Quasi-Ellipsoidal Photocathode Laser at PITZ.

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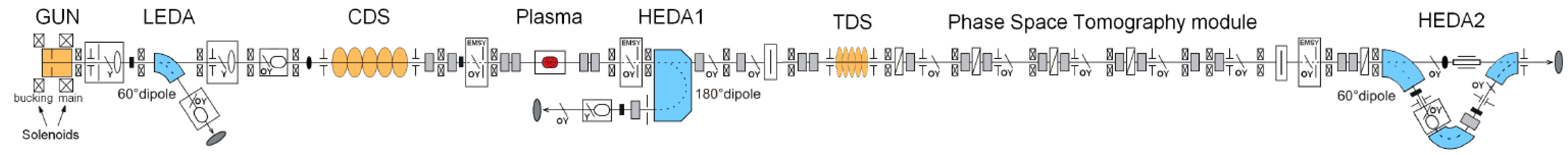
Abstract

Work has been on-going on the facility's prototype photocathode laser capable of producing homogeneous quasi-ellipsoidal pulses. Simulations have shown that these pulses allow the production of high brightness electron bunches with minimized emittance [1] when compared to traditional Gaussian or cylindrical pulses. The laser system was developed in collaboration with the Institute of Applied Physics (Nizhny Novgorod, Russia) and the Joint Institute for Nuclear Research (Dubna, Russia), and with their continued support and development.

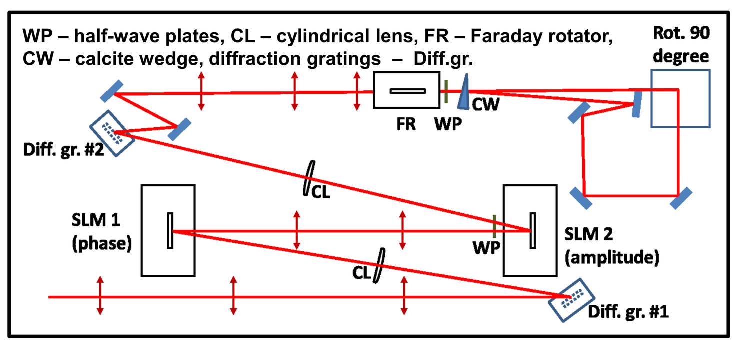
Here is presented the recent progress, calibration and characterization results, infrared spectrographic reconstruction, and the potential simplified, stability-focused redesign.

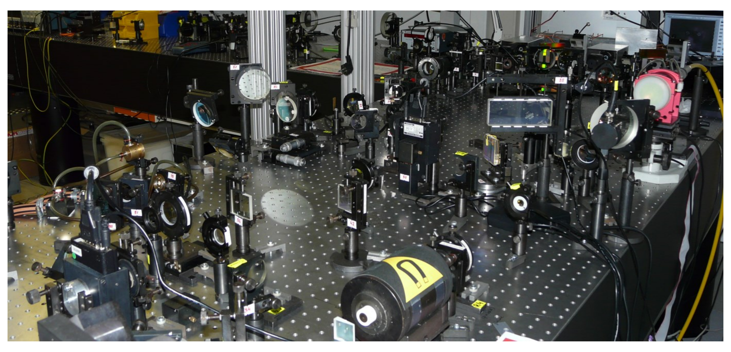


Above: Current PITZ beamline with TDS and Plasma Cell

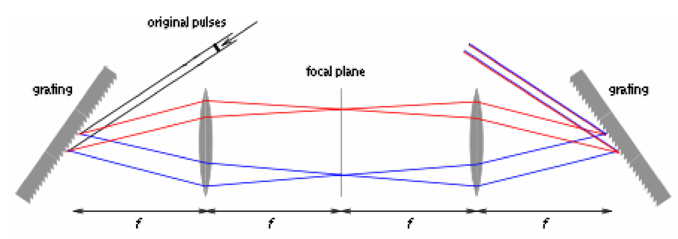
Quasi-Ellipsoidal Photocathode Laser System*

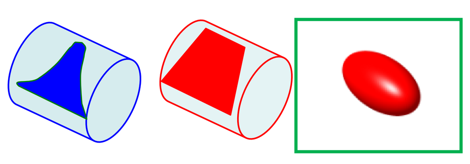
Double-pass spectral amplitude-phase masking technique

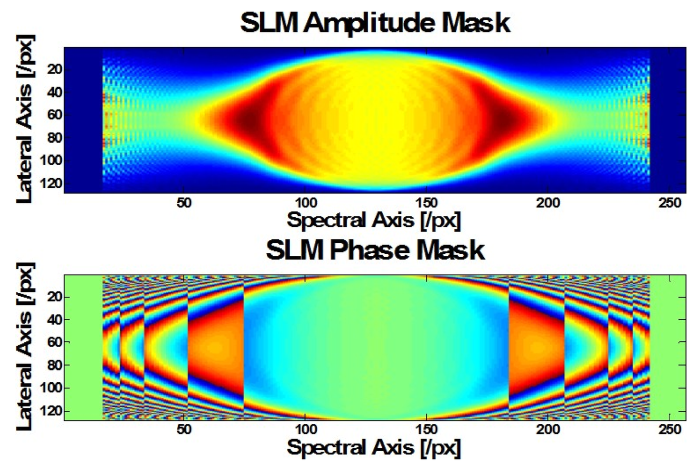




- Spectrally transformed chirped pulse imaged onto SLMs
- Frequencies modulated by separate amplitude(/phase) masks
- Pulse recombined, laterally rotated, and perpendicularly reshaped





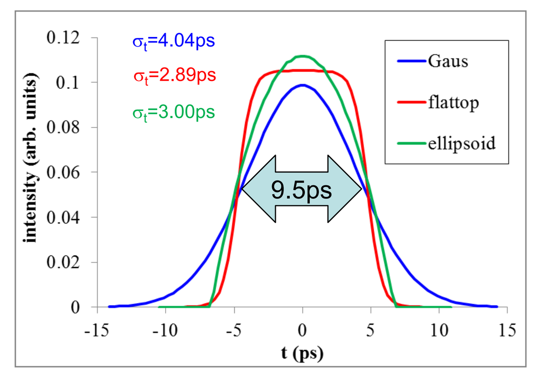


- **Frequency conversion crystals (2nd and 4th harmonics**

Characterization and optimization by:

- Transverse camera imaging (IR & UV), IR cross-correlator, UV:IR cross-correlator [3], IR spectrograph, & electron beam diagnostics

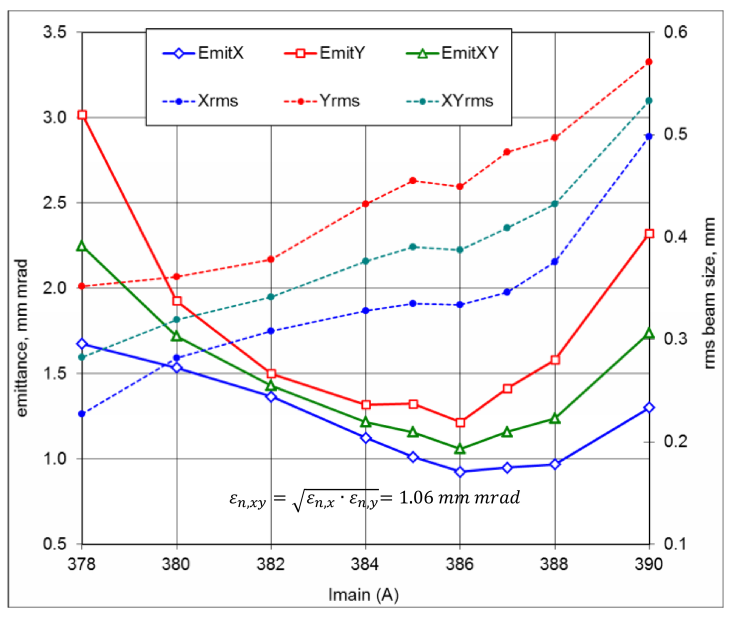
ASTRA simulations

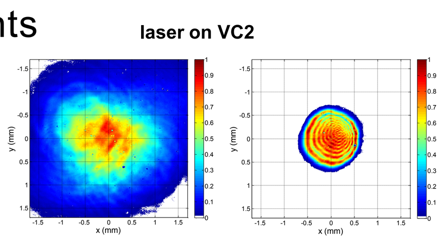


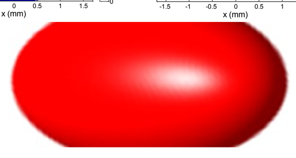
Pulse shape→	cylindrical		ellipsoid
Temporal profile→	Gaussian	Flattop	
Projected normalized emittance [/mm·mrad]	0.80	0.64	0.35
Average slice emittance [/mm·mrad]	0.49	0.57	0.33
Bunch length (rms) [/mm]	1.44	1.20	1.34
Peak current [/A]	35.4	39.5	37.8
Longitudinal emittance [/mm keV]	34	22	12.5

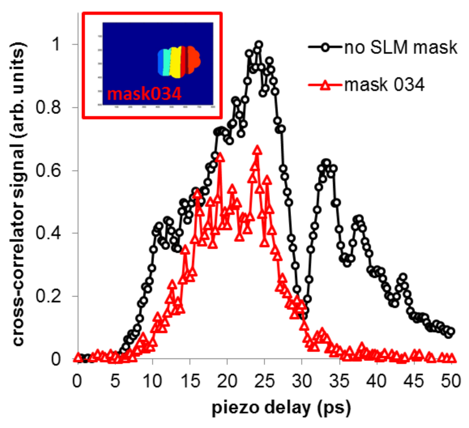
Progress & Development

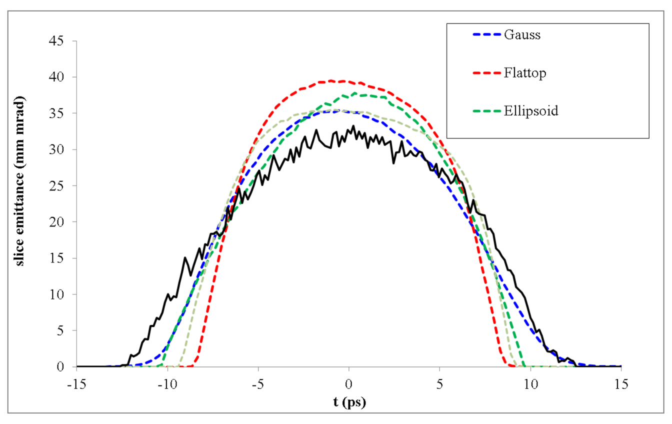
- 1st photoelectrons generated in Nov 2016 w/ uTCA-based synchronization
- Electron bream measurements
  - Emittance measured
    - w/ spectral masking
    - Truncated ellipsoid
  - TDS streaking & beam current measured

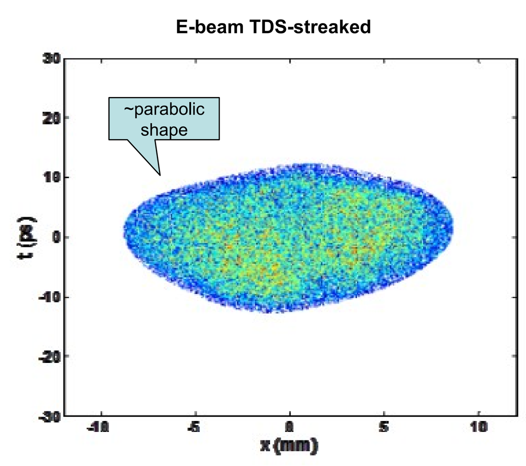






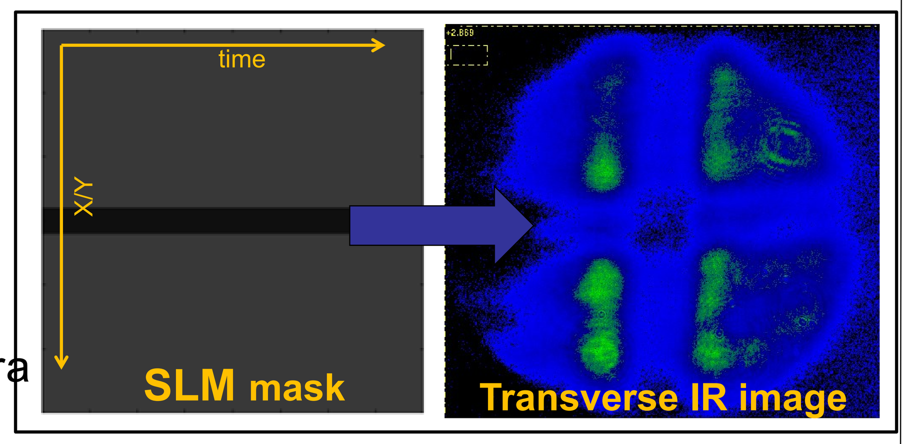




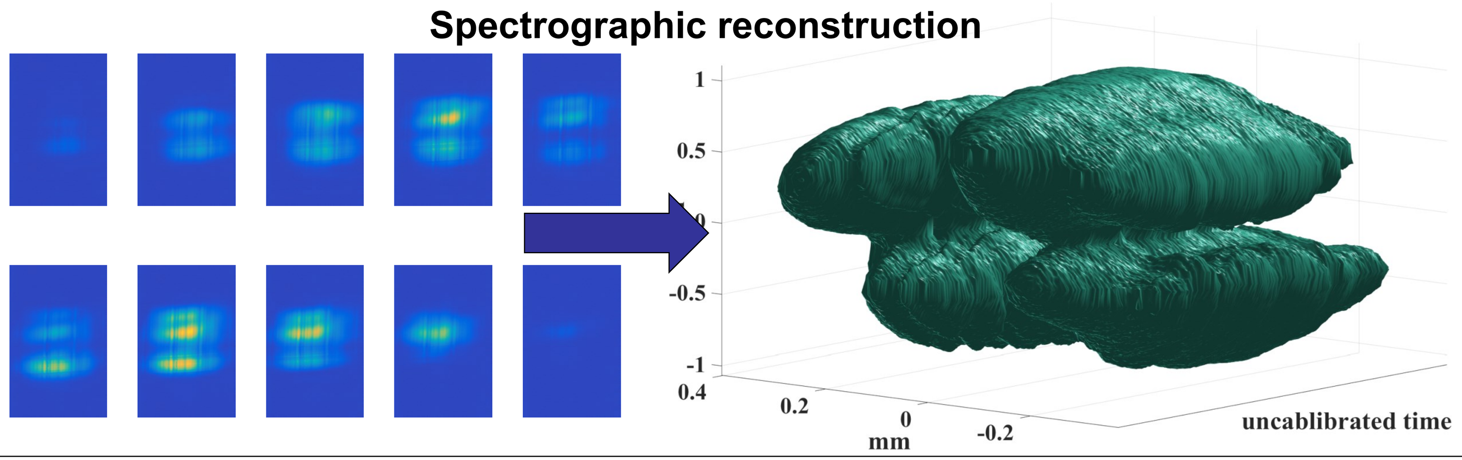


IR spectrograph

IR cross-correlator coupled
- Slit-scan spectrometer [4] (modified IAP f600 design)
- Standard Czerny-Turner layout w/ 20 nm on-camera spectral dispersion

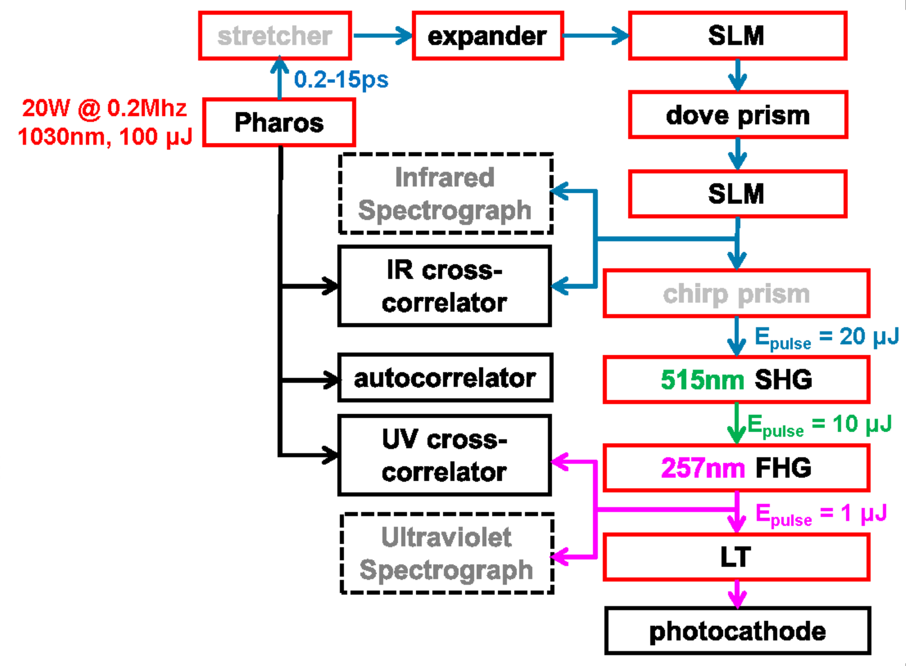


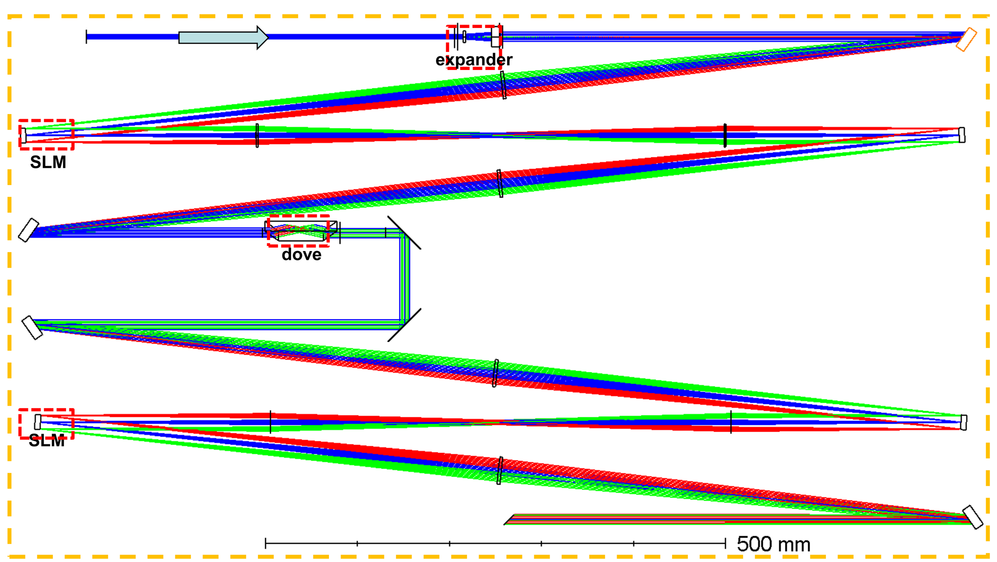
Spectrographic reconstruction



Pharos-based revision

- Simplified, linear layout with modularized, & mechanically robust co
- 50% reduction in path length & optical
- Improved thermal robustness & pointin
- Greater mask resolution & temporal sta
- Dichroic SLMs (IR/green)
- Single source oscillator-amplifer (Pharos) *at reduced rep. rate* *→ 100 μJ/pulse*





References

[1] M.Khojoyan et al., Optimization of the PITZ photoinjector towards the best achievable beam quality, Proc. FEL2014, Basel, Switzerland (2014).
[2] A. Oppelt et al., Facility Upgrade at PITZ and First Operation Results, IPAC'15, Richmond, VA, USA (2015).
[3] V V Zelenogorskii, Scanning cross-correlator for monitoring uniform 3D ellipsoidal laser beams, 2014 Quantum Electron. 44 76
[4] S. Mironov, et al.,"Shaping of cylindrical and 3D ellipsoidal beams for electron photoinjector laser drivers," Appl. Opt. 55, 1630-1635 (2016).
[5] S. Mironov, et al.," Generation of 3D ellipsoidal laser beams by means of a profiled volume chirped Bragg grating", Laser Physics Letters, V. 13, N5 (2016)

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