ALLEGRO: data rates / DAQ

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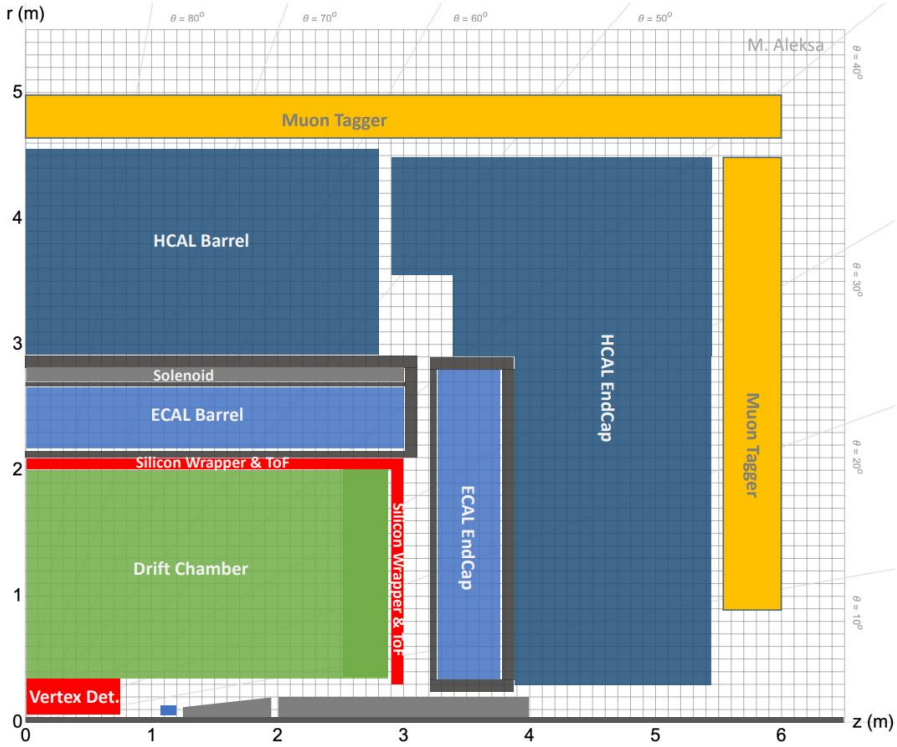
Introduction: the ALLEGRO detector concept

A concept still in its infancy

- Trackers: assume similar structure as IDEA, because of its superb expected performance
  - 5 MAPS layers for vertex detector
  - Drift chamber (112 layers)
    - Slightly longer, e.g 5m
  - Numbers shown here are the same as Franco's
- ECAL: Noble liquid technology
  - Inside super transparent CF cryostat
- 2T solenoid after ECAL, in same cryostat
- HCAL: baseline is "Tile" calorimeter
- Simple muon tagger (not planning for standalone measurements)



Introduction: how to compute expected rates ?

rate(r, Θ, detector) = Σ (process rate x occupancy x data/cell)

- Physics events (Z)
- Backgrounds
  - IP backgrounds
  - Single beam effects

Physics process	Rate (kHz)
Z decays	100
$\gamma\gamma \rightarrow$ hadrons	30
Bhabha	50
Beam background	20
Total	$\sim$ 200

2111.04168

- Need full simulation
  - Including precise description of MDI
- Integration time of detectors
- Reasonable choice of zero-suppression thresholds

- Number of bytes needed
  - Very detector-dependent

Beam induced backgrounds

See talk by Manuela Boscolo

Luminosity induced backgrounds

Radiative Bhabha

Beamstrahlung: photons and spent beam

Incoherent/ Coherent e^+e^- Pair Creation

$\gamma\gamma$ to hadrons

Dominant effect

Synchronous with the interaction, can be discriminated at trigger level

Single Beam effects

Synchrotron Radiation

Beam-gas

Thermal photons

Touschek

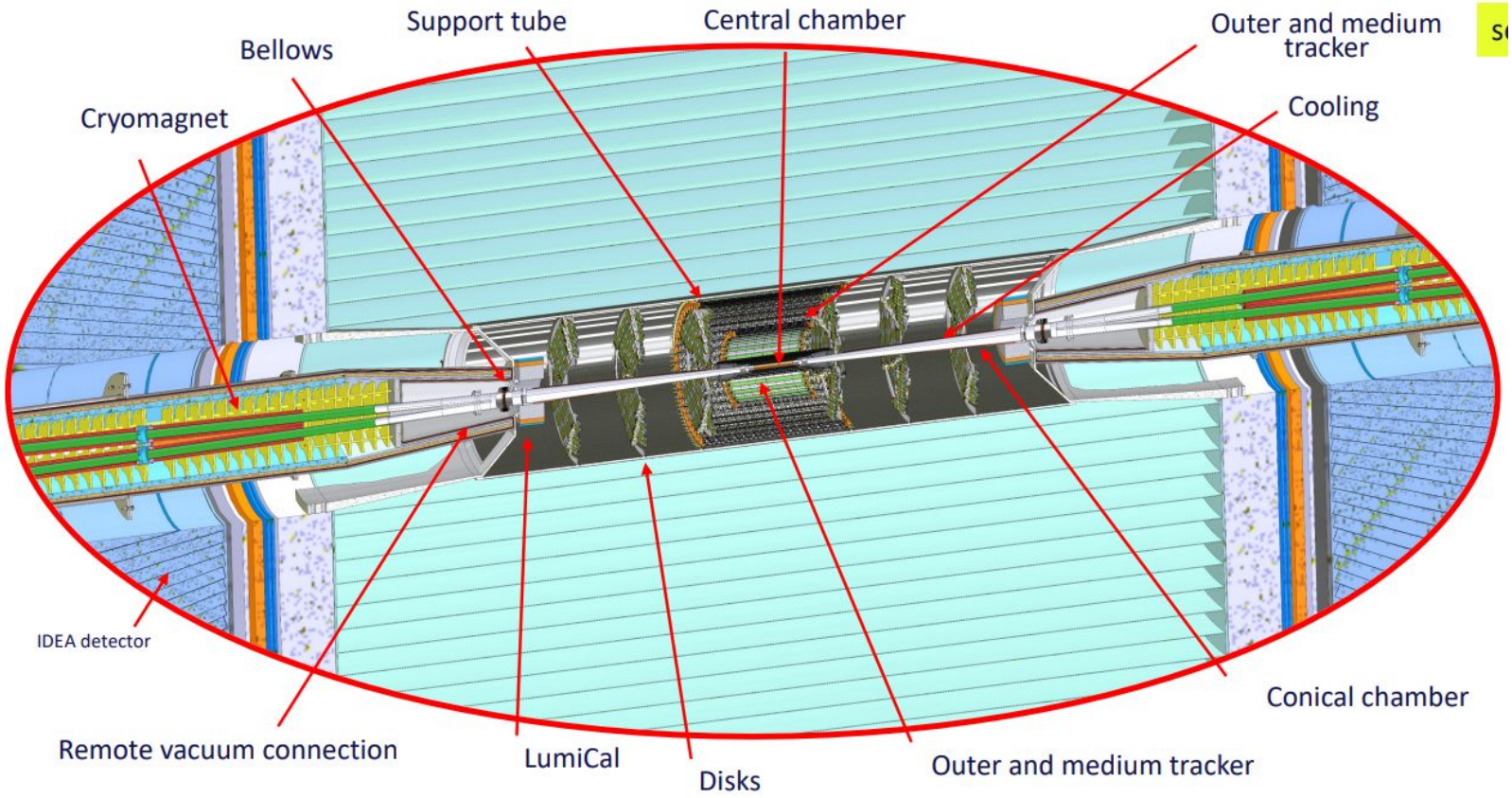
Injection backgrounds

Dominant effect (a priori)

Mostly can be mitigated with collimators & shieldings, except for those produced just in the IR

For the feasibility study the single beam effects was tackled starting from developing a new code for particle tracking and study the **halo beam**, with an LHC-like approach. **A collimation region was implemented for halo beam.**

BIB: dependent on MDI design



Ref: M. Boscolo, F. Palla, et al., *Mechanical model for the FCC-ee MDI,* EPJ+ Techn. and Instr., https://doi.org/10.1140/epjti/s40485-023-00103-7

Methodology

- Simulate the various processes
- Integrate over detector readout times
- Compute occupancies
- Then convert into rates

Vertex detector

Studied in details for CLD so far

- Occupancies per BX:

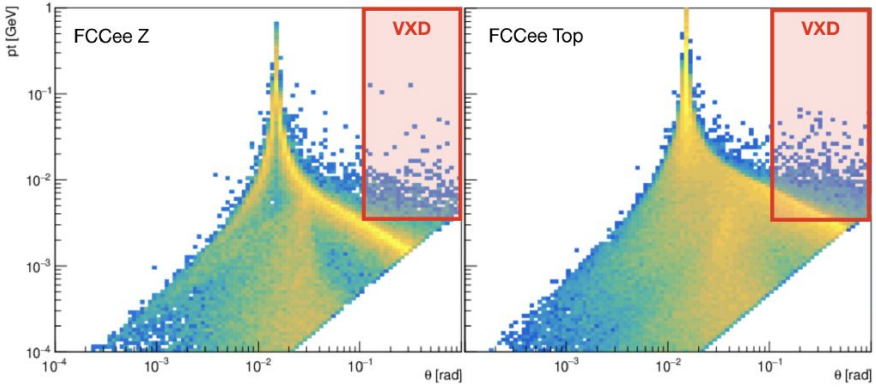
Observable	Units	Z	WW	ZH	$t\bar{t}$
Pairs/BX	1	1300	1800	2700	3300
VXDB Occupancy	10^{-6}	70	280	410	1150
VXDE Occupancy	10^{-6}	23	95	140	220
TRKB Occupancy	10^{-6}	9	20	38	40
TRKE Occupancy	10^{-6}	110	150	230	290

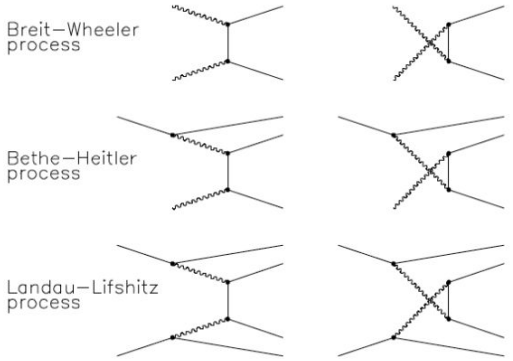
  - Occupancy/BX increases with √s

- Overall occupancy (assume conservative 10μs integration):
  - **2-3%** in VXD at the Z pole

- Translation into rates:
  - See Franco's talk for details !
  - Untriggered readout seems difficult

Incoherent Pair Production

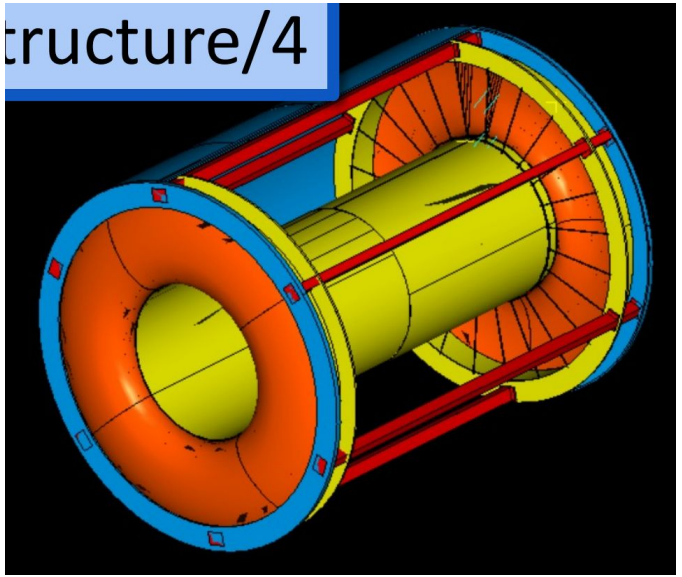




Drift chamber

IDEA Drift chamber simulation in progress…

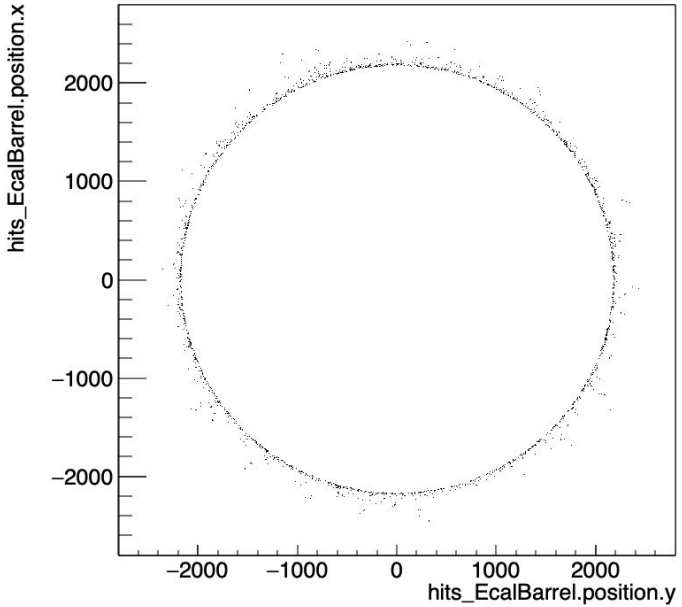
- Basic numbers:
  - 56000 drift cells in 112 layers
  - Drift time ~400ns
  - Signal digitization with 2GHz digitizer
- Unfiltered rates:
  - See Franco's slides for details
  - ~500 GB/s
- Mitigation:
  - Assume on-detector cluster finding
    - Amplitude and time of peaks
  - ~50 GB/s, dominated by Z physics
  - **Can we store this on disk ?**



ALLEGRO Ecal

Work ongoing…

- Strategy is clear:
  - Simulate events in one BX
  - Collect distributions as function of (r,θ)
  - Integrate over 400ns (very conservative)
  - Use threshold like MIP/5 for zero-suppression
  - Compute occupancy
  - Translate into rates
- Backgrounds
  - Simulations ongoing

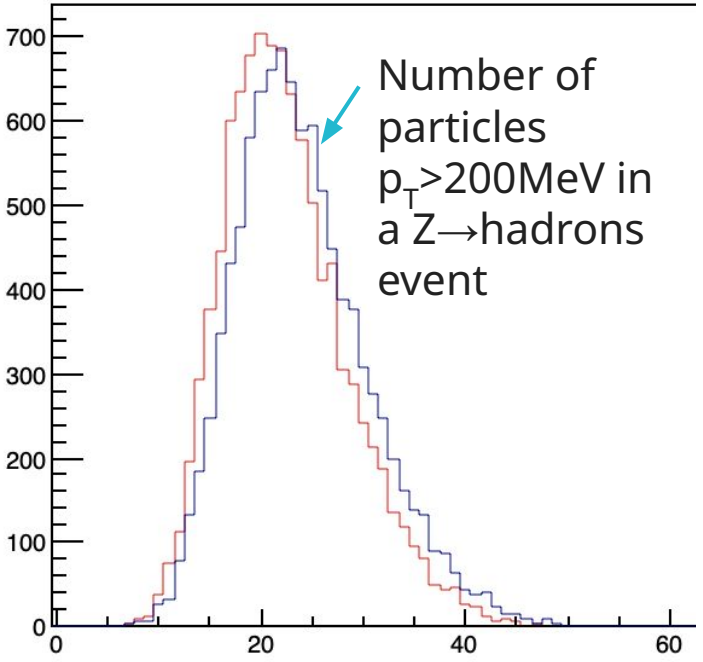


ALLEGRO Ecal

Physics at Z pole

- Detailed simulations to be done
- Crude estimate
  - Assume zero-suppression well above electronics noise
  - 20 showers / event for Z or γγ→hadrons
  - 2 showers / event for Bhabha
  - 500 cells / shower (typical of a 25 GeV γ shower… so probably conservative)
  - 2B energy + 1B timing + 3B cellID
  - ➢ Grand total **8GB/s**
  - ➢ **Easy to deal with**

3B for ID to write on tape
Only 1B needed to readout multiplexed signals from frontend to backend



ALLEGRO HCAL

Nothing started yet

- Backgrounds probably negligible
- Z pole physics: simulations to be done
  - Certainly very manageable rates

Muon tagger

Nothing…

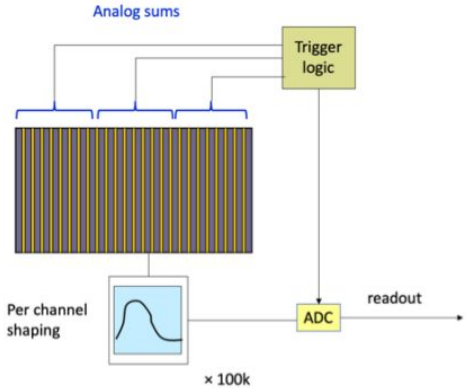
- Should get estimates of cavern backgrounds
- How do we get that ?

Luminometer

See Mogen's talk

Source	Cross section / rate	Energy
$\mu^+\mu^-$ (possibly valuable for alignment)	10 Hz	Deposit: 0.25 GeV equivalent
Bhabha	40 nb / 70 kHz	45.6 GeV
Single arm Bhabha ($E>0.1 \times E_{BEAM}$)	40 nb / 70 kHz (single arm)	5 - 45.6 GeV (peaking low)
Beam-beam interaction e^+e^- pairs	100 kHz (single arm)	~ 5 GeV
Bhabha scattered from Manifold	1100 kHz (mainly double arm)	0-7 GeV

- Seems we cannot push out all active channels, i.e. all channels above mip threshold (60 keV deposited) in all bunch crossings
- Probably need some kind of local trigger, e.g.
  - Analog sum in depth of e.g. 3 x 8-9 layers with some ϕ segmention
  - From fast shaped analog sum signals, take local decision per LumiCal on readout
    - Energy threshold for Bhabha
    - Depth requirement for muons
- Slower (more precise/less power hungry) shaping of the full set of channels
  - On local trigger accept, digitize and read out all channels (w. zero suppression)



Conclusions

- This is just the start… lots of work ahead
- Vertex detector
  - For sure need some filtering before writing to tape
  - Probably some trigger needed to readout the detector ?
- Drift chamber
  - Readout manageable
  - Probably filtering needed before writing out to tape
- Calorimeters
  - Z rates under control
  - Background rates to be evaluated
- Muon tagger
  - To be done… where to start ?