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PAR RF Overview - for Operations Group

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U.S. Department of Energy

UChicago Argonne LLC

Office of Science
U.S. DEPARTMENT OF ENERGY

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Outline

- System specifications
- RF drawings & general overview
- What the equipment looks like & where it is located
- Manual Turn on of both Par systems
- Requirements - after system modifications occur
- System phase stability
- Recent ongoing Harmonic Par efforts

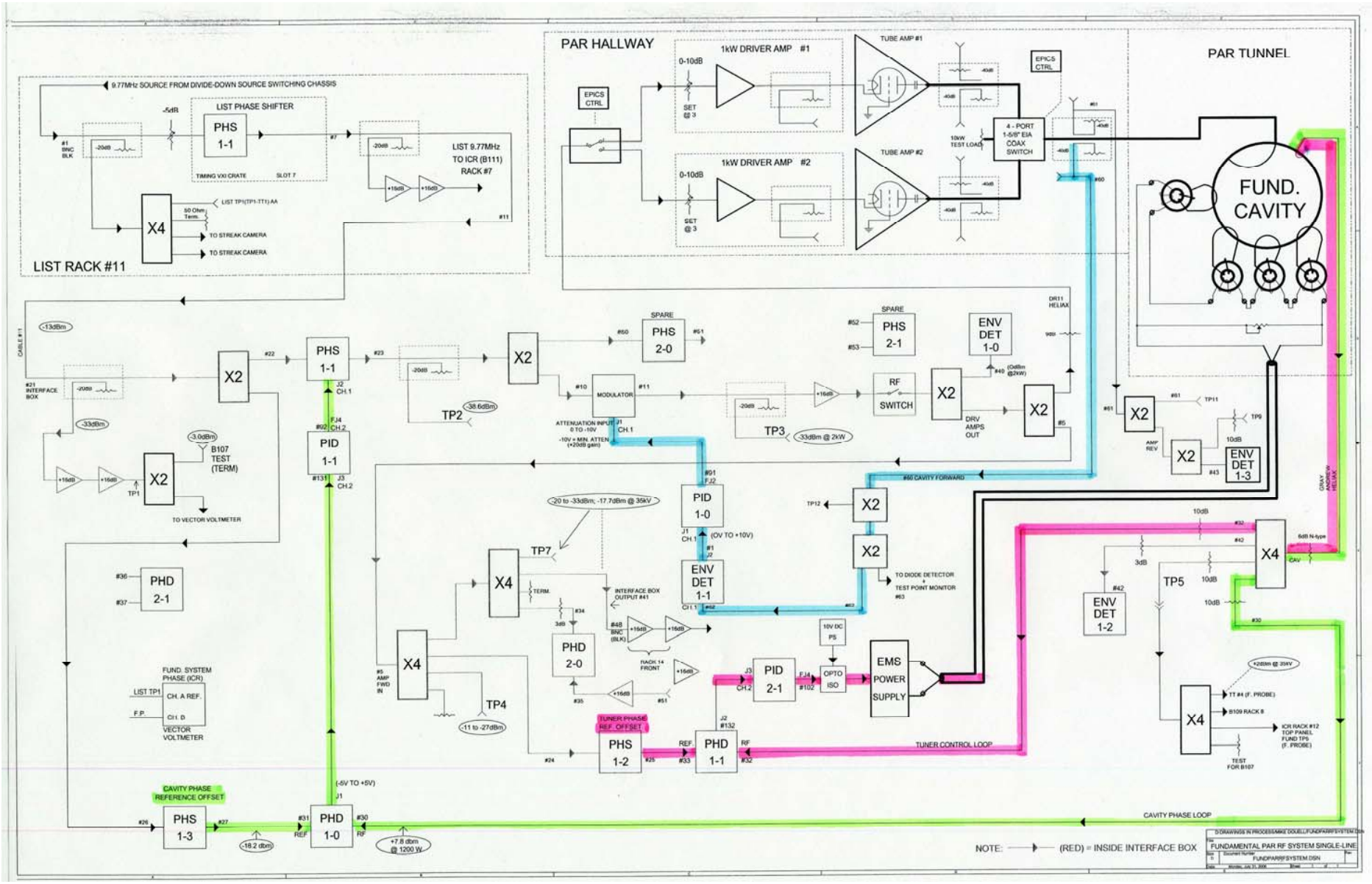
Fundamental PAR RF

- Operates at approximately 9.77 MHz.
- Operates 100% duty cycle or CW
- Maximum gap voltage of 40 kV.
- RF power required is ≤ 3 kW.
- Fundamental Par is the primary rf system used to restore energy to electrons due to synchrotron radiation loss.
- Provides the primary bunch length compression.

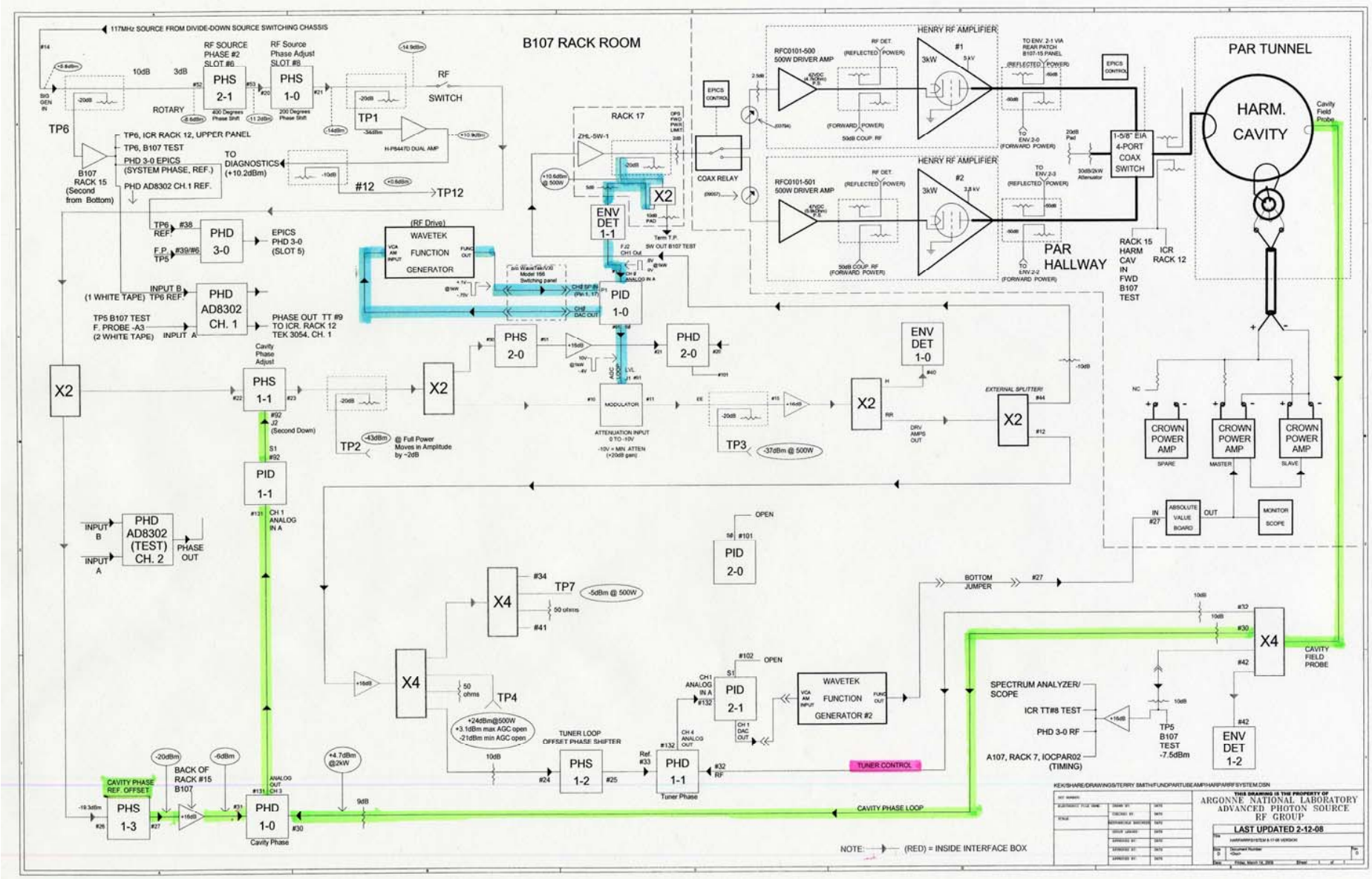
Harmonic PAR RF

- Operates at approximately 117.3 MHz.
- Nearly 50% duty cycle, 240 ms on, 260 ms off, 2 Hz rate.
- Gap voltage ~ 30 kV.
- RF power required is ~ 2 kW.
- The twelfth harmonic system is used to further compress the electron bunch length before injection into the booster.

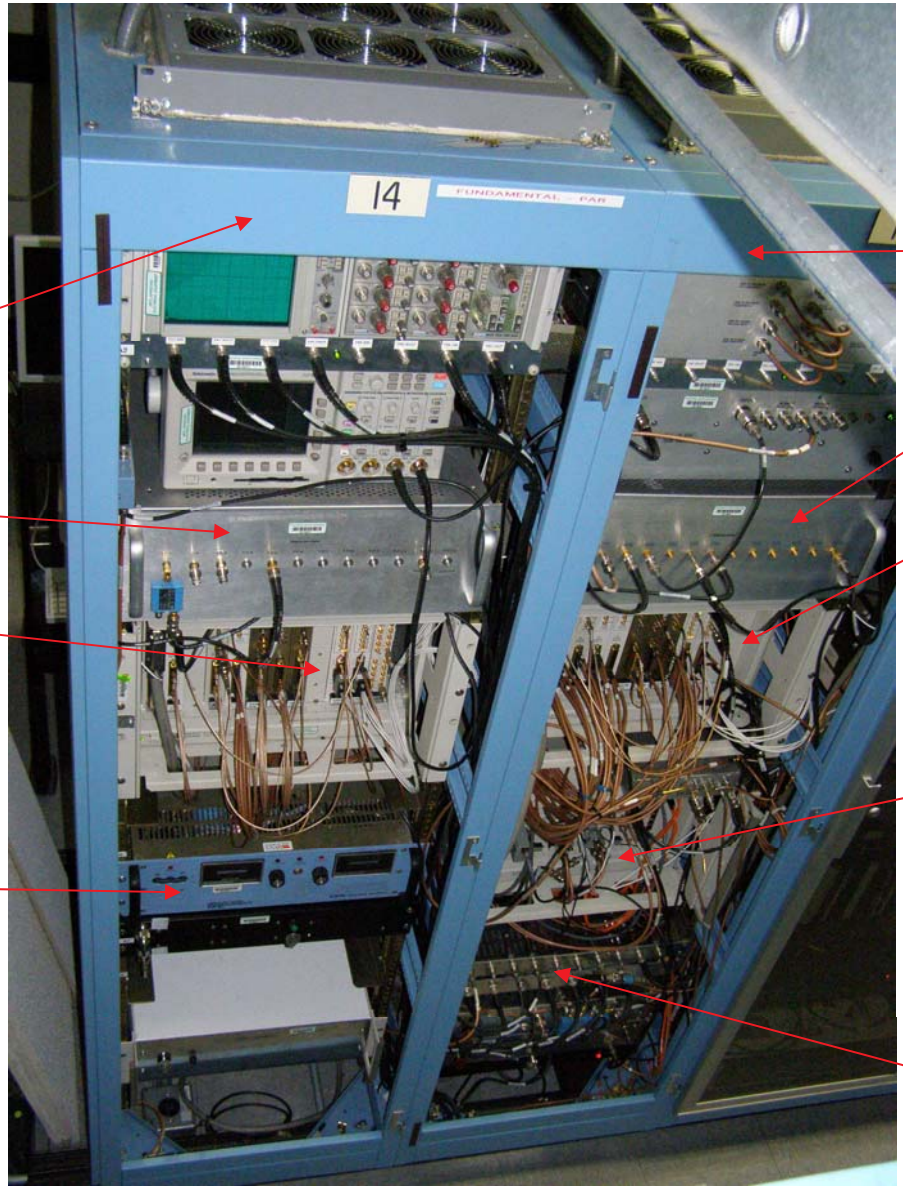
Fundamental PAR Line Drawing



Harmonic PAR Line Drawing



Par LLRF in Building 412, B105 - (racks 14 & 15)



Fundamental LLRF Rack (#14)

Harmonic LLRF Rack (#15)

Fundamental interface box

Fundamental VXI Crate:
Envelop Detector Card
Phase Detector Card
Phase Shifter Card
Modulator Card
Feedback Card

Power supply for Fundamental Cavity Tuner Current

Harmonic interface box

Harmonic VXI Crate:
Envelope Detector Card
Phase Detector Card
Phase Shifter Card
Modulator Card
Feedback Card

Harmonic VXI Crate:
Arbitrary Function Generators

Patch panel to ICR for both Par systems

Fundamental Par HLRF in Building 412 Hallway
1 kW Driver Amplifiers (9.77 MHz)

Fundamental Par HLRF in Building 412 Hallway Tube Amplifiers (9.77 MHz, ~ 3 kW CW)

Harmonic Par HLRF in Building 412 Hallway
Crown Amplifiers (supplies cavity tuner current)

Scope shows tuner current waveforms

Crown Amplifier - Master

Crown Amplifier - Slave

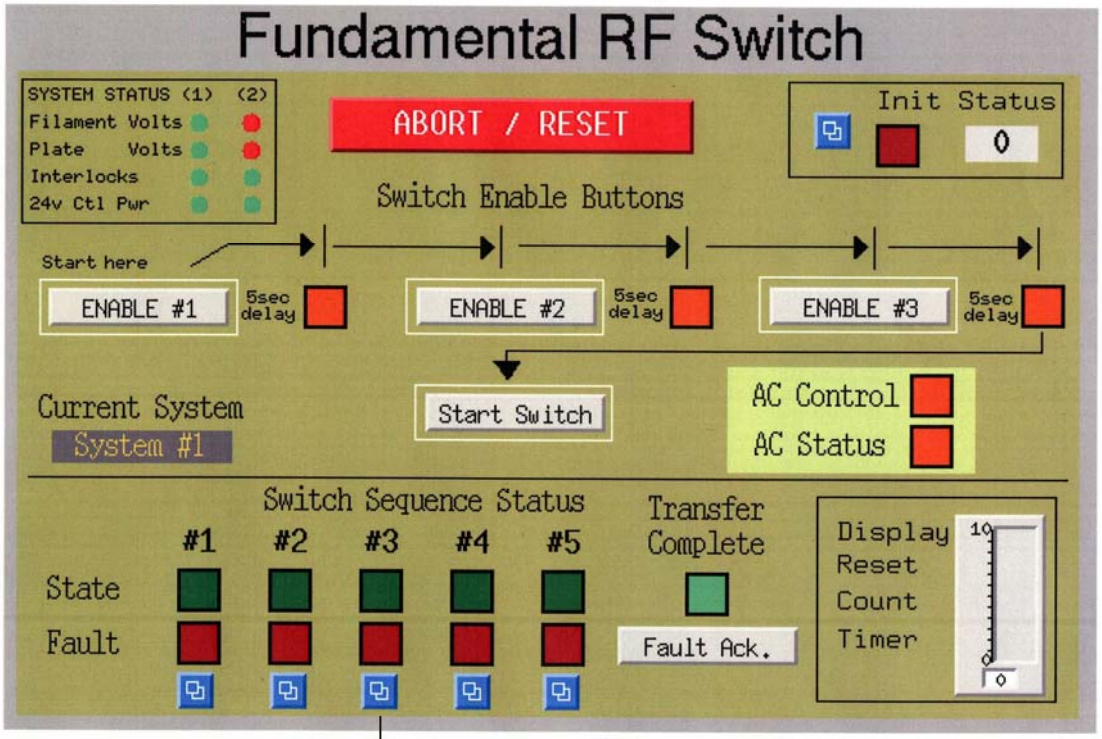
Crown Amplifier – Cold Spare

Power supplies for 500 Watt driver amplifiers located inside Harmonic tube amp racks.

Harmonic Par HLRF in Building 412 Hallway Tube Amplifiers (117.3 MHz, ~ 2 kW Pulsed)

Par HLRF Coaxial Switching in Building 412 Hallway

Switching High Power RF Systems

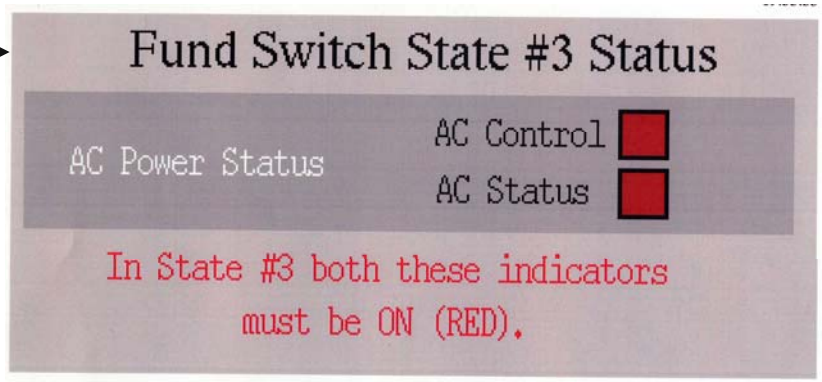


Screen is used when it is necessary to operate with the backup tube amplifier:

1) Switches high power RF coaxial switch leading into tunnel.

2) Switches low power RF switch leading into tube amplifiers.

example



These five separate unopened screens could be used as troubleshooting aids if the switching process will **not** complete.

Par RF System Turn-On

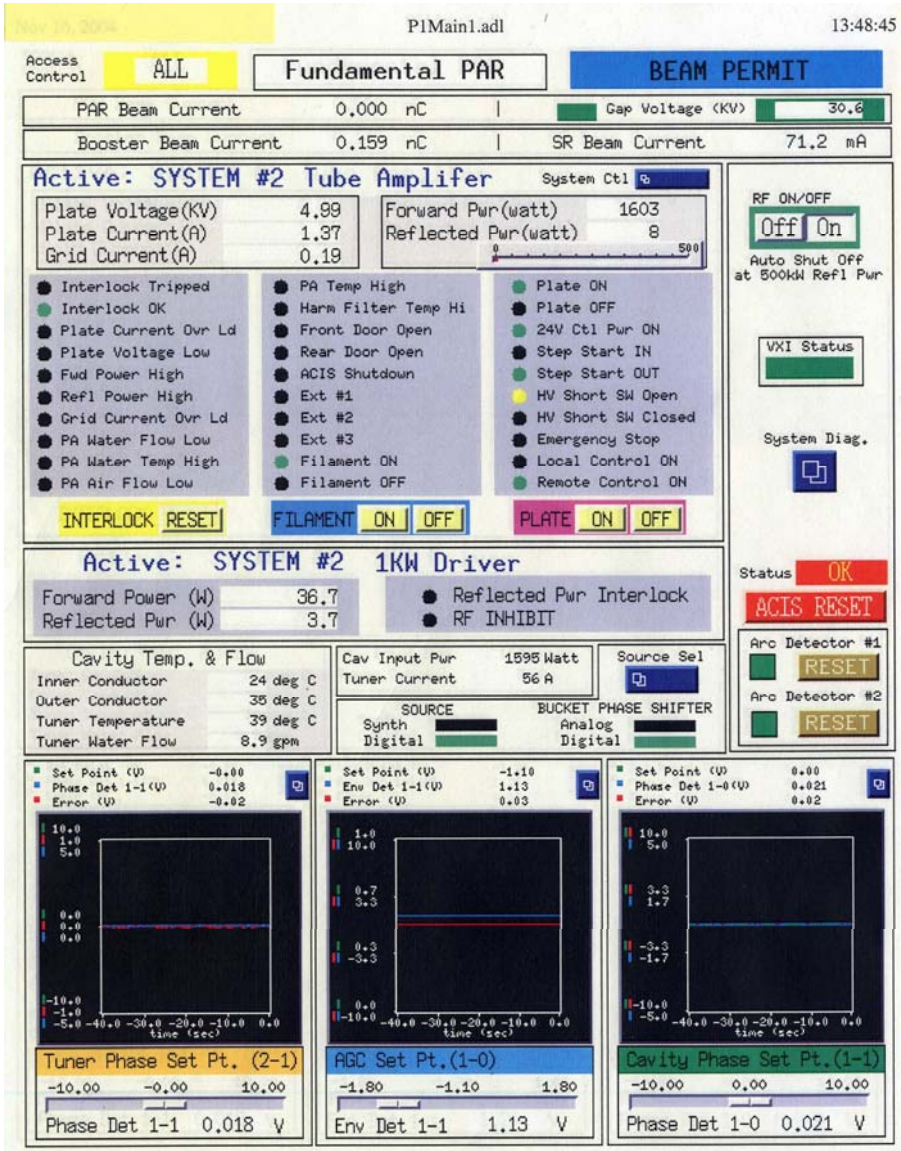
- At the start of a run, normally both par systems are set to the desired running conditioned and turned over to operations.

- If required, Operations could use the following procedure:

  #2504-00013
  PAR RF Systems Start-up Procedure for MCR Personnel

  (note title change & additional table for storage instructions)

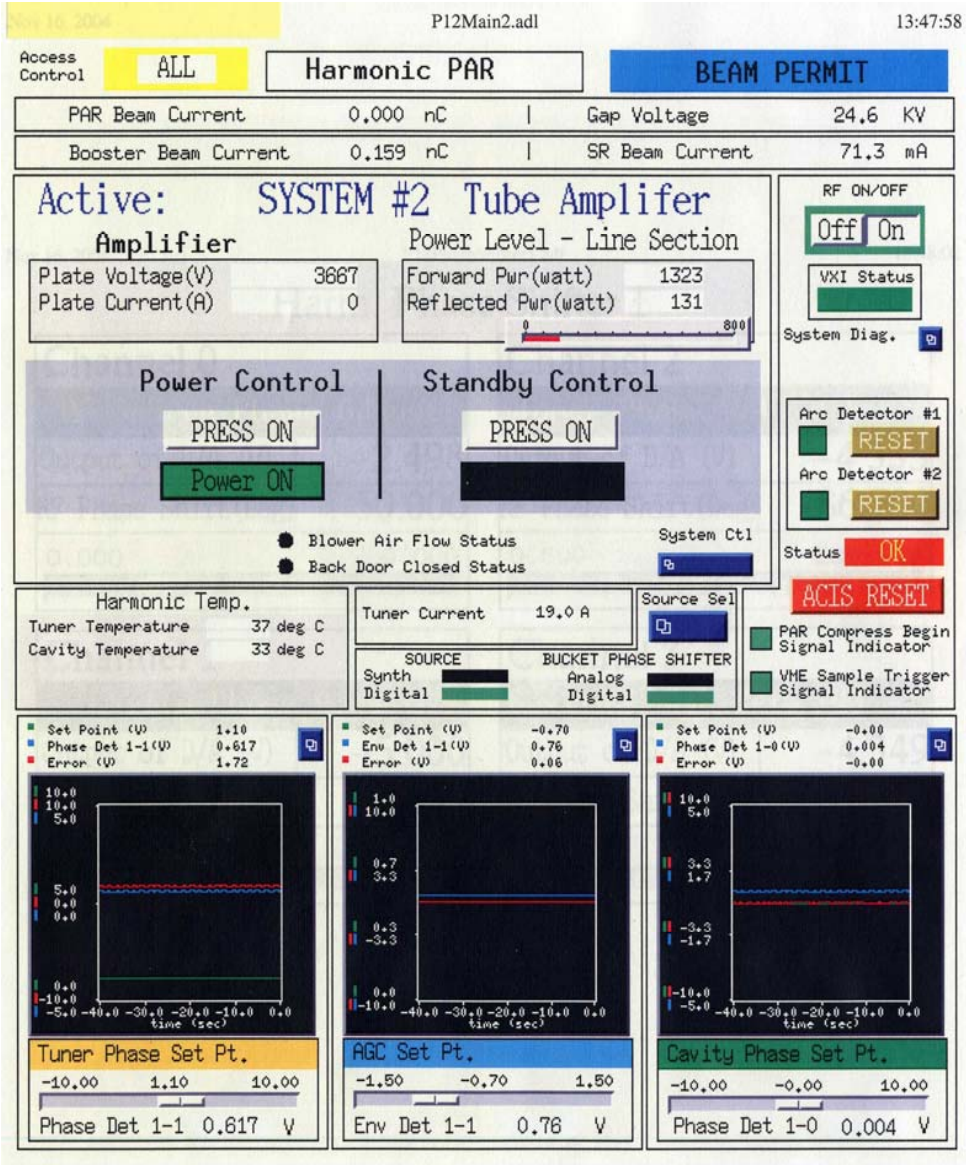
For Manual Turn On of Fundamental Par System:



- Set RF ON/OFF switch to OFF position. (Will set Tuner & AGC to off positions; Sets Tuner to -10V, AGC to +0.10V)
- Bring up digitizer screens.
- Set RF ON/OFF switch to On.
- Increase tuner current set point to +1.0V while monitoring digitizer tuner control. Once loop comes into lock, set tuner set point to zero volts.
- Bring up the AGC level by slowly adjusting the set point in the negative direction in 0.1V increments.
- Monitor digitizer screens to be sure all three loops lock, feedback card outputs in middle of the range.
- If required, reflected power could be minimized by adjusting “tuner phase ref. offset”, PHS 1-2.

Path:
RF Panel
Linac / Par
Operator Par RF
Fundamental Tube Amp

For Manual Turn On of Harmonic Par System:



- Set RF ON/OFF switch to OFF position. (Will set Tuner & AGC to off position; Sets Tuner to -10V, AGC to +0.10V)
- Bring up digitizer screens.
- Slowly adjust Tuner Phase Set Point positive to ~13 amps (~ +0.85V).
- Set RF ON/OFF switch to On.
- Bring up the AGC level by slowly adjusting the set point in the negative direction (0.1V increments).
- Monitor the digitizer screens to be sure the AGC & Cavity Phase loops lock, feedback card outputs in the middle of the range.
- If required, reflected power could be minimized by slightly adjusting the tuner current (Tuner Phase Set Point).

Path:
RF Panel
Linac / Par
Operator Par RF
Harmonic Tube Amp

Changes in Par Systems – After a Shut-Down

- During a shut-down the RF Group may change many things such as coaxial cabling, tube amplifiers, solid state drivers, adjust function generators, etc. These changes may cause a change in electrical delay or phase shift.

- After a shut-down, the “Offset Phase Shifters” may need to be set to a new position to keep the “Closed Loops” in the middle of their range.

- The modified parameters must be saved to a new file & from that point forward, the new file must be used by operations.

If Closed Loops Become Unlocked

- Loops could unlock due to the restoring of an old file, where the offset phase shifters could be set to a wrong position.
- May cause “double bunching.”
- Bunch Purity could be adversely affected.

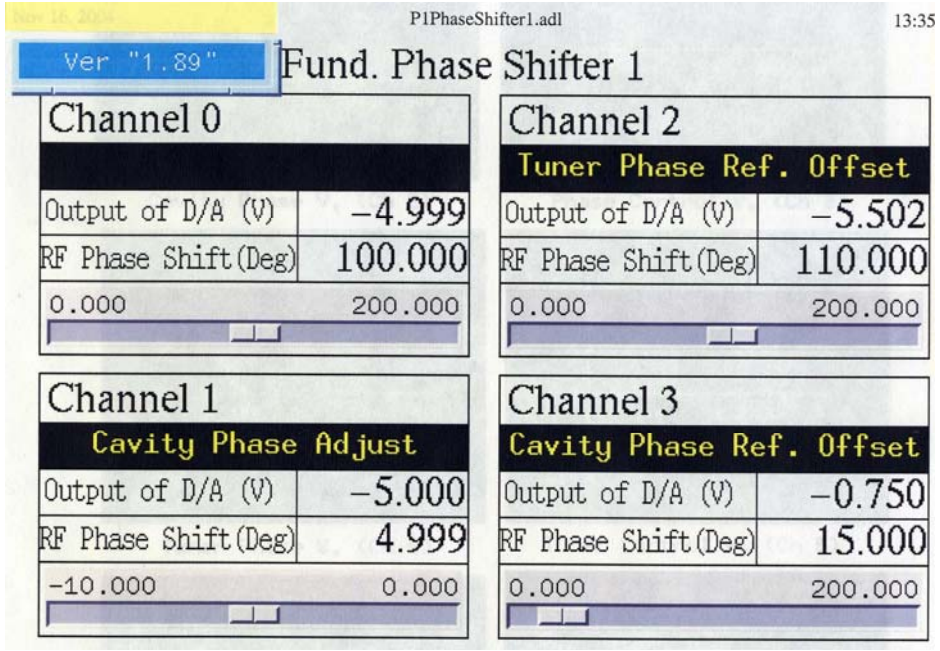
Fundamental / Harmonic Offset Phase Shifters

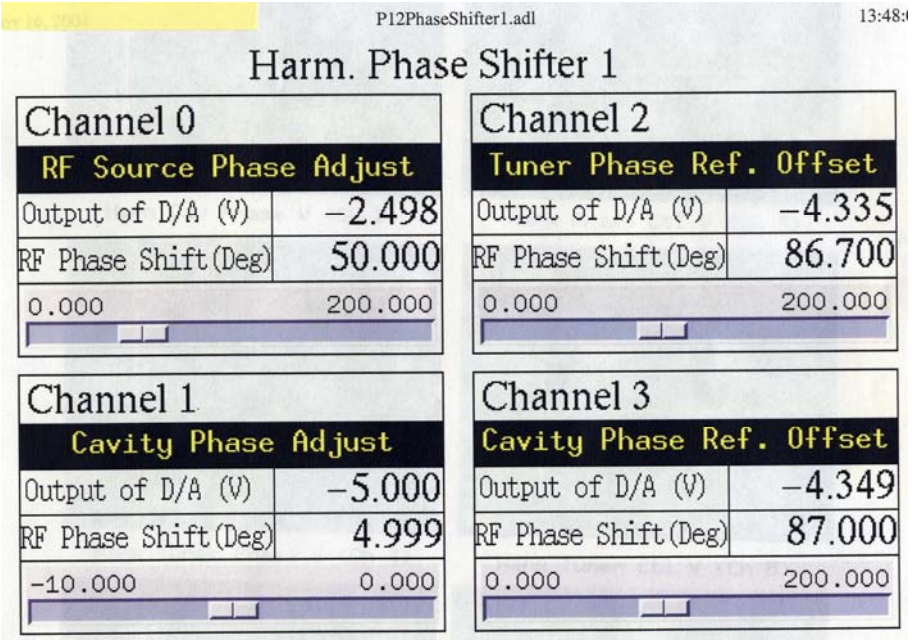
- Fundamental System

Path:
RF Panel
Linac / Par
Operator Par RF
Fundamental Tube Amp
System Diag.
LLRF Main
RF Source
Phase Shifter 1

- Harmonic System

Path:
RF Panel
Linac / Par
Operator Par RF
Harmonic Tube Amp
System Diag.
LLRF Main
RF Source
Phase Shifter 1





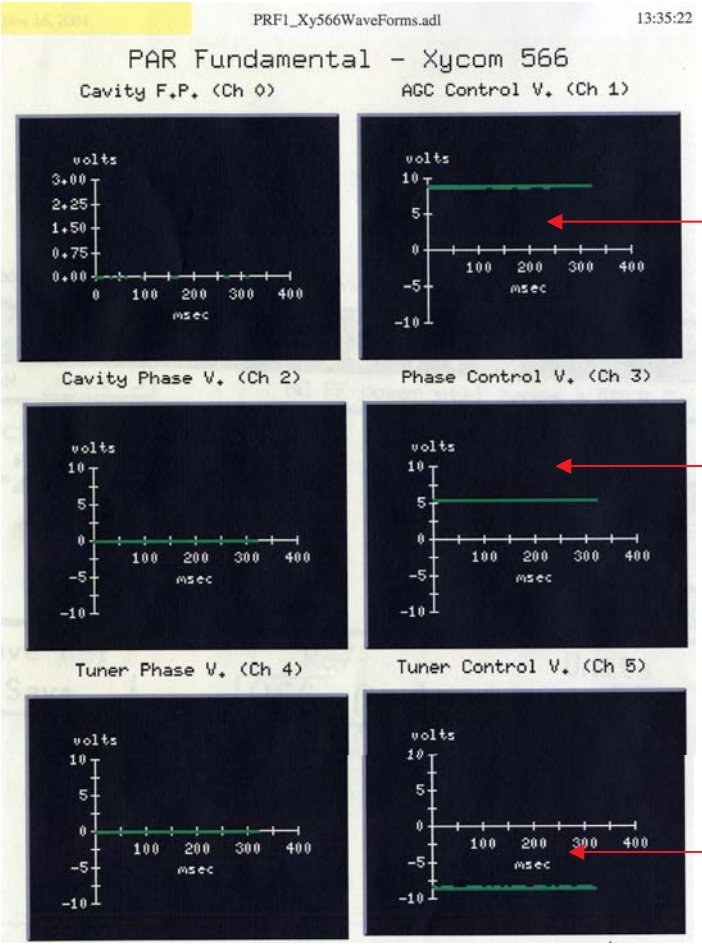
Digitizers (Are Loops Locked ?)

- Fundamental Digitizers

Path:
RF Panel
Linac / Par
Fundamental RF
XYcom 566 Digitizer

- Harmonic Digitizers

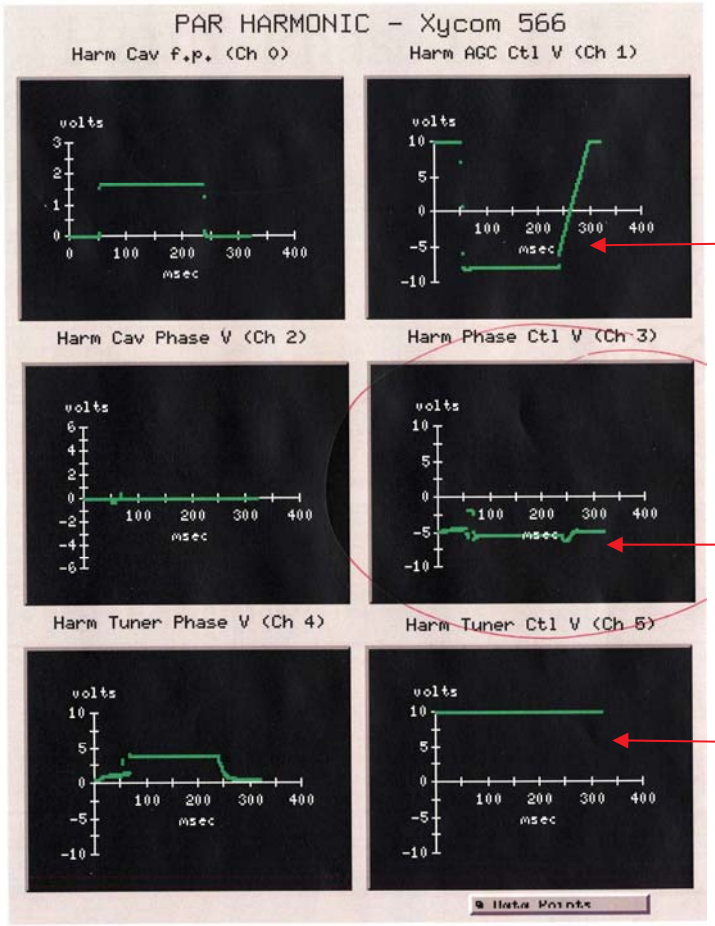
Path:
RF Panel
Linac / Par
Harmonic RF
XYcom 566 Digitizer



0V to +10V

0V to +10V

0V to -10V



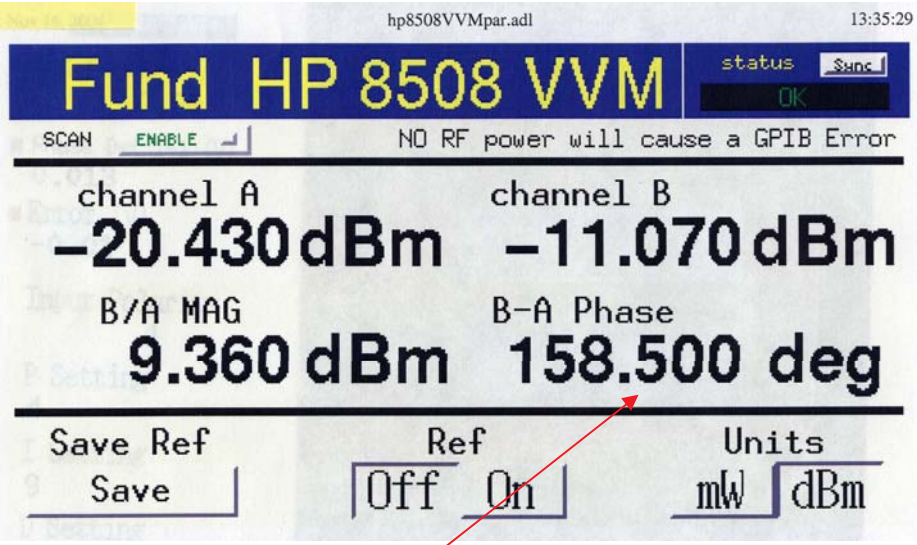
0V to -10V

0V to -10V

Unlocked

System Phase Stability

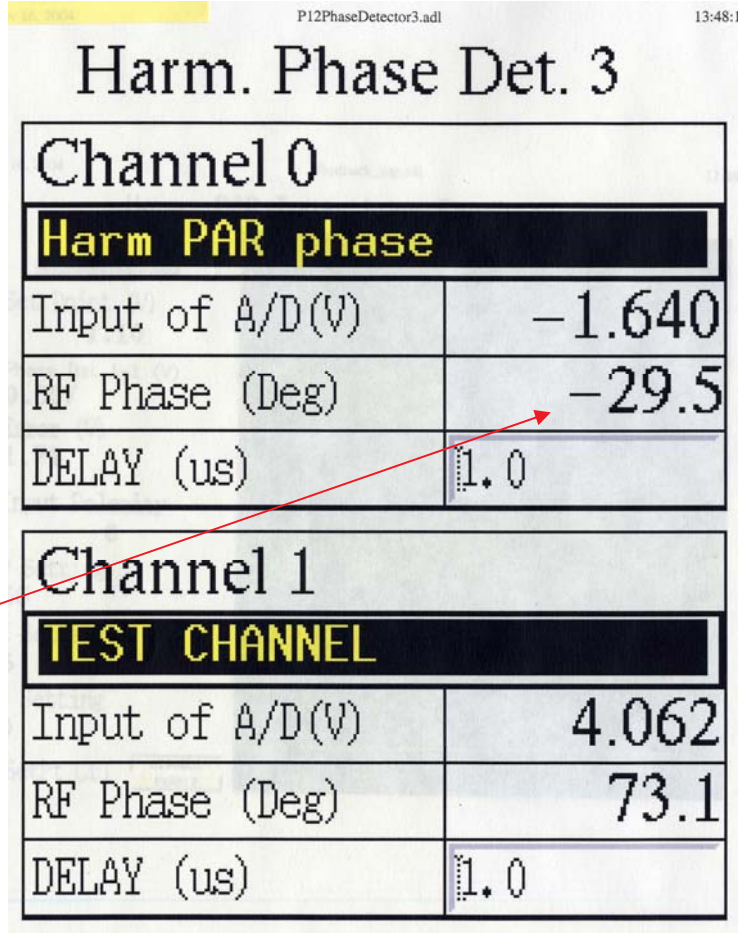
- Fundamental System



Varies ~ ± 0.1 degree
(continuously)

Path:
RF Panel
Linac / Par
Fundamental RF
Fund. Par Phase (VVM)

- Harmonic System

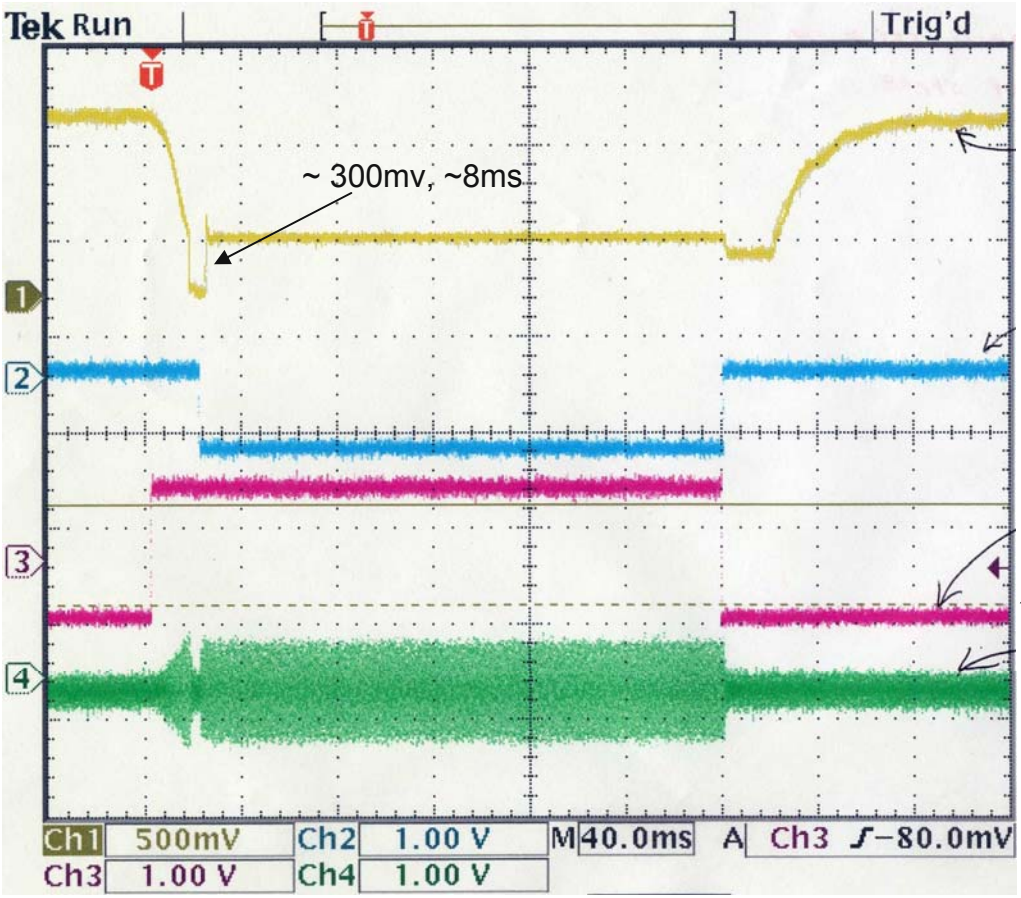


Varies ~ ± 0.2 degree
(shot to shot)

Path:
RF Panel
Linac / Par
Harmonic RF
Harm. Par Phase (PHD)

Recent Ongoing Harmonic Par Efforts

Would like to increase Harmonic Par RF output level to achieve a shorter bunch length!



System using Modulator Module sn.100 (mixer configuration):
Normal operating conditions

Phase Detector (AD8302)

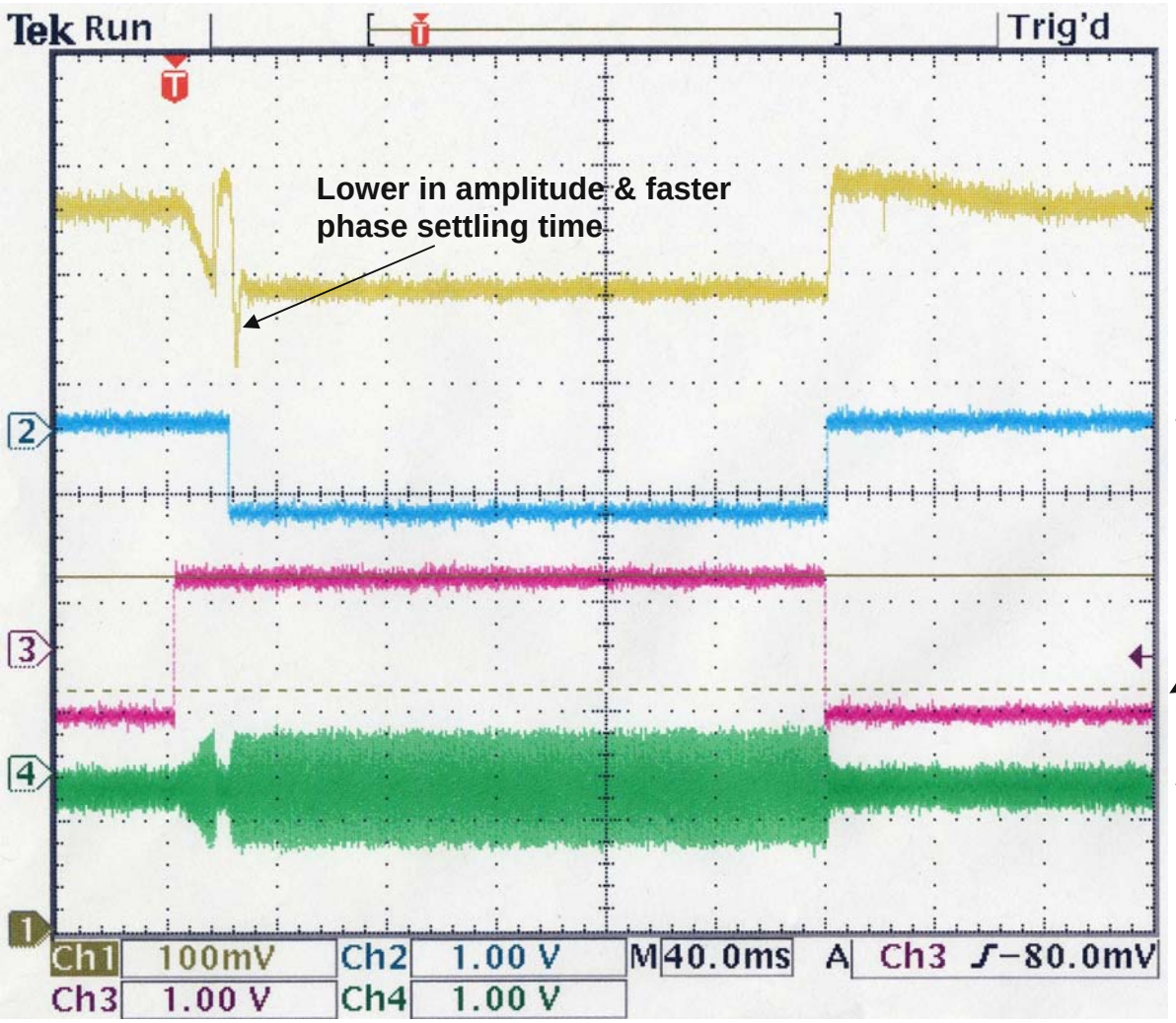
RF Waveform (VXI Wavetek Function Gen.)

Tuner Waveform (VXI Wavetek Function Gen.)

Harmonic Field Probe

Recent Ongoing Harmonic Par Efforts

System using new prototype modulator module
UMCC AT-3000-30V
(pin diode atten configuration):



Phase Detector (AD8302)

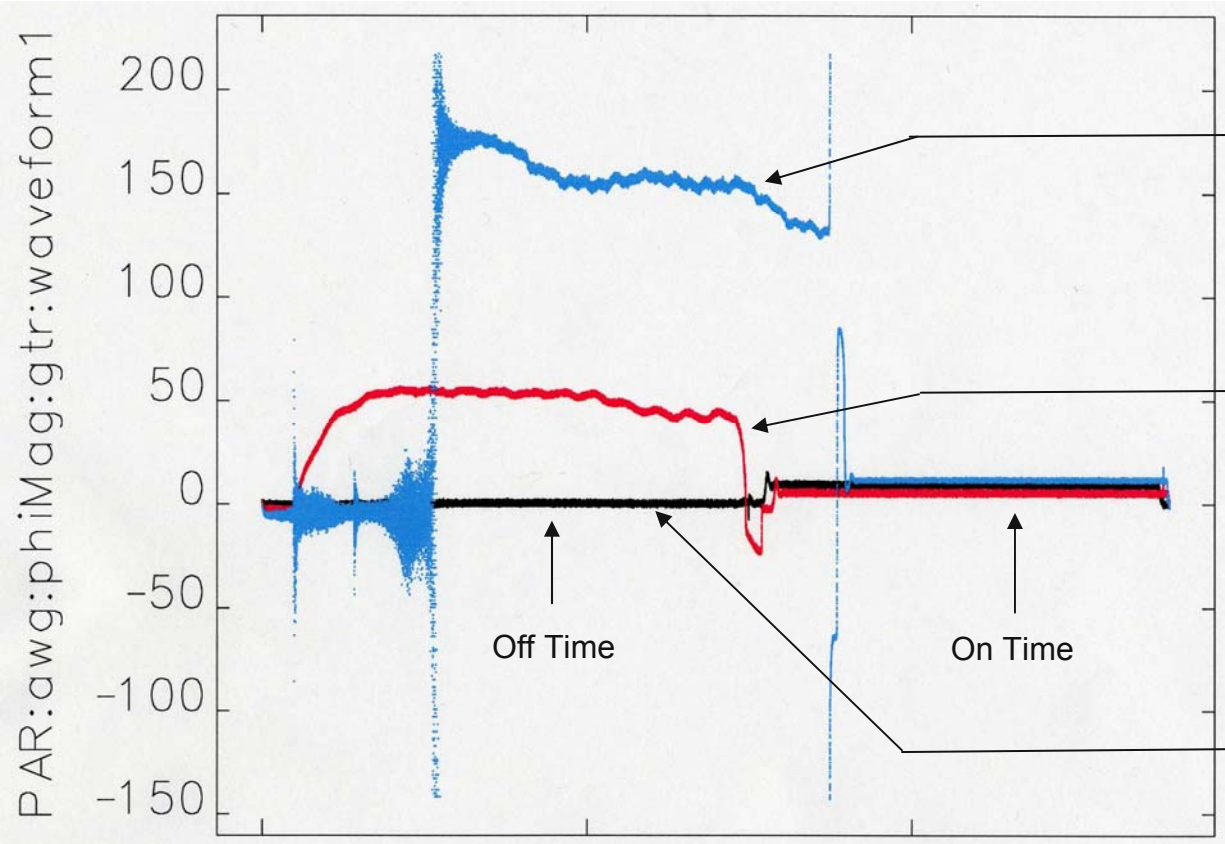
RF Waveform (VXI Wavetek Function Gen.)

Tuner Waveform (VXI Wavetek Function Gen.)

Harmonic Field Probe

Recent Ongoing Harmonic Par Efforts

Harmonic Par System Phase:



Modulator Module sn.101
Mixer configuration
(used for the last several runs)

Modulator Module sn.100
Mixer configuration
(installed during 2009-01 run)

Prototype Modulator Module
UMCC AT-3000-30V
Pin diode atten.configuration
(installed 2009 May shutdown)

Data taken (overlaid) from different runs, on start time does not exactly line up.
(Measurements taken from the Bunch Cleaning FPGA chassis.)