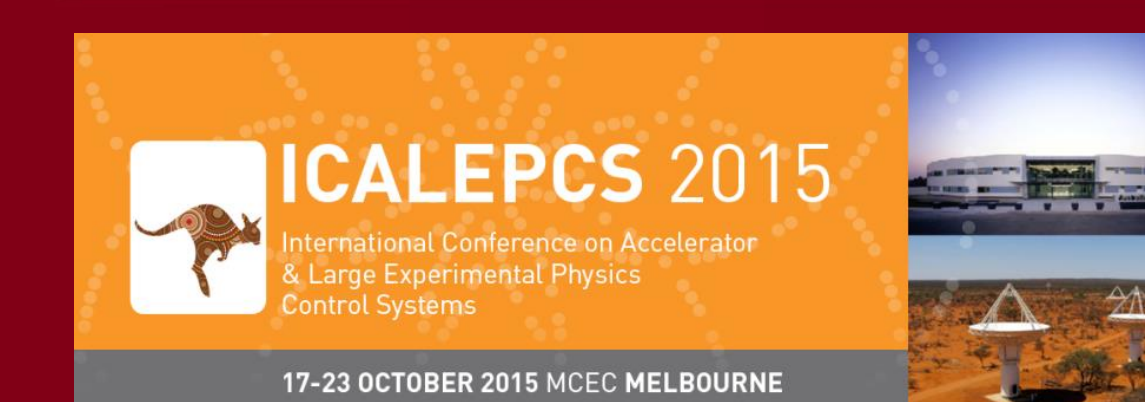


LLRF and HPRF Controls Upgrade for the LCLS XTCMV project

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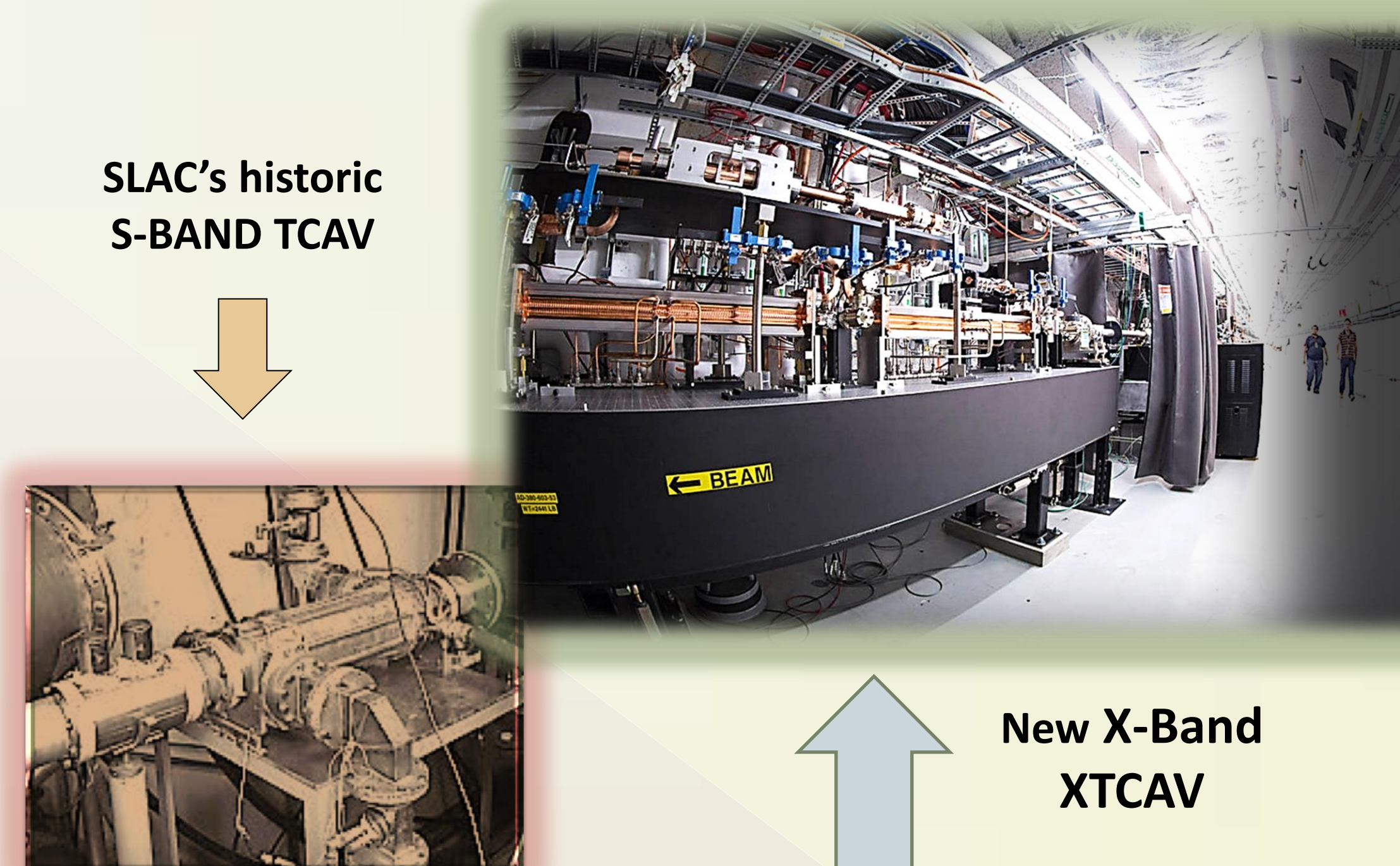


ABSTRACT

SLAC's Low Level Radio Frequency (LLRF) controls software for S-Band deflecting structures needed to be upgraded significantly when a new X-band Transverse deflector CAVity (XTCMV) was installed downstream of the LCLS undulators in Spring 2013 to assist in FEL diagnostics such as characterizing the temporal profiles of X-ray pulses that vary shot-to-shot. Very narrow RF pulses (200 ns) are output to the cavity, the precise control of which posed significant challenges. Also, a new High Power RF interlock chassis (Modulator Klystron Support Unit II) was introduced for the first time in the XTCMV RF station that needed new controls. The timing setup was also different from the rest of the Linac. This poster highlights some of the key elements of the XTCMV project and the controls upgrade efforts. XTCMV has become a successful tool in gathering data that enables reconstruction of X-ray FEL power profiles with greater resolution.

The diagnostics system includes the transverse deflector "XTCMV", the magnetic spectrometer and the Ce:YAG screen located downstream of the FEL undulator. Two 1-m-long X-band rf deflecting structures provide horizontal streaking followed by a vertical-bend dipole magnet for measuring the energy spectrum. A camera captures the transverse images of the electron beam density distribution on the diagnostic screen.

S-BAND TCAV → X-BAND XTCMV



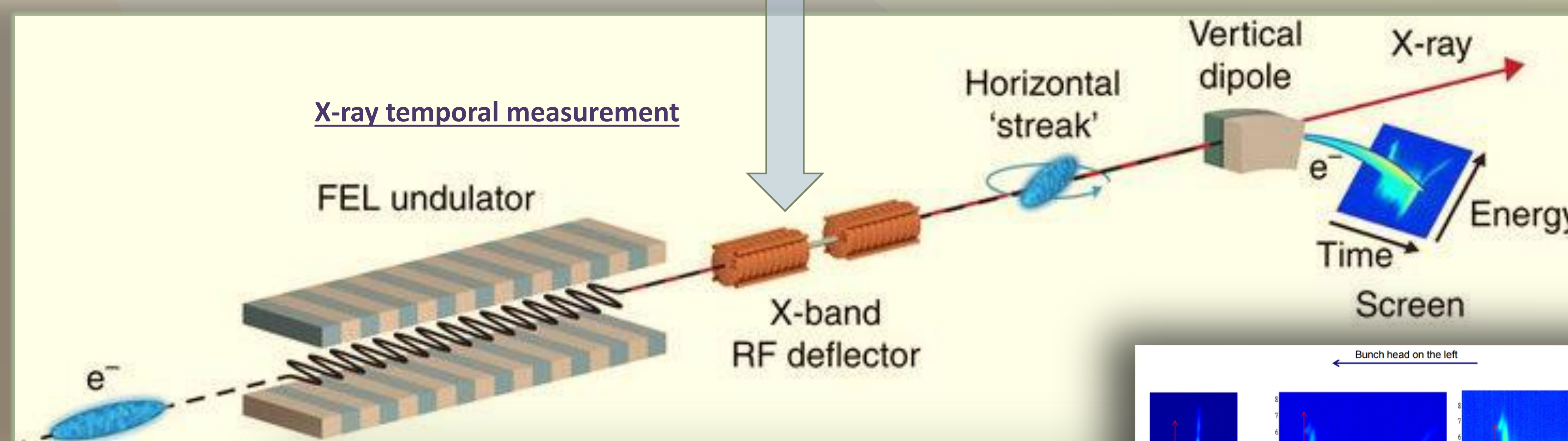
XTCMV Transverse Deflecting Cavity

- Is a key e-beam deflecting diagnostics device for characterizing FEL temporal profiles of upstream LCLS X-ray pulses which aids in better machine tuning.
- When used in conjunction with high speed camera, gives information about length and energy profile of e-beam bunches as well as pulse length and arrival time of X-rays.
- Is a successor to SLAC's S-BAND TCAV
- Is not invasive to FEL delivery.
- Commissioned in May 2013.

XTCMV Controls

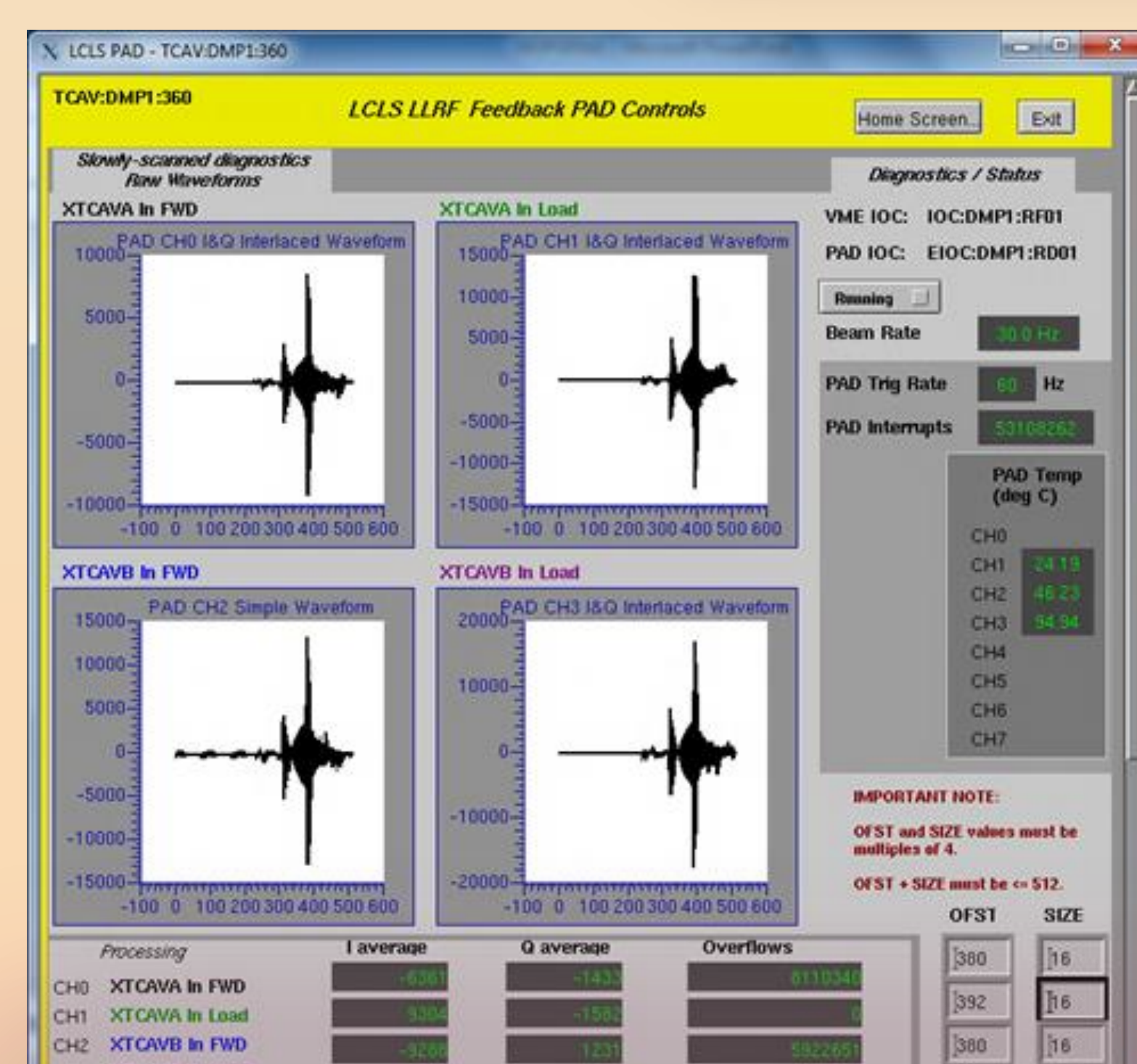
- The XTCMV was the first stand-alone RF station in LCLS with all EPICS controls. There are several key differences in this station setup.
- Unlike other RF Stations in the injector or linac:
 - Uses only VME modules for all controls. No CAMAC.
 - Has a new upgraded Modulator Klystron Support Unit (MKSU-II) for interlocks with several improvements including fast waveforms.
 - Uses EVR-RF module with clock input to better sync timing with the RF that is derived directly from the 476 MHz MDL in the tunnel.
 - Fans out just one trigger to all LLRF and HPRF HW via the MKSU-II and automatically adjusts trigger delays based on Beam Accelerate or Standby modes. Reduces complexity of timing setup.
 - Uses slow speed VME ADC to monitor Klystron parameters.

X-ray temporal measurement



XTCMV SW Upgrades

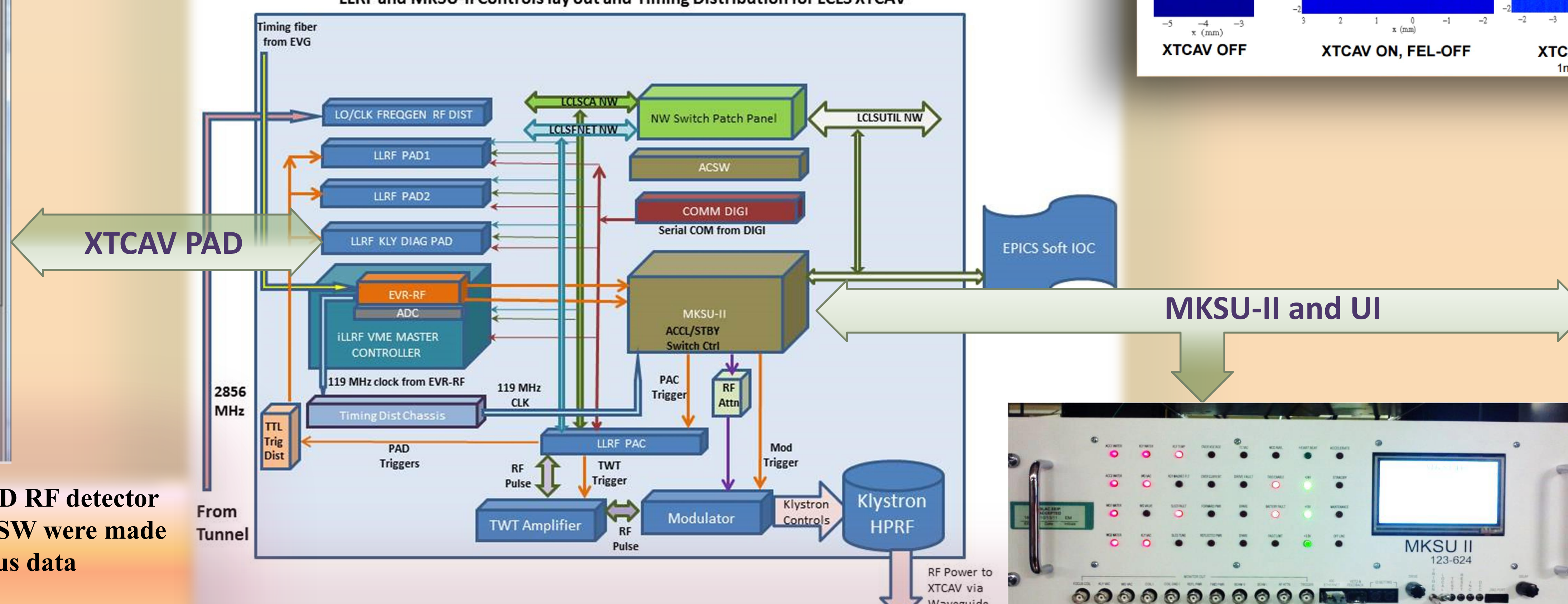
- XTCMV station was the first LCLS RF station to implement significant changes to the LLRF SW which were subsequently adopted for all EPICS-controlled RF stations.
- This was also the first (and only) station to feature a new user interface paradigm for the MKSU-II unit. It provides a simple remote view of the interlocking chassis that matches exactly what the chassis front panel displays.
- New business logic for MKSU-II controls was implemented.



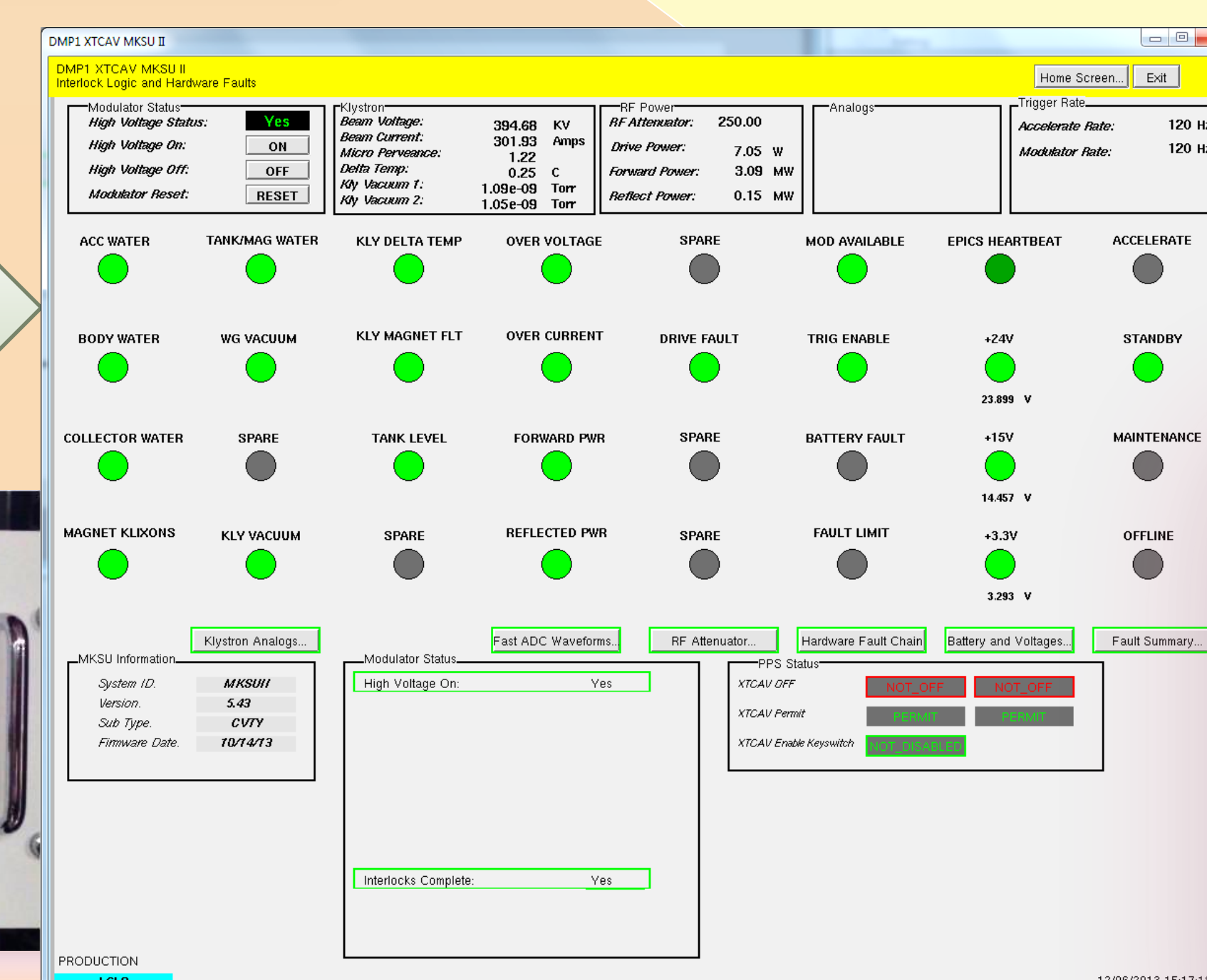
- Significant design improvements to LLRF PAD RF detector (digitizer) SW and VME Master IOC EPICS SW were made to handle 120 Hz beam rate, beam synchronous data acquisition and in feedback algorithms.

MKSU-II and LLRF Controls Layout

LLRF and MKSU-II Controls layout and Timing Distribution for LCLS XTCMV



MKSU-II and UI



- MKSU-II has a new feature that provides access to continuously updated FAST ADC waveforms for the Klystron Beam Voltage & Current and Forward & Reflected Power. The UI displays these waveforms along with fault threshold limits and ROI windows.