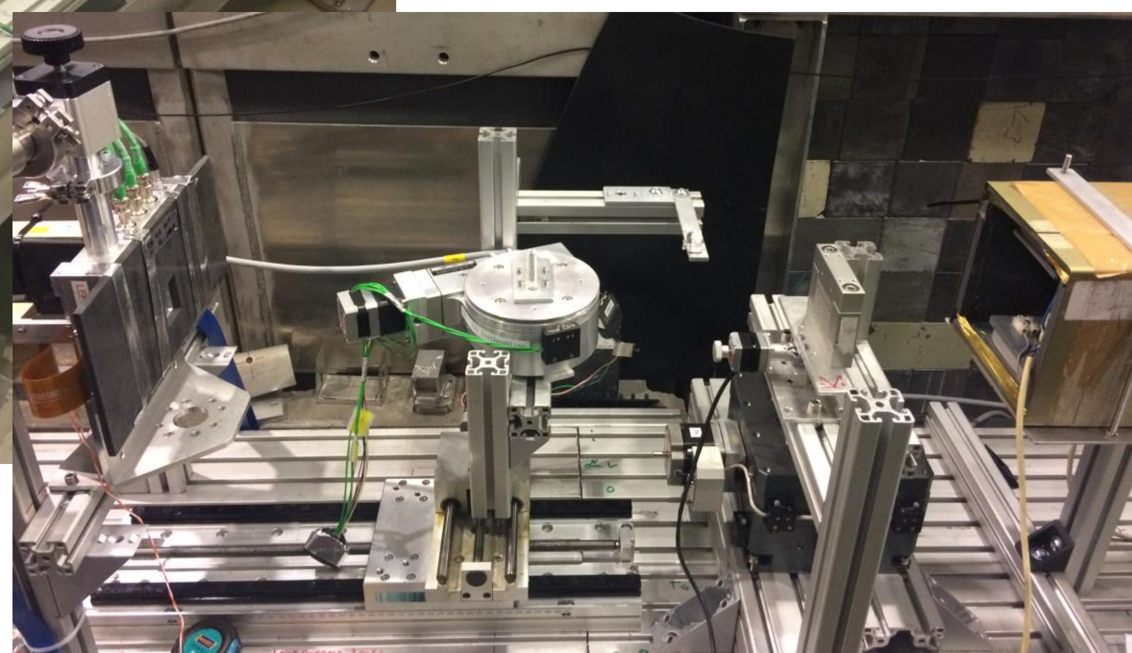


31 m
29 m
27 m
25 m

Layout

Flexible equipment

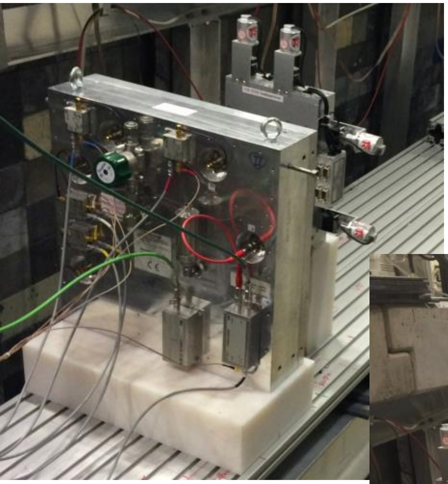


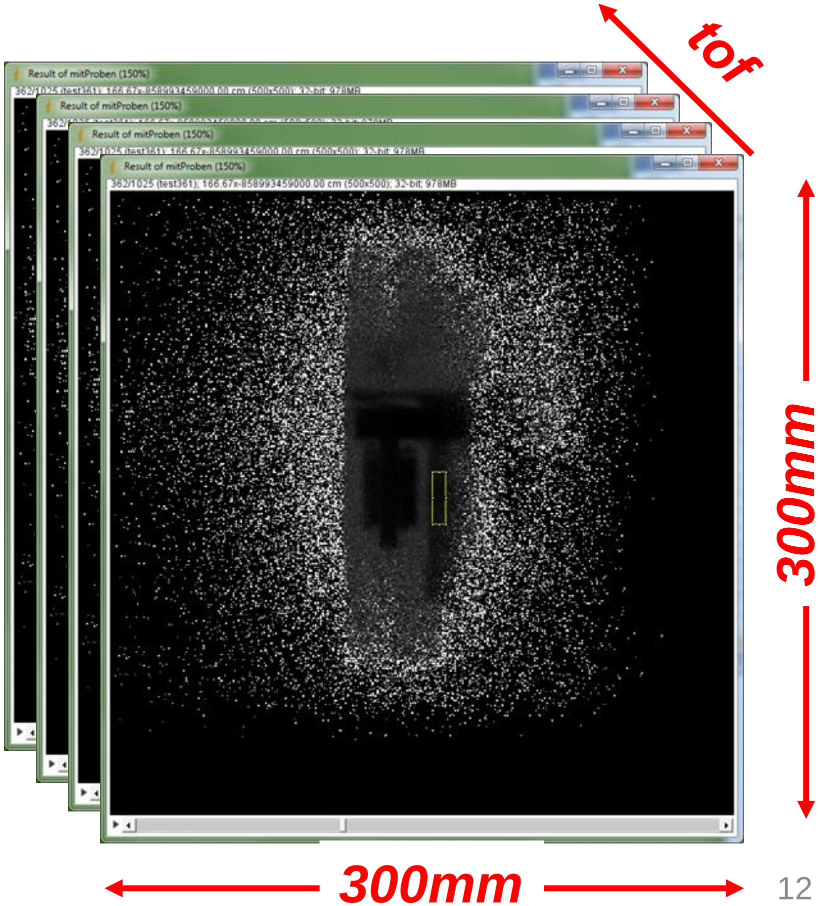


Available Detectors

Available Detectors

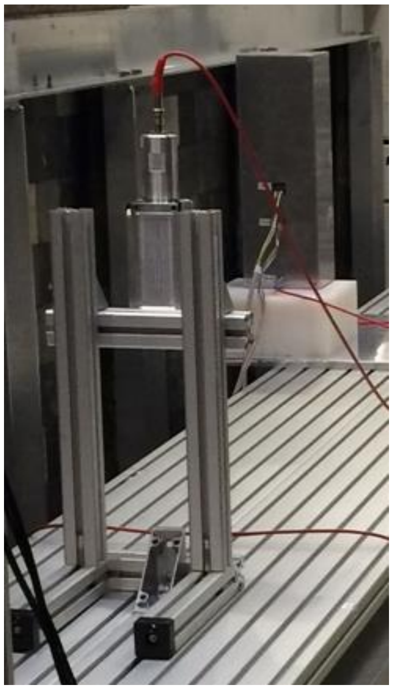
- ToF PSD (DENEX), 3He Delay Line
- 30cm x 30cm active area, ~2mm spatial resolution
- Free configuration (Transmission, Reflectometry, SANS, Diffraction, etc)
- Data can now be saved as (tiff) image stacks

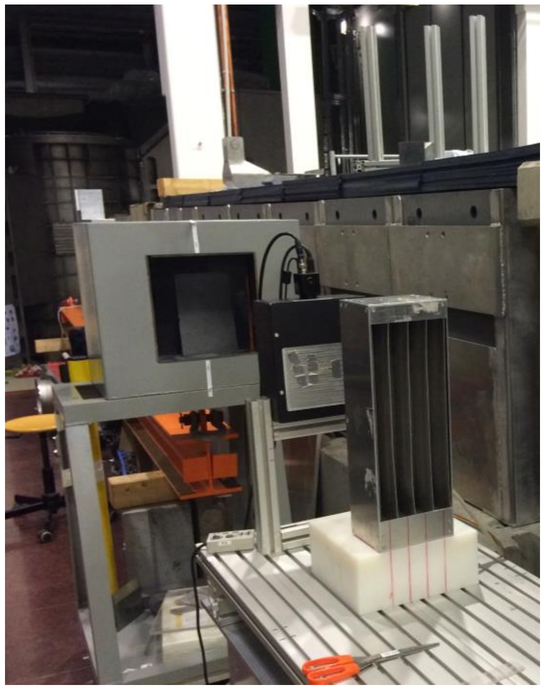




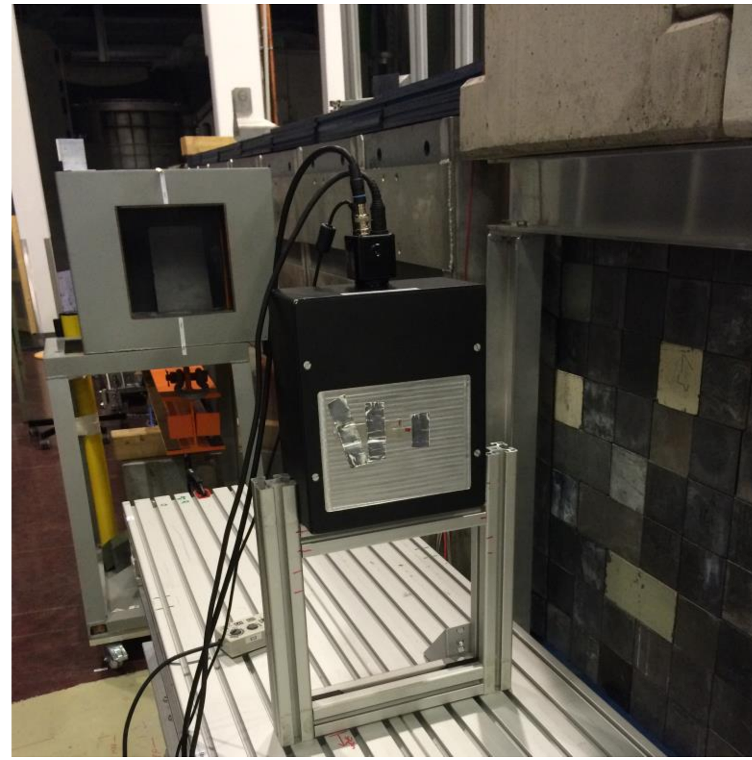
Available Detectors

- ^{3}He Beam Monitors
- ^{3}He tubes: 4 tubes/channels





- CCD camera



- Other detectors available through ongoing collaborations (e.g. ToF imaging camera with 55um pixel size)

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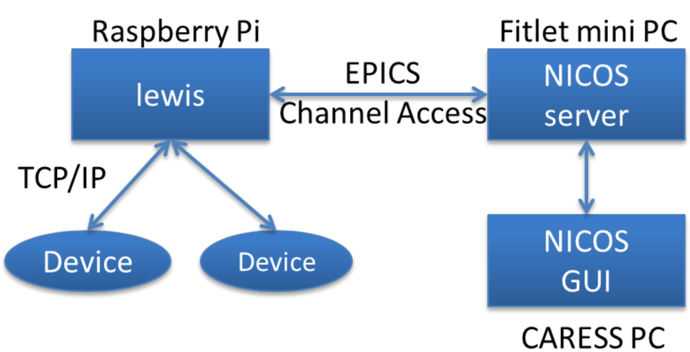
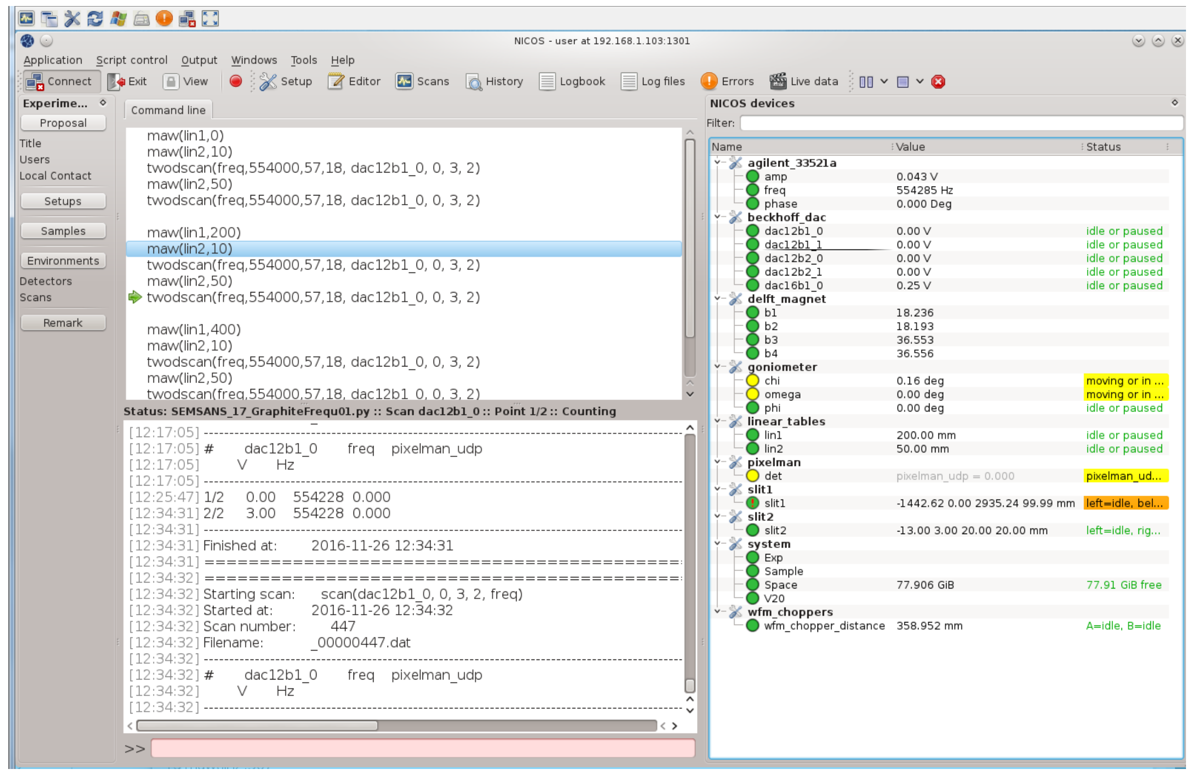
Integration of ESS technology:
Control Software

- **V20 is a test bench for ESS technology and solutions**
- NICOS now used as high level control software (originated at FRM-II)
- Open source, Python, fully scriptable, supports different protocol (EPICS, Tango, CARESS), GUI





Integration of ESS technology:
Data reduction

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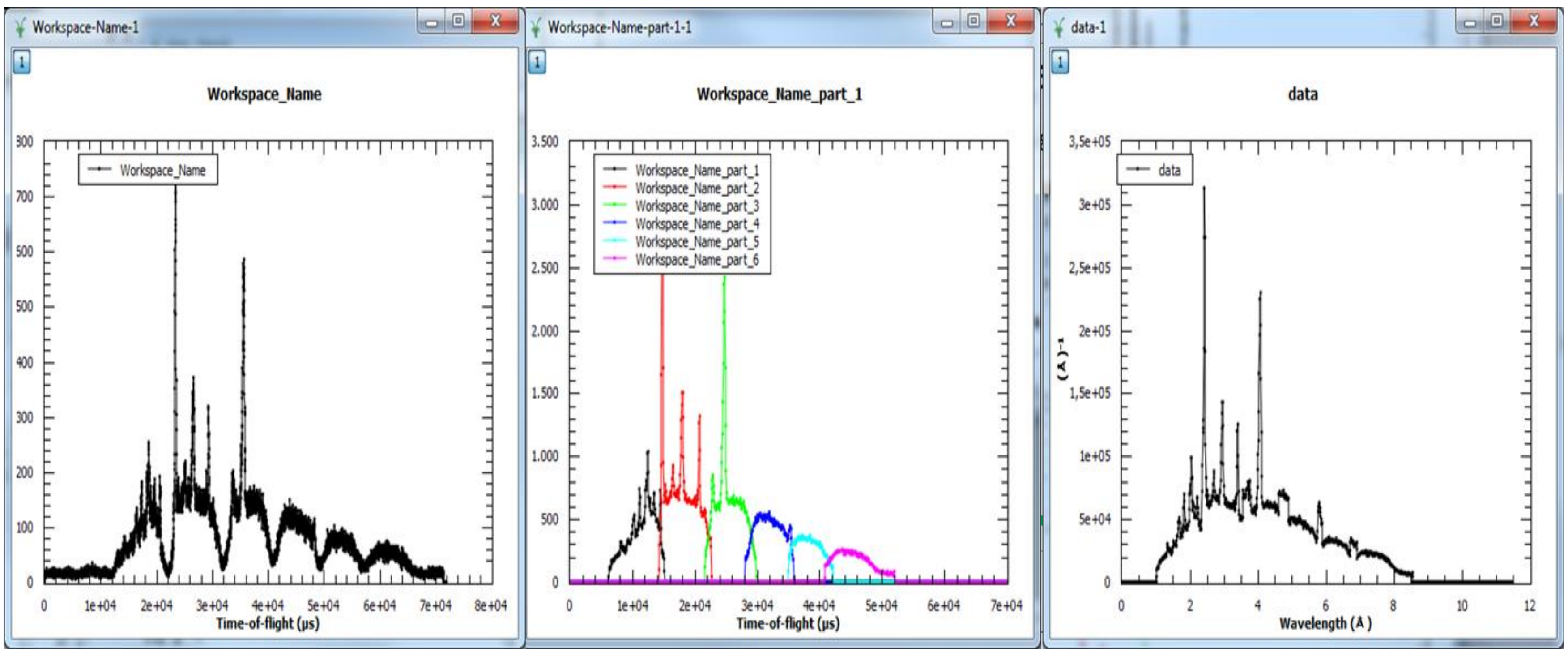
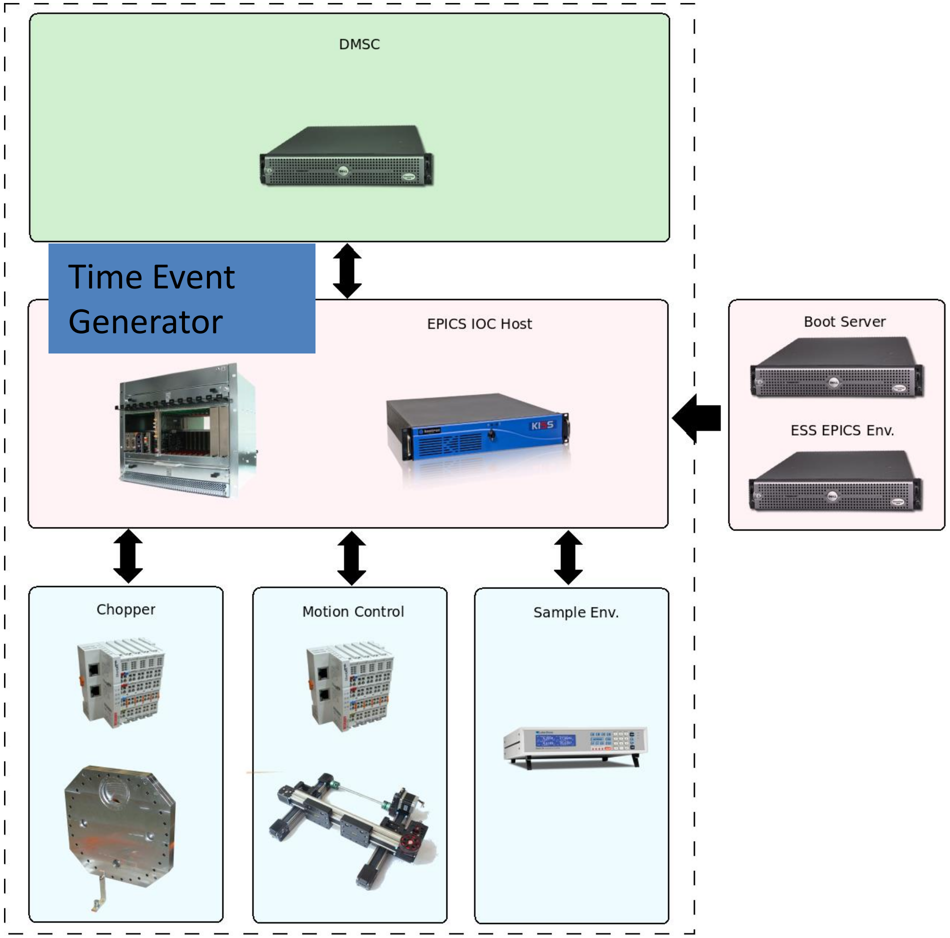
- **V20 is a test bench for ESS technology and solutions**
- Software development of WFM data reduction ('stitching') ongoing

Y203



Integration of ESS technology:
EPICS and time stamping

- **V20 is a test bench for ESS technology and solutions**
- Next: Deploy EPICS infrastructure and timing event generator



- **At V20: Demonstrate a full ESS neutron instrument run from central timing system and EPICS control**

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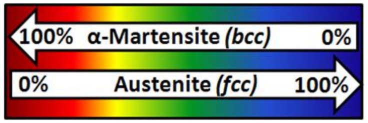
Applications: ToF Bragg edge Imaging

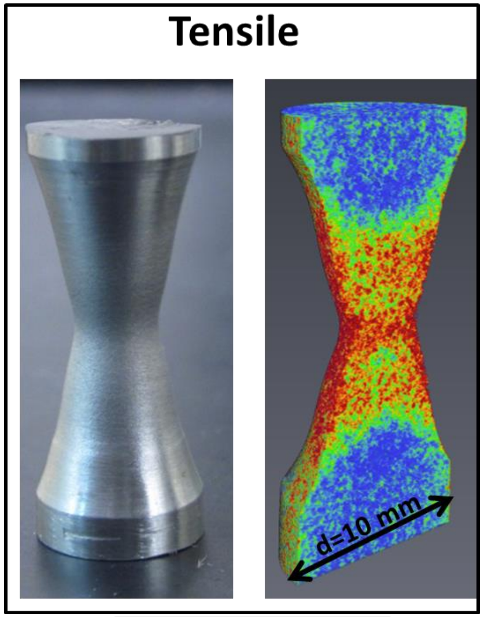
Goals:

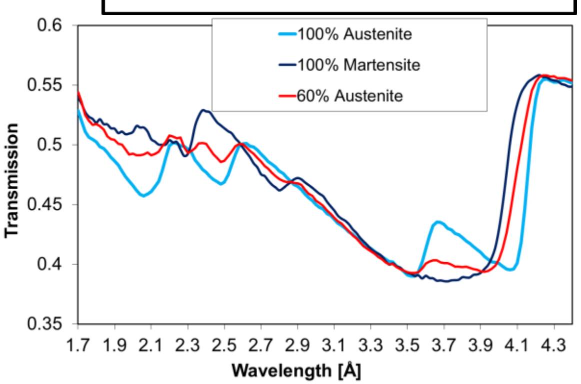
- Testing ToF imaging detectors
    - neutron sensitive Micro Channel Plate detectors by UC Berkeley (Anton Tremsin) and Proxivision/Surface Concept
- Demonstrate WFM mode and related data reduction (‘stitching’) for imaging applications
- Demonstrate tunable wavelength resolution

Applications: ToF Bragg edge Imaging

Sample

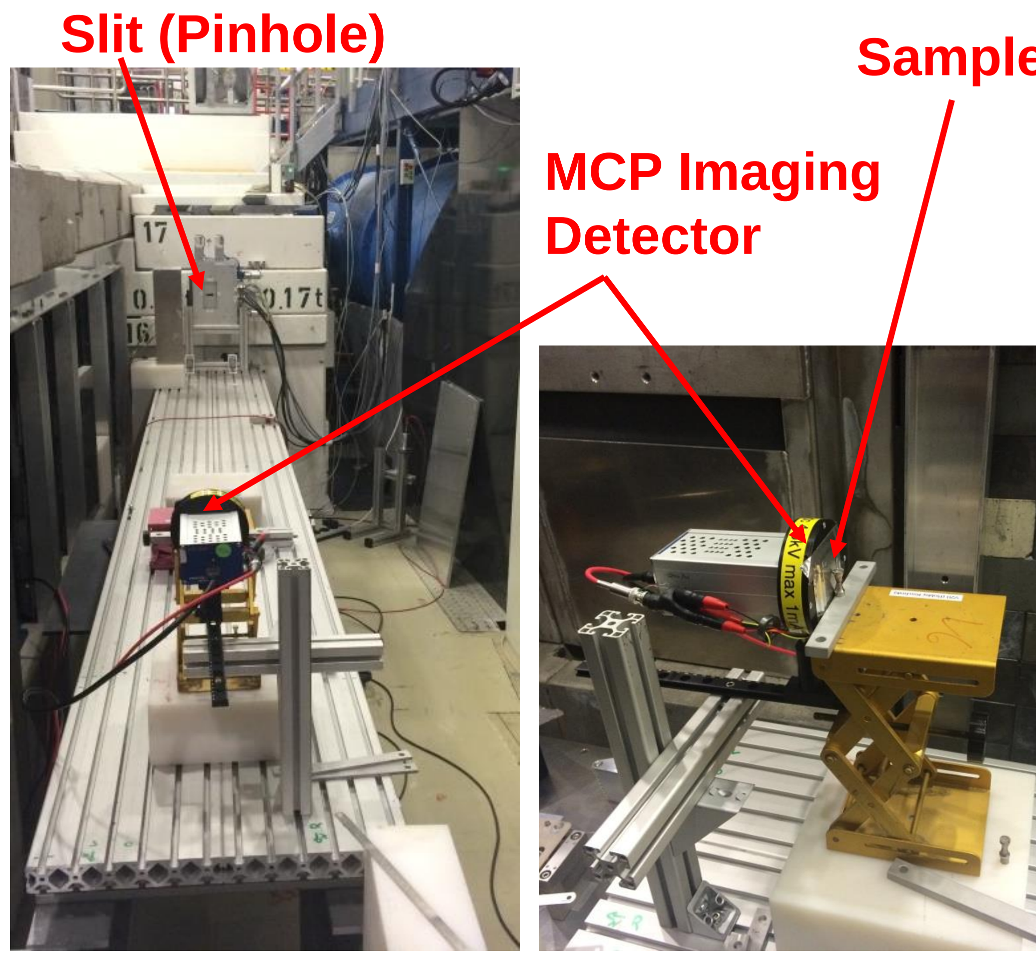






R. Woracek, et al. Adv. Materials 26 (2014)

Experimental Setup at V20



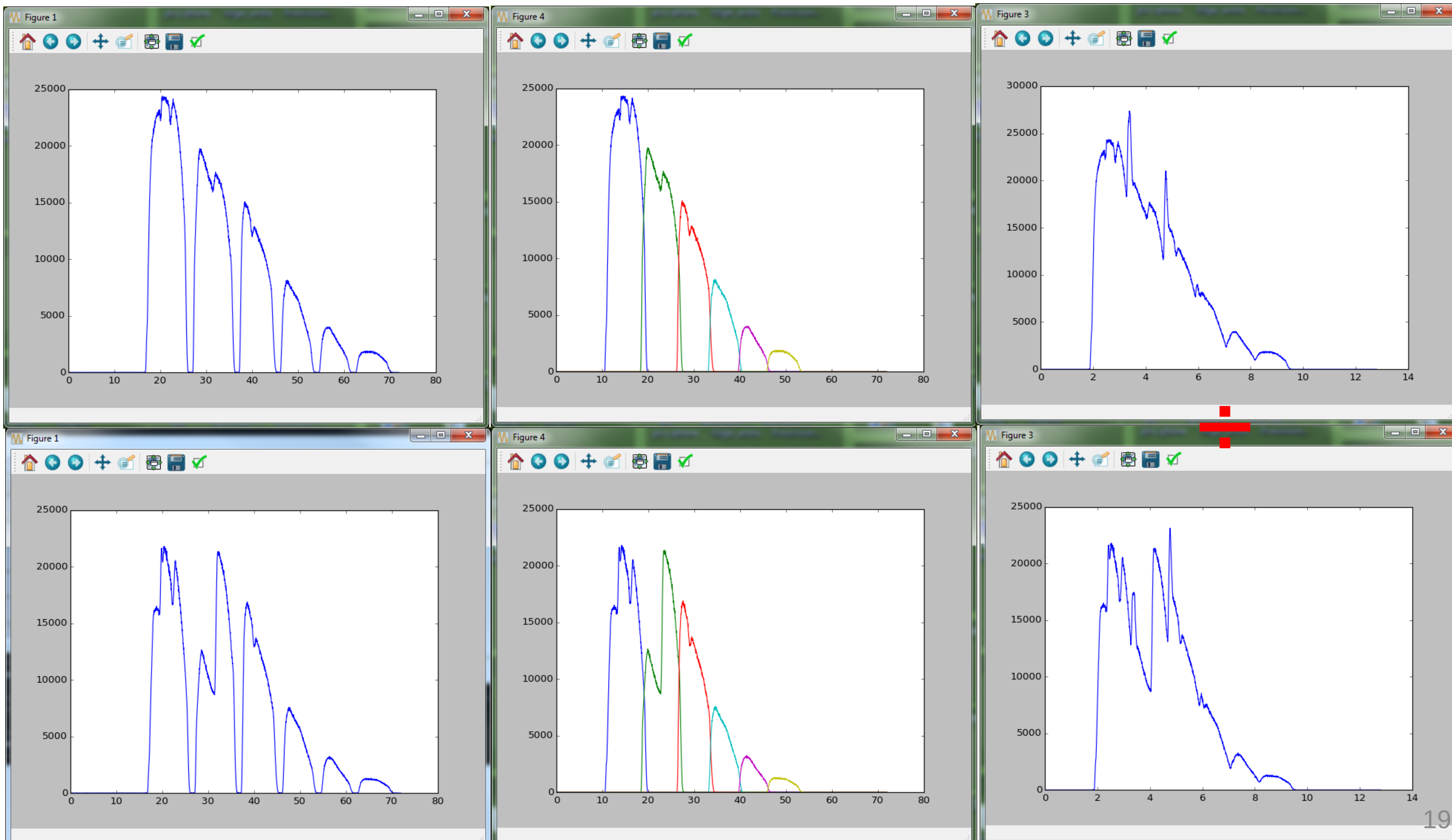
Applications: ToF Bragg edge Imaging

Offset frames

Stitch & Convert to λ

Empty Beam

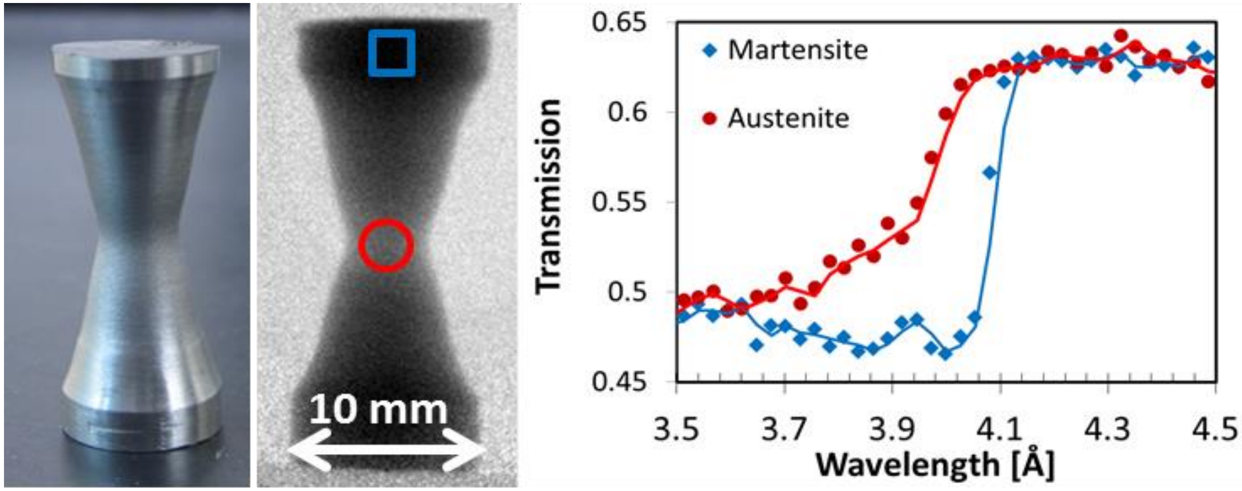
Sample

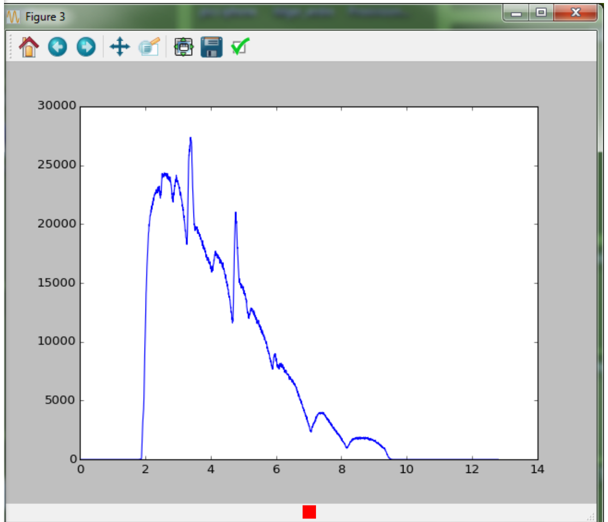


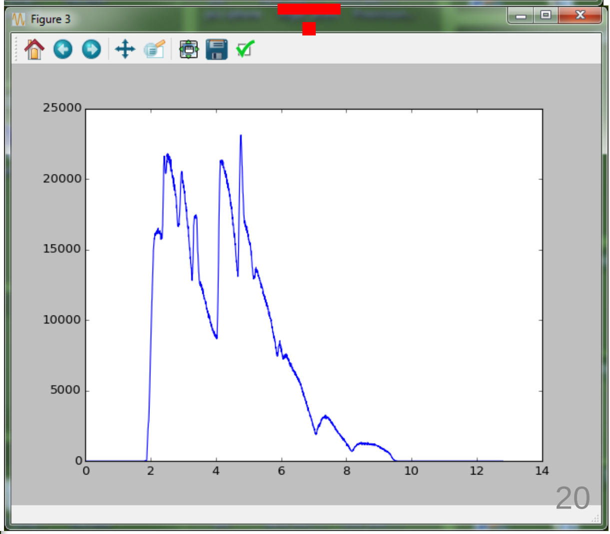
Applications: ToF Bragg edge Imaging

Stitch &
Convert to λ

phase discrimination

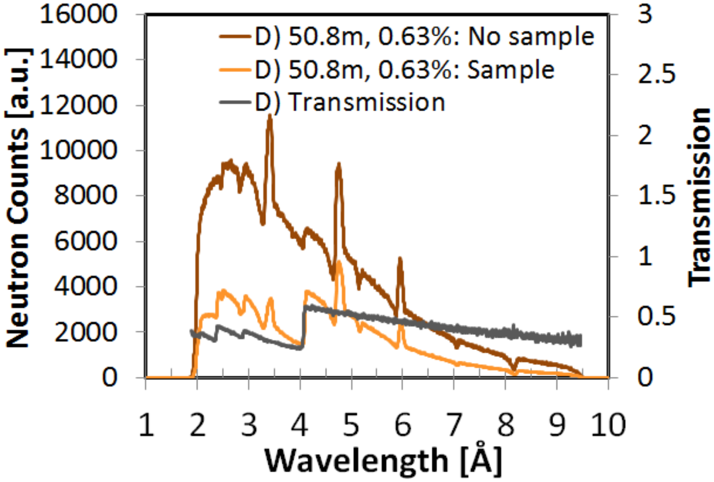


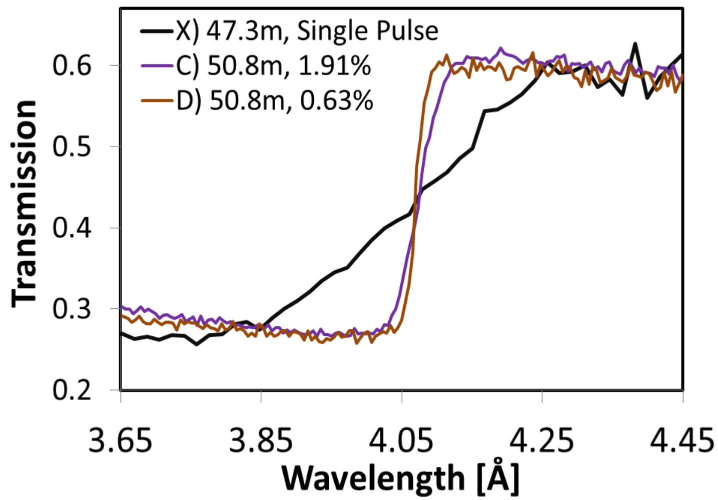


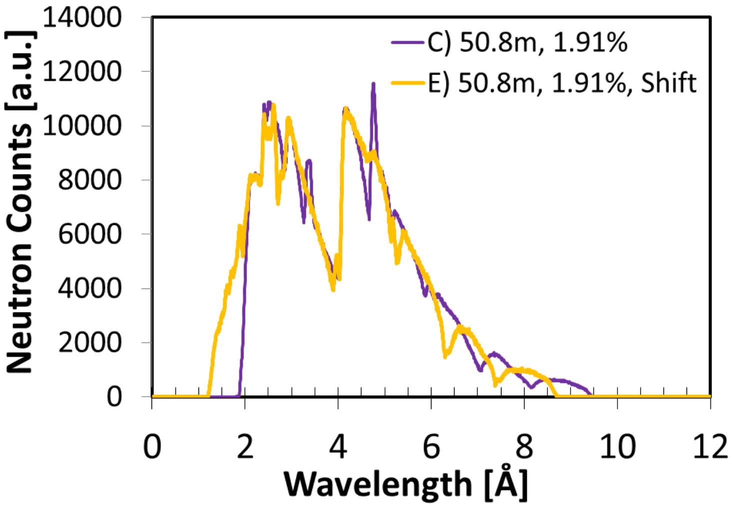


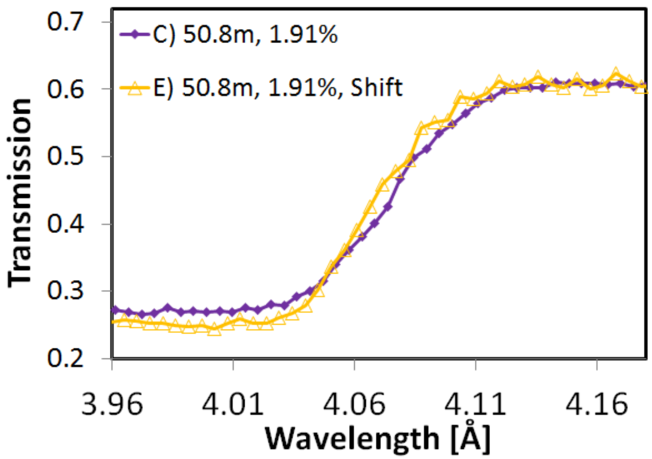
Applications: ToF Bragg edge Imaging

- Demonstrate **tunable wavelength resolution**
- **& stitching when Bragg edge overlap region**



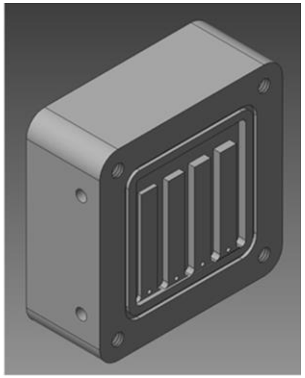


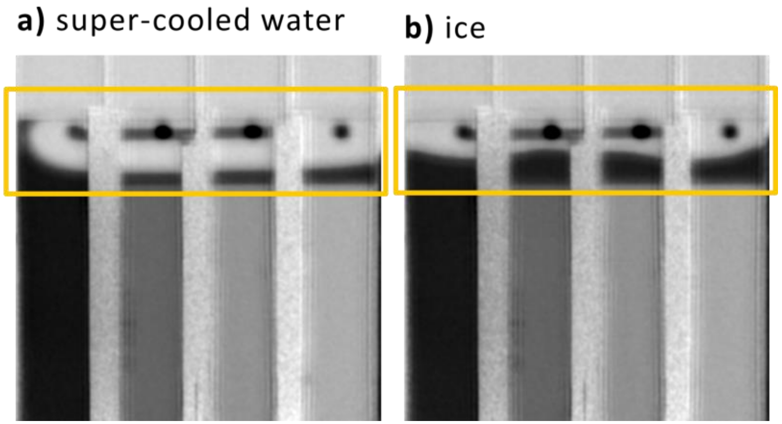


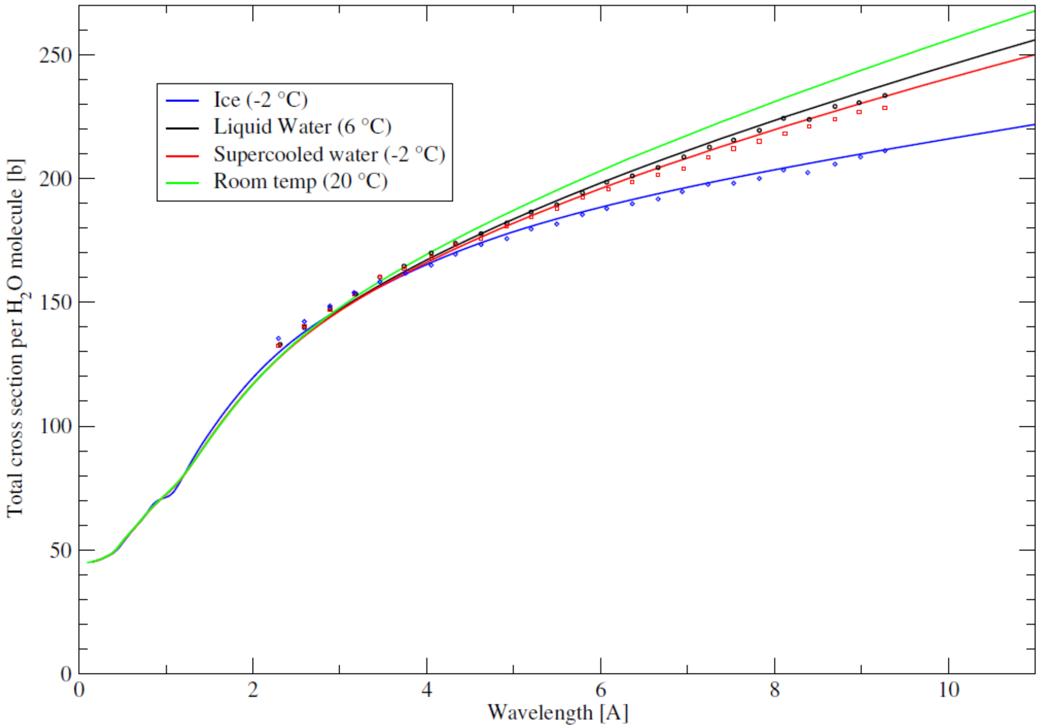


Applications: ToF Imaging

Distinction of liquid (super-cooled) water and ice with neutron imaging



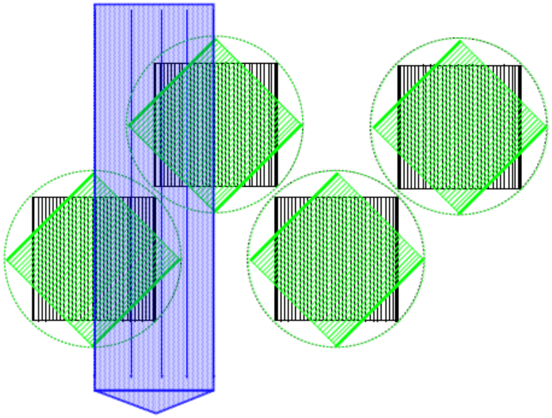


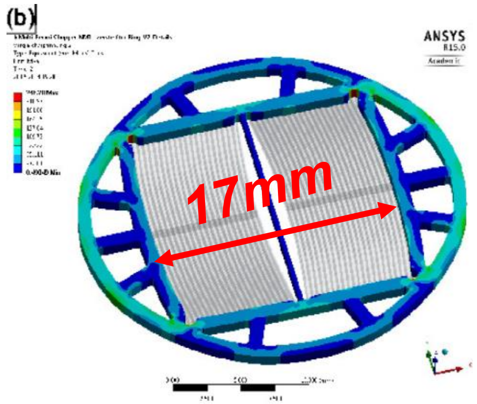


M. Siegwart et al, Modval 14, 2016

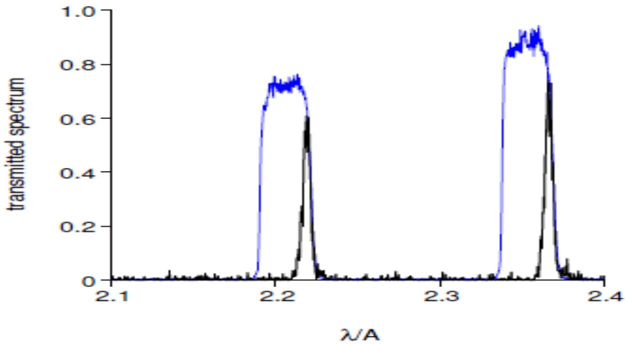
Applications: Component Characterization

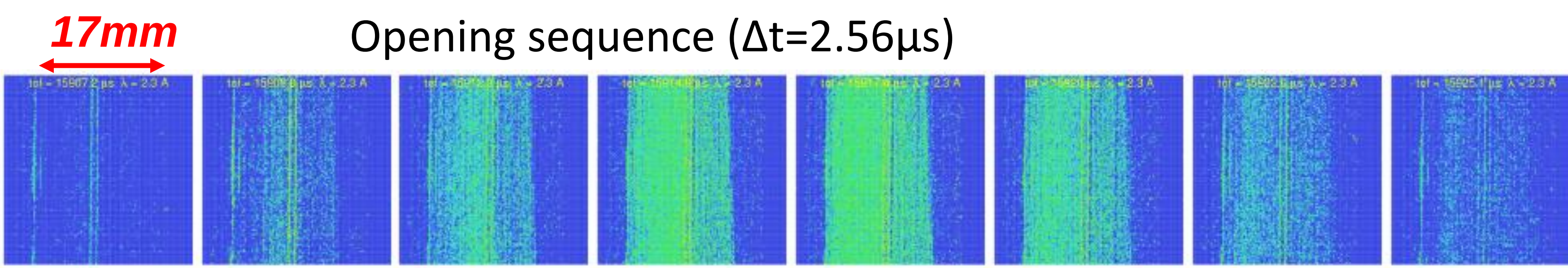
- Fast rotating Fermi Chopper (1kHz) for chopper array
- Neutronic test at 490Hz with use of MCP imaging detector (UC Berkeley)





- Move detector 2.4m downstream





- Left side better transmission: indication of deformation

M. Monkenbusch et al., Lightweight fast rotating Fermi-chopper…., *to be submitted*

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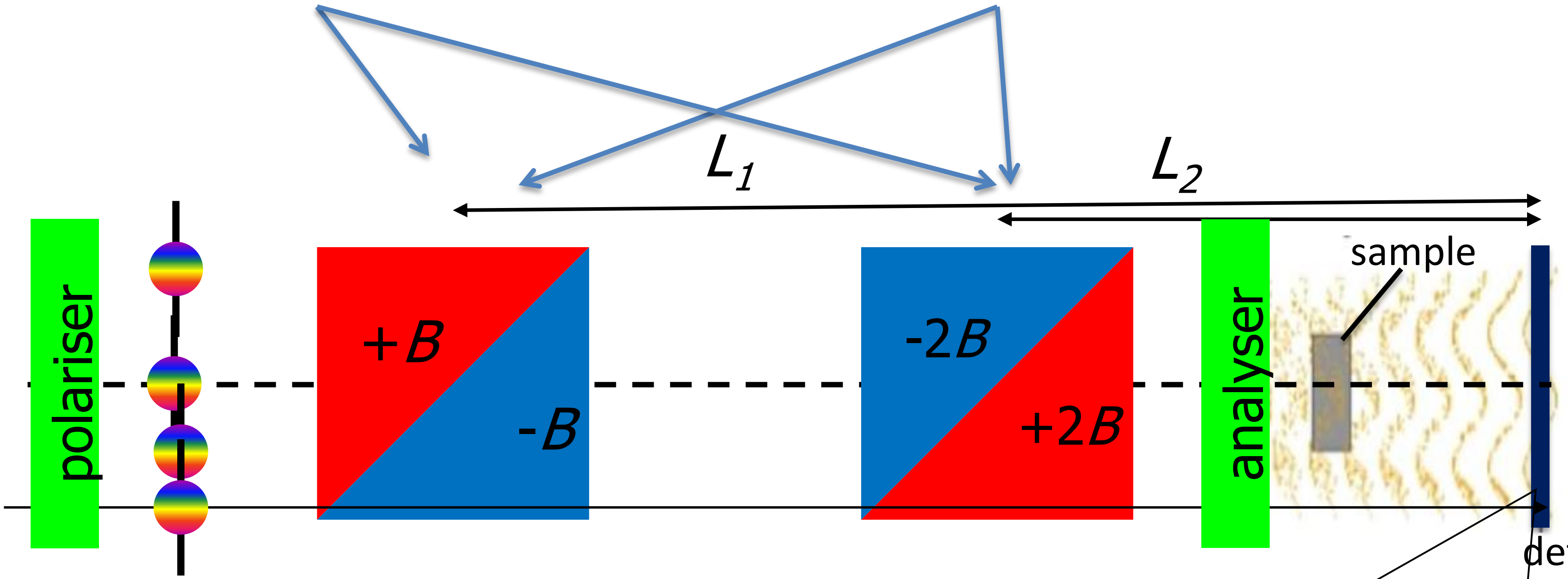
SEMSANS in practice at V20

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

1st setup: Triangular

2nd setup: RF magnets



neutrons arriving same point
same polarisation

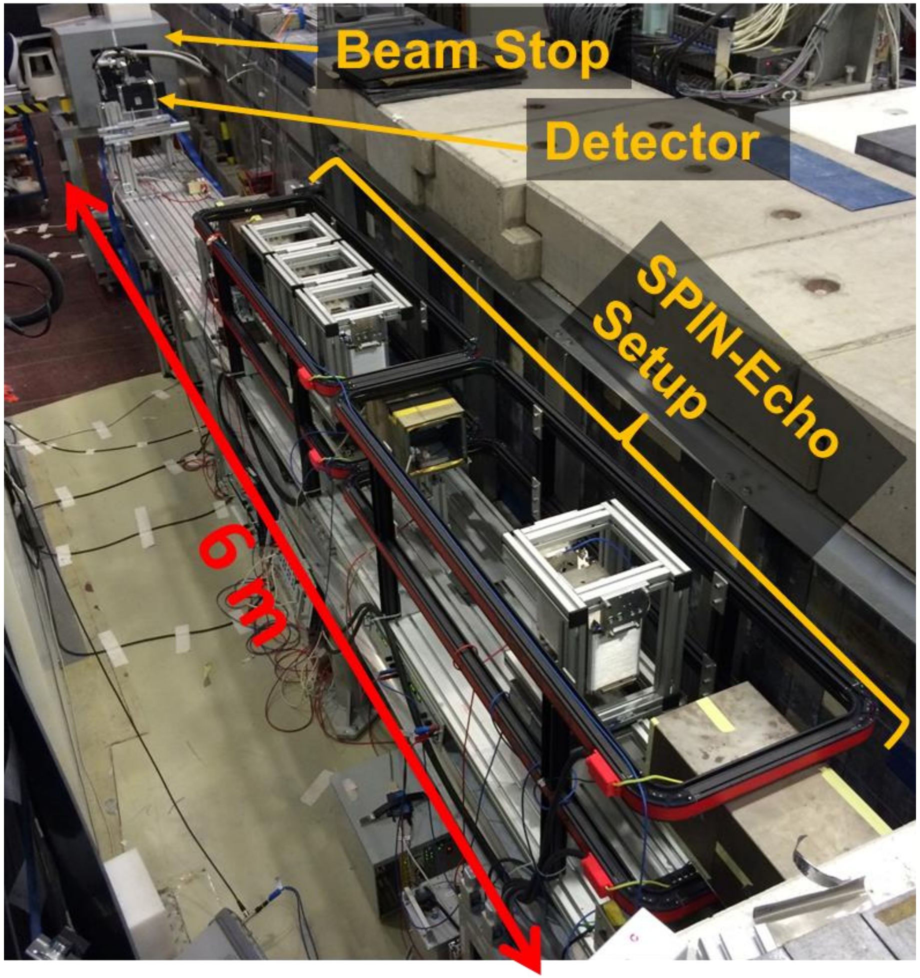
W.G. Bouwman, C.P. Duif, R. Gähler, Physica B **404** 2585-2589 (2009)

Animation: Courtesy of J. Plomp

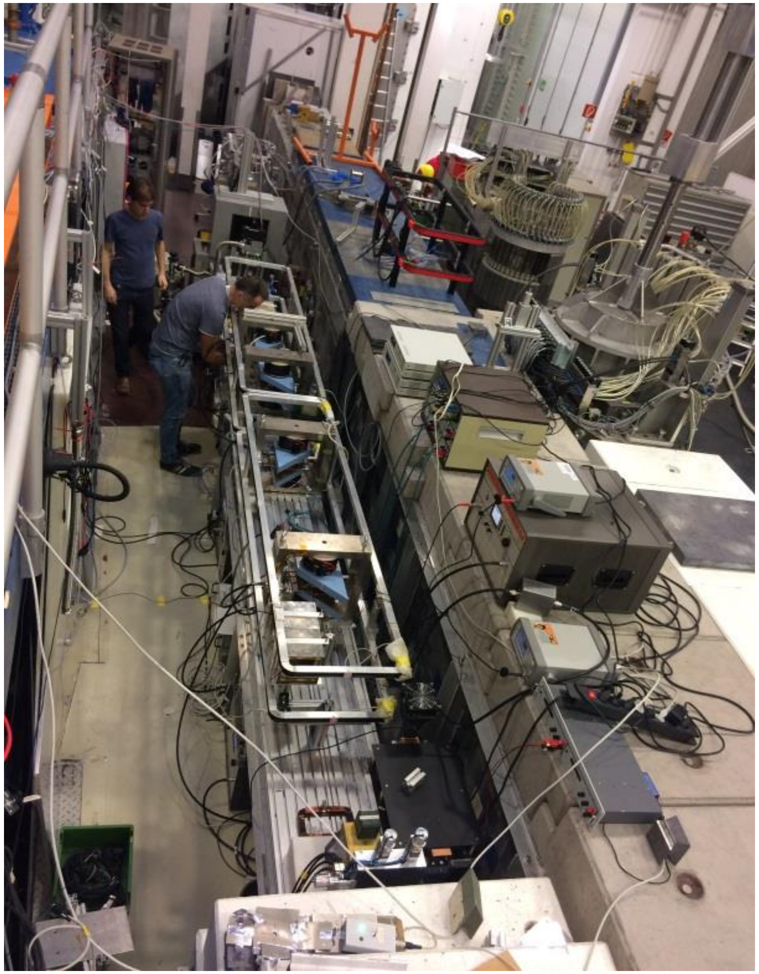
SEMSANS in practice at V20

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

1st setup: Triangular



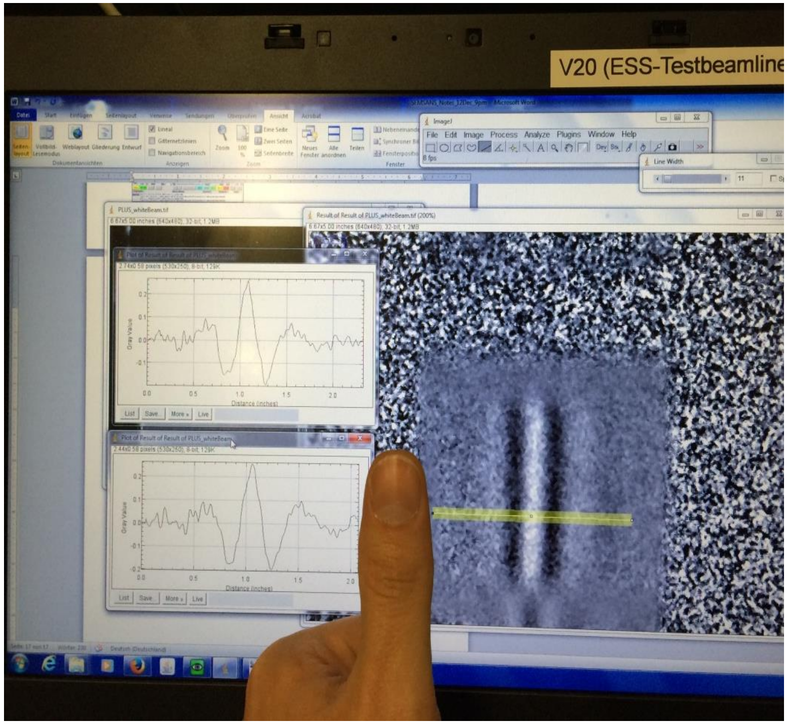
2nd setup: RF



SEMSANS in practice at V20

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

1st setup: Triangular



2nd setup: RF

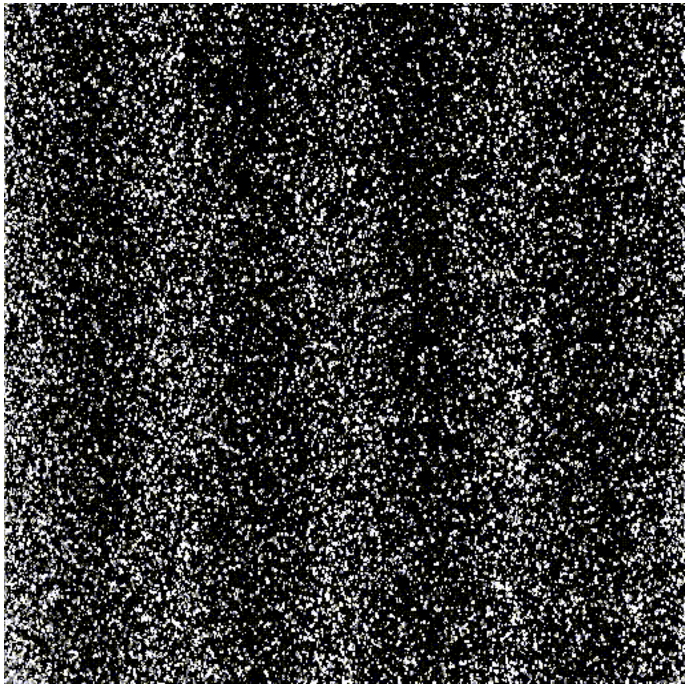
Modulation periods: $\zeta = \pi \tan\theta_0 / (c\lambda(B_2 - B_1))$

SE lengths: $\delta^{SE} = c\lambda^2 L_s (B_2 - B_1)/(\pi \tan\theta_0) = \lambda L_s / \zeta$

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

1st setup: Triangular

2nd setup: RF



Modulation periods: $\zeta = \pi \tan\theta_0 / (c\lambda(B_2 - B_1))$

- limited by the maximum field we could reach.

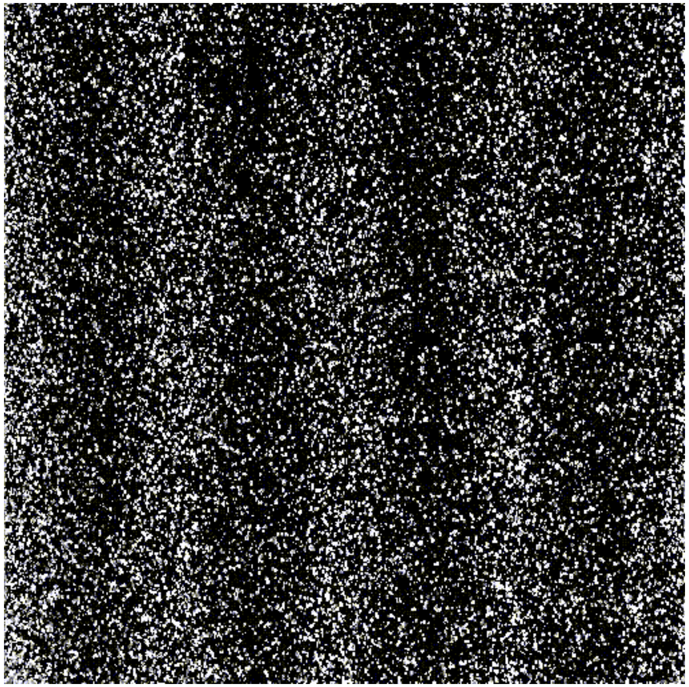
SE lengths: $\delta^{SE} = c\lambda^2 L_s (B_2 - B_1)/(\pi \tan\theta_0) = \lambda L_s/\zeta$

- S-D distance large (50-100cm) to get ~10-**150nm**

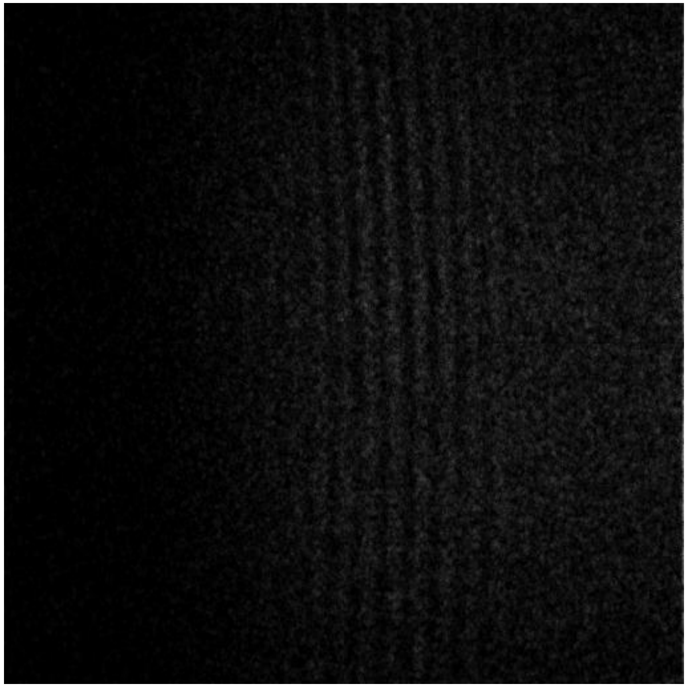
SEMSANS in practice at V20

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

1st setup: Triangular



2nd setup: RF



Modulation periods: $\zeta = \pi \tan \theta_0 / (c\lambda (B_2 - B_1))$

- limited by the maximum field we could reach
- limited by the detector resolution

SE lengths: $\delta^{SE} = c\lambda^2 L_s (B_2 - B_1)/(\pi \tan \theta_0) = \lambda L_s / \zeta$

- S-D distance large (50-100cm) to get ~10-**150nm**
- S-D of 20cm is reasonable to get **~400nm** (at 6Å)

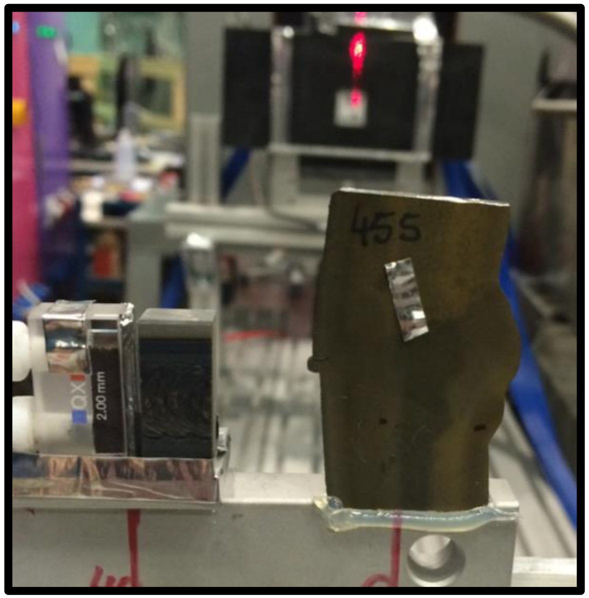
SEMSANS in practice at V20

Jeroen Plomp, Michel Thijs, Andre Kusmin
Markus Strobl,
Ralph P. Harti

EUROPEAN SPALLATION SOURCE

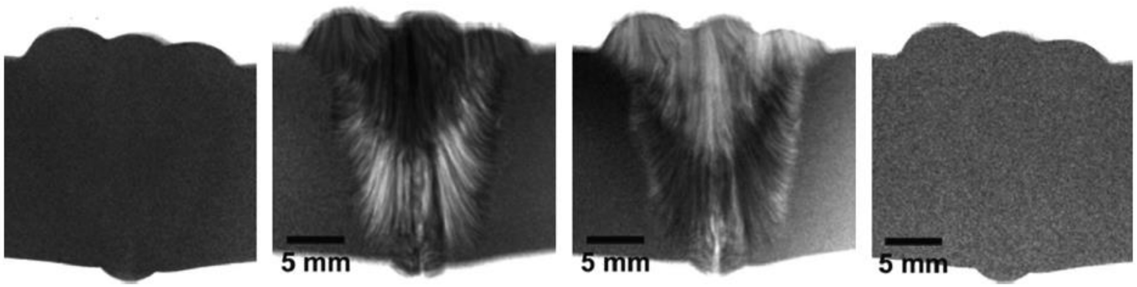
- Practical example (initial results using triangular coils): metallic weld

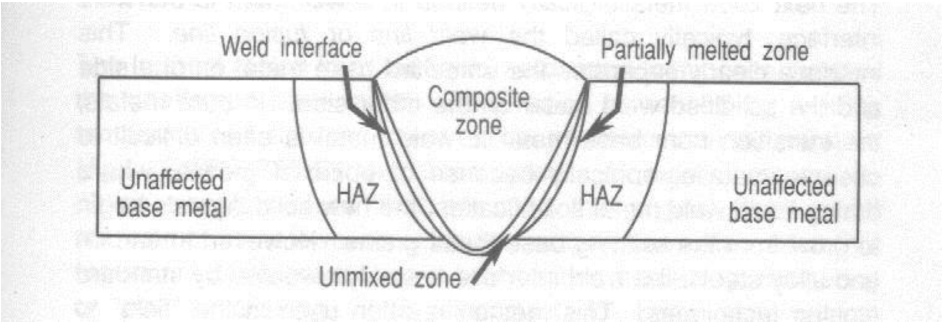
Example: first results



Wavelength resolved transmission imaging

WB | Lambda 1 | Lambda 2 | Lambda 3





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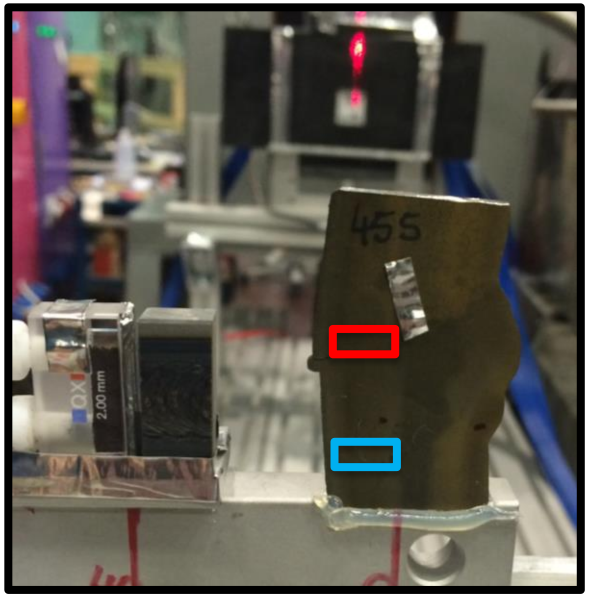

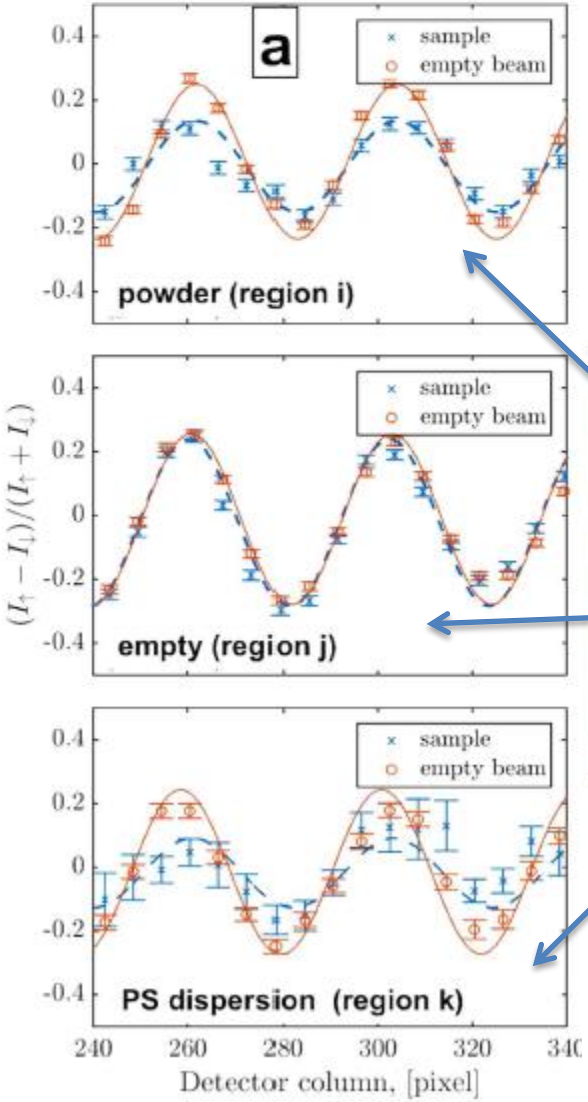

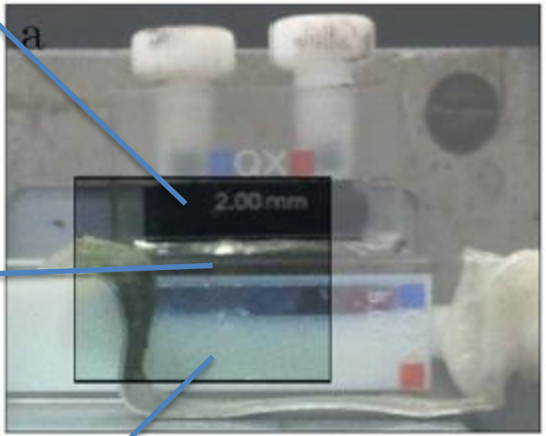

M. Strobl et.al., Scientific Reports, 2015

SEMSANS in practice at V20

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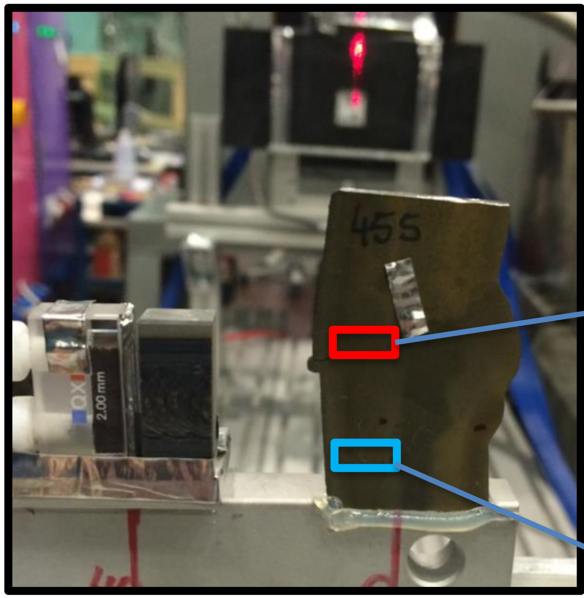
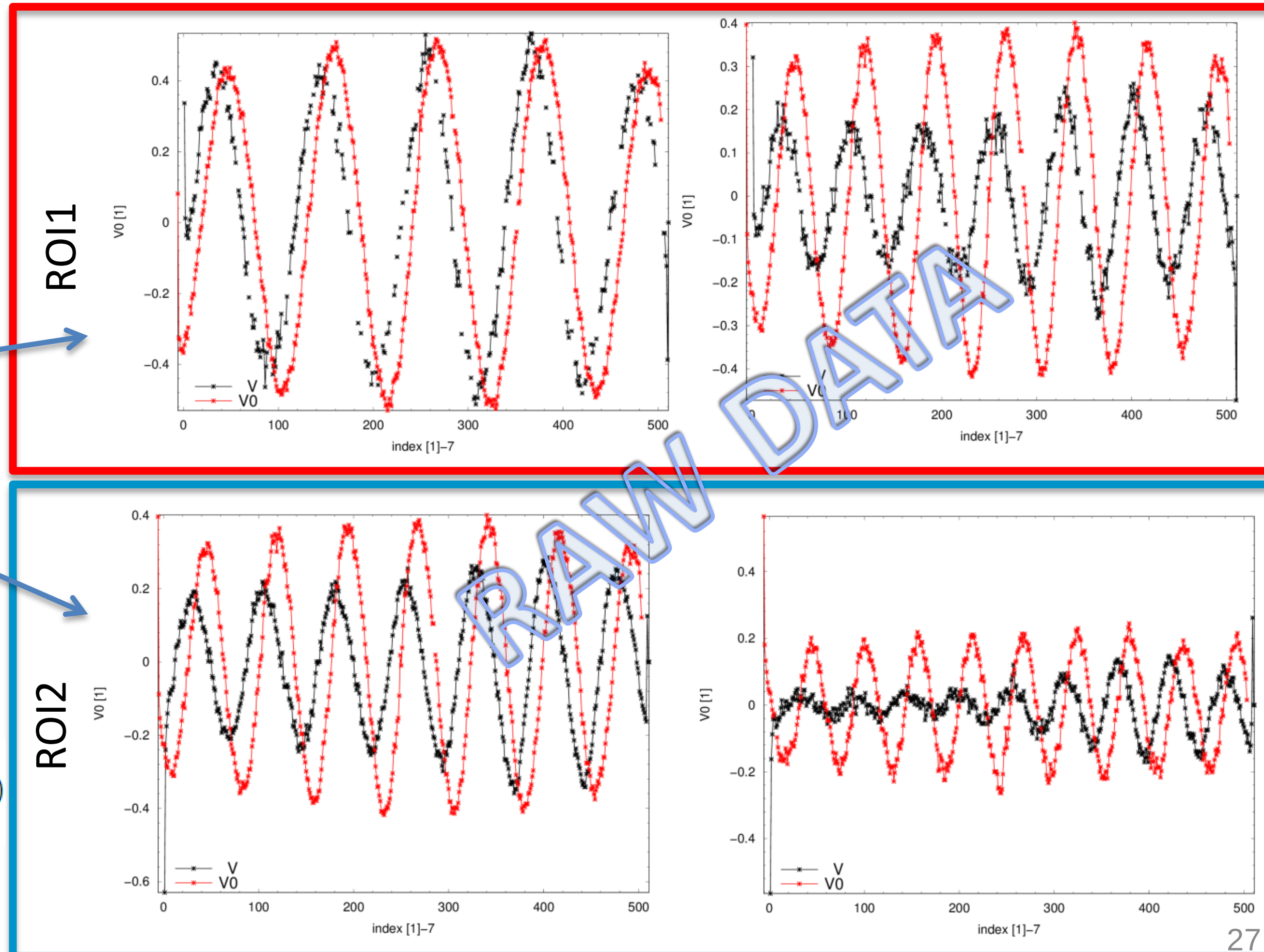
- Practical example (initial results using triangular coils): metallic weld
- Local differences visible between regions of a weld

Example: first results



Lambda 1 | Lambda 2



$$V=(I_{max}-I_{min})/(I_{max}+I_{min})$$

$$V_S(\delta^{SE})/V_0(\delta^{SE}) = e^{\Sigma t\,(G(\delta^{SE})-1)}$$

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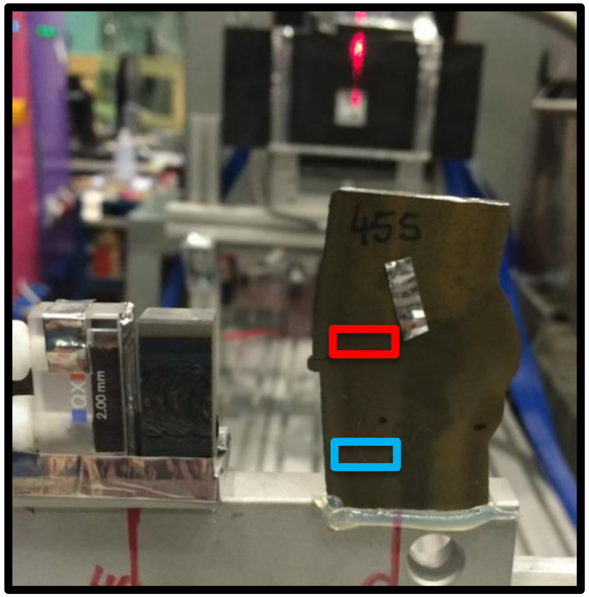

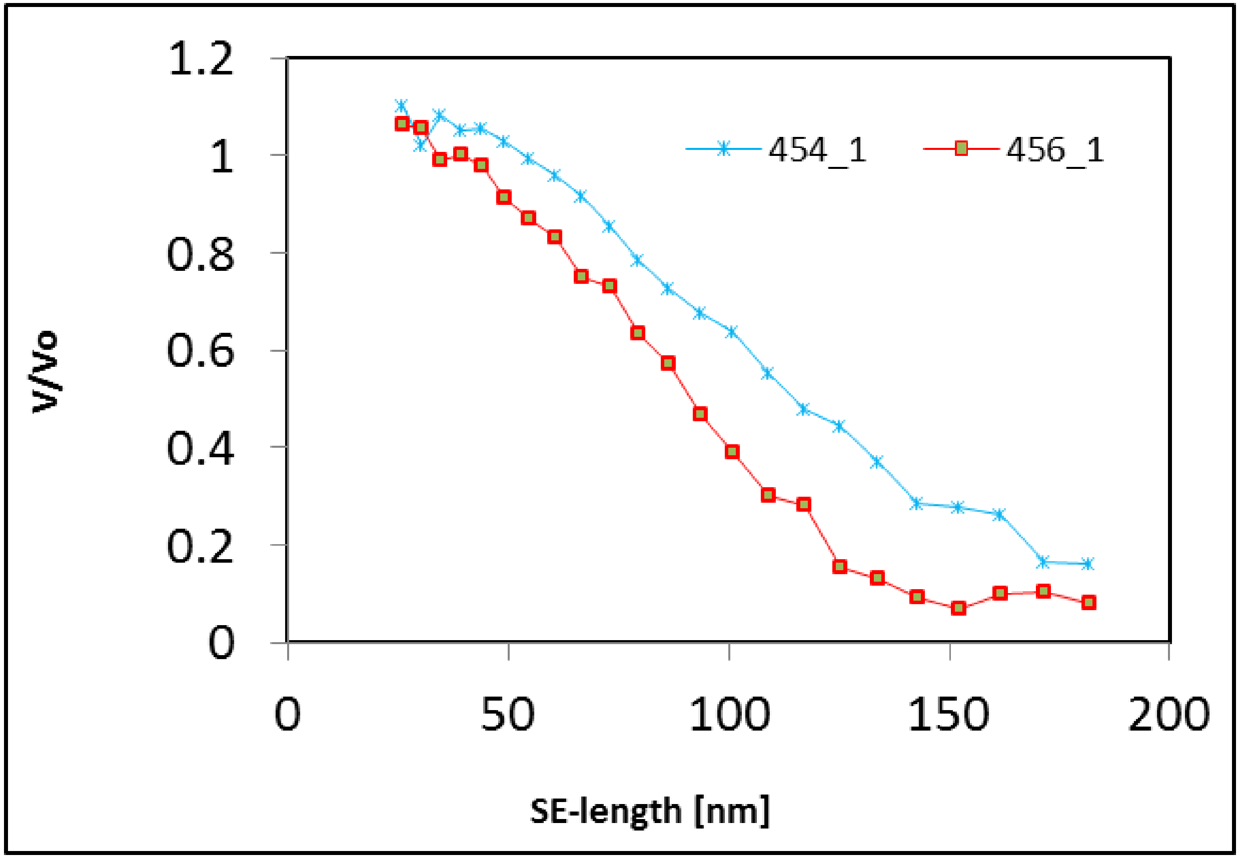

$$V = (I_{max} - I_{min})/(I_{max} + I_{min})$$

$$V_S(\delta^{SE})/V_0(\delta^{SE}) = e^{\Sigma t(G(\delta^{SE})-1)}$$

SEMSANS in practice at V20

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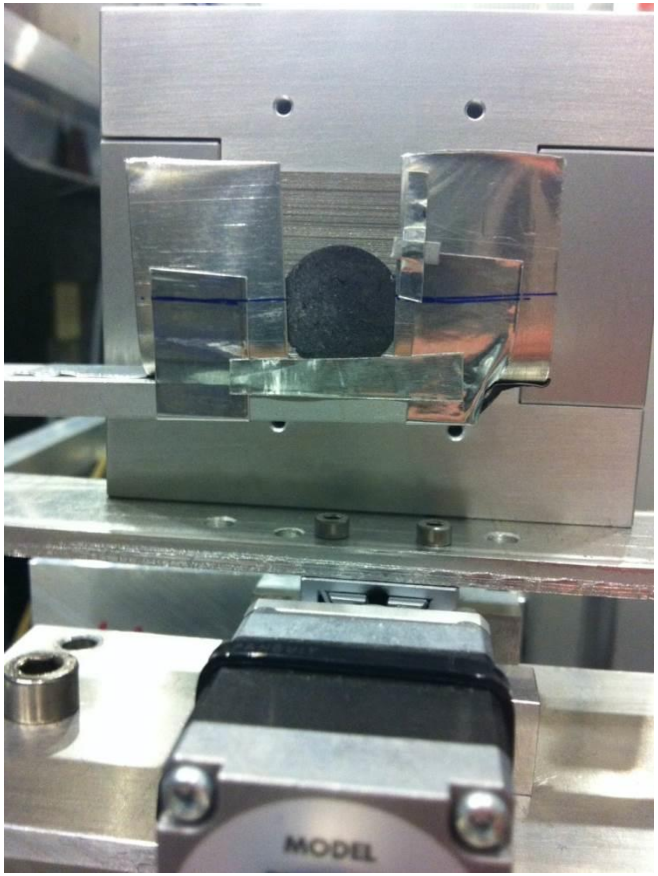
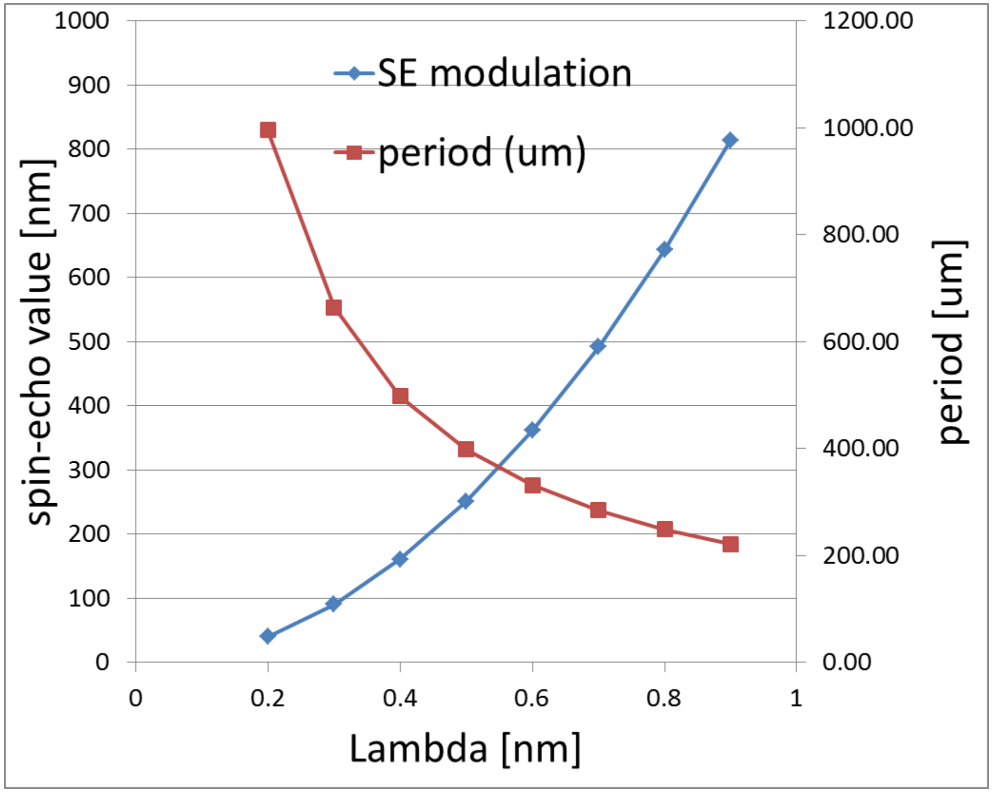
- Initial results from setup with RF magnets
- Sample: carbon disk
- Here: Scanning of SE position

Wim just showed SANS+SESANS+Imaging

ImageJ demonstration



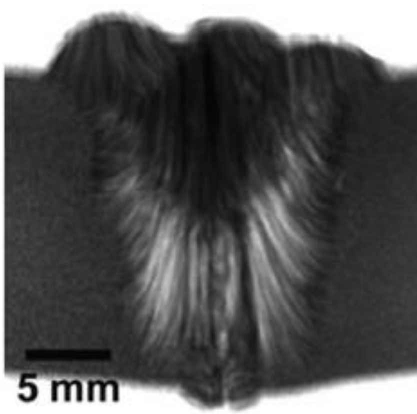


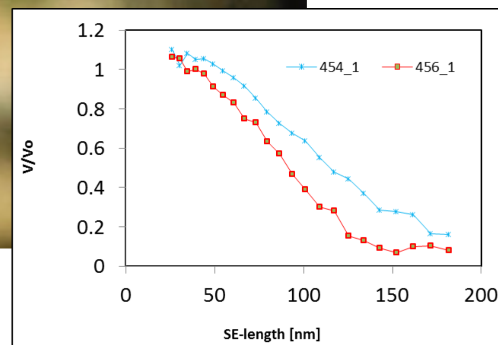
SUMMARY

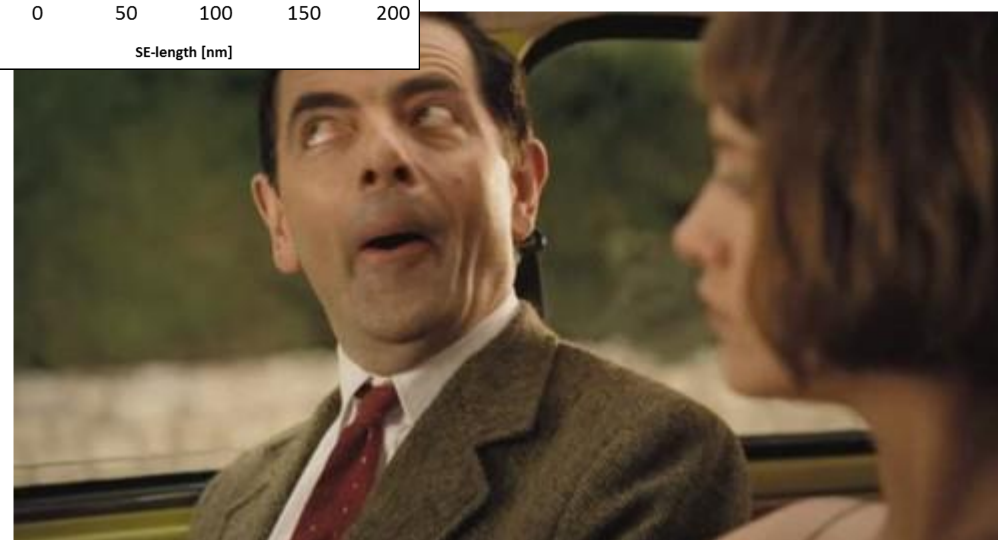
- V20 provides platform to integrate and test new methods, components, hardware…., to develop data reduction and analysis
- Methods like SEMSANS appear to have huge potential for relevant questions: Now let’s start to make use of it!

- **V20 open to develop and test novel techniques**
- Contact: robin.woracek@esss.se

Look in new directions…







THANK YOU!

EUROPEAN SPALLATION SOURCE

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Oliver Merle

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TU Delft

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DTU

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