Laser lines for run 2c

Miguel Martinez Calderon (SY-STI)

Eduardo Granados (SY-STI)

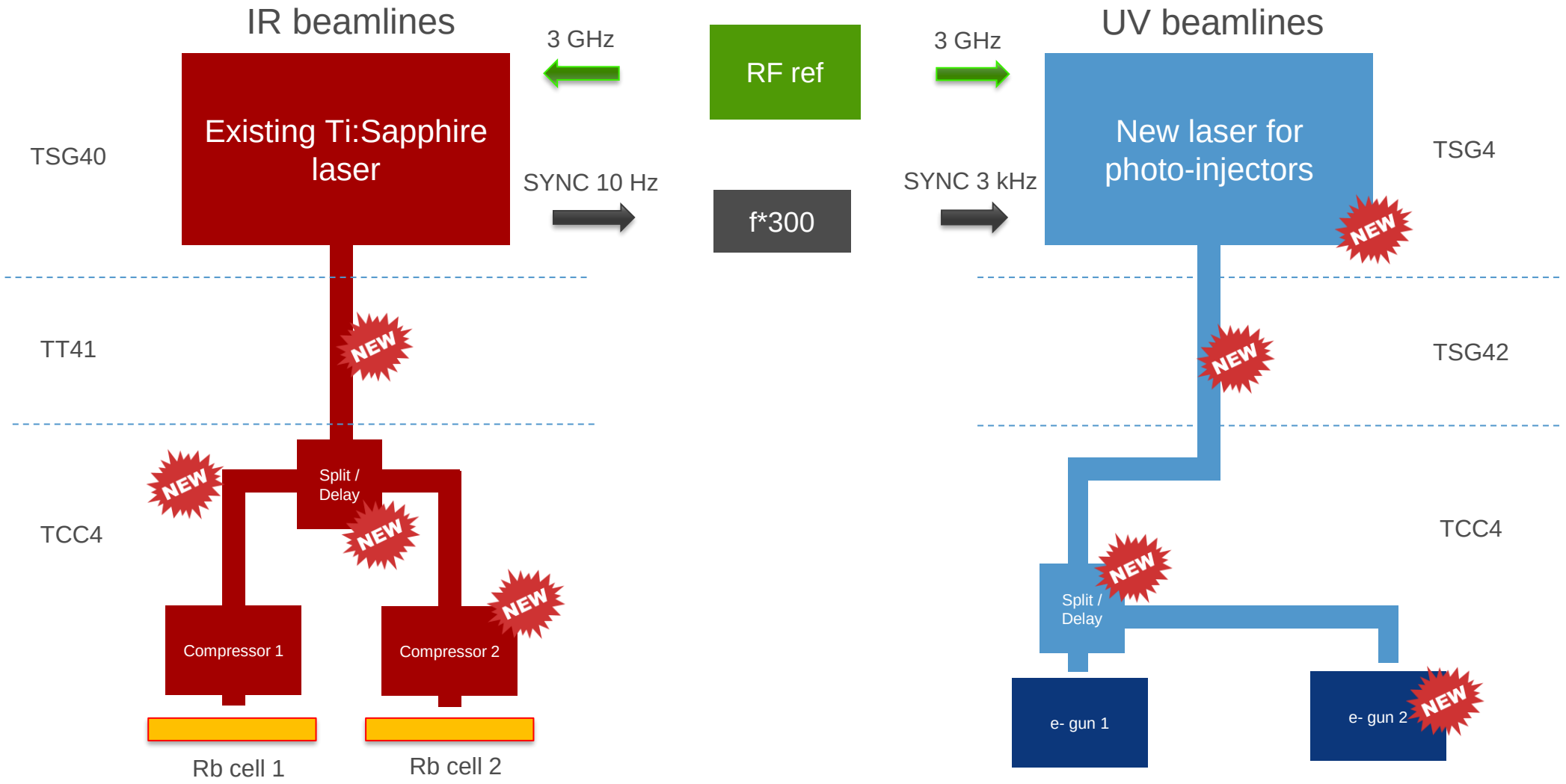
Valentin Fedosseev (SY-STI)

Baptiste Groussin (SY-STI)

Agenda

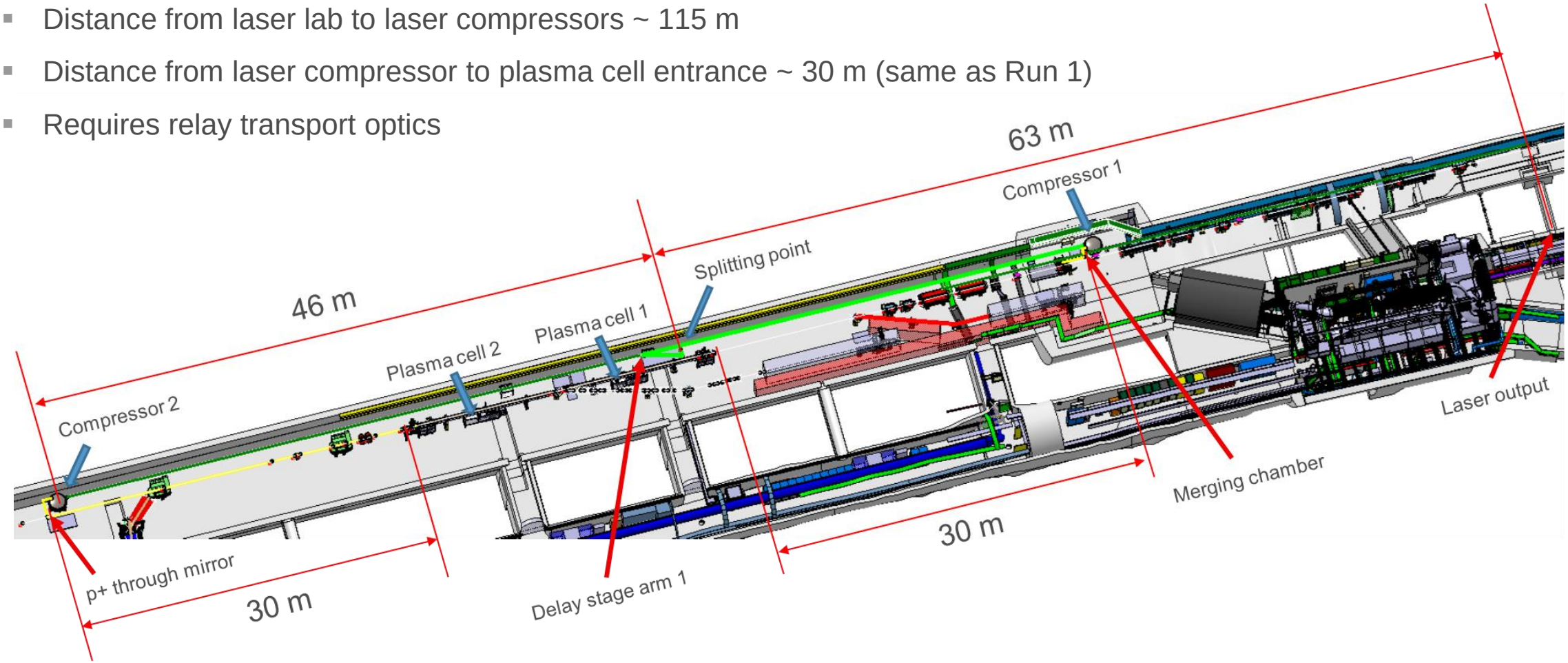
- Overview of laser lines for run 2c
  - IR beamlines
  - UV beamlines
  - Electron beams generation
- Status of new photoinjector
  - Laser performance
  - Photocathode performance
- Outlook and conclusions

Laser beams concept for Run 2c



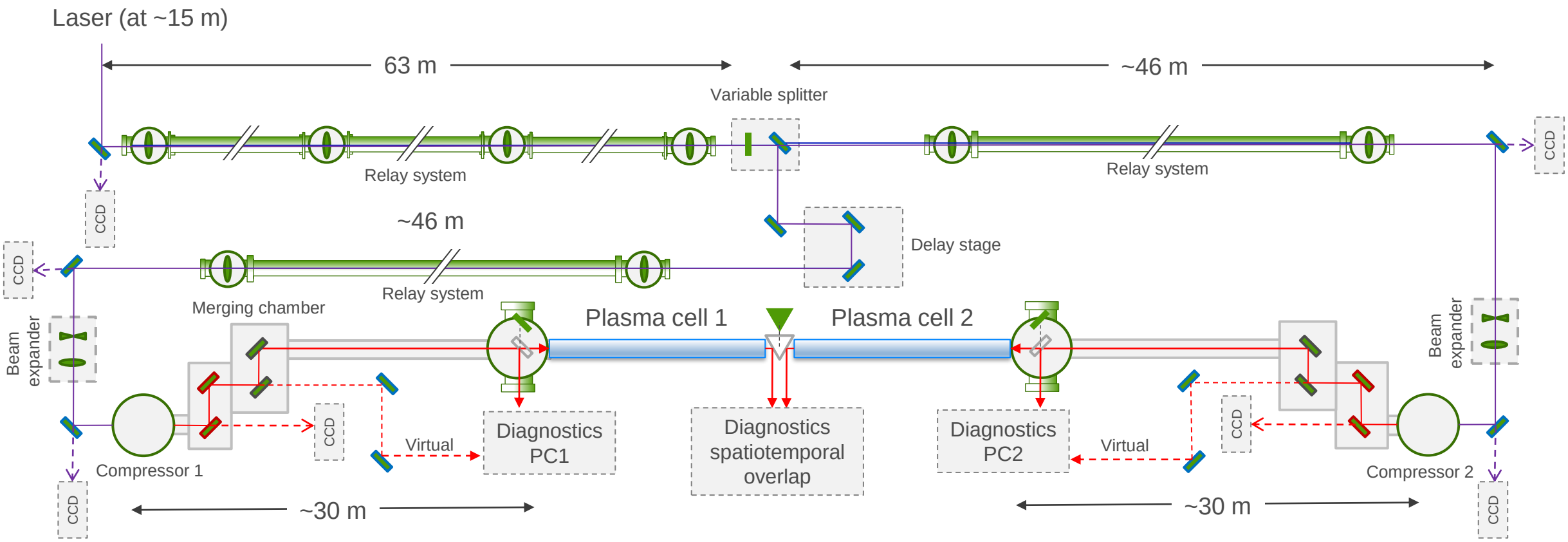
IR beamlines for run 2c

- Distance from laser lab to laser compressors ~ 115 m
- Distance from laser compressor to plasma cell entrance ~ 30 m (same as Run 1)
- Requires relay transport optics



Floorplan courtesy of P. Wiwattananon

IR beamlines for run 2c



- Relay imaging systems require only low-level primary vacuum, blue mirrors are “in air”
- Focusing on plasma cell attained by mismatching beam expanders
- Content of diagnostics sets still to be determined, location of safety devices, etc…

IR beamlines for run 2c

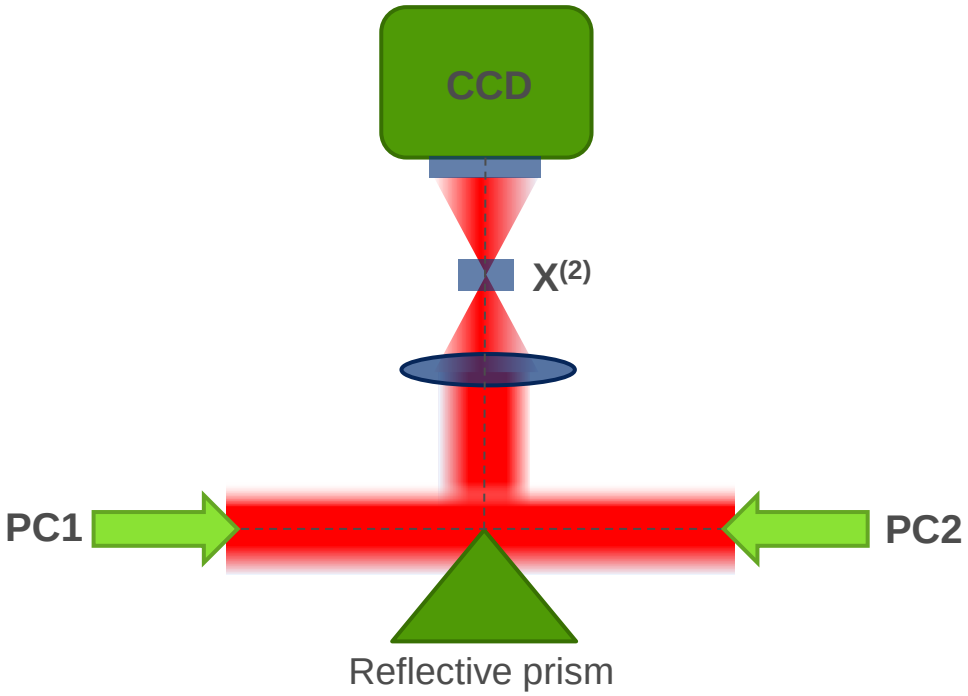
Diagnostics pre-PC1 and pre-PC2 "Beam conditioning section"

Parameter	Diagnostic	Control
Pulse energy	Energy meter (leak / real beam)	TBD
Beam position	Virtual camera (BI?)	Motorized mirrors (stepper or picomotor)
Timing (arm 1)	Spatiotemporal overlap diagnostics table	Delay stage
Beam size	Virtual and real imaging (BI?)	Beam expander
Pulse duration	Auto-correlator	Motorized compressor

Diagnostics spatiotemporal overlap (mostly TBD) "Beam matching section"

Parameter	Diagnostic	Control
Relative beam positions	CCD camera (BI?)	Motorized mirror (stepper motor)
Timing	X-correlator / fast PD	Delay stage
Beam sizes	CCD camera (BI?)	Beam expander

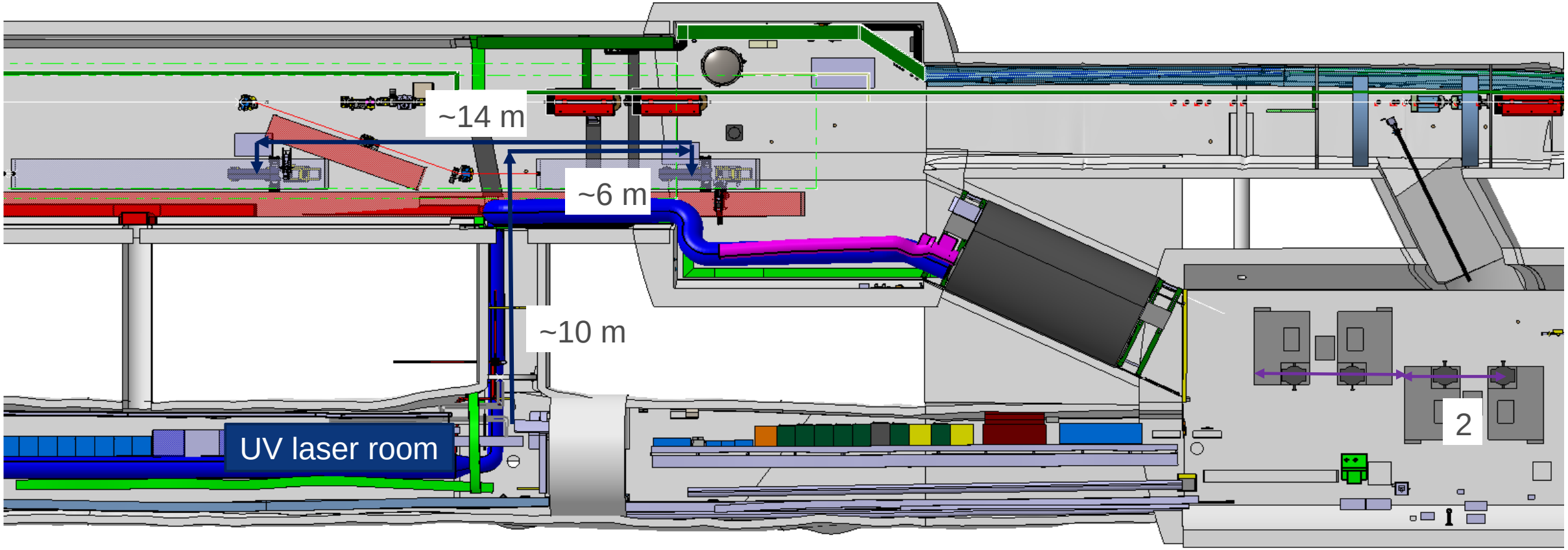
To be developed



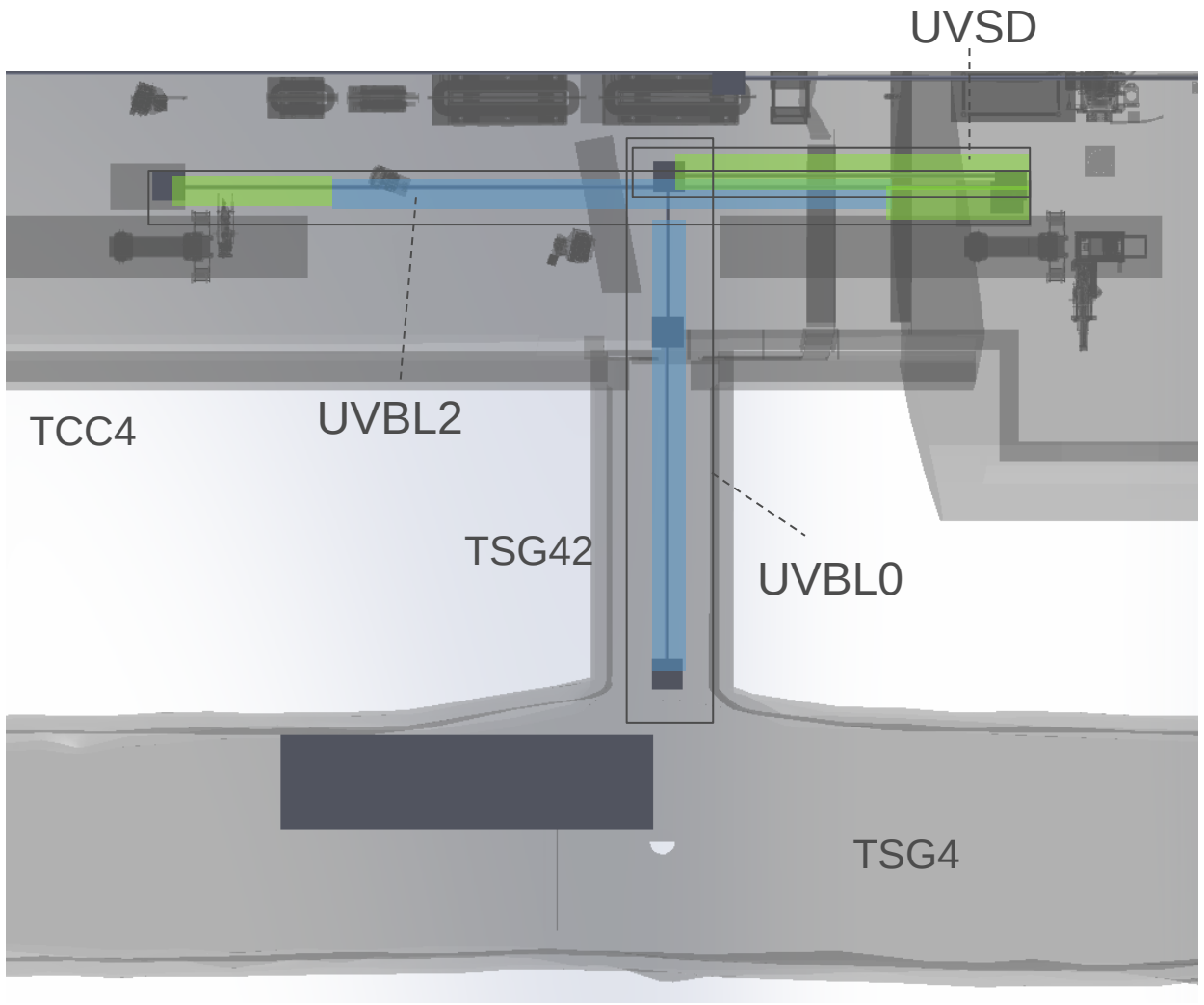
Unfortunately this device is located at the injection point of e- bunch to 2nd cell

UV beamlines for run 2c

A dedicated UV laser in TSG4



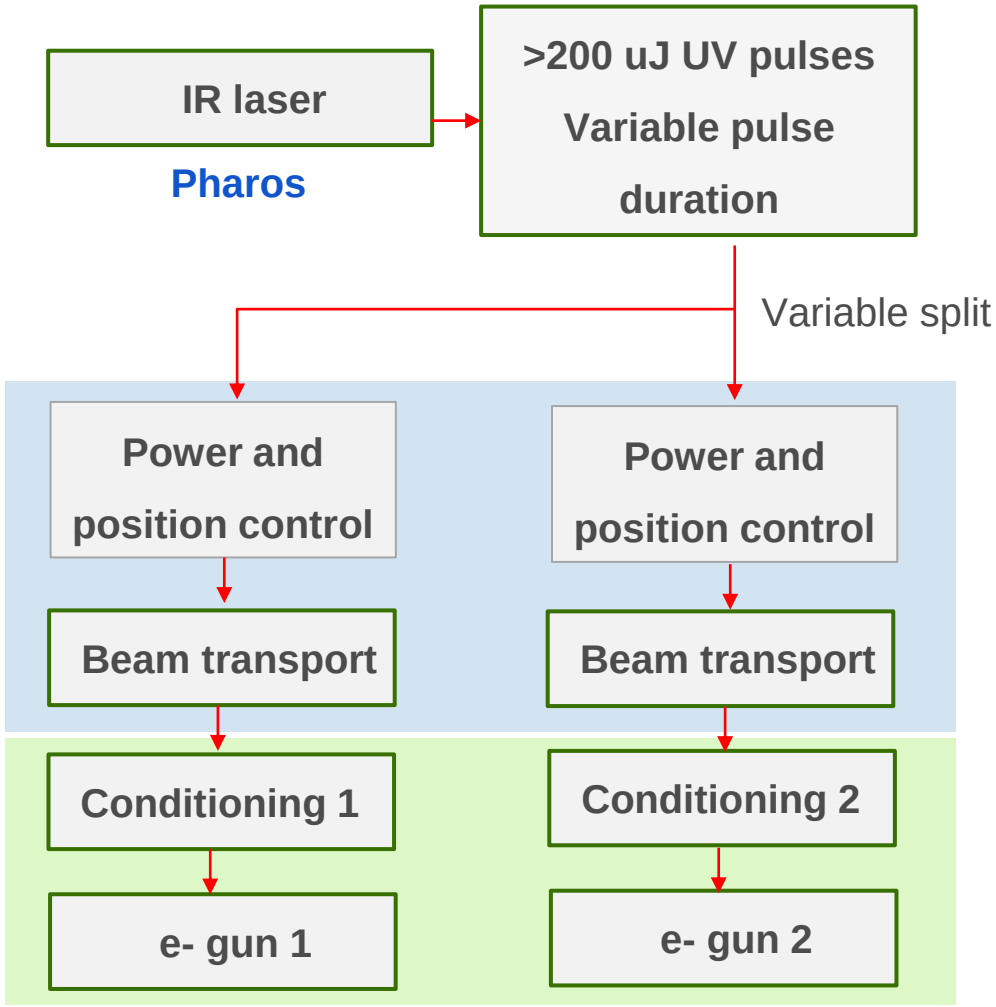
UV beamlines for run 2c



- UVBL0: UV Beamline from UV laser lab to 1st electron gun (UV Split and delay sub-system)
- UVSD: UV Split and delay system, produces UV beams for each e- gun
- UVBL2: UV Beamline from gun 1 to gun 2

No vacuum
Primary vacuum
UHV

UV beamlines for run 2c



***Baseline (for Cs_2Te photocathodes)**

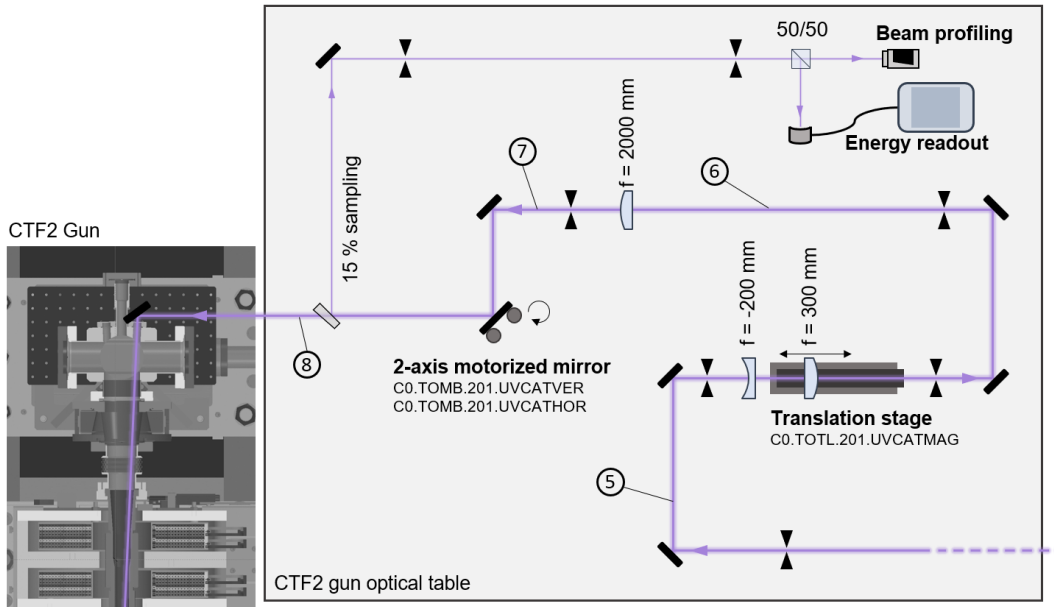
UV Beam transport diagnostics and controls for each line

Parameter	Diagnostic	Control
Pulse energy (IR+UV)	Samplers + energy meters	Motorized waveplates
Beam positioning	Leakage cameras	Motorized mirrors (picomotor)

UV Beam conditioning diagnostics and controls for each line

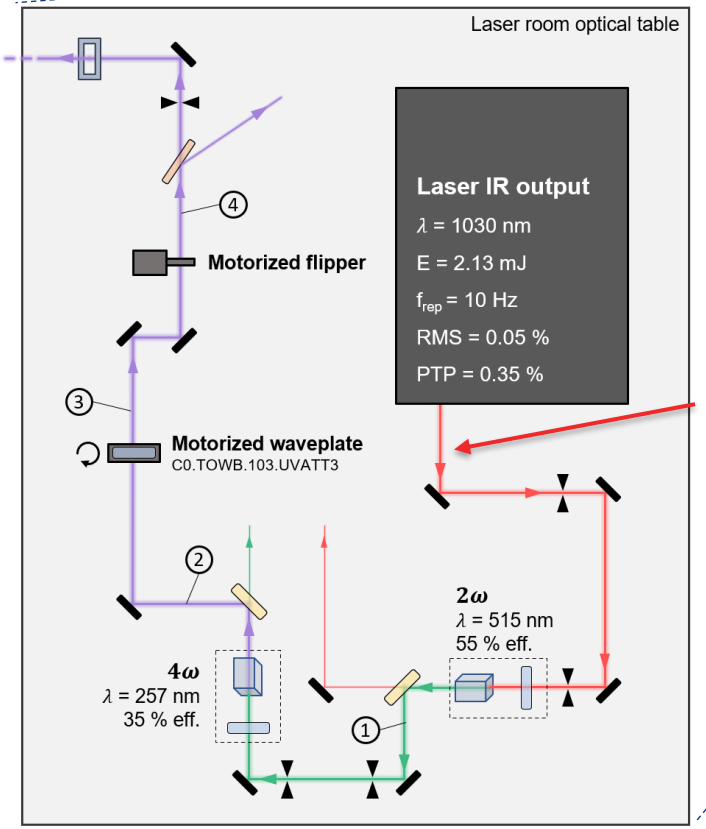
Parameter	Diagnostic	Control
Pulse energy	Sampler + energy meter	Motorized filterwheel
Beam position	Virtual cathode camera	Motorized mirror (stepper motor)
Timing	Sampler + photodiode	Delay stage
Beam size	Virtual cathode camera	Motorized iris
UV pulse duration	X-correlator / streak camera	Motorized compressor or UV stretcher

UV beamlines for run 2c: New photoinjector laser

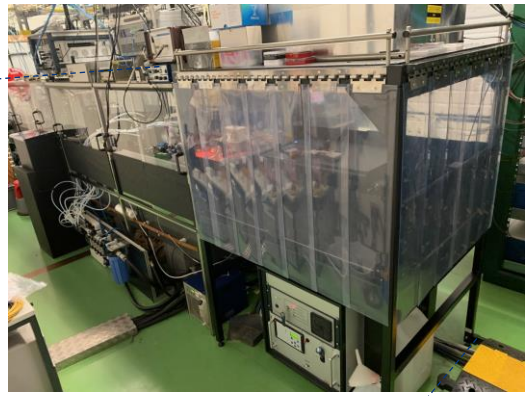


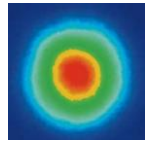
		E (μJ)	RMS (%)	PTP (%)
515 nm	1	1240	0.06	0.48
	2	480	0.09	0.56
	3	435	0.07	0.53
	4	427	0.07	0.45
257 nm	5	369	0.16	0.95
	6	304	0.45	5.39
	7	286	0.61	5.89
	8	245	1.04	11.70

Optical setup of CTF2 Photoinjector laser and energy stability



Dedicated laminar flow tent



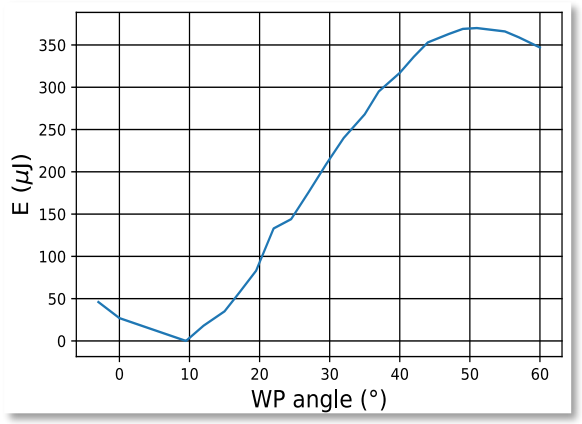


Conversion efficiency:

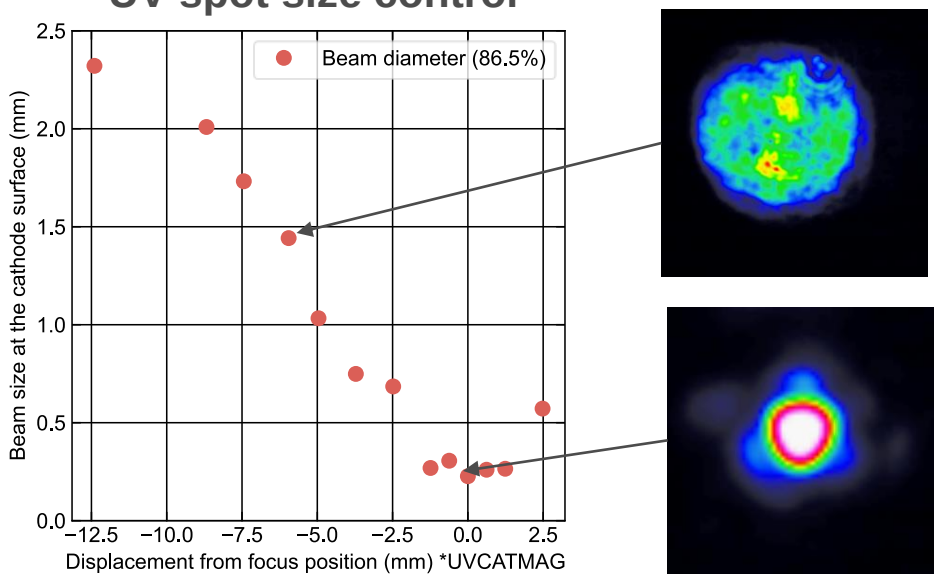
- IR to green ~60%
- Green to UV ~30%
- Overall ~ **18%**

UV beamlines for run 2c: New photoinjector laser

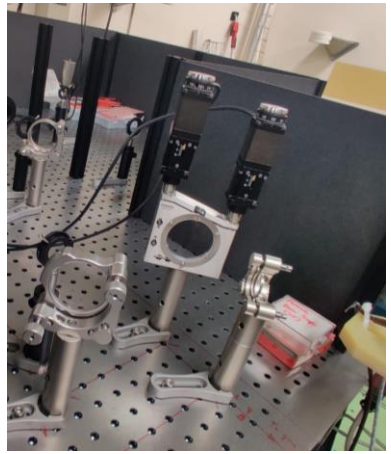
UV pulse energy control



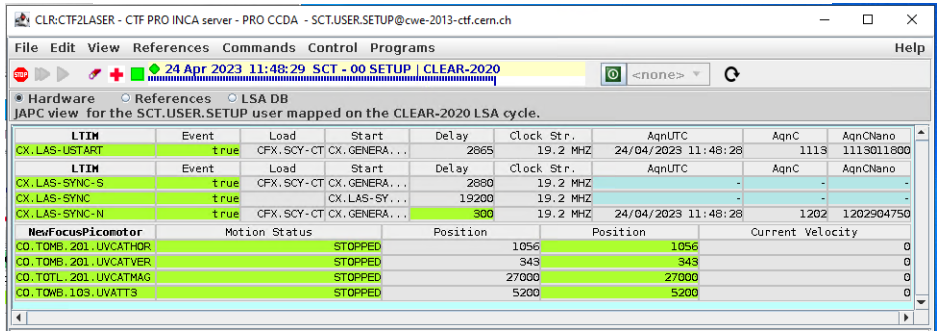
UV spot size control



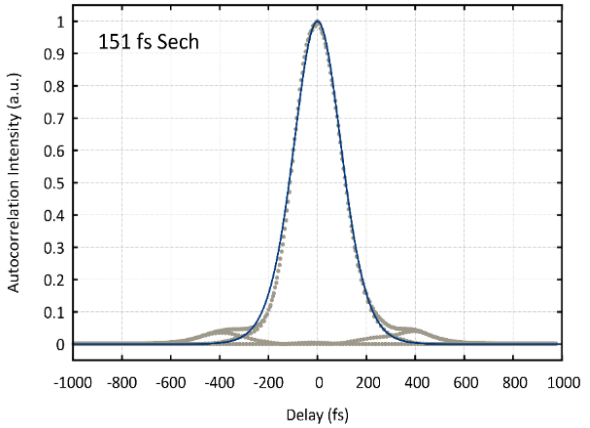
UV position on cathode



Controls integrated in WorkingSet



Last tests and improvements:
UV pulse duration



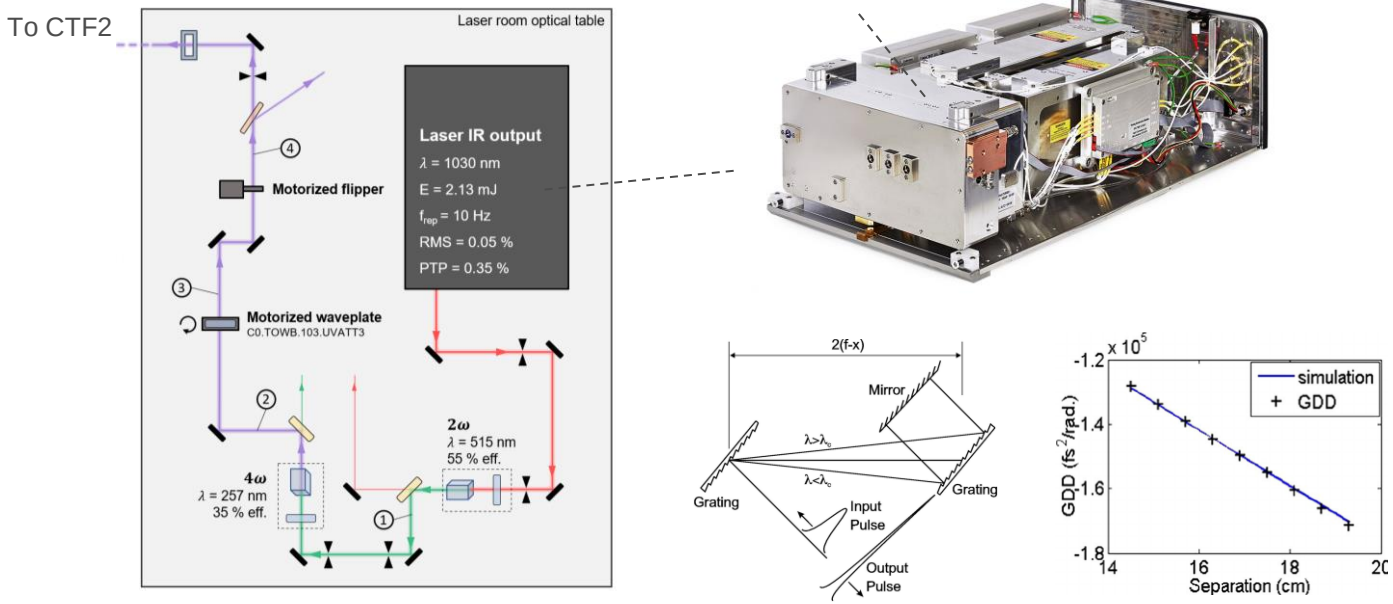
UV beamlines for run 2c: New photoinjector laser

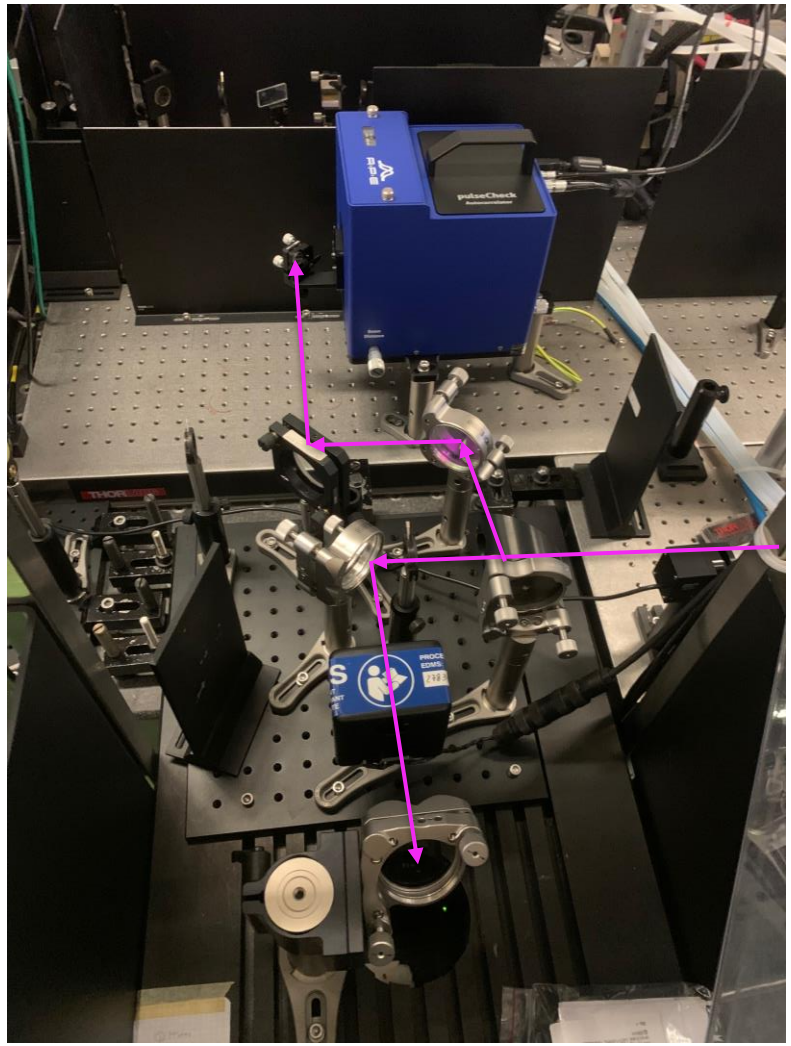
Setup for control and measurement of UV pulse duration

- “online” measurement of UV pulse duration, remotely operated
- Remote control for grating separation in laser compressor allows selectable IR pulse duration during operation.
- IR and DUV pulse duration are non-linear related, so the duration is not directly predictable with accuracy.
- Existence of dispersion in the UV line and B-integral

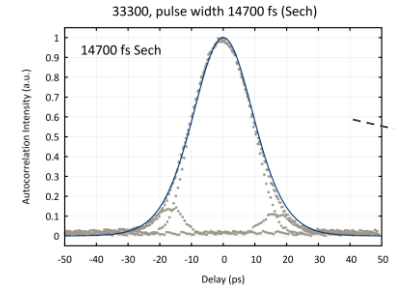
TPA autocorrelator

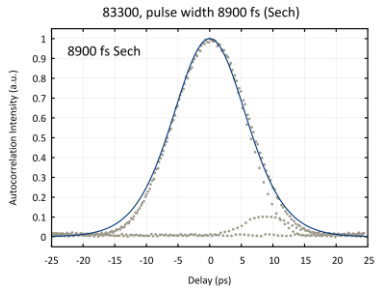
Motorized compressor

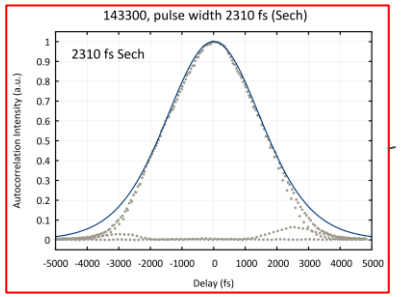


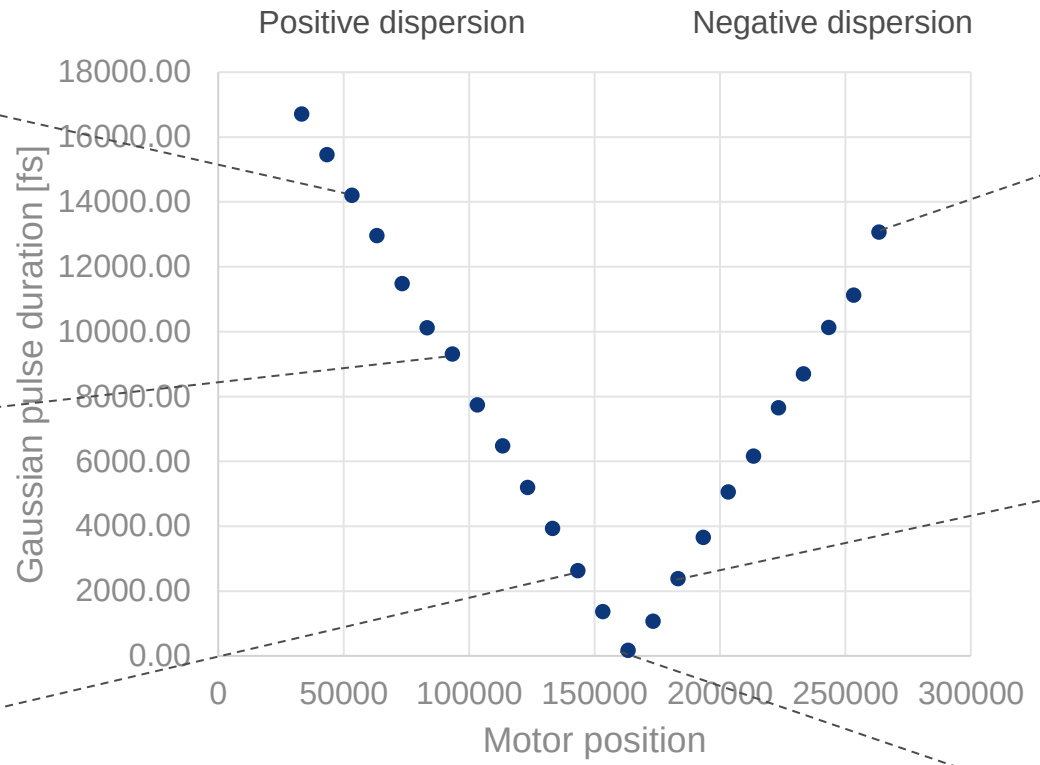


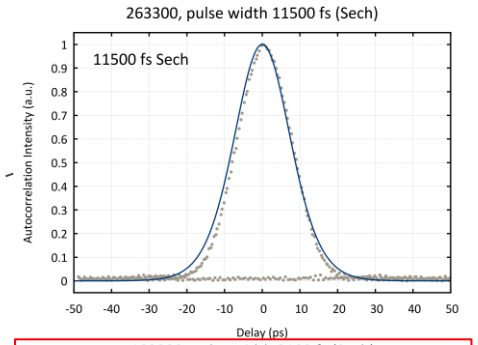
UV beamlines for run 2c: New photoinjector laser

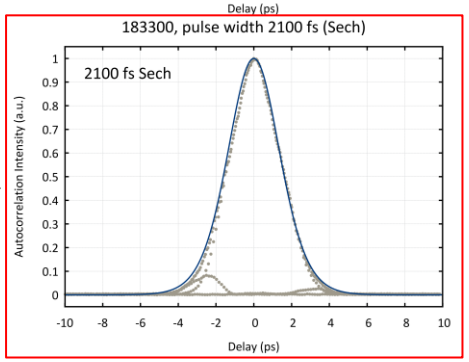


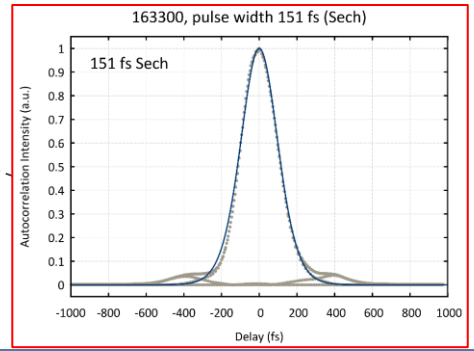






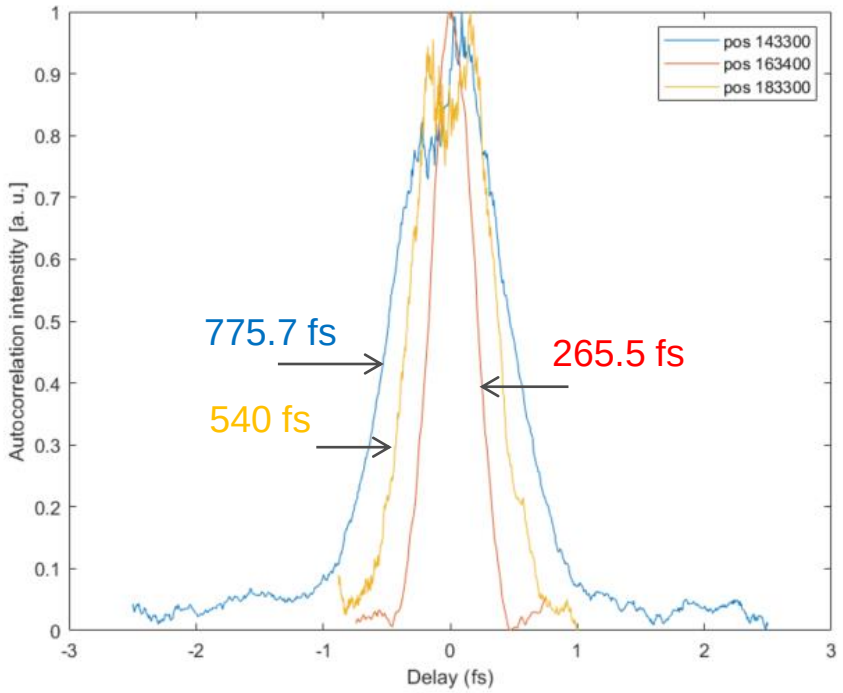






- To solve B-integral and study space charge effect in CTF2 photoinjector, 3 pulse durations in the IR were tested.

UV beamlines for run 2c: New photoinjector laser

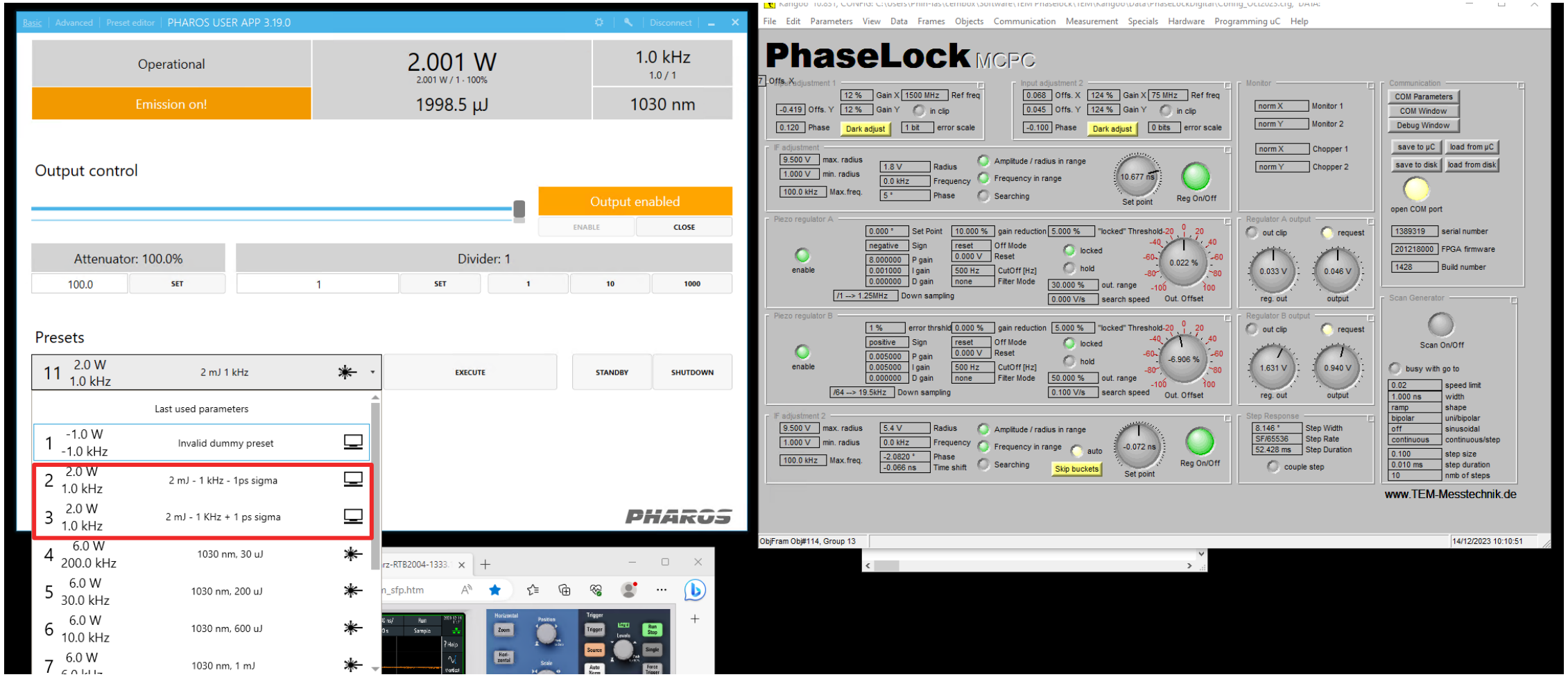


Motor position	IR pulse duration*	UV pulse duration*
163400	151 fs	265.5 fs
143300	2100 fs (negative chirp)	540 fs
183300	2310 fs (positive chirp)	775.7 fs

* Deconvolved values are given at FWHM for Gaussian fits

- The UV pulse energy was reduced to 65 uJ (by a factor of 6.2) when the longer IR pulse was used.
- For the 775 fs pulse, the energy delivered on the cathode was around 35 uJ. The energy stability was better, going to below 1% RMS on cathode

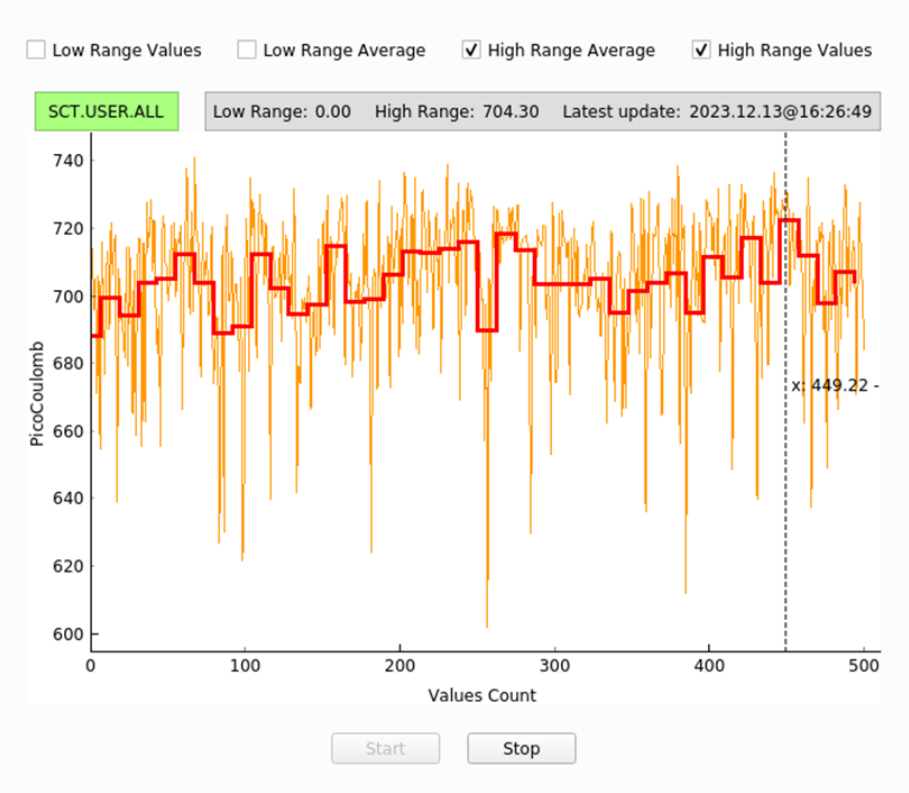
UV beamlines for run 2c: New photoinjector laser



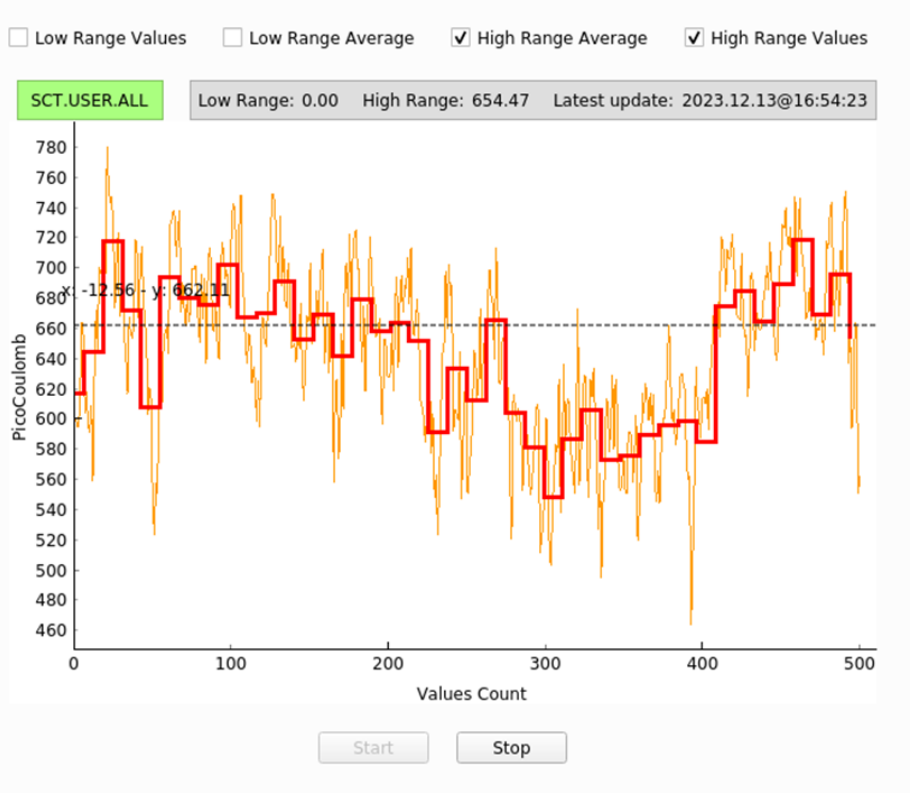
UV beamlines for run 2c: New photoinjector laser

- Maximum bunch charge tests!
- Checked at both pulse lengths (better stability with longer pulse, from 1% to 5%)

700 pC bunch charge!!! 775.7 fs (FWHM) UV pulse length

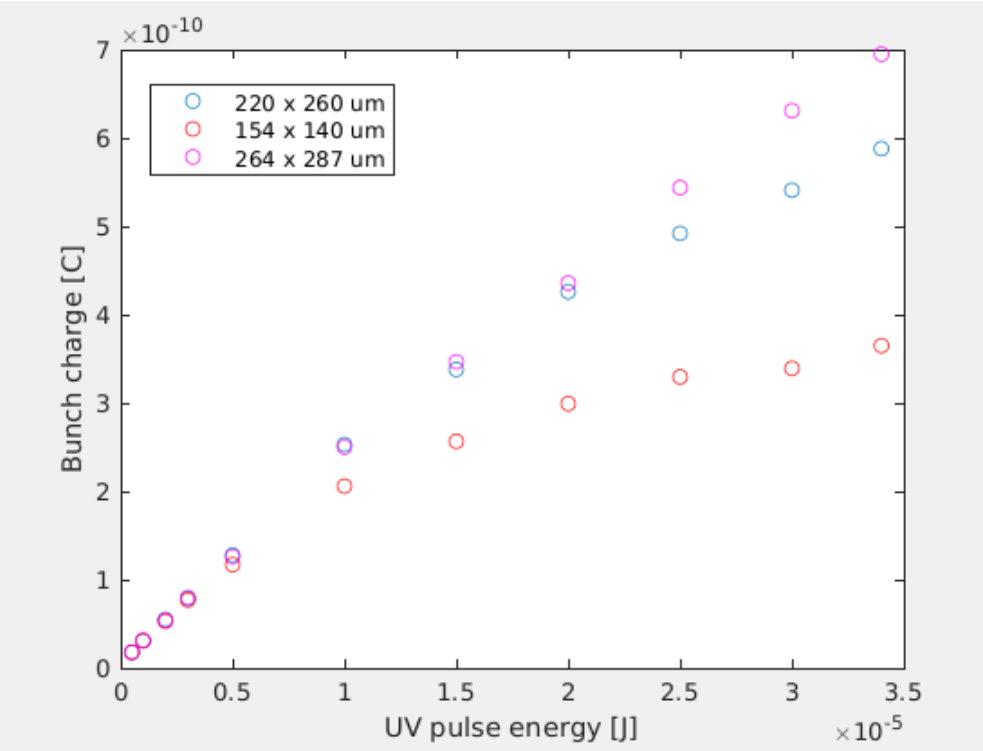


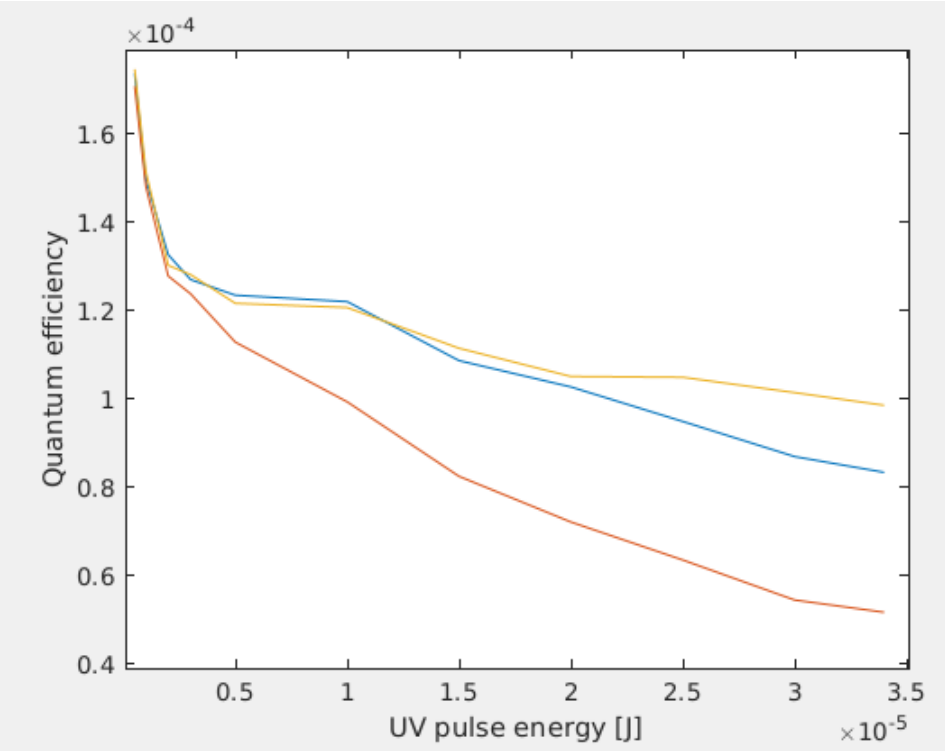
Again 700 pC bunch charge 265.5 fs (FWHM) UV pulse length



UV beamlines for run 2c: New photoinjector laser

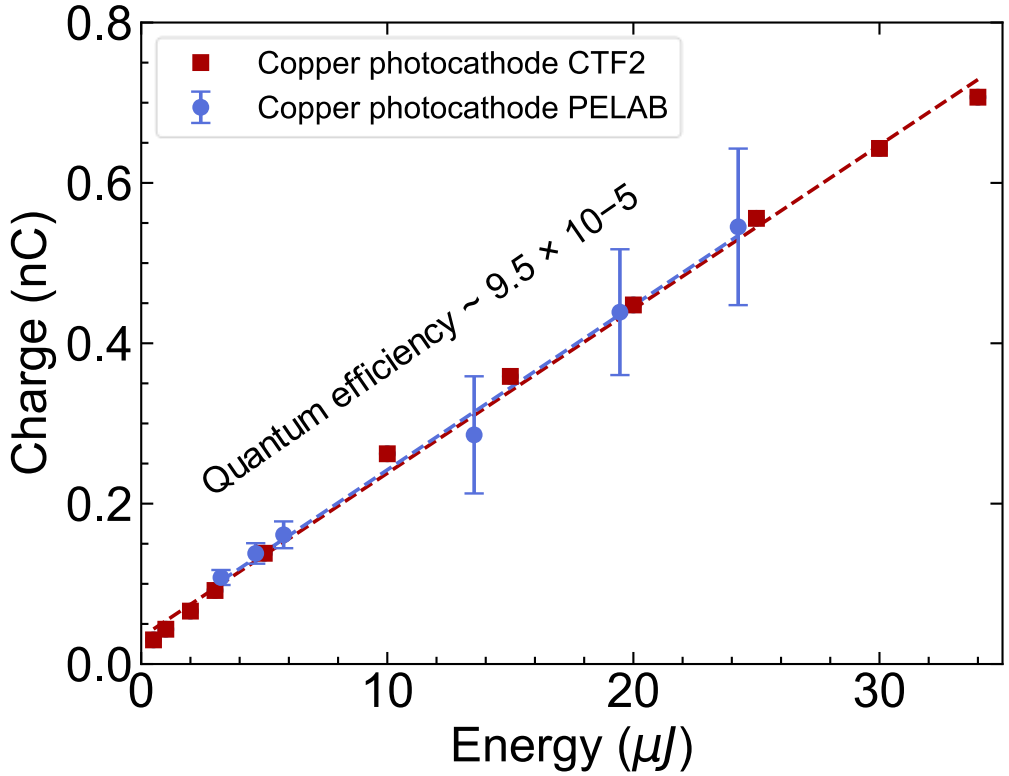
- Systematic measurements of the QE with the new pulse length at 3 different magnifications (beam size at the photocathode surface)
- Very nice saturation curves!





UV beamlines for run 2c: New photoinjector laser

QE measurements with different fields (PELAB = **6.5 MV/m** Vs CTF-2 = **100 MV/m**)



Laser beamlines: open questions, outlook

- **IR beams**
  - Timing resolution required for synchronization -> Development of specific optical/electronic diagnostics
  - 2nd Compressor vessel design -> size, location
  - Pulse energy required in each cell? -> May not need reflective telescopes?

- **UV beams**
  - Preferable option is to use a separate laser (as in CLEAR) due to:
    - Synchronization with ionizing laser without additional delay lines (~ 80 m extra)
    - Location of compressors and harmonic stages (laser lab, near gun?) -> better pointing stability
    - Higher energy of UV pulse
    - Possibility to produce electron beams independently of the main laser status
  - Pulse duration tunability capabilities, ranges? Variable compressor/stretcher? Different pulse durations for each e- gun? CLEAR/CTF2 tests will help answering these questions

New photoinjector conclusions

- The photoinjector laser for AWAKE run 2c is ready and operative, alongside with controls and diagnostics.
- The integration of cesium telluride cathodes at CTF2 is under study, with a view on simplifying the future AWAKE run2c layout and cost.
- The pulse duration capability has been tested and optimized allowing flexibility in the experiment.
- Photocathode material for fs gun -> emittance and charge requirements -> UV energy needs.

Thank you for
your attention!