ESS Bilbao: overview and planned contributions to HEP

Jornada de las red española de futuros colisionadores

https://indico.ific.uv.es/event/5365/

06 Oct 2020

Who are we?

Public consortium of Central and Basque Governments; bringing knowledge and added value in particle accelerator and neutron scattering science and technologies; by leveraging its in-kind contribution to the European llation Neutron Source, in Lund (Sweden)

48 employees
age average: 40

29% women **71% men**

Qualification

- **27% PhD**
- **13% Post Graduate Degree**
- **44% Master's Degree**
- **8% Bachellor**
- **8% Technician**

Headquarters

Poligono Ugaldeguren III
Zamudio (Bilbao)

R&D Center

Parque Tecnológico
Zamudio (Bilbao)

AWF

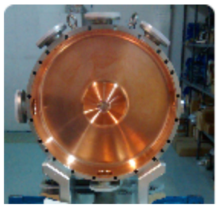
Polígono Industrial Júndiz
Vitoria-Gasteiz

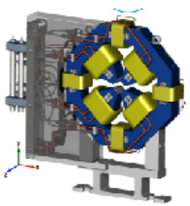
Madrid Satellite

Instituto de Fusión Nuclear
Madrid

Contributions to ESS

MEBT



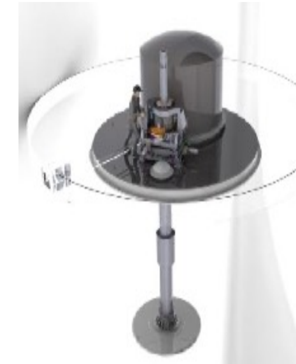


Accelerating element: complete subsystem that goes after the RFQ and integrates: design, manufacturing, diagnostics, control, assembly and testing.

RF Systems


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

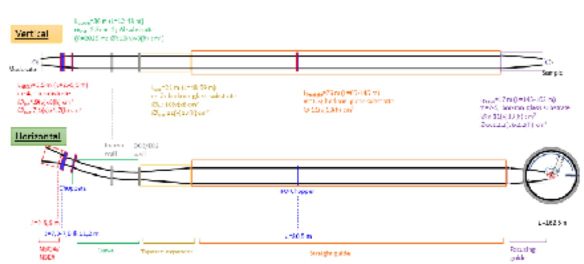
TARGET

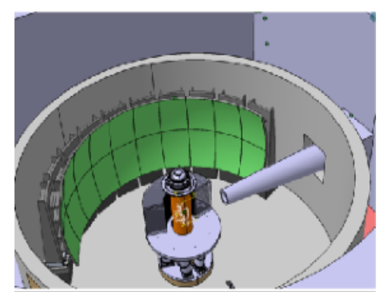


Internal structures (SS-316L)


The spallation process takes place when the accelerated proton beam hits the Tungsten bricks of the 11-tonne target wheel. This will produce neutron brightness for scientific experiments across multiple disciplines.

MIRACLES INSTRUMENT





Time-of-Flight backscattering instrument for polymer science, energy materials, and magnetism studies.
Prime contractors: design, manufacturing, assembly &cold commissioning

EUROPEAN SPALLATION SOURCE

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

EUSKO JAURLARITZA GOBIERNO VASCO

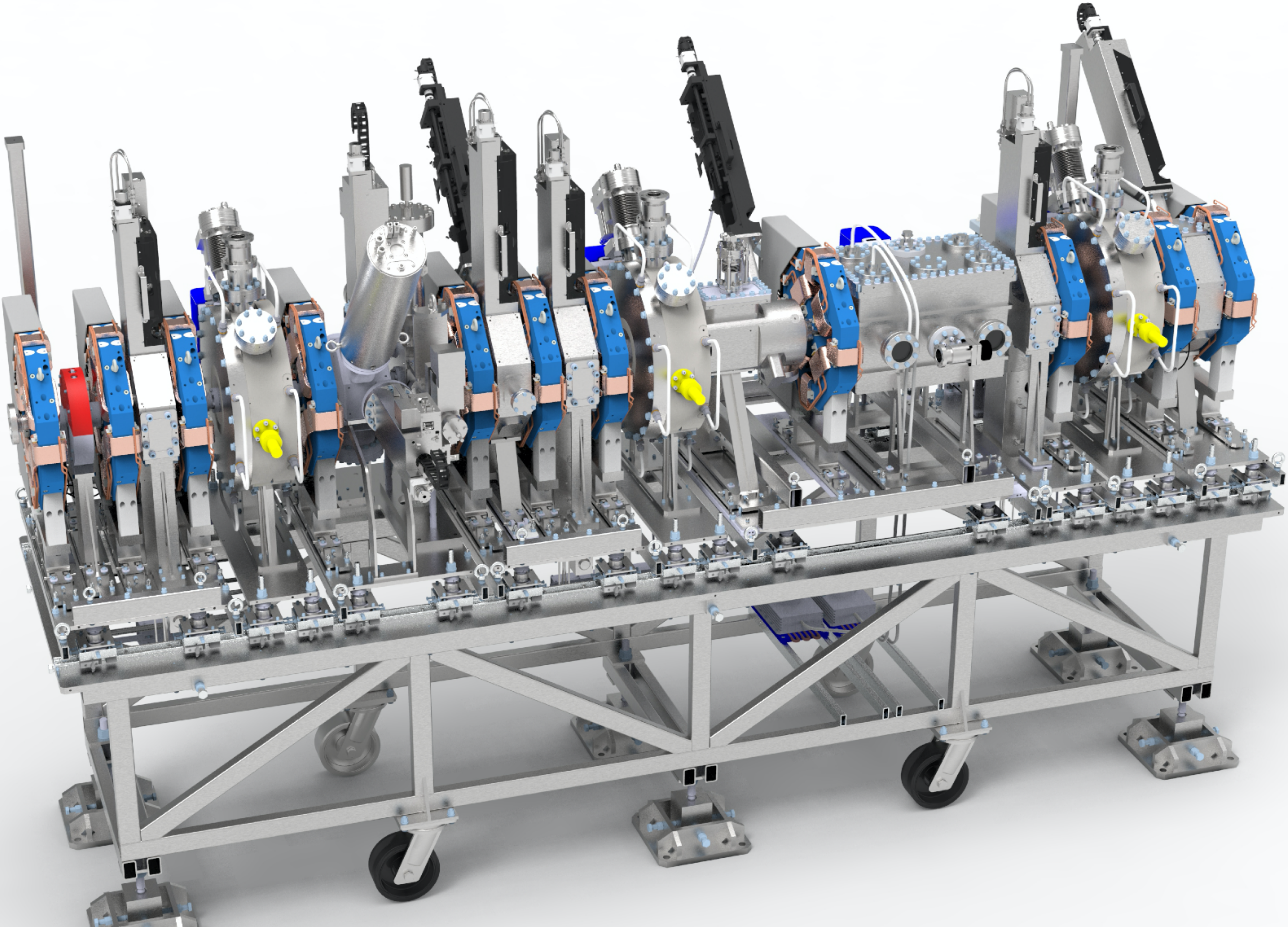
Capabilities in the Beam Line

Our team is made of many different disciplines, from beam dynamics, magnet design, RF cavities design, RF characterisation, RF conditioning, control integration and beam commissioning,…

In the next years we will still be focused in finalising the contribution to ESS.

With the build up experience we will keep upgrading the Bilbao accelerator from 45 KeV up to 3 MeV.

EUROPEAN SPALLATION SOURCE



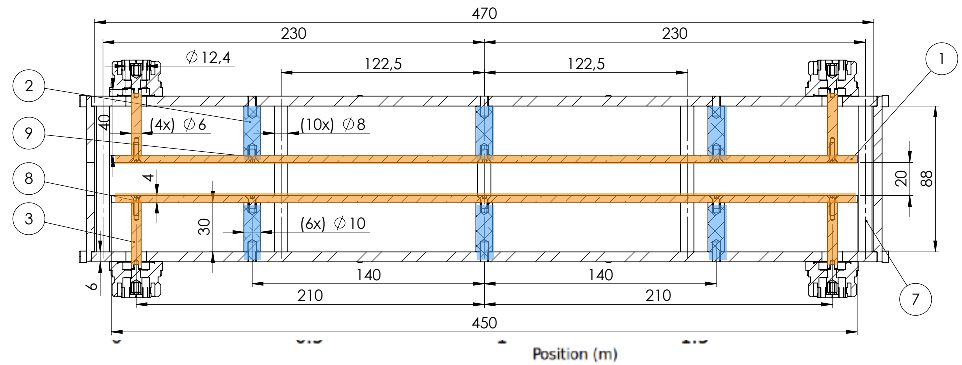
Courtesy of Thomas Grandsaert

FAST KICKER

Regular Pulser In-factory acceptance tests. Including effects of employed load, jitter, cable length, etc. Overall, performance is promising.

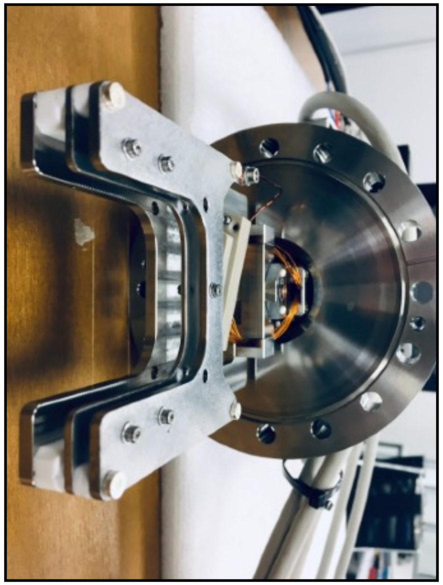
Chopper Strip-line: Components delivered to ESS-Bilbao, acceptance tests performed. Low voltage RF measurements performed: Rise time and fall time contribution of the SL, the jitter between positive and negative cells, reflection and insertion parameters and flat top amplitude loss meet the requirements with margins.

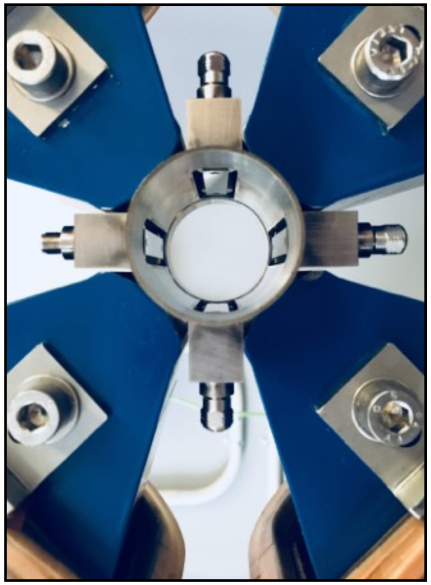
Combined system (pulser and strip-line chopper)
Rise time total (10%-90%): 5.73 ns
(requirement 10 ns)



Diagnostics Systems

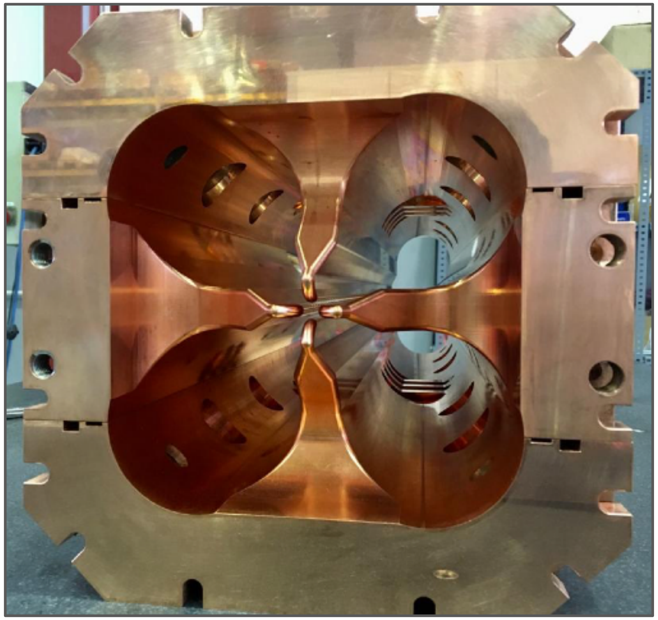
Design, development, fabrication, test and implementation of the beam instruments to characterise and monitor the accelerator beam parameters. This includes the precise diagnostics for beam position monitors (Strip-lines, Buttons), beam current measurements (ACCT, FCT, Faraday cup), beam profile and emittance measurement systems. Depending on the functionality, these diagnostics compose of interceptive and non-interceptive devices to be installed in the accelerator beam line. The rang of environment pressure extends from in-air to ultra high vacuum (UHV) diagnostics devices.

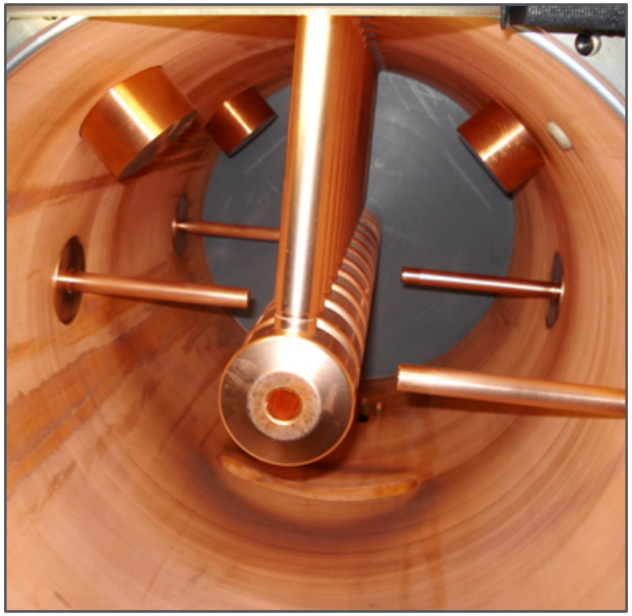




Beam Dynamics and Accelerator Structures

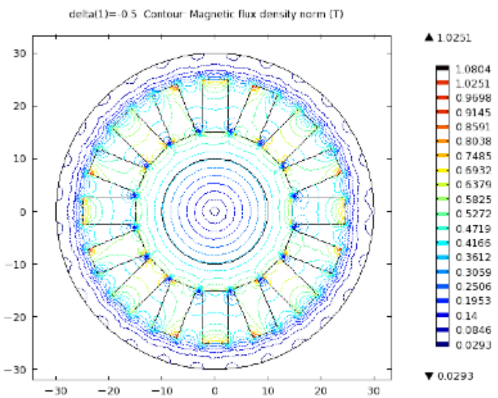
Design, fabrication and testing of accelerating structures has been carried out by ESS-Bilbao for different projects and institutions, also with different levels of involvement. To cite the most relevant activities: design, fabrication and installation of the MEBT line for ESS (Lund); design, fabrication and operation of the injector for ESS-Bilbao linac (ion source, LEBT and RFQ), the RFQ is a local design currently under testing and fabrication; collaboration with CERN Linac4 DTL; extensive experience in computational design and simulation (FEM, beam dynamics) of NC and SC cavities.

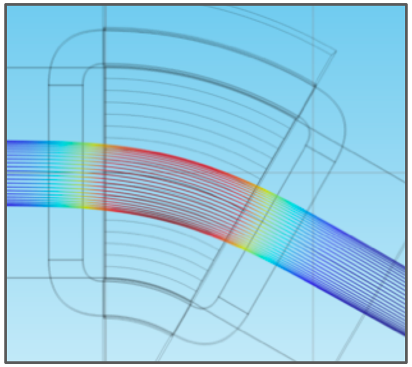


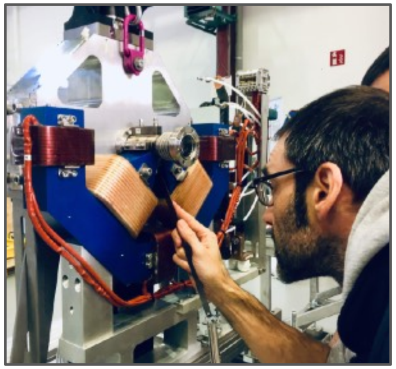


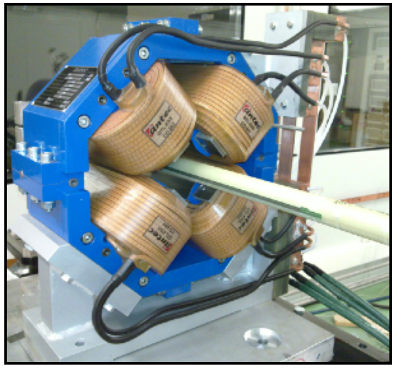
Magnets (warm)

Broad experience in different types of magnets, Permanent Magnet Quadruples, solenoids and Quadrupoles, from the early conceptual designs, detailed design, simulation, and validation, collaborating with local manufacturers.









Ecosystem

IHS
AMETS S.L.
tecnalia Inspiring Business
PROACTIVE R&D
ELYTT ENERGY
CFAA
avs
IK4 TEKNIKER Research Alliance
the vacuum projects
Baikor2k Mecanizados
BASQUE CENTER FOR MATERIALS, APPLICATIONS & NANOSTRUCTURES ehugroup
BCMATERIALS
mufer
Jema Irizar Group innovative energy
BTESA BROAD TELECOM
MANCISIDOR
swisslan precision machining
doilan Committed to Precision
UPV EHU eman ta zabal zazu
ARILAN
TTi Tecnologías de Telecomunicaciones e Información
INMEPRE, S.A. INDUSTRIAS MECÁNICAS DE PRECISIÓN
NORTEMECANICA, S.A.
SGS
DMP Egile
cadinox
ThuneEureka
antec®

Expression of interest

8.3.4 Extraction line

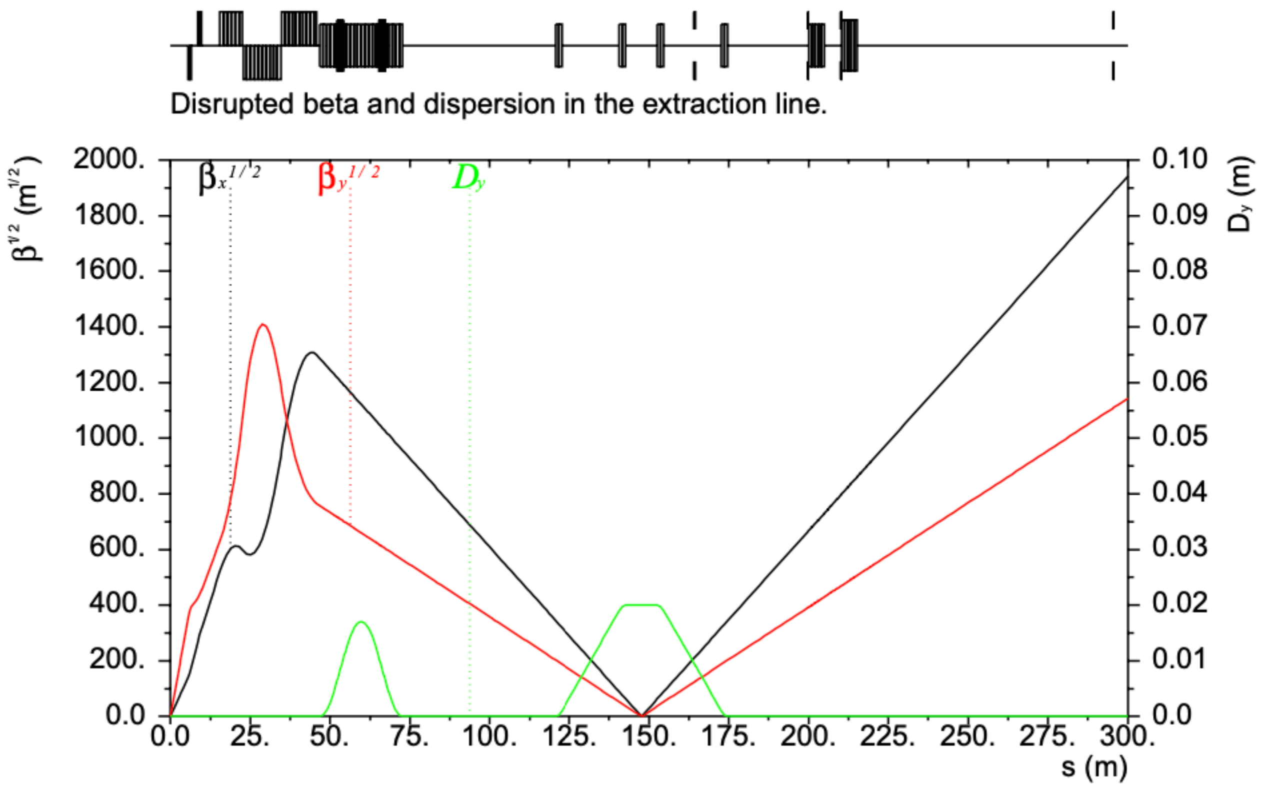
The ILC extraction line [167,168] has to transport the beams from the IP to the dump with acceptable beam losses, while providing dedicated optics for beam diagnostics. After collision, the beam has a large angular divergence and a huge energy spread with very low-energy tails. It is also accompanied by a high-power beamstrahlung photon beam and other secondary particles. The extraction line must therefore have a very large geometric and energy acceptance to minimise beam loss.

The optics of the ILC extraction line is shown in Fig. 8.4. The extraction line can transport particles with momentum offsets of up to 60 % to the dump. There is no net bending in the extraction line, which allows the charged-particle dump to also act as a dump for beamstrahlung photons with angles of up to 0.75 mrad.

The first quadrupole is a superconducting magnet 5.5 m from the IP, as shown in Fig. 8.7. The second quadrupole is also superconducting, with a warm section between their cryostats. The downstream magnets are normal conducting, with a drift space to accommodate the crab cavity in the adjacent beamline. The quadrupoles are followed by two diagnostic vertical chicanes for the energy spectrometer and Compton polarimeter, with a secondary focal point in the centre of the latter. The horizontal angular amplification (R_{22}) from the IP to the Compton IP is set to -0.5 so that the measured Compton polarisation is close to the luminosity weighted polarisation at the IP. The lowest-energy particles are removed by a vertical collimator in the middle of the energy chicane. A large chromatic acceptance is achieved through the soft D-F-D-F quadruplet system and careful optimization of the quadrupole strengths and apertures. The two SC quadrupoles are compatible with up to 250 GeV beam energy, and the warm quadrupoles and the chicane bends with up to 500 GeV.

Expression of interest

Figure 8.4
Disrupted β-functions and dispersion in the extraction line for the nominal 250 GeV beam.



Parts

- **17 MW Main Beam Dump**
    - Fast Sweepers
    - Polarimeter
    - Energy spectrometer
    - Collimators
    - SC Crab Cavities
    - Superconducting Magnets
    - Normal conducting Magnets
- **400 kW TuneUp Dump**
    - Fast sweepers
    - Rastering kickers
    - Compton polarimeter
    - Superconducting Magnets
    - Normal conducting Magnets

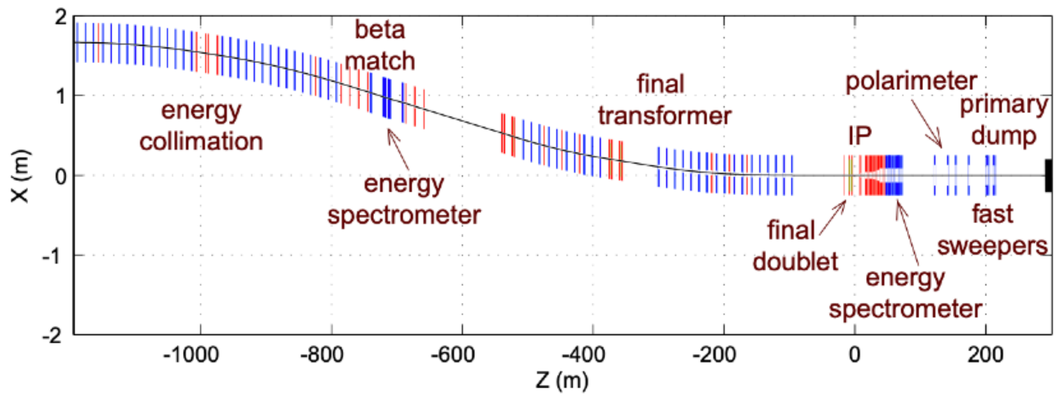
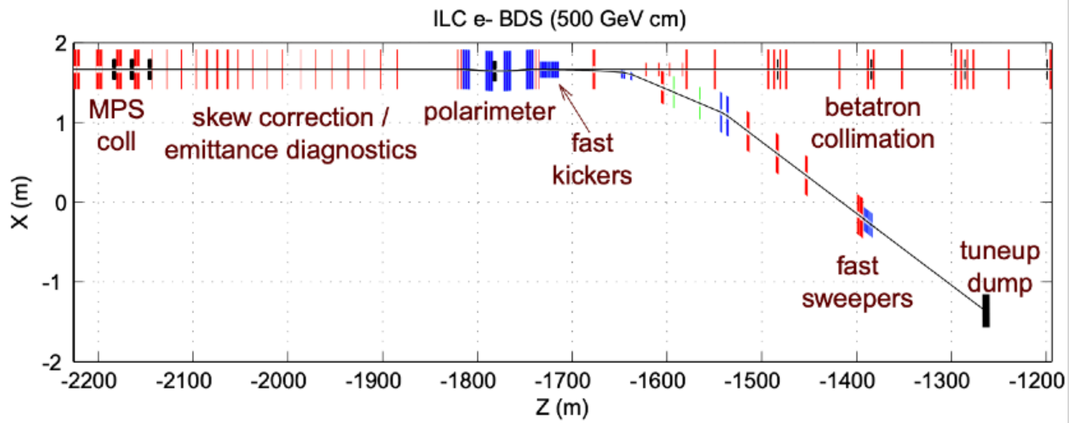


Figure 8.1. BDS layout showing functional subsystems, starting from the linac exit; X – horizontal position of elements, Z – distance measured from the IP.

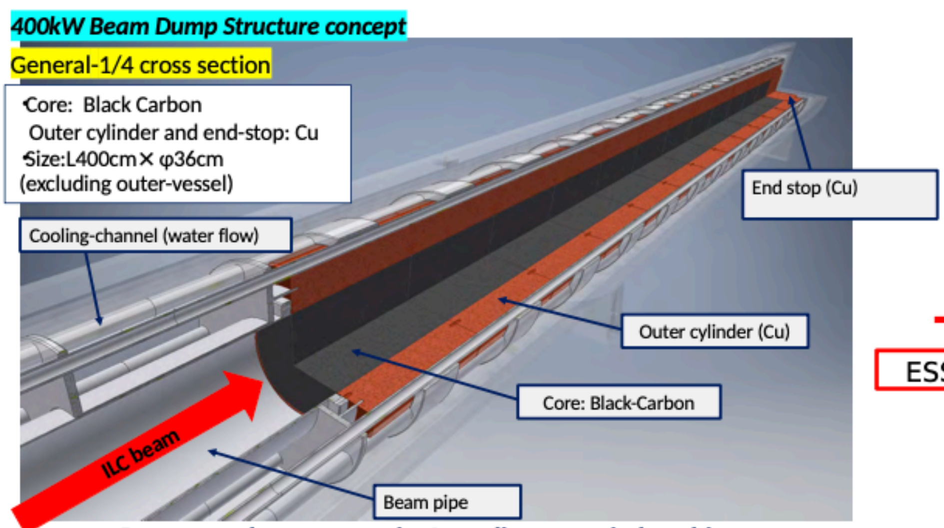


Beam Tuning Dump, 400 kW

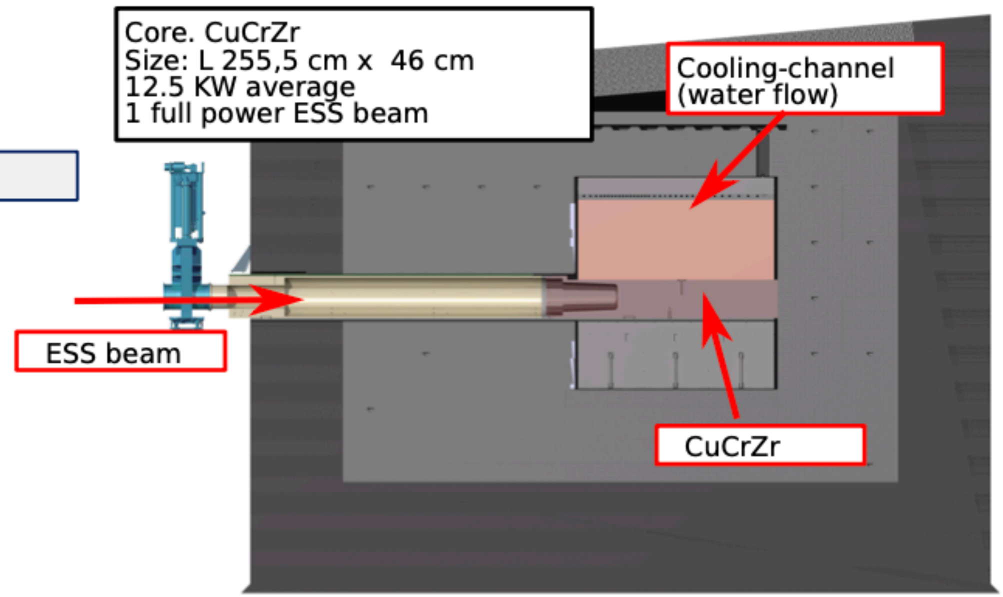
Comparison between ILC-ML and ESS TBD

There is a significant difference in total power (12.5 kW vs 400 kW) but considering the different penetration range of the particles the difference decreases (0.25 kW cm^{-1} vs 1.3 kW cm^{-1}). The main dimensions of the equipment are comparable.

Conceptual design



- **Beam envelope: swept in 4 cm diameter circle orbit.**
- **to be used also for beam abort.**



Beam Tuning Dump, 400 kW

Auxiliary equipment

Auxiliary equipment is mainly drive by the level of radiation (shielding) and the dimensions of the equipment. Technical solutions for both system will be similar.

Auxiliary equipment (Shielding, installation tools and cooling loop)

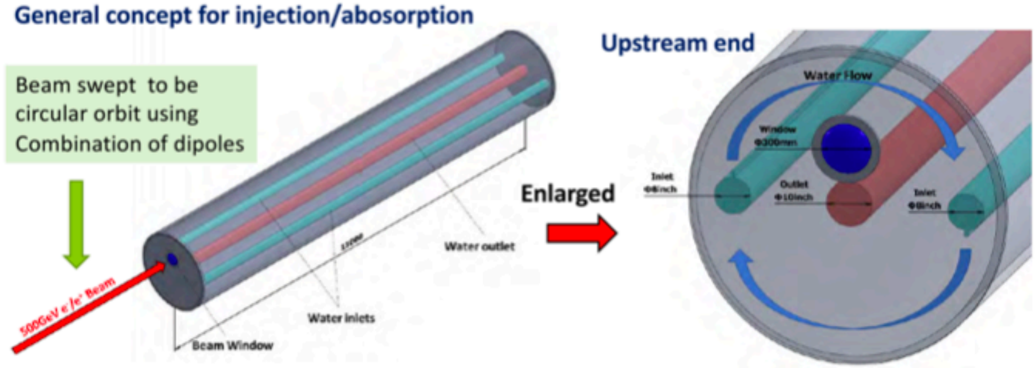
Main Beam Dump 17 MW

Comparison between ILC MBD and ESS Target

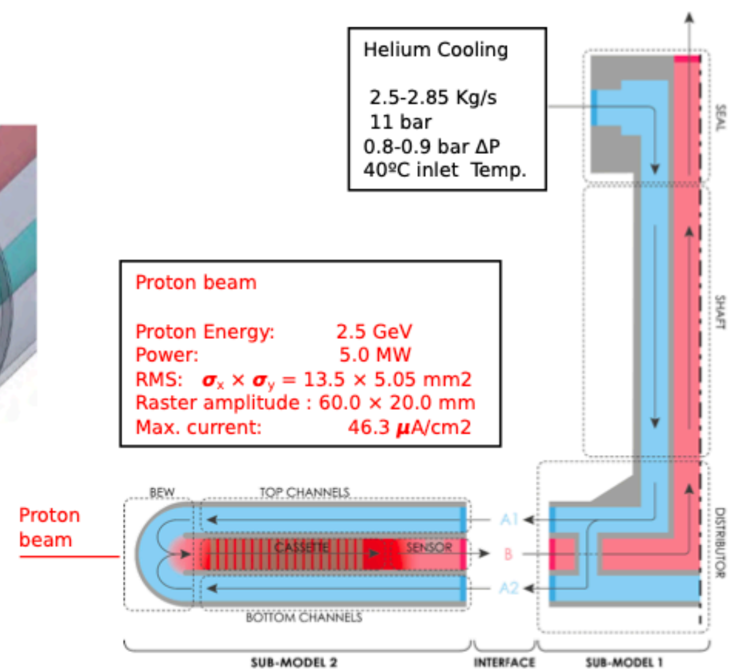
The total power of ILC MBD and ESS Target seams is similar (17 MW vs 5 MW). However the specific heat load is several orders of magnitude larger on ESS Target (71 kW cm^{-1} (2 kW cm^{-1} considering rotation) vs 0.0011 kW cm^{-1})

Conceptual design

ILC-ML Beam Dump Overview



- **Design for the highest power (17 MW including contingency, at 500+500 GeV) to be absorbed, and to be cooled.**
- **Water absorber and forced convection/flow cooling for removing power.**
  - * Water pressure, 1 MPa at boiling temperature 180°C
  - * Screwing forced flow: mass flow rate: 104.5kg/sec each inlet, velocity: 2.17m/sec
- **Beam window** using Ti alloy **(Ti-6Al4V)**
  - * Bulkhead, ϕ300mm × t5mm, and **injection** with beam sweeping.

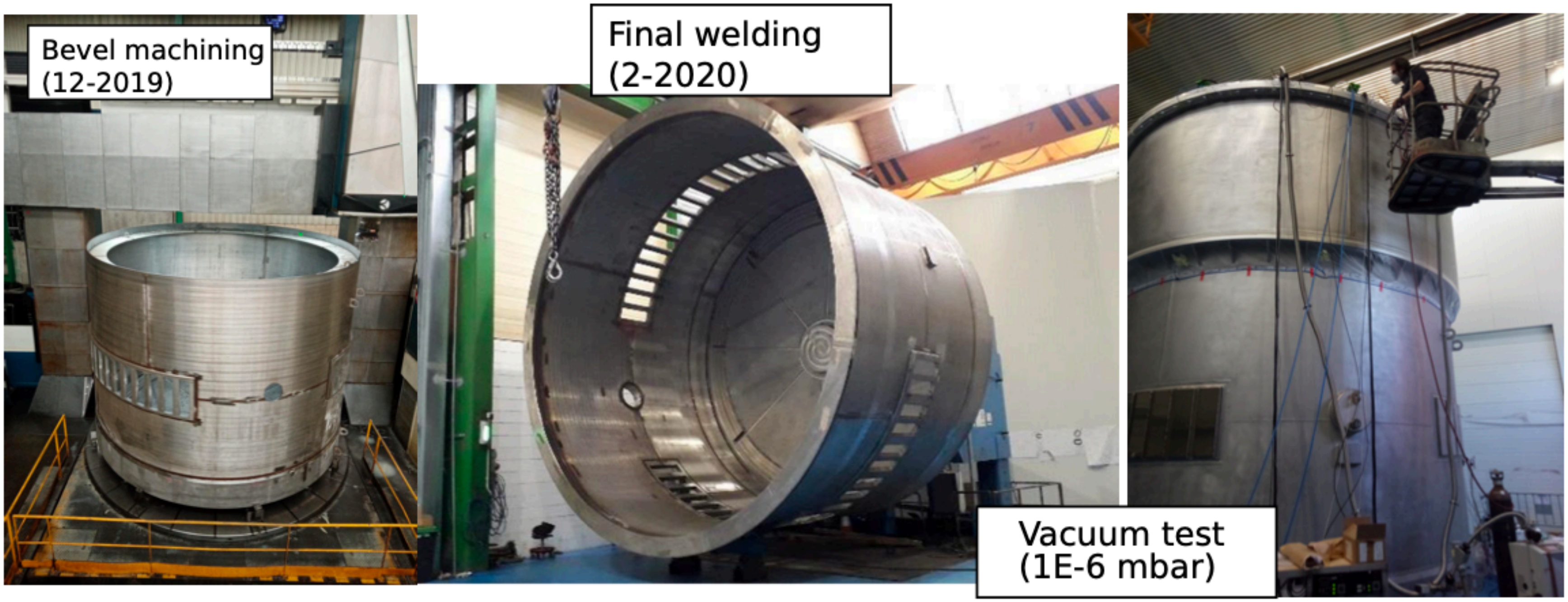


Main Beam Dump 17 MW

Comparison between ILC MBD and ESS Target

They is a large difference in volume between ILC MBD and ESS Target thus probably it is not comparable. However, the component is similar to ESS monolith vessel (6 m in diameter, 8 m in hight). ESS Monolith vessel is manufacture on stainless steel

Conceptual design



Conclusions

400 kW Tuning Beam dump

- LC-ML and ESS TBD shows significant similarities.
- Auxiliary equipment will be analogous.
- Sizes of the equipment, manufacturing processes and critical technologies will be common.

17 MW Main Beam dump

- ILC-MBD is not similar to ESS Target due to the differences on cooling fluid, volumetric heat load, rotation, volume etc.
- It could like a combination between ESS monolith vessel and proton beam window technologies.
- There are common technologies on radiation protection, activation, manufacturing for nuclear equipment, etc.

Accelerator components

- Normal conducting and super conducting magnets can be designed in-house, manufactured by local companies and validated in partner labs.
- Similar previous developments have been delivered like *Fast sweepers*, *Rastering kickers*, *Compton polarimeters* but it needs further study.

Summary

Introduction:

The ILC extraction line has to transport the beams from the IP to the dump with acceptable beam losses, while providing dedicated optics for beam diagnostics.

Schedule and Cost Estimate:

100 M€

OPIs / Participants:

ESS Bilbao, Collaborations foreseen with: ALBA and IFIC

Spanish Companies Expertise:

Magnets, Power supplies, Beam dump, ancillaries, shielding, water cooling system, Remote handling engineering.