

Performance and Upgrades of the Advanced Photon Source (APS) 2-MW DC Klystron Power Systems

Gian Trento Accelerator Systems Division Argonne National Laboratory



Abstract

 Essential for operation of the APS booster and storage ring are the high power radio frequency (rf) systems. The highpower rf system consists of five individual 100-kV, 20-A DC power systems each feeding its respective 1-MW continuous wave klystron. Each power system contains a medium voltage electrical substation, a 1400-V SCR gated voltage regulator, a 100-kV rectifier, an ignitron crowbar stack, and a hard tube modulator. Performance and upgrades to these klystron power systems will be discussed.

2MW DC POWER SYSTEM FOR SR & BOOSTER







Replaced Motorized Fused Disconnect



- OEM disavowed knowledge of its existence yet sold replacement parts at a premium price.
- Obsolete.
- Averaged 2 failures / year after sacrificial rollers installed. This actually increased reliability!
- Concrete foundation deteriorated and sourced moisture to GPO3.
- Violent open / close action wore out the mechanical components.



Old MFD in Operation. Don't Blink.



Upgraded MFD





- Specified to operate 750 X prior to maintenance
- Unit and replacement parts available from OEM
- No projectiles during operation!

Transformer/ Rectifier Set





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TR Set Maintenance



Cause of Diala Oil Contamination





Capacitor Vendor







Strike 3, You're OUT!

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Capacitor Vendor B - Acceptance Testing



Terminal exploded within 15 seconds of high voltage test.

Kraft paper failed to cover edge of cells & can connector wire improperly ran.

Tetrode Tester



Designation	Description
Source Power	-60kV, 12mA
Screen Voltage	670V
Filament Power	7.5V, 35A nominal
Grid Bias	-500V adjustable
Construction Cost	< \$2k Parts

Purpose

- Operate a Thomson TH5188 across range of V – I conditions
- Perform QA testing on repaired and new pull-down cage(s)
- Tune control circuitry
- Determine what "shot-gunned" component failed.
- Provided hands-on training for support personnel.

Tetrode Tester's Unit Under Test Yield 2009 - Present

Component	Tested	Failed
TH5188	43	1
PD Cage	17	2 after repair
Control Card	4	0

Summary of MA Failures:

- Workmanship
- Carbon composite resistors
- Fiber optic cable
- Grid drive transistor
- Screen PS capacitor



Obsolete Klystron PS Control Interface





- 1. 486 PC running Windows 95 GUI code
- 2. Proprietary E²PROM
- 3. OEM PC Boards and various I.C.s obsolete
- 4. GPIB communication error if left in analog monitoring

Updated

ACCESS SCR Croubar Anode Control Fuse Disc SCR Wand Croubar Wand Croubar Wand Disc Sw Open Disc Closed Local Renote Enable Cont Cont On Enable Cont Cont On SCR Armed CB Closed Crowbar Test	INTERLOCKS SCR SW Open Body 1 Flow SCR Cont On Body 2 Flow SCR Cont On Body 2 Flow SCR Marker Kly Varue SCR Maker Kly Varue Anode Tenp Holy Air Flow SCR Maker Kly Varue Anode CP Rad Shield Anode OP Rad Shield Anode OP Rad Shield Anode OP Rad Shield Anode CP Rad Shield Brode Level Coll H28 Tenp Crow Tenp Heater Warm TR OverTres RF Load ok TR Mitrogen DC Intlk E1 TR Fres Rei Pers Safety E TR Oli Level Acis E3 TR OverTenp MPS E4 HT OverTenp MS W Intlk E5 Crow Short Sol	FAULTS SCR DC DV SCR DC DL SCR AC DL AC ADA Cathode DL Heater UL Heater UL Heater UL Heater UL Hon OL 184A Coroubar Fired Ion OL 184A Foroubar Fired Ion OL 184A High Ripple Higg #1 0L Heg #2 UL Hag #2 UI	READY High Voltage Mag #1 Ion Punp Heater Mod Anode Anode Ready Crow Ready Person Protect Equipteent Pault Intl
Concession of the local division of the loca	🔍 =Good 🛑 =Fault 🔵 =Status	Code Version	



- Reliable EPICS interface
- Flexible
- Up-to-date software & hardware
- Low \$\$

In the Beginning.....

"A major concern during initial commissioning and early operation of the APS was the reliability of it's RF power systems.

At the beginning of 1997, the APS machine was only delivering beam to users 75% of scheduled time. Approximately 70% of the lost beam was caused by indiscriminate high voltage power supply interlock trips."

G. Pile & A. Cours

Performance

USER RUN	SCHEDULED USER BEAM HOURS	# PS FAULT(S)	DOWN TIME HOURS
2009-3	1553	2	6.58
2010-1	1727	1	2.02
2010-2	1720	1	0.58
2010-3	1553	0	0
2011-1	1719	0	0
2011-2	1728	1	0.8
2011-3	1545	1	0.85
2012-1	1727	0	0

NOTE: each of the 5 Klystron Power Systems has > 100k operational hours

Thank You CWRF2012 Participants

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