Laser beamlines for run 2c/d

Eduardo Granados (SY-STI)

On behalf of the LP section

Requirements for AWAKE Run 2 laser beamlines

Run 1

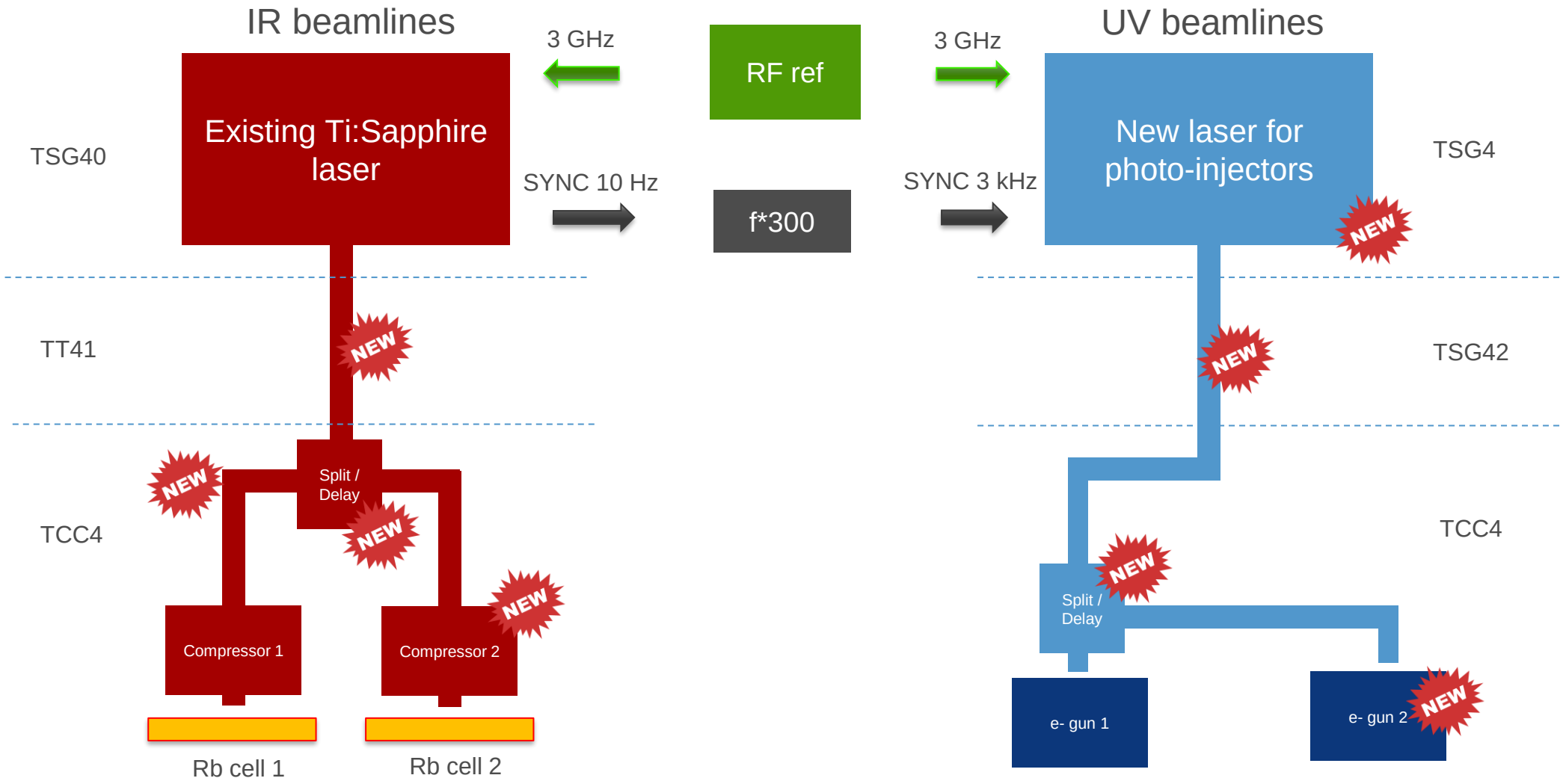
- Laser beam line to plasma cell 1
  - λ = 780 nm (depending on oscillator)
  - t pulse = 100-120 fs
  - E > 200 mJ (unless new laser amplifier)
  - (Reflective telescope after compressor)
  - Beam delivery
- Laser beam line to electron gun 1
  - λ ~ 267 nm
  - t pulse = 0.2-10 ps
  - E ~ 0.5 uJ
  - (Beam delivery via image relay)
  - **Synchronization** based on IR laser
  - Spot size and fluence control
- Diagnostic beam line(s)
  - λ = 780 & 260 nm: imaging, energy, timing.

Run 2 c/d

- Laser beam line to plasma cell 2
  - λ = 780 nm (depending on oscillator)
  - t pulse = 100-120 fs
  - E > 200 mJ (unless new laser amplifier)
  - (Reflective telescope after compressor)
  - *Relay imaging beam delivery*
  - *Variable delay after split point.*
- Laser beam line to electron gun 2
  - λ ~ 260-267 nm
  - t pulse = 0.2-10 ps
  - E ~ 20 uJ
  - (Delivery via image relay)
  - ***Synchronization** depending on laser source*
  - Spot size and fluence control
- Diagnostic beam line(s)
  - *Synchronization and overlap counter-propagating IR beams with p+ beam*

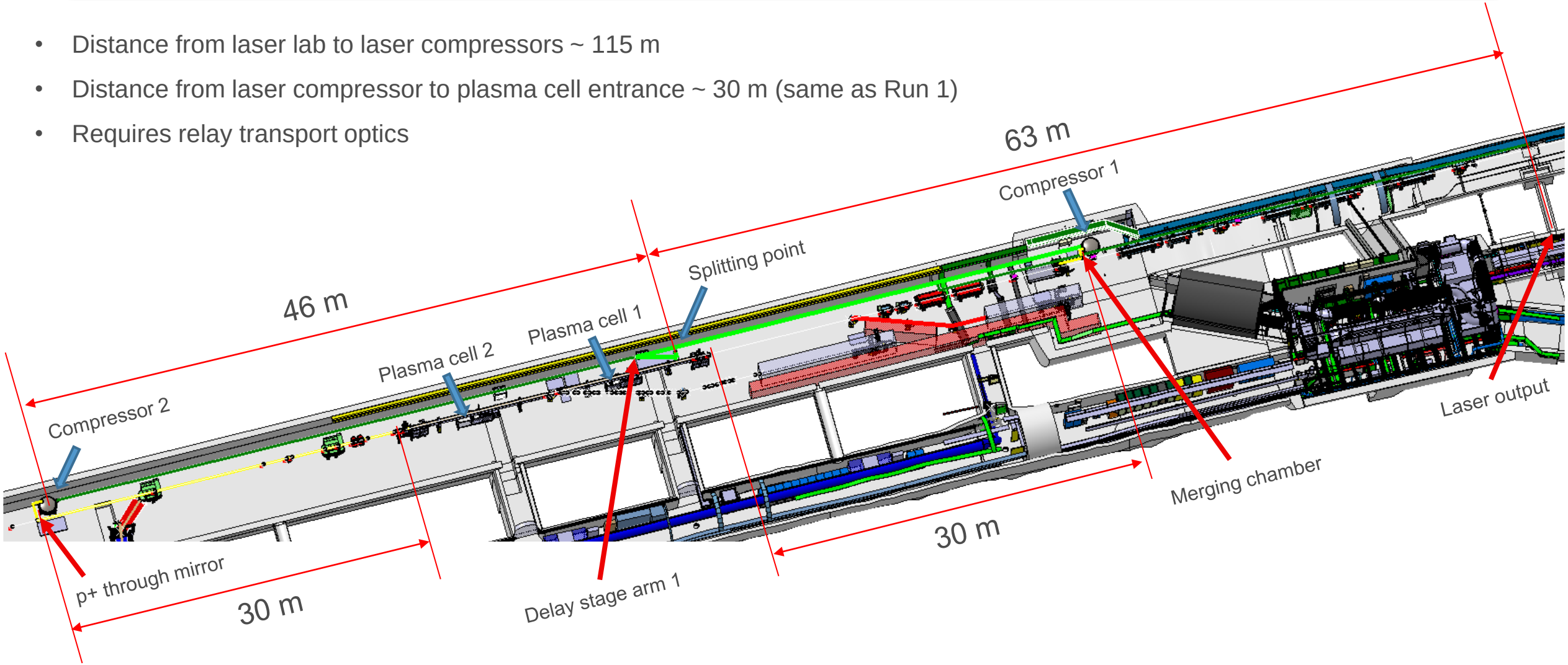
In essence, Run 2 = 2 x Run 1, but needs re-build and relocation of major Run 1 components due to different location of plasma cells

Laser beamline concept for run 2 c/d

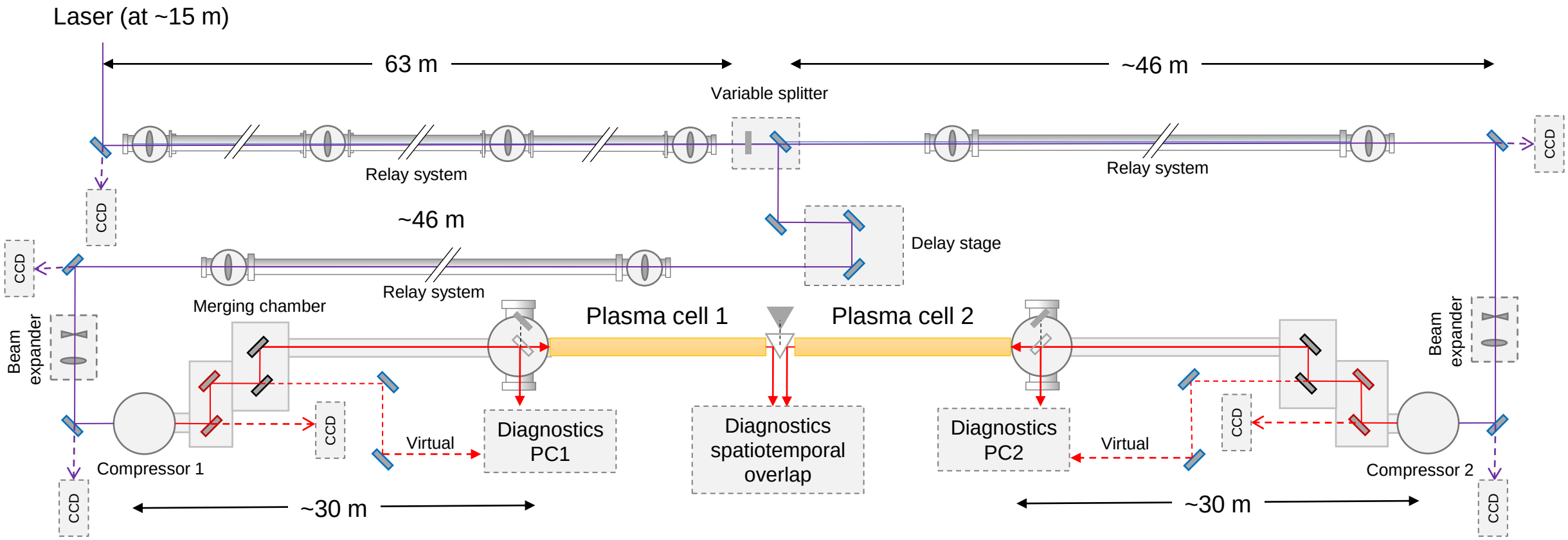


IR beamlines for plasma cells

- 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



IR beamlines for plasma cells



- 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…

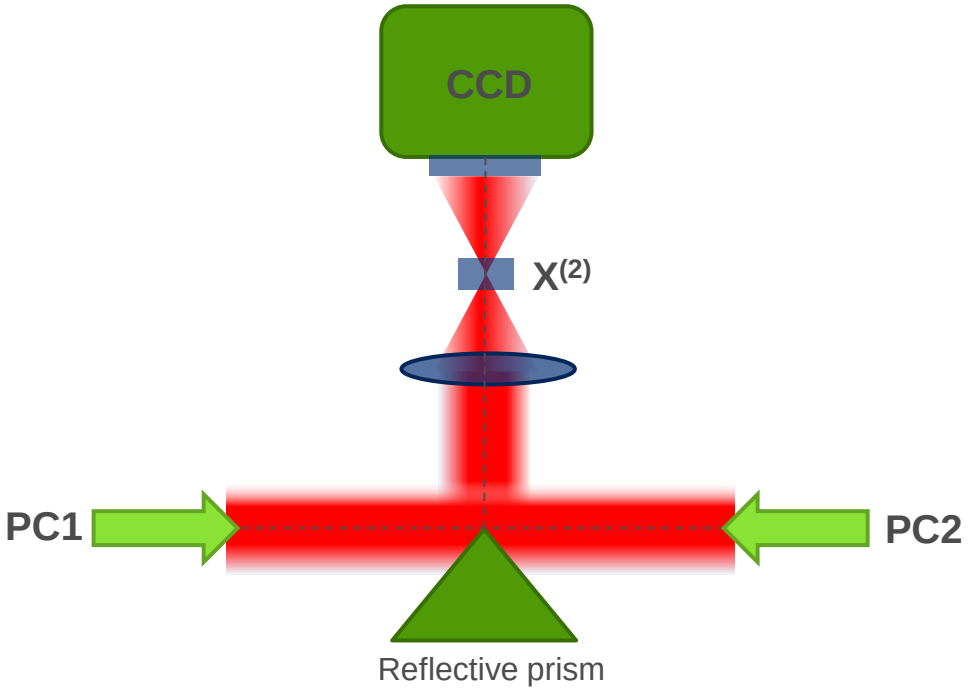
IR beamlines diagnostics

Diagnostics pre-PC1 and pre-PC2 “Beam conditioning section”

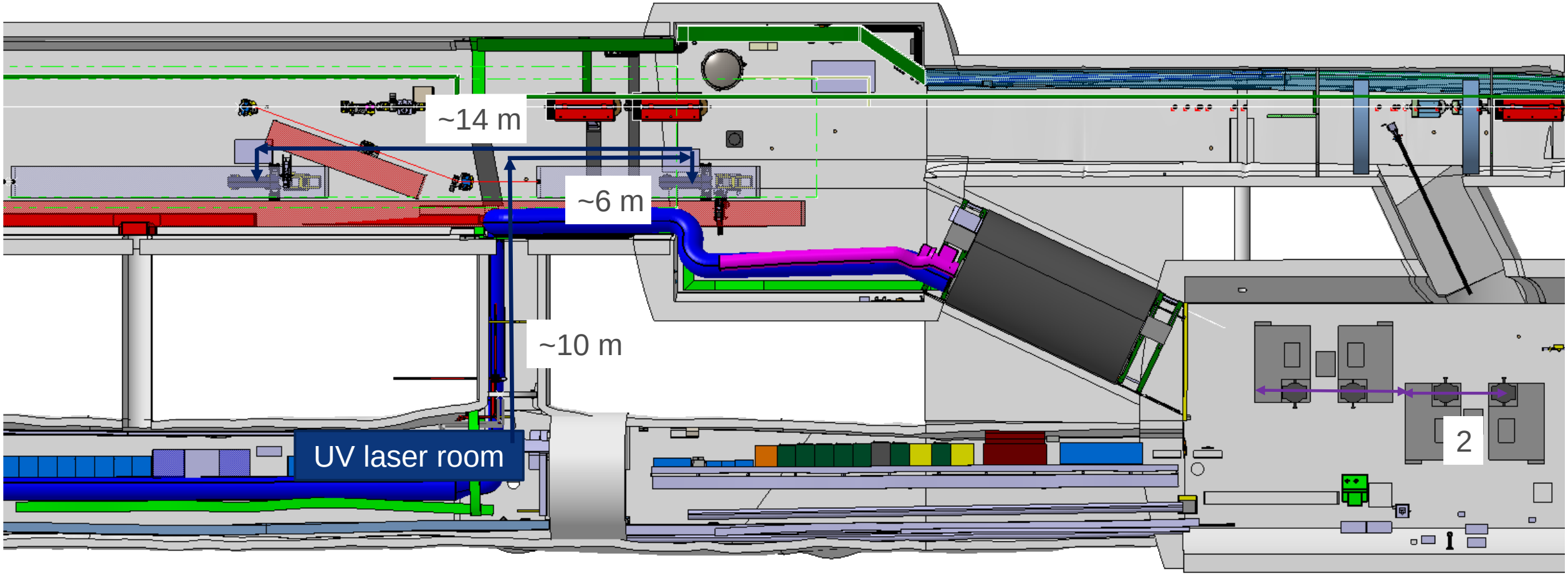
Parameter	Diagnostic	Control
Pulse energy	Energy meter (leak / real beam)	TBD
Beam position	Virtual camera (BI?)	Motorized mirrors (stepper or picomotor)
Timing (arm 1)	Spatiotemporal overlap diagnostics table	Delay stage
Beam size	Virtual and real imaging (BI?)	Beam expander
Pulse duration	Auto-correlator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

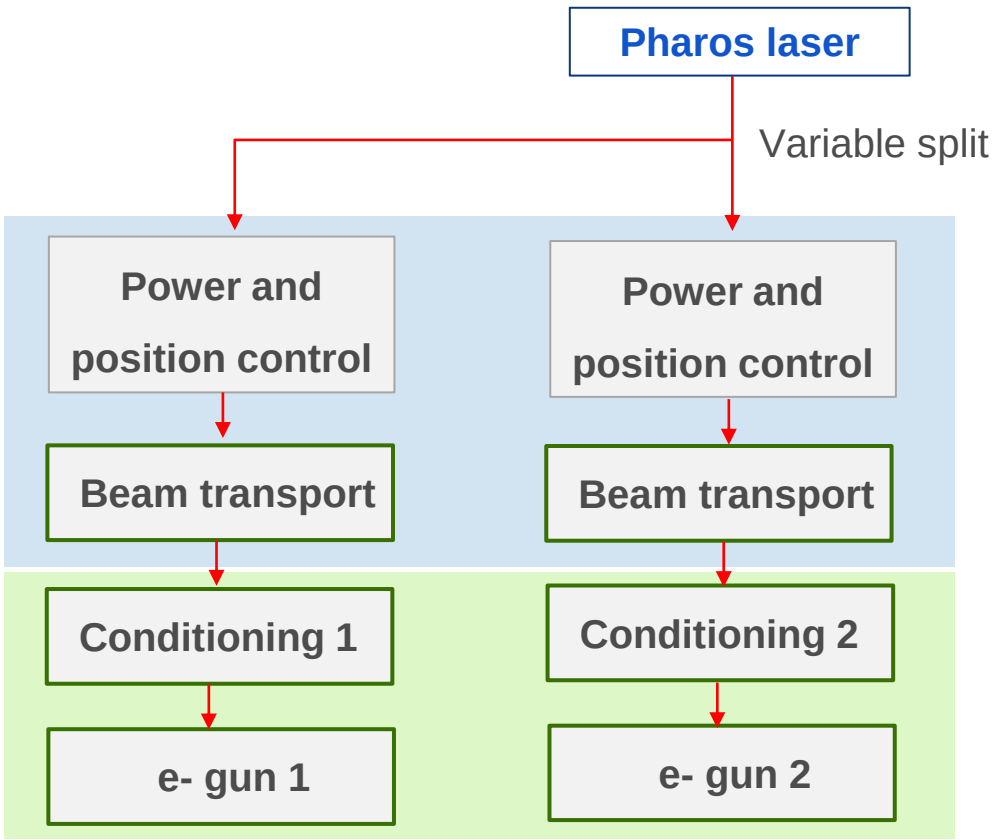


UV beamlines for RF guns



A dedicated UV laser in TSG4

UV beamlines for RF guns – controls and diagnostics

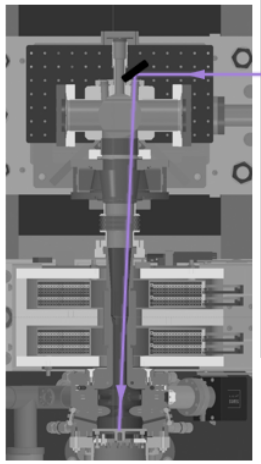


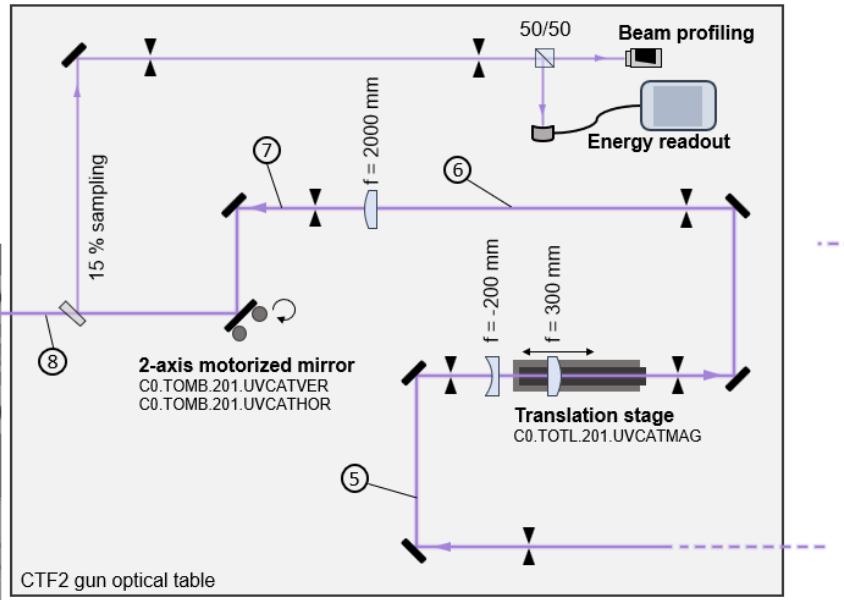
Parameter	Diagnostic	Control
Pulse energy (IR+UV)	Samplers + energy meters	Motorized waveplates
Beam positioning	Leakage cameras	Motorized mirrors (picomotor)

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

New photoinjector already operative at CTF2

CTF2 Gun

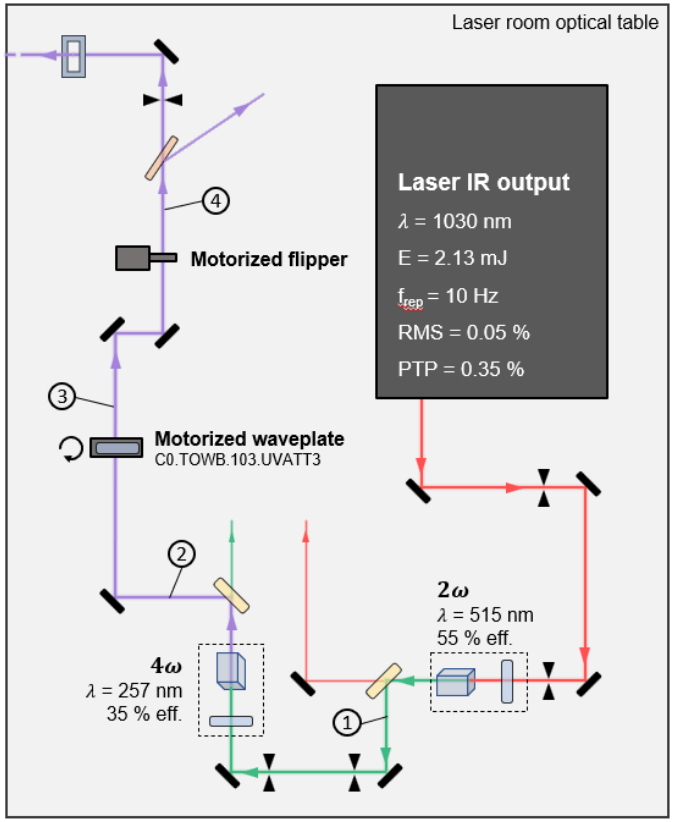




	E (µJ)	RMS (%)	PTP (%)
1	1240	0.06	0.48
2	480	0.09	0.56
3	435	0.07	0.53
4	427	0.07	0.45
5	369	0.16	0.95
6	304	0.45	5.39
7	286	0.61	5.89
8	245	1.04	11.70

Dichroic mirror
β - BBO crystal
$\lambda/2$ waveplate
Iris
Thin Film Polarizer
Mirror
Beam splitter
Plano-concave/ convex lens
Interlocked shutter

Optical setup of CTF2 Photoinjector laser and energy stability



Open questions

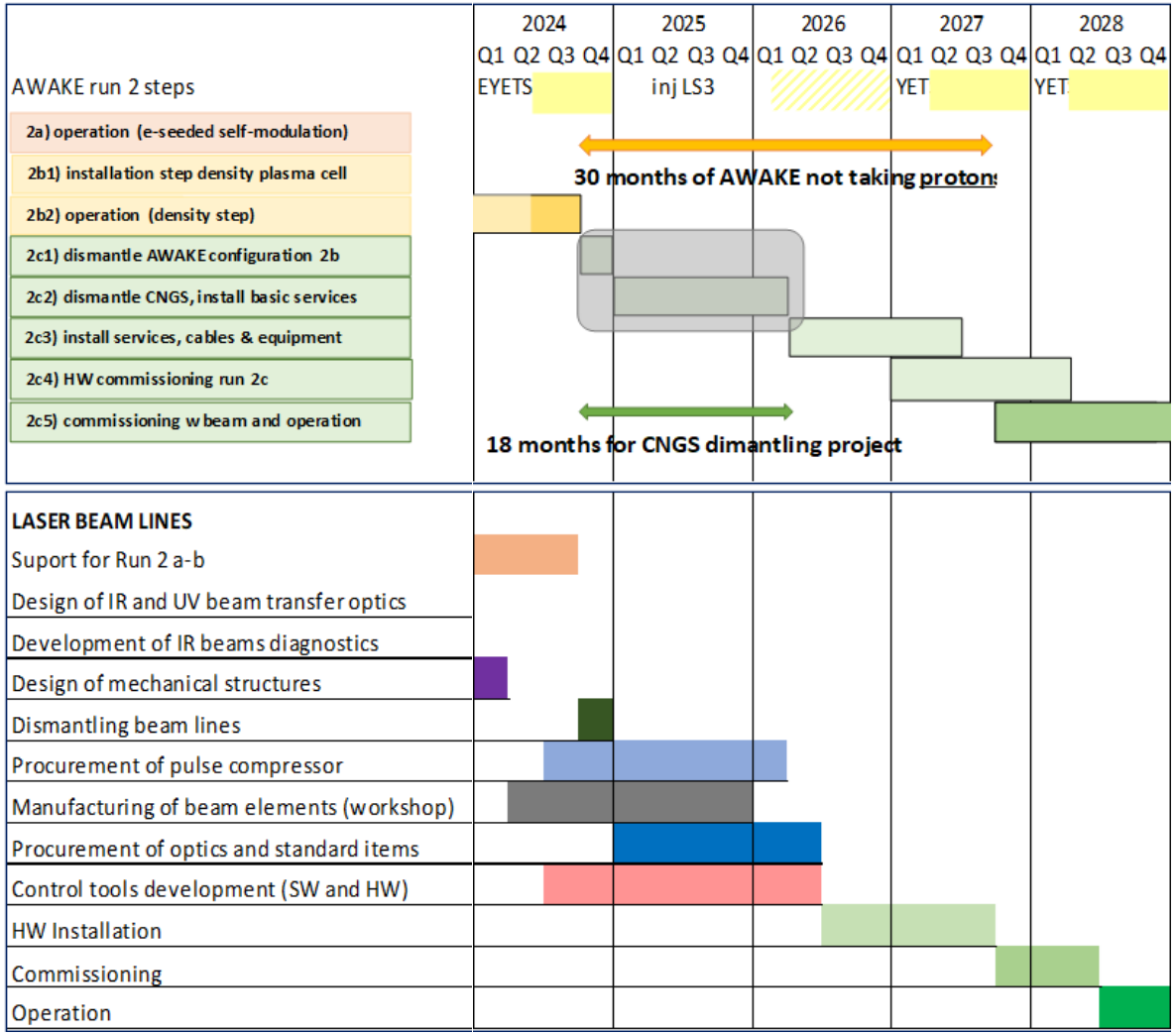
- **IR beams**
  - Timing resolution required for synchronization -> Development of specific optical/electronic diagnostics
  - 2nd Compressor vessel design -> size, location
  - Pulse energy required in each cell? -> May not need reflective telescopes?
  - 2nd cell may be compatible with non-diffractive beam shaping optical elements.
  - Relays with compressed or stretched pulses? Location of the compressor(s)

- **UV beams**
  - Preferable option is to use a separate laser (as in CTF2) 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, copper cathode capability
    - 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? CTF2 tests will help answering these questions
  - Photocathode material for fs gun -> emmitance and charge requirements -> UV energy needs.
  - Pulse shaping in transverse/longitudinal capabilities?

Design work, integration, production, commissioning…

- Design office – EN/MME
  - IR and UV beamline elements and systems with Nicolas Chritin
- Vacuum – TE/VSC
  - IR and UV transfer systems (Chiara Pasquino) with Jose
- Access system – EN/AA
  - Input from Vitor to the integration WP is available (?)
  - Laser PPS by Miriam Munoz Codoceo
- Equipment control – BE/CEM
  - Coordinate with Odd Andreassen and Mario De Castro, foreseen to hire a QUEST and PJAS
- Overall Integration – EN/ACE
  - To coordinate with Frederick Galeazzi
- Cooling for new UV laser and laser cabin ventilation – EN/CV
- Timing/synchronization and RF gun – SY/RF
  - To coordinate with Ben Wooley for RF locking systems
  - To coordinate with Steffen Doebert for photocathode needs
- Diagnostics integration / handshaking – SY/BI
  - To be discussed with BI CP Stefano Mazzoni
- Cabling requests to be detailed (and new racks) – EN/EL
- New UV laser room construction – BE/EA (Vincent Clerc)

Schedule of activities and spending profile



Task	2024				2025				2026				2027				2028				2029				2030				Total
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Design work and jobs																													
Optical design of IR and UV beams			20		75																								95
Opto-mechanical design main components			10		20																								30
IR/UV standard boxes					40				20																				60
IR/UV standard piping vacuum							50		200				300				200												750
Supports for standard boxes									50				50																100
Procurement of main components																													
Pulse compressor					250																								250
UV laser																													
Optical elements			20		20				20				20																80
Optomechanical components			20		10				10				10																50
Diagnostics and instrumentation							20		50				50				40												160
Motorization and controls							40		40				50				50												180
Optical tables													60																60
Installation																													
UV laser room (electricity, water, ventilation)																													
Pedestals and supports														300															300
Safety systems														40															40
Control Systems										100				100				80											280
RF locking systems														40															40
																													2475
Materials	40				340				120				190				90				50				50				
Jobs	30				185				270				350				200												
Personnel									100				100				80												
Fellows STI-LP	0				150				150				150				50				50				50				
Sum per year (estimate)	**70**				**675**				**640**				**790**				**420**				**100**				**100**				**2795**
MTP	**386**				**565**				**580**				**545**				**205**				**148**				**94**				**2523**

Thank you for
your attention!