Estimating the Accidental Coincidence Rates in Searches for Gravitational Waves from Compact Binary Coalescences with LIGO

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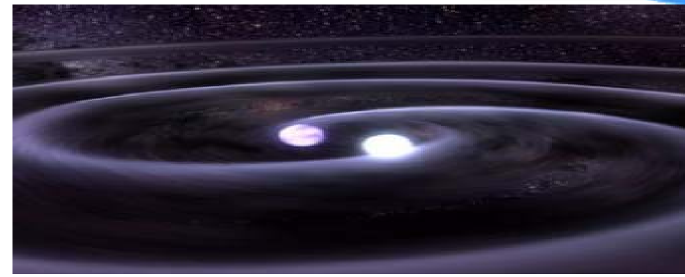
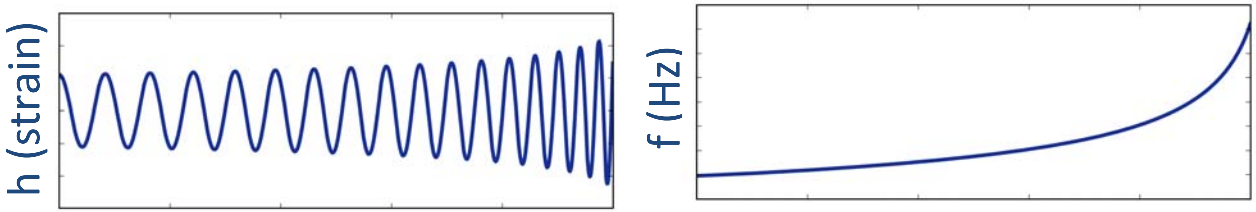
The Compact Binary Coalescence Search

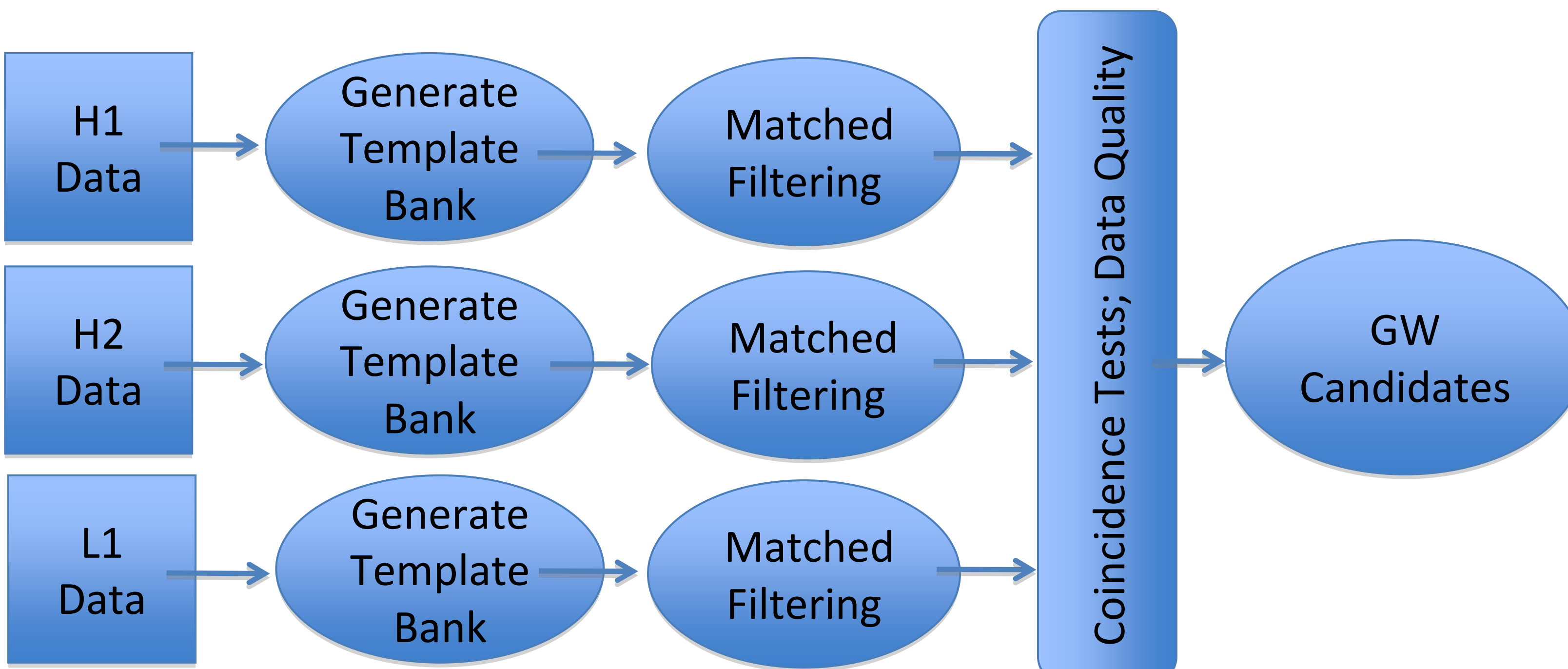
- Binary Neutron Stars (BNS)
- Binary Black Holes (BBH)
- Black Hole-Neutron Star Binary (BHNS)



Chirp Signal

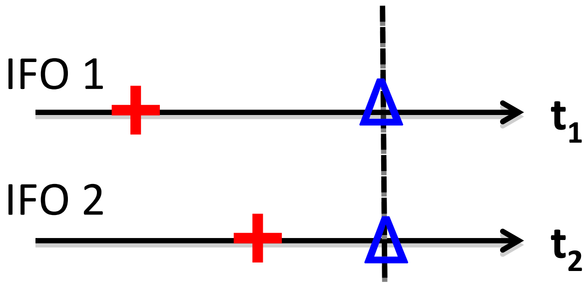


CBC Search Pipeline

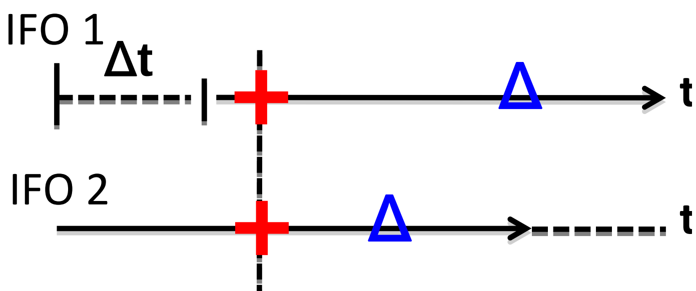


Statistical Significance

The statistical significance of the cbc candidates is estimated from time-shifted triggers



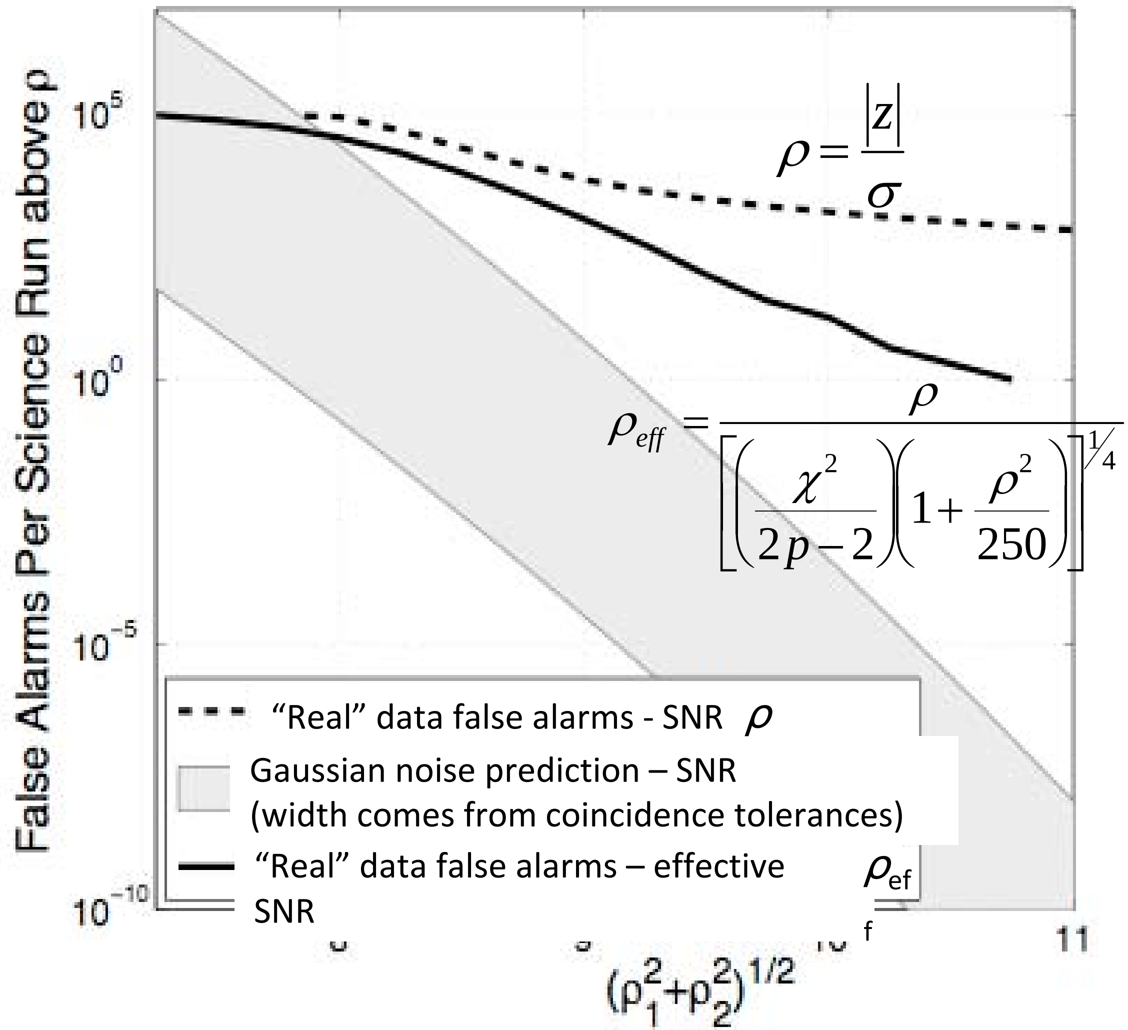
In-time Coincident trigger: *potential gravitational wave*



Time-shifted coincident trigger: *not a gravitational wave; accidental coincidence*

$\Rightarrow$ **100 time slides = 100 independent experiments**

Combined SNR ρ Histogram*



*LIGO Technical Doc. T070109-01-Z

Utilizing Time-shifted Triggers

Ex: S4 Binary Neutron

Star search

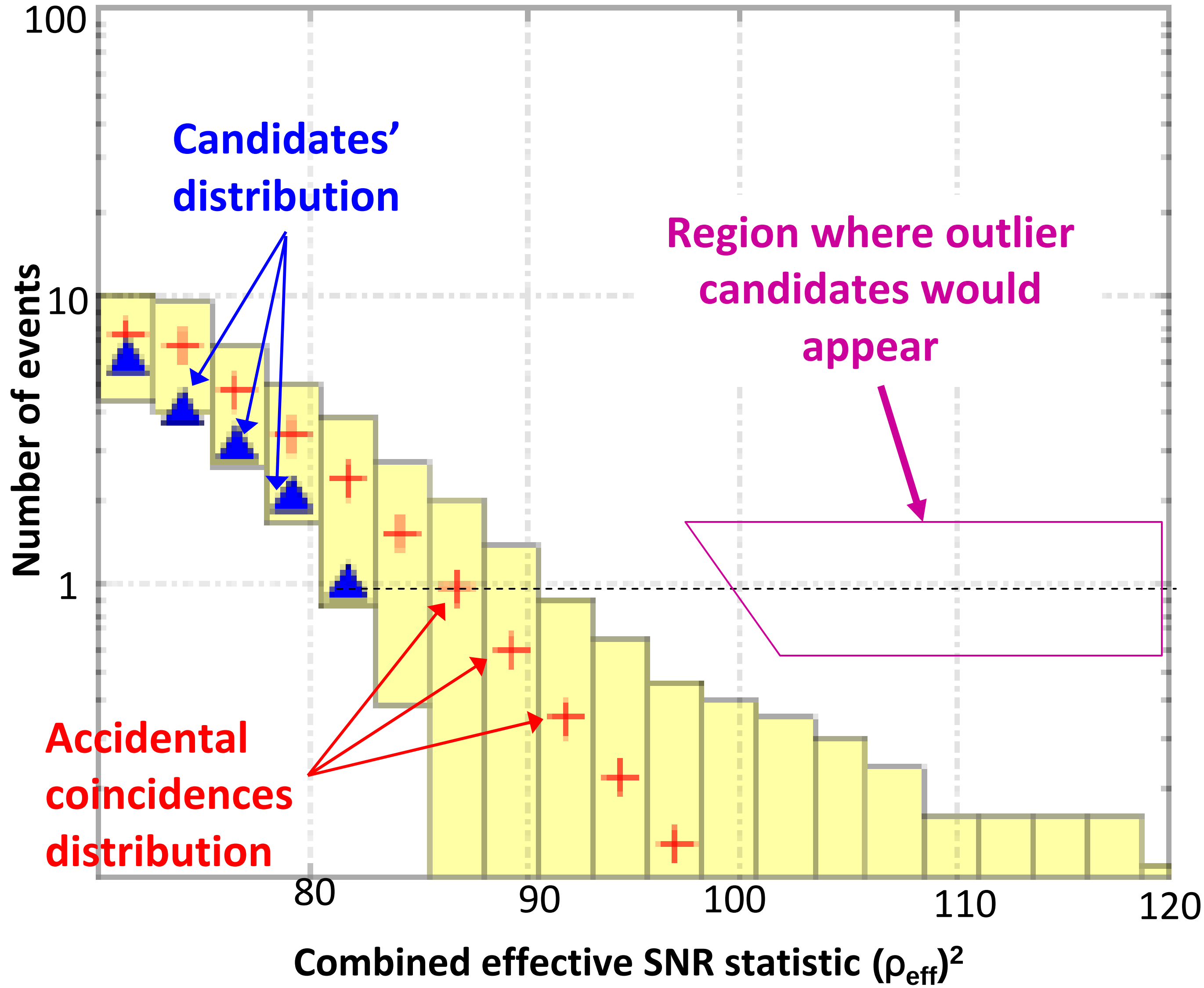
[Phys. Rev. D **77**

(2008) 062002]

Total analyzed time = 576 hrs;

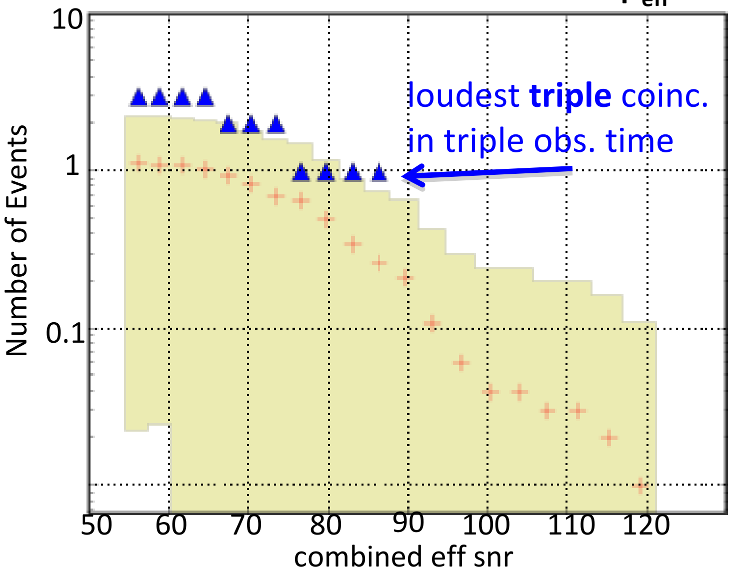
No detection found

Histogram of coincident triggers versus statistic



Problems with ρ_{eff} ranking:

Cum. hist of num. events vs combined ρ_{eff} H1H2L1



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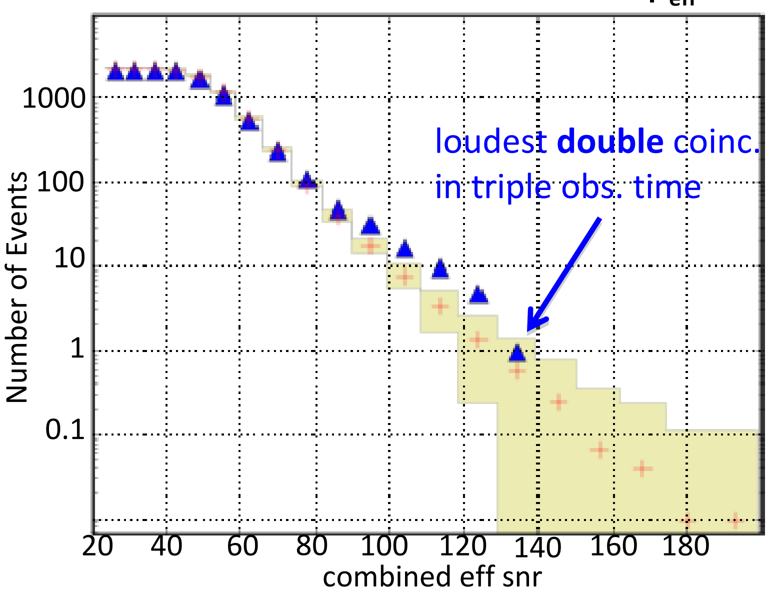


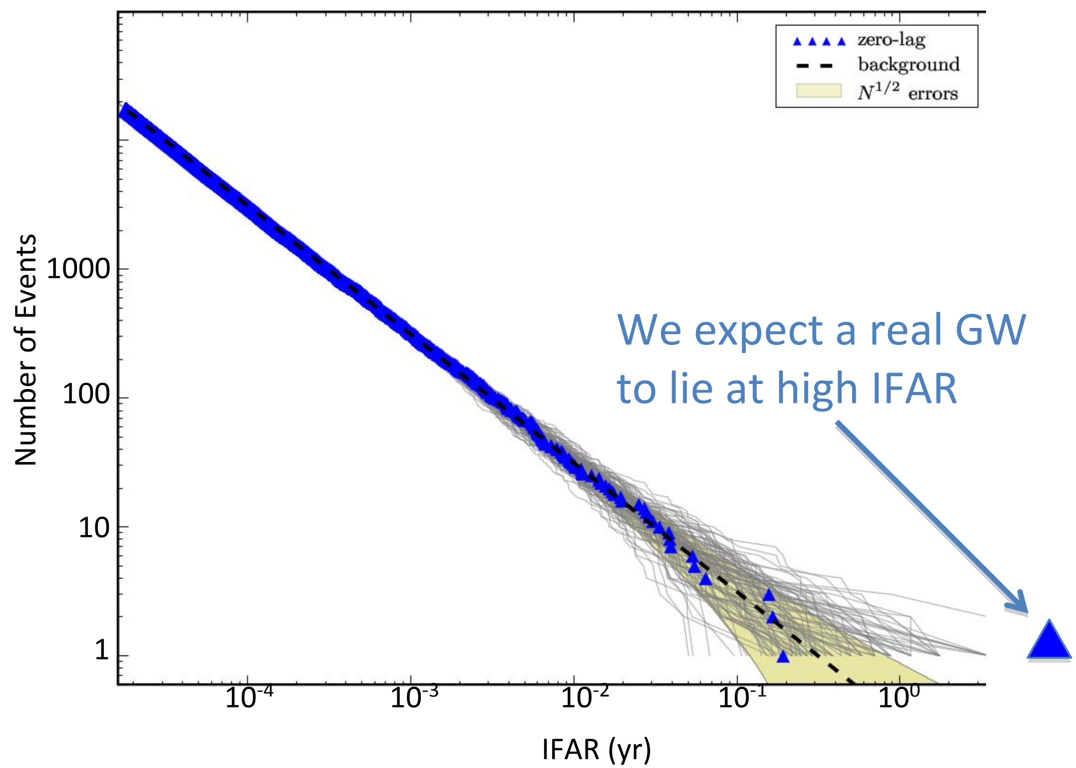
Solution:

Rank by False Alarm Rate (FAR)

Combine double, triple coincidences

Plot IFAR = 1/FAR

Cum. hist of num. events vs combined IFAR for triple obs. time



plots from s5 1st yr low mass search [**arXiv:0901.0302**]

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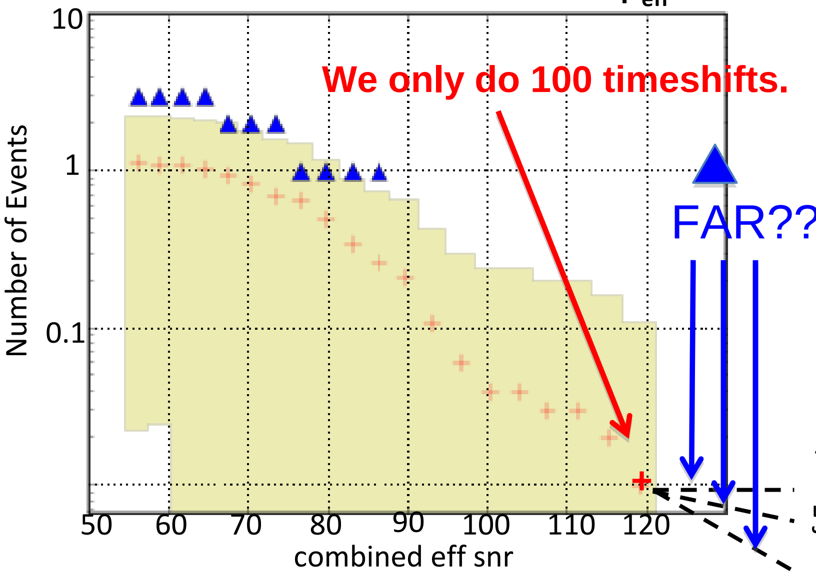

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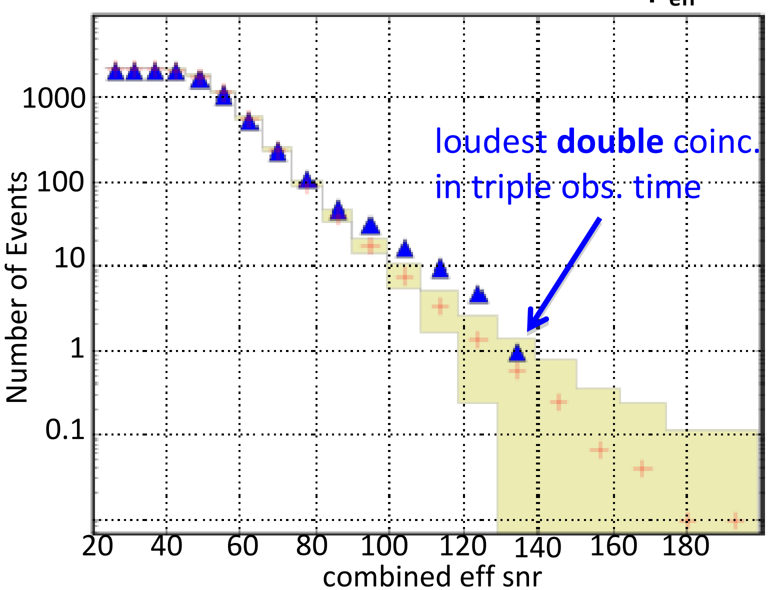

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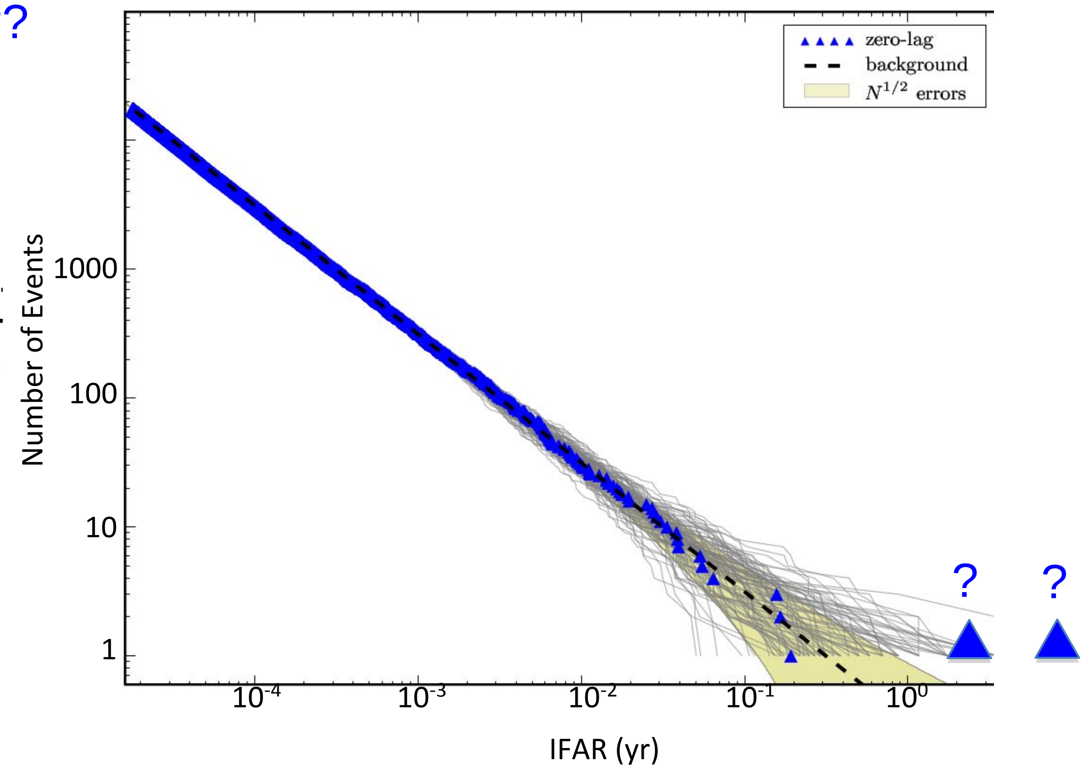

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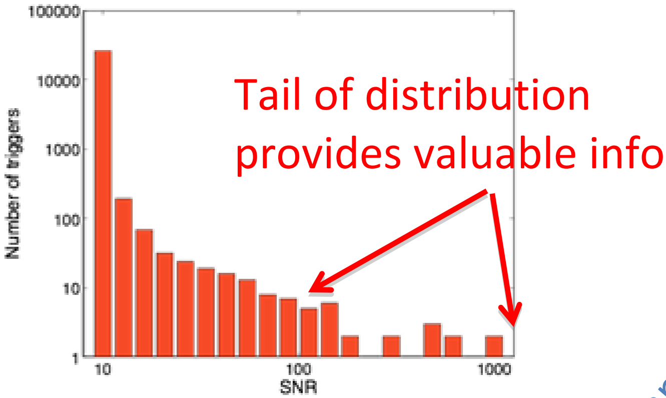
Better Estimation of Accidental Coincidence Rate

H1 Single Detector SNR*

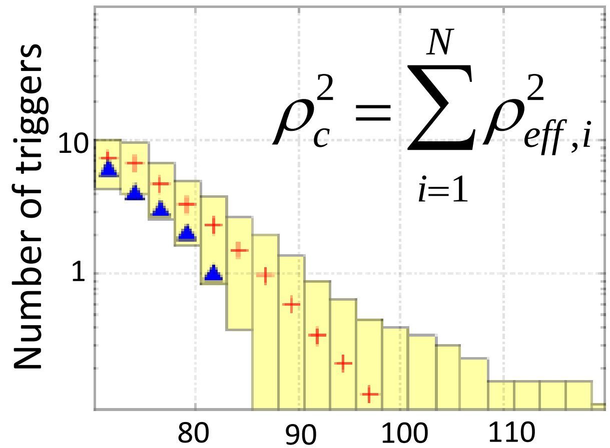


Map from single detector ρ dist.'s to single detector ρ_{eff} dist.'s

$$\rho_{eff}^2 = \frac{\rho^2}{\sqrt{\left(\frac{\chi^2}{2p-2}\right)\left(1+\frac{\rho^2}{250}\right)}}$$

Map to account for coinc. in time and mass

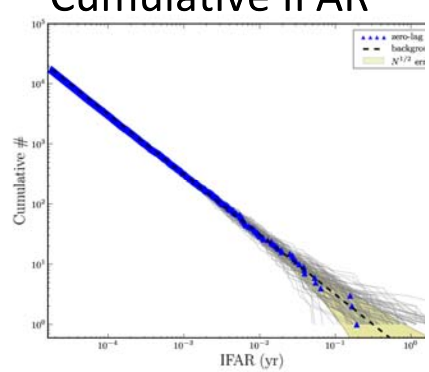
Combined Effective SNR



$$\rho_c^2 = \sum_{i=1}^{N} \rho_{eff,i}^2$$

Convert to IFAR dist.

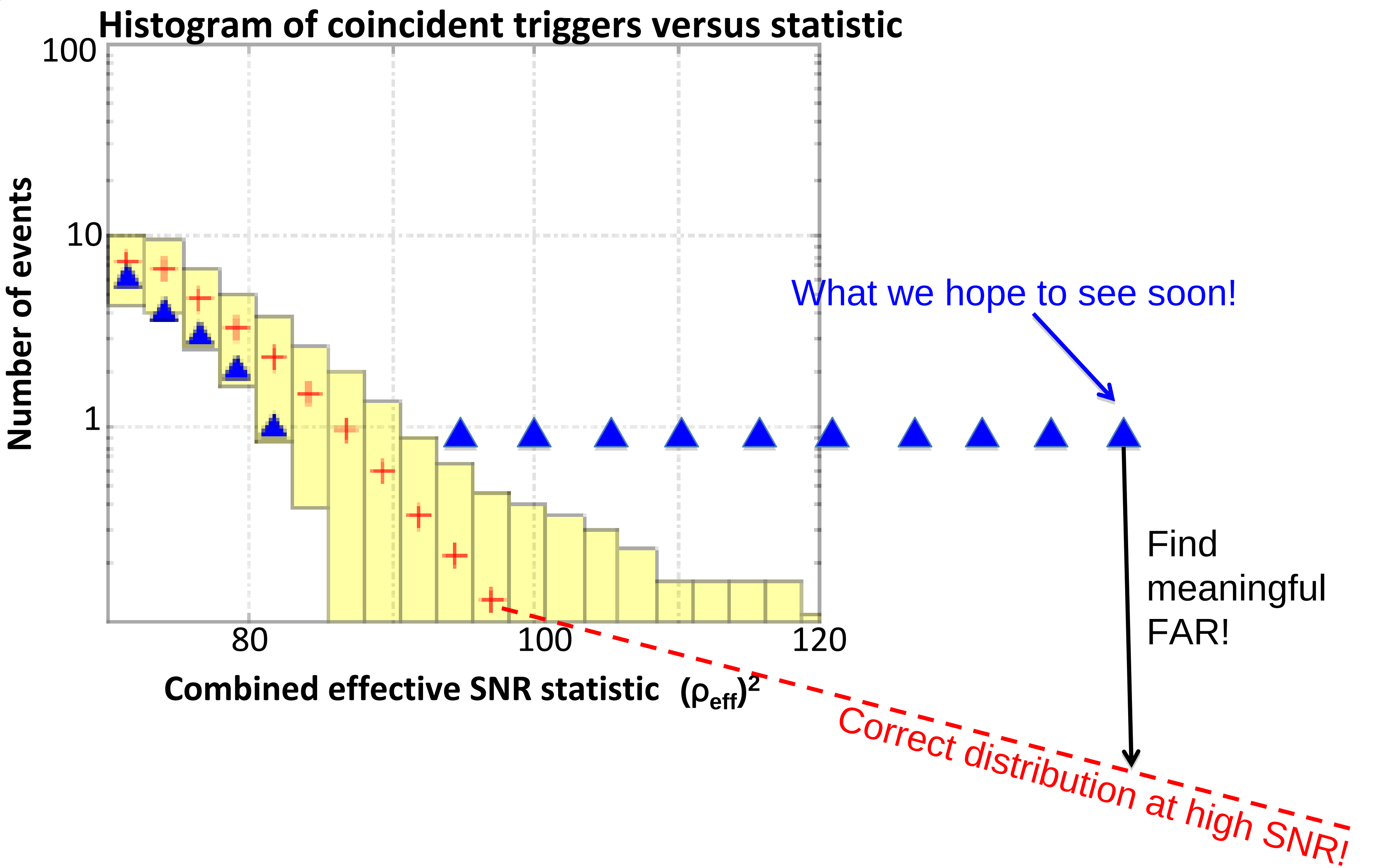
Cumulative IFAR



If the information in the tails of the single detector ρ dist. is not lost due to time-shifts, we can determine the correct accidental coincidence distribution at large IFAR.

*S4 Primordial Black Hole Search [Phys. Rev. D **77 (2008) 062002**]

Meaningful False Alarm Rates



THANK YOU!