ANALYSIS AND OPERATIONAL FEEDBACK ON THE CURRENT HIGH ENERGY BEAM DUMP IN THE CERN SPS

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CERN | EN ENGINEERING DEPARTMENT

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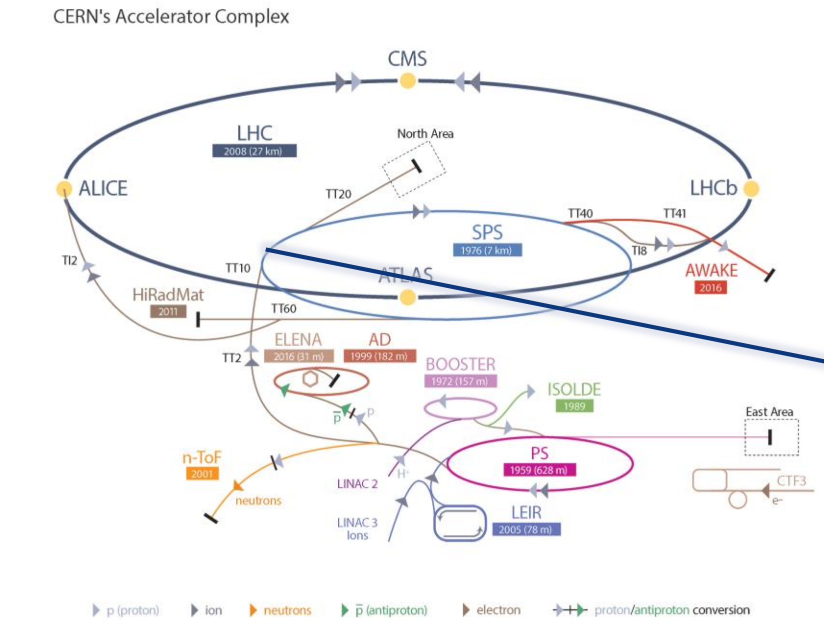
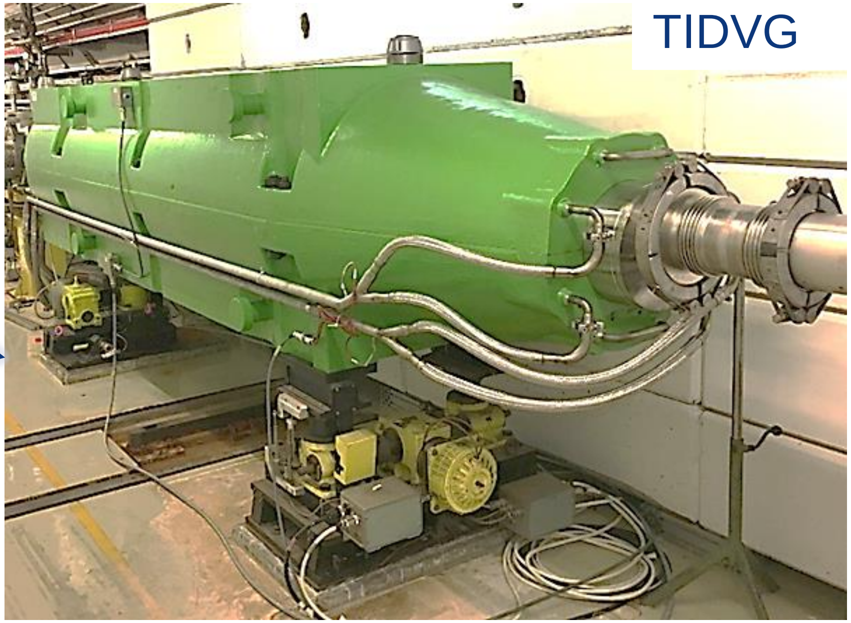
Introduction of the SPS beam dump



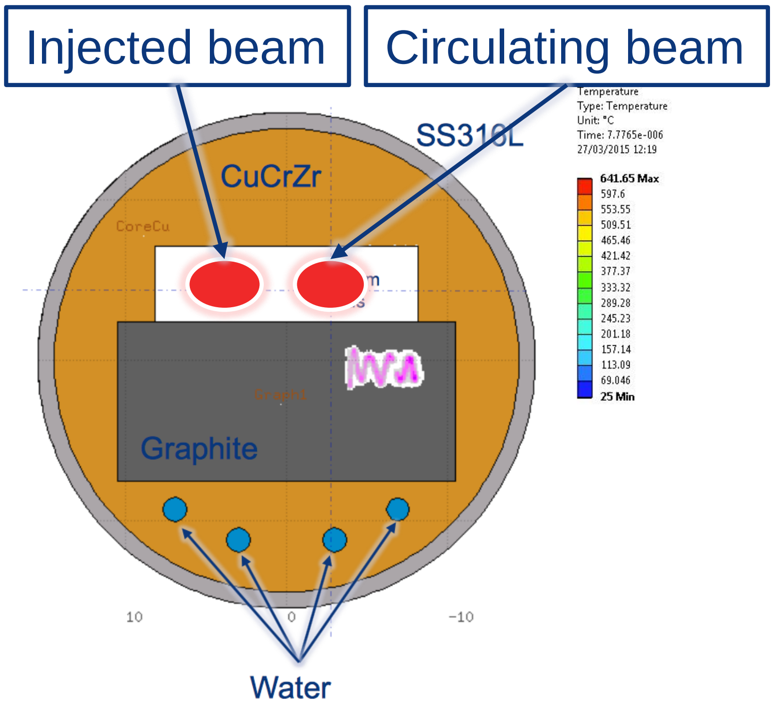


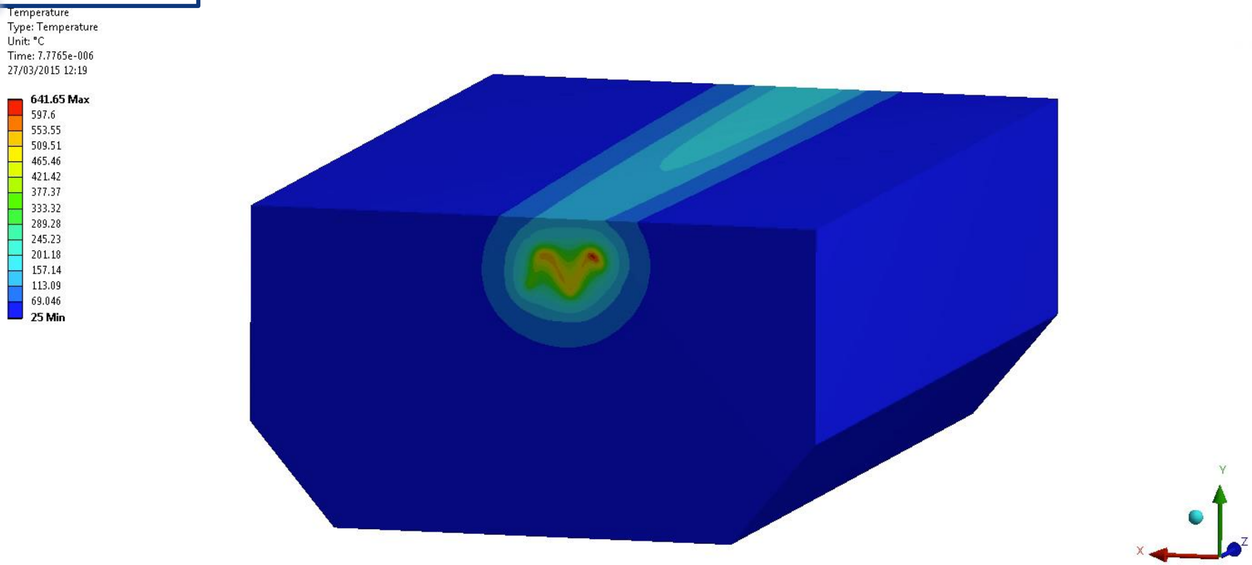
Two beam dumps in the SPS:

- **TIDH** (Target Internal Dump Horizontal): <28 GeV
- **TIDVG** (Target Internal Dump Vertical Graphite): 105-450 GeV
  - Total length 4.3 m, 30 cm core diameter
  - Internal dump (in UHV)

Beam dilution on dump

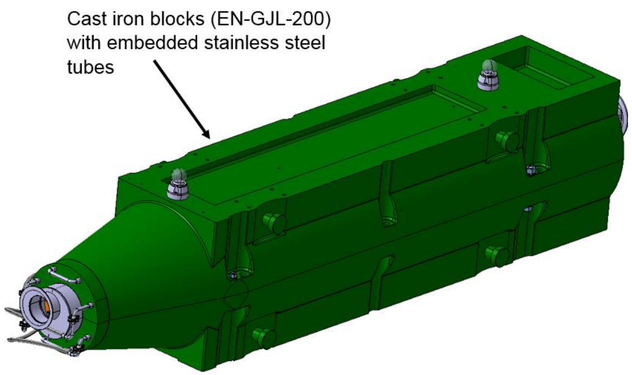
- In order to avoid damaging the absorbing material, the beam is diluted over ~7.2 μs (for LHC beams)
- Asymmetry in the energy deposition in the dump induced by the position of the device with respect to the injected beam

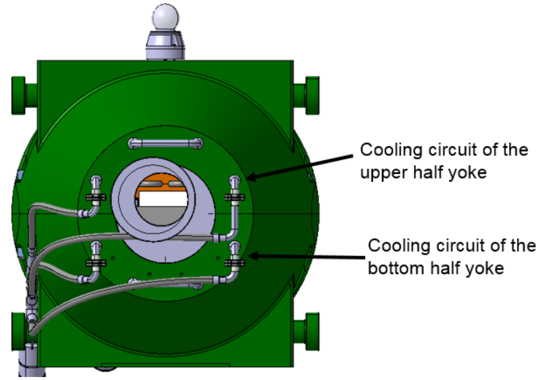


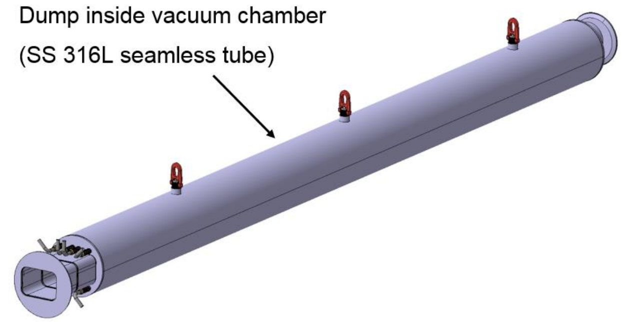


Current SPS beam dump – TIDVG#4

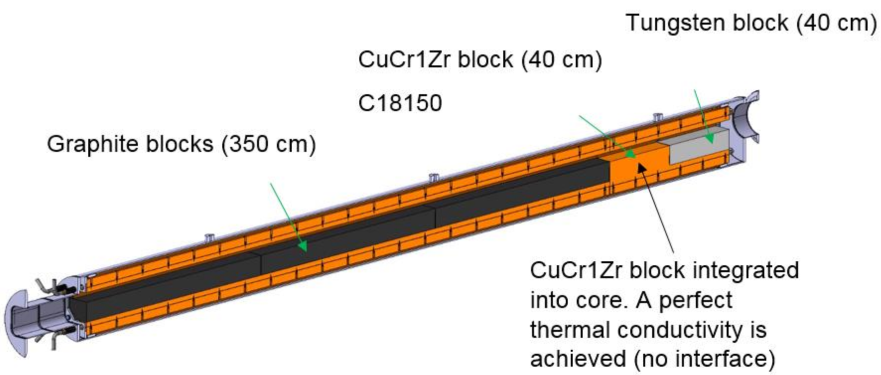
Installed in March 2017



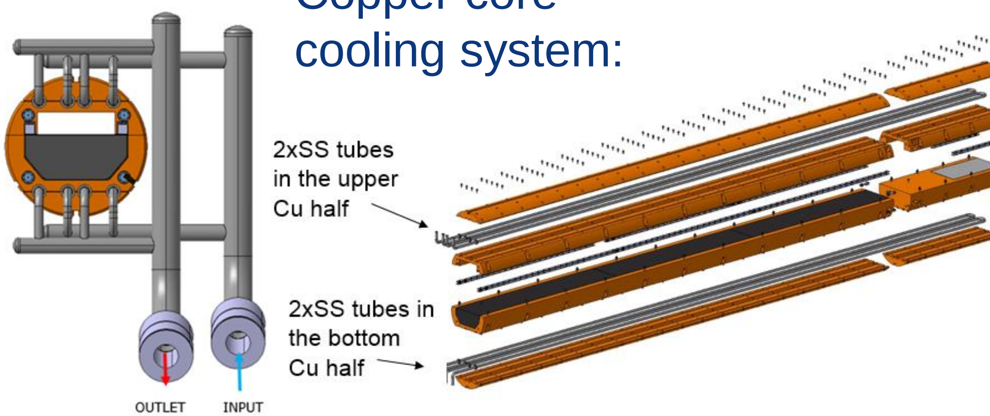




Absorbing blocks



Copper core cooling system:



- Limited time window:
  - Faster manufacturer
  - Use of known technologies. No R&D
- T sensors on all the parts (18 in total)
- T sensors for the water +1 flow meter
- Copper core made of CuCr1Zr

Material selection for TIDVG#4

General material requirements for the SPS beam dump design

- **Good thermal and mechanical properties**
  - High power to be dissipated and high stresses due to the beam impact
- Materials available in needed quantities, sizes and easy to machine + delivery
- **UHV compatibility**
- **Avoid Al as absorbing block** (molten in previous design)

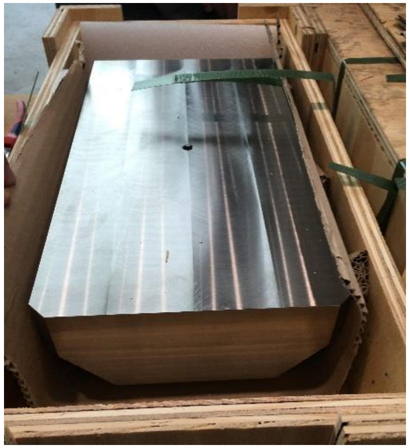
Component	CERN specifications	Additional treatments applied
Graphite	Isotropic properties Grade with proven high thermal shock resistance	Machined without lubricants Purified in Ar @ T>2000ºC Vacuum fired @ 950ºC at CERN
Tungsten alloy	Density, mechanical properties, machinability	Degreased at CERN Vacuum fired @ 950ºC at CERN
CuCrZr	Homogeneity / 3D forged	Degreased at CERN
Tube for vacuum chamber	Homogeneity + small grain size 3D forged 316L as per CERN spec. Seamless	Degreased at CERN

Current SPS beam dump – TIDVG#4

Forging of SS vacuum chamber

Vacuum firing of the Gr blocks

Tungsten alloy

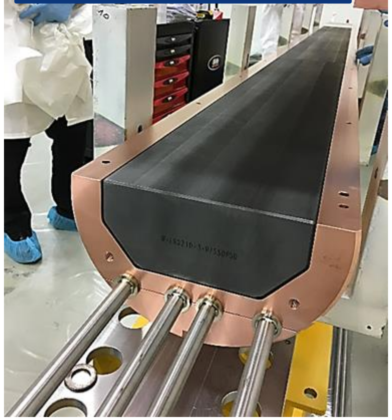


SS vacuum chamber

CuCrZr core

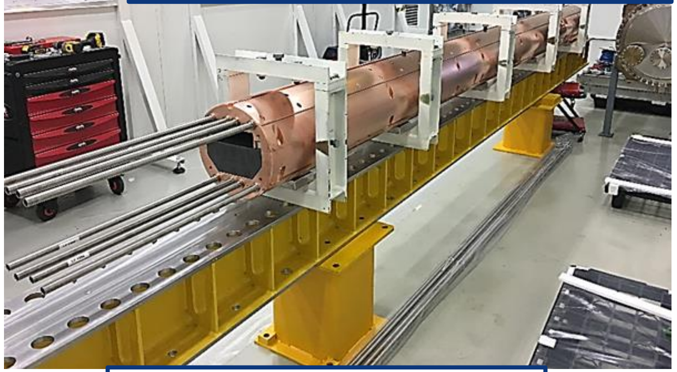
Current SPS beam dump – TIDVG#4

Graphite inside the CuCrZr core

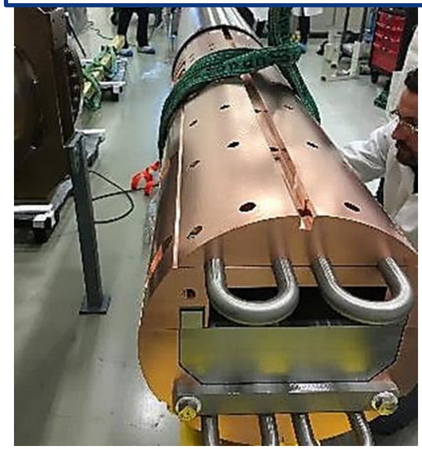


Medium/high-Z absorber

TIDVG#4 core fully assembled and ready for insertion in the vacuum tube



TIDVG#4 core being pulled into the vacuum chamber

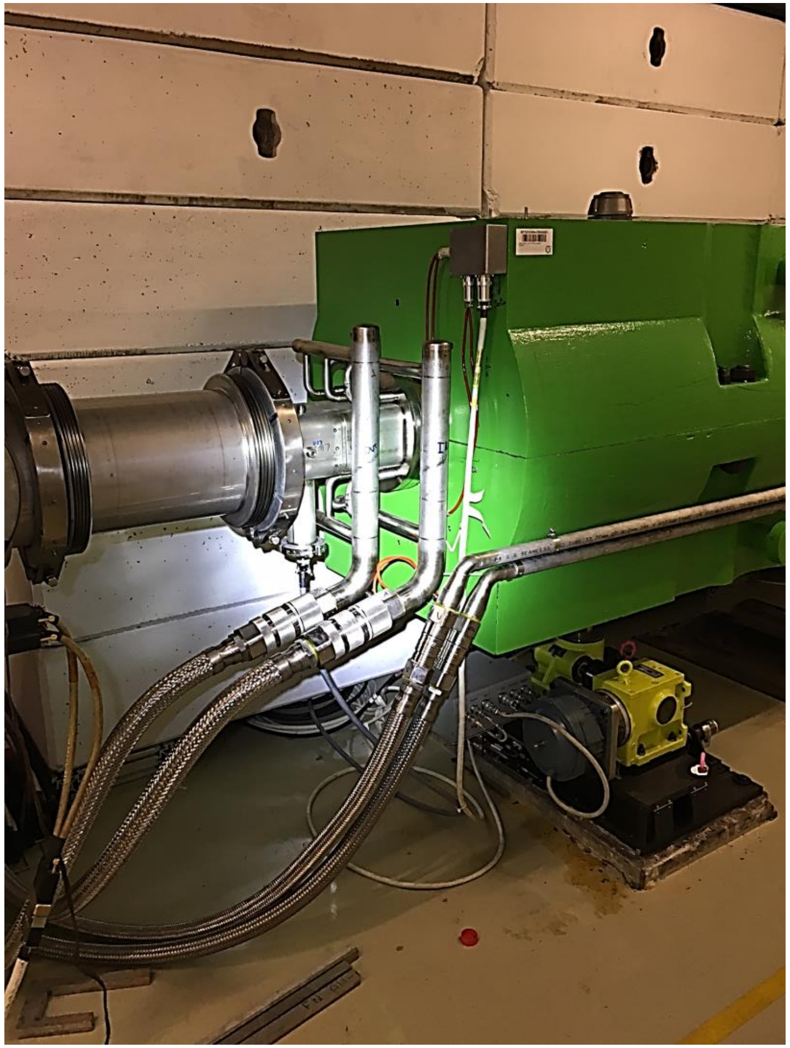


TIDVG#4 core fully inserted (upstream)

Final leak detection (upstream/ water manifolds)

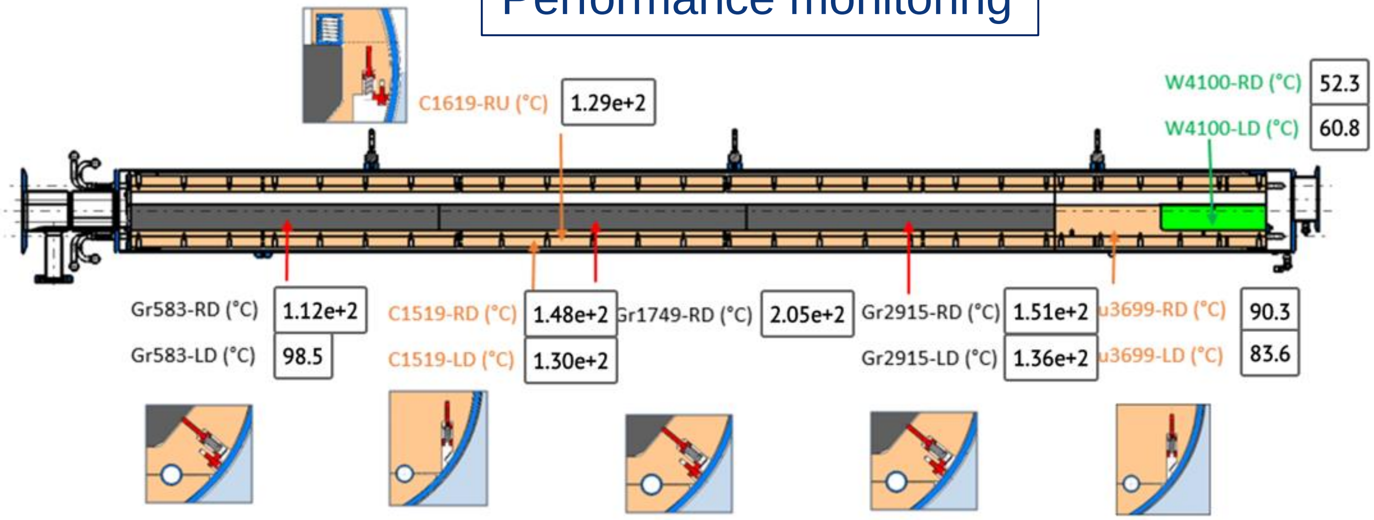
Current TIDVG#4 Installation

Installation during EYETS 2017 (March)



Operational feedback for TIDVG#4

Performance monitoring



P-VACUUM-VGHB11860 (mbar)	7.00e-8
P-VACUUM-VGHB11879 (mbar)	1.90e-7
P-VACUUM-VGHB11931 (mbar)	1.10e-8
P-VACUUM-VGHB11936 (mbar)	1.60e-9
P-VACUUM-VGHB11952 (mbar)	6.00e-9
P-VACUUM- VGHB11959 (mbar)	1.80e-8

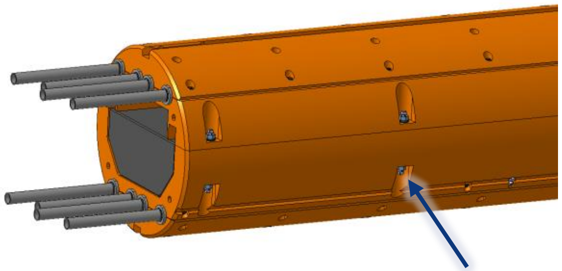
Beam intensity: 7.63e+11 charges

Beam energy: 4.00e+2 GeV

Average beam power over last 10 mins: 4.27e+1 kW

Average beam power over last 10 SC: 4.83e+1 kW

Average beam power over last hour: 1.88e+1 kW

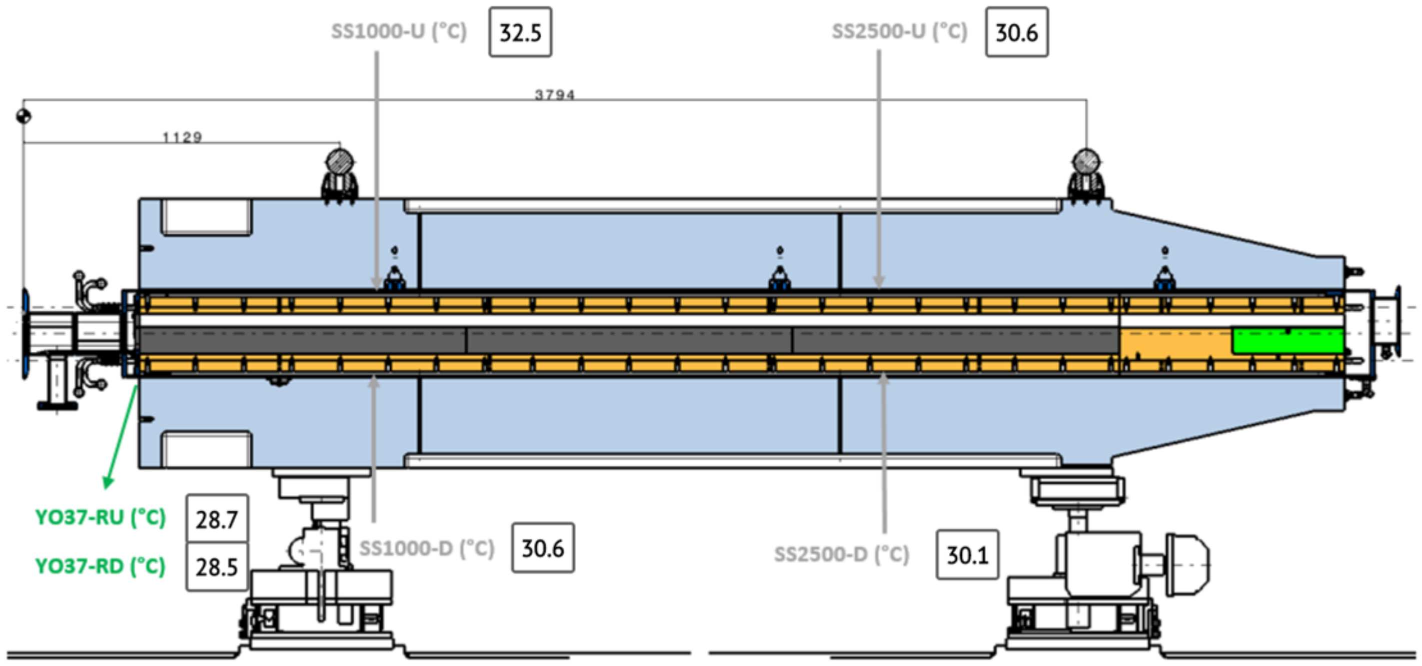


Gr583-RD

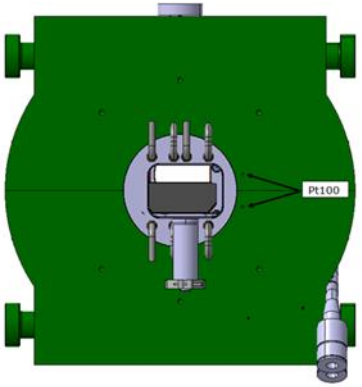
14 PT100 installed in the dump core

(2 PT100 were damaged during assembly)

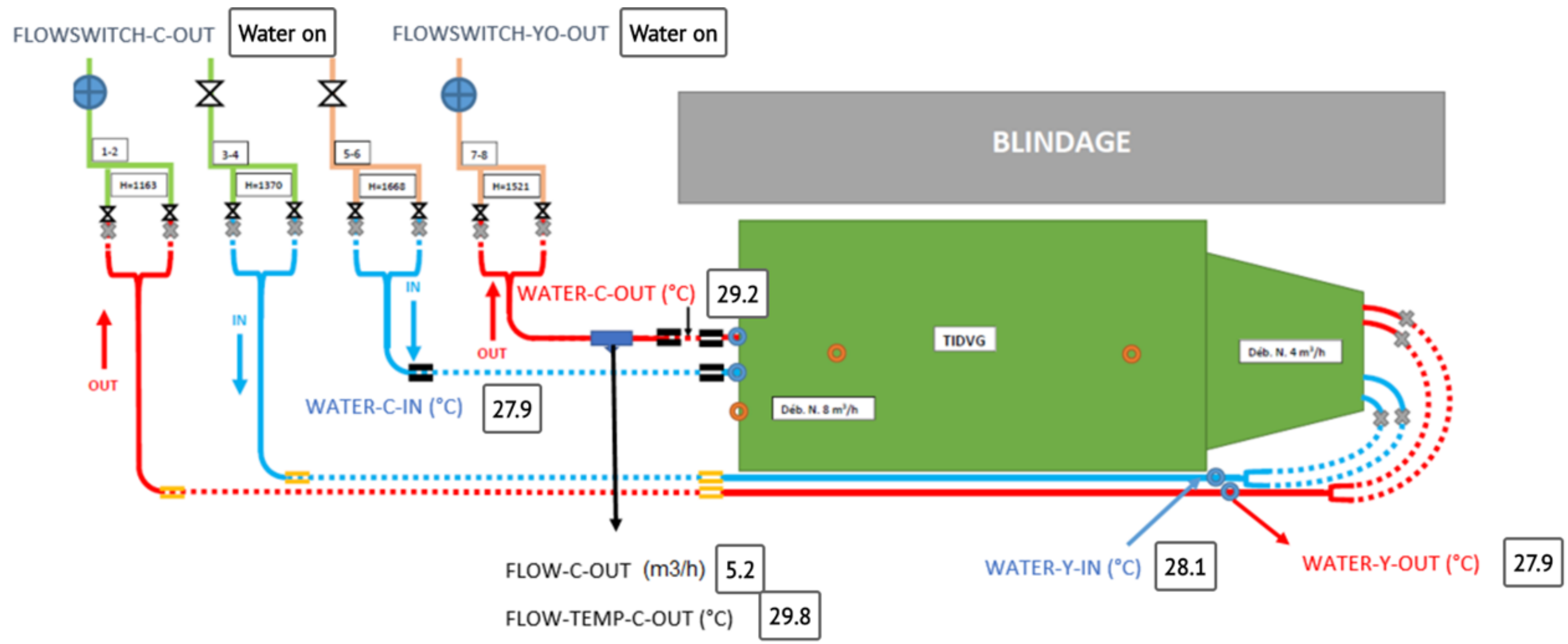
Operational feedback for TIDVG#4



4 PT100 on the SS vacuum chamber
2 PT100 on the shielding



Operational feedback for TIDVG#4



Sensors located in the water:

- 2 flow-switches
- 4 PT100 in the water
- 1 water flow sensor (water flow and outlet T)

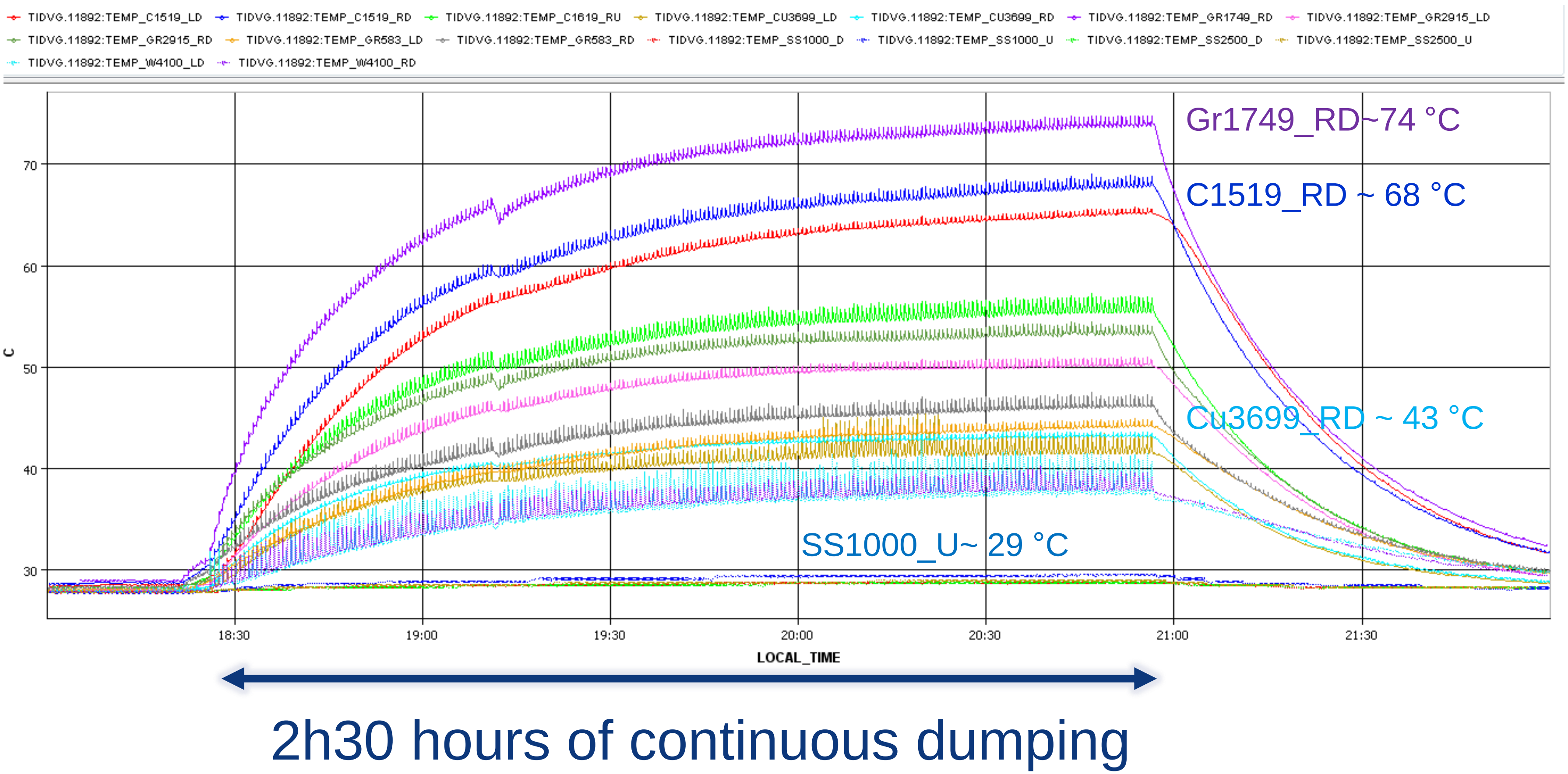
Operational feedback for TIDVG#4

Beam Type	p GeV/c	Bunch Intensity (protons)	# Bunches	Total Intensity (protons)	Continuous beam dump	Average power (kW)
LHC	440	$1.10*10^{11}$	48	$5.3*10^{12}$	2h30	9
LHC	440	$1.25*10^{11}$	72	$9.0*10^{12}$	4h00	16
LHC	440	$1.10*10^{11}$	144	$1.6*10^{13}$	3h00	27
LHC	440	$1.10*10^{11}$	288	$3.2*10^{13}$	1h30	55

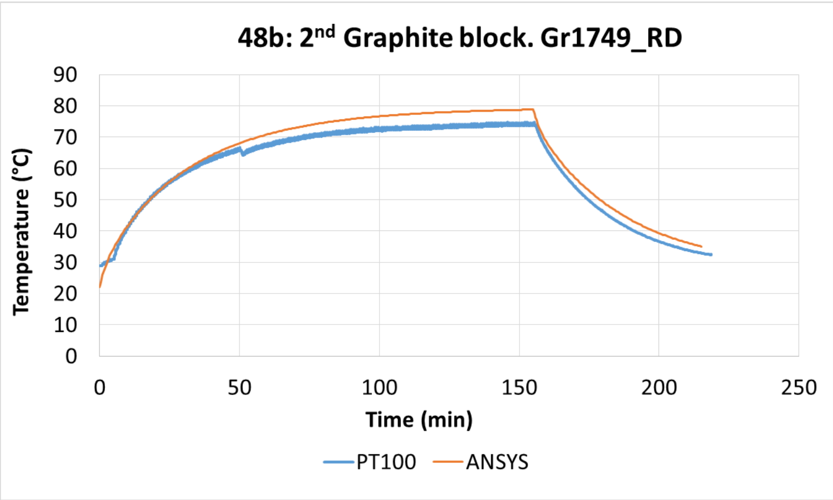
- Dedicated **commissioning beams** have been requested in order to validate the performances of the dump (simulation cross-check) as well as to condition graphite
- TIDVG4 can operate safely under continuous average beam power of **~60 kW**

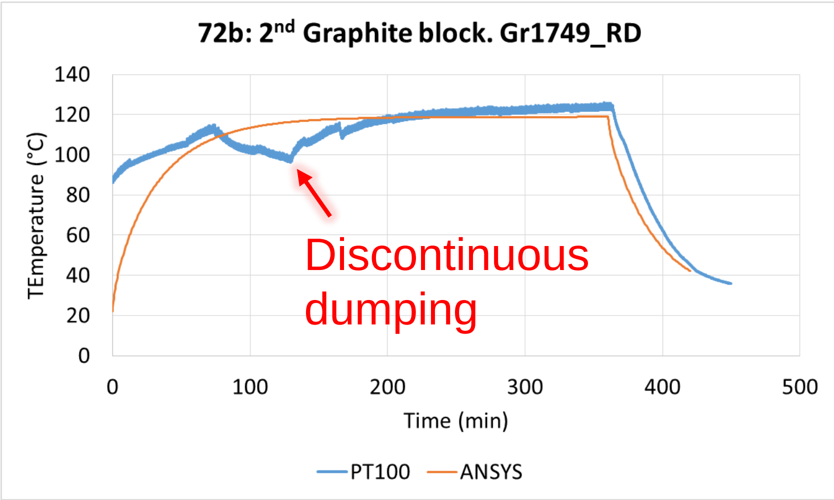
Operational feedback for TIDVG#4

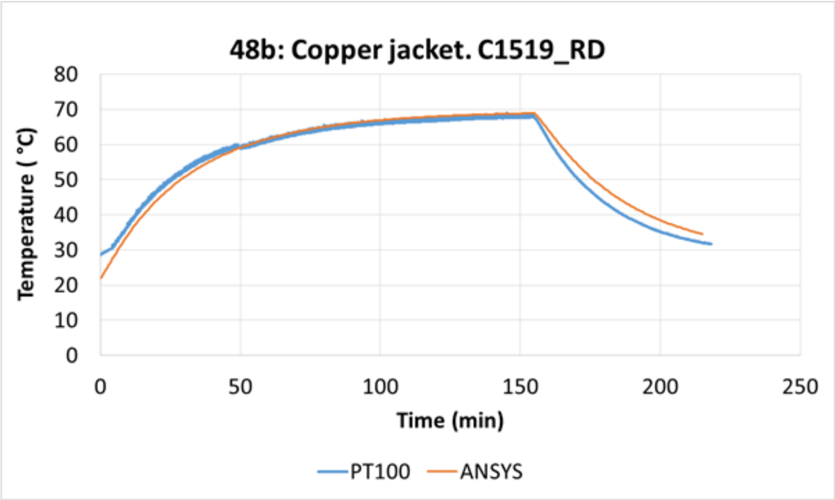
Behavior under 48b beam

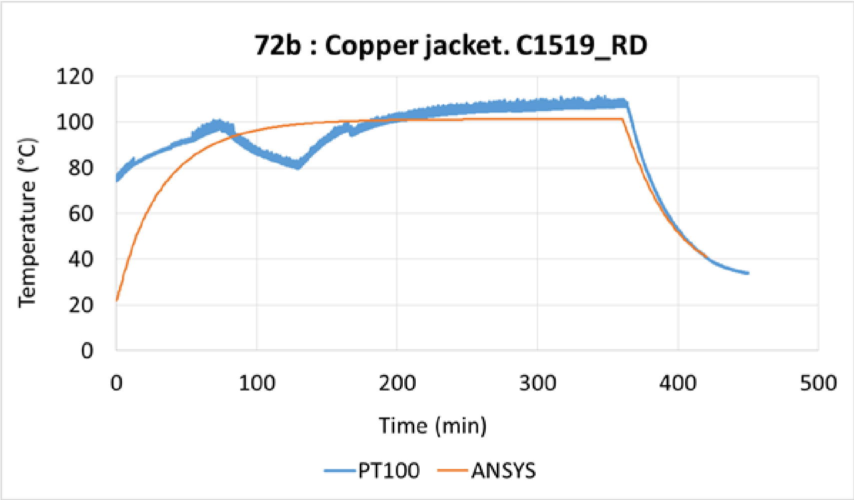


Operational feedback for TIDVG#4

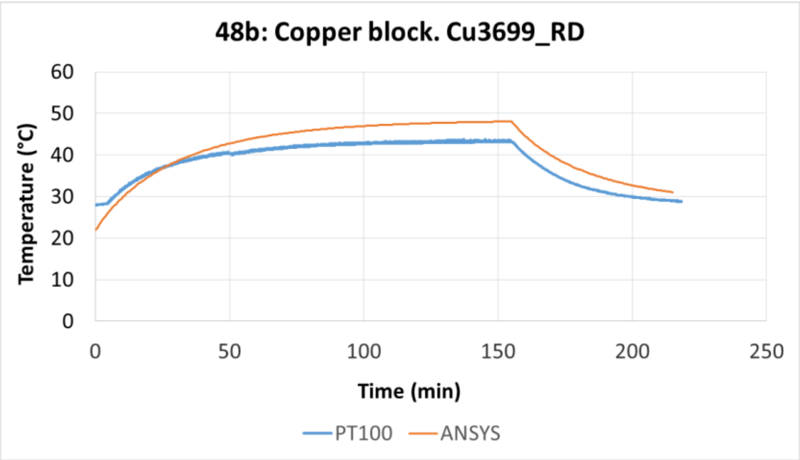


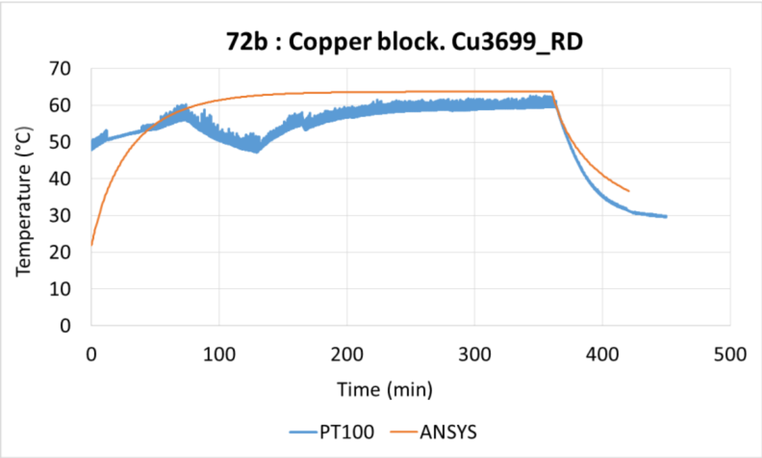




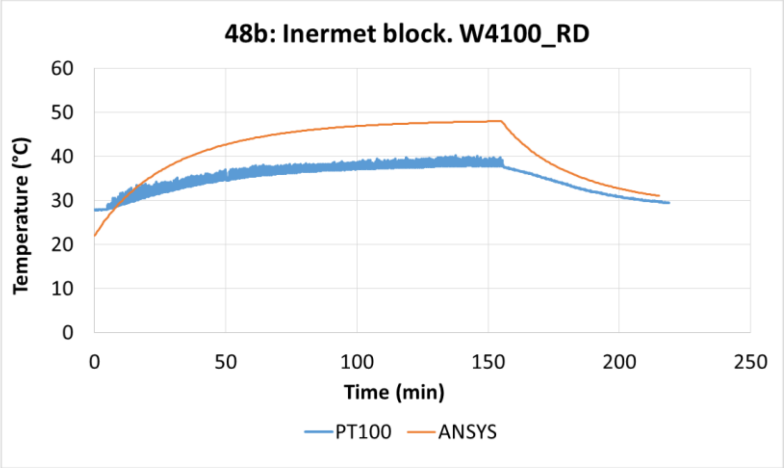


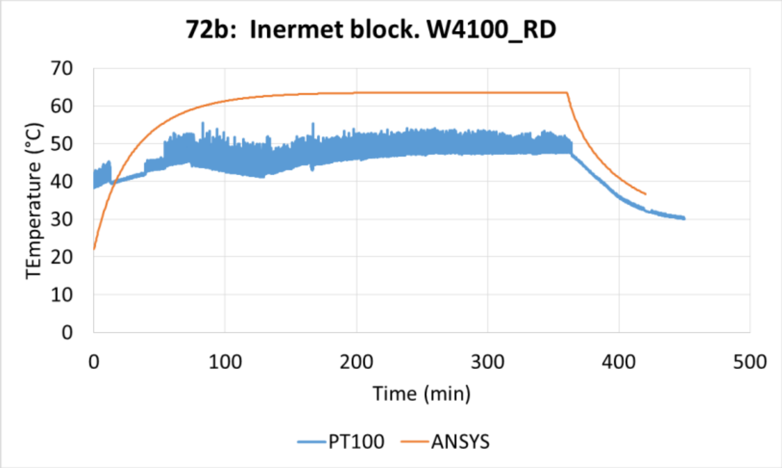
Operational feedback for TIDVG#4





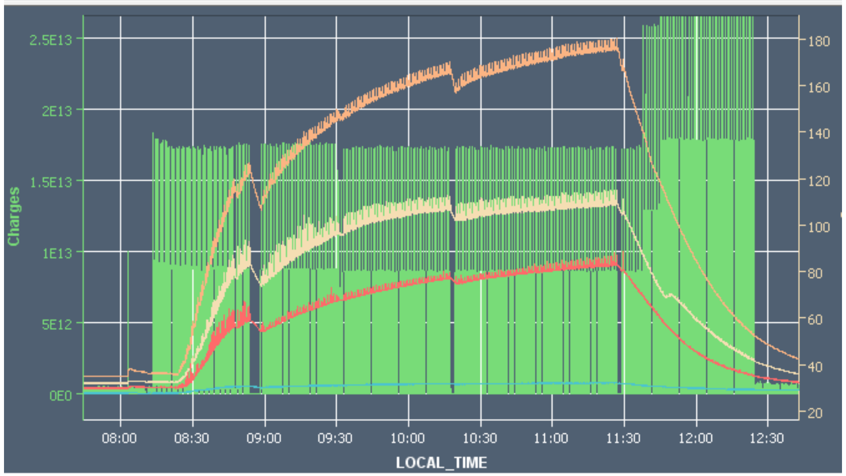
Good agreement (within ~25%)





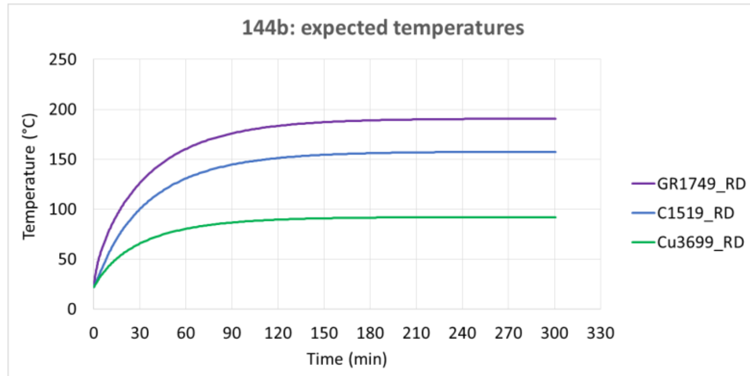
Operational feedback for TIDVG#4

~Steady state at **144** bunches (27 kW deposited)

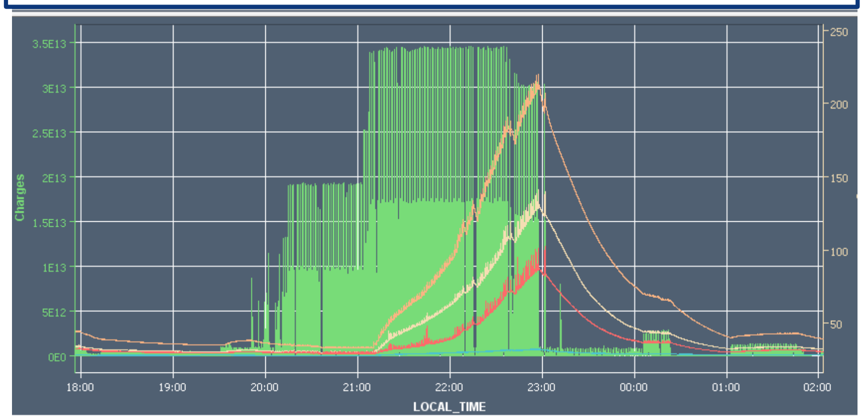


Temp. (°C)

Simulation for **27 kW**
(**144** bunches x $1.1*10^{11}$
$I_{total}=1.6*10^{13}$)

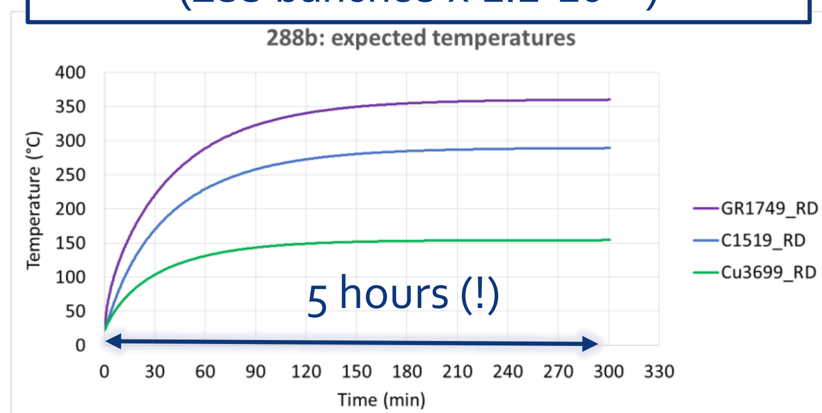


288 bunches (1h30– 55 kW deposited)



Temp. (°C)

Simulation for **56 kW**
(**288** bunches x $1.1*10^{11}$)



Conclusions

- The SPS beam dump (TIDVG) is a critical component of the CERN's accelerator complex
- TIDVG#4 successfully installed and operational according to the project schedule
- Good vacuum performance with a fast conditioning observed
- Good thermal performance (tested for high power beams)
- Longitudinal welds along the core were avoided (using a seamless vacuum chamber)
- Design features tested in TIDVG#4 to be implemented in TIDVG#5, to be installed in 2020 (details in poster presented here)
- Numerical model validated and able to predict dump performance
- No significant degradation observed after 1 year of operation

Thank you for your attention.

Do you have any questions?

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