Center for the Advancement of Natural Discoveries using Light Emission

AREAL Laser System

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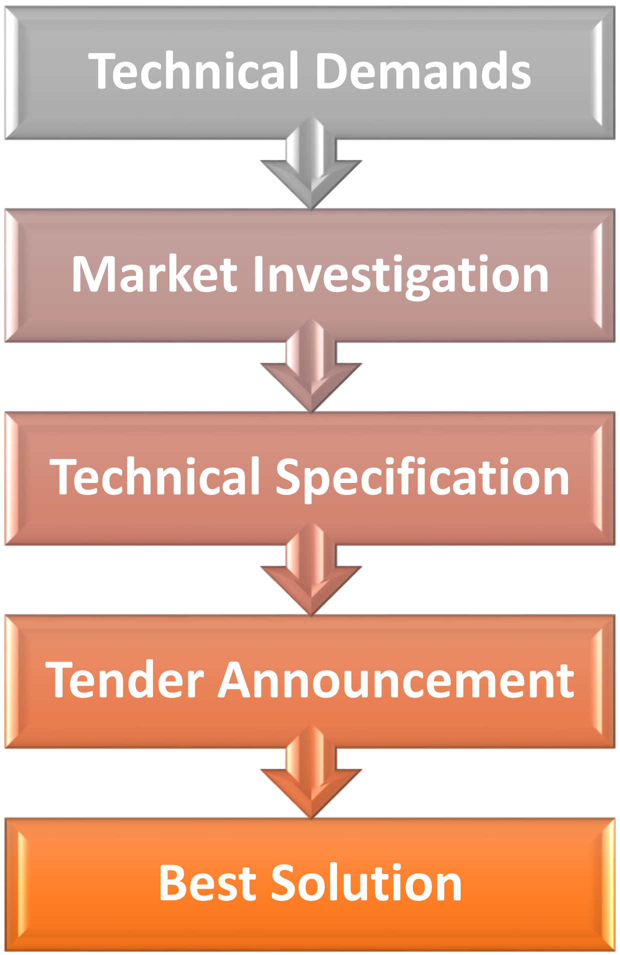
Table of content

Introduction

- ✓ AREAL Laser System provided by Amplitude Systemes is designed to produce UV high energy ultrashort pulses with transverse and longitudinal Gaussian profiles for single and multibunch operation.
- ✓ Laser laboratory placed in temperature stabilized room with air filtration system, equipped with optical table and with necessary tools and diagnostic devices.
- ✓ Laser beam optical path designed with minimal optical elements which are optimized for specific UV radiation. Also minimized direct contacts with the vibrations sources.

How we have chosen the laser system?



- Investigated over 35 famous companies
- For tender was invited over 30 companies
- Only 4 companies participated in tender
  - Coherent GmbH
  - Amplitude Systemes
  - Amplitude Technologies
  - Avesta
- Tender won Amplitude Systemes

Laser system performance

Output parameters	Single bunch	Multibunch
Central wavelength	258nm ± 1nm	
Pulse width (FWHM)	0.5 – 4ps (motorized tuning)	0.5ps
Pulse to pulse jitter @49.9654MHz	< 0.5ps rms	
Output pulse repetition rate	1 – 100Hz	49.9654MHz
Pulse energy @258nm	> 200µJ	> 10µJ
Number of pulses within 1µs train	1	16
Beam mode	Gaussian, TEM_{00} $M^2 < 1.3$	
Beam divergence (FWHM)	< 300µrad	< 1200µrad
Beam diameter	4mm	1mm

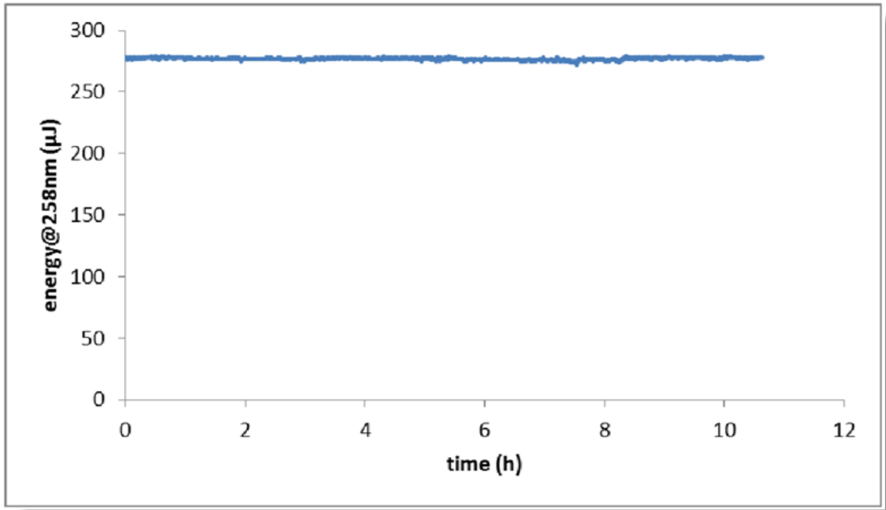
Additional:

- ✓ possibility to synchronize oscillator with external clock
- ✓ possibility to adjust oscillator rep. rate within 10 kHz range with < 100 Hz accuracy
- ✓ Pulse picker able to select any pulse from oscillator pulse train

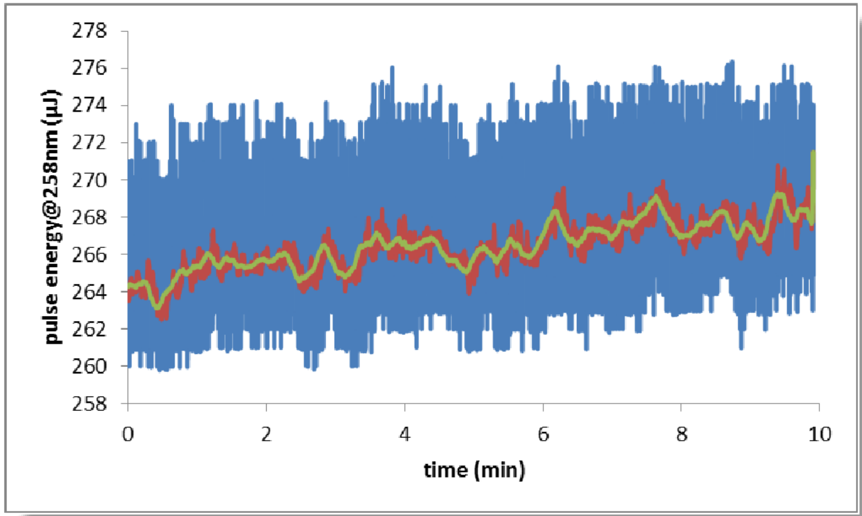
Laser system performance

Operation Parameters	
Cold start-up time	15 min
Ambient temperature	20°C to 24°C ± 1.5°C

Pulse energy stability @258nm	
short term ~10 min	< 1% rms @ ±1.5°C
long term ~11 hours	< 0.3% rms @ ±1.5°C



Long-term stability. Typical power stability of FHG on s-Pulse HP² laser: 0.3% rms over 11 hours. Measure done on an energy averaged over 16s.



Short-term stability. Typical energy stability of FHG on s-Pulse HP² laser: 1.0% rms. Measure done on each UV pulse @100Hz (blue), averaged over 1s (red) and 10s (green).

t-Pulse Oscillator

Average power	1 W
Pulse duration	200 fs
Pulse energy	20 nJ
Central wavelength	1030 nm
Spectral bandwidth	5 nm
Beam quality	TEM_{00}
Repetition rate	49.9654 MHz
tuning range	10 kHz
tuning accuracy	100 Hz
Gain material	Yb doped
Dimensions	60 x 20 cm

t-Pulse is a highly stable and compact diode pumped femtosecond oscillator with high average power, exceptional energy per pulse and excellent pulse-to-pulse stability.

s-Pulse HP^2 Amplifier

Average power	8 W
Pulse duration	0.5 – 4 ps
Pulse Energy	2 mJ
Central Wavelength	1030 nm
Spectral bandwidth	5 nm
Beam quality	TEM_{00} (M^2<1.3)
Repetition Rate	1 – 100 Hz
Gain material	Yb:KGW
Dimensions	75 x 50 cm

The s-Pulse is a femtosecond regenerative amplifier built on a single, compact, and hermetically sealed monolithic housing for improved stability. It features simple control electronics, user adjustable repetition rate without internal laser adjustment, complete set of diagnostics, and no requirements for external water cooling.

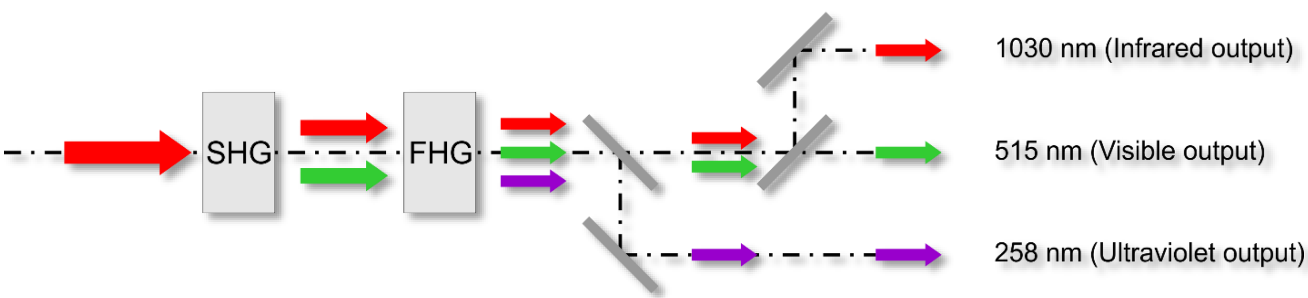
Multibunch Module

The pulse splitter or multibunch module will allow to get 16 pulses per 1 μs train at 49.9654 MHz repetition rate with pulse energy of 10 μJ @258 nm. Pulse duration will be 500 fs and 1 mm of beam diameter with 600 μrad divergence.

This module is under development.

FHG Module

The frequency converter consists in two nonlinear conversion stages. The first stage is a second harmonic generation stage, designed to convert the fundamental wavelength of 1030nm into 515nm wavelength radiation. The setup consists in a BBO crystal used in type I configuration. The conversion efficiency is adjusted to 50%, in order to keep the excellent beam quality. The second stage is a second harmonic generation designed to convert the 515nm beam into 258nm wavelength radiation. The setup consists in a BBO crystal used in type I configuration. The conversion efficiency from green to UV is designed to achieve >20%, together with an excellent beam quality. The overall conversion efficiency from IR to UV is then >10%.
Dielectric filters are then used to isolate the UV beams by spatially separating the IR, green and UV radiation.



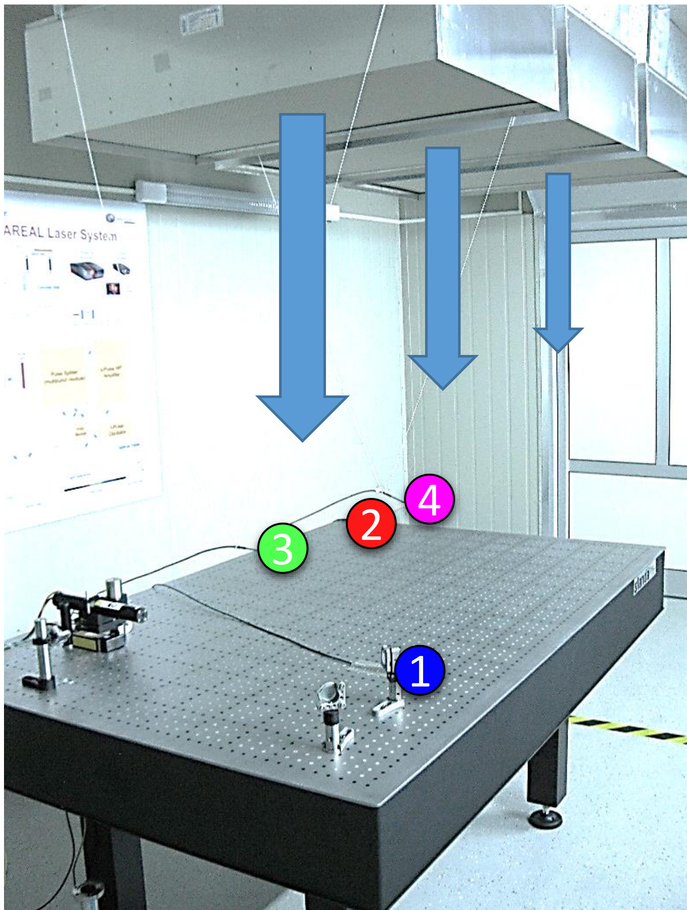
Control Electronics

The control electronics consists of a power supply, a timing unit, and a synchronization unit, integrated in three 19" racks. The laser can be controlled from the front panel but also via a RS232 protocol. The laser software is user-friendly and is programmable via RS232.

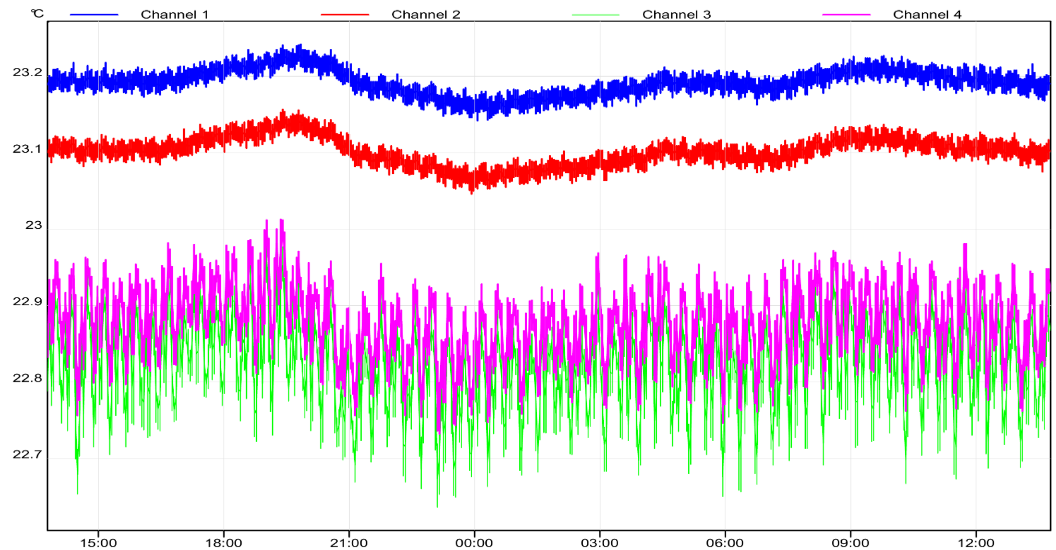
Power supply	
Voltage	90 – 265 V
Frequency	47 – 63 Hz
Consumption	
During warm up	< 1 kW
After warm-up	< 400 W

A monitor output "TRIG OUT" provides a control signal at the laser repetition rate. It can also be controlled in external mode (TTL signal), where the user provides a signal at the desired repetition rate, or an enable/disable signal for the laser emission (GATE).

Laser Laboratory



Laser laboratory equipped with an air filtering and temperature stabilization systems. Air filters pleased above optical table and provides laminar air flow, due to that optical table surface have stable temperature with ±0.1°C accuracy.



Temperature measurement data during 24 hours

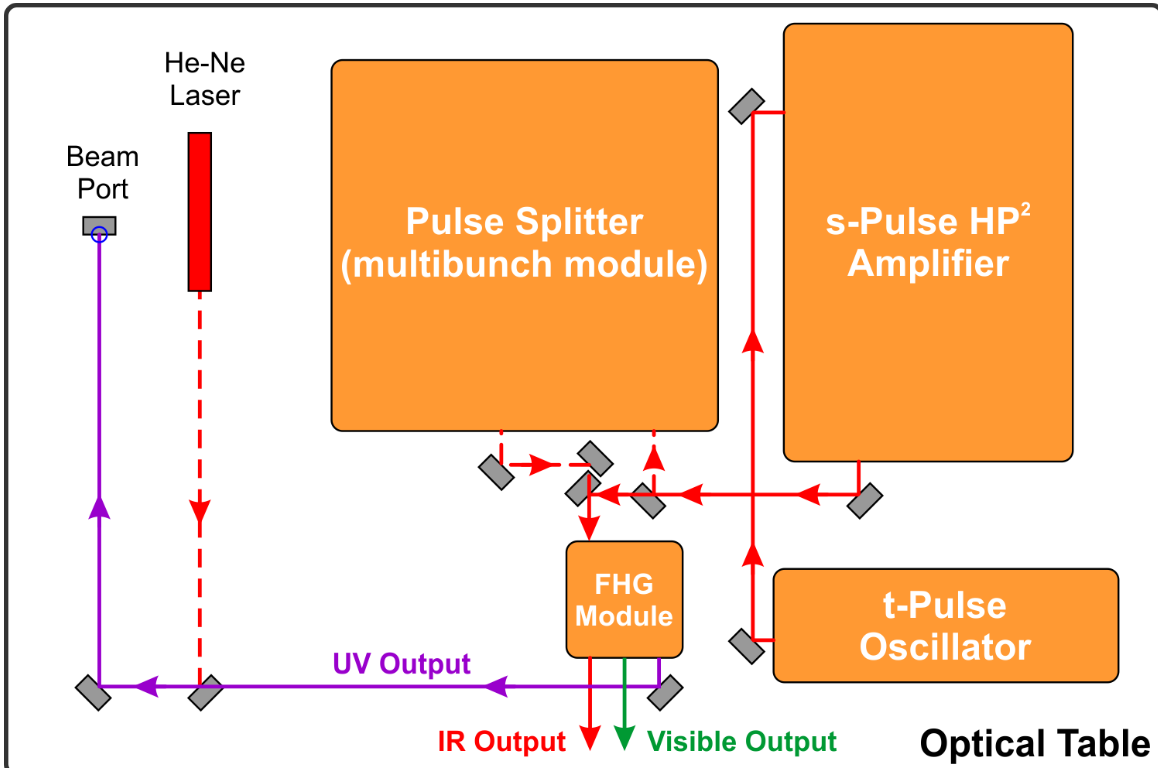
Optical Table

Optical table consists of honeycomb breadboard and rigid connected table support. Optical table is type of passive vibration isolation.

The table top have laser port which location is designed as to lead laser beam trough the table directly to the tunnel laser port.

Honeycomb breadboard	
Top skin	5mm ferromagnetic stainless steel
Surface flatness	±0.1 mm/m^2
Pattern	M6 holes spaced by 25mm
Honeycomb core	0.25 mm thick steel
Deflection under load	4 µm (100 kg centrally loaded)
Resonant frequency	~200 Hz
Transient excitation delay time	50 ms
Dimensions	1200 x 1800 x 200 mm
Laser port diameter and location	21 mm / 150 x 375 mm
Support	
Material	Steel Tube 100 mm square section
Shape	assemble of two “П” type supports
Dimensions	650 x 1200 x 500 mm
Leveling Elements	Solid, top and bottom
Table total height	~800 mm

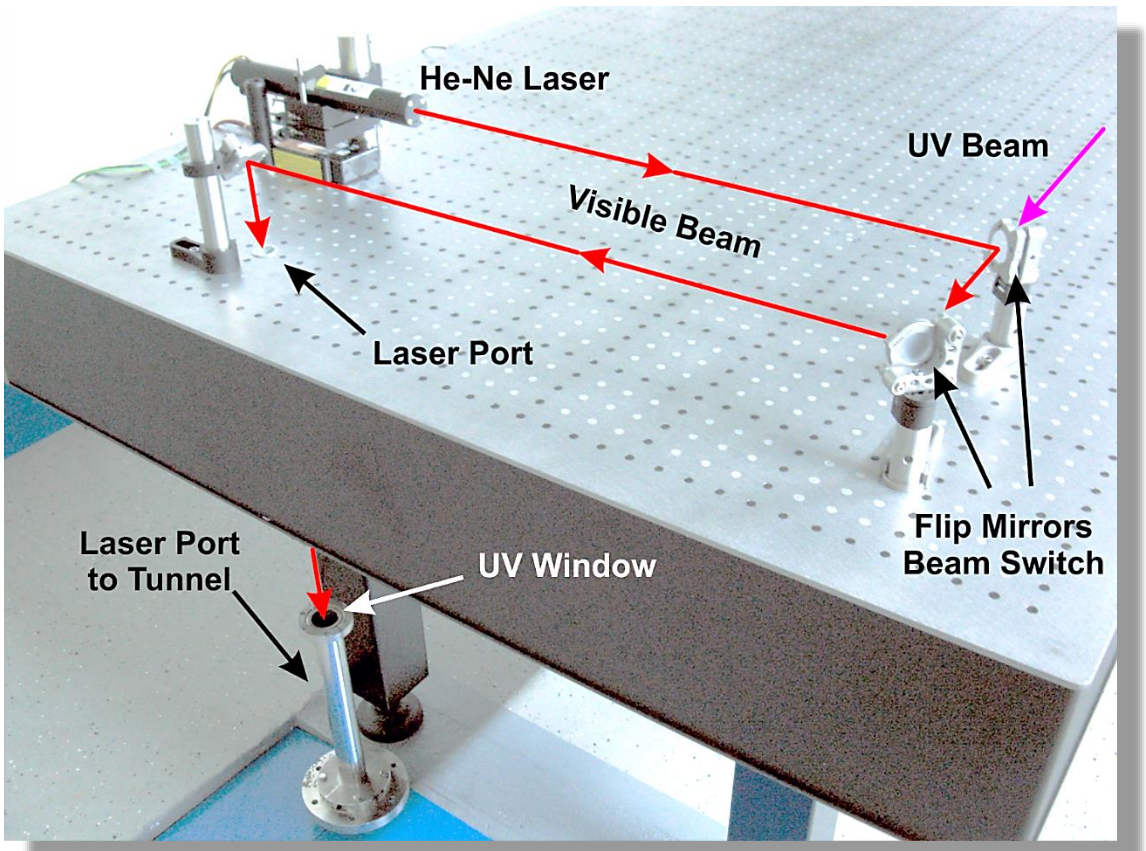
Laser system layout



AREAL Laser System consists of:

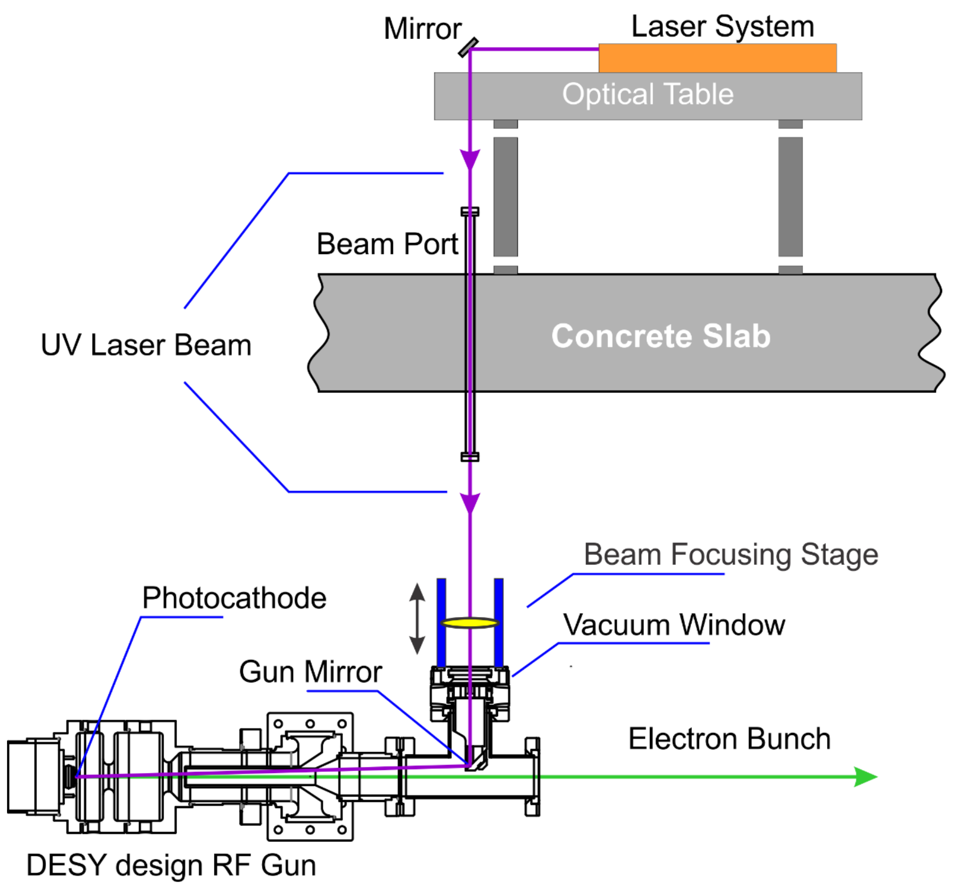
- t-Pulse Oscillator
- s-Pulse HP^2 Amplifier
- Pulse splitter (multibunch) module
- FHG module (frequency converter)
- Control electronics

Laser system layout



- ✓ For laser beam alignment along whole optical path, instead of UV beam will be used visible He-Ne laser.
- ✓ Layout have ability to correlate UV and visible beams and easily switch between them using flip mirrors.
- ✓ Special optomechanics chosen for specified layout to keep long term, high precision stability.
- ✓ For laser beam transportation from laser laboratory to the tunnel used direct, vertical laser port through optical table and concrete slab between floors.

Laser system layout

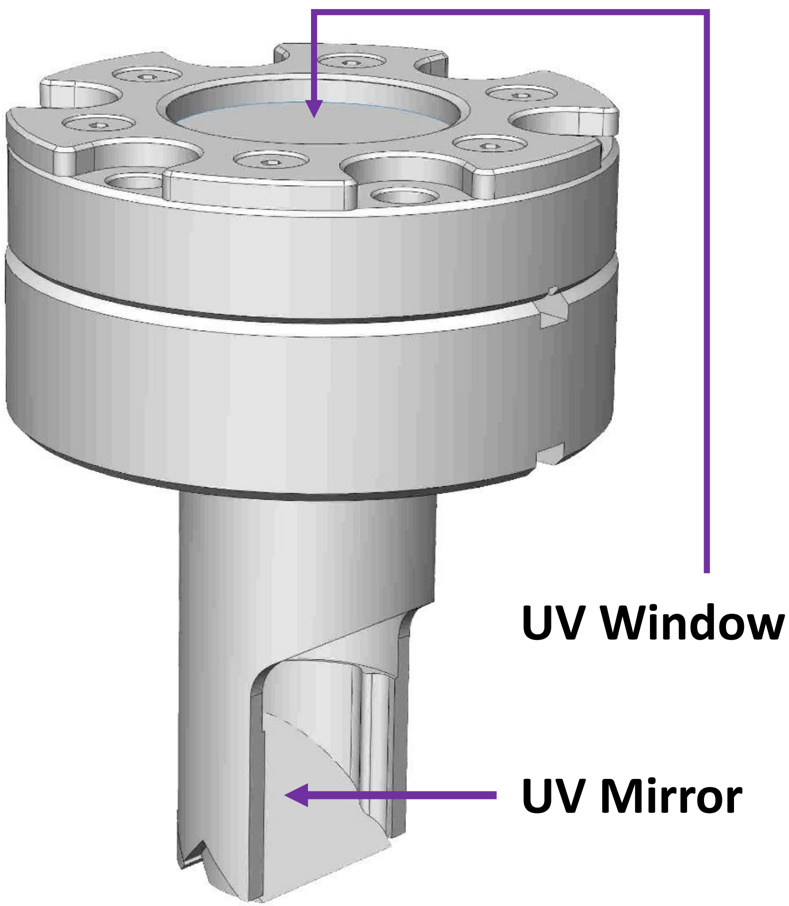


In the tunnel laser beam will vertically drop near the RF Gun. Two layouts are possible to enter RF Gun laser port:

- vertical, direct entrance with vertical beam focusing stage connected to the gun vacuum UV window
- side entrance with the same vertical focusing stage and with directive mirror

Tunnel part of optical layout is under consideration.

RF Gun Optics



Last chain of Laser system optics is RF Gun laser port with directive mirror.
In order to keep high quality of UV laser beam, window for UV with AR coating is necessary which can keep high vacuum.
Directive mirror inside of RF Gun should be metallic, for UV with HR coating.
Another solution can be dielectric mirror with conductive coating.
Conductivity is necessary to not charge mirror from electron bunch.

RF Gun directive mirror fabrication is under consideration.

UV Optics

All optical elements ordered with optimization for specific UV laser radiation in order to keep laser beam quality and pulse energy as good as possible.

List of ordered optics:

- ✓ HR coating 45° mirror for random polarization – 4 pc
- ✓ AR coating parallel window – 2 pc
- ✓ AR coating plano-convex spherical lens f = 750 mm – 1 pc
- ✓ AR coating plano-convex spherical lens f = 1000 mm – 1 pc

These optics are under fabrication in this moment.

Optomechanics

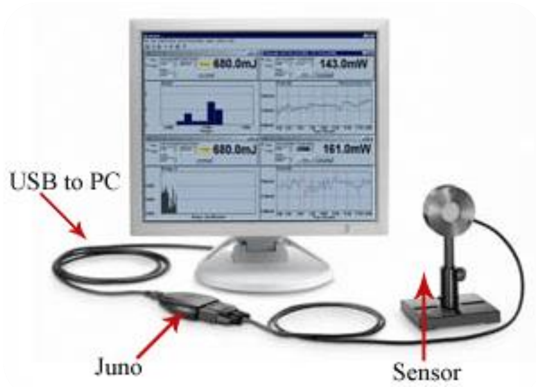
Ordered

- All necessary optomechanics for AREAL 1st phase.
- He-Ne laser to align laser beam optical path.
- Al mirrors for He-Ne laser.
- Necessary tools and kits to work with optomechanics.

To Order

- He-Ne laser for other alignment works.
- Additional optomechanics as an upgrade to existing.
- Missed items.

Laser Beam Diagnostics



Active Area	0.11 cm^2
Spectral Range	150 – 1200nm
Pulse Width	30 µs
Power Density, Maximum Average	50 W/cm^2
Cooling	Sensor Body
Active Diameter	12 mm
Power Range	1 µJ - 2 W
Maximum Repetition Rate	25KHz for pulse width < 1 µs
Linearity	±2% for energy > 10% of full scale
Operating Temperature	15 to 28ºC, RH< 80%
Weight	0.25 kg

Unique Pyroelectric Energy Sensor was ordered to be able to measure high energy UV pulse energy in order to monitor pulse to pulse energy stability.

To Do

- ❑Laser system installation
- ❑Laser system performance measurements
- ❑Laser system layout finalization
- ❑Laser beam alignment
- ❑Laser system control automation

Thank you for attention!