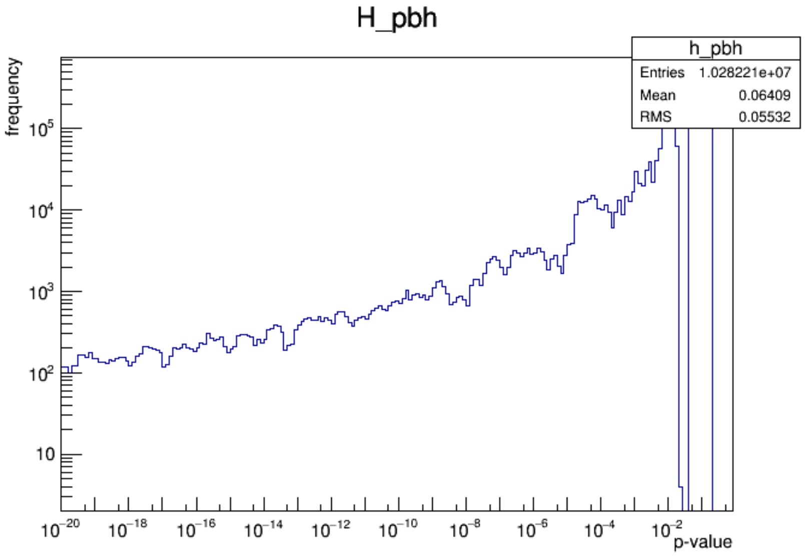
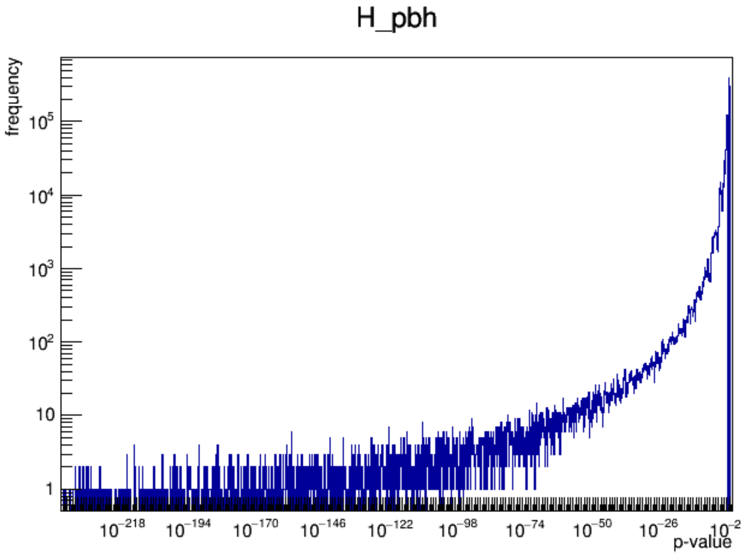
Preliminary PBH Results

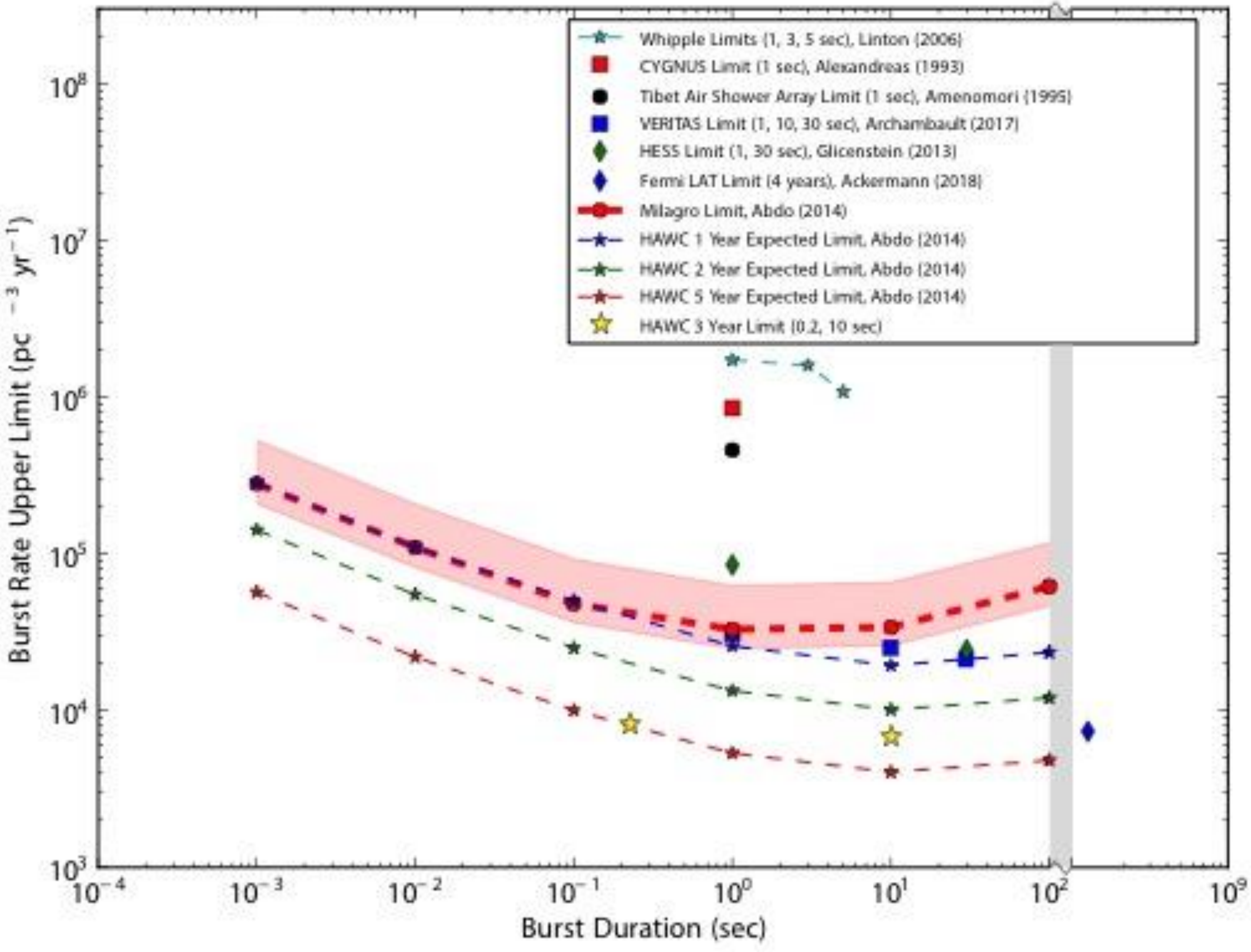
11/29/2018

Results

- 0.2s burst: upper limit = 8156 bursts yr-1 pc-3
- 10s burst: upper limit = 7140 bursts yr-1 pc-3
- Can get better limits by using entire tail of the distribution, only went down to p-values of 10-20 here







Whipple Limits (1, 3, 5 sec), Linton (2006)
CYGNUS Limit (1 sec), Alexandreas (1993)
Tibet Air Shower Array Limit (1 sec), Amenomori (1995)
VERITAS Limit (1, 10, 30 sec), Archambault (2017)
HESS Limit (1, 30 sec), Glicenstein (2013)
Fermi LAT Limit (4 years), Ackermann (2018)
Milagro Limit, Abdo (2014)
HAWC 1 Year Expected Limit, Abdo (2014)
HAWC 2 Year Expected Limit, Abdo (2014)
HAWC 5 Year Expected Limit, Abdo (2014)
HAWC 3 Year Limit (0.2, 10 sec)
Burst Rate Upper Limit (pc^{-3} yr^{-1})
Burst Duration (sec)
10^3
10^4
10^5
10^6
10^7
10^8
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^9

Still to do

- Background histograms
  - Issues with Josh's background files
  - For now using histograms that Pat generated using power law extrapolation based on the data
- 1s duration
  - We have some moderately significant events in the 1s search that might be messing up the limit, so we need to be careful thinking about this one
- Data for 100s
  - Move into a different spatial bin for times longer than 10s

Backup

Upper Limit with Log Likelihood

For each value of D, the PBH burst duration:

1. Calculate the background Poisson log-likelihood

$$\ln \mathcal{L}_0 = \sum_p \left[H_{data}(p) \ln\left(H'_{bkg}(p)\right) - H'_{bkg}(p)\right]$$

H_{data}: Observed "bursts" from Josh's simple-grb results

H'_{bkg}: Background distribution scaled to the time of the searched data

2. Calculate the model Poisson log-likelihood

$$\ln \mathcal{L}_1 = \sum_p \left[H_{data}(p) \ln\left(H_{model}(p)\right) - H_{model}(p)\right]$$

H_{data}: Observed "bursts" from Josh's simple-grb results

H_{model}: PBH distribution + background distribution (both scaled)

*factorial term neglected as it will cancel out later

Upper Limit with Log Likelihood

3. Calculate the TS for the rate of PBH bursts, R, being evaluated

$$TS = 2\left[\ln \mathcal{L}_1 - \ln \mathcal{L}_0\right]$$

4. Find the value of R that yields the largest TS → TS_{max}

5. Define:

$$TS_{99} = TS_{max} - 5.41$$

6. Starting with the rate that yielded TS_{max}, repeat steps 1 – 3 until:

$$TS = TS_{99}$$

The rate that satisfies this expression is the limit for the PBH burst duration currently being evaluated.