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Very basic readout questions

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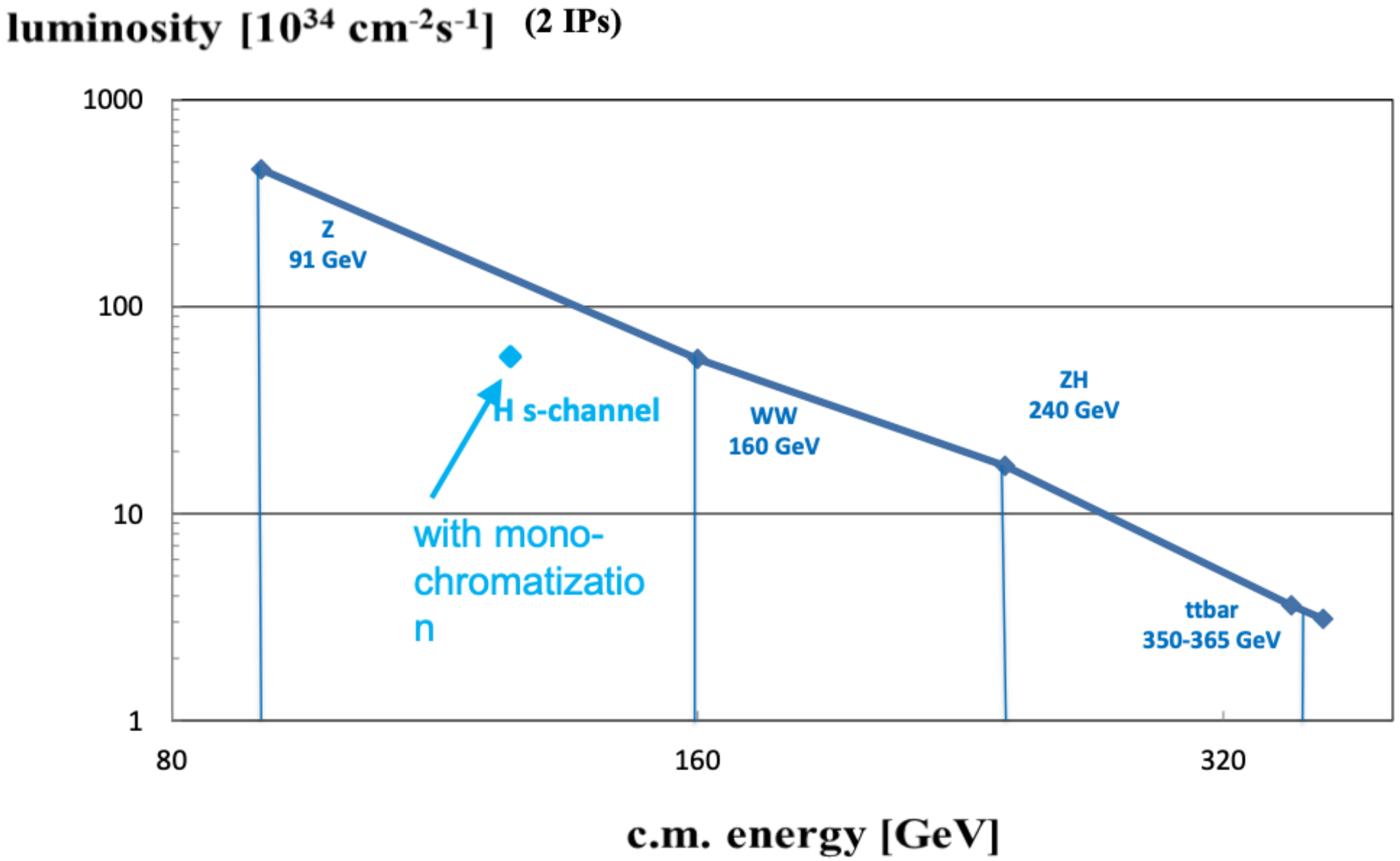
FCC-ee Luminosity vs Energy



FCC-ee parameters		Z	W^+W^-	ZH	ttbar
Beam energy	**GeV**	**45.6**	**80**	**120**	**182.5**
Luminosity / IP	**10^{34} cm^{-2} s^{-1}**	**230**	**28**	**8.5**	**1.55**
Beam current	mA	1390	147	29	5.4
Bunches per beam	#	16640	2000	328	48
Average bunch spacing	ns	19.6	163	994	3396
Bunch population	10^{11}	1.7	1.5	1.8	2.3
Horizontal emittance ε_x Vertical emittance ε_y	nm pm	0.27 1.0	0.84 1.7	0.63 1.3	1.46 2.9
β_x^* / β_y^*	**m / mm**	**0.15 / 0.8**	**0.2 / 1.0**	**0.3 / 1.0**	**1.0 / 1.6**
beam size at IP: σ_x^* / σ_y^*	µm / nm	6.4 / 28	13 / 41	13.7 / 36	38.2/68
Energy spread: SR / total (w BS)	%	0.038 / 0.132	0.066 / 0.131	0.099 / 0.165	0.15 / 0.192
Bunch length: SR / total	mm	3.5 / 12.1	3 / 6.0	3.15 / 5.3	1.97 / 2.54
Energy loss per turn	**GeV**	**0.036**	**0.34**	**1.72**	**9.2**
RF Voltage /station	GV	0.1	0.75	2.0	4/6.9
Longitudinal damping time	turns	1273	236	70.3	20.4
Acceptance RF / energy (DA)	%	1.9 / ±1.3	2.3 / ±1.3	2.3 / ±1.7	3.36 / (-2.8; +2.4)
Rad. Bhabha/ actual **Beamstr. Lifetime**	min	**68** / **> 200**	**59** / **>200**	**38** / **18**	**40** / **18**
Beam-beam parameter ξ_x / ξ_y		0.004 / 0.133	0.01 / 0.141	0.016 / 0.118	0.099 / 0.126
Interaction region length	mm	0.42	0.85	0.9	1.8

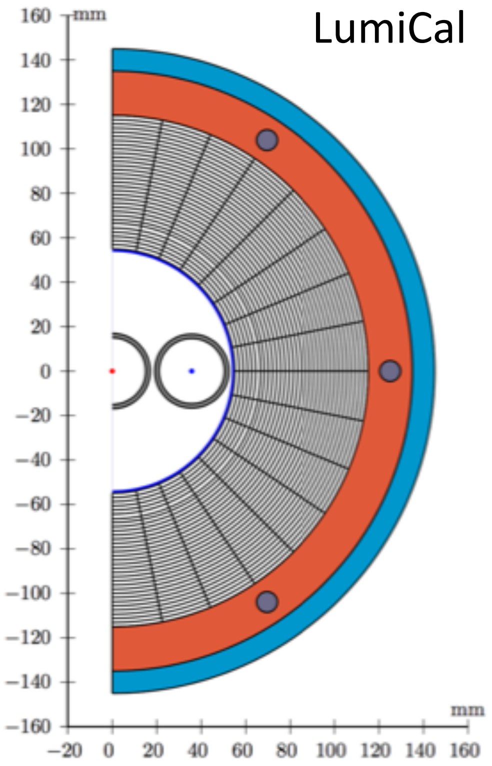
Extremely high luminosity: Z rate of ~100 kHZ

BX crossing rate of ~50 MHz

Pileup at the 0.2% level

T/DAQ ?

- Z production
  - Z rate: ~100 kHz
  - BX rate: ~50 MHz
  - One Z for each 500 BX => Pileup of 0.002 (fraction of events with > one visible Z decay)
- Similarly for luminosity measurement:
  - Bhabha rate: ~50 kHz
  - One Bhabha for each 1000 BX => Pileup of 0.001
- To control normalisation to 10^{-4}, have to be able to monitor amount of pileup events precisely



So, how do we read out the detector?

- Naïvely, I would suggest to read out each BX separately
  - If not, the pileup parameter would increase correspondingly.
  - Such readout could be a la LHC [ATLAS, CMS]: Events are stored in on-detector pipelines running at the BX frequency; on a L1Accept the event is read out to mass storage
    - possibly via a higher order trigger system running at ~200 kHz input
- Is it possible to read the detector for each BX?
  - Shaping, digitisation => power consumption => cooling needs => material budget
- If it is not possible, time stamping to ~10 ns would be required to tell BXs apart

Example of CDR Sect. 7.6 concerning VXD

Assume we read each BX separately

- Z event has typically 20 charged tracks => 800 readout channels x 13 bits = 1.3 kB/event
- 750 background hits from ICP per BX => 1.2 kB/BX
- => 2.5 kB/BX => **2.5 kB/event after L1 trigger**

Assume, as in CDR, that integration time is 1 μs (i.e. 50 BX)

- Background per event: 50 x 1.2 kb = 60 kB/event
- => Total of **61 kB/event**
  - This probably does not include time stamping information
  - To reduce event size on storage (remember 10^{13} events!), strip data from non-interesting BXs at ”event building” stage

PS. In CDR it is stated that Lumi events can go in a separate stream; no nead to read out complete event. Experience from LEP says, however, that indeed you should always read full detector in order to assure identical deadtime for Z and Bhabha events.