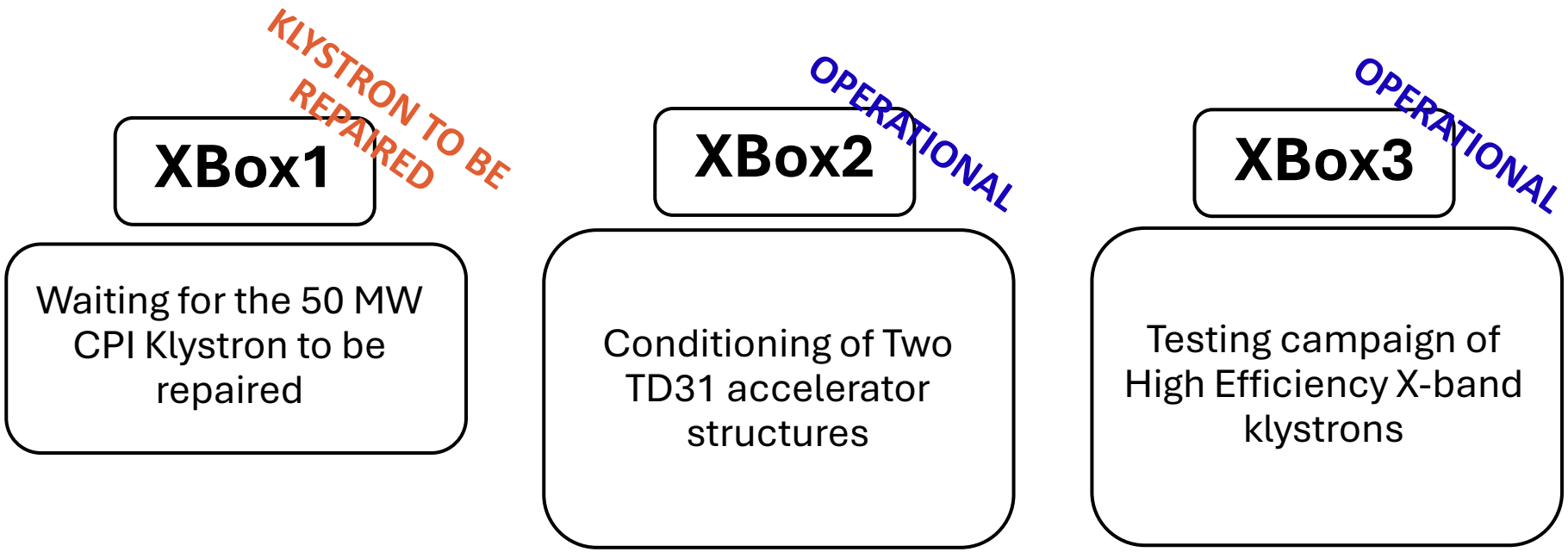
Update on CERN Xboxes and X-Band technologies

P. Alonso Arias, on behalf of the Xboxes team

CLIC Project Meeting #47, Dec 11 2024

Xboxes Update



XBOX2

Conditioning of TD31N3 and N4

Breakdown and missing energy studies

Xbox 2: TD31 for CLIC380

P_{in} [MW] for <G=72MV/m>

Unloaded = 36.1 MW

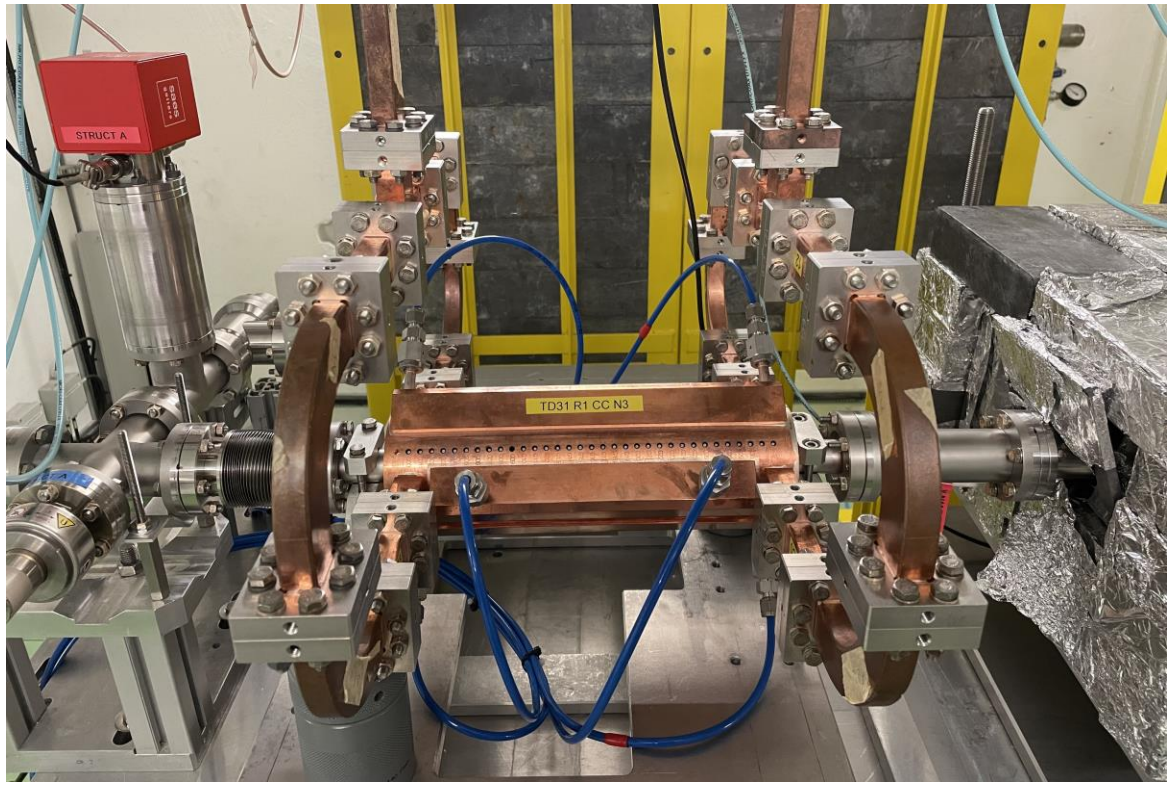
P_{in} [MW] for <G=92MV/m>

Loaded = 59.2 MW

Four structures manufactured and installed in Xboxes. Conditioning started by the end of 2022

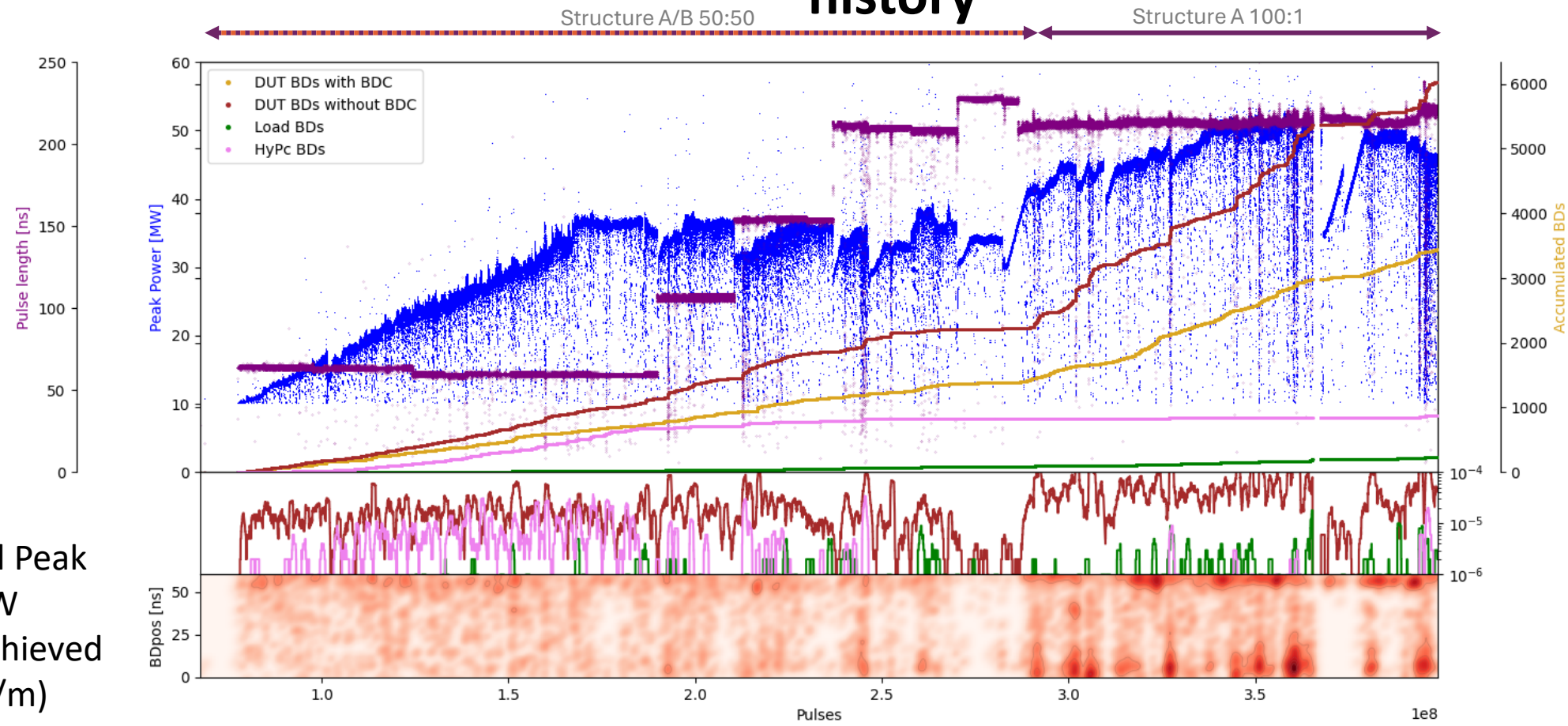
N3 and N4 in Xbox 2

N1 and N2 installed in Xbox3



Xbox 2 TD31

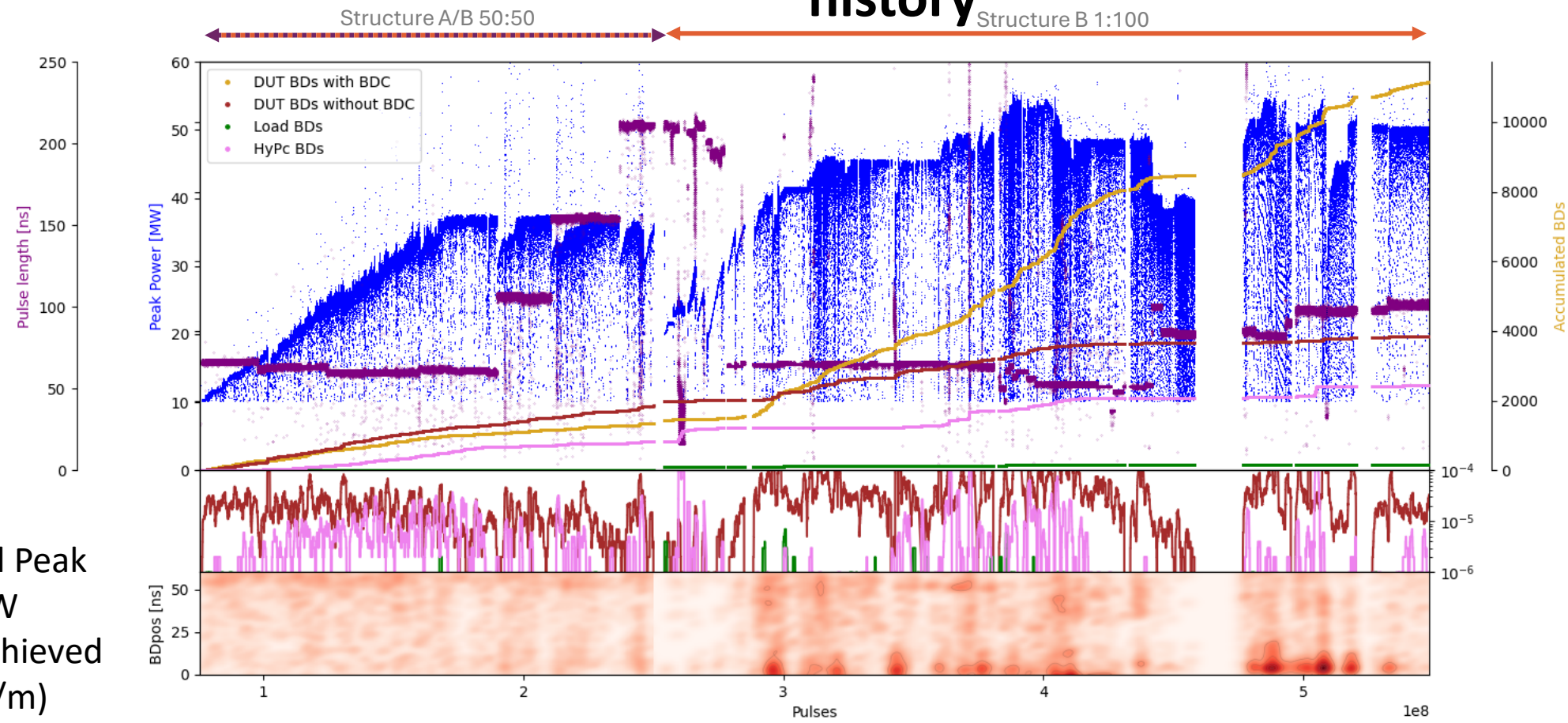
TD31N3 conditioning history



Achieved unloaded Peak Power 36.1MW
Max. Peak Power achieved 50MW (~80 MV/m)

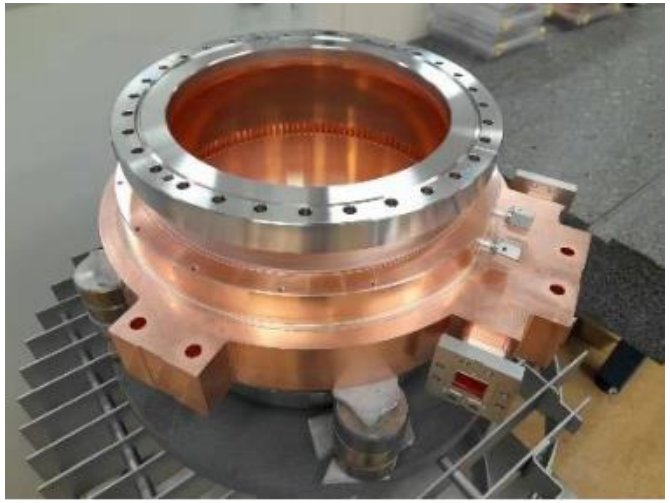
Xbox 2 TD31

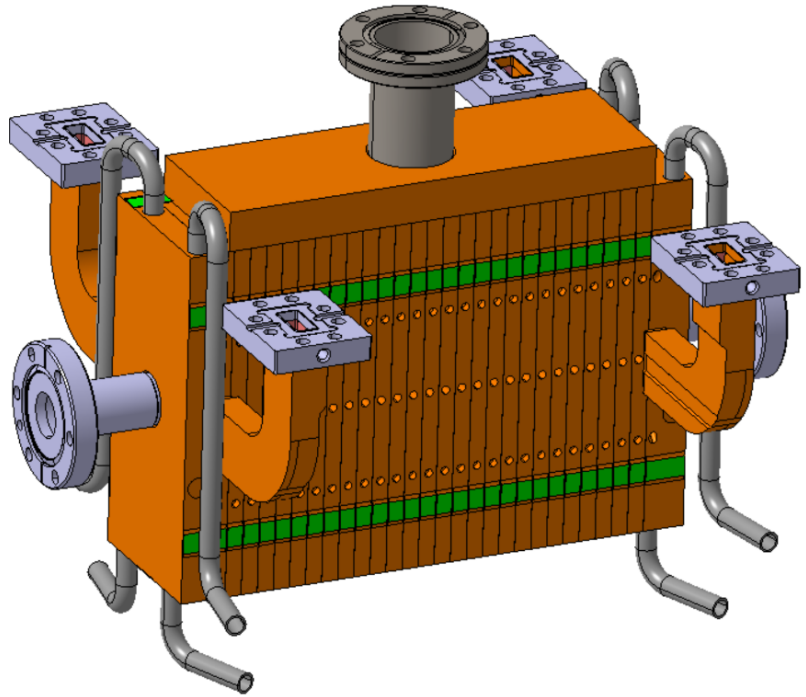
TD31N4 conditioning history



Achieved unloaded Peak Power 36.1MW
Max. Peak Power achieved 54MW (~89 MV/m)

Xbox 2 future plans



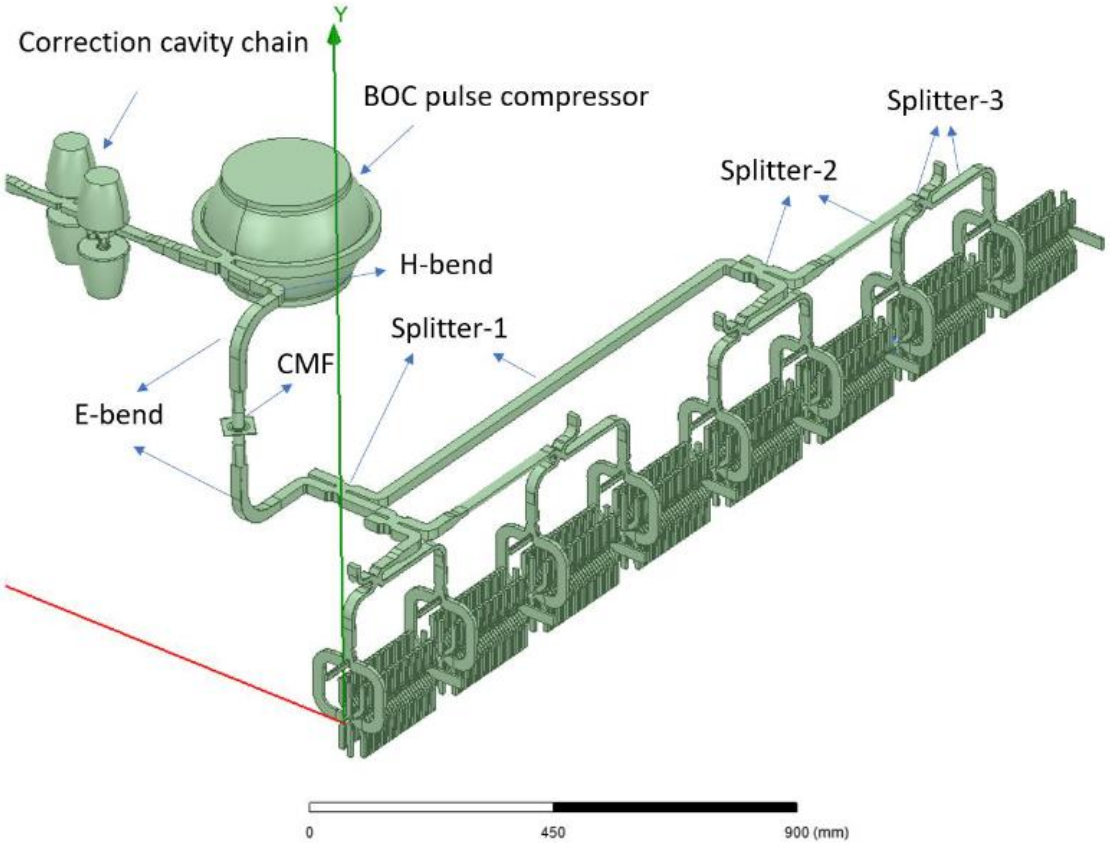


Refurbishment of Scandinova modulator to improve operation at higher voltages

Integration of Barrel Open Cavity pulse compressor for high power testing

Integration and high power testing of Smartcell

Xbox 2 future plans



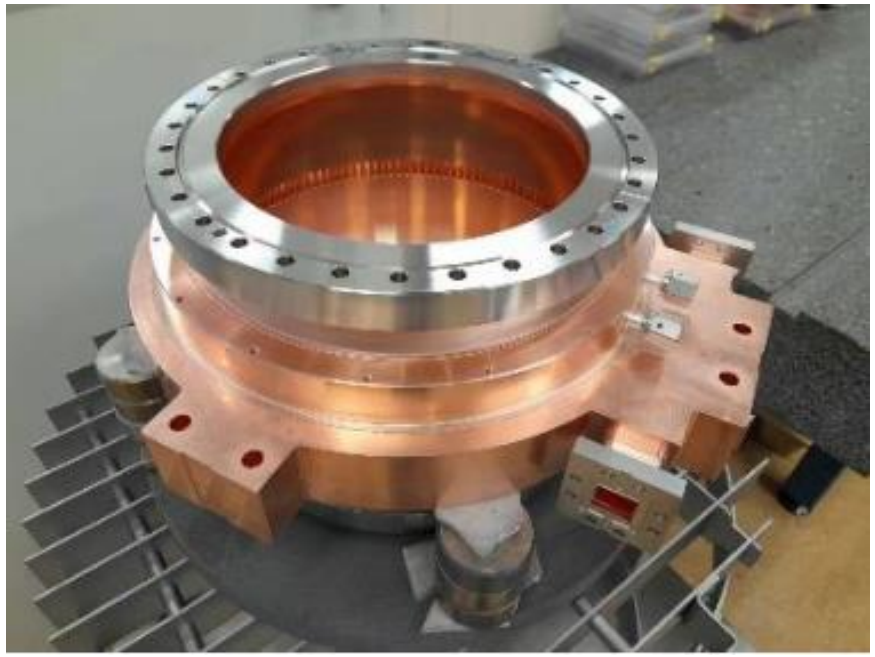
BOC for klystron-based CLIC

Pulse compressor system based on the BOC design + 4 correction cavities optimised to obtain a power gain of 3.82 for the CLIC-K structure pulse shape

Prototype already manufactured and ready for integration in Xbox2 for high power testing

RF design of the pulse compression system for the klystron-based CLIC main linac; Ping Wang; Alexej Grudiev JACoW. IPAC2023, WEPA115. 2023. Available on-line at: <doi:10.18429/JACoW-IPAC2023-WEPA115>

Xbox 2 future plans



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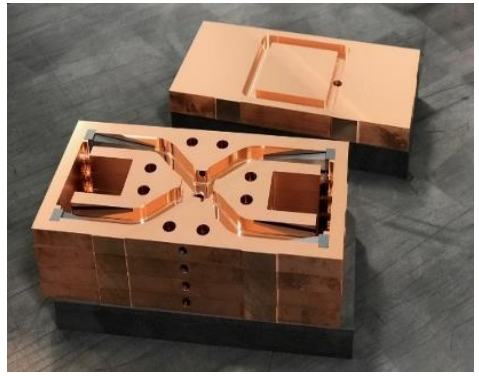
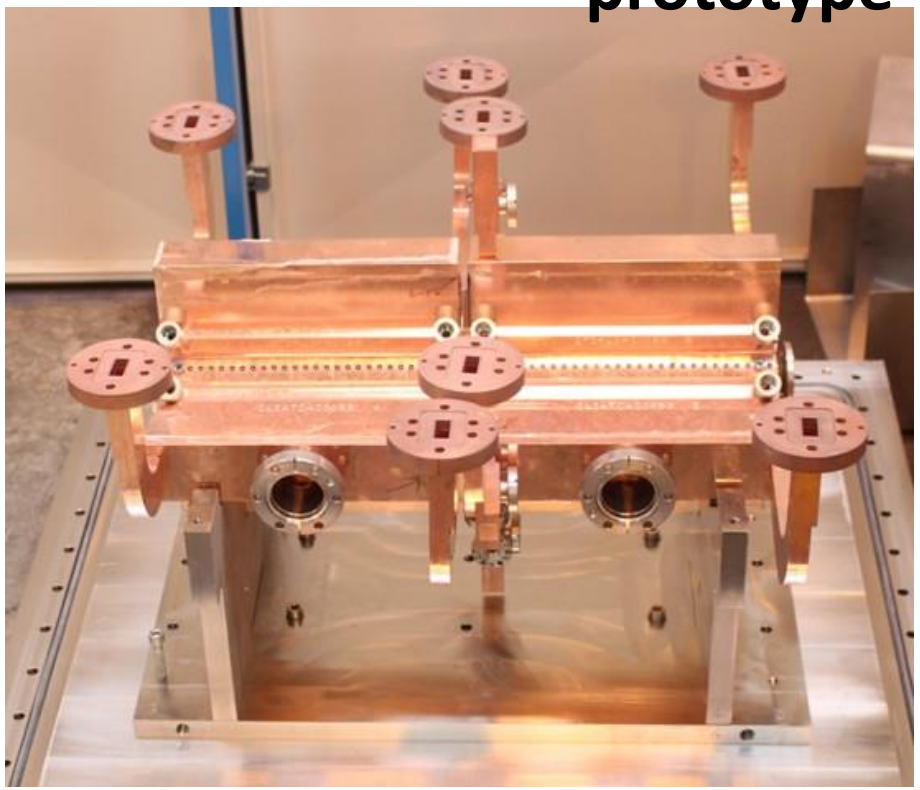
Xbox 2 future plans

Redesigned to evolve from pure bonding to bonding+brazing and reducing steps

The new design integrates the RF area, HOM loads, the cooling circuits, and part of the vacuum system in one part



SmartCell prototype



More info here: P. Morales, Normal Conducting High Gradient prototype manufacturing

Xbox 2 future plans

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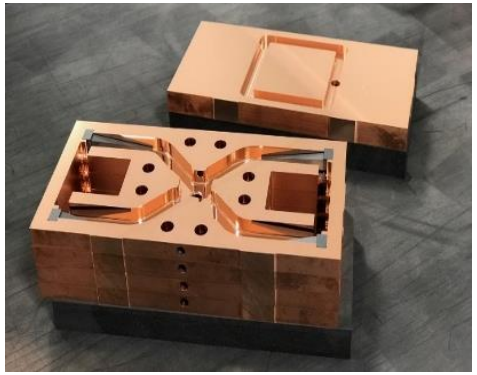
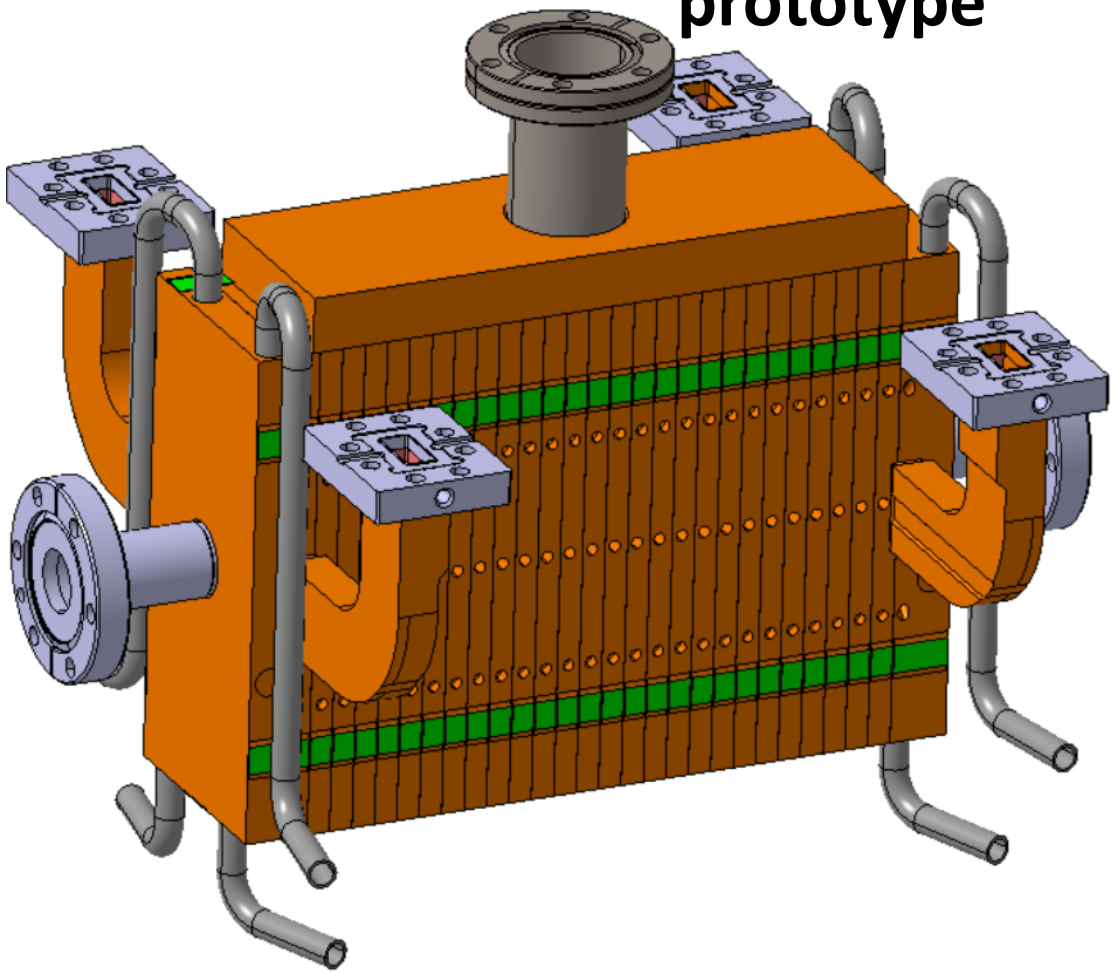


Disk in production, will be assembled in 2025

More info here: P. Morales, Normal Conducting High Gradient prototype manufacturing

SmartCell prototype



XBOX3

Setup modified for klystron testing

Canon E37117 klystron tested

Xbox 3 High Efficiency Klystrons

Operating frequency	11.994 GHz
Peak RF Output Power	**8.1 MW**
Peak RF Input (Drive) Power	121 W
RF Pulse length	1us
Pulse repetition rate	400 Hz max.
Load VSWR	1.2 max.
HV Pulse length	6.4 us max
Beam Voltage	**157 kV**
Beam Current	**96.8 A**
Perveance uPe	1.56
Efficiency	**53.3%**
Filament Current	9.5 A
Filament Power	138 W
Main Coil Current	32 A
Counter Coil Current	7 A

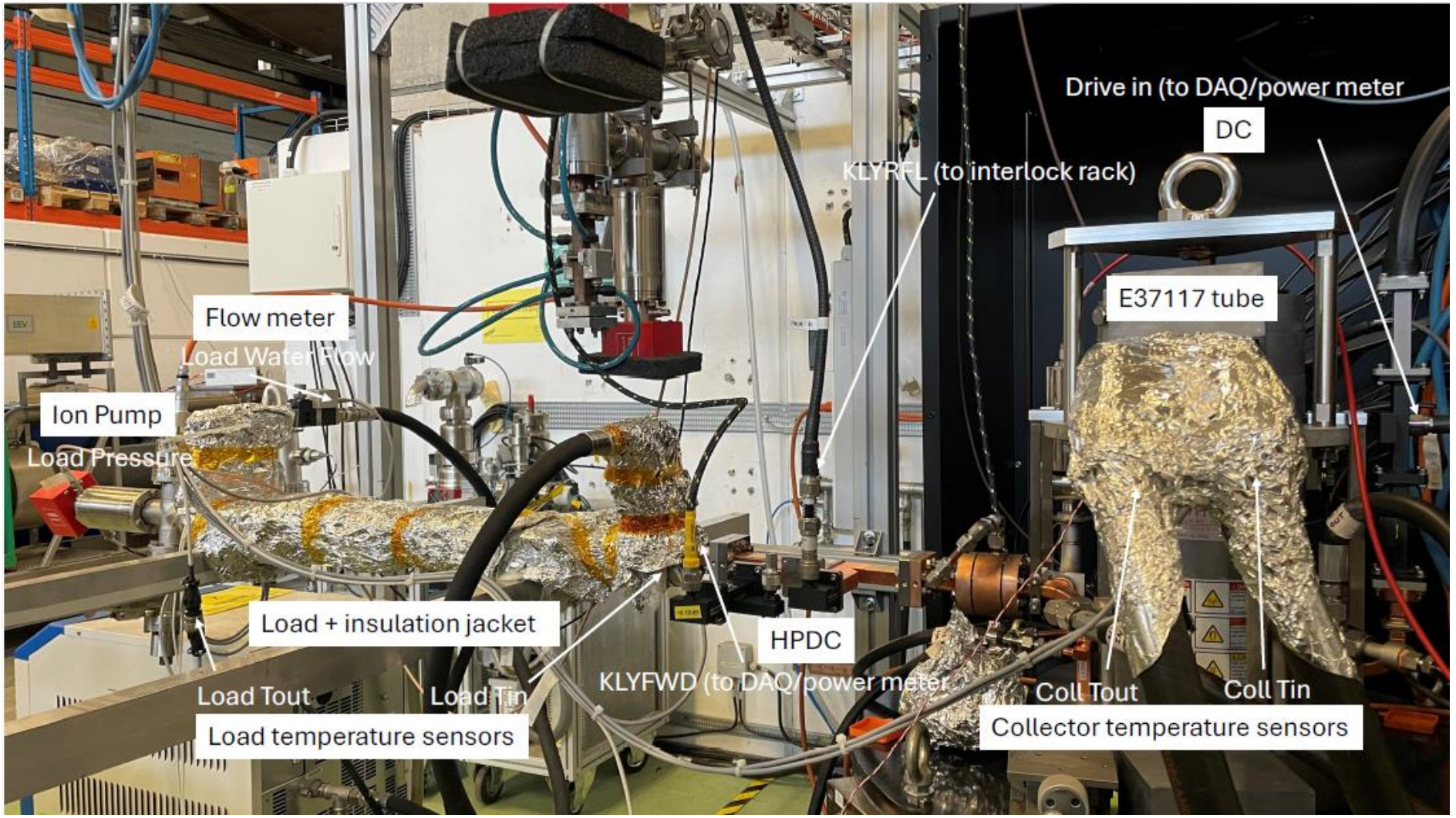
Refurbishing of 6 MW Canon E37113 (re-used solenoid and cathode; same modulator; new RF window)

Retrofit design with a COM circuit+ 2nd harmonic cavities

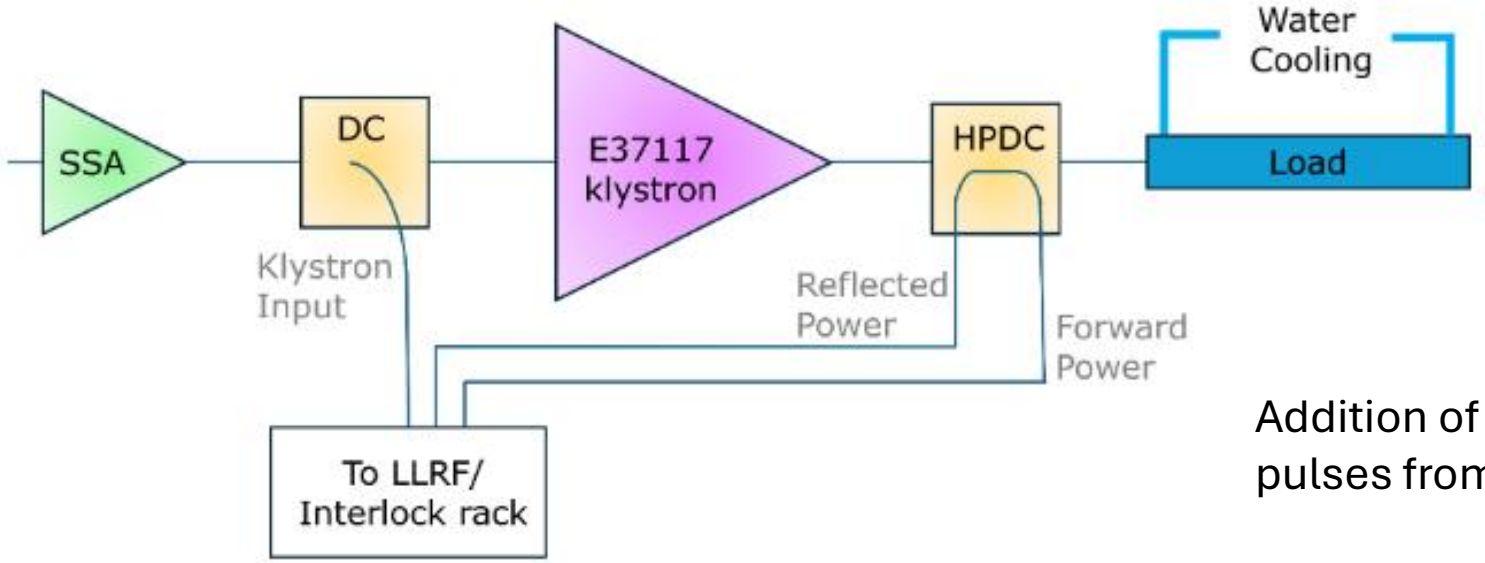
First testing campaign at the end of 2023
Second testing campaign just finished

J. Cai and I. Syratchev, "Design Study of X-band High Efficiency Klystrons for CLIC," 2020 IEEE 21st International Conference on Vacuum Electronics (IVEC), 2020, pp. 121-122, doi: 10.1109/IVEC45766.2020.9520585.

Xbox 3 Test bench modification



Xbox 3 Test bench modification



Load return loss better than -40dB in <100 MHz bandwidth
LLRF error in frequency of ~hundreds of kHz

Addition of channels to acquire high-voltage pulses from the modulator

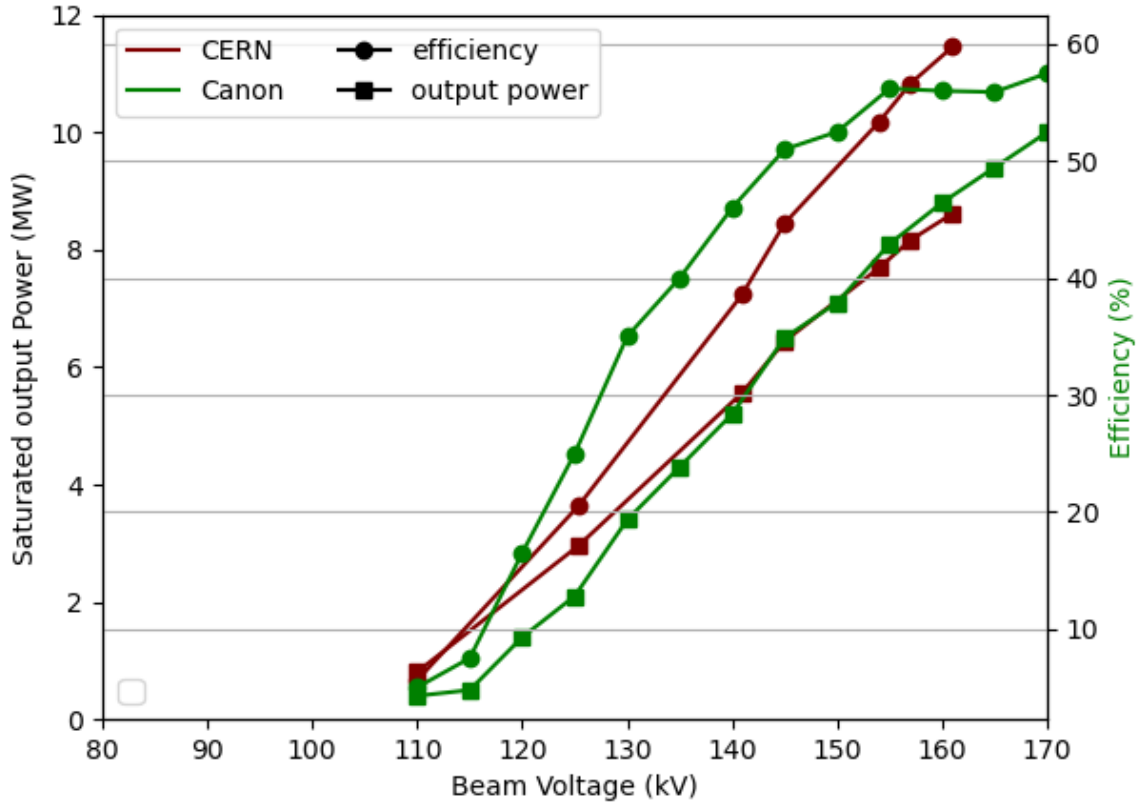
Addition of temperature sensors and flow meters for calorimetry measurement

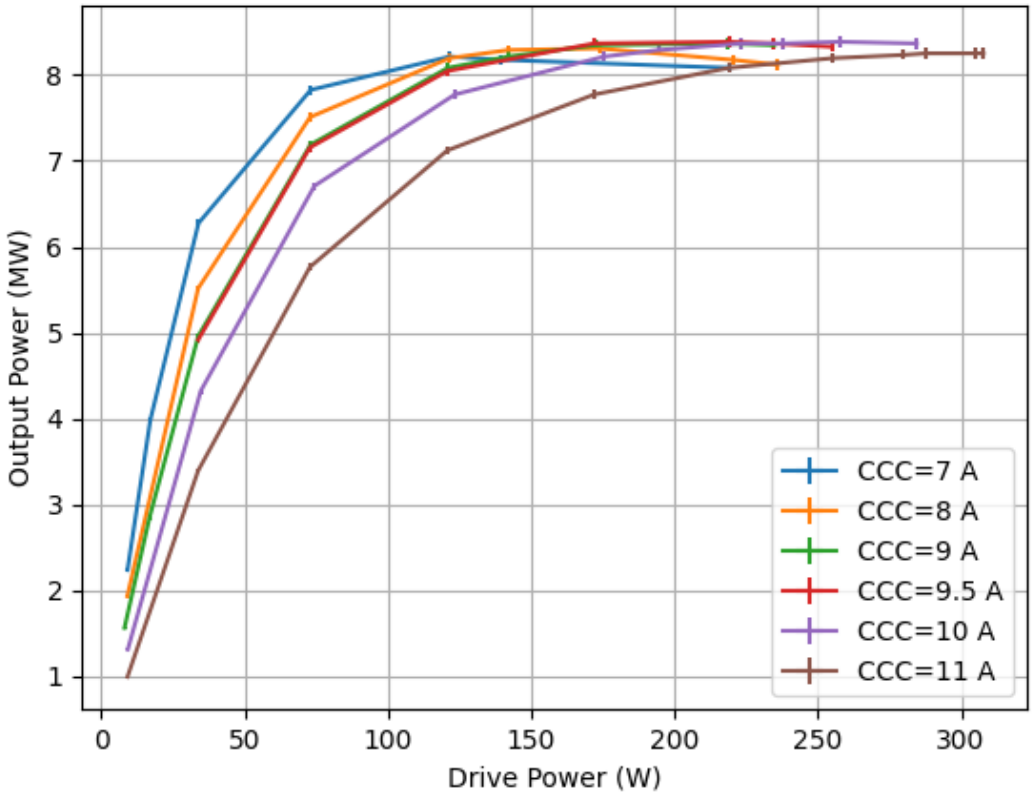
Improvement of interlocking system to protect klystrons

Calibration load in collaboration with Scandinova

Xbox 3 HEK test results

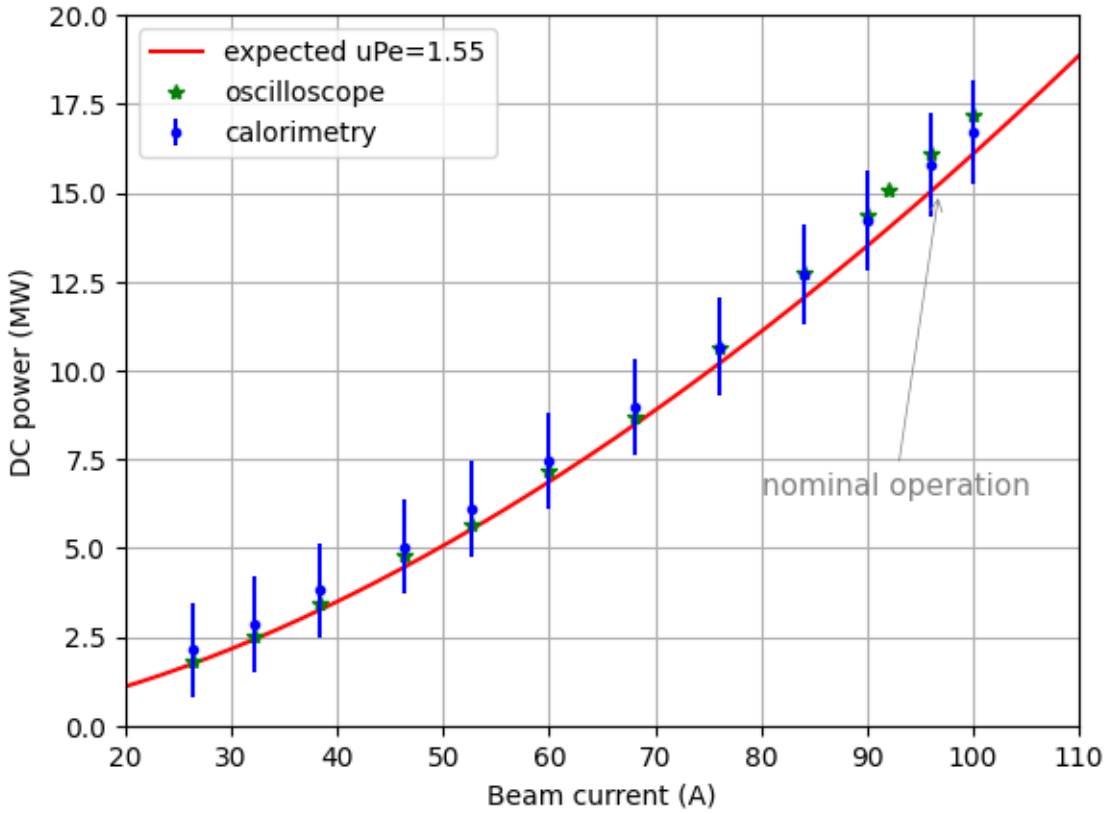
22M001





Xbox 3 HEK test results

22G002

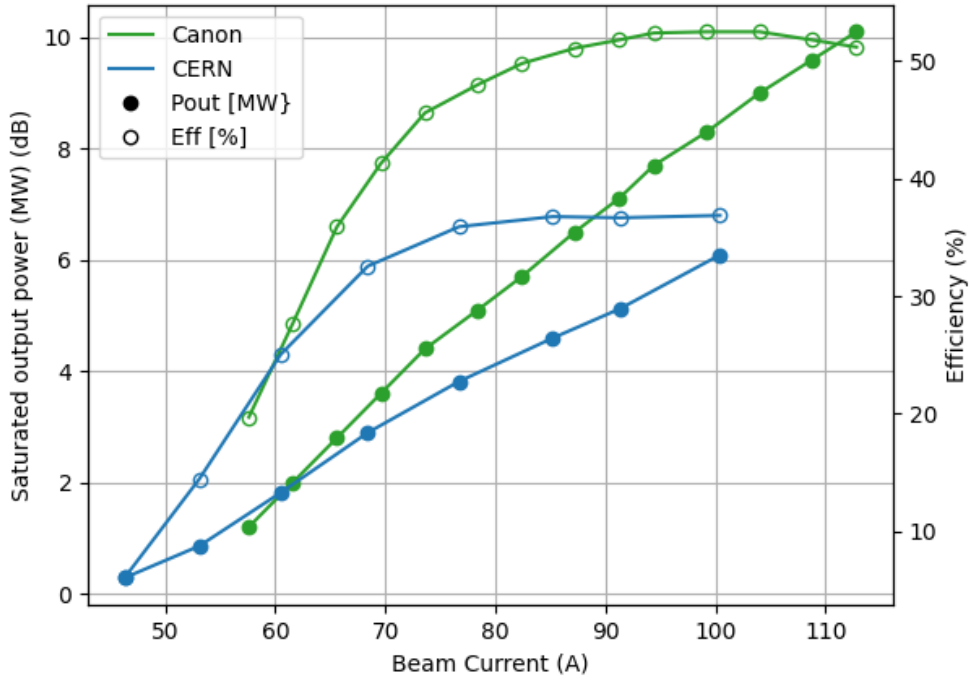


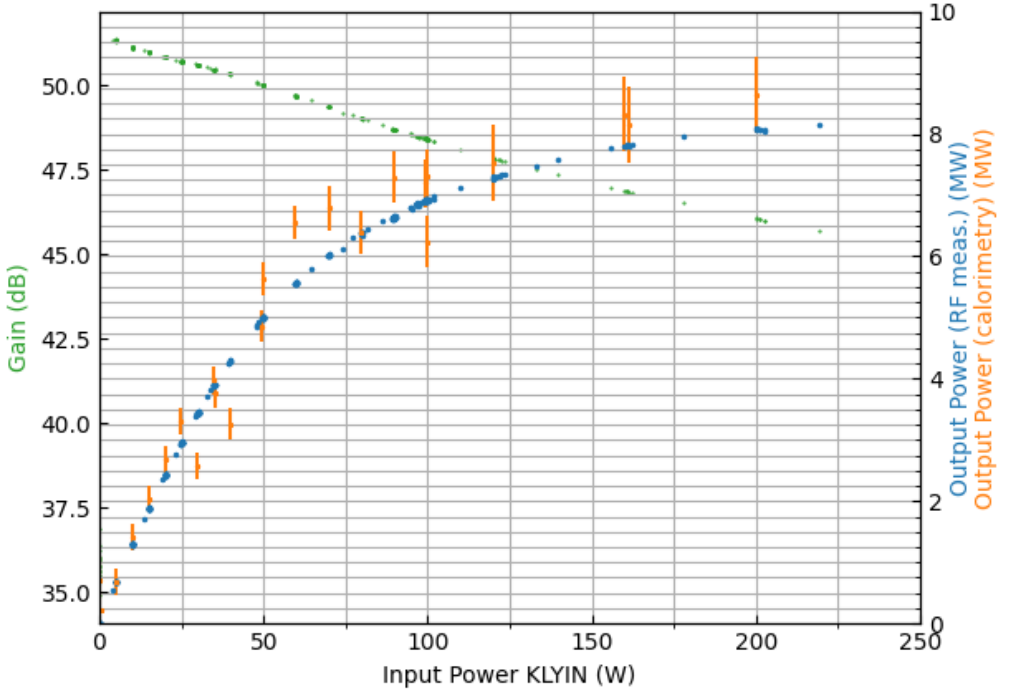
Perveance uPE reported by Canon	**1.55**
Perveance uPE from meas. with oscilloscope	1.394
Perveance uPE from calorimetry	1.398

At nominal beam voltage of 157 kV, we have measured a DC peak power of 15.6 MW, i.e., **a 6.4% more of what we expected**

Xbox 3 HEK test results

22G002





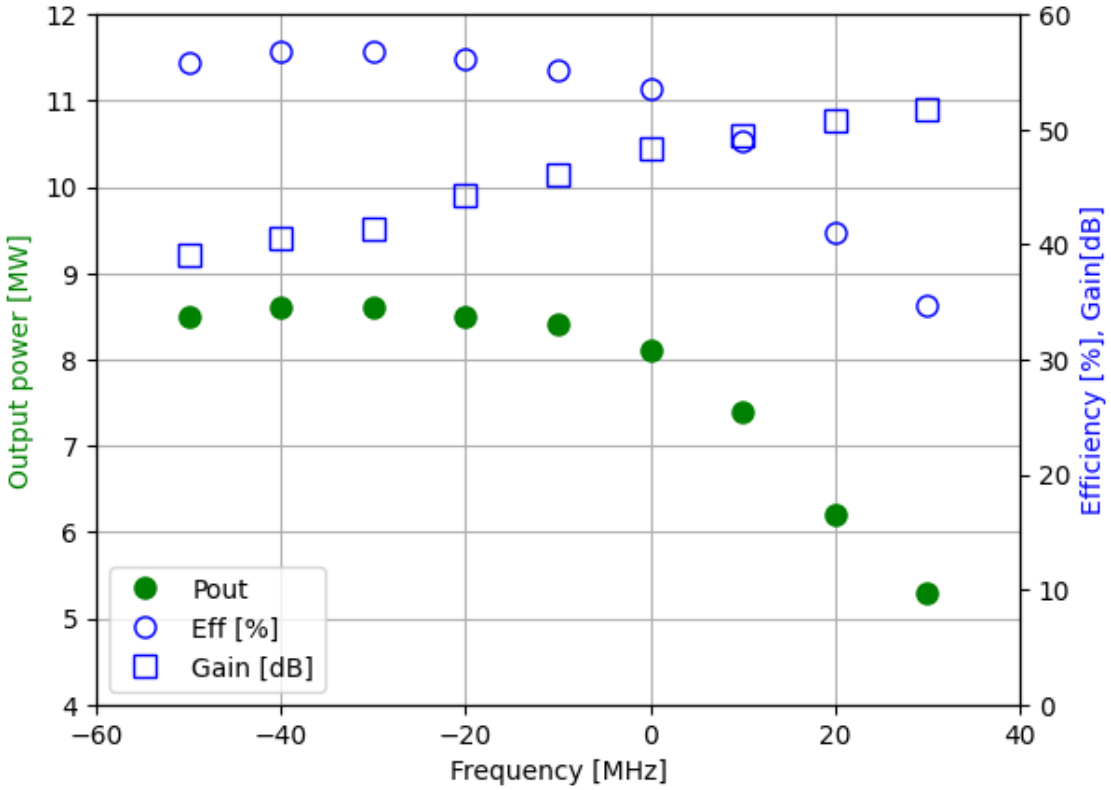
Saturation power at nominal operation (157 kV) is **2MW lower than expected (meas. by Canon)**

Higher power is restored at **20 MHz below nominal frequency** (11.994GHz)

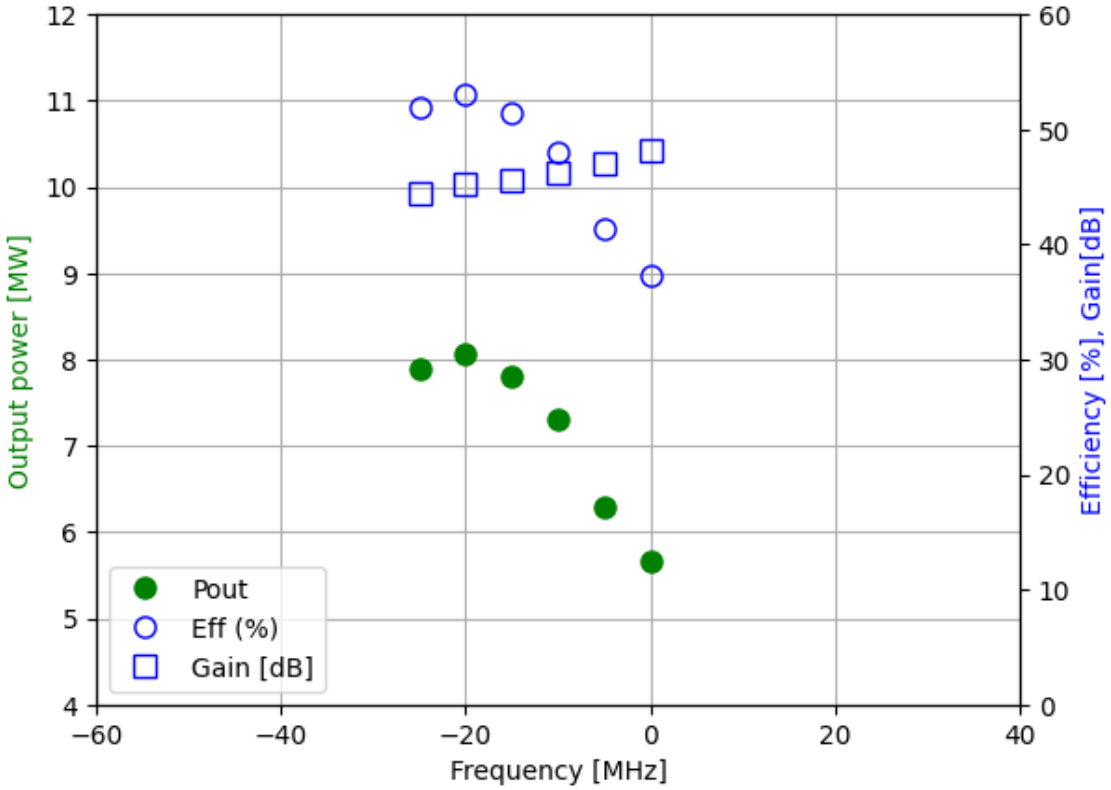
Xbox 3 HEK test results

22G002

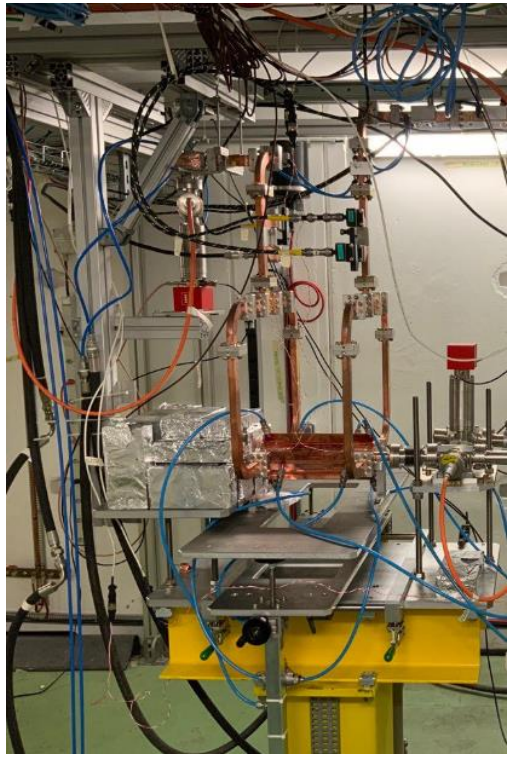
Canon results



CERN results



Xbox 3 future plans



Continue conditioning of TD31 N1 and N2

Integration and conditioning of structures TD26 from CIEMAT

Integration and conditioning of iFast accelerating structure

Summary

KLYSTRON TO BE REPAIRED

XBox1

Waiting for the 50 MW CPI Klystron to be repaired

OPERATIONAL

XBox2

(Almost) ready for the integration and testing of the BOC pulse compressor

Manufacturing Smartcell has been approved

OPERATIONAL

XBox3

Canon E37117 HE Klystron campaign is finished

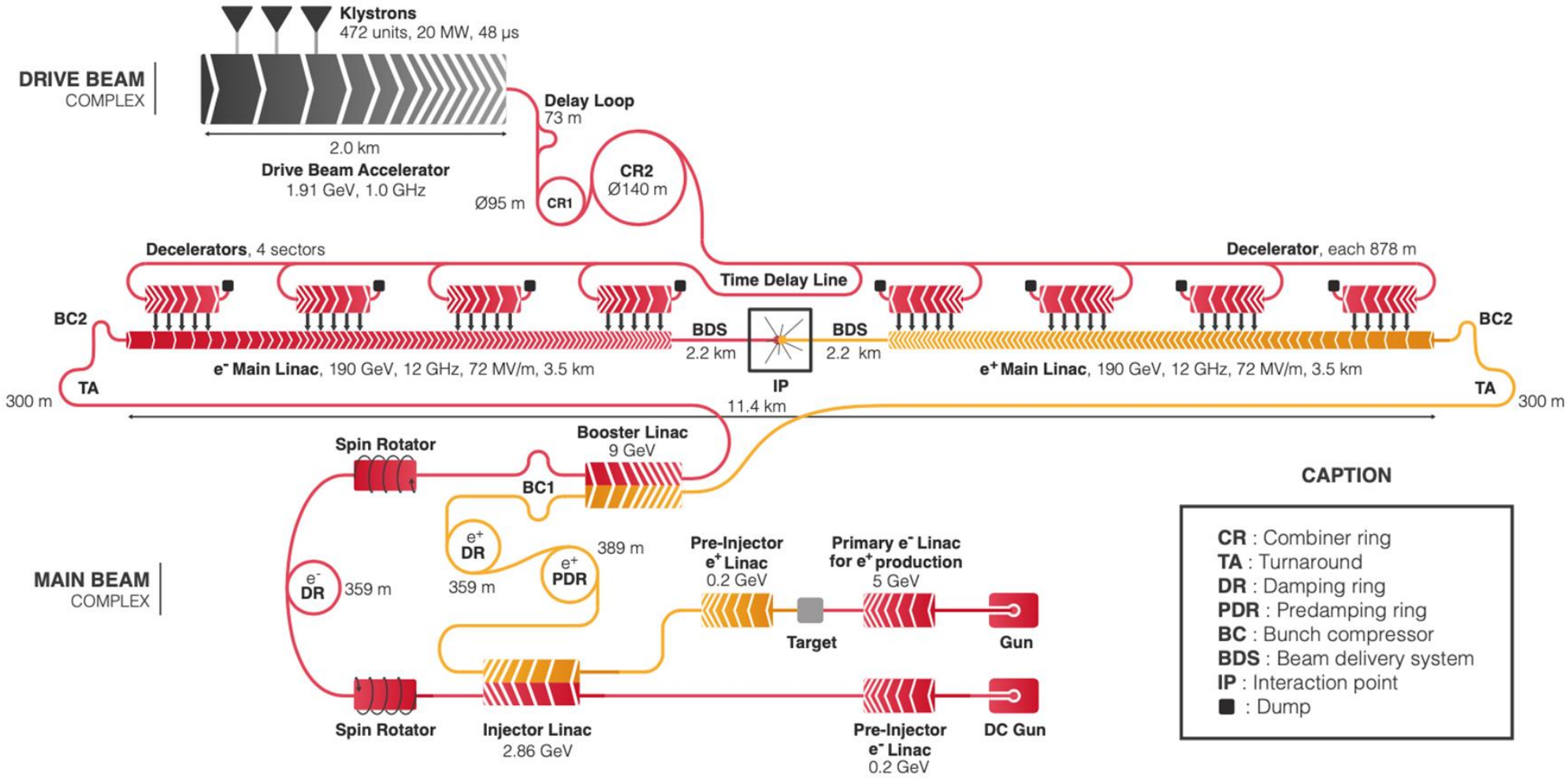
Ready for integration of structures TD31, TD26 and iFAST

Update on CERN Xboxes and X-Band technologies

Special thanks to all the people who have contributed with their work and advice during this year, including N. Catalán Lasheras, A. Baig, M. Boronat, A. Chauchet, S. Curt, A. Grudiev, S. González-Antón, C. Marrelli, P. Martínez-Reviriego, L. Millar, P. Morales Sánchez, D. Soriano, I. Syratchev, M. Volpi, P. Wang, B. Woolley, W. Wuensch…

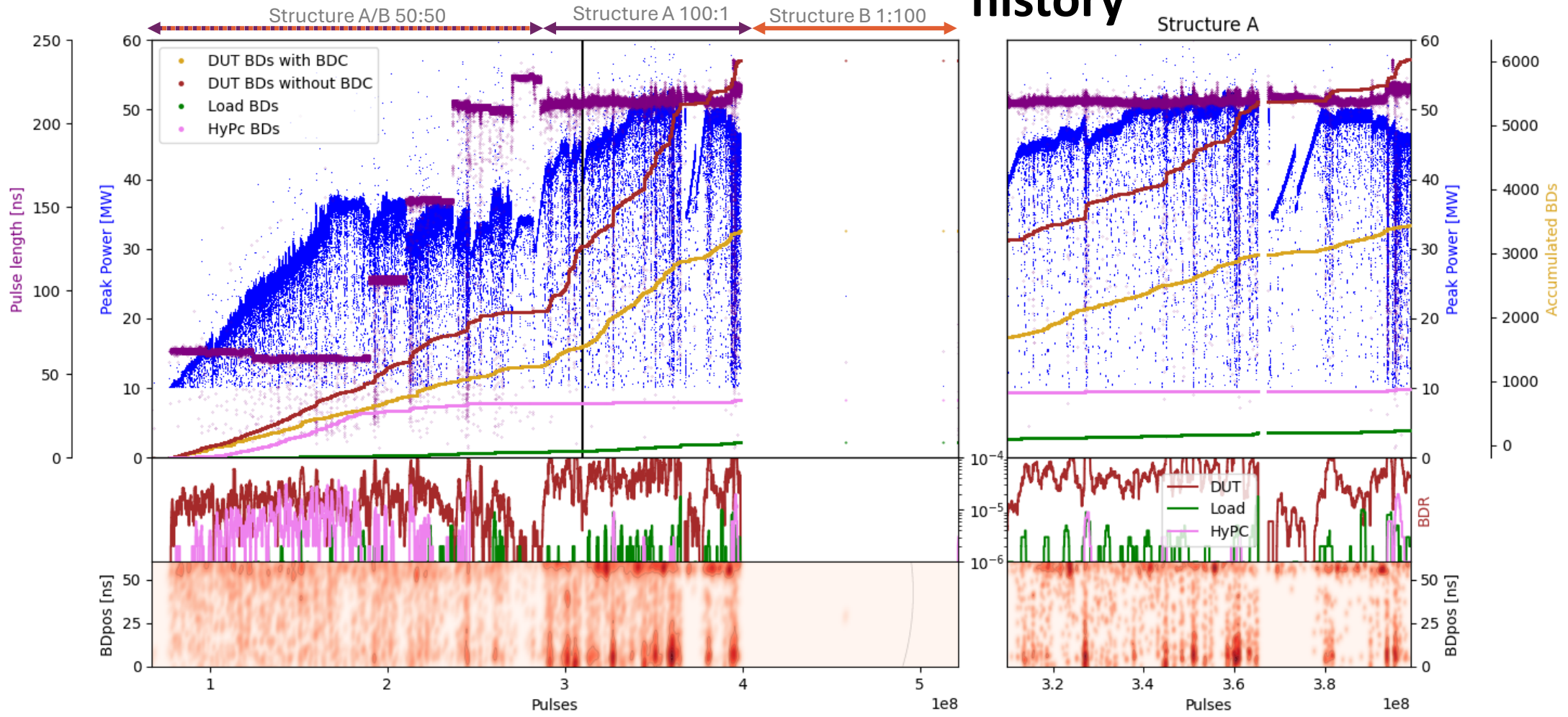
CLIC Project Meeting #47, Dec 11 2024

Xbox 2: TD31 for CLIC380



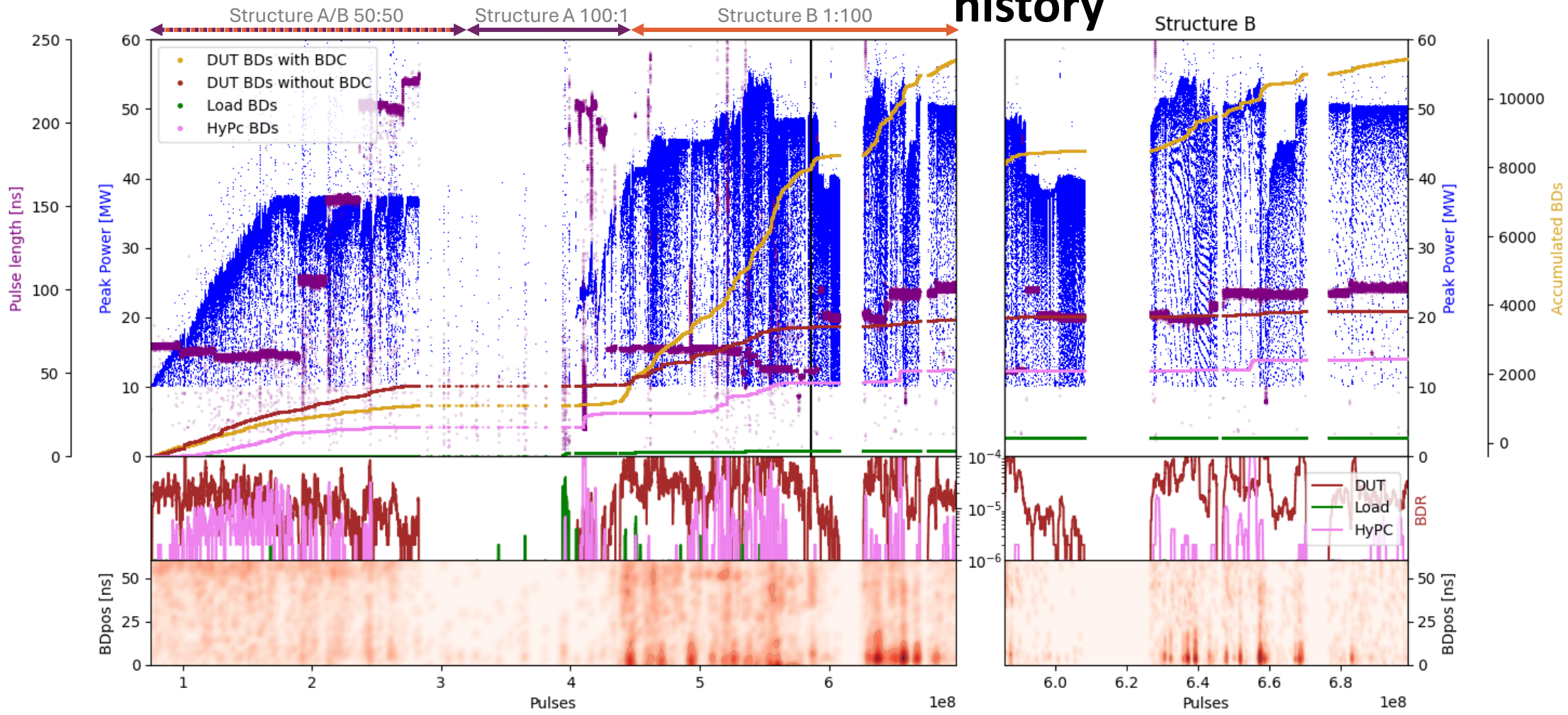
Xbox 2 TD31

TD31N3 conditioning history

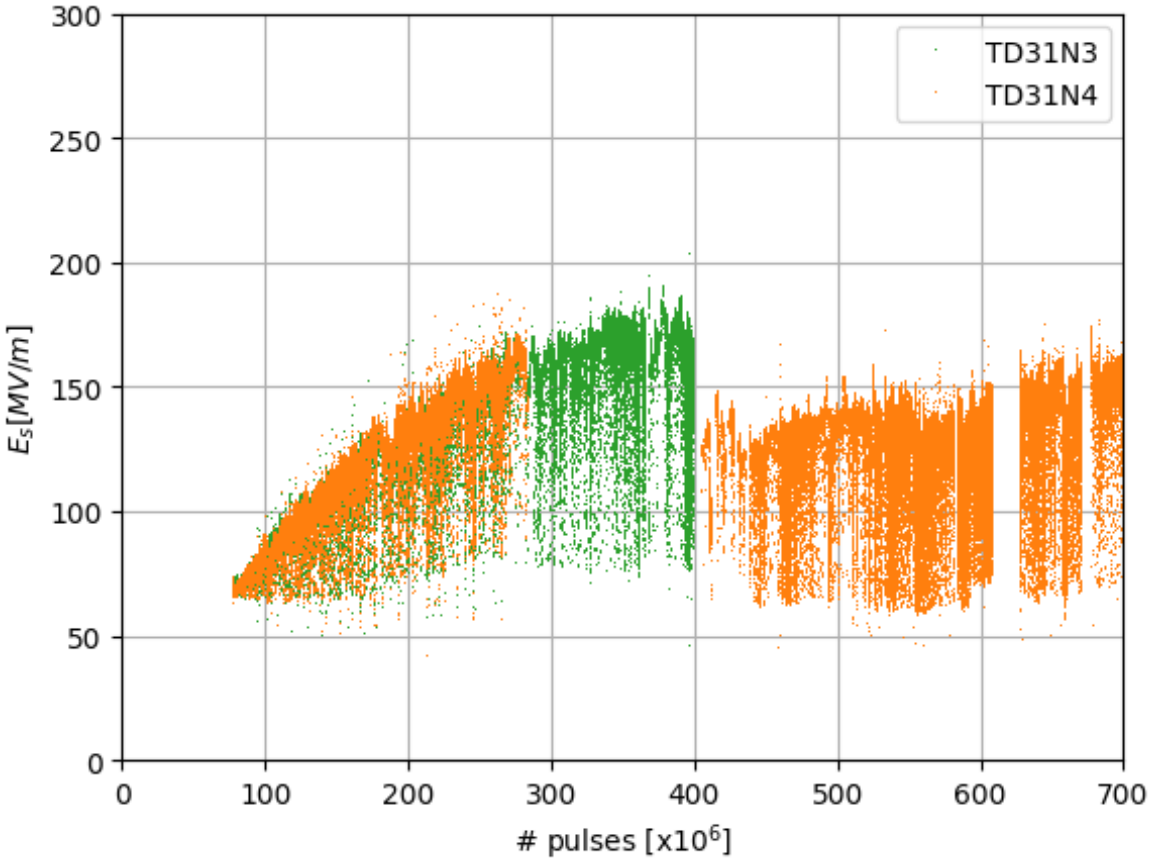


Xbox 2 TD31

TD31N4 conditioning history



Xbox 2 TD31



Conditioning history comparison