LLRF Results, Status and Near Term Plans for the HINS 6-Cavity Test

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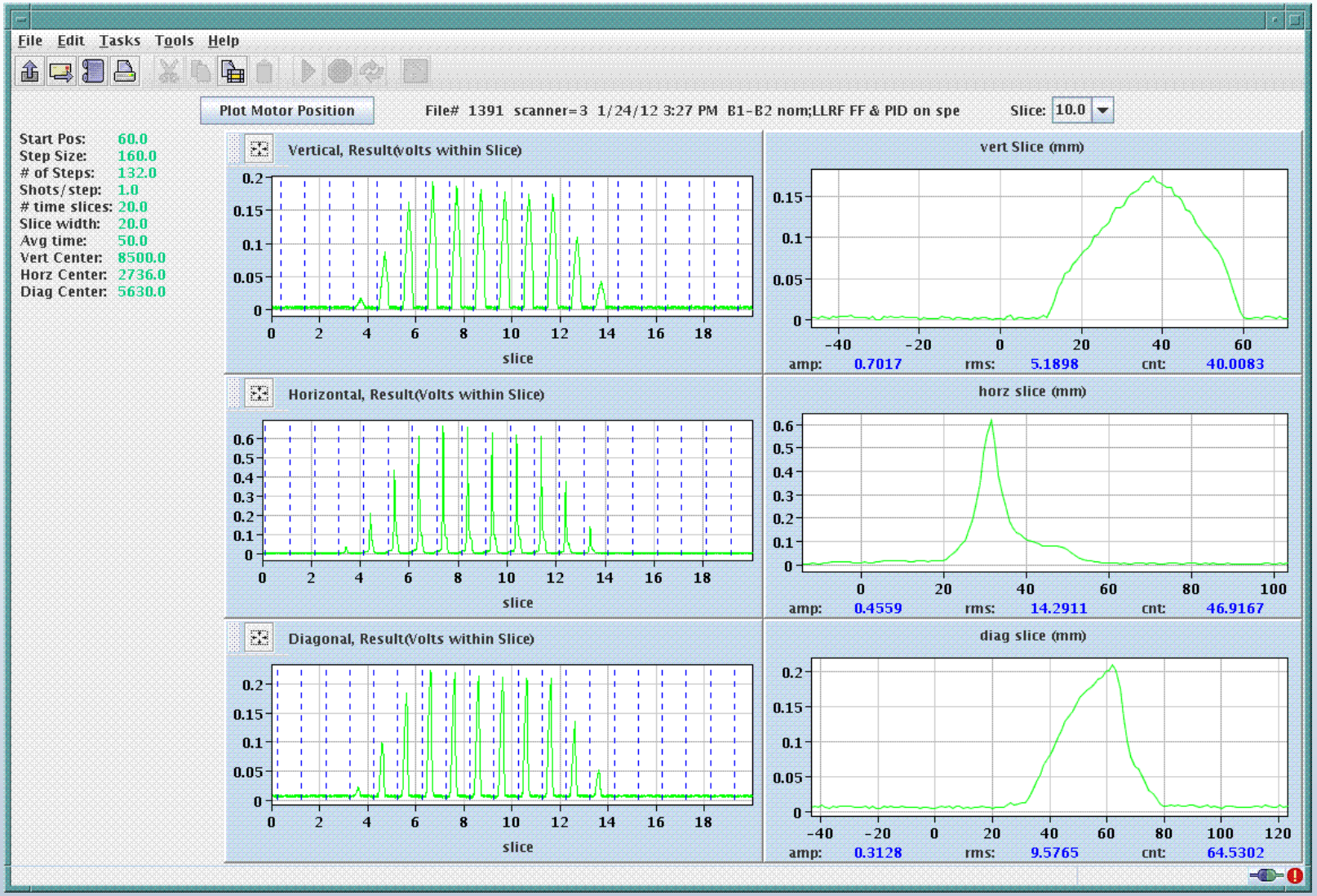
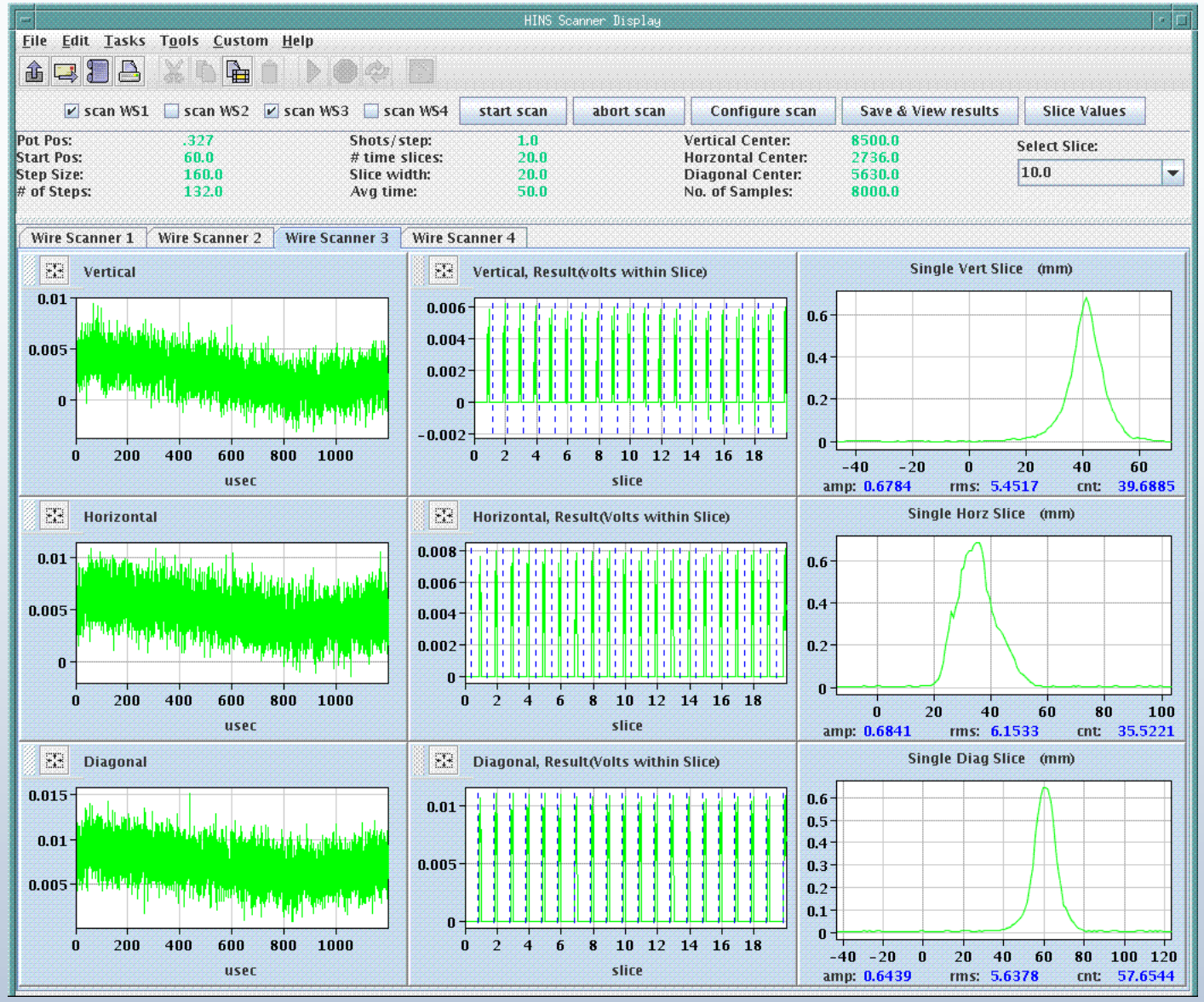
Great Progress over the last few weeks!

- We have gone from a state of confusion to having:
  - A new lattice generated by Jean Paul with longitudinal focusing (bunching) in all cavities. Machine agrees with the Track model
  - Good cavity vector control provided by cavity tuner PID loops and FVM control loops
  - An understood and repeatable cavity phase scan procedure
  - Better diagnostics from a new BPM and LLRF detection of the 325MHz component on 4 BPM pickups
- We now have a stable repeatable machine! Where is the Champagne?

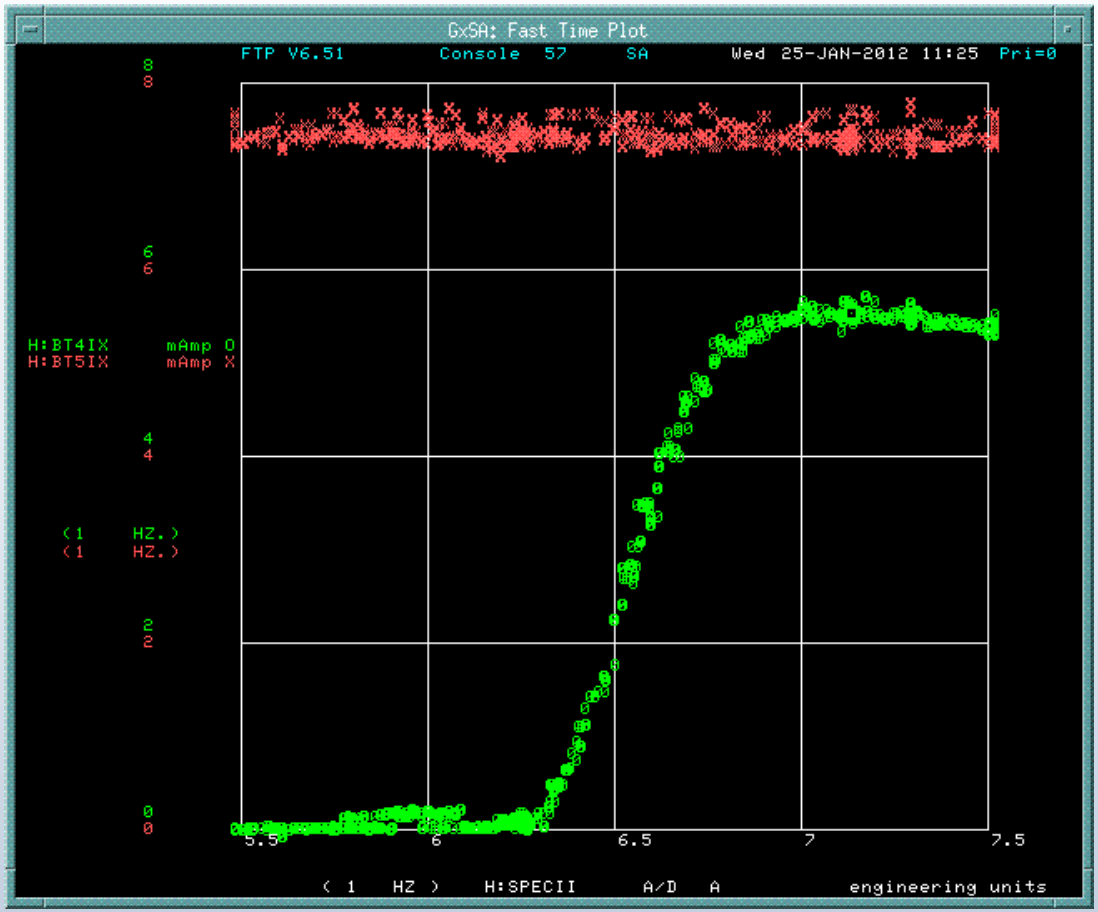
Original lattice Spectrometer Line Wire Scan



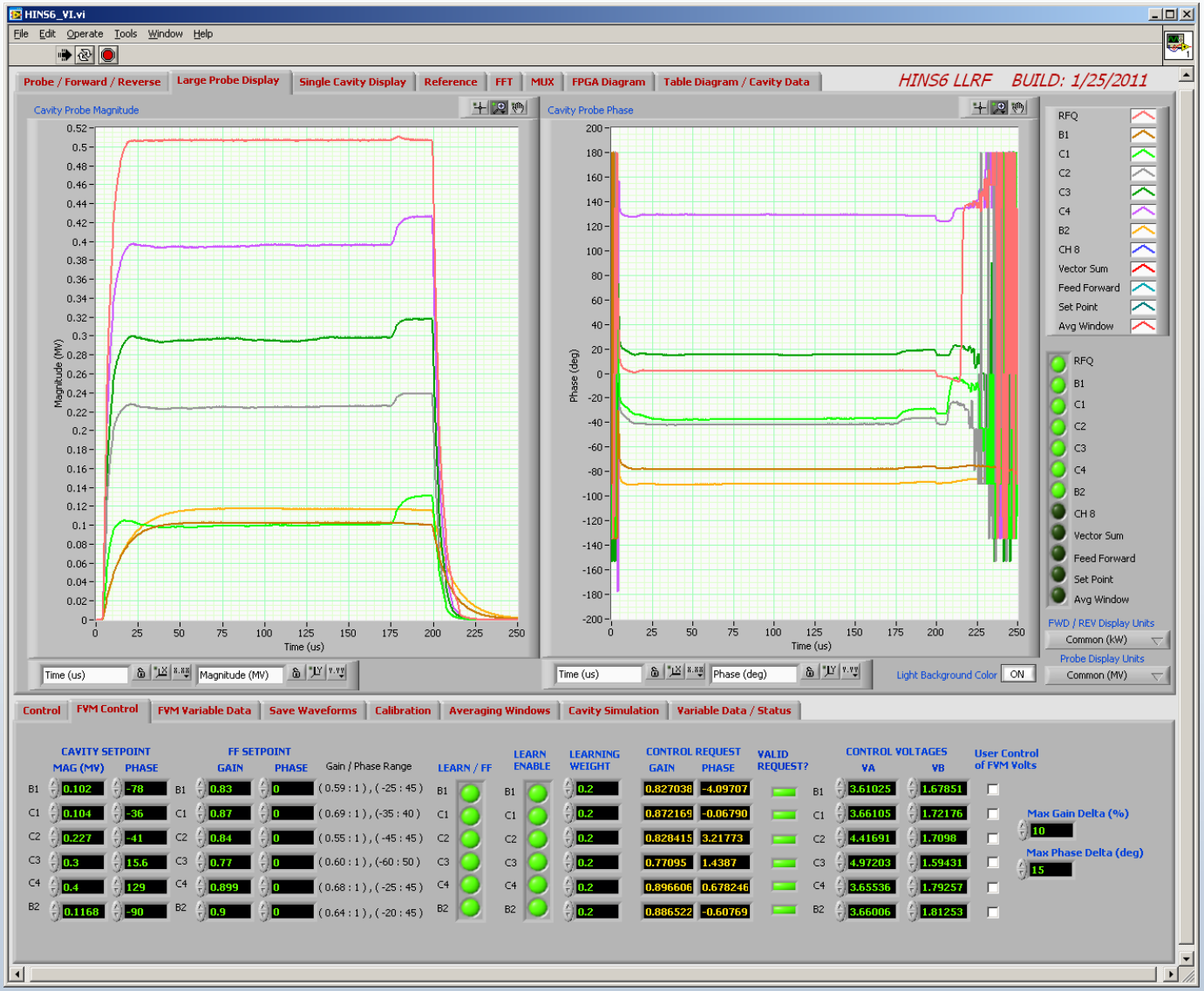
New lattice Spectrometer Line Wire Scan



Spectrometer magnet scan shows higher beam energy



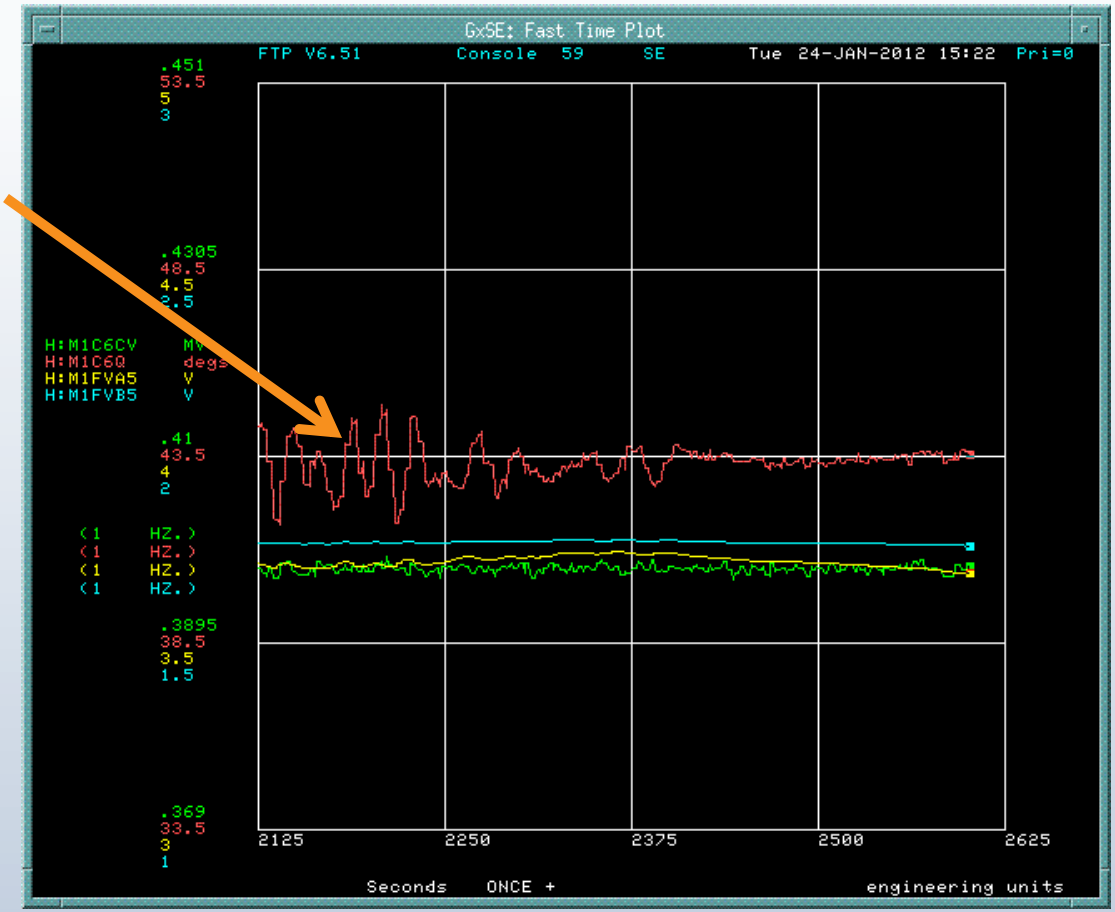
Amplitude and Phase Waveforms



Tuning loops switched from On to Off

Phase jumps caused by smallest controller move request

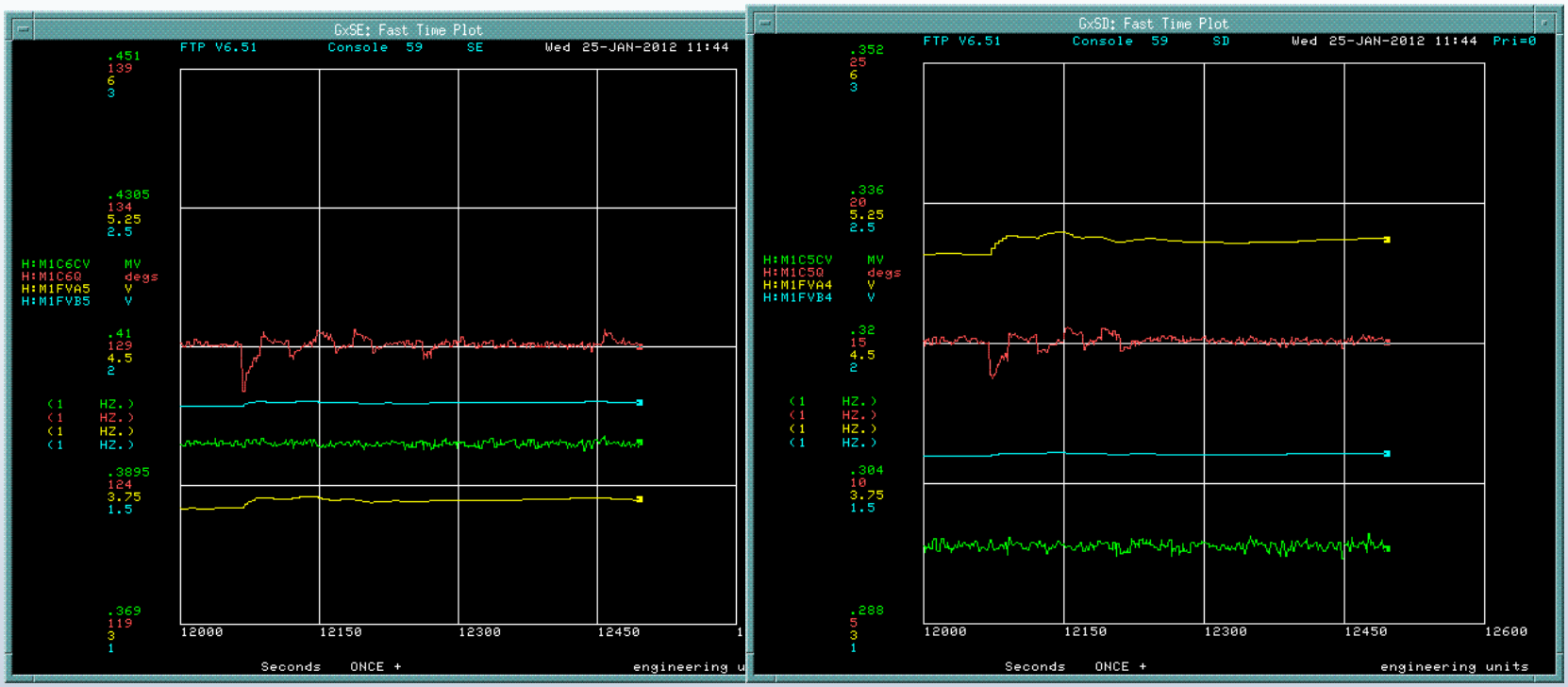
5 deg/div



10 minutes full scale

All control loops on with added deadband in tuner loops

5 deg/div



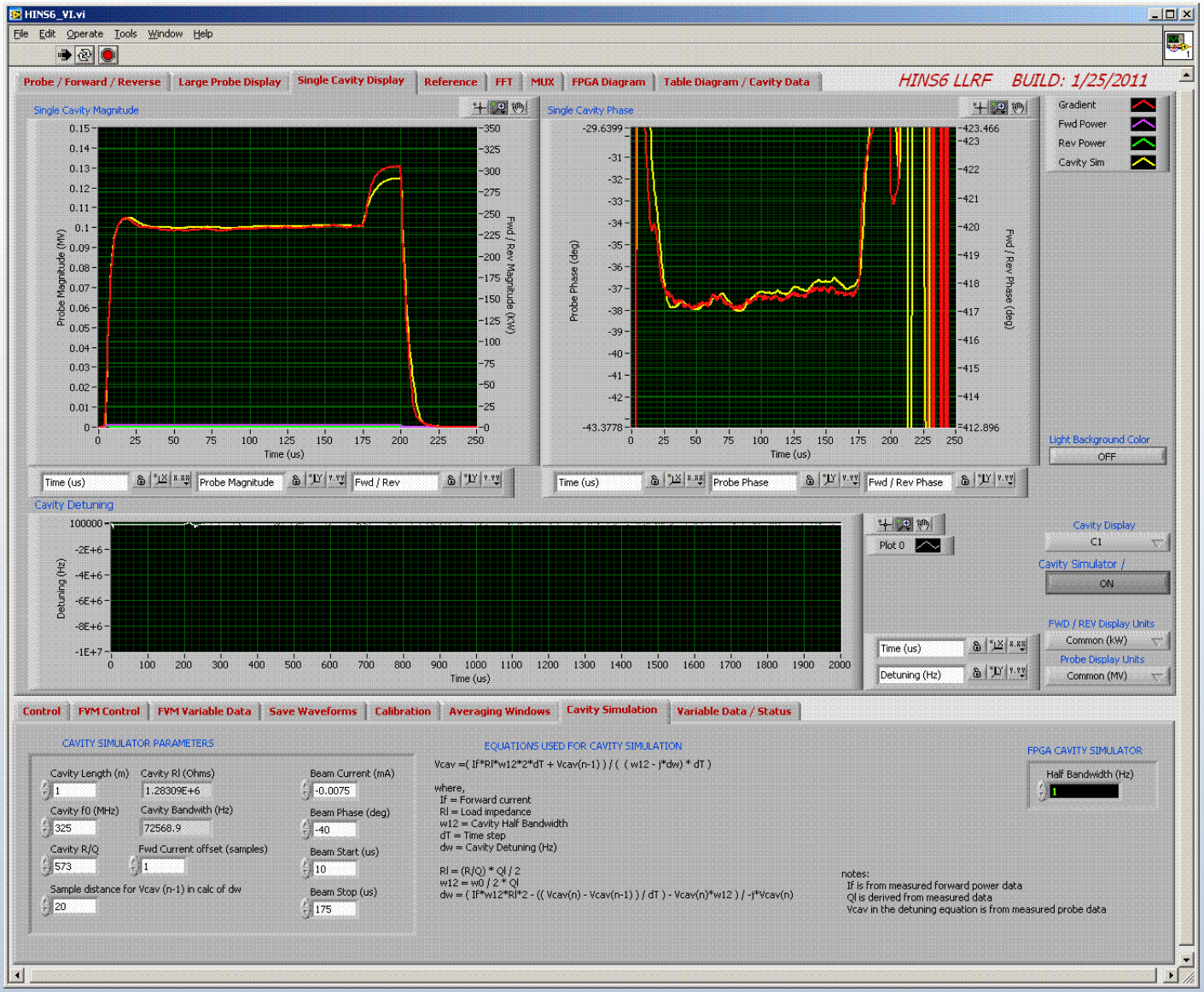
10 minutes full scale

Live Cavity Model

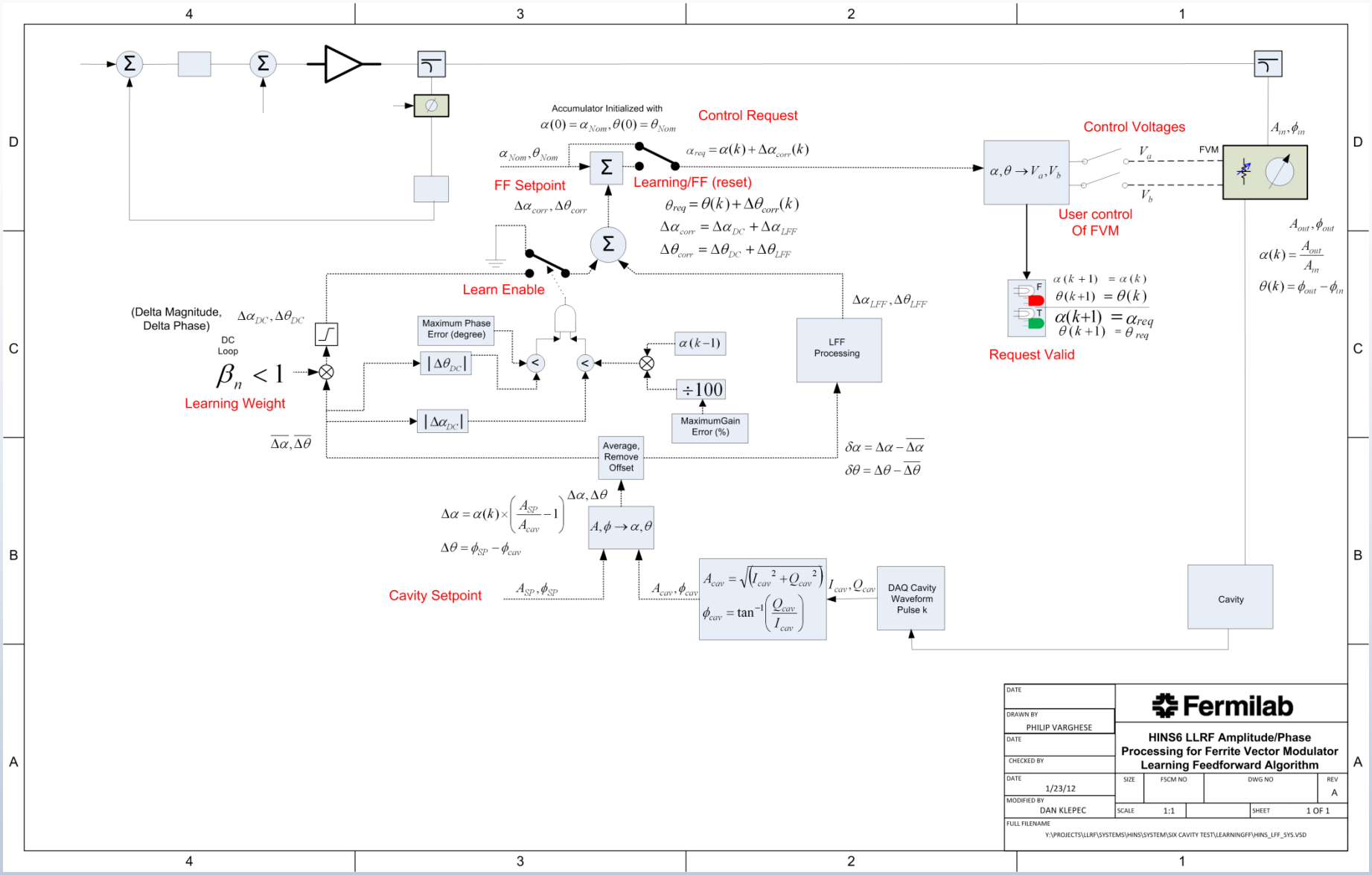
Cavity Probe in red

Model in yellow

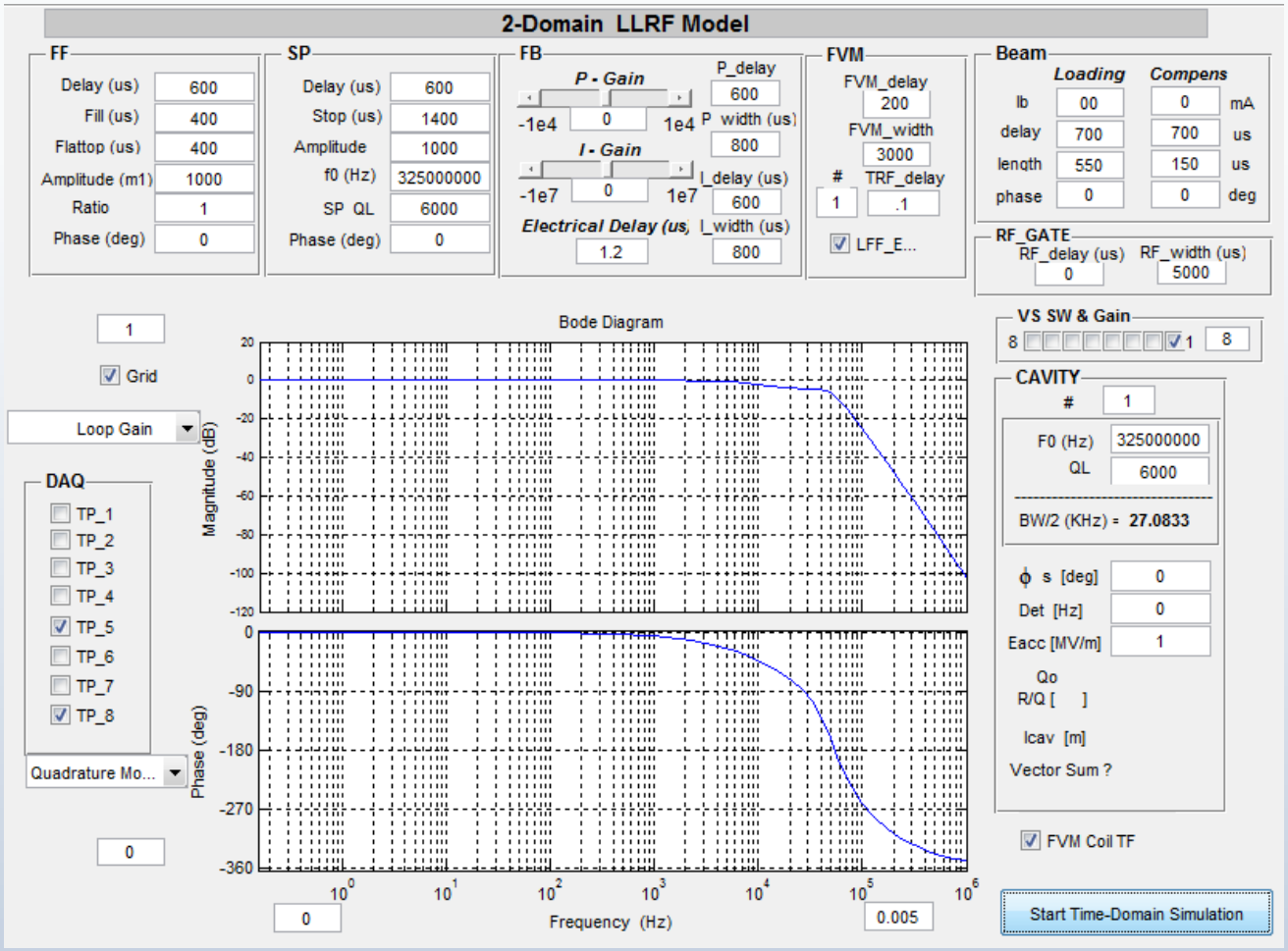
Model driven by forward power and cavity current



HINS RF and Ferrite Vector Modulator Control

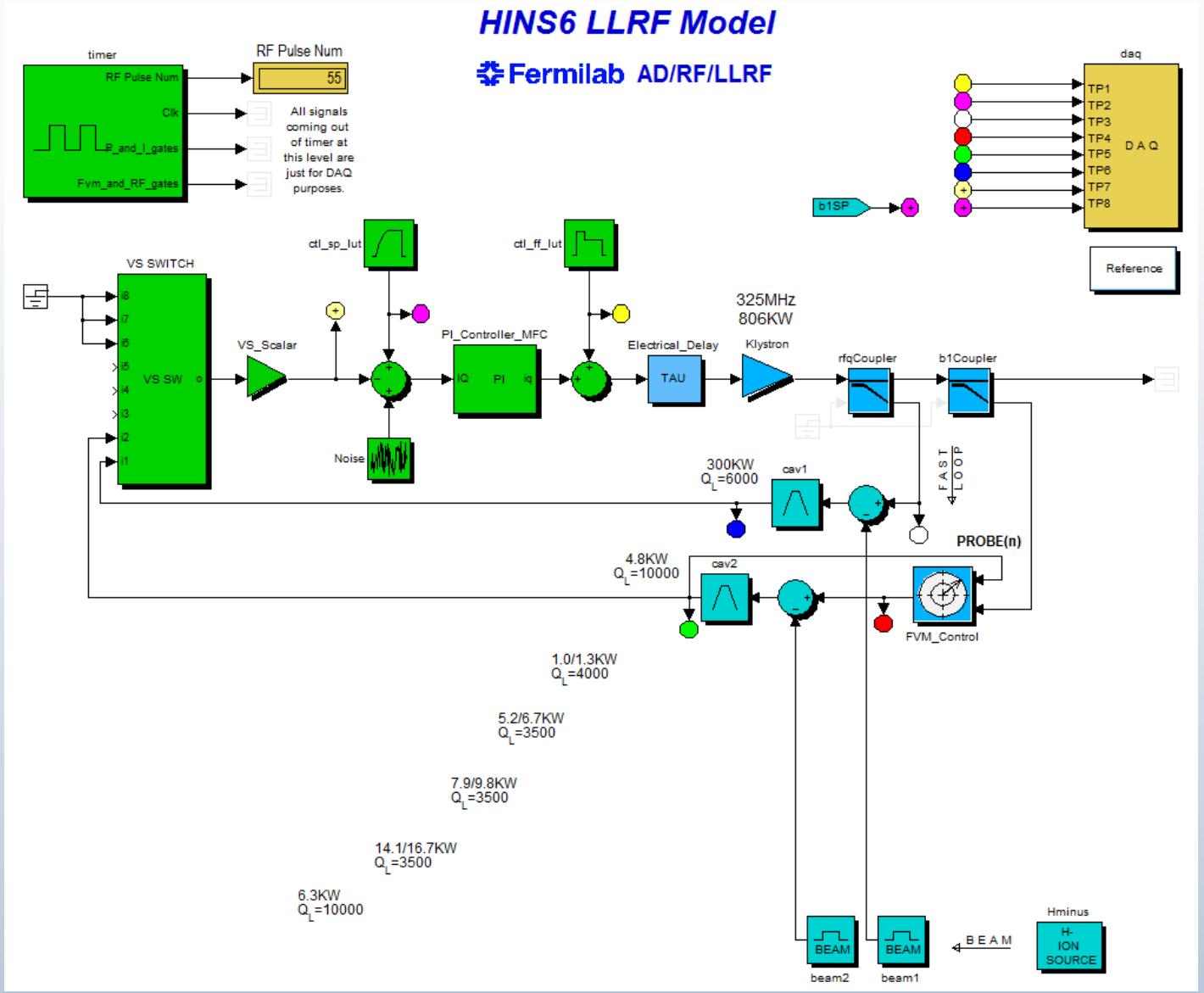


MATLAB LLRF-Model GUI



- Provides an easy access to Simulink buried parameters;
- Bode plots for RFQ loop versus P/I gain, cavity Q;
- Bode Plot for FVM power supply;

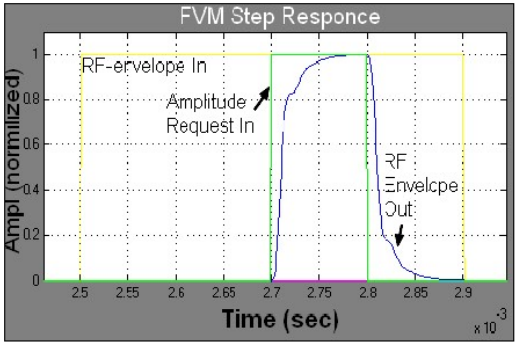
Simulink Top Model



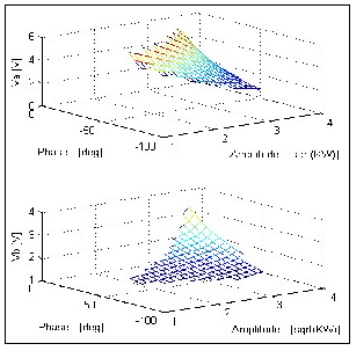
- Each subsystem is described within corresponding Simulink block;
- Two closed loops are shown:
  - RFQ;
  - Buncher 1;
- General data plotting from selected test points is done within DAQ block;

FVM LUT-based Model

FVM Output VS Step Function on "fvm_ampl" (Control Path).
Responce is Mostly Defined by PS_TF1 & PS_TF2.

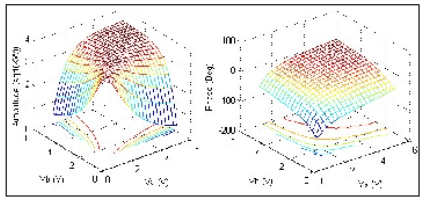


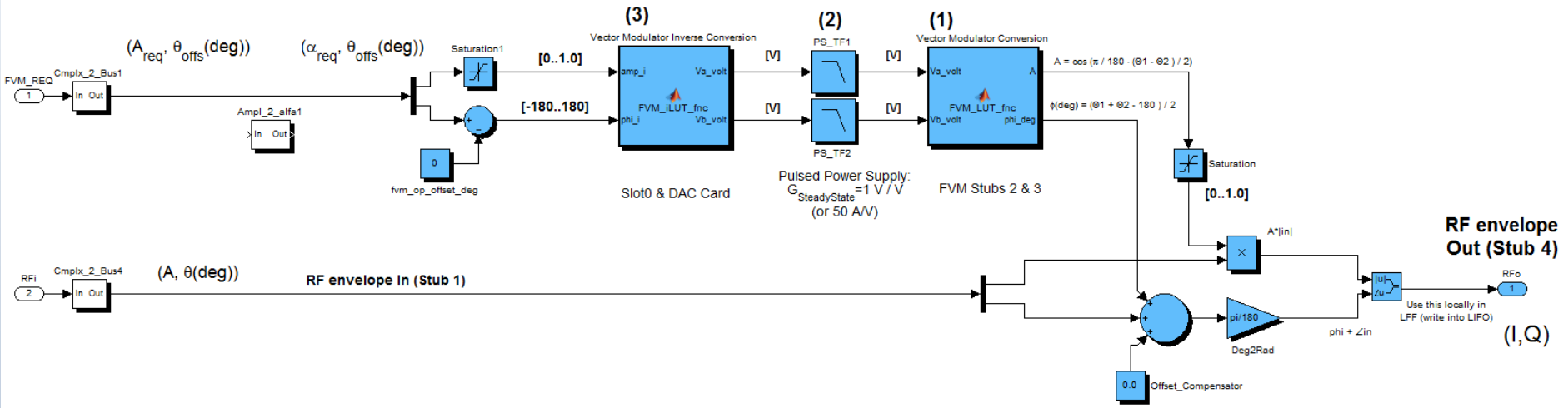
The result of "fvmScanCalcRev" calculation (from fvm_lib.m)



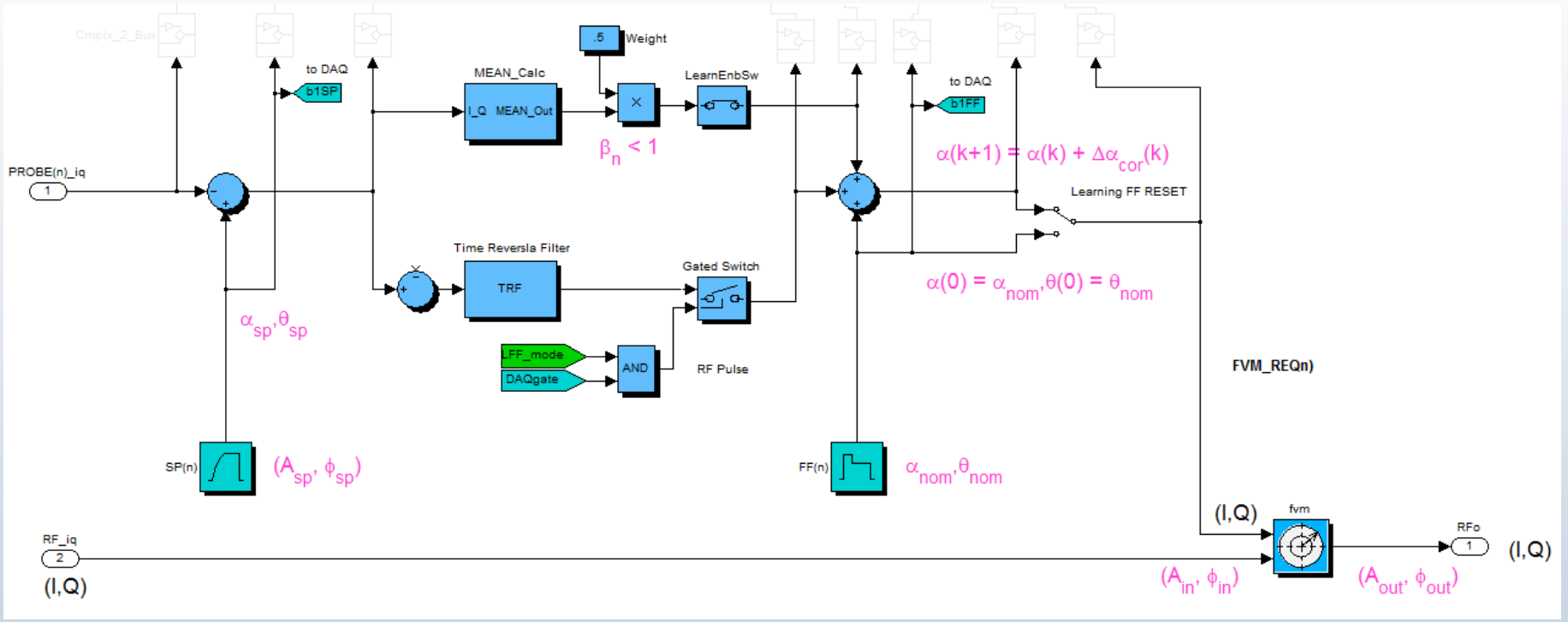
used as an input param. in func. call

The result of scan measurement (separate for each cavity)

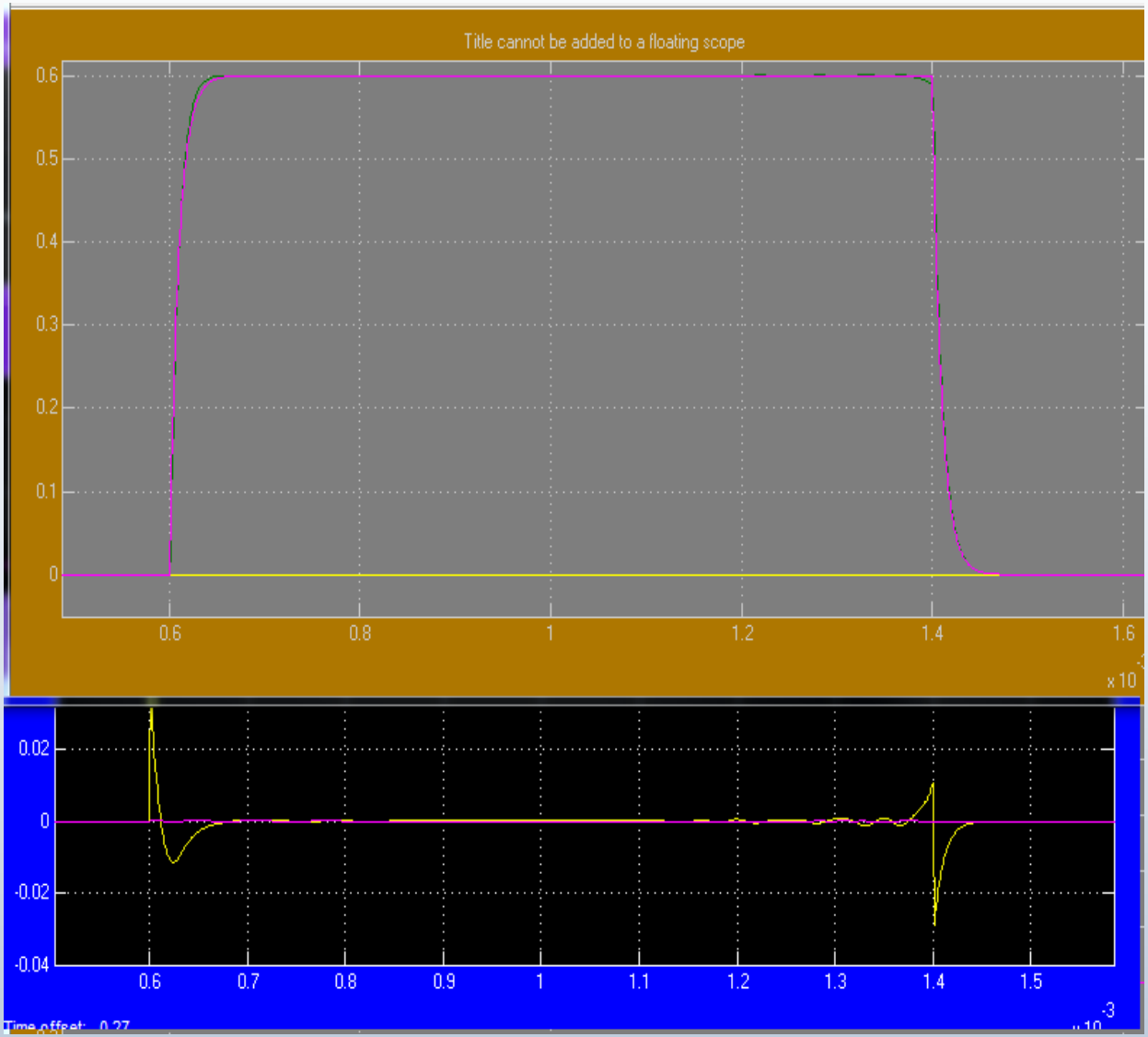




Two nested loops for FVM Adaptive Learning Controller



Buncher cavity simulation (both loops are on)



- SP request for Buncher cavity 1 – magenta;
- Cavity probe signal after B1 – green;
- Bottom plot is error = b1SP – b1CAV

Near Term Plans

- Reduce disturbances from the cavity tuning loops
  - Present worst case is about 2 deg peak
- Understand and eliminate the noise source in the FVM power supply drive chain
  - Present worst case error 1% peak
- Finish development of the Adaptive controller and commission
  - Achieve flatter pulses – flatter beam
- Study long pulse operation
  - This may require RFQ cooling (RFQ cooling will help many things)