

# Seeding the FEL of the SPARC Facility with the 3<sup>rd</sup> laser harmonic of a Ti: Sa laser produced in gases

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## MOTIVATIONS

- SPARC: European Project for the development of a FEL source based on a LINAC, producing short wavelengths.
- Principle of Self Amplified Spontaneous Emission: already demonstrated.
- Drawbacks: → limited temporal and spectral coherences  
 → long saturation length  
 → heavy equipment

- Seeded FEL:
  - \* Shorter saturation lengths → compact facility
  - \* Reproduces the coherence properties of the seeded signal
  - \* Reduces the intensity fluctuations  
 → increases the interest of the source for users

- Harmonics Generation in gases:
  - \* VUV seed: 266 and 160 nm.
  - \* Intense seed: >50 nJ
  - \* Ultra-short seed: <100 fs
  - \* Coherent seed

## GENERAL PRINCIPLES AND CHARACTERISTICS

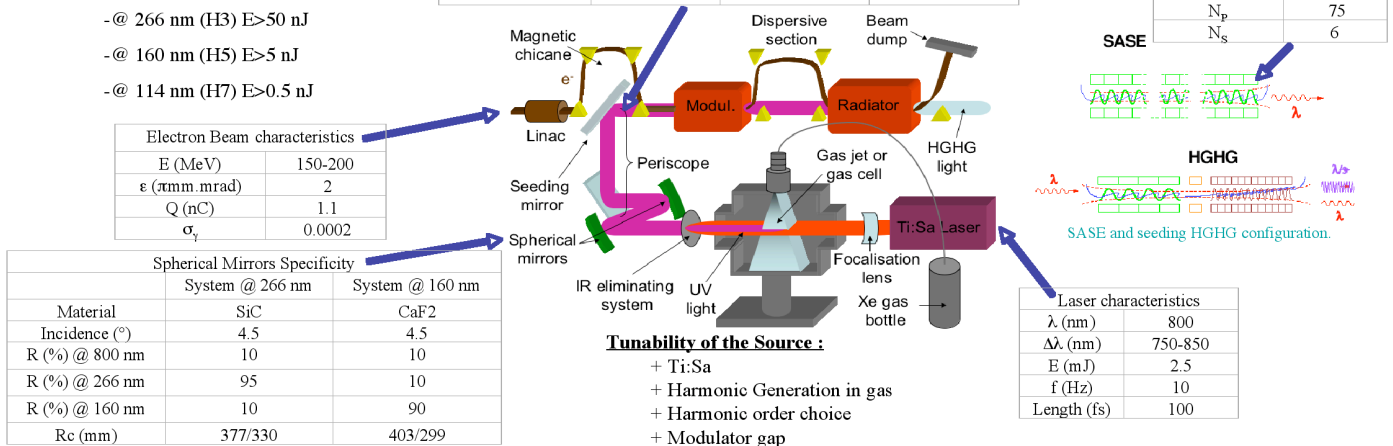
### Harmonic Generation in gases :

- \* Coherent Light source at  $\lambda/n$
- \*  $M2 \approx 2-4$
- \* Performances of the conversion:
  - @ 266 nm (H3)  $E > 50$  nJ
  - @ 160 nm (H5)  $E > 5$  nJ
  - @ 114 nm (H7)  $E > 0.5$  nJ

Electron Beam characteristics	
E (MeV)	150-200
$\epsilon$ (mm.mrad)	2
Q (nC)	1.1
$\sigma_x$	0.0002

Harmonic Beam Characteristics (System for 266 nm)			
	@ 800 nm	@ 266 nm	@ 160 nm
E (nJ)	250	800	0.02
Peak Power	2.5 MW	8 MW	200 W

Undulators characteristics	
$\lambda_0$ (cm)	2.8
Gap (cm)	0.6 – 2.5
K	3.2 – 0.38
$N_p$	75
$N_s$	6



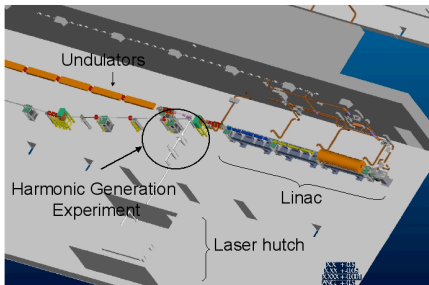
### Tunability of the Source :

- + Ti:Sa
- + Harmonic Generation in gas
- + Harmonic order choice
- + Modulator gap

Laser characteristics	
$\lambda$ (nm)	800
$\Delta\lambda$ (nm)	750-850
E (mJ)	2.5
f (Hz)	10
Length (fs)	100

Spherical Mirrors Specificity		
	System @ 266 nm	System @ 160 nm
Material	SiC	CaF2
Incidence (°)	4.5	4.5
R (%) @ 800 nm	10	10
R (%) @ 266 nm	95	10
R (%) @ 160 nm	10	90
Rc (mm)	377/330	403/299

## DESIGN



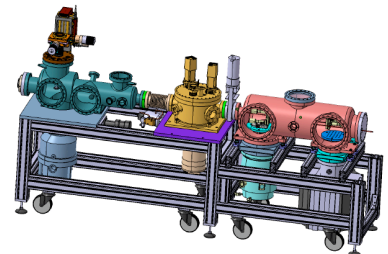
General implantation of the experiment

### Criteria taken into account:

- performances of the harmonics production
- resistance of the materials to damages
- vacuum needs ( $10^{-9}$  mbar in the linac)
- remote control of the whole for security reasons
- geometrical constraints

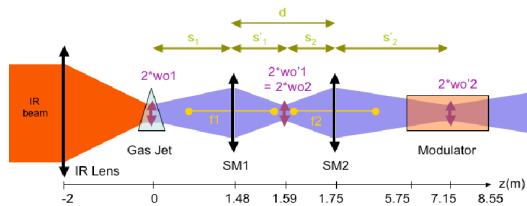
### Choices:

- three chamber systems for faster and better pumping and decreasing the possible damages on mirrors
- In vacuum remote control stepper motors for tils and translations



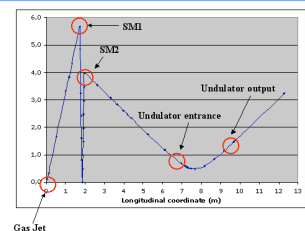
Drawing of the experiment implantation. Thanks to M. Bougeard.

## OPTICAL CALCULATIONS

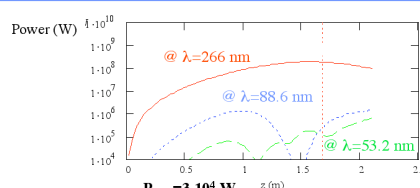
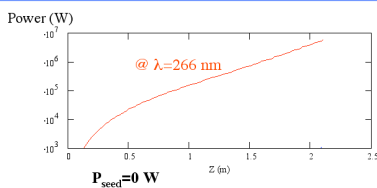


Longitudinal evolution of the IR and harmonics beams in the transversal domain.

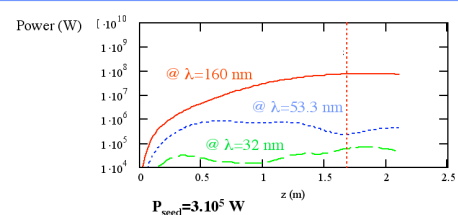
Beam waist profile evolution for H3 radiation from the gas output to the exit of the undulator.



## SIMULATIONS WITH PERSEO



Output radiations produced in the radiator (2<sup>nd</sup> undulator)



## CONCLUSIONS

### Planning:

- November – December 05: end of orderings and reception of the experiment elements
- First trimester 06: assembly of the experiment and tests with the Ti:Sa laser at Saclay
- May-June 06: transportation of the experiment to Frascati, and implementation on SPARC

### Expectations:

- Totally remote control experiment with high vacuum levels
- Seeded radiation fully coherent in the VUV range: harmonic generation in gases
- Control of the position/size/focussing point of the seeded radiation
- Obtention of a compact FEL, with short wavelengths and high peak powers.