DAQ Overview

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Data Model Workshop – 2019-08-14

Outline

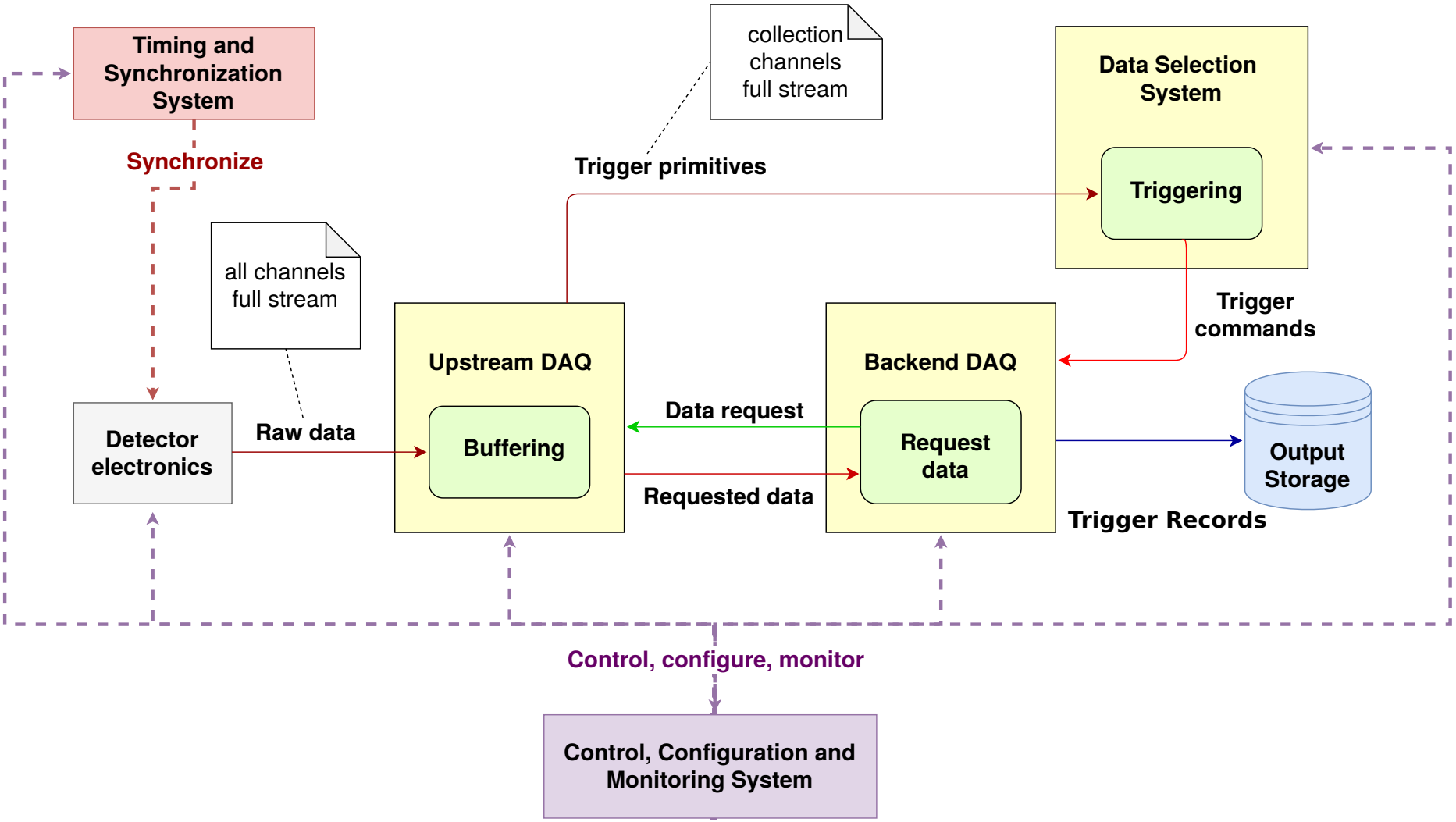
DAQ Design Overview

Data Rates

Trigger and Readout

DAQ Conditions

Summary


Timing and Synchronization System
Synchronize
collection channels full stream
Trigger primitives
Data Selection System
Triggering
Trigger commands
all channels full stream
Upstream DAQ
Buffering
Backend DAQ
Request data
Data request
Requested data
Detector electronics
Raw data
Output Storage
Trigger Records
Control, configure, monitor
Control, Configuration and Monitoring System

Top-down data rate limit

> *Thine far detector shalt not produce*
> *to tape in excess of 30 PB/year.*

This limit in relevant units:

network	8 Gbps
storage	1 Gbyte/sec
workload	80 TB/day

Note: eventual connectivity FD: $\mathcal{O}$(100 Gbps).

Bottom-up data rate estimates (SP 10kt)

Cosmics and atmospheric neutrinos	10,000 TB
Radiological backgrounds (**SNB**)	1000 TB
Laser calibration	200 TB
Radioactive source calibration	100 TB
Random triggers	60 TB
Beam interactions	30 TB
Cold electronics calibration	4 TB

Full set of trigger primitives	15000 TB

- Numbers assume: **lossless compression** (expect 2-4$\times$ reduction) and initial **full-detector readout** (eventual $\approx 10\times$ reduction)
- ? Offline may want to consider producing streams of certain trigger categories for **prompt processing**. DAQ **high-level filter** may play a role.
- ? Output **trigger primitives** preceding an SNB trigger? (1000 s per SNB trigger $\Rightarrow$ 500 GB/year, 1 day/SNB $\Rightarrow$ 40 TB)

DP, M3, M4

Dual-phase 10 kt compared to SP 10 kt:

- Similar ADC sample rate and resolution.
- About half the channels.
- 10$\times$ lossless compression (SP: 2-4$\times$).
- About 2-4$\times$ longer readouts (longer drift).

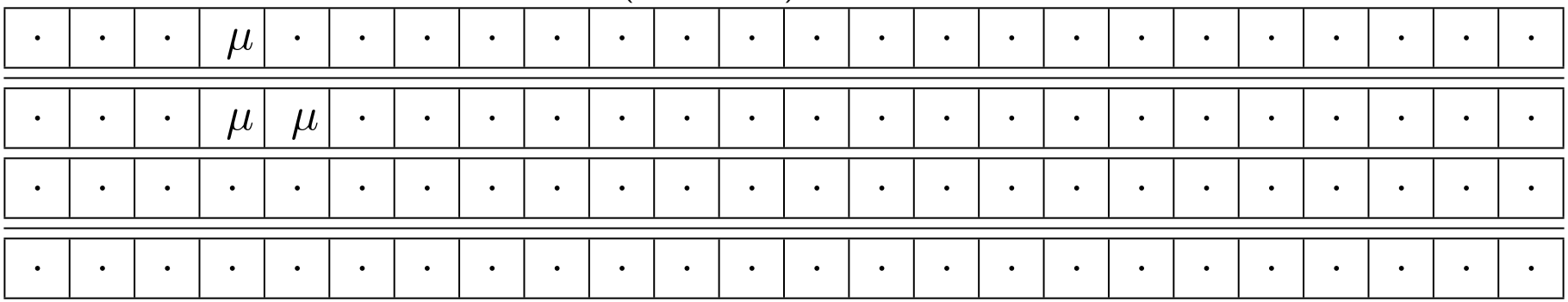
$\rightarrow$ Expect DP 10kt have 20-100% the data of SP 10kt

M3 and M4

- SP? DP? Pixels? Your favorite guess goes here: **( )**
- Generous simplicity: assume data rate of FD = 4$\times$ SP

Full-detector vs Active-only Readout

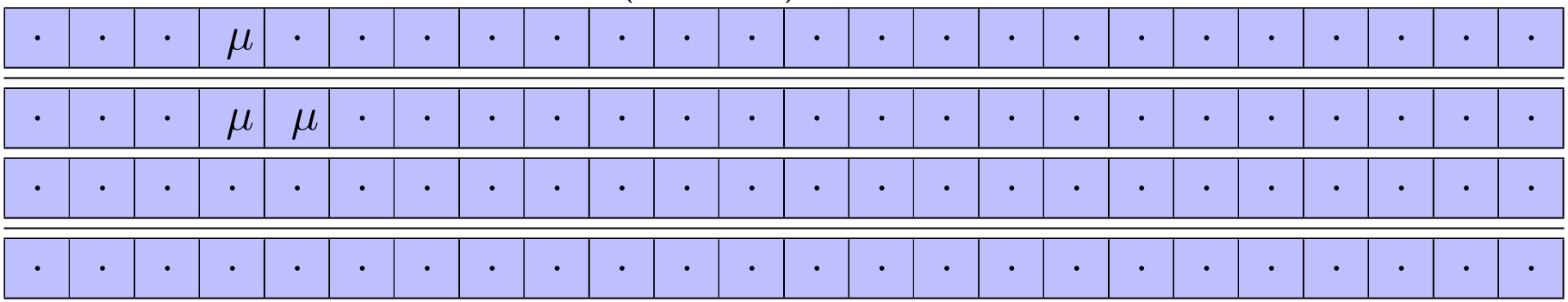
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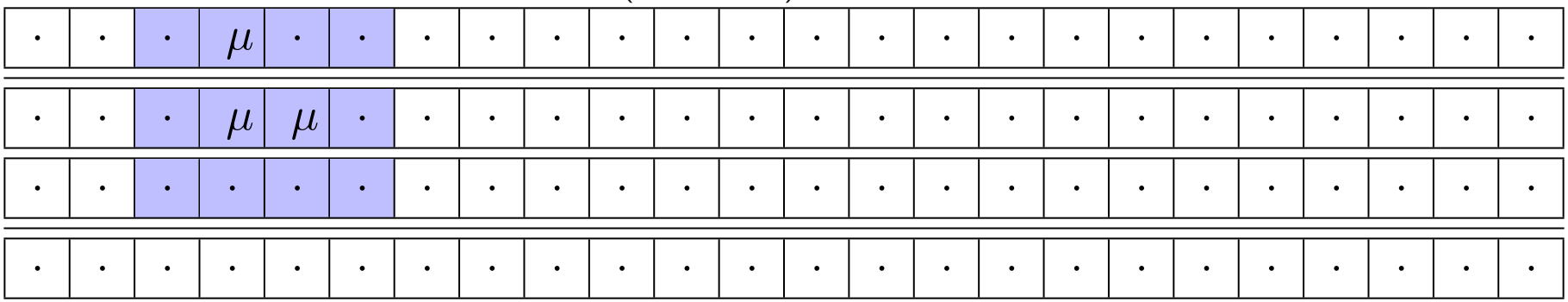
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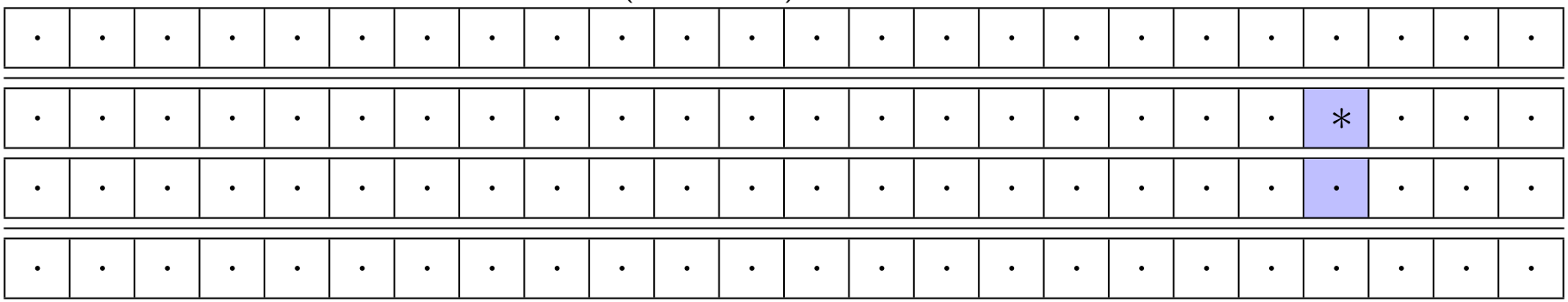
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  - Usually $<$ 15 APAs/cosmic-μ $\rightarrow$ 600 MB readout (10 PB/yr $\rightarrow$ 1 PB/yr)
    - See Oxford DAQ workshop, Slide 11 for distribution.
    - Study needed to determine how much data in long tail
  - Include also nearest neighbors? 10$\times$ $\rightarrow\approx$ 3$\times$ reduction?

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- Compact readout for low-energy or "controlled" activity ? ($*$), eg:
  - Sparsification of low-energy activity not associated with SNB?
  - Tight selection around expected calibration laser tracks?

Supernova Neutrino Burst

- Expected SNB rate: **approximately never**.
- **False positives** drive the "SNB" trigger rate:
  - Driven by **radioactive + noise** backgrounds.
  - The **configured** average rate is **1/month**.
  - Poisson: each decade expect 2 fake SNB in 10 hours[1].
- "SNB" full-readout for 100s $\rightarrow$ 115 TB per trigger
  - SP 10kt, no compression
- Likely, readout all 10kt detector modules when at least raises an "SNB" trigger decision.
  - Retain ability to modulate (eg, veto) cross-module triggers, eg to combat some transient high rate false-positive problems.

[1] DocDB 11461

What about PDS data?

SP-PDS TDR Chapter:

	SP	APA
Channels	6000	40
Dark current data rate	8 Gpbs	53 Mbps
All-detector event size	4 MB	30 kB

The largest possible PDS contribution ("all-detector") to the smallest possible TPC data (localized low-energy) is 10%.

Details are still under study.

DAQ Output Shape

The Idealized DAQ Spigot

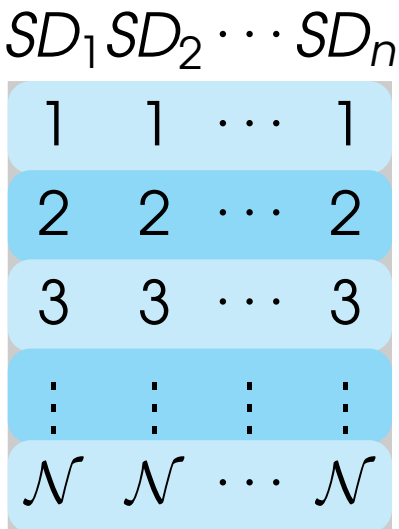
SD_1	SD_2	$\cdots$	SD_n
1	1	$\cdots$	1
2	2	$\cdots$	2
3	3	$\cdots$	3
$\vdots$	$\vdots$	$\vdots$	$\vdots$
∞	∞	$\cdots$	∞

Conceptually, DAQ streams out a ribbon ∞ triggers long and n **sub-detectors** wide

- An "*SD*" is one "unit" of APA, CRO, PDS, etc.

DAQ Output Shape

Traditional "event building": $\mathcal{N}$ records spanning n SDs per file.

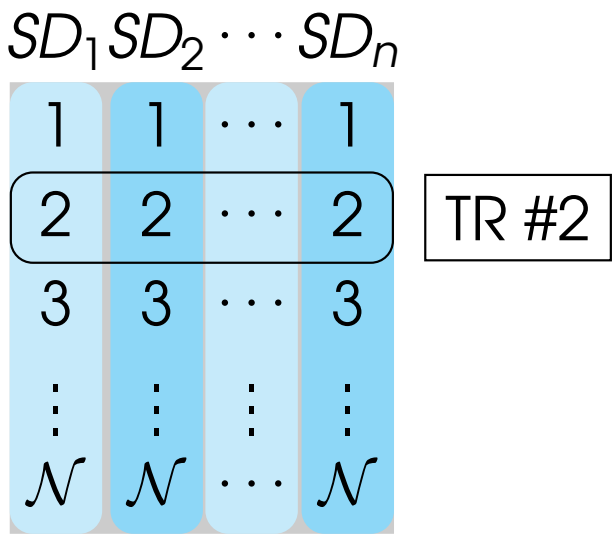


- SP file size: $\mathcal{N} \times n \times$ 40 MB = $\mathcal{N} \times$6 GB (for $n = 150$ APAs).
  - $\mathcal{N} \gg 1, n = 150$: × event too big, × file too big, ×non-sequential
  - $\mathcal{N} = 1, n = 150$: × event too big, ✓ file okay, ✓"sequential"
  - $\mathcal{N} > 1, n \approx$ *few*: × event usually too big, ✓ file okay, ×non-sequential

    "event too big": $n = 150$, 12 GB "event" in RAM, "file okay": 5-10 GB good for tape, "sequential" refers to trigger number.

DAQ Output Shape

The Generally Accepted New Way



Per-subdetector "file streams" best for DAQ and Offline

- Trigger record **spans** n **files** of size: $\mathcal{N}\times$ 40 MB, $\mathcal{O}(100)$ APA-trigger/file.
  - An $n+1^{st}$ **header file** may provide **per-trigger-record** meta info.
- DAQ can provide sequential trigger numbers ("one writer per APA").
- First stage offline processing[a] is inherently APA-parallel, so would prefer this.

[a] DocDB 15418

What about SNB Dump Files?

SNB dump: 100s $\times$ 150 APA is 115 TB (uncompressed)

- Far far too big to read into RAM as one "event"
- Even far too big for a single file.
- And, too big for per-subdetector files (800 GB/APA-file)

$\rightarrow$ Must break up by sub-detector and time slices.

Eg: 100 $\times$ 1s $\times$ 150 APAs gives **15,000 files** of 8 GB each.

Comments for offline:

- 8 GB (1s) of 1 APA is 200 nominal readouts, too much for one job to process all together.
- Time slicing is needs support both in DAQ format and Offline reader.
  - Offline needs to duplicate $\approx 100\mu$s on both sides of slice to keep efficient signal processing.

PDS Data Files

PDS output data handling not yet decided. Likely choices:

(a) Include PDS with TPC (eg, on per-APA basis).

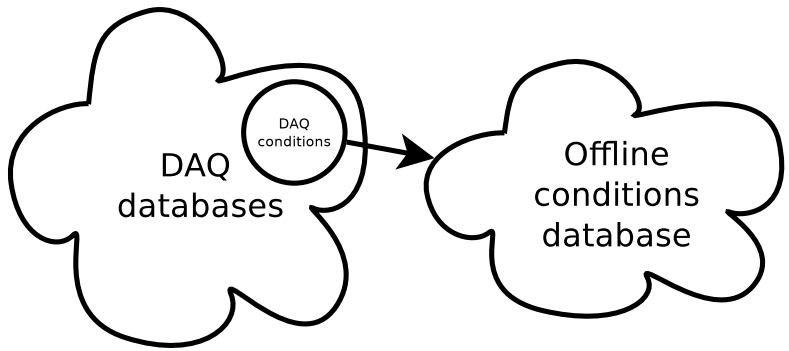
(b) Separate PDS and TPC files.

Comments:

- DAQ prefers **(b)**
- I think Offline prefers **(b)**
  - TPC noise filter + signal processing occurs with no PDS info.
  - PDS files maybe need isolated pre-processing?
  - TPC signal output files are then relatively tiny.
  - Can then bring together TPC signal + PDS files as input to flash matching, write out combined TPC signal + PDS flash-matched file.

DAQ Conditions Expectations

Any info from DAQ which is needed for analyzing detector data, besides the detector data itself.[2]



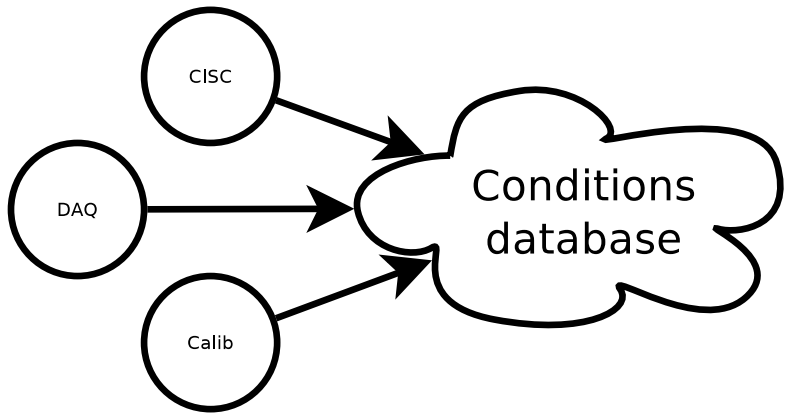
DAQ will export all **DAQ Conditions** to **Offline Conditions DB**.
DAQ will maintain other databases holding a superset, eg

- DAQ (and detector electronics) configuration
- Internal DAQ performance metric monitoring
- DAQ process logging

[2] HSF Community White Paper – Conditions Data, arXiv:1901.05429

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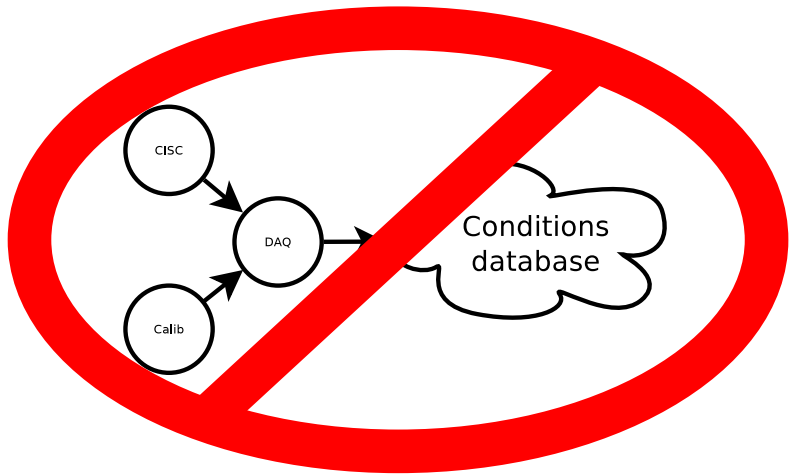
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DAQ expects to be one of several **peers** feeding a CondDB.
DAQ does **not** expect to **proxy** feeds from others.

Summary

- DAQ plan allows to not output in excess of 30 PB/year limit.
- Per-sub-detector file-streams output from DAQ to Offline.
- DAQ will provide feed of just DAQ-related info to Offline Conditions database.