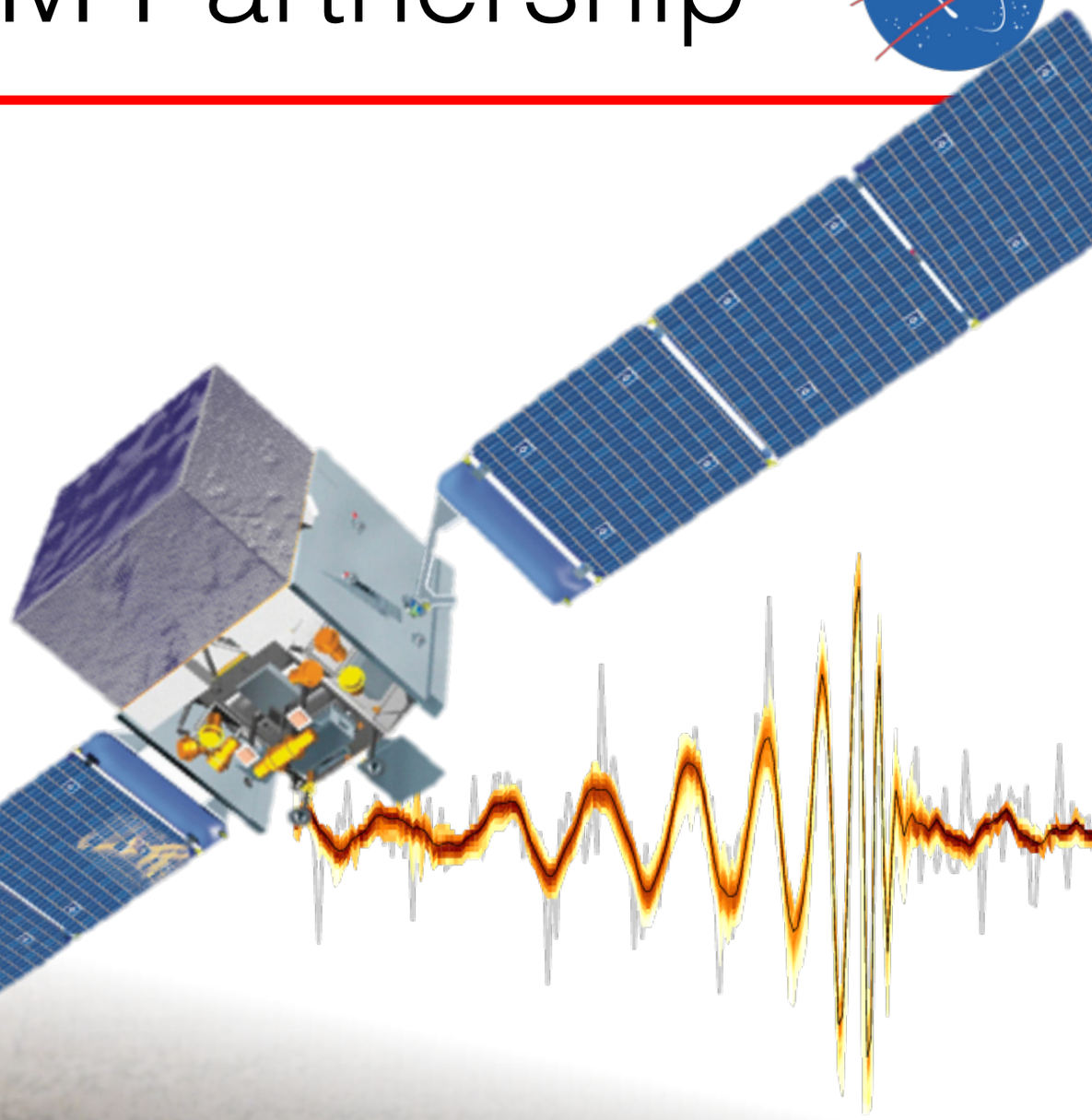
Searching for EM Signals Coincident with aLIGO GW Candidates using the *Fermi* GBM

Tyson B. Littenberg (NASA/MSFC)
on behalf of the
Fermi GBM Team, LIGO Scientific Collaboration, and Virgo Scientific Collaboration

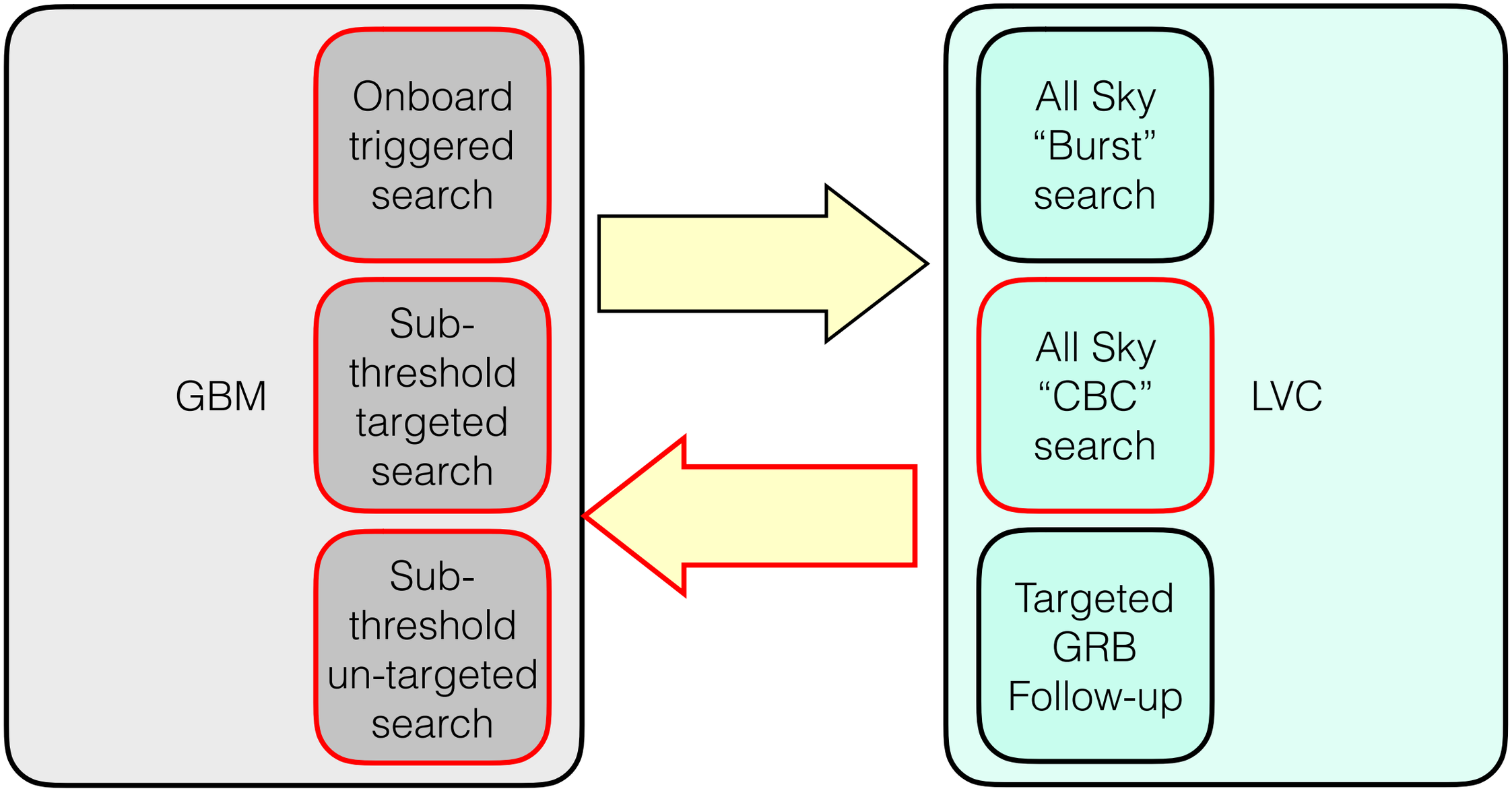
LIGO/Virgo & *Fermi* GBM Partnership

- GBM & LVC have a unique data-sharing agreement
  - GBM receives GW candidates in low-latency for GRB follow-up
  - GBM provides sub-threshold GRBs to LVC for GW follow-up



LIGO/Virgo & *Fermi* GBM Partnership

This report focuses on searching for GBM counterparts to CBC triggers.



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The GBM+LVC follow-up searches

- During O1
  - GBM searched for offline CBC triggers in archival data and received “EM Alerts” for low-latency analysis
    - GW Offline Analysis:
      - Combine GstLAL & PyCBC coincidences
      - Use best calibration at the time (not final, but little difference in triggers)
    - GBM Analysis
      - Search for contemporaneous *triggered* and *un-targeted* GRBs
      - Use trigger time to seed *sub-threshold targeted* GBM search

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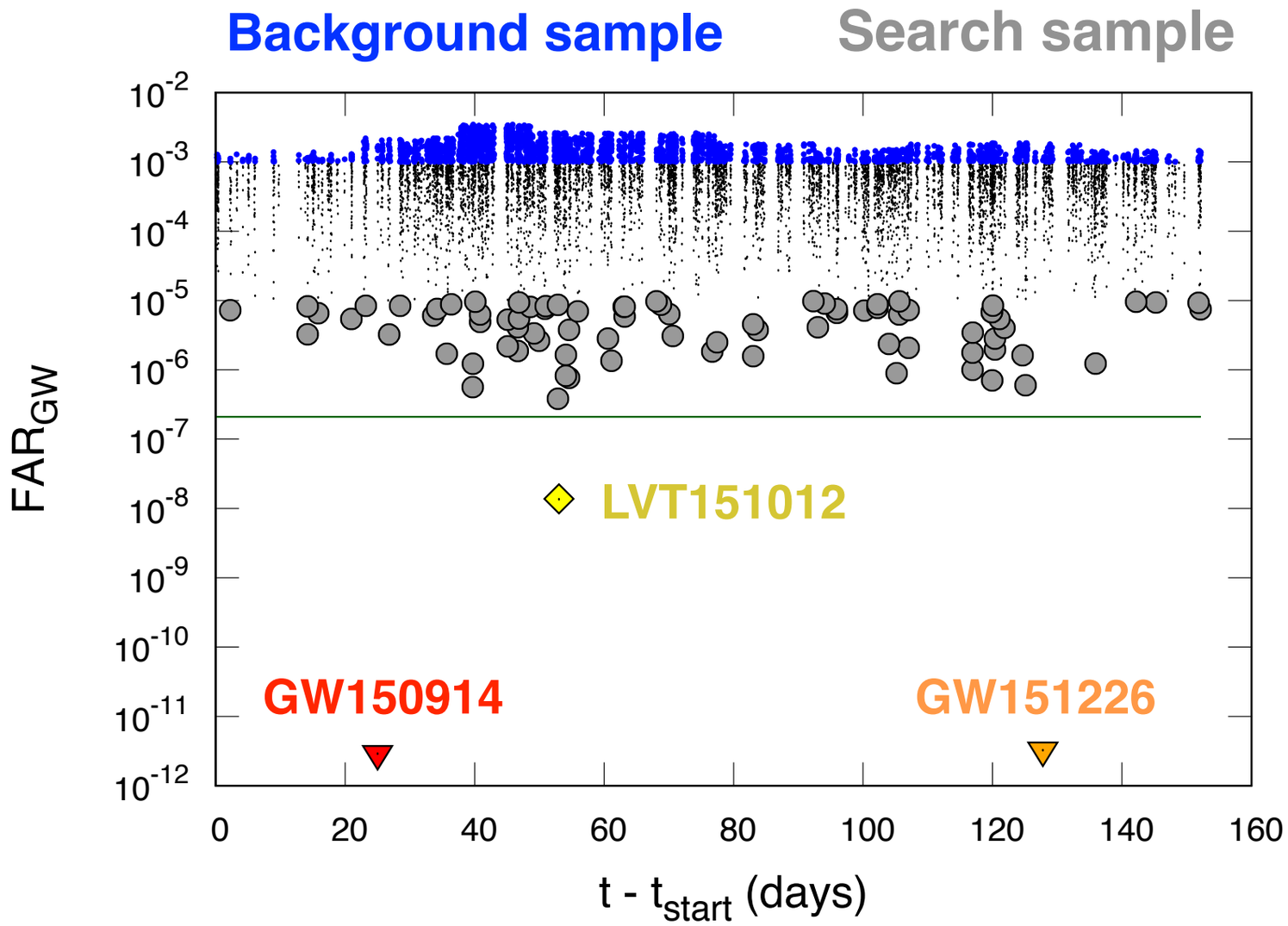
O1 analysis

All results are still under review by LVC & GBM

Selecting GW triggers

PRELIMINARY

- PyCBC & GstLAL offline using best calibration available at the time
- Search sample: FAR < ~1/day
- Background sample: FAR > ~1/15min
- Triggers combined into superset.
  - For overlapping triggers higher FAR discarded



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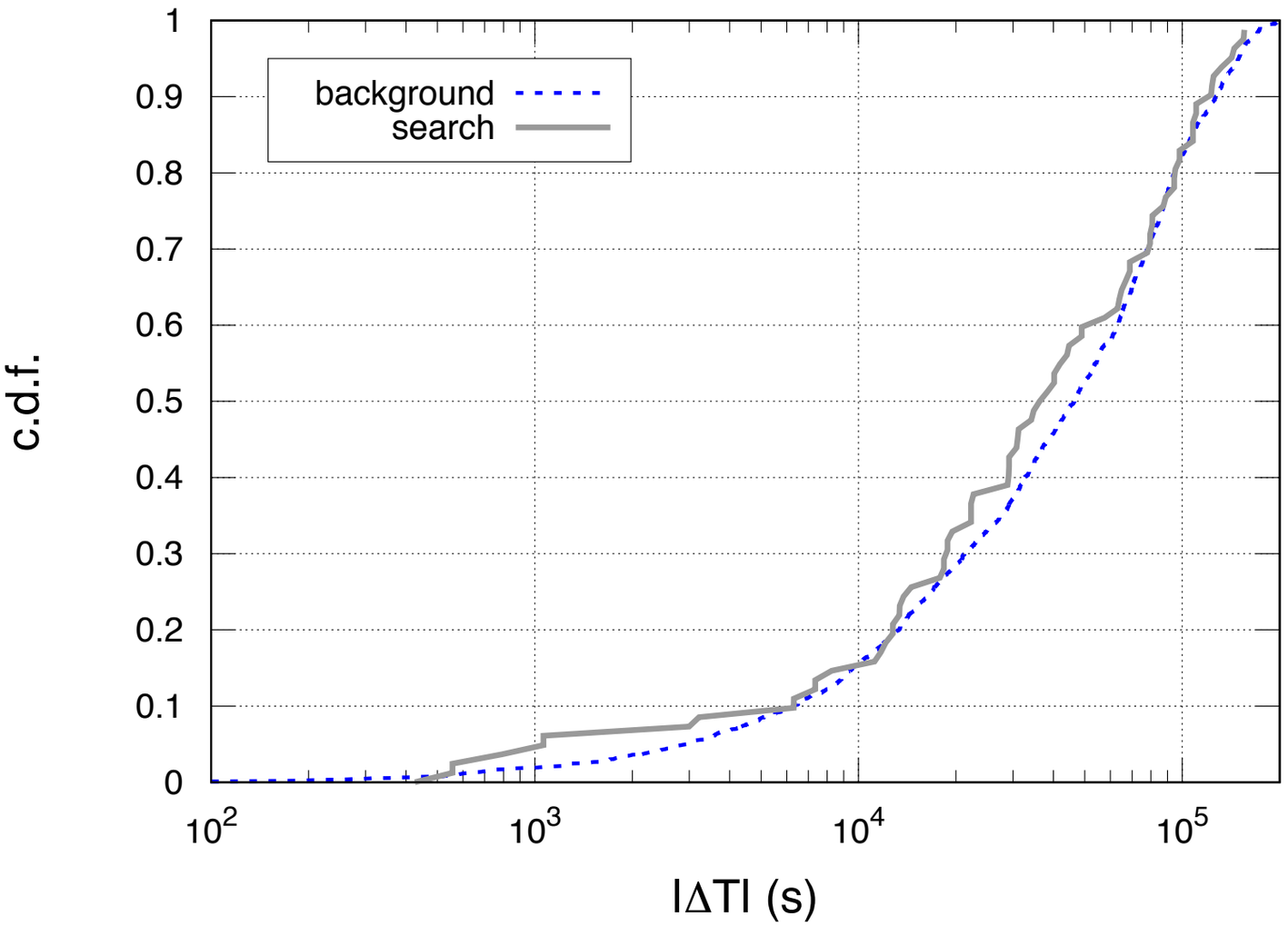
Search for coincident GBM triggers

PRELIMINARY

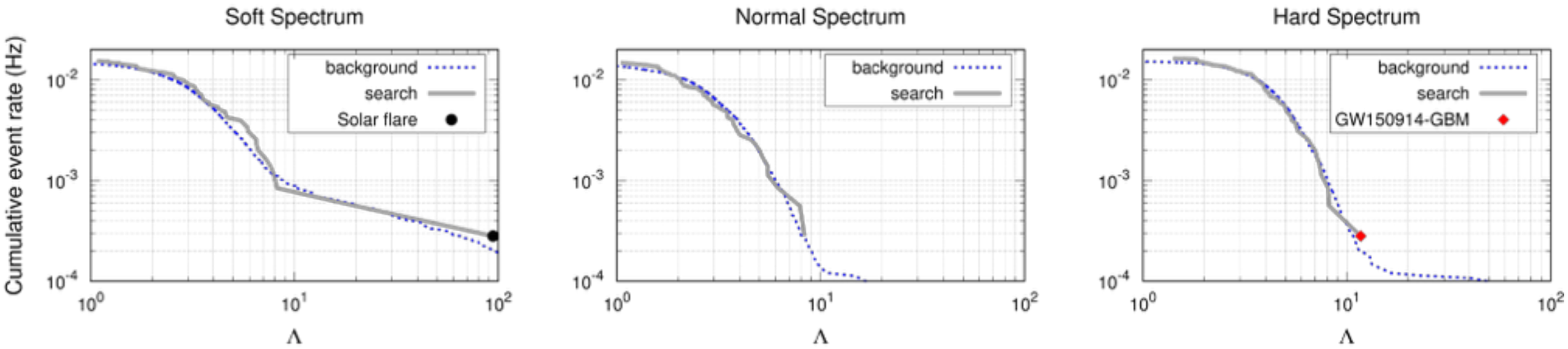
- Find time offset between each GRB found by GBM and it's nearest CBC trigger
- No discernible difference between background and search
- 90% of samples (bkgd and search) had offsets > +/- 10^4 s with nearest triggered GRB
- No candidates from search sample occurred within O(100) seconds of a triggered GRB



Targeted search (GBM sub-threshold events)

PRELIMINARY

- Search algorithm developed by L. Blackburn et al
  [Astrophys.J.Suppl. 217 (2015) no.1, 8]
- Search performed over 3 template spectra: “soft,” “normal,” and “hard”
- GW150914 seed produces most significant search result w/ FAR~2×10^{-4} Hz.
  [Astrophys.J. 826 (2016) no.1, L6]
- 2nd lowest FAR is chance coincidence with solar flare



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Combining targeted-search results

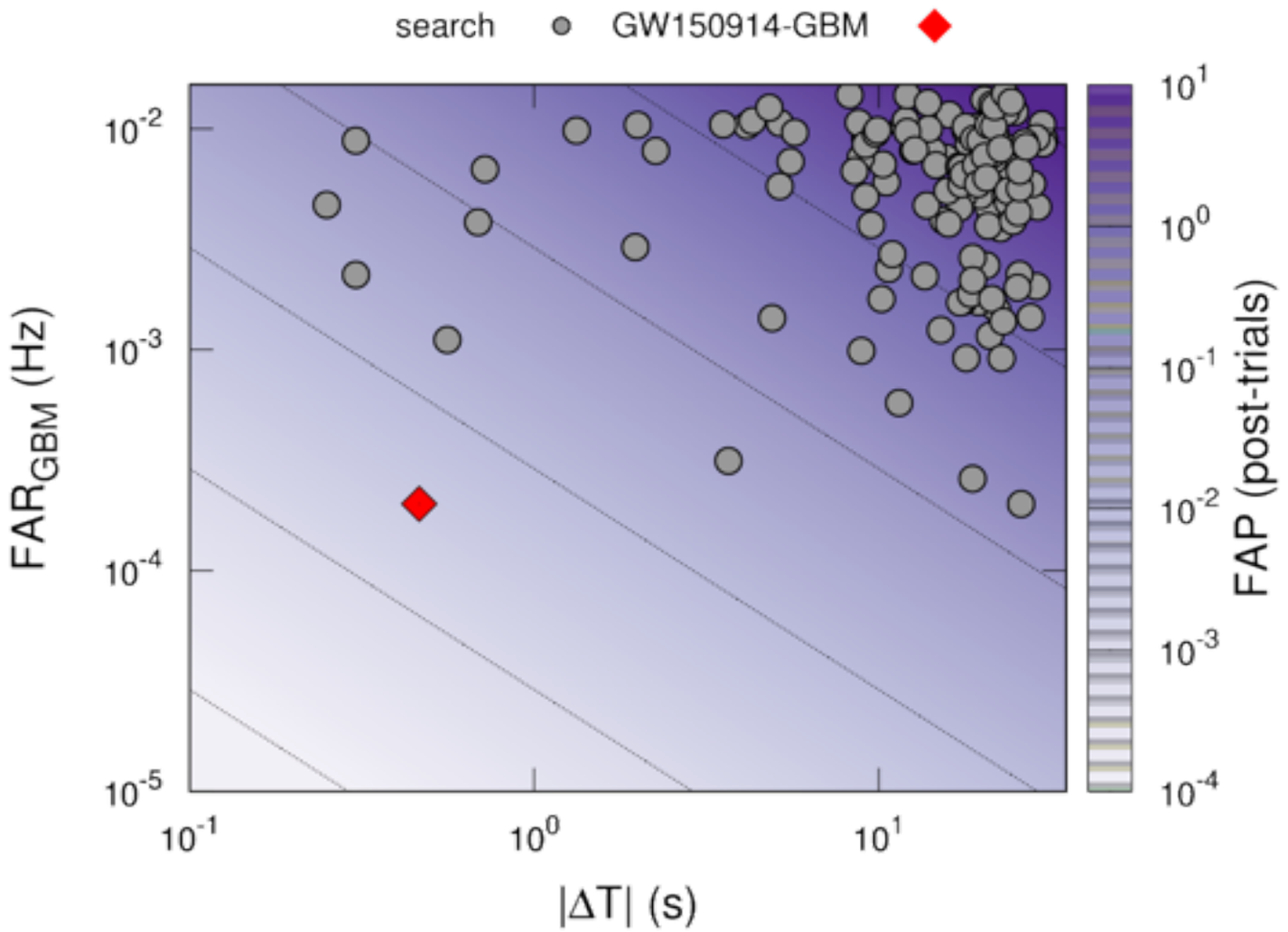
PRELIMINARY

- Computing False Alarm Probability [Astrophys.J. 826 (2016) no.1, L6]:

- GBM transient found in follow-up of GW150914 has lowest FAP of combined search (~2×10^{-3})

- GW150914-GBM significance is too low to declare an unambiguous EM counterpart. More observations are needed to reach a sound conclusion.

- No other candidates had FAR< 1/100



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LIGO/Virgo & *Fermi* GBM Partnership

- New in O2 [Goldstein et al, arXiv:1612.02395]
  - Low latency, autonomous, *sub-threshold targeted* GBM search for CBC online triggers
  - Manual follow-up of significant “burst” candidates.
  - LVC receives sub threshold GBM candidates from “un-targeted” search.