Update on SBN DAQ and data pre-processing activities

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for Joint SBN DAQ and data-preprocessing group

SBN DAQ and data pre-processing group goals

- Coordinate common efforts between far (ICARUS) and near (SBND) detector in the realm of DAQ and online data handling
  - Work together wherever possible, developing and using common tools
- Areas of common effort include
  - DAQ hardware and infrastructure
  - PMT and CRT readout
  - Common DAQ dataflow software
  - GPS and beam timing signals
  - Run control and process management
  - Online data quality monitoring
  - Online databases
  - Online data management

General status

- This is a critical time, especially as we prepare to commission and operate the far detector (ICARUS)
- We are strongly benefitting from our investment in common tools and approaches
  - Capitalizing on expertise and development from ICARUS, MicroBooNE, SBND vertical slice test, and ProtoDUNE
- We are continuing on the path towards an online software system that can be operated in common for the near and far detector
- I will highlight some of the recent progress and status on many of the main efforts
  - With apologies to the ones I don't cover as well

DAQ data-flow software

- We use the common *artdaq* software developed at Fermilab as a framework for our DAQ software system
  - *artdaq* is highly configurable and handles the basic movement of data
  - Directly compatible with offline-software framework to allow for shared efforts in event filtering, monitoring, and data management
  - Frequent feature requests and debugging help from core development team

- *sbndaq* software contains experiment-specific pieces and configuration
  - Periodic releases capturing recent updates
  - Installed at test stands both on and off-site (and SBN-FD of course!)
  - Maintaining a common repository with ability to tailor to each experiment's needs
  - Creating documentation as we go

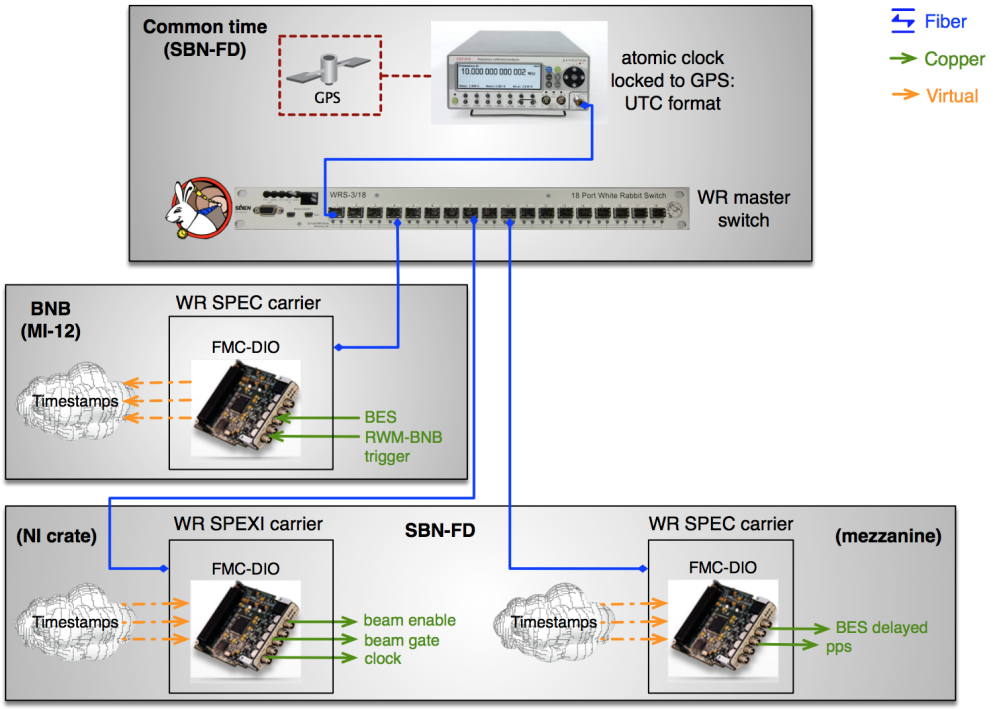
sbndaq online 'Wiki' page

PMT and CRT readout software

- PMT readout software
  - In well-defined state with data-throughput tested to maximum readout link bandwidth
  - Interactions of timing and trigger tested with fine-detail debugging
    - PMT trigger outputs and 125 MHz timestamp synchronization fully established
  - Integration with TPC readout accomplished (and adding complexity in further testing now)
- CRT readout software
  - Significant progress over last months on data format and acquisition
    - Will be incorporating into *sbndaq* release soon for further event-building and integration testing
  - CRT DAQ tutorial held to bring other groups on-board and contributing
    - Work to do: data quality monitoring, hardware interface optimization

GPS and beam timing signals

- Using the *White Rabbit* timing network system to timestamp and distribute GPS and beam signals
- Network established and timing/clock signals verified at SBN buildings
  - Final testing/debugging of the signals is ongoing with ICARUS
- Initial work started on integrating readout of timing signals into DAQ data stream



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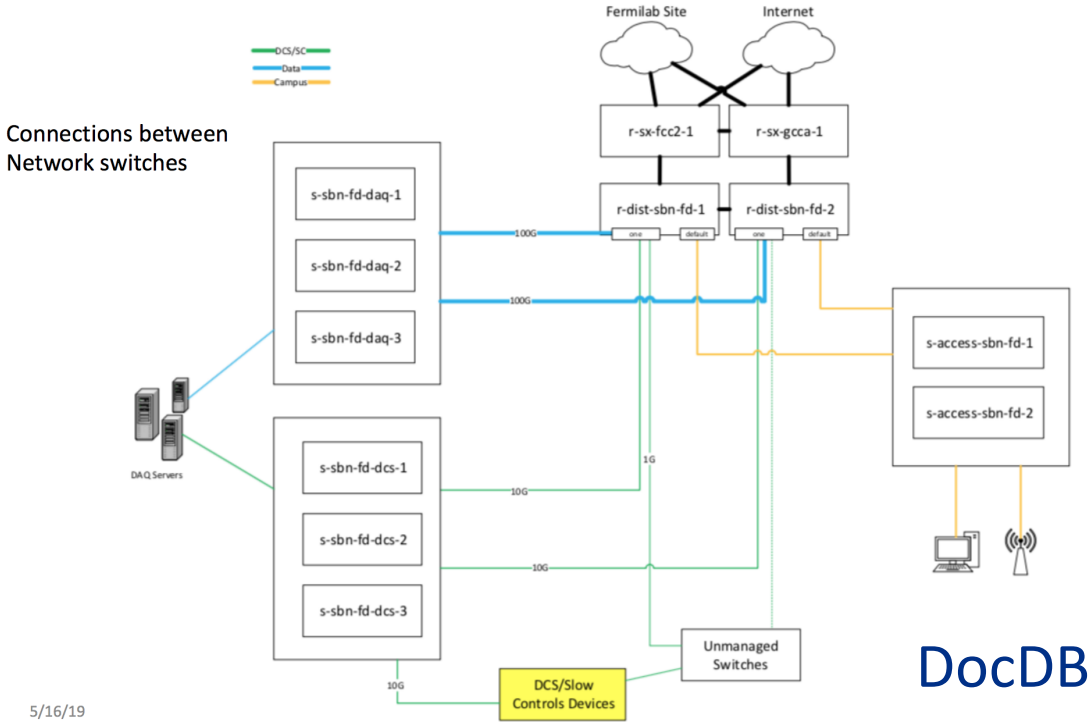
DAQ hardware and infrastructure

- Common DAQ server specifications for near (SBND) and far (ICARUS) detectors → planning for a shared pool for spares
- Working with Fermilab Scientific Computing Division (SCD) groups on system administration and networking to layout detailed plans for SBN far detector (ICARUS)
  - Will use common design principles for near detector where applicable



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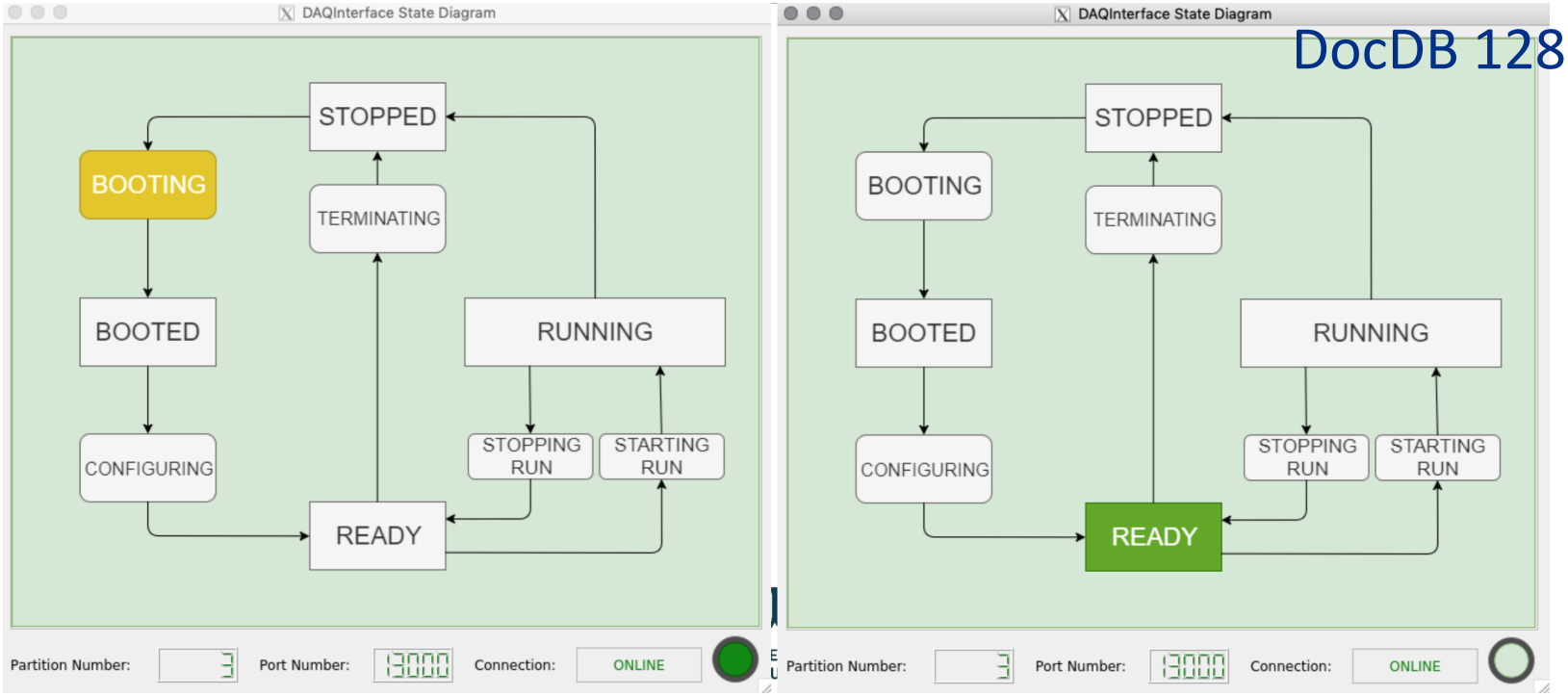
Run control and process management

- Improvements in *artdaq* supplied *DAQInterface* program
  - E.g. allow for subconfigurations of components, better process management control and stability
- Initial run control interface working!



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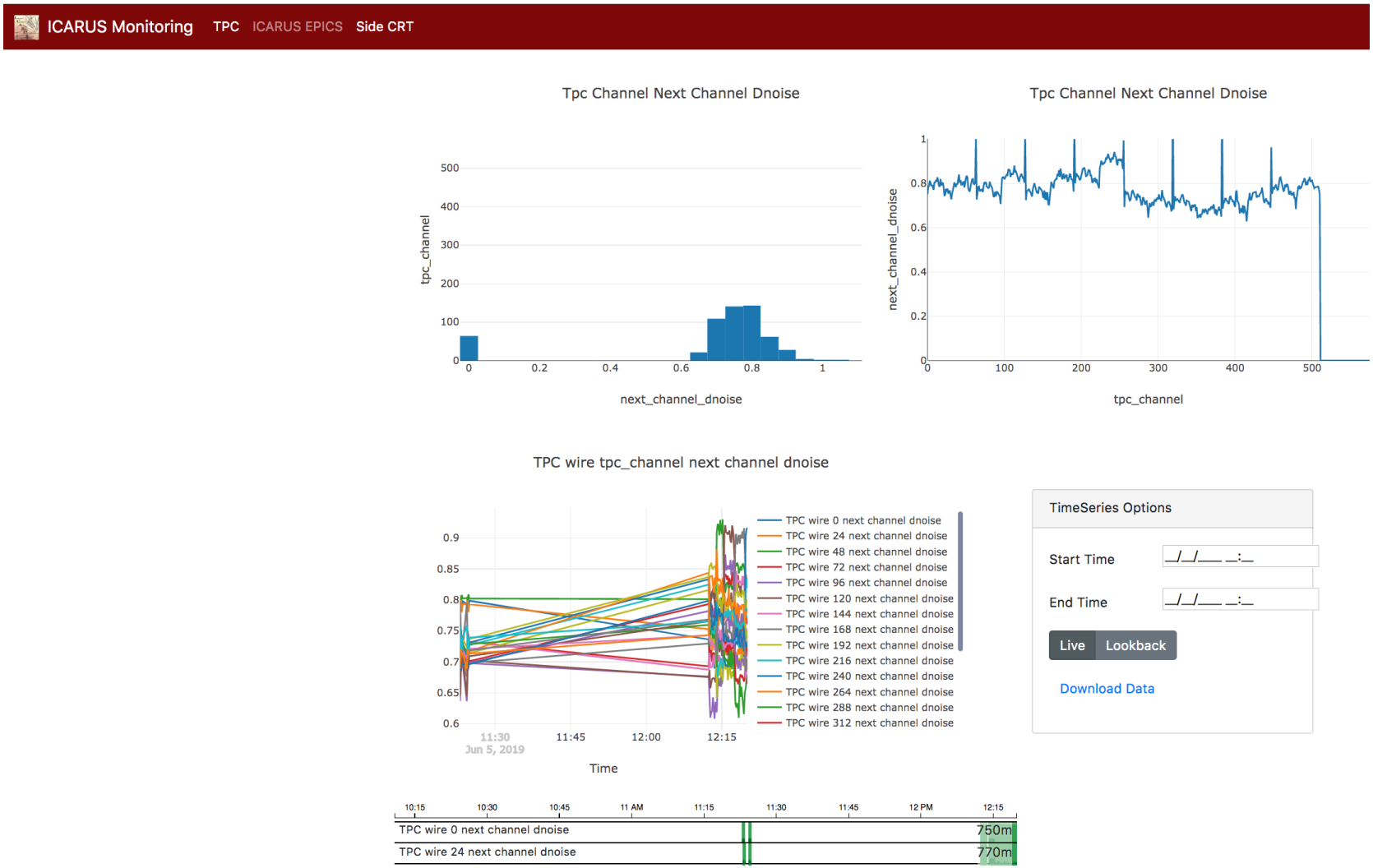
Data quality monitoring

- Expanded on effort from SBND vertical slice test to a more complete data quality monitoring software suite
  - *sbndqm* software package also routinely updated
  - Added in additional monitoring tools from ICARUS experience (including purity monitoring)

- First demonstration with far detector accomplished
  - Few minor issues identified and already fixed

- Active effort to add more monitoring information (PMT and CRT), work on how best to display it for expert and shifter use, and archive data over time

Data quality monitoring at far detector (ICARUS)



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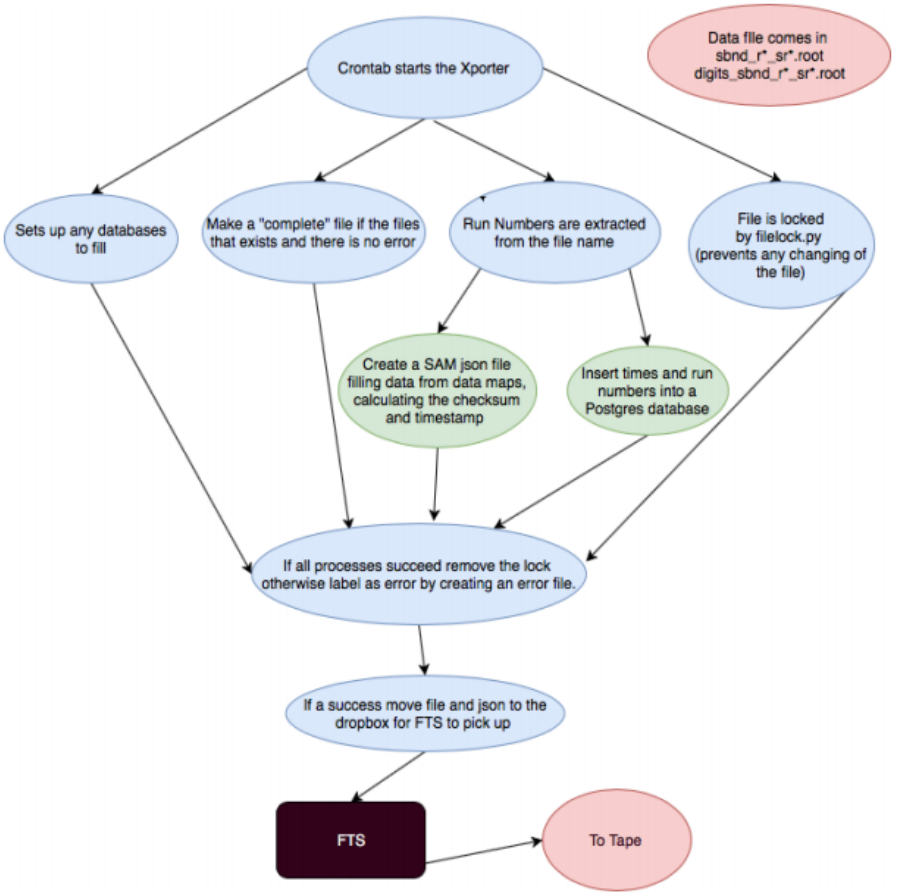
Online databases

- Many databases for each detector already exist (and follow a shared design)
  - E.g. run configuration, hardware databases
- Active effort to expand this and provide a cohesive database structure and strategy
  - Defined interfaces of databases to different hardware and software components
  - Now developing “event-by-event” database inspired by ICARUS
- Getting assistance on design and implementation from FNAL SCD databases groups

Online data management

- Have tools developed for LArIAT and SBND-VST using basic FNAL toolkit
- Starting to implement at SBN-FD to move ICARUS noise data to tape
  - Needs further effort: working to coordinate details with FNAL SCD experts and focusing on common solutions with ProtoDUNE



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Summary

- This is a critical time, especially as we prepare to commission and operate the far detector (ICARUS)

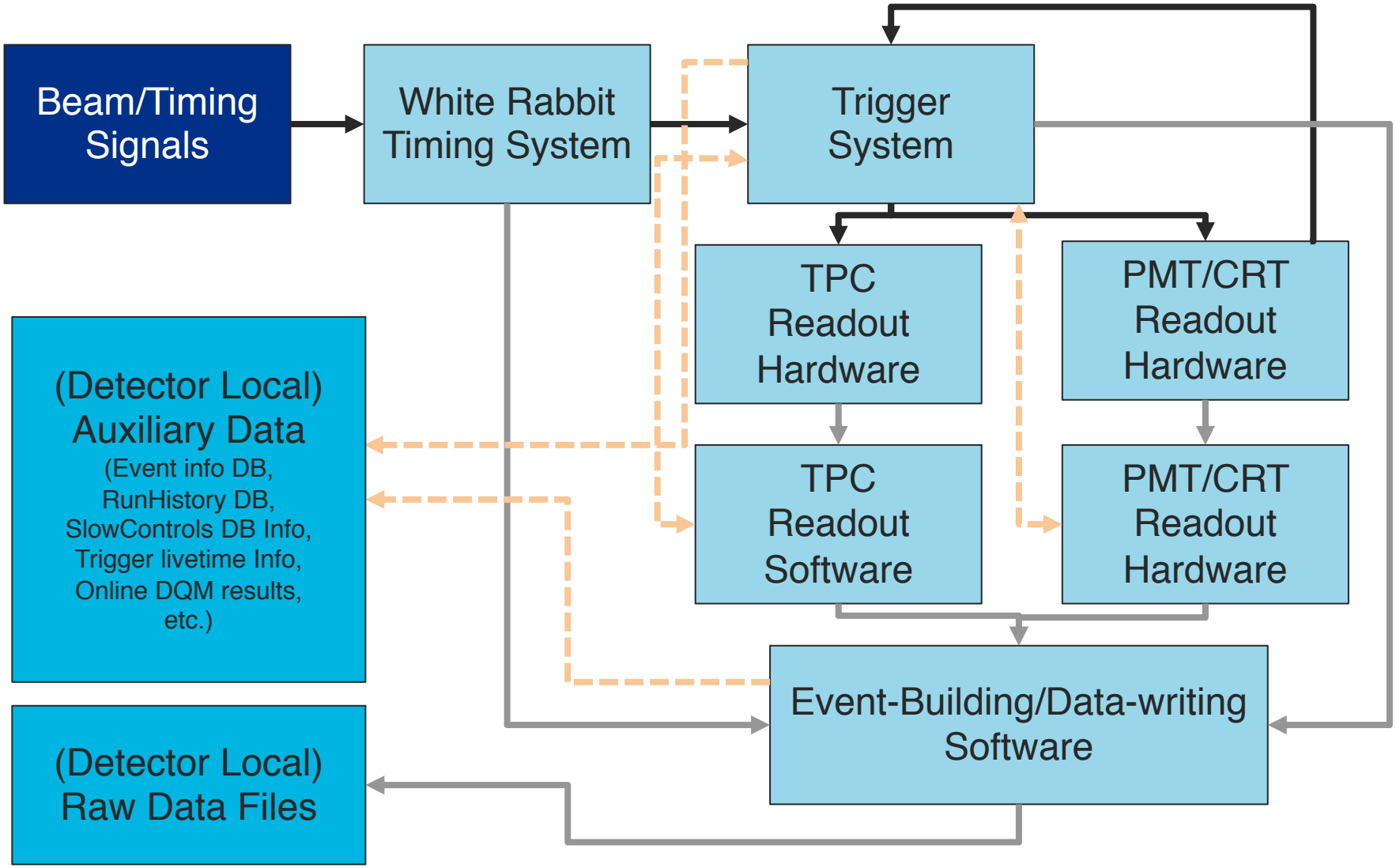
- We are strongly benefitting from our investment in common tools and approaches
  - Capitalizing on expertise and development from ICARUS, MicroBooNE, SBND vertical slice test, and ProtoDUNE

- We are continuing on the path towards an online software system that can be operated in common for the near (SBND) and far (ICARUS) detectors

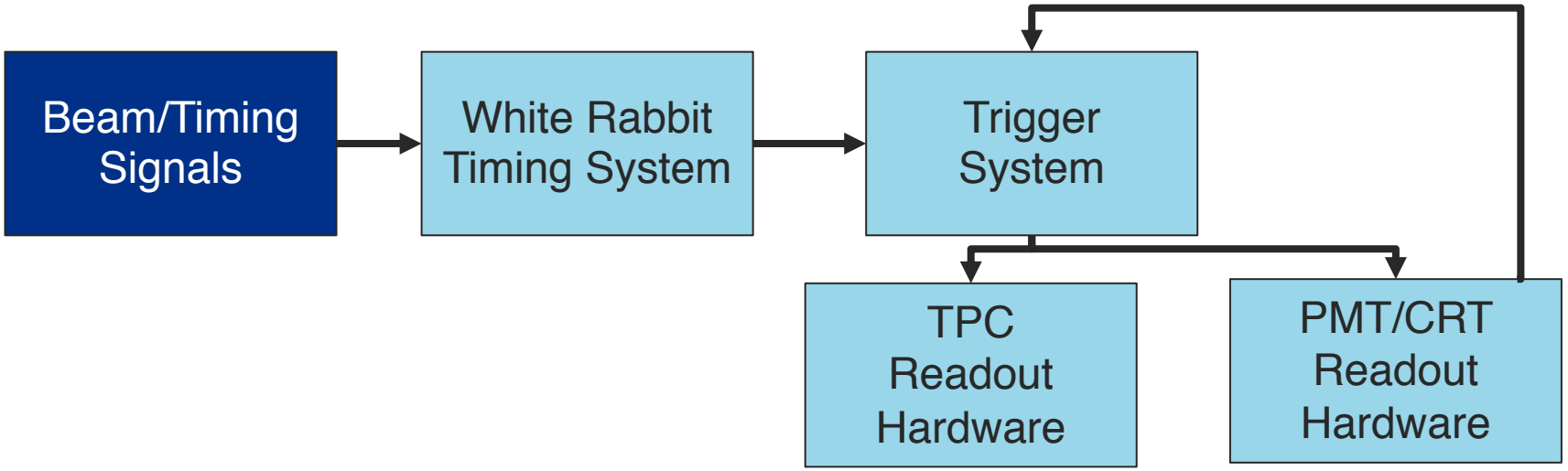
- Working together as an SBN team, we have made lots of recent progress but will need continued and dedicated effort!

Backup

Cartoon data flow, ‘real time’



Cartoon data flow: hard signals



- "Hard" signals related to triggering readout
  - Beam (BNB and NuMI) signals from AD
    - Sent to detector sites via IRM box, as well through WR network
    - AD/Main control room will support/respond to beam signal issues
    - Collaboration/ND will need to support WR-related info
  - Information from PMT and(?) CRT fed to detector-specific trigger systems
    - (Experiments still need to define full trigger menu)

Trigger transition to operations

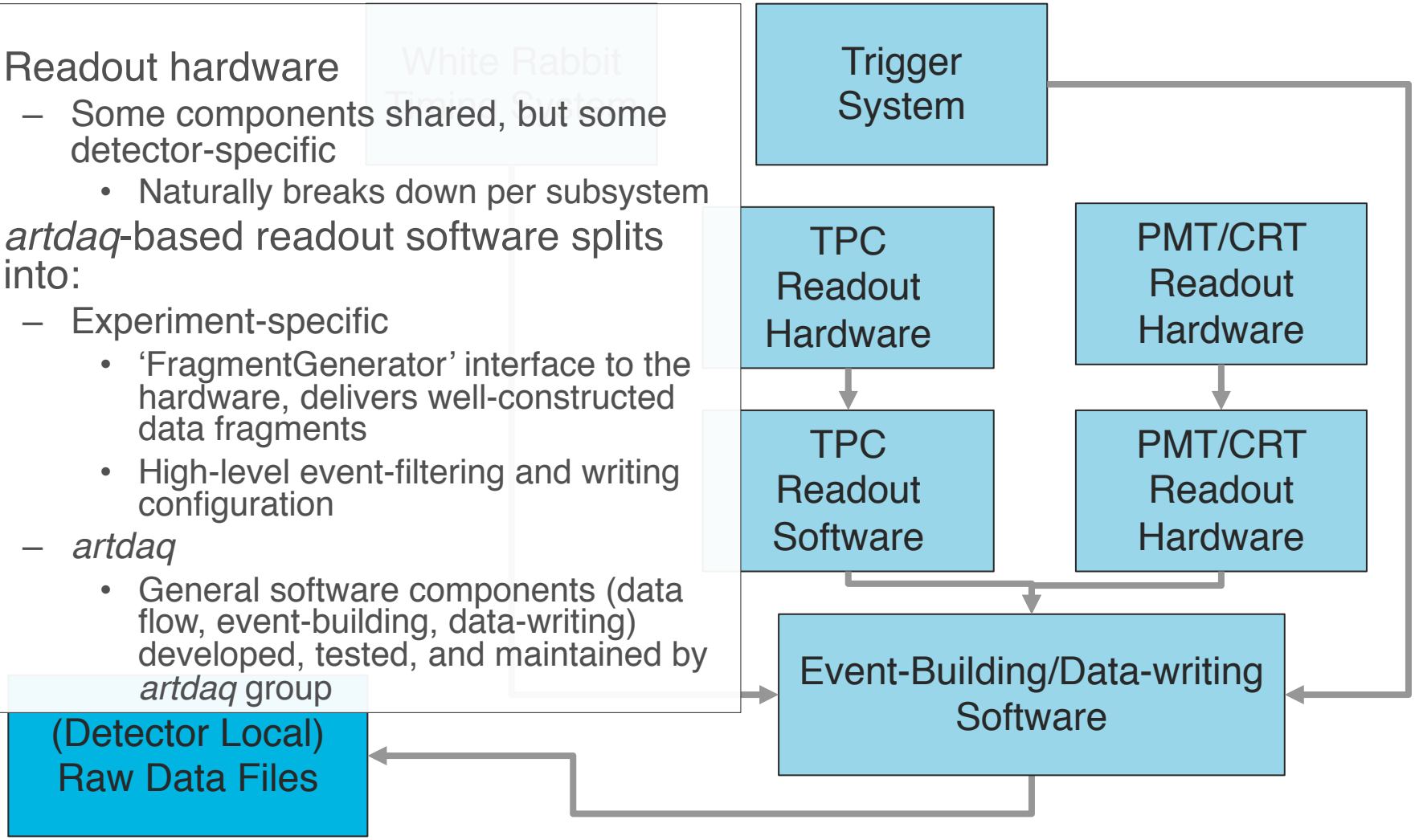
- Both detectors need a fully commissioned and operating trigger system for stable operations
  - Designed to support full beam rate during smaller commissioning period
  - But cannot operate long-term and acquire necessary data without incorporating scintillation light into trigger decision

- Staged commissioning/operation of the detectors envisioned
  - Early: trigger signal flow, trigger inhibit mechanisms, ‘operable’
  - Late: final trigger algorithms and trigger menu

- Long-term: will need identified trigger experts ready to handle any problems, interface updates, and trigger configuration updates
  - These will need to be detector-specific

Cartoon data flow, readout data

- Readout hardware
  - Some components shared, but some detector-specific
    - Naturally breaks down per subsystem
- *artdaq*-based readout software splits into:
  - Experiment-specific
    - 'FragmentGenerator' interface to the hardware, delivers well-constructed data fragments
    - High-level event-filtering and writing configuration
  - *artdaq*
    - General software components (data flow, event-building, data-writing) developed, tested, and maintained by *artdaq* group



Expertise and support for readout

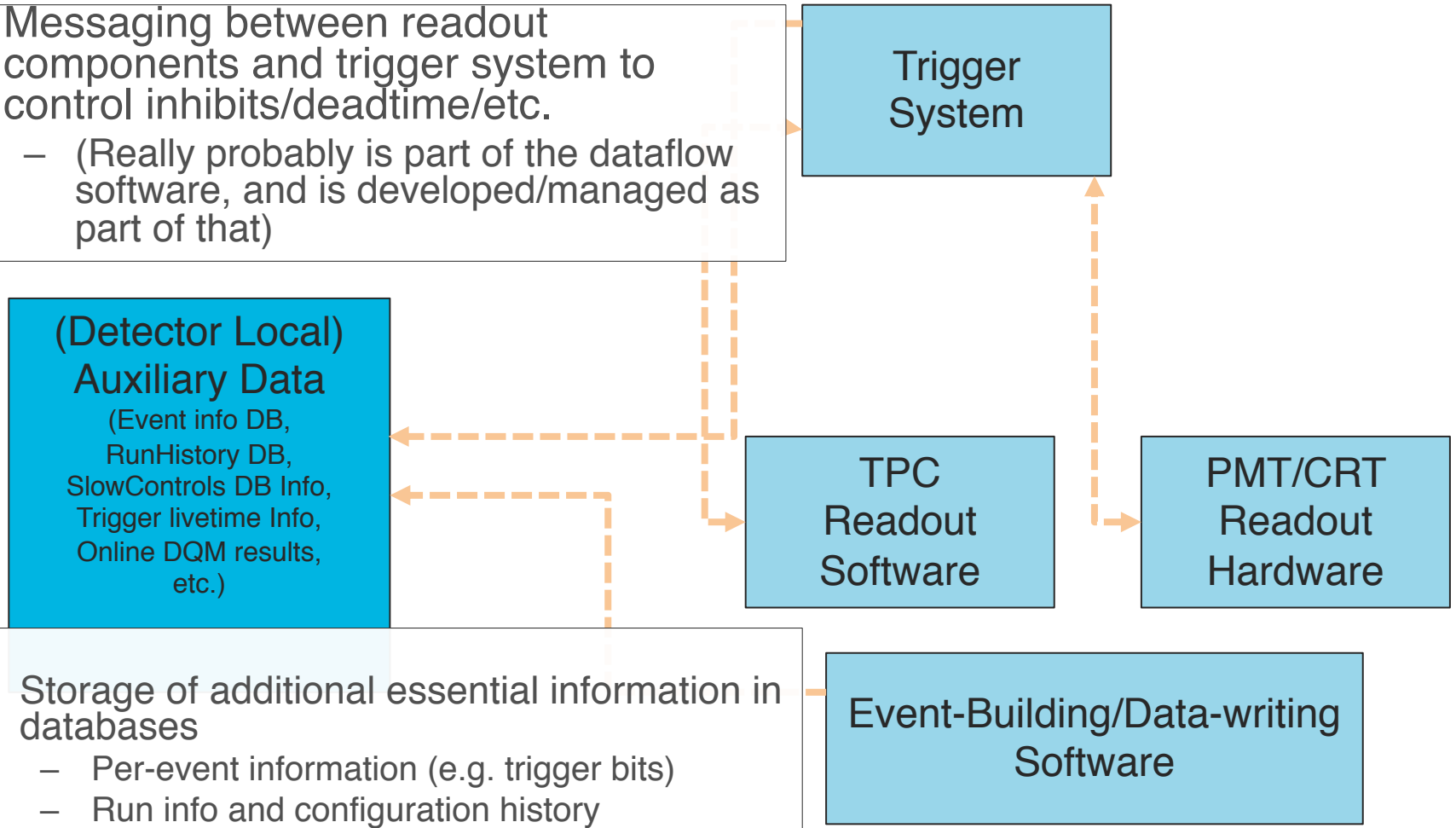
- Experiment responsible for maintaining/operating readout hardware
  - Would expect experts per subsystem, which can be shared between detectors if common subsystem

- Experiment also responsible for DAQ software
  - Collaboration members take lead on developing the software interfaces to readout hardware → expect them to maintain it
  - Detailed consulting, troubleshooting, development of feature requests, etc. available from the *artdaq* team, but operations typically not dependent on them

- Typically have general infrastructure support from operations groups
  - SLAM, database, and networking from SCD, ND operations group, etc.
  - Can make sure all computer systems, databases, networking is configured and operating
  - Also manage backups and restore in case of failures

Cartoon data flow, ‘out of band data’

- Messaging between readout components and trigger system to control inhibits/deadtime/etc.
  - (Really probably is part of the dataflow software, and is developed/managed as part of that)



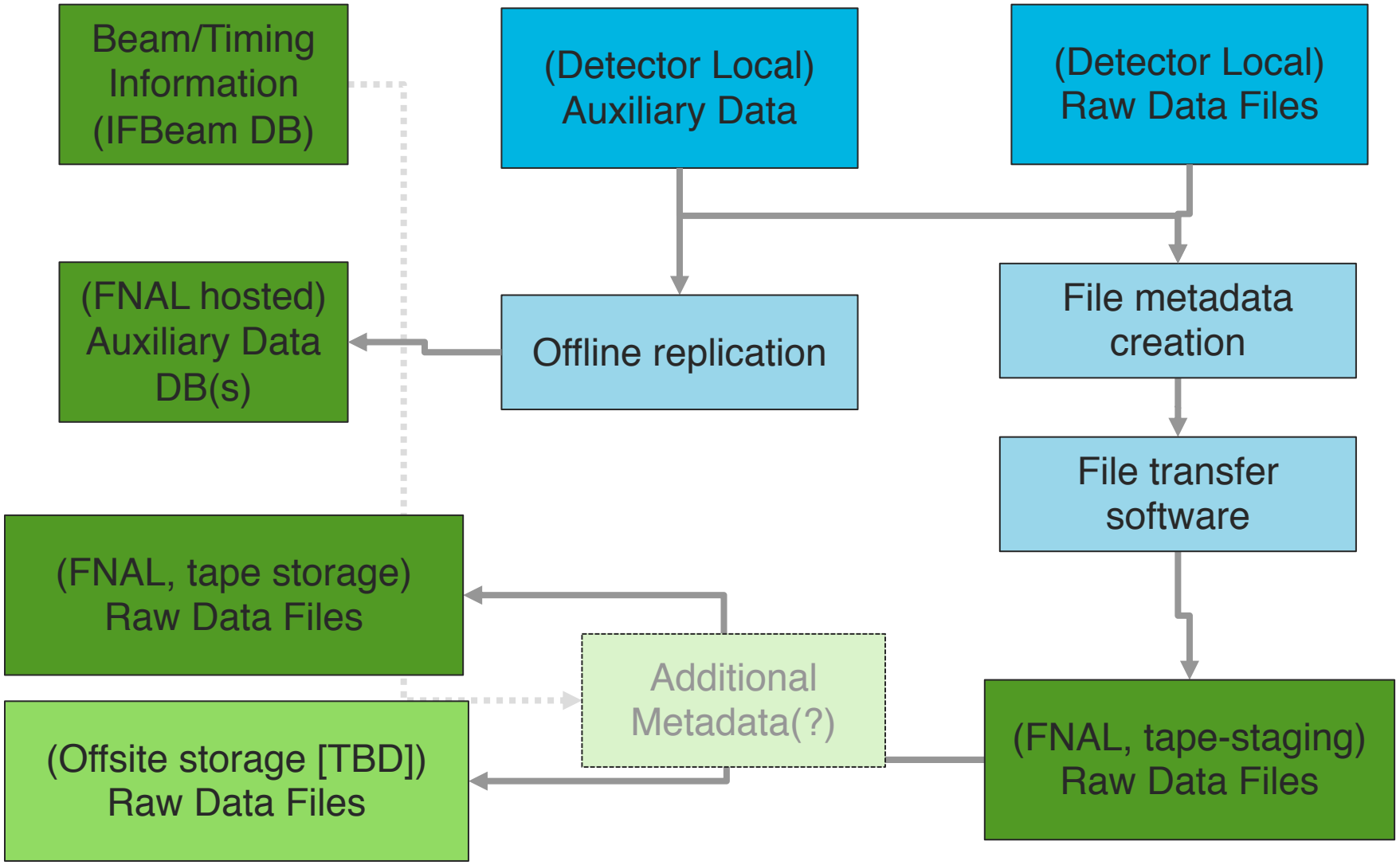
- Storage of additional essential information in databases
  - Per-event information (e.g. trigger bits)
  - Run info and configuration history
  - Trigger livetime/deadtime accounting
  - Detector state info from slow controls

Auxiliary data support

- Again, general infrastructure support for configuration and maintenance/backup of computing
  - Database support, networking support, etc.
  - Additional software consulting available from real-time systems (*artdaq*) group

- Experiment responsible for defining information to be stored and managing interfaces between systems
  - Would expect maintaining experts here to ensure information is good and update as needed

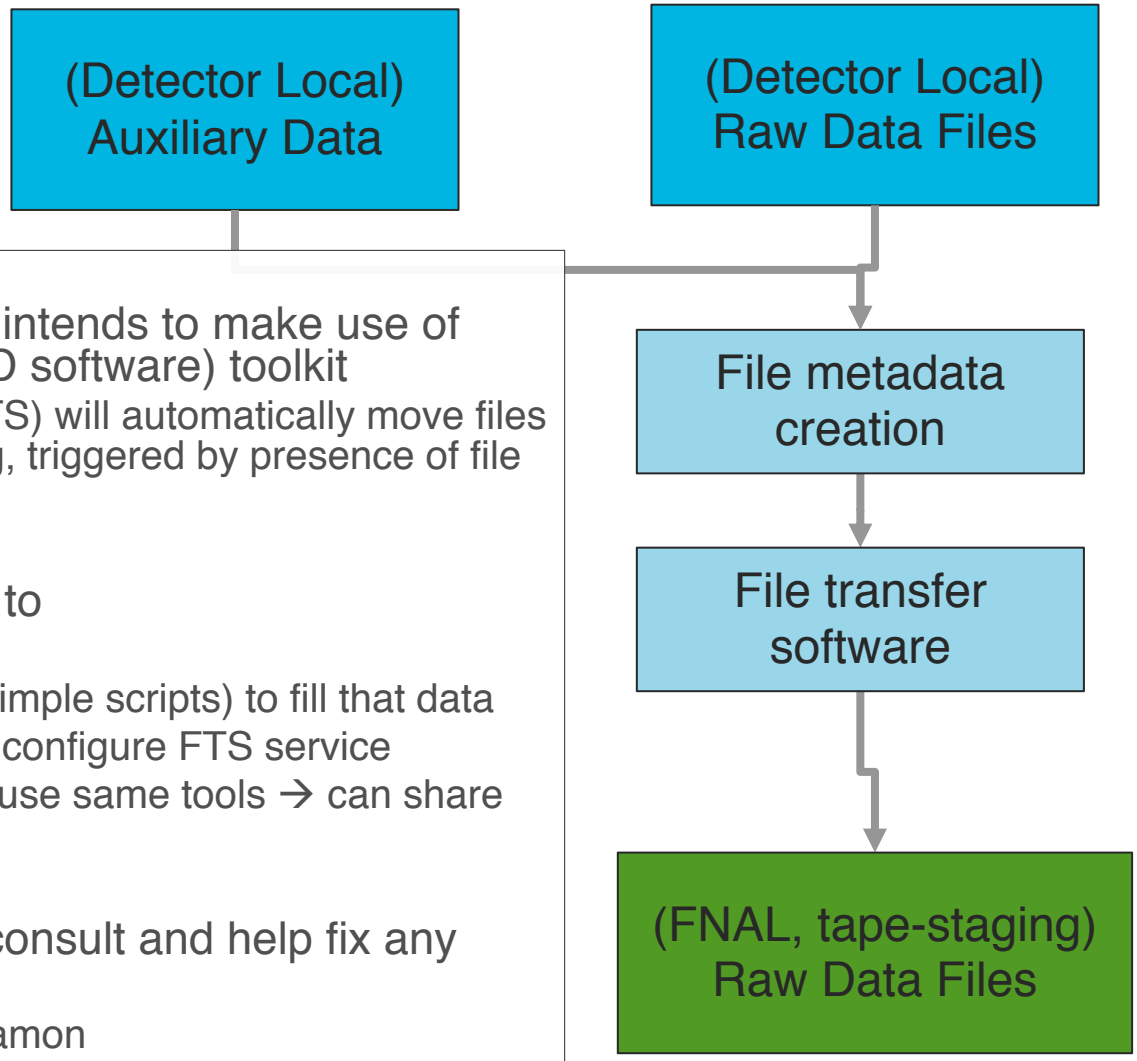
Cartoon data flow, ‘nearline’



‘Nearline’ strategy

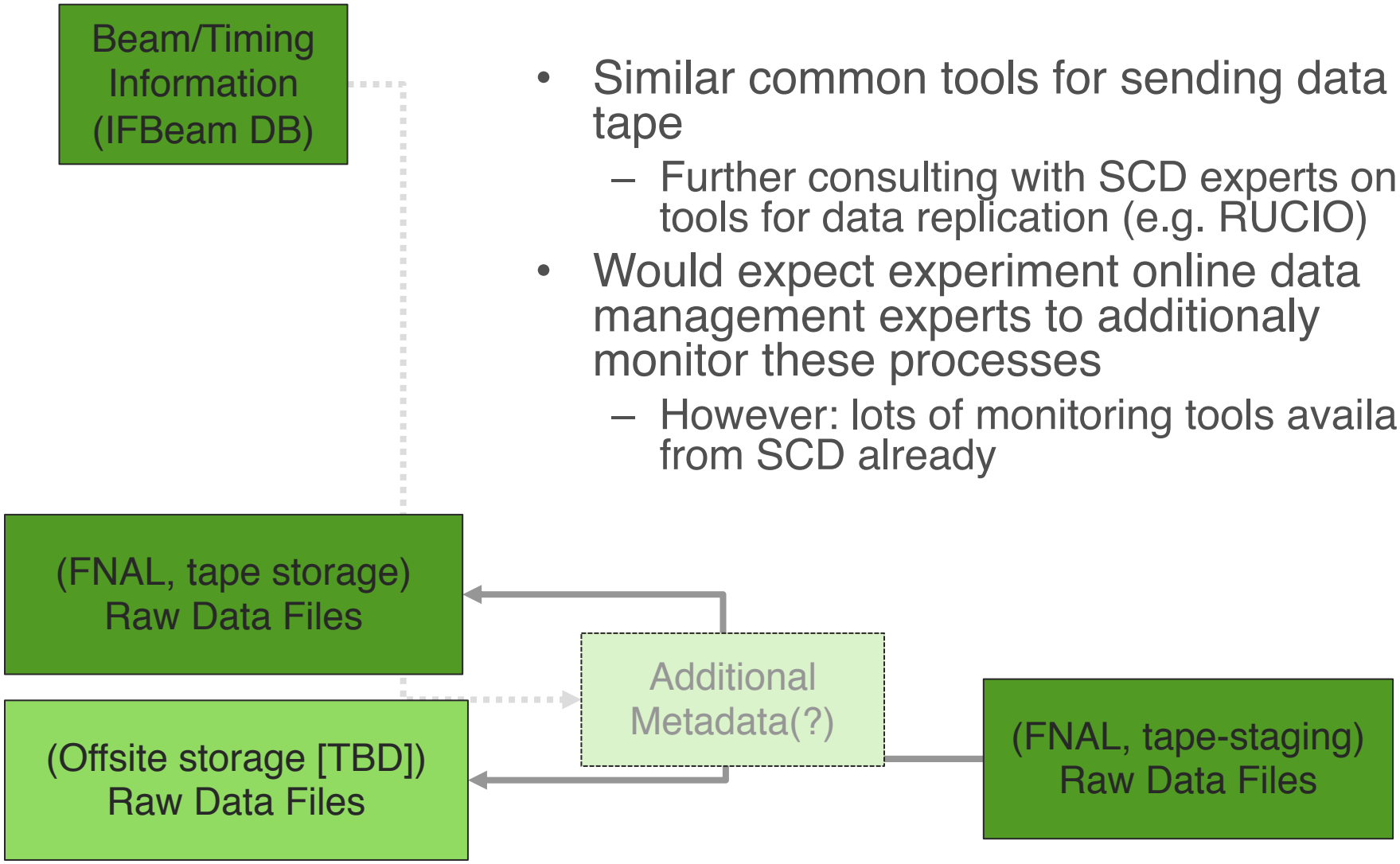
- ‘Raw data’ (*art*-ROOT wrapped event data) stored in local files at detector site
  - Local clusters have sufficient storage capacity to hold data for many days (at minimum) and are RAID-protected
- Initiate process to transfer files upon file or run completion
  - Files first transferred to central FNAL computing
  - They are staged there to be sent to FNAL tape storage
    - Additional copies can be transferred offsite, but those locations to be determined
  - Files deleted at detector site after some time and/or confirmation they are backed to tape
- Additional first-round processing/high-statistics monitoring can be done efficiently on files in staged area
  - But I would consider this out of scope for standard operations unless demonstrated need

Cartoon data flow, online data file management



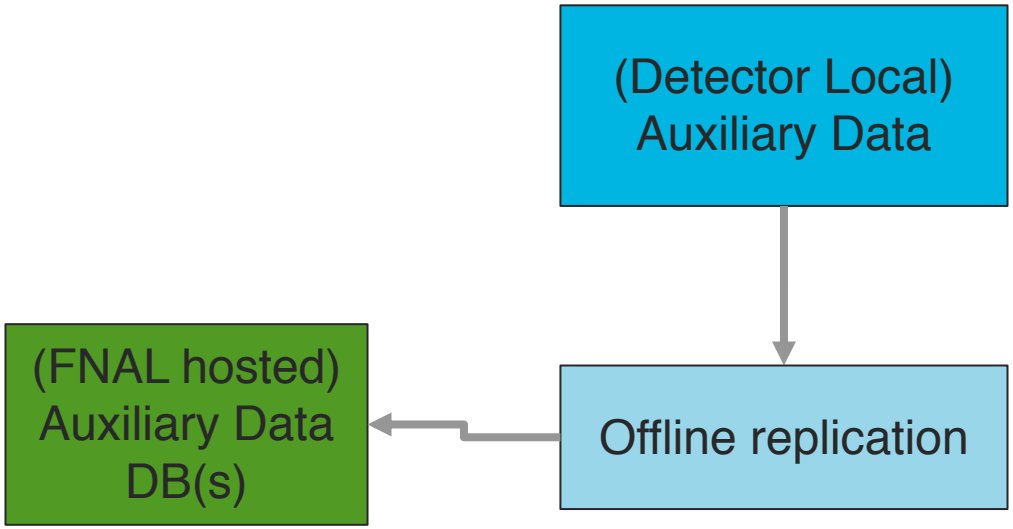
- Online data management intends to make use of standard FIFE (FNAL SCD software) toolkit
  - File Transfer Service (FTS) will automatically move files to off-detector computing, triggered by presence of file and metadata
- Collaboration responsible to
  - Define file metadata
  - Write software (usually simple scripts) to fill that data
  - Additionally monitor and configure FTS service
  - Both detectors intend to use same tools → can share expertise
- FTS experts available to consult and help fix any issues
  - Typically: restarted a deamon

Cartoon data flow, final data storage



- Similar common tools for sending data to tape
  - Further consulting with SCD experts on tools for data replication (e.g. RUCIO)
- Would expect experiment online data management experts to additionaly monitor these processes
  - However: lots of monitoring tools available from SCD already

Cartoon data flow, ‘nearline’



- Auxiliary data in online databases need to be replicated and made available to offline processes
  - Can use DB support at FNAL to help set this up for standard database types → may not need much additional expert input besides ensuring replication happens in timely fashion
- (Importantly: should ensure no race conditions for offline production and necessary info replicated from online DBs)