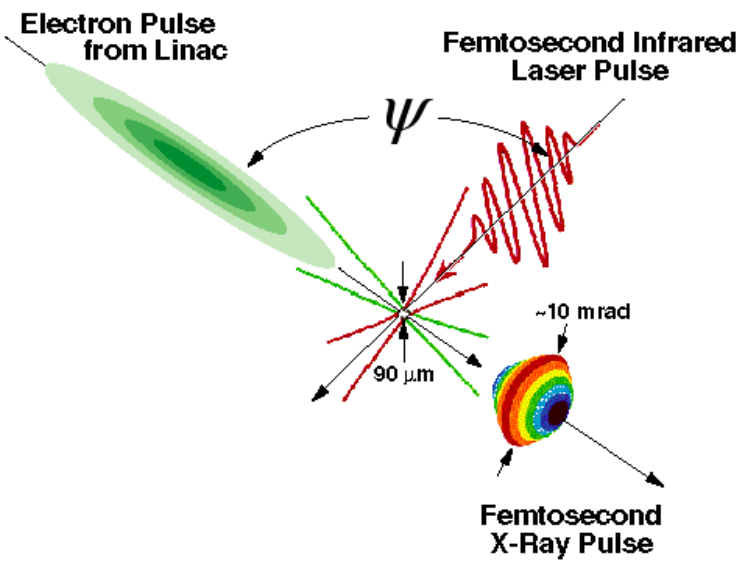
Thomson Scattering X-ray Source at Tsinghua University

Jiaru Shi

2015.01.29

for TTX team

Thomson scattering x-ray



- Small source size(~30 um)
- Adjustable for energy of X-ray
- Quasi-Monochromatic spectrum
- Radiation in a small angle（～1/γ)
- Ultra-short X-ray Pulse
- Good synchronization for pump-probe
- High Peak Brightness
- Polarization
- compact and affordable
- …

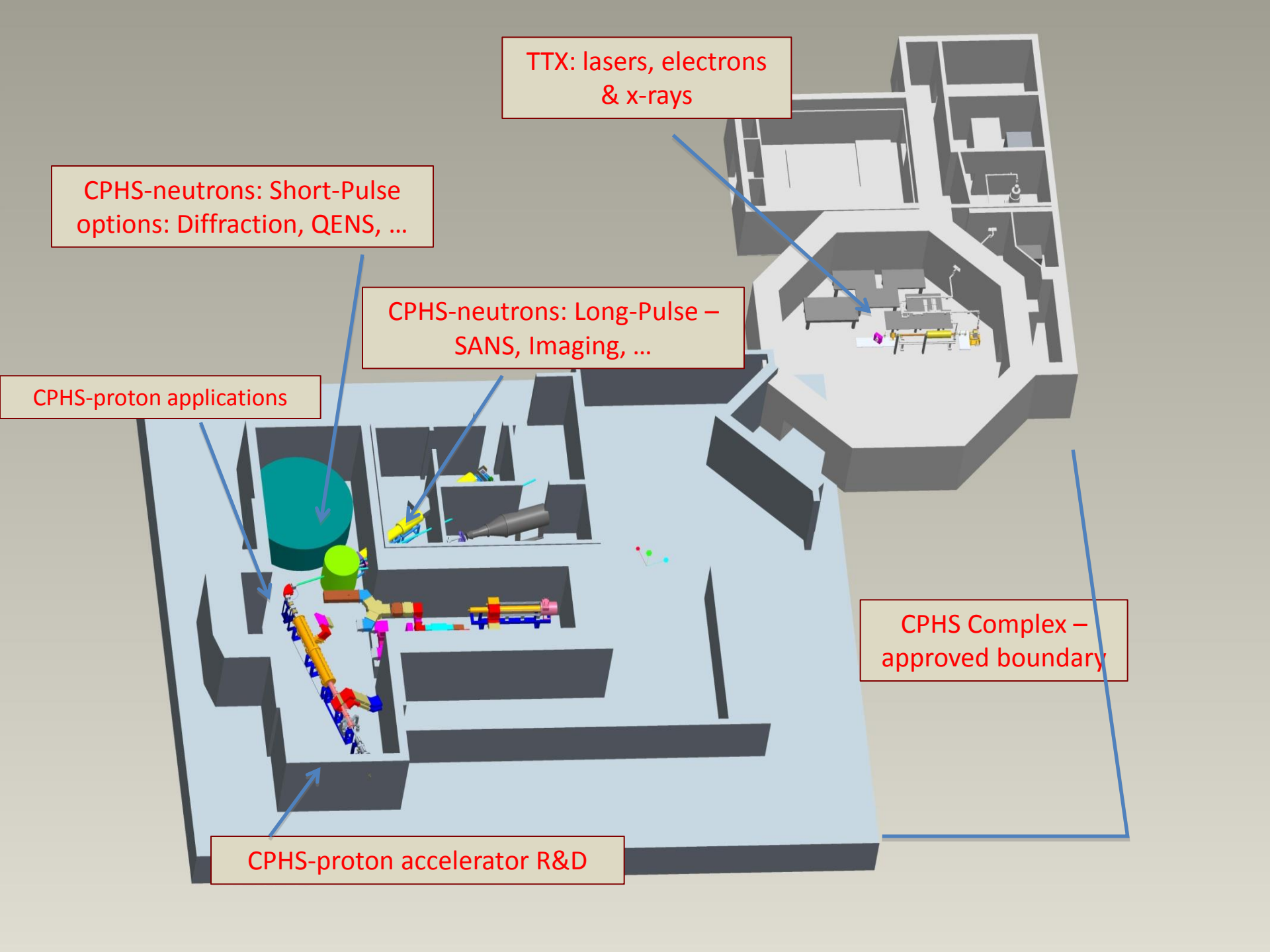
Energy of electron

Scattering angle

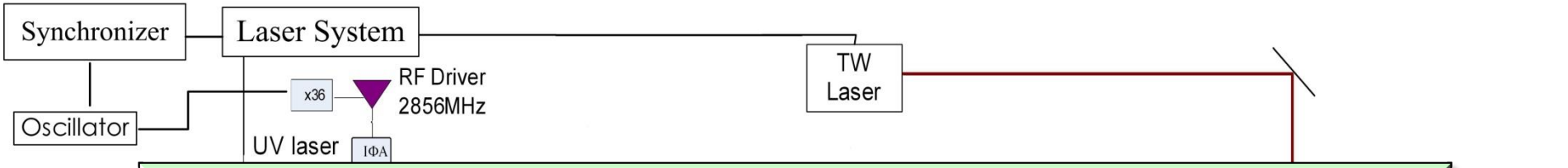
$$\omega_x = \frac{2\gamma^2(1-\cos\psi)}{1+a_0^2/2}\omega_0$$

Frenquency of laser

Tsinghua University-
Scientific Facility for Advanced Quantum Probes
(TTX&CPHS)


TTX: lasers, electrons & x-rays
CPHS-neutrons: Short-Pulse options: Diffraction, QENS, …
CPHS-neutrons: Long-Pulse – SANS, Imaging, …
CPHS-proton applications
CPHS Complex – approved boundary
CPHS-proton accelerator R&D

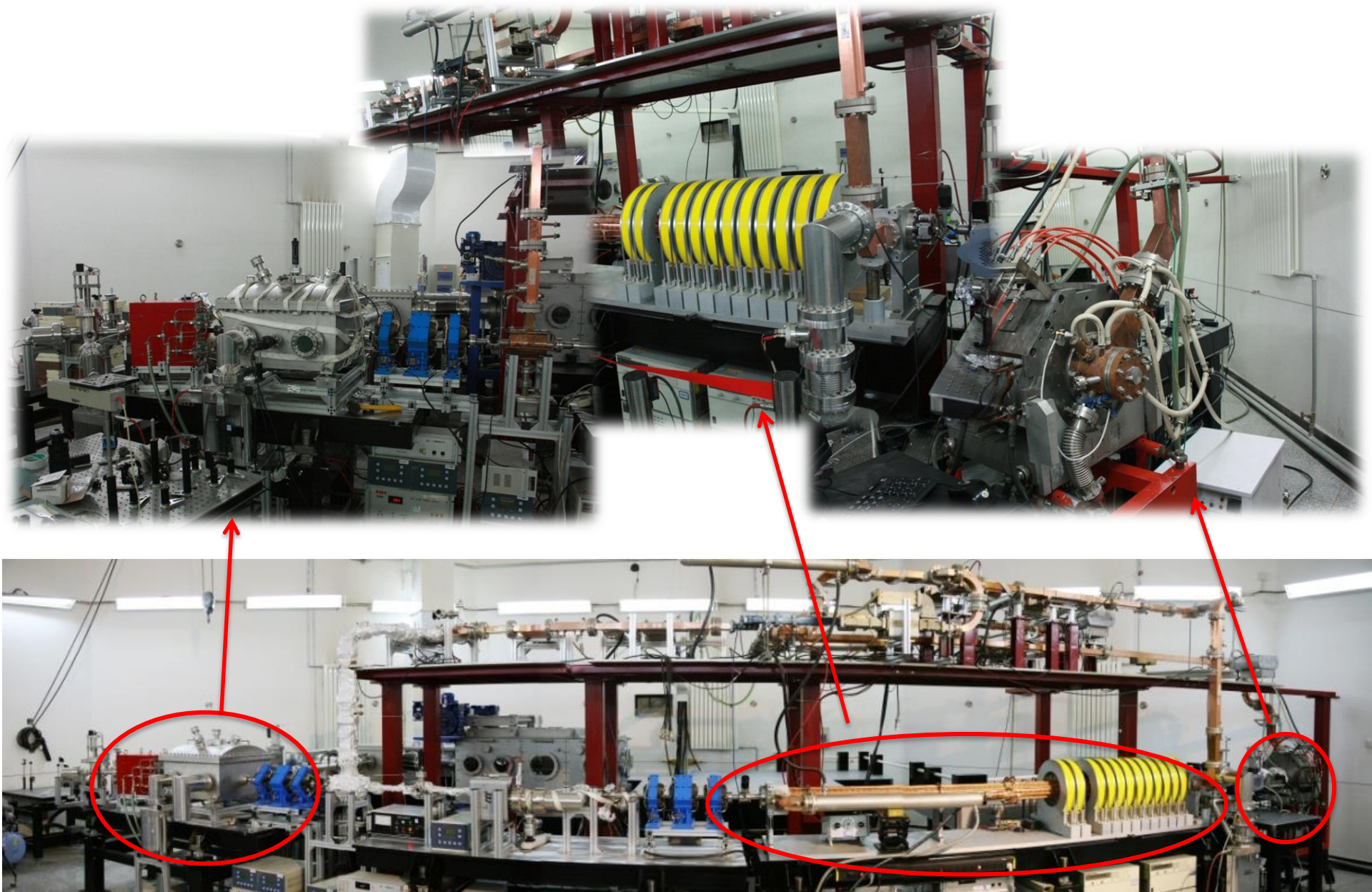
Tsinghua Thomson scattering X-ray source (TTX)



Parameters of Scattering X-ray	
Photon energy	24(90deg)~48(180deg)kev
Pulse duration	0.16(90deg)~3(180deg)ps
Number photons	$8.4X10^6$(90deg)~$5.5X10^7$(180deg)

Energy	45MeV	Wavelength	800nm
Bunch length	1~4ps	Pulse duration	~30fs
Charge	~0.7nC	Pulse energy	~500mJ
Beam size	30(H)x25(V)um	Beam size	~30um

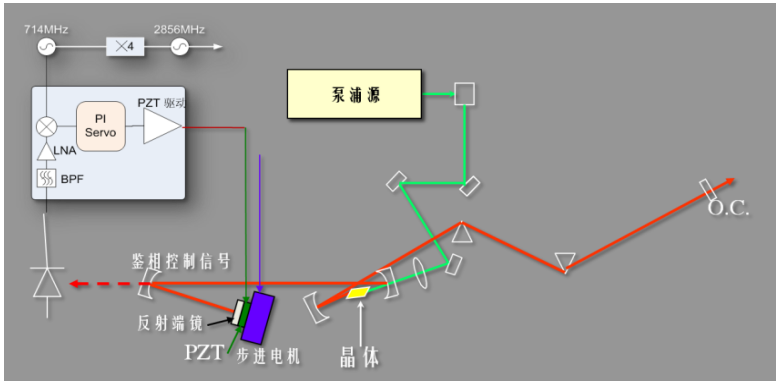
Electron beam line



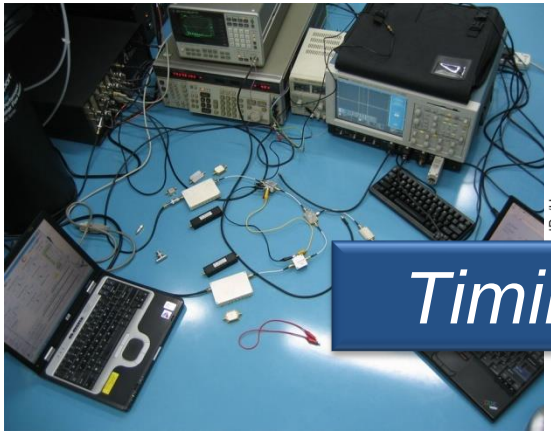
Laser System

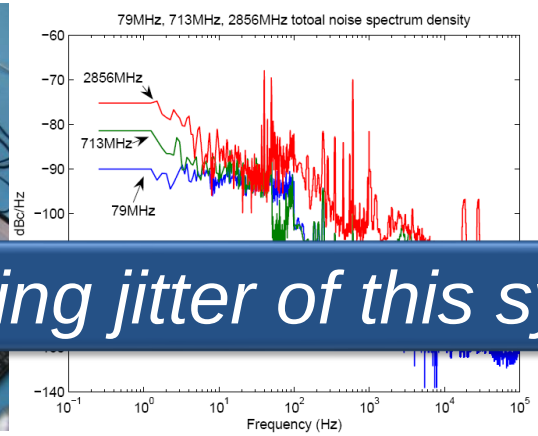
Time jitter control and measurement

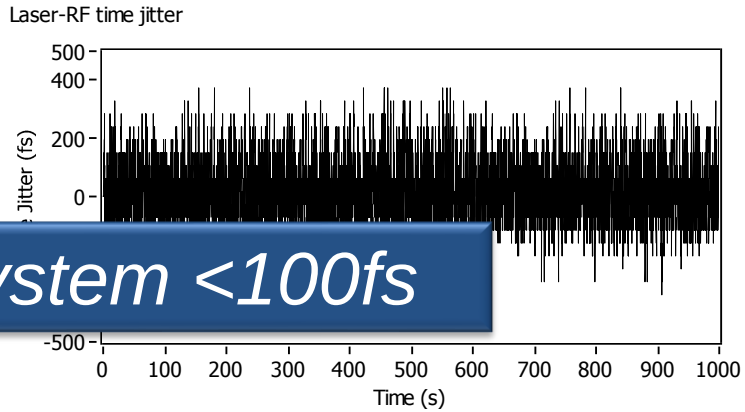
Synchronization system between microwave and laser



phase locking feedback loop based on harmonic phase noise measurement

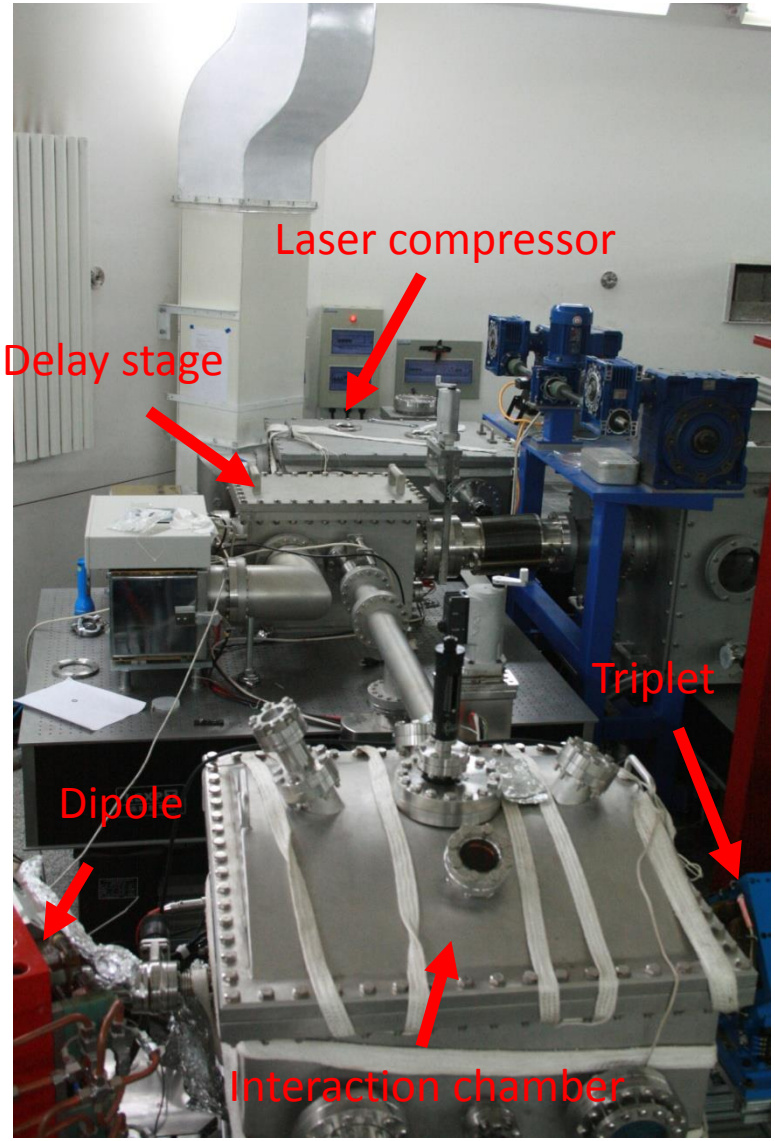


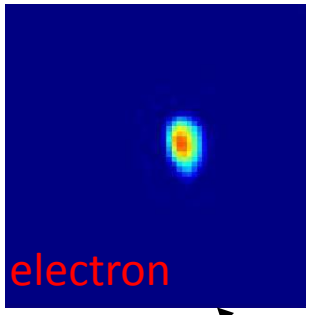


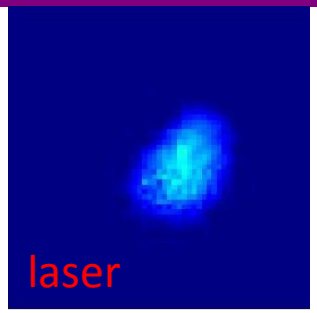


Timing jitter of this system <100fs

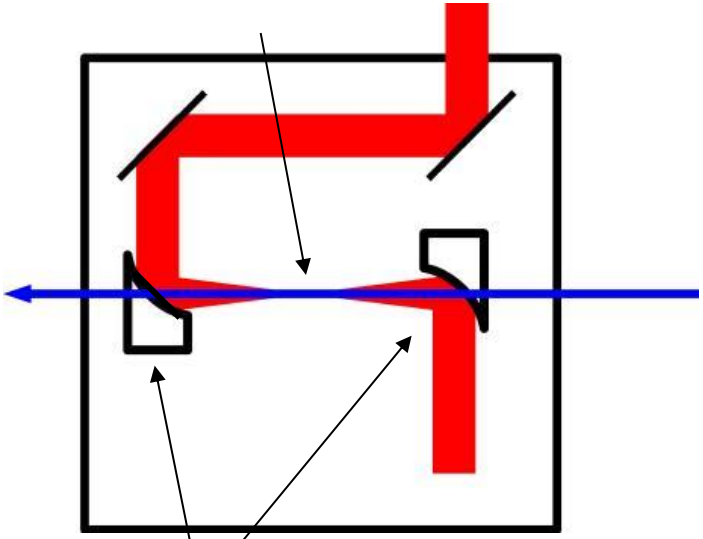
Thomson Scattering Experiment







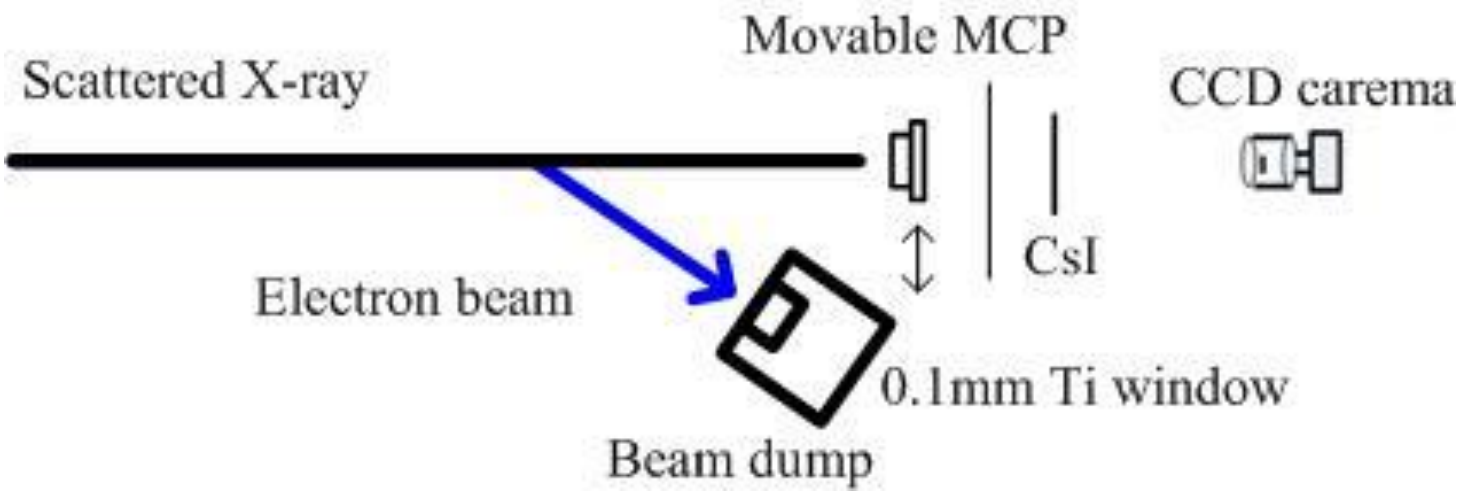
Ground glass screen for beam profile measurement

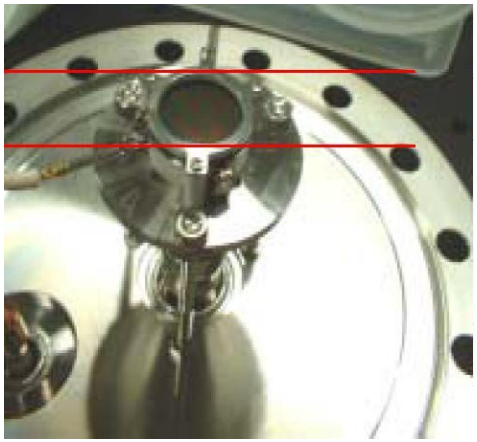


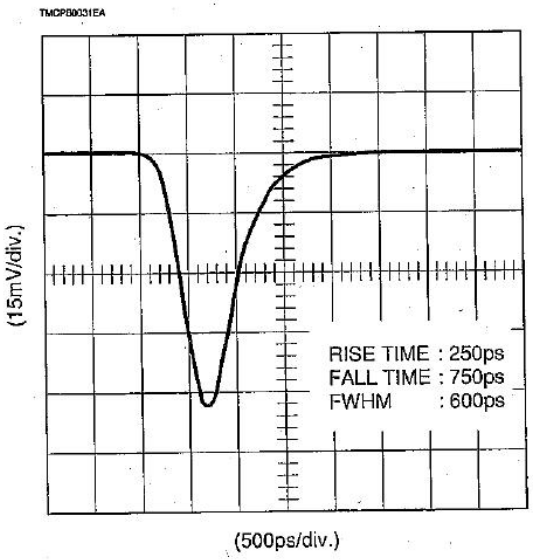
The laser is focused by a parabolic mirror with 4mm hole in center.

Thomson Scattering Experiment

- X-ray detector



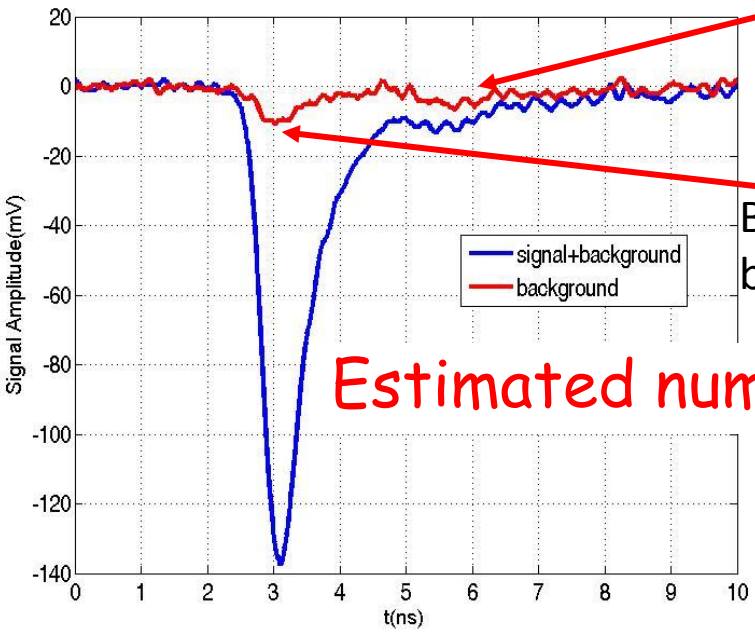




F4655-11 MCP from Hamamatsu

Thomson Scattering Experiment

- Typical background and X-ray signal



Background x-ray from beam dump

Background x-ray from beam lost in the hole

The background from the beam is suppressed successfully.

Estimated number of X-rays: ~1.2X10^5;

Reasons:
misalignment in transverse and longitudinal?
detector efficiency or gain incorrect ?

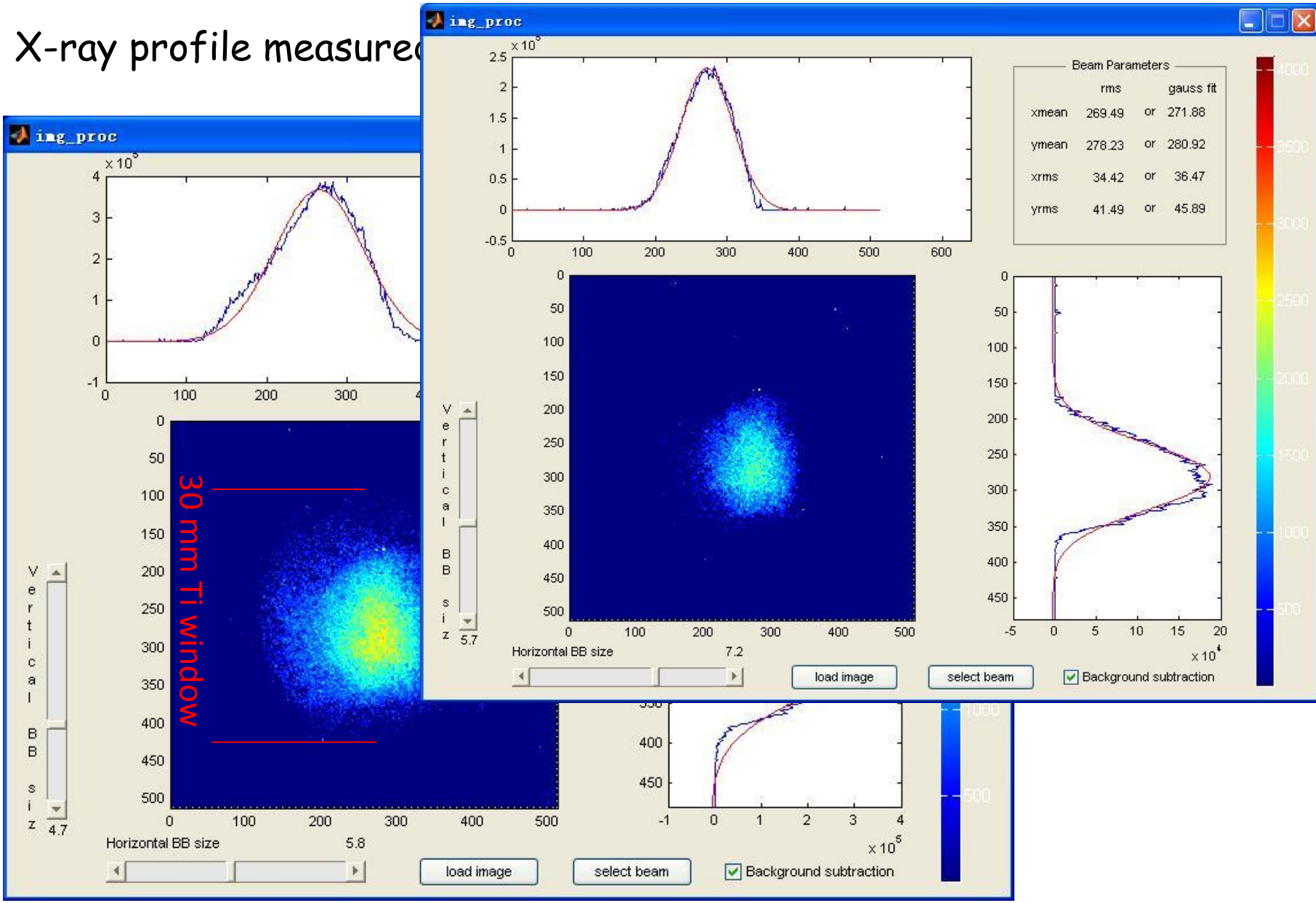
- Expected number of X-rays

	laser	electron
Energy		
Intensity	150mJ (4.8X10^17)	0.1nC (6.25X10^8)
Beam size	~100um	~40um
Pulse width	~50fs	~2ps

Expected number of X-rays: ~3.5X10^5;

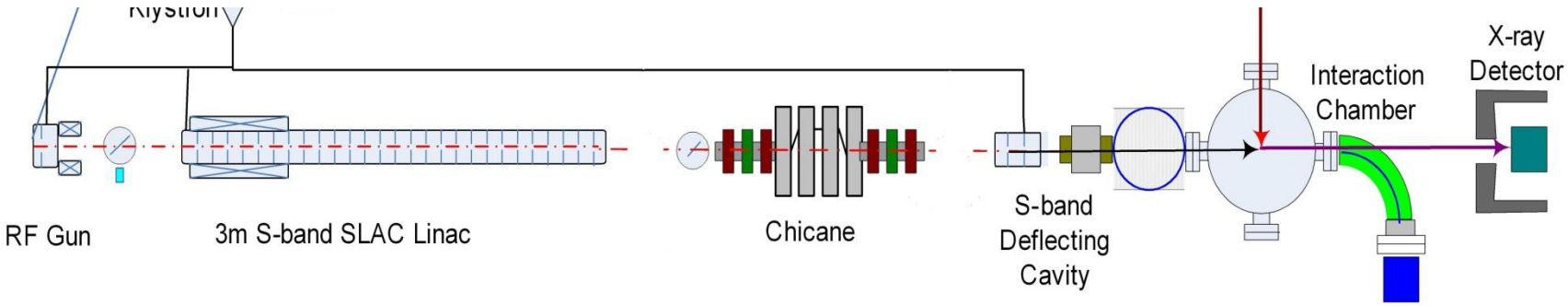
Thomson Scattering Experiment

- X-ray profile measured



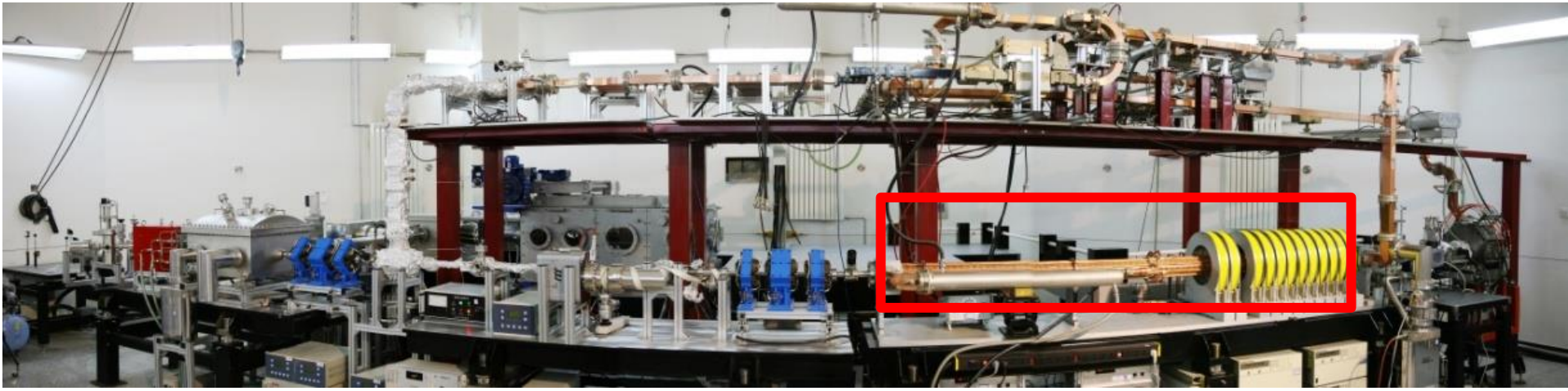
the TTX Status

- Some applications are being considered: X-ray imaging, and x-ray polarization detector calibration for astronomy…
- Chicane has be installed recently;



TTX Next

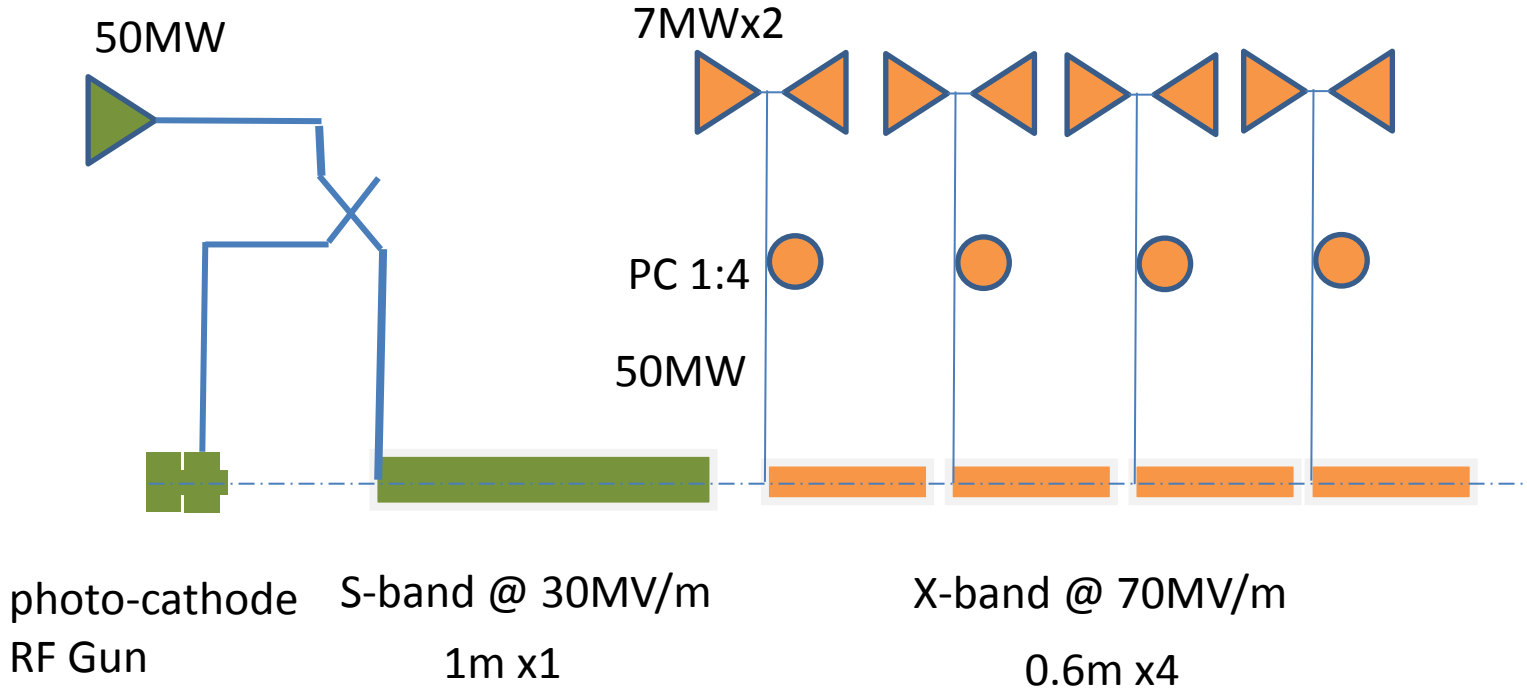
- Replace the 3-m linac with higher gradient structures
  - Boundary of the experiment hall. Limited to 12 meters
  - Space for beam physics study and beam manipulation, as well as other experiments
- S-band klystron available now.
- 1.5m x30MV/m looks reasonable.



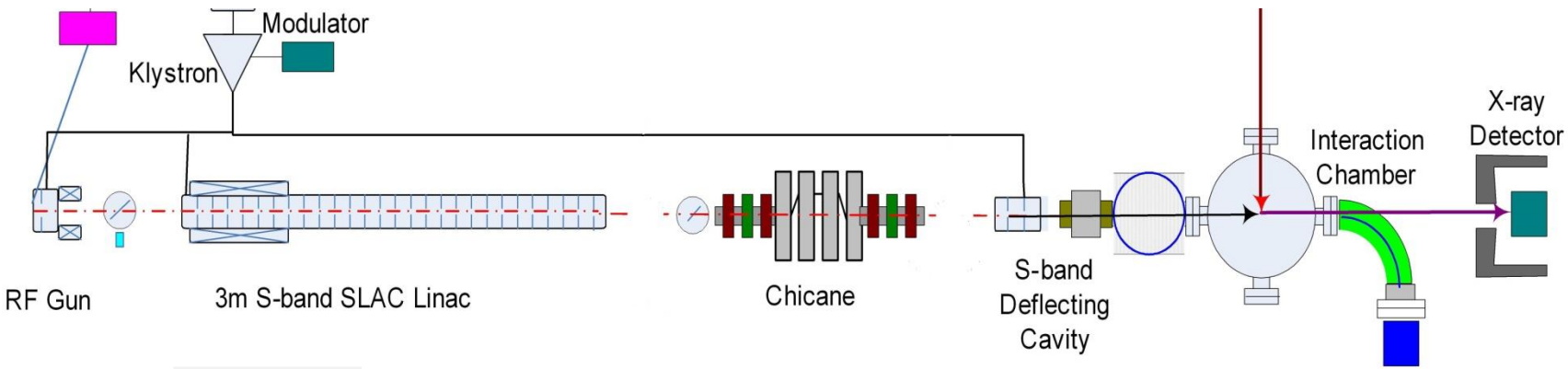
New Compact γ-ray source

- Demand for photons above 2MeV with narrow energy spread.
- To meet the requirement:
  - Energy of e-beam: 200MeV
  - Wavelength of laser: 400nm
- Compact within 10m
  - Limited length of the experiment hall
  - Tabletop facility

200MeV linac layout (Preliminary design)

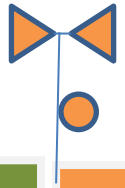


TTX linac upgrade



1 year

1.5m x30MV/m



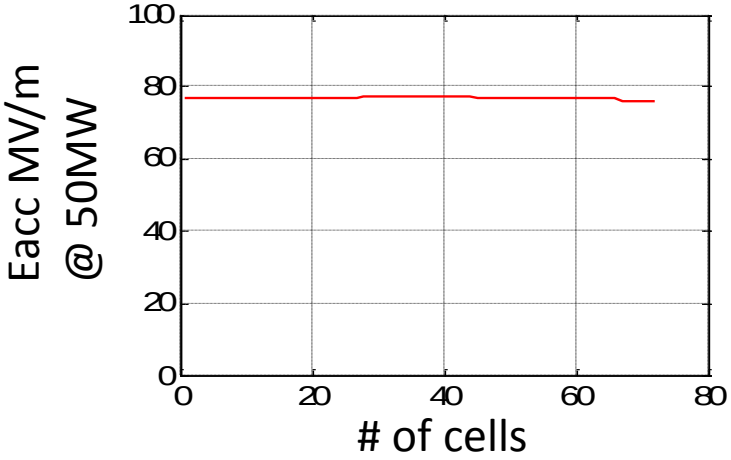
~3 year

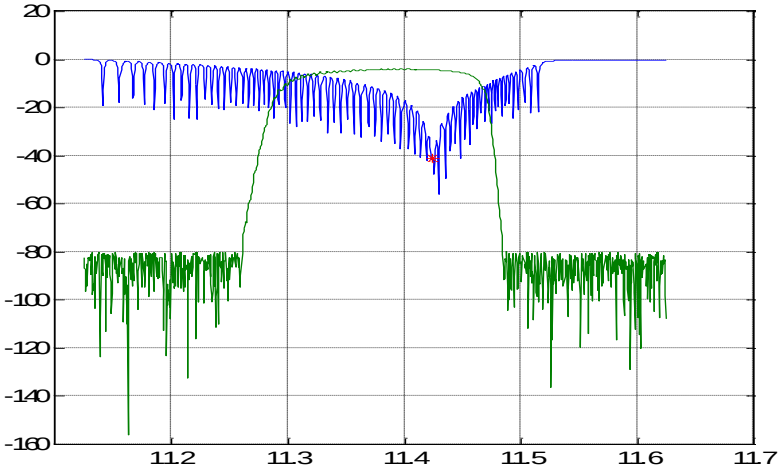
1.5m x30MV/m + 0.6m x70MV/m

New beam line

X-band structure design, Preliminary

Will be refined with the info of RF power source available.





parameters		
frequency	11.424	GHz
Phase adv	120	degree
# cells	72	
length	630	mm
Filling time	88	ns
a	4, 3	mm
vg/c	3.76, 1.38	
R/Q	14.2, 16.3	(kOhm/m)
Q	6900, 7100	
P Input	50	MW
Eacc	75	MV/m
S21	-4.3	dB

Summary

- TTX with 50MeV e^-
- 200MeV linac under design:
  - X-band structure aiming 70MV/m
- Near future
  - S-band @30MV/m replacement
  - X-band unit demonstration: add one accelerating structure to existing beam line; build the RF power supply

- Inputs are welcomed!

TTX Group

HG2015

- HG structures
  - Design
  - Producing
  - Testing
- Klystrons/Test Stands
- Basic breakdown theory
- Industry Exhibition