

Short pulse and double pulse production

Proposals for accelerator related experiments at FLASH from PITZ

M.Krasilnikov, F.Stephan, PITZ

- Short pulse production by off-crest operation of the RF gun
- Double pulse production – to test particle driven wakefield acceleration

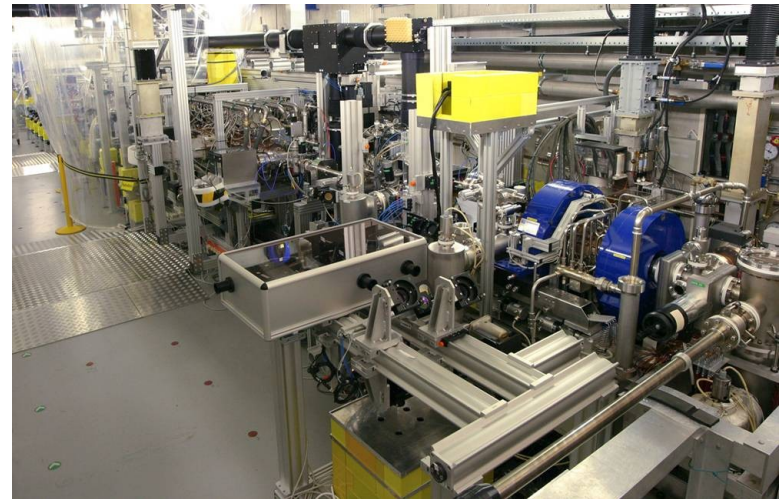
PITZ = Photo Injector test facility at DESY in Zeuthen

> Setup:

- RF-gun (FLASH, XFEL) → 60MV/m at the cathode
- CDS booster → up to now final beam energy ~25MeV
- Extensive beam diagnostics

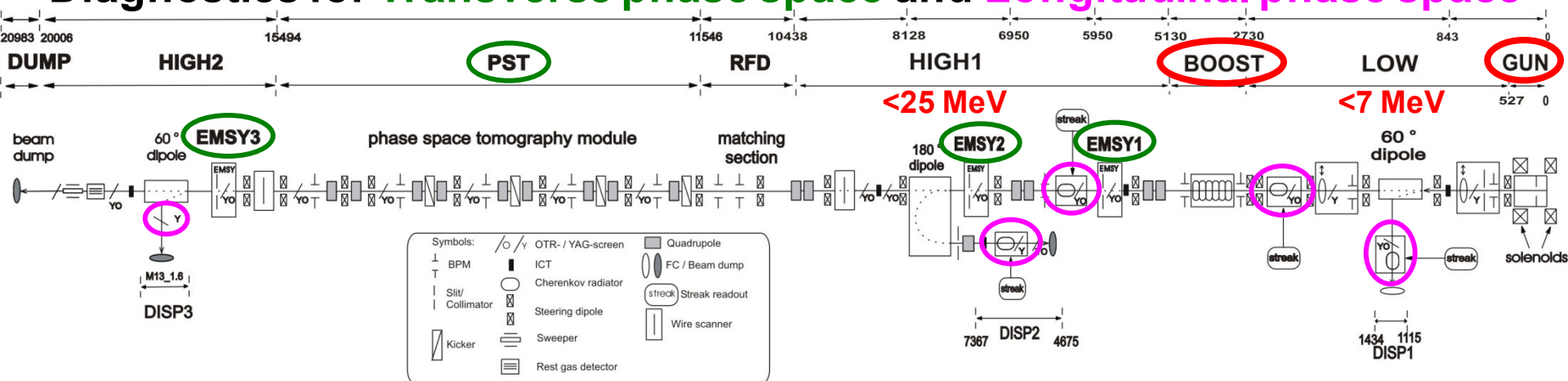
> Photo injector studies (optimization, special regimes etc), no user run

> Test bench for photocathode laser(s)



Beam diagnostics at PITZ

Diagnostics for Transverse phase space and Longitudinal phase space



Component	Property	Diagnostics
Cathode laser	temporal profile	OSS, streak-camera
	transverse distribution	Virtual cathodes, CCD cameras
	pulse energy	Energy-meter, PMT
	position stability	Quadrant-diode
Electron beam	bunch charge	Faraday cups, Integrating current transformers
	beam position	BPMs
	longitudinal momentum	Dipoles+ dispersive arms (LEDA, HEDA1,2)
	transverse distribution	YAG and OTR screens with CCD cameras
	transverse phase space (emittance)	Slit masks (EMSY1,2,3), quadrupoles, tomography module
	longitudinal profile	Radiators (straight section) + streak read-out, upcoming – Transverse Deflecting Cavity
	longitudinal phase space	Radiators (dispersive arms) + streak read-out, upcoming – Transverse Deflecting System (TDS)+HEDA2 (slice energy spread)
	slice emittance	HEDA with booster off-crest, upcoming → TDS+HEDA2

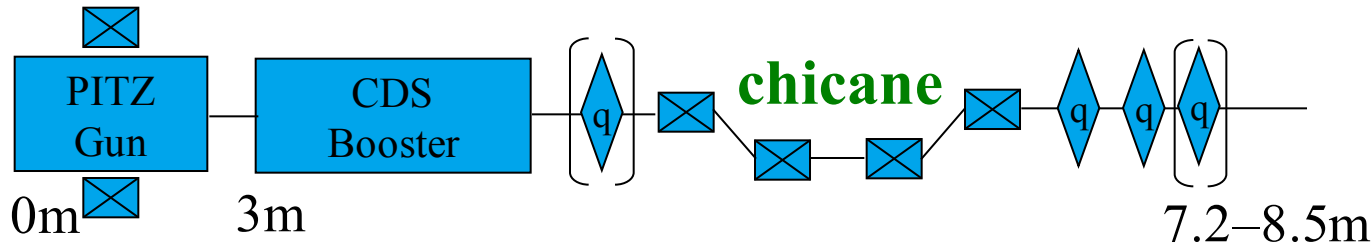
Idea and motivation

- > Short bunch production for XFEL (single spike lasing)
- > Pre-experiments at PITZ and FLASH

Short pulse production by **off-crest** operation of the **RF gun**

- Try ballistic bunching from the gun using short cathode laser pulses at low charges ($\sim 1\text{pC}$)
- BD simulation for the PITZ setup (slightly modified = + small magnetic chicane) demonstrate the possibility to produce rather short bunches ($\sim 10\text{fs}$)

Modified PITZ Setup:



Try different laser shapes:

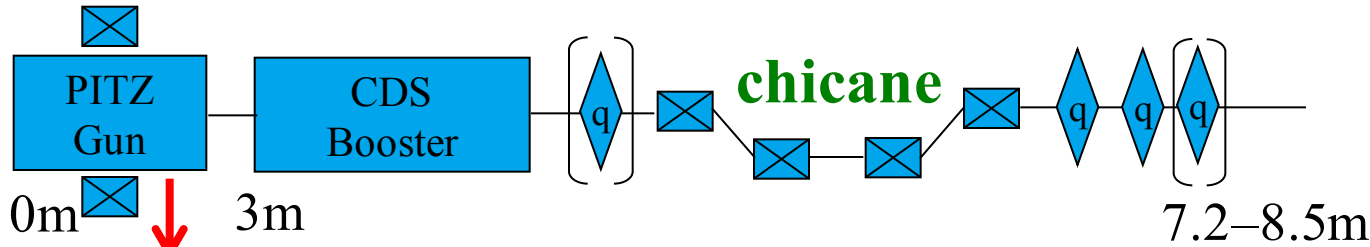
$Q = 1\text{pC}$	$\sigma_t = 1.2\text{ps}$	$\text{FWHM} = 1.4\text{ps}$	$\sigma_t = 1\text{ps}$
σ_t	9.1 fs	9.6...8 fs	10.3 fs
I_{peak}	$\sim 60\text{A}$	65...90A	$\sim 200\text{A}$
σ_x	8.5 μm	5.4...13.4 μm	7.7 μm
σ_y	8.8 μm	9.9...4.7 μm	10.4 μm

$\sim 10\text{fs}$

$< 10\mu\text{m}^2$

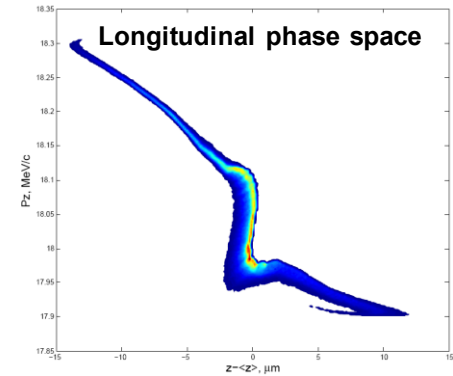
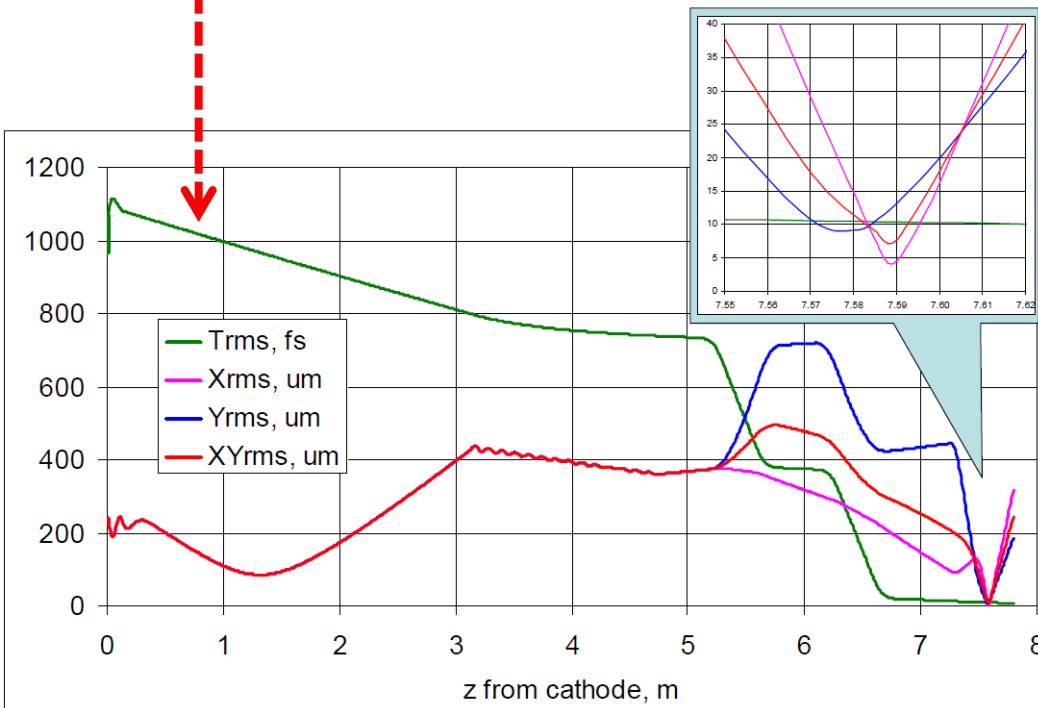
All not yet fully optimized

Short pulse production by **off-crest** operation of the **RF gun**

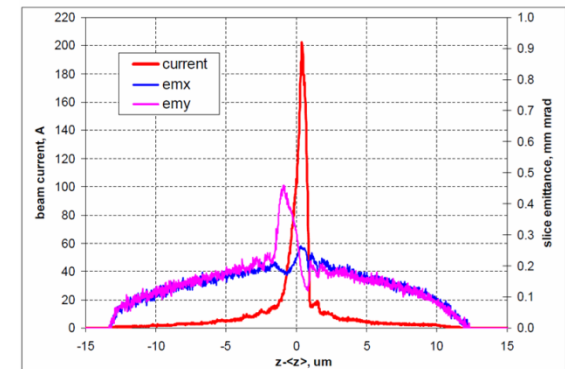


Gun phase = -38deg
(from MMMG)

Electron beam RMS parameters along beam line



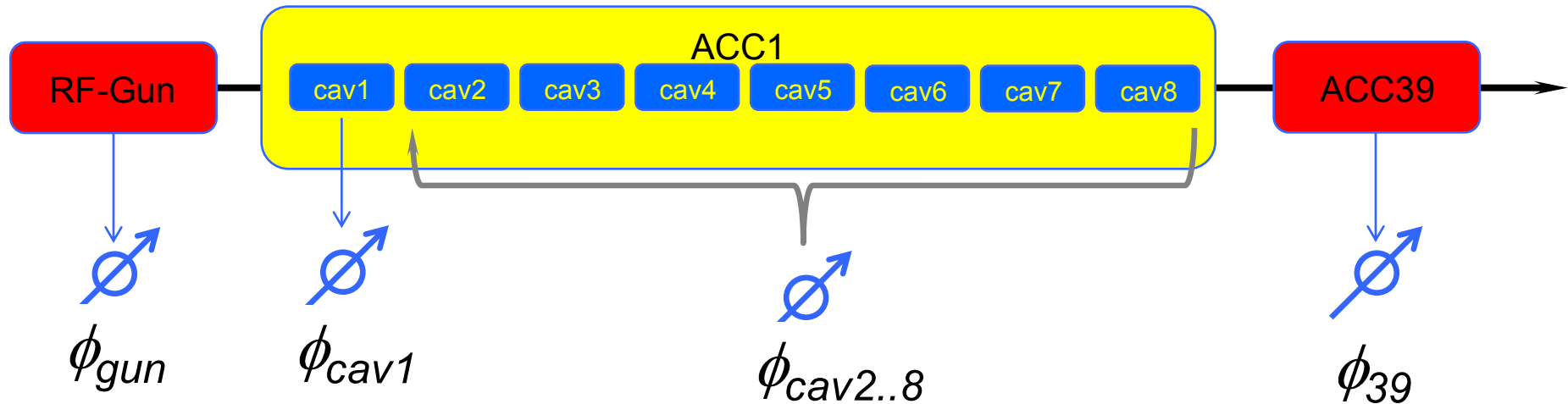
Slice parameters



Short pulse production by **off-crest** operation of the **RF gun**

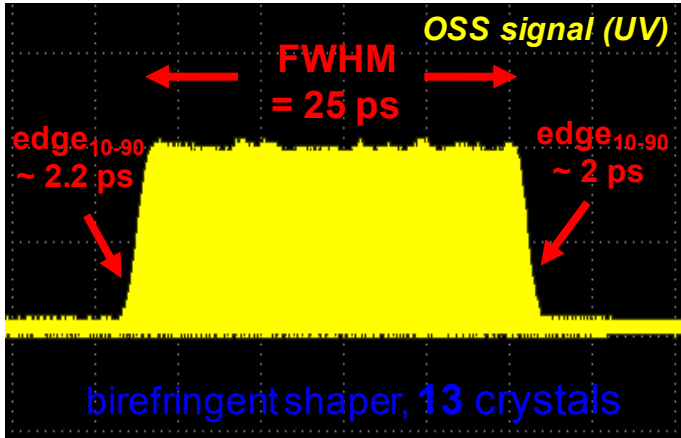
Photo injector optimization for a short bunch production:

- **PITZ** (extensive tests, study domain of machine parameters):
 - Gun phase
 - CDS booster phase*
- **FLASH** (more knobs to tune):
 - Gun phase
 - ACC1 phases:
 - 1st cavity phase for the ballistic bunching
 - 2nd – 8th cavity phases and 3rd harmonic cavity for the efficient compression

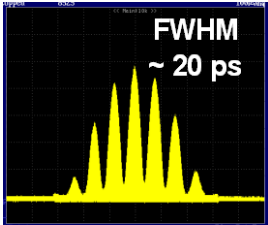
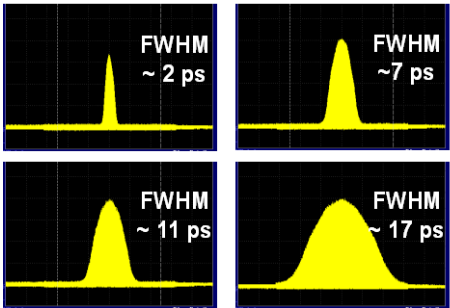


Double pulse production – PITZ Cathode laser pulse shaping

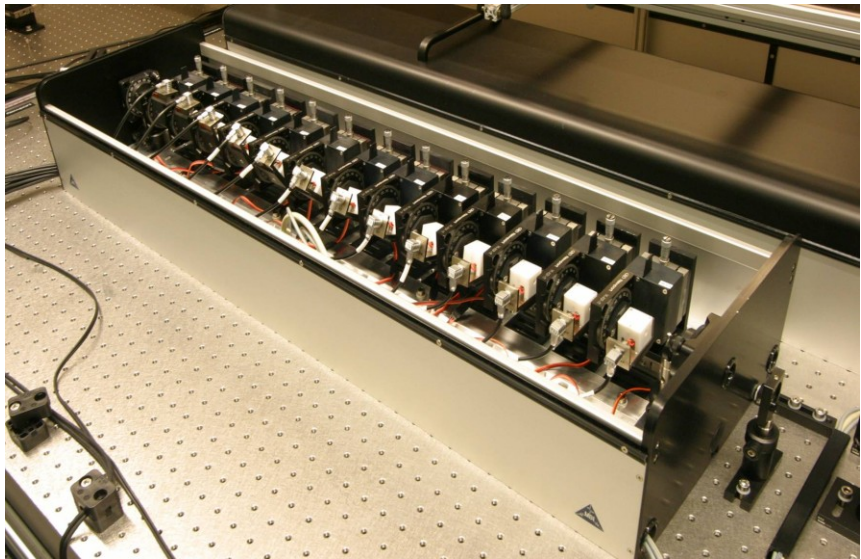
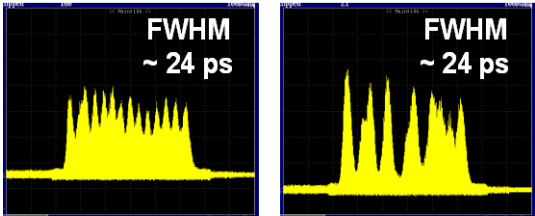
PITZ Cathode laser pulse shaping



Gaussian:



Simulated pulse-stacker



→ Very high flexibility of photo cathode laser system running at PITZ !!!

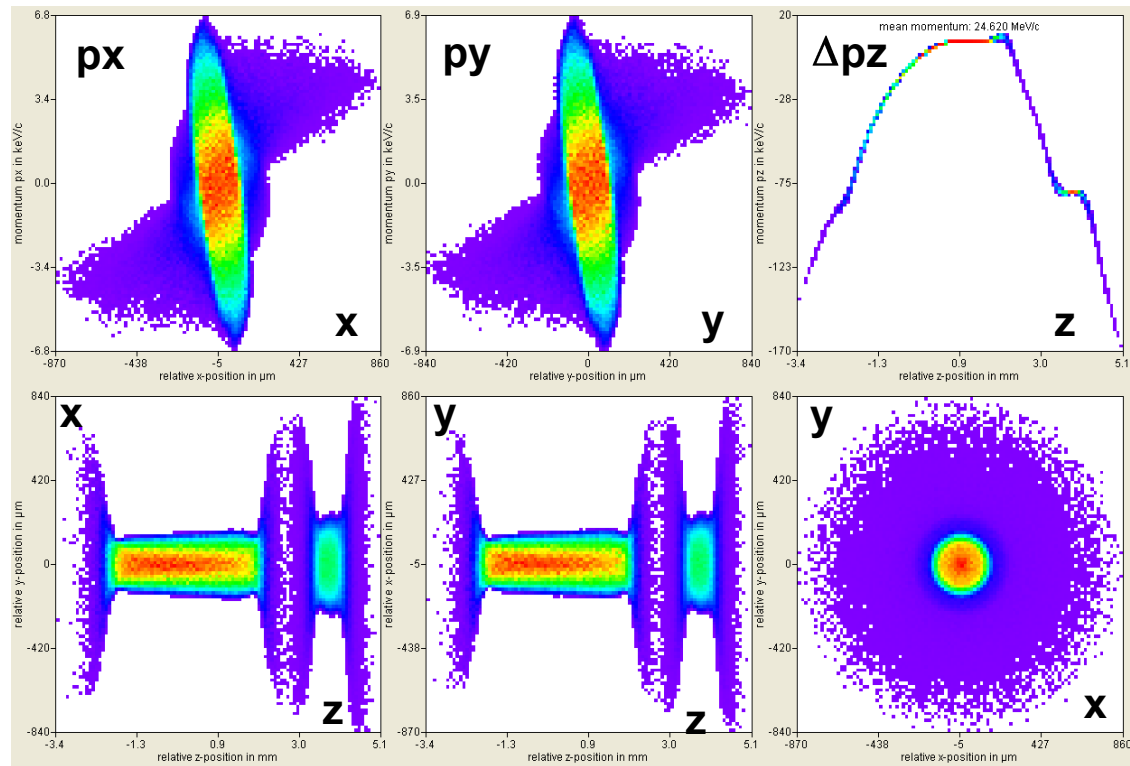
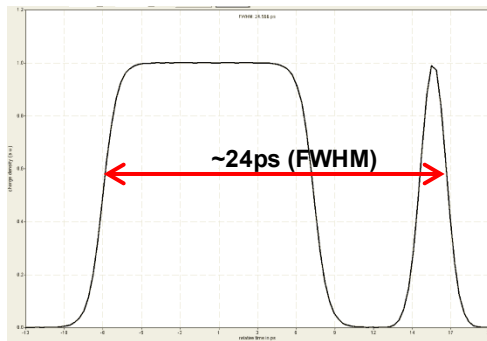
Double pulse production - to test particle driven wakefield acceleration (or other application?)

- Using the flexibility of the present photocathode laser system:

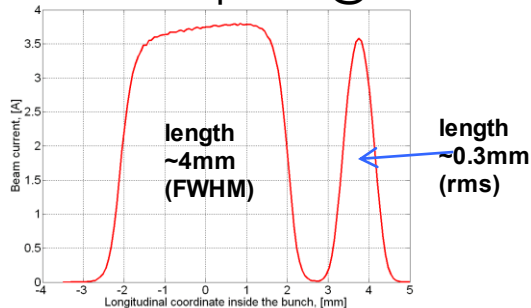
- Total maximum length ~25ps, minimum separation ~2ps
- Same transverse size

Beam dynamics simulations (60pC) – M.Khojayan, PITZ

Cath.laser temp.profile



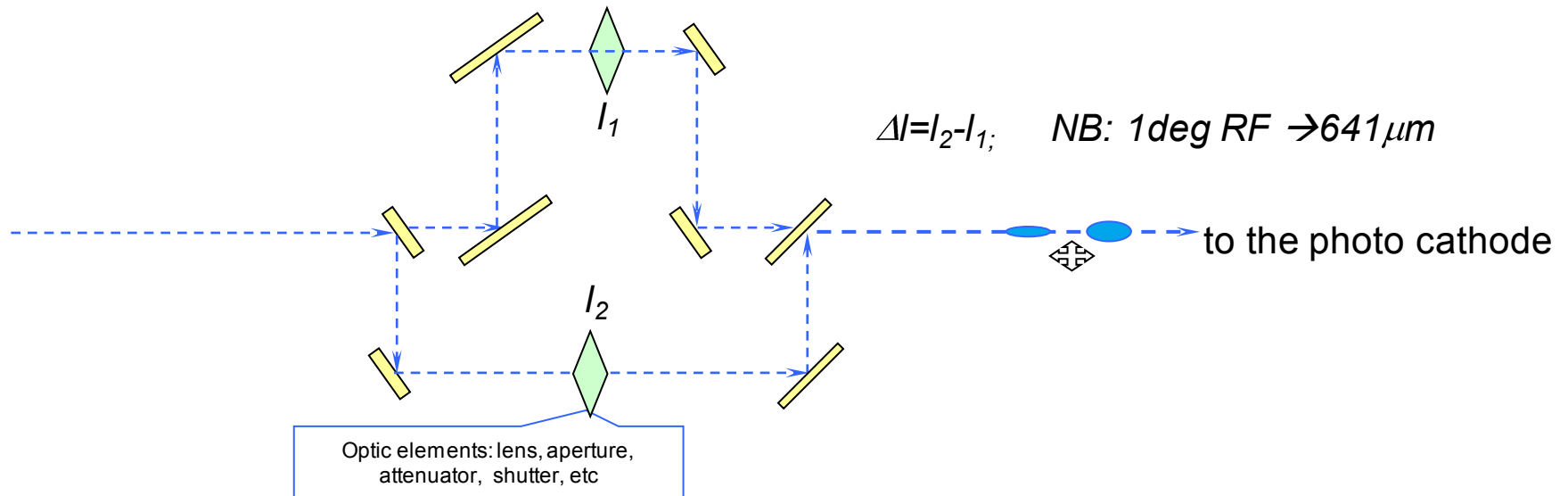
E-beam current profile @6.28m



Double pulse production

- Cathode laser at FLASH: no temporal pulse shaper (like at PITZ) → Split the cathode laser pulse into 2 (or more?) pulses:

- Same temporal profile
- Adjustable delay
- Variable ratio of intensities
- Variable ratio of transverse sizes



- Check the beam dynamics (its compatibility for both pulses) in the linac
- Experimental tests at PITZ and FLASH → particle driven wakefield acceleration (?plasma cell available?)
- Other applications?

- > Short pulse production by off-crest gun operation
 - Proof of principle at PITZ (mainly gun phase tuning)
 - More knobs at FLASH
- > Double pulse production (for e.g. wakefield acceleration)
 - Using PITZ cathode laser pulse shaper
 - At PITZ and FLASH using splitting scheme