Operational Aspects of Beam-Driven Facilities

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Stanford University | U.S. DEPARTMENT OF ENERGY

Disclaimer

This talk is influenced by my time at FACET and AWAKE and may not reflect experiences at other beam-driven facilities.

Acknowledgements

Thank you to my colleagues for providing valuable input to this presentation!

- Riccardo Pompili: SPARC_LAB
- Giovanni Zevi Della Porta: AWAKE
- Carl Lindstrøm: FLASHFoward

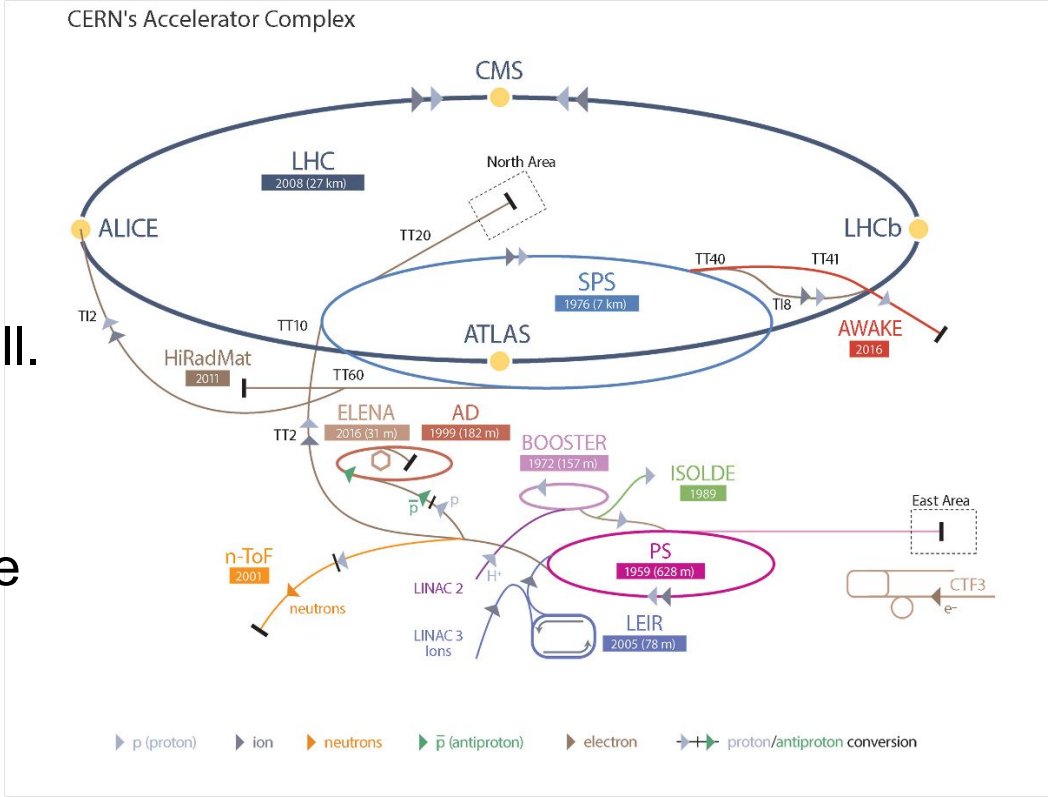

AWAKE

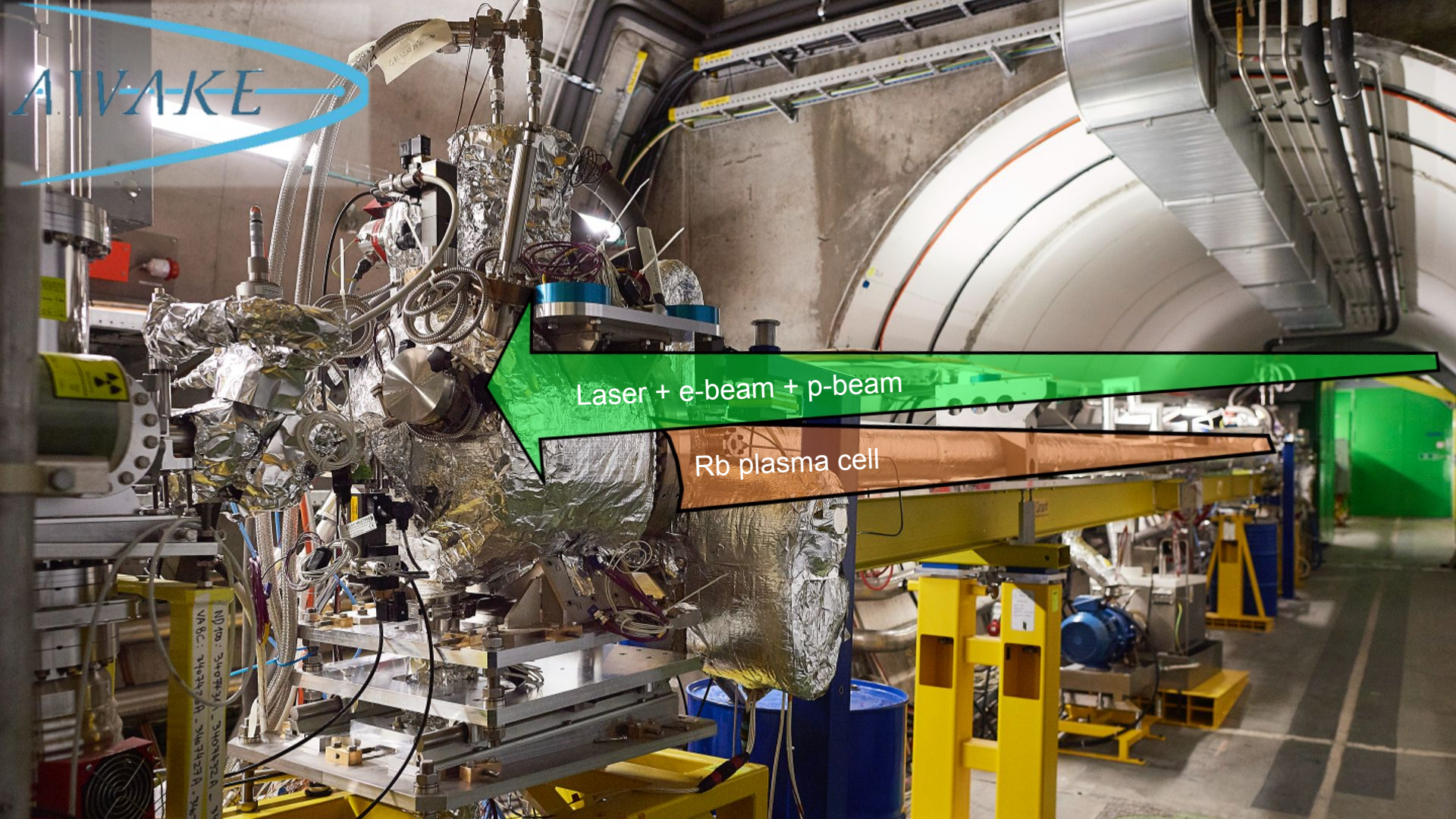
AWAKE @ CERN

Unique in many aspects!

- Only p^+-driven facility.
- Driver energy 400 GeV.
- World's longest plasma cell.

The AWAKE Collaboration is large and this reflects the scale of the experiment!




AIVAKE
Laser + e-beam + p-beam
Rb plasma cell

Operations

Experimenters at AWAKE operate the Ti:Sapph laser, electron beam, and Rubidium plasma cell.

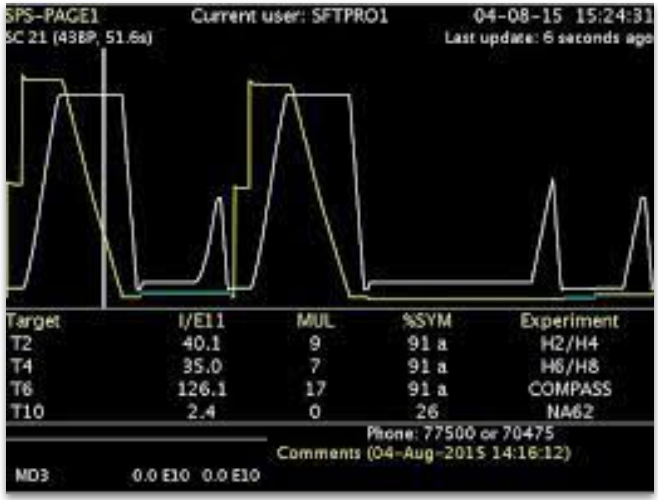
- Requires at least 3 experts!

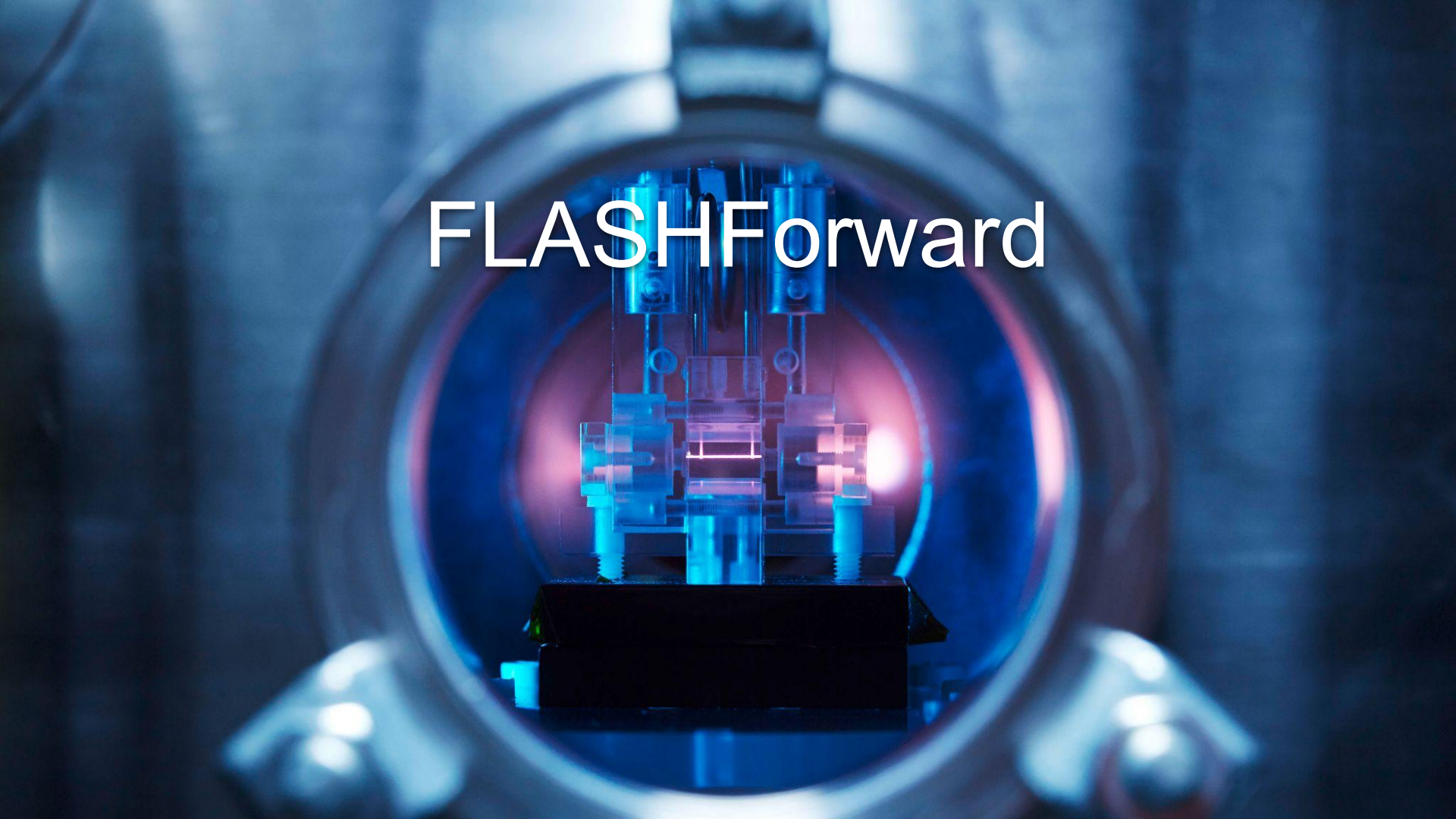
Experimenters relay proton beam requests to SPS operators.

Facility Challenges

The SPS delivers beam to AWAKE as frequently as the supercycle allows (~once every 20 seconds).

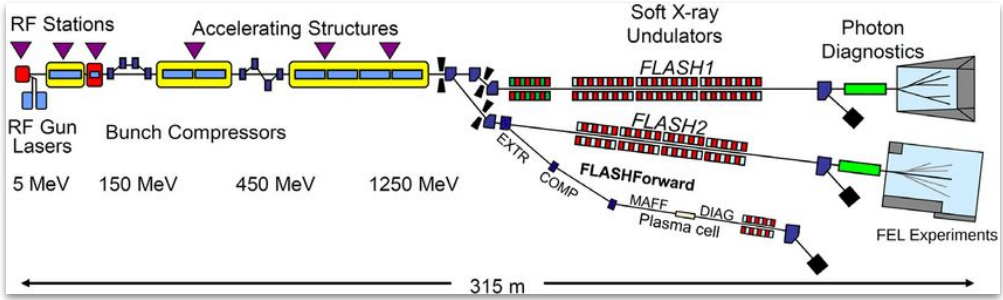
Beam delivery may be interrupted by LHC fills.




FLASHForward

FLASHForward @ DESY

A machine for *precision* PWFA experimentation that can demonstrate collider-quality parameters.



Unique capabilities:

- Beam stability.
- High-rep rate operation.

Operations

The FLASHForward team tunes up the entire beamline from gun to plasma.

- FLASH operators provide support for low-level systems.

Many experiments at FF use capillary plasma source.

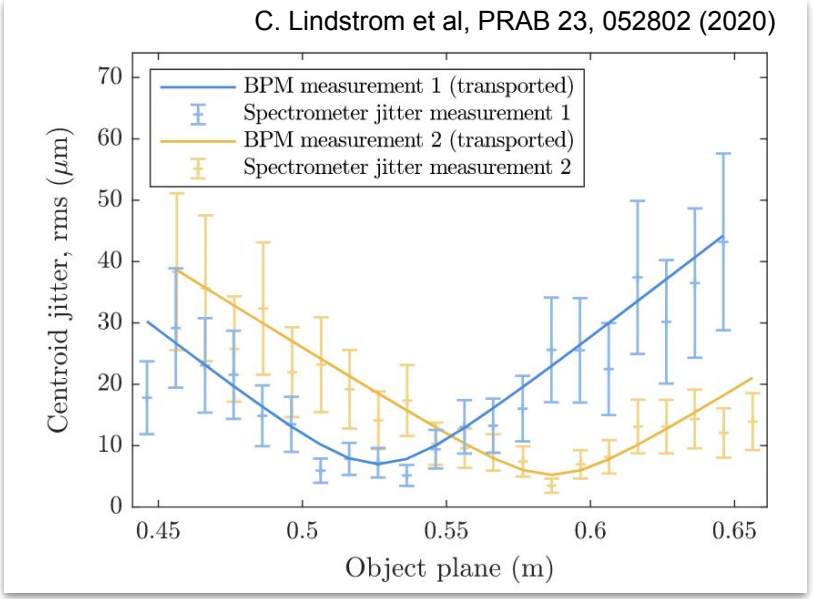
- In this case, laser tuning not required.

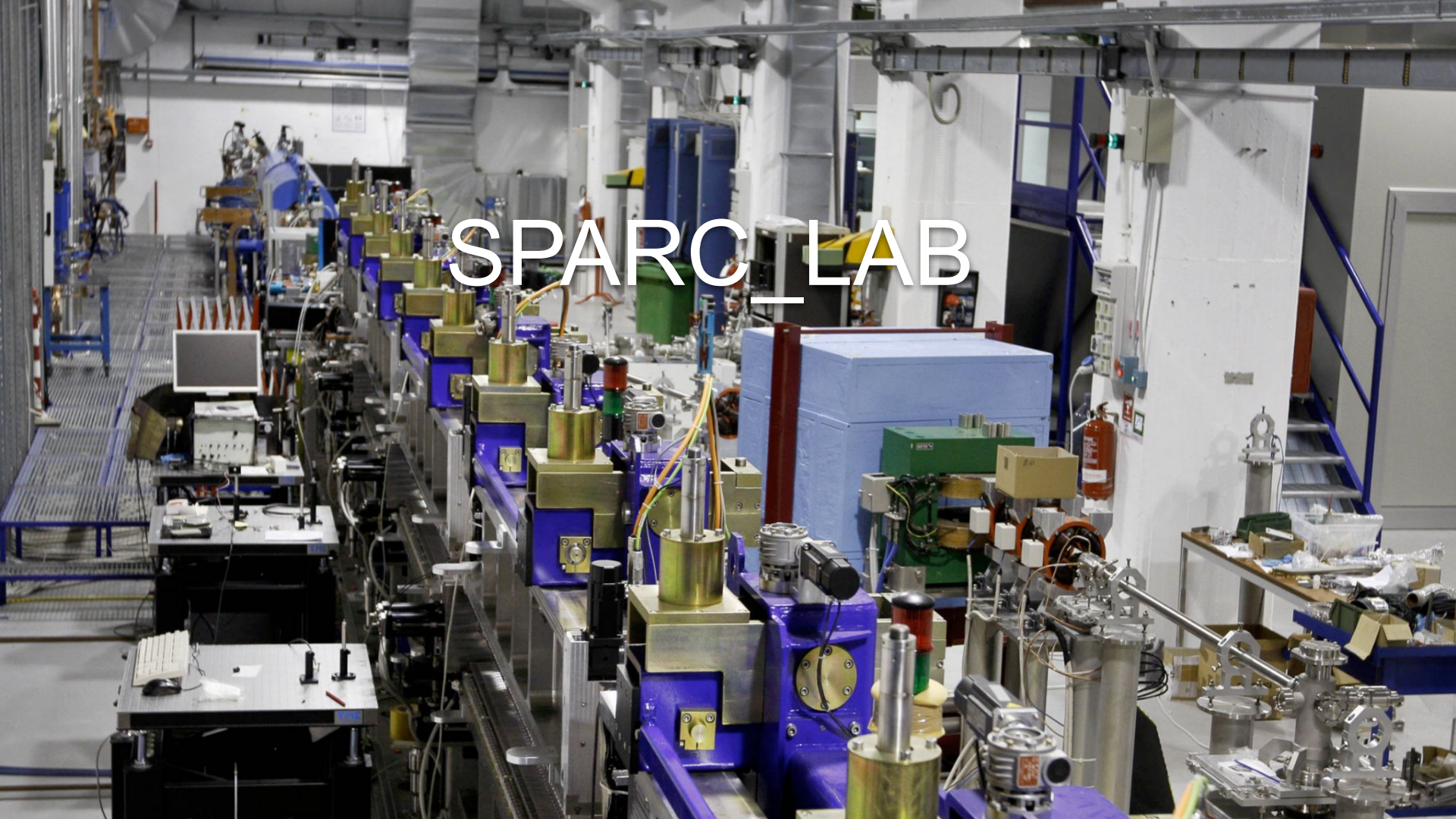
Facility Challenges

FLASHForward pursues ultra-precise measurements that require extensive beam tuning.

Even with excellent stability from the FLASH linac, beam jitter and feedback drift can prevent progress.

C. Lindstrom et al, PRAB 23, 052802 (2020)



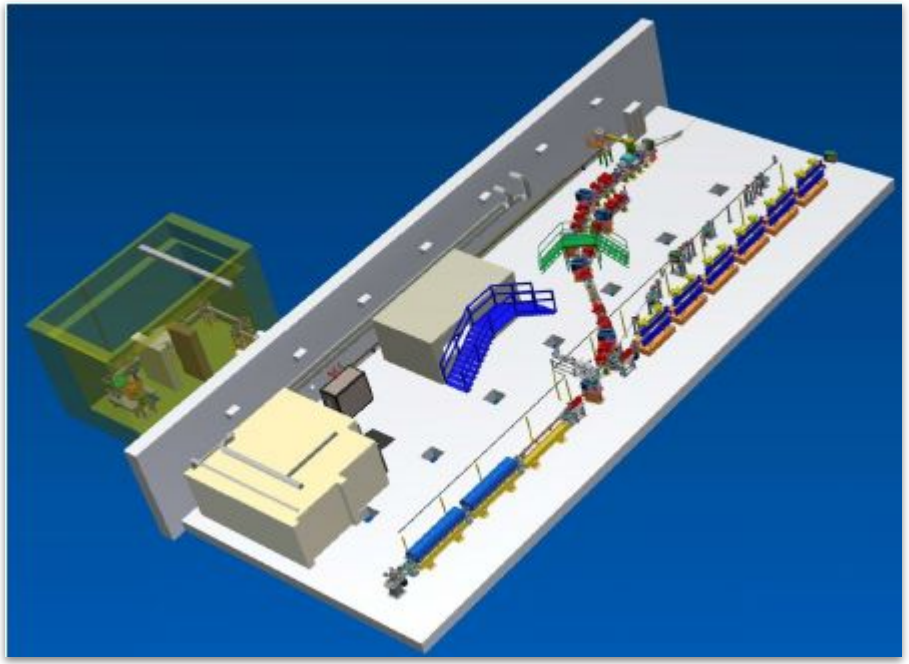

SPARC_LAB

SPARC_LAB @ LNF

SPARC_LAB combines an electron beam linac (SPARC) with a high-power laser (FLAME).

Unique capabilities:

- FEL beamline.
- High-power laser.



Operations

The SPARC team runs the electron linac and the experiment.

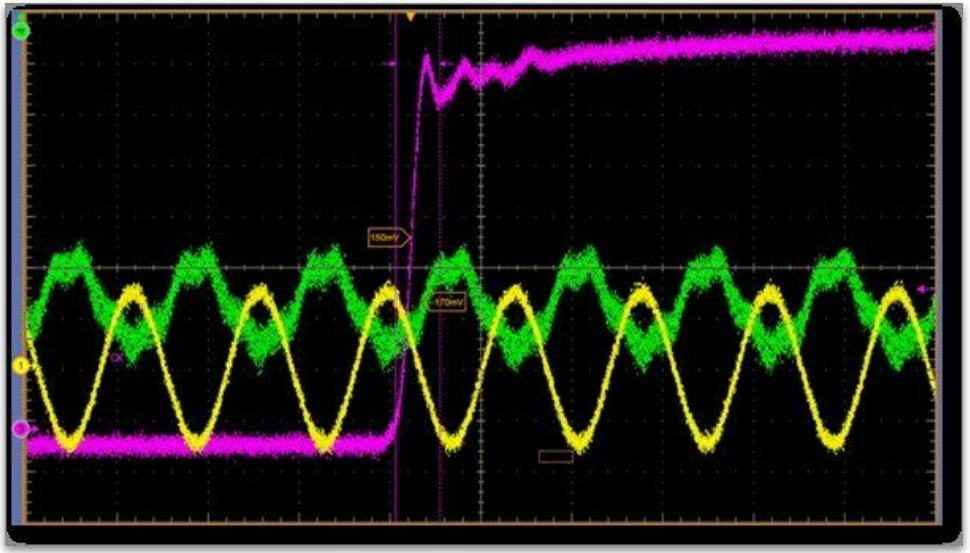
- Most of the time, this is for internal experiments, but they also provide beam to THz users.

There is also support from technicians for all 3 shifts.

Facility Challenges

RF jitter from klystrons translates into energy/longitudinal jitter for the electron beam.

This affects the two-bunch configuration which is a challenge for PWFA drive/witness experiments.




FACET-II

FACET-II @ SLAC

Successor facility to the FFTB and FACET. Operates as a User Facility.

Unique capabilities:

- *Extremely large* peak currents (~100 kA)
- Positron PWFA 🤞

Operations

FACET has dedicated Beam Physicists that work on beam quality and configurations.

- SLAC operators contribute to running the machine.

SLAC-based FACETeers operate the experimental systems and also contribute to beam tuning.

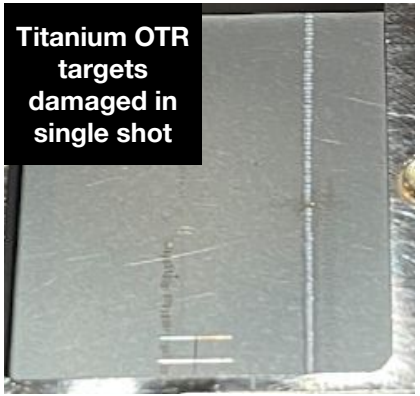
- FACET Users come to SLAC to run experiments (or join by Zoom!)

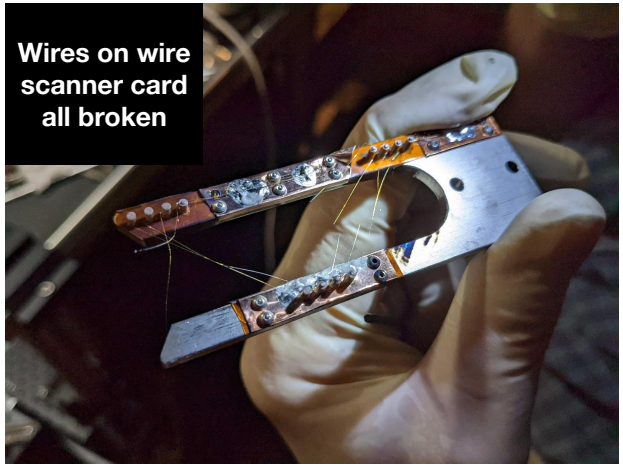
Facility Challenges

Nothing can stop a 100 kA beam.

Intercepting diagnostics are damaged on every shot!

The beam drills holes in vacuum windows.

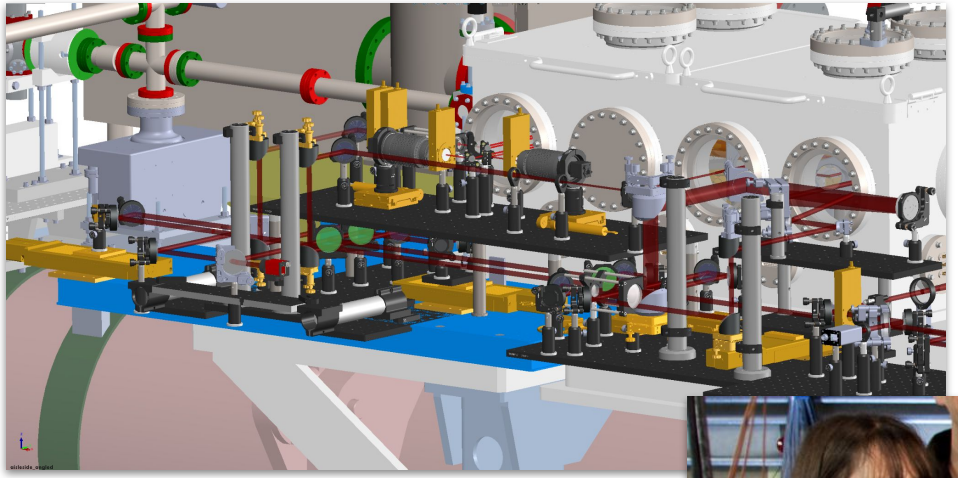




Common Challenges

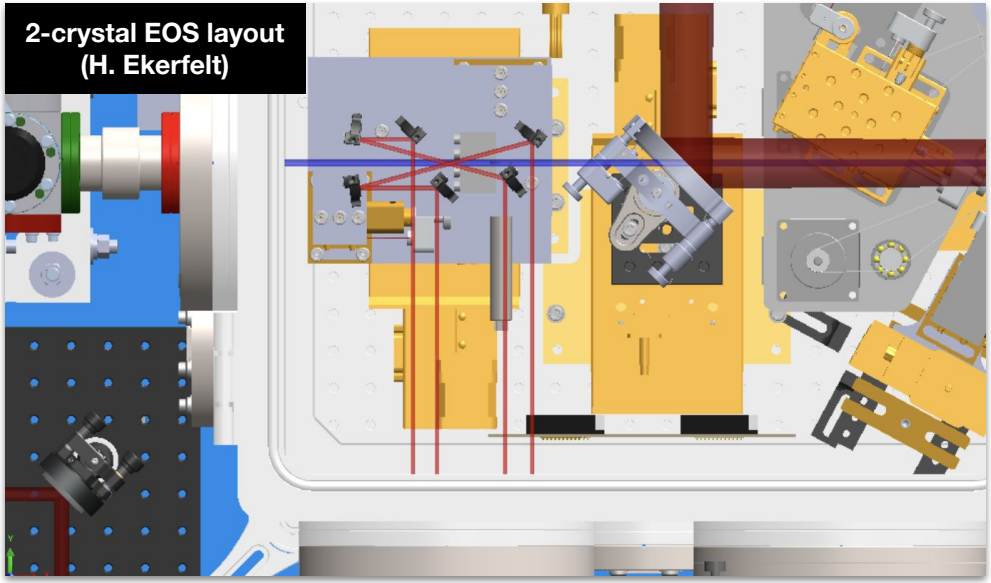
Work Planning

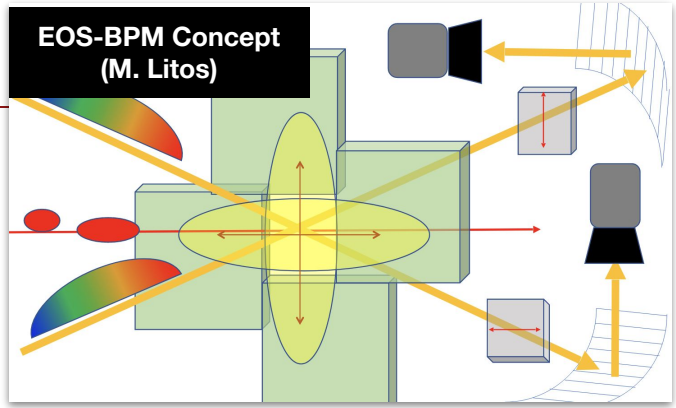
	A	B	C	D	E	F	G	H	I	J
1	Date of Access	Point of Contact / Coordinator	Experiment	CATER	Job Status (Released / Approved)?	EWPC (yes /no / maybe)	Task	Task Lead	Personnel Working in Tunnel	Total Number of Workers
2	Upstairs work to be done prior to next PAMM									
3										
4	Impromptu access 2/2									
5	2/2	Spencer	Facility	154927	Yes	no	Replace pump on notch collimator / inspect whether the seal holds or if there is a leak	Juan	Juan, Doug	2
6	2/2	Spencer	E-320	154925	Yes	no	Attempt interferometric alignment of both OAPs	Elias	Zhijiang, Elias	2
7	2/2	Spencer	E-320	154925	Yes	no	Check alignment of top view cameras	Elias	Zhijiang, Elias	2
8	2/2	Spencer	E-320	154925	Yes	no	Inspect components in IP	Elias	Zhijiang, Elias	1
9	2/2	Spencer	E-320	154925	Yes	no	Fix beam clip near OAP (+full beam alignment)	Elias	Zhijiang, Elias	2
10	2/2	Spencer	E-320/general laser	154925	Yes	no	Fix beam clip just outside PB	Elias	Zhijiang, Elias	2

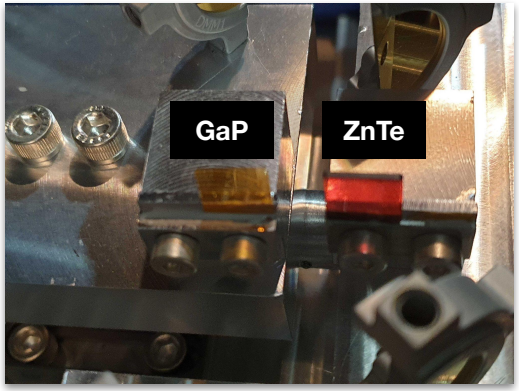


Work planning is a critical to making progress at beam test facilities. Work must be completed safely and in the allotted amount of time.

Non-Intercepting Diagnostics

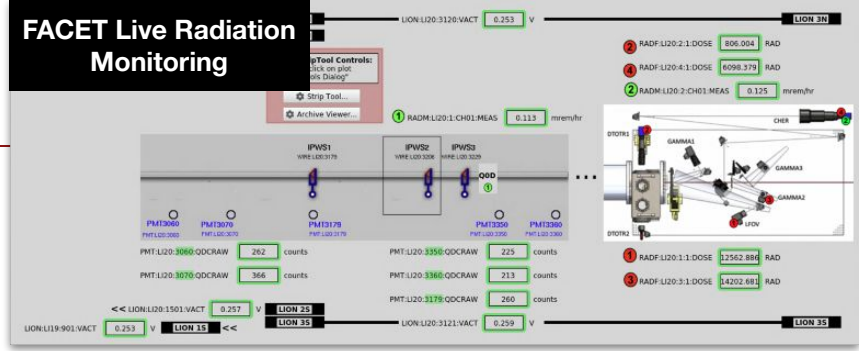


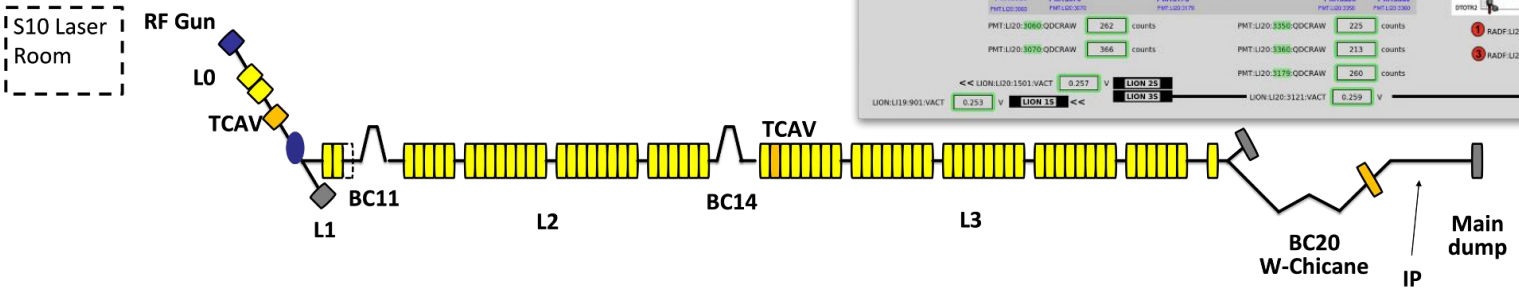




As we move toward collider applications, all facilities must adopt non-intercepting diagnostics.

Radiation to Electronics

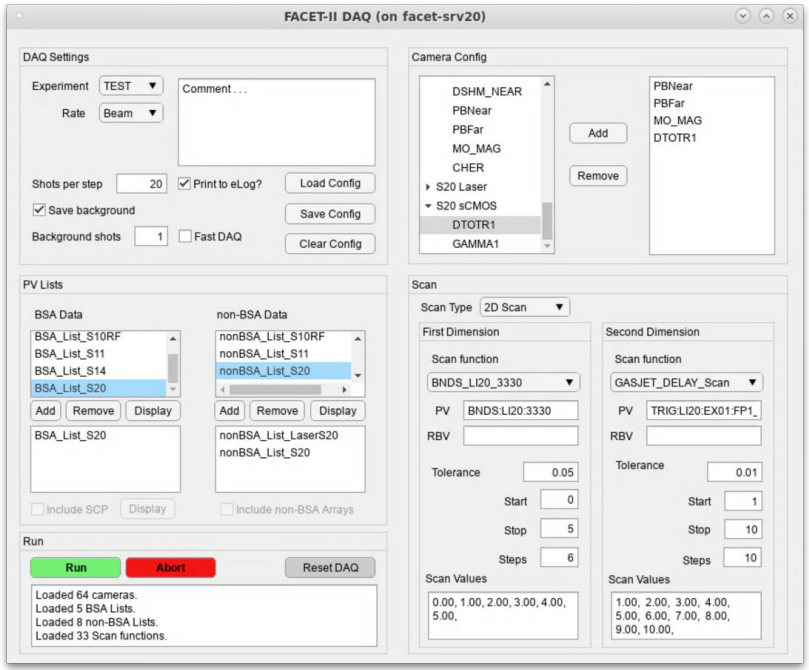


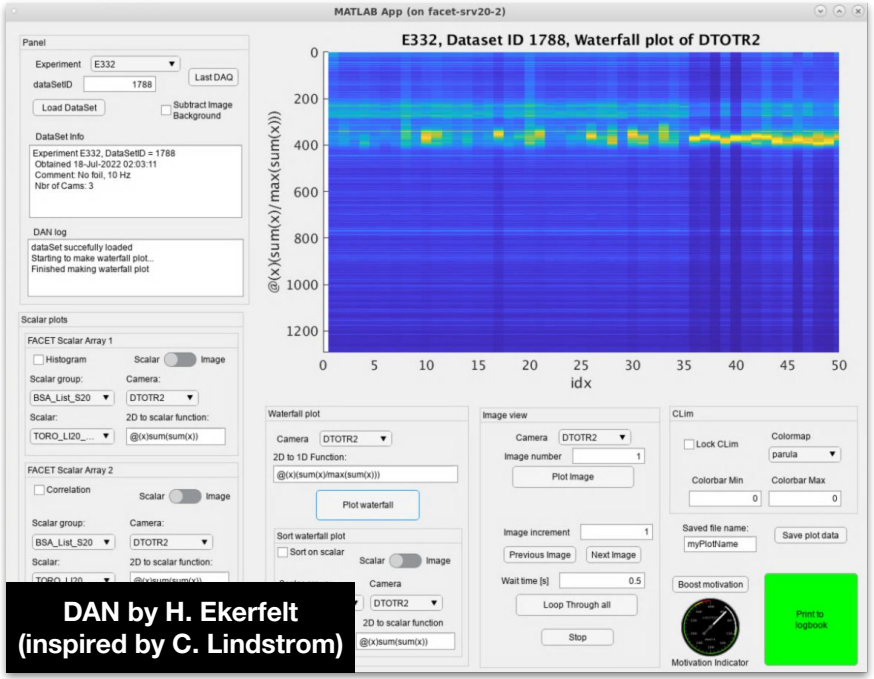


Region	S10 Laser	Injector	L1 and BC11	L2 and BC14	BC20	S20 Laser	IP Area	EDC+ Dump	Total
Deployed	7	3	6	3	2	21	24	12	78
Planned	11	5	10	6	5	24	30	16	107

Beam-driven facilities use digital cameras as key beam diagnostics. FACET uses over 100 cameras. Uptime is a must!

Data Acquisition and Analysis





DAN by H. Ekerfelt (inspired by C. Lindstrom)

Coordinated DAQ and Analysis is a critical aspect to understanding results on the fly and proceeding to subsequent measurements.

Additional Items

- Proceduralization
  - Many tasks are repetitive.
  - Can we turn procedures into software tools and GUIs?

- People Management
  - Physicists are humans(?)
  - How do we balance the desire to do excellent science safely and without burnout?

What Unites Us?

Collaborative work and a shared mission!

Conclusion

- Operation of Beam-Driven PWFA facilities is both challenging and rewarding.

- We can learn from each other!
  - Share “best practices”.
  - Recommend useful technologies and diagnostics.
  - There is natural circulation of physicists between facilities.

Beam Test Facilities in the US

https://arxiv.org/pdf/2203.11290.pdf

Beam Test Facilities for R&D in Accelerator Science and Technologies

Christine Clarke,[1] Michael Downer,[2] Eric Esarey,[3] Cameron Geddes,[3] Mark J. Hogan,[1] Georg Heinz Hoffstaetter,[4] Chunguang Jing,[5,6] Steven M. Lund,[7] Sergei Nagaitsev,[8,9] Mark Palmer,[10] Philippe Piot,[11,6] John Power,[6] Carl Schroeder,[3] Donald Umstadter,[12] Navid Vafaei-Najafabadi,[13,10] Alexander Valishev,[8] Louise Willingale,[14] and Vitaly Yakimenko[1]