



# Progress of CEPC ref-TDR TDAQ

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On behalf of CEPC TDAQ Group



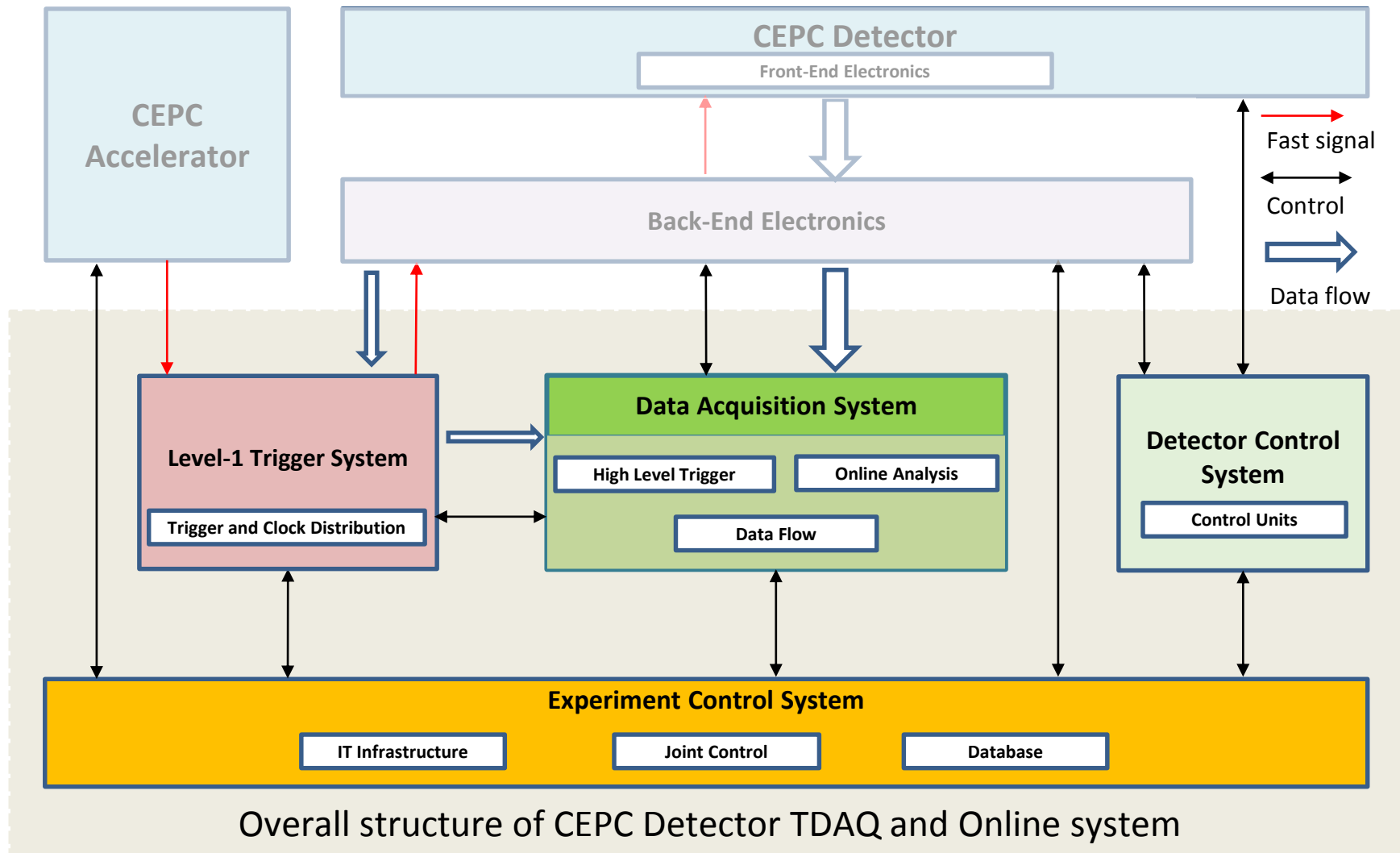
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# Progress of TDAQ

- TDR draft v1.0
  - 100% ready for draft 0
- To be confirmed
  - Background for Z mode
    - Event rate
  - Readout window
    - Event size
  - HLT algorism
  - System scale

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# Overall Design



# Trigger & Data Rate

## ■ L1 trigger rate

- 13 kHz@Higgs
- 120 kHz@low. Z

## ■ DAQ data rate

- Read out:
  - 240 GB/s @ Low lum. Z
  - 800 GB/s @ High lum. Z
- Storage:
  - 7.5 GB/s @Low lum. Z
  - 30GB/s @ High lum. Z
- 1 year(3600h):
  - 100 PB @ Low lum. Z
  - 400 PB @ High lum. Z

**Table 12.5:** Trigger rate estimation table for different run conditions.

Condition	Higgs	Z(10MW)	Z(50MW)	W	$t\bar{t}$
Luminosity ( $10^{34}/cm^2/s$ )	8.3	38	192	26.7	0.8
Bunch space (ns)	346.2	69.3	23.1	253.8	4523.1
Bunch crossing rate (MHz)	1.34	12	39.4	6.5	0.18
Raw data rate (Tbyte/s)	0.4	3.6	11.82	1.95	0.048
Physical event rate (kHz)	0.087	15.3	76.6	0.1	0.002
L1 trigger rate (kHz)	13	120	400	65	2
DAQ readout rate (Gbyte/s)	26	240	800	130	4
High level trigger rate (kHz)	1	25	100	6	1
DAQ storage rate (Gbyte/s)	0.3	7.5	30.0	1.8	0.3

# Backup

# Physical Event Rate

## ■ Higgs 240GeV(30MW/50MW)

- BX rate: 0.8(1.74)/1.34(2.9) MHz
- Physical event rate: **5Hz/8Hz** (Higgs: 0.02Hz)

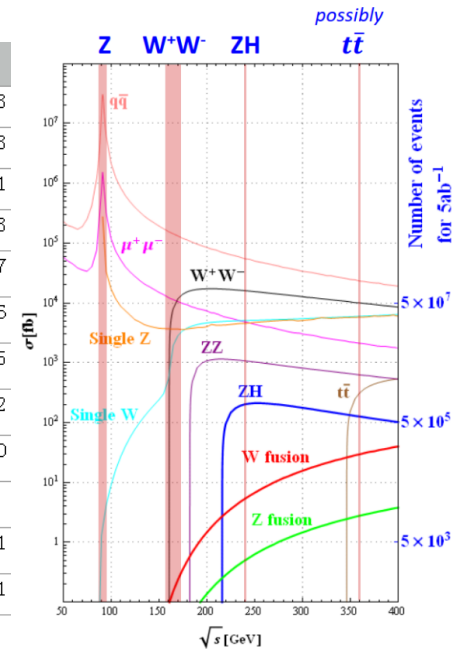
## ■ Z pole 91GeV(10MW/50MW)

- BX rate: 12(14.5)/39.4(43.3) MHz
- Physical event rate: **13.2kHz/66kHz**

	Higgs	Z		W	$t\bar{t}$
SR power per beam (MW)	30	30	10	30	30
Bunch number	268	11934	3978	1297	35
Bunch spacing (ns)	576.9 (×25)	23.1(×1)	69.2(×3)	253.8(×11)	4523.1(×196)
Train gap (%)	54	17	17	1	53
Luminosity per IP ( $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ )	5.0	115	38	16	0.5

	Higgs	Z	W	$t\bar{t}$
SR power per beam (MW)	50			
Bunch number	446	13104	2162	58
Bunch spacing (ns)	346.2 (×15)	23.1 (×1)	138.5 (×6)	2700.0 (×117)
Train gap (%)	54	9	10	53
Luminosity per IP ( $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ )	8.3	192	26.7	0.8

过程	xsection(nb)	百分比	事例率kHz
Bhabha	0.0586	0.001371951	0.068597543
muon	1.5361	0.035963374	1.798168703
tau	1.5249	0.035701158	1.78505791
qq	30.6522	0.717633315	35.88166573
电子中微子	2.9607	0.069316296	3.465814777
muon中微子	2.9896	0.069992906	3.499645306
tau中微子	2.9909	0.070023342	3.501167095
中微子总	8.9411	0.209330202	10.46651012
总共	42.7129	1	50
		亮度	
30MW		1.15E+36	4.91E+01
50MW		1.92E+36	8.20E+01



Z pole, ref: [MC /cfs/data/stdhep/CEPC91/2fermions/wi\\_ISR\\_20220618\\_50M/2fermions/](https://mc.cern.ch/data/stdhep/CEPC91/2fermions/wi_ISR_20220618_50M/2fermions/)

# Beam Backgrounds

## Ave. hit rate Higgs Vs Low Z

- Vertex: 0.49 -> 1.96, 5 times
- ITK: 0.0021 -> 0.08, 40 times
- ECal: 0.011 -> 0.35, 30 times

## Higgs Vs Low Z

- BX rate 1.34 -> 12 MHz

## Raw data rate @Higgs

- 400GB/s

## Raw data size per BX @Higgs

- 300KBytes

	50MW Higgs, 346ns/BX
Pair Production	~1.82GHz in IR
Beam Thermal Photon	~0.30MHz/beam in IR
Beam Gas Bremsstrahlung	~0.04MHz/beam in IR
Beam Gas Coulomb	~0.23MHz/beam in IR
Touschek Scattering	~0.06MHz/beam in IR
Radiative Bhabha	
SR	~630 PHz/beam generated at last bending magnet

	50MW Higgs, 23ns/BX
Pair Production	~25.5GHz in IR
Beam Thermal Photon	~0.26GHz/beam in IR
Beam Gas Bremsstrahlung	~0.01GHz/beam in IR
Beam Gas Coulomb	~2.36GHz/beam in IR
Touschek Scattering	~6.24GHz/beam in IR

	10MW Z, 69ns/BX
Pair Production	~3.2GHz in IR
Beam Thermal Photon	~63MHz/beam in IR
Beam Gas Bremsstrahlung	~2.5MHz/beam in IR
Beam Gas Coulomb	~272MHz/beam in IR
Touschek Scattering	~62MHz/beam in IR

Sub-Detectors	Ave. Hit Rate(MHz/cm <sup>2</sup> )	Max. Hit Rate(MHz/cm <sup>2</sup> )	Max. Occupancy/BX(%)
Vertex	0.49	0.61	0.0022
ITK	0.0021	0.25	0.025(Strip)
TPC	2.7	6.0	0.0045
OTK – Endcap	0.0002	0.0006	0.35(Strip)
ECal – Endcap	0.011/bar	0.3/bar	0.0008
HCal – Endcap	0.002/GS	0.05/GS	0.0005
Muon – Endcap	0.00000001/cell	0.00002/cell	0.006
LumiCal – Crystal	3.37	7.82	9.1

Sub-Detectors	Ave. Hit Rate(MHz/cm <sup>2</sup> )	Max. Hit Rate(MHz/cm <sup>2</sup> )	Max. Occupancy/BX(%)
Vertex	15.64	18.34	3.73e-3
ITK	0.61	57.61	0.0543
TPC	2	3.5	0.0026
OTK – Endcap			
Ecal – Barrel	1.54/bar	22.3/bar	7.03
ECal – Endcap	2.84/bar	43.5/bar	9.29
HCal – Endcap			
Muon – Endcap			1.5

Sub-Detectors	Ave. Hit Rate(MHz/cm <sup>2</sup> )	Max. Hit Rate(MHz/cm <sup>2</sup> )	Max. Occupancy/BX(%)
Vertex	1.96	2.30	3.73e-3
ITK	0.08	7.20	0.0543
TPC	0.25	0.45	0.0026
OTK – Endcap			
ECal – Barrel	0.2	2.79/bar	7.03
ECal – Endcap	0.35	5.44/bar	9.29
HCal – Endcap			
Muon – Endcap			1.5
LumiCal – Crystal			

# Raw Data Rate

## Data rate before trigger

- <1 TB/s @ Higgs
- Several TB/s @ Z

## L1 trigger rate

- O(1k) Hz @ Higgs
- O(100k) Hz @ Z

## Event size < 2 MB

- Related to occupancy and read out window

## Storage rate after HLT

- <100 Hz(200 MB/s) @ Higgs
- 100 kHz (200 GB/s) @ Z

	Vertex	Pix(ITKB)	Strip (ITKE)	OTKB	OTKE	TPC	ECAL-B	ECAL-E	HCAL-B	HCAL-E	Muon
Channels per chip	512*1024	512*128	1024	128		128	8~16				
Data Width /hit	32bit	42bit	32bit	48bit		48bit	48bit				
Avg. data rate / chip	0.18Gbps/chip, 1Gbps/chip inner	3.53Mbps/chip	21.5Mbps/chip	2.9Mbps/chip	38.8Mbps/chip	~70Mbps/module Inmost	10kHz/ch	10kHz/ch	5kHz/channel	5kHz/channel	10kHz/channel
Detector Channel/module	1882 chips @Stch &Ladder	30,856 chips 2204 modules	23008 chips 1696 modules	83160 chips 3780 modules	11520 chips 720 modules	492 Module	0.96M chn ~60000 chips 480 modules	0.39 M chn	3.38M chn 5536 aggregation board	2.24M chn 1536 Aggregation board	43,176 chn, 288 modules
Avg Data Vol before trigger	474.2 Gbps	101.7 Gbps	298.8 Gbps	249.1 Gbps	27.9 Gbps	34.4 Gbps	460.8 Gbps	187 Gbps	811.2 Gbps	537.6 Gbps	24 Gbps
Occupancy(%)	0.022	0.025(Strip)		0.35(Strip)		0.0028	0.58		0.002		0.038
Sum	3.2 Tbps = 400GB/s										

Collected from each detectors @Higgs



# Trigger & Data Rate

## L1 trigger rate

- 13 kHz@Higgs, 120 kHz@low. Z

## Read out window

- TPC 34 us
- CLIC rec. time window
  - ECAL & HCAL Endcaps & Silicon 10 ns
  - HCAL Barrel 100 ns

## Readout event size

- 620KBytes @ Higgs
  - 100 BX/events and 3.2 KBytes/BX for TPC
- 2 MBytes @Low lum. Z
  - 500 BX/event for TPC(full readout)
  - 2 BX for Hcal (75 KBytes/BX)
- 5.3 MBytes @High lum. Z
  - 1472 BX/event for TPC(full readout)
  - 5 BX for HCal

## DAQ data rate

- Read out: 8 GB/s @Higgs, 83.4 GB/s @ Low lum. Z (120kHz\*375KB + 12MHz\*3.2KB)
  - 366 GB/s @ High lum. Z (400kHz\*(300+75\*4)KB + 39.4MHz\*3.2KB)
- Storage: 0.6 GB/s @Higgs, 50 GB/s @Low lum. Z (7.5GB/s after event size compression)
- 1 year(3600h): 8 PB, 100 PB

	Higgs	Z(10MW)	Z(50MW)	W	tt
Luminosity(10E34/cm2/s)	8.3	38	192	26.7	0.8
Bunch space(ns)	346.2	69.3	23.1	253.8	4523.1
Bunch cross rate(MHz)	1.34	12	39.4	6.5	0.18
Raw data rate before trigger (TBytes/s)	0.4	3.6	11.82	1.95	0.048
Physical event rate(kHz)	0.008	13.2	66	0.1	0.002
L1 trigger rate(kHz)	13	120	400	65	2
DAQ readout rate(Gbyte/s)	26	240	800	130	4
High level trigger rate(kHz)	1	25	100	6	1
DAQ storage rate(Gbytes/s)	0.3	7.5	30	1.8	0.3

Event size: readout 2MB, storage 300KB

# Trigger strategy on High Lumi-Z

## ■ Trigger on High Lumi-Z

- Same hardware trigger structure on High Lumi-Z and low Lumi-Z
- Hardware resource may increase-  
common trigger boards

## ■ Electronic system

- Trigger send to FEE from BEE if needed.
- If trigger latency can not meet the requirements, private trigger link may needed from FEE to BEE.

