Preliminary Results from the Laser System generating Quasi 3-D Ellipsoidal Photocathode Laser Pulses at PITZ

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1. Introduction
2. Concept
3. First results
4. Conclusion

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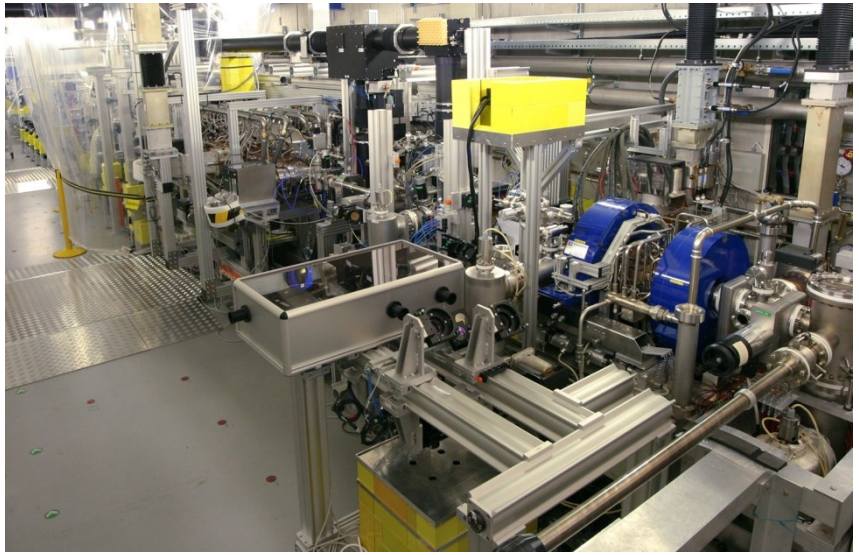
HELMHOLTZ ASSOCIATION

DESY

1.1 Photoinjector Test Facility

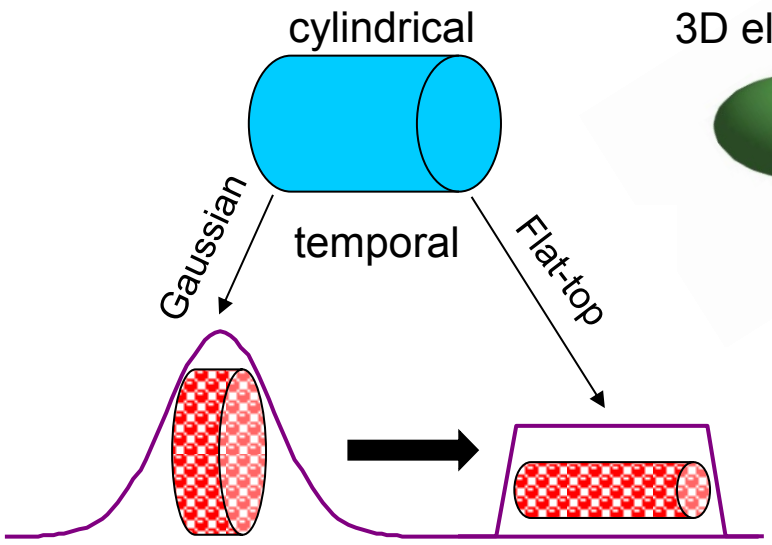
Focus:

- Conditioning, characterization, testing, development, and optimization of high brightness electron sources for superconducting linear accelerator driven Free Electron Lasers (FELs), e.g. FLASH and the European XFEL



1.2 Introduction

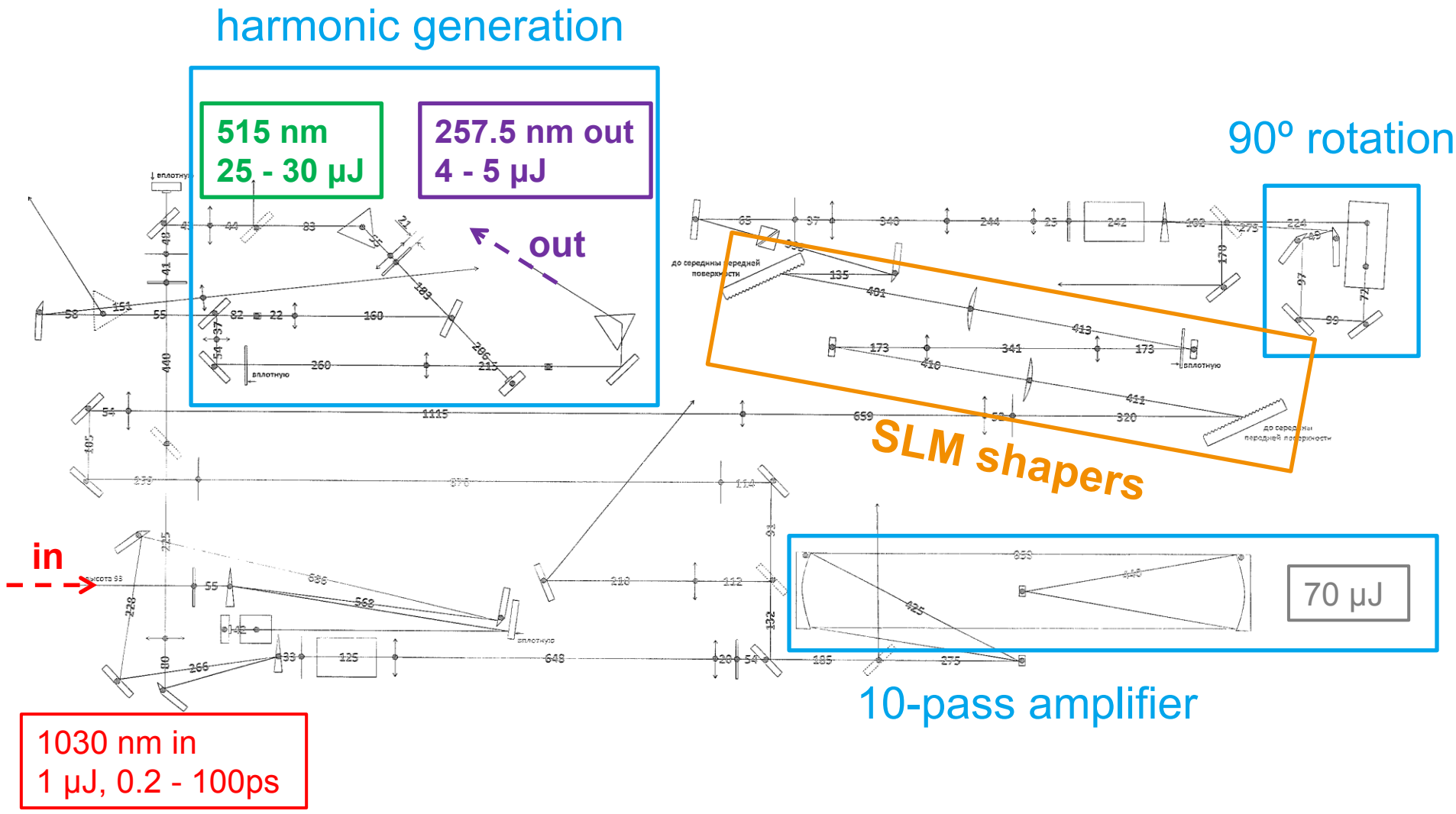
> **Motivation:** Improve the electron beam quality by improving photocathode laser profile



> Advantages:

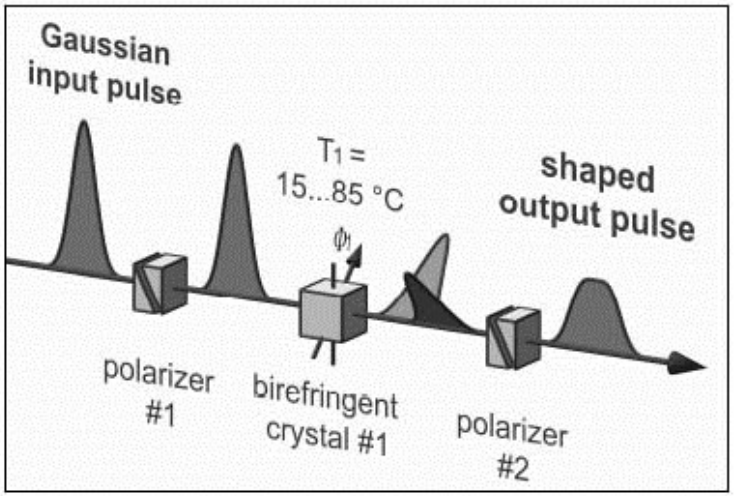
- Minimizes space charge influence on emittance
- Improved longitudinal compress
- Reduced beam halo
- Reduced machine sensitivity

1.3 New laser optical layout

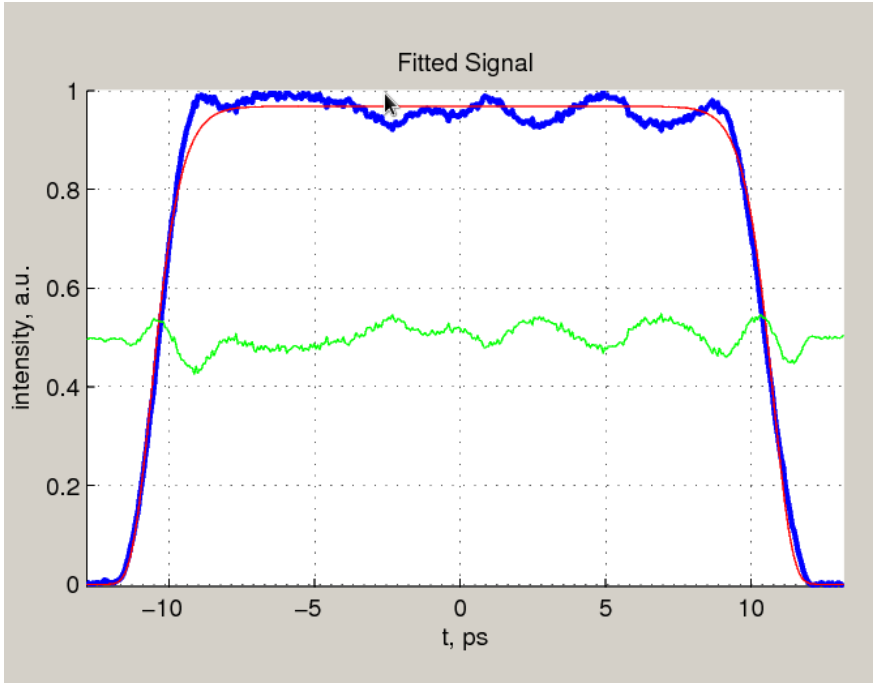


2.1 Current pulse shaper: Super-Gaussian

- „Generation of flat-top picosecond pulses by coherent pulse stacking in a multicrystal birefringent filter“, Ingo Will & Guido Klemz
  Optics Express, Vol. 16, Issue 19, pp. 14922-14937 (2008)



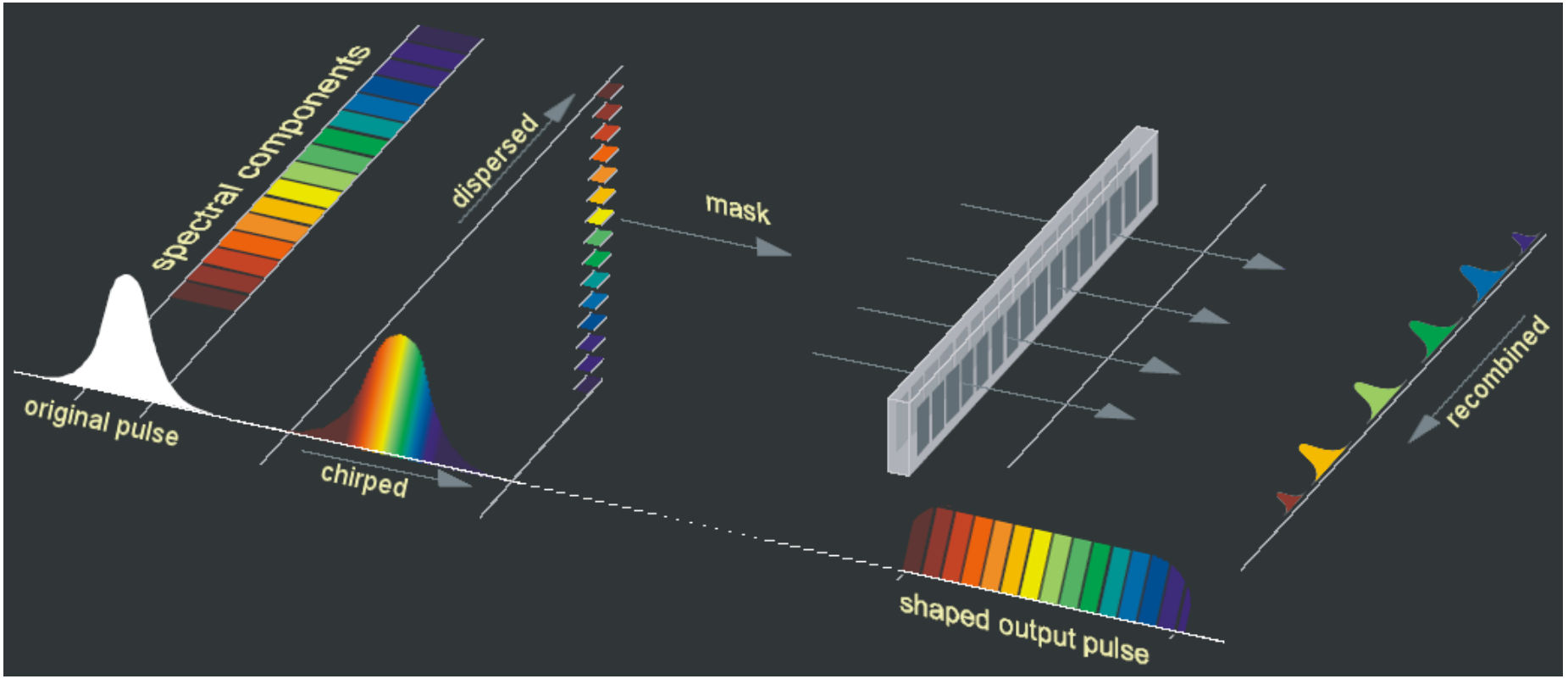
principal of operation



optically sampled 20 ps super-gaussian

2.2 Spectral mask-based pulse shaping

- Concept: Spectrally separated chirped pulse transversally modulated by amplitude-phase mask prior to recombination



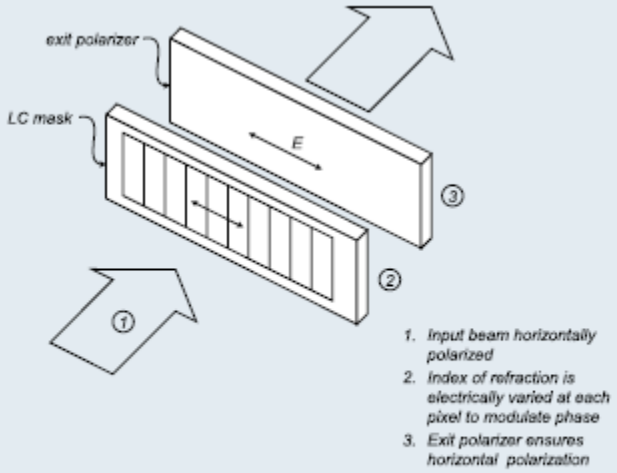
2.3 Masks: Spatial Light Modulator (SLM)

> Masks

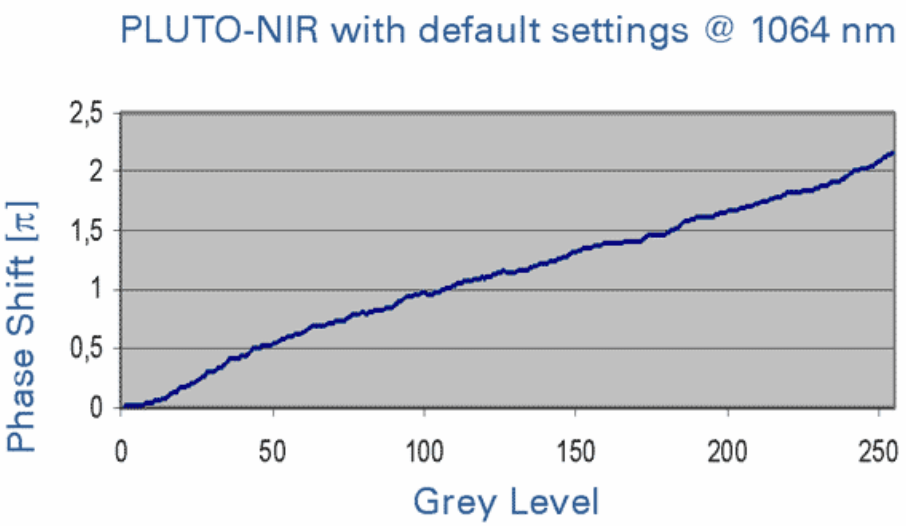
- Binary array
- Lithographic plates
- **Spatial Light Modulators**

> Holoeye Pluto

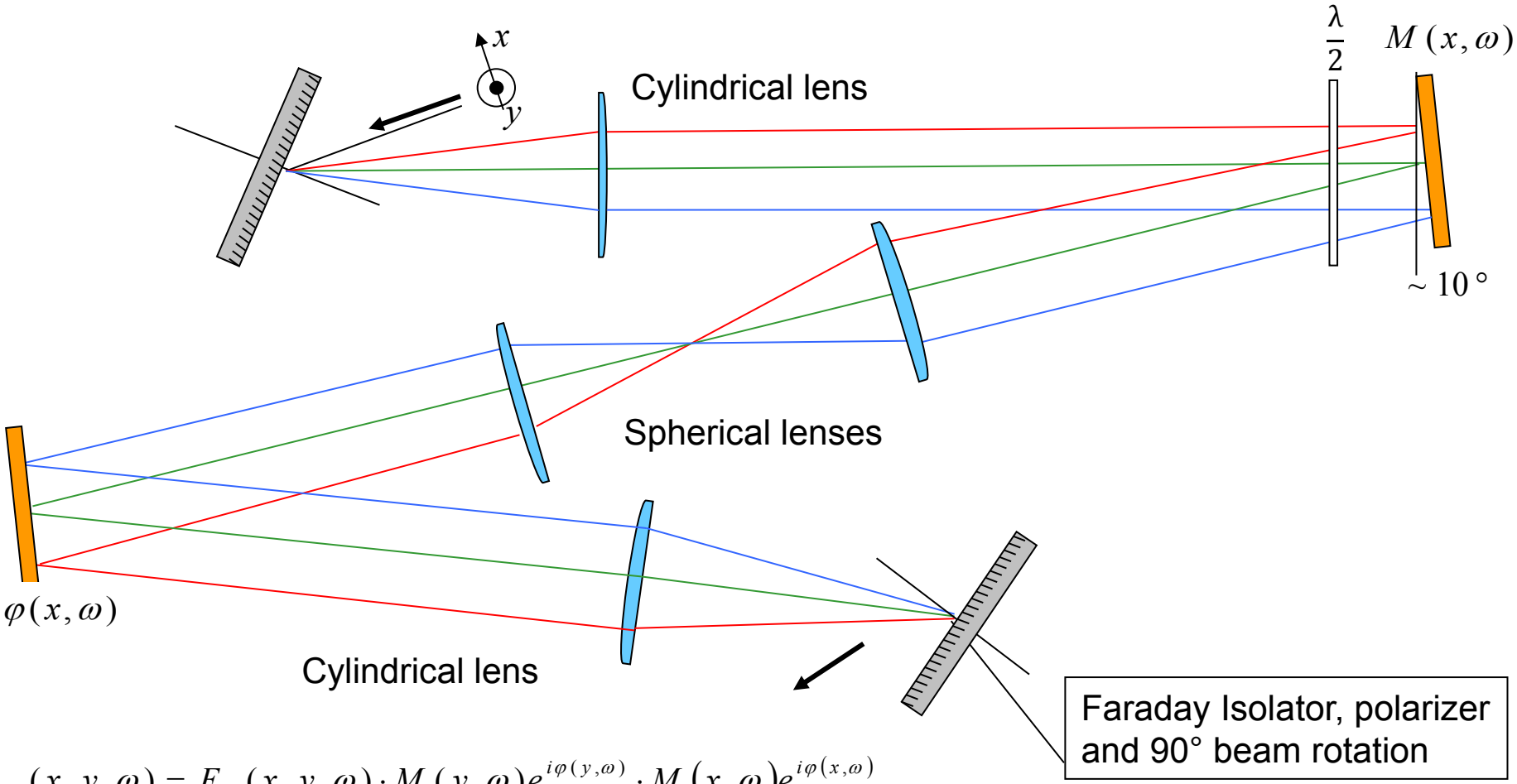
- High-resolution LCOS phase-only SLM
- 1920x1080 8 µm matrix of 8-bit phase retarders



Phase Modulation Transmissive Mode



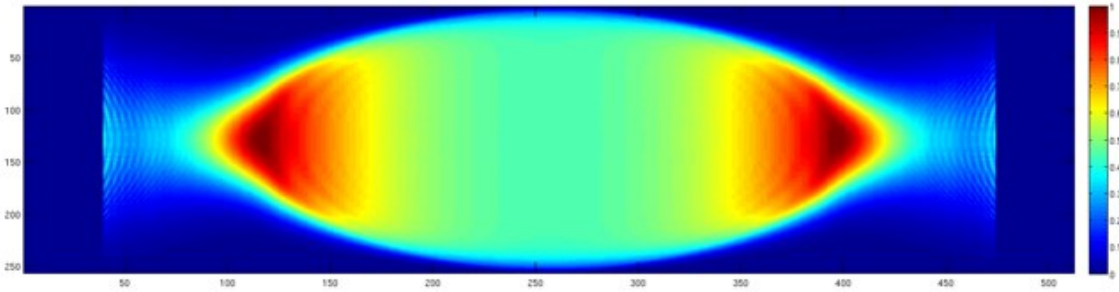
2.4 1D Spatial Light Modulator (SLM) shaping



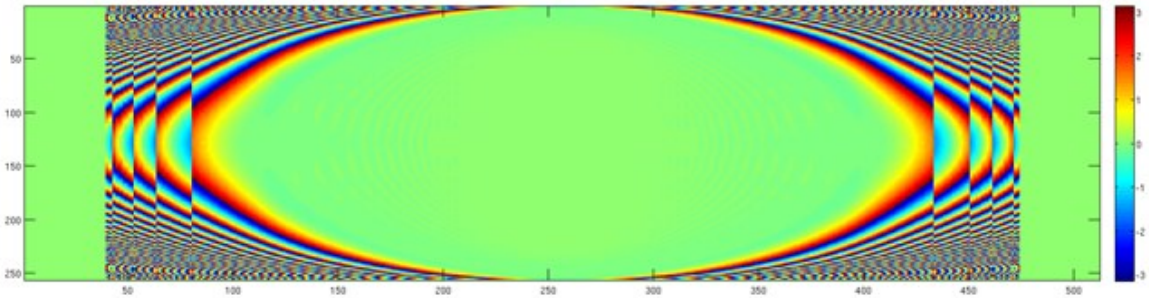
$$E_{out}(x,y,\omega) = E_{in}(x,y,\omega)\cdot M(y,\omega)e^{i\varphi(y,\omega)}\cdot M(x,\omega)e^{i\varphi(x,\omega)}$$

3.1 SLM mask simulations

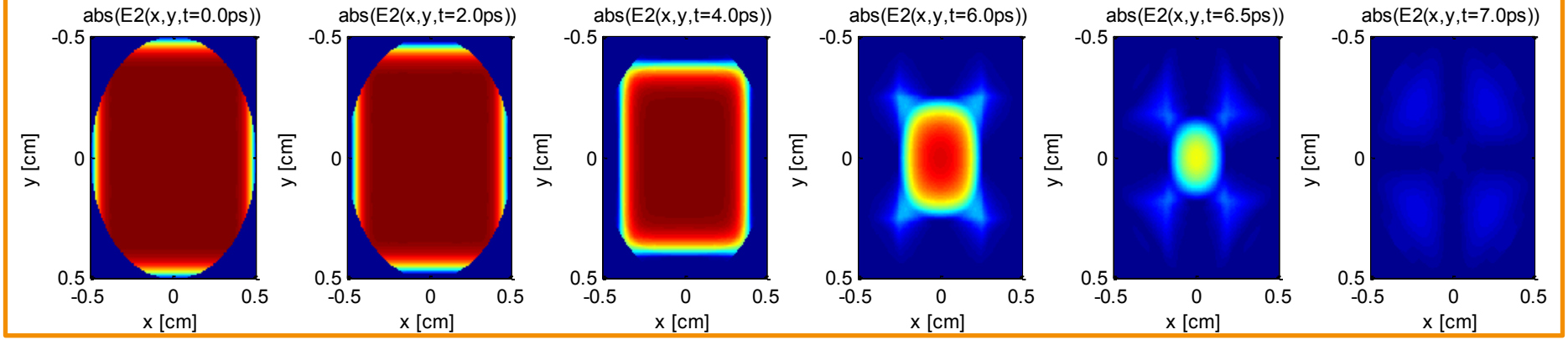
Amplitude mask:



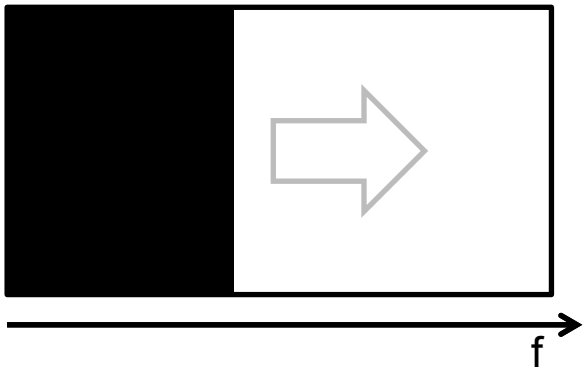
Phase mask:

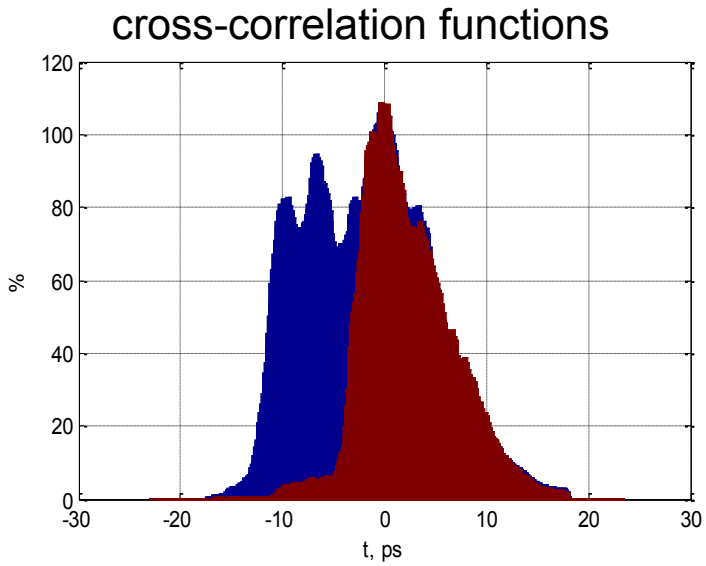


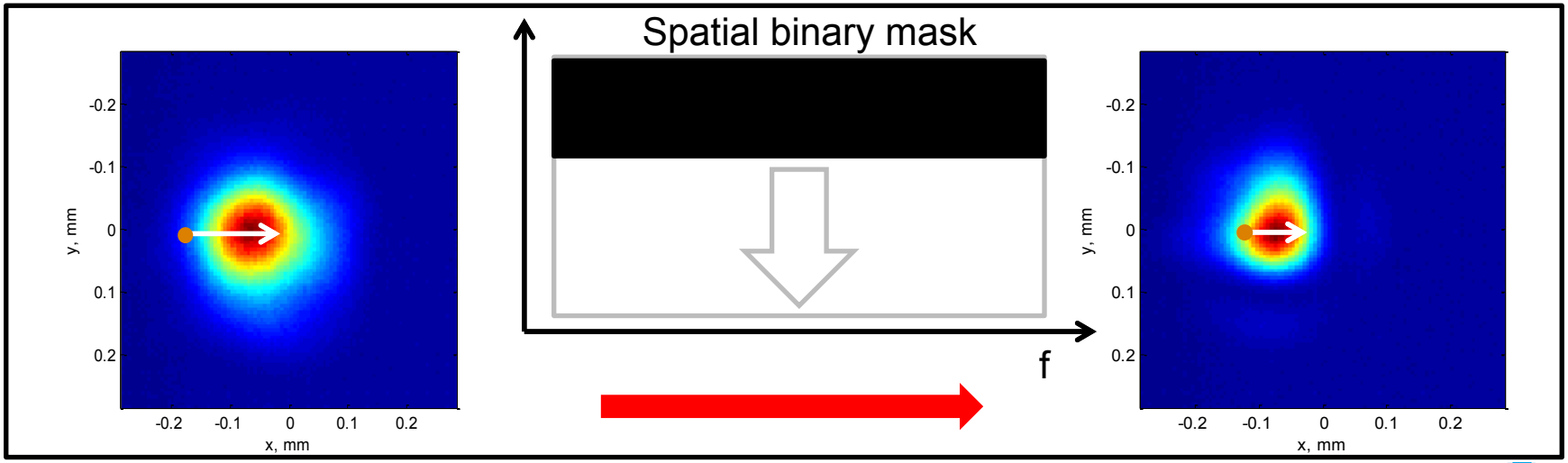
Simulated temporal slices



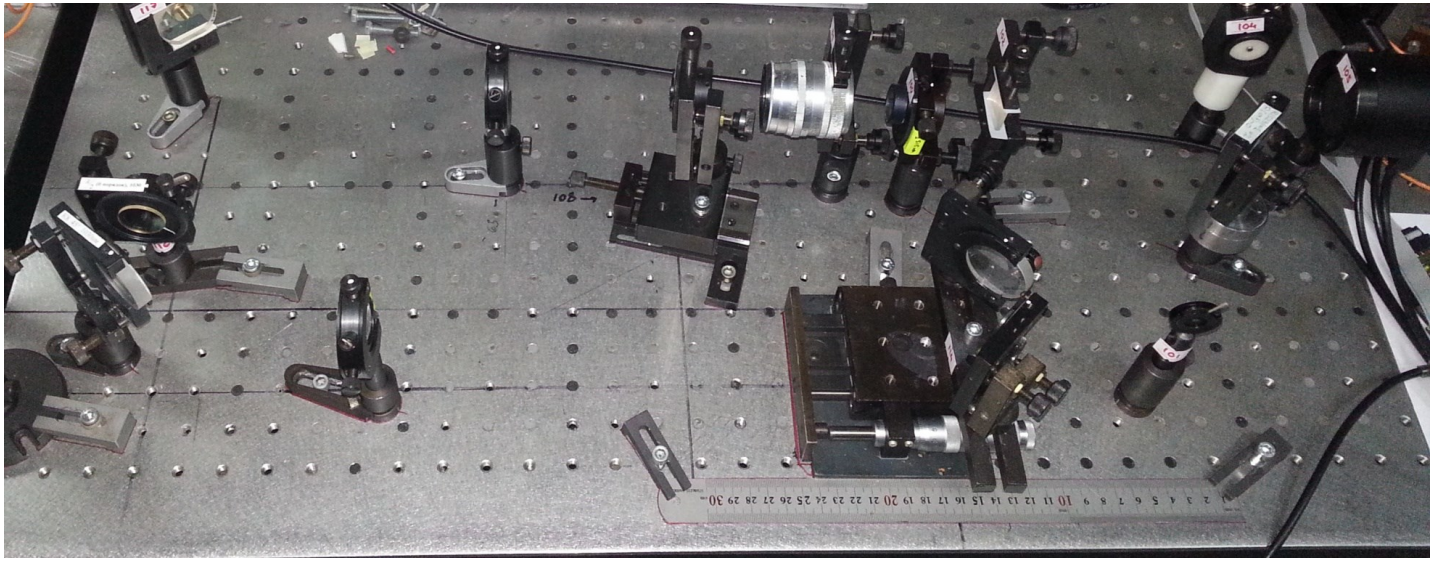
3.2 Temporal and spatial correlation





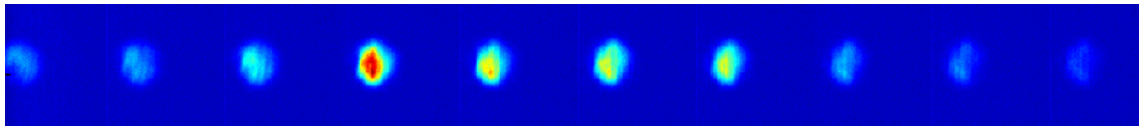


3.3 Cross-correlated camera images

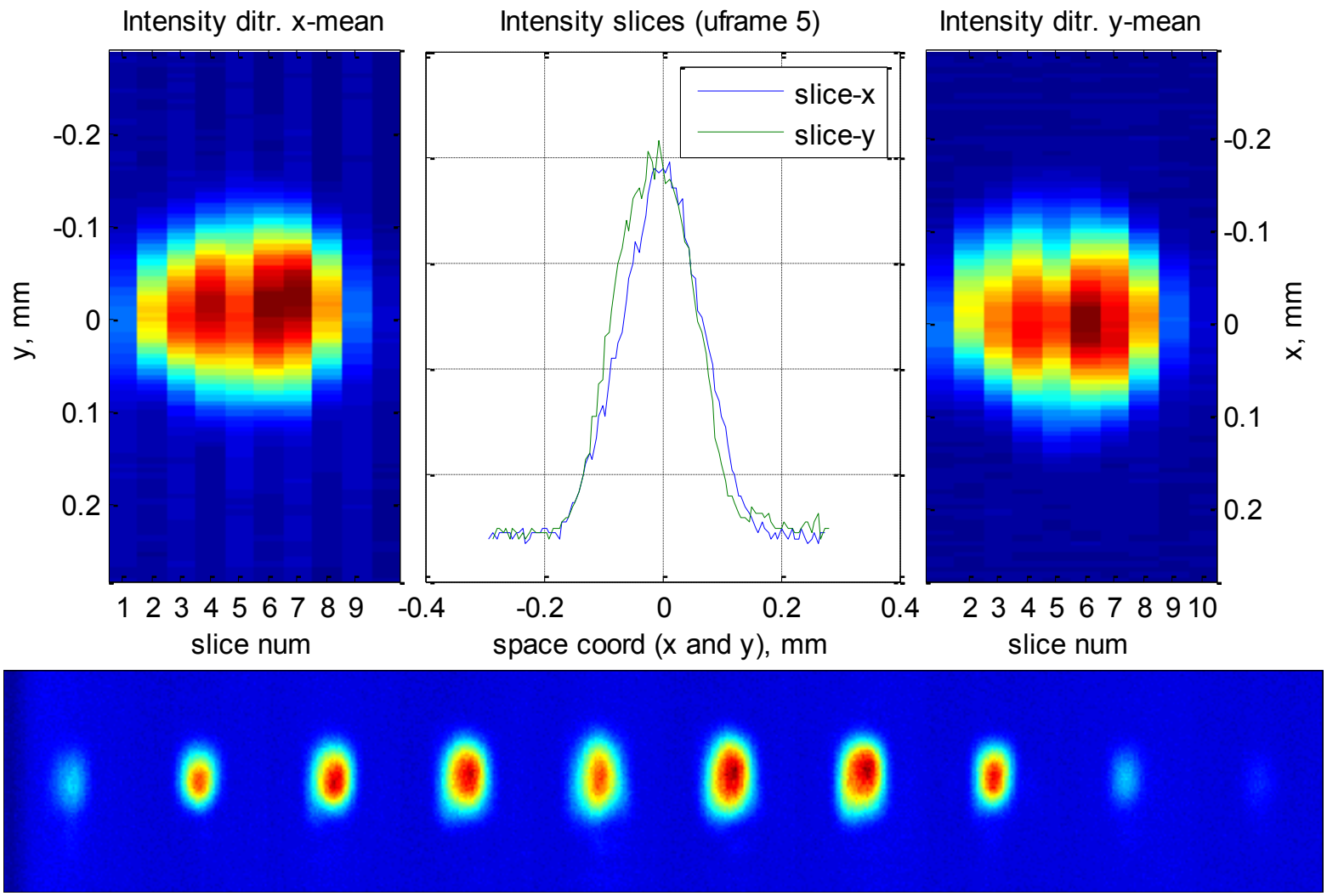


Spatial shaping experiments:

Cross-correlation slices of laser pulses without shaping



3.4 Measured temporal laser pulse profiles



4. Conclusions and projections

- In conclusion:
  - Homogenous pulse with quasi-ellipsoidal envelope shown by simulations
  - Laser system capable of producing quasi 3-D ellipsoidal laser pulses installed and undergoing commissioning
  - Diagnostics implemented and utilized
  - Temporal slicing and intensity modification demonstrated

- Outlook
  - Beam transport to cathode and generation of photoelectrons ongoing
  - 1st electron beam characterization using shaped laser pulses
  - Iterative/adaptive pulse shaping
  - (Demonstrate improvement in electron beam quality)

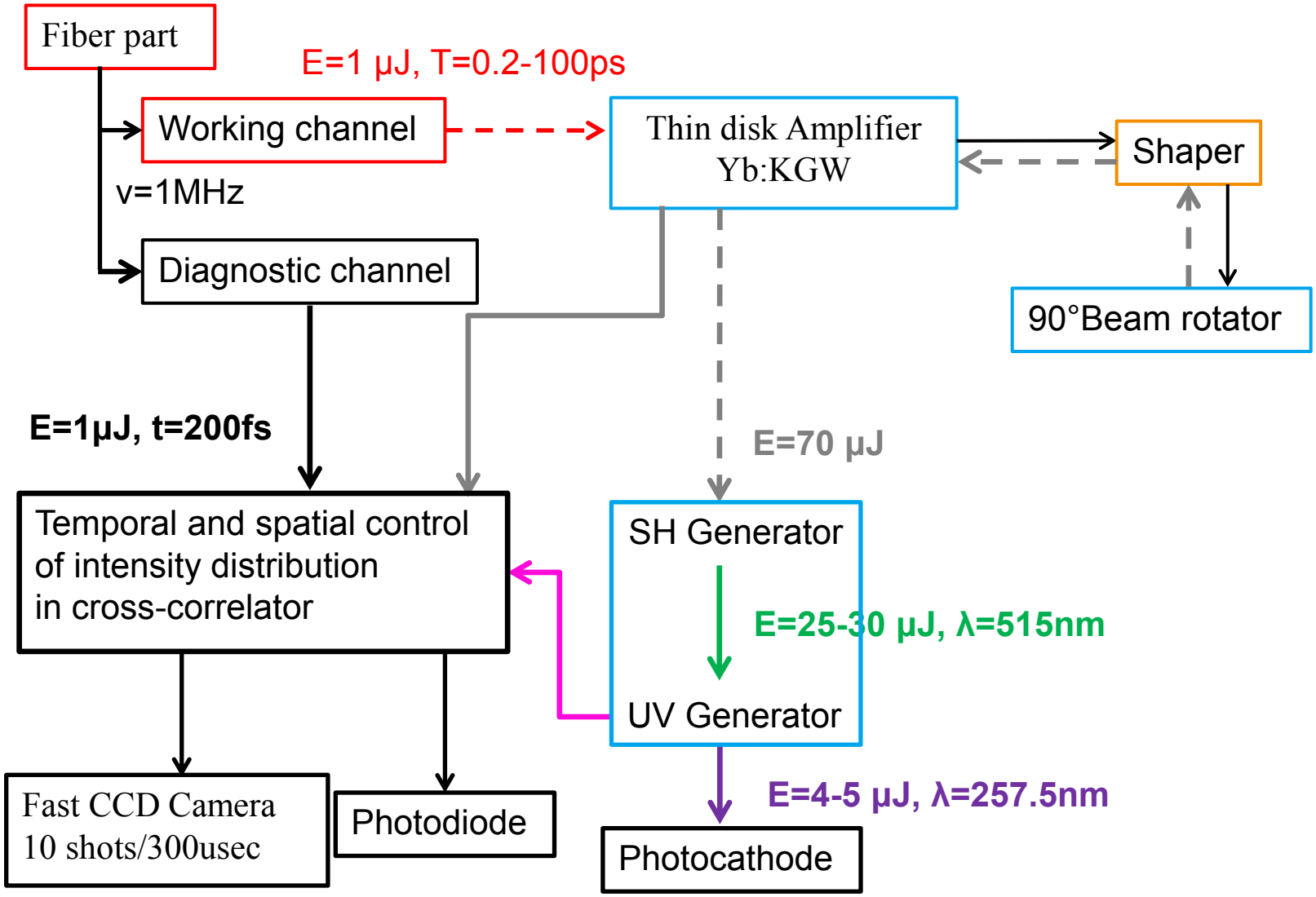
Thank you for your attention

Backup slides

Laser parameters

Parameter	Value	Unit	Remark
wavelength	255-270	nm	4th harmonic of Nd
micropulse energy	10-12	µJ	for 1 nC bunch production from Cs_2Te photo cathodes
pulse train frequency	1	MHz	In the future 4.5 MHz will be a goal
pulse train length	0.3	ms	In the future 0.6 ms will be a goal
pulse train rep.rate	10	Hz	1,2,5 Hz as an option
micropulse rms duration	6±2	ps	3D quasi ellipsoidal distribution
diagnostic pulse duration	150	fs	
transverse rms size	0.5±0.25	mm	

General Scheme of PITZ Ellipsoidal Laser (ELLA)



Perpendicular quantization