

Performance Assessment Electrical Quality Assurance

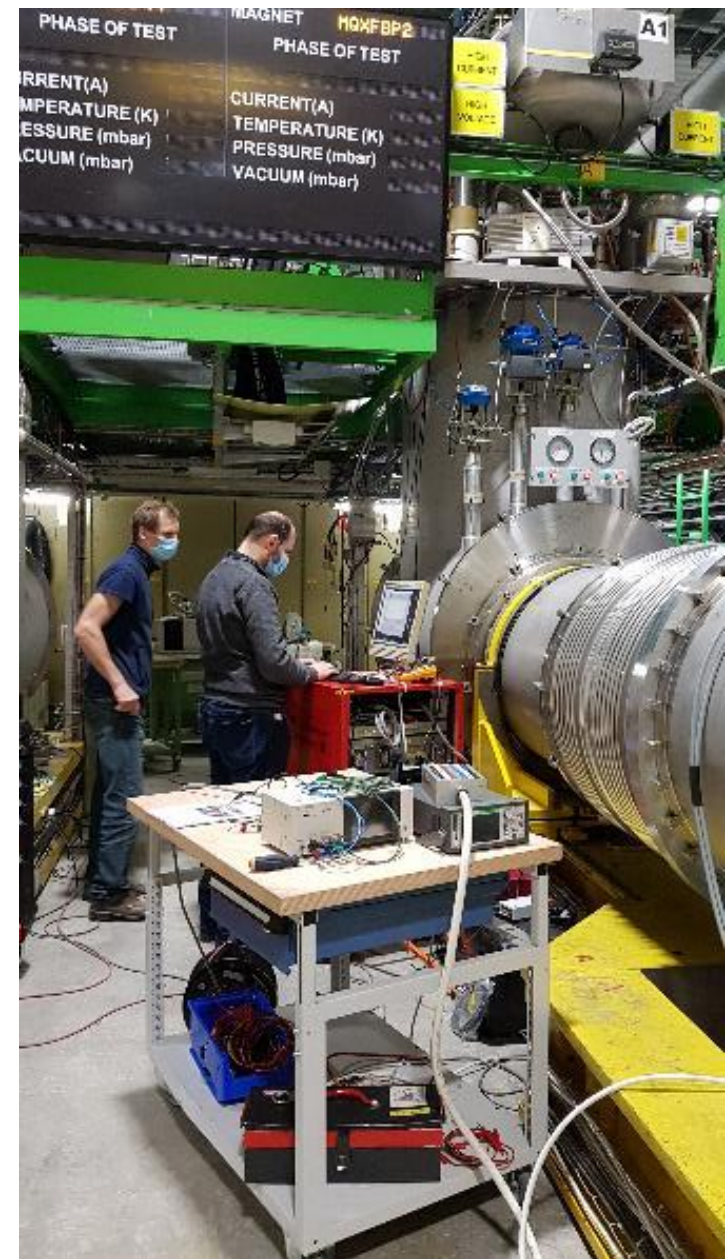
2021: A very busy year

- ❖ **ELQA testing** of all superconducting circuits in the LHC, @warm and @ cold
- ❖ **HWC tests** of all SC circuits
- ❖ **STEAM** development & workshop & simulations
- ❖ **Hi-Lumi** activities, especially:
 - MQXF simulations & comparison with SM18 tests
 - Tests and docs for voltage withstand levels
 - Hollow eLens
 - Cold bypass diodes & IFS box preparations
- ❖ **Additional work** (lots of simulations & measurements & analysis, ELQA testing, recommissioning) due to:
 - Inter-turn short in S78 → thermal cycle
 - Diode arcing/shorting in S23 → thermal cycle
 - RF finger buckling in S23 → thermal cycle

<https://cern.ch/te-mpe-pe>

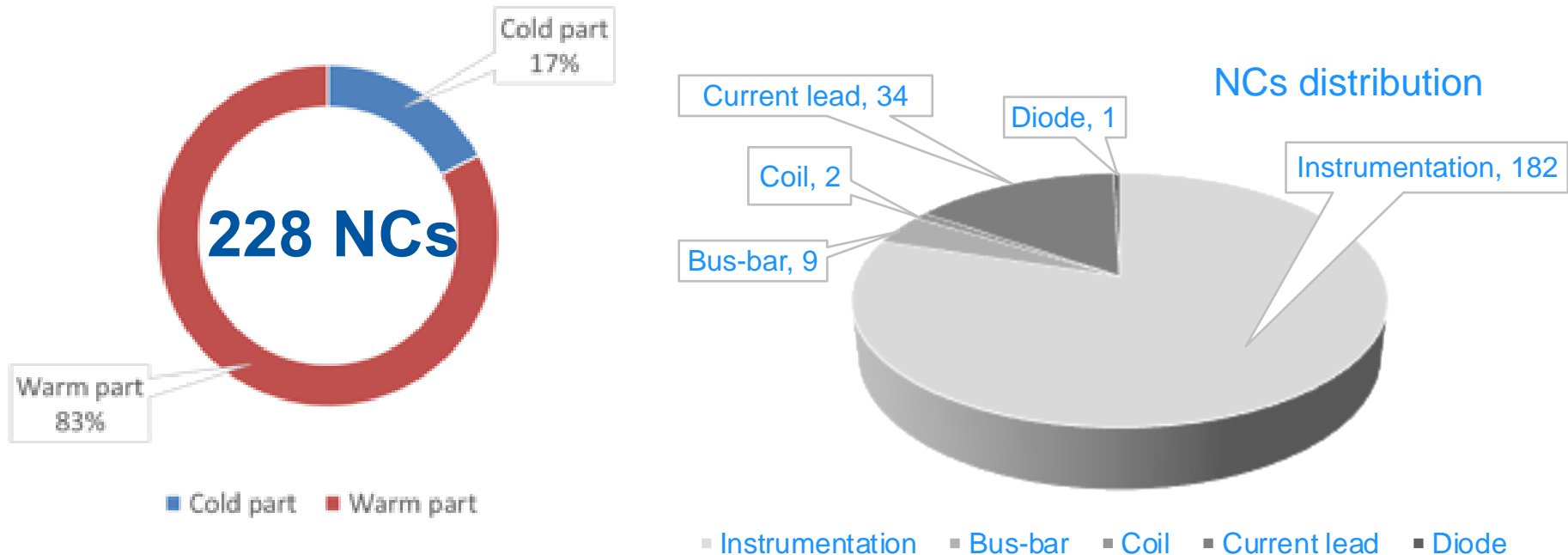
ELQA testing of all superconducting circuits in the LHC

Let's go **LIVE** to the tunnel



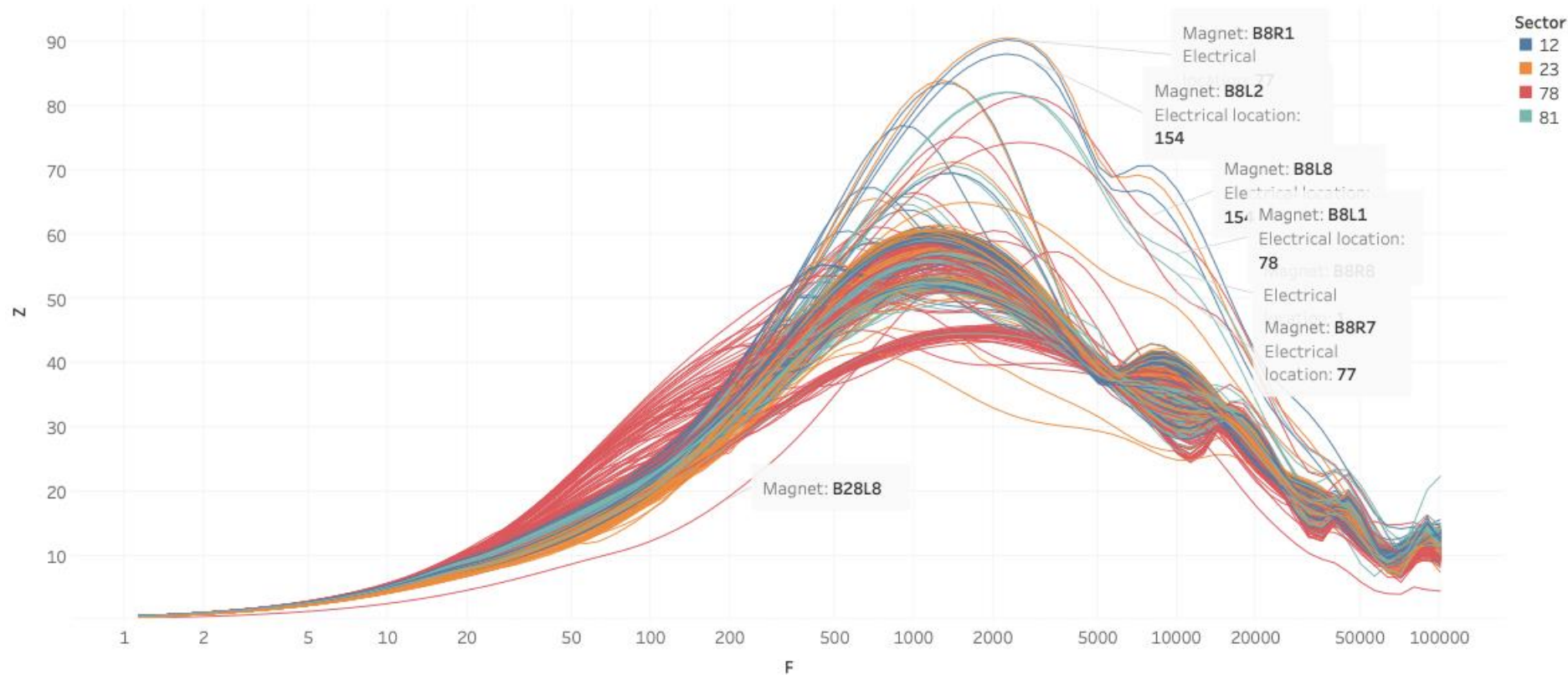
Non conformities – ELQA summary

- All magnets and all circuits were tested at warm and at cold
- Flexibility and large involvement from HNINP
- 228 nonconformities were identified, reported and treated
- Multiple additional tests and special diagnostics were executed following issues and anomalies

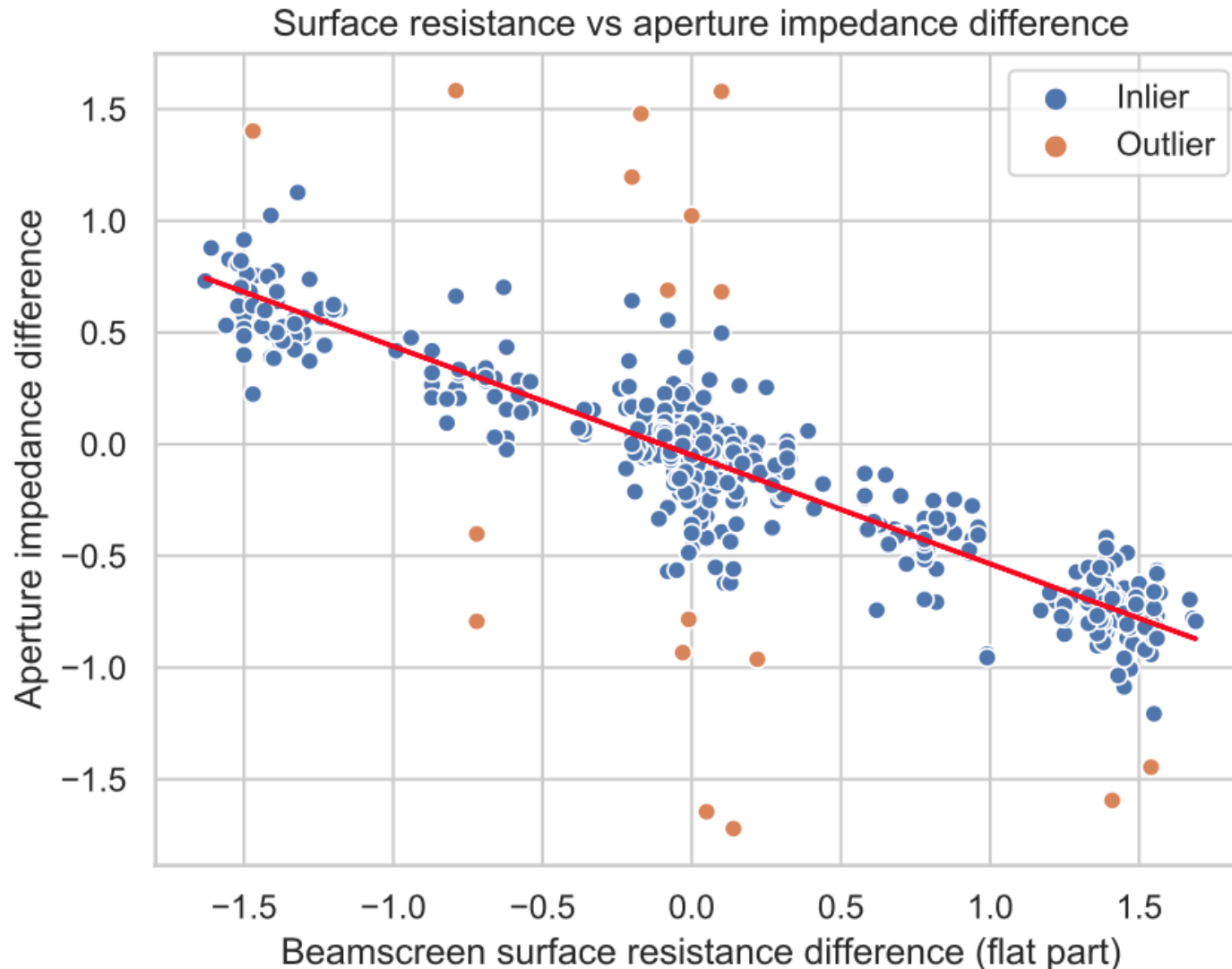


More details: <https://indico.cern.ch/event/1085327/>

Searching for precursors of possible inter-turn shorts or other anomalies by Transfer Function Measurements



Searching for precursors of possible inter-turn shorts or other anomalies by Transfer Function Measurements

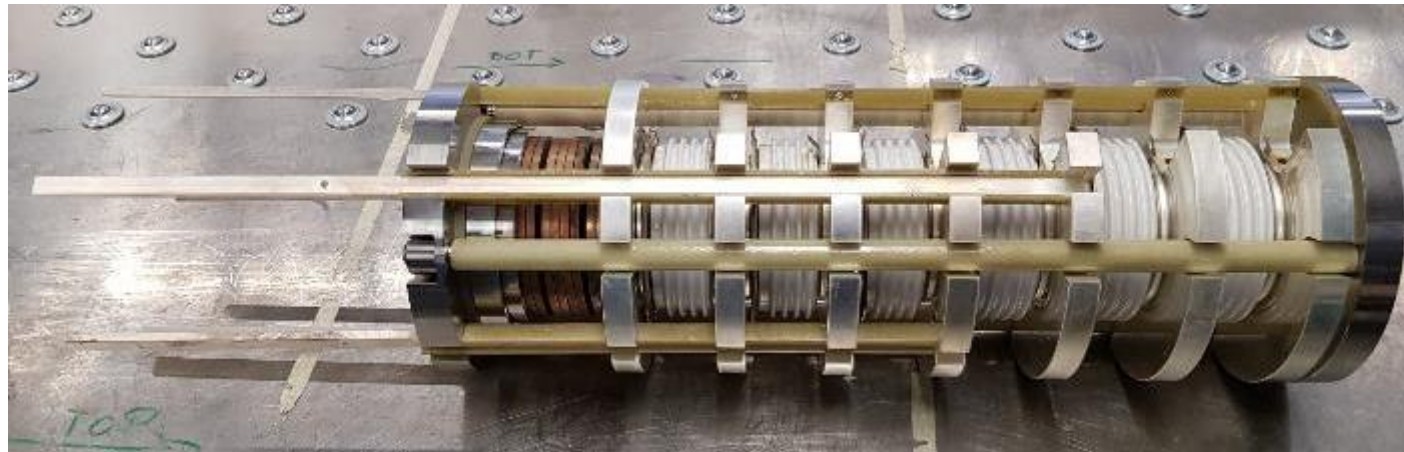


Cold bypass diodes for HL-LHC

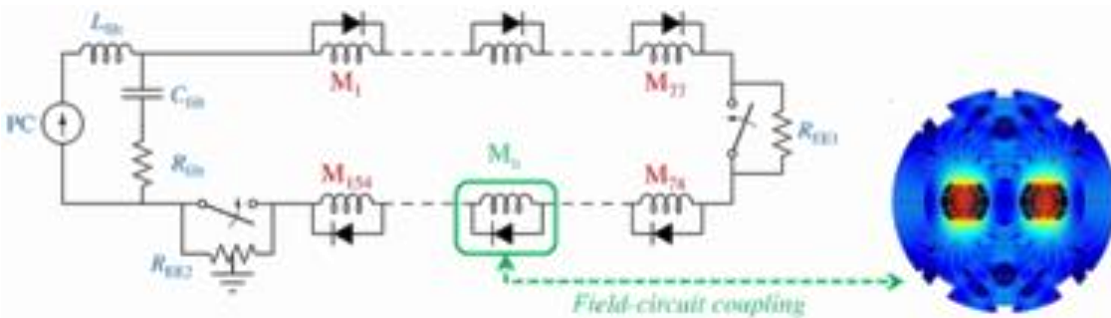


All 60 diodes produced, delivered, and retested at CERN (at warm and at 77 K)

Diode stack
prototype
assembled and
validated

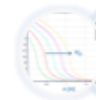


Circuit simulations and Protection studies for the (HL-)LHC



STEAM:
Co-Simulation framework

- **Multiphysics**
- **Space domain ($\mu\text{m} \rightarrow \text{km}$)**
- **Time domain ($\mu\text{s} \rightarrow \text{DC}$)**



BBQ



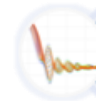
SIGMA



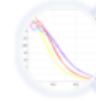
LEDET



PROTECCT



SING



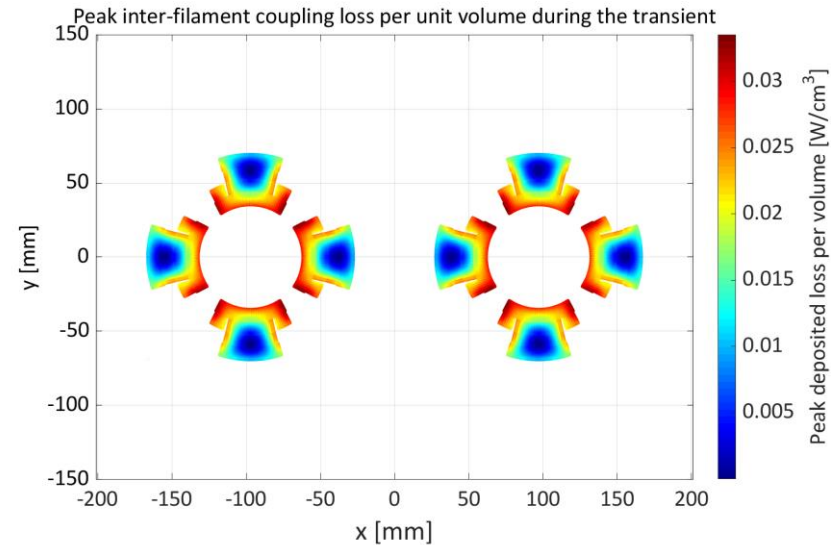
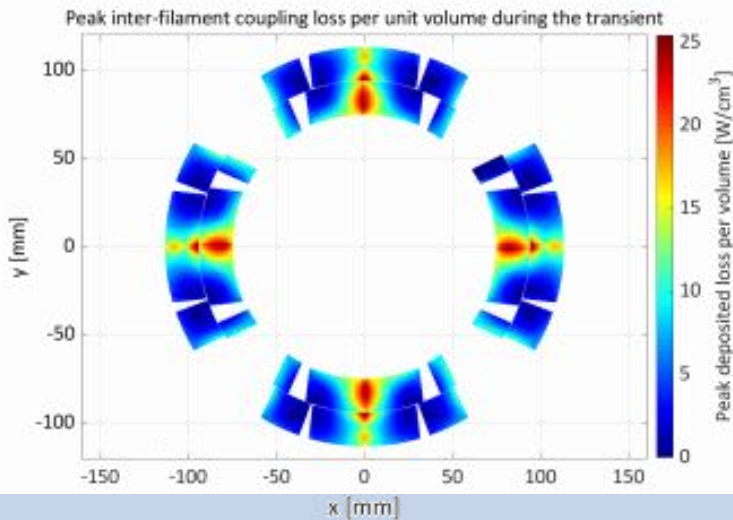
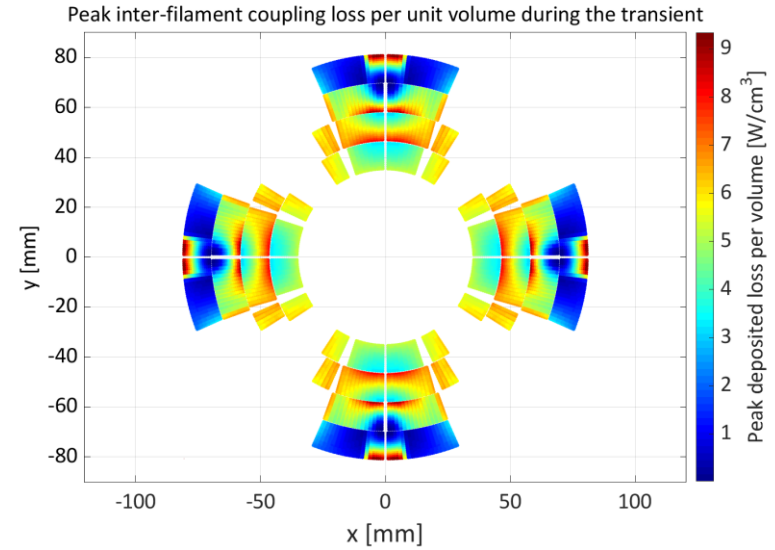
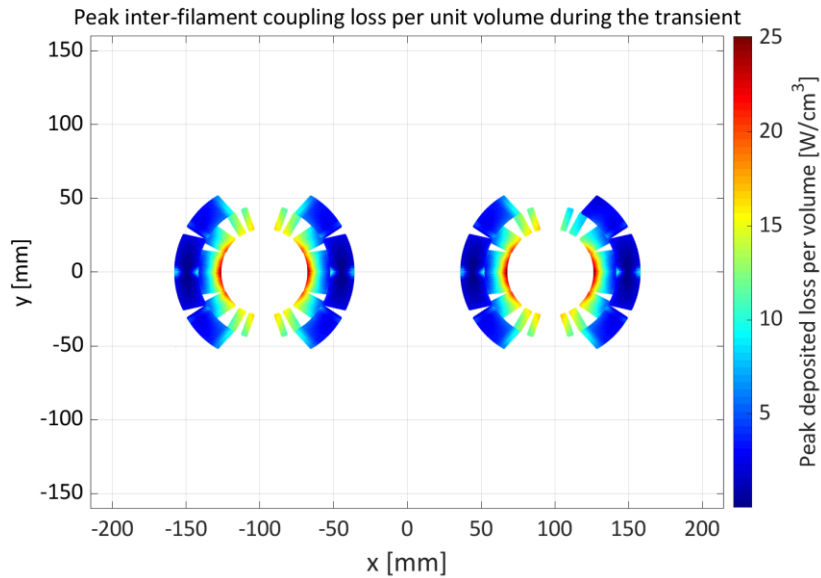
COSIM

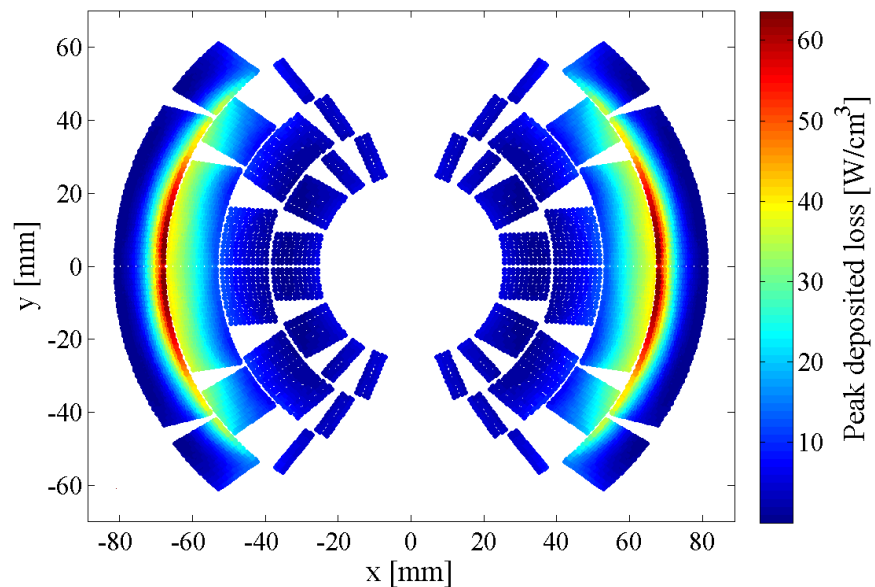
FINITE
ELEMENT
MODELS

FINITE
DIFFERENCE
MODELS

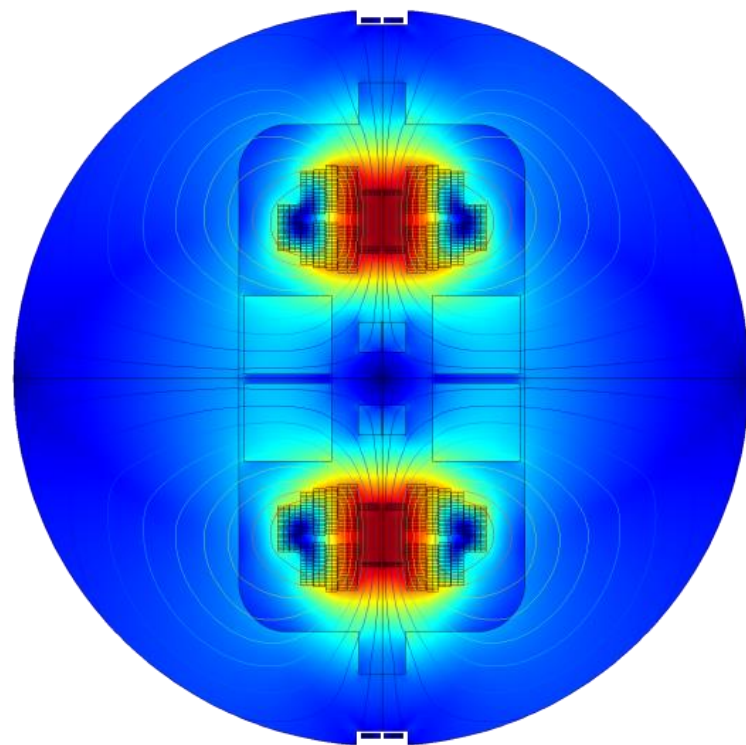
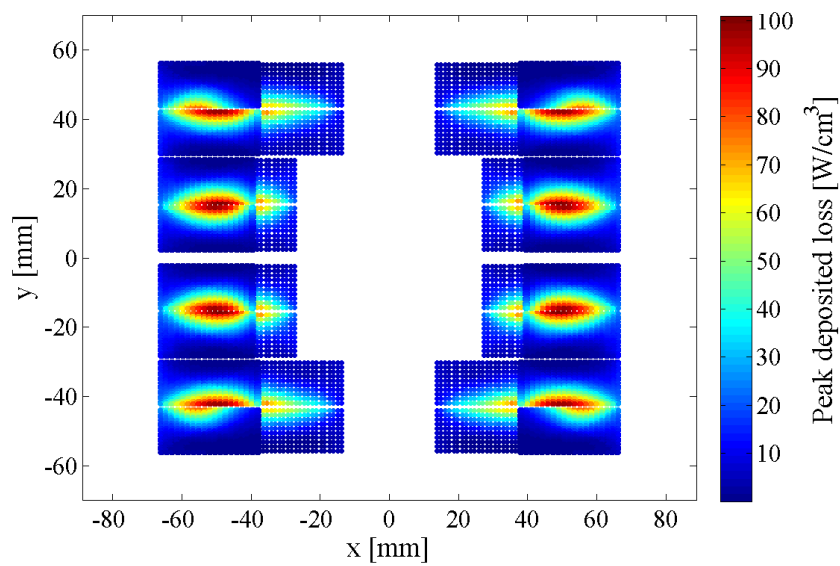
CIRCUIT
MODELS

STEAM: Completing the library of LHC and HL-LHC magnets

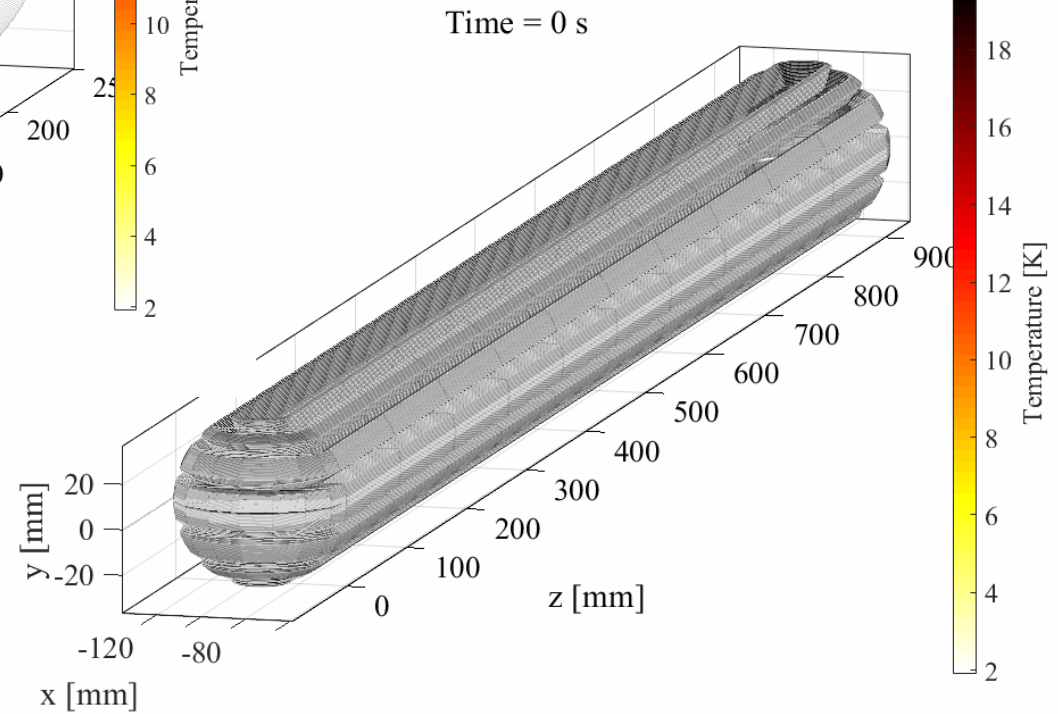
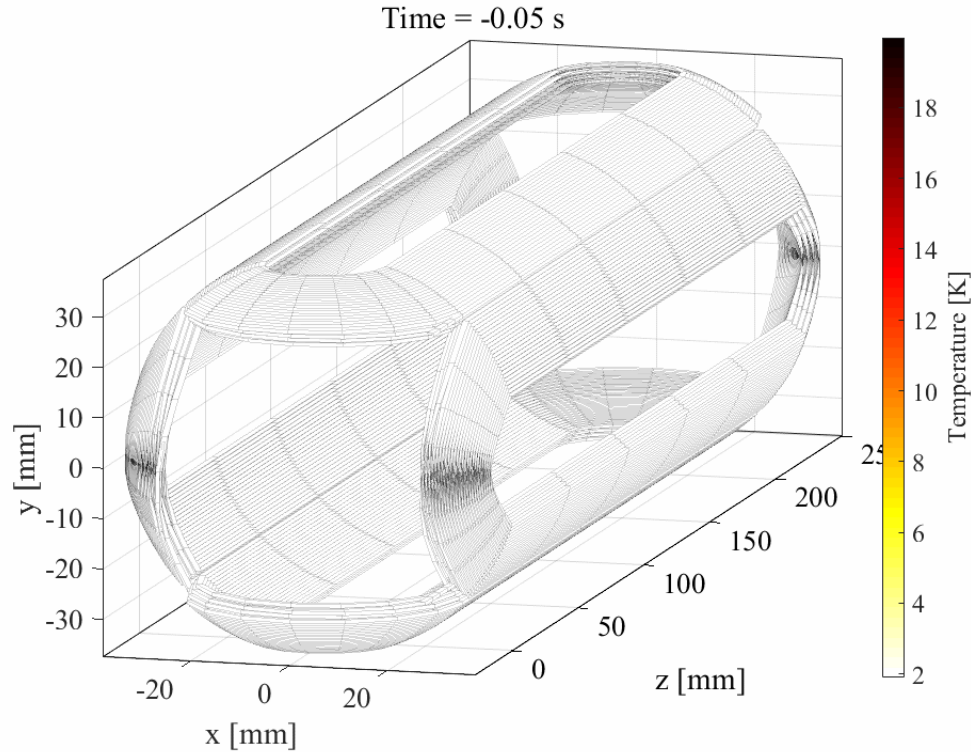




... and designs for
the far future

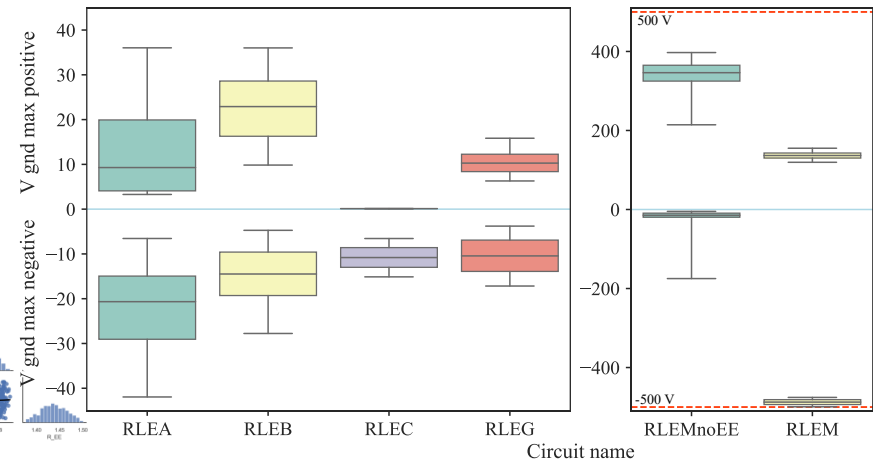
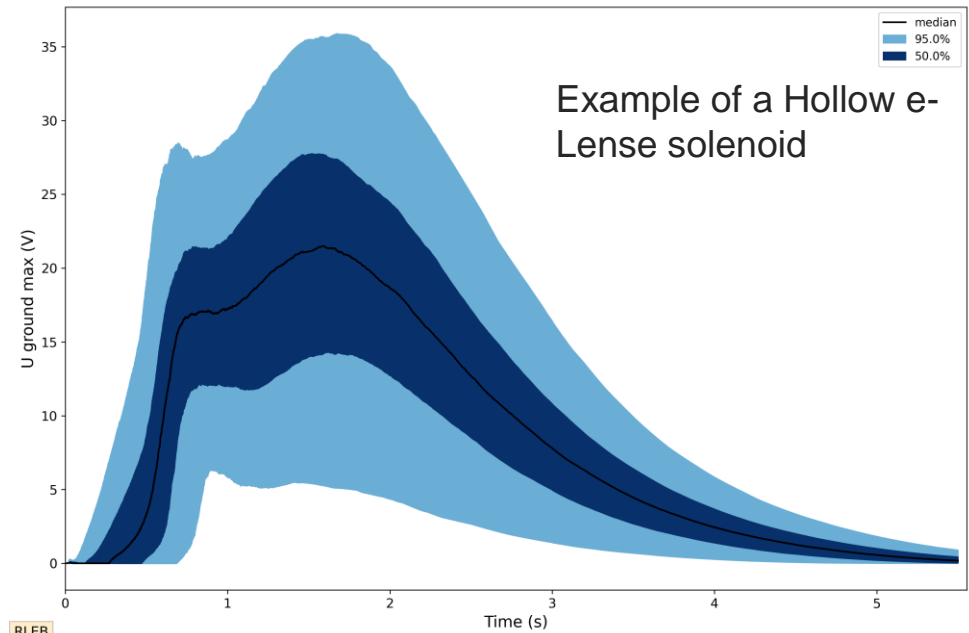


STEAM-LEDET: Going from 2D to 3D



STEAM: Including uncertainty quantification

Effect of material and manufacturing **tolerances** becomes more and more important for quench simulations and failure studies.



Organising the 2nd STEAM workshop:

Training, networking, building simulation community

<https://indico.cern.ch/event/1060073/>

<https://videos.cern.ch/search?page=1&size=21&q=keywords.name:%22STEAM%22>

2nd STEAM Workshop

Oct 11 – 15, 2021

Europe/Zurich timezone

Enter your search term

Overview

Timetable

Contribution List

Registration

Participant List

Participant List

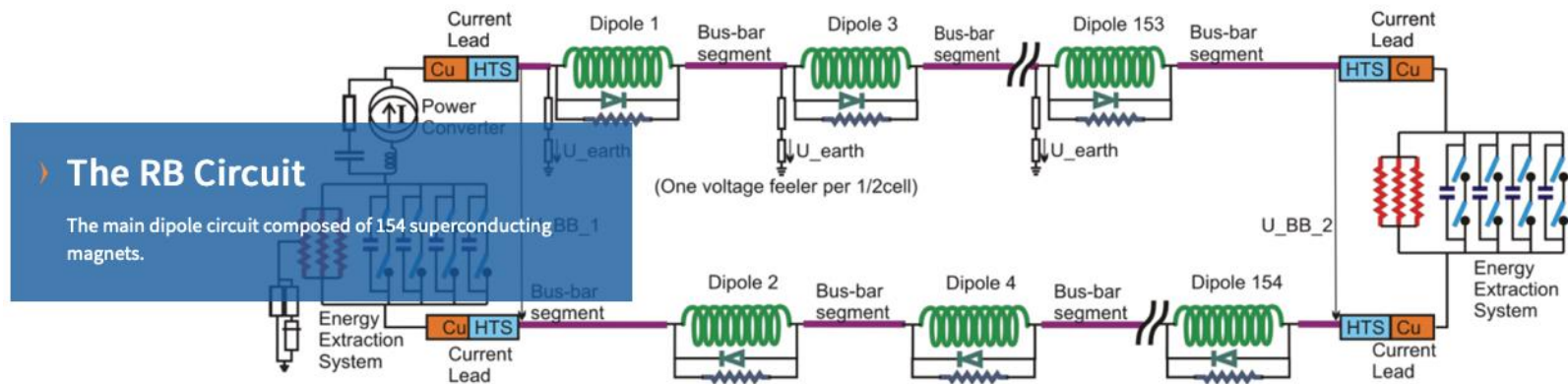
47 participants

Last Name	First Name	Affiliation
AVRONSAERT	Julien	Brookhaven National Laboratory
E		CEA - IRFM
E		Wigner Research Centre for Physics
E		KIT

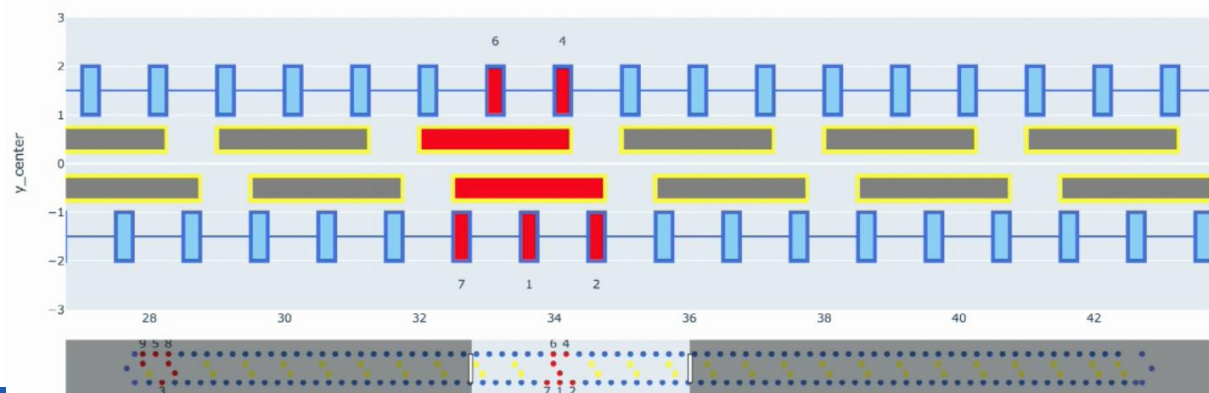
- Updates on STEAM development
- Presentations from STEAM users
- Hands-on sessions on all the tools

HWC+MP3: Commissioning of 1572 SC circuits

- 29'000+ tests analysed during HWC 2021
- Analysis based on eDSL, LabView & **SWAN python notebooks** **NEW!!**
- Consistent, efficient, fast
- 60+ notebooks for all types of tests and for all types of circuits



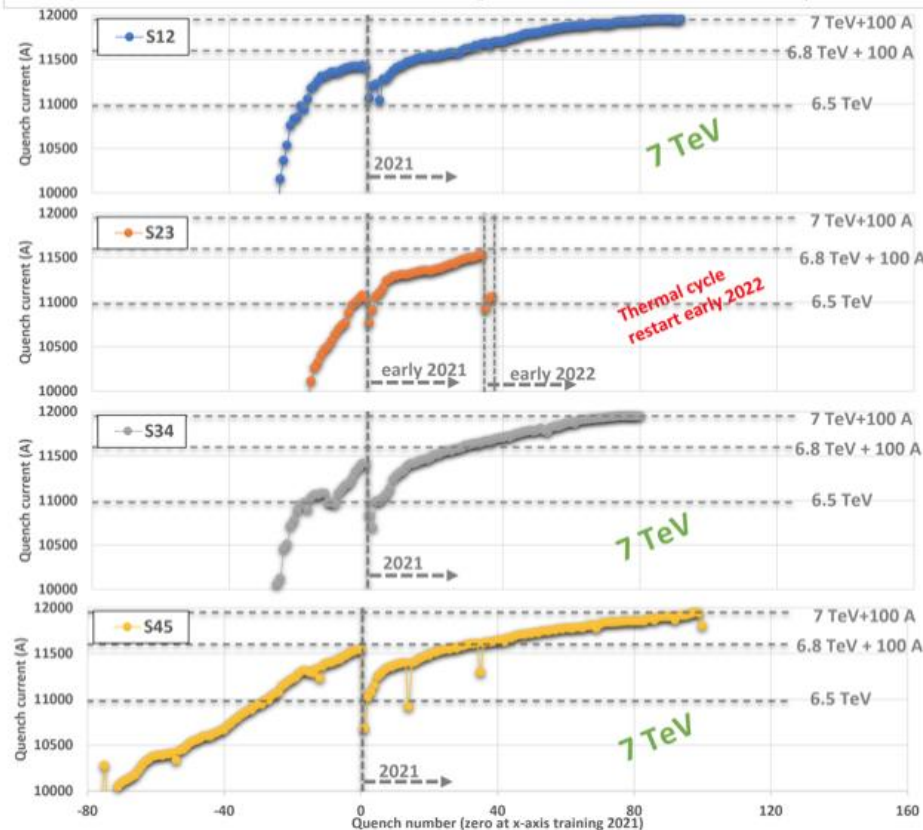
See
<https://cern.ch/sigmon>



HWC – MP3

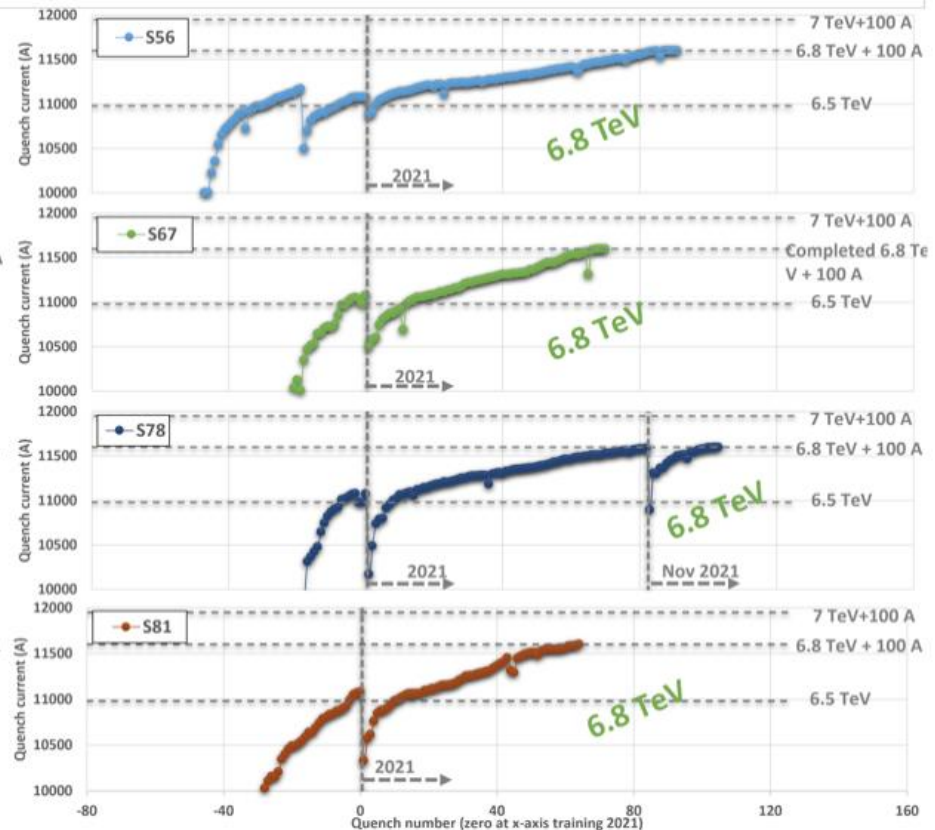
Training the Main Dipole circuits to 11.6-12 kA

RB training curves - HWC 2021 - by MP3



Current for 6.8TeV = 11600 A

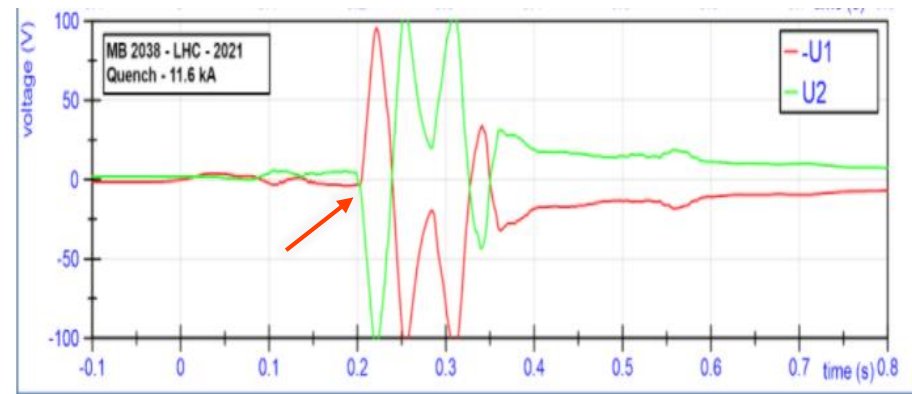
Updated 18 November 2021



3 major issues

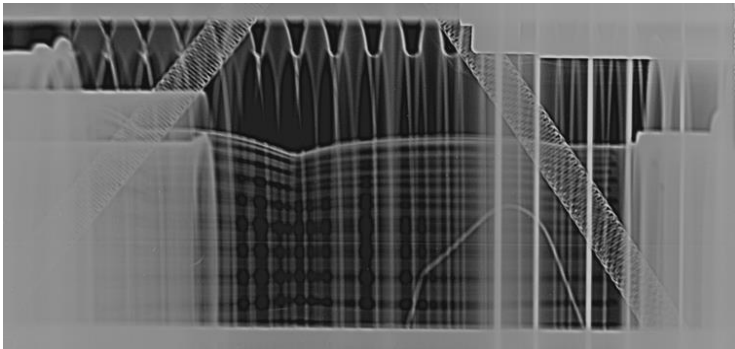
Internal coil short circuit on magnet B28L8

- Sector warm-up + magnet replacement
- **Diagnostics + simulations + analysis + ELQA campaign + re-commissioning + retraining**



Cold bypass diode short circuit on magnet A23R2 due to insufficient He venting

- Sector warm-up + diode replacement
- **Diagnostics + simulations + analysis + ELQA campaign + re-commissioning + retraining**



RF finger deformation

- Sector warm-up + replacement PIM
- **ELQA campaign + re-commissioning + retraining**

So much more:

- GSI FAIR SIS100
- High-Field Magnet (HFM) program
- HTS protection studies
- IFS boxes for HiLumi
- Arcing studies
- New detection & protection methods
- TERA Gantry
- Hollow e-Lens
- ...

