Optimizing Low Latency LIGO-Virgo Localization

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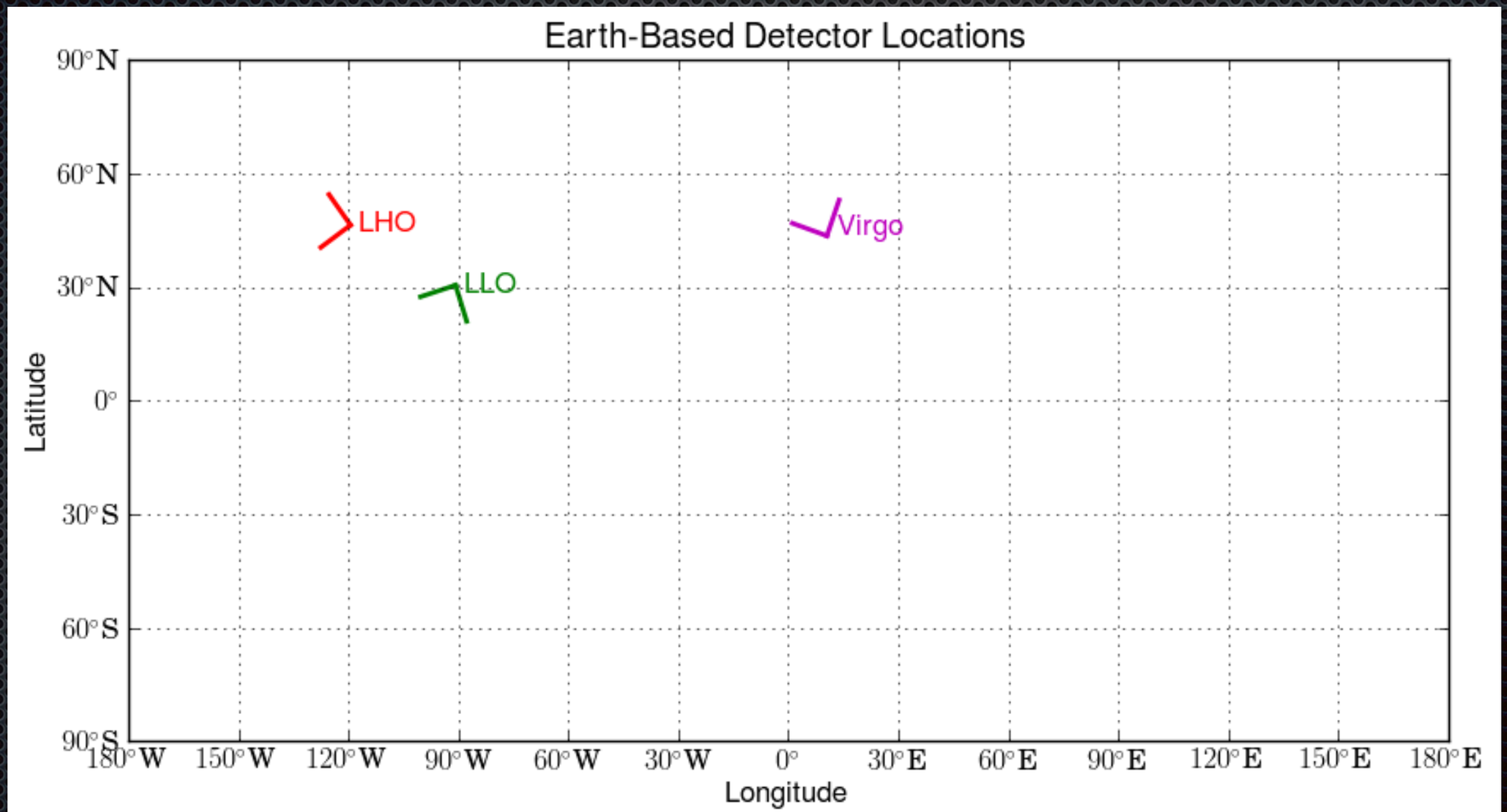
DES Chicagoland Meeting, Dec. 2014

GW multi-messenger Astronomy

- Advanced LIGO online: Fall 2015
- Most promising source: Compact binary coalescence
- Possible EM counterpart for NSNS or NSBH merger:
  - Short gamma-ray burst (seconds)
  - **Kilonovae[optical or IR] (hours to days)**
  - Radio Afterglow (months)

Low latency LIGO-Virgo Localization

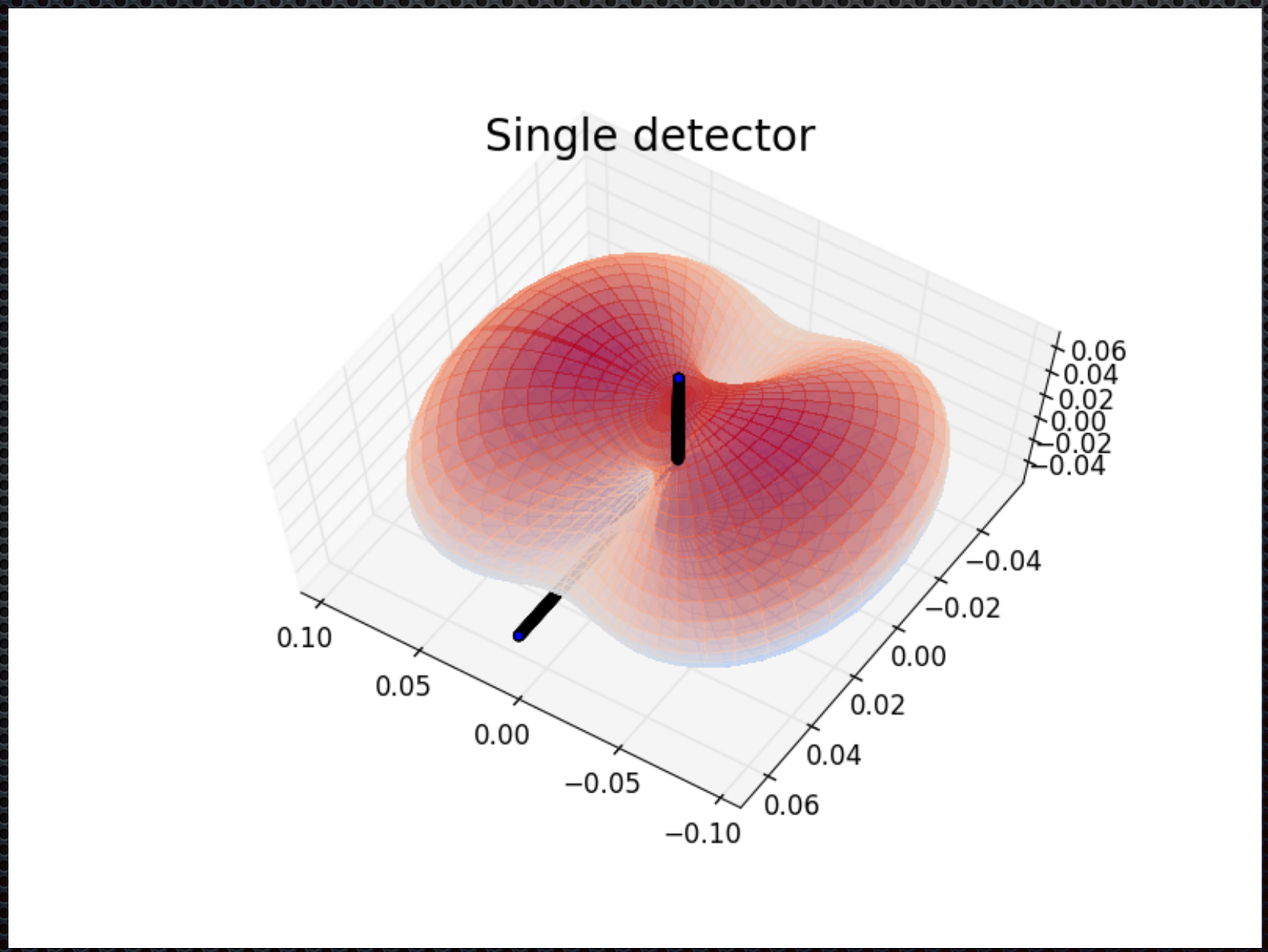
Timing Triangulation



www.ligo.org/scientists/GW100916/GW100916-geometry.html

Low latency LIGO-Virgo Localization

Timing Triangulation + **Antenna Response**



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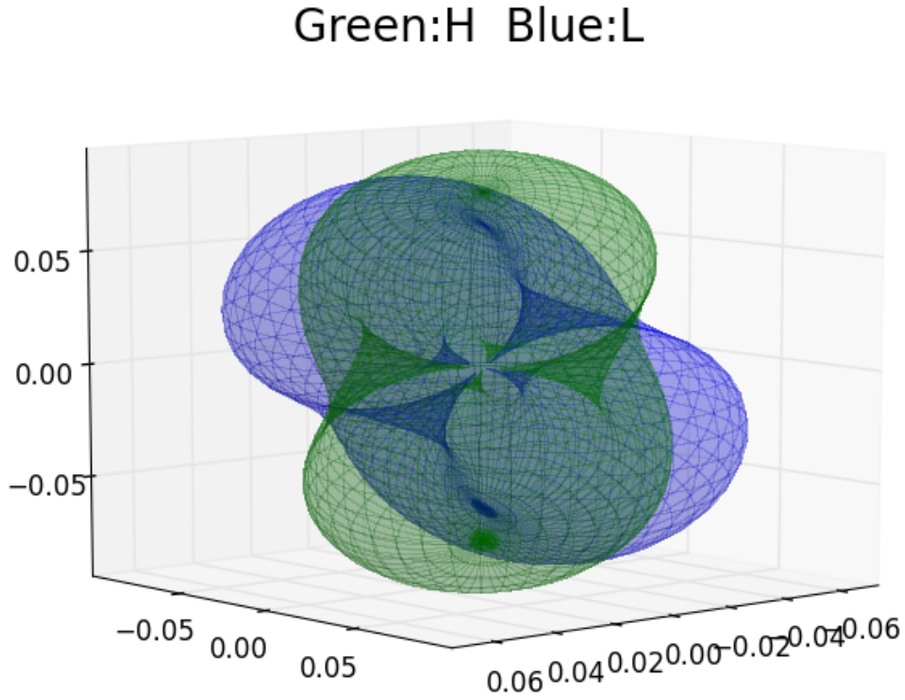
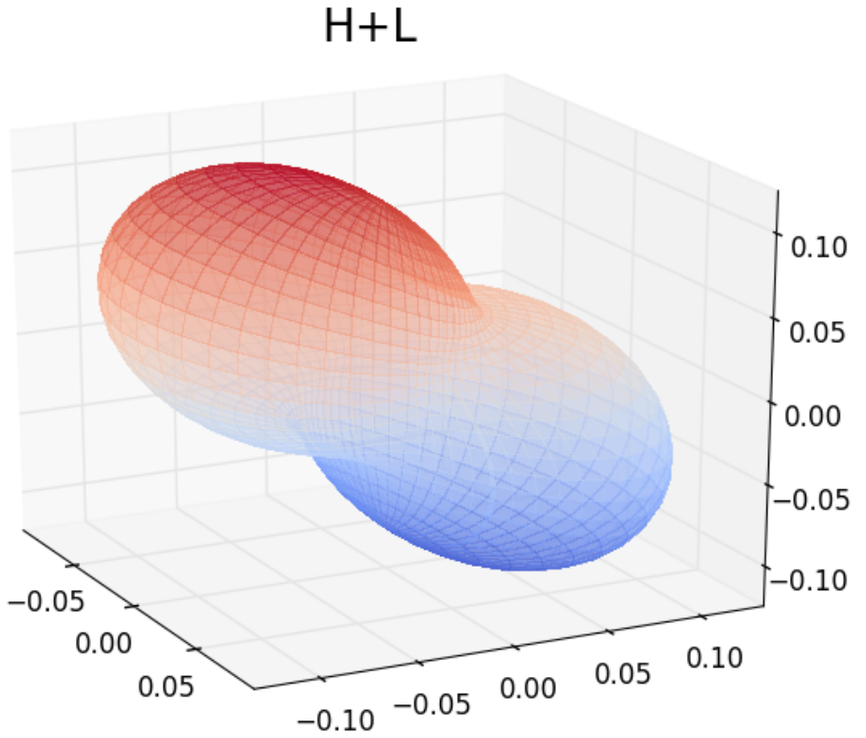
Timing Triangulation + **Antenna Response**





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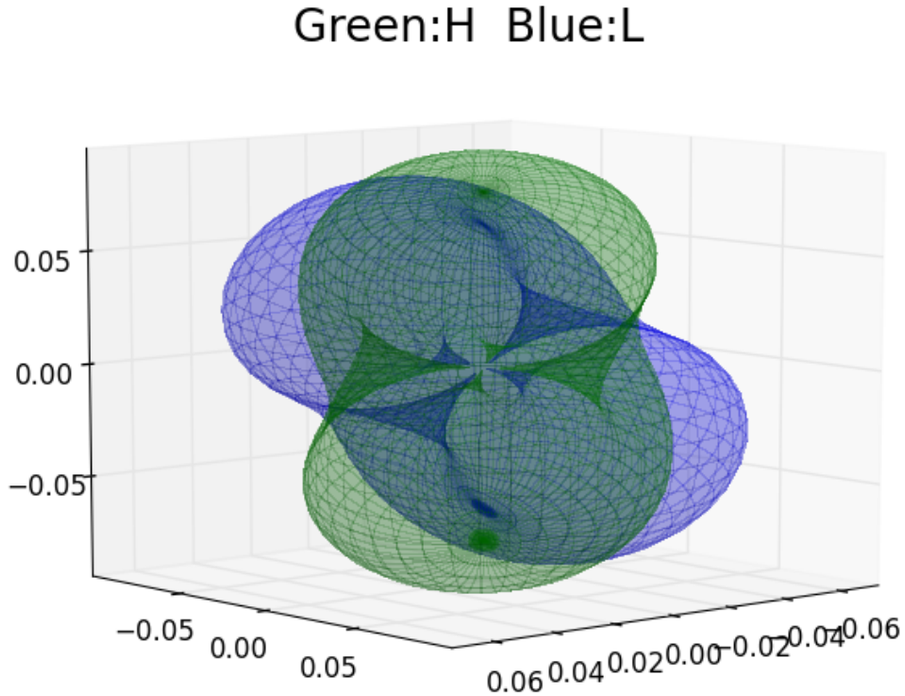
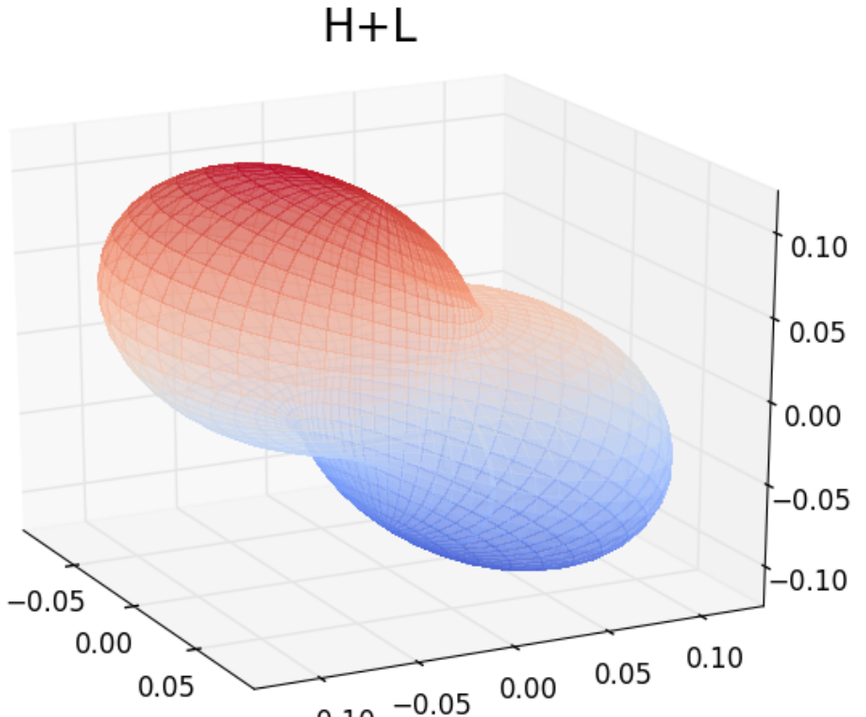
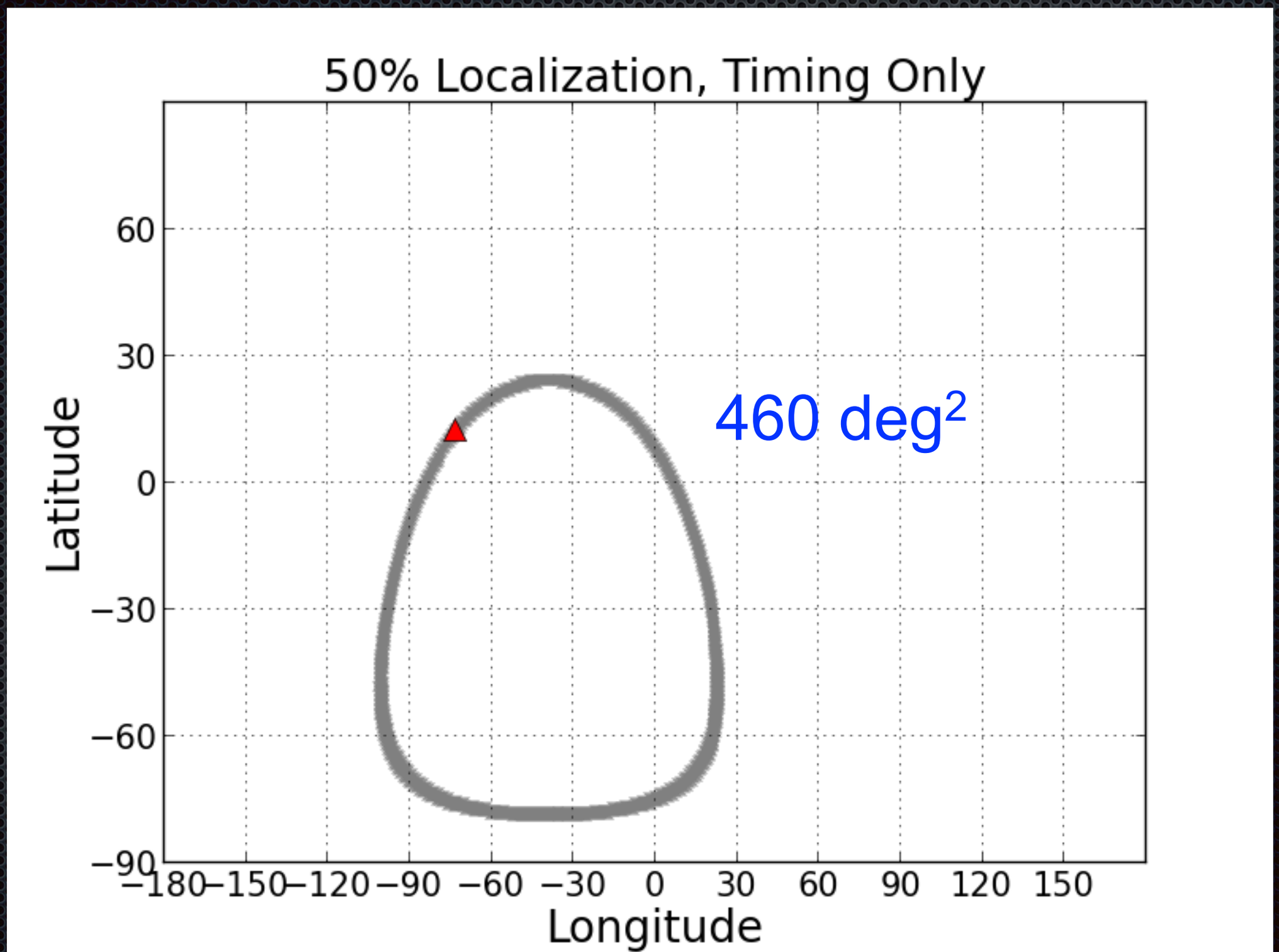


SNR



Sky Prior

Binary Neutron Star / 55 Mpc / SNR=14



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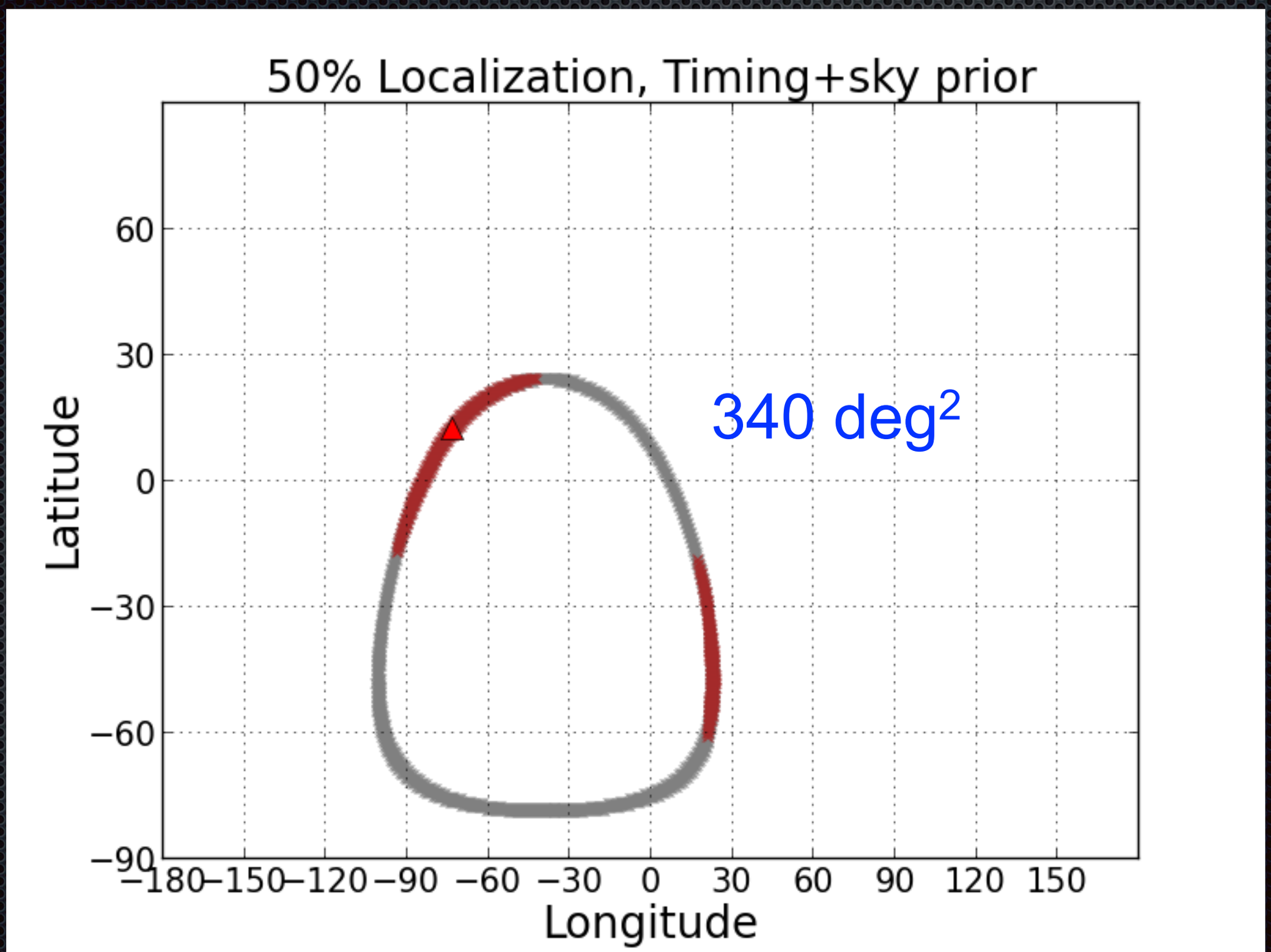

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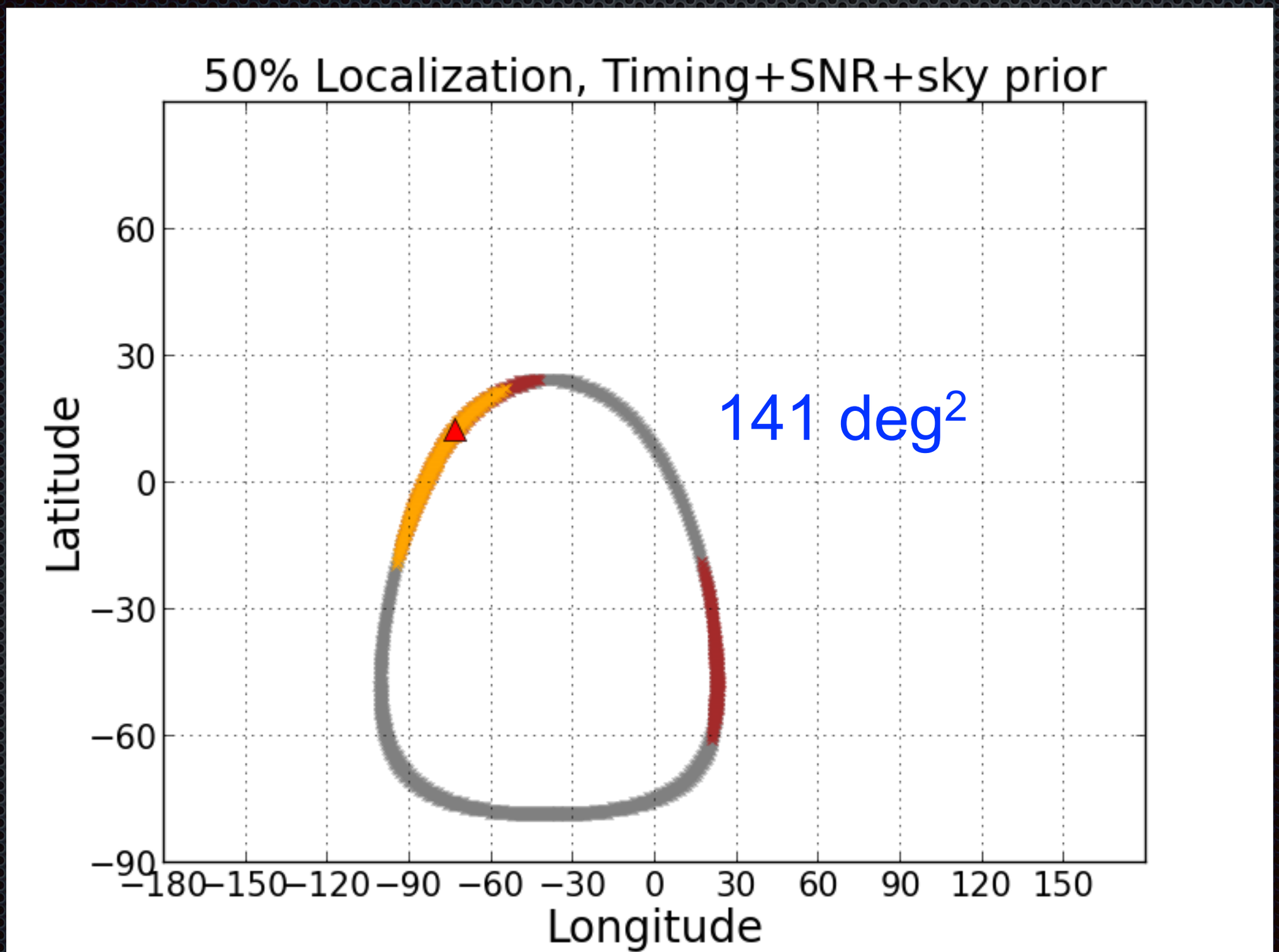
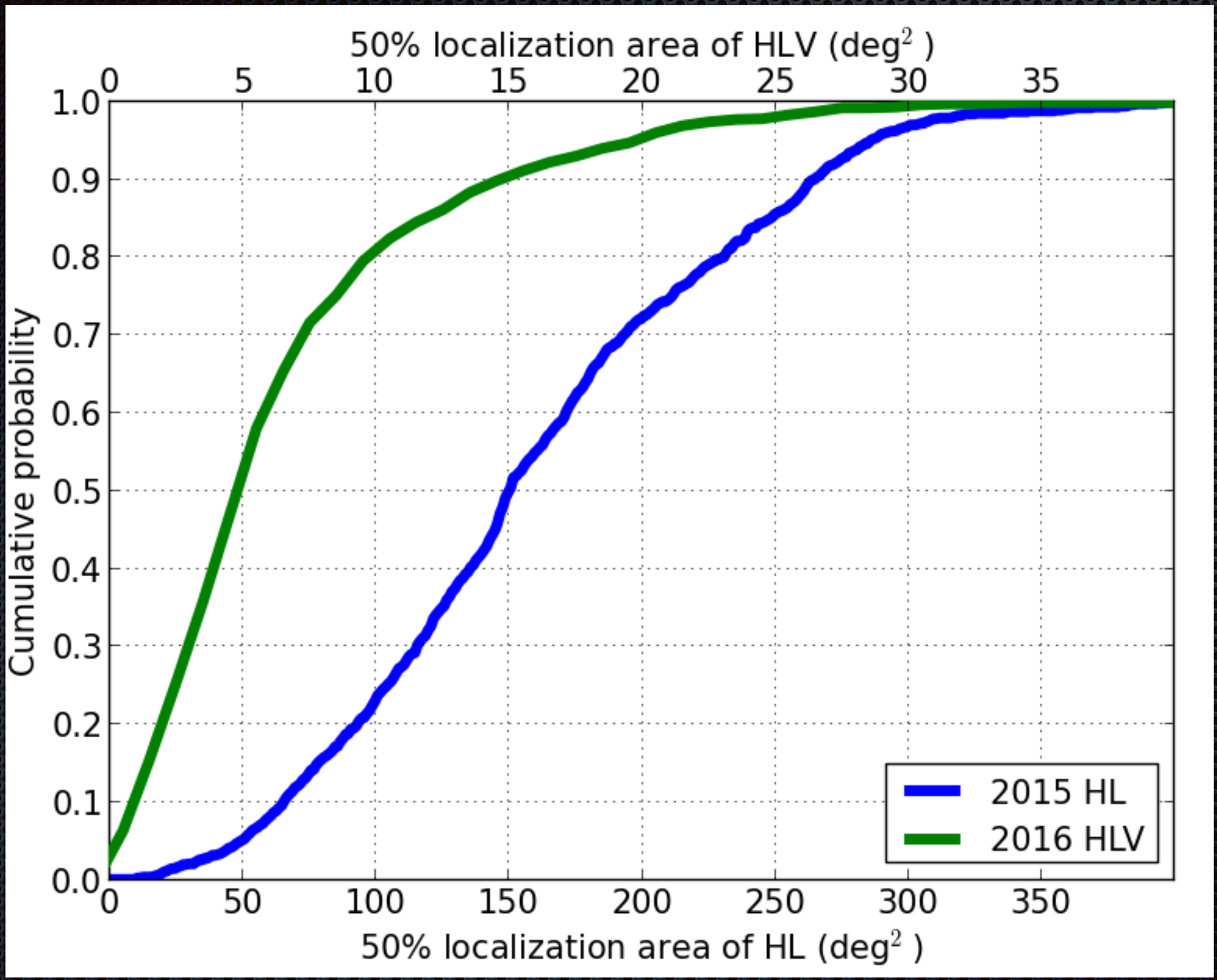
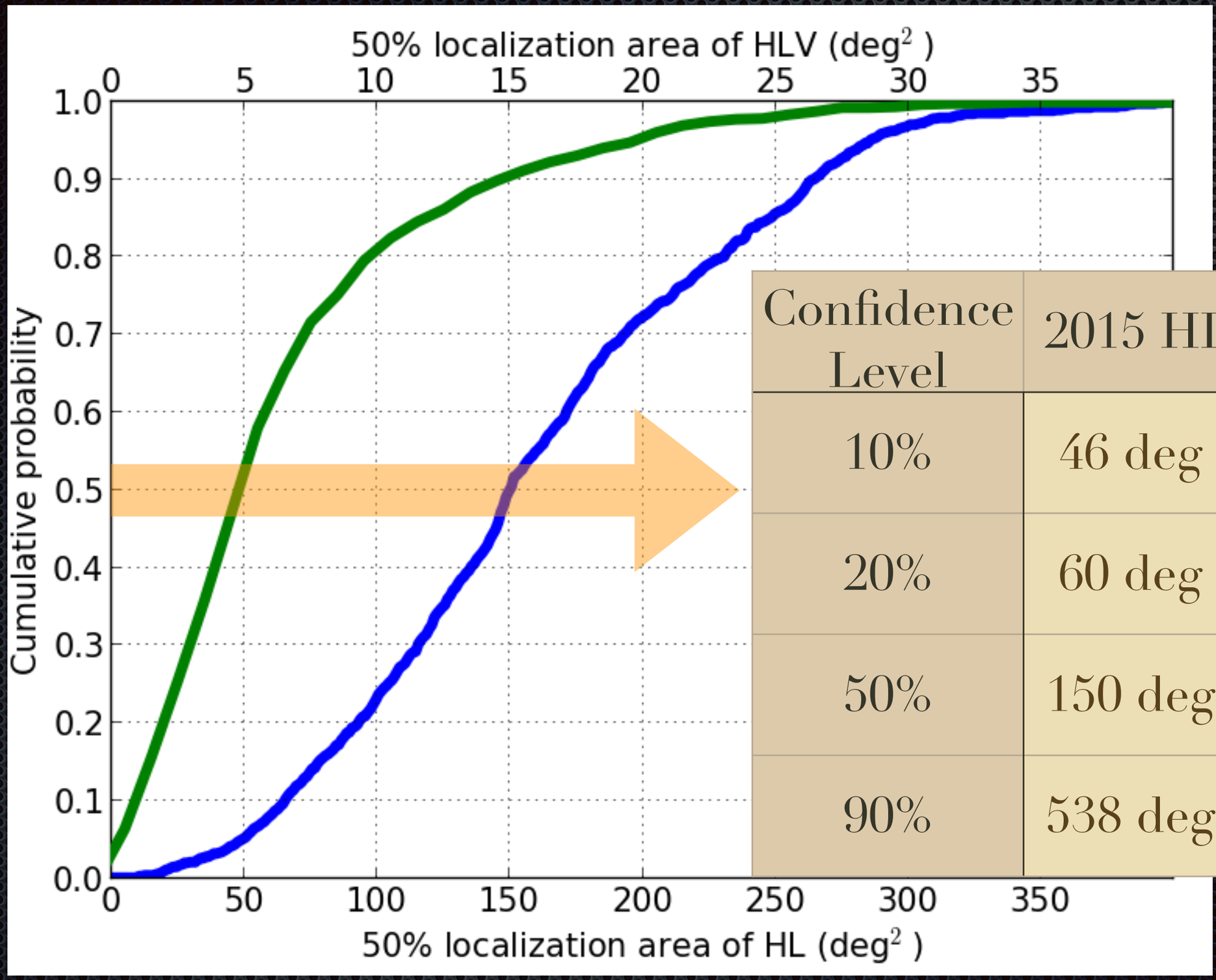
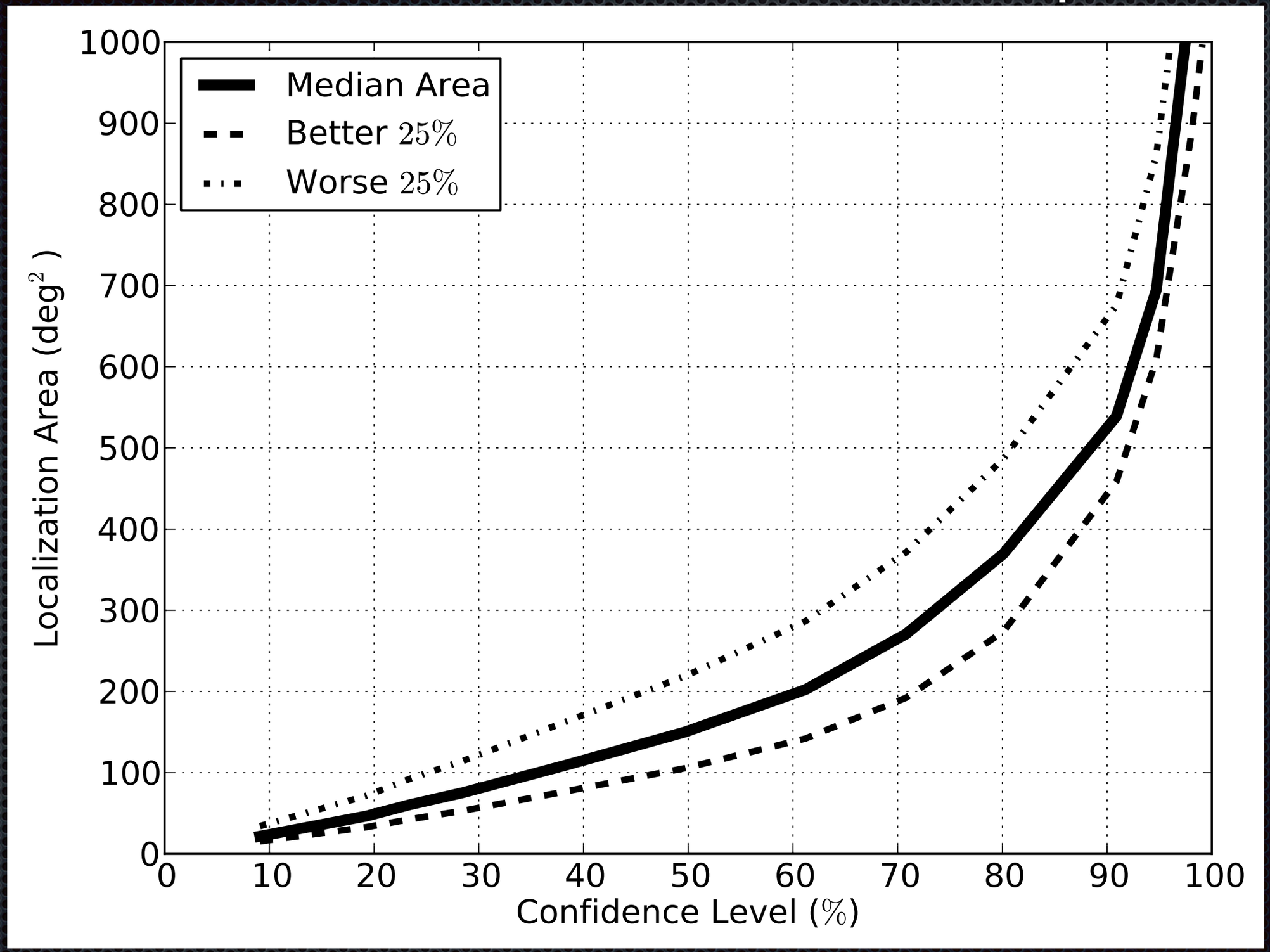



50% localization area of HLV (deg^2)
0
5
10
15
20
25
30
35
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Cumulative probability
0
50
100
150
200
250
300
350
50% localization area of HL (deg^2)
2015 HL
2016 HLV

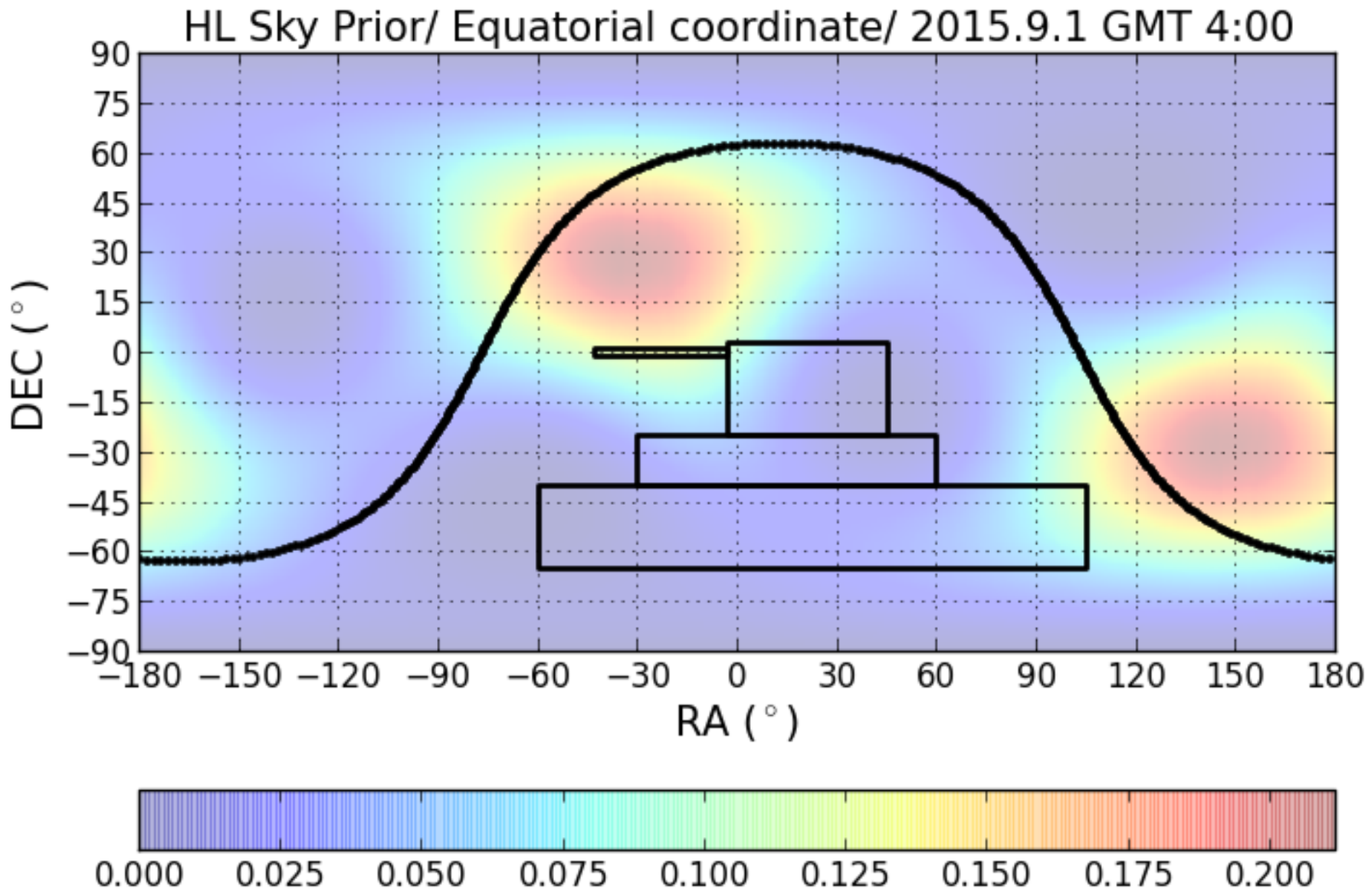


Confidence Level	2015 HL	2016 HLV
10%	46 deg	1.55 deg
20%	60 deg	2.0 deg
50%	150 deg	5.3 deg
90%	538 deg	31 deg

Given event localization map



2015 Sky Prior
DES footprint/ Galactic Plane



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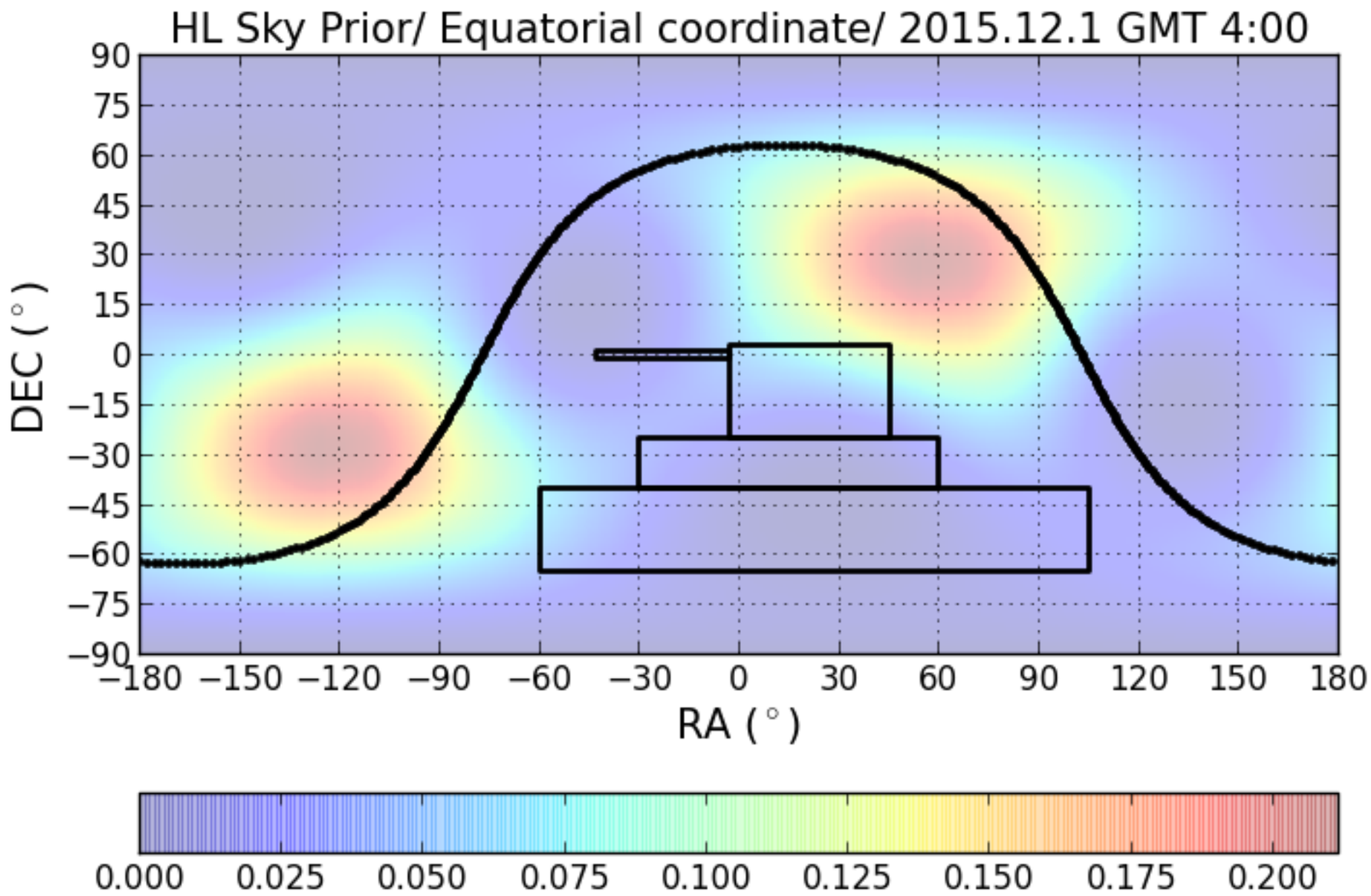

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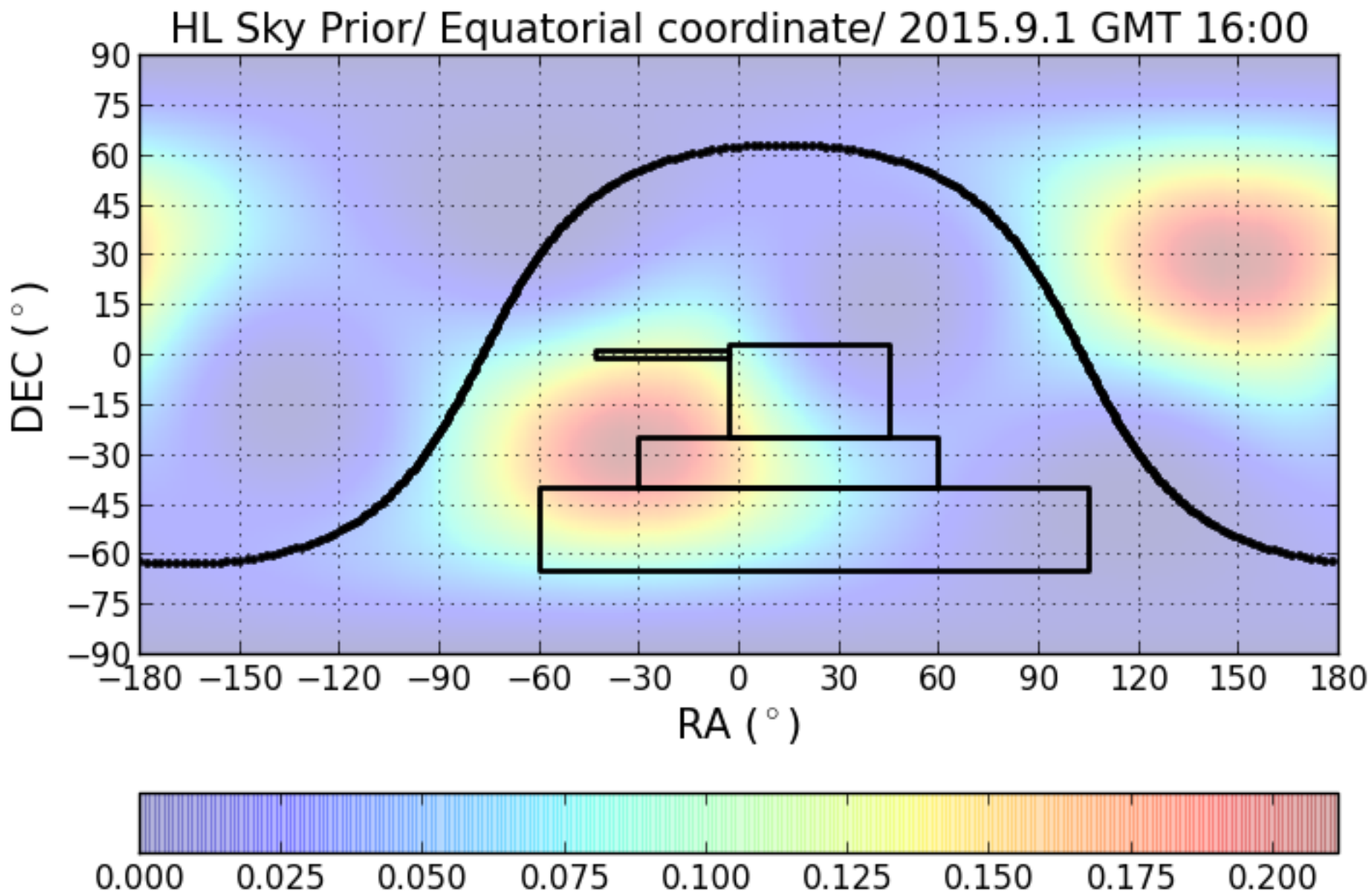

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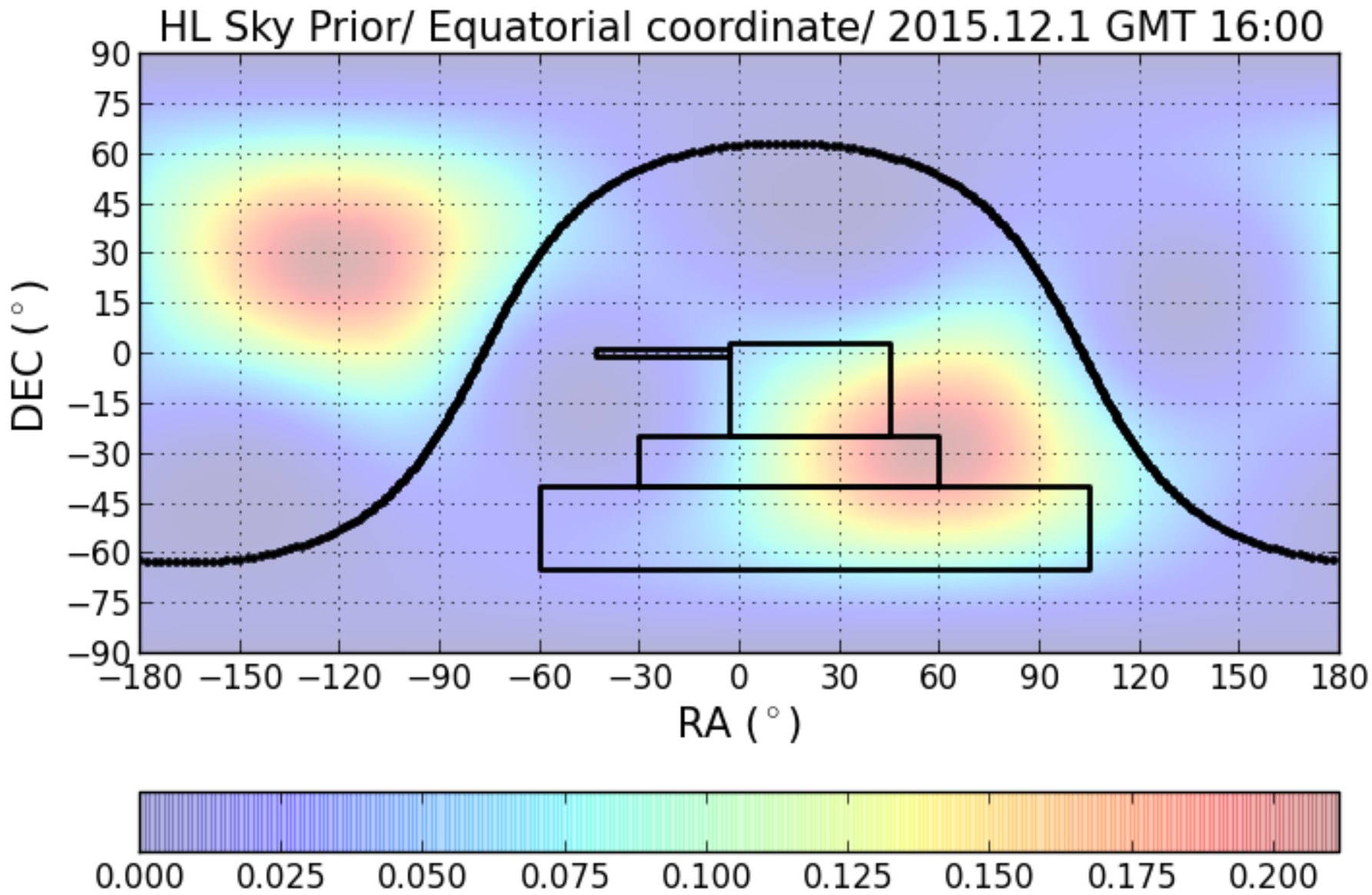

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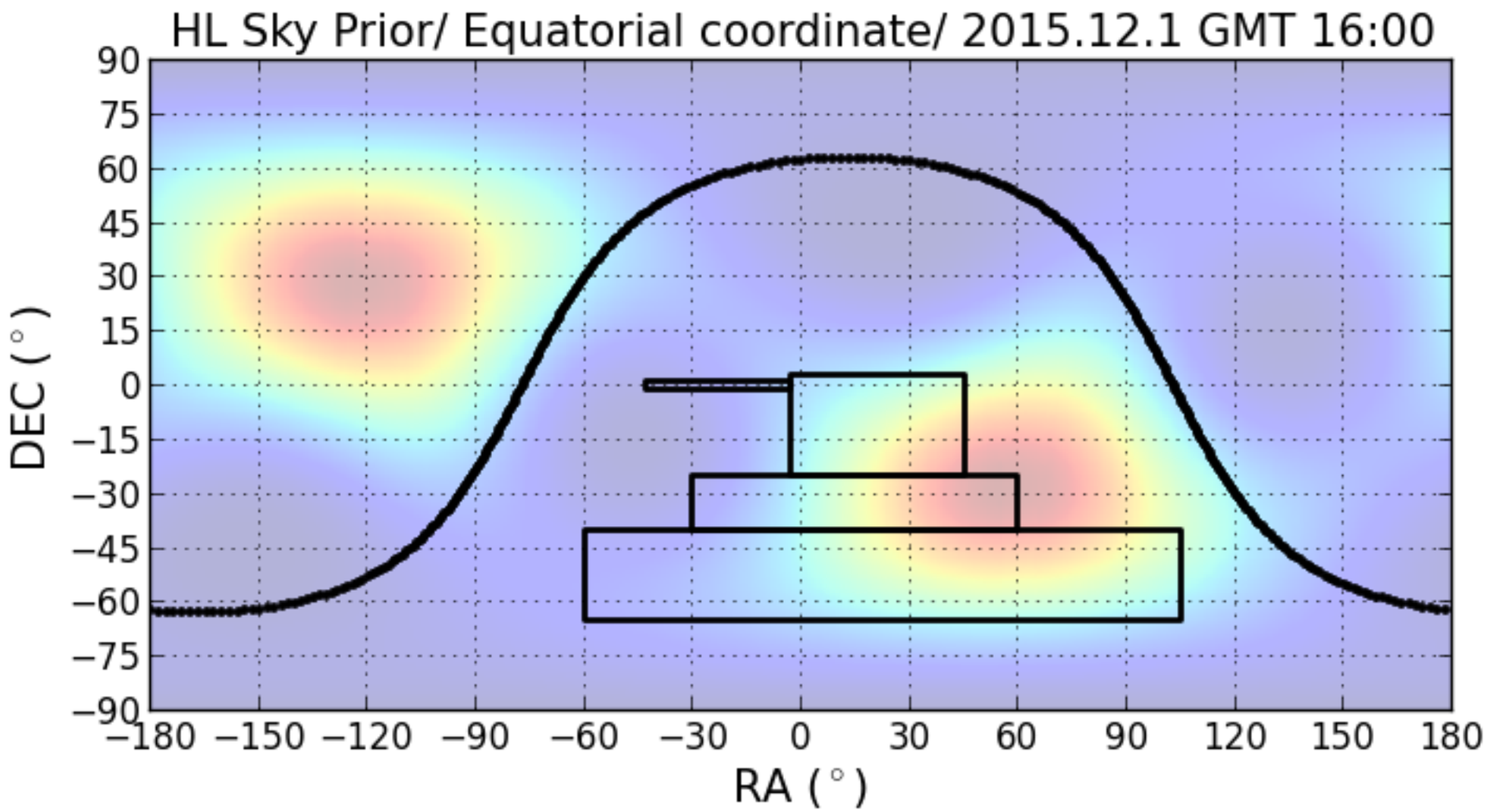
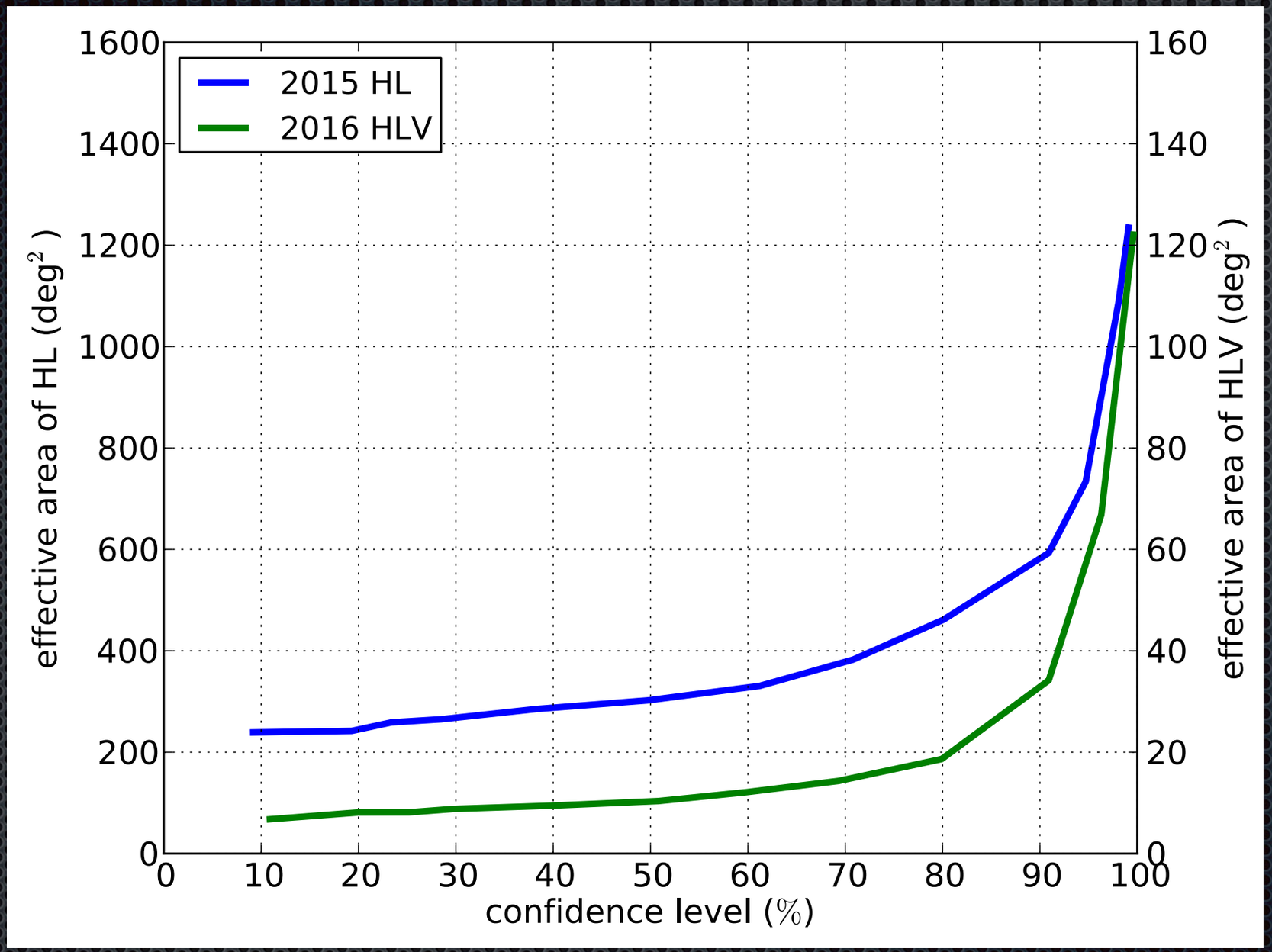


Aug-Jan: Daytime, kilonova

Feb -Jul: Nighttime, precursor

Effective Area=Area/confidence



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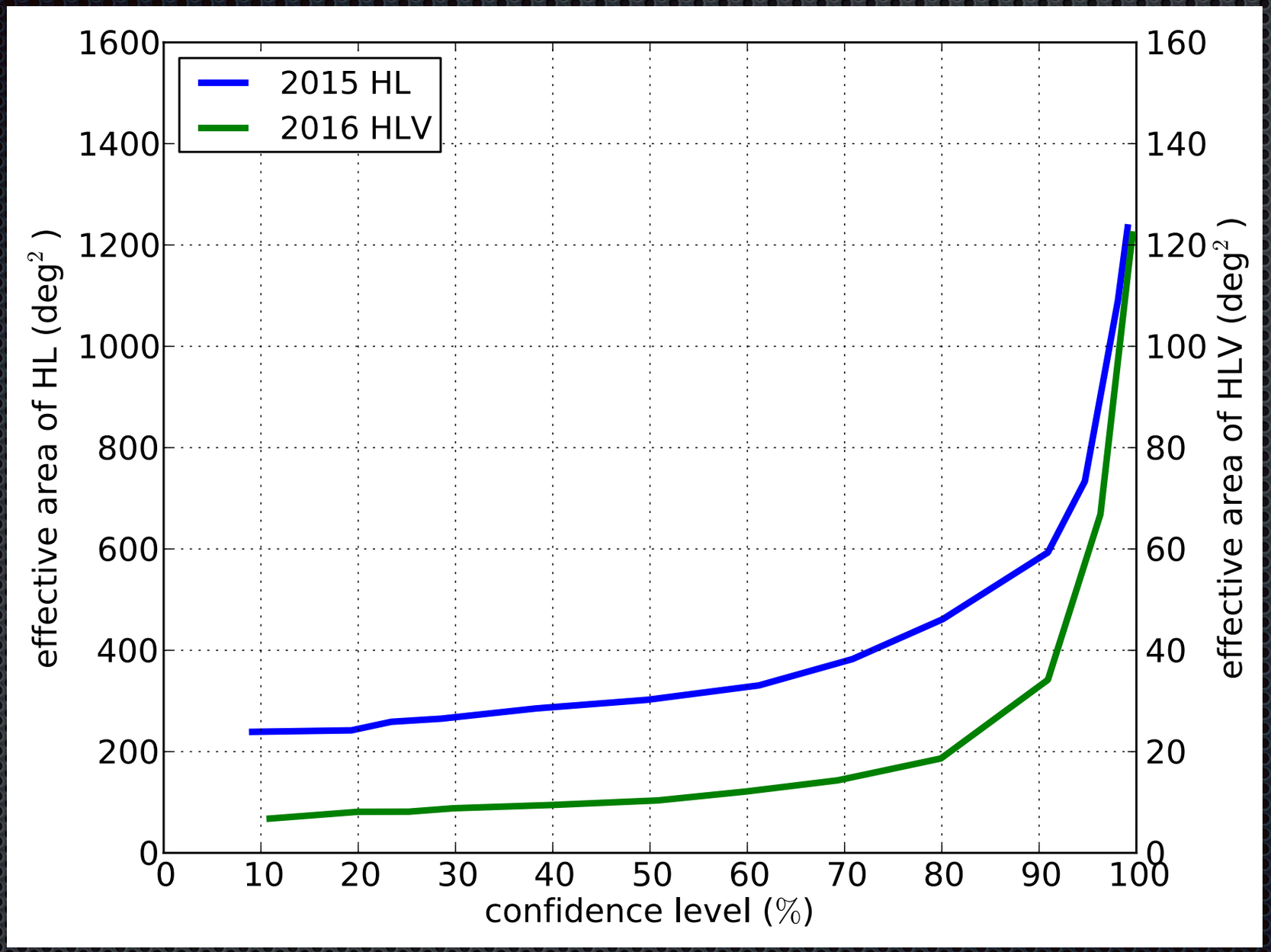
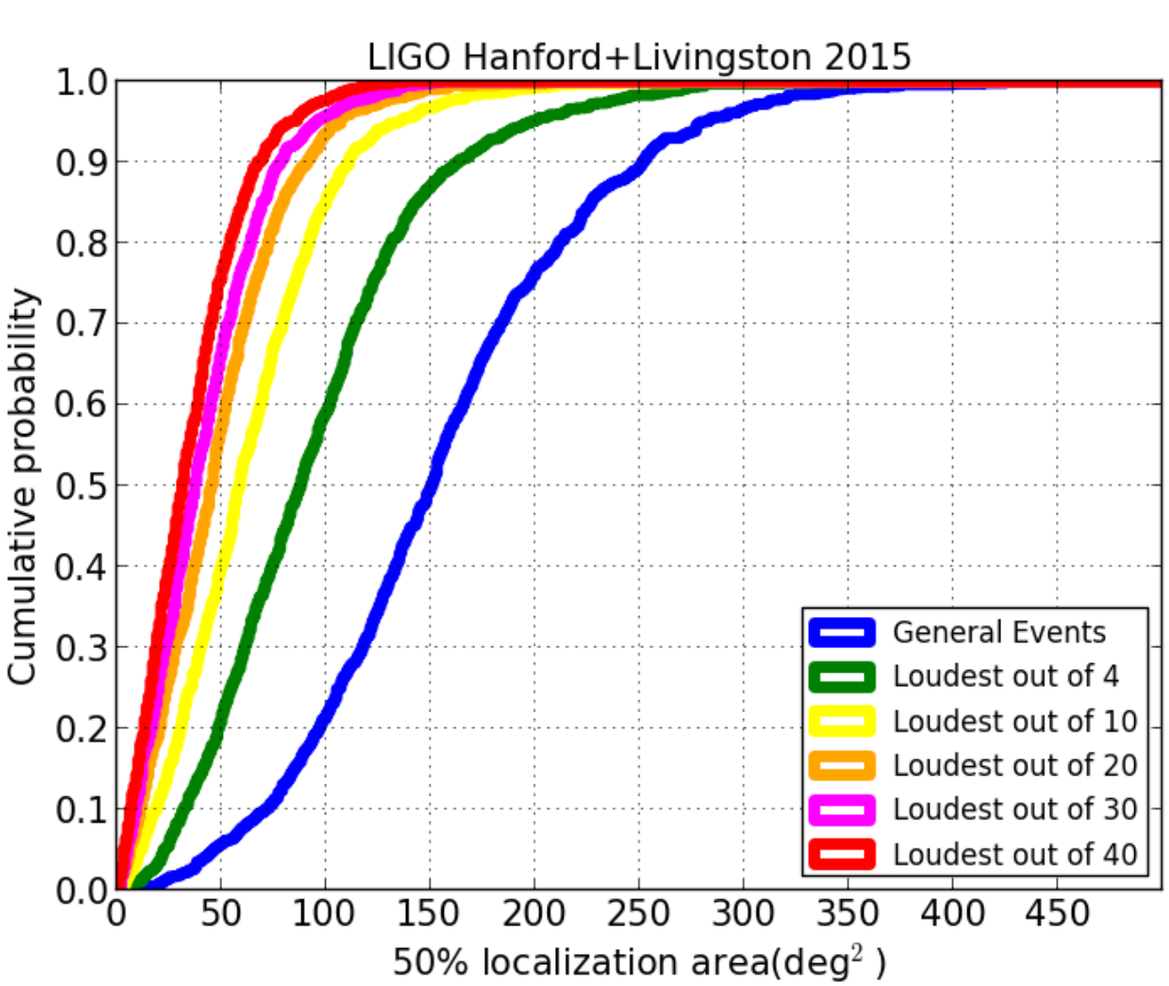
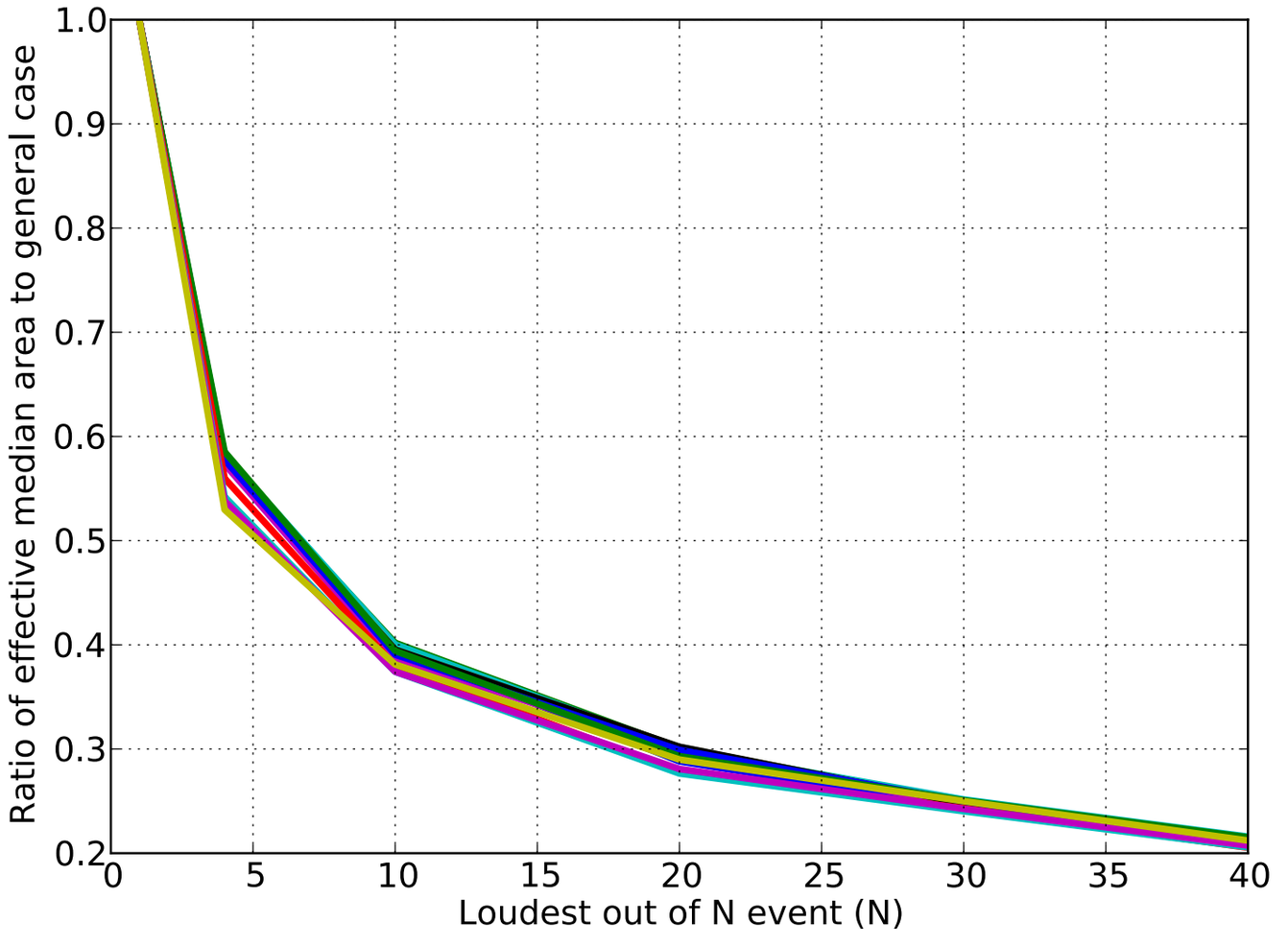


- Efficiently cover the area

Localization Improvement from the Loudest Event





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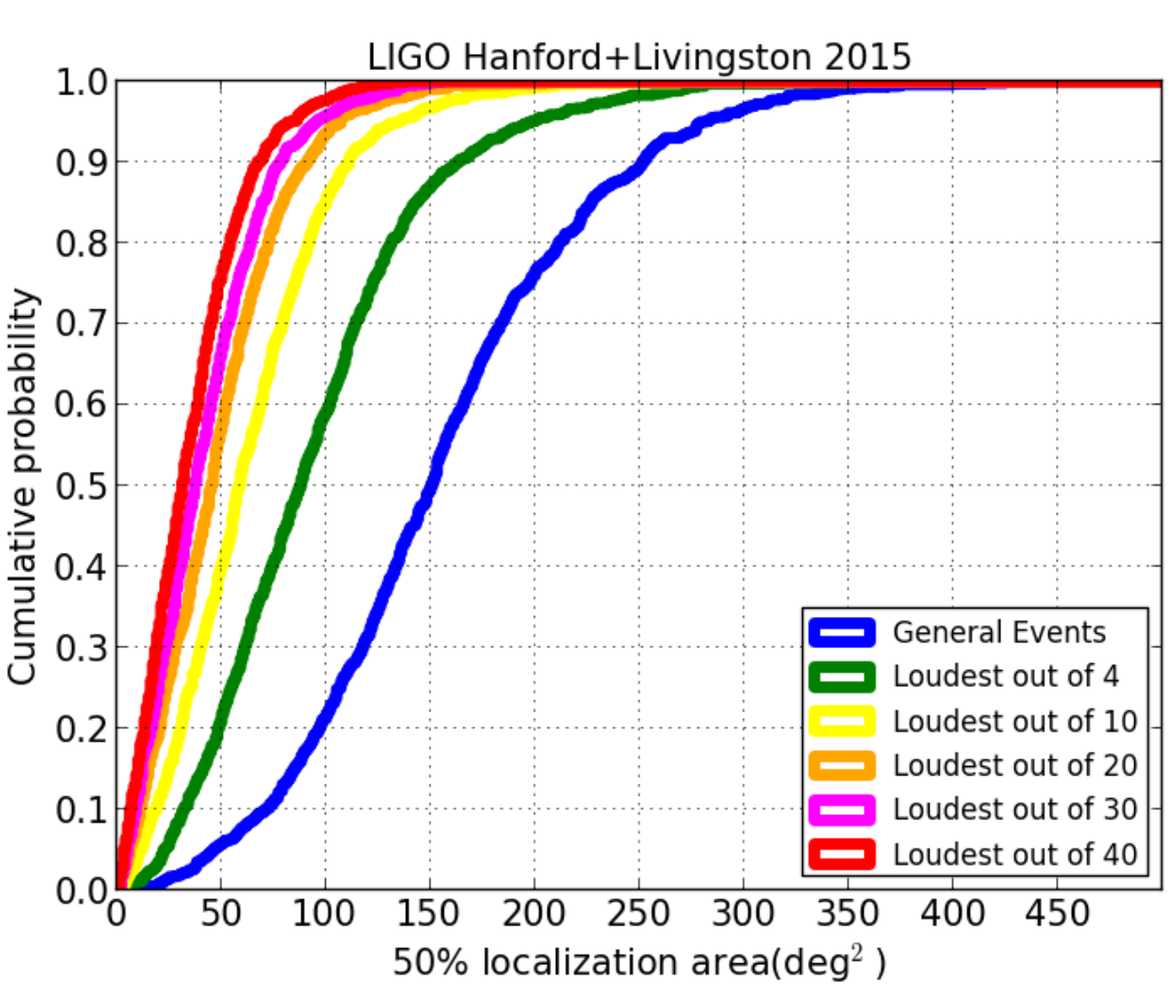
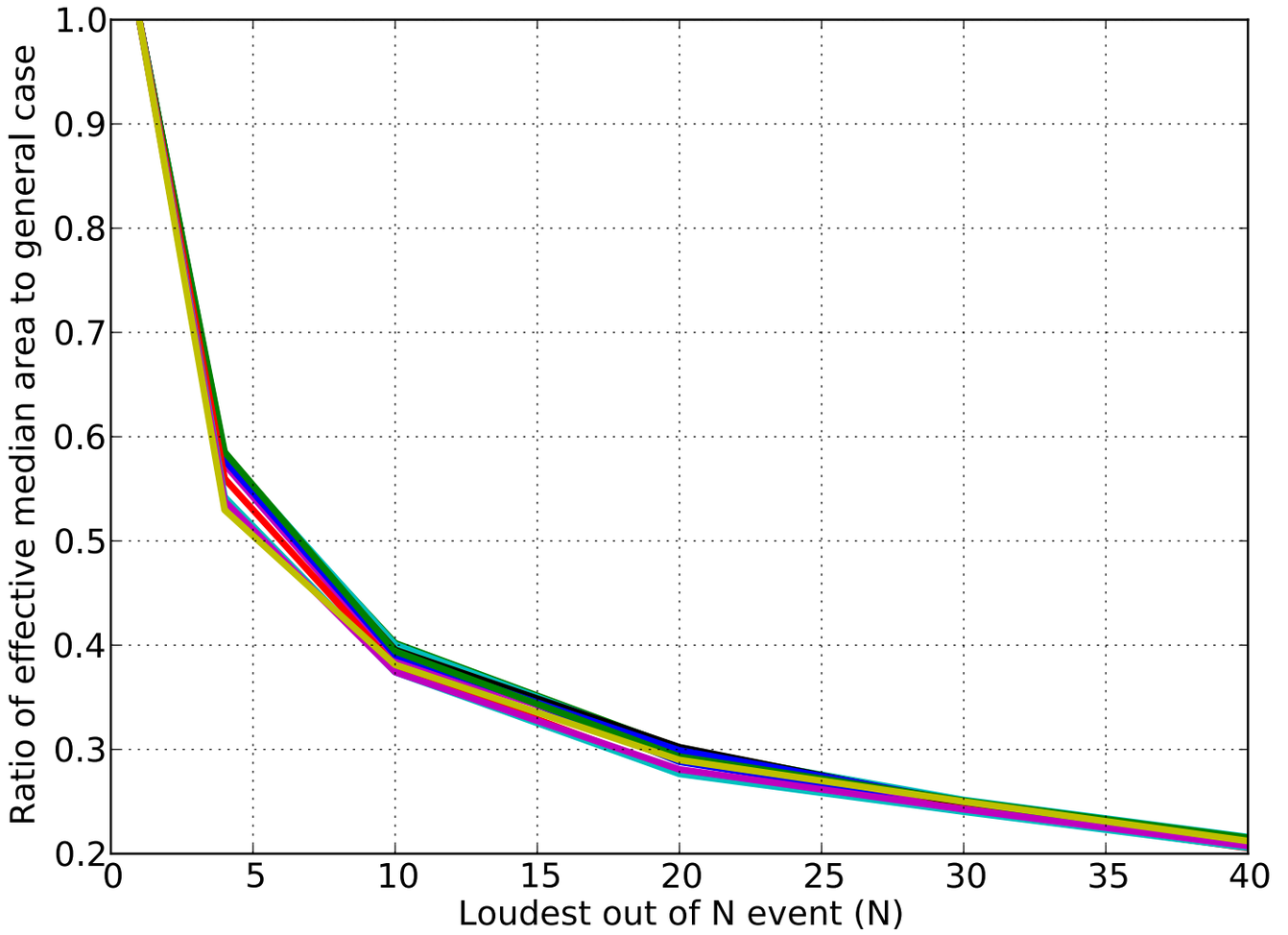
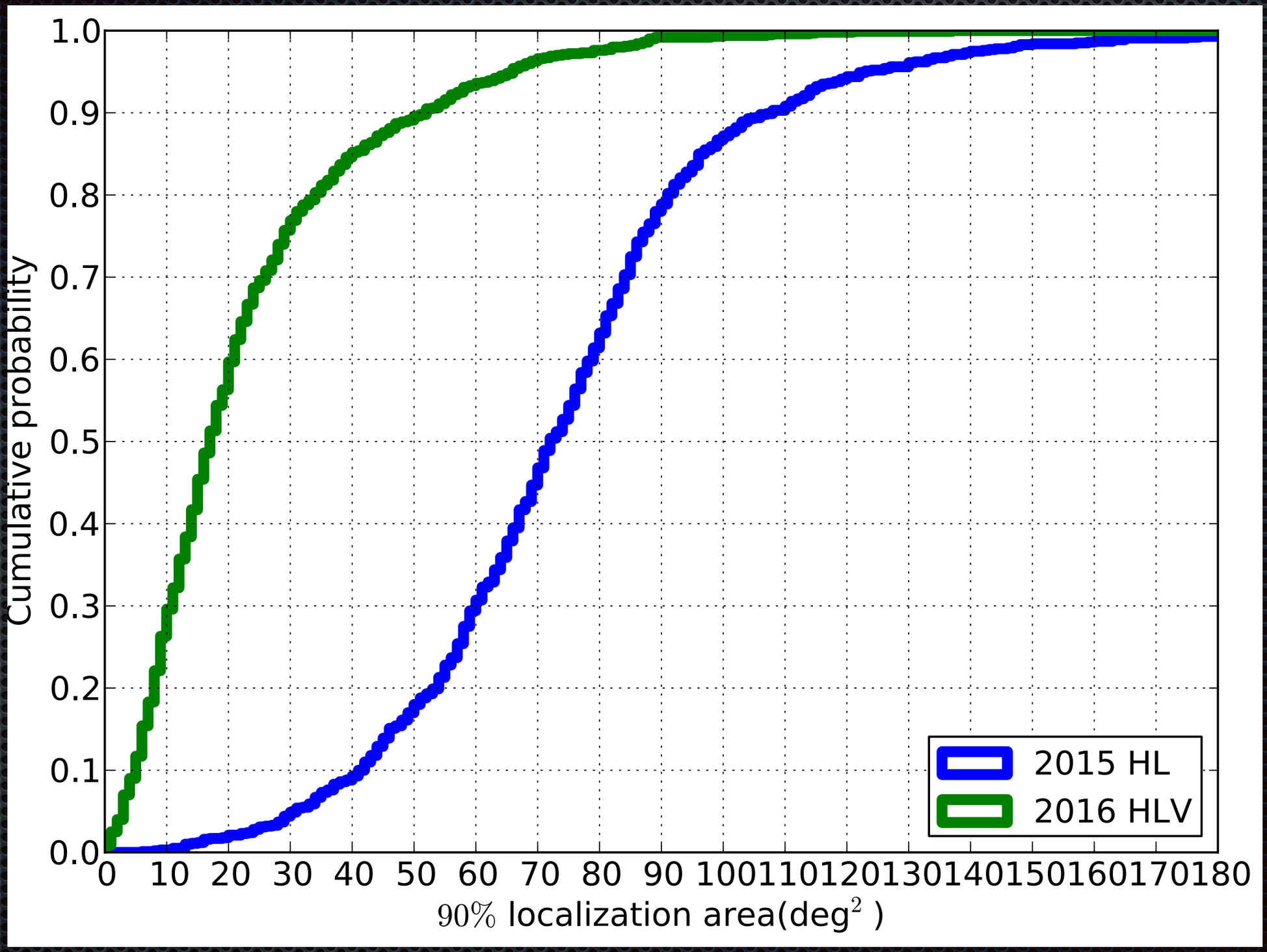




- Carefully select event

Fermi GBM-GW Joint Detection



Sub-second Localization

- Sky prior $f(\theta, \phi)$
- Only two input: arrival time and SNR
- Utilize the SNR ratio: $\rho \sim \frac{\mathcal{M}^{5/6}}{D}(\Omega(\theta, \phi, \iota, \psi) I_7)^{1/2}$

$$\frac{\rho_i}{\rho_j}(\theta, \phi, \iota, \psi) = \left(\frac{\Omega_i(\theta, \phi, \iota, \psi)\, I_{7,i}}{\Omega_j(\theta, \phi, \iota, \psi)\, I_{7,j}} \right)^{1/2}$$

- Pre-grid and pre-calculate: table lookups and compare