

finger Low Voltage Power Supply Upgrade for the ATLAS Tile Calorimeter in South Africa

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ATLAS
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Agenda

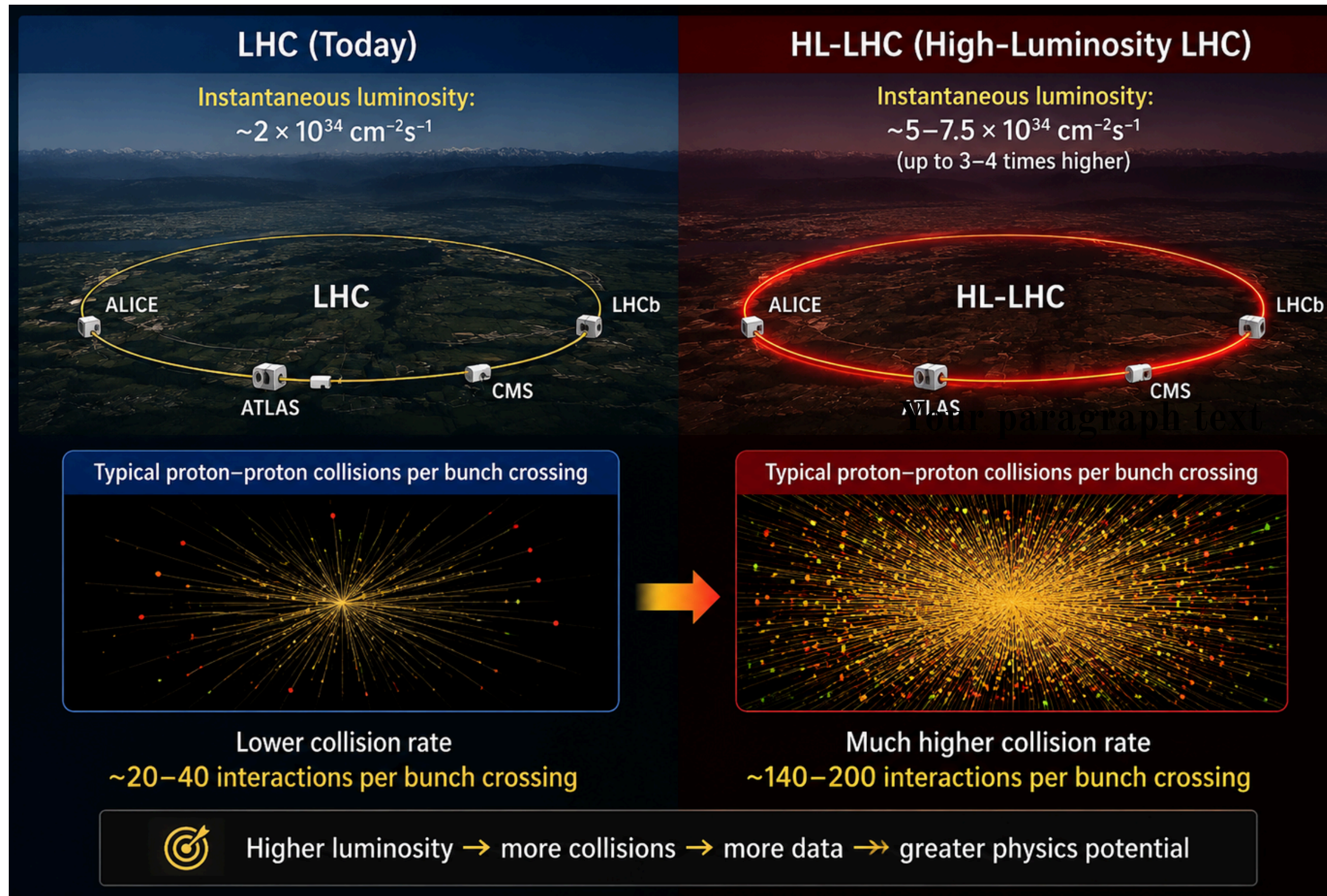
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MOTIVATION

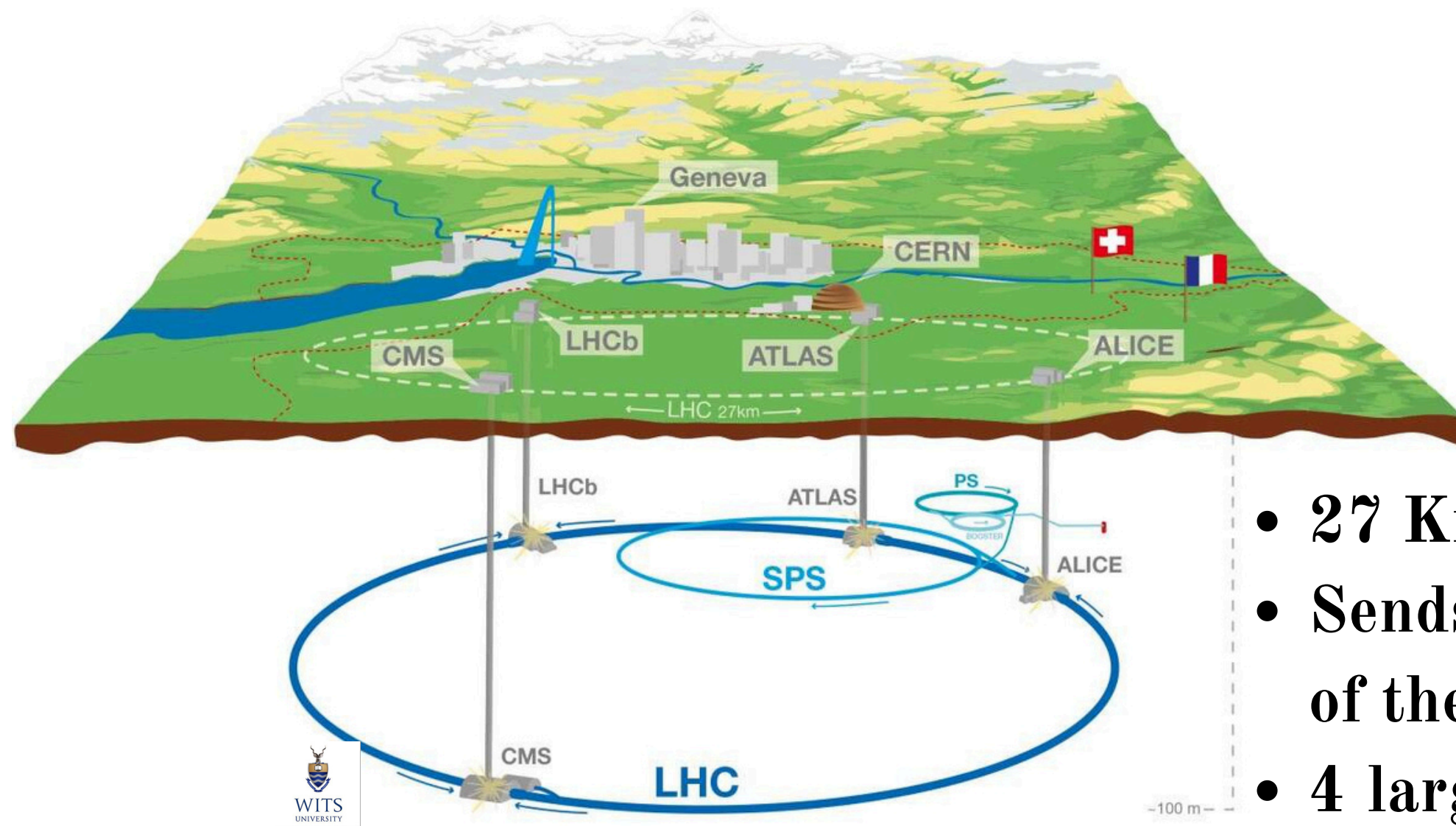
Unprecedented collision rates and radiation levels

- Requiring more reliable detector electronics
- To ensure stable operation of the ATLAS Tile Calorimeter, a new front-end Low Voltage Power Supply (fLVPS) has been developed
- SA's role in producing & validating these power supplies to meet the reliability requirements of the HL-LHC.



INTRODUCTION

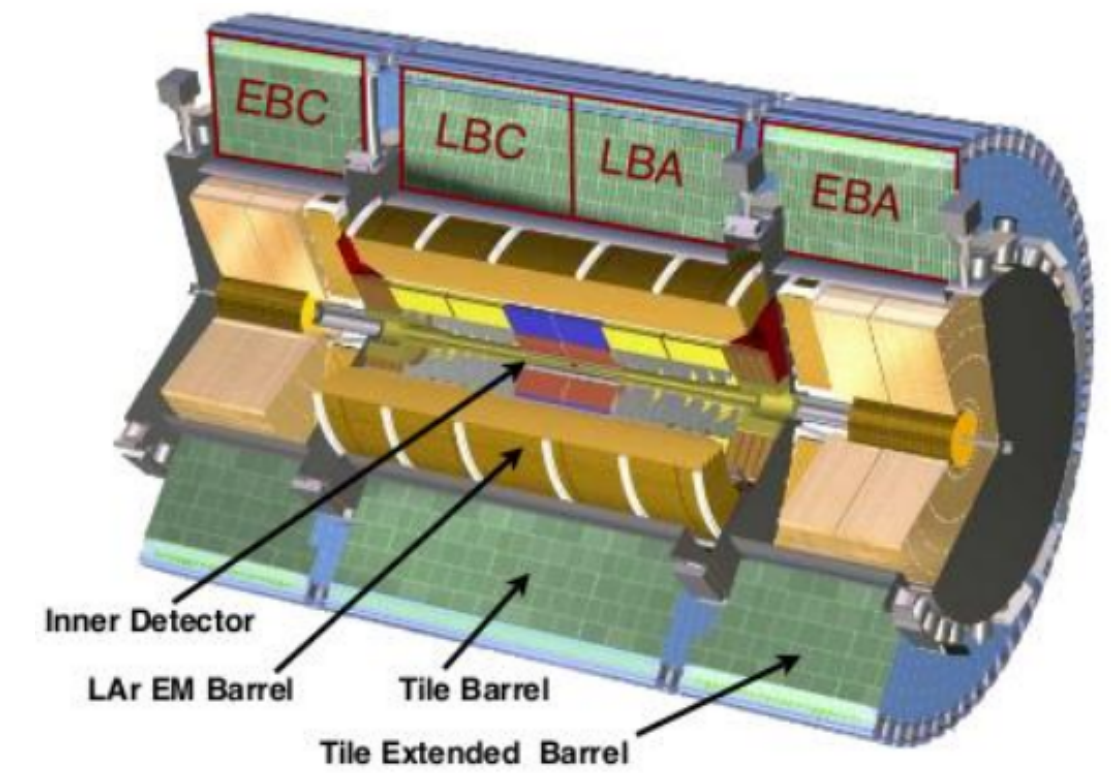
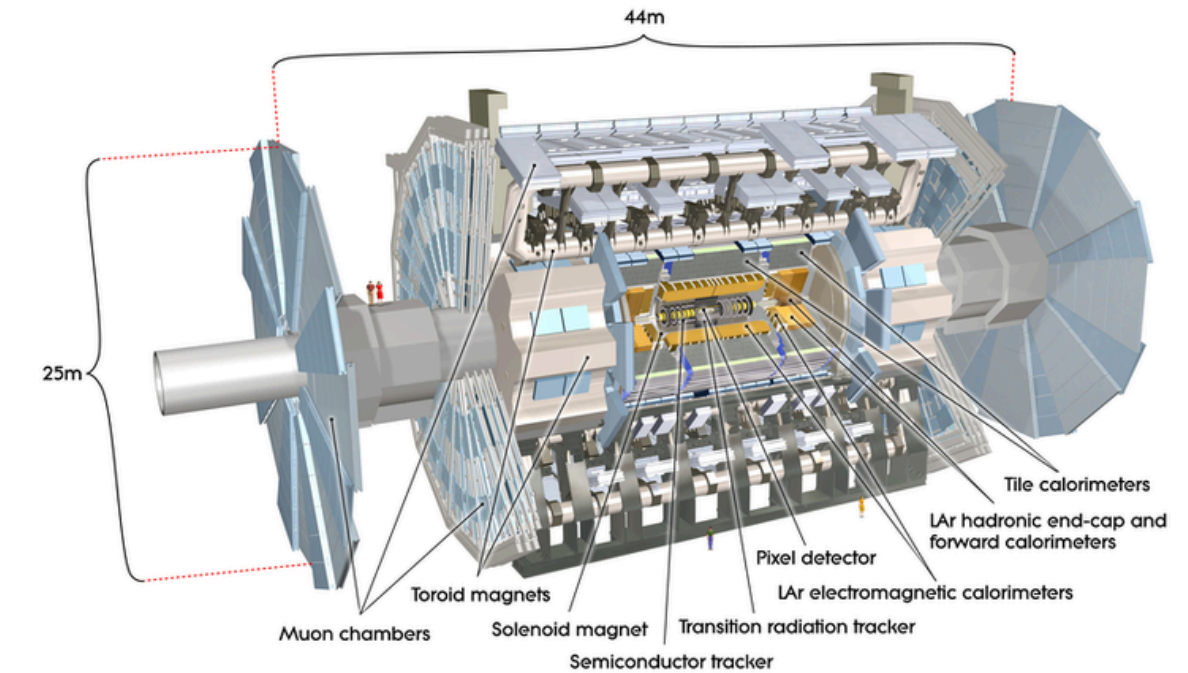
- The European Organization for Nuclear Research (CERN)
- Large Hadron Collider (LHC)



- 27 Km tunnel 100 m underground.
- Sends proton bunches round and round at 99.99 % of the speed of light and collides them together.
- 4 large experiments (interaction points) that try to work out what happened.

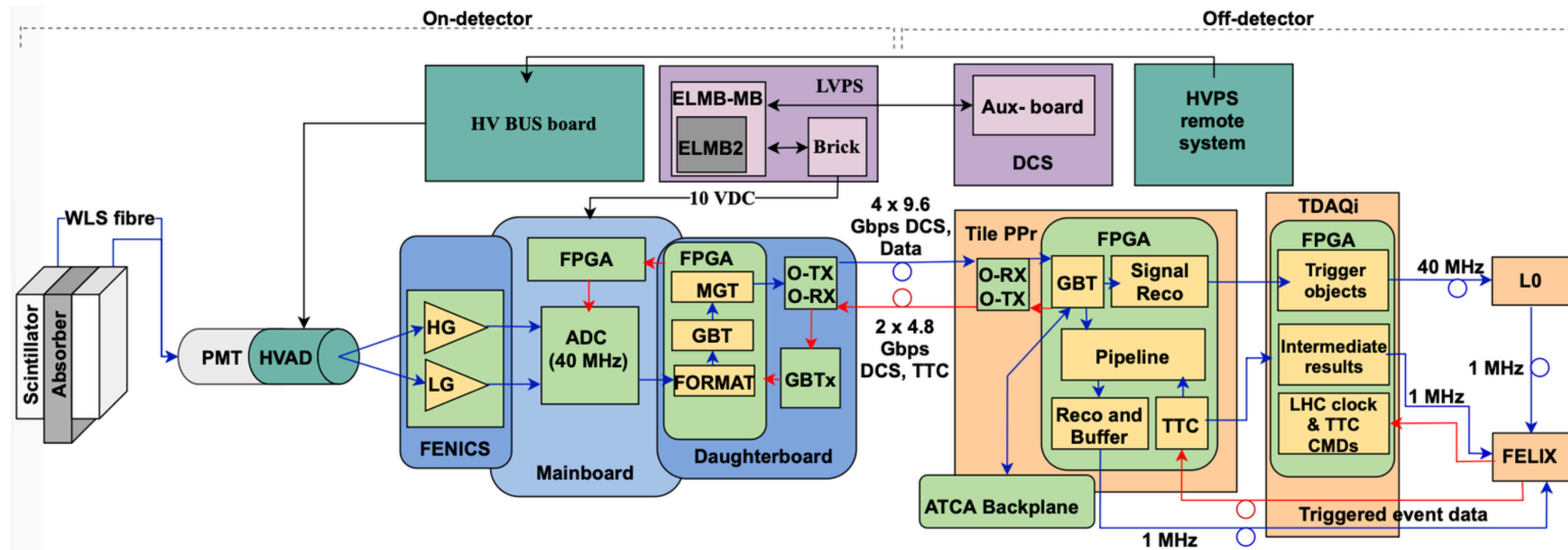
ATLAS & TileCal

- **ATLAS Detector** - General purpose, with numerous sub-detectors organised in concentric layers to study variety of Physics such as the Higgs boson, additional dimensions, and dark matter
- **Tile Calorimeter** - Central hadronic calorimeter:
 - Hadronic sampling calorimeter - iron/scintillator
 - 3 segments and 4 readout partitions
 - 64 independent modules in every partition
 - Measure energy using light produced by charged particles in plastic scintillators (tiles)
 - Particle identification, direction, and energy measurements



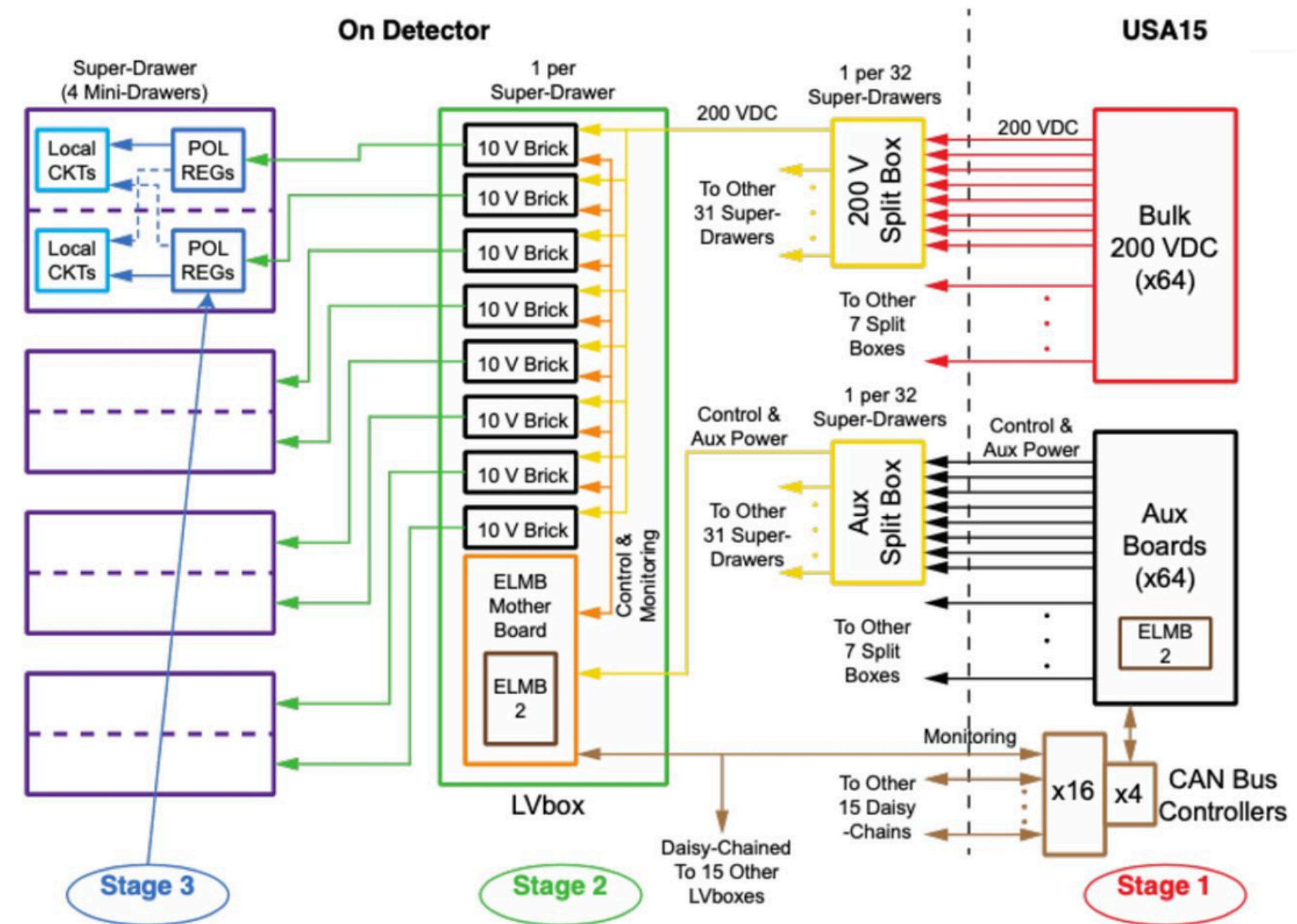
TileCal Phase-II Upgrades

- High Luminosity LHC (HL-LHC) is set to commence in 2030
- The HL-LHC will introduce higher radiation levels and increased data rates
- To meet these challenges, the ATLAS Tile Calorimeter is undergoing a Phase-II upgrades of its front-end electronics and power supply systems
- A key upgrade is the new front-end Low Voltage Power Supply, designed for efficient, stable, and radiation-tolerant power delivery

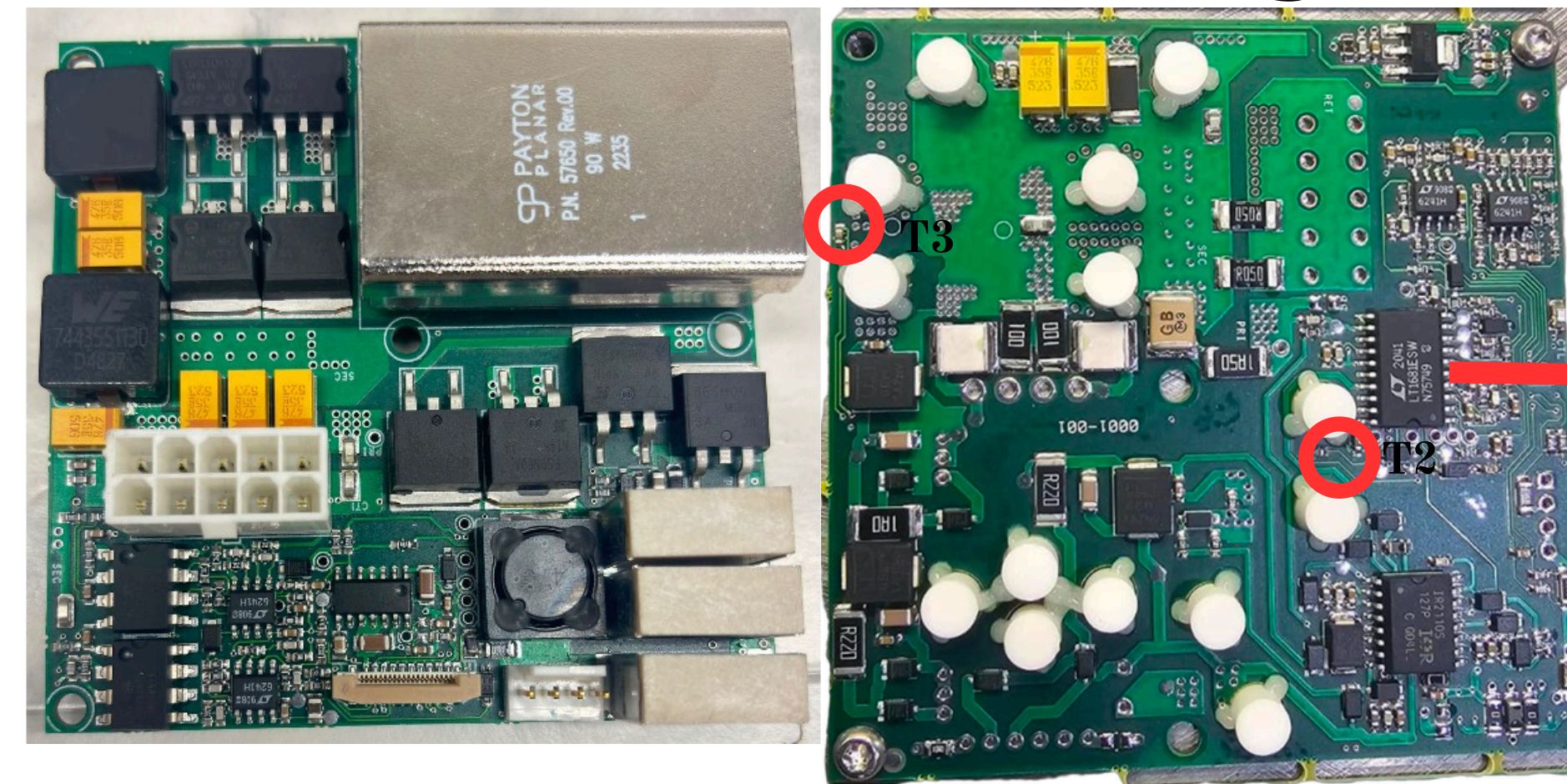


Low Voltage Power Distribution

- Two stage System (**Current System**)
 - 200 V DC power supply located Off detector
 - finger Low Voltage Power Supply (fLVPS) located On-detector producing different voltages (3.3V, 5V, 15V)
- Three stage System (**Phase-II Upgrade**)
 - Point of Load located on the front-end electronics (Reduces design complexity and costs).



Phase-II Upgrade fLVPS Boards

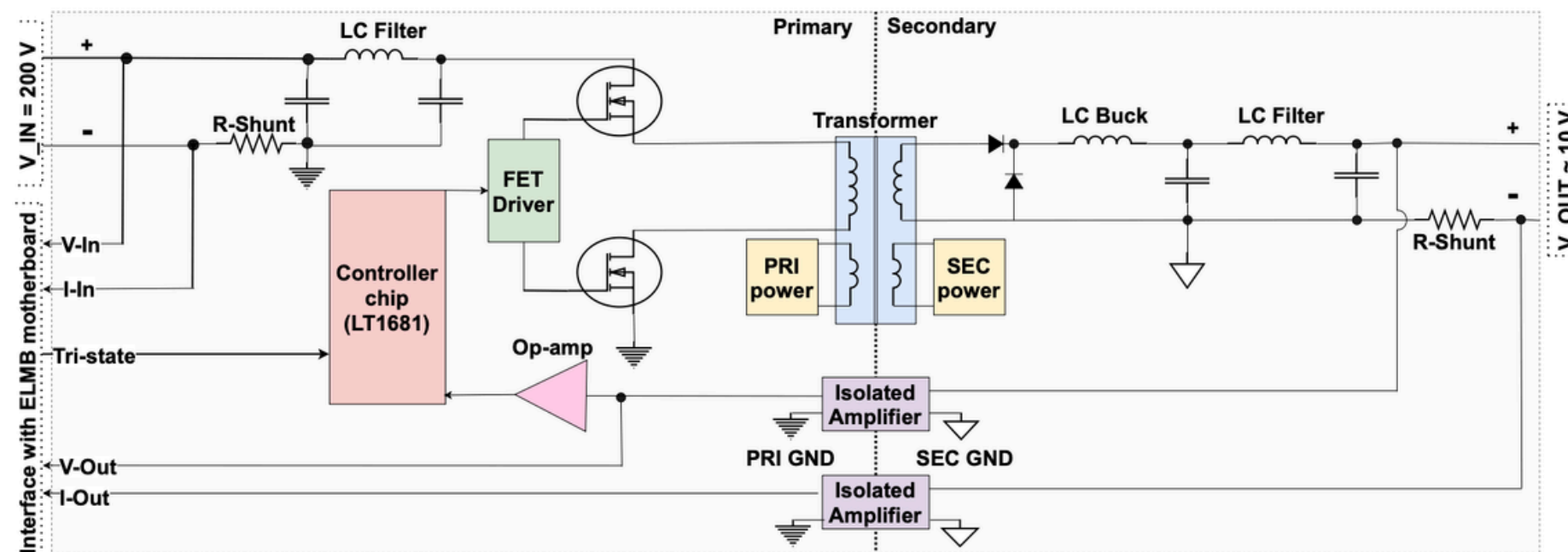


- The low-voltage distribution system has been completely redesigned for the TileCal Phase-II upgrade.

fLVPS Design

- LT1681 PWM controller operating at 300 kHz.
- Employs synchronous MOSFETs and a high-frequency 14:1 transformer.
- Secondary-side buck converter with LC filtering ensures stable 10 V output.

The V8.6.0 fLVPS board's top (left) and bottom (right) view

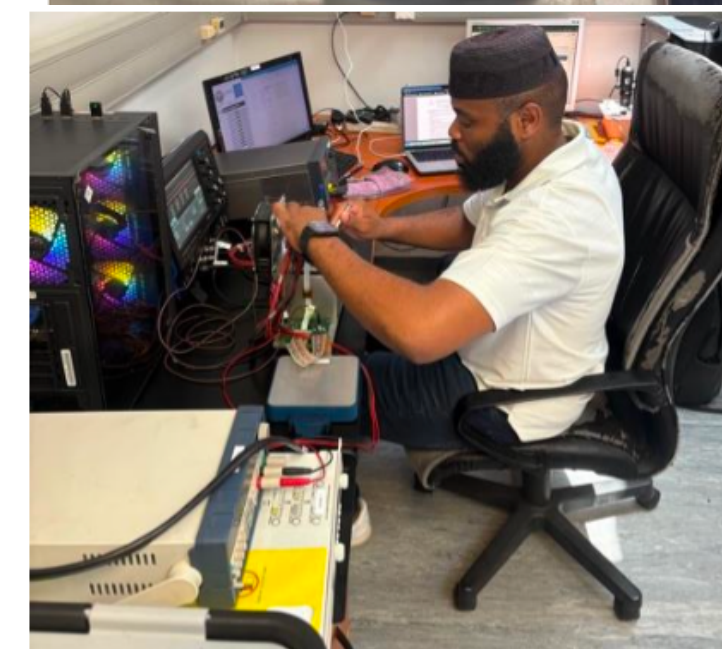
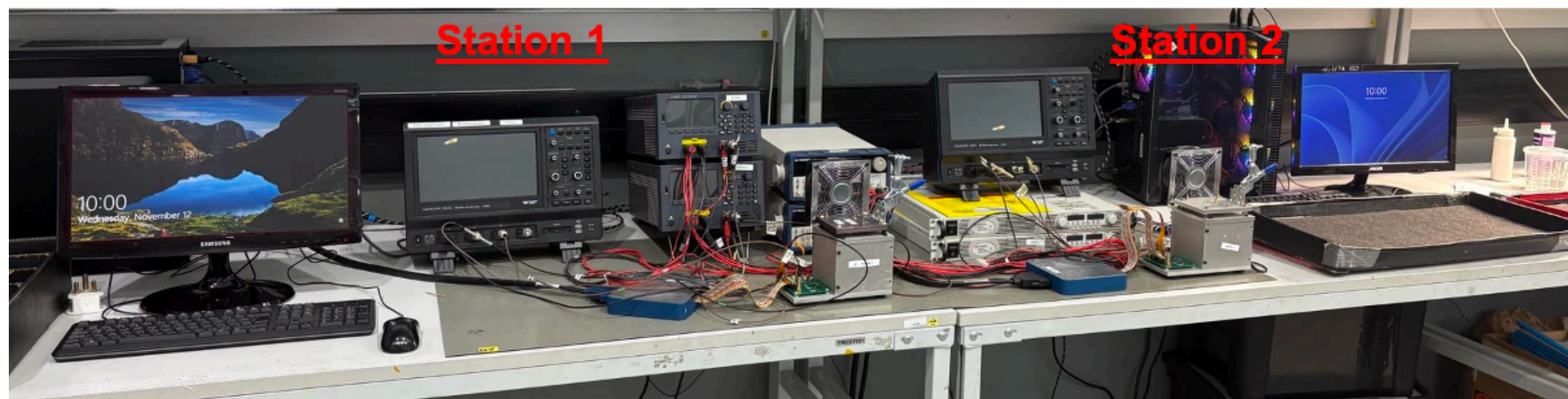
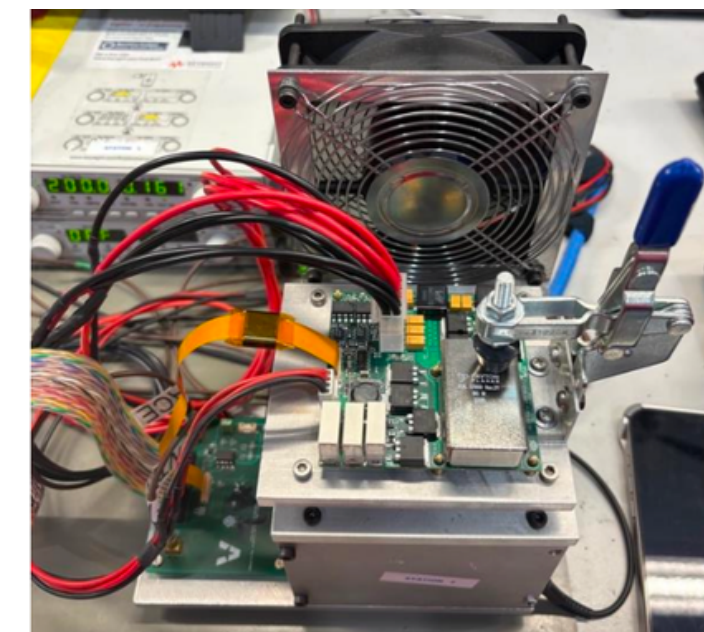
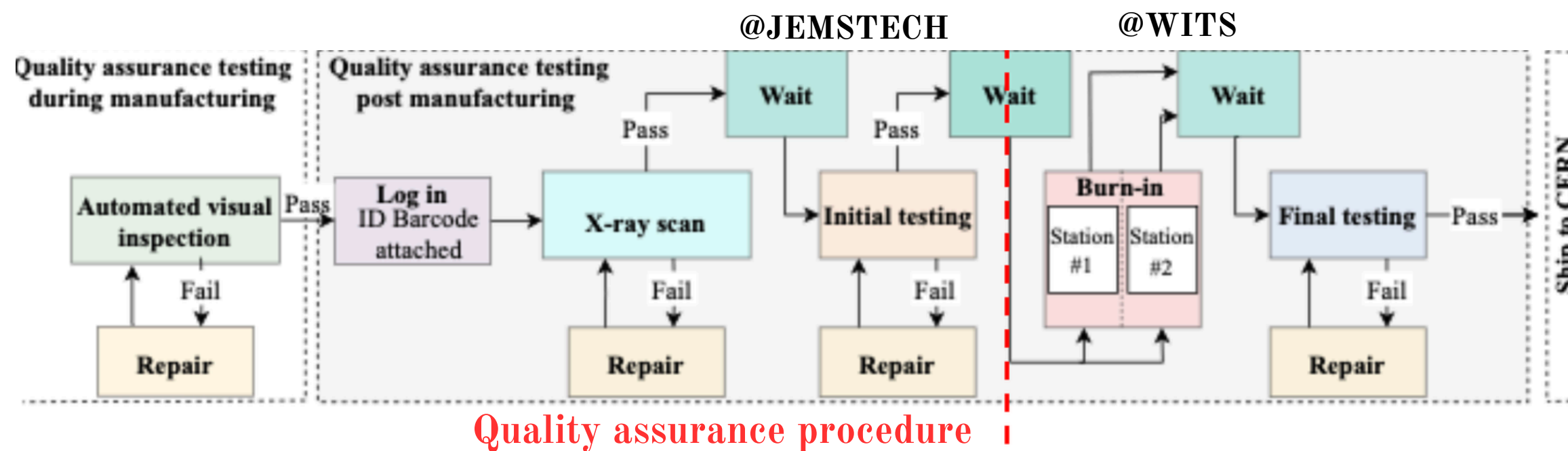


Protection & Monitoring

- Integrated T2 and T3 thermistors provide continuous temperature monitoring.
- Built-in protection mechanisms enhance system reliability:
 - Over-Temperature Protection: 70 °C
 - Over-Voltage Protection : 11.85 V
 - Over-Current Protection : 6.9 A

Production & Quality Assurance

- There were 1029 fLVPS boards produced in SA in Nov 2025-March 2026 and shipped to CERN.
- **Initial & Final Testing**
 - Identical testing procedure performed before (Initial) and after (Final) the burn-in stage.
 - Verifies electrical performance (e.g., output voltage, temperature) and compliance with design specifications.
 - Final testing verifies that each fLVPS board continues to meet its design specifications after burn-in.



Single test stand

**HOW DO WE KNOW A fLVPS
BOARD WONT FAIL ONCE
INSTALLED INSIDE TILECAL??**

Burn-in Testing

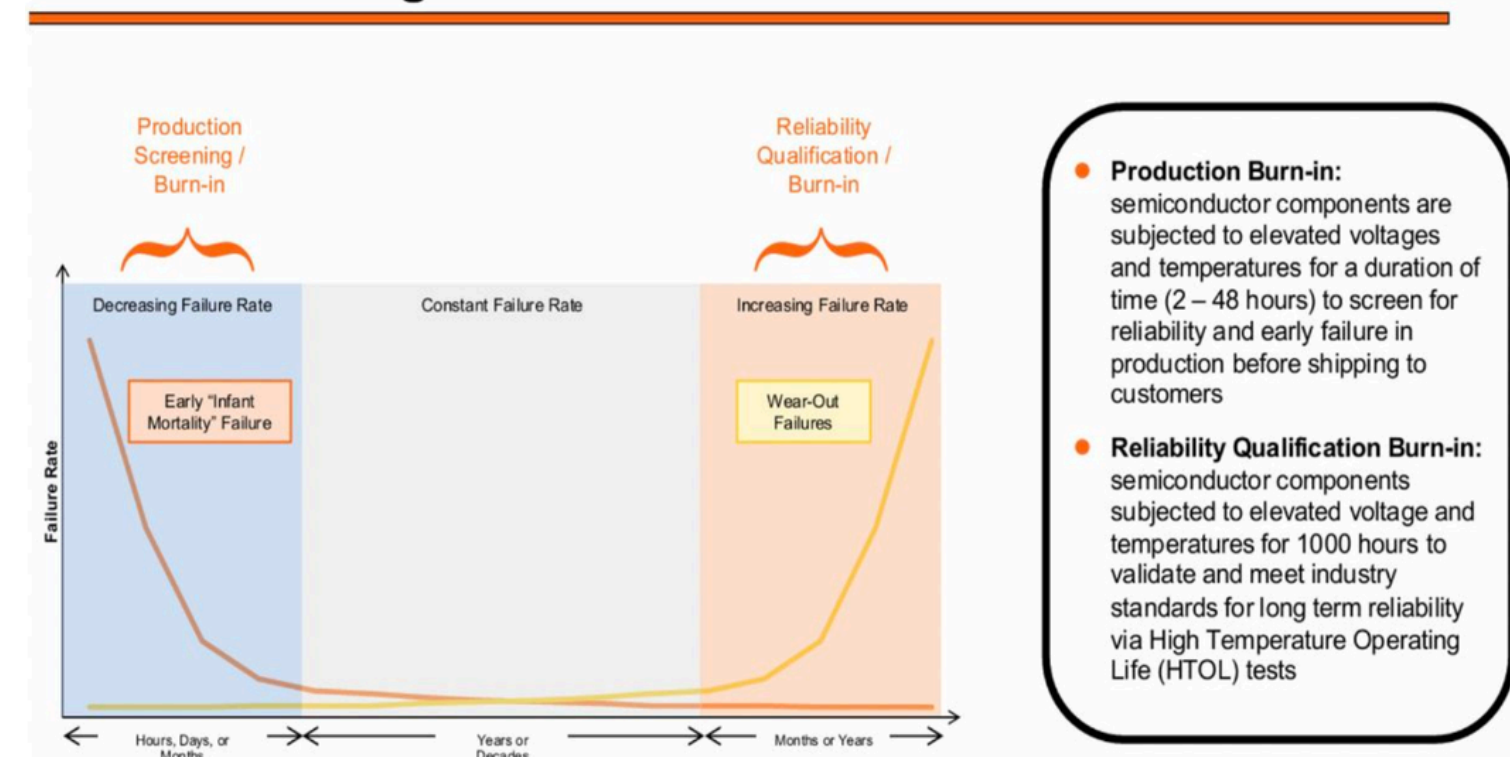
- **Burn-in**

- Accelerates aging to identify early-life (infant mortality) failures before deployment in TileCal
- Elevated temperature and electrical load to simulate long-term operating conditions
- Two Dummy Load Boards (DLBs) emulate the front-end electronics by dissipating the 10 V DC output from the fLVPS as heat through MOSFETs



Parameter	Burn-In	Nominal	Protection
Operating temperature	60 °C	35 °C	70 °C (OTP)
Applied load	5.0 A	2.3 A	6.9 A (OCP)
Output voltage	10 V	10 V	11.85 V (OVP)
Run-time	8 h	-	-

Burn-in Testing – The Bathtub Curve

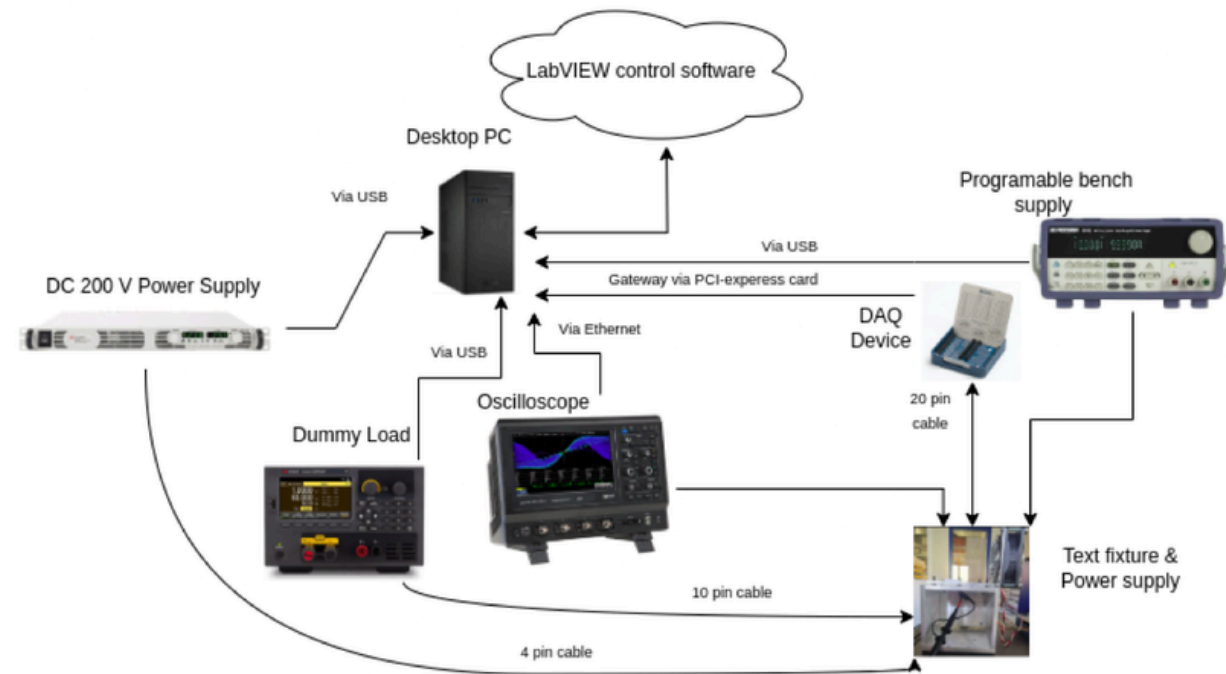


- **Infant Mortality:** High initial failure rate caused by manufacturing or assembly defects; failures decrease over time.
- **Useful Life:** Low, nearly constant failure rate dominated by random faults.
- **End of Life:** Failure rate increases due to component aging and wear-out.

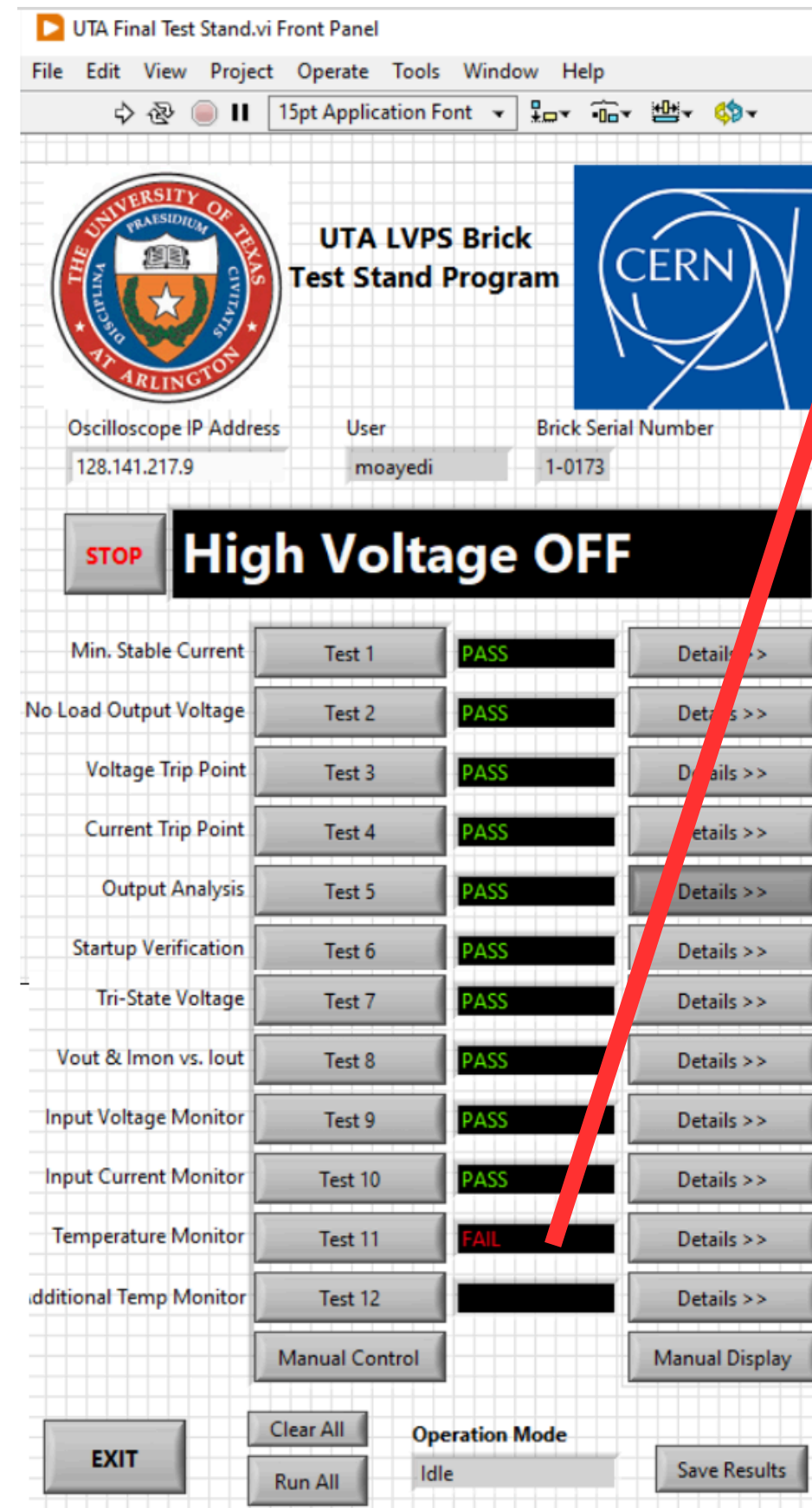


SEE Donalds talk

Quality Assurance Results



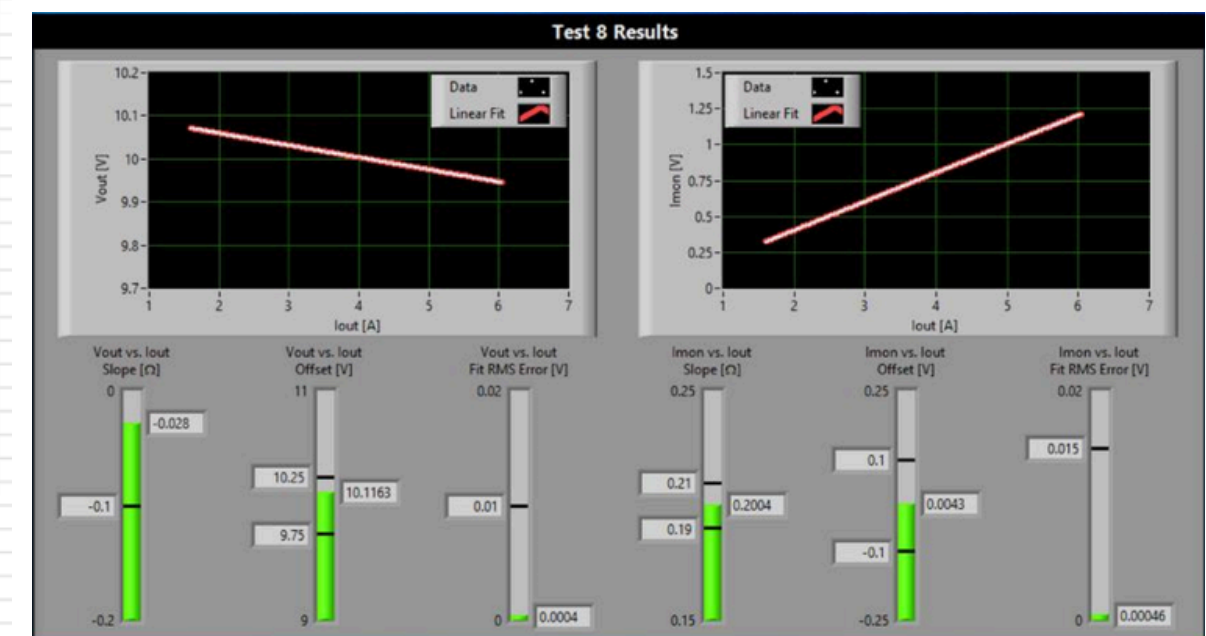
- LabVIEW software manages the setup and reads out the necessary evaluation parameters
- A full test procedure consists of eleven distinct tests all of which need to be passed for the Brick to pass initial/final testing. Test 12 is an additional test that does not form part.



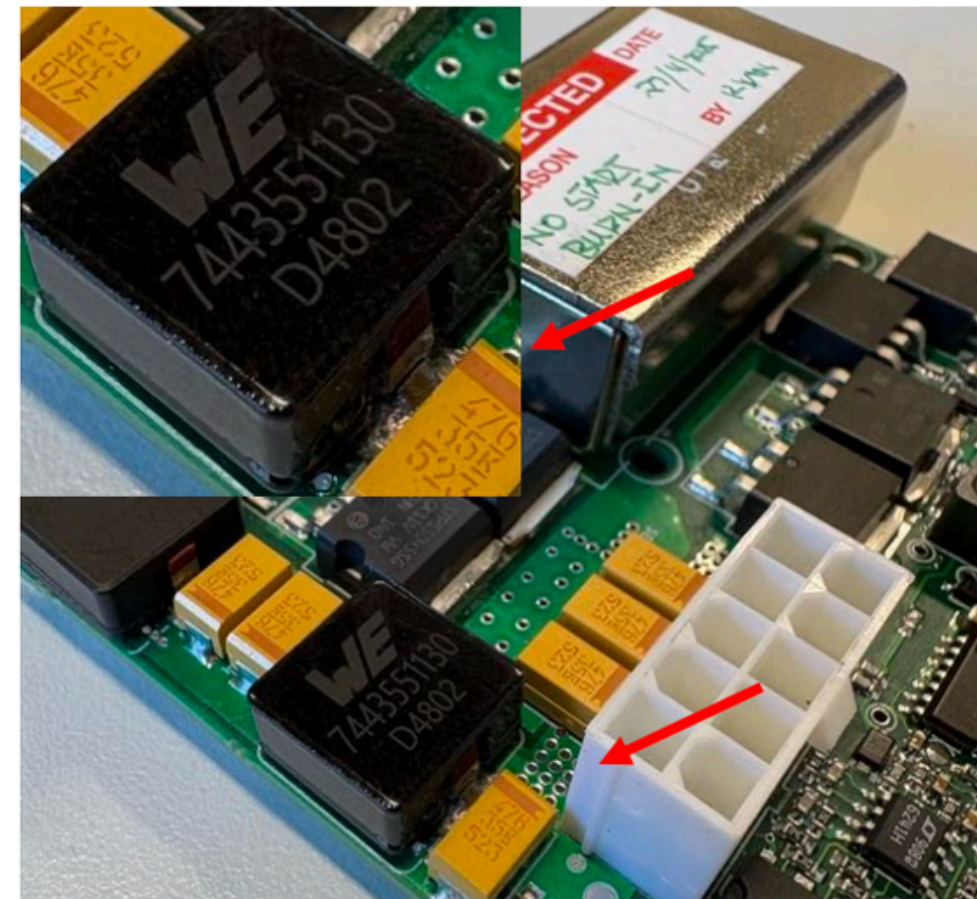
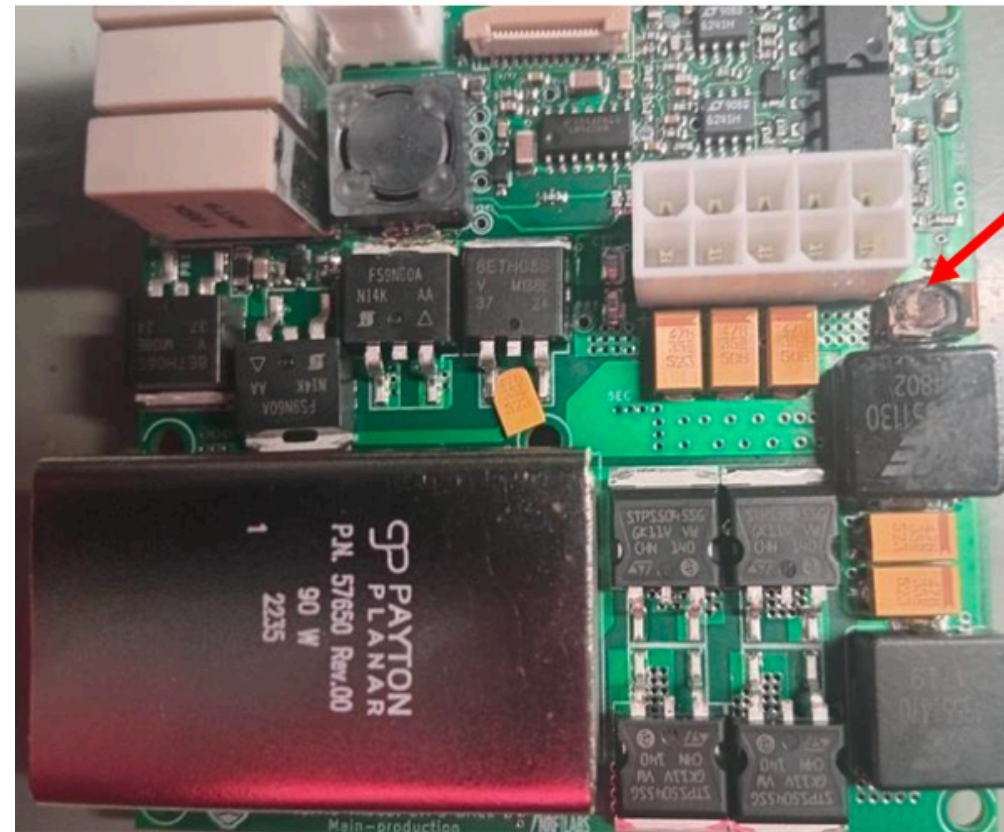
- Failed test, that brick is considered to be failed

Other Failers

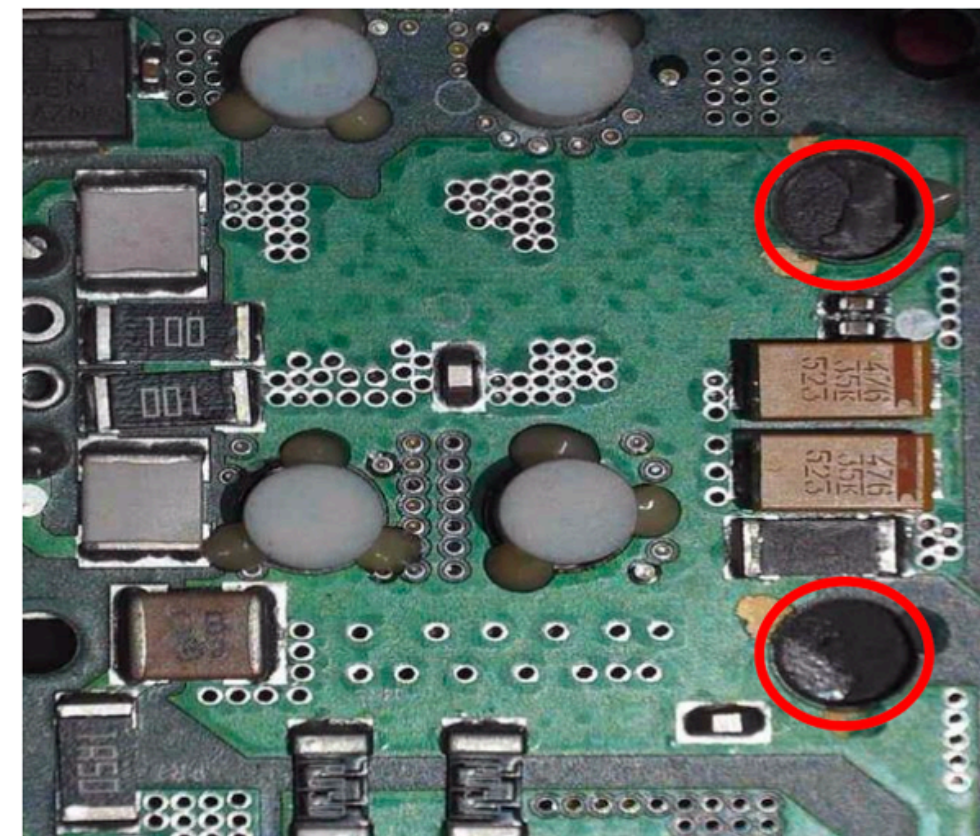
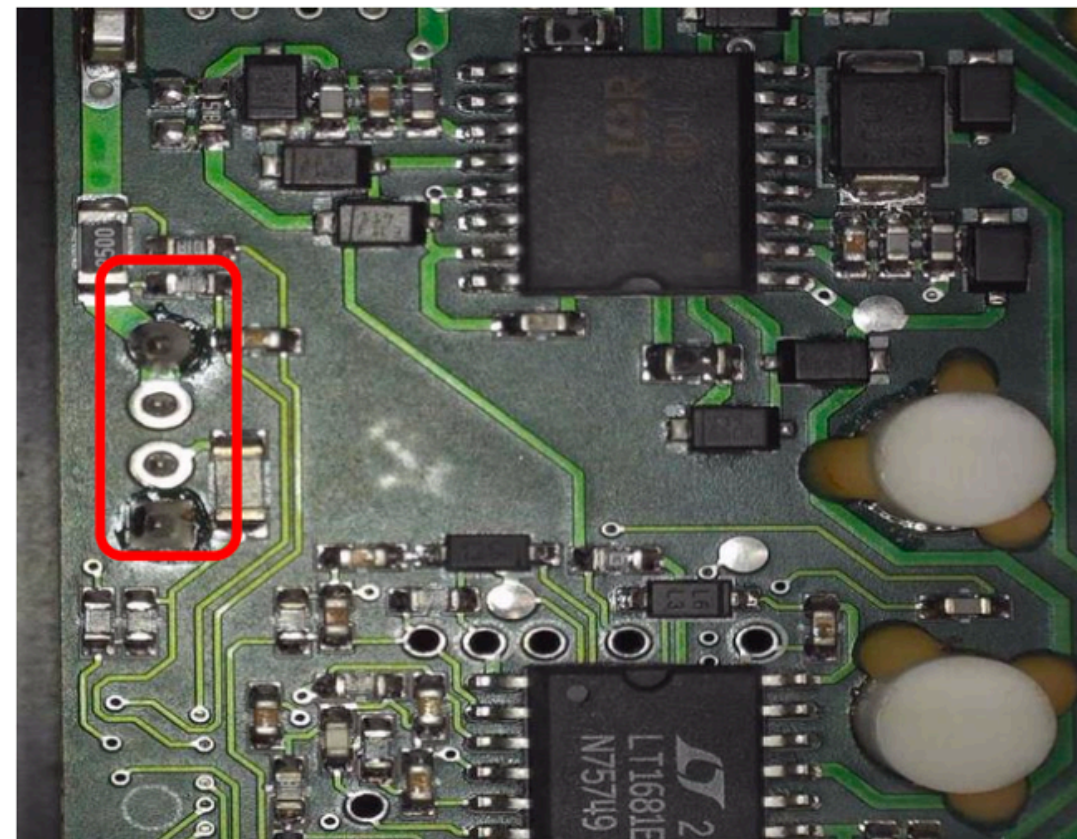
- Cold solder
- Brick non-start
- Brick over temperature
- Component installed with incorrect polarity
- Mechanical damage



Other Failers



Conducting performance testing both before and after Burn-in offers valuable insights into potential performance degradation resulting from the Burn-in process and helps screen out fLVPS boards that may have suffered permanent damage.



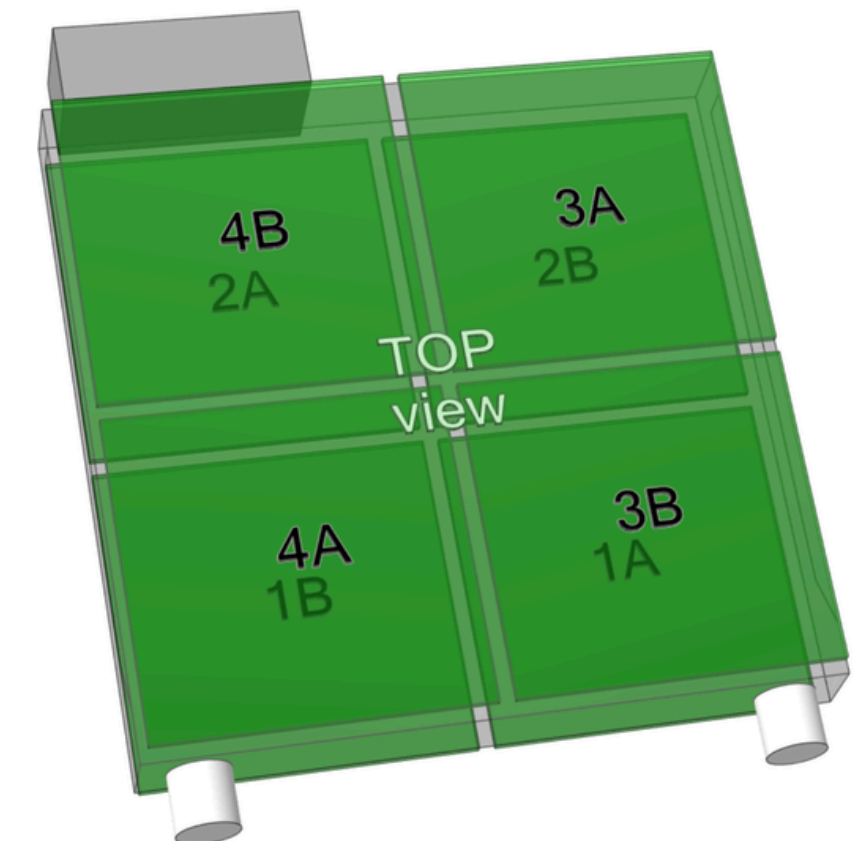
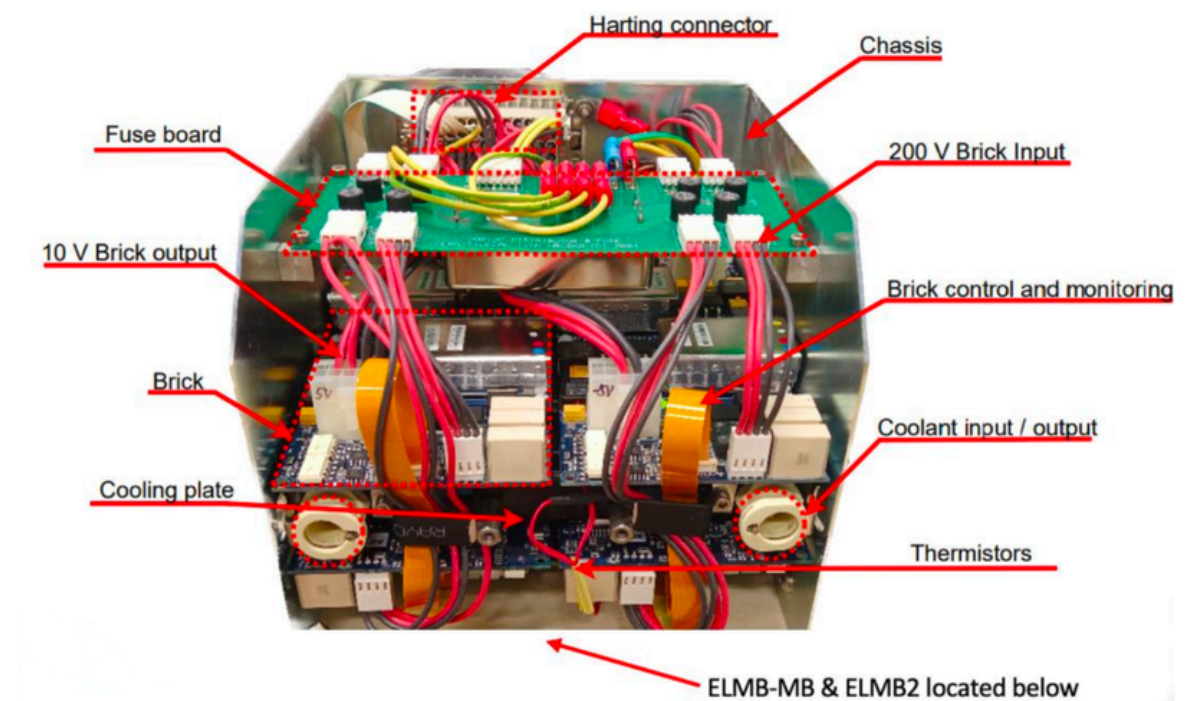
fLVPS boards with latent defects that marginally affect their functionality may not be identified through performance testing alone, potentially leading to their installation within the TileCal.

The burn-in process helps to detect such cold solder joints, which are often invisible to the naked eye and can cause system failures.

LV Box

The TileCal contains a total of 256 fLVPS & has its own LV Box

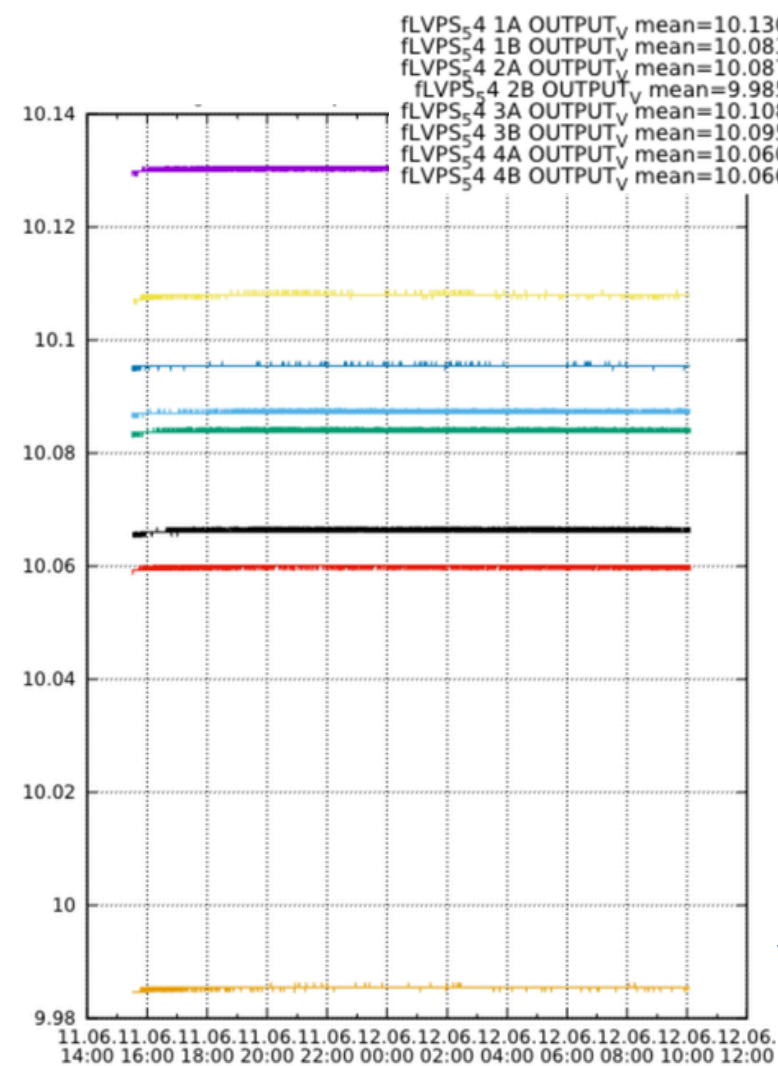
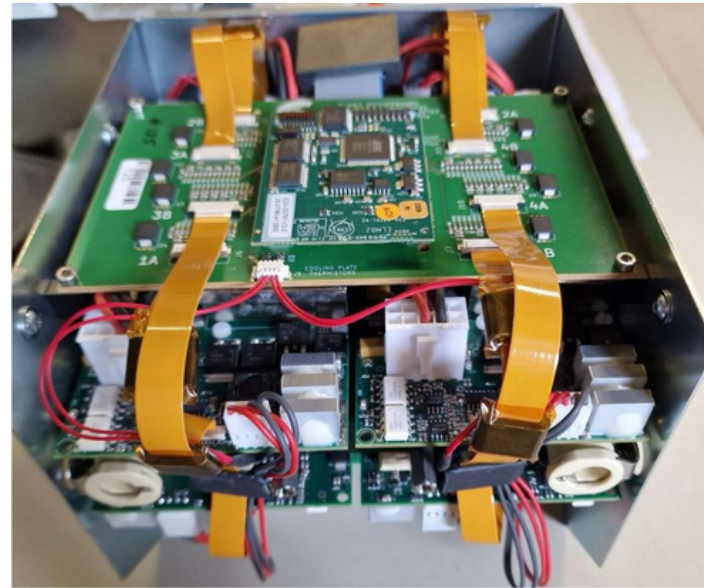
- **8/6 fLVPS boards** : convert the 200 V DC input to 10 V DC for the front-end electronics. (In case of extended barrels 4A & 4B are not connected.)
- **ELMB2**, mounted on the **ELMB-MB**, provides monitoring and control of the fLVPS boards.
- **Fuse Board** : Provides overcurrent protection and fault isolation.
- **Cooling Plate**: Water-cooled plate for efficient heat dissipation from the fLVPS boards.



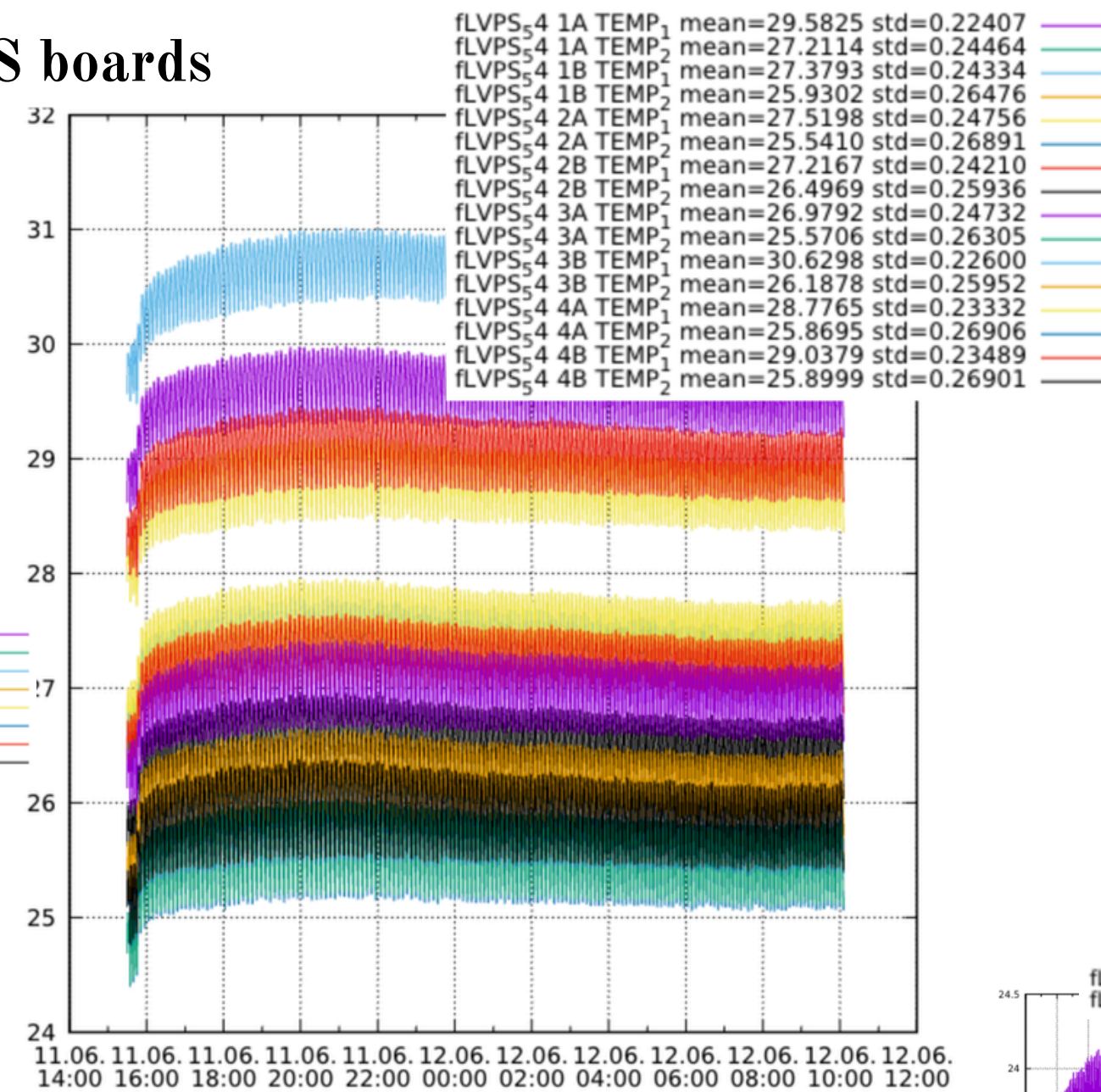
Arrangement of fLVPS boards on cooling plate

Assembled LVBoxes

- Assembled box with SA fLVPS boards

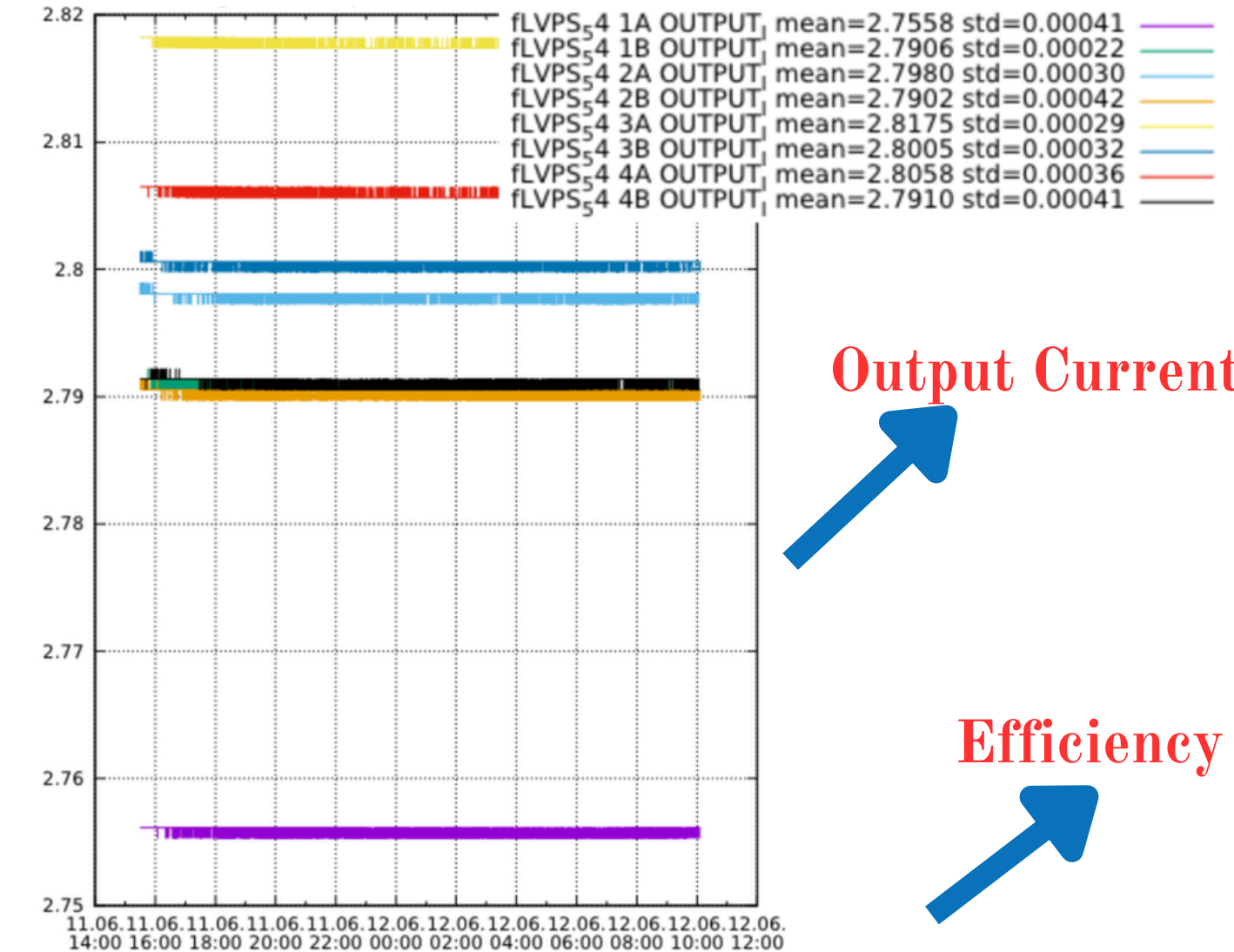
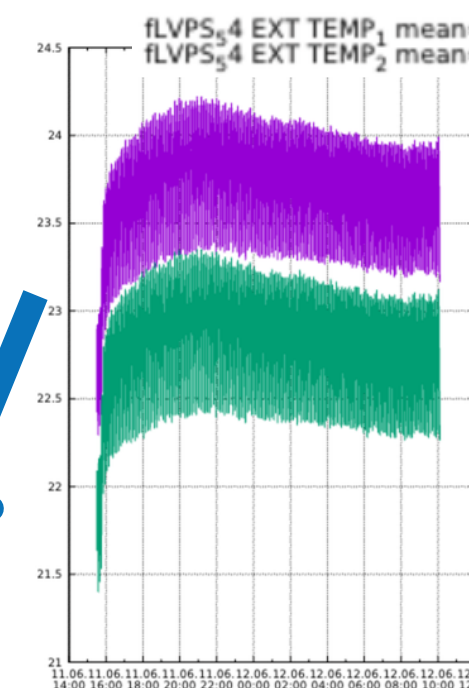


Output Voltage



T1 & T2 of the bricks

T1 & T2 cooling water



Output Current

Efficiency

```
[fpedroma@pcatlttest04 lvpsEffCalc]$
Processing 2049 1A
  Mean efficiency = 85.33%
Processing 2049 1B
  Mean efficiency = 85.37%
Processing 2049 2A
  Mean efficiency = 84.85%
Processing 2049 2B
  Mean efficiency = 83.51%
Processing 2049 3A
  Mean efficiency = 84.15%
Processing 2049 3B
  Mean efficiency = 83.80%
Processing 2049 4A
  Mean efficiency = 85.92%
Processing 2049 4B
  Mean efficiency = 87.73%
```


SUMMARY

- ★ **South Africa successfully completed production of the Phase-II fLVPS boards.**
- ★ **Nearly one thousand qualified boards have already been delivered to CERN.**
- ★ **Quality assurance and burn-in testing ensured only reliable boards will proceed to detector integration.**
- ★ **Current LV Box testing demonstrates stable operation, bringing us one step closer to HL-LHC readiness.**

A wide-angle, low-perspective shot of the 'The Large Hadron Collider' sculpture at CERN. The sculpture is a massive, golden, intertwined ring structure, resembling a trefoil knot. It is covered in numerous signatures and drawings, including a prominent spiral and a complex geometric diagram. The sculpture is set against a backdrop of a clear blue sky with scattered white clouds. In the background, the CERN building is visible, its distinctive copper-colored, ribbed dome illuminated from within. The foreground shows a paved area and some distant trees and lights.

THANK YOU!!

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