YAG Status, Experimental Support & Instrumentation

Marcus Babzien BNL/ATF

Igor Pogorelsky	*CO_2 laser and experimental support*
Mikhail Polyanskiy	*LDRD post-doc, simulations, diagnostics*
Marcus Babzien	*YAG laser, general optical diagnostics*
Daniil Stolyarov	*Post-doc, fs solid-state laser*
Karl Kusche	*Laser safety, computer controls*
Vitaly Yakimenko	*Global laser strategy*

Additional thanks to ATF mechanical, electrical & computer engineers & technicians

Operating Parameters

Energy: (dual pulse mode)	
UV on cathode	0-30 μJ
IR at CO_2 table	7 mJ
Laser output: total IR	20 mJ
IR to gun	5 mJ / pulse
Green	**1 mJ / pulse**
UV	200 μJ
Repetition rate	1.5, 3 Hz

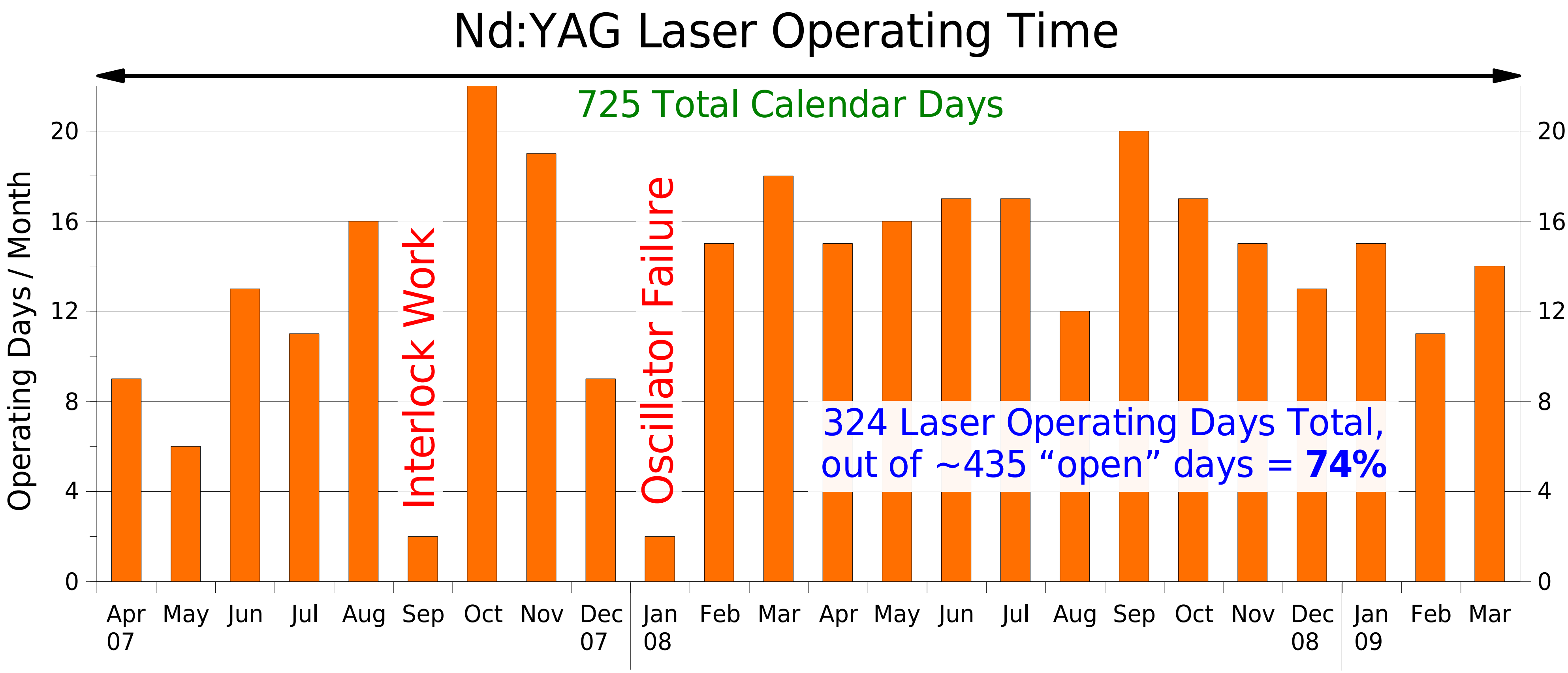
Pulse duration (FWHM):	
Oscillator IR	7 ps
Amplified IR	14 ps
Green	10 ps
UV	8 ps

Transverse Distribution:	
Size range on cathode (Ø)	0.2 - 3mm
Variation from Top-Hat (P-P)	<20%

Stability	
Shot-to-shot (rms)	
Timing	<0.2 ps
Energy	2 %
Pointing (% of beam Ø)	<0.3%
Drift (8 hour P-P)	
Timing	<2ps
Energy	<15%
Pointing (% of beam Ø)	<1%

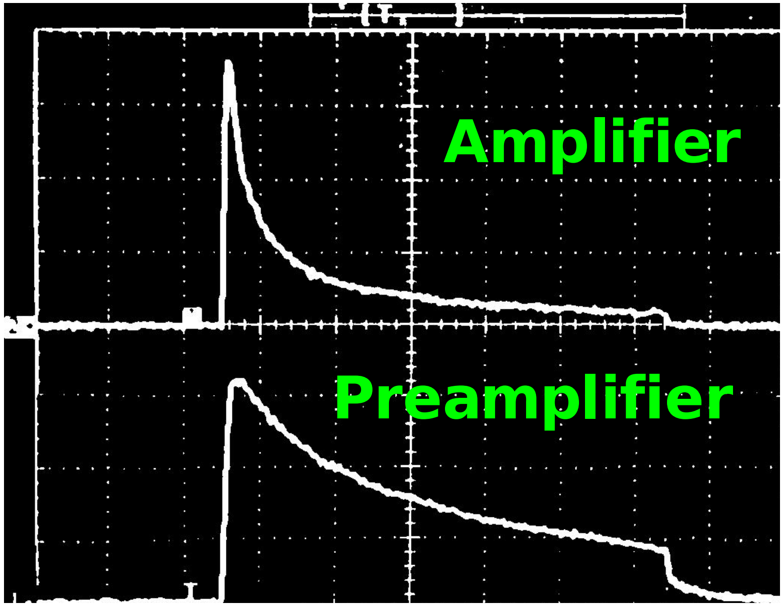
- Similar to previous years – reliability maintained
- Deliver more energy for Cu cathode by reducing UV losses

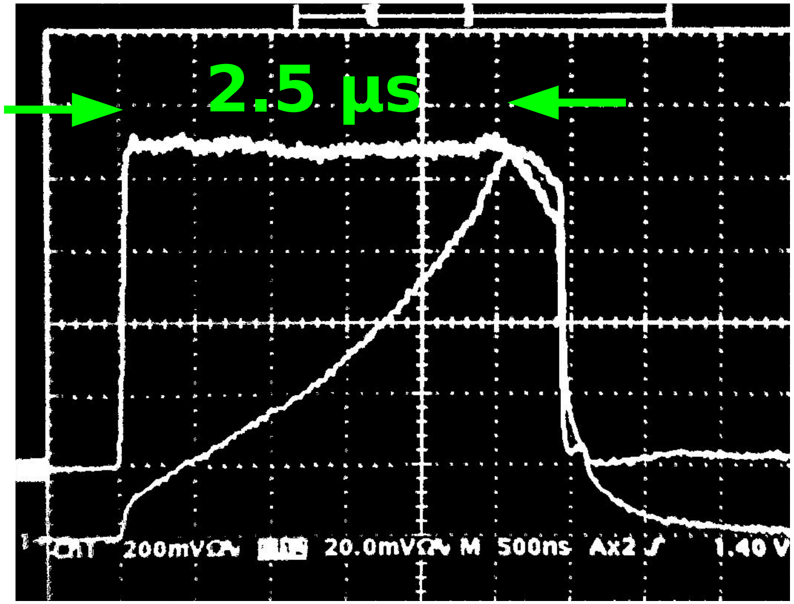
Operating Time



- Combined need for CO_2 laser slicing & Linac operations put the YAG system in high demand
- Mean daily running time > 10 hours

Pulse Train Operation

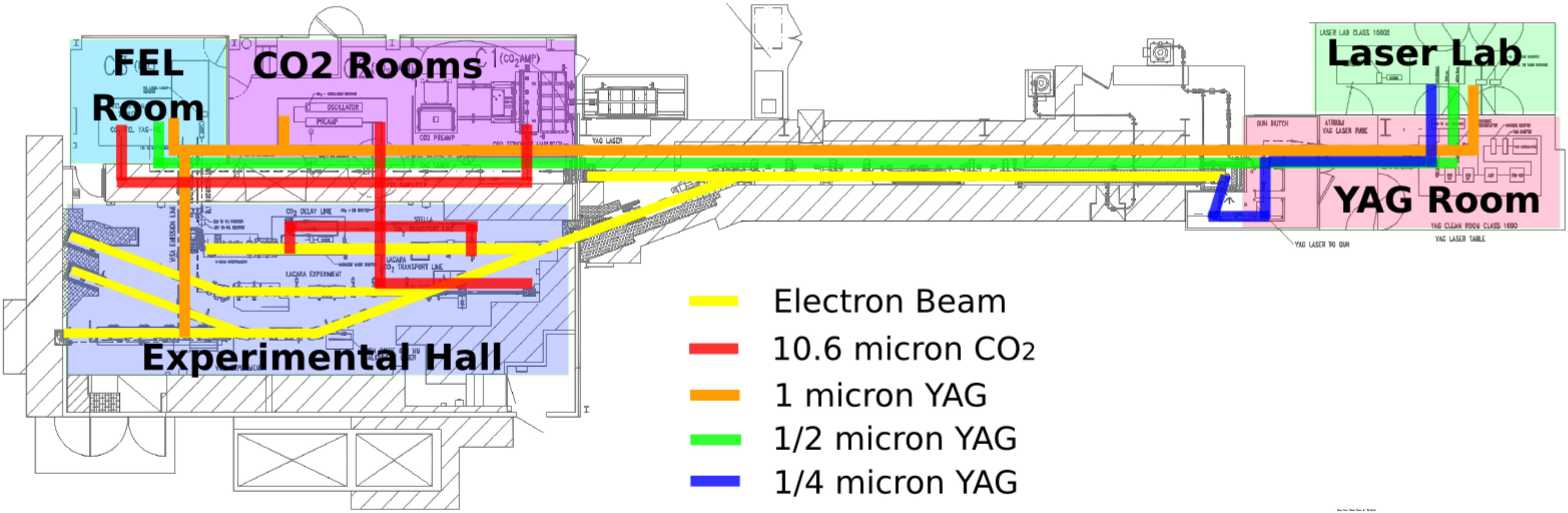




Oscilloscope traces of 40.8 MHz pulse train envelope measured by photodiode

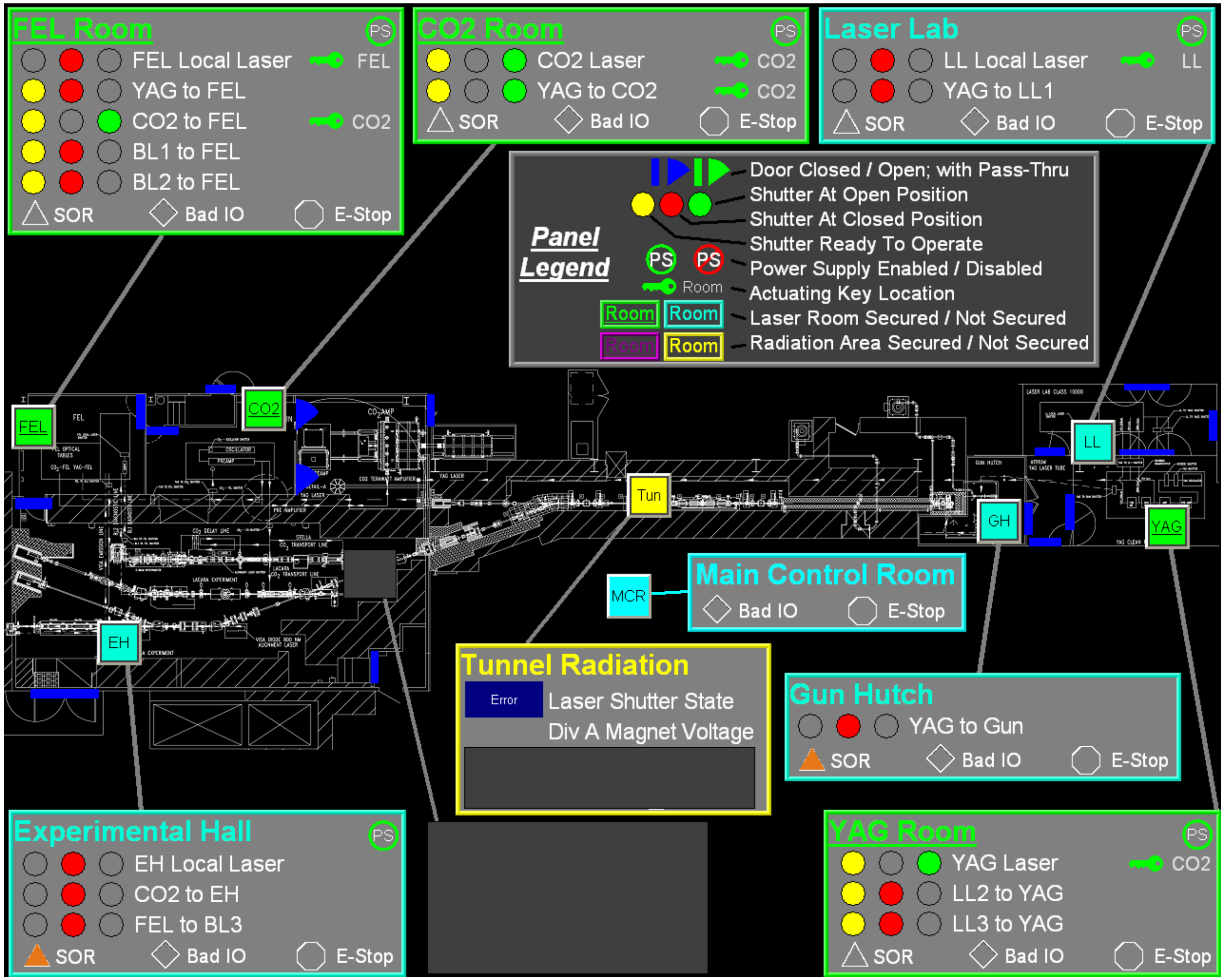
- Demonstrated & used extensively in FEL oscillator experiment ca. 1997
- Produce up to 200 pulses flat within 5%
- S. Boucher proposal yesterday requires such a capability
- All hardware & expertise still in place!

Personal Protection Interlocks



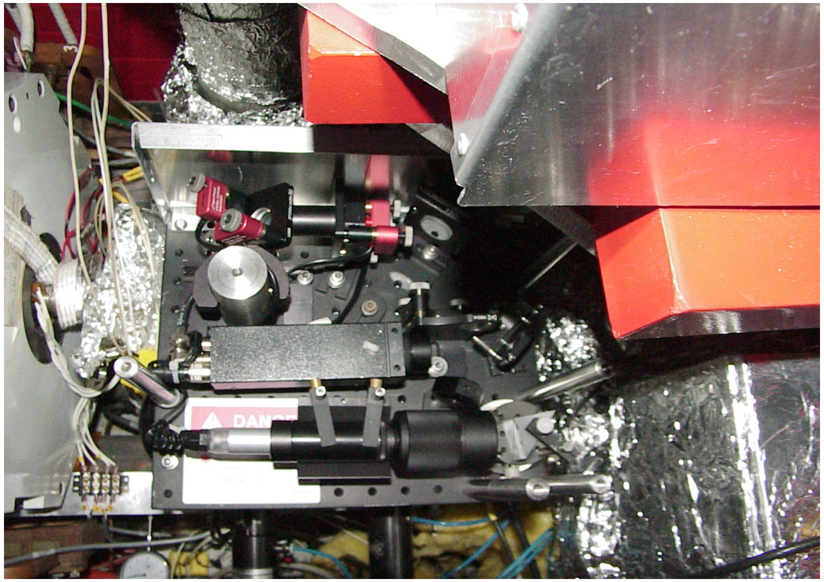
- Manifold beam paths for flexibility & efficiency
- Old documentation not adequate
- Old hardware (PLC) no longer programmable

Personal Protection Interlocks



- Entirely replaced all logic hardware: PLC's, IO blocks, PS, cabling & cabinets
- Software thoroughly documented
- Approval process means redundant, independent review
- New touchscreen display system streamlines testing & provides global status display
- Entire system now in ATF hands!

Gun/LINAC Laser Alignment

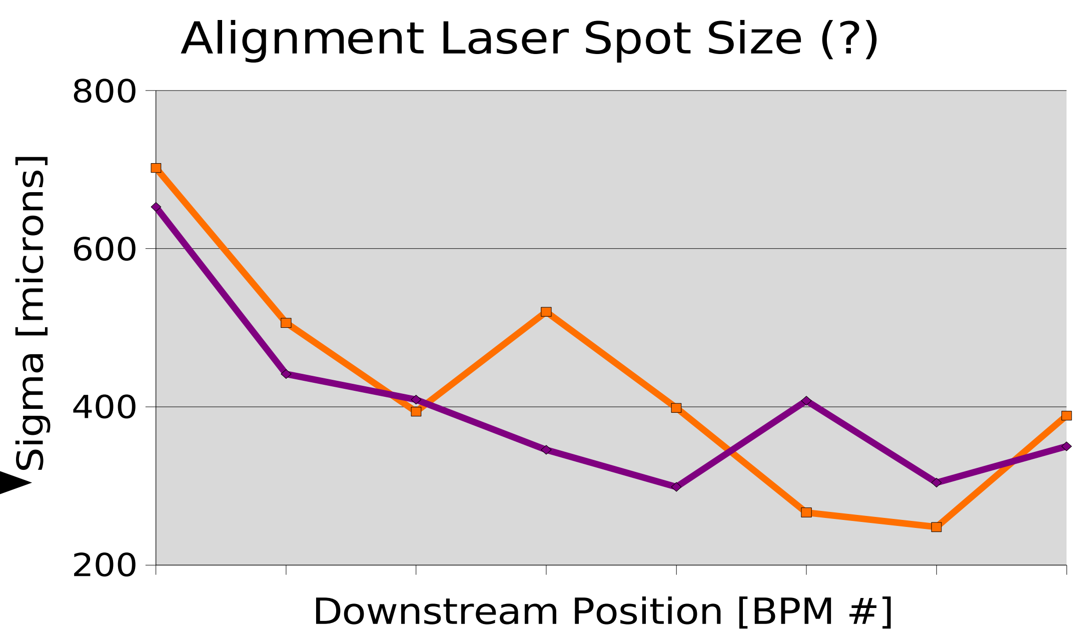


- On-line surveying and beam alignment tool extends from gun, down 20° dipole and into F-line
- Allows more accurate & reliable installation of diagnostics
- Promotes understanding & limitations of beamline (F-line bent!)
- Speeds experiment assembly

Example:

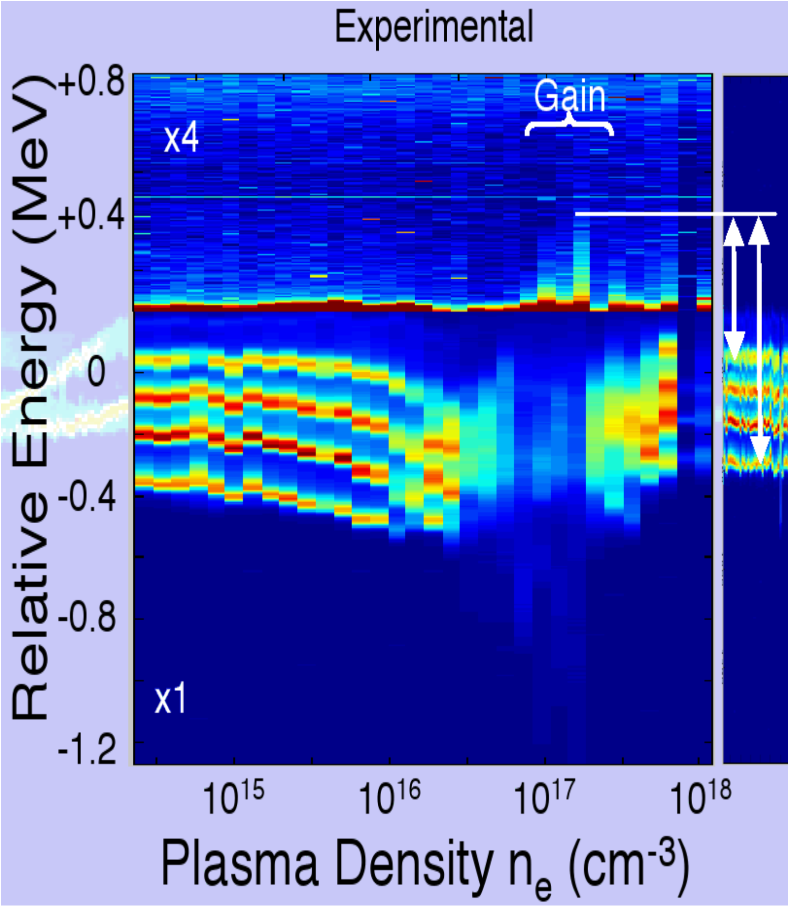
Unexpected e^- beam emittance measured?

Check laser "emittance" on BPM and track down problems



CCD Study

- Experiments have different needs. e.g. PWFA needs high dynamic range over two consecutive linac pulses
- Determine absolute camera performance offline
- Provide a baseline to make determination of "best" camera for given experiment
- Digital camera ready or in use on Streak Camera, BL2 Spectrometer (PWFA & LACARA) & BL1 (Current Filamentation Instability)



Courtesy P. Muggli

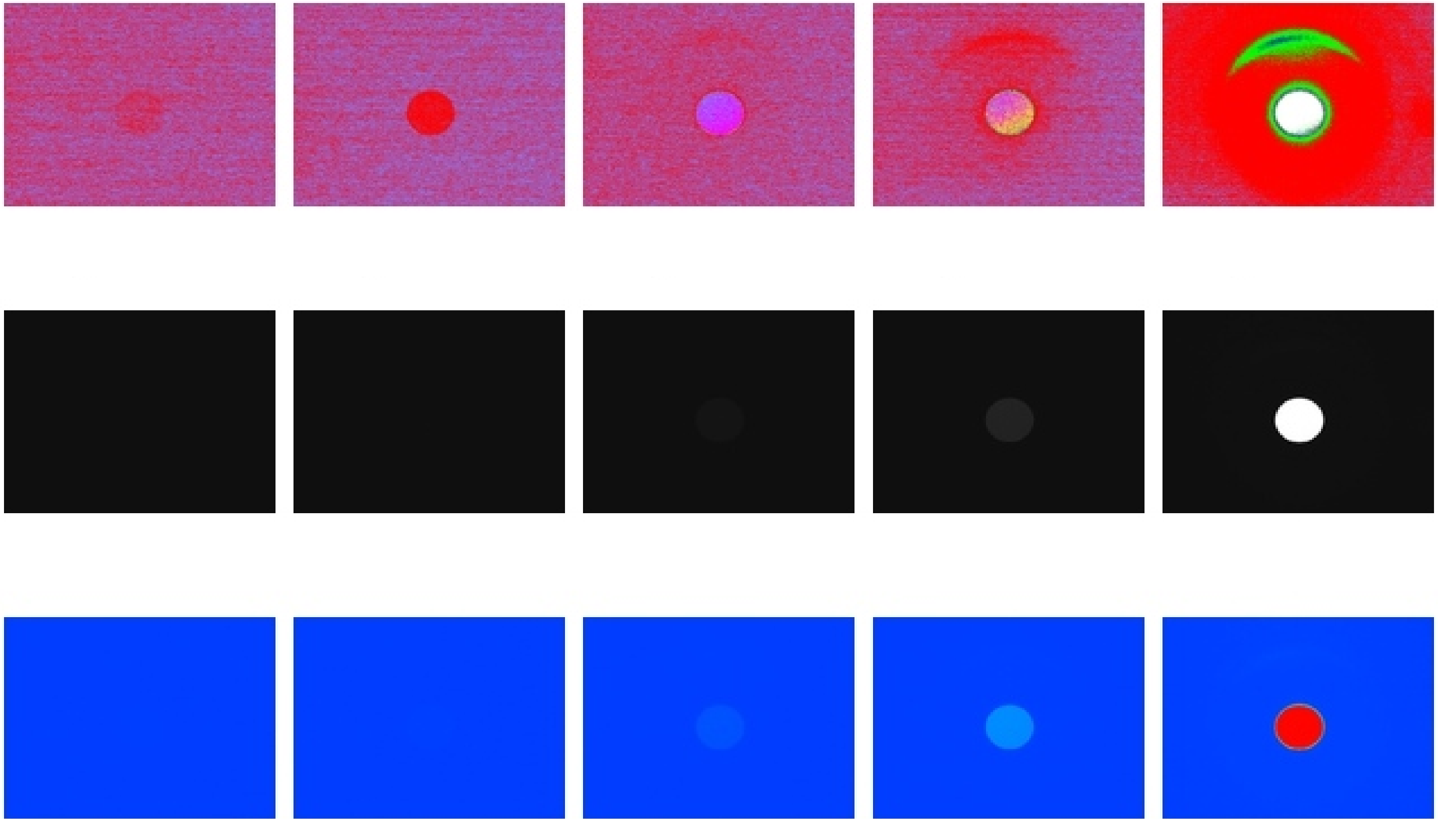
CCD Critical Parameters

Camera	Bit Depth	Gain Setting	Photons /pixel /count	Dark Noise [photons/ pixel]	Max Signal [photons/ pixel]	Signal / Noise Limit
Cohu 4922 (Cooled)	10	Maximum	1.5	28	1535	55
"	10	Middle	3.7	31	3785	123
"	10	Minimum	40	60	40920	682
Cohu 2122 ("Small")	10	High	3.4	68	3478	51
Pulnix TM-745E	10	NA	39	90	39897	443
Basler scA1400-17gm	12	Maximum	3.3	23	13514	588
"	12	Middle	15	25	61425	2457

- Modern digital camera (Basler) demonstrates improvements over older analog units
- Digital (Gigabit ethernet) interface makes synchronization much simpler as no continuous video stream necessary – operate camera single shot
- Additional factors more dependent upon particular experimental needs, i.e. pixel size & count, pulse duration & integration

CCD Study

Colormap affects image visibility more for 12-bit digital image and manual “beam tuning” tasks

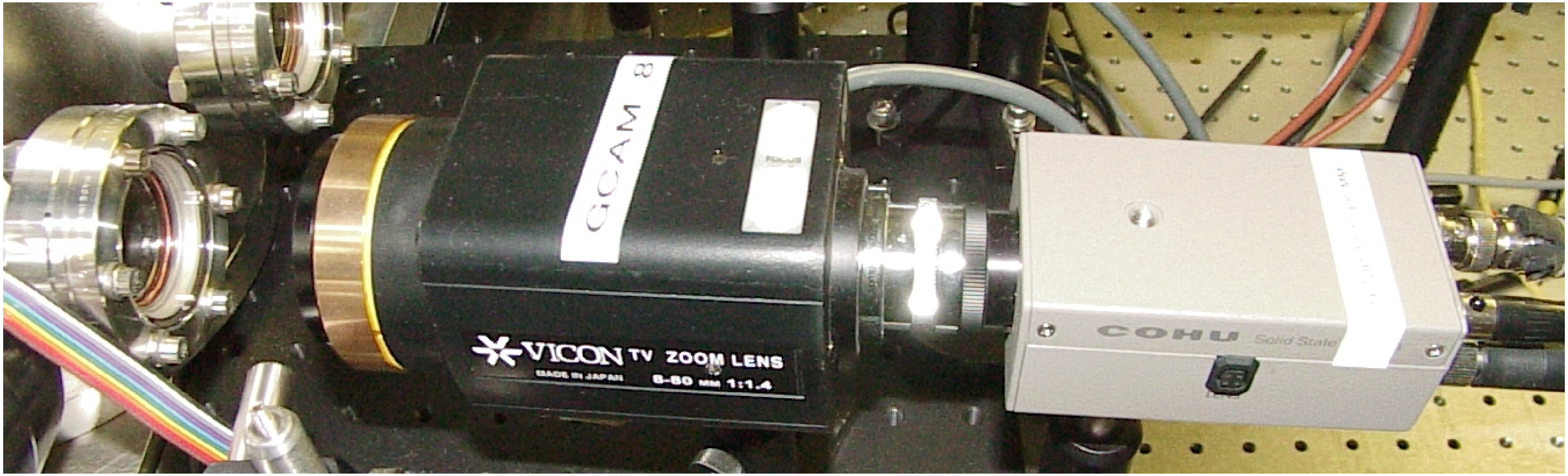


Higher Intensity →

Basler camera now supported by new ATF frame grabber – including multiple colormap manipulation tools

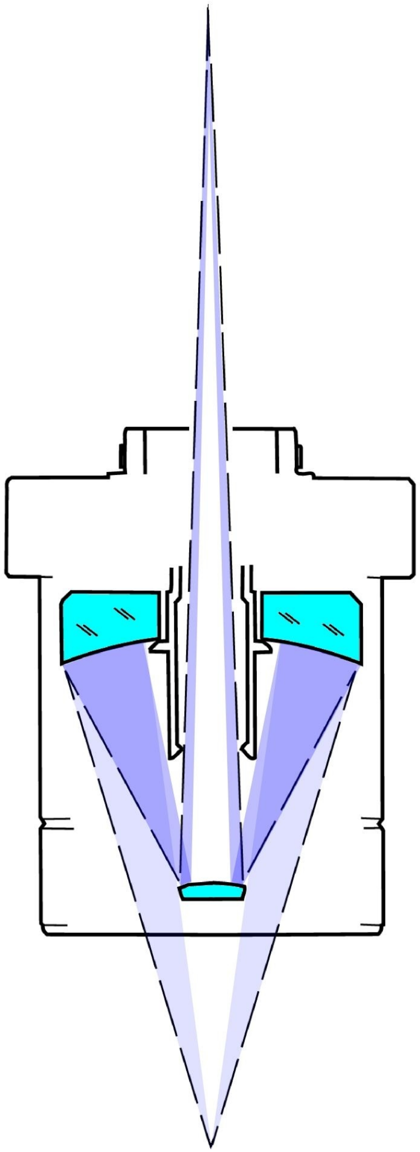
Standard BPM Enhancement

- Existing "Standard" BPM imaging optics widespread on all beamlines
- Use off-the-shelf components to meet variety of requirements
- Additional focal length doubler creates useful variation of Standard BPM
- Further doubler additions cause significant to extreme loss of contrast
- New configuration improves resolution from 15 to 10 microns
- "On-demand" retrofit to any existing BPM in facility



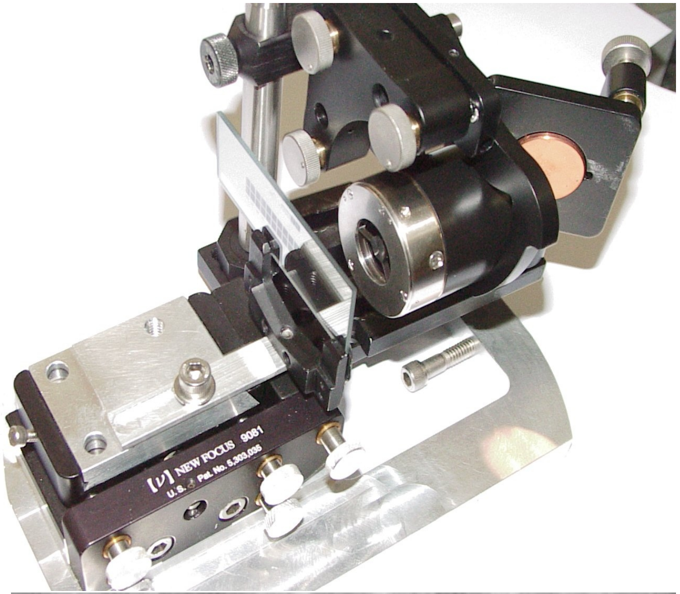
In-vacuum Imaging Optics

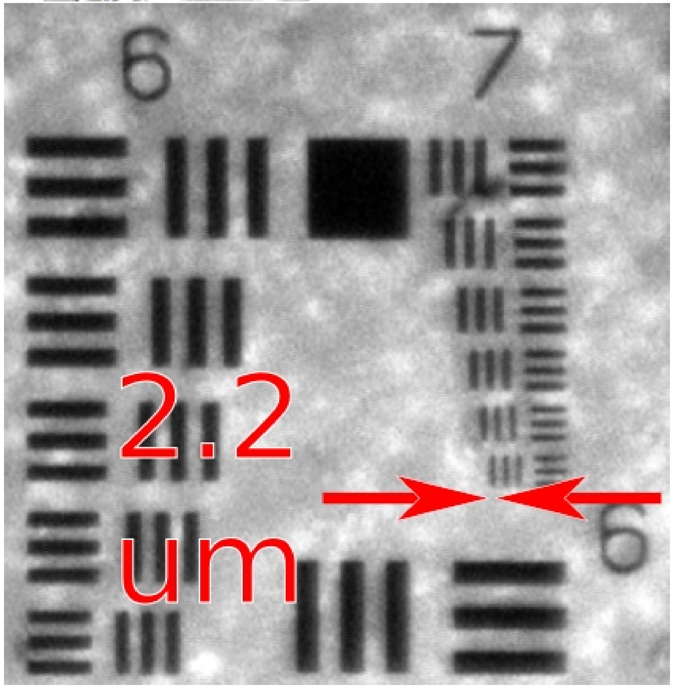
- For plasma filamentation measurements, extend imaging resolution to sub-10 micron expected filament size
- Useful for vacuum acceleration experiment where smallest possible interaction region is desired
- Useful for Compton scattering with 1 μm laser
- All three experiments require sub 10 μm resolution or e^- beam focus
- ->Image OTR with this configuration



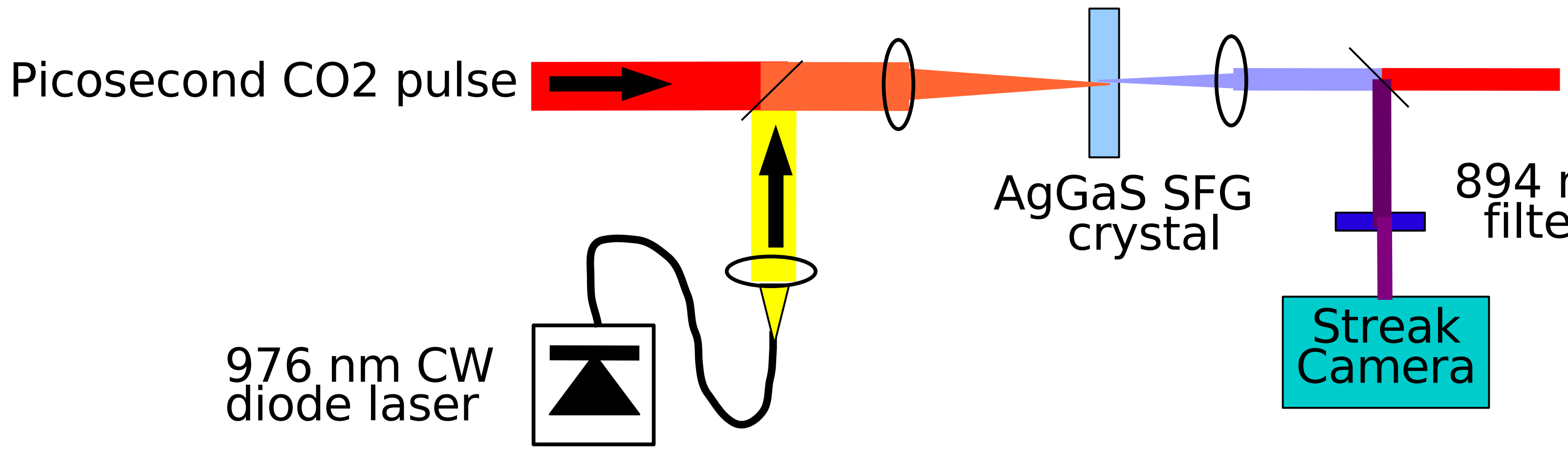
In-vacuum Imaging Optics

- Disassembled, cleaned & vented, not damaged at 10^{-6} Torr vacuum
- With better preparation 10^{-7} Torr should be achievable
- Flexible imaging schemes possible with objective in-vacuum, secondary lenses outside beamline
- 50% MTF @ ~4 micron
- All metal or metalized components can intercept beam without damage



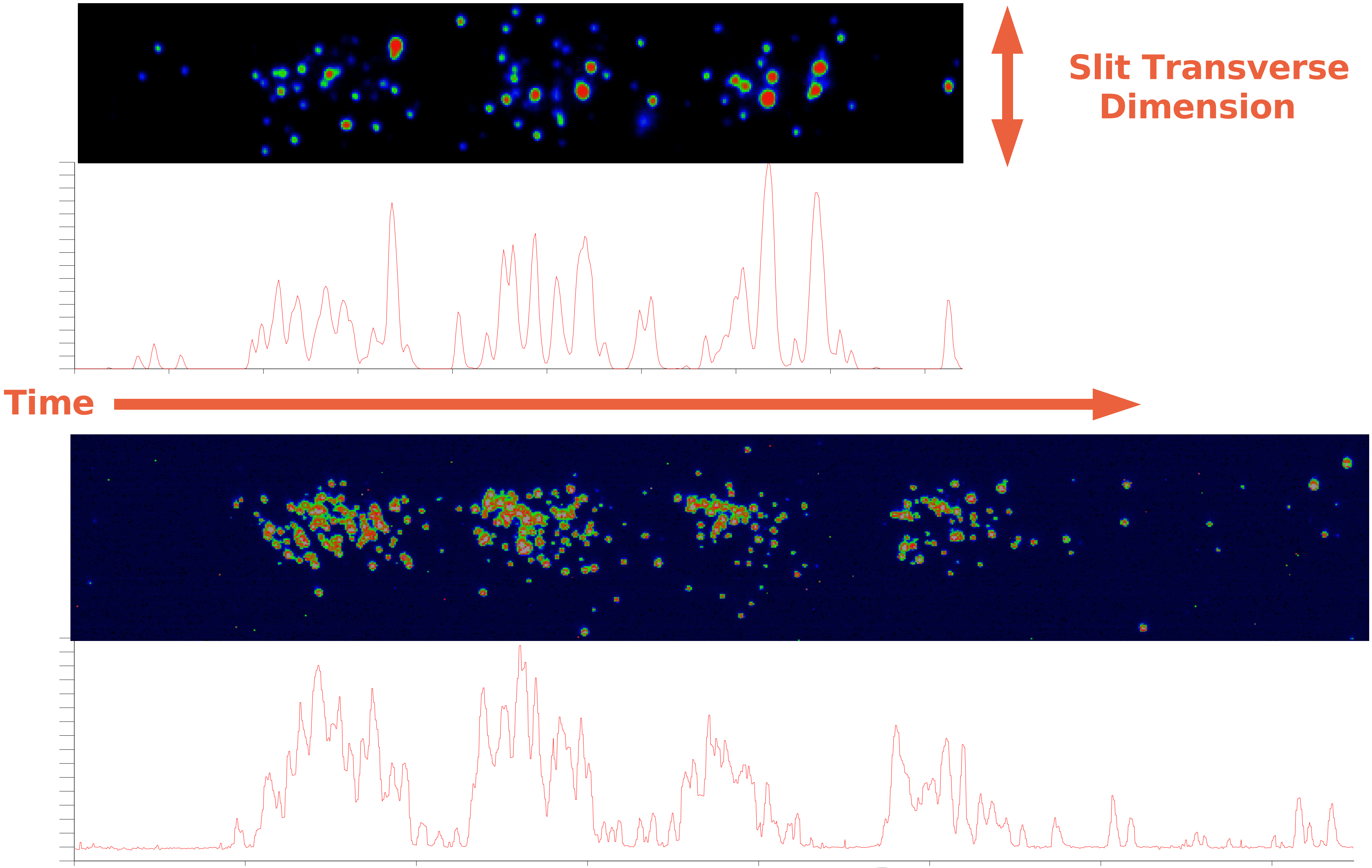


SFG Diagnostic Improvement

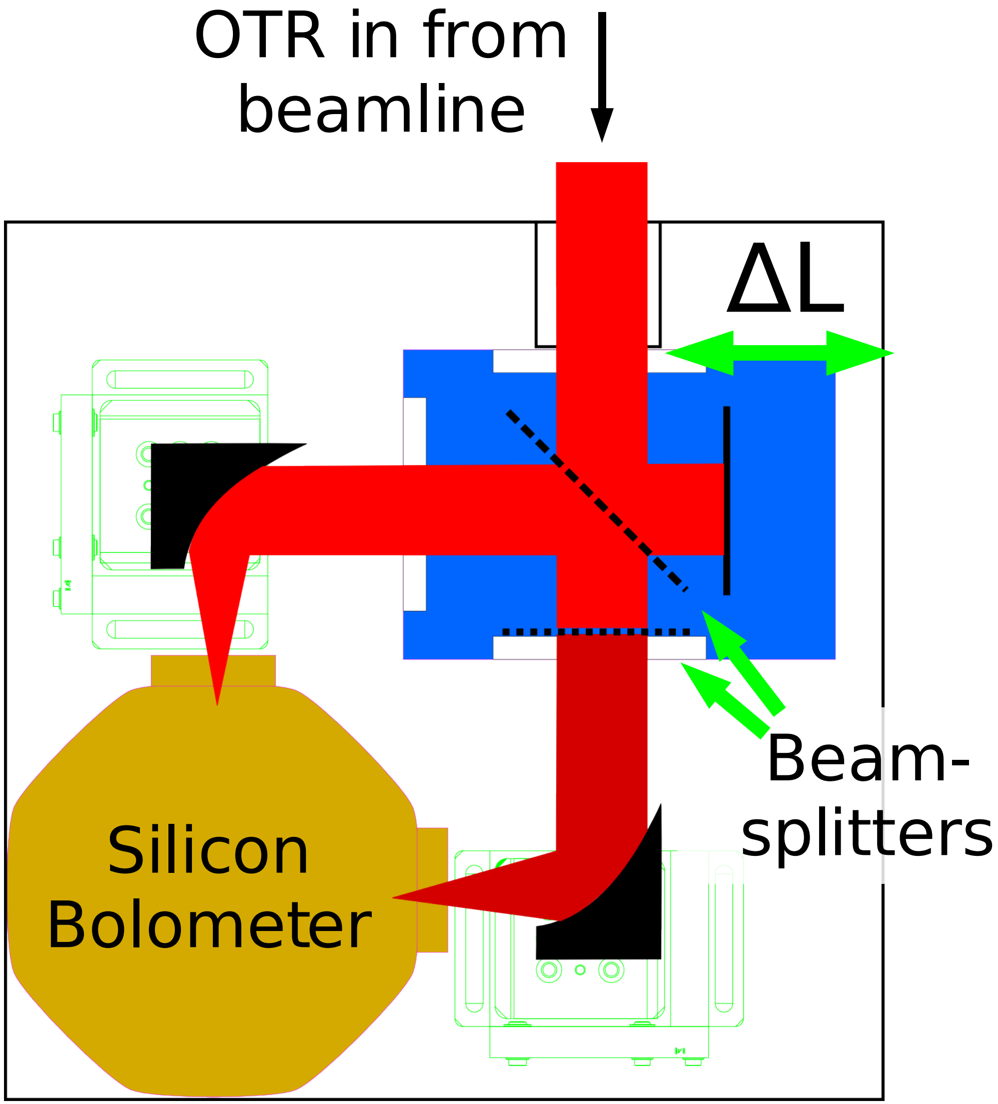


- Achieved brighter images & higher resolution camera & frame grabber
- Changes: 6W to 50W laser diode, photodiode triggering, reduced transport losses, elliptical spot on slit, camera improvement
- Still suffering from low streak camera QE

SFG Diagnostic Improvement

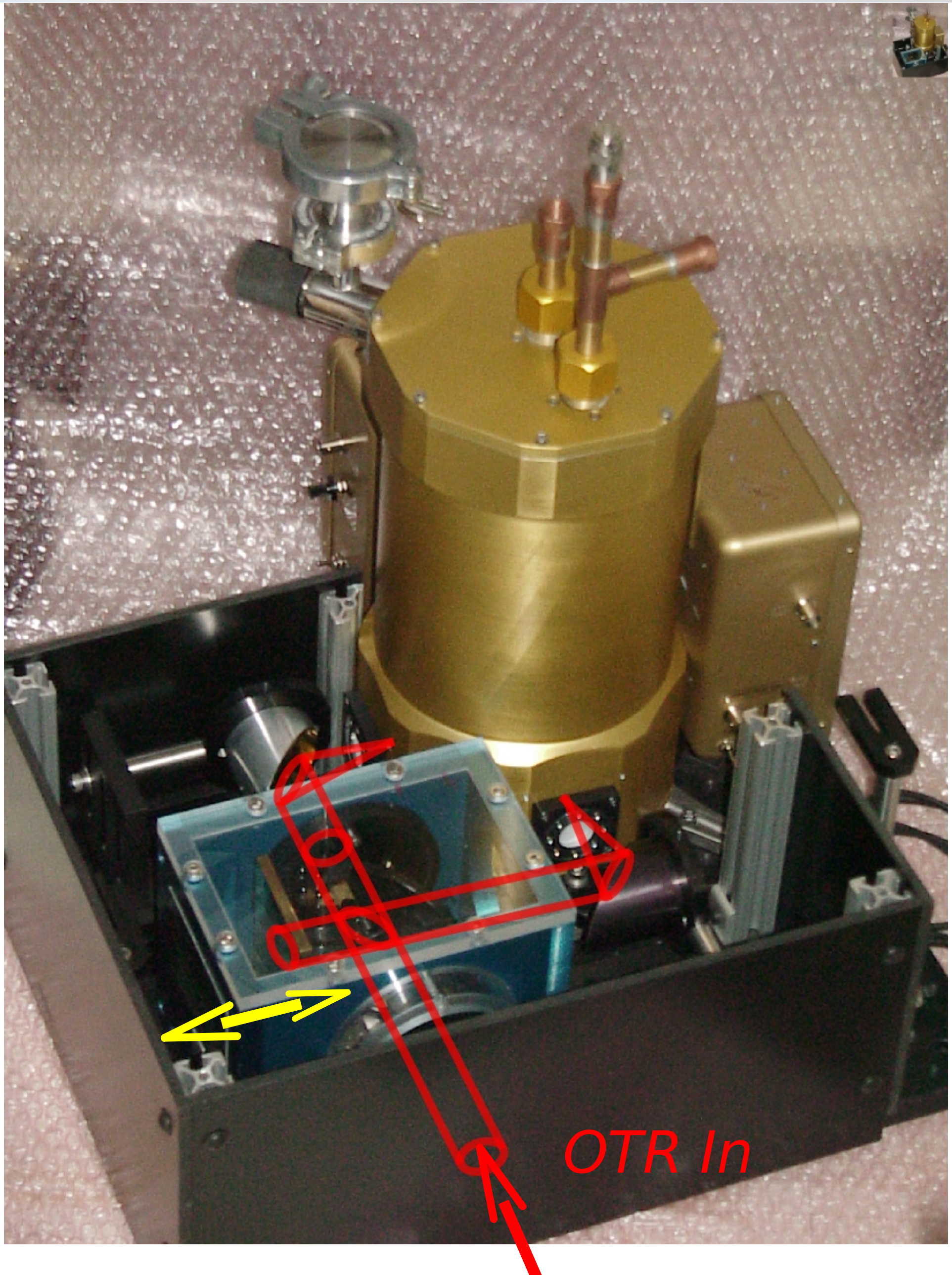


OTR Interferometer/Bolometer

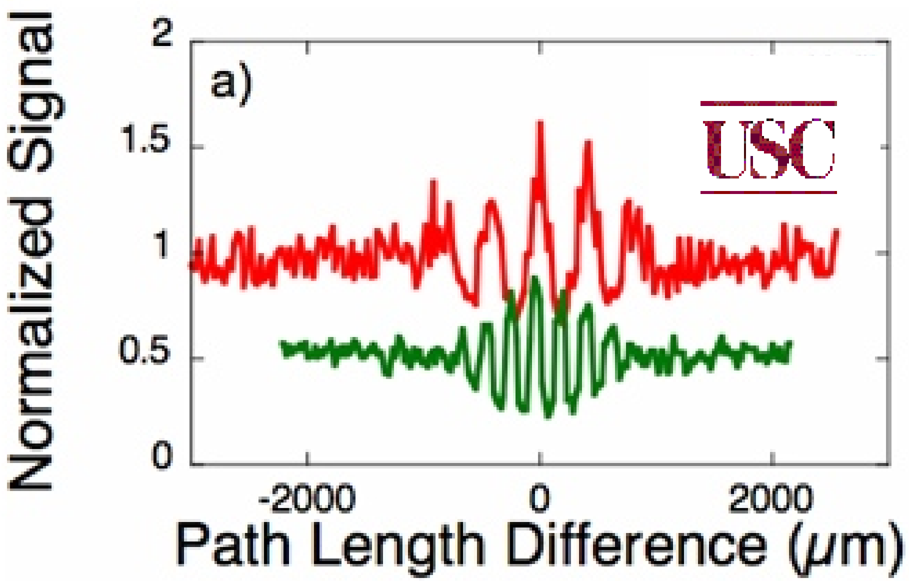


- $\lambda \approx$5-500 μm OTR from metal mirror at BPM
- Interferometer designed by RadiaBeam Technologies
- LN_2/Helium-cooled dual-port bolometer detects thermal background

OTR Interferometer/Bolometer



- Kinematically interchangeable between BL 1 & 2
- On-line tool available as needed
- Cool down time <2 hours
- He hold time >6 hours



Courtesy P. Muggli