

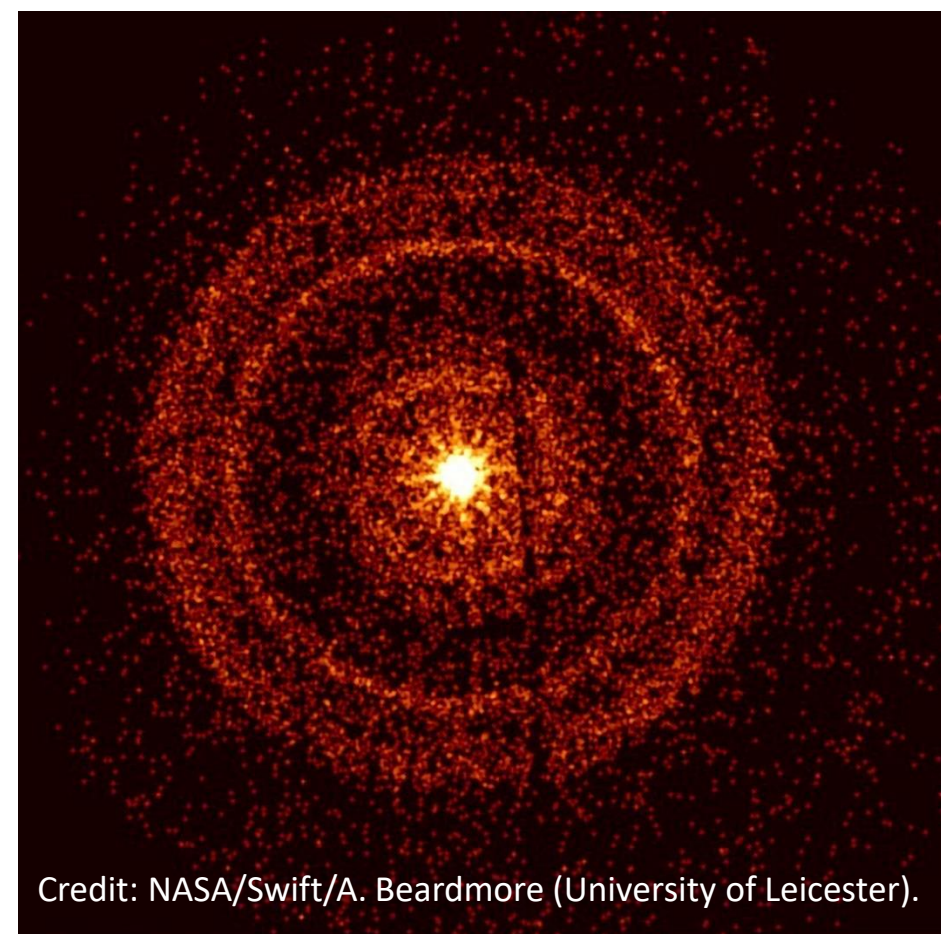
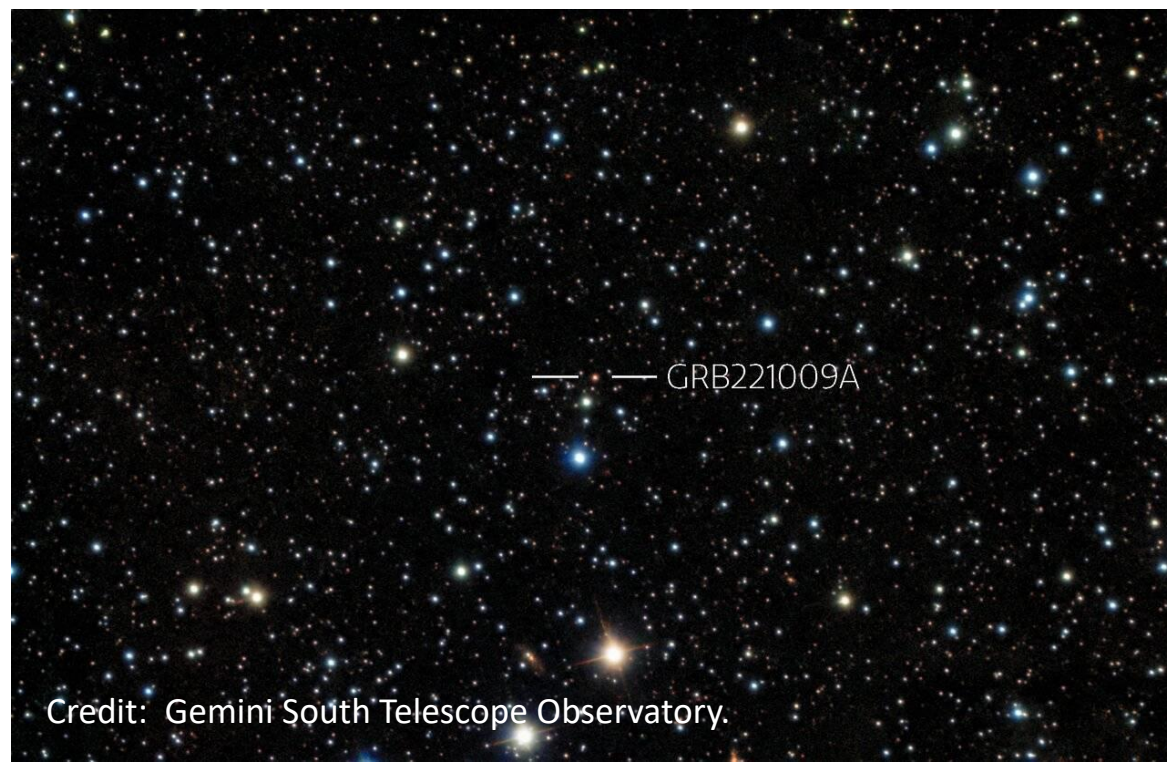
SEARCH FOR NEUTRINOS EVENTS COINCIDENT WITH GRB 221009A IN SK

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INTRODUCTION

On October 9, 2022, a gamma ray burst GRB 221009A was observed by several observatories. This is one of the closest and most luminous gamma ray bursts, and is also the first time to detect photons above 10 TeV from a gamma ray burst.



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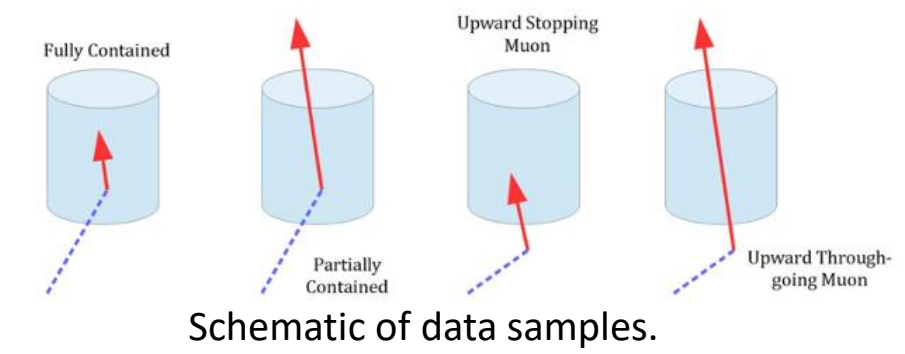
OBSERVATION

- Swift-BAT:
 - Trigger time = 2022/10/09 14:10:17 UTC
 - T90 = 1068.4s
- Fermi-GBM:
 - Trigger time = 2022/10/09 13:16:59 UTC
 - T90 = 325.8s
- LHASO:
 - Photos above 10 TeV observed.
- IceCube:
 - No significant neutrino emission was observed.

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DATA SAMPLE

- Using high energy neutrino data above 30 MeV in SK:
 - Fully contained: > 0.03 GeV
 - Partially contained: > 0.35 GeV
 - Upward-going muon: > 1.6 GeV



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RESULTS

$$-500 \text{ s} < t - t_0 < +500 \text{ s}$$

	FC	PC
Observed	0	0
Expected	0.10	6.0×10^{-3}
p value	100%	100%
N90	2.3	2.3

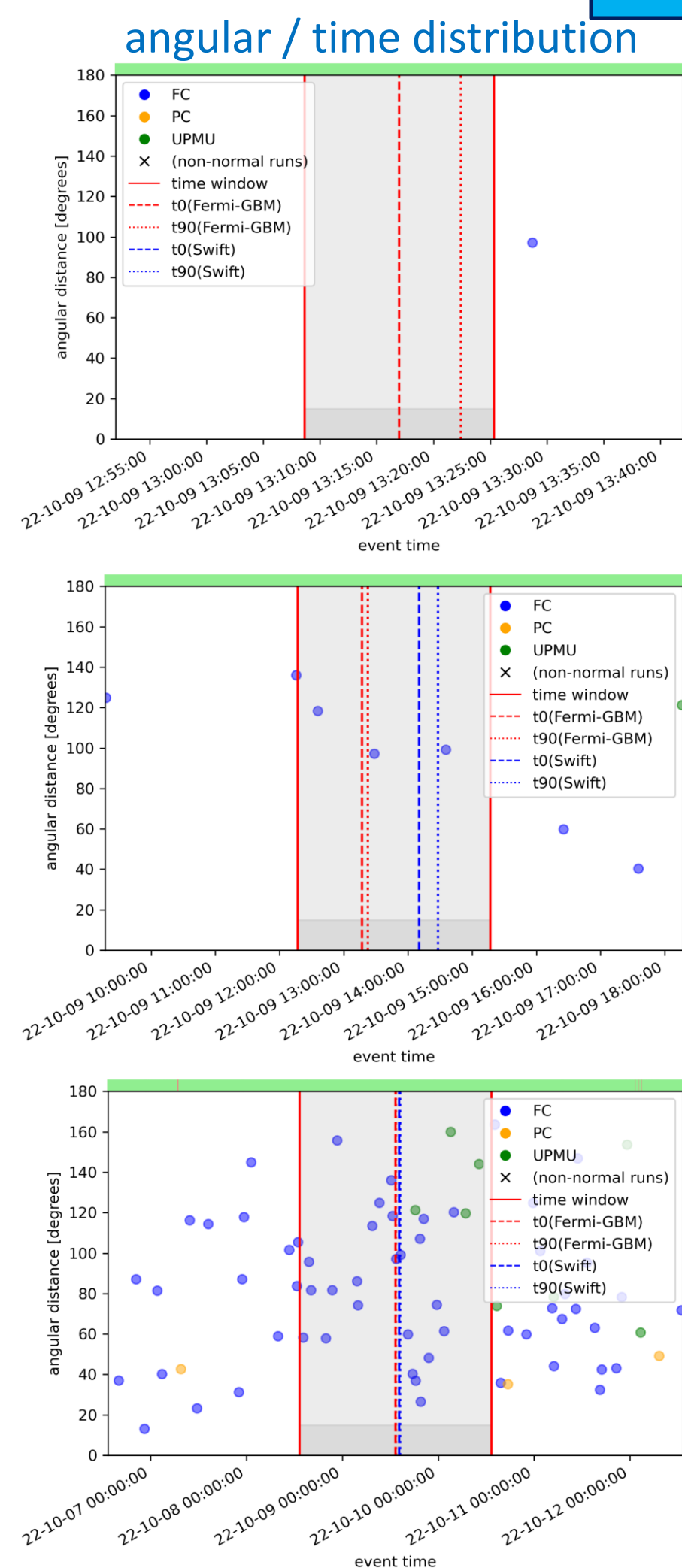
$$-1 \text{ h} < t - t_0 < +2 \text{ h}$$

	FC	PC
Observed	3	0
Expected	1.1	6.5×10^{-2}
p value	10.4%	100%
N90	5.6	2.3

$$-1 \text{ d} < t - t_0 < +1 \text{ d}$$

	FC	PC	UPMU
Observed	24	0	0
Expected	17.9	1.0	0.01
p value	9.8%	100%	100%
N90	13.7	2.3	2.3

- ◆ GRB 221009A is out of UPMU sensitive region during time window[-500s, +500s] and [-1h, +2h].
- ◆ Number of expected background events was estimated using off-time data.
- ◆ According to p value no significant neutrino emission excess against background was found, thus number of signal event upper limit was set.



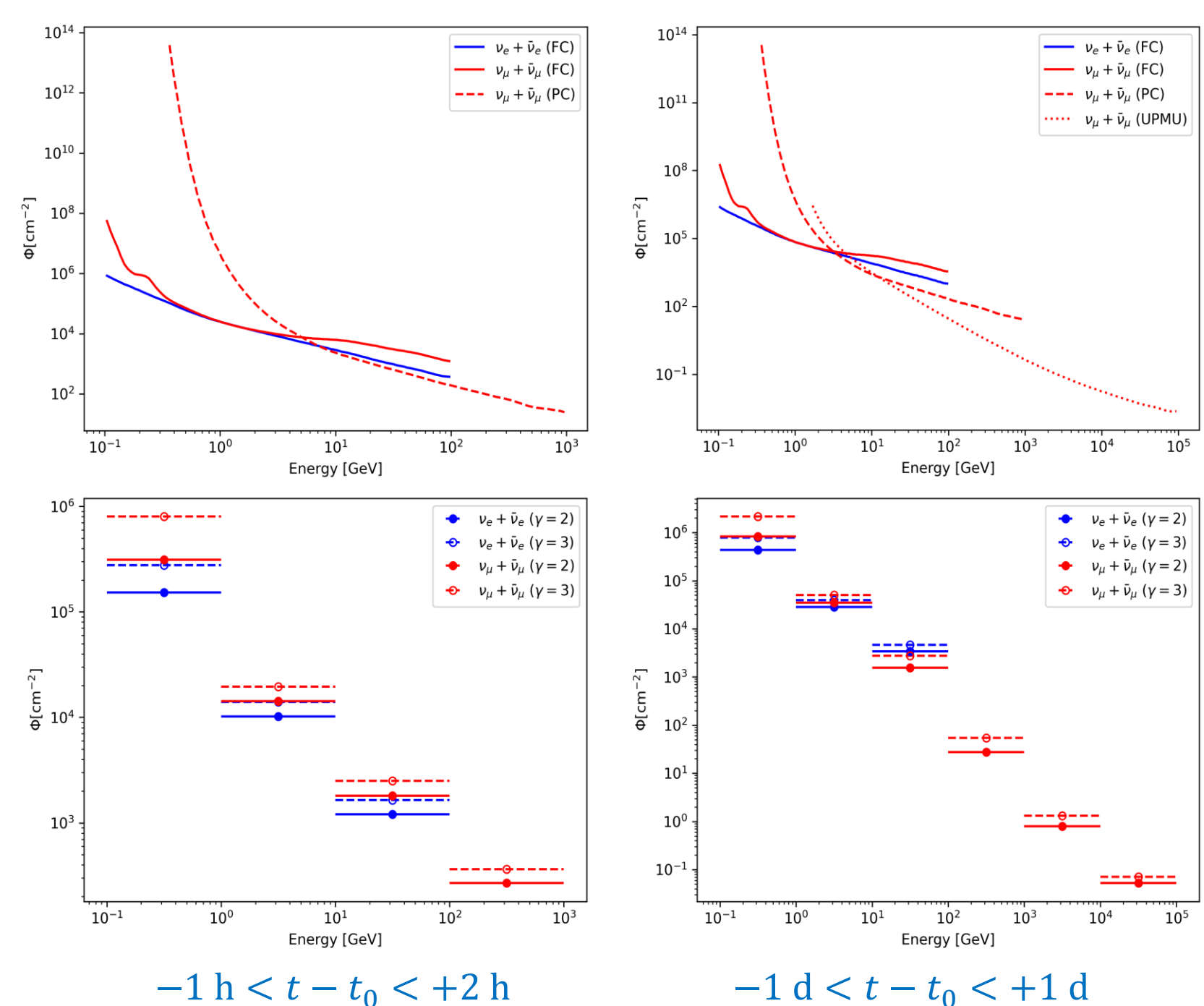
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SEARCH TIME WINDOW

- Center of time (t_0) chosen as trigger time of Fermi-GBM.
 - +/- 500s (Normal GRB search time window)
 - +2h/-1h (Consistent with IceCube search)
 - +/-1d (Extended search time window)

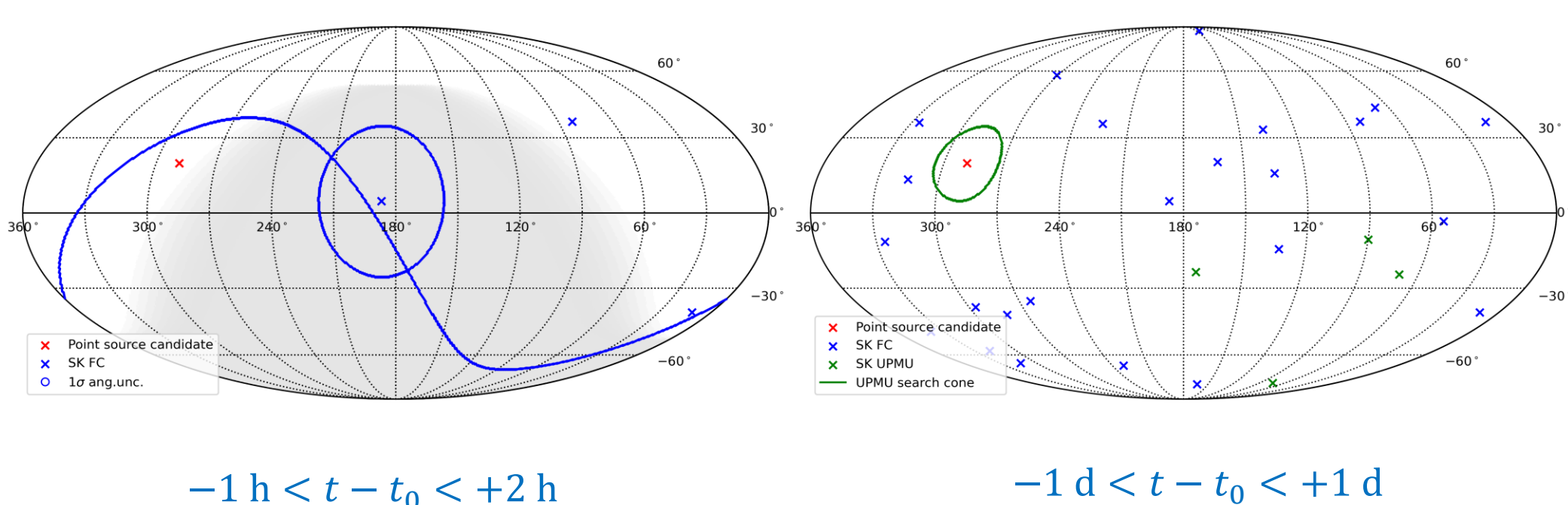
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FLUENCE UPPER LIMIT



- ◆ Model independent fluence limit (top).
- ◆ Model dependent fluence limit (assume $E^{-\gamma}$ spectrum) (bottom).

SKY MAP



- ◆ Gray shadow area is UPMU sensitive region.
- ◆ Angular uncertainty is estimated using SK4 MC.
- ◆ 15° search cone is set for UPMU.

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SUMMARY

Searched for neutrino events in coincidence with GRB 221009A with ATPMD:
Three time-window ([-1h, +2h], [-500s, +500s], [-1d, +1d]) used.
No significant excess of neutrino emission found.
Two types of flux upper limit calculated:
1. Model independent fluence
2. Fluence assuming power law spectrum emission model

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