BeamCal Readout System Requirements

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BeamCal Readout Requirements

Outline

- Introduction to BeamCal
- Beam Timing
- Data Rates
- Readout Electronics/Data Transmission
- FCAL Prototype
- Summary
- Acknowledgements

Introduction to BeamCal

Aim:

- detect high energy electrons on top of a large lower energy e^+e^- beamstrahlung backgrund
- provide ultrafast beam condition information

Coverage:

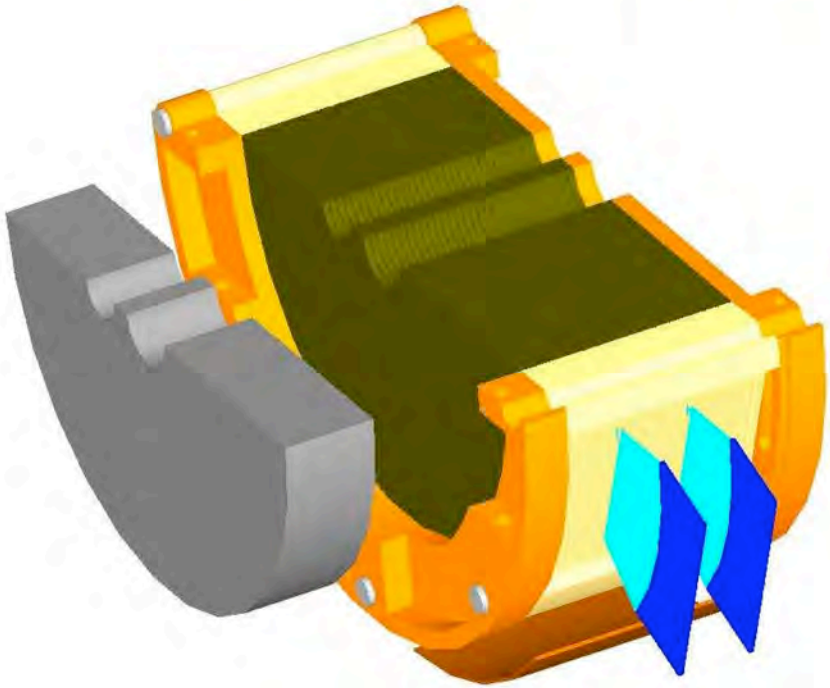
very fwd & bwd regions:

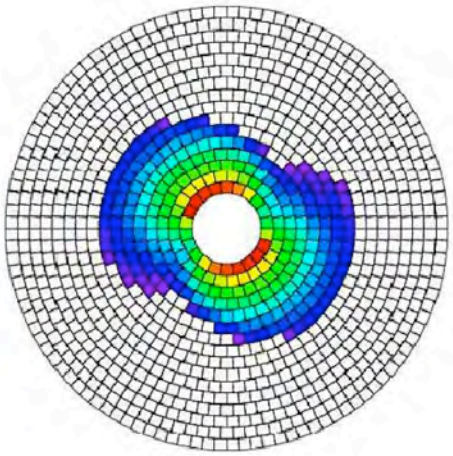
z=±3.5m, 5...45mrad, 150mm outer radius

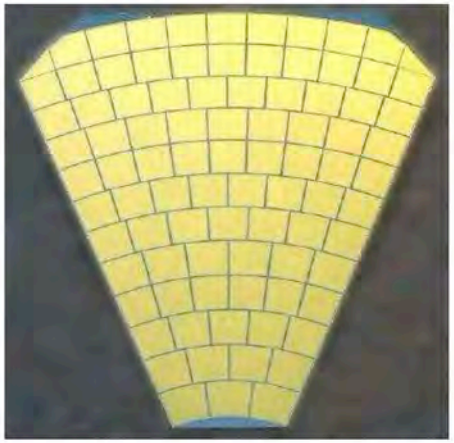
BeamCal Readout Requirements

BeamCal Construction

- Tungsten/sensor sandwich, 30 layers, 8 sectors
- 38.400 channels each (~160 pads per sensor)
- ~100 channels included in luminosity feedback







GaAS Sensor Prototype

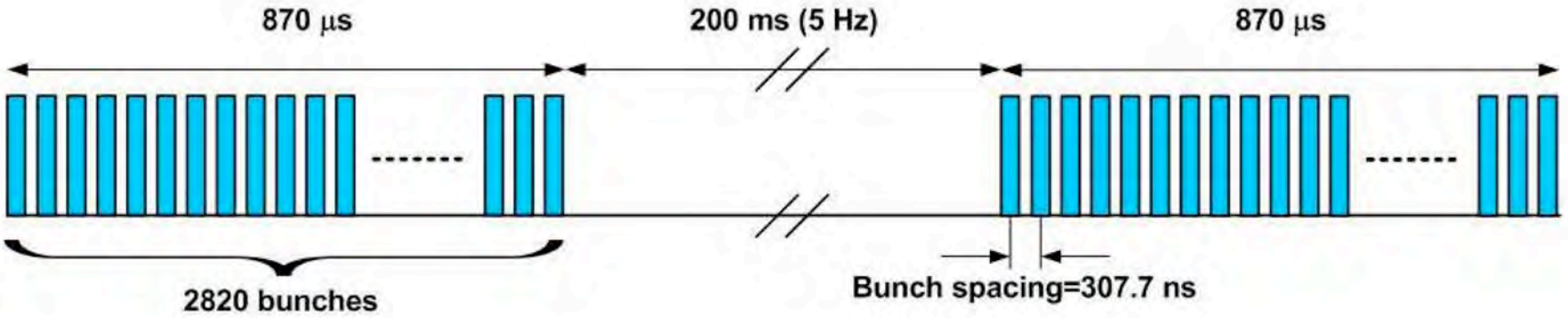
BeamCal Readout Requirements

Readout Timing

High occupancy -> no frontend sparsification!

Physics Data: 130MByte per bunch train, to be buffered and readout during 200ms intertrain pause

Luminosity Data: immediate readout with bunch clock (3MHz)



BeamCal Readout Requirements

Data Rates (1)

calculations prescind from parity bits...

Physics Data:

38400 ch * 10bit per bx

2820 bx

-> 130MByte per bunch train

(16MByte/sector - to be buffered at the frontend!)

200ms intertrain time

-> 650MByte/s readout rate

(~5GBit/s or 650MBit/s per sector)

Data Rates (2)

Luminosity/Beam Parameter Feedback Data:

use 2 layers only (proved by MC simulations),
integrate over 32 channels

2 * 1280 ch / 32 = 80 channels * 8bit

-> 640 bit per bx
(immediate readout with bunch clock!)

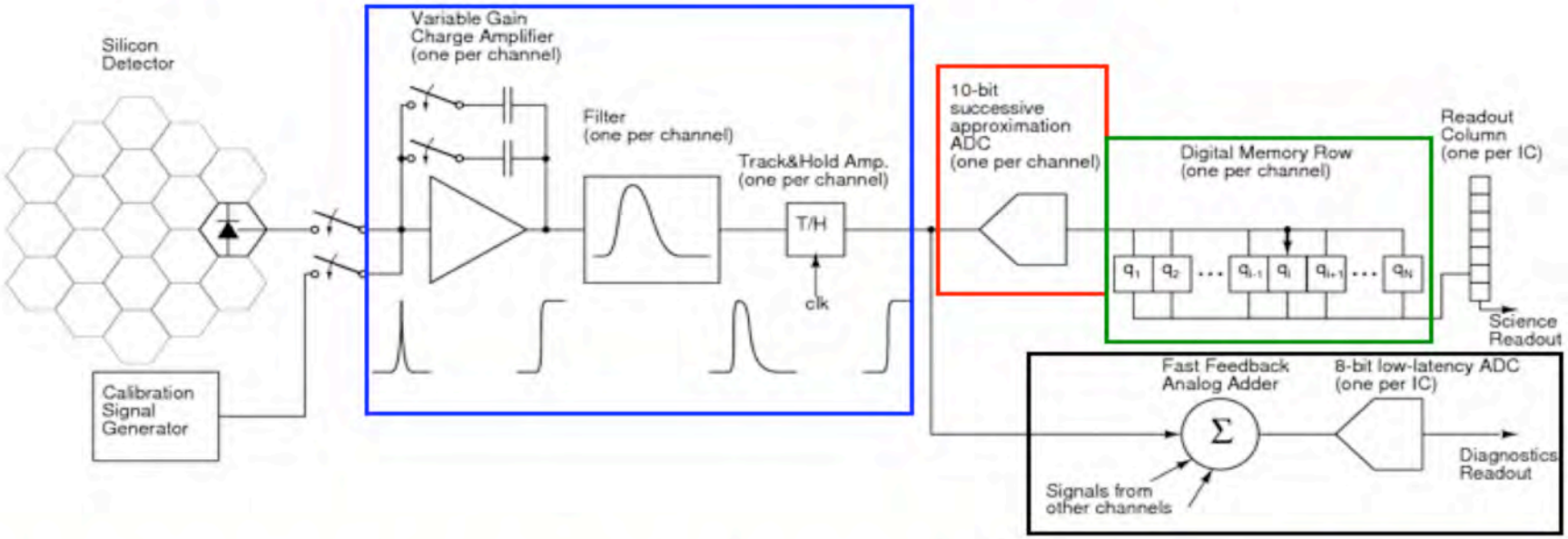
300ns bunch time

-> 250MByte/s readout rate
(~2GBit/s or 250MBit/s per sector)

BeamCal Readout Requirements

Readout Electronics (Frontend)

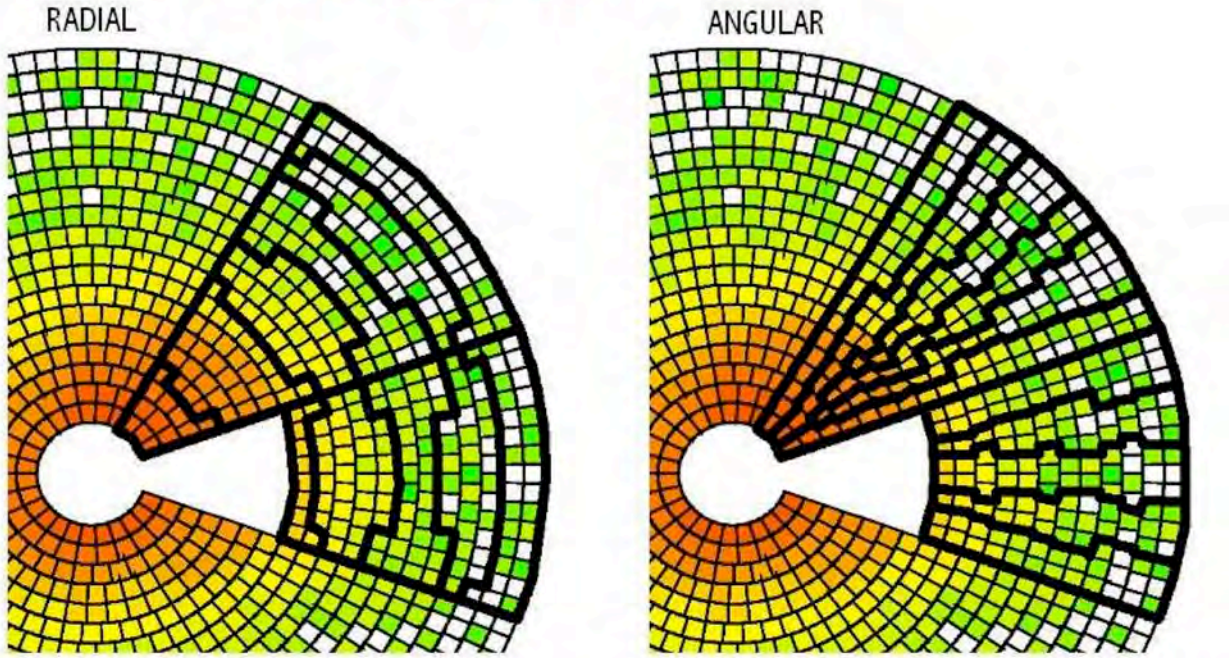
- 32 channels per chip
- variable gain preamp (high input capacitance)
- fast peaking time (~100ns)
- 10bit ADC, large digital buffer (2820 samples)
- analog summation over all channels/8bit low latency ADC



BeamCal Readout Requirements

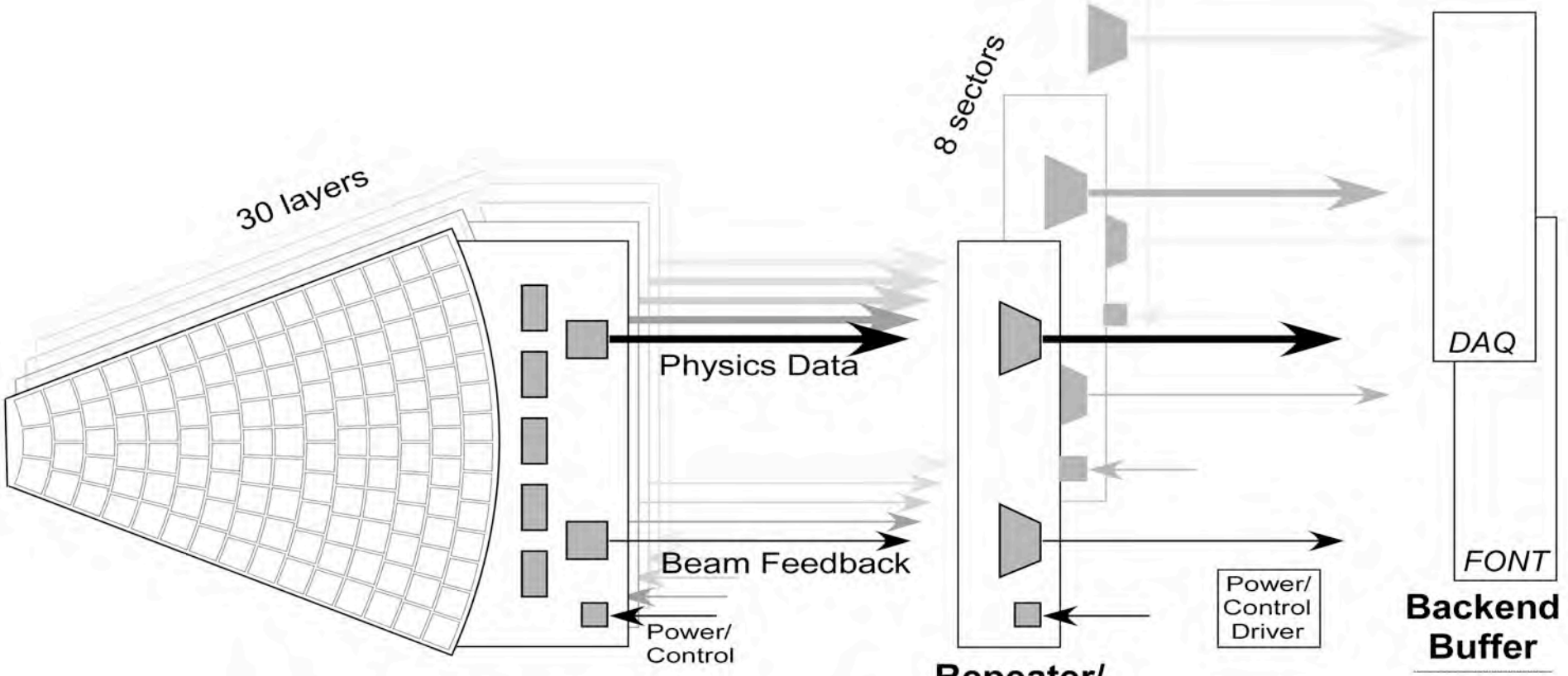
Readout: Fast Luminosity Feedback

- use layers 5 + 6 (maximum of shower energy deposition)
- 160 pads/32 channels per chip -> 5 chips per sensor
- radial or azimuthal clustering
- no physics preferences from MC
- angular clustering helps load & power balancing between chips
- radial clustering may reduce crosstalk effects



BeamCal Readout Requirements

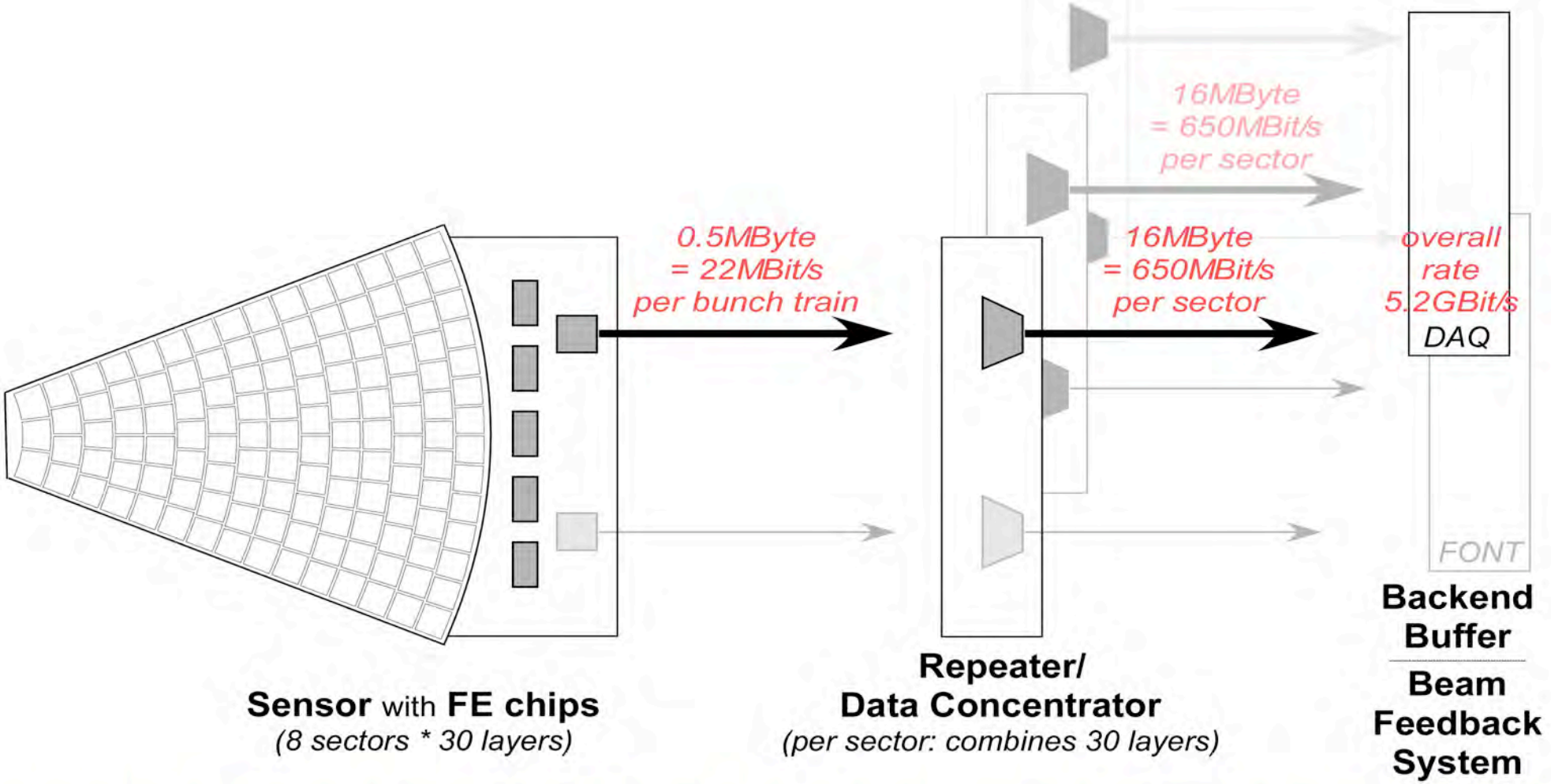
Readout Electronics (Structure)



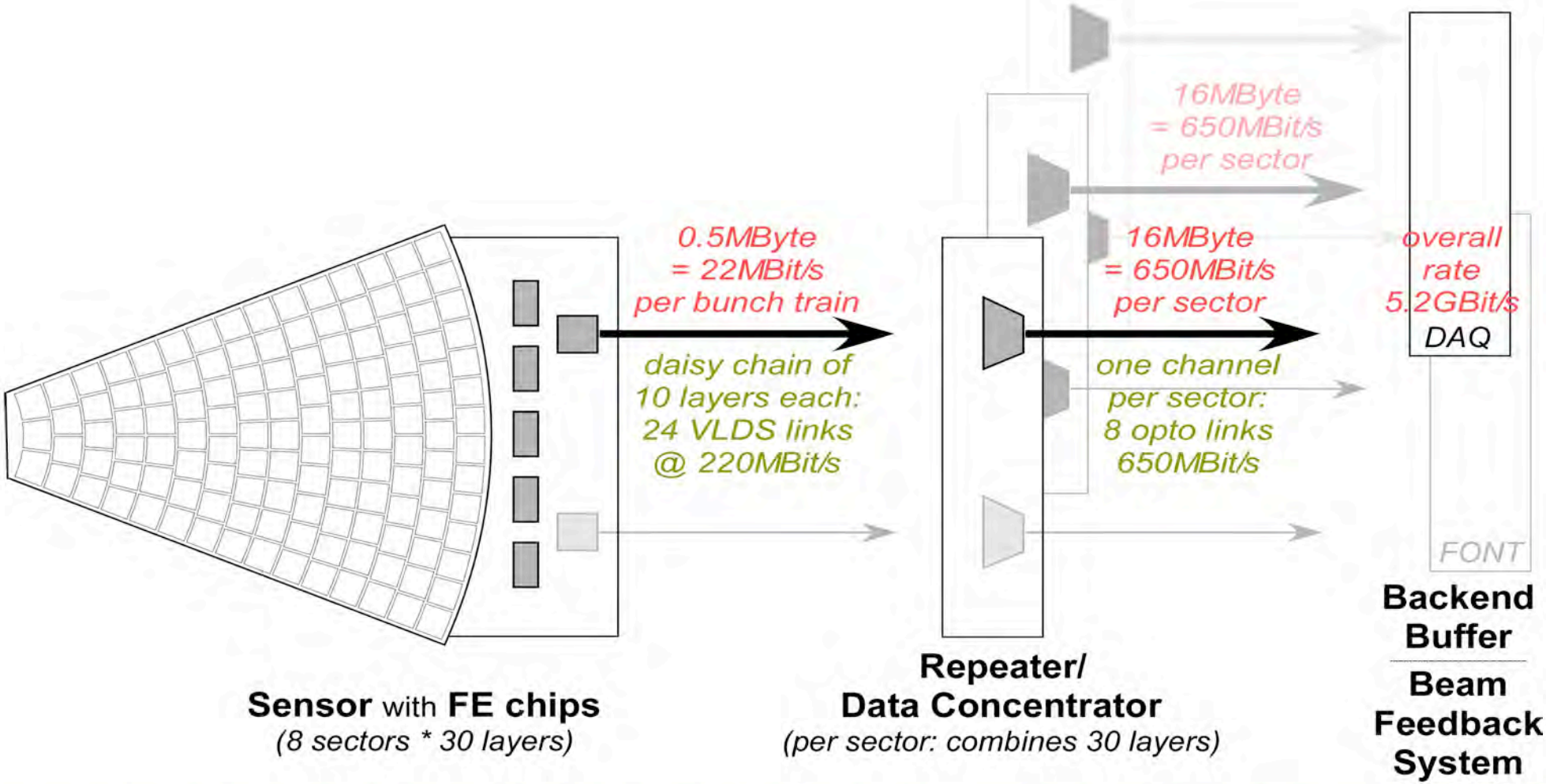
Sensor with **FE chips**
*(8 sectors * 30 layers)*

Repeater/
Data Concentrator
(per sector: combines 30 layers)

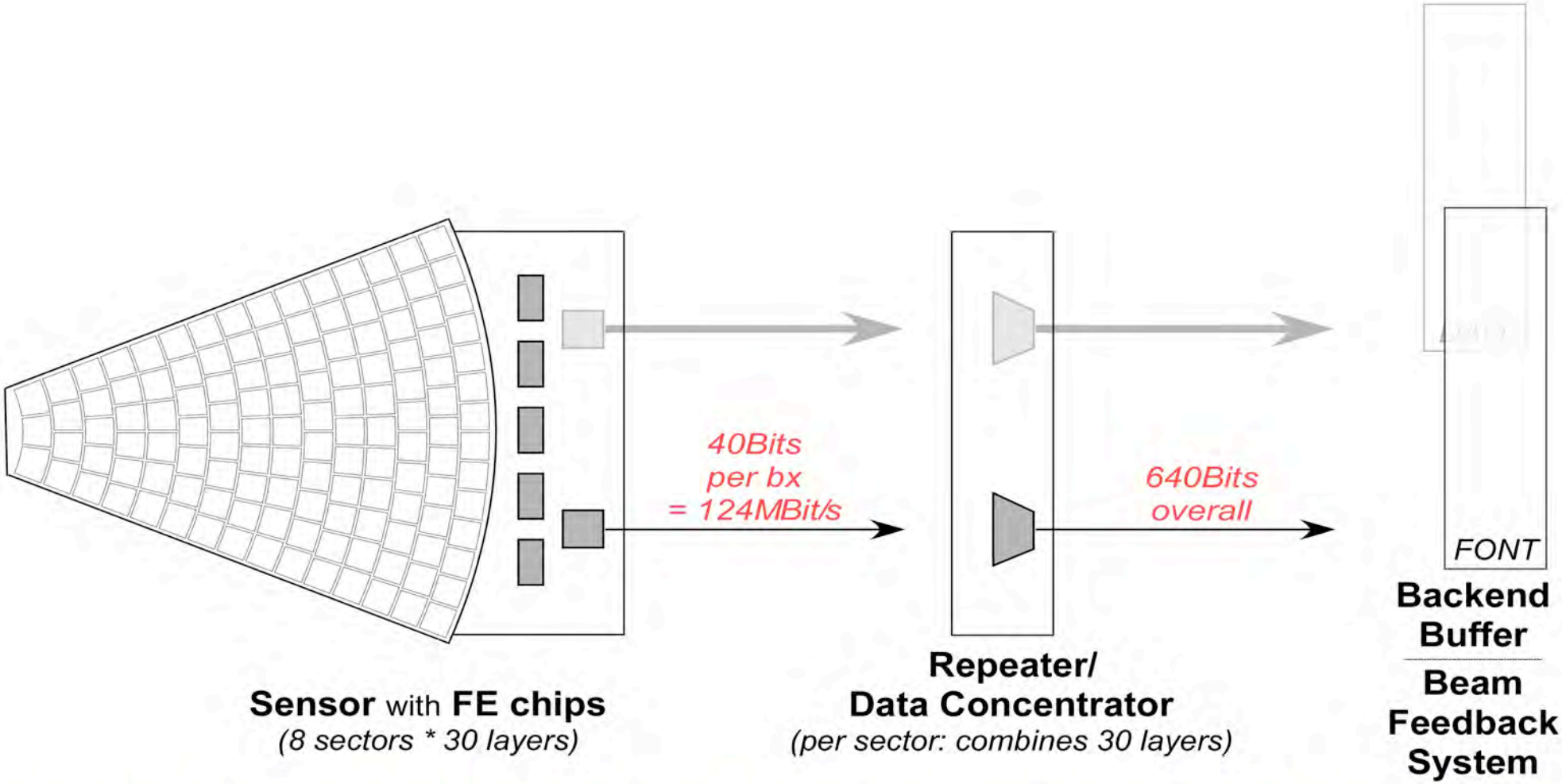
Readout Electronics (Physics Data)



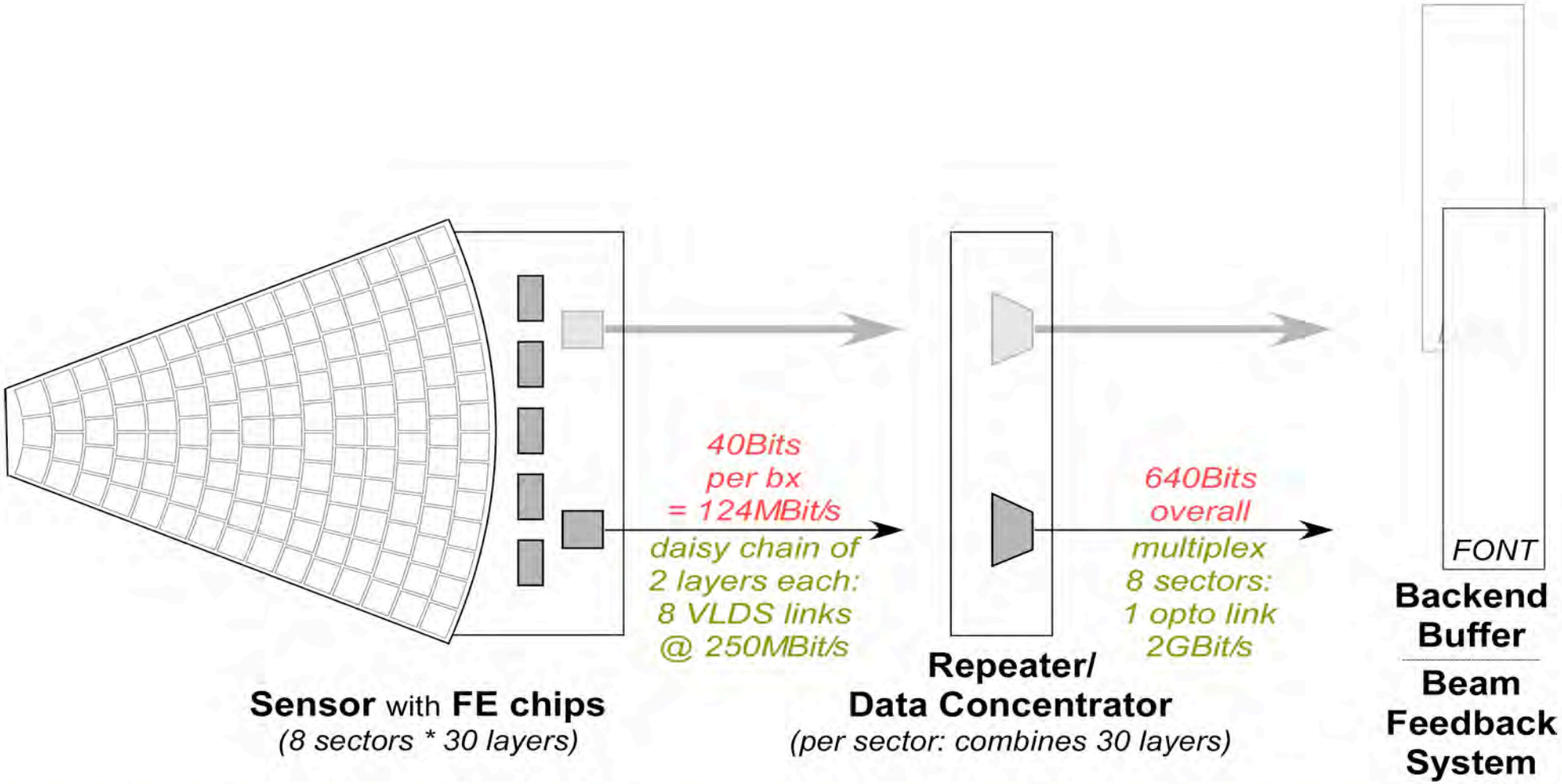
Readout Electronics (Physics Data)



Readout Electronics (Beam Feedback)

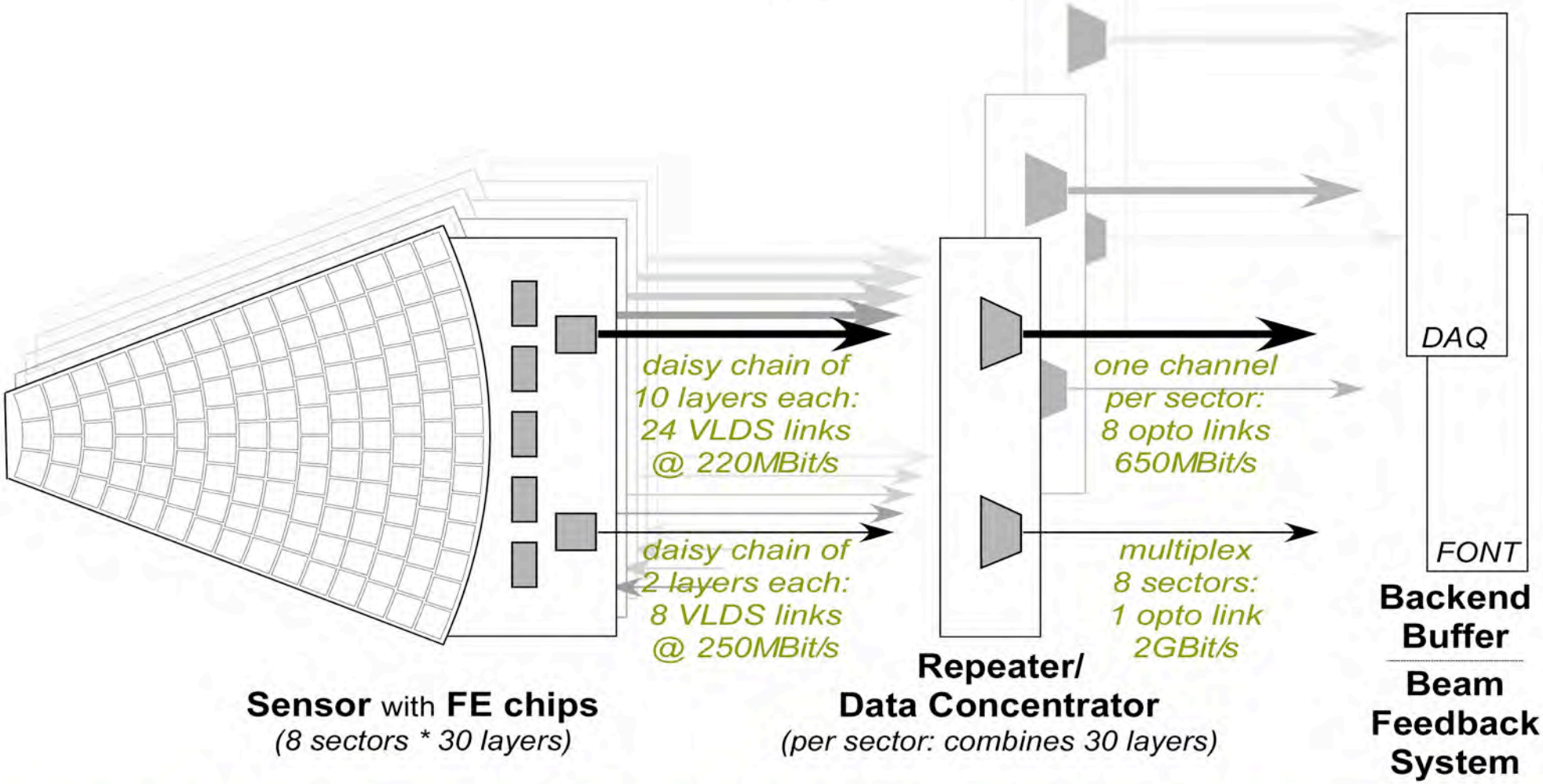


Readout Electronics (Beam Feedback)



BeamCal Readout Requirements

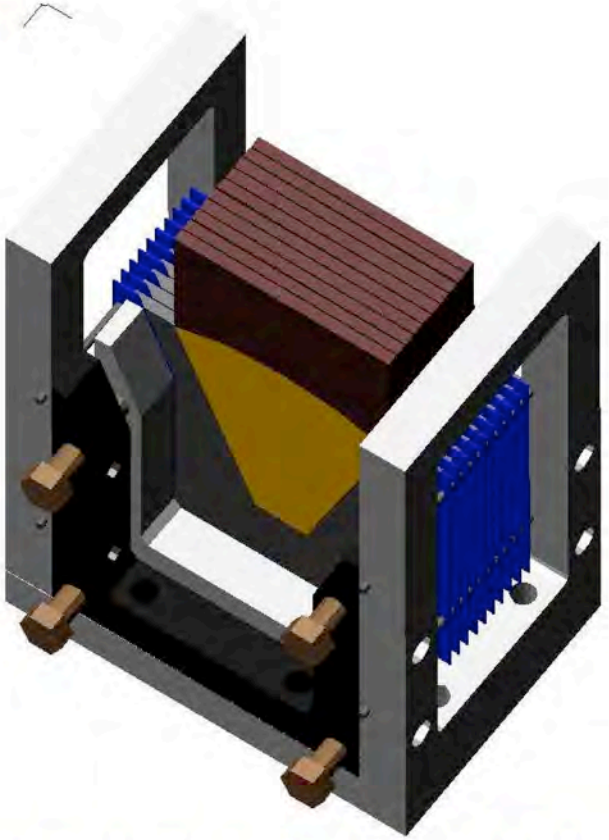
Readout Electronics (Summary)



BeamCal Readout Requirements

Prototype (1)

- single sector, some 10 layers
- granularity ~100 channels
- sensors Si or GaAs, absorber Tungsten
- readout chip pending
  - 8 … 16 channels?
  - integrated fast ADC??
  - analog summation??
- realistic:
  - 16 channels per chip
  - serialized (slow) analog readout
  - off-detector ADC & buffer
  - no fast feedback channel



BeamCal Readout Requirements

Prototype (2) - possible readout chain "A" (PHY3)

- 6 FE chips per sensor, 16 channels each
- multiplexed analog readout @ 40MHz
- analog transmission off detector, 6 coaxial cables per layer
- 200MS/s 10bit ADC, some 60 channels
- on board dual ported buffers

BeamCal Readout Requirements

Prototype (2) - possible readout chain "B" (Krakow)

- 3 FE chips per sensor, 32 channels each
- integrated pipelined ADC, multiplexed for 8 channels (10bit)
- running @ 26MHz (condition: ≤10% occupancy!)
- digital transmission, 4 LVDS lines per layer
- data concentrator @ ~100MHz -> 1 LVDS line to buffer
- some 10 dual ported 100MS/s buffers

BeamCal Readout Requirements

Prototype (2) - possible readout chain "C" (Stanford)

- 3 FE chips per sensor, 32 channels each (?)
- integrated 10bit ADC for each channel (3MHz)
  and 8bit ADC for sum over all channels
- integrated buffer for 2820 10bit samples per channel
- integrated readout multiplexer (~100MHz?)
- digital transmission, 3 LVDS lines per layer
- some 30 dual ported 100MS/s buffers
  and fast feedback processor (some 10 signals)

BeamCal Readout Requirements

Summary

- BeamCal dimensioning and granularity nearly settled
- Sensor material and PreAmp rather tentative
- Data rates ambitious although state of the art
  (both for Physics Mode and Luminosity Feedback)
- Prototype:
  custom solutions required but
  no challenging data rates

Acknowledgements

- Data rates compiled by Elena Castro
- PreAmp schemes by A. Abusleme, Stanford and by M. Idzik, Krakow
- MC considerations on fast luminosity feedback by Zeuthen group (C. Grah, I. Sadeh)