The status of the SPARC project

Alessandro Cianchi
University of Rome "Tor Vergata"
and INFN
On behalf of
SPARC collaboration

Outline

- The Sparc/SparX project
- Status of SPARC
- Recent results
- On going activities
- Conclusions

Ministero dell'Università
e della Ricerca

Consiglio Nazionale delle Ricerche

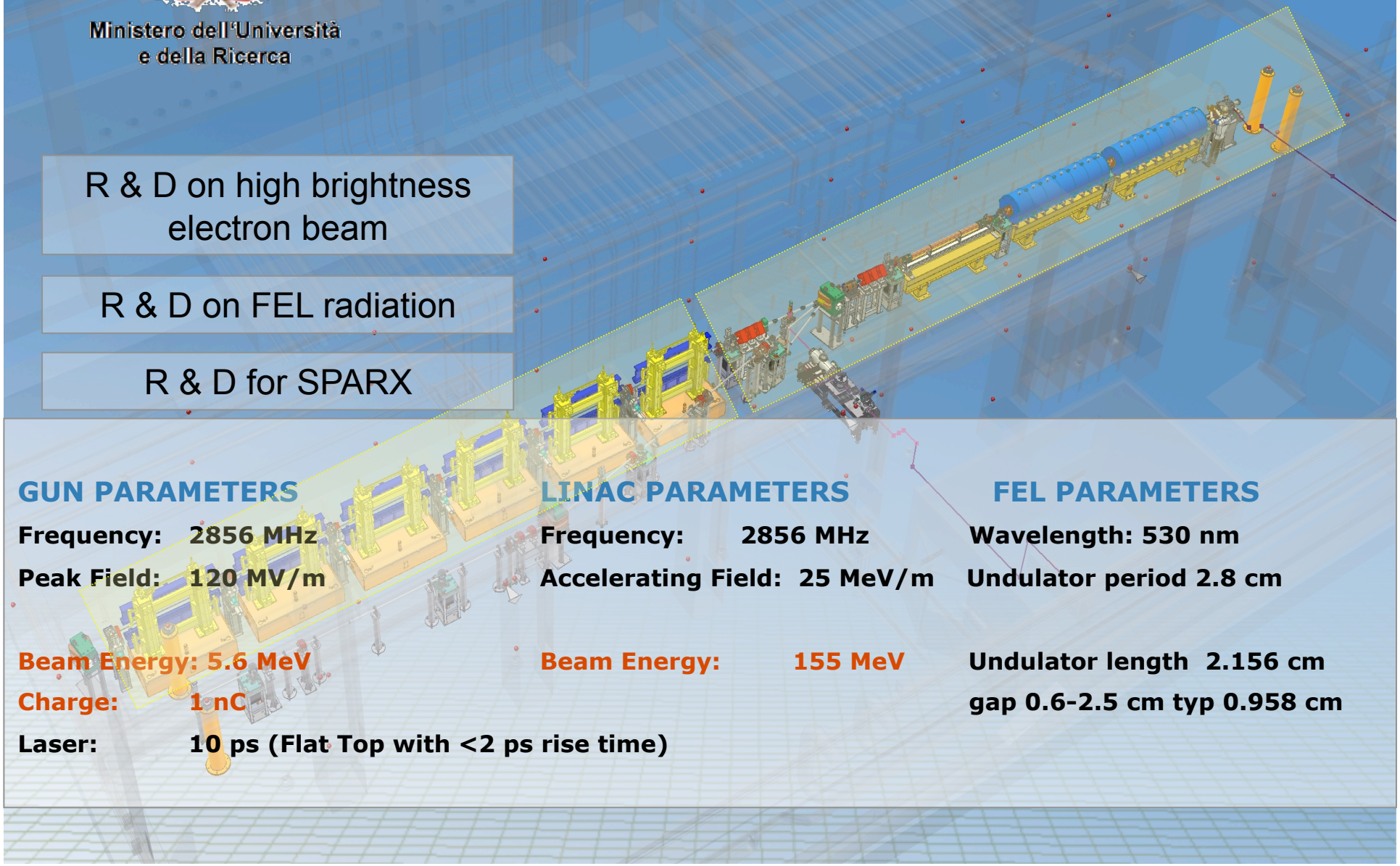
ENEA C.R. Frascati

INFN

R & D on high brightness electron beam

R & D on FEL radiation

R & D for SPARX



GUN PARAMETERS

Frequency: 2856 MHz

Peak Field: 120 MV/m

Beam Energy: 5.6 MeV

Charge: 1 nC

Laser: 10 ps (Flat Top with <2 ps rise time)

LINAC PARAMETERS

Frequency: 2856 MHz

Accelerating Field: 25 MeV/m

Beam Energy: 155 MeV

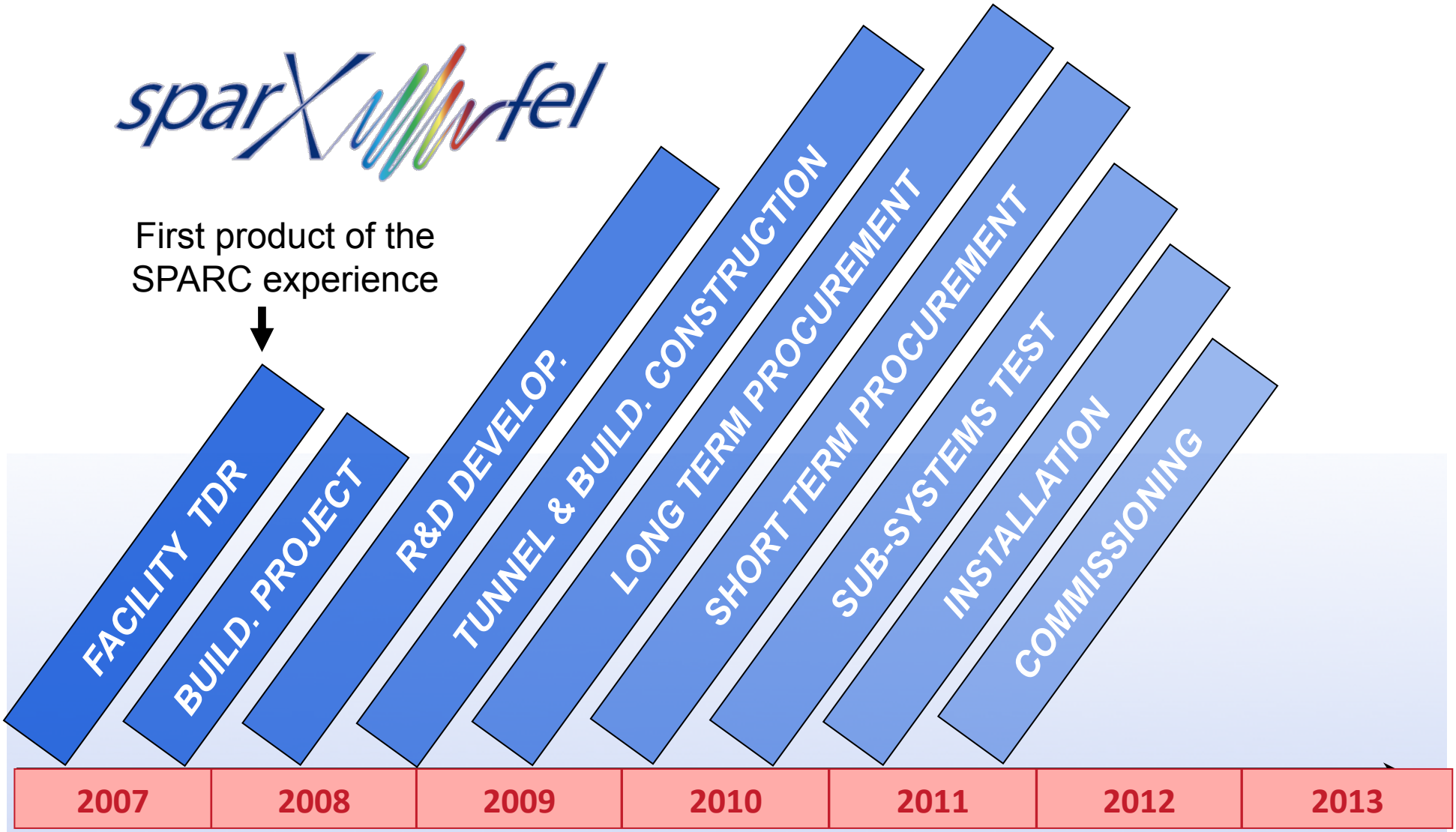
FEL PARAMETERS

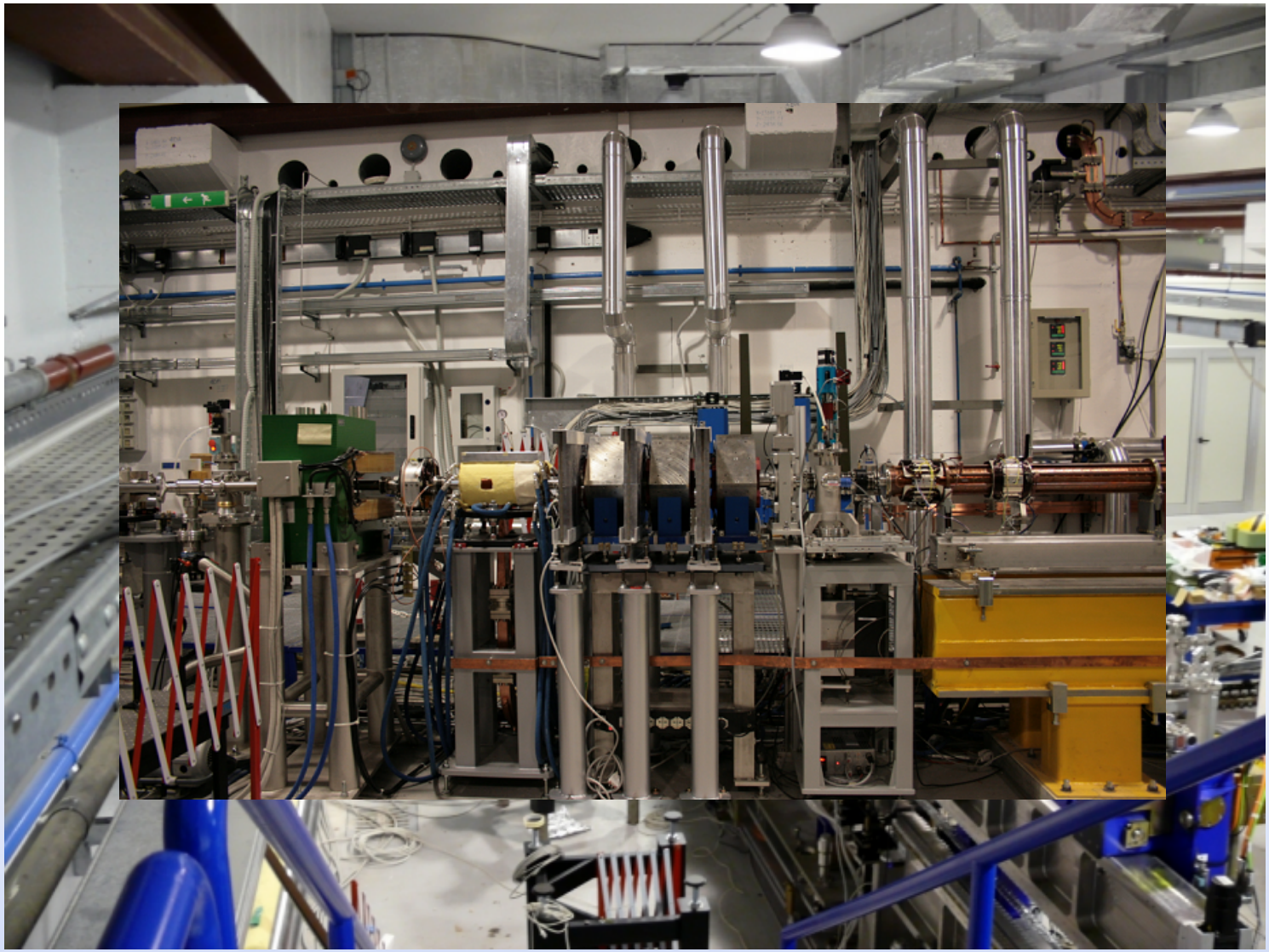
Wavelength: 530 nm

Undulator period 2.8 cm

Undulator length 2.156 cm

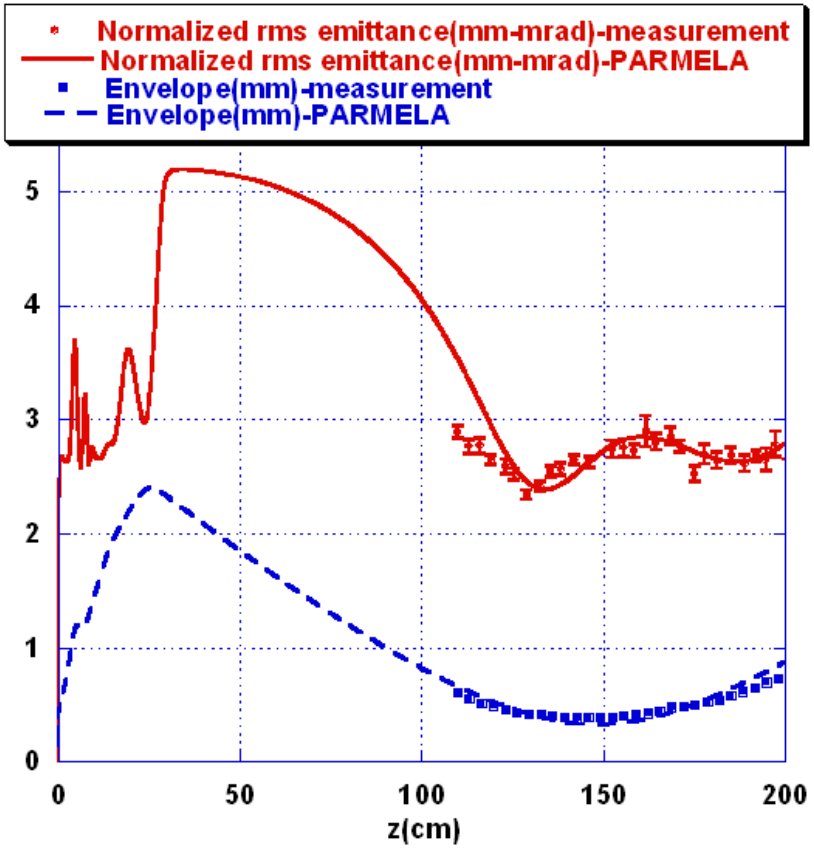
gap 0.6-2.5 cm typ 0.958 cm


SPARC
sparXfel
First product of the
SPARC experience
FACILITY TDR
BUILD. PROJECT
R&D DEVELOP.
TUNNEL & BUILD. CONSTRUCTION
LONG TERM PROCUREMENT
SHORT TERM PROCUREMENT
SUB-SYSTEMS TEST
INSTALLATION
COMMISSIONING
2007
2008
2009
2010
2011
2012
2013



Dynamic studies

Beam parameters:
Energy=5.5 MeV
Q ~ 500 pC
flat top pulse
(FWHM length~5 psec
Rise time ~ 1.5 psec)
$\varphi - \varphi_m = +12°$
$\langle\sigma\rangle = 420\ \mu m$



PRL 99, 234801 (2007) PHYSICAL REVIEW LETTERS week ending 7 DECEMBER 2007

Direct Measurement of the Double Emittance Minimum in the Beam Dynamics of the Sparc High-Brightness Photoinjector

M. Ferrario,[1] D. Alesini,[1] A. Bacci,[3] M. Bellaveglia,[1] R. Boni,[1] M. Boscolo,[1] M. Castellano,[1] L. Catani,[2] E. Chiadroni,[1] S. Cialdi,[3] A. Cianchi,[2] A. Clozza,[1] L. Cultrera,[1] G. Di Pirro,[1] A. Drago,[1] A. Esposito,[1] L. Ficcadenti,[5] D. Filippetto,[1] V. Fusco,[1] A. Gallo,[1] G. Gatti,[1] A. Ghigo,[1] L. Giannessi,[4] C. Ligi,[1] M. Mattioli,[7] M. Migliorati,[5] A. Mostacci,[5] P. Musumeci,[6] E. Pace,[1] L. Palumbo,[5] L. Pellegrino,[1] M. Petrarca,[7] M. Quattromini,[4] R. Ricci,[1] C. Ronsivalle,[4] J. Rosenzweig,[6] A. R. Rossi,[3] C. Sanelli,[1] L. Serafini,[3] M. Serio,[1] F. Sgamma,[1] B. Spataro,[1] F. Tazzioli,[1] S. Tomassini,[1] C. Vaccarezza,[1] M. Vescovi,[1] and C. Vicario[1]

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **11**, 032801 (2008)

High brightness electron beam emittance evolution measurements in an rf photoinjector

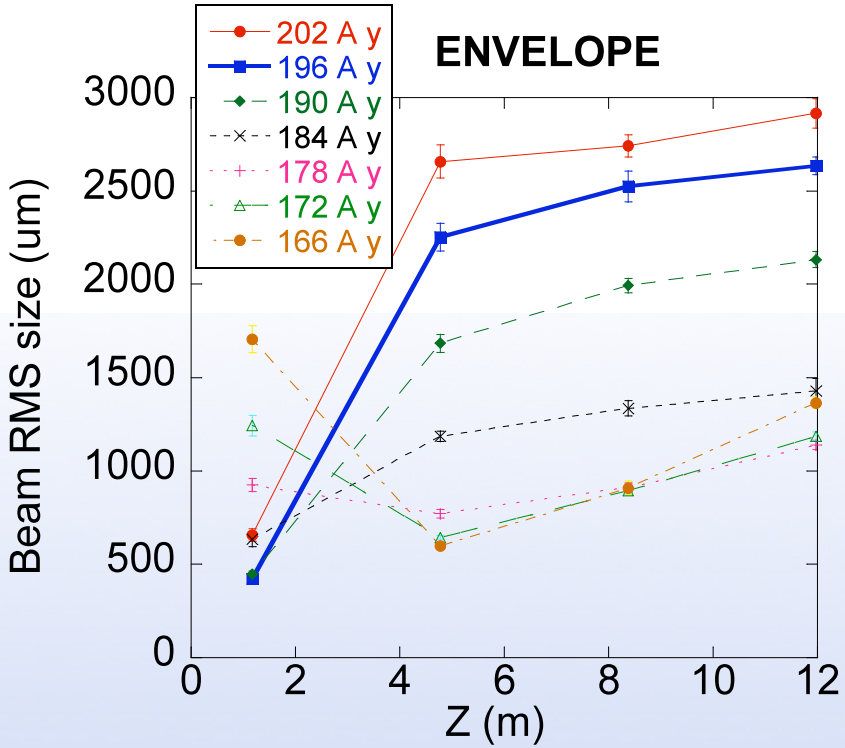
A. Cianchi,[1,*] D. Alesini,[2] A. Bacci,[3] M. Bellaveglia,[2] R. Boni,[2] M. Boscolo,[2] M. Castellano,[2] L. Catani,[1] E. Chiadroni,[2] S. Cialdi,[3] A. Clozza,[2] L. Cultrera,[2] G. Di Pirro,[2] A. Drago,[2] A. Esposito,[2] M. Ferrario,[2] L. Ficcadenti,[4] D. Filippetto,[2] V. Fusco,[2] A. Gallo,[2] G. Gatti,[2] A. Ghigo,[2] L. Giannessi,[5] C. Ligi,[2] M. Mattioli,[6] M. Migliorati,[2,4] A. Mostacci,[2,4]

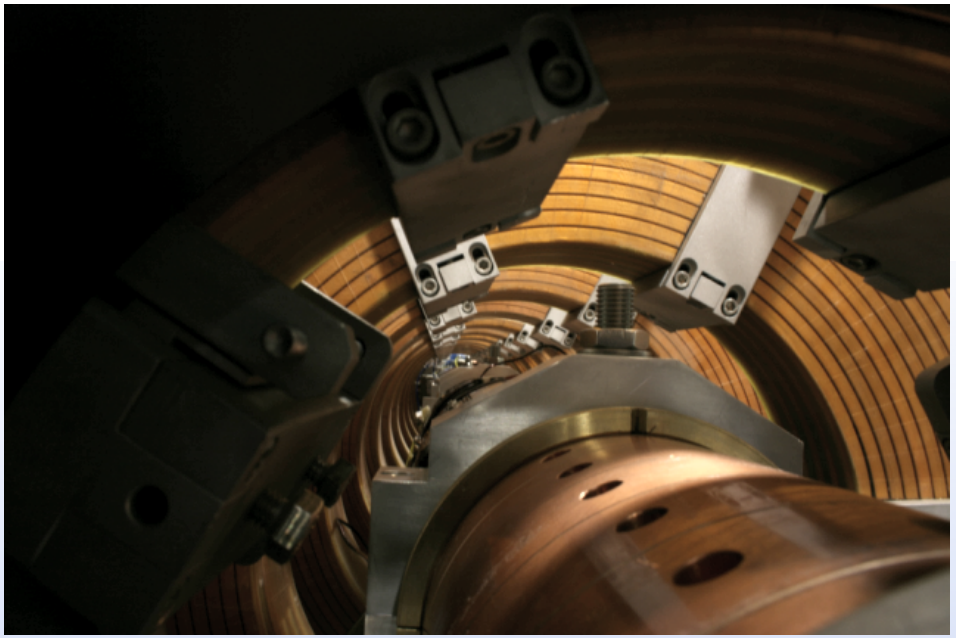
REVIEW OF SCIENTIFIC INSTRUMENTS **79**, 013303 (2008)

Analysis methodology of movable emittance-meter measurements for low energy electron beams

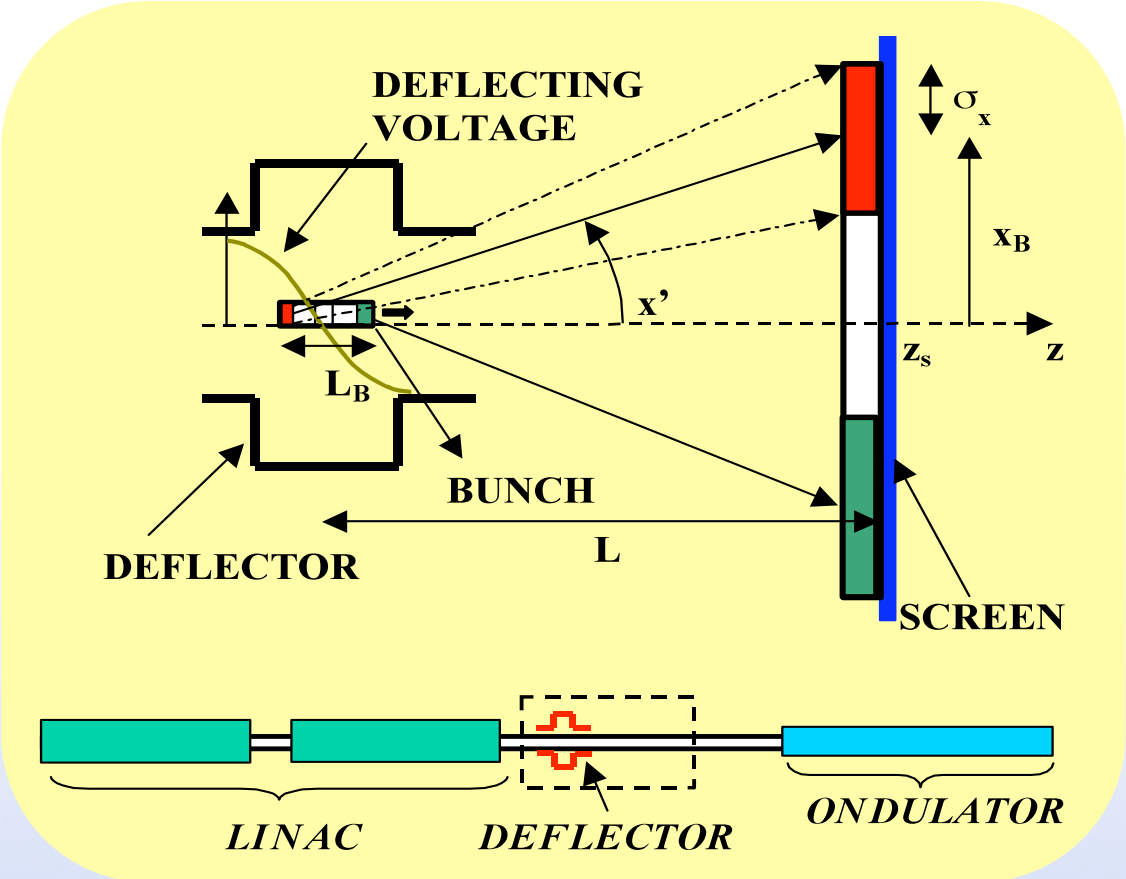
A. Mostacci,[1,a),b)] A. Bacci,[2] M. Boscolo,[3] E. Chiadroni,[3] A. Cianchi,[4] D. Filippetto,[3] M. Migliorati,[1,b)] P. Musumeci,[5] C. Ronsivalle,[6] and A. R. Rossi[2]

Envelope control





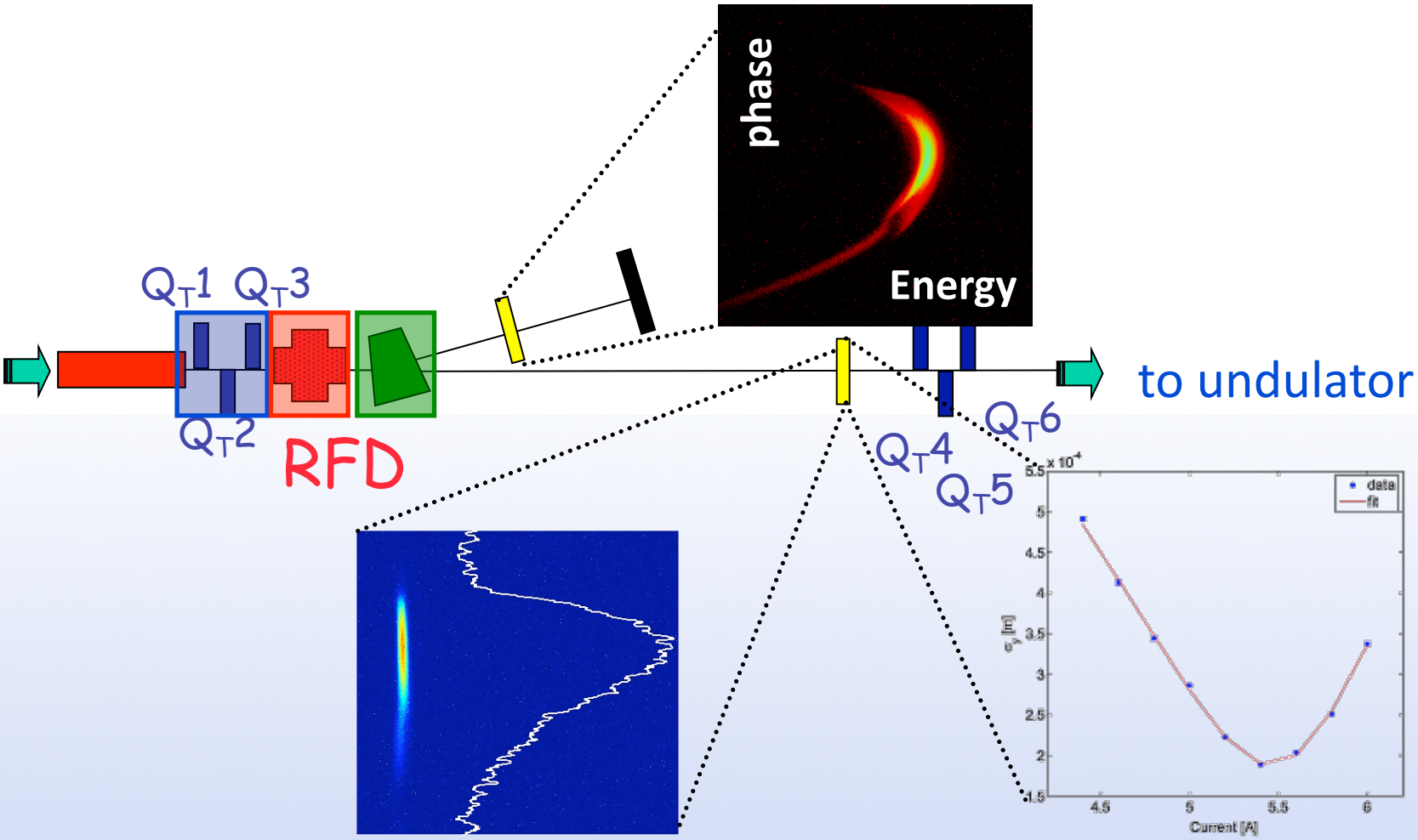
RF deflector



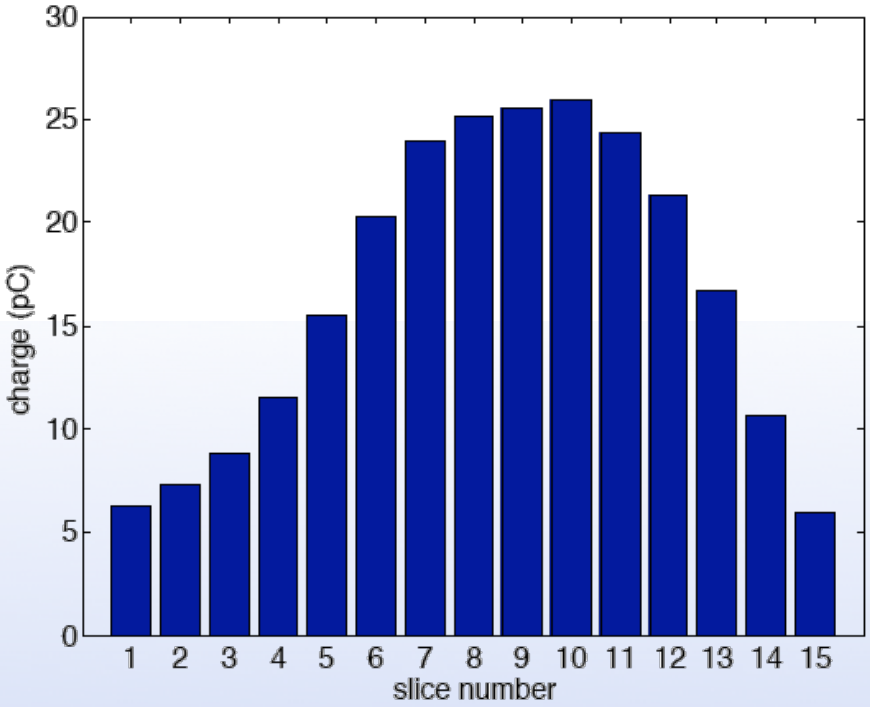
$$x_B = \frac{\pi f_{RF} L L_B V_\perp}{cE/e}$$

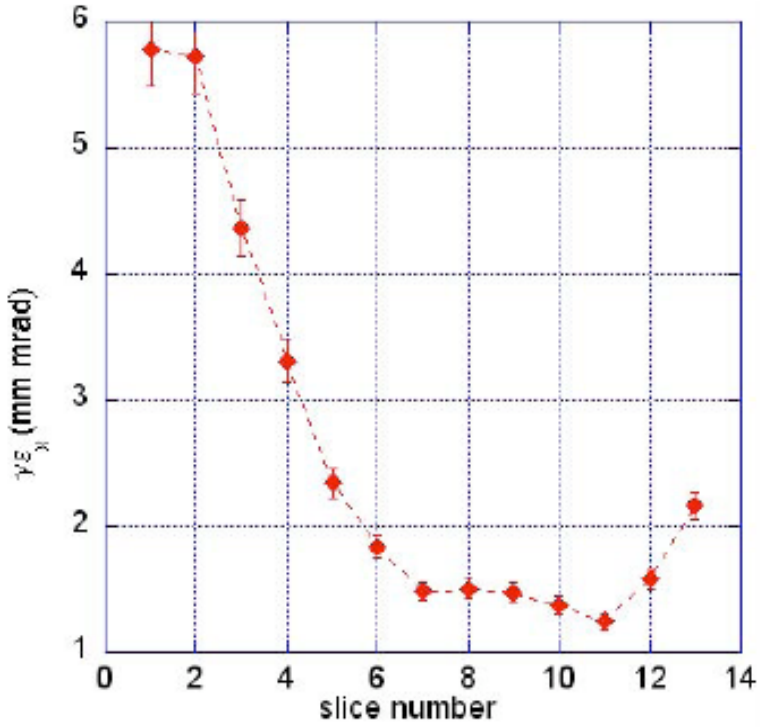
$$V_\perp = \frac{\sigma_x cE/e}{\pi f_{RF} L L_{res}}$$

Complete diagnostic

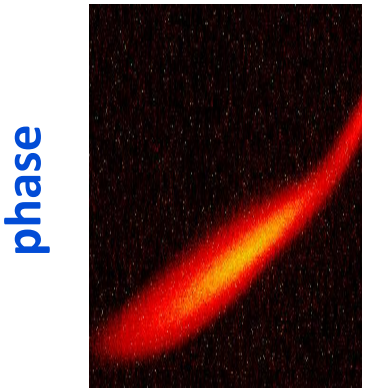


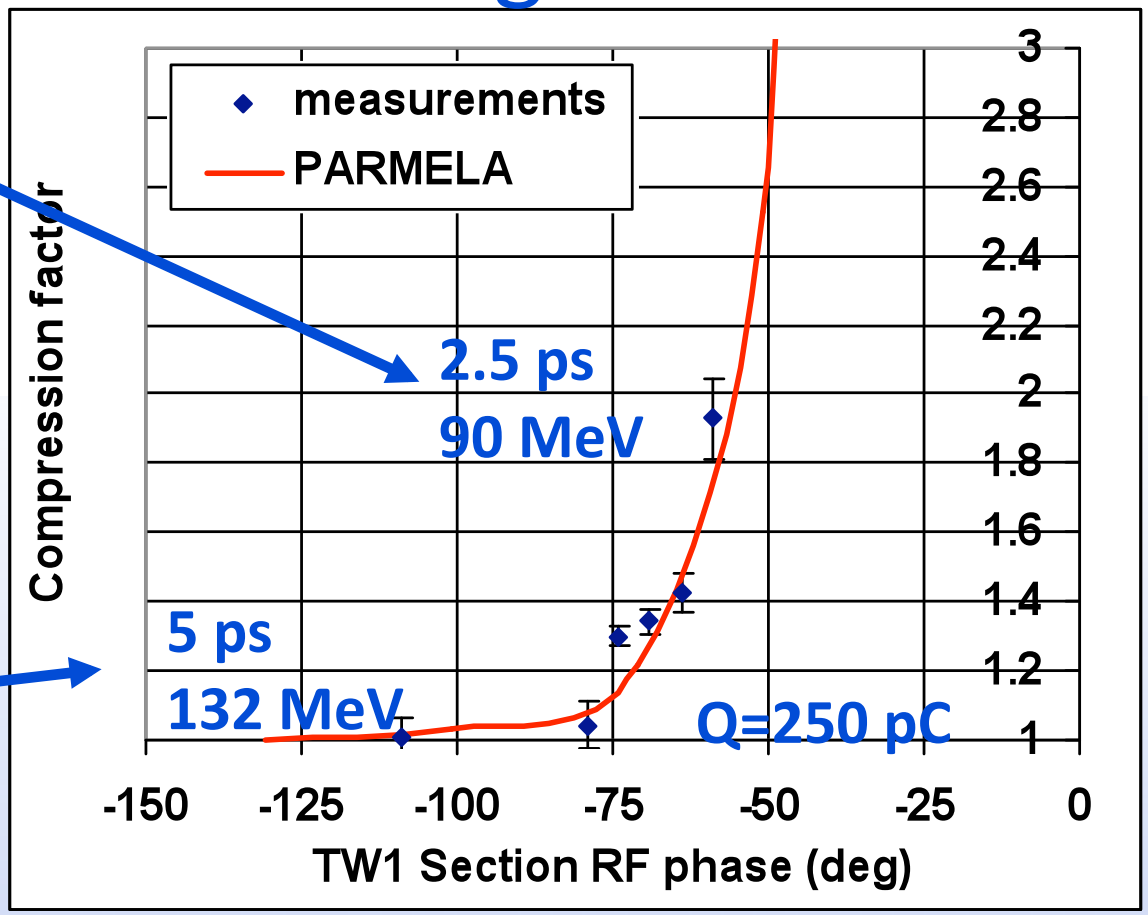
Slice emittance measurements



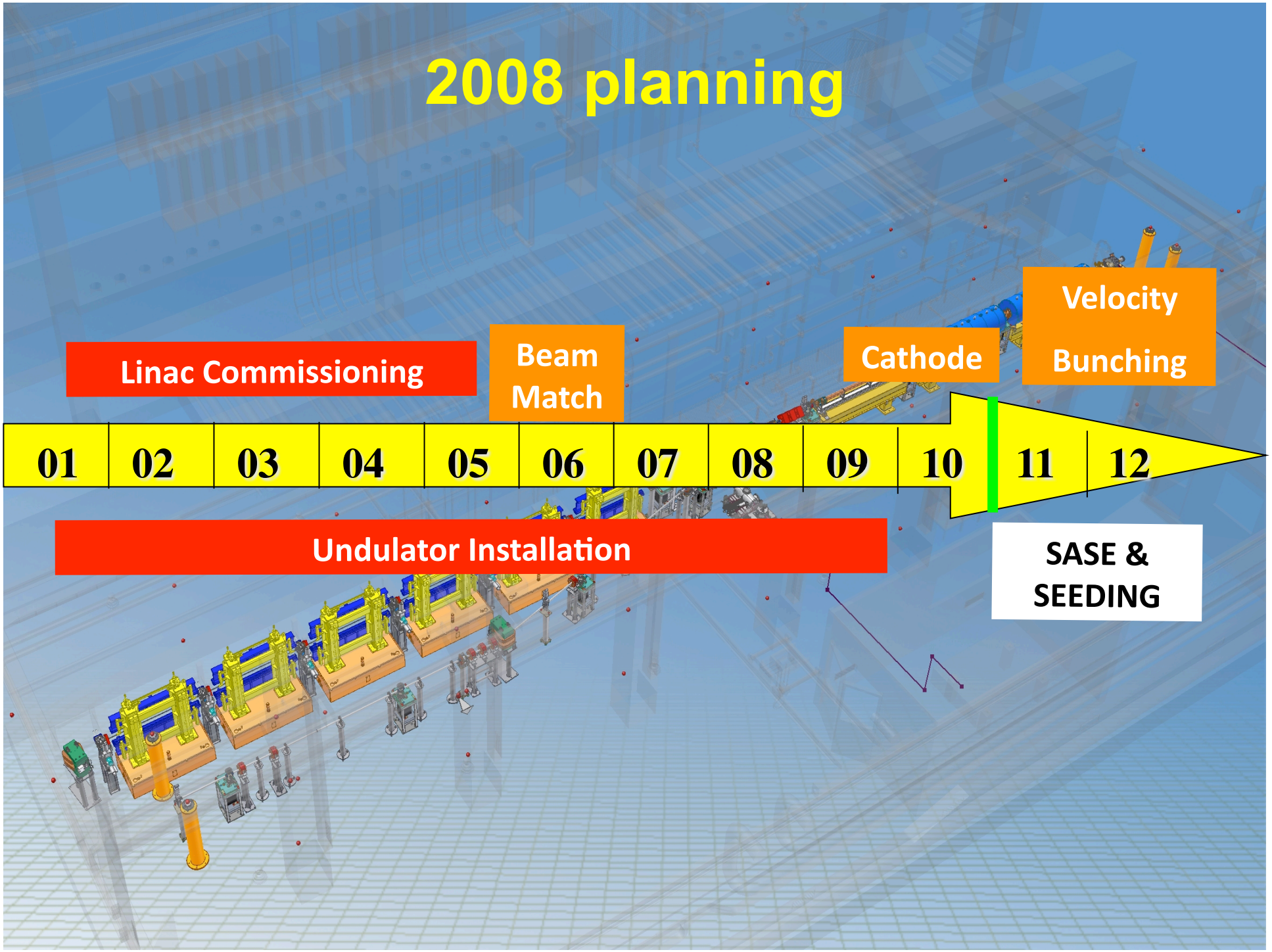


Preliminary results for the velocity bunching





2008 planning

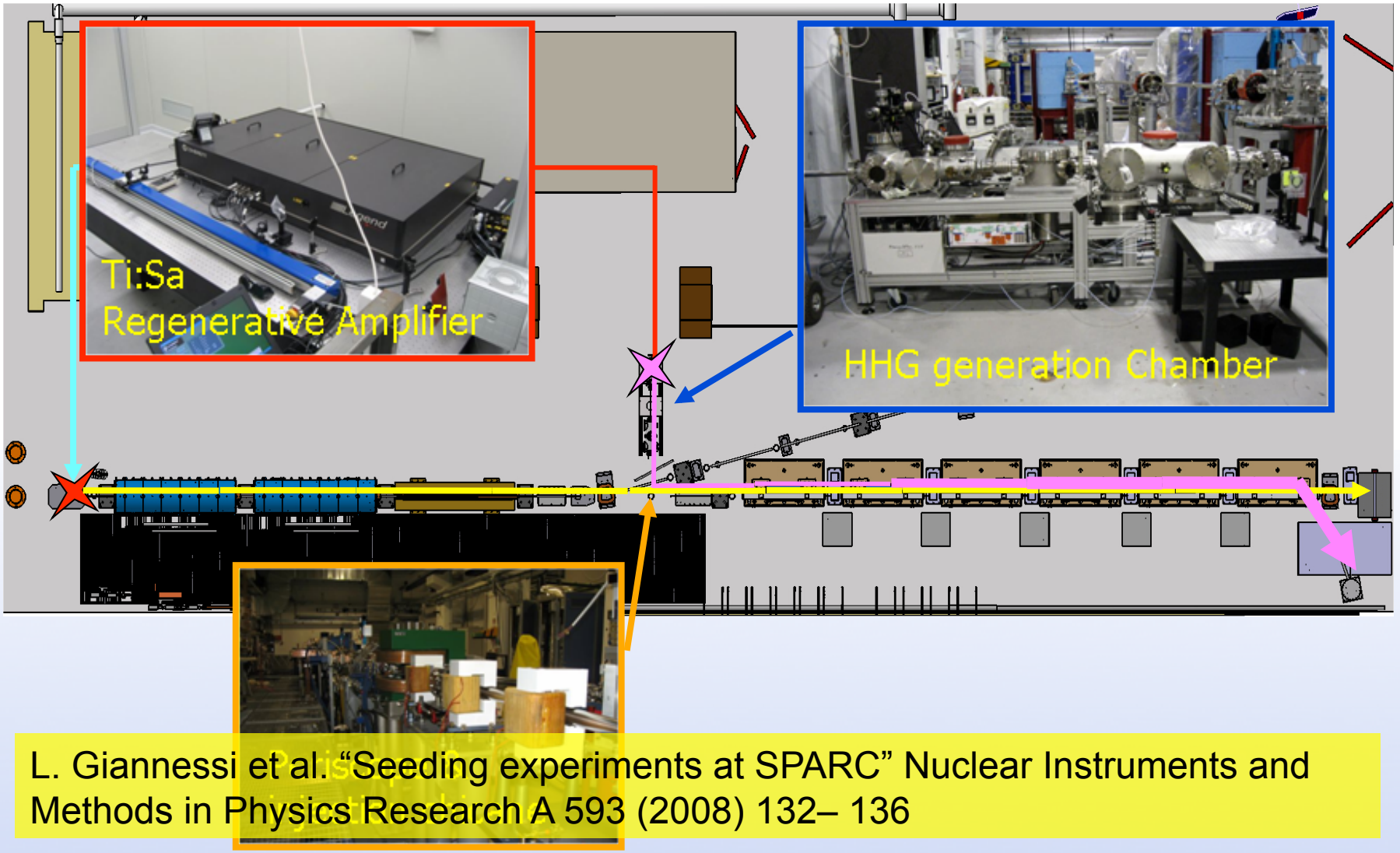


Seeding

- Shortening the saturation length
- Extending the wavelength range
- Reducing the shot to shot fluctuation
- Narrowing the bandwidth

SEED SOURCES

Ti:Sa Regenerative amplifier
800 nm - 2.5 mJ – 1 kHz
+
High order harmonics
400 & 266 nm
+
High order armonics in gas:
266, 160, 114 nm
High Energy
Short duration
Spatial and temporal Coherence

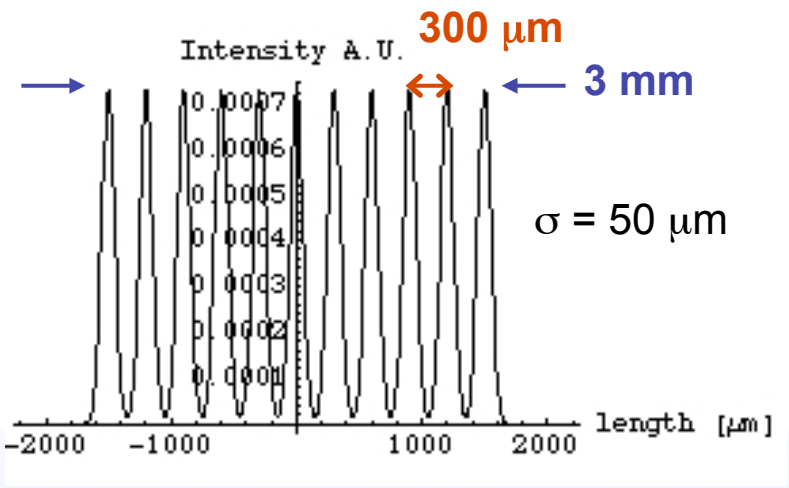


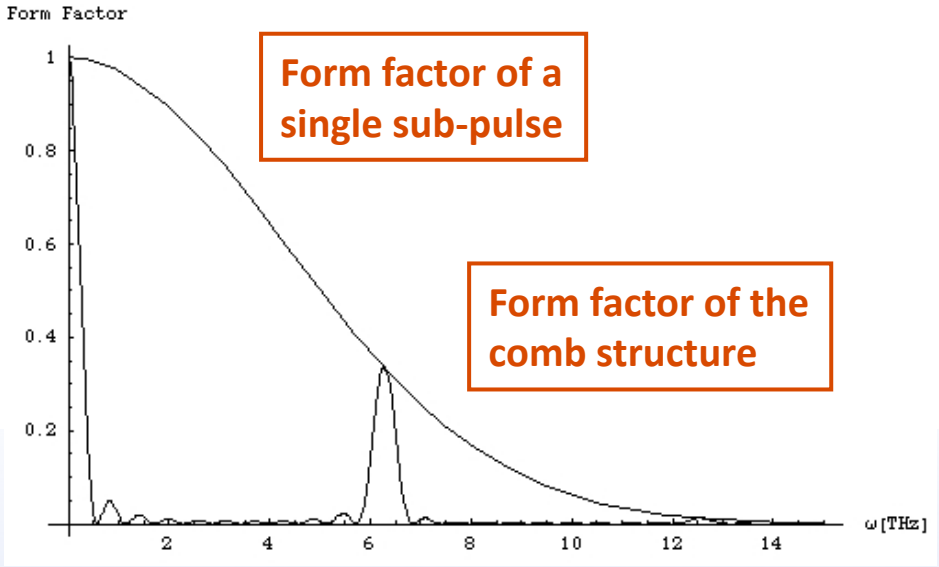
L. Giannessi et al.“Seeding experiments at SPARC” Nuclear Instruments and Methods in Physics Research A 593 (2008) 132– 136

Single spike

- If the bunch length is 2π shorter of the cooperation length the FEL emission is not anymore constituted by several random spike
- The emission produces a radiation pulse shaped in one single spike
- The phenomena can be studied at SPARC confirming the prediction of the simulations and the scaling laws

THz source and Laser Comb



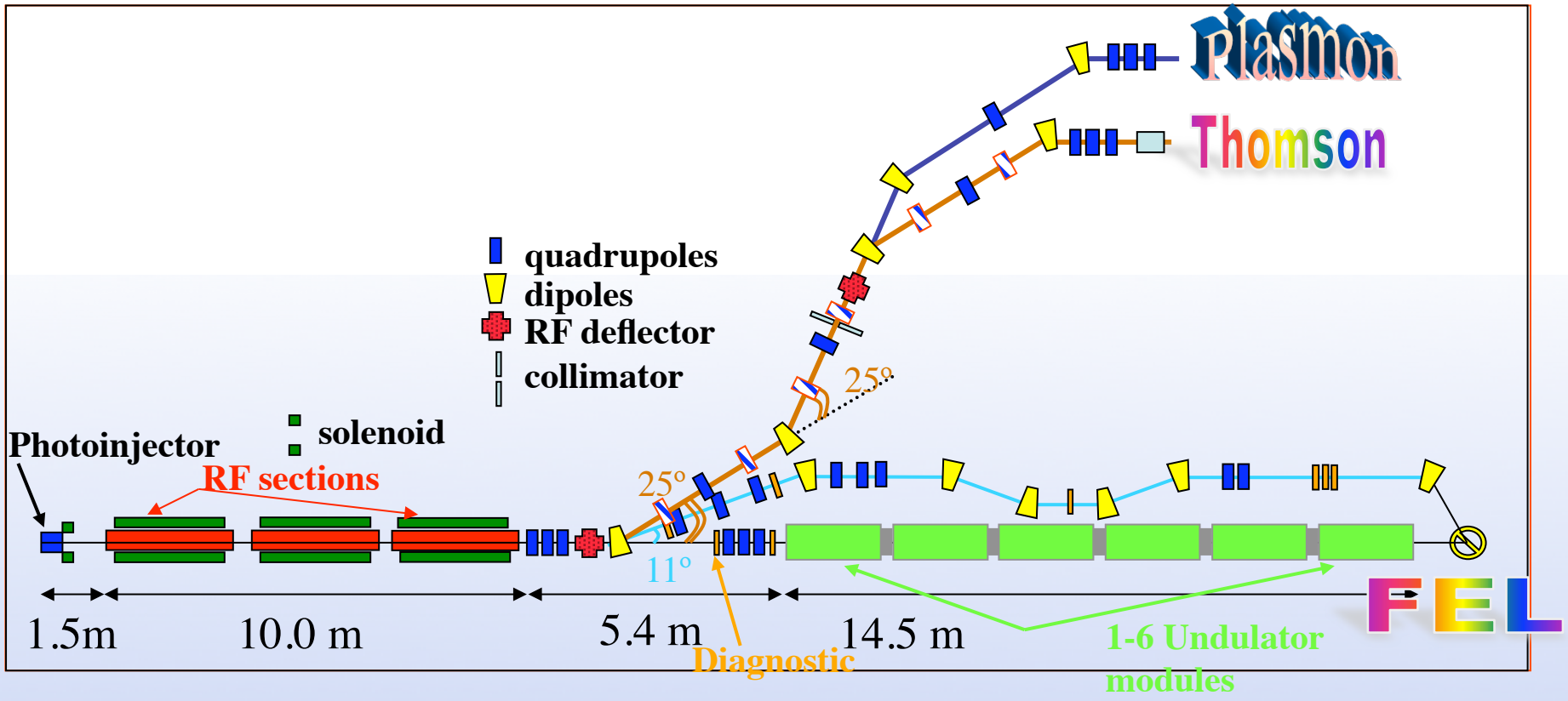


THz radiation can be easily produce by means of CTR

It is difficult to put high charge in sub-ps bunches

A particular structure in the longitudinal laser profile can solve this problem

Additional beam lines



SPARC experiments

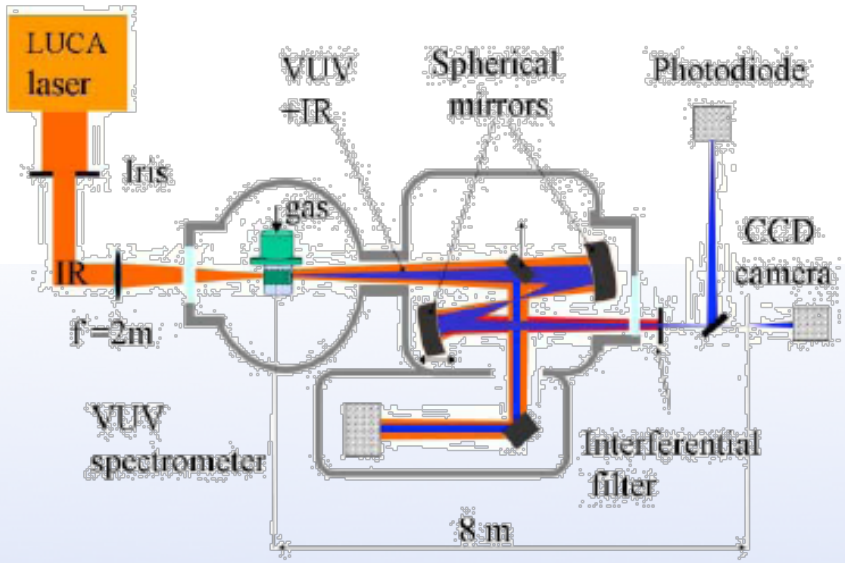
- Laser/Plasma Acceleration of ultra-short (fs) e-bunches
- Compact Sources of mono-chromatic tunable X-rays for advanced clinical diagnostic and nano-biology.

Application	Bunch charge (nC)	Energy (MeV)	Bunch length rms (ps)	Norm. rms emittance (mm)	Energy Spread (%)
Plasmon	0.025	100-200	0.025	0.1	0.2
Thomson	1-3	28-200	3	2-5	0.2-0.1

See the talk of L. Serafini (Sunday) and D. Giulietti (Thursday afternoon)

Conclusion

- A lot of activities are ongoing
  - Experimental activities on SPARC
  - TDR for SPARX
- Also several others are foreseen in the next future in the SPARC
  - Plasmon X
  - Thompson
  - THz radiation
  - Single spike


LUCA
laser
Iris
IR
f =2m
gas
VUV
+IR
Spherical
mirrors
Photodiode
CCD
camera
VUV
spectrometer
Interferential
filter
8 m