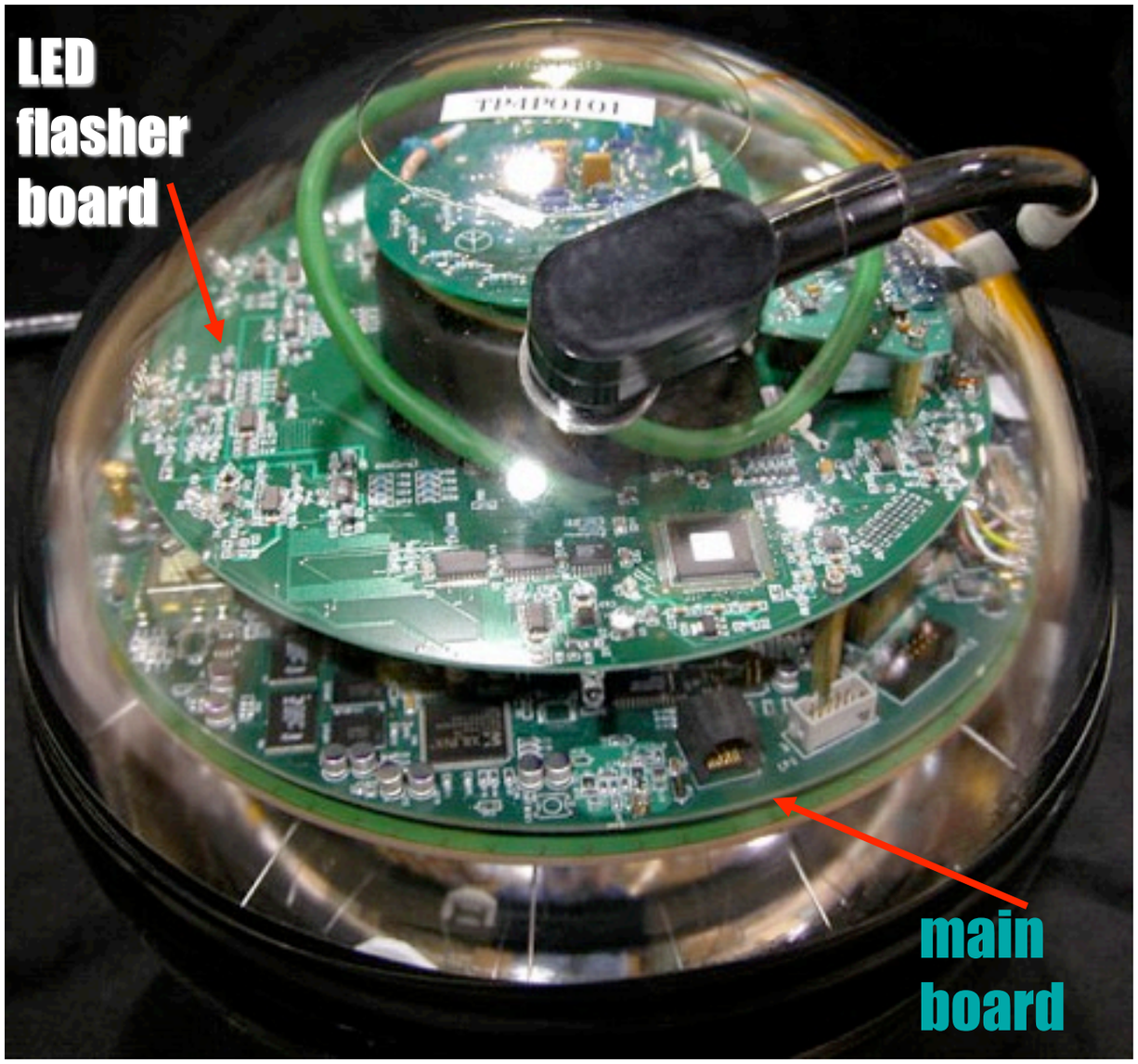
Online Filtering in IceCube

Erik Blaufuss - University of Maryland

MANTS 2009

Digital Optical Module (DOM)

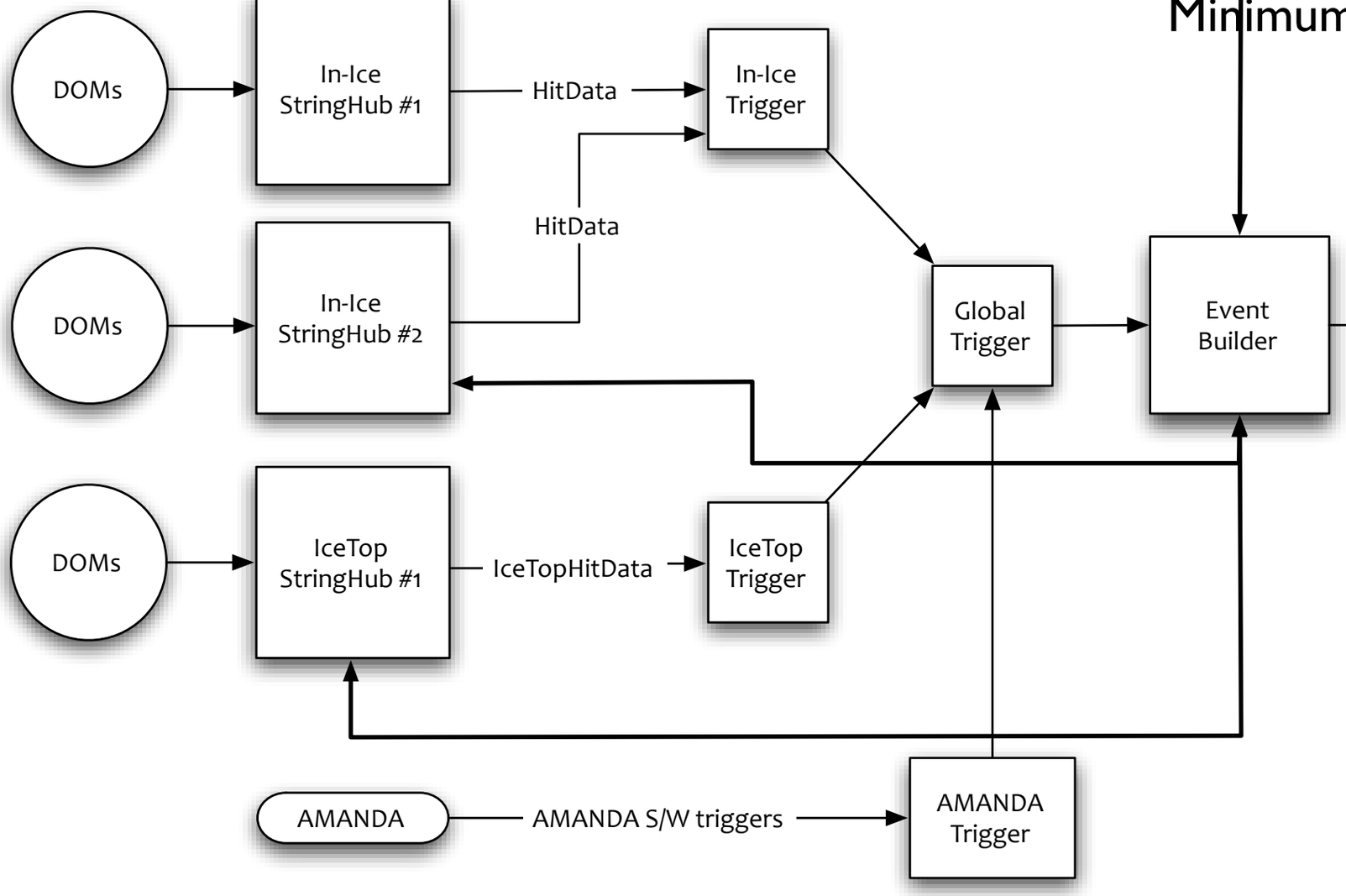


Self triggering with 0.25 pe threshold
Waveform sampling on main board:
    300 MHz for 400 ns ATWD
    40 MHz for 6.4 µsec w/ 'fast' ADC
Digital data packets sent to surface
Time calibration with surface GPS
    with 2 ns resolution
Readouts fall into two types:
    Full waveform readout (HLC)
        -1 of 4 neighbors in coincidence.
        -Used to generate triggers
    Summary readout (SLC)
        - Isolated hits
        - Summary info only (time/amplitude)
        - Not used in triggering

IceCube DAQ

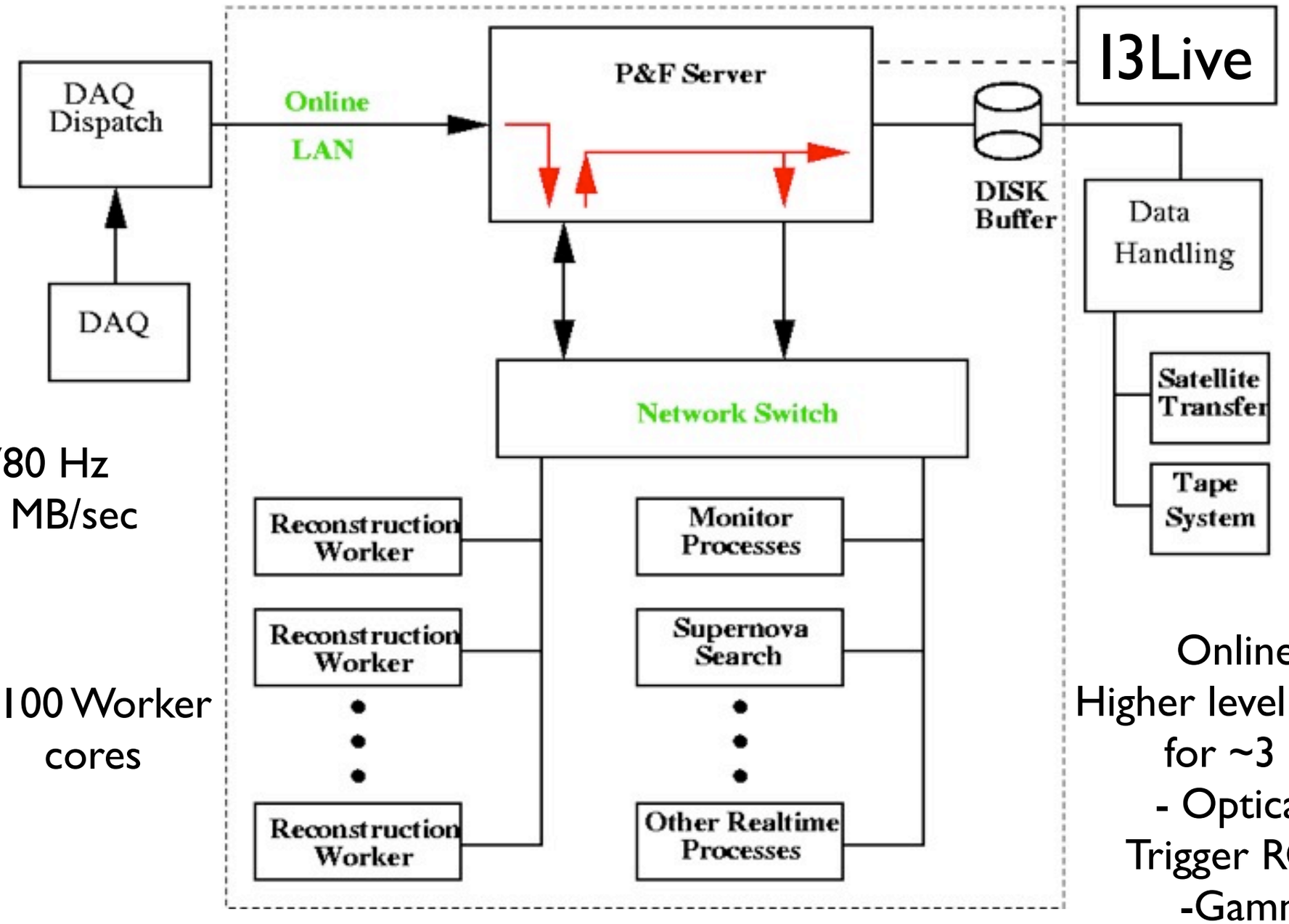
Triggers:
Multiplicity triggers (8 InIce/6 IceTop)
String triggers (5/7 doms all, 3/4 central)
Minimum bias triggers

Each DOM:
~10Hz HLC
~400Hz SLC



Total Rate
for IC59
1780 Hz
~18 MB/sec
(600 GB/day,
gzipped)

Online Processing and Filtering



1780 Hz
~18 MB/sec

~100 Worker cores

TDRS-1
~50 GB/day
Filter selected events + DST

LTO Tape
~700 GB/day
All raw data

Online searches
Higher level reconstruction for ~3 Hz of data
- Optical followup:
Trigger ROTSE (running)
-Gamma followup:
Trigger MAGIC (testing)

Filtering needs

- Neutrino signals are much smaller than background (10^6 or smaller).
- Filters running at South Pole generally try to apply the simplest possible cuts that:
  - Reduce the data just enough to fit over the satellite.
  - Select candidate events using robust as possible cuts
- For IC59, ~90Hz of events (5%) , ~45 GB/day
  - First season we are not using all possible allowance
  - Cost of data in the North (storage/processing)

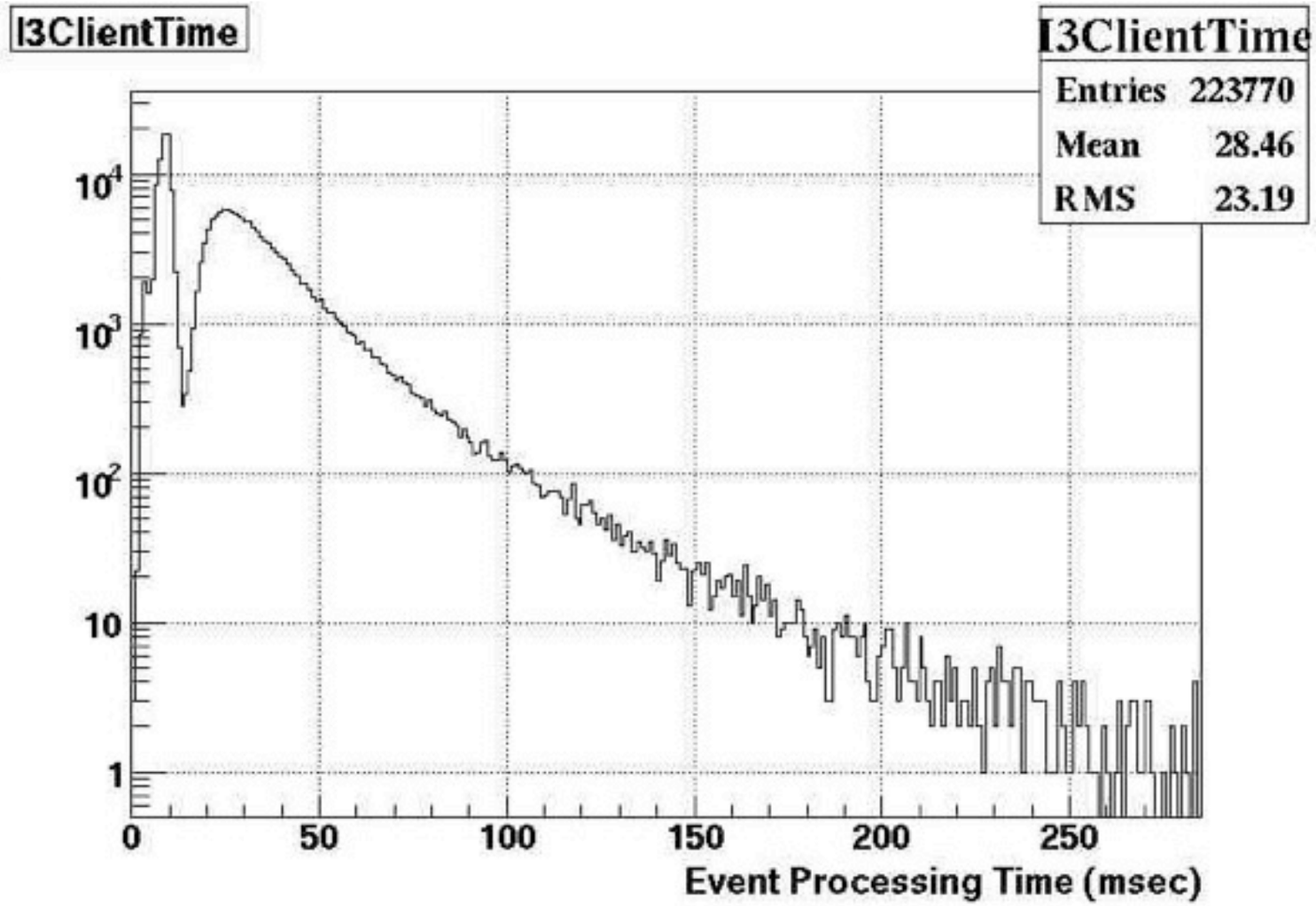
How are filters selected

- IceCube has a Trigger/Filter/Transmission (TFT) board to coordinate:
  - DAQ/Trigger configurations
  - Filter settings
  - Satellite bandwidth allocations
- Physics working groups prepare proposals each year and the TFT:
  - Balances requests with available resources

IC59 Filters

Name in FilterMask	Prescale (1/N)	Summary of event selection
MuonFilter_09	1	Muon Working group filter for I3DAQ events Gulliver LLH
CascadeFilter_09	1	Cascade Working group filter for I3DAQ events using Linefit, TOI and Gulliver LLH
EHEFilter_09	1	EHE filter selection based on Portia total PE value (>=10^2.8 PE)
IceTopSTA3_09	8	Cosmic ray filter, selects events with 3 or more stations, with prescale
IceTopSTA3_InIceSMT_09	3	Cosmic ray filter, selects events with 3 stations && InIce SMT trigger, with prescale
IceTopSTA8_09	1	Cosmic ray filter, selects events with 8 or more stations
InIceSMT_IceTopCoincidence_09	80	Cosmic ray filter, selects events with InIce SMT trigger and any IceTop station hit, with prescale
IceTopSTA8_InIceSMT_09	1	Cosmic ray filter, selects events with 8 or more stations && InIce SMT trigger
DownStarting_09	1	Filter searching for down-going, contained-like events
MoonFilter_09	1	Select down-going events in region around moon location. Only active when moon is sufficiently above the horizon
LowUpFilter_09	1	Filter for low energy upgoing muon tracks
LowEnergyContainedFilter_09	1	Filter for I3DAQ events (SMT and String trigger events), looking for near vertical low energy contained tracks.
DC4Filter_09	75	Filter selecting events on most central 4 of Deep Core strings for studying deep core events.
FilterMinBias_09	600	Filter Mim Bias selection, selects random 1/N events of all events sent to filter system
PhysicsMinBiasTrigger_09	50	Selects events with Physics Min Bias trigger active, prescaled applied in filter as well as in DAQ trigger system
DeepCoreSMTTrigger_09	35	Prescaled selection of the Deep Core SMT3 (from DC7 strings) trigger.
ULEEFilter_09	1	Selects set of ULEE trigger events with 2 or less veto hits.

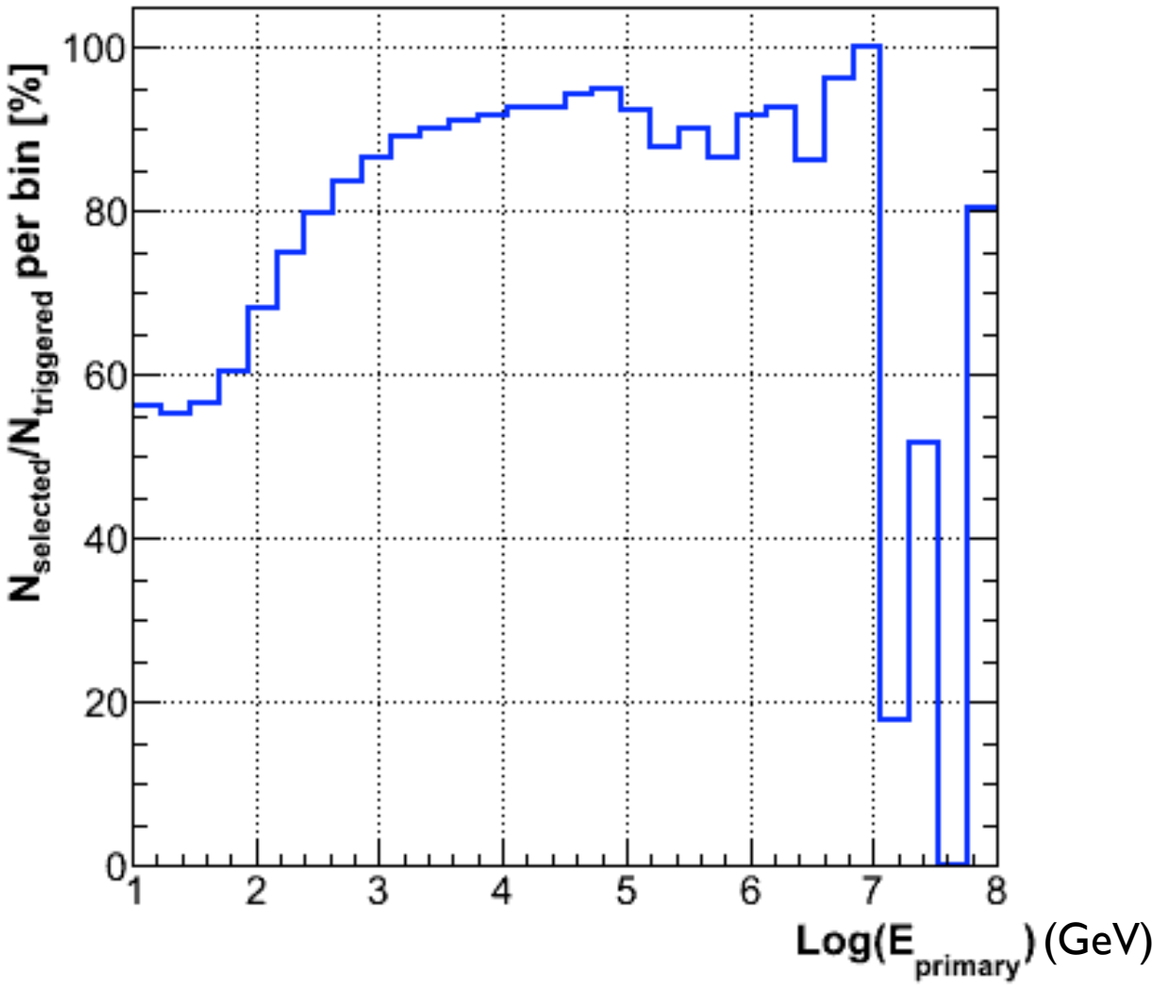
IC59 Filters - CPU needs



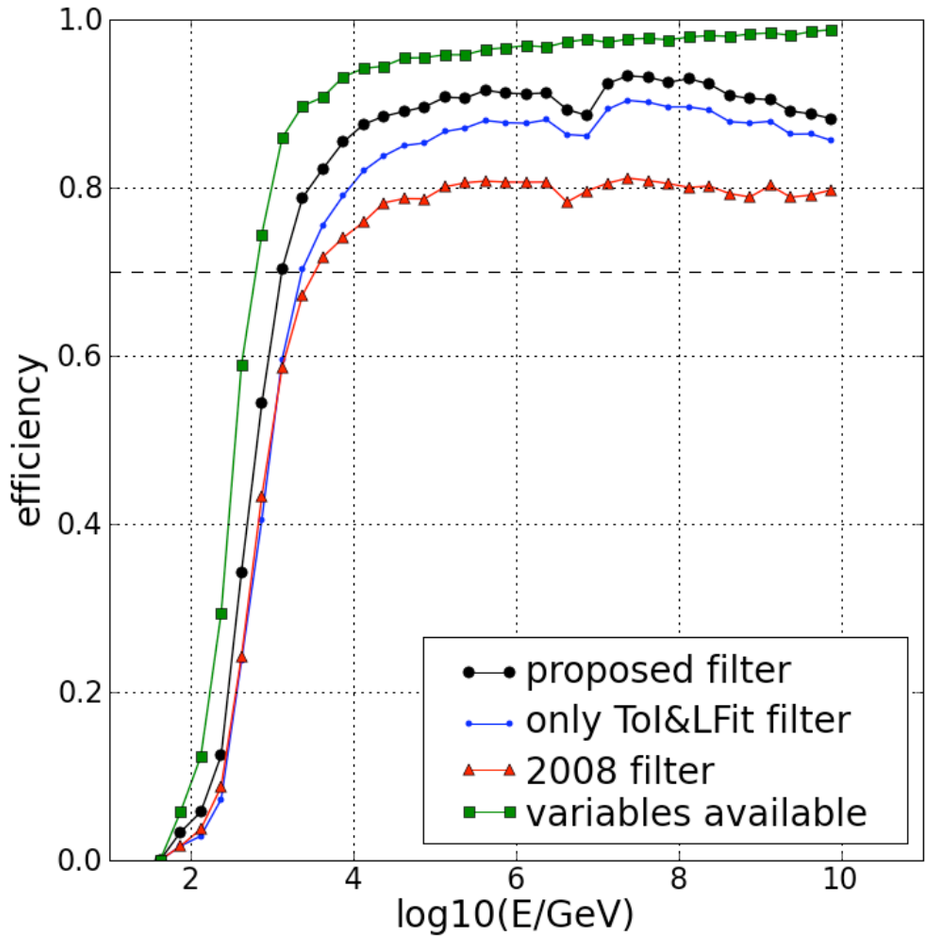
Online Filter CPU usage

Name	Cores to keep up with IC59 trigger rate
Gulliver LLH reco	25
Cascade FeatureExtractor	15
Muon FeatureExtractor	5
I3Moni analysis	3
Online Level 2 reconstructions	3
I3DAQ event decoder	2
I3Portia(EHE)	1
Everthing else (each less than 0.5 cores)	8
Total	62 cores

Example filters



Muon Filter



Cascade Filter

Filtering Challenges

- Large data rates online (18 MB/sec @ IC59)
  - Improved efficiency DAQ data format will help
- Trade off between more specialized, harder cutting filtering online vs. a generic online filter.
  - Online L2 analysis selects almost all of final point-source sample neutrinos.
    - Harder cuts would make things less generic
- Limited contact with online systems due to remote location, difficult connection
  - Well developed testing system at UW
- Leave filters for a single season as constant as possible
  - Bugs, improvements in algorithms push the other way