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Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Low Level RF Control System

Brian Chase

MaRIE Meeting

March 2016

LLRF Experience and capabilities

- RF systems –
  - Broadband through 3.9 GHz
  - Copper and SRF
  - Triodes, Tetrodes, IOTs, Klystrons and Magnetrons
  - Linacs and Synchrotrons
  - Analog, DSP and FPGA based systems
  - Presently we have about 50 systems in operation

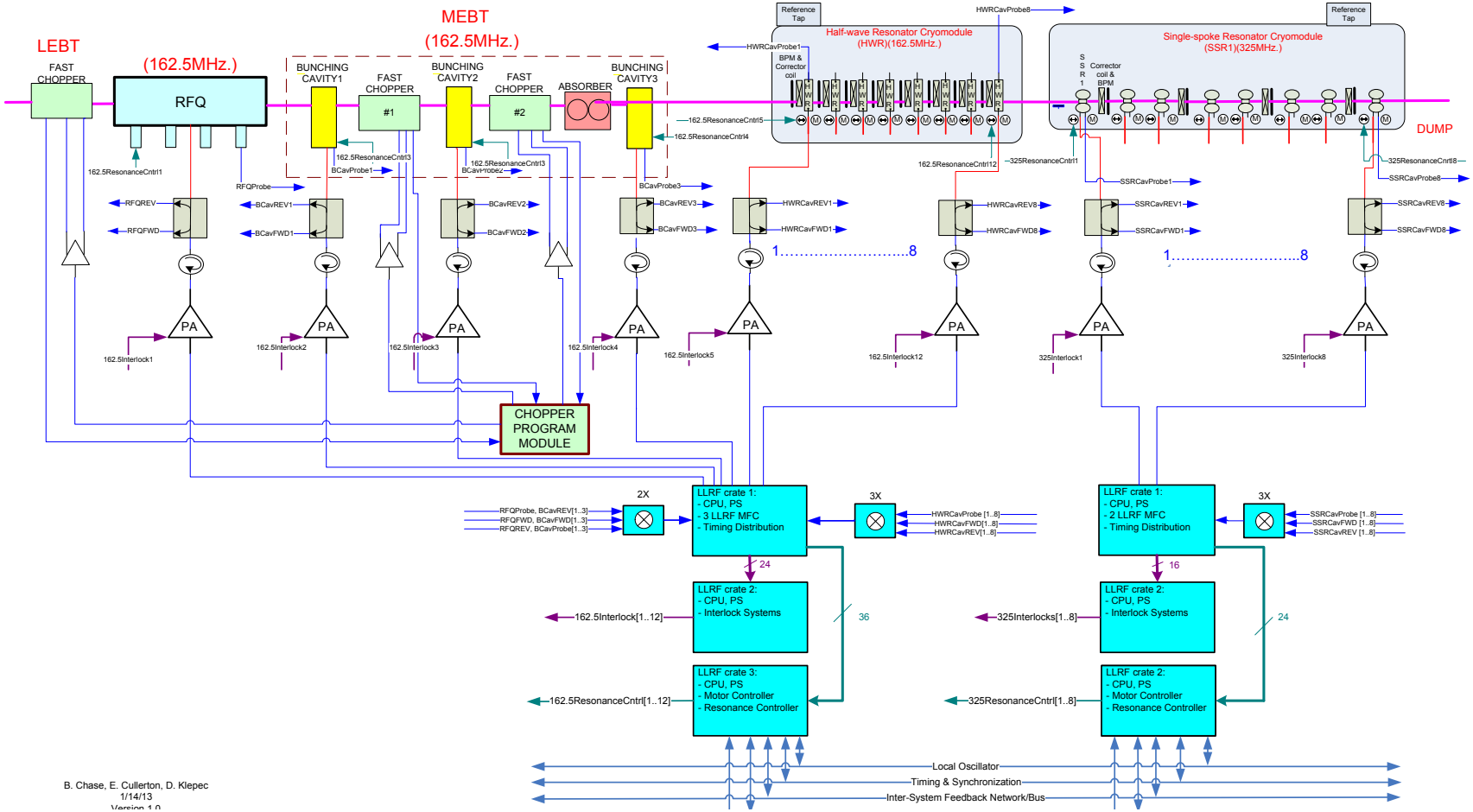
SRF LINAC Involvements

- Tesla Test Facility
- A0 Photo Injector
- ILC LLRF Development team

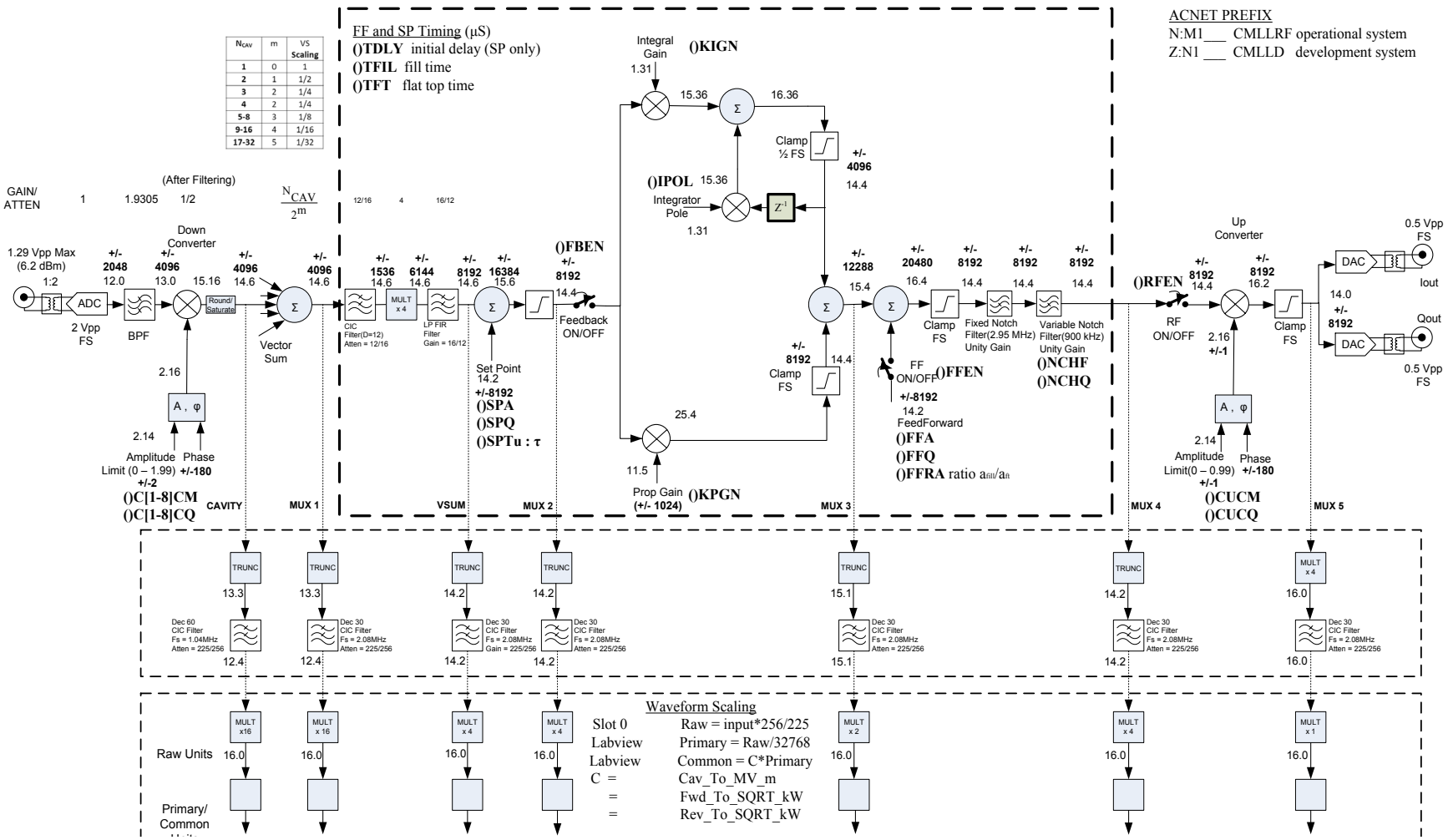
Helen Edwards

- NML -> FAST
  - 32 cavities/klystron
- Interactions with XFEL team
- Project X, PIP-II, PXIE
- CMTS-1
- LCLS-II LLRF team
  - LBNL, JLAB, FNAL, SLAC

RF Stations Diagram



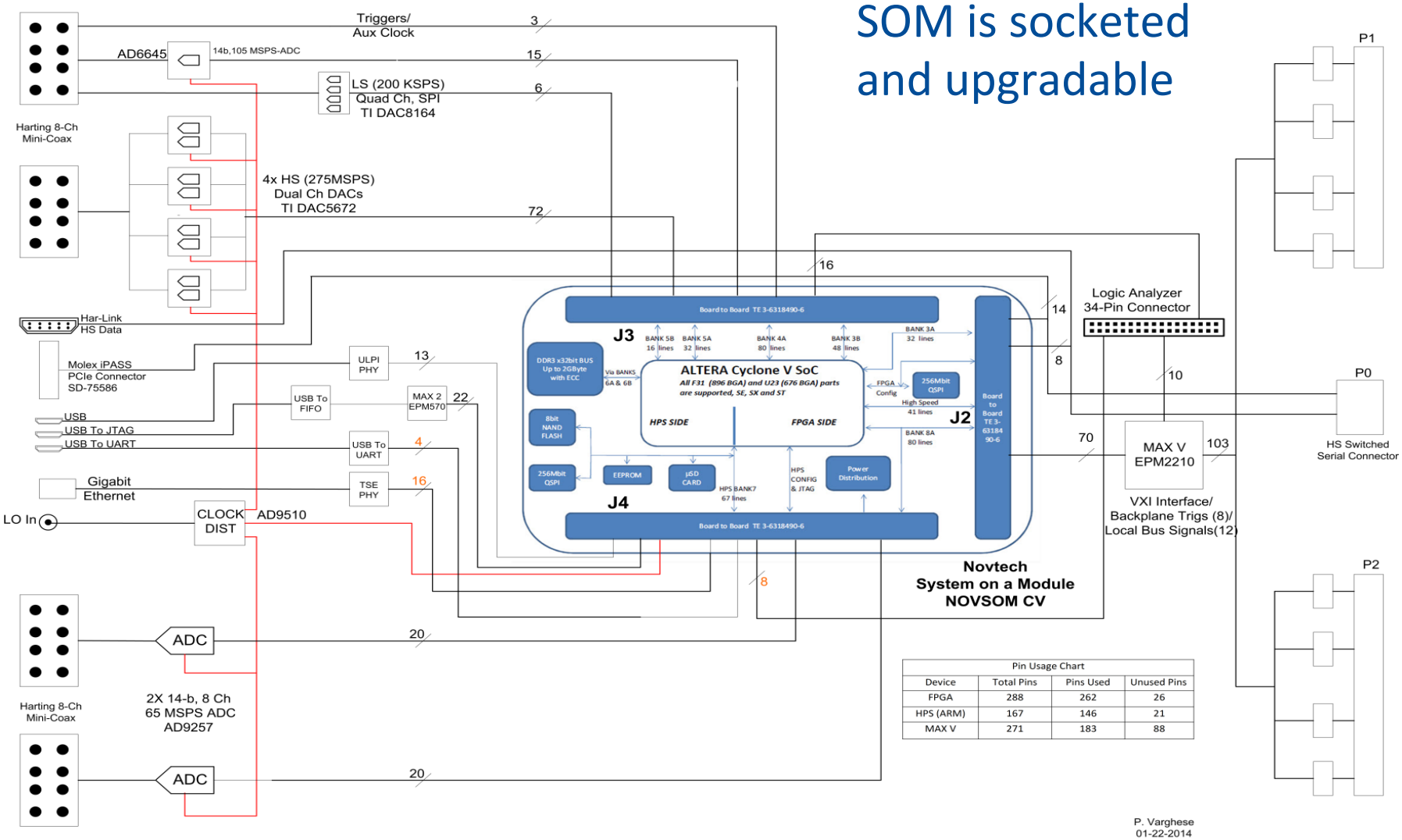
Control system interface diagram (NML)



N_{CAV}	m	VS Scaling
1	0	1
2	1	1/2
3	2	1/4
4	2	1/4
5-8	3	1/8
9-16	4	1/16
17-32	5	1/32

System on Module Multi-cavity Field Controller (SOM-MFC)

SOM is socketed and upgradable

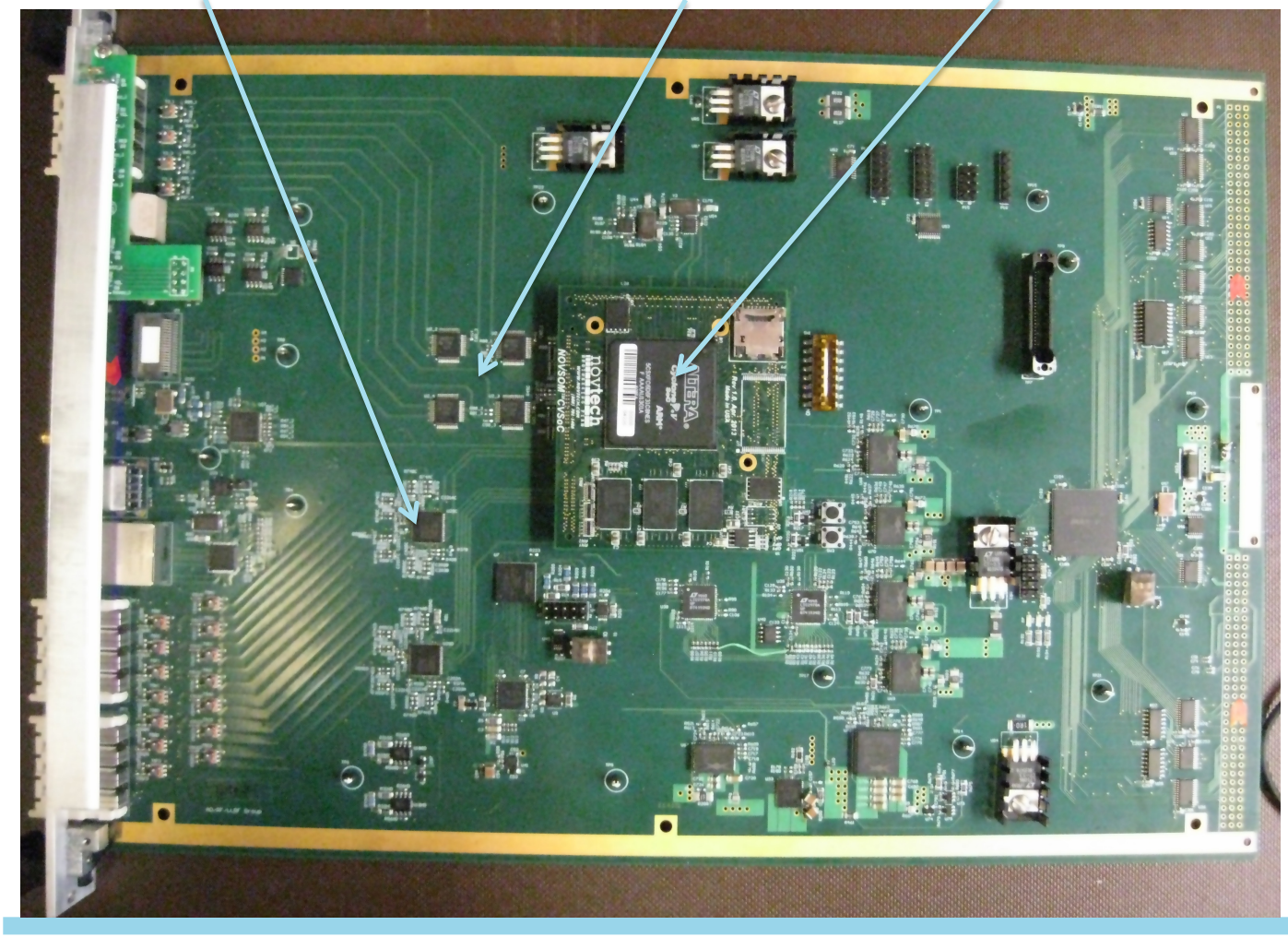


Pin Usage Chart			
Device	Total Pins	Pins Used	Unused Pins
FPGA	288	262	26
HPS (ARM)	167	146	21
MAX V	271	183	88

P. Varghese
01-22-2014

SOM-MFC LLRF Controller

(16) 14 bit ADCs (8)14 bit DACs System on Module



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NML CM1 LLRF Racks

Receivers and Up-converter

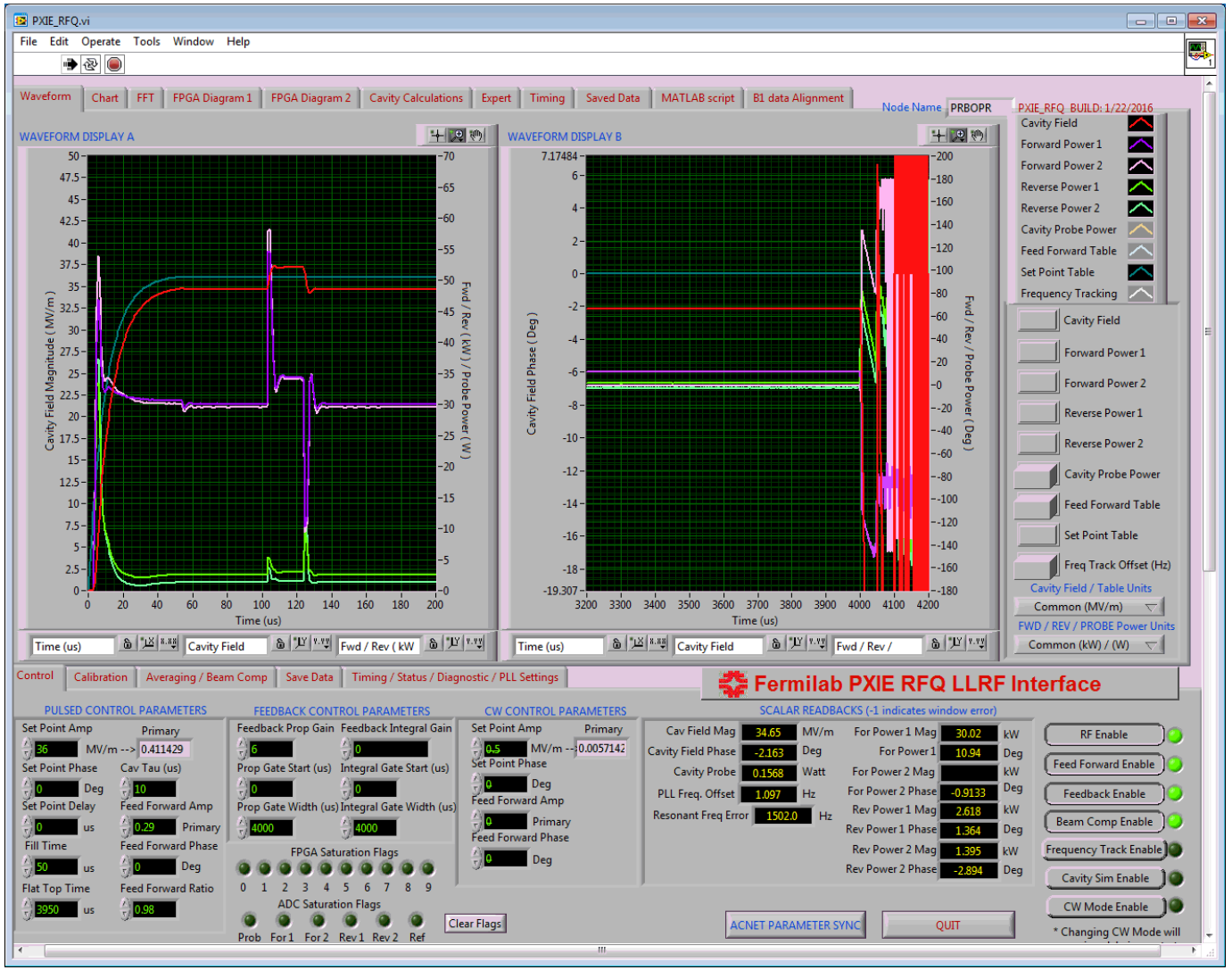
VXI CPU &
3 R3MFC Controllers

Capable of driving
32 cavities from a
single klystron

Master Oscillator

Power Supplies

LLRF Control interface



LCLS-II and MaRIE XFEL

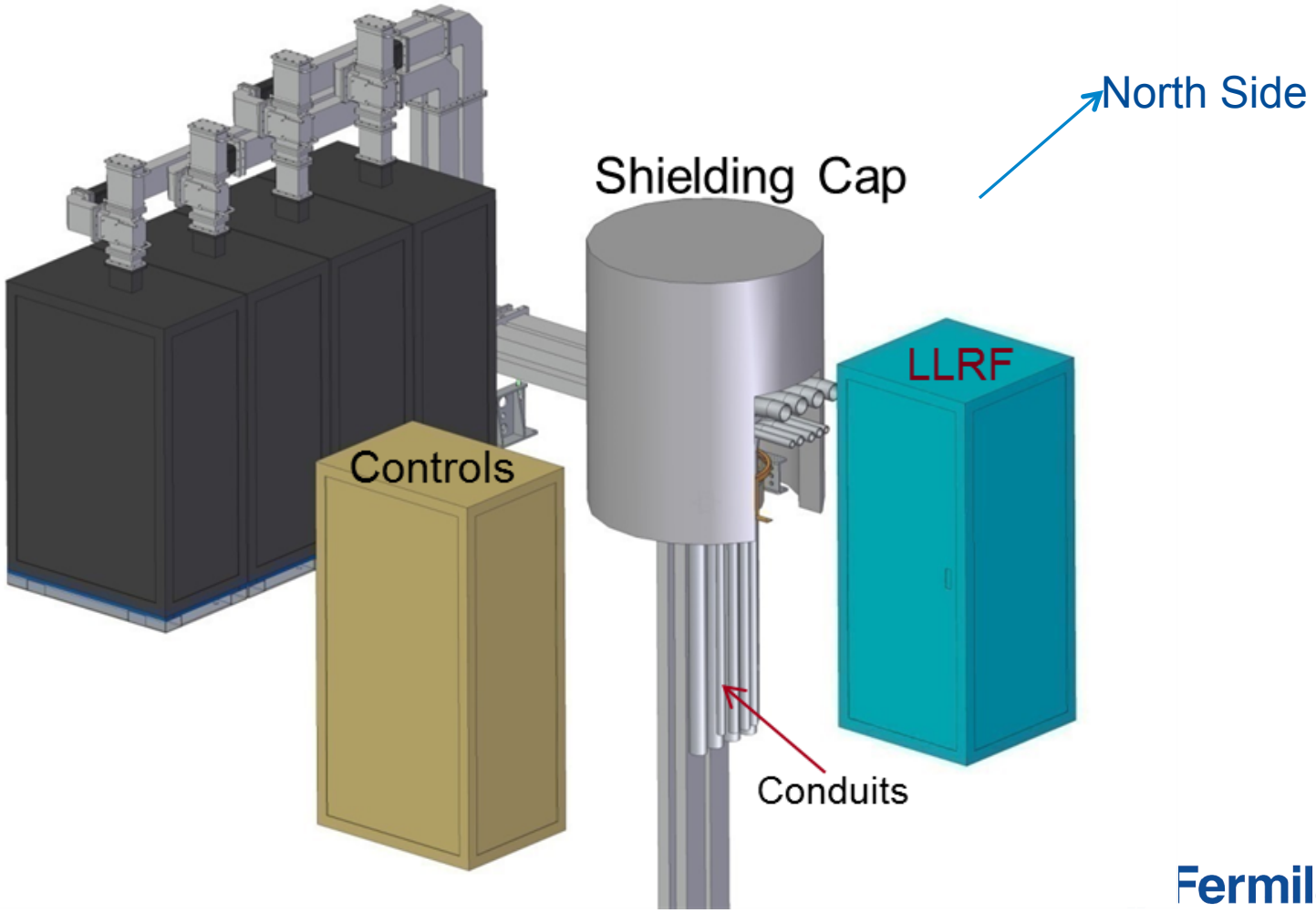
- Project is very closely aligned
  - 1.3 GHz 9-cell cavities
  - 3.9 GHz in bunch compressor section
  - 0.004% rms, 0.004 degree rms
- LCLS-II LLRF collaboration team
  - Larry Doolitte* (LBNL), Curt Hovater (Jefferson Lab), Brian Chase (FNAL), Sandeep Babel(SLAC)
  - Strong groups at each lab
- Complete prototype system tests at Jlab and FNAL this summer
- Multi-lab support for a basically drop in system

*Technical lead

RF parameters

- 900 usec fill, 100 usec beam
- 0.01%, 0.01 deg
- 60 Hz operation
- 10 MW klystrons split 26 ways
- Ql = 2.9E6

LCLS-II 1.3 GHz HPRF Penetration Layout



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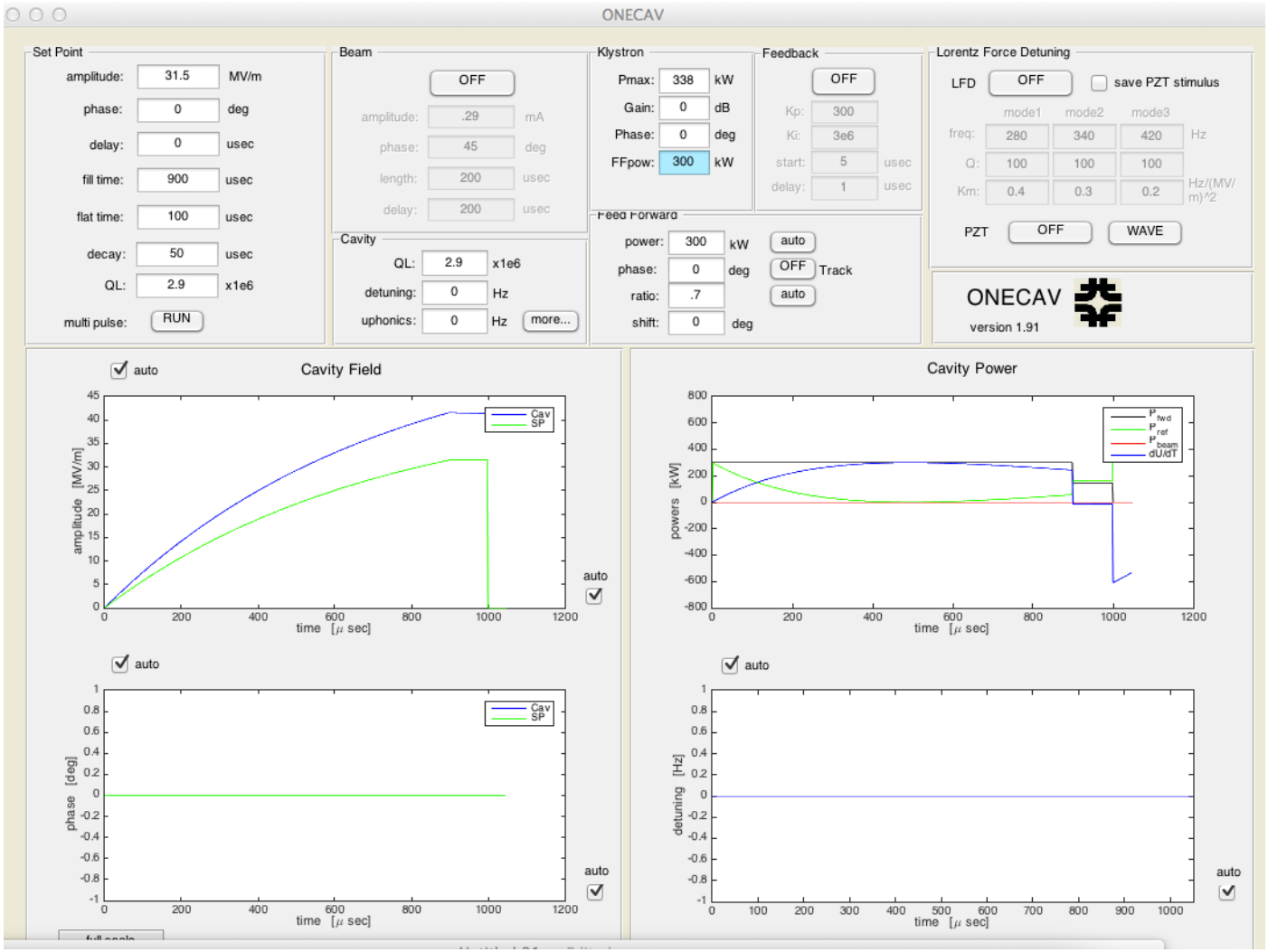
Nantista, Stewart w/ team input

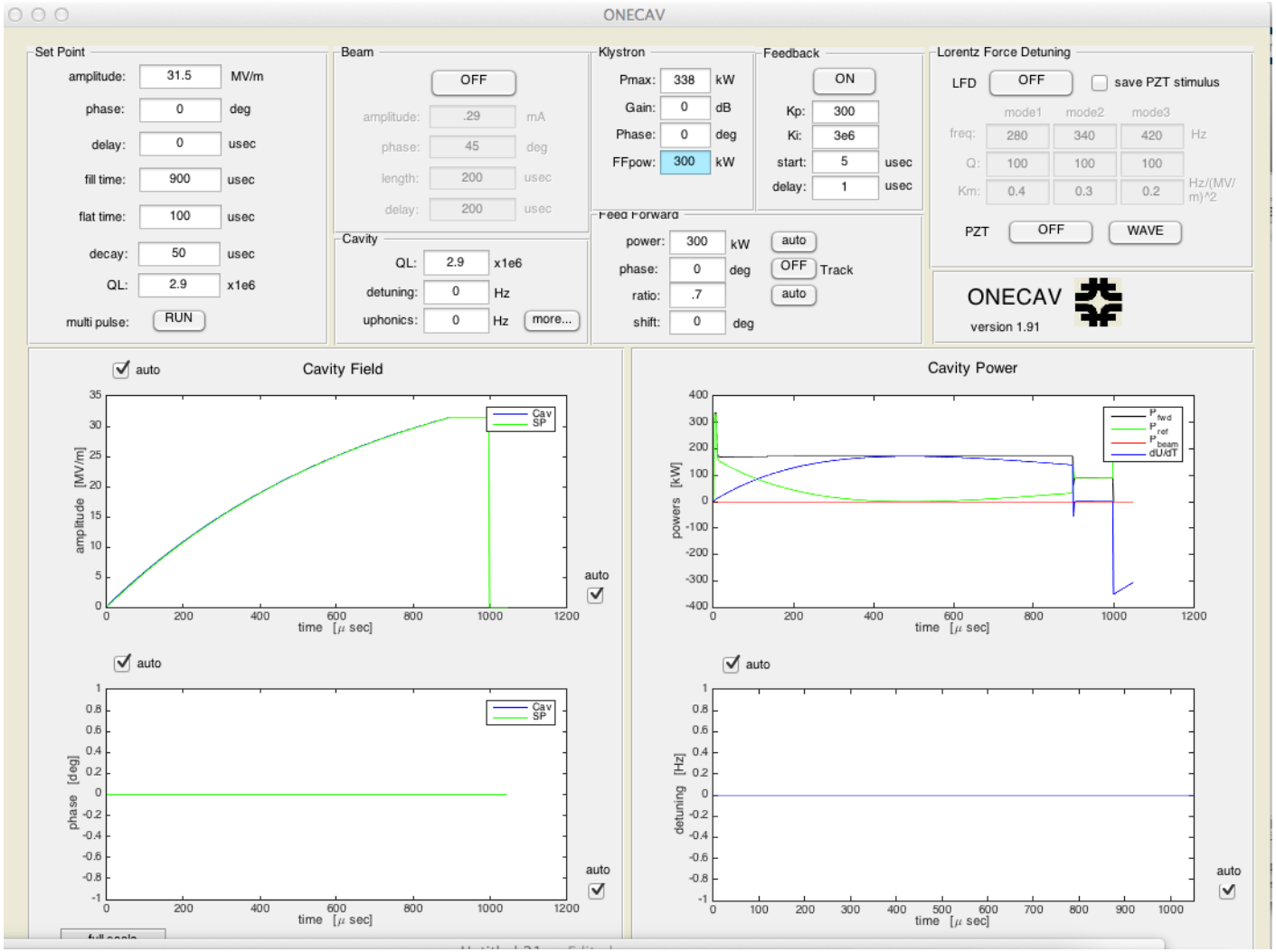
Because of the XFEL style split

- Best technical fit
- Recommend that the XFEL LLRF system be cloned
  - It is developed by a very large team, has all the firmware and software
  - Hardware is available from industry
- If this is nonviable for non-technical reasons then the LCLS-II team is very capable to complete this project

Feedforward only 300kW 2.9E6



Closed loop with current parameters



Optimized for power/fill/flattop/cryo

550usec fill
500usec flattop