The CERN Accelerator School

Design a high repetition FEL

- at a wavelength of 13.5 nm
- with an average power of more than 2 kW

CASe study – WG1
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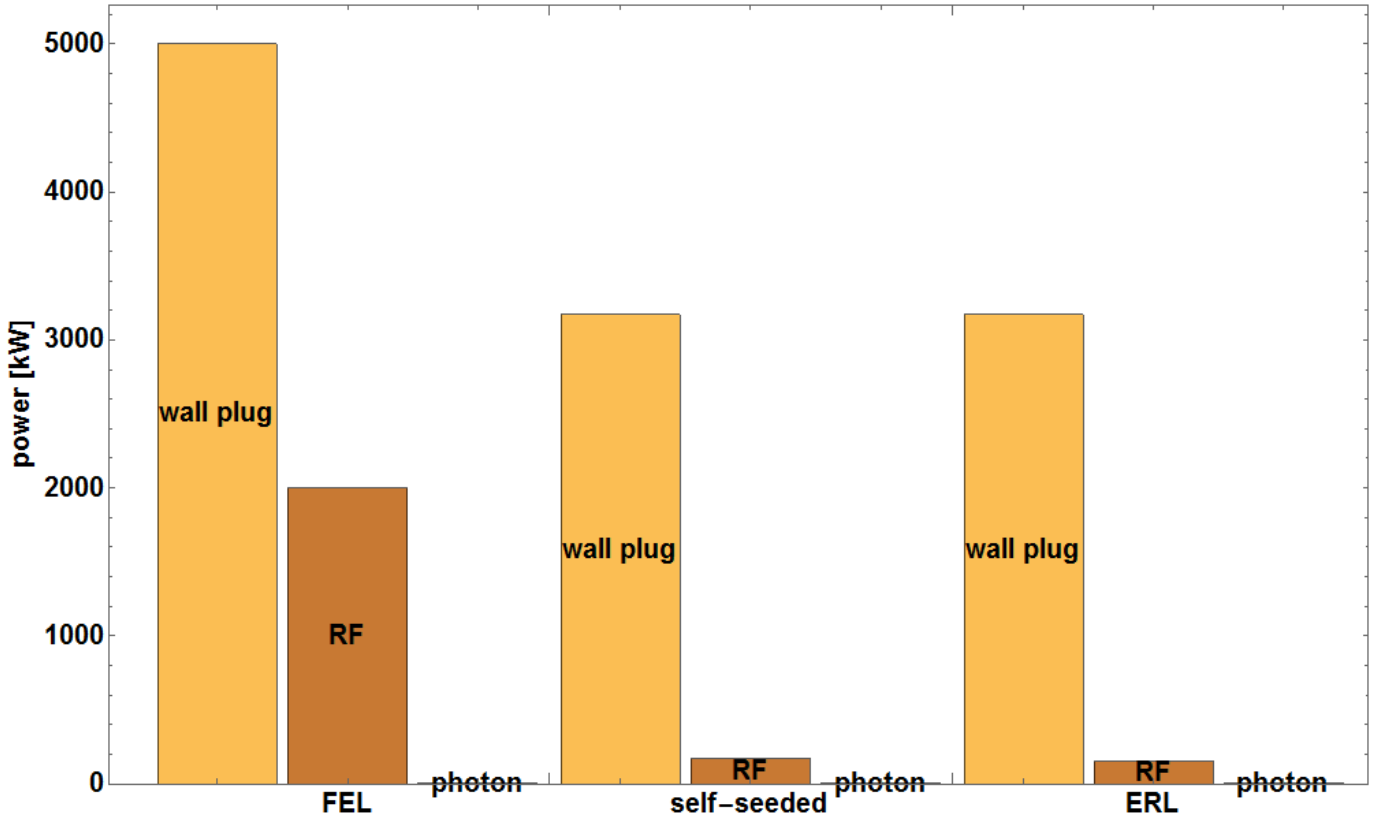
Fabich, Adrian (CERN)

Electricity Consumption

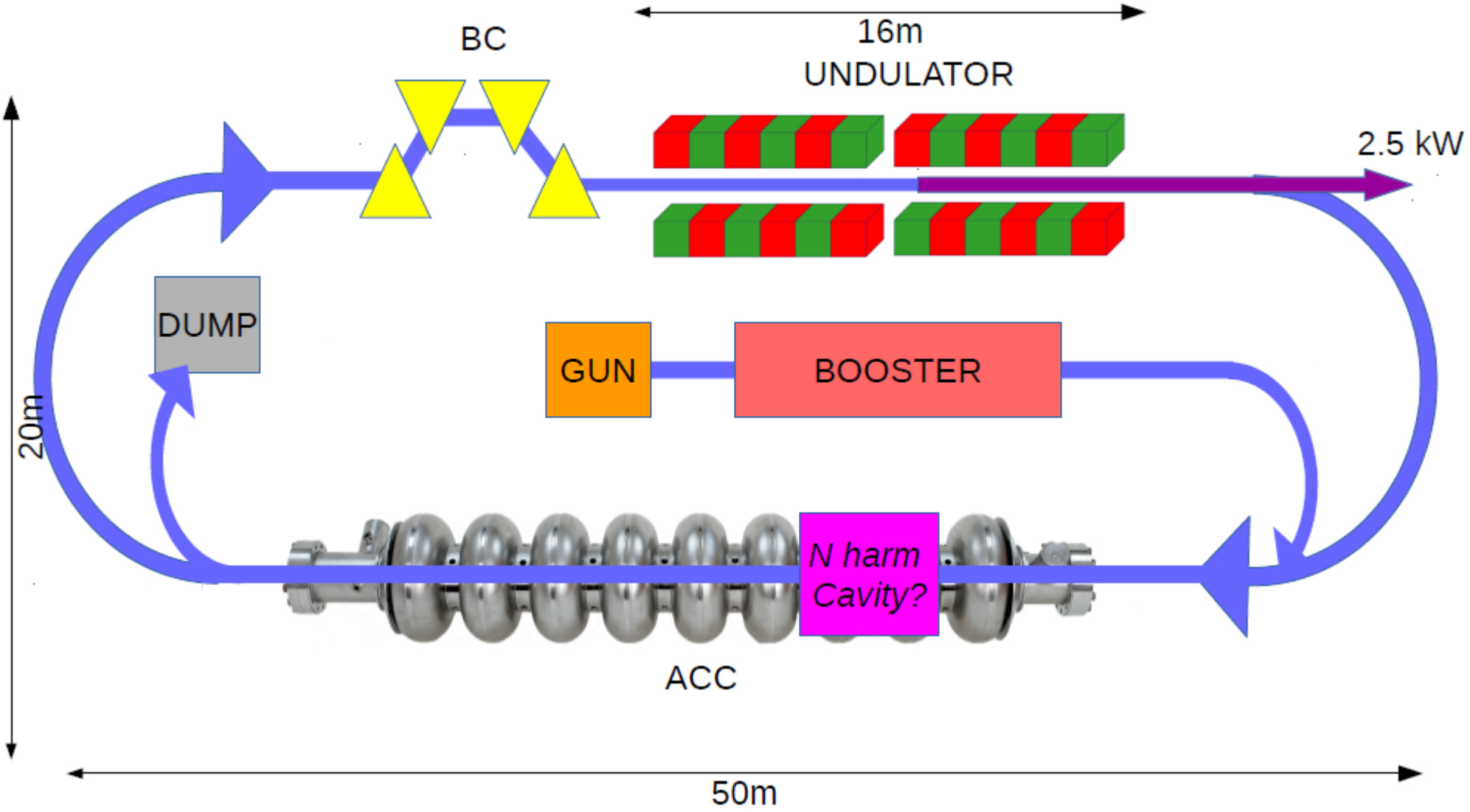


80 Euros/MWh industrial price (Germany)

1 MW in 1 year (8000 hours) → 640 kEuro/year

Plant costs (educated guess): 42 MEuros

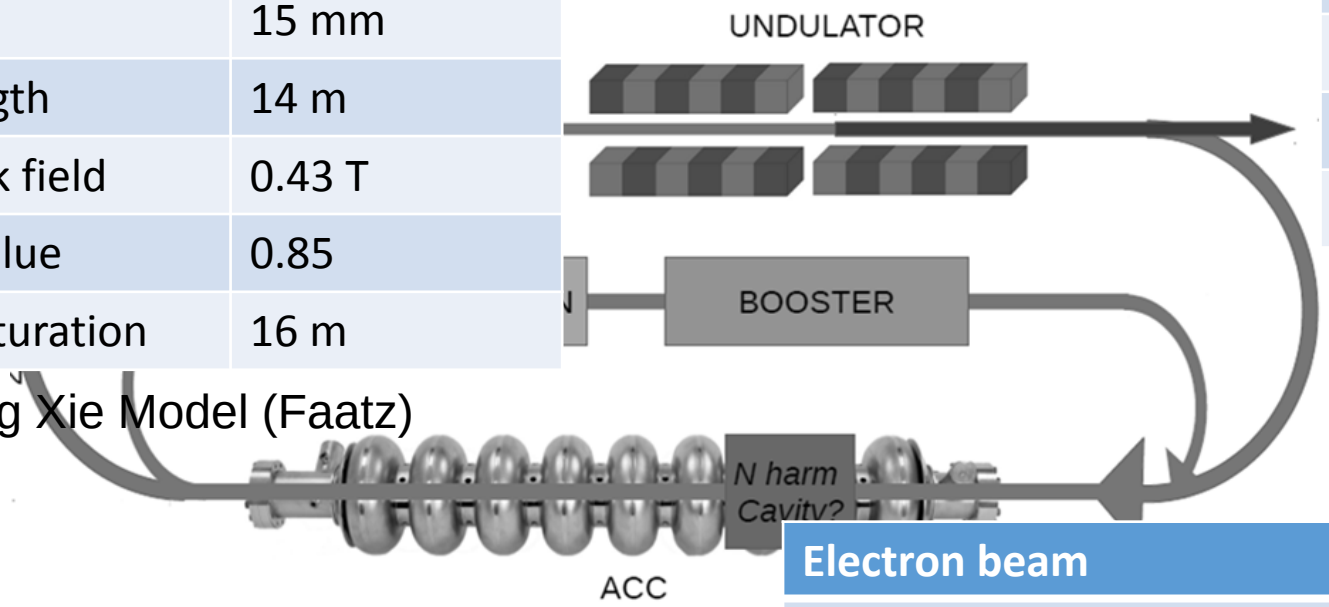
Layout


BC
16m
UNDULATOR
2.5 kW
DUMP
GUN
BOOSTER
20m
N harm
Cavity?
ACC
50m

Parameters

Undulator	
period	30 mm
gap	15 mm
Length	14 m
Peak field	0.43 T
K-value	0.85
L saturation	16 m

Ming Xie Model (Faatz)



Photon beam	
Wave length	13.5 nm
Beam power	> 2 kW
Spot at exit	125 mum
Divergence	49 murad

Electron beam	
Energy from gun	10 MeV
Energy from booster	50 MeV
Energy from linac	700 MeV
Peak current	1 kA
Bunch charge	77 pC
Bunch rep. rate	54 MHz

Gun

	optional	BASELINE
Beam Energy	10-15 MeV	10 MeV
Charge per bunch	77 pC	77 pC
Average Current	100 mA	4 mA
Bunch Length	2-3 ps	2.5 ps
Transv. Emittance	0.2 µm	1 µm
Operating Frequency	1.3 GHz	54 MHz

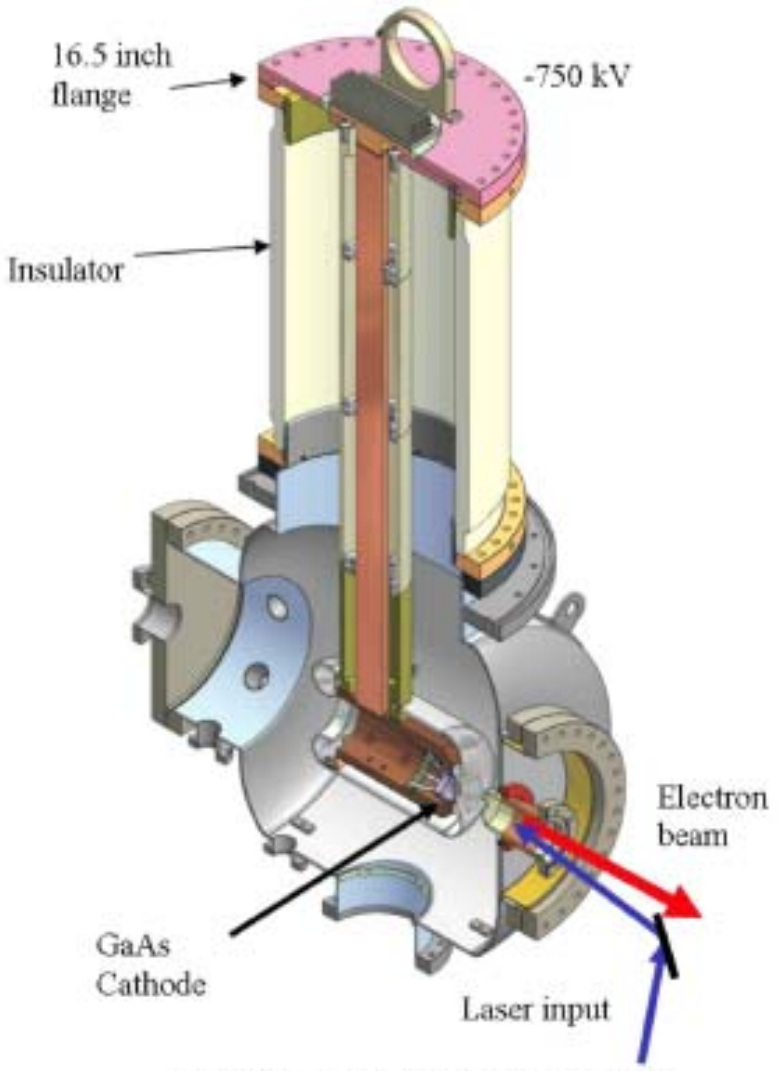
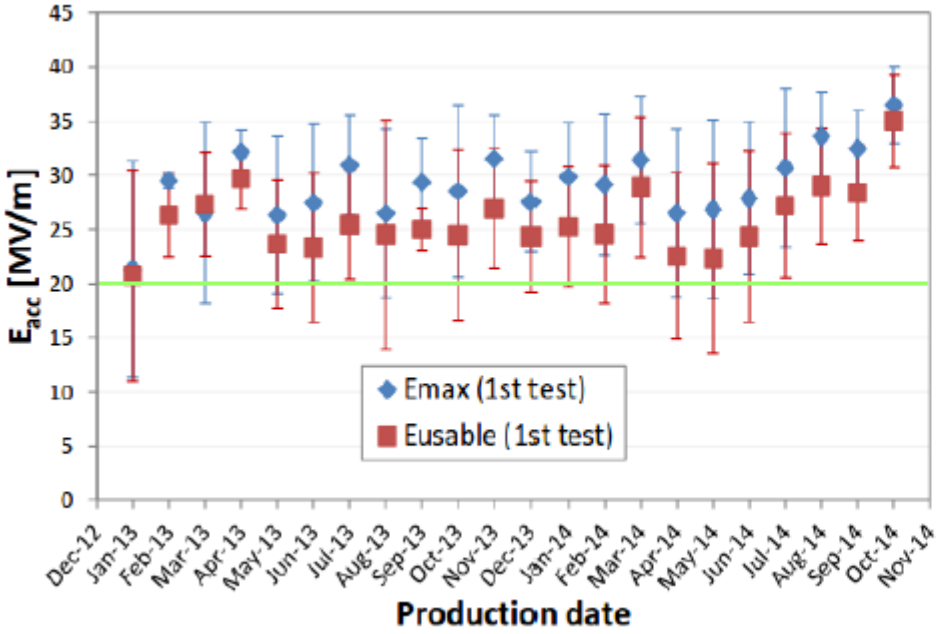
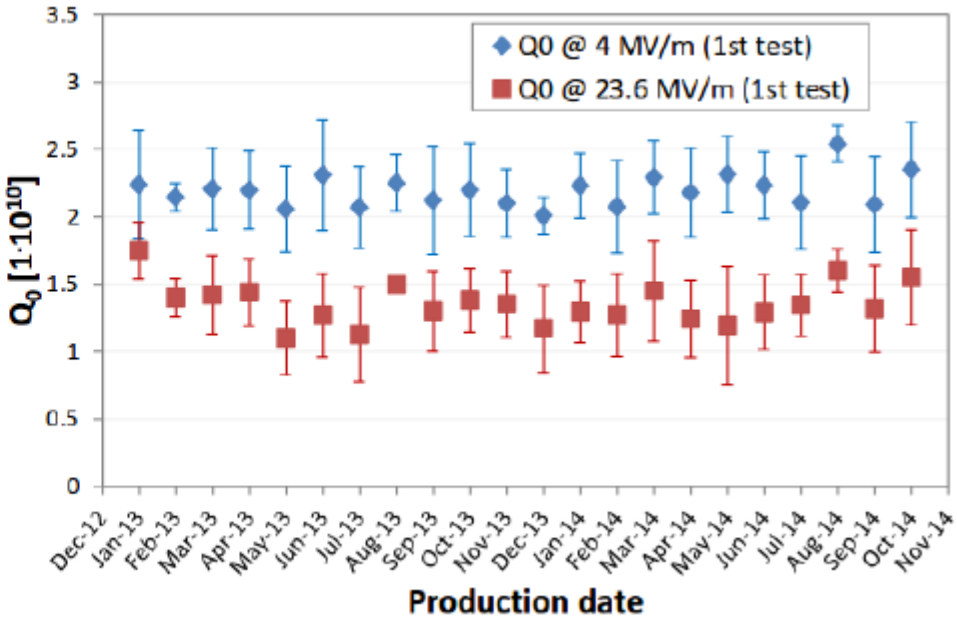


FIGURE 2. The Cornell Photoemission Gun.

ACC
(almost TESLA type)

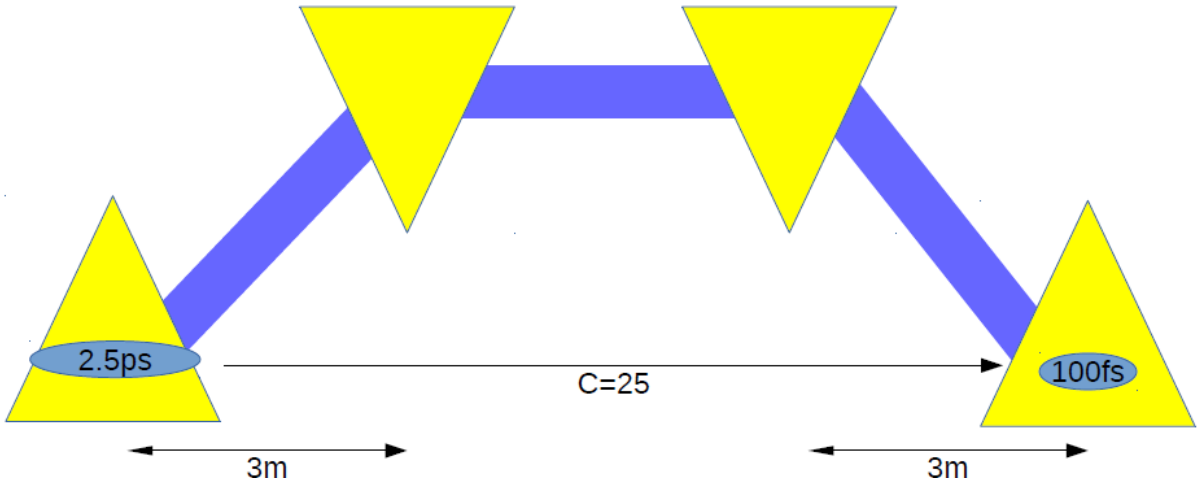




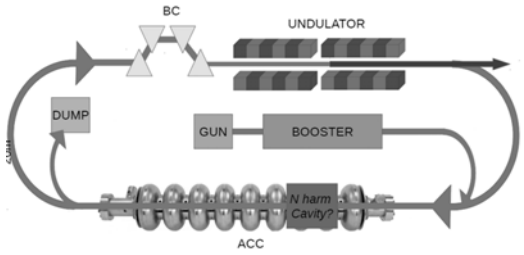
XFEL Performance

Conservative E-field assumption: 20MV/m
→ ~40m of ACC structure + beam optics + HHC

Bunch Compressor

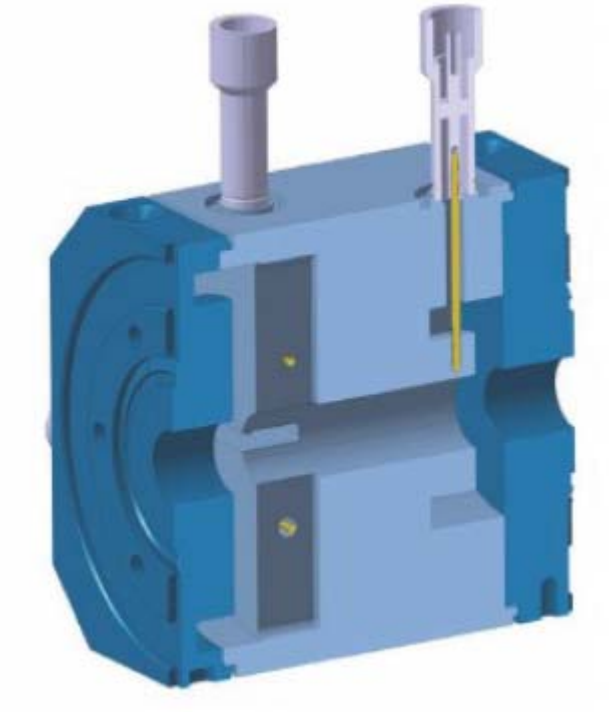


Bending angle	0.15 rad (9 deg)
B-Field	0.6 T
Effective magnet length	0.6 m
R_56	-14 cm
Chirp	6.85 m^-1

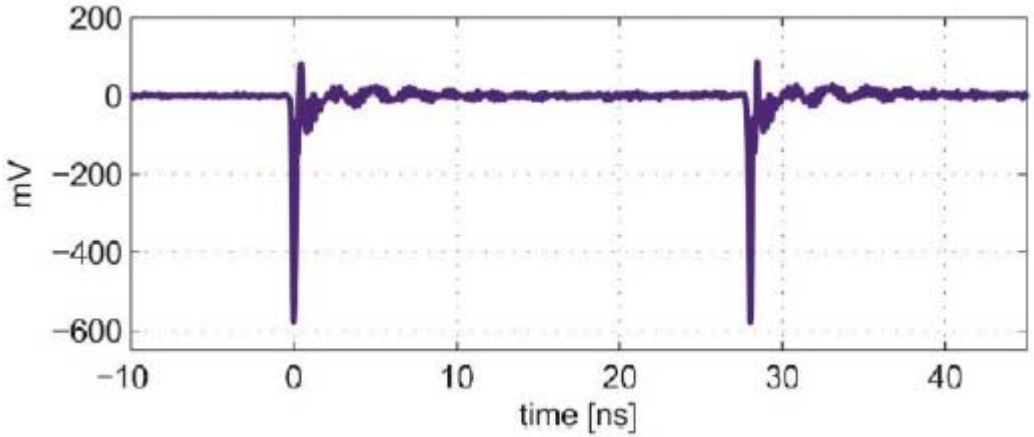


Diagnostics

Cavity BPM for charge and position:



Pyro-electric detector for longitudinal measurements:

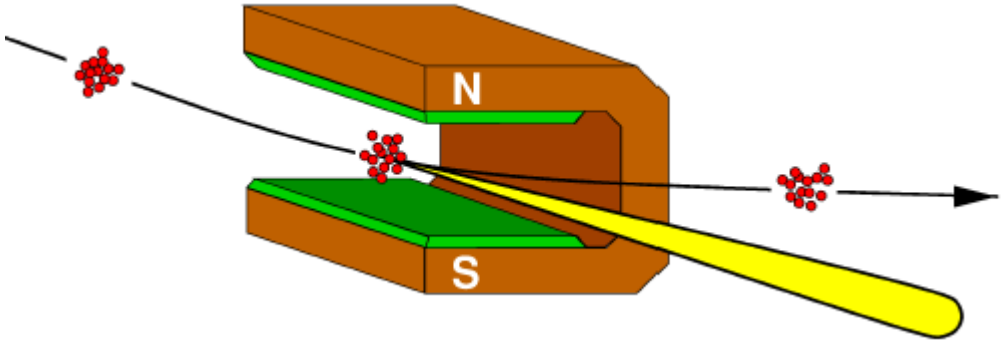


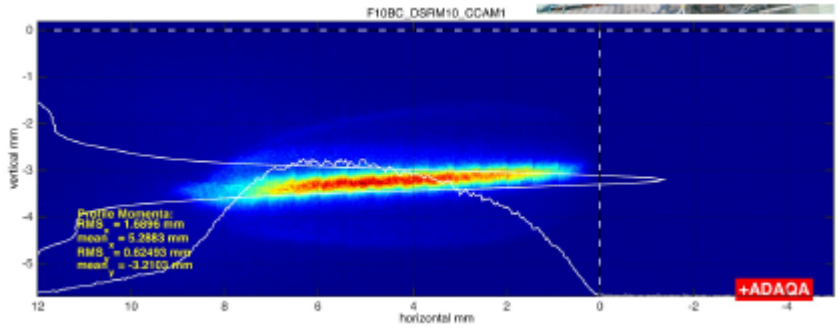
Screens for commissioning (only 1 bunch)
Use ICT during commissioning for absolute charge measurement & calibration of BPMs

Diagnostics

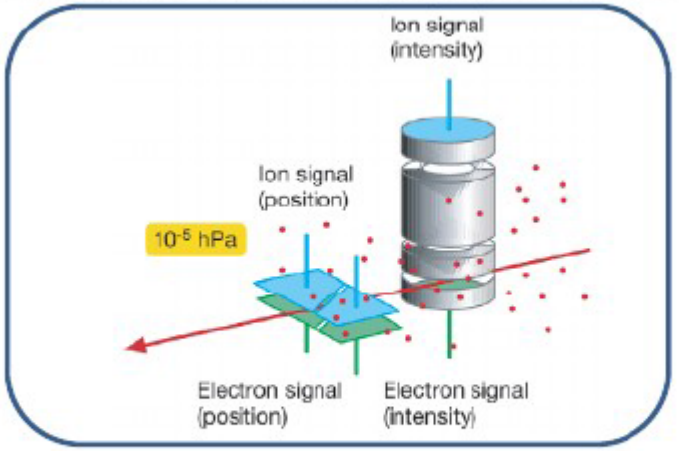
Photon position and intensity:

Bunch profile measurement via SR in arcs:





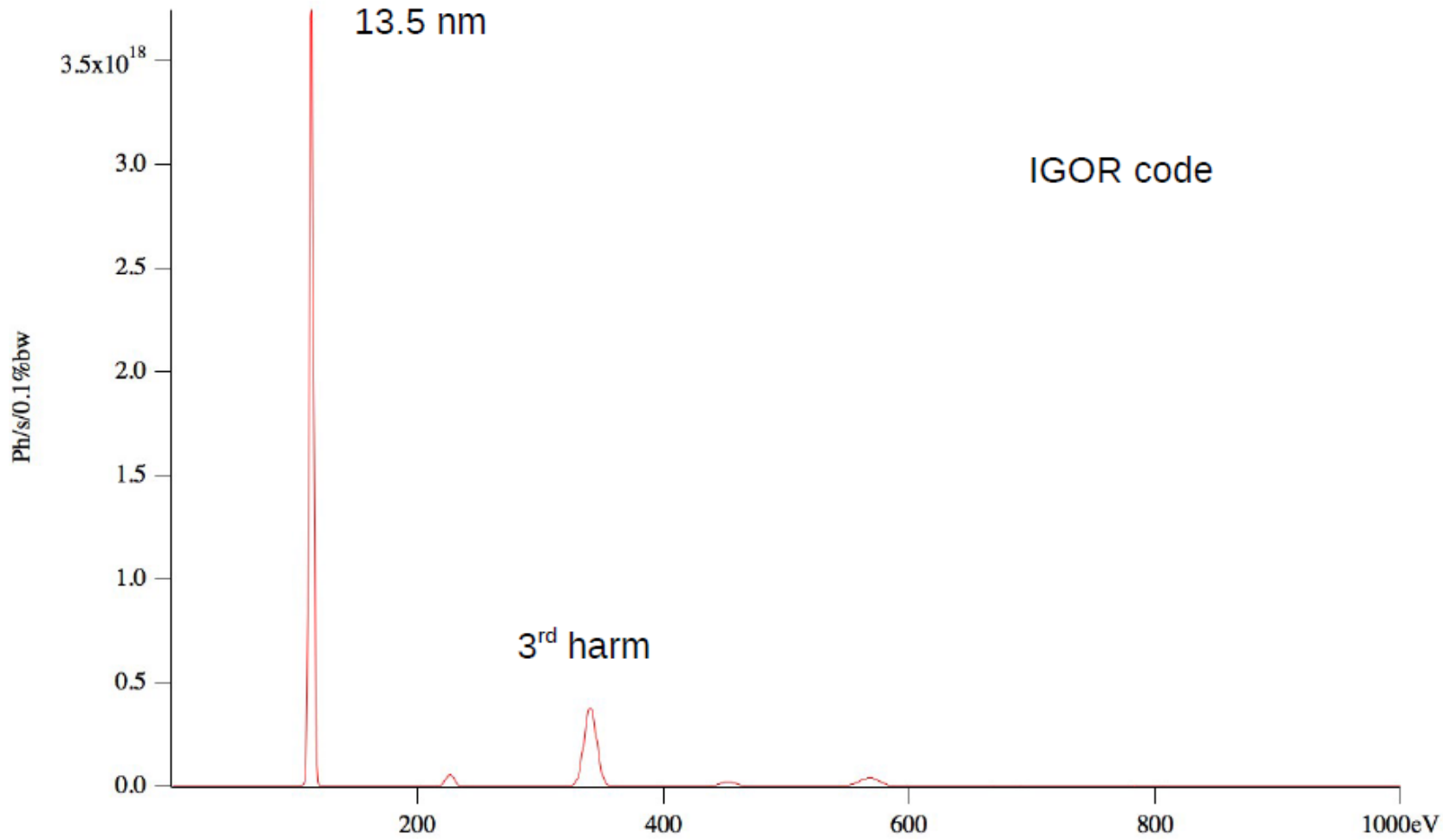
XGMD: Gas monitor detector (DESY, PTB)



Detection of electrons/ions ionized with x-ray irradiation

Spectrometer for wavelength

Undulator spectrum



References

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Thanks for your attention!

A big thanks to Barbara, Christel, Roger, Werner and Kai for arranging this interesting CAS in Hamburg.