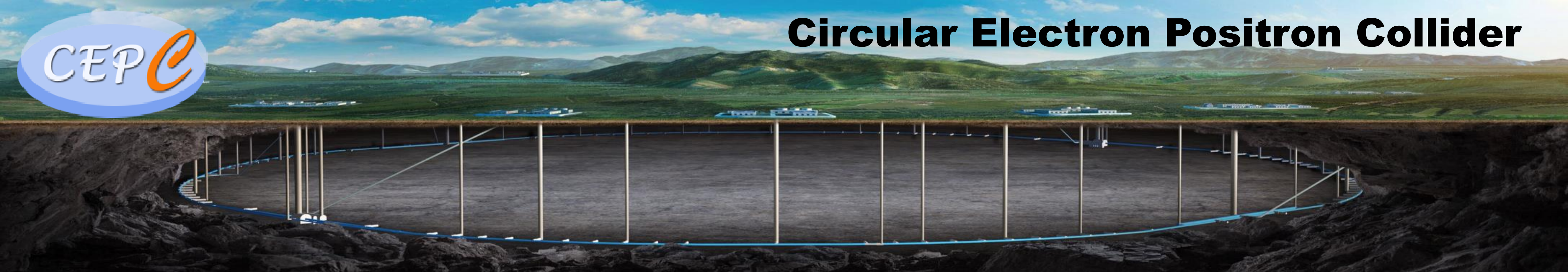

CEPC dumps and the dump experimental hall

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On behalf of RP team of IHEP

Outline

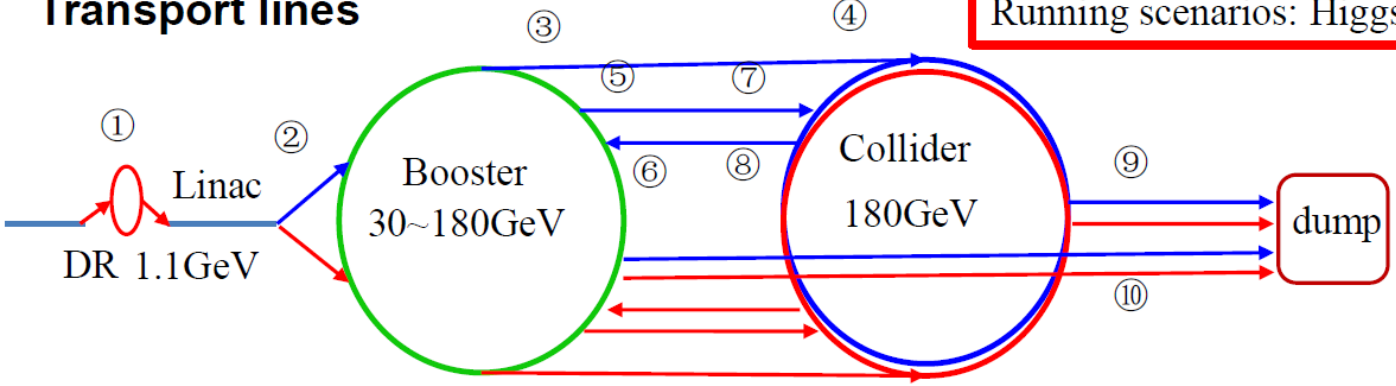
- Introduction to dumps in CEPC
- Functional design for dumps in TDR
- Dumps used for machine protection
- Other possible application for the wasted beam
- Summary

Introduction to dumps in CEPC

CEPC as a Higgs Factory: H, W, Z, upgradable to ttbar, followed by a SppC (a Hadron collider) ~125TeV
30MW SR power per beam (upgradable to 50MW) , high energy gamma ray 100Kev~100MeV

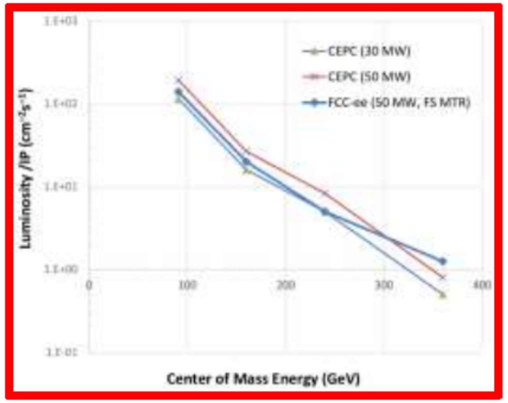
- Dumps in the CPEC is used for machine commissioning/unwanted beam collection/collect beam in abnormal situation/sudden beam loss for machine protection
  - In the Linac, there are 6 Beam energy analysis stations used for beam characteristic analysis, 6 dump in the end for commissioning, 1 collimation station
  - In the Booster and Collider, there are now 2 dumps, can be added according to design

Transport lines



CEPC Accelerator EDR -J. Gao

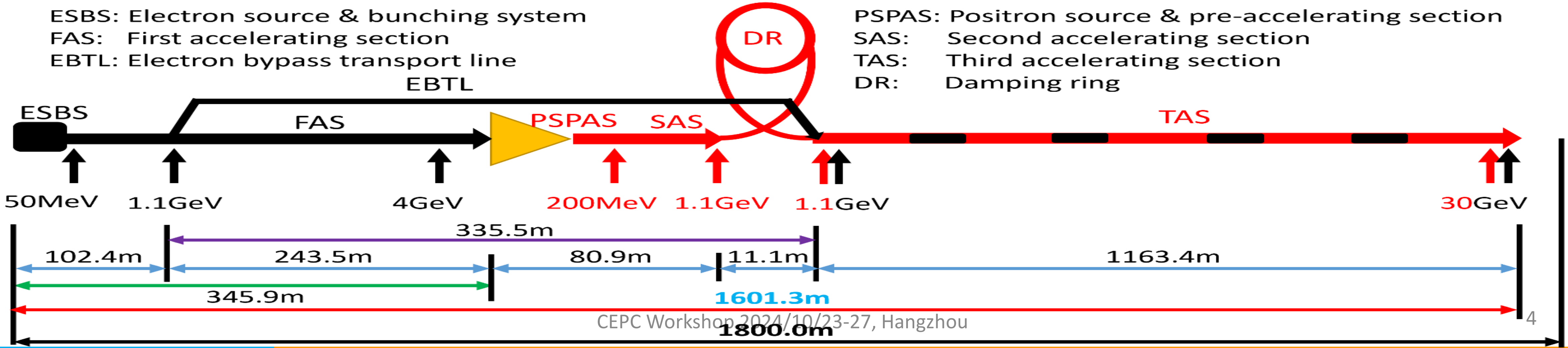
Running scenarios: Higgs 10 years, Z 2 years, W 1 year, ttbar 5 years



Functional design in TDR- Linac dumps Intro

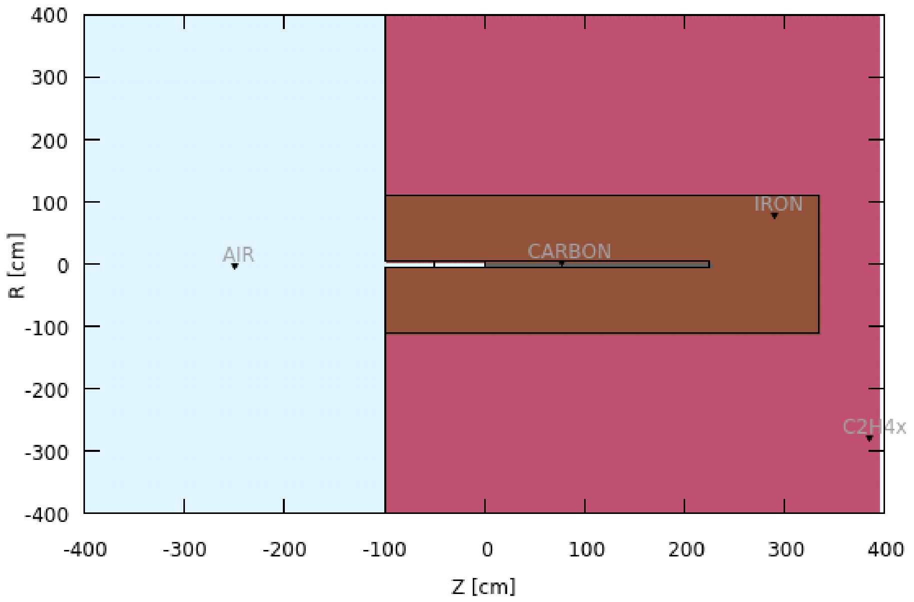
- Electron energy in the Linac is increased step by step
- Radiation dose induced by hot points(beam energy analysis station or dumps) is higher
- Shielding thick for the Linac tunnel is determined by the random beam loss alone the beam line

	No.	Beam energy	Bunch size/mm	Frequency/Hz	bunch charge/nC	Number of particles [10^{10}/s]	Total energy[W]
TDR 30GeV	1	60MeV	2/1	2	10	12.5	1.2
	2	4GeV	0.5/0.5	2	10	12.5	80
	3	250MeV	1.5/1.5	2	5	6.3	2.5
	4	1.1GeV	0.5/0.5	2	5	6.3	11
	5	6GeV	0.5/0.3	2	3	3.7	36
	6	30GeV	0.3/0.3	2	3	3.7	120
	7	30GeV	0.3/0.3	2	3	3.7	120
	8	250MeV	1.5/1.5	200	5	624	250



Functional design in TDR- Design principle

- 3 layers cylindrical structure is used for dump design
  - Carbon and iron is selected as the absorber material, surrounded by the polyethylene as local shielding.
  - 5.5mSv/h is set as upper limit to decide the thickness of local shielding.



- To suppress the back scattering radiation, there exiting extra iron and polyethylene on the left part from the negative side of z=0 position.
- Radiation level nearby each energy analysis station was figured out, also specify a roughly space for the future local shielding.

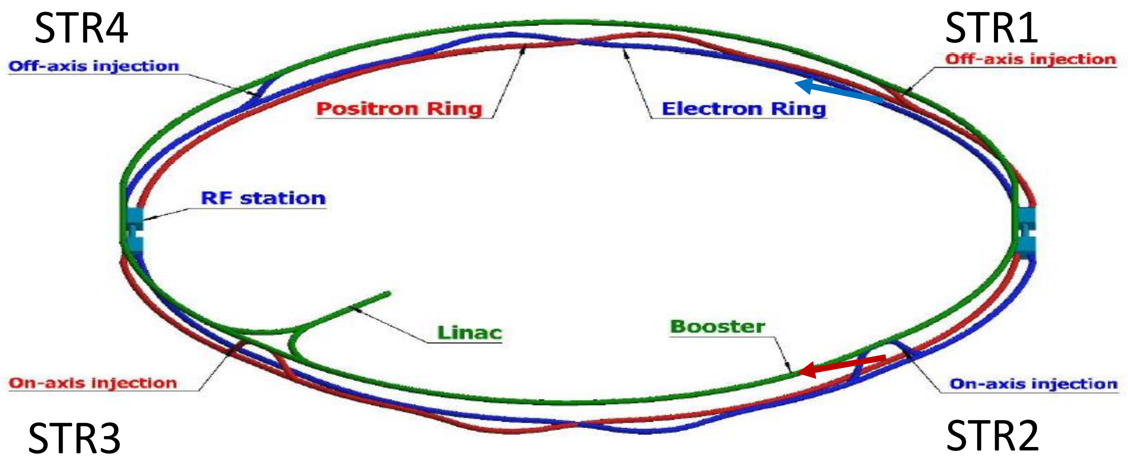
Functional design in TDR- Design results

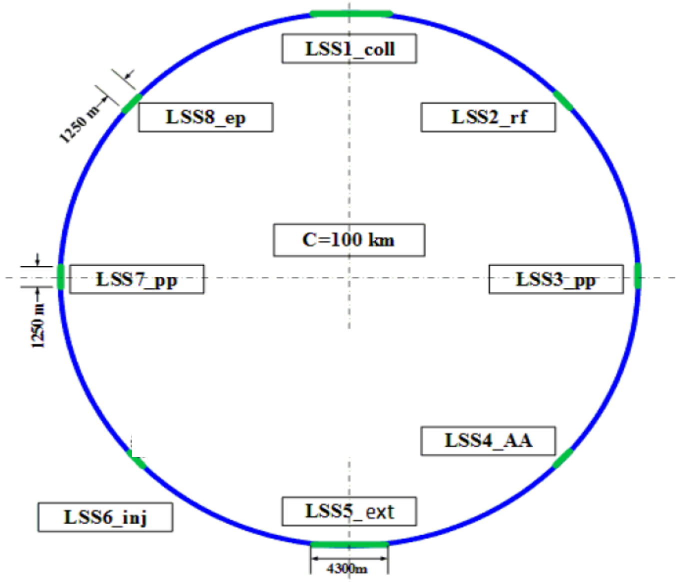
No.	Beam energy	C		C+Fe		C+Fe+Polyethylene	
		R/m	Length/m	R/m	Length/m	R/m	Length/m
Dump_1	60MeV	0.05	0.15	0.7	1	---	---
Dump_2	4GeV		1.25	1.1	2.4	1.2	2.6
Dump_3	250MeV		0.4	0.5	0.95	0.55	1
Dump_4	1.1GeV		0.75	0.75	1.6	0.85	1.7
Dump_5	6GeV		1.45	0.92	2.4	1	2.5
Dump_6/7	30GeV		2.6	1.2	3.7	1.3	3.8
Collimator	250MeV	R=1.3m L=1.8m (outer dimension)					

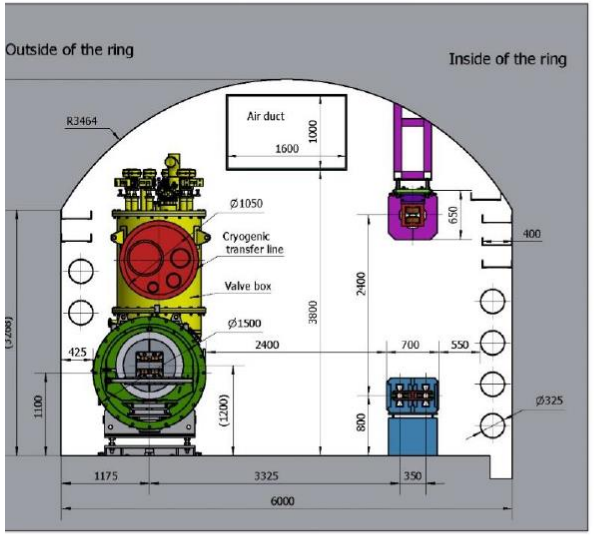
- Outline of external dimensions for each dumps were designed
- Thickness of local shielding can be further optimized combined with Linac tunnel thickness

Functional design in TDR- Dumps for Booster/Ring

- Dumping system for collider ring
  - Not necessary to be close to IP
    - **Active machine protection** for the beam loss with time larger than **multi turns**
  - Located at **STR1 and STR2**
    - At least one dump for each collider ring
    - STR4 for future option of ep collision
  - **Inner side of tunnel**
    - SPPC will locates outer side of CEPC
    - Maintenance of the dump
- Dumping system for booster ring
  - Low charge bunches can be dumped by collimator
  - Dumping for bunches can **share the dump with collider ring**

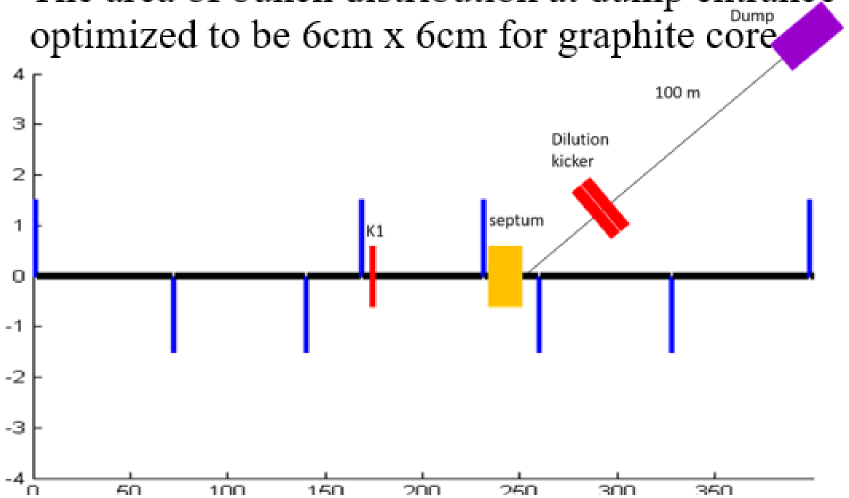






Functional design in TDR- Design scheme

- **A dump system have been designed to cover all the operation model**
  - The sorted beam energy and the heat deposition is the most serious in Z model
- A set of kicker magnets is used to dilute the beam horizontally and vertically.
- The length of transfer tunnel is about 100m; the diameter of the transfer tunnel is about 2m, considering the vacuum equipment, pipe installation.
- The area of bunch distribution at dump entrance is optimized to be 6cm x 6cm for graphite core



	Higgs	WW	Z	ttbar
beam energy [GeV]	120	80	45.5	180
current [mA]	27.8	140.2	1339.2	5.5
bunch population/10^{10}	14	13.5	14	20
number of bunches	415	2162	19918	58
total energy [MJ]	1.1	3.7	20	0.33

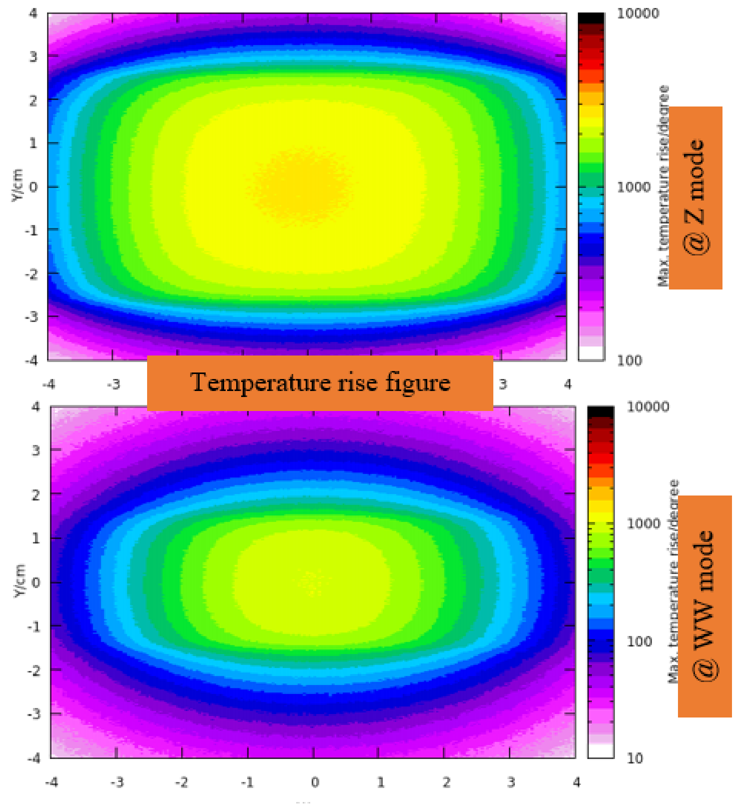
Beam parameter of CEPC collider with power 50MW

		Extraction kicker	Septum	Dilution kickers
Length (m)		2	20	10
Magnetic flux density (Gauss)	Z	280	2600	40(Max.)
	WW	493	4700	
	Higgs	740	7000	
	ttbar	1110	10500	

Functional design in TDR- Design results

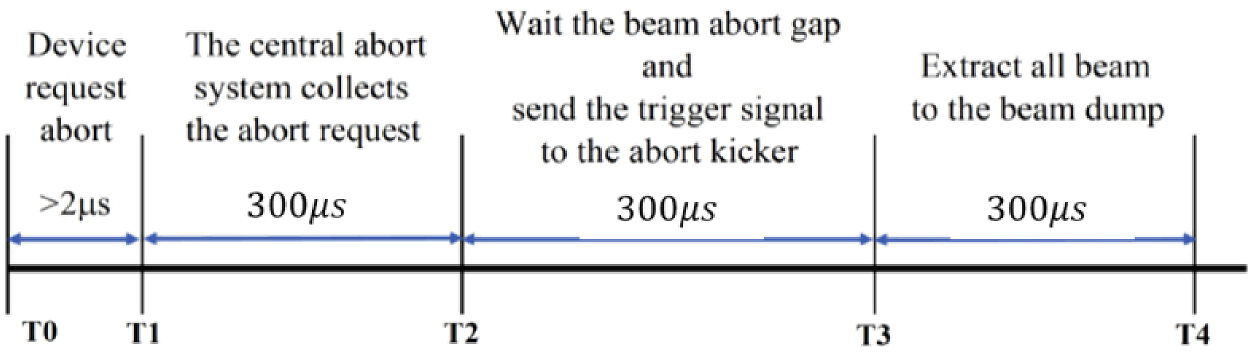
- Energy deposition from FLUKA simulation& temperature rise calculated from specific heat capacity formular
  - Max. temperature rise is smaller than graphite melting point.
  - Dimension (graphite + Iron): R~2.3m, L~8m; constrained by the condition that dose-eq is smaller than 5.5mSv.
  - The graphite core will surrounded by inert gas to avoid fire and chemical reaction

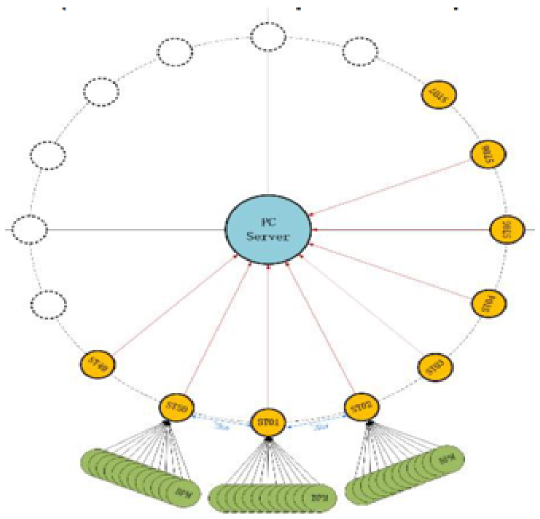
	Higgs	WW	Z	ttbar
Beam energy/GeV	120	80	45.5	180
Ne/bunch/10^{10}	14	13.5	14	20
Bunch number (50MW)	415	2162	19918	58
Max. temperature rise	510 ± 15℃	1020 ± 30℃	2620 ± 15℃	194 ± 2℃
Max. temperature rise by one bunch	7.31 ± 0.03℃	5.38 ± 0.03℃	3.76 ± 0.02℃	10.08 ± 0.04℃



Dumps used for machine protection

- A task forced group was established to research on the beam abort system
- Beam should be aborted while receiving the stopping signals from:
  - Beam loss monitors/Synchrotron oscillation phase monitor/Hardware components/Manual abort
- Time duration needed to abort the whole beam in one cycle
  - Device request → local control →Central control →Dump system → Extract all beam in one cycle
  - Response time ~ 1ms;
  - Need collimators to deal with beam losses faster than 1ms





Dumps used for machine protection- Main issues

Offered by guangyi Tang

- Total energy stored in the machine:
  - Maximum: 20 MJ
- Collider dump response time: 1 ms.
- Passive protection is needed to deal with beam losses faster than 1 ms, aiming to,
  - Protect detector/IR,
  - Protect beam pipe, flange, magnets
  - …
- Scenarios:
  - Failure cases, such as power loss, sudden beam loss, quench, …
  - Beam halo

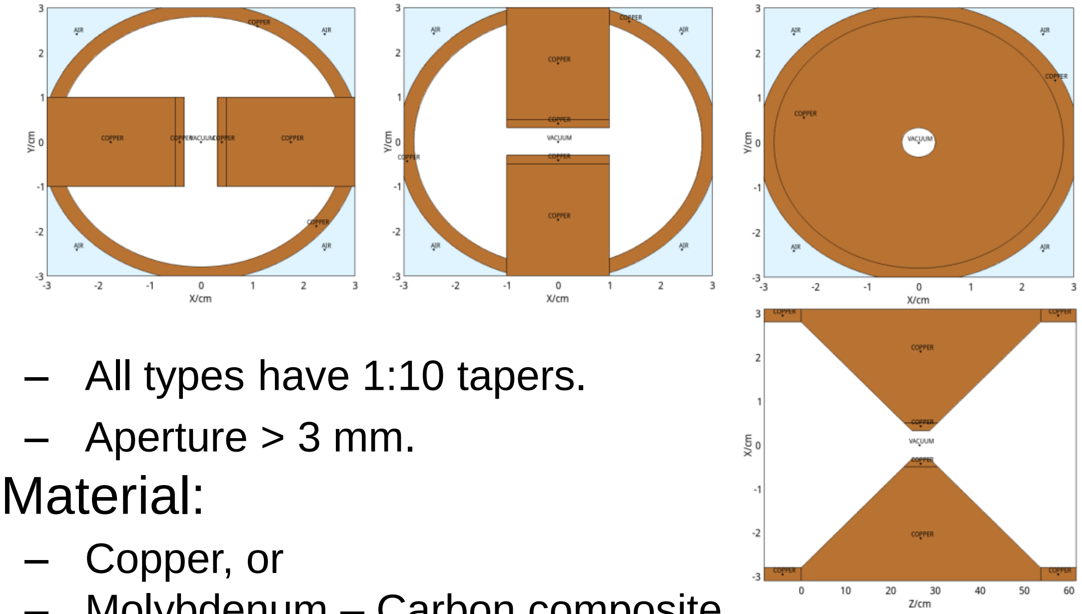
	Higgs	Z	WW	ttbar
Beam energy/GeV	120	45.5	80	180
Energy stored in the machine/MJ	1.1	20	3.7	0.33

- The time limits of power loss scenarios:
  - RF failures: 800 μs (2.7 turns)
  - Quenches of superconducting quadrupole magnets: 10 ms – 100 ms (33 turns – 333 turns)
  - Power failure of normal magnets: 10 ms – 100 ms (33 turns – 333 turns) (current study)

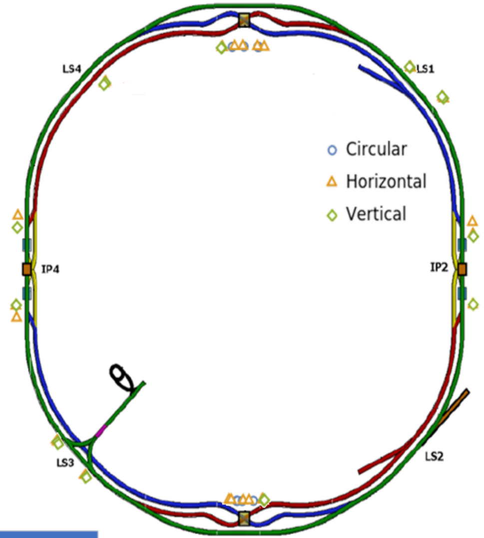
Dumps used for machine protection- Add passive devices

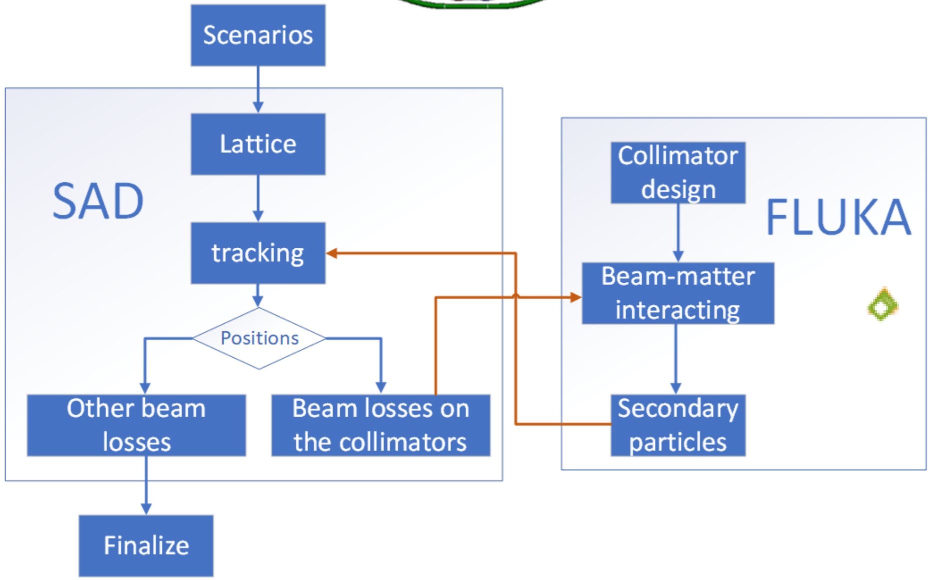
Offered by guangyi Tang

- 58 collimators for each ring
  - located at positions where the beta function or dispersion is larger than at other position.
- Three types:
  - horizontal collimator, vertical collimator and circular collimator



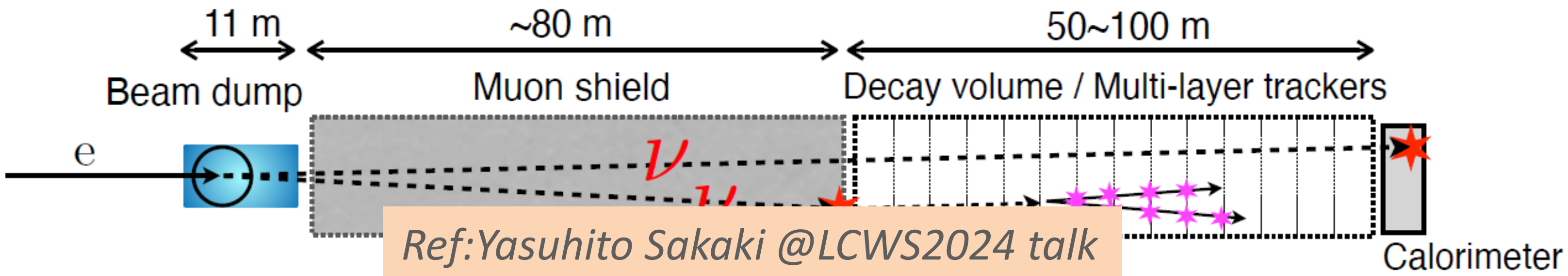
  - All types have 1:10 tapers.
  - Aperture > 3 mm.
- Material:
  - Copper, or
  - Molybdenum – Carbon composite



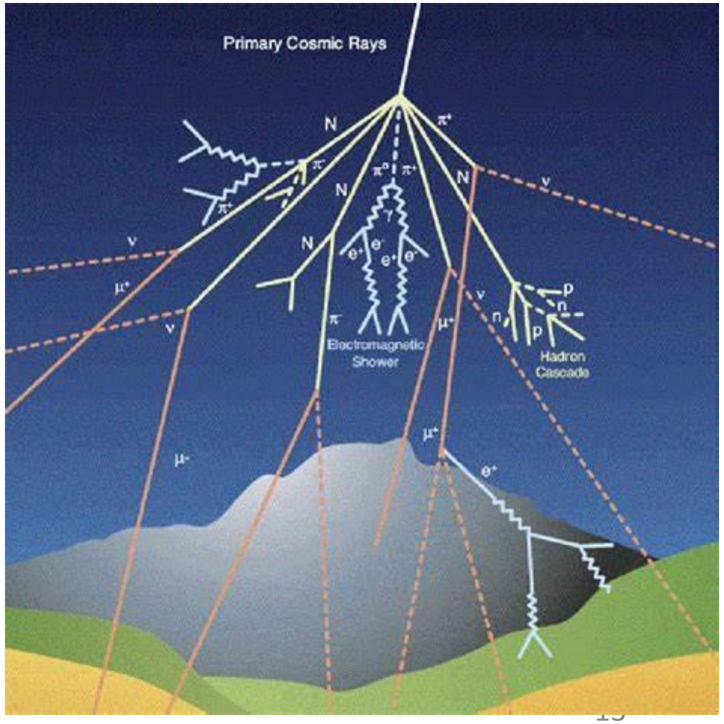


Other possible application for the wasted beam

- Electromagnetic cascade shower similar to cosmic rays
  - Rich of secondary particles， neutrons and muons have atmospheric-like spectra
  - high-intensity, large-area, Irradiation field are favored
  - Physics Beyond Colliders (PBC)
    - Heavy Neutral Leptons (HNLs), New particles from electromagnetic showers, Searches for Long-Lived Particles, etc

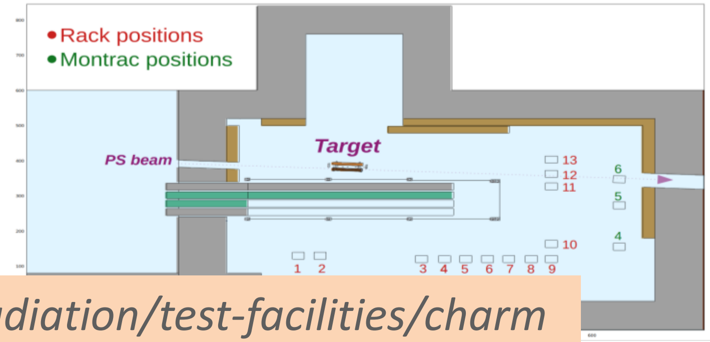


Ref:Yasuhito Sakaki @LCWS2024 talk



CHARM

- **Beam specification:**
  - **Normal PS conditions:** p+ at 24GeV/c, 1 to 2cm FWHM at the target
  - **'Blown-up' beam setting:** p+ at 24GeV/c, 8cm FWHM horizontal, 12cm FWHM vertical
  - **Lead beam:** 6.75 GeV/c and 1 to 2cm FWHM
- **Test positions:** the users device is installed on a rack and moved to one of 13 test positions (see next slide)
- **Montrac positions:** 6 extra positions along a Montrac rail system where a shuttle stop and one can leave the equipment to be irradiated
- **Beam loss monitors:** There are two BLMs located in the test area in order to measure the absorbed dose deposited in their active region



Ref:https://r2e.web.cern.ch/about-radiation/test-facilities/charm

Summary

- Dump design for Linac and main ring had been finished, can be further optimized or detailed in the EDR stage.
- Dumps used for machine protection have been studied and combined by the passive devices as collimators, now in iterative design stage.
- Other possible applications for the wasted beam is under consideration, and the feasibility can be serious treated only after the physics goal or experiment scheme had been studied and fixed.

Thank you for your attention!