23nd ATF Users' Meeting
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BNL-ATF NIR Systems

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BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

BNL-ATF Nd:YAG System

Parameter	Value	Comments
Energy	>5mJ	@ 1064nm 30mJ demonstrated To be increased to 150mJ with additional amplifier (<5% rms shot-to shot stability) <10% P-P drift over 8hr ~500mJ/100 pulses. Limited by final amplifier stored energy & gain depletion
Pulse train length	250ns	@40.8Mhz
Duration	<20ps @ 1064nm 10ps @ 532nm 8ps @ 266n	FWHM
Pointing stability	<0.3%	Of beam diameter on cathode
Polarization	Vertical	Horizontal upon request
Synchronization	Synchronized to the facility 81.6MHz master clock	<3ps drift (P-P, 8 hr)
Repetition rate	1.5Hz, 3 Hz	

BNL-ATF Nd:YAG System – Laser Layout

User Experiment Capabilities

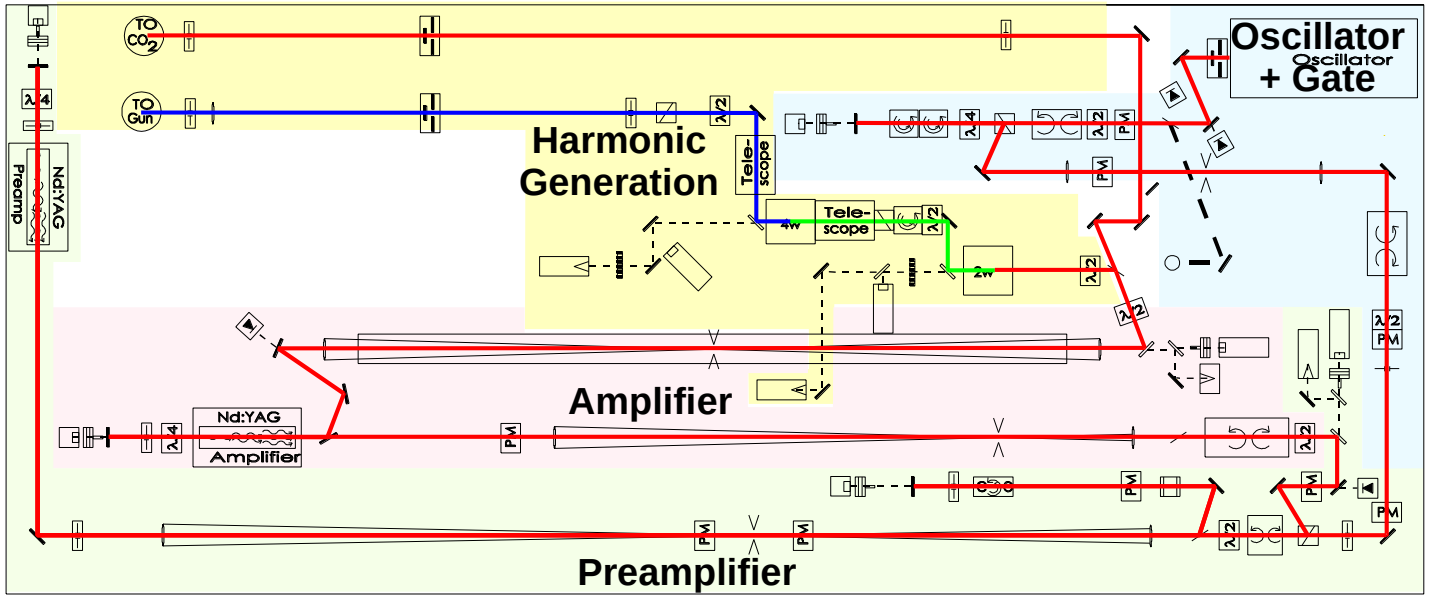
- Electron/laser pulse trains are a distinguishing capability of ATF
- Used for interaction with optical cavities (e.g. Compton scattering) & raising linac average current
- Single ps NIR pulses available for experiments at up to 5 mJ Phase I (now) & 100 mJ Phase II(2021)

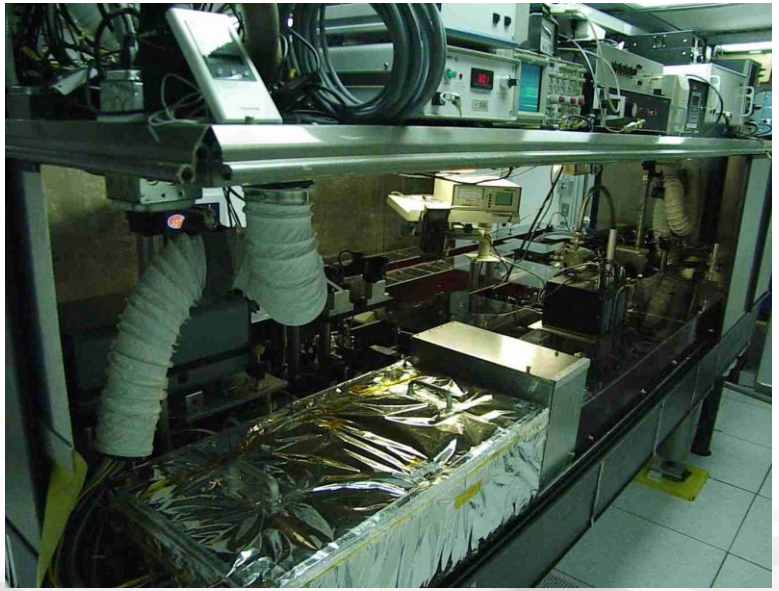
High Reliability

- Typical utilization & availability is >80% of BNL workdays
- Turn on time <15 minutes to full stability
- Laser physicist not required for turn on/off & experimental runs

High performance

- IR Energy at IP 2% RMS stability (single pulse)
- Pointing stability ~20% of beam diameter
- Timing jitter 0.2ps
- Trains up to 100 micropulses

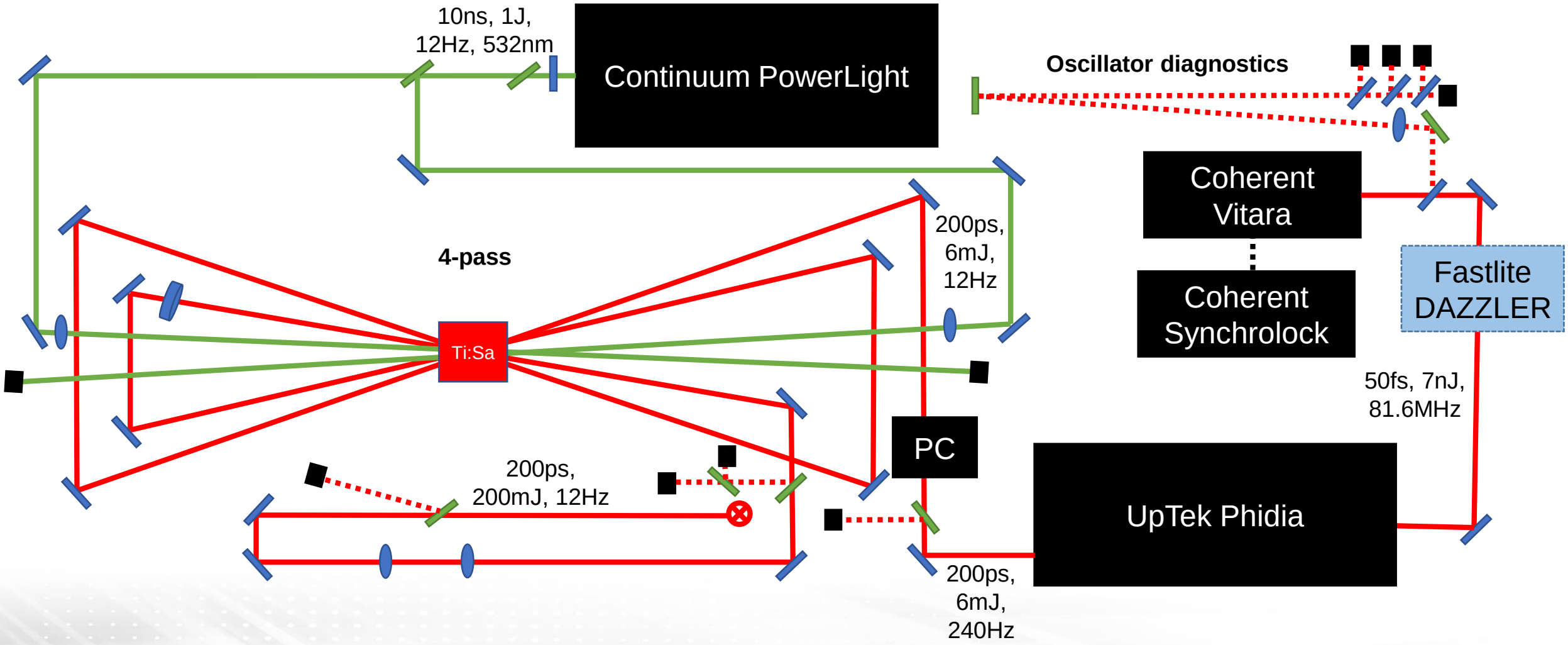




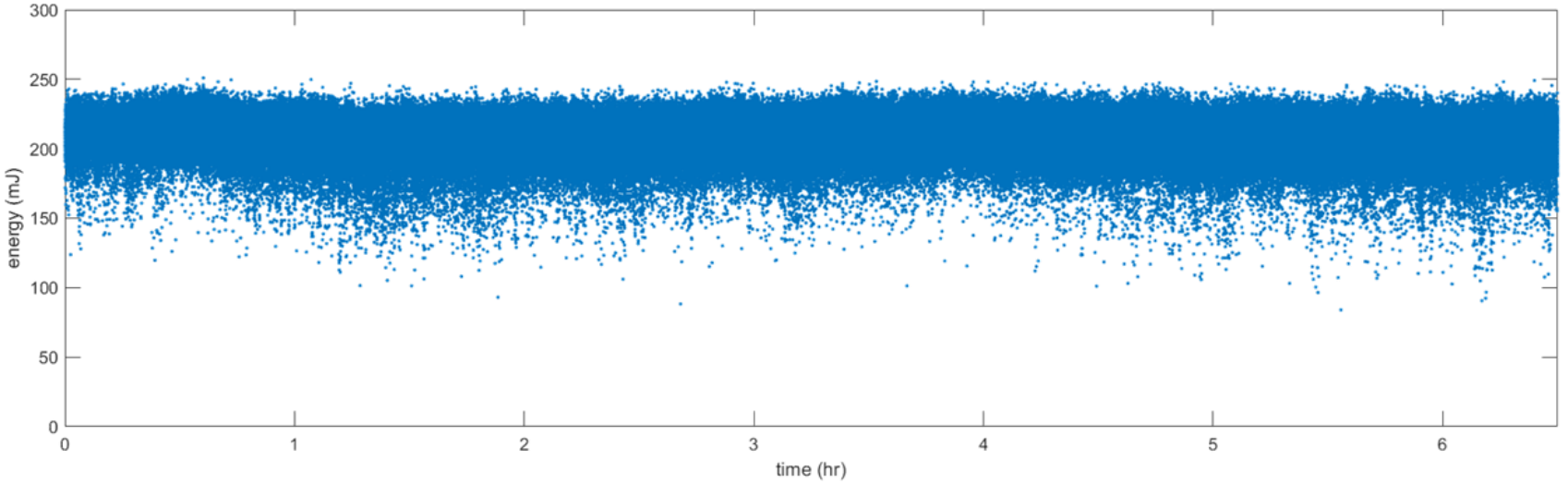
BNL-ATF Ti:Sa System – Stage I Parameters

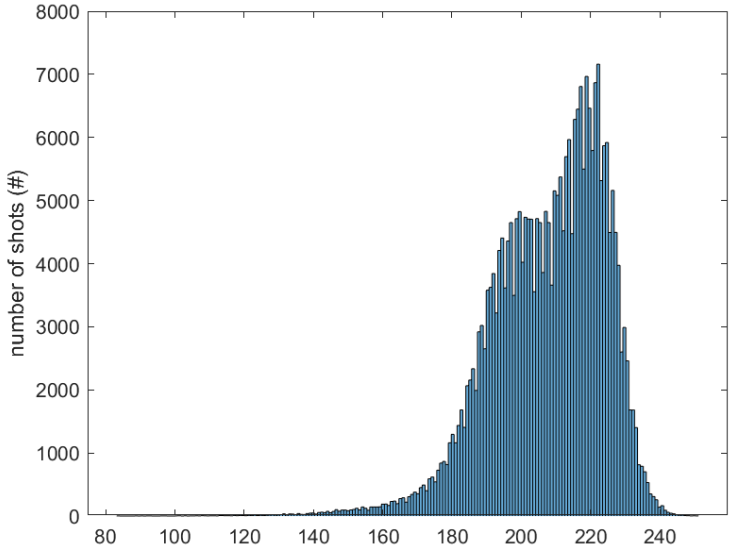
Parameter	Value	Comments
Energy (compressed)	>15mJ @ 12Hz	Compressed on target <5% STD long-term variation * To be increased to 100mJ @ 12Hz compressed in stage II
Energy (Stretched)	>200mJ @ 12 Hz	* Out of 4-pass amplifier <8% STD long-term variation
Duration	<55fs	FWHM
Focused spot size	<4μm FWHM	FWHM with F/1.5 OAP <1μm STD pointing stability (~25μrad STD)
Polarization	Vertical	Horizontal upon request
Synchronization	Synchronized to the facility 81.6MHz master clock	Rough timing (ns) by SRS delay generators. Fine adjustments (~10fs) by phase tuning the oscillator (Coherent Vitara + Synchrolock)
Transport line + compressor transmission	~33%	13.4mJ compressed out of 40mJ sent
Peak intensity	$>10^{18}$ W/cm^2	
Beam size in transport	<1.5”	Limited by aperture of vacuum line between Nd:YAG and Gun Hutch rooms

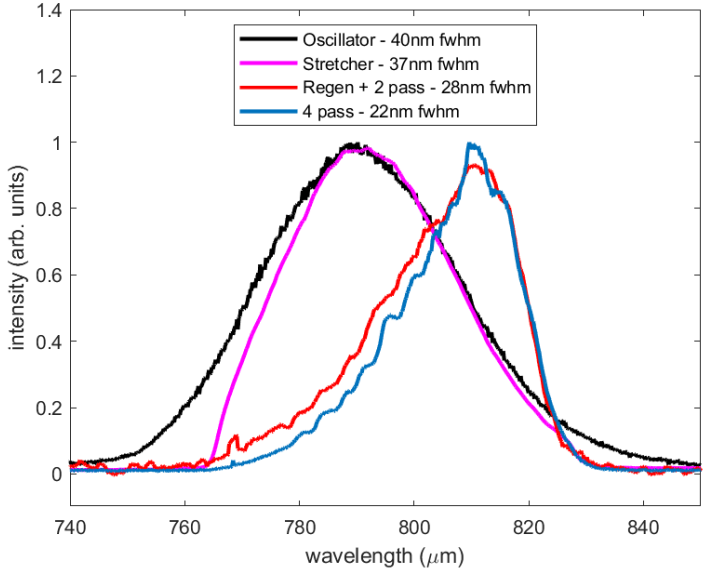
BNL-ATF Ti:Sa System – Laser Layout



BNL-ATF Ti:Sa System – Energy Output/ Stability



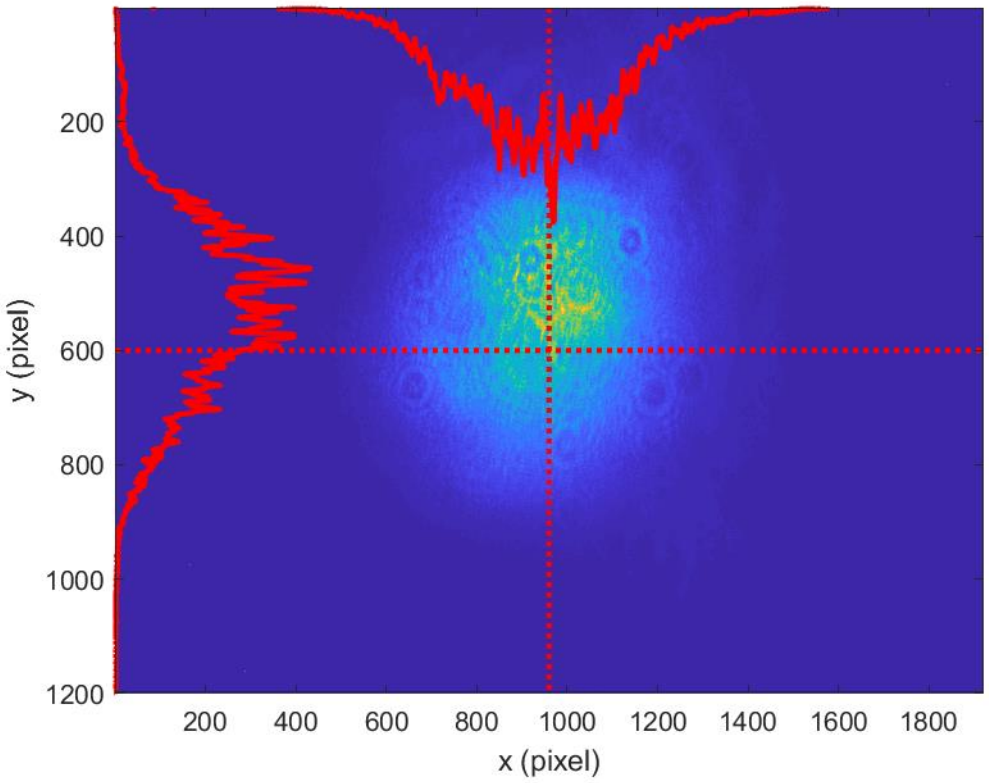




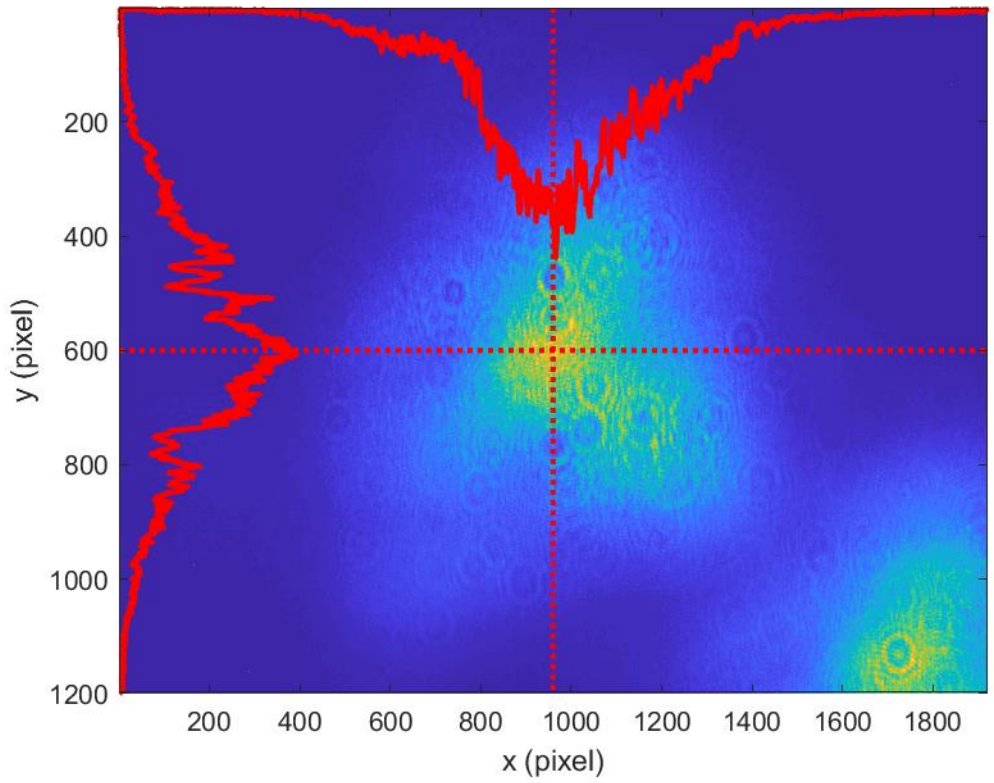
6.5 hours of continuous operation (281432 shots), RMS energy: 208.4mJ (STD 16.3mJ / 7.8%, max 251mJ, min 84mJ)

BNL-ATF Ti:Sa System – Near Field

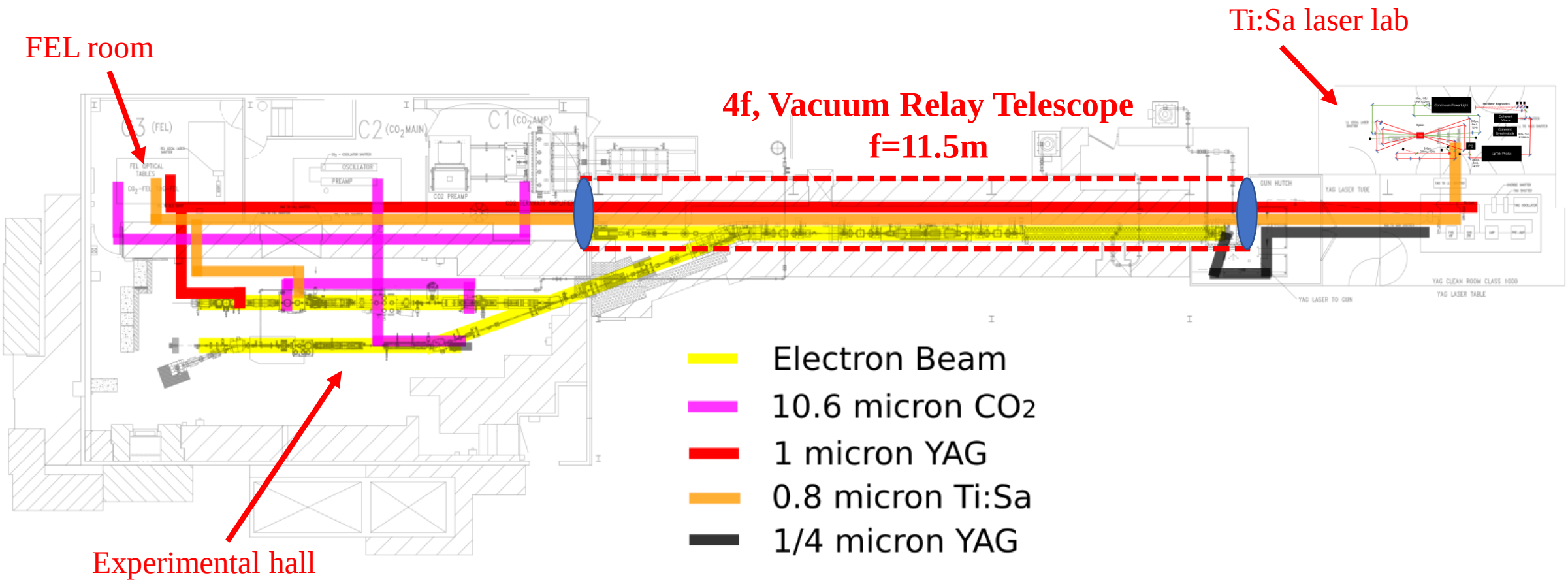
50mJ



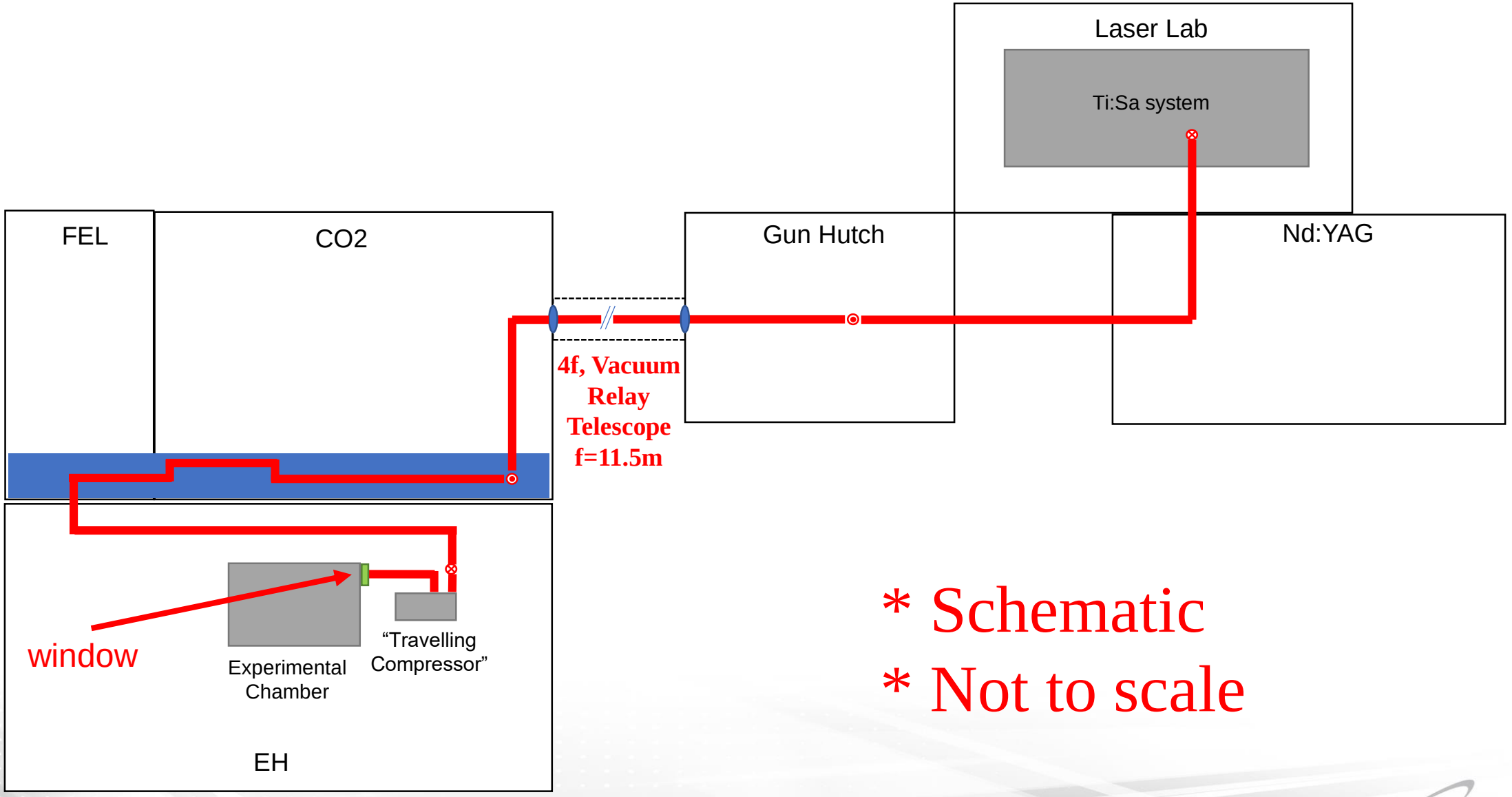
200mJ



BNL-ATF NIR Systems - Shared Transport

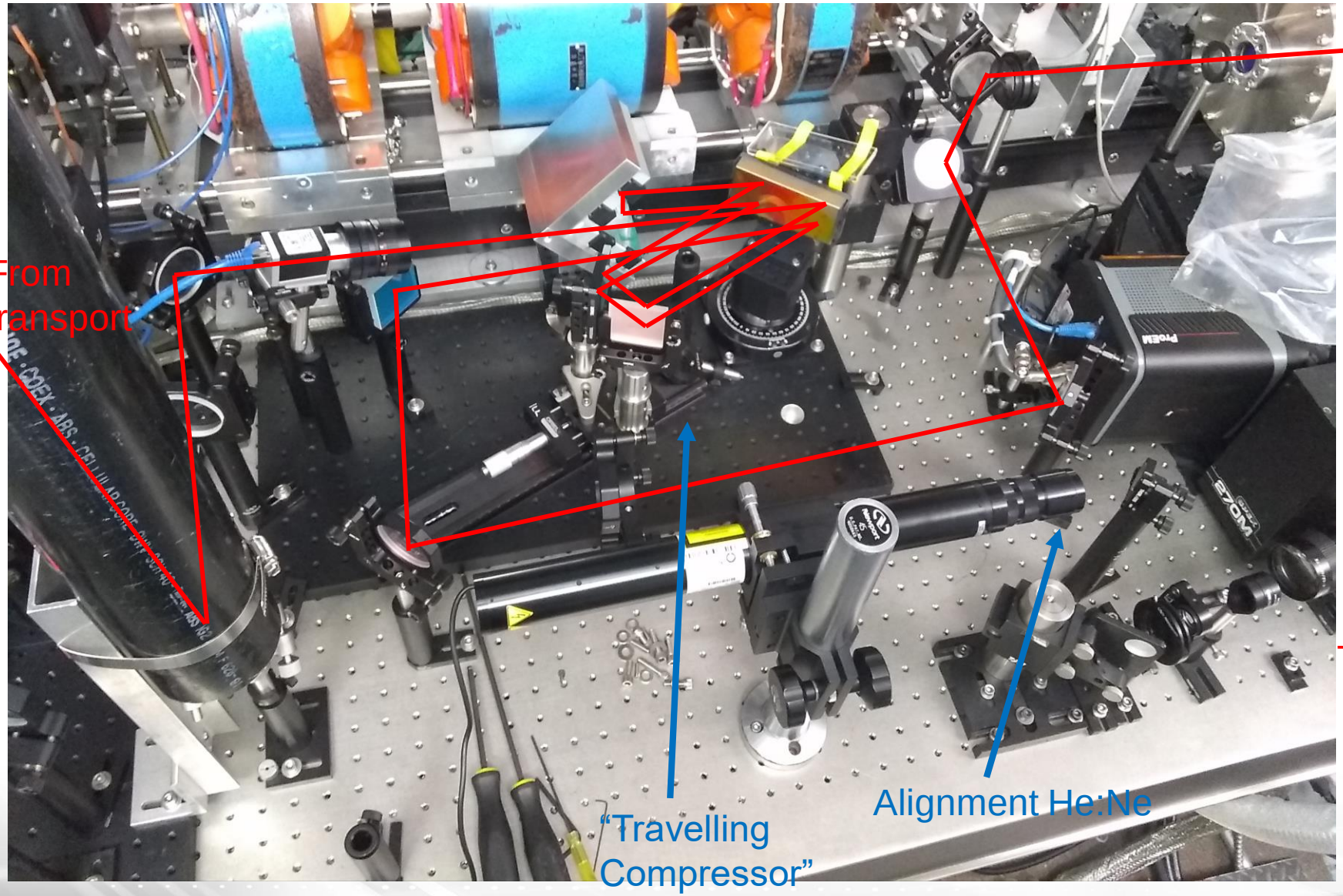


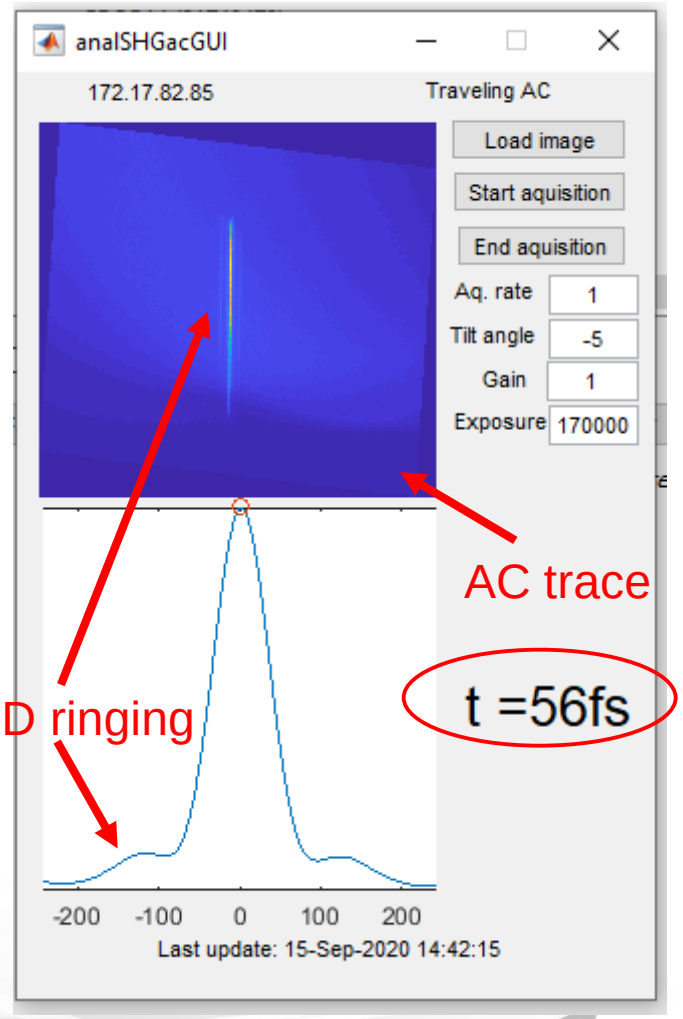
BNL-ATF Ti:Sa System - Transport



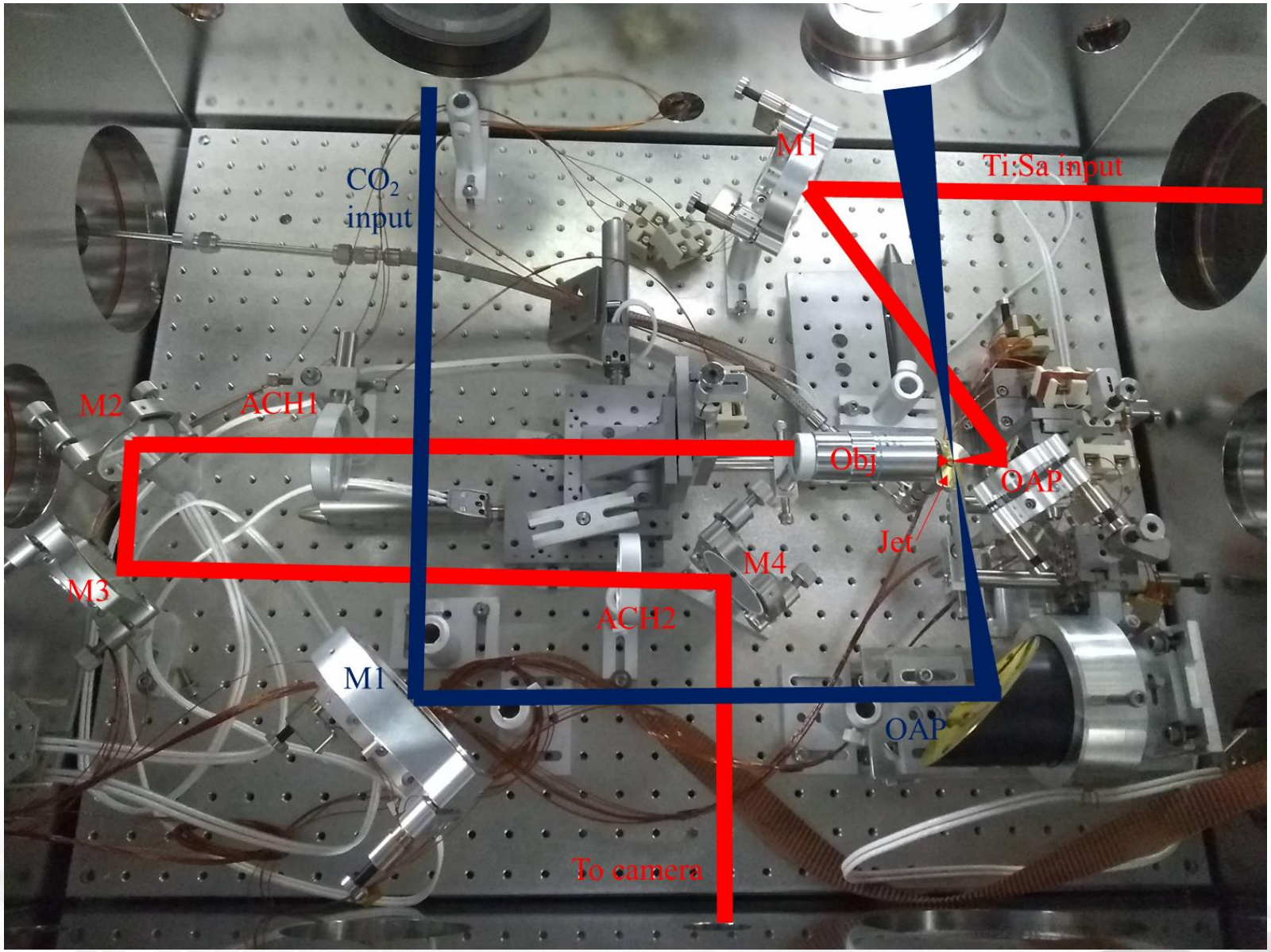
* Schematic
* Not to scale

BNL-ATF Ti:Sa System – 'Travelling Compressor'

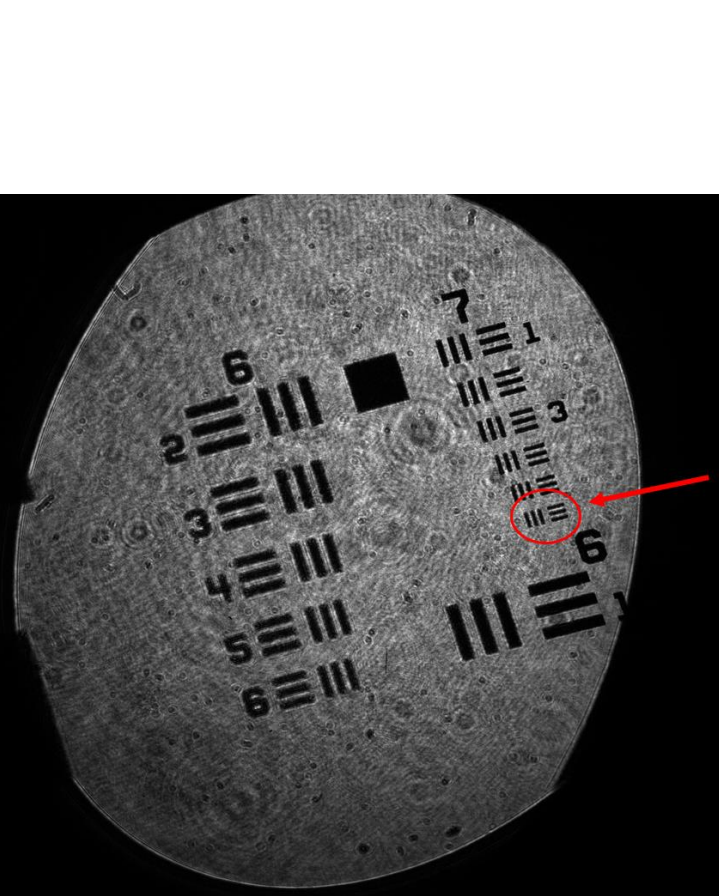




BNL-ATF Ti:Sa System – Tight Focus Delivery



BNL-ATF Ti:Sa System – Focus Imaging

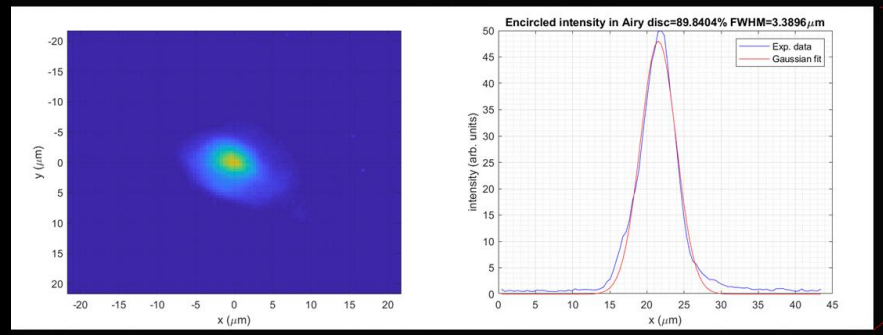


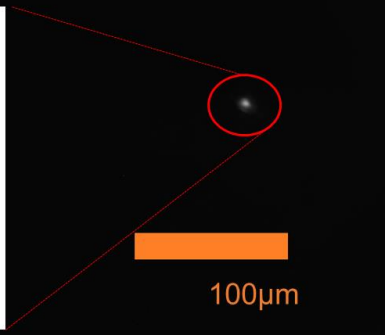
Each line is 2.19μm thick

Scale factor is 0.43μm per pixel

~ 100 μm DOF

~370μm x 450μm FOV

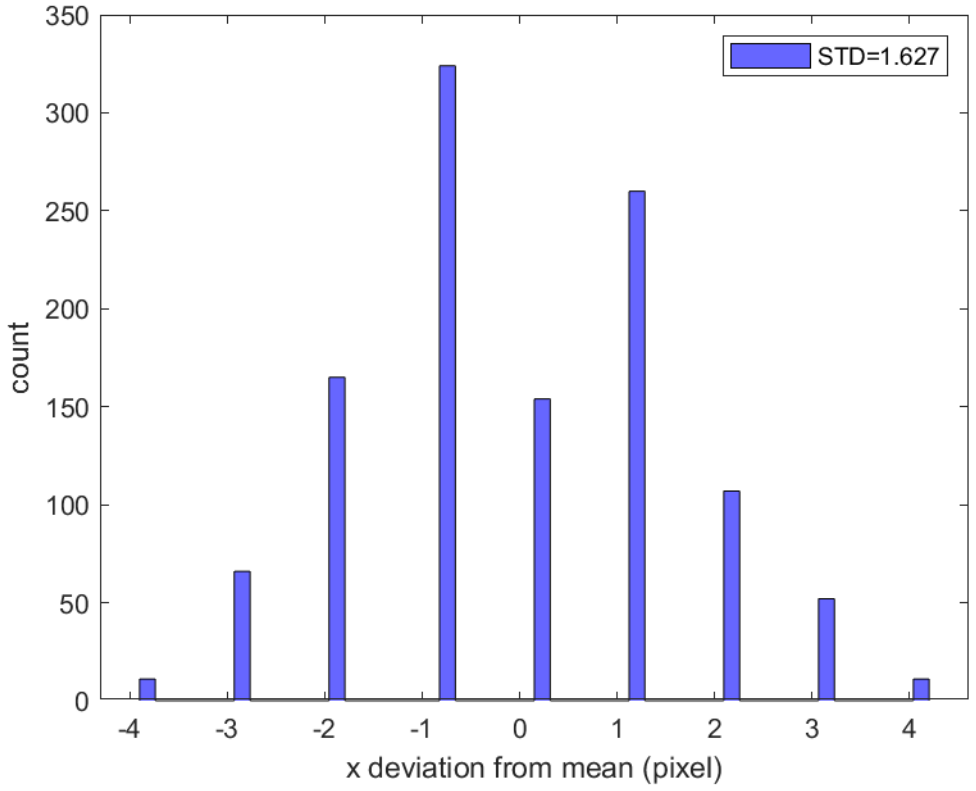


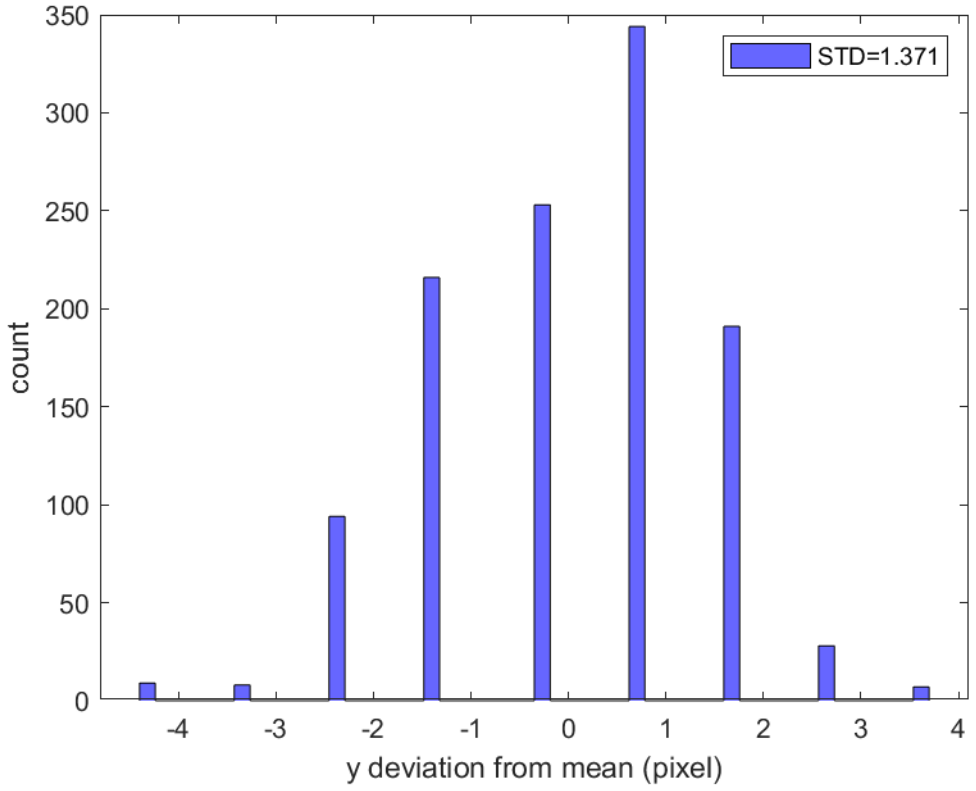


(Attenuated) 13.4 mJ/pulse Ti:Sa focus imaged from the chamber

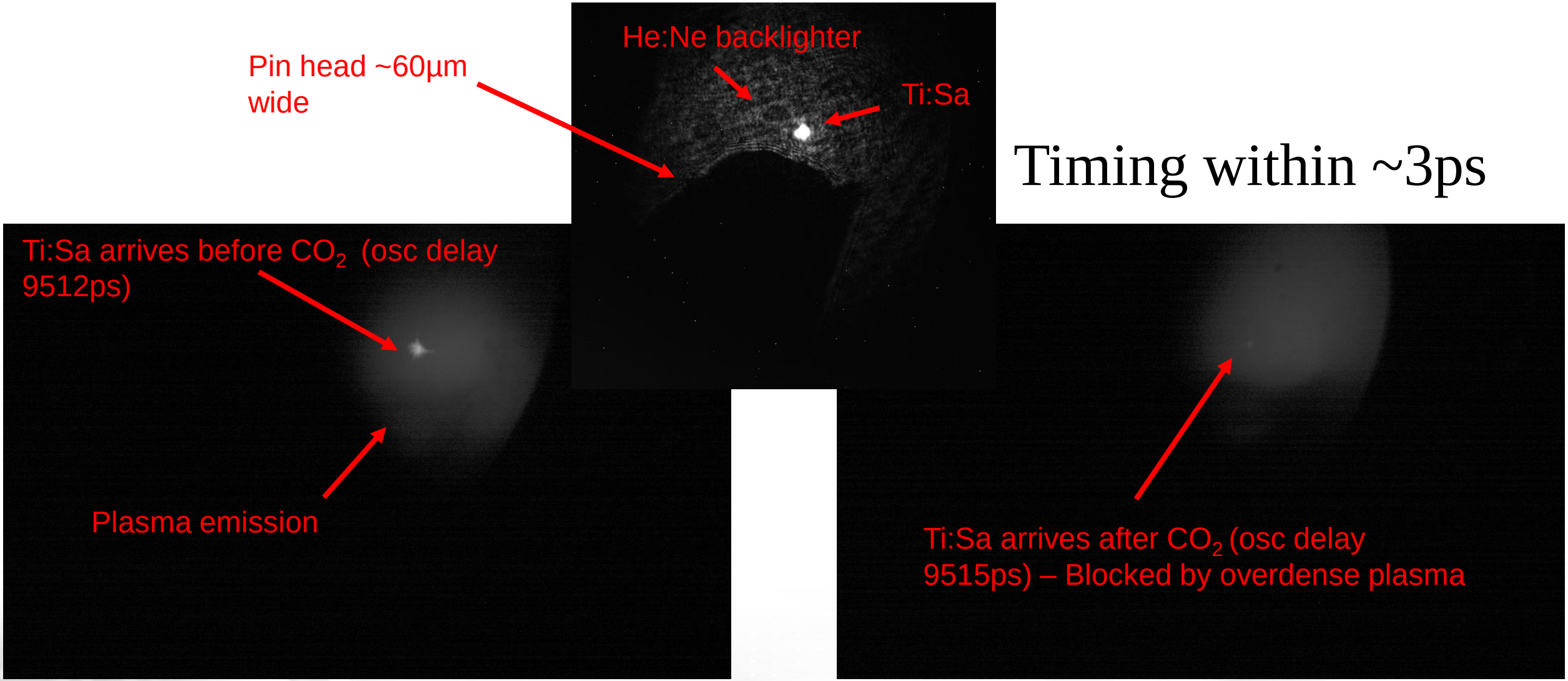
BNL-ATF Ti:Sa System – Pointing Stability

*0.43μm per pixel, 1150 shots total, ~25μrad STD

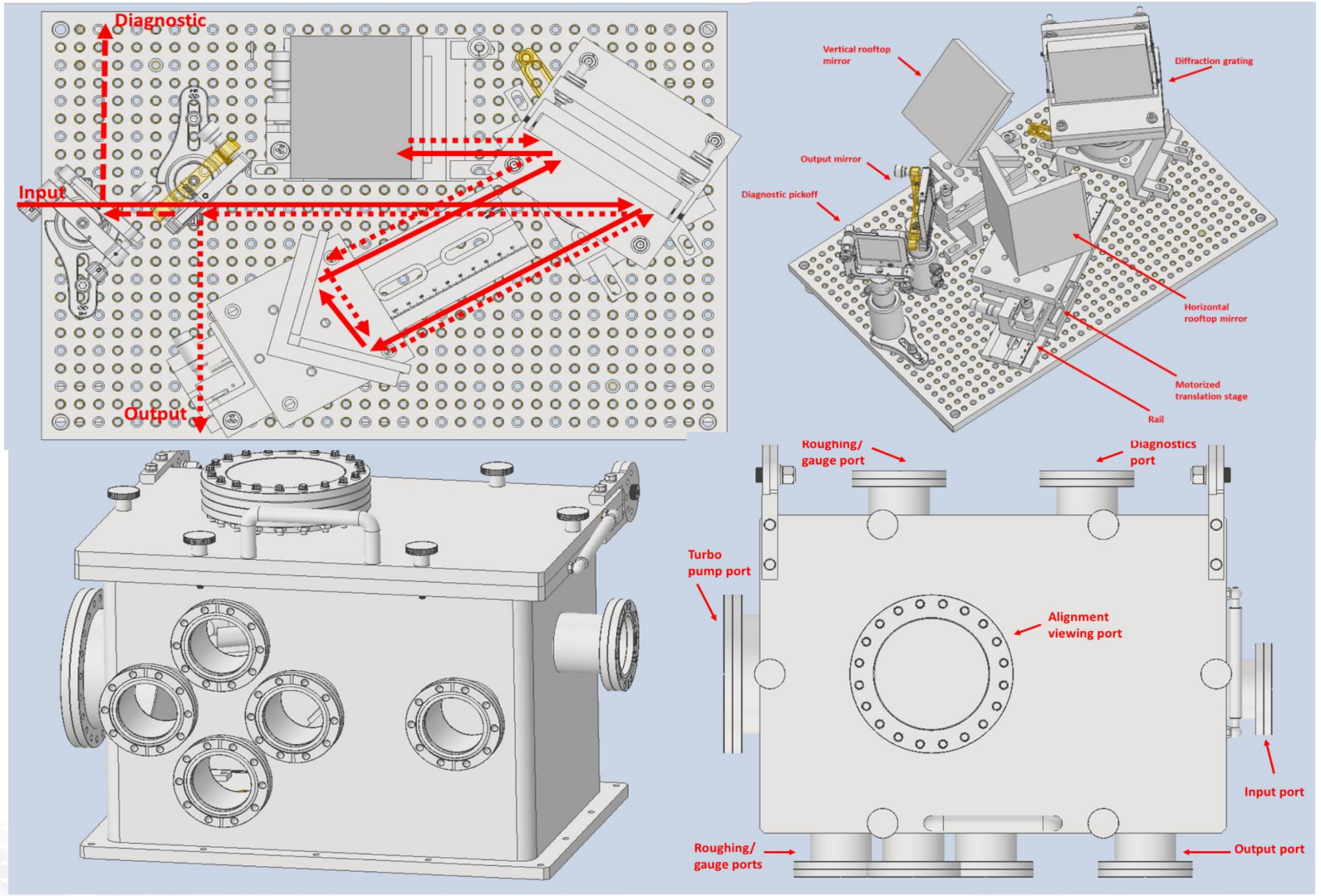




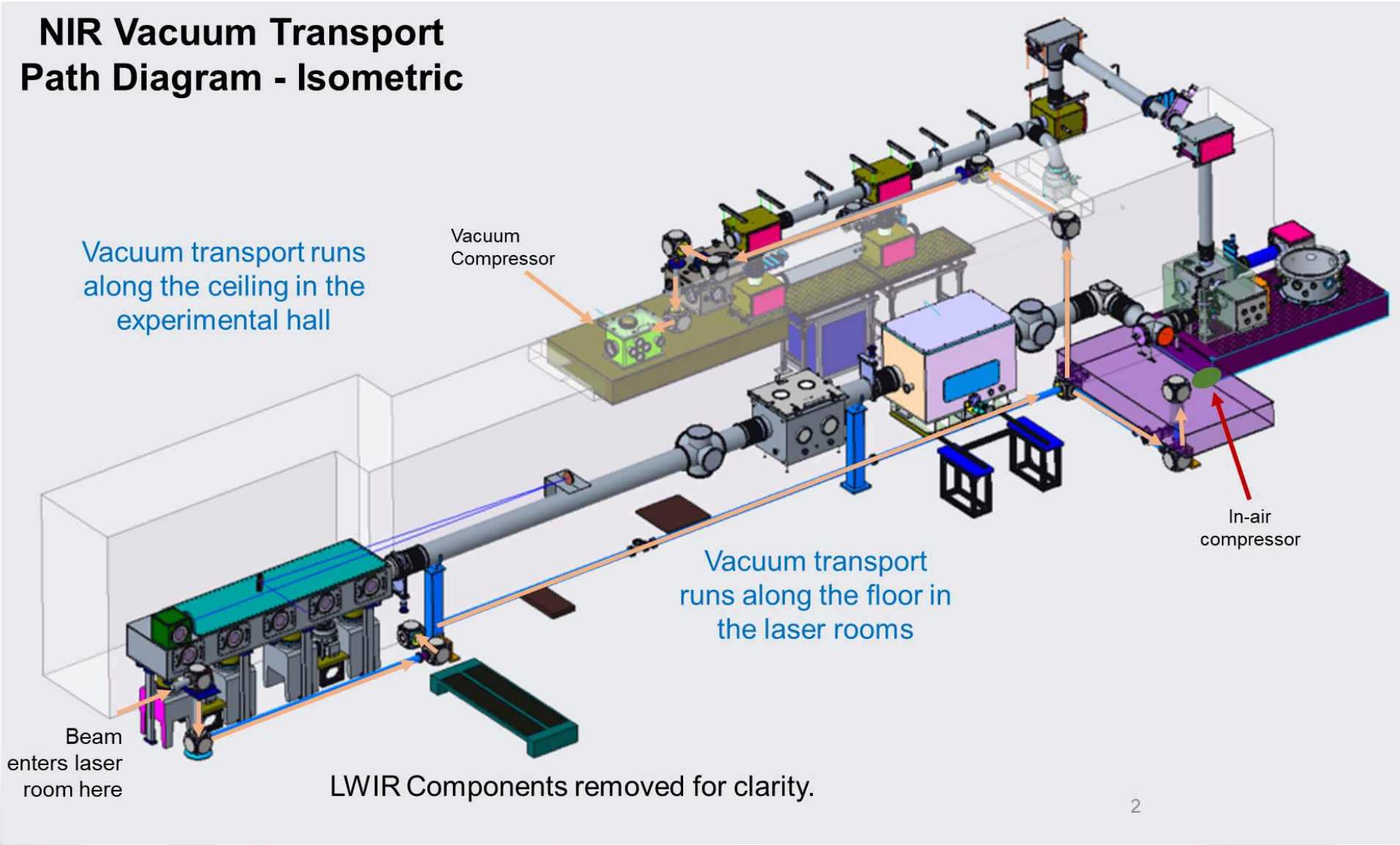
BNL-ATF Ti:Sa System – Spatial Positioning & Timing



BNL-ATF Ti:Sa System - Stage II - Vacuum Compressor



BNL-ATF NIR Systems – Stage II - Vacuum Transport



BNL-ATF NIR Systems

- Energy upgrades for Nd:YAG and Ti:Sa
- Transition to vacuum transport and vacuum compressor
- Planned vacuum transport is an upgrade of the existing transport line
  - Will reduce the risk for optical damage to components.
  - Will reduce transport instabilities.
  - Eliminate the window between the Ti:Sa compressor and chamber to allow higher energies.
  - Will allow additional relay telescopes if needed
  - Nd:YAG and Ti:Sa share the same transport path to reduce complexity and cost

BNL-ATF NIR Systems

NIR vacuum compressor

Parameter	Value	Notes
Maximum compressed pulse energy	100mJ (damage threshold limit < 1J)	Input 200mJ
Input beam size	1”	
Maximum supported pulse bandwidth	40nm	
Compressed pulse duration	<70fs	
Grating	Spectrogon 715.705.480 PC 1500 110x110x16 NIR	[2]
Motorized grating separation range	1”	
Rail grating separation range	5” – 12”	
Grating angle adjustment range (deviation angle)	30 +/- 5 degrees	
Angle of incidence	53.5 degrees +/- 5 degrees	
GDD tunability	$-1.3x10^{6}$ to -3.2×10^{6} fs^{2}	
TOD/GDD tunability	-1.85 to -2.15 fs	
Vacuum requirement	10^{-6} Torr or better	
Construction	Welded stainless steel	
Flanges	Conflat	
Cover seal	Elastomer	
Kinematic mount for breadboard		
Maximum deflection of base under vacuum loads	.0007”	Much less near kinematic mounts