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NEUTRINOS FROM PRIMORDIAL BLACK HOLES

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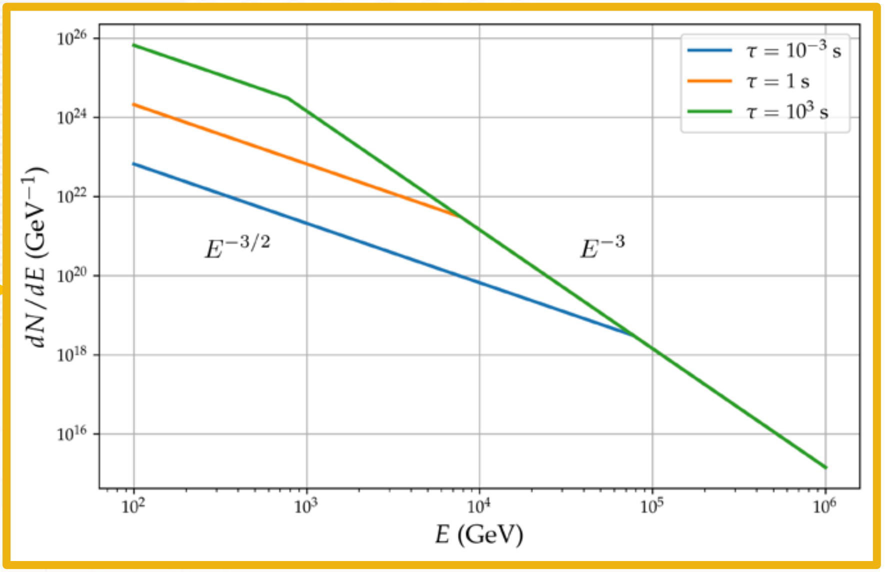
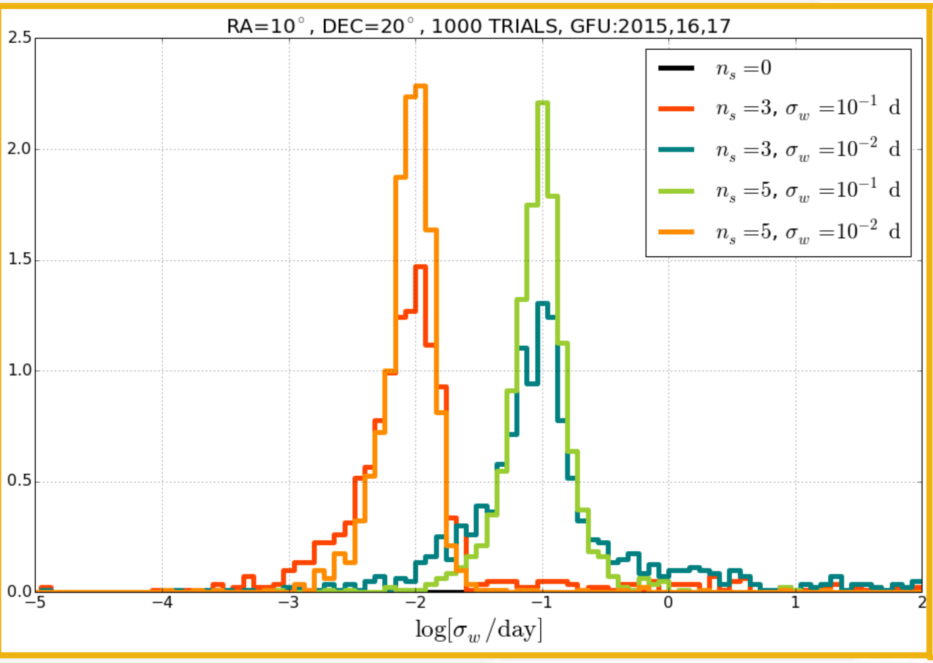
PRIMORDIAL BLACK HOLE BURSTS: ANALYTICAL APPROXIMATION

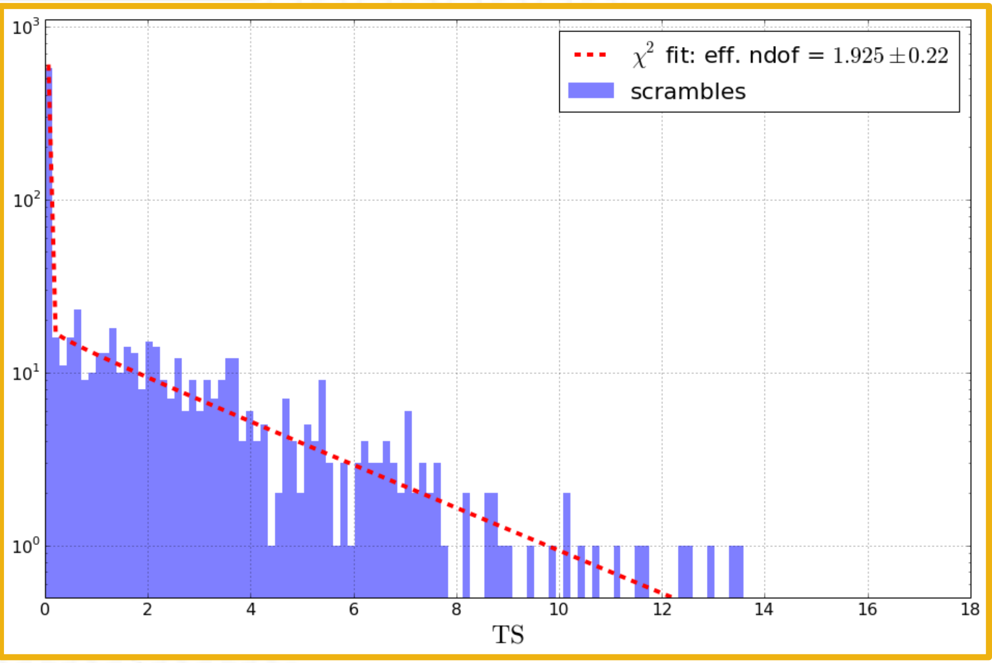
- Hawking's instantaneous spectra: $$\frac{d^2N}{dE\,dt} = \frac{n_{\rm dof}}{2\pi\hbar}\,\frac{\Gamma_s(E,M)}{\exp\left(8\pi GM/\hbar c^3\right) - (-1)^{2s}}$$
- Holes initially below critical mass, $M_* \simeq 4 - 6 \times 10^{14}$ g, would evaporate today
- $M \approx 1.36 \times 10^9 \left(\frac{\tau}{1\,\rm s}\right)^{1/3}$ g, $kT \approx 7770 \left(\frac{1\,\rm s}{\tau}\right)^{1/3}$ GeV $\quad (kT >> m_\pi)$
- Time Integrated Flux
- Contributions from:
  - Direct neutrinos
  - Direct muons, pions to neutrinos
  - Hadronization to muons, pions to neutrinos



ICECUBE'S SENSITIVITY TO BURST DURATION

- Reinterpret existing analyses to constrain PBH burst density rate
- Imen's analysis: Untriggered Time-Dependent All-Sky Search with GFU data (most recent)
- Modify injected Gaussian flare (broken power law depends on the burst duration) [Work in progress]





BACKUP

BACKUP: ANALYTICAL ESTIMATES

$$kT = \frac{\hbar c^3}{8\pi G M}, \quad x \equiv \frac{E}{kT}$$

$$\frac{d^2N}{dEdt} \propto \frac{x^2}{e^x - (-1)^{2s}}$$

$$L = \sum_i \int \frac{d^2N_i}{dEdt} E \, dE$$

$$L \propto kT \sum_i \int \frac{x^2}{e^x - (-1)^{2s}} E \, dx$$

$$L \propto (kT)^2 \sum_i \int \frac{x^3}{e^x - (-1)^{2s}} \, dx$$

$$L \propto (kT)^2$$

$$-\frac{dM}{dt} \propto \frac{1}{M^2} \propto (kT)^2$$

$$M \approx 1.36 \times 10^9 \left(\frac{\tau}{1\,\mathrm{s}}\right)^{1/3} \mathrm{g}$$

$$kT \approx 7770 \left(\frac{1\,\mathrm{s}}{\tau}\right)^{1/3} \mathrm{GeV}$$

$$\frac{dN}{dE} = \int_\tau^0 \frac{d^2N}{dEdt} \, dt \propto \int_{T_0}^\infty \frac{d^2N}{dEdt} \frac{dT}{T^4}$$

$$\frac{dN}{dE}(E < kT_0) \propto \int_{T_0}^\infty \frac{T^{5/2}}{E^{3/2} T^4} \, dT$$

$$\frac{dN}{dE}(E < kT_0) \propto \frac{1}{E^{3/2}} \frac{1}{T_0^{3/2}}$$

$$\frac{dN}{dE}(E > kT_0) \propto \int_{T_0}^\infty x^2 e^{-x} \frac{dT}{T^4}$$

$$\frac{dN}{dE}(E > kT_0) \propto \int_0^{x_0} x^6 e^{-x} \frac{E dx}{x^2 E^4}$$

$$\frac{dN}{dE}(E > kT_0) \propto \frac{1}{E^3} \int_0^{x_0} x^4 e^{-x} \, dx$$

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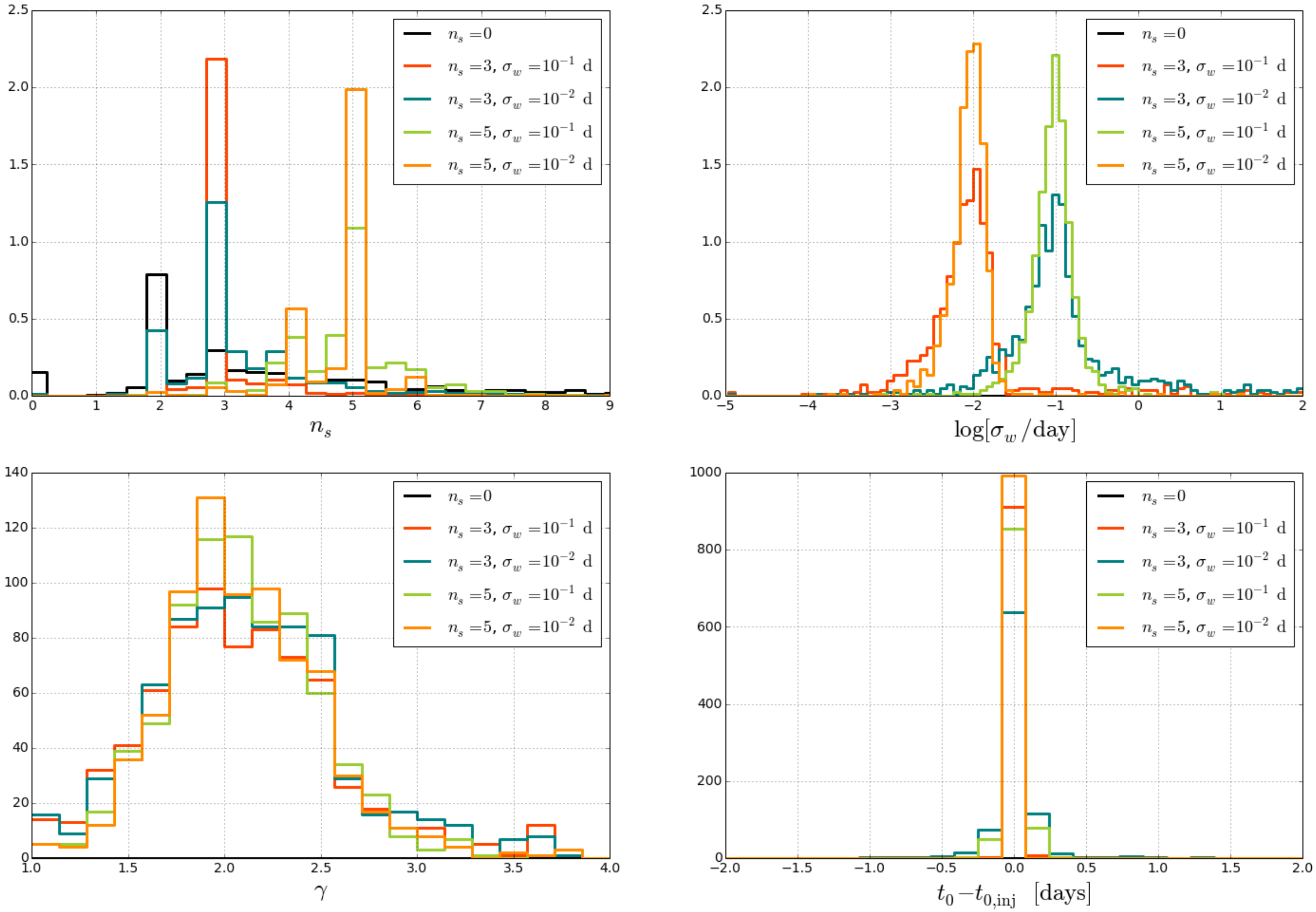
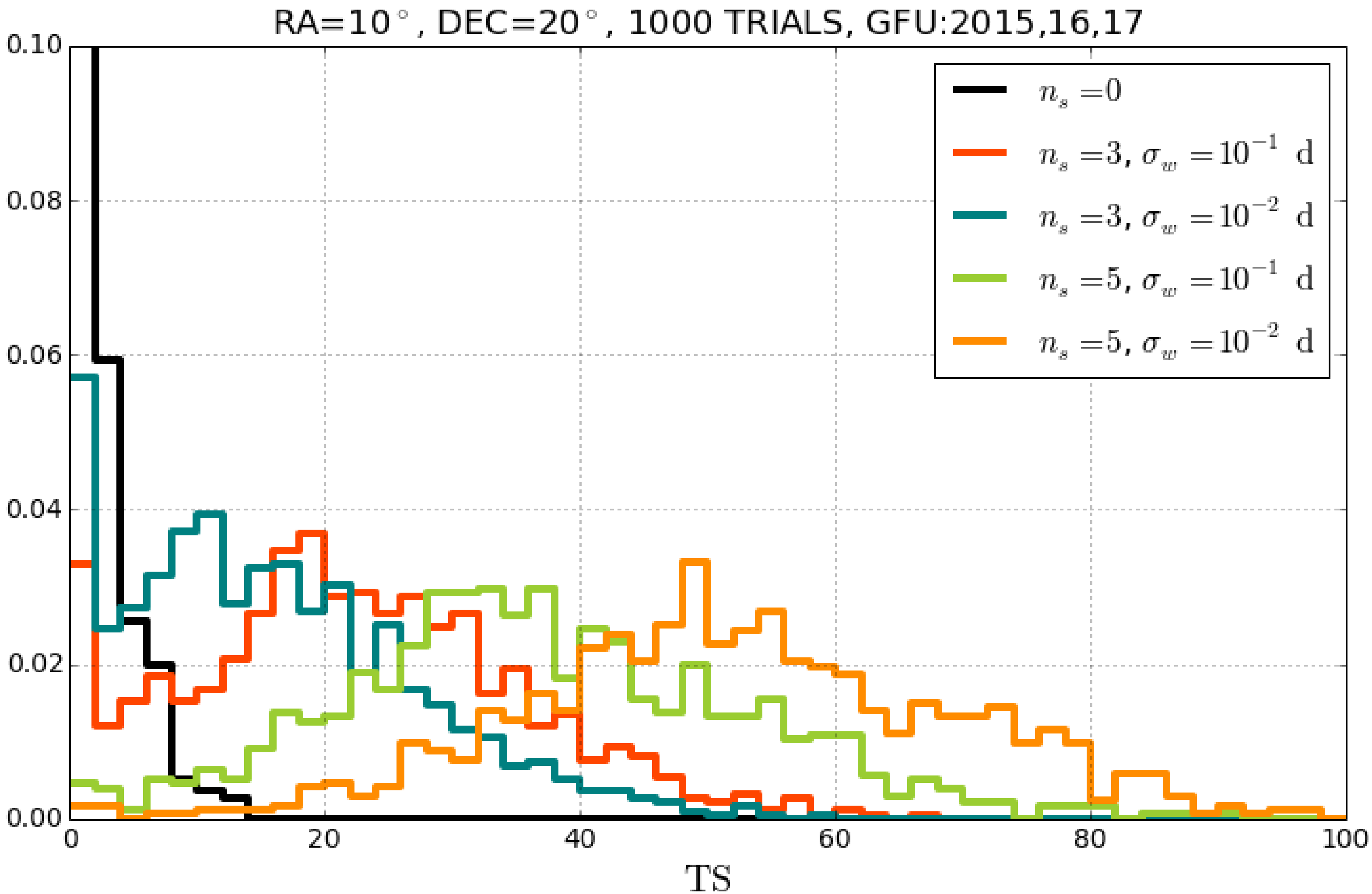
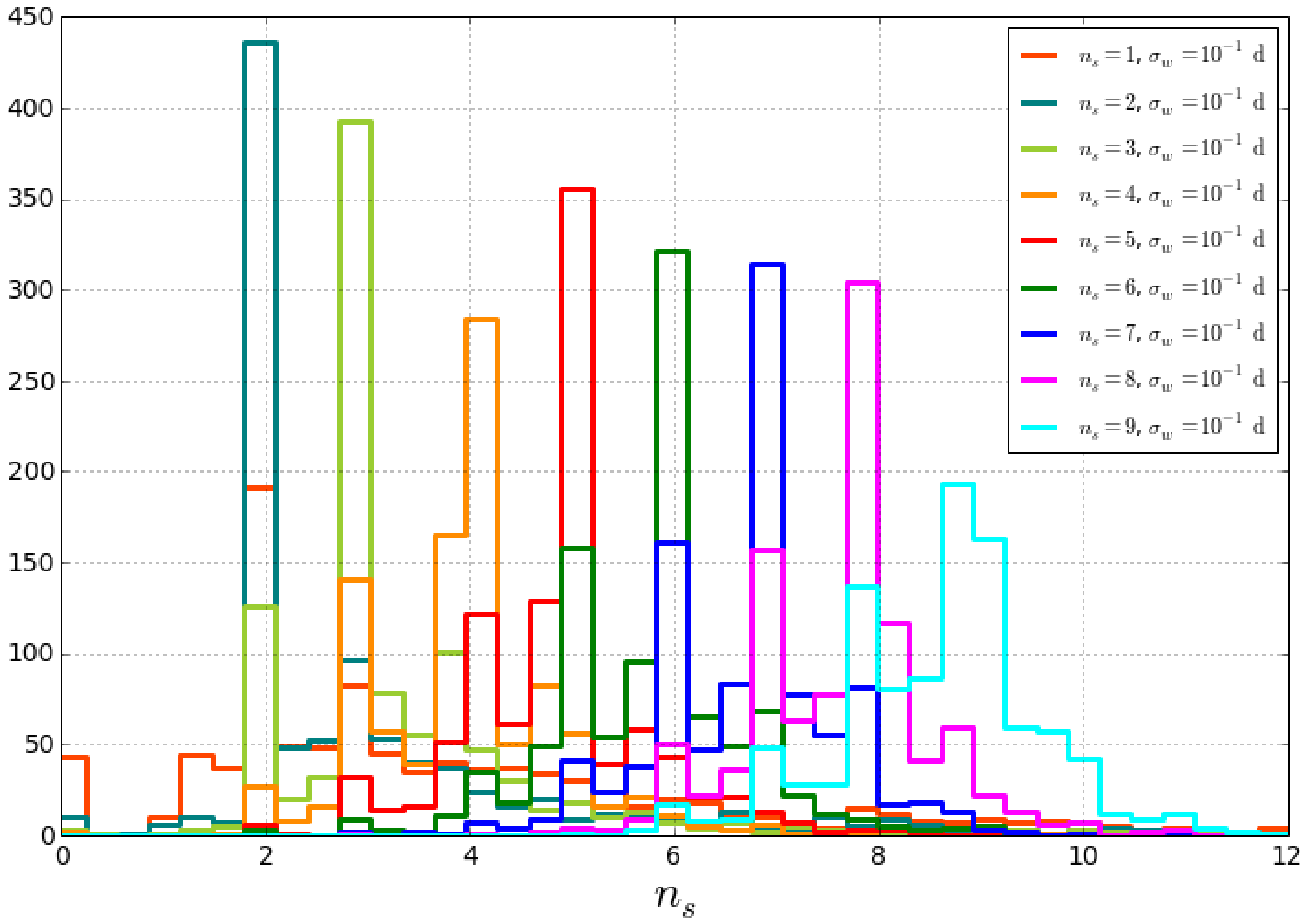
BACKUP: PSLAB FIT PARAMETERS



BACKUP: TS DISTRIBUTIONS



BACKUP: PSLAB FIT NS FOR WIDTH = 0.1 DAYS



BACKUP: PSLAB TS DIST FOR WIDTH = 1 DAY