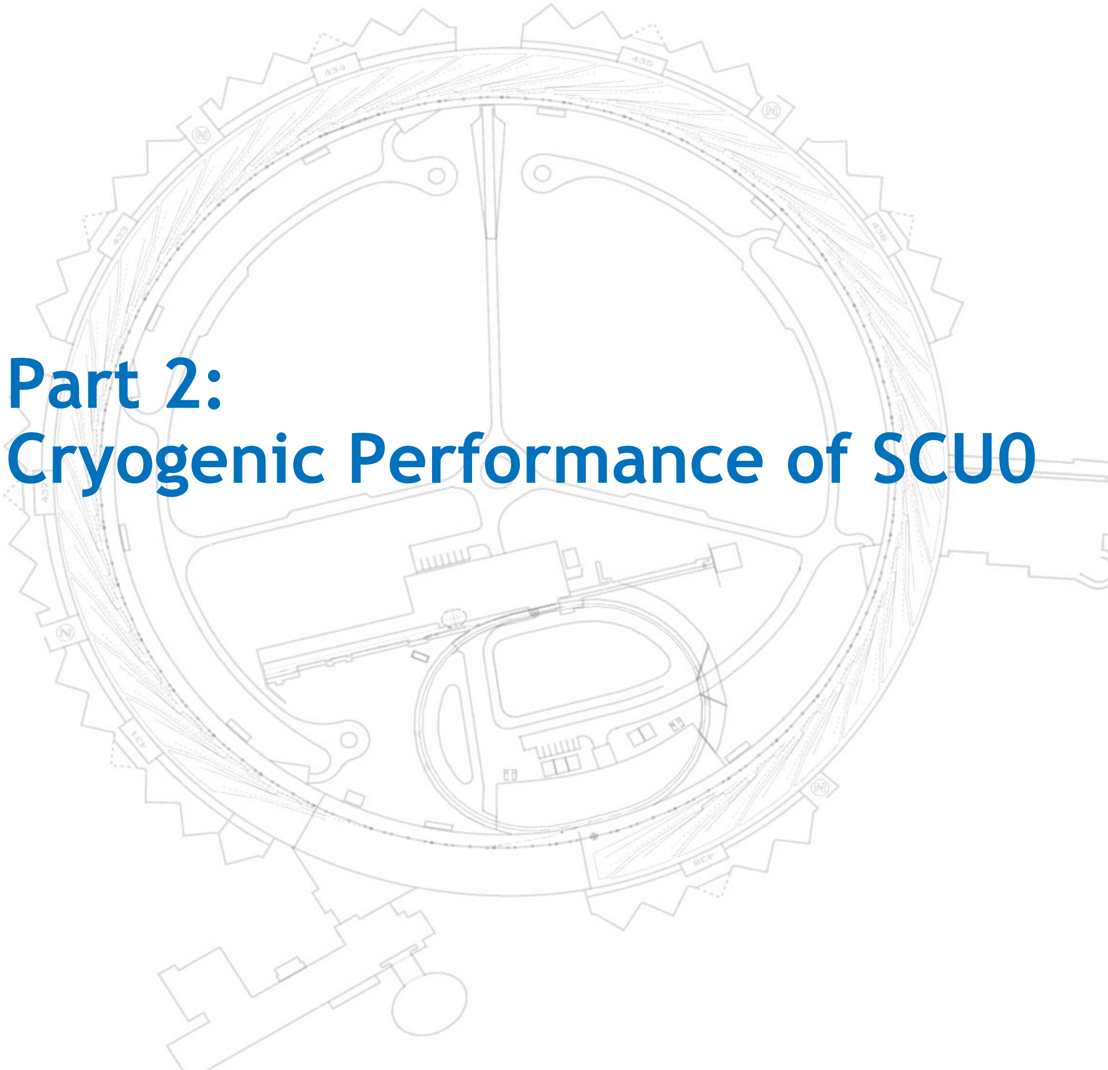
Part 2:
Cryogenic Performance of SCU0



Joel Fuerst

ASD/RF

ASD Seminar

04 March 2013

Outline

- Introduction
- Design heat loads
- Operating conditions
- Review of cryocooling
- Performance
- Summary

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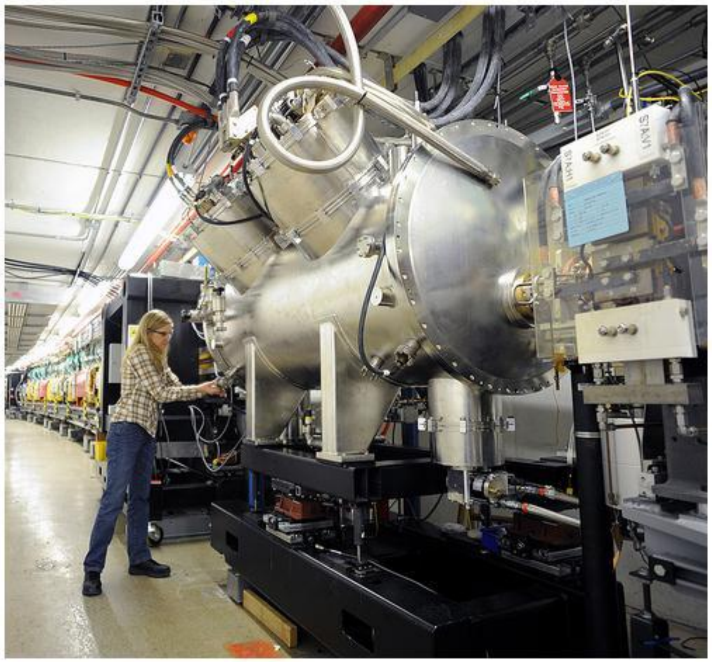
First light from the first high-energy superconducting undulator

February 4, 2013 by Rick Fenner



The SCU installed at the straight section of Sector 6 of the Advanced Photon Source at Argonne National Laboratory. To view a larger version of the photo, click on it.
Credit: Argonne National Laboratory

(Phys.org)—More than eight years of effort by Advanced Photon Source (APS) physicists, engineers, and technicians culminated on Jan. 21, 2013, with the production of the first X-rays from the prototype of a novel superconducting undulator (SCU), which has been installed in the APS electron accelerator and storage ring at the U.S. Department of Energy's (DOE) Argonne National Laboratory. It is the first such SCU operated at a third-generation synchrotron X-ray facility.

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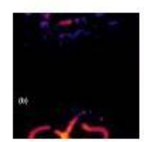

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Heat load/Operating temperature

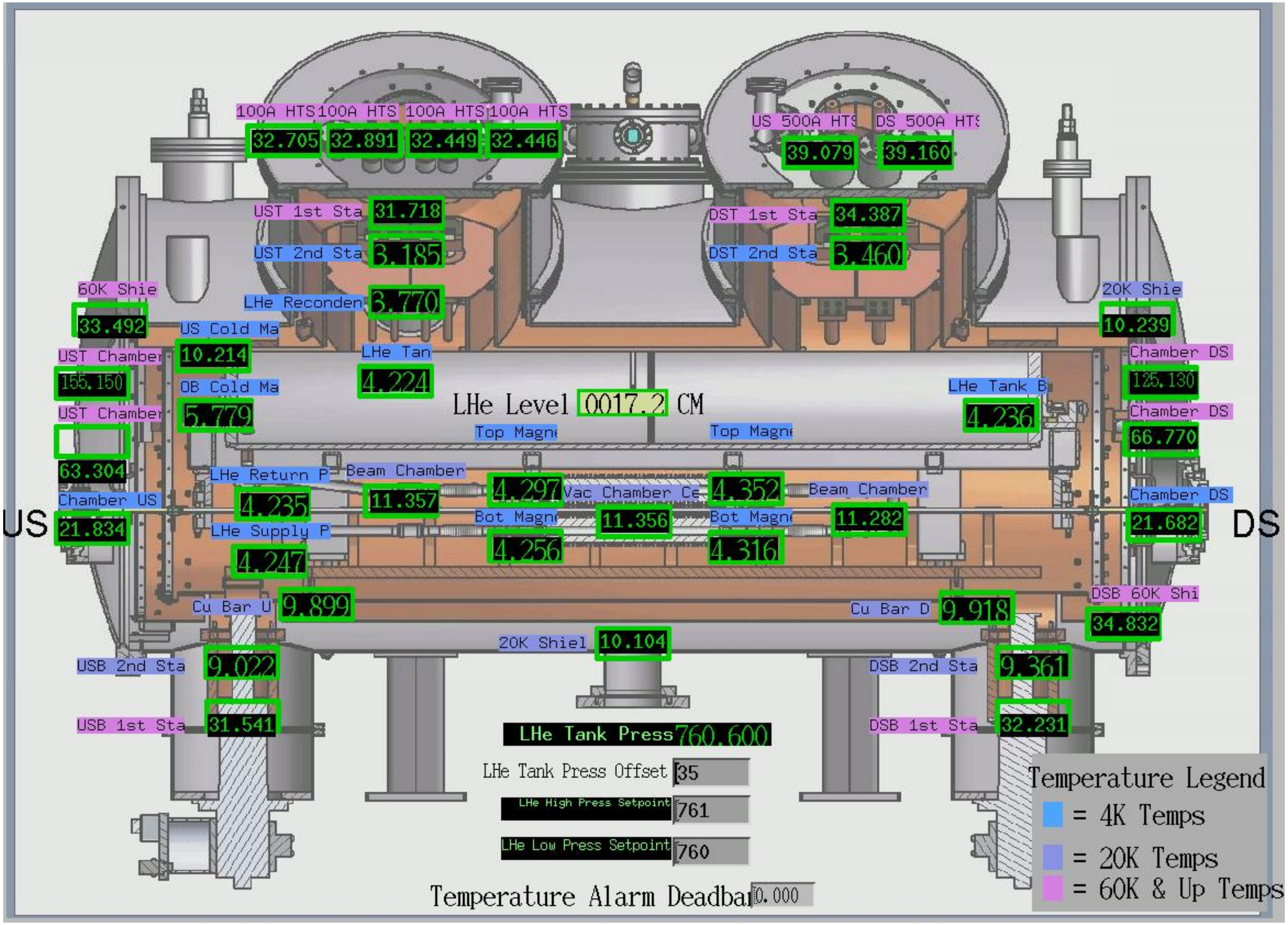
Heat source	Temp [K]	Design load [W]	Installed capacity [W]
Magnet	4.3	0.7	3
Rad shield/ beam tube	20	12	40
Rad shield	60	86	224

Main coil current [A]	500*	600	700
Critical temp [K]	6.10	5.55	4.95

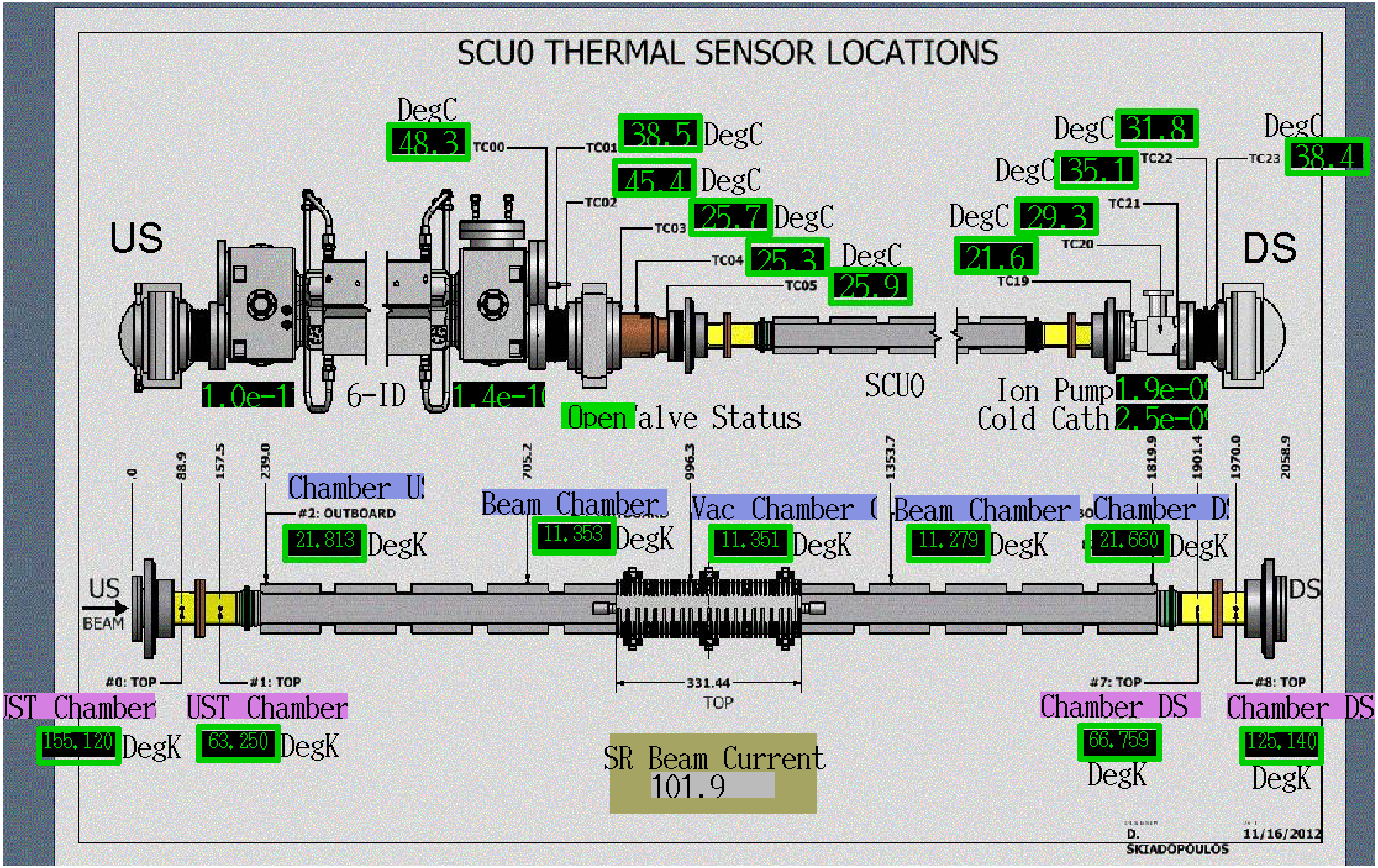
*design current

Measured Heat Loads, W			
	4K - stage (415D 2nd Stage)	20K – stage (408S 2nd Stage)	60K - stage (1st Stages)
I=0A (Beam chamber: 0W)	0.61	1.46	60.2
I=500A (Beam chamber: 0W)	0.61	< 12.5	63.2
I=500A (Beam chamber: 10W)	0.61	< 12.5	80.9
I=500A (Beam chamber: 20W)	0.61	21.3	87.4
Design Estimation Heat Loads, W			
I=500A (Beam chamber: 10W)	0.685	12.5	86.1

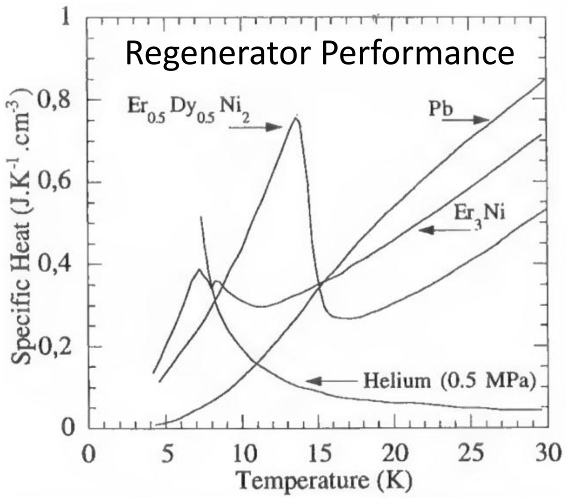
SCU Temperatures

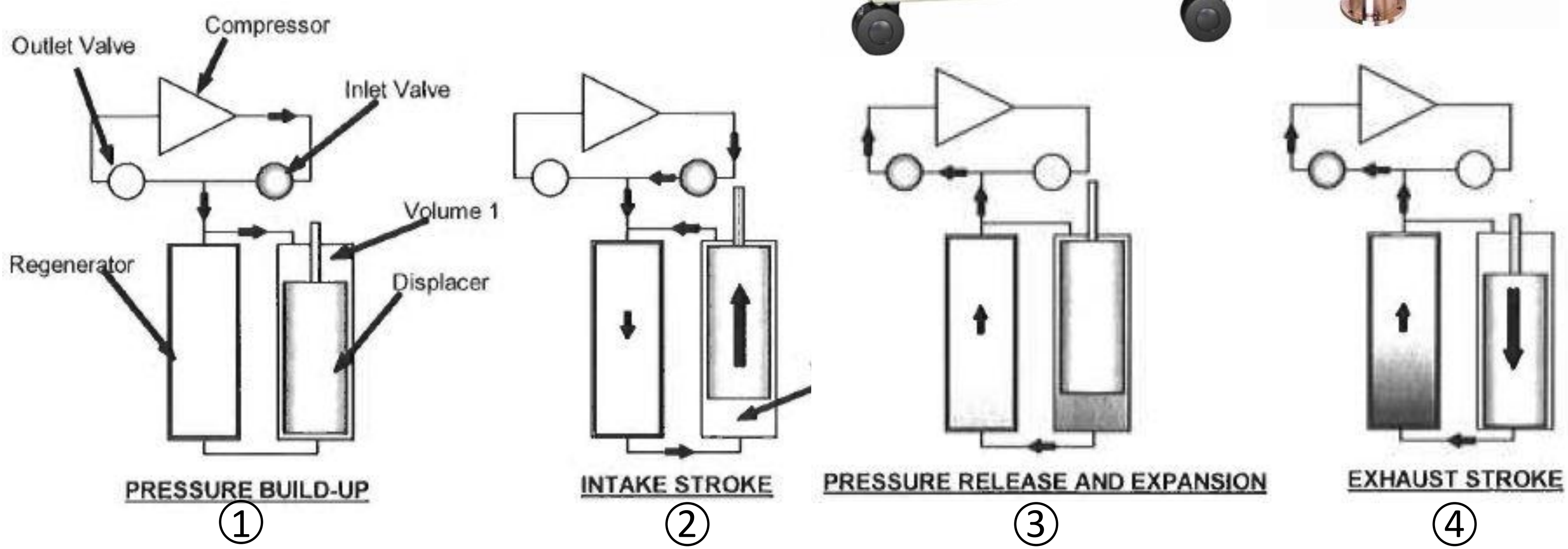


Beam Chamber Temperatures

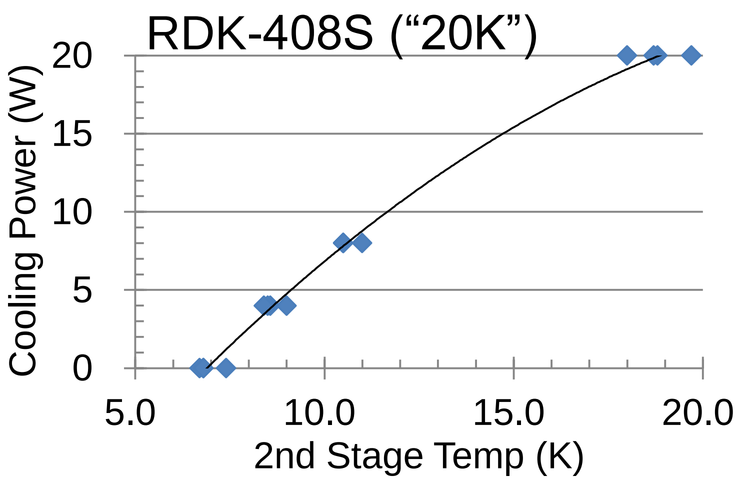


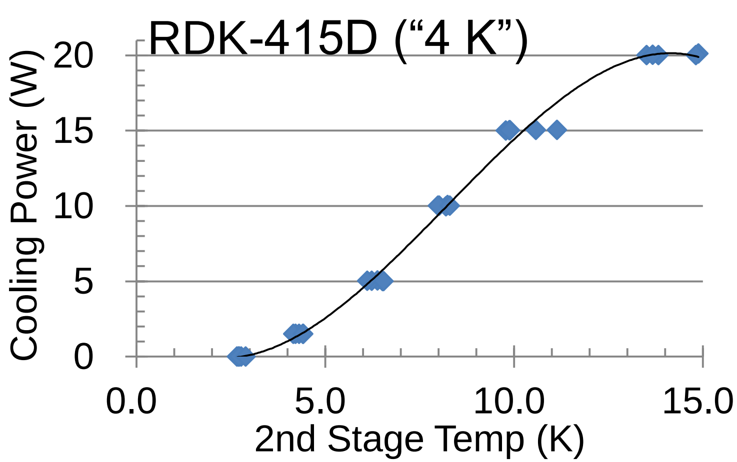
SCU: Gifford-McMahon (GM) cryocooler cycle

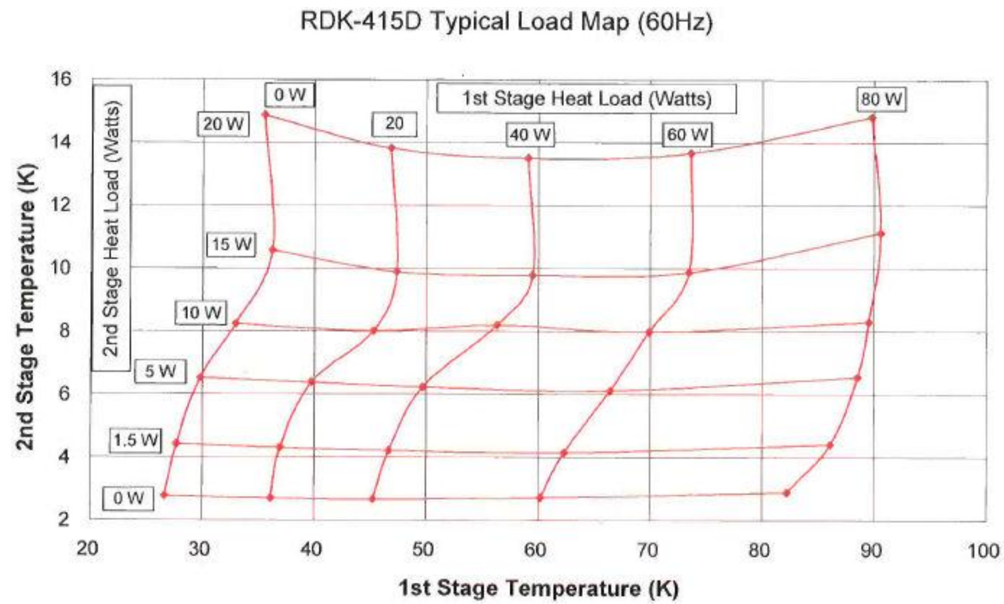


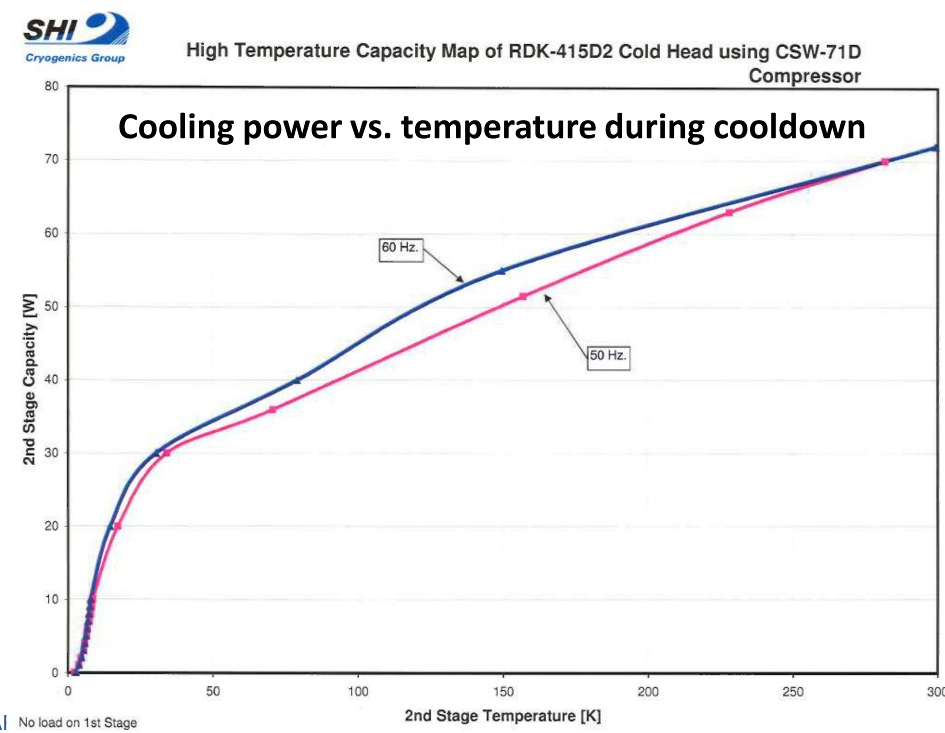


Sumitomo Cryocooler Performance Maps

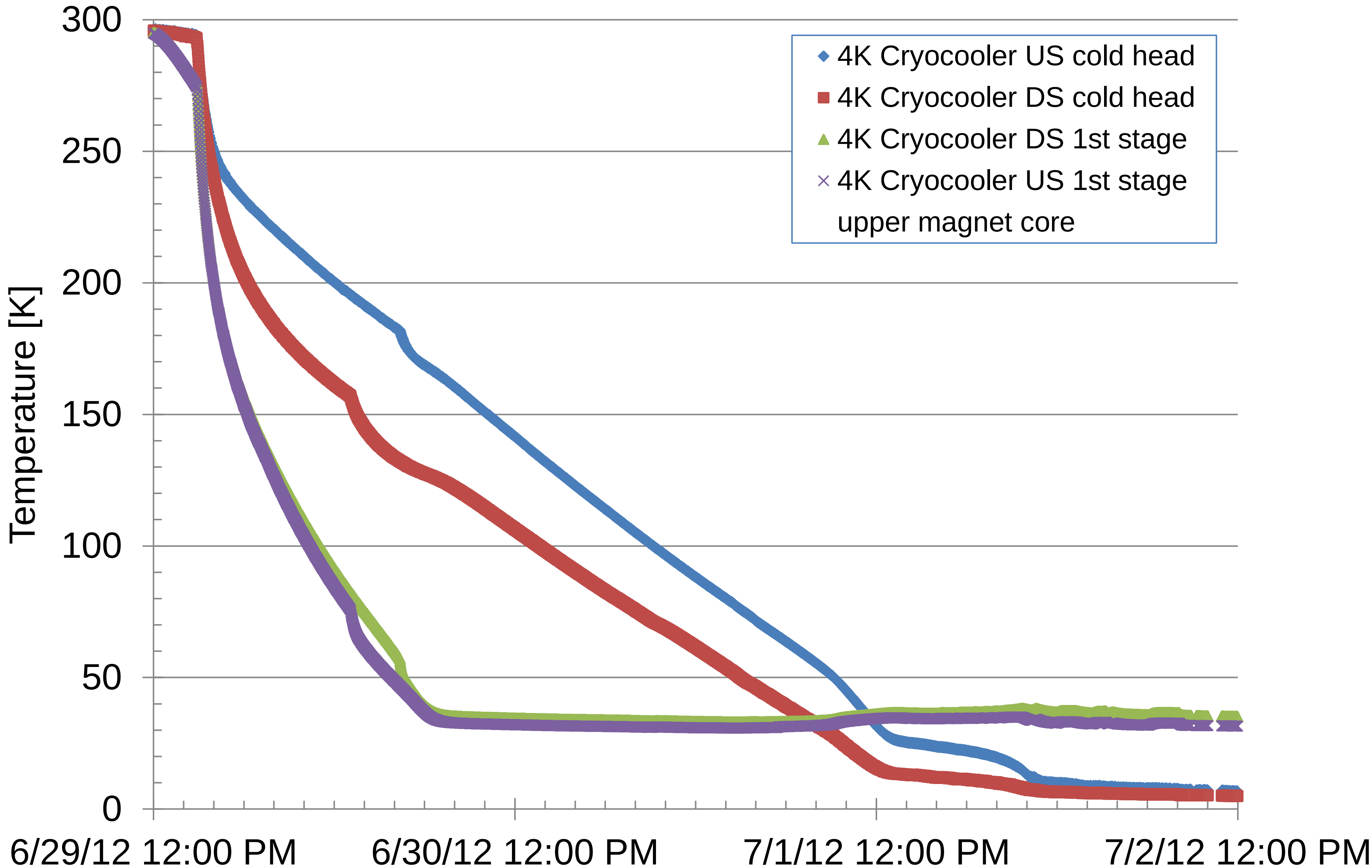




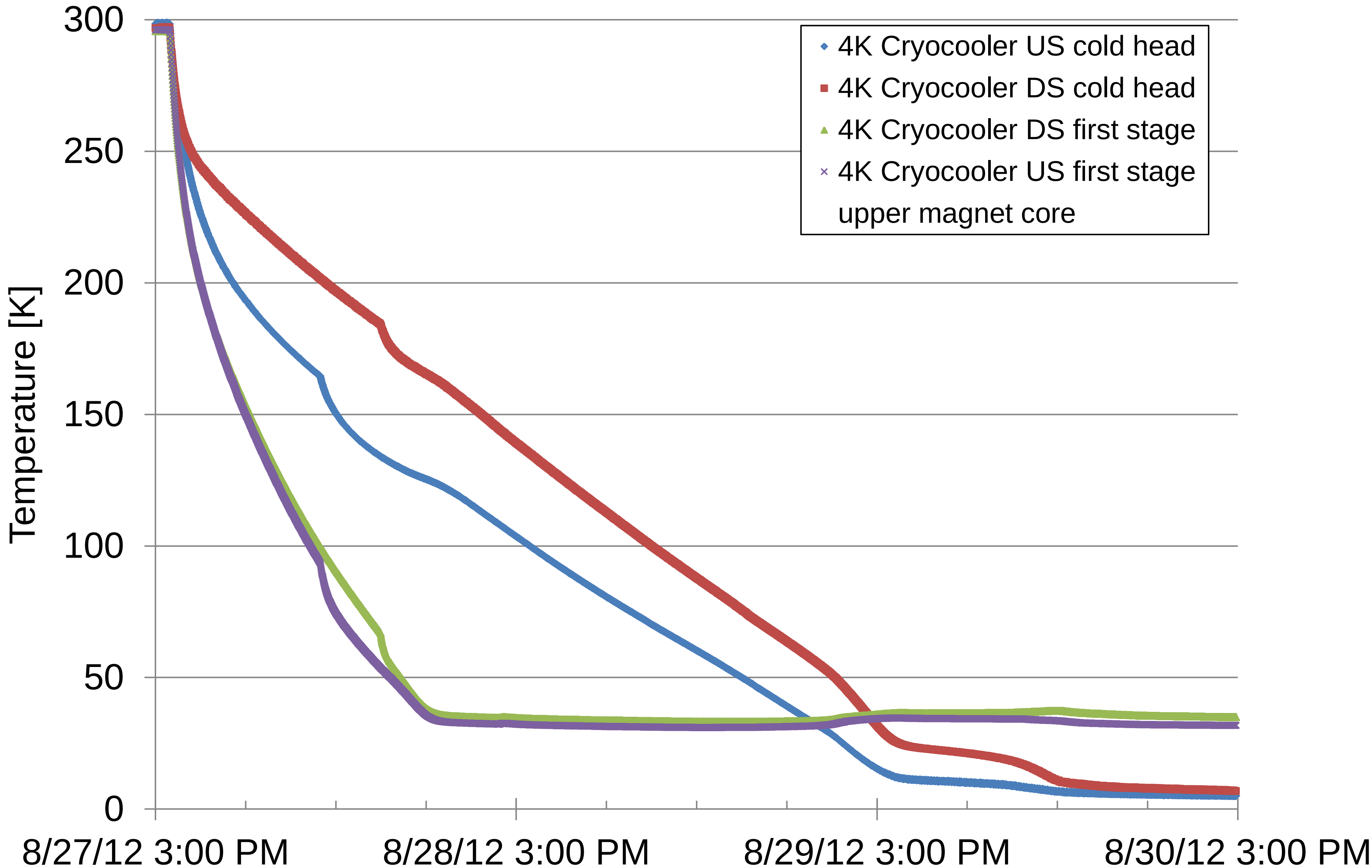




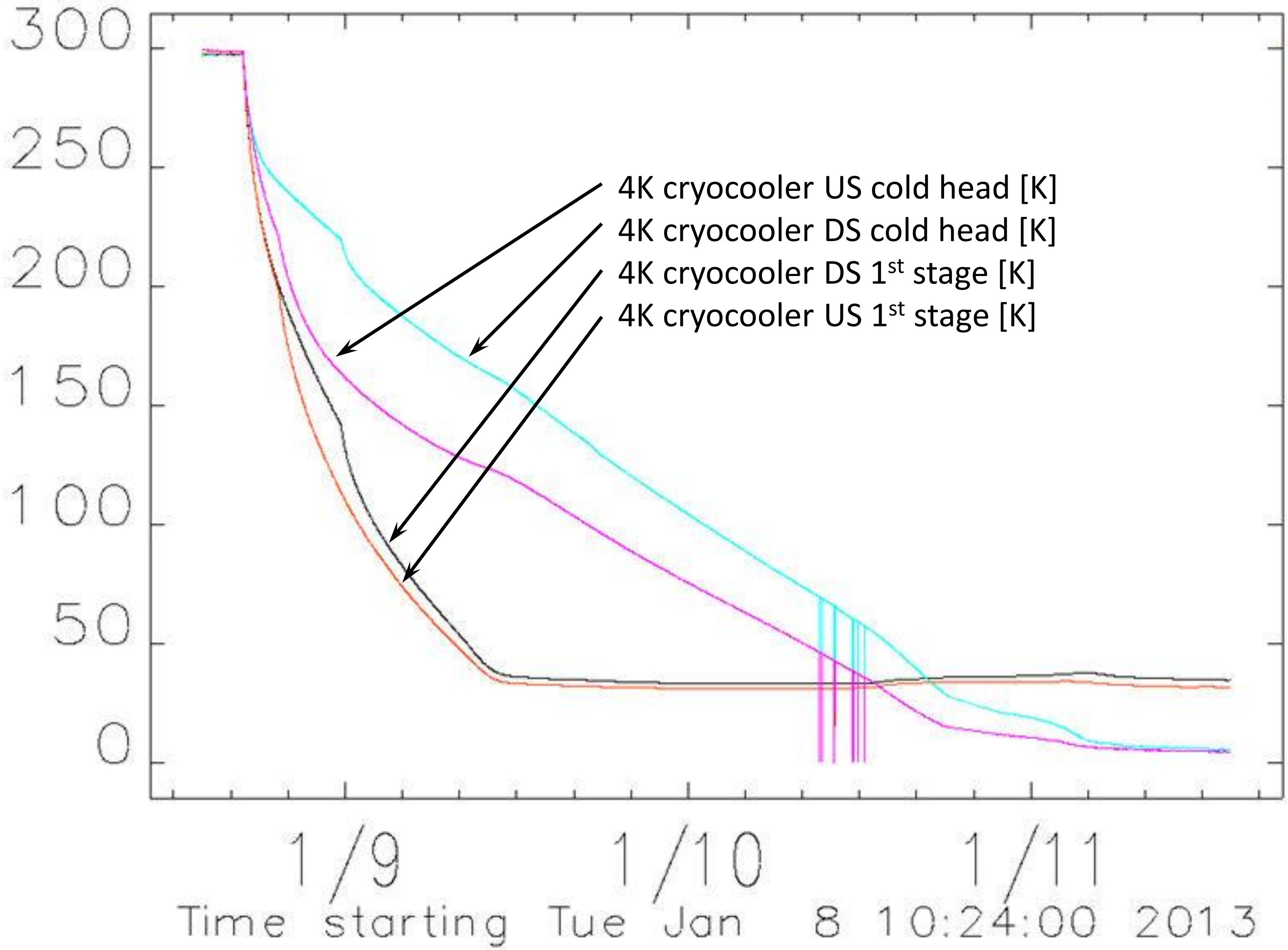
First Cooldown (bldg 314)



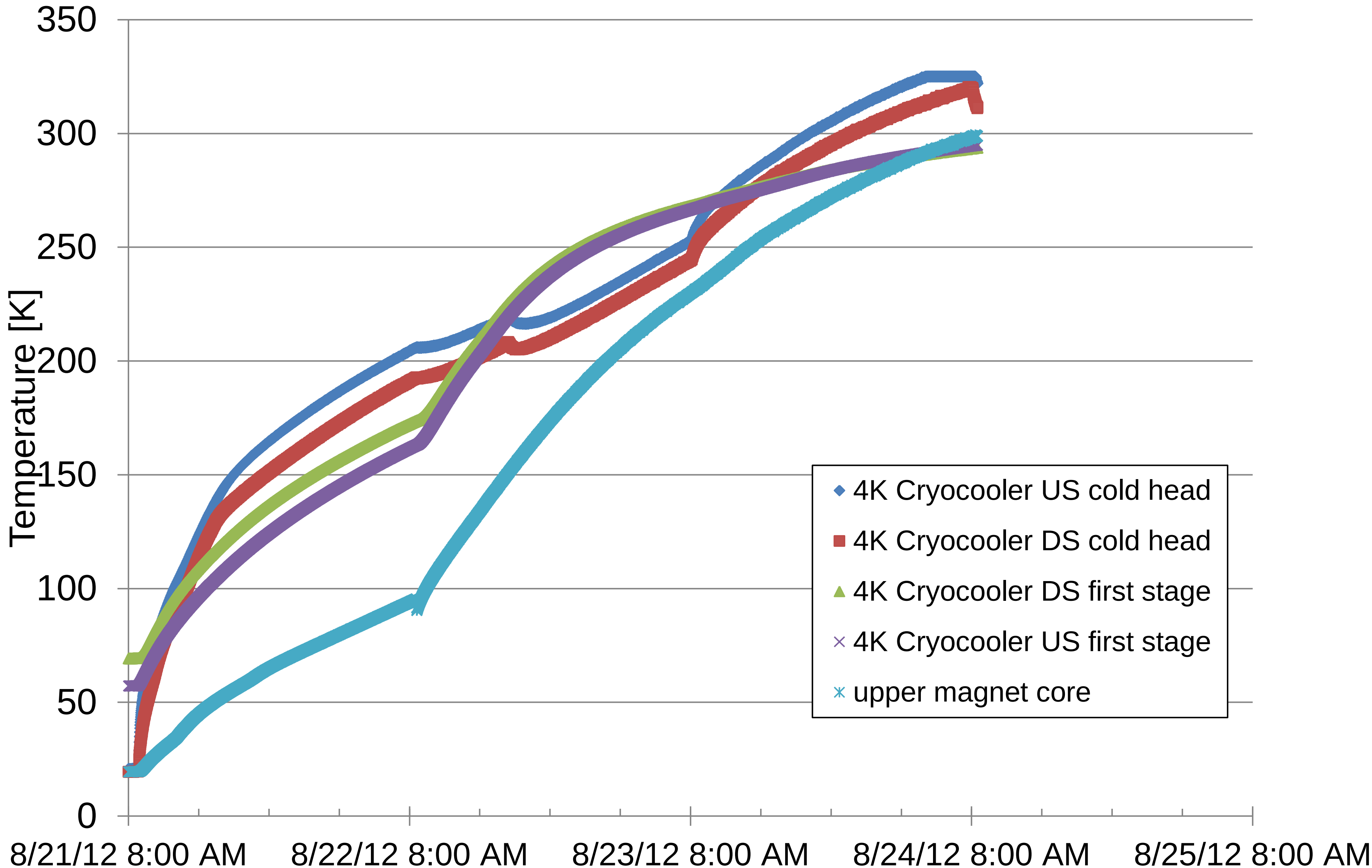
Second Cooldown (bldg 314)



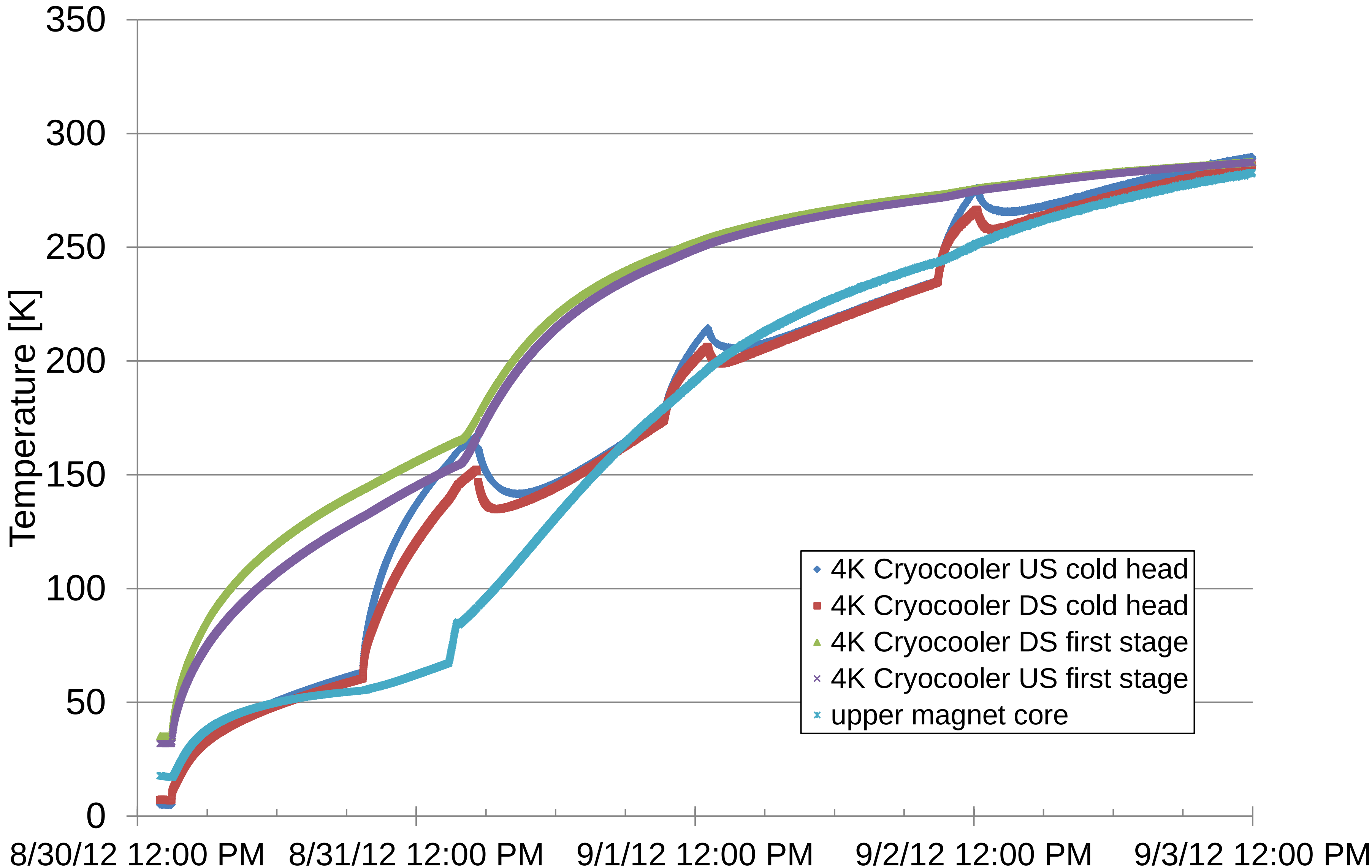
First Cooldown (SR)



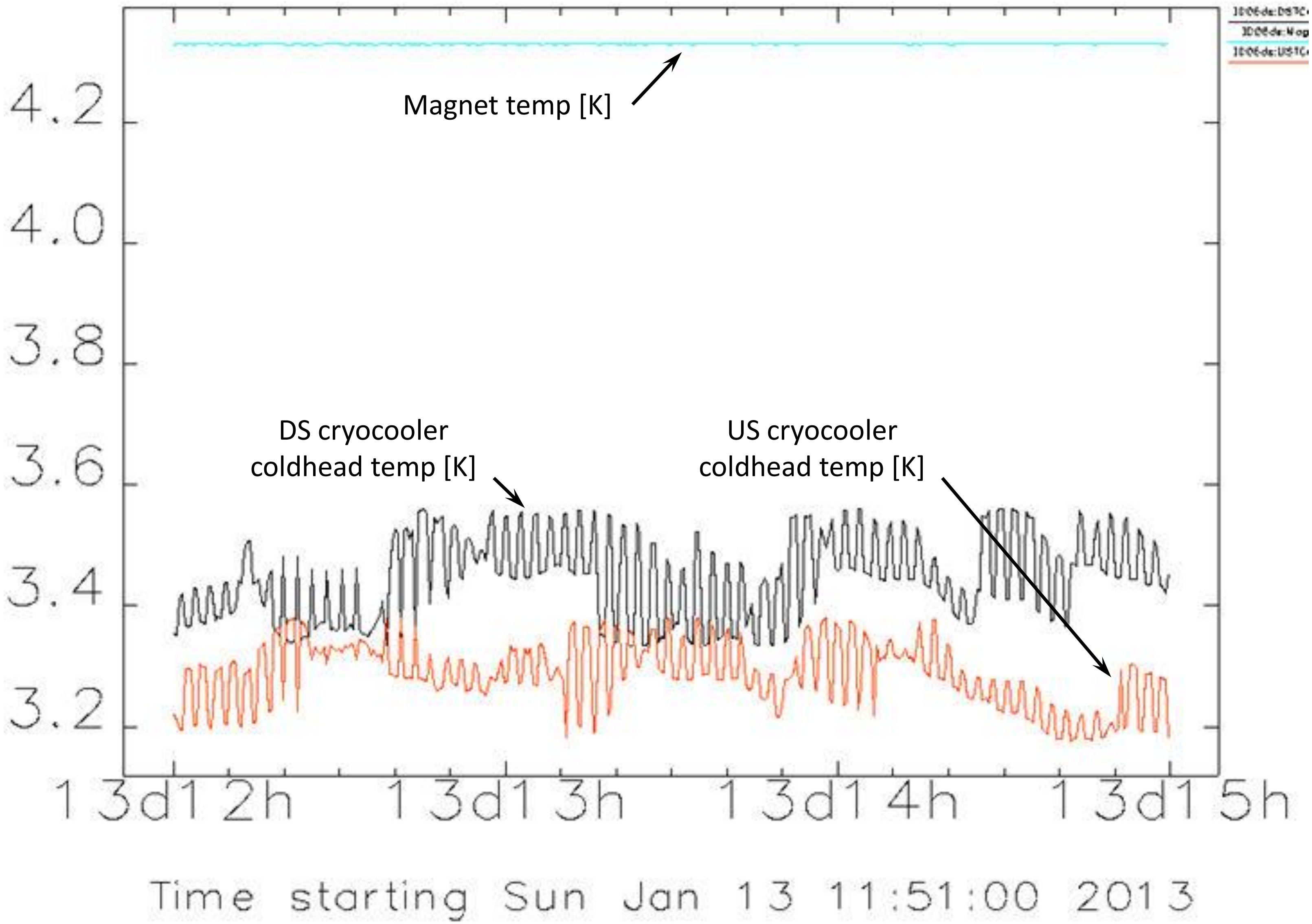
First Warmup (bldg 314)



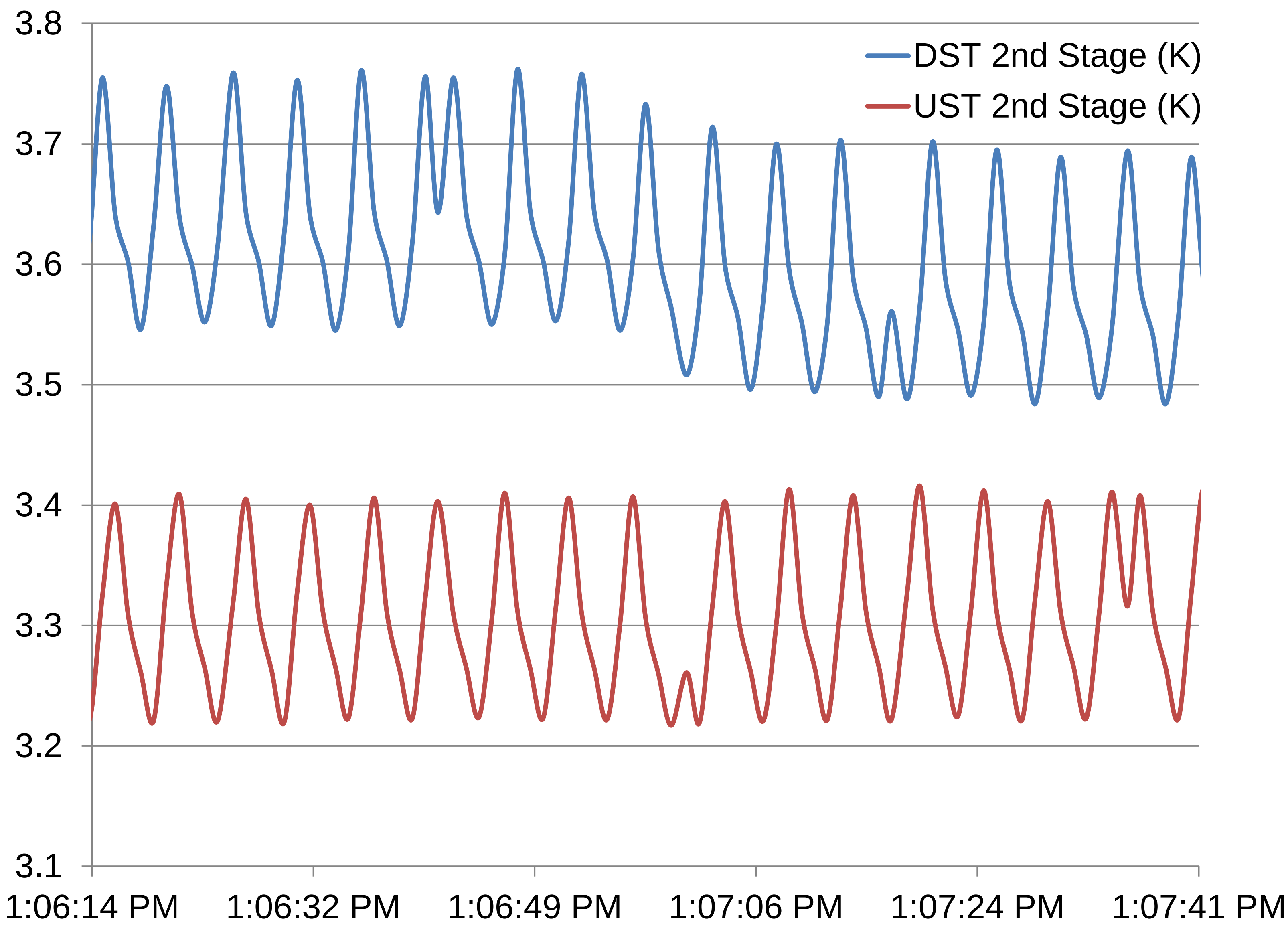
Second Warmup (bldg 314)



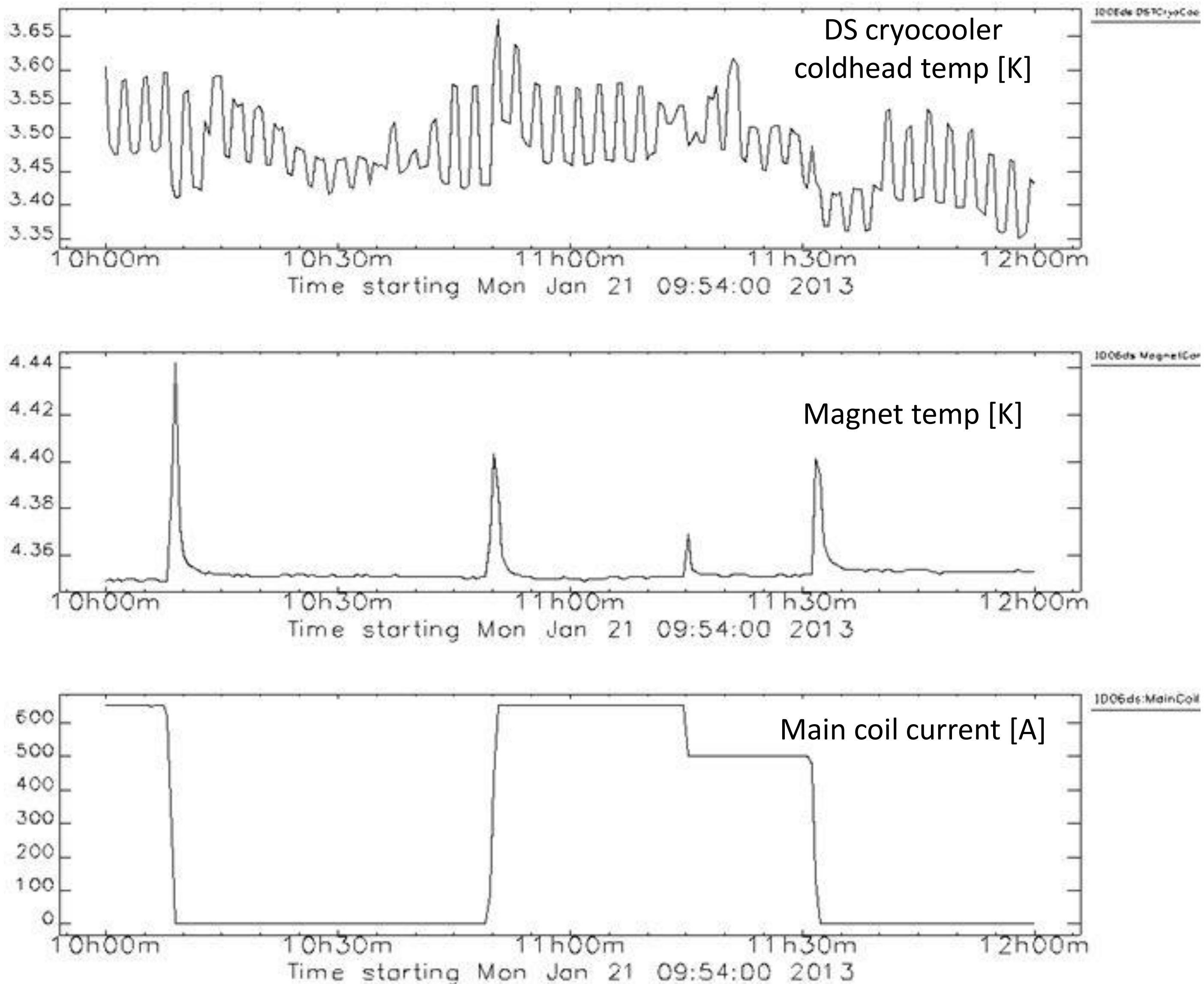
Steady State – Cryocooler Operation (1)



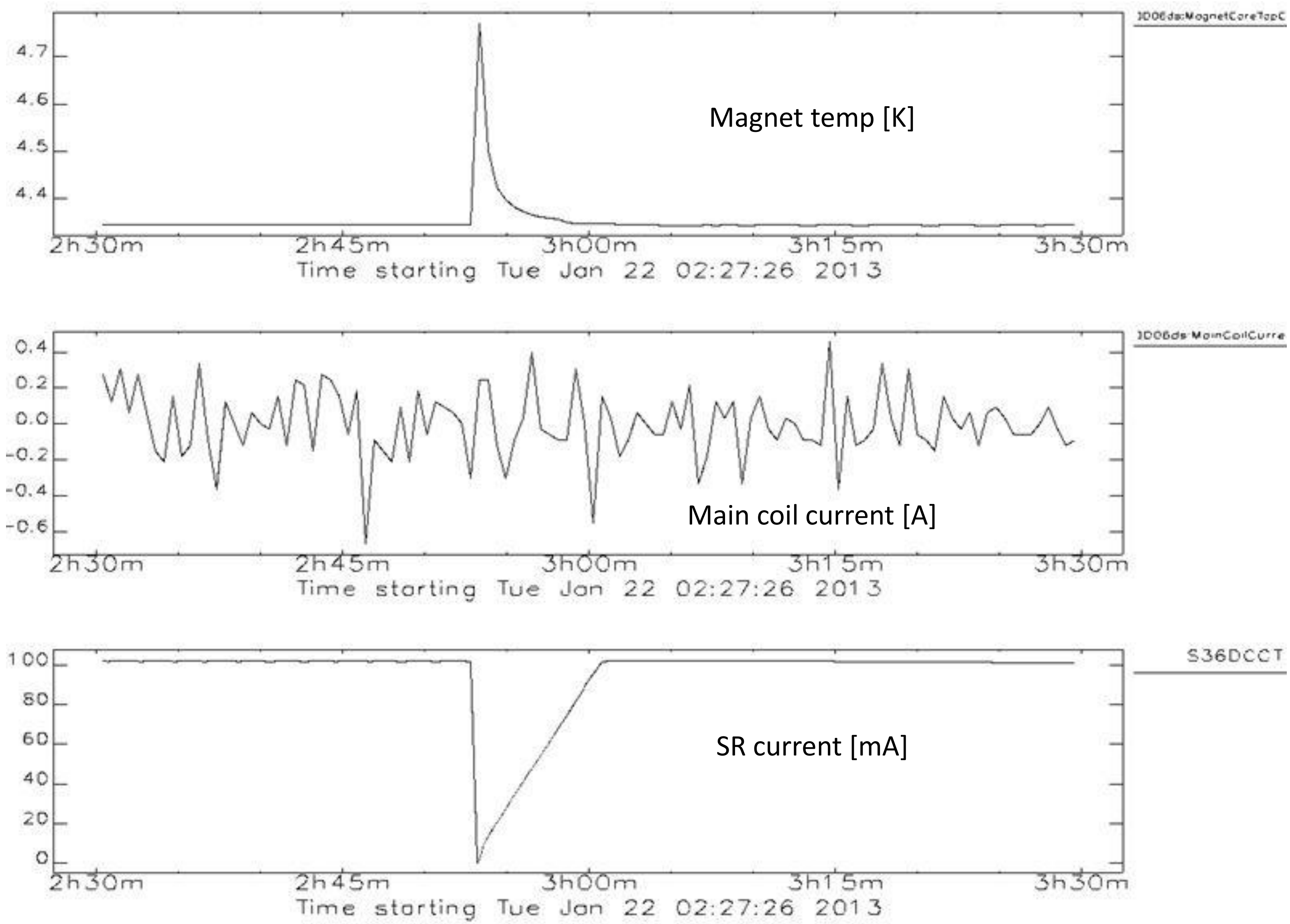
Cryocooler Operation (2)



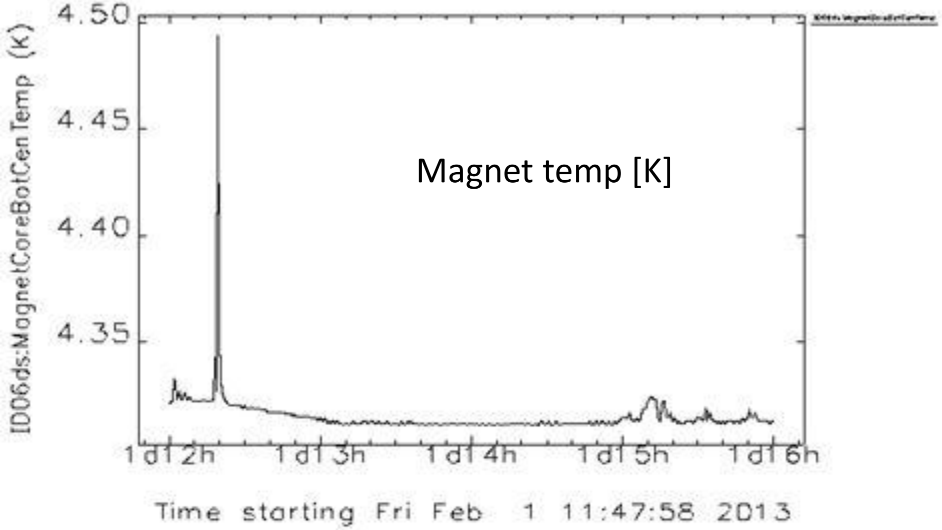
Changes in magnet current affect coil temperature

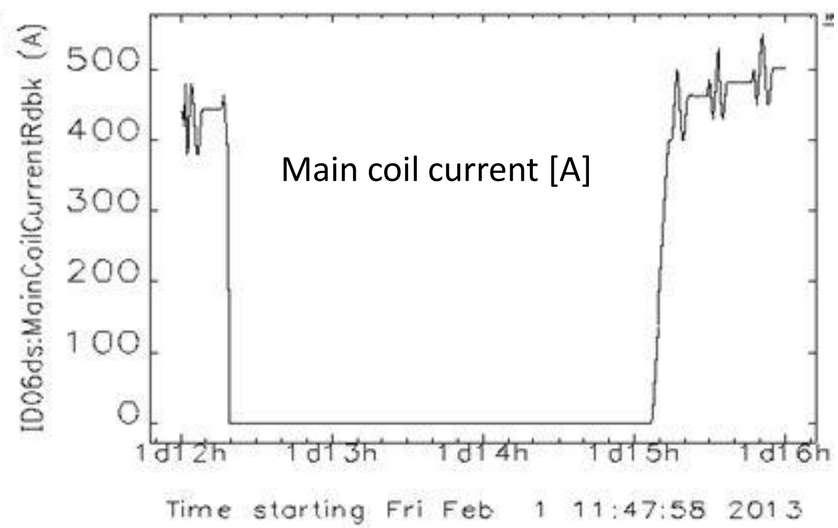


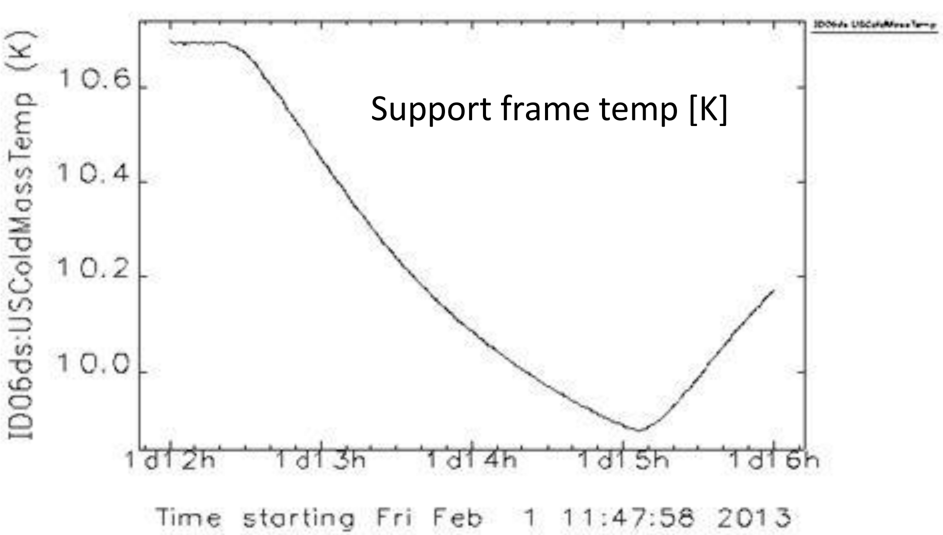
Loss of SR beam current affects magnet temperature

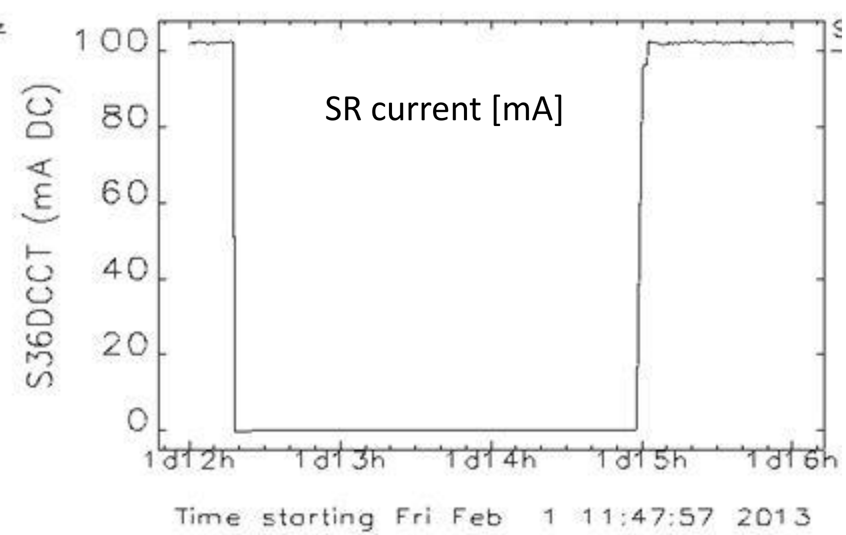


Beam and magnet currents impact cold mass temps

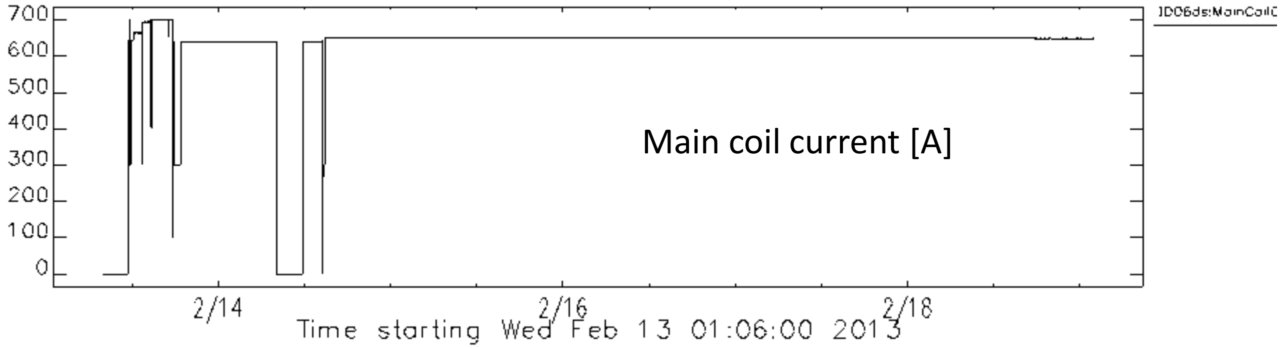


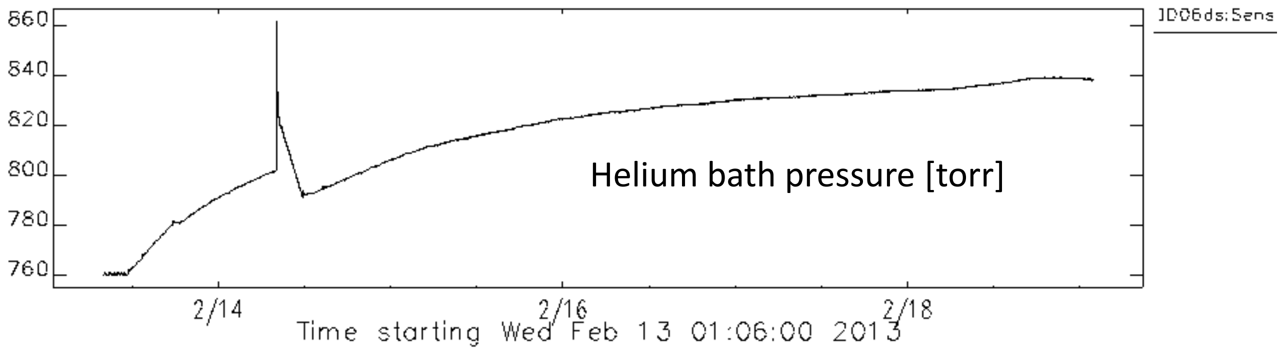


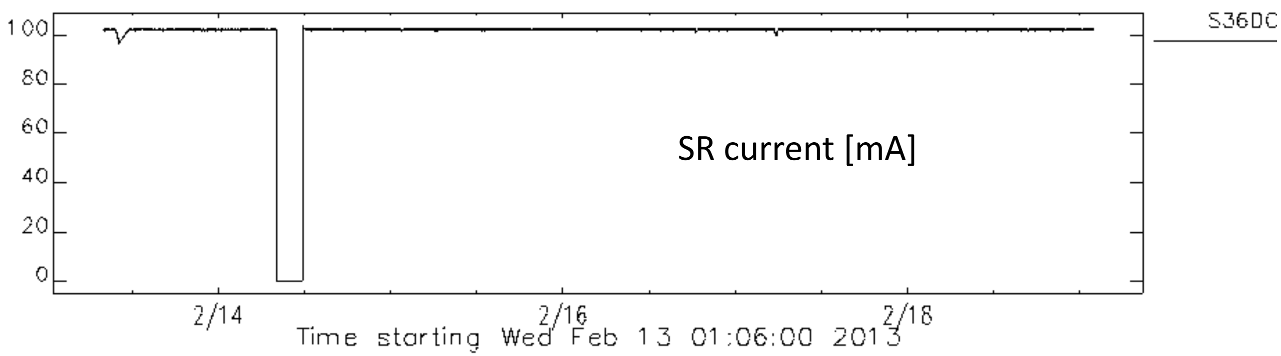




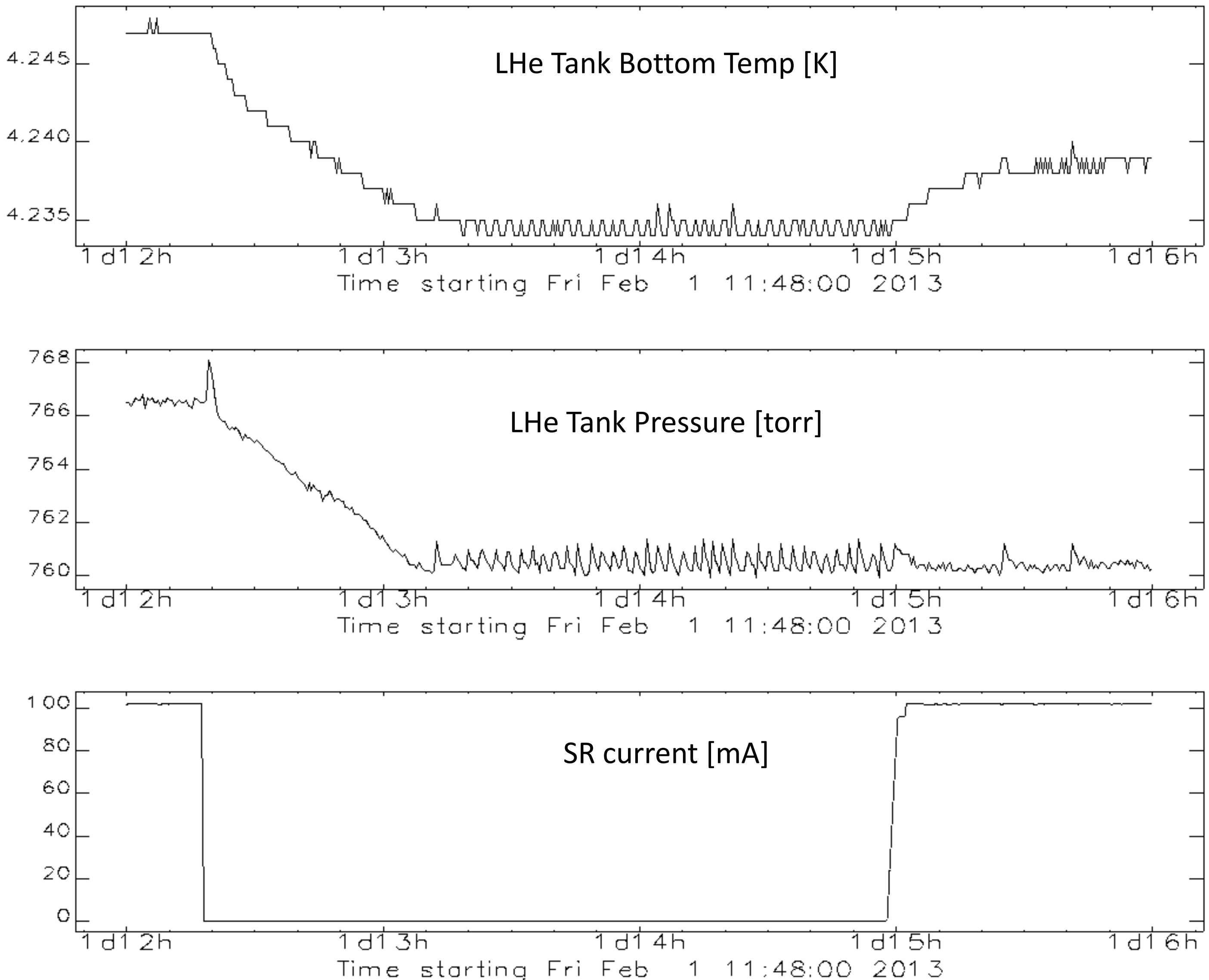
Long-term Operation



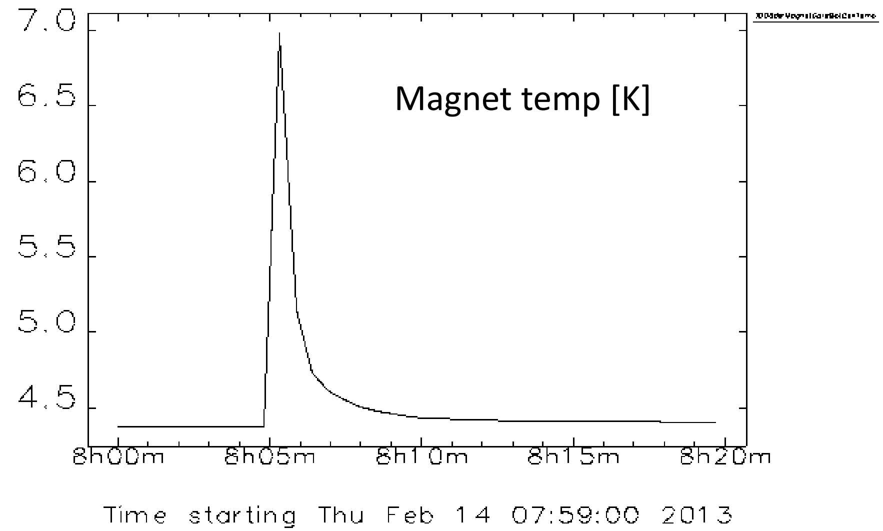


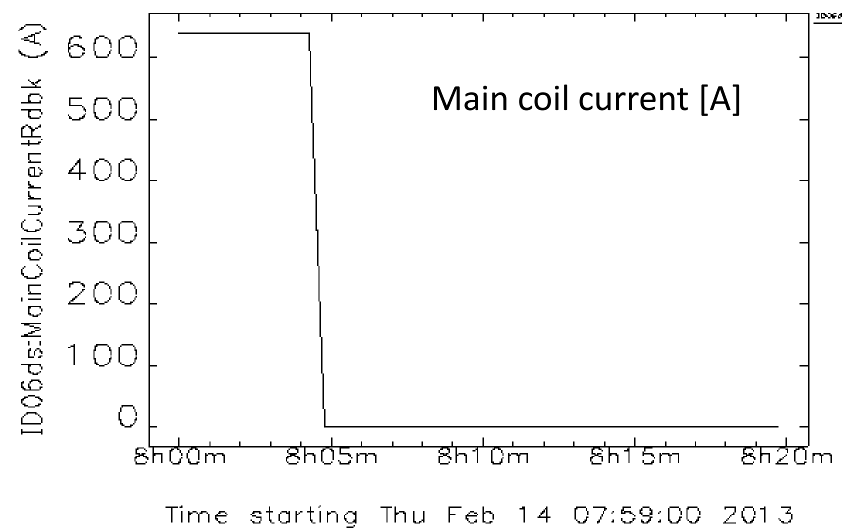


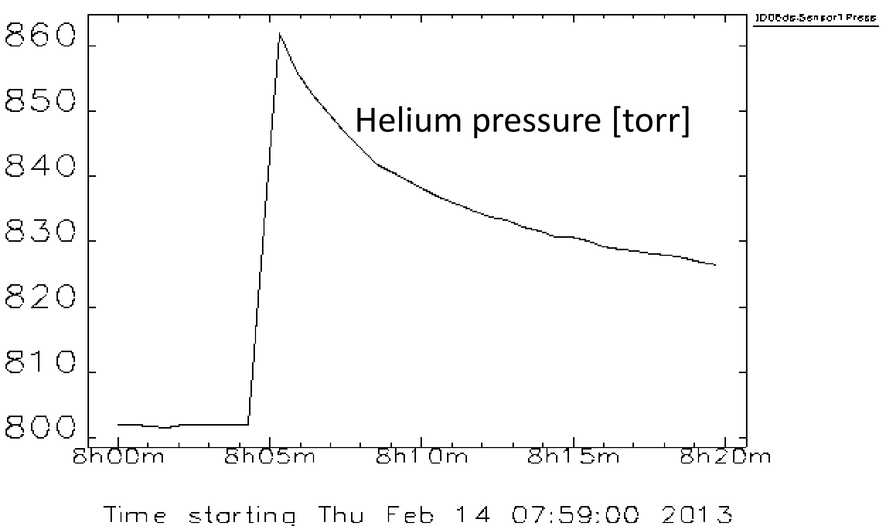
LHe Tank Pressure Regulation

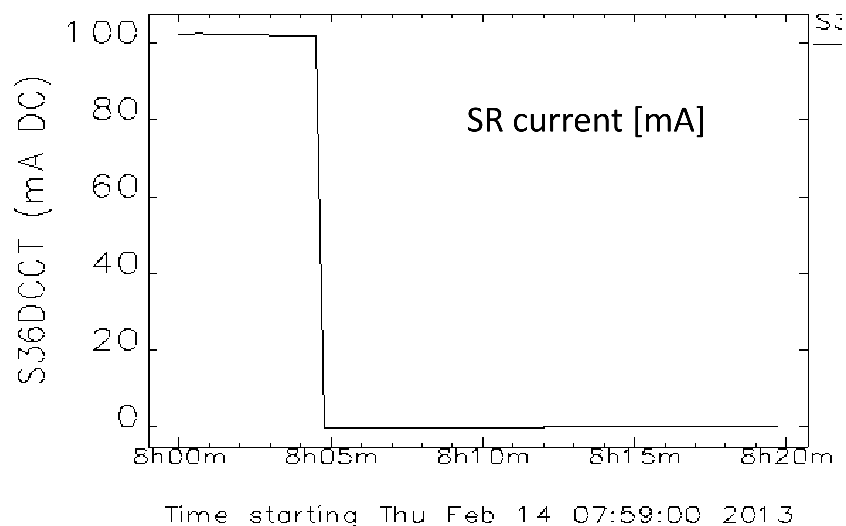


Beam-induced Quench

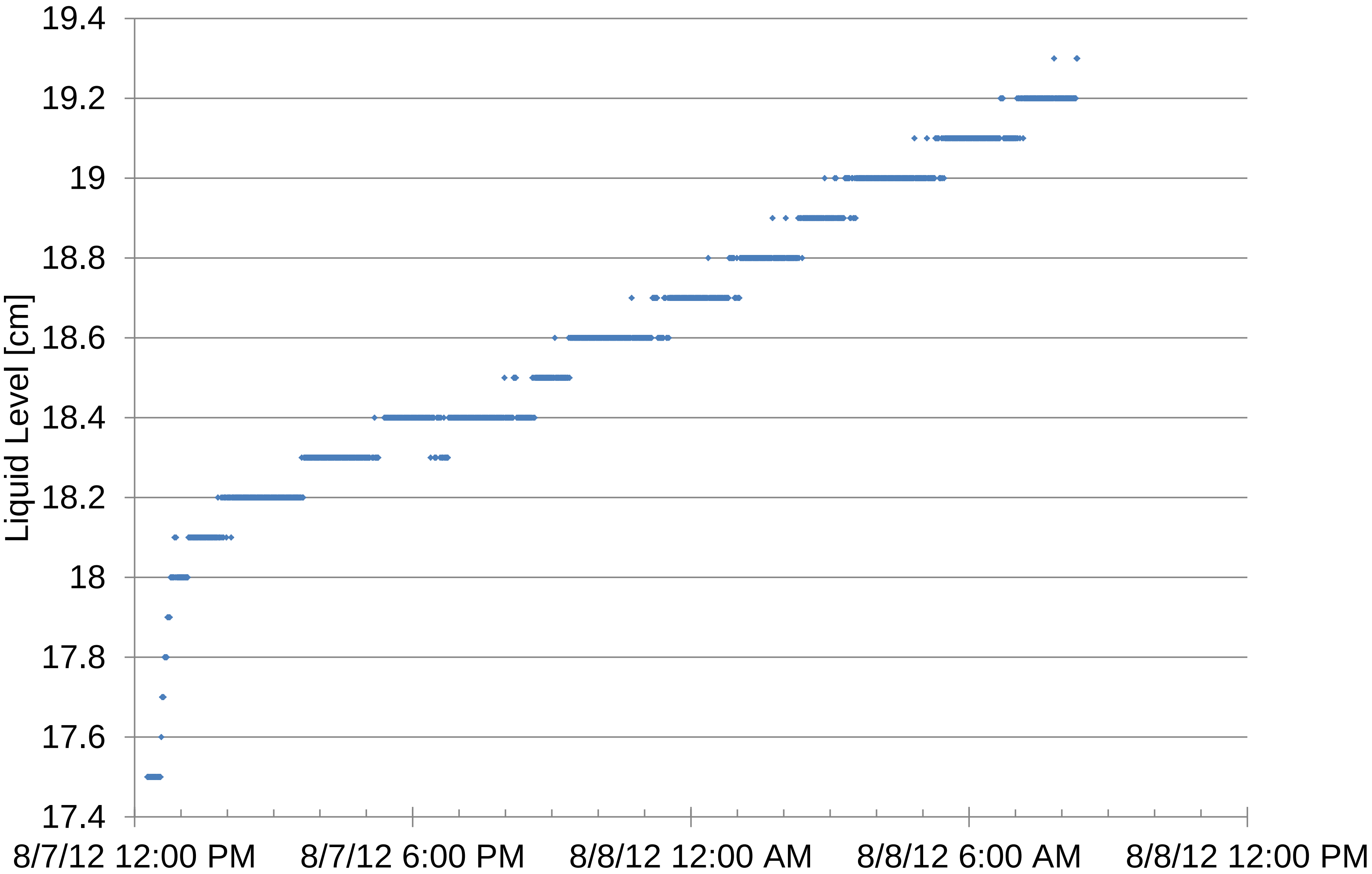




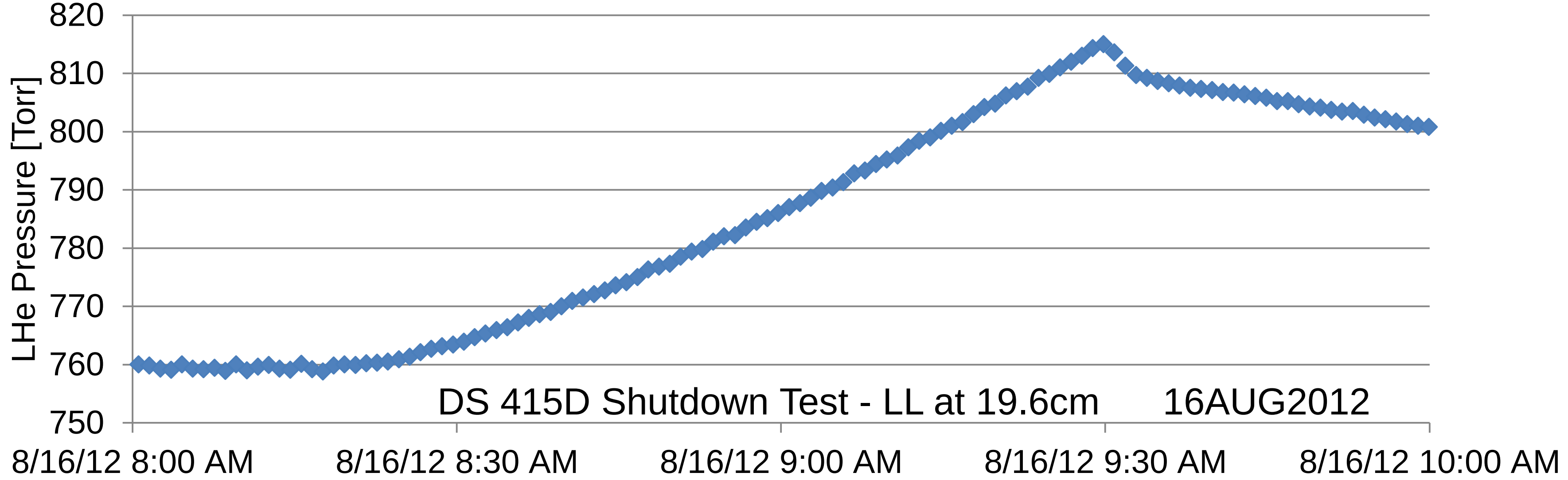


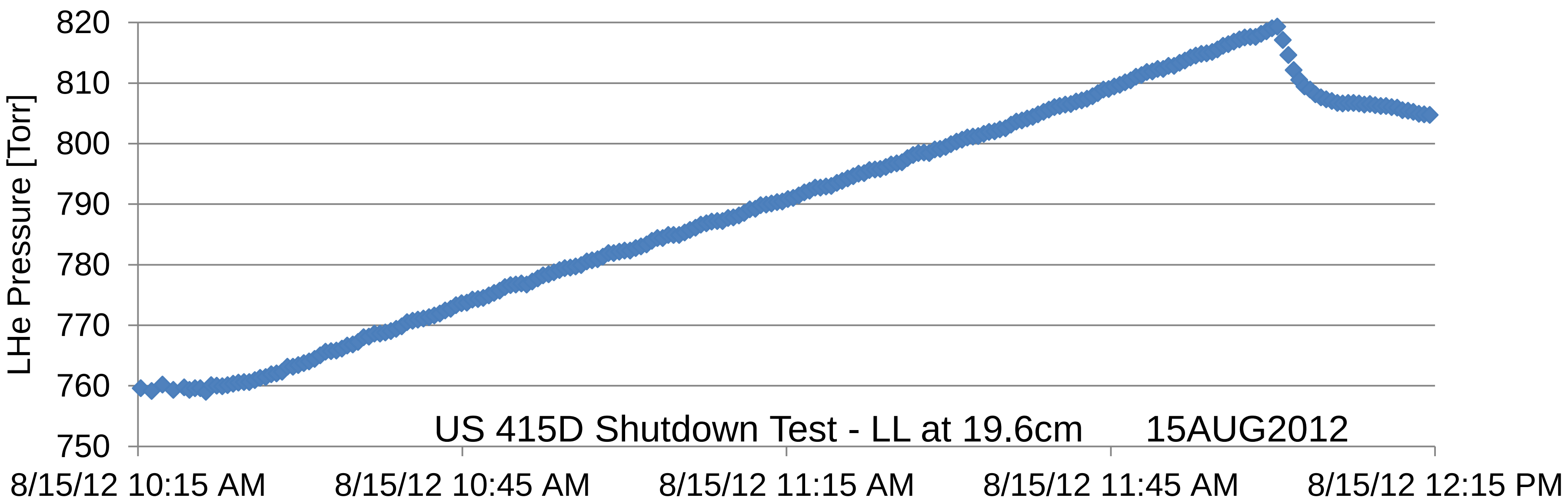


Helium Liquefaction (bldg 314)



Cryocooler shutdown tests (bldg 314)





Room to Improve

- Add visible cold mass fiducials for external alignment check while cold
- Consider abandoning the recondenser bulb in favor of direct attachment to the LHe reservoir exterior for both 4 K coolers to improve 4 K capacity
- Explore optimization of refrigeration levels – consider abandoning “20 K” thermal shield to save cost and improve overall capacity
- Consider reducing LHe reservoir volume (but maintain interior surface area for efficient recondensation…) to reduce cryostat size
- Optimize current lead design to reduce heat load
- Improve subsystem designs to enable highest possible magnet current (since this seems to be what users want)
- 1+ meter magnets
- Cryogen-free (“dry”) magnets?