Status of Multi-Blade detector for the Test Beam Line facility at European Spallation Source

WP7-Task 7.3

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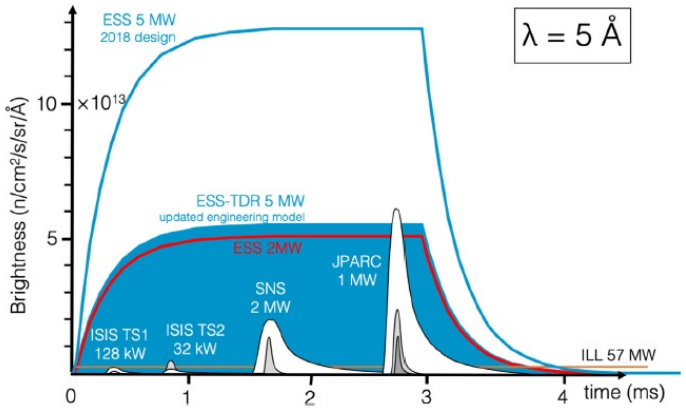
EURIZON Annual Meeting - 9th Feb 2023

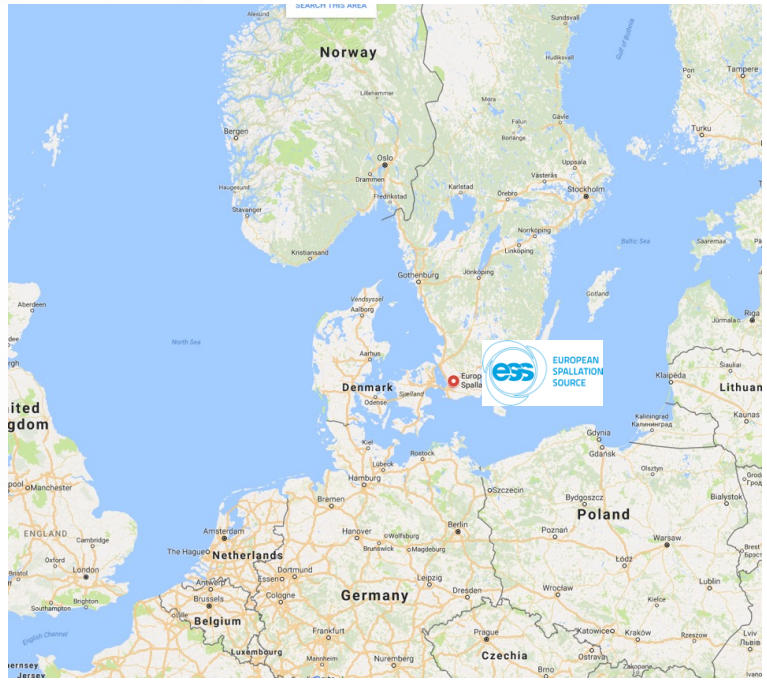
European Spallation Source- ESS

life sciences
magnetism & superconductivity
soft condensed matter
engineering & geo-sciences
chemistry of materials
archeology & heritage conservation
energy research
particle physics

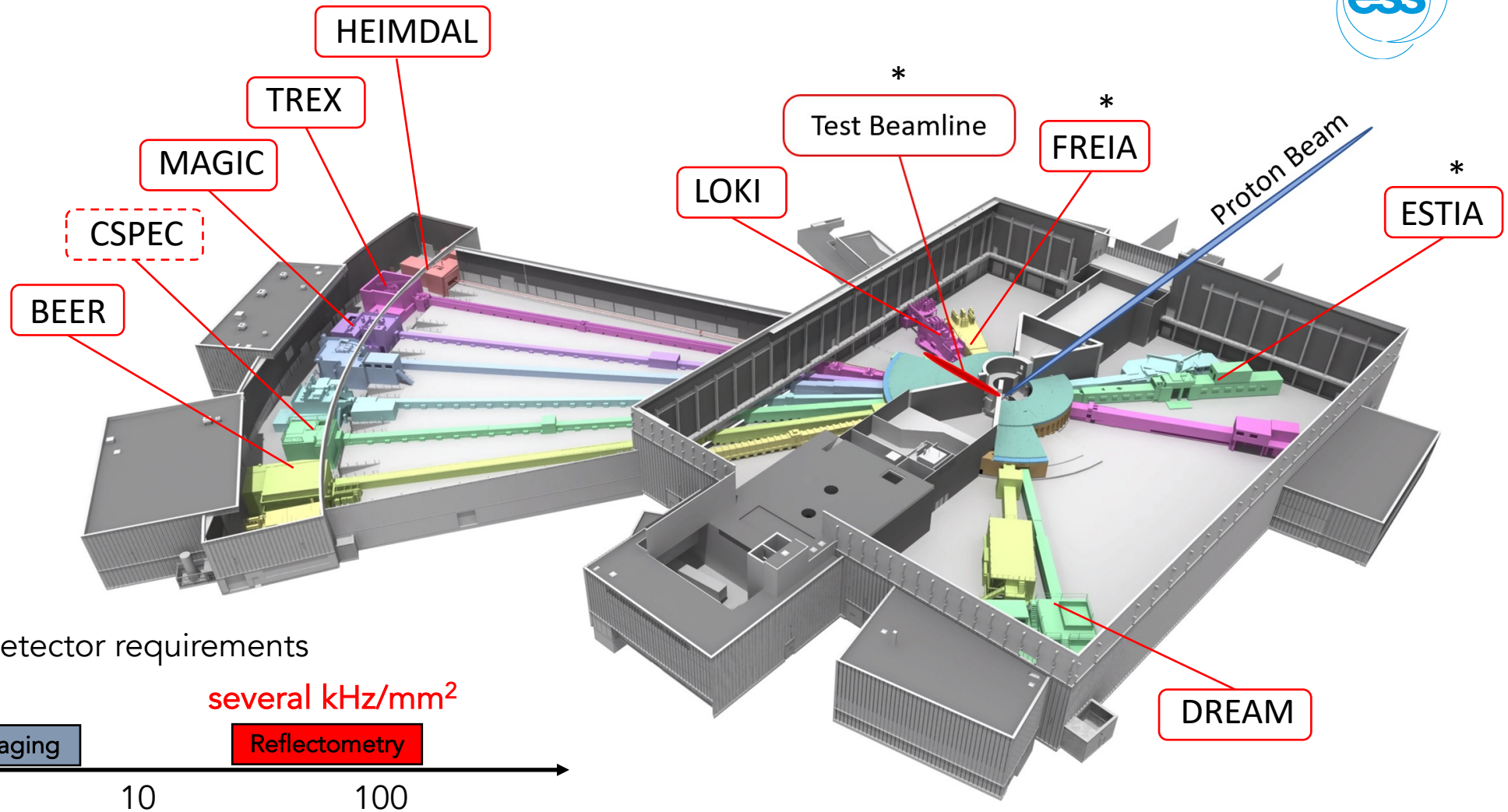
instruments

Linear proton accelerator



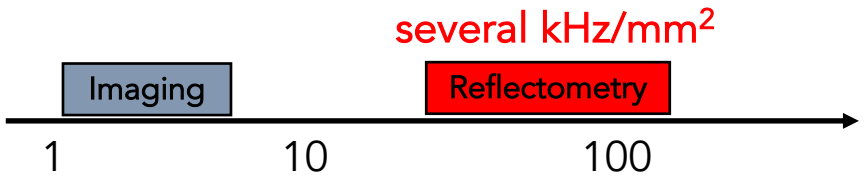


Boron-10-based Detectors at ESS



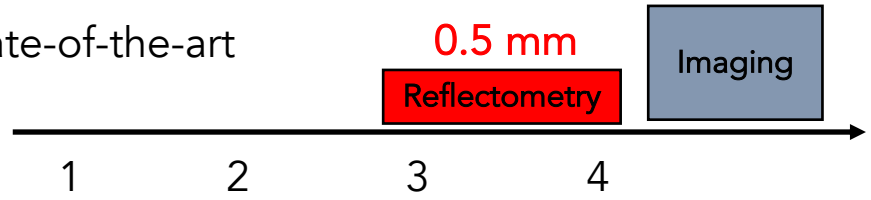
High detector requirements

Instantaneous Rate Capability



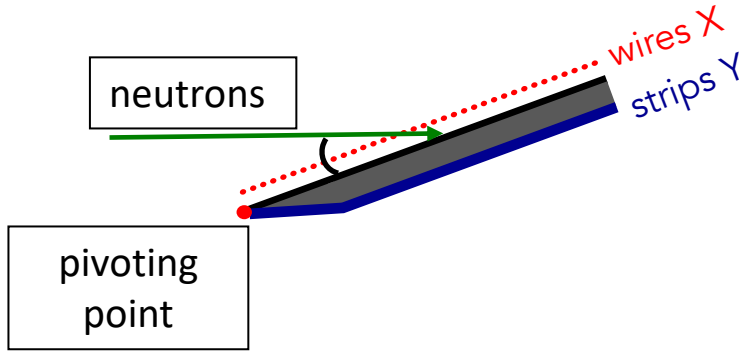
1 = state-of-the-art

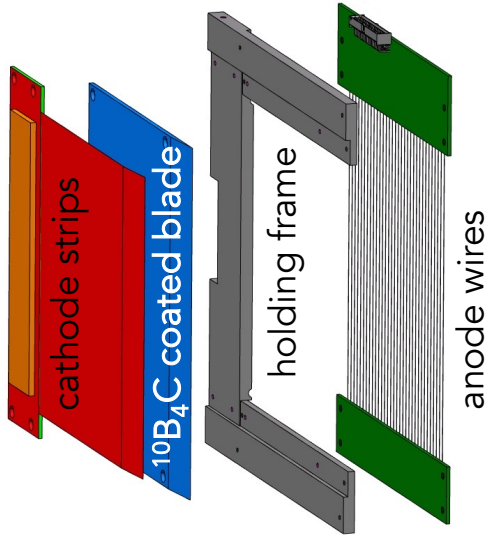
Spatial Resolution

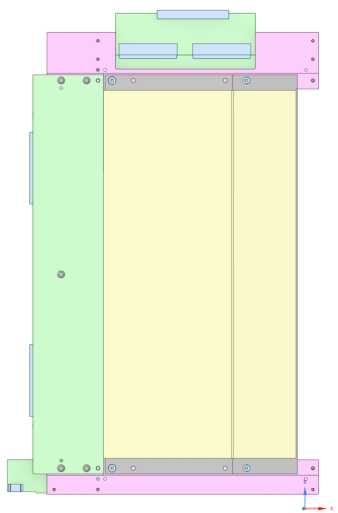


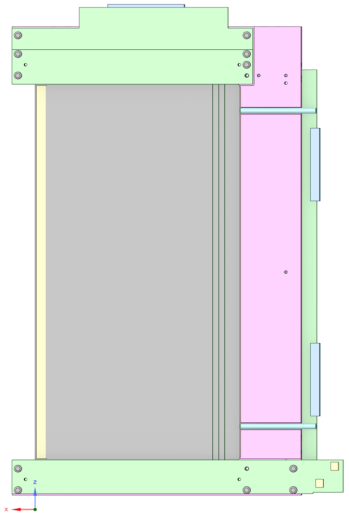
Multi-Balde Detector Principle

Neutrons impinging detector at θ_i = 5°

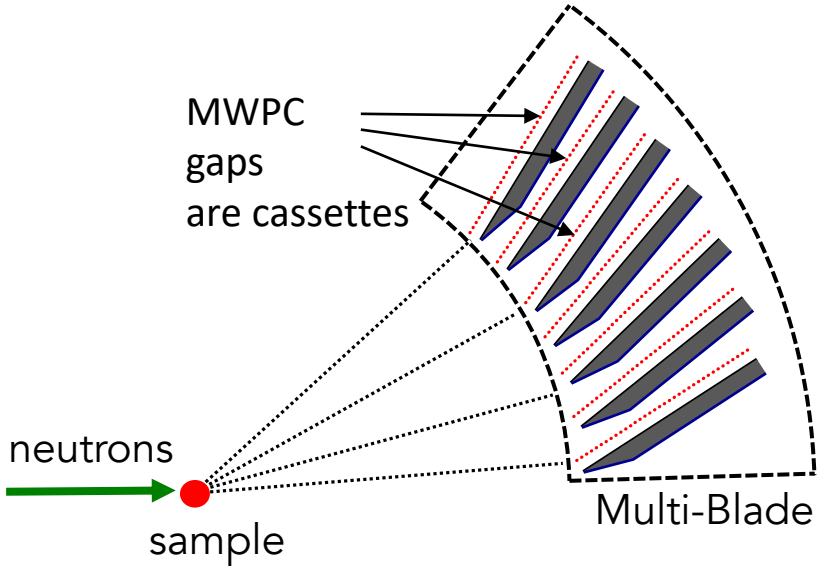




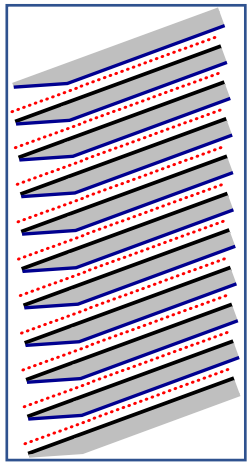


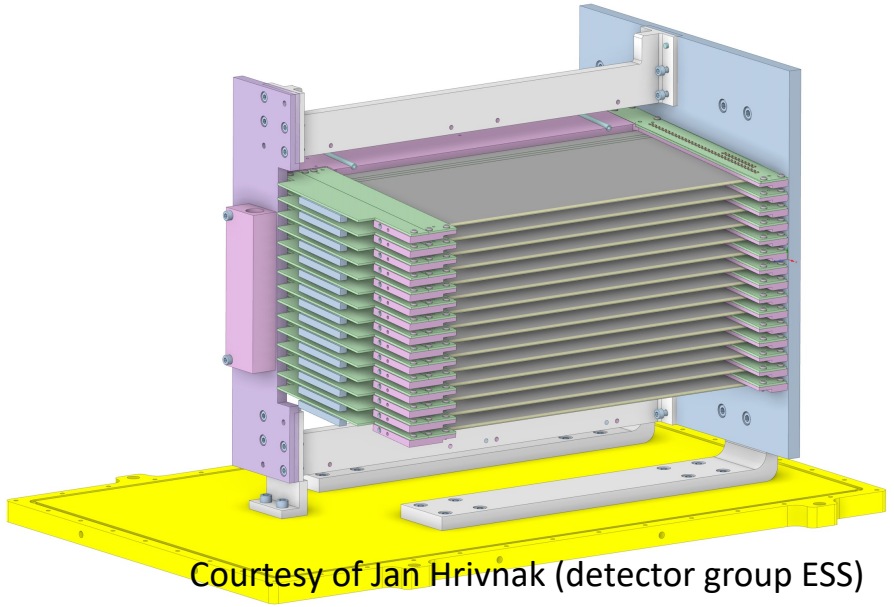


Focusing reflectometry



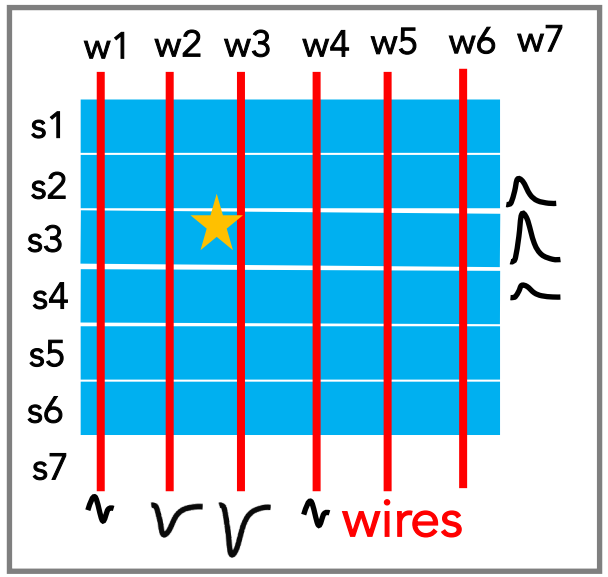
Imaging

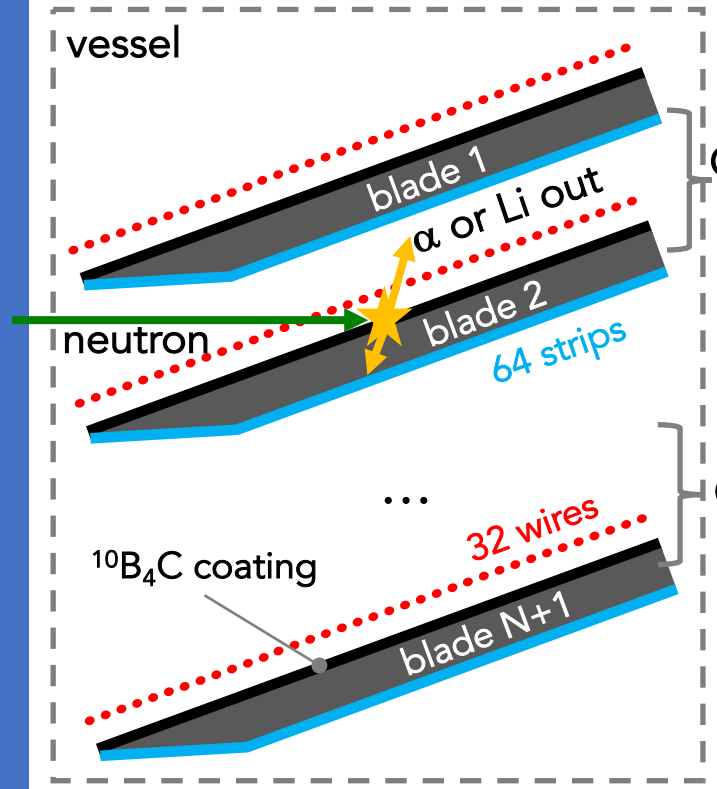


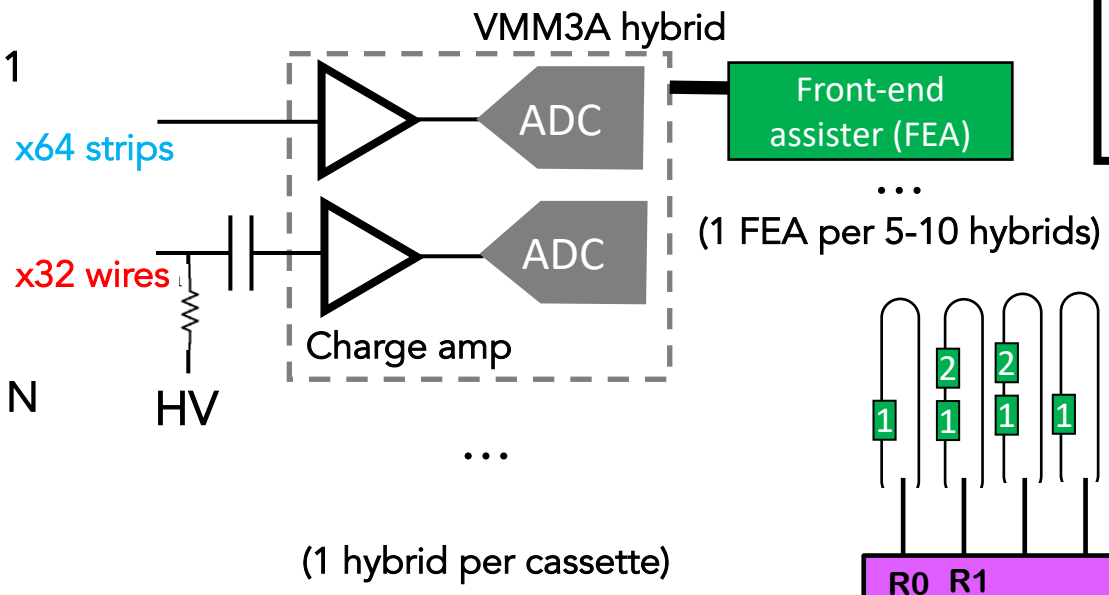


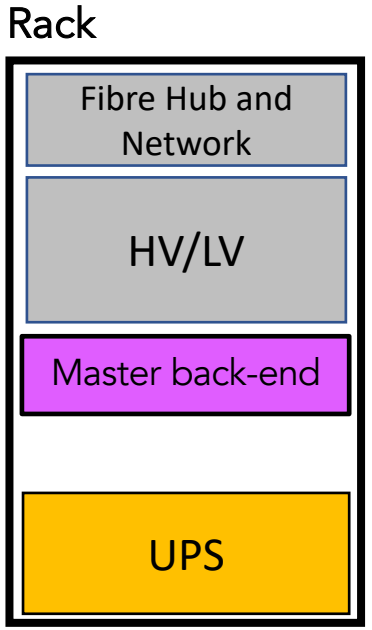
Courtesy of Jan Hrivnak (detector group ESS)

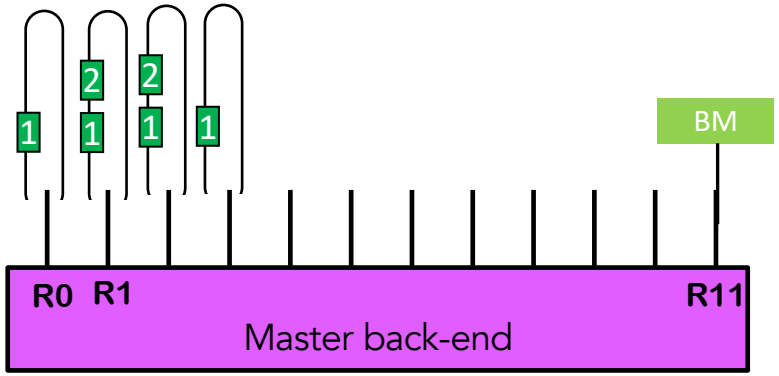
Multi-Balde Detector Principle



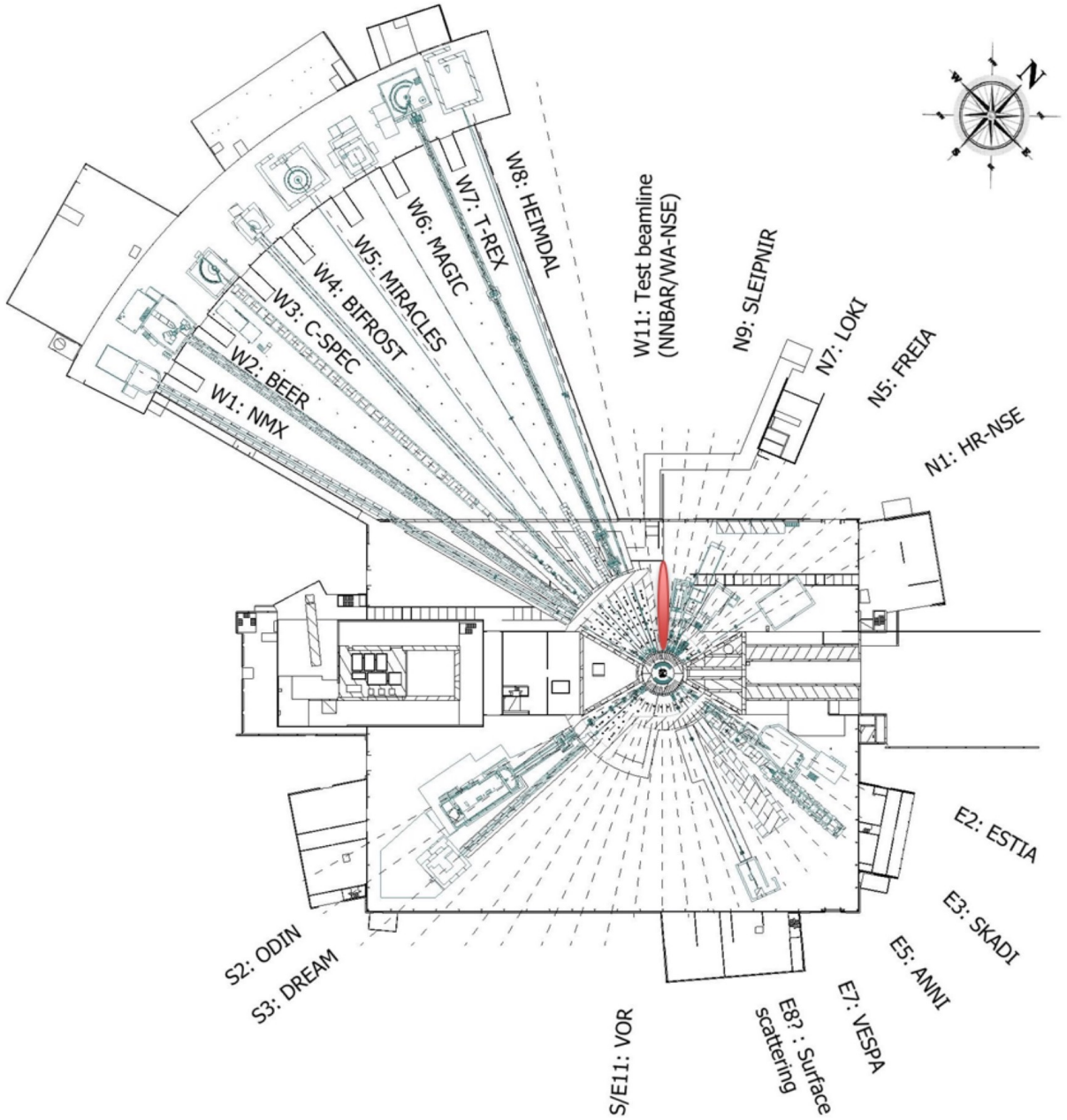








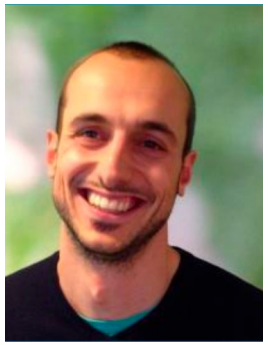
Scientific Validation of Multi-Blade



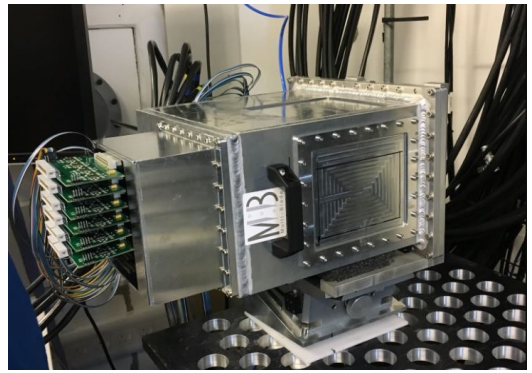
brightness

- WP1
- WP2
- WP3
- WP4 — Innovation in Key Neutronic Technologies
  - TASK 4.1
  - TASK 4.2
  - TASK 4.3
  - TASK 4.4
  - TASK 4.5
- WP5
- WP6

Dr. Francesco Piscitelli
Francesco.Piscitelli@ess.eu



The Intensity Frontier



General Detector Features

Matching ESS requirements

Active area /one cassette	260 x 10	mm^2
Spatial resolution (FWHM) y Spatial resolution (FWHM) x	0.55 4	mm mm
Maximum instantaneous pixel rate at 2% dead time	10	kHz/mm^2
Gamma ray-sensitivity	$< 10^{-6}$ (100 kev threshold)	
Fast neutron sensitivity	$<10^{-5}$	
Time resolution	< 5	µs
Efficiency	45% @ 2.5 60% @ 4.2 75% @ 6	Å Å Å

Better than state-of-the-art

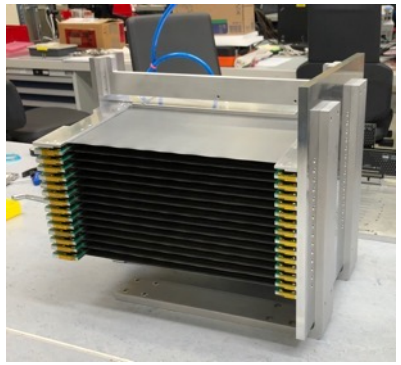
X3-4

X20

Equally good

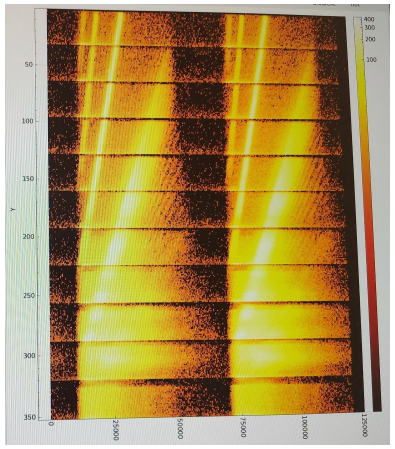
X100

Multi-Blade at AMOR (PSI)



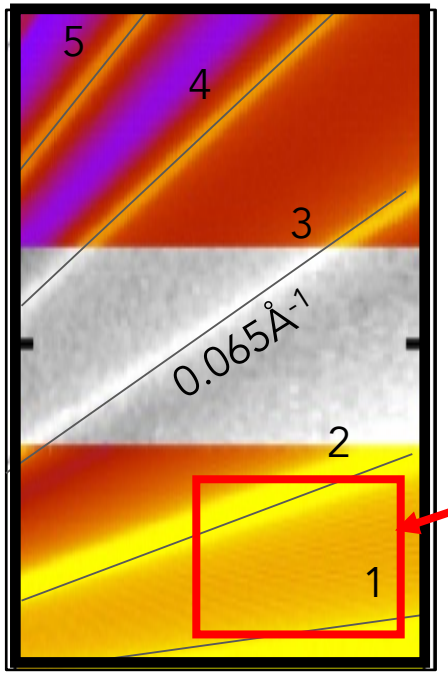
14-unit detector for AMOR
(active area 260x140mm^2)
Same units as ESTIA (48 units), FREIA (32 units) and TBL (10 units)

MB AMOR is operational on AMOR (PSI) from 9th May 2022

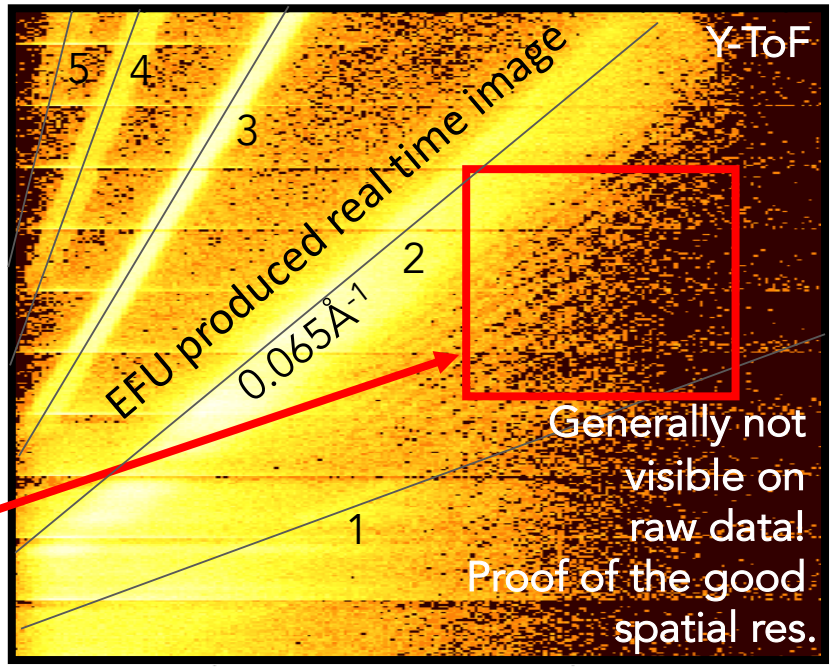


Direct beam 1.7MHz over 10x10cm^2

Thanks to Jochen Stahn
(AMOR instr. scient.)



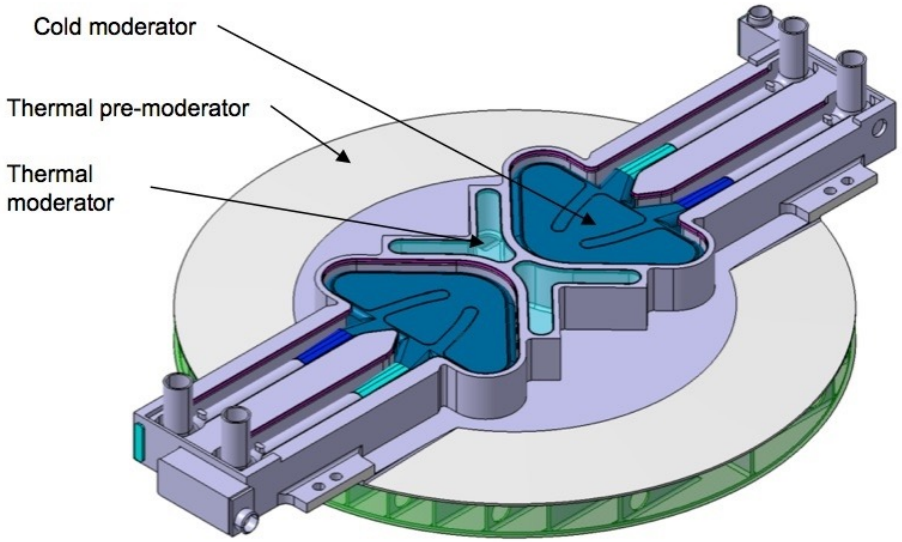
SIMULATED

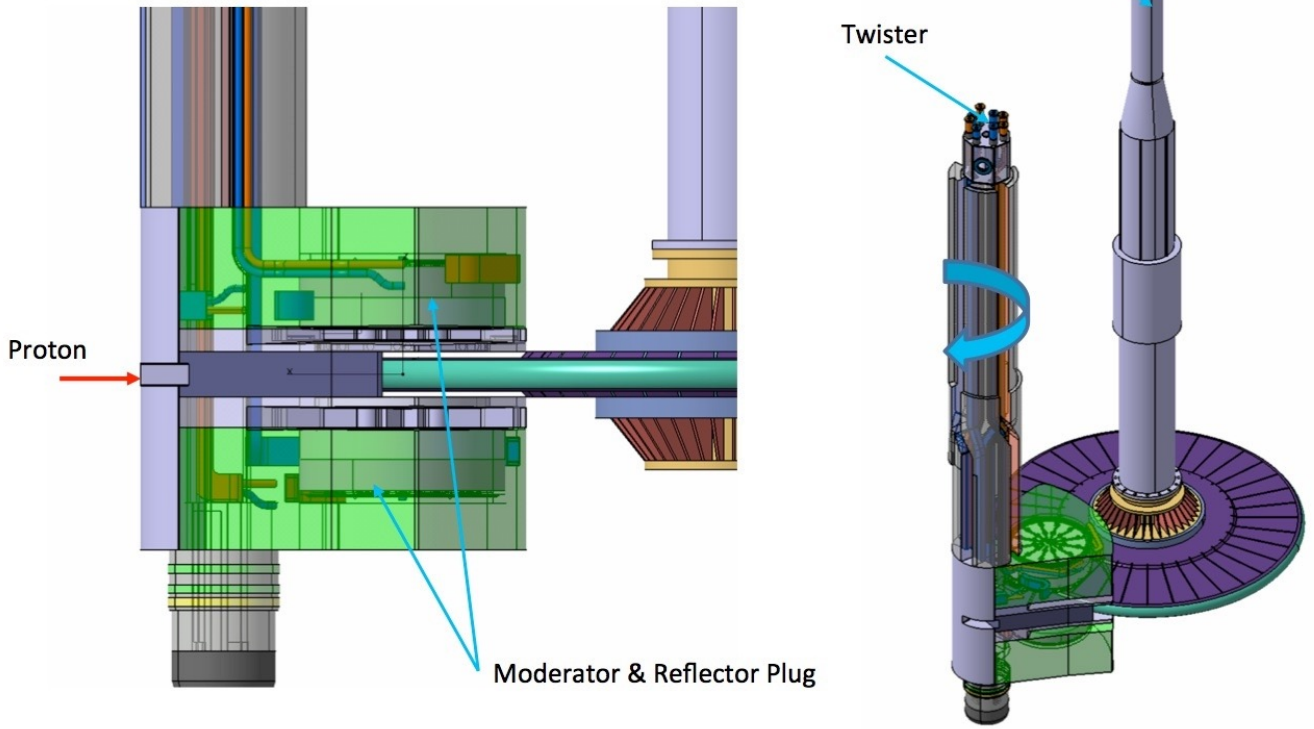


MEASURED with Multi-Blade NiTi sample

- G. Mauri et al., JINST 15, P03010, 2020.
- F. Piscitelli et al., JINST 13 P05009 (2018).
- G. Mauri et al., Proc. R. Soc. A 474: 20180266 (2018).
- G. Mauri et al., JINST 13 P03004 (2018).
- F. Piscitelli et al, JINST 12 P03013 (2017).
- F. Piscitelli et al., JINST 9 P03007 (2014).

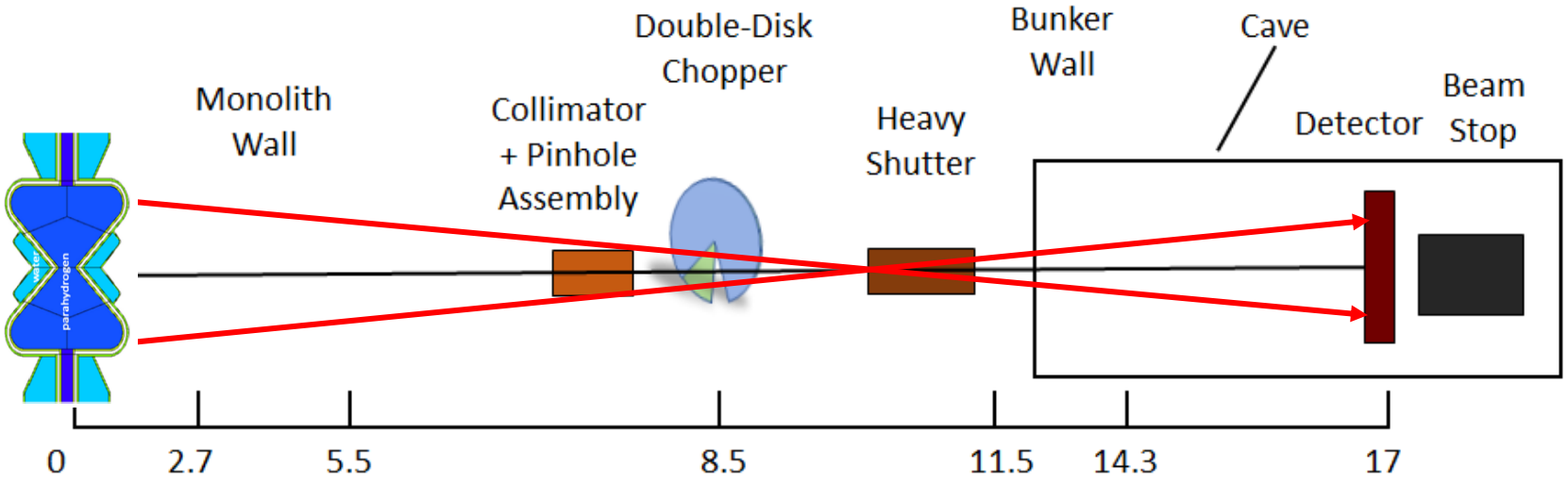
ESS Target - Moderator

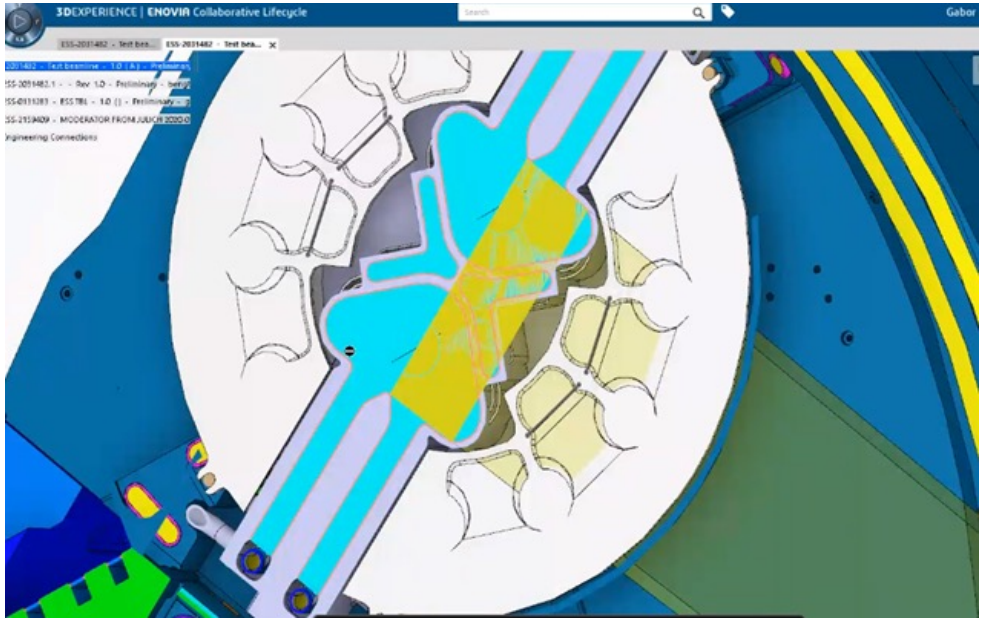




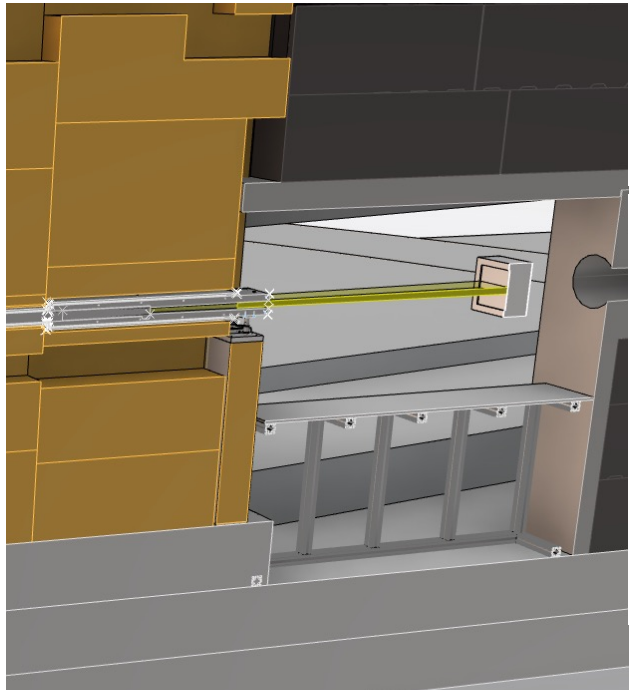
Courtesy of Robin Woracek (TBL group ESS)

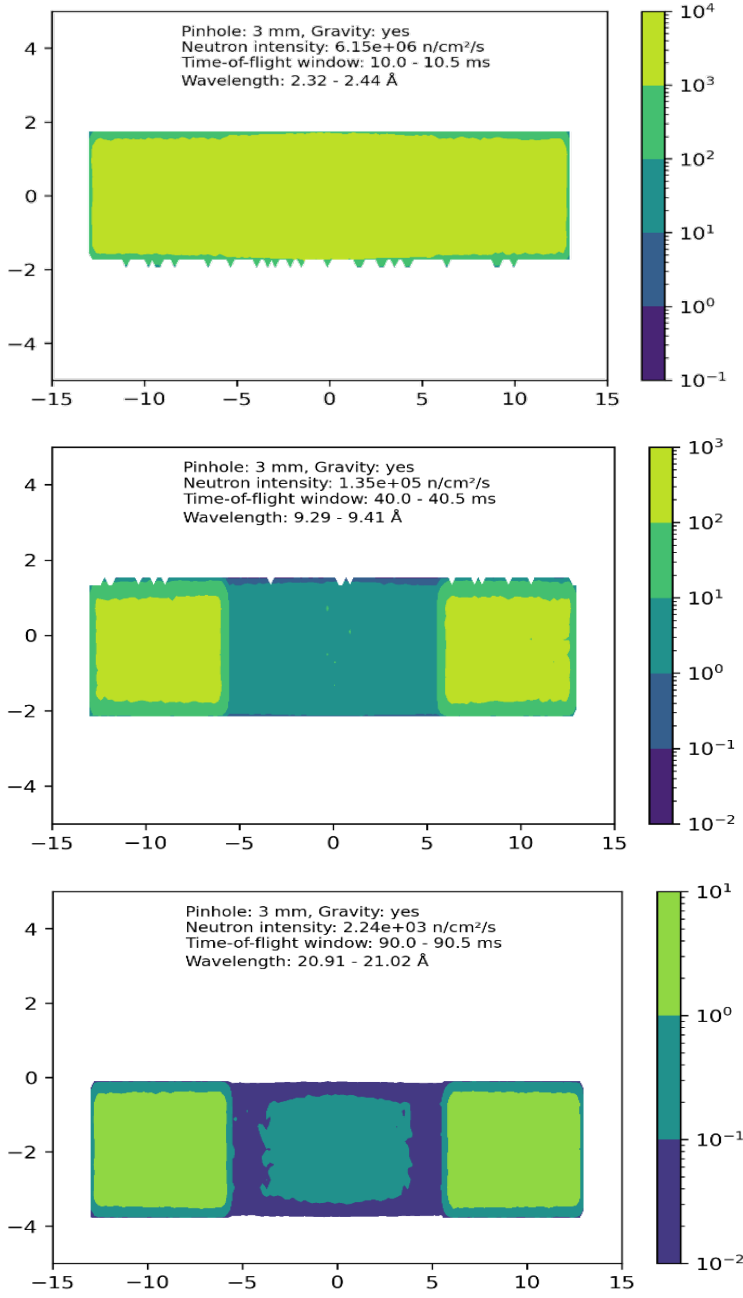
Moderator and Detector Position





Courtesy of Robin Woracek (TBL group ESS)





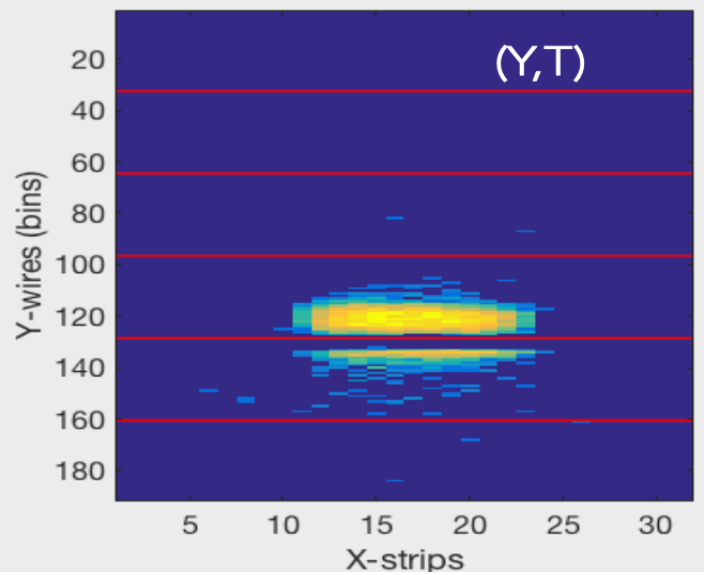
Courtesy of T. Chulapakorn (TBL group ESS)

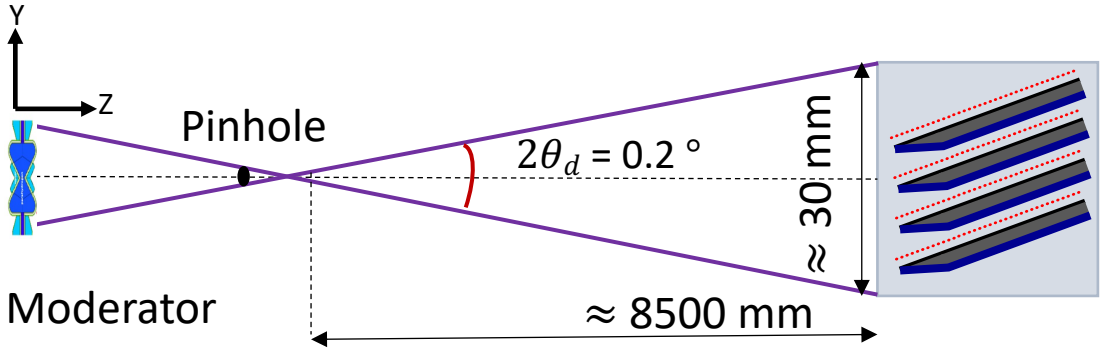
Multi-Blade for Test Beam Line

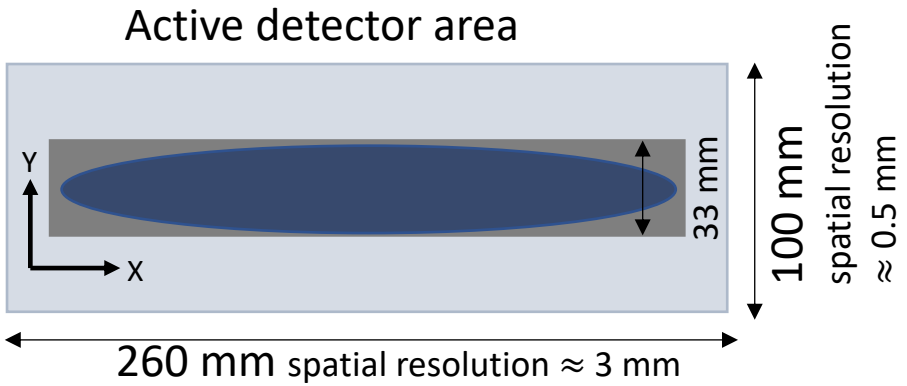
European network
for developing new horizons for RIs

Test Beam Line desirable specifications for Imaging

Active area coverage	**≈ 300 (W) x ≈ 100 (H)**	**mm²**
Spatial resolution (V) (FWHM) **Spatial resolution (H) (FWHM)**	≈ 0.5 ≈ 3.5	mm mm
Instantaneous rate capability	≈ 10	kHz/mm²
Time resolution for imaging **Time resolution for neutron pulse shape**	< 100 < 30	µs µs





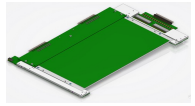


System Overview

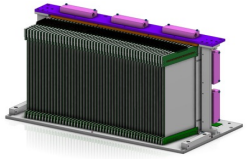
Detector

Mechanics

Cassettes

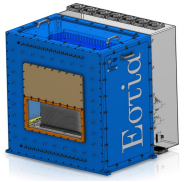


Alignment and array plates



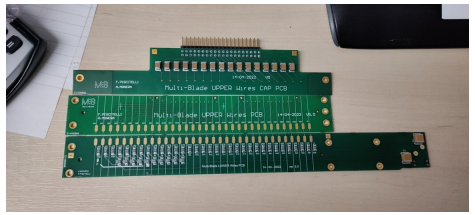
Coatings

Vessel



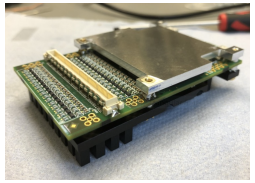
Electronics box incl. heat management

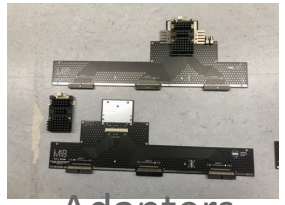
Internal PCBs



Readout

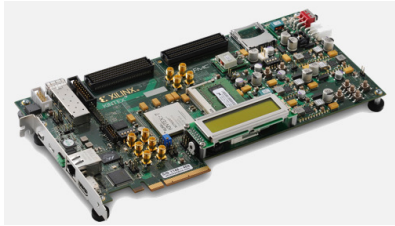
Front-end





Adapters

Front-end assisters



Back-end

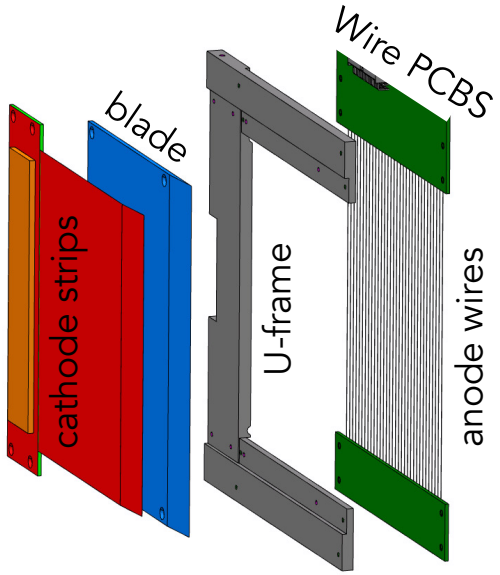
Services

Racks

- HV/LV
- UPS
- Cables

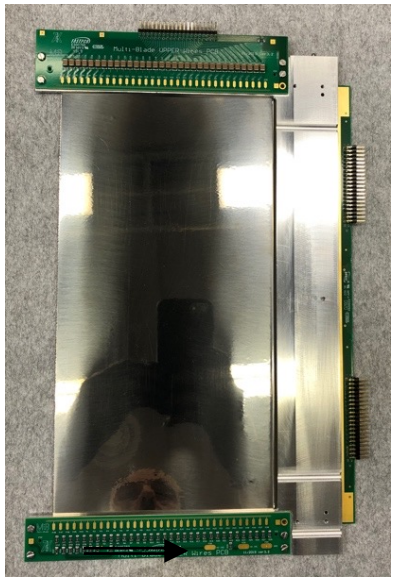
Gas management

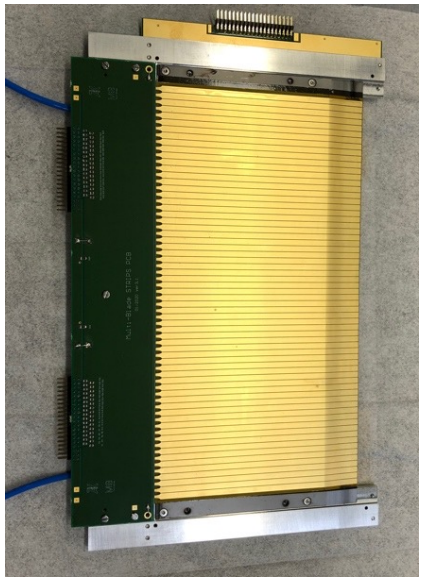
Blade Assembly

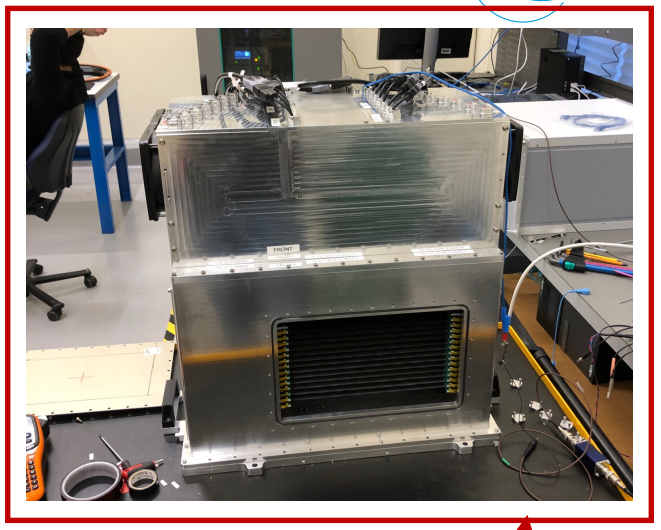


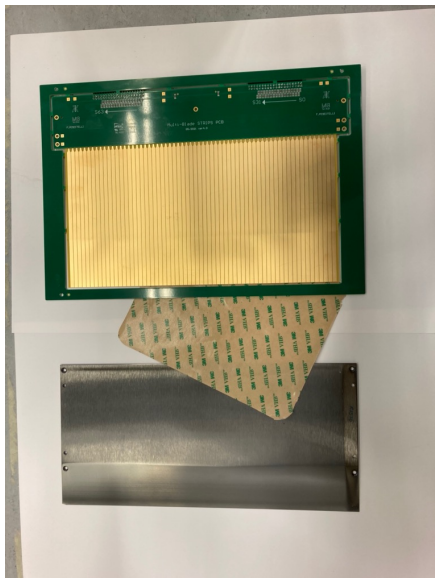
Front

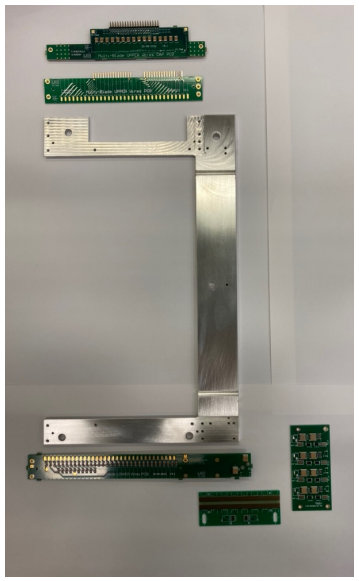
Back

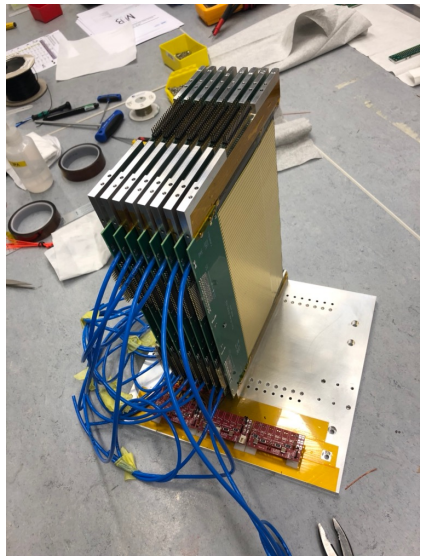


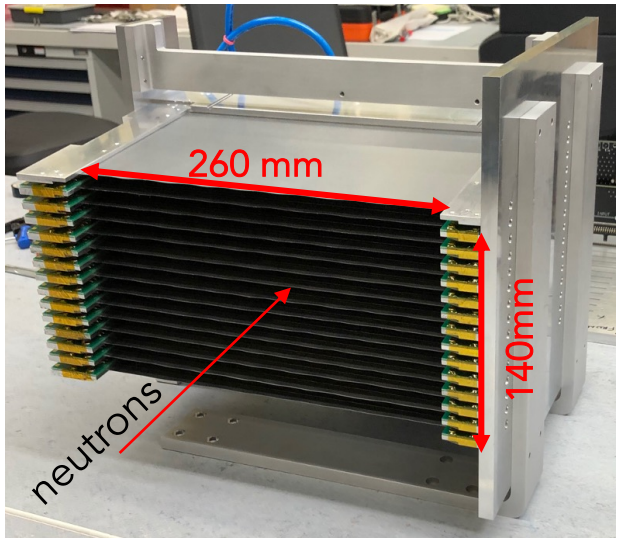




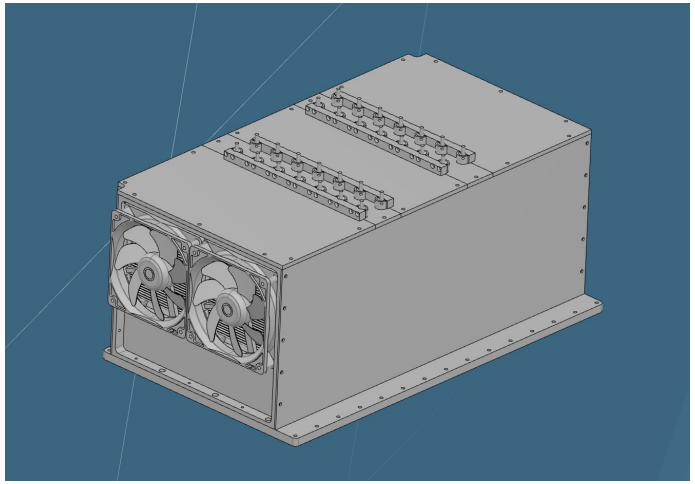


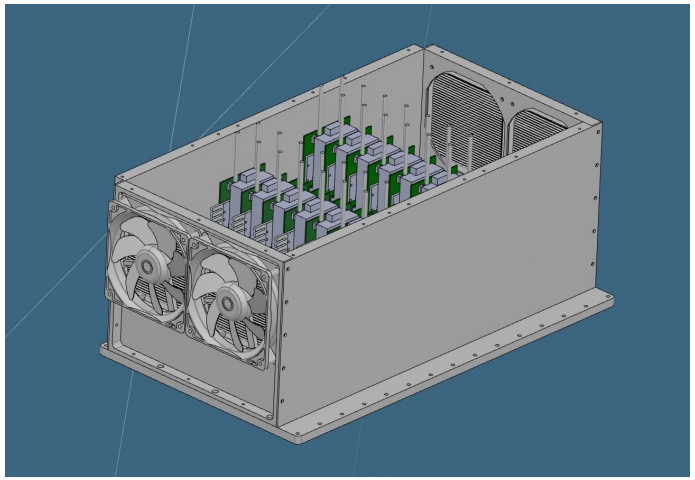






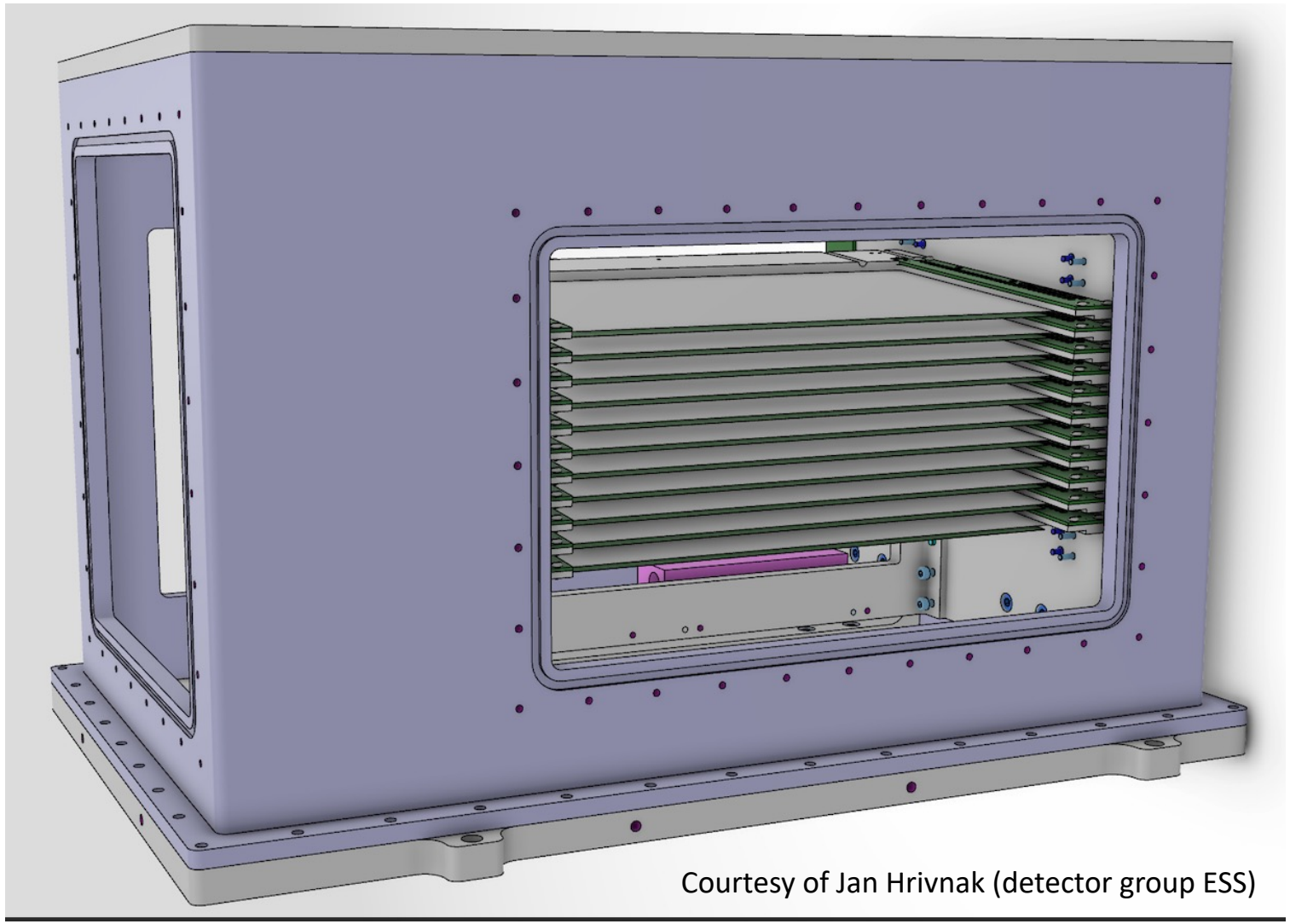
Mechanical Design





VMM electronics enclosure box

Schematic of Multiblade orientation for Test Beam Line



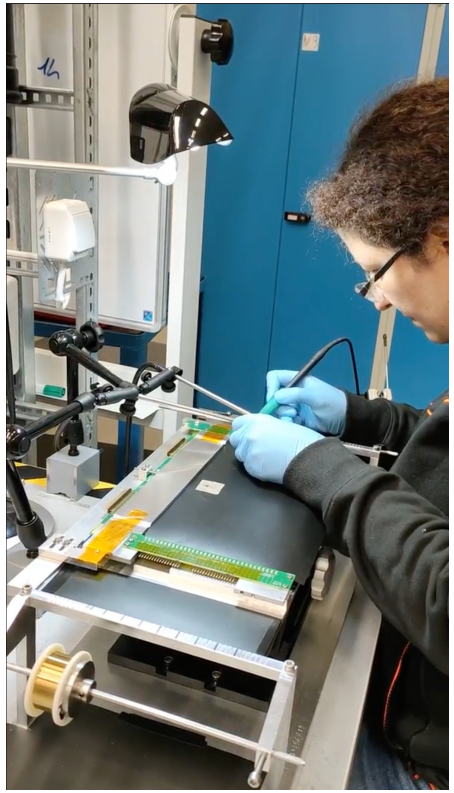
Courtesy of Jan Hrivnak (detector group ESS)

Towards the line production of Multi-Blade

Case: TBL

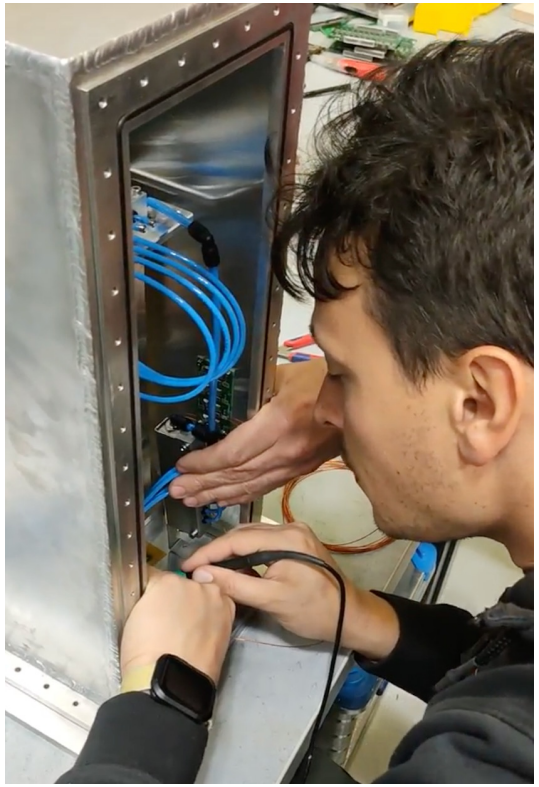
Building the final testing prototype (5 cassettes) @ ESS detector group- Six blades were built and assembled
Final mechanical and electronical design was implemented
Detector was tested at Lund Source Test Facility

Blade assembly @ESS

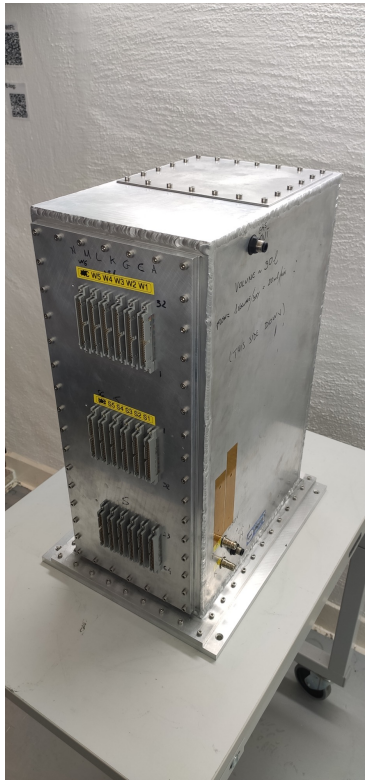


Prototype Wiring @ESS
Final production by CDT

Detector assembly @ESS

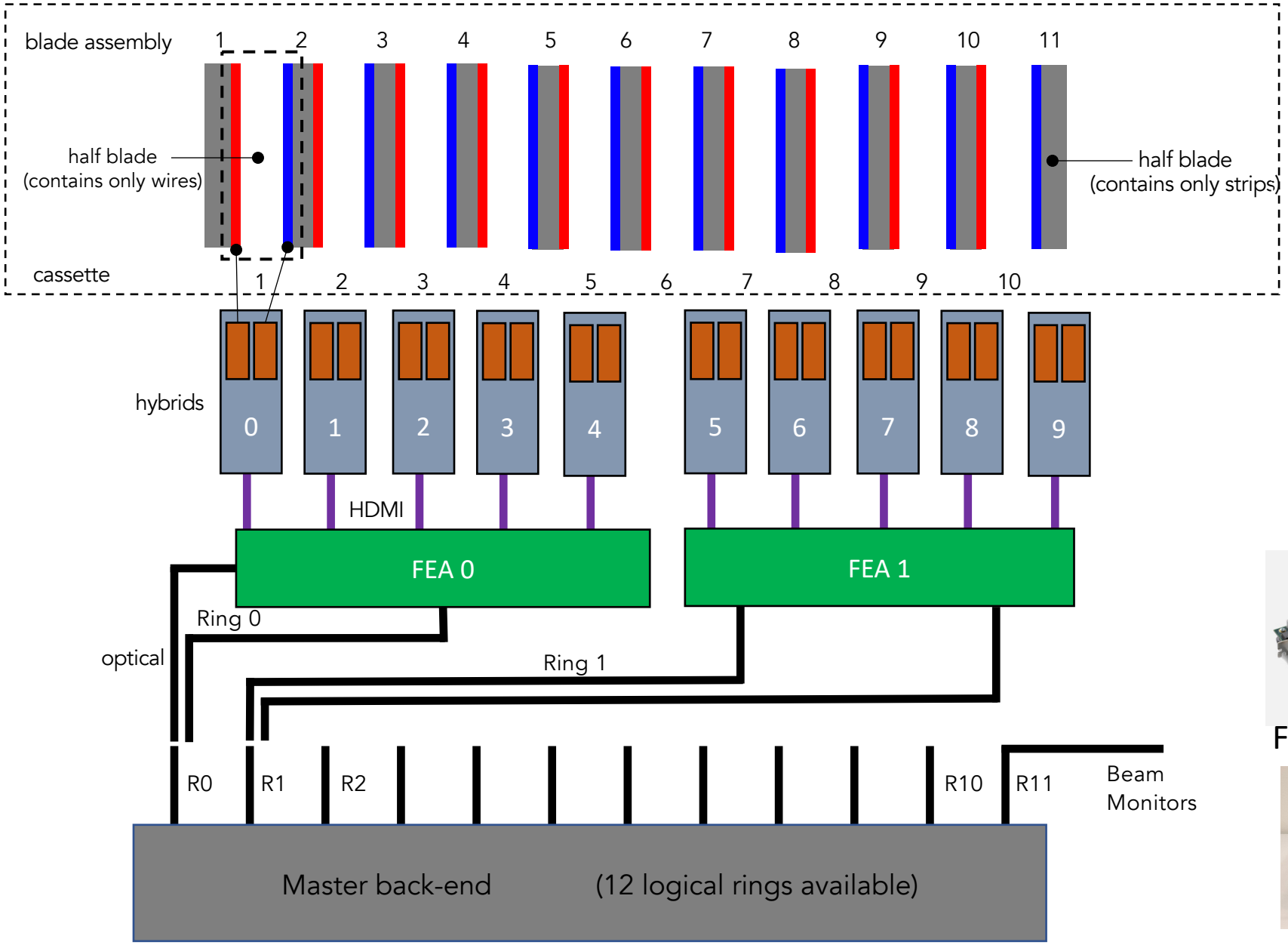


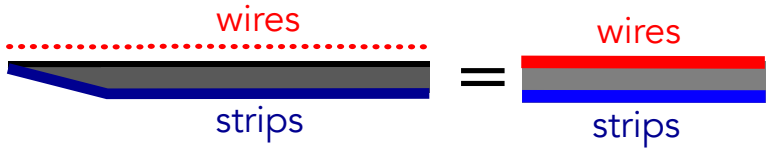
Vessel@ESS

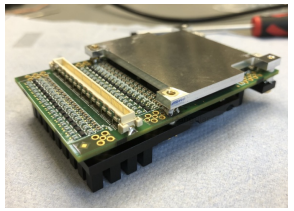


Full unit

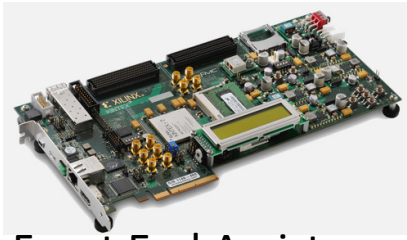
Multi-Blade Readout Integration



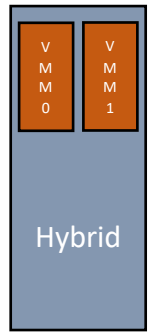




Vmm3a

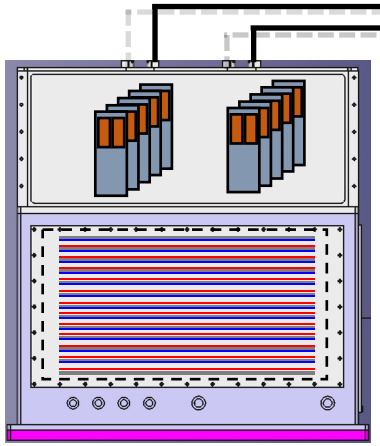


Front End Assister



Hybrid = 2 VMMs = 128 ch

Multi-Blade Main Componets for TBL



10 HDMI cables

2 logical rings

Fiber Hub

Front End Assister

Front End Assister

Network Switch

Fiber Hub

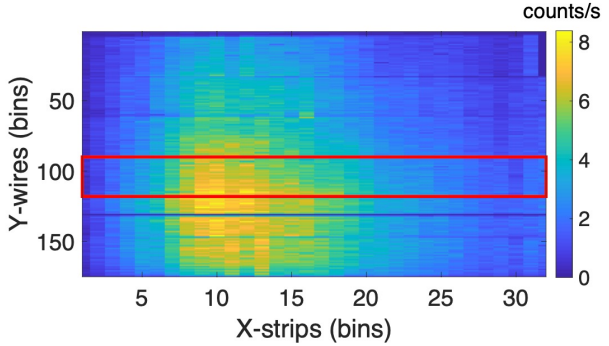
Master Module

Detector Monitor

H.V. and L.V.

UPS

Python MBUYTYcap code



Detector and Vmm3a hybrids

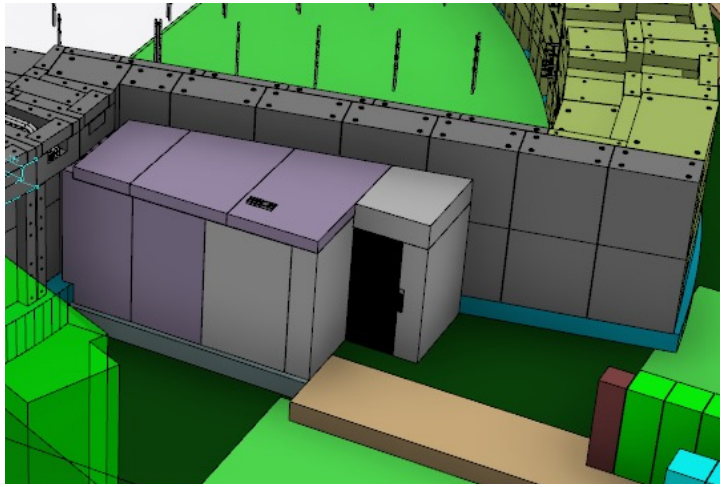
Front-End Assister rack
5 hybrids into 1 FEA

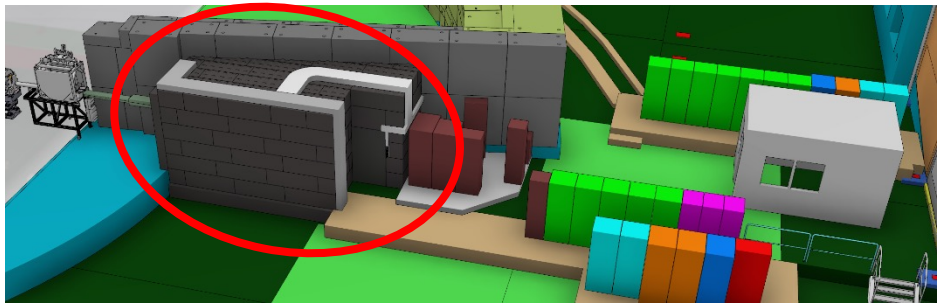
Master Module Rack

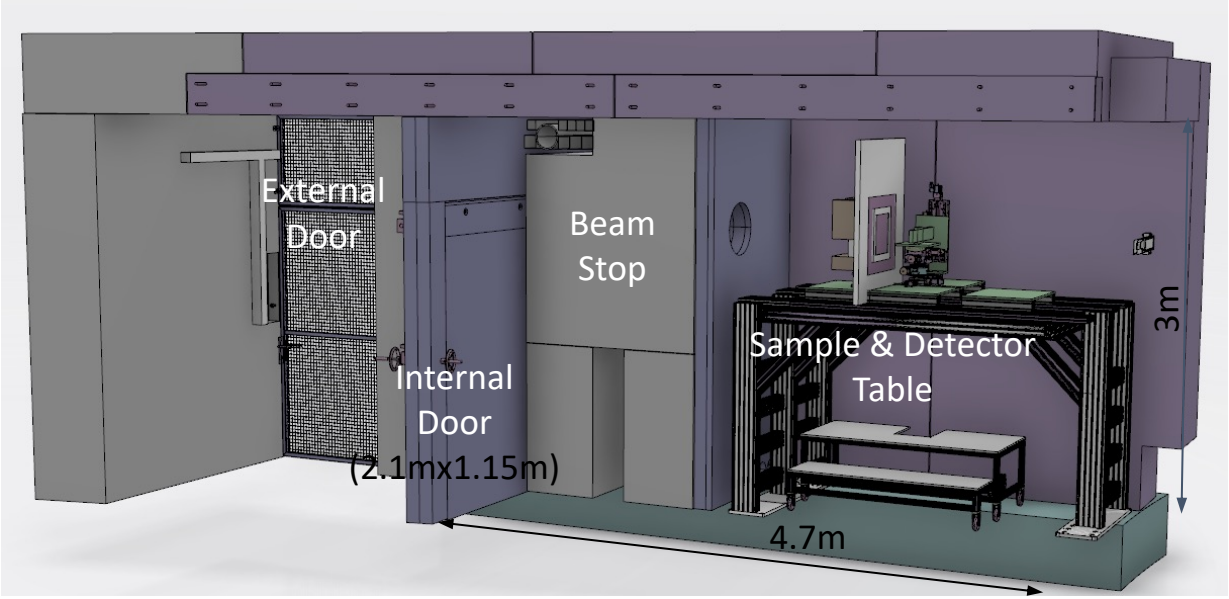
DAQ software
Event Formation Unit (EFU)
at DMSC

Test Beam Line Status

Cave





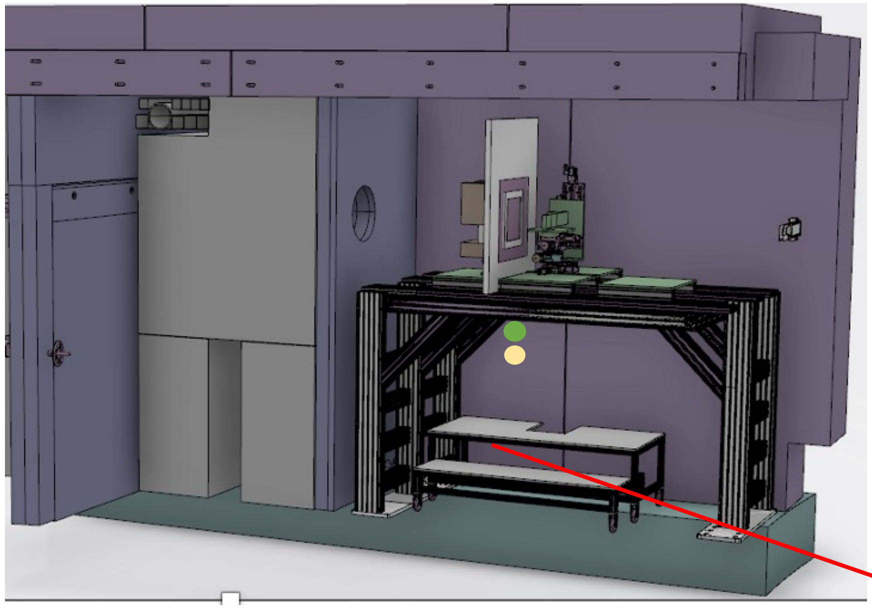


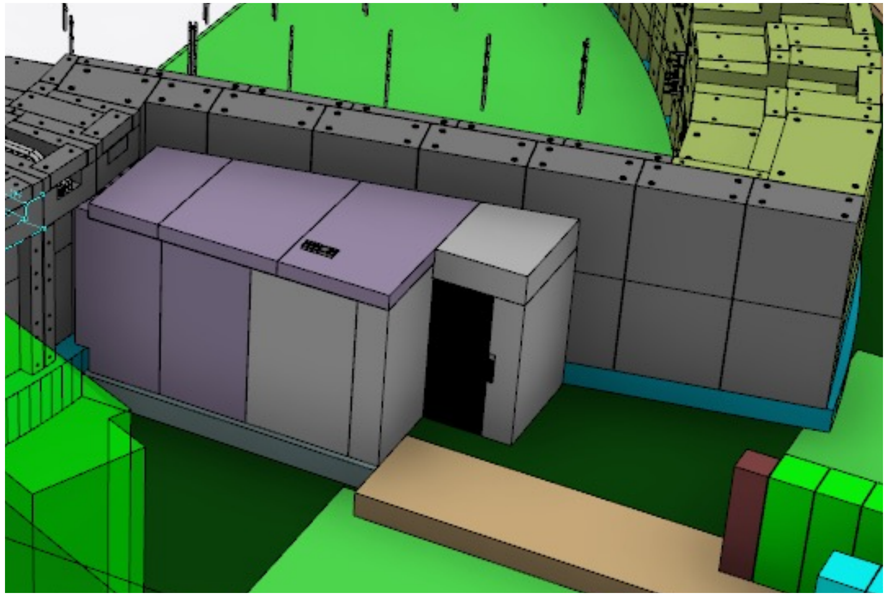
- Design ready
- Neutronics simulations finalized
- Construction of the cave started
- Layout of detector installations ready

Test Beam Line Status

- **TBL**-The shielding wall installation for the cave of the ESS Test Beamline is in progress. A control cabin will follow early 2023.

Primary Locations

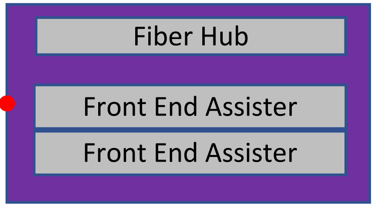




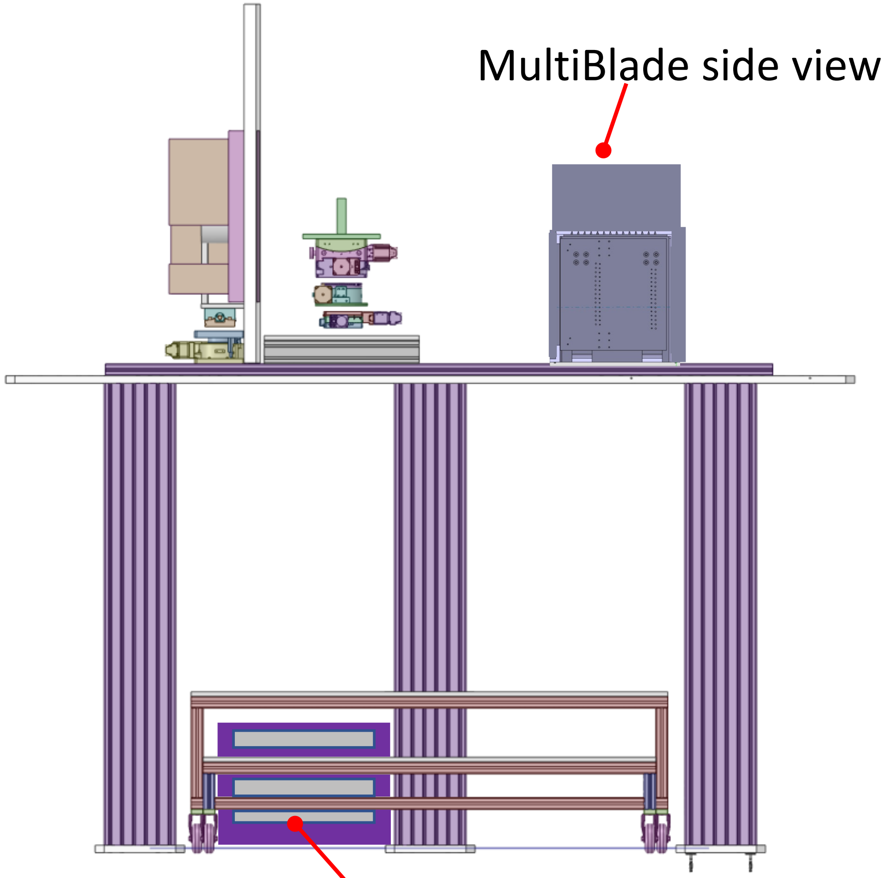
Routing

- Detector
- Detector gas

Front End Assister



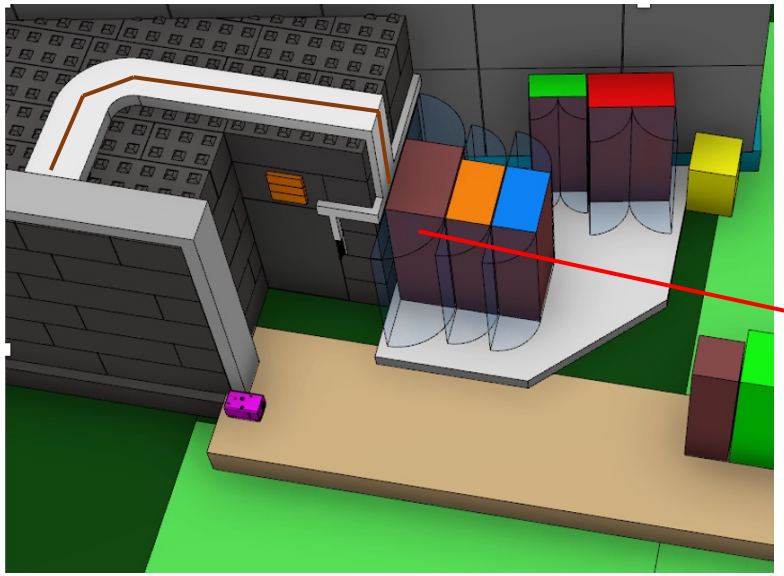
MultiBlade side view

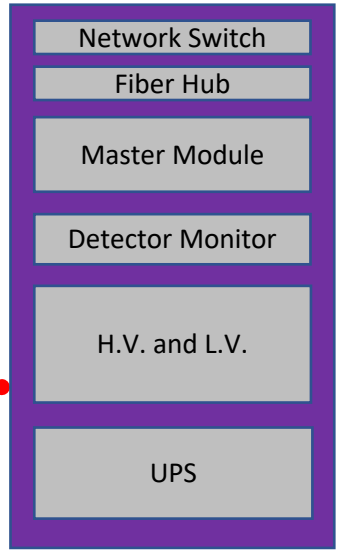


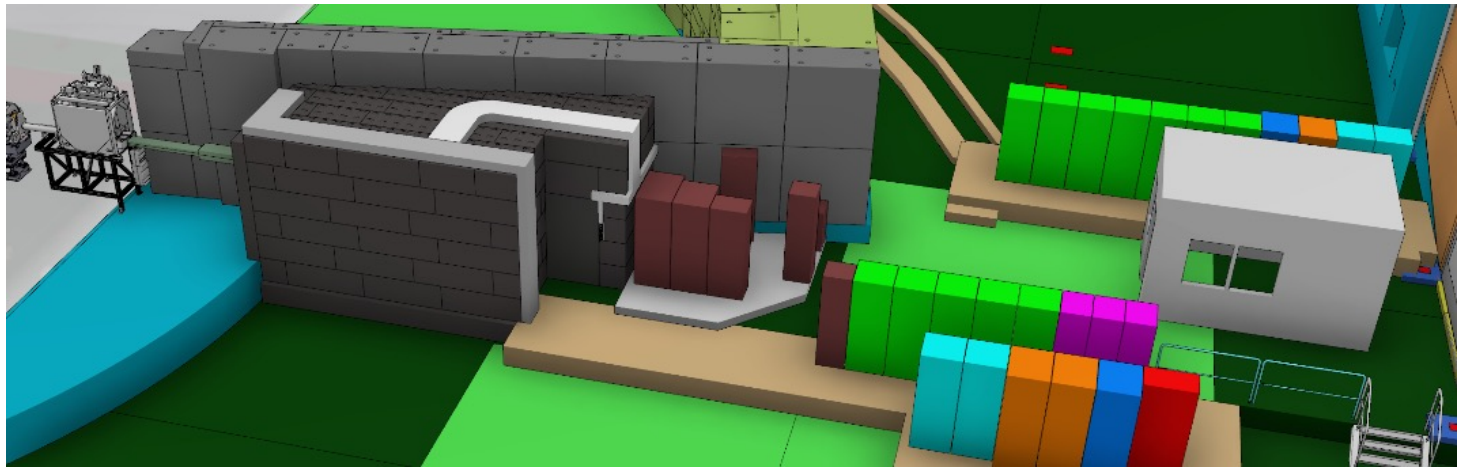
Front End Assister

Priliminray

Primary Locations








THANK YOU