# Progress in the Construction of ESS Bilbao accelerator as the First Phase of the ARGITU Project

ICANS XXV, 14.04.2026, Malmö

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GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
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# ARGITU

A unique infrastructure fostering the R&D&I ecosystem in Euskadi and Beyond

# HiCANS Platform

A collaboration at the core of Europe…
staggered approach towards ARGITU.

# Accelerator Based Neutron Sources

ELENA
European Low Energy accelerator-based Neutron facilities Association

https://elena-neutron.iff.kfa-juelich.de/

## From CANS* to HiCANS**

(*Compact Accelerator based Neutron Source , ** High-Current Accelerator based Neutron Source)

| 0.01 kW | 0.1 kW | 1 kW | 10 kW | 100 kW |
|---|---|---|---|---|
| 0.001-0.01 mA | 0.01-1 mA | 0.5-5 mA | 1-20 mA | 50-100 mA |
| ~$10^{11}$ n/s | ~$10^{12}$ n/s | ~$10^{13}$ n/s | ~$10^{14}$ n/s | ~$10^{15}$ n/s |

10 Mio EUR → 500 Mio EUR

### Running CANS facilities:

LENS, Indiana University (USA)
HUNS, Hokaido University (Japan)
RANS, RIKEN (Japan)
NUANS, Nagoya University (Japan)
CPHS, Tsinghua University (China)
IREN, JINR Dubna (Russia)

### HiCANS projects:

**HBS, JCNS (Germany)**
ICONE, CEA LLB (France)
ARGITU, ESS Bilbao (Spain)
LENOS, INFN LNL (Italy)
SARAF, SOREQ (Israel)

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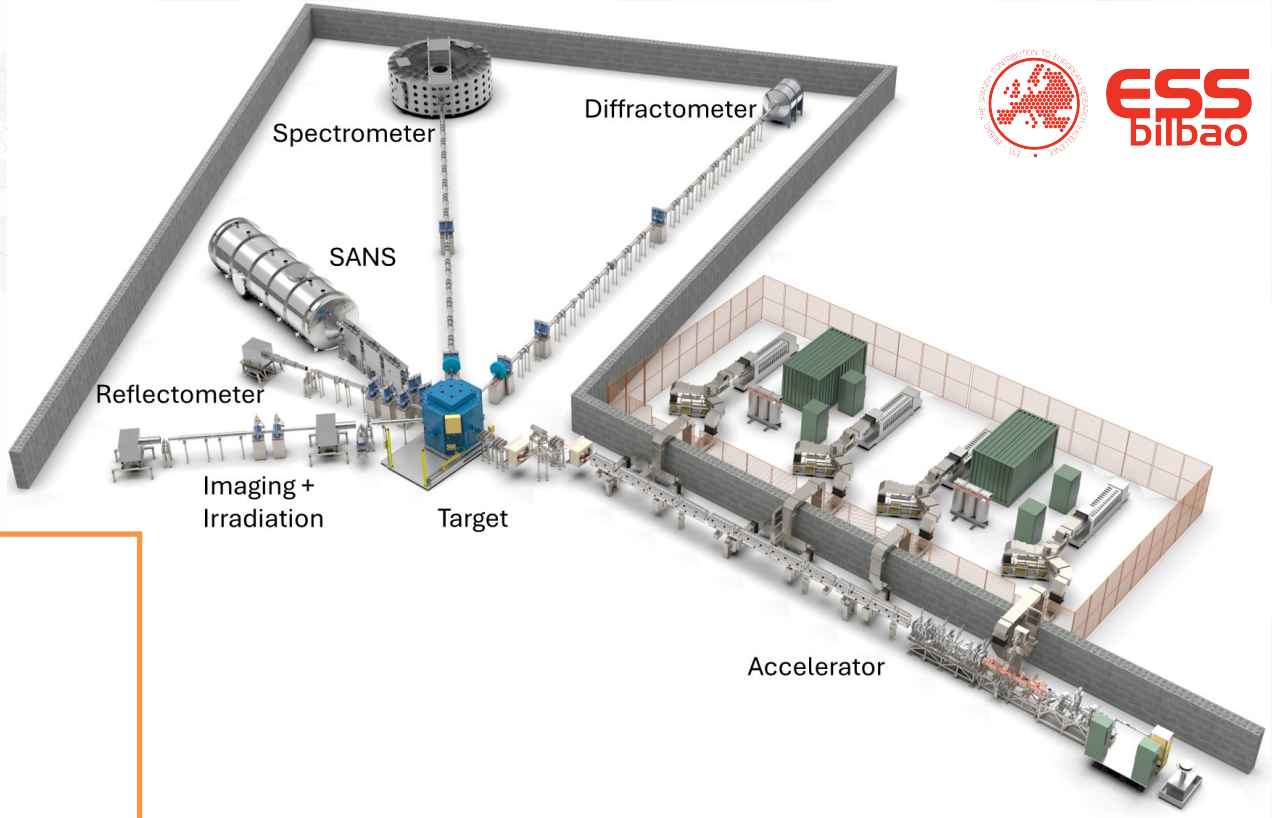
ESS bilbao

# ARGITU, a Neutron Source based on the HiCANS concept

*Baseline proposed 2025*




- E=50 MeV (a third DTL)
- $I_{peak}$=50 mA
- t=1.5 ms; f=30 Hz (same 4.5 % DC)
- P=112 kW
- 5 instruments

# ARGITU, a Neutron Source based on the HiCANS concept

**ICONE**

- E=25 MeV
- $I_{peak}$=80 mA

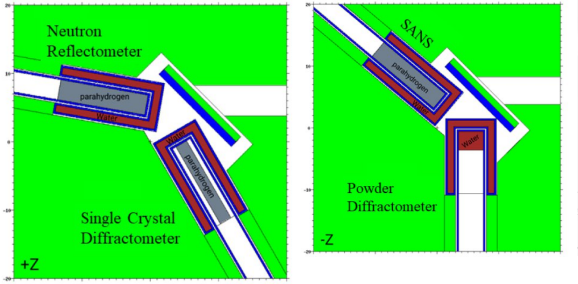
**HBS**

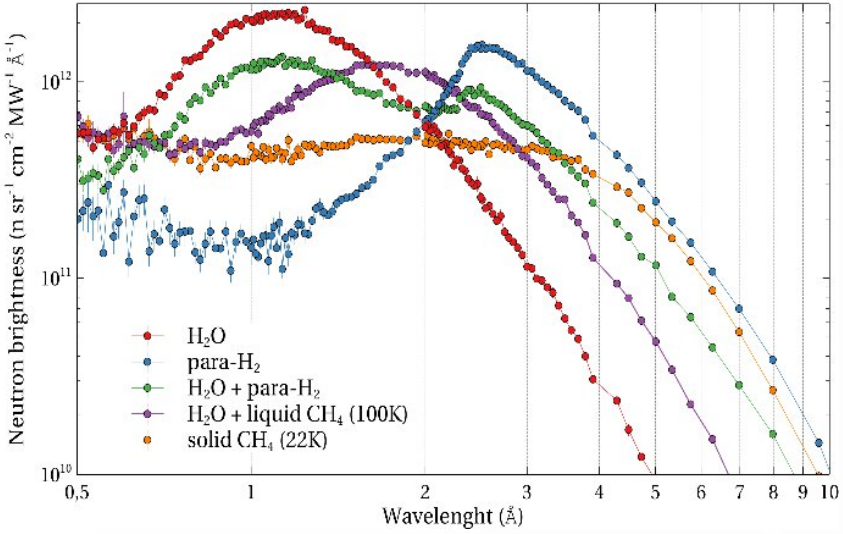
- E=70 MeV
- $I_{peak}$=90 mA

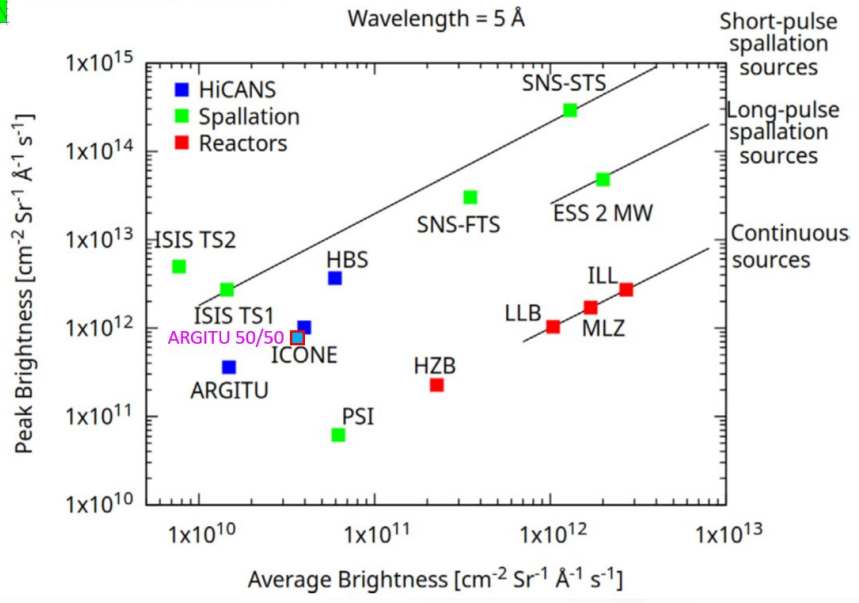
| | ICONE | HBS | ARGITU (3-DTL) |
|---|---|---|---|
| **Material** | Beryllium | Tantalum | Beryllium |
| **Target size (cc)** | 15 x 15 x **1** | 15 x 15 x **0.6** | 15 x 15 x **1** |
| **Beam section (cm2)** | 4 x 10 | 4 x 10 | 9 x 12,7 (9 x 9) |
| **Ep (MeV)** | 25 | 70 | 50 |
| **Power (KW)** | 80 | 100 | 112 |
| **Beam current (mA)** | 3.2 | 1.43 | 2,25 |
| **Primaire proton/sec** | 2.E+16 | 9.E+15 | |
| **Neutron production yield** | **2.77E-02** | **1.82E-01** | |
| **Neutron mean energy** | **3.4** | **2** | |
| **Neutron production/sec** | **5.54E+14** | **1.64E+15** | **9,3E+14** |

# ARGITU, a Neutron Source based on the HiCANS concept

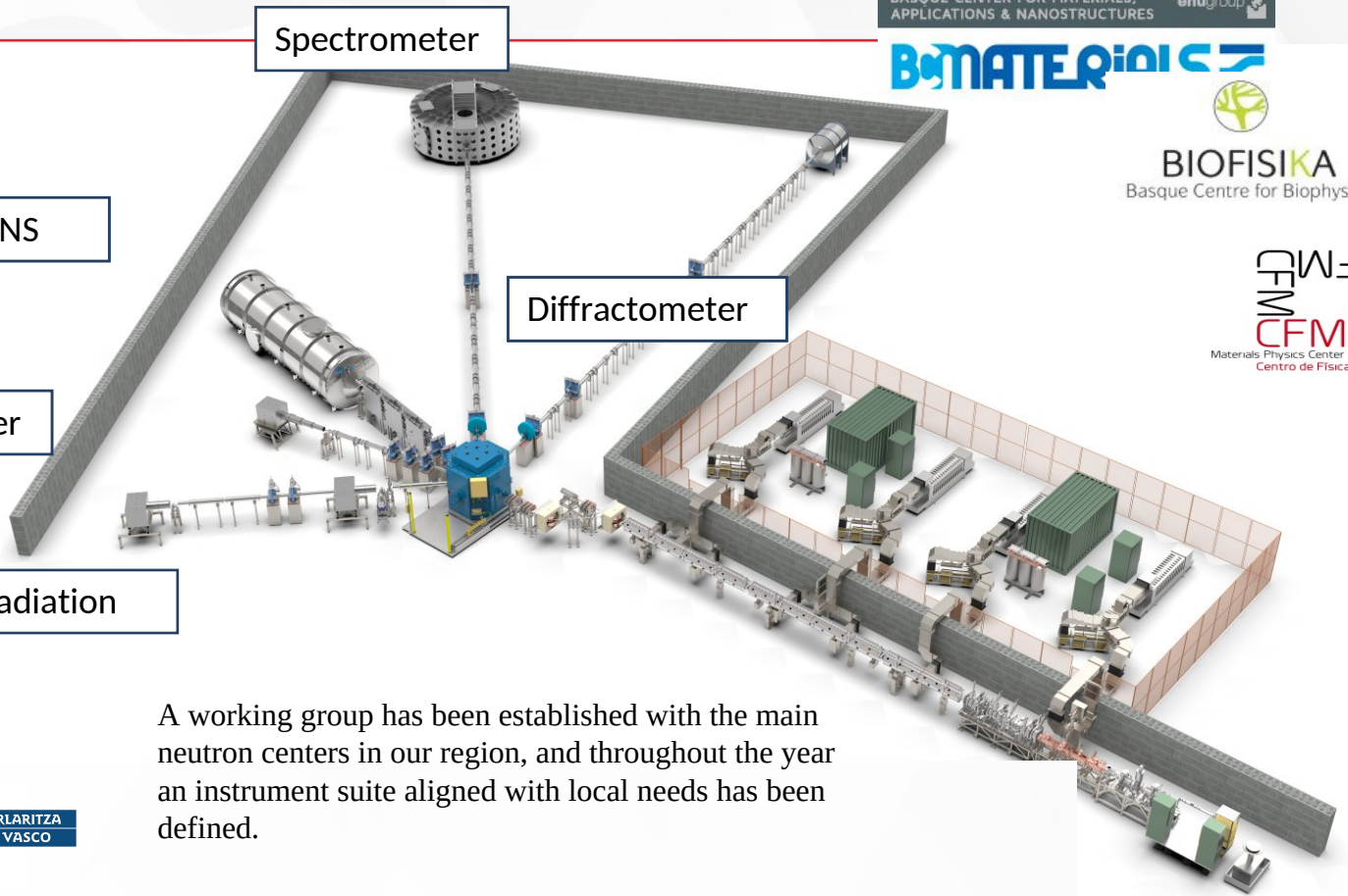
**ARGITU**: water cooled Berilium Target



# ARGITU




A working group has been established with the main neutron centers in our region, and throughout the year an instrument suite aligned with local needs has been defined.

# ARGITU

Main characteristics of the ARGITU backscattering spectrometer.

| | |
|---|---|
| Source (moderator) | p-$H_2$ |
| Length (source–sample) | 58 m |
| Length (sample–detector) | 3.75 m (analyzer radius = 2 m) |
| Bandwidth $\Delta\lambda$ | $\Delta\lambda$ = 2.3 Å (1.6 meV) |
| Sample (beam) size | 30 × 30 mm |
| $\delta E$ (QENS) | HR: $\delta E$ = 4.5 μeV ($\Delta t$ = 100 μs), $t_{obs} \sim$ 0.5 ns |
| | HF: $\delta E \sim$ 60 μeV ($\Delta t$ = 1.5 ms), $t_{obs} \sim$ 0.04 ns |
| Max. energy transfer (INS) | 20 meV |
| $Q$ range | $Q \sim$ 0.2–2 Å$^{-1}$ |
| Detector coverage $\Delta 2\theta$ | 10–165° |
| Divergence | <5 × 5° |
| Additional features (day 1) | FEWS |
| | Guide exchanger (small samples 10 × 10 mm) |
| | Diffractometer |

JOURNAL OF APPLIED CRYSTALLOGRAPHY
ISSN 1600-5767

## The instrument suite and science case for ARGITU, the Spanish high-current accelerator-driven neutron source

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Received 20 November 2025
Accepted 18 February 2026

Main characteristics of the ARGITU powder diffractometer.

| | |
|---|---|
| Source (moderator) | $H_2O$ |
| Length (source–detector) | 58 m |
| Wavelength range | $\lambda$ = 0.5–2.8 Å |
| Bandwidth $\Delta\lambda$ | $\Delta\lambda$ = 2.3 Å |
| Sample (beam) size | 20 × 20 mm |
| $Q$ range | $Q \sim$ 0.31–21 Å$^{-1}$ |
| $d$-spacing range | $d \sim$ 0.3–20 Å |
| Detector coverage $\Delta 2\theta$ | 8–170° (7 sr) |
| Sample–detector distance | ~1 m |
| Divergence (FWHM) | 0.5 × 0.5° |
| $\delta d/d$ (range) | ~0.25%–5% |

Main characteristics of the ARGITU imaging and irradiation instrument.

| | |
|---|---|
| Source (moderator) | Bispectral: $H_2O$/p-$H_2$ |
| Wavelength range (workhorse) | 0.5–5 Å |
| Techniques | Imaging (radiography, tomography, Bragg-edge imaging) |
| | Irradiation (fast and thermal neutrons) |
| | PGNAA (fast and thermal neutrons) |
| Length (irradiation and analysis) | 3–6 m |
| Length (imaging – camera obscura) | 6 m |
| Length (imaging – Bragg) | 18 m |
| Diaphragm diameter, $D$ | 2–5 cm |
| $L/D$ (imaging – camera obscura) | 120–300 |
| $L/D$ (imaging – Bragg) | 240–600 |
| Divergence | Beam opening < 3.5 × 3.5° |
| $d/(L/D)$ resolution (camera obscura) | 50–400 μm |
| $d/(L/D)$ resolution (Bragg) | 20–150 μm |
| Wavelength band | 0.5–5 Å |
| FOV$^{max}$ (aperture at 1.7 m) | Up to 35 × 35 cm |

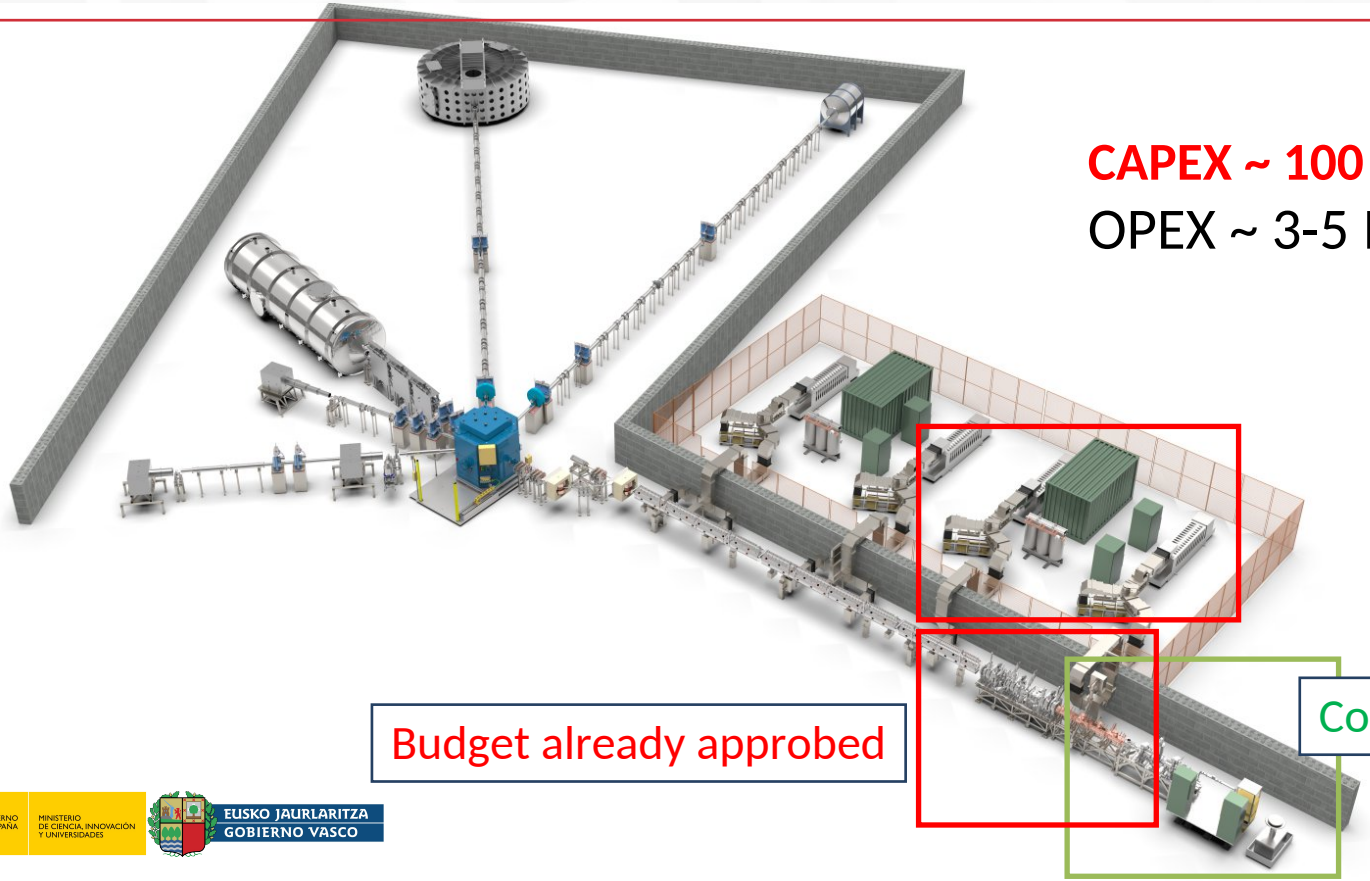
Main characteristics of the ARGITU SANS instrument.

| | |
|---|---|
| Source (moderator) | p-$H_2$ |
| Length (source–detector) | 23 m (a 10–10 SANS) |
| Wavelength range | $\lambda$ = 2–12 Å |
| Bandwidth $\Delta\lambda$ | $\Delta\lambda$ = 6 Å (at $L_2$ = 10 m)–$\Delta\lambda$ = 7.7 Å (at $L_2$ = 5 m) |
| Sample (beam) size | 20 × 20 mm |
| Divergence | <0.3 × 0.3° |
| $Q$ range | $Q \sim 2 \times 10^{-3}$–0.6 Å$^{-1}$ |
| $d$-spacing range | $d \sim$ 1–300 nm |
| Detector coverage $\Delta 2\theta$ | 0.2–11.3° |
| Sample–detector distance | $L_2$ = 2.5, 5–10 m |
| $\Delta\lambda/\lambda$ | ~2%–17% |
| Upgrade | Small-angle X-ray scattering |

Main characteristics of the ARGITU reflectometer.

| | |
|---|---|
| Source (moderator) | p-$H_2$ |
| Length (source–detector) | 13.8 m |
| Bandwidth $\Delta\lambda$ | $\Delta\lambda$ = 10 Å (*e.g.* $\lambda$ = 2–12 Å) |
| Sample (beam) size | 3 × 10 cm |
| $Q$ range | $Q \sim$ 0.01–0.3 Å$^{-1}$ |
| $d$-spacing range | $d \sim$ 2–150 nm (depends on $dQ/Q$) |
| Detector coverage $\Delta 2\theta$ | $\Delta 2\theta$ = 0–4.8°, 0.5 × 0.25 m |
| Sample–detector distance | $L_2$ = 3 m |
| Divergence | <0.12 × 3° |
| $\delta\lambda/\lambda$ | ~0.5%–10% |
| $\delta d/d = \delta Q/Q$ | ~4%–9% (workhorse 5%–7%) |
| Additional features | Polarization |

# ARGITU



**CAPEX ~ 100 M€ over 5 years**

OPEX ~ 3-5 M€/year

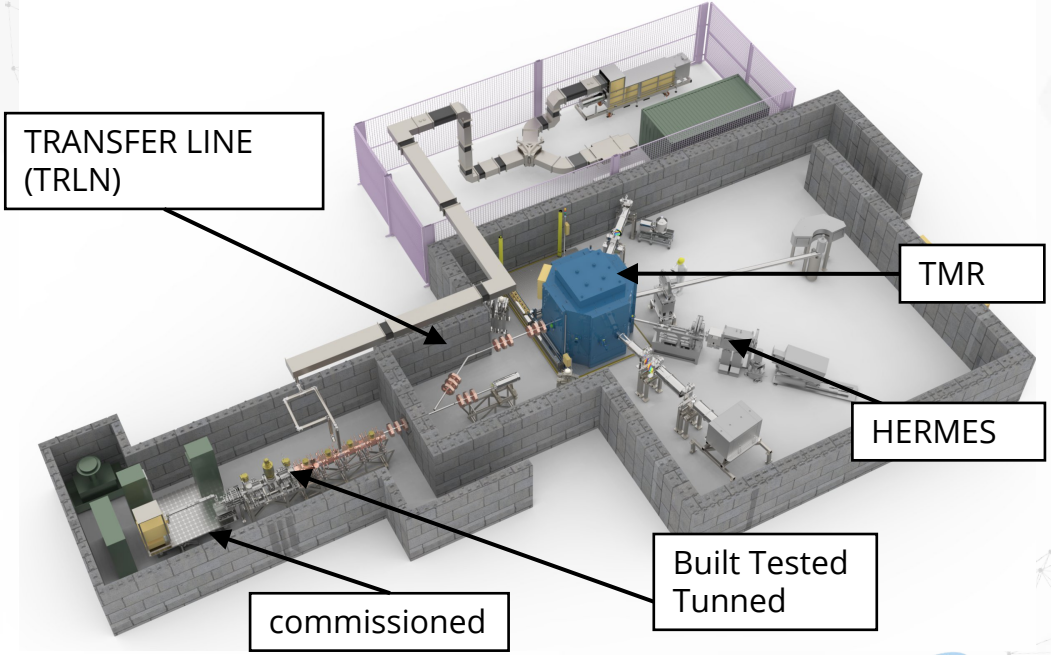
Budget already approbed

Completed

# HiCANS platform
# International collaboration with leading European R&D Centers


Photo: Members of ELENA, Thomas Gutberlet (JCNS) on the left, Mario Perez (ESS Bilbao) in the middle, and Arnaud Desmedt (LLB CEA-CNRS) on the right, during the IMoH Workshop held in Bilbao.

# HiCANS platform – (a.k.a ARGITU-Zero)
# International collaboration with leading European R&D Centers

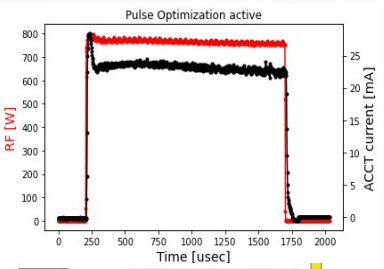


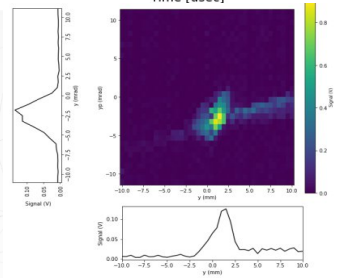

| Accelerator Parameters | | |
|---|---|---|
| Energy | [MeV] | 3 |
| Peak Intensity | [mA] | 30 |
| Pulse length | [ms] | 1.5 |
| Repetition Rate | [Hz] | 30 |
| Average Current | [mA] | 1.35 |
| Duty | % | 4.50 |
| **Target Parameters: Lithium Target** | | |
| Power | [kW] | 4.05 |
| Y_n(Ep) | [n/mu-C] | 4.39E+08 |
| Neutron yield | [n/s] | 1.92E+12 |
| Proton Current | [p/s] | 2.16E+16 |
| Neutron yield | [n/p] | 8.87E-05 |
| Head load Target | [MeV/n] | 3.38E+04 |

# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – Ion Source + LEBT

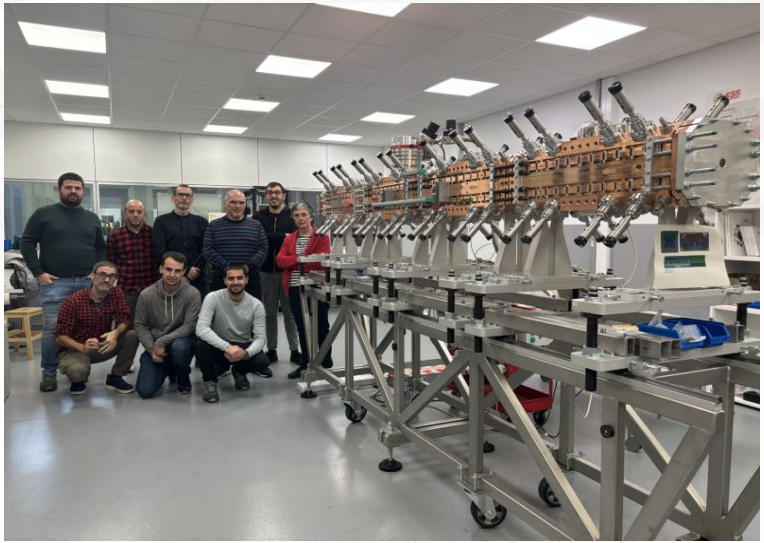
## ISHP

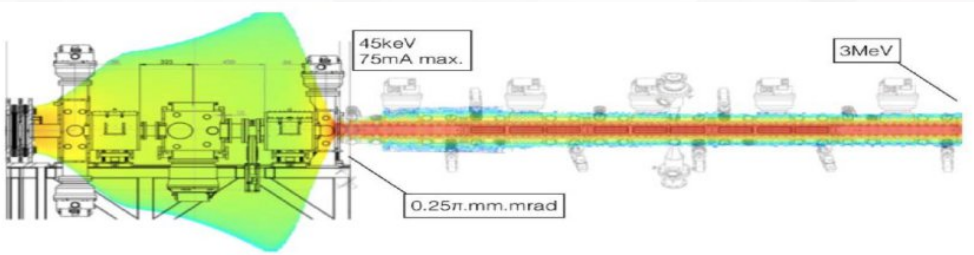
- 45 KeV Proton beam
- Up to 30 mA
- Pulse length up to 2 msec
- Pulse repetition rate up to 20 Hz



# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – RFQ






- All four segments delivered at our facilities.
- RFQ assembly successfully finished
- **Beadpull and tuning completed**
- Power couplers v1.0 tested in low and high power
- Next step high-power conditioning

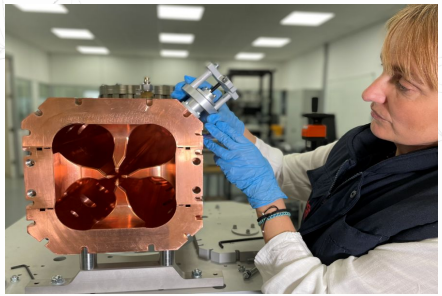


Table 1: ARGITU-RFQ Main Specifications

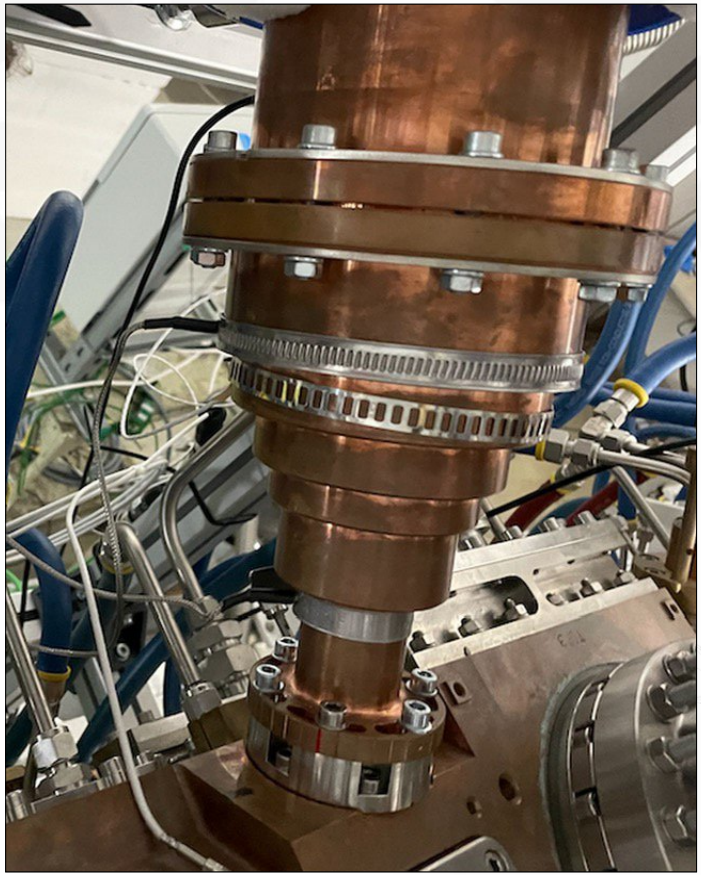
| Parameter | Value |
|---|---|
| Specimen | H+ |
| Beam current | 32 mA |
| Beam energy | 45 keV→3 MeV |
| RF Frequency | 352.2 MHz |
| Pulse Operation | 30 Hz; 1.5 ms; 4.5 % |
| Intervane Voltage | 85 kV |
| Kilpatrick | 1.85 |
| Input emittance | 0.25 π mm rad |

# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – RFQ

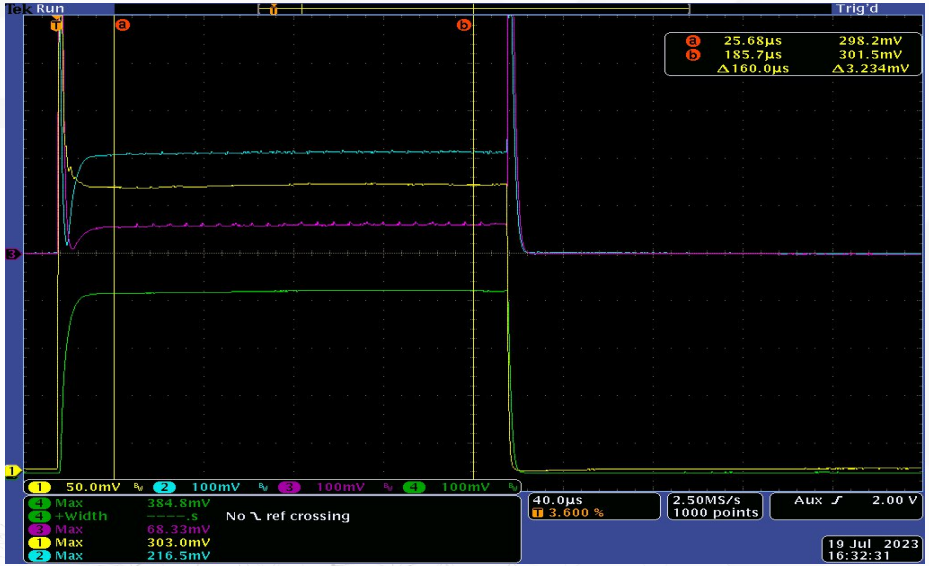
**Sept 2025** Progress report:

- Moving everything to integration lab (temperature controlled)
- Low power measuremeAlignment asisted by laser tracker
- **LPRF characterization.**
- **Bead pull and static tuning**
- **COOLING SYSTEM READY**
- Pickups characterisation
- Vacuum tests whole RFQ
- Outside of lab, RF power conditioning.

# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – RFQ



- High power tests at ISIS-FETS (in their RFQ)
- Nominal field level (545 kW)
  (low duty cycle)




UKRI Science and Technology Facilities Council | ISIS Neutron and Muon Source

ESS bilbao

# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – RF Power System

ESS Bilbao’s high-power RF test stand in Zamudio is a key facility for validating accelerator RF systems in support of ESS activities and the HiCANS/ARGITU platform. It includes the RF power system infrastructure needed for high-power testing and commissioning ( 3 MW / 352 MHz klystron).

After a klystron failure, ESS Bilbao maintained the program through a loaned Thales unit from ESS, which required adaptation and integration work before commissioning. The 2025 objectives record the RF test stand commissioning as completed.

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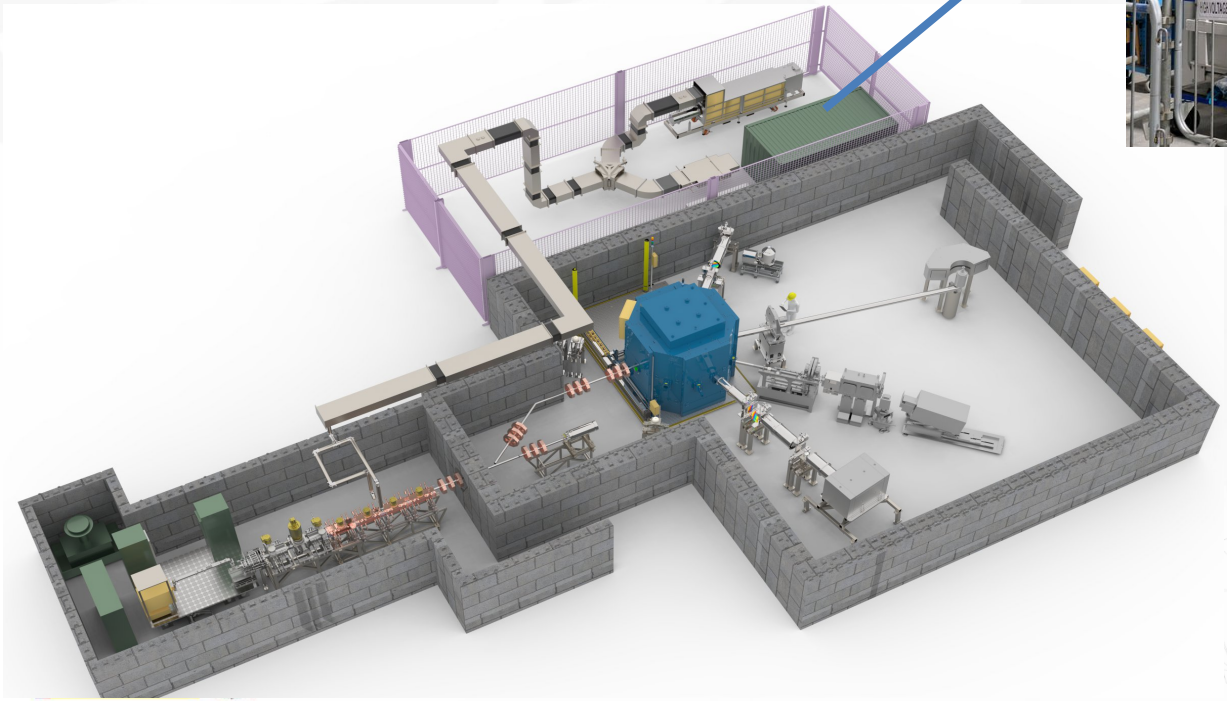
# ARGITU-Zero as a dedicated HiCANS platform – High Currrent Accelerator – RF Power System


- **Lending agreement with ESS in place**
- Klystron is already at our R&D lab in Zamudio. Adaptation is on-going
- Modulator (Prototype) has been set up ready for operations by JEMA – procurement of a new one Q2 2025.
- Modulator, Waveguides and other auxiliaries are ready at our RF Test Stand in Bilbao.
- RF Power System integrated test is scheduled to run in parallel with the RFQ tunning activities along this year.

Replacement of the current modulator — a 2014 prototype — with a new modulator identical to the industrialized model for ESS ERIC.


- ESS Bilbao is a growing **center of excellence in accelerator, target, and neutron technologies**, delivering advanced engineering and R&D capabilities.
- Actively involve in **HiCANS-based neutron source** development within Europe (ELENA, ARGITU, HiCANs Platform).
- **ARGITU** / HiCANs emerging as a **strategic next-generation neutron source**, enabling multi-instrument capability and strengthening the European neutron science ecosystem.