Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

25th Annual

Accelerator Test Facility (ATF) Users' Meeting

ATF Status

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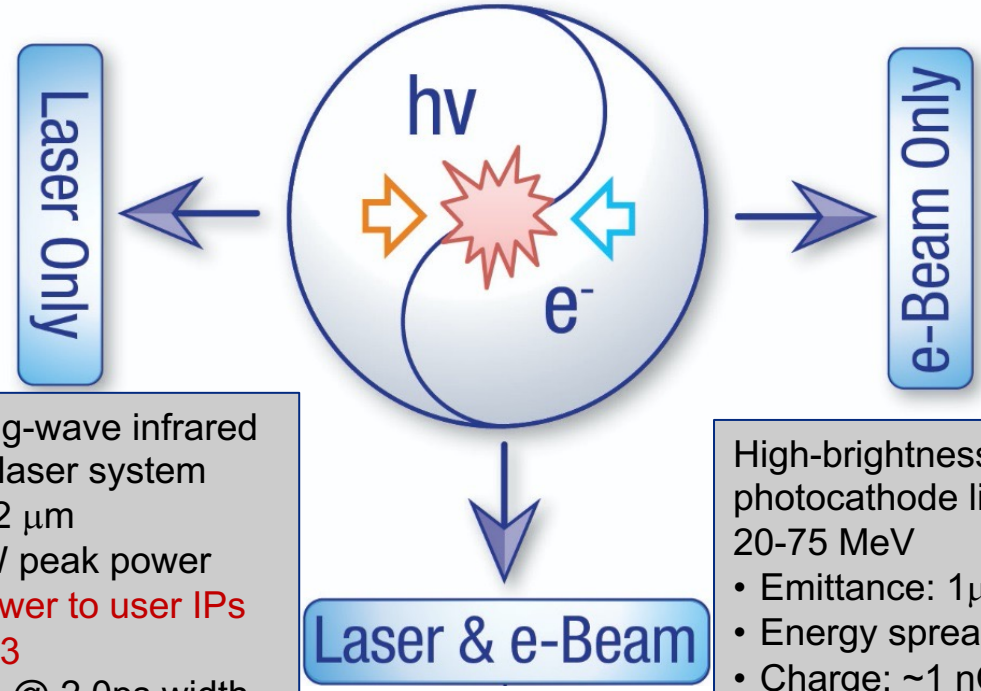
The ATF User Program

Designated a DOE National User Facility in 2015

Accelerator Stewardship Program

User Research Thrusts:

- **Novel particle acceleration techniques**
  R&D for smaller, more cost-effective accelerators including:
  - Plasma and dielectric wakefield acceleration
  - Direct laser acceleration
  - Inverse free-electron lasers…
- **High-brightness radiation sources**
  New techniques to produce electromagnetic radiation from THz to X-rays:
  - FEL R&D
  - Inverse Compton scattering
  - THz radiation from dielectric structures…
- **Beam manipulation and beam instrumentation**
  Sophisticated longitudinal and transverse beam manipulation capabilities
  - Wide range of beam parameters enabling development and testing of advanced accelerator hardware, beam diagnostics and detectors
- **Ion generation and acceleration**
  - Experimental hardware for producing supersonic hydrogen gas jets provides capabilities for generating mono-energetic multi-MeV proton beams
- **Ultrafast Electron Diffraction/Microscopy**
  Technique for characterizing materials that is complementary to x-ray sources
  - Developmental beam line and experimental station for diffraction and imaging studies with MeV-class electron beams

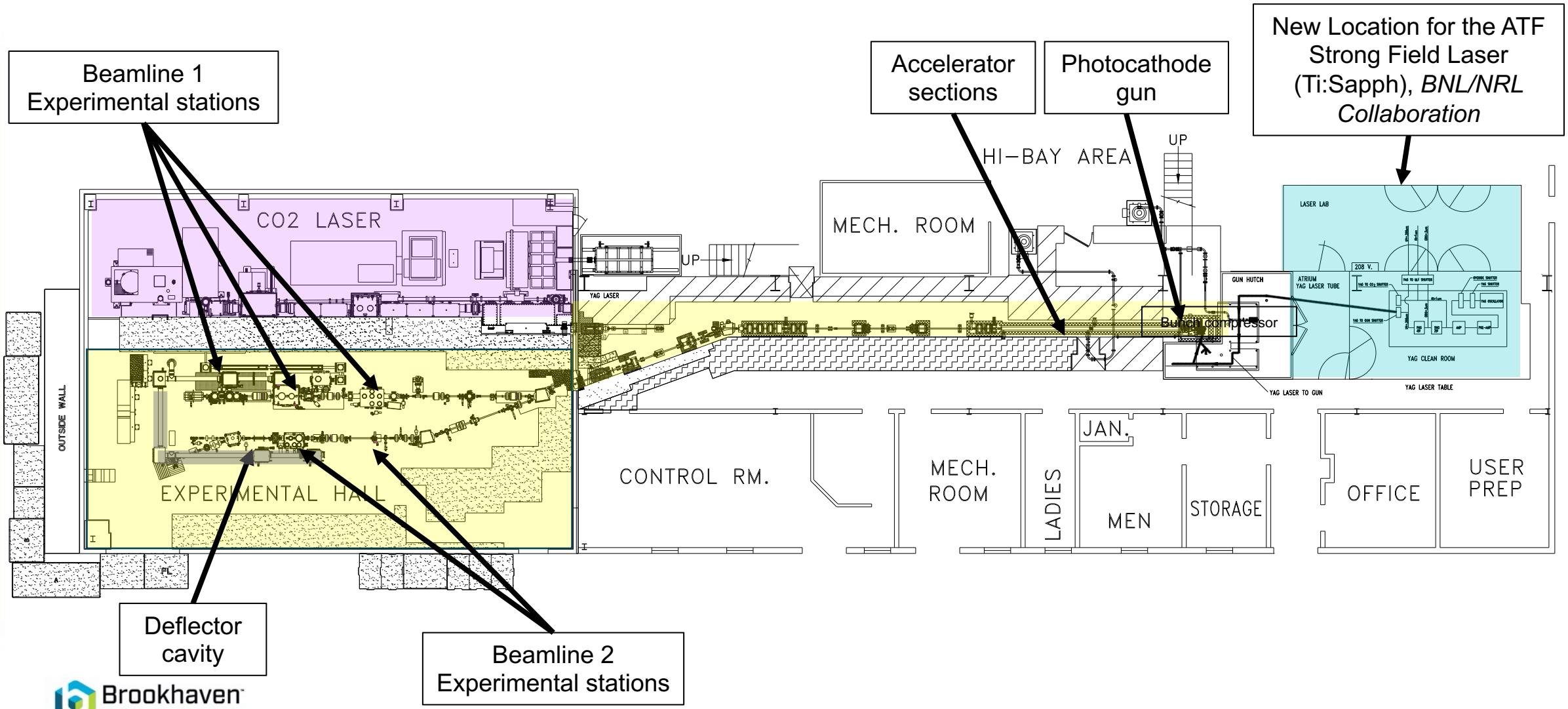


CO_2 long-wave infrared (LWIR) laser system
- λ = 9.2 μm
- >5 TW peak power
  full power to user IPs in 2023
- 5-15 J @ 2.0ps width
- 0.05 Hz repetition rate

New near IR capabilities

High-brightness photocathode linac: 20-75 MeV
- Emittance: 1μm
- Energy spread: 0.1%
- Charge: ~1 nC
- Single bunch: 10 ps – 200 fs
- Multi-bunch trains

Current Layout of the ATF at B820



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Electron Beam Parameters

Parameter	Units	Typical Values	Comments
Beam Energy	MeV	50-65	*Full range is ~15-75 MeV with highest beam quality at nominal values*
Bunch Charge	nC	0.1-2.0	*Bunch length & emittance vary with charge*
Compression	fs	Down to 100 fs (up to 1 kA peak current)	*A magnetic bunch compressor available to compress bunch down to ~100 fs. Beam quality is variable depending on charge and amount of compression required.* *NOTE: Further compression options are being developed to provide bunch lengths down to the ~10 fs level*
Transverse size at IP (σ)	μm	30 – 100 (dependent on IP position)	*It is possible to achieve transverse sizes below 10 um with special permanent magnet optics.*
Normalized Emittance	μm	1 (at 0.3 nC)	*Variable with bunch charge*
Rep. Rate (Hz)	Hz	1.5	*3 Hz also available if needed*
Trains mode	---	Single bunch	*Multi-bunch mode available. Trains of 24 or 48 ns spaced bunches.*

CO_2 Laser Parameters

Configuration	Parameter	Units	Typical Values	Comments
CO_2 Regenerative Amplifier Beam	Wavelength	μm	9.2	*Wavelength determined by mixed isotope gain media*
	Peak Power	GW	~3	
	Pulse Mode	---	Single	
	Pulse Length	ps	2	
	Pulse Energy	mJ	6	
	M^2	---	~1.5	
	Repetition Rate	Hz	1.5	*3 Hz also available if needed*
	Polarization	---	Linear	*Circular polarization available at slightly reduced power*
CO_2 CPA Beam	Wavelength	μm	9.2	*Wavelength determined by mixed isotope gain media*
Note that delivery of full power pulses to the Experimental Hall is presently limited to Beamline #1 only.	Peak Power	TW	5	*~5 TW operation will become available shortly into this year's experimental run period. A 3-year development effort to achieve >10 TW and deliver to users is in progress.*
	Pulse Mode	---	Single	
	Pulse Length	ps	2	
	Pulse Energy	J	~5	*Maximum pulse energies of >10 J will become available within the next year*
	M^2	---	~2	
	Repetition Rate	Hz	0.05	
	Polarization		Linear	*Adjustable linear polarization along with circular polarization can be provided upon request*

Near IR Laser Parameters

Ti:Sapphire Laser System	Units	Stage I Values	Stage II Values	Comments
Central Wavelength	nm	800	800	*Stage I parameters are presently available and setup to deliver Stage II parameters should be complete during FY22*
FWHM Bandwidth	nm	20	13	
Compressed FWHM Pulse Width	fs	<50	<75	*Transport of compressed pulses will initially include a very limited number of experimental interaction points. Please consult with the ATF Team if you need this capability.*
Chirped FWHM Pulse Width	ps	≥50	≥50	
Chirped Energy	mJ	10	200	
Compressed Energy	mJ	7	~20	*20 mJ is presently operational with work underway this year to achieve our 100 mJ goal.*
Energy to Experiments	mJ	>4.9	>80	
Power to Experiments	GW	>98	>1067	

Nd:YAG Laser System	Units	Typical Values	Comments
Wavelength	nm	1064	*Single pulse*
Energy	mJ	5	
Pulse Width	ps	14	
Wavelength	nm	532	*Frequency doubled*
Energy	mJ	0.5	
Pulse Width	ps	10	

ATF FY22 Status Report

Introduction

FY22 Planned User Hours

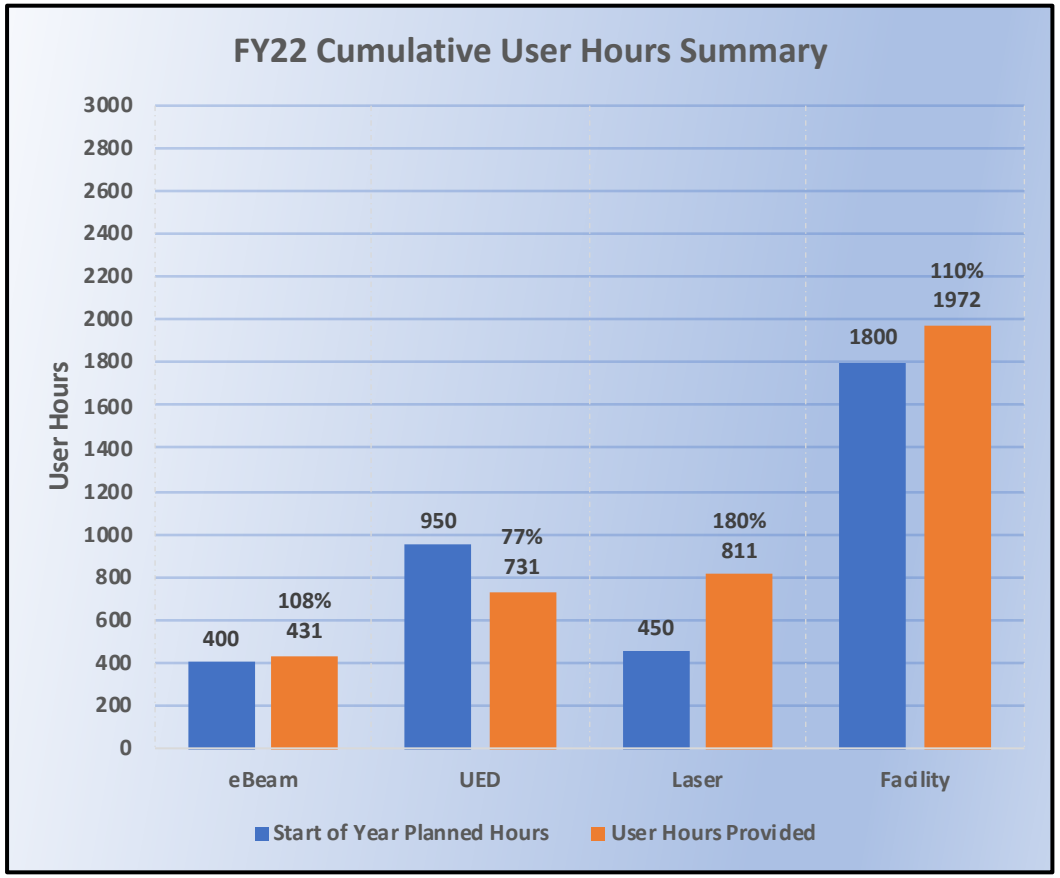
- Severely constrained by required ARR process at B820 (see later talk)
- FY22 Targets
  - Electron Beam: 400
  - UED: 950
  - Laser (LWIR + NIR): 450
  - Facility Total: 1800

Overall Availability

FY22 Overall User Hour Target Met

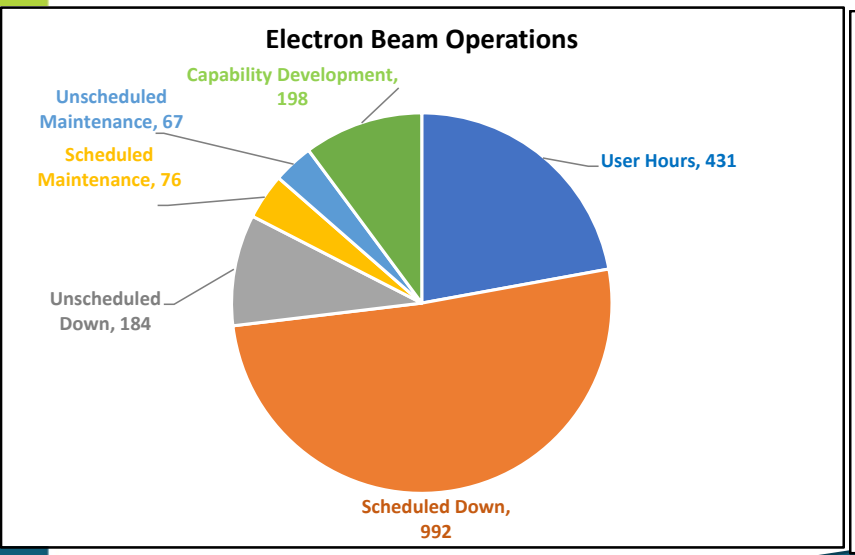
Challenges:

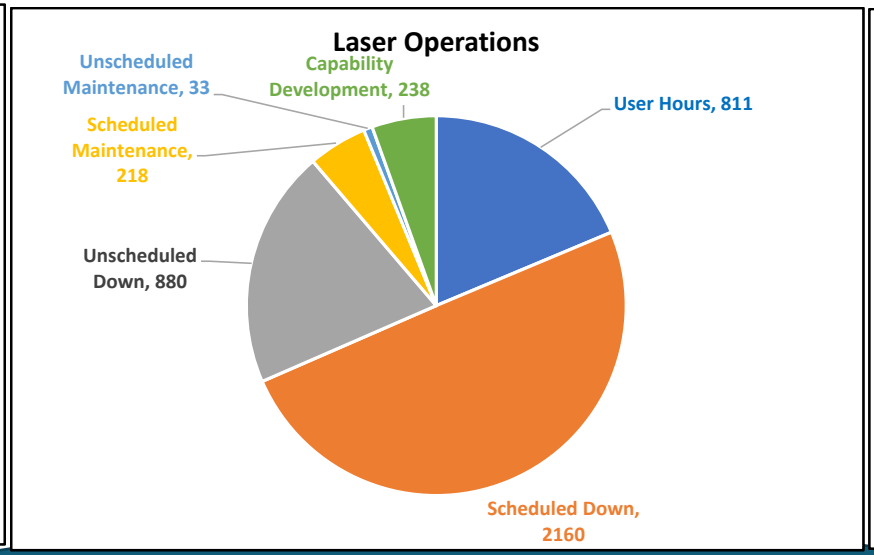
- Electrical Failures at B912 impacted UED maintenance
- ARR preparations and surprise discoveries at B820 led to significant extension of the planned down period
  ⇨ leading to significant ***unscheduled down time***
  - Major impacts - particularly for the ATF laser systems
- Gun klystron failure near end of the FY22 user campaign

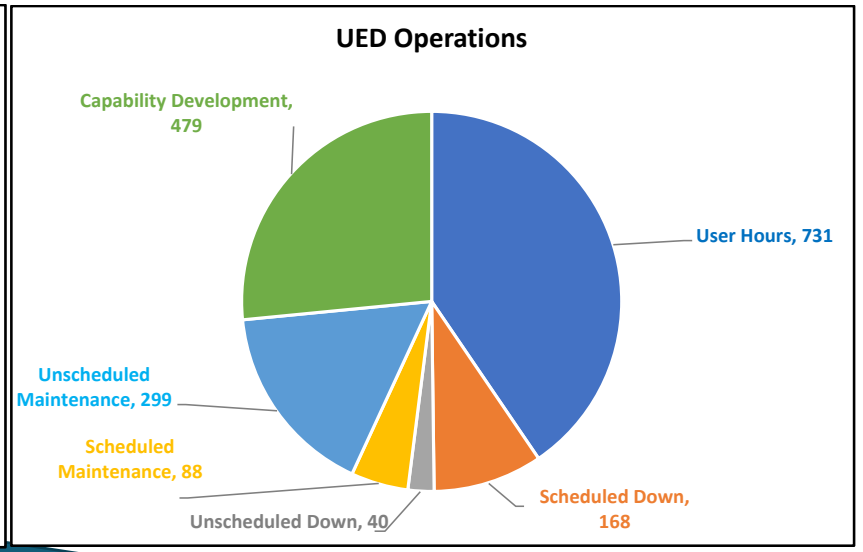


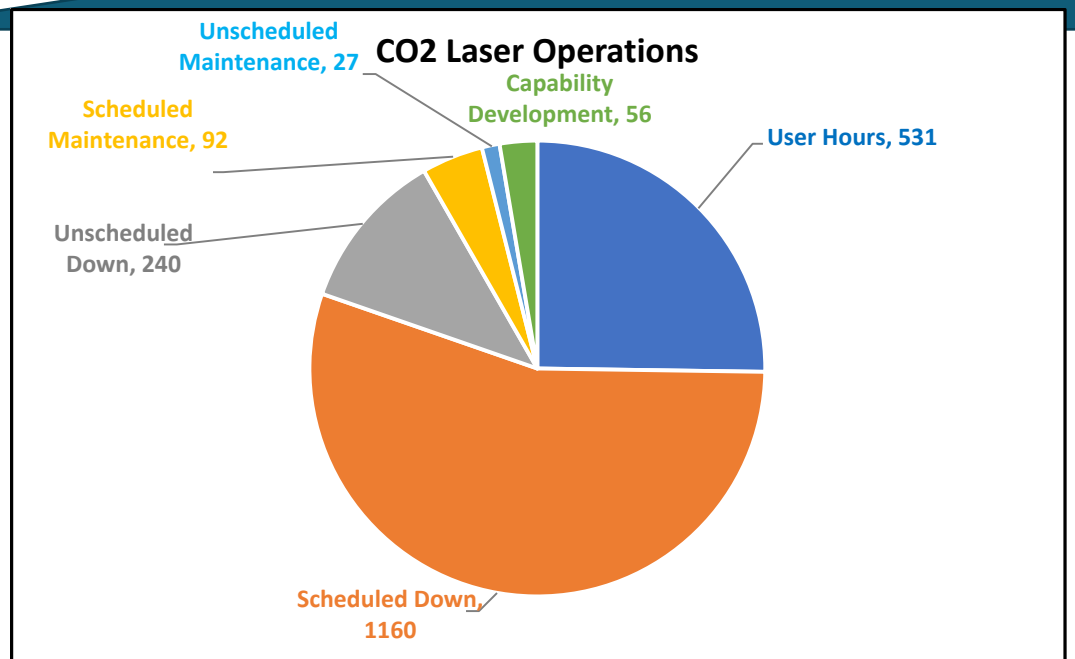
	Unscheduled Maintenance (hrs) - Lost time during user operations or machine development for each facility capability.				Unscheduled Downtime (hrs) - Extensions to planned capability downtime due to facility-level issues and/or realized project risks.		
	e-Beam	UED	Laser		e-Beam	UED	Laser
FY19 Total	52.0	228.0	108.0		136.0	60.0	0.0
FY20 Total	40.0	52.0	72.5		0.0	71.7	24.0
FY21 Total	226.2	204.8	158.5		0.0	192.0	0.0
FY22 Total	66.6	299.1	32.5		184.0	40.0	880.0

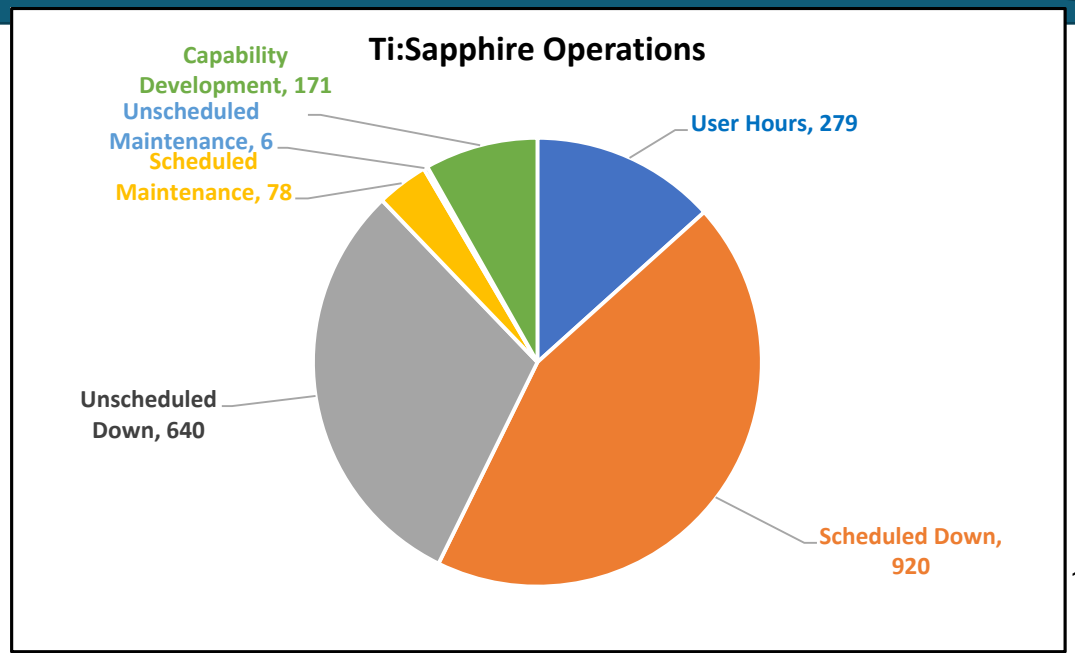
FY22 Hours Summary











ATF FY23 Operations Plan

FY23 Planned Hours and Progress-To-Date

User Hour Constraints:

- Pre-ARR corrective actions
- Complete 5TW peak power CO2 upgrade
- Gun klystron replacement
- UED Facility to be removed from the ATF SC User Facility portfolio effective **April 1, 2023**
  - Operations to continue as an Non-Designated User Facility (NDUF) with full cost recovery

⇨ **2nd year with severe operating hour limitations:**

1900 capability hours planned (*versus 2500 optimal*)

	Facility Cumulative		
Capability	**Start of Year Planned Hours**	**User Hours Provided**	**% of Target Delivered**
eBeam	450	111	25%
LWIR Laser	650	211	32%
NIR Laser	450	151	33%
UED	350	172	49%
Facility	**1900**	**645**	**34%**

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Summary

FY23 is our 2nd "non-standard" year for ATF User operations

- Reduced user hours due to Accelerator Readiness Review preparations (see later talk)
- UED Facility is providing user hours only to experiments already underway
  - Transition to a NDUF will take place on April 1
- Ongoing challenges of aging hardware → Gun klystron failure

Nonetheless,

- We are continuing with improvements to our laser capabilities (both NIR and LWIR)
- We will offer a major user run from April to early September at B820

Questions?