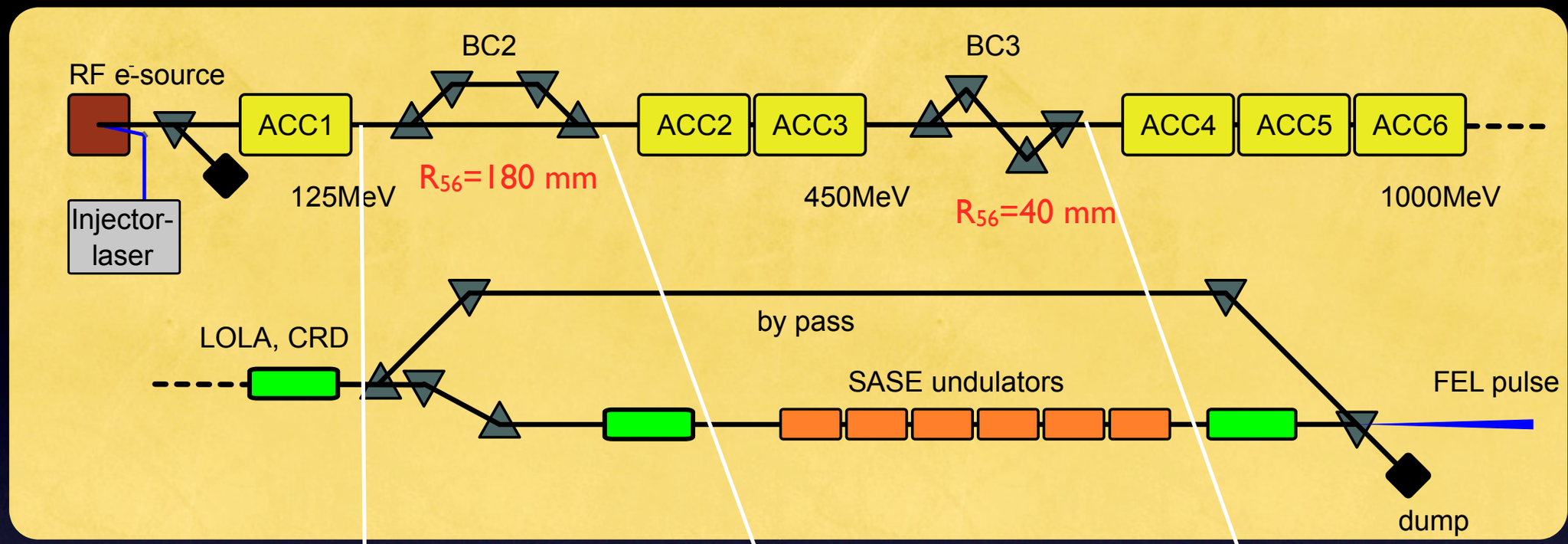
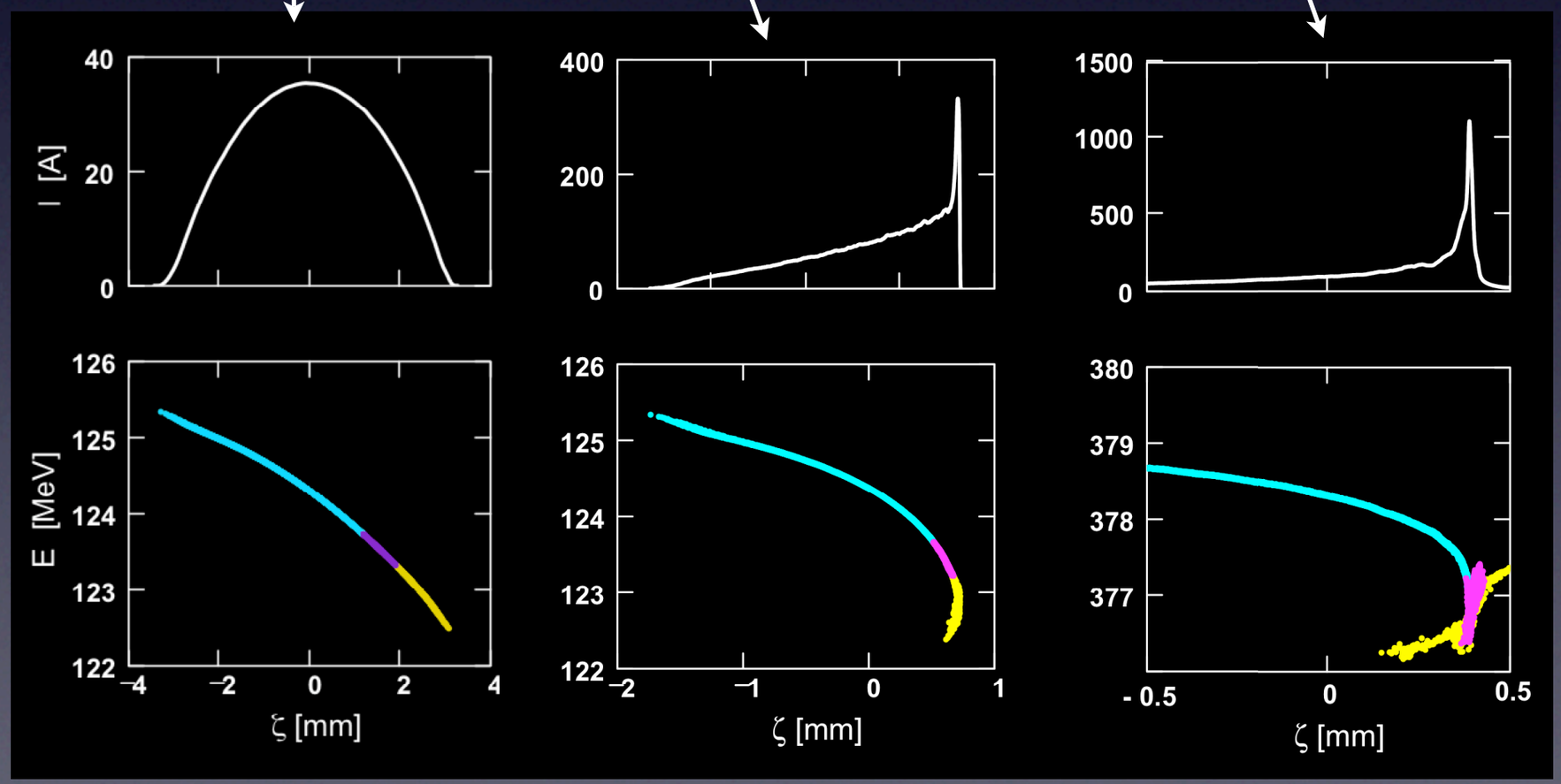
# Microbunching observations at FLASH

Bernhard Schmidt - DESY - for the THz-team

# Layout of FLASH



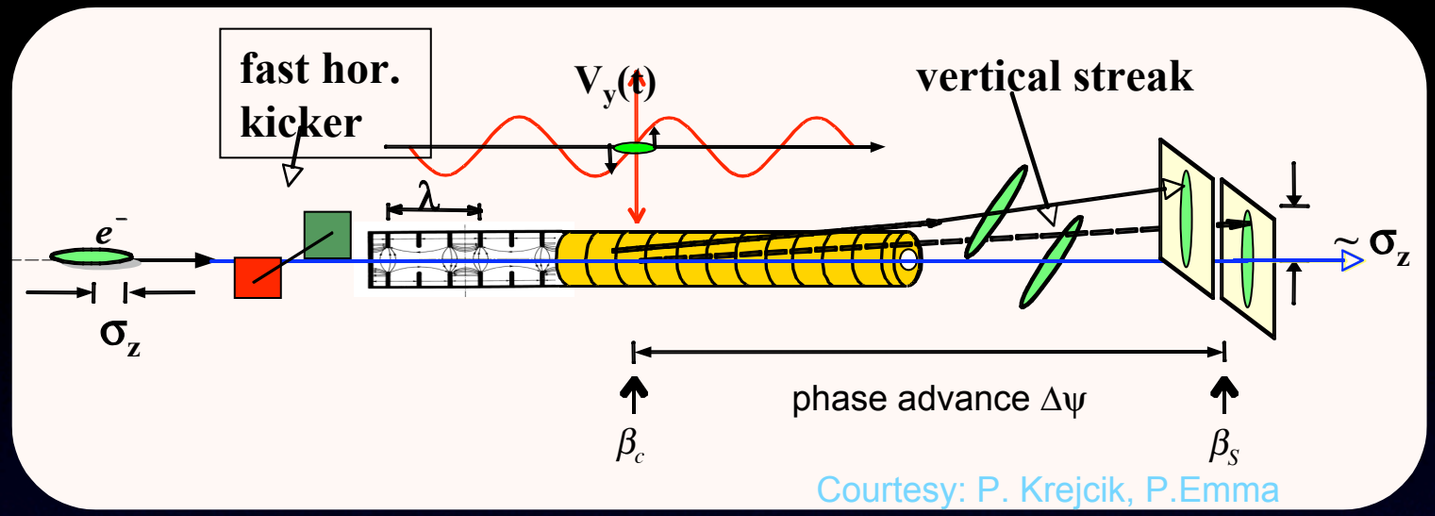

longitudinal phasespace



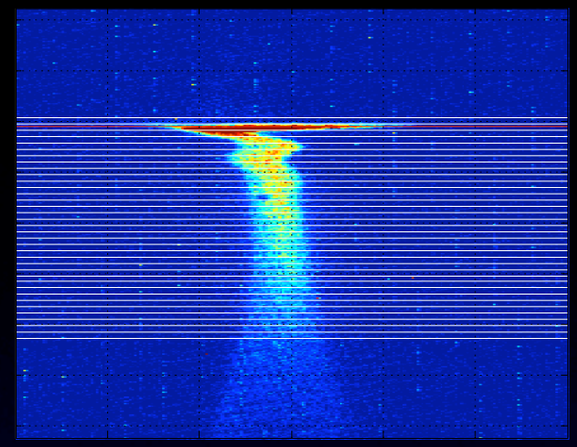

Simulations by Martin Dohlus

# Longitudinal diagnostics

**T**ransverse
**D**eflecting
**S**tructure

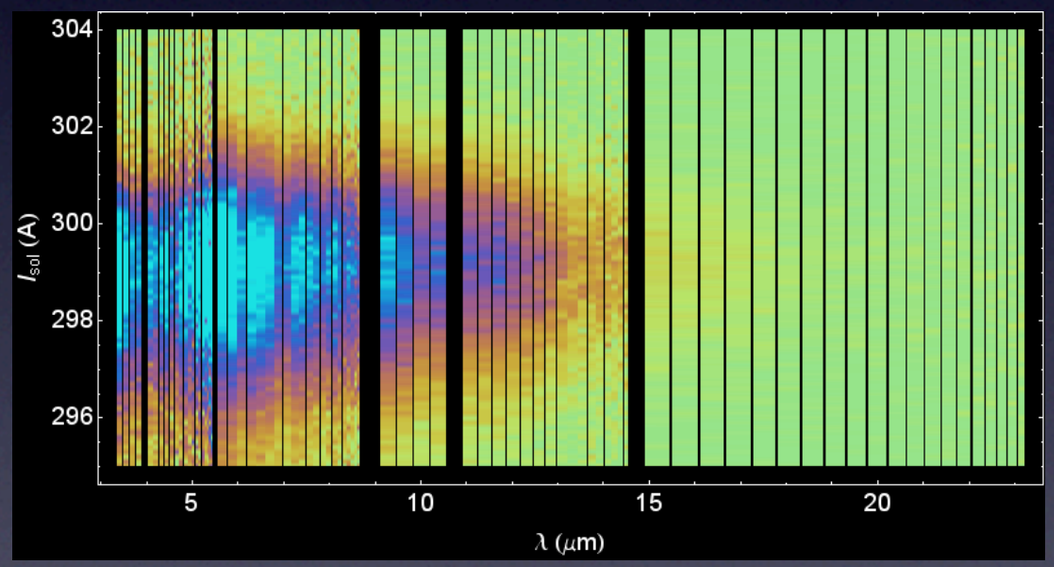



Courtesy: P. Krejcik, P.Emma



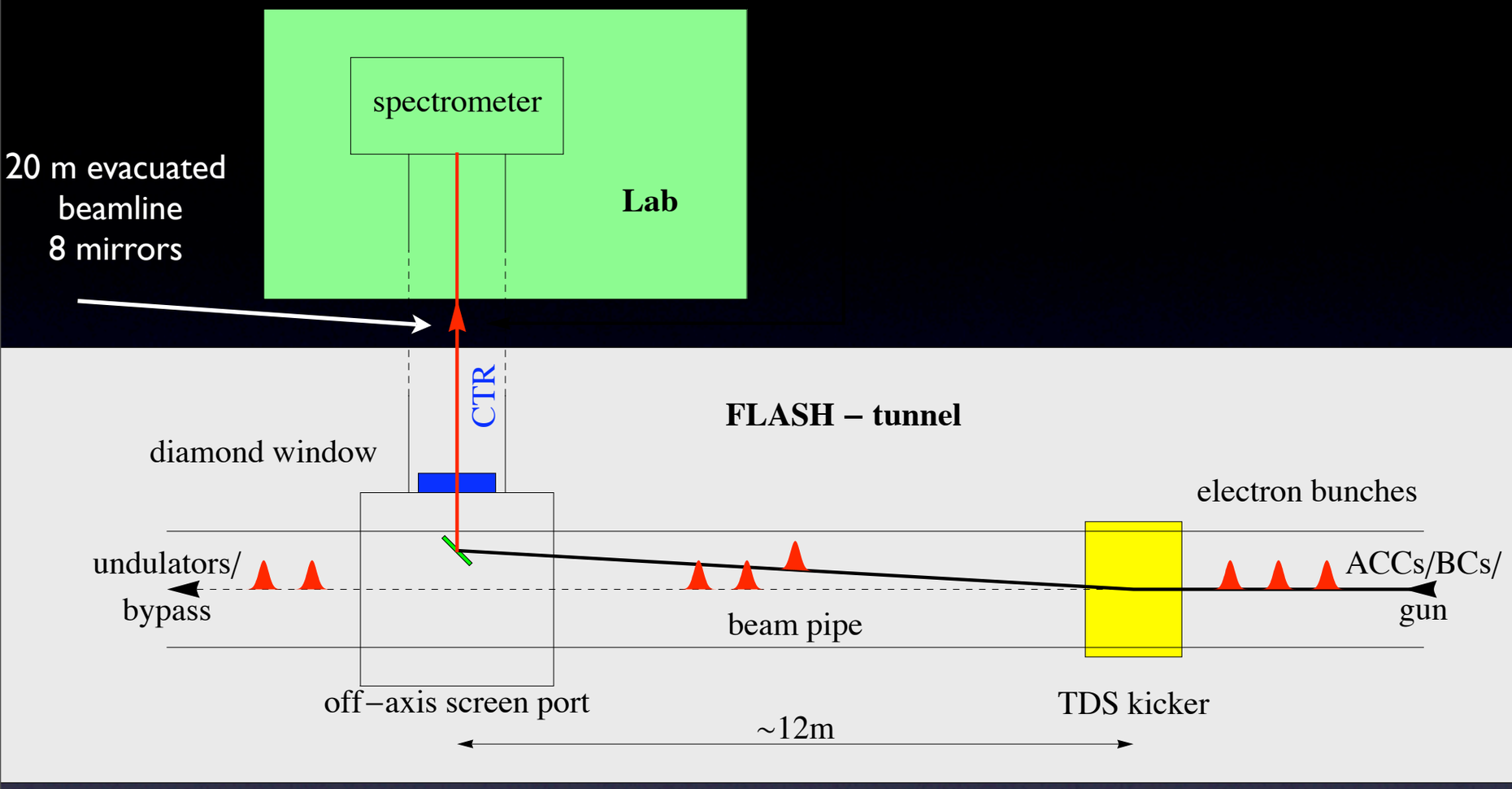
resolution ~ 15 - 20 μm
direct temporal profile

**C**oherent
**R**adiation
**S**prectroscopy

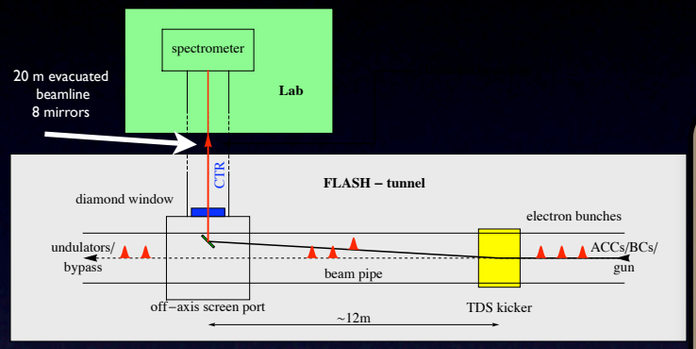


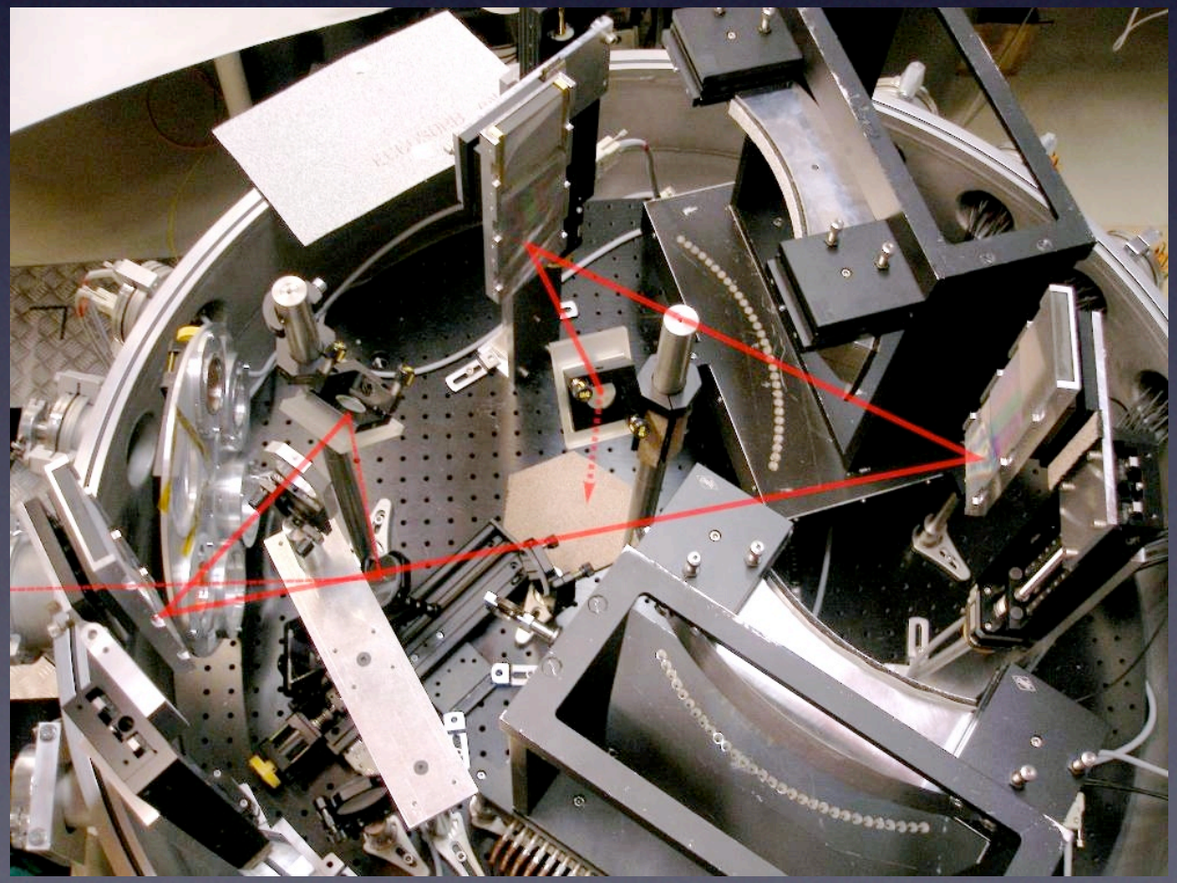

resolution < 1 μm
wavelength domain
no direct temporal profile

# Coherent radiation spectroscopy

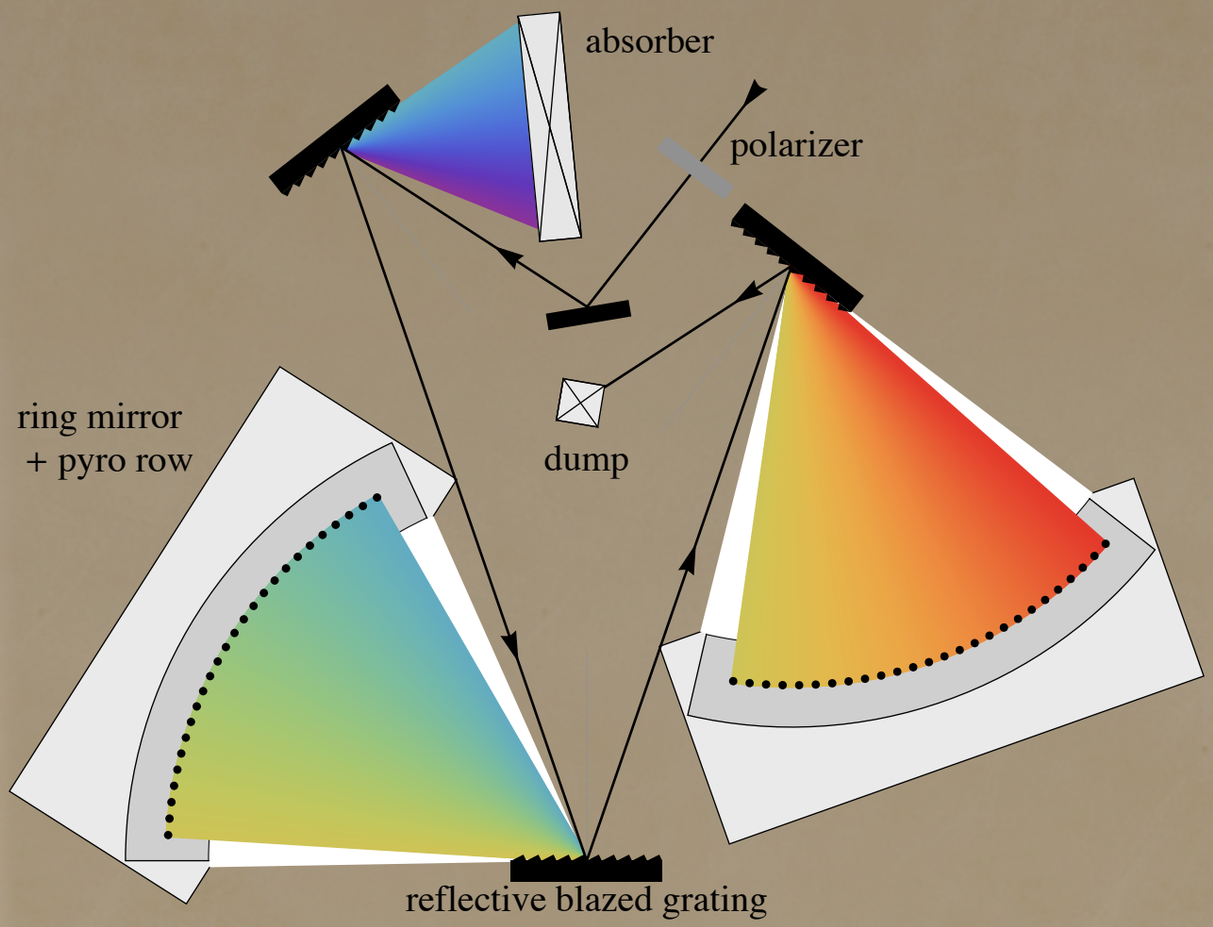


# Coherent radiation spectroscopy



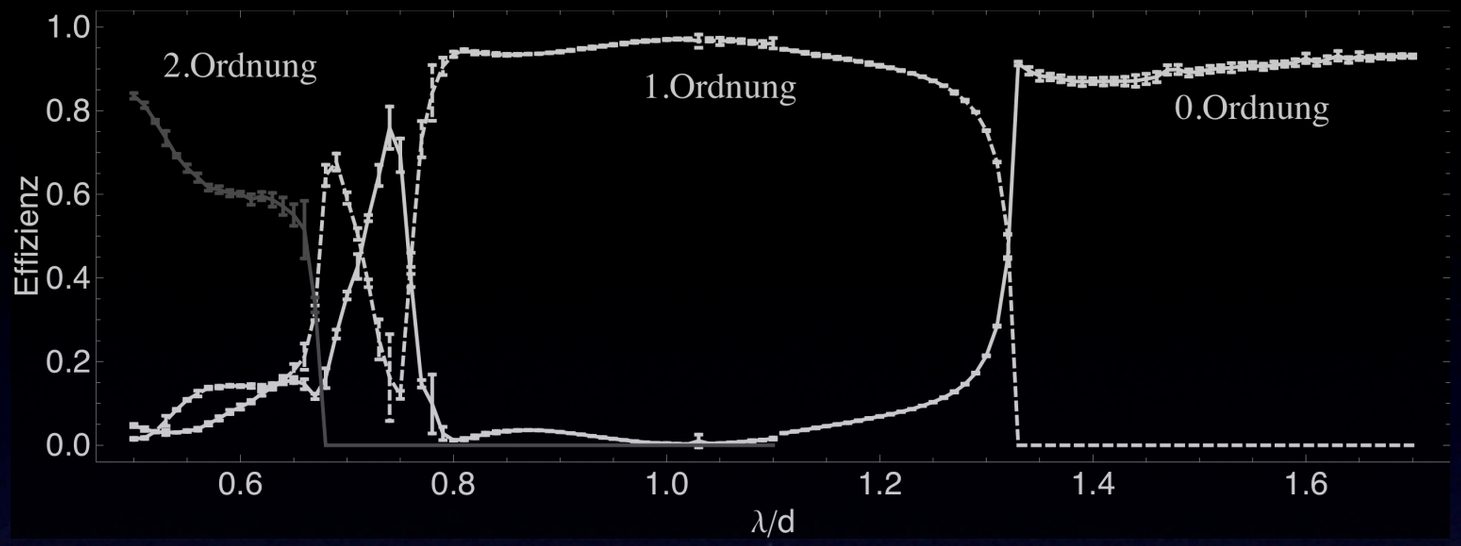



## 2 stage single shot spectrometer

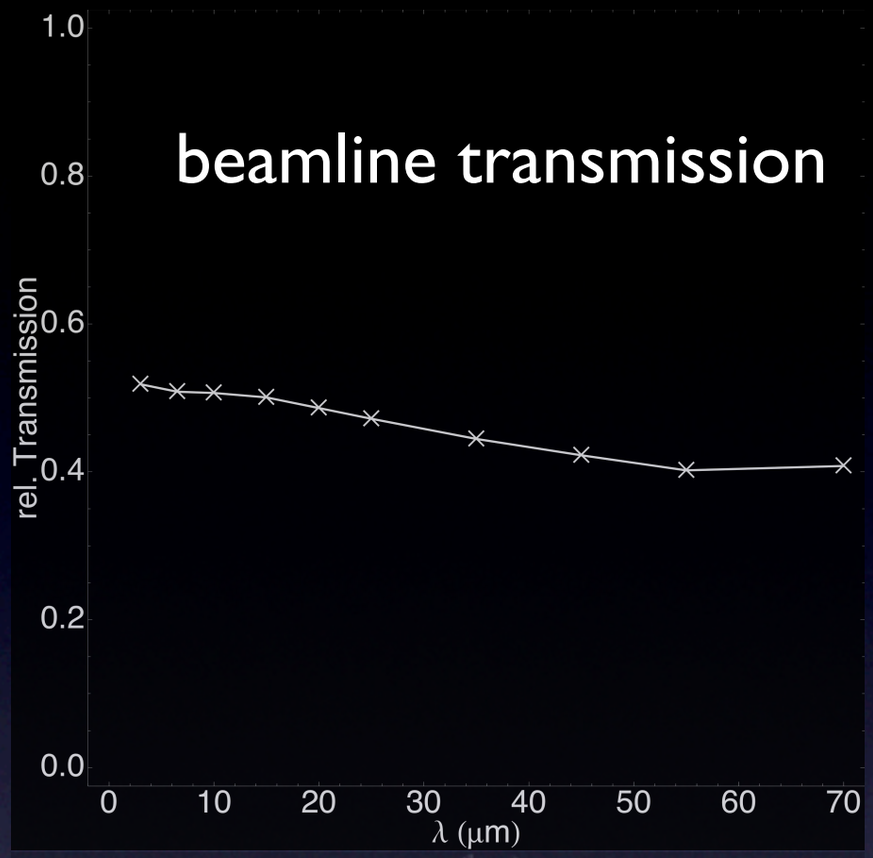



developed by Hossein Delsim - Hashemi

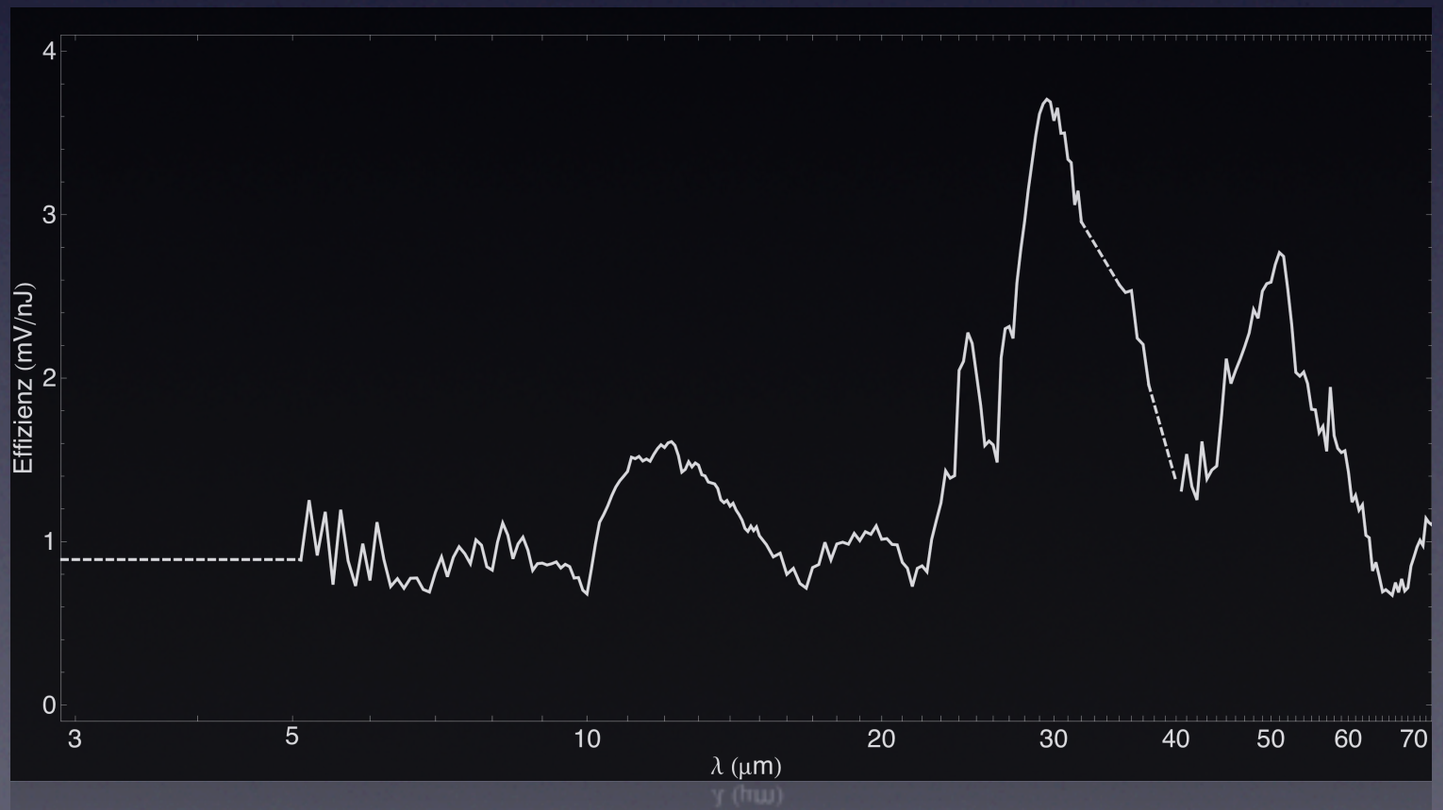
# calibration and more




grating efficiency



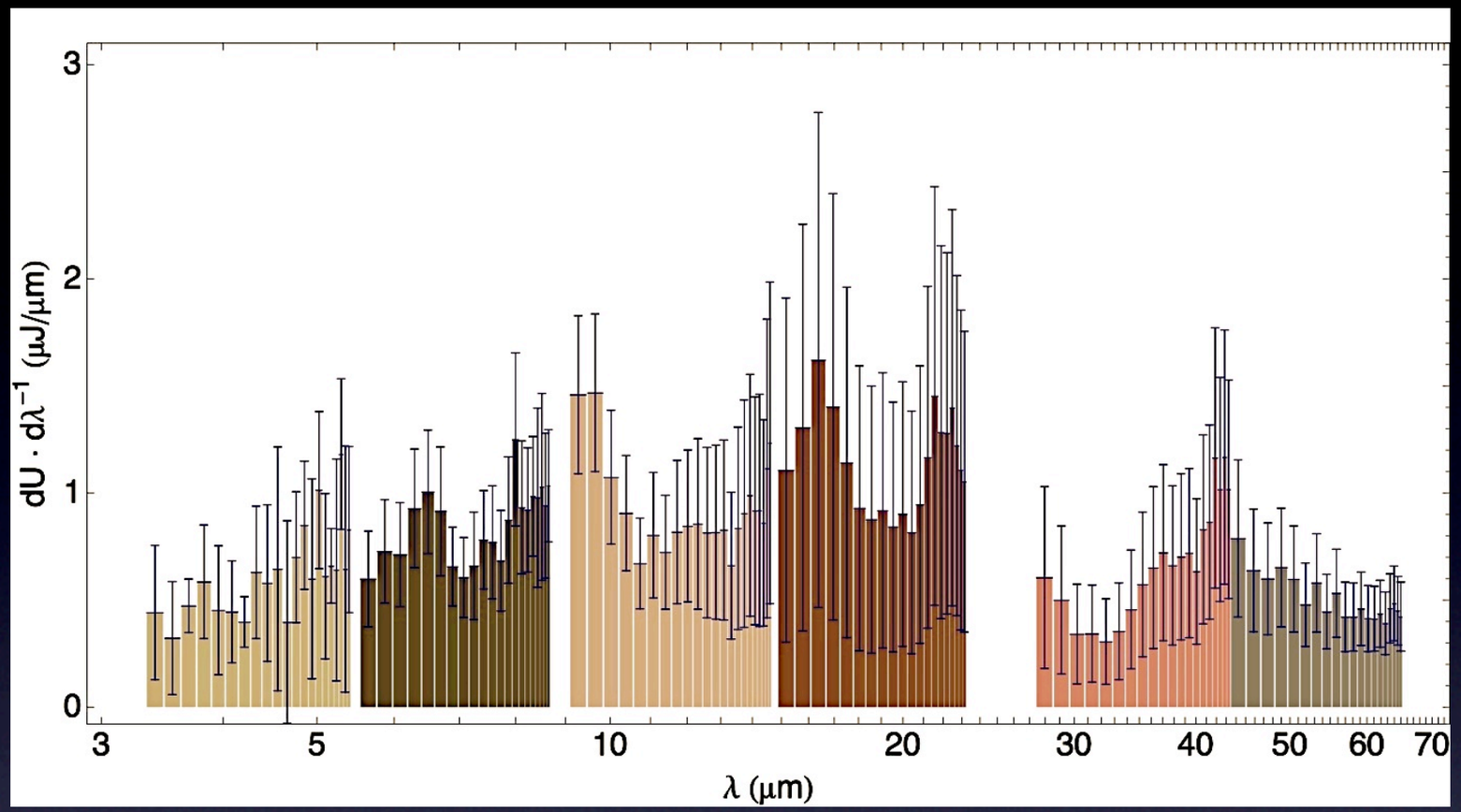

beamline transmission




pyroelectric sensors

see talk by S. Wesch

# CTR spectra from compressed bunches




broadband, flat spectrum

extends down to μm scale

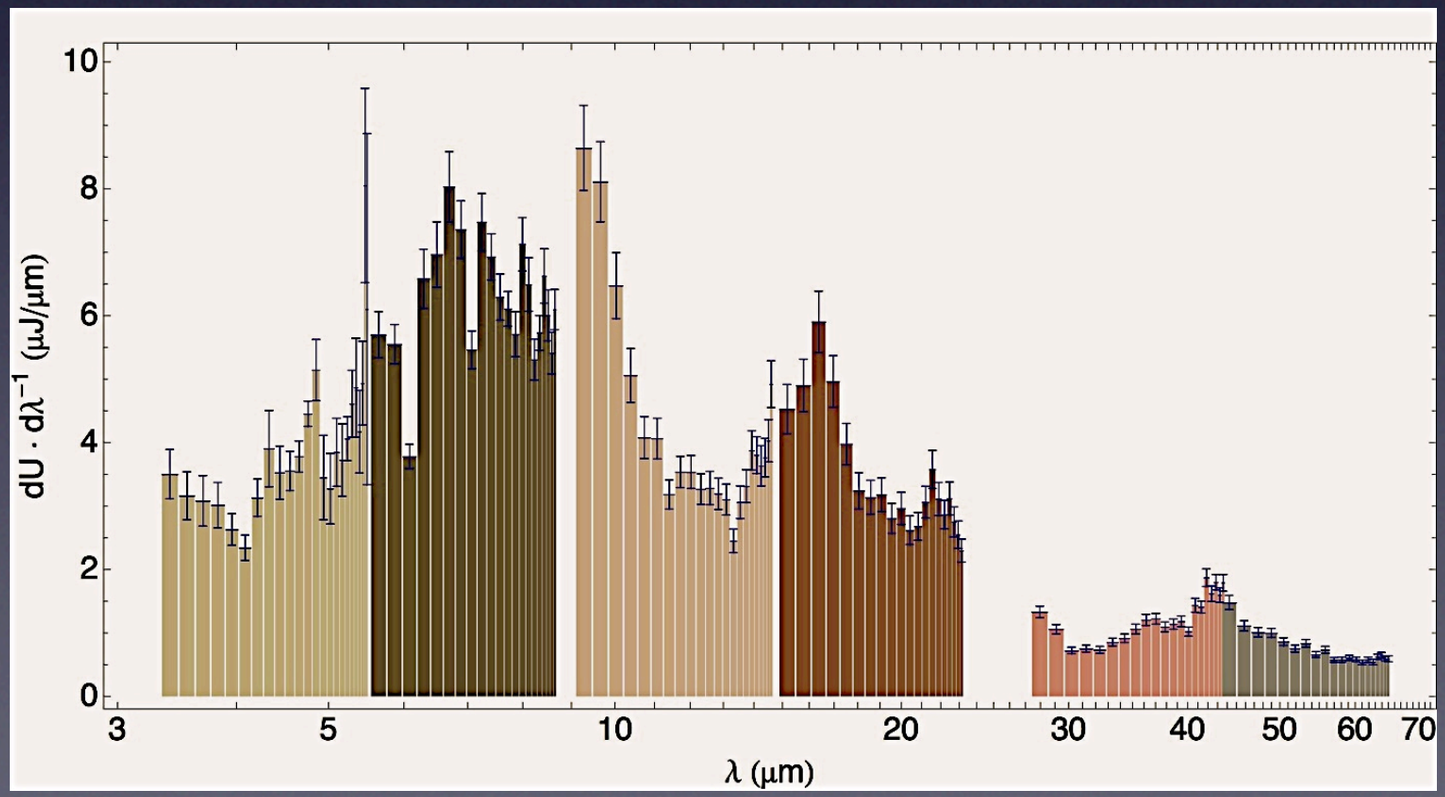
large shot/shot fluctuations

## one stage compression

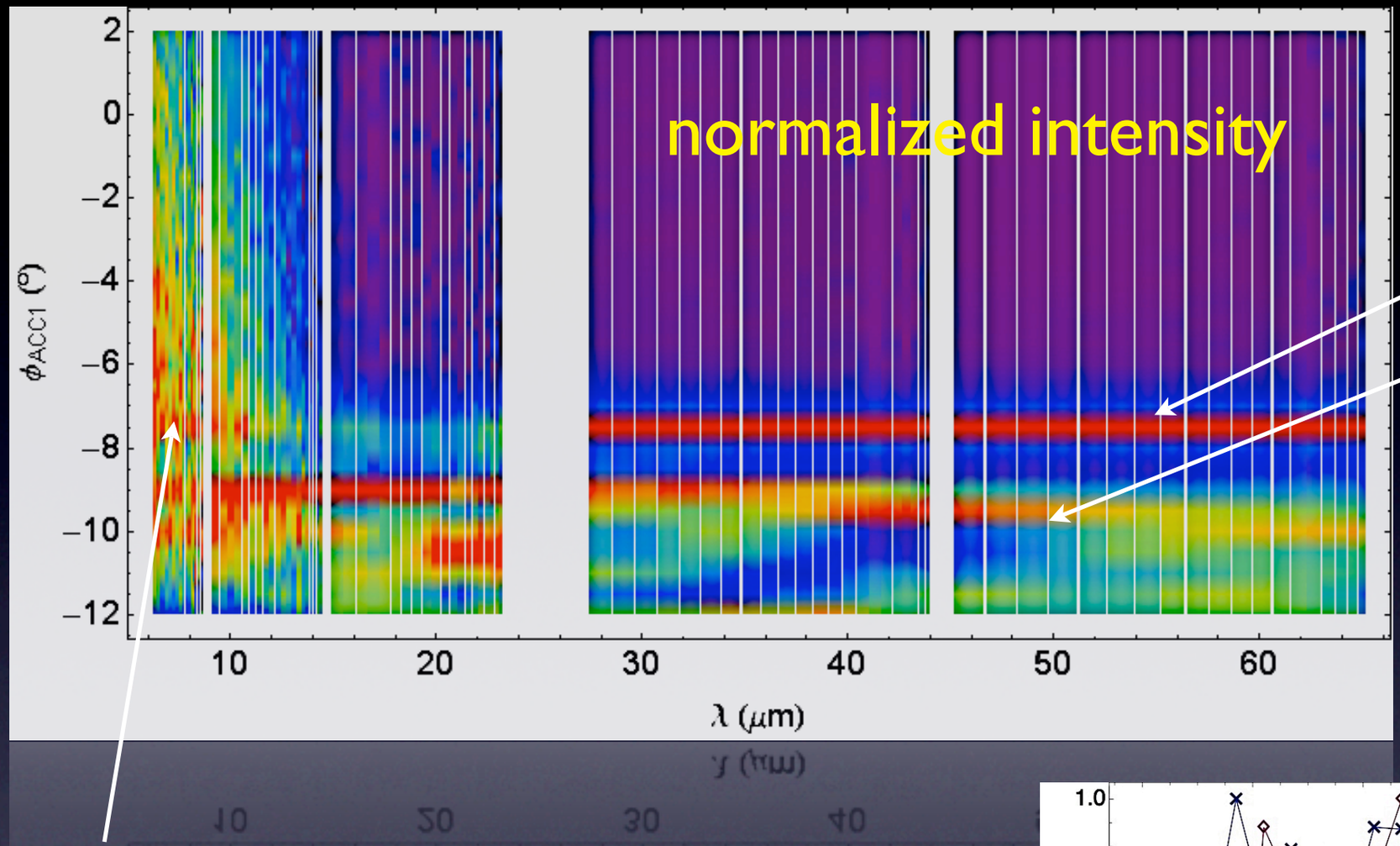
pronounced short wavelengths

more intense

less fluctuations

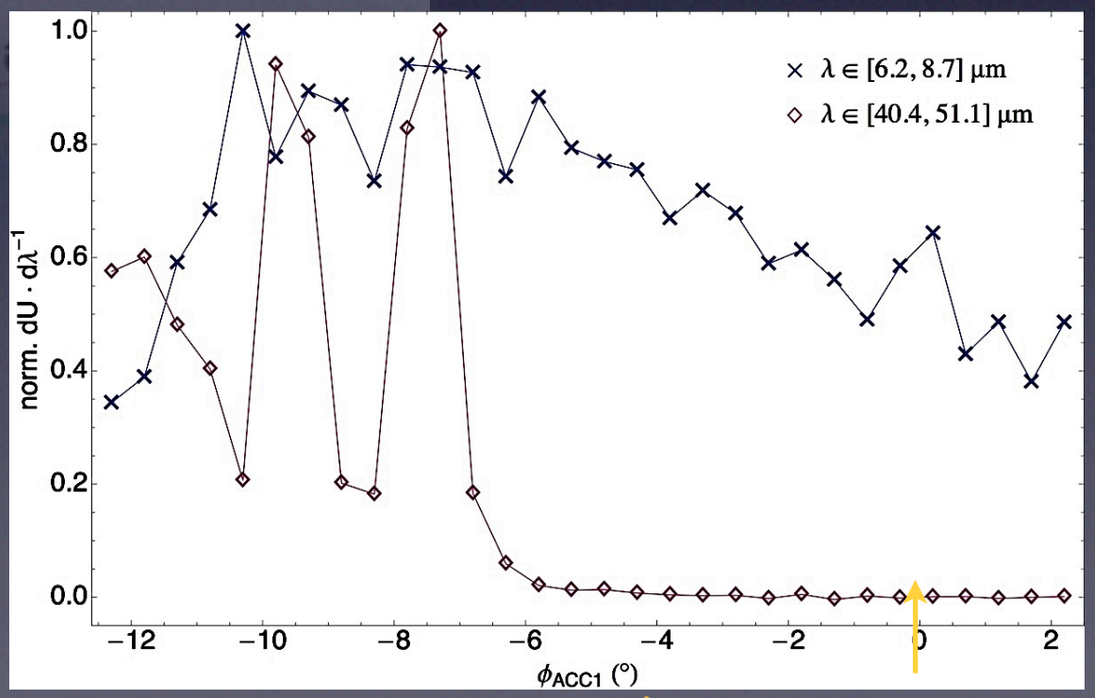


# influence of phase in ACC1 (first compression)




sharp, distinct structures

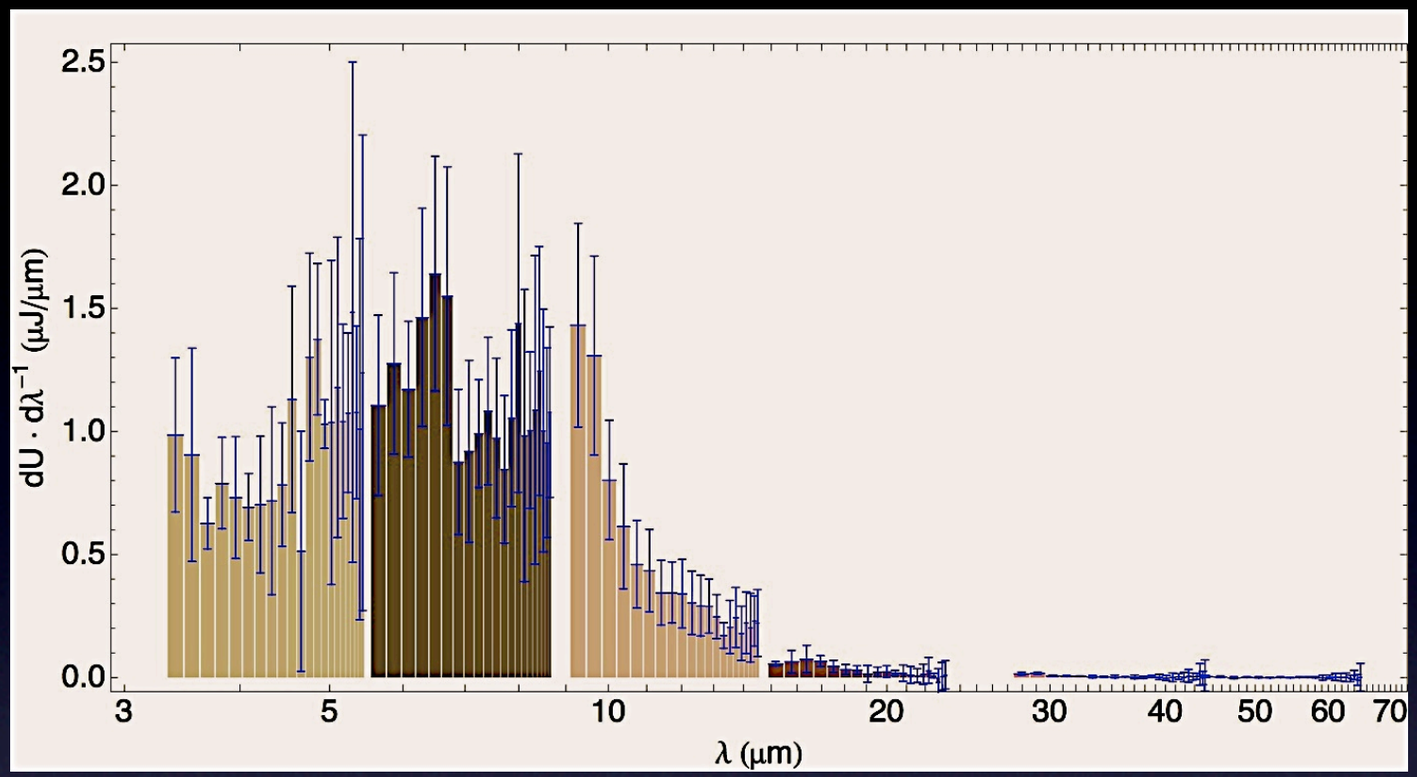
phase insensitive regime




← more compression

on crest

# CTR spectra from uncompressed bunches



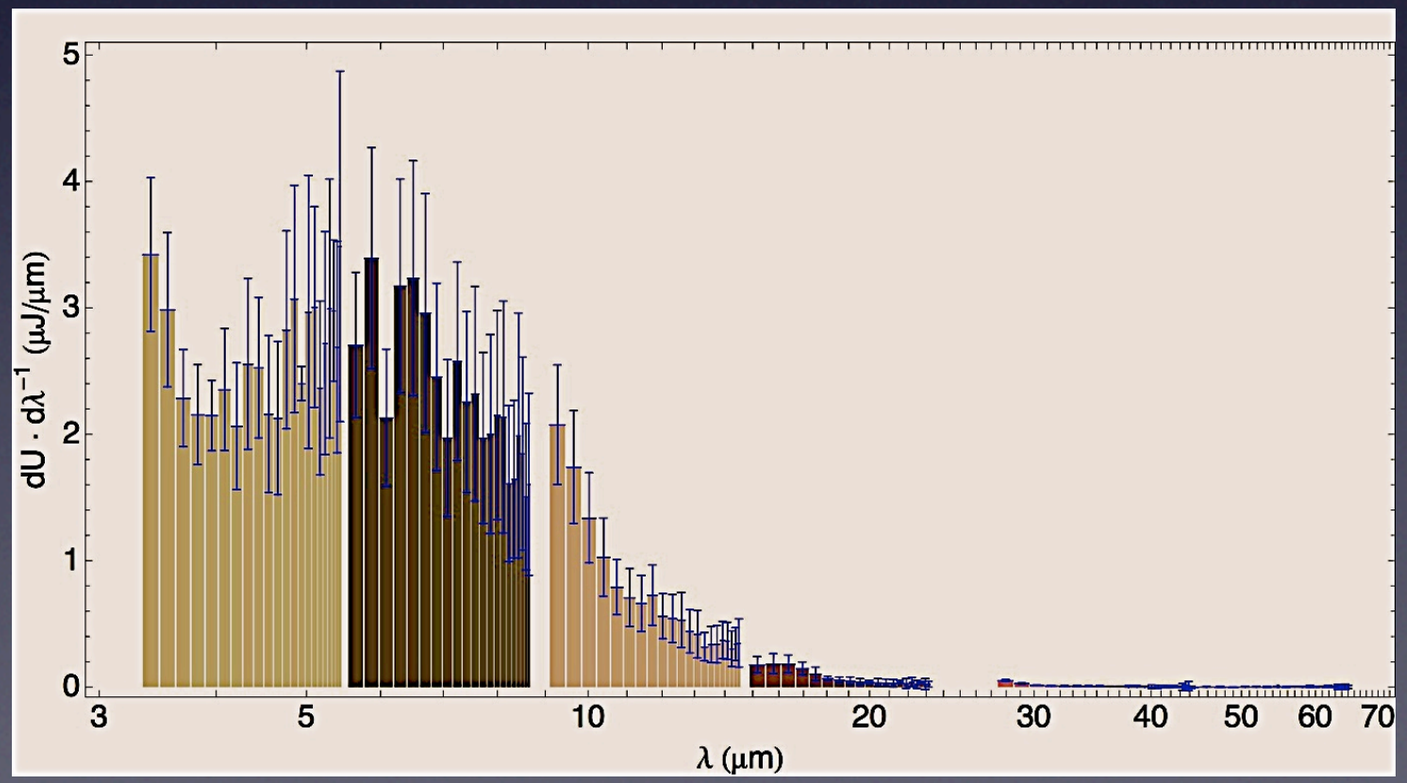

strong spectrum below 10 μm
intensity comparable to „spike regime“
large shot to fluctuations

720 MeV (13 nm lasing)

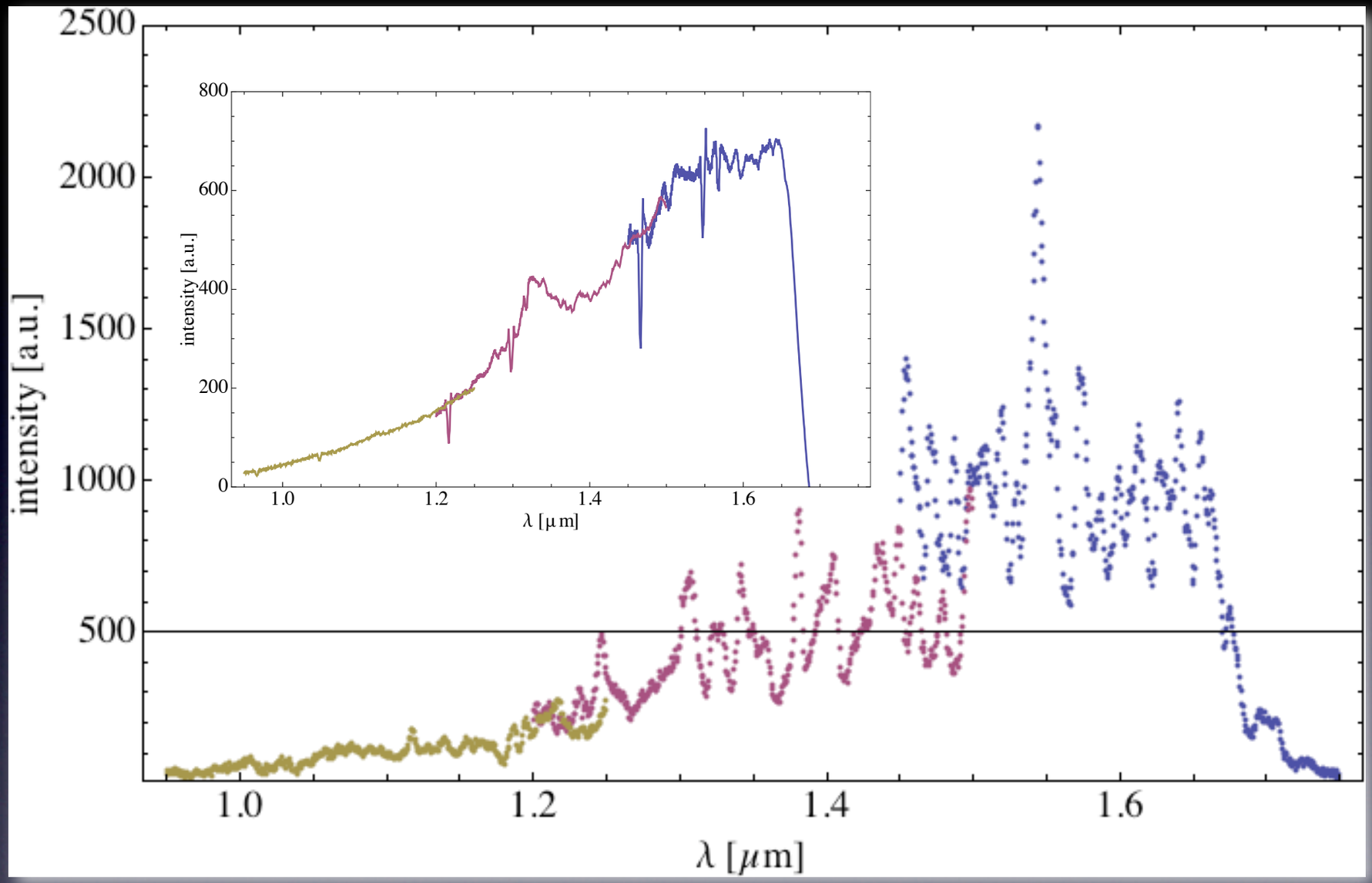
intensity ~$10^4$ -$10^5$ x incoherent level

980 MeV (6 nm lasing)

about 4 times more intensity
spectrum „harder“
less fluctuations

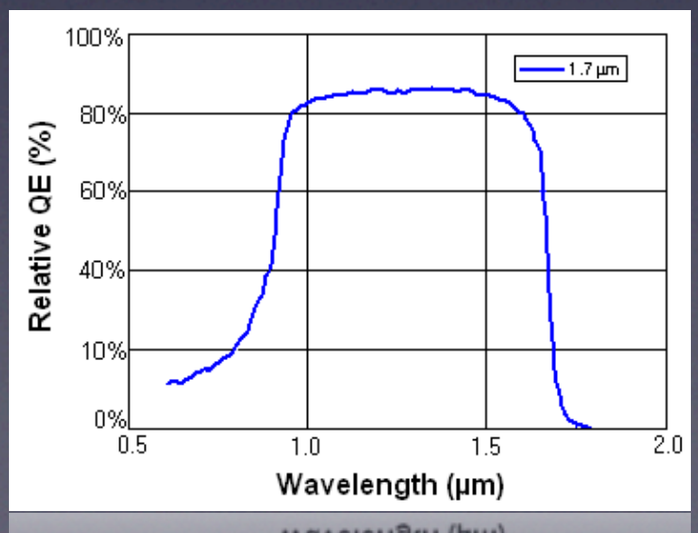


# extending to NIR



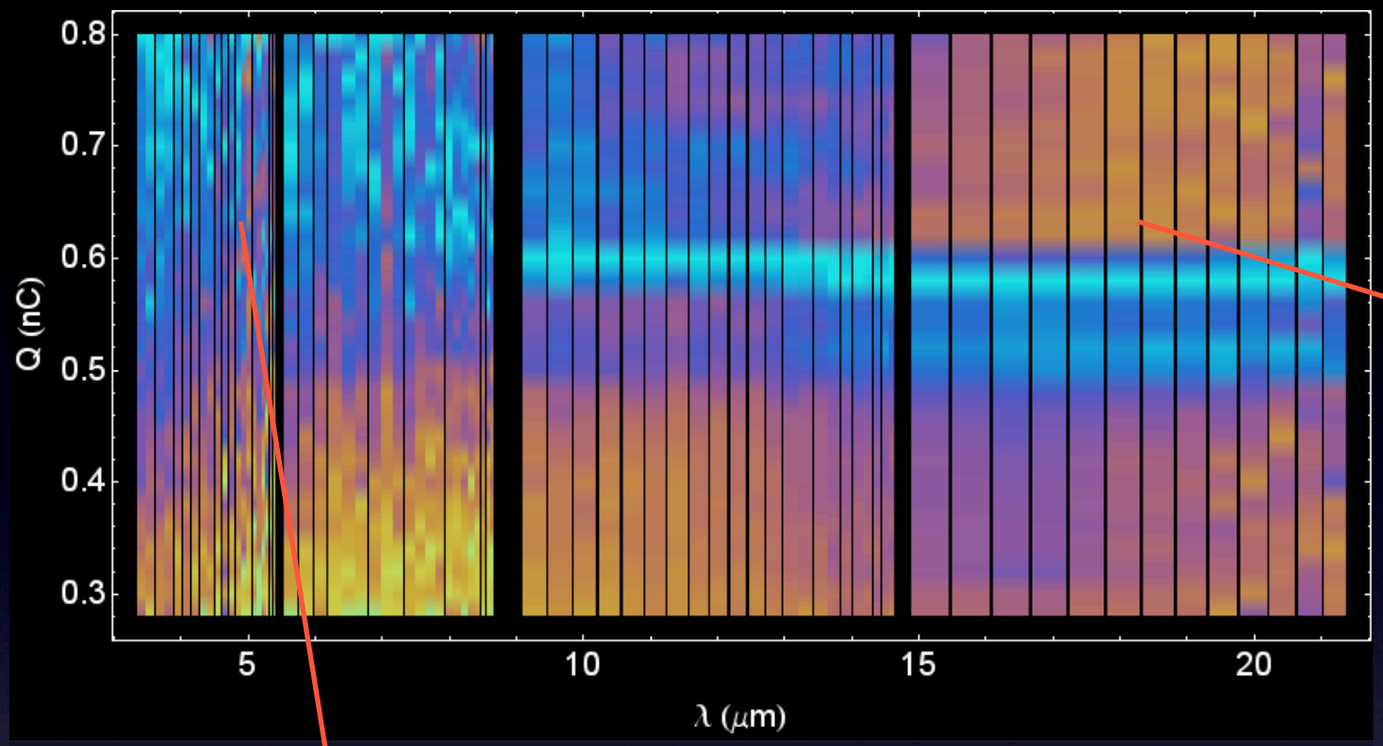

commercial spectrometer
+ InGaAs Camera

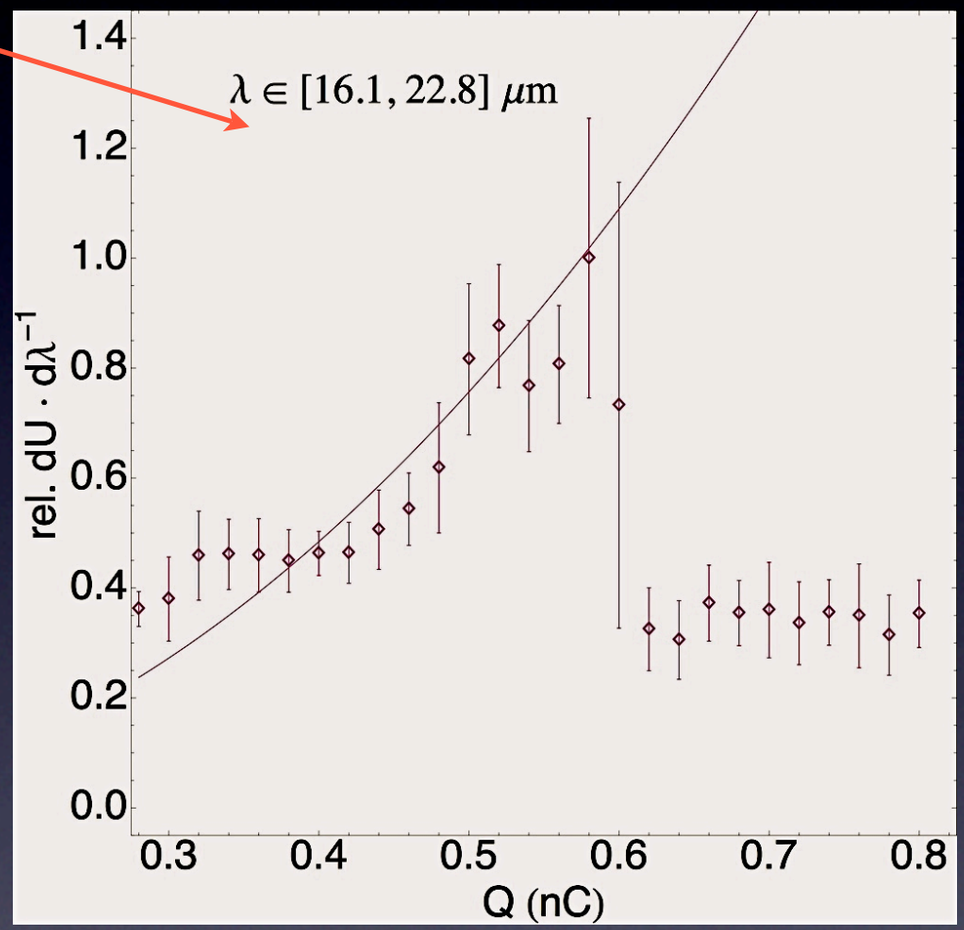
sensitivity

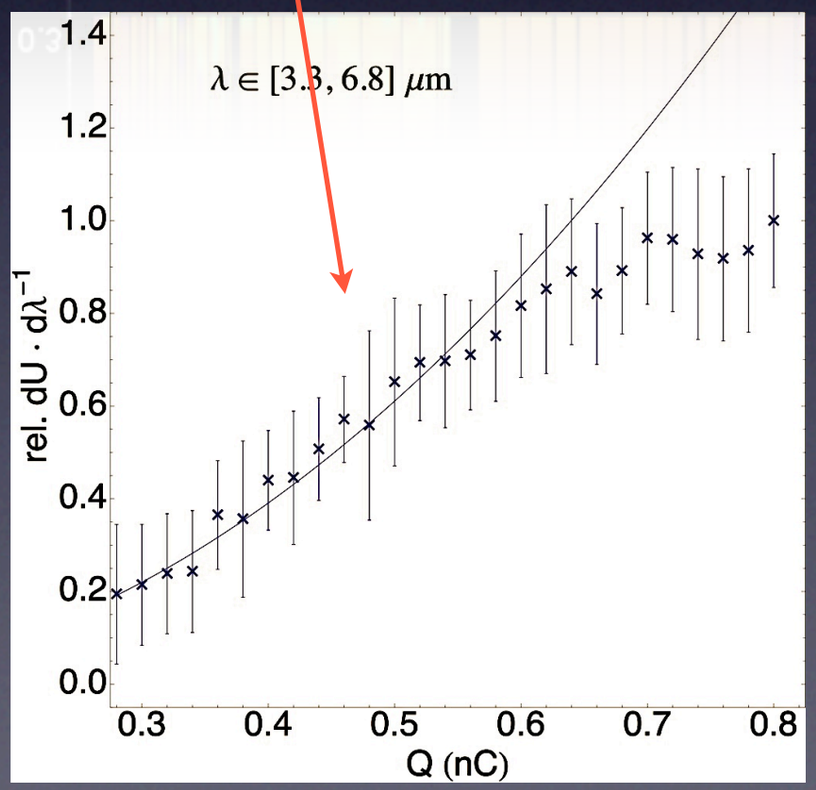


# charge dependence

compressed bunch

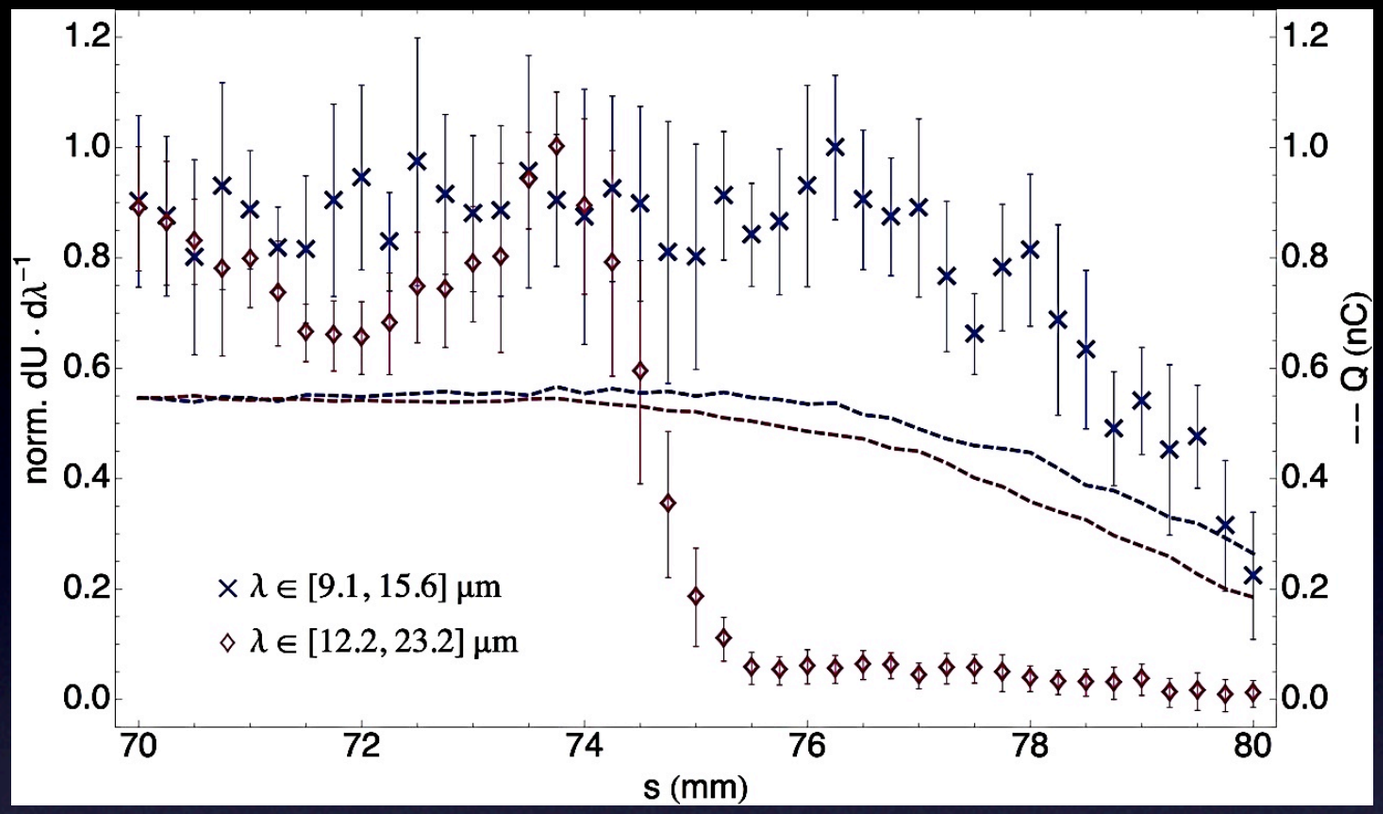


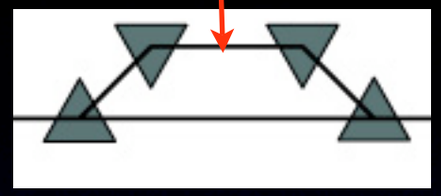



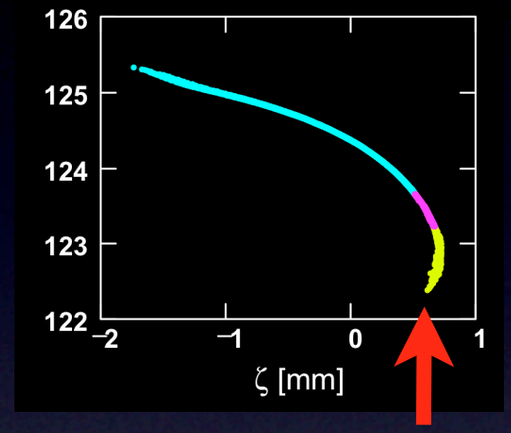



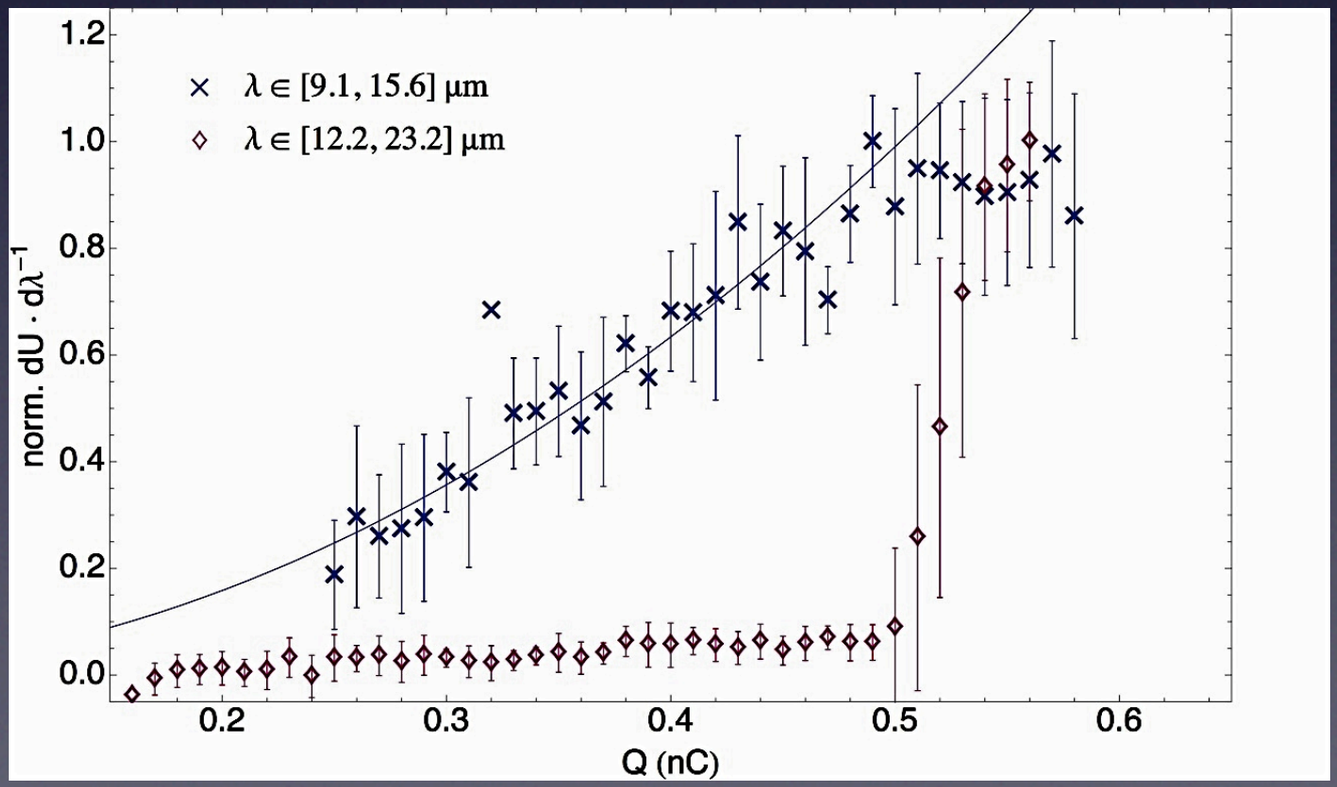

short wavelength : ~ $q^2$

# scraping the bunch in phase space



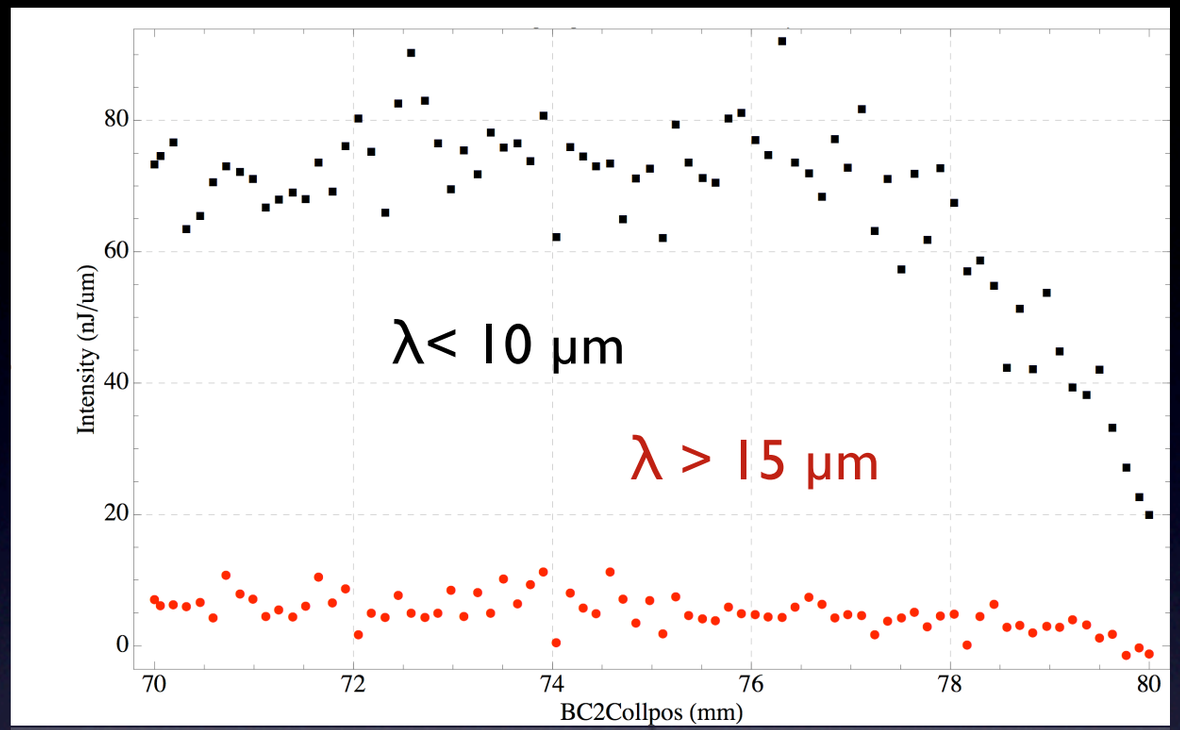



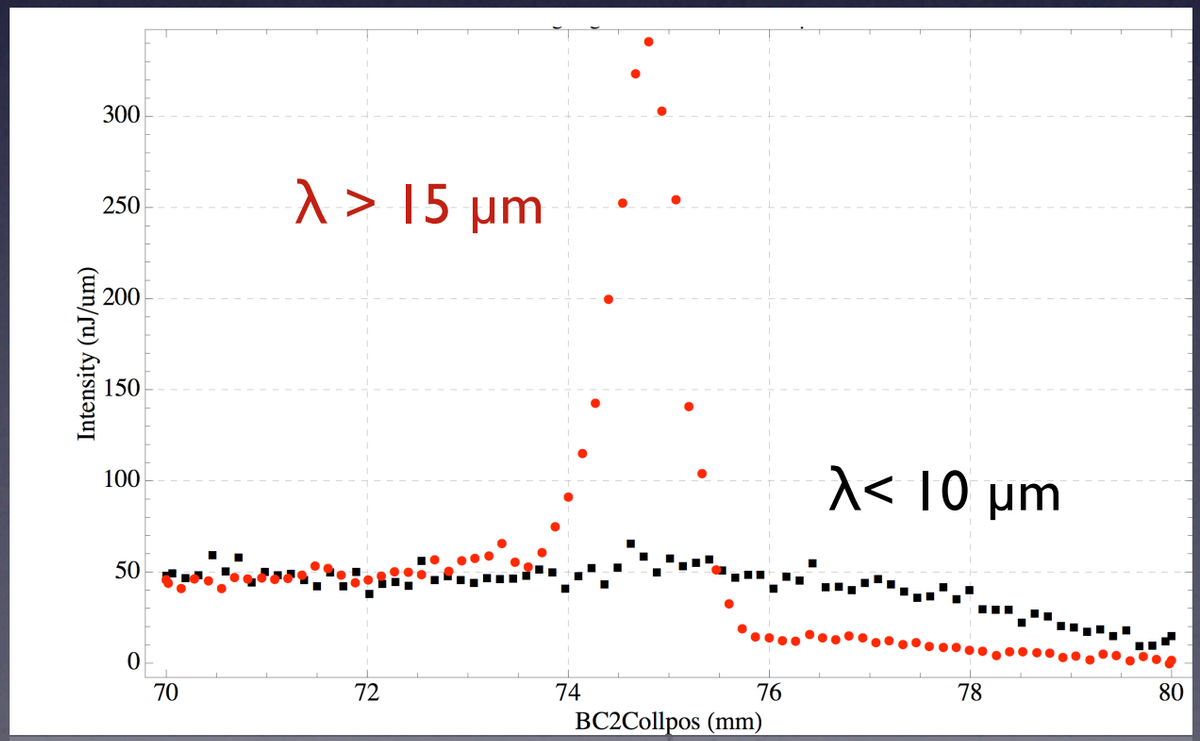

origin of µ-bunch radiation is extended over a large fraction of the bunch

# BC2 collimator - II

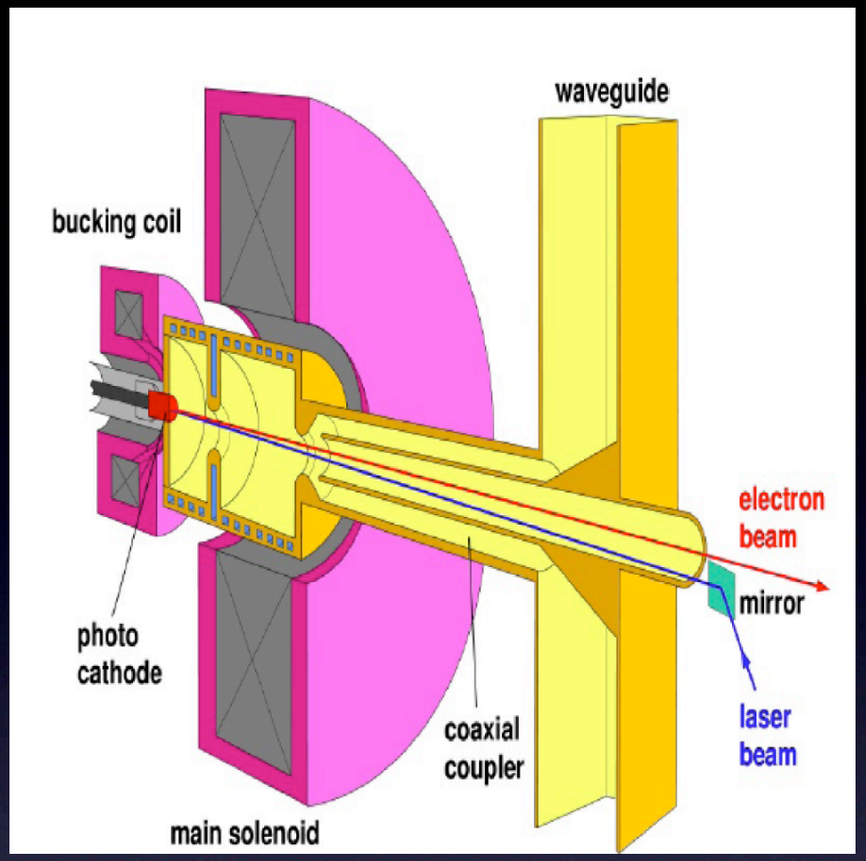


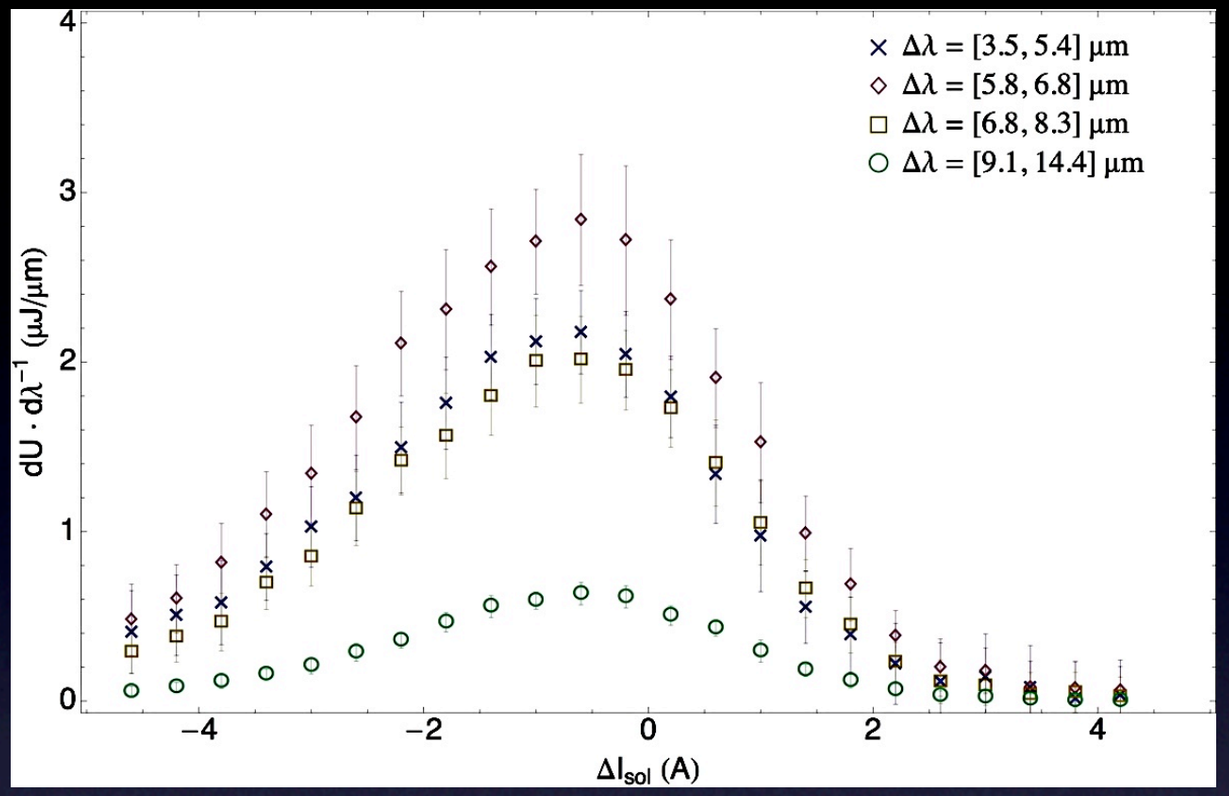

ACC1 1° less compression

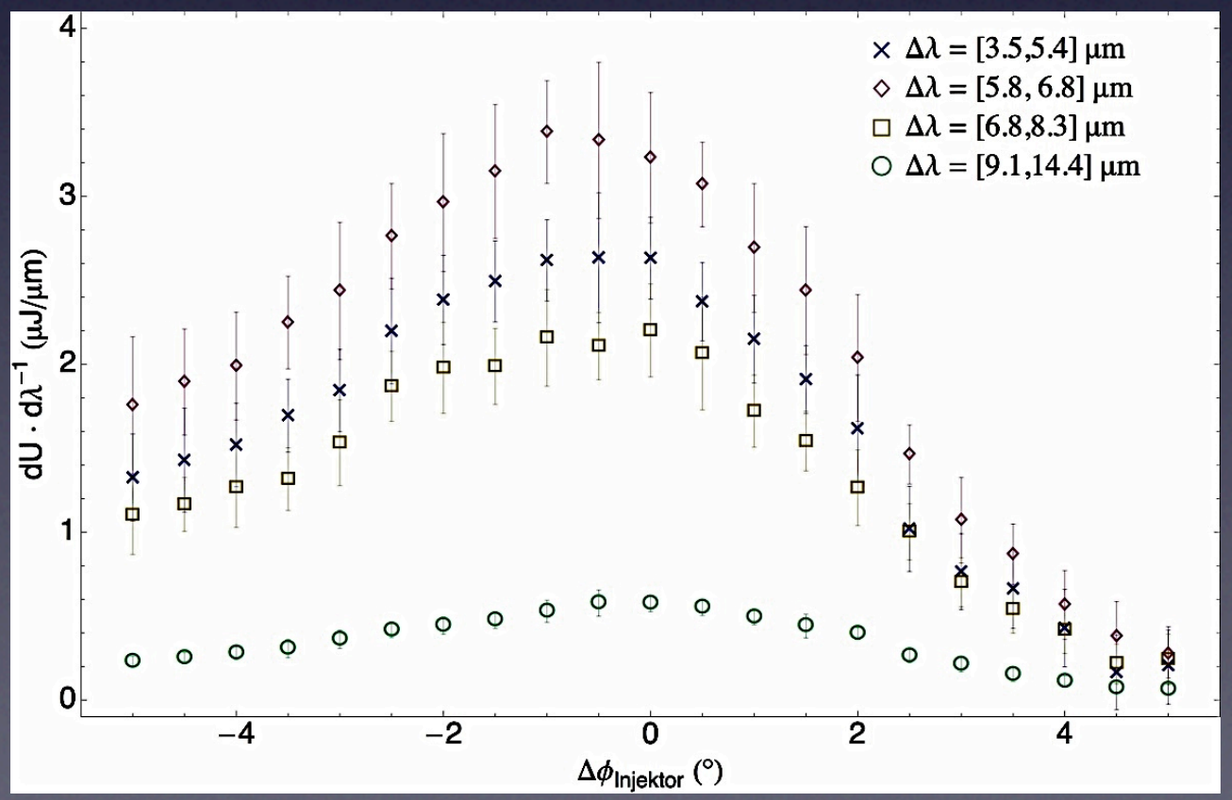
ACC1 1° more compression



# injector parameters, solenoid and gun phase



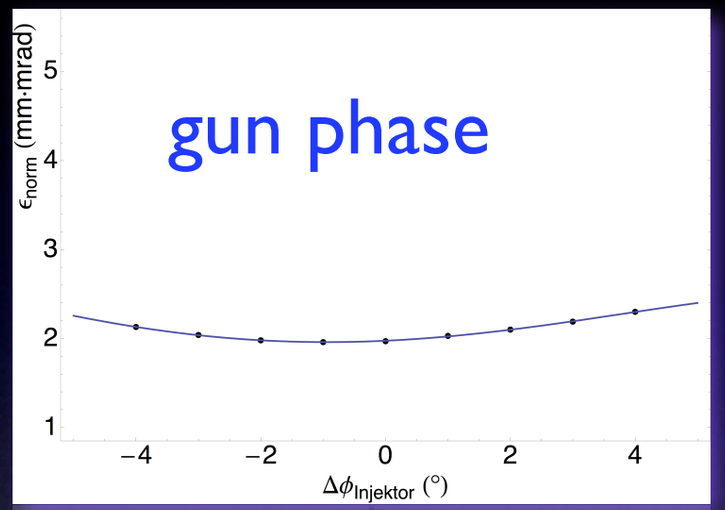



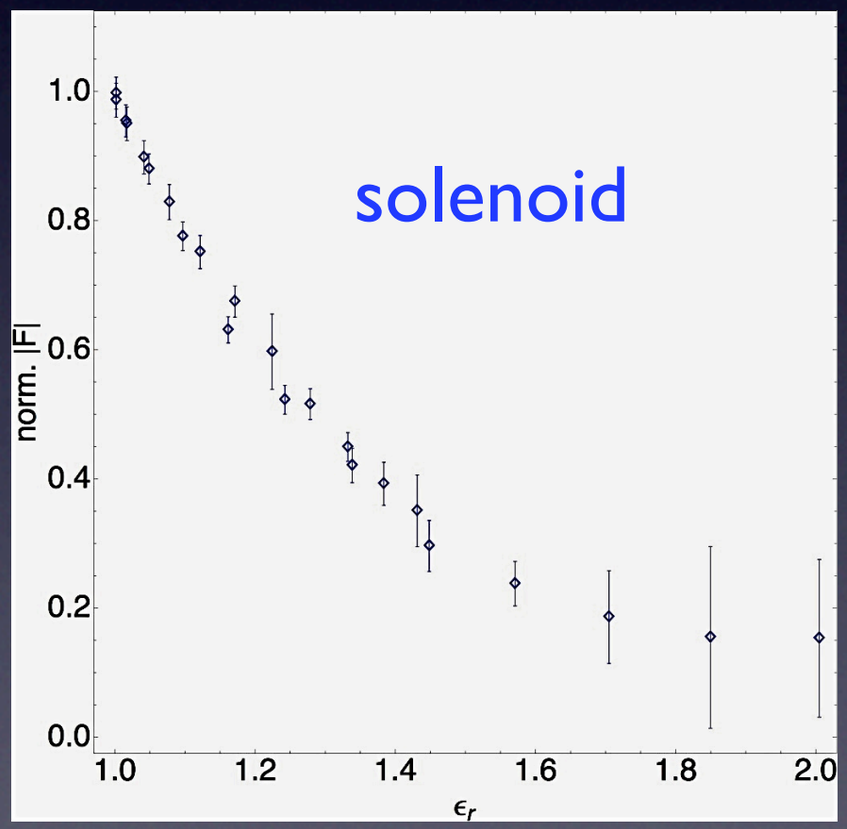

solenoid current and gun phase have strong influence on µ-bunching ( 3 - 15 µm)
no wavelength dependence

# emittance effect

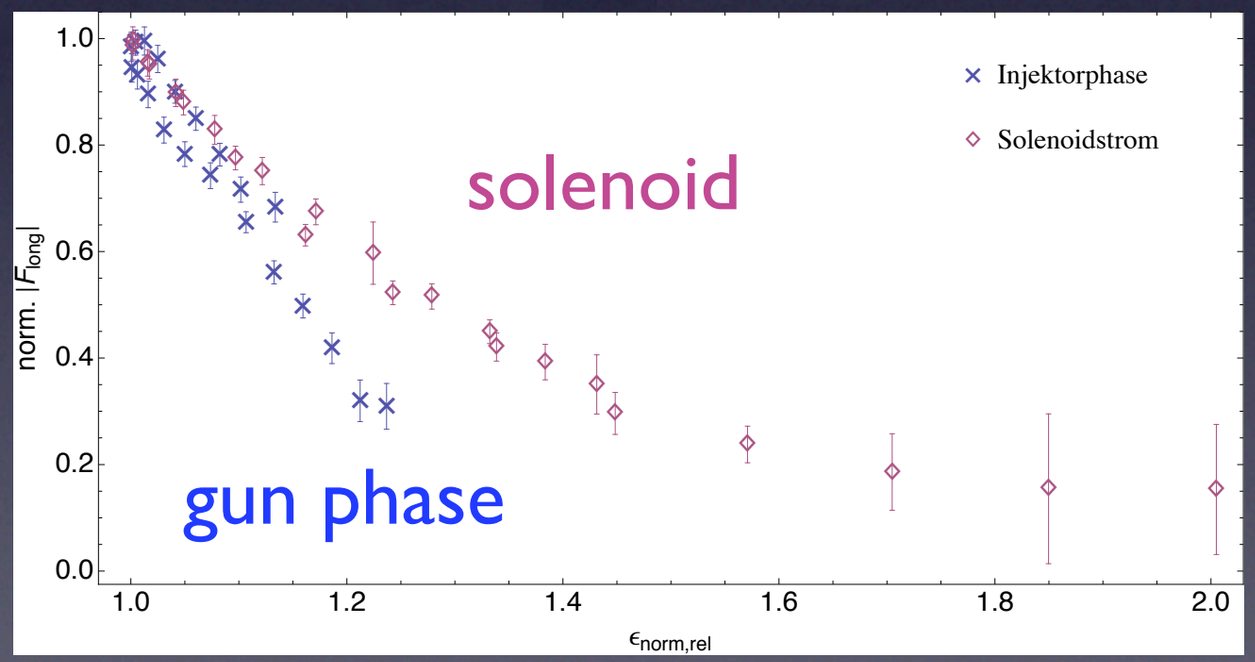
solenoid and phase determine emittance
common picture ?

emittance by ASTRA simulations,
courtesy Mikhail Krasilnikov


norm. emittance



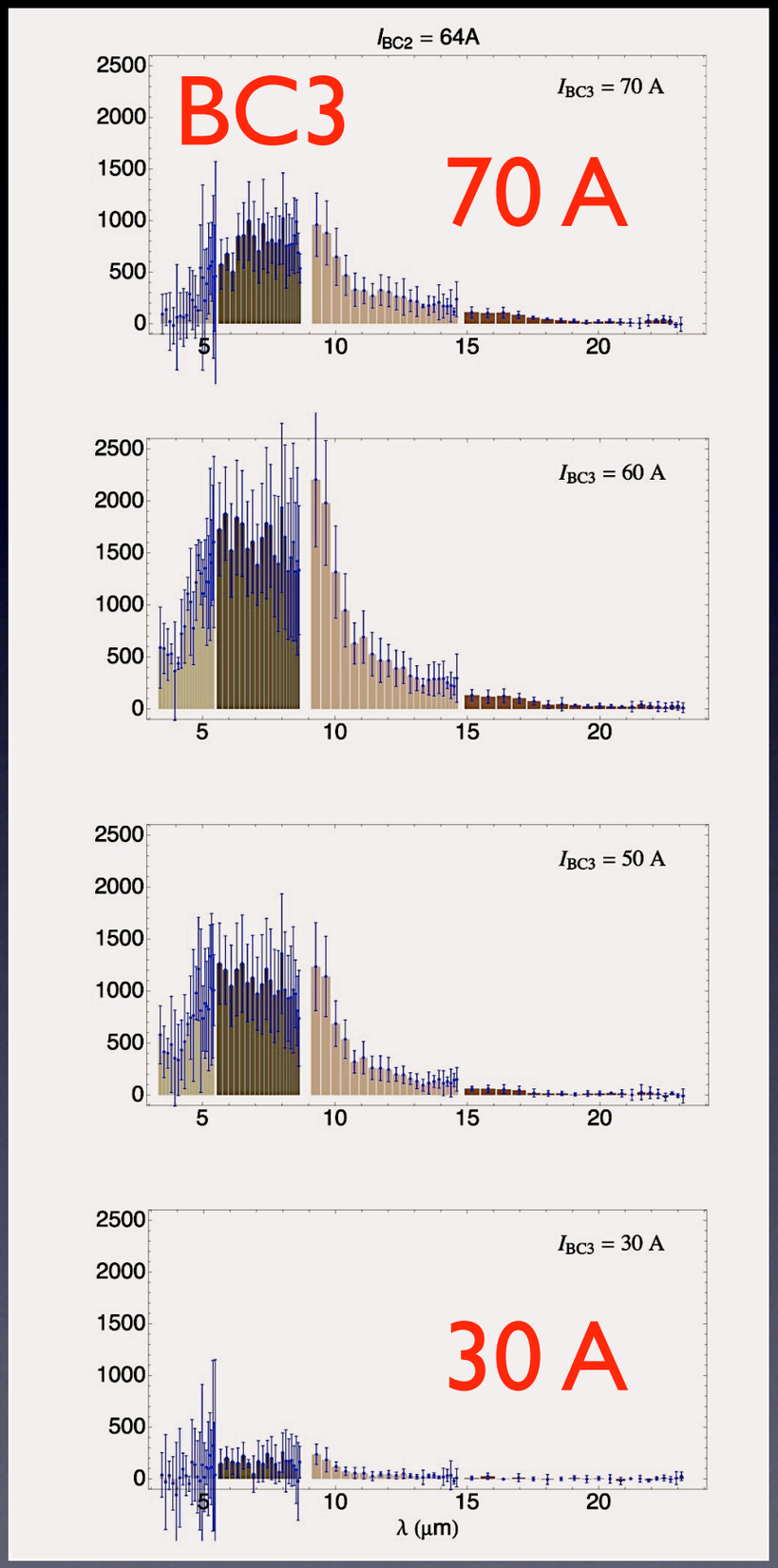

norm. emittance

# dipol strength of bunch compressors

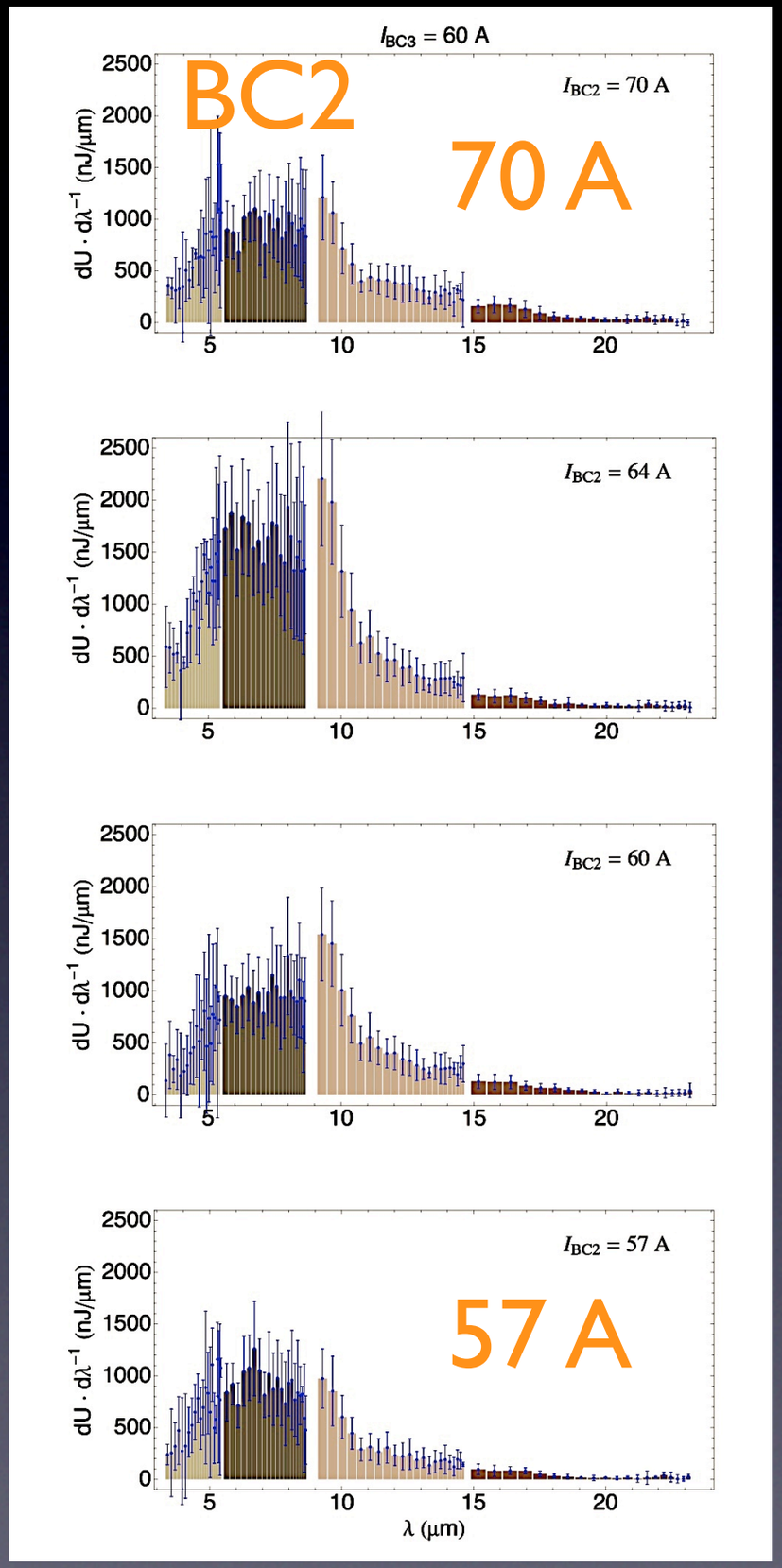
if ONE magnetic chicane OFF → no detectable μ-bunch radiation

# dipol strength of bunch compressors

BC2 fix at 60 A




BC3 fix at 64 A

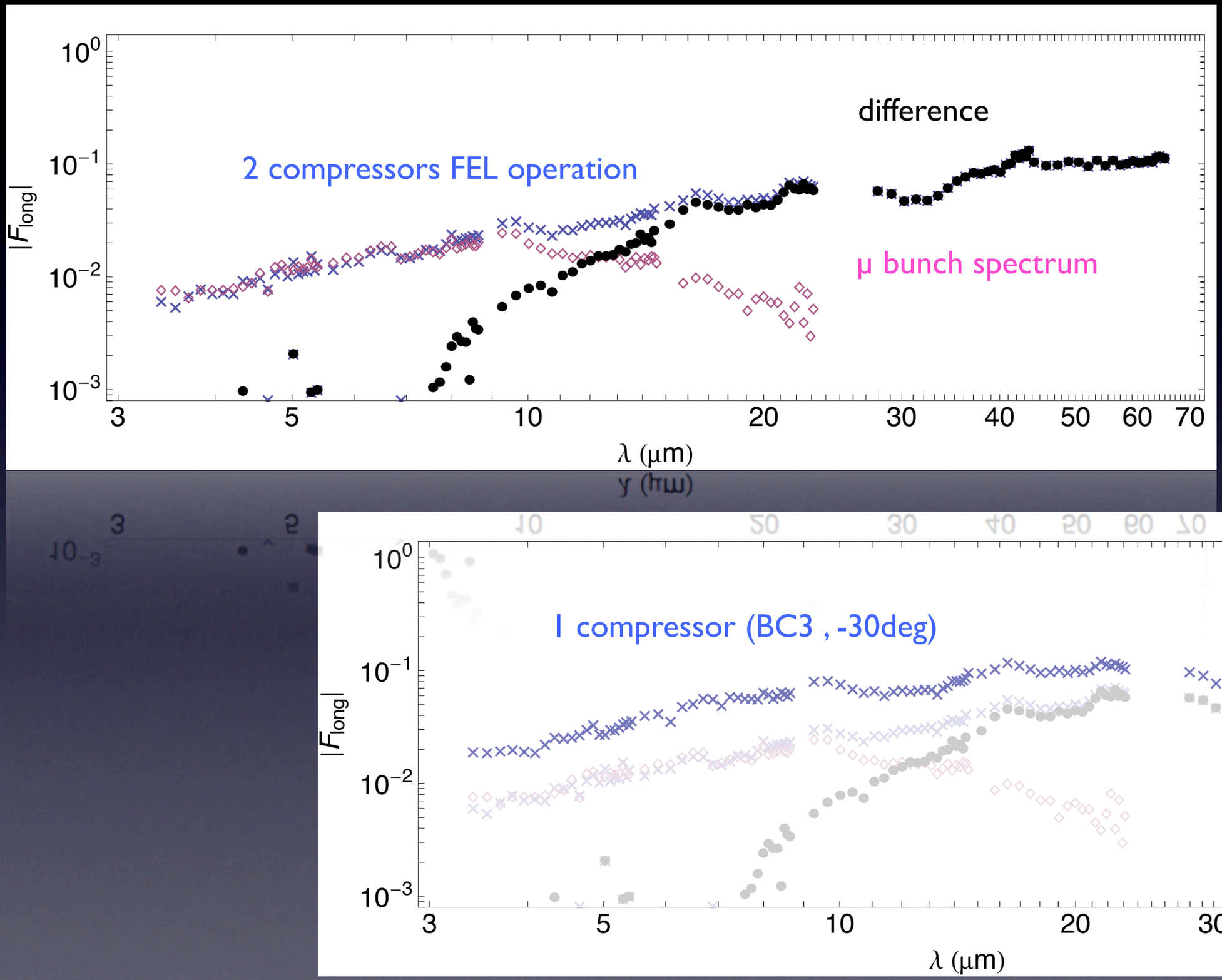


# what has to come

n-d linear models
Vlasov solver
single particle tracking
....

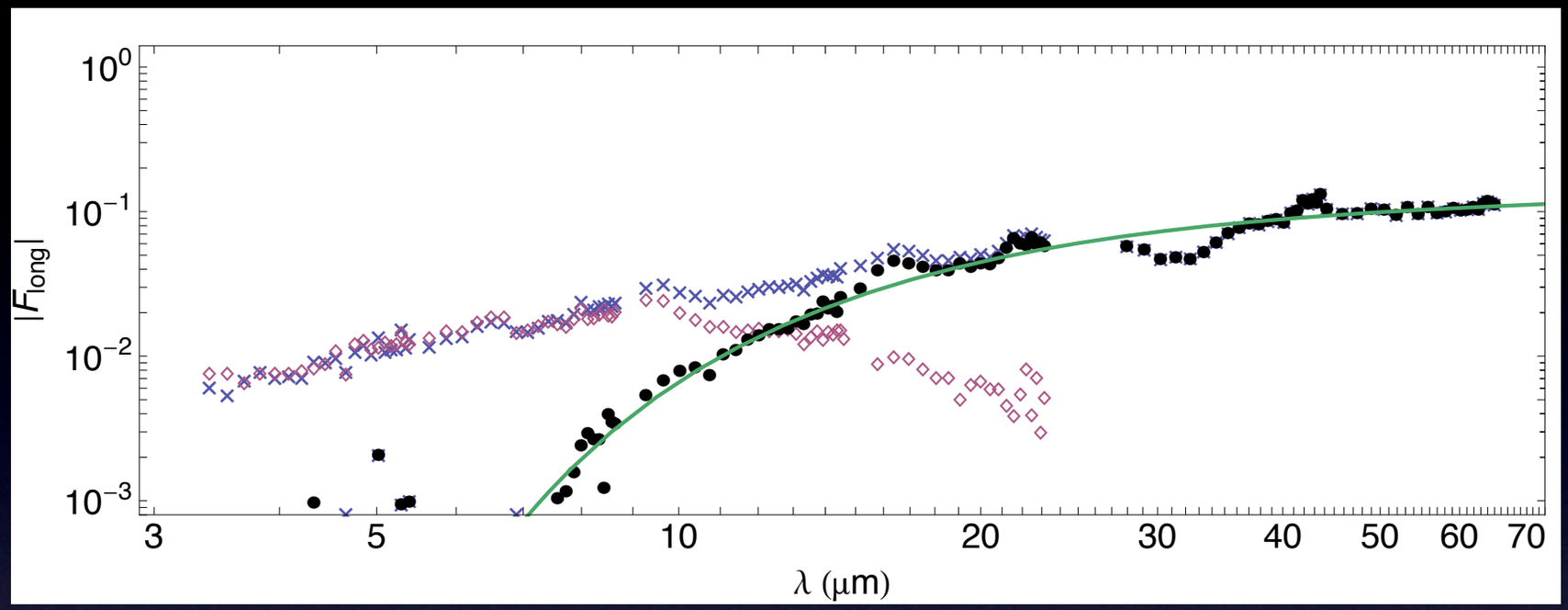
- overall level of  radiation
- spectrum of radiation
- (in)dependence on machine parameters
  - ACC phases (compression)
  - $R_{56}$ of chicanes
  - injector parameters (emittance)

# form factors and temporal profiles



# temporal profiles

needs model assumptions (no phase information)

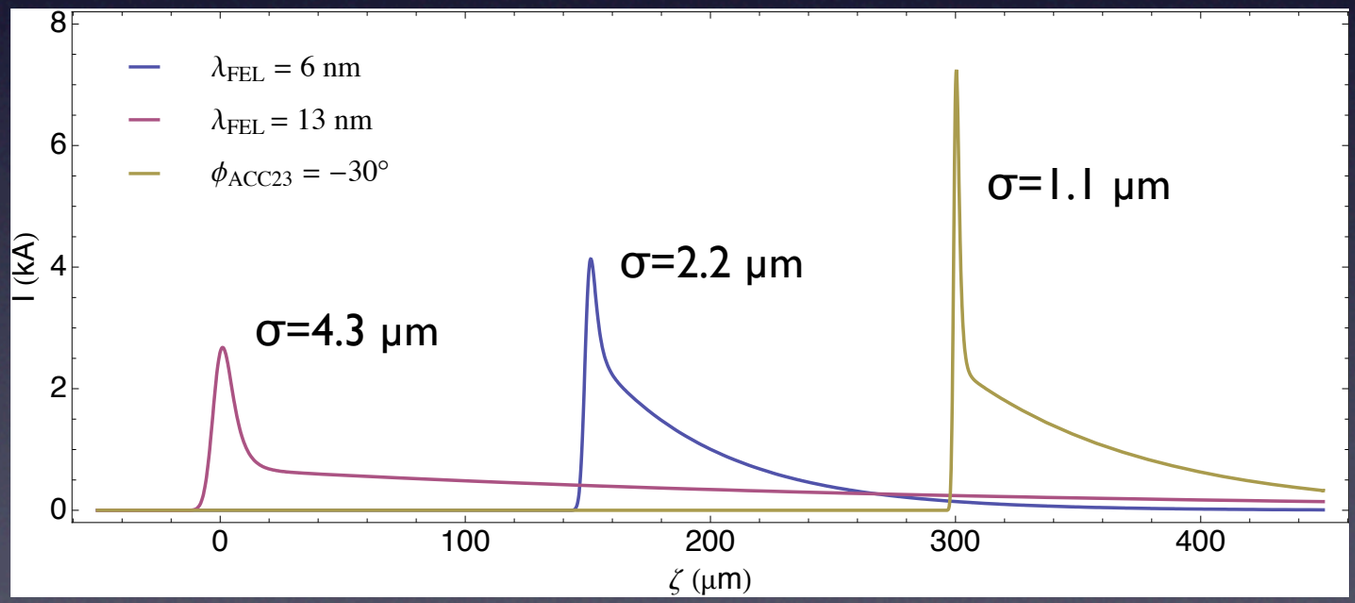



simple parametrisation
leading spike + tail

for μ-bunch rad. : model
= „amplified noise“

few percent of charge is
„modulated“

n*100 gain required to
produce this level from
shot noise



# conclusions

✳CTR spectroscopy in the regime (1 μm) - 60 μm has shown, that bunches at FLASH have μ structures at the few percent level with a predominant length scale around 8 μm

✳the  coherent radiation reaches about $10^4$-$10^5$ time incoherent level and exhibits large shot to shot fluctuations with narrow „spectral lines“

✳the presence of both magnetic chicanes is mandatory

✳the phenomenon is basically compression independent and exists even for on-crest operation of both compressors

✳the shape of the radiation spectrum is insensitive to $R_{56}$ of both chicanes

✳collimator scraping indicates that the modulation is extended over te entire bunch tail

# more on FLASH

there is more :

COTR indications, structured OTR images ...
dedicated machine settings and simulations..
plans, next steps and outlook..

see talks by Thorsten and Bolko

the results presented here were measured and analyzed by
Stephan Wesch with the assistance of
Christopher Behrens and based on the spectrometer developed by
Hossein Delsim- Hashemi and myself.