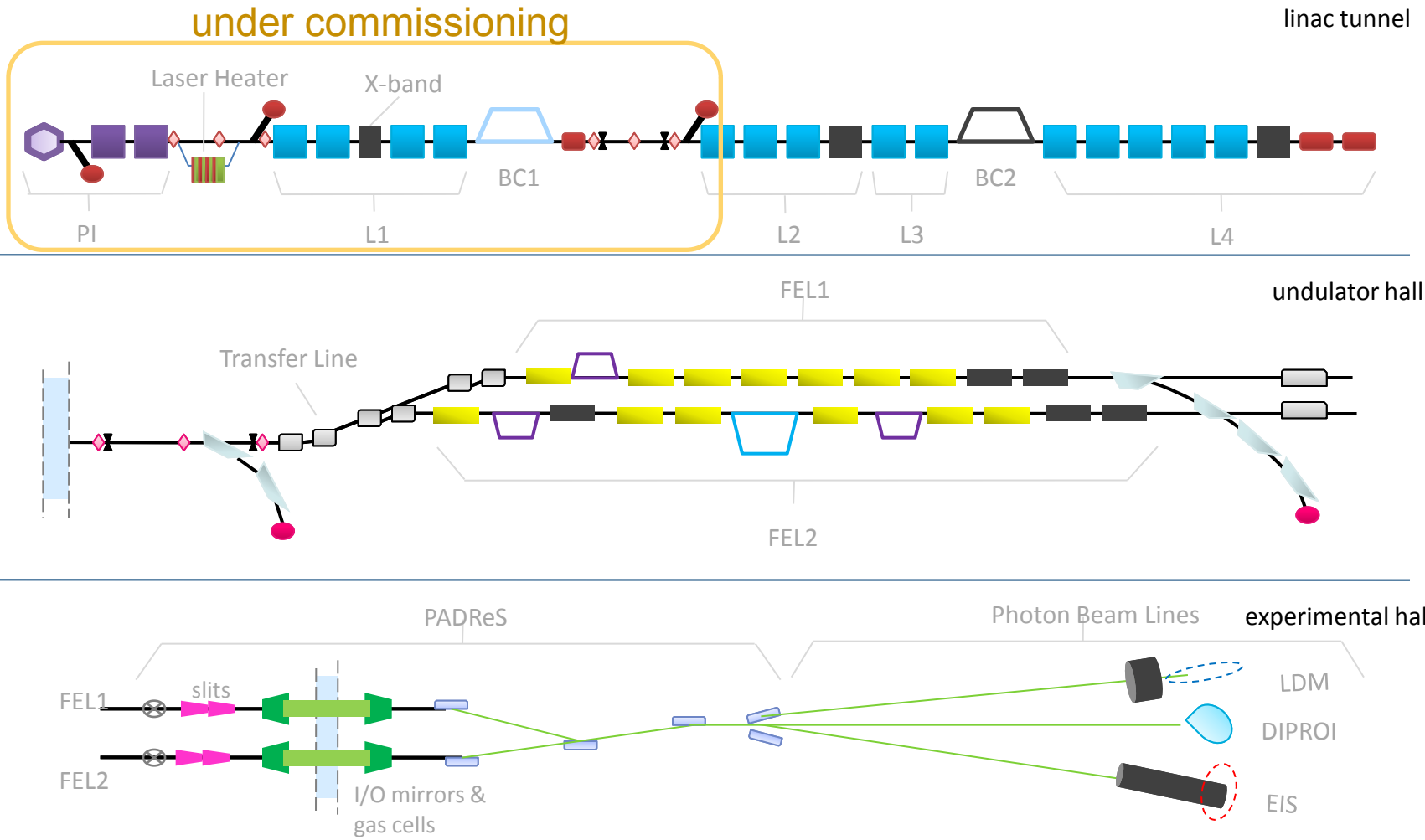
FERMI@elettra is under commissioning

Simone Di Mitri on behalf of the FERMI@elettra Team



project

Electrons:

0.9 – 1.5 GeV

800 A, 1 ps

slice emittance = **1.0 mm mrad**

slice energy spread = **150 keV**

Photons:

10 – 50Hz single-pass FEL user-facility

λ_{FEL} = **100 nm** (12 eV) – **4 nm** (310 eV)

0.3 – 4.0 GW peak power

Apple II type undulators → tunable λ_{FEL} & variable polarization

peak brilliance 10^{30} – 10^{31} ph/sec/mm^2/mrad^2/0.1%bw

ph/pulse 10^{12} – 10^{14}

accelerator layout
e-beam parameters
undulators

have been chosen to allow:

multiple FEL schemes
→ maximize number and type of exps.

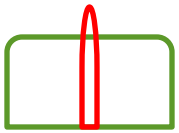
flexible FEL output
→ output tuning

machine upgrades
→ shorter wavelengths

FEL schemes

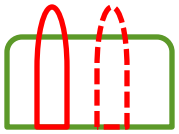
(ref. G. De Ninno, E. Allaria)

SASE →



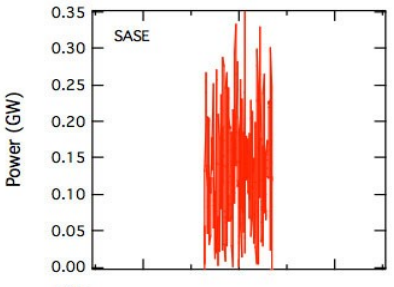
Seeded FEL
Short pulse →

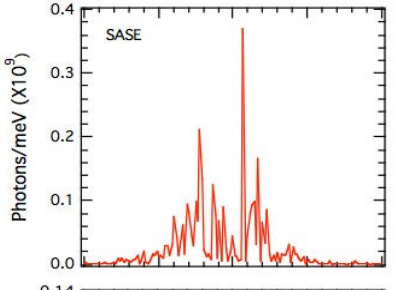
Seeded FEL
Low charge →

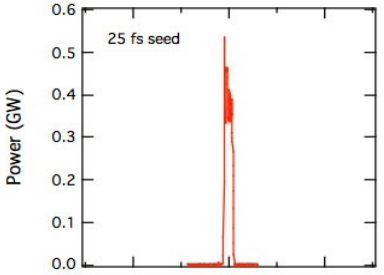


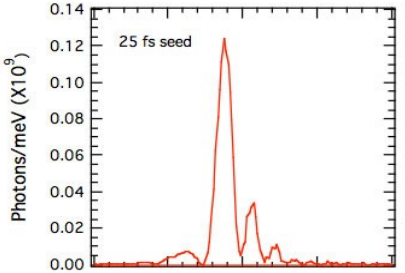
Seeded FEL
Fresh bunch →

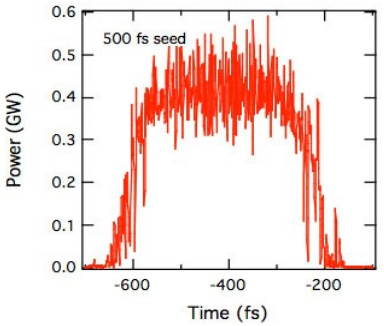
10^{13} photons at 10 nm
5 meV bandwidth (1.5xFTL)

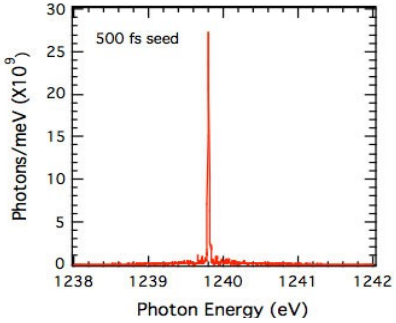


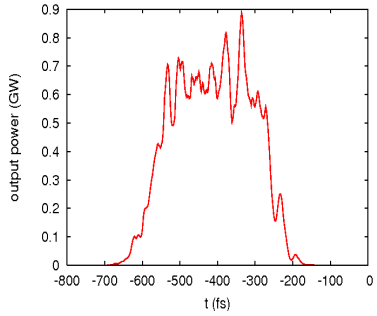


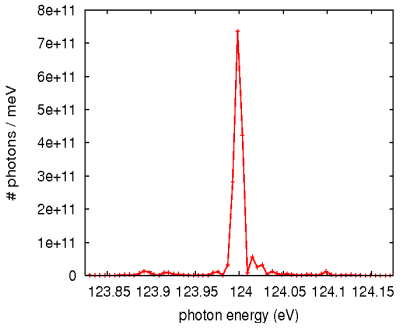






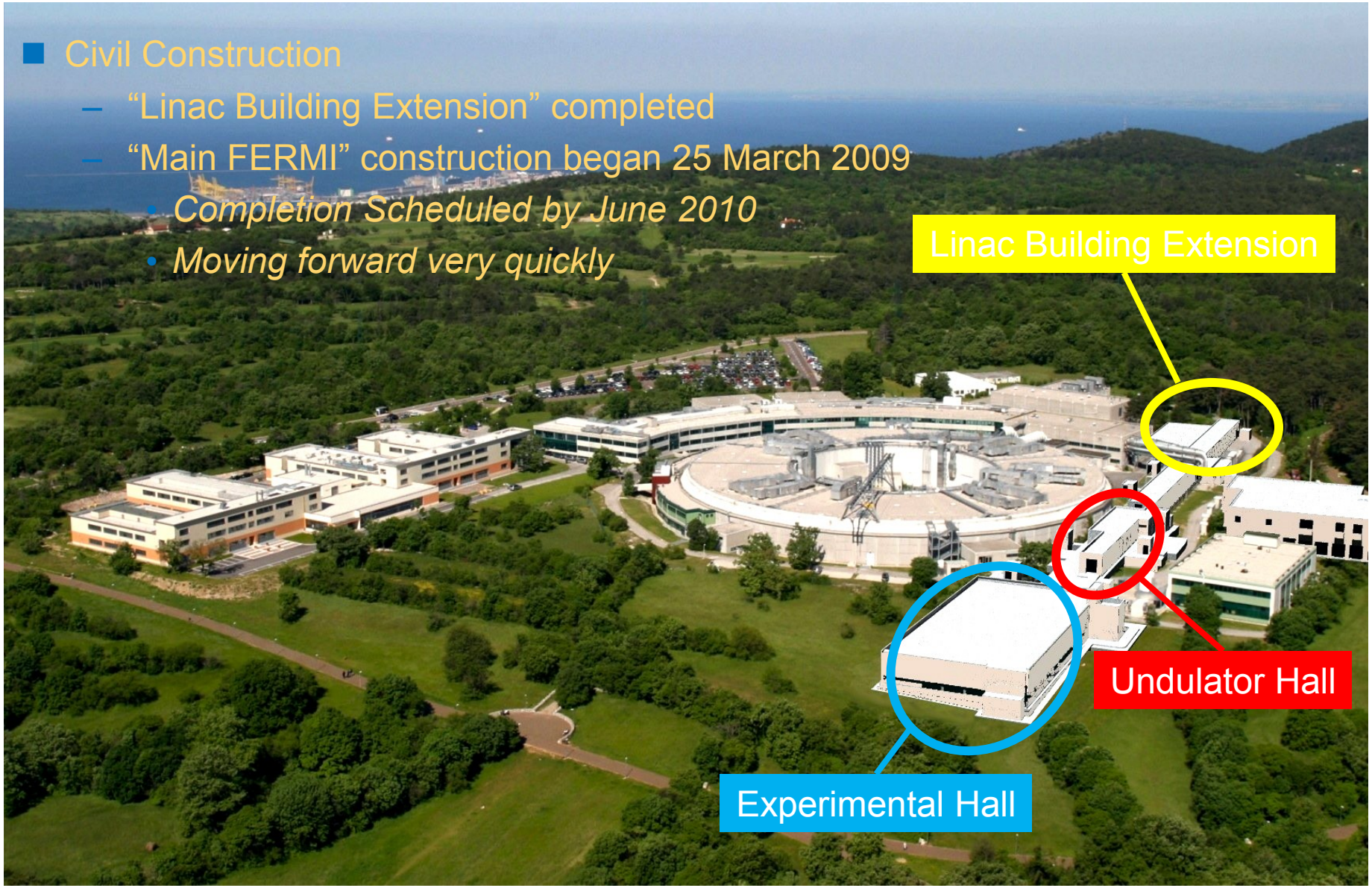




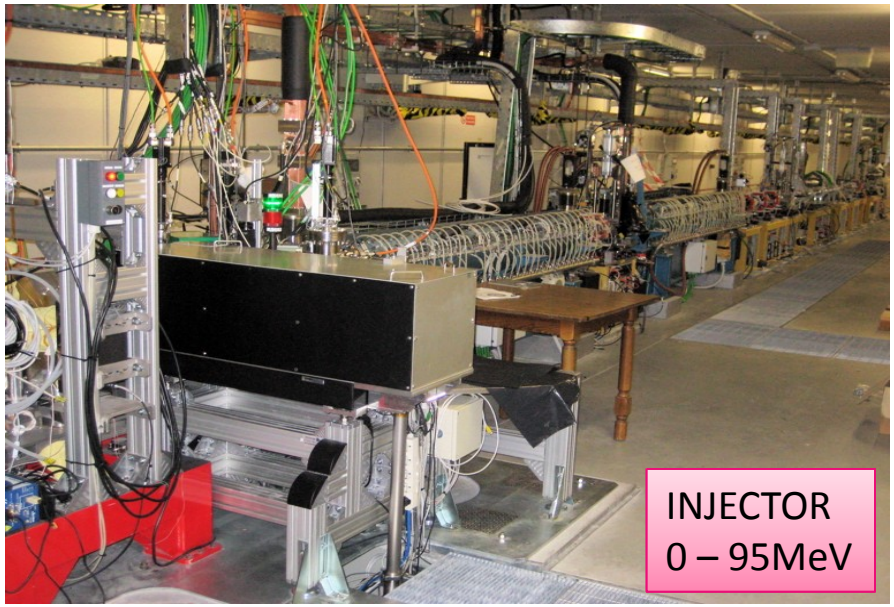


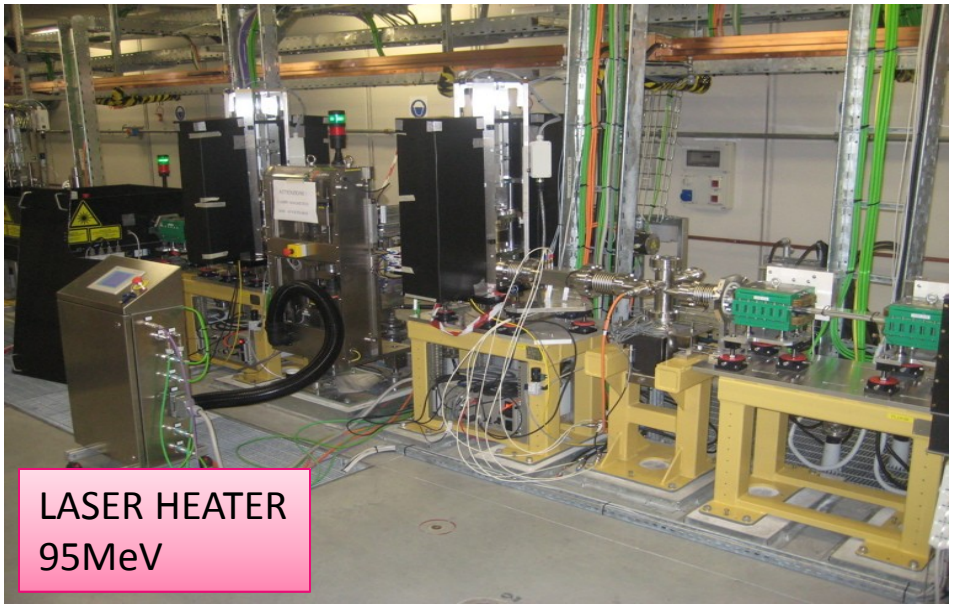
civil engineering

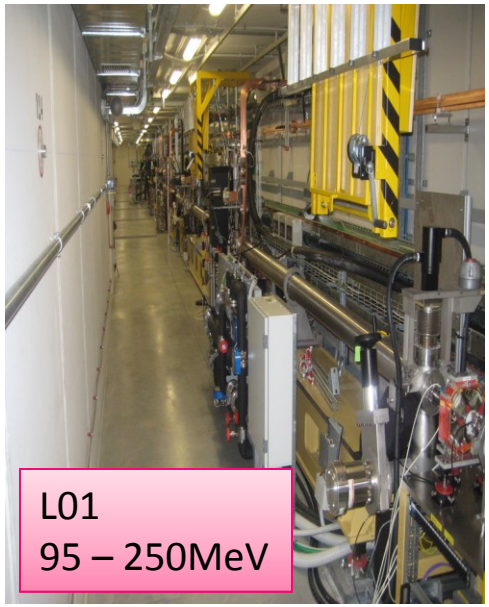
(ref. S. Noe')

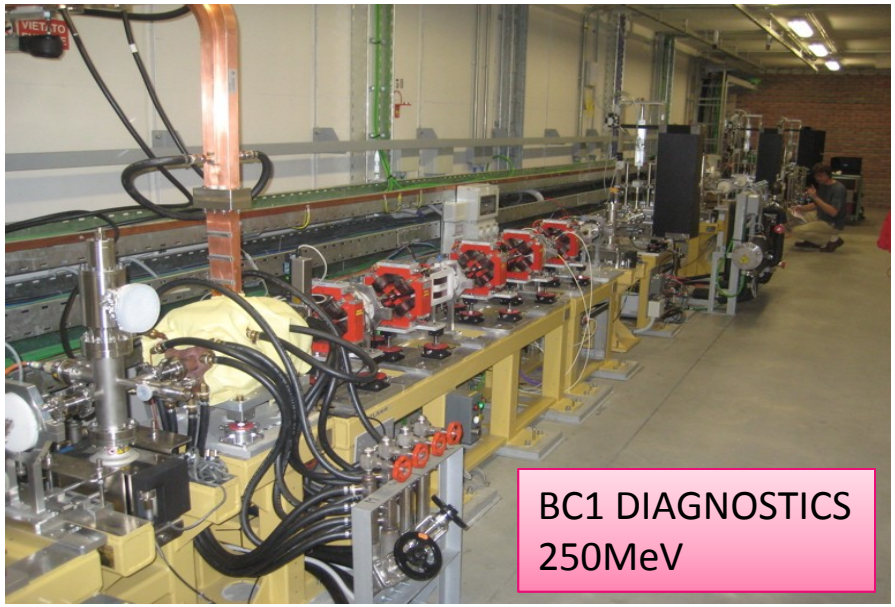


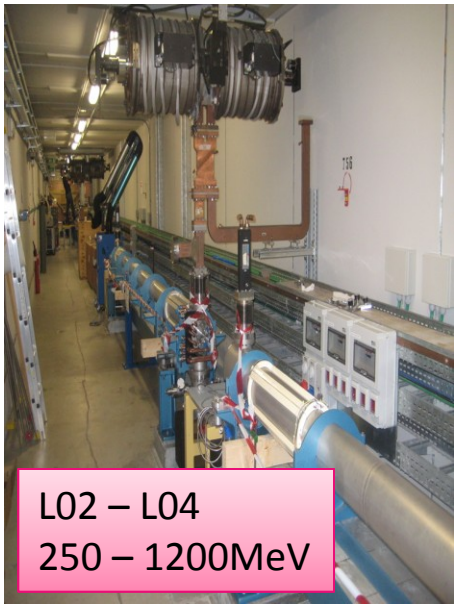
accelerator



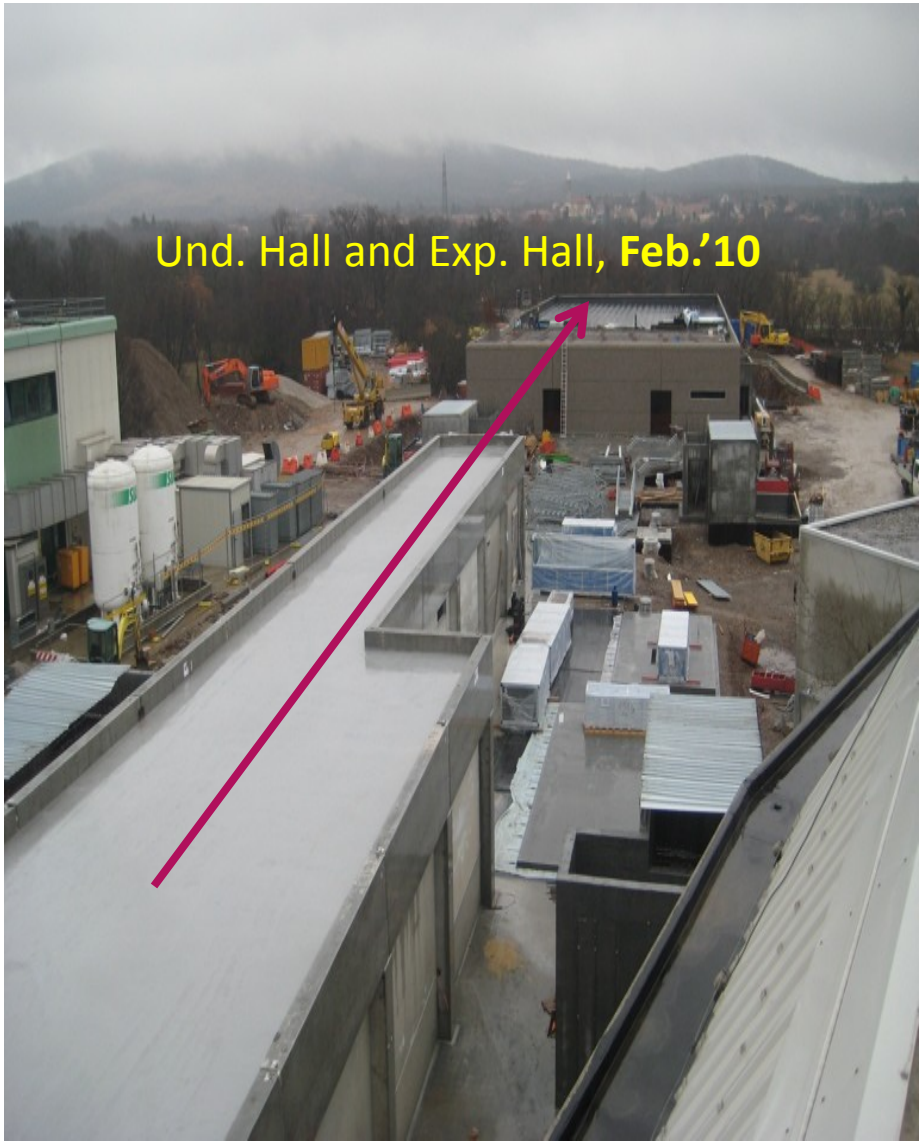




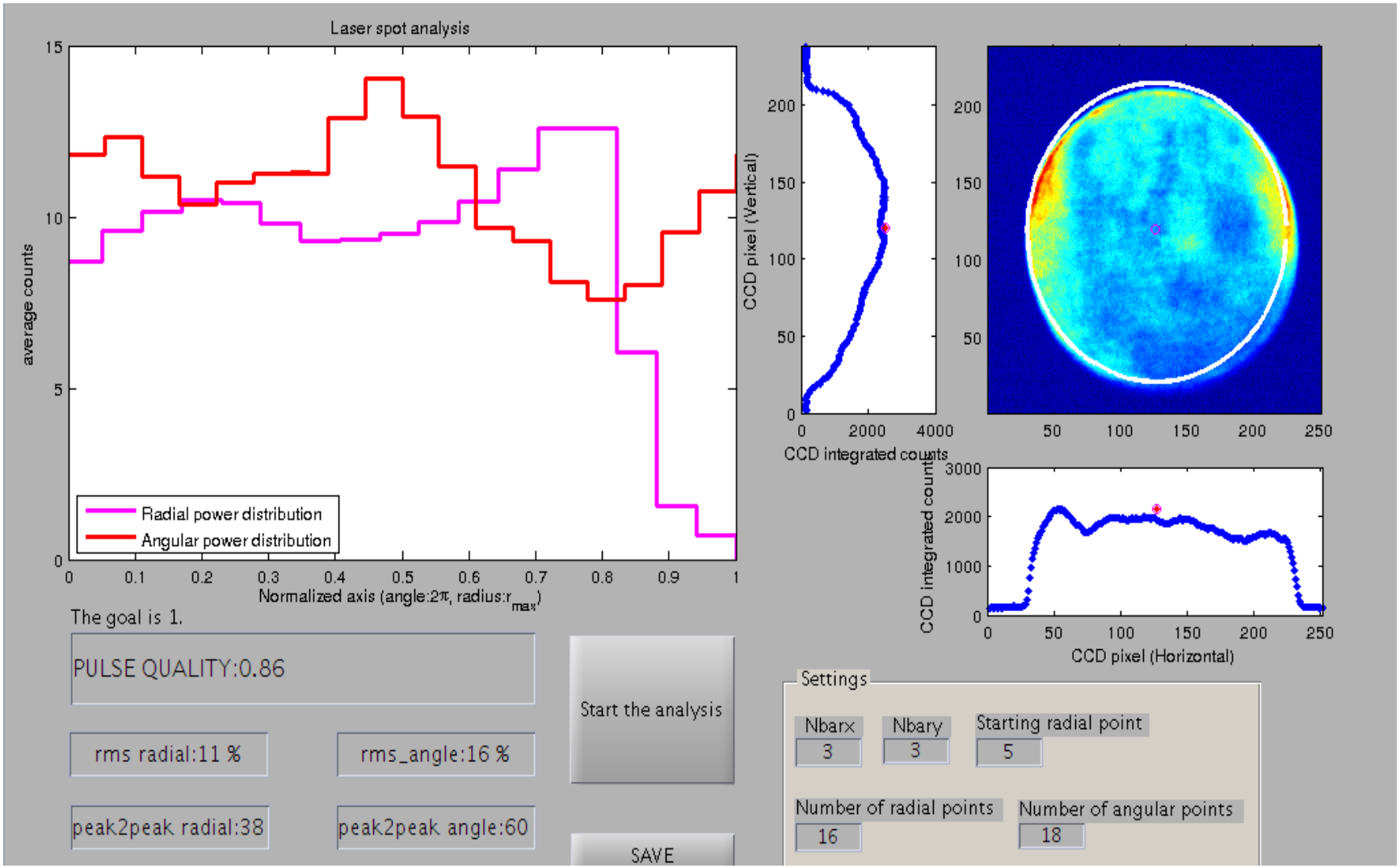




undulator and experimental hall



A Matlab script evaluates the transverse quality of the PI laser at the virtual cathode:

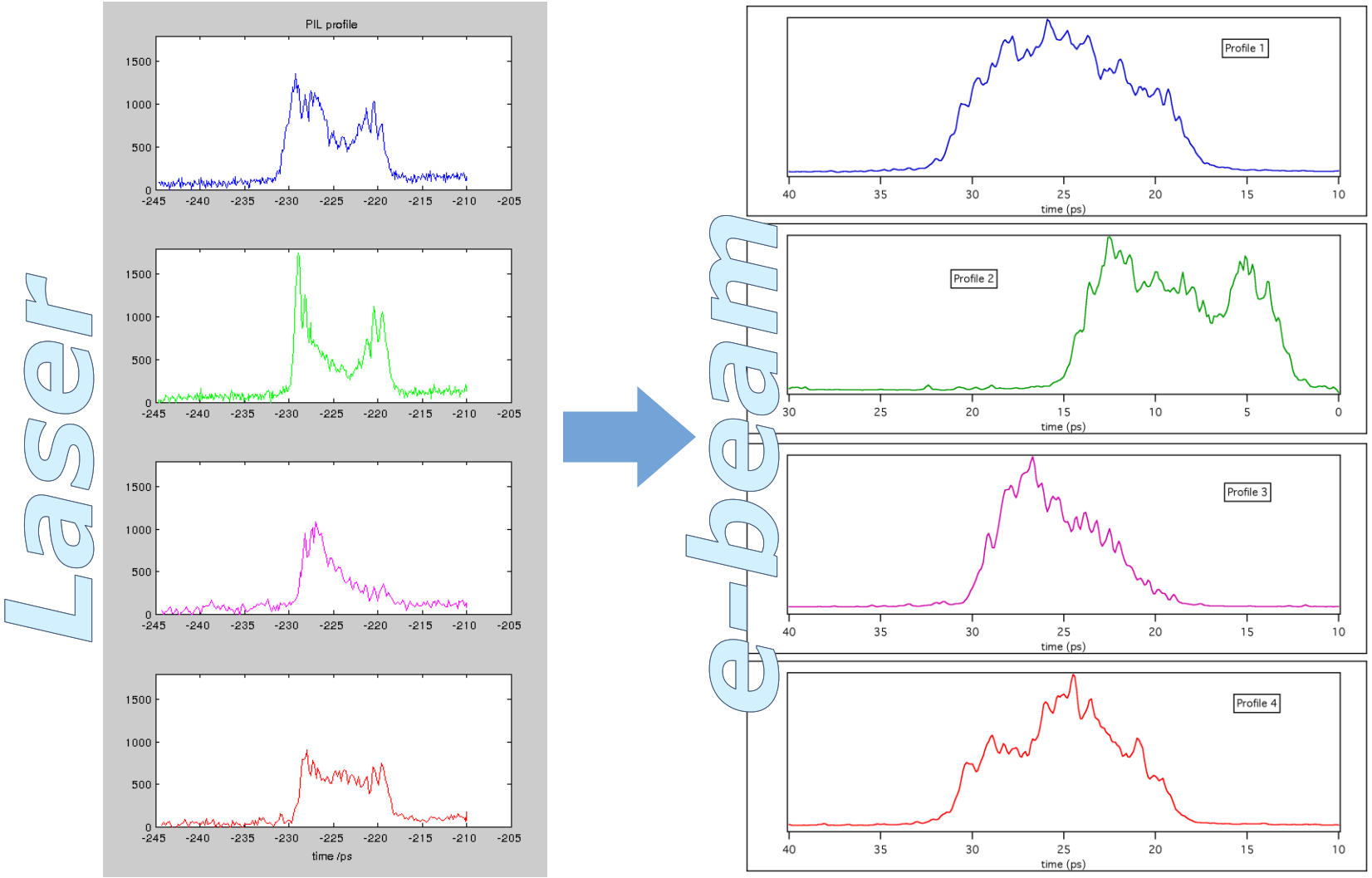


meas. 15/02/2010

longitudinal profile

(ref. L. Badano, M. Danailov)

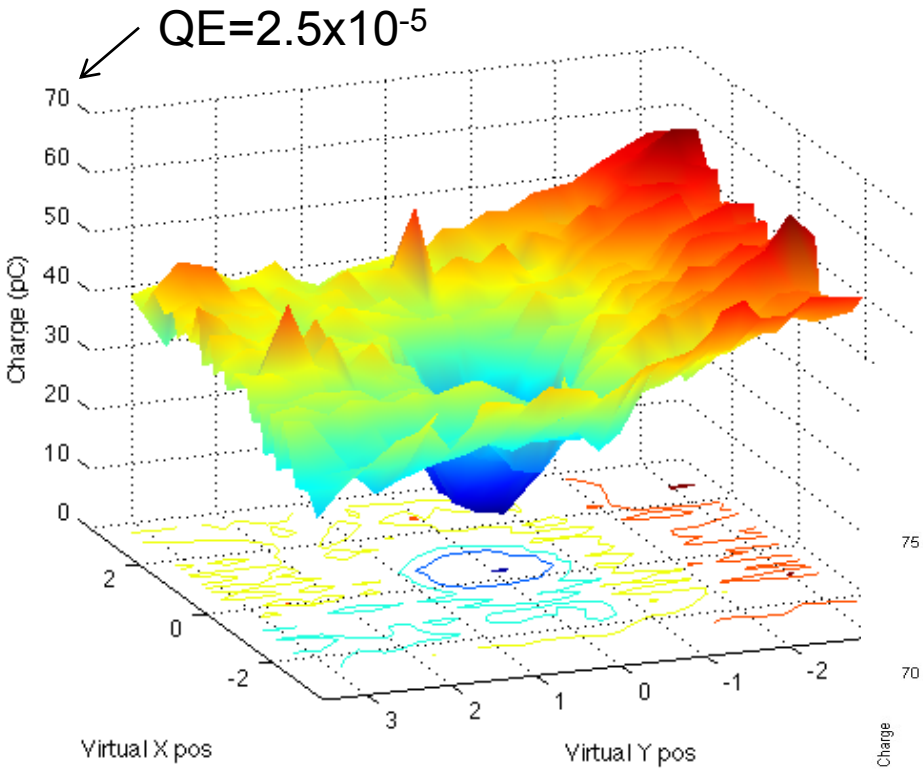
laser shaping measured with the cross-correlator vs. e-beam (800pC) temporal profile measured with the Cerenkov radiator combined with a streak camera:



meas. 12/11/2009

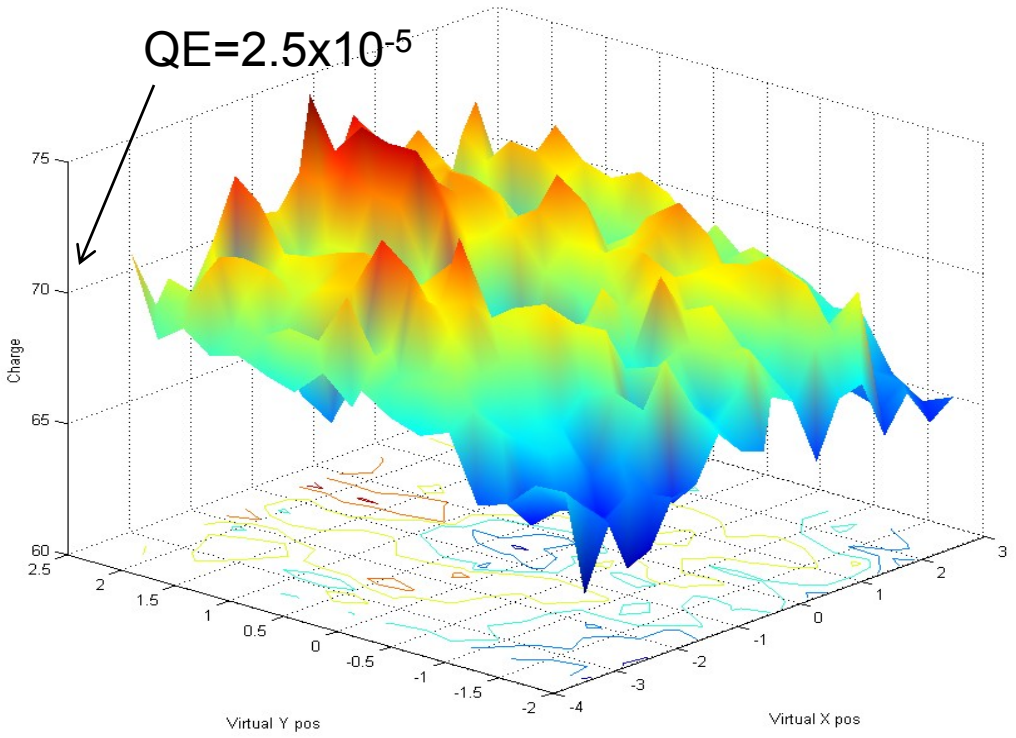
quantum efficiency

(ref. M. Trovo')



Cathode surface sampled by a 200 µm laser spot and 10 µJ, after 2 months operation

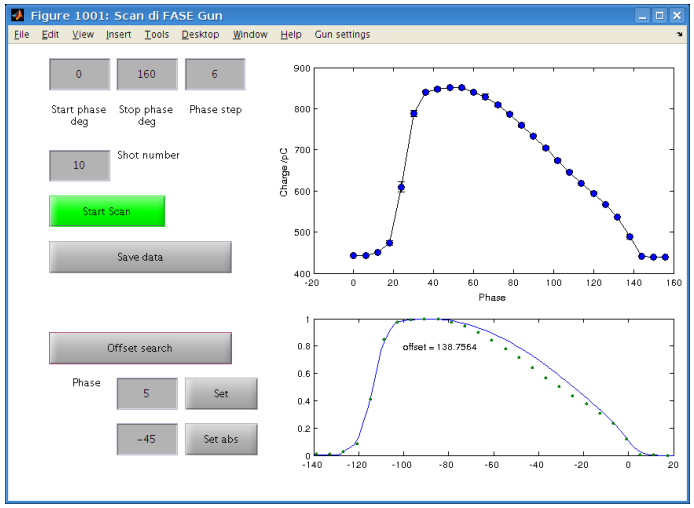
After cleaning with ozone



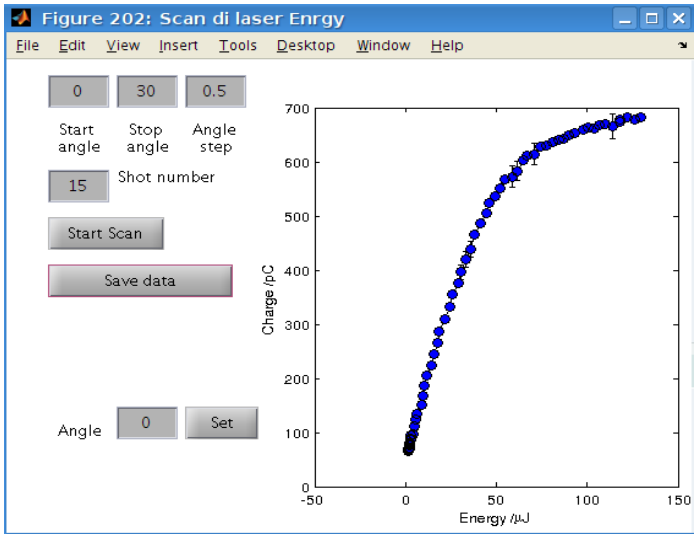
meas. 26/10/2009 – 23/01/2010

phase scan & cathode lifetime

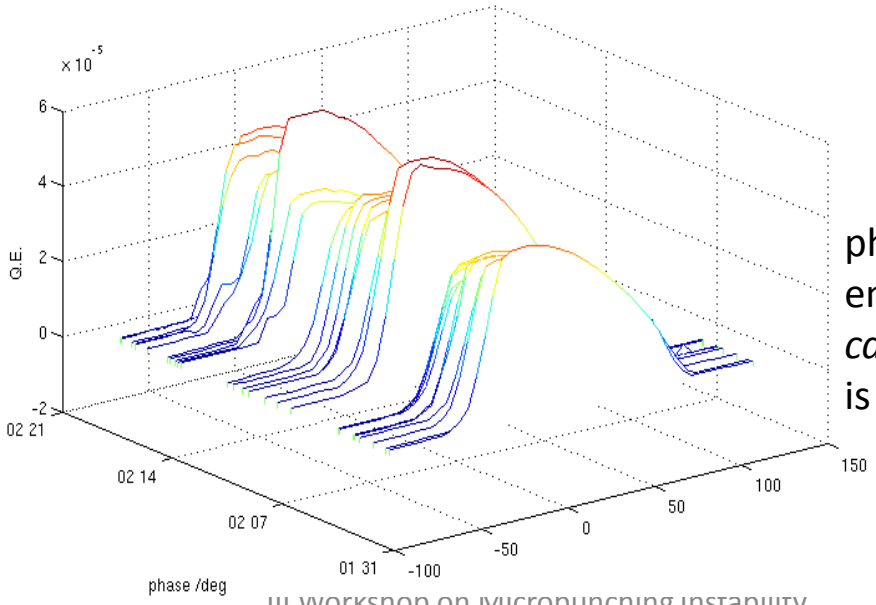
(ref. M. Trovo')



phase scan with Matlab tool: fit the measurement and set the phase for max. energy



total charge vs. laser energy

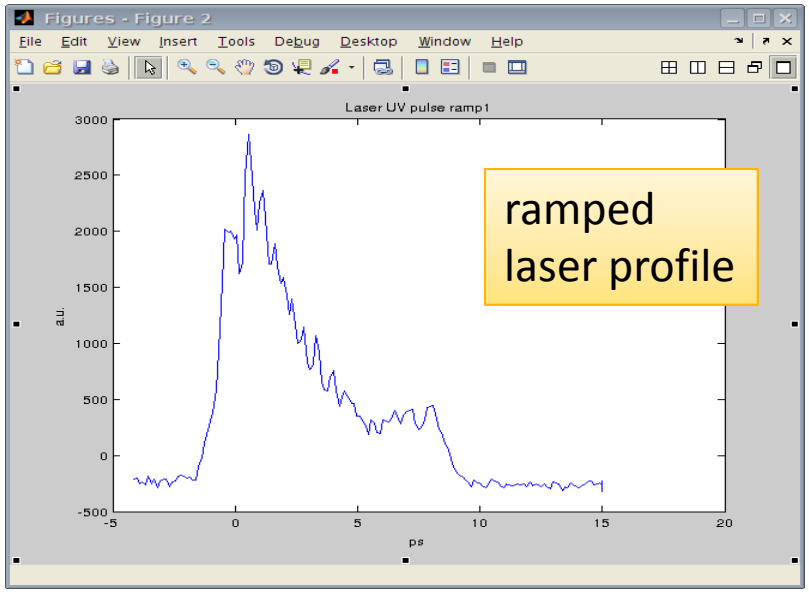


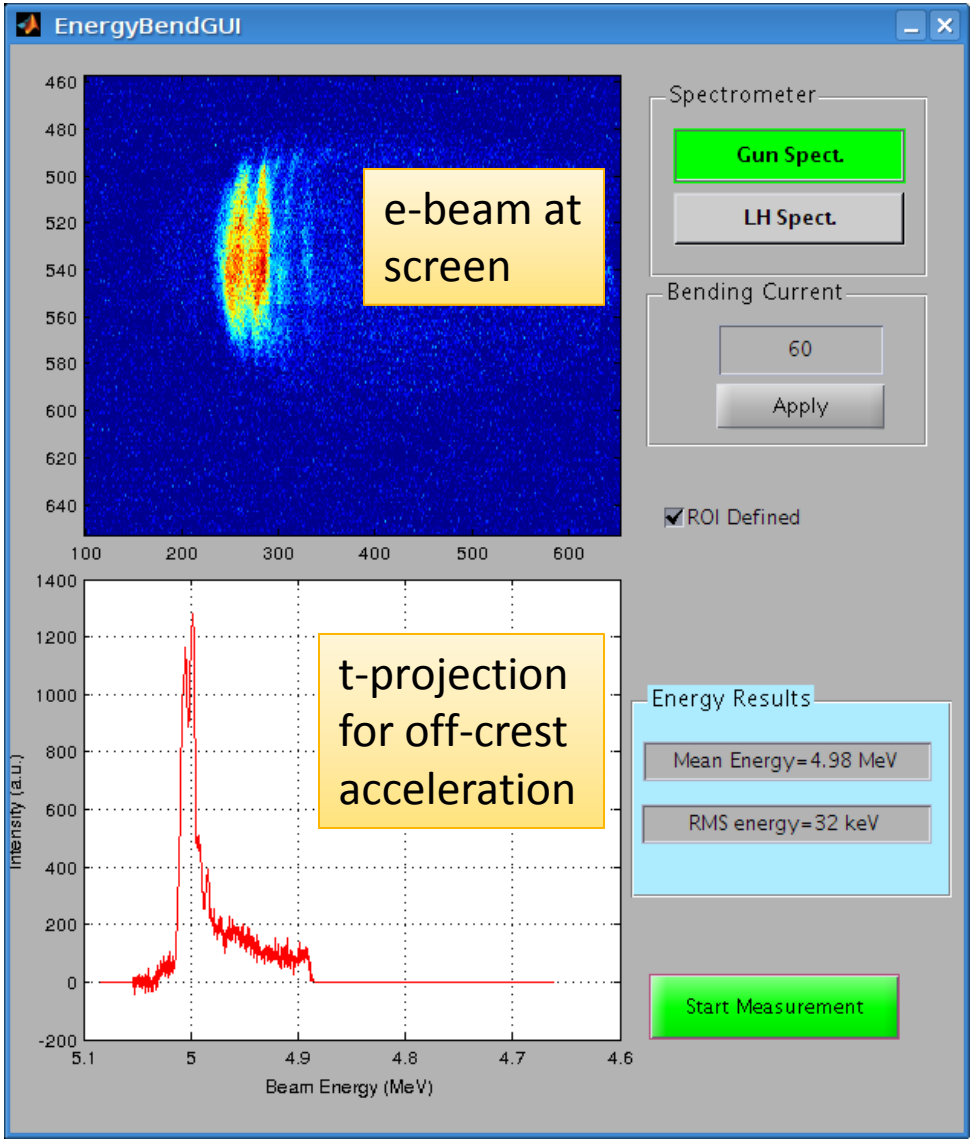
phase scan normalised to laser energy over 1 months *after cathode cleaning*: a longer lifetime is observed.

meas. 11/2009 – 02/2010

gun spectrometer line

(ref. G. Penco, P. Craievich)

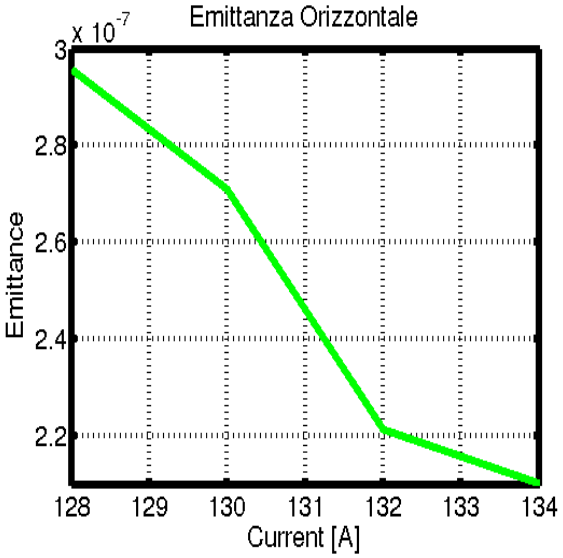


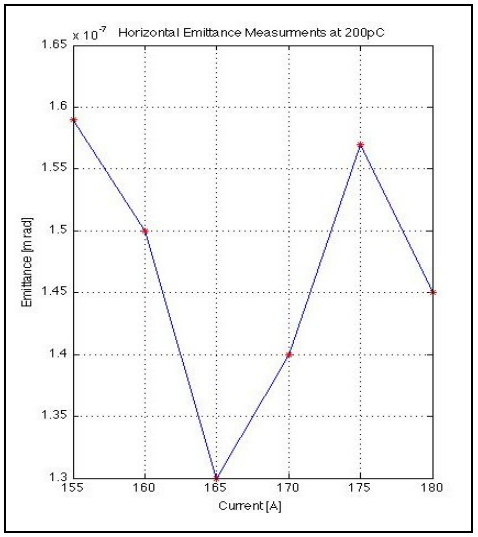


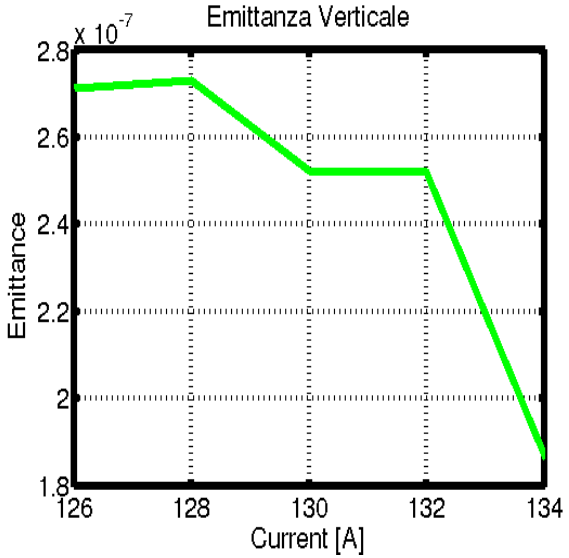
- Automatic search of the linac RF crest and energy measurement.
- $(\Delta E/E)_{rms} \leq 0.06\%$ over 1h, neither feedback nor LLRF.

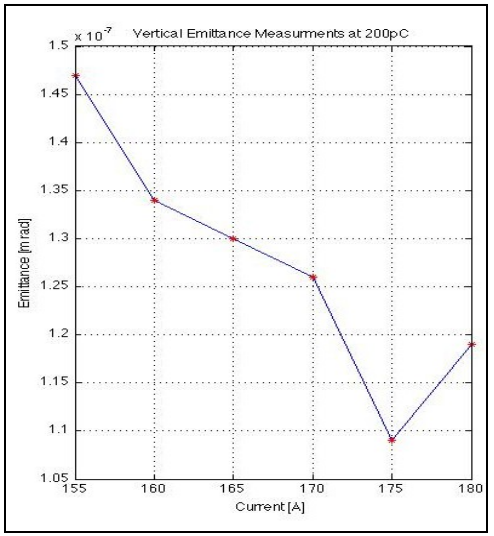
emittance at low energy

(ref. G. Penco, A. Lutman, M. Petronio)





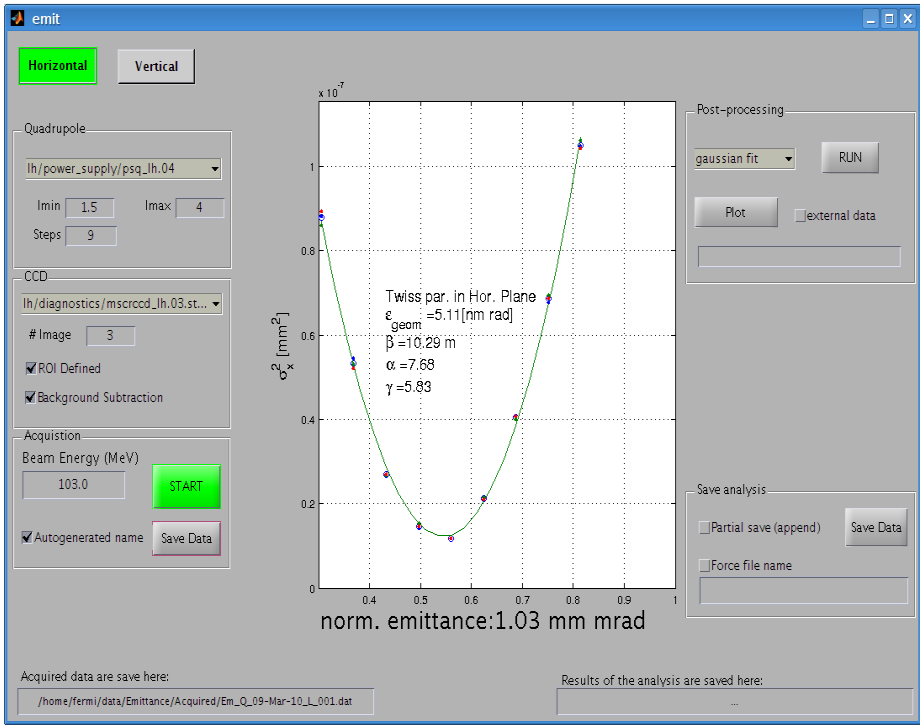


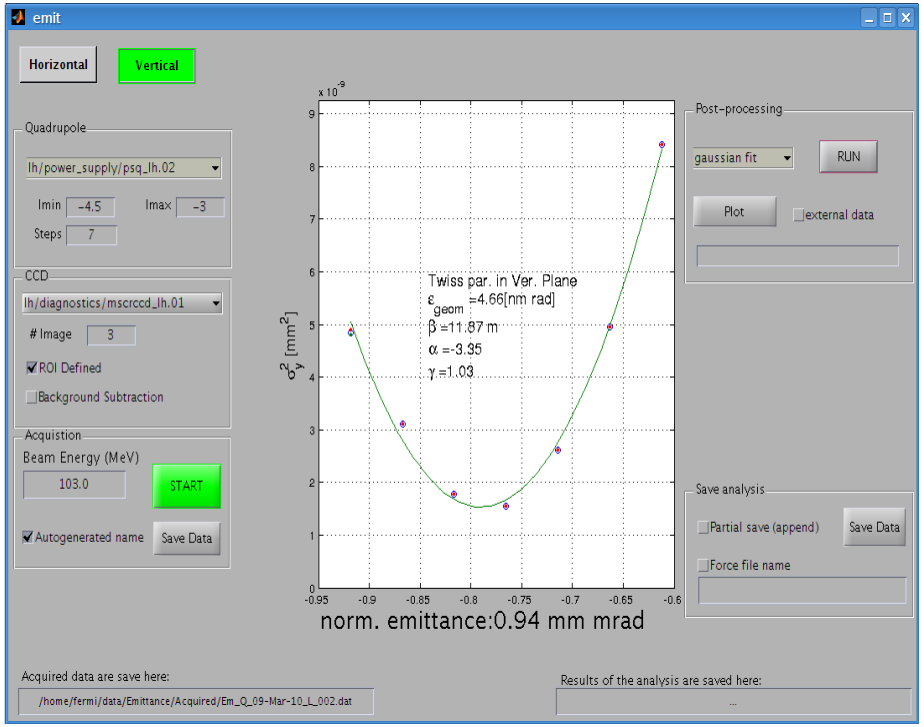


- $\varepsilon_{x,y}$ measured with slits at 5MeV, 200pC. Scan of gun solenoid reveals 15% x/y asymmetry.
- ε_x depends on the trajectory in the booster linac: the x/y asymmetry can grow up to 100%: RF kick in x-plane ??
- All measurements have ROI including 100% of beam spot.

emittance at higher energy

(ref. G. Penco et al.)



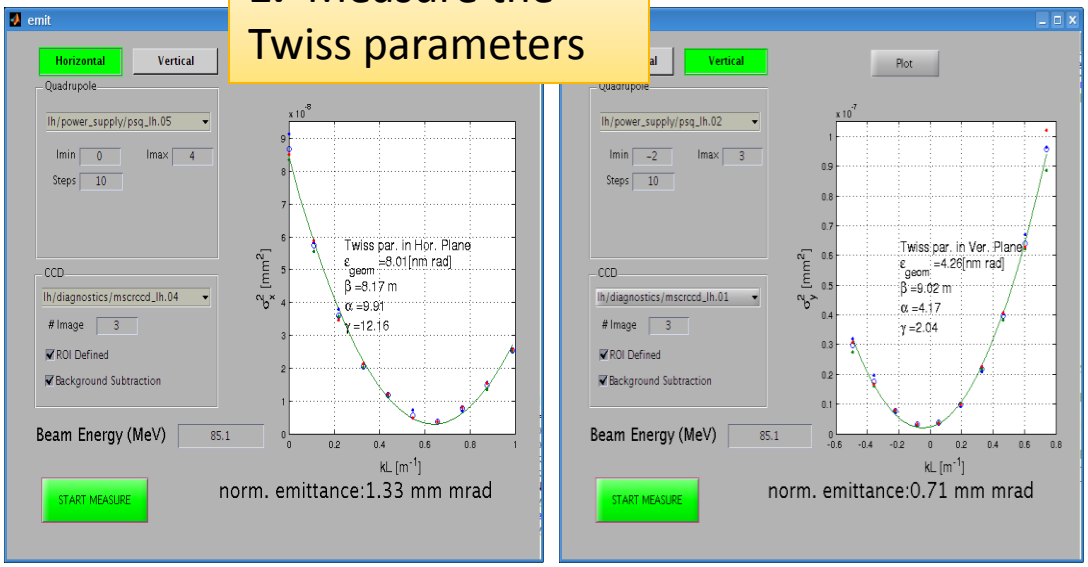


- Projected emittance measured with quadrupole scan at 100MeV for 5ps, 330pC, flat pulse.
- Post-processing takes 100% of the spot size and then applies fitting (symmetric or asymmetric Gaussian) to the transverse intensity distribution.
- 3-screen at 60^{O} phase advance also available.

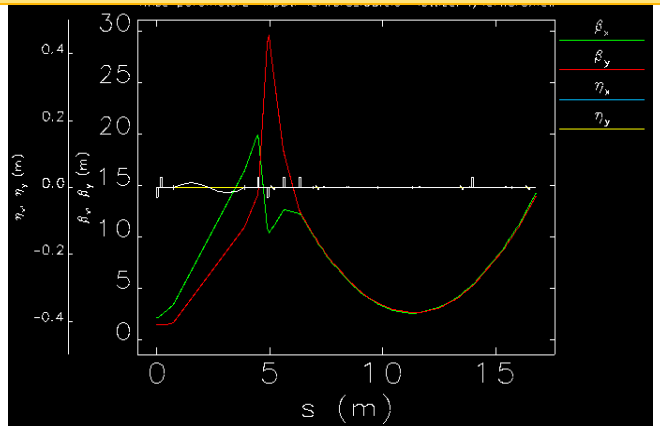
optics matching & trajectory feedback

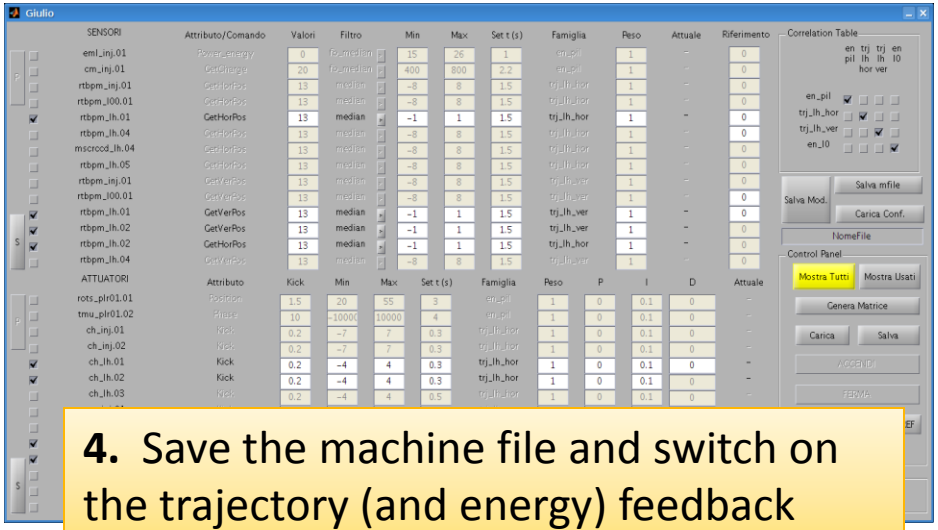
(ref. G. Gaio, A. Lutman, C. Scafuri, S. Spampinati)

1. Measure the Twiss parameters

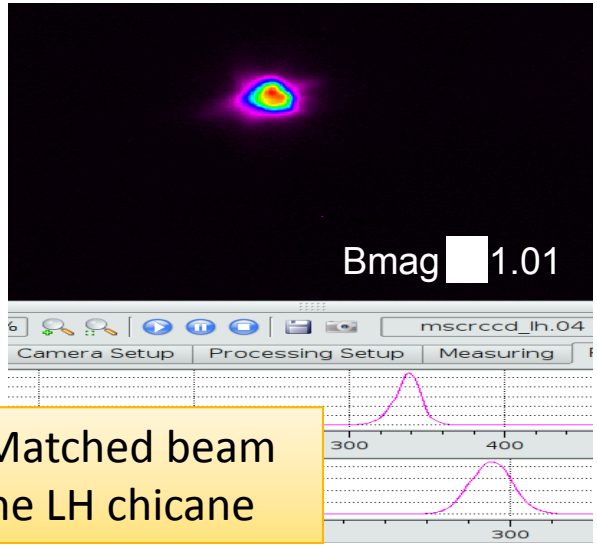


2. Use *elegant* to match the real beam to the nominal machine optics (Matlab tool)





4. Save the machine file and switch on the trajectory (and energy) feedback



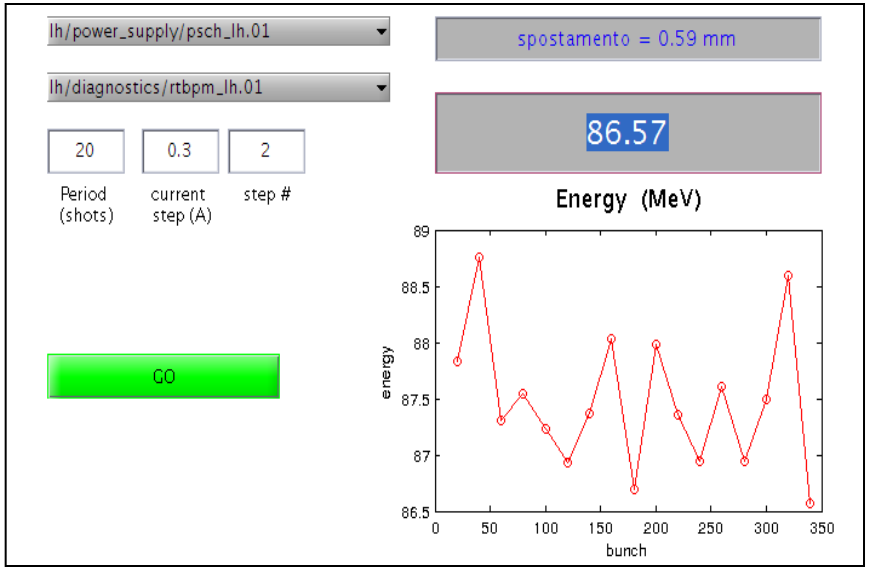
3. Matched beam in the LH chicane

real time measurements

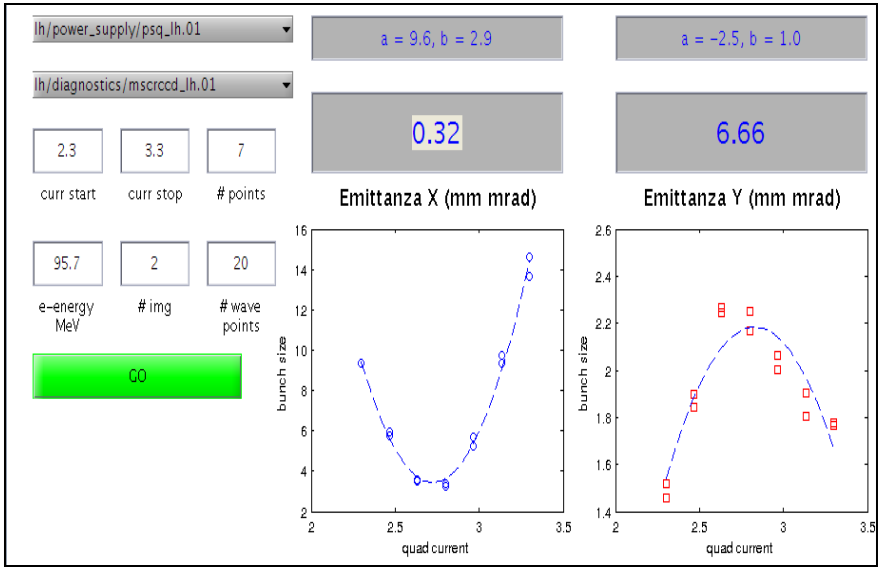
(ref. M. Trovo', G. Gaio, L. Giannessi)

Real time measurements of energy and emittance (bunch number available): technique proved. now debugging codes….

energy measurement with a corrector magnet

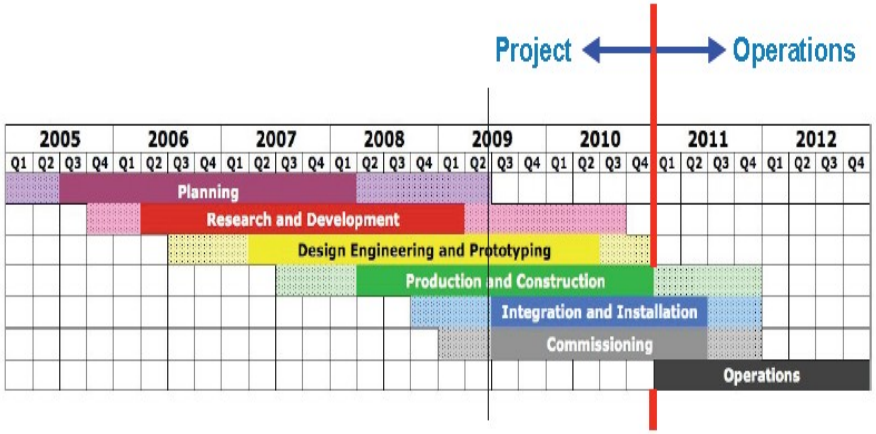


emittance measurement with quad scan

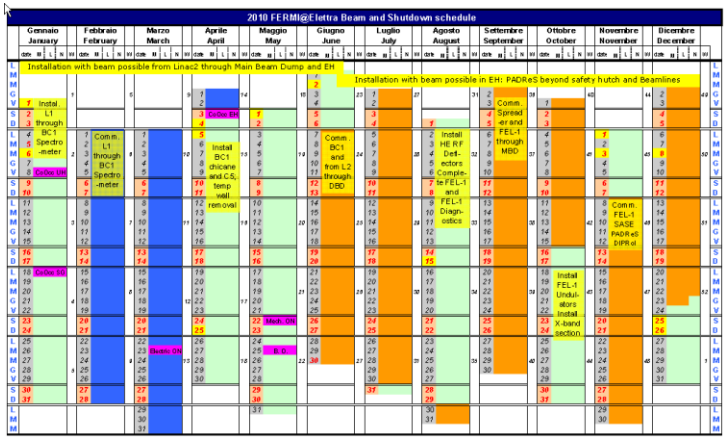


scheduling

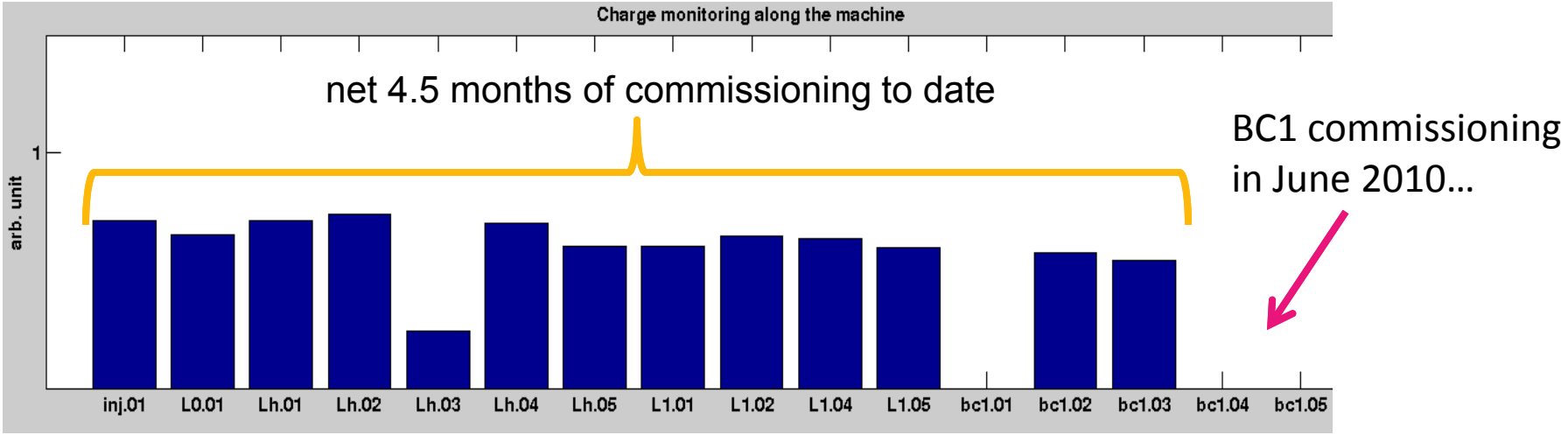
1. Annual plan (management)



2. Monthly plan (installation + commissioning)



3. Weekly planning of the commissioning shifts



summary

- Design study
  - CDR completed over 2003 – 2007
  - now improving the original design: higher linac energy, shorter wavelength
- Civil Engineering
  - Linac extension complete
  - Undulator and Experimental Hall completion by June 2010
- Machine
  - 1st photo-electons at MaxLab, with INFN-LNF (July 2008)
  - Commissioning progressing as planned
- Schedule
  - Aggressive, but plausible:
    - understaffed *for commissioning* (help is welcome!)
    - expect minimum beam quality for FEL1 saturation at 60nm by Dec.'10
- Goal
  - Operations begin start of 2011
  - 100 nm to 10 nm promised, 4 nm (fundamental) stretch goal

Acknowledgement

current FERMI@elettra *Commissioning* Team (technical support + machine physics):
(~ ½ shared with Elettra, 4 senior scientists full time in CR)

E. Allaria, F. Asnicar, L. Badano, S. Bassanese, A. Borga, R. Borghes, M. Bossi, D. Castronovo, M. Cautero, G. Ciani, P. Cinquegrana, S. Cleva, P. Craievich, M. Danailov, P. Del Giusto, A. Demidovich, G. De Ninno, S. Di Mitri, M. Ferianis, S. Ferry, L. Froelich, G. Gaio, F. Gelmetti, R. Ivanov, M. Lonza, A. Lutman, G. Mian, M. Miculin, M. Milloch, A. Milocco, D. Molaro, L. Pavlovic, G. Penco, M. Petronio, M. Predonzani, F. Pribaz, F. Rossi, C. Scafuri, C. Serpico, P. Sigalotti, N. Sodomaco, S. Spampinati, C. Spezzani, G. Strangolino, M. Trovo', R. Umer, L. Veljak, M. Veronese, R. Visintini, D. Wang, L. Zambon

Thank you for your attention