MEBT Overview

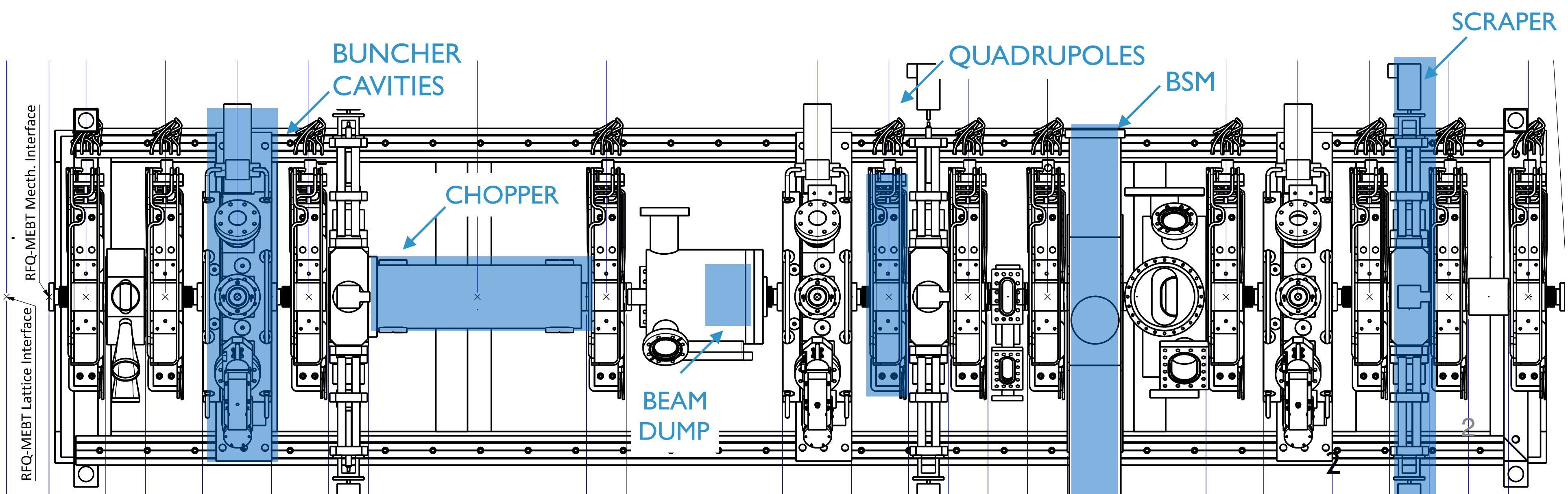
BIF October 2016, Bilbao

I. Bustinduy, on behalf of ESS-Bilbao Team

Scope of work

ESS-BILBAO team will deliver the complete MEBT for ESS

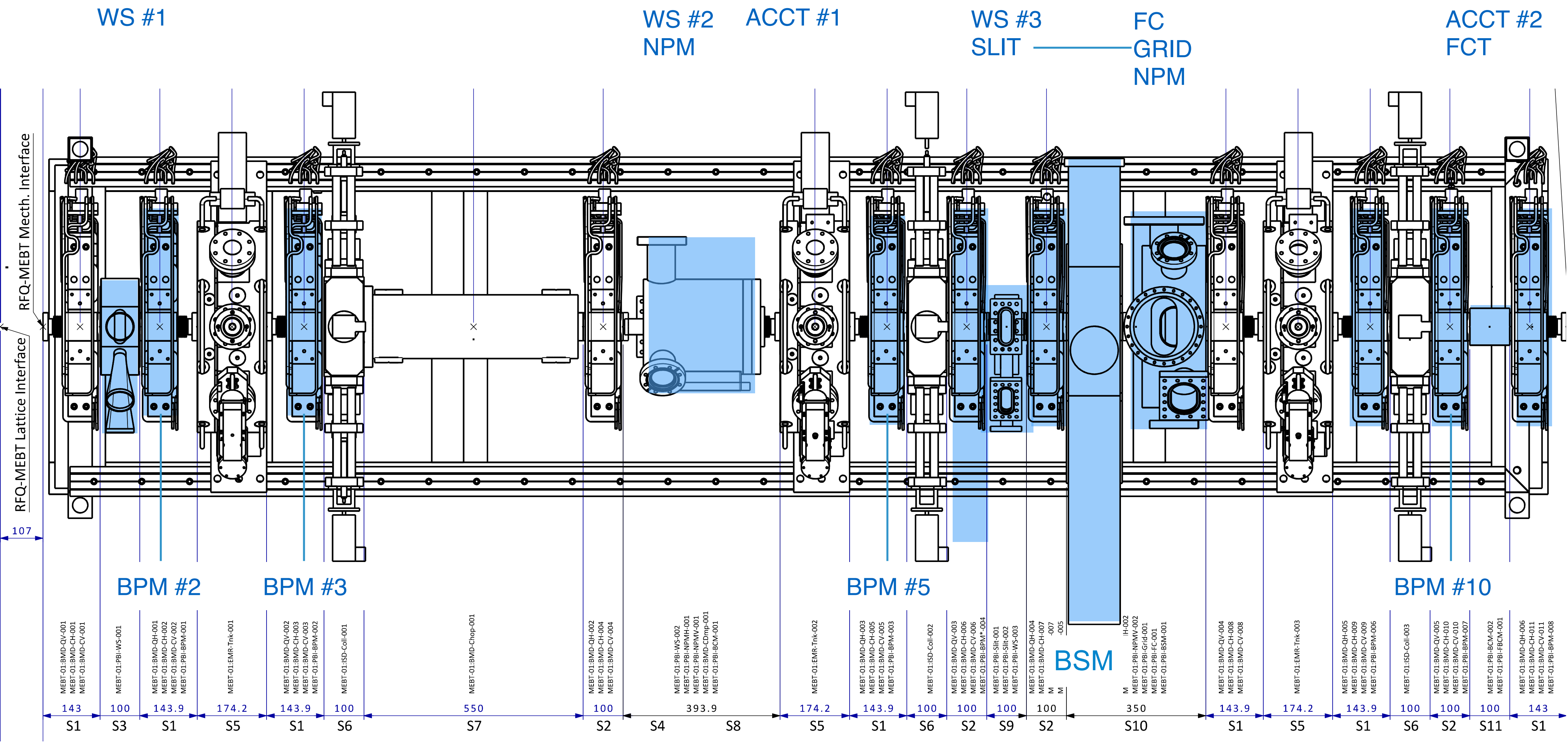
- **Quadrupole** Magnets and their correspondant power supplies
- **RF Buncher** cavities
- **LLRF** system
- High power **RF amplifiers**, and corresponding distribution for MEBT
- **Beam Instrumentation**
- **Vacuum** system
- Mechanical **Support**, pipe and vessels
- Fast **kicker** and beam dump



Instrumentation

Out of scope:

- BSM
- NPM

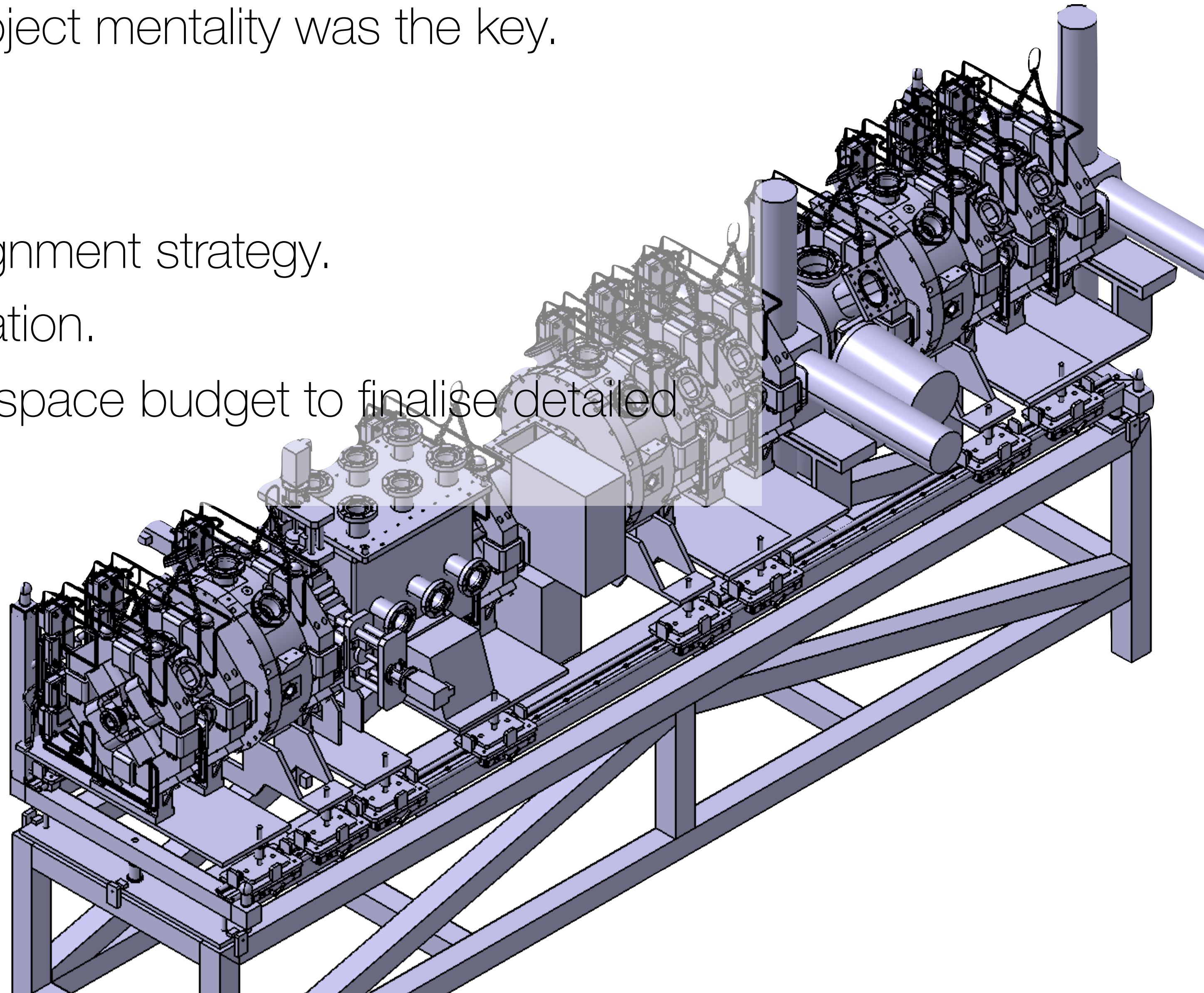


Beam Instrumentation Team

- Angel R. Páramo, FC presenter
- Zunbeltz Izaola, EMU, presenter
- Alvaro Vizcaíno, WS, presenter
- Seadat Varnasseri, BCM/BPM, presenter
- Idoia Mazkiaran, EMU EEE integration
- Alberto Milla, FC EEE integration
- Carlos de la Cruz, EMU & FC Analog stage integration
- Ion Ortega, EMU & FC Analog stage integration
- Valentin Toyos, EMU Grid
- Ander Serrano, Motion Control
- Tomás Mora, Thermo-mech. calculations
- Miguel magán, Thermo-mech. calculations
- Gorka Bakedano, Thermo-mech. calculations
- Igor Rueda, Mech. Integration
- Aitor Zugazaga, Vacuum

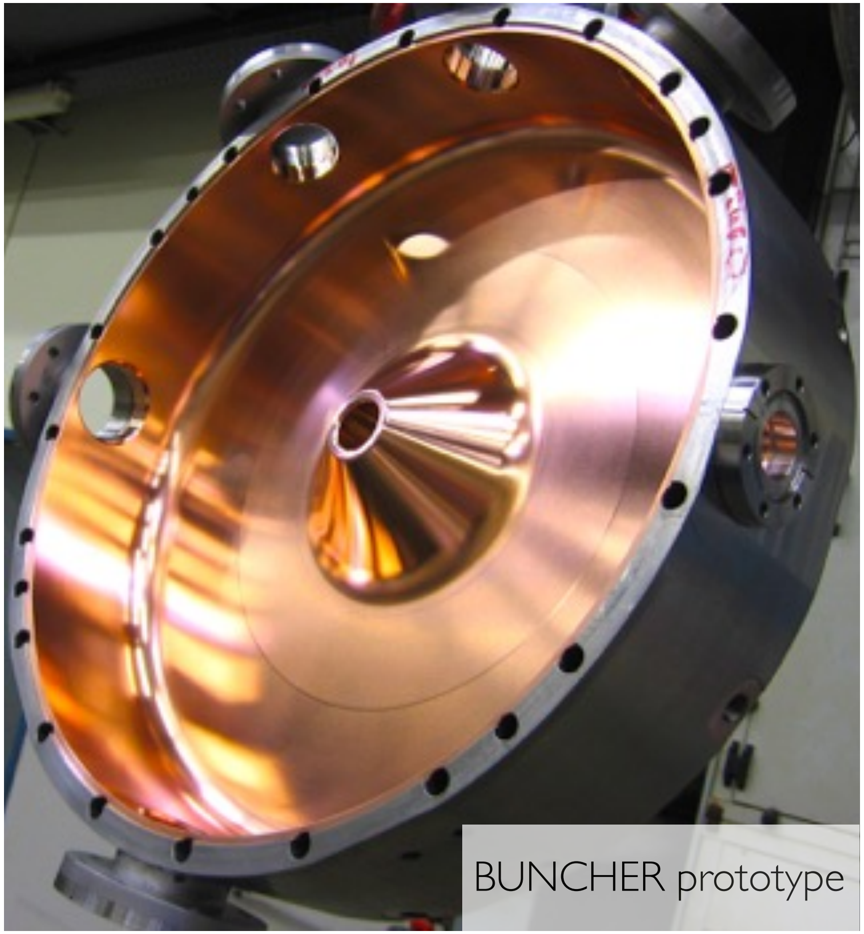
Mechanical Integration

- Deeply entangled problem.
- The adoption of a project mentality was the key.
- Three stage problem:
  - Optical elements.
  - Assembly and alignment strategy.
  - Beam instrumentation.
- Each system has an space budget to finalise detailed design.



RF BUNCHER CAVITY

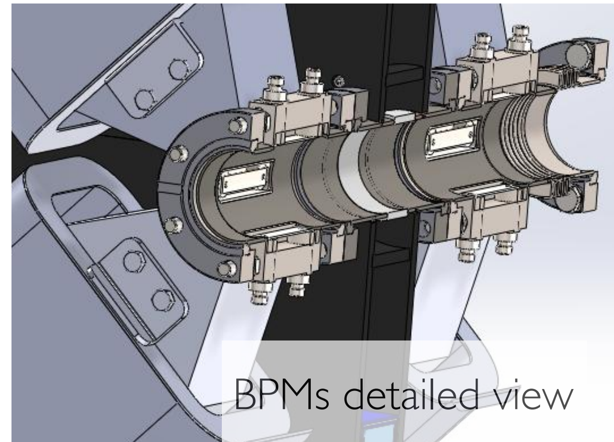
- Layout: Optical design & engineering design.
- For an EoTL≈150kV, get higher ZT^2 with compromise.
- Best diameter and location for the tuners.
- Efficient cooling circuit (max temp. in the "nose cone" is ~194°C).
- Power coupler to hold ~22.5kW peak power.
- 190mm max. length. 136 mm cavity width (vacuum)
- Room-temperature copper, bulk resistivity of 1.7241 **μΩ**-cm.
- Different parametric studies: SUPERFISH (2D), COMSOL (3D), HFSS (3D)
- Prototype designed, manufactured, measured (metrology & RF), and characterised by bead pull.

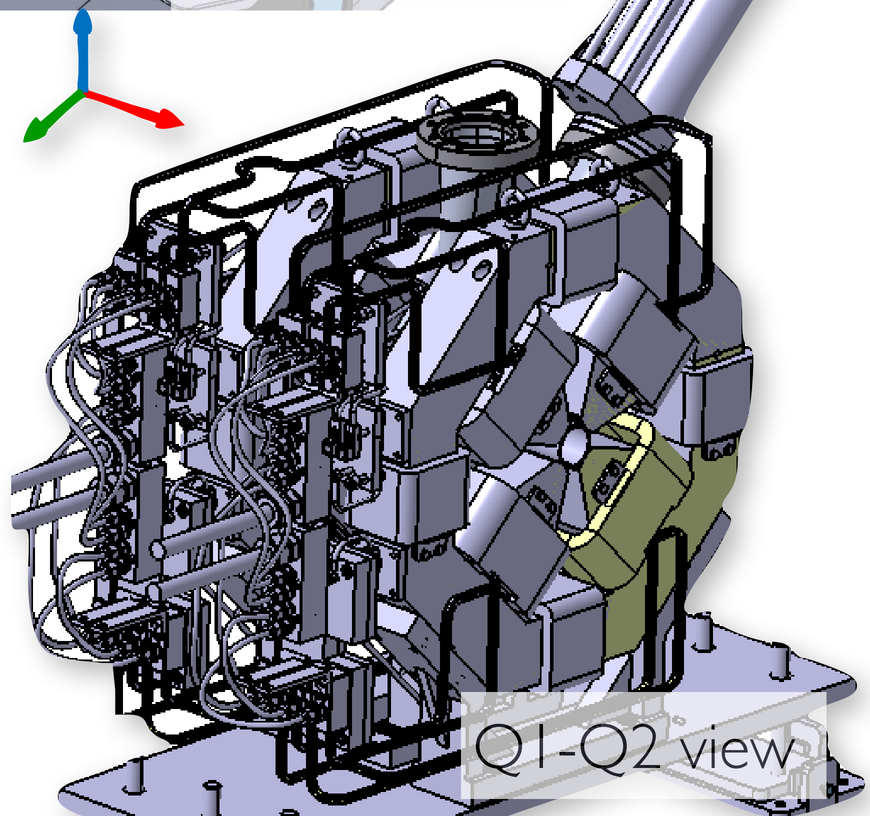


BUNCHER prototype

QUADRUPOLE

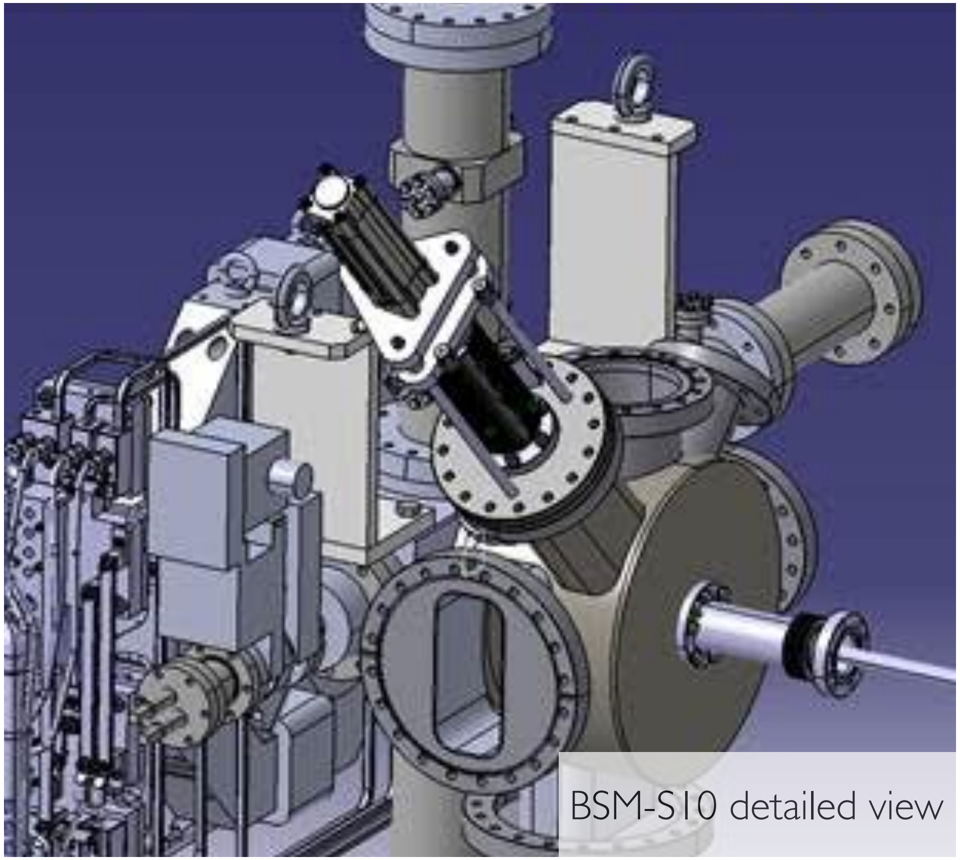
- MEBT needs of 11 Quadrupoles for focusing and steering the beam.
- The magnet series from a unique design to generate the required quadrupole and dipole fields.
- A full magnetic design developed to generate the maximum quadrupole fields plus 10% contingency.
- The magnetic design calculated with ROXIE and COMSOL software throughout a combination of 2D and 3D simulations.
- Design deeply correlated to embedded BPMs.
- Dismountable in 2/4 parts
- PDR held in Feb.2016 (https://indico.esss.lu.se/event/503/)
- Call for tender in progress





Mechanical Integration

- This milestone <u>unlocks</u>:
  - Support Frame.
  - Assembly and Alignment strategy refinement
  - Diagnostics (FC, BPM, EMU, WS, CT) and corresponding boxes detail design.
  - Chopper Beam Dump finalisation.
  - Chopper Vessel
  - Vacuum simulations refinement.

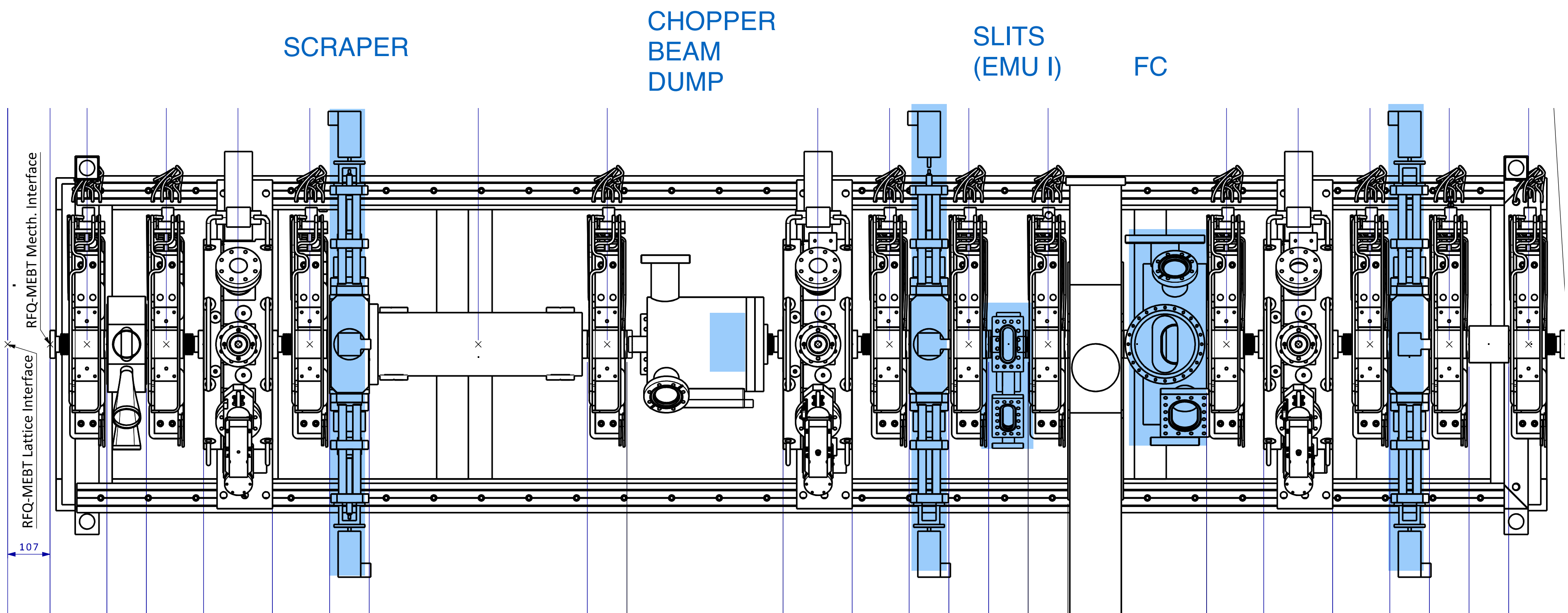


BSM-S10 detailed view

Beam stoppers

Problem Description

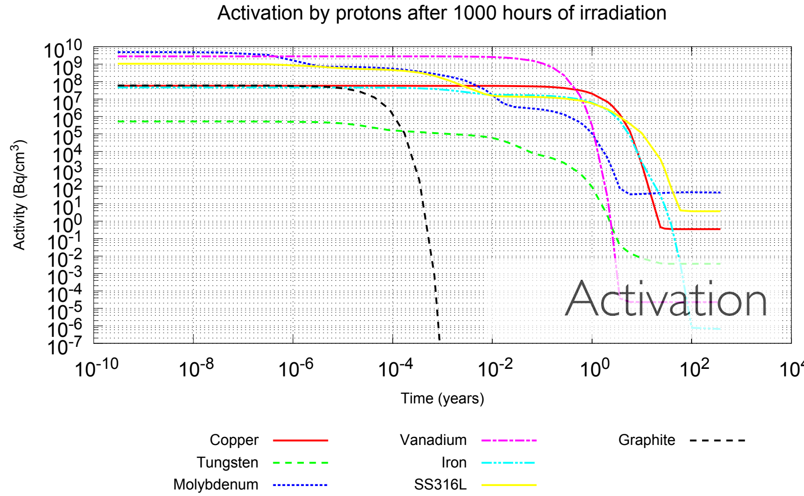
- From the **transient state** calculations, one can infer that this model has to be discarded given the combination of **high power** distributed in a **very concentrated** beam size and a **swallow deposition surface**.
- Please note that current and energy combination result in a **230 kW** peak power which exceeds other MEBTs, SNS peak power **130 kW**, LINAC4, RAL, JPARC (~**180 kW**).
- A limit of proton beam power density per unit of time and area allowed should be identified. This is crucial in order to ensure thermo-mechanical integrity of different interceptive devices along the MEBT.
- I (mA) x W(MeV) x pulse length (μs) x $\sigma_{(x,y)}$ (mm^2)

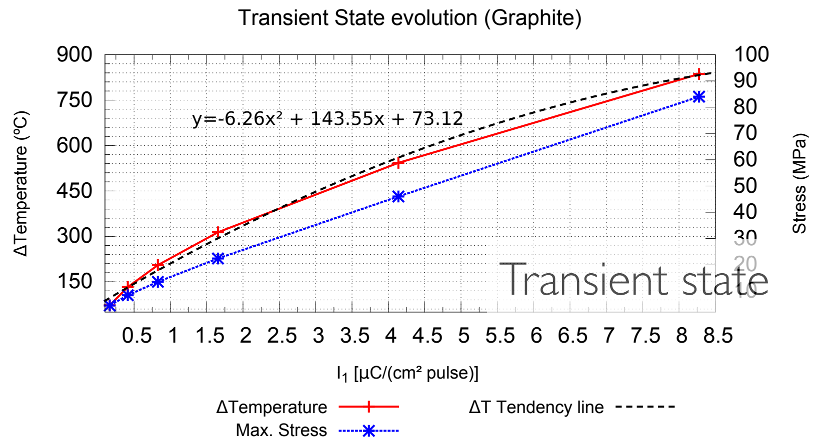


Beam stoppers

The proton beam has to fulfil the **Temperature** and **stress** criteria simultaneously to ensure the thermo-mechanic integrity of the Beam Stoppers.

- Tungsten has a limit of **0.6 μC/(cm²pulse)** and could work with **14Hz**, depending on the cooling conditions.
- Graphite has a limit of **6 μC/(cm²pulse)** and could work with **14Hz**, depending on the cooling conditions.
- Graphite is the best option as Beam Stopper material. The decision of choosing one material will also depend on other aspects:
  - Vacuum conditions and possible problems with the materials in a vacuum environment.
  - Fatigue process resistance.
  - Fabrication process, machining and assembly, etc.



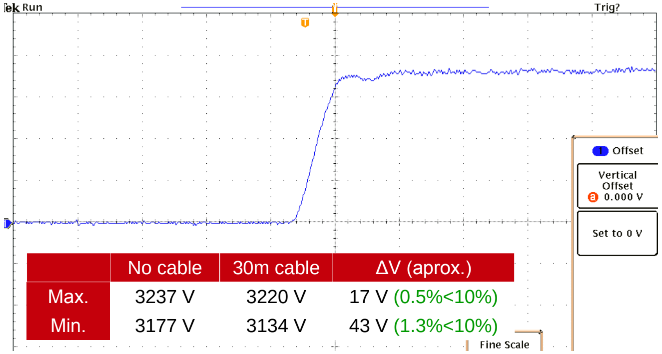


Peak current (mA)	Angle (°)	Beam size		I'' (μA/cm2)	Pulse Length MAX (μs)
		σ_x (mm)	σ_y (mm)		
65	90	2,5	1	4,14E+05	14,5
65	45	2,5	1	2,93E+05	20,5
65	30	2,5	1	2,07E+05	29,0
65	90	2,5	2,5	1,66E+05	36,2
65	45	2,5	2,5	1,17E+05	51,3
65	30	2,5	2,5	8,28E+04	72,5
65	90	5	2,5	8,28E+04	72,5
65	45	5	2,5	5,85E+04	102,5
65	30	5	2,5	4,14E+04	145,0
65	90	7,5	5	2,76E+04	217,5
65	45	7,5	5	1,95E+04	307,6
65	30	7,5	5	1,38E+04	435,0
65	90	7,5	7,5	1,84E+04	326,2
65	45	7,5	7,5	1,30E+04	461,4
65	30	7,5	7,5	9,20E+03	652,5

Exposure Limits

FAST CHOPPER

- The design is based on fast transmission line strips, which the perpendicular electromagnetic fields will deflect the beam in the vertical position.
- The strip-line is designed to match with 50 ohm termination loads, therefore removing the voltage reflections and maximising the power transfer.
- The strip-lines have matched input ports from pulser and matched output ports to the load.
- Chopper Strip-line is based on fast transmission line scheme with overall rise time less than **10 ns** and maximum differential voltage of **5 kV**.



	No cable	30m cable	ΔV (aprox.)
Max.	3237 V	3220 V	17 V (0.5%<10%)
Min.	3177 V	3134 V	43 V (1.3%<10%)


Chopper Stripline

Planning

Rapid prototyping strategy to get a set of successful systems in 2018.

Assembly stage #1 Bilbao (Mechanical assembly of most systems) 15-01-2018

Assembly stage #2 Lund (Verification of all parts).

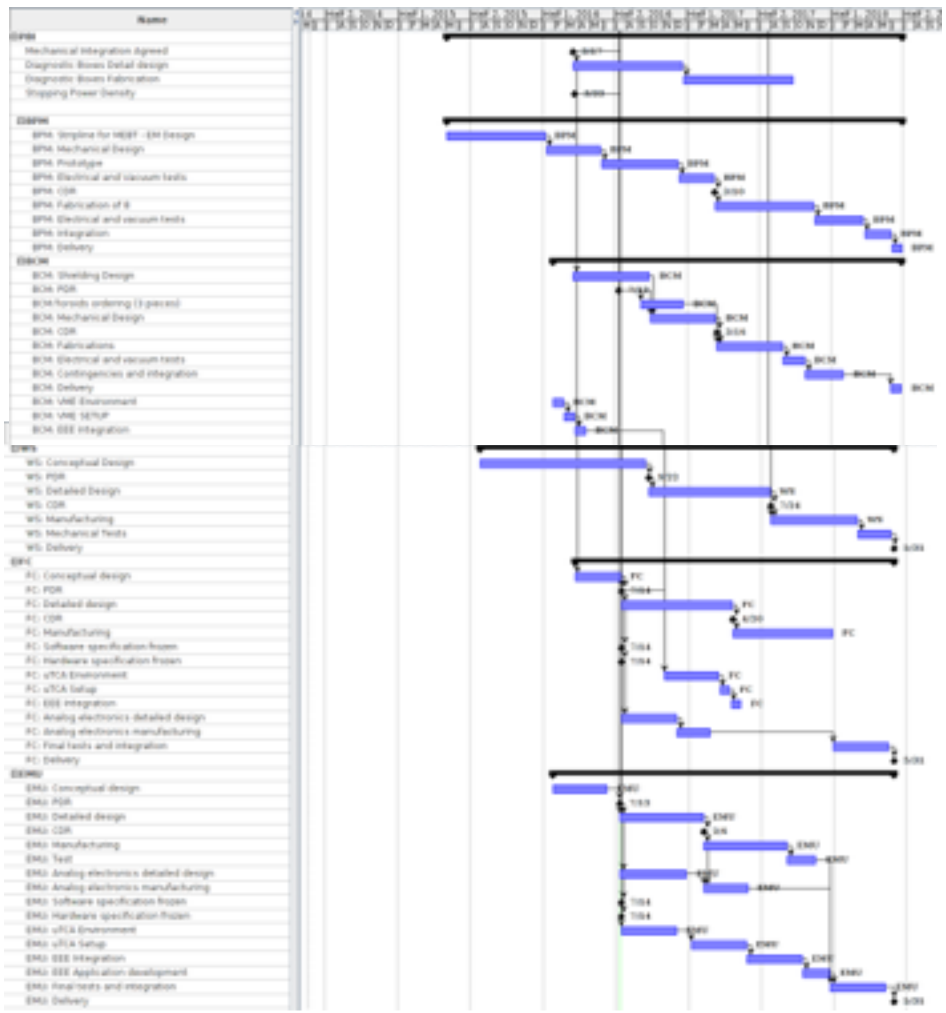
Assembly stage #3 Tunnel (reassembly and final alignment)

Expected times fit well in the overall calendar.

PDR: https://indico.esss.lu.se/event/592/

Each System has a different life-cycle (design, fabrication, testing), it is difficult to merge into 1 single CDR.

- BPM, WS, BCM (Q1 2017)
- FC, EMU (Q2 2017)

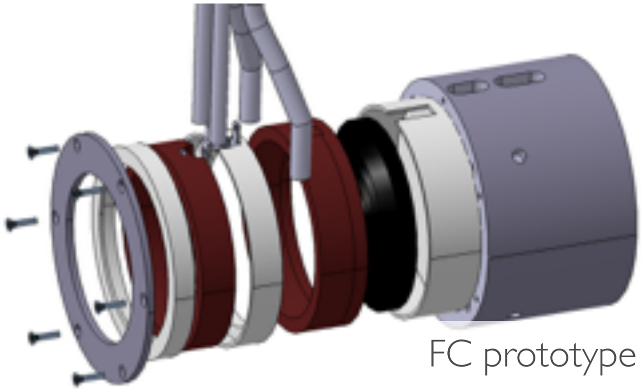


Verification

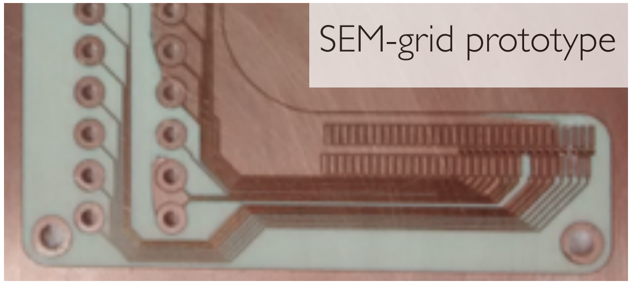
Specific mechanical parts are being prototyped to ensure mechanical tolerances (BPMs)

Electronic boards will be design in-house following standards and tested (for functionality and calibrated).

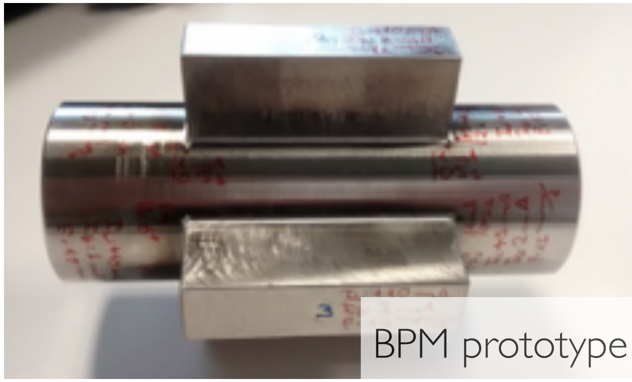
Off the self, standard commercial products will be required to fulfil relevant regulations. For the specific components designed or assembled by ESS-B will be thoroughly tested. These tests will be based on agreed ESS requirements.



FC prototype



SEM-grid prototype



BPM prototype