Data Quality Vetoes for High-mass Compact Binary Coalescences in LIGO's 5th Science Run

JUN-QI GUO

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Department of Physics and Astronomy
The University of Mississippi

LIGO Scientific Collaboration
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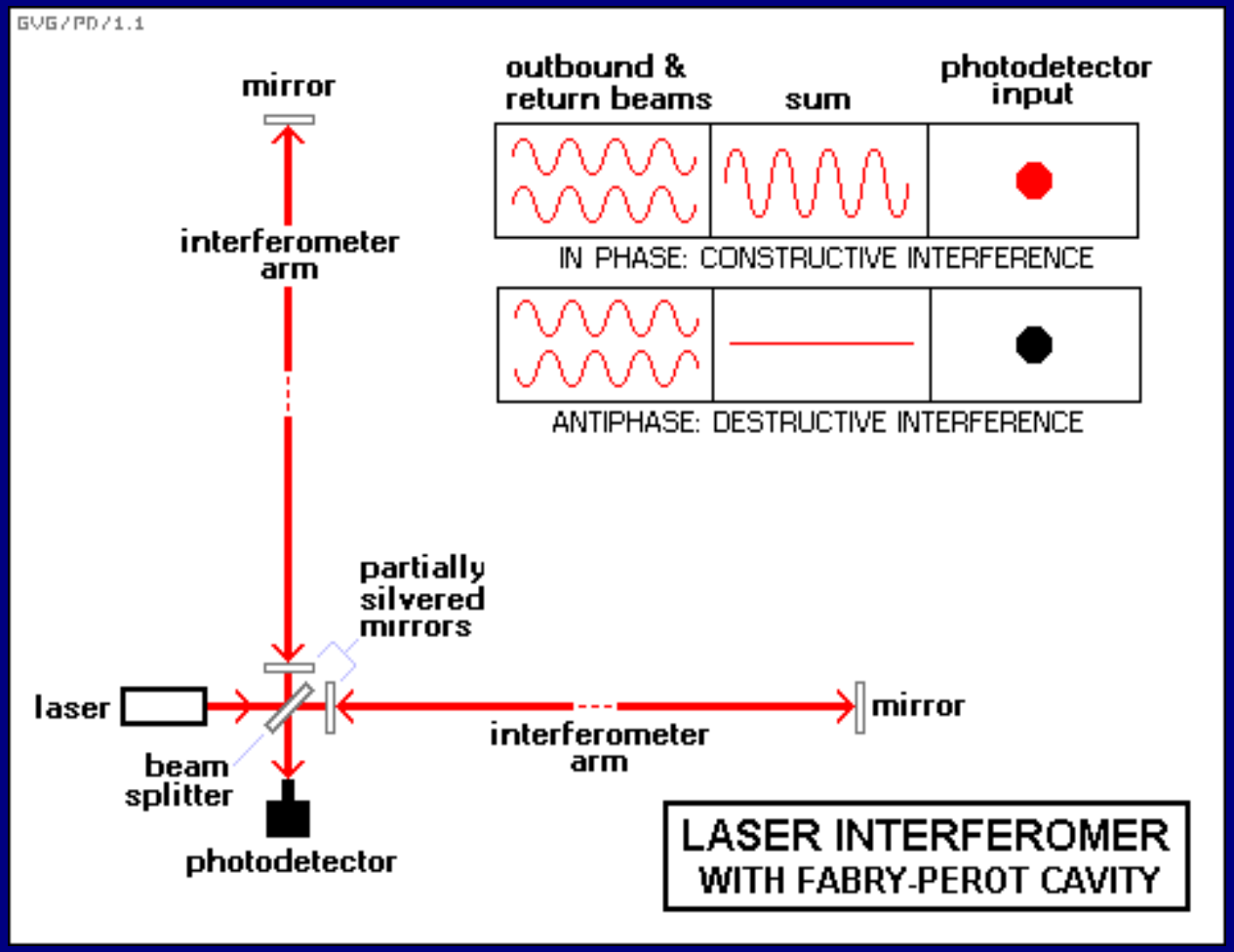
Introduction



What's measured is $\Delta L = hL$, or $\Delta\Phi \sim \Delta L/\lambda$

Sources of gravitational waves

- Coalescing binary neutron stars or black holes
- Spinning neutron stars
- Gravitational bursts (e.g. supernovae)
- Stochastic cosmological background from Big Bang

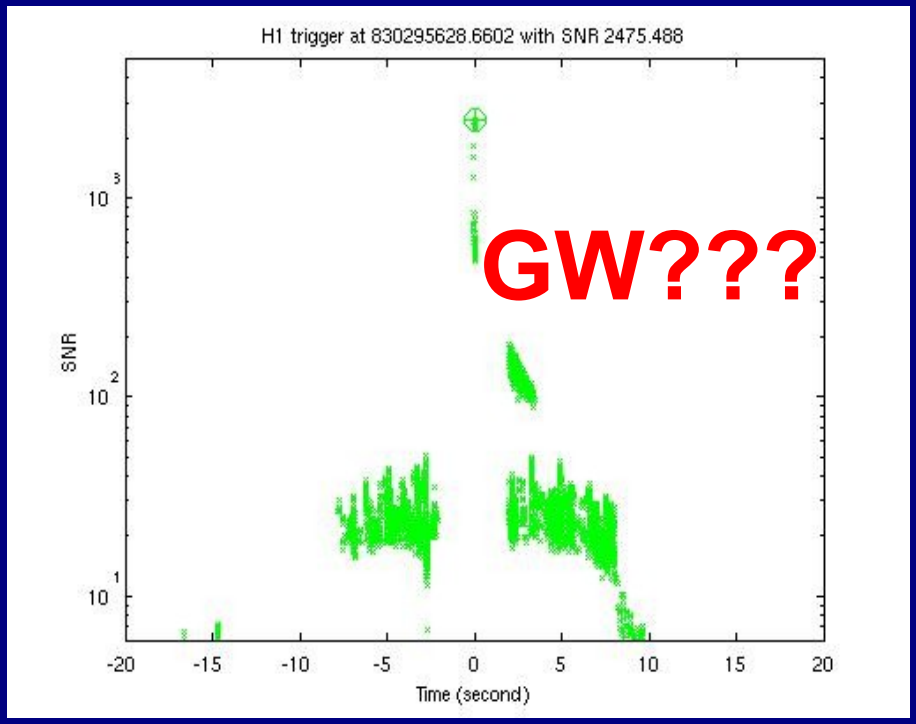
Matched Filtering

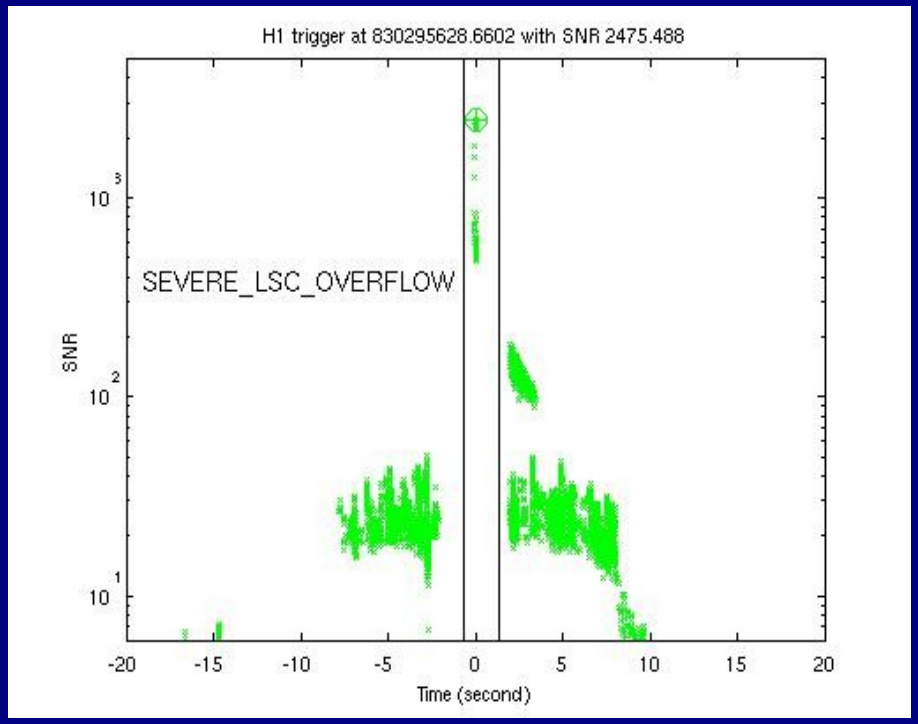
For binary neutron star/black hole inspirals

- h(t): template waveform
  $S_n(f)$: noise power spectral density
  s(t): detector output

- **Template bank:** Template waveforms parametrized by m_1 , m_2 --masses of the compact objects,etc.

- **Trigger:** significant correlation between s(t) and h(t); *signal-to-noise ratio* (SNR), parameters...

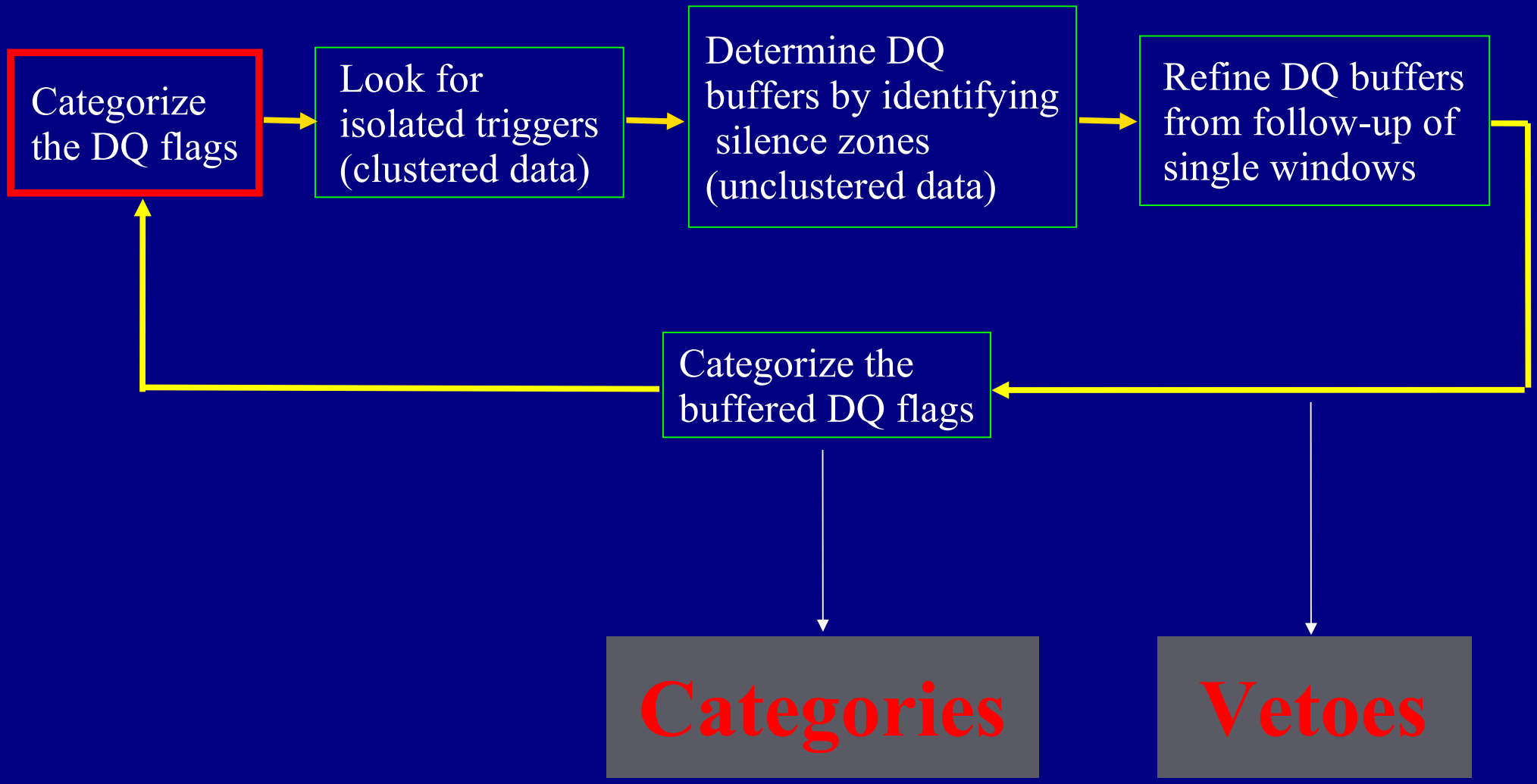




LSC: Length Sensing and Control system

Data Quality flag: when we can identify the source of a non-gravitational disturbance, we ***flag*** the time period.

Diagram of DQ tuning procedure



Step 1: Categorize the DQ flags

- Category 1 is based on whether or not the interferometer is in Science Mode.
- Category 2 includes times when known instrumental effects cause false alarms
- Category 3 includes veto flags with statistically significant correlations but more signal based, with less clearly explained mechanisms
- Category 4 covers suspect times without clear physical or statistical correlation to inspiral triggers, but still times where data is suspect in some way

Categorize the DQ flags for high-mass search

- **Low mass:**
  component mass: 1-34 Mʘ; Maximum total mass: 35 Mʘ.

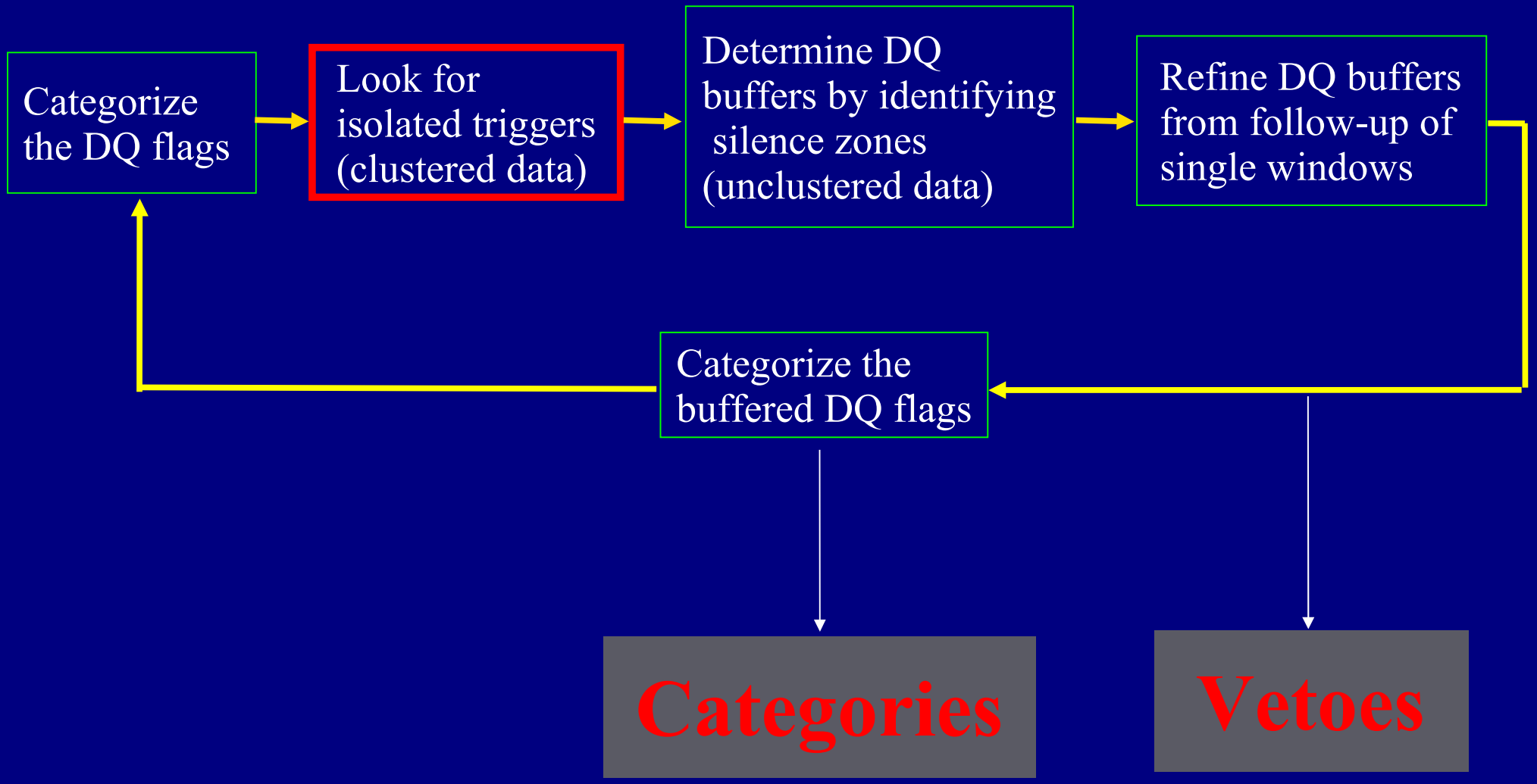
- **High mass:**
  component mass: 1-99 Mʘ; Maximum total mass: 25-100 Mʘ.

  (Refer to: Drew Keppel: http://www.ligo.caltech.edu/docs/G/G070820-00.pdf)

- **Similar criteria** to those used in the low-mass search by Jake Slutsky, Gabriela Gonzalez (LSU) and Laura Cadonati (U of Mass. Amherst).

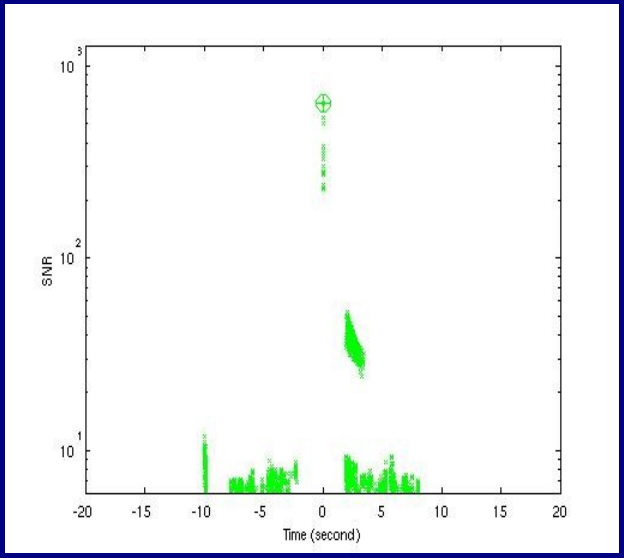
- **Categorization**: consider the veto "quality" of the available flags, e.g. the correlation between DQ flags and the clustered triggers etc.

Diagram of DQ tuning procedure



Step 2: Look for isolated triggers (clustered data)

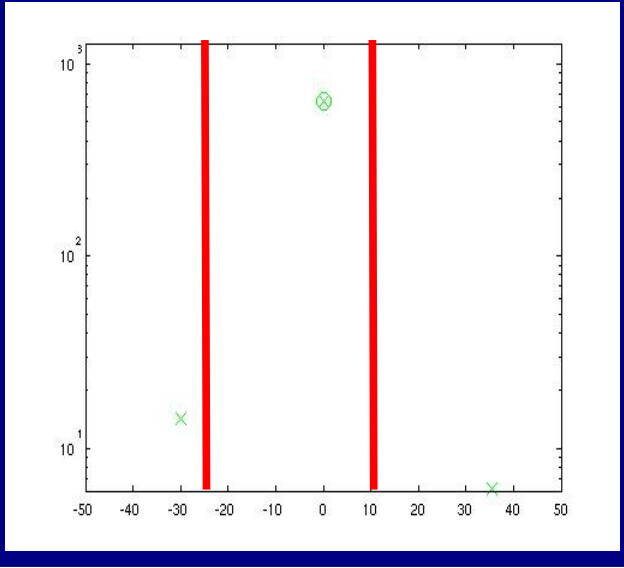
unclustered data:

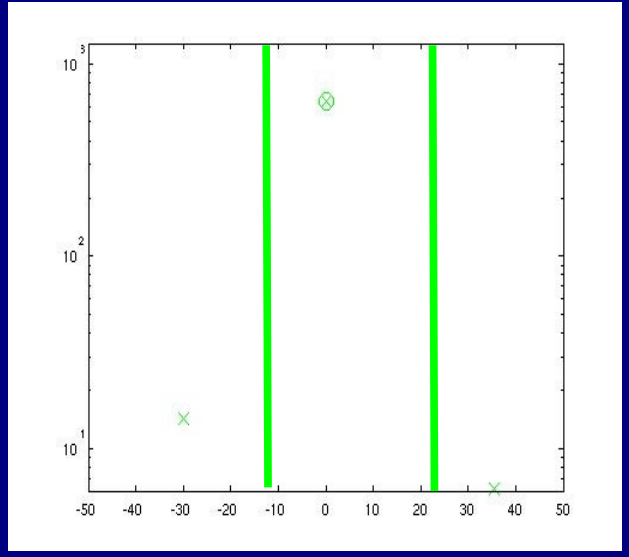


DQ flag 1

DQ flag 2

clustered data:





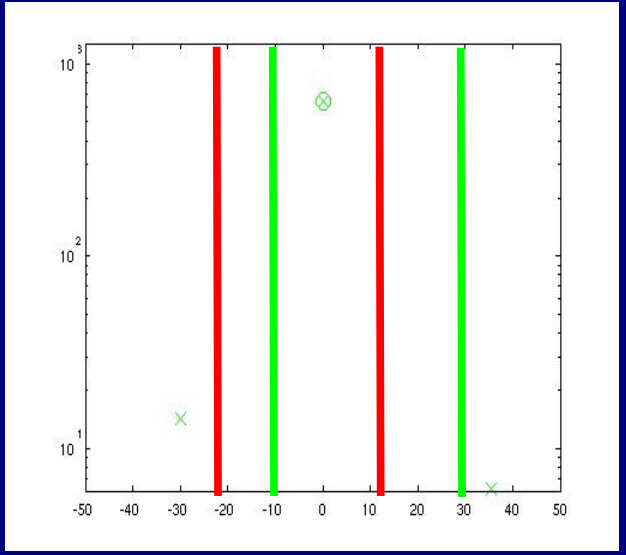
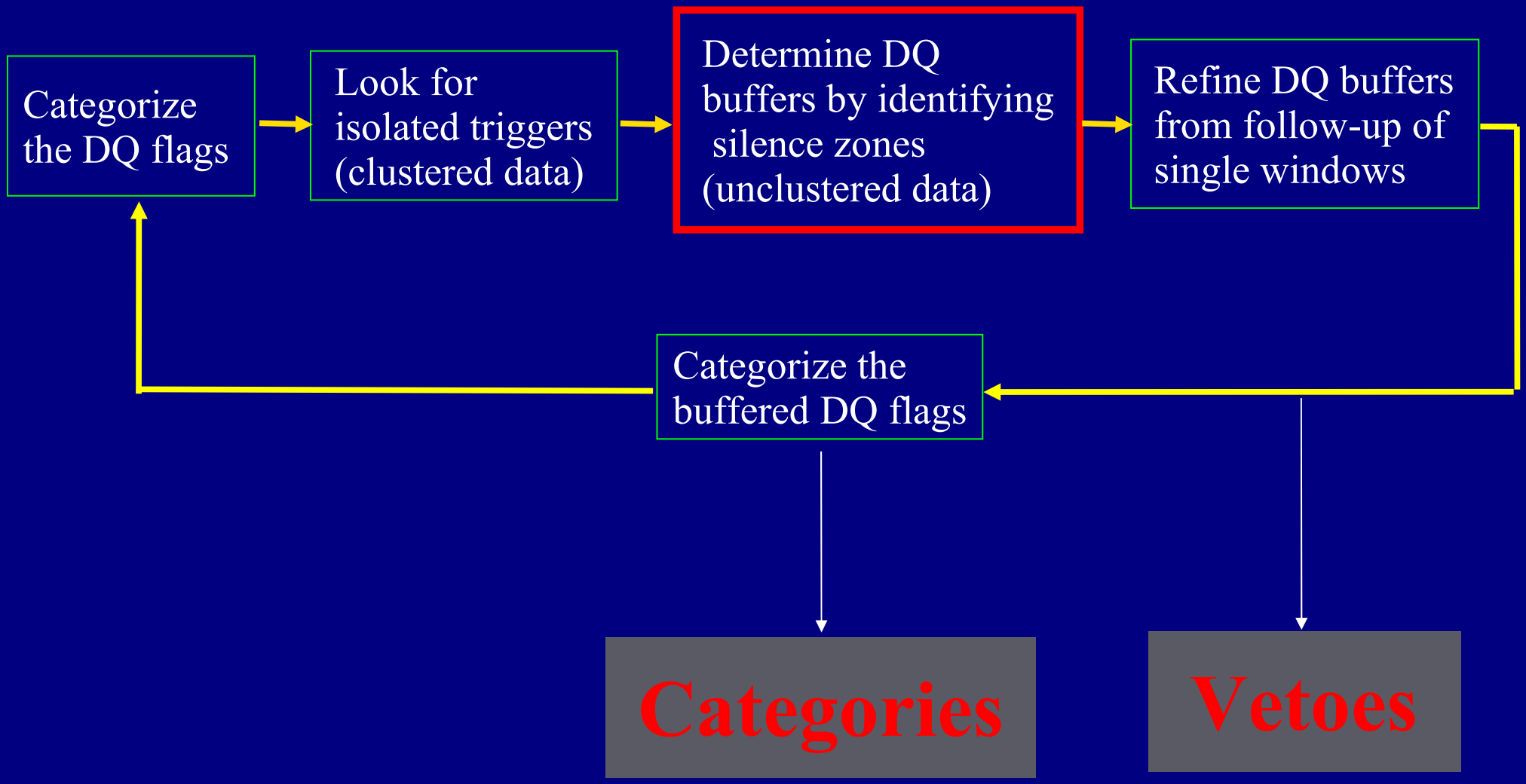
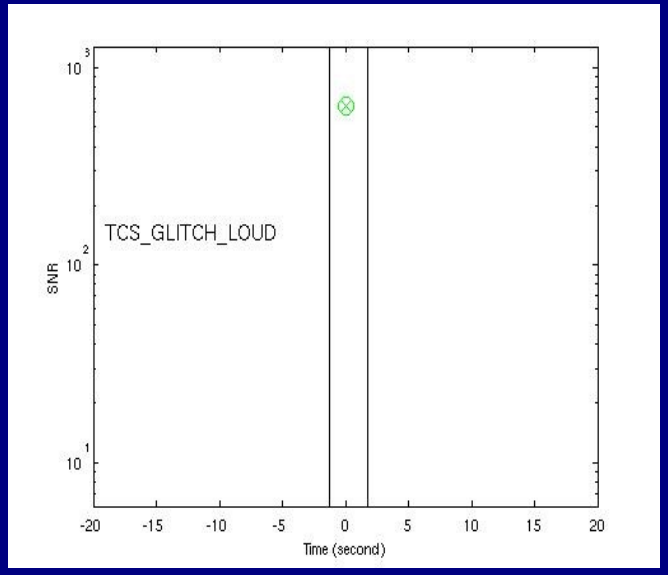


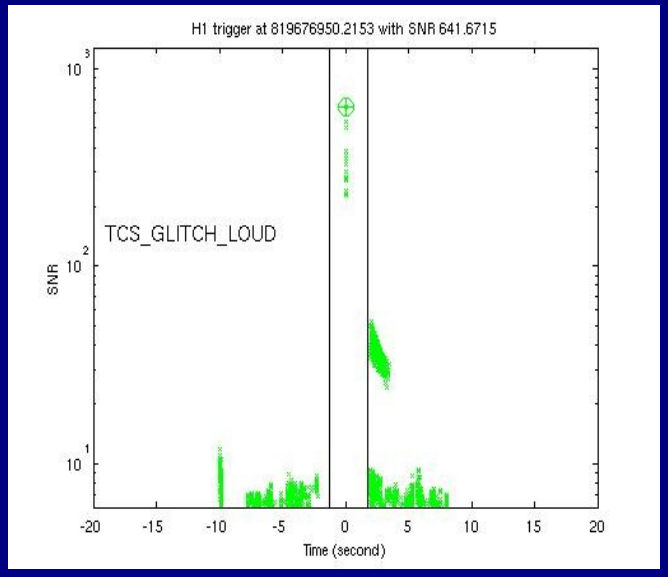
Diagram of DQ tuning procedure

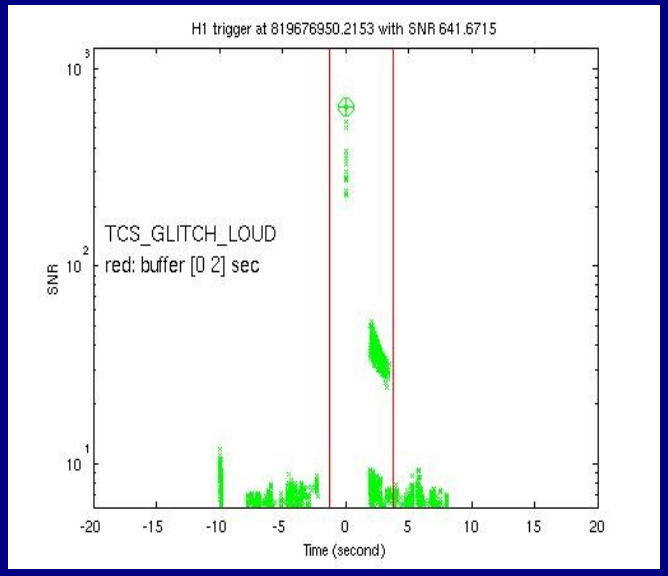


Step 3: Determine DQ buffers by identifying silencezones

- Identify the isolated triggers **in unclustered data**.
- Refine the windows by looking at the silence zone on left and right sides of the windows.
- **Silence zone:** time intervals where SNR remains below a tuning-threshold.

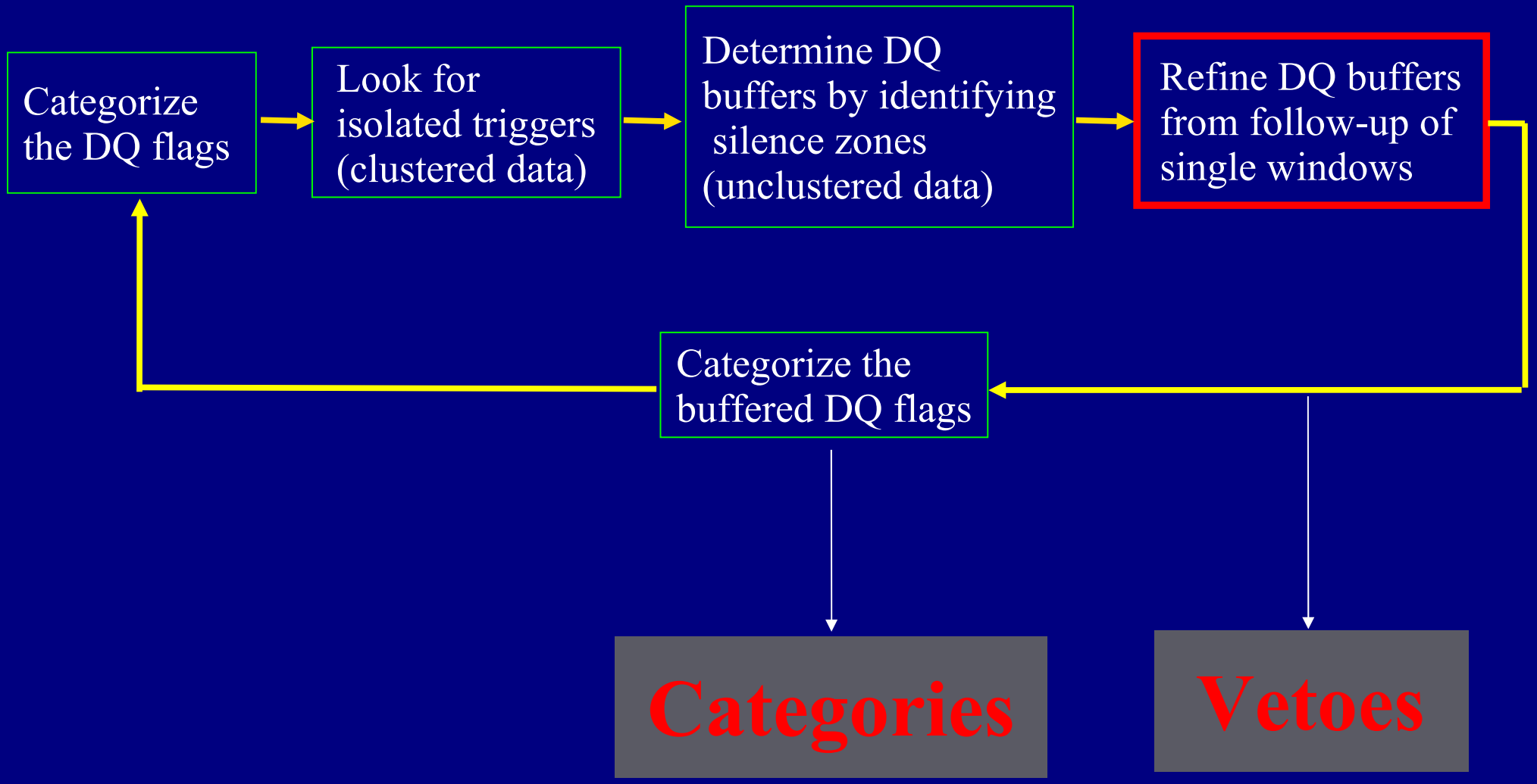






TCS: Thermal Compensation System

Diagram of DQ tuning procedure



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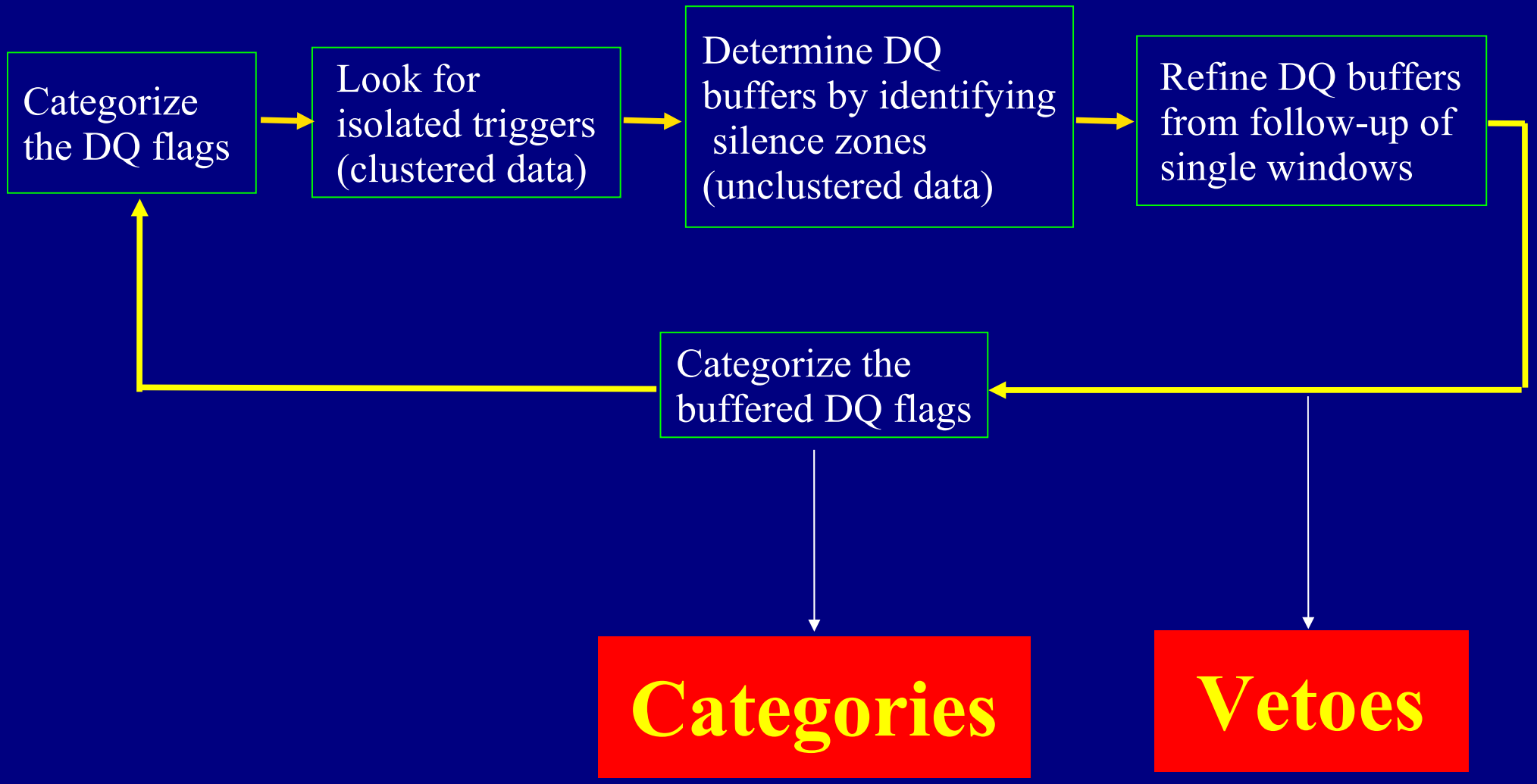

Summary

1. Searches for gravitational waves in data are hindered by the presence of non-Gaussian noise, which produces false alarms.

2. The identification and removal of these noise transients greatly reduces the false alarm rate, lowering the background for detection likelihood.

3. A well-established procedure for the identification of DQ flags is implemented.