TDAQ Progress
of CEPC Detector ref-TDR

Fei Li

On behalf of CEPC TDAQ Group

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences
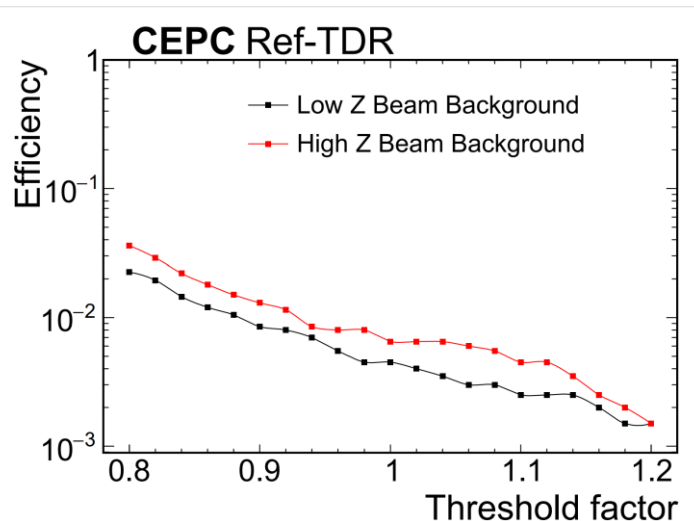
Discussion After Review

- L1 trigger rate

- Safety factor

- Editorial comments just before 24th review data.
  - Almost finish all of them.

Trigger Simulation Update

Figure 12.11

- **Basic L1 Trigger algorithm**
  - Calorimeter + Muon
- **High trigger efficiency**
- **BG veto efficiency**
  - BG rate 46.9 kHz@ZH
  - 90 kHz @Low Lumi. Z
  - 473 kHz @High Lumi. Z

Higgs mode	Efficiency(%)	Z mode	Efficiency(%)
Higgs production	>99.9	$q\bar{q}$	>99.9
$q\bar{q}$	99.8	$\mu^+\mu^-$	>99.9
$\mu^+\mu^-$	99.2	$\tau^+\tau^-$	99.7
$\tau^+\tau^-$	98.7	Bhabha	>99.9
Bhabha	99.8		

Di-photon processes		Di-photon processes	
Di-photon event rate	**Efficiency(%)**	**Di-photon event rate**	**Efficiency(%)**
6.4 kHz	28.2	Low Lumi: 17.7 kHz	41.1
		High Lumi: 130.7 kHz	41.1

Beam Background		Beam Background	
Background event rate	**Veto efficiency(%)**	**Background event rate**	**Veto efficiency(%)**
46.9 kHz	96.5	Low Lumi: 90.0 kHz	99.2
		High Lumi: 473 kHz	98.8

Total		Total	
53.3 kHz		Low Lumi: 118.2 kHz	
		High Lumi: 681.1 kHz	

Acceptable for HLT, but trigger rate higher than expected @high lumi. Z

Trigger Simulation with Higher Threshold

- **Optimal threshold for calorimeter**

Subdetector	Baseline threshold		Subdetector	Baseline threshold	
	Higgs mode	Z mode		Higgs mode	Z mode
ECAL Barrel	> 0.39 GeV	>0.14 GeV	HCAL Barrel	> 0.05 GeV	>0.03 GeV
ECAL Endcap	> 9.60 GeV	>1.90 GeV	HCAL Endcap	> 0.34 GeV	>0.09 GeV
	Optimal threshold			Optimal threshold	
	Higgs mode	Z mode		Higgs mode	Z mode
ECAL Barrel	> 0.41 GeV	>0.21 GeV	HCAL Barrel	> 0.08 GeV	>0.042 GeV
ECAL Endcap	> 10.2 GeV	>2.10 GeV	HCAL Endcap	> 0.35 GeV	>0.09 GeV

- **Hits of Muon Endcap with R>1m:**
  - Change from >1 to > 2
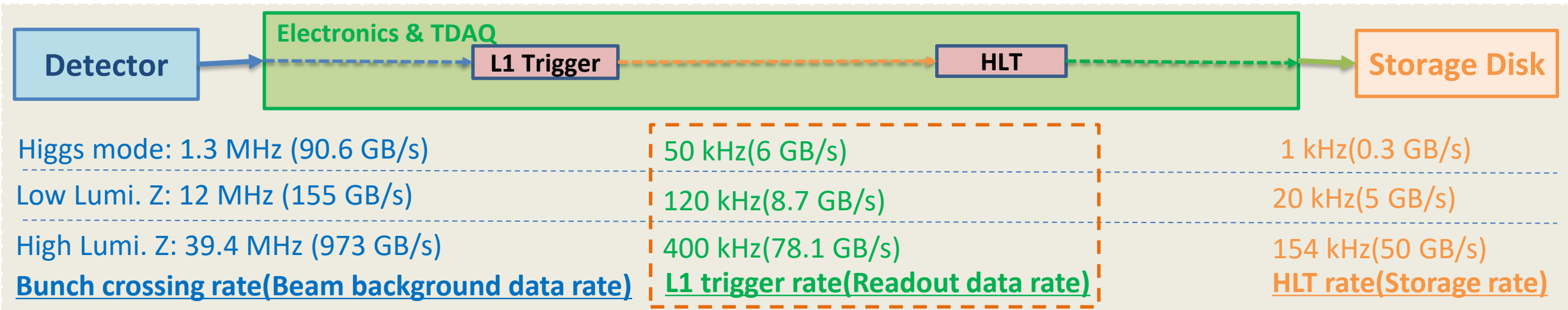- **Trigger rate decreased significantly without noticeable loss of physics efficiency.**
- **Beam BG reduce to <1% of BX rate for all modes**
- **Need more event samples and noise studies.**

Higgs mode	Efficiency(%)	Z mode	Efficiency(%)
Higgs production	>99.9	$q\bar{q}$	>99.9
$q\bar{q}$	99.8	$\mu^+\mu^-$	>99.9
$\mu^+\mu^-$	99.2	$\tau^+\tau^-$	99.7
$\tau^+\tau^-$	98.4 -0.3	Bhabha	>99.9
Bhabha	99.7 -0.1		

Di-photon processes		Di-photon processes	
Di-photon event rate	Efficiency(%)	Di-photon event rate	Efficiency(%)
5.0 kHz	22.0 -6.2	Low Lumi: 16.8 kHz	39.1
		High Lumi: 124.0 kHz	39.1 -2

Beam Background		Beam Background	
Background event rate	Veto efficiency(%)	Background event rate	Veto efficiency(%)
9.4 kHz	99.3 +2.8	Low Lumi: 42.0 kHz	99.6 +0.4
		High Lumi: 197 kHz	99.5 +0.7

Total	Total
14.4 kHz	Low Lumi: 69.3 kHz
	High Lumi: 398.7 kHz

Number change summary to be added to TDR.

Estimation of Trigger and Data Rate

Detector → Electronics & TDAQ [L1 Trigger → HLT] → Storage Disk

Higgs mode: 1.3 MHz (90.6 GB/s)	50 kHz(6 GB/s)	1 kHz(0.3 GB/s)
Low Lumi. Z: 12 MHz (155 GB/s)	120 kHz(8.7 GB/s)	20 kHz(5 GB/s)
High Lumi. Z: 39.4 MHz (973 GB/s)	400 kHz(78.1 GB/s)	154 kHz(50 GB/s)
Bunch crossing rate(Beam background data rate)	**L1 trigger rate(Readout data rate)**	**HLT rate(Storage rate)**

- **L1 trigger rate**
  - Expect to reduce beam BG to <1% of BX rate
- **HLT rate**
  - Expect to reduce beam BG to <0.1%
  - Expect to reduce event size by ROI
- **DAQ data storage volume(two weeks)**
  - 0.36 PB@ Higgs, 6 PB@ Low L. Z

Table 12.4

Operation phase		I		II	III
Running mode	Higgs	Z	W	Z	$t\bar{t}$
SR power	50 MW	12.1 MW	50 MW	50 MW	50 MW
Non-empty bunch crossing rate(MHz)	1.34	12	6.5	39.4	0.17
Luminosity (10^{34}/cm^2/s)	8.3	26	26.7	192	0.8
Physical event rate (kHz)	0.5	10	1.1	77	0.057
L1 triger rate (kHz)	50	120	65	400	2
DAQ readout rate (Gbyte/s)	6.04	8.70	-	78.1	-
HLT rate (kHz)	1	20	2	154	1
Raw event size (kbyte)	301	251	500	1368	500
DAQ storage rate (Gbyte/s)	0.301	5.02	1	50.4	0.5

Maintained trigger rate unchanged, but DAQ data rate dropped an order of magnitude.

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Answers to Comments

- C-A-12-2: The safety factors applied in system design should be made explicit, clearly motivated, and documented to allow for easy updates and assessment of their impact on different subsystems.

  - >>A safety factor "1.5" is applied when estimating the event size, mentioned in section 11.2: "During the calculation, a safety factor of 1.5 was considered for the background rate.".

  - Another safety factor "10" is applied when estimating the trigger efficiency <mark>only for beam background</mark>, as mentioned in section 12.4.1(line 10422): "For both the Higgs and the Z mode, each beam background event includes 10 bunch crossings, corresponding to a safety factor of 10."

All plots need update if choose only one bunch crossing for beam background samples.