# WUT Contribution to ESS

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# WUT Contributions to ESS

- **MTCA. 4 based ESS LLRF** control system components (within the Polish Electronic Group - PEG), completed in 2025
- **Phase Reference Line (PRL),** completed in 2024

- RF electronics, cabling and infrastructure design, installation and tests for the **Beam Diagnostics**

Polish In-Kind to ESS

Direct collaboration + small R&D grant

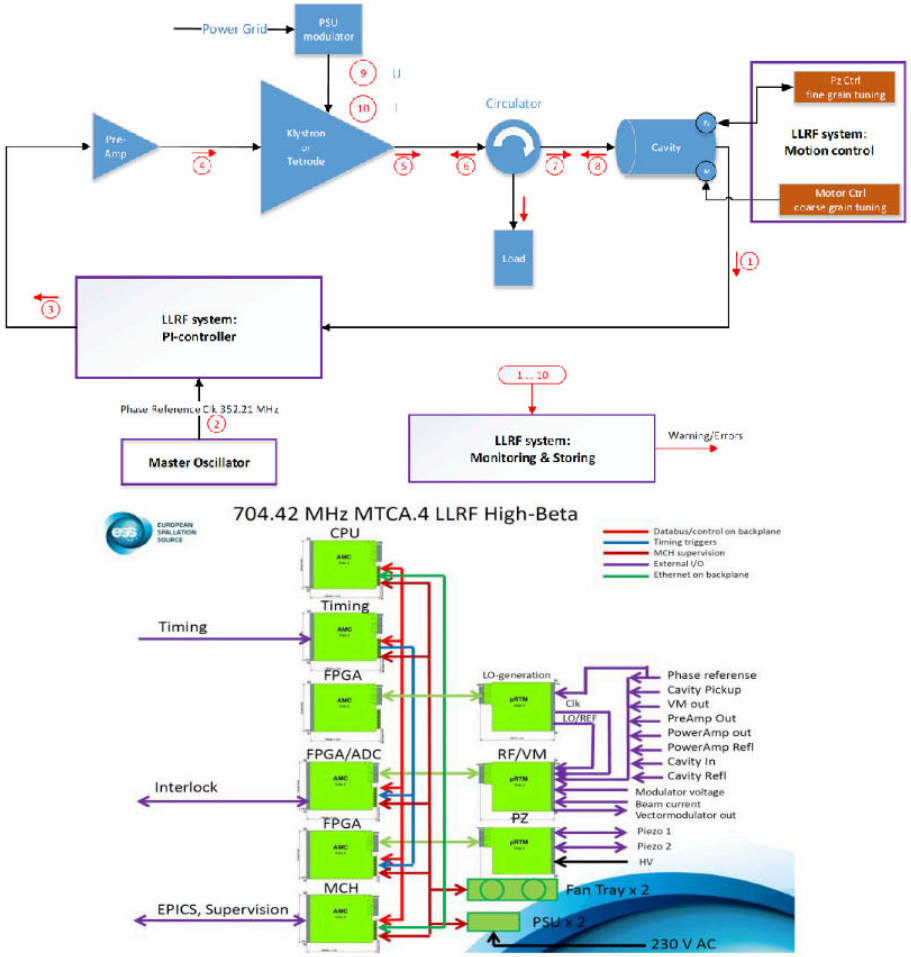
# Elliptical cavities LLRF control system (PEG)

PEG Contribution – see talk by J. Szewiński/T. Kowalski for details

Responsible for optimal energy transfer from superconducting resonator to the accelerated proton beam,

Incorporates fast RF feedback loop and frequency tuning loops mechanisms,

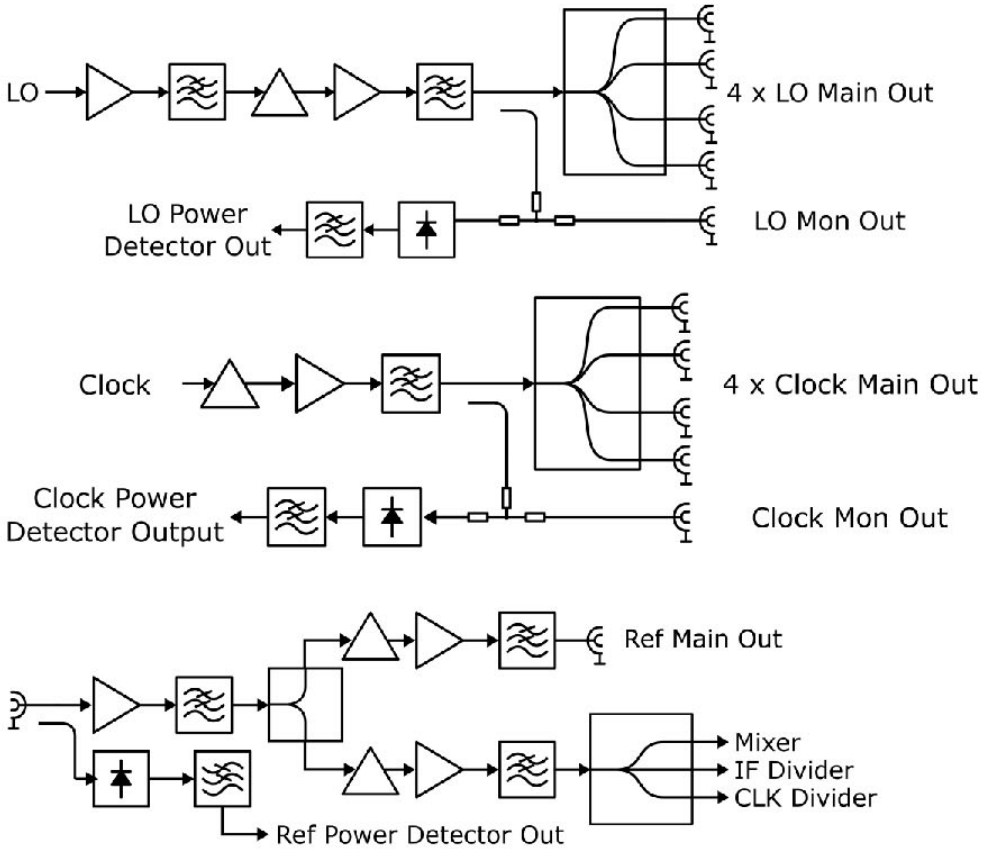
Based on the MTCA.4 hardware form factor.




*Source: A. Johansson „LLRF for ESS CDR", 2016*

# Local Oscillator RTM Card for ESS

- Low-phase nose signal generation:
  - LO (25.16 MHz or 32.02 MHz)
  - Clock (117.4 MHz)
- One device is used to drive 4 LLRF  stations
- **Delivered 30 pieces**



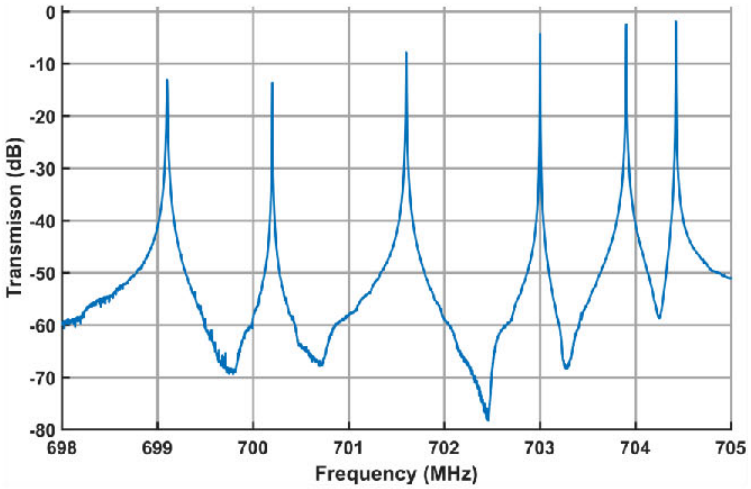
# RF Splitbox (2)

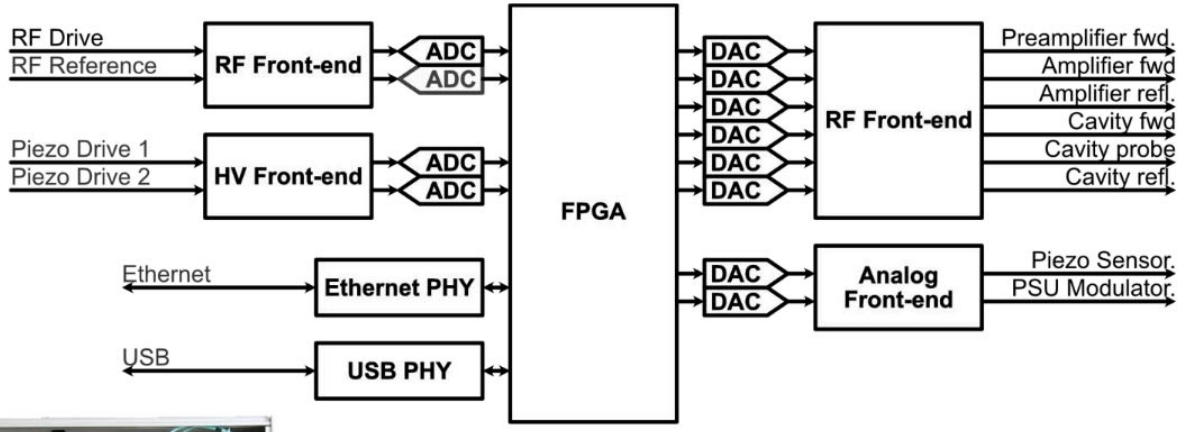
- Optimised for phase stability 10-channel passive RF signal splitter

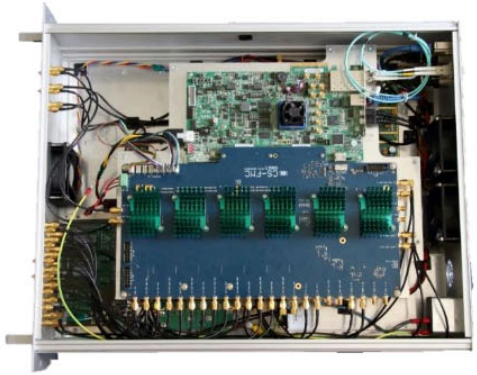
- Delivered 141 units, incl. 10 spares:
  - 12 for RFQ and DTL
  - 3 for Buncher
  - 26 for Spokes
  - 36 for Medium Beta
  - 45 for High Beta


# ESS Cavity Simulator

- Simulates the behavior of entire ESS RF station based on superconducting accelerating cavity
- Allows for testing of ES control system without risking damage of the accelerating module
- Delivered  4 units

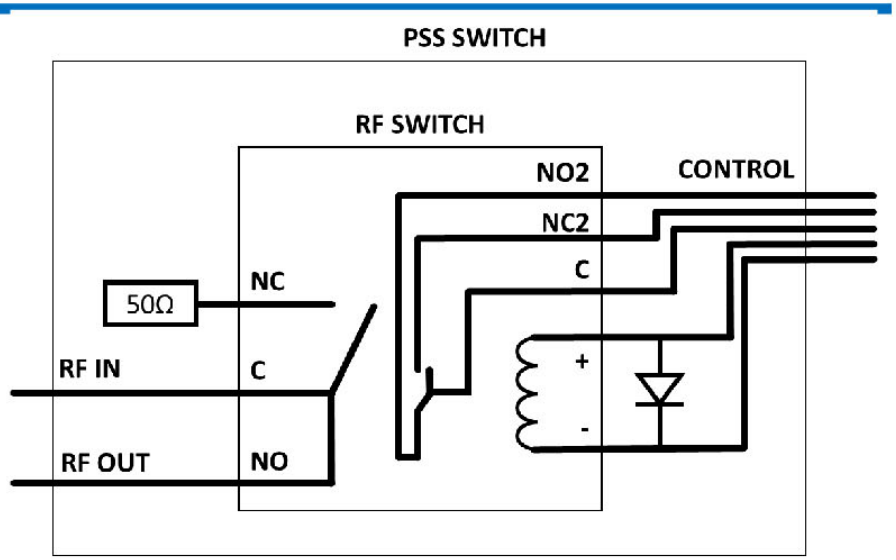


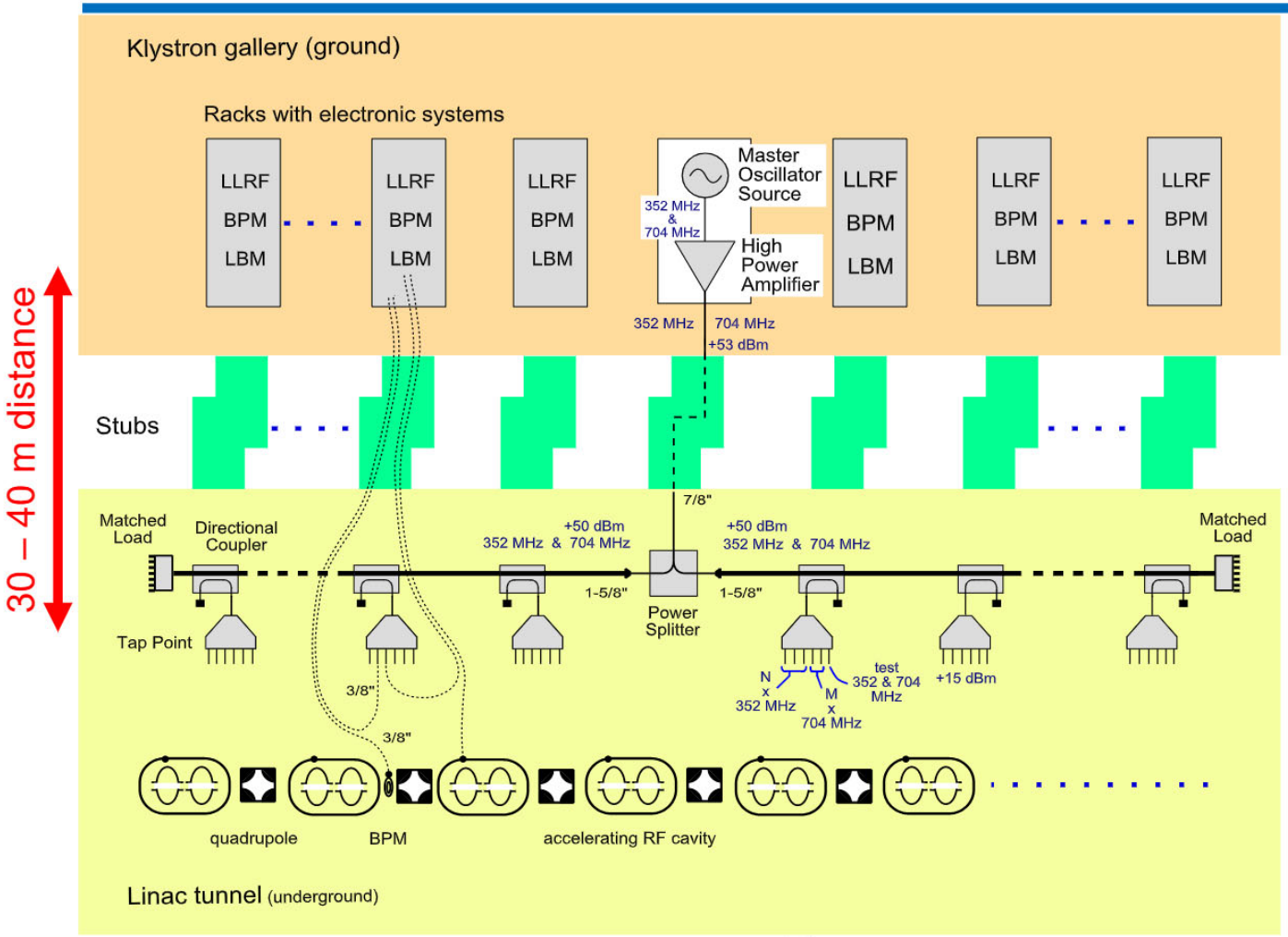



# PSS Switch for ESS

- Safety system switch used to turn off RF signal based on information from the PSS System
- Simple, robust, no human interface
- Delivered 126 units




# Phase Reference Line (PRL)




- Passive distribution along the accelerator tunel (radiation)
- **Single** 1/5” coaxial rigid line **for 352 MHz and 704 MHz**
- 58 signal taps (3 or 6 way), 294 total outputs
- Frequency selective, configurable tap outputs
- Equal power level at each output (+17 dBm +/- 1 dBm), at both frequencies – **min. +14 dBm for most of vices**
- Temperature and internal gas (Nitrogen) pressure control
- All active electronics in the Klystron Gallery hall

# PRL Installation Summary

**System was installed including:**

- Hanging fixtures with rollers allowing to accommodate for thermal system expansion, cable shelves
- Tap Points (58)
- Temperature Control Boxes (19) - **202 temperature control loops**
- Cables **(355 connections, 26 km of cables)**
- Gas pressure stabilization system
- MO to Tunnel connection including 200 W power amplifiers and active drift compensation system (PDC)

# Performance Summary

- Power levels within specs
- Drift compensation in the link between MO and tunnel 0.15 °C p-p
- **Phase drift: 0.12 ° p-p** and **temperature change of 0.01 °C p-p** at 123 m distance
- Phase drift **0.5 ° p-p vs tunnel temp. change of 2°C p-p over 10 days at 406 m distance** (required 2 ° p-p)
- **Possible installation of permanent drift monitoring system but out of in-kind scope.**

# WUT Contributions For Beam Instrumentation

Very effective collaboration since 2017

Electronic Infrastructure design and installation support for Beam Instrumentation systems including:

Electronic circuits and units

Mechanical design

Rack and cabling design

Detailed documentation

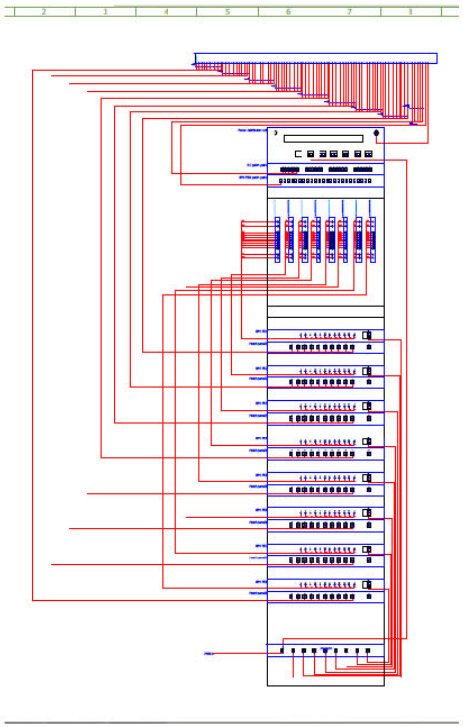
**A lot of implemented devices – designed and produced several thousands of units and PCBs for dozens of types of diagnostic devices**

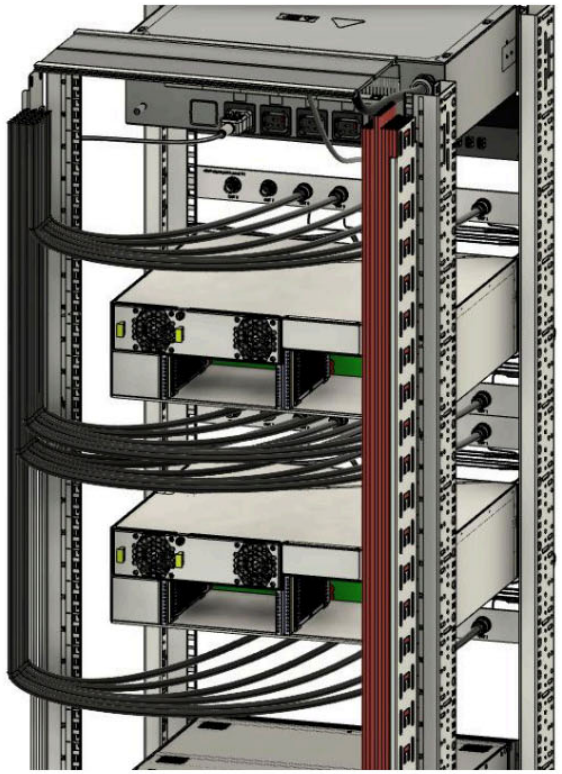
# ESS Beam Instrumentation Infrastructure Design and Installations

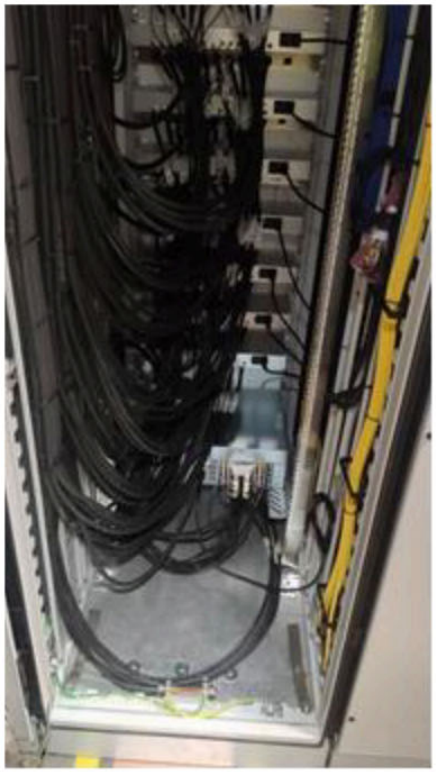
Designed cabling and electronics infrastructure (patch panels, housings, interface boards) for almost all ESS Beam diagnostic systems.

Actively supported ESS in assembly and installations of BD systems.

**Created E-Plan documentation for 55 racks**.



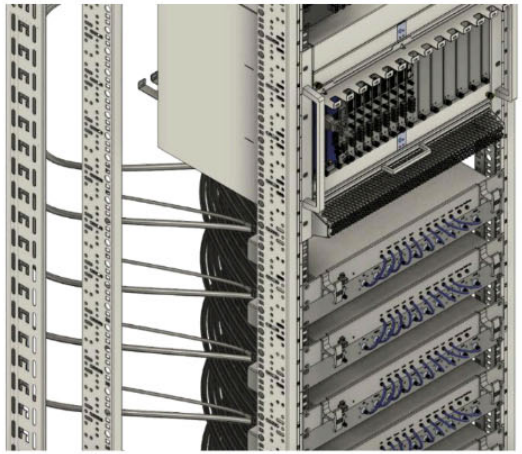




# BPM Front End Mechanics and Integration

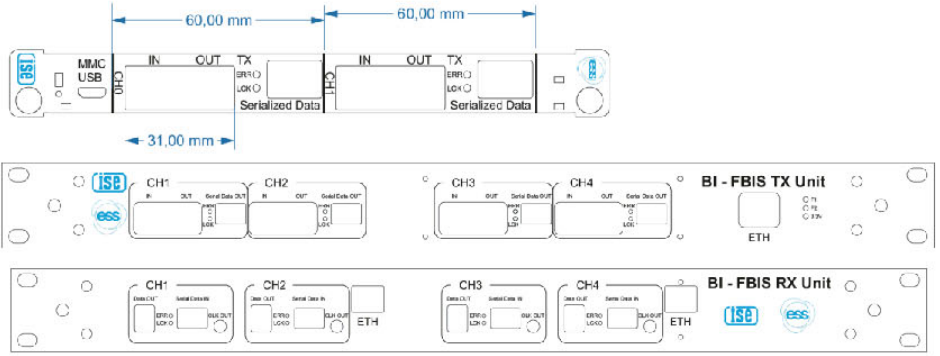
BPM Front End PCB design by ESS
WUT:

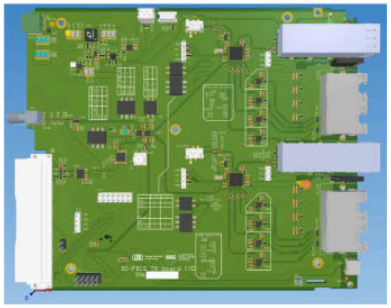
- Designed housing
- Produced, tested and delivered 70 pieces
- Designed rack infrastructure
- Supported rack and cabling installations



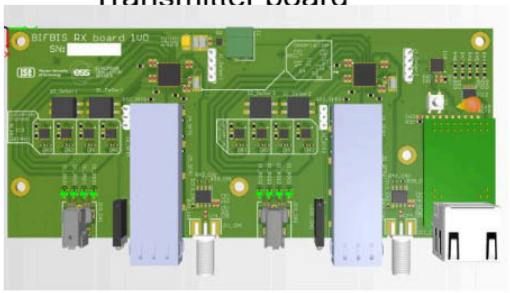
# BCM/BPM – FBIS Signal Converters

- Conversion from LVDS to RS485 and fiber optic
- Transmitter and receiver boards designed
- Mechanical components designed

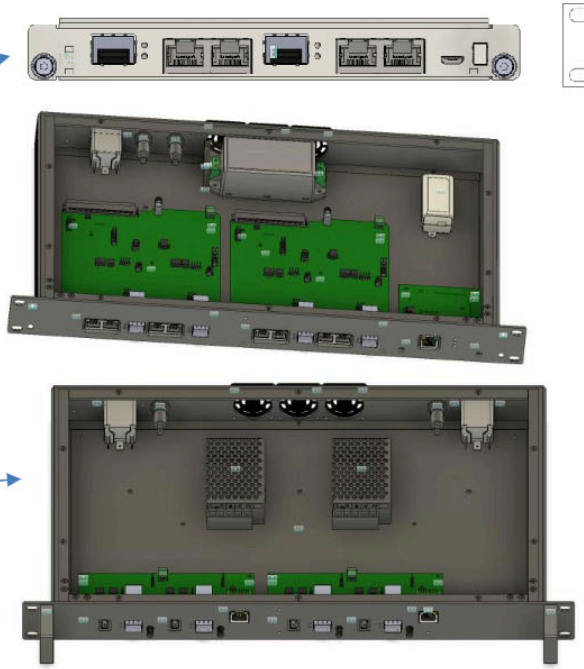


Transmitter board

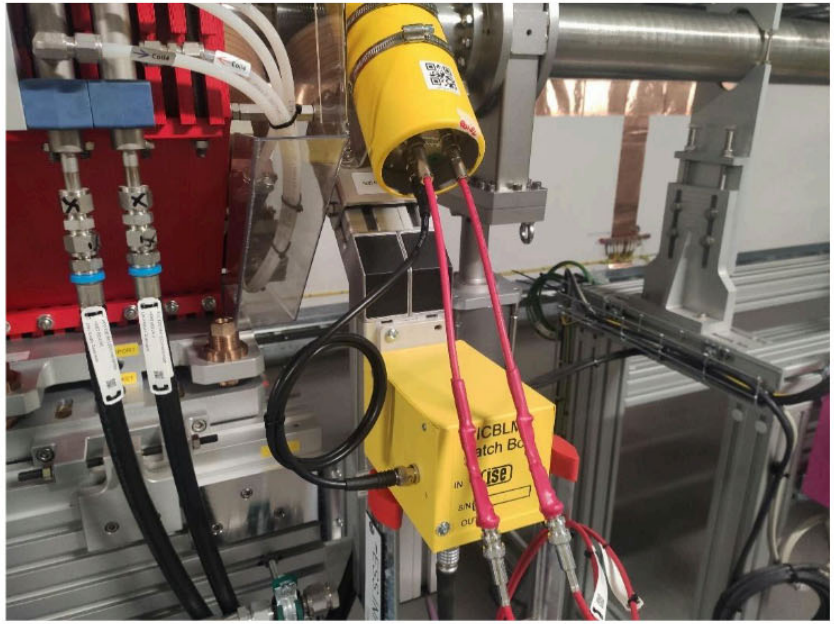


Receiver board



# ICBLM Patch Box Design, System Installations

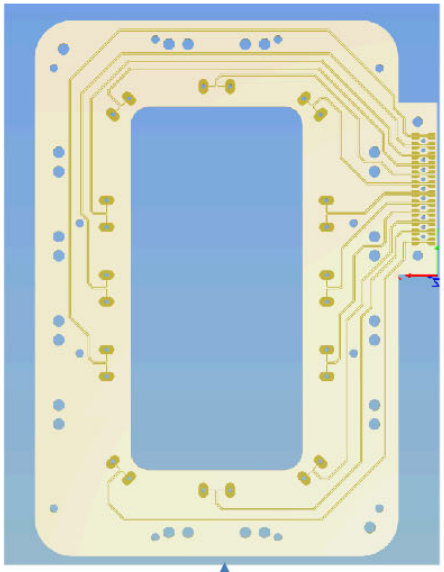
Produced 260 patch boxes
Installed all ICBLMs, cabling and patch boxes



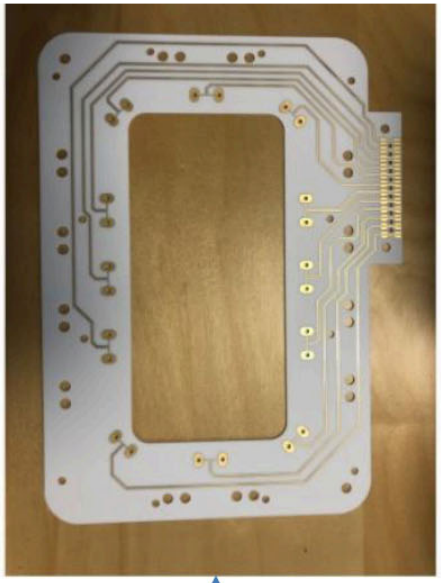
# PBI ICBLM 19” Patch Panel Boxes (for Gallery)

# APTM Interface Modules and Blade Boards

All boards are produced and are being tested in ESS

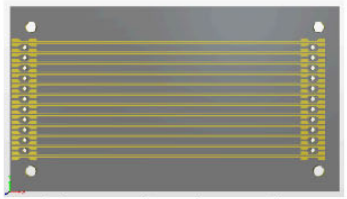


3D model

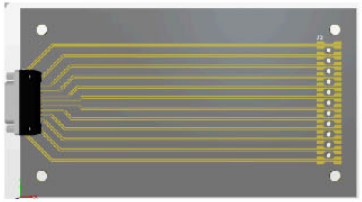


Main board

Produced board



Extension board

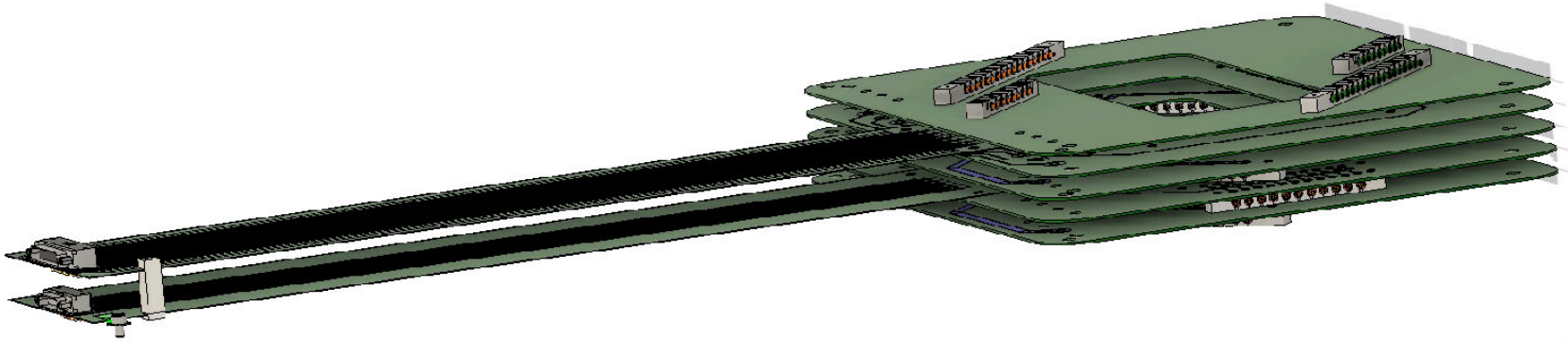


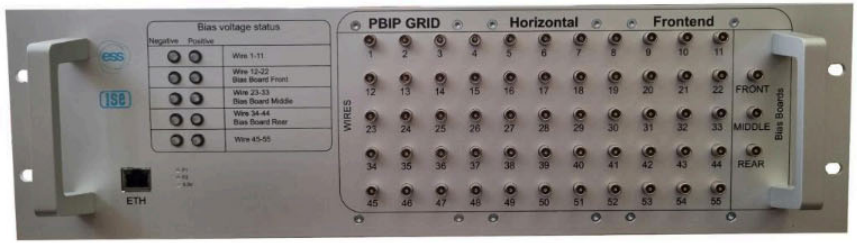
Connector board

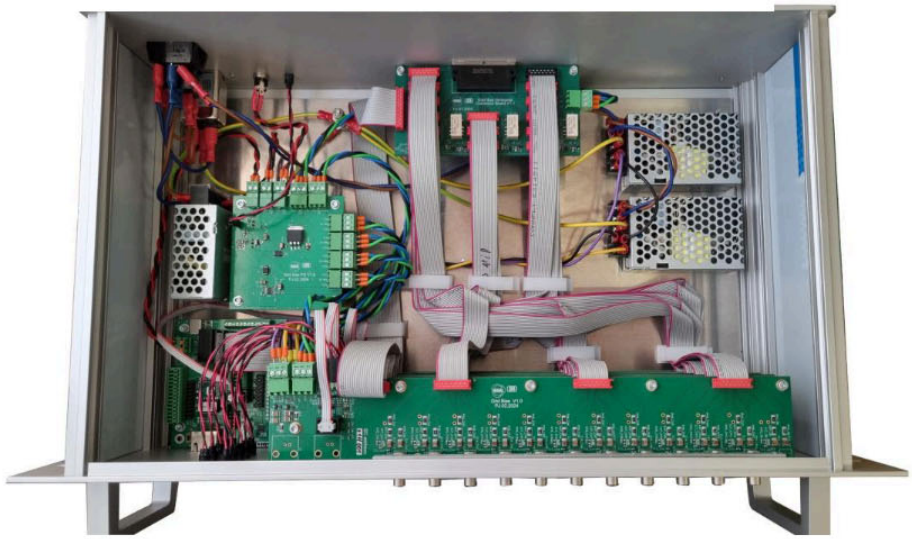
APTM – NSW interface module


- 8 modules designed and delivered to ESS

# GRID  Detector and Horizontal Front End Box

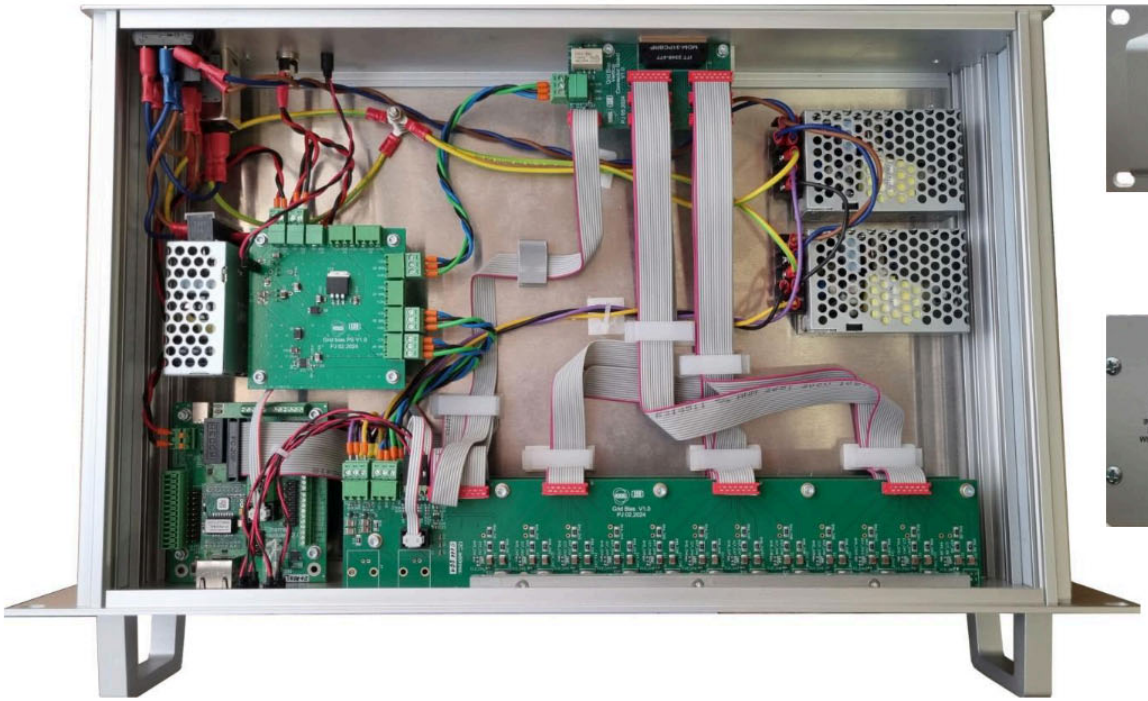


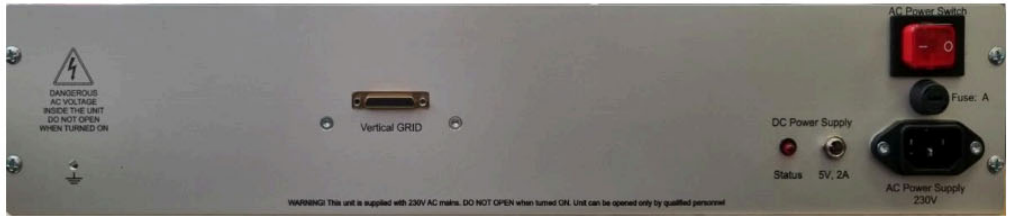


# PBIP GRID Vertical Bias Boxes

- Modules tested and sent to ESS




GRID Vertical Frontend

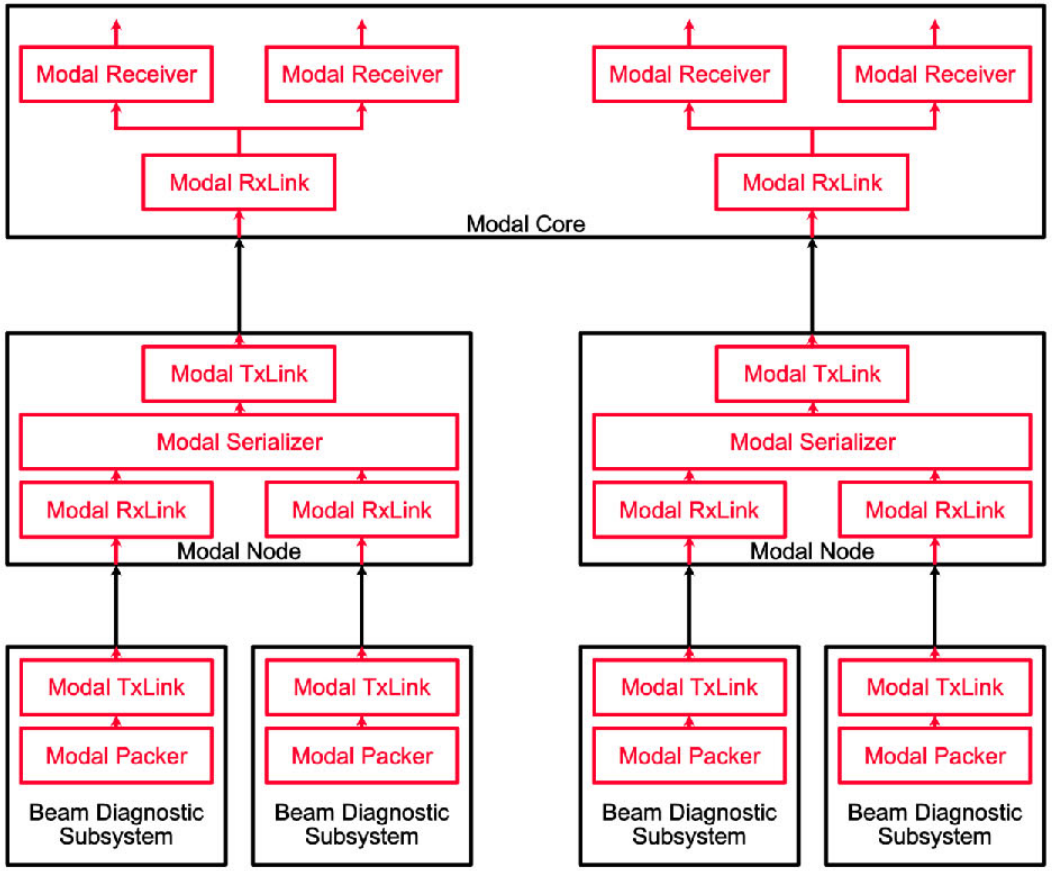
# Platform Gathering Beam Diagnostic Data at ESS (MODAL) - Architecture

## Minimum-latency Optical Data Acquisition Link (MODAL)

Two types of modules:
- Modal Node
- Modal Core

Firmware is based on 5 components:
- Modal Packer
- Modal Serializer
- Modal Receiver
- Modal TxLink
- Modal RxLink

Modal Node board



# Summary

- Very effective and fruitful collaboration
- Developed and installed PRL system and large number of high-performance devices and units
- Excellent integration with ESS teams
- Interesting ideas for potential future collaboration

# Thank You for Attention!