



# Latest Progress, ion-TOF test and Scientific Commissioning Plan at AMO End-station

Speaker: Xincheng Wang

On behalf of AMO Group

Oct. 20, 2026

# Outline

- **Update of AMO End-station**
- **Ion-TOF testing plan**
- **Commissioning plan**

# Outline

## ■ Update of AMO End-station

■ Ion-TOF testing plan

■ Commissioning plan

# AMO end-station at SHINE

Momentum imaging of ions and electrons

Super sonic gas jet

COLTRIMS

Super sonic gas jet

FEL

XFEL

Laser

MBS: magnetic bottle spectrometer

Experimental parameters:

- Energy range: 0.2~3 keV
- Beam spot size: < 10  $\mu\text{m}$
- Pulse duration: 10 ~ 150 fs
- Repetition rate: 100 kHz
- Pulse energy: 10-300  $\mu\text{J}$

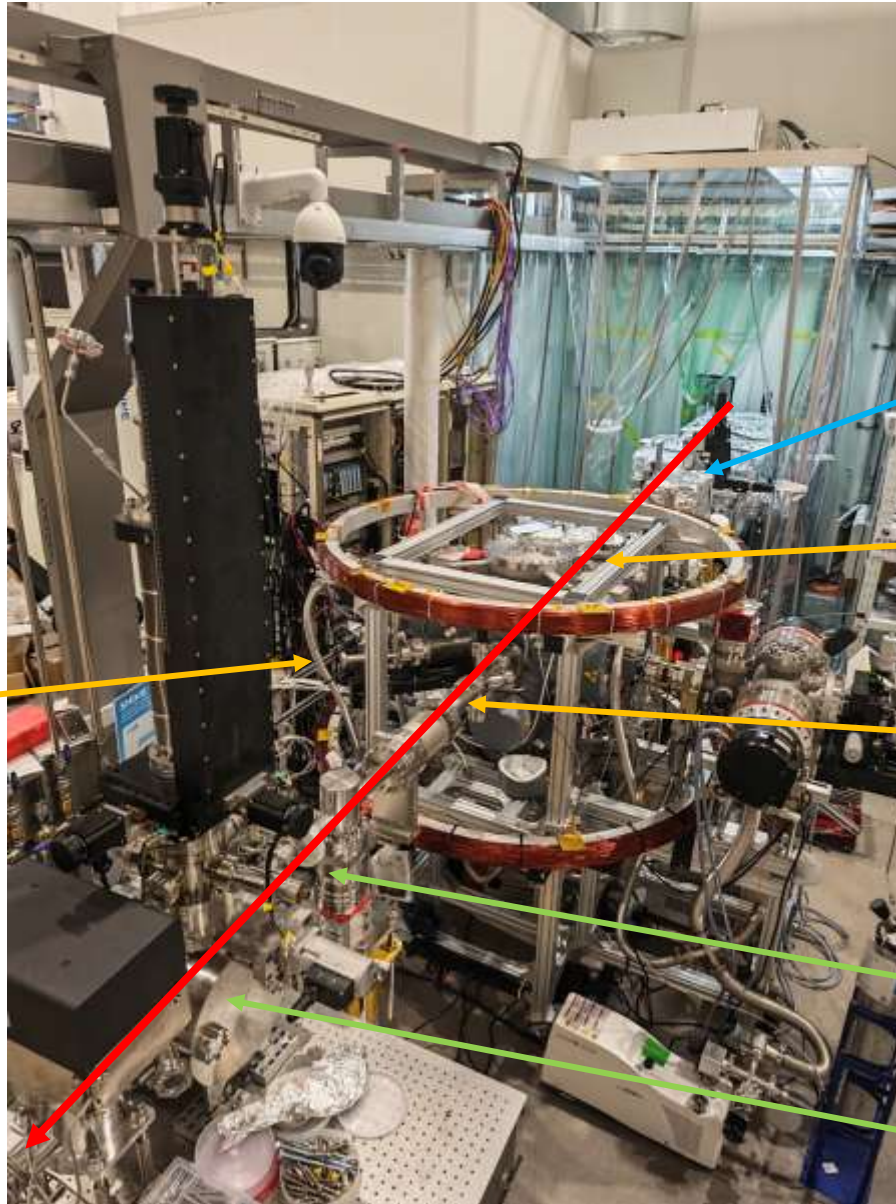
- Wavelength: 266-3000 nm
- Repetition rate: 100 kHz
- Spot size: <100  $\mu\text{m}$
- Pulse energy: >100  $\mu\text{J}$   
@fundamental
- Pulse duration: 30 ~ 150 fs
- Jitter: < 40 fs

diagnostic tools:

- Beam position monitor: Imager
- Foci : imager & WFS
- Pulse flux: GMD/Hamps
- Photon energy: PES
- Pump-probe jitter: PAM



# Current status



Gas needle

Wavefront Sensor & imager @1<sup>st</sup> focus

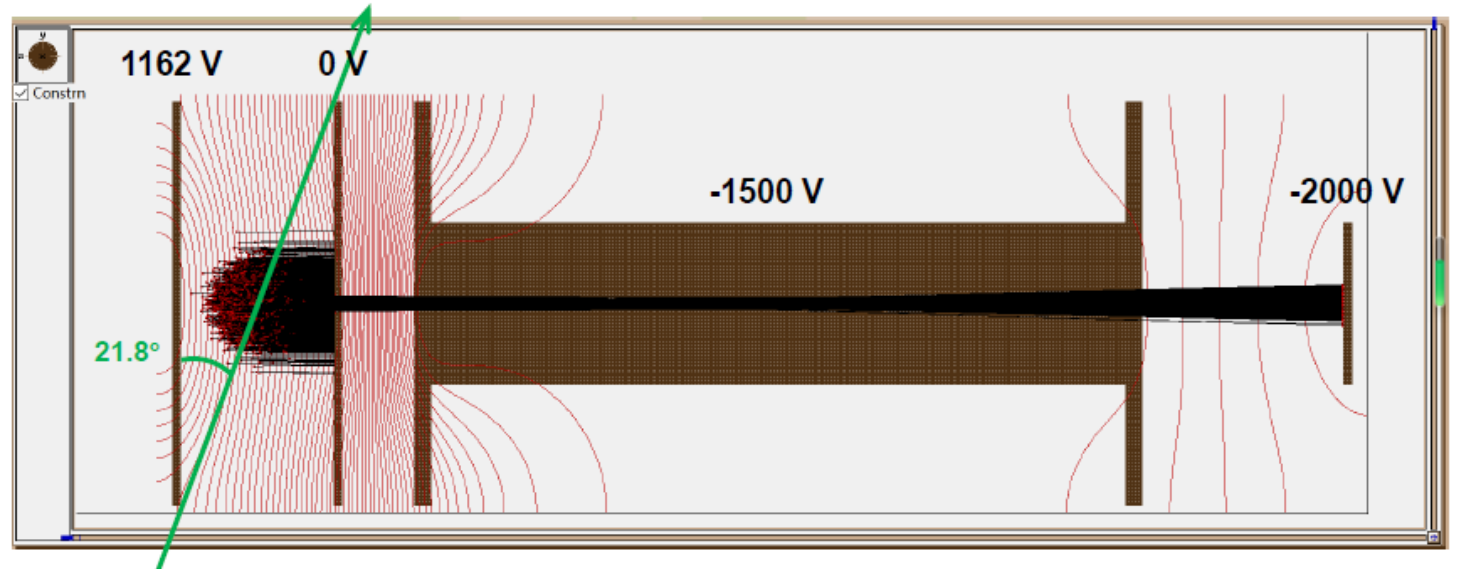
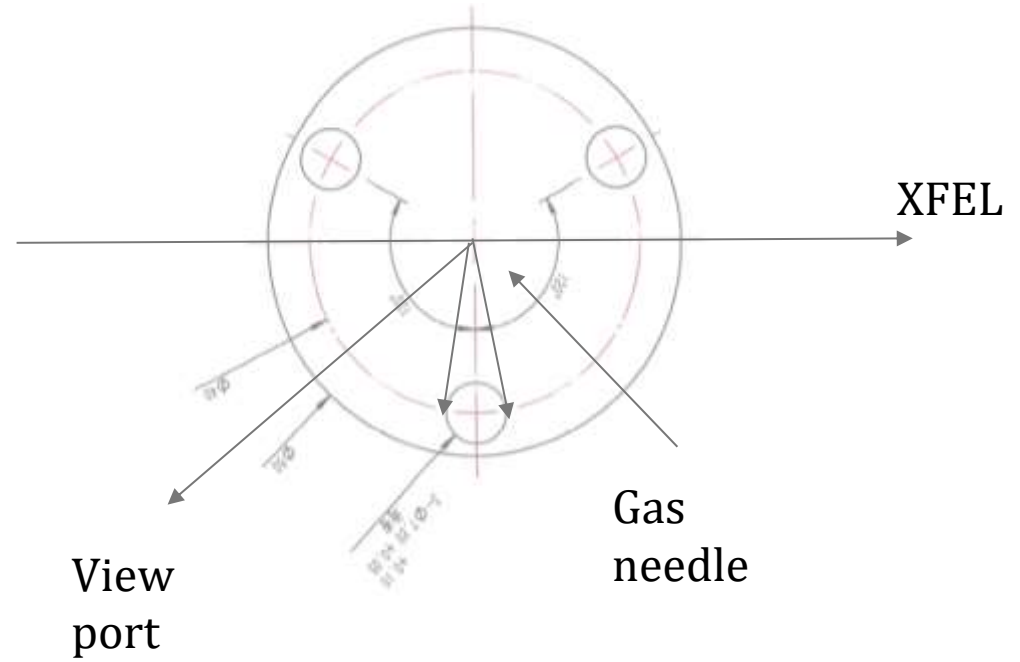
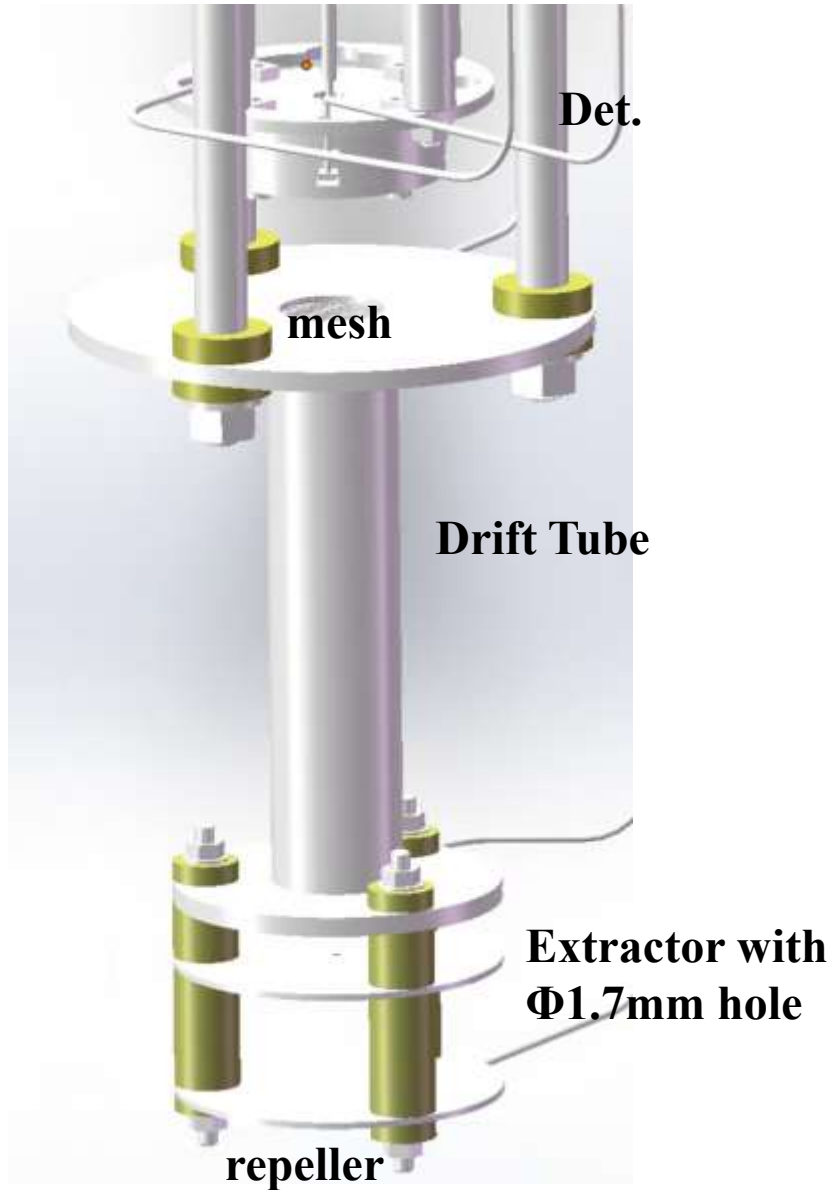
Ion-TOF spectrometer installed @COLTRIMS chamber

Imager after 2<sup>nd</sup> focus

Differential stage

PAM

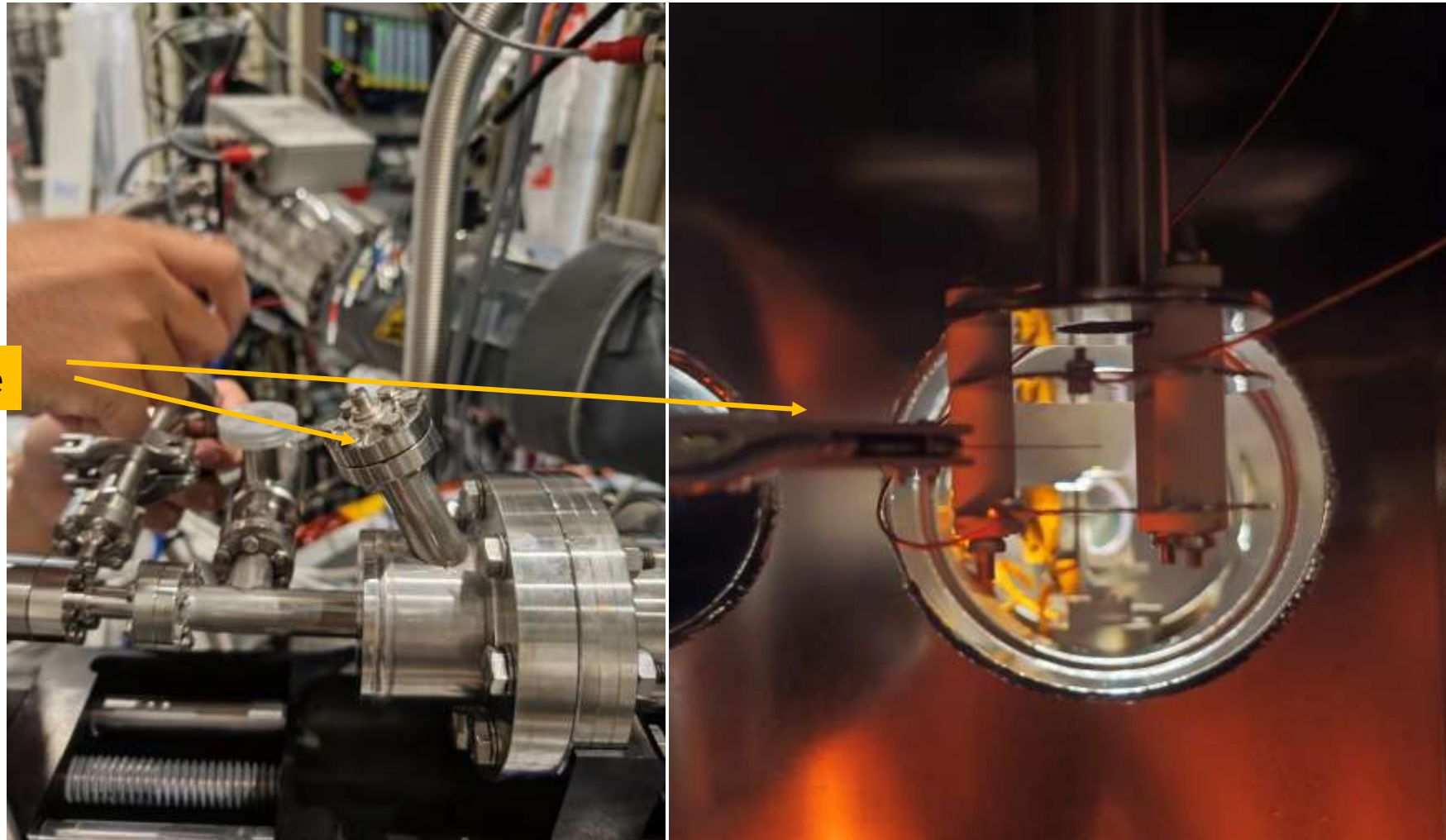
# Current status



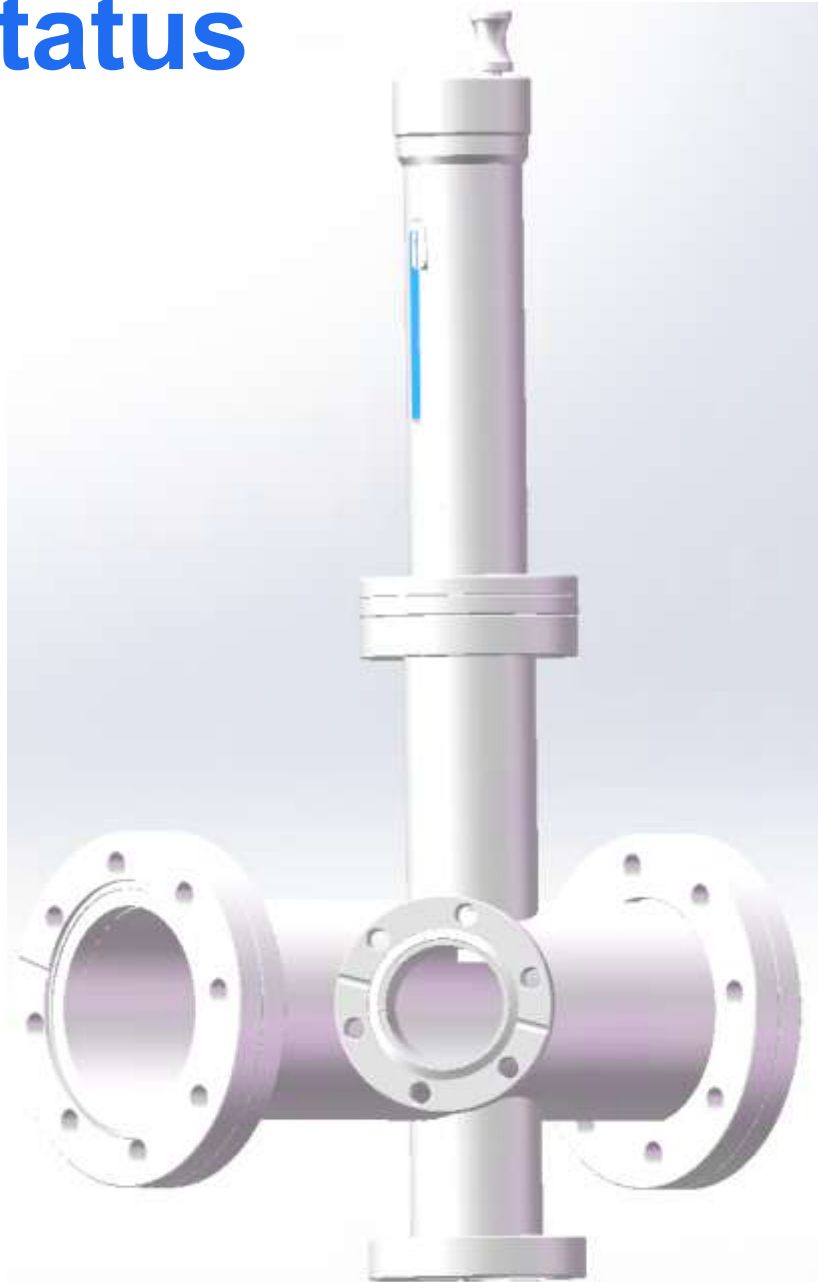
# Current status

Ion-TOF spectrometer installed @COLTRIMS chamber

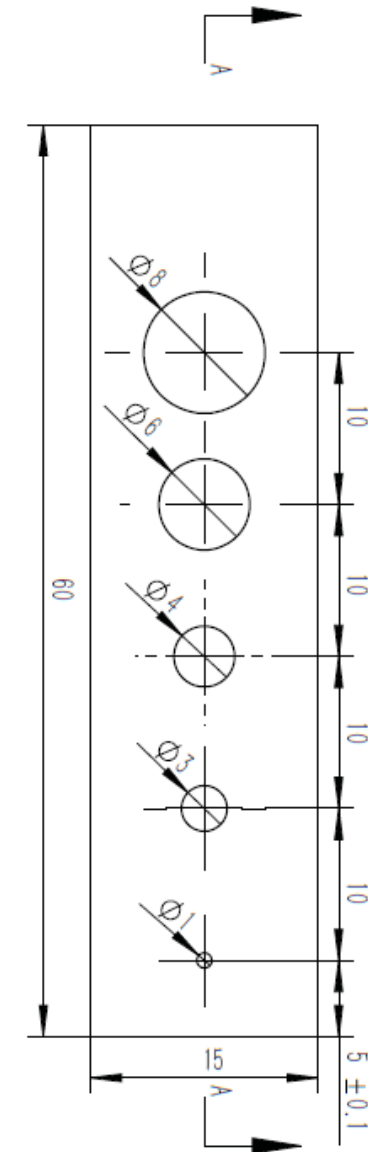
Gas needle



# Current status



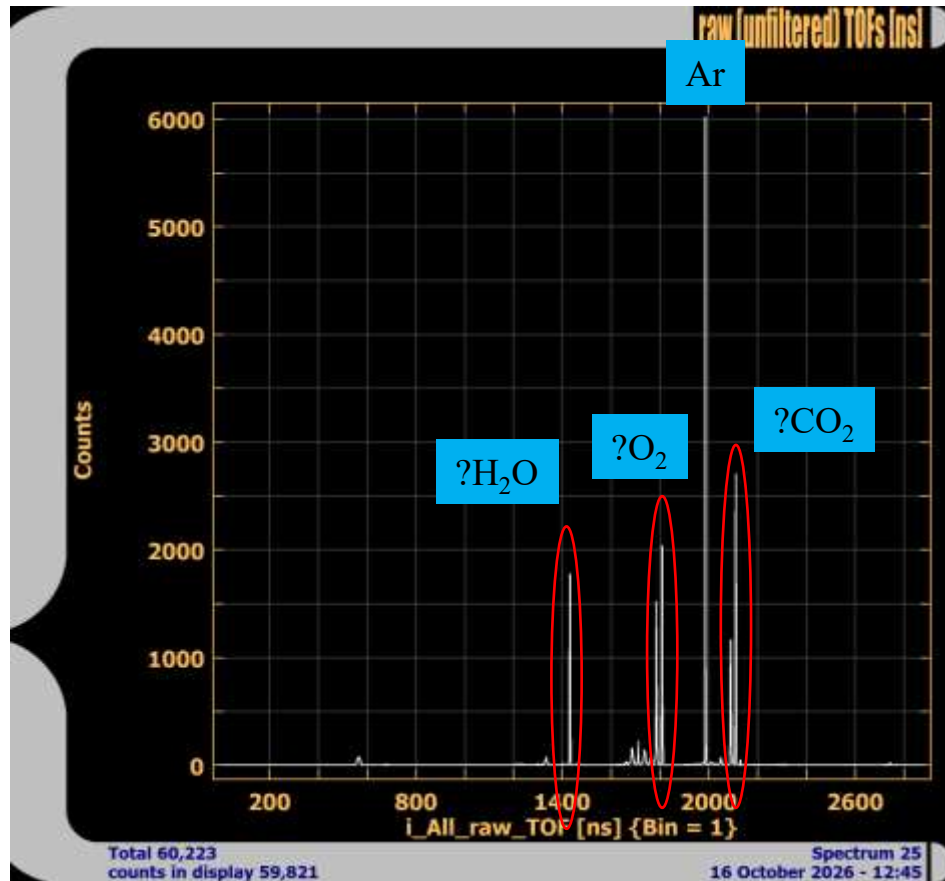
Imager after 2<sup>nd</sup> focus



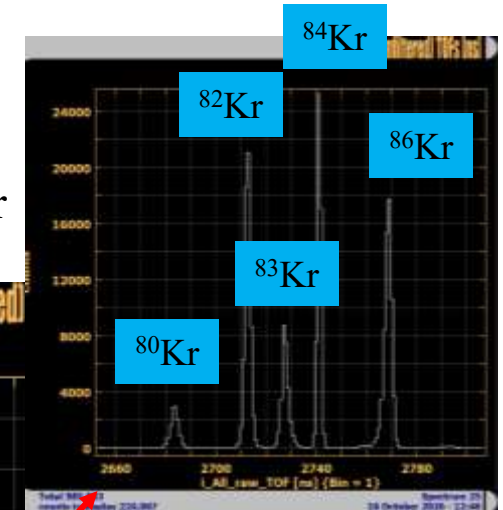
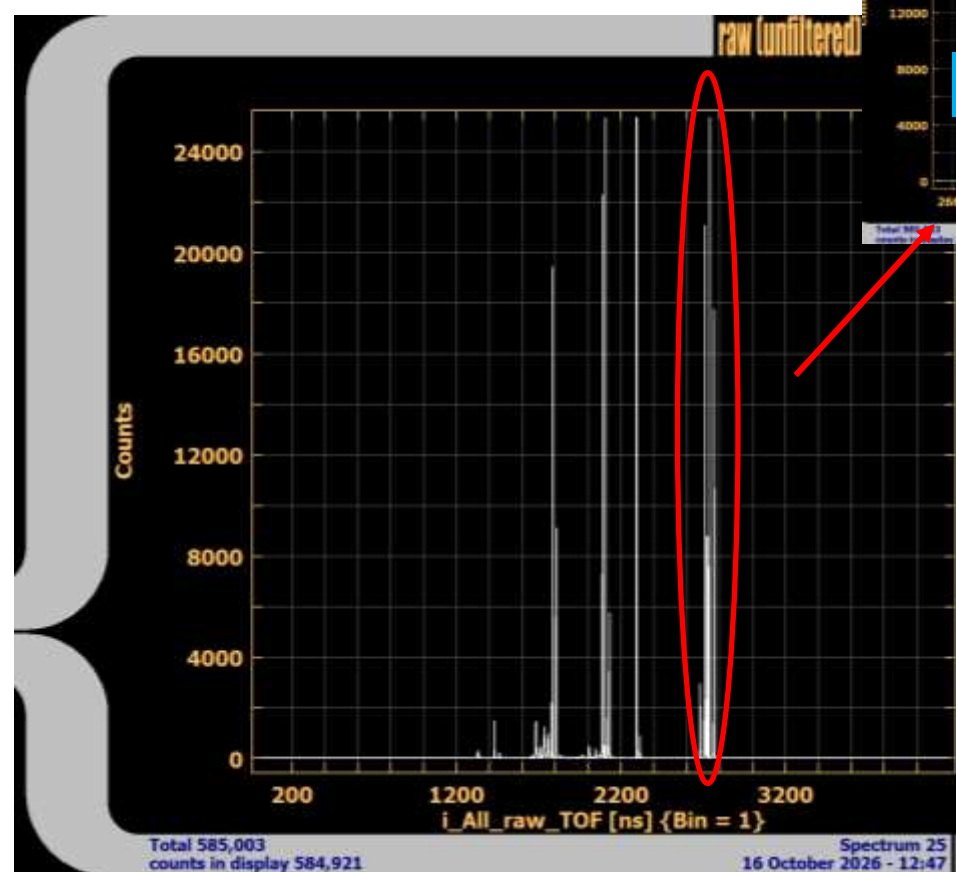
# Current status: ion-TOF

Background pressure is  $\sim 1\text{E-}8$  torr, need to be improved

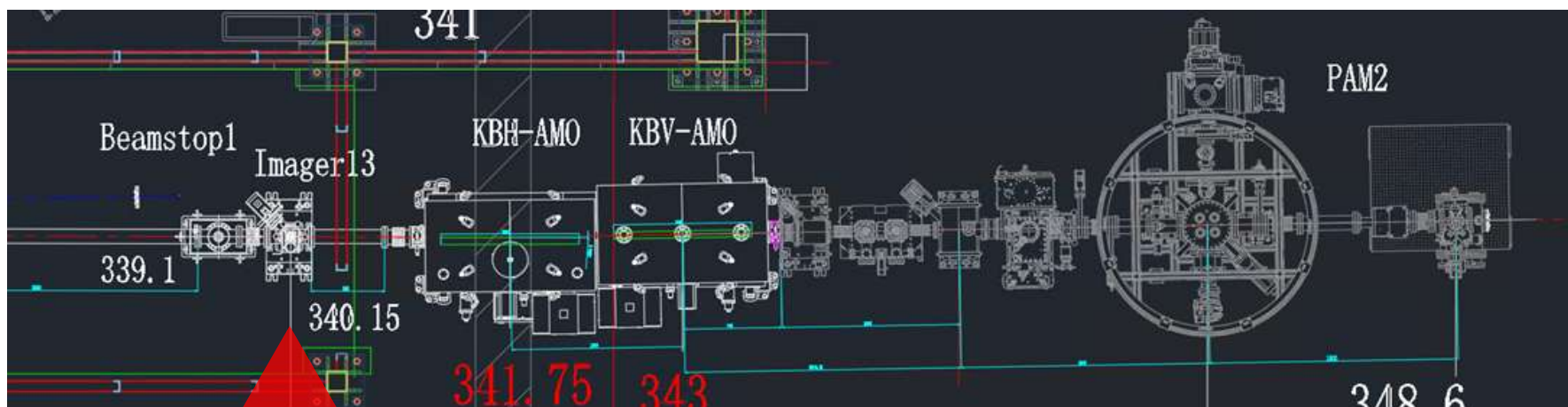
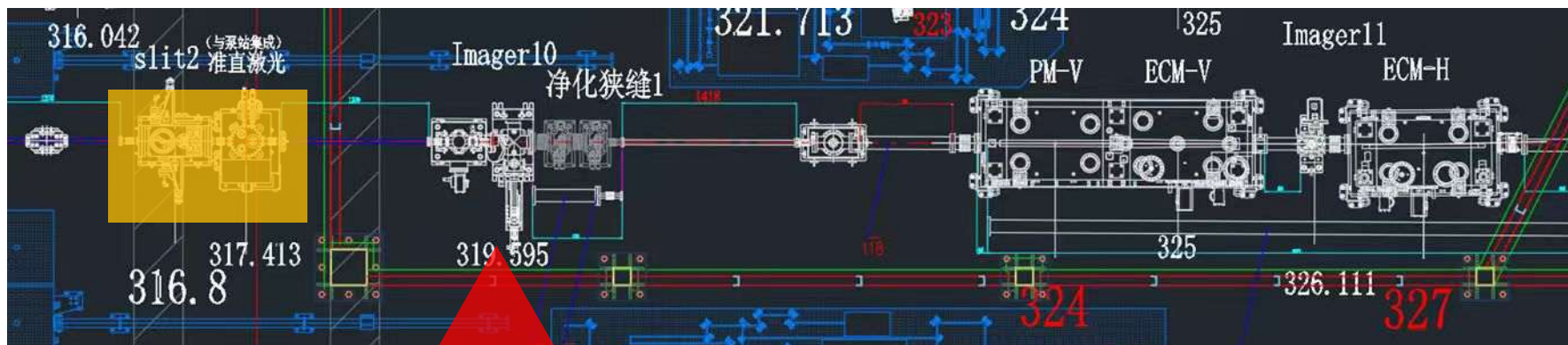
With Ar injection to  $<1\text{E-}6$  torr



With Kr injection to  $<1\text{E-}6$  torr



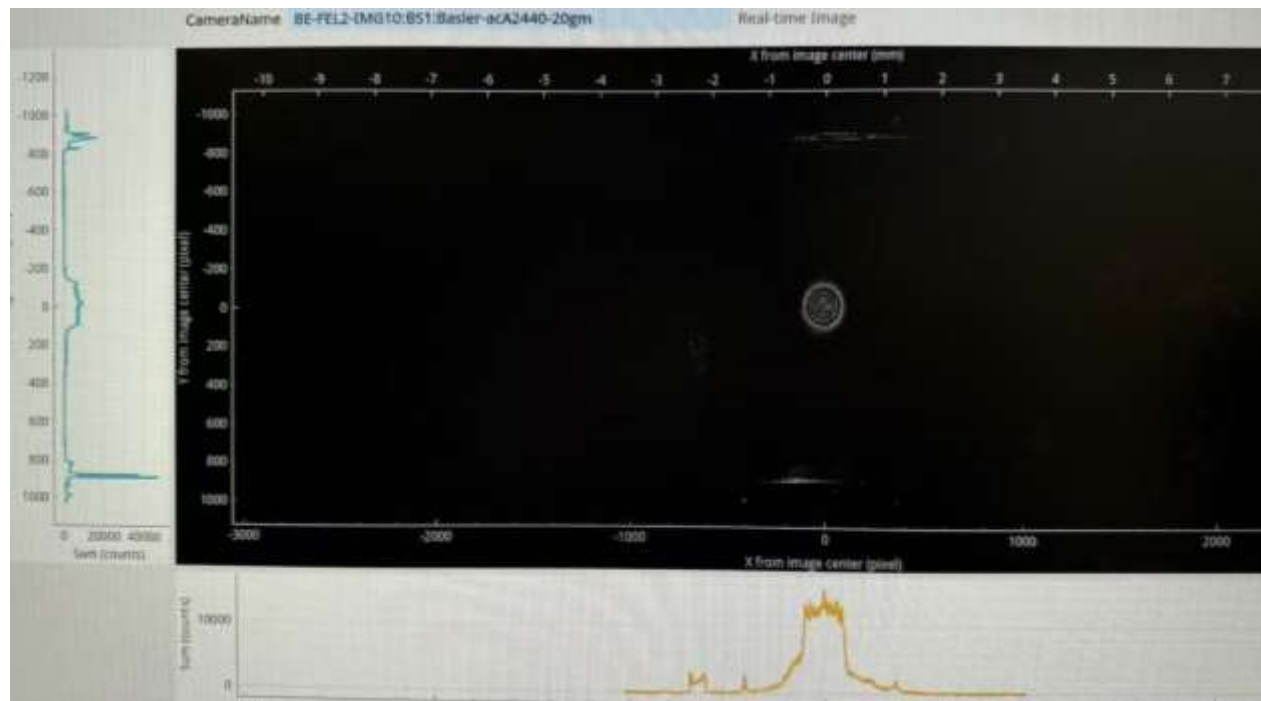
# Current status



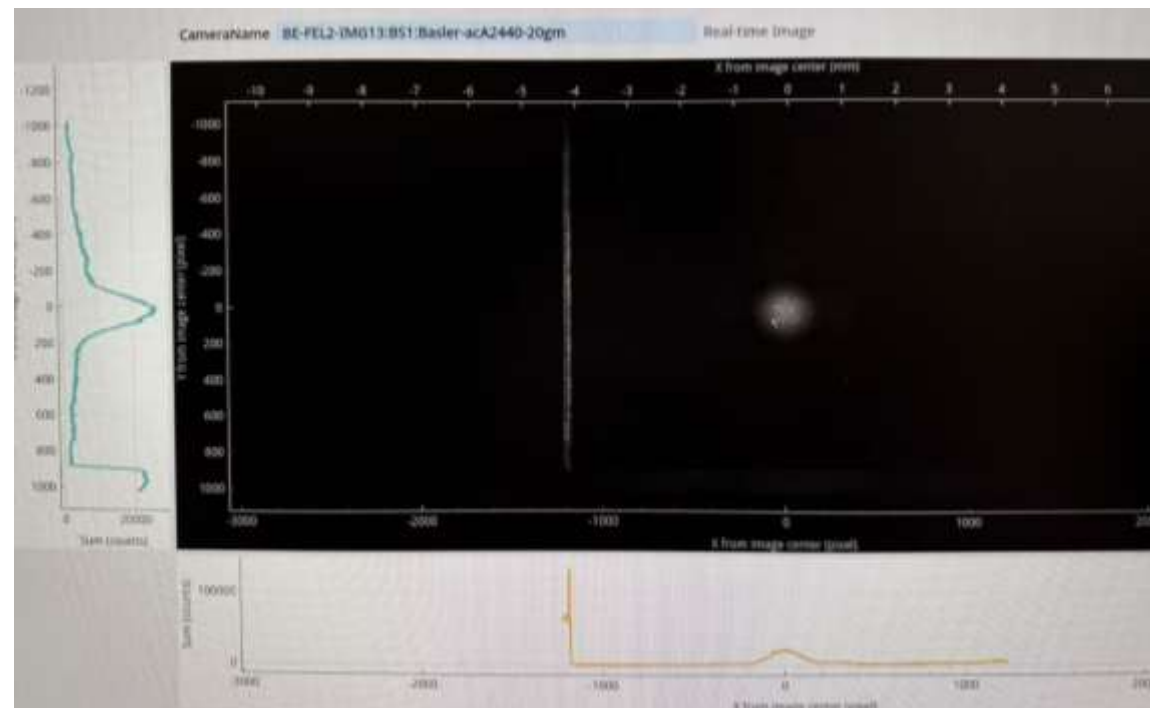
## Reference laser

# Current status:

imager10



imager13

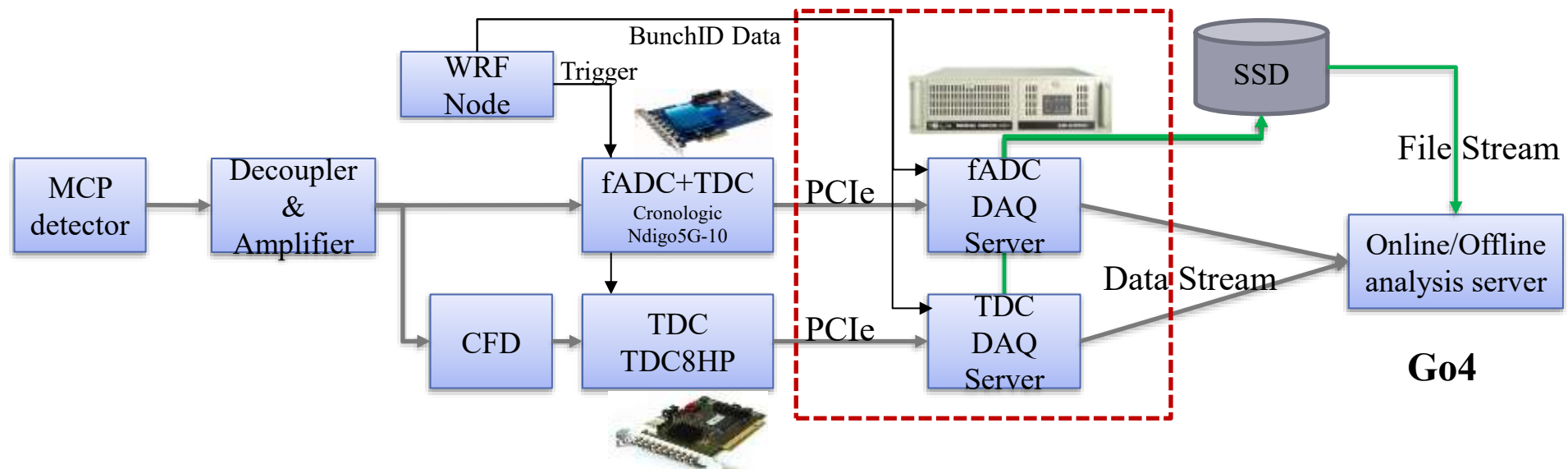


# Current status



# Current status

|   | Software requirements                                      | Devices                 | Software        |
|---|------------------------------------------------------------|-------------------------|-----------------|
| 1 | Timing control and Bunch-ID integration                    | WRF Node                | Timing IOC      |
| 2 | Laser delay line control                                   | Laser Delay line        | Delay line IOC  |
| 3 | Beamline diagnostic data acquisition                       | PAM, PES, HAMPs, Imager | Diagnostic DAQ  |
| 4 | Beamline motion control                                    | KB, Imager, etc         | Motion IOC      |
| 5 | AMO DAQ for TDC and fADC, integration with Timing Bunch-ID | AMO TDC, fADC           | End-station DAQ |
| 6 | A data stream pipeline with online analysis software       |                         |                 |
| 7 | Integration of diagnostic and experimental data            | PAM, PES, HAMPs, KB     | Event building  |



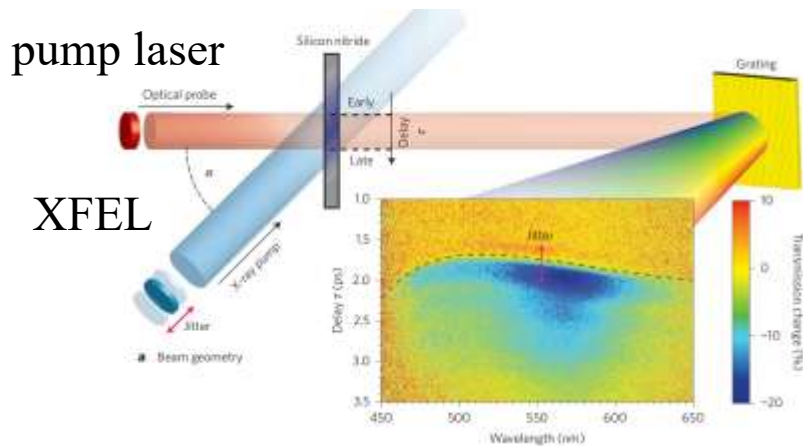
# Photon Arrival Time Monitor (PAM)

The photon arrival time monitor contributes to the arrival time diagnose between the XFEL pulse and laser pulse in the pump-probe experiment basing on the spectral/spatial encoding method.

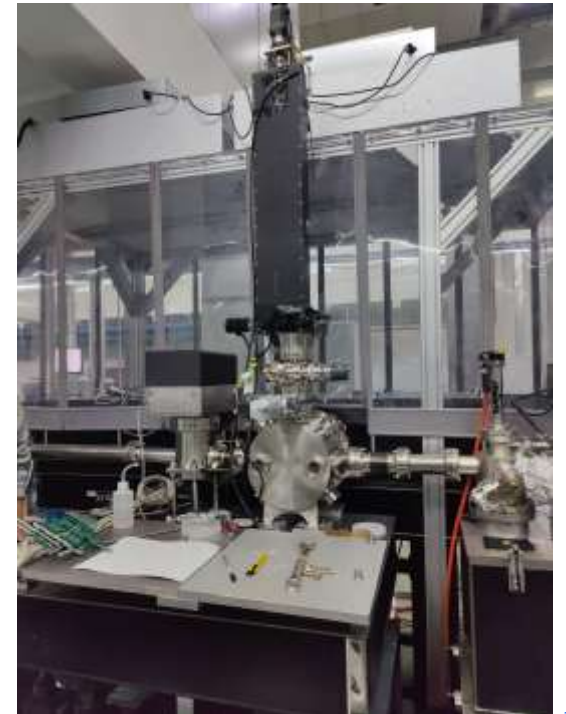
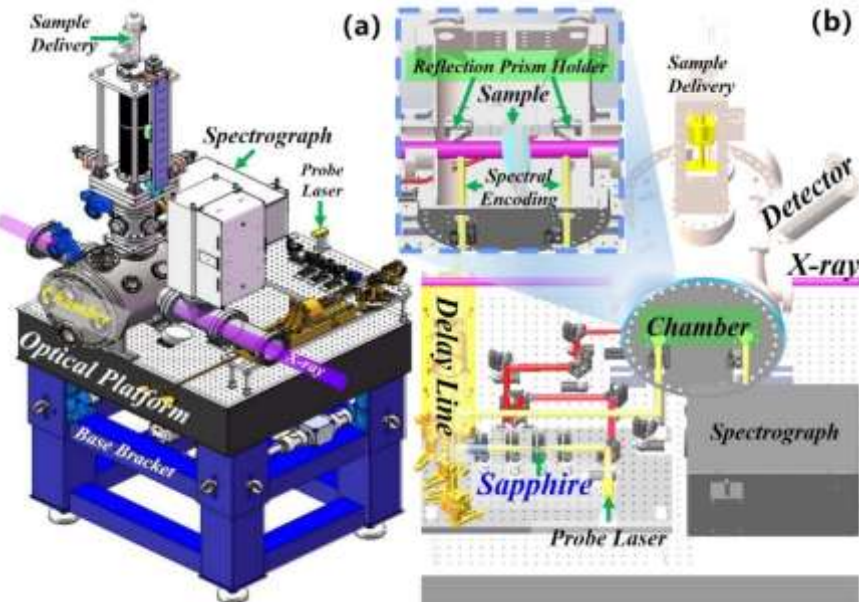
**Accuracy:~38fs (RMS)**

provided by **diagnosis Group** in SHINE

## Spectral/spatial encoding



## optical layout and equipment



# Outline

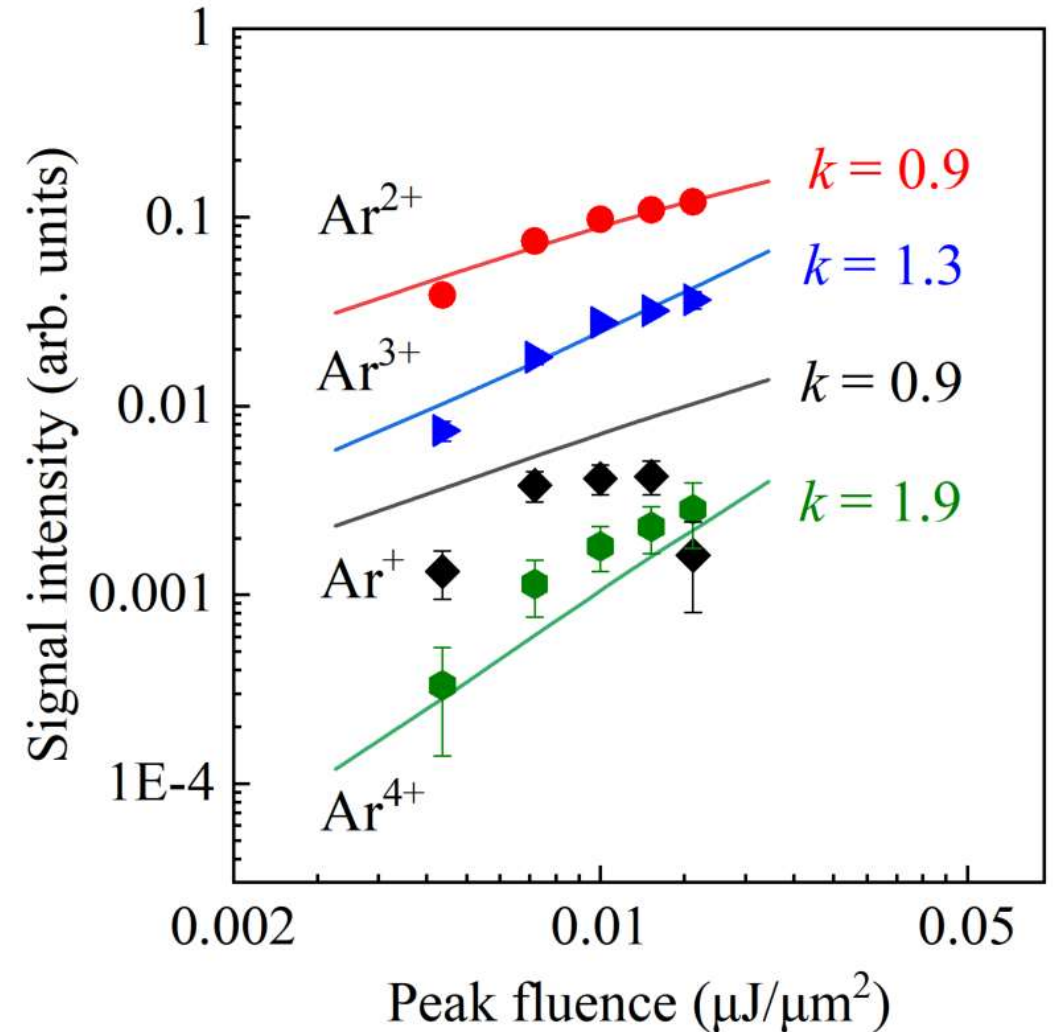
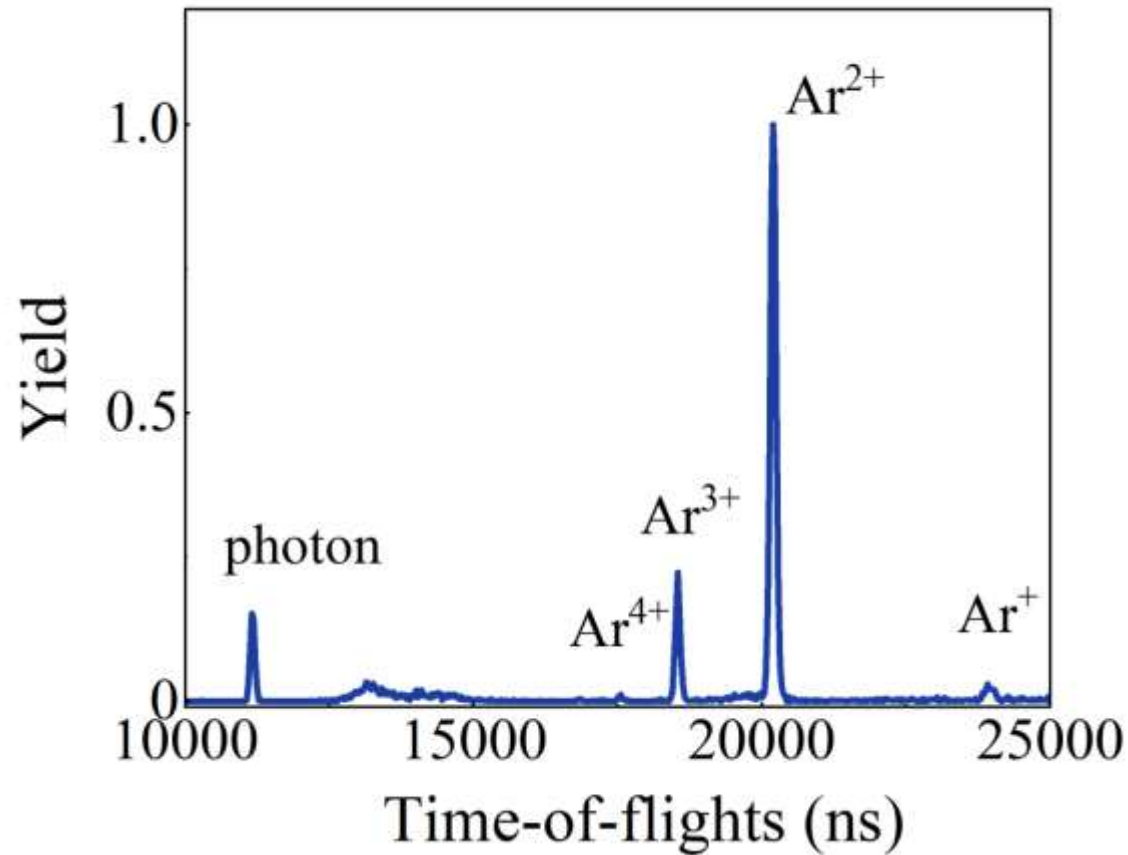
- Update of AMO End-station
- **Ion-TOF testing plan**
- Commissioning plan

# FEL Parameters for testing period

| FEL Parameters       | T0   | T0<br>+5 months | T0<br>+10 months |
|----------------------|------|-----------------|------------------|
| FEL MODE             | SASE | SASE            | SASE             |
| Photon energy (eV)   | 240  | 100~1000        | 100~1000         |
| wavelength (nm)      | 6.2  | 6.2,3.1         | 6.2~3.1          |
| pulse width (fs)     | ~100 | ≤100            | ≤100             |
| Repetition rate (Hz) | 10   | 10k             | 100k             |
| Pulse energy (μJ)    | ≥10  | ≥10             | ≥30              |
| Pump-probe jitter    | /    | ≤50             | ≤30              |
| Trigger              | Yes  | Yes             | Yes              |
| Bunch ID             | Yes  | Yes             | Yes              |

# FEL Parameters for testing period

With 4-5 days, test the spectrometer with bunchID、Time 0 and obtain intensity dependent Kr TOF measurement



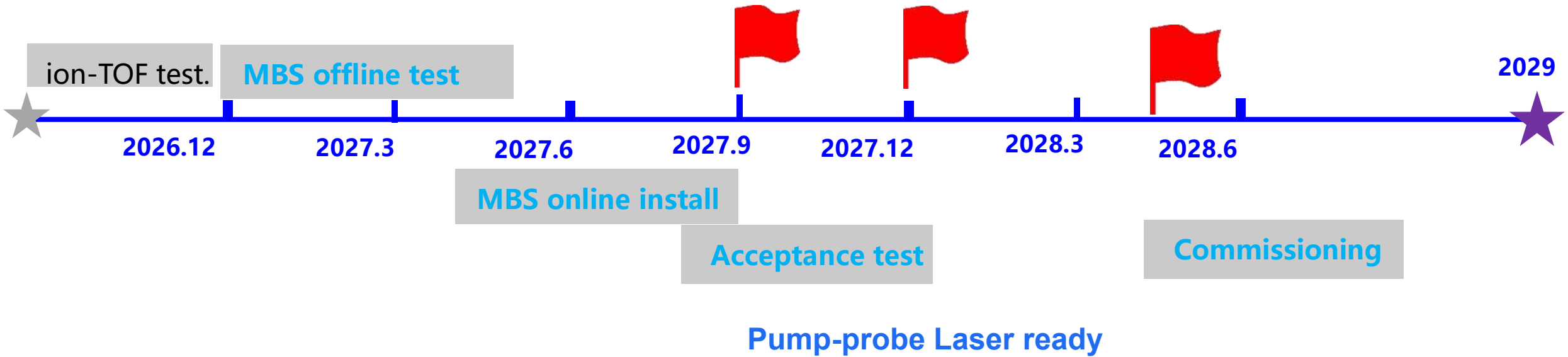
# Ion-TOF testing plan

- ◆ **Day 1** : Align the XFEL beam with imagers and get the timing sequence
- ◆ **Day 2** : Test of the triggering time zero and get ion-TOF spectrum on-line
- ◆ **Day 3** : Accumulate Data & Analyze Data along with GMD data with the same bunch ID.
- ◆ **Day 4** : Accumulate Data .
- ◆ **Day 5** : Accumulate Data .

# Outline

- Update of AMO End-station
- First Light testing plan
- **Commissioning plan**

# Commissioning Schedule



- ◆ **Nov. 2026:** ion-TOF test.
- ◆ **Sep. 2027:** MBS online installation.
- ◆ **Dec. 2027:** Ready for the acceptance tests.
- ◆ **Apri. 2028:** Commissioning with high rep. rate.

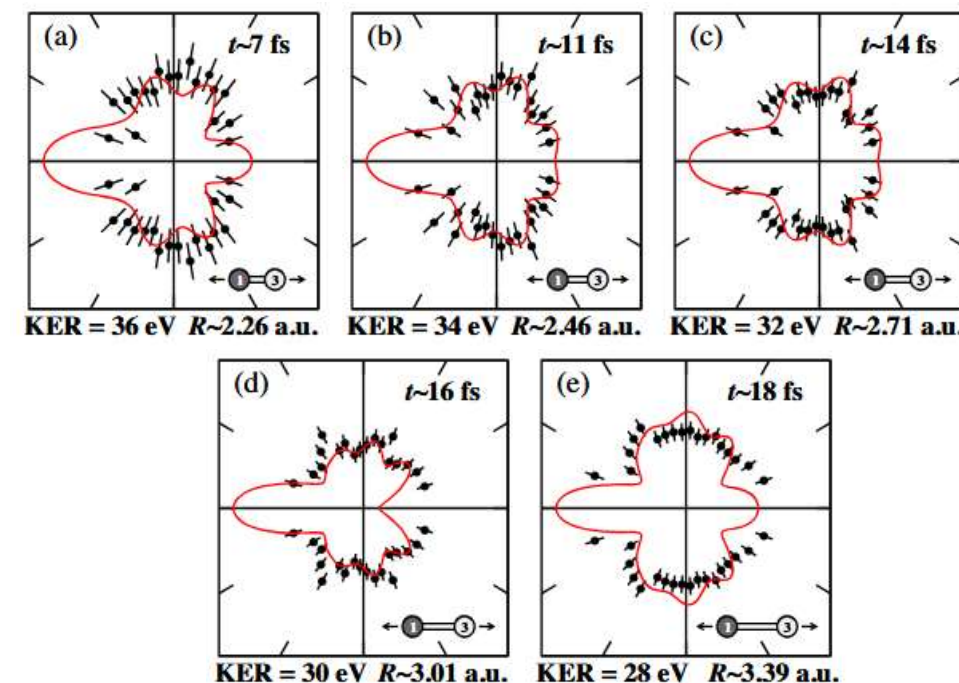
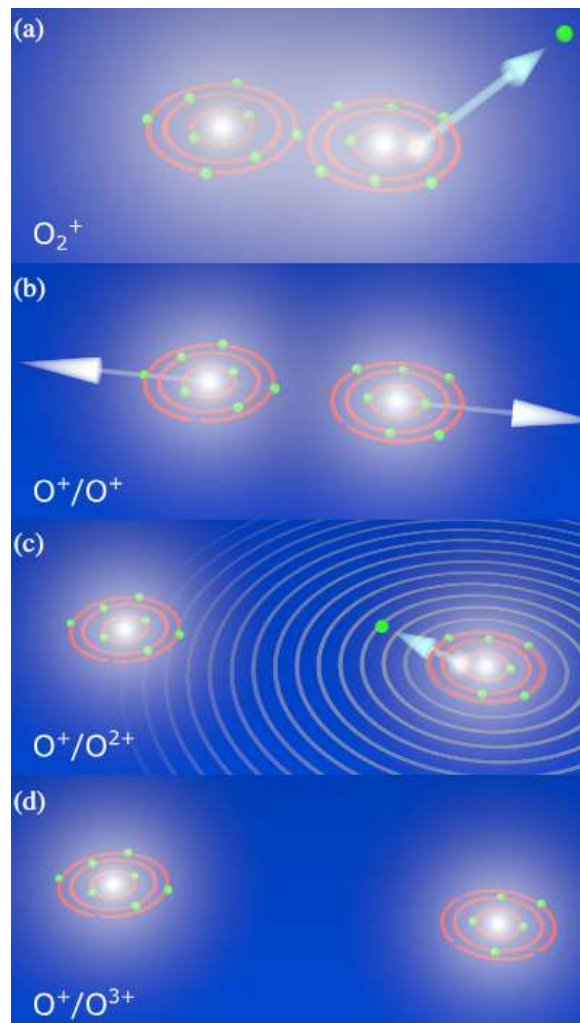
# FEL Parameters for commissioning

| FEL Parameters       | T0   | T0<br>+5 months | T0<br>+10 months |
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| Pump-probe jitter    | /    | ≤50             | ≤30              |
| Trigger              | Yes  | Yes             | Yes              |
| Bunch ID             | Yes  | Yes             | Yes              |

# Commissioning plans

## Molecular frame photoelectron angular distribution measurement

| XFEL           |             |
|----------------|-------------|
| Photon energy  | 400-1000 eV |
| Pulse duration | ~100 fs     |
| Rep. rate      | ~10 kHz     |
| Pulse energy   | ≥10 μJ      |



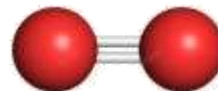
➤ quasi time-resolved imaging

Challenges from the background electrons  
& multi-fold coincidence measurements

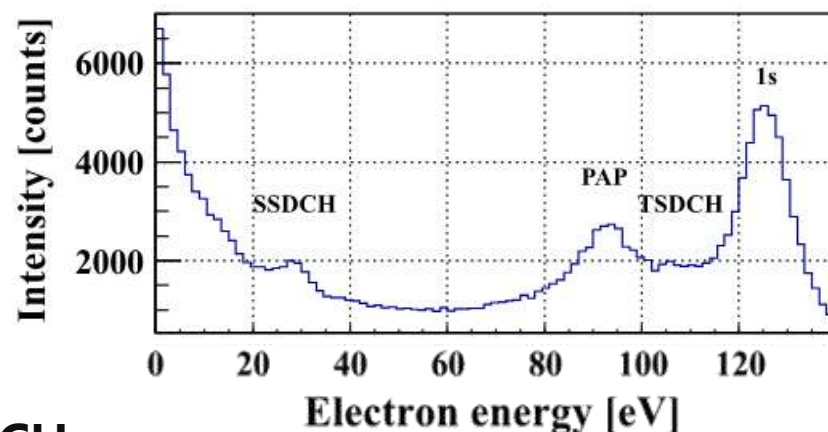
# Commissioning plans

## Molecular frame photoelectron angular distribution measurement

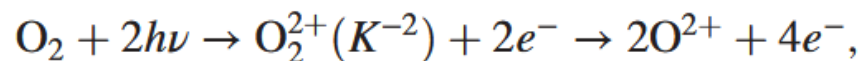
Double core-hole state related measurements



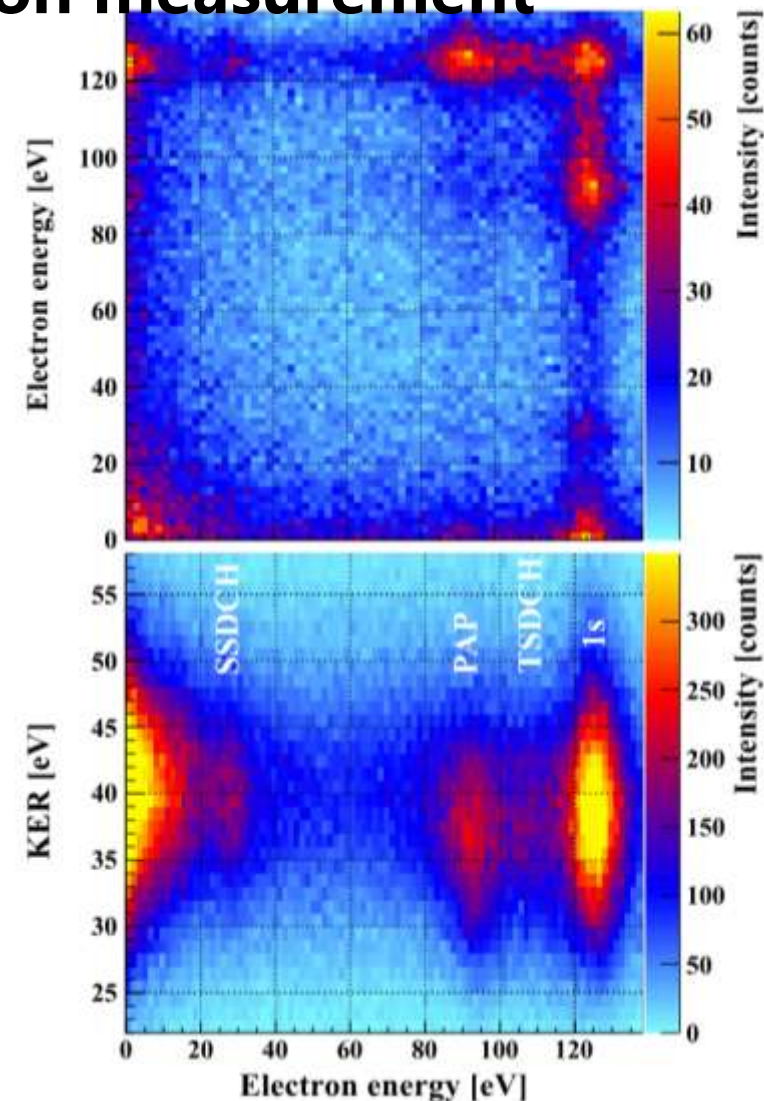
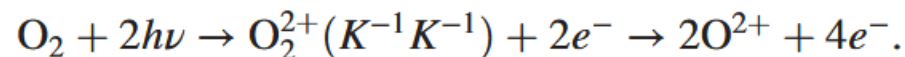
| XFEL           |             |
|----------------|-------------|
| Photon energy  | 400-1000 eV |
| Pulse duration | <35fs       |
| Rep. rate      | ~100 kHz    |
| Pulse energy   | ≥30 μJ      |



**SSDCH:**



**TSDCH:**



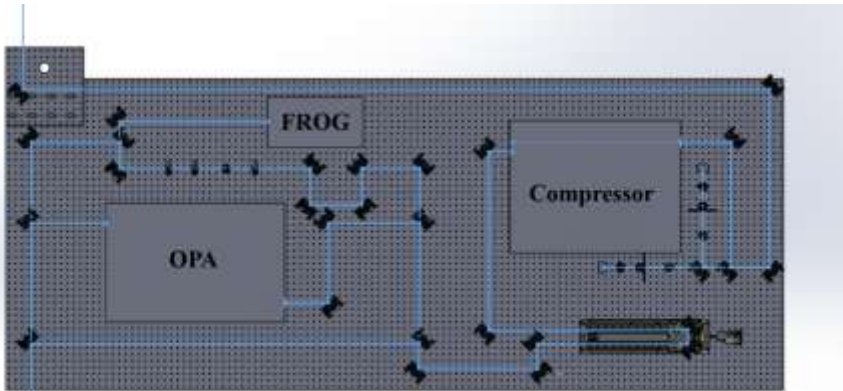
# Pump-probe Laser system for AMO

## ❑ Laser available

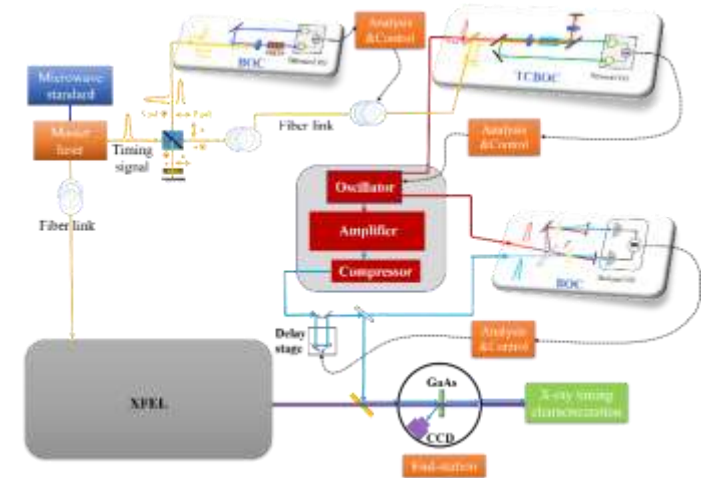
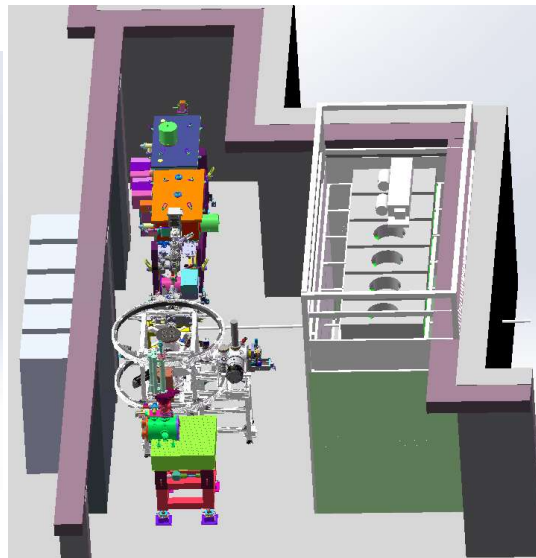
- ✓ High repetition rate and high-power laser: 1030 nm, 25~40 fs, 100 W @100 kHz
- ✓ **Uncompressed** fundamental laser pulse transported through **evacuated tubes** and **re-compressed** at end-station
- ✓ Frequency conversion units: UV to IR by OPA; Harmonic Generator (SHG/THG)

## ❑ Synchronization between pump-probe laser and XFEL

- ✓ Oscillator locked to the master laser and timing drift between oscillator and amplifier will be further compensated
- ✓ **< 40 fs jitter** between pump-probe laser and XFEL pulse



Optical design of pump-probe laser at AMO end-station



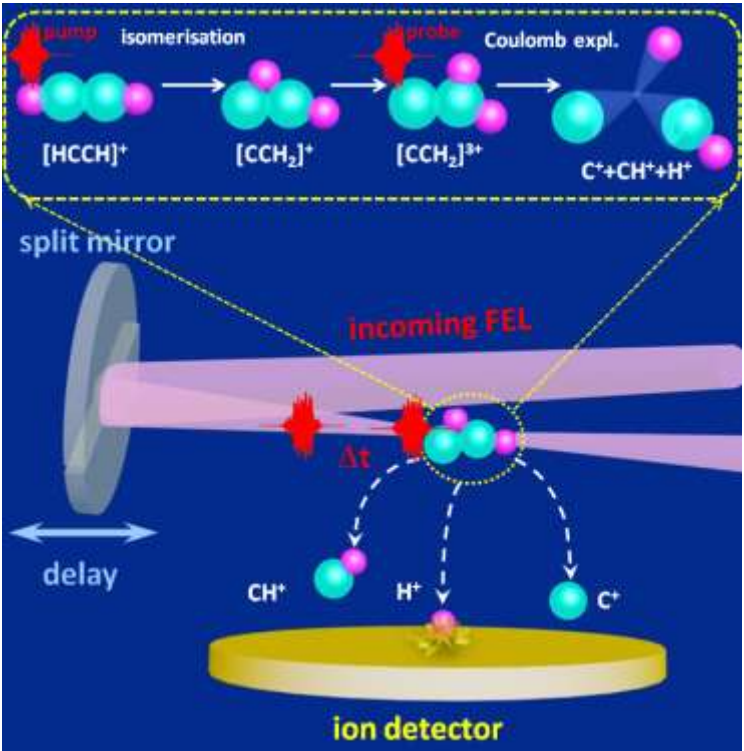
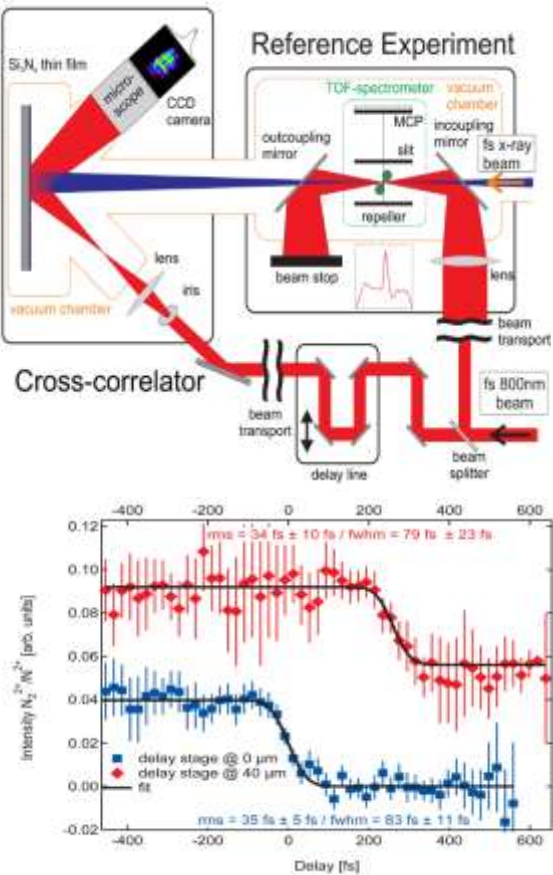
Synchronization between pump-probe laser and XFEL

\*Pump-probe laser system is provided by **Laser Group** in SHINE25

# Commissioning plans

## Time resolve measurement of bond breaking, isomerization ...

| XFEL           |             |
|----------------|-------------|
| Photon energy  | 200-1000 eV |
| Pulse duration | <35fs       |
| Rep. rate      | ~100 kHz    |
| jitter         | <35fs       |
| Pulse energy   | ≥30 μJ      |



Schorb et al., Appl. Phys. Lett. **100**, 121107 (2012)

Jiang et al., Phys. Rev. Lett. **105**, 263002 (2010)

# Acknowledgement

AMO team:



Xincheng Wang



Xiaojing Liu



Zhenjie Shen



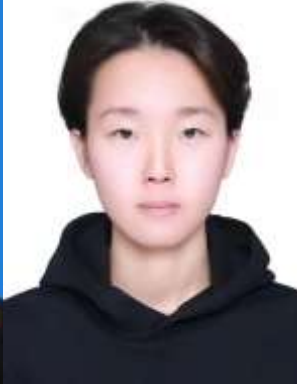
Yikang Zhang



Jinze Feng



Hailong Guo



XiuRan Zhu



Jianfeng Liao



**Thank you for your attention!**



