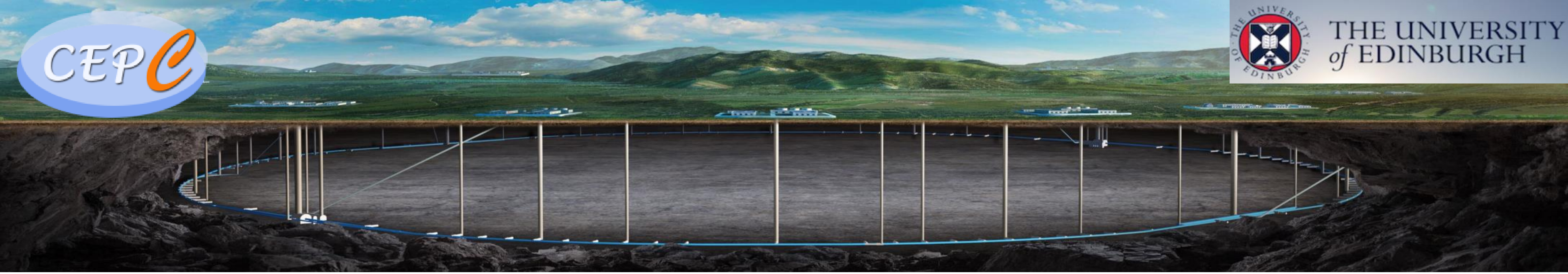

CEPC booster and damping ring design

Dou Wang (IHEP)

on behalf of CEPC AP group

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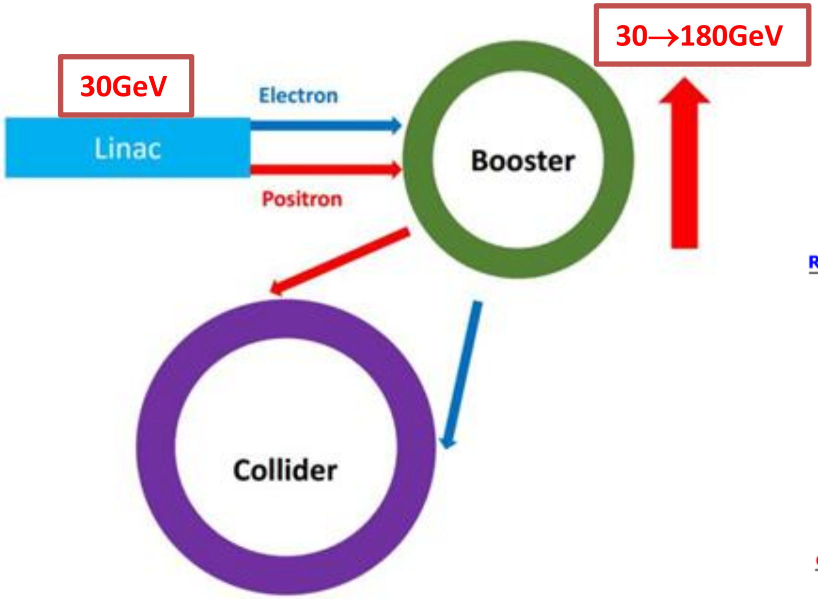
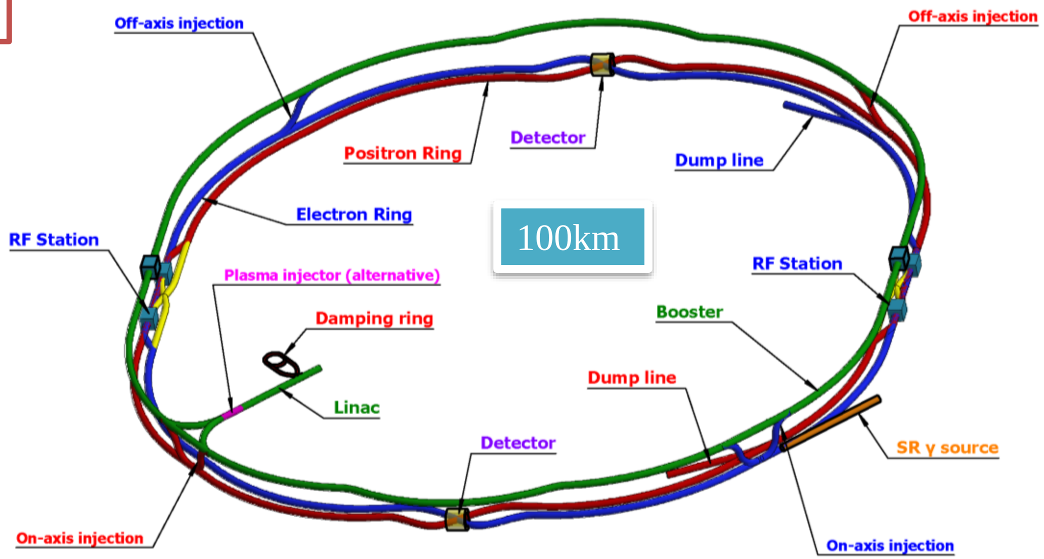
Institute of High Energy Physics
Chinese Academy of Sciences

Content

- **Design status for CEPC Booster**
  - Booster design requirements in TDR
  - Booster TDR optics (including errors)
  - Timing structure & dynamic parameters during ramping
  - Summary of Booster TDR parameters
- **Design status for CEPC positron damping ring**
  - DR parameters
  - DR optics (including errors)
  - Particle tracking through the transport lines
- **Summary**

CEPC injector chain



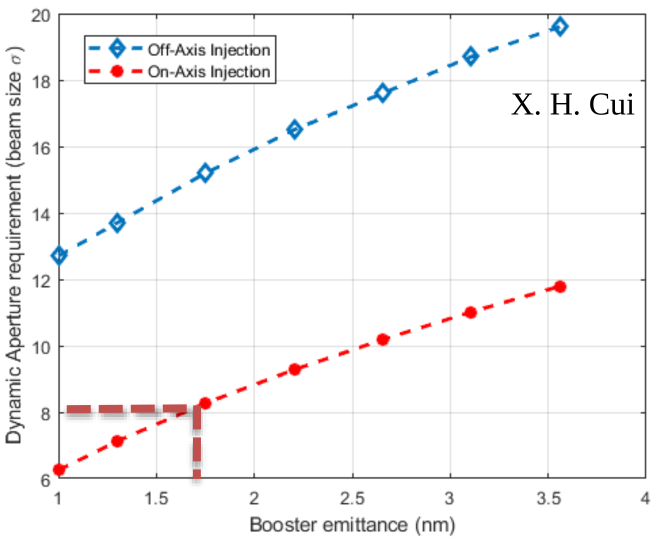


- 30 GeV linac provides electron and positron beams for booster.
- Top up injection for collider ring ~ 3% current decay
- Booster is in the same tunnel as collider ring, above the collider ring, bypass in IRs (same circumference).
- Budget for transfer efficiency **90%**: 95% for booster + 95% for transport lines (inj. to collider).
- Beam current threshold in booster is limited by RF system.
- Feedback systems (Transverse & longitudinal) are need to damp the instability at low energy.

Requirement update after CDR

Collider ring	Higgs (CDR)	Higgs (TDR)
Number of IPs	2	2
Energy (GeV)	120	120
Circumference (km)	100	100
SR loss/turn (GeV)	1.73	1.8
Half crossing angle (mrad)	16.5	
Piwinski angle	3.48	4.88
N_e/bunch (10^{10})	15.0	13.0
Bunch number	242	268
Beam current (mA)	17.4	16.7
SR power /beam (MW)	30	30
Bending radius (km)	10.7	10.2
Momentum compaction (10^{-6})	11.1	7.1
β_{IP} x/y (m)	0.36/0.0015	0.3/0.001
Emittance x/y (nm)	1.21/0.0024	0.64/0.0013
Transverse σ_{IP} (um)	20.9/0.06	14.0/0.036
ξ_x/ ξ_y/IP	0.018/0.109	0.015/0.11
V_{RF} (GV)	2.17	2.20
f_{RF} (MHz) (harmonic)	650 (216820)	
Nature bunch length σ_z (mm)	2.72	2.3
Bunch length σ_z (mm)	4.4	4.1
Energy spread (%) (SR/BS)	0.1/0.134	0.1/0.17
Energy acceptance requirement (%)	1.35	1.6
Energy acceptance by RF (%)	2.06	2.2
Lifetime due to beamstrahlung (min)	80	40
Lifetime (min)	25	20
F (hour glass)	0.89	0.9
L_{max}/IP (10^{34}cm^{-2}s^{-1})	**2.93**	**5.0**

- Horizontal DA requirement of collider ring due to injection



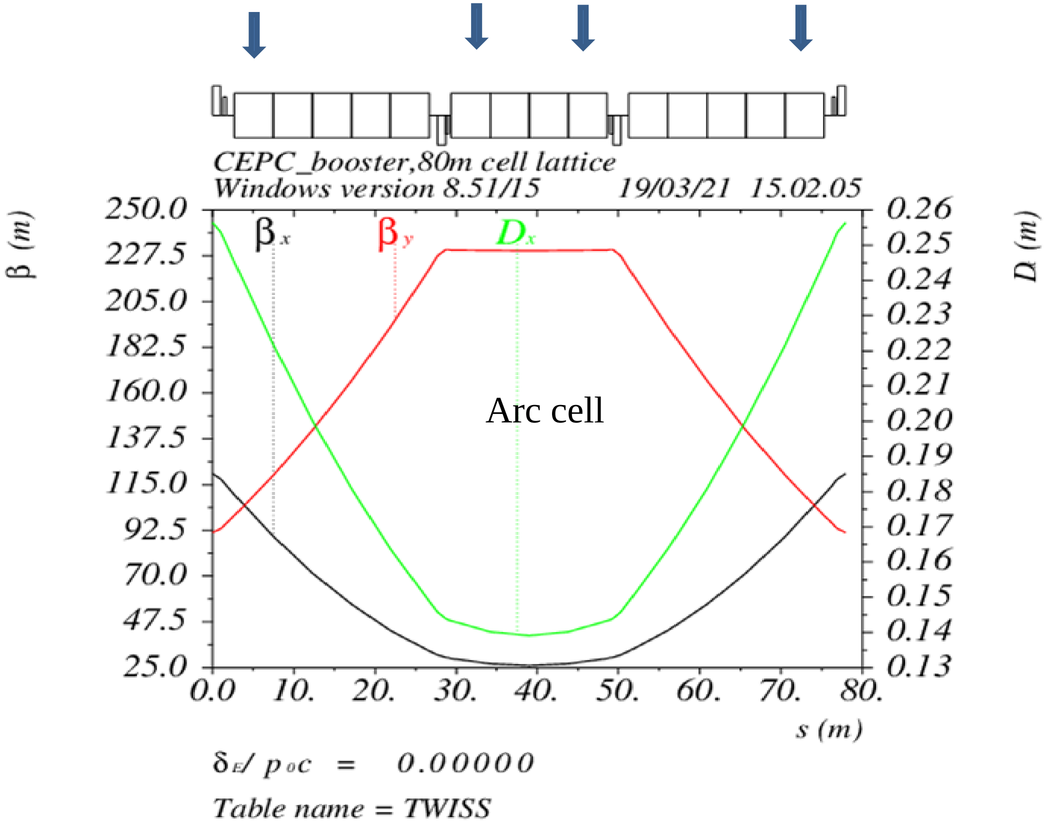
- **Booster emittance @120 GeV <1.7nm (3.6nm in CDR)**

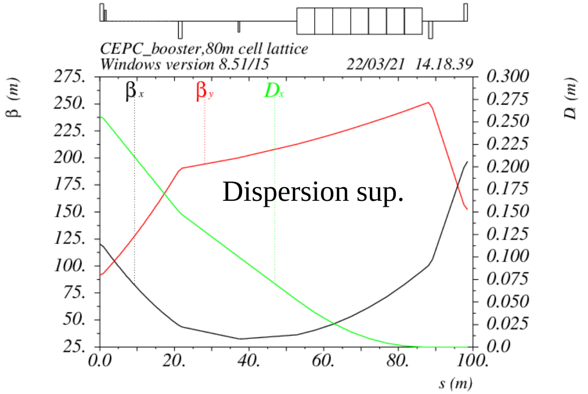
Booster TDR optics

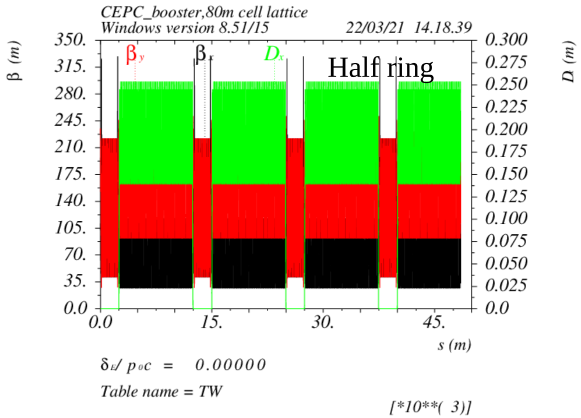
D. Wang, C. H. Yu, Y. M. Peng…

- TME like structure (cell length=78m)
- Interleave sextupole scheme
- Emittance@120GeV=1.26nm

- Overall idea: uniform distribution for the Q
- Combined magnet (B+S) scheme possible
- Phase advance/cell: 100° (H) / 28° (V)



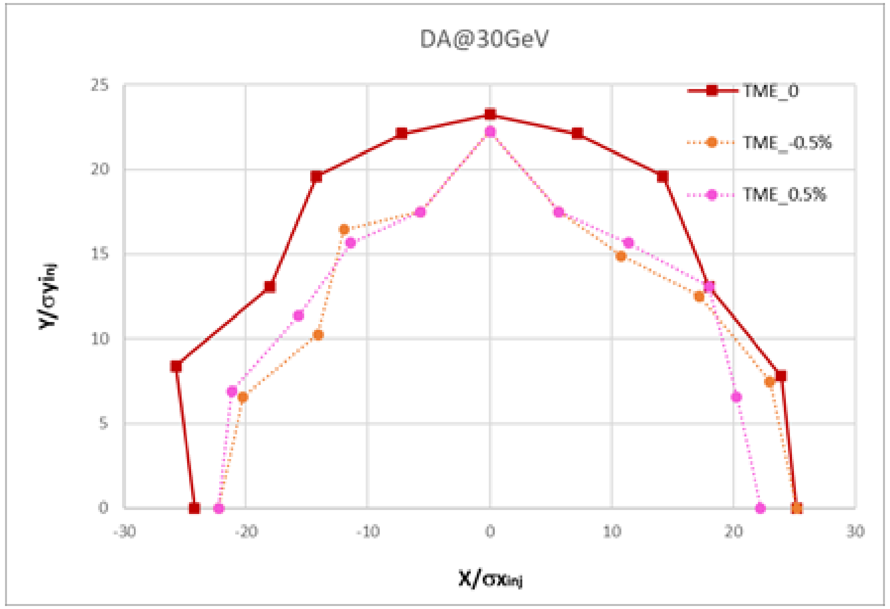


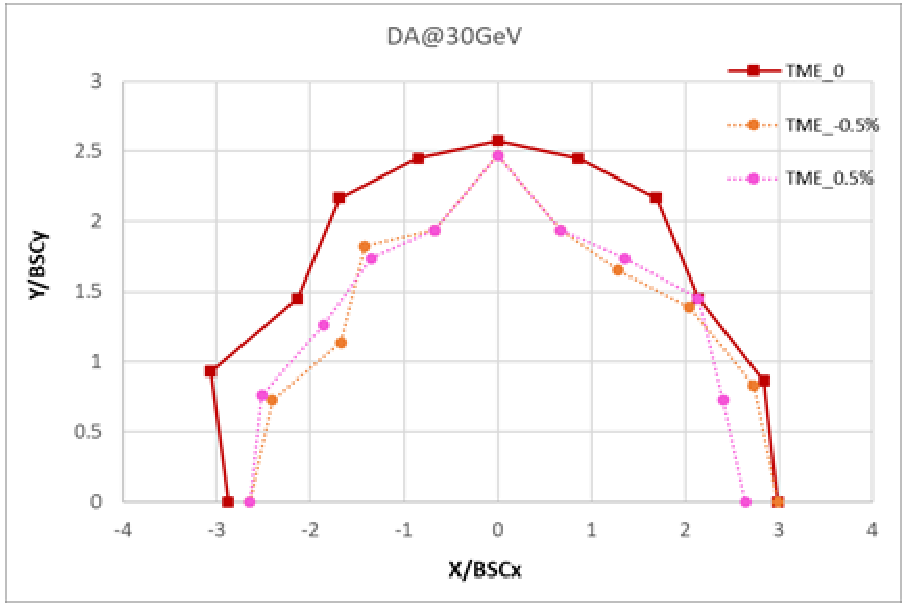


DA results @ 30GeV

- Booster energy: 30GeV~180GeV
- 30GeV: $BSC_{xy}=(4\sigma_{xy}+5mm)*2$

- Inj. emittance from Linac: ≤10nm
- Energy spread from Linac: ≤0.16%

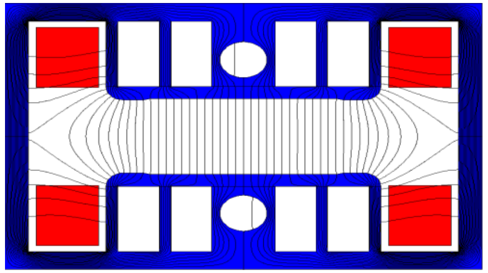


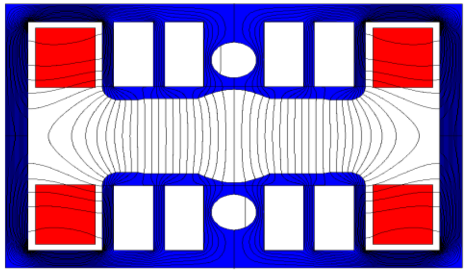


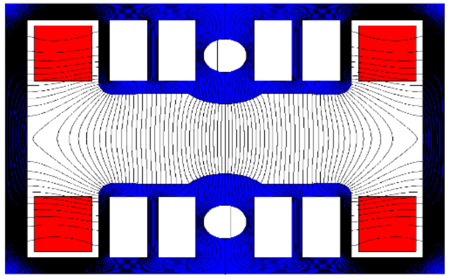
Injection energy change to 30GeV

- 30GeV injection is adopted for the cost saving in TDR.
  - The non-oriented steel laminations for the iron dominated dipole magnet can be used at 30GeV.
  - A cost balance between Linac and booster
- Linac parameters at 30GeV

  - bunch length= 0.4mm, energy spread= 0.15%, emittance=6.5nm
- Magnetic design: the quality of the dipole and sextupole fields meet the physical requirements.







DA results with errors and correction

D. H. Ji

	Dipole	Quadrupole	Sextupole
Transverse shift X/Y (μm)	100	100	-
Longitudinal shift Z (μm)	100	150	-
Tilt about X/Y (mrad)	0.2	0.2	-
Tilt about Z (mrad)	0.1	0.2	-
Nominal field	1e-3	2e-4	3e-4

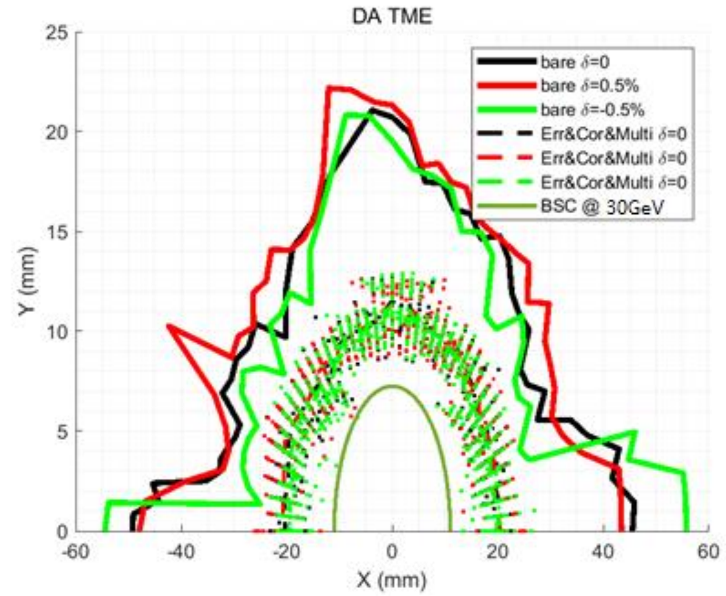
	Accuracy (m)	Tilt (mrad)	Gain	Offset w/ BBA(mm)
BPM(10Hz)	1e-7	10	5%	30e-3

- Include multipole errors

dipole	quadrupole
$B1/B0 \leq 2\times10^{-4}$	
$B2/B0 \leq 5\times10^{-4}$	$B2/B1 \leq 3\times10^{-4}$
$B3/B0 \leq 2\times10^{-5}$	$B3/B1 \leq 2\times10^{-4}$
$B4/B0 \leq 8\times10^{-5}$	$B4/B1 \leq 1\times10^{-4}$
$B5/B0 \leq 2\times10^{-5}$	$B5/B1 \leq 1\times10^{-4}$
$B6/B0 \leq 8\times10^{-5}$	$B6/B1 \leq 5\times10^{-5}$
$B7/B0 \leq 2\times10^{-5}$	$B7/B1 \leq 5\times10^{-5}$
$B8/B0 \leq 8\times10^{-5}$	$B8/B1 \leq 5\times10^{-5}$
$B9/B0 \leq 2\times10^{-5}$	$B9/B1 \leq 5\times10^{-5}$
$B10/B0 \leq 8\times10^{-5}$	$B10/B1 \leq 5\times10^{-5}$

- Orbit & Dispersion Correction (100 seeds)
  - Response Matrix (RM)+SVD
- Optics Correction (93 seeds)
  - RM + LOCO
- DA track in AT w/o SR

RMS	TME
Orbit (mm)	0.062/0.071
Beta Beating(%)	0.16/0.1
Δ Dispersion(mm)	1.2/3.3



* refer to Daheng Ji' talk on this workshop

DA@30GeV

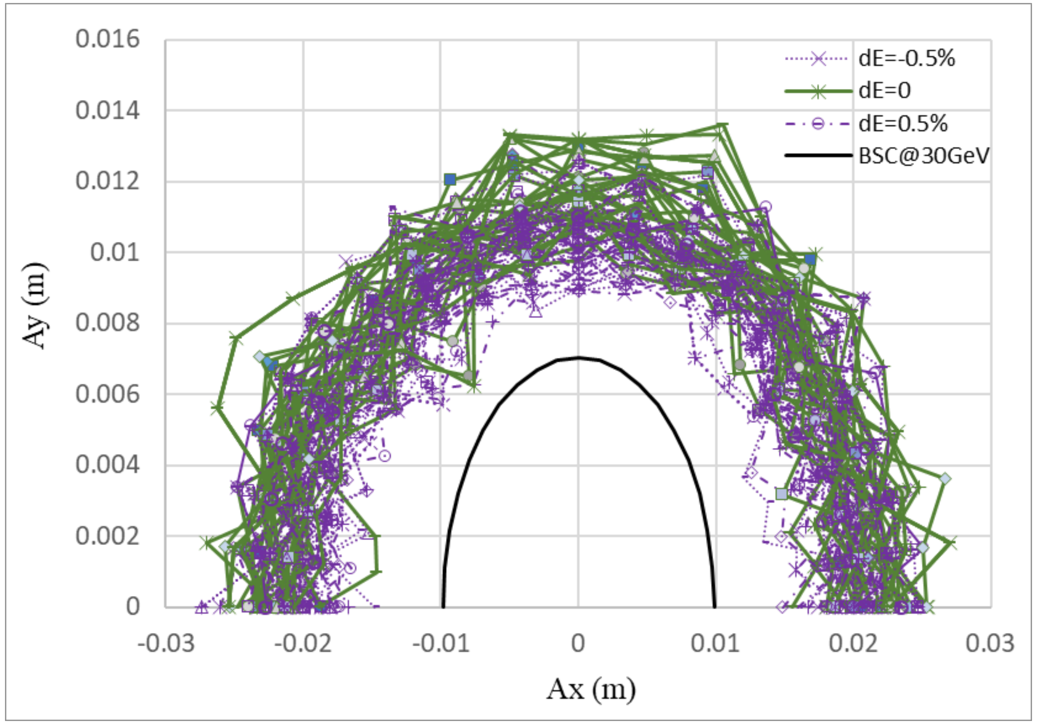
Dou Wang, Daheng Ji

- Tracking by **SAD** (1500 turns)
- include errors (w. multipole errors)
- Include SR sawtooth orbit (without taper)
- Include SR damping & fluctuation

- On axis injection from Linac to booster
- BSC definition (ε_{inj}=6.5nm):

$$BSC_{x,y} = 2\times(4\cdot\sigma_{x,y} + 5mm)$$

- Energy acceptance: $3*\delta_{inj}$ =0.45%



DA@45GeV

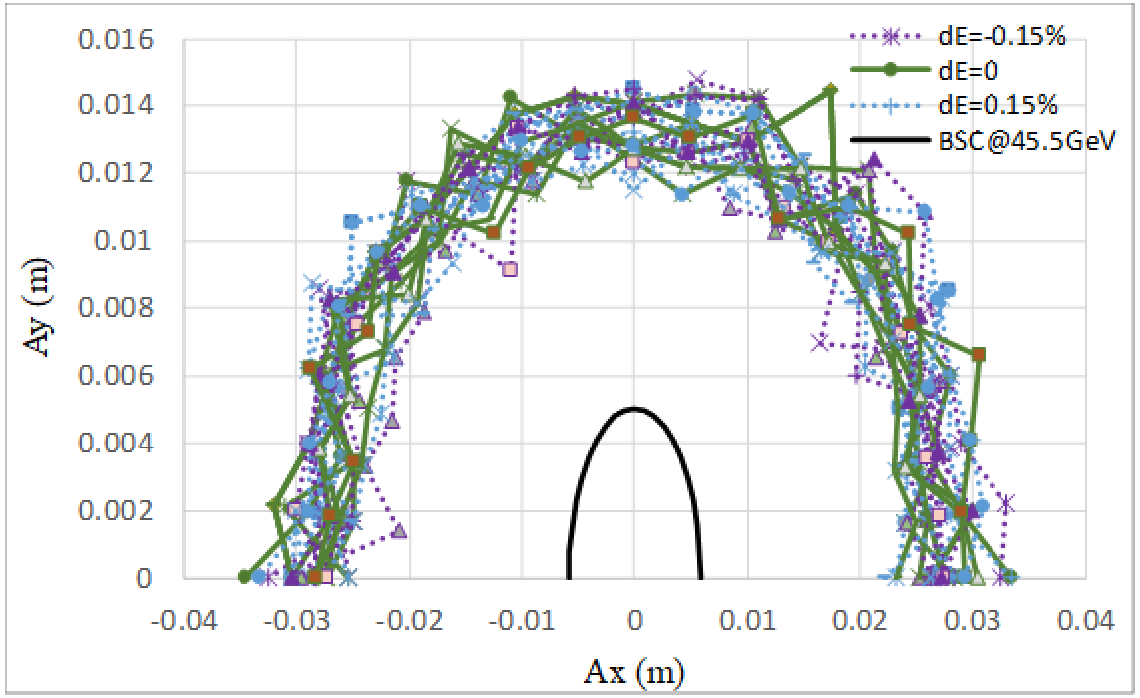
Dou Wang, Daheng Ji

- Tracking by **SAD** (1200 turns)
- include errors (w. multipole errors)
- Include SR sawtooth orbit (without taper)
- Include SR damping & fluctuation

- Off axis injection from booster to collider
- BSC definition (ε_x=0.18nm, ε_y=ε_x *1%):

$$BSC_{x,y} = 2\times(4\cdot\sigma_{x,y} + 5mm)$$

- Energy acceptance: 4*δ=0.15%



DA@80GeV

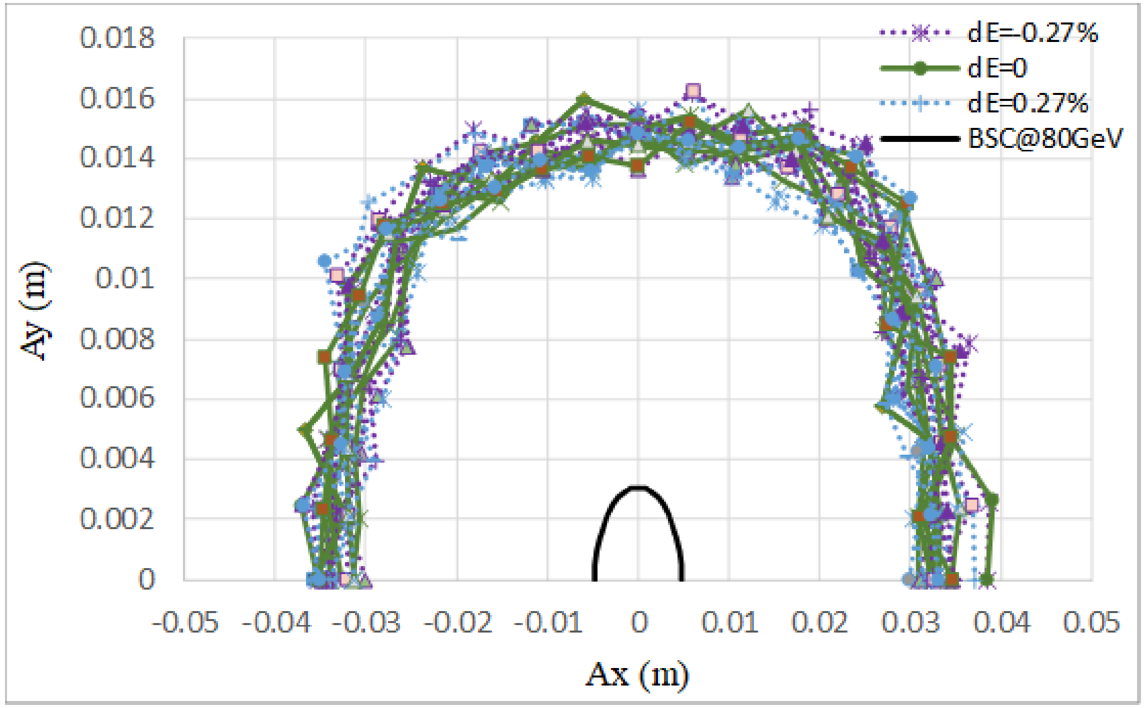
Dou Wang, Daheng Ji

- Tracking by **SAD** (500 turns)
- include errors (w. multipole errors)
- Include SR sawtooth orbit (without taper)
- Include SR damping & fluctuation

- Off axis injection from booster to collider
- BSC definition (ε_x=0.56nm, ε_y=ε_x *1%):

$$BSC_{x,y} = 2\times(5\cdot\sigma_{x,y} + 3mm)$$

- Energy acceptance: 4*δ=0.27%



DA@120GeV

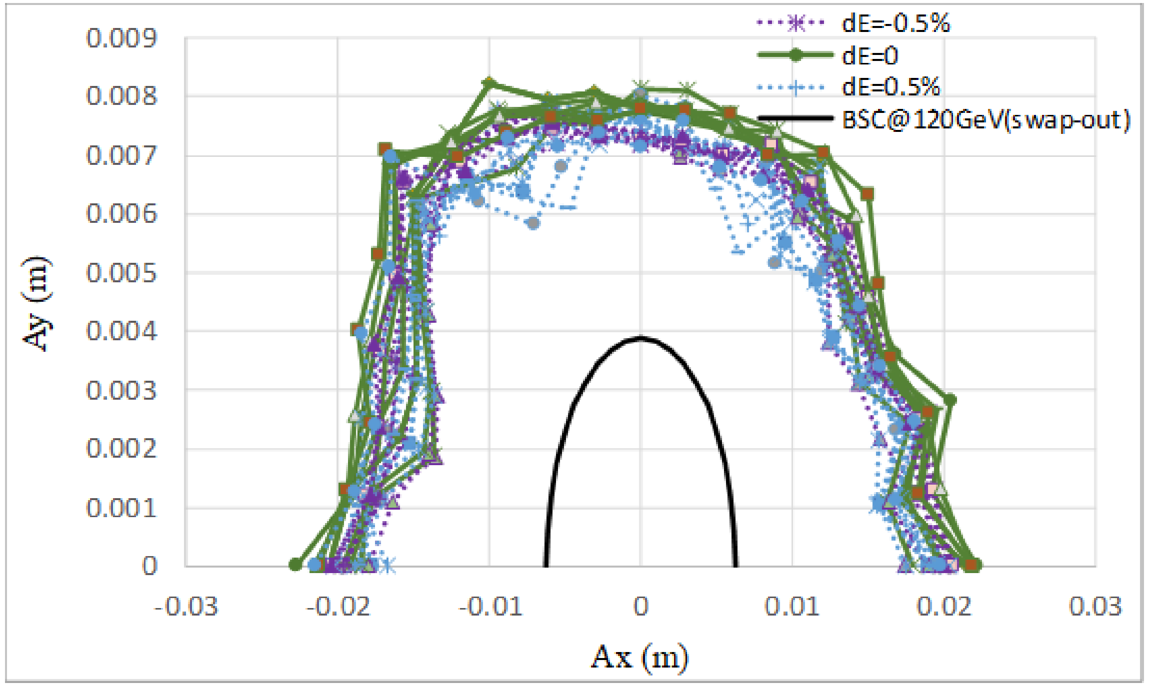
Dou Wang, Daheng Ji

- Tracking by **SAD** (250 turns)
- include errors (w. multipole errors)
- Include SR sawtooth orbit (without taper)
- Include SR damping & fluctuation

- On axis injection from booster to collider
- BSC definition (ε_x=1.26nm, ε_y=ε_x *1%):

$$BSC_x = 2\times(6\cdot\sigma_x + 3mm) \quad BSC_y = 2\times(39\cdot\sigma_y + 3mm)$$

- Energy acceptance: 5*δ=0.5%

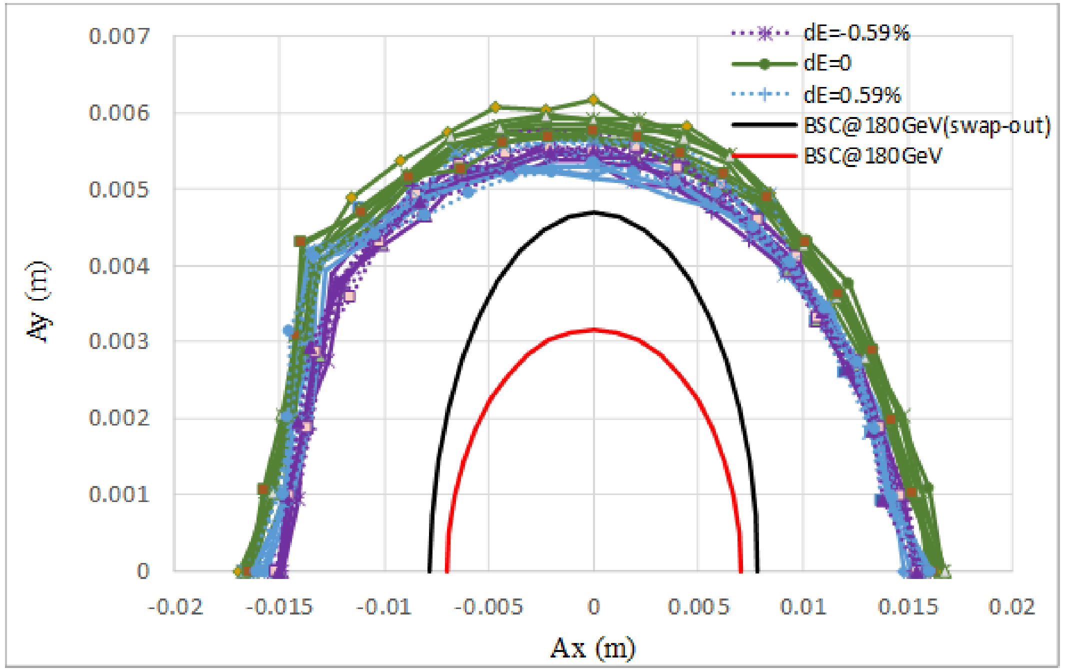


DA@180GeV

Dou Wang, Daheng Ji

- Tracking by **SAD** (150 turns)
- include errors (w. multipole errors)
- Include SR sawtooth orbit (**with taper**)
- Include SR damping & fluctuation

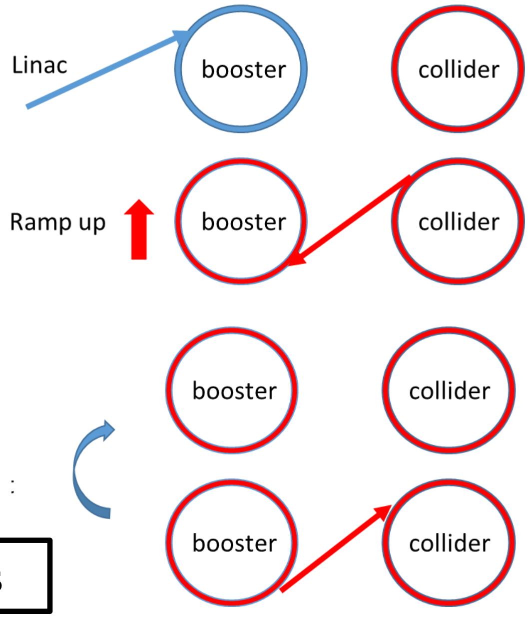
- Keep possibility for on axis injection to collider
- BSC definition (ε_x=2.84nm, ε_y=ε_x *1%):
  -- $BSC_x = 2\times(6\cdot\sigma_x + 3mm)$ $BSC_y = 2\times(50\cdot\sigma_y + 3mm)$ (On-axis)
  -- $BSC_{x,y} = 2\times(5\cdot\sigma_{x,y} + 3mm)$ (Off-axis)
- Energy acceptance: 4*δ=0.59%



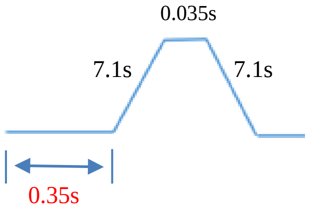
Booster ramping scheme

Dou Wang, Xiaohao Cui

On-axis injection @Higgs



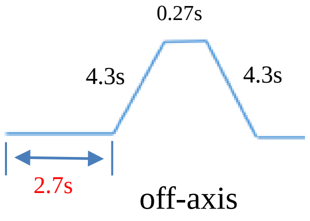
tt



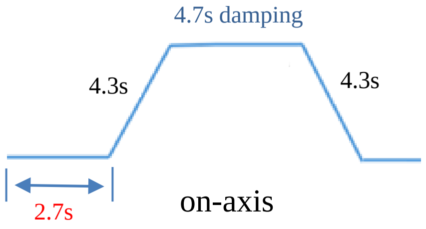
1 cycles/beam

0.35s+7.1s+0.035s+7.1s=14.6s

Higgs

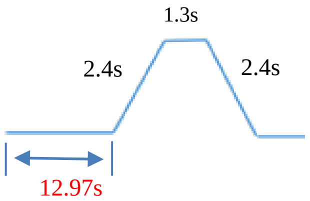


1 cycles/beam



2.7s+4.3s+4.7s+4.3s=16.0s

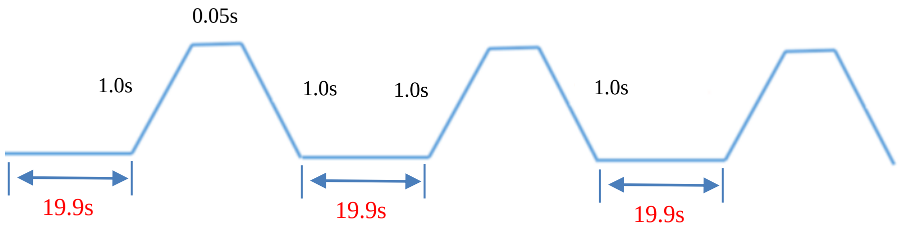
W



1 cycles/beam

12.97s+2.4s+1.3s+2.4s=19.1s

Z



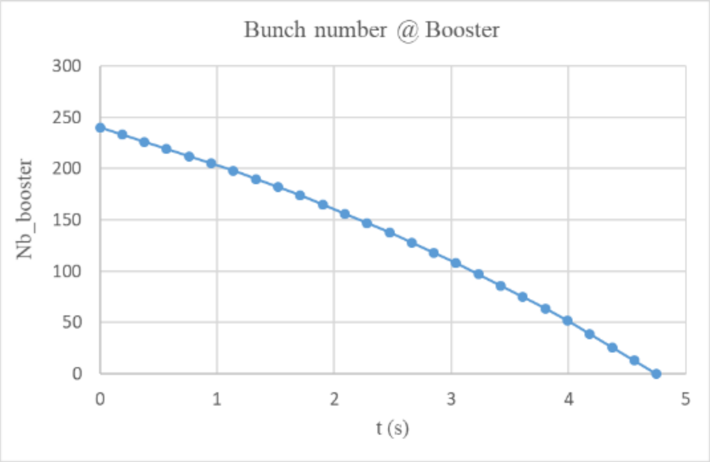
(19.9s+1.0s+0.05s+1.0s)*3=65.9s

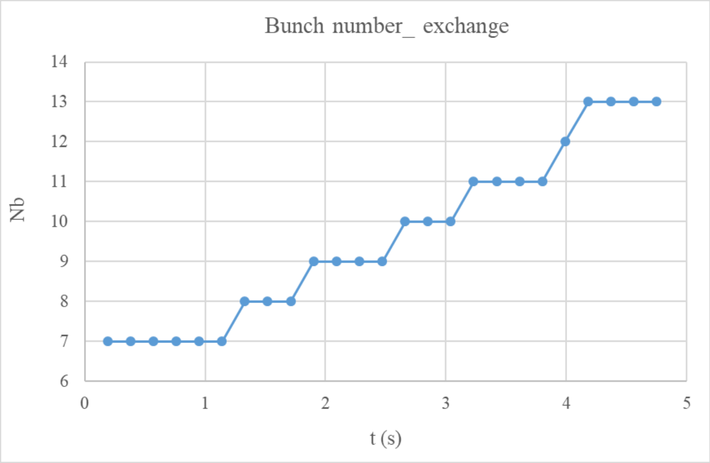
3 cycles/beam

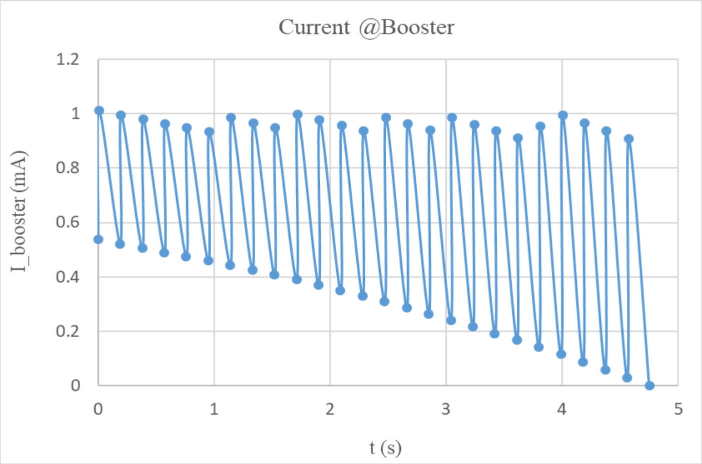
On-axis injection at Higgs energy (30MW)

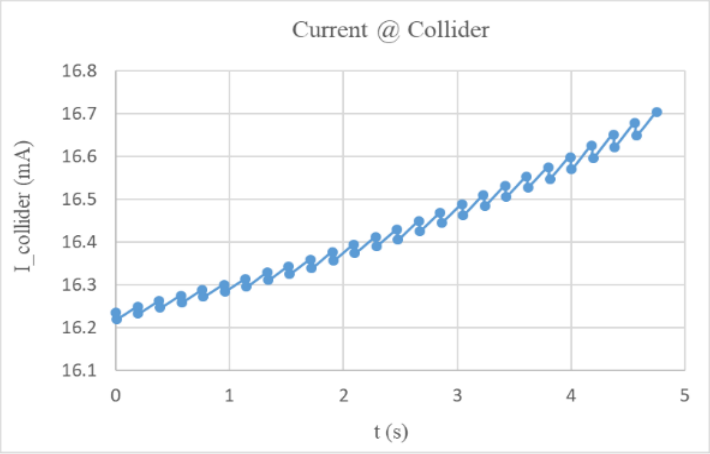
- Swap-out injection
- Current threshold in booster: 1mA

- Current decay for collider: 3% (top up mode)
- 4 damping times to merge the bunches in booster



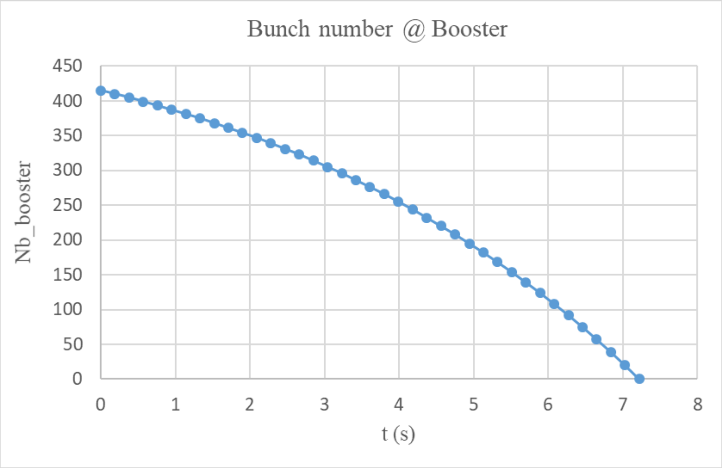


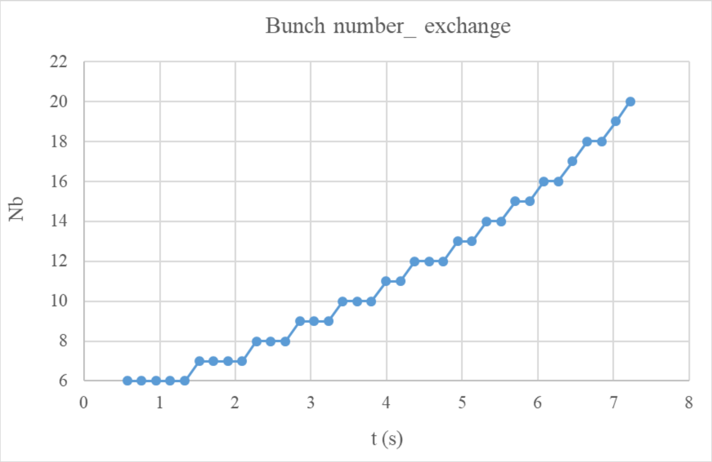


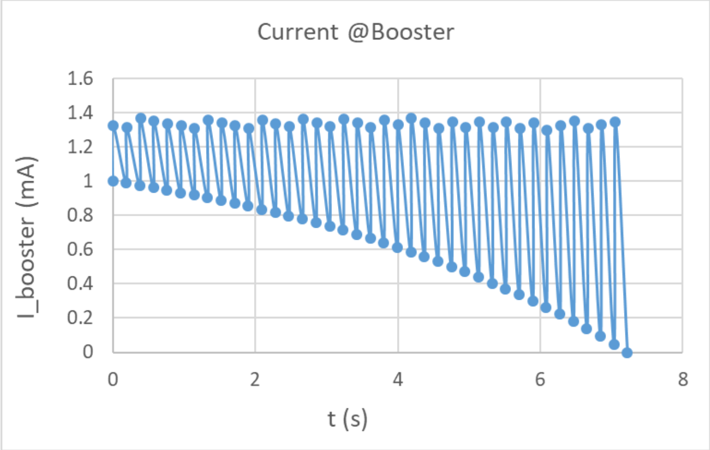


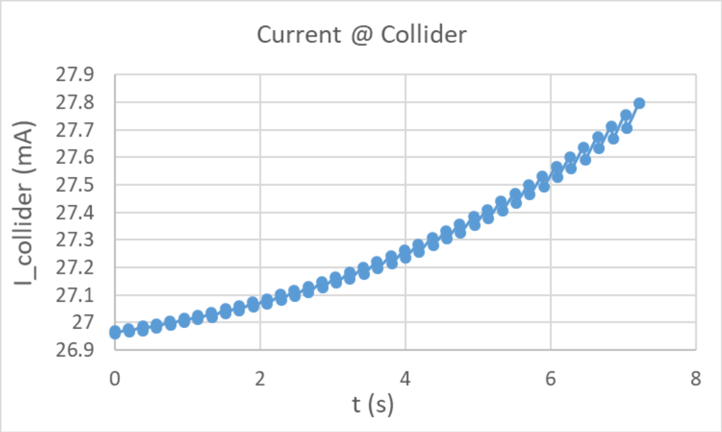
On-axis injection at Higgs energy (50MW upgrade)

- Swap-out injection
- Current threshold in booster: 1.4 mA
- Current decay for collider: 3% (top up mode)
- Small upgrade for the RF power source







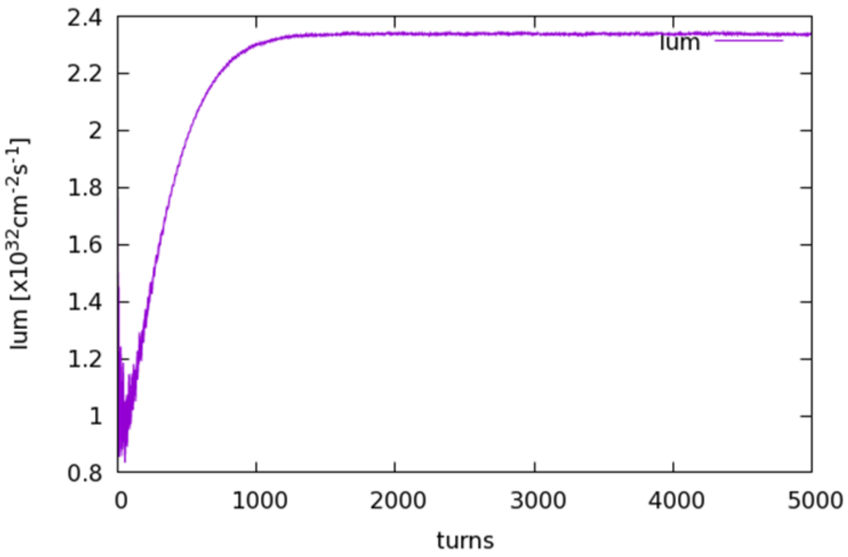


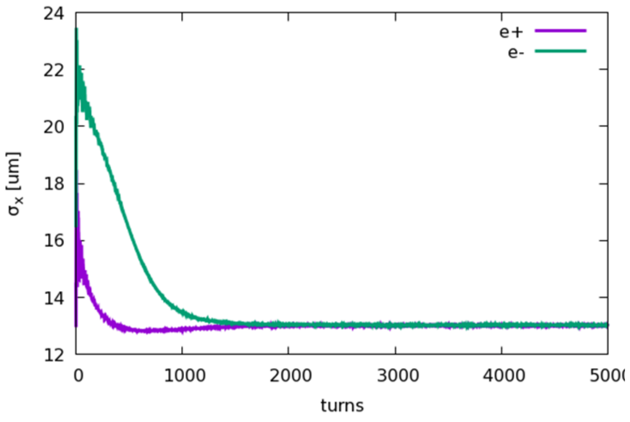
Beam beam instability for on-axis injection

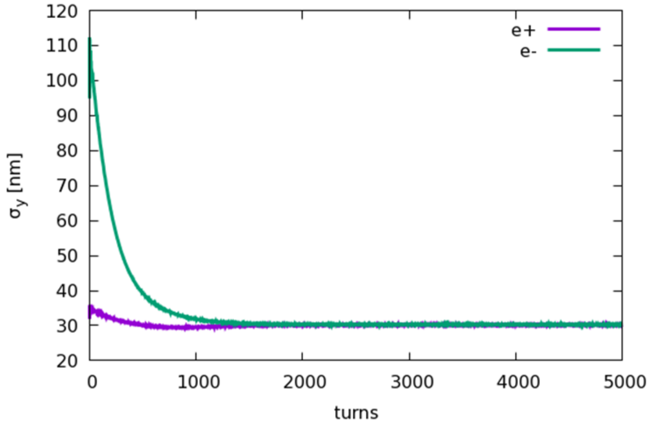
Yuan Zhang

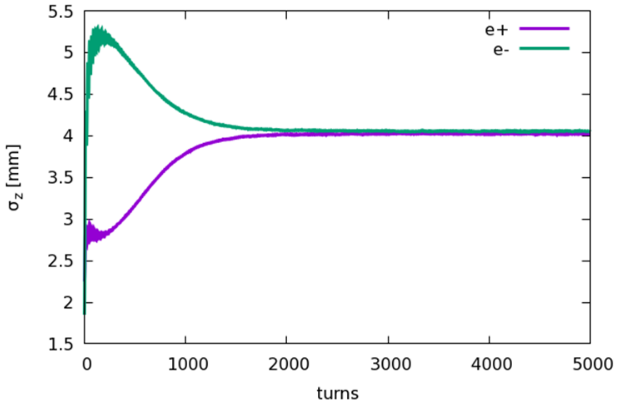
- Collision stability check for on-axis injection scheme at 120GeV

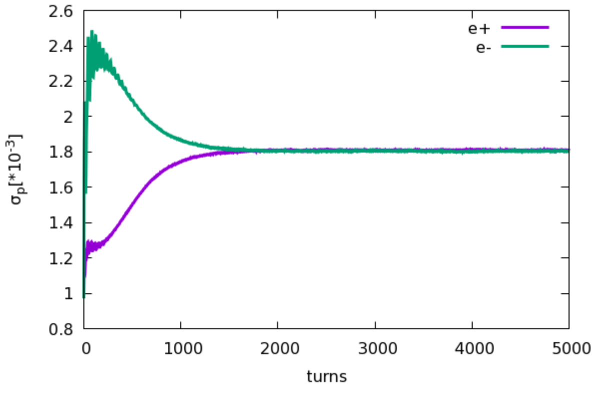
  - e- (Ne=14×10^{10})
    - Emittance X = 1.26nm
    - Energy spread = 0.1%
    - Bunch length=1.85mm
    - Coupling=1.0%
  - e+ (Ne=14×10^{10})
    - Emittance X = 0.64nm
    - Energy spread = 0.1%
    - Bunch length=2.25mm
    - Coupling=0.2%







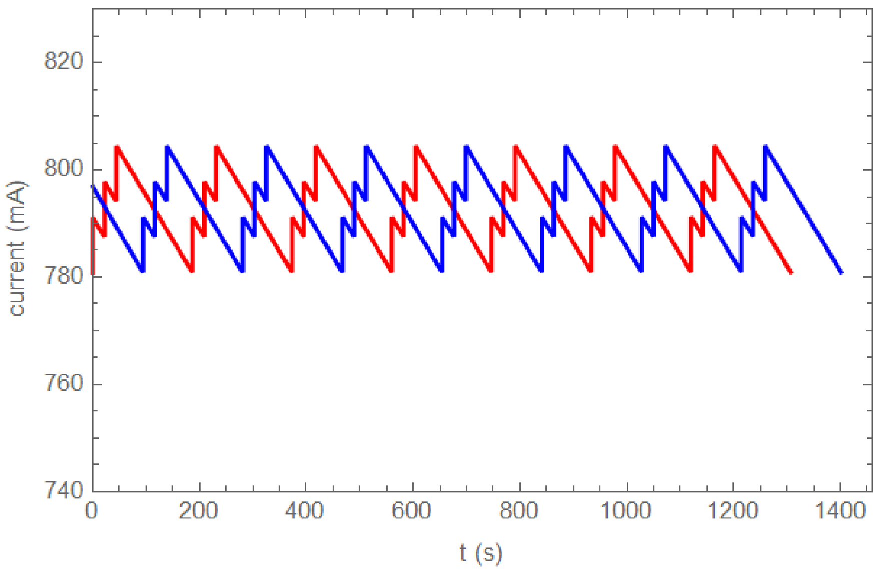




Injection scheme at Z pole

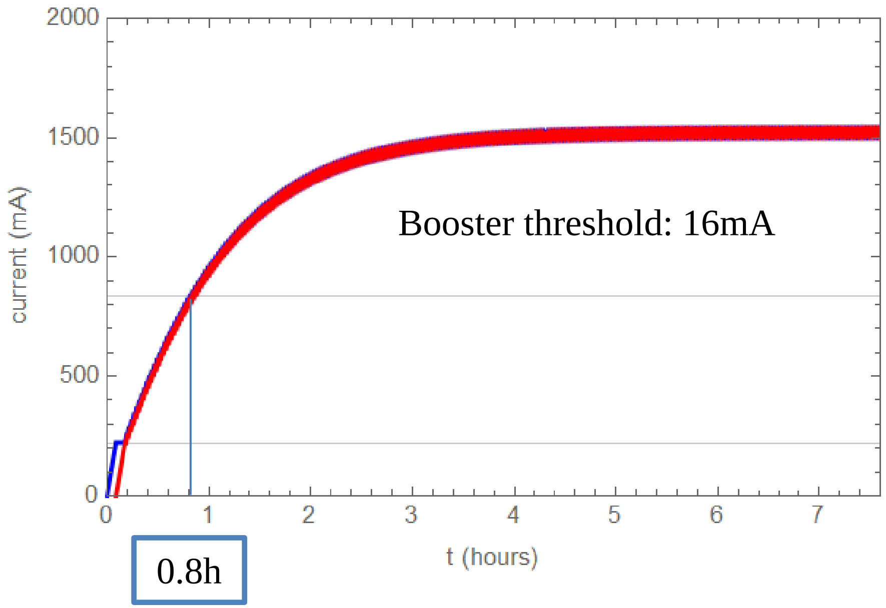
➢ Top-up injection

- Current drop: 3.0% (804mA in collider)
- Booster current = **9.5mA**
- Train num. @ booster = train num.@collider / 3
- Injection speed of Linac: double bunch@100Hz



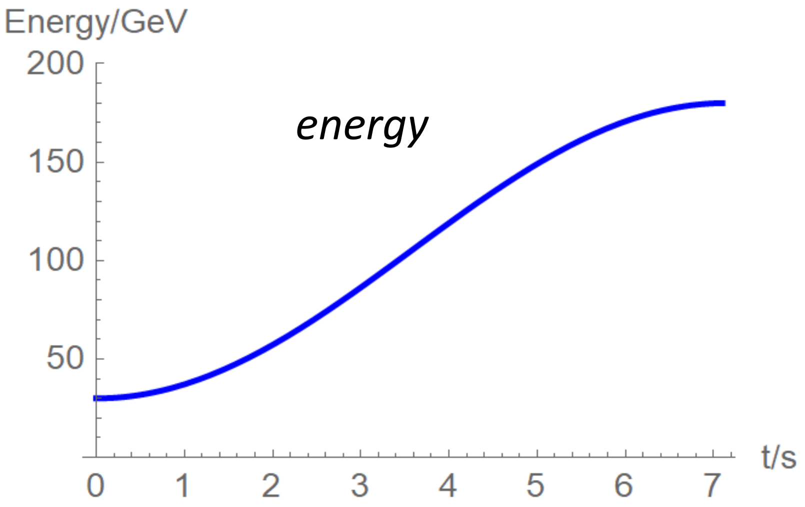
➢ Full injection

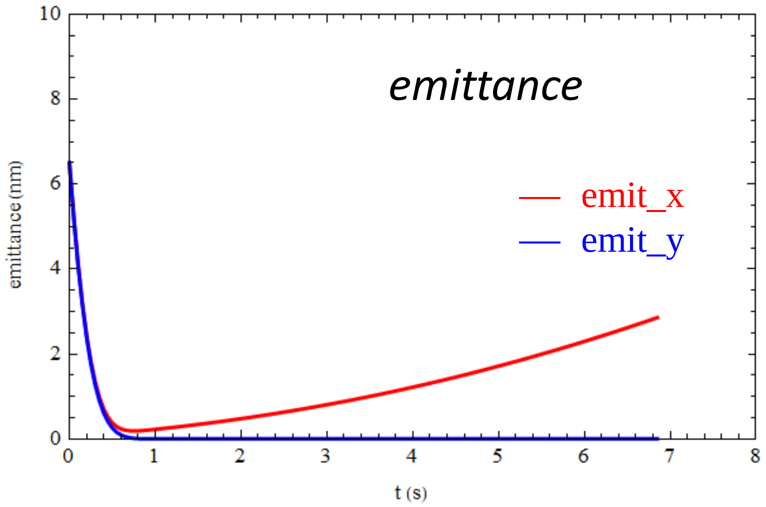
- Train num. @ booster = train num.@collider / 2
- Bootstrapping from 220mA (beam-beam stability)
- Injection speed of Linac: double bunch@100Hz

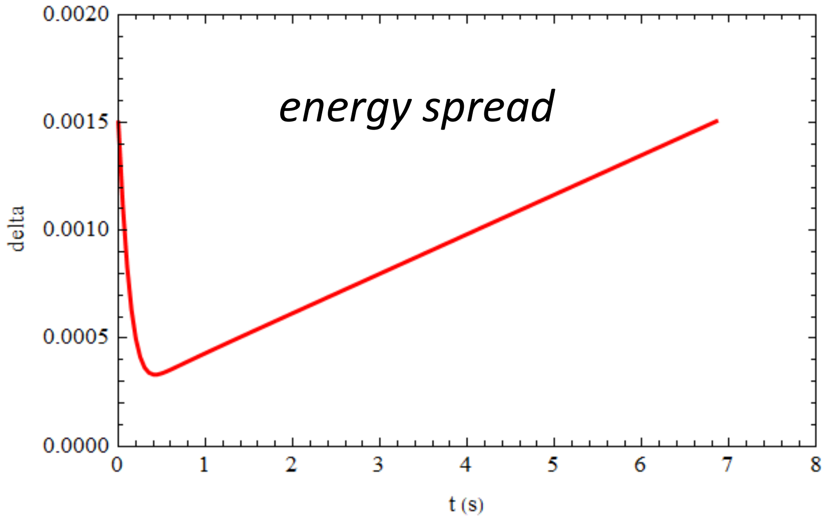


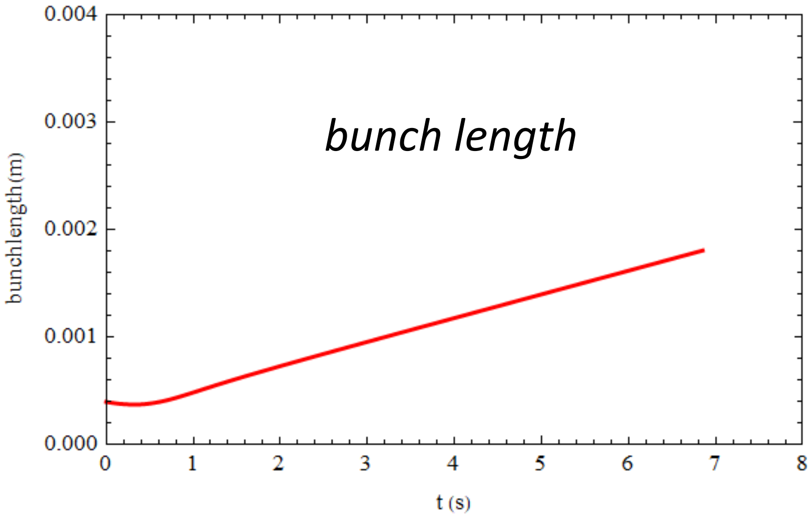
Beam parameter evolution

- Injection emittance: 6.5nm @30GeV
- Beam parameters reach balance after 45GeV.





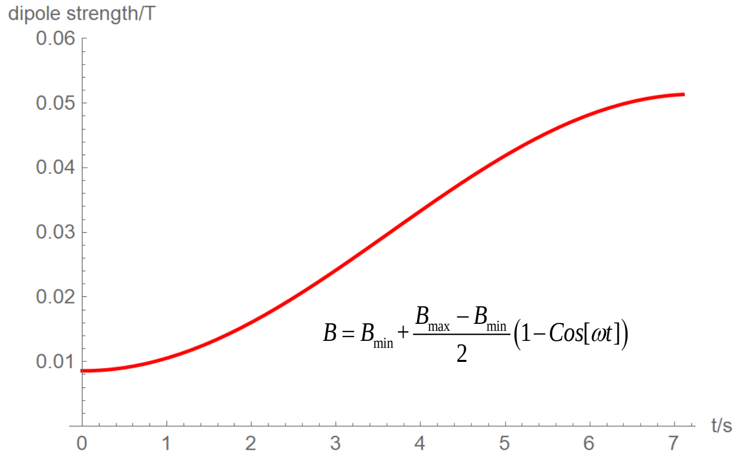




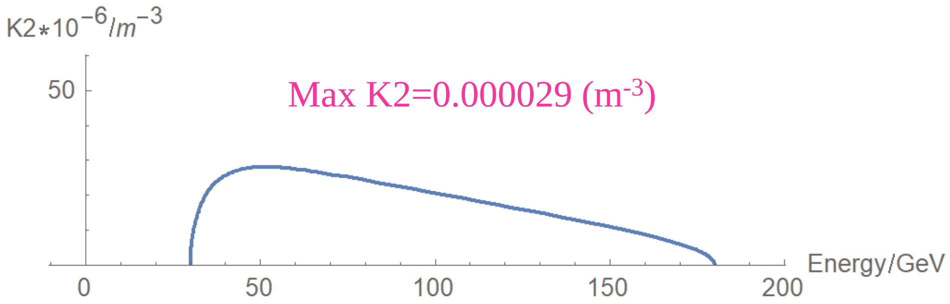
Eddy current effect

Dou Wang, Yuemei Peng, Daheng Ji

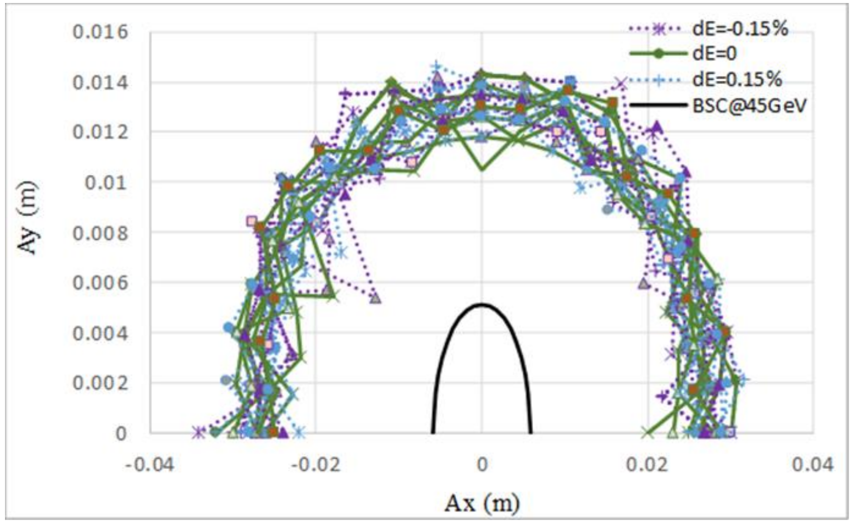
- Dedicated ramping curve to control the maximum K2.



- Analytical estimation for eddy effect*
- K2 reaches max at 45GeV.



- Al beam pipe (round shape)
  - inner diameter: 56mm, thickness: 2mm
- Dynamic chromaticity is not corrected.
  - Sextupole field is attached to dipole
- 30 GeV injection weaken the eddy effect
- Independent sext. (~100) — chromaticity adjustment

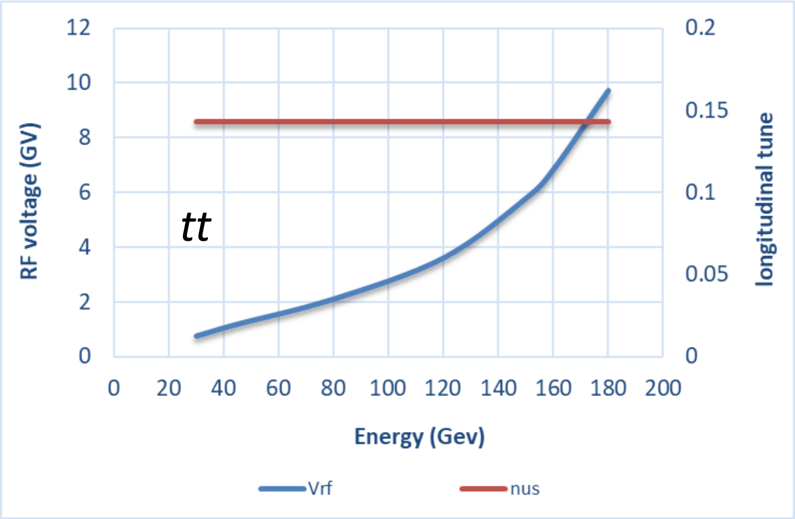


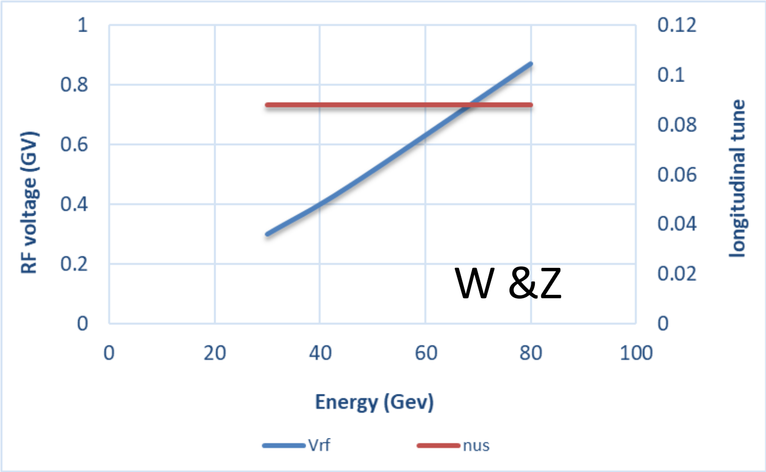
*Yuan Chen et al., Analytical expression development for eddy field and the beam dynamics effect on the CEPC booster, IJMPA, Vol. 36, No. 22 (2021) 2142010

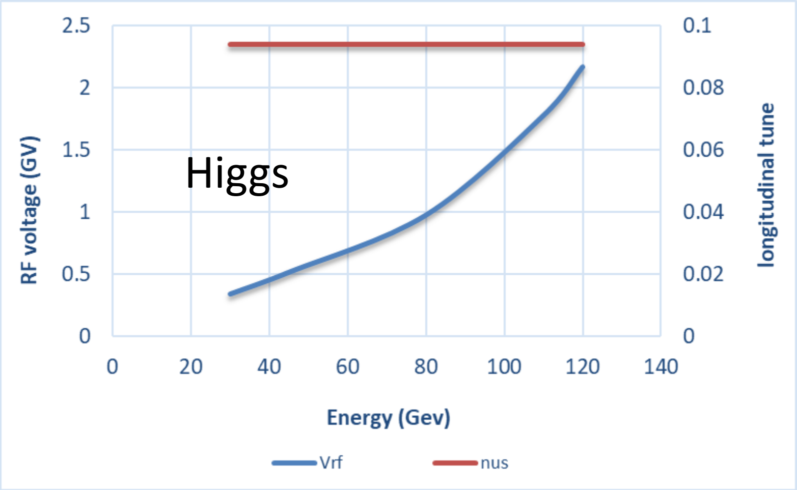
RF ramping curve

D. Wang, J.Y. Zhai

- Different RF ramping curve for each energy mode (constant νs)
  - νs for *tt*: 0.14
  - νs for Higgs: 0.094
  - νs for W & Z: 0.088
- Max RF voltage @*tt* determined by longitudinal quantum lifetime & DA.
  - η_{RF}: ~ 12 ×δ
  - VRF (180GeV)=9.8GV



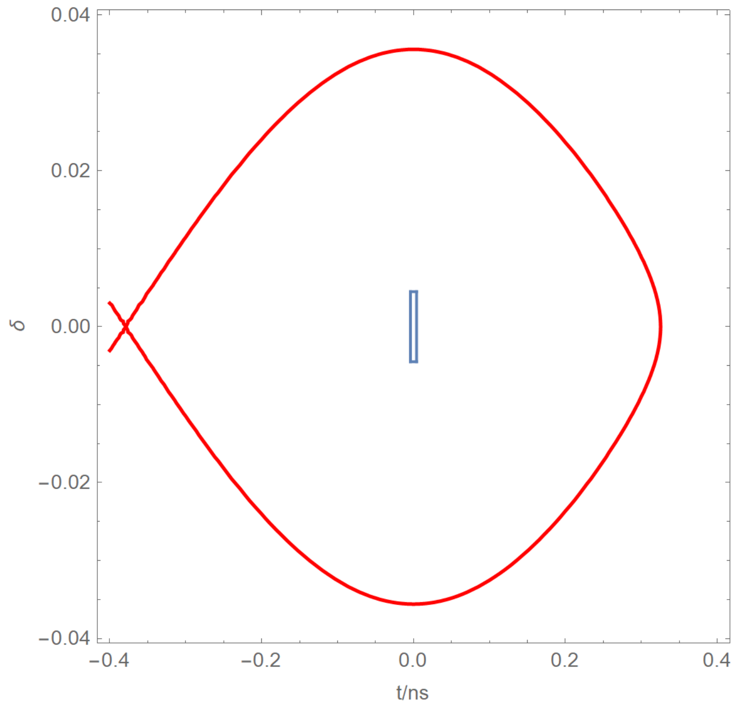




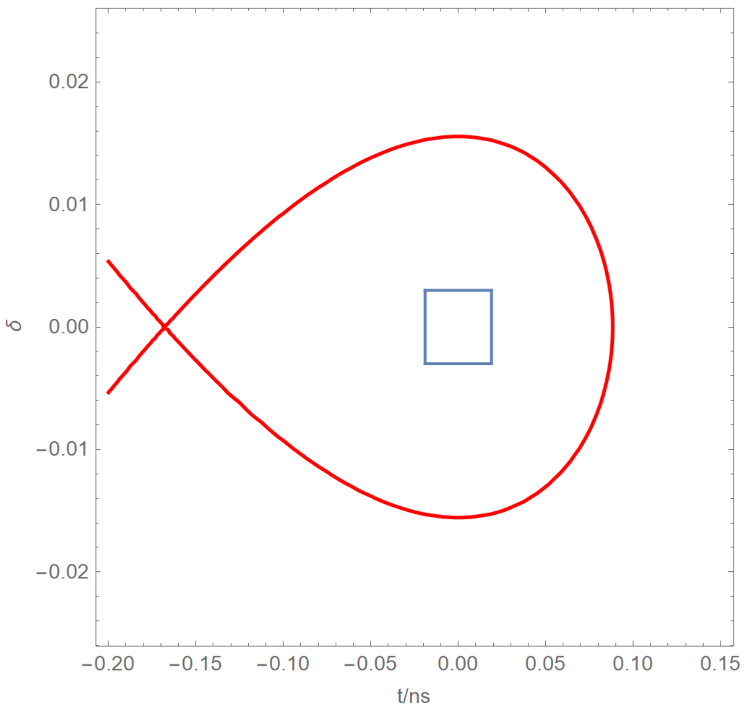
Longitudinal acceptance

- ±3 times of sigma for the longitudinal beam size and the energy spread

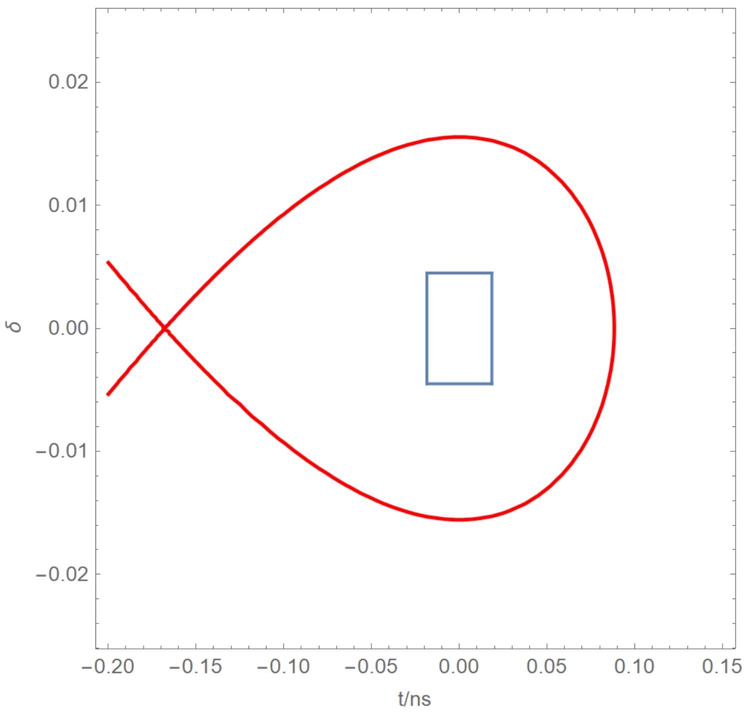
30GeV



120GeV



180GeV



Booster instability

Y. D. Liu, J. Y. Zhai, D. Yin, Y. F. Sui, J. H. Yue

- **30GeV:** Multi-bunch coupled instability
  - Growth time (Z mode) ~ 18ms (transverse) ~ 250ms (longitudinal)
  - Damping time of feedback
    ~ 10ms (transverse)
    ~ 200ms (longitudinal)
- **120GeV:** Single-bunch TMCI instability due to swap-out injection
  - Threshold of bunch current: 70uA (56mm aluminum chamber)
  - Maximum bunch current: 62uA

Optics parameter comparison

D. H. Ji, W. Kang

Lattice	FODO 0 （CDR）	TME (TDR-combine magnets)
Emittance X (nm) @120GeV	3.57	1.26
Momentum compaction (×10^{-5})	2.44	1.12
Tunes	[263.201/261.219]	[321.271/117.193]
Quad amount	2110	3458
Quad Strength (K1L rms)	0.0383	0.0259
Sext amount	512	100
Sexts Strength (K2L rms)	0.179	0.0492
H Corrector	1053	1218
V Corrector	1054	1220
BPM	2108	2400
Power consumption of magnets@120GeV (MW) (max/average)	15/6	12.1/4.8

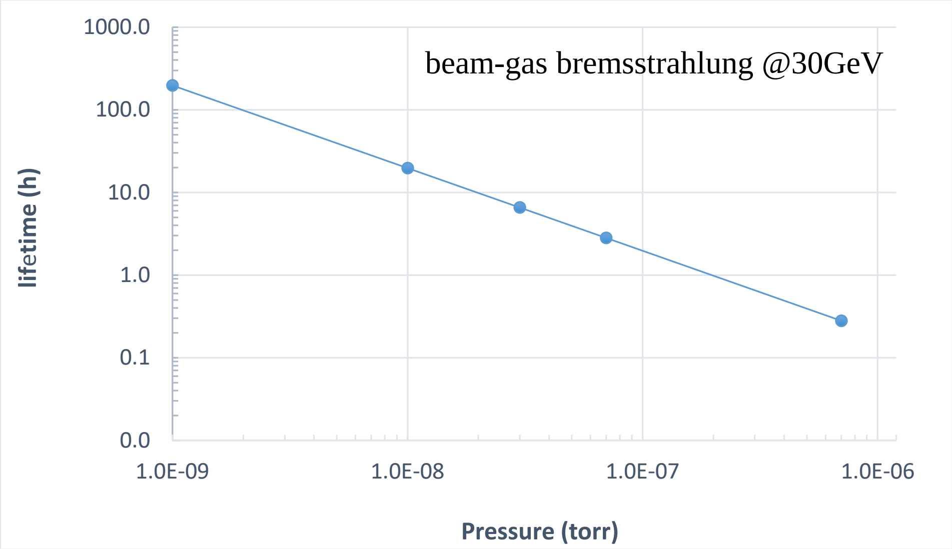
- TME is less sensitive to error effects
  - Weaker quad/sex strength
- TME has lower magnets' power consumption

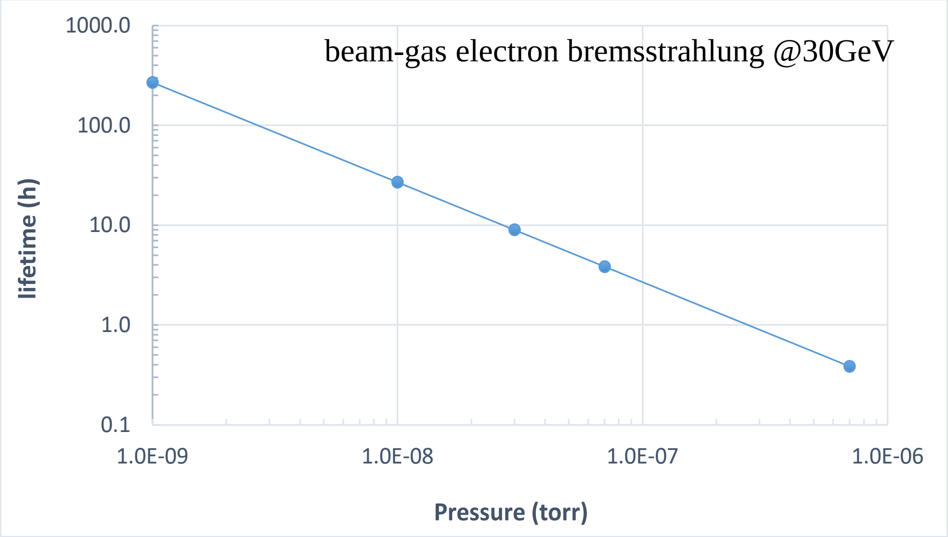
Vacuum requirement in booster

D. Wang, Y. S. Ma

	30GeV	45.5GeV	80GeV	120GeV	180GeV
P (ntorr)	30	30	30	30	40

- Vacuum lifetime at five energy > 3 hours (include 50MW upgrade)
- 30 GeV is the most demanding energy from the view of vacuum lifetime.





Booster TDR parameters

- Injection energy: 10GeV → 20GeV → 30GeV
- Max energy: 120GeV → 180GeV
- Lower emittance ─ new lattice (TME)

Injection		*tt*	*H*	*W*	*Z*	
Beam energy	GeV	30				
Bunch number		35	268	1297	3978	5967
Threshold of single bunch current	μA	8.68	6.3	5.8		
Threshold of beam current (limited by coupled bunch instability)	mA	97	106	100	93	96
Bunch charge	nC	1.1	0.78	0.81	0.87	0.9
Single bunch current	μA	3.4	2.3	2.4	2.65	2.69
Beam current	mA	0.12	0.62	3.1	10.5	16.0
Growth time (coupled bunch instability)	ms	2530	530	100	29.1	18.7
Energy spread	%	0.025				
Synchrotron radiation loss/turn	MeV	6.5				
Momentum compaction factor	10^{-5}	1.12				
Emittance	nm	0.076				
Natural chromaticity	H/V	-372/-269				
RF voltage	MV	761.0	346.0	300.0		
Betatron tune ν_x/ν_y		321.23/117.18				
Longitudinal tune		0.14	0.0943	0.0879		
RF energy acceptance	%	5.7	3.8	3.6		
Damping time	s	3.1				
Bunch length of linac beam	mm	0.4				
Energy spread of linac beam	%	0.15				
Emittance of linac beam	nm	6.5				

Extraction		*tt*	*H*		*W*	*Z*	
		Off axis injection	Off axis injection	On axis injection	Off axis injection	Off axis injection	
Beam energy	GeV	180	120		80	45.5	
Bunch number		35	268	261+7	1297	3978	5967
Maximum bunch charge	nC	0.99	0.7	20.3	0.73	0.8	0.81
Maximum single bunch current	μA	3.0	2.1	61.2	2.2	2.4	2.42
Threshold of single bunch current	μA	91.5	70		22.16	9.57	
Threshold of beam current (limited by RF system)	mA	0.3	1		4	16	
Beam current	mA	0.11	0.56	0.98	2.85	9.5	14.4
Growth time (coupled bunch instability)	ms	16611	2359	1215	297.8	49.5	31.6
Bunches per pulse of Linac		1	1		1	2	
Time for ramping up	s	7.1	4.3		2.4	1.0	
Injection duration for top-up (Both beams)	s	29.2	23.1	31.8	38.1	132.4	
Injection interval for top-up	s	65	38		155	153.5	
Current decay during injection interval		3%					
Energy spread	%	0.15	0.099		0.066	0.037	
Synchrotron radiation loss/turn	GeV	8.45	1.69		0.33	0.034	
Momentum compaction factor	10^{-5}	1.12					
Emittance	nm	2.83	1.26		0.56	0.19	
Natural chromaticity	H/V	-372/-269					
Betatron tune ν_x/ν_y		321.27/117.19					
RF voltage	GV	9.7	2.17		0.87	0.46	
Longitudinal tune		0.14	0.0943		0.0879	0.0879	
RF energy acceptance	%	1.78	1.59		2.6	3.4	
Damping time	ms	14.2	47.6		160.8	879	
Natural bunch length	mm	1.8	1.85		1.3	0.75	
Full injection from empty ring	h	0.1	0.14	0.16	0.27	1.8	0.8

*Diameter of beam pipe is 56mm for re-injection with high single bunch current @120GeV.

Content

- **Design status for CEPC Booster**
  - Booster design requirements in TDR
  - Booster TDR optics (including errors)
  - Timing structure & dynamic parameters during ramping
  - Summary of Booster TDR parameters
- **Design status for CEPC positron damping ring**
  - DR parameters
  - DR optics (including errors)
  - Particle tracking through the transport lines
- **Summary**

Damping ring design requirement

Dou Wang, Cai Meng

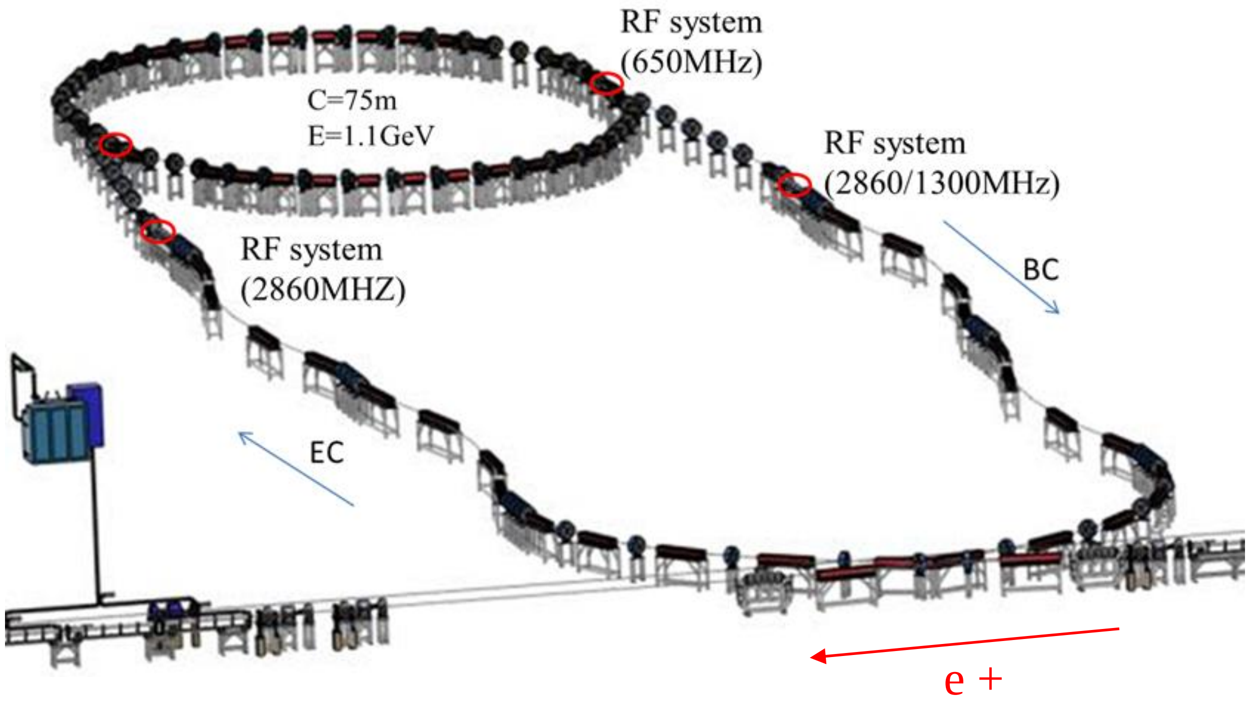
- lower emittance collider → lower emittance booster → lower emittance linac

	CDR	TDR	remark
Energy (GeV)	1.1	1.1	
Inj. Emittance (mm·mrad)	2500	2500	
Ext. emittance (mm·mrad)	530	<200	1) Linac lower emittance: 10nm@30GeV, 2)use C band acc. structure as early as possible
Storage time (ms)	20	20	
Damping time (ms)	15	<13	1) Smaller ext. emittance with same storage time
Circumference (m)	75	~150	1) Smaller nature emittance for DR

Damping ring layout (CDR)

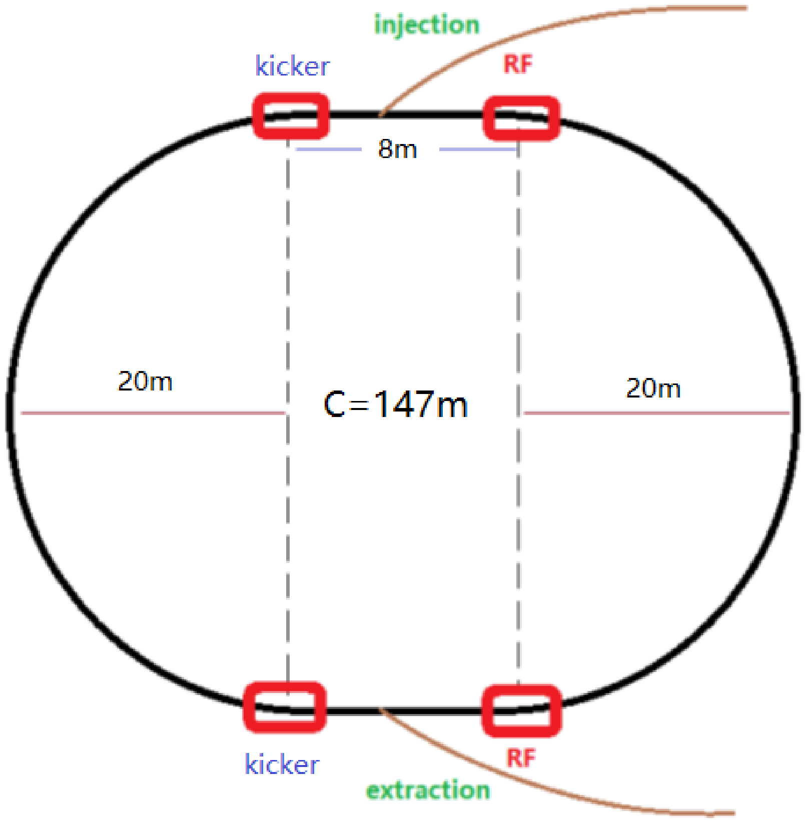
- Linac repetition: 100Hz
- Only for positron beam

- Storage time: 20 ms
- Emittance (norm.): 2500→ 530 mm.mrad



DR parameters in TDR

- Damping with **reversed bending magnet**
- 4 (max. 8)-bunch storage, storage time:20 (40) ms
- Emittance: 2500→ 166/75 (97/3) mm.mrad
- Flexibility for extr. emittance

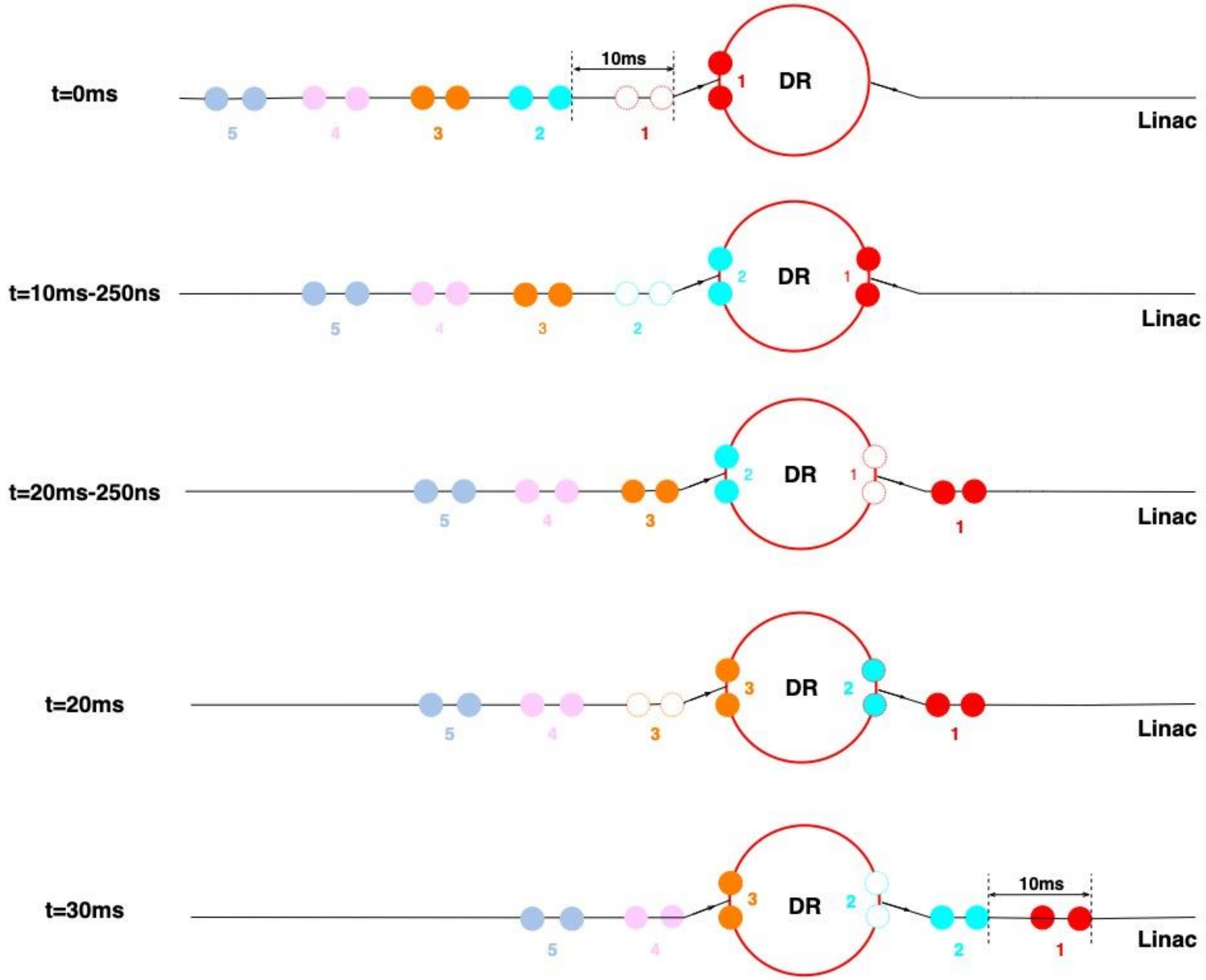


	DR V3.0
Energy (Gev)	1.1
Circumference (m)	147
Number of trains	2 (4)
Number of bunches/trian	2
Total current (mA)	12.4 (24.8)
Bending radius (m)	2.87
Dipole strength B_0 (T)	1.28
U_0 (kev/turn)	94.6
Damping time x/y/z (ms)	11.4/11.4/5.7
Phase/cell (degree)	60/60
Momentum compaction	0.013
Storage time (ms)	20 (40)
δ_0 (%)	0.056
ε_0 (mm.mrad)	94.4
injection σ_z (mm)	4.4
Extract σ_z (mm)	4.4
ε_{inj} (mm.mrad)	2500
$\varepsilon_{ext\ x/y}$ (mm.mrad)	166(97)/75(3)
δ_{inj} /δ_{ext} (%)	0.18 /0.056
Energy acceptance by RF(%)	1.8
f_{RF} (MHz)	650
V_{RF} (MV)	2.5
Longitudinal tune	0.0387

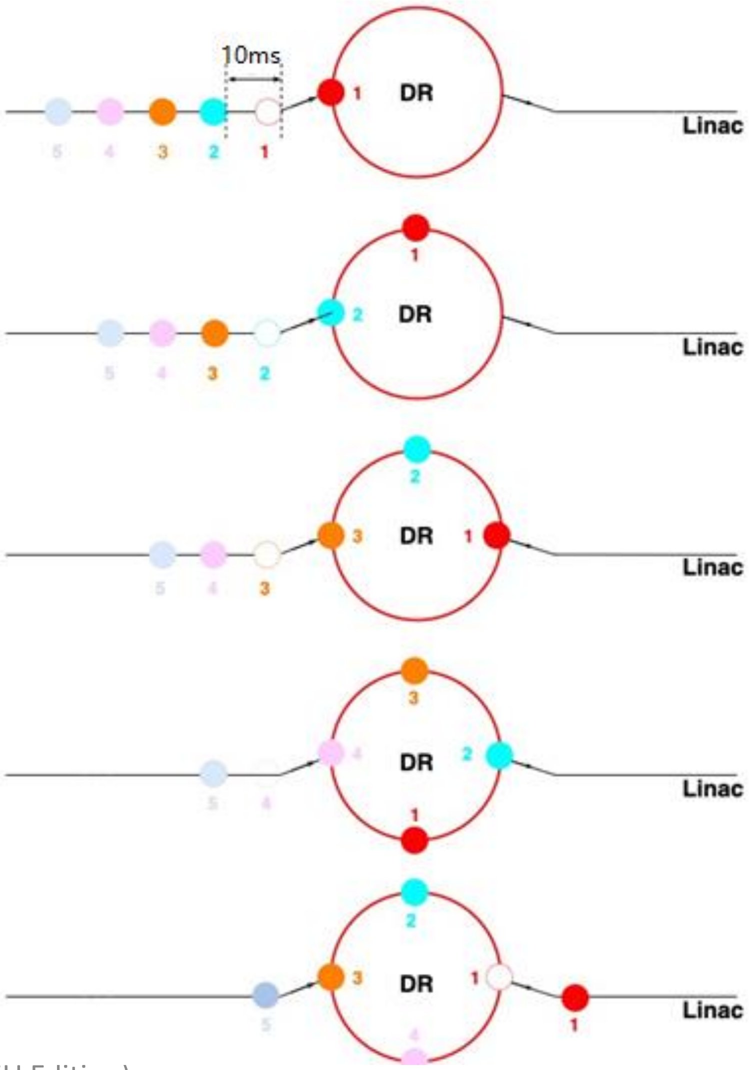
DR time structure

Xiaohao Cui, Cai Meng, Gang Li, Ge Lei, Jinhui Chen…

- Double bunch (Inj./Ext.: two by two) — at Z pole



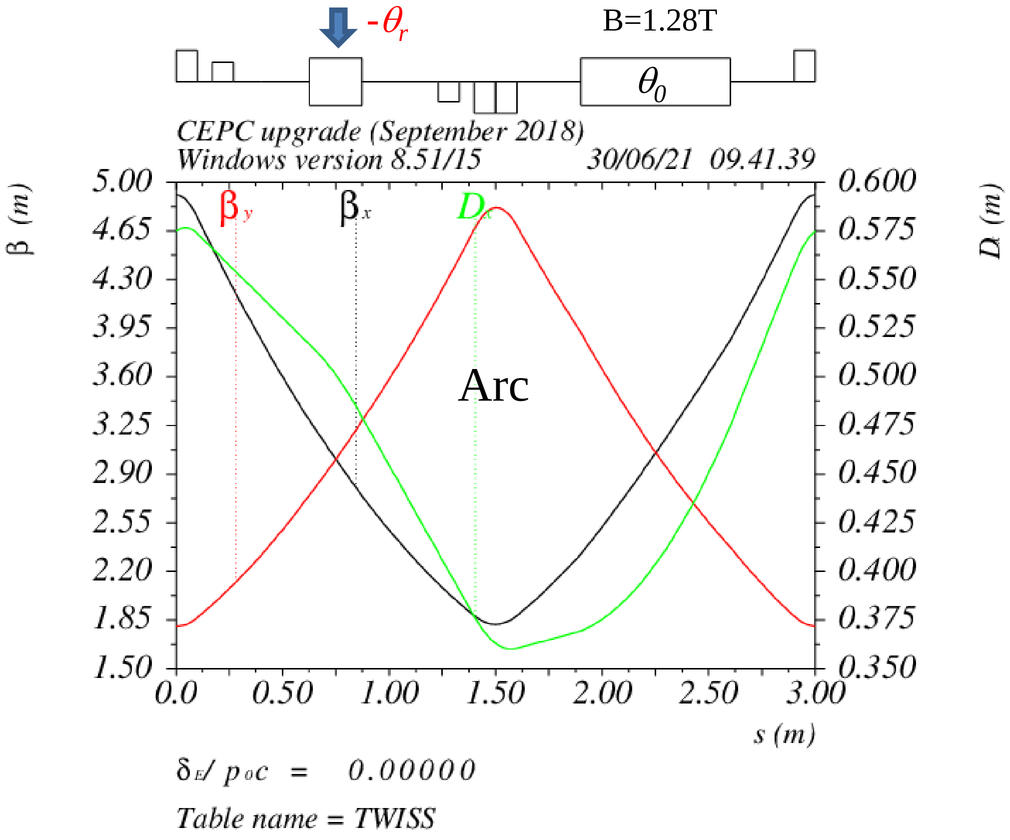
- tt/Higgs/W: 100Hz (Inj./Ext.: bunch by bunch)

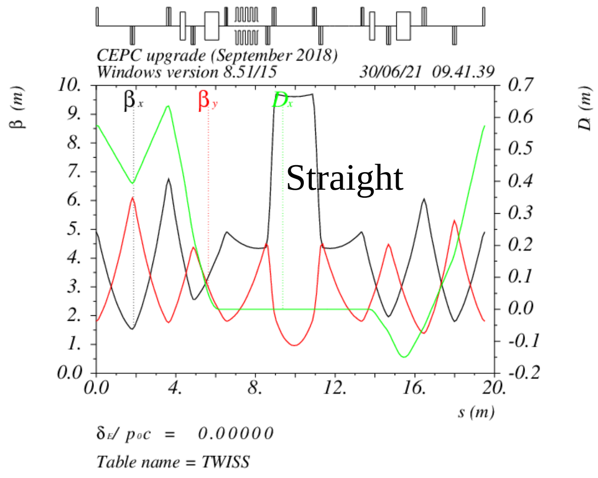


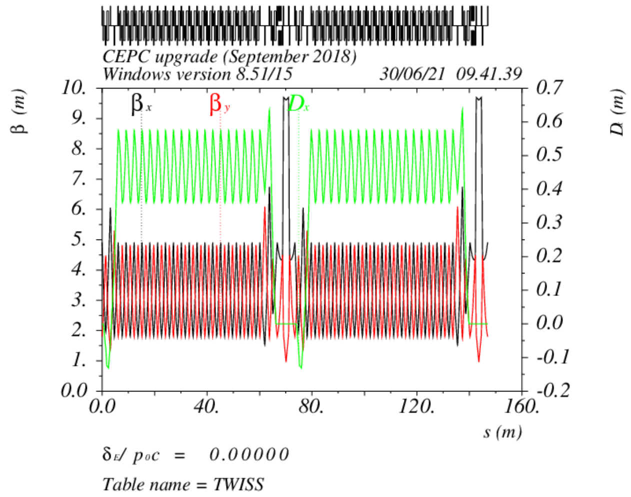
DR optics

- Phase/cell: 60°/60°
- Interleave sextupole scheme
- 2 sex. families

- Cell length: 3m
- B=1.28T
- θ_r/θ_0=0.355

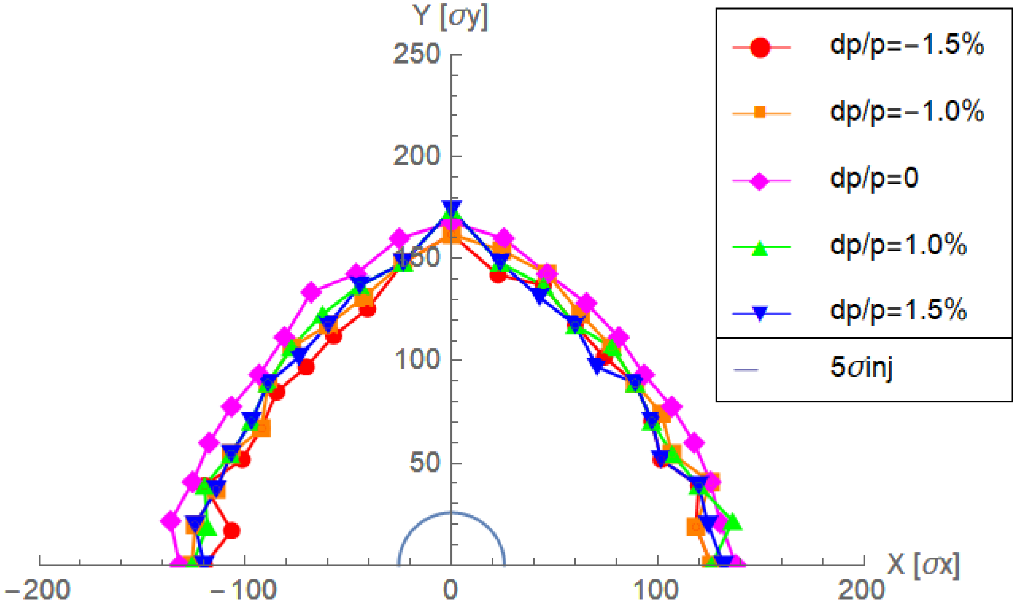






DR DA results

- Large trans. acceptance→ inj. efficiency
  - DA > 5 inj. beam size (ε_{inj}=2500mm.mrad)
  - Energy acceptance =1.8% (RF)



Phase/cell: 60°/60°

Error study for DR

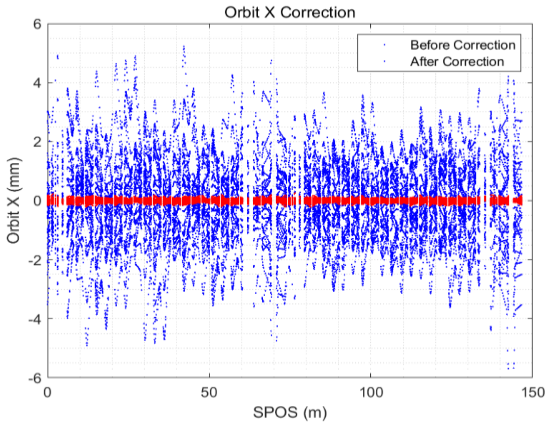
Daheng Ji, Dou Wang

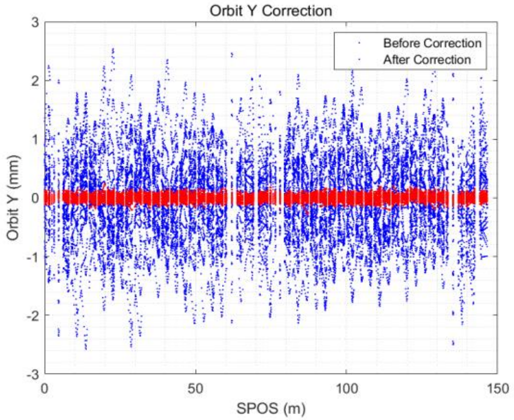
Parameters	Dipole	Quadrupole	Sextupole
Transverse shift X/Y (μm)	100	100	100
Longitudinal shift Z (μm)	100	150	100
Tilt about X/Y (mrad)	0.2	0.2	0.2
Tilt about Z (mrad)	0.1	0.2	0.1
Nominal field	1×10^{-3}	2×10^{-4}	3×10^{-4}

Parameters	BPM (10 Hz)
Accuracy (m)	1×10^{-7}
Tilt (mrad)	10
Gain	5%
Offset after beam based alignment (BBA) (mm)	30×10^{-3}

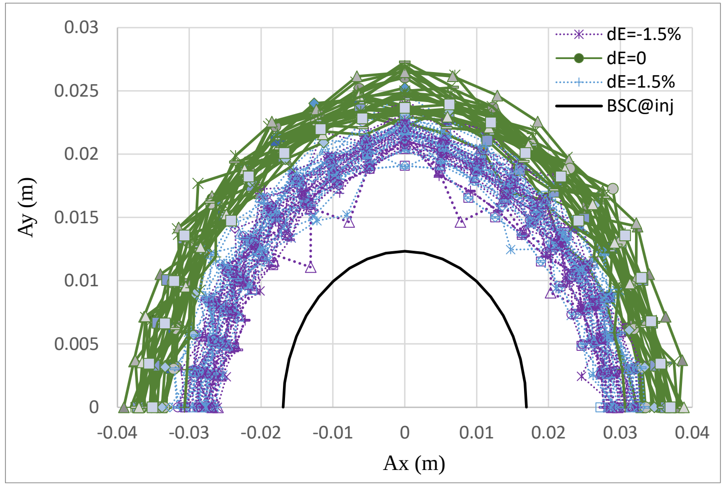
Dipole	Quadrupole	Sextupoles
$B_1 \le 2$		
$B_2 \le 3$	$B_2 \le 3$	
$B_3 \le 0.2$	$B_3 \le 2$	$B_3 \le 10$
$B_4 \le 0.8$	$B_4 \le 1$	$B_4 \le 3$
$B_5 \le 0.2$	$B_5 \le 1$	$B_5 \le 10$
$B_6 \le 0.8$	$B_6 \le 0.5$	$B_6 \le 3$
$B_7 \le 0.2$	$B_7 \le 0.5$	$B_7 \le 10$
$B_8 \le 0.8$	$B_8 \le 0.5$	$B_8 \le 3$
$B_9 \le 0.2$	$B_9 \le 0.5$	$B_9 \le 10$
$B_{10} \le 0.8$	$B_{10} \le 0.5$	$B_{10} \le 3$

- Orbit correction only



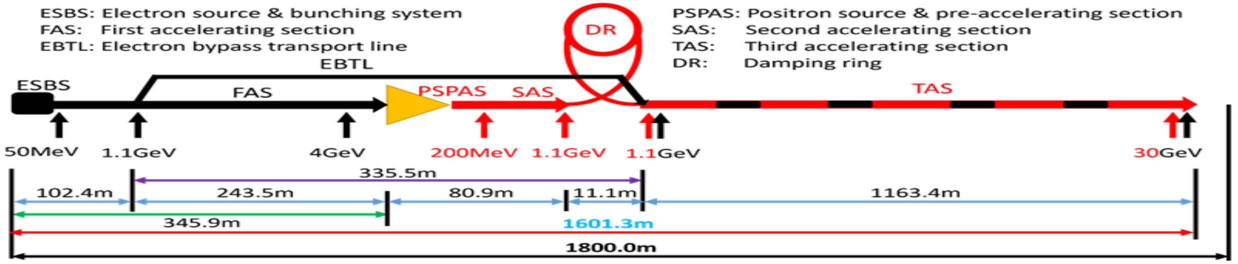


- $BSC_{x,y}=5\sigma_{inj\_x,y}+5\text{mm}$
- Energy acceptance: $8.3\delta_{inj}=1.5\%$



* refer to Daheng Ji' talk on this workshop

Transport lines between DR and Linac



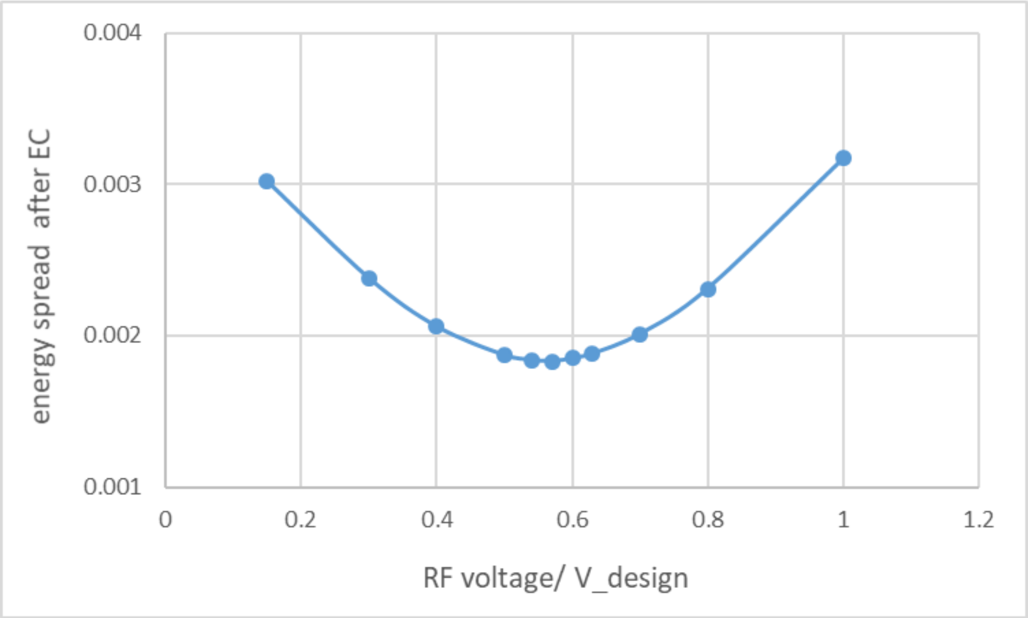
X. H. Cui, D. Wang

Linac→DR	EC
E_0 (Gev)	1.1
δ_0 (%)	0.5
σ_{z0} (mm)	1.5
f_{RF} (MHz)	2860
V_{RF} (MV)	16.5
Length of acc. Structure (m)	1.0
ϕ_{RF} (degree)	87
R_{56} (m)	-0.83
E_f (Gev)	1.1
δ_f (%)	0.18
σ_{zf} (mm)	4.4

DR→Linac	BC
E_0 (Gev)	1.1
δ_0 (%)	0.056
σ_{z0} (mm)	4.4
f_{RF} (MHz)	2860
V_{RF} (MV)	20.6
Length of acc. Structure (m)	0.76
ϕ_{RF} (degree)	89.7
R_{56} (m)	-0.89
E_f (Gev)	1.1
δ_f (%)	0.55
σ_{zf} (mm)	0.5

Optimization of the EC design

- We optimized the RF voltage of EC based on the particle tracking with realistic distributions of particles from the target.
- The injected energy spread at the entrance of DR is 0.185% (RMS).
- RF acceptance of DR is enlarged by a higher RF voltage (1.8%).

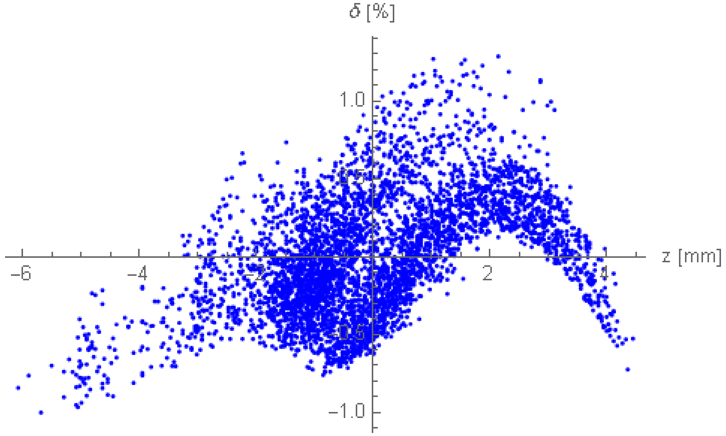


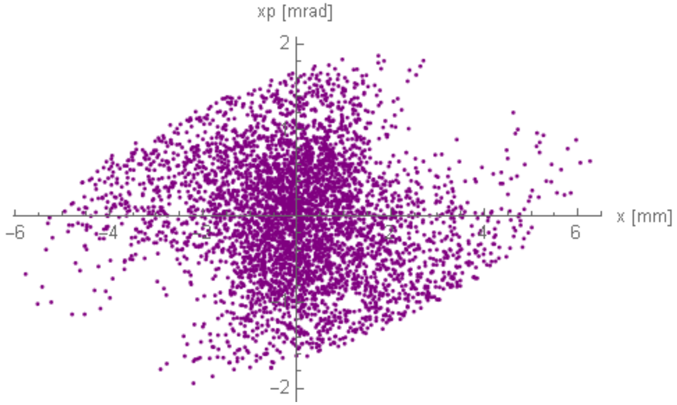
Particle tracking from Linac to DR (before ECS)

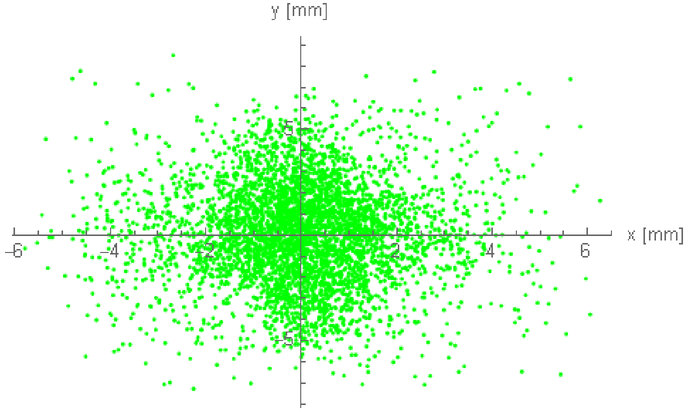
Cai Meng

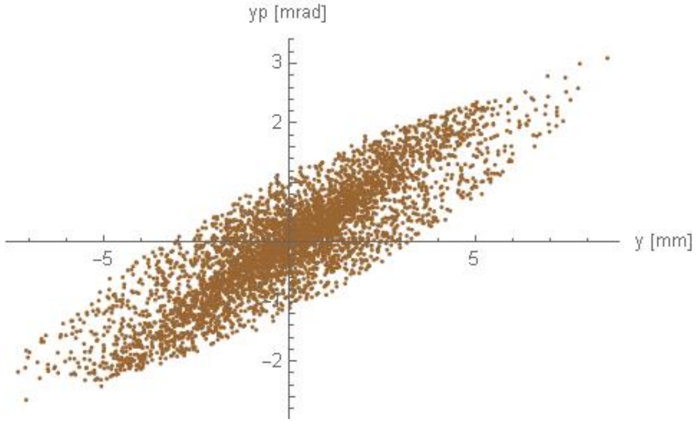
- Track by SAD (real distribution)
- Inj emittance: ~2500mm.mrad

- σ_0 :~1.5mm (RMS)
- δ_0 :~0.4% (RMS)







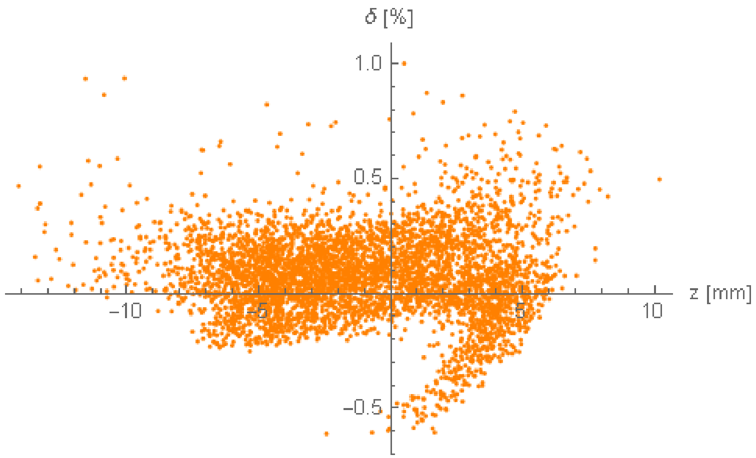


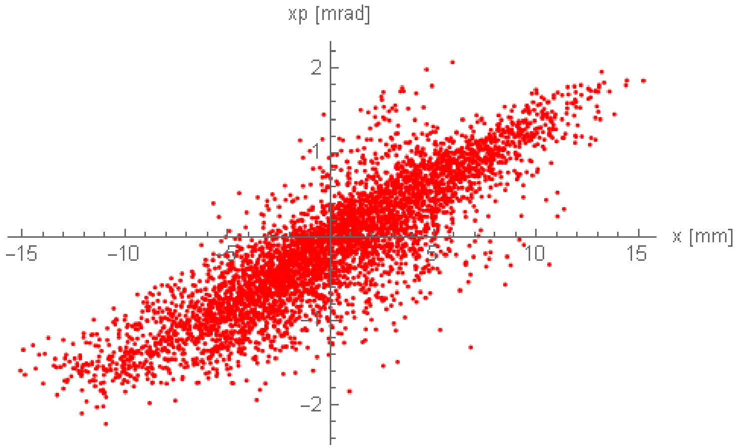
Particle tracking from Linac to DR (after ECS)

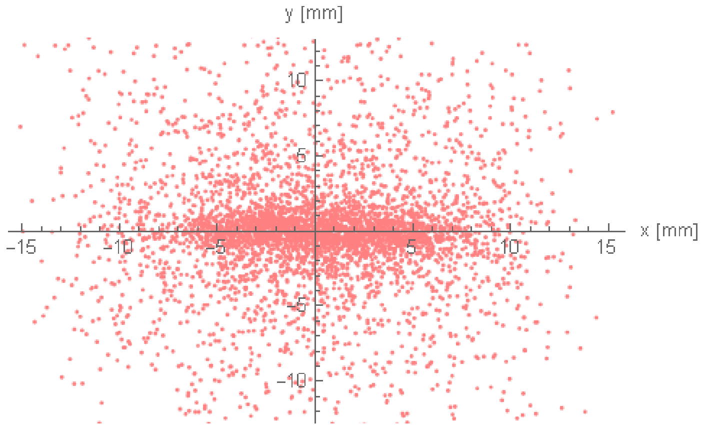
- Track by SAD (real distribution)
- Transporting efficiency: ~95%

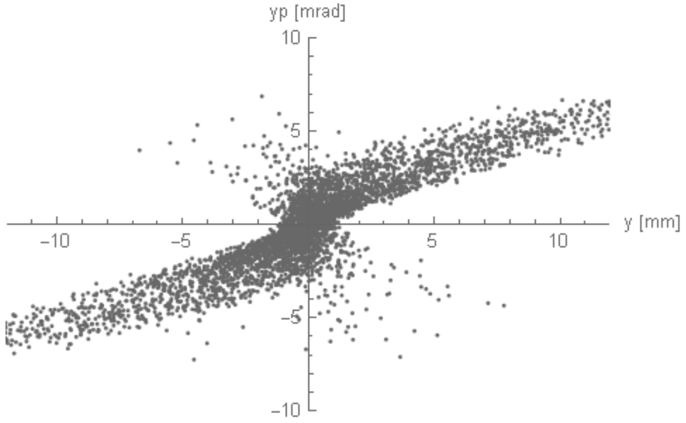
- σ_f :~ 4 mm (RMS)
- δ_f :~0.18% (RMS)

Dou Wang,
Xiaohao Cui,
Cai Meng









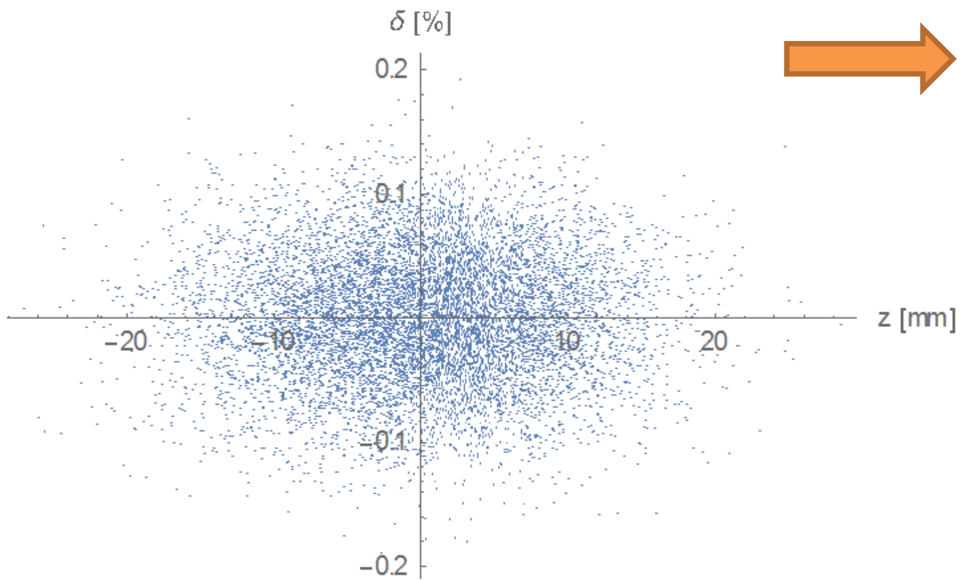
Particle tracking from DR to Linac

Dou Wang,
Xiaohao Cui

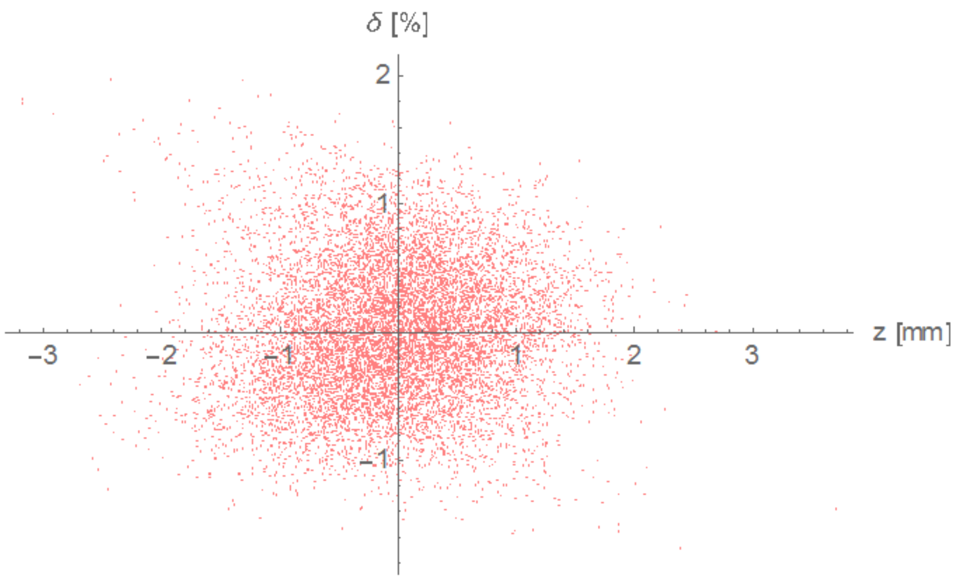
- Track by SAD (Guass distribution)
- Ext. emittance: 166 (H) /75 (V) mm.mrad

- σ_f :~ 0.5 mm (RMS)
- δ_f :~0.55% (RMS)

Initial



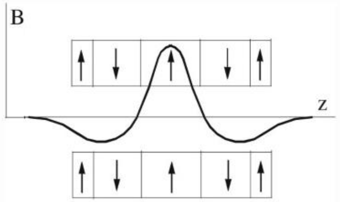
Final



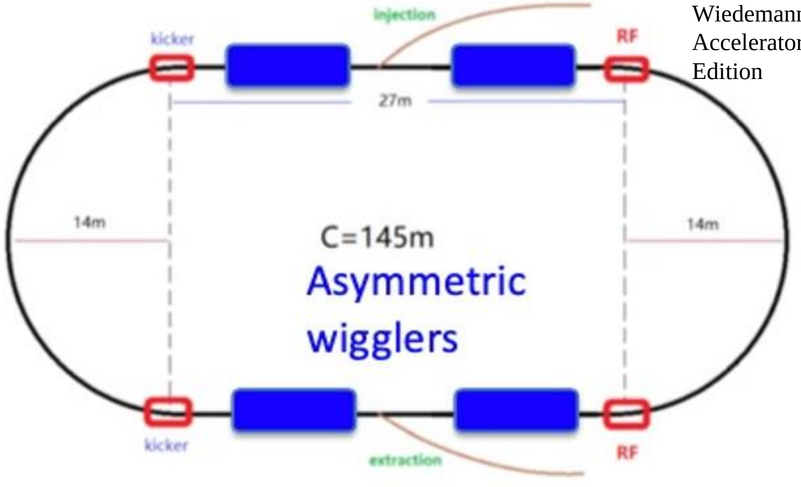
Alternative design for the DR with polarization

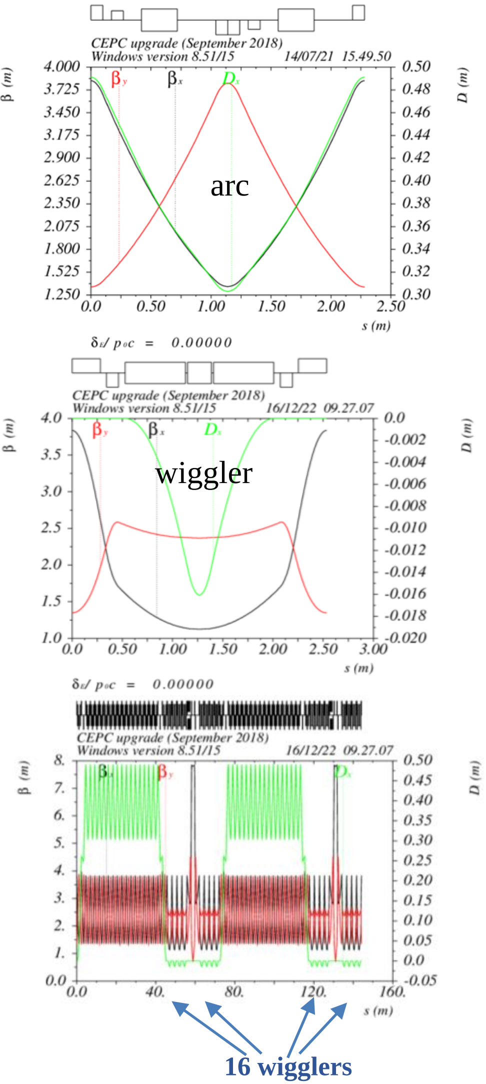
Z. Duan, D. Wang

- Produce polarized positron beam for the purpose of energy calibration @ Z & W*.
  - 10 min storage → ~20% polarization
- Compatible with standard top up operation
- Asymmetric wigglers
  - B_+=1.8T=5 B_-
  - cell length=1.5m



Wiedemann, Particl
Accelerator Physics
Edition





DR V4.0	unpolarized e+	polarized e+
Energy (Gev)	1.542	
Circumference (m)	145	
Number of trains	2(4)	
Number of bunches/trian	1(2)	
Total current (mA)	12.4	
Bending radius (m)	3.44	
Dipole strength B_0 (T)	1.5	
Wiggler strength B_+ (T)	1.8	
Wiggler cell length (m)	1.5	
U_0 (kev/turn)	190.9	
Damping time x/y/z (ms)	7.77/7.77/3.89	
Momentum compaction	0.015	
Storage time	20 ms	10 min
δ_0 (%)	0.072	
ε_0 (mm.mrad)	138	
injection σ_z (mm)	6	
Extract σ_z (mm)	5.7	5.6
ε_{inj} (mm.mrad)	2500	
$\varepsilon_{ext\ x/y}$ (mm.mrad)	150/15	138/14
$\delta_{inj}/\delta_{ext}$ (%)	0.18 /0.072	
RF acceptance (%)	1.8	
f_{RF} (MHz)	650	
V_{RF} (MV)	3.95	
Longitudinal tune	0.044	

* detail in Zhe Duan' talk on this workshop

Summary

- Booster energy range is modified in TDR. (10GeV/120GeV → 30GeV/180GeV)

- Update booster design with smaller emittance in TDR— support for CEPC high lum. scheme
  - TME structure with combined magnets (B+S)
  - Booster parameters update — consistent with CEPC TDR parameters at 4 energy
  - Booster design meets all energy mode requirements of collider (inc. error effects/SR/eddy current).

- Damping ring update is also the requirement of higher luminosity goal for TDR.
  - Circumference: ~150m, energy: 1.1GeV
  - Reversed bending, extracted emittance=97~166 mm·mrad (adjustable)
  - Damping time: 15ms (CDR) → 11ms (TDR)
  - DR design meets the requirements of Linac (inc. error effects).

Thanks for your attention!