TG5/SAR Meeting

ODIN: Detector Report

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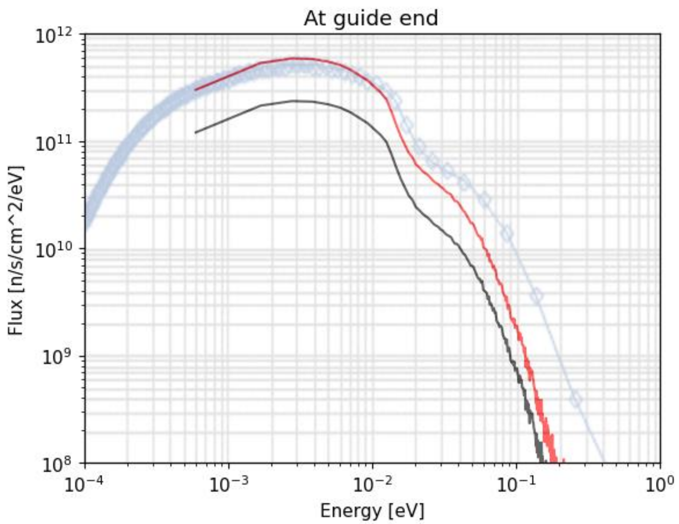
support groups

LUND
17 DEC 2025

ODIN - SAR

Recap

ODIN Quick Facts	
Instrument Class	Imaging
Moderator	Bispectral
Primary Flightpath	50 m (to pinhole)
Secondary Flightpath	2 – 14 m (pinhole to detector)
Wavelength Range	1 – 10 Å
Field of View	20 x 20 cm²
L/D Ratio	Tunable 300 – 10000
Incident Beam Polarisation	Optional
Polarisation Analysis	Optional
Bandwidth at 14 Hz	4.5 Å



- **Large space**
  - ➢ sample environments
  - ➢ setups *(e.g. polarization, grating interferometry)*
- Bi-spectral extraction
- Direct line-of-sight (T0 chopper)
- **Three main modes:**
  - ➢ White beam
  - ➢ high flux wavelength dispersive (basic ToF)
  - ➢ high resolution wavelength dispersive (WFM)
- **Detectors:**
  - ➢ Scintillator CMOS (+optional gating)
  - ➢ LumaCam (Scintillator event mode)
  - ➢ + *Users bring own detectors*

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Detector Overview

System purpose: detect the neutrons transmitted through the sample

(working in direct – and hence most intense – beam)

Day-1 scope:

Instrument scope (PSI WP)

- White Beam detector
- Time-of-Flight detector

→

- Cameras, scintillators, optics, light intensifiers, detector enclosures
- All development and expertise (so far) by instrument team

Detector Group contribution

- Rack hosting all physical connections to the cameras
- Cabling
- UPS
- Readout Master Module (RMM) for the BM

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Detector Overview

Tag	Description	Classification	Operation and Maintenance Manuals	Verification & Validation Plan (includes Hot Commissioning Plan, RP survey plan)
=ESS.NSS.H01.ODIN.B01	Scattering Characterization System	Neutron Detector System	Covered in the nodes below	
=ESS.NSS.H01.ODIN.B01.B01.B01	TimePix3 CMOS Camera	Neutron Detector System	ESS-5066842: (SoPhy user Manual and TPX3CAM Manual) ESS-5512704: (Image intensifier manual) ESS-5283134: (TimePix3 camera manuals) ESS-5066841: Datasheets for cameras, lenses and scintillators ESS-5091491: Datasheets for camera box and Instructive/Manual to mount the mirror	ESS-5820246. INTEGRATED TEST PLAN FOR ODIN – TIMEPIX3 DETECTOR
=ESS.NSS.H01.ODIN.B01.B01.B02	Orca Flash v3 CMOS Camera	Neutron Detector System	Included in ESS-5066842: (CMOS camera Manual) listed above	ESS-5754643. LOCAL AND SYSTEM INTEGRATED TEST PLAN FOR ODIN – CMOS DETECTOR

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Detector Overview

Tag	Description	Classification	FAT/DAT reports	SAT/Local test reports	Integrated Test reports
=ESS.NSS.H01.ODIN.B01.B01.B01	TimePix3 Camera	Neutron Detector System	ESS-5844511. ODIN - FAT TIMEPIX3 DETECTOR ESS-5586286 (Motion FAT Report For ODIN Camera Boxes)	Detector SAT superseded by Integrated Test Included in ESS-5768833. MCA Local Testing (SAT1) Plan for ODIN MCC4 listed below	ESS-5849590. ODIN INTEGRATED TEST REPORT – TIMEPIX3 DETECTOR
=ESS.NSS.H01.ODIN.B01.B01.B02	CMOS Camera	Neutron Detector System	ESS-5654274. FAT - CMOS Detector Included in ESS-5586286 listed above	Detector SAT superseded by Integrated Test Included in ESS-5768833. MCA Local Testing (SAT1) Plan for ODIN MCC4 listed below	ESS-5849591. ODIN INTEGRATED TEST REPORT – CMOS DETECTOR

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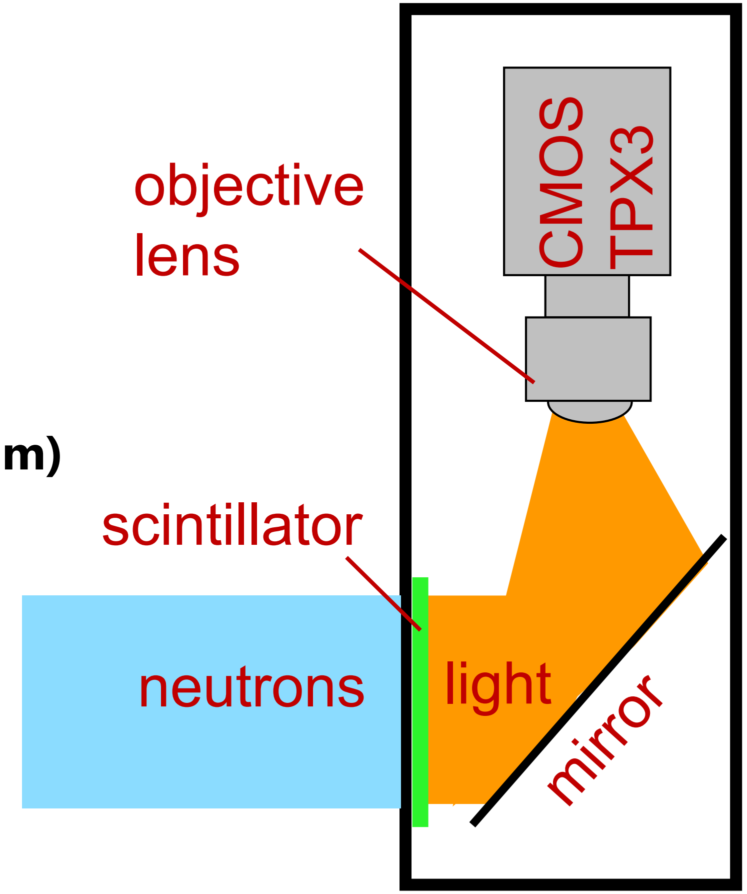
Detector Overview

The cameras itself are not inherently neutron detectors, but require integration with several components:

In case of the integrating camera type (CMOS)
- light-tight optical housing
- different optical magnification lenses
- a scintillator
- an optional gated image intensifier

In case of the Time-of-Flight camera-based event mode detector (TPX3cam)
- light-tight optical housing
- an image intensifier
- different optical magnification lenses
- a scintillator
- event-mode reconstruction software



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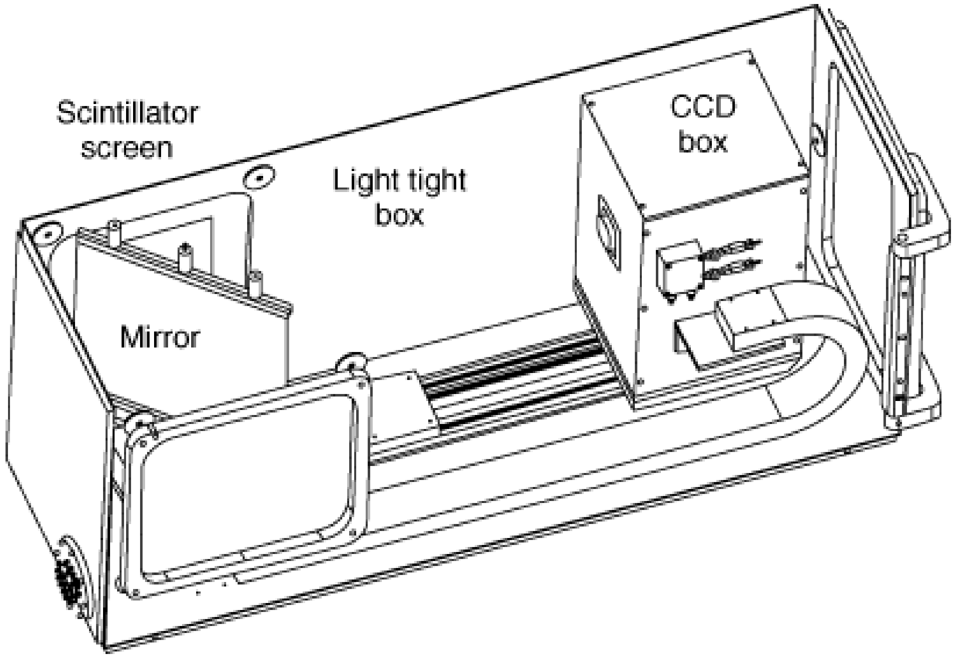
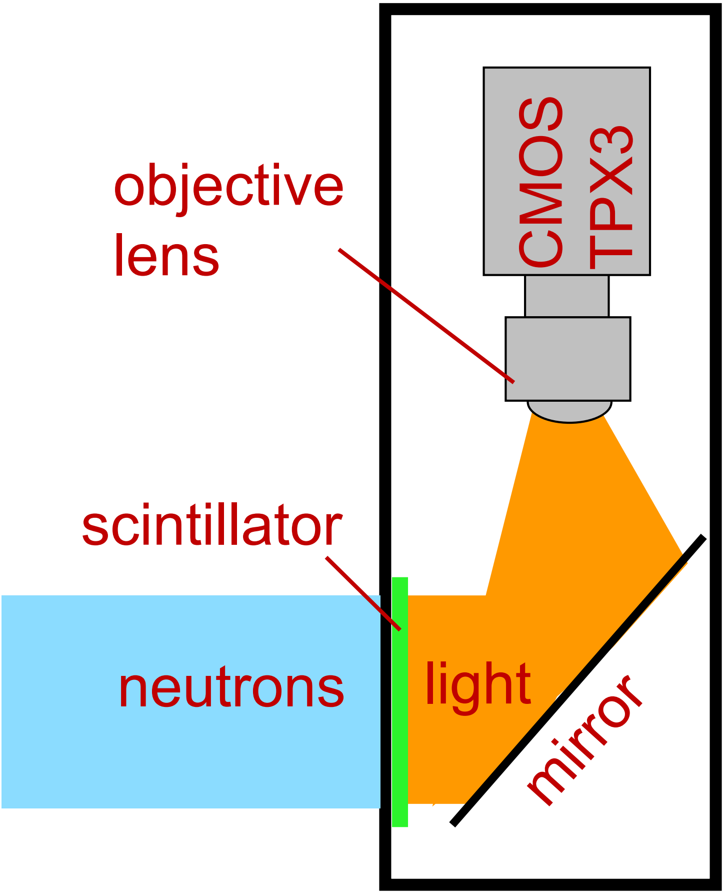
Detector Overview

Both detectors must be configured for individual experiments, including:

- Active area (field of view)
- Light collection efficiency (choice of scintillator, thickness, and optical coupling)
- Spatial resolution versus efficiency trade-off
- Readout mode and frame rate
- Dynamic range and exposure settings





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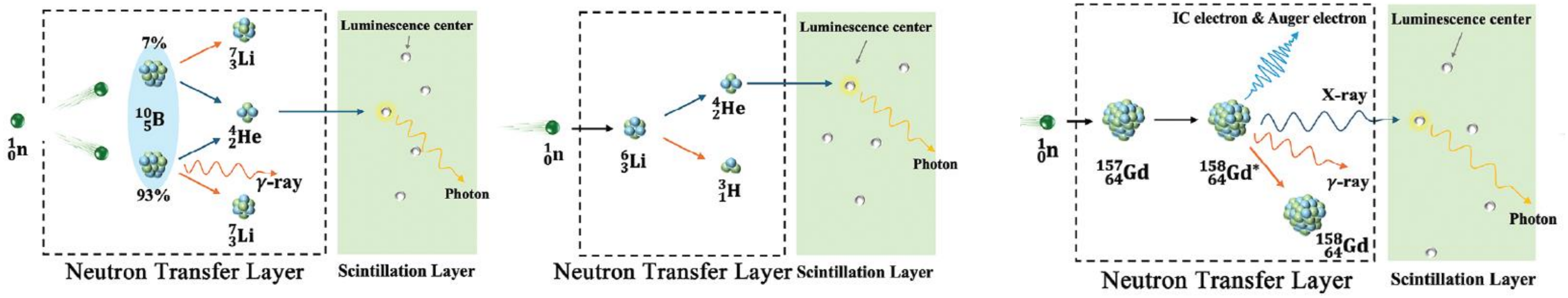
Detector Overview

A range of **scintillators** (types and thicknesses) needs to be available (for both camera types)



<u>**Main scintillators for ODIN**</u>

6LiFZnS:Ag (300um, 200um, 100um)
6LiFZnO:Zn (300um, 200um, 100um)
Gd2O2S:Tb (40um, 30um, 20um, 10um)

➔ This requires significant configuration before each experiment

➔ An additional detector enclosure has been procured to minimize down-time

➔ In the future, ESS should be able to manufacture such enclosures in-house

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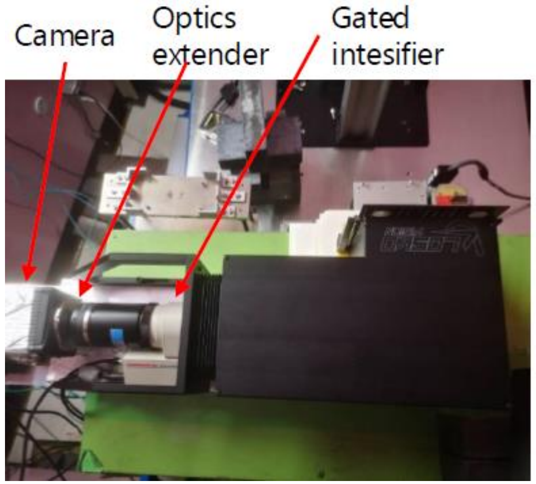
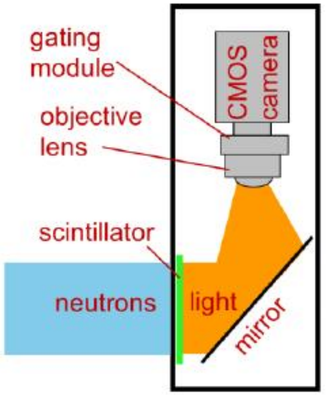
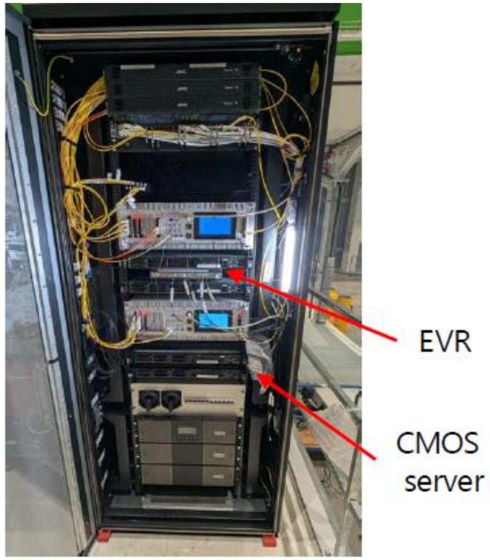
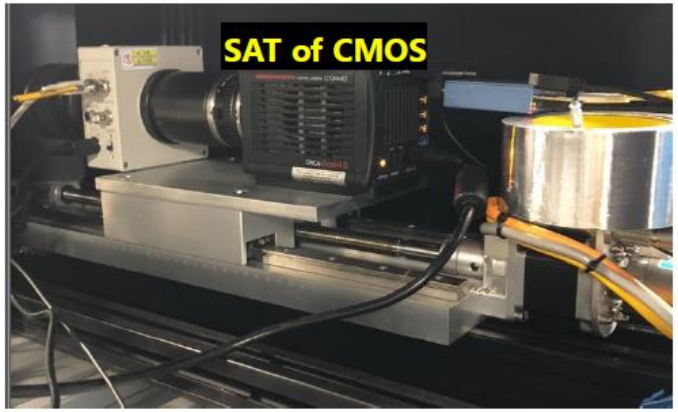
CMOS based detector

- Scintillator-based detector (frame-based)
- Commercial camera delivered by Hamamatsu Photonics B.V. , Neutron detector is custom build by TBL scientist(s)
- Field-of-view 20x20 mm^2 to 300x300 mm^2









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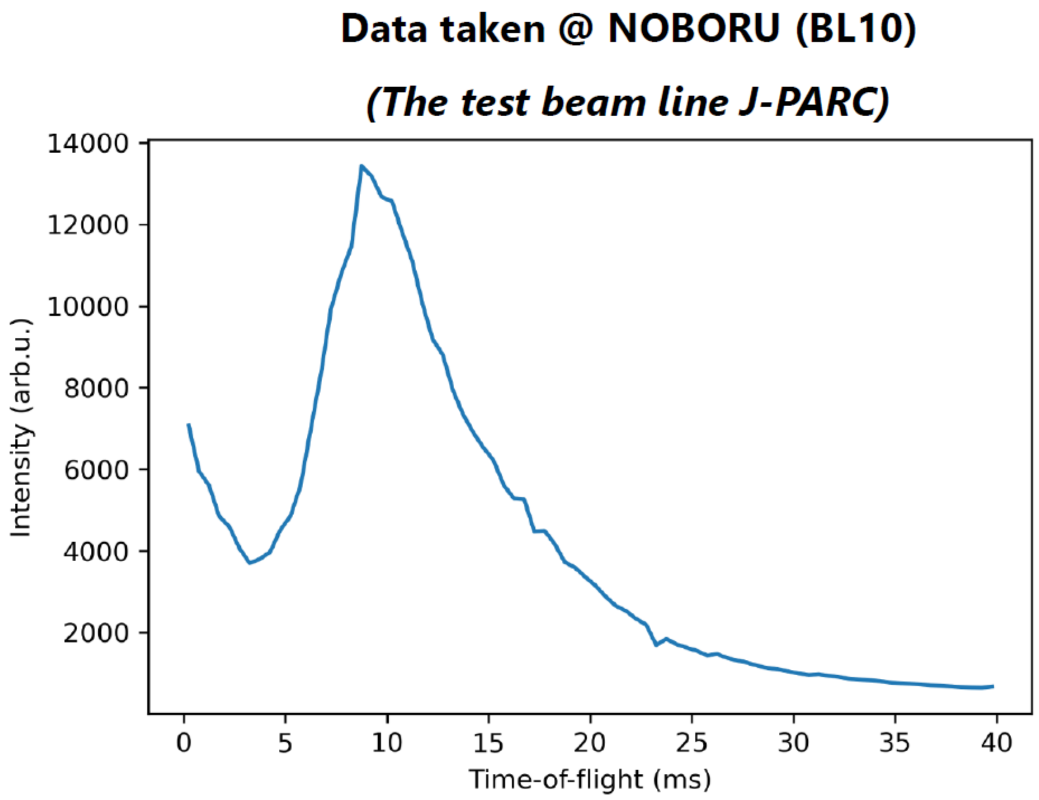
CMOS based detector: Commissiong with neutrons



Courtesy of T. Chulapakorn

- Each frame will be gated for just 5 ms (with intensifier)
- One can obtain ToF spectra for individual pixels

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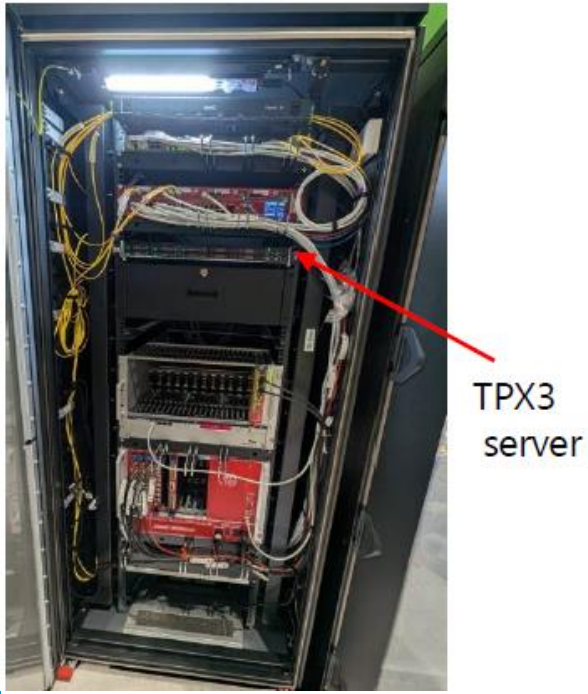
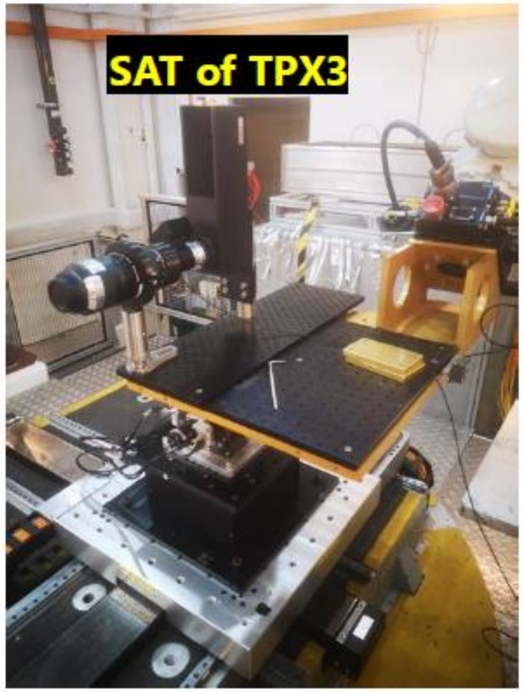
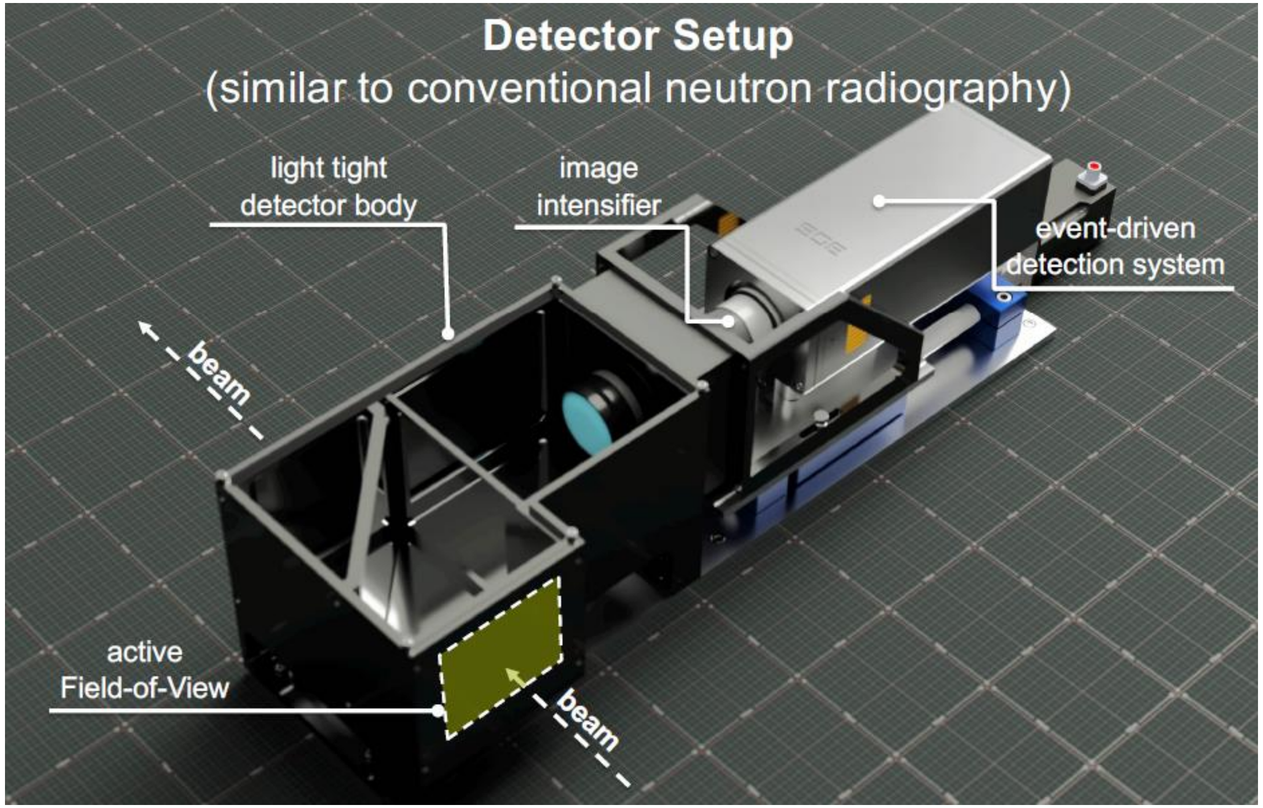
ToF detector

- Scintillator-based detector (event-based)
- Commercial camera delivered by Amsterdam Scientific Instruments, neutron detector developed by LoskoVision
- Field-of-view 20x20 mm^2 to 260x260 mm^2.







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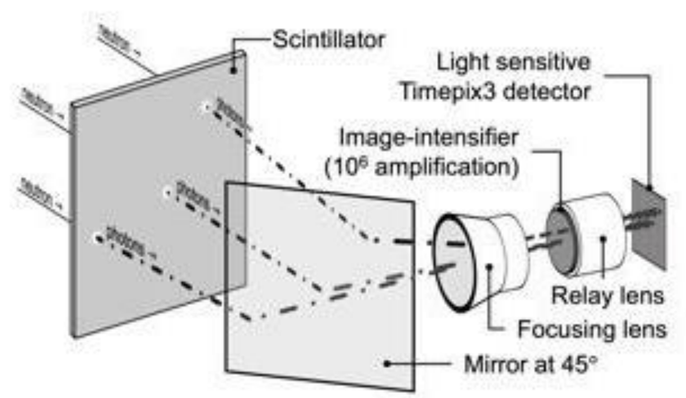
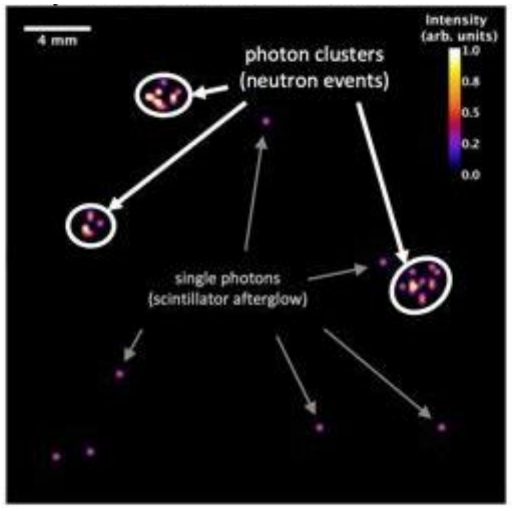
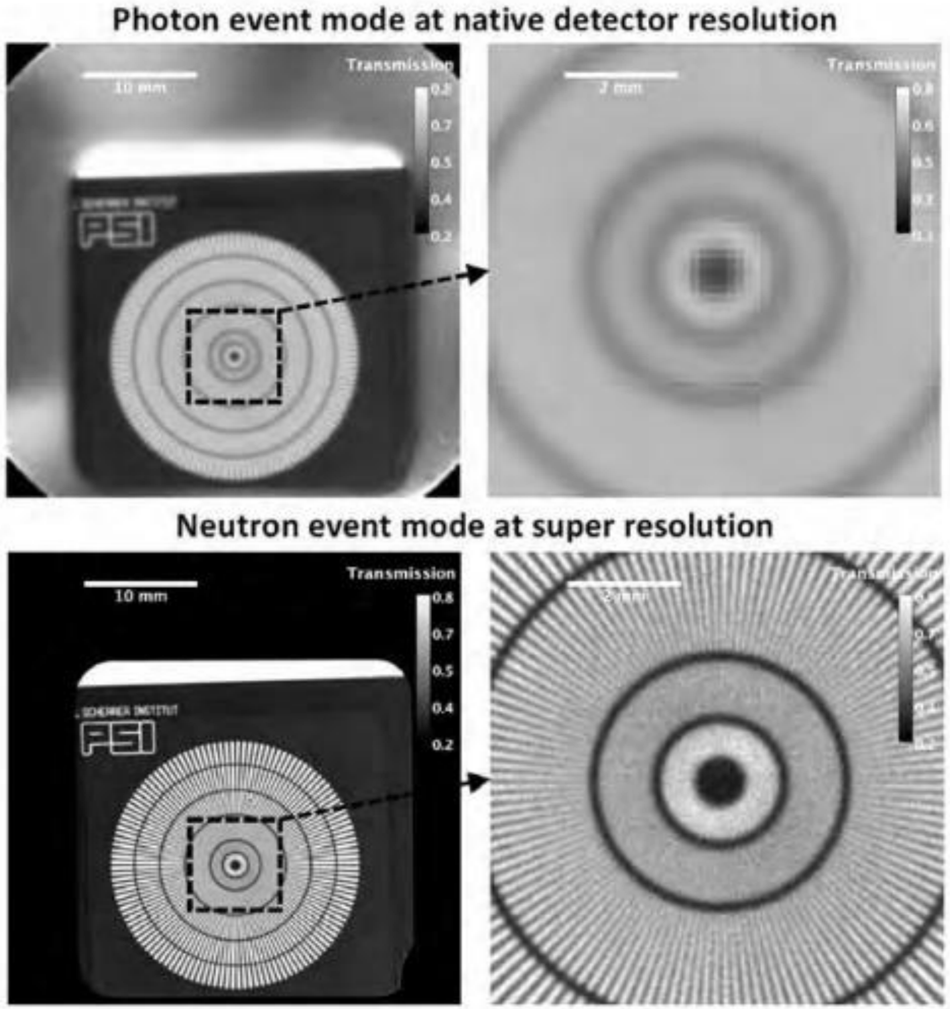
ToF detector: Commissiong with neutrons

B) Schematic of the detector concept







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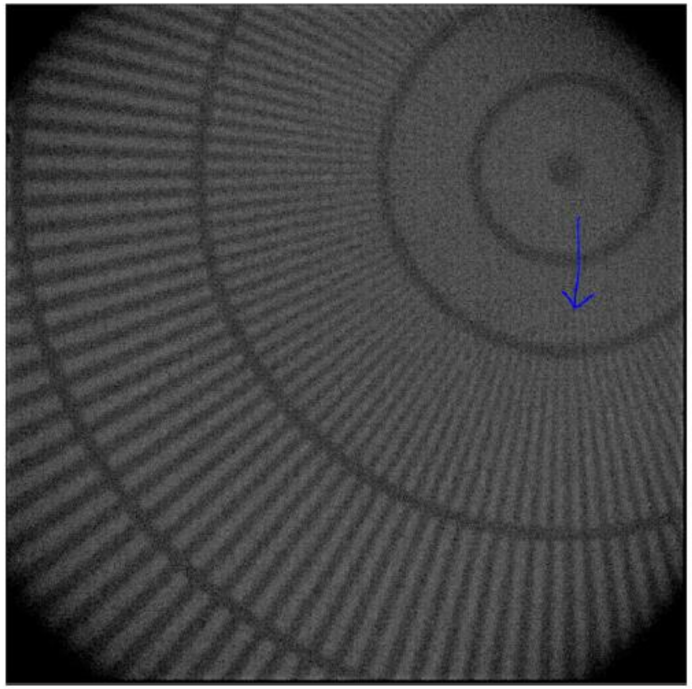
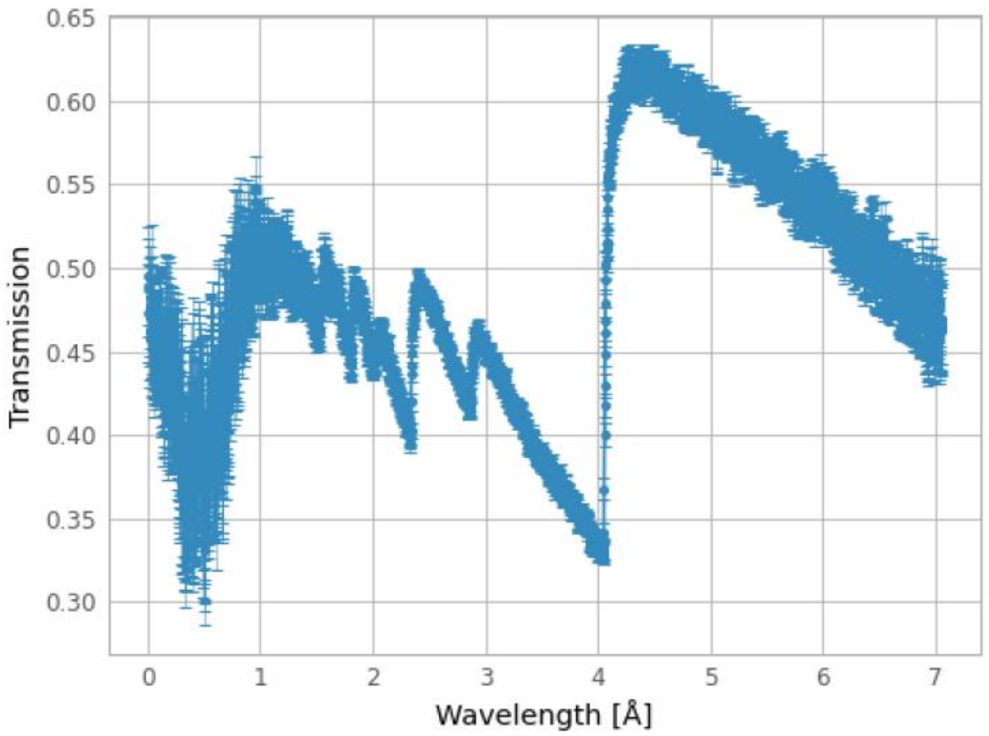
ToF detector: Commissiong with neutrons



Data taken @ IMAT

Imaging and Materials Science & Engineering at ISIS



Courtesy of T. Chulapakorn

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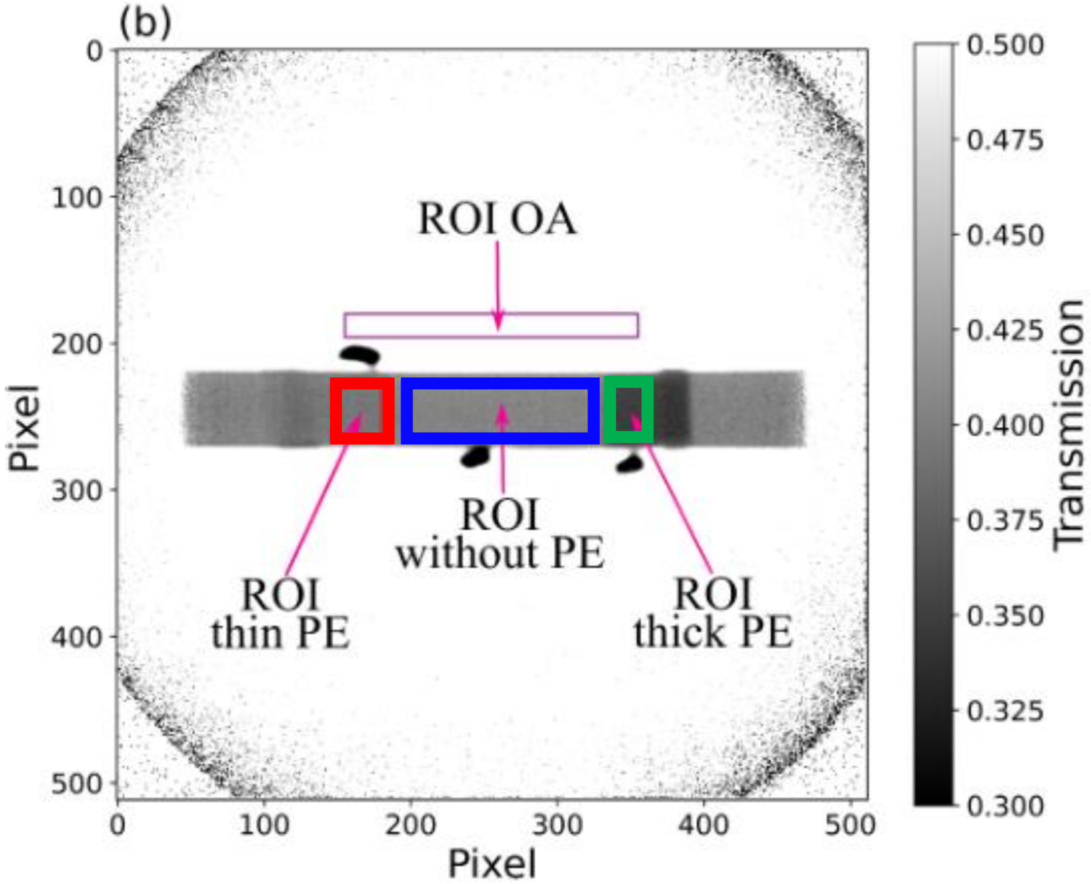
ToF detector: Commissiong with neutrons

Shuqi Xu

2.2. Top-level requirements for ODIN

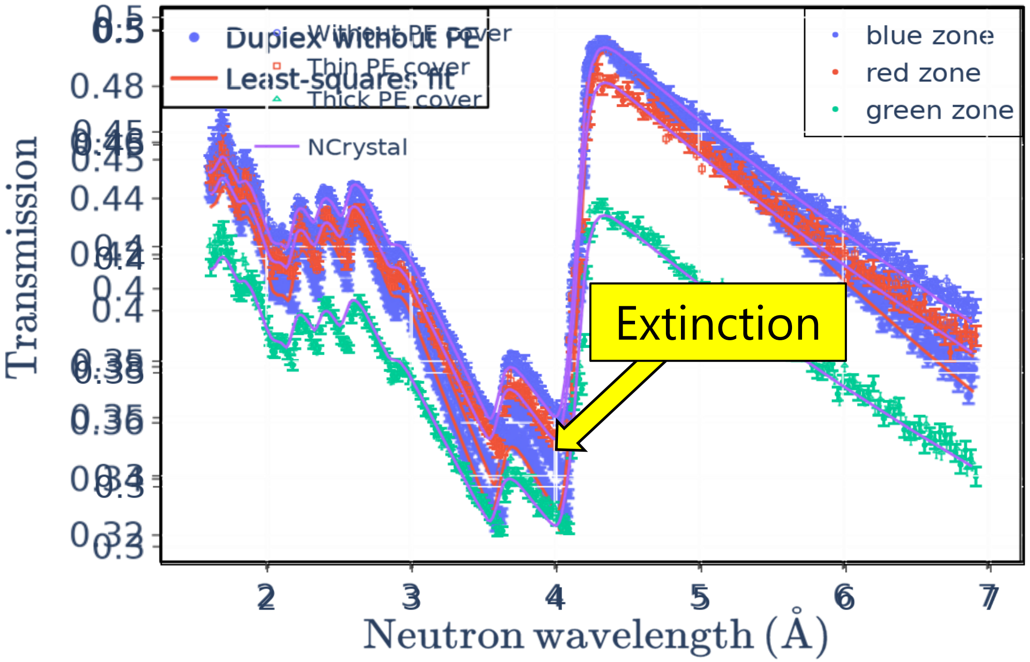
Corresponding to 2.1.1 above, the top-level requirements for the basic scope are[1]:

5) ODIN shall allow the detection of contrast equivalent to 10 ppm H_2 in steel, with a spatial resolution down 100 µm.



1) Establish Fit for **Sample Composition**
2) Mimic H with **PE sheets**
3) Derive PE thickness from Fit

NCrystal : a library for thermal neutron transport



Fitted thickness:
thin PE: 44±2 µm ≈98 wt.ppm H
thick PE: 230±2 µm ≈ 495 wt.ppm H

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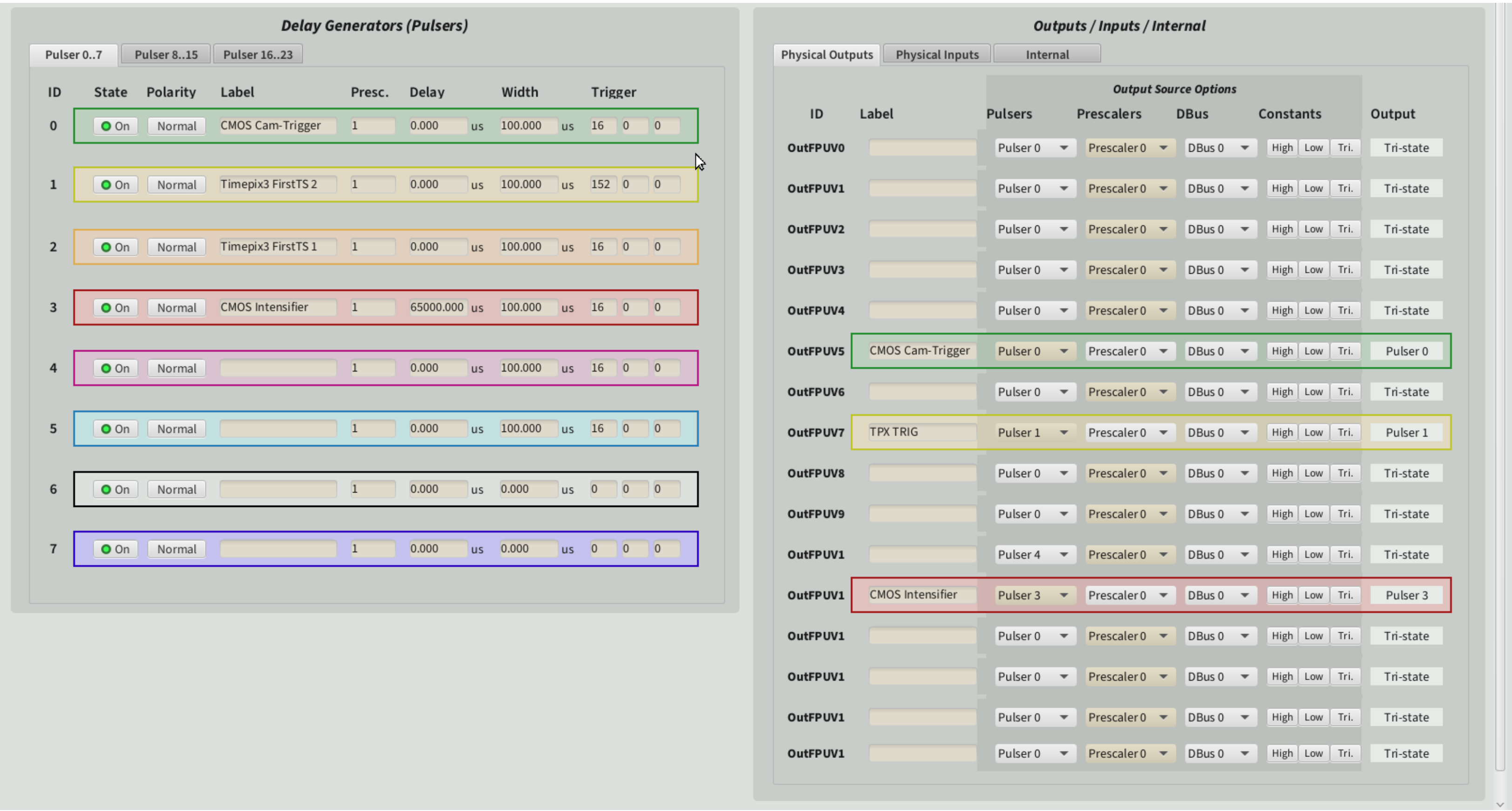
Detector: ICS EVR is crucial for timing

Physical Connections

Cave side	Cable	Cable	EVR	EVR Type
TPX3cam			UNIV 7	Out 5V
LumaCam Intensifier	-	-	-	not configured so far
CMOS Camera			UNIV 5	Out 3.3V
CMOS Gating			UNIV 11	Out 5V

EVR Settings and Connections ODIN



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Summary detectors

- The ODIN and TBL teams regularly use ESS detectors at facilities such as ISIS and J-PARC
- Integration into the ESS DAQ architecture has been achieved and demonstrated (ICS-ECDC-DMSC)
- The detectors are ready for use @ESS
- The more hands-on experience for staff ahead of BOT – the better!

THANK YOU!

ODIN

System Requirement Specification (ESS-0129650)

46	Time resolution – ToF Imaging The SCS shall provide detector time resolutions down to the ns range (sub-μs range) for ToF imaging measurements.	ConOps 2.1.: II 2.2: 3,6-13 3.2. & 3.4.9.
47	Time resolution – Kinetic Imaging The SCS shall provide detector time resolutions down to ~70 ms for kinetic imaging applications.	ConOps 2.1. & 2.2: 2 3.2.
48	Time resolution – Stroboscopic measurements The SCS shall provide detector time resolutions of at least 10ns to allow stroboscopic measurements with time resolutions around 1 μs.	ConOps 2.1. & 2.2: 2 3.2.
49	Efficiency – Lower acceptable limit Detection efficiency of the SCS shall not fall below 30% at 4 Å for any specific detector system.	ConOps 2.1. 3.2. & 3.4.9.
50	Efficiency – Optimal minimum Detection efficiency of the SCS shall in optimum case reach at least 90% at 4 Å.	ConOps 2.1. 3.2. & 3.4.9.
51	Efficiency – Ambition The detection efficiency of the SCS shall be optimum according to the state of the art available in 2019/20.	ConOps 2.1. 3.2. & 3.4.9.

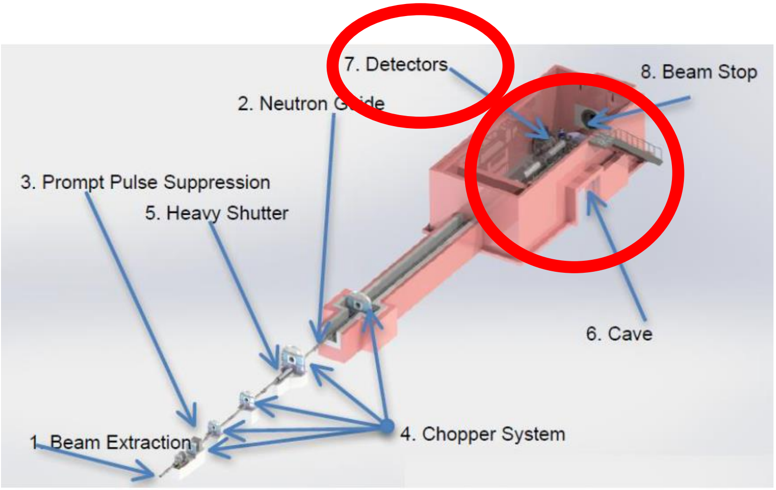


Figure 2 - ODIN conceptual layout

Cave Interior

ODIN

System Requirement Specification (ESS-0129650)

52	**Count rate – Limitation and Decay** The detectors should have no count rate limitation and corresponding efficiency decay.	ConOps 2.1. 3.2. & 3.4.9.
53	**Count rate – Local minimum** Detectors shall reach values of $10^{8}cm^{-2}s^{-1}$, for local count rates and corresponding integrated count rates over their respective detection area. That should even apply for systems used for ToF	ConOps 2.1. 3.2. & 3.4.9.
54	**Count rate – Local optimum** Detectors should in optimum case allow for local count rates and corresponding integrated count rates over their respective detection area of higher than $10^{10}cm^{-2}s^{-1}$.	ConOps 2.1. 3.2. & 3.4.9.
55	**Gamma Sensitivity** The gamma sensitivity of SCS systems shall be at least as low as the state of the art of specific currently used systems for corresponding applications. (A minimum requirement should potentially be defined for each specific system based on the current choice and the corresponding state of the art.)	ConOps 2.1. 3.2. 3.4.9.

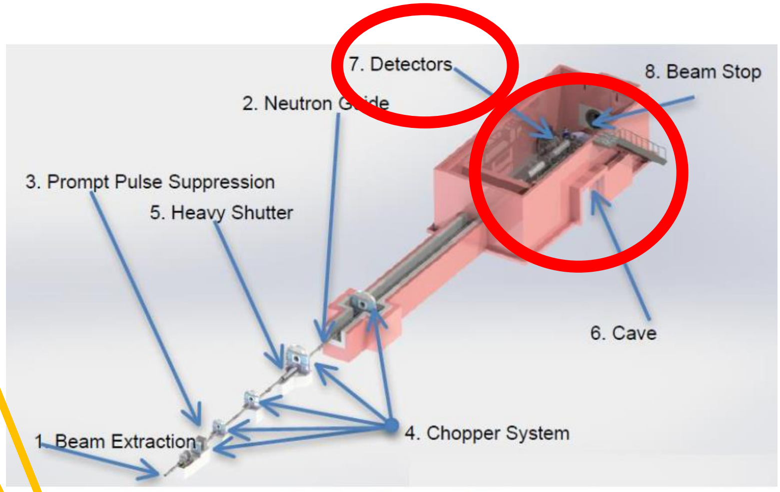


Figure 2 - ODIN conceptual layout

Cave Interior

Highly dependent on the detector settings and configuration.

ODIN uses the best available technology. To fulfill these requirements, a range of detectors is needed.

ODIN

System Requirement Specification (ESS-0129650)

56 ✓	Background Noise The background noise (read out noise) of specific SCS detection systems shall be at least as good as the state of the art of specific currently used systems for corresponding applications.	ConOps 2.1. 3.2. & 3.4.9.
57 ✓	Space requirement The active detection area of every SCS detection systems shall be possible to be placed not more than 10 mm from the closest surface of a sample or any sample environment respectively at very foreseen position of the SES.	ConOps 2.1. 3.2. 3.4.9.
58 ✓	Alignment – Hot Alignment Live view mode of imaging detectors shall allow quick alignment (hot alignment).	ConOps 2.1. & 3.2. 3.4.9. & 5.
59 ✓	Beam Stop – Attenuation The beamstop of the SCS shall be able to attenuate a direct beam to a level below 3 μSv/hr outside the Experimental Cave	ESS-0001786 "Supervised area" versus 3rd safety area

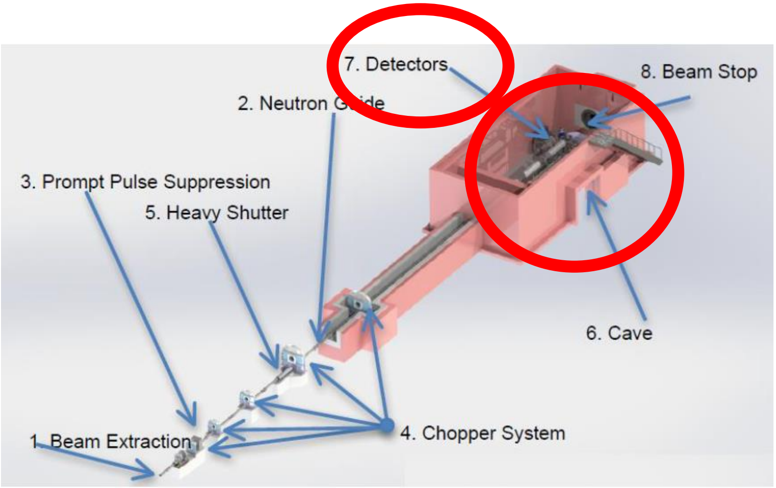


Figure 2 - ODIN conceptual layout

Cave Interior

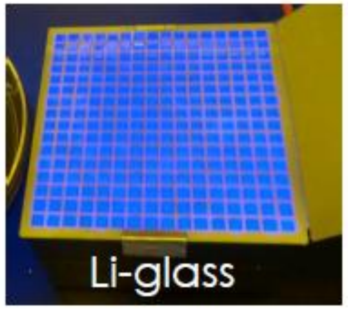
Detectors

ToF detectors for imaging **A quickly developing field**

<u>Detectors at RADEN (JPARC)</u>

Counting type

- nGEM (boron)
- μNID (^{3}He)
- Li-glass scintillator
- Anton's MCP also available



Counting-type detectors at RADEN

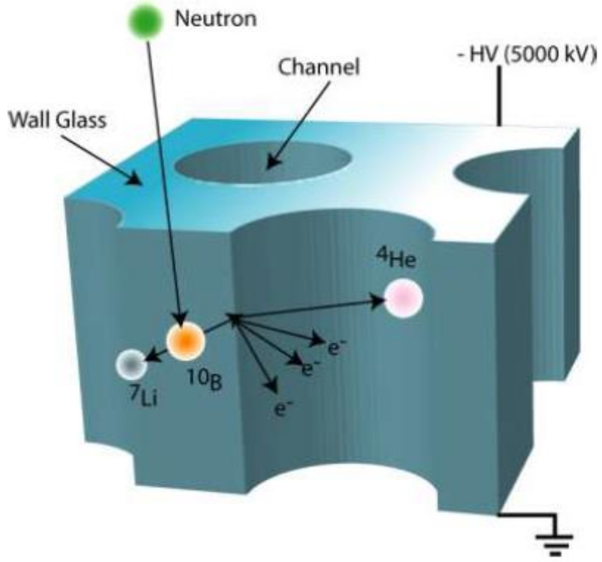
Detector	Type	Performance	Primary imaging methods
μNID	Micropattern, ^{3}He converter	• Area: 10 x 10 cm^2 • Spatial resolution: 0.2 mm • Time resolution: 0.25 μs • Efficiency: 25% (thermal) • Count rate: 100~300 kcps	• Resonance absorption • Bragg-edge • Magnetic imaging • Phase-contrast imaging
nGEM	Micropattern, ^{10}B converter	• Area: 10 x 10 cm^2 • Spatial resolution: 1 mm • Time resolution: 10 ns • Efficiency: 10% (thermal) • Count rate: 200~400 kcps	• Resonance absorption • Bragg-edge
Li-glass	GS20 scintillator pixels with ^{6}Li	• Area: 5 x 5 cm^2 • Spatial resolution: 3 mm • Time resolution: >40 ns • Efficiency: 25% (thermal) • Count rate: 6 Mcps	• Resonance absorption • Bragg-edge

Courtesy: J. Parker

Detectors

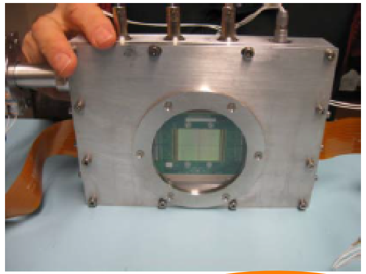
ToF detectors for imaging **A quickly developing field**

MicroChannel Plates (MCP's): Timepix readout



- Similar principle of photo-multiplier tube
- ^{10}B or ^{nat}Gd in wall glass absorbs neutron
- Reaction particles and high electric field create an electron avalanche

Detector configuration and performance



- Detection of photons, ions, neutrons, alphas, high energy electrons, atoms.
- Up to ~25000 simultaneous events can be detected.
- Active area 28x28 mm^2 (2x2 Timepix chips).
- Fast parallel readout (x32) allowing ~1200 frames per second with ~320 μs readout time
- Event centroiding (~12 μm resolution, at ~5x10^6 events/s) or 55 μm resolution at >5x10^8 events/s.
- Time resolution can be ~20 ns at ~2.5x10^7 events/s rates with 55 μm resolution.
- Timing within frames – TOF(energy) or dynamic processes can be studied. Wide energy range or most phases measured in one experiment.

High count rate

Small FoV

Leads to gaps

Best spatial resultion of any ToF detector

Better than needed for most applications