Electronics for SiD

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Introduction

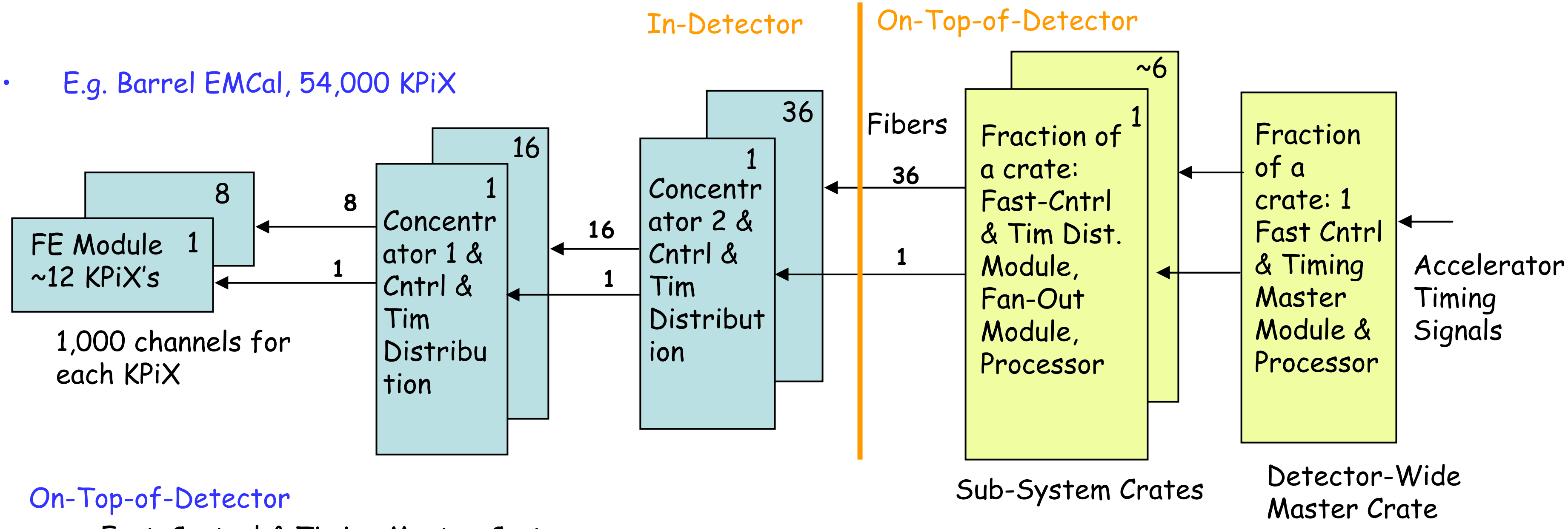
- For the purpose of this presentation, split into following systems
  - Data-Acquisition
    - Control & timing including configuration readback
    - Dataflow (science data readout)
  - Power
    - Low voltage supplies
    - High voltage supplies
  - Magnet power supplies, control & monitoring (including machine quads)
  - Cryo and Vacuum equipment (~ 1 rack)
  - Safety & health monitoring
    - Temperatures, voltages, etc
  - Others
    - Controls for final quad and beampipe alignment (~ ½ rack)
    - Tracker alignment system ("Frequency Scanning Interferometers") (~ 1/2 rack + opt. table)
    - Machine Inst. & Control that travels with detector (~ ½ rack)
    - Also controls for moving the detector (push-pull) and an altitude adjustment system (~ 1 rack)
- Investigate how much rack-space might be required for
  - Control & Timing
  - Dataflow
  - Power Supplies

Front-End: KPiX

- ASIC (TSMC 0.25um CMOS)
- 1,024 channels (less for some subsystems)
  - Charge Amplifier
  - Discriminator
  - 4-deep analog storage
  - 13-bit ADC
  - Time-stamp
- Readout in 199msec between bunches
  - Serial differential readout of all 1,024 channels via one 20 Mb/s output (< 6 msec)
  - Each channel contains
    - Time-stamp and amplitude of up to 4 samples for each bunch-train

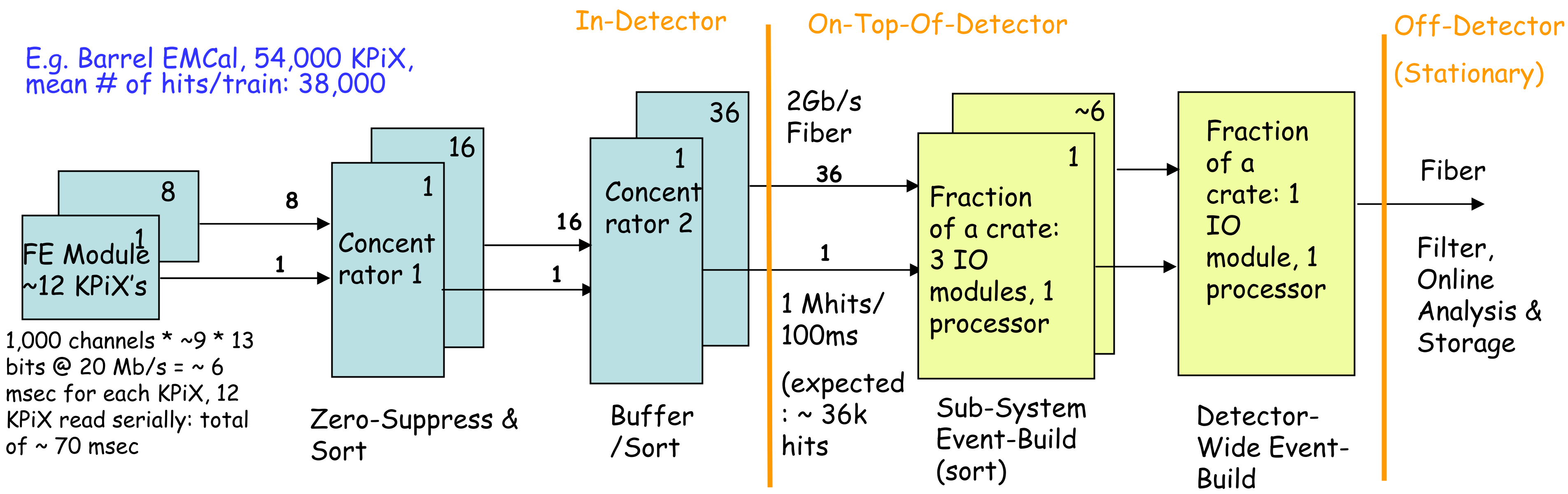
Fast Control and Timing Example

- E.g. Barrel EMCal, 54,000 KPiX



- On-Top-of-Detector
  - Fast-Control & Timing Master Crate
    - Contains Fast-Control & Timing Master Module (FCMM) & Processor
    - Receives Timing Signals from Accelerator
    - Executes Finite-State-Machine for Calibration/Run/etc
    - Distributes Command & Timing to Sub-System Crates
  - Sub-System Crates
    - One for each Sub-System (for Partitioning Purposes)
    - Each Crate contains Fast-Control & Timing Distribution Module (FCDM) & Processor
    - 4 Fan-Out Modules, Fiber Output to In-Detector Electronics
- In-Detector
  - Fan-Out of Control & Timing Signals via Concentrator/Fanout Modules to KPiX ASICs
    - Modules also include Dataflow Path Electronics
    - Number of Modules driven by Dataflow (might be much less modules, tbd).

Dataflow Example



- In-Detector
  - KPiX Readout via two levels of concentrator boards (FPGA-based, reconfigurable)
  - Readout to On-Top-Of-Detector crates via 2Gbit/s fibers (easy today, faster in the future)
- On-Top-Of-Detector
  - Event-Builder for sub-system (housed in same sub-system crate as FCMM)
  - Event-Builder for complete detector (housed in same crate as FCDM)
  - Processor power not an issue, event-building simple since pre-sorted
- Off-Detector (Stationary)
  - Filter (could also be running in on-detector processors), Online-Analysis, Storage
- For endcaps: a few more IO event-builder modules in crate since occupancy is higher

Number of Crates for Control & Dataflow

Sub-System	# of KPiX (or equivalent)	Mean # Hits/Train	# crates control & dataflow
TrackerBarrel	10,000	36,000	Crate 1
Tracker Endcap	2 * 3,500	250,000	Crate 1
EM Barrel	54,000	38,000	Crate 2
EM Endcap	2 * 18,000	250,000	Crate 2
HAD Barrel	27,000	7,000	Crate 3
HAD Endcap	2 * 10,000	330,000	Crate 3
Muon Barrel	5,000 (64-CH KPiX)	tbd	Crate 4
Muon Endcap	2 * 1,600	tbd	Crate 4
Vertex	tbd	tbd	tbd
LumCal	tbd	tbd	<1
BeamCal	tbd	tbd	<1

- Numbers are all estimates
- For partitioning reasons use one crate for each sub-system (or sub-divide crate in partition)
- Total for control & dataflow: < 10 crates, 2 racks

* Vertex, LumCal, BeamCal are still under investigation

Low-Voltage Power

- E.g. Barrel EMCal Low-Voltage
  - 54,000 KPiX
  - Regulation locally to 2.5V
  - 12-KPiX section: 12 x 20 mW average= 240 mW
  - Concentrator 2 level: 8 * 16 * 240 mW = ~ 30W average
  - Peak power during acquisition at Concentrator 2 with 1W/KPiX for 1 msec: ~ 1.5 kW
  - Assume local storage at concentrator 2 level, assume incoming voltage up to 350V (350V to low-voltage converters are readily available).
    - 35-Channel ~ 4 kW Crate Power-Supply including control
    - < 1 Rack
- Need ~ 1/2 Rack for each sub-system for Low-Voltage
  - ~6 racks
- High-Voltage
  - ~ 50V for EMCal & Tracker
  - ~ few kV for HCAL & Muon
  - ~ 4 racks, mainly for distribution

Space for Racks

- ~ 2 racks for control & dataflow
  - Note that these racks could easily move off-detector via service-loops in the fibers, in other words there racks don't have to move with detector
- ~ 6 racks for low-voltage
- ~ 4 racks for high-voltage
- ~ 4 racks for monitoring
- ~ 4 racks for misc (see earlier slide)
- Total of >~ 20 racks but need 100% margin

Space for Racks

- On 10 m x 10 m can fit ~ 70 racks (0.6m x 0.9m), see below
  - Large margin to ~20 racks from last slide
- For push-pull:
  - Connection to "outside" world are mainly a few AC connections, a few (<10) fibers: easy to connect/disconnect.
  - Plus one needs water quick-disconnects for chiller connections, assuming chillers don't move (unless there is space left on detector).