

New X-band RF Deflector for Femtosecond Diagnostics of LCLS-II Beams

Valery Dolgashev, Harmanpreet Bassan, Shantha Condamoor, Andy Haase, Patrick Krejcik, Timothy Maxwell, Juwen Wang

SLAC, Menlo Park, CA, 94025, USA

ABSTRACT

An X-band Transverse deflector cavity (XTCAV) has been successfully developed for femtosecond electron and x-ray pulse temporal diagnostic at the LCLS. The working frequency for the deflector is 11.424 GHz. New free electron laser LCLS-II has two undulator beamlines, one Soft-X-Ray (SXR) and another Hard-X-Ray (HXR). The Hard-X-Ray line deflector is made of two one-meter long XTCAVs. We have designed, built, installed and commissioned another, 1.5 meter long X-band deflector in the Soft-X-Ray beam line. Both Hard-X-Ray and Soft-X-Ray deflectors share one klystron. RF power is transmitted from a 50 MW klystron to a tunnel in an overmoded circular waveguide and then directed to either of the deflectors using a remotely controlled RF switch. The power split ratio can be changed arbitrarily, and both deflectors can work simultaneously. The system is successfully commissioned and operational.

PROJECT GOALS

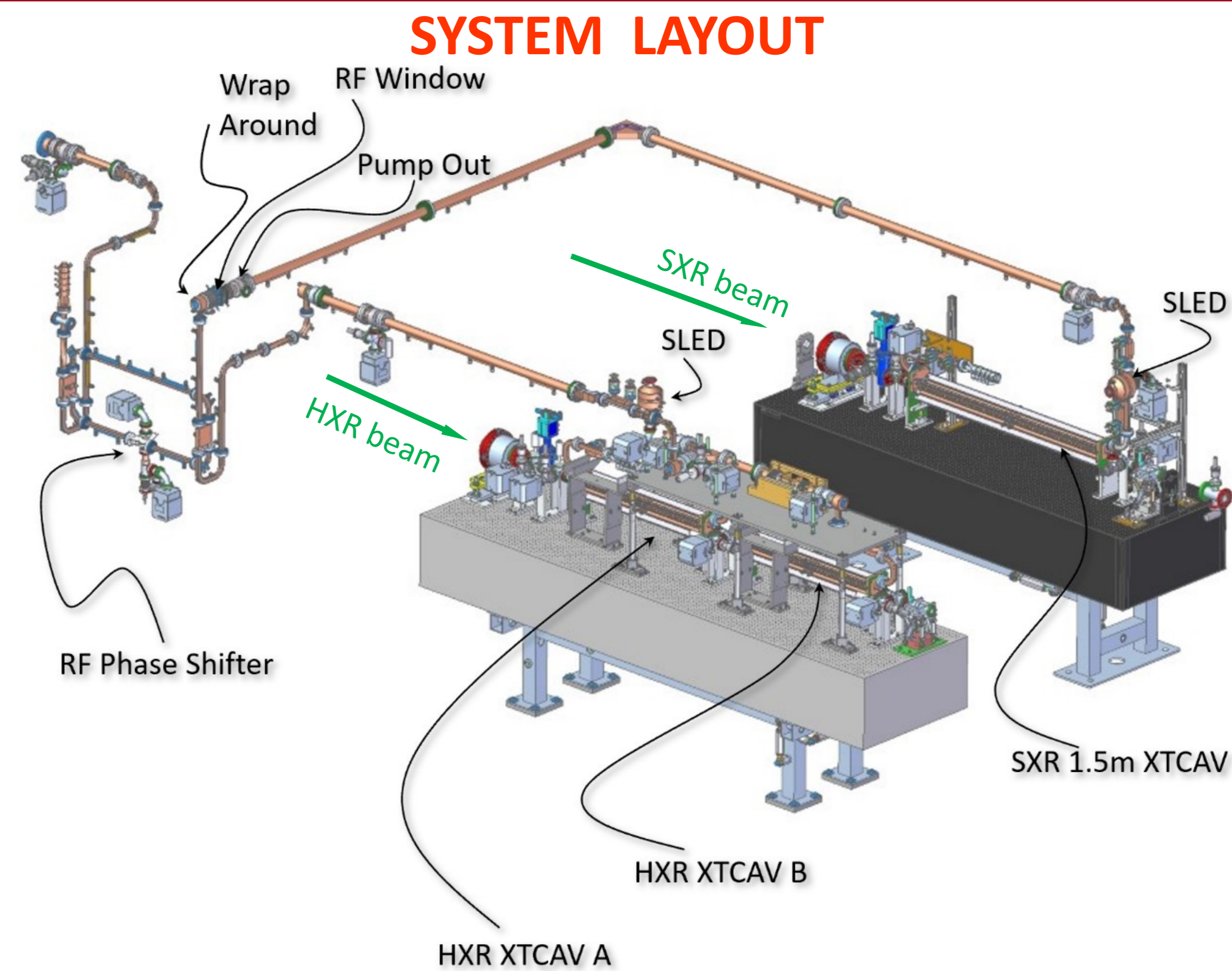
- Build system for measurements of longitudinal phase space of the electron beams with femtosecond resolution which allows reconstruction of time structure of FEL X-ray pulse for interleaved operation in two X-ray beamlines.
- Up to 120 Hz acquisition rate.
- Build, tune and install a new, longer RF deflector in the Soft X-Ray beamline to compliment existing rf deflector in Hard-X-Ray beamline.
- Build, tune, install a new SLED rf-pulse compressor for operation with new 1.5 m deflector.
- Leverage of existing high-power X-band RF klystron to drive both XTCAVs.
- Distribution of rf power between two beamlines using a multi-megawatt RF variable power splitter controlled with a phase shifter.
- Commissioning and operation with copper linac, then upgrade of control system for superconducting linac of LCLS-II.

COMMON PARAMETERS OF BOTH 1 M AND 1.5M TRAVELING WAVE DEFLECTORS

Parameter	Value
Frequency	11.424 GHz
Beam pipe diameter	10 mm
Group velocity	0.032 c
Cell quality factor	6300
Dipole mode frequency separation	100 MHz
Phase advance per cell	2pi/3
Max magnetic field (input coupler)@20MW	405 kA/m
Max electric field in first regular cell@20MW	115 MV/m
Peak pulse heating in coupler at 110 ns@20 MW	23 °C

1 M VS 1.5 M

Parameter	1m	1.5m
Total number of cells	117	171
Total structure kick@20MW	24 MeV	30 MeV
Total attenuation	0.62 Np	0.9 Np
Power dissipated in the structure@20MW	14 MW	16.7 MW
Structure length (with beam pipes)	1.185 m	1.657 m
Fill time	~110 ns	~160 ns

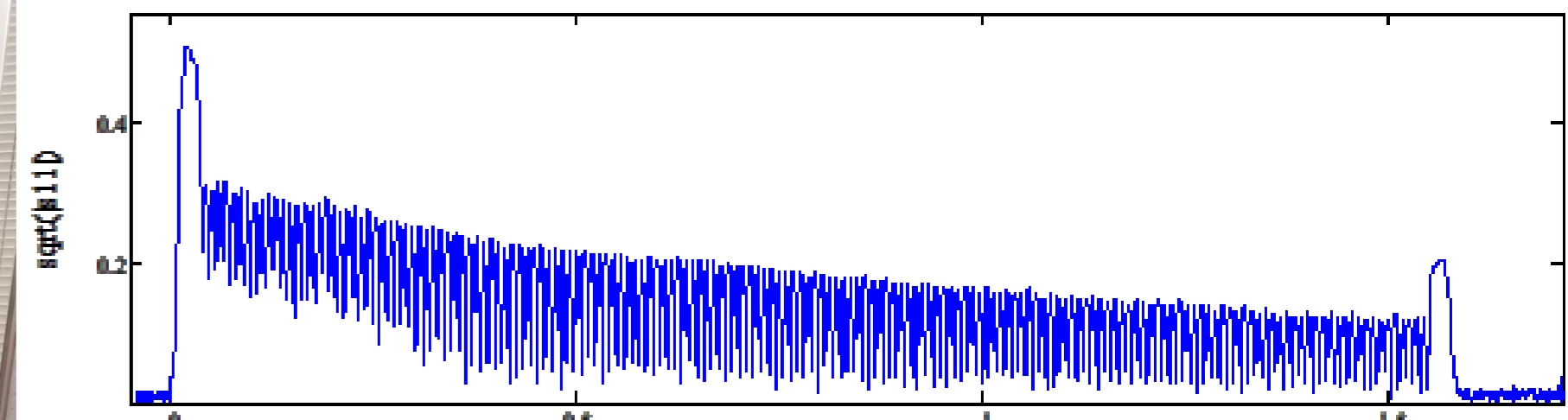


System layout showing the rf deflectors (XTCAVs) of HXR and SXR beam lines

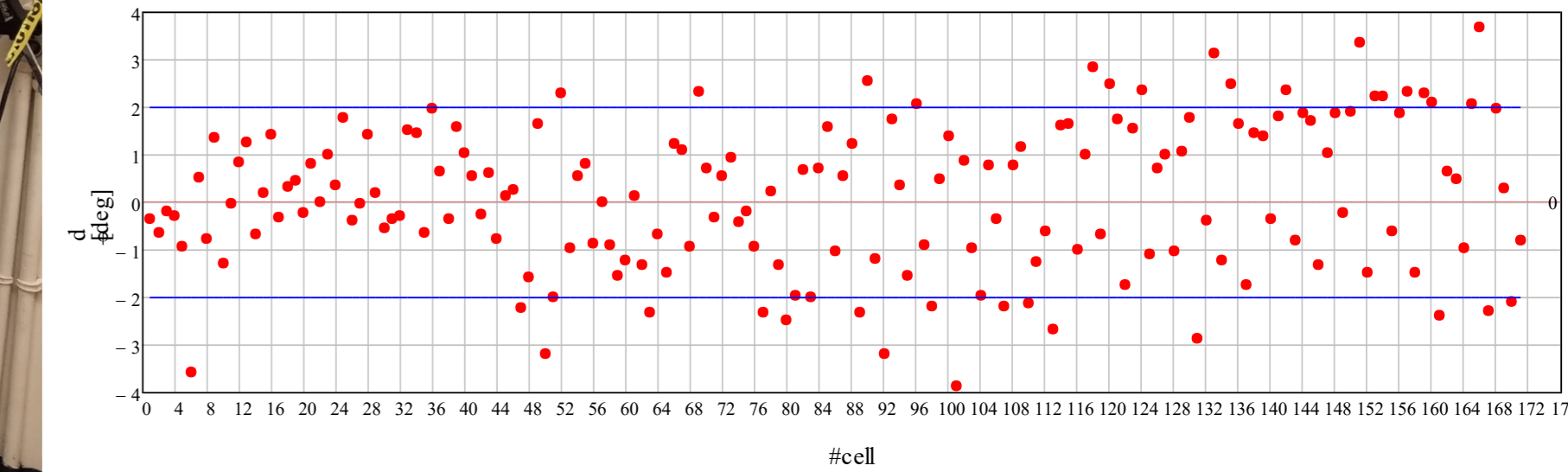


Final beadpull measurements of new 1.5 m rf deflector

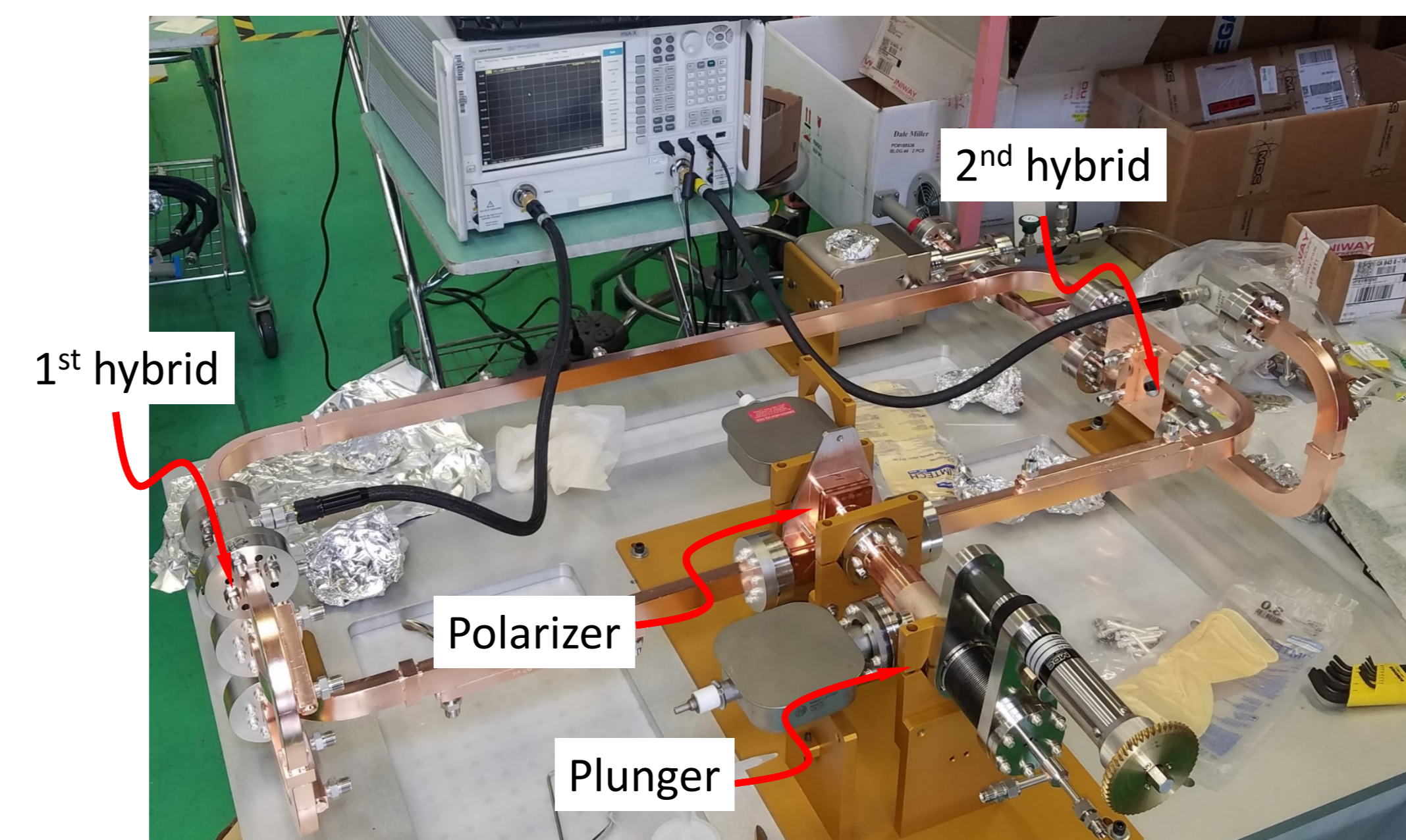
TUNED 1.5 M RF DEFLECTOR



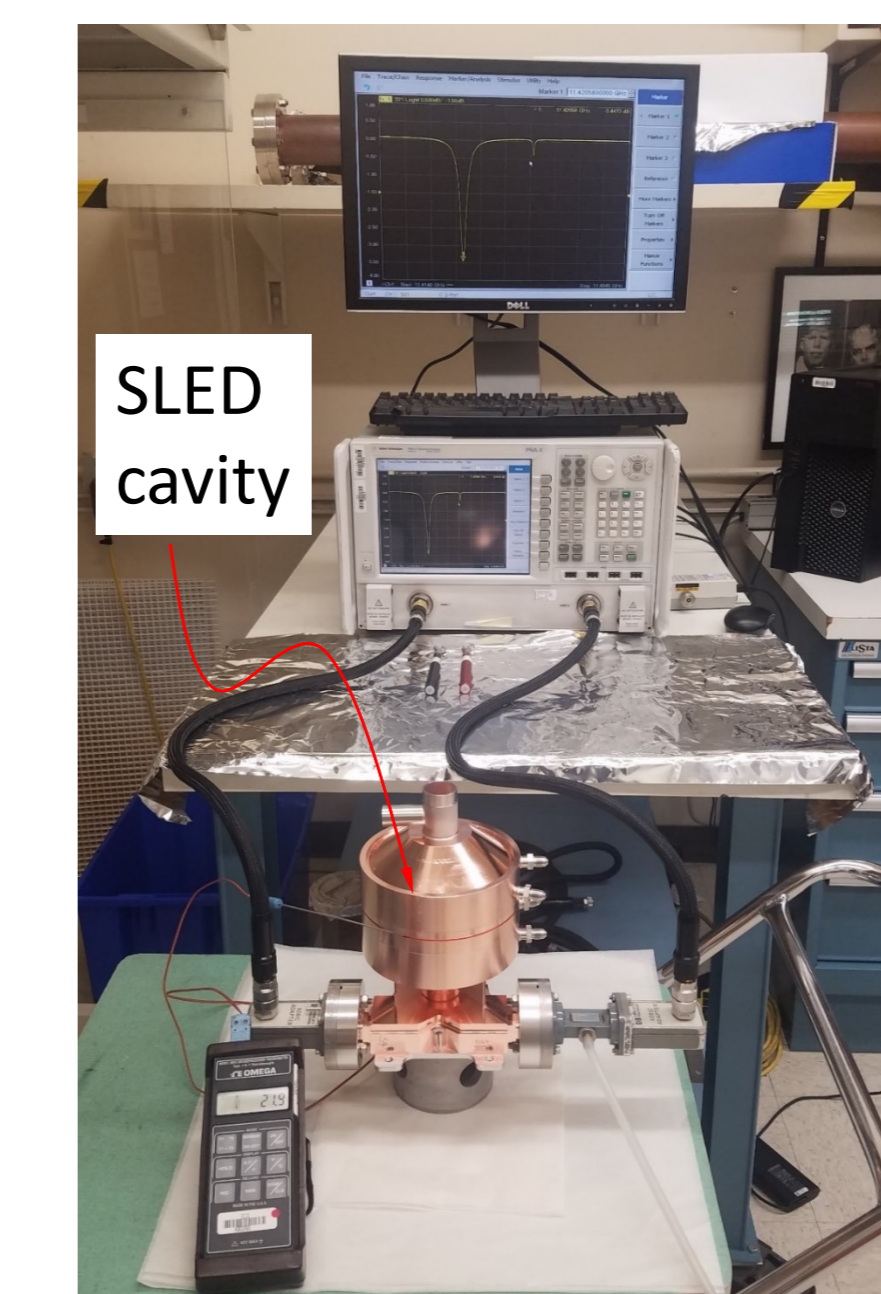
RF electric field amplitude along the central axis of the 1.5m rf deflector



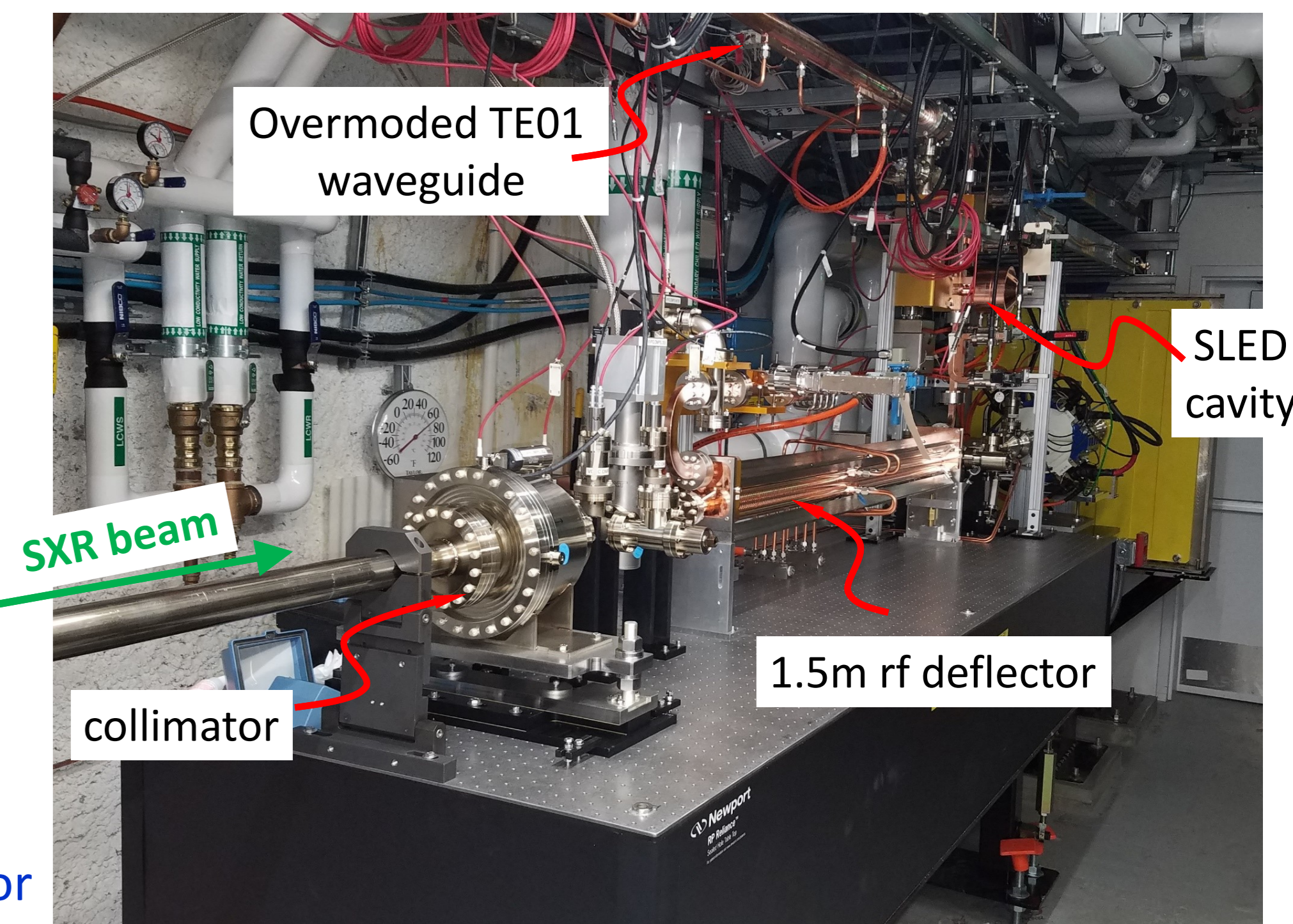
Difference between beam synchronous phase and rf phase along the central axis of the 1.5 m rf deflector



Cold test of new RF switch, or variable power splitter



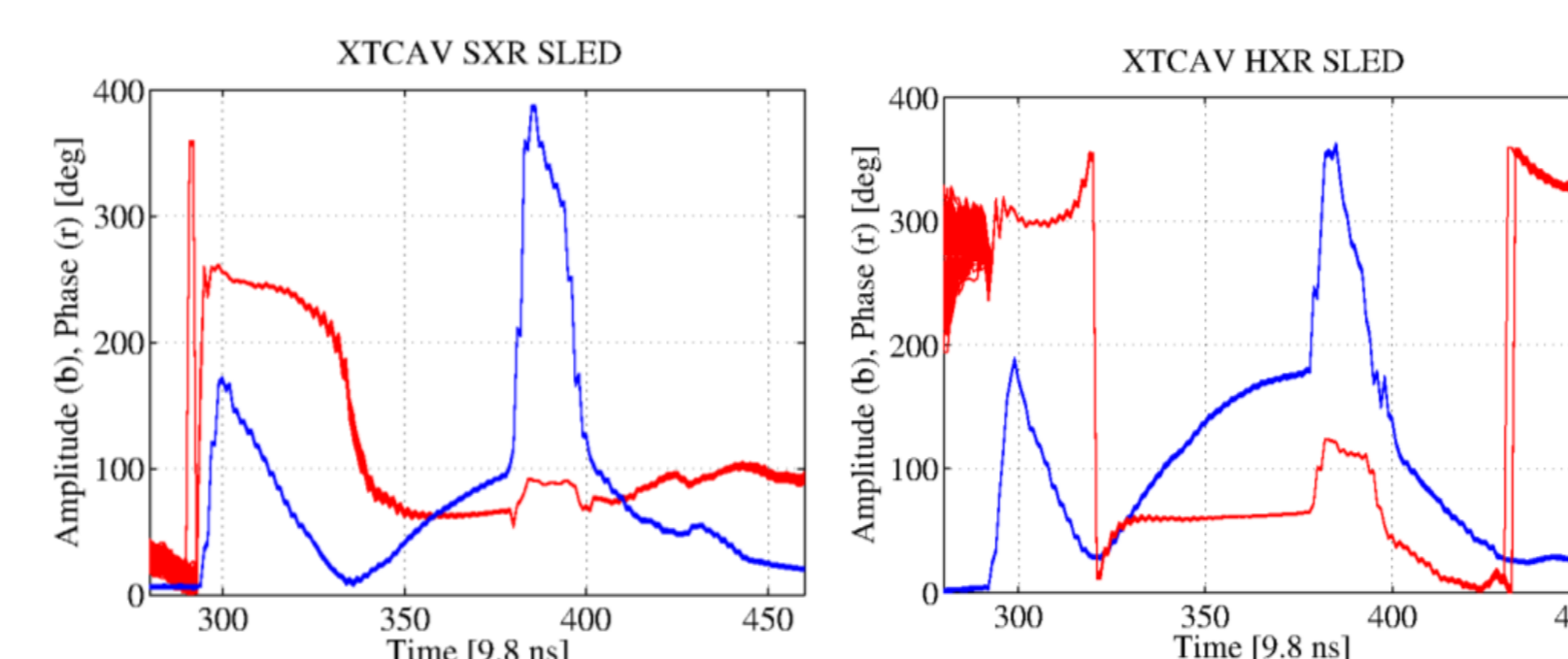
Cold test of new SLED rf pulse compressor



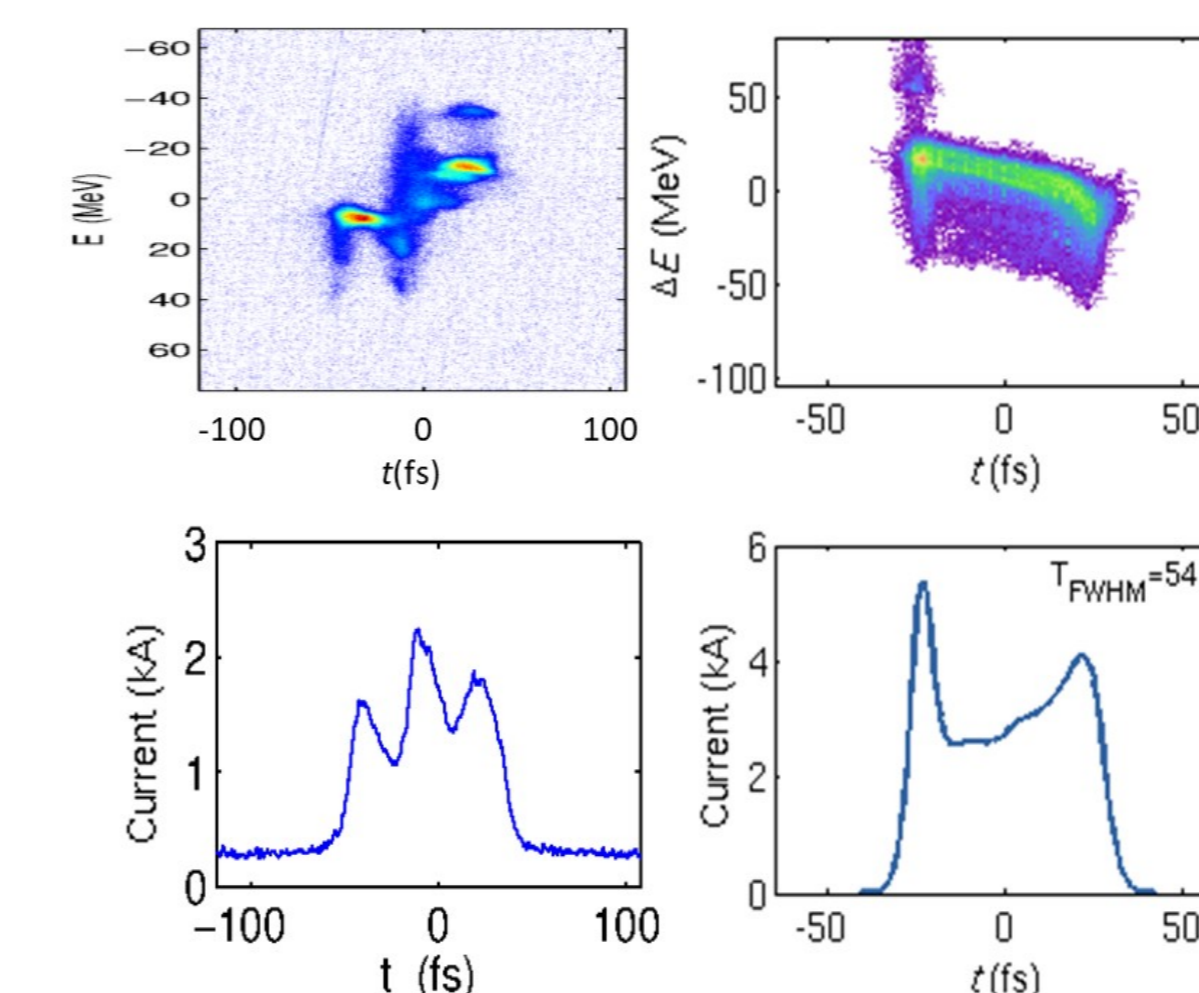
New 1.5 m rf deflector installed in Soft-X-Ray beamline

SYSTEM PERFORMANCE

Soft-X-Ray beam line Hard-X-Ray beam line



Output signals of SXR and HXR SLED RF pulse compressors. The resonant frequencies of the SLED cavities are controlled independently from each other.



Measurement of lasing LCLS beam's longitudinal phase space using SXR and HXR rf deflectors

Parameter	HXR	SXR	Units
Beam energy	4-14	4-10	GeV
Beam emittance	0.5	0.5	um
Structure length (with beam pipes)	2 x 1.185	1.657	m
Number of regular cells (including joining ring)	2 x 113	171	
Input RF power averaged over SLED pulse	70 + 70	70	MW
On-crest deflecting voltage	80	60	MV
Resolution Achieved	0.5-2	1-4	fs
Distance to deflector screen	32	32	m
Beta functions at rf deflector	80 at 8 GeV	80 at 8 GeV	m
Beta functions at the screen	63 at 8 GeV	55 at 8 GeV	m