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APPLICATIONS

EuPRAXIA

Laser systems for EuPRAXIA@SPARC_LAB

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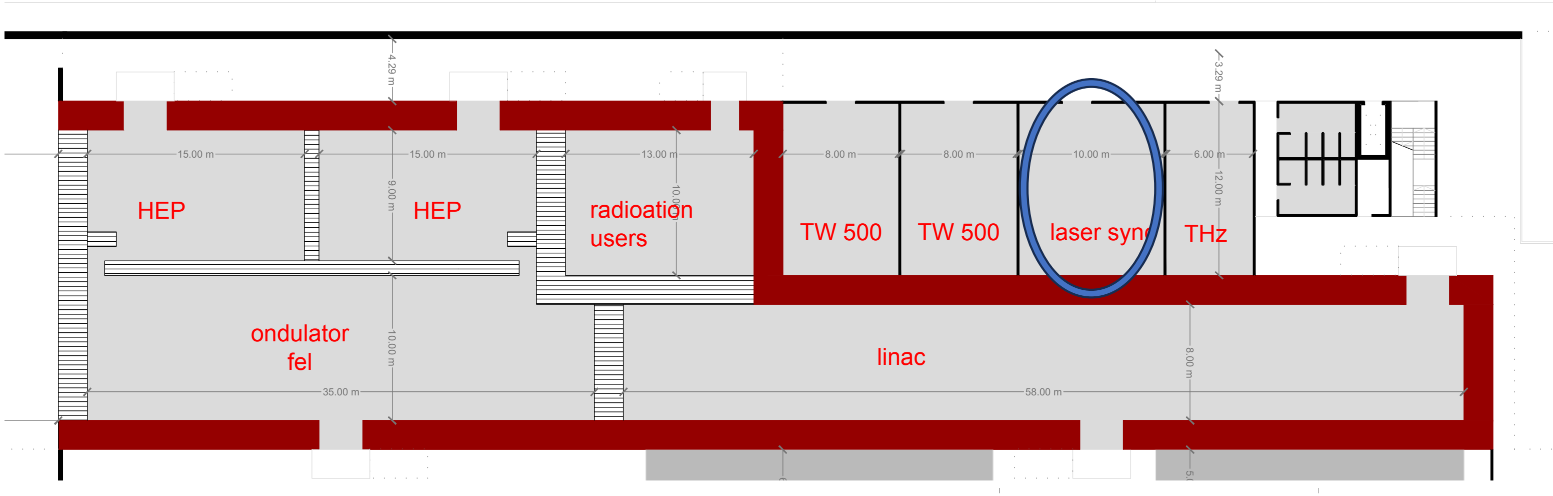
Funded by the European Union

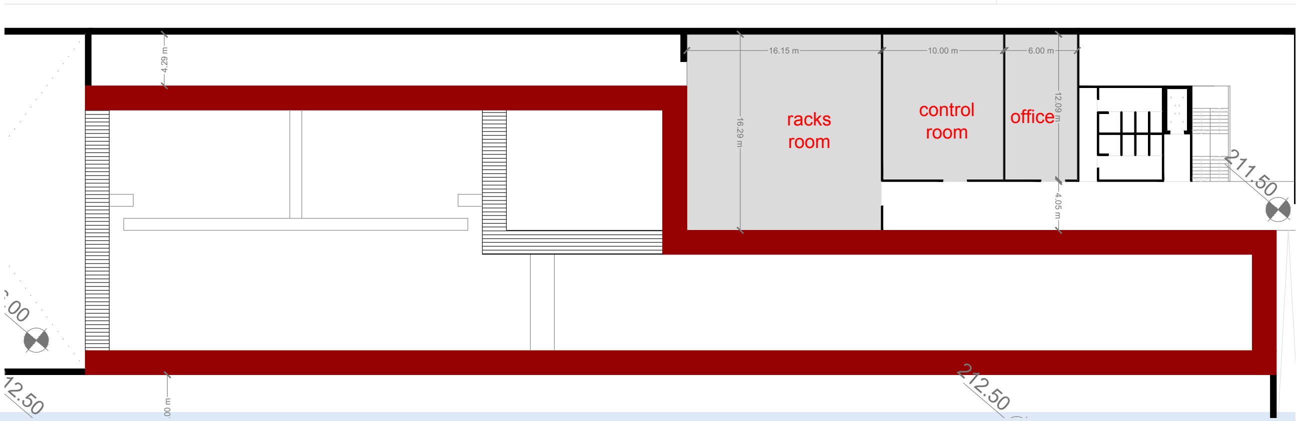
Outline

- The photocathode laser:
  - General layout
  - Machine requests on the laser side
  - General laser scheme
  - Example of an existing IR laser system
  - R&D: Transverse profile and energy stability on SABINA
  - Full scheme (UV part)
  - Estimation of the losses
  - Conclusions

The photocathode laser: layout



Ground floor



First floor

The photocathode laser: main requests

«n» laser beams (COMB configuration) in UV on the cathode with:

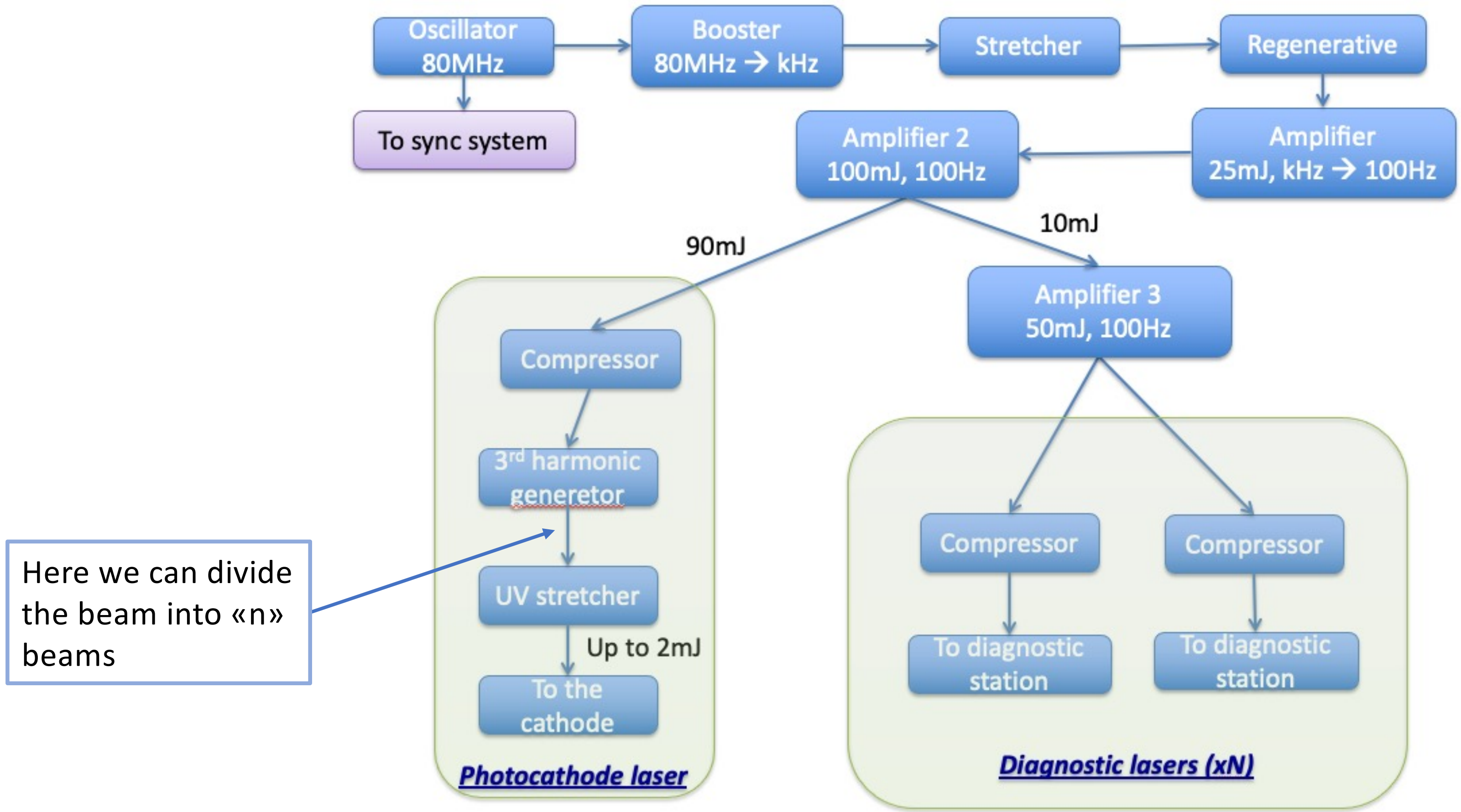
a. Different spot-sizes

b. Different temporal lengths

c. Transversally homogeneous (peak-to-peak difference <10%)

d. Energy stability <1%

The photocathode laser: the scheme



The photocathode laser: example of system

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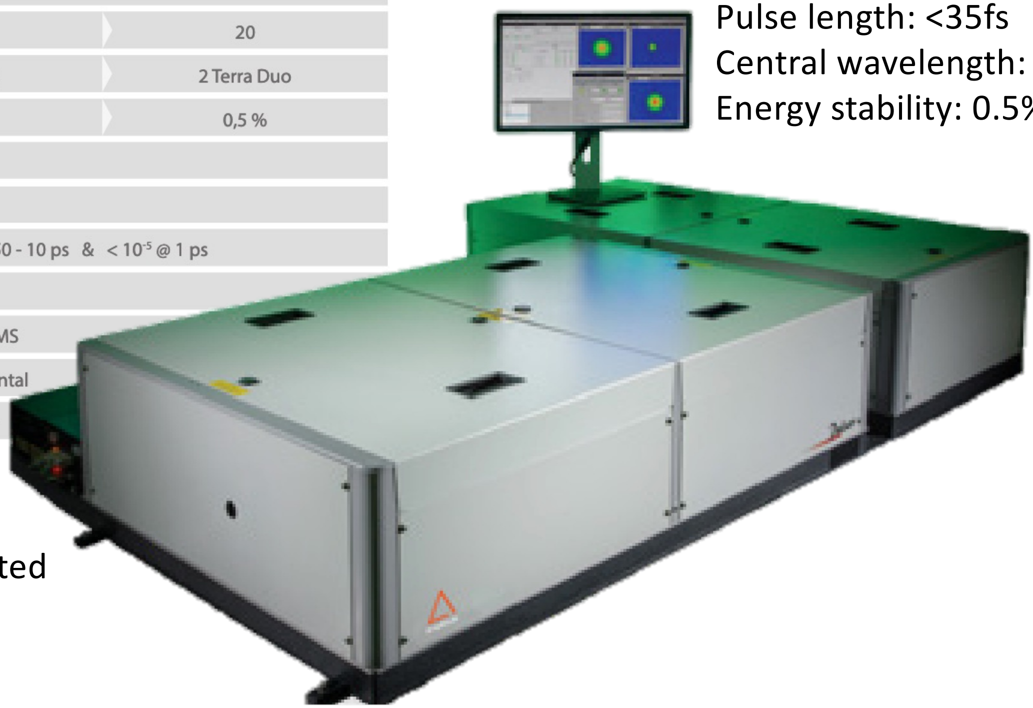
Specifications

ARCO C (100 Hz) & ARCO M (1 kHz)

Repetition Rate [1]	100 Hz for Arco C			1 kHz for Arco M		
Energy Per Pulse [2]	6 mJ @ 100 Hz	5 mJ @ 1 kHz	12 mJ @ 100 Hz	10 mJ @ 1 kHz	25 mJ @ 100 Hz	20 mJ @ 1 kHz
Pulse Width (fwhm) [3]	< 100 fs or < 35 fs or < 20 fs					
Central Wavelength (nm) [4]	800 ± 10					
Average Power (W)	5		10		20	
Pump Lasers	Terra		Terra Duo		2 Terra Duo	
Pulse To Pulse Energy Stability (RMS)[5]	0,7 %		0,7 %		0,5 %	
Power Stability (RMS) [6]	1 %					
Nanosecond Contrast [7]	$< 5.10^{-4}$					
Picosecond Contrast [8]	$< 5\ 10^{-7}$ @ 300 - 50 ps & $< 10^{-6}$ @ 50 - 10 ps & $< 10^{-5}$ @ 1 ps					
Beam Quality M²	< 1.3					
Pointing Stability	< 10 µrad RMS					
Polarization	Linear horizontal					
Warm-up Time	< 1 hour					



IR part

Rep rate: 100Hz
Energy per pulse: 100 mJ
Pulse length: <35fs
Central wavelength: 800nm
Energy stability: 0.5%

100mJ – 100 Hz is feasible and rms stability is expected not to exceed the 0.5% in IR and <1% in UV.

The photocathode laser: main requests

Once that the IR part is chosen, we have to understand how to satisfy the machine requests:

«n» laser beams (COMB configuration) on the cathode with:

a. Different spot-sizes
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The photocathode laser: main requests

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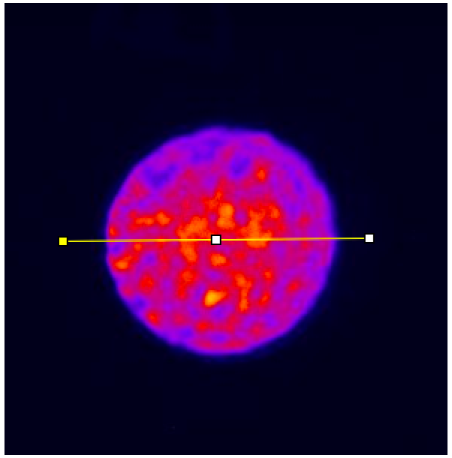
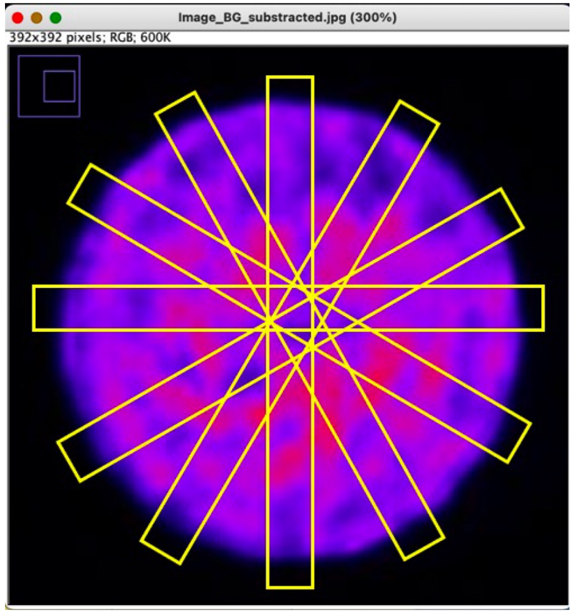
R&D with SABINA

The photocathode laser: R&D on SABINA



This was the laser beam transverse profile before SABINA project.
Energy stability was 3-5%.
Peak-to-peak uniformity: about 30%.



In order to have the highest peak-to-peak uniformity and to avoid to have areas within the beam where the uniformity did not correspond to the requests, we have ask the supplier to measure the transverse uniformity in rectangles rotated by 30 degrees (6 measurements in total)

The photocathode laser: R&D on SABINA

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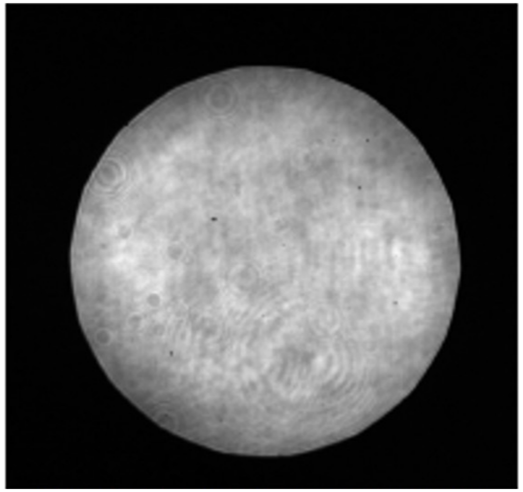
To reach the goal, Amplitude has chosen to pump the main amplifier with 3 pumps instead of 2 and use DOE at the pump exit so to have homogeneous pump heating the crystal.

This is the laser beam transverse profile now.

Peak-to-peak uniformity is <10%.

The use of more pumps for the last amplifier has also an impact on Energy stability which is now <1%.



The photocathode laser: main requests

«n» laser beams (COMB configuration) on the cathode with:

a. Different spot-sizes

b. Different temporal lengths

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The photocathode laser: full scheme

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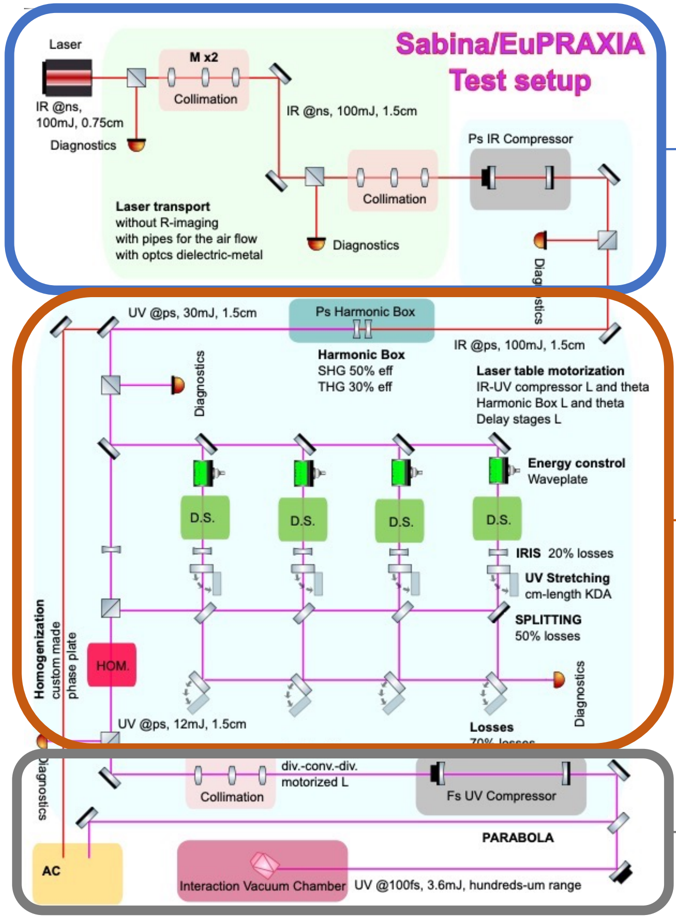

Located in the clean room
I.E. the ARCO system

Located in the clean-room:
n beam with different spot size and different length

Located near the cathode

The photocathode laser: full scheme

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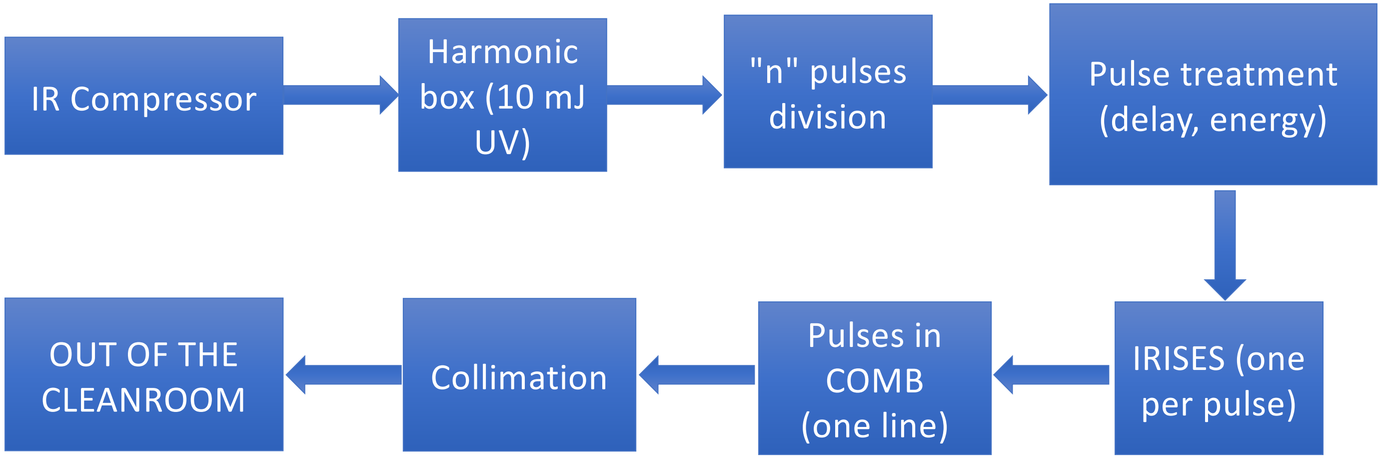
IN THE CLEAN ROOM AFTER COMPRESSION



RISES will be one per pulse to guarantee maximum flexibility on transverse pulse diameter on the cathode).

To have flexibility on pulse duration, we can use dispersive materials (an example is KDA).

The photocathode laser: full scheme

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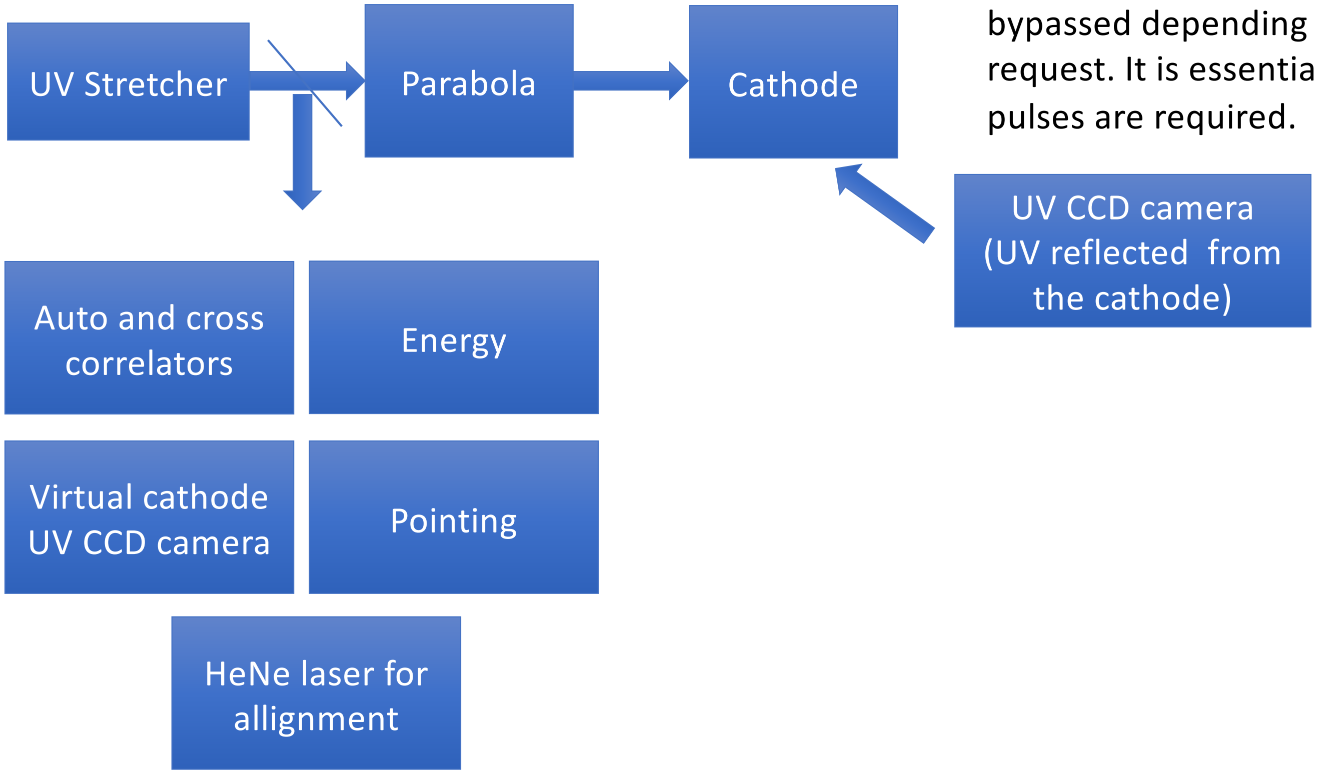
ON THE OPTICAL TABLE NEAR THE CATHODE



UV stretcher can be used or bypassed depending on the request. It is essential if short pulses are required.

The photocathode laser: losses

EXTIMATION OF LOSSES AND FINAL ENERGY ON THE CATHODE

1. Compressor exit 90 mJ IR →
2. Harmonic box (30 mJ UV) →
3. "n" pulses division →
4. Pulse treatment (delay, energy) 30%losses →
5. IRISES (one per pulse) 20% losses →
6. Pulses in COMB (one line) 50% losses →
7. Collimation →
8. UV Stretcher 70% losses

2 CASES:

1. All pulses have the some duration:
   we will have 2.5 mJ on the cathode
   (TOTAL MAX ENERGY, to be divided by n number of pulses);

2. All pulses have different pulse duration:
   we have to use a material to introduce dispersion
   → other 30% of losses, ending up with about 1.75 mJ
   on the cathode (TOTAL MAX ENERGY, to be divided by n number of pulses).

Cathode Laser System			
	Witness	Driver	
Charge [Q]	30	200	pC
Time delay [Δt]	- 4.8	0	ps
Laser Spot size [σ_r]	175	300	µm
Laser Pulse length [σ_t]	0.30	0.40	ps

Conclusions

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FOR THE PHOTOCATHODE LASER:

«n» laser beams (COMB configuration) on the cathode with:

- ✓ Different spot-sizes
- ✓ Different temporal lengths
- ✓ Transversally homogeneous (peak-to-peak difference <10%)
- ✓ Energy stability <1%

EuPRAXIA-PP Consortium

EuPRAXIA

Coordinator

INFN Istituto Nazionale di Fisica Nucleare

Consiglio Nazionale delle Ricerche

Elettra Sincrotrone Trieste

ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

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FBH Leibniz Ferdinand Braun Institut

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hhu Heinrich Heine Universität Düsseldorf

HZDR Helmholtz Zentrum Dresden Rossendorf

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- EuAPS

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The seeding laser

Courtesy of M. Galletti