Digital LLRF for Max-IV

Lars Malmgren, Antonio Milan, Robert Nilsson, Angela Salom

Maxlab, Lund University - National Electron Accelerator Laboratory for Synchrotron Radiation Research, Nuclear Physics and Accelerator Physics

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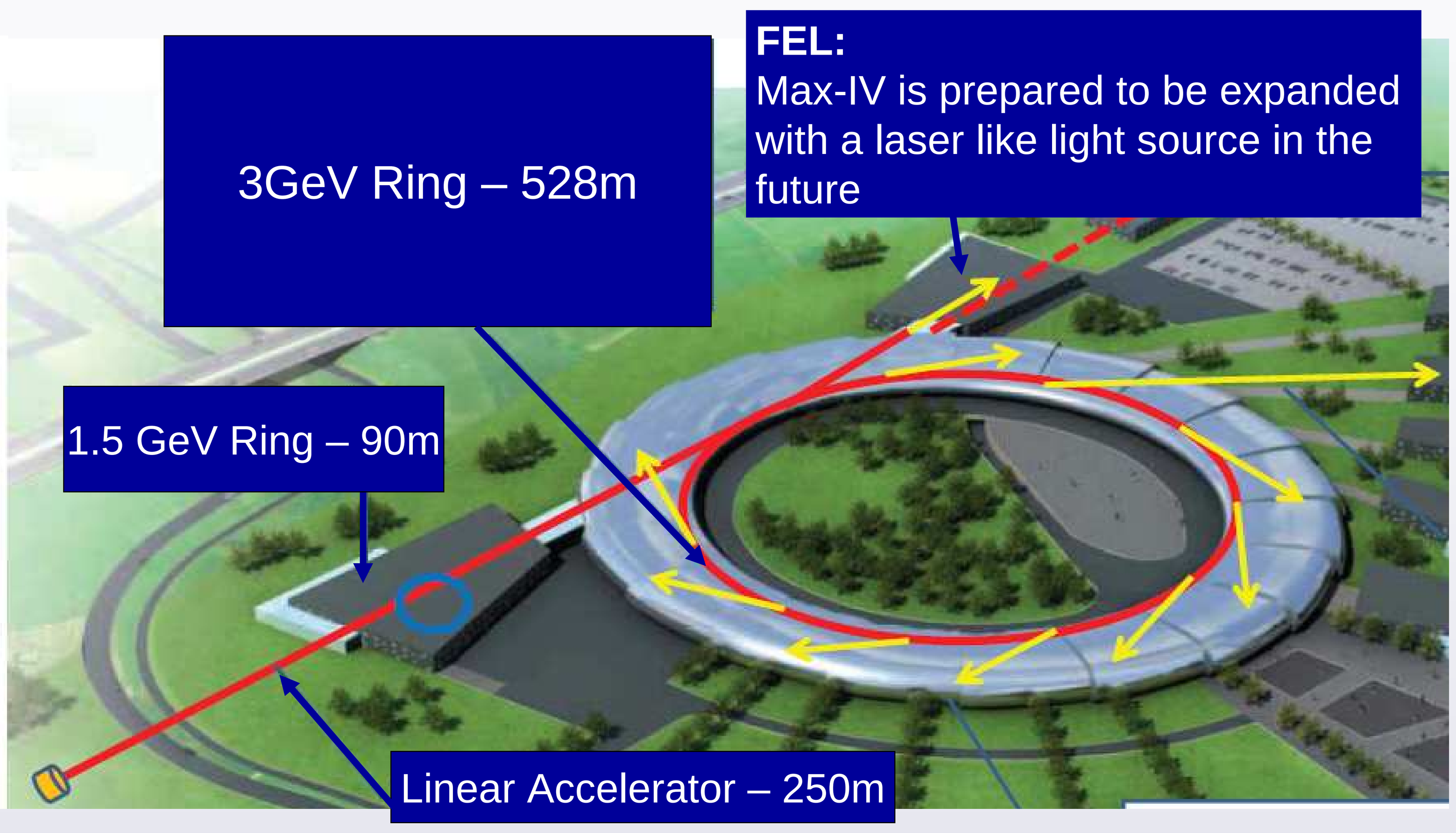
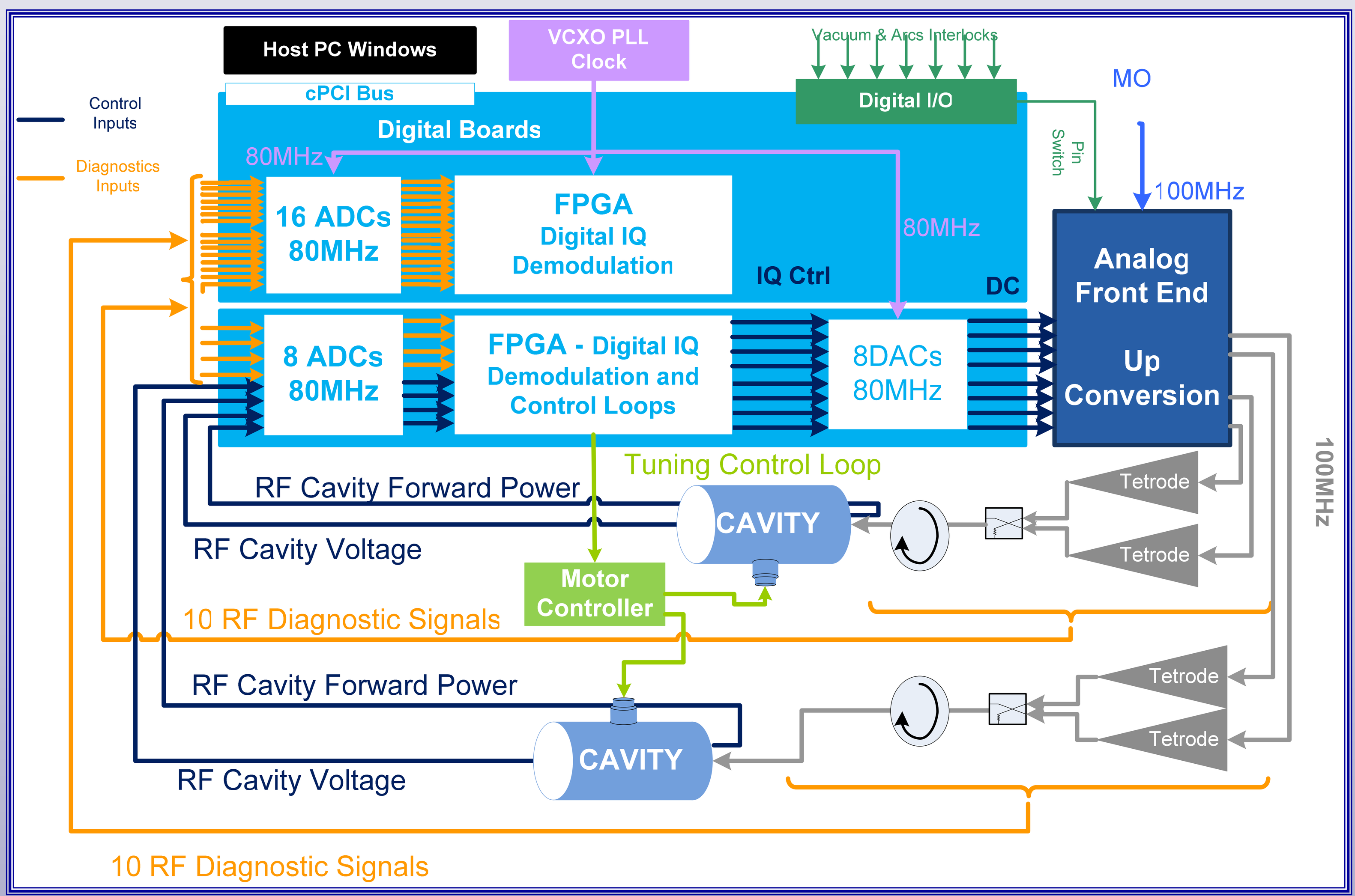
Introduction

- ✓ **Max-IV will be 3rd generation synchrotron light source in Lund, Sweden**
- ✓ **The accelerators of Max-IV will be:**
  - 1 Linac – 250m – injecting in two SR at full energy. Prepared to be expanded with a Free Electron Laser
  - 1.5GeV SR – 96m – 500mA; full energy injection and top up operation
  - 3GeV SR – 528m – 500mA; full energy injection and top up operation
- ✓ **The characteristics of the RF Stations are:**
  - 6 RF stations in 3GeV SR; 4 RF Stations in 1.5GeV Ring.
  - Components in one RF Station
    - One Cavity: Capacitive load type and running at 100MHz
    - Two Tetrodes of 60kW each
    - One Hybrid combiner to provide 120kW
    - One Circulator
    - One 120kW Load



LLRF Conceptual Design



Main Characteristics

- Design based on ALBA LLRF Systems
- 1 LLRF system to control 2 cavities

Extra Utilities

- Automatic conditioning
- Fast Interlocks utilities (vacuum, arcs and reflected power)
- Fast and slow diagnostics
- Automatic startup
- Landau Cavity Tuning

Loops Requirements

	Resolution	Bandwidth	Dynamic Range
Amplitude Loop	< 0.5% rms	< 10kHz	30dB
Phase Loop	< 0.5º rms	< 10kHz	360º
Tuning	< ± 1º	< 1kHz	< ± 75º

Hardware

cPCI Commercial Boards (VHS-ADAC from Lyrtech)

Loops Board: 8 ADCs 14bits 105MHz; 8DACs 14Bits 480MHz; Virtex-4 FPGA; 128MB RAM; GPIO 32 bits

Diagnostics/Interlocks Board: 16 ADCs 14bits 105MHz; Virtex-4 FPGA; 128MB; GPIO 32 bits

Timing System

Commercial PLL Board (TI: CDC7005-EVM) with 80MHz VCXO locked with Master Oscillator (100MHz)

Analog Front Ends for Up-Conversion

Up-Conversion: DC signals IQ modulated with Master Oscillator signal (100 MHz) using an IQ quadrature modulator from mini-circuits.

BNC Tests Points accesible in front panel to monitor main RF signals using a scope

First High Power tests with beam in Max-III

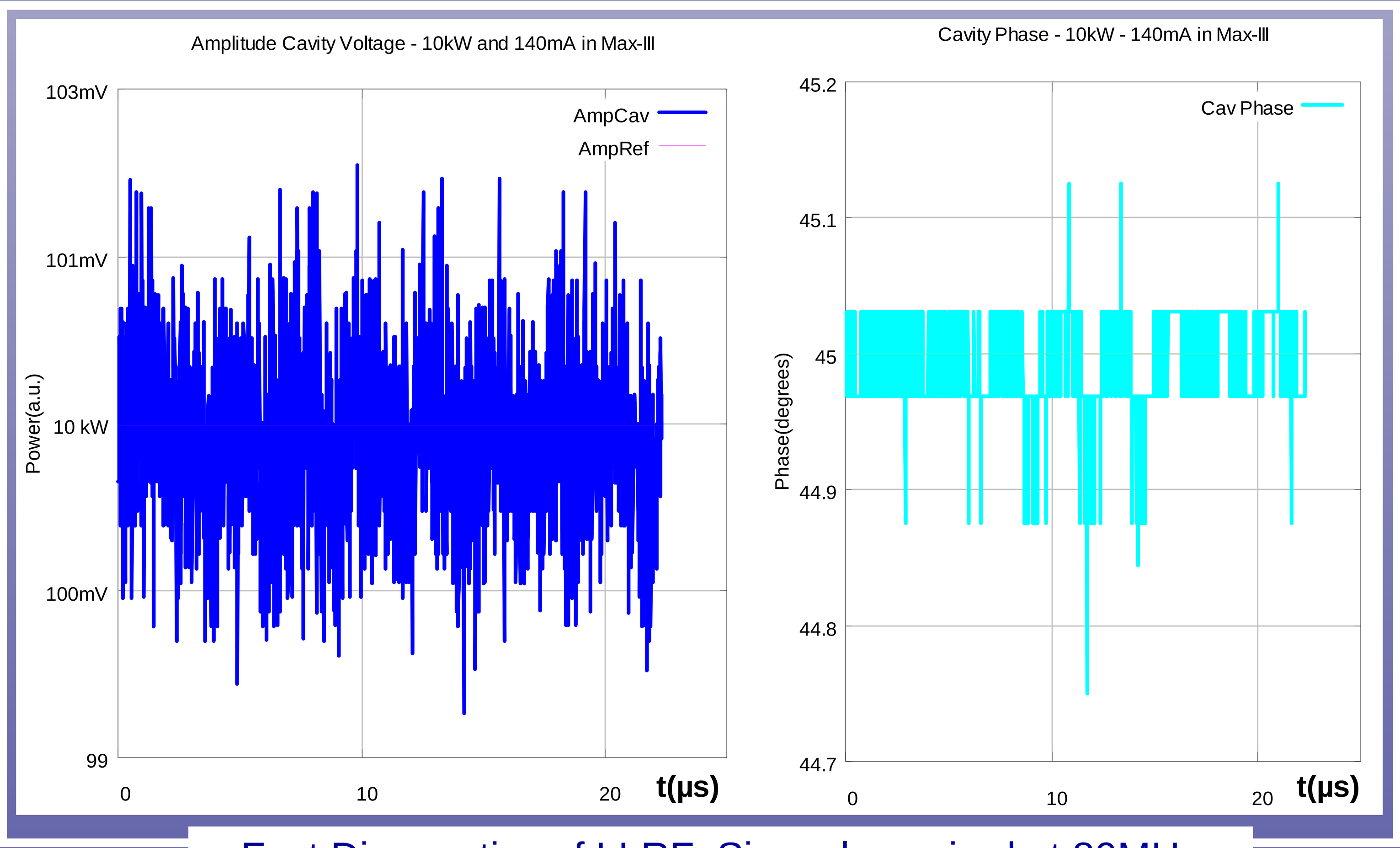
✓First LLRF Prototype was tested at high power and with beam in Max-III.

✓Amplitude, phase and tuning loops working under specifications

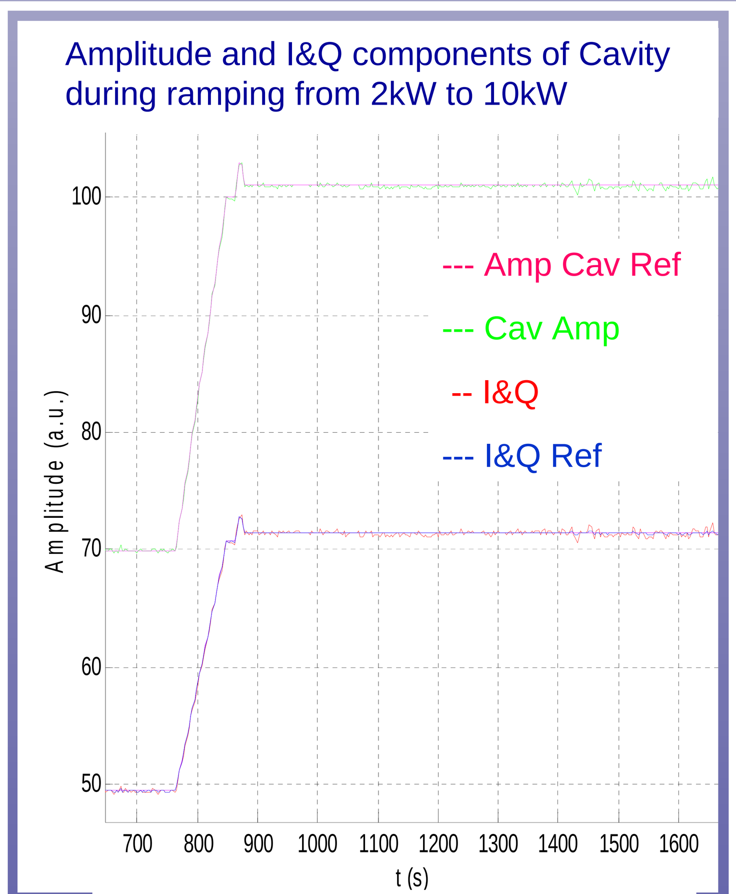
✓Fast and slow diagnostics tested

✓Local control system integrated in Tango and tested

	Loop resolution at 2kW	Loop resolution at 10kW
I&Q Cavity Voltage	0.12 % rms	0.14 % rms
	2mVpp	2.5mVpp
Amplitude Voltage	0.48% rms	0.5% rms
	2.5mVpp	3mVpp
Phase	0.24º rms	0.3º rms
	0.3ºpp	0.5ºpp



Fast Diagnostics of LLRF: Signasl acquired at 80MHz

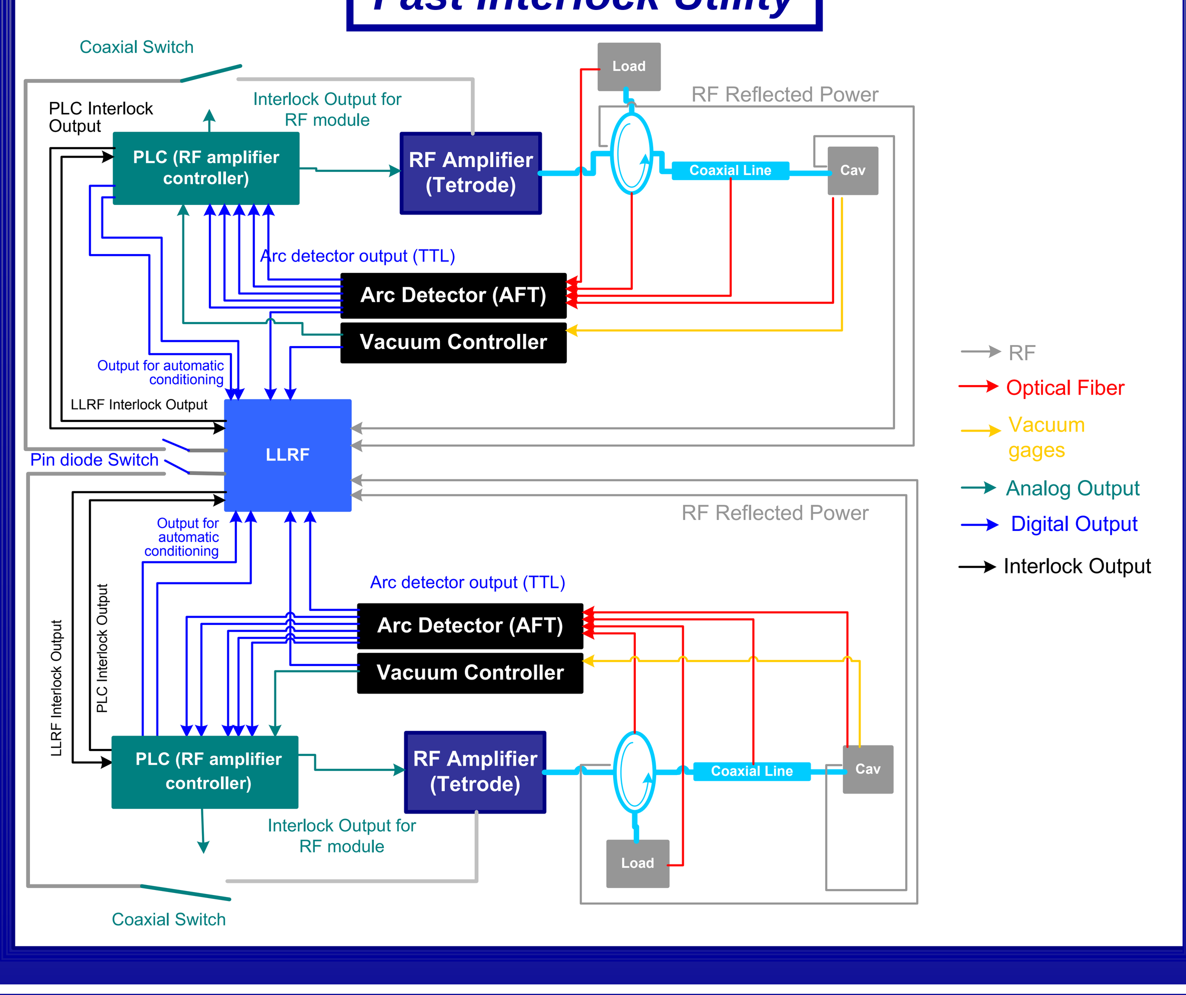


Slow Diagnostics of LLRF: Signasl acquired at 1Hz

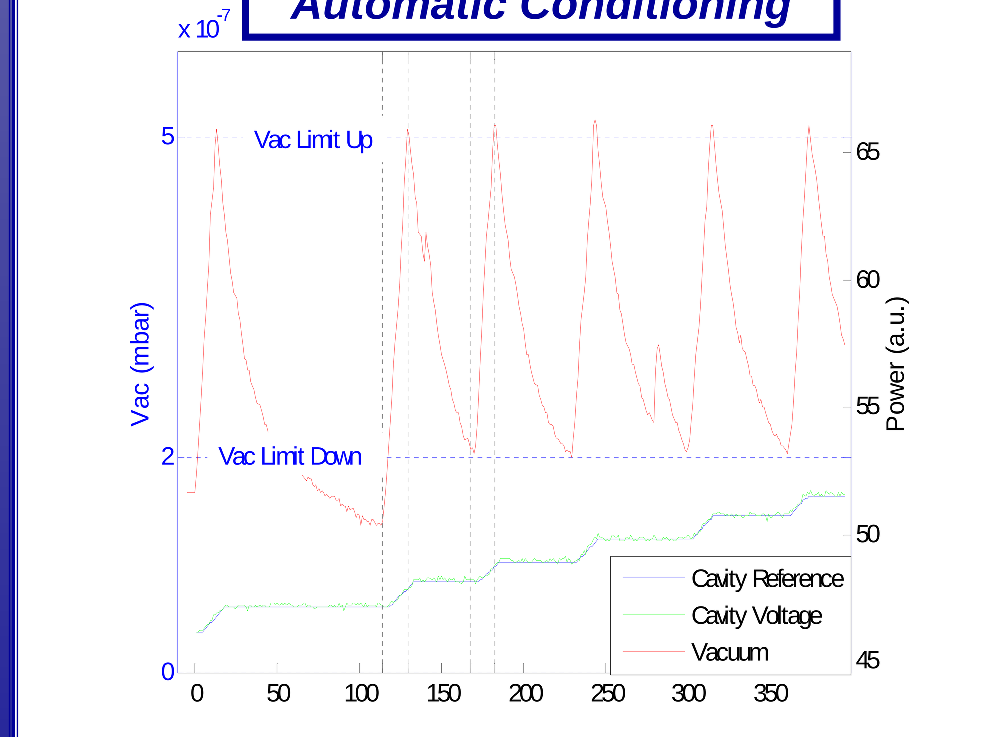
Next Steps

- ✓ Implementation of Fast Interlock Utility: RF Drive cut in less than 10µs when interlock condition happens
- ✓ Automatic Conditioning
- ✓ Landau cavity tuning
- ✓ Extra diagnostics integration
- ✓ Automatic startup
- ✓ LLRF Series production (2013)

Fast Interlock Utility



Automatic Conditioning



- •RF Drive Square modulated: Amplitude and Duty Cycle adjusted by operator
- •Vacuum < Limit Down → Amplitude/Duty Cycle Increases/Decreases
- •Vacuum > Limit Up → Amplitude/Duty Cycle remains constant until vacuum is below limit down

(Data From ALBA Cavities Conditioning)