

CEPC injection and extraction system

(Latest progress in EDR phase)

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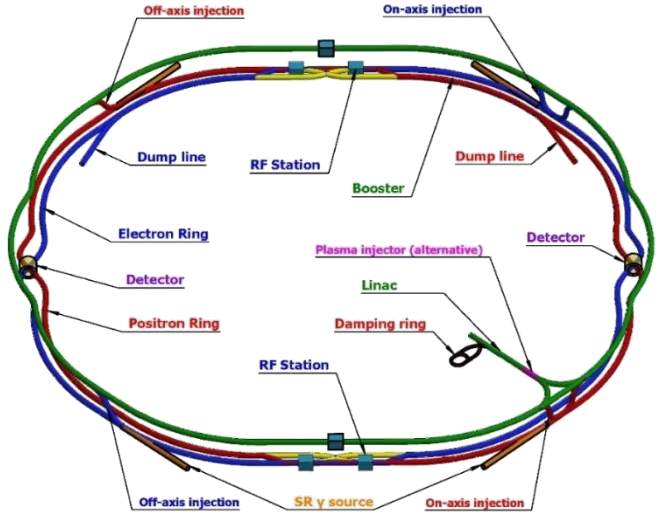
Content

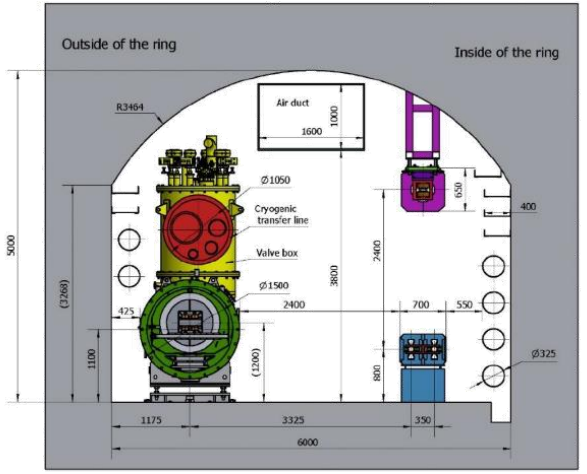
- Scope and overall progress status in EDR phase
- Design update of Septa in the EDR phase
- Design update of kicker systems in the EDR phase
- Alternative option of EMS
- Summary

Scope and overall progress status in EDR phase

Scope of the inj. & ext. system in CEPC

- The CEPC complex consists of 4 circular accelerators:
  - A damping ring (1.1GeV/147m)
  - A booster ring (30~120/180GeV/100km)
  - 2 storage rings (120/180GeV/100km)
- The 4 rings being linked with 10 injection and extraction sub-systems per beam:

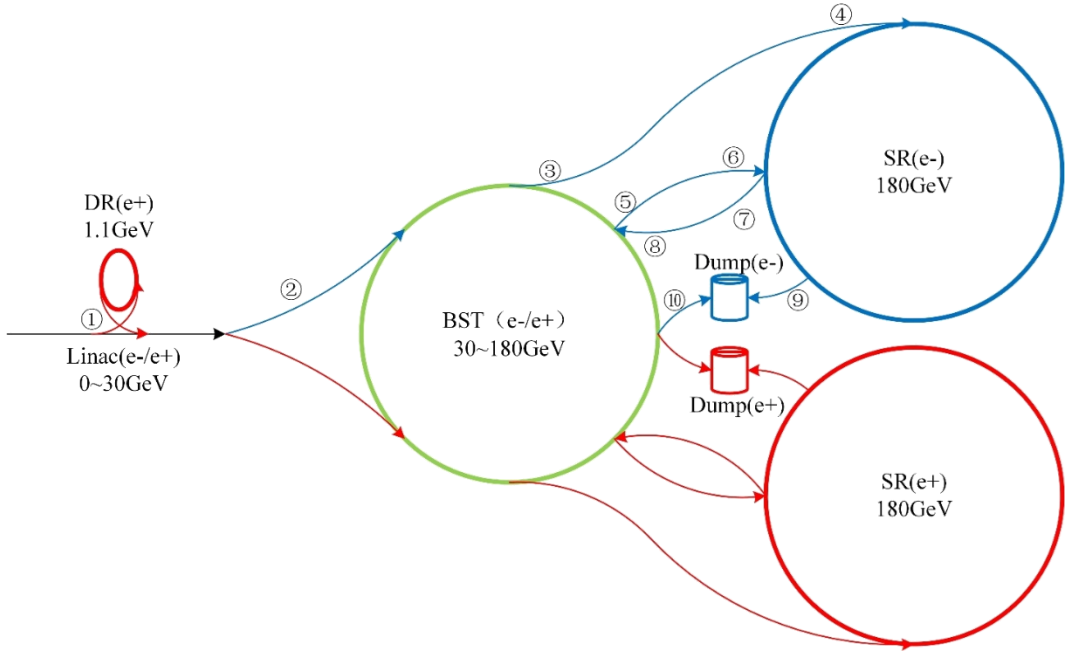




① DR injection and Extraction system(e+)
② Booster LE injection system (e+,e-)
③ Booster Extraction system1 (e+,e-)
④ Collider off-axis injection system (e+,e-)
⑤ Booster Extraction system2 (e+,e-)
⑥ Booster HE injection system (e+,e-)
⑦ Collider swap out injection system (e+,e-)
⑧ Collider swap out extraction system (e+,e-)
⑨ Collider beam dump system(e+,e-)
⑩ Booster beam dump system(e+,e-)

Off-axis injection (in W, Z and $t\bar{t}$ mode)

On-axis injection (only in Higgs mode)



Overall progress status in EDR phase

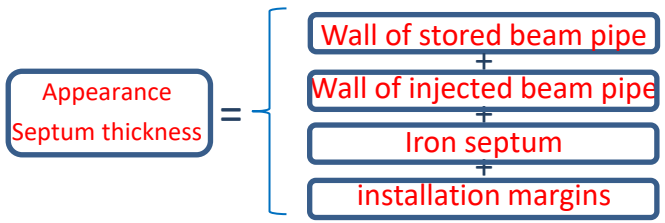
- 2025
  - The initial layout and survey iterative designs of all 10 inj. & ext. sub-systems have completed.
  - The preliminary physical designs and mechanical design of all septa and kickers have been completed.
- 2026
  - Further in-depth research on injection and extraction hardware:
    - Septa: the mechanical structures and manufacturing processes of the two types of septum magnets——in-air and half-in-vacuum Lambertson magnets
    - Kicker: Research on ferrite-core kickers, solid-state pulser schemes and metallic coated ceramic vacuum chambers
  - R&D on separation kicker system to replace Electrostatic-Magnetic Separator (EMS)

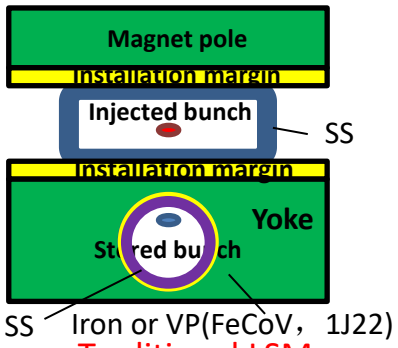
Septum magnets EDR design update

Contributed by Lihua Huo and Yongsheng Ma

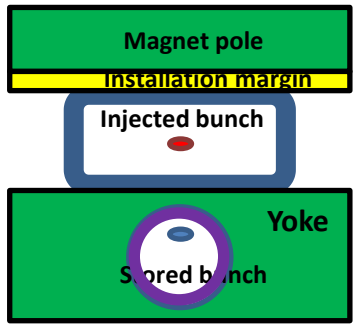
Physical requirements of all LSMs for CEPC

Subsystem	DR inj&ext	BST LE inj	BST HE ext. (off-axis)	BST HE ext. (on-axis)	BST HE re-injection	BST ext. to dump	CR off-axis injection	CR on-axis injection	CR on-axis extraction	CR ext. to dump
Operation mode	Z, W, Higgs, tt	Z, W, Higgs, tt	Z, W, Higgs, tt		Higgs, tt	Z, W, Higgs, tt	Z, W, Higgs, tt	Higgs, tt		Z, W, Higgs, tt
Max Energy （GeV）	1.1	30	180		180	180	180	180		180
Deflection direction	Horizontal	Horizontal	Vertical		Vertical	Horizontal	Vertical	Vertical		Horizontal
Total Integral field strength of septa (T-m)	0.44	4.5	12.6		12	12.6	11.68	11.6		12
Total deflection angle (m rad)	120	45	21		20	21	20	20		20
Deflection Radium (m)	4.167	133.333	800		800	800	800	800		800
Magnetic field strength for injected/extracted beam (T)	0.88	0.75	0.75		0.75	0.75	0.7/0.75	0.7/0.75		0.75
Total magnetic length (m)	0.5	6	16.8		16	16.8	16	16		16
Septum thickness (incl. septum board, inj./ext. beam pipe wall, installation gap) (mm)	6	10	10		10	5	2/3.5	2/3.5		5
Clearance of inj. & ext. beam at Lambertson (H×V) (w.r.t. inj. & ext. beam orbit) (mm)	30 × 22	30 ×30	10×5		10×5	10×10	9.2×4	6.6×4		7×6
Field uniformity in clearance of inj. & ext. beam	< ±0.05%	< ±0.05%	< ±0.05%		< ±0.05%	< ±0.05%	< ±0.05%	< ±0.05%		< ±0.05%
Clearance of stored beam at Lambertson (H×V) (w.r.t. stored beam orbit) (mm)	22 × 11	30 ×50	50 × 50		50 × 50	30 × 20	50 × 10	20 × 10		20 × 10
Integral leakage magnetic field / Integral main magnetic field	≤1×10-3	≤1×10-3	≤1×10-3		≤1×10-3	≤1×10-3	≤1×10-3	≤1×10-3		≤1×10-3
The leakage magnetic field position from septum plate in circulating tube (mm)	11	25	25		25	25	20	5.4		25

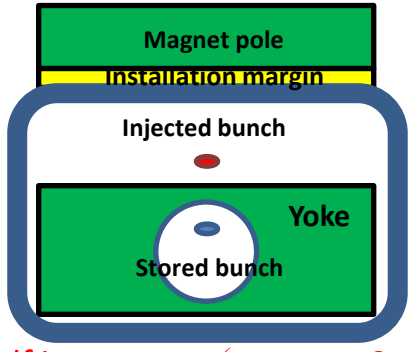




Traditional LSM



In-air（septum≥3.5mm）



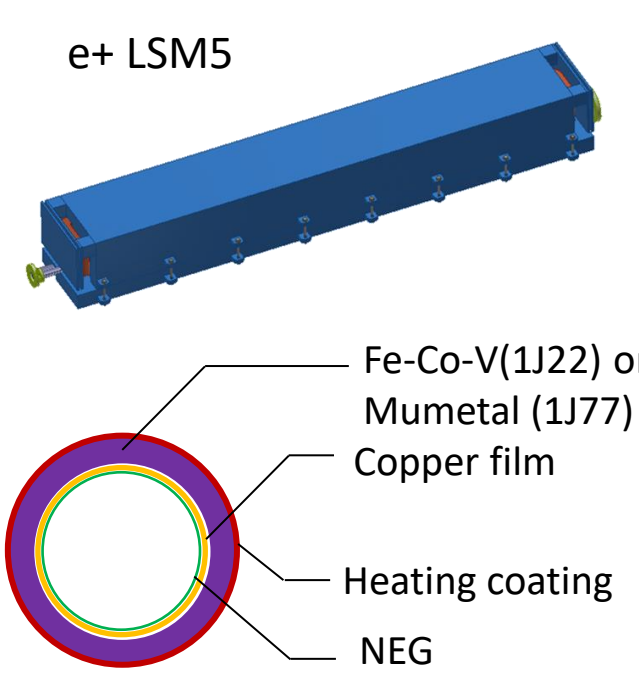
Half in-vacuum（septum=2mm）

In-Air Lambertson magnet (IA-LSM)

Progress: study on vacuum chamber of IA-LSM

- **Booster（BST）:**
  - No NEG coating
  - No in-situ baking
- **Collider Ring （CR）:**
  - NEG coating – in-situ activation baking at 180~230 °C
    - Conductive heating coating is under development (0.5 mm thick, ceramic/metal)
  - No NEG coating，conventional heating tape baking to 120 °C at magnet ends，the worst vacuum :
    - $t\bar{t}$: ~4.5 × 10^{-7} Torr
    - *Higgs* : ~2.5 × 10^{-8} Torr

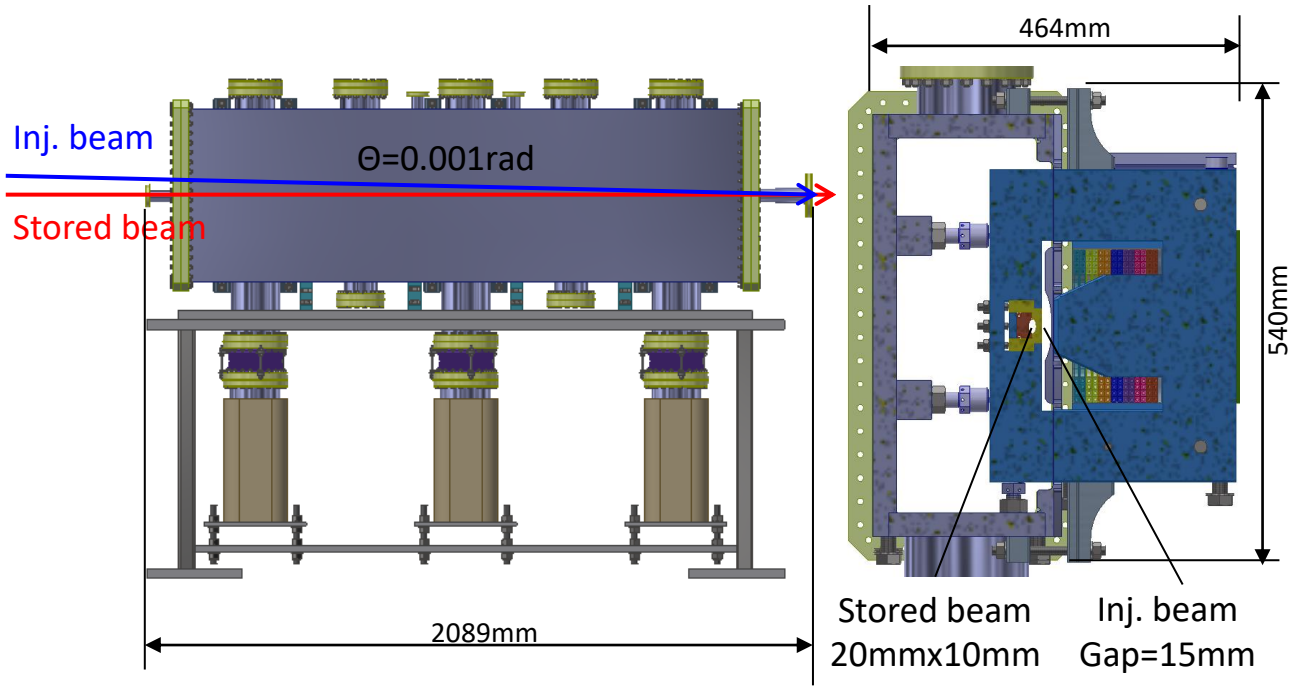
**** Courtesy of Yongsheng Ma***



In-air LSM in CR	CR off-axis inj.	CR on-axis inj.	CR on-axis ext.	CR ext.to dump
Quantity per beam	4	4	4	8
Length of vacuum pipe per magnet（m）	2.6	2.4	2.4	2.4
Total length in straight section （m）	12.4	11.6	11.6	22.8
Distance between magnets （m）	0.4	0.4	0.4	0.4
Quantity of vacuum pump	5	5	5	9
Ion pump （L/s）	100	100	100	100
Inner diameter of beam pipe（mm）	50	20	20	20
Thickness of vacuum pipe（mm）	0.7	0.7	0.7	0.7

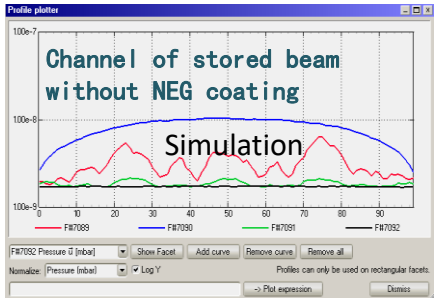
Half-In-Vacuum Lambertson magnet (HIV-LSM)

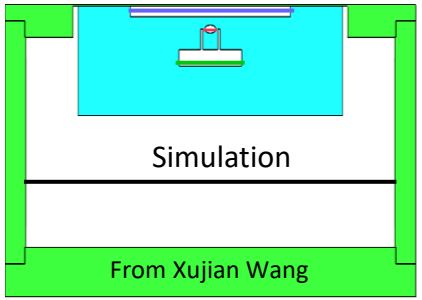
- **Progress:**
  - **Preliminary mechanical design of HIV-LSM updated**
  - **More technical details presented**
  - **In-situ baking and vacuum performance experience based on the HIV-LSMs for HEPS**



e+LSM1

HIV-LSM for HEPS







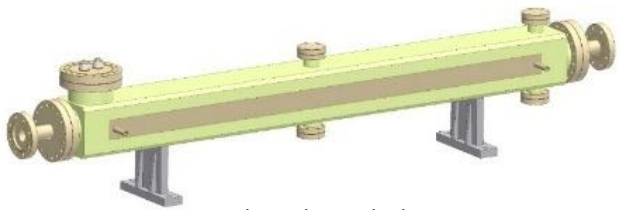
HEPS HIV- LSM	Measurement (Pa)	Simulation (Pa)	Requirements (Pa)	Pump Current (μA)
Vacuum chamber	5.0×10^{-8}	2×10^{-7}	$<6.0\times10^{-8}$	0.2, 0.3, 0.2, 0.3, 0.2, 0.1, 0.2, 0, 0.5, 0.4
End of vacuum pipe	2.2×10^{-7}	5×10^{-7}		

Kicker system EDR design update

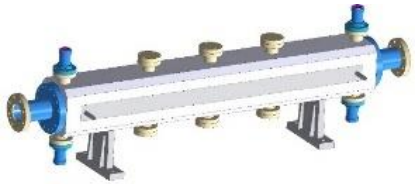
Contributed by Lei Wang, Guanjian Wu , Guanwen Wang

Kickers for CEPC injection & extraction

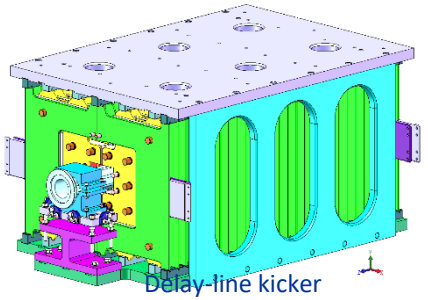
Type	Magnetic strength（T）	Total quantity
Slotted-pipe kicker	0.02095	2
Strip-line kicker	/	6
In-air delay-line dipole kicker	0.04	14
	0.02	8
In-air lumped inductance dipole kicker	0.035	14
	0.02	8
Total		52



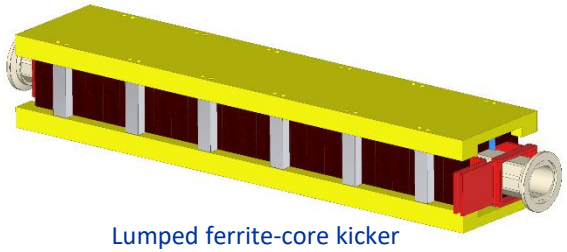
Slotted-pipe kicker



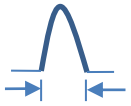
Strip-line kicker



Delay-line kicker



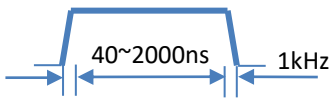
Lumped ferrite-core kicker

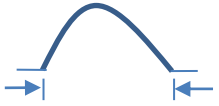


<245ns,1kHz



<50ns,1kHz





<1360ns,1kHz

Comparison between CEPC and FCC-ee

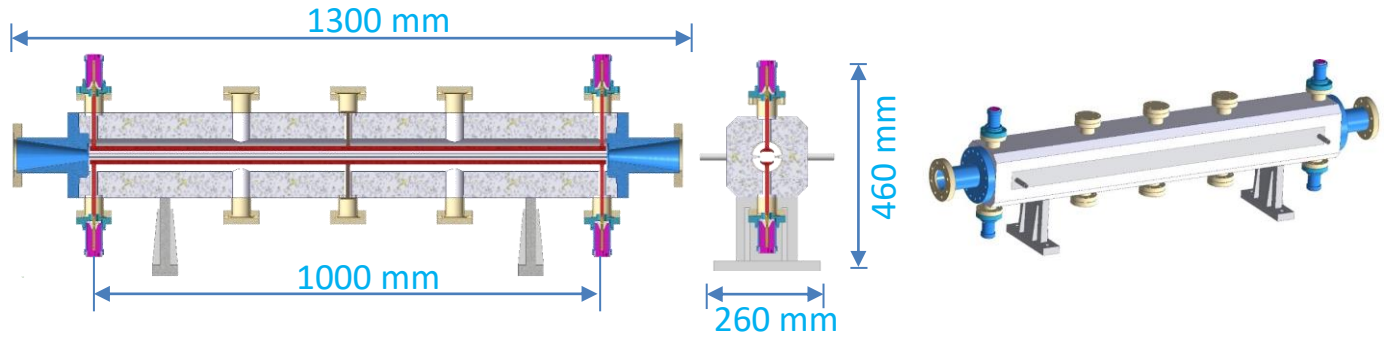
Facility		CEPC (TDR)	FCC-ee – (Feasibility Study Report)
Circumference of CR and BST		100 km	90.66 km
Quantity of sub-systems per beam		10	6
CR	**Top-up injection scheme**	$W/Z/ t\bar{t}$: Off-axis with 4-K bump or MIK Higgs: On-axis swap-out	On-axis off-energy injection with: 4-K bump or MIK for all modes
	Injection method	Train by train and bunch by bunch with high repetition rate of 1kHz	Full 1-turn injection with low repetition rate of 0.3Hz
	T_r/T_f of kicker system	<200ns	<600ns
	Flat Top of kicker system	40ns~2μs (adjustable)	304μs
	Types of kicker magnet	In-air distributed and lumped inductance kicker with ferrite core and ceramic vacuum chamber	In-air lumped inductance kicker with ferrite core and ceramic vacuum chamber
	Types of kicker pulser	Capacitor + solid-state switch (inductive adder)	PFN + solid-state switch (Marx generator)
BST	**LE injection method**	On-axis/bunch by bunch (min. bunch spacing=25ns)	On-axis/bunch by bunch (min. bunch spacing=25ns)
	LE Kicker system	Strip-line kicker + DSRD pulser (tr/tf<25ns)	Strip-line kicker + inductive adder pulser (tr/tf<25ns)
DR	**Injection and extraction**	On-axis/bunch by bunch	On-axis/bunch by bunch
	Kicker system	Slotted pipe kicker + inductive adder pulser(pw=245ns)	Strip-line kicker + inductive adder pulser(pw=244ns)

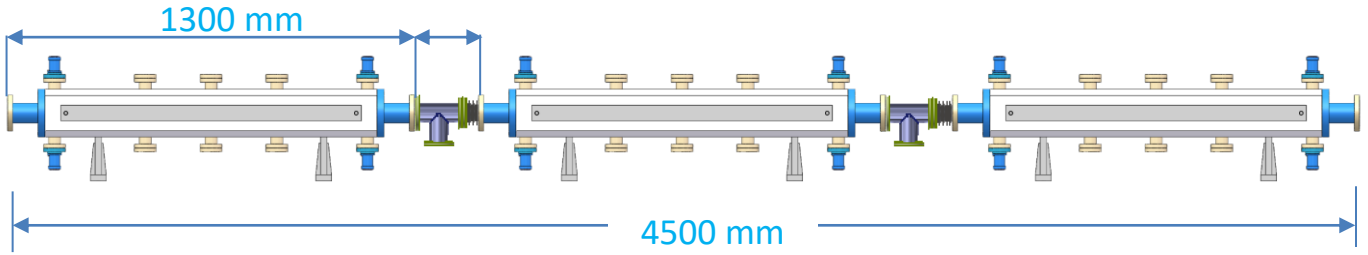
Solid-state pulser technologies

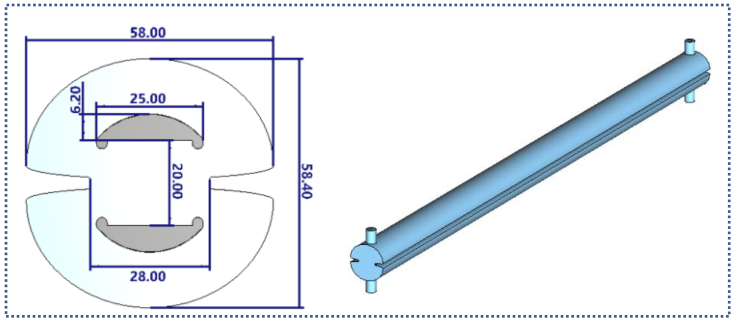
- Solid-state pulser are the only option for CEPC, due to high requirements:
  - High repetition rate = 1 kHz
  - Adjustable pulse width = 440~2400ns
  - Fast rise-time/fall-time = 25~200ns
- Although high-speed, high-power solid-state switches are not yet sufficiently mature. It is difficult to achieve all high indicators in a single device.
- Most special high-power solid-state switches are non-COTS (Commercial Off-The-Shelf) products：
  - COTS：SiC MOSFET （1.2kV/1.7kV/3.3kV…）, IGBT, IGCT…
  - Non-COTS: SGTO, LTMGT, FID, SOS, DSRD…
- CEPC pulser baseline designs: use COTS components wherever possible to avoid single-vendor risks.

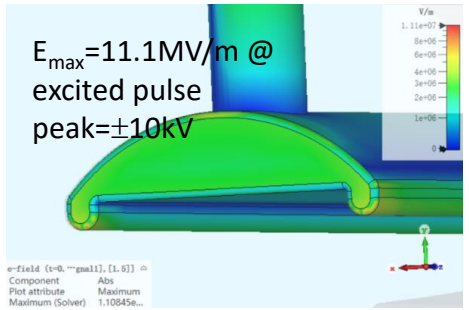
1）Strip-line kicker for BST LE injection

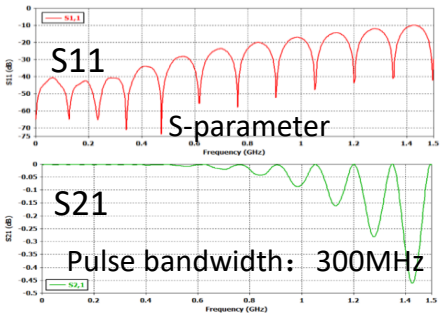
parameter	Unit	CEPC-BSTLEIK
Quantity	-	3 ×2
Type	-	Strip-line kicker
Deflect direction	-	Vertical
Beam Energy	GeV	30
Deflect angle of each magnet	mrad	0.0366(total 0.11)
Effective Length of Strip-line kicker electrode	mm	1000
Gap between two electrodes	mm	20
Odd mode impedance	Ω	50±1
Even mode impedance	Ω	<65
Clearance region(H×V)	mm	20×13
Good field region(H×V)	mm	10×12
Integral field uniformity	-	±1.5%
Amplitude of electrical pulse（into 50Ω）	kV	±10
Repetition rate	Hz	100
Amplitude repeatability	-	<2% (RMS)
Pulse jitter	ns	≤1
Bottom width of electrical pulse（3%-3%）	ns	< 43.3

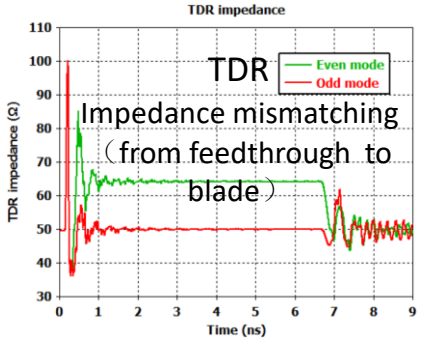


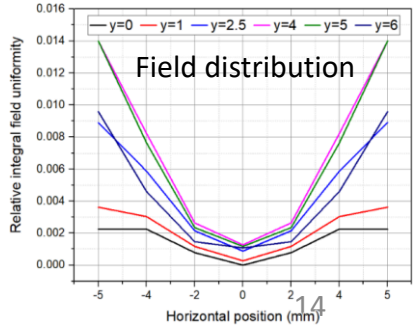








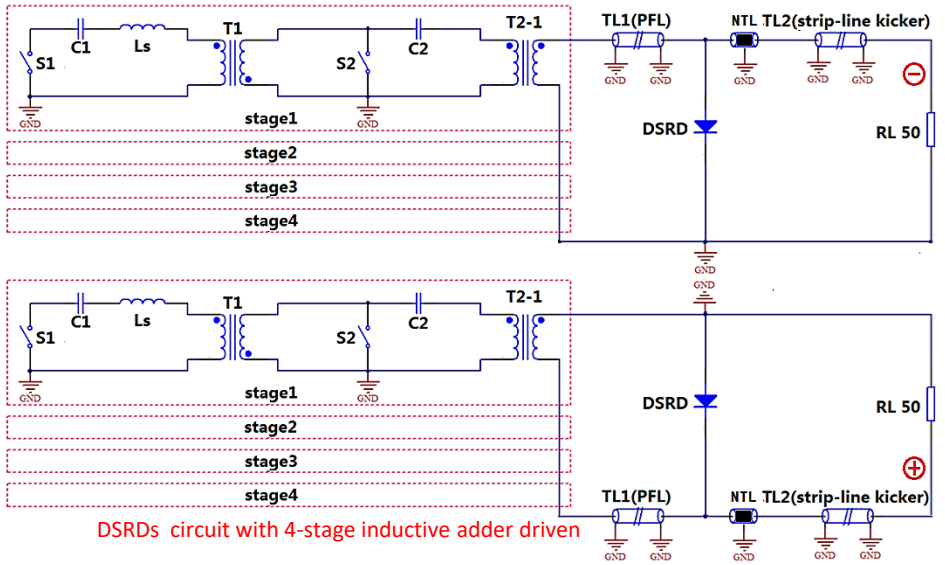




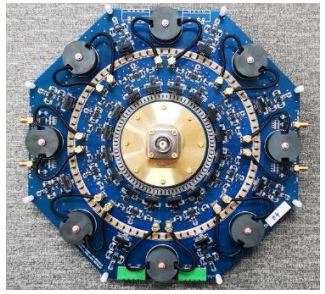
Super-fast pulser for strip-line kicker (HEPS)

- **Features**
  - Being based on DSRD（Drift Step Recovery Diode， Opening in sub-ns）
  - DSRD chips (i_p≥300A/ V_p=10kV) being from the domestic vender
  - Dual 4-stage inductive adders being designed as DSRD pumper to achieve ±18kV pulses

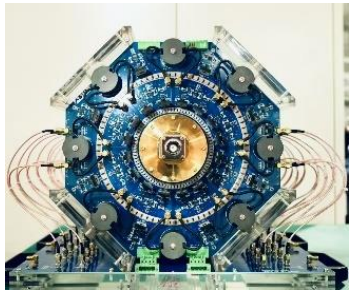
- All self-developed pulsers at HEPS have been operating well since Sept. 2024.
- Next step: to verify whether it can run at a high repetition rate for CEPC.



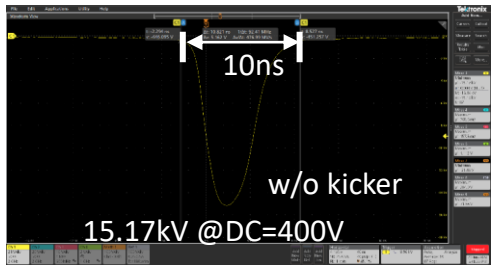
DSRDs circuit with 4-stage inductive adder driven

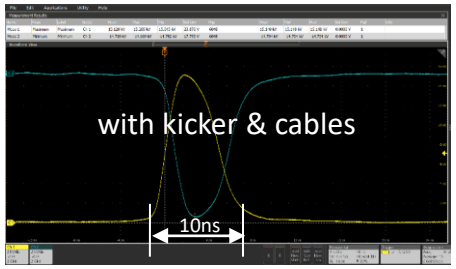


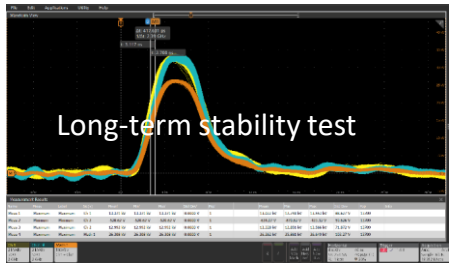


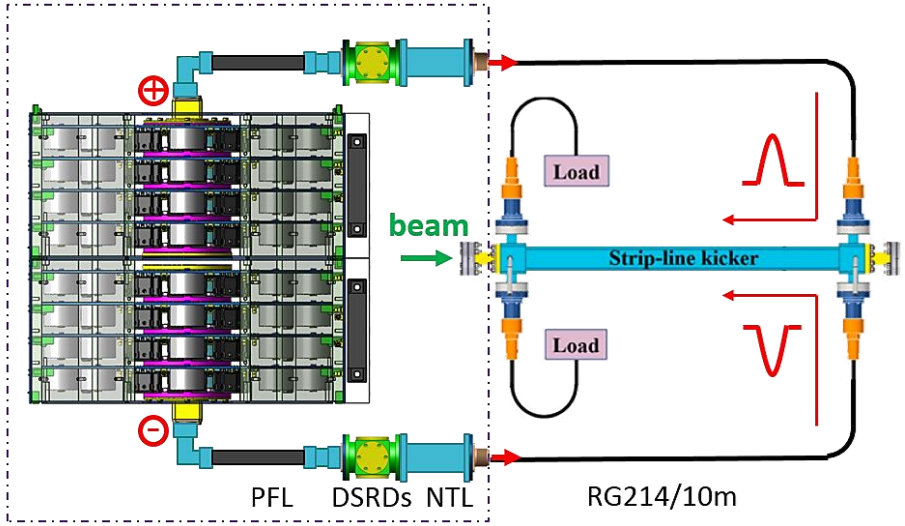






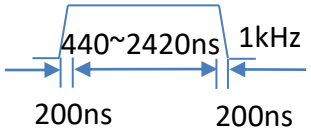






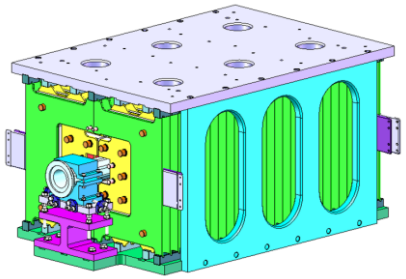
J.H. Chen, Strip-line kicker and fast pulser R&D for the HEPS on-axis injection system, NIMA 920(2019)1-6

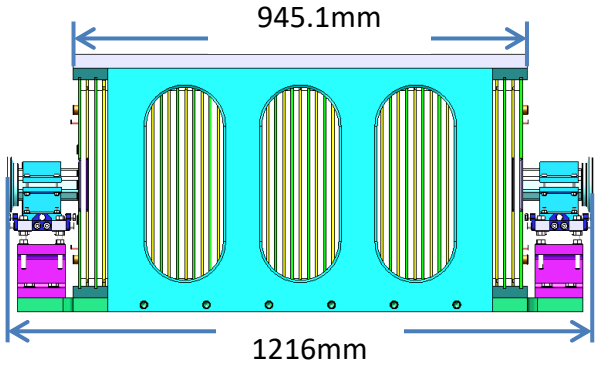
2） Delay-line kicker for CR off-axis inj.

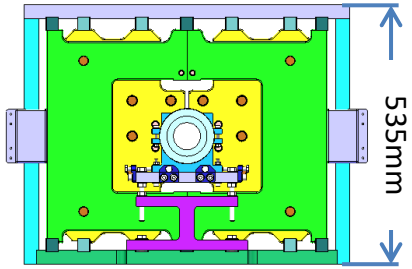


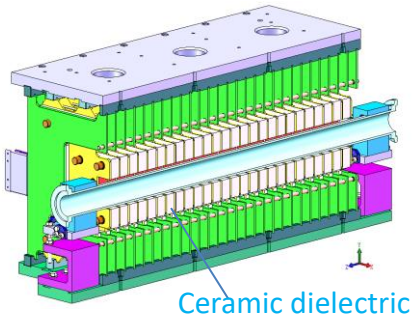
- Trapezoid kicker system: delay-line dipole kicker prefer
  - In-air magnet
  - Dual-C ferrite core
  - Ceramic dielectric capacitor
  - Ceramic vacuum chamber with TiN-Ag ladder-pattern film

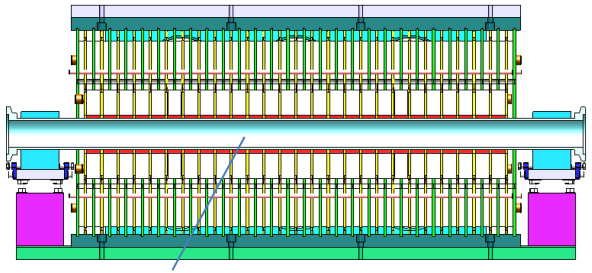
- Design update: In order to improve kicker system reliability, the operating voltage (maximum in air: < 30 kV) and excitation current have to be reduced.
  - Increase number of magnets to reduce the B-field strength and the excitation current.
  - Decrease vertical aperture of magnet and vacuum chamber, which is a trade-off with beam impedance.







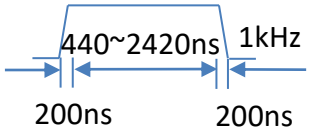




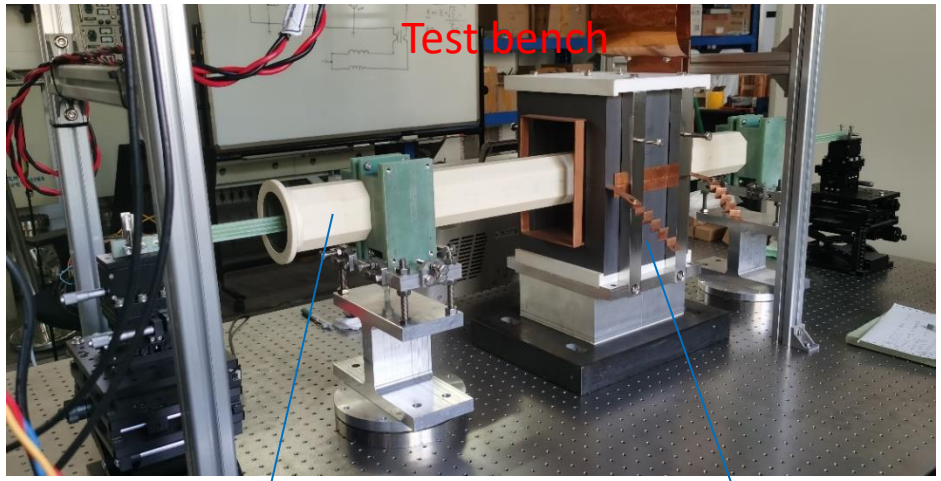


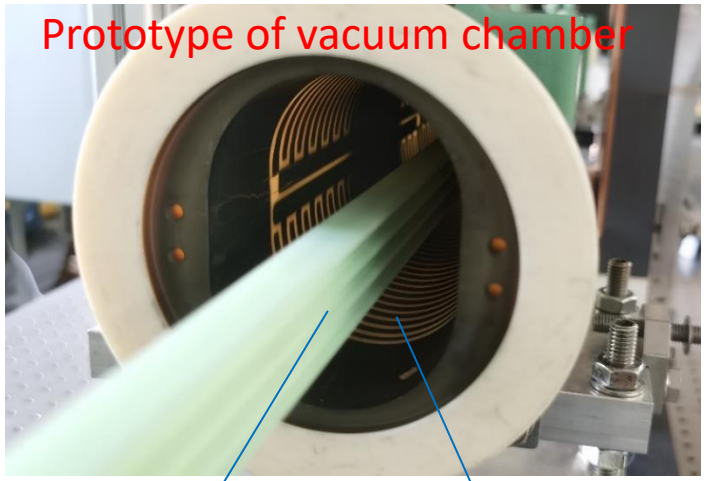
Delay-line kicker and pulser Parameter	Value (TDR)	Update
Aperture of magnet (mm)	100 × 80	
Longitudinal length of magnet cell (mm)	36	
Cell number of magnet	26	
Differential impedance of magnet (Ω)	12.5	
Length of magnet (mm)	942	
Total mechanical Length of magnet (mm)	1018	
Inductance of magnet cell (nH)	56.6	
Total inductance of magnet (nH)	1471.6	
Capacitance of magnet cell (pF)	362	
Total capacitance of magnet (nF)	9.412	
Magnetic strength (Gs)	425	
Exciting current of magnet (A)	2703	1352
Differential voltage of magnet (kV)	+/-16.96	+/-8.45
Pulse waveform	trapezoid	
Rise/fall time (ns)	200	
Flat-top width of pulse (ns)	40~2000 adjustable	
Filling time of magnet (ns)	117.728	
Rise/fall time of pulser (ns)	80	
Repetition rate (kHz)	1	

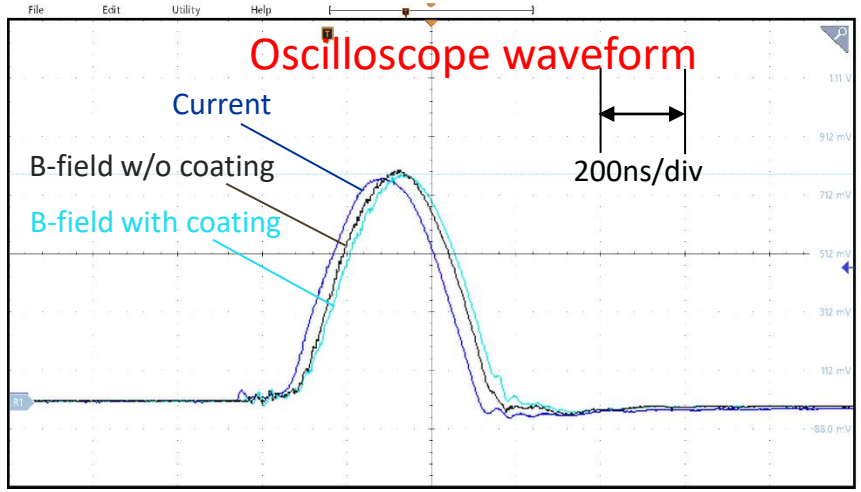
Ceramic vacuum chamber for delay-line kicker



- **Building a test bench to study the ladder-pattern metallic coating of ceramic vacuum chamber:**
  - Eddy-current shielding effect on pulsed magnetic field
  - Contribution to beam impedance
- **Due to limited funding: reuse the HV pulser retired from BEPCII (bottom width of sine-wave ≈ 450ns) and the kicker magnet prototype for CSNS.**
- **Preliminary measurement results show that the ladder-pattern metallic coating has a relatively small shielding effect on the pulsed magnetic field with rise-time of ~200ns.**

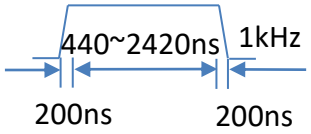




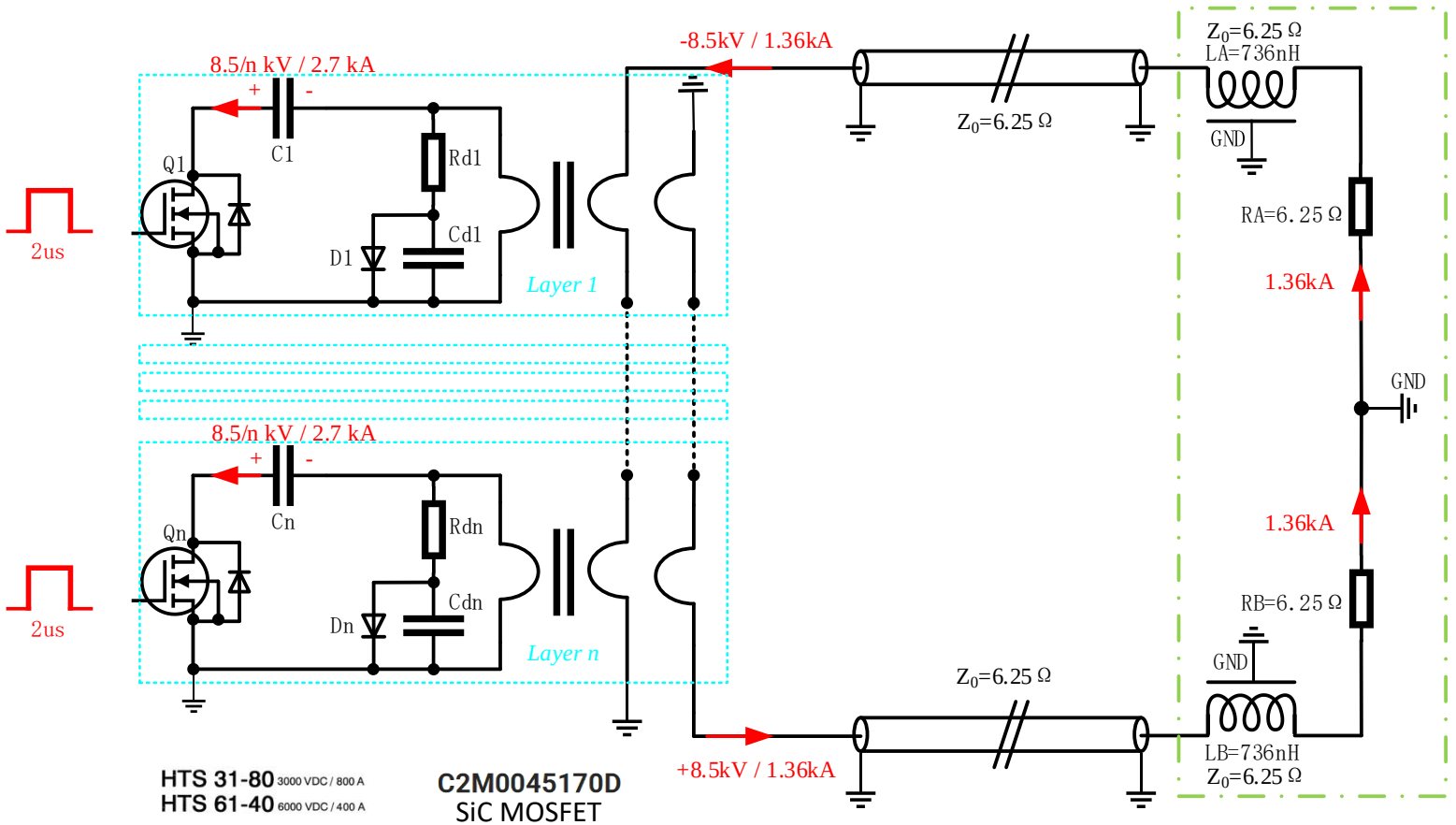


B-field comparison measurement by inductive coil and analog RC integrator

Trapezoid-wave pulser (inductive adder)



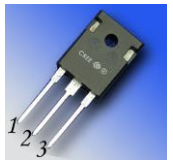
- **Features:**
  - The pulser located in the auxiliary tunnel (or alcove) adopts an inductive adder topology based on SiC MOSFETs.
  - The adder output is ±8.5kV/2.7kA, stage number is n.
  - MOSFET: U>8.5/n kV, I=2.7kA
  - Excitation current of kicker magnet is 1.36kA.
  - Half of the magnet: L=736nH, Z_0= 6.25Ω.
  - Kicker magnet operates in matching discharge mode.
  - Filling time of magnet is L/Z=117.76ns
  - Two 6.25 Ω HV RF cables, connect kicker and pulser.
  - A fast charging circuit for the energy-storage capacitors is needed to ensure 1 kHz high-repetition-rate operation.





Ton/Toff=12ns/35ns

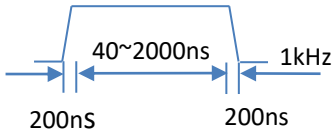
C2M0045170D
SiC MOSFET
1700V/72A



Ton/Toff=20ns/18ns

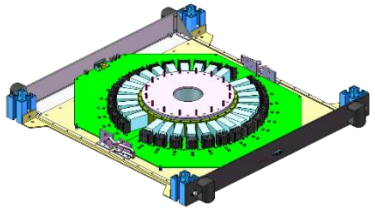
$$t_r = \sqrt{t_{ir}^2 + \left(\frac{L}{R}\right)^2}$$

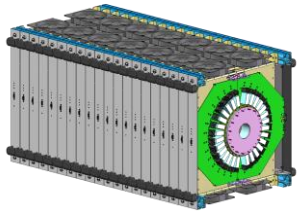
Inductive adder R&D activities



- **Status：** An 18-stage inductive adder prototype based on SiC MOSFET was developed in TDR phase, but the overall scheme has not yet been fully validated—especially for high repetition rate = 1kHz— due to a lack of funding.

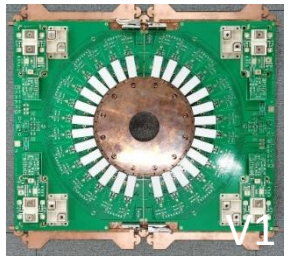
Structure and design

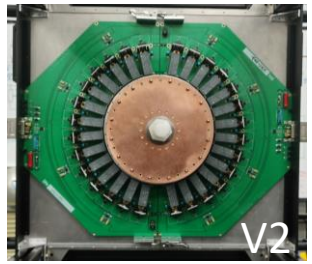


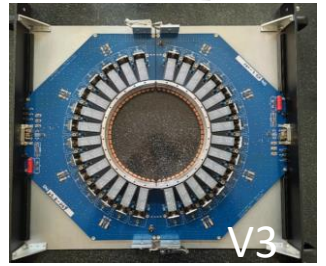




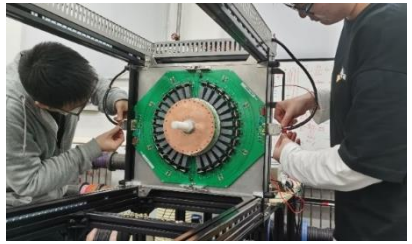
Circuit and PCB design iteration

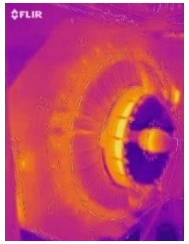


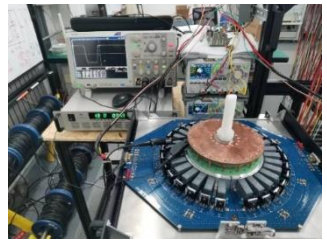


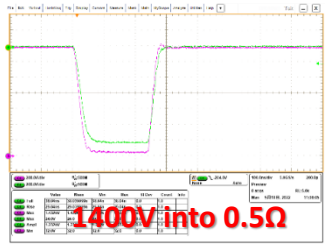


Single stage and double stages full power test has been completed（1400V into 0.5Ω）



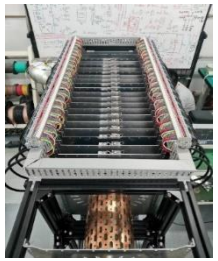


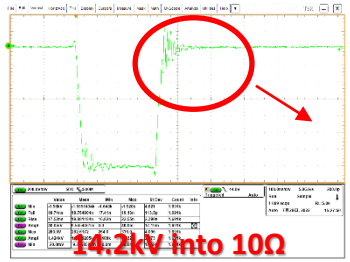




Gradual stacking test (1→2→5→10→15→18 stages). 18-stage adder output pulse voltage = 14.2kV into 10Ω @ DC HV=800V.

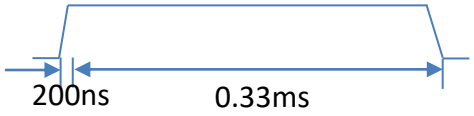






- Caused by parasitic inductance
- To increase risk of MOSFET overvoltage breakdown

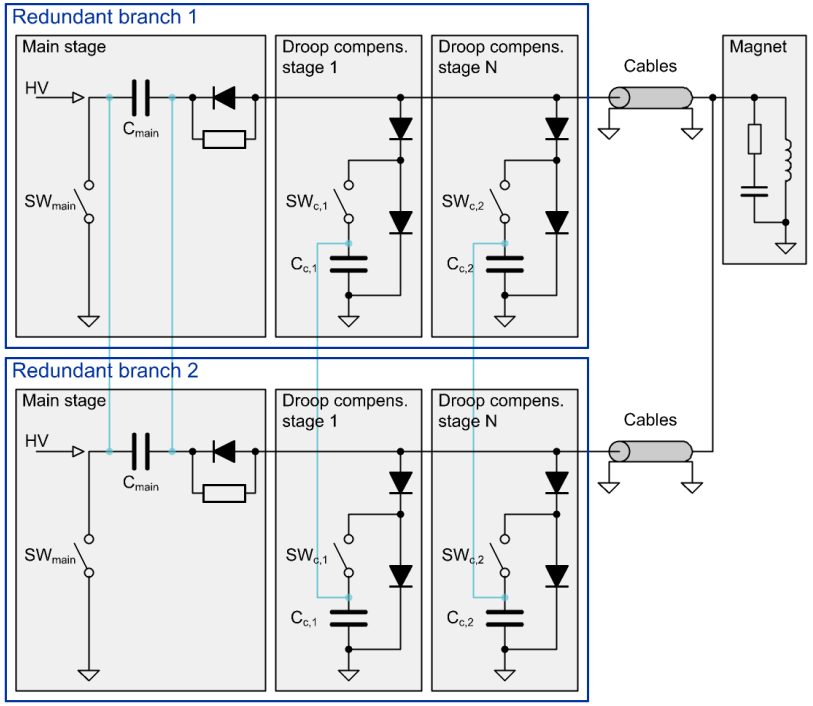
Long-pulse pulser for dump kicker



- **Based on CERN LHC experience: improve dump kicker system reliability as much as possible, minimize worst-case probability.**
  - More kickers for deflection → beam extraction still works if one kicker fails
  - Simple, reliable pulser & kicker structures
  - Redundant branches in pulser design
  - Relaxed flat-top requirements for long pulses
- **Pulser design considerations：**
  - Inductive adder is not suitable for long pulses (0.33ms) due to core saturation
  - Based on staggered capacitor discharges and solid-state switches
  - Potential solid-state switches from domestic vendors (non-COTS device)：
    - SGTO
    - LTMGT

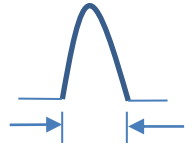
  Need R&D for CEPC team in the future.

Dump kicker pulser for FCC-ee



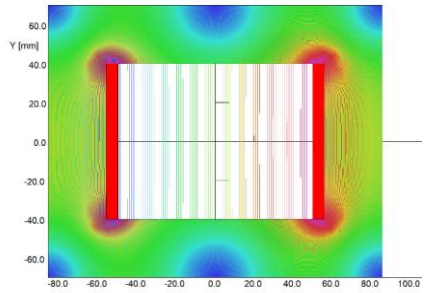
J. Ruf, Y. "Kicker Magnets and Generators for the FCC-ee" FCC week 2026, CERN
T. Kramer et al., "Feasibility of kicker systems for FCC-ee and injectors", in Proc. IPAC'25, Taipei, Taiwan, Jun. 2025
L. Ducimetire, LHC Beam Dump System Kicker magnets and generators, LBDS Audit, Geneva, Jan. 2008

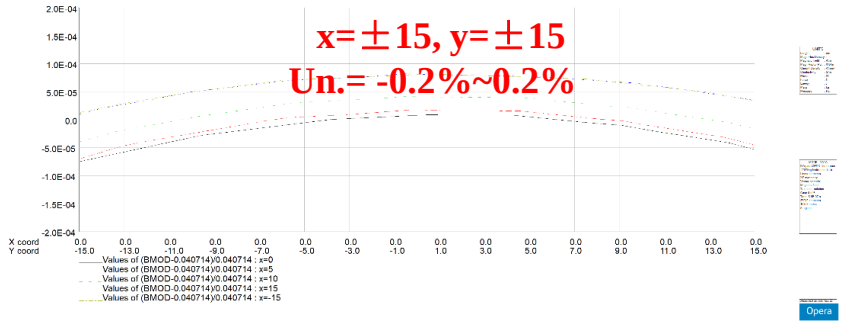
3） lumped inductance kicker for CR on-axis inj.

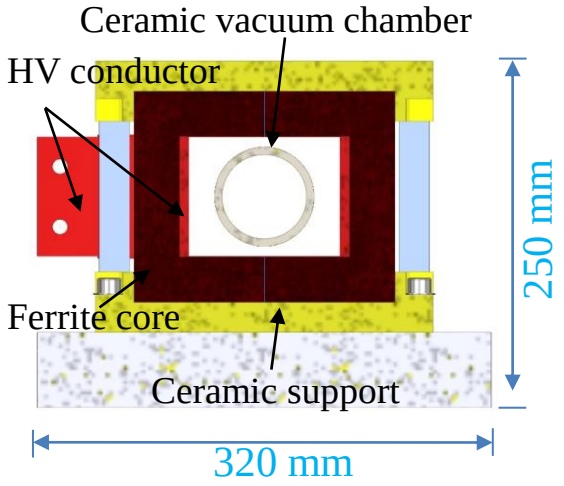


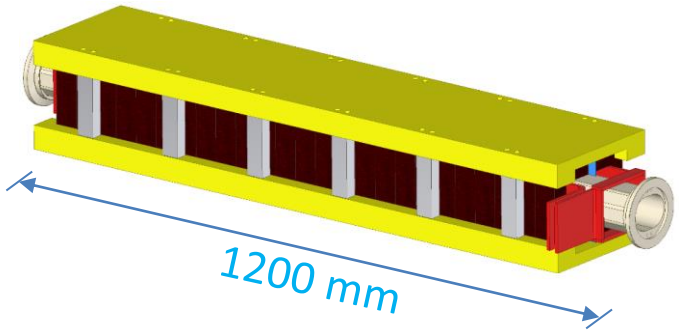
- As for 1.3us half-sine wave kicker system, the lumped parameter type kicker is adopted, because of its simpler structure and lower cost.
- The kicker magnet with ferrite core is preferred due to its higher exciting efficiency.
- Ceramic vacuum chamber with TiN-Ag continuous coating is applied due to in-air magnet structure.

Lumped dipole kicker Parameter	Value
Magnetic field B (T)	0.04
Inner aperture of ceramic vacuum chamber (mm×mm)	56×56
Ceramic vacuum chamber outer aperture (mm×mm)	85×66
Magnet aperture w × h (mm×mm)	100×80
Length of magnet l (m)	1
Inductance of magnet L (μH)	1.6
Magnet exercitation current I (kA)	2.6
Impedance Z (Ω)	3.7
Voltage of magnet U (kV)	9.62
Pules bottom width τ (ns)	1360
Repetition rate（Hz）	1000





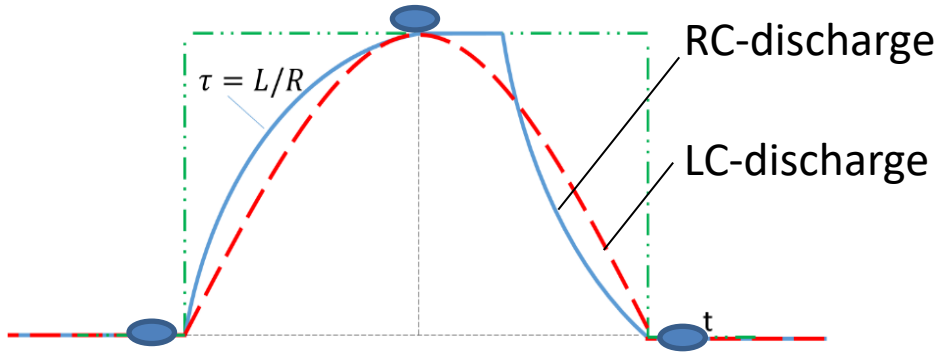


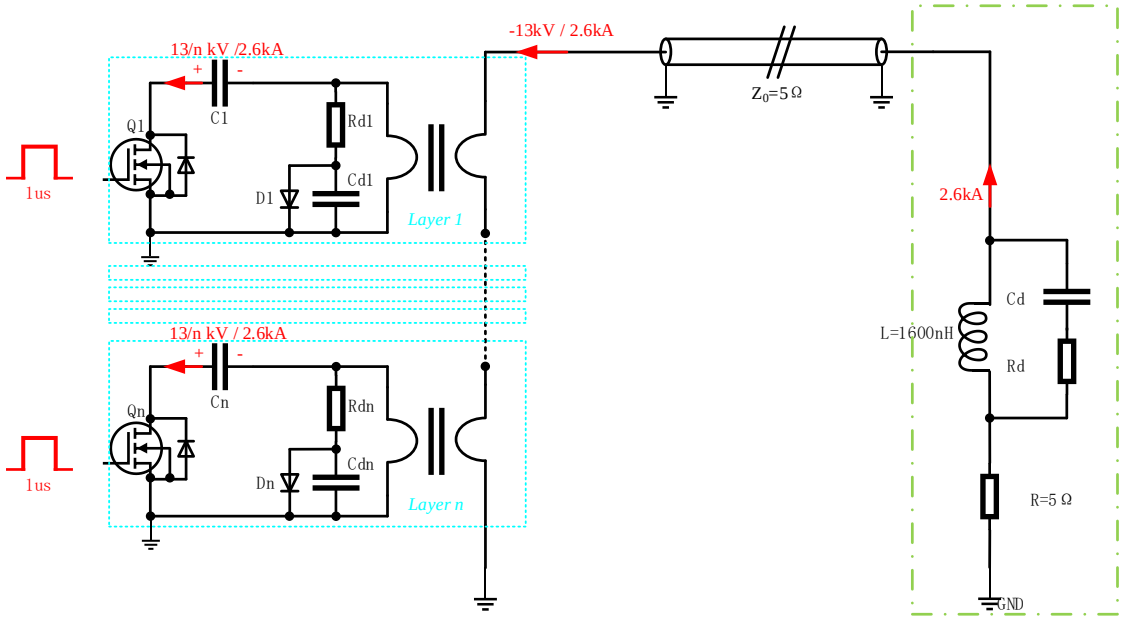


Pulser for lumped inductance kicker

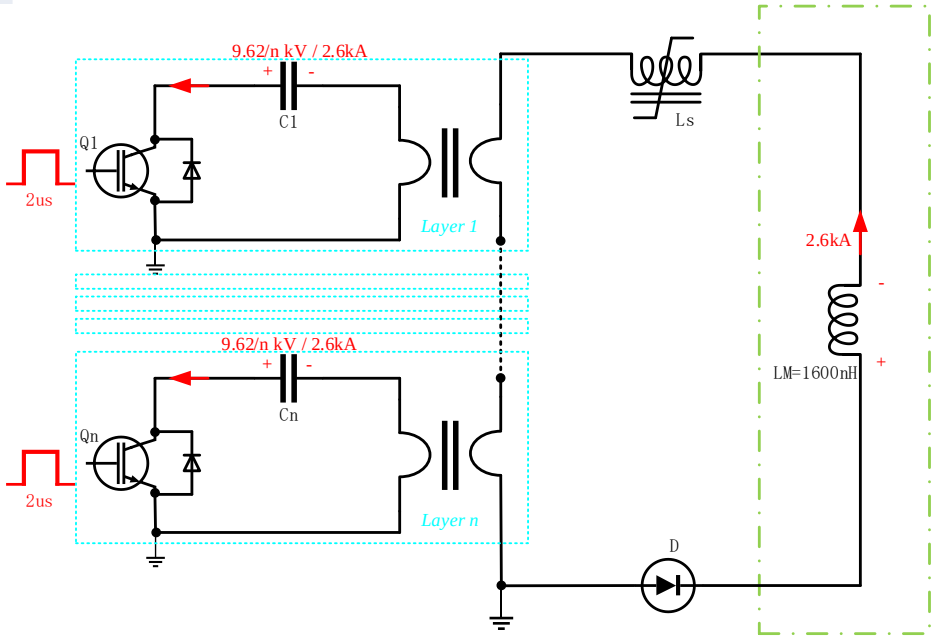
- **2 inductive adder schemes are proposed：**

Inductive scheme	RC discharge	LC discharge
Pulser location	Out of main tunnel	In main tunnel
Radiation shielding	Not required	Required
Long HV RF cables	Required	Not required
Stage number (n)	More	Less
Solid-state switch	MOSFET	IGBT
Performance-core	low	high



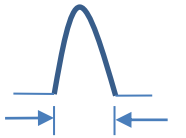


RC-discharge： Out of the main tunnel



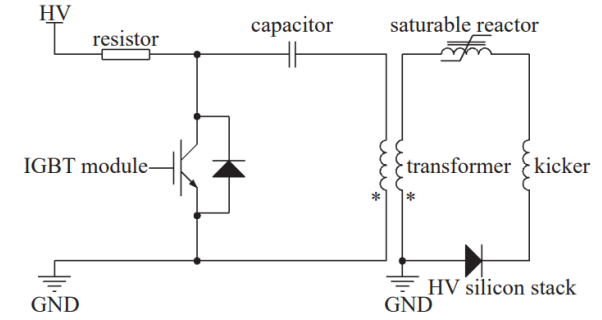
LC-discharge： In the main tunnel

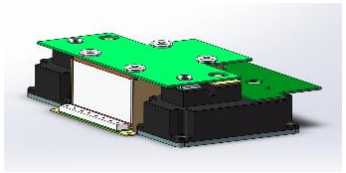
LC-resonance discharge inductive adder (half-sine wave)

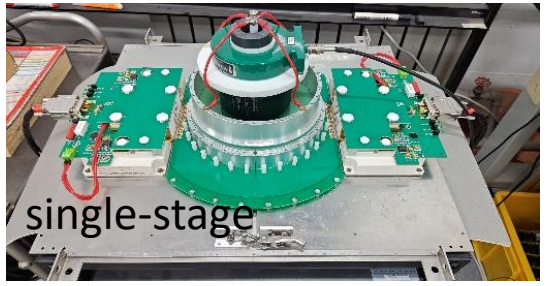


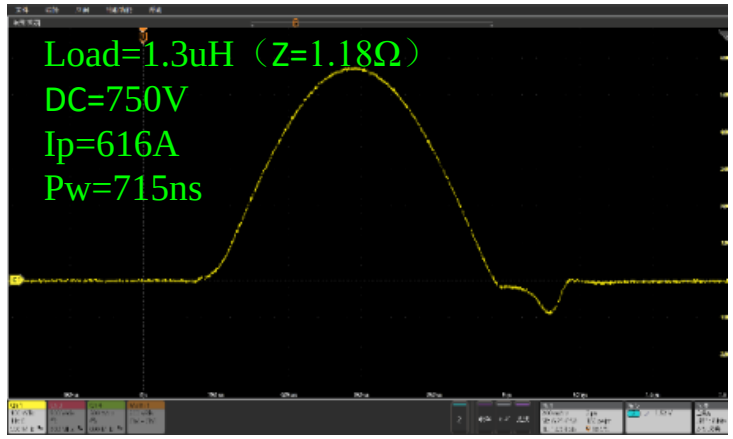
- **Research status： The principle of the LC-discharge inductive adder was verified.**

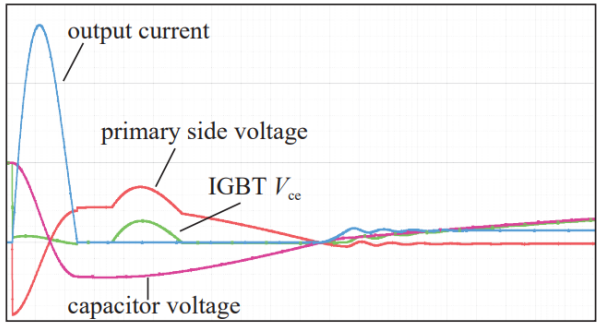

FZ600R12KS4: 1.2kV/1200A

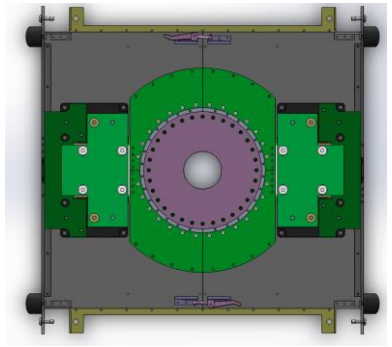


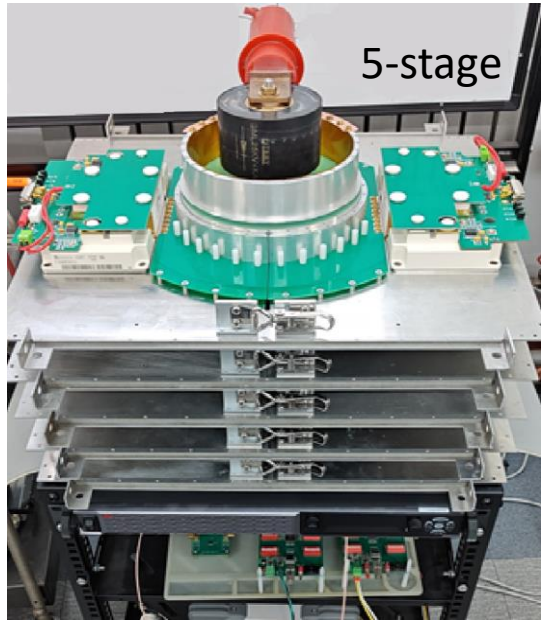


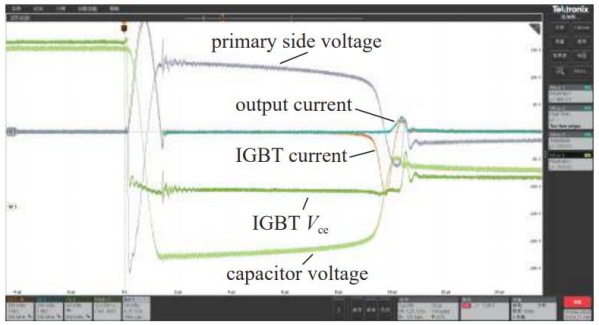


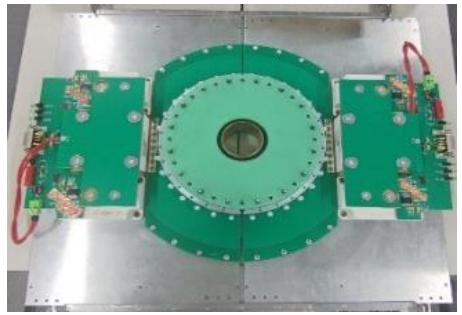


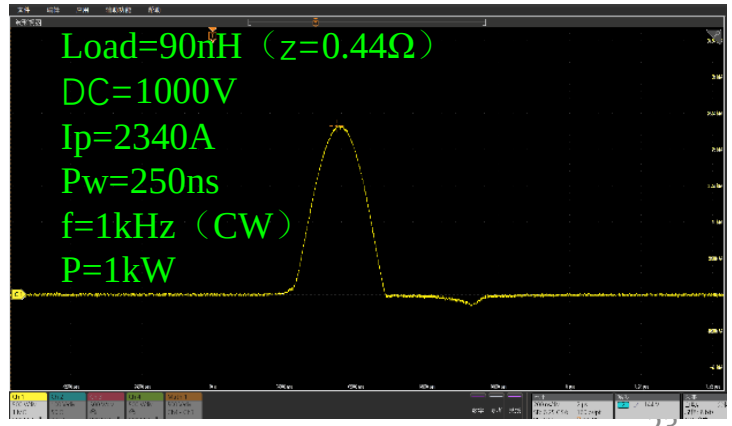












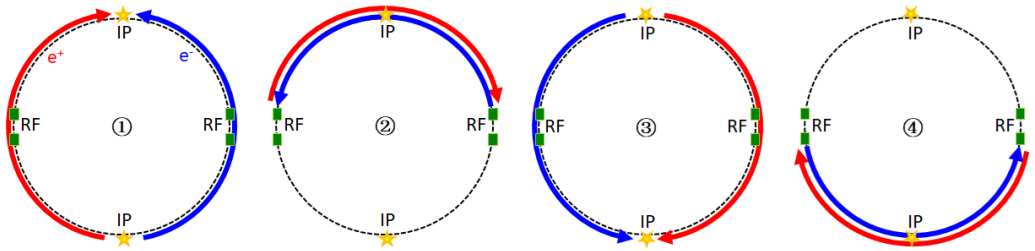
Alternative option of E-M-Separator in CEPC: Separation Kicker

Alternative option of EMS in CEPC: Separation Kicker

- Motivation: the beam impedance issue of EMS in CEPC is serious
- The alternative scheme was first proposed at the CEPC Workshop 2019:

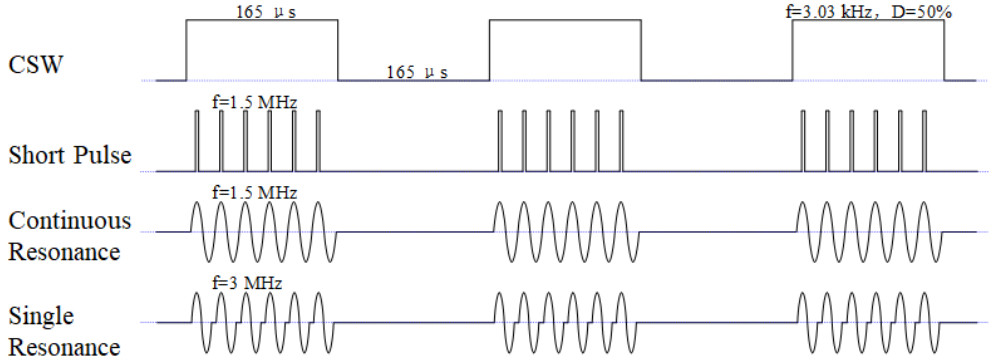
  4 groups of kicker with DC septa were located at both sides of RF regions, K1/K4 are used to deflect e+ beam, and K2/K3 used to e- beam.

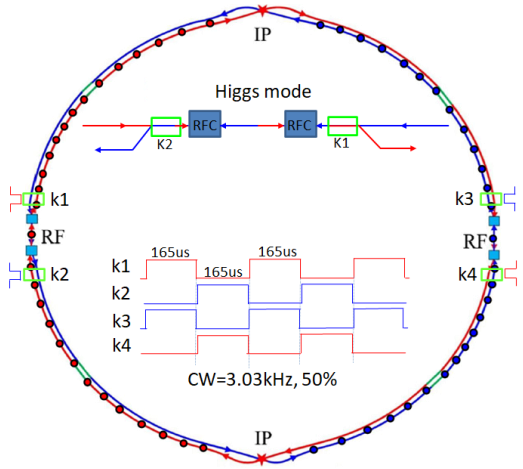
  - Pulse width is 165 μs, and the repetition frequency is 3.03 kHz (duty cycle = 50%)
  - The timing requirements are highly related to the beam filling scheme

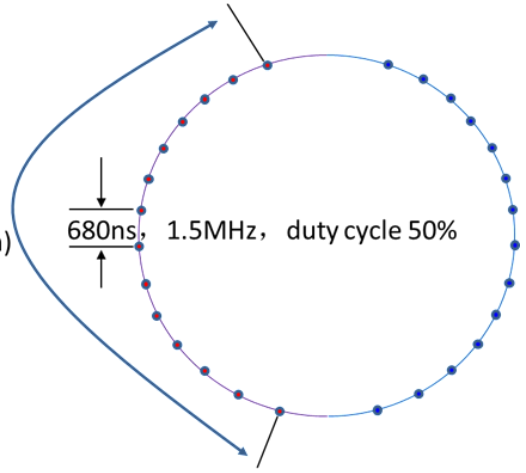


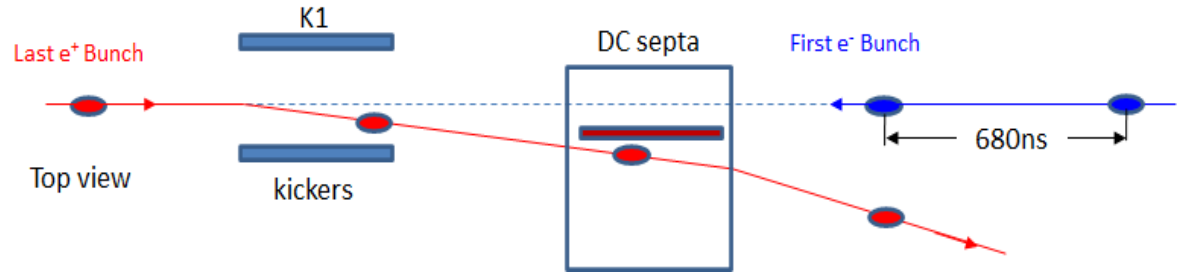
*In Higgs mode, the both beams only fill half of the ring respectively.

- Potential topologies: Strip-line, resonance, CSW kicker system





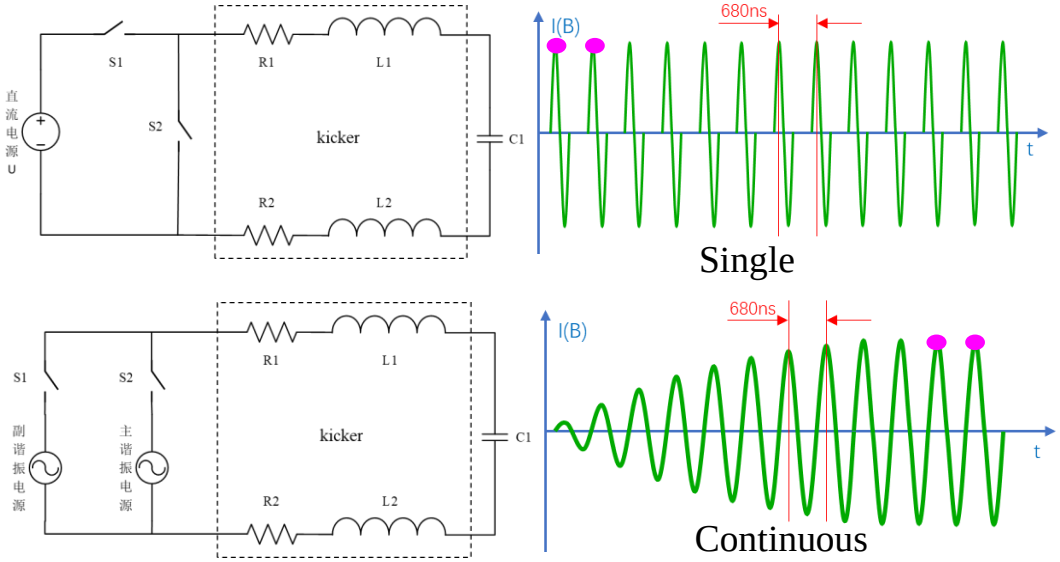


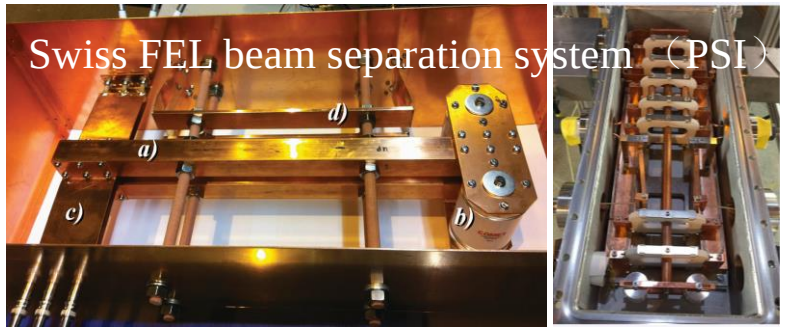


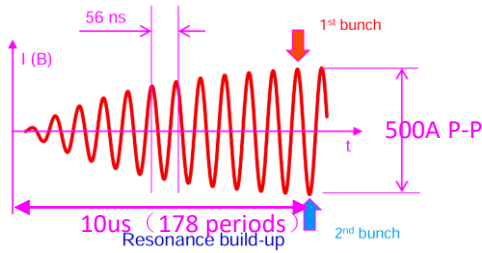
Parameters	Kicker	Septa
Integrated strength BL [T*m]	0.1624	1.4
Strength B [Guass]	203	1000
Effective length Leff [m]	8	14
Half width of good field region Hgf/Vgf [mm]	10.1/3.8@ 5E-4	18.9/3.8@ 5E-4
Half width of beam stay clear Hbsc/Vbsc [mm]	9.6/3.6	9.2/3.6
Septum width [mm]	-	10

Resonance Kicker system

- 2 pulse solutions: continuous and single-shot resonance
- Air-core kicker design
  - Current is very high: 2176 A
- Ferrite-core kicker design
  - Higher magnetic excitation efficiency
  - Better field uniformity





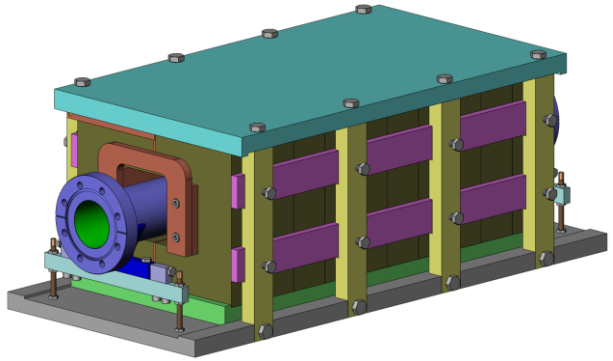


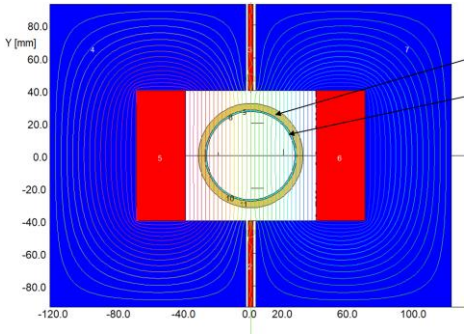
*Martin Paraliev，Development of High Performance Electron Beam Switching System for Swiss Free Electron Laser at PSI, IEEE

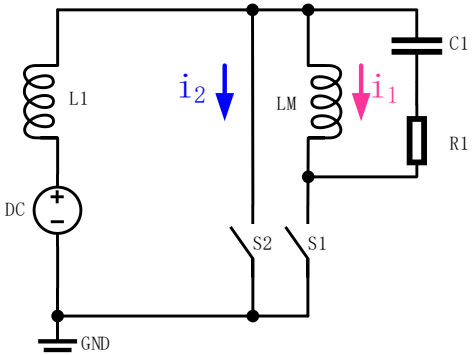
Kicker type	Air-core / in-vacuum		Ferrite-core / in-vacuum		Ferrite-core / in-air	
Operation mode	Single-shot	Continuous	Single-shot	Continuous	Single-shot	Continuous
Excitation Current（I）	2176A	2176A	905A	905A	1292A	1292A
Resonance impedance (Z)	7.4Ω	3.7Ω	11.1Ω	5.5Ω	11.1Ω	5.5Ω
Voltage across capacitor (U)	16.4kV	8.1kV	10.1kV	5kV	14.4kV	7.2kV
Kicker inductance (L1)	400nH	400nH	600nH	600nH	600nH	600nH
Coil resistance (R1)	8mΩ	5.6mΩ	2.9mΩ	2mΩ	2mΩ	1.4mΩ
Resonance capacitor (C1)	7.32nF	29.28nF	4.88nF	19.52nF	4.88nF	19.52nF
Source level (V1/V5)	16.4kV	367/37.2V	10.1kV	223/14.2V	14.4kV	318/18V
Resistance of switch (S2/S3)	850/21.2mΩ	11.3/11.3mΩ	550/25mΩ	13.6/13.6mΩ	750/23.4mΩ	12.5/12.5mΩ
Power loss on kicker coils	4.8kW	6.8kW	299W	413W	419W	585W
Power loss on switches	13.1kW	13.6kW	2.6kW	2.8kW	5.1kW	5.23kW
Power of source	18kW	20.9kW	2.9kW	3.3kW	5.5kW	6.07kW

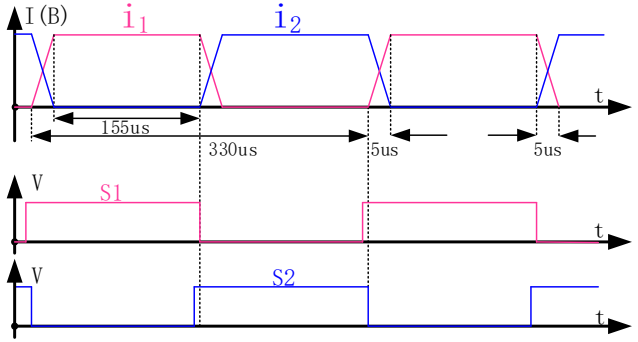
Continuous Square Wave (CSW) kicker system

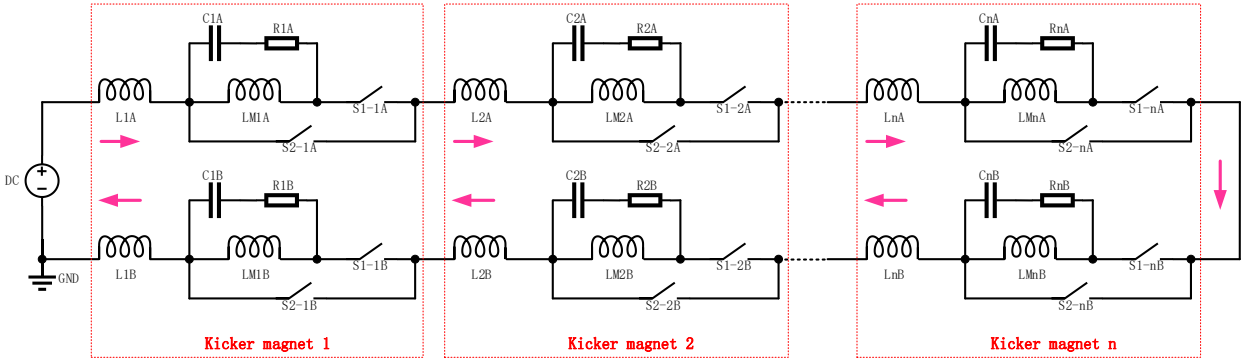
- CSW kicker system
  - Generator: alternating switching + conventional DC current source
  - Kicker: in-air ferrite core kicker + ceramic vacuum chamber with TiN coating (2 μm)
  - The in-air CSW kicker solution is preferred
    - It has very good field uniformity: ±0.05%
- Beam impedance
  - Beam-induced heating power is 489 W for a total of 16 kickers
    - Much lower than the EMS





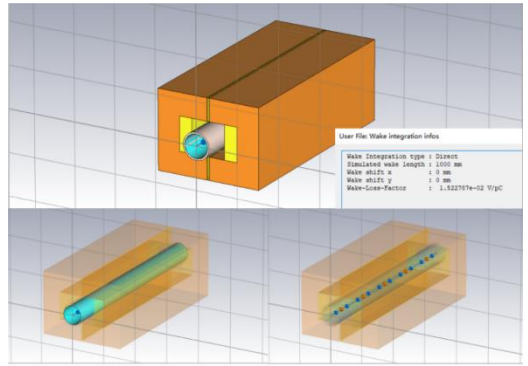






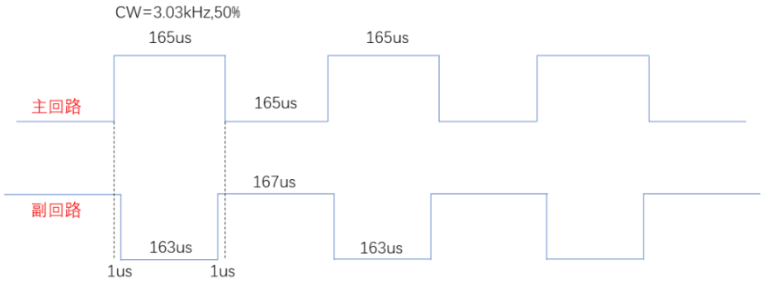
Problem to be concerned:

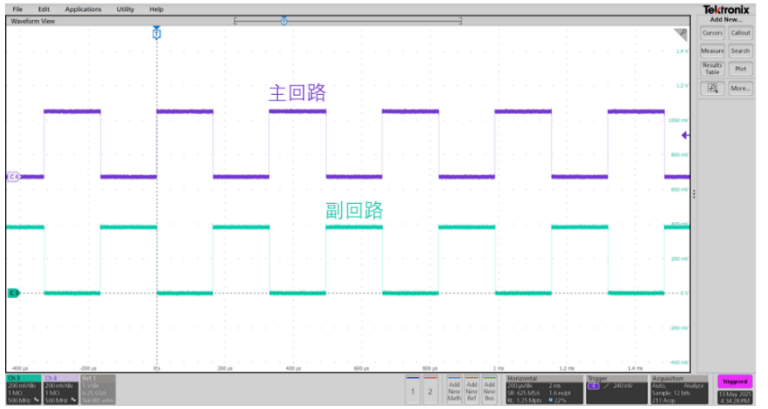
- The switches must locate as close as possible to the magnets.
- Radiation shielding are necessary.

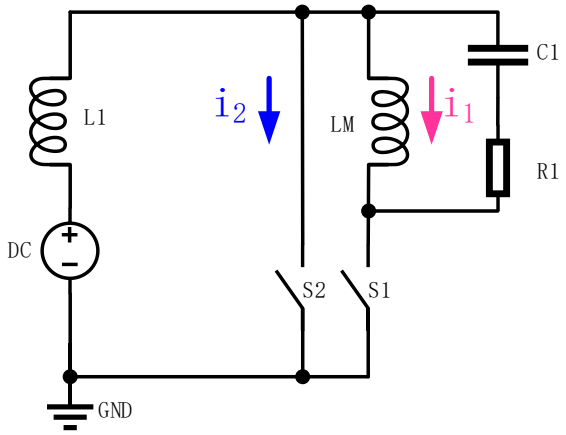


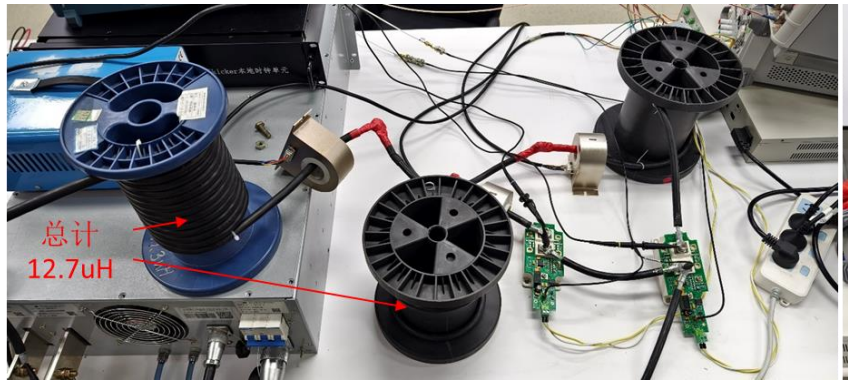
Desktop Low-Power Circuit Experiment

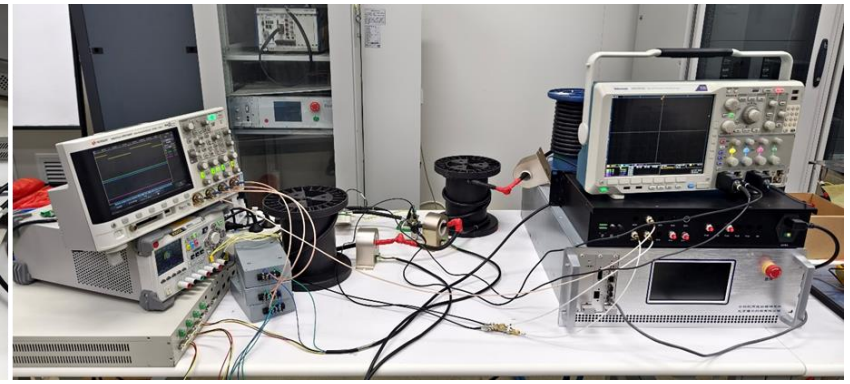
- Test circuit setup and conditions:
  - DC current source : 300A/50V
  - Energy storage inductor L1: 1.4μH →12.7μH
  - Magnet inductor LM: 700nH
  - S1/S2: IGBT Infineon FZ 600R12KS4 (1200V/600A)
  - Test current: 5A/10A/20A/25A/40A











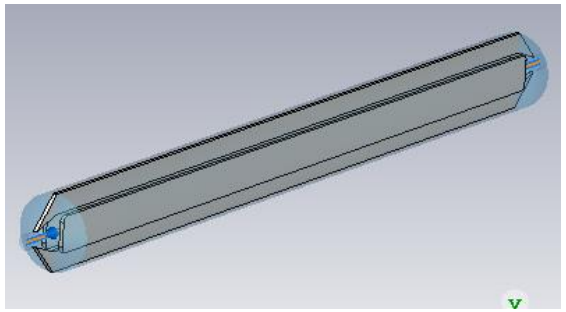
Conclusion of alternative scheme： kicker systems

- We prefer the in-air CSW kicker with a DC source and alternating switches, based on technical maturity, complexity, cost, and beam impedance.
- Ceramic vacuum chambers with TiN coating are impedance components that contribute to electron and positron beams.

	Resonance kicker		CSW kicker	Unit
Operation mode	Single-shot	Continuous	DC source + Alternating Switch	-
Type of kicker	Ferrite core	Ferrite core	Ferrite core	-
Structure of kicker	In-vacuum	In-vacuum	In-air (TiN coated ceramic chamber)	-
Turn of coil	Single	Single	Single	-
Quantity	16	16	16	set
Magnetic effective length	0.5	0.5	0.5	m
Magnetic field strength	0.0203	0.0203	0.0203	T
Good field region (H×V)	[-10.1,10.1]×[-3.8,3.8]	[-10.1,10.1]×[-3.8,3.8]	[-10.1,10.1]×[-3.8,3.8]	mm
Field uniformity	Better than±1‰	Better than±1‰	Better than±5‰	-
Inductance of magnet	600	600	600	nH
Resonance capacitance	4.88	19.52	-	nF
Resonance impedance	11.1	5.5	-	Ω
Peak current	905	905	1292	A
Charging voltage	10100	223/14.2	700 (inductive) @ edge=10us	V
Frequency	3M/3.03K	1.5M/3.03K	3.03K	Hz
Pulse bottom width	340	680	165000	ns

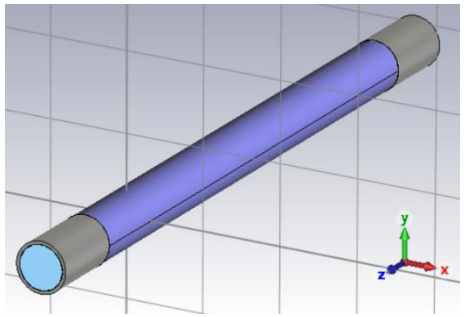
Beam power deposition comparison: EMS vs Kicker

EMS



VS

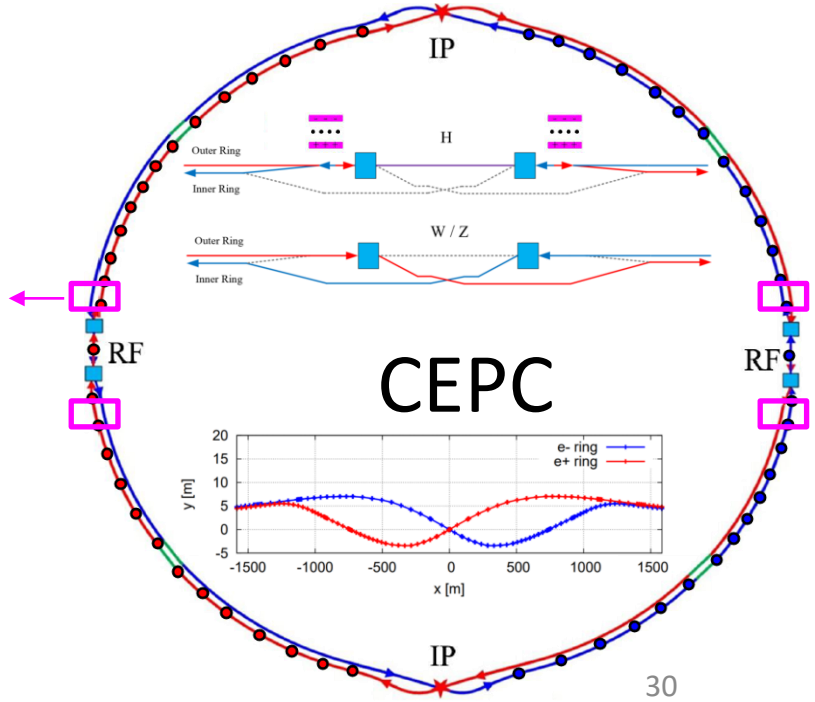
Kicker



Ceramic Vacuum chamber with continuous TiN coating:

- Length=600mm/unit
- Inner aperture=⌀56mm
- Outer diameter=⌀64mm
- Wall thickness=4mm
- Coating thickness=2μm
- TiN Conductivity =5.8×10^6 S/m

	EMS	CSW kicker
Maximum operation voltage (V)	±75k	700 (inductive @10us edge)
Total effective length per group (m)	32	8
Quantity of unit per group (set)	8	16
Total beam power deposition per group in Higgs mode (W)	8*486=3888	16*12.6W=201.6
Total beam power deposition per group in Z mode (W)	8*14436=115488	16*30.6W=489.6



Summary

- Toward EDR, further in-depth hardware R&D will focus on three areas:
  - septum magnets, including the mechanical structures and manufacturing processes of in-air and half-in-vacuum Lambertson magnets;
  - kicker systems, covering ferrite-core kickers, solid-state pulser schemes, and metallic-coated ceramic vacuum chambers;
  - a separation kicker system to replace EMS.
- As work progresses, interface discussions and design iterations with physics, vacuum, mechanical, timing, control, MPS, common interface and civil engineering, must continue. Funding permitting, full scheme validation and engineering prototype development will be necessary in the future.

END

Thank you for attentions!