Detectors for Diffraction & Engineering update

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ESS Detector Group

Project allocations for detectors

Instrument	Phase	ESS DG contact
DREAM	Kick-off meeting expected in summer 2016	Irina Stefanescu
BEER	Kick-off meeting expected in summer 2016	Irina Stefanescu
HEIMDAL	Kick-off meeting expected in summer 2016	Irina Stefanescu (tbc)
MAGIC	-	Dorothy Pffeifer (tbc)
ODIN	1	Tomasz Brys

Work done so far for the diffraction instruments

Assessment of the detector requirements

- Collected the requirements from the proposals.
- Assessed and evaluated the feasibility of the detector technology proposed by the instrument team.
- Identified the gap between the performance of the current detector technologies and the detector requirements for a specific instrument.

Input and feedback to the instrument teams on issues related to detectors

- Estimated the expected detector rates based on MC-simulations, analytical calculations and comparison with data from existing instruments.
- Engaged in discussions with most of the instrument teams concerning the detector requirements as well as the technological options.
- Preliminary discussions/working visits with potential partners from industry/universities interested to deliver the detection systems for the future diffraction instruments.

Work done so far for the diffraction instruments

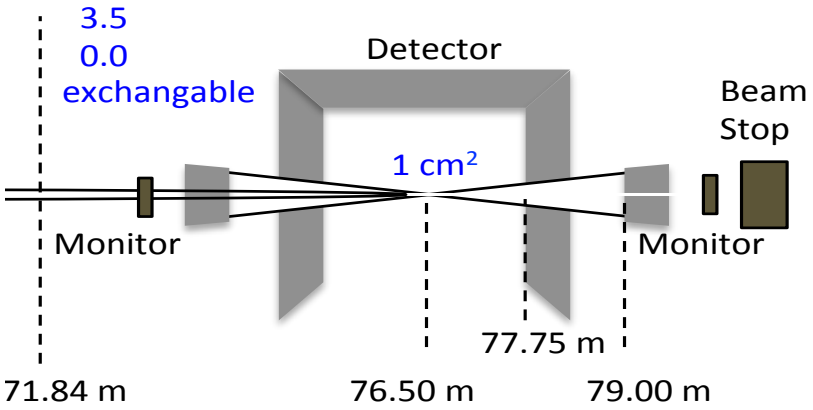
Instrument	Position resolution (H x V)	Area detector	No of detector pixels	Integrated flux on sample, HI mode ($n/s/cm^2$)	Δd/d (90°)	Detector technology	
						Comments	Options
DREAM	4 mm x 4 mm	6.2 sr ($9.7\ m^2$)	$6*10^5$	$3.4*10^8$ (calculated)	0.006	^{3}He tubes ruled out by the position resolution requirement. Rate capability of current technologies could be a challenge.	Scintillators, ^{10}B-based gas detectors
HEIMDAL	< 3 mm x 10 mm	1.8 sr ($4.7\ m^2$)	$1.5*10^5$	$2*10^9$ (calculated)	0.01		
BEER	< 2 mm x 5 mm	1 sr ($4\ m^2$)	$4*10^5$	10^9 (calculated)	0.01		
MAGIC	4 mm x 4 mm	3 sr ($3.4\ m^2$)	$2.1*10^5$	10^9 (calculated)			^{10}B-based gas detectors
WISH@ISIS	8 mm x 8 mm	2.8 sr ($13.8\ m^2$)	$2.1*10^5$	$1.1*10^8$ (experimental)	0.005	^{3}He tubes	
IMAT@ISIS	4 mm x 100 mm	1 sr ($4\ m^2$)	10^4	10^7 (calculated)	0.7	ZnS-based scintillators, under construction	
SXD@ISIS	3 mm x 3 mm	7 sr ($0.44\ m^2$)	$4*10^4$	$6*10^6$ (experimental)	0.01	ZnS-based scintillators	

Obs: in modern detection systems, the number of detector pixels is NOT the same as the number of electronics channels!

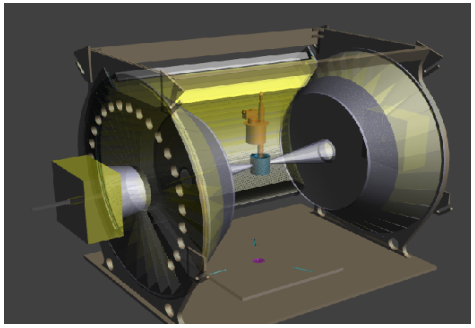
The general goal for readout systems: # of electronics channels << # of detector pixels.

Detectors for DREAM

DREAM will be the ESS bi-spectral powder diffractometer.



Preliminary drawing for the DREAM sample station.



- DREAM requires a large-area powder detector, a back-scattering and a forward detector.
- Size powder diffraction detector: ~9.7 m^2 (6.2 sr, ~2π).
- Detector pixel size: 4 mm x 4 mm.
- Expected flux on the sample (MC): 3.4 x 10^8 $n/cm^2/s$.

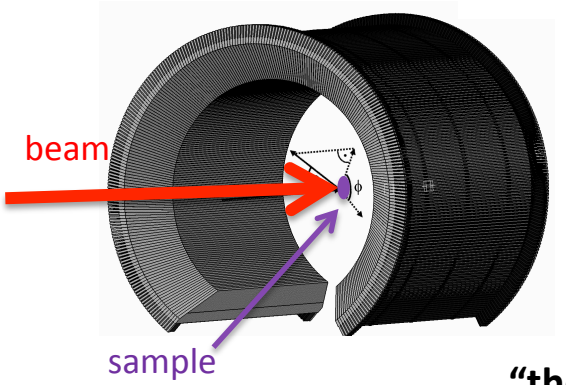
W. Schweika et al., ESS Instrument Construction Proposal DREAM (POWHOW), 2014.

Detectors for DREAM

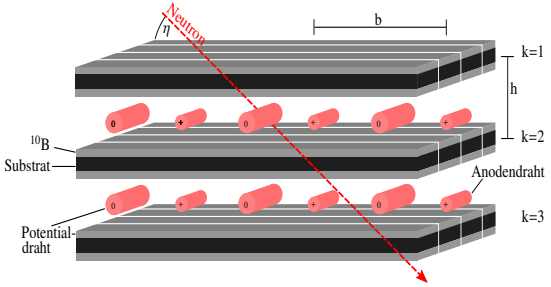
- The powder diffraction detector will be based on the Jalousie concept (^{10}B-based) under construction for the similar instrument, POWTEX@FRM2.
- The Jalousie concept was proposed by CDT Heidelberg (n-cdt.com). Same company will deliver the POWTEX detector.
- CDT Heidelberg was founded in 2006 as a spin-off of University of Heidelberg.
- The company provides detector systems based on ^{10}B (e.g., the CASCADE detector in use at RESEDA and MIRA instruments @FRM2).

See talk by Christian Schmidt, CDT-H, this afternoon in the Detector Session.

CDT GmbH
CASCADE Detector Technologies



"the Jalousie detector"



^{10}B-layers @ 10°, ε_{det} ~ 53% @ 1 Å.

M. Henske et al., The ^{10}B-based Jalousie neutron detector – An alternative for ^{3}He-filled position sensitive counter tubes, NIMA 686 (2012) 151.

Detectors for DREAM

Expected peak-event rate in detector: ~1 kHz/cm^2.

➔ instantaneous peak rate 2.3*10^4 events/cm^2 (14 Hz, 3 ms).

➔ ~2.5*10^3 events/wire, as in the preliminary design for the POWTEX detector the wire pitch seen by the beam is 6.3*sin(η=10°) mm.

➔ In the geometry with stacked MWPCs, the first counter records ~50% of the total events hitting the detector.

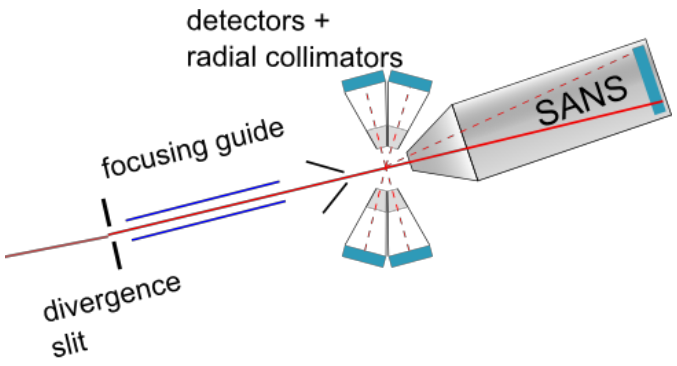
➔ an event rate of 1.2 kHz/wire (expected instantaneous peak-event rate) is not expected to be challenging for the readout electronics.

Status of DREAM detectors:

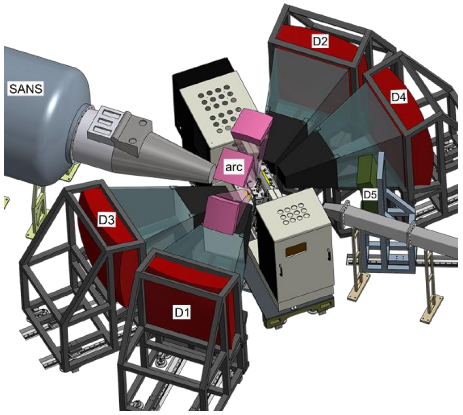
- The detector technology proposed by the instrument team is feasible.
- Discussions on how to integrate this concept into ESS started in May 2015.
- Awaiting the BMBF funds to become available to start Phase 1 design.

Detectors for BEER

BEER will be the ESS materials science and engineering diffractometer.



Preliminary drawing for the BEER sample station.



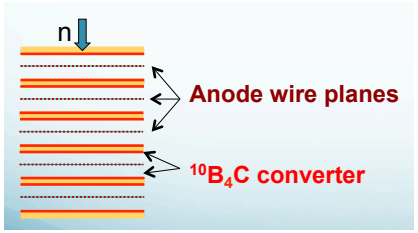
- BEER requires powder diffraction detectors, detectors for texture studies (arc detectors), SANS and NI detectors.
- The size of the powder diffraction detectors: 4x1 m^2 (~1 sr).
- Size arc detectors (texture analysis): 3 x 0.5 m^2
- PD and texture detectors pixel size: <2 mm x 5 mm.
- Expected flux on the sample (MC): 10^9 n/cm^2/s (~IMAT x 100).

A. Schreyer et al., ESS Instrument Construction Proposal BEER, 2014.

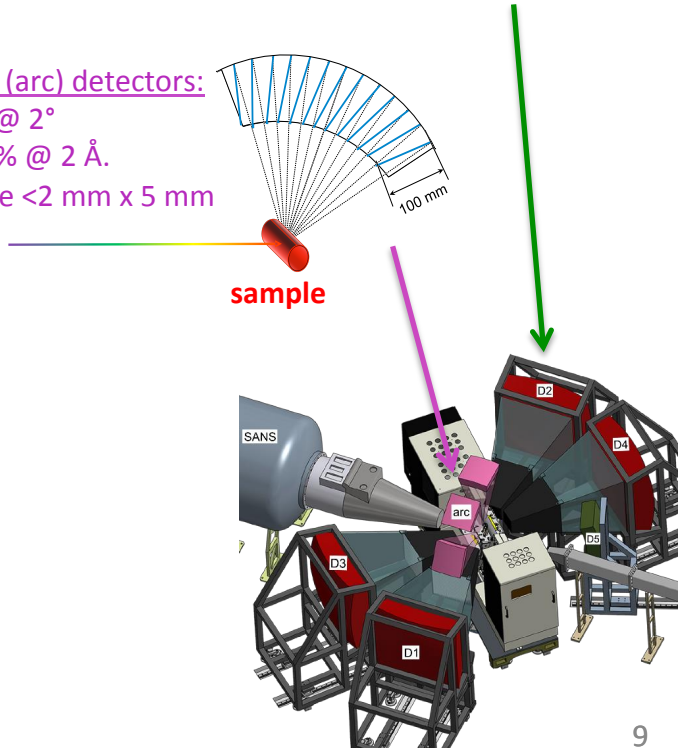
Detectors for BEER

- The PD and texture detector technology will be based on stacked MWPCs with ^{10}B-coated cathodes.
- BEER conceptual proposal suggests detectors to be delivered by the collaboration DENEX/HZG/CTU-REZ.
- DENEX is a company specialized in the manufacturing of 2D-position sensitive MWPC based on ^{3}He (e.g., REFSANS@FRM2).
- The validity of the detector concepts proposed for BEER was demonstrated during the BMBF-funded project " German InKind contribution to the ESS upgrade phase" (2011-2014).

Powder and strain detectors:
15 layers @ 90°
ε_{det} >60% @ 2 Å.
Pixel size <2 mm x 5 mm



Texture (arc) detectors:
1 layer @ 2°
ε_{det} >60% @ 2 Å.
Pixel size <2 mm x 5 mm



See talk by Gregor Nowak, HZG, this afternoon in the Detector Session.

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Zentrum für Material- und Küstenforschung

Nuclear Physics Institute of the CAS
public research institution

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Detectors for BEER

Expected peak-rate on the PD detector: ~1 kHz/cm^2.

➔ instantaneous peak rate 2.3*10^4 events/cm^2.

➔ 4.6*10^3 events/wire assuming independent wire readout for a 2 mm wire pitch.

➔ geometry with stacked MWPCs perpendicular to the beam direction, first counter will collect <20% of the events.

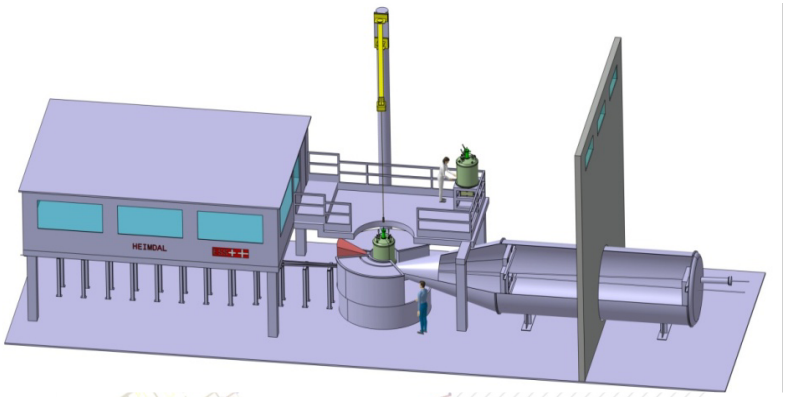
➔ an event rate of ~900 Hz/wire (expected instantaneous peak-event rate) is not expected to be challenging for the readout electronics.

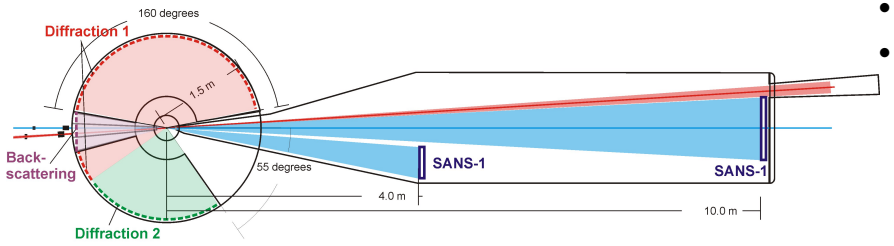
Status of the BEER detectors:

- The detector technology proposed by the instrument team is feasible.
- The first BEER-detector meeting took place at the HZG in March 2015.
- Also, we planed meetings with the BEER-detector team during this IKON.
- Everyone is awaiting for the BMBF funds to become available to start Phase 1.

Detectors for HEIMDAL

HEIMDAL will be the ESS thermal diffractometer.





Preliminary drawing for the HEIMDAL sample station.

- HEIMDAL requires powder diffraction detectors, a back-scattering detector, several SANS detectors and NI detectors.
- The size of the powder diffraction detector: 4.7 m^2 (~1.8 sr, Day-1).
- PD detectors pixel size: <3 mm x 10 mm.
- Expected flux on the sample (MC): $2x10^9$ $n/cm^2/s$.
- Expected peak-rate on the PD detector: ~4 kHz/cm^2
  ➔ instantaneous peak rate $9.5*10^4$ $events/cm^2$.

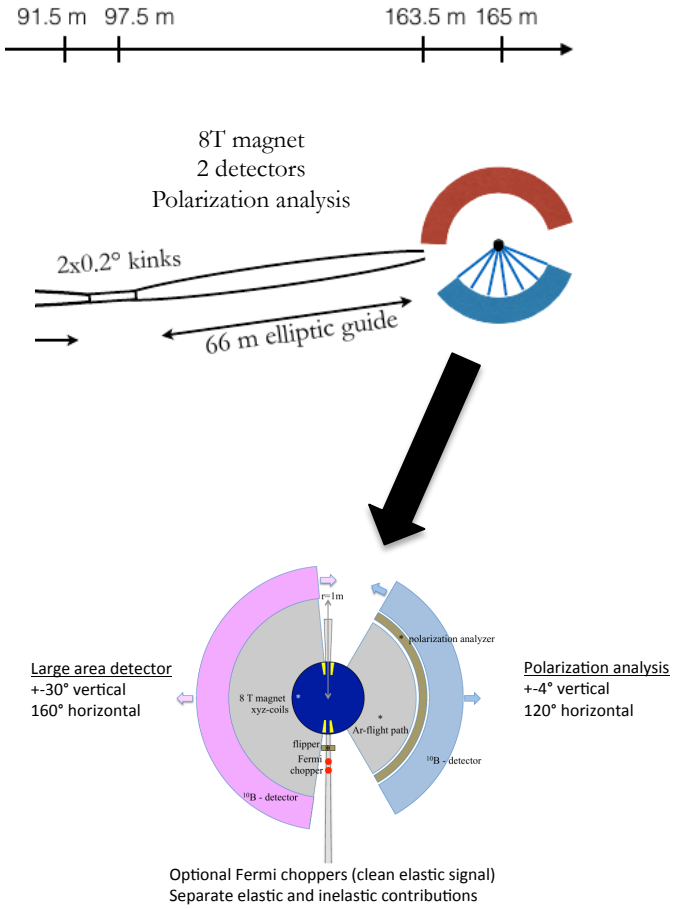
M. Christensen et al., ESS Instrument Construction Proposal HEIMDAL, 2014.

Detectors for HEIMDAL

- We made contact with the instrument team and discussed detectors only a few weeks ago.
- The instrument team is in favor of a detector technology based on scintillators.
- However, the pixel size requirement is beyond the limit of the scintillator technology currently available for powder diffraction instruments.
- We will have a HEIMDAL detector meeting at PSI on March 14.
- In Europe, both ISIS and PSI have expertise in scintillator detectors for diffraction instruments, representatives of both detector groups will be at the PSI meeting.

Detectors for MAGIC

MAGIC will be the ESS magnetic single-crystal diffractometer.



- Size powder diffraction detectors: 3.2 + 0.22 m^2.
- PD detectors pixel size: 4 mm x 4 mm.
- Expected flux on the sample: ~10^9 n/cm^2/s (~WISH x 10).

- It will use a strong magnet, therefore PMT-based detectors are excluded.

- The instrument team favors the Jalousie detector concept, same as for POWTEX@FRM2 and DREAM@ESS.

- Detector concept and timeline feasible, MAGIC expected to become operational after DREAM.

X. Fabreges, A. Goukassov, W. Schweika et al., ESS Instrument Construction Proposal MAGIC, 2015.

Work foreseen for Phase 1

- Reminder: aim of phase 1 is to arrive at a realistic scope, budget and schedule and strategy for the instrument concept.

- Following from this, the phase 1 required work for detectors:
  - Well-defined and verifiable requirements for the detector performance based upon the instrument requirements.
  - Costing of this, including labour and integration into the ESS suite.
  - Schedule to achieve this.
  - Strategy and partners to achieve this, including identifying and mitigating risks.

- NMX TG2 documents contain example.

- Detector group is happy to assist you in this.
  - Default is to help review the documents and provide technical assistance (nominal PM).
  - Further effort in terms of work and preparation of documents should be discussed asap to aid planning.
  - We are open to help out here.

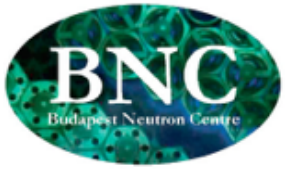
Conclusions, outlook

- ESS diffraction instruments will employ predominantly ^{10}B-based detectors, the only technology that can fulfill the challenging requirements of the ESS diffractometers.
- While DREAM, BEER and MAGIC instrument teams have a clear strategy for the detector concepts to be employed, the detector technology for HEIMDAL is still under consideration.
- SANS and NI imaging detectors for BEER and HEIMDAL will be taken care later.
- None of these instruments has a signed Technical Annex yet.
- We will continue to offer input and feedback in all detector-related issues whenever we can, and hope that our degree of involvement and tasks will become clearer in the upcoming months.

ESS DG partners

EUROPEAN SPALLATION SOURCE



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