



# Radiation testing of Quench Protection Systems

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# Quench Protection Systems

## DQLPUBv2



- Replacing 392 DQLPUBv1
- Enhanced diagnostics and maintainability
- Components radiation tested in PSI

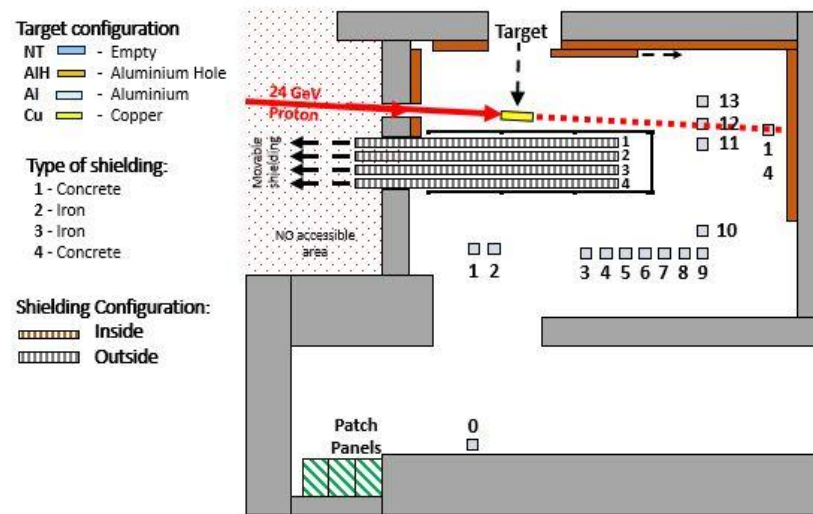
## Universal QDS (uQDS)



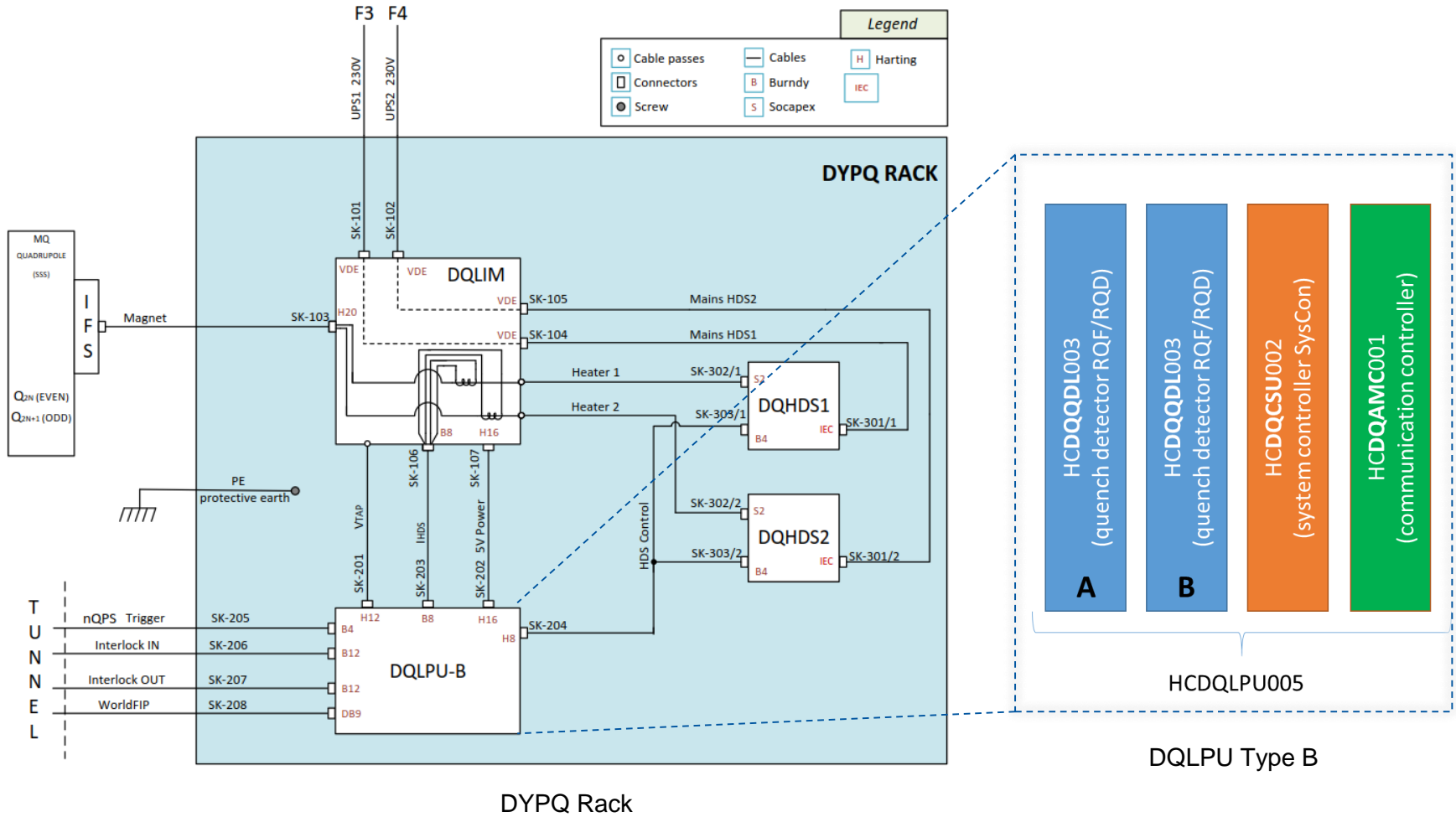
- Modular, versatile and universal quench detection system
- Uses tested commercial out of the shelf (COTS) components

# CHARM Irradiation campaigns

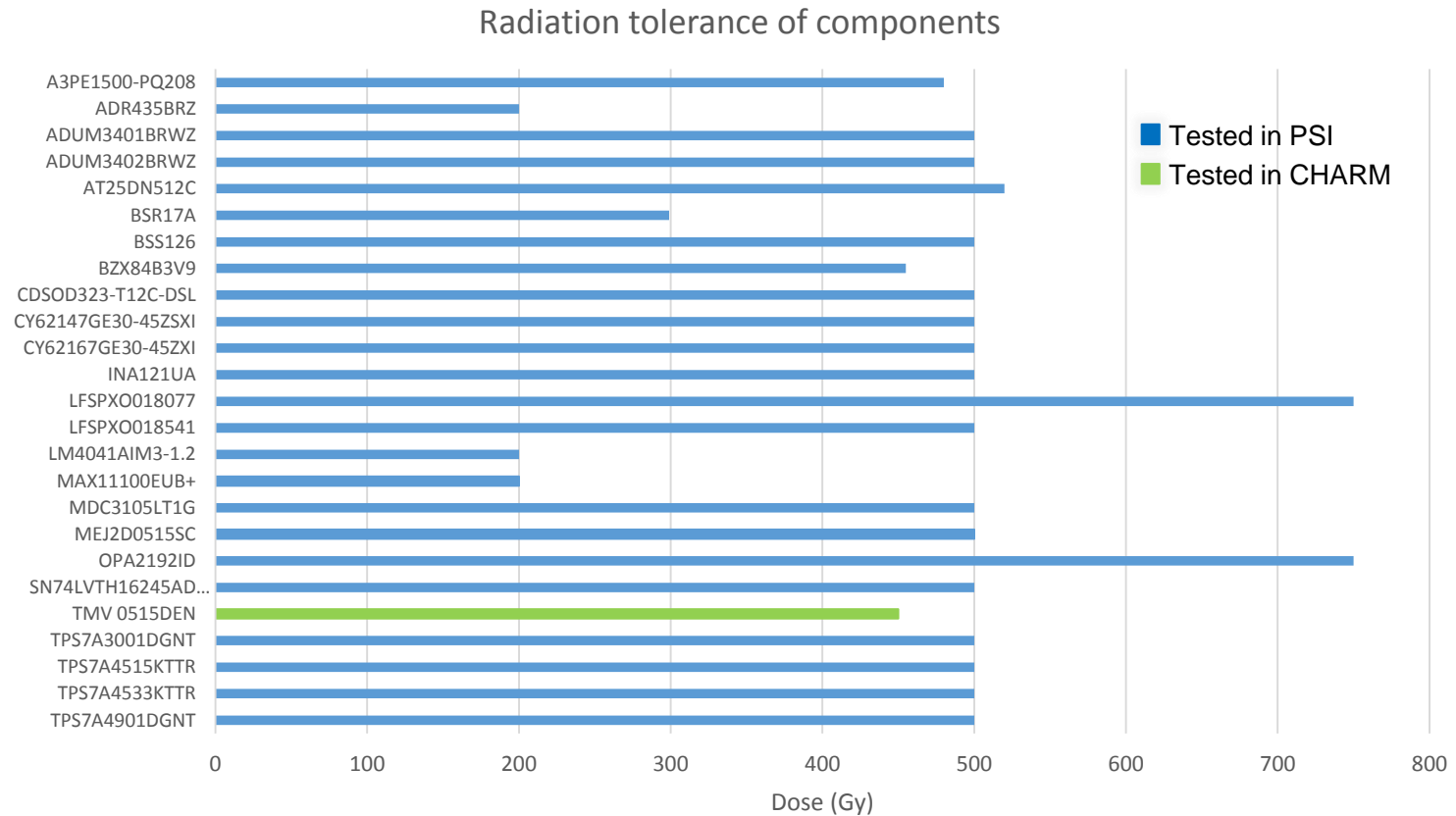
	Configuration	Position	Target Inside	Target Outside	Dose [Gy]	Total POT	
DQLPUBv2(1)	“CuOOOO”	10	2018-06-13	2018-06-18	218.69	1.27E+16	Run 1
DQLPUBv2(2)	“CuOOOO”	10	2018-06-20	2018-06-25	229.25	1.64E+16	Run 2
DQLPUBv2(1)	“CuOOOO”	10	2018-09-05	2018-09-10	156.5	1.78E+16	Run 3
DQLPUBv2(2)	“CuOOOO”	10	2018-09-12	2018-09-17	197.22	1.47E+16	Run 4
uQDS	“CuOOOO”	10	2018-09-26	2018-10-01	247.7	1.98E+16	Run 1



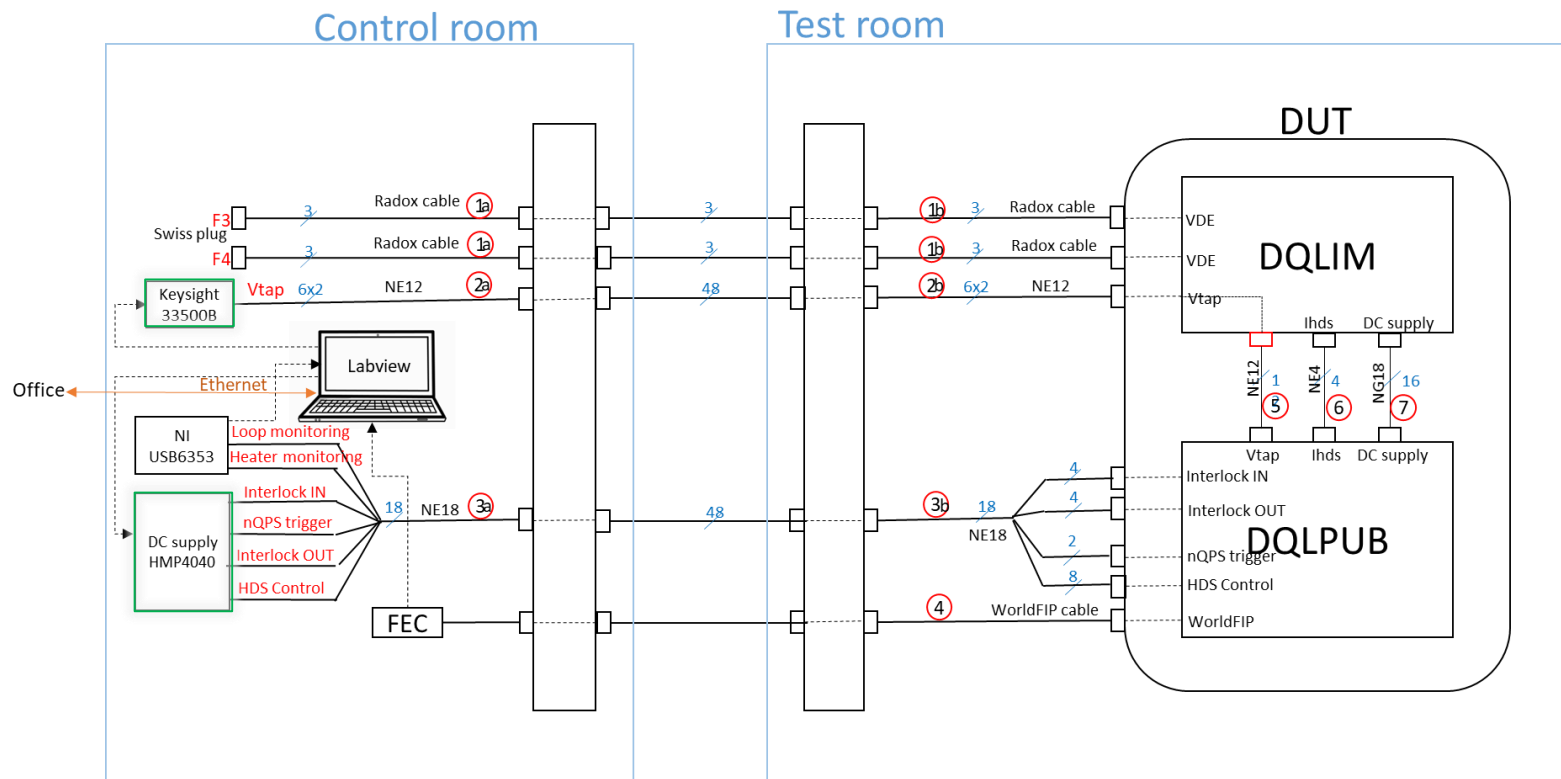
# About DQLPUBv2



# Radiation test campaigns: DQLPUBv2



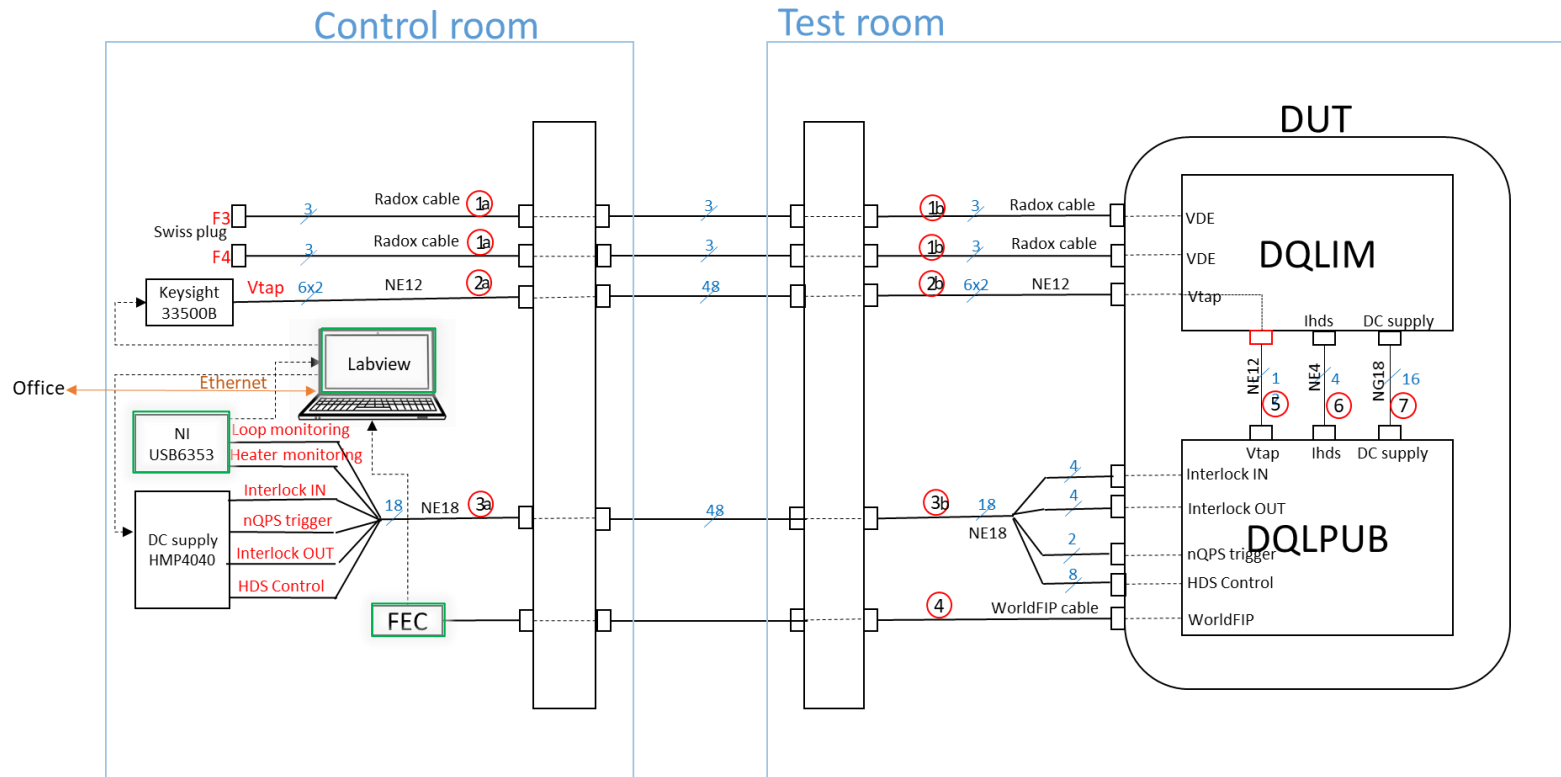
# Test setup: Signals and supplies



- Differential sinusoidal signals with amplitude 18Vpp and frequency 10mHz were used as Vtaps
- A fix voltage of 4.265V was used as Heater discharge supply voltage
- Interlock loop was provided with 60mA current using 12V, 200Ω
- 1kΩ resistors were used as loads to mimic DQHDS relay loads

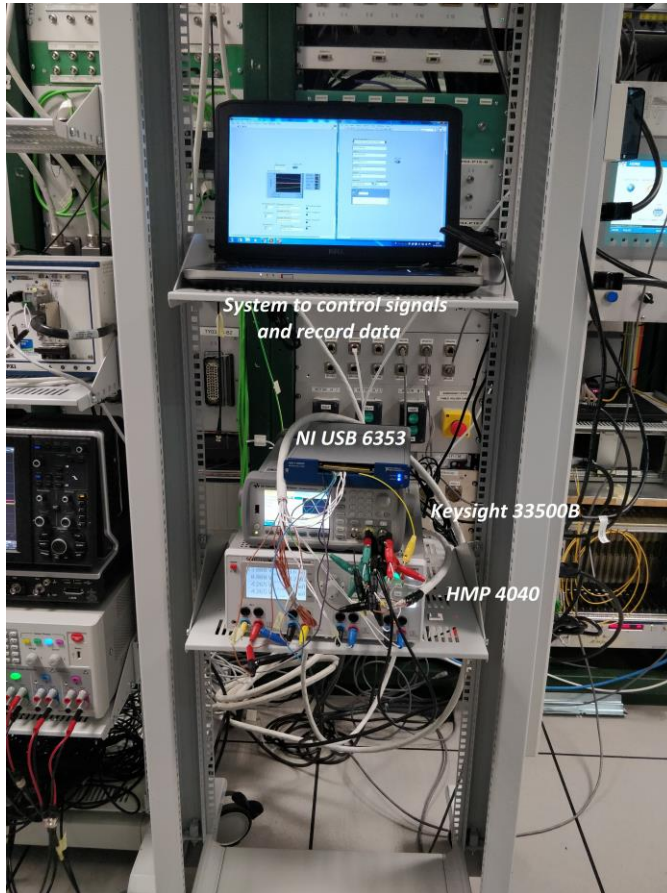


# Test setup: Data recording



- **National Instrument I/O box:** to monitor Interlock loop and heater firing
- **WorldFIP:** to record analog voltages, status registers and configuration parameters and save the data on NAS server
- **Labview:** to control the NI box, signal generator and DC supplies remotely

# Test setup: DQLPUBv2



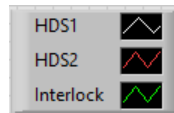
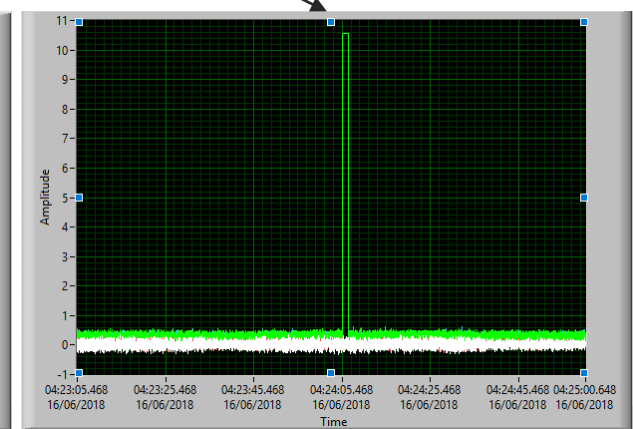
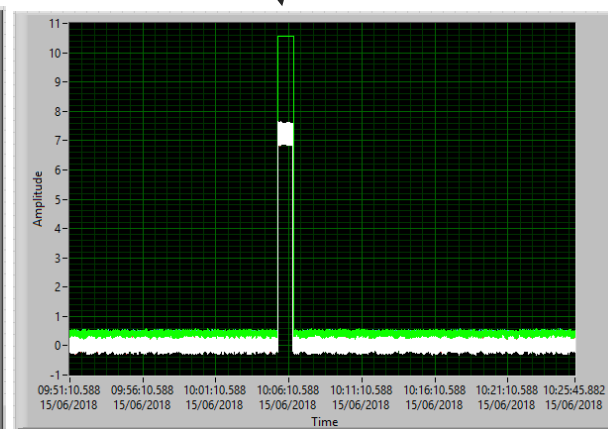
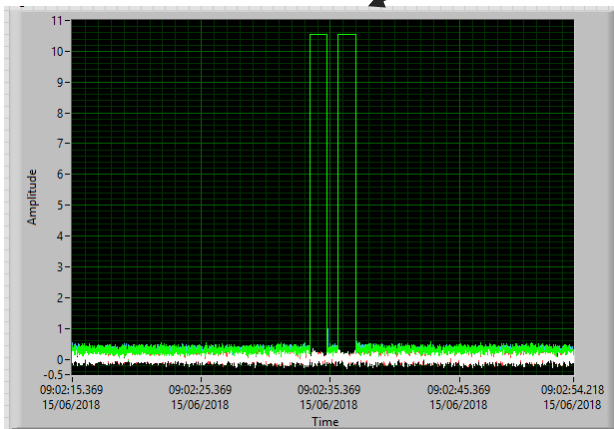
Control Room



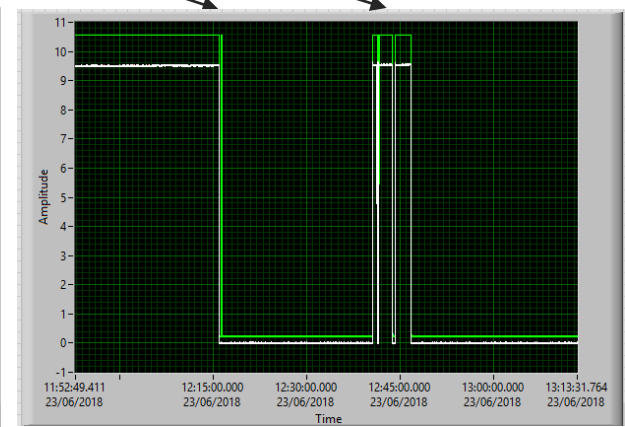
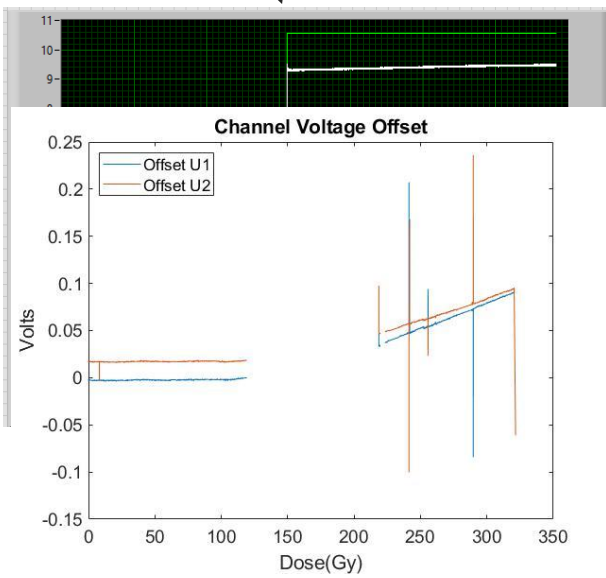
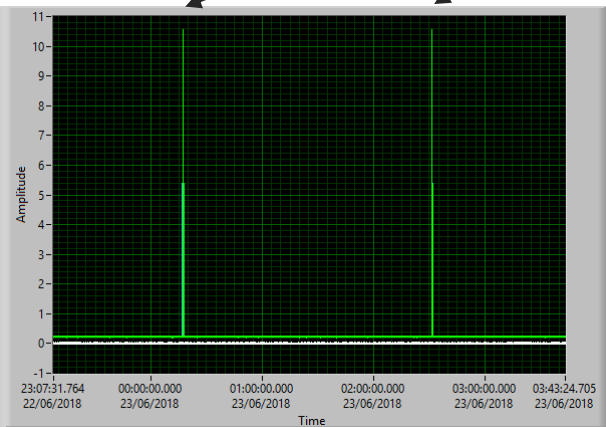
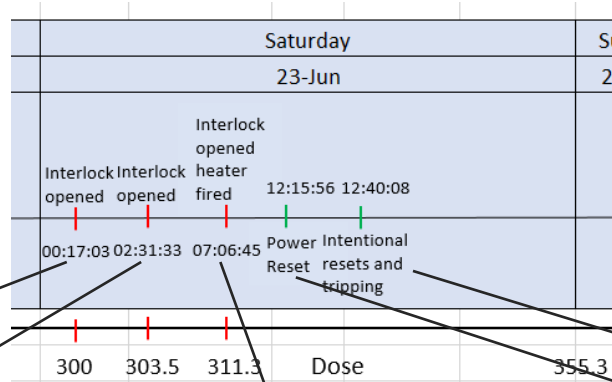
DUT in facility

# Events observed

Friday	
15-Jun	
Function generator tripped	6:54:xx
Reset	09:02:33
Intentional trip (offset>55mV)	10:05:24
Reset	14:54:01
Reset of DQAMC	16:40
Interlock opened	04:24:05
Dose	62
Dose	99.5

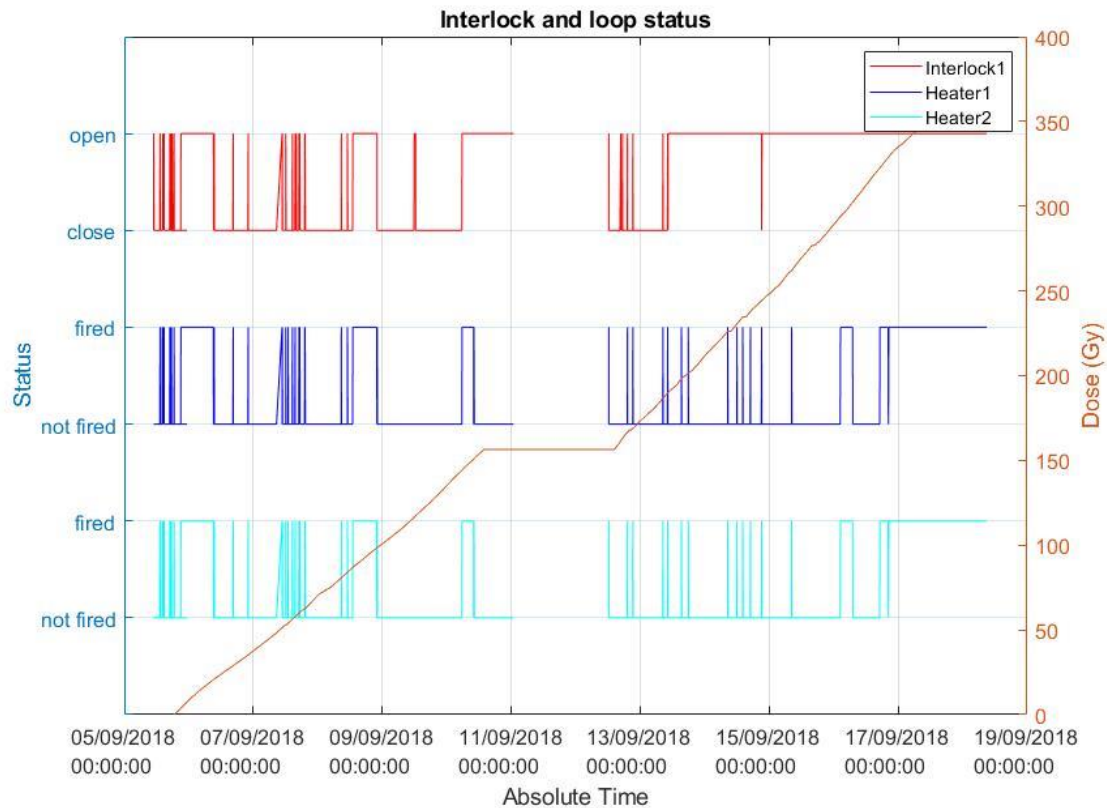


# Events observed

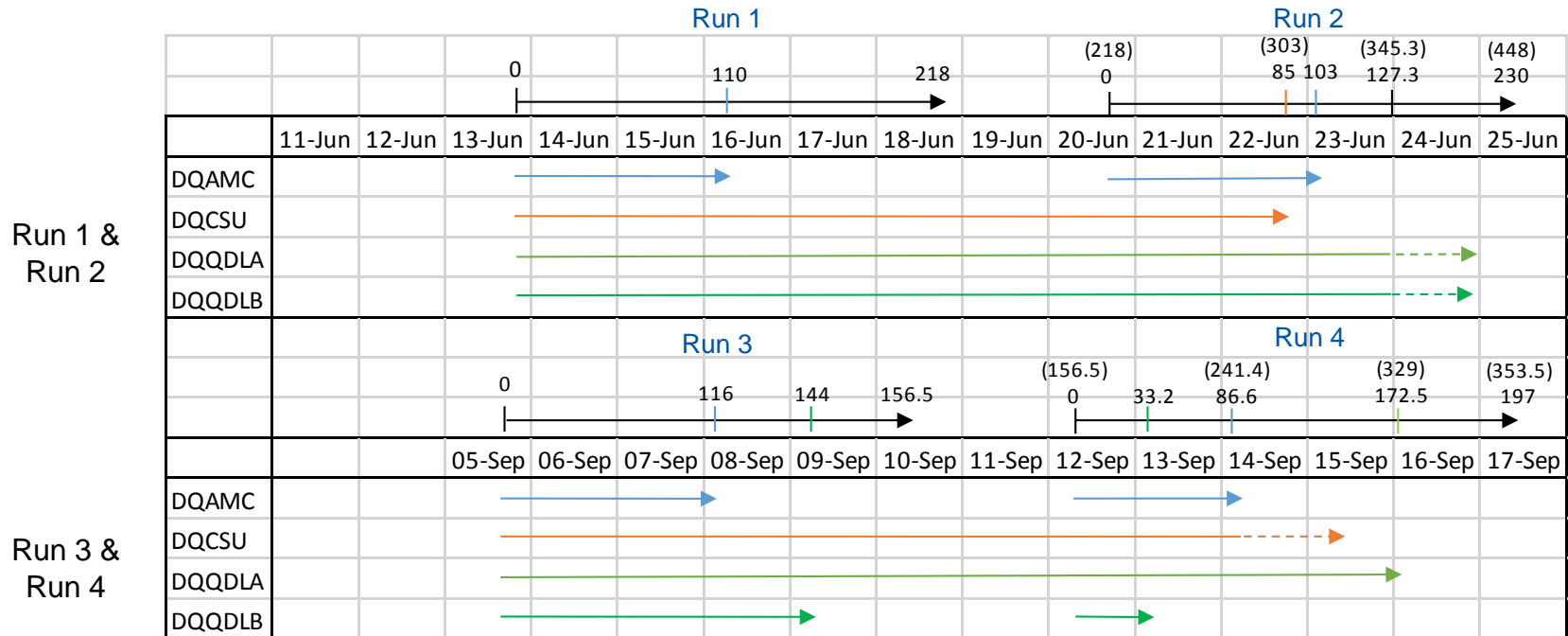


# Run 3 & 4

- Feedback from the review community and team members
- To test updated hardware and firmware
- To improve test statistics and diagnosis

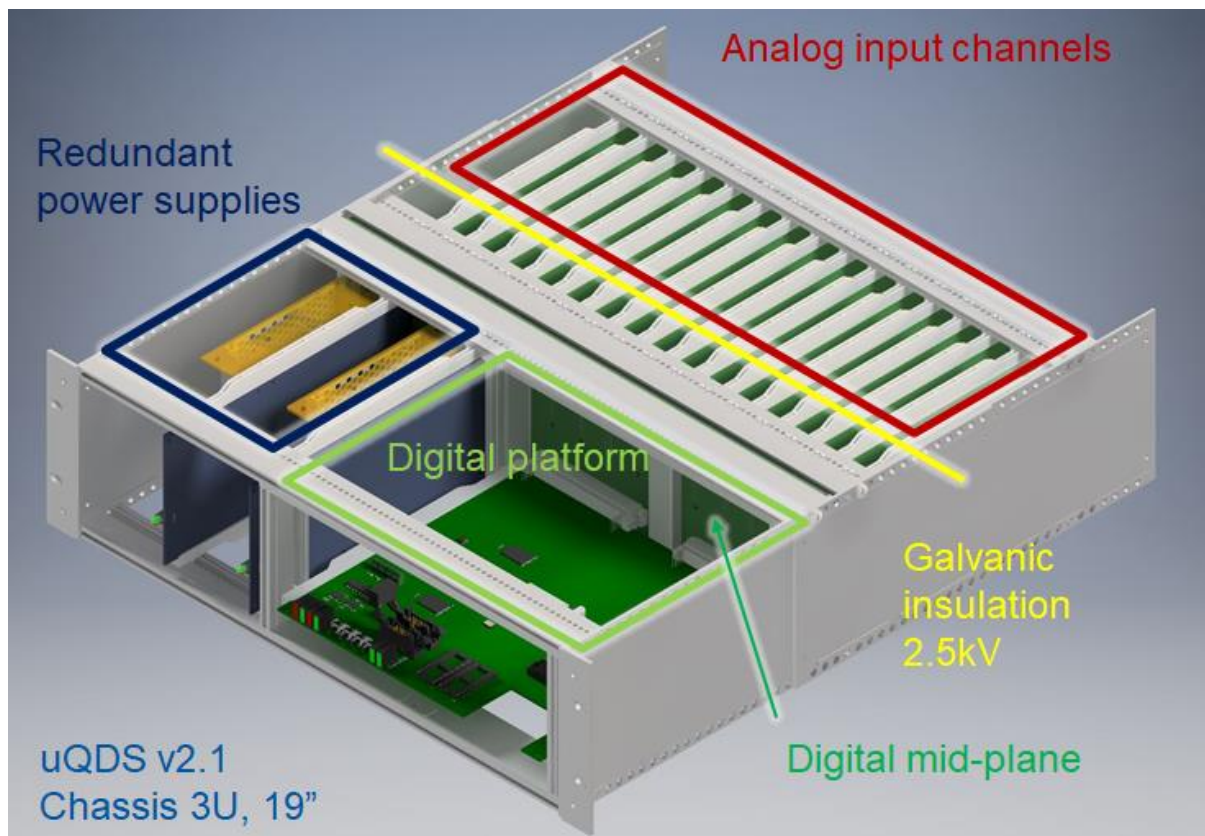


# Summary of performance of DQLPUBv2

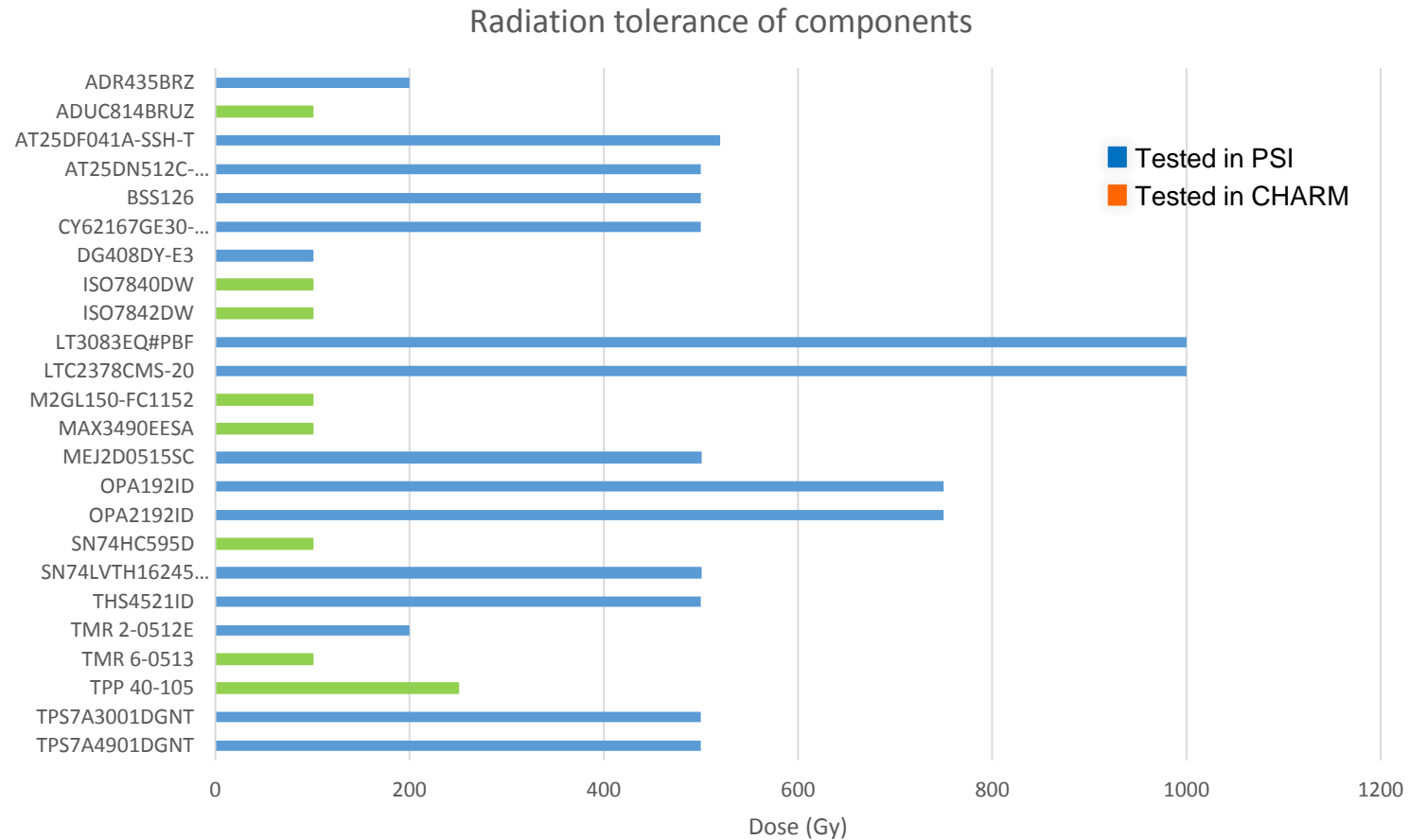


- DQAMC survives for 100 Gy on average, then it fails due to the microFIP IC
- DQCSU works atleast upto 240 Gy
- DQQDL performs well upto 330Gy
- For Run 3 and Run 4, failure of DQQDLB was attributed to failure of one digital isolator and one opamp respectively.
- Individual tests of isolator and opamp show good performance upto 500 Gy.

# About uQDS

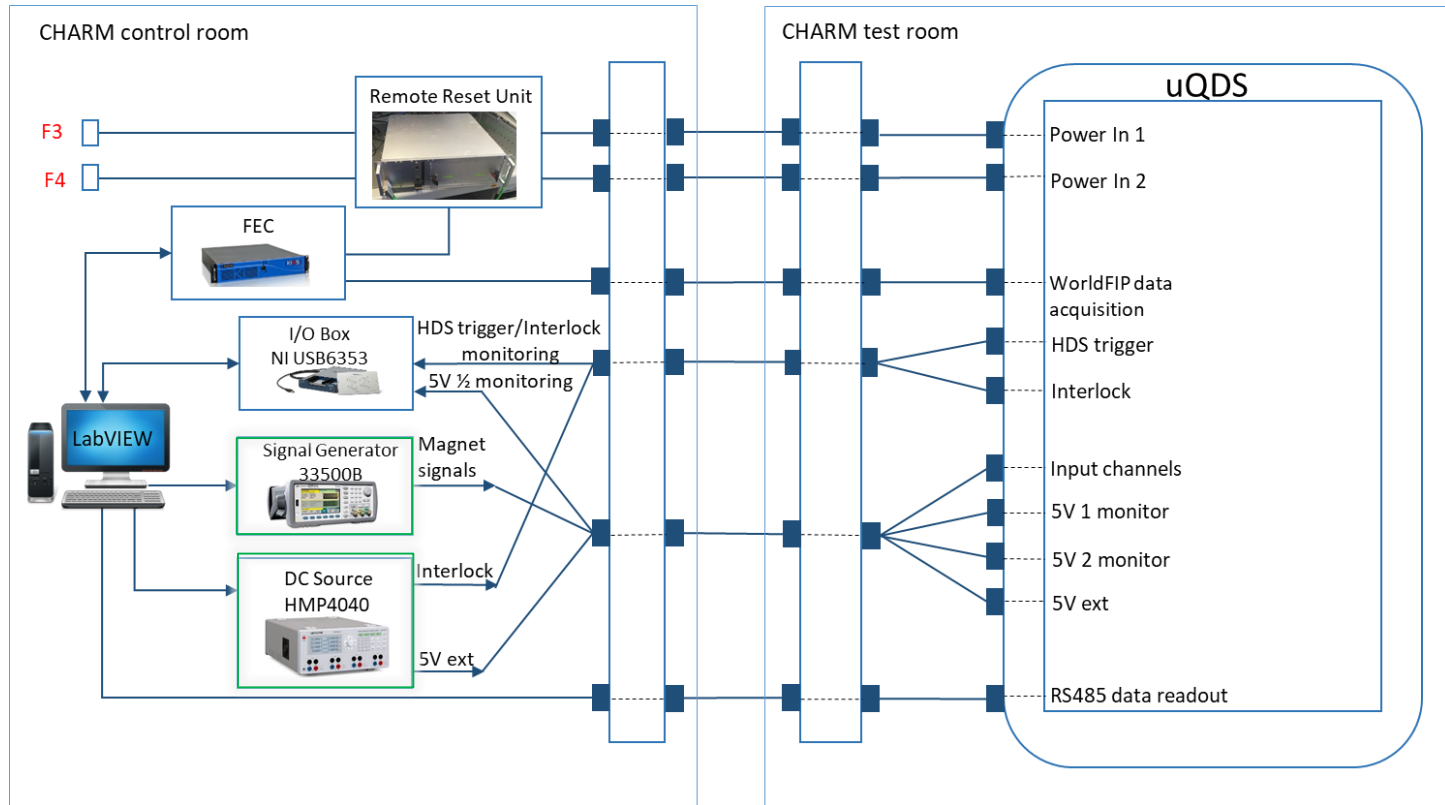


# Radiation test campaigns: uQDS



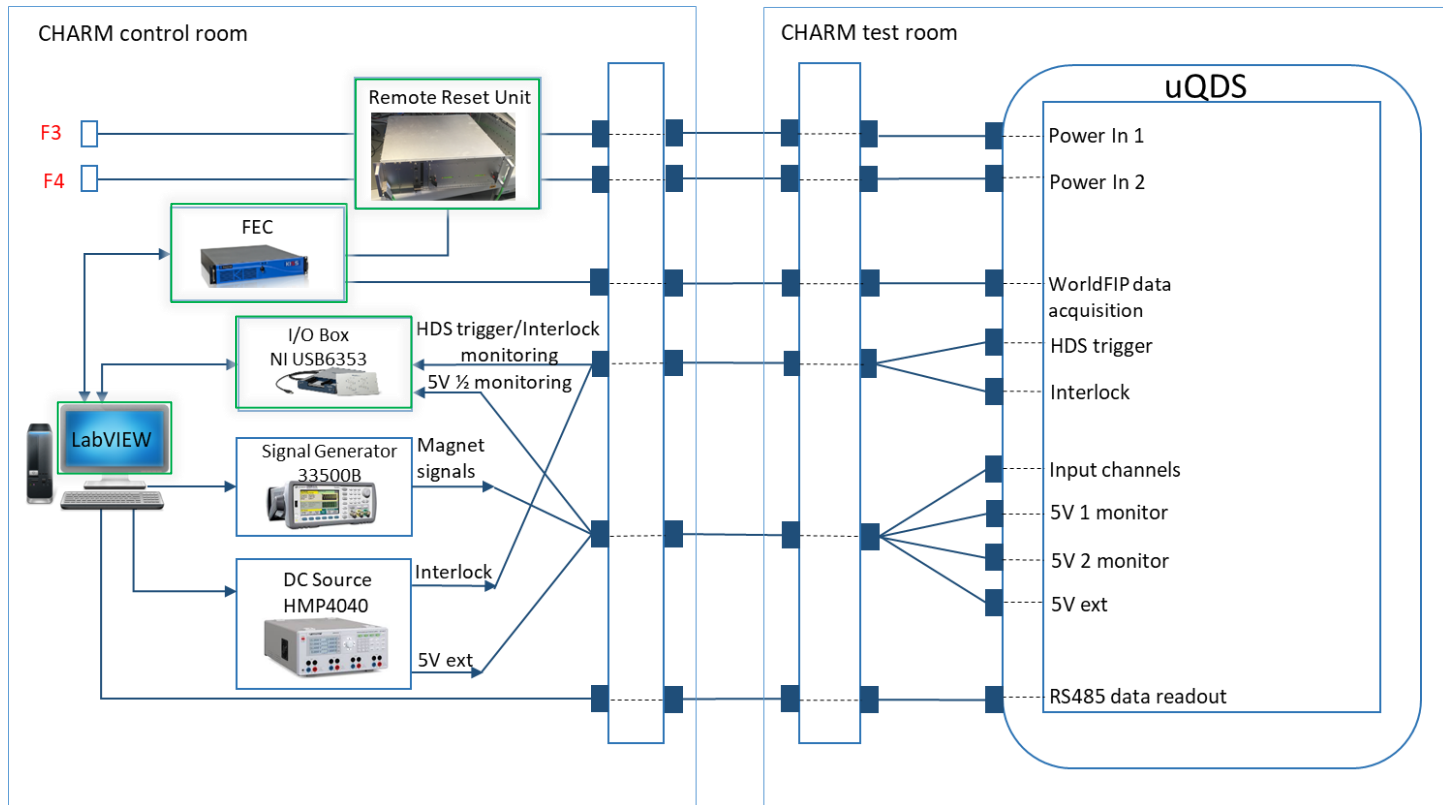


# Test setup: uQDS



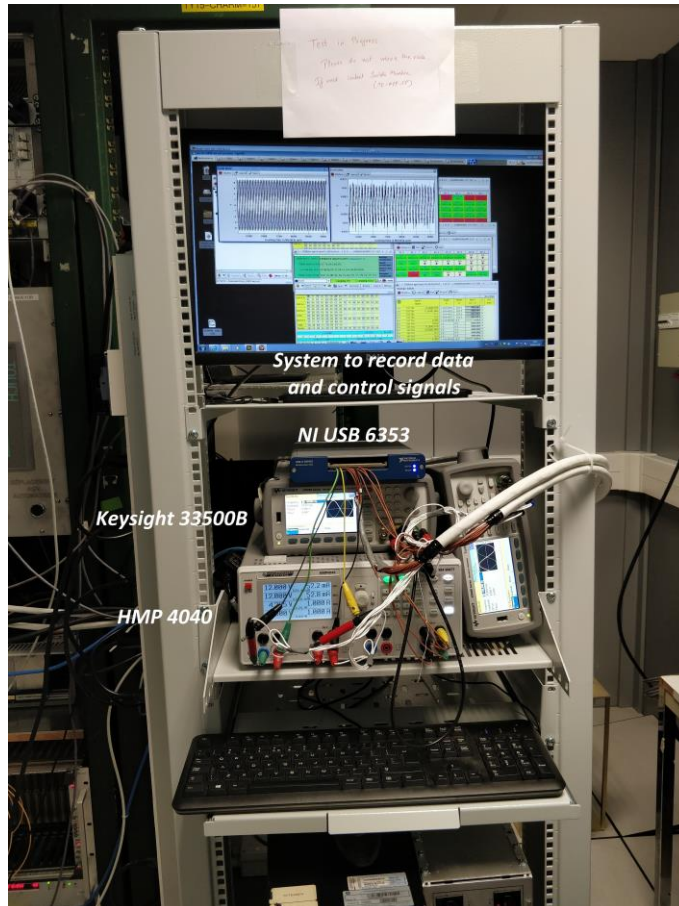
- 2 channels were equipped with lead voltage signals and other 2 with magnet voltage signals all supplied through signal generators
  - sinusoidal signal with 100 mHz frequency and 20 mV amplitude as lead voltage
  - sinusoidal signal with 100 mHz frequency and 18 V amplitude as magnet voltage
- Interlock loop was provided with 60mA current using 12V, 200 $\Omega$
- 2k $\Omega$  resistors were used loads to mimic DQHDS relay loads

# Test setup: uQDS



- **National instrument box:** to monitor interlock loop and heater trigger status. It also kept track of 5V supplies coming form AC-DC converters.
- **WorldFIP:** to record analog voltages, status registers and configuration parameters and save the data on NAS server
- **RS485:** to log data from FPGA using SPI communication
- **Labview:** to control the NI box, signal generator and DC supplies remotely
- **Remote reset unit:** to power cycle the unit using WorldFIP

# Test setup: uQDS

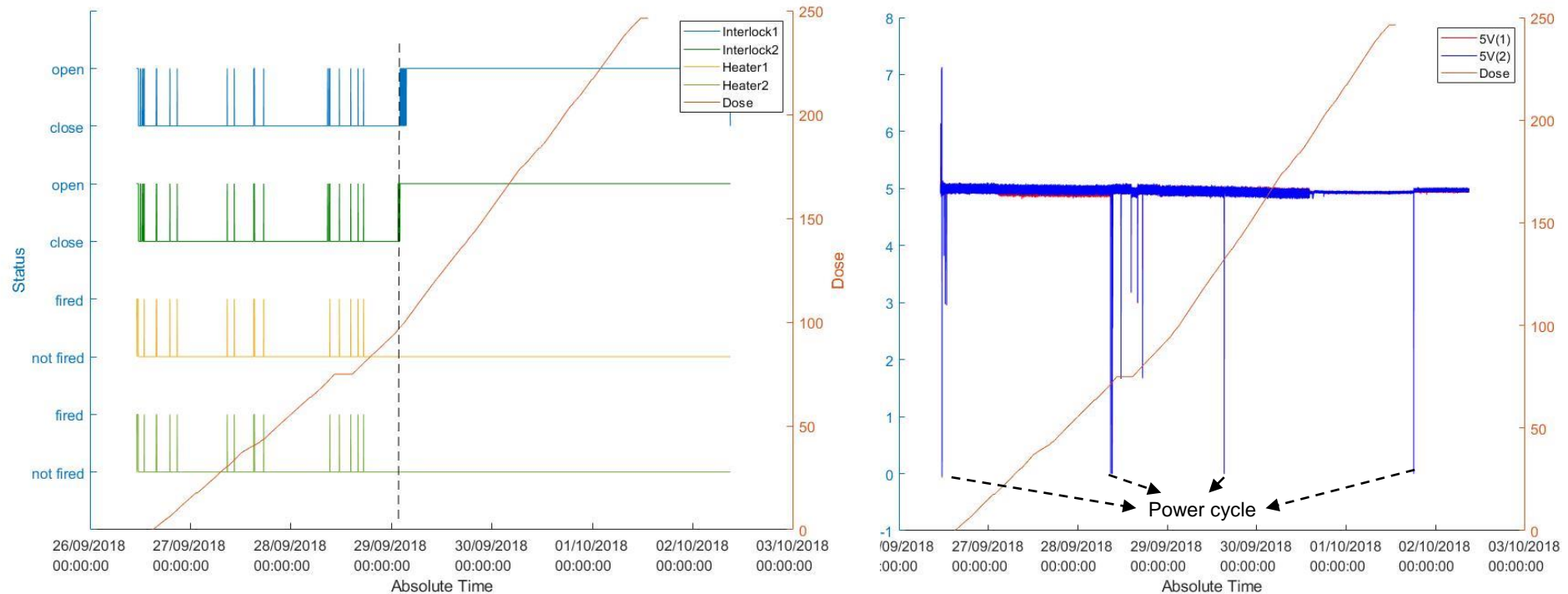


Control Room



DUT in facility

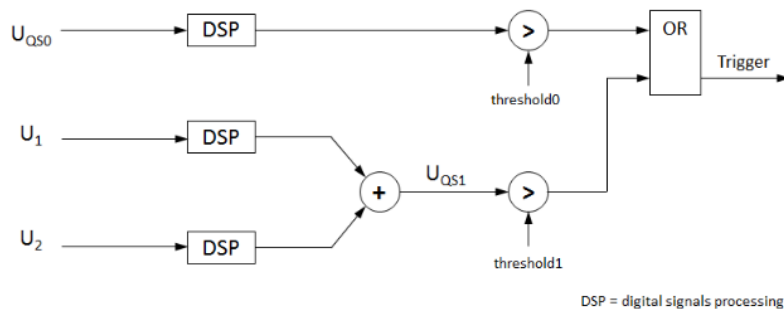
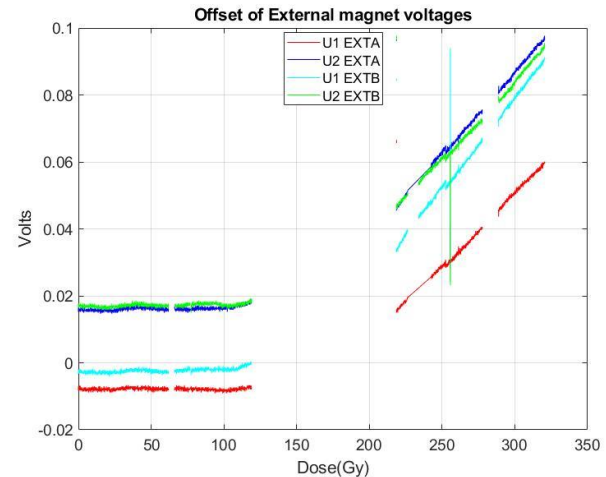
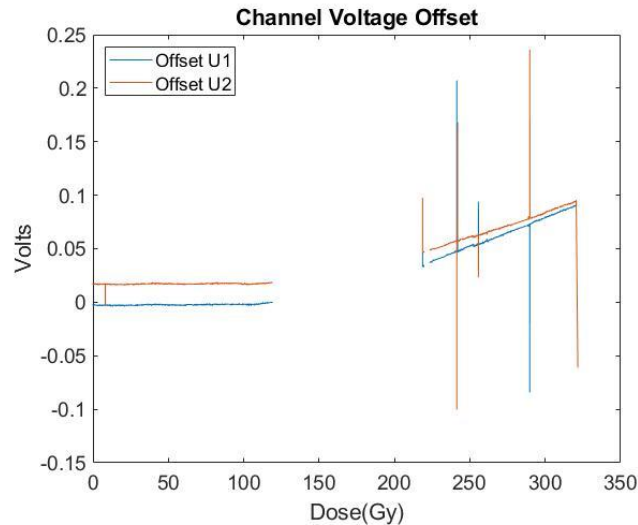
# Summary of performance of uQDS



- WorldFIP interface card stopped working at 60 Gy
- At ~100 Gy Interlock loop opened and could not be closed
- Analog channels worked well (at least) up to 130 Gy (RS485 reading was stopped at 130Gy, unable to resume at 250 Gy)
- Power supply survived 250 Gy!
- More detailed analysis of the irradiated unit pending|

# Questions?

# Results: Trigger voltage of External magnets



- Offset voltage increases rapidly for higher dose
- This variation is due to the variation of reference voltage known to show variation with dose
- The same variation is observed in  $U_{QS0} \rightarrow$  Trigger

# Results: Trigger voltage variation (uQDS)

