Summary Working Group II

T. Limberg

Working Group II Agenda

- ***09:00-10:45 LC:***
- 09:00-09:15 Report on Crossing Angle pre-meeting — P. Bambade (15')
- 09:15-09:30 Beam Diagnostics from Beamstrahlung — A. Stahl (15')
- 09:30-09:45 Report on Optics pre-meeting — D. Angal-Kalinin (15')
- 09:45-10:05 Spent Beam + Beamstrahlung studies — E. Merker (20')
- 10:05-10:25 Report on RunII of FONT — P. Burrows (20')
- 10:25-10:45 Report on PETRA Laserwire — T. Kamps (20')
-
- 10:45-11:00 Coffee
-
- ***11:00-13:00 XFEL***
- 11:00-11:20 Bunch compression at the XFEL — T. Limberg (20')
- 11:20-11:40 3D CSR calculations for XFEL Bunch Compression — M. Dohlus (20')
- 11:40-12:00 "On Bunch Compressor Optimization against
- Microbunching Instability and CSR" — Y. Kim (20')
- 12:00-12:15 S2E Simulations on Jitter Tolerance at TESLA XFEL — Y. Kim (15')
- 12:15-12:35 Velocity bunching calculations — J.P. Carneiro (20')
- 12:35-12:55 XFEL optics considerations — W. Decking (20')

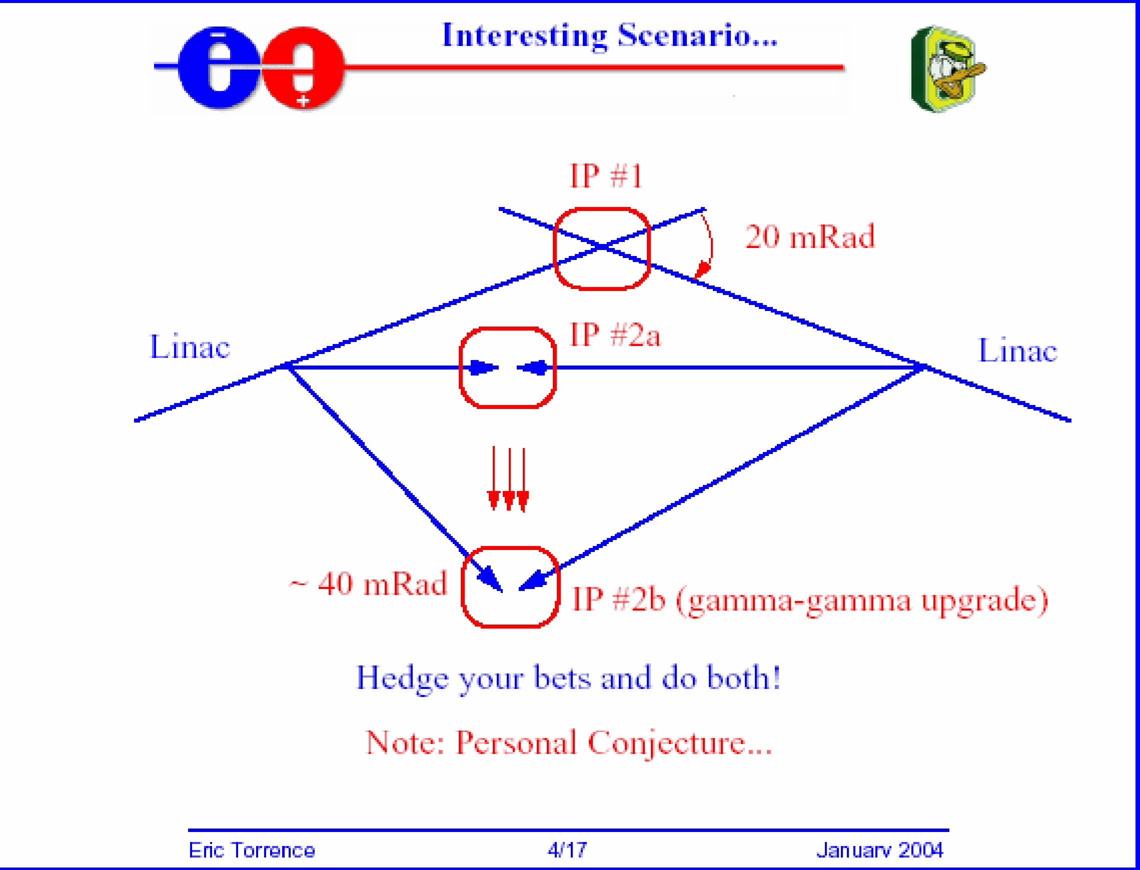
Crossing-angle-or-not physics implications

report from 19-01-04 phone-meeting

cold	crossing-angle	head-on
warm	crossing-angle	-
technical issues	more IP tuning crab-cavity req. SC mini-quad. backgrounds	optics design constraints beam(strahlung) extraction electrostatic separators collimation
	→ get worse at 1 TeV	
physics issues evaluated	hermetic γγ veto transverse boost $\vec{B}$ and $\vec{P}$ not $\parallel$	post-IP diagnostics for energy and polarisation

no killer arguments either way - quantify physics impact consensually

Bottom-line on crossing-angle-or-not physics implications (preliminary)



Head-on is quantifiably better for some topics while crossing-angle is preferable for some others

Both are acceptable for physics

$\Rightarrow$ With TESLA one can in principle choose one or the other

? Proposed intermediate solution : 0.3 mrad x-angle

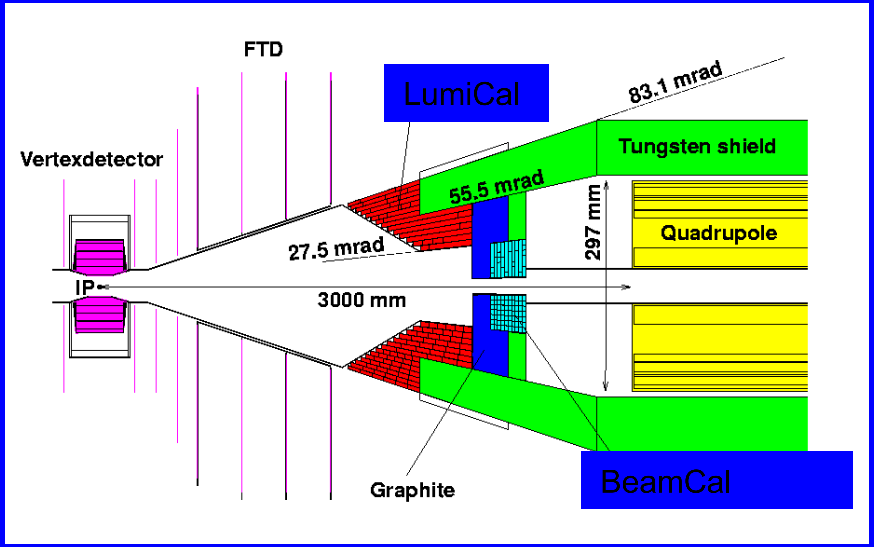
Comparison and optimisation of cold/warm very forward veto capability and more comprehensive background studies seem more important

Will report in Paris

Beam Monitoring from Beam Strahlung

work mainly by summer students

- Gunnar Klämke (U Jena, 01)
- Marko Ternick (TU Cottbus, 02)
- Magdalena Luz (HU Berlin, 03)
- Regina Kwee (HU Berlin, 03)



1st Results:

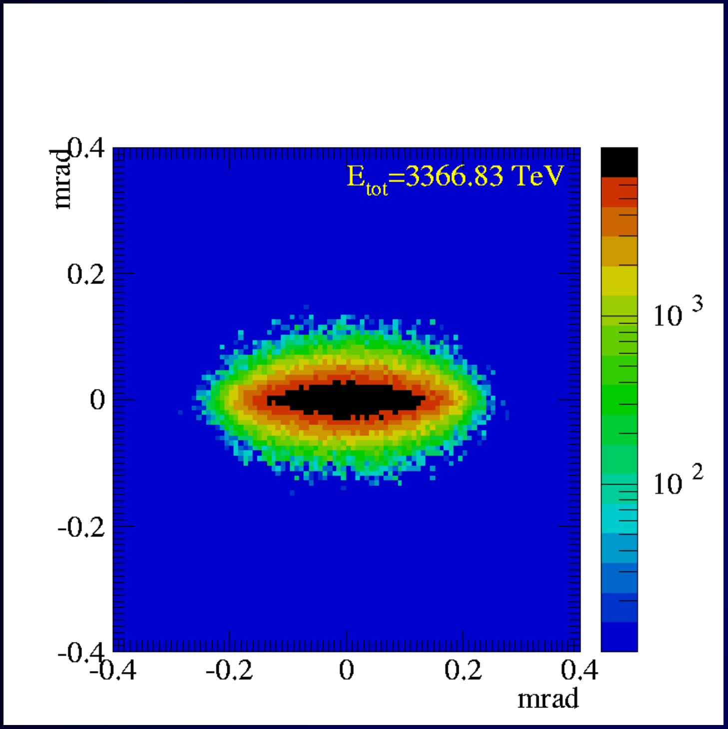
Single Parameter Analysis

		nominal	our precision	Beam Diag.
Bunch width x	Ave.	553 nm	2.1 nm	~ 10 %
	Diff.		3.8 nm	~ 10 %
Bunch width y	Ave.	5.0 nm	0.2 nm	Shintake
	Diff.		0.6 nm	Monitor
Bunch length z	Ave.	300 μm	7.9 μm	~ 10 %
	Diff.		3.7 μm	~ 10 %
Emittance in x	Ave.	10.0 mm mrad	None	?
	Diff.		1.2 mm mrad	?
Emittance in y	Ave.	0.03 mm mrad	0.002 mm mrad	?
	Diff.		0.004 mm mrad	?
Beam offset in x		0	50 nm	5 nm
Beam offset in y		0	1 nm	0.1 nm
Horizontal waist shift		0 μm	None	None
Vertical waist shift		360 μm	40 μm	None

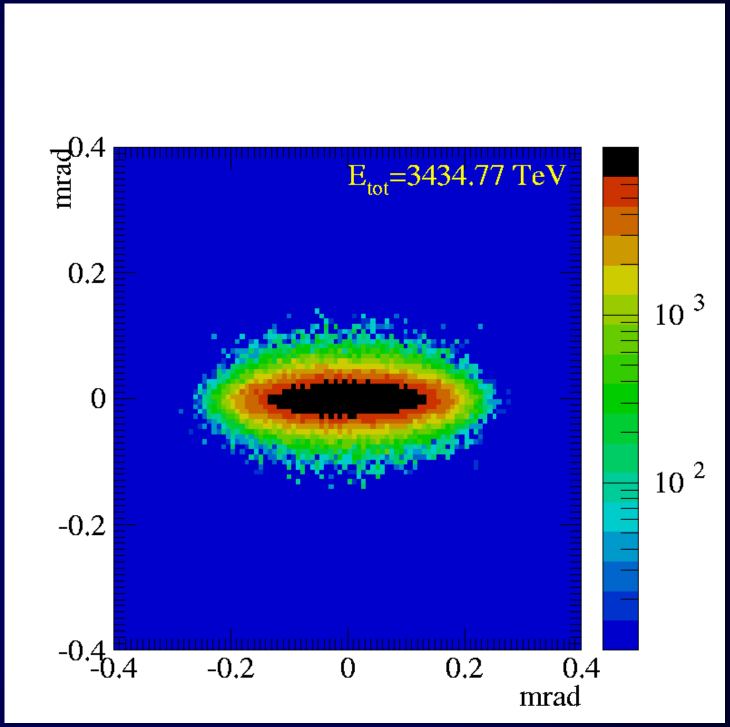
1^{st} Results:
Multi Parameter Analysis

σ_x	$\Delta\sigma_x$	σ_y	$\Delta\sigma_y$	σ_z	$\Delta\sigma_z$
0.4 %	0.7 %	4.9 %	11 %	2.7 %	1.2 %
0.4 %	0.7 %	4.8 %	11 %	2.8 %	1.3 %
2.1 %	5.7 %	9.4 %	8.4 %		
		3.6 %	12 %	3.9 %	0.9 %
38 %	82 %	360 %	2000 %	42 %	370 %

First Look at Photons



nominal setting
(550 nm x 5 nm)



$\sigma_x = 650$ nm
$\sigma_y = 3$ nm

Next Steps:

- Test on realistic beam simulation
- Include photons from beamstrahlung
- Input on the detector design
- Think about hardware implementation

Thanks

Optics and Collimation Mini-Review Meeting Summary

Deepa Angal-Kalinin

22nd January, 2004

Optics and Collimation Mini-Review Meeting

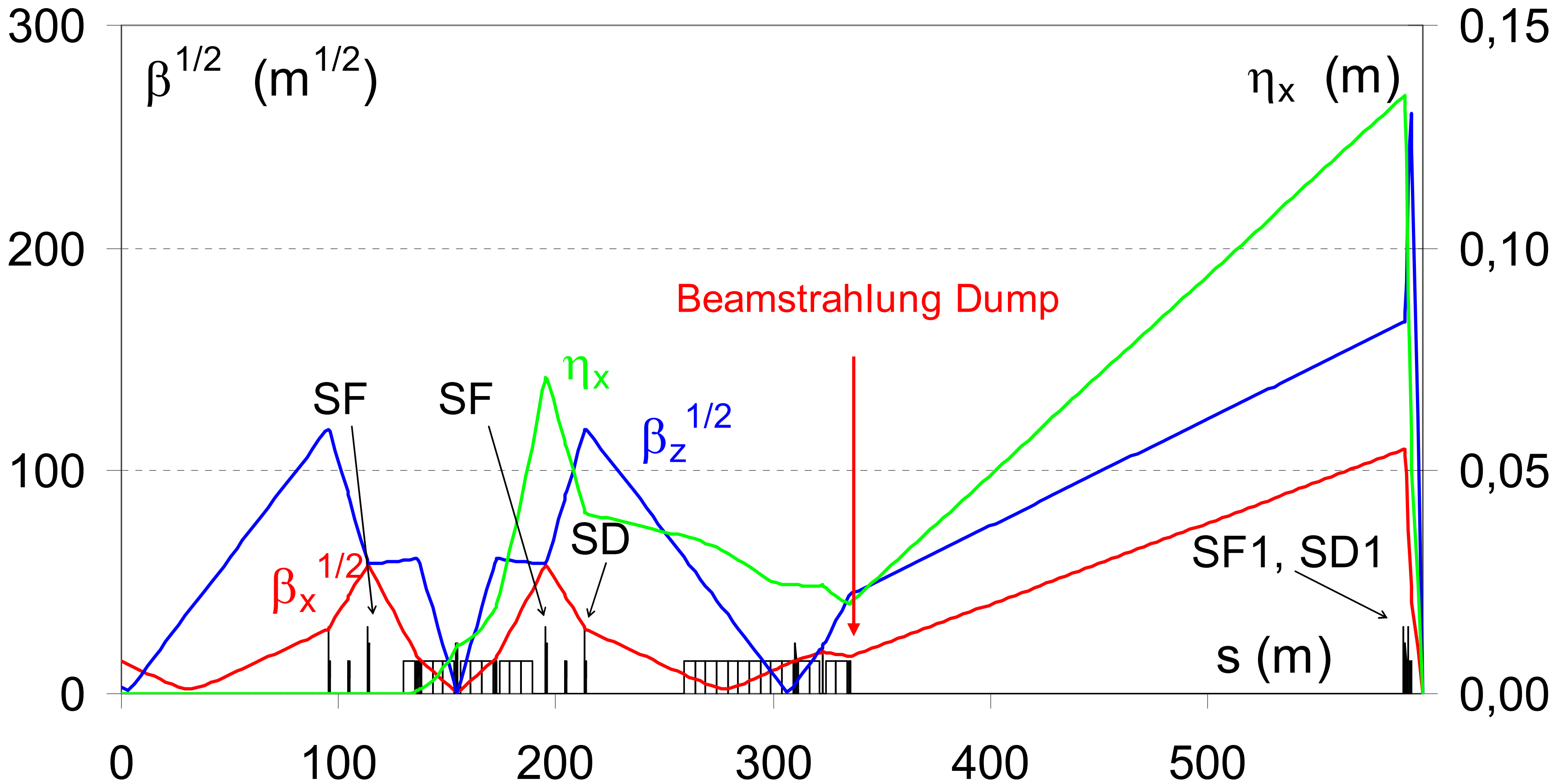
20^{th} January, Zeuthen

Agenda

Introduction	Nick Walker
The current design	Olivier Napoly
TESLA TDR Collimation System	Nick Walker
Collimation requirements with & w/o crossing angle	Philip Bambade
Final Focus Design for crossing angle layout	Deepa Angal-Kalinin
Collimator wake field issues	Nigel Watson
Beamstrahlung on the septum blade	Karsten Buesser
Status of detector background simulations & comparison of Beamstrahlung pairs calculations	Karsten Buesser
IR layout	Achim Stahl
Report from crossing angle meeting	Philip Bambade

Participants : 18

NLC-like Optics



@ IP η'_x = 10 mrad

O.Napoly,20/01/04

Discussion and Plan

- Try to find optics solution with (new) 0.3mrad vertical angle → check that incoming and outgoing beams satisfy the required conditions.

- Possible solutions for the electrostatic separators?

- Redesign the entire line → with good collimation + separate diagnostics section + machine protection & ensure that extraction can be safely done.

Feedback on Nanosecond Timescales (FONT): FONT2 December 2003 run results

Philip Burrows
Queen Mary, University of London

People

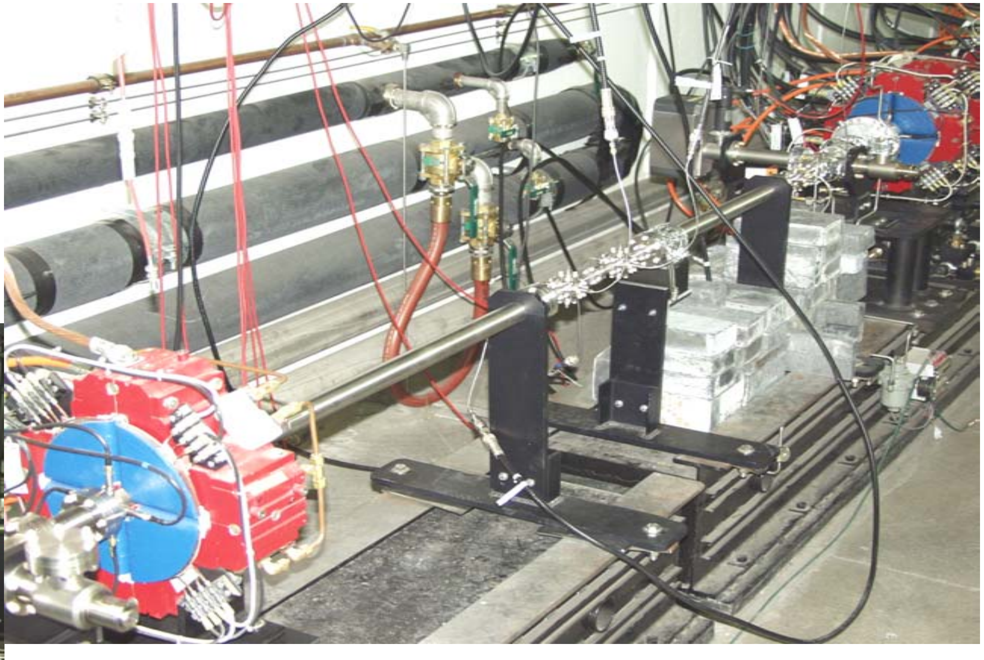
FONT1 (2002)

FONT2 (2003/4)

Future FONT plans

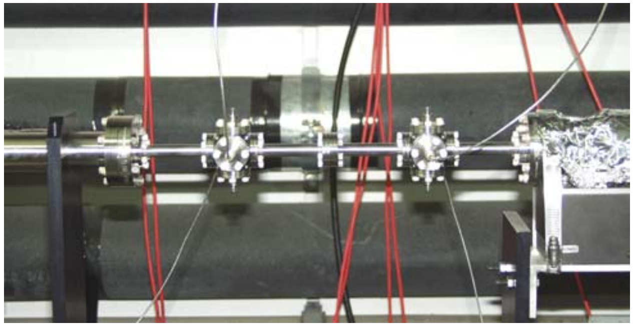
FONT2 at NLCTA: new beamline configuration

Dipole and kickers

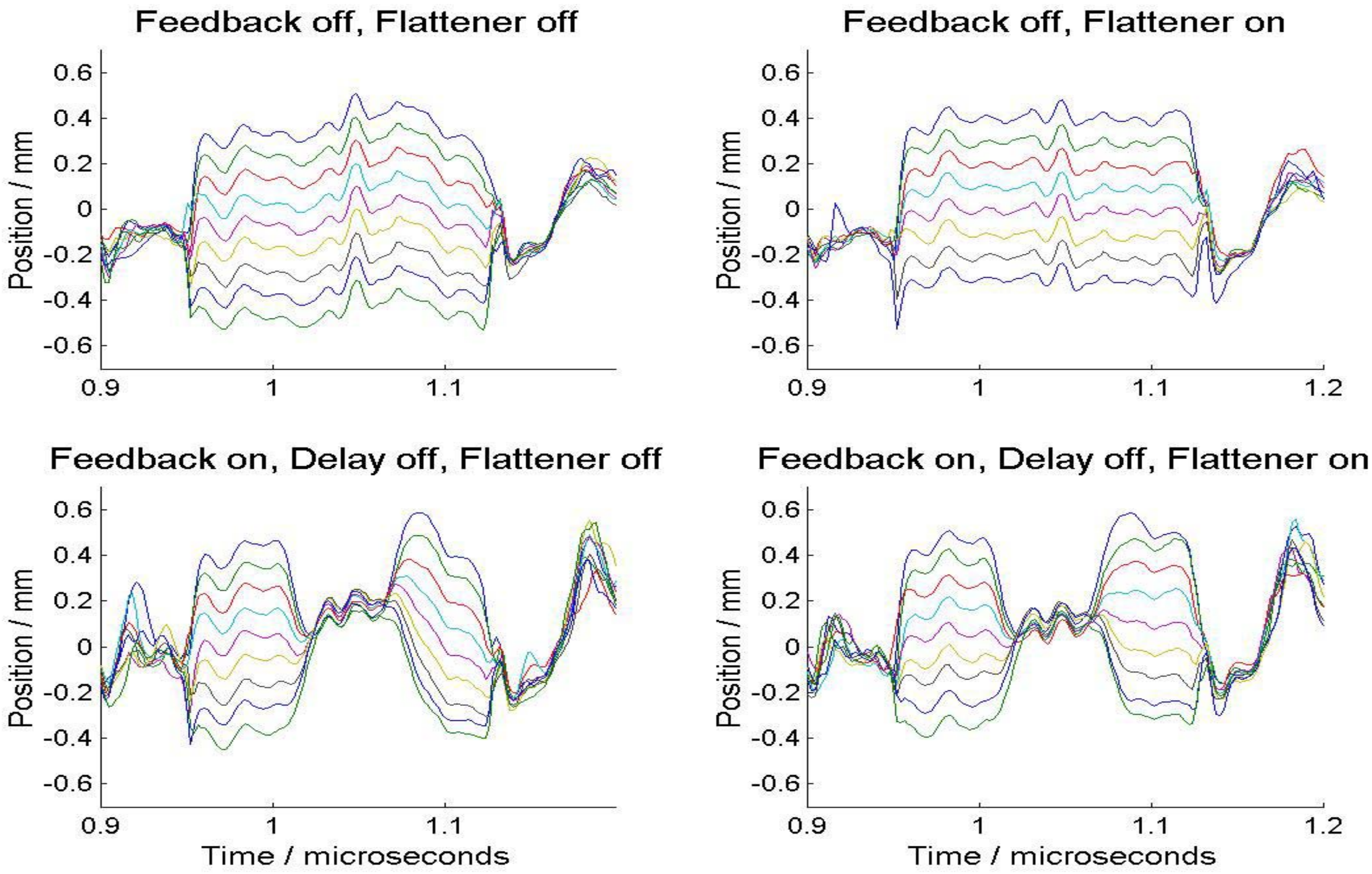


New

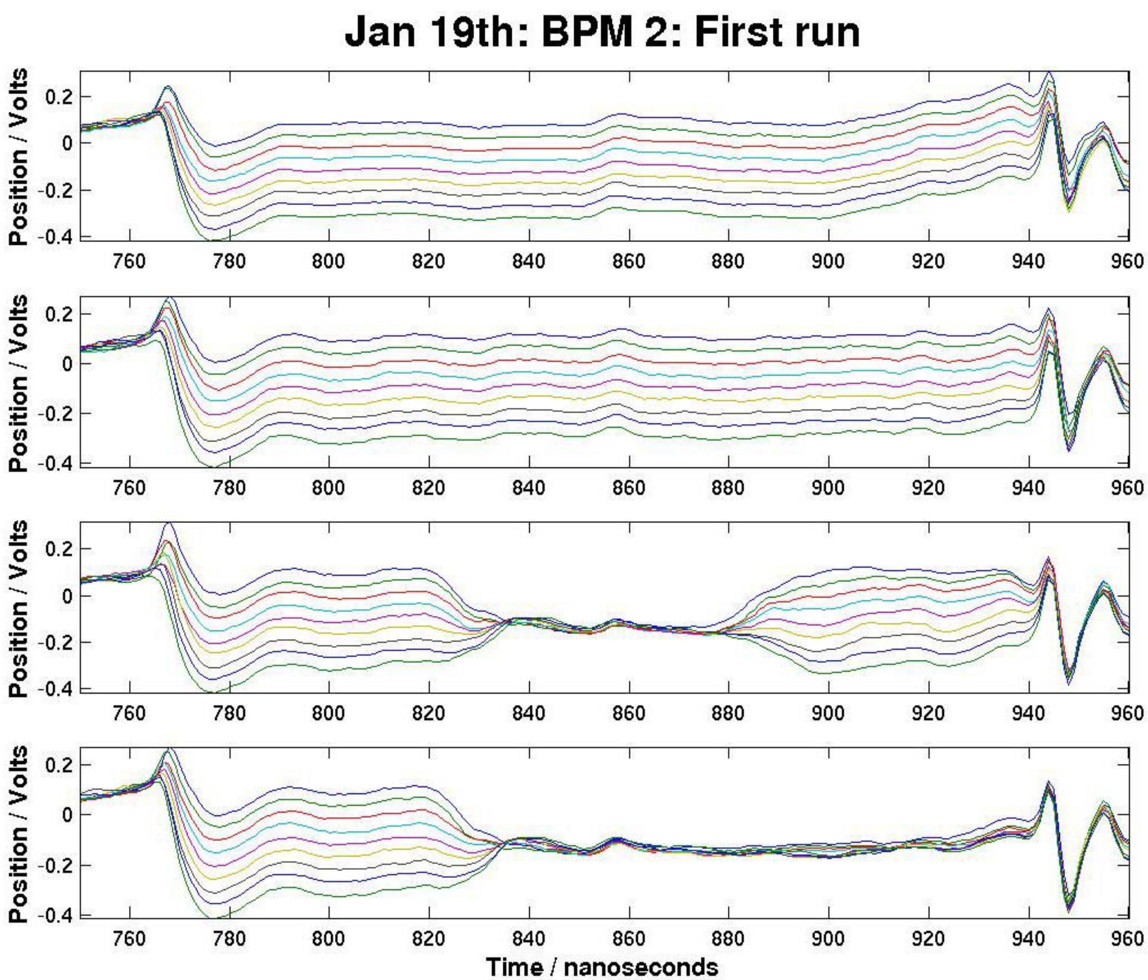
BPMs



FONT2 initial results: beam flattener



FONT2 initial results: feedback mode



Beam starting positions

Beam flattener on

Feed forward on

Feedback on

Comparison of ATF with NLCTA

	NLCTA	ATF
Train length	170 ns	300 ns
Bunch spacing	0.08 ns	2.8 ns
Beam size (y)	500 mu	5 mu
Jitter (y)	100 mu	1 mu
Beam energy	65 MeV	1.3 GeV

ATF has ‘right’ bunch spacing and train length, and the beam is smaller and more stable than at NLCTA

-> much better place for fast feedback prototypes

Ideas for further development work

e+e- background studies in SLAC A-line

World's smallest emittance e- beam is at KEK/ATF

Scaling:

1 micron at ATF (1 GeV) ~ 1 nm at LC (1000 GeV)

Beam-based feedback at ATF could be scale model for LC

Possible future developments for FONT at ATF

3 suggestions:

1. Stabilisation of extracted bunchtrain at 1 micron level:
   - low-power (< 100W), high stability amplifier
   - stripline BPM w. ~ 1 micron resolution

   these are exactly what are needed for the LC!

2. Stabilisation of extracted bunchtrain at 100 nm level:
   - requires special BPM and signal processing

   useful for nanoBPM project

3. Test of intra-train beam-beam scanning system:
   - high-stability ramped kicker drive amplifier

   very useful for LC

PETRA Laserwire Experiment
Status and Outlook

T Kamps, BESSY FEL

TESLA Meeting, APDG Working Group

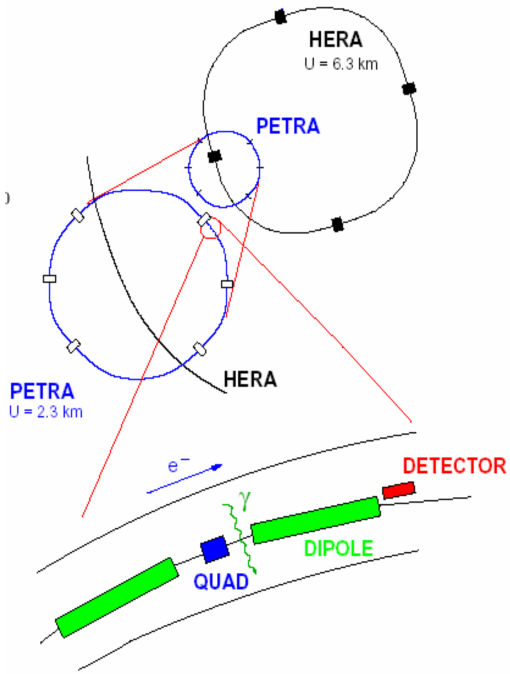
16 January 2004

DESY Zeuthen

Laserwire at PETRA

LBBD Laserwire

- Positron Electron Tandem Ring Accelerator
- Injector for HERA, upgrade to synchrotron light source
- Long free straight section in north-east sector
- Easy installation of hardware due to existing access pipe and hut outside tunnel area
- New IP chamber with viewports and BPM
- Dedicated run time between HERA fills
- Parasitic running during HASYLAB operation
- Training of people to run the machine, bumps

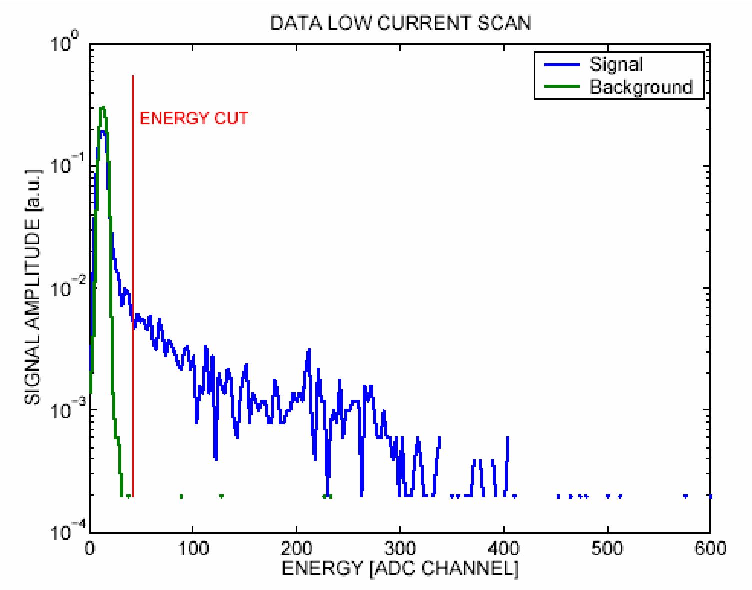


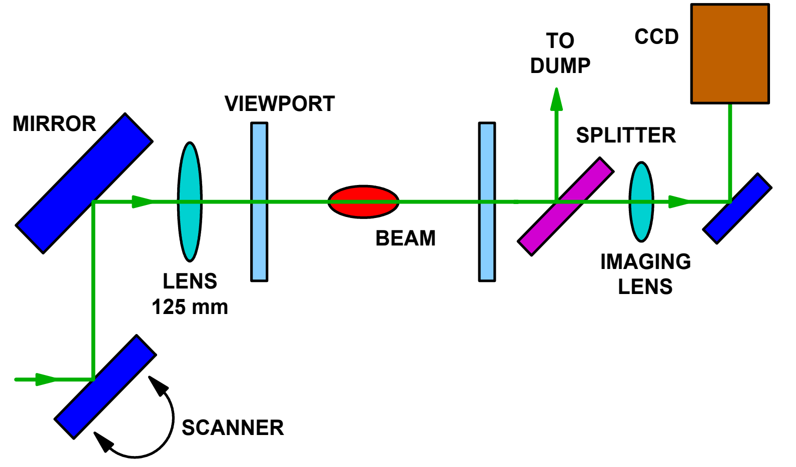
Energy	E/GeV	4.5 to 12
Bunch Length	σ_z/ps	~100
Charge/bunch	nC	3 to 20
Hor. beam size	σ_x/μm	1000 to 100
Ver. beam size	σ_y/μm	100 to 10

Fast Scanner Operation (Dec run)

LBBD Laserwire

- First scan with signal on scope
- Then sampling of peak using ADC
- Changing piezo voltage from 0 to 9.5 V in 0.5 V steps (amp times 10)
  - ± 2.5 mrad scan range
- 5000 events at each position
- In total 20 position points
- Complete scan done in 40 min
- Background scan with 20k events
  - Mainly synchrotron radiation and bremsstrahlung
- Signal rate expected at peak
  - 100 gammas x 380 MeV avg energy
- Strong fluctuations because of laser mode beating
- Oscillating pedestal in ADC data

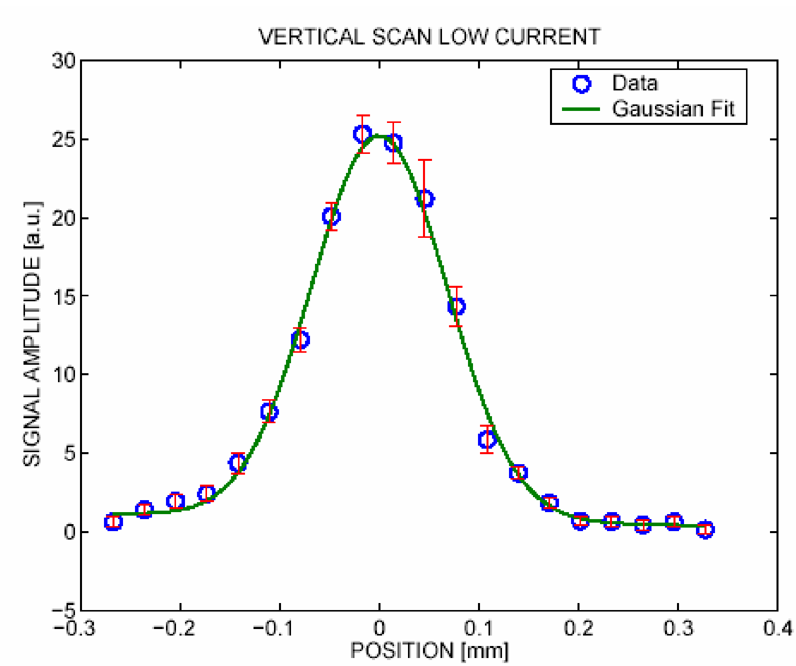


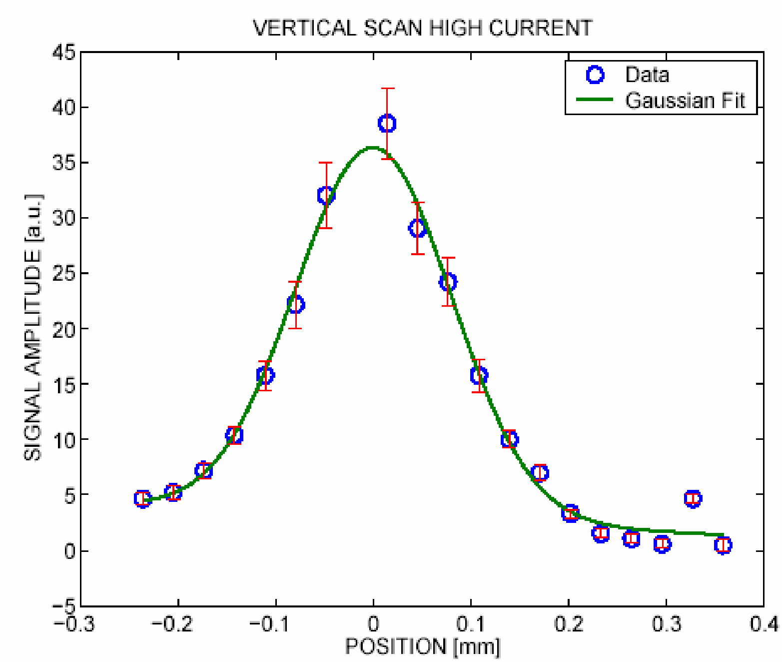


Results from Scanner Operation

LBBD Laserwire

- Slopy Background Gaussian approximation of beam shape
  - $\sigma_m = (68 \pm 3 \pm 14)$ μm at low current
  - $\sigma_m = (80 \pm 6 \pm 16)$ μm at high current





Conclusions and Outlook

LBBD Laserwire

- Laserwire at PETRA setup and in operation
- Measured vertical beam size
  - using orbit bumps
  - with fast piezo scanner
- Results agree with std error with expectation from PETRA operation

Next steps

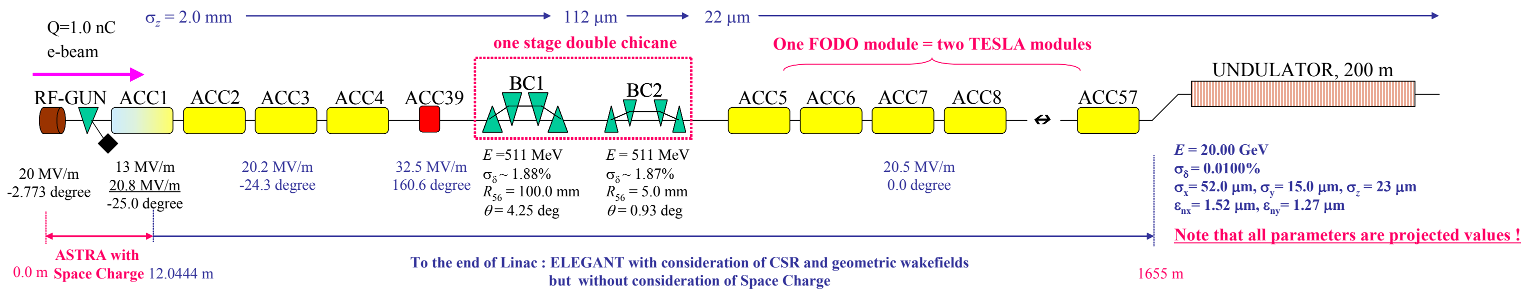
- Understand low Compton rate
  - Laser characterisation (profile and power)
  - Study Compton path from IP to detector
  - Detector calibration
- Improve Compton rate
  - Background suppression with shielding
  - Improve trans. and long. laser profile
- Machine studies
  - Profile measurements at different energies and optics setups
- Second dimension
- Next run Feb04, analysis meeting end of Jan04

Bunch Compression at the TESLA XFEL

T. Limberg

Zeuthen, 22.1.2004

New Lattice



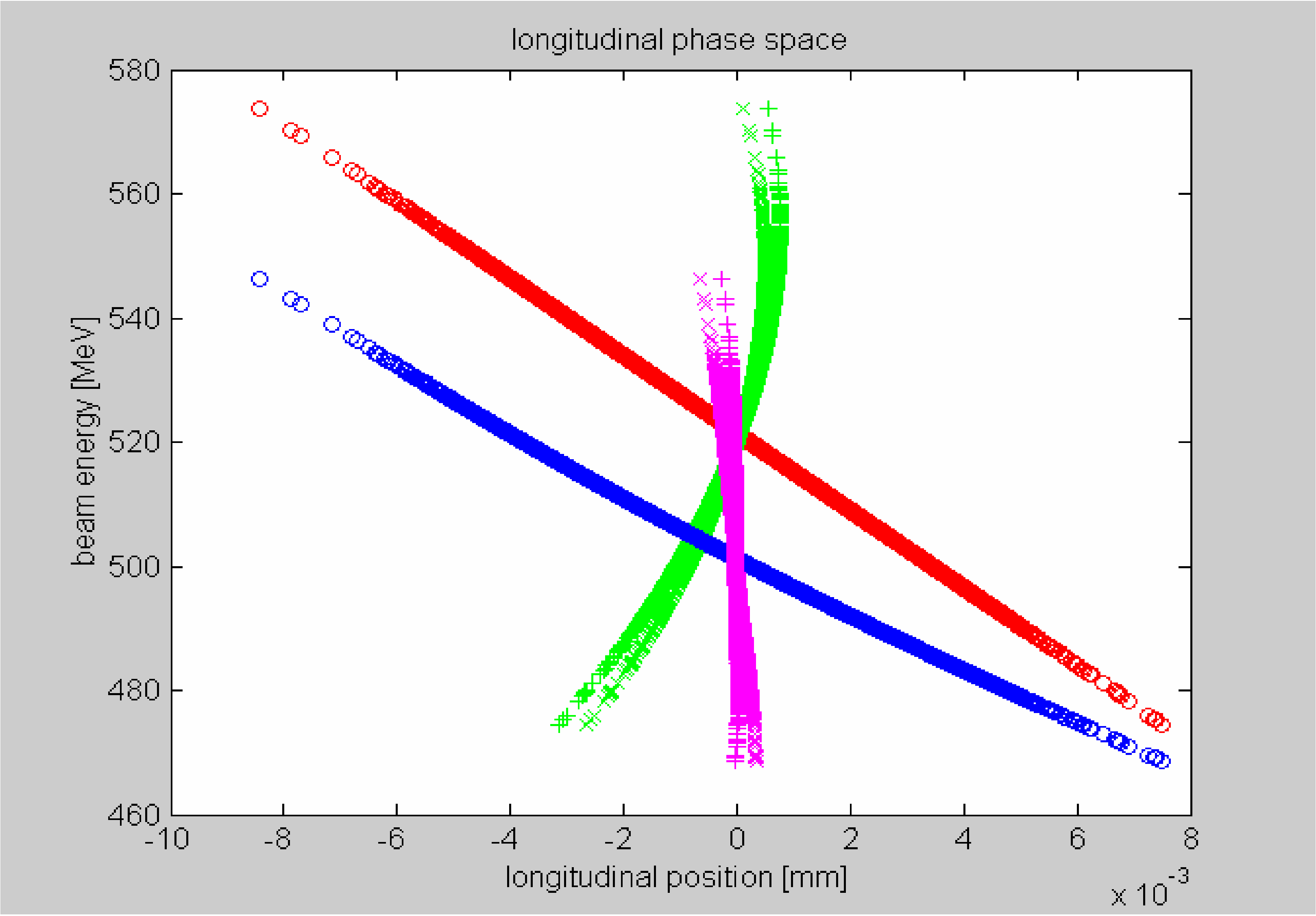
Elegant calculations: Yujong Kim

CSRtrack calculations: Martin Dohlus

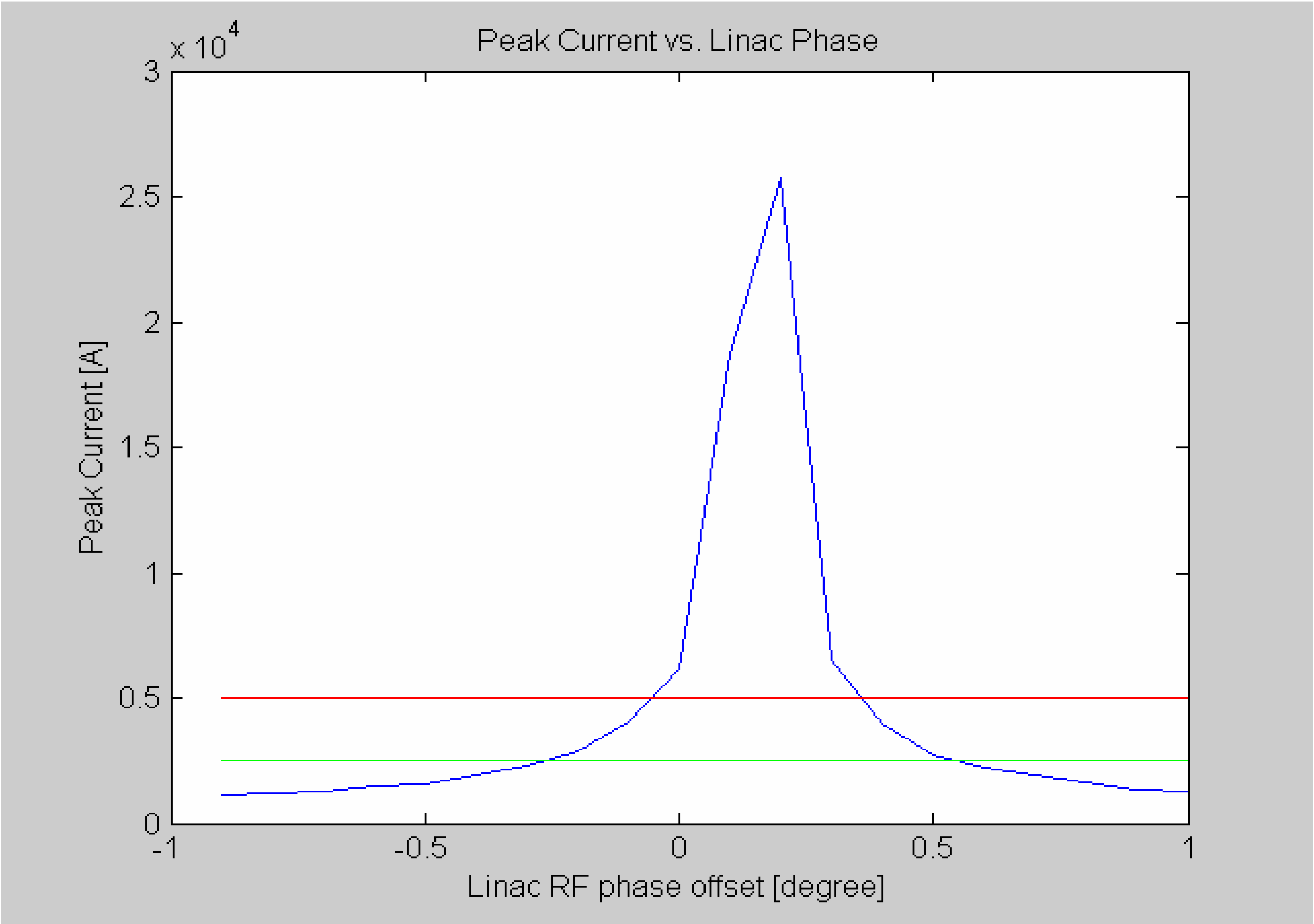
Longitudinal Phase Space

red and green: before and after compression using the 3rd harmonic RF to linearize upstream of the compressor

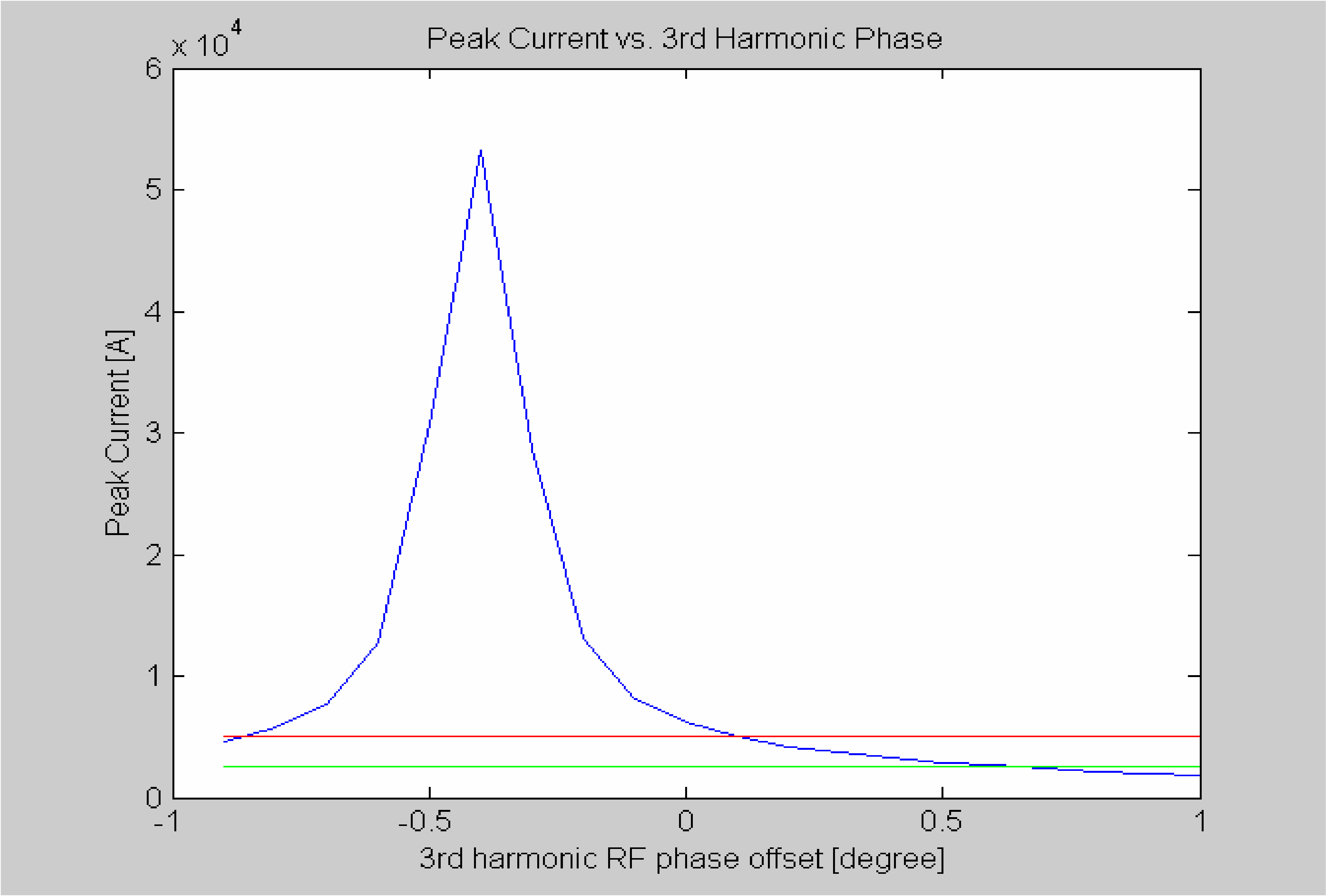
blue and magenta: using the 3rd harmonic RF to compensate R566 of chicanes



Varying the Linac RF Phase



Varying the 3rd Harmonic RF Phase



Then form 'jitter budget' based on uncorrelated jitter: $\sqrt{\sum_{i=1}^{n}\left(\frac{p_{\rm tol}}{p_{\rm sen}}\right)_i^2} < 1$

Table 2. A possible longitudinal jitter tolerance budget for LCLS and TESLA-XFEL.

$|\langle\Delta E/E_0\rangle| < 0.1\%$ and $|\Delta I/I_0| < 12\%$

Parameter	Symbol	LCLS	XFEL$_2$	Unit
Gun timing jitter	Δt_0	0.80	1.5	psec
Initial bunch charge	$\Delta Q/Q_0$	2.0	10	%
mean L0 rf phase	φ_0	0.10	0.05	deg
mean L1 rf phase	φ_1	0.10	0.08	deg
mean L*h* rf phase 3.9-GHz & X-band	φ_h	0.50	0.07	*h*-deg
mean L2 rf phase	φ_2	0.07	0.10	deg
mean L3 rf phase	φ_3	0.15	1.0	deg
mean L0 rf voltage	$\Delta V_0/V_0$	0.10	0.08	%
mean L1 rf voltage	$\Delta V_1/V_1$	0.10	0.20	%
mean L*h* rf voltage	$\Delta V_h/V_h$	0.25	0.30	%
mean L2 rf voltage	$\Delta V_2/V_2$	0.10	0.20	%
mean L3 rf voltage	$\Delta V_3/V_3$	0.08	0.09	%

degrees of X-band or 3.9-GHz

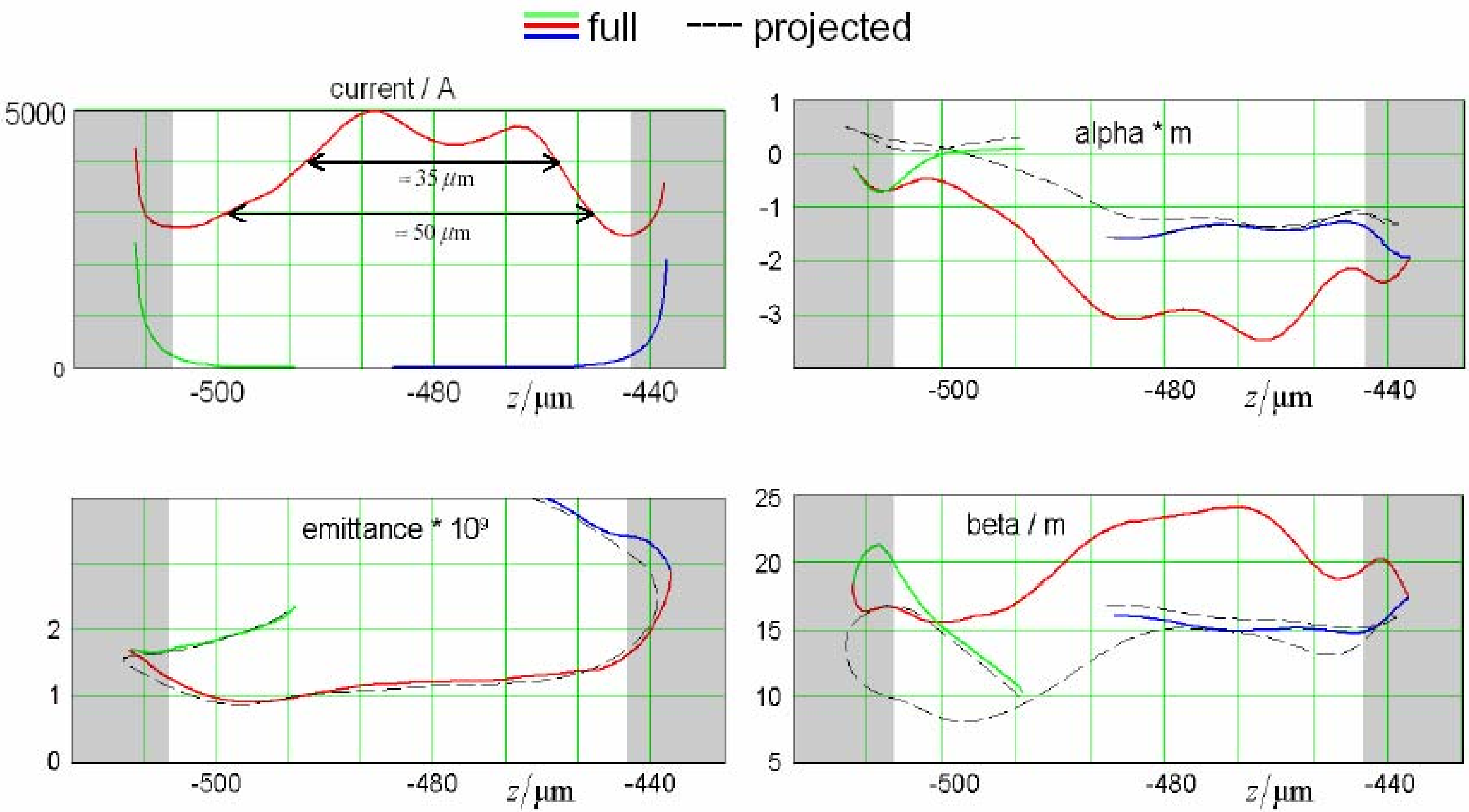
What´s next?

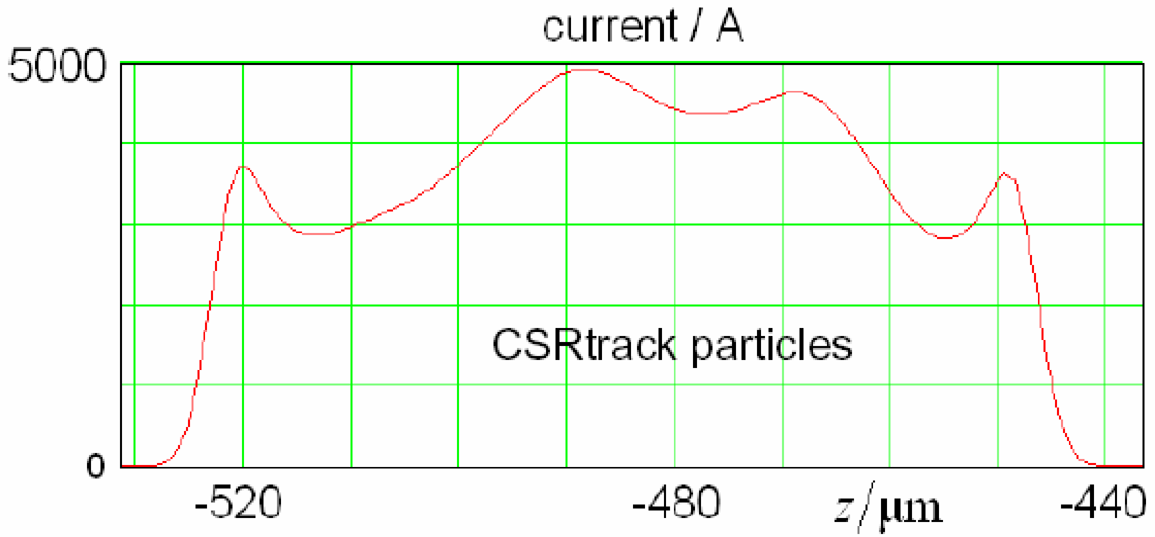
- Comparison Jitter-Sensitivity for different designs
- Do s2e for off-phase (off-amplitude) cases
- Remove last doubts about space-charge instabilities
- Study CSR optics sensitivities
- Detailed design

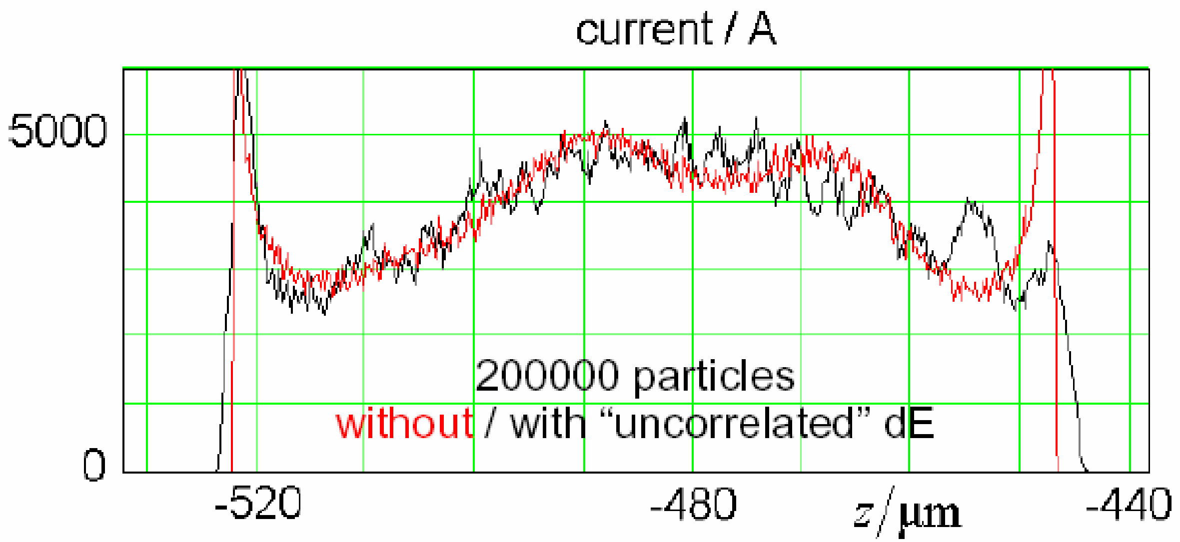
M. Dohlus: 3D CSR calculations for XFEL Bunch Compression

- **double BC**
- **proposed setup**
- **tracking with ASTRA, ELEGANT and CSRtrack**
- **BC1 entrance**
- **conversion (200000 → 8120)**
- **BC1 exit**
- **BC2 entrance**
- **conversion (200000 → 10100)**
- **BC2 exit**
- **conversion (10100 → 200000)**

1.5 m after BC2, analysis of “initial” slices




current / A
5000
0
CSRtrack particles
-520
-480
$z/\mu m$
-440


current / A
5000
0
200000 particles
without / with “uncorrelated” dE
-520
-480
$z/\mu m$
-440

TESLA

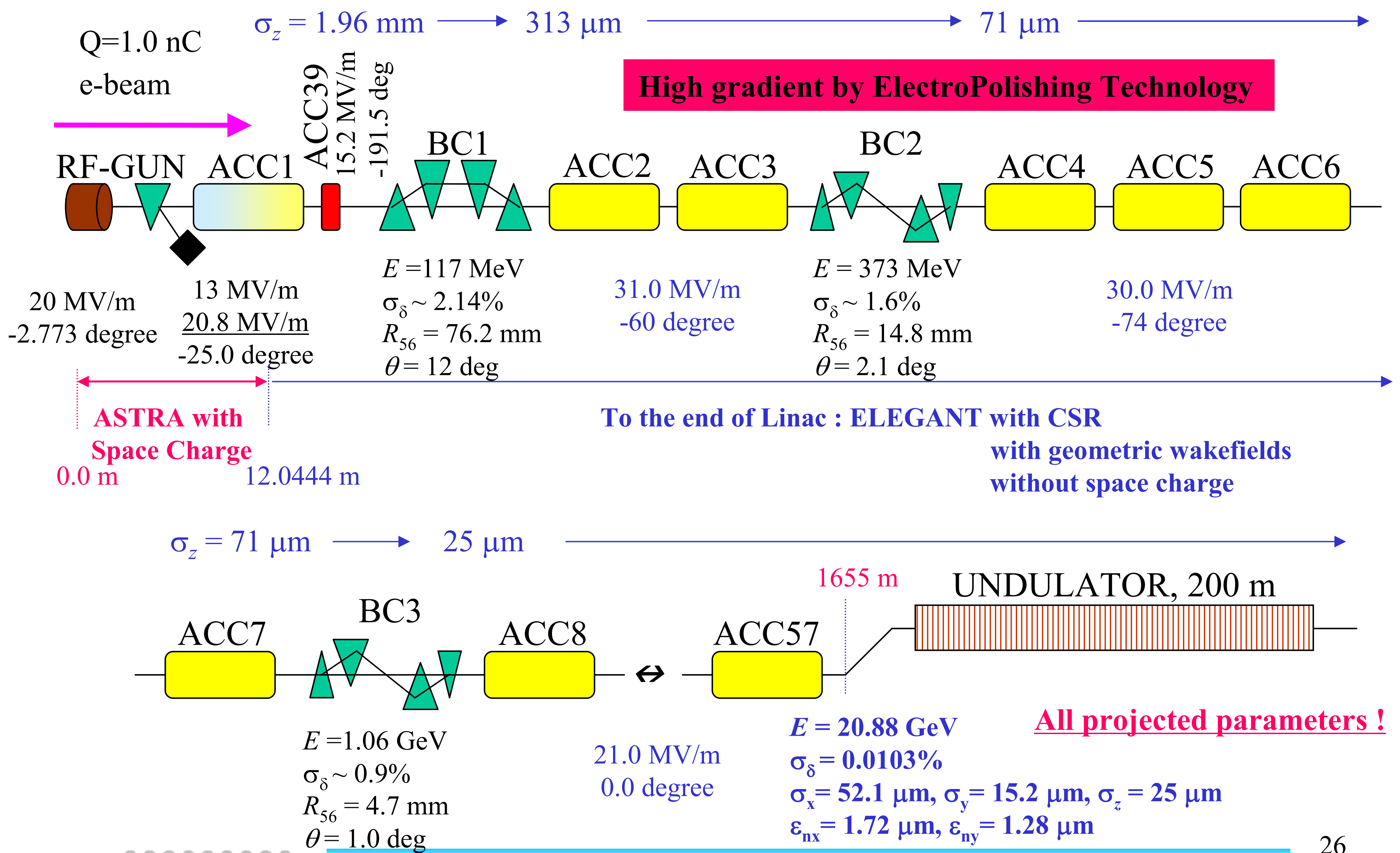
On Bunch Compressor Optimization against Microbunching Instability and CSR

Yujong Kim, K. Flöttmann, and T. Limberg

DESY Hamburg, Germany

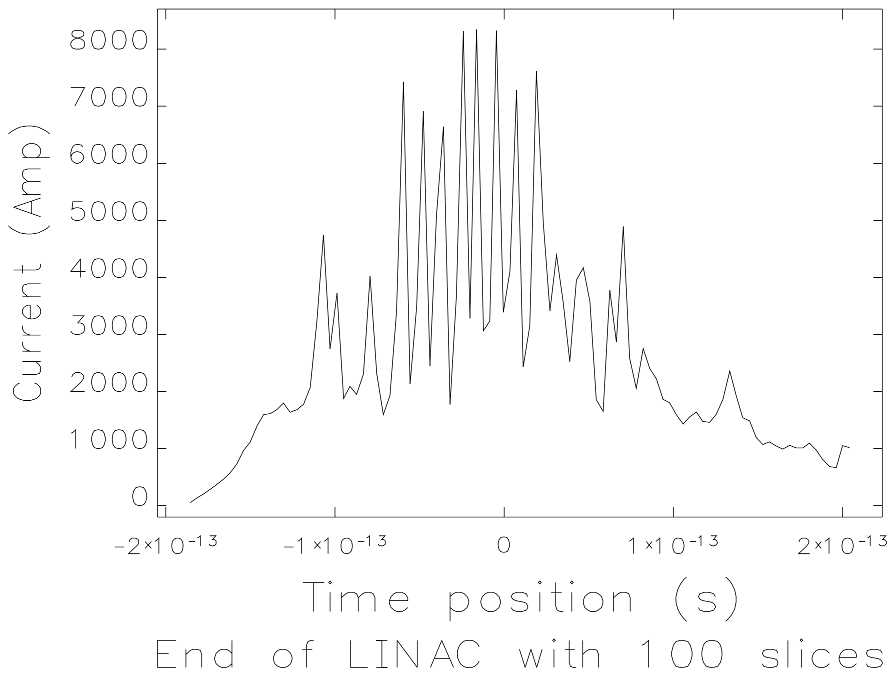
Yujong.Kim@DESY.de, http://www.desy.de/~yjkim

Old Lattice for TESLA XFEL - 2nd Version

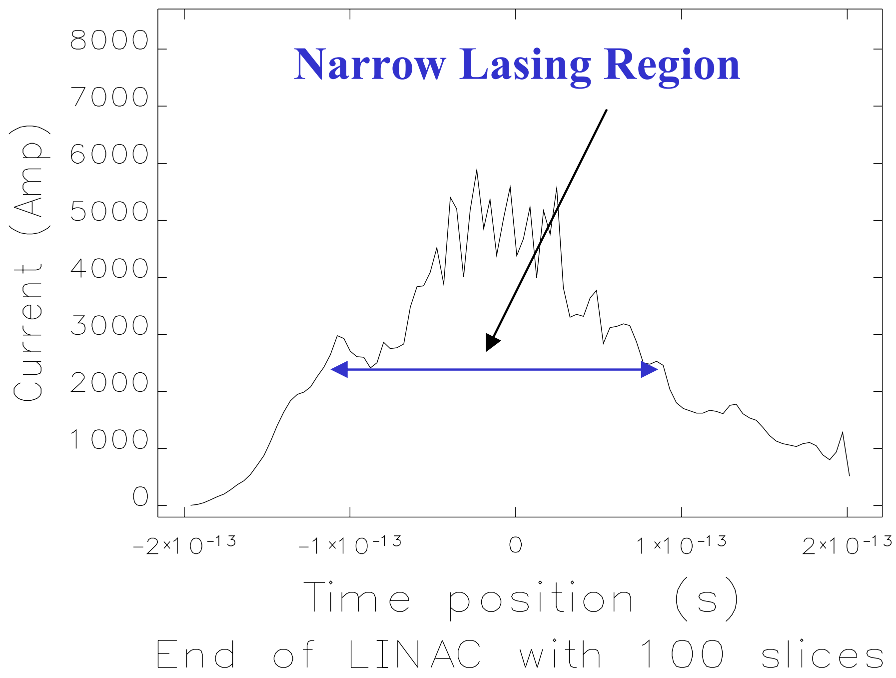


Old Lattice - Slice Parameters

Simulated Particles = 500000



Simulated Particles = 2000000



When the number of particles is 500000, there are many high spikes in the current due to the strong microbunching instability at S-type chicanes. But those spikes are somewhat damped when we use 2000000 particles !

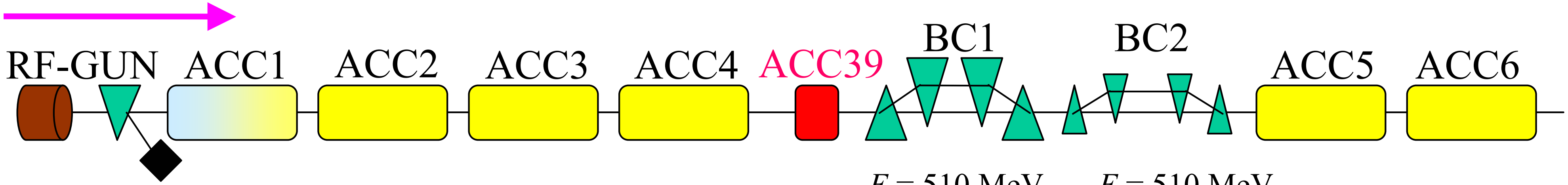
New Lattice for TESLA XFEL – 4th Version

With TESLA XFEL Injector, ε_n= 0.9 μm

Q=1.0 nC

e-beam

σ_z = 1.76 mm → 113 μm → 23 μm →



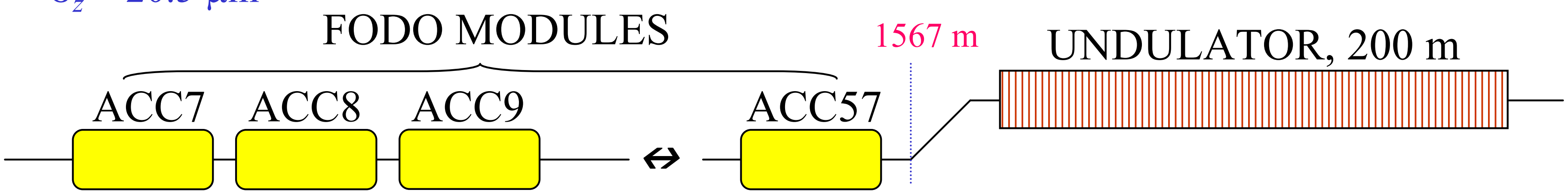
RF-GUN	ACC1	ACC2	ACC39	BC1	BC2	ACC5, ACC6
30 MV/m -0.724 deg	11.5 MV/m 25.0 MV/m -18.3 deg	20.5 MV/m -29.6 deg	34.8 MV/m 160.6 deg	E = 510 MeV $\sigma_\delta \sim$ 1.89% R_{56} = 87 mm θ= 3.95 deg	E = 510 MeV $\sigma_\delta \sim$ 1.88% R_{56} = 4.8 mm θ= 0.93 deg	20.65 MV/m 0.0 deg

ASTRA with Space Charge

0.0 m – 12.0444 m

To the end of Linac : ELEGANT with CSR
with geometric wakefields
without space charge

σ_z = 20.5 μm →



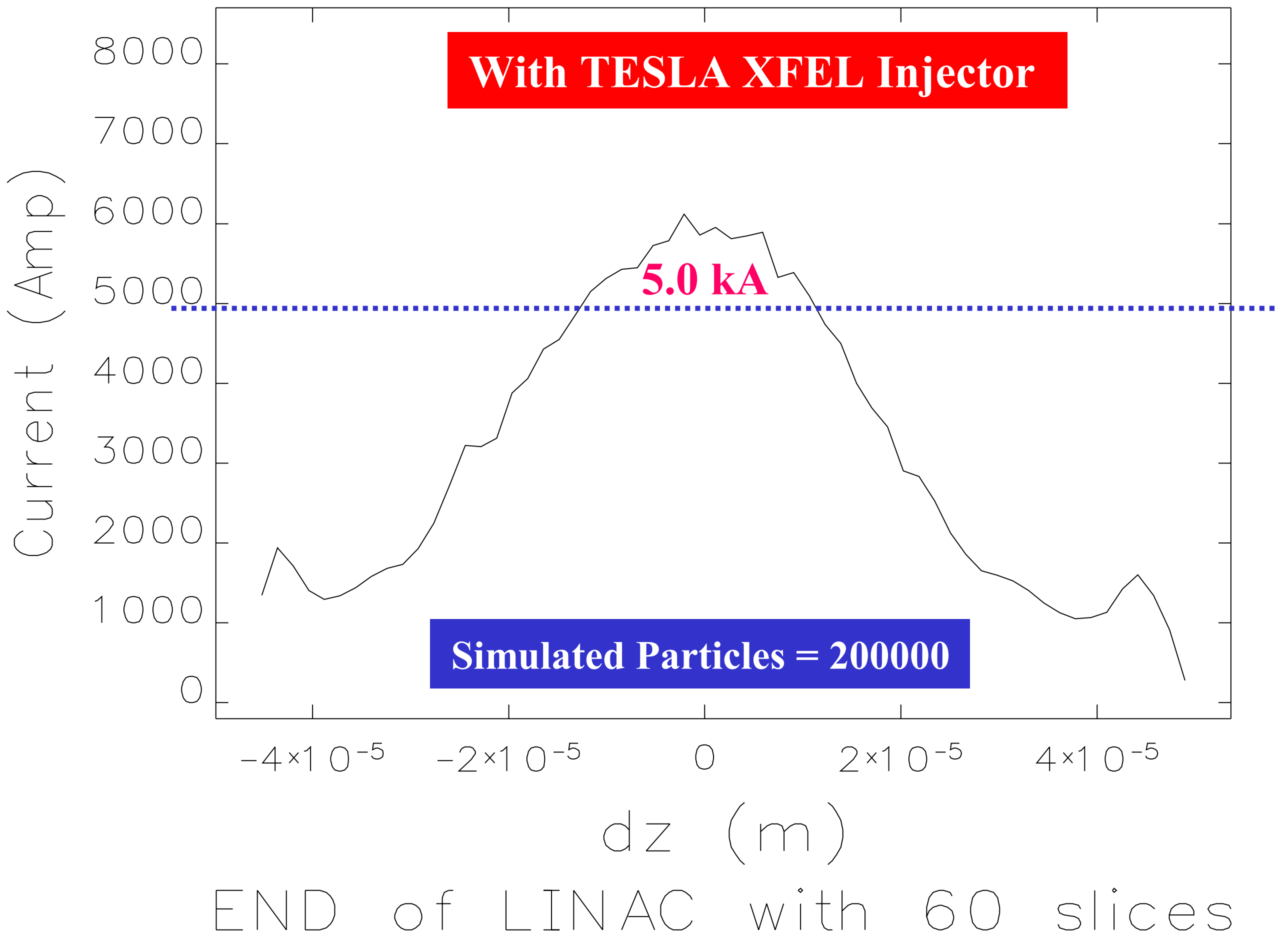
20.65 MV/m
0.0 deg

All projected parameters !

E = 20.0 GeV
σ_δ = 0.008%
σ_x= 37.3 μm, σ_y= 31.6 μm, σ_z = 20.5 μm
ε_{nx}= 1.5 μm, ε_{ny}= 0.94 μm

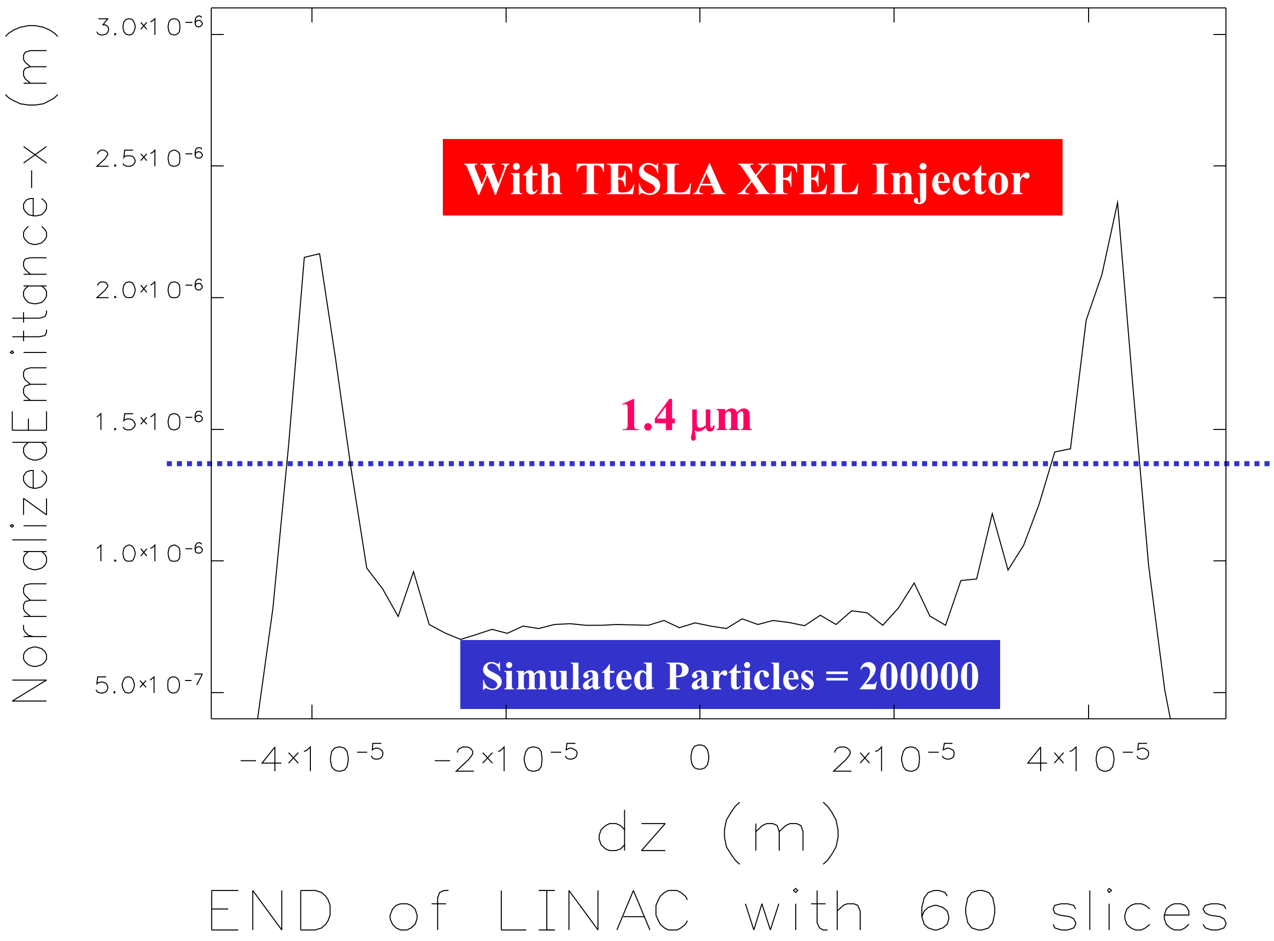
4^{th} Lattice with TESLA XFEL Injector Layout

With TESLA XFEL Injector, ε_n= 0.9 μm



4th Lattice with TESLA XFEL Injector Layout

With TESLA XFEL Injector, $\varepsilon_n = 0.9\ \mu m$



Summary

We have optimized a new lattice for TESLA XFEL and PAL XFEL projects to reduce the slice parameter growths due to the microbunching instability.

By removing two S-type chicanes and by using only one BC stage with double chicanes, the total number of dipoles in BCs is reduced from 16 to 8, which certainly helped in reducing the microbunching instability at TESLA XFEL.

Although we did not use any laser beam heater in the low energy region or any superconducting wiggler before BC2, we have achieved promising beam parameters for TESLA XFEL and PAL XFEL projects only by optimizing BC layout.

We do not worry about too much on the emittance growth in BCs any more if we optimize BC well with a large energy spread and a long space for BCs.

TESLA

S2E Simulations on Jitter Tolerance at the TESLA XFEL Project

Yujong Kim and T. Limberg

DESY Hamburg, Germany

Dongchul Son

The Center for High Energy Physics, Korea

Yujong.Kim@DESY.de, http://www.desy.de/~yjkim

Jitter Investigation Method with S2E simulation

By the help of S2E simulations, let's apply artificial jitter or error to all important components (GUN, ACC1 ~ ACC57, ACC39, BC1 and BC2) in order to investigate the sensitivity $p_{\text{sensitivity}}$ of those components on the longitudinal phase space at the end of linac (bunch length and dE/E).

After considering FEL performace, let's choose the tightest $p_{\text{sensitivity}}$ by limiting

> **change in bunch length within +10% (~ 2 μm) at the end of linac**
> **change in dE/E within +0.1% at the end of linac**

Then choose the tolerance p_{tolence} which gives $\sqrt{\sum_{i=1}^{n}\left(\frac{p_{tolence}}{p_{sensitivity}}\right)^2} < 1$

Let's check FEL performance under above tolerances with S2E simulations.

S2E simulation Results – Tolerance

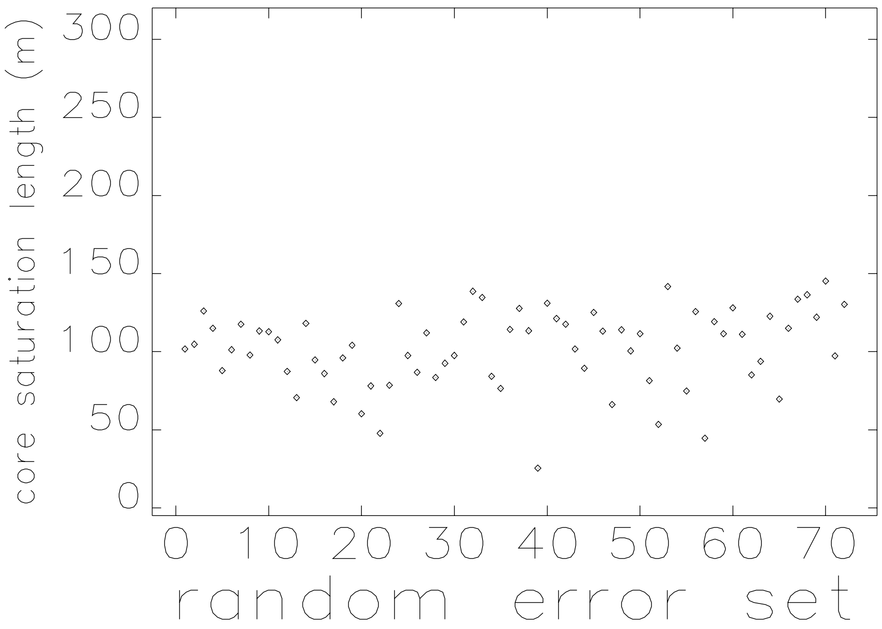
ACC234 phase (0.02 degree) and ACC39 phase (-0.04 degree) are lower than our control range !!!

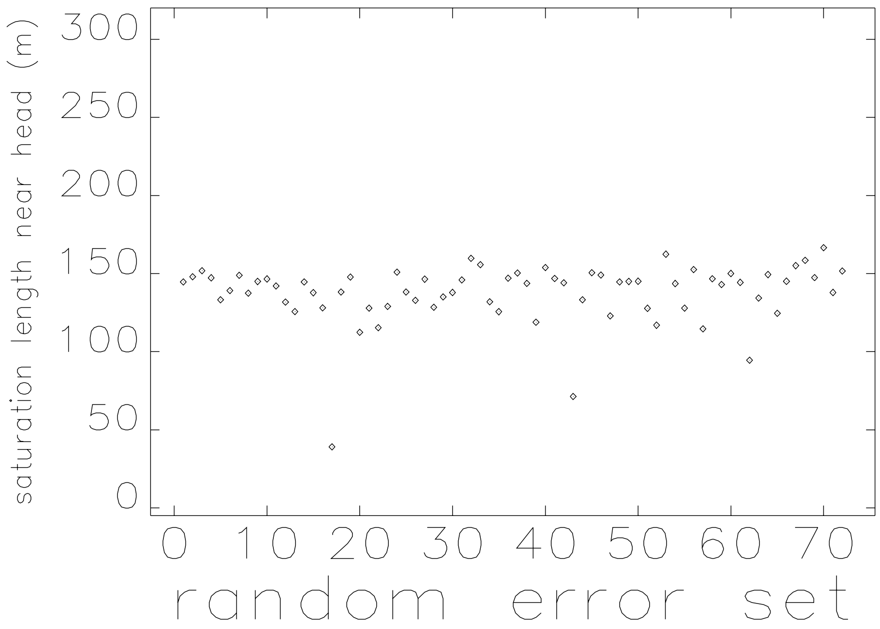
Anyway, I applied 70 random error set with following tolerances to TESLA XFEL linac, and checked FEL performance.
Here error cutoff is 3 sigma !

Gun Timing jitter : 0.3 ps (rms)
Charge change : 1% (rms)
Phase errors for all modules : 0.1 degree (rms)
Amplitude errors for all moduels : 0.03% (rms)
Power suppy error for BC1 and BC2 : 0.02% (rms)

S2E simulation Results – Tolerance

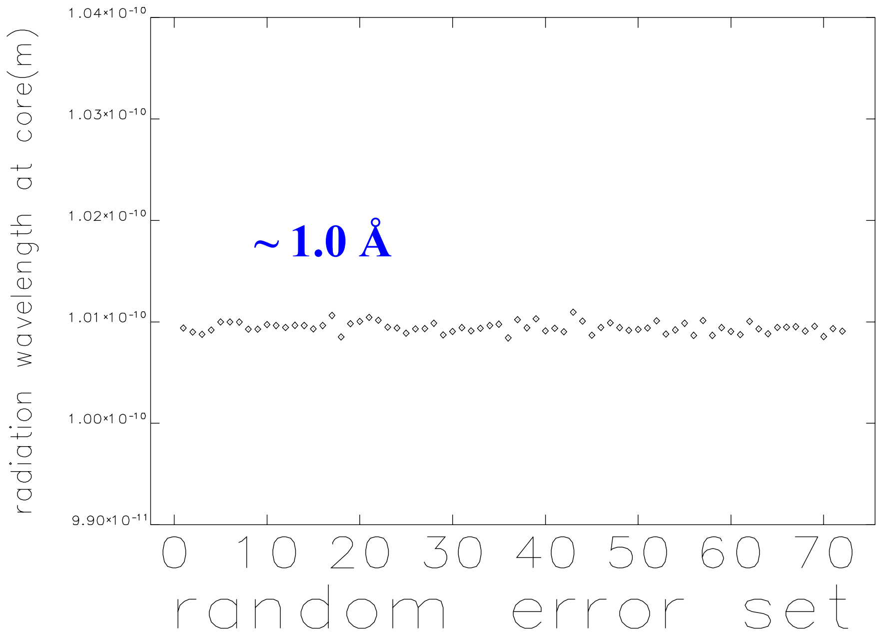
Saturation length is safe enough (< 200 m) under jitters and erros !!!



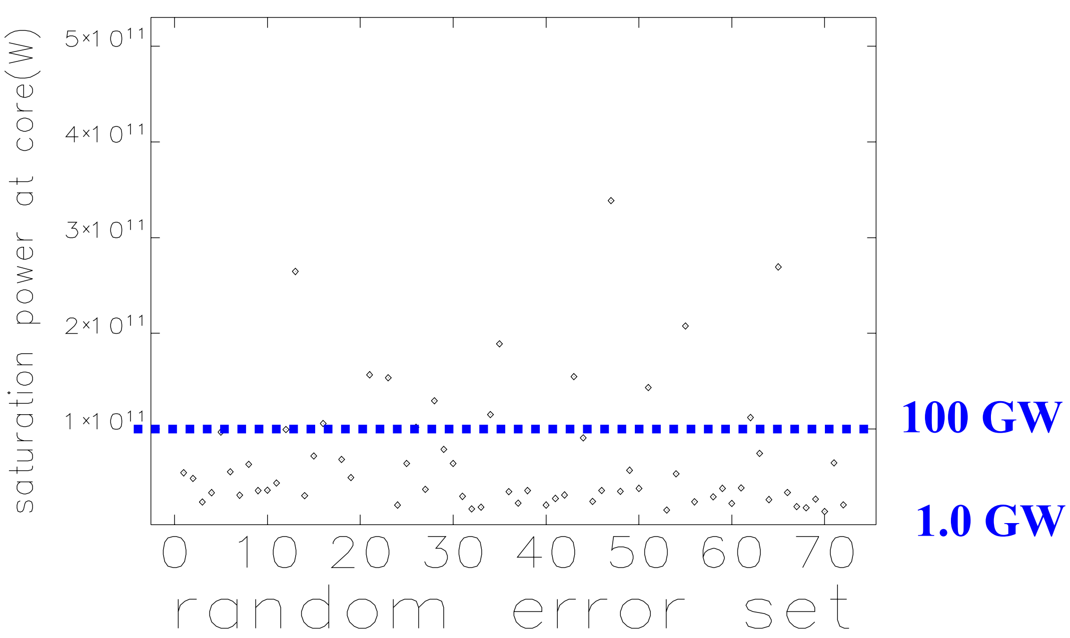


S2E simulation Results – Tolerance

Wavelength is no problem but the jitter in the saturation power is high !!!



Planned Power ~ 24 GW



Summary

After considering the space charge force at Gun, CSR in BCs, and geometric wakefields in linac, we have investigated jitter tolerance in the new TESLA XFEL lattice.

At the moment, it seems that we can not control phase jitters in ACC234 and ACC39 modules.

Under current controllable jitter tolerances, we met strong fluctuations in FEL output power. There is no big problem in all other things.

Continuously, we should study on the jitter tolerance and a new linac lattice for TESLA XFEL with large jitter margin.

TTF2 Start-to-End Simulations

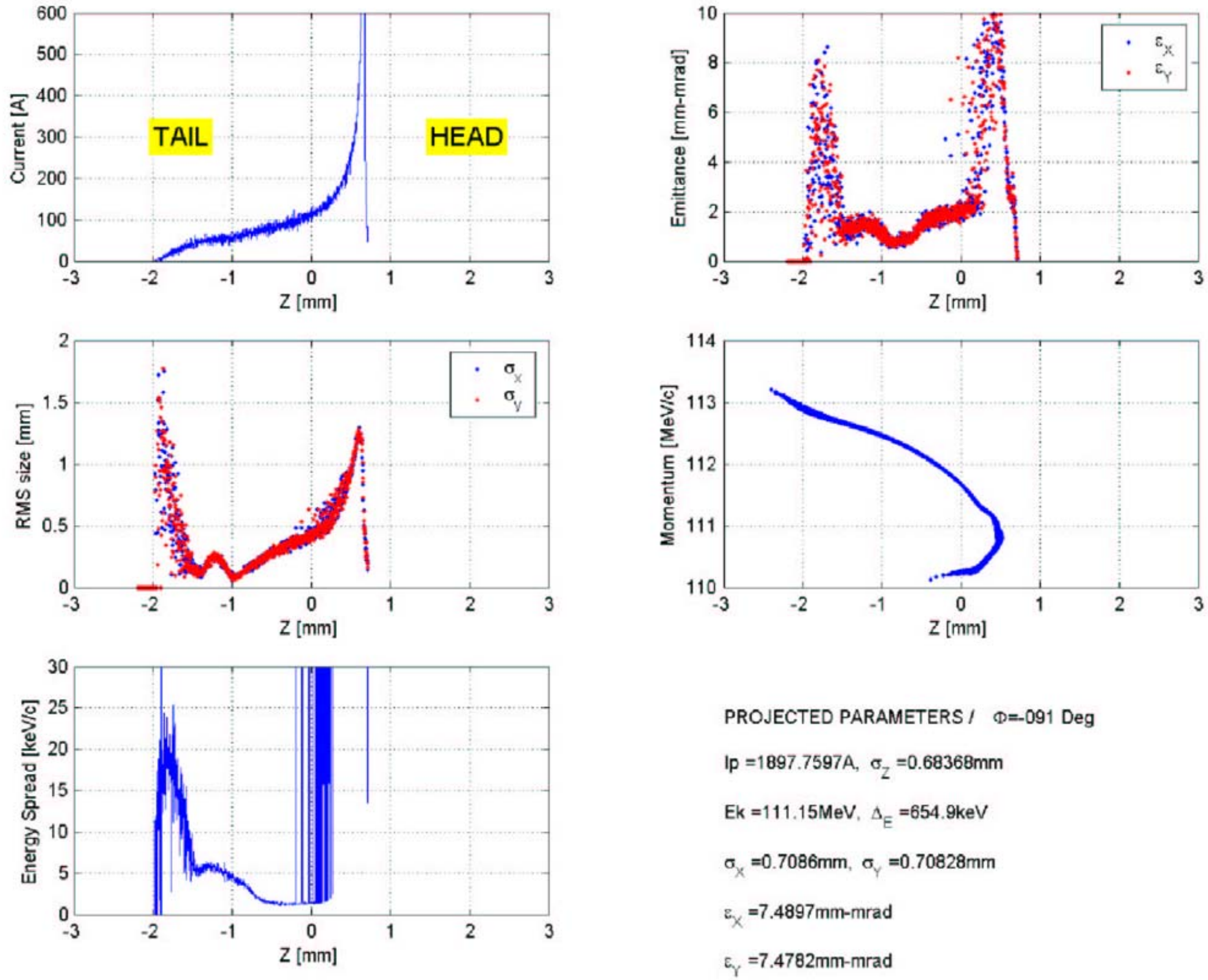
Jean-Paul Carneiro
DESY Hamburg

TESLA COLLABORATION MEETING

DESY Zeuthen, 22 Jan 2004

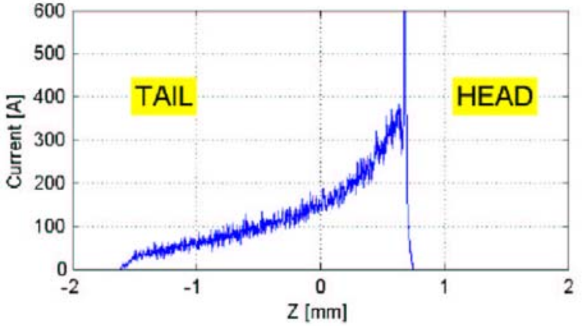
TTF2 Velocity Bunching

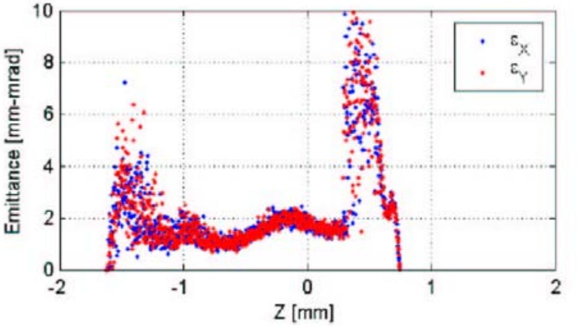
- Case 20 ps
  Phase -91 Deg

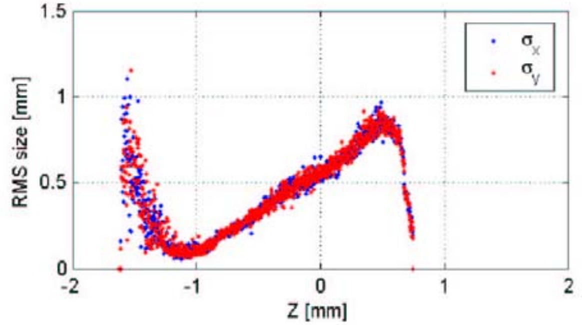


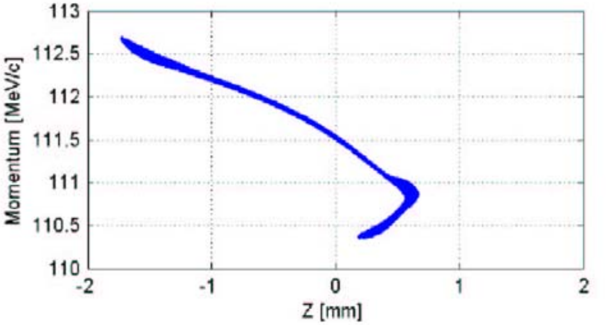
TTF2 Velocity Bunching

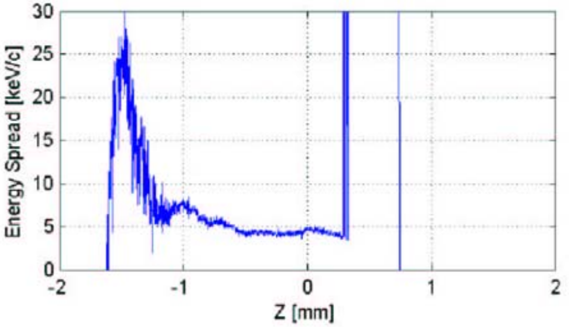
- Case 4 ps
  Phase -92 Deg











PROJECTED PARAMETERS / Φ=-92 Deg

Ip =882.487A, σ_Z =0.58414mm

Ek =111MeV, Δ_E =487.42keV

σ_X =0.60362mm, σ_Y =0.60508mm

ε_X =5.381mm-mrad

ε_Y =5.4495mm-mrad

XFEL Optics Considerations

Winni Decking

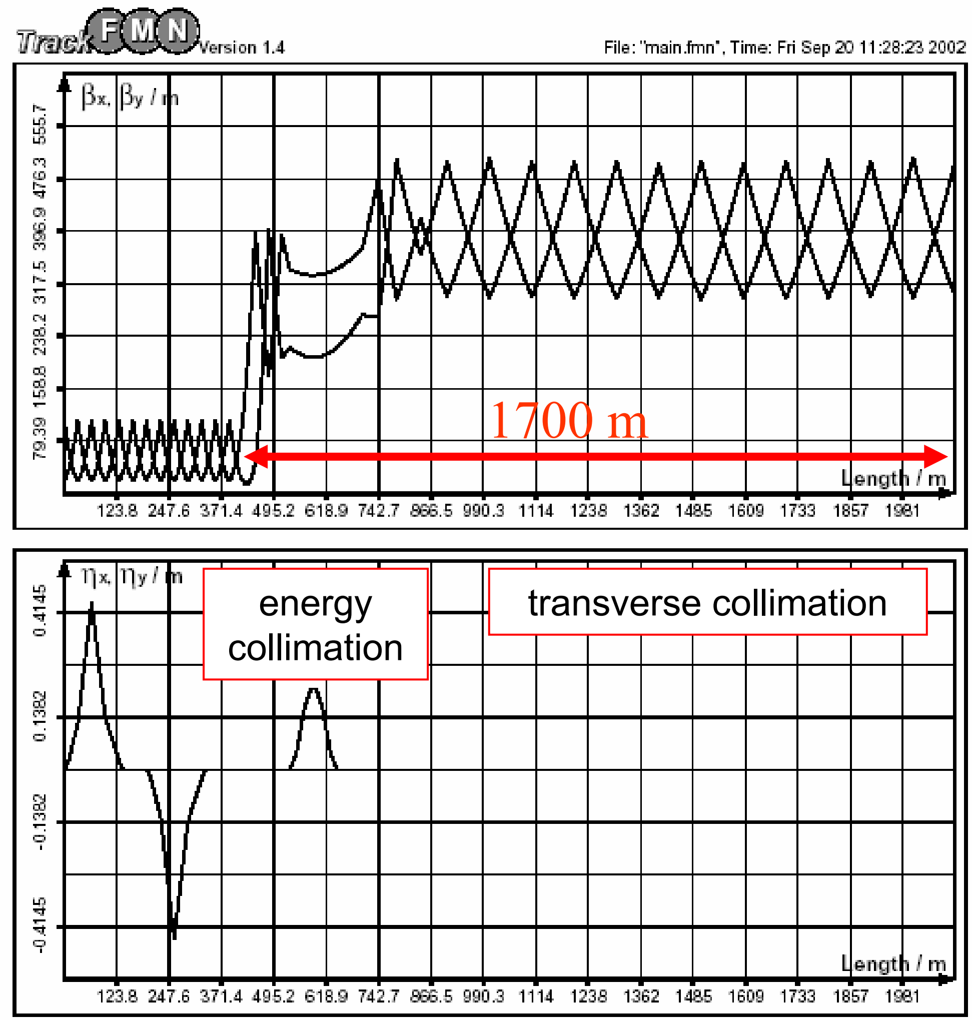
TESLA Collaboration Meeting

Zeuthen 01/04

Collimation – TDR Layout

Optimized for:
- ≈ 200 bunches impact on spoiler (time to switch of gun)
- Diagnostics within collimation
- Large energy acceptance and bandwidth (3 % resp. 9 %)

Too long for XFEL
Alternatives:
- Learn from LC designs
- Revive emergency dump



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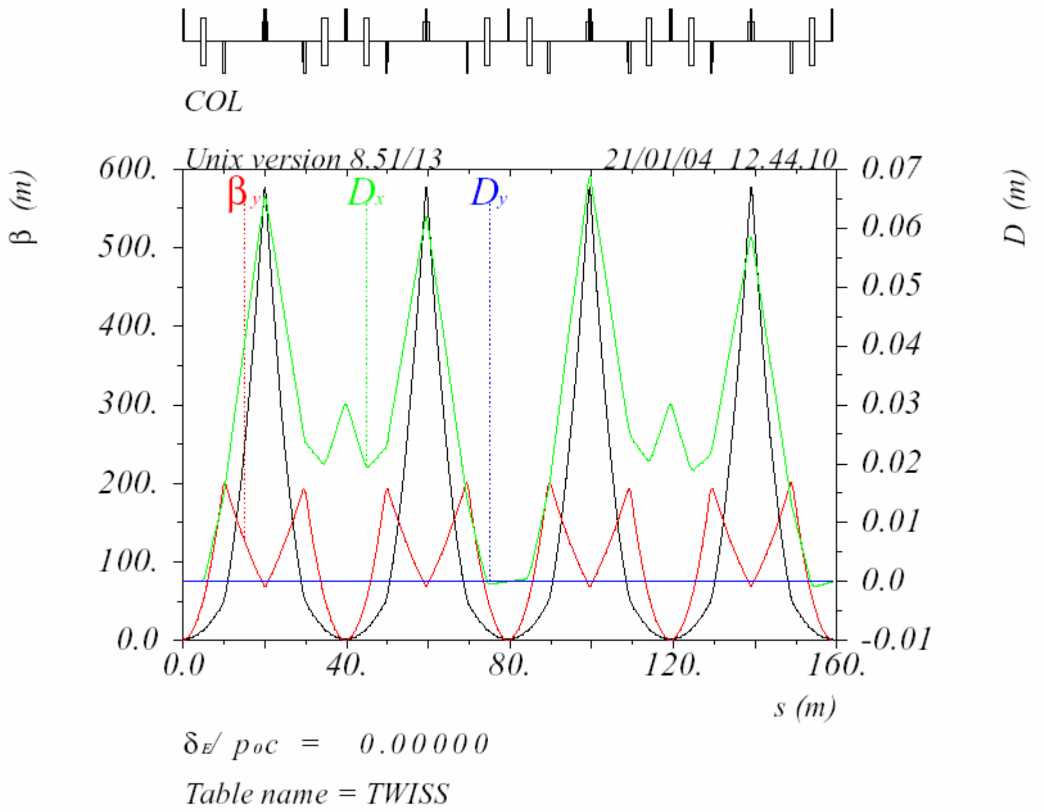
LC-like Collimation System (R.B.)



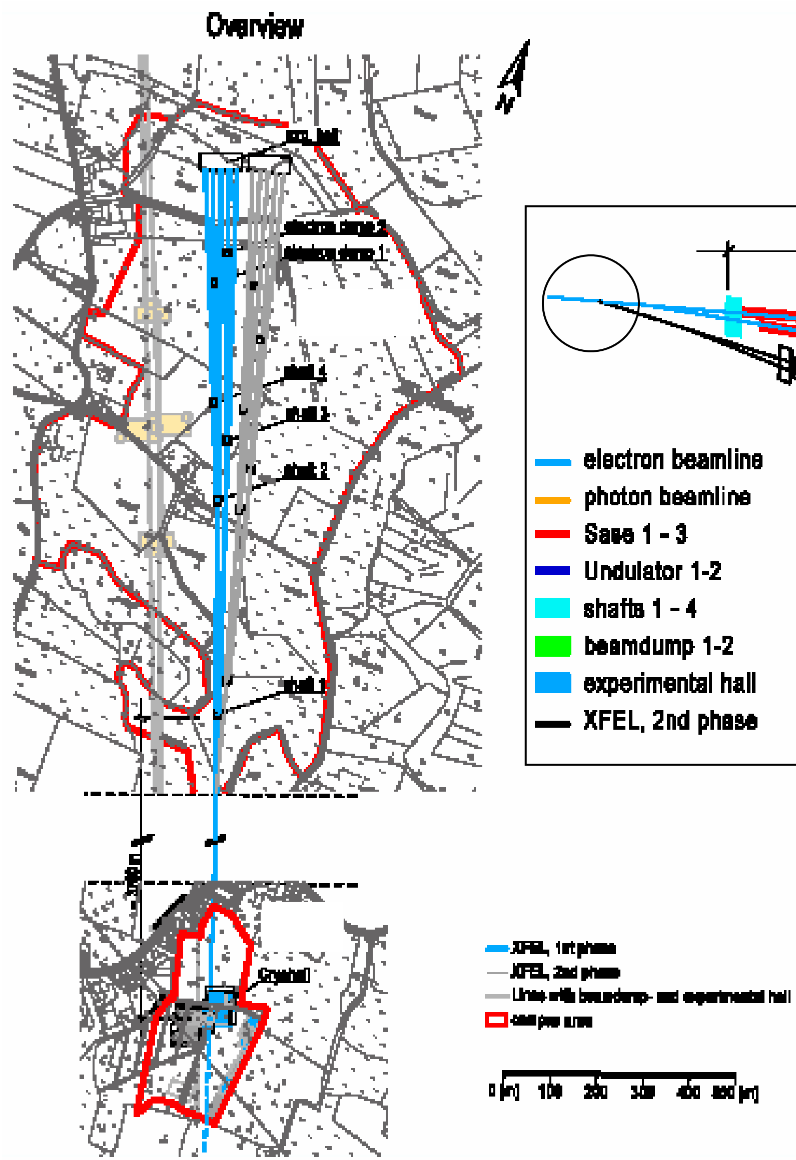
Mismatched 90 deg FODO leads to large betas

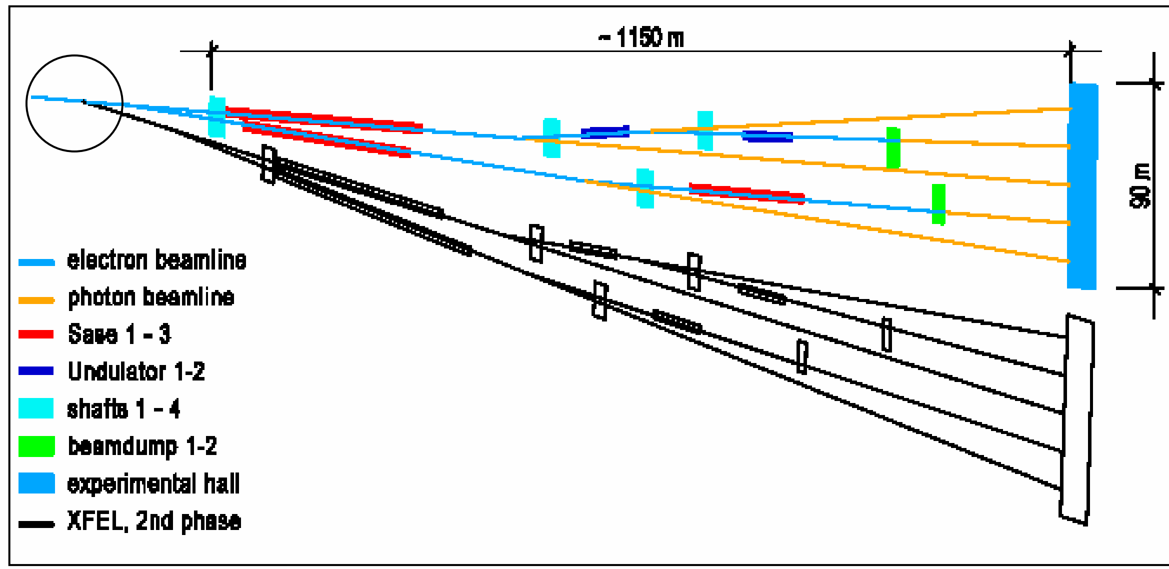
Combine longituidnal and transeverse collimation

Sextupoles for chromatics correction

Bandwidth ???

TDR Layout


Overview
shaft 4
shaft 3
shaft 2
shaft 1
XFEL, 1st phase
XFEL, 2nd phase
0 [m]
100
200
300
400
500 [m]


~ 1150 m
90 m
electron beamline
photon beamline
Sase 1 - 3
Undulator 1-2
shafts 1 - 4
beamdump 1-2
experimental hall
XFEL, 2nd phase

What´s next

- Work on collimation/fast switch section
- Orbit feedback by SLS
- Beam distribution ok for time being
- Work on transverse jitter budget
- Work on XS1 shaft lay-out