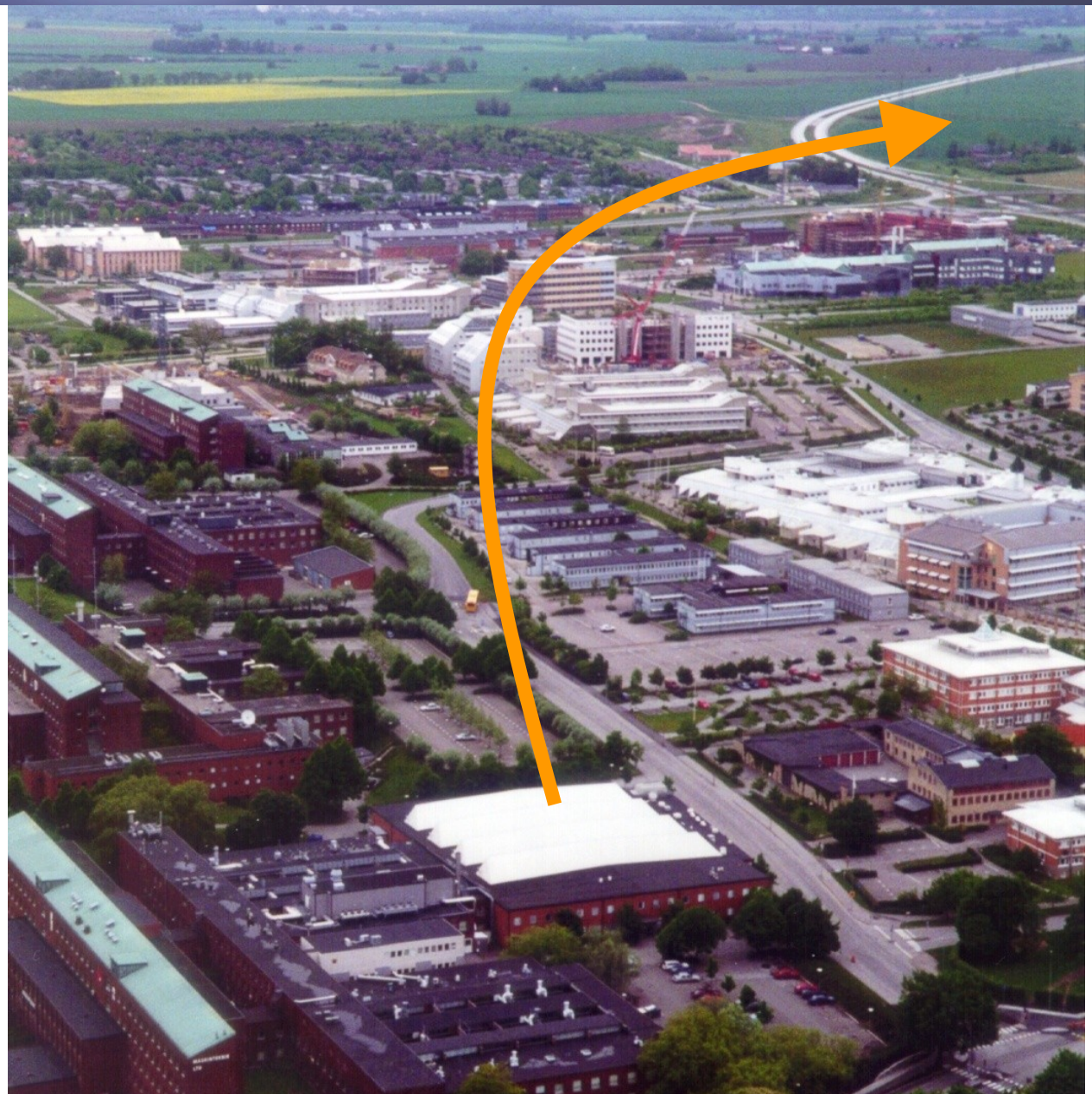
The MAX IV Injector

Sara Thorin

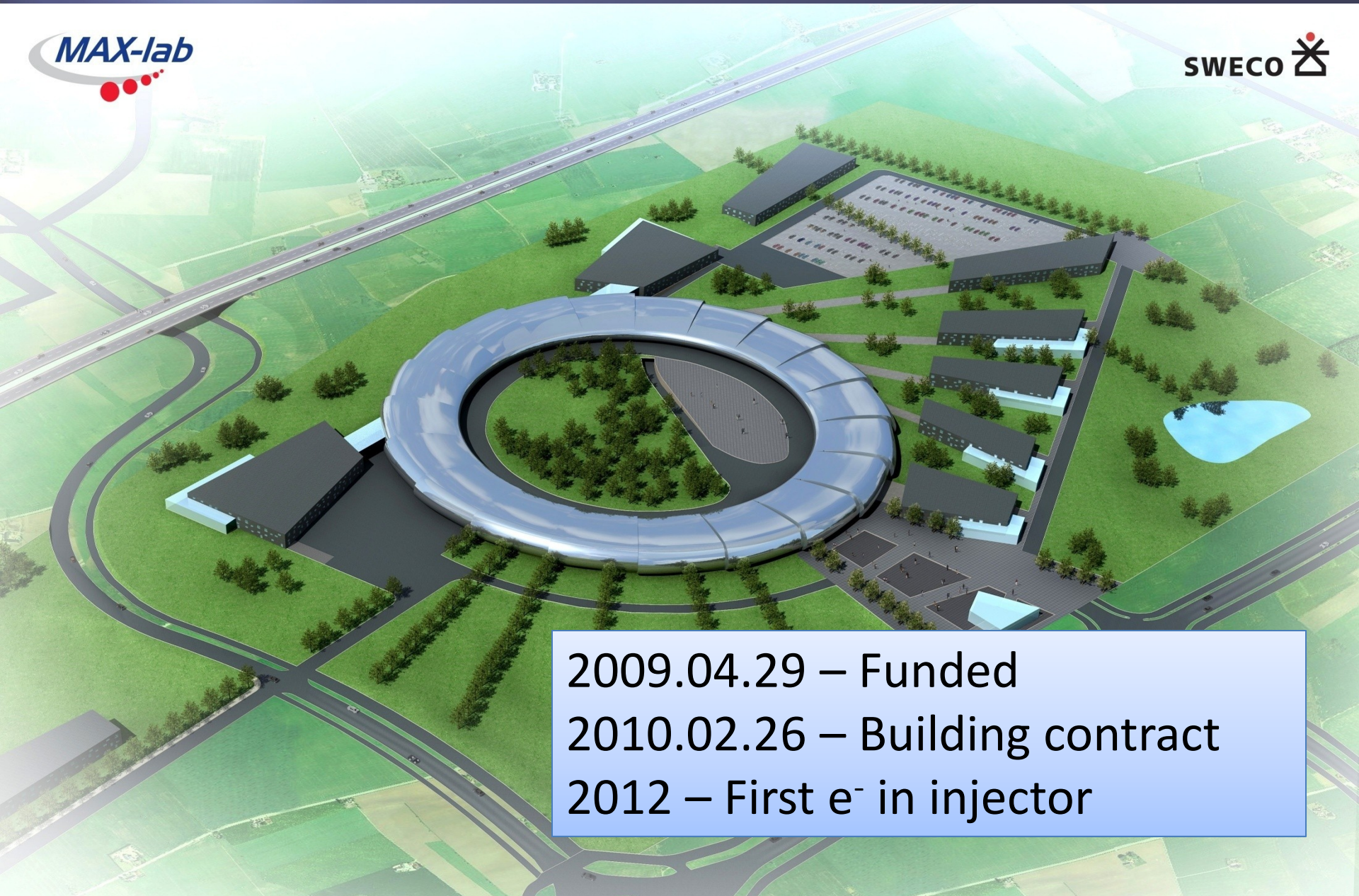
Microbunch instability workshop, 24-26 of March, Frascati

MAX IV



We are moving!

MAX IV

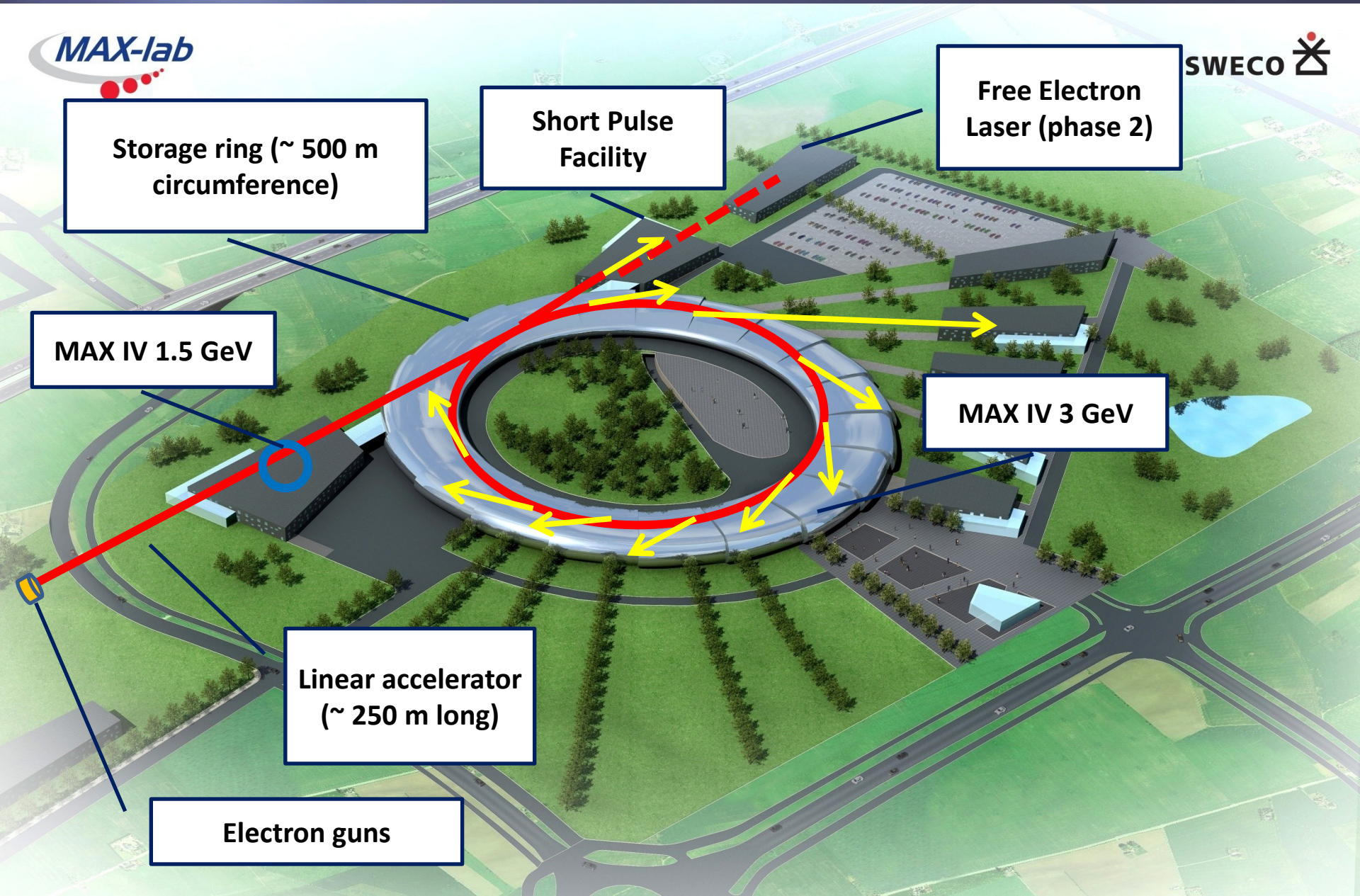


2009.04.29 – Funded

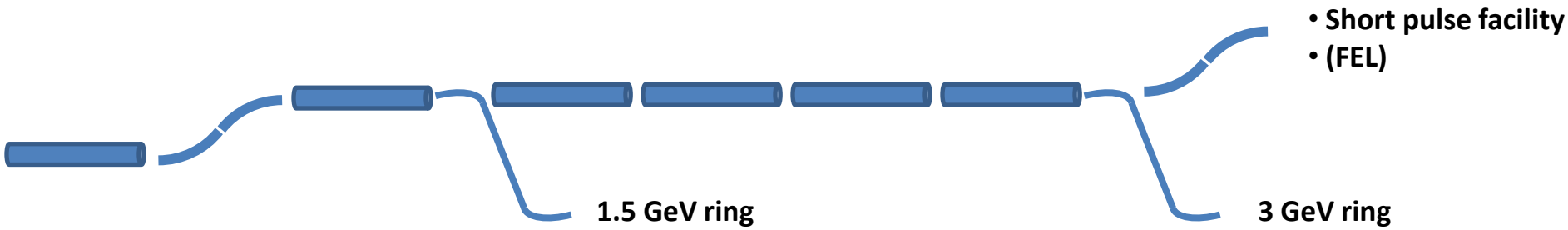
2010.02.26 – Building contract

2012 – First e^- in injector

MAX IV


MAX-lab
SWECO
Storage ring (~ 500 m circumference)
Short Pulse Facility
Free Electron Laser (phase 2)
MAX IV 1.5 GeV
MAX IV 3 GeV
Linear accelerator (~ 250 m long)
Electron guns

Different modes for the injector



Injection and top up for the two rings

- 1.5 GeV and 3 GeV
- 1 nC charge
- ~1 ns bunch length
- ~ 4 mm rad emittance

High brightness injector for

- SPF – different pulses
  - 100 pC
  - 100 fs clean pulses
  - vary pulse length/emittance
- FEL (phase two)
  - shorter pulses
  - lower emittance
  - few fs, few pC, very low emittance

MAX IV - Injector

- 3 GHz warm
- 3.5 GeV
- 100 Hz

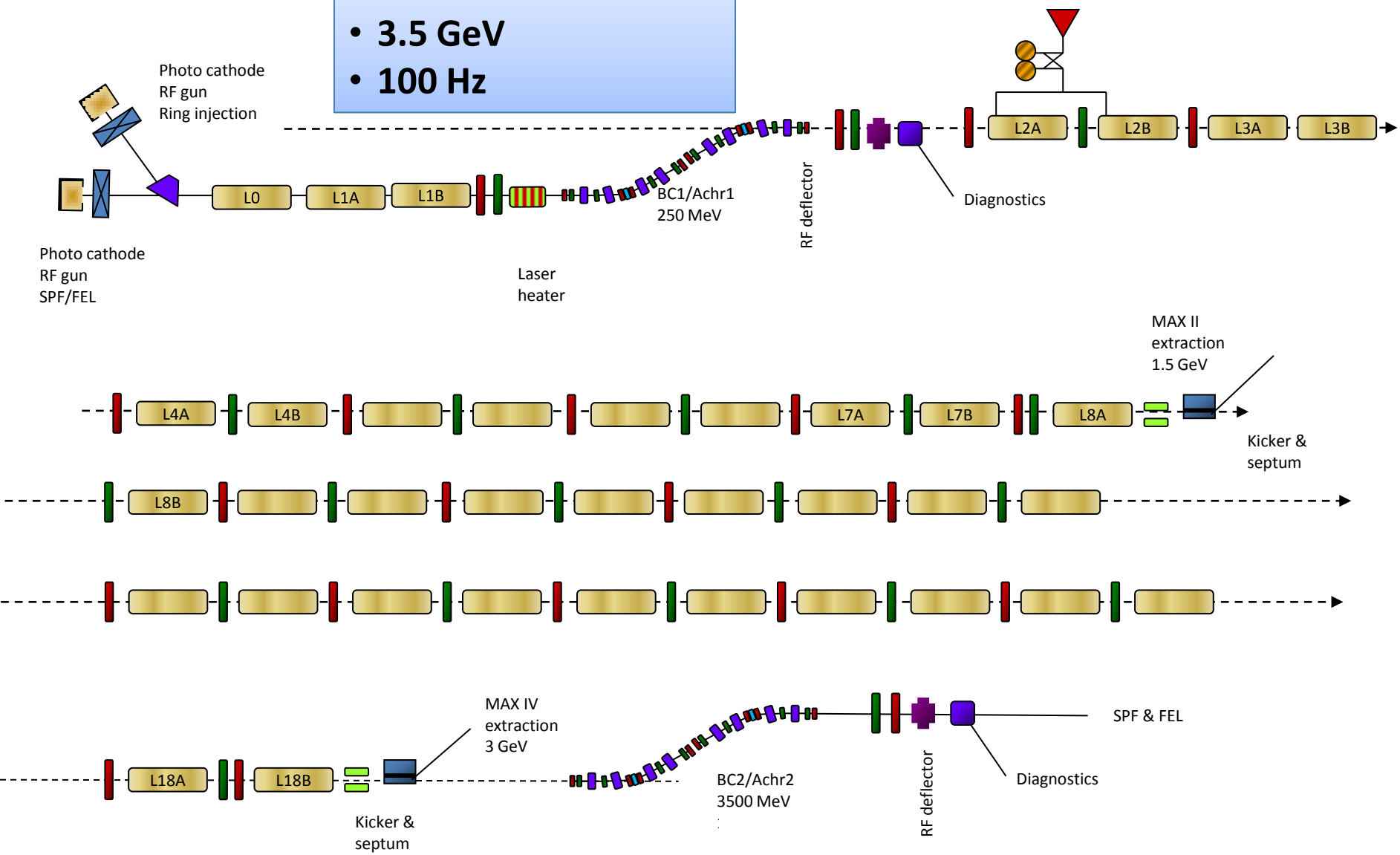
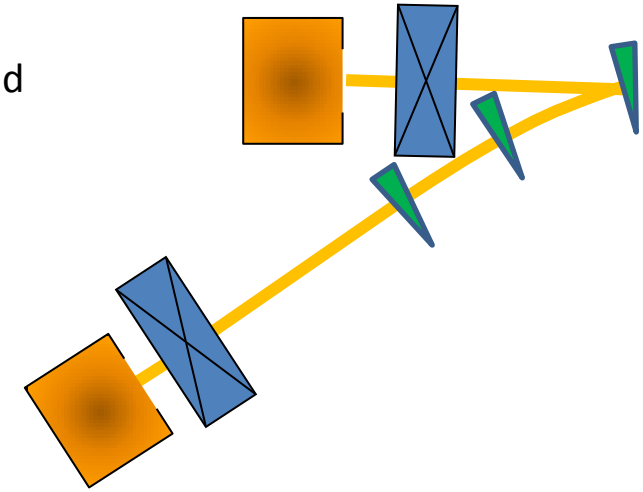


Photo cathode guns

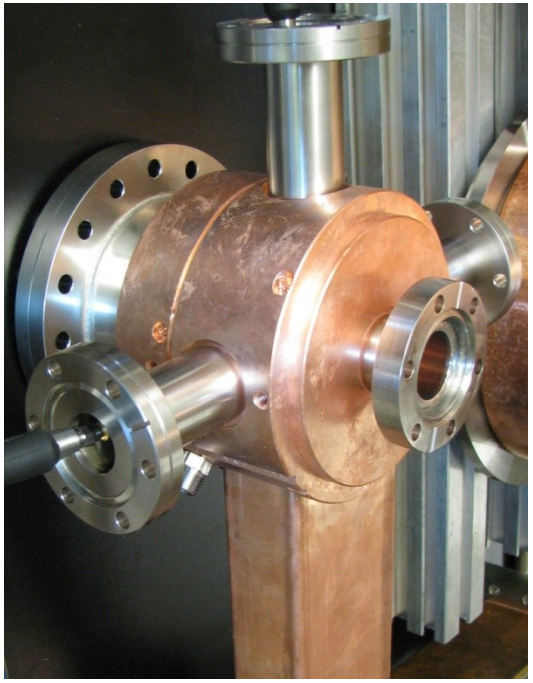
High brightness gun

- copper cathode
- 100 pC
- 5 ps
- 0.4 mm mrad



Ring injection gun

- BaO cathode
- 1 nC
- ~1 ns
- ~4 mm mrad

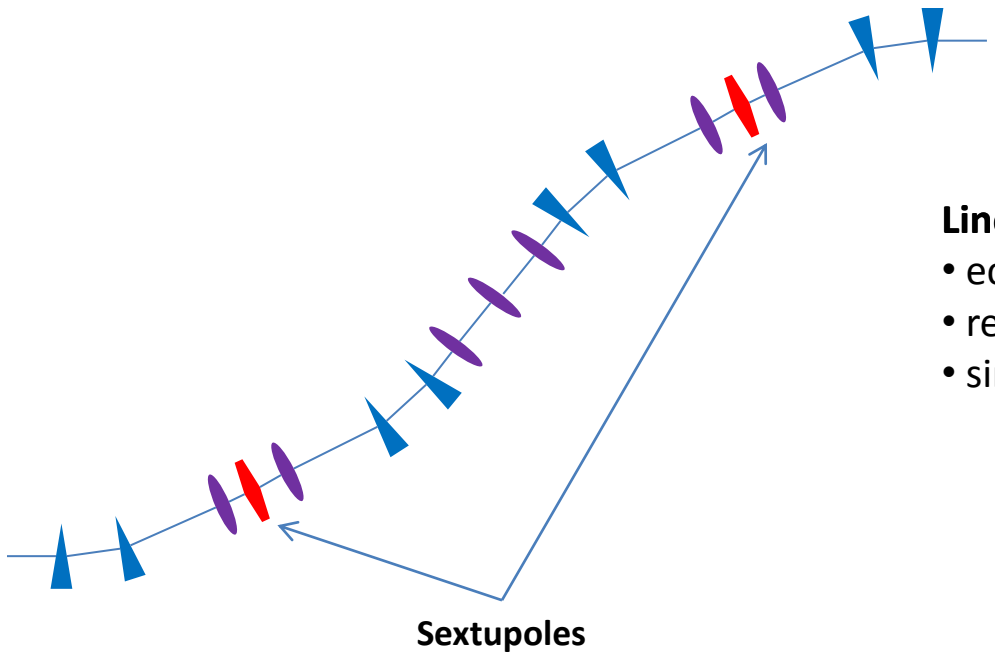


In collaboration with Elettra

M. Trovò et al., EPAC 08, MOPC080.

Bunch compression and linearisation

done in double achromats

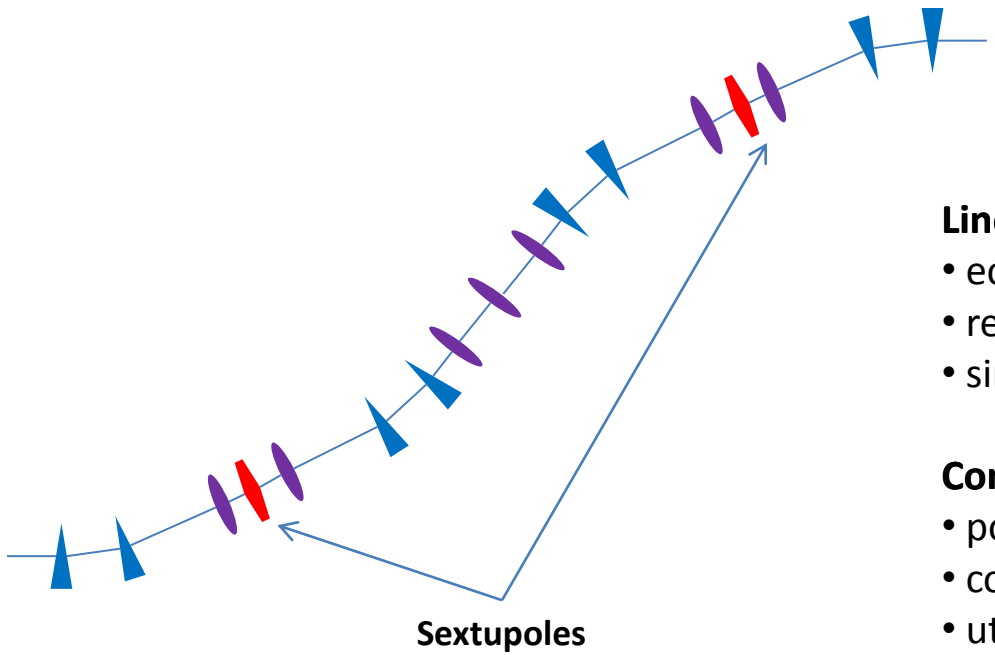


Linearisation with sextupoles

- economy
- reliability
- simplicity

Bunch compression and linearisation

done in double achromats



Linearisation with sextupoles

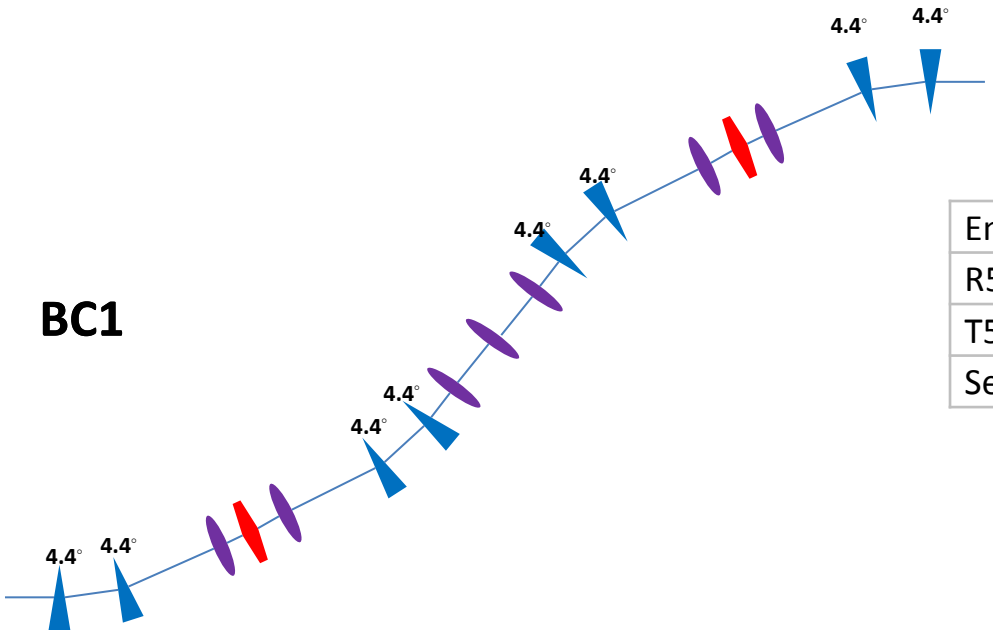
- economy
- reliability
- simplicity

Compression in double achromats

- positive R56 (fixed)
- compression varied with RF phase
- utilise the natural T566 for linearisation
- “weak” sextupoles for tuning linearisation
- symmetry keeps the second order energy dependent matrix elements small

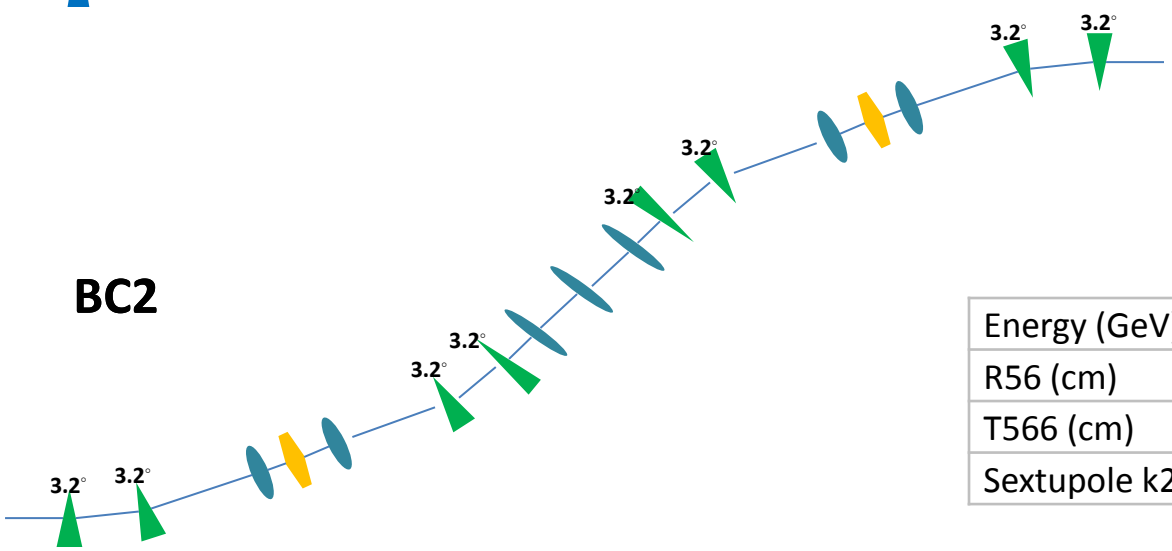
Bunch compression and linearisation

BC1



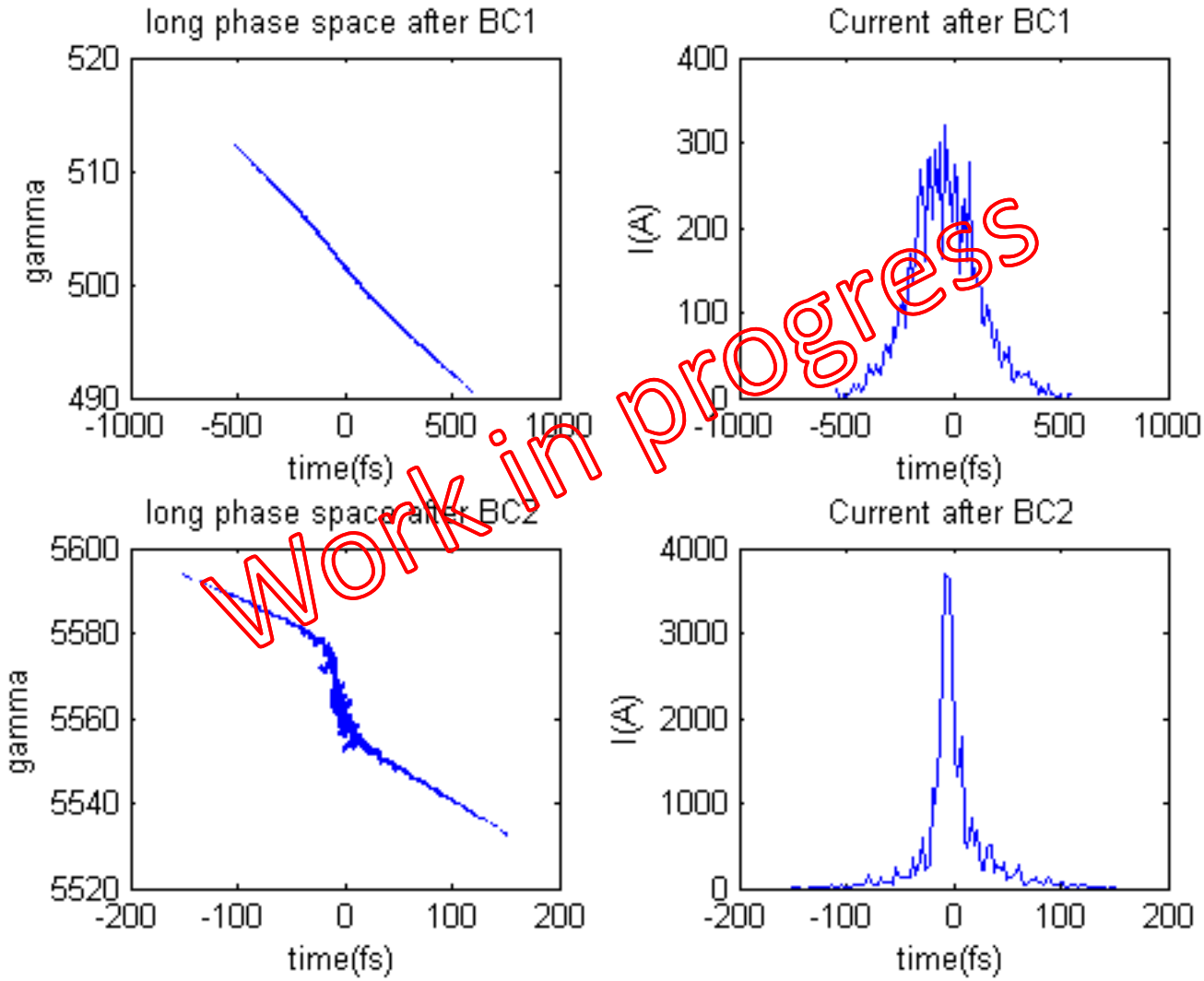
Energy (MeV)	260
R56 (cm)	3.053
T566 (cm)	7.289
Sextupole k2 (m^{-3})	± 57

BC2

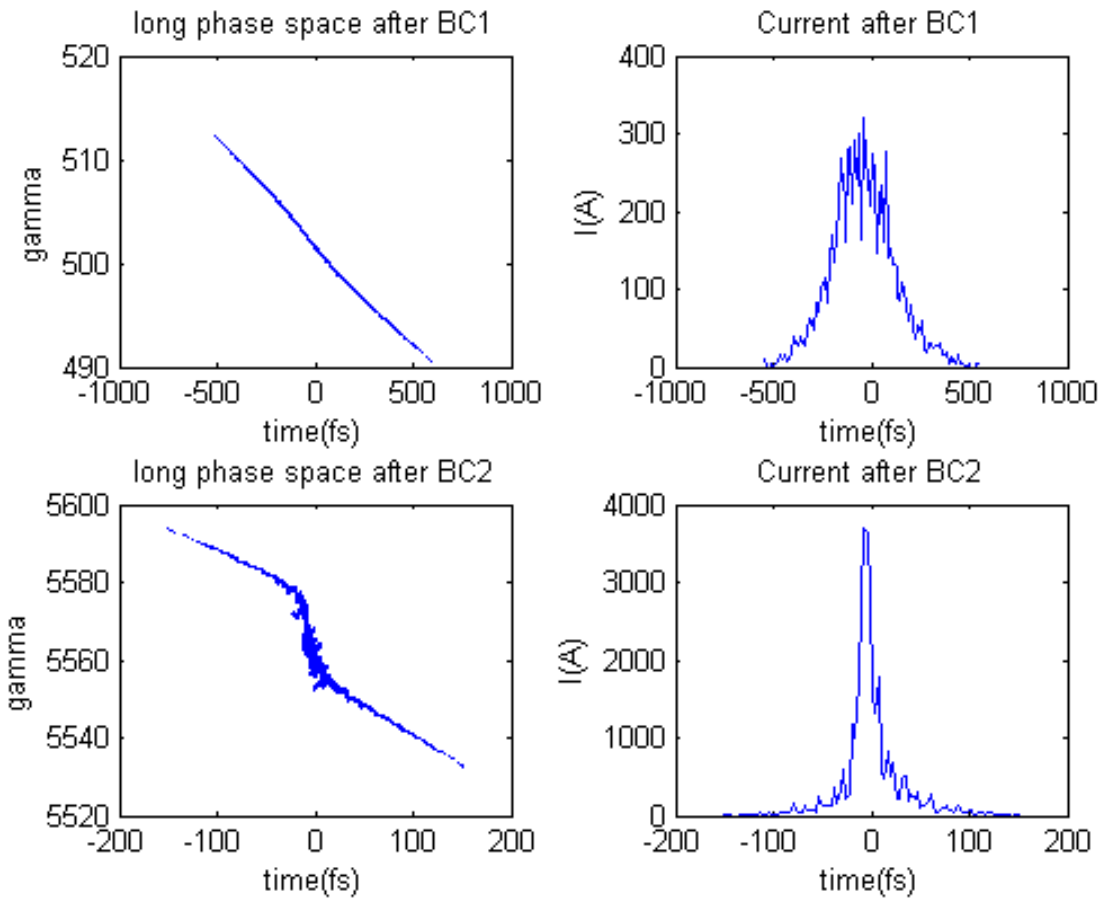


Energy (GeV)	3.3
R56 (cm)	2.176
T566 (cm)	15.510
Sextupole k2 (m^{-3})	± 200

Bunch compression and linearisation

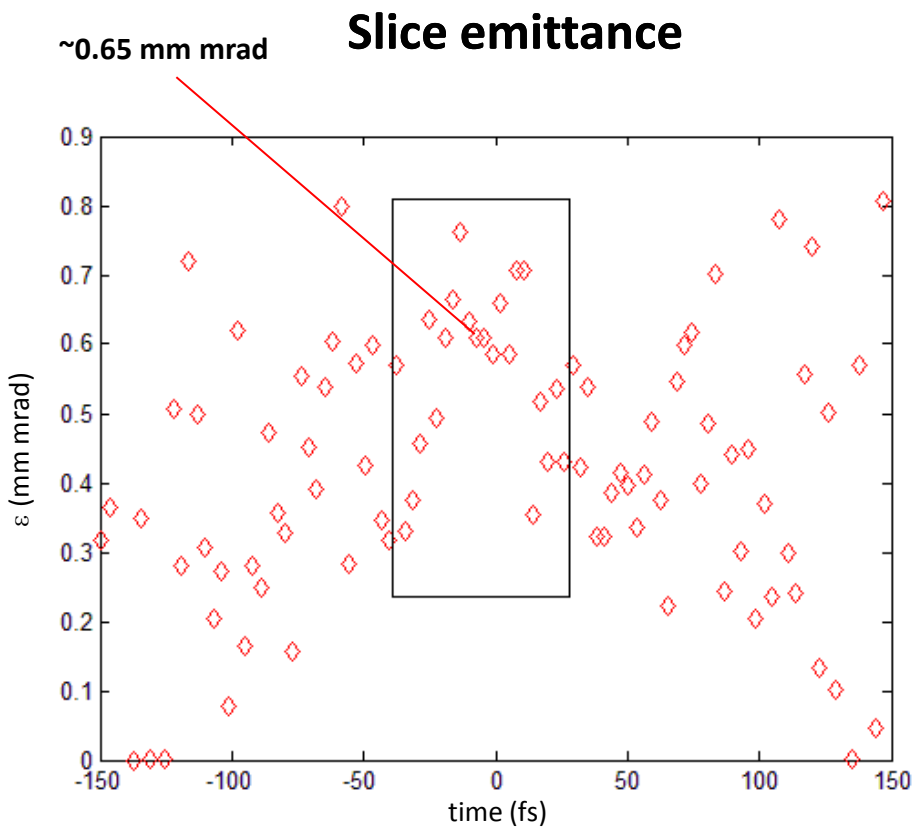


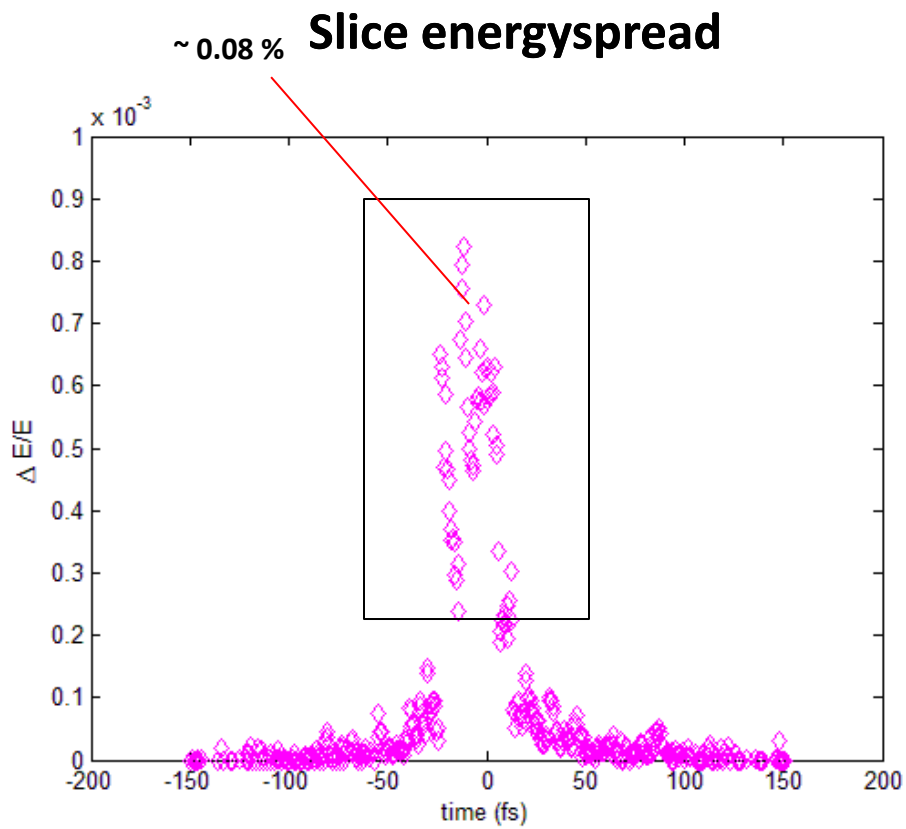
Bunch compression and linearisation



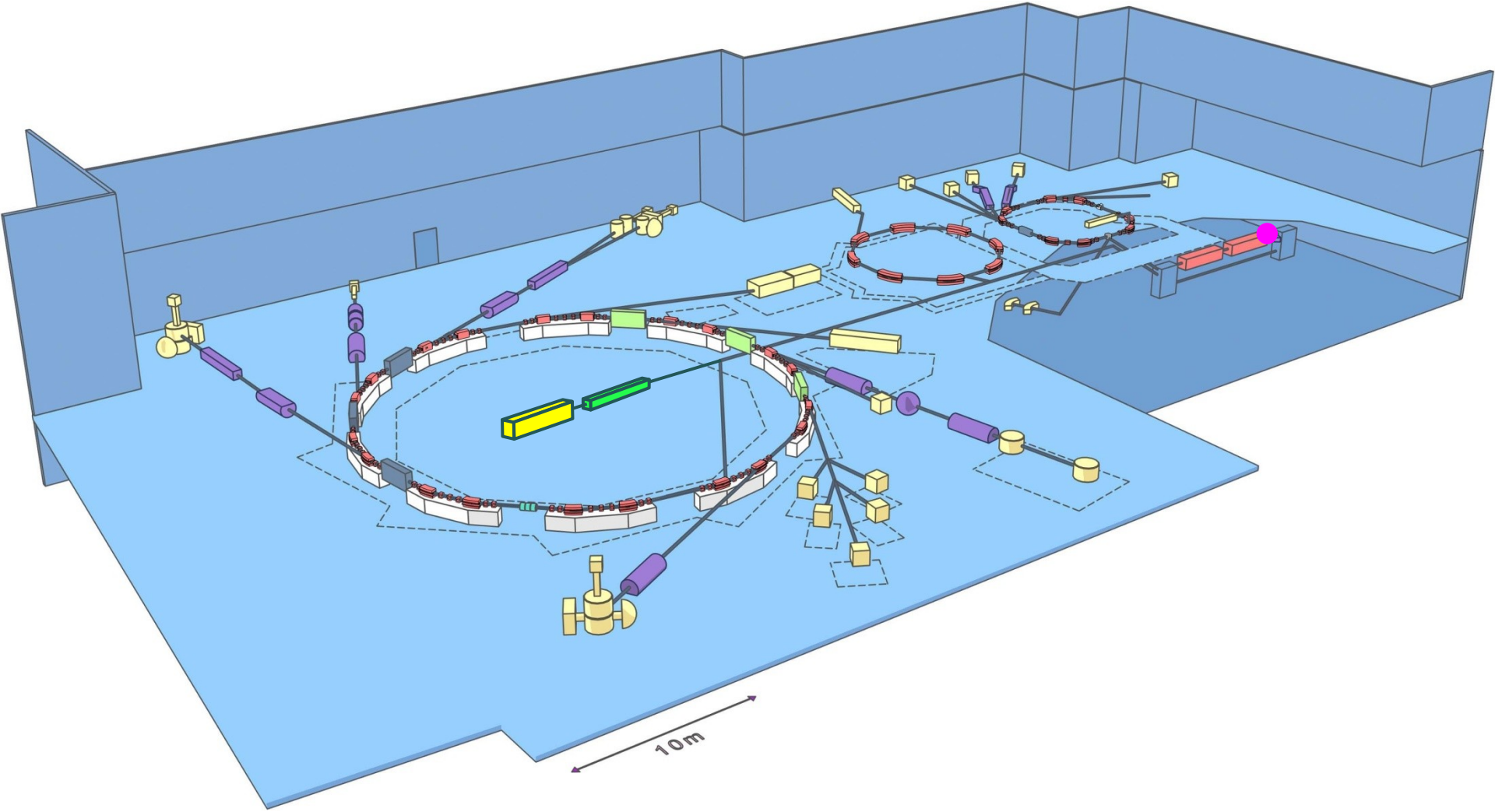
Input beam	
Energy (MeV)	100
RMS bunch length (ps)	3
Projected emittance (mm mrad)	0.4
Charge (pC)	100
After BC1	
Energy (MeV)	260
RMS bunch length (fs)	163
Projected emittance (mm mrad)	0.408
Projected rms energy spread dE/E	0.7 %
linac phase (deg)	34.5
After BC2 (final bunch)	
Energy (MeV)	2850
RMS bunch length (fs)	31
Projected emittance (mm mrad)	0.997
Projected rms energy spread dE/E	0.19 %
linac phase (deg)	18

Bunch compression and linearisation





The current MAX-lab injector

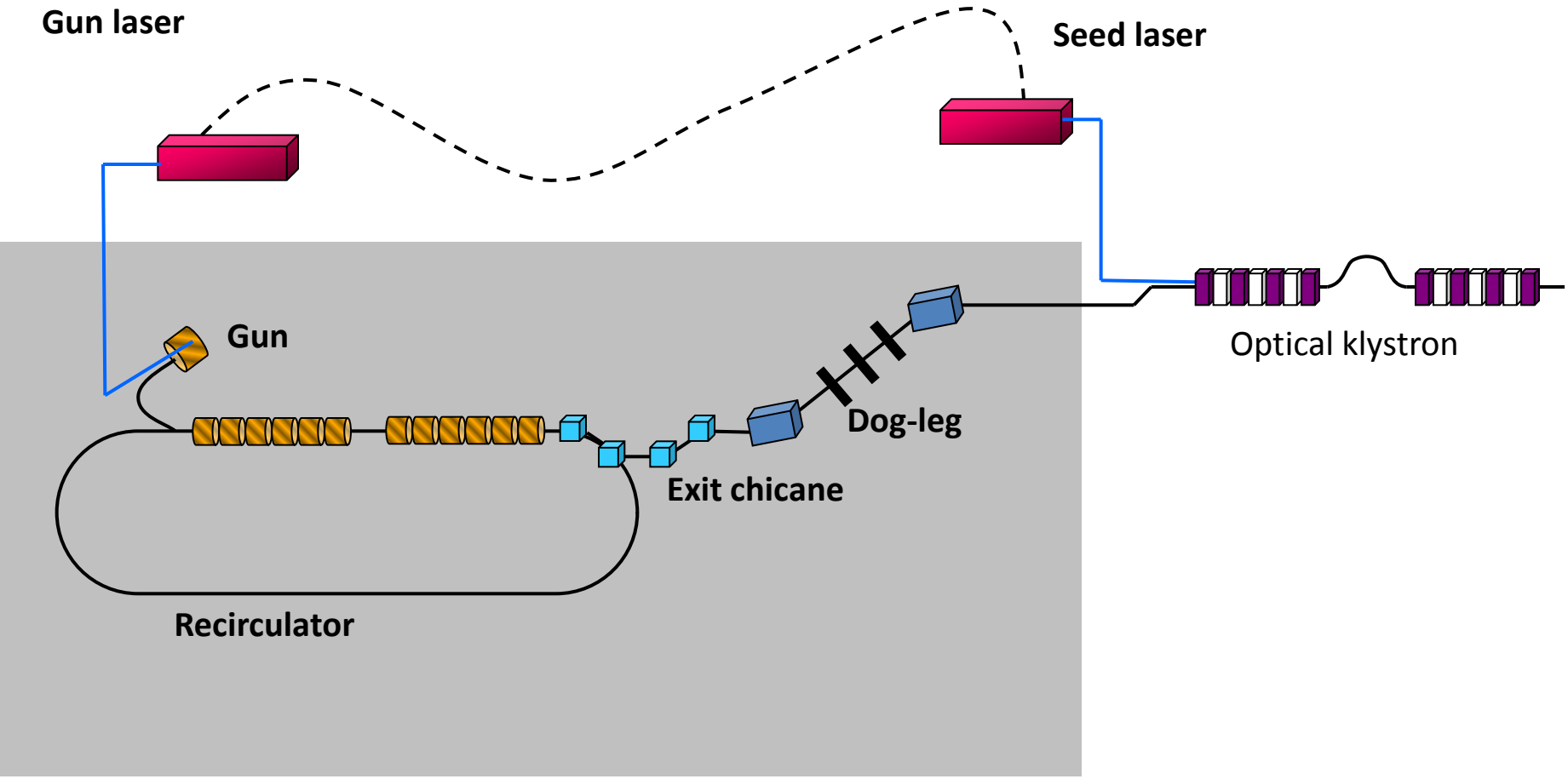


FEL test facility

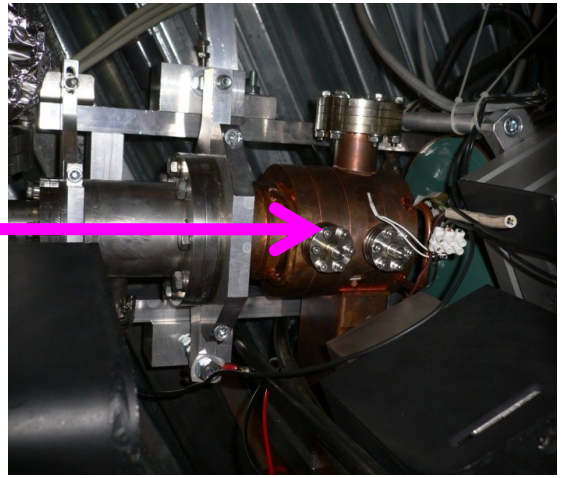
MAX-lab
Francesca Curbis*, Nino Cutic, Filip Lindau, Sara Thorin and Sverker Werin
HZB/BESSY
Johannes Bahrdt and Karsten Holldack
Atomic Physics
Christian Erny and Erik Mansten

*) Now at FLASH DESY

Seeded CHG test facility

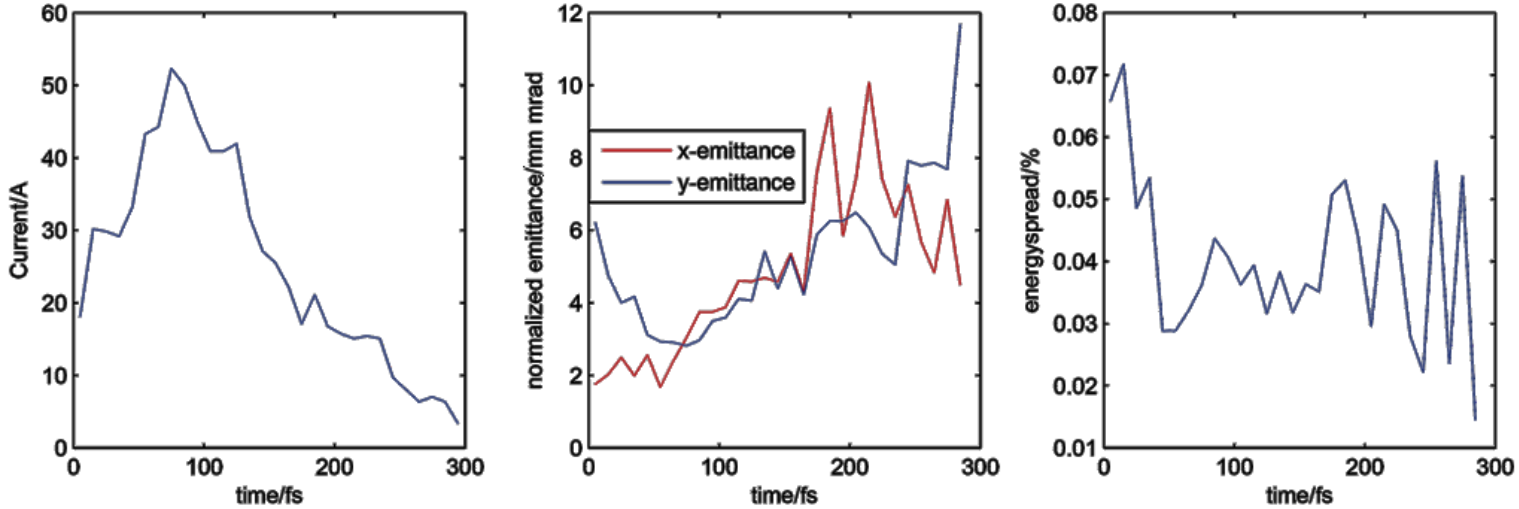


Gun



Thermionic gun
BaO cathode
Ti:Sapphire 263 nm
Jitter < 300 fs
Pulse length 10 ps

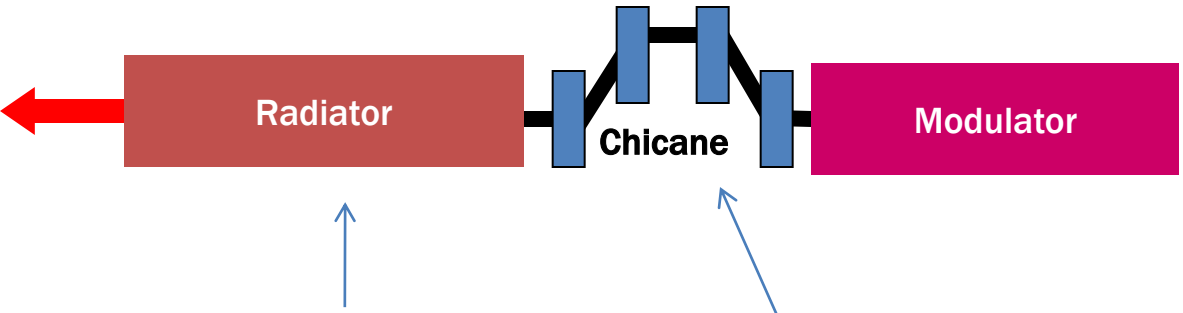
Compression

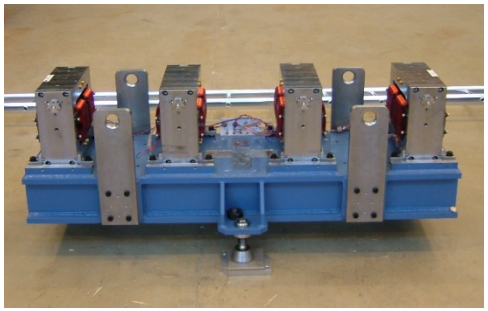


Charge = 10 pC

R56 ≈ 5 cm, fixed
Ideal phase for compression ≈ 30
Compression after full acceleration =>
Optimized acceleration phase ≈ 8°

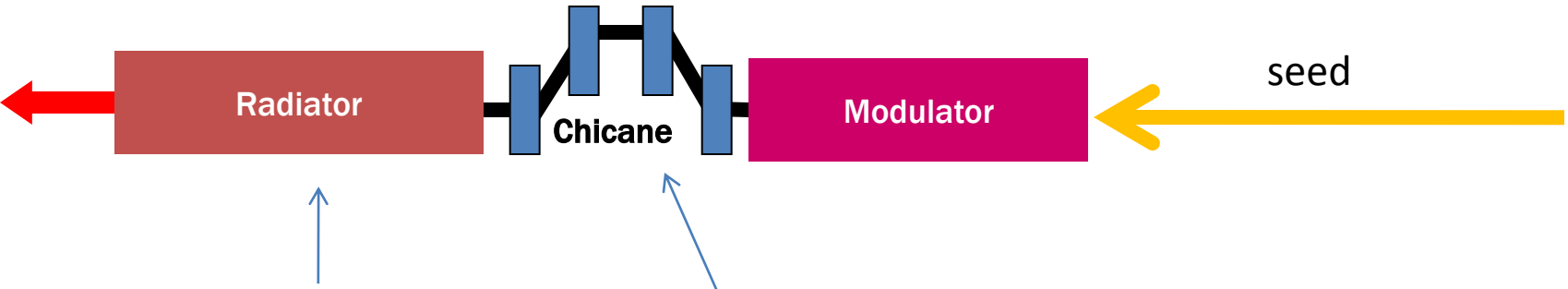
Optical klystron

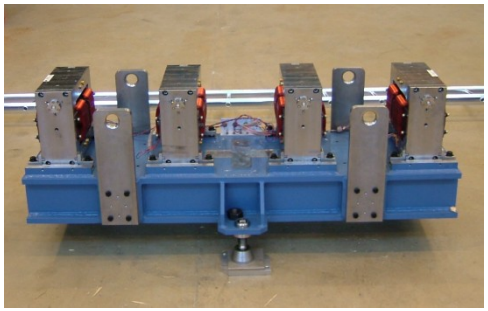




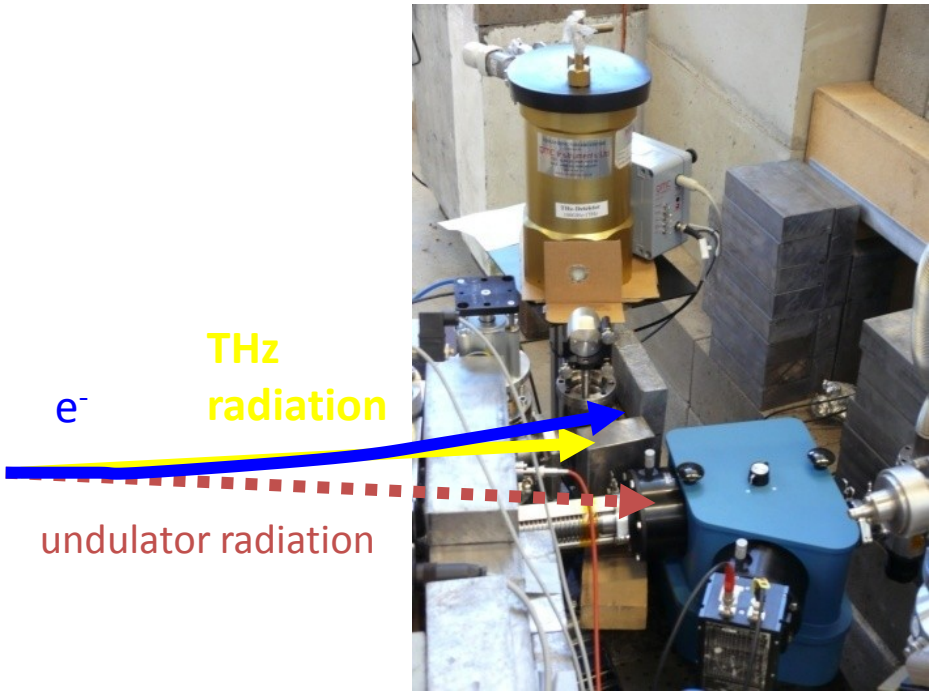
Modulator	Planar (ESRF)
Period	48 mm
# of periods	30
Min. gap	10 mm
K max	4.3
Radiator	Apple II (BESSY)
Period	56 mm
# of periods	30
Min. gap	12 mm
K max	4.3
Chicane	
# of magnets	4
Gap	15 mm
B max	0.2 T

Optical klystron





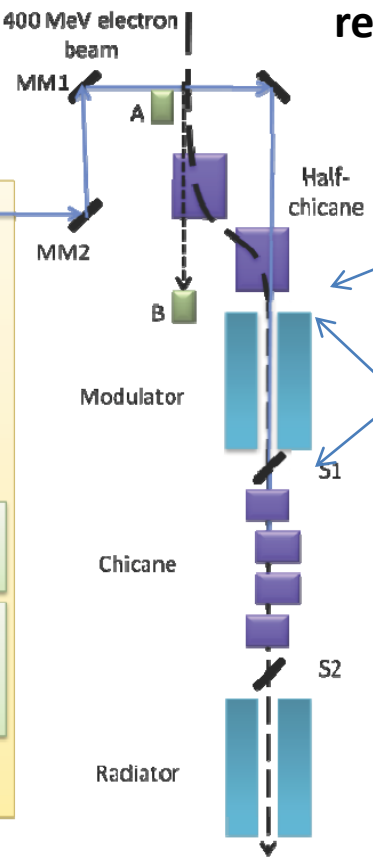
Compression and microbunch measurments - THz



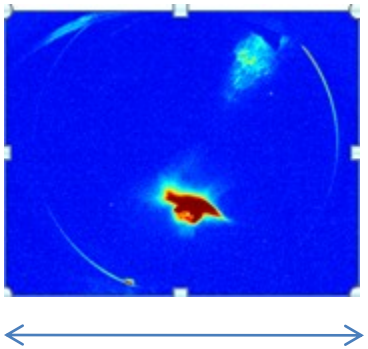
- THz radiation from the dump magnet was measured
- When the bunches become shorter, or microbunching stronger, THz radiation increases

Spatial and temporal overlap

e- 200 fs
seed 300 fs
res 800 fs

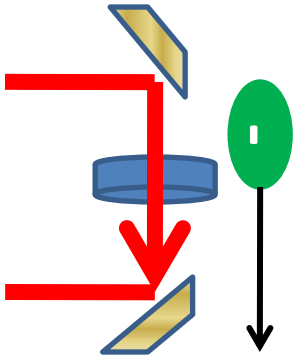


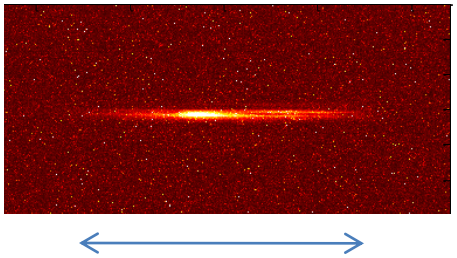
Spatial overlap
YAG screen



20 mm

Temporal overlap
EO crystal
Spectral decoding
(Nino Cutic)





≈ 2 ps

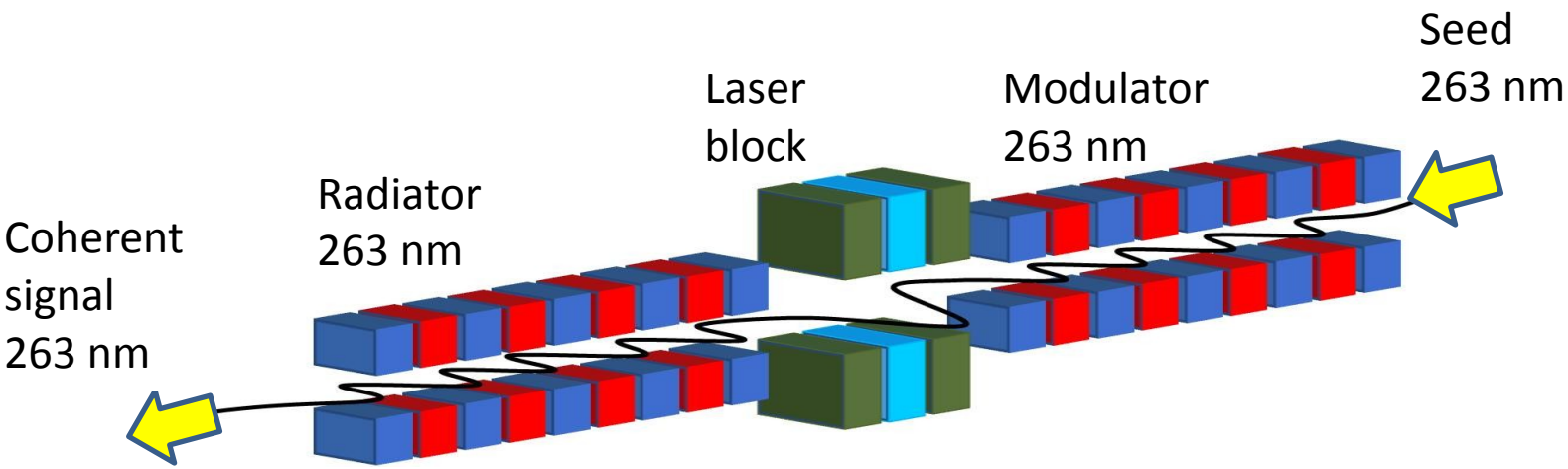
FEL test facility

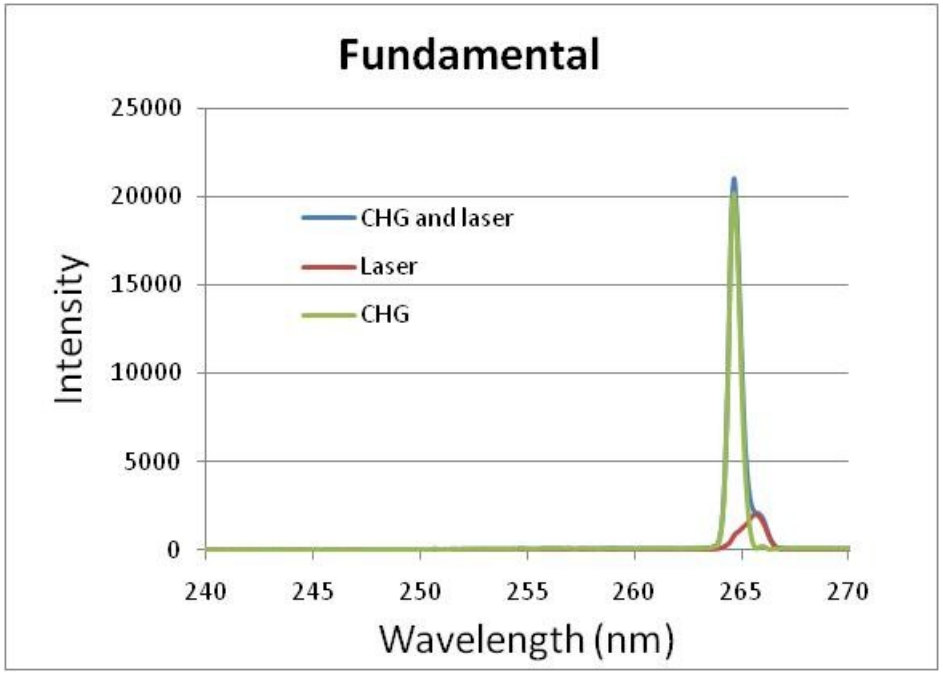
380 MeV

CHG @ (263), 133, 88, 66, 53 nm

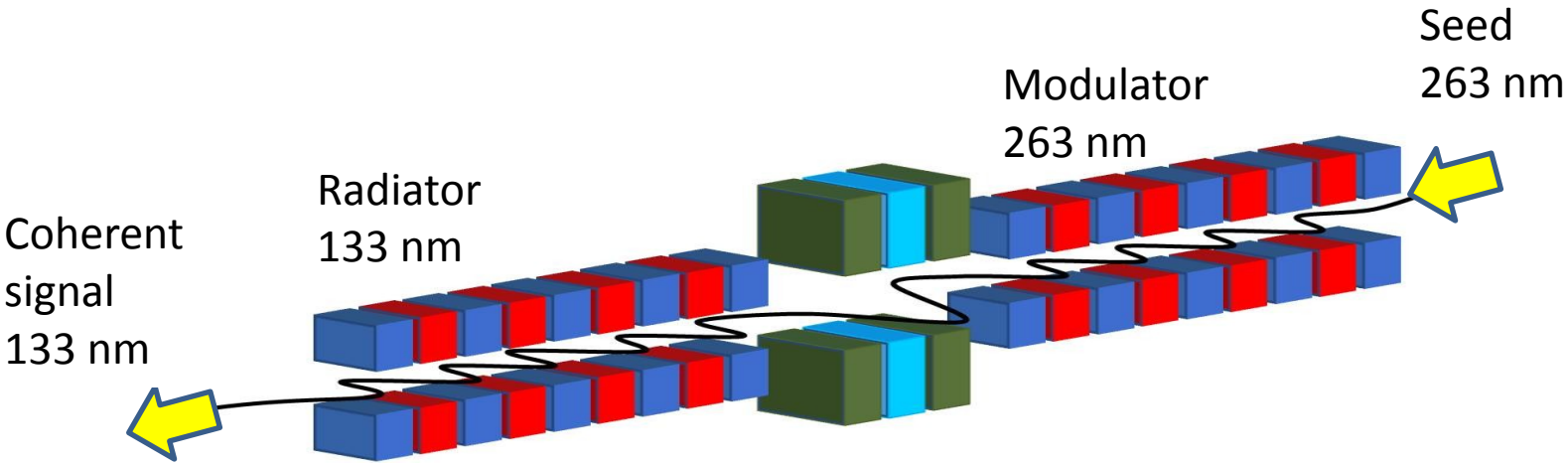
Seeded HG (Seed λ=263 nm)

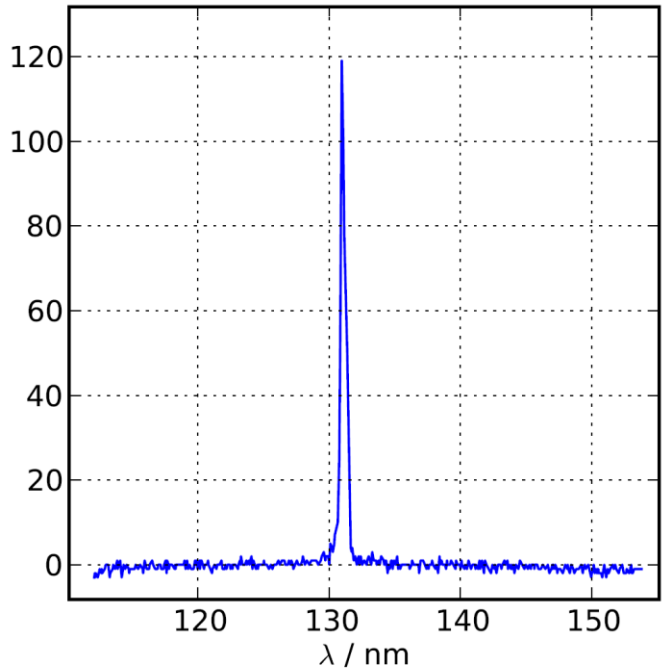
Results – fundamental 263 nm



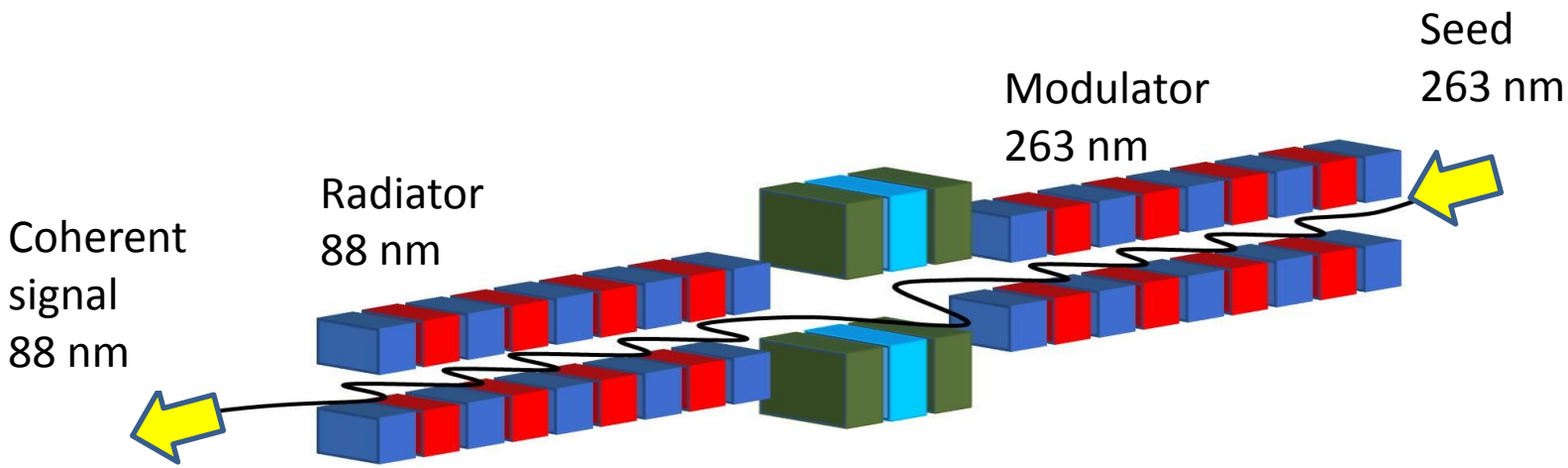


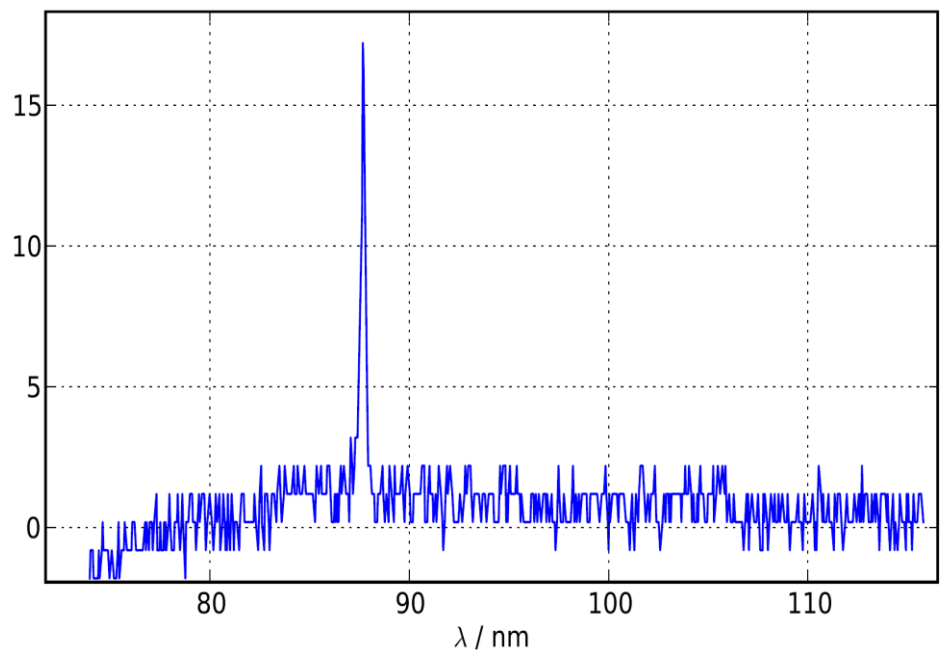
Results – 2nd harmonic 133 nm



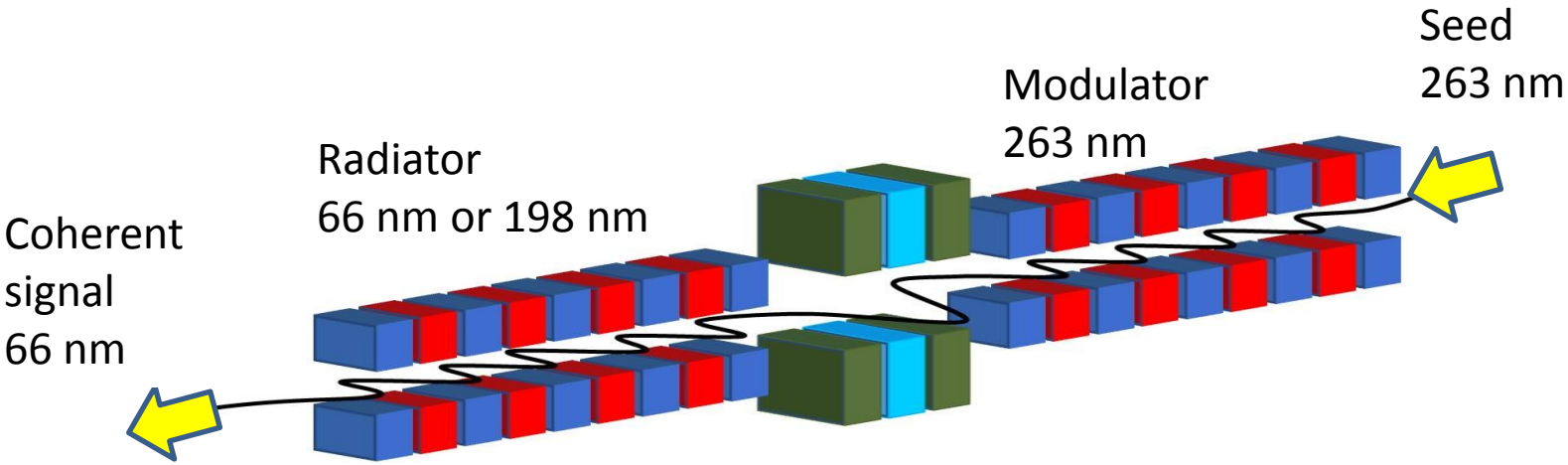


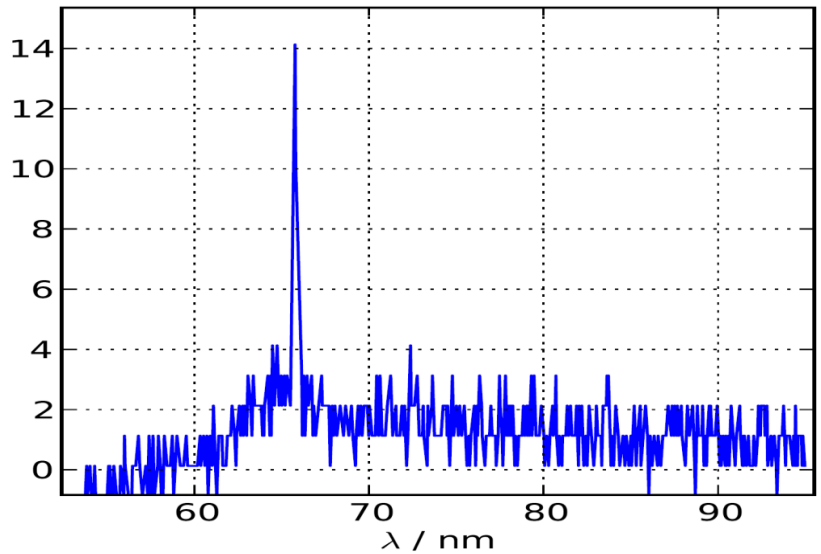
Results – 3rd harmonic 88 nm





Results – 4th harmonic 66 nm





Thank you for your attention