Compact Binary Formation History from Cross-correlation studies

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@EPS5:Unlocking Gravity through Computation

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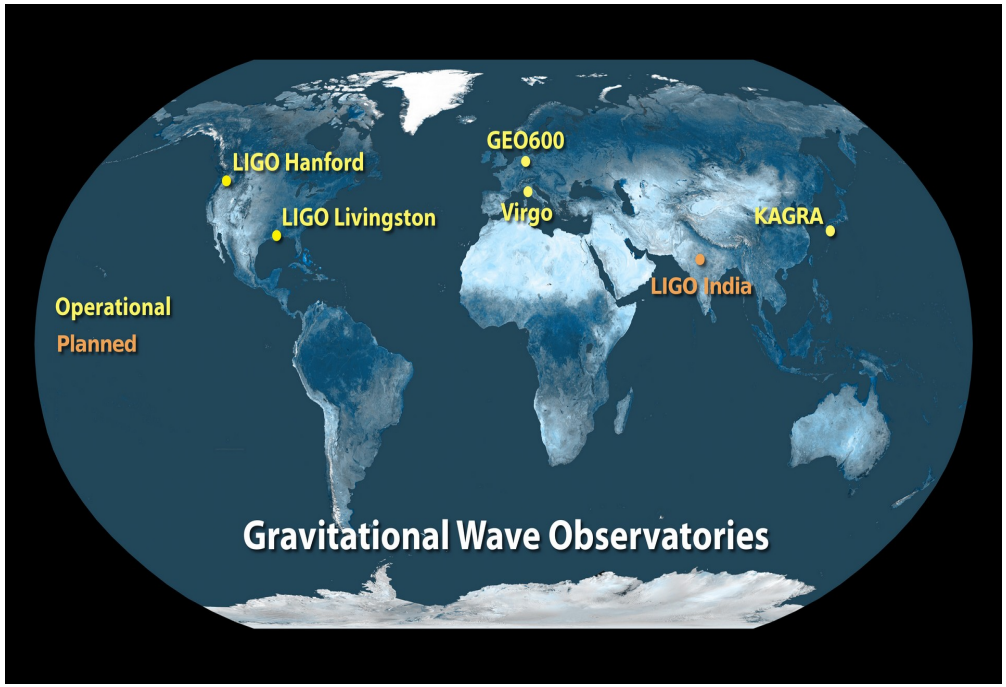
Outline of Presentation

- Statistics of merger events: Past and future
- Probable(?) merger pathway.
- Linkage of mergers and LSS
- Computational tools necessary
- Preliminary results
- Conclusion

Merger Statistics: Detectors

Current Generation detector network (CG)



Catalogue	Detectors	BBH	BNS	Total
GWTC-1 (Aug, 2017)	HL+V	10	1	11
GWTC-3 (Mar, 2020)	HLV+K	>75	2	~90

Image Credit: www.ligo.caltech.edu

Table from: gwosc.org/eventapi/html/allevents/

Merger Statistics: CG/XG

Next Generation (**XG**) detectors
a) 1 X Einstein Telescope
b) 2 X Cosmic Explorer

Noise curves

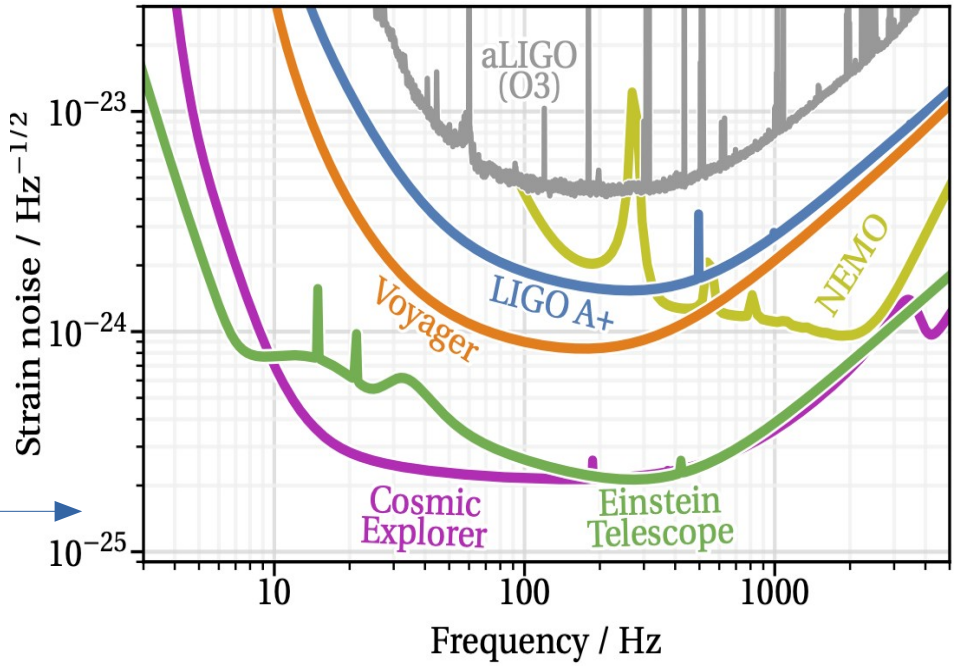


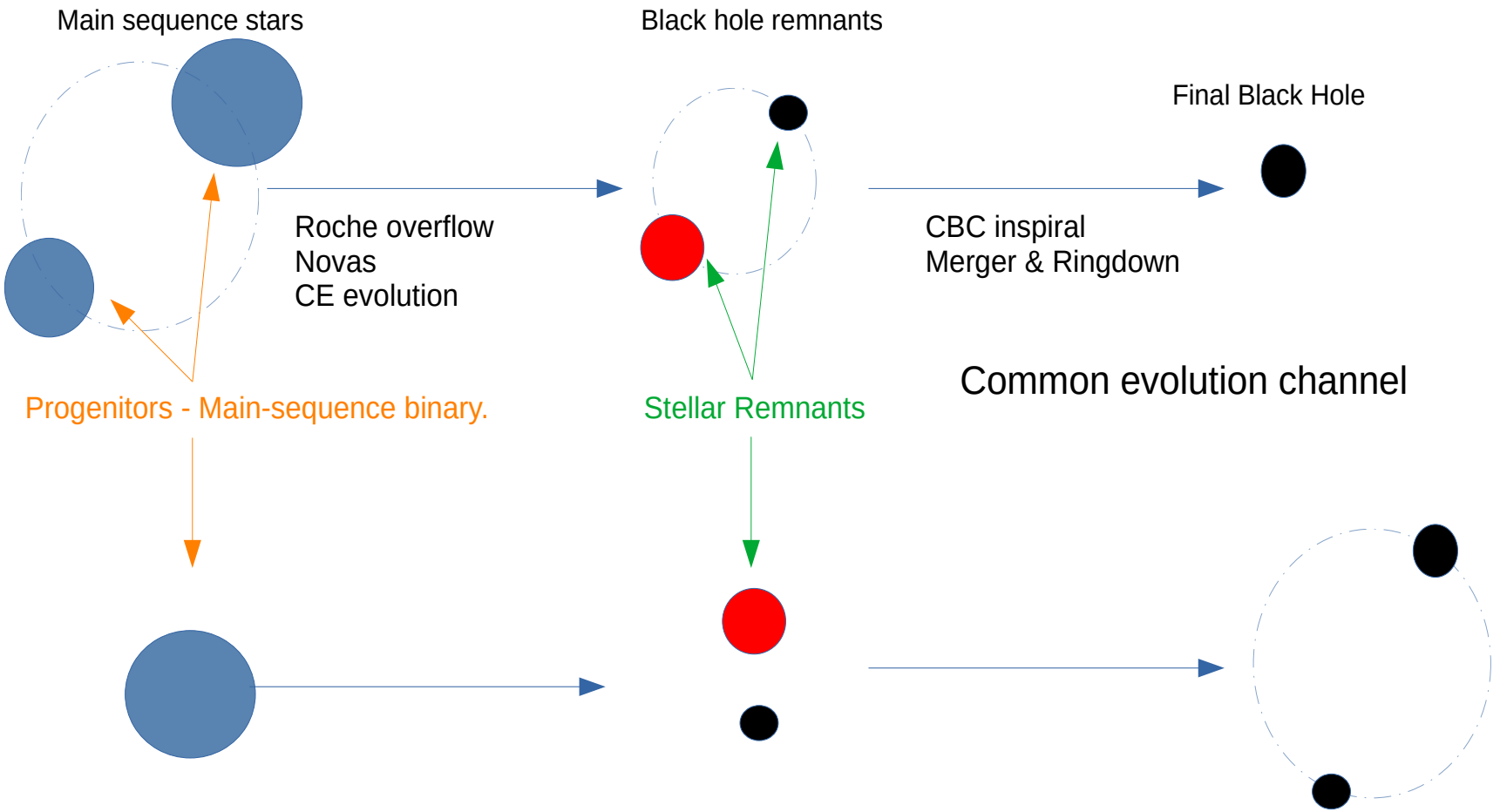
Image credit: cosmicexplorer.org/sensitivity.html

Detector Network	Detection Rate [yr^{-1}]
HLVIK (CG)	~ O(10^2)
ET2CE (XG)	~ O(10^4-10^5)

Detection statistics

Baibhav et.al., PhysRevD.100.064060

Merger Pathways



Observations & Uncertainties

Common Evolution (CE) possibly more common

- Star-to-BH population vs redshift
- Spin-alignment in obs (?)
- Spin not well-measured.

Uncertainty within CE

- Stellar-endpoint transfer function (?)
- Disruption from kicks
- Does a kick happen (?)
- Is the kick isotropic (?)

The Answer that matters

- Require dedicated Hydrodynamical Simulations & population synthesis simulations
- Computationally 'very' expensive.

Semi/Analytical Handles ?

- Stellar endpoint $m_i \rightarrow m_f$
- All uncertainties packed into $\Delta\tau$
- $P(\Delta\tau) \sim (1/\Delta\tau)^{\alpha}$

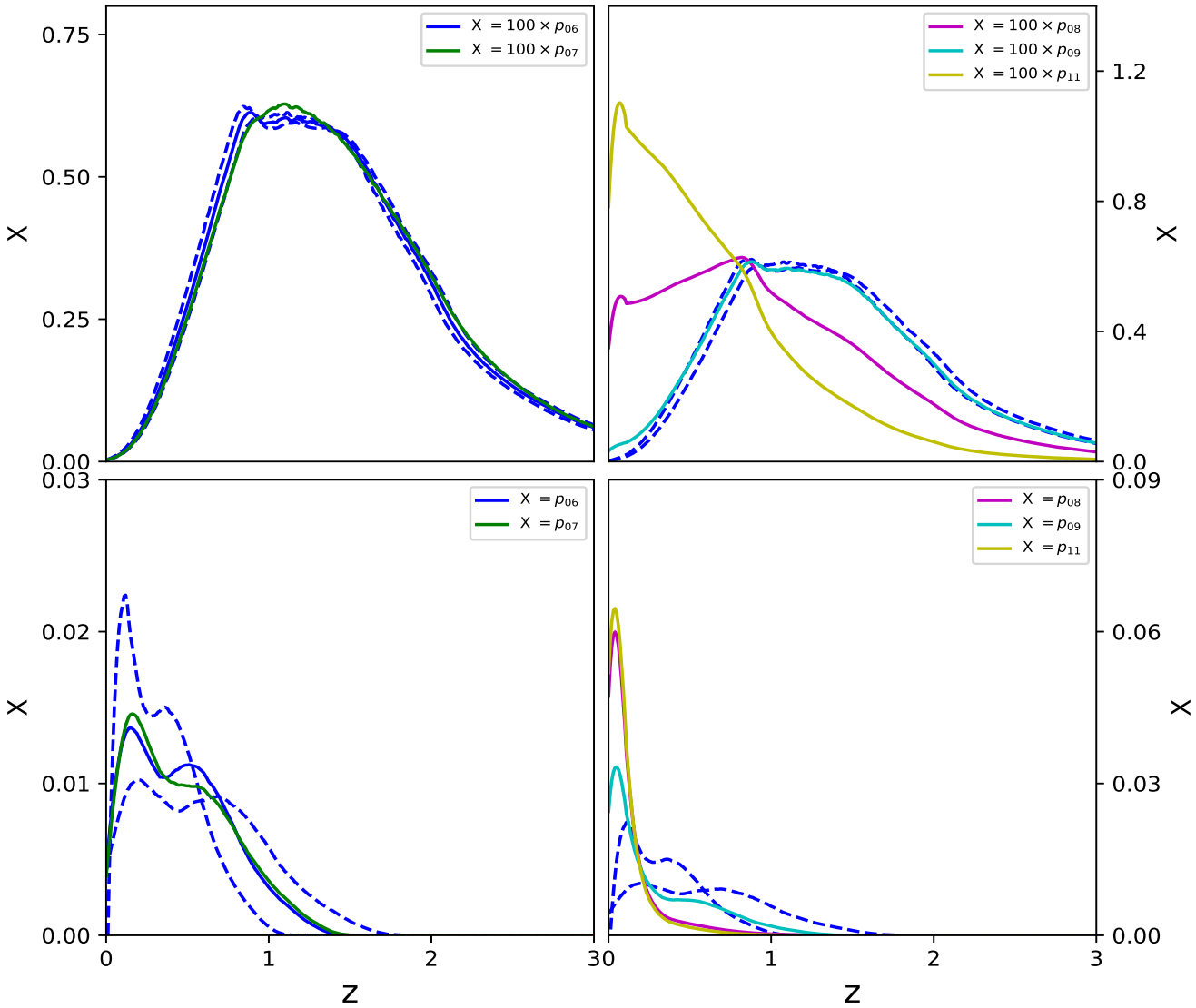
Merger Catalogues

Merger Catalogues with Mass transfer and Delay

Catalogue	Mass Transfer	α	$N_{\rm xg}/600$
06	Rapid-Nova	1.00	80024
07	Delay-Nova	1.00	82067
08	Rapid-Nova	0.75	7984
09	Rapid-Nova	0.95	45111
11	Rapid-Nova	0.50	3908

Baseline Catalogue is 6

Redshift distribution of **detected** mergers: XG (above) & CG



Large scale structure & mergers

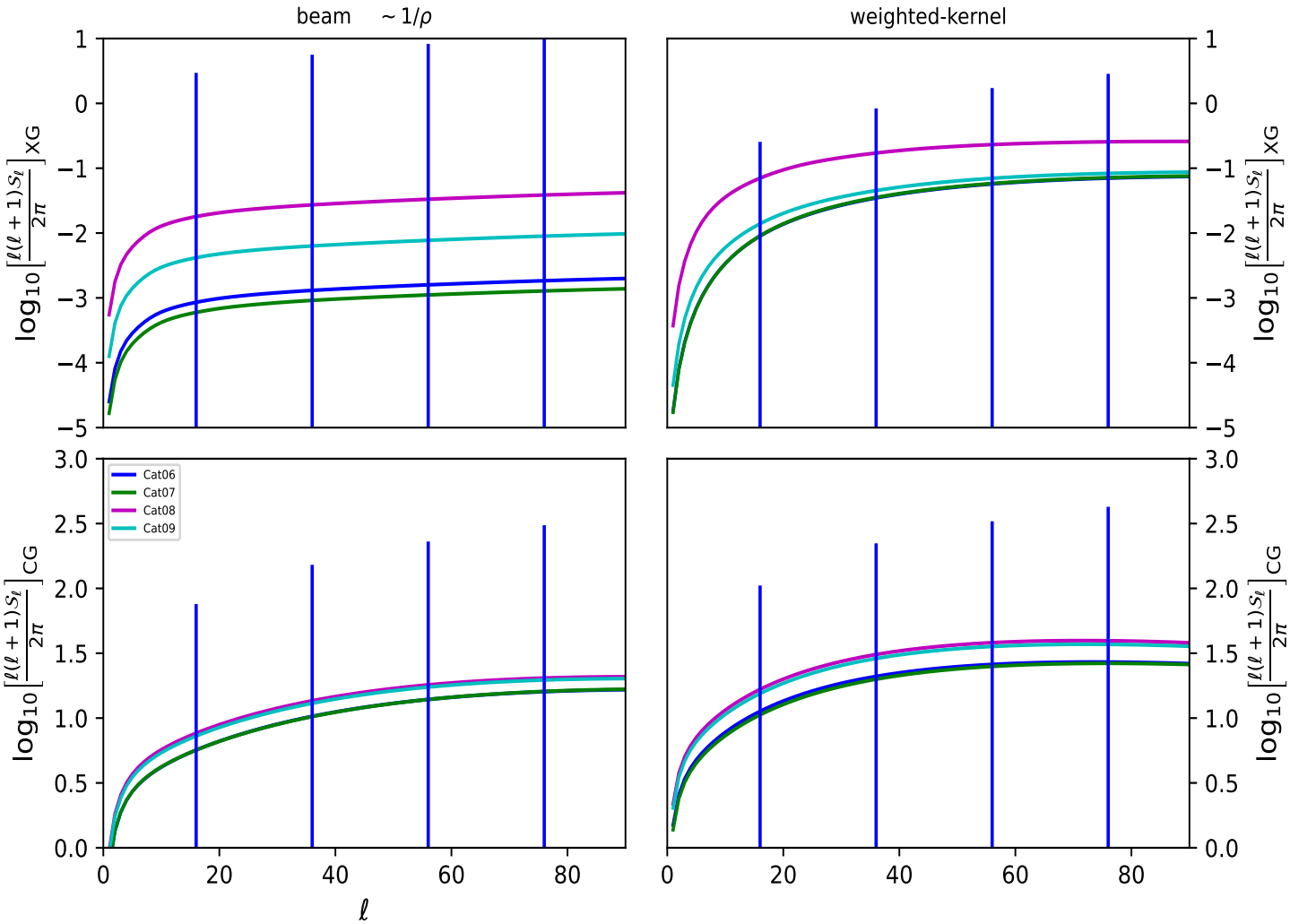
Galaxys and GWs

- Mergers should happen in Galaxies
- Nearly same power spectrum
- Should Cross-correlate if the z-distribution correlates

XCs with Galaxy caltalogue: 2MRS

- Carry signature of α, transfer
- Dependent on detector

Preliminary results of the XC



Computational tools

Necessary Packages

- Galaxy Catalogs: Numpy/Scipy libraries
- Detected events: SNR calculation using PyCBC
- XC: Calculation of Kernels/Angular spectrum using PyCCL
- PyCBC/PyCCL - Python based open source software.

Caution!

- Numpy/Scipy or PyCBC stable libraries
- PyCCL - prone to version conflicts.

Conclusion

- Pathways will affect detection rate
- α causes the greater impact - possibly strong constraint
- Mass transfer is finer detail - possibly needs EM input
- XCs will carry the signature of pathway.