Update of beampipe design and background simulation

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On behalf of the CEPC MDI Working Group

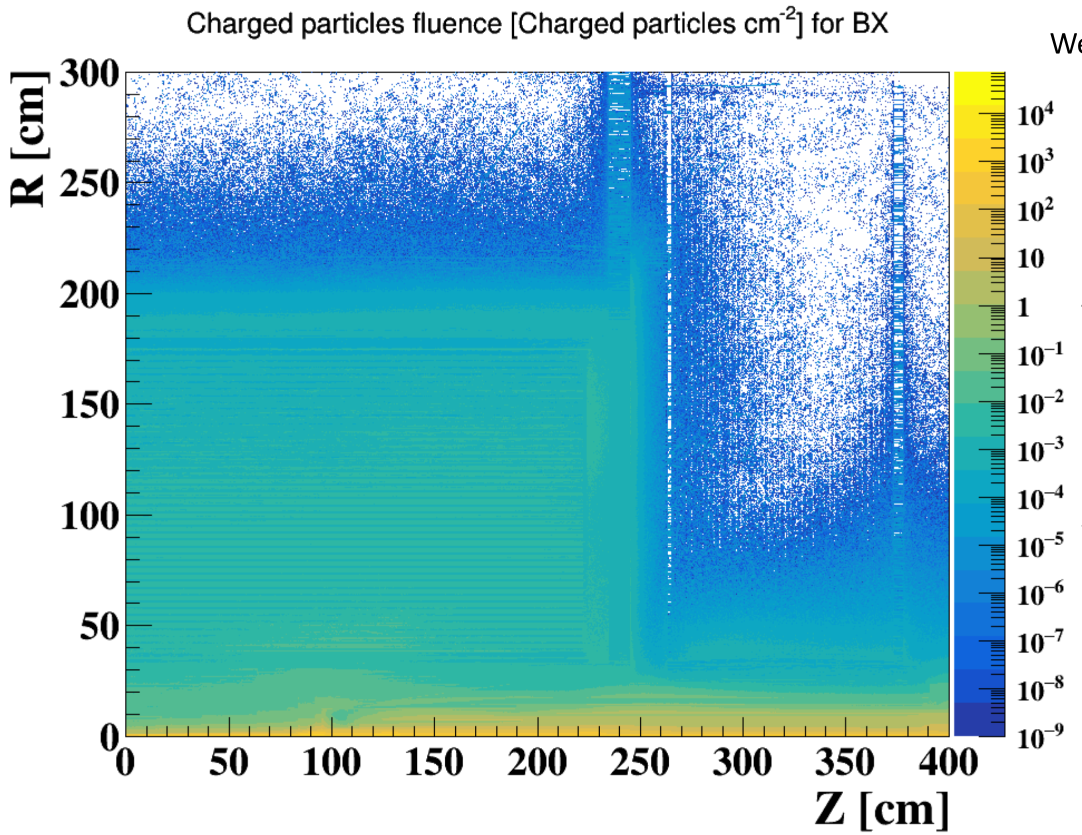
CEPC Physics and Detector Plenary Meeting

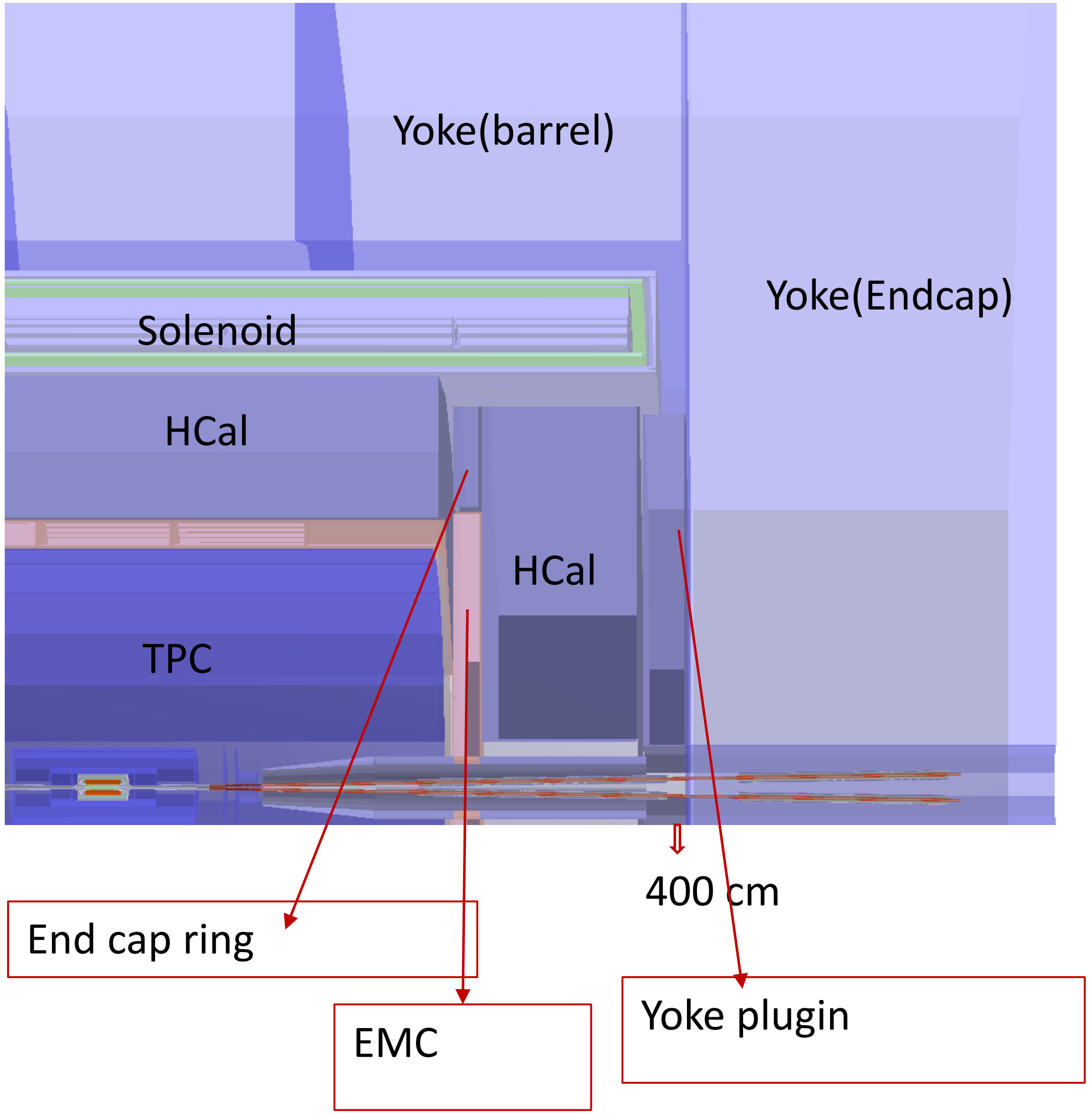
2022.4.13

Outline

- Updates on BG Simulation
- A New design of the central beampipe

Full Detector Simulation(Higgs CDR)





- Could reach Beyond ECal
- Characterized by Hit Density, TID and NIEL

Updates on BG Simulation

- The detector simulation(with a safety factor of 10 for TID/NIEL):
  - Simulate more bunches/particles
  - Read the numbers from the Figure/Histogram
  - Scale according to Luminosity(1e34/cm2/s): CDR→TDR

	CDR	TDR(30MW)	TDR(50MW)
Higgs (3T)	2.93	5.00	8.00
Z (2T)	32.1	115.0	184.0

Updates on BG Simulation

- The detector simulation(with a safety factor of 10 for TID/NIEL):
  - Detector Impacts, Vertex : CDR→TDR(Scale)

Wei Xu

	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($cm^{-2} \cdot BX^{-1}$)	2.3	2.3	2.3	0.63	0.63	0.63
TID($krad \cdot yr^{-1}$)	930	1490	2540	10.5	3150	5360
NIEL($n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	2.2	3,5	6.0	23.6	70.8	120.4

  - Detector Impacts, TPC : CDR→TDR(Scale)

Wei Xu

	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($cm^{-2} \cdot BX^{-1}$)	2.59e-2	2.59e-2	2.59e-2	6.365e-3	6.365e-3	6.365e-3
TID($krad \cdot yr^{-1}$)	4.385	7.483	11.973	67.53	241.93	387.09
NIEL($n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	0.4519	0.7712	1.234	7.415	26.565	42.503

Updates on BG Simulation

- The detector simulation(with a safety factor of 10 for TID/NIEL):
  - Detector Impacts, Ecal Barrel : CDR→TDR(Scale)

Wei Xu

	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($cm^{-2} \cdot BX^{-1}$)	1.162e-3	1.162e-3	1.162e-3	2.714e-4	2.714e-4	2.714e-4
TID($krad \cdot yr^{-1}$)	0.319	0.544	0.871	5.505	19.722	31.555
NIEL($n_{eq}\times10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	0.1285	0.2193	0.3509	1.396	5.001	8.002

  - Detector Impacts, Ecal Endcup: CDR→TDR(Scale)

Wei Xu

	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($cm^{-2} \cdot BX^{-1}$)	1.356e-3	1.356e-3	1.356e-3	2.335e-4	2.335e-4	2.335e-4
TID($krad \cdot yr^{-1}$)	0.2841	0.4848	0.7757	2.473	8.860	14.175
NIEL($n_{eq}\times10^{12} \cdot cm^{-2} \cdot yr^{-1}$)	0.1248	0.2130	0.3408	1.069	3.830	6.128

Updates on BG Simulation

- The detector simulation(with a safety factor of 10 for TID/NIEL):
  - Detector Impacts, HCal Barrel : CDR→TDR(Scale)

Wei Xu

	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($\boldsymbol{cm^{-2} \cdot BX^{-1}}$)	2.778e-5	2.778e-5	2.778e-5	1.1e-5	1.1e-5	1.1e-5
TID($\boldsymbol{krad \cdot yr^{-1}}$)	7.603e-3	12.974e-3	20.76e-3	0.2529	0.906	1.450
NIEL($\boldsymbol{n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}}$)	0.0116	0.198	0.317	0.1627	0.5829	0.9326

  - Detector Impacts, HCal Endcup: CDR→TDR(Scale)

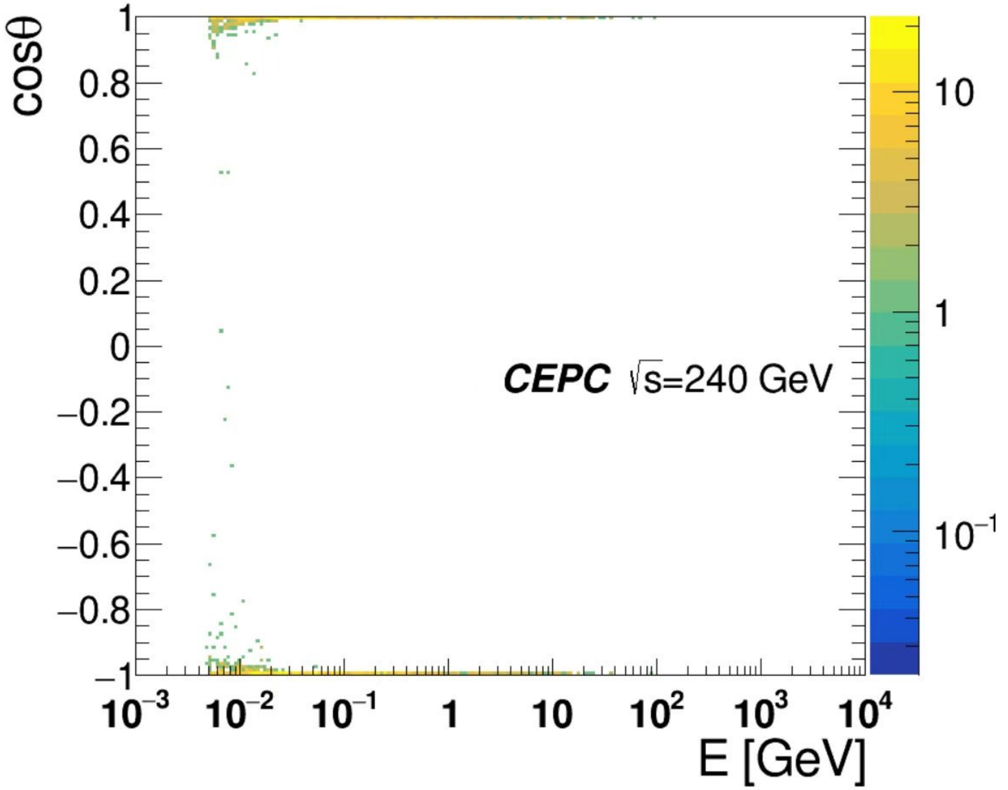
Wei Xu

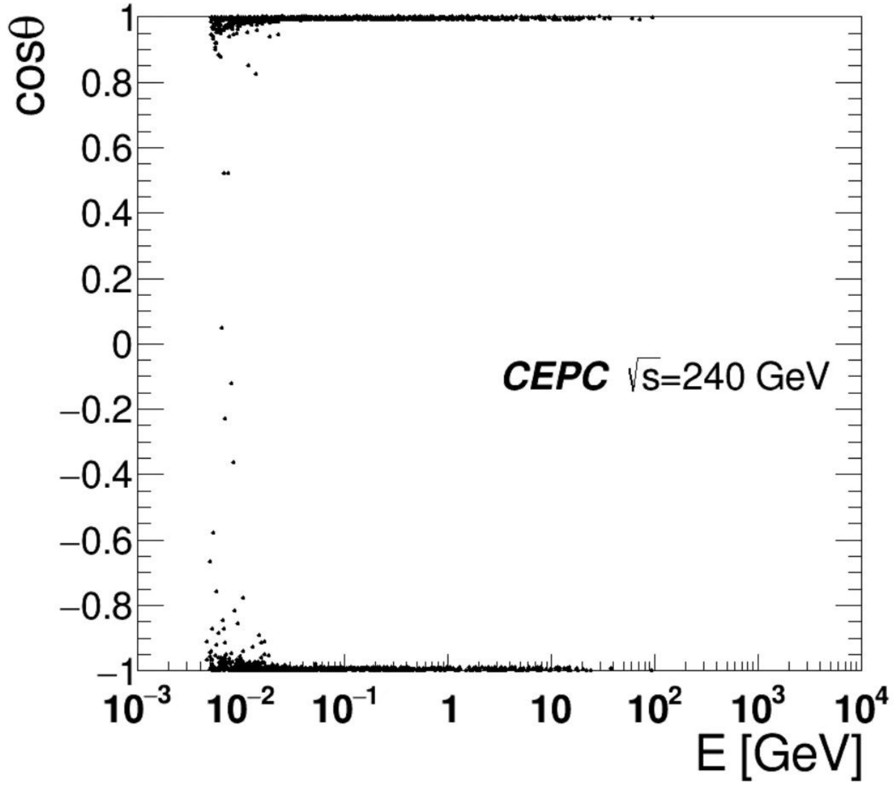
	Higgs			Z		
	CDR	TDR-30	TDR-50	CDR	TDR-30	TDR-50
Hit Density($\boldsymbol{cm^{-2} \cdot BX^{-1}}$)	1.321e-3	1.321e-3	1.321e-3	2.732e-4	2.732e-4	2.732e-4
TID($\boldsymbol{krad \cdot yr^{-1}}$)	0.284	0.485	0.775	4.589	16.44	26.31
NIEL($\boldsymbol{n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}}$)	0.159	0.271	0.434	1.108	3.97	6.351

TDR Pair Production(Higgs)

- Previous results were based on scaling of the CDR numbers
- We also performing the TDR simulation
- Starting with pair production:

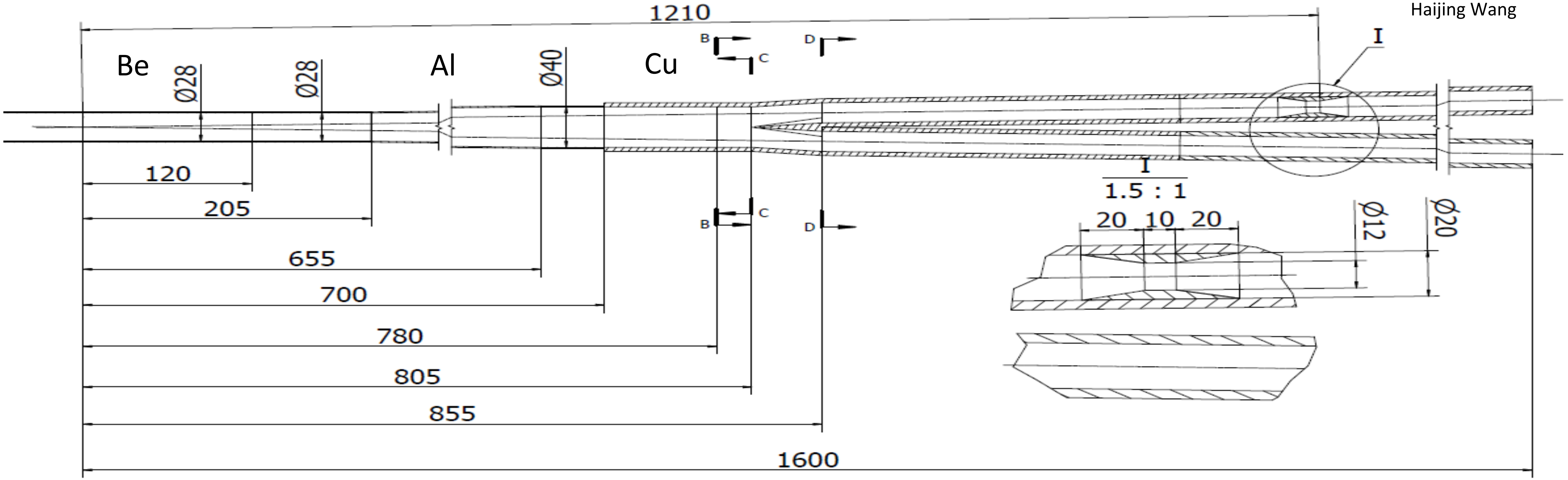
Wei Xu





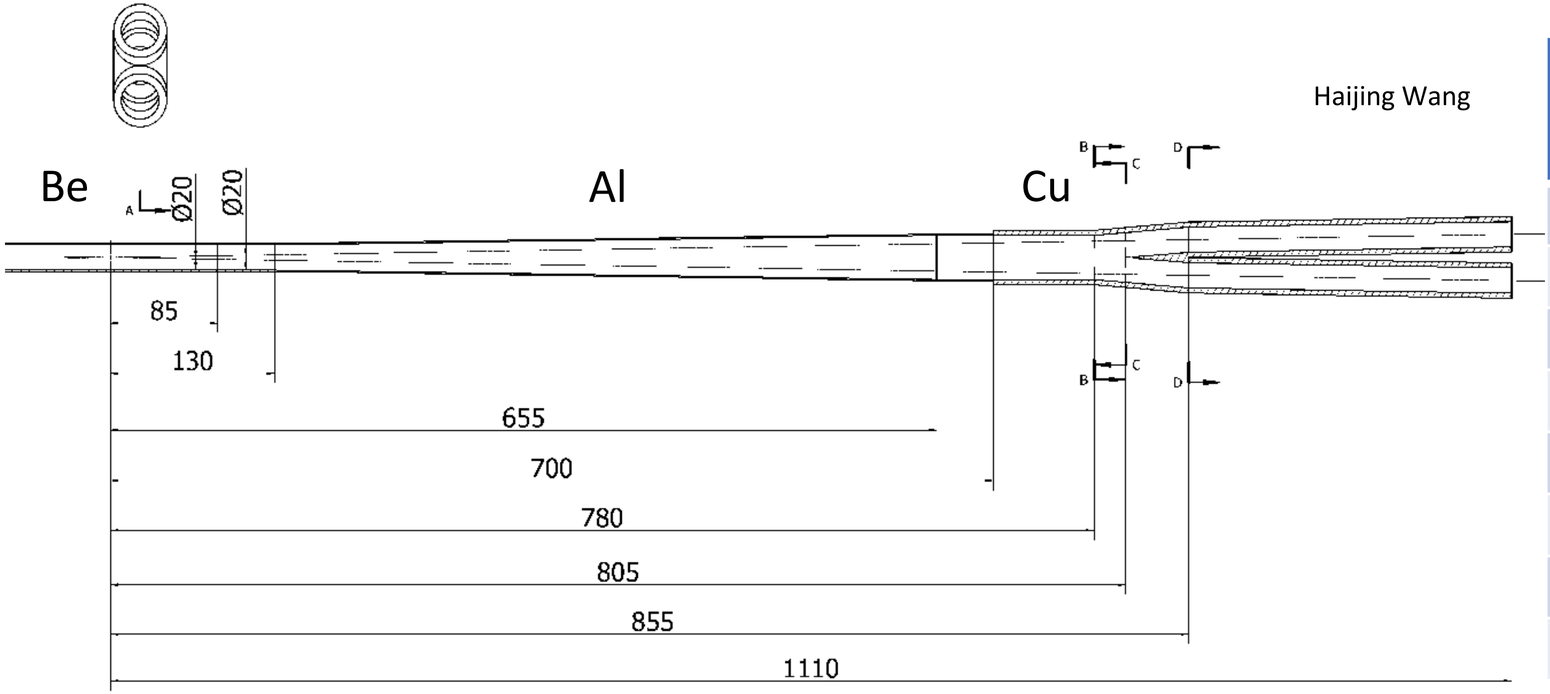
The new central beampipe design

- At CDR phase, we have the following design
  - 28 mm Central beampipe diameter
  - Cylinder Design



The new central beampipe design

- Moving to TDR, with high luminosity:
  - Trying to shrink the central beampipe diameter to 20mm
  - Might be better for Physics
  - Higher HOM & Higher Backgrounds



Position	Position Start-end（mm）	material	Length (mm)
Be pipe (w)	0-85	Be	85
Be pipe transition(w)	85-130	Al	45
Transition pipe (w)	130-655	Al	525
Transition （w）	655-700	Al	45
RVC bellow （w）	700-780	Cu	80
Transition on Y-shape	780-805	Cu	25
Y- shape (w)	805-855	Cu	50
Quadrupole pipe(w)	855-1100	Cu	245

The new central beampipe design

- If we still keep the cylinder design, the HOM heat would be unacceptable: P: H/W/Z/tt: 84.78w/413.6w/4097.23w/23.54w

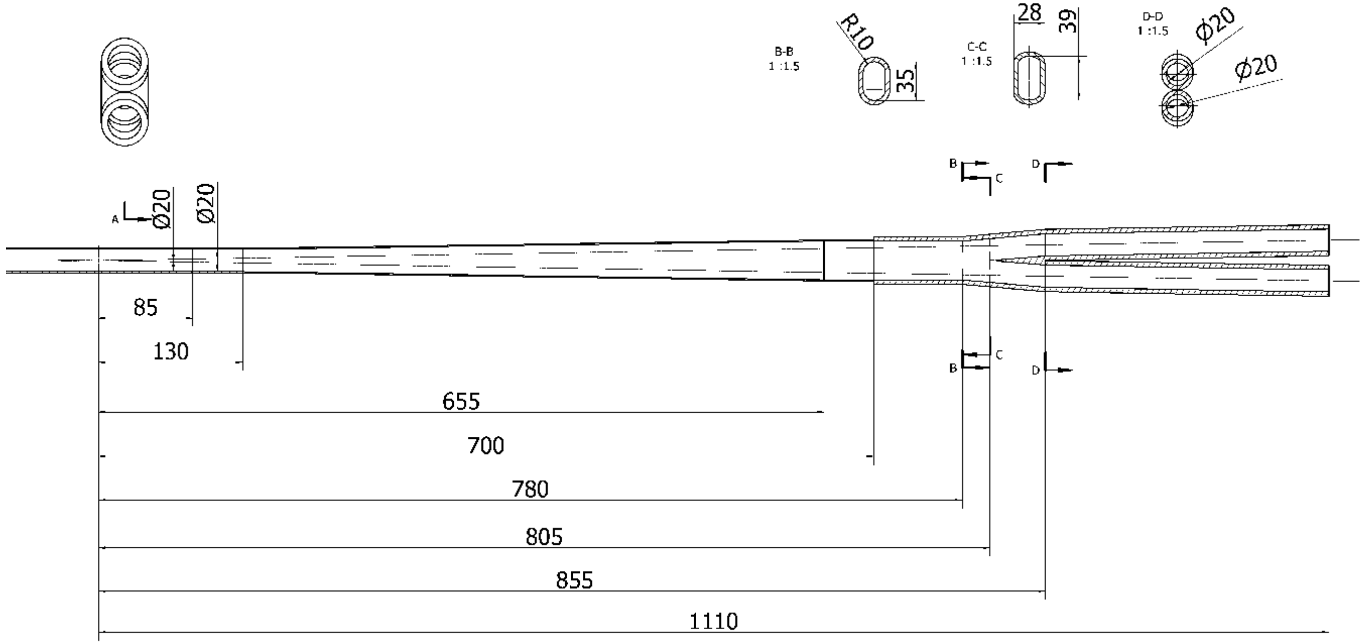
Yudong Liu

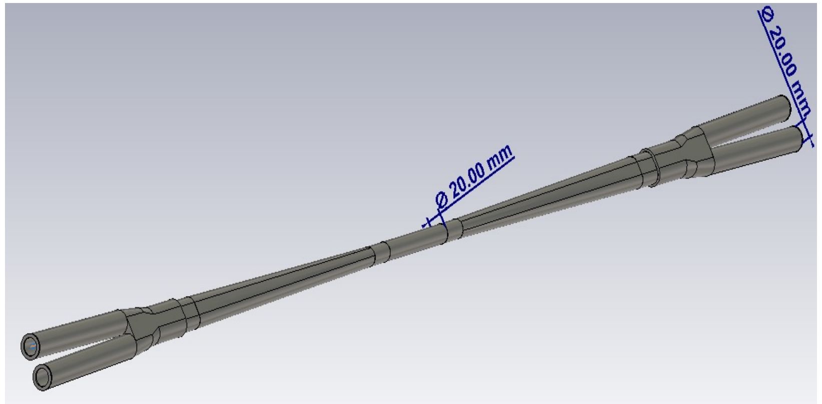
Position	Position Start-end (mm)	material	Length (mm)	Higgs(w) & (w/cm^2)	W (w) & (w/cm^2)	Z(w) & (w/cm^2)	ttbar (w) & (w/cm^2)
Be pipe (w)	0-85	Be	85	3.99 & 0.075	19.72 & 0.369	**195.16 & 3.65**	1.10 & 0.021
Be pipe transition(w)	85-130	Al	45	2.17 & 0.077	10.41 & 0.368	**103.34 & 3.66**	0.61 & 0.021
Transition pipe (w)	130-655	Al	525	24.90 & 0.055	121.70 & 0.268	**1205.51 & 2.66**	6.91 & 0.015
Transition (w)	655-700	Al	45	2.17 & 0.044	10.41 &0.210	**103.34 & 2.09**	0.61 & 0.012
RVC bellow (w)	700-780	Cu	80	1.85 & 0.021	8.93 & 0.102	**88.24 &1.00**	0.50 & 0.006
Transition on Y-crotch	780-805	Cu	25	0.57 & 0.02	2.77 & 0.095	**27.61 & 0.95**	0.18 & 0.006
Y- crotch (w)	805-855	Cu	50	1.18 &0.016	5.55 & 0.076	**55.15 & 0.75**	0.32 & 0.004
Quadrupole pipe(w)	855-1100	Cu	245	5.59 & 0.017	27.30 & 0.085	**270.33 & 0.84**	1.53 & 0.005
Total	0-1100	-	1100	42.39 &0.039	206.80 & 0.189	**2048.69 & 1.87**	11.76 & 0.011

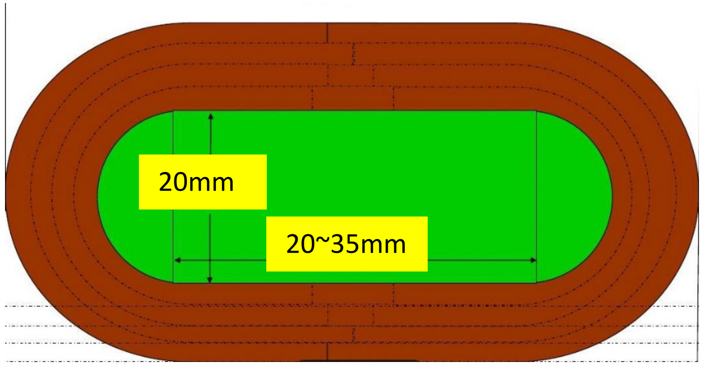
The new central beampipe design

- If we still keep the cylinder design, the HOM heat would be unacceptable: P: H/W/Z/tt: 84.78w/413.6w/4097.23w/23.54w
- Therefore the racetrack design comes : 4097.23w→1150.1w

Haijing Wang







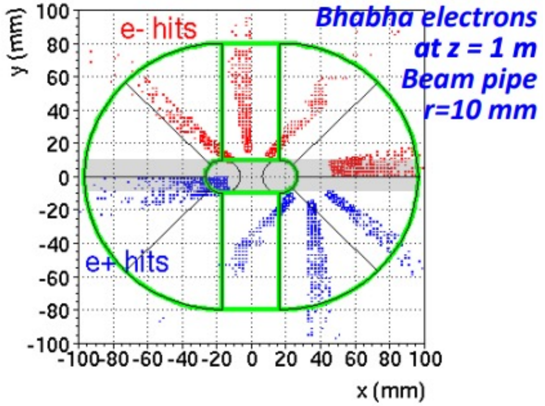
The new LumiCal position

Suen Hou

BHlumi X-section

flat beam pipe, y= ±10 mm

Bhlumi counting electrons in fiducial region at z = 1m



Lab round r>20 mRad, |y|>20 mm

CMS 10 ~ 80 mRad		LAB detect *ONE* electron		LAB detect *both* electrons	
BARE1		R>20 mRad full phi coverage	R>20 mRad cut off ±20mm	R>20 mRad full phi coverage	R>20 mRad cut off ±20 mm
Nevents	457232	274420	53724	93311	51360
Xsec (nb)	1168.3	701.2	137.3	238.4	131.2

Lab round r>15 mRad, |y|>15 mm

CMS 10 ~ 80 mRad		LAB ONE electron		LAB both electrons	
BARE1		R>15 mRad full phi coverage	R>15 mRad cut off ±15mm	R>15 mRad full phi coveage	R>15 mRad cut off ±15mm
Nevents	457232	330952	100152	204263	96221
Xsec (nb)	1168.3	845.6	255.9	521.9	245.9

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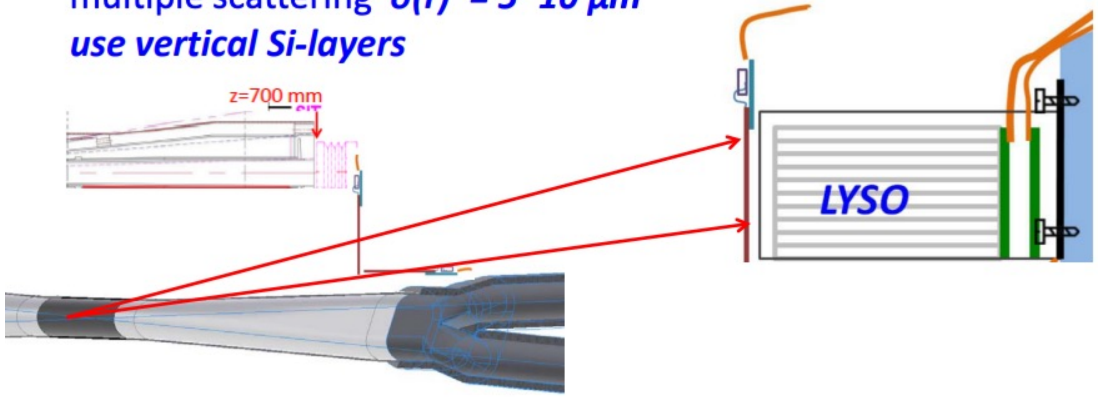
Electron @ 15 mRad

Beampipe= 0.5^{Al}+0.5^{Air}+0.35^{Al}
Distance dz in beampipe= 1.35/tan(0.015 mRad) = 90 mm

- Electrons at ϑ_{min} = 15 mRad needs a Si-layer attached on beam-pipe to minimize multiple scattering expansion
  σ(Z) ~ 200 μm, σ(ϑ) ~ 20 μRad,
- Inner tracker region z = 400~700 mm
  (***ϑ range 15 ~35 mRad)***
  multiple scattering ***σ(r) = 5~10 μm***
  use vertical Si-layers



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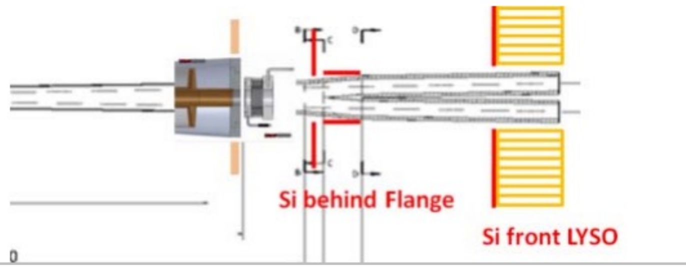
Alignment error less than 1μm

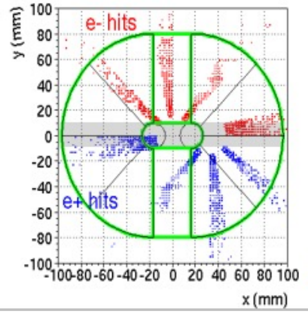
The new central beampipe design

Summary, tube-pipe
Fixed $r_y = \pm 10$mm, split-x to dual-pipes

Suen Hou

- **Bhabha cross-section** with both electrons detected in Lab frame of Θ_{min} >15 mRad, |y|>15mm
  ➔ X-section ~250 nb
- **LumiCal simplified** (need detailed GEANT study)
  - fiducial range cut off x-axis for mechanical and probes
  - Si-layers outside Flange
    two horizental flat layers upon/below beam-pipe ➔ θ_{min} edge
    vertical layers to beampipe for θ coverage





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- HOM and LumiCal both prefer the racetrack design
- LumiCal wants to change the material to Al as much as possible
- IP BPM will be added to single beampipe part
- BG simulation will be based on this new design

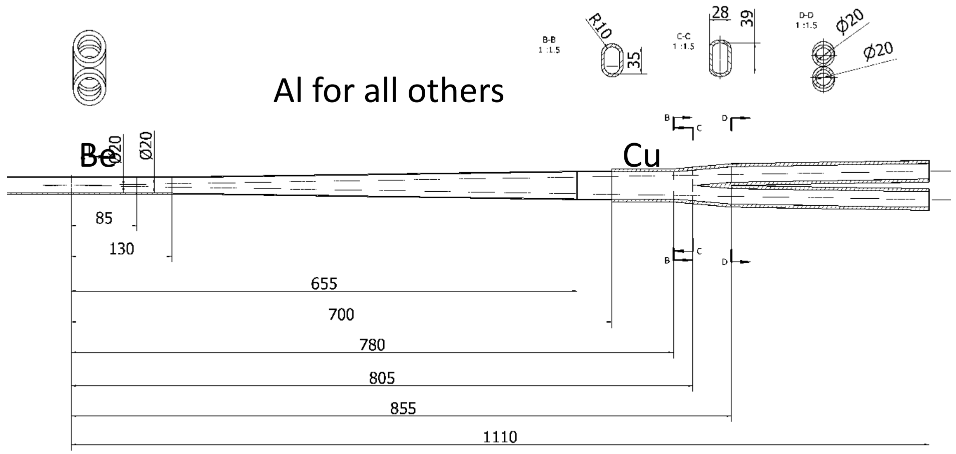
How about other sub-detectors?

Summary & Outlook

- The TDR detector simulation based on CDR scaling got initial numbers:

	Hit Density($cm^{-2} \cdot BX^{-1}$)	TID($krad \cdot yr^{-1}$)	NIEL($n_{eq} \times 10^{12} \cdot cm^{-2} \cdot yr^{-1}$)
Vertex	2.3	5360	120.4
TPC	2.59e-2	387.09	42.503
Ecal Barrel	1.16e-3	31.56	8.002
Ecal EndCup	1.36e-3	14.175	6.128
Hcal Barrel	2.78e-5	1.450	0.9326
Hcal EndCup	1.32e-3	26.31	6.351

- The new racetrack design of central beampipe has been made:

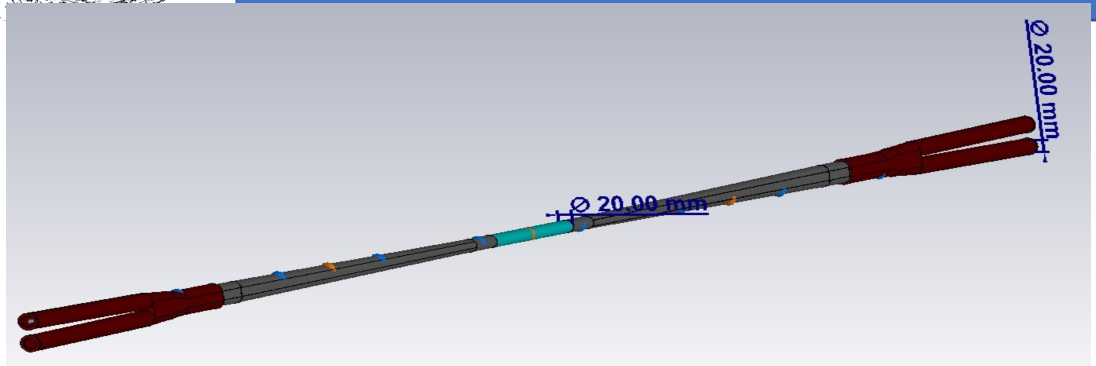


- The BG Simulation based on new design has been started

Thank You

Backup

Transition region: Racetrack (including materials)& power distribution



σ_z=5mm: Two beam in the IR

Yudong Liu

Loss factor Trap in IR @k_trap: 0.032v/pc

P_{trap}: H/W/Z/tt: 23.8w/116.1w/1150.1w/6.61w

Position	Position Start-end (mm)	material	Length (mm)	Higgs(w) & (w/cm²)	W (w) & (w/cm²)	Z(w) & (w/cm²)	ttbar (w) & (w/cm²)
Be pipe (w)	0-85	Be	85	1.12 & 0.02	5.535 & 0.104	**54.781 & 1.02**	0.31 & 0.005
Be pipe transition(w)	85-130	Al	45	0.61 & 0.02	2.923 & 0.104	**29.008 & 1.02**	0.17 & 0.007
Transition pipe (w)	130-655	Al	525	6.99 & 0.017	34.16 & 0.085	**338.39 & 0.83**	1.94 & 0.005
Transition (w)	655-700	Al	45	0.61 & 0.014	2.923 & 0.069	**29.008 & 0.69**	0.17 & 0.003
RVC bellow (w)	700-780	Cu	80	0.52 & 0.007	2.508 & 0.035	**24.77 & 0.33**	0.14 & 0.002
Transition on Y-crotch	780-805	Cu	25	0.16 & 0.007	0.778 & 0.031	**7.7492 & 0.31**	0.05 & 0.002
Y- crotch (w)	805-855	Cu	50	0.33 & 0.005	1.557 & 0.024	**15.481 & 0.24**	0.09 & 0.002
Quadrupole pipe(w)	855-1100	Cu	245	1.57 & 0.005	7.663 & 0.024	**75.883 & 0.24**	0.43 & 0.002
Total	0-1100	-	1100	11.9 & 0.012	58.05 & 0.057	**575.07 & 0.57**	3.3 & 0.003