

Status and Commissioning of Timing and DAQ for Beamlines and End-stations

Speaker: Congcong Yin

On behalf of Data Acquisition and Analysis Group

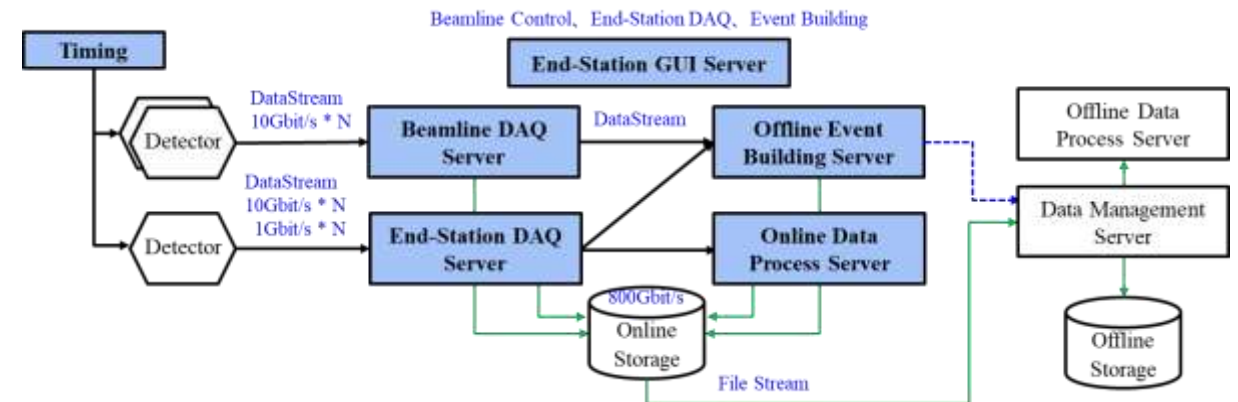
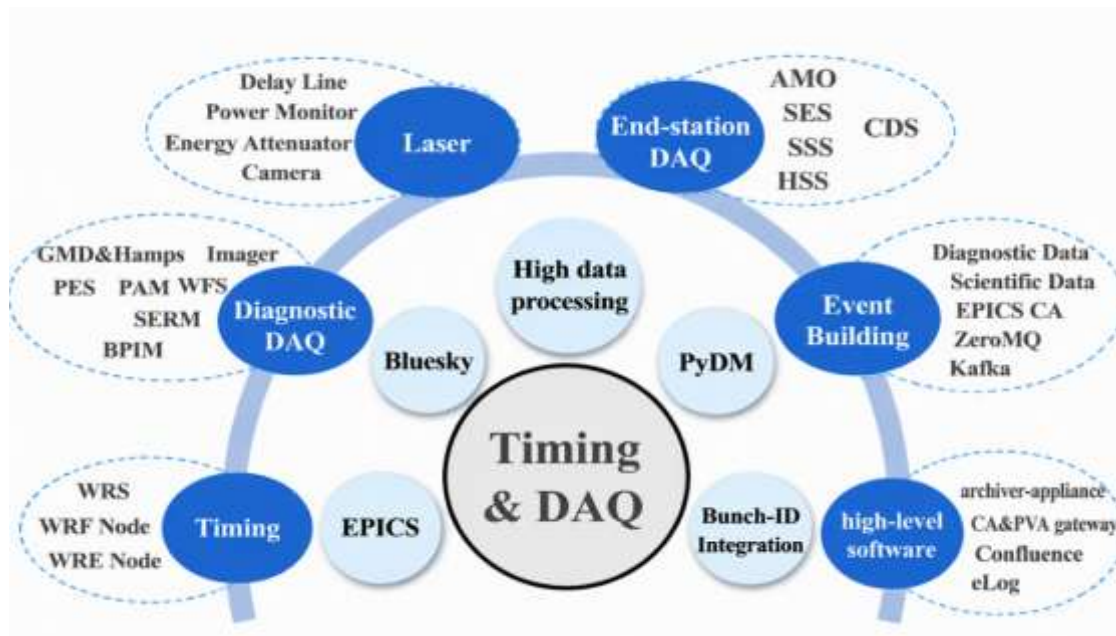
Oct. 20, 2026

Outline

- **System Overview and Progress**
- **Timing System Status**
- **DAQ Software Status**
- **Commissioning Roadmap**

Timing & DAQ for Beamlines and End-stations

- ❑ Timing and DAQ form the core of the system.
- ❑ The architecture covers timing, diagnostic DAQ, laser Control, end-station DAQ, event building, and high-level applications.
- ❑ The system provides an end-to-end workflow: **precise timing** → **multi-source data acquisition** → **Data Standardized Storage** → **event building** → **high-level applications**.



Summary of Timing and DAQ Progress

- ❑ FEL-II Timing deployed, FEL-I Timing hardware and optical fibers installed.
- ❑ 12 DAQ programs deployed, 3 company-developed diagnostic programs integrated into the DAQ system.
- ❑ SSS and HSS DAQ software scheduled for completion by the end of 2026; CDS DAQ software in May 2027.

	software	requirements discussion	solution design	software development	testing	integration testing with Timing in the lab	deployment	commissioning	Apri Progress	Now Progress
1	FEL2 Timing Software	completion	completion	completion	completion	completion	completion	completion	95%	100%
2	FEL2 Laser Control	completion	completion	completion	completion	N.A.	in progress	in progress	50%	70%
3	FEL2 SES TAP DAQ	completion	completion	completion	completion	completion	completion	completion	85%	100%
4	FEL2 AMO TDC DAQ	completion	completion	completion	completion	completion	completion	in progress	85%	95%
5	FEL2 SSS DAQ	completion	completion	in progress	in progress	in progress			10%	80%
6	FEL1 HSS DAQ	completion	completion	in progress	in progress	completion			10%	70%
7	FEL1 CDS DAQ	completion	completion	in progress	in progress	completion			5%	20%
8	FEL2 Imager DAQ	completion	completion	completion	completion	completion	completion	completion	90%	100%
9	FEL2 PAM DAQ	completion	completion	completion	completion	completion	completion	completion	80%	100%
10	FEL2 Spectrometer Control	completion	completion	completion	completion	N.A.	completion	completion	80%	100%
11	FEL2 WFS DAQ	completion	completion	completion	completion	completion	completion	completion	90%	100%
12	FEL2 SERM DAQ	completion	completion	completion	completion	completion	completion	in progress	15%	100%
13	FEL1 BPIM DAQ	completion	completion	completion	in progress	completion			15%	50%
14	FEL2 PES DAQ(support)	completion	completion	N.A.	N.A.	completion	completion	completion	80%	100%
15	FEL2 GMD&Hamps(support)	completion	completion	N.A.	N.A.	completion	completion	completion	80%	100%
16	FEL2 Event Building Software	completion	completion	completion	completion	completion	completion	in progress	80%	90%
17	FEL2 Integrated GUI	completion	completion	completion	completion	completion	completion	in progress	20%	95%
18	Achive Application, Autosave, ProcServControl, IOCStats...	completion	completion	completion	completion	N.A.	completion	in progress	80%	95%

□ FEL-II

- All 17 fan-out and 9 embedded timing nodes deployed and online.
- All nodes now **operating normally**; earlier instability may have been related to other equipment being installed at the same time.
- **New UI enables simultaneous timing configuration for multiple devices.**

□ FEL-I

- All 23 fan-out timing nodes, WR switches and timing fiber **deployed** and will be online when rack power is available.

FEL-II Expert GUI



FEL-II User Interface



FEL-I Timing Installation and Deployment



□ FEL-II

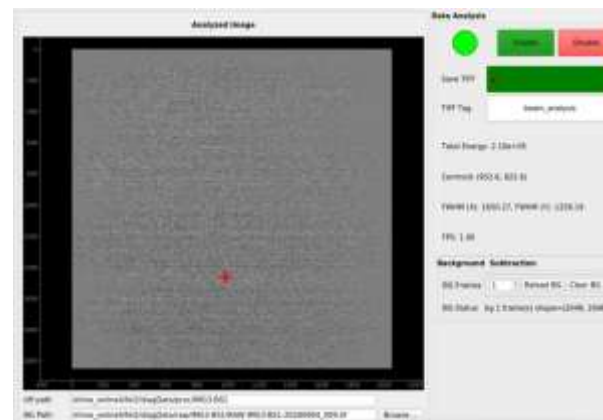
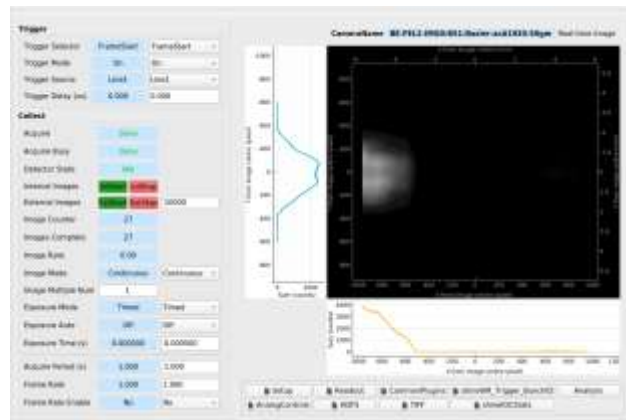
- **53** detectors total: **1** undergoing on-site installation; **7** not scheduled for Phase I beam commissioning.
- **45** detectors: Timing and DAQ integration testing complete; integrated with central DAQ control interface
- Issues resolved: High-speed data writes to online GPFS storage, electromagnetic interference on timing trigger lines, etc.

No.	Device	Timing-DAQ Offline Integration	Beam-On Check
1	Imager0	Completed	Completed
2	Imager1	Completed	Completed
3	Imager2	Completed	Completed
4	Imager3	Completed	Completed
5	Imager4	Completed	Completed
6	Imager5	Completed	Completed
7	Imager6	Completed	Completed
8	Imager7	Completed	Completed
9	Imager8:BS1	Completed	Completed
10	Imager8:BS2	Completed	Completed
11	Imager9	Previously used by IEB; no longer needed	Not online
12	Imager10	Completed	Completed
13	Imager11	Used by IEB KB; will be brought online after IEB KB is installed, during the next round of beam tuning	Not online
14	Imager13	Completed	Completed
15	m_Imager9	Completed	Completed
16	m_Imager10	Completed	Completed
17	m_Imager11	Used for SSS laser beam combining; will not be brought online during this round of beam tuning	Not online
18	m_Imager12	Completed	Completed
19	GMD&Hamps1	Completed	Completed
20	GMD&Hamps2	Completed	Completed
21	m_Hamps2	Completed	Completed
22	PES fADC	Completed	Completed
23	PES Basler1	Completed	Completed
24	PES Basler2	Completed	Completed
25	BLM1	Completed	Completed
26	BLM2	Completed	Completed
27	BLM3	Completed	Completed

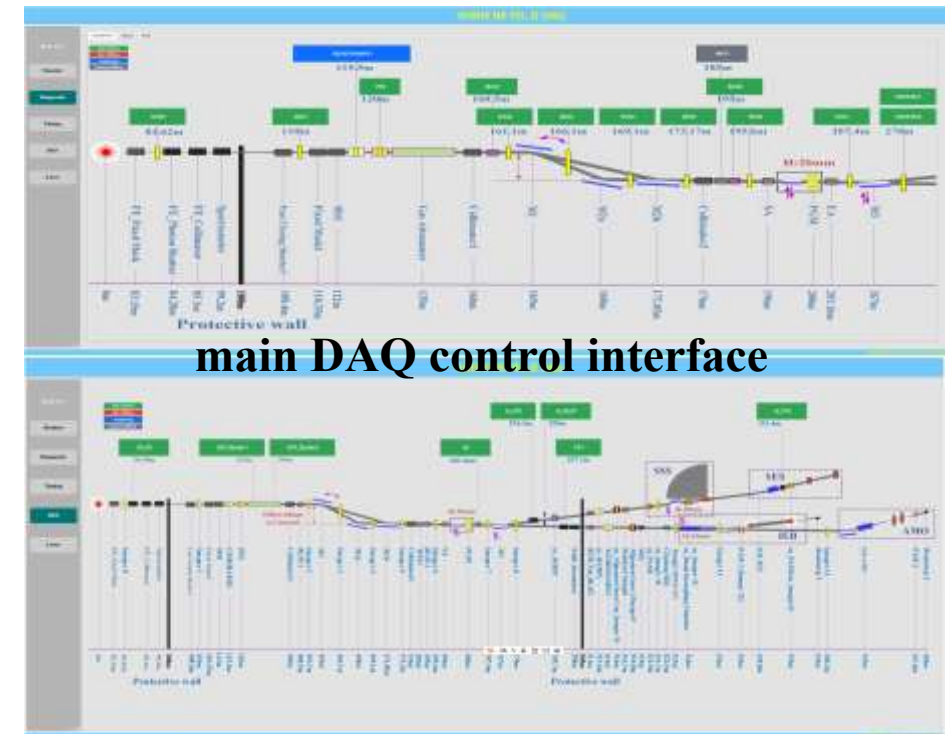
No.	Device	Timing-DAQ Offline Integration	Beam-On Check
28	m_BLM3	Completed	Completed
29	M2-WFS	will not be brought online during this round of beam tuning	Not online
30	AMO-WFS Andor	Pending	
31	AMO-WFS Balser1	Completed	Completed
32	AMO-WFS Balser2	Completed	Completed
33	AMO-WFS Balser3	Completed	Completed
34	SES-WFS Andor	Completed	Completed
35	SES-WFS Basler1	Completed	Completed
36	SES-WFS Basler2	Completed	Completed
37	SSS-WFS Andor	will not be brought online during this round of beam tuning	Not online
38	SSS-WFS Basler1	will not be brought online during this round of beam tuning	Not online
39	SSS-WFS Basler2	will not be brought online during this round of beam tuning	Not online
40	AMO-PAM2	Completed	Completed
41	SES-m_PAM2	Completed	Completed
42	SERM MCP fADC	Completed	Completed
43	SERM Basler1	Completed	Completed
44	SERM Basler2	Completed	Completed
45	SESC Andor	Completed	Completed
46	FE_PS Basler1	Completed	Completed
47	GAT Basler1	Completed	Completed
48	GAT Basler2	Completed	Completed
49	EA Basler1	Completed	Completed
50	m_PS1 Basler1	Completed	Completed
51	m_ESLIT Basler1	Completed	Completed
52	m_PS2 Basler1	Completed	Completed
53	PS1 Basler1	Completed	Completed

Beam-tuning Imager

- ❑ All 23 Basler CMOS cameras are on line at imagers, Photon Shutter, Gas Attenuator, Exit Aperture, and Exit Slit.
- ❑ All IOCs deployed 3 servers in Shaft#4 DAQ server room. OPIs integrated into the main DAQ control interface.
- ❑ Each OPI supports parameter control, data display, timing configuration, data storage and data analysis.



One Camera OPI

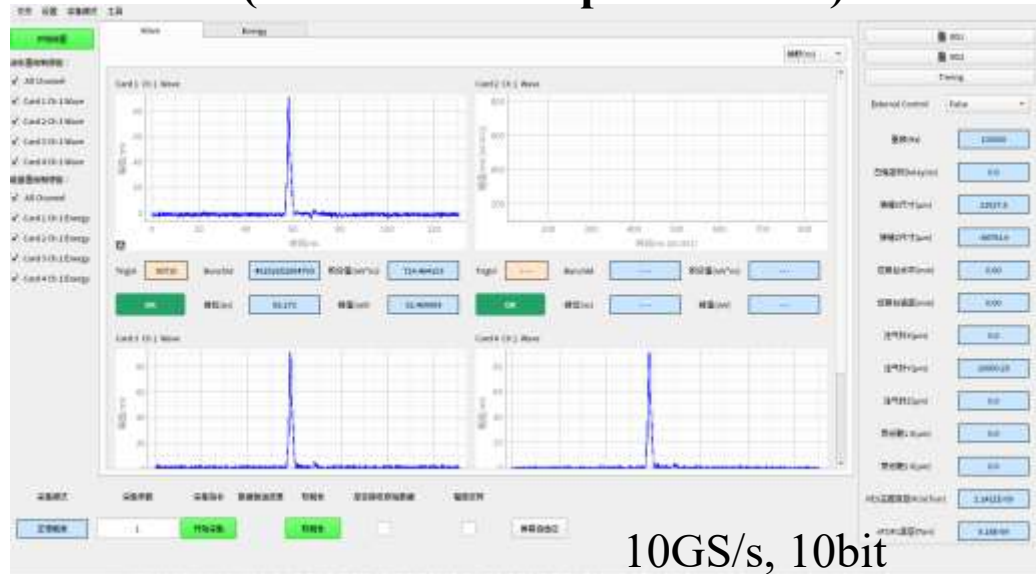


main DAQ control interface

Diagnostic DAQ—PES and GMD&Hamps

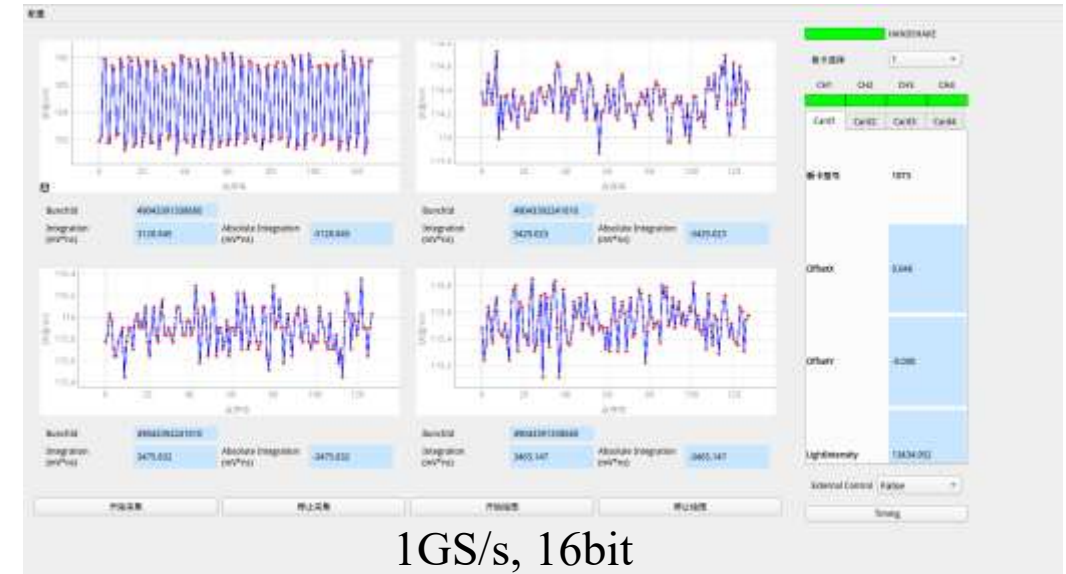
- ❑ **Single-pulse diagnostics for experimental data analysis.** fADC hardware and DAQ software mainly developed by vendor.
- ❑ PyQt interfaces replaced with PyDM for central DAQ integration; **Storage directories and file names** updated for event building.

PES(Photoelectron Spectrometer)



```
(base) [daaopi@FELII-opi r00026]$ pwd
/shine_online4/fel2/diagData/raw/PES/20260915/r00026
(base) [daaopi@FELII-opi r00026]$ ls
card1Channel1Para.cfg      RAW-R0026-PES-ADC-Card2-S00061.dat
card2Channel1Para.cfg      RAW-R0026-PES-ADC-Card3-S00000.dat
card3Channel1Para.cfg      RAW-R0026-PES-ADC-Card3-S00001.dat
card4Channel1Para.cfg      RAW-R0026-PES-ADC-Card3-S00002.dat
RAW-R0026-PES-ADC-Card1-S00000.dat  RAW-R0026-PES-ADC-Card3-S00003.dat
RAW-R0026-PES-ADC-Card1-S00001.dat  RAW-R0026-PES-ADC-Card3-S00004.dat
RAW-R0026-PES-ADC-Card1-S00002.dat  RAW-R0026-PES-ADC-Card3-S00005.dat
RAW-R0026-PES-ADC-Card1-S00003.dat  RAW-R0026-PES-ADC-Card3-S00006.dat
RAW-R0026-PES-ADC-Card1-S00004.dat  RAW-R0026-PES-ADC-Card3-S00007.dat
```

GMD&Hamps

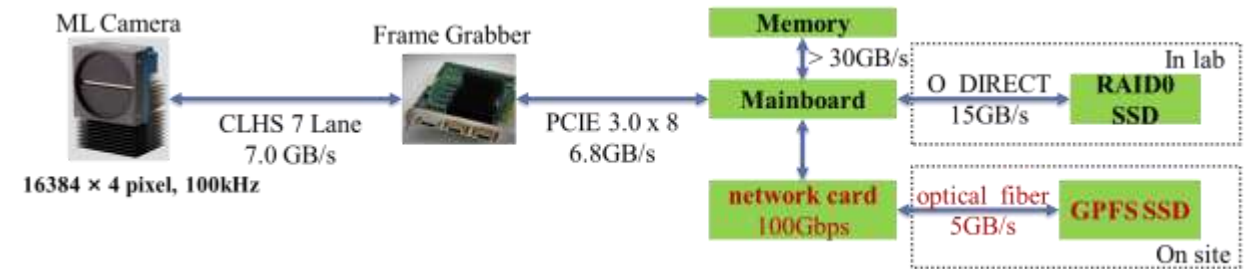


```
(base) [daaopi@FELII-opi r00204]$ pwd
/shine_online4/fel2/diagData/raw/HAMPS1/20260917/r00204
(base) [daaopi@FELII-opi r00204]$ ls
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620216290670-S00000.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620230271680-S00001.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620244252690-S00002.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620258233700-S00003.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620272214710-S00004.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620286195720-S00005.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620300176730-S00006.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620314157740-S00007.dat
RAW-R0204-XGMD1-fADC-Card10-Channel1-B48620328138750-S00008.dat
```

Diagnostic DAQ—PAM(Pulse Arrival Monitor)

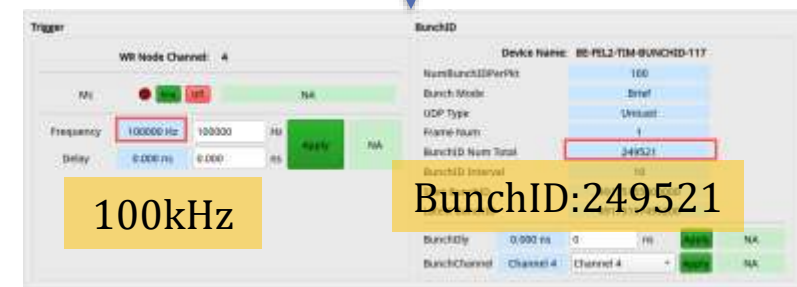
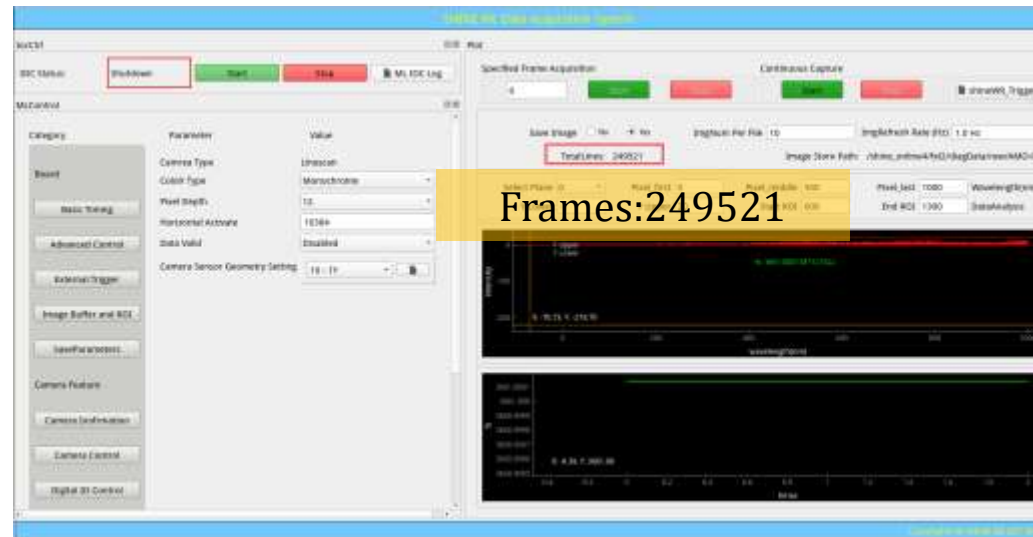
❑ Back-end DAQ Software:

- ✓ IOC: control PAM ML camera, Bunch-ID DAQ
- ✓ **Data processing layer**: ML camera DAQ
- ✓ Align: integration of ML data and Bunch-ID

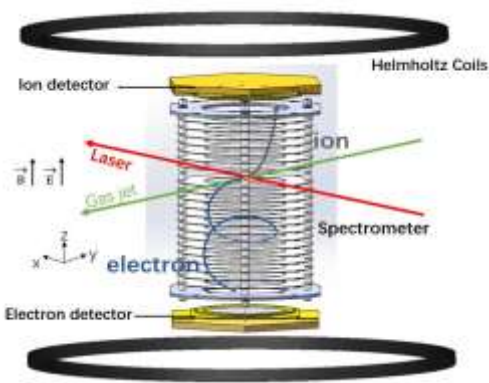


❑ The PAM camera hardware and software have been deployed **on site**.

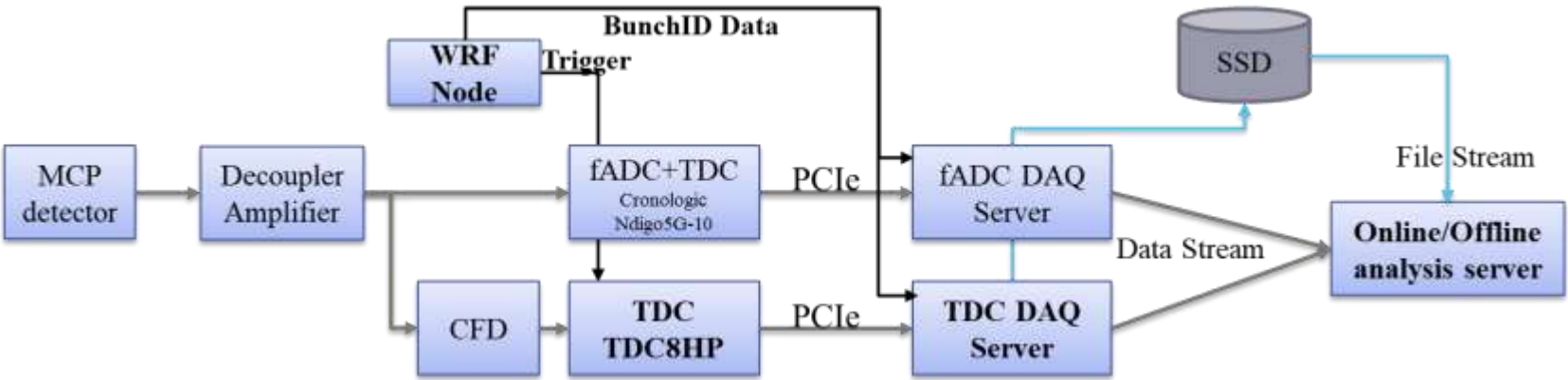
❑ **Online GPFS storage**: 16k pixels at 100 kHz; 5 GB/s single-threaded write speed; **one-to-one match** between bunch IDs and acquired camera data frames.



❑ Single-pulse, pump-probe, TDC(Time-to-Digital Converter) and fADC DAQ



from AMO

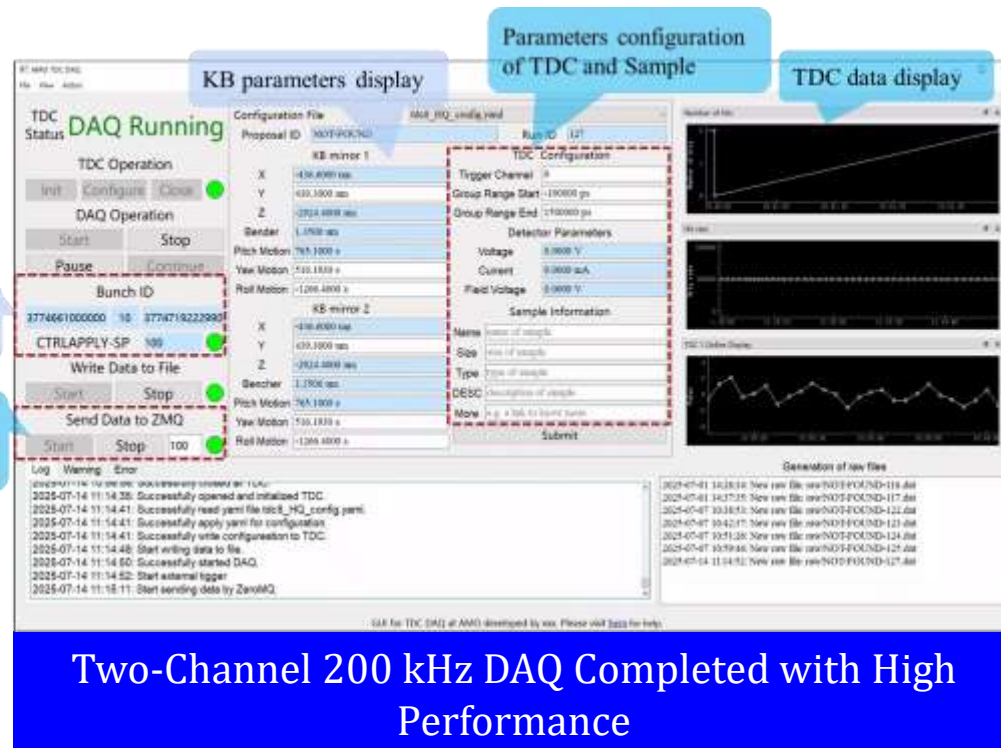


	Software requirements	Devices	Software	Last year's progress	This year's progress
1	Timing control and Bunch-ID integration	WRF Node	Timing IOC	100%	100%
2	Laser delay line control	Laser Delay line	Delay line IOC	90%	90%
3	Beamline diagnostic data acquisition monitoring	PAM, PES, HAMPs, Imager	Diagnostic DAQ	75%	95%
4	Beamline motion control	KB, Imager, etc	Motion IOC	80%	100%
5	AMO DAQ for TDC and fADC, with Bunch-ID	AMO TDC, fADC	End-station DAQ	50%	100%
6	Data stream pipeline with online analysis software				
7	Integration of diagnostic and experiment data	PAM, PES, HAMPs, KB	Event building	70%	90%

AMO DAQ — 95% Complete

- ❑ The AMO ADC DAQ reuses the TDC DAQ software framework, with the main differences lying in the control parameter interfaces.
- ❑ ADC DAQ development and **on-site testing at 1 kHz** completed. Integration testing with event building and diagnostic devices is underway.

TDC DAQ

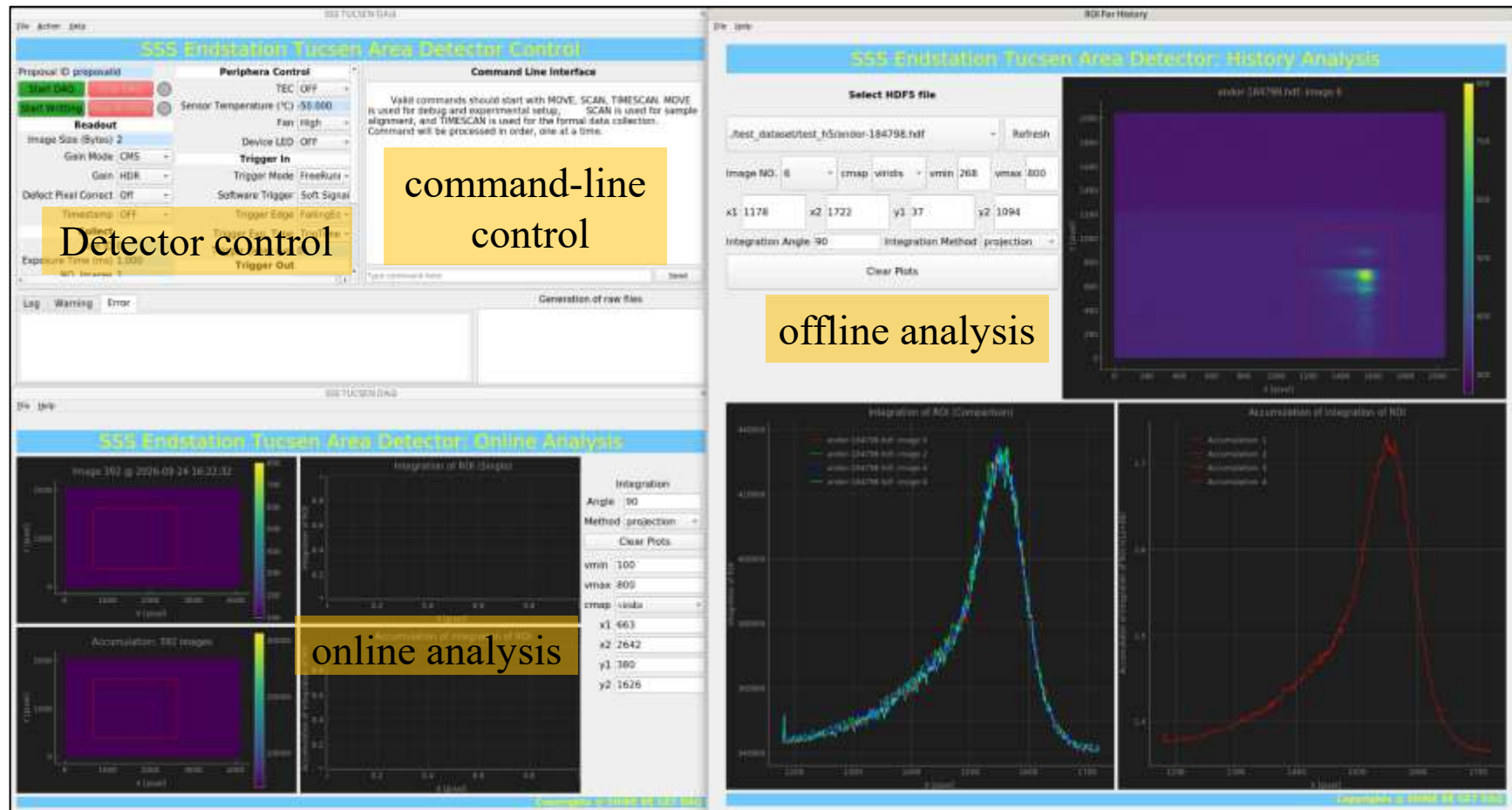


fADC DAQ



SSS DAQ — 80% Complete

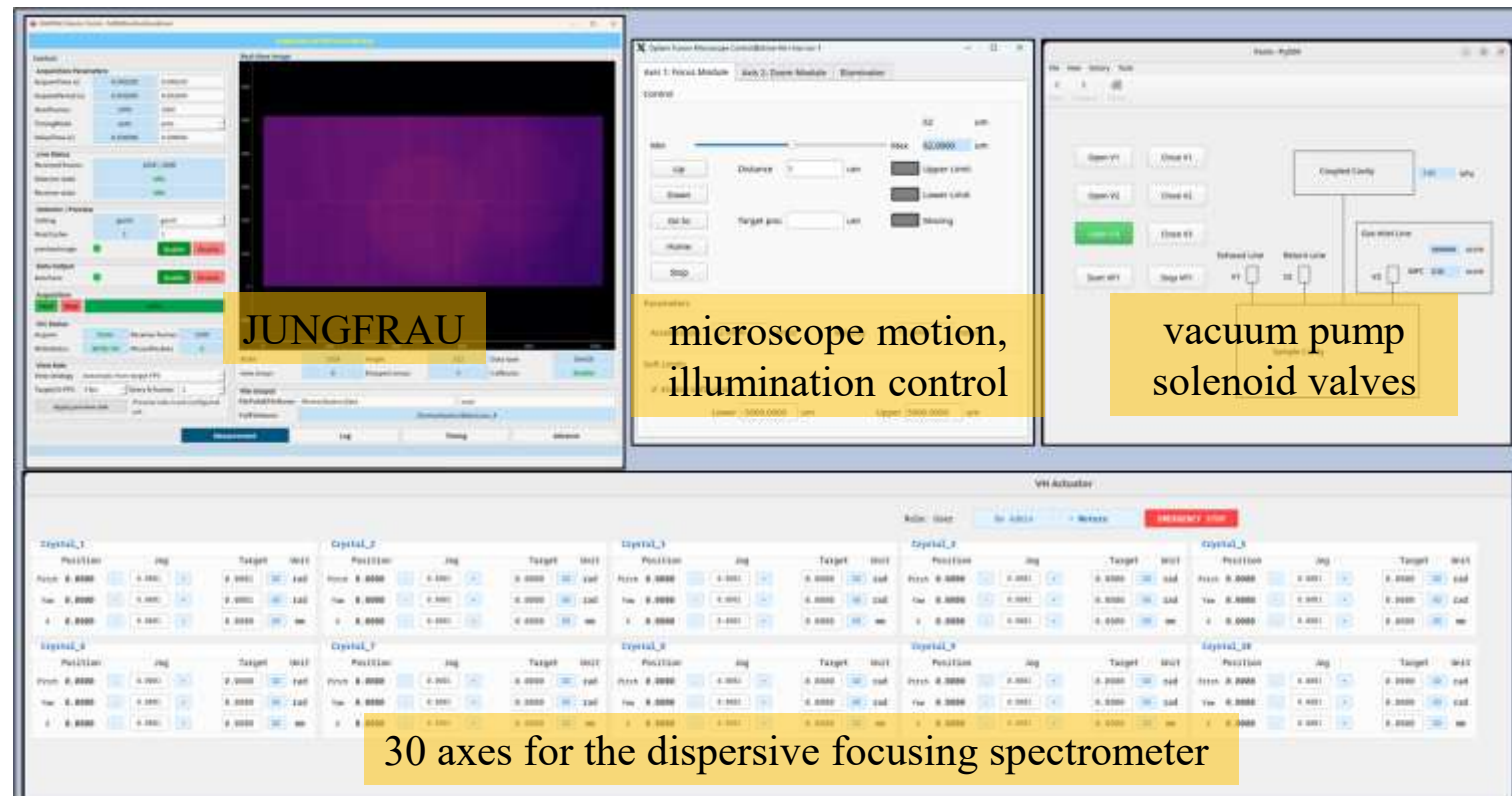
- ❑ **Functions:** Detector control, data storage, motor-coordinated command-line control, and online/offline analysis
- ❑ **Completed:** Detector control, data storage software, and online/offline analysis
- ❑ **Pending integration testing:** Data storage (detector availability) and motor-coordinated command-line control (motor availability)



HSS DAQ — 70% Complete

□ DAQ Functions:

- DAQ for three JUNGFRAU 500K detectors (80%)
- Control of 30 axes for the dispersive focusing spectrometer (80%)
- Control of 45 motion axes for the xHuber scattering spectrometer (10%)
- **Sample environment system:** microscope motion(100%), microscope LED illumination (100%), vacuum pump solenoid valves (80%), Shimadzu liquid delivery pump (100%), and three-axis translation stage (0%)
- Bluesky-based coordinated scanning across multiple devices (0%)



Data Standardized Storage and Event Building

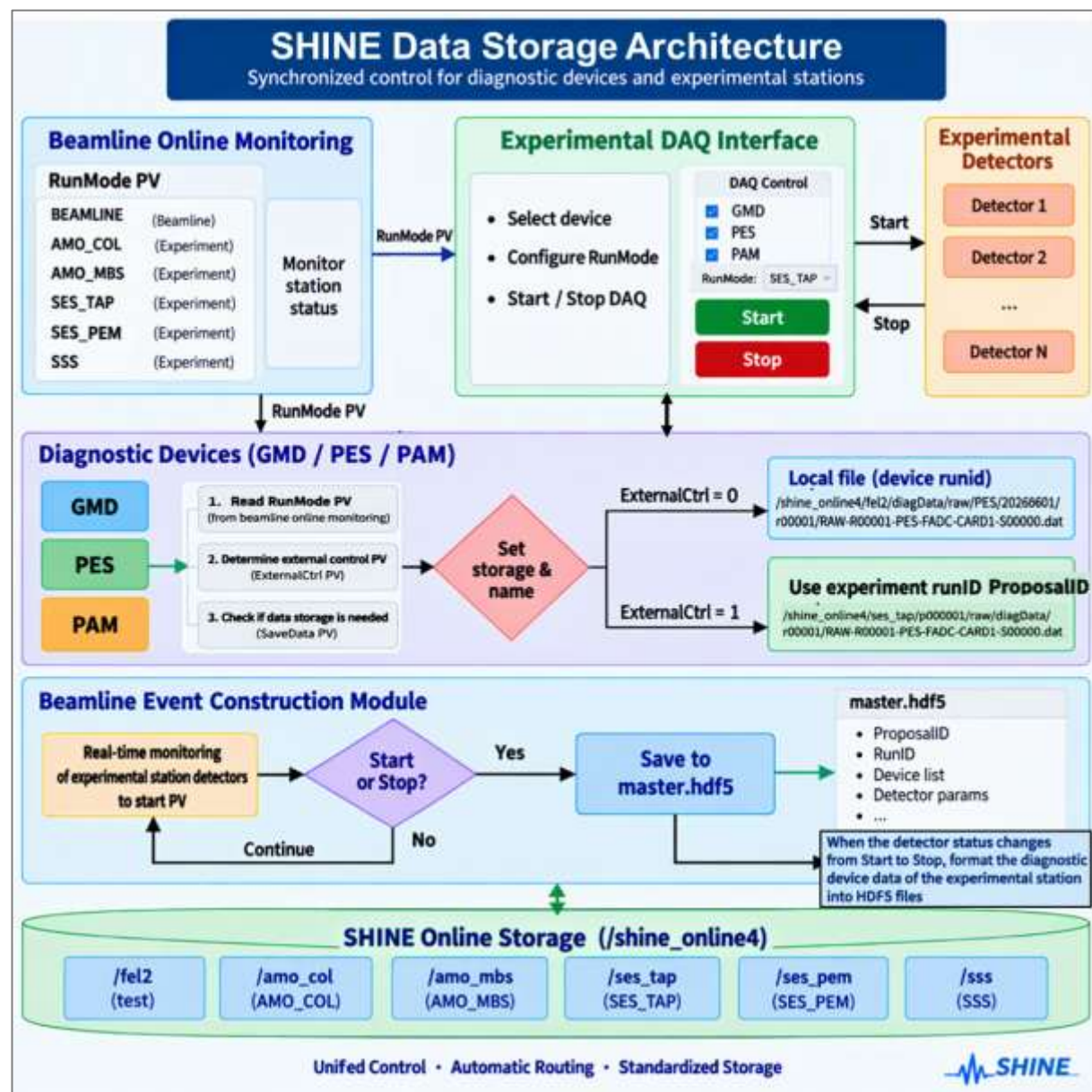
□ Data Standardized Storage

- FEL2:RunMode
- PAM ExternalCtrl, SaveData, RUNID
- PES ExternalCtrl, SaveData, RUNID
- Hamps ExternalCtrl, SaveData, RUNID
- AMO-COL:PROPOSALID, RUNID
- AMO-MBS:PROPOSALID, RUNID
- SES-TAP:PROPOSALID, RUNID
- SES-PEM:PROPOSALID, RUNID
- SSS:PROPOSALID, RUNID

```
(base) [daaopi@FELII-opi raw]$ pwd
/shine_online4/fel2/diagData/raw
(base) [daaopi@FELII-opi raw]$ ls
AMO-PAM  BLM3-BS1  IMG3-BS1  M_BLM3-BS1  SERM-BS1  SES_WFS-BS2
AMO_WFS-AD1  HAMPS1  IMG4-BS1  M_IMG10-BS1  SERM-BS2  SSS_WFS-AD1
AMO_WFS-BS1  IMG0-BS1  IMG5-BS1  M_IMG12-BS1  SERM-MCP  SSS_WFS-BS1
AMO_WFS-BS2  IMG10-BS1  IMG6-BS1  M_IMG9-BS1  SESC-AD1  SSS_WFS-BS2
AMO_WFS-BS3  IMG13-BS1  IMG7-BS1  PES  SES-PAM  test
BLM1-BS1  IMG1-BS1  IMG8-BS1  PES-BS1  SES_WFS-AD1
BLM2-BS1  IMG2-BS1  IMG8-BS2  PES-BS2  SES_WFS-BS1
```

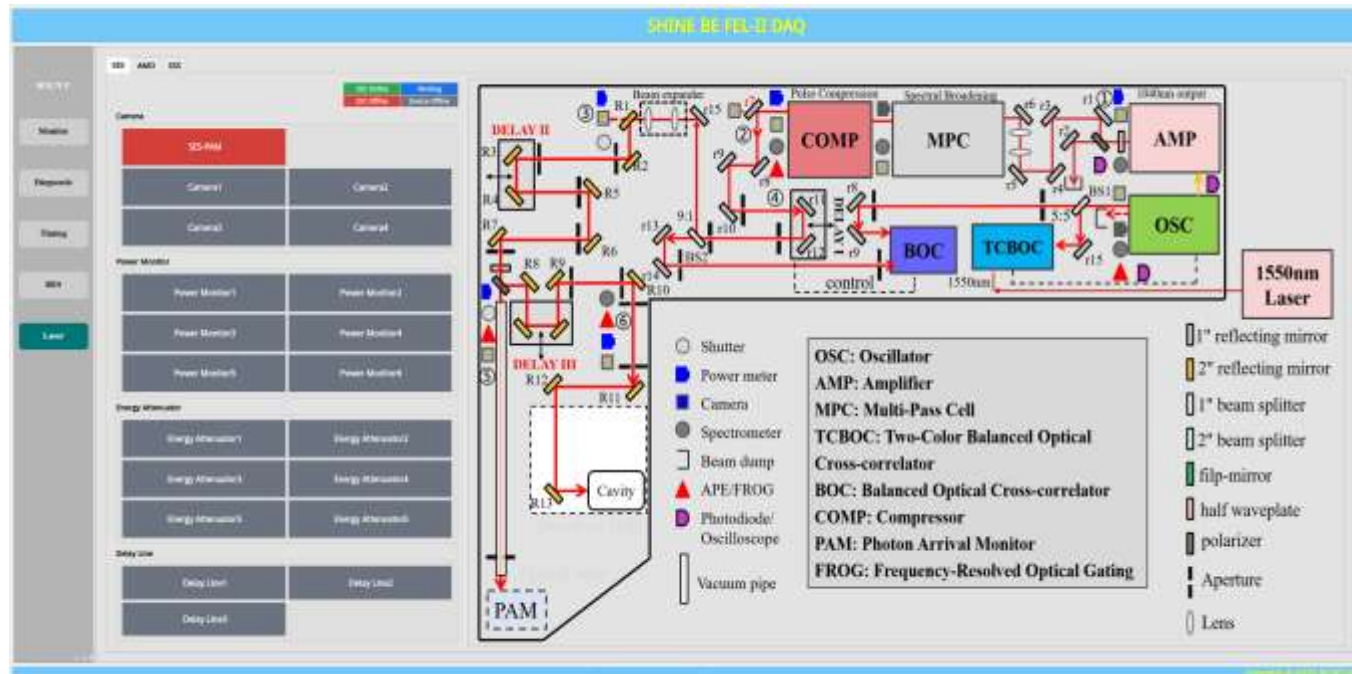
□ Event Building: master.hdf5, convert diagnostic binary data to HDF5.

Diagnostic Device	Program Version	Conversion Time	Size Before Conversion	Size After Conversion
HAMPS	C++ version – scalar	43 s	512 MB	177 MB
PES	C++ version – scalar	52 s	965 MB	403 MB
PAM	C++ version – uncompressed	0.463 s	320 MB	321 MB
PAM	C++ version – compression level 4	5.746 s	320 MB	65 MB



Laser Control —70% Complete

- ❑ Design main laser control interface with laser system, including **Delay line control, laser beam spot monitor, power monitor and energy attenuator.**
- ❑ The software for delay lines, cameras, and rotation stages has been developed.
- ❑ Ready for integration testing once the laser devices are deployed.



Delay line



High-Speed Rotation Stage

High-level applications — Confluence and eLog SHINE

- ❑ **Confluence:** Timing control and DAQ software user manuals; data specifications guide
- ❑ **Language:** Currently in Chinese; English translations planned



Confluence

- ❑ **eLog:** Jointly developed by IHEP and ShanghaiTech University;
- ❑ **Now in use** at the experimental stations.



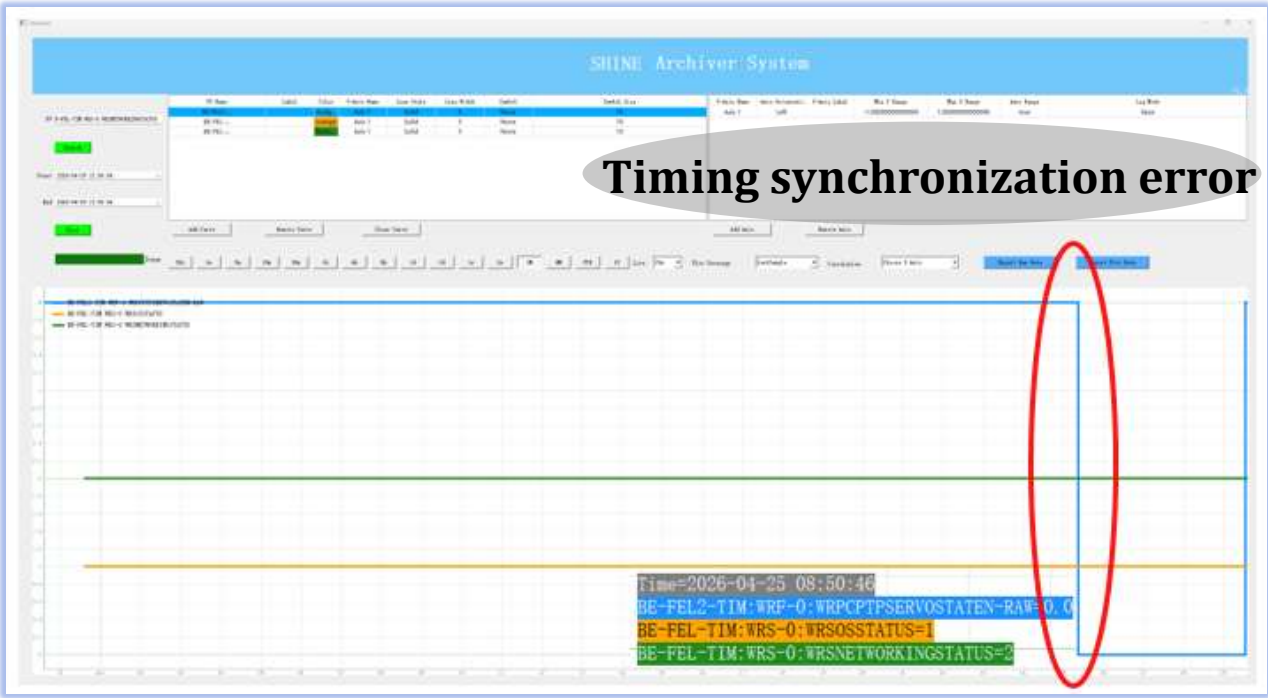
eLog

❑ Archiver-appliance

- **AA deployed**, >2,000 PVs archived, all required FEL-II parameters to be added before beam tuning.
- Official AA and SHINE-developed **query tools deployed** for access to PV history.

❑ Gateway

- **CA and PVA gateways deployed**, PV communication between beamline stations and accelerator.
- An list of PVs identified, and beamline stations can now access accelerator PV.



Archiver-appliance

No.	Parameter	PV / Status	Unit
1	Electron energy	Not yet available	GeV
2	Electron energy jitter	Not yet available	—
3	Bunch charge	AC-LA-EXT4-BI:CT01:CH2_Q	pC
4	Electron beam position	AC-UN-FEL2-BI:CBPM-CELL34-EBPM_X AC-UN-FEL2-BI:CBPM-CELL34-EBPM_Y	μm
5	Photon energy	Not yet available	keV
6	Photon energy and bandwidth	Not yet available	—
7	Accelerator repetition rate	AC-UN-FEL2-TIM:REP-RATE AC-UN-FEL1-TIM:REP-RATE	Hz
8	Accelerator operating status	Interlock status: AC-LA-INJ1-MPS:MPS00:COMLASSHUPMT AC-LA-INJ1-MPS:MPS00:TIMING_PERMIT_TO_DRIVER_LASER AC-LA-INJ1-MPS:MPS00:DEVLASSHUPMT AC-LA-INJ1-MPS:MPS00:DEV_DRI_LASER_AOM_PMT AC-LA-INJ1-MPS:MPS00:FPGA:OPERATIONMODE_I AC-LA-INJ1-MPS:MPS00:FPGA:REPETITIONMODE_I AC-LA-INJ1-MPS:MPS00:LASERMODE_SET Operating mode: Already sent to the beamline stations via hardware signals. Photon polarization: Not yet available	—
9	FEL pulse duration	Not yet available	fs
10	Vacuum pressure at the undulator exit	Please clarify which vacuum reading is required.	Pa

Accelerator PVs Required by the Beamline Stations

DAQ CPM for Beamlines and End-stations

- ❑ CPM schedule remains unchanged since April 2026, thanks to the efforts of all DAQ team members.
- ❑ **FEL-II timing system, FEL-II diagnostic software, SES and AMO software** deployed and jointly tested.
- ❑ Designed a 43-day shift schedule to support Phase 1 beam tuning of FEL2.
- ❑ **Next six months:** Deploy **FEL-I diagnostic software** and **develop software for SSS, HSS and CDS**.

		2025												2026												
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
Timing	FEL-II timing	Hardware calibratin, testing										install,commissioning		joint commissioning,operation and maintenance												
	FEL-I timing				technical specification					equipment delivery			hardware calibratin and testing									install,commissioning				
EndStations Software	SES TAP DAQ	custom development, testing							deployment, joint commissioning					operation and maintenance												
	AMO TDC DAQ	software development for TDC, testing								integration testing				joint commissioning, operation and maintenance												
	SSS DAQ								requirement discussion				solution design, software development, testing													
	HSS DAQ								requirement discussion				solution design, software development, testing													
Laser、 Diagnostic Software	Laser Control	development							deployment					joint commissioning,operation and maintenance												
	Imager DAQ		software development, testing								deployment				joint commissioning, operation and maintenance											
	PAM DAQ							software development, testing				deployment				joint commissioning, operation										
	WFS DAQ						requirement discussion		software development,testing				deployment				joint commissioning, operation									
	SERM DAQ						requirement discussion		software development, testing				deployment				joint commissioning, operation									
	PES DAQ(support)							software development				integration testing				operation and maintenance										
	GMD&Hamps(support)								software development				integration testing				operation and maintenance									
	BPIM DAQ									software development,				integration testing				operation and maintenance								
	Spectrometer Control										development,testing				deployment				joint commissioning,operation							
Integrated Software	Event Building Software	development							deployment,integration testing					joint commissioning, operation and maintenance												
	Achive Application, IOCStats, Autosave,ProcServControl...								deployment, joint commissioning								operation and maintenance									
	Integrated GUI for Beamline													development, testing						deployment, joint commissioning						

Acknowledgements

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Data Acquisition and Analysis Group Lead: **Congcong Yin**

Team members: **Xiaofeng Zhang, Dong Jiang, Jituo Zheng, Yaru Yin, Xue Hai, Yiqian Du**(new member)

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Thank you for your attention!

