ESS beam instrumentation and detector overview

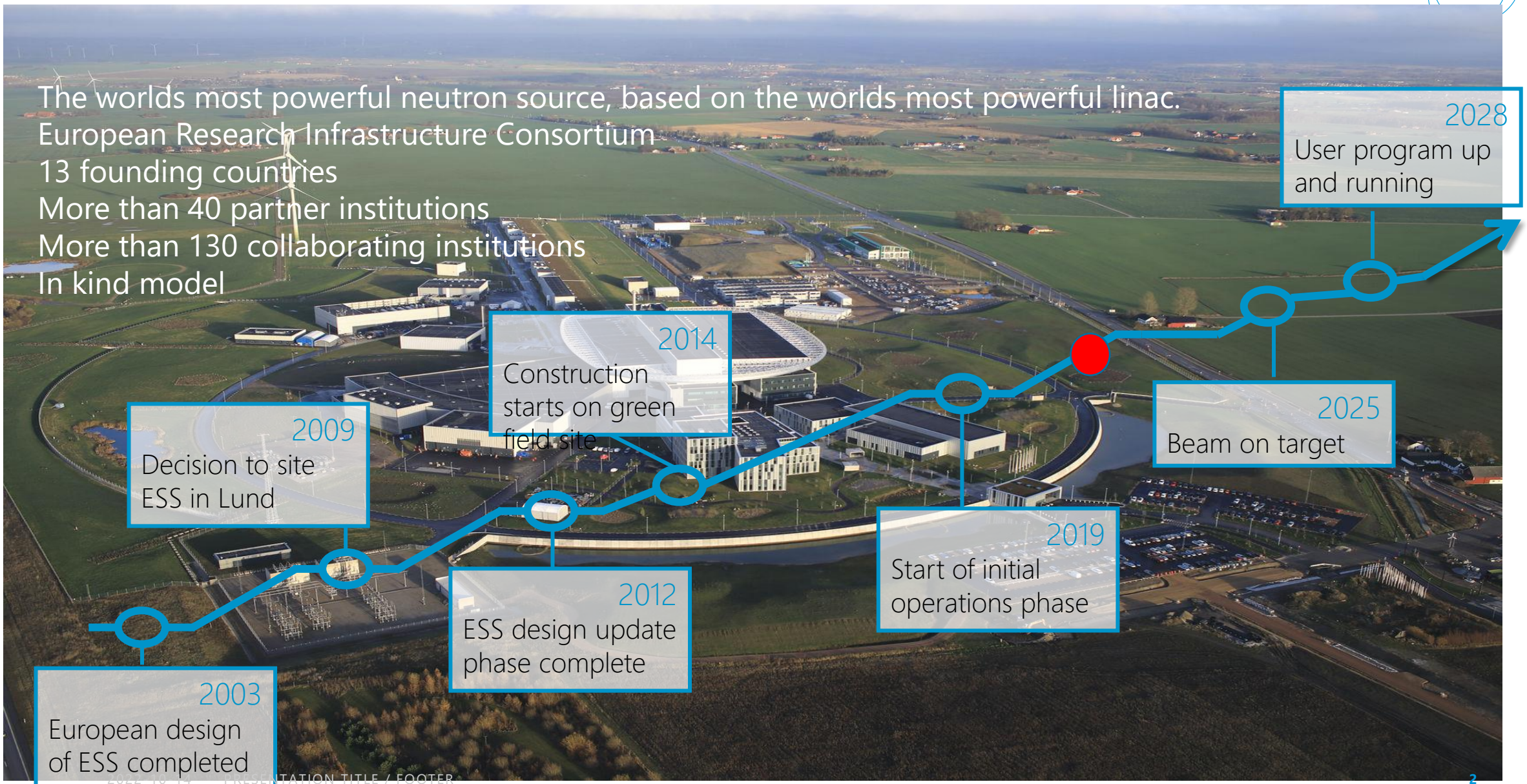
Big Science Business Forum 2022
Granada, Spain

ANDREAS JANSSON
GROUP LEADER FOR BEAM PHYSICS, OPERATIONS AND BEAM DIAGNOSTICS

(SPECIAL THANKS TO TOM SHEA, ANDREW JACKSON AND FRANCESCO PISCITELLI FOR PROVIDING MATERIAL)

2022-10-05

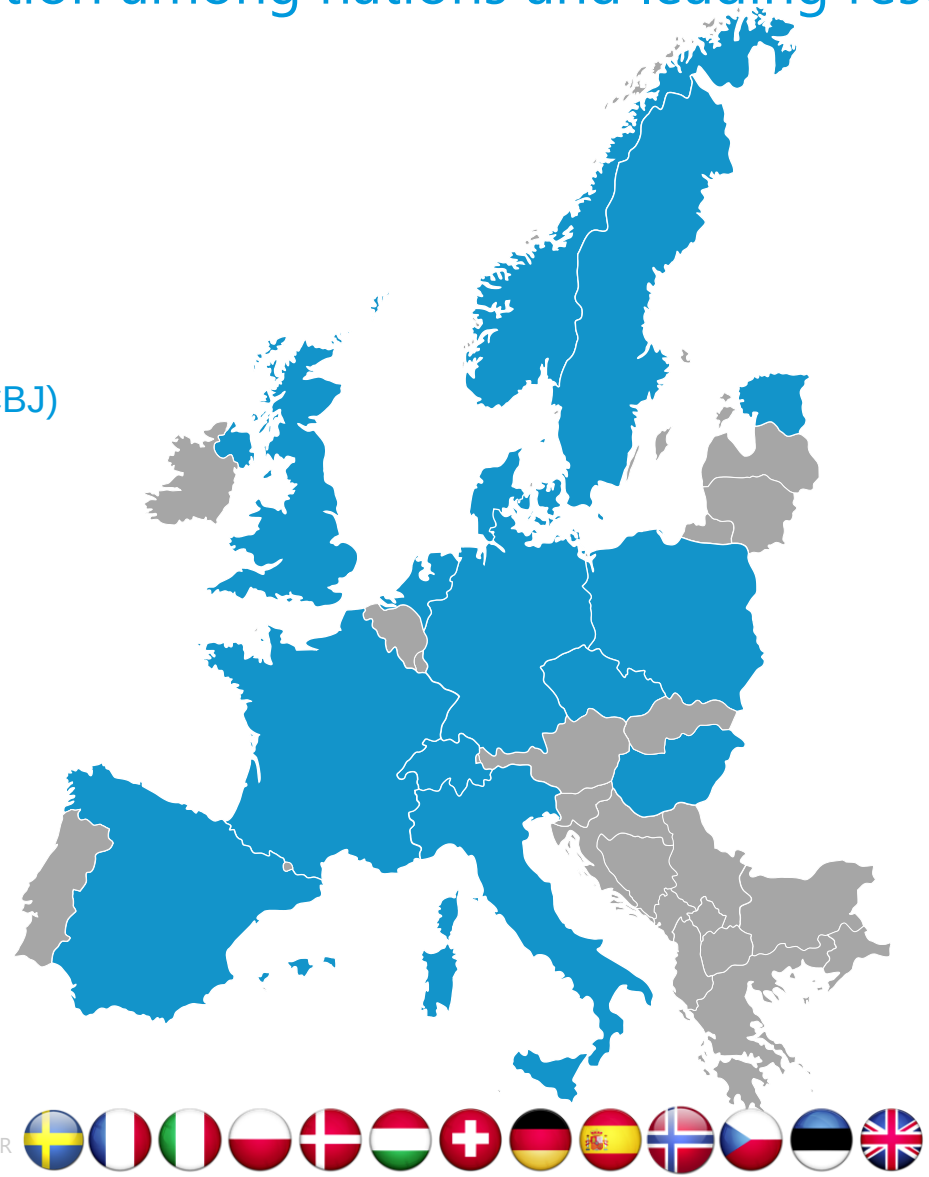
The ESS Journey



Unique International Project

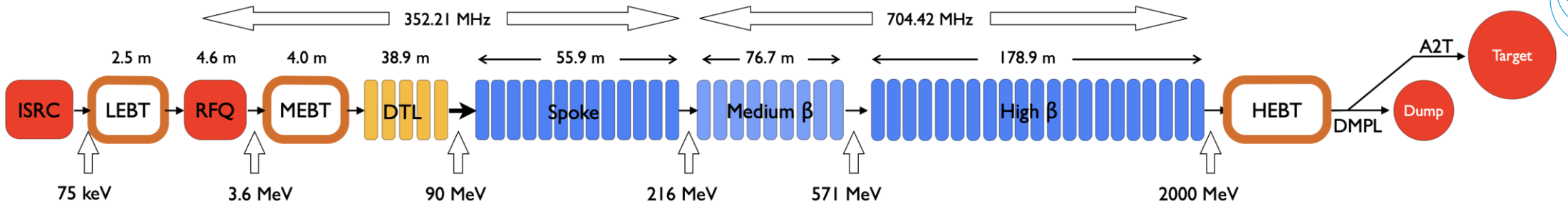
With unique cooperation among nations and leading research insitutes

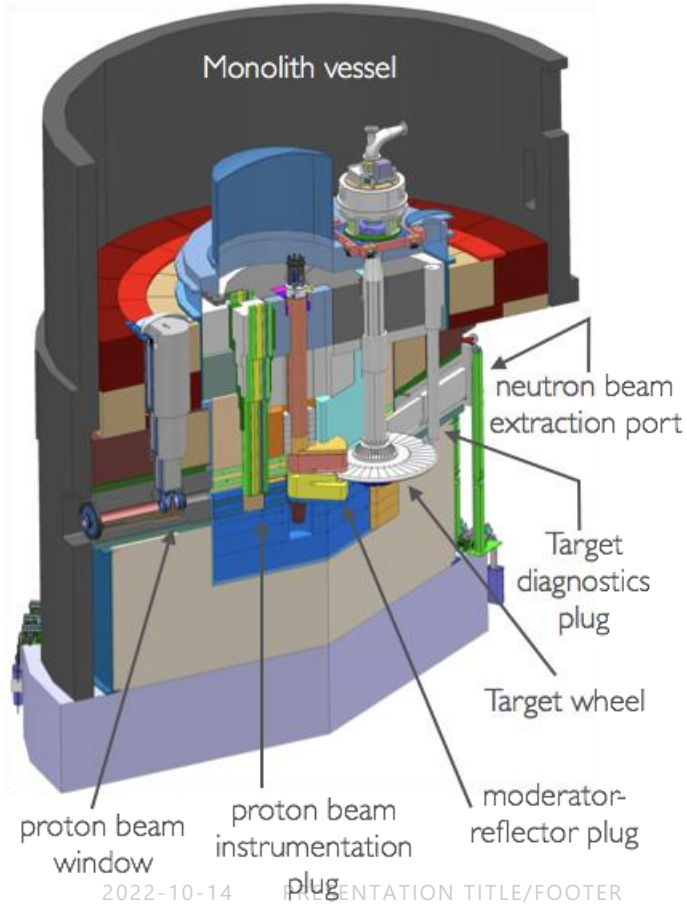
Aarhus University
Atomki - Institute for Nuclear Research
Bergen University
CEA Saclay, Paris
Centre for Energy Research, Budapest
Centre for Nuclear Research, Poland, (NCBJ)
CNR, Rome
CNRS Orsay, Paris
Cockcroft Institute, Daresbury
Elettra – Sincrotrone Trieste
ESS Bilbao
Forschungszentrum Jülich
Helmholtz-Zentrum Geesthacht
Huddersfield University
IFJ PAN, Krakow
INFN, Catania
INFN, Legnaro
INFN, Milan
Institute for Energy Research (IFE)
Rutherford-Appleton

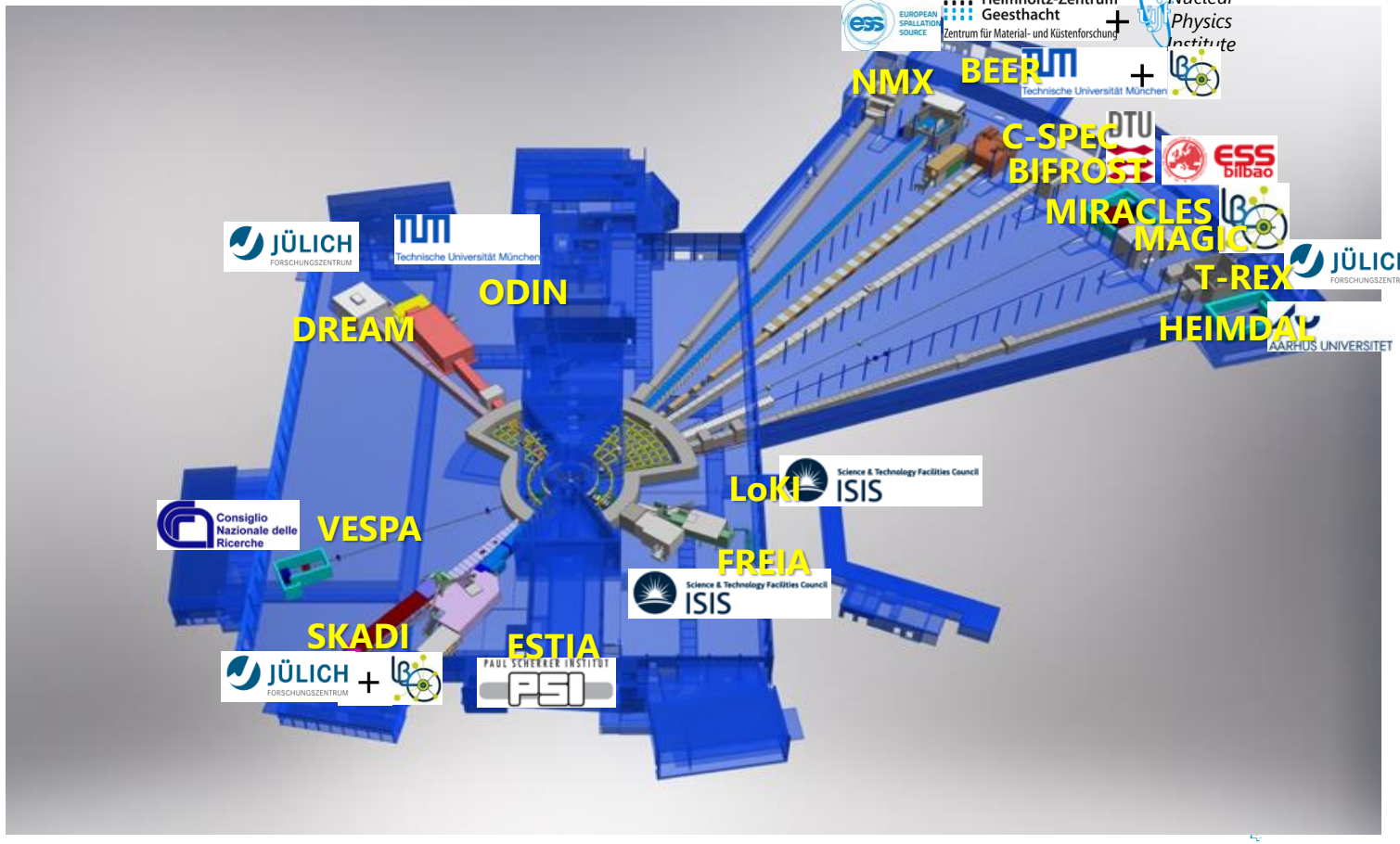


Laboratory, Oxford(ISIS)
Kopenhagen University
Laboratoire Léon Brilouin (CEA/CNRS/LLB)
Lund University
Nuclear Physics Institute of the ASCR
Oslo University
Paul Scherrer Institute (PSI)
Polish Electronic Group (PEG)
Roskilde University
Tallinn Technical University
Technical University of Denmark
Technical University Munich
Science and Technology Facilities Council
UKAEA Culham
University of Tartu
Uppsala University
WIGNER Research Centre for Physics
Wroclaw University of Technology
Warsaw University of Technology
Zurich University of Applied Sciences (ZHAW)

ESS Overview







Big Science Business Forum 2022

Accelerator Beam Measurements and Methods

Accounting

Type of beam

- Spectrometers

Amount of beam

- Toroids and other

Lost beam

- Particle detectors
  - Gaseous
  - Solid State
  - Secondary Emission

Centroid

Position of beam (Transverse, and w.r.t.. RF)

- Electrodes
  - Buttons
  - Striplines
  - Cavities
- Also, as result of distribution measurement

Distribution

Beam Emittance

- Slit, Grid

Beam Profile

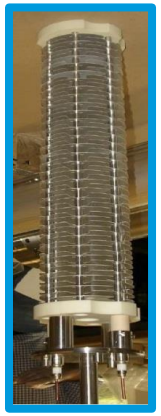
- Wires
- Screens
- Beam-gas

Accelerator beam diagnostics also overlap with neutron instruments (physically and technically)

- Many shared detector technologies
- Proton instrumentation embedded in neutron production target

Sensors and Detectors for Beam Accounting and Position

AC Current transformers



Ionization chamber loss monitors

Button electrodes

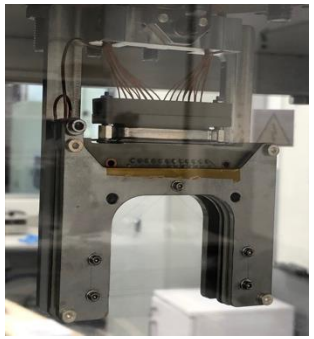
Faraday Cup

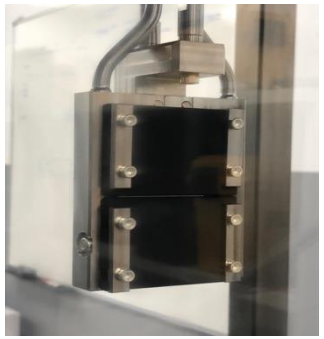
MICROMEGAS neutron loss monitor

Strip lines

Detectors for Beam Distribution Measurements

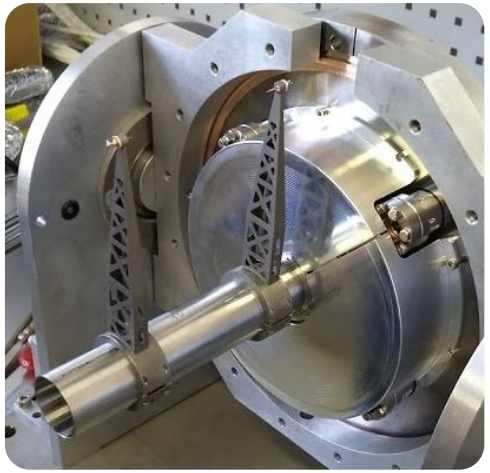
Allison emittance scanner



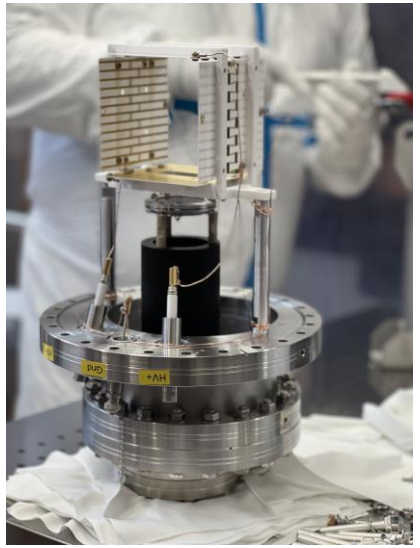


Slit & grid emittance monitor

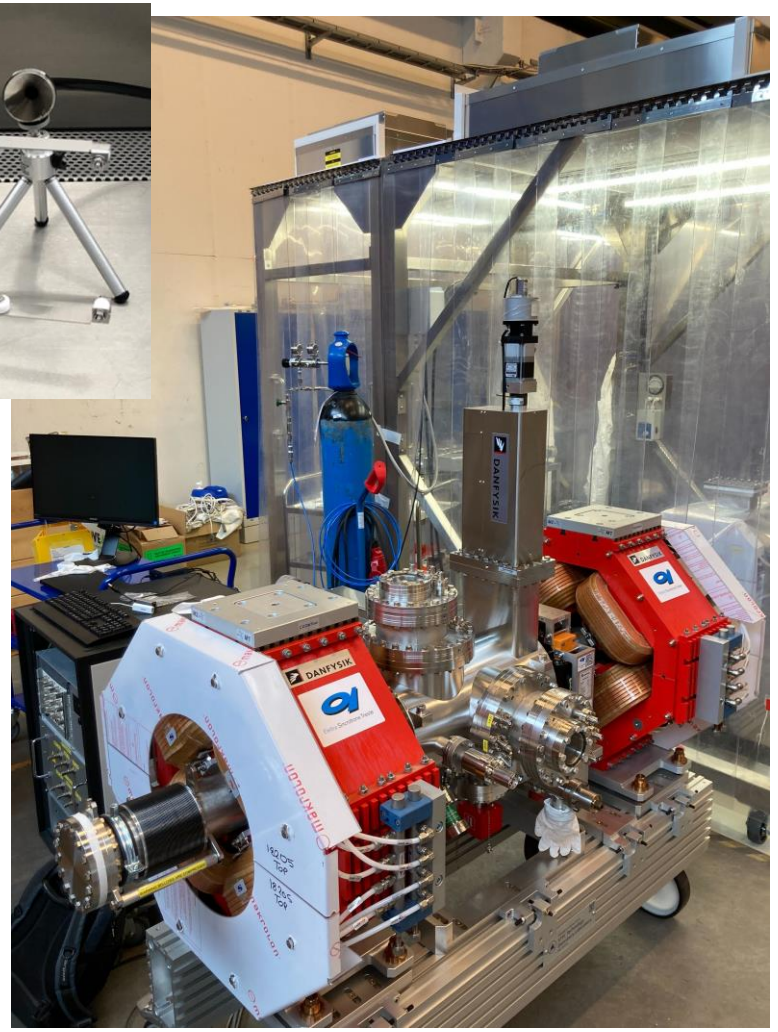
Wire scanner



Fast wire scanner

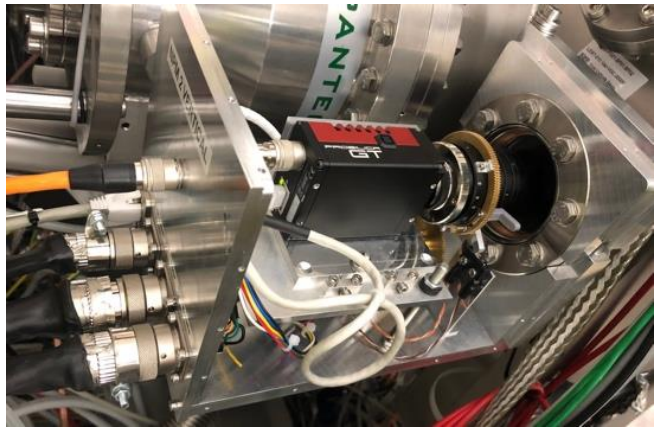


Ionization profile monitor



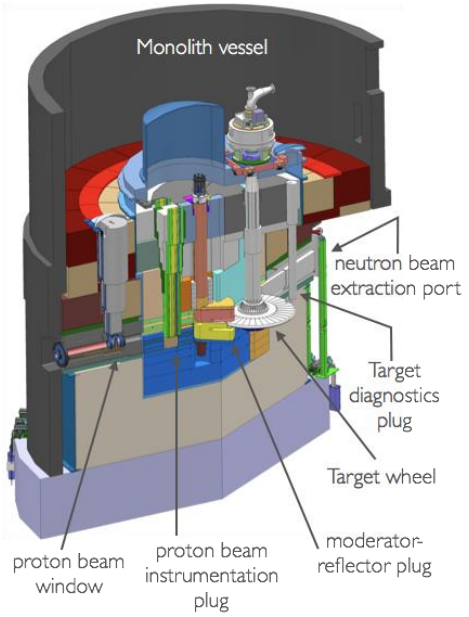
Linac warm unit with diagnostics

Detectors for Beam Distribution cont'd



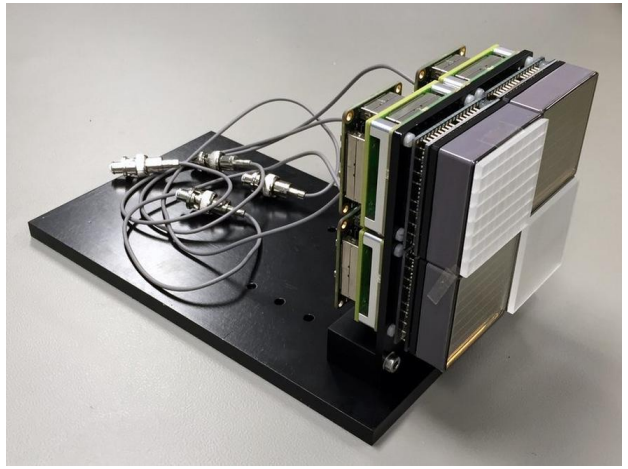
Beam induced gas flourescence

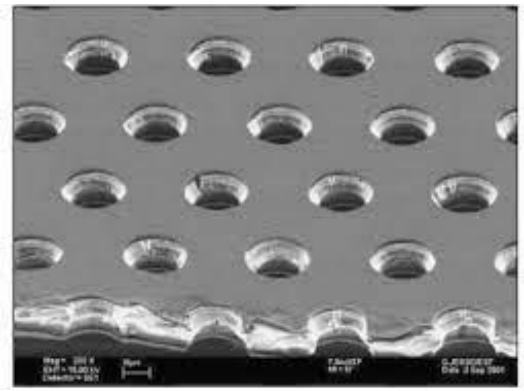
Bunch shape monitor

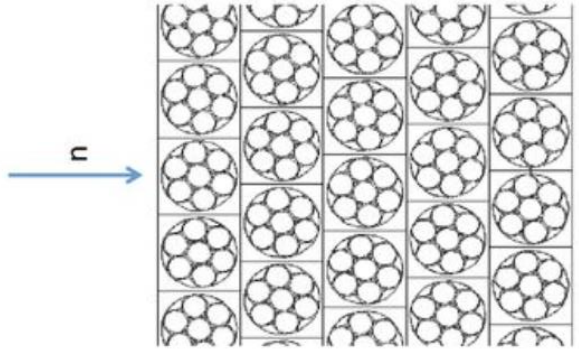


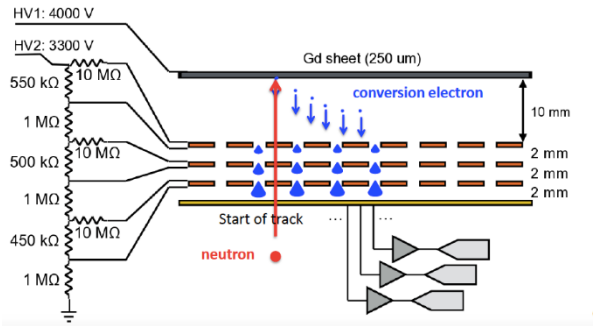
Target luminescent coating

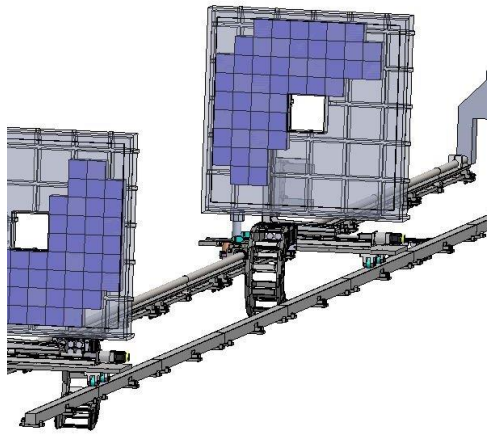
Detectors for Neutron Instruments

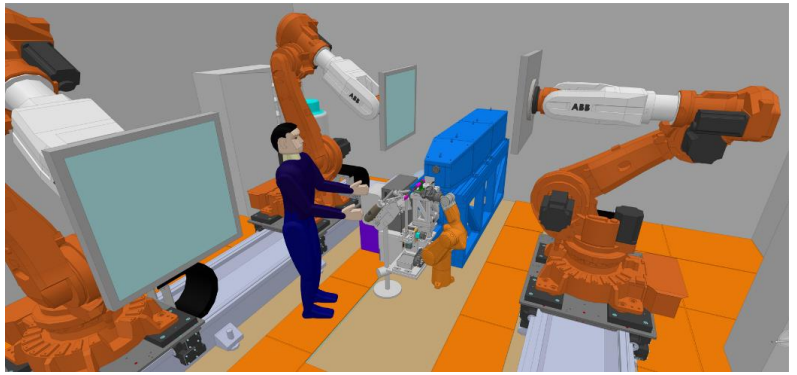






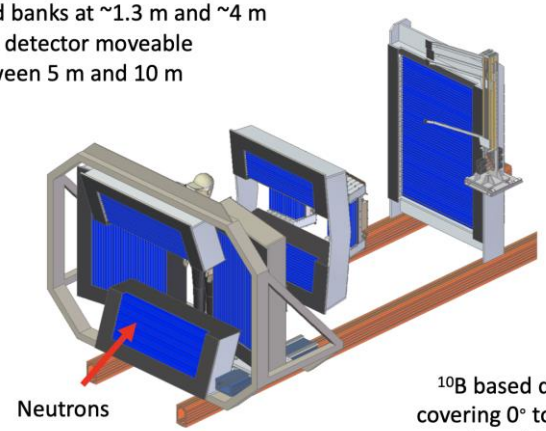






Large detector array:

- Fixed banks at ~1.3 m and ~4 m
- Rear detector moveable between 5 m and 10 m



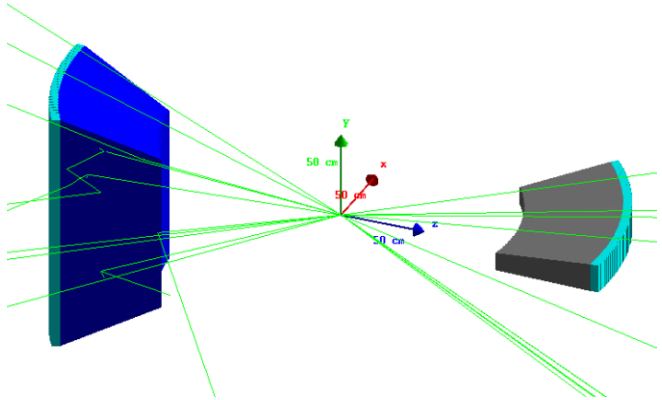
^{10}B based detector system covering 0° to 45° in scattering angle and 360° in azimuthal angle (180° Day 1).

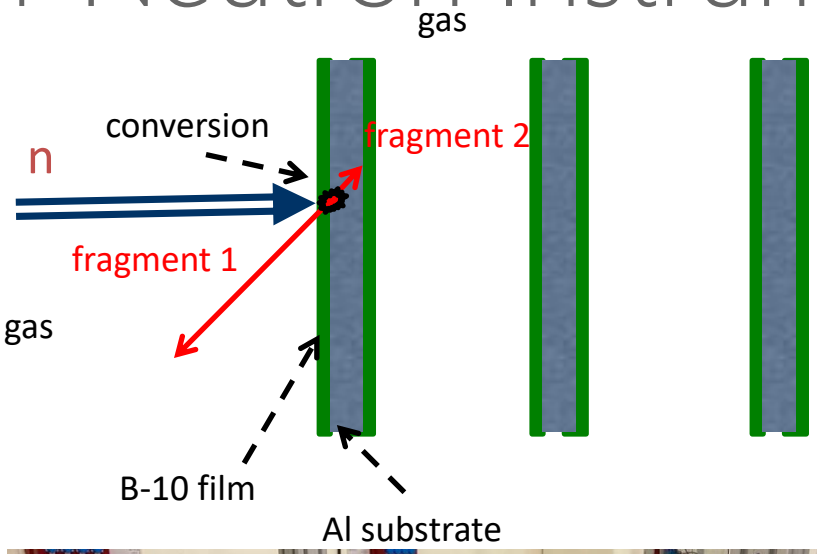
Scintillator multi Anode PMT (SKADI)

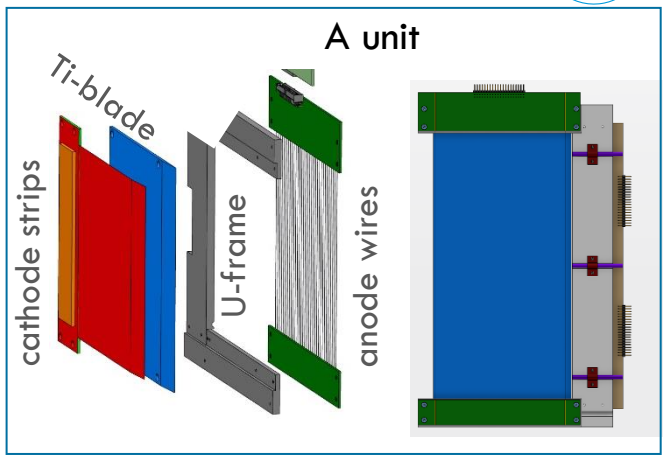
Gadolinium GEM micro TPC (NMX)

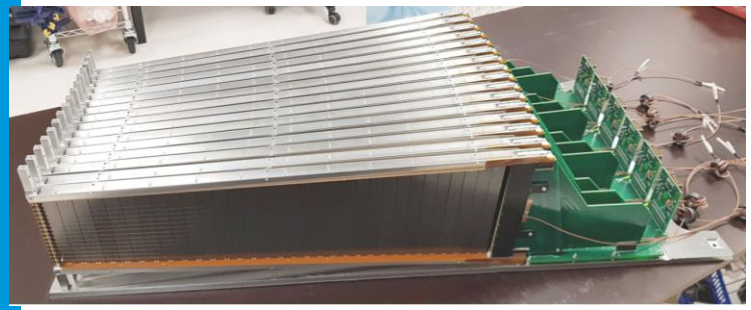
Boron-10 straw tube detector (SKADI)

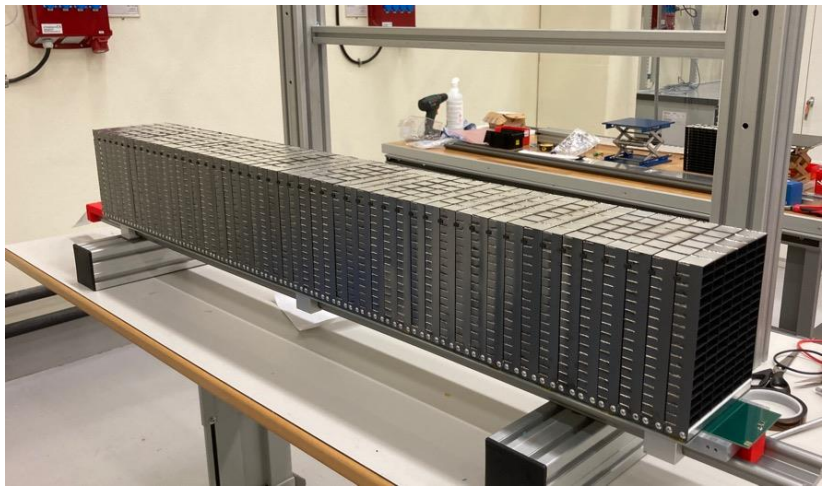
Detectors for Neutron Instruments cont'd

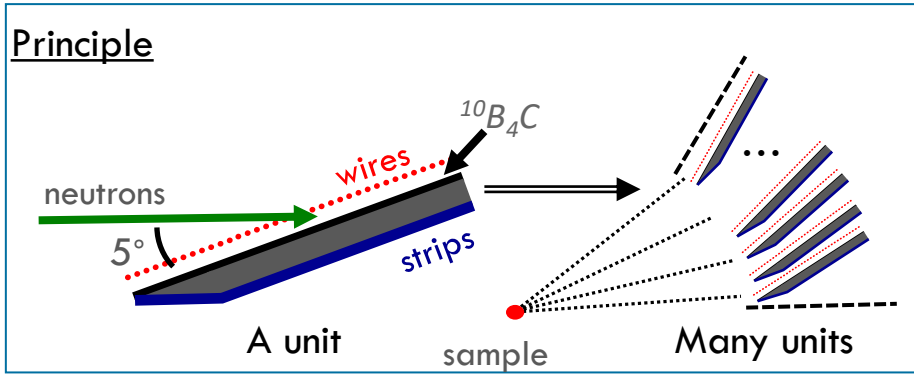












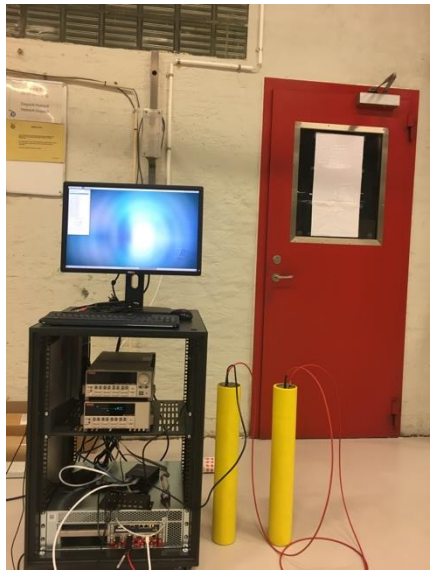
Boron-10 Jalousie Detector (DREAM, HEIMDALL, MAGIC)

Boron-10 multi-grid detector (SKADI)

Boron-10 multi-blade detector (FREIA, ESTIA)

Areas of Interest to Industry

- Cables (~90km for beam diagnostics)
  - Low dispersion
  - Low loss, phase stable RF cable
  - Low capacitance
  - Rad hard
  - Optical fibers
- Signal acquisition and processing
  - 1 Ms/s nA current readout, ~**500** channels for BI
  - Up to 250 Ms/s wideband acquisition, ~**800** channels for BI
  - Up to 5 Gs/s direct oversampling of RF, a **few** channels for BI
  - Modular standards for accelerator: FMC and MTCA.4
  - FPGA processing: Xilinx, Vivado
- Test devices and support equipment
  - Oscilloscopes, network/spectrum analyzers, signal sources
  - Power supplies (high and low voltage)
  - Racks/crates



Areas of Interest to Industry, cont'd

- UHV assemblies
  - UHV, particle free
  - Pneumatically actuated or motorized
- Motion control and industrial IO
  - EtherCat
  - Stepper motors, translational and rotational stages
  - Resolvers, Encoders
- Scintillator assemblies
- Luminescent coatings and screen
- Rad hard cameras
  - Visible, Near-IR, Intensified
- Engineering services
  - Software, EPICs integration,
  - FPGA development
  - Mechanical design and fabrication

Procurement Outlook

- Construction budget scale
  - About 25MEUR for Beam Diagnostics
  - About 250MEUR for Neutron Instruments (15 instruments)
  - Majority of equipment procured via in-kind partners
  - Construction budget mostly committed
- Maintenance and operations (NB: Operations budget not yet approved)
  - Maintenance hardware budget for beam diagnostics approx. 1.4 MEUR/year in full operation
  - Maintenance hardware budget for instruments approx. 20 MEUR/year in full operation
  - May be partly procured via in-kind partners
- Upgrades and new projects (not yet budgeted or approved)
  - Additional beam diagnostics (scale of few MEUR)
  - Additional neutron instruments (e.g. 7 more in original plan, about 20MEUR each)
  - May be procured via in-kind partners

Thank you for your attention!