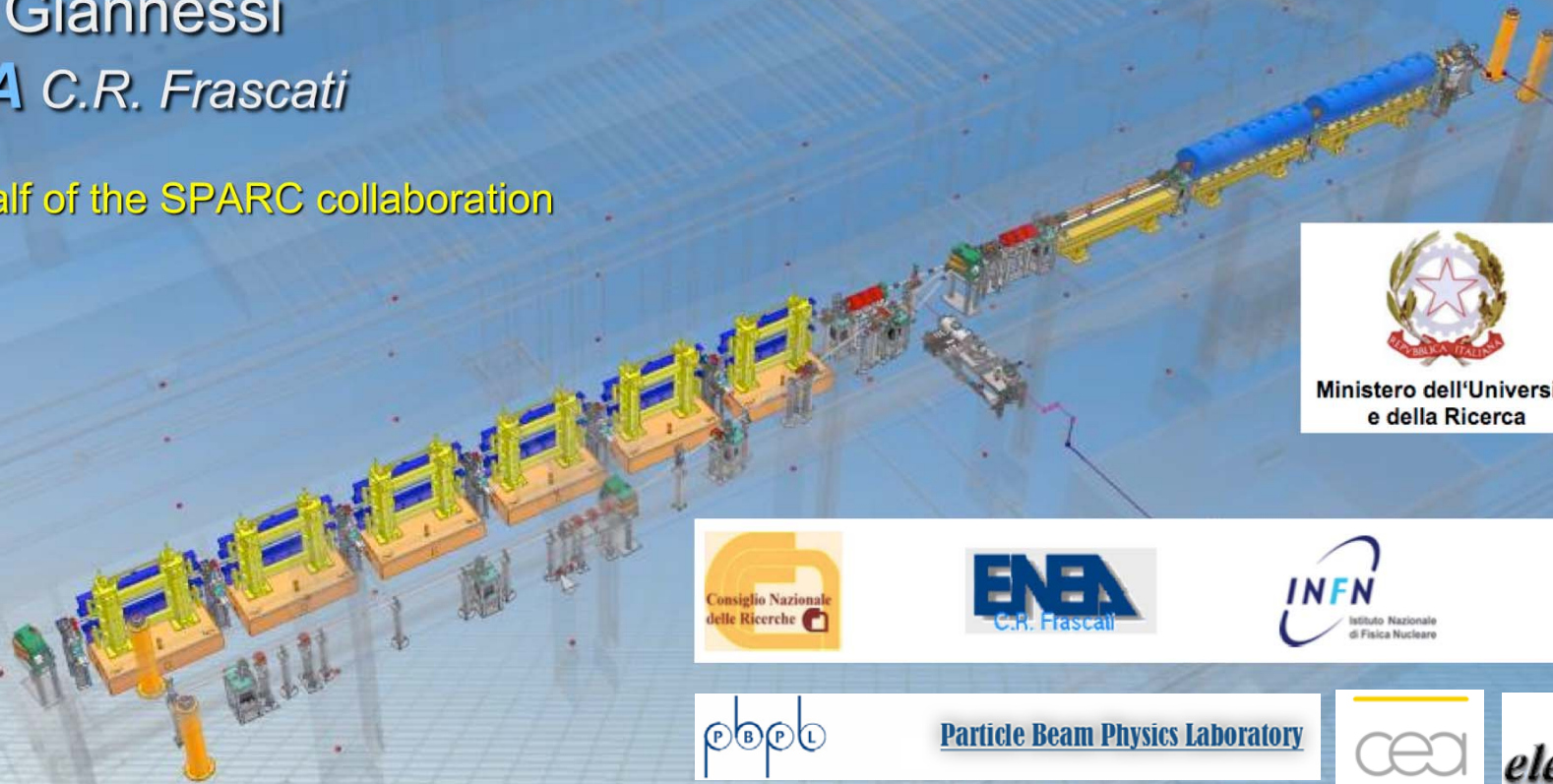


International Conference on Charged and Neutral Particles Channeling Phenomena, 4-8 October 2010, Ferrara, Italy

SEEDING EXPERIMENTS AT SPARC

Luca Giannessi
ENEA C.R. Frascati

On behalf of the SPARC collaboration



Ministero dell'Università
e della Ricerca



Particle Beam Physics Laboratory



Laboratory for
UV and X-ray
Optical Research



Contributors

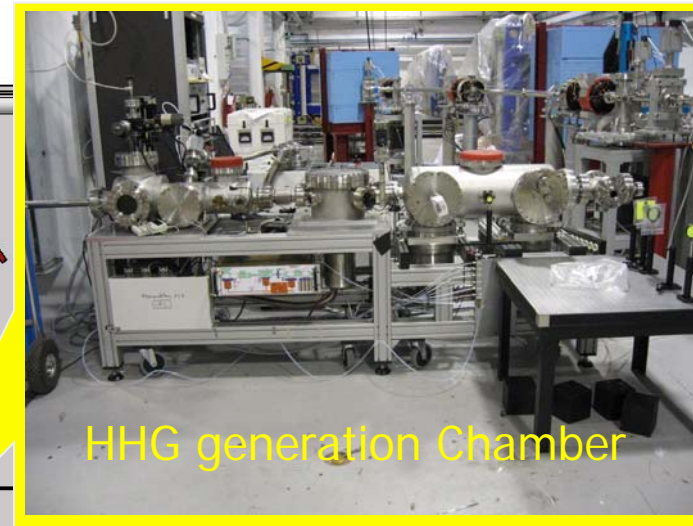
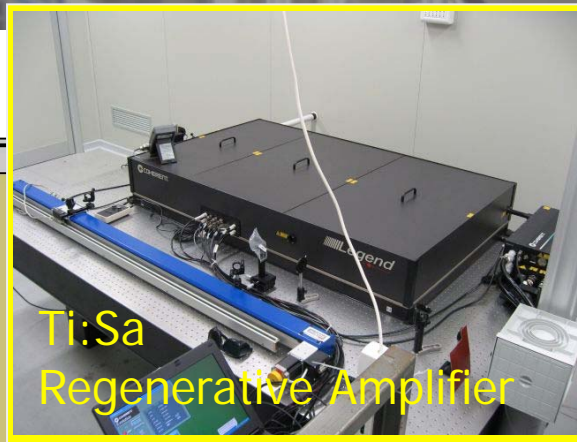
L.G., A. Petralia, G. Dattoli, F. Ciocci, M. Del Franco, M. Quattromini, C. Ronzivalle, E. Sabia, I. Spassovsky, V. Surrenti ENEA C.R. Frascati, P. D. Filippetto, G. Di Pirro, G. Gatti, M. Bellaveglia, R. Boni, D. Alesini, M. Castellano, E. Chiadroni, L. Cultrera, M. Ferrario, L. Ficcadenti, A. Gallo, A. Ghigo, E. Pace, B. Spataro, C. Vaccarezza, INFN-LNF, P. A. Bacci, V. Petrillo, A.R. Rossi, L. Serafini INFN-MI, P. M. Serluca, M. Moreno INFN-Roma I, P. L. Poletto, F. Frassetto CNR-IFN, P. J.V. Rau, V. Rossi Albertini ISM-CNR, P. A. Cianchi, UN-Roma II TV, P. A. Mostacci, M Migliorati, L. Palumbo, Un. Roma La Sapienza, P. G. Marcus, P. Musumeci, J. Rosenzweig, UCLA, CA, USA. S. Spampinati, ST, P and University of Nova Gorica, Nova Gorica, M. Labat, F. Briquez, M. E. Couprie, SOLEIL, FR. B. Carré, M. Bougeard, D. Garzella CEA Saclay, DSM/DRECAM, FR. G. Lambert LOA, FR. C. Vicario PSI, CH.



Seeded SPARC Layout



+ MUR



L. Giannessi, Channeling 2010





Seeding @ SPARC



Ministero dell'Università e della Ricerca

GAS Cell

Infrared



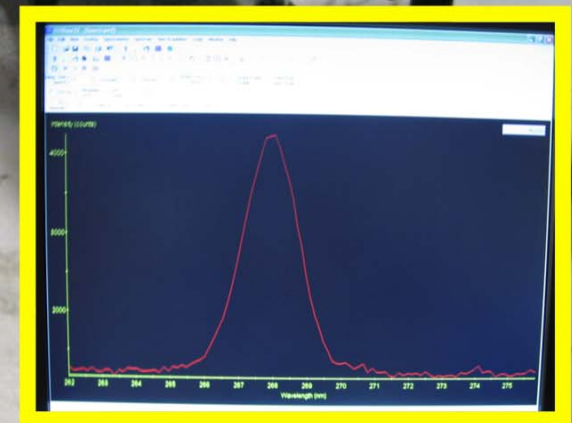
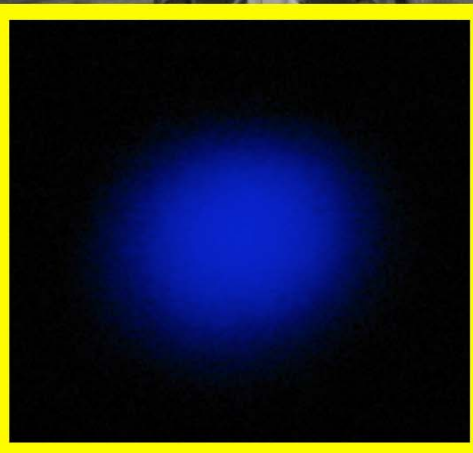
Focusing mirrors

to Undulators

Differential vacuum

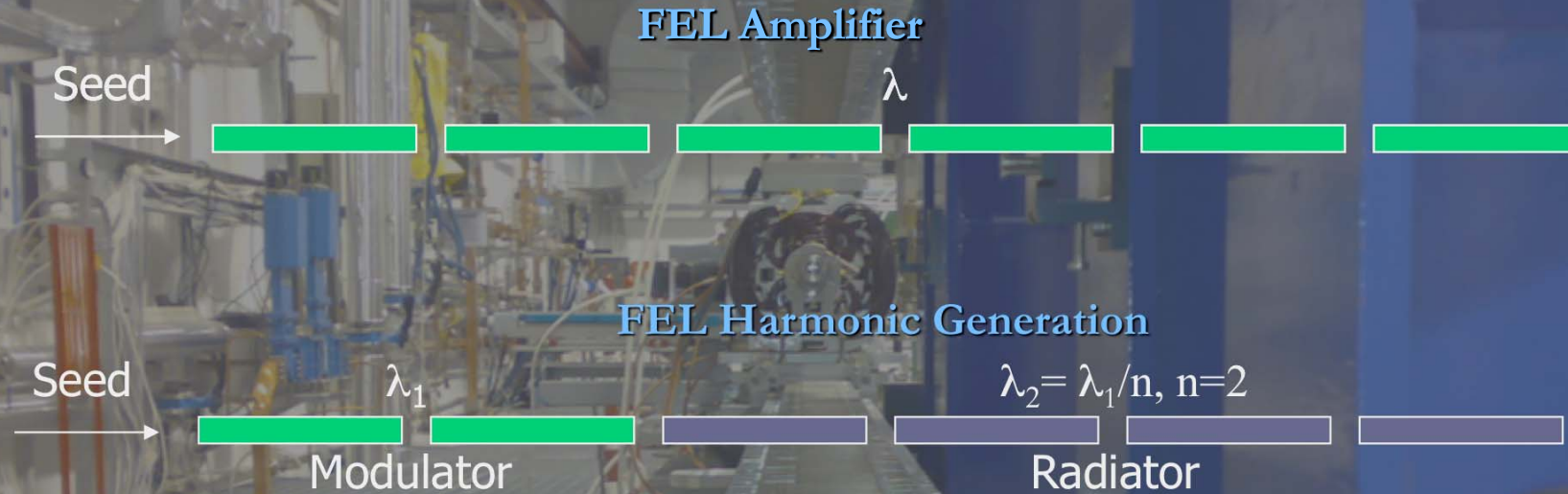


Dec. 2007



L. Giordano, INFN Frascati

Seeded Operation



- Seed Sources:

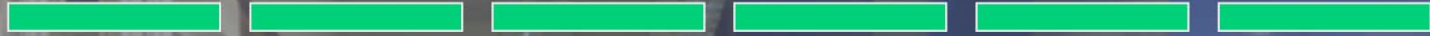
- 400 nm in BBO crystal (high seed energy)
- 266 nm & 160 nm generated in gas

Cascaded FEL tested with both seed configurations



FEL Amplifier

Seed



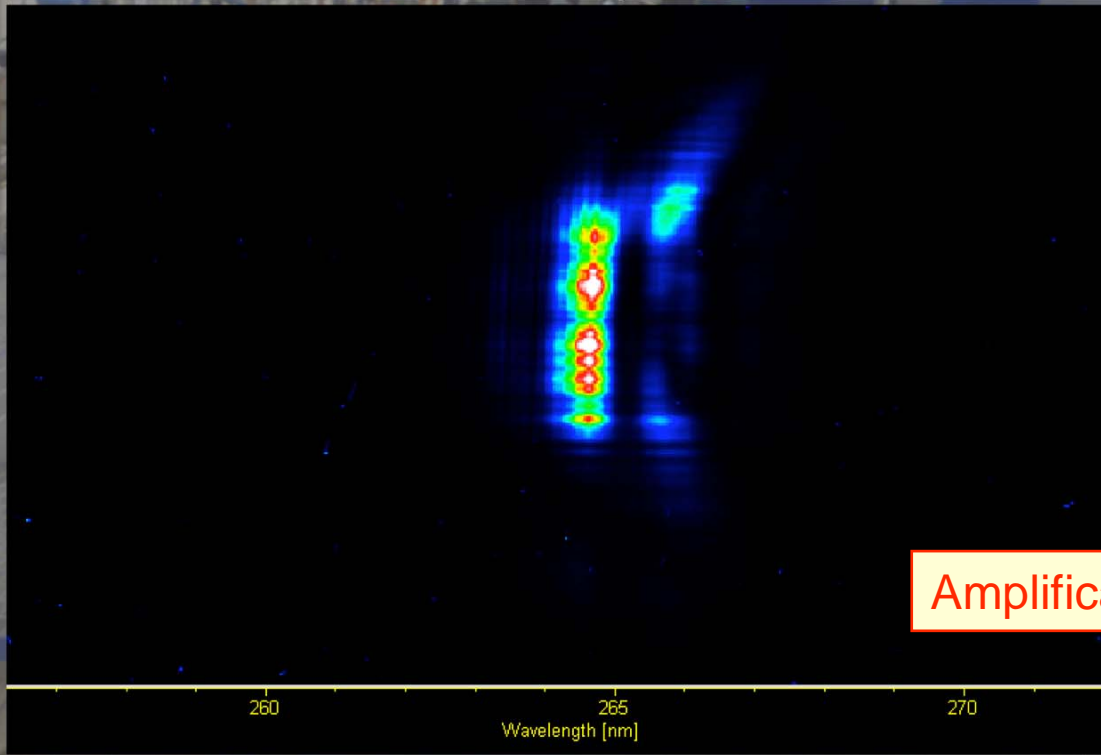
λ

Seed @ 266 nm generated in Ar, ~50 nJ (± 20 nJ)

6 UM 266 nm

Spectrometer slit @ 5 μ m - CCD saturated with nb filter @ 266nm, 17%

T



Amplification $\approx 20x$



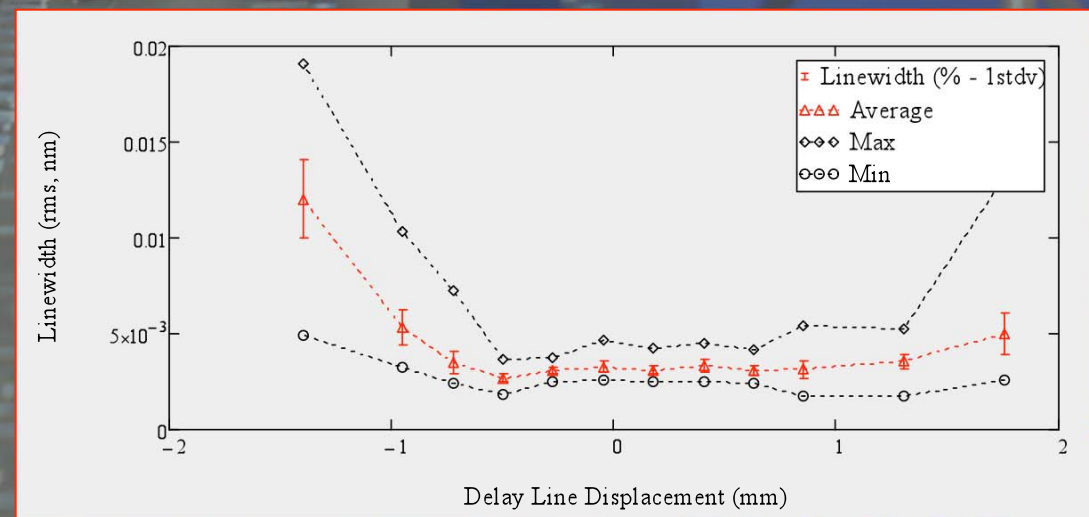
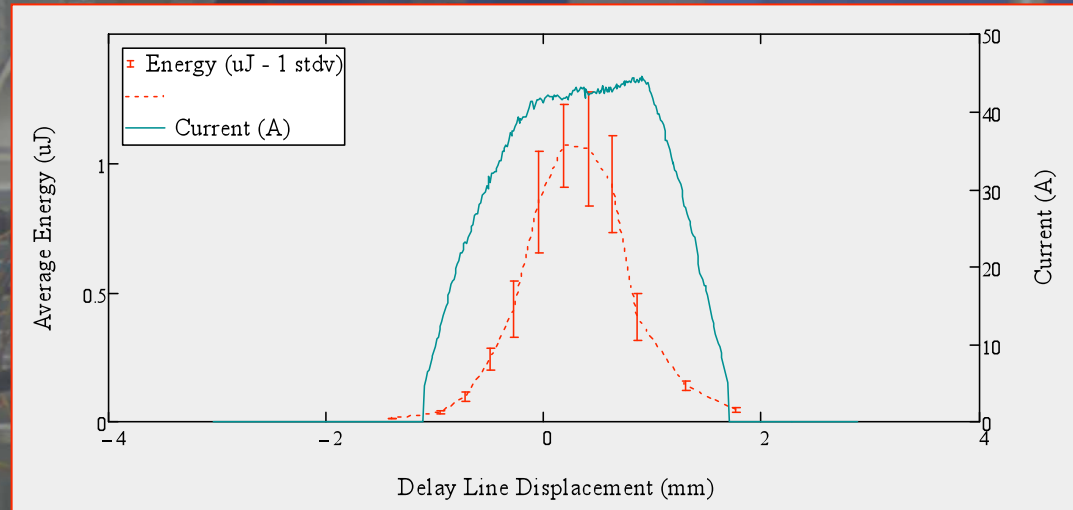
L. Giannessi, Channeling 2010



Delay line Scan

Delay line

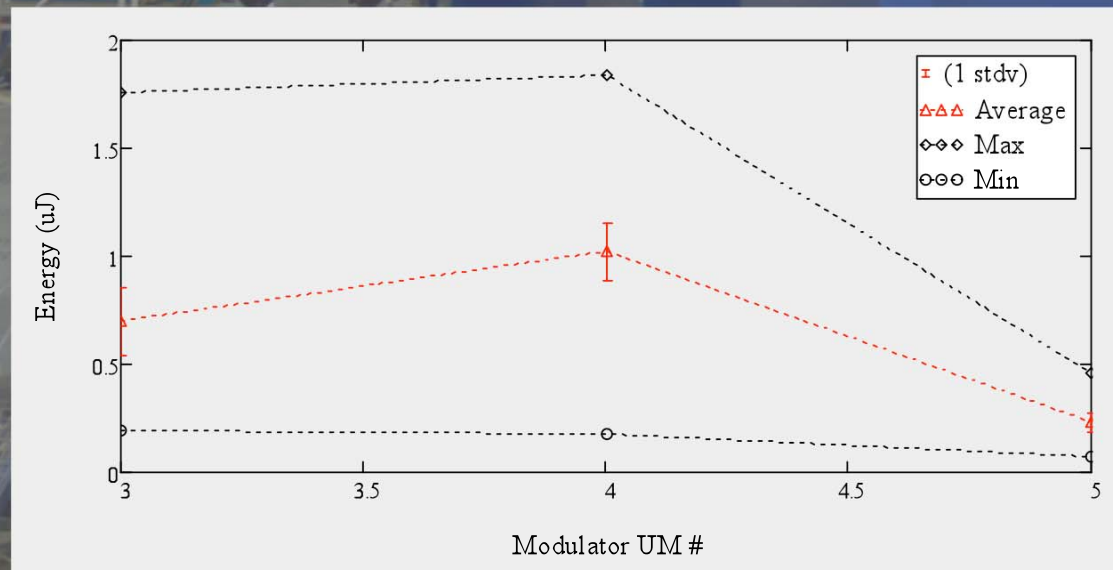
Adjustable delay up to 4m



Cascaded FEL

- Seed @ 266 nm, 50 nJ 5-4-3 UM tuned @ 266 nm – 1-2-3 UM tuned @133 nm

FEL Harmonic Generation



FEL Harmonic Generation

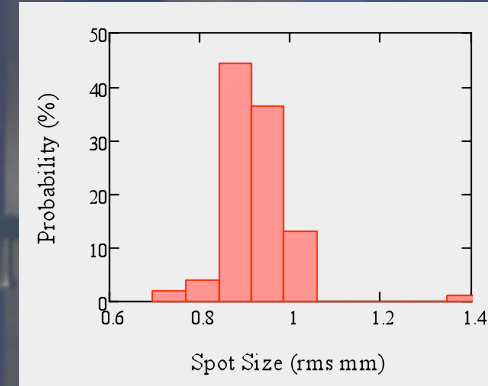
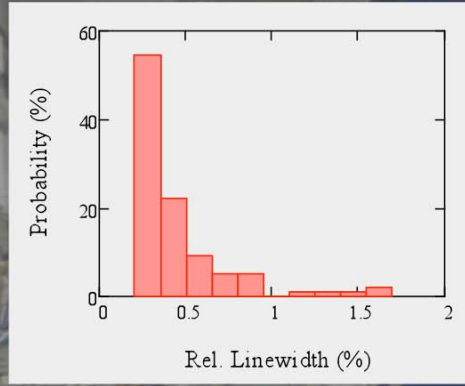
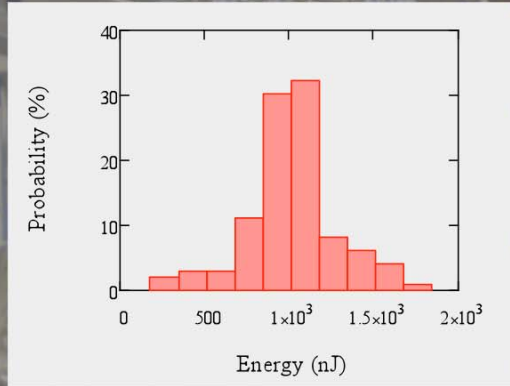
Seed

λ_1

$\lambda_2 = \lambda_1/n, n=2$

Modulator

Radiator



FEL Harmonic Generation

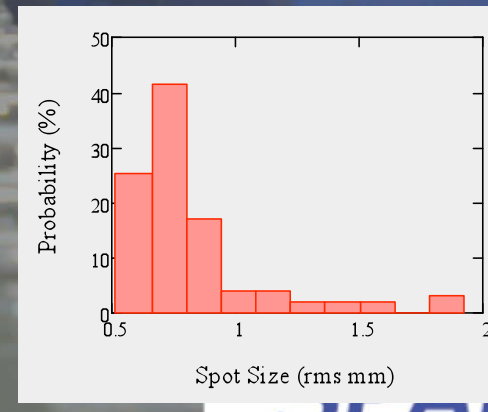
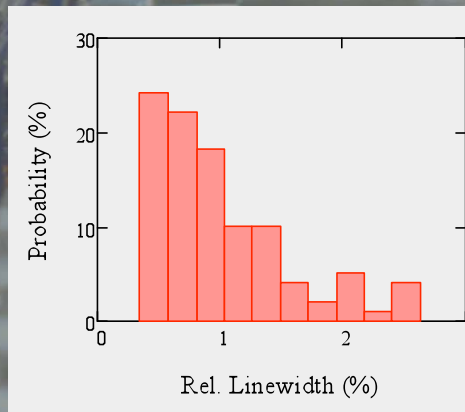
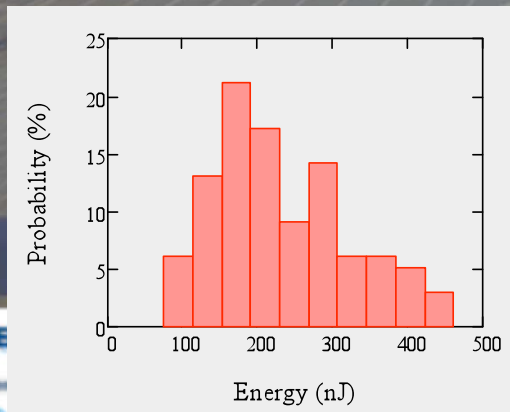
Seed

λ_1

$\lambda_2 = \lambda_1/n, n=2$

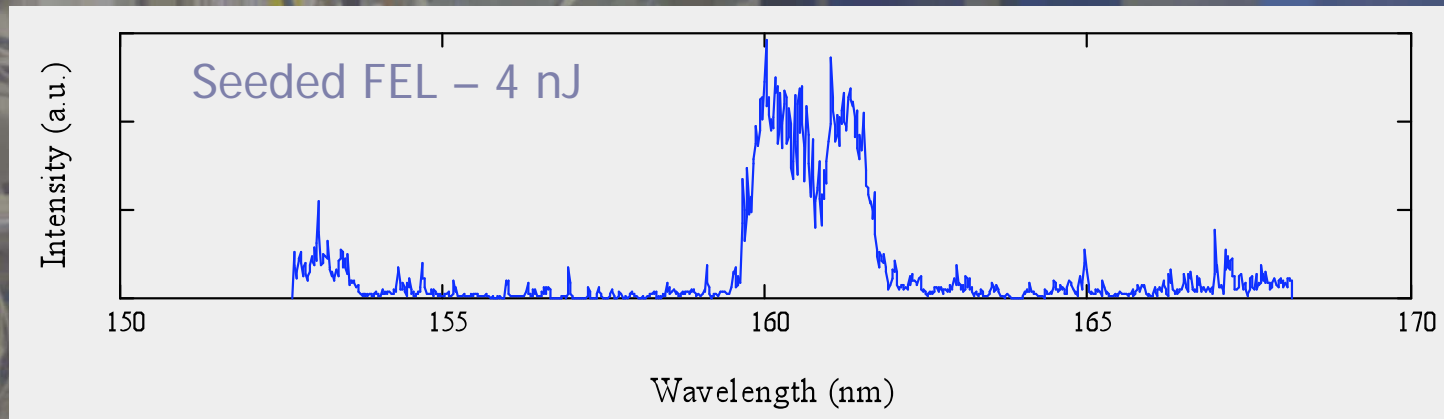
Modulator

Radiator

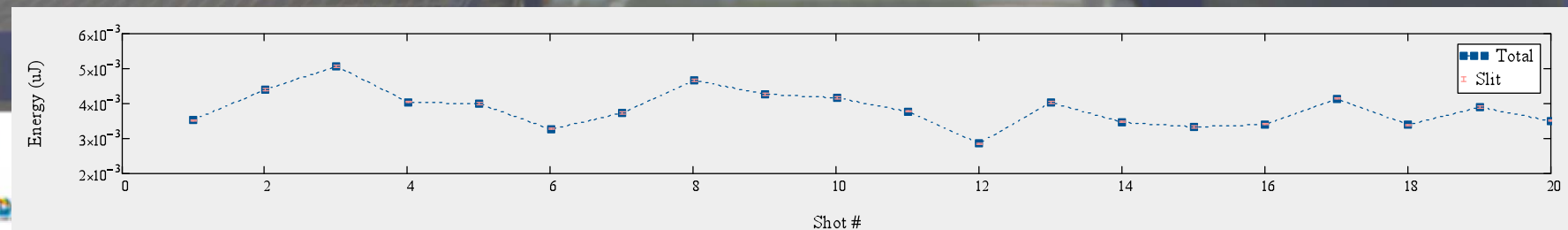
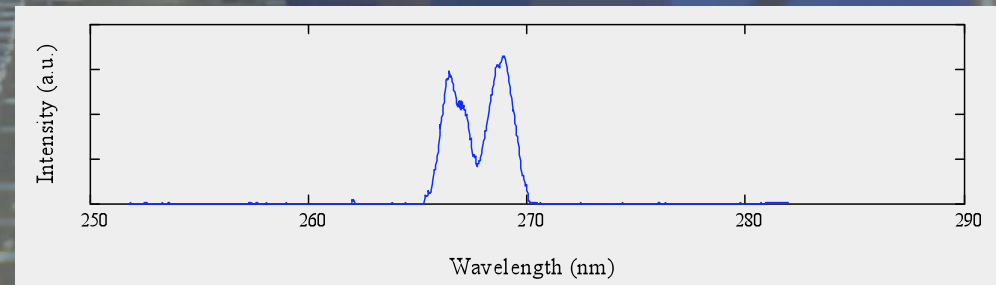


(2010/06/04) Seed @ 160nm

- Seed intensity & SASE too low to be detected at the spectrometer (< 1 nJ)



The seed @ 266 measured 1 day before shows the same double peak structure



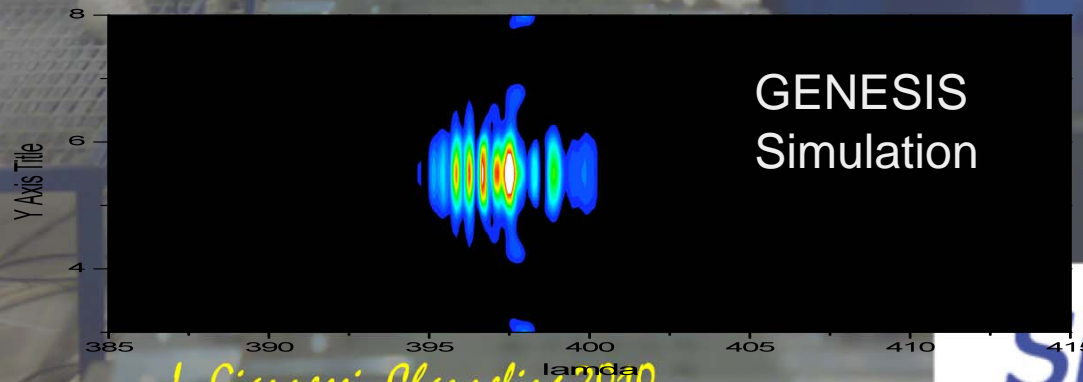
Effect of high intensity seed

Seed Energy < 0.5 μ J

~ 0.7 μ J

~ 3 μ J

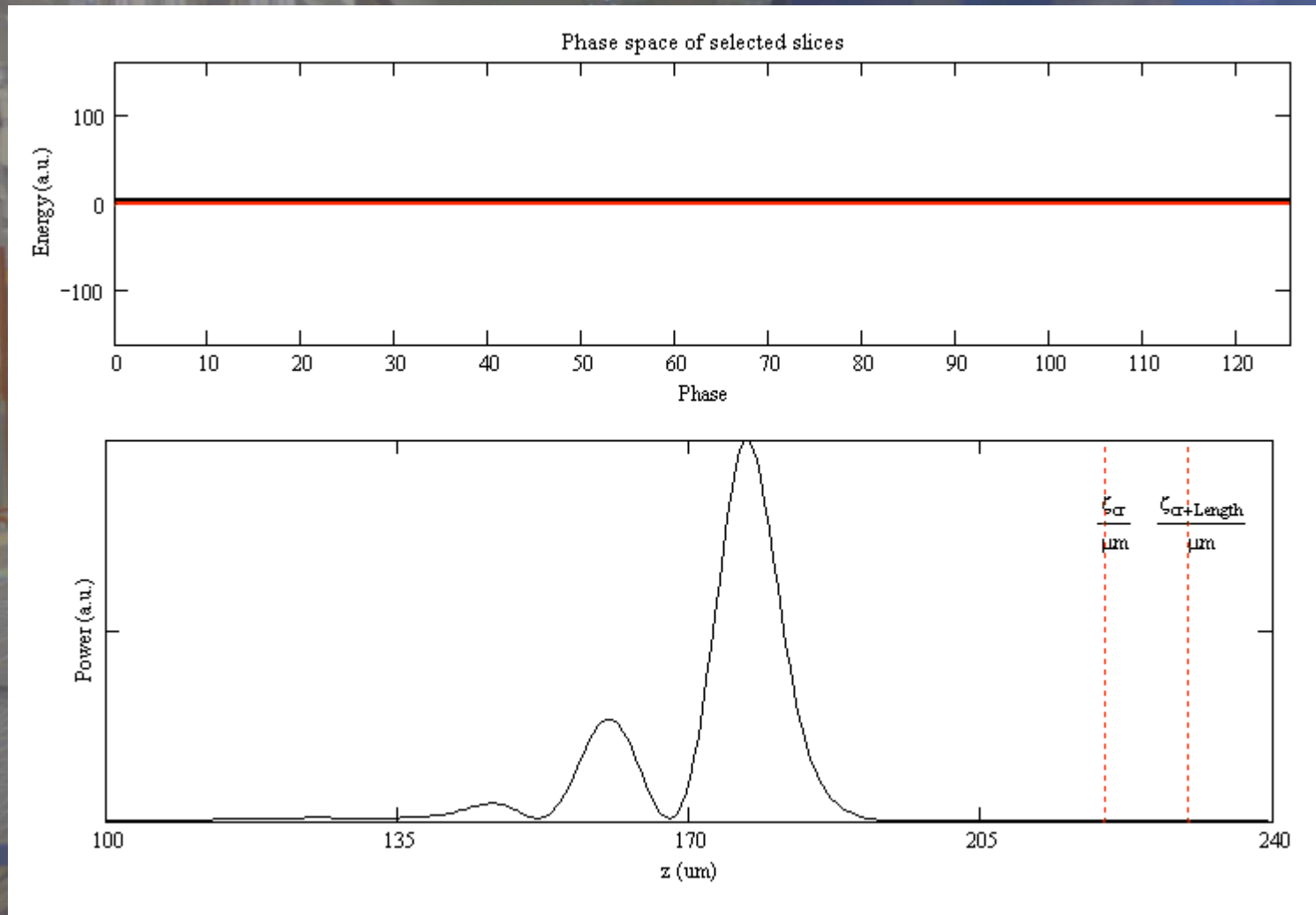
~ 9 μ J



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SPARC

Seeded FEL: field intensity above saturation



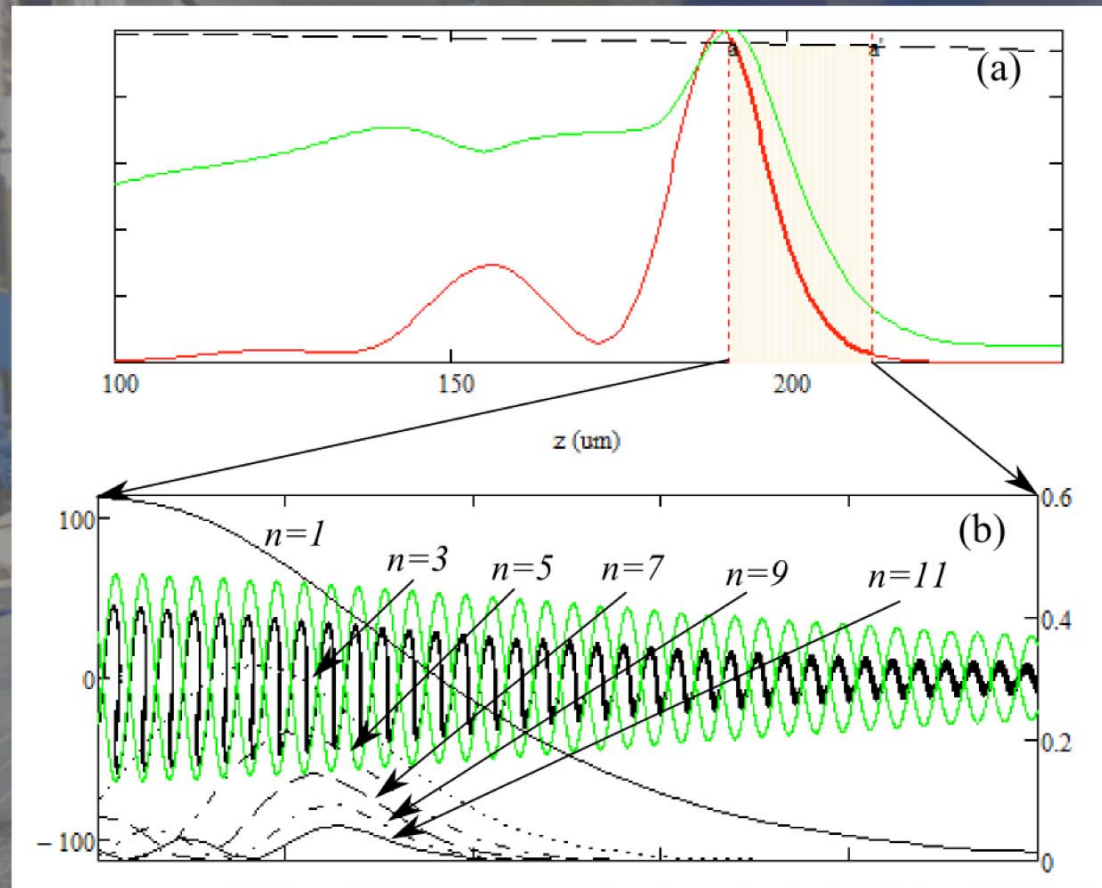
Simulation with Perseo (www.perseo.enea.it)



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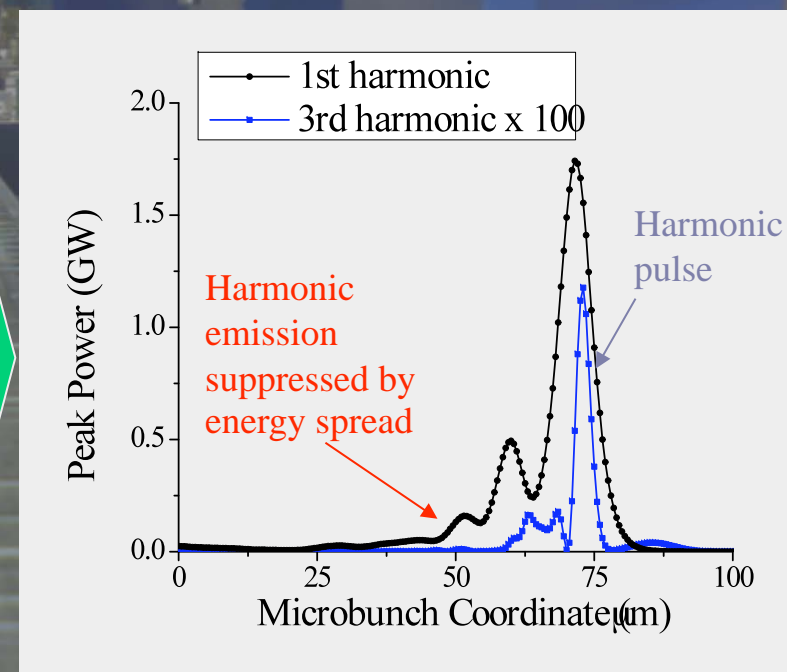
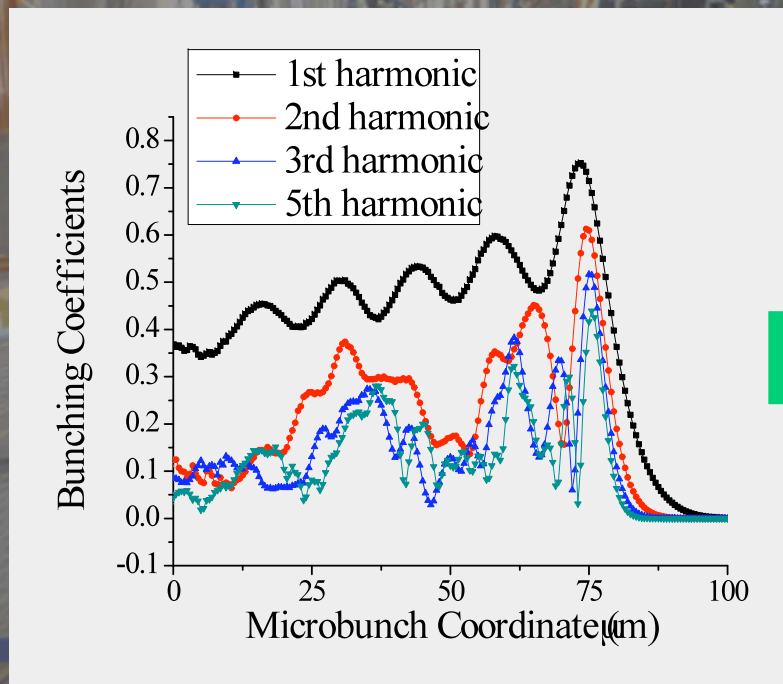
Bunching coefficients in the front side of the pulse



Expected very efficient generation of high order harmonics

Harmonics in a Superradiant pulse

- Short bunching peaks on the pulse front side at the higher order harmonics
- Dynamics for non-linear harmonic evolution "faster" by the harmonic factor n . (i.e. $L_{g,n} \sim L_g/n$)
- Short bursts of harmonic radiation
- Pulse structure preserved by the "solitary wave" behavior of this solution



High harmonics down to 37 nm



Observation of 11° harmonic at 37nm

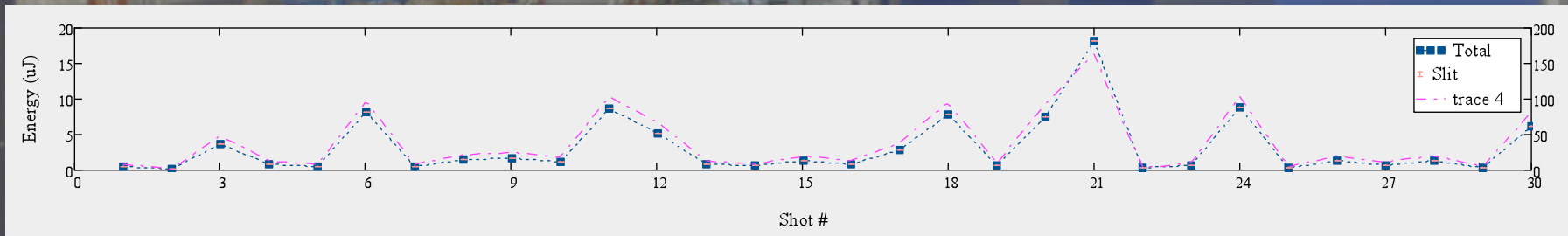
Measured energy per pulse, spot size & and bandwidth of the first 11° harmonics



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High intensity seed in a cascaded configuration

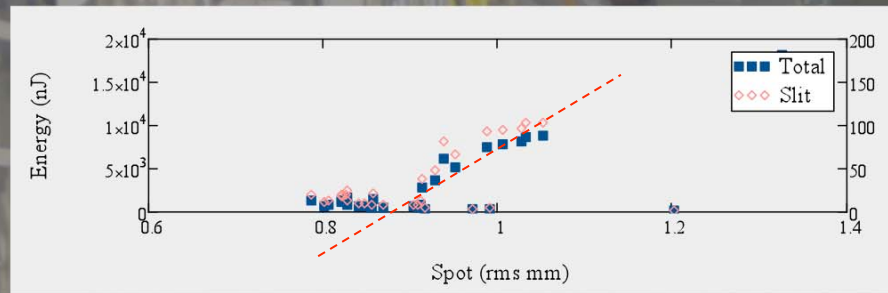


Energy jitter mainly due to e-beam energy jitter

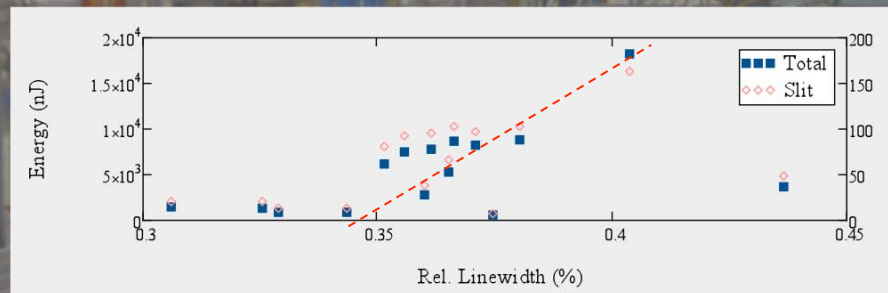
Correlations

Large energy jitter \rightarrow large energy fluctuations

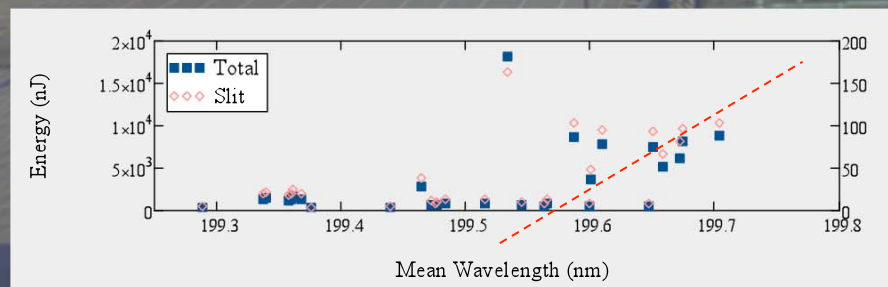
Indication of saturation @200 nm



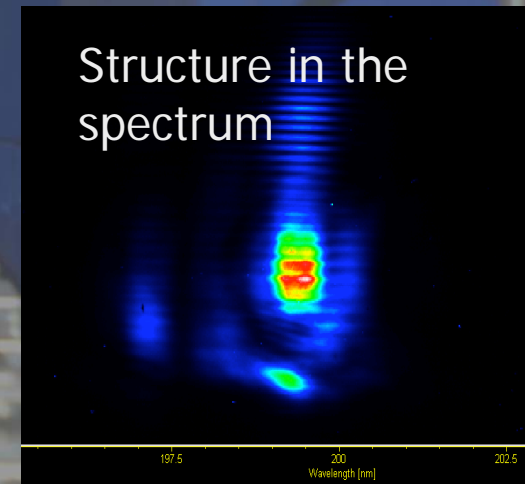
Correlation Energy – Spot size



Correlation Energy – Linewidth



Redshift

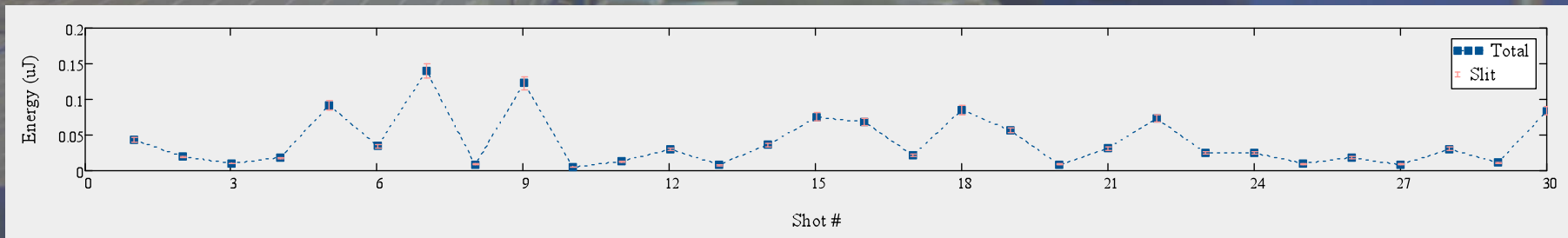
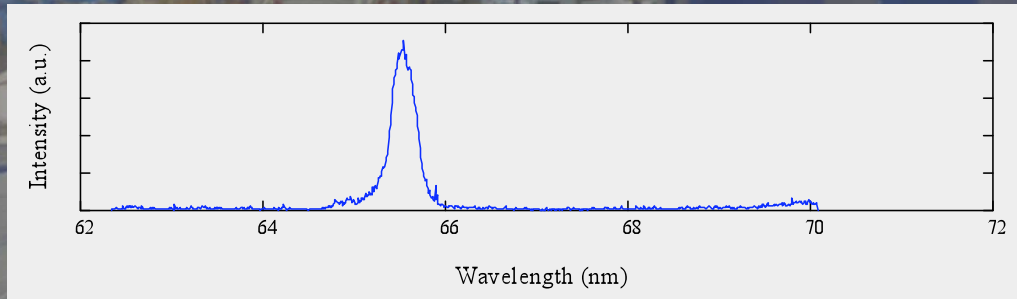
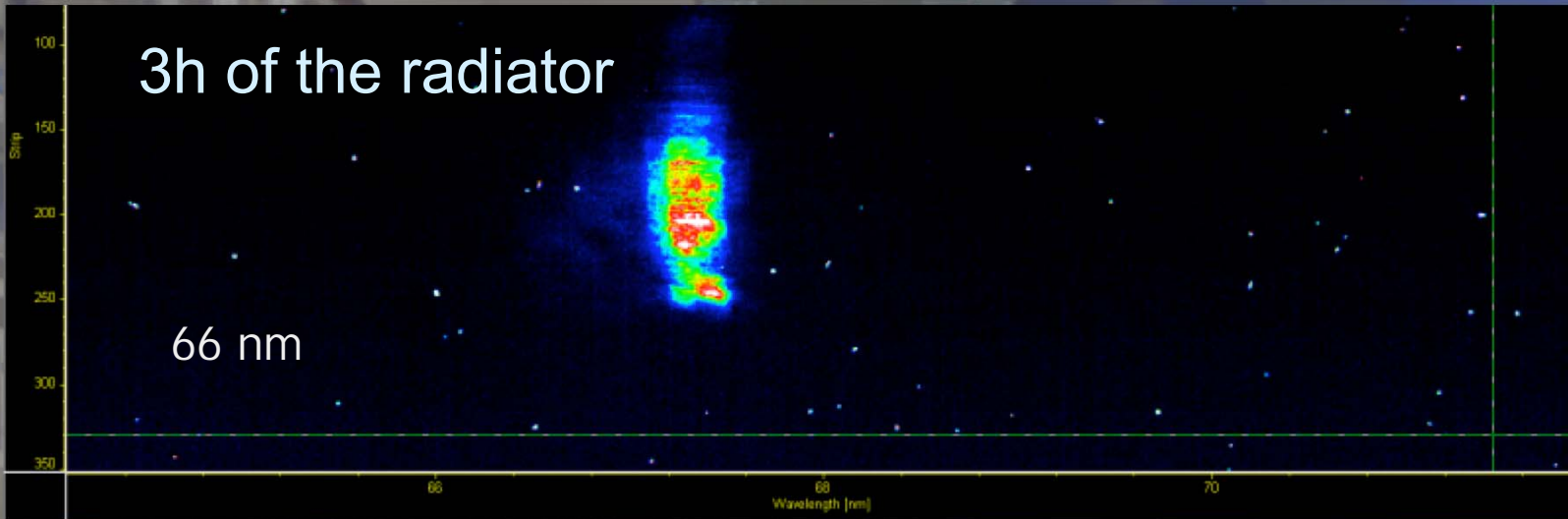


Structure in the spectrum



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SPARC



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Conclusions (From Channeling 2006)

ok

SPARC represents a unique opportunity for studying single pass FEL and FEL cascades in seeded mode

ok

Conventional lasers and FEL are merged in a single device

- New experiments are foreseen in the next future
 - **The harmonic cascade**
 - Multistage cascade and the Fresh Bunch injection technique
 - Superradance in a cascade and **the harmonic cascade**
 - **FEL amplification from a gas HHG source/harmonic generation**

In progress

true

These new schemes extend the foreseen SPARC spectral range to ~~44 nm -~~ 500 nm

37 nm

The experience resulting from those experiments will provide the confidence to extend the seeded FEL cascade wavelength operation range in higher beam energy devices as **SPARX**