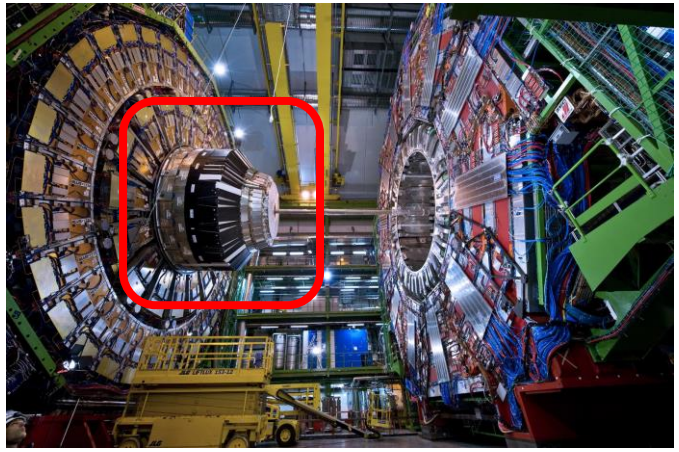
HGCAL DCDC modules

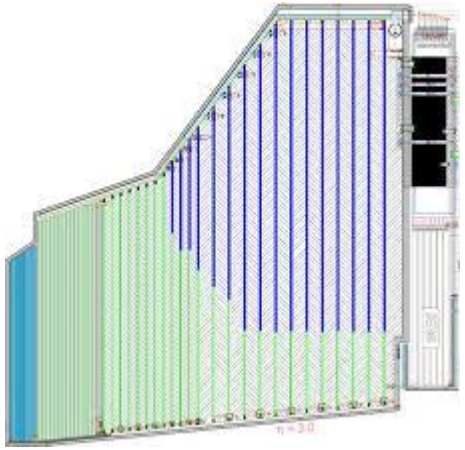
Taiwan Instrumentation and Detector Consortium

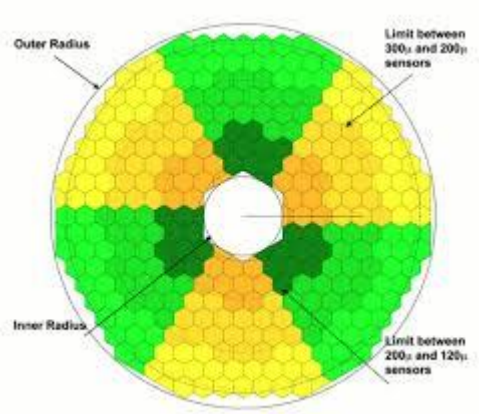
Stefano Caregari (National Central University)

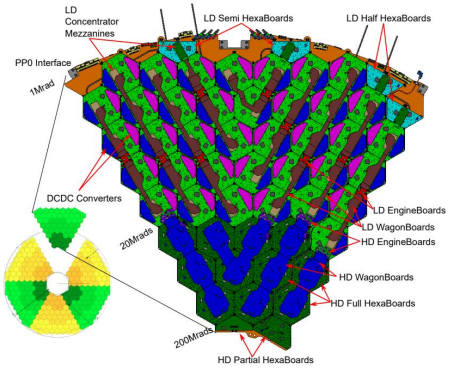
bPOL12V for HGCAL

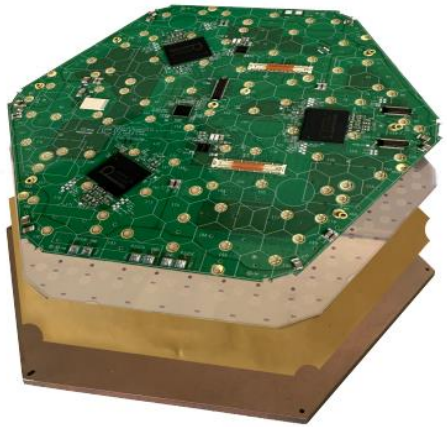
CMS High Granularity Calorimeter

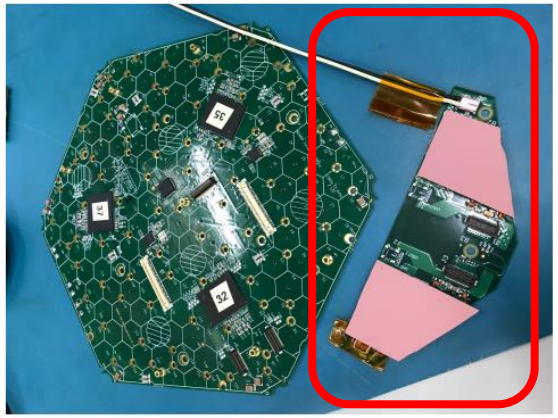












The front-end electronics of HGCAL is powered by bPOL12V:
a rad-hard buck converter developed by EP-ESE,
hosted on HGCAL-dedicated PCBs

bPOL12V placement in HGCAL

HGCAL dedicated DCDC modules are based on bPOL12V:
an integrated buck converter designed at CERN
for the power distribution in High Energy Physics experiments.

HGCAL LD region radiation levels
min: 1Mrad, 2e14n/cm2 **max: 20Mrad, 2e15n/cm2**

HGCAL HD region radiation levels
min: 20Mrad, 2e15n/cm2 **max: 200Mrad, 8e15n/cm2**

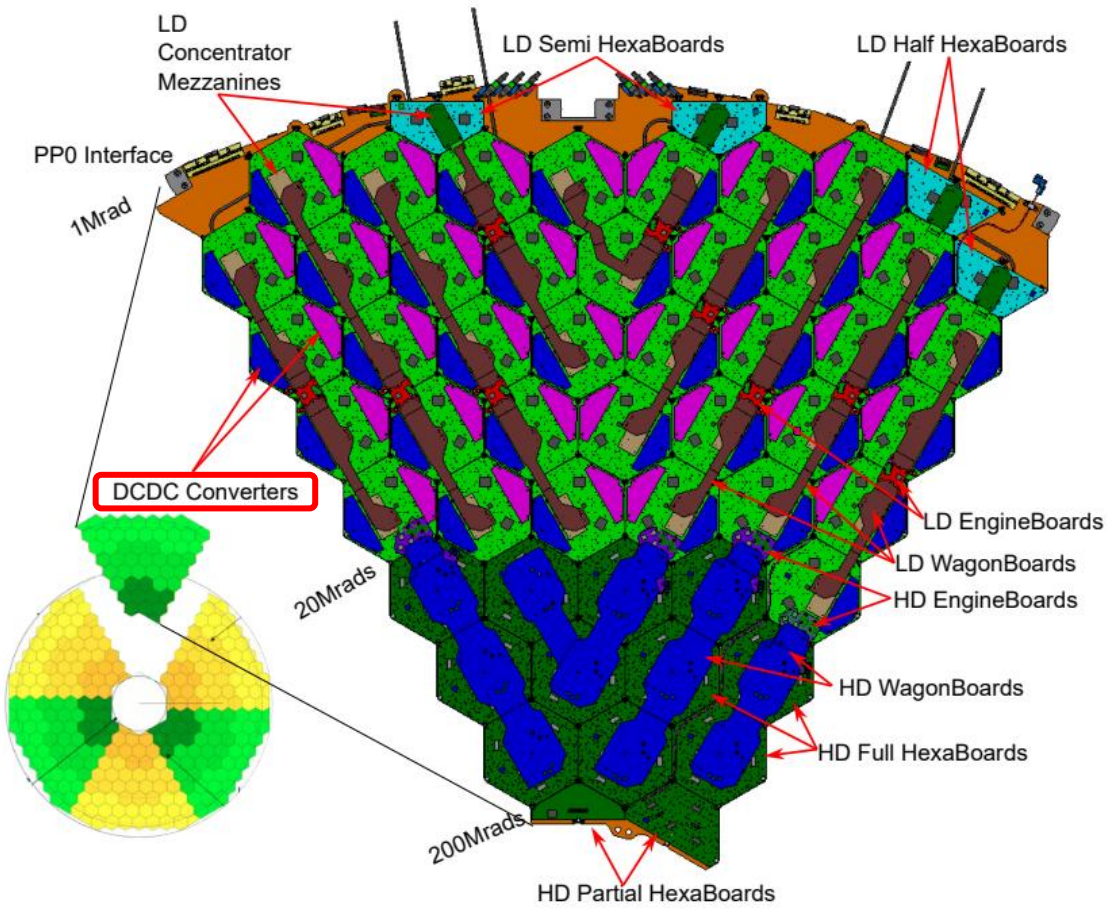
bPOL12V_V6 max specifications: **150Mrad, 7e15n/cm2**

bPOL12V use in HGCAL is limited to the LD region
due to the high radiation levels reached in the HD region.
Still, it is used to power both the LD and HD Hexaboards and Engines.

TID max	150Mrad
SEE max	45 MeV/(mg/cm²)
DD max	7e15n/cm2 1.2e15p/cm2 (27MeV) 2.34e15p/cm2(230MeV) 4.71e15p/cm2(24GeV) 4e14p/cm2 (27MeV) + 6e14 n/cm2

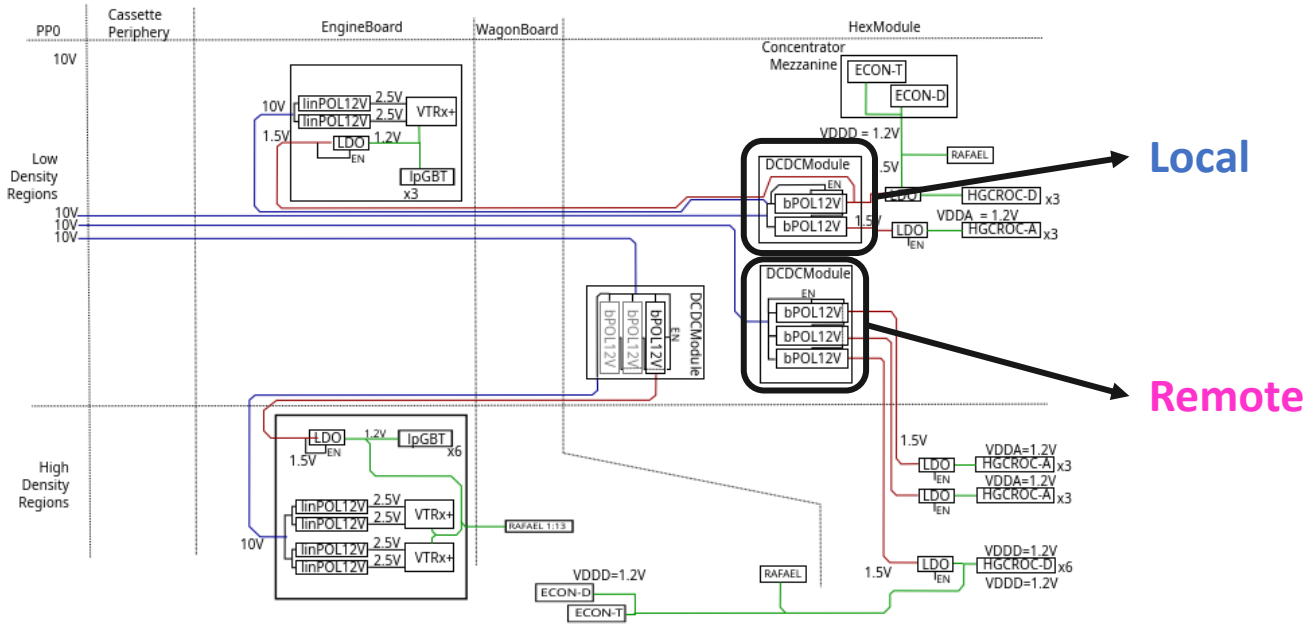
[ASICs - CERN Power Distribution Website]

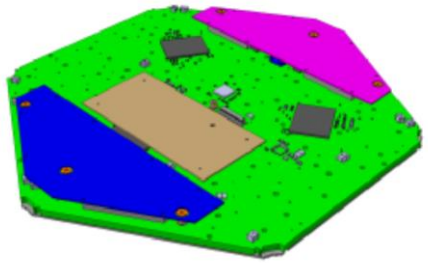
Courtesy of Matthew Noy

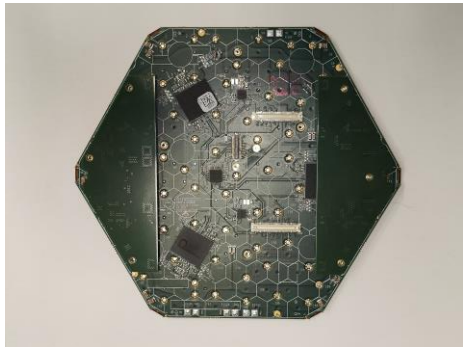


Local and Remote bPOL12V DCDC modules

Courtesy of Matthew Noy







The most common variants of DCDC mezzanines across HGCAL will be the Local and Remote:

- **The Local hosts 2xbPOL12V powering the LD Hexaboard on which it is mounted**
  LD Hexaboard (full) current requirement : Analog: ~1.95A Digital: ~1.65A
  (up to ~2.92A when powering also the LD Engine)

- **The Remote hosts 3xbPOL12V powering an HD Hexaboard, further inside the cassette**
  HD Hexaboard (full) current requirement: Analog1: ~1.95A Analog2: ~1.95A Digital: ~2.12A

Development Status

DCDC Status

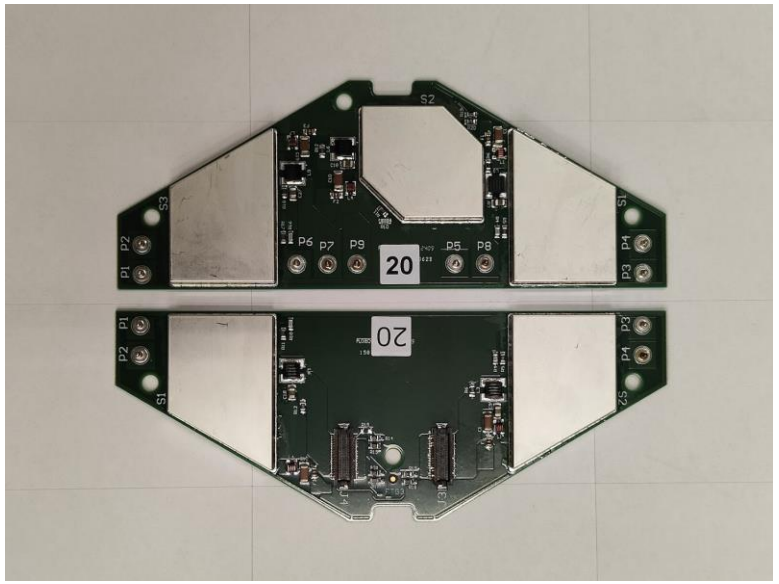
Main activities and advancements of the past year:

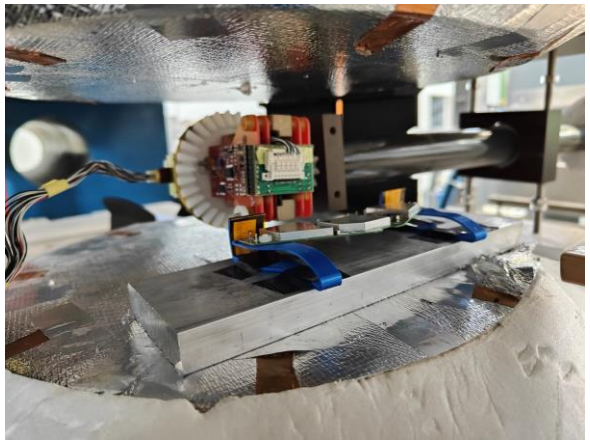
- 200 bPOL12Vs mounted on 80 boards have been assembled using:
  - *bPOL12V_V6*
  - *Production grade coils*
  - *Prototype shields (200um copper + nickel tin plating)*

The assembly was performed as 2-stage reflow from two different companies in Taiwan.

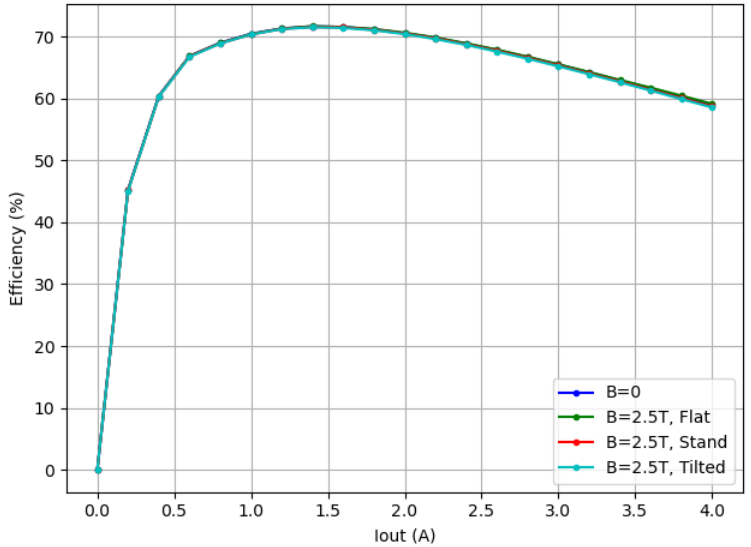
Out of 80, **48 PCBs were thermal cycled** from 10 to maximum 30 times in range -40°C, 70°C**, without revealing any loss of functionality, or degradation of the performance**.

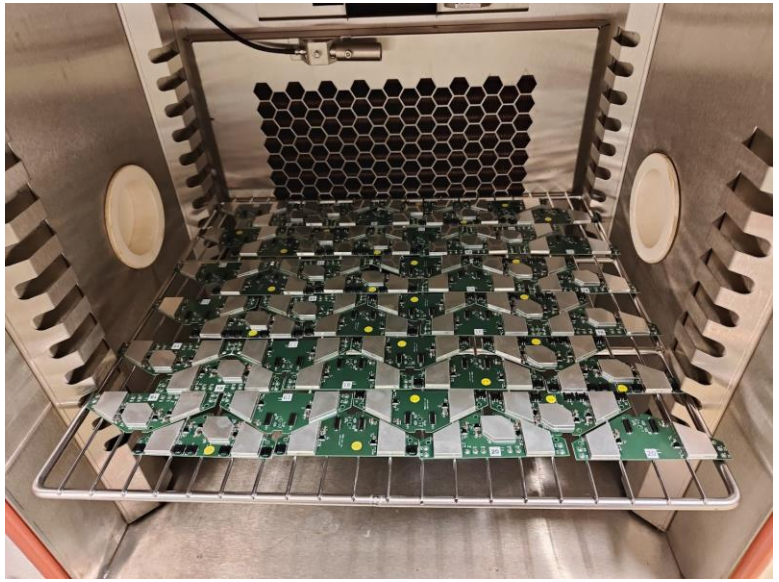
Few among these have been **tested** also **in magnetic field (2.5T) without** any noticeable **effect**.





DCDC in the Magnet





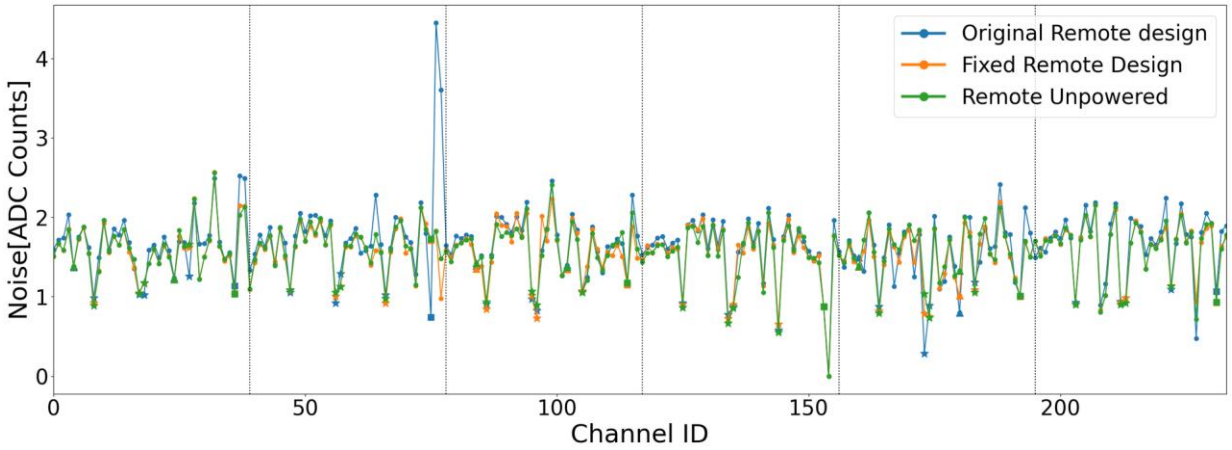
Thermal Cycling

DCDC Status

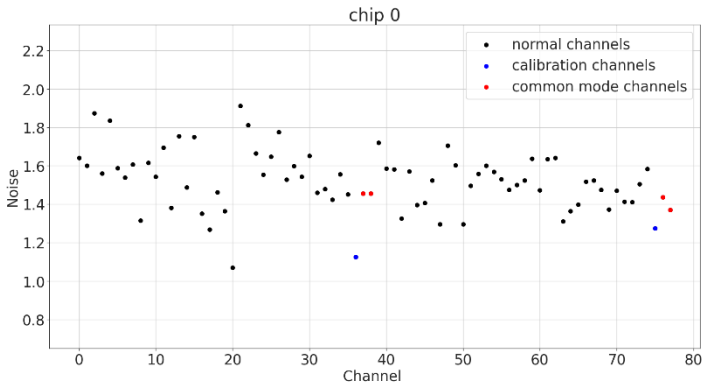
Main activities and advancements of the past year:

- Testing with the Front-end modules highlighted a weakness in the design that affects in particular the Remote variant (3xbPOL) a new Remote design has been prototyped, assembled and tested successfully to verify the proposed fix

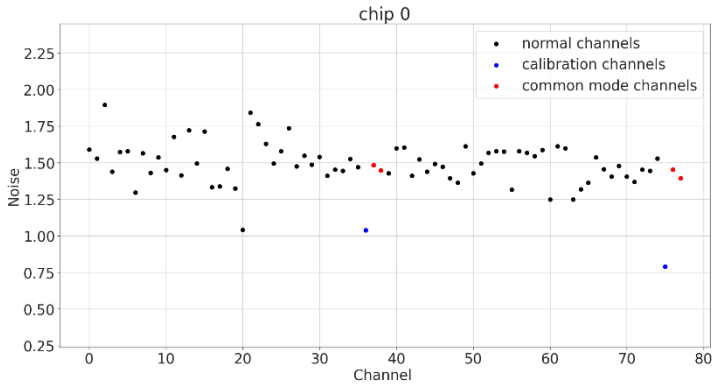
LD Module Noise



HD Module Noise



Fixed Remote Design



Original Remote Design

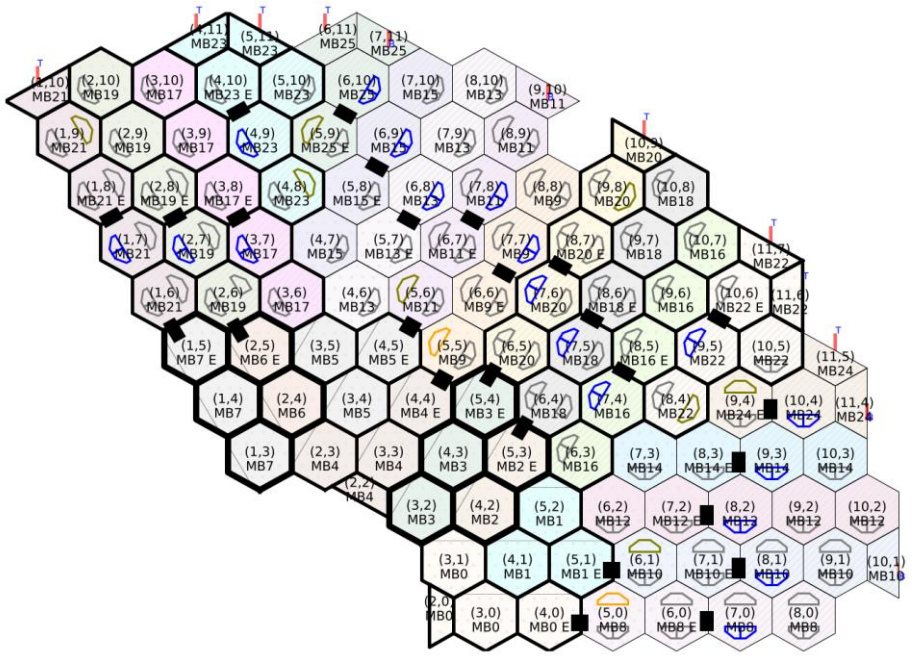
FE Module Testing

DCDC Status

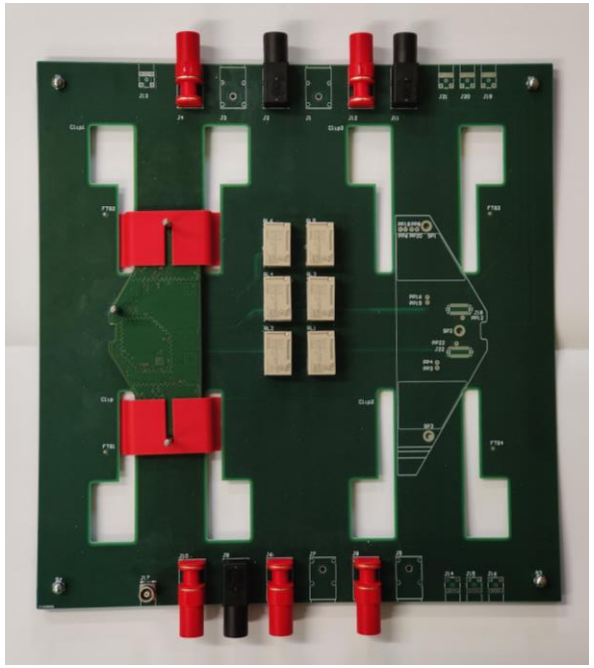
Main activities and advancements of the past year:

- 200 bPOL12Vs mounted on 80 boards have been assembled, thermal cycled and tested standalone successfully
- Testing with the Front-end modules highlighted a weakness in the design that affects in particular the Remote variant (3xbPOL)
  a new Remote design has been prototyped, assembled and tested successfully to verify the proposed fix

- All **10 PCB variants designs** and their **mapping** throughout the detector **are now mature** *(Design Review passed the 26th of September)*
- A **QC Testboard** has been **designed, prototyped and tested** – detailed QC steps to be formalized



DCDC Mapping



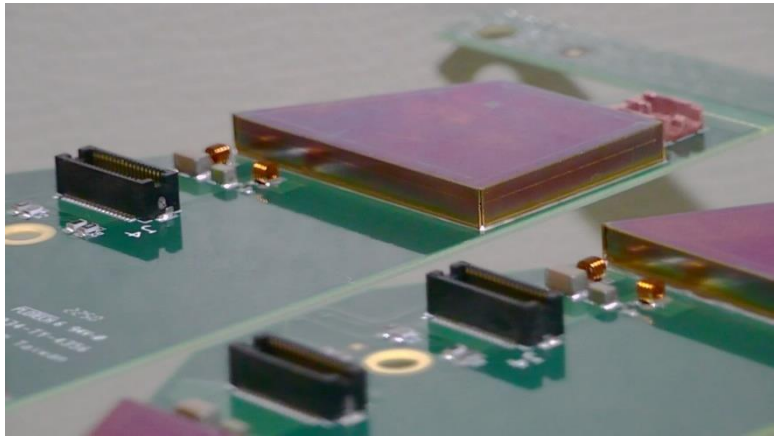
QC Testboard

Towards Pre-Production

Custom shields

Ensures proper EMI shielding to reduce irradiated noise by the converter:
it is custom since special shape and thickness are required

Pre-Production Order Placed:
Expected delivery: January 2025

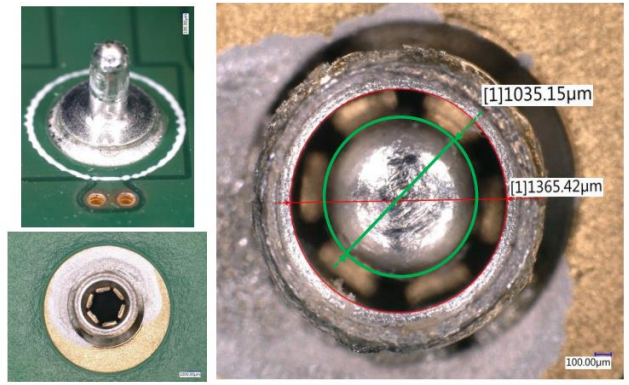


Prototype shield: pure copper foil 0.2mm thick

Custom pins

Ensures good connectivity with the busbar in a limited space:
it is custom since special length of the pin is required

Pre-Production Order Placed:
Expected delivery: January 2025



MAC8 PARTS CATALOG 2022 ENGLISH REV.1.00 (mac8japan.com)

Custom Pin-Socket Busbar connection
Courtesy of Pablo Antoszczuk

Custom coils

Ensures the proper functionality of the buck converter in the shielded volume in presence of strong magnetic field:
it is custom since special thickness, shape and materials are required

Pre-Production Parts in hand

Prototype toroidal air core coil

Towards Pre-Series, Pre-Production

With the available DCDC boards, it is already possible to assemble several trains for system tests, beam tests and some first cassettes pre-series trains.

The next steps towards the assembly of Pre-Series and Pre-Production are:

- Custom parts:
  - Coils: Pre-Production parts already in hand
  - Pins: Procurement done, expected for January 2025
  - Shields: Procurement done, expected for January 2025
- **PCBs:**
  Pre-Series and Pre-Production parts procurement starting soon
- **Assembly & QC foreseen to start in January, February 2025**