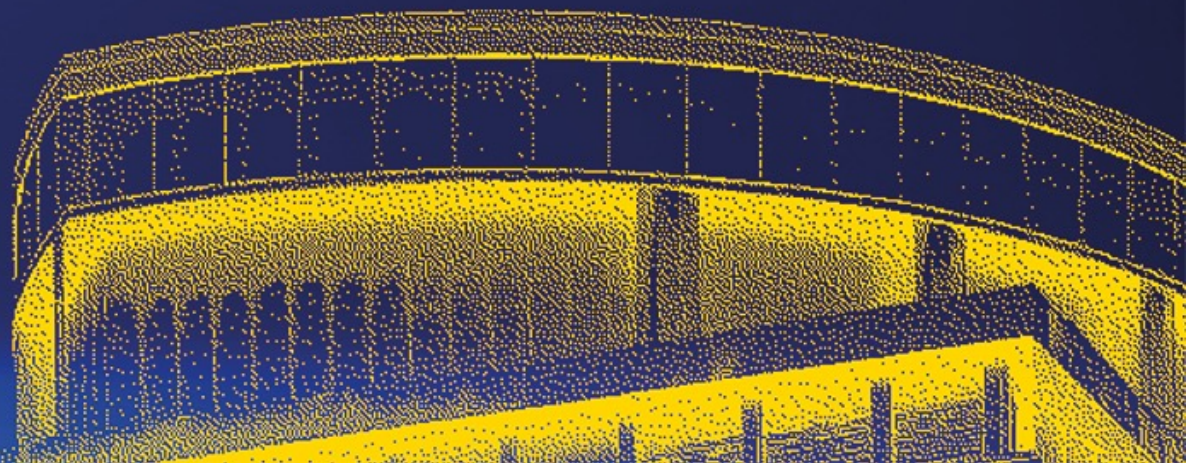
big science sweden

SWEDISH BIG SCIENCE FORUM



ELECTRONICS

Peter Sjöblom
Research Engineer
MAX IV

Kevin Fissum
In-Kind
Collaborator
ESS

Martin Zwaan
Head of the European
ALMA Regional
Centre (ARC)
ESO

MAX IV

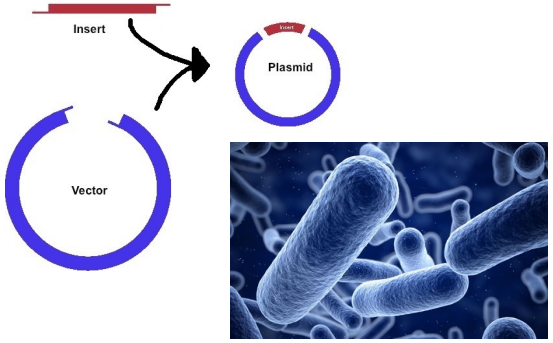
Electronics

Peter Sjöblom 2024

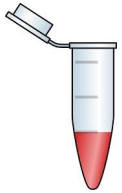
Photo: Felix_Gerlach, Thu 30 Nov 2017 11:40:14

What does MAX IV do?

One thing is: Macromolecular Crystallography

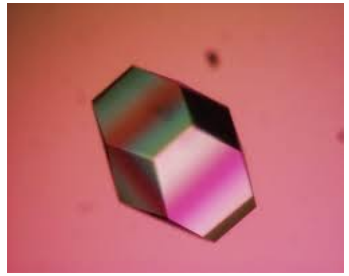


Heterologous expression in host cells (E. coli, insect cells, etc.)

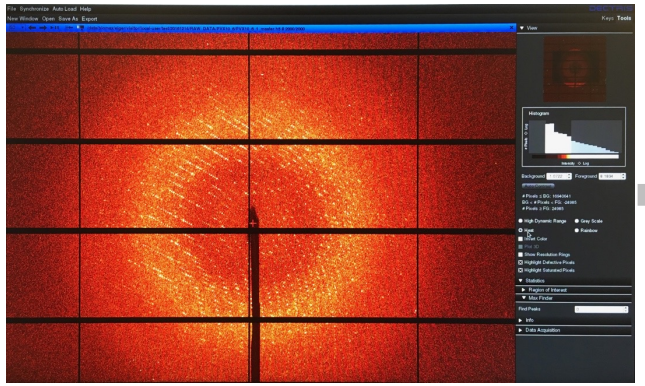


Highly purified protein in mg quantities

Protein crystallization

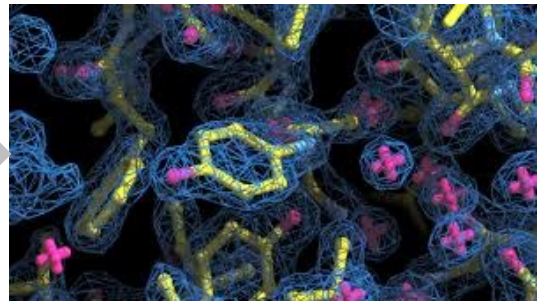


Single, diffracting protein crystal

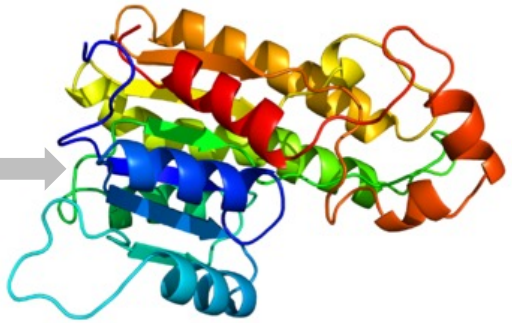


Complete diffraction experimental data-set at high resolution

Phase problem



Interpretable electron density



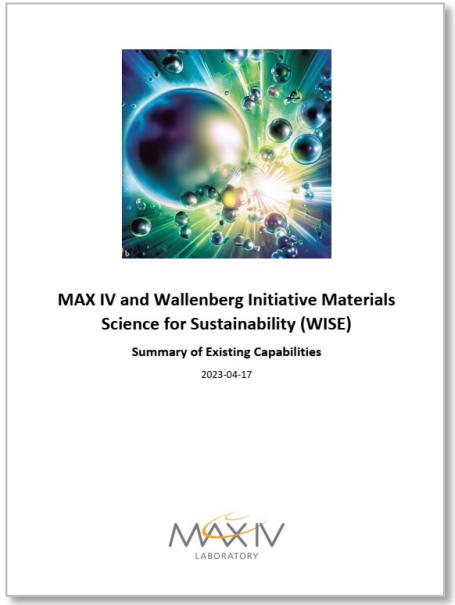
Final structure model

Pictures on this slide from ? to Thomas Ursby to me.

Wallenberg Initiative Materials Science for Sustainability (WISE)

https://wise-materials.org/

Three new beamlines to further broaden our support for materials science:



Diffraction beamline

A high-throughput, flexible diffraction beamline for fast and time-resolved structural characterization of surfaces, powders, and crystals.

Spectroscopy beamline

A tender-to-hard X-ray spectroscopy beamline for *in situ* and *operando* characterization of surfaces and buried interfaces under realistic conditions.

Imaging beamline

A hard X-ray tomography beamline dedicated to microstructure characterization and 4D imaging of materials.

Upcoming challenges, motion

- IcePAP collaboration, ESRF, ALBA, MAX IV
- Each cassis have 8 axis, cassis CAN Bus linked
- “IcePAP: An Advanced Motor Controller for Scientific Applications in Large User Facilities”, in Proc. 14th Int. Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'13)

- MAX IV approaching 2000 axis
  - But limited stock

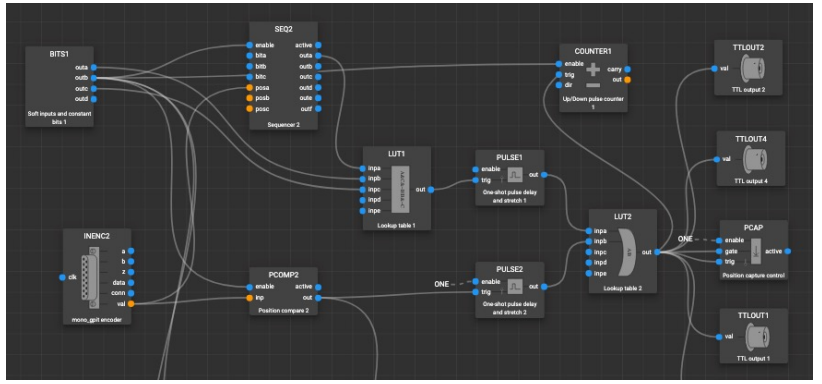
- 3 x 150 hybrid stepper motor axes
  - Driver modules
  - Controller modules, master and slave
  - Chassis 19¨

IcePAP stepper motor system

Upcoming challenges, PandABox 2.0

- PandABox 1.0 collaboration through open hardware, 40 units at MAX IV
  - Gerber available
  - Cad available
  - FW available
  - https://ohwr.org/project/pandabox/wikis/home
  - Production only in France and UK at the moment
  - “PandABox: A Multipurpose Platform for Multi-technique Scanning and Feedback Applications”, in Proc. ICALEPCS'17, Barcelona, Spain, Oct. 2017.
- It has performed very well, recommend to use it.
- Next generation, PandABox 2.0 needs to be designed, and produced.

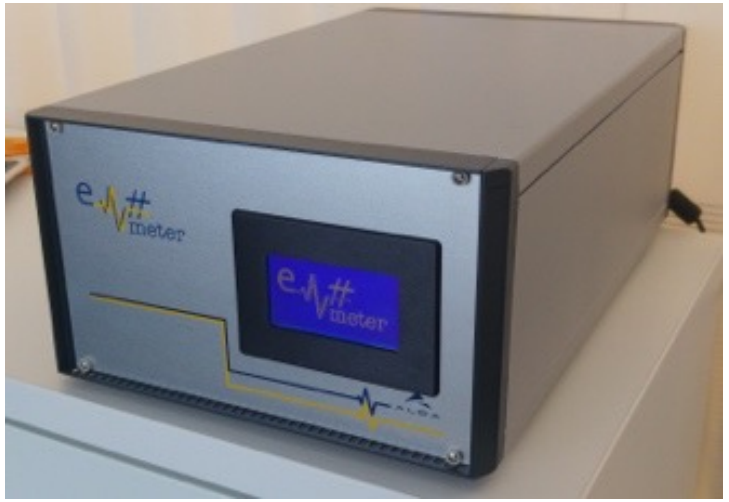
Trigger and acqusition system



Upcoming challenges, electrometers

- Collaboration between ALBA, MAX IV.
- 4 channel, fA resolution,
- “Em# Electrometer Comes to Light”, in Proc. ICALEPCS'17, Barcelona, Spain, Oct. 2017.
- 5 electrometers on average x 3 beamlines + spares = 15+ units

EM# 4-CHANNEL ELECTROMETER SPECIFICATIONS	
Current Amplifier	Eight independent ranges (from 100pA to 1mA) and five 2nd order analog filters (from 0.1Hz to full bandwidth)
ADC	4x 400kS/s @18 bits SAR
Ground Voltage Bias	Up to 1kV
Analog Outputs	4x ±10V 100kS/s @16 bits
Trigger In	1 x CMOS/TTL compatible
High-Speed I/O	100MHz BW (can be used as independent channel triggers)
General I/O	(unipol/diff) + 4x 5V output max 500mA



Electrometer

Upcoming procurements

- Electronic components, Lund University, 2024
  - Las one was with ELFA and RS
- Test instruments. (?), Lund University, 2024
  - Last one was with R&S
- IcePAP motion
- Electrometers
- PandABox 2.0

Mercell, TendSign,

https://info.mercell.com/sv-se/

39 open procurements as per Jan 2024 for Lund University

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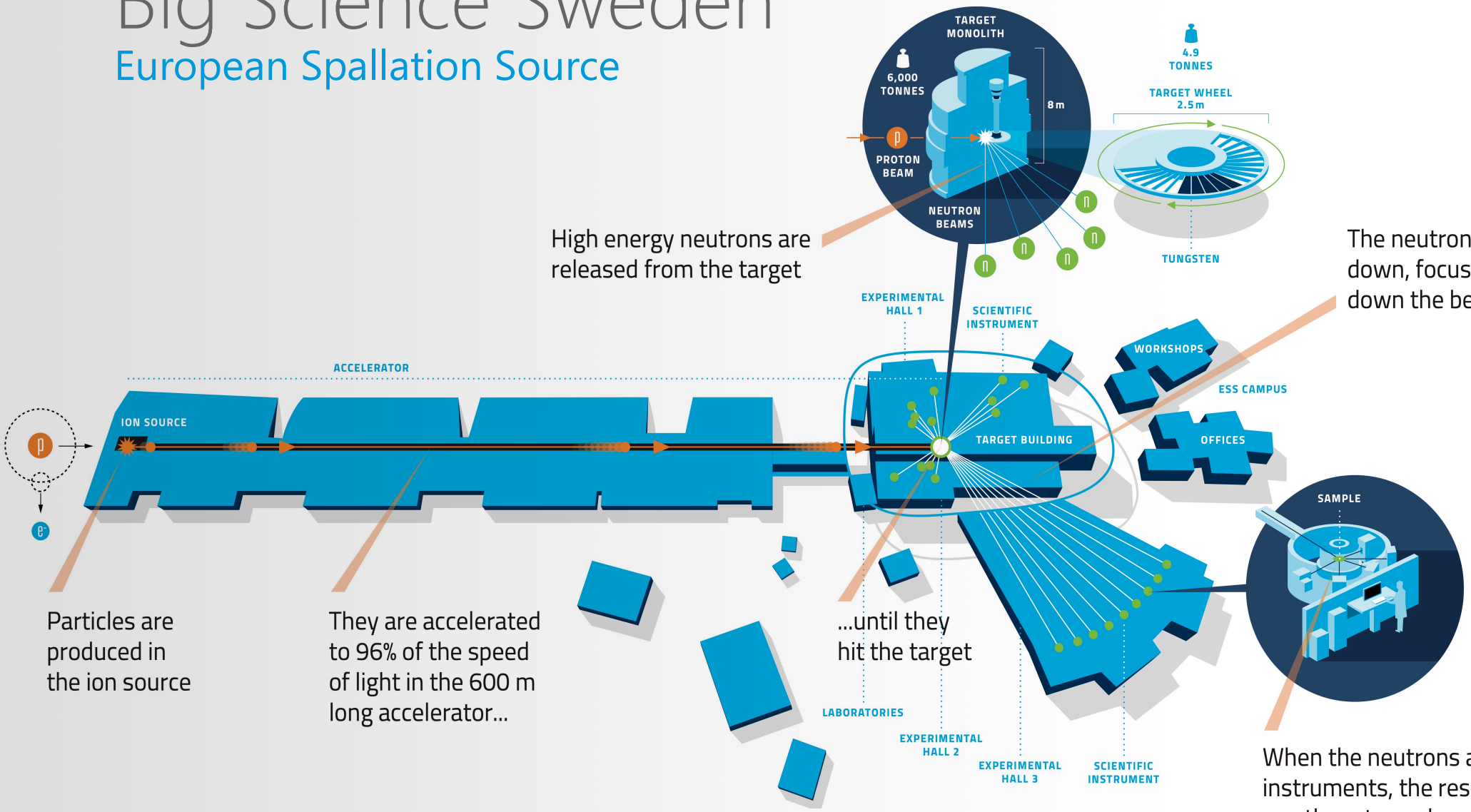
European Spallation Source Detector Group Electronics

KEVIN FISSUM ON BEHALF OF THE DETG

2024-01-31

Big Science Sweden

European Spallation Source



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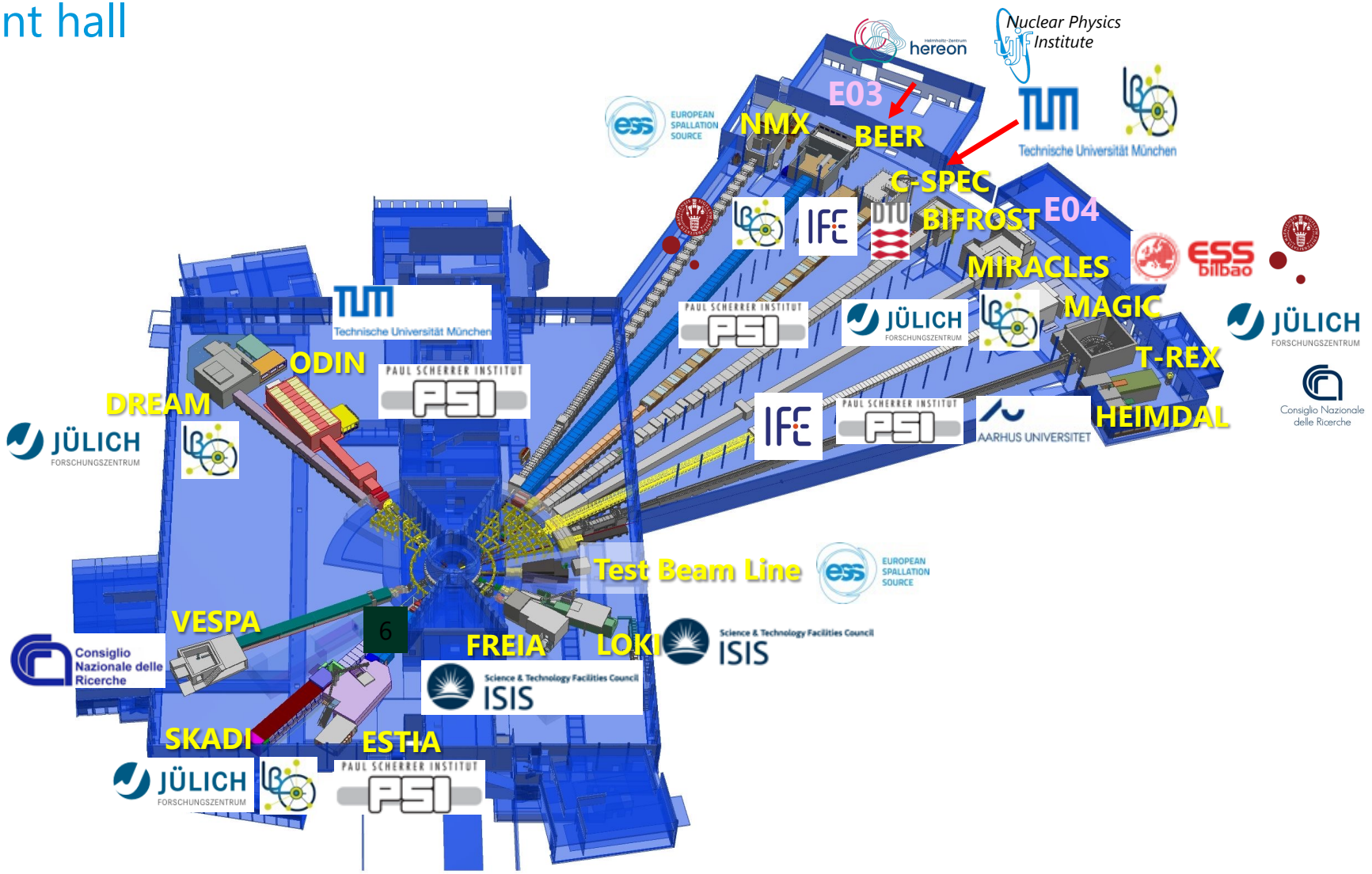
Instrument hall



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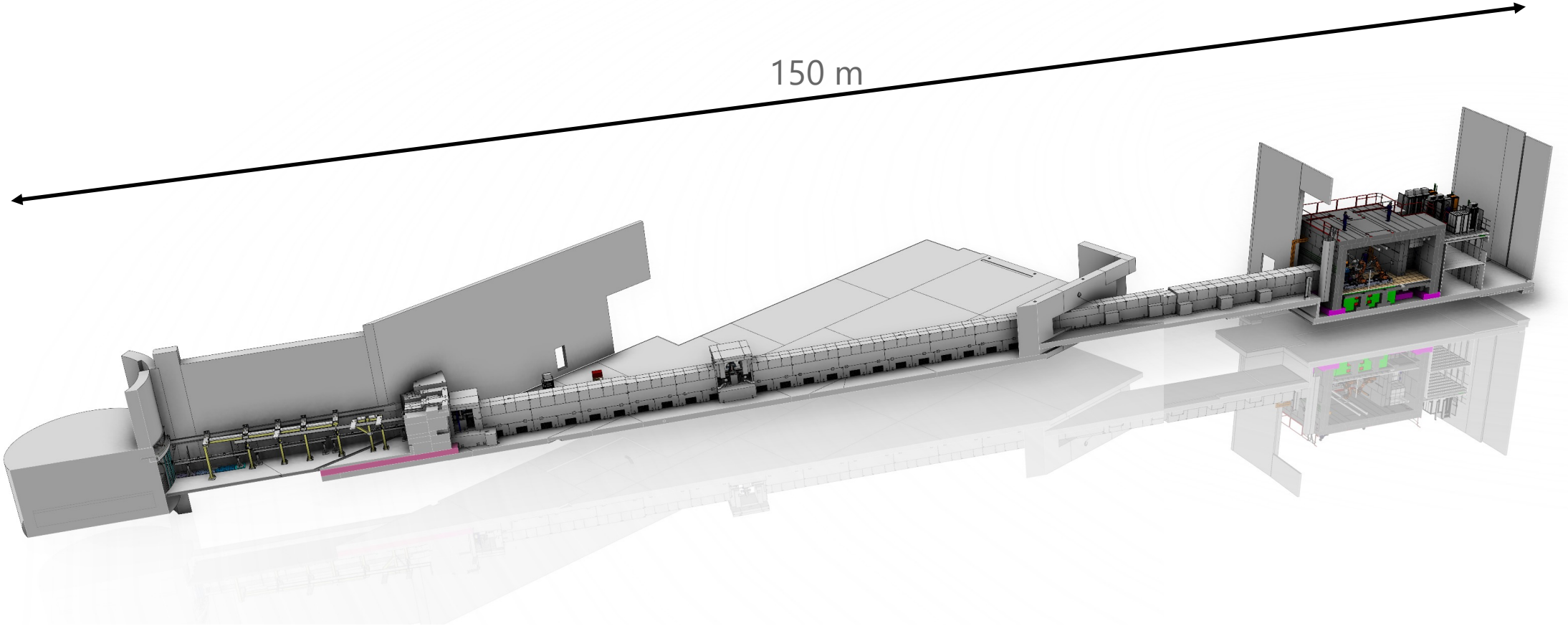
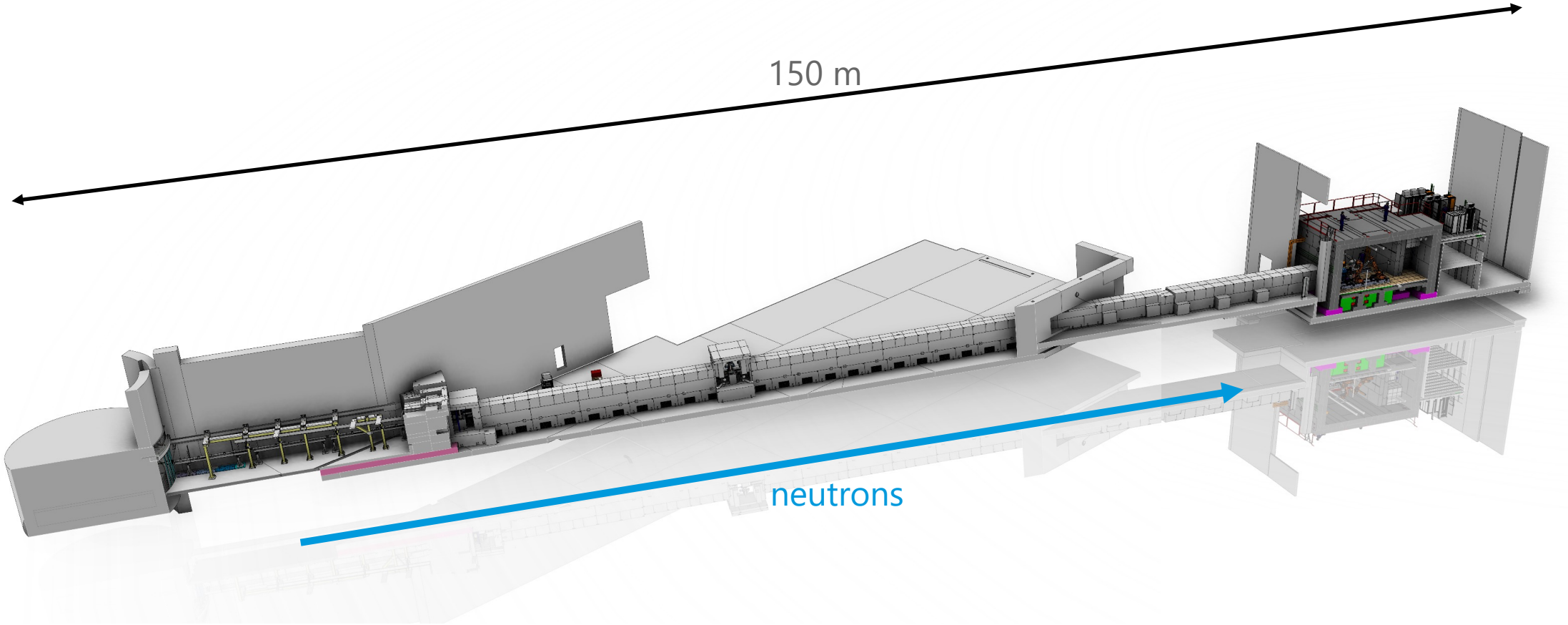
NMX Macromolecular neutron time-of-flight diffractometer



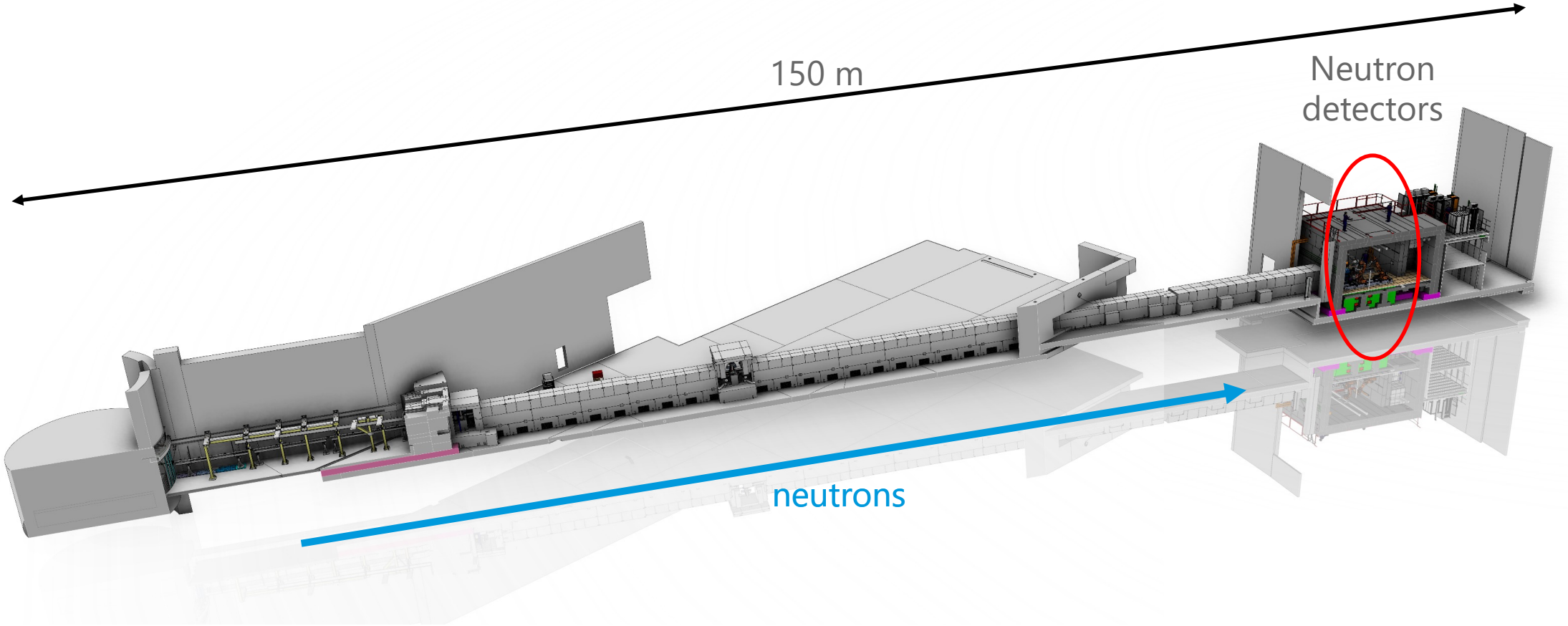
Big Science Sweden

NMX Macromolecular neutron time-of-flight diffractometer



Big Science Sweden

NMX macromolecular neutron time-of-flight diffractometer



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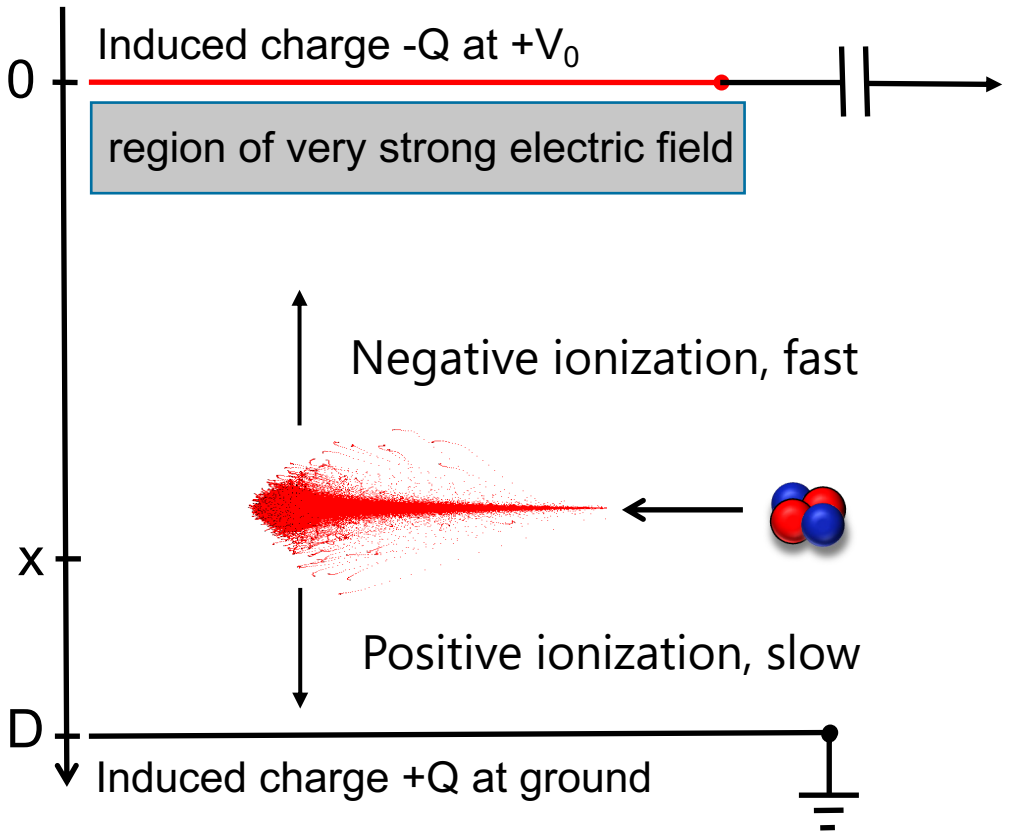
Neutron detectors

- neutrons are converted into charged particles via nuclear reactions
- these charged particles move through a gas
- the gas is ripped apart as the charged particles slow down resulting in clusters of + and – charges
- electric fields are used to channel this ionization towards wires (or strips)
- the motion of the ionization induces signals on the wires
- these analog signals are processed with high-speed electronics
- the original neutrons are inferred from analog signals with specific characteristics



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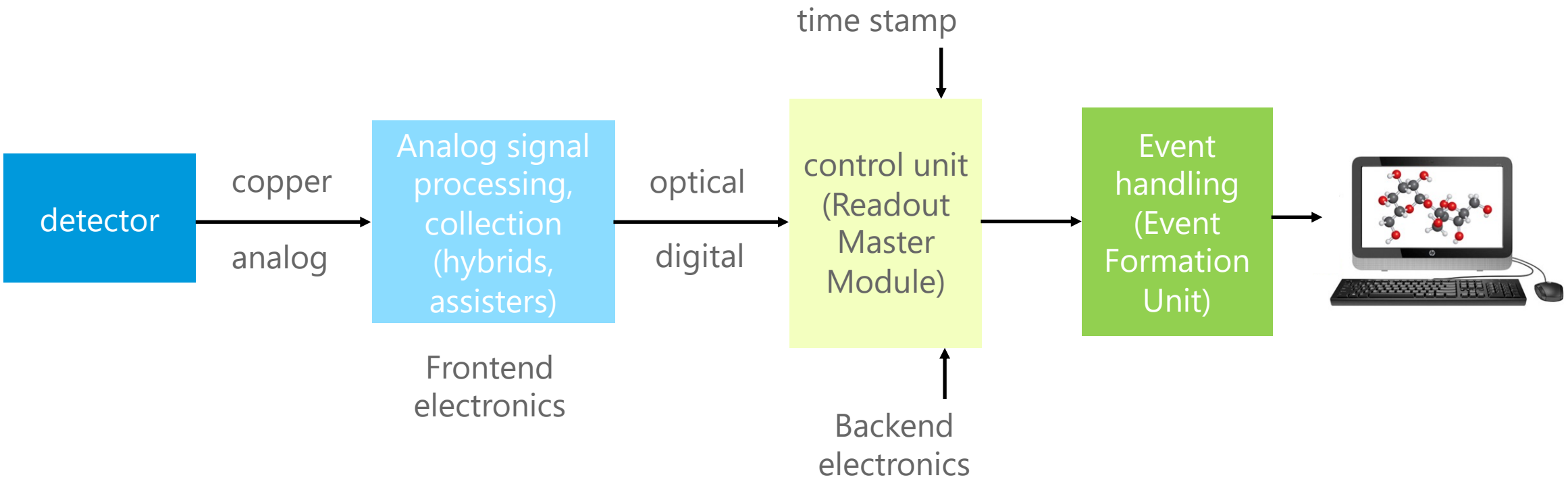
Schematic



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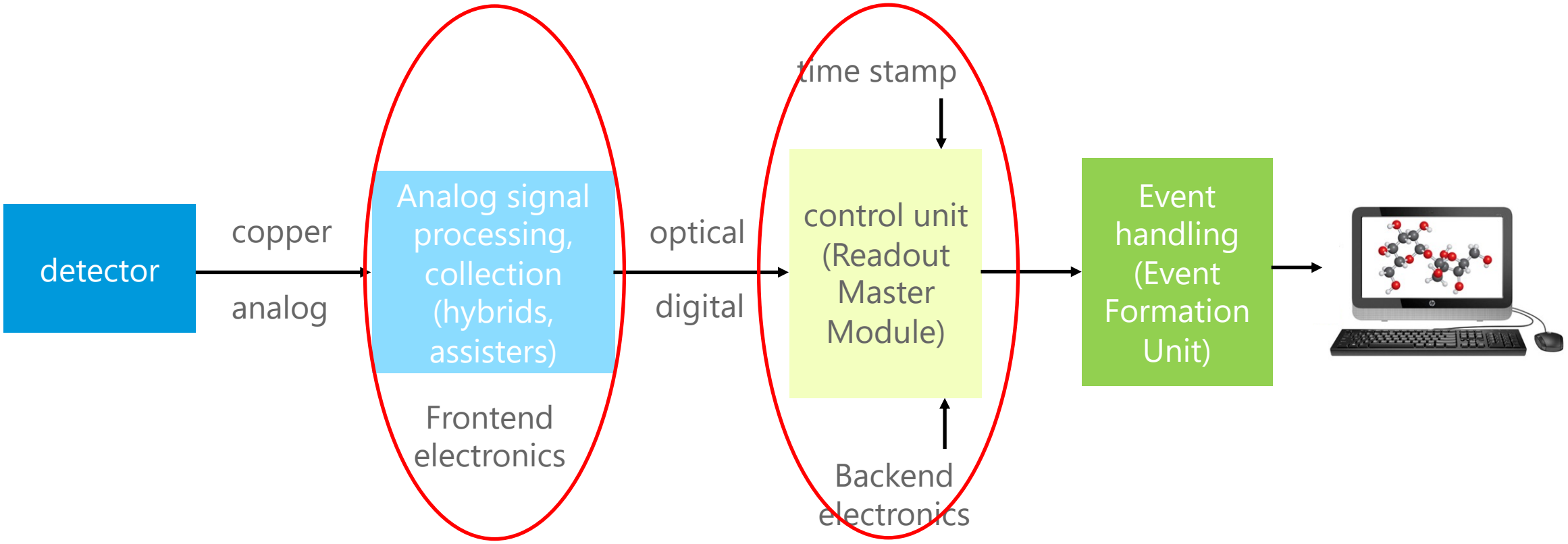
Schematic



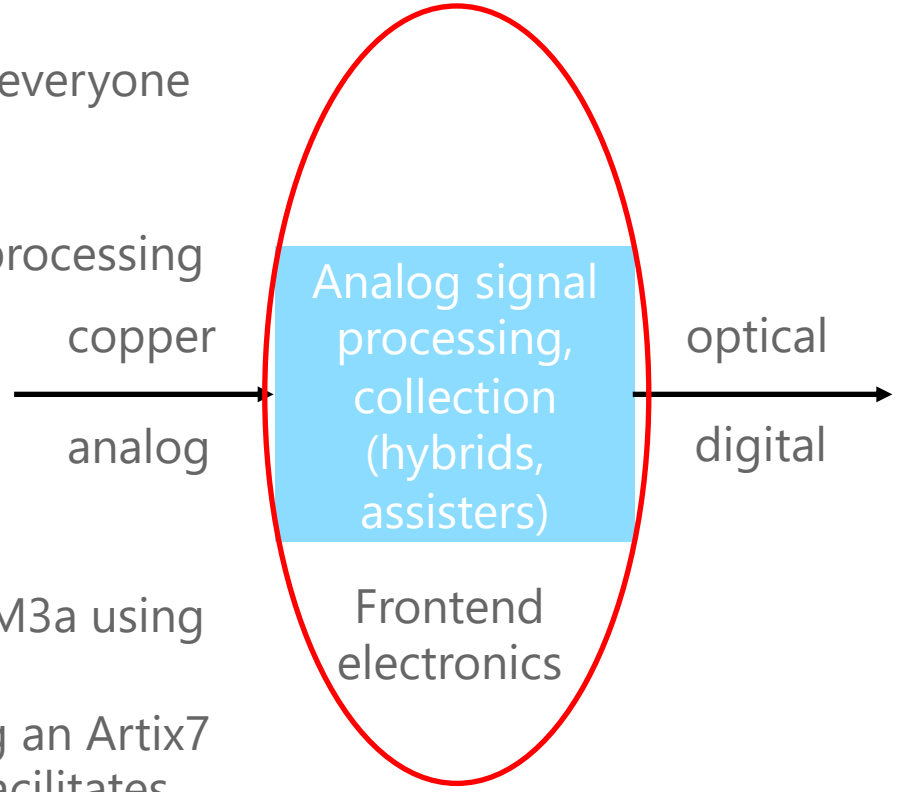
DetG electronics needs

Big Science Sweden

DetG needs: analog signal processing, collection

- analog-to-digital signal processing and copper-to-optical transitioning (frontend electronics) must be very close to the detector
  - crossing grounding zones with copper is a headache for everyone involved
  - attenuation, noise, crosstalk are all reduced
  - space near the detector is always an issue, so increased processing density is a must – make it smaller, pack it tighter

- current DetG frontend electronics
  - VMM3a 64 ch ASICS, charge-sensitive amplifier, shaper, discriminator, 10 bit peak-sensing ADC
  - RD51 hybrid card (hybrid) which allows readout of 2 VMM3a using a Spartan7 FPGA, output is to HDMI
  - Frontend assister (FEA) card accepts multiple HDMI using an Artix7 200T FPGA, SFP+ to bi-directional optical fiber (greatly facilitates transitioning grounding zones and long-distance signal transmission)



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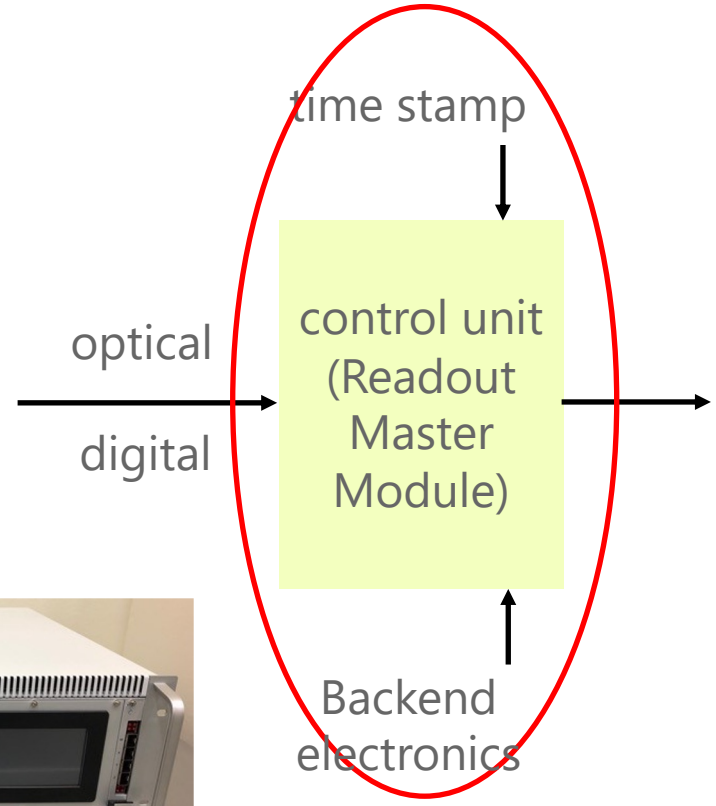
DetG needs: control unit, Readout Master Module (RMM)

- the RMM is a structural point of aggregation
  - located some distance from the detector/frontend electronics
  - accepts via fiber the digitized data due to a neutron event from the frontend electronics
  - accepts via fiber and attaches a time stamp (essentially the energy of the incident neutron) from the accelerator
  - passes the time-stamped event to the event handler (EFU) via ethernet
  - acts as a gateway to the detector for all monitoring and control software

- current DetG RMM
  - based on an off-the-shelf AMD Xilinix board
  - CE marked



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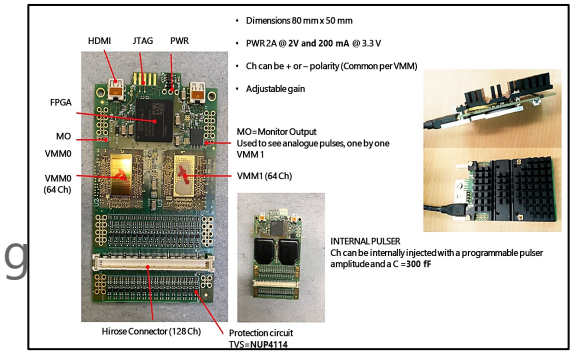
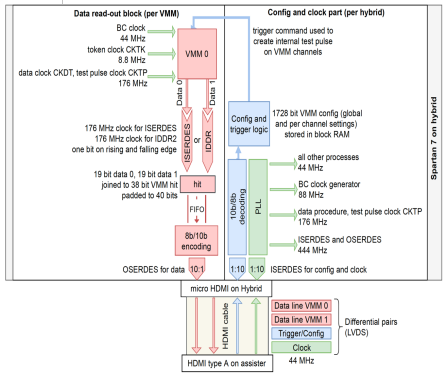
Summary - DetG needs: planned future efforts

- **Project Hybrid:** Core ASIC transition for higher density instrumentation, increased finesse
  - migrate from VMM3a to VMM4 (improved ADC, longer shaping time) or SALSA (complete waveform), new hybrid
  - 300ish cards, industrial partner?
- **Project FEA:** continued miniaturization of the frontend assisters
  - increase the number of HDMI, decrease the size
  - 300ish cards, industrial partner?
- **Project RMMv2:** replace existing AMD Xilinux RMM board
  - develop a DetG tailored acquisition board
  - 50ish modules, industrial partner?
- **Project preCluster:** reduce pressure on the event handler (EFU)
  - perform (pre)clustering on the hybrid using unutilized FPGA resources, perhaps AI driven
  - academic partner?





DRD1 brightness

NEUTRONS FOR SOCIETY

Science and Technology Facilities Council

ECFA
European Committee for Future Accelerators

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Peter Sjöblom
Research Engineer
MAX IV

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In-Kind
Collaborator
ESS

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Atacama Large Millimeter Array and its Wideband Sensitivity Upgrade

Martin Zwaan

ESO

What is ALMA?

- ALMA = Atacama Large Millimeter/submillimeter Array
- ALMA is an interferometer for millimetre and submillimetre astronomy
- The main scientific objectives are the origins of galaxies and the origins of stars and planets
- ALMA is10-100 more sensitive and has 10-100 times better angular resolution than other existing instruments
- ALMA is built and operated by Europe (**European Southern Observatory, ESO**), North-America (NRAO) and East-Asia (NAOJ)
- Construction cost: $1600 million

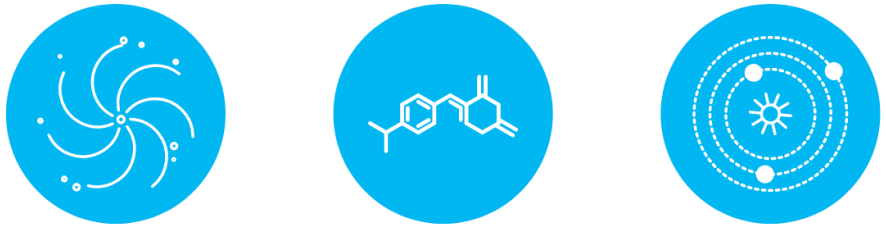
What is ALMA?

- ALMA based in the Atacama desert in Northern Chile
- Chajnantor plain at 5000 m
- Operations base at 2900 m

- ALMA has been in operations for more than 10 years
- Produced >3600 peer-reviewed publications
- Now embarking on a significant technological upgrade

Wideband Sensitivity Upgrade (WSU)

- WSU aims at implementing ***highest-priority items of the ALMA2030*** roadmap, approved by ALMA Board in 2017
- Keep ALMA at the forefront!
- Upgrade of the **bandwidth** and **throughput** of the ALMA system with improved sensitivity
  - receivers with increased bandwidth and improved receiver temperatures
  - new digitizers and data transmission system
  - correlator with improved efficiency
  - improved data processing and archive
- Major upgrade of virtually the entire ALMA system!
- White paper on the WSU scientific motivation has been released



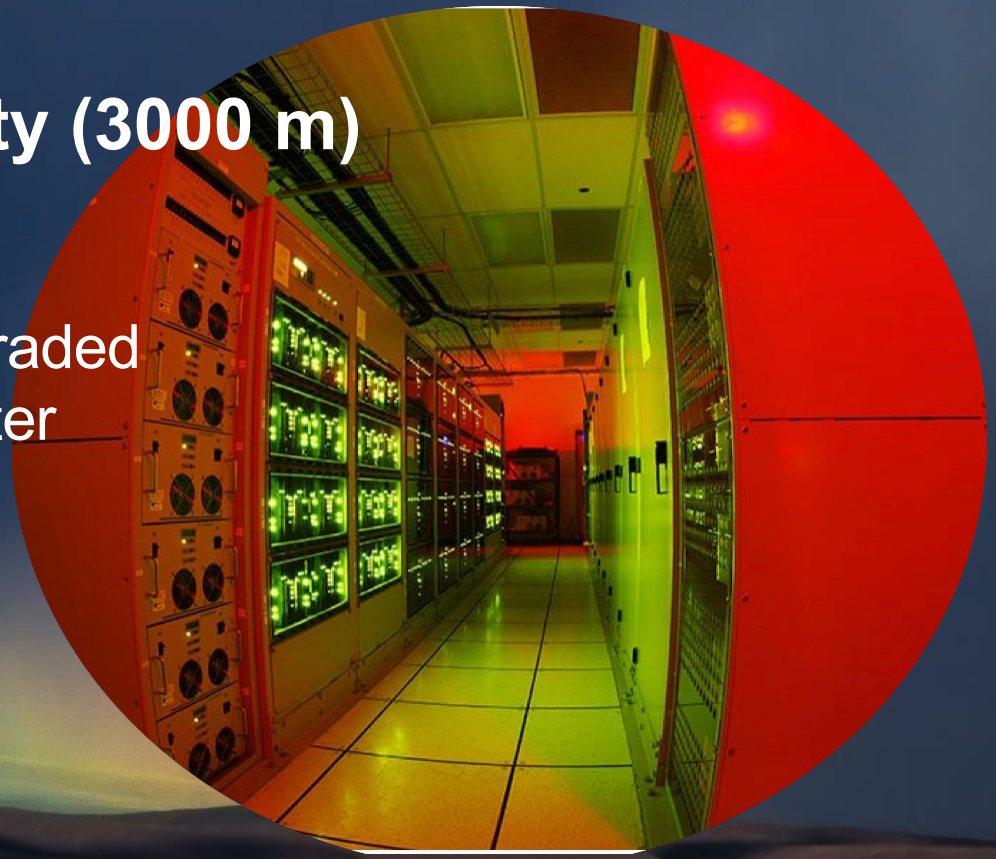
Array Operations Site in Chajnantor (5050 m)

Upgrade of electronics
(including digitizers)

Upgrade of receivers

Upgraded fibers to Operations Support Facility

Operations Support Facility (3000 m)



2nd generation correlator and upgraded ALMA Compact Array Spectrometer

Upgrade of ALMA software

Wideband Sensitivity Upgrade

- The **three ALMA executives manage development activities in their respective regions**, and ultimately bring forward development projects (and their funding) to the ALMA partnership
- All executives have assembled proposals to develop and the major subsystem components that will put ALMA on the path to WSU
- Total WSU cost ~150 MEUR
- Europe is preparing for Band 2, Digitizers, Fibre Optics, Band 7 and 9
  - All (apart from Band 2) contingent on full approval and funding
- WSU conceptual system design and project plan being prepared
- ESO's Guaranteed Time Observations (GTO) policy: access to ALMA observing time in exchange for contributions to ALMA development

Band 2: 67-116 GHz
Band 7: 275-373 GHz
Band 9: 602-720 GHz

ESO's *current* major WSU projects

Digitizers

- New antenna-based high speed system to digitize analogue receiver outputs, and to process and format the resulting data stream before it is transferred to the central correlator
- Contract with University of Bordeaux (F)

Band 2

- RF bandwidth: 67-116 GHz
- 2SB (Sideband separating), for total IF bandwidth of 24 GHz (up to 32 GHz)
- Cold cartridge assembly (CCA), with NOVA (NL), **GARD (S),** and INAF (IT)
- Low Noise Amplifiers (LNAs): MPIfR (D) and **LNF (S)**

Fibre Optics

- Currently assessing whether to build new fibres or use multiplexing on existing ones

ESO's *future* major WSU projects

- Most activity directed to wideband receiver technology
- Wideband: aiming for total 32 GHz IF bandwidth
- Technologies investigated: SIS junctions, MMIC-based cryogenic low noise amplifiers (LNAs), integrated and scalable approaches to building the LNAs and mixers
- ESO's priority bands:
  - **Band 7 (~275-373 GHz)**
  - **Band 9 (~602-720 GHz)**
  - **Band 4(+5) (~125-211 GHz)**
- Timeline to start new project: ~2026 onward
- Industrial and institutional collaboration between ESO member states (or executives) welcomed

Ongoing development studies

- ‘Studies’ funded at ~100 keuro, potentially leading to prototypes
- Studies looking into increasing receiver bandwidth by a factor of 3-4
  Study website: https://www.eso.org/sci/facilities/alma/developmentstudies.html
  - Band 9 upgrade, mostly in NL (with collaborations)
    - Upgrade from DSB to 2SB
    - Feasibility to upgrade all Band 9 receivers
  - Band 7 upgrade, concentrated in Sweden, France
  - General wideband development, in UK, Spain, Sweden, NL
- Specifically, in Sweden:
  - B6+7 cartridge demonstrator (GARD)
    - Target 4-20 GHz, wideband optics, OMT
  - SIS process development (GARD)
    - Lower-capacitance junctions
  - Advanced waveguides (GARD)
    - Components technologies for 2SB
  - Prototype ALMA Spectral Line Pipeline (OSO)

WSU opportunities in Sweden

- Opportunities focussed on receiver component development for the higher ALMA frequencies
- Industrial procurement opportunities in ~3 years
- Sweden has excellent track record with large number of ongoing studies

Thank you!

Martin Zwaan
ALMA development lead
mzwaan@eso.org

@ESOAstronomy
@esoastronomy
@ESO
european-southern-observatory
@ESOobservatory

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BREAK

Swedish fika – refreshments with opportunities for informal networking and 1-to-1 meetings