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Commissioning Procedures and Software for the CMS Strip Tracker

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- Strip tracker readout system
- Overview of commissioning procedures
- Strip tracker DAQ software (within XDAQ and CMSSW)
- Status, results, future work
- Conclusions

CMS strip tracker readout system

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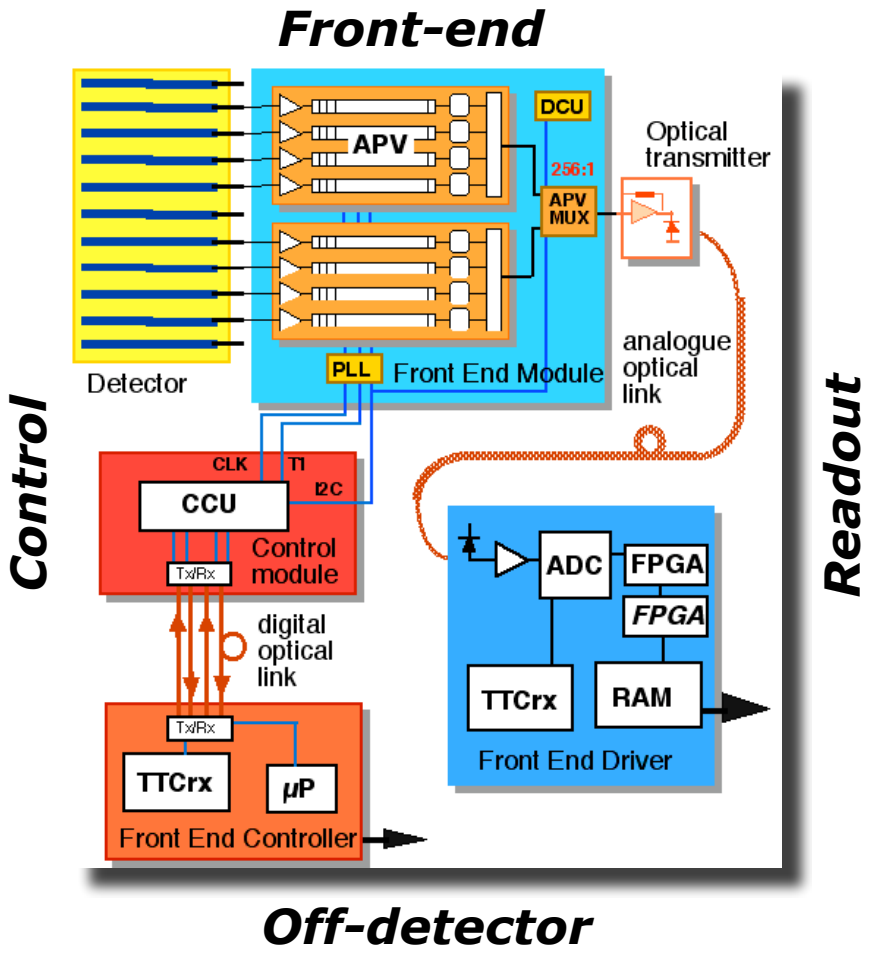
- Strip tracker is unprecedented in size and complexity
  - Active area >200 m^2
  - 15k readout modules
  - ~10 million channels
- Control system
  - Distributes clock, trigger and slow control (configuration)
  - Based on FECs and CCU "rings"
- Readout system
  - APV25 front-end readout chip
  - Analogue optical link system
  - Off-detector FED VME board



Commissioning the strip tracker

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- What?
  - Commissioning brings the detector into an operational state suitable for physics and comprises several tasks that do one of the following:
    - Optimize the ***configurations*** of all hardware components
    - ***Synchronize*** the system, both internally and to LHC collisions
    - Performs low-level ***calibrations*** for the readout system
- How?
  - Strip tracker DAQ provides dedicated DAQ loops (one per task)
  - Data analysis provide optimized HW configurations
  - Online configuration DB containing HW configurations is updated
- When?
  - Validation and tuning of the readout system during Start-Up
  - B/w fills just prior to physics (each task with varying frequency)

Some commissioning tasks…

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- Identify trigger partitions
  - Automated HW scans detect all front-end devices
  - Automatic detection of cabling connections b/w FE and BE (~38k fibers)
- Front-End APV25 Readout Chip
  - Pulse shape tuning
  - Tuning of gain and bias settings
- Off-detector Front-End Driver board
  - Sampling time of ADCs
  - Calibration constants for zero-suppression algorithms (and recon software)
- Optical link readout system
  - Gain matching across entire link system
  - Optimize use of dynamic range
- Synchronization of the strip tracker
  - Internal synch: accounts for signal propagation delays in control system
  - Global synchronization: to LHC collisions and other sub-detectors
  - Signal attenuation: ~4% / ns misalignment (nominal operating modes)

Strip tracker DAQ software

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- Strip tracker DAQ fully integrated with XDAQ
  - XDAQ fwk tools: configuration of and communication b/w processes, event builders, shared memory management…
  - Allows DAQ processes to be distributed across multiple machines

- Hardware control/configuration provided by xdaqApplications
  - FecSupervisor: allows configuration of front-end ASICs
  - FedSupervisor: data capture and digitization
  - TriggerSupervisor: definition of (local) trigger patterns
  - DataSender: forwards event fragments to event builder
  - TrackerSupervisor: steering of data acquisition loops

- Root histogram-based analysis (RootAnalyzer)
  - Optimized hardware configurations are inferred from histograms

    NB: analysis modules are being ported to offline CMSSW

Strip tracker DAQ software

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- Event building
  - Uses standard event builder tools provided by XDAQ (RU/BU/FU)
  - Custom "FED builder" (DataSender) interfaces with ReadoutUnits
  - FilterUnit process simply forwards event to RootAnalyzer
- Error handling and problem solving
  - Prototype framework exists: provides generic tools for handling and reporting errors to global "problem solver"
- Other aspects
  - Run Control
  - Detector Control System (environmental info, power, interlocks)

DAQ software: architecture

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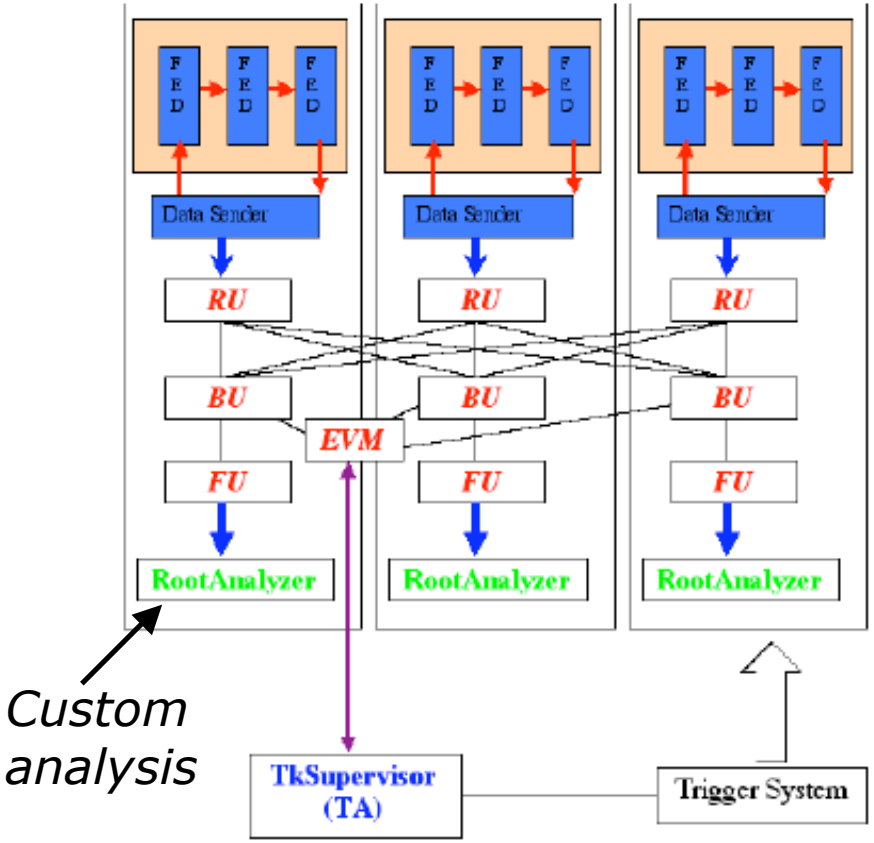
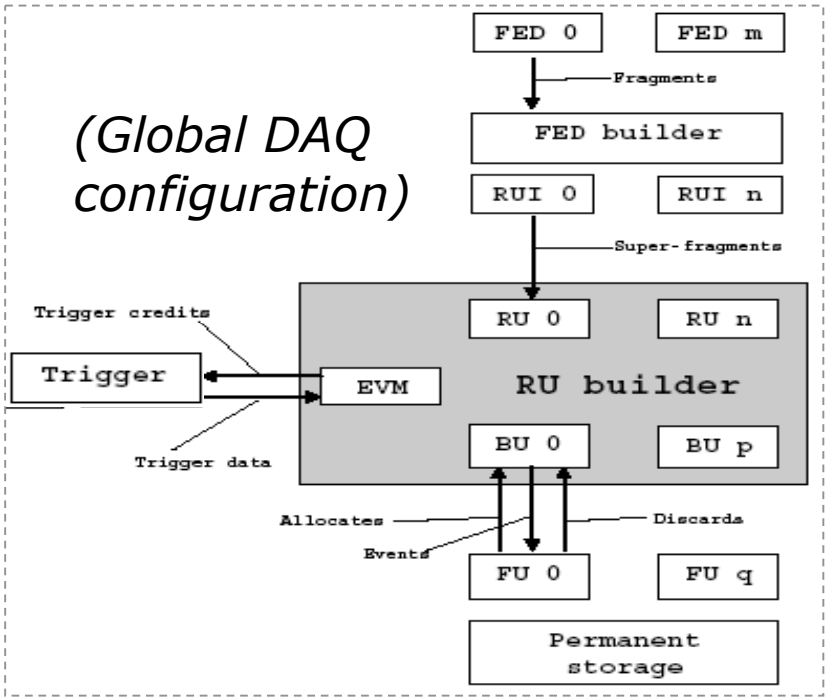
- Adopted solution (local DAQ)
  - Read data from FEDs via VME
  - Use local computing resources
- Data acquisition using FEDs
  - 10 racks of 440 FEDs
  - 1 PC per crate (3 per rack)
  - Standard XDAQ event builder
  - Crate PC's host RU/BU/FU





Motivations for using CMSSW

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- Custom analysis is currently being ported to offline fwk (CMSSW)
  - Existing XDAQ implementation is not easily scalable
  - System is reaching performance limits (can handle up to ~50 FEDs)
  - Urgent need for developments to handle final strip tracker system
- CMSSW provides many useful services / tools
  - Data Quality Monitoring framework
  - Conditions DB, geometry, low level reconstruction software
- Data Quality Monitoring (see talk of C.Leonidopoulos)
  - Remote clients can subscribe to histograms published by source(s)
  - "Collation" permits use of multiple sources and parallel processing
- Can use either local or global DAQ resources (if available)
  - Filter Farm has significant advantages over local DAQ in terms of:
    - trigger rates: *O*(kHz) via S-Link c.f. *O*(Hz) via VME
    - and processing power: hundreds c.f. tens of PCs

Commissioning analysis in CMSSW

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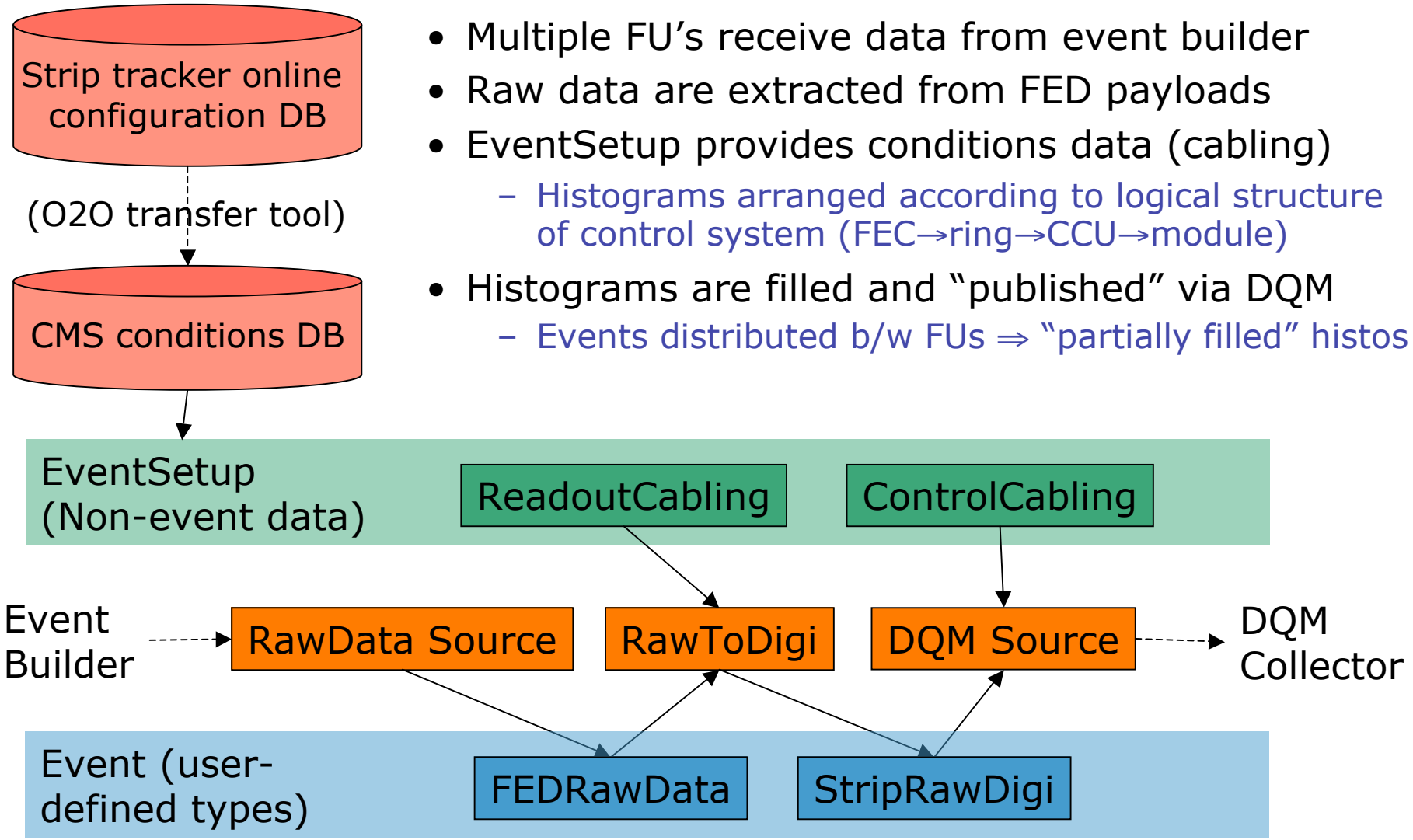

- Multiple FU's receive data from event builder
- Raw data are extracted from FED payloads
- EventSetup provides conditions data (cabling)
  - Histograms arranged according to logical structure of control system (FEC→ring→CCU→module)
- Histograms are filled and "published" via DQM
  - Events distributed b/w FUs ⇒ "partially filled" histos

Commissioning analysis in CMSSW

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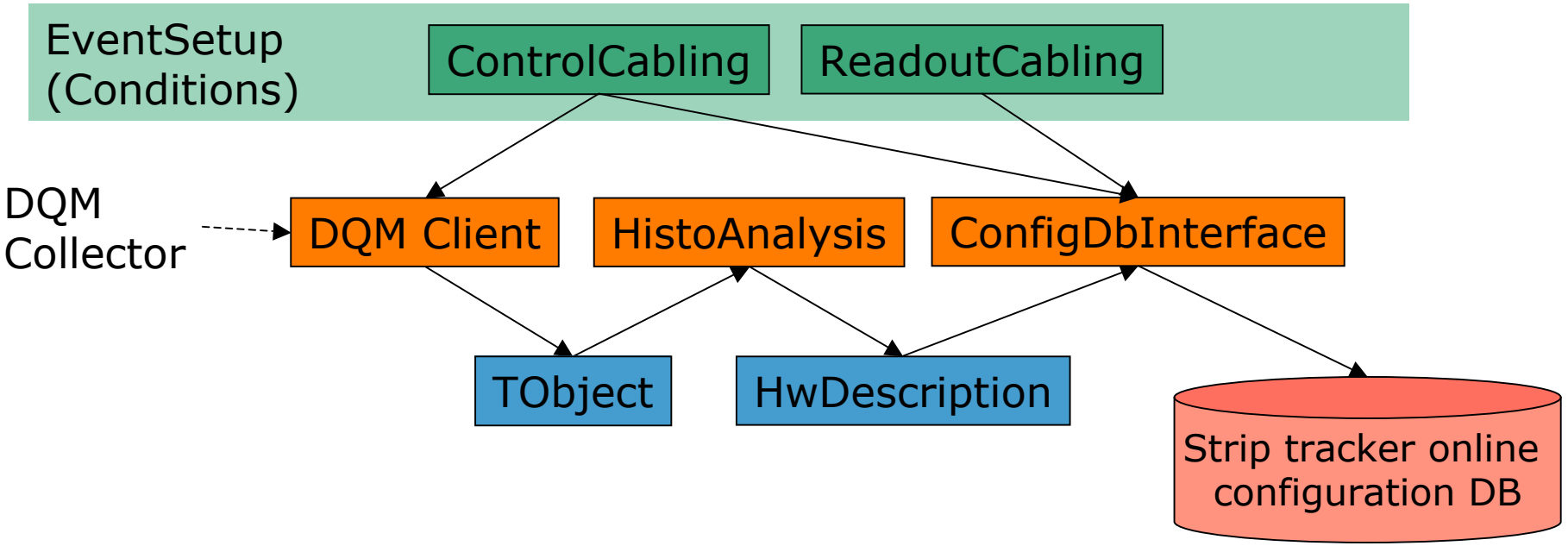
- DQM client subscribes to commissioning histograms
  - Histograms from multiple sources made available via "DQM Collector"
- Client provides complete (merged) histograms to user
- Histogram analysis extracts hardware configuration parameters
- Parameters are encoded within xml descriptions and uploaded to DB



Monitoring of readout system

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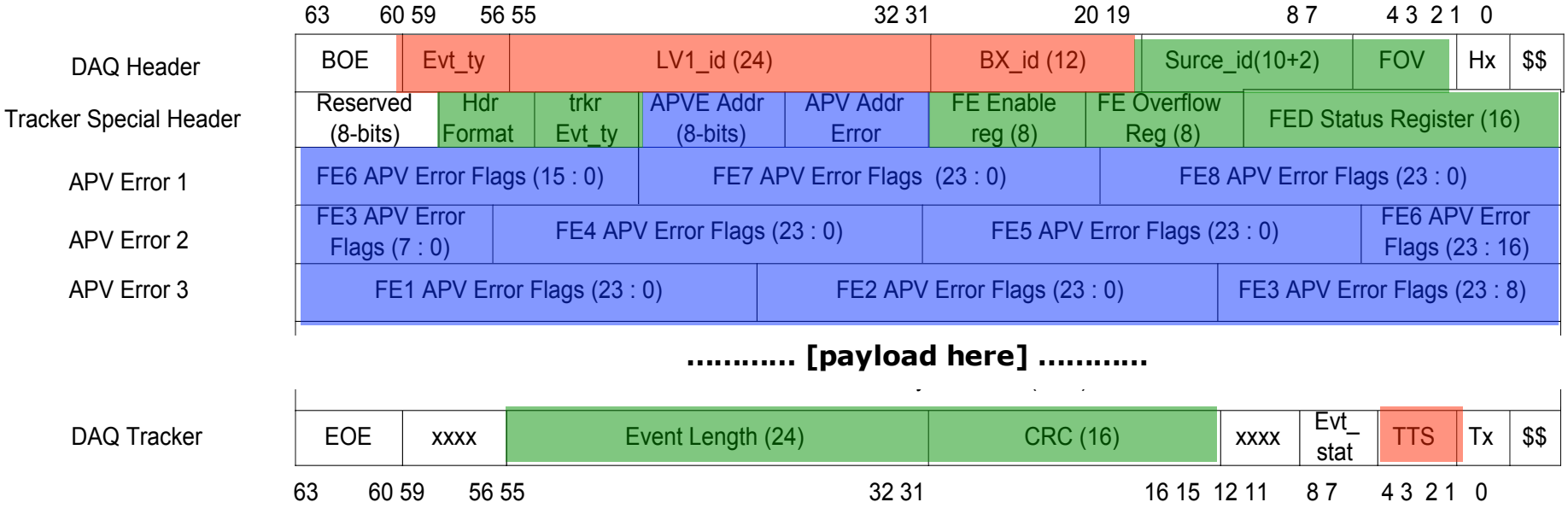
- Can monitor operational state of readout system during physics
  - FED buffer contains (limited) information on operational state of hardware

Event / trigger info: trigger type and id, BX id

APV25 readout chip: logic errors, synchronization

Front-end Driver: buffer lengths, buffer occupancies, throttle status



Development status

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- Strip tracker DAQ software within XDAQ
  - Mature and stable system, used by strip tracker integration centres
  - Commissioning procedures established and well understood
  - Latest development: full integration with configuration database
  - Now optimizing performances (HW configuration, DB access)
  - Need to integrate final trigger and throttle systems
  - Need to interface with Run Control and Problem Solver

- Distributed analysis within CMSSW
  - Complete prototype exists within old ORCA framework
  - First time within tracker collaboration using final readout system and full (local) DAQ chain *with FU-based online analysis*
  - Port to CMSSW is underway
  - Expect to have complete prototype in time for Cosmic Challenge

Some results: raw data unpacking

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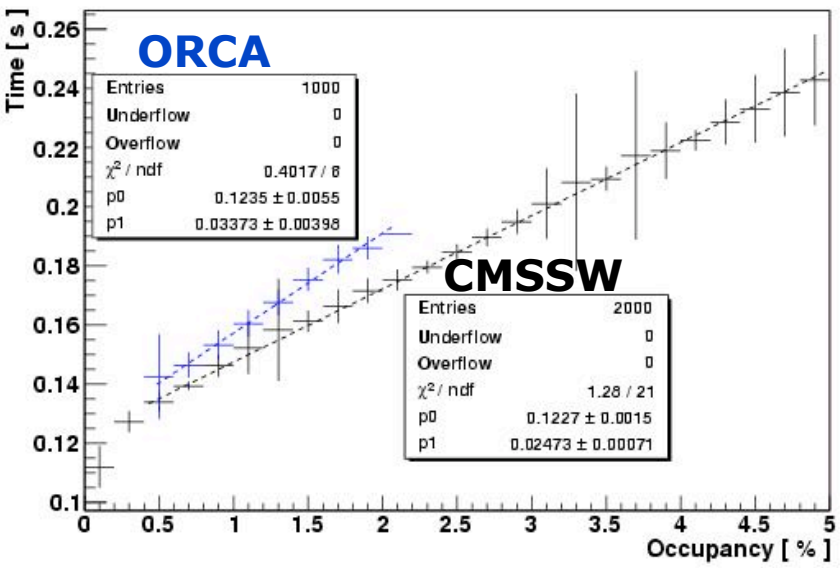
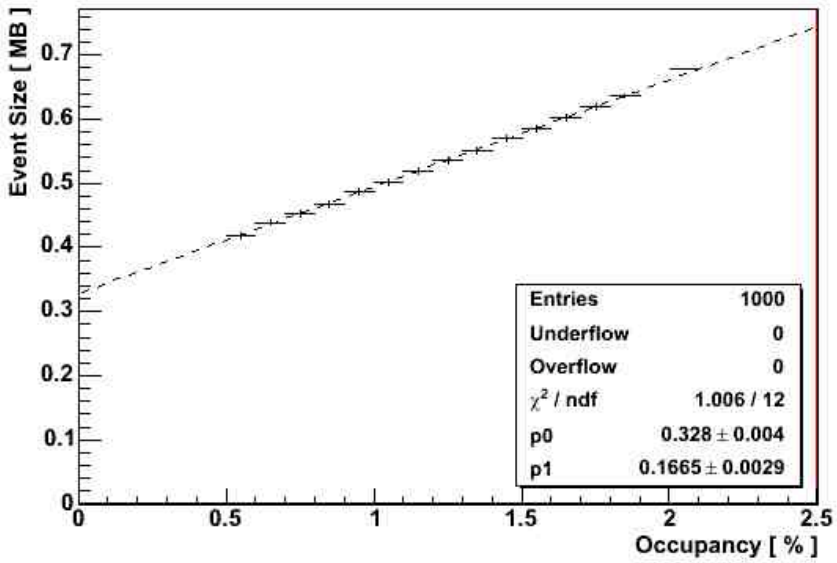
- Unpacking is first step in reconstruction
  - Digis created from FED payloads
  - Use cabling map to assign to DetId
- Pertinent results
  - Generate samples of FED buffers containing hit info (from sim events)
  - Samples reflect full strip tracker
  - FEDs: nominal zero-suppressed mode
  - Analysis run on *2 GHz* machine
  - For tracker average of 1.2% occ:
    - Unpacking time: 140 ms / ev
    - Event size: 496 kB
    - Root compression factor: 1.7
- Consequences for HLT
  - HLT decision within 300 ms / ev (1 GHz)
  - Unpacking presently takes full quota
  - Strong argument for regional reconstruction and unpacking-on-demand





Future milestones

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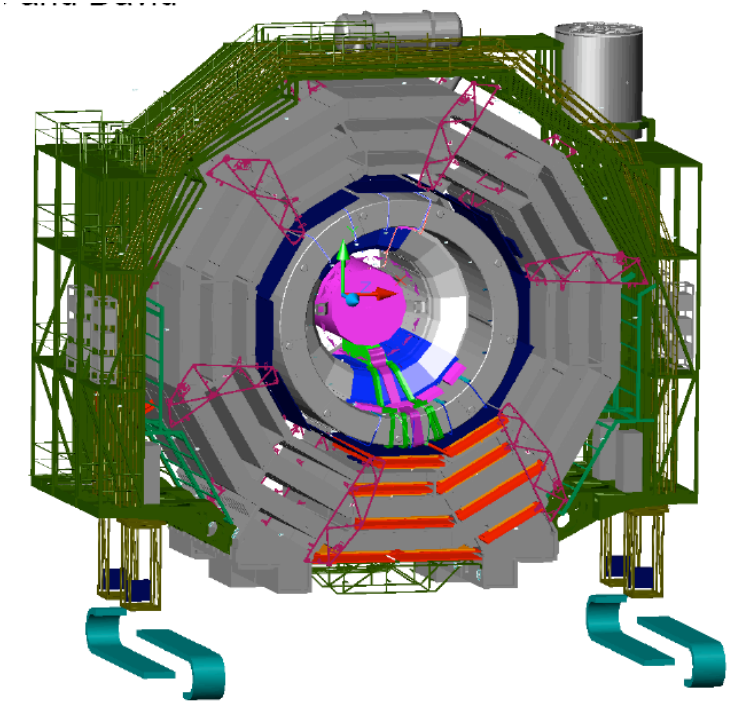
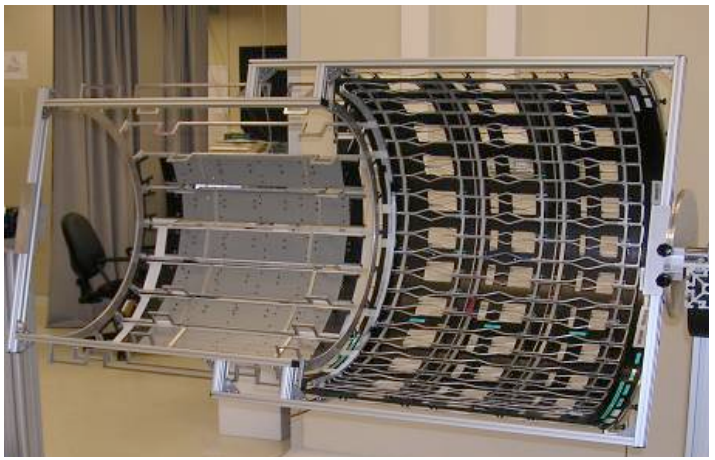
- "Slice" tests in CMS Electronic Integration Centre (bldg 904)
  - Acts as development centre
  - Tests already underway
- Magnet Test / Cosmic challenge
  - Tracker contribution: 200 modules
  - Commissioning and DAQ tests
  - Timescale: April/May
- "25% tests" in Tracker Assembly Hall
  - Commissioning of final tracker partitions prior to installation
  - Timescale: May onwards





Summary

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- Commissioning procedures established and well understood
- Strip tracker DAQ software is mature and stable
  - System is being used by all strip tracker integration centres
- Port of analysis modules to CMSSW framework is underway
  - Provides distributed analysis and improved performances
  - Allows to use global DAQ resources (ie, filter farm)
- Expect to have final DAQ software architecture ready for Cosmic Challenge in spring 2006