Instrument System Acceptance Review

DREAM: Scientific overview of the instrument

DREAM team

26 March 2026

EUROPEAN SPALLATION SOURCE

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ESS Instrument Construction Proposal
DREAM (POWHOW)

(see europeanspallationsource.se/instruments2013)

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CONCEPT OF OPERATIONS FOR THE DREAM INSTRUMENT

	Name	Role/Title
Owner	Mikhail Feygenson, Werner Schweika	Instrument Scientists, DREAM instrument
Reviewer	Ken Andersen	Science Directorate
Approver	Shane Kennedy	Science Directorate

For this revision		
	Name	Role/Title
Owner	Mikhail Feygenson	Head of Diffraction
Reviewer	Beate Linnenberg	Team Assistant, Science Directorate
Approver	Florence Porcher	Instrument Scientist, DREAM instrument

JÜLICH FORSCHUNGSZENTRUM

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Scientific Overview of Instrument – High Level Requirements

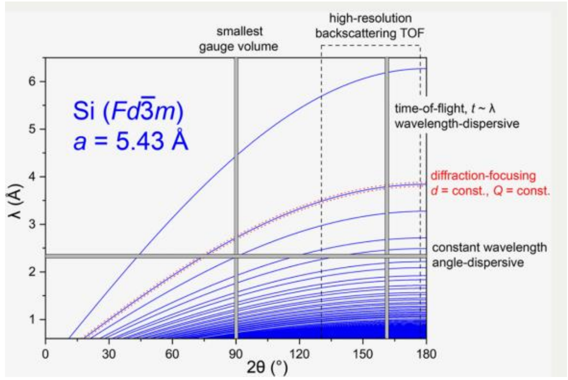
- DREAM Science case
- High Level Requirements
- System Requirements & Design

A FLEXIBLE, MULTIPURPOSE DIFFRACTOMETER

ASSETS OF NEUTRON SCATTERING: Magnetism, Light elements, Contrast, Q-independent "formfactor"
Weak absorption, Sample environment

ASSETS OF TOF: Using full wavelength spectrum with flexible Resolution/Intensity

Diffraction by Si powder
(from Neutron diffraction - a primer)



Nuclear Structures

Magnetic structures

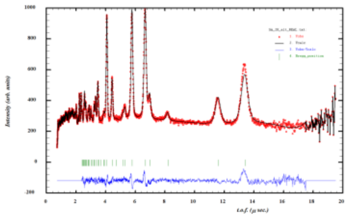
Microstructure (texture)

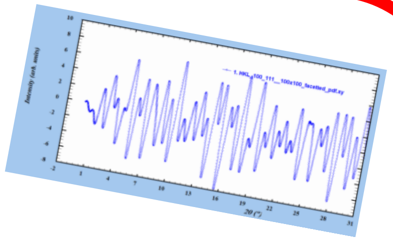
Organization

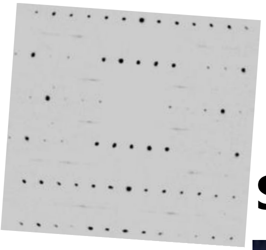
Faults

Local structure

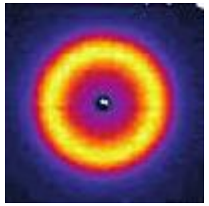
...



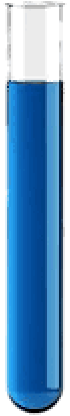


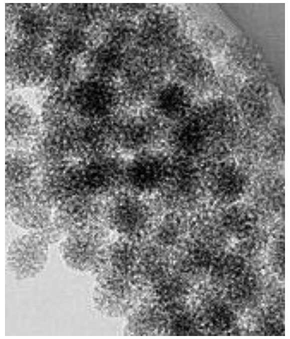


Powder Diffraction
Total scattering/ pdf
Nano-SANS
Single crystal diffraction



Powders
Nanoparticles
Polycrystals
Liquids
Single crystals





Batteries

(multi) Ferroics

MOFs

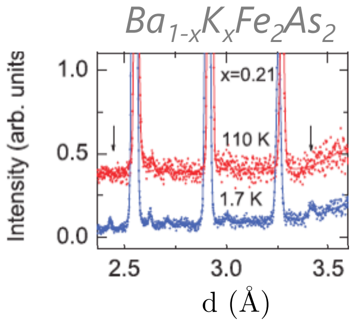
H-mat.

Supracond.

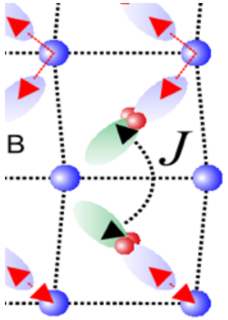
...

A FLEXIBLE, MULTIPURPOSE DIFFRACTOMETER

Magnetism

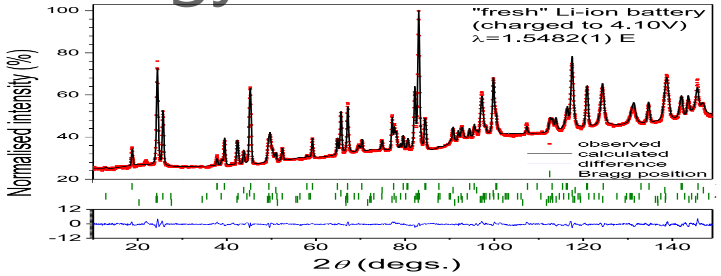


weak moments
phase diagrams of superconductors
multiferroics



orbital ordering
charge ordering
distortion
magnetic exchange

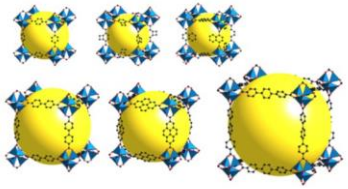
Energy Materials

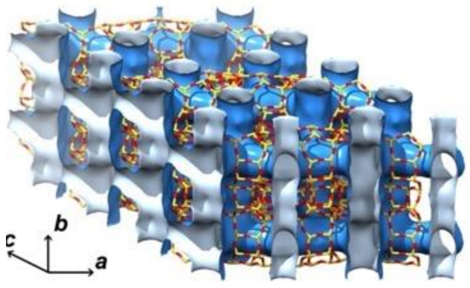


multiphase
catalysts
in-operandi
batteries

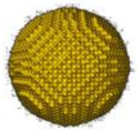
Large Unit Cells

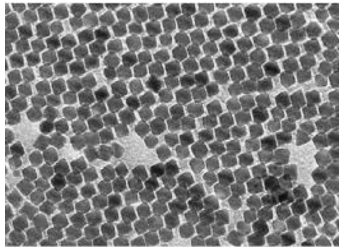
MOFs
thermoelectrics
molecular sieves
H_2 - storage





Nanostructures



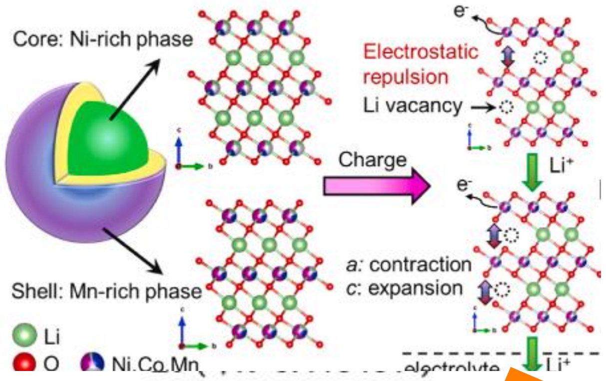


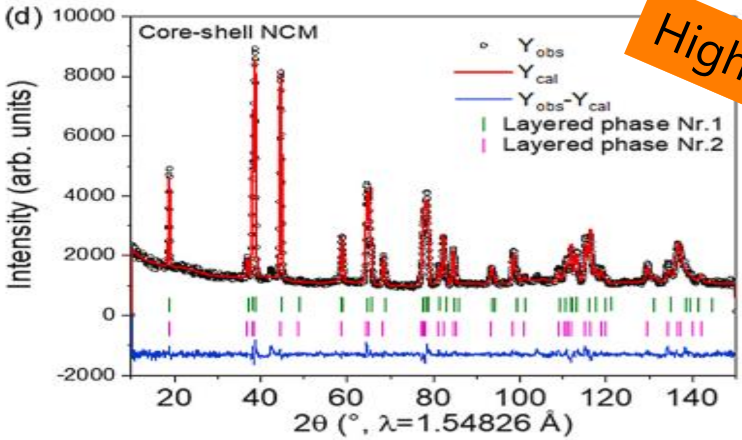
novel materials
magnetic nanoparticles
core-shell structures
self-assembly
synthesis

Instrument upgrades (Third-party funding)
NanoSANS detector (installed)
(Cold) neutrons polarizer (scheduled)

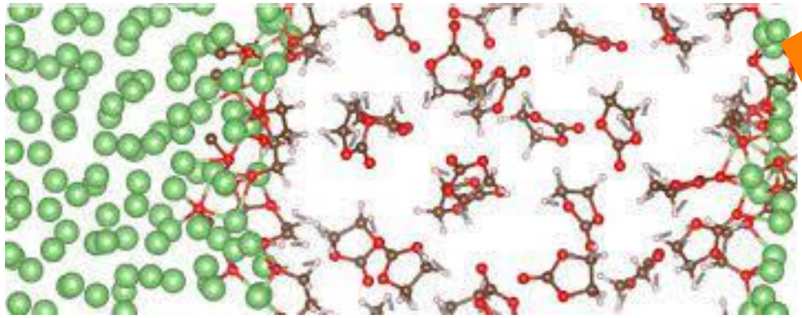
RöntgenÅngströmCluster

A TYPICAL SCIENCE CASE: CYCLING AND AGING OF BATTERIES





Cathode: defects / Electrolyte: (DMC/EC...) $LiPF_6$



Sample environnement

High resolution

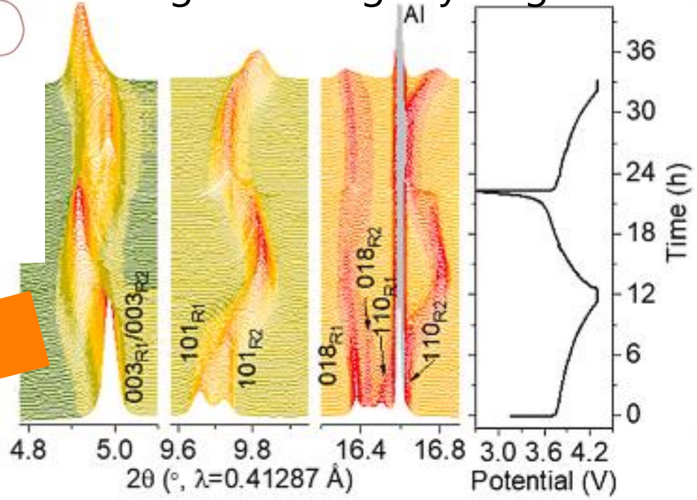
?

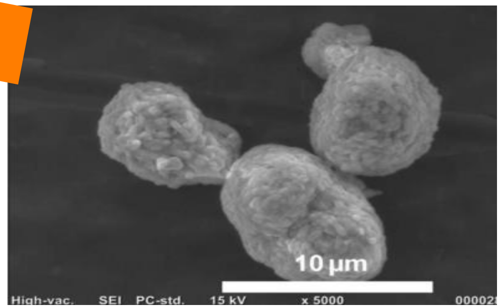
High intensity

Nano-SANS

Pdf analysis

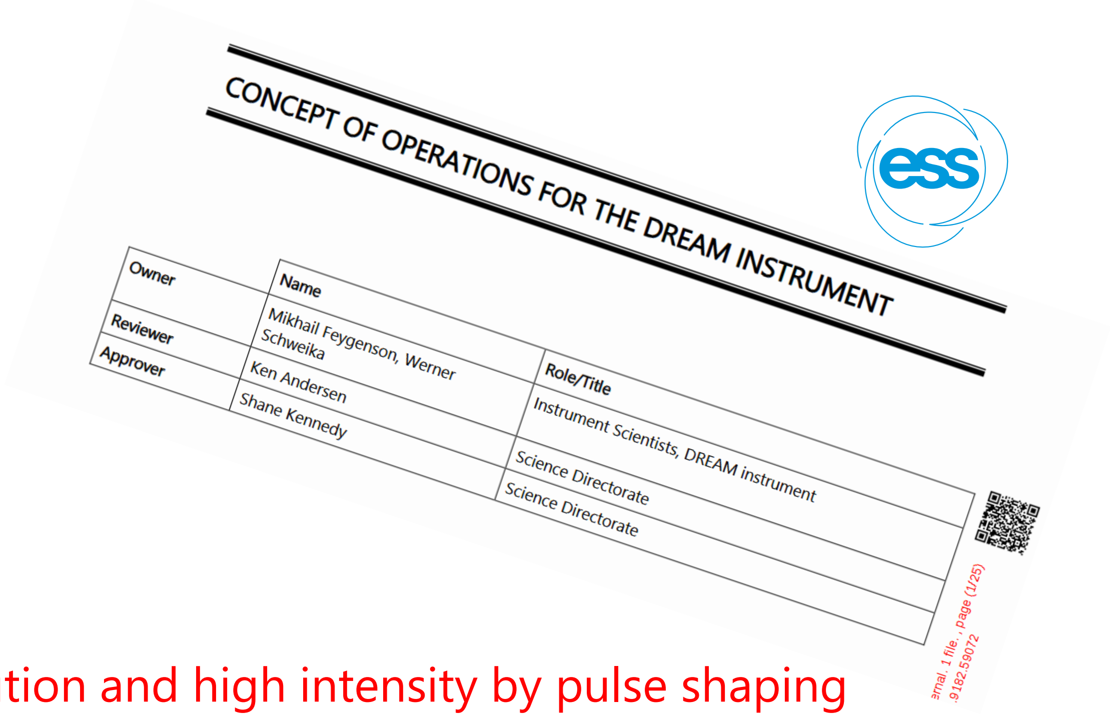
Charge-decharge cycling





Weibo Hua et al., Nano Energy 78 (2020) 105231
L. Vitoux et al., Front. Energy Res. 6:76. doi: 10.3389/fenrg.2018.00076
D. Petz et al. ECS Meeting Abstracts doi 10.1149/MA2021-012137mtgabs
Sou Taminato et al., Scientific Reports | 6:28843 | DOI: 10.1038/srep28843

HIGH LEVEL REQUIREMENTS


CONCEPT OF OPERATIONS FOR THE DREAM INSTRUMENT

	Name	Role/Title
Owner	Mikhail Feygenson, Werner Schweika	Instrument Scientists, DREAM instrument
Reviewer	Ken Andersen	Science Directorate
Approver	Shane Kennedy	Science Directorate

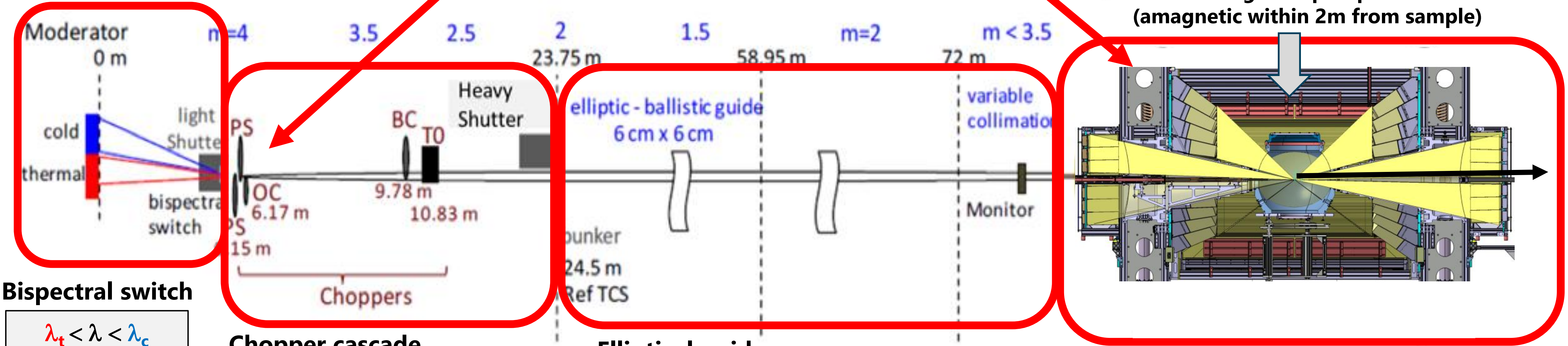
High level scientific requirements
based on the project scope and upgrade capabilities:

1. DREAM shall enable data collection up to a Qmax of 25 Å^{-1}.
2. DREAM shall enable data collection down to a Qmin of 0.2 Å^{-1} (the upgrade design will allow for Qmin = 0.01 Å^{-1}).
3. DREAM shall provide a flexible choice between the high resolution and high intensity by pulse shaping within two orders of magnitude from ~10^{-2} ms to ~ms.
4. DREAM should deliver data for samples as small as 1 mm^3, in high intensity mode within 30 minutes.
5. DREAM shall deliver a best resolution of Δd = 0.00035(10) Å near backscattering.
6. DREAM shall enable data collection for samples as small as 10 mm^3 with best resolution.
7. DREAM shall be able to detect structural changes with a time resolution of 10 ms for samples as large as 0.5 cm^3.
8. DREAM shall enable TOF Laue single crystal measurements.
9. DREAM shall provide the infrastructure to support fast in-situ measurements and quick user turnover.
10. DREAM should provide user community with the wide range of generic and instrument-specific sample environment within its upgrade path.
11. DREAM should reduce the sample environment turnaround time as much as reasonably achievable.
12. DREAM shall be compatible with high magnetic field sample environments.

Concept: Diffraction Resolved by Energy & Angle Measurements

In one shot, Q-range: 0.01 – 25 Å^{-1} ($Q=4\pi \sin\theta/\lambda$)

Large sample space (amagnetic within 2m from sample)



Bispectral switch

$\lambda_t < \lambda < \lambda_c$

$0.5A < \lambda < 10A$

Chopper cascade

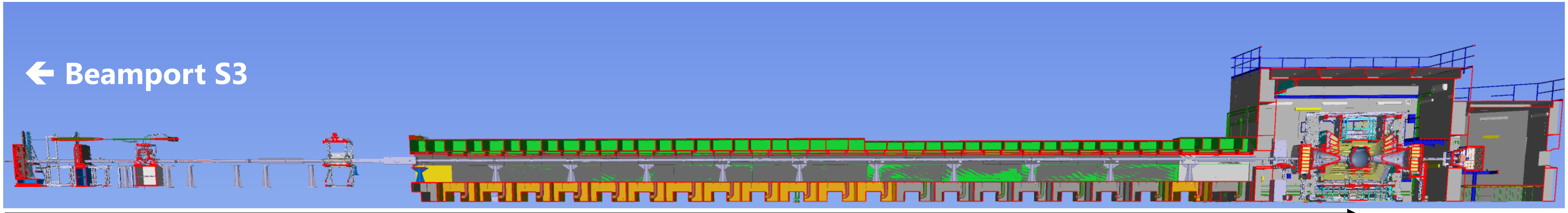
- **Flexible resolution/flux**
- **WFM, 2 frames**

Elliptical guide

Windows-less guide +Sample vessel

Detector

- **Maximum 2theta coverage**
- **Adapted resolution**
- **Modular, upgradable**



76.5 m

Design: Product Breakdown Structure (PBS) and System requirements

13.6.8 DREAM

- 13.6.8.1 Beam transport and conditioning system
- 13.6.8.2 Sample exposure system
- 13.6.8.3 Scattering characterization system
- 13.6.8.5 Experimental cave
- 13.6.8.6 Control Hutch
- 13.6.8.7 Sample preparation area
- 13.6.8.8 Utilities distribution (Infrastructure)
- 13.6.8.9 Support infrastructure
- 13.6.8.10 Control racks
- 13.6.8.11 Integration control and monitoring

DREAM - SYSTEM REQUIREMENTS

	Name	Role/Title
Owner	Florence Porcher	DREAM Instrument Scientist
Reviewer	Gabor Laszlo Pascale Deen	NSS Instrument Engineer Section Leader Head of Spectroscopy Division
Approver	Giovanna Fragneto Robert Connatser	ESS Science Director Head of Neutron Scattering Systems Division

3.1.1. Beam Transport and Conditioning System, BTCS– PBS 13.6.8.1

Table 1. Beam Transport and Conditioning System

ID	Text	Trace up to
1	Wavelength Transportation – Range The BTCS shall be optimized to transport neutrons with wavelength from 0.5 Å to 4.4 Å from the thermal and cold moderator surfaces.	ConOps HLSR: I-VI; 1, 2, 5, 8 and 3.4.2, 3.4.3
2	Beam Divergence – Profile The wavelength dependent divergence transported by the BTCS shall be adjustable by slit system and should provide flexible choices between 0.269 ° and 0.498° FWHM, horizontally, and 0.267° and 0.572° FWHM, vertically.	ConOps HLSR: I, II, V; 1, 2, 5, 3.4.2, 3.4.3 and *DREAM guides Vitess simulations & report* (ESS-3873171) [1]
3	Wavelength Resolution and Selection – Pulse Shaping The BTCS shall allow pulse shaping to tune the wavelength resolution for the chosen wavelength band. The BTCS shall be able to provide various selectable resolutions from higher than 0.2% to lower than 10% at shortest wavelength of 0.5 Å.	ConOps HLSR: I, II, V; 3-9, 3.4.6 and ESS-0451350 [2]

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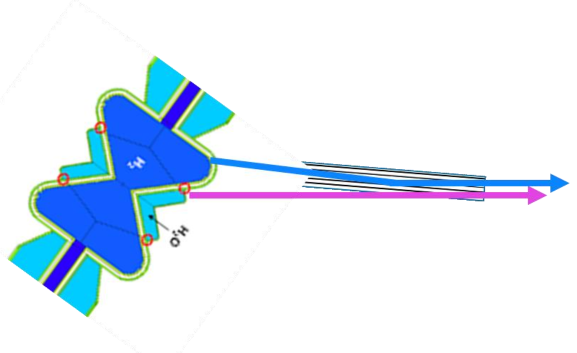
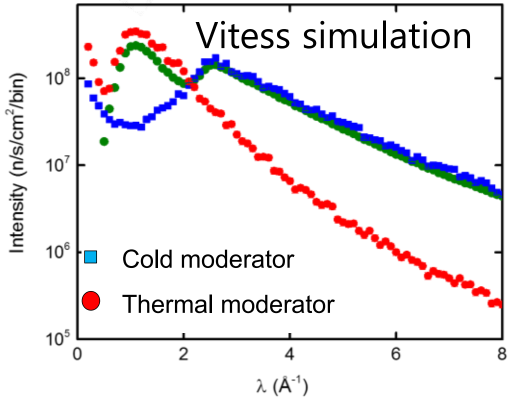
71 System requirements + 13 external requirements

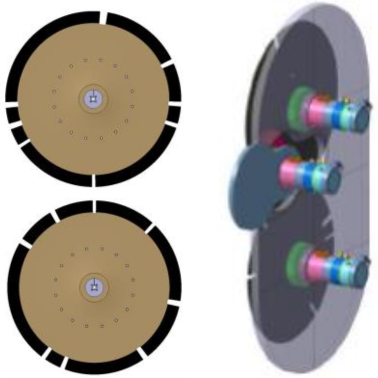
Selected Key features: Beam Transport and Conditioning

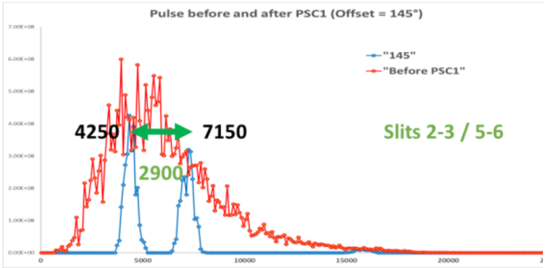
Bi-Spectral switch

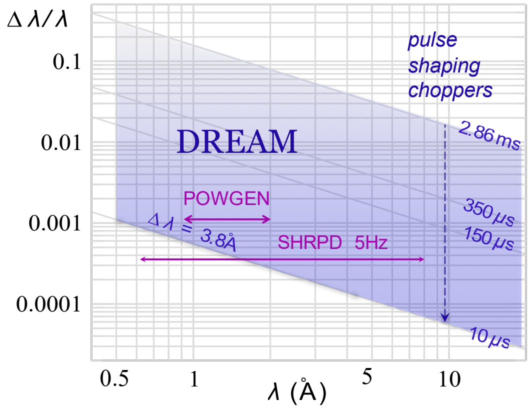


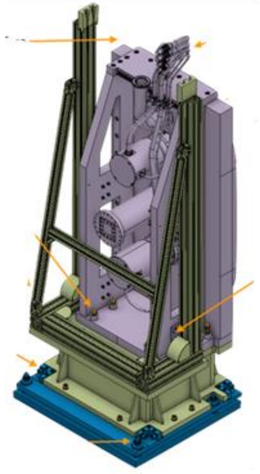


Chopper cascade (PSC-OC, BC, T0)



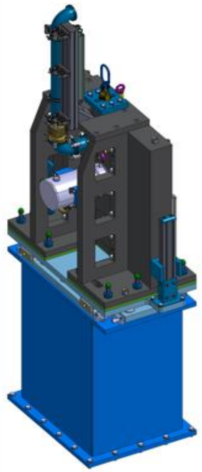


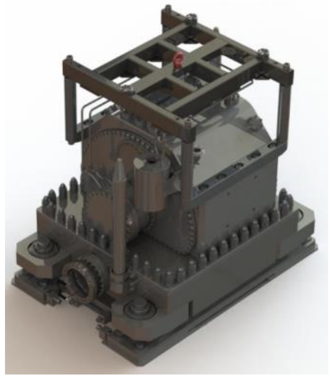




PSC: ν={14, 28,…, 308} Hz – 8 slits/disk WFM, 2 frames Δλ=3.6Å

3	Wavelength Resolution and Selection – Pulse Shaping The BTCS shall allow pulse shaping to tune the wavelength resolution for the chosen wavelength band. The BTCS shall be able to provide various selectable resolutions from higher than 0.2% to lower than 10% at shortest wavelength of 0.5 Å.	ConOps HLSR: I, II, V; 3-9, 3.4.6 and ESS-0451350 [2]
5	Bandwidth Selection The "natural" usable wavelength bandwidth of DREAM is 3.6 Å. The band width shall be flexible to shift in order to achieve easy access within [0.5 Å, ~10 Å] and should be capable of offering neutrons up to 20 Å.	ConOps HLSR: I-VI; 1-4, 9,3.2, 3.4.6 and ESS-0451350 [2]

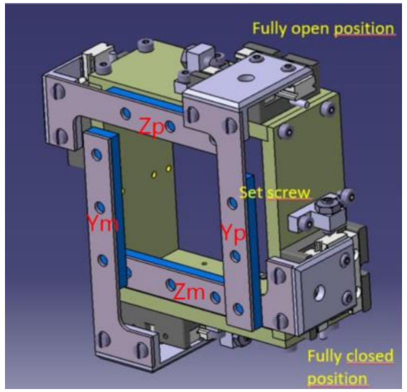




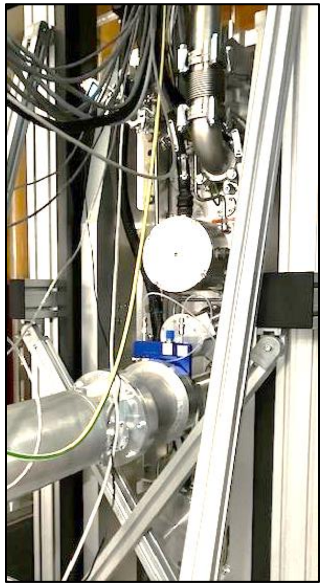
Selected Key features: Beam Transport and Conditioning

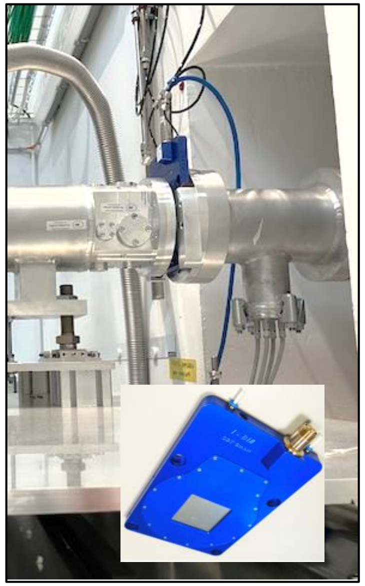
Divergence slits

2	Beam Divergence – Profile The wavelength dependent divergence transported by the BTCS shall be adjustable by slit system and should provide flexible choices between 0.269 ° and 0.498° FWHM, horizontally, and 0.267° and 0.572° FWHM, vertically.	ConOps HLSR: I, II, V; 1, 2, 5, 3.4.2, 3.4.3 and *DREAM guides Vitess simulations & report* (ESS-3873171) [1]



Beam monitors (CDT I-BM)

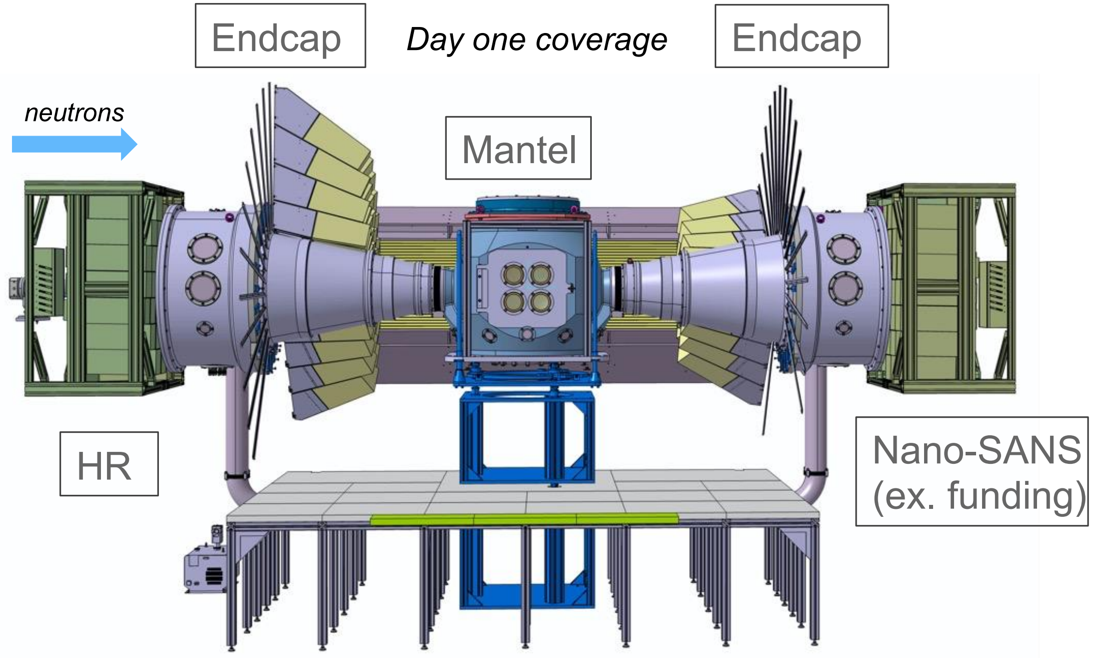


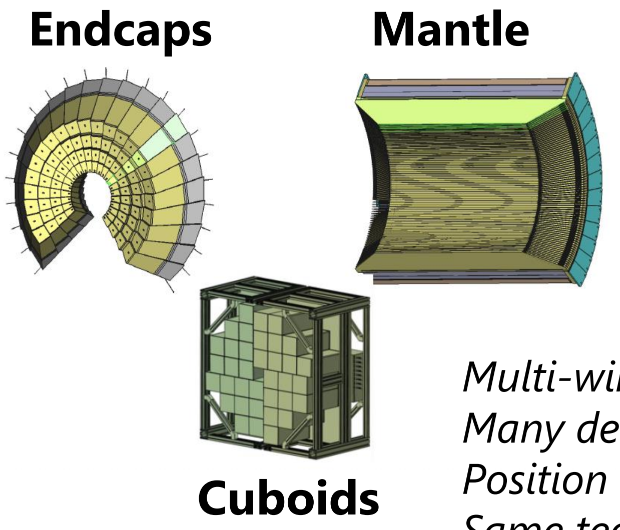


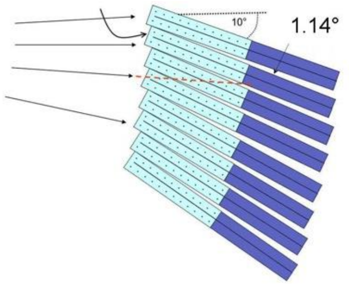
9	Beam Monitoring The BTCS shall allow for monitoring the beam flux with at least two monitors located in front and behind the sample. An additional monitor may be installed in the bunker, downstream of the chopper system.	ConOps HLSR 8, 9 and ESS-0454189 [3]

Selected Key features: Scattering characterization system

Detector (CDT Jalousie)

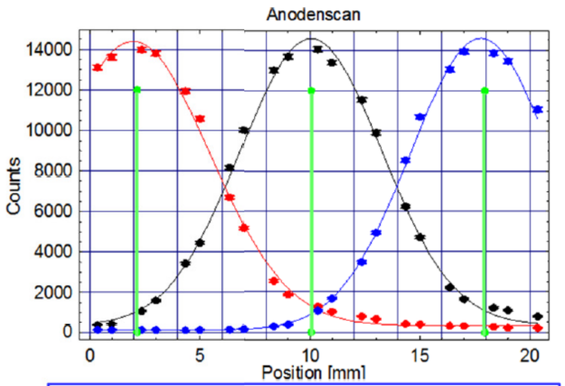






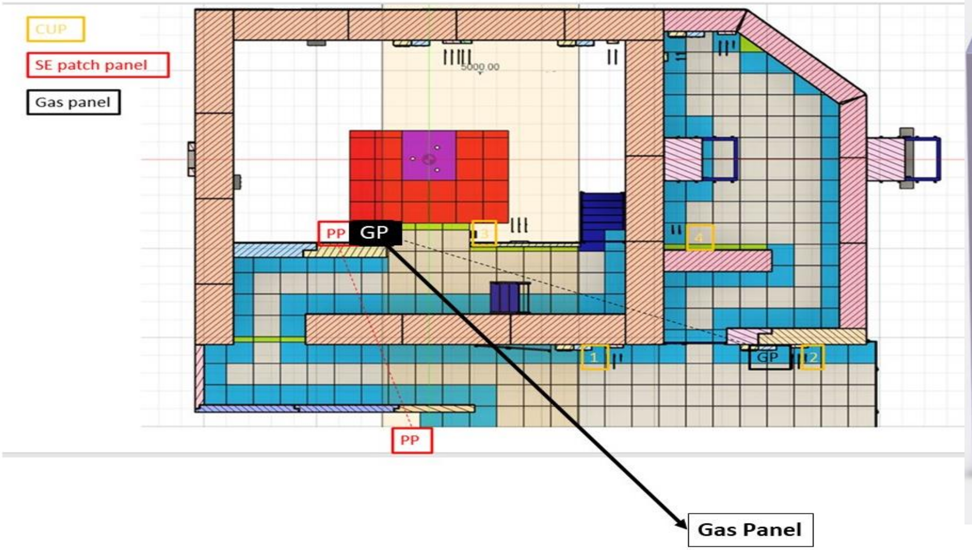
Multi-wire chamber
Many detection layers
Position sensitive detectors
Same technology as
MAGiC & HEIMDAL

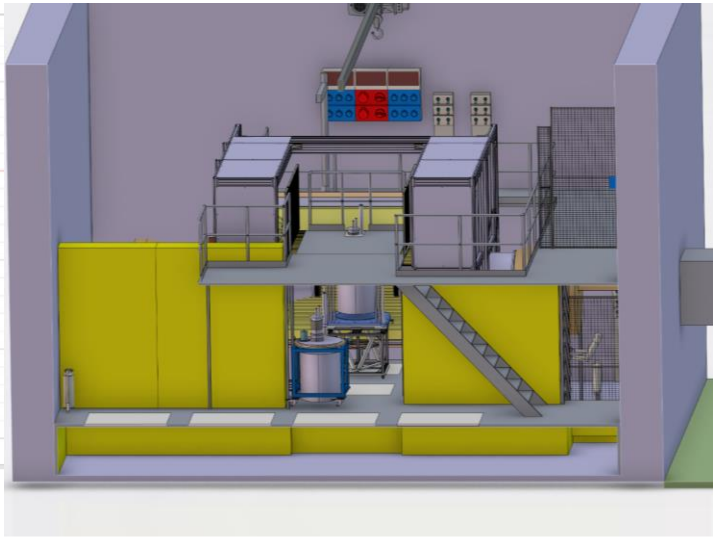
17	A continuous increase of the detector coverage up to the Full Scope shall be planned from the beginning of Phase 2. The detector support structure shall be able to accommodate the full detector coverage of 5.11 sr, including dedicated SANS detector.	ConOps HLSR 3.4.10
19	Spatial Resolution The SCS should provide detector resolutions of ~5 mm (in θ) and ~10 mm (in φ).	ConOps HLSR 3.4.10
21	Efficiency – Lower Acceptable Limit Detection efficiency of the SCS for all detector elements shall be more than 50% at 1 Å.	ConOps HLSR 1, 3, 5 and 3.4.10

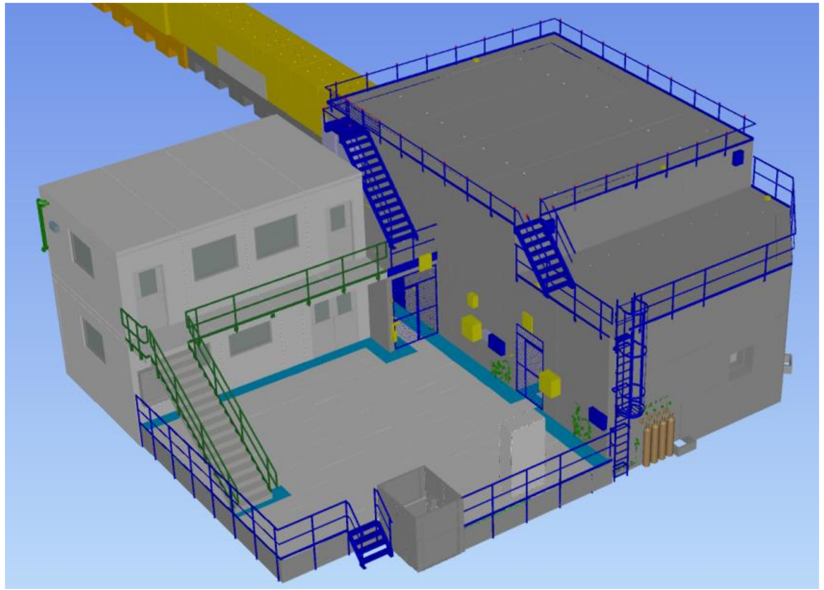


determined 2Θ resolution FWHM:
(6,5 ± 0,4) mm ⇔ (0,38 ± 0,02)°

Selected Key features: Cave, Sample Preparation Hutch & Sample area







29	The Experimental Cave – Utilities Access The Experimental Cave shall have access to a variety of utilities including various power	ConOps 3 and 5
36	Experimental Cave – Floor Space The Experimental Cave shall provide a sufficient floor space for sample environment equipment.	ConOps 3 and 5
40	Experimental Cave – SEE Installation The Experimental Cave shall have a crane inside with a minimum capacity of 1000 kg.	ConOps 3 and 5
46	SPA – Sample Preparation Tables SPA should have at least two tables for sample preparation to support simultaneous operation of two user groups.	ConOps 3 and 5

THANK YOU