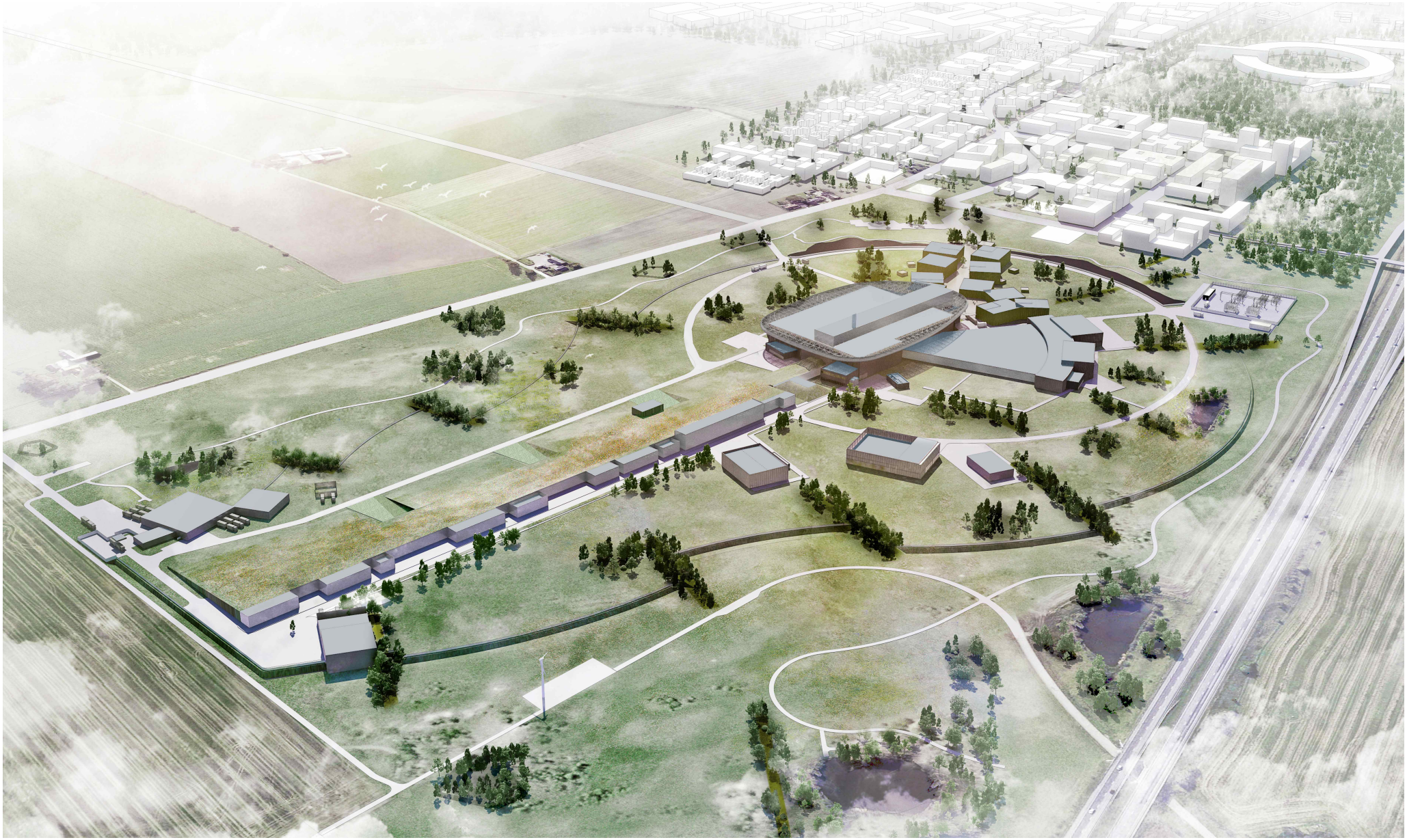
EUROPEAN
SPALLATION
SOURCE

# The ESS Accelerator & Beam Diagnostics

BI Collaboration Meeting,

Australian Synchrotron, 18 March 2015

Andreas Jansson



# Build and operate a 5 MW SCRF linac

Design Drivers:

High Average Beam Power

5 MW

High Peak Beam Power

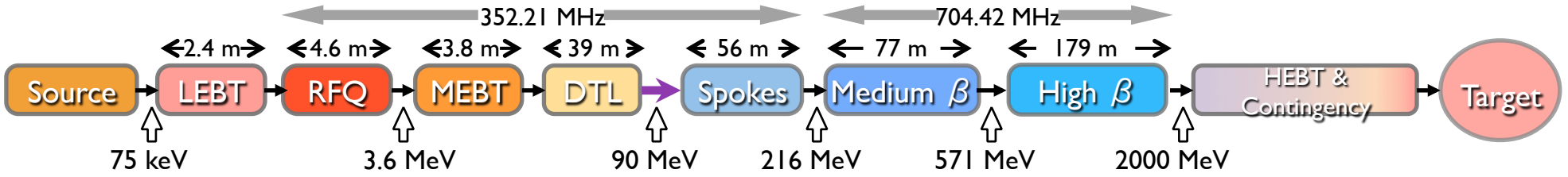
125 MW

High Availability

> 95%

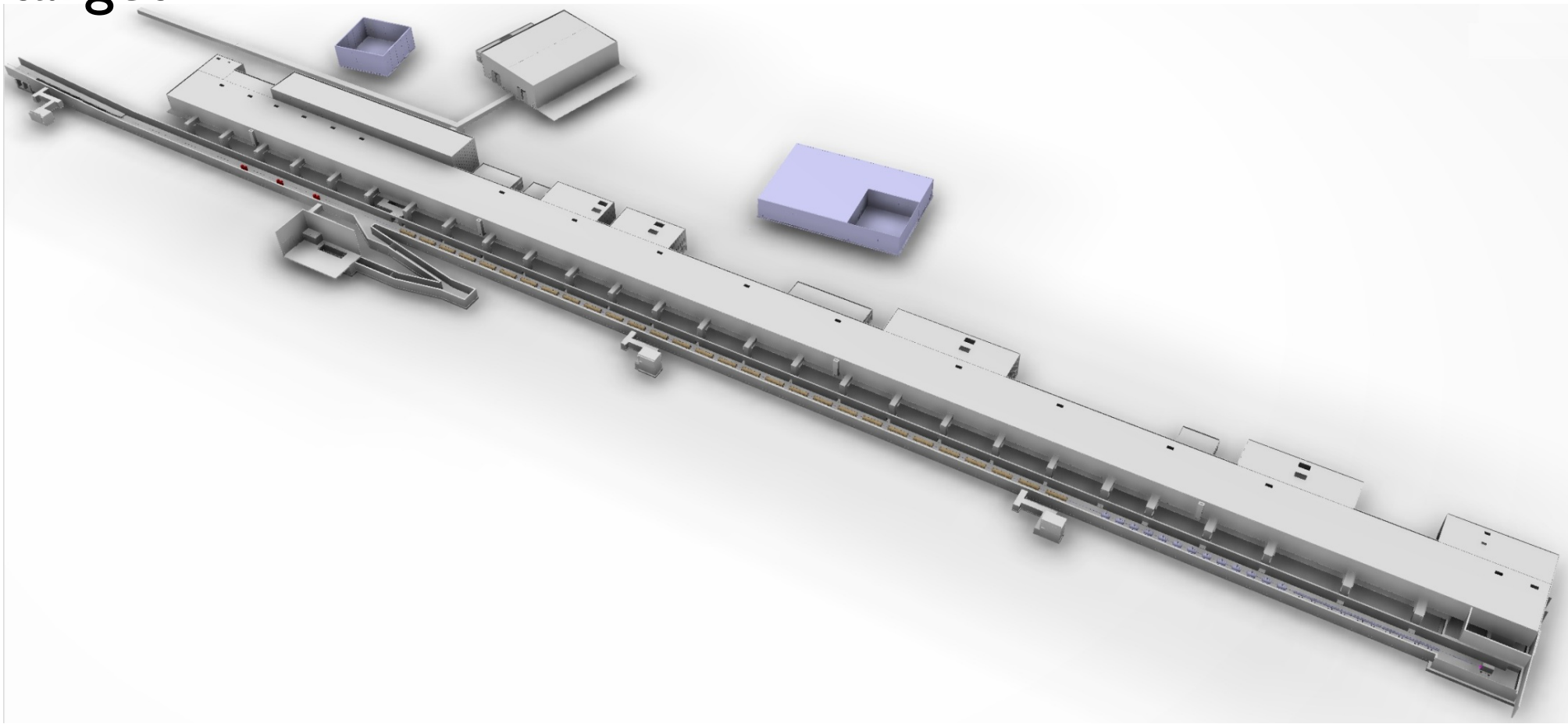
Key parameters:

-2.86 ms pulses
-2 GeV
-62.5 mA peak
-14 Hz
-Protons (H+)
-Low losses
-Minimize energy use
-Flexible design for future upgrades



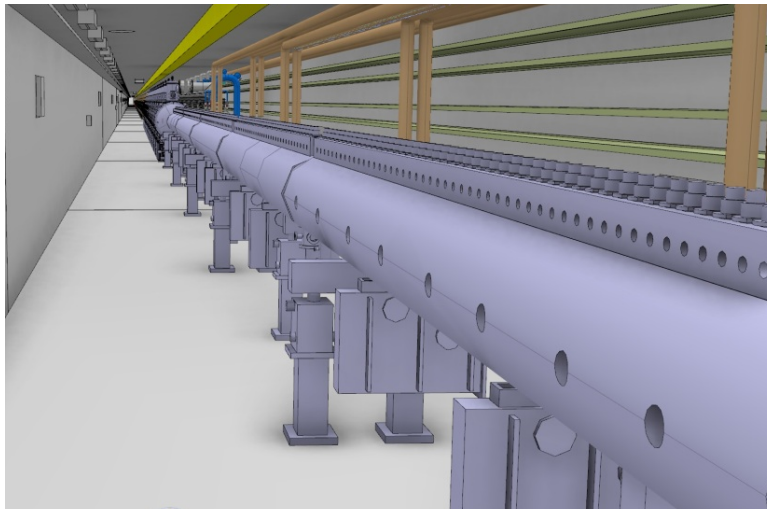
# ESS accelerator buildings

target



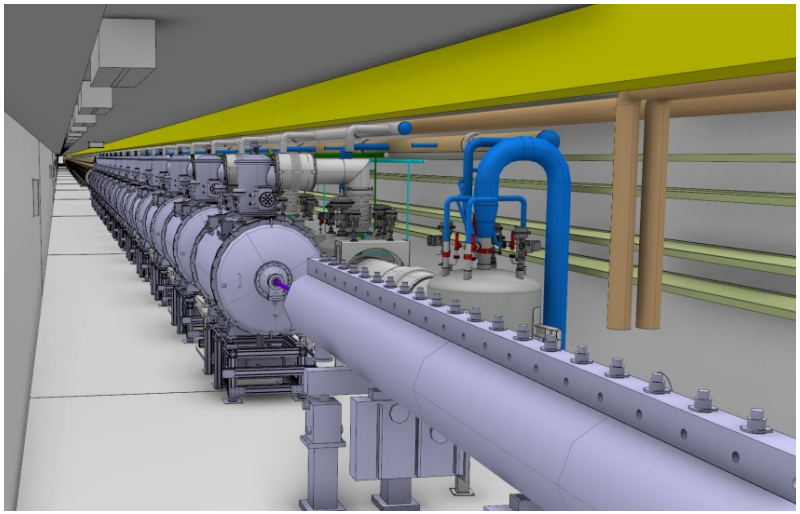
source

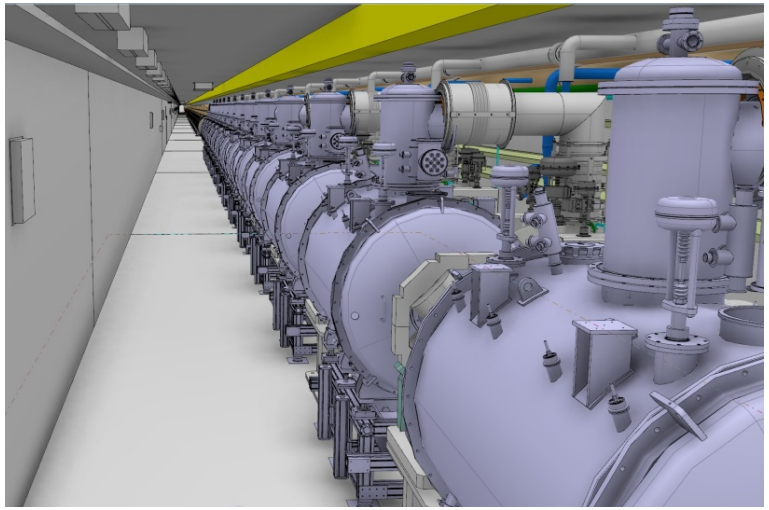
# Accelerator Tunnel (AT) design



← 1. Drift Tube Linac (DTL)

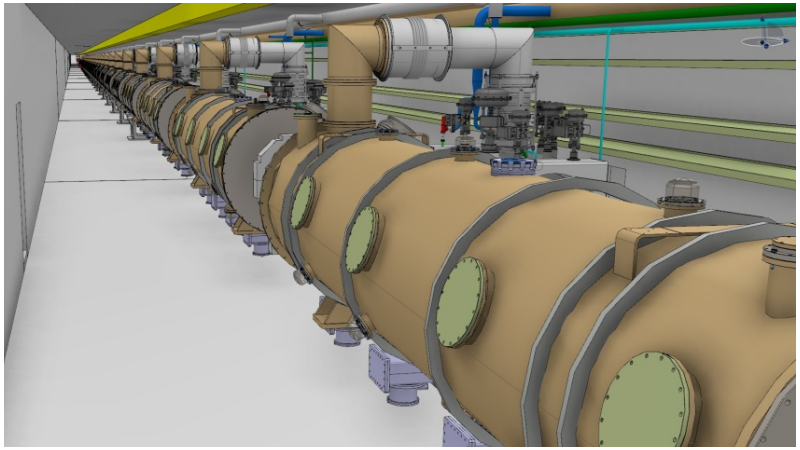
2. DTL to Spoke →



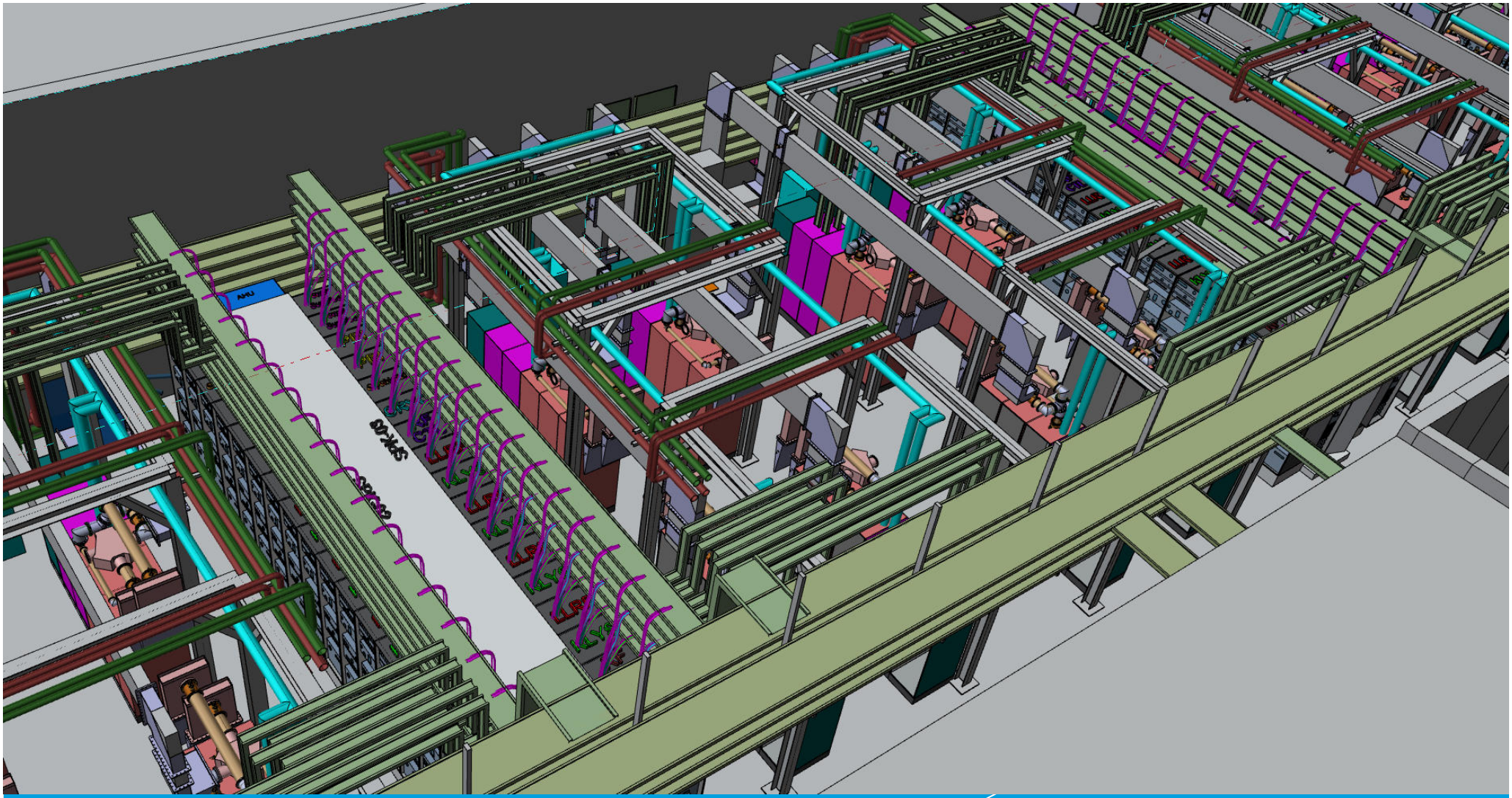


← 3. Spoke

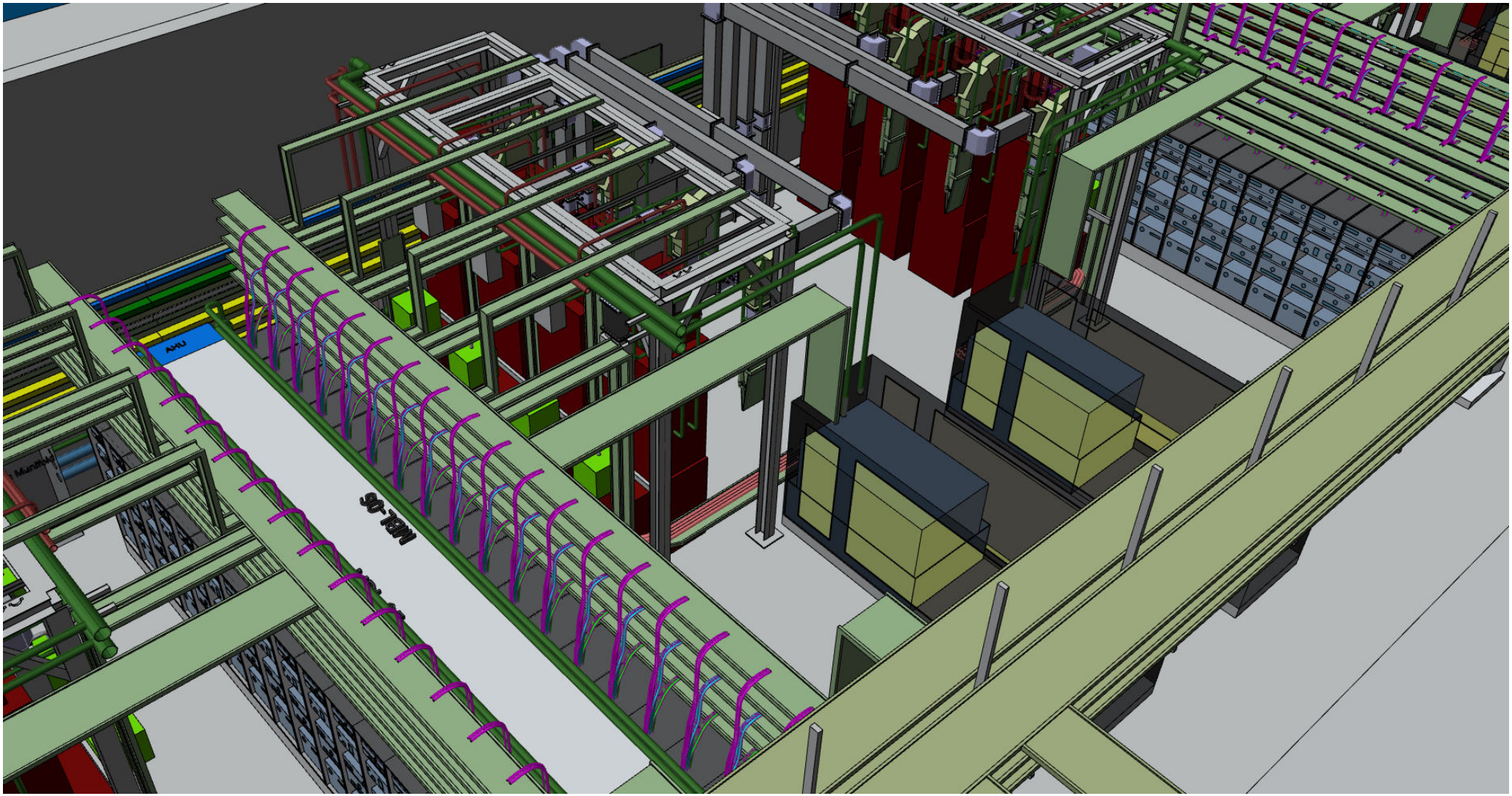
4. Medium Beta → Linac (MBL)



# Spoke

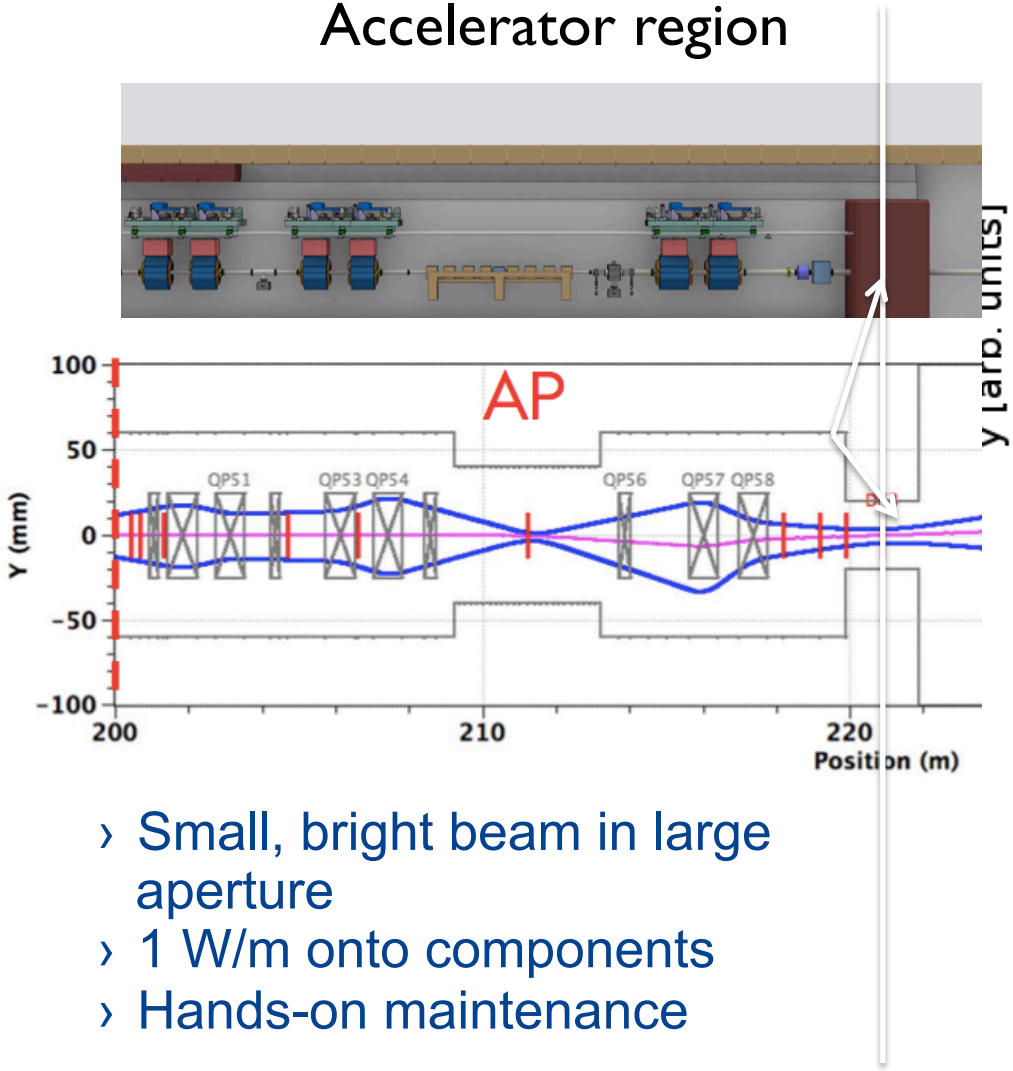


# CAD view of medium/high beta RF

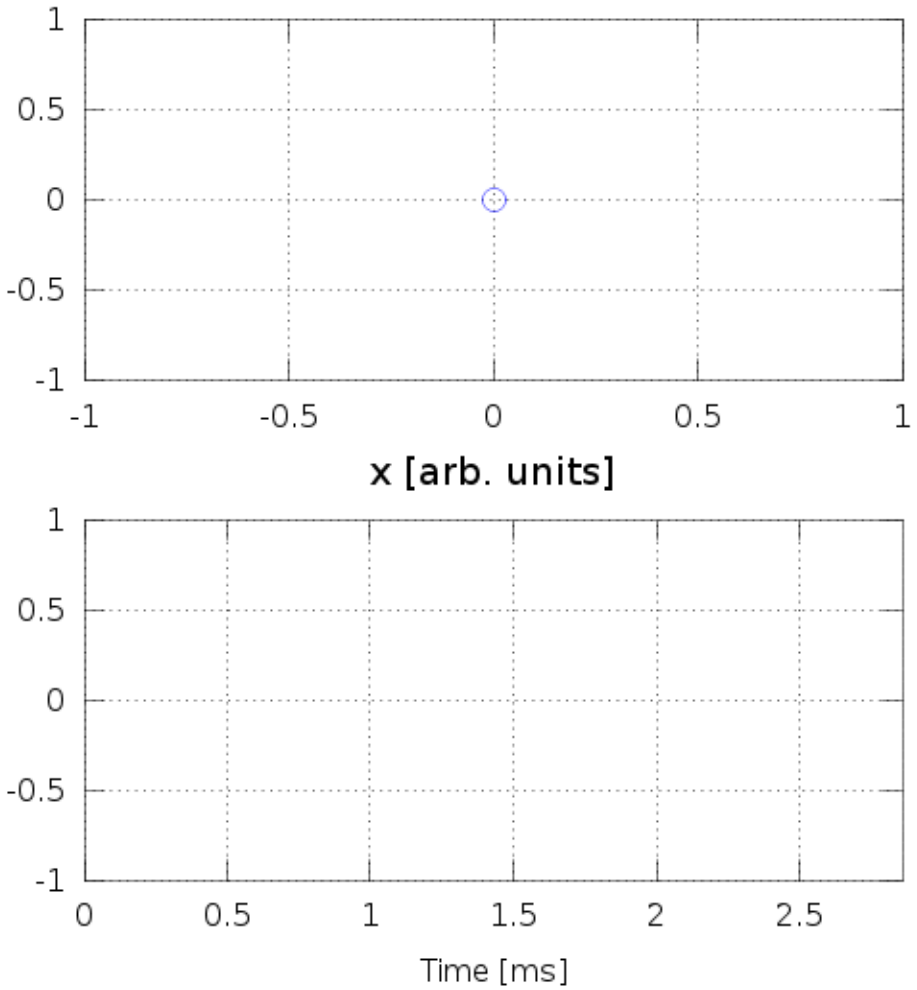


# Beam delivery system

## Accelerator region



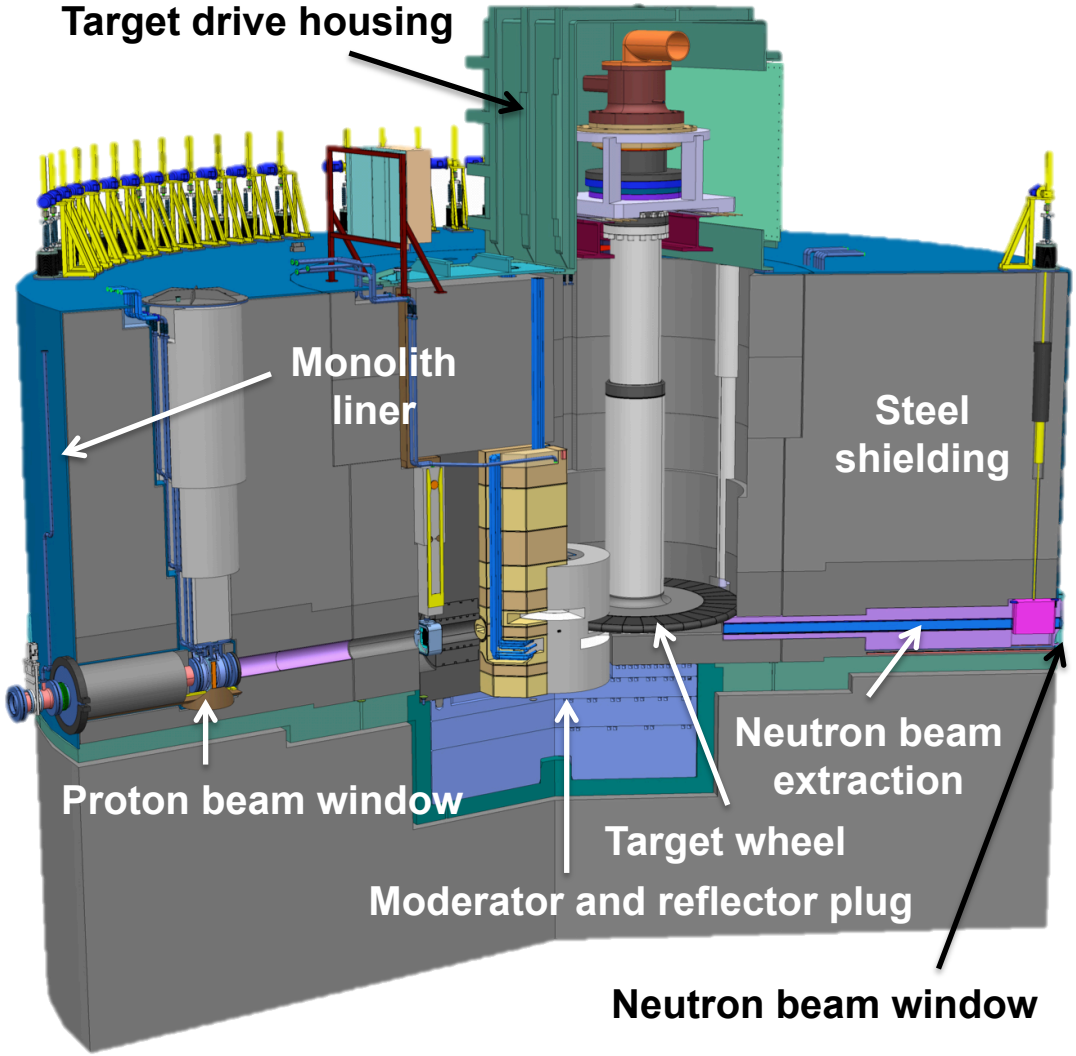

## Target region




- Small, bright beam in large aperture
- 1 W/m onto components
- Hands-on maintenance

# Target station converts protons to “slow” neutrons

- Diameter ~ 11 m; Height ~ 8 m
- Mass ~ 7000 tonnes (mainly steel)




Functions:

- Convert protons to usable neutrons
- Heat removal
- Confinement and shielding

Unique features:

- Rotating target
- He-cooled W target
- High brightness moderators

# Accelerator High Beta Section

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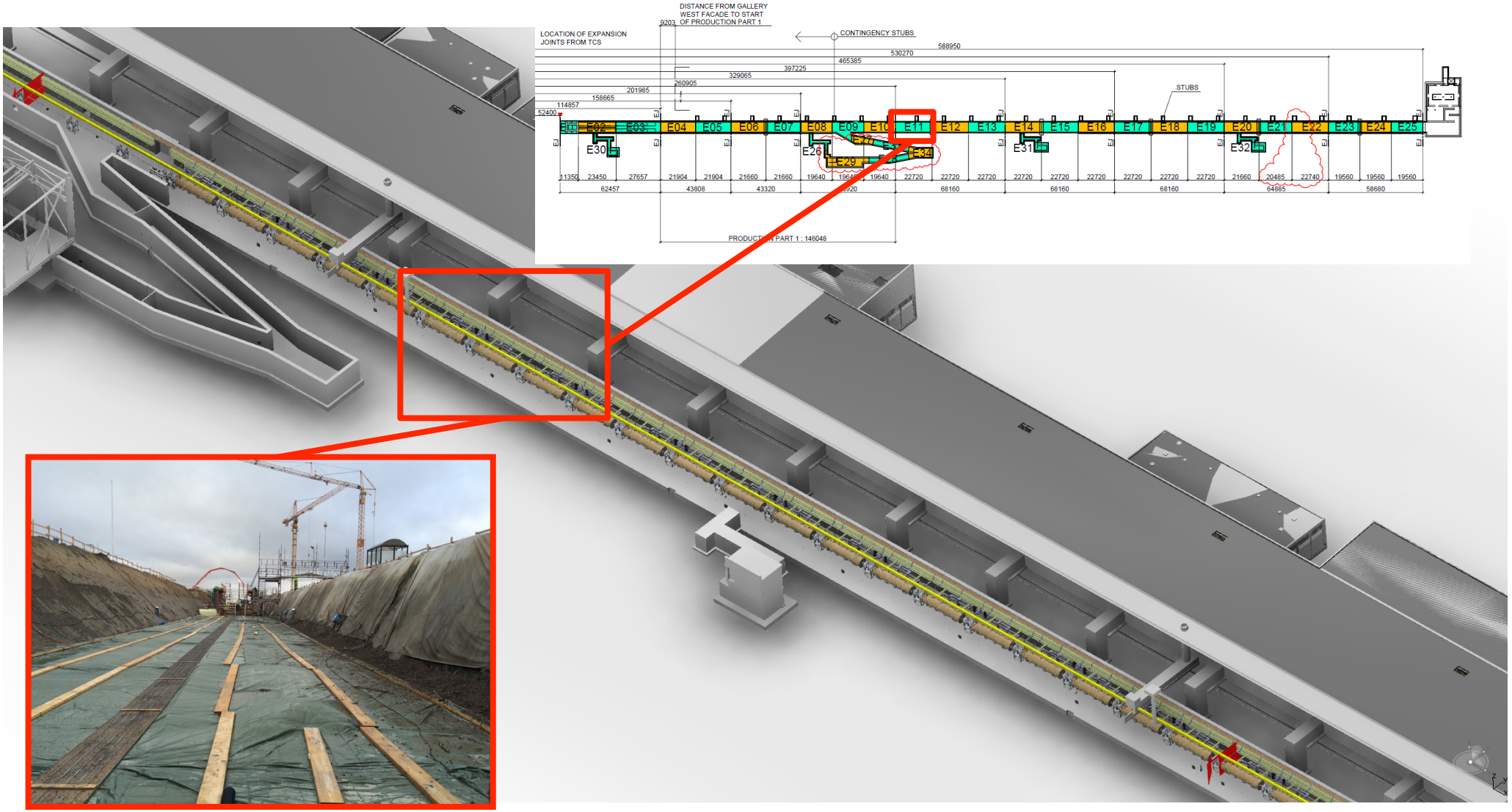
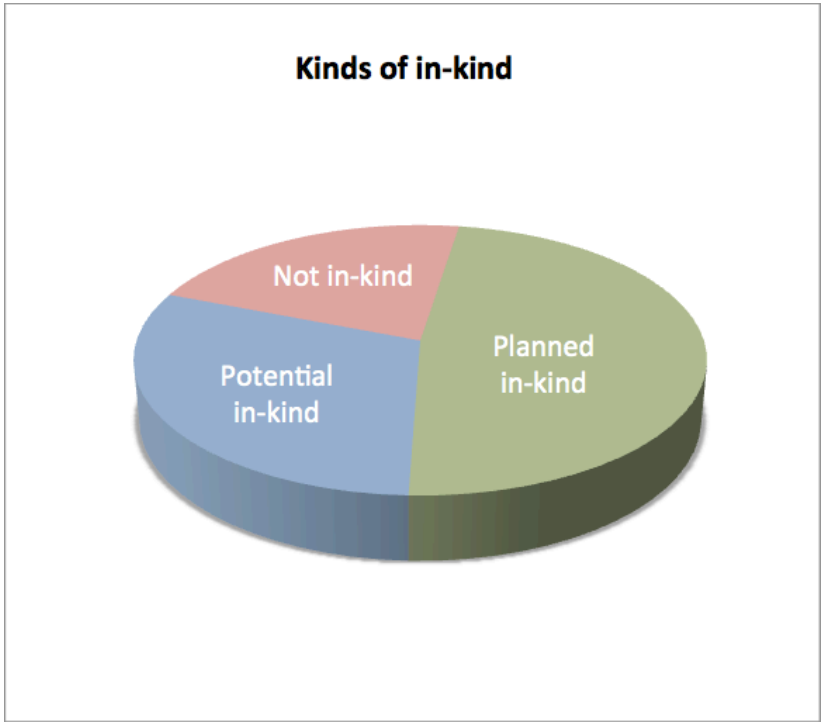
Nick.Gazis@esss.se



# Accelerator High Beta Section

EUROPEAN SPALLATION SOURCE
Nick.Gazis@esss.se

# Status Accelerator in-kind discussions




Planned In-kind

CEA
CNRS
Cockcroft Inst
Daresbury Lab
Elettra
ESS-Bilbao
Huddersfield Univ
IFJ PAN
INFN Catania
INFN Legnaro
INFN Milan
NCBJ
RAL
Tallinn UT
Warsaw UT
Wroclaw UT
Aarhus Univ
Uppsala Univ.

Discussed in-kind

DESY
GSI/FAIR
Lund Univ
PSI

- Potential/Planned in-kind is 78% of accelerator budget
- Potential partners for **in-kind identified for 47%** of the total potential/ Planned in-kind value, contracting under way!
- Discussions going on with 22 organizations!

# BI scope

Beam instrumentation group responsible for all proton beam diagnostics in ESS linac up and including the target

~13 different systems

~33- 48 (major/minor) variants of beam line components

~21 variants of readout systems

~500 device instances in all

Lots of inter-dependencies, and possible synergies.

Always planned to do this in collaboration with other labs. Recently, focus on outright in-kind contributions from member country institutions.

# Overview of BI systems

- BLM: LHC style Ionization chamber BLMs. Looking into CERN readout as well. Likely a few special loss monitors.
- BCM: ACCT + uTCA readout, one FCT for chopping efficiency measurement. Differential current measurement for machine protection.
- BPM: Buttons and striplines + uTCA readout (+special BPM for target raster scanning)
- FC: Commercial and custom designs.
- Allison scanner and Linac4 style slit-grid
- Wire scanners: Carbon and Tungsten scanning wires, also in cold linac warm sections. SEM and shower readout. Electronics with high dynamic range( also for halo). Also for plan fast wires (CERN style)
- Non-invasive profile: IPMs and Luminescense, co-located with wires
- Longitudinal profile: Feschenko style BSM, new development needed for high energy
- Target diagnostics: Imaging, grid and aperture monitors (and special BPM)

# The Beam Diagnostics In-kind Challenge

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How to do diagnostics as in-kind without ending up with multiple technical solutions to the same problem (e.g. different BPM electronics in different parts of the linac) and still make in-kind packages interesting for partners?

# System similarities

EUROPEAN SPALLATION SOURCE

| | | LEBT | MEBT | DTL | Spoke | MBE | HBE | HEBT | A2T |
|---|---|---|---|---|---|---|---|---|---|
| BLM (IC) | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| BCM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| BPM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| FC | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| EMIT | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| WS/Halo | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| IPM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| Lumi/BIF | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| BSM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| Imaging | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| SEM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| TC | BLD | | | | | | | | |
| | DAQ | | | | | | | | |

# In-kind Strategy

Development of common readout system in a separate work unit (which could be in-kind, partially or fully)

- May also include production of custom electronics boards (typically analog front end boards).
- Custom boards can also be licensed and commercialized through an industrial partner (DESY/Helmholtz model)

Vertical system (e.g. MEBT BPMs) include the delivery of the readout system, based on a central design (can be in-kind, partially or fully)

- Beam line device mechanical design
- Procurement of commercial components
- Non COTS hardware may be provided by central design in-kind partner (TBC)
- Integration and testing

Bundle vertical systems with same or similar beam line devices (sensor-detector)

Still requires a strong team in Lund

NB. Similar scheme as for LLRF

# In-kind status (approximate)

EUROPEAN SPALLATION SOURCE

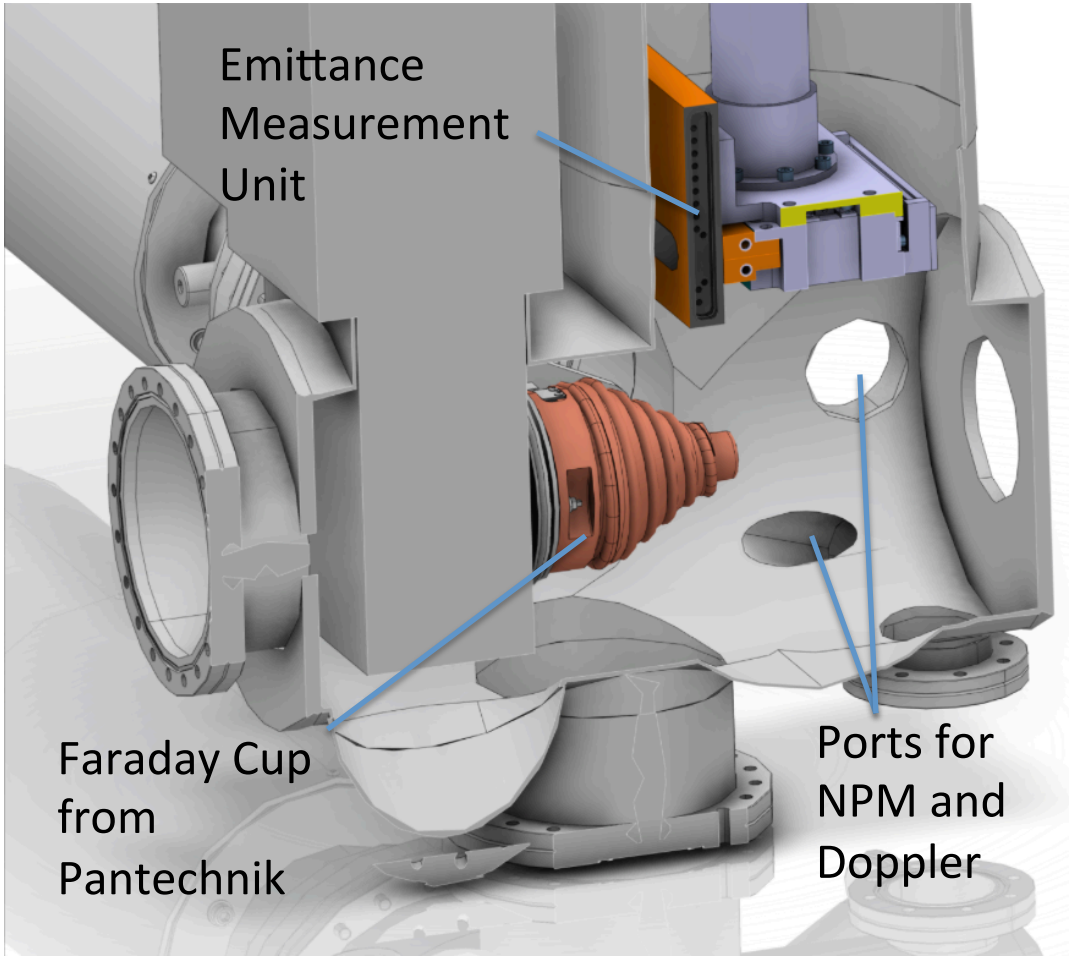
| | | LEBT | MEBT | DTL | Spoke | MBE | HBE | HEBT | A2T |
|---|---|---|---|---|---|---|---|---|---|
| BLM (IC) | BLD | | | procurement with CERN | | | | | |
| | DAQ | | | | | | | | |
| BCM | BLD | | Bilbao | | | | | | |
| | DAQ | | | | | | | | |
| BPM | BLD | | Bilbao | Legnaro | | | | | |
| | DAQ | | | | | | | | |
| FC | BLD | procurement | Bilbao | | | | | | |
| | DAQ | | | | | | | | |
| EMIT | BLD | Saclay | Bilbao | | | | | | |
| | DAQ | Saclay | Bilbao | | | | | | |
| WS/Halo | BLD | | Bilbao | | | | | | |
| | DAQ | | | | | | | | |
| IPM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| Lumi/BIF | BLD | | Bilbao | | | | | | |
| | DAQ | | | | | | | | |
| BSM | BLD | | Bilbao | | | | | | |
| | DAQ | | Bilbao | | | | | | |
| Imaging | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| SEM | BLD | | | | | | | | |
| | DAQ | | | | | | | | |
| TC | BLD | | | | | | | | |
| | DAQ | | | | | | | | |

Overarching agreement exists, technical details/specification to be refined

Discussions with specific potential partner ongoing

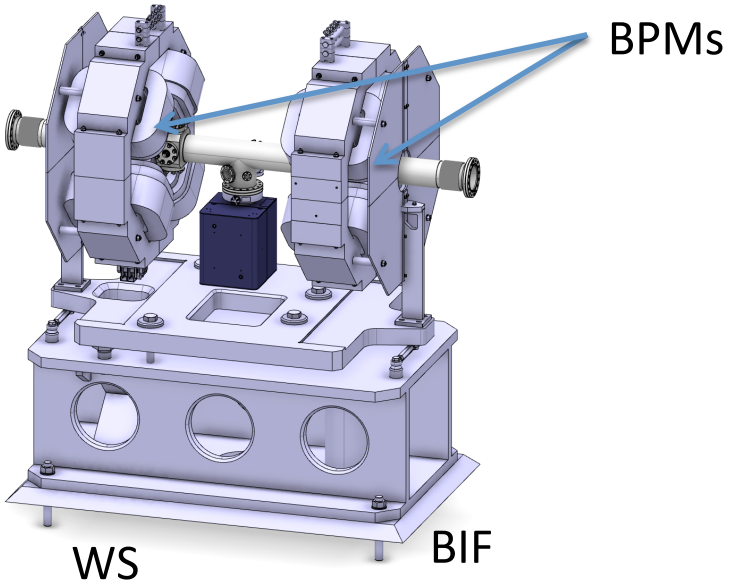
# LEBT

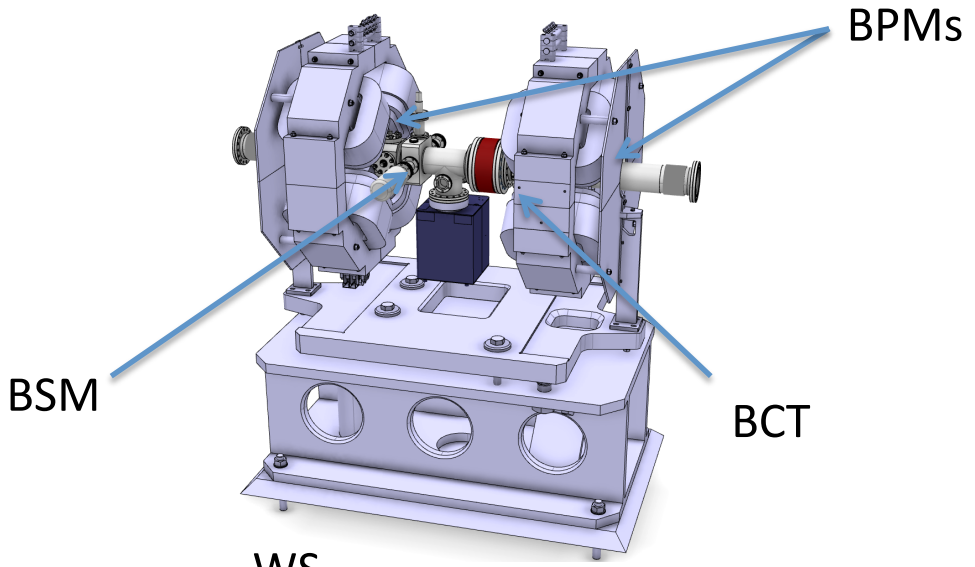
CATIA Model of
LEBT Diagnostic and Chopper Tank

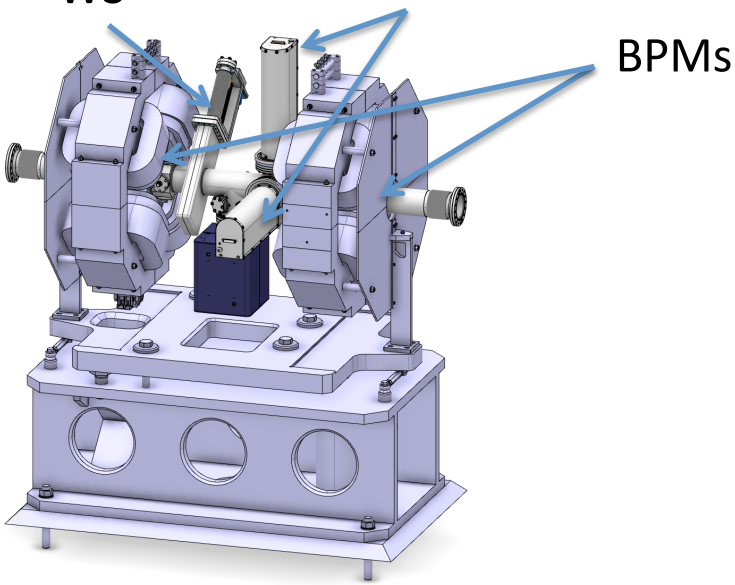


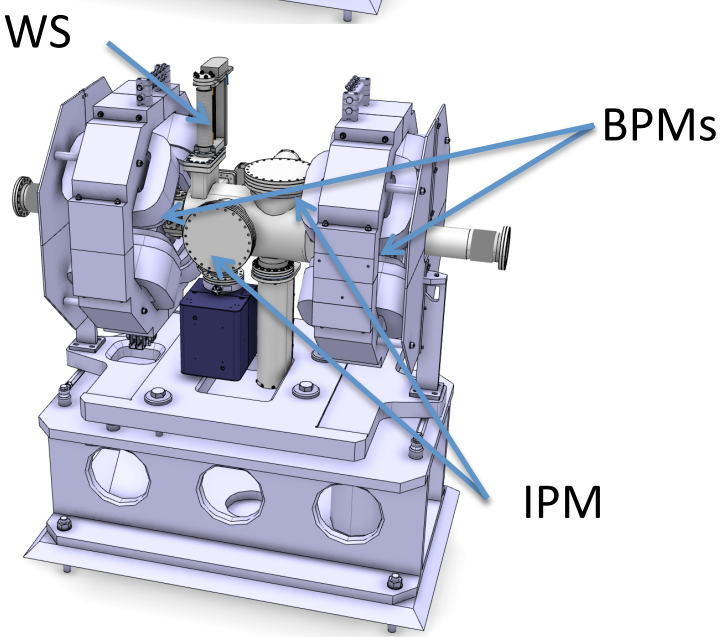
# Linac Warm Section Layouts

EUROPEAN SPALLATION SOURCE

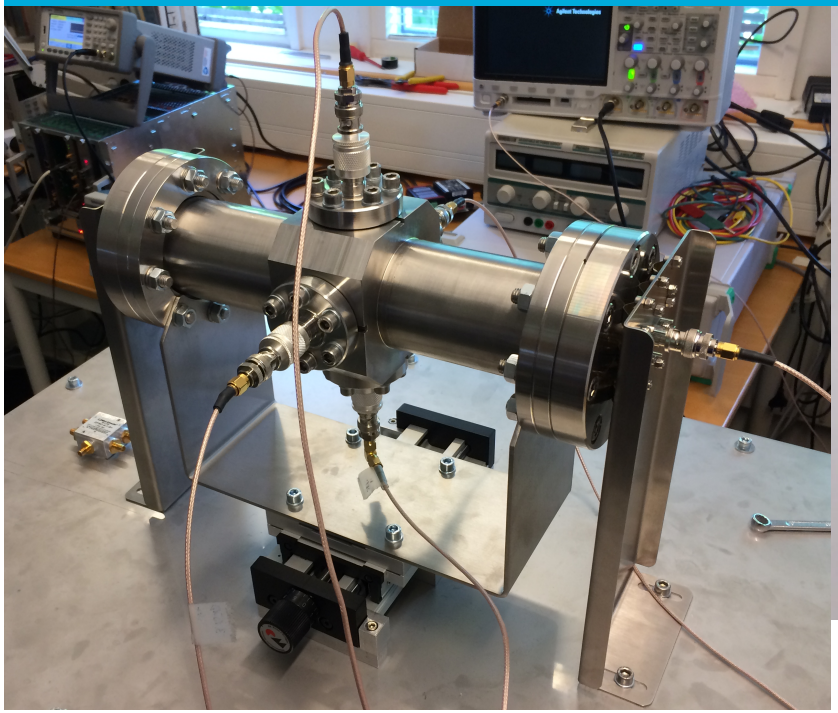


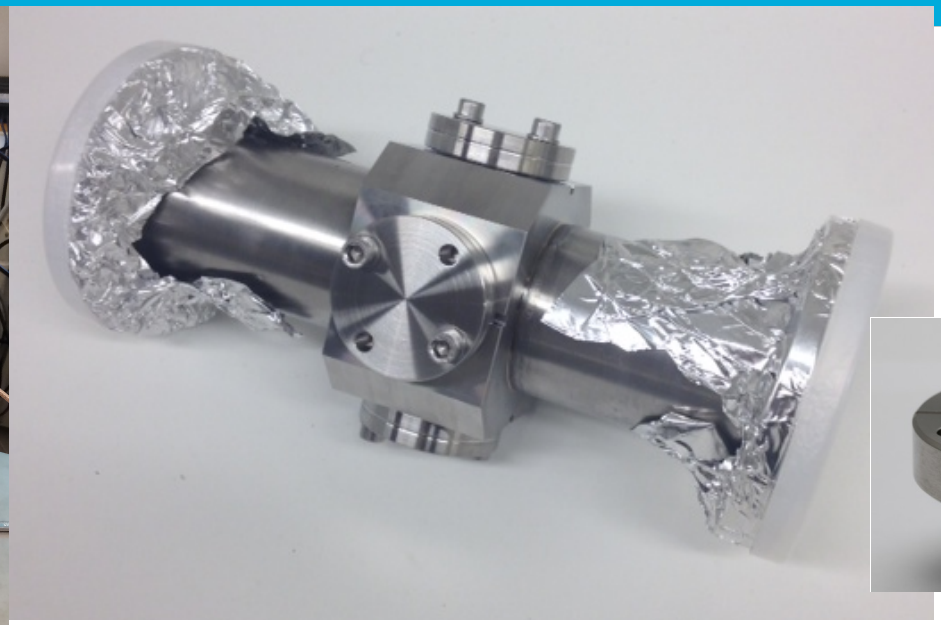



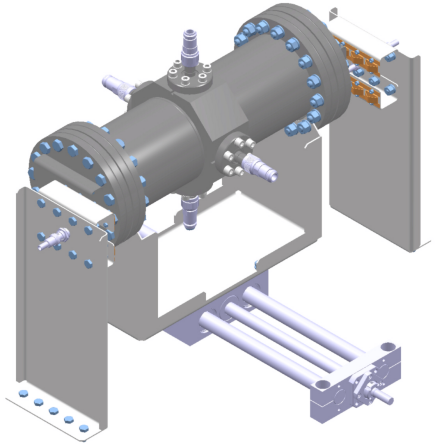



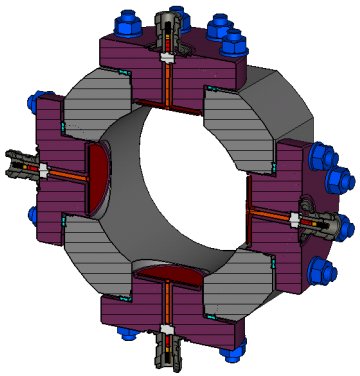



# Cold BPM prototyping (w DESY)

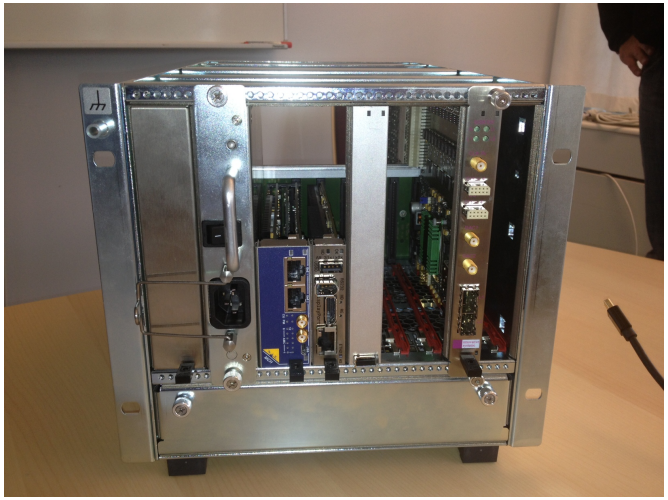




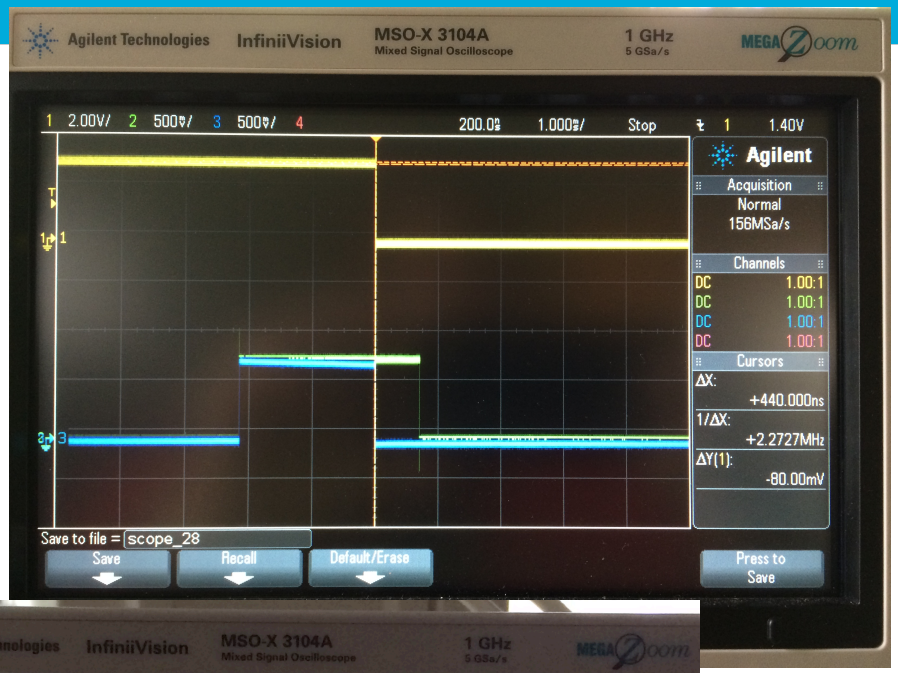



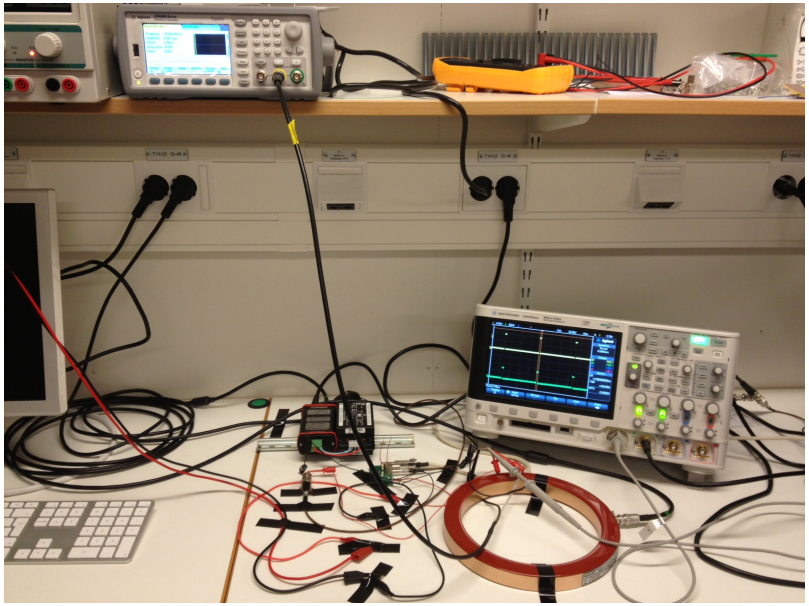


# BCM Prototype Electronics



Diff current test:
BCM 1 signal
BCM 2 signal
MPS output



# BPM Electronics Prototyping

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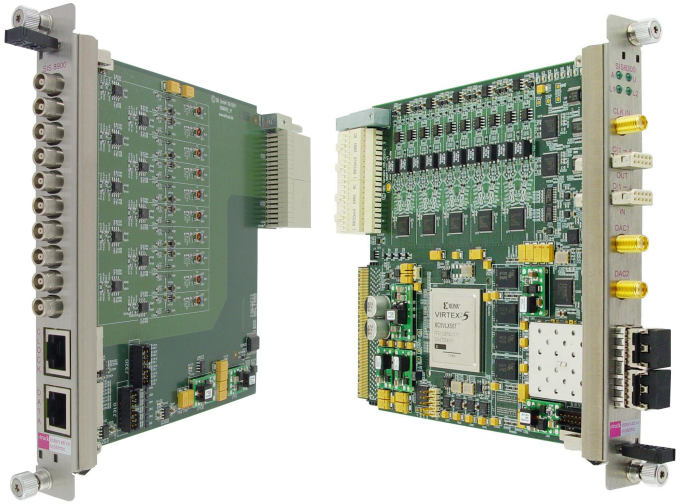
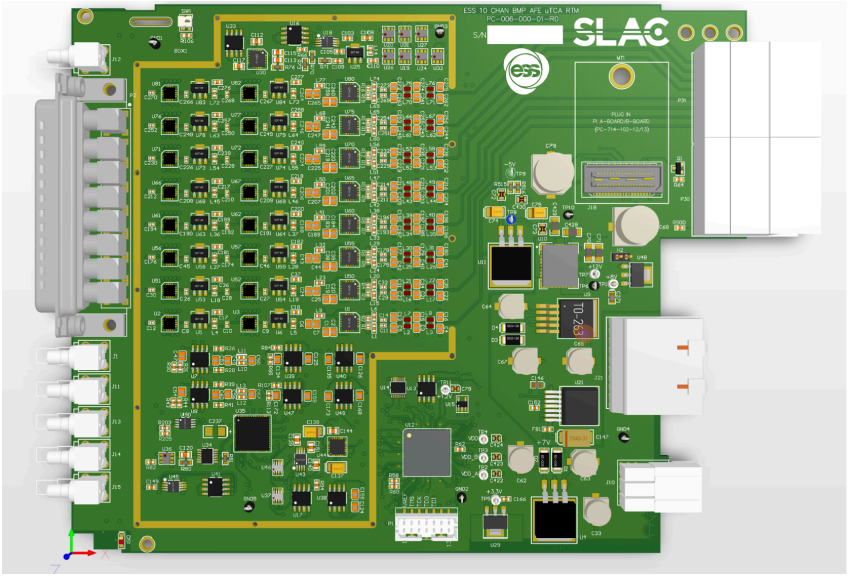
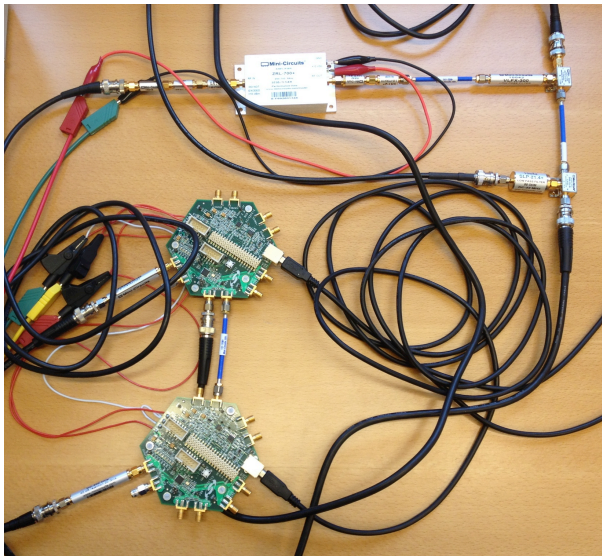
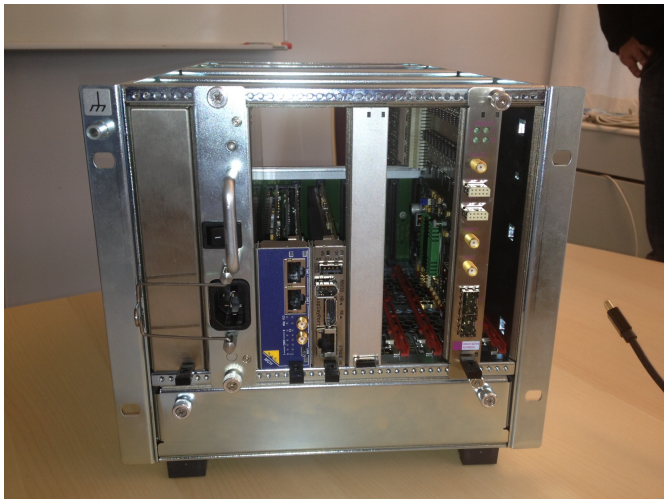
uTCA based
(standard platform)





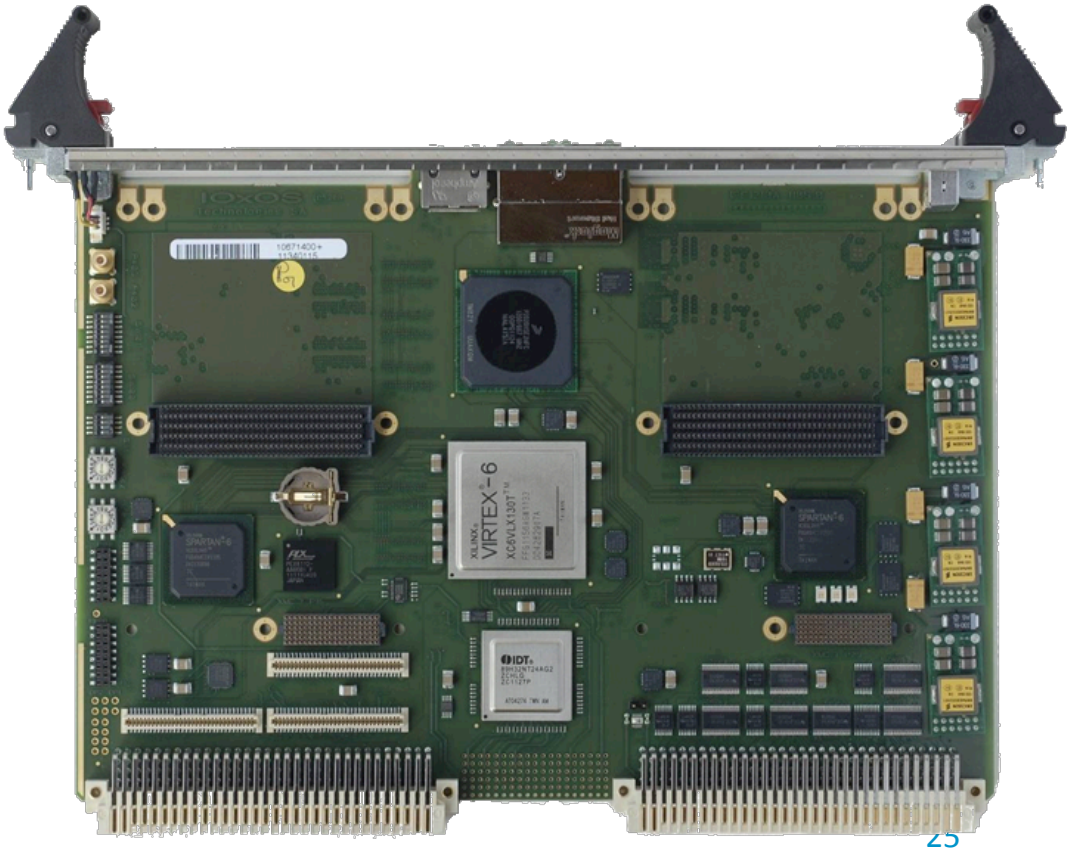





# uTCA FMC carrier

ESS Controls is proposing a standardized UTCA FMC carrier card, with integrated FPGA and processor, to be developed with PSI (and an external Swiss company), based on an existing PSI VME card.

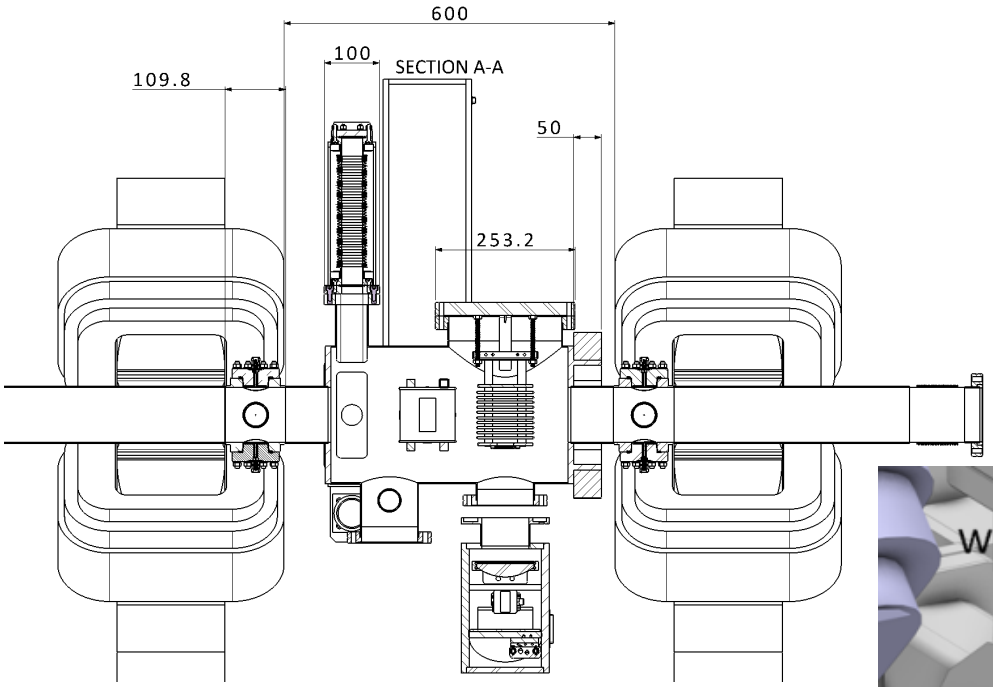
For the moment, this is a pre-study

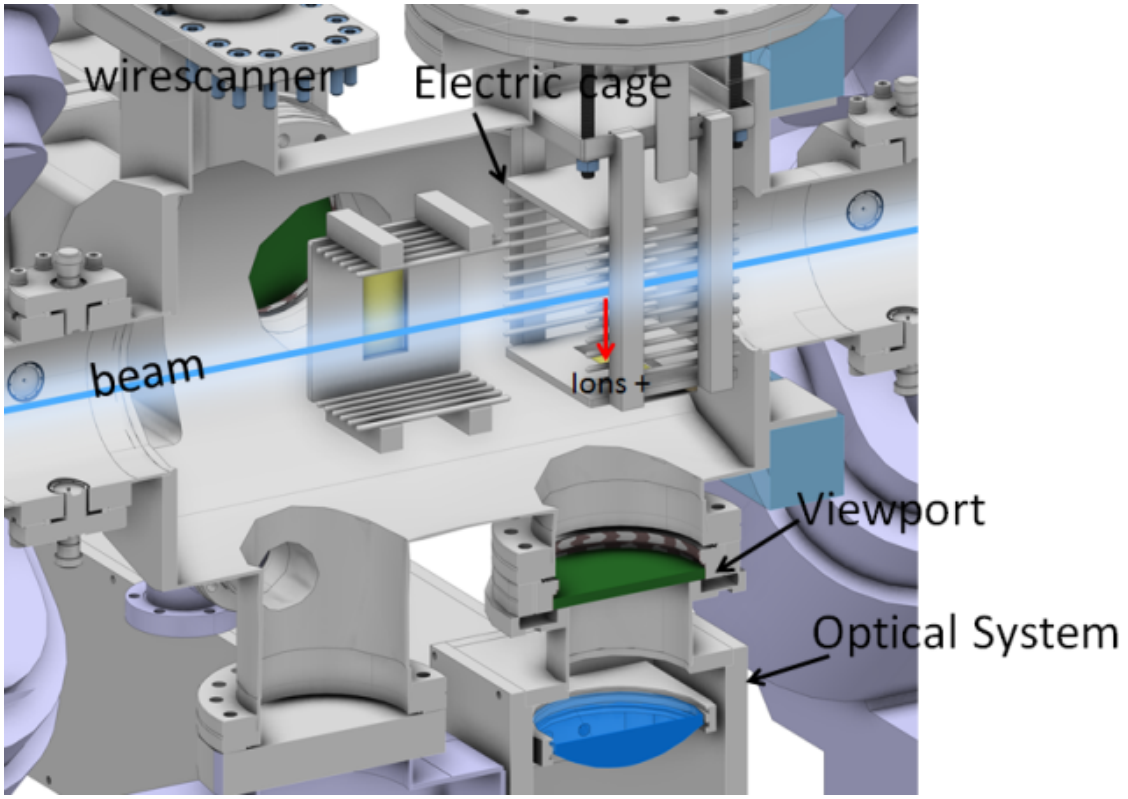



Standard platforms:

- uTCA.4
- EtherCat
- PLC (flavour to be selected)

# IPM and Luminescence

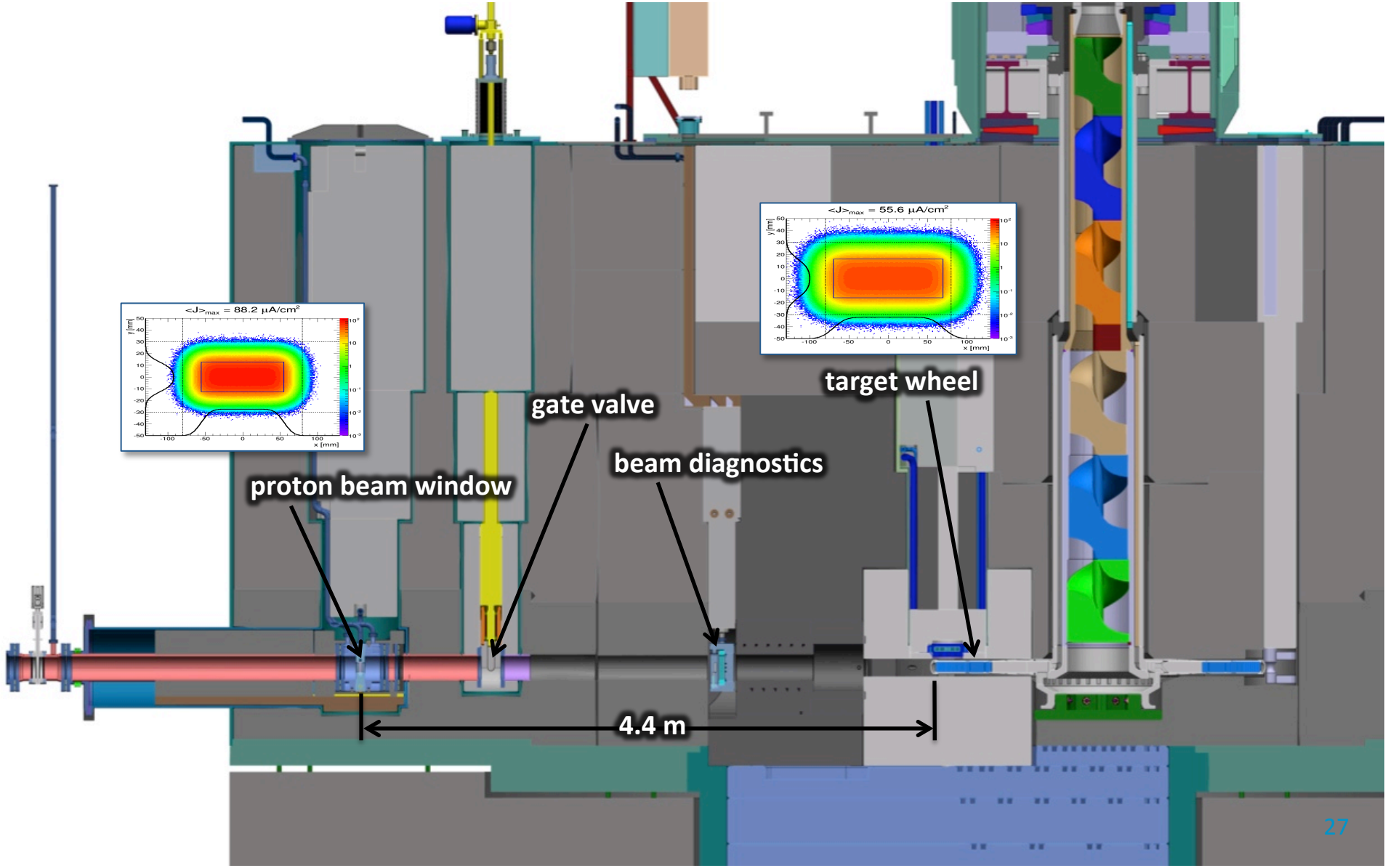



Source term
and background?

Gas injection?

# Monolith and beam image



# Diagnostics plug

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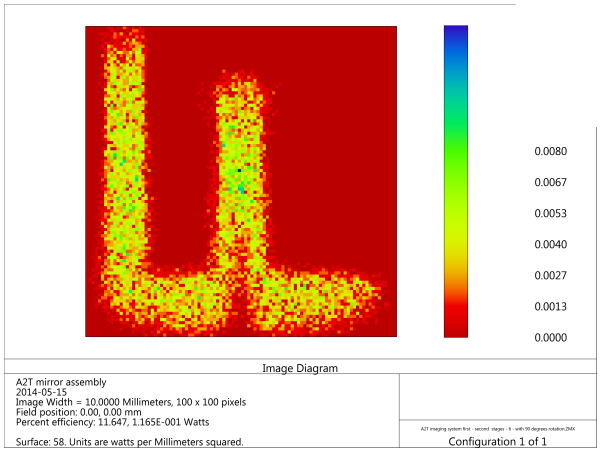
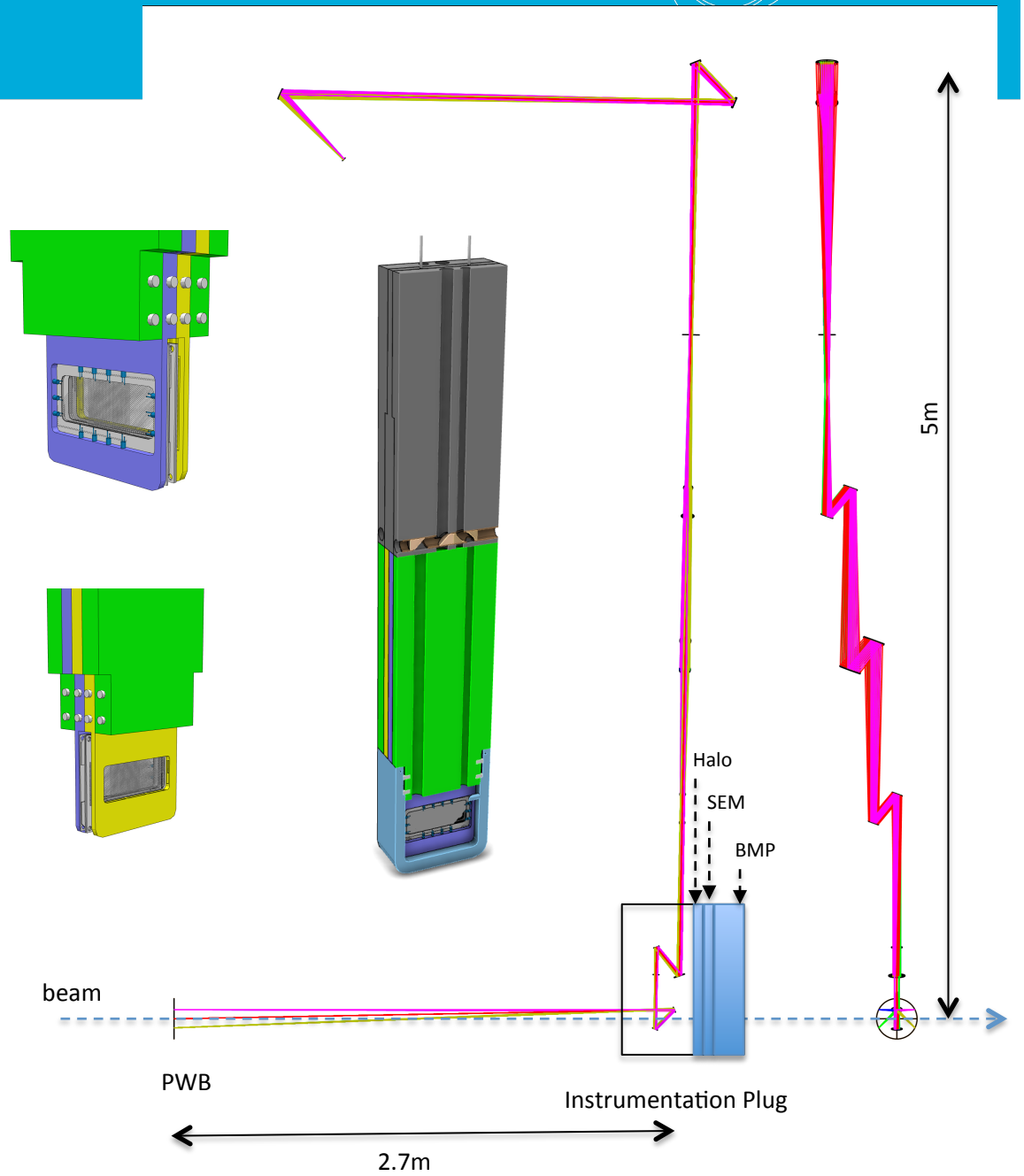
Example: Optical system

Power transmission: 11%
Resolution: ~ 1.5mm (beamlet size 15x
PBW size: 250x100mm$^2$

First 4 mirrors exposed to radiation
- Thermo-mechanical stress
- Radiation hard materials
- No motion controlled allowed
- Removed by remote handling
- Waste management

Object: 250x250 mm$^2$



# Some Collaboration Ideas

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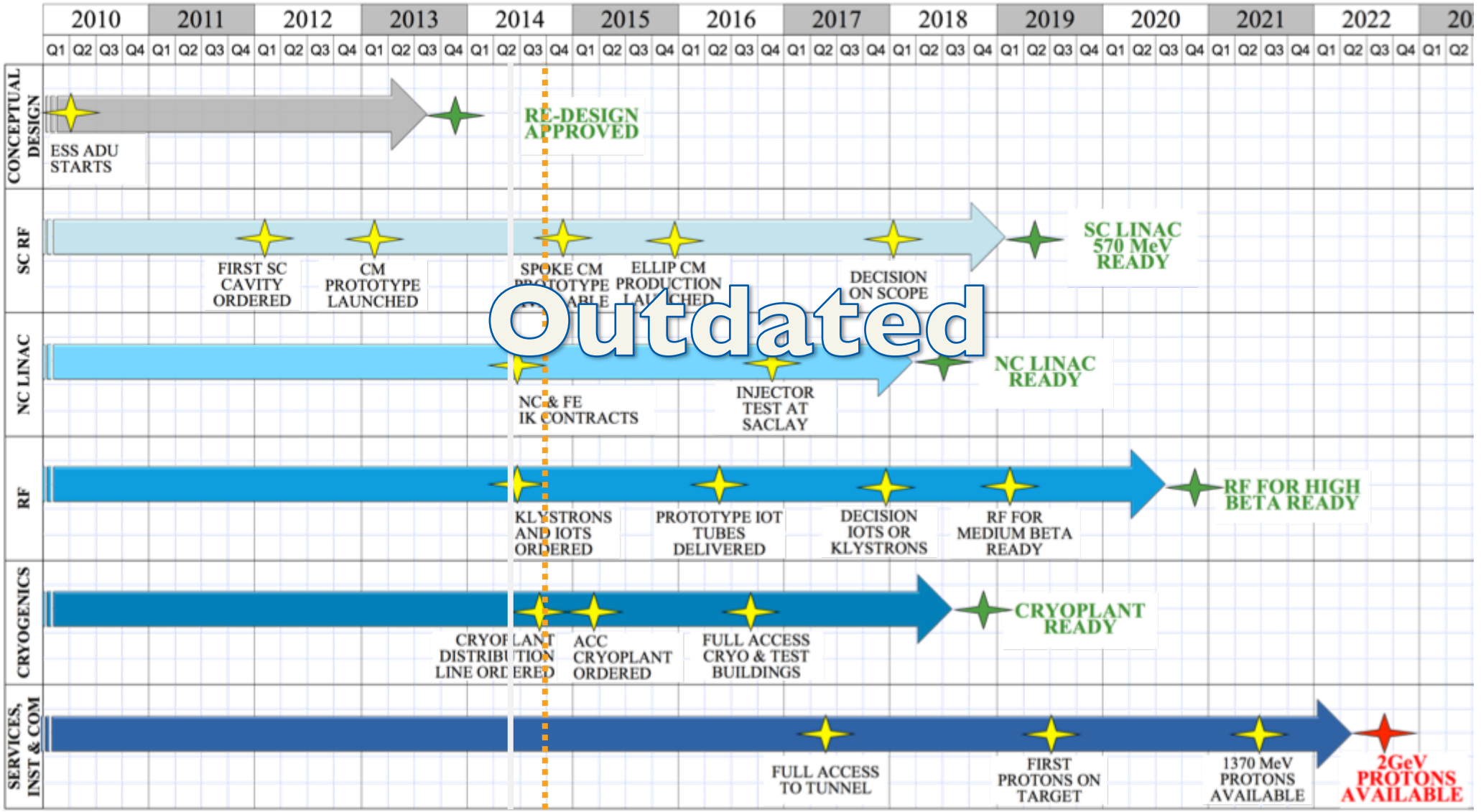
- uTCA hardware development & standard platform
- Target diagnostics
- Rad tolerant cameras for non-invasive profile and target imaging
- Non-invasive devices (e.g. gas jet)
- Rad qualification of devices
- …

# Welcome to ESS!

# ESS LINAC PROJECT SCHEDULE

EUROPEAN SPALLATION SOURCE



# BI Scope

| | BLM | BCM | BPM | EMU | Slit | Grid | FC | WS | NPM | Img | Halo | BSM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LEBT | | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| MEBT | | 0 | 3 | 10 | 0 | 1 | 1 | 1 | 3 | 2 | 0 | 0 | 1 |
| DTL | | 15 | 5 | 15 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| Spk | | 52 | 0 | 26 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| MB | | 36 | 1 | 18 | 0 | 0 | 0 | 1 | 3 | 3 | 0 | 0 | 1 |
| HB | | 84 | 1 | 42 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| UHB | | 45 | 2 | 30 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 1 |
| DgLg | | 23 | 1 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A2T | | 15 | 2 | 8 | 0 | 0 | 1 | 0 | 3 | 3 | 2 | 4 | 0 |
| DmpL | | 6 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| TOTAL | | 276 | 19 | 166 | 1 | 1 | 2 | 5 | 16 | 14 | 3 | 5 | 4 |

About a dozen different systems.

~50 beam line component variants.

>20 readout system variants

(post scrub numbers)

Requirements (including numbers) still being discussed