Detectors for the MIRACLES instrument

Estefanía Abad & Marita Mosconi

ESS Bilbao

- Centre for neutronic technologies
- Spanish contribution to ESS (3%)
- Public consortium
  - 66% Spanish Government
  - 34% Basque Government
- 60 people
- Bilbao, Vitoria & Madrid
- In-kind contribution to ESS
- Develop capabilities
- Driving force for the local industry
- Participating in EU projects

Spanish contribution to ESS

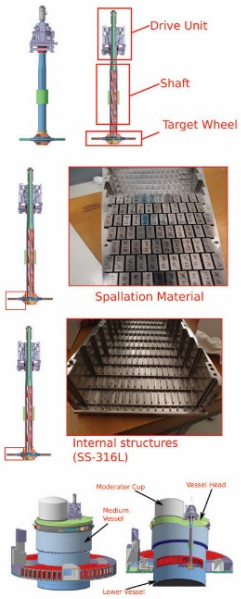
MEBT

Accelerating element: design, fabrication, assembly, testing.

RF

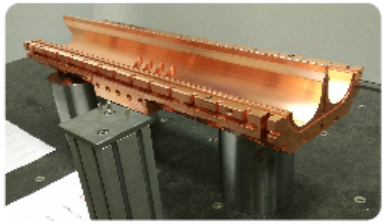
RF chains: 1 for RFQ and 5 for DTL. Composed by klystrons, modulators, loads, waveguides, interlocks and LLRF

TARGET



Place where the proton beam collide and the neutrons emerge

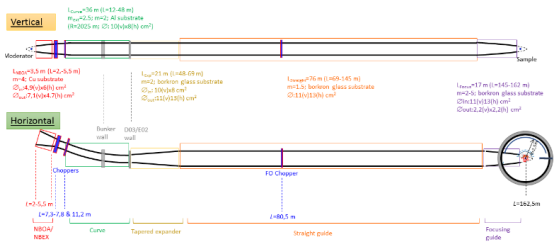
RFQ*



Accelerating structure used in the preliminary stages of ion accelerators

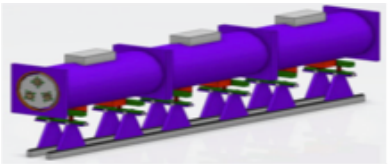
*ESSBilbao propieatry structure

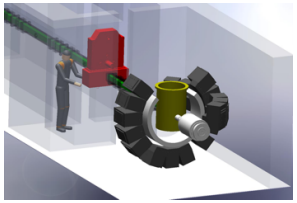
MIRACLES INSTRUMENT



Prime contractors: design, manufacturing, assembly and cold commissioning

Contributions to: LOKI design, ESPRESSO proposal, MC&A





EUROPEAN SPALLATION SOURCE

ESSBilbao detector development

Activities:

1. Providing the detectors and BM for MIRACLES instrument

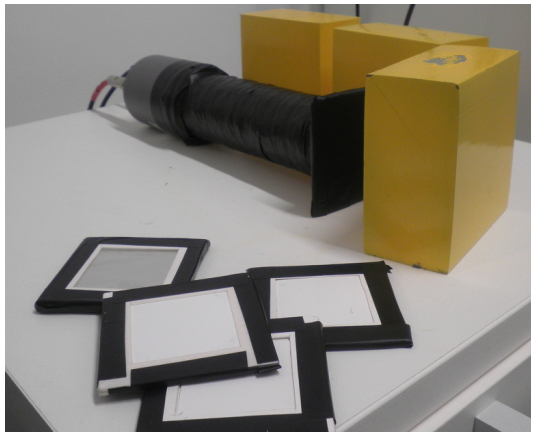
2. Feasibility study of low attenuation and background beam monitors for ESS

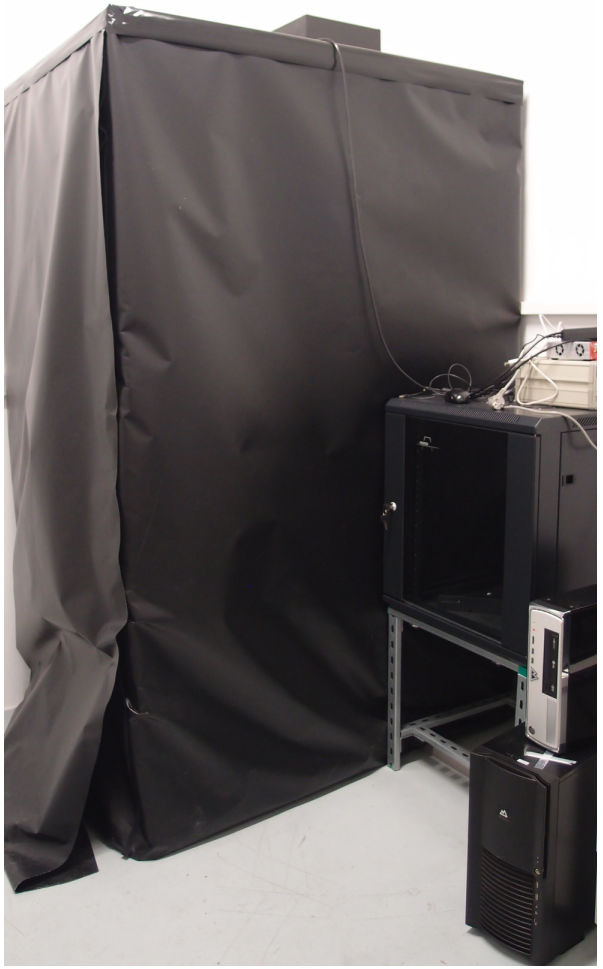
3. Evaluation of scintillation mature technologies (Scientifica)
   - ZnS(Ag) coupled with PMTs by clear fibers & coincidence coding
   - ZnS(Ag) coupled with PMTs by WLS fibers
   - ZnS(Ag) coupled with SiPMs by WLS fibers

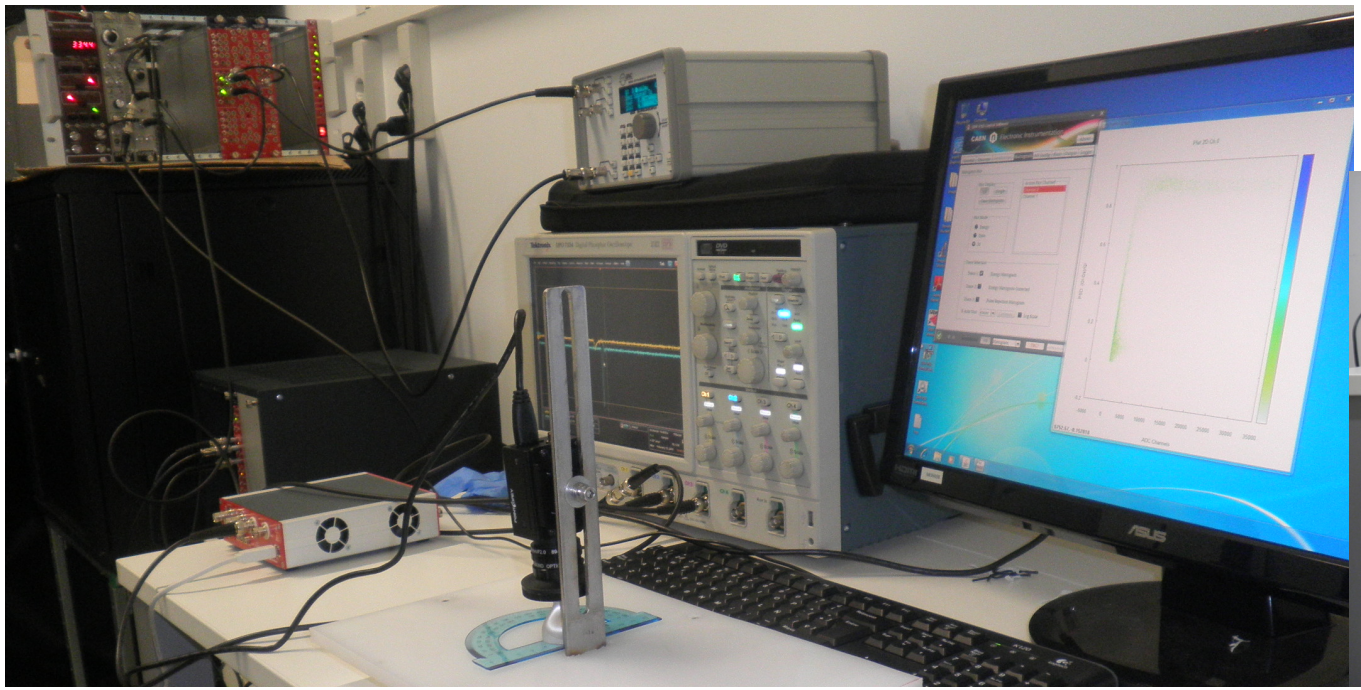
4. Evaluation of the feasibility of visualization of single events of neutron detection in scintillators by CMOS cameras

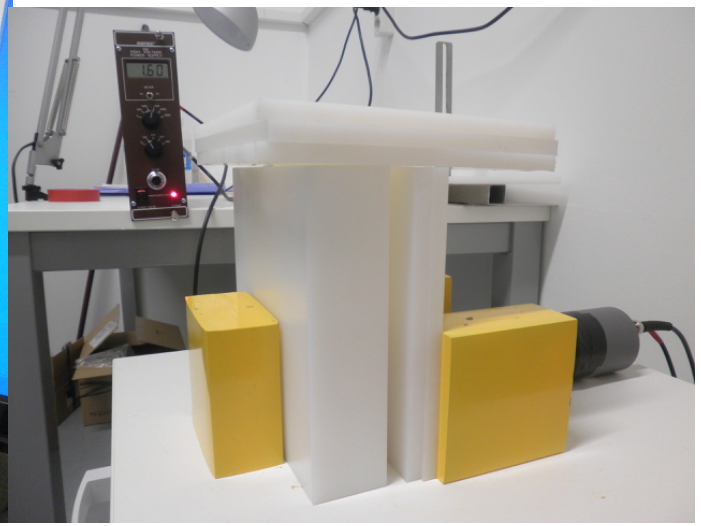
ESSBilbao detector lab

- Selection of scintillators:
  - ZnS(Ag), ZnS(Cu,Au,Al)
  - ^{6}Li glass: GS20, KG2
- Cf source 7.8 kBq
  - 6 MeV alphas
  - Soft gammas
- Dark room
- Electronics for n/γ discrimination of PMT pulses



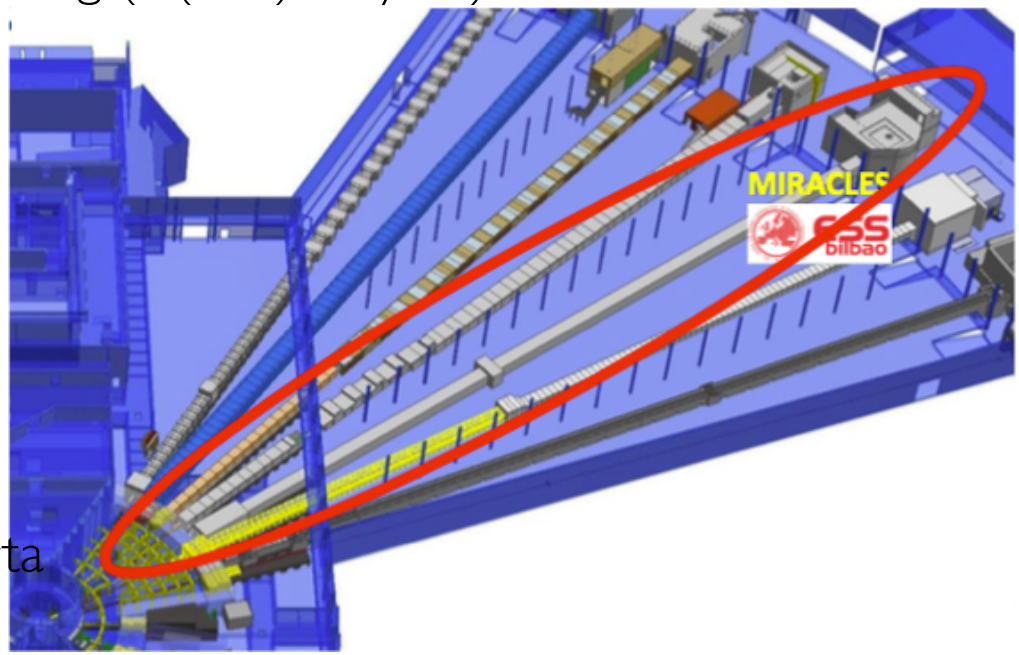






MIRACLES: the Tof backscattering spectrometer at ESS

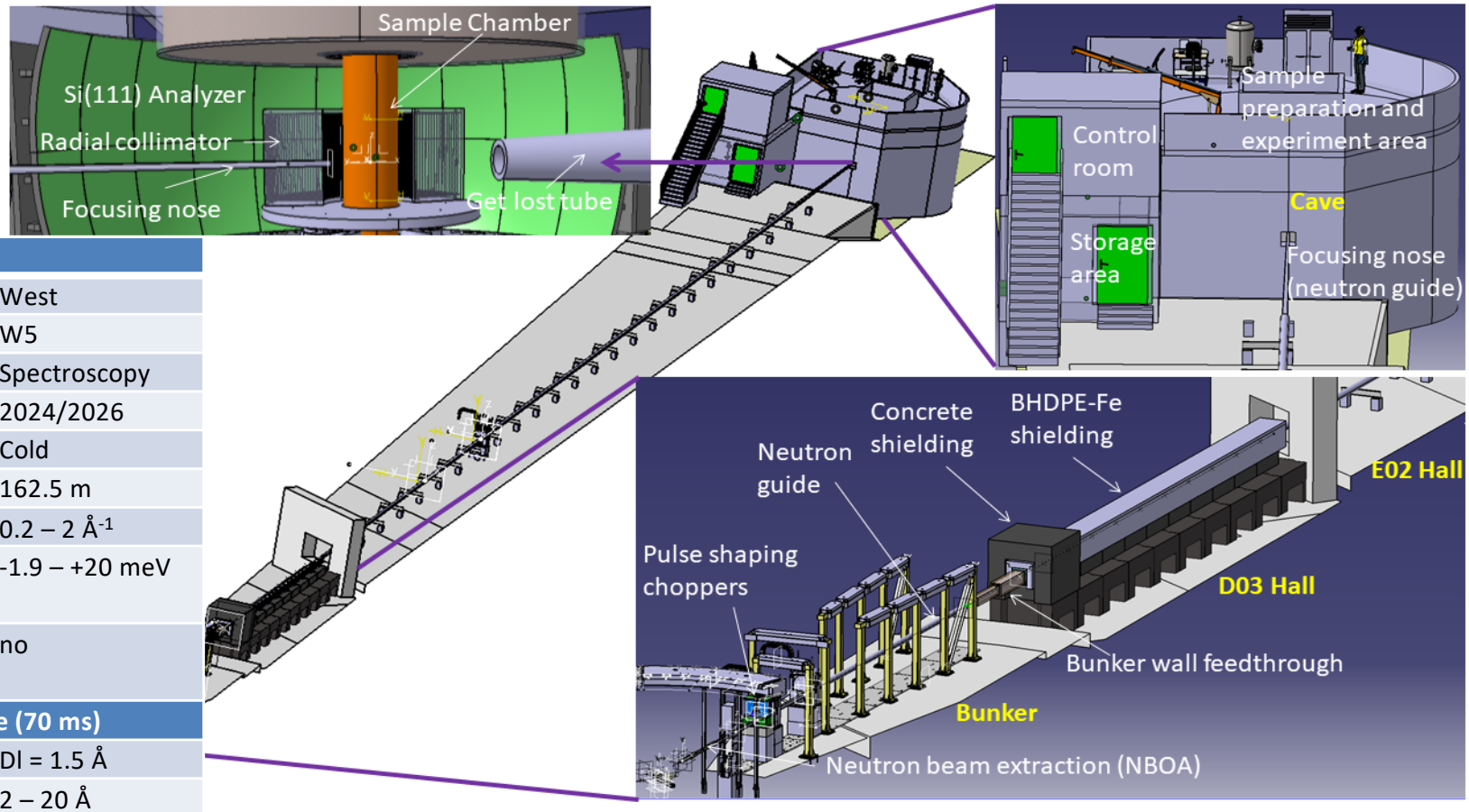
- High-resolution TOF-Backscattering spectrometer at the ESS
  - Incident beam: time of flight (chopper cascade)
  - Indirect geometry: backscattering (Si(111)analyzer)
  - High resolution/high flux



- QENS, INS spectrometer
  - W5, 160 m
  - TG2 October

- ESSBilbao prime contractor
  - Lead Scientist: Felix J. Villacorta
  - Lead Engineer: Paula Luna
  - Part-time scientists: Heloisa N. Bordallo (KU) and Melissa Sharp (ESS)
  - ESS Integration Engineer: Clara I. López (ESS)
  - Detectors: M. Mosconi, J. Ortega and E. Abad
  - ESS contact for detectors: F Issa & R Hall-Wilton
  - ESSB Team: J. Aguilar, O. González, M. Huerta, M. Magán and F. Sordo

MIRACLES: the Tof backscattering spectrometer at ESS

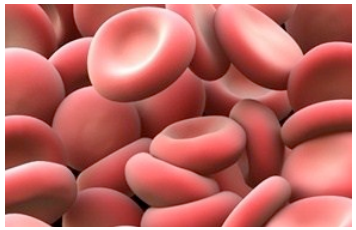
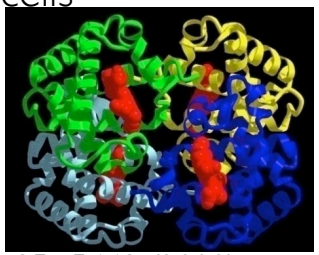


Quick Facts	
Sector	West
Beam Port	W5
Class	Spectroscopy
Commissioning/Operation	2024/2026
Moderator	Cold
Length (source to sample)	162.5 m
Q-Range (at l = 6.27 Å)	0.2 – 2 $Å^{-1}$
E-Transfer Range (E = 2.08 meV)	-1.9 – +20 meV
Spin-Polarization/-Analysis	no
High Resolution Mode (70 ms)	
Wavelength Band	Dl = 1.5 Å
Wavelength Range	2 – 20 Å
Momentum Resolution	ΔQ/Q= 5-10 %
Energy Resolution (QENS)	dE = 2.5 μeV
High Flux Mode (2.8 ms)	
Wavelength Band	Dl = 1.7 Å
Wavelength Range	2 – 20 Å
Momentum Resolution	ΔQ/Q = 5-10 %
Energy Resolution (QENS)	dE = 45 μeV

MIRACLES Science Case: QENS & INS

Life science

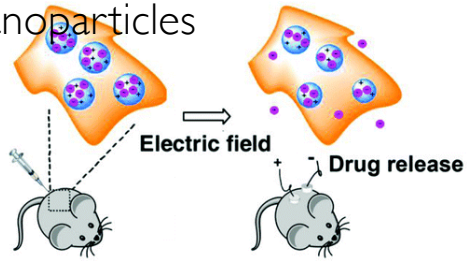
Dynamics of Proteins and Water
Example: Self-diffusion of haemoglobine and water diffusion in human red blood cells

M. Stadler et al., Biophysical J. 95, 5449 (2008)

Pharmaceutical science

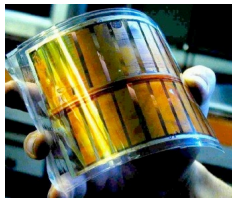
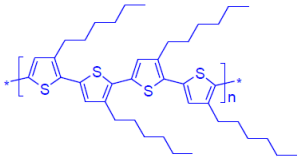
Drug Delivery
Example: drug release from electric-field responsive nanoparticles



J. Ge et al., ACS Nano. 6, 227-233 (2012).

Polymer science

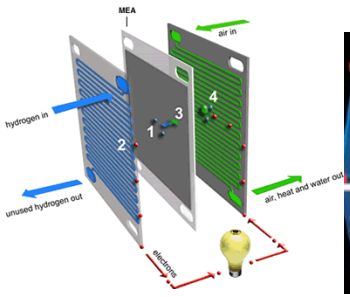
Morphology-performance connections
Example: Polymers in organic photovoltaic devices

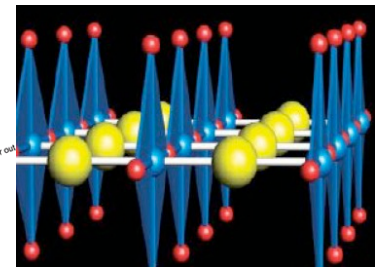



G. Paternó et al.,Chem. Phys.427, 142 (2013)

Energy science

Fuel Cells – Hydrogen Storage
Example: Hydrogen conduction in the solid state

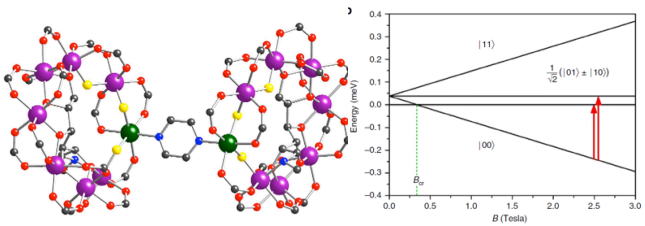




M. A. Haywarth et al., Adv. Mater. 18, 3304 (2006)

21st century Magnetism

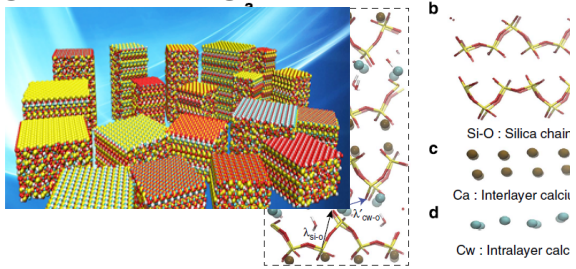
Quantum Information Processing
Example: Molecular magnets and quantum entanglement



E. Garlatti et al., Nature Commun. 8, 14543 (2017)

Environment science

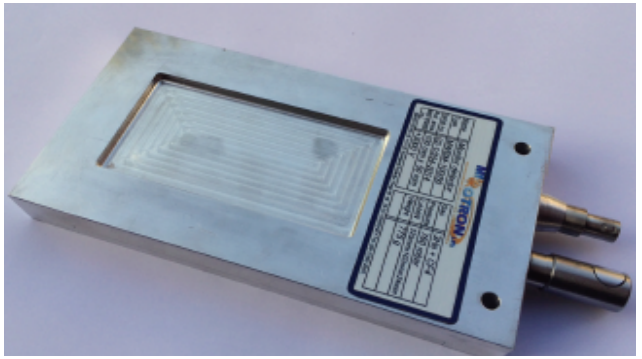
Greener building materials
Example: use of greener cements to reduce greenhouse gases



J. Jacobsen et al., Sci. Reports 3, 2667 (2

MIRACLES Beam Monitors

- 3 Beam monitors agreed SSMtg:
  1. BM1 pulse & TOF diagnosis (beam guide)
  2. BM2 normalization & TOF (before the sample)
  3. BM3 sample positioning (after the sample)



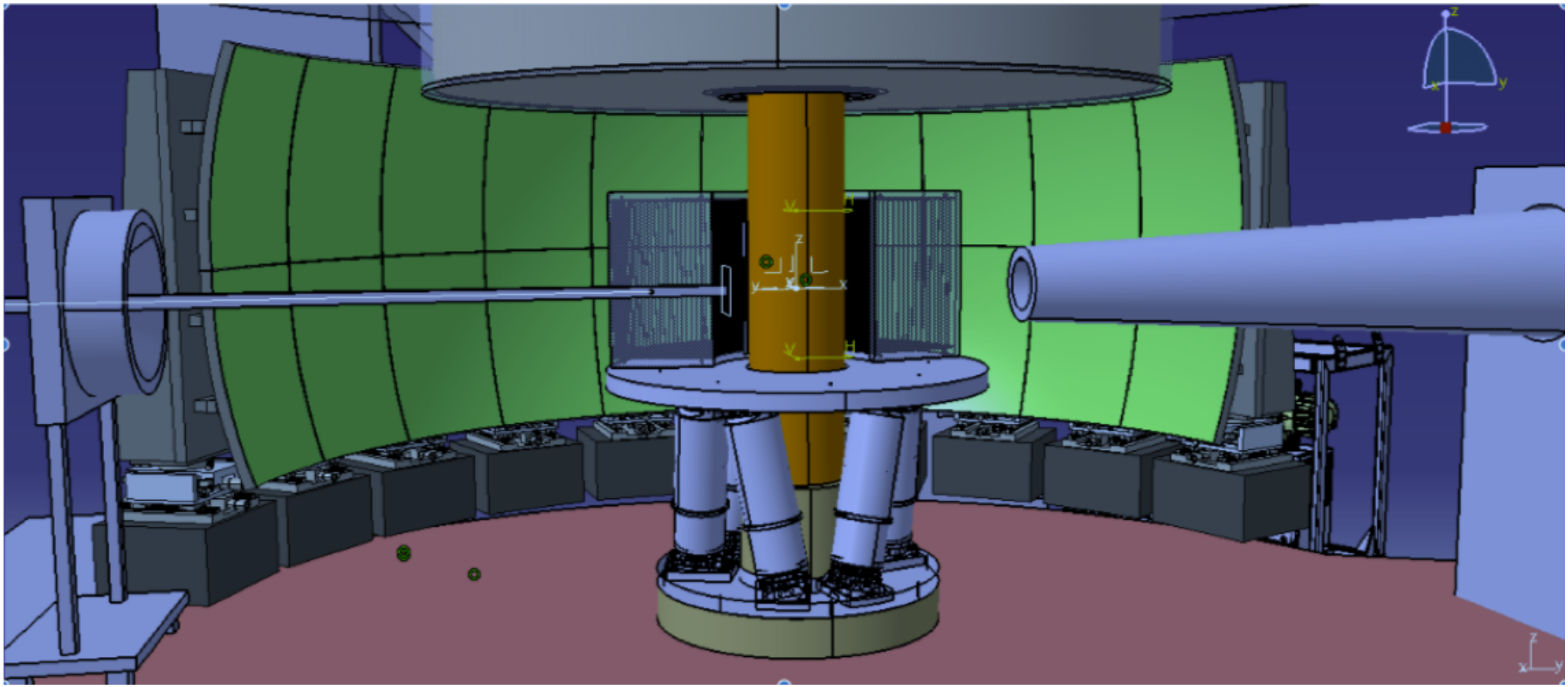
- Specifications:
  - Time resolution: 10 μs
  - Size: Neutron guide (11cmx13cm); sample size (3cmx3cm); beam stop
  - Efficiency as small as possible (10^{-5})
  - At least one position sensitive for sample positioning

- Technologies (according to ESS recommendations)
  - BM1&2 Mirrotron ^{3}He position insensitive neutron (transmission)
  - BM3 Mirrotron if PS or BCS

MIRACLES Secondary spectrometer

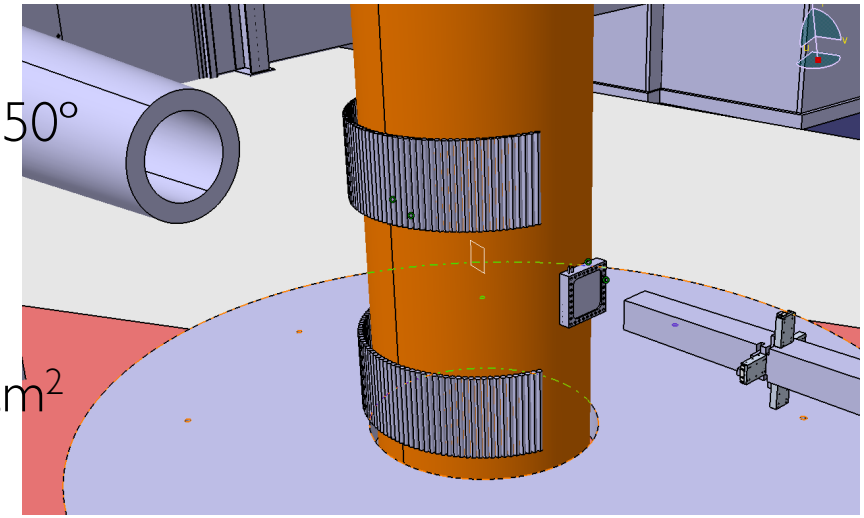
Cylindrical (R ~ 3m H ~ 3m) vacuum tank (10^{-2}mbar)

- Sample environment
- Detectors
- Radial collimator + Be filter (upgrade)
- Analyzer



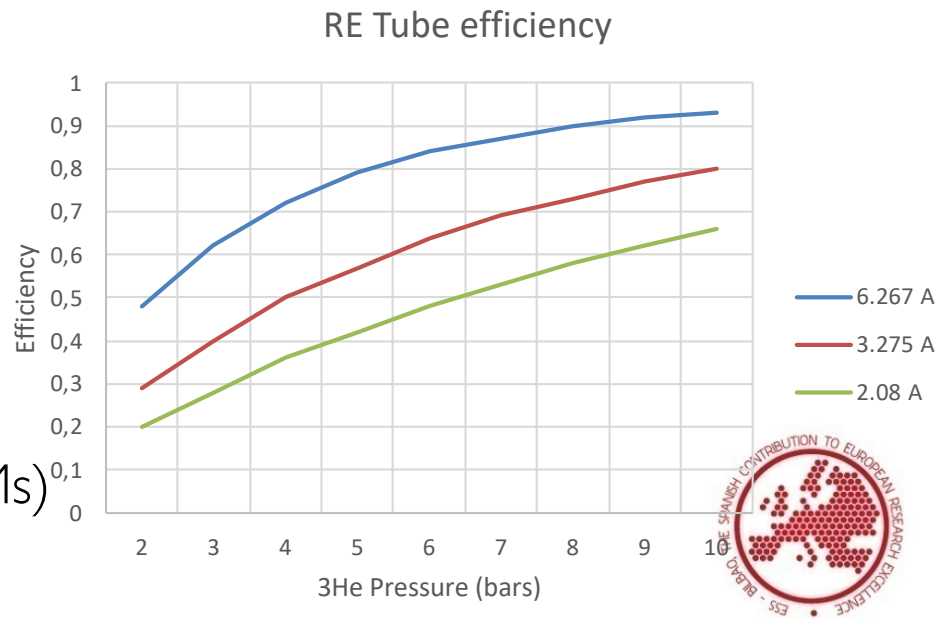
MIRACLES spectroscopy detectors

- Specifications
  - Cylindrical (23 cm), 12 cm height, 150°
  - Spatial resolution: 1x1cm;
  - Efficiency: 90%@6Å and 40%@2Å
  - Gamma sensitivity at 1 Mev $<10^{-5}$
  - Rate capability: 13 kHz over 1x12 cm^2
  - Time resolution: 10 μs



- Technology
  - PSD ^{3}He tubes (8 atm)
  - Stainless steel 0.25 mm wall

- Back up
  - Small volume
  - PSI for Heimdal (Scin+WLS+SiPMs)
  - BCS



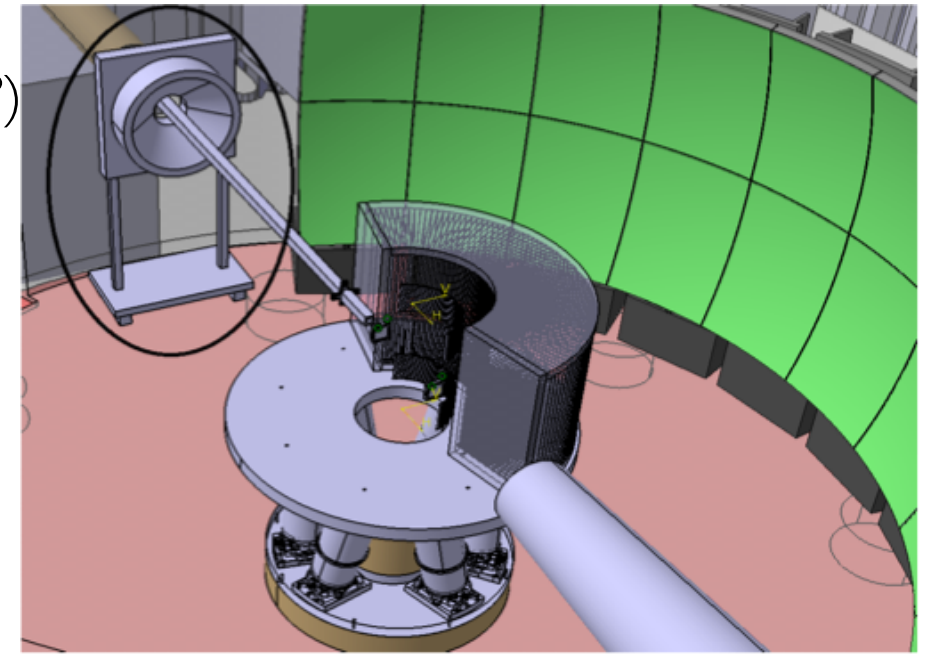
Detector electronics

- Front-End
  - Preamps inside the vessel, close to the tubes in an airbox
  - Digitizer (CAEN, ORTEC) outside the vessel
  - High Voltage supplies outside the vessel
  - Feedthrough connection between high voltage cables for air and vacuum

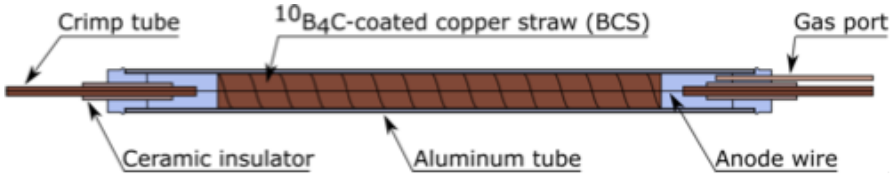
- ESS Back-End compatibility

MIRACLES Diffraction detector

- Specifications
  - Near backscattering position (170º)
  - 30 cmx 30 cm
  - Spatial resolution: 1x1cm;
  - Efficiency >50%@6Å
  - Gamma sensitivity at 1 Mev $<10^{-5}$
  - Rate capability: ~ 68 kHz
  - Time resolution: 10 μs



- Technology
  - He3 PSD tubes (2 bar)
  - FE and BE electronics compatible with ESS standards

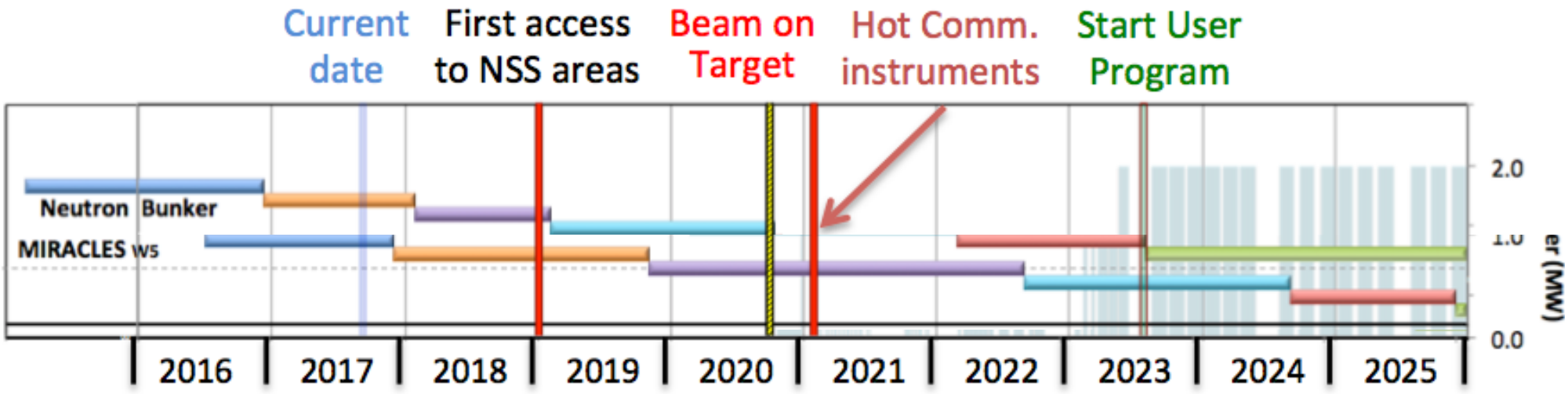


- Backup
  - BCS (Proportional Technologies)

Budget (GE/RE & Toshiba)

Task Name	Qtty	Cost/U	Total Cost (ESS-B)
MIRACLES			
Detectors			**709.060,00 €**
1 Spectrometer Detector			**389.820,00 €**
3He-Tubes	60	1.600,00 €	96.000,00 €
Power supplies + cables	1	13.820,00 €	13.820,00 €
Front-end electronics	1	70.000,00 €	70.000,00 €
Back-end electronics	1	160.000,00 €	160.000,00 €
Mounting frames	1	50.000,00 €	50.000,00 €
2 Diffractometer backscattering detector			**60.960,00 €**
3He-Tubes	1	3.000,00 €	3.000,00 €
Power supplies + cables	1	7.960,00 €	7.960,00 €
Front-end electronics	1	30.000,00 €	30.000,00 €
Back-end electronics	1	- €	- €
Mounting frames	1	20.000,00 €	20.000,00 €
3 Monitors			**78.670,00 €**
Flux monitor	2	20.000,00 €	40.000,00 €
Position sensitive	1	30.000,00 €	30.000,00 €
Power supplies + cables	3	2.890,00 €	8.670,00 €
4 Labour cost			**76.650,00 €**
Detailed design (1Person/1months)	175	60,00 €	10.500,00 €
Specs & procurement (1Person/2months)	350	60,00 €	21.000,00 €
Tests in ESS Bilbao (1Person/1month)	175	60,00 €	10.500,00 €
Installation (1Person/1months)	175	78,00 €	13.650,00 €
Commissioning (1Person/2months)	350	90,00 €	31.500,00 €
5 Management (coordination, monitoring, quality and risk management, documentation, meetings…)	**500**	**77,00 €**	**38.500,00 €**
6 Detector contingency	**1**	**64.460,00 €**	**64.460,00 €**

Schedules



	Q2 2017	Q3 2017	Q4 2017	2018	2019	2020	2021	2022	2023	2024	2025
MIRACLES Detectors											
Preliminary design											
Detailed design											
Manufacturing & procurement											
Installation and integration											
Hot commissioning											

Ackowledgements

People

- Group: Marita Mosconi, Ion Ortega, Roberto Martínez and Mónica Huerta
- ESSBilbao team & previous directors (J Bermejo and JL Martínez)
- ESS detector group: R Hall-Wilton, F Issa, J Freita-Ramos, I Stefanescu

Founding

- Spanish (SEIDI) Government
- Basque Country Government

Thank you for your attention

ESS - BILBAO THE SPANISH CONTRIBUTION TO EUROPEAN RESEARCH EXCELLENCE