A Possible Approach to the SiD Data Acquisition

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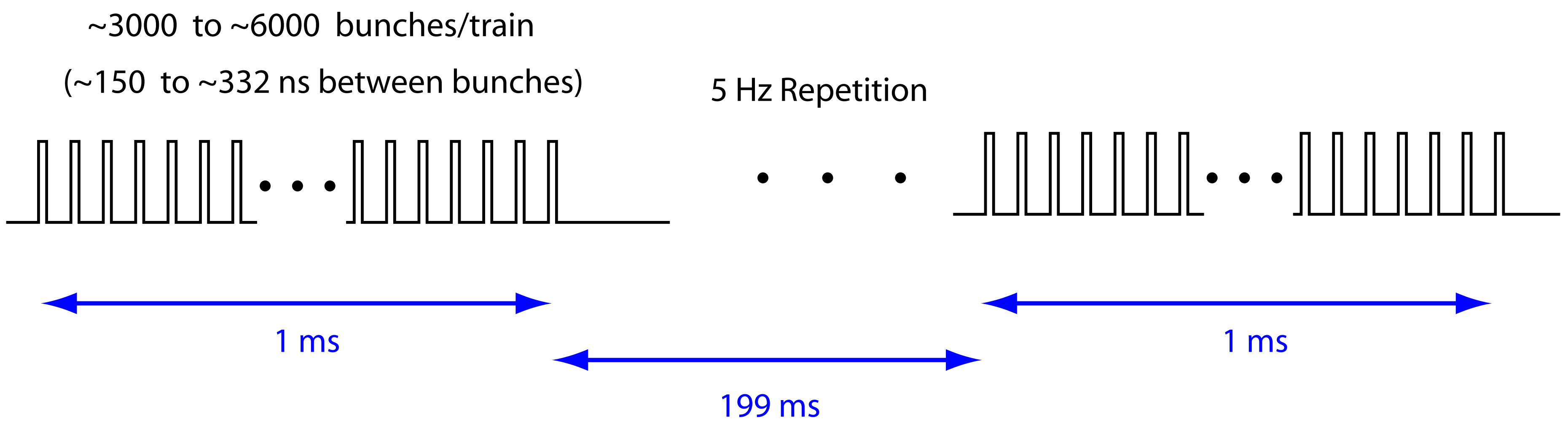
- Bunch structure at the ILC
- SiD Detector
- Expected detector occupancies
- Possible common approach to on-detector DAQ
- Implication for data rates and volumes

Bunch Structure at the ILC



- Final bunch structure of cold machine not yet known
- Bunches unlikely to be closer than 150 ns (kickers)
- Total length of bunch train unlikely to be more than 1 ms (damping ring size)

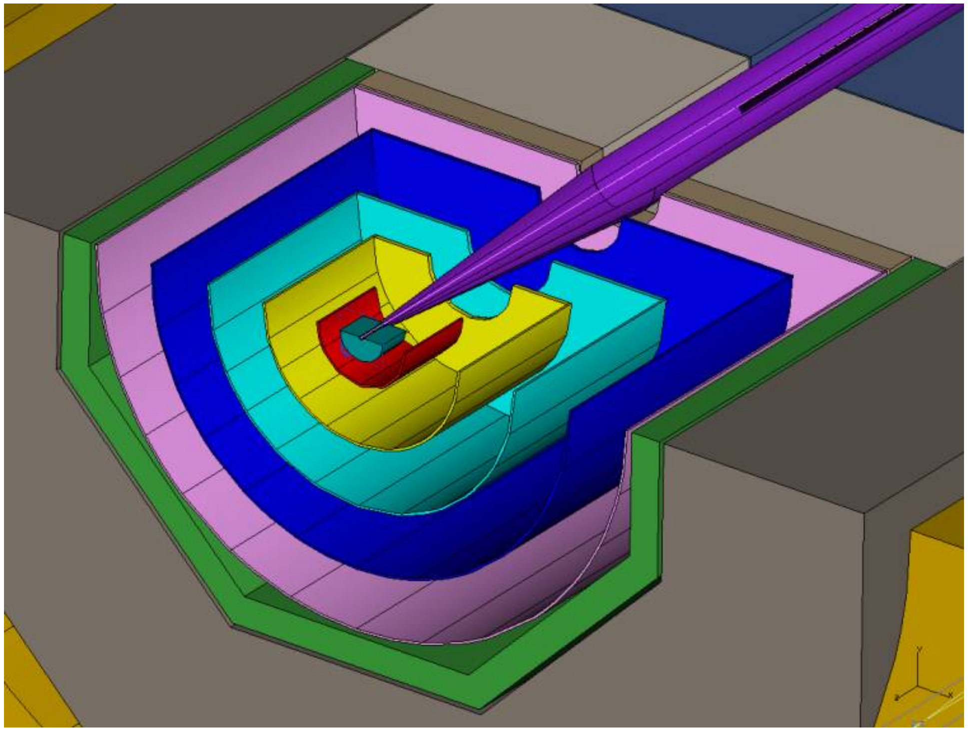
SiD Detector

- Cost optimization $\Rightarrow$
small tracker and calorimeter radius ($\sim$ 1.2m)

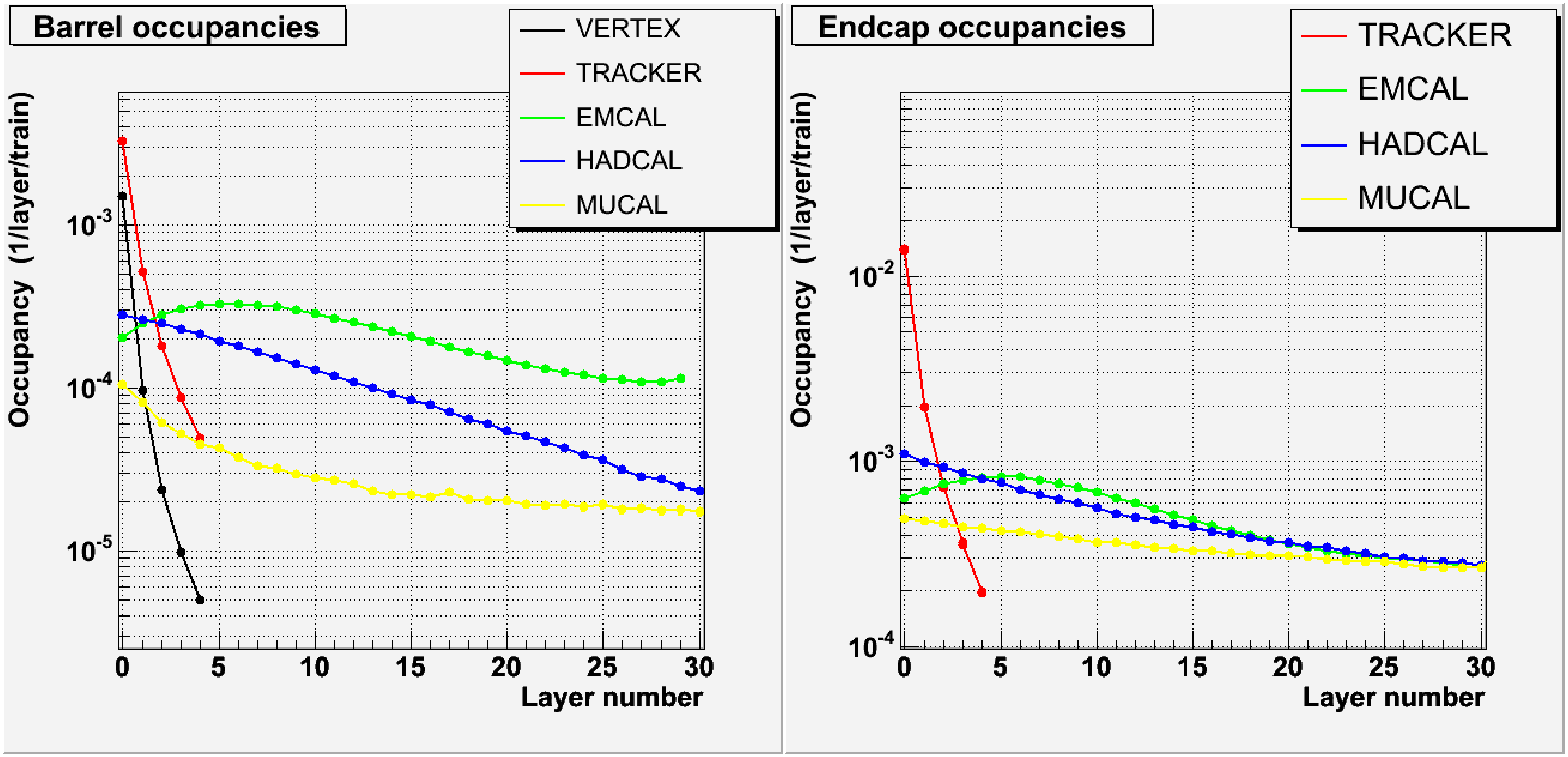
- Tracker with 5 layers
(50μm pitch and 10cm long detectors)

- ECAL segmentation $0.2^\circ \times 0.2^\circ$
(0.4cm/125cm) $\times 30$

- HCAL segmenation $0.3^\circ \times 0.3^\circ$
(1.0cm/200cm) $\times 36$



Except in forward region occupancies will be very low



Toshi Abe's (LCWS04-Victoria) warm occupancies ($\times \sim 20$ **for cold**)

⇒ **A system with a limited number of buffers in the Front-End Electronics seems viable for most subsystems**

• Small occupancy and 1/200 duty cycle allows for relatively low power front end systems.

• Excessive heat would require invasive cooling systems which would compromise several detector goals:

> $\Rightarrow$ Effective calorimeter granularity would decline due larger gap size

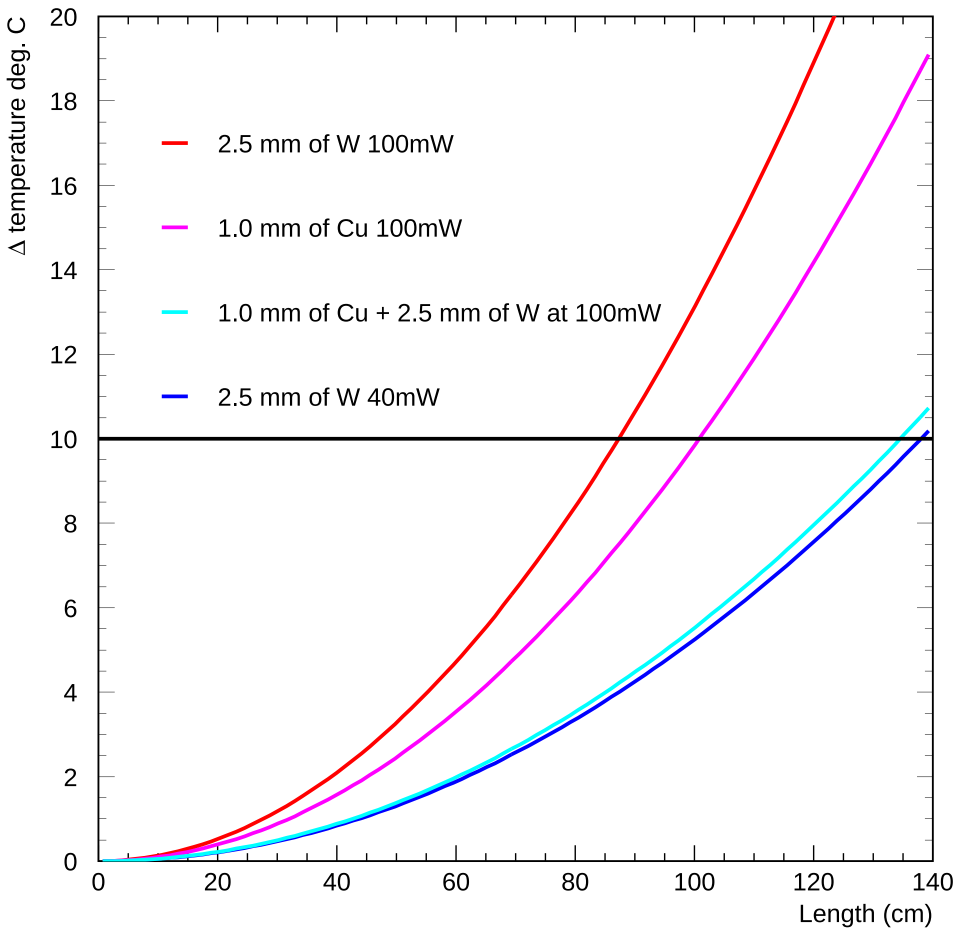
> $\Rightarrow$ Additional material causes conversions and multiple–scattering in the tracker

Can we get the heat out of the ECAL?

Back of the envelope calculation of change in temperature:

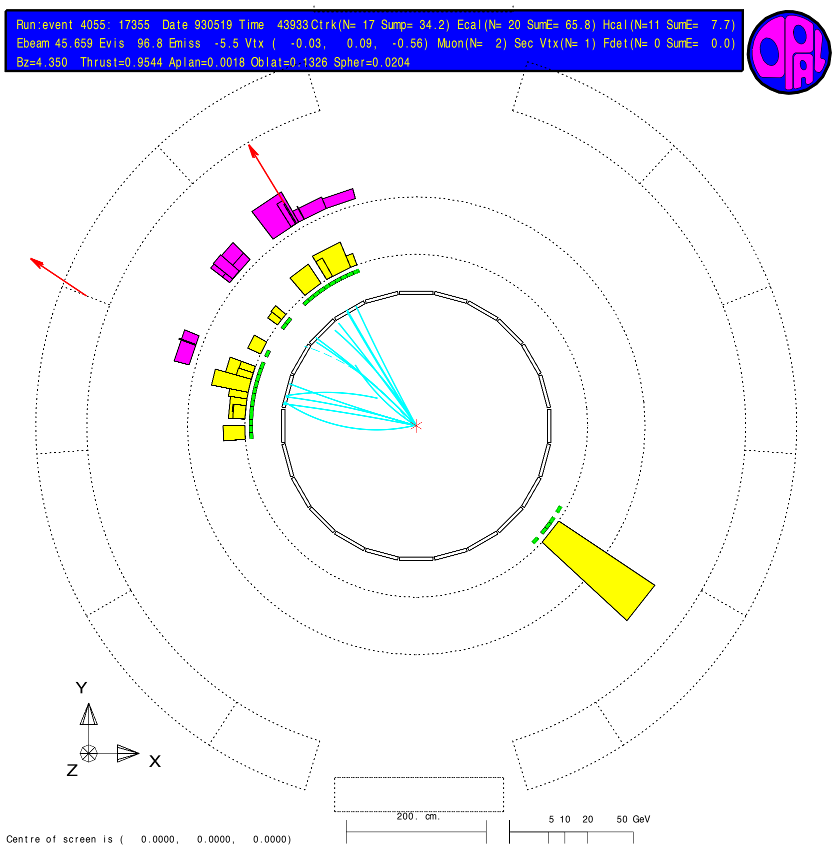
- Thermal Conductivity of W alloy 120W/(K-m)
- Thermal Conductivity of Cu 400W/(K-m)

Need to reduce heat to below 100mW/wafer.

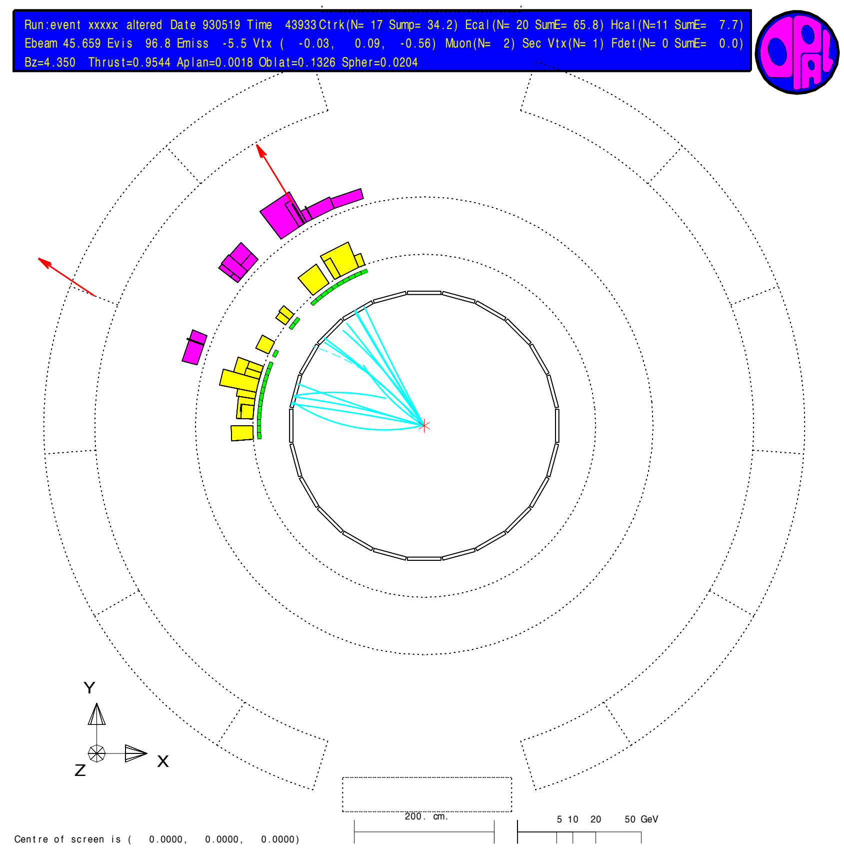


Main physics impact of buffer overflow:

- If a missing energy event occurs when buffers are full it will be impossible to exclude background such as $f\bar{f}\gamma$



Background



New Physics?

Suggested criterion for buffer size: In any region in θ require that 1% of buffers are full in at most 1% or all events.

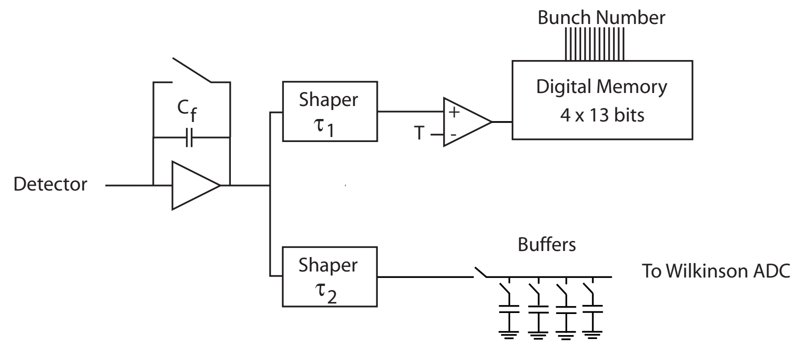
Main implication for DAQ system:

• Except in the forward region data should time tagged and locally stored during the bunch train.

• Each bunch train should be analyzed as whole. This allows buffer overflows to be flagged.

• DAQ should be able to continuously readout detector with completely full buffers – e.g. temporary bad background, but this will in general not be necessary.

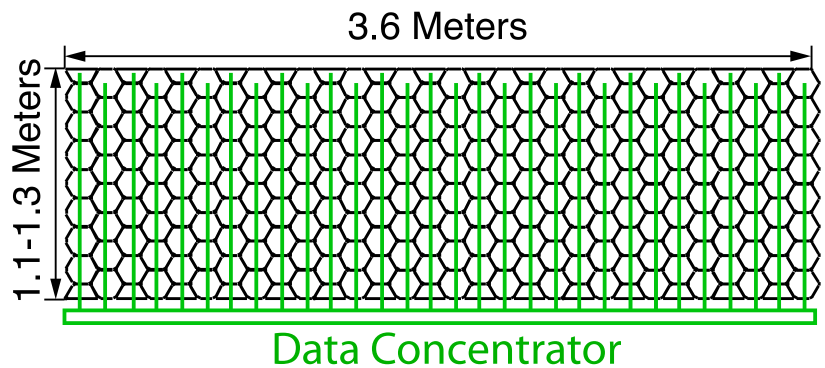
Possible Common Architecture for Tracker, ECAL, HCAL



Simplified circuit of single channel (1024 channels/chip)
(See M. Breidenbach's talk in Calorimetry)

- Digitize buffers during time between bunch trains
- Adjust number of buffers for detector occupancy
- Adjust charge amplifier for detector type

Data Concentrator – ECAL barrel module



- Each plane of the ECAL will have ~ 250 wafers, each with 1024/channels.

- Raw rate out of the concentrator is $\sim 150\,$Mbits/s

Estimated* maximum data volumes

Detector	Channels (M)	Amp bits	TS bits	Buffers	Raw Size Gbits	Raw Rate Gbits/s
VXD**	3300	3		1	9.9	50
	132		13	4	6.9	34
Tracker	20	8	13	16	6.8	34
ECAL	85	13	13	4	8.8	42
HCAL	40	8	13	4	3.3	16
Total					36	176

- The total raw event size for a single bunch crossing is ~ 5 GBytes, so it is possible that this could be analyzed in a single CPU at once

- In the normal case, there would be a zero suppression factor of ~ 20 or more, giving typical bunch train "event" sizes of ~ 250 MBytes

- Have ignored contribution from hadron tail catcher and muon system

*educated (and biased) guesses **$10\mu m \times 10\mu m$ pixels

What about forward region of the detector?

• In the forward region (below about 100 milliradians) we quickly encounter high occupancies and it will probably be necessary to read everything out.

• If we keep the same segmentation as in the reset of the detector (60 longitudinal layers and 4mm $\times$ 4mm pixels) and readout every beam crossing separately:

Detector	Channels (M)	Amp bits	Buffers	Raw Size Gbits	Raw rate Gbits/s
Forward	2	13	2820	77	383

Challenge for Data Acquisition system – how to handle such a large data rate

Observations:

- Main physics need is to veto high energy ($>$ 100 GeV) electrons, photons and muons

- Next most important physics need is the luminosity spectrum

- Solid angle below 100 mrad is probably not key for hadronic jet reconstruction

- Background from tails of low energy electromagnet showers will complicate reconstruction of low energy hadrons

$\Rightarrow$ MIP sensitivity and excellent energy resolution probably not needed in this region

$\Rightarrow$ Could use hardware processing to find quantities of interest to physics

$\Rightarrow$ Detector DAQ/Design work very much needed in forward area

Conclusion

- "Triggerless" DAQ for a granular LC detector such as SiD looks plausible

- Occupancy in almost all of the detector is sufficiently low that for each channel only a few buffers/bunch train will be needed

- Front-end electronics could be based on a common chip design

- Main challenge will be far-forward region
  $\Rightarrow$ **may require dedicated hardware reconstruction**