TMO in Run 23

LCLS Run 23 Users Town Hall

January 30th 2024

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TMO Instrument Lead

AMOS Department Head

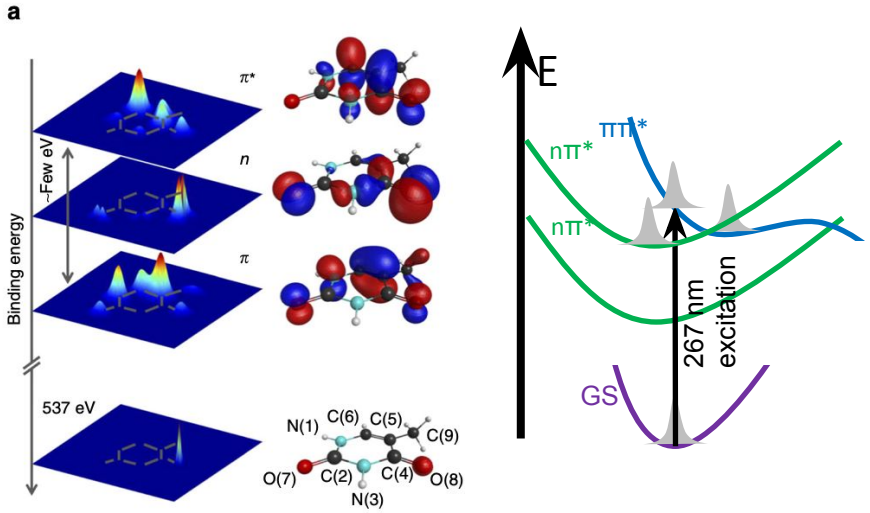
SLAC NATIONAL ACCELERATOR LABORATORY

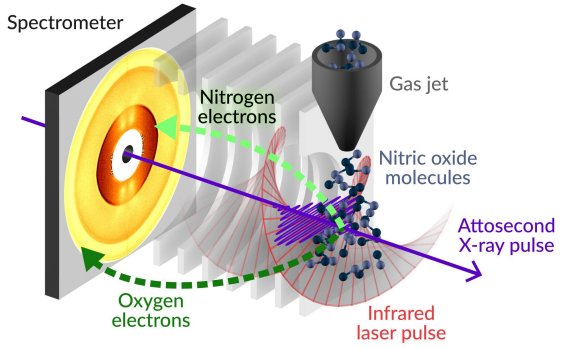
Stanford University | U.S. DEPARTMENT OF ENERGY

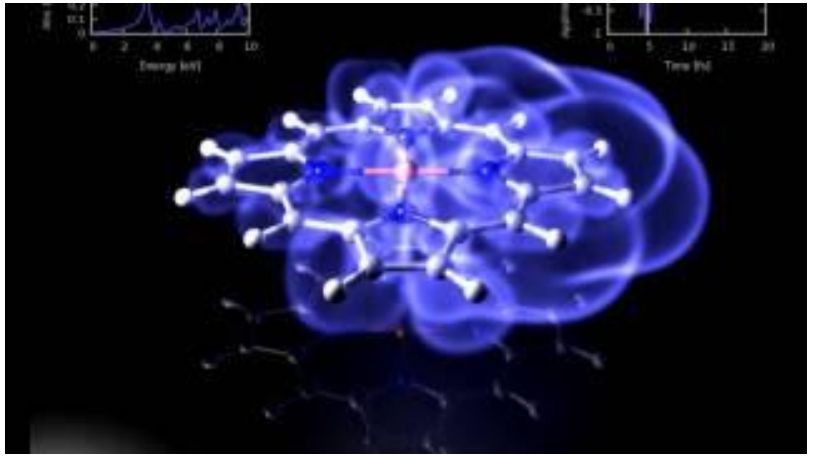
Science Areas

Science areas we are well positioned to address in TMO in Run 22

- Ultrafast Gas Phase Photochemistry
  - X-ray spectroscopy (XAS, XPS) of small molecular systems
- Attosecond Electron Dynamics
  - Fundamental charge and energy dynamics
  - Electronic Coherence
- Strong-field laser/matter interactions
  - Probed by X-ray spectroscopy

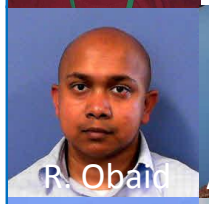


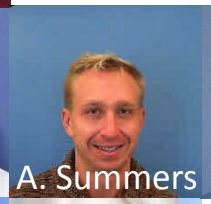


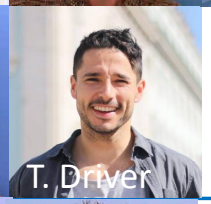


TMO Instrument Team

TMO Instrument Lead



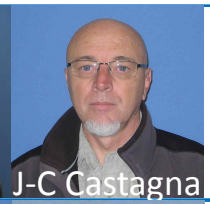




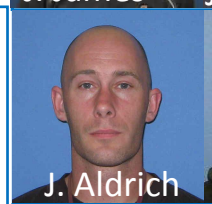
TMO Instrument Scientists

TMO Laser Scientists

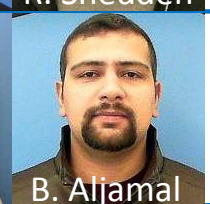
TMO Research Associates



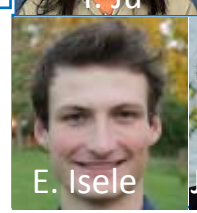
TMO Engineering Team

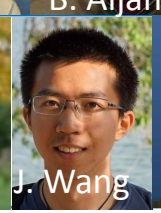


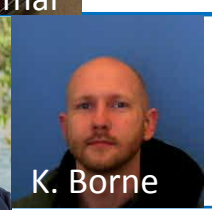
TMO Area Manager and Support Team



TMO Controls Team



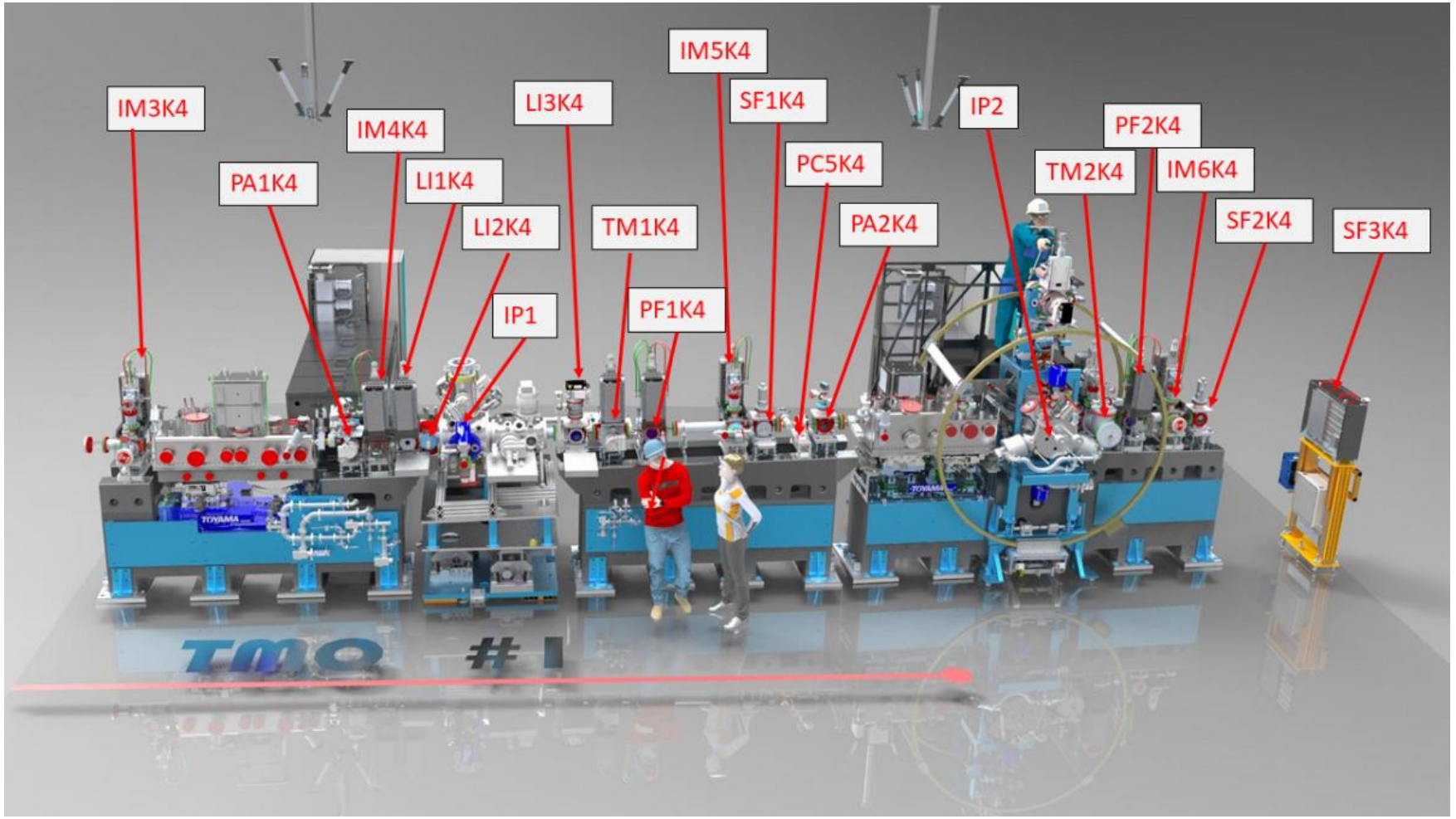




Graduate Students

TMO Beamline for Run 23

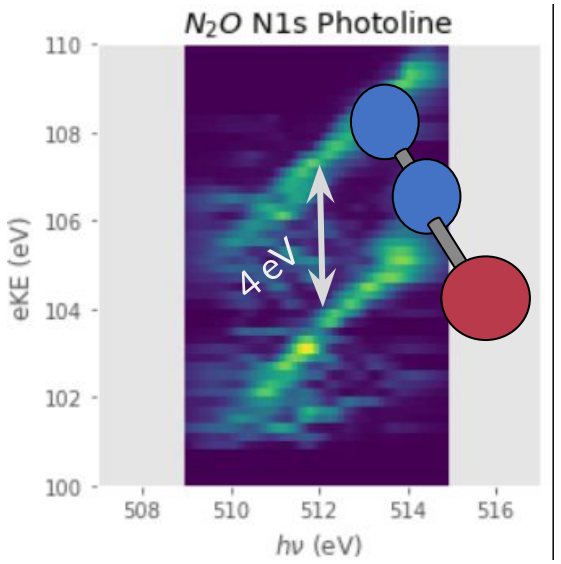
- For Run 23, TMO will offer two endstations: MBES and MRCO at IP1
- Commissioning of IP2 will continue in Run 23.
- DREAM should be available for User science in Run 24

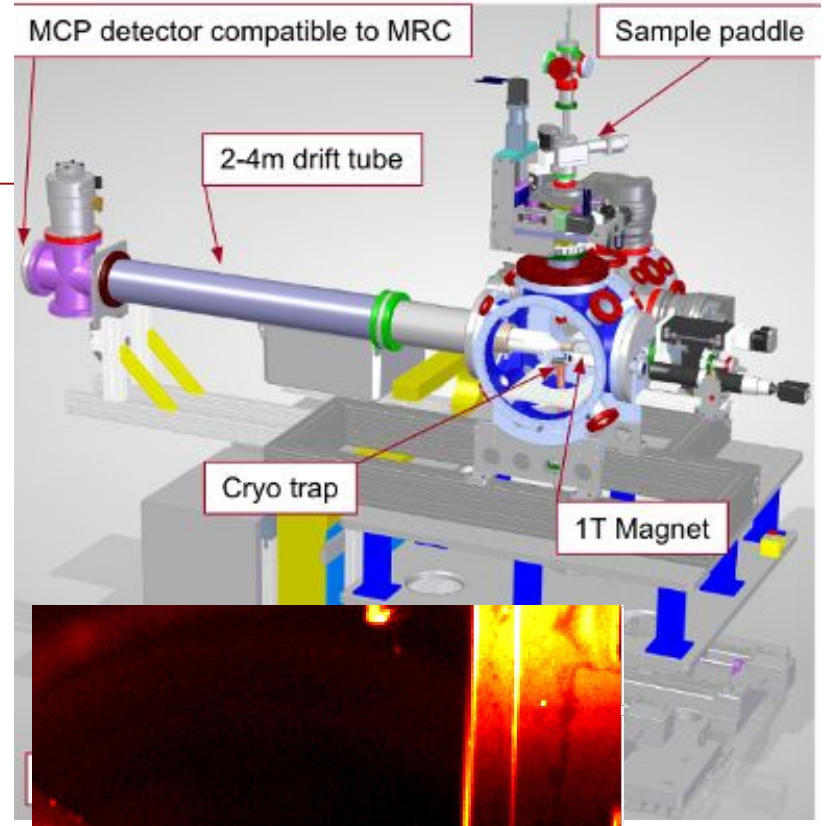


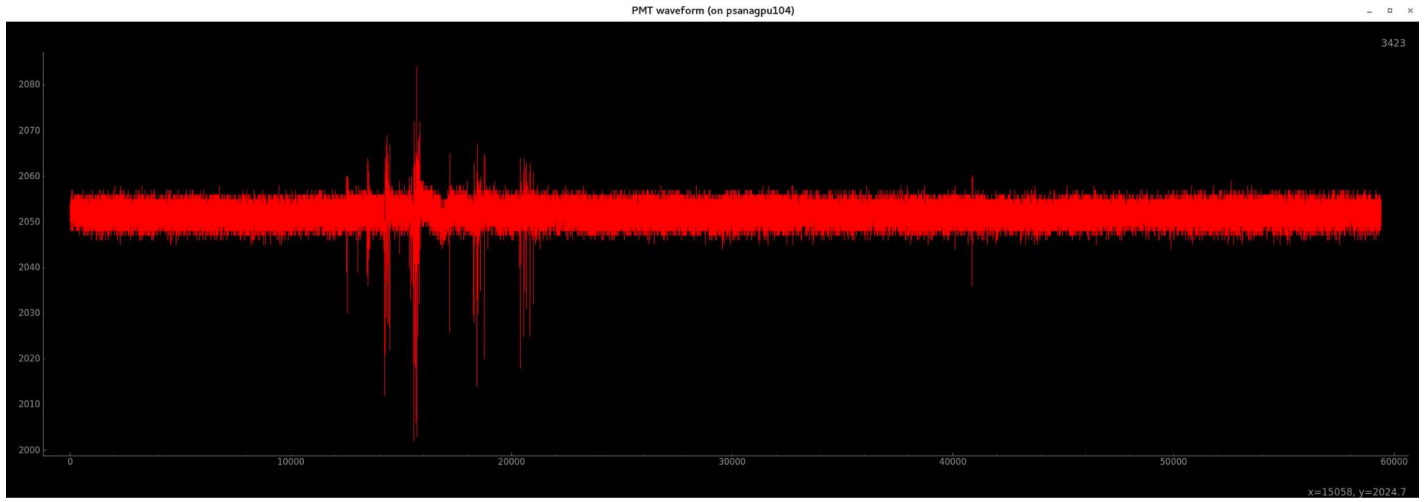
TMO Standard Configuration

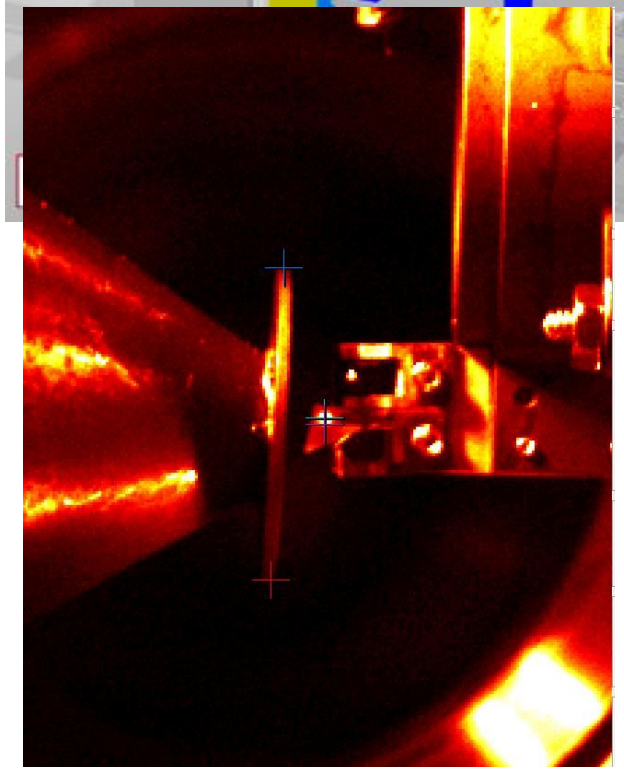
Magnetic Bottle Electron Time-of-Flight Spectrometer (MBES)

- 2m flight tube with retardation section, >50% collection efficiency
  - Retardation up to 400 eV
- Gas targets:
  - Either heated gas needle or
  - In-vacuum oven
- Ion extraction plate and coincident Ion ToF capability





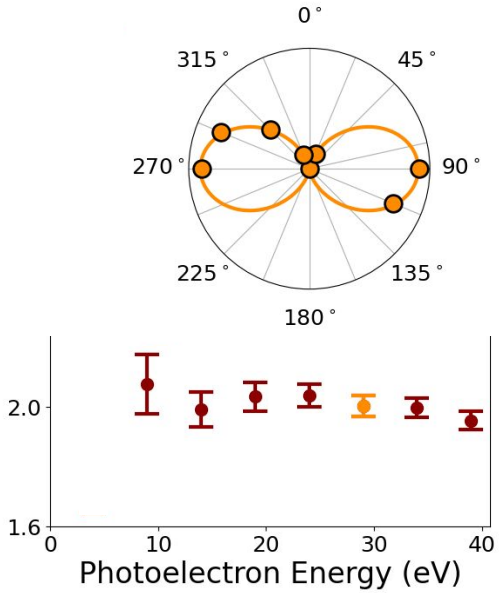


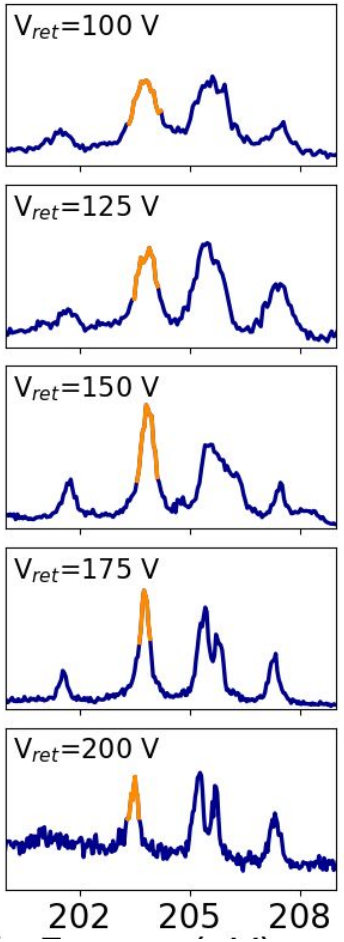


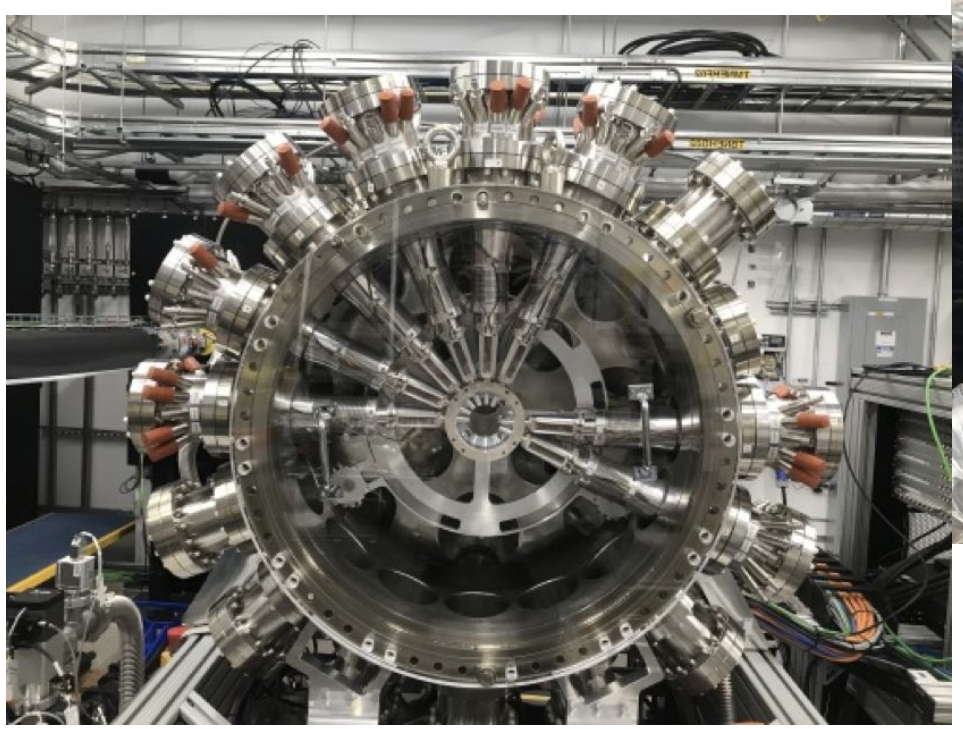
TMO Standard Configuration

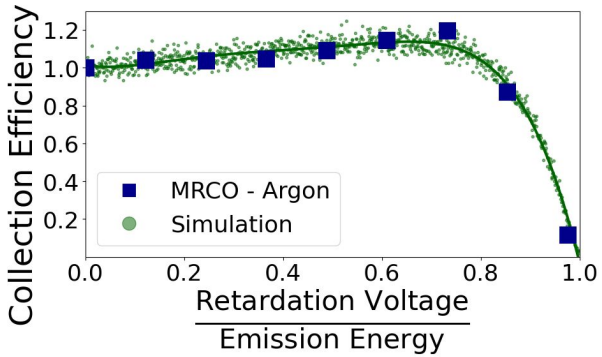
Angle-resolving Time-of-Flight Spectrometer (MRCO)

- Array of ToF spectrometers:
  - 8 guaranteed, 16 planned
  - 1% Total collection efficiency
- Retardation upto 2000 V
- Heated needle for sample delivery

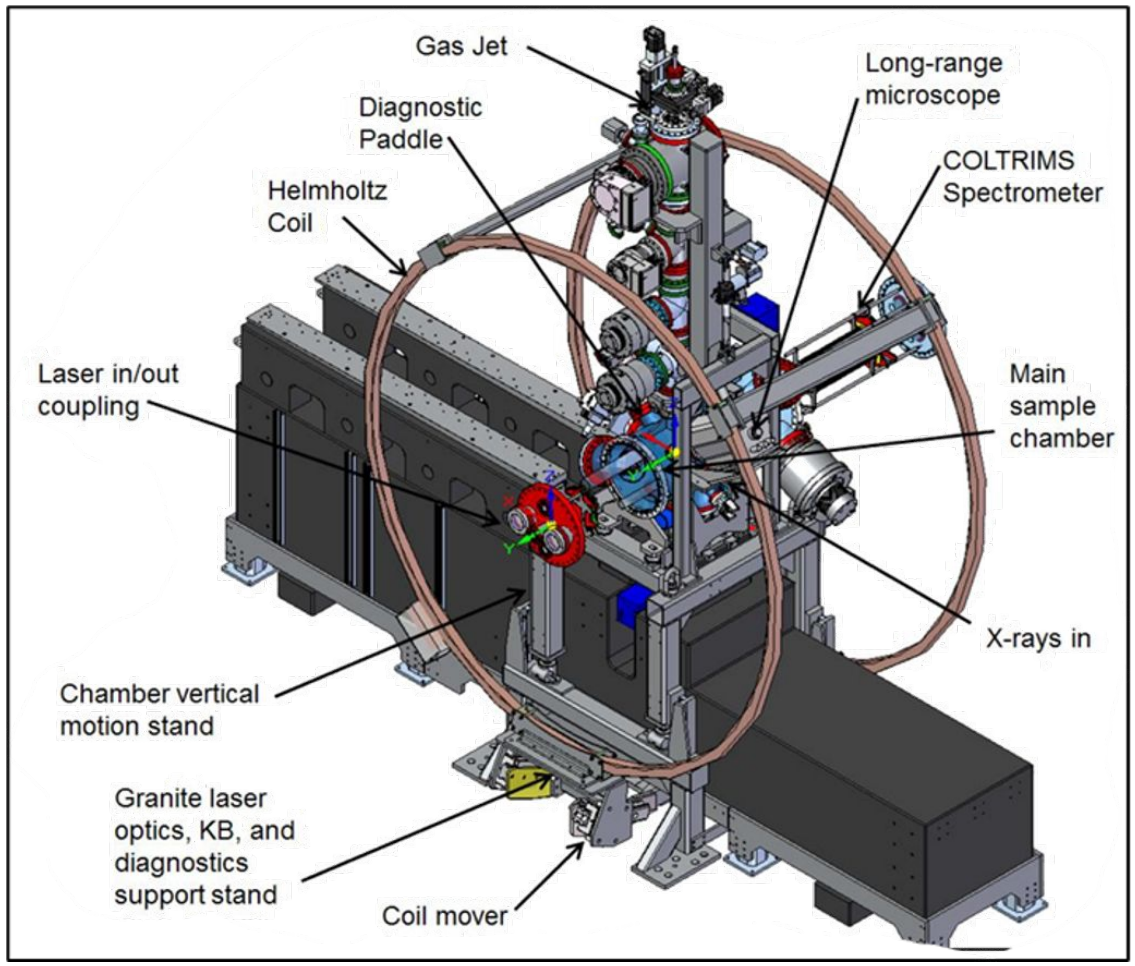








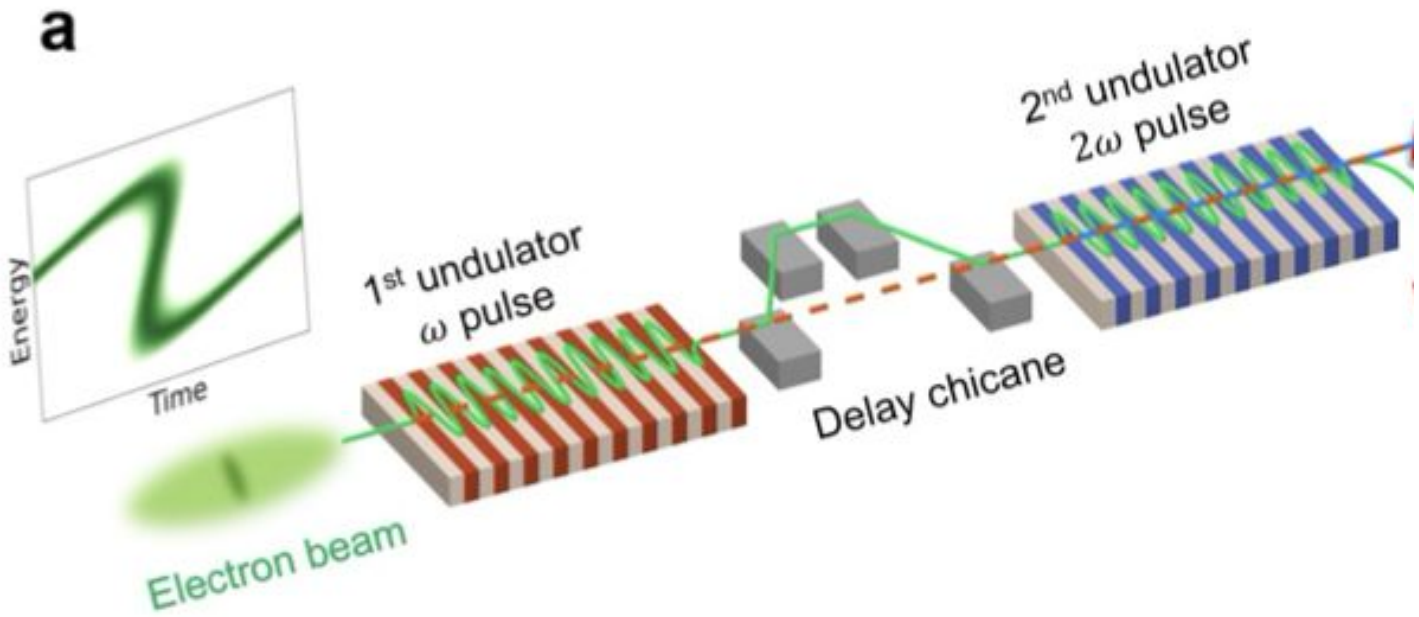
Dynamic REAction Microscope (DREAM)



Status

- Planned Laser-based commissioning
  - Assembly is ongoing:
  - We hope to finish in mid-February
  - Then we will start commissioning with the OPCPA laser system.
- Time allocated in Run 22 and 23 for X-ray commissioning
- Early Science:
  - We will plan for Early Science in Run 23.
  - We have several proposals from the community.
  - We plan to have a workshop once construction is complete.

Attosecond Pulses @ TMO



- Recommissioning Attosecond pulses in Run 22.
- Expect two-color (atto/atto) for Run 23 (baseline > 1 kHz rep. rate)

Expected Beam Parameters (Laser and X-ray)

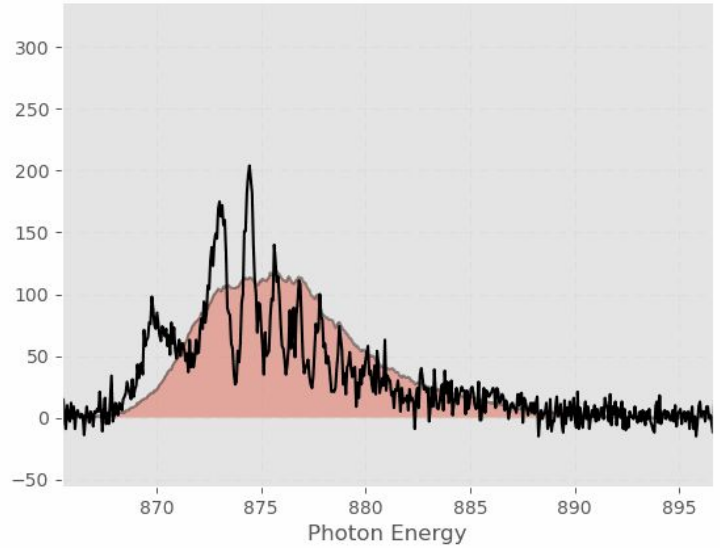
Laser Parameters				
Repetition rate (Hz)	Synchronized up to 33 kHz			
Wavelength	800 nm	400 nm	266* nm	1200-2300* nm
Pulse Duration	< 25 fs	< 30 fs	~ 30 fs	< 100 fs
Energy per pulse (on target)	< 600 μJ	< 100 μJ	~ 10 μJ	< 130 μJ (signal) > 10 μJ (idler)
*commission in run 22				
Spot Size, FWHM (800 nm)	50 to 100 um			
Polarization	Variable: linear, circular			
Angle	~0.5 deg angle with x-ray beam			
Arrival Time Monitor	< 20 fs accuracy in x-ray/laser arrival time tagging.			

X-ray Parameters			
Repetition rate (Hz)	Up to 100 kHz		
Energy Range (eV)	250 - 1800		
Pulse Duration	20 fs (nominal)	Under Development (increased risk)	
		Tunable to 5 fs	< 1 fs (XLEAP-II)
Energy per pulse	~ 50 μJ	Scales linear with pulse energy	~10 μJ
Bandwidth (FWHM)	0.5%	0.5%	>1%
Repetition Rate	> 30 kHz	> 30 kHz	>1 kHz
Spot Size, FWHM (range)	1.0 - 200 (um) diameter		
Polarization	Linear, Horizontal		
Two Pulse Modes	< 10 μJ / pulse with tunable delay via split undulator method. This provides a minimum delay of ~10 fs for arbitrary wavelength. For harmonic operation (ω/2ω, ω/3ω) the minimum delay ~300 as.		

TMO Standard Configuration

Single-Shot Photon Spectrometer

- Off-axis Fresnel Zone Plate design
  - array of zone plates for different photon energies
- Coupled to 200 kHz line-camera to measure single-shot
- Image intensifier for low energy operation
- Able to resolve SASE sub-structure



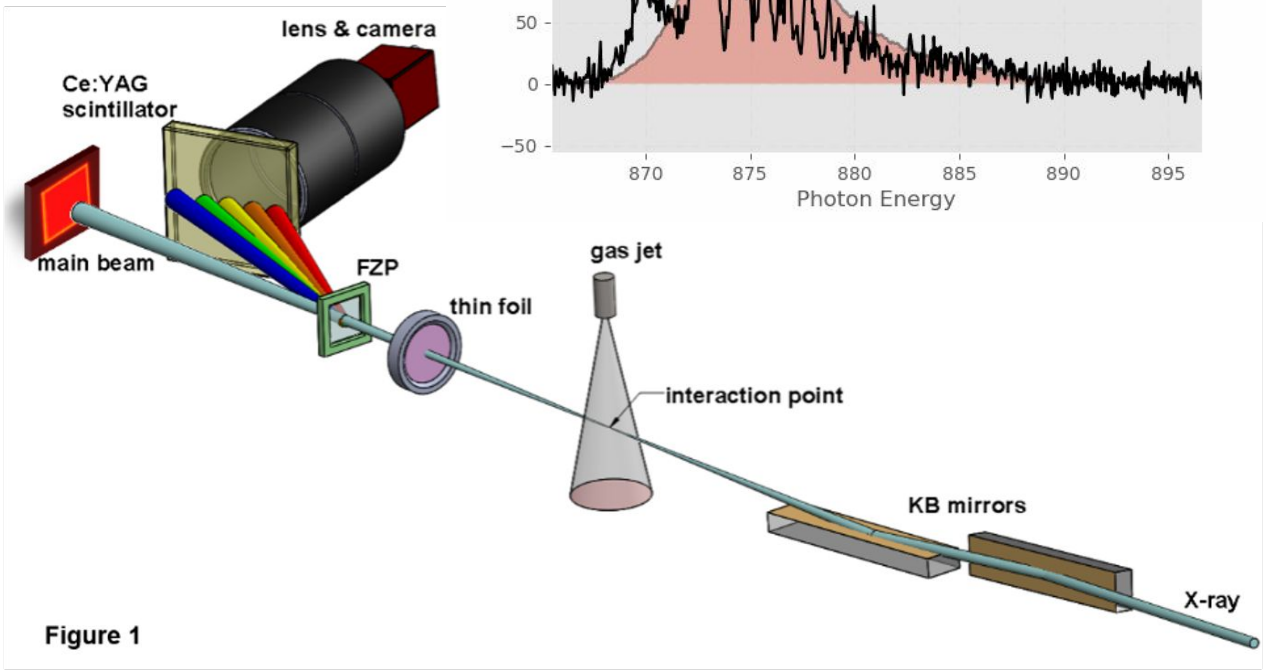


Figure 1

TMO Standard Configuration

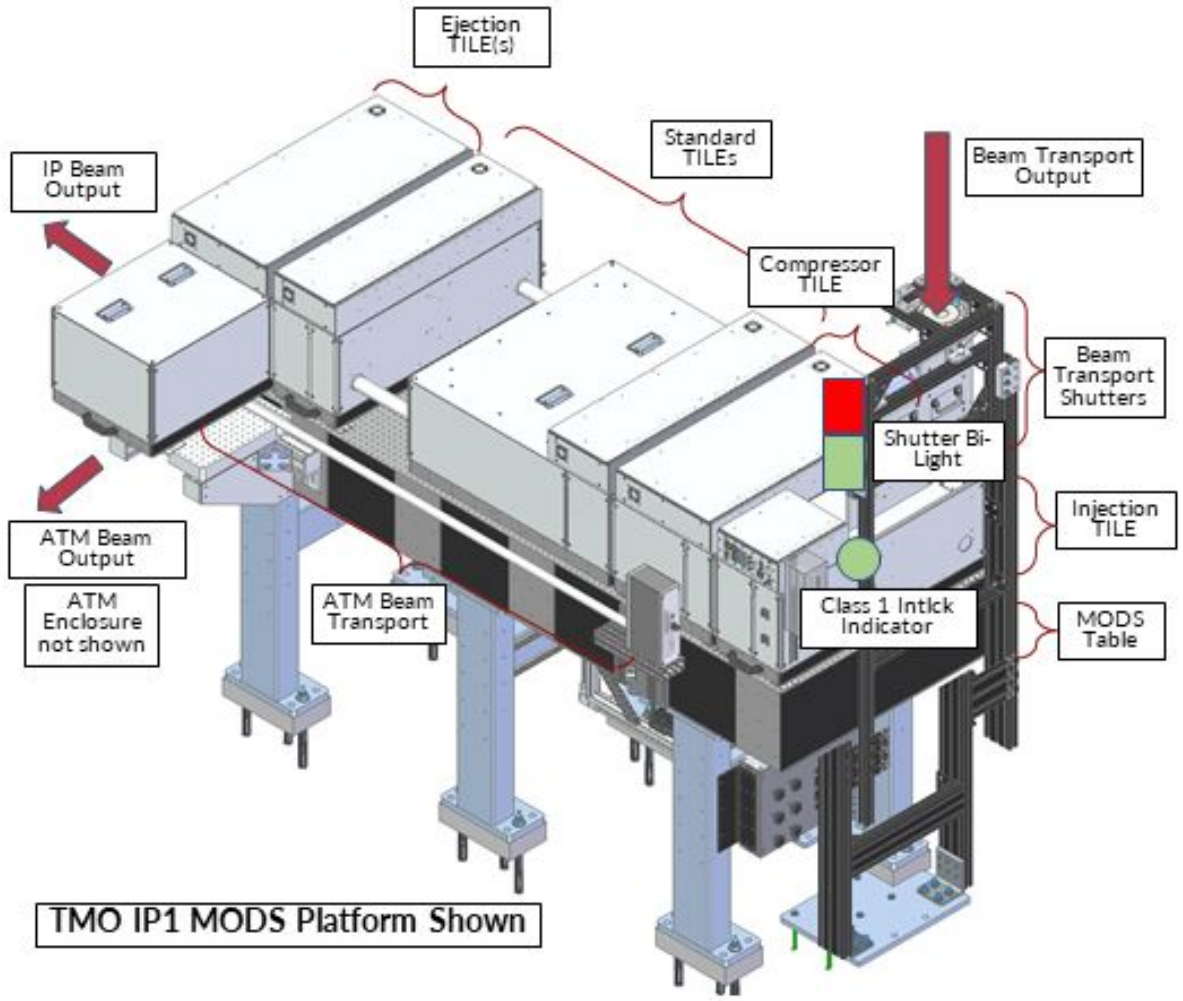
TMO Laser System

800 nm beam delivered to TMO from the laser hall.

Modular units tailor, compress, and perform wavelength conversion on the beam.

Harmonics module to make <30 fs 800 and 400 nm at IP. 266 nm planned to be tested in-house early in run 22.

High repetition rate TOPAS PRIME HE will be available for streaking experiments (1200-2300 nm)



LCLS-II Timing

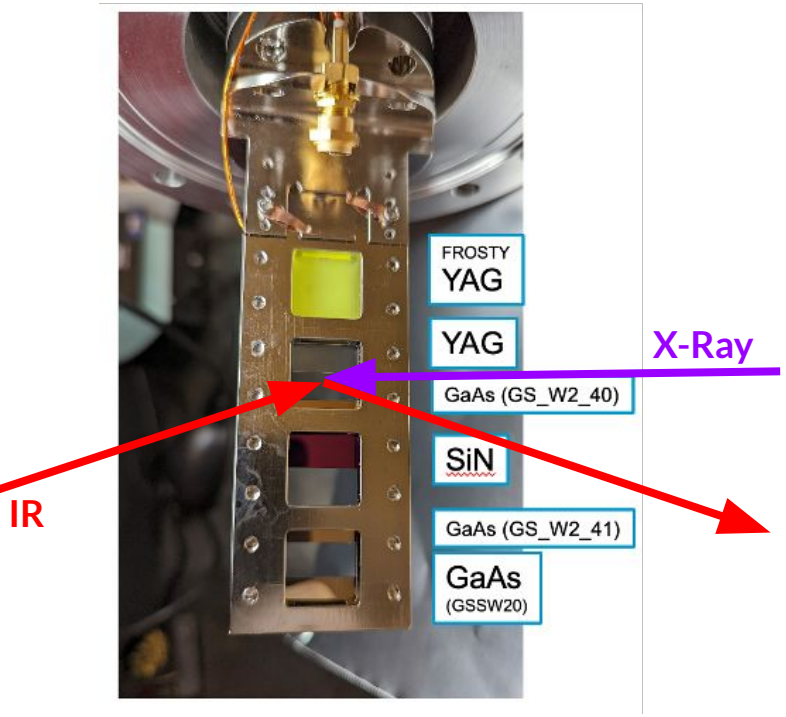
Arrival Time Monitor

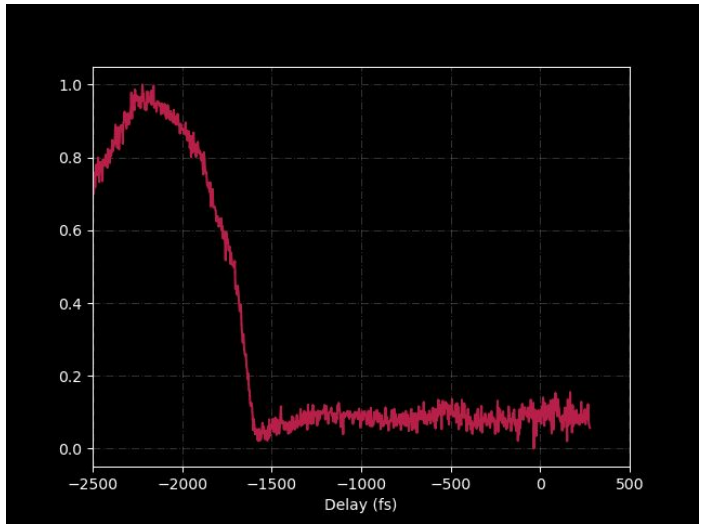
Single shot arrival time monitor at full rate will be available.

Measurements at LCLS I rates have worked well down to few microjoule X-ray pulse energies.

R&D is ongoing to push the sensitivity to enable lower pulse energies.

Proof of principle interaction point t_0 measurements part of commissioning and early science.





Thank You

Questions?