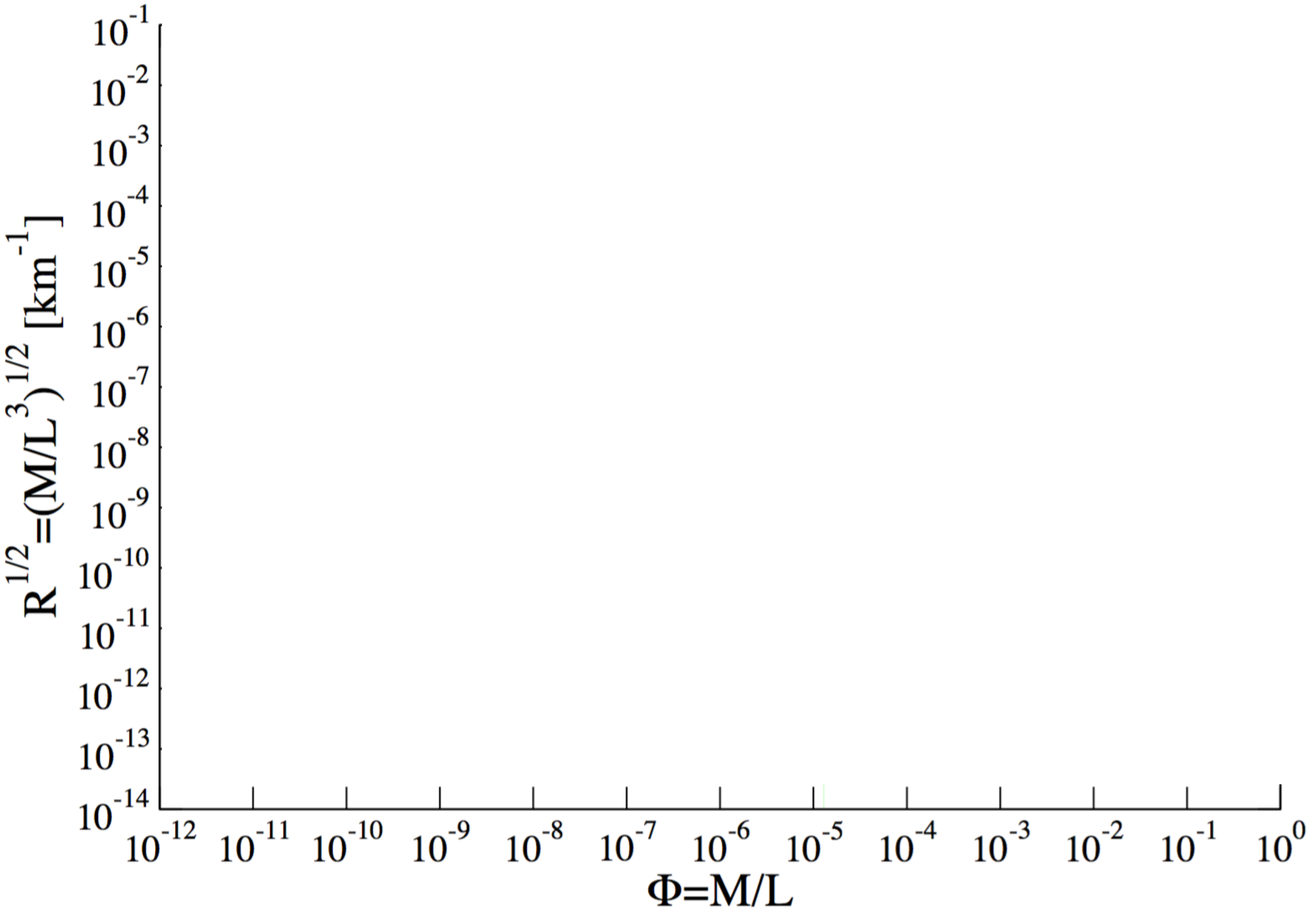
What will LISA reveal about theoretical physics?

Nicolas Yunes
eXtreme Gravity Institute
Montana State University

for the PCOS GWSIG

April APS Meeting, Columbus, Ohio
April 14th, 2018

What Physics Regime do GWs Probe?



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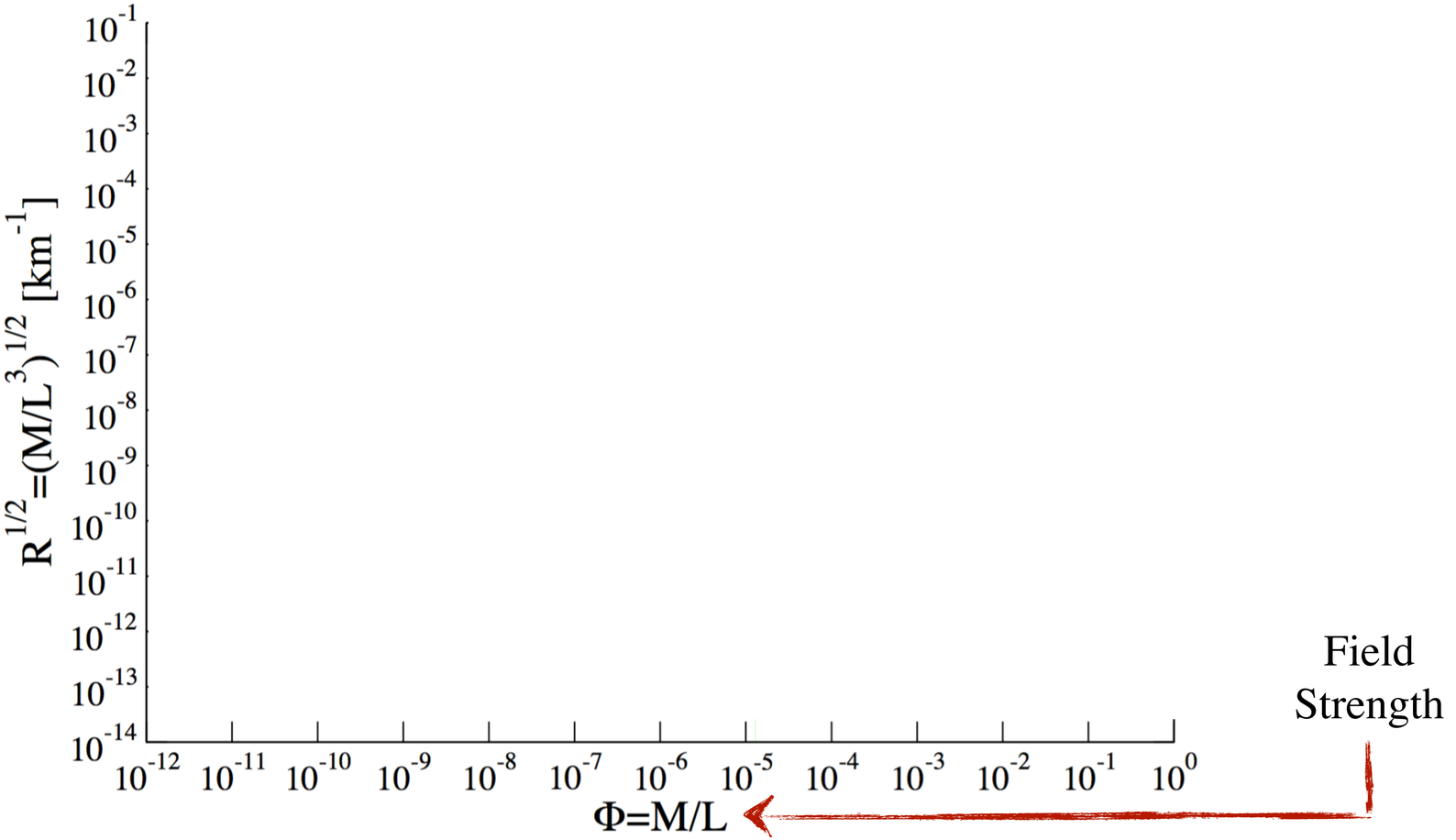

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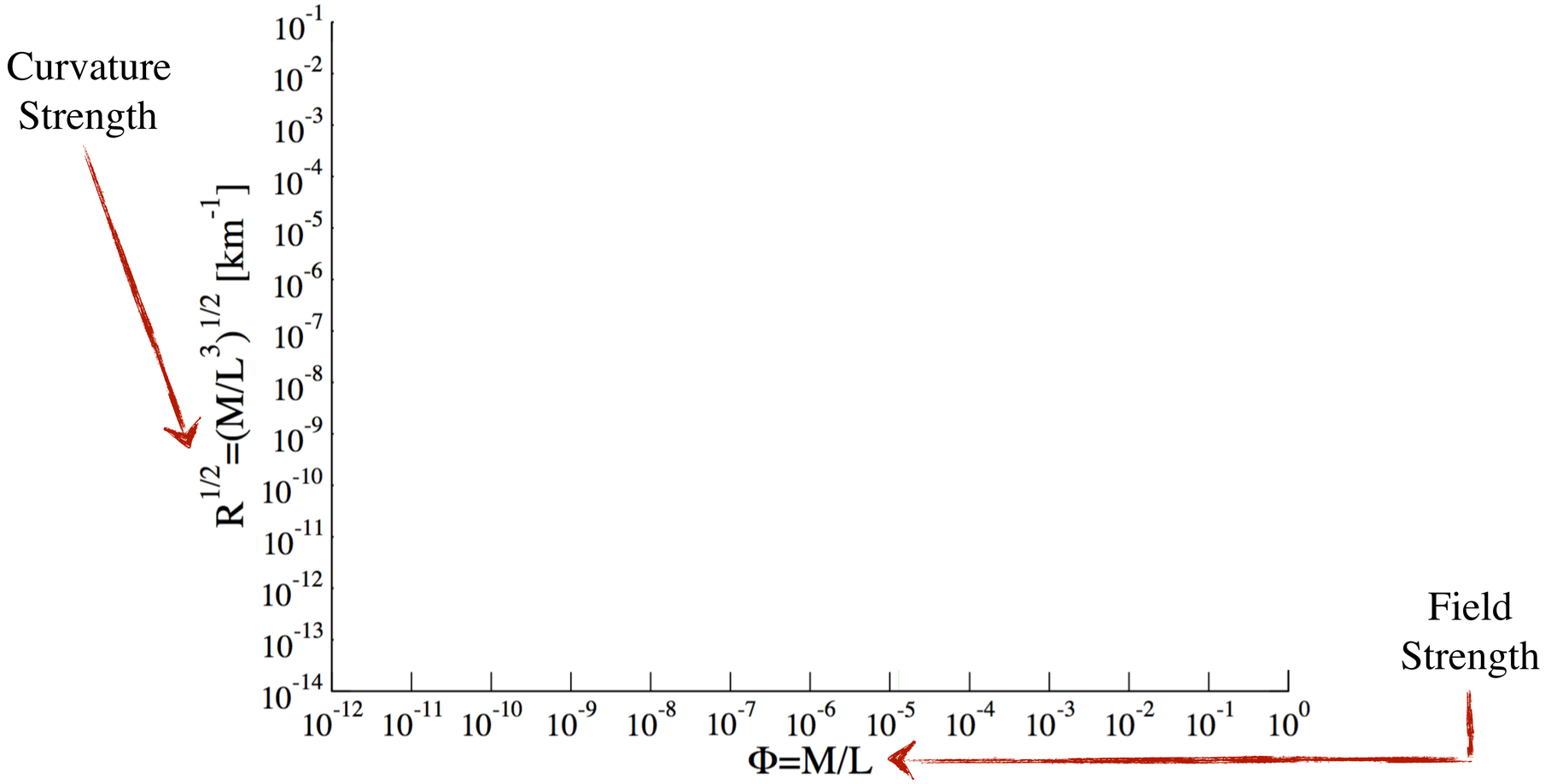

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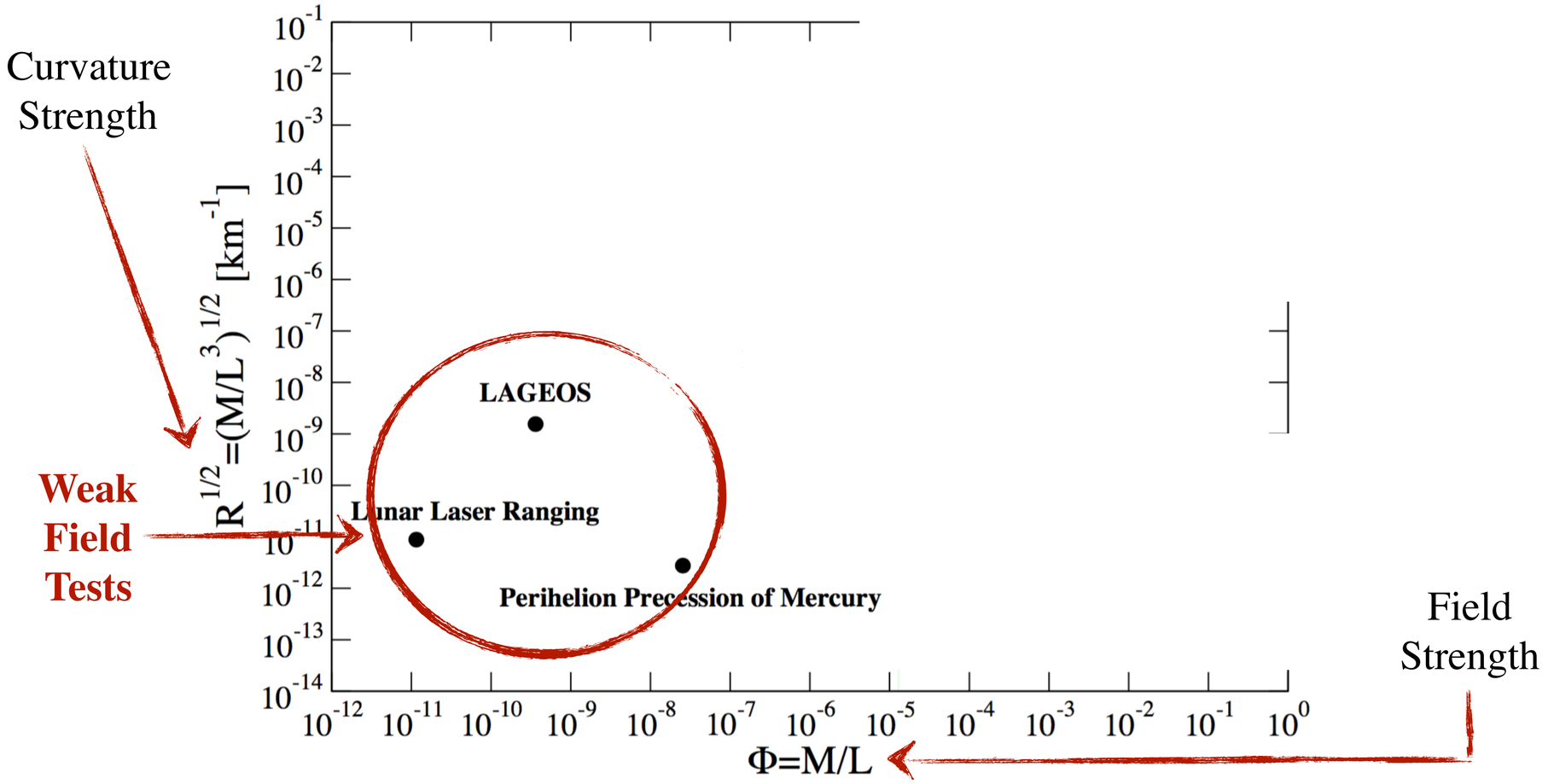

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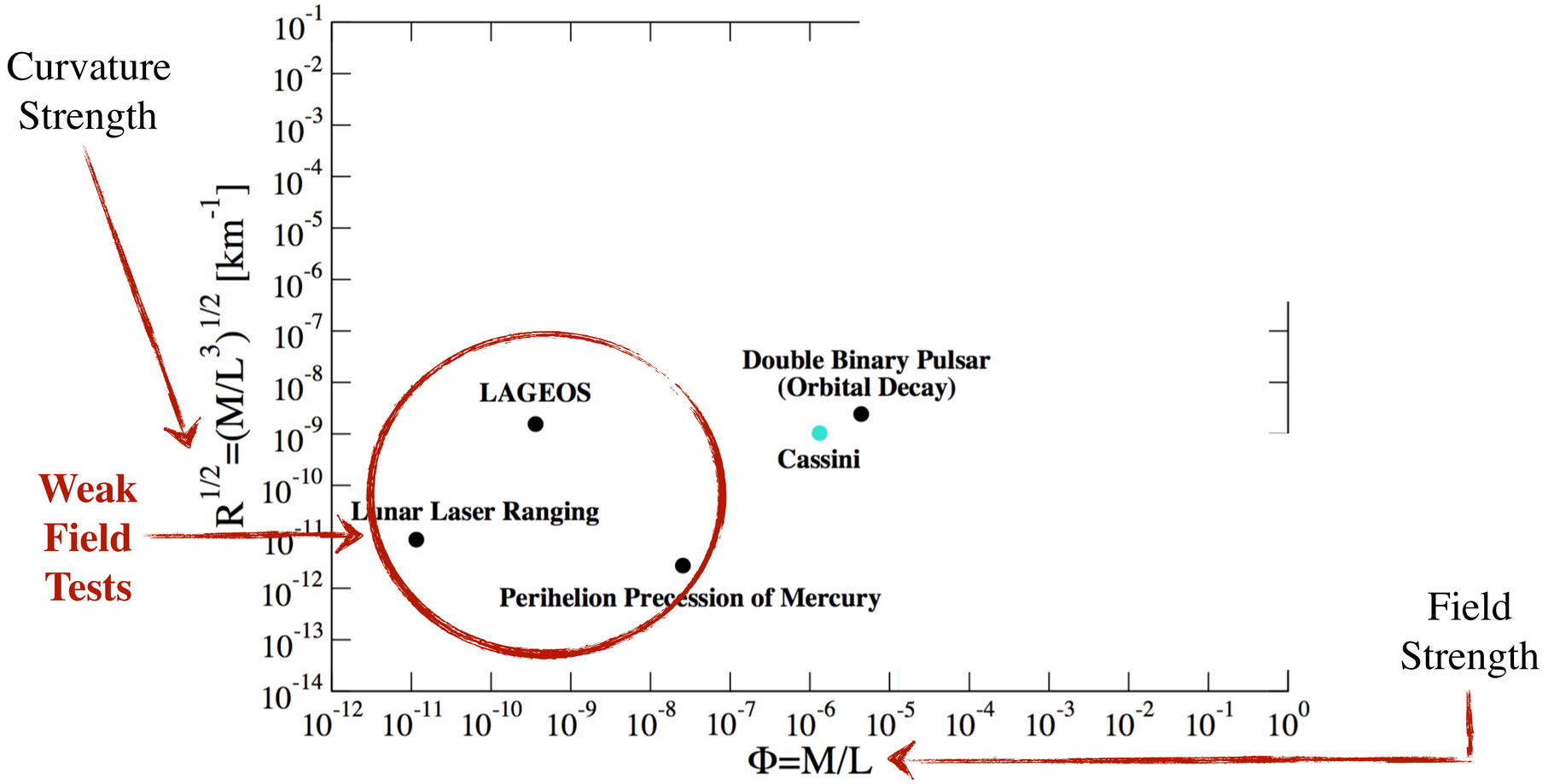

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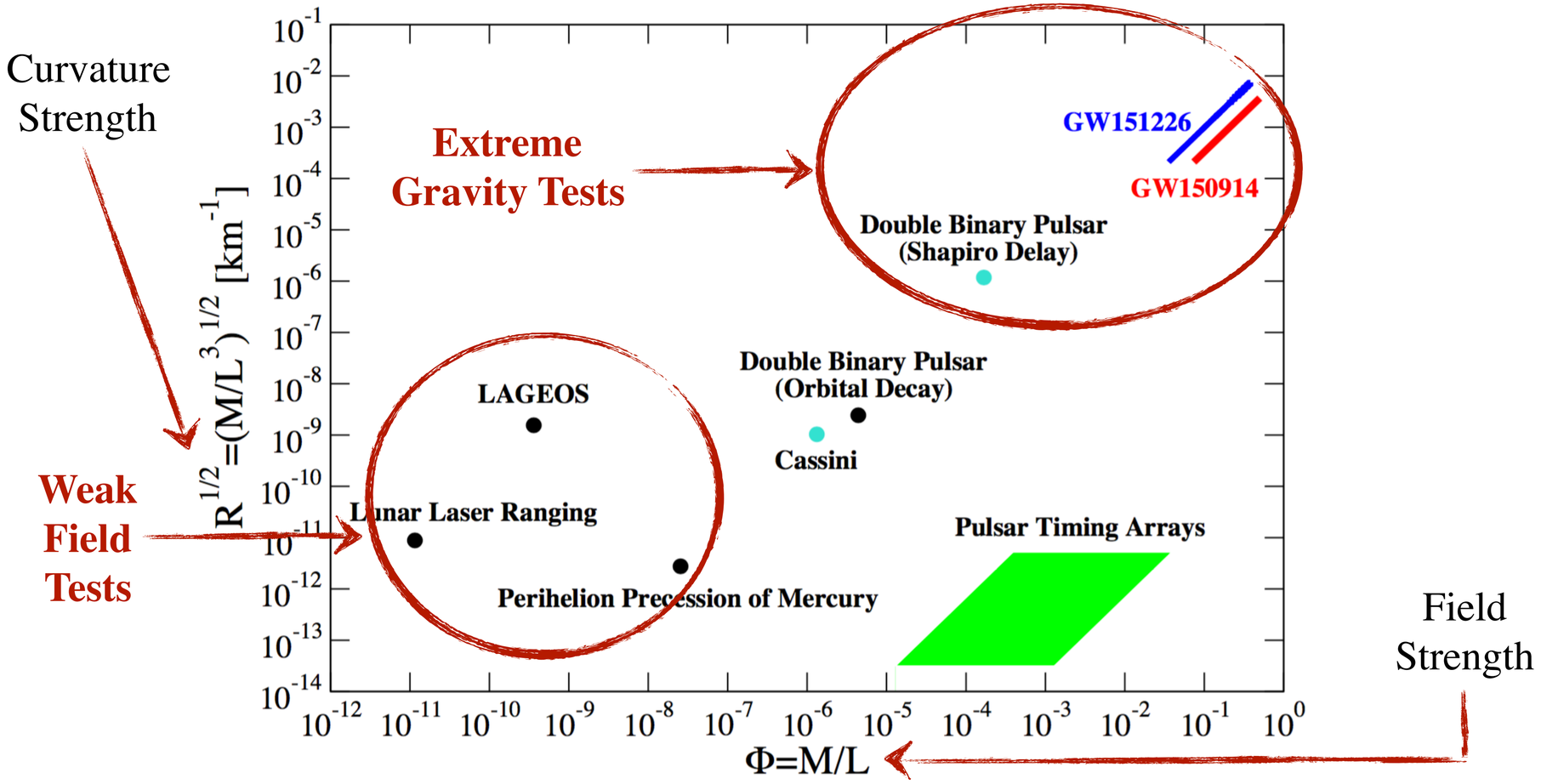

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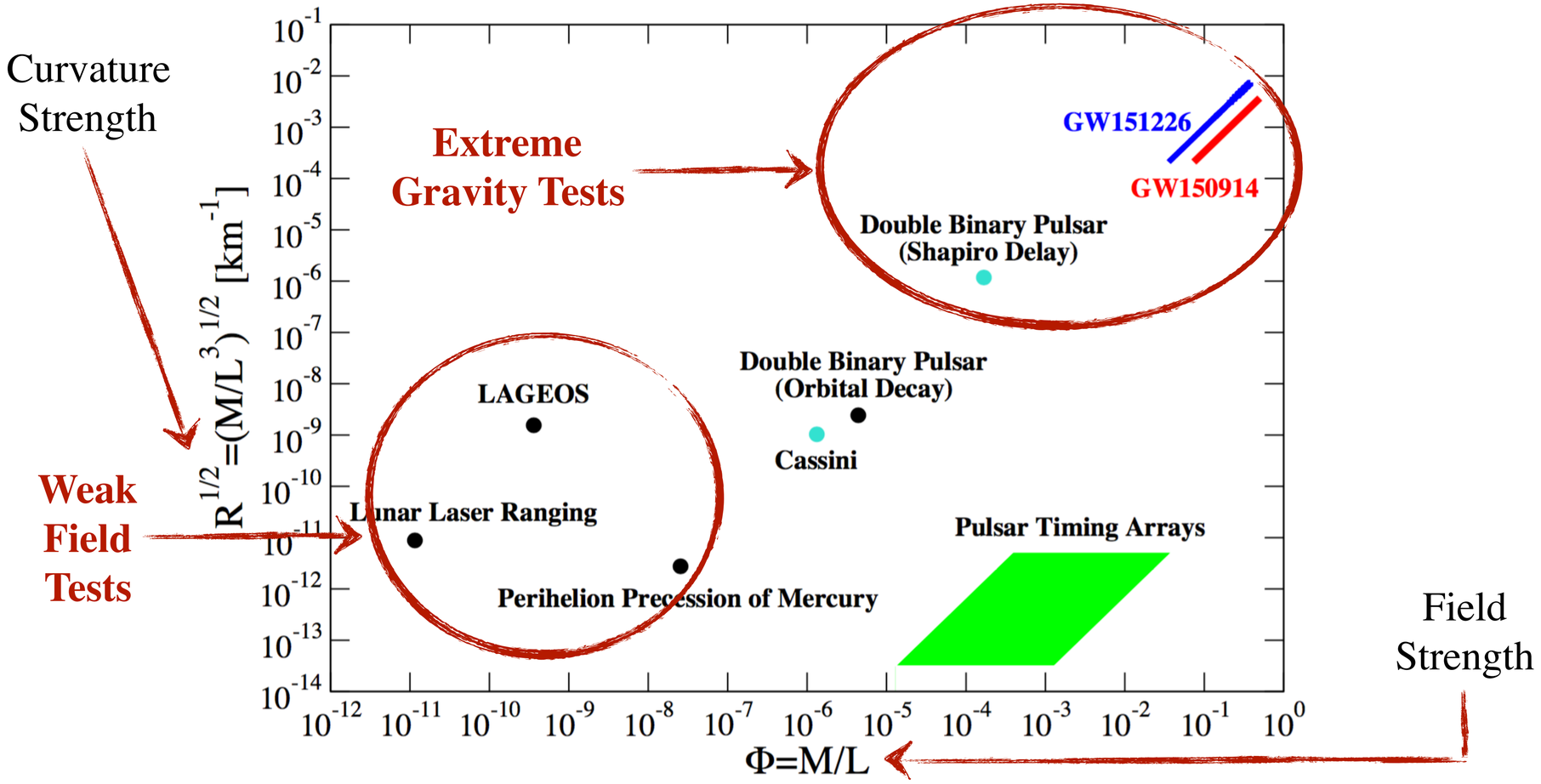

GWs probe eXtreme Gravity

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Stochastic Backgrounds — **Cosmological modified gravity, cosmic strings**

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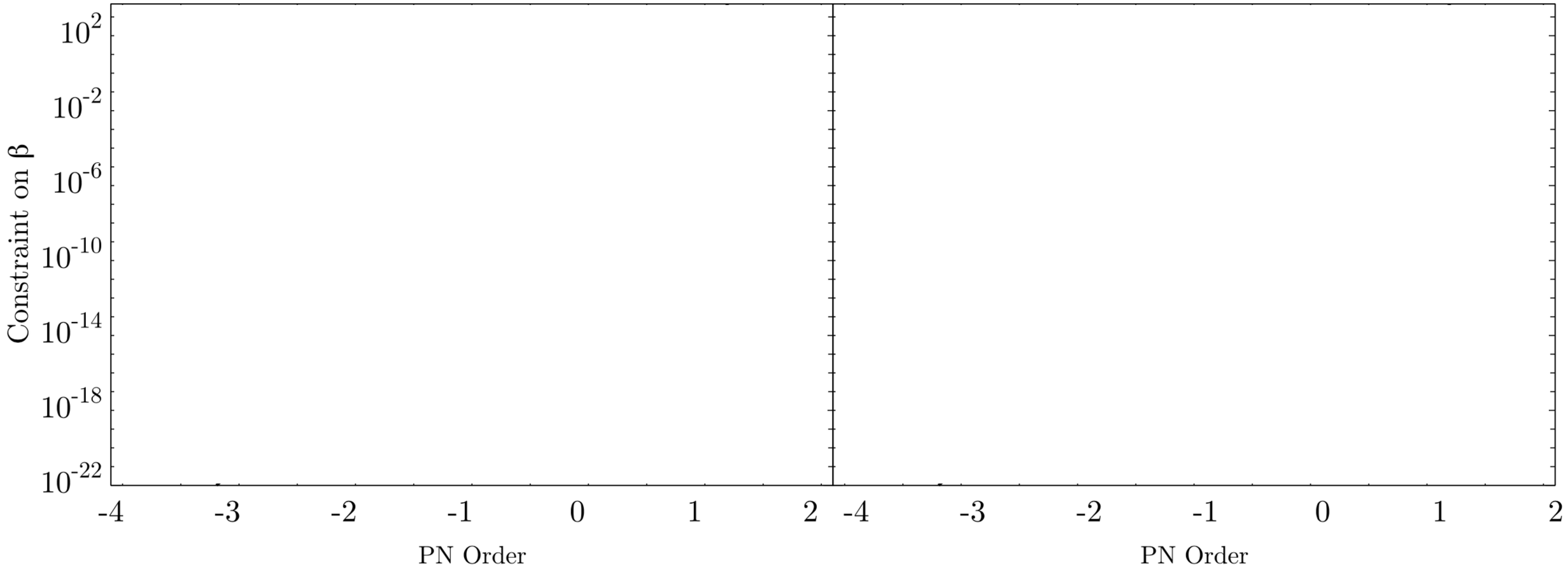
Theoretical Effect	Theoretical Mechanism	Theories	ppE b	Order	Mapping
Scalar Dipolar Radiation	Scalar Monopole Field Activation	EdGB [140, 142, 149, 150]	-7	-1PN	$\beta_{\rm EdGB}$ [140]
	BH Hair Growth	Scalar-Tensor Theories [59, 151]	-7	-1PN	$\beta_{\rm ST}$ [59, 151]
Anomalous Acceleration	Extra Dimension Mass Leakage	RS-II Braneworld [152, 153]	-13	-4PN	$\beta_{\rm ED}$ [141]
	Time-Variation of G	Phenomenological [137, 154]	-13	-4PN	$\beta_{\dot{G}}$ [137]
Scalar Quadrupolar Radiation Scalar Dipole Force Quadrupole Moment Deformation	Scalar Dipole Field Activation due to Gravitational Parity Violation	dCS [140, 155]	-1	$+2$PN	$\beta_{\rm dCS}$ [146]
Scalar/Vector Dipolar Radiation	Vector Field Activation due to Lorentz Violation	EA [109, 110], Khronometric [111, 112]	-7	-1PN	$\beta^{(-1)}_{\text{Æ}}$ [113]
Modified Quadrupolar Radiation			-5	0PN	$\beta^{(0)}_{\text{Æ}}$ [113]
Modified Dispersion Relation	GW Propagation/Kinematics	Massive Gravity [156–159]	-3	$+1$PN	$\beta_{\rm MDR}$ [145, 156]
		Double Special Relativity [160–163]	$+6$	$+5.5$PN	
		Extra Dim. [164], Horava-Lifshitz [165–167],	$+9$	$+7$PN	
		gravitational SME ($d=4$) [179]	$+3$	$+4$PN	
		gravitational SME ($d=5$) [179]	$+6$	$+5.5$PN	
		gravitational SME ($d=6$) [179]	$+9$	$+7$PN	
		Multifractional Spacetime [168–170]	3–6	4–5.5PN	

[Cornish et al PRD 84 ('11), Sampson et al PRD 87 ('13), Sampson, et al PRD 88 ('13),
Sampson et al PRD 89 ('14), Yunes, Yagi & Pretorius ('16),
and many, many others…see Yunes & Siemens Living Reviews in Relativity]

Future ppE Constraints

[Chamberlain & Yunes, PRD '17]



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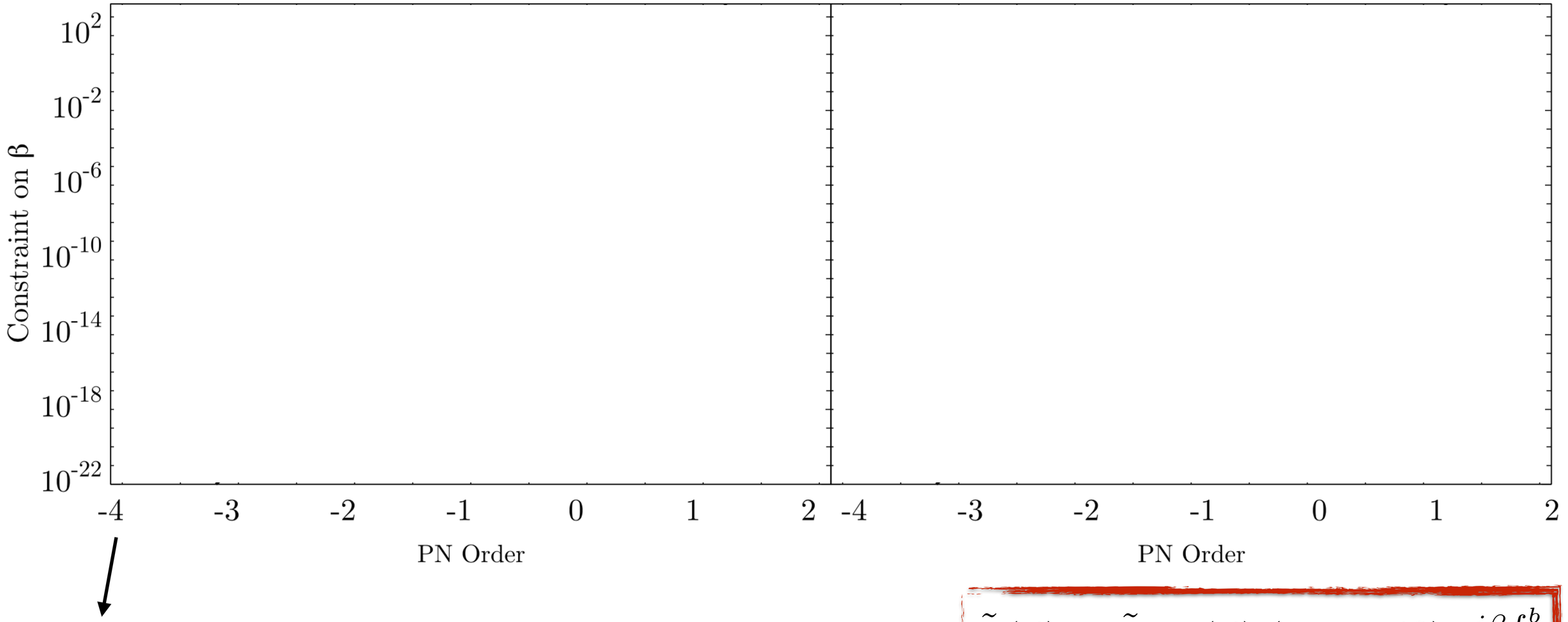

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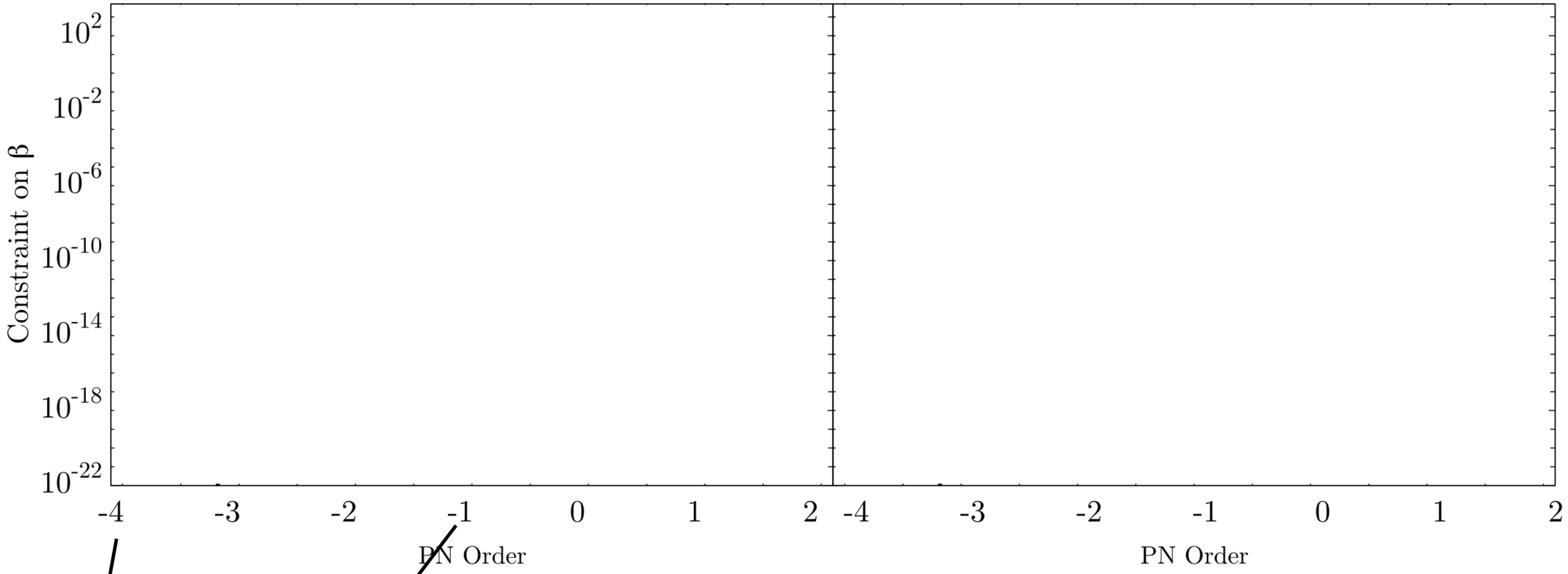

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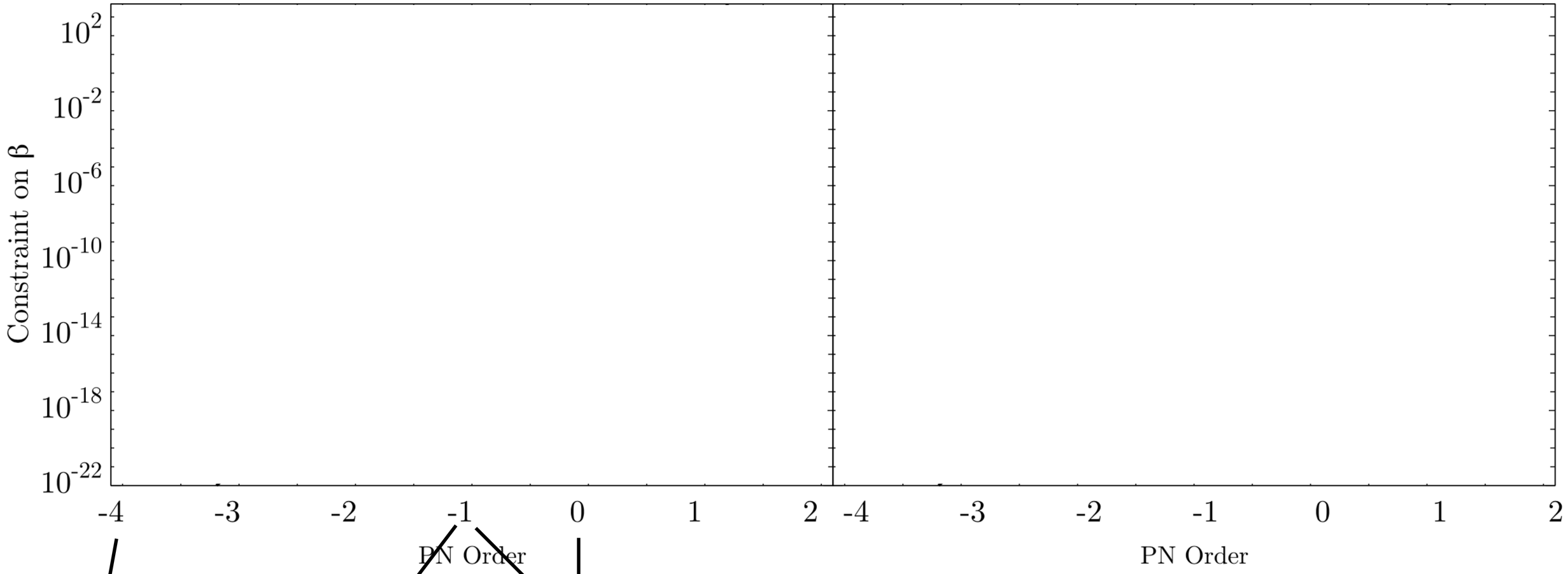

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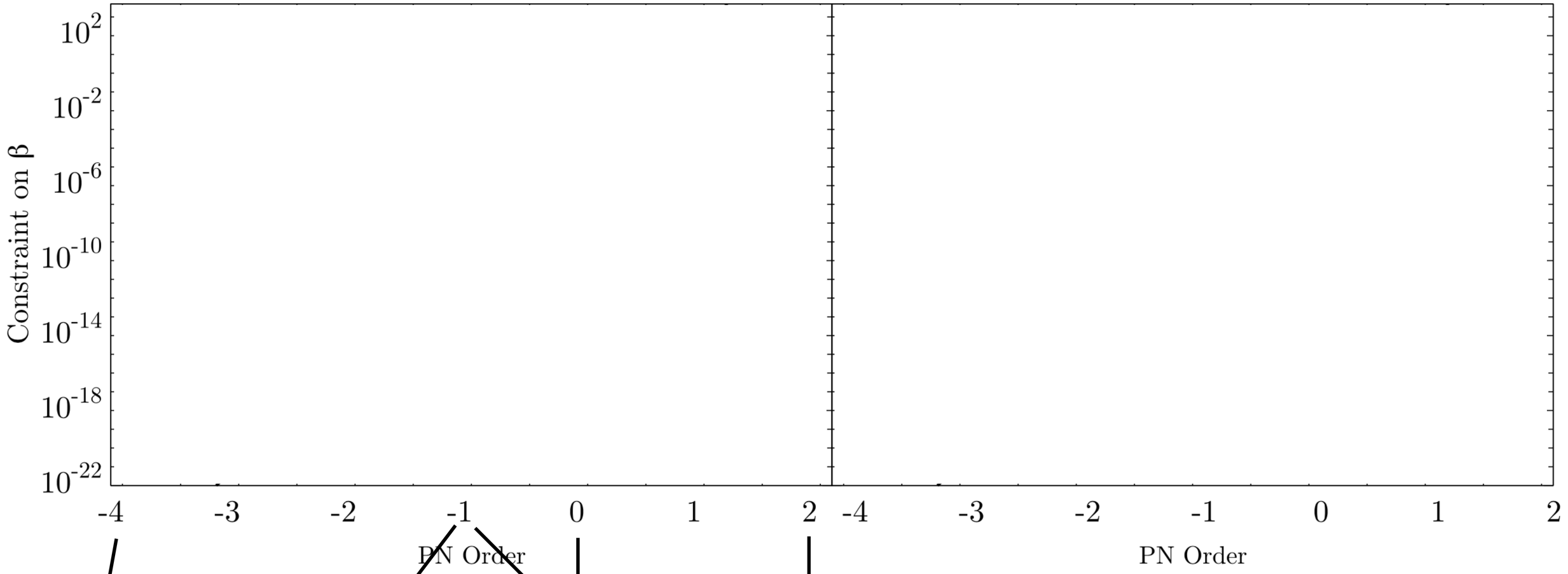

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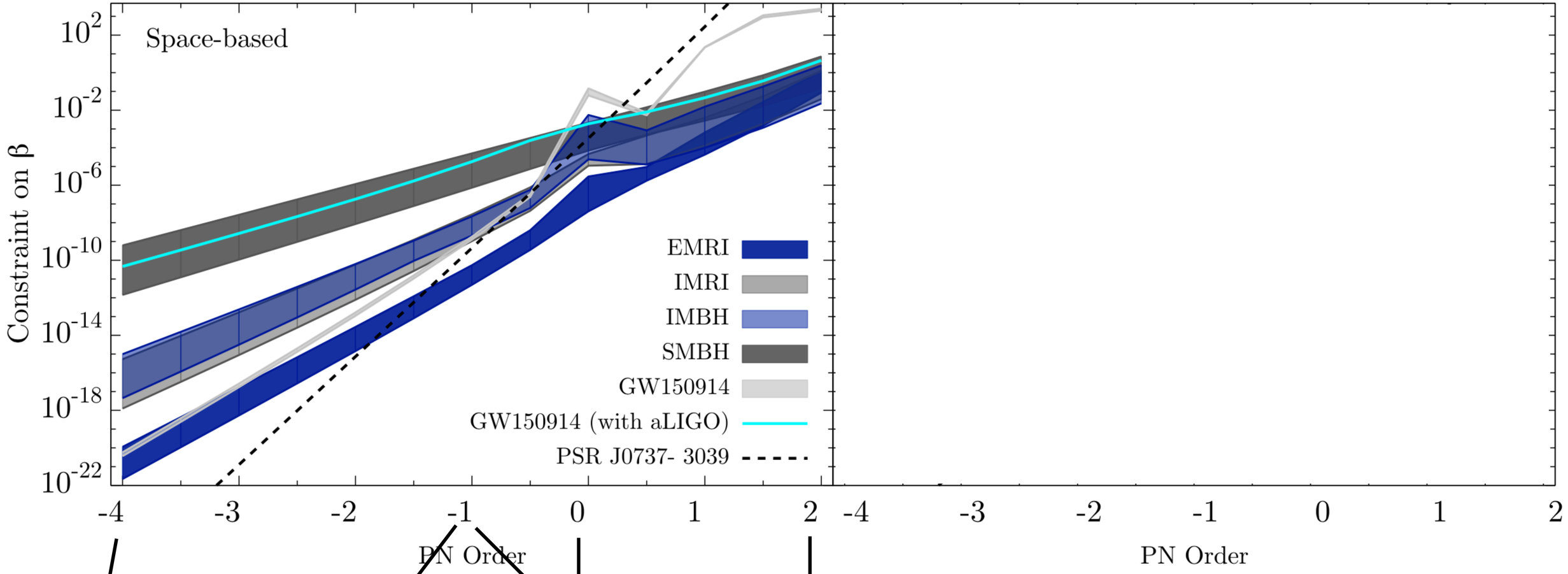

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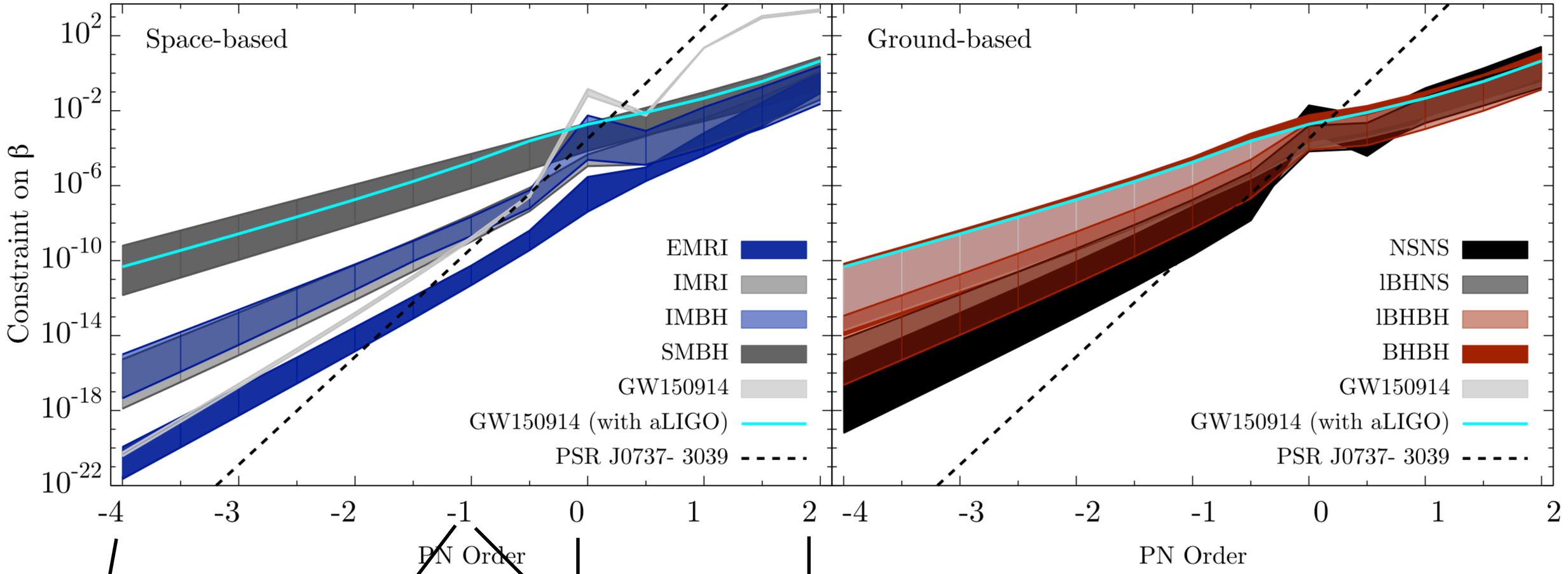

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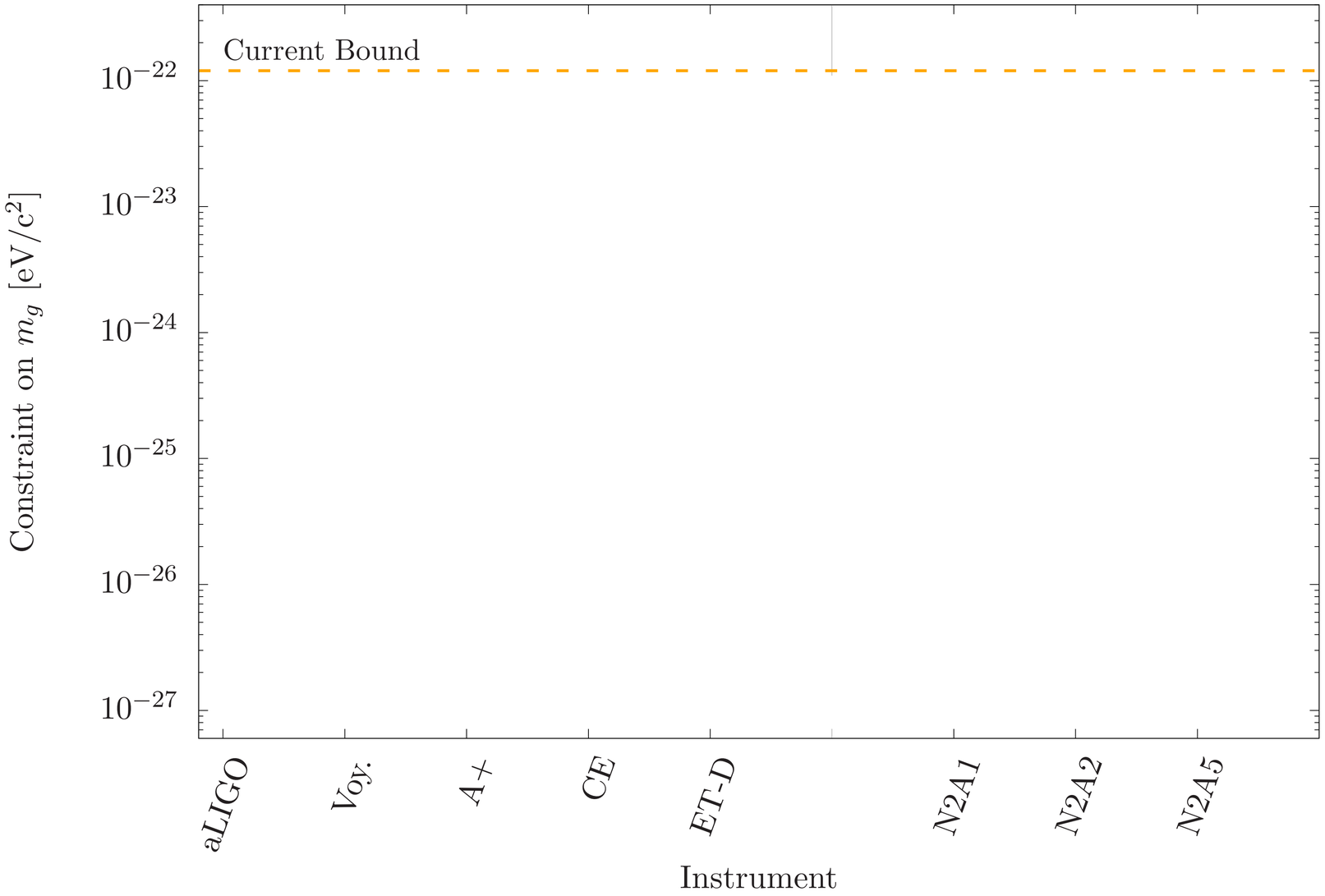

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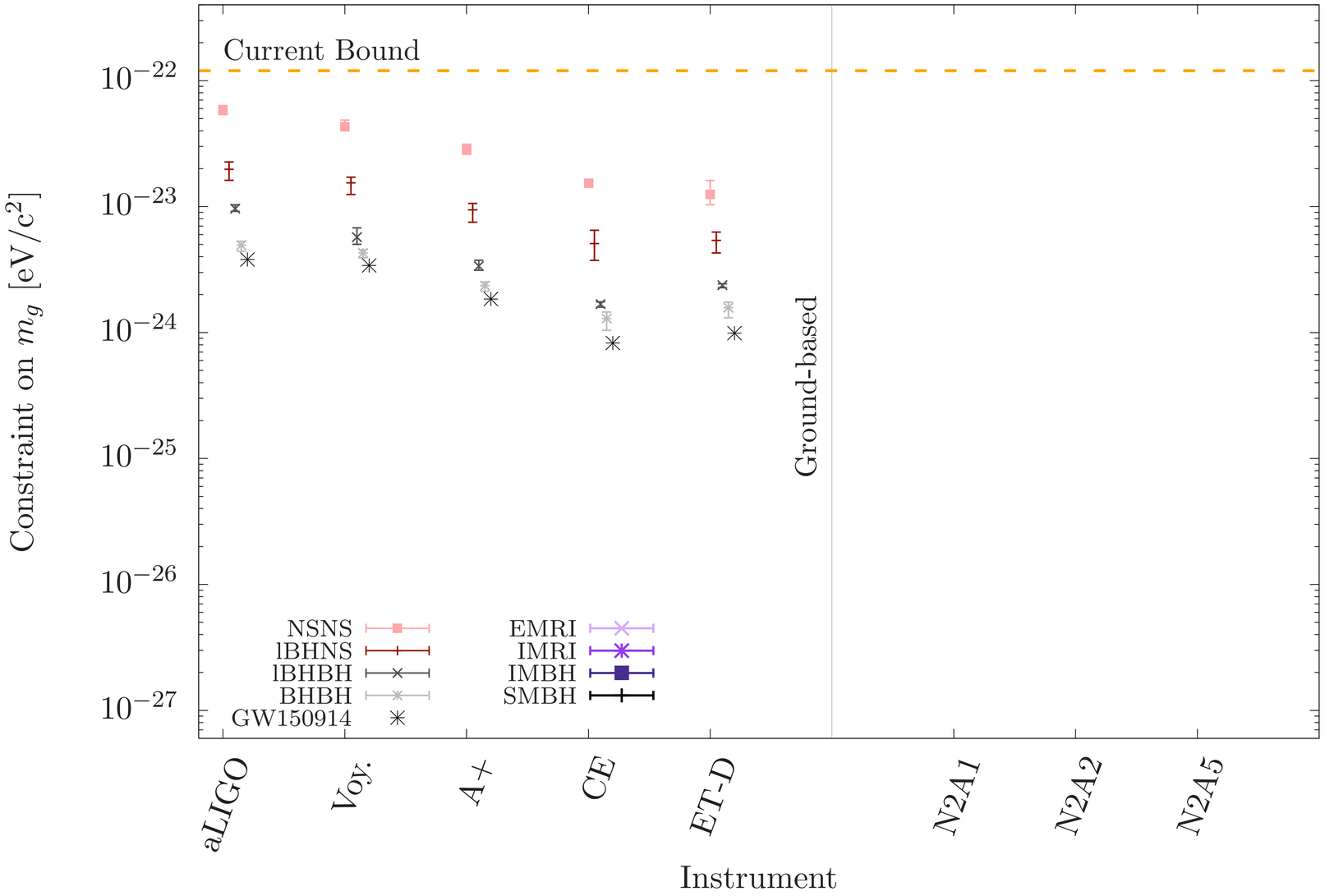

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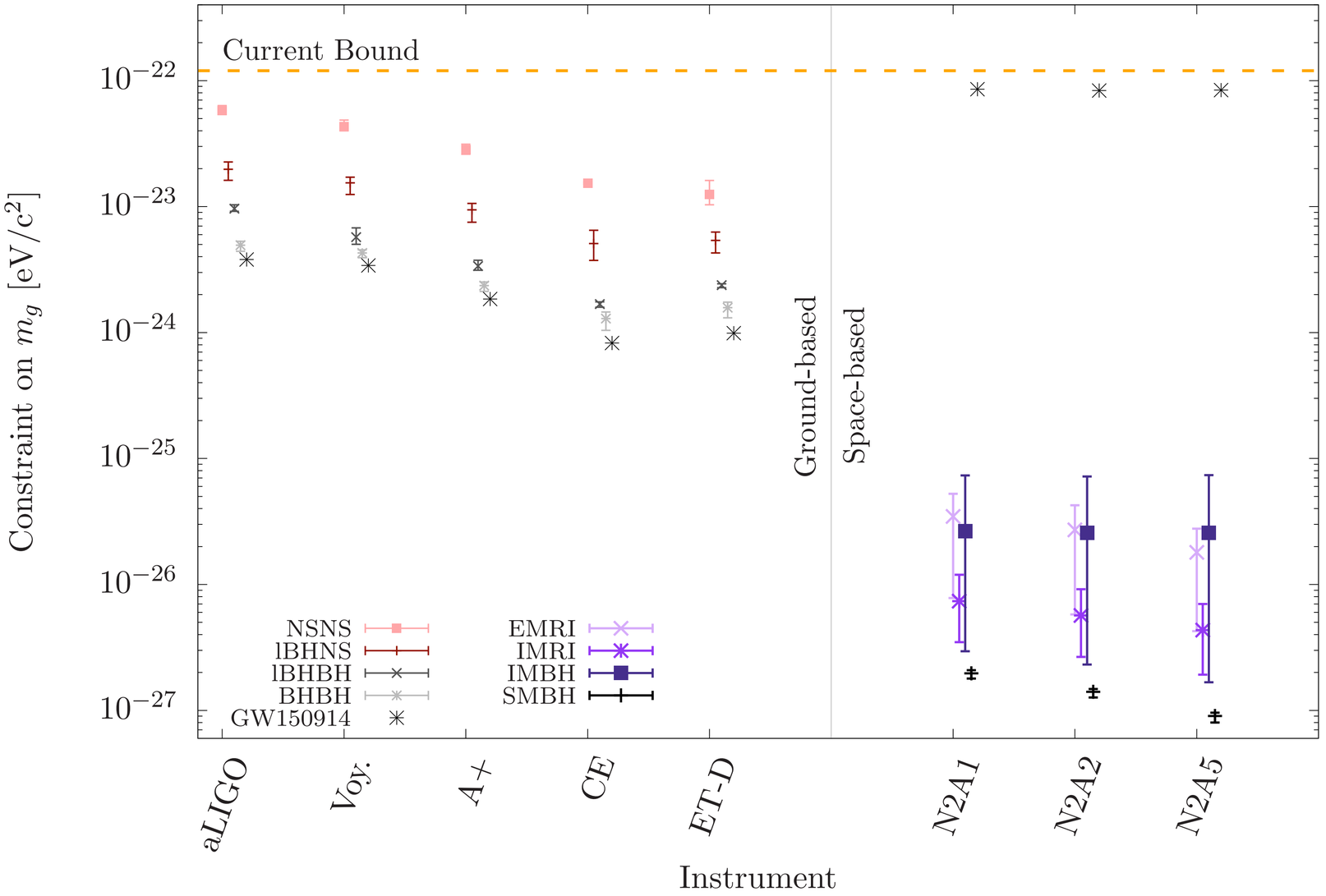

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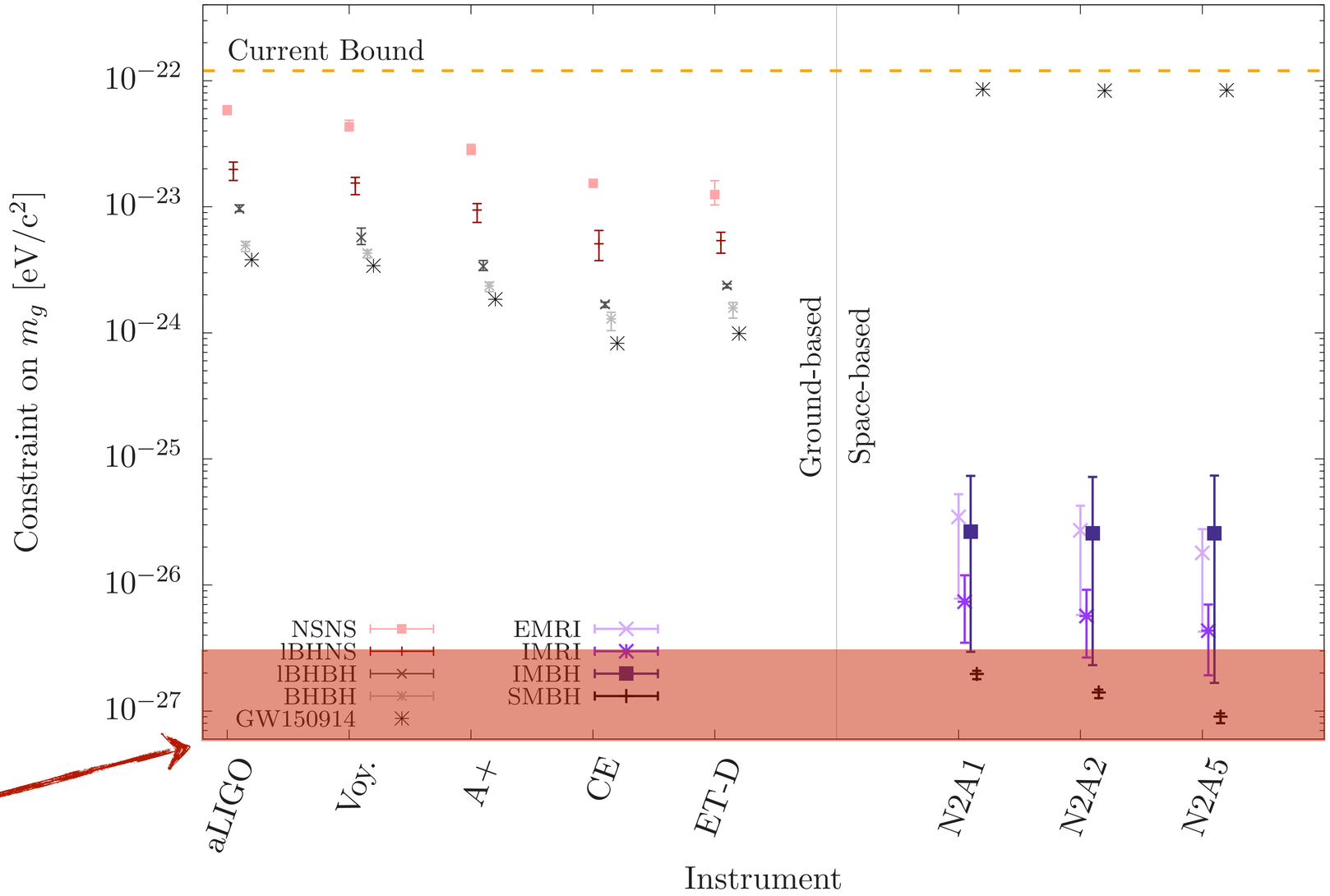

10^5 times better than current bounds!!

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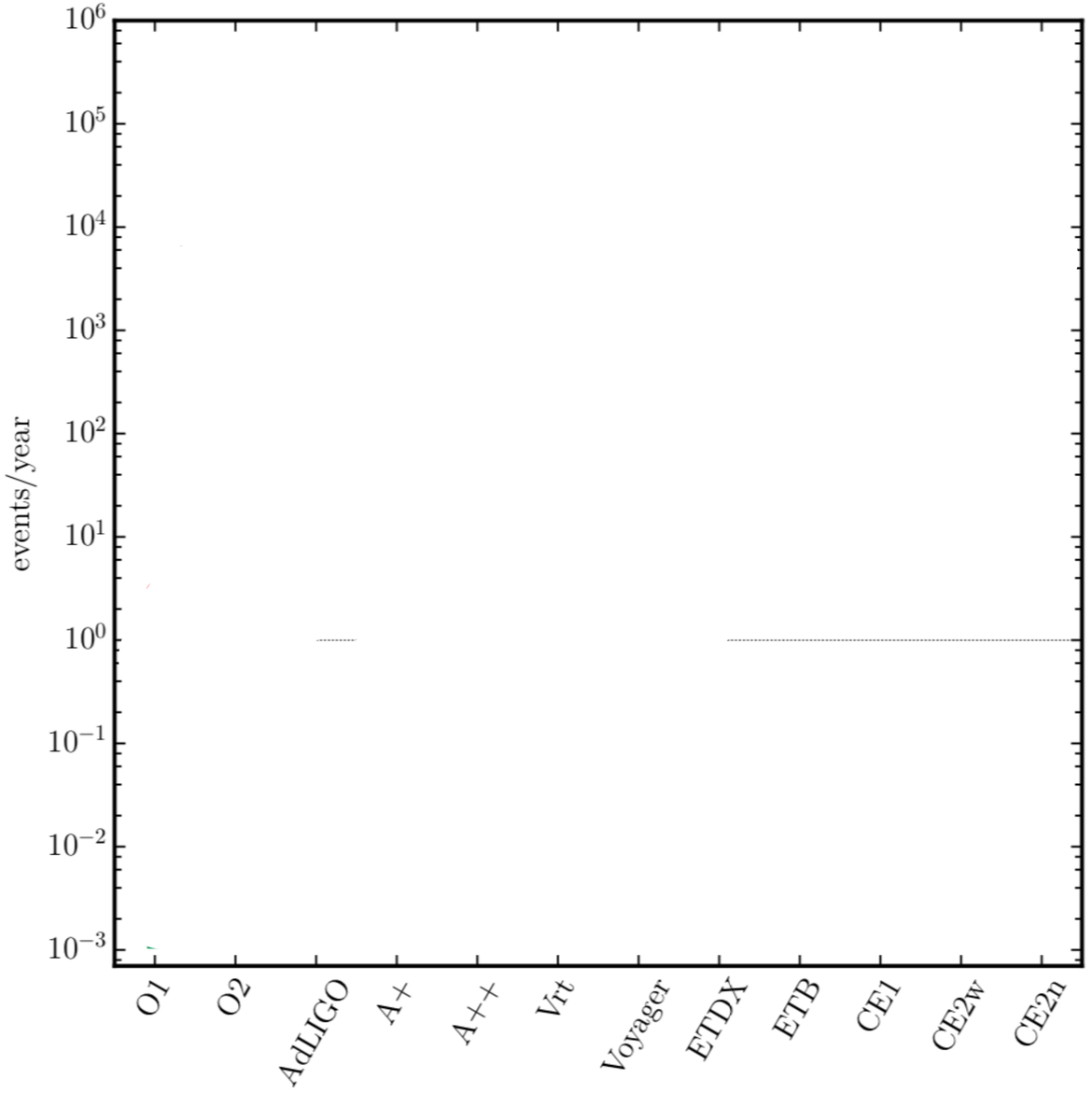

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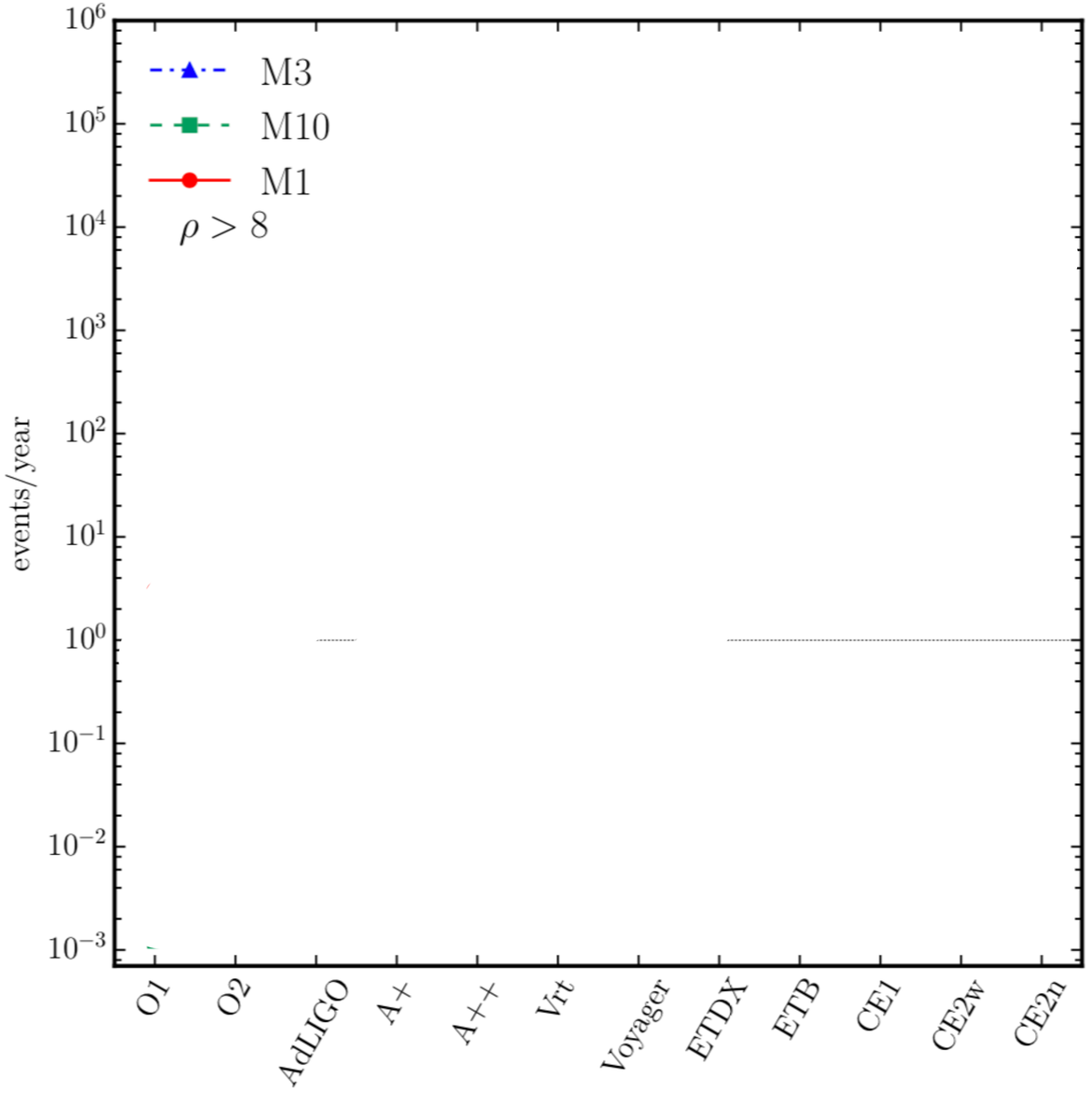

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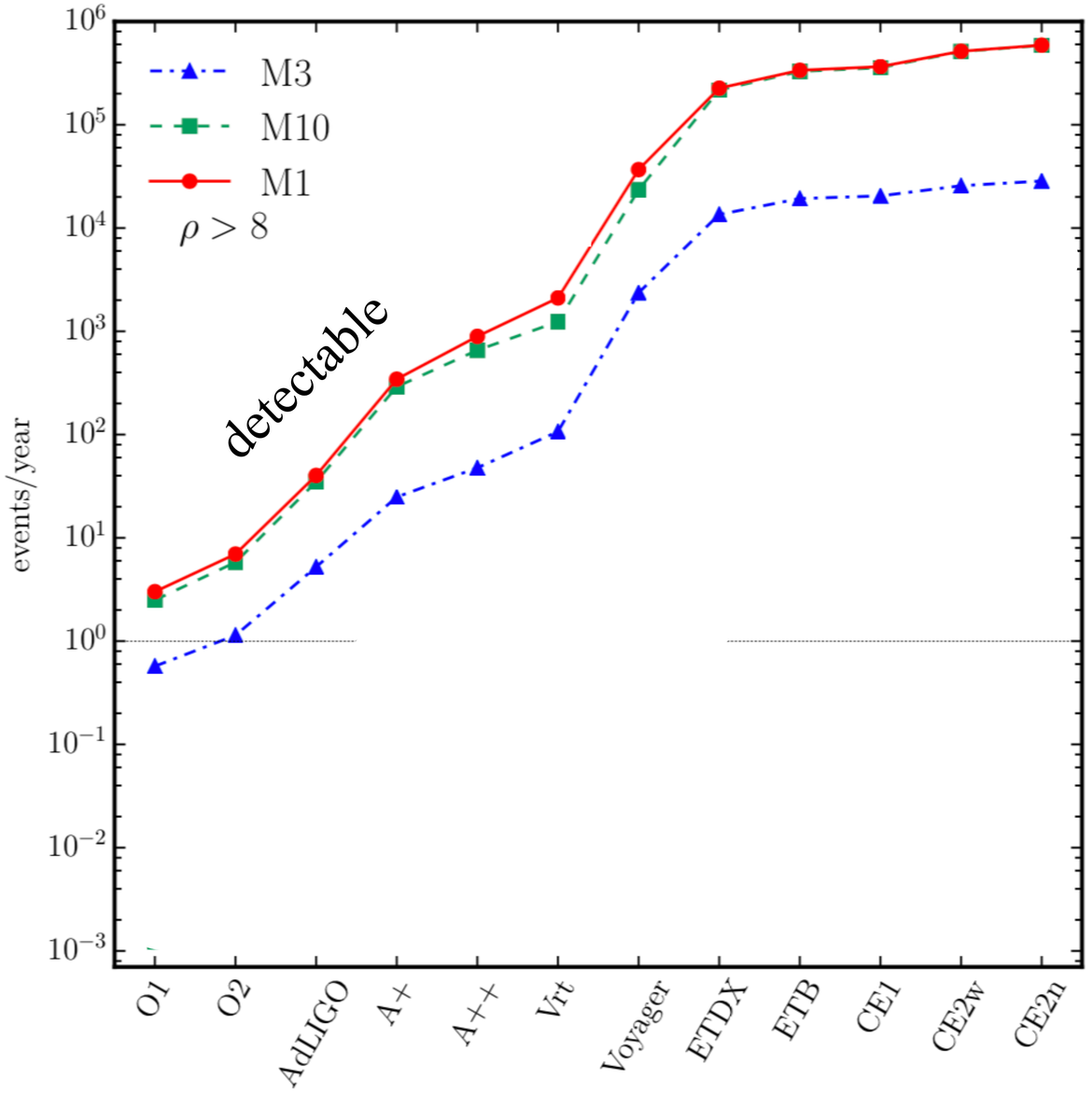

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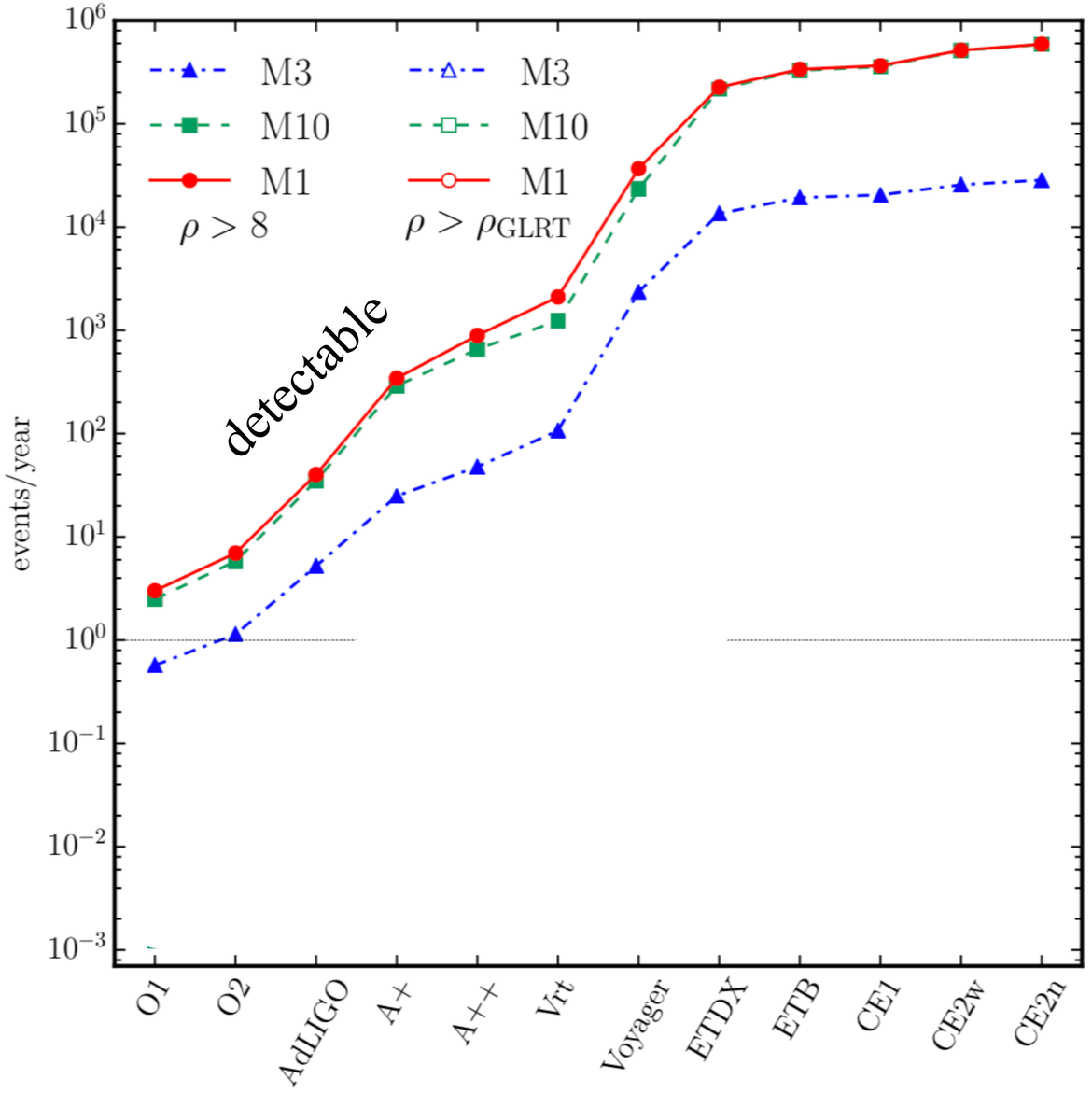

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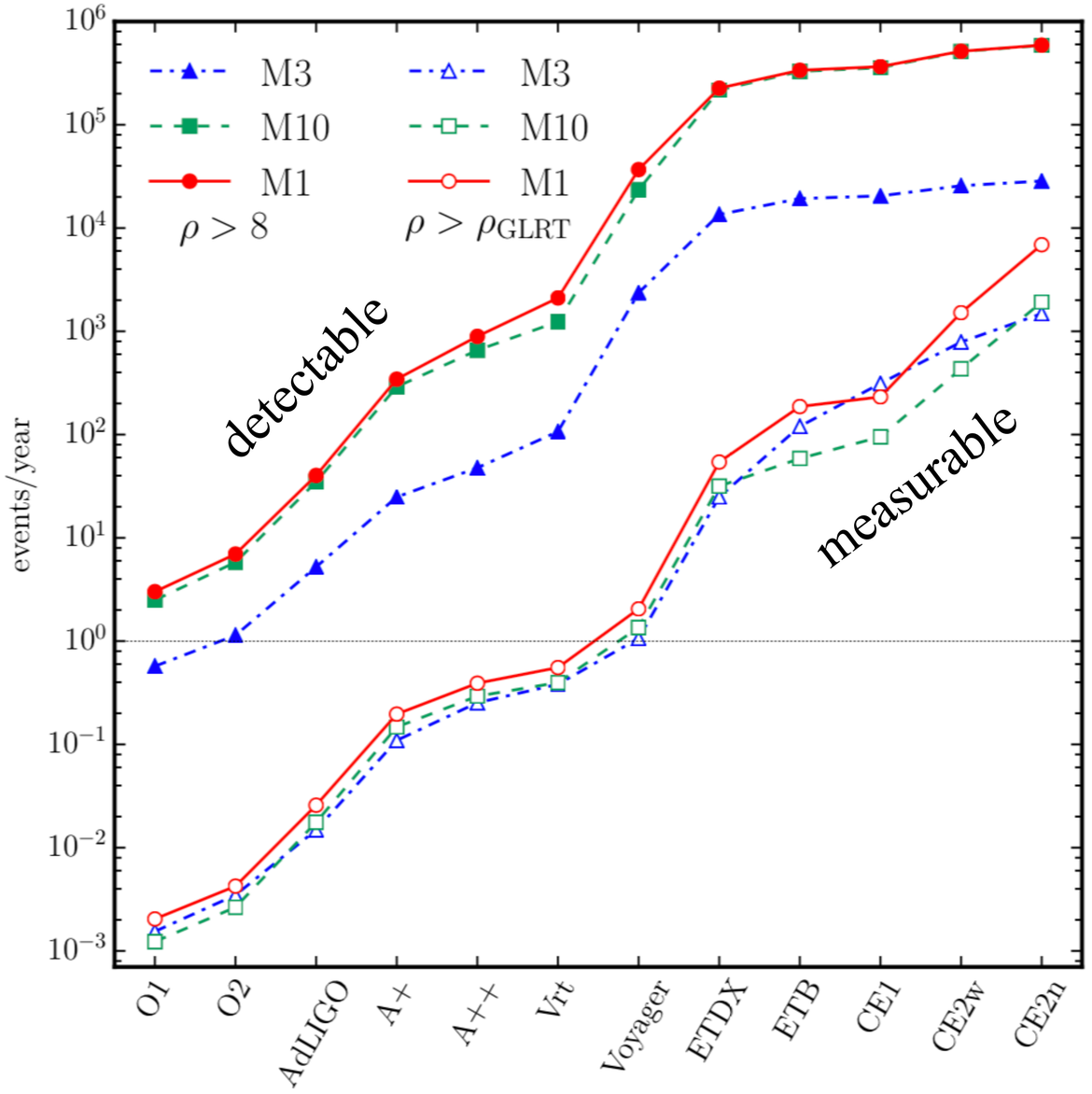

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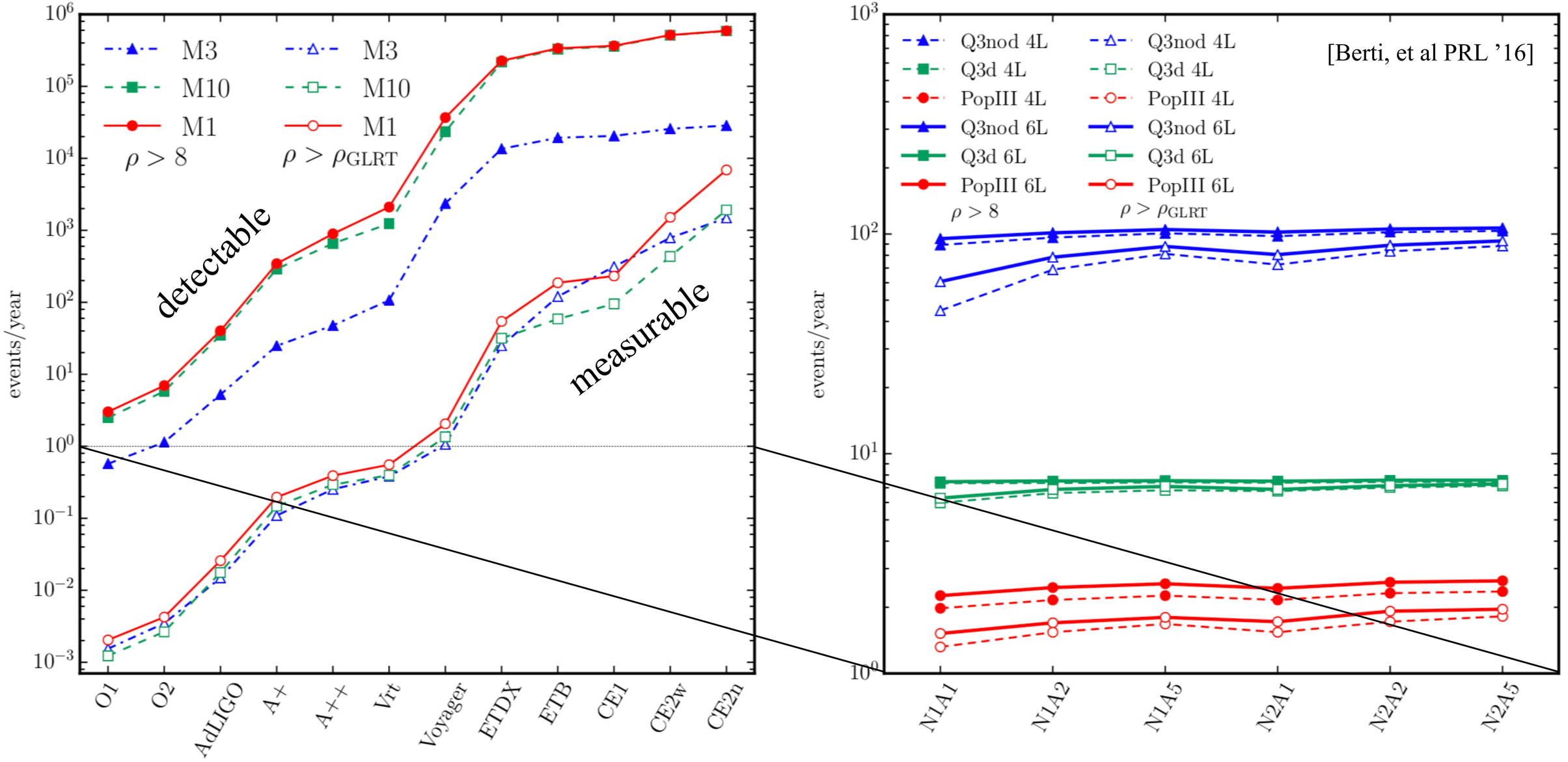
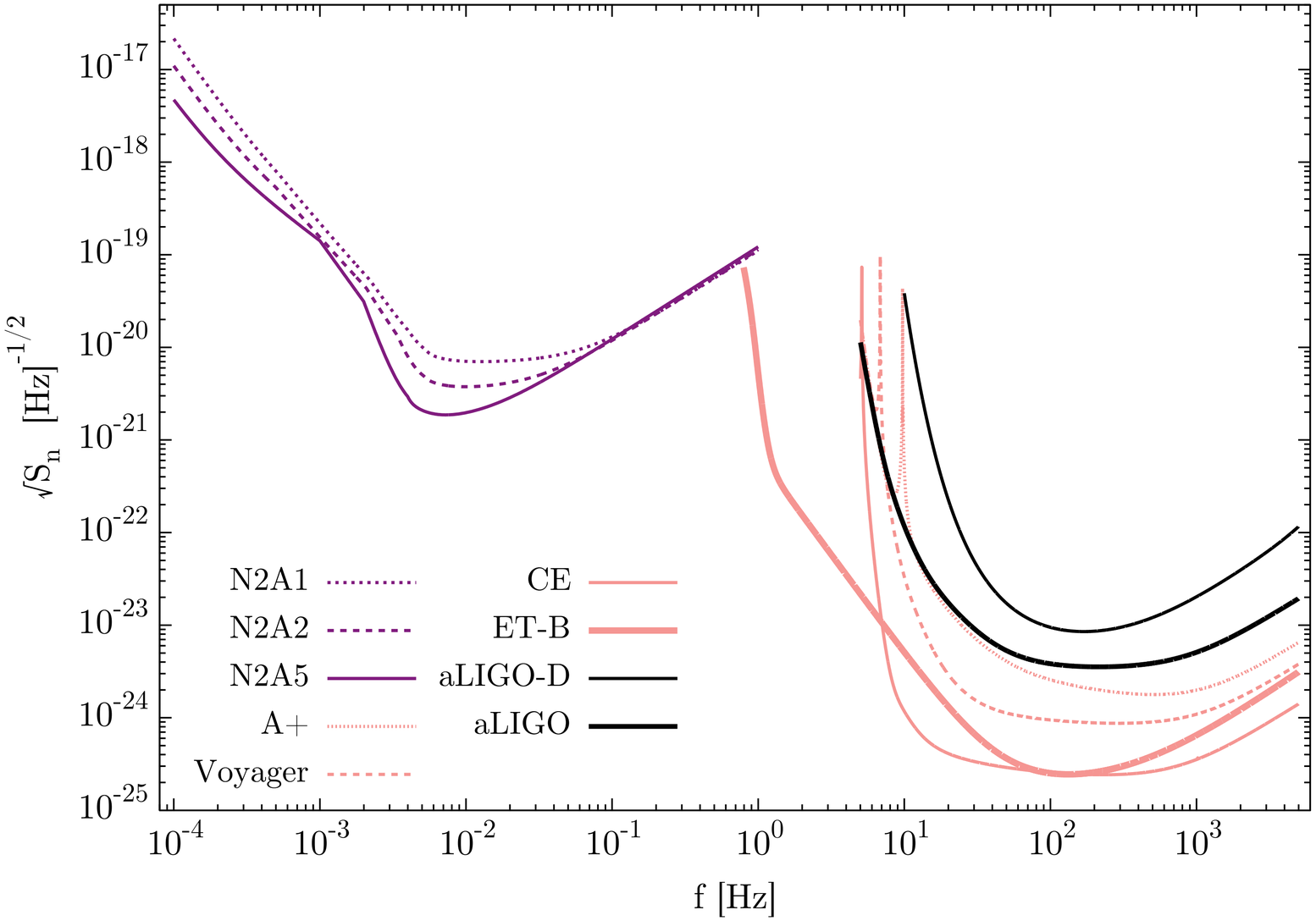


Multi-Band Events



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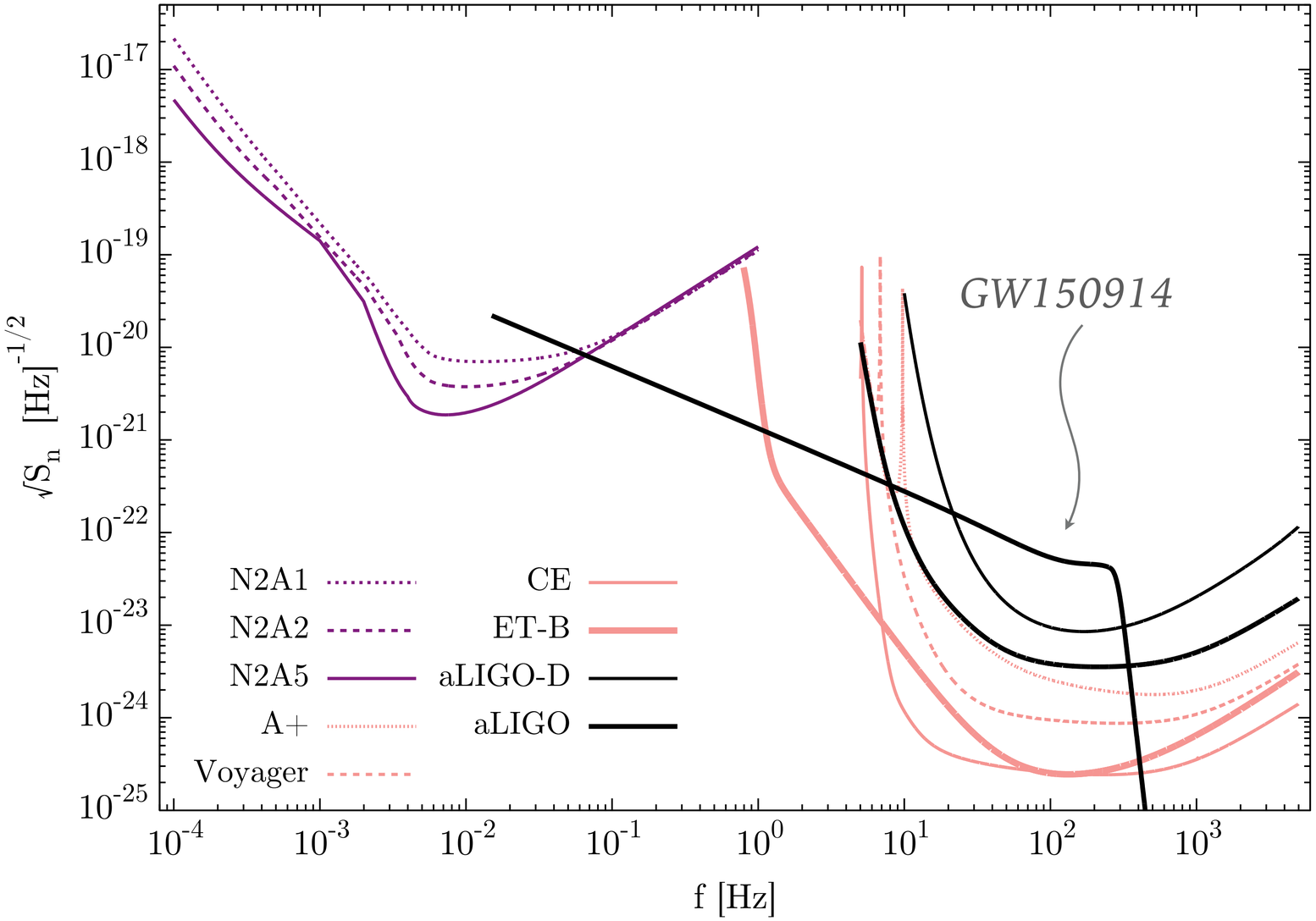

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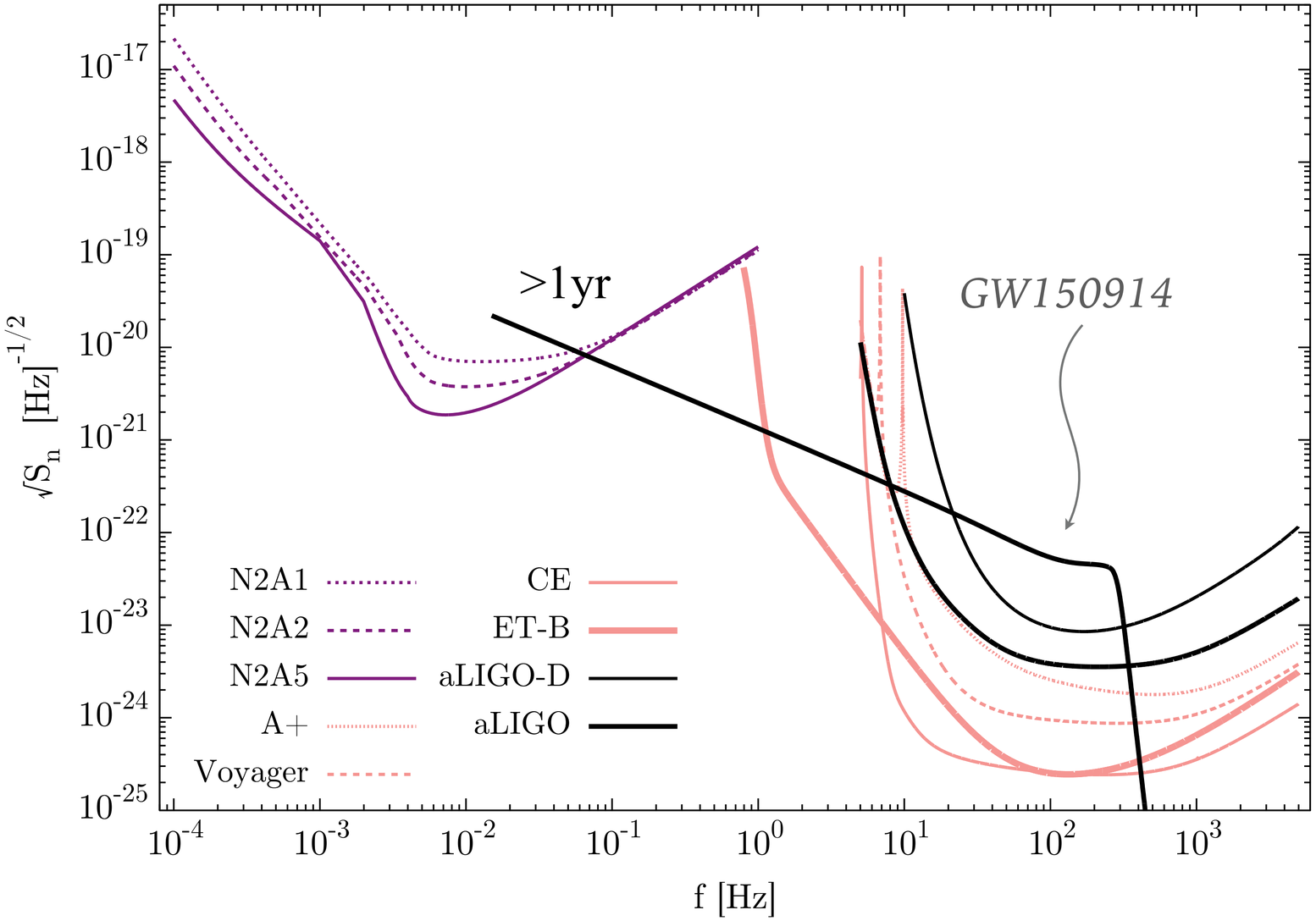

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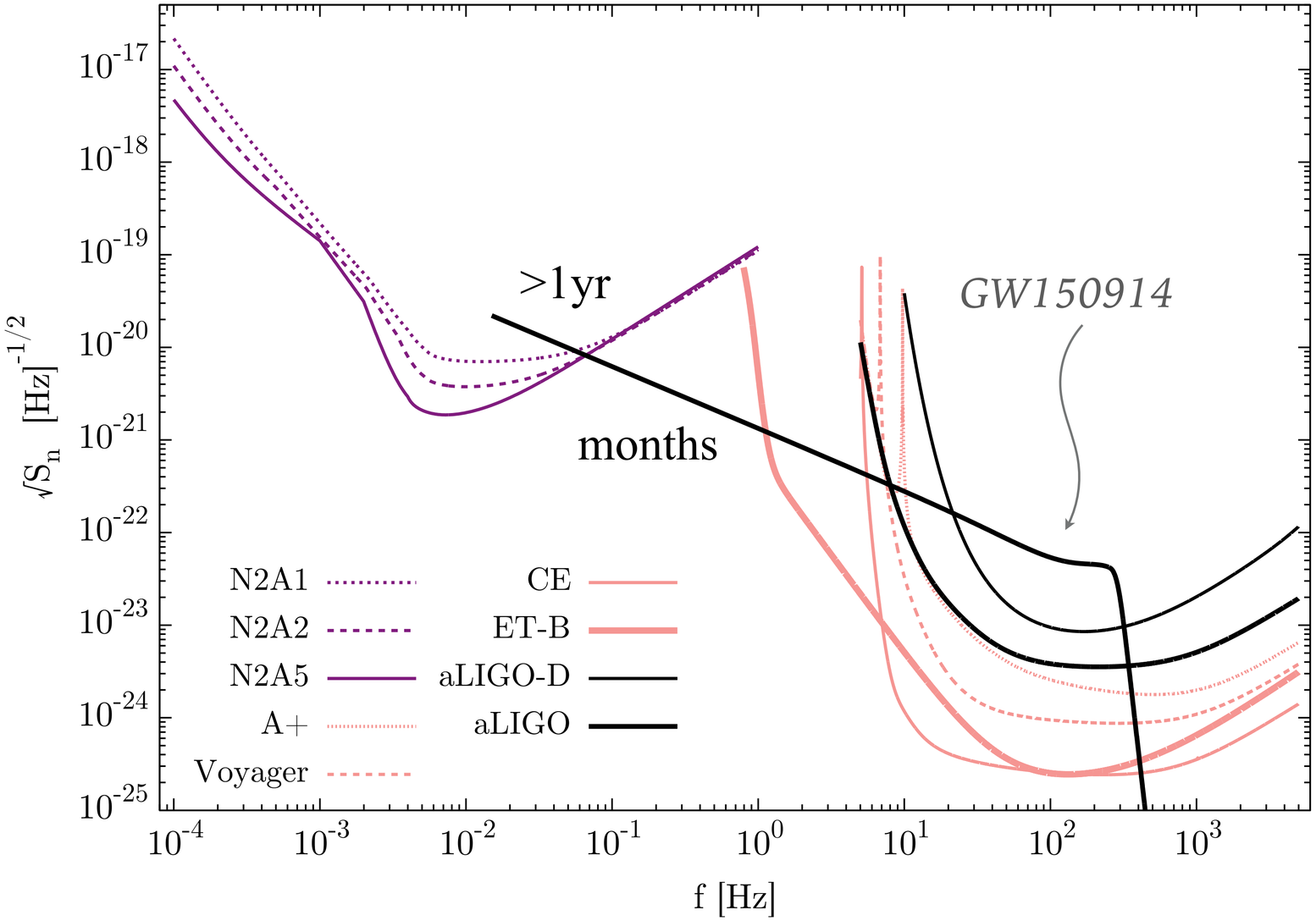

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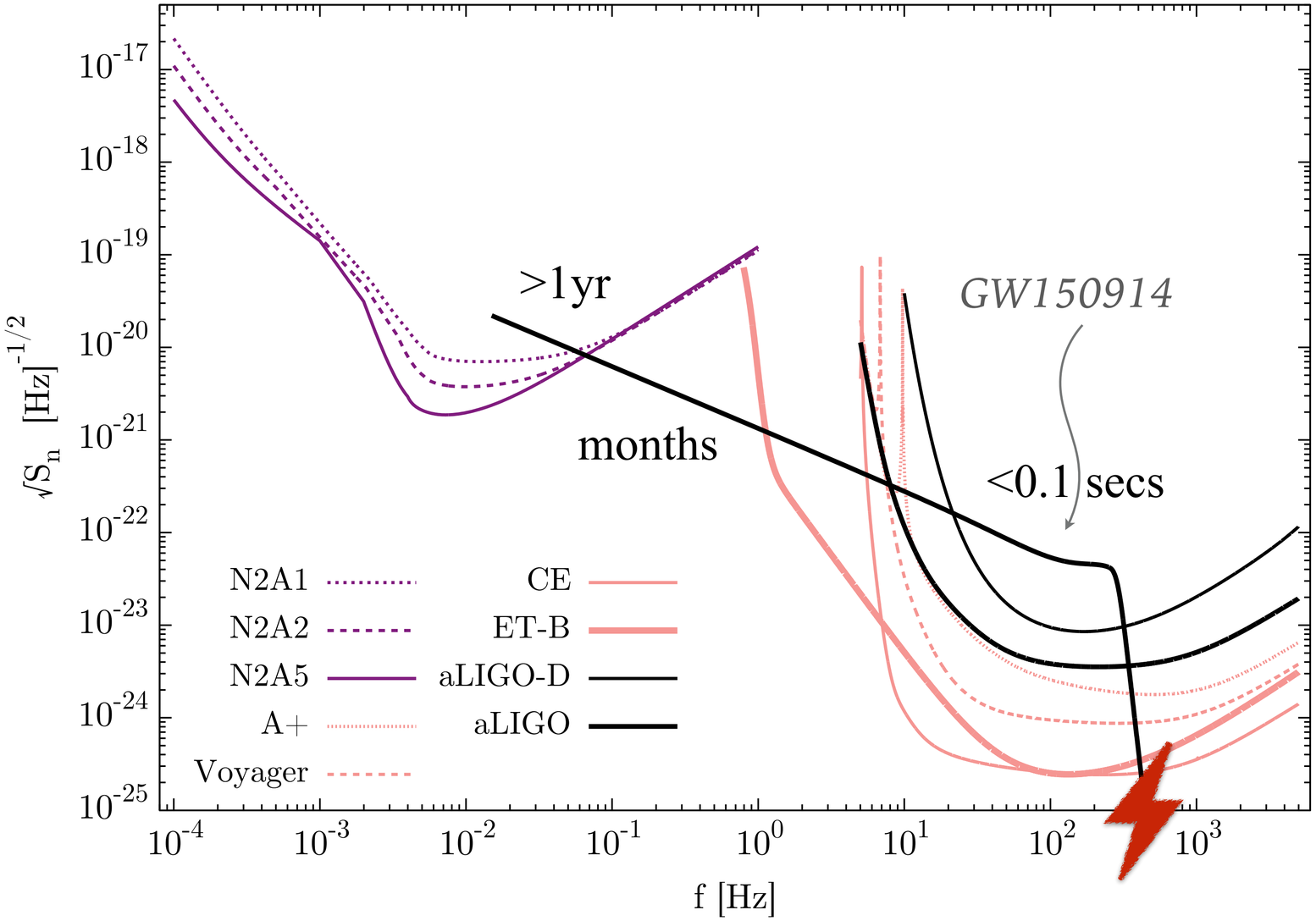

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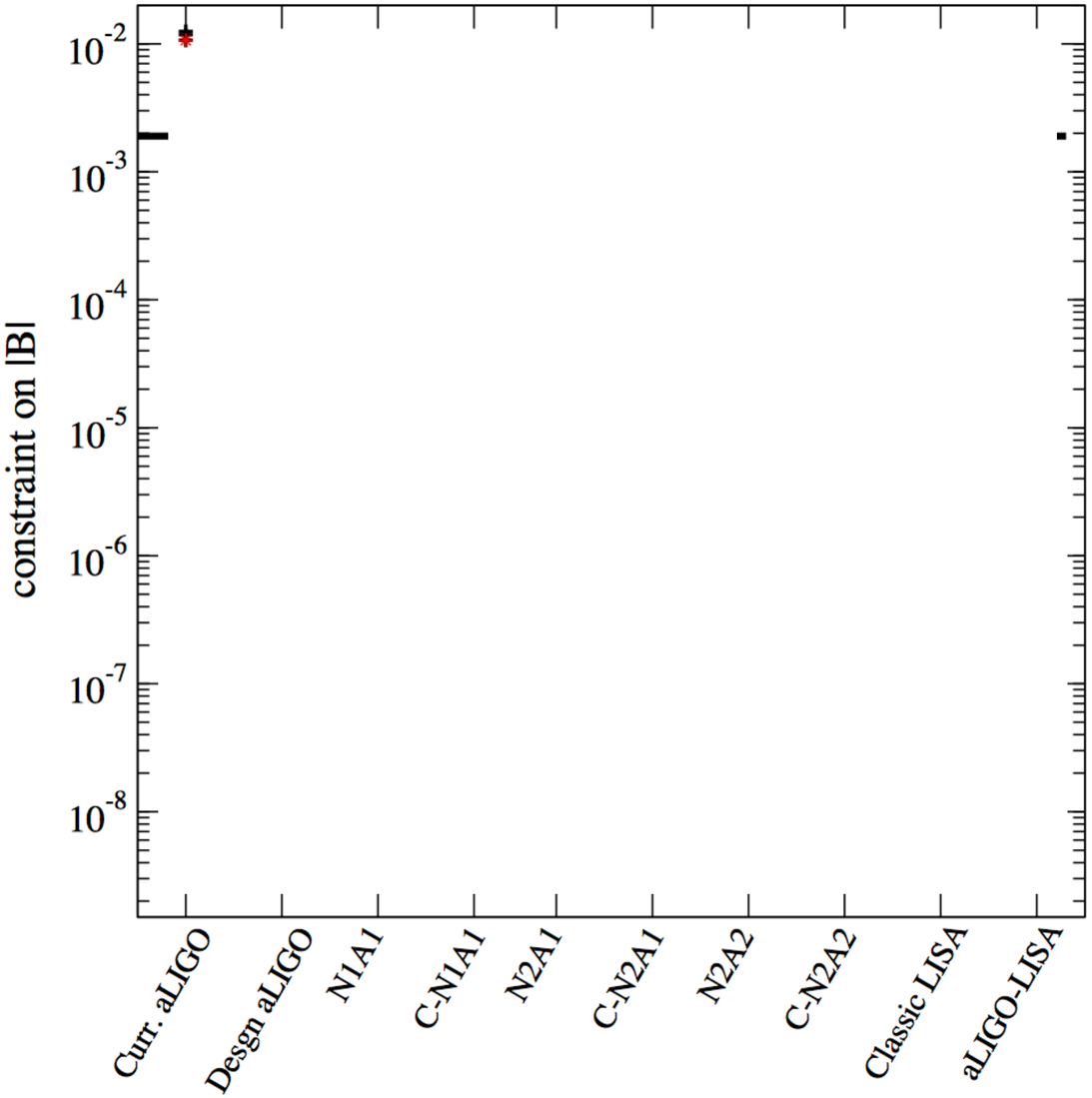

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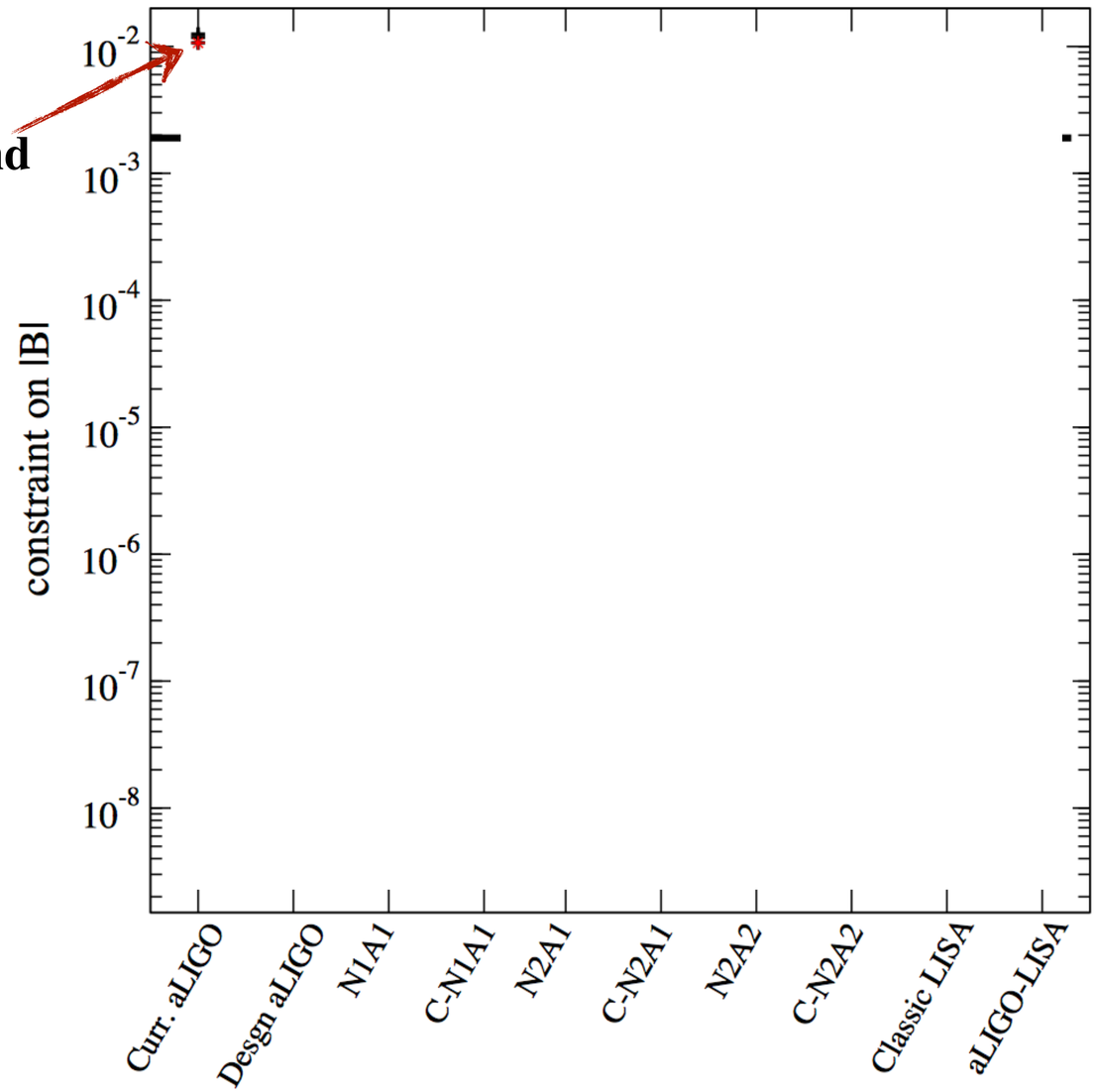

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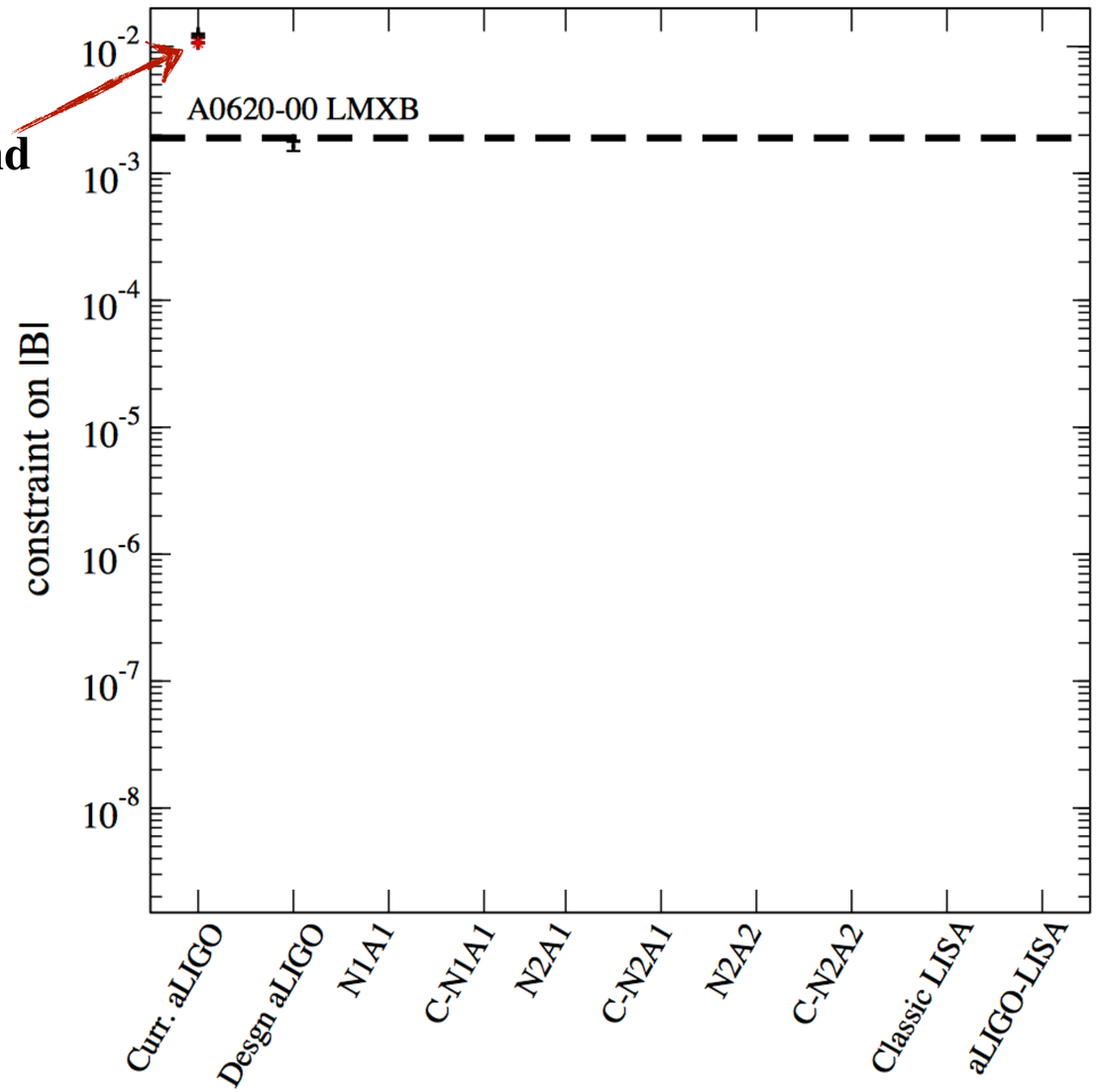

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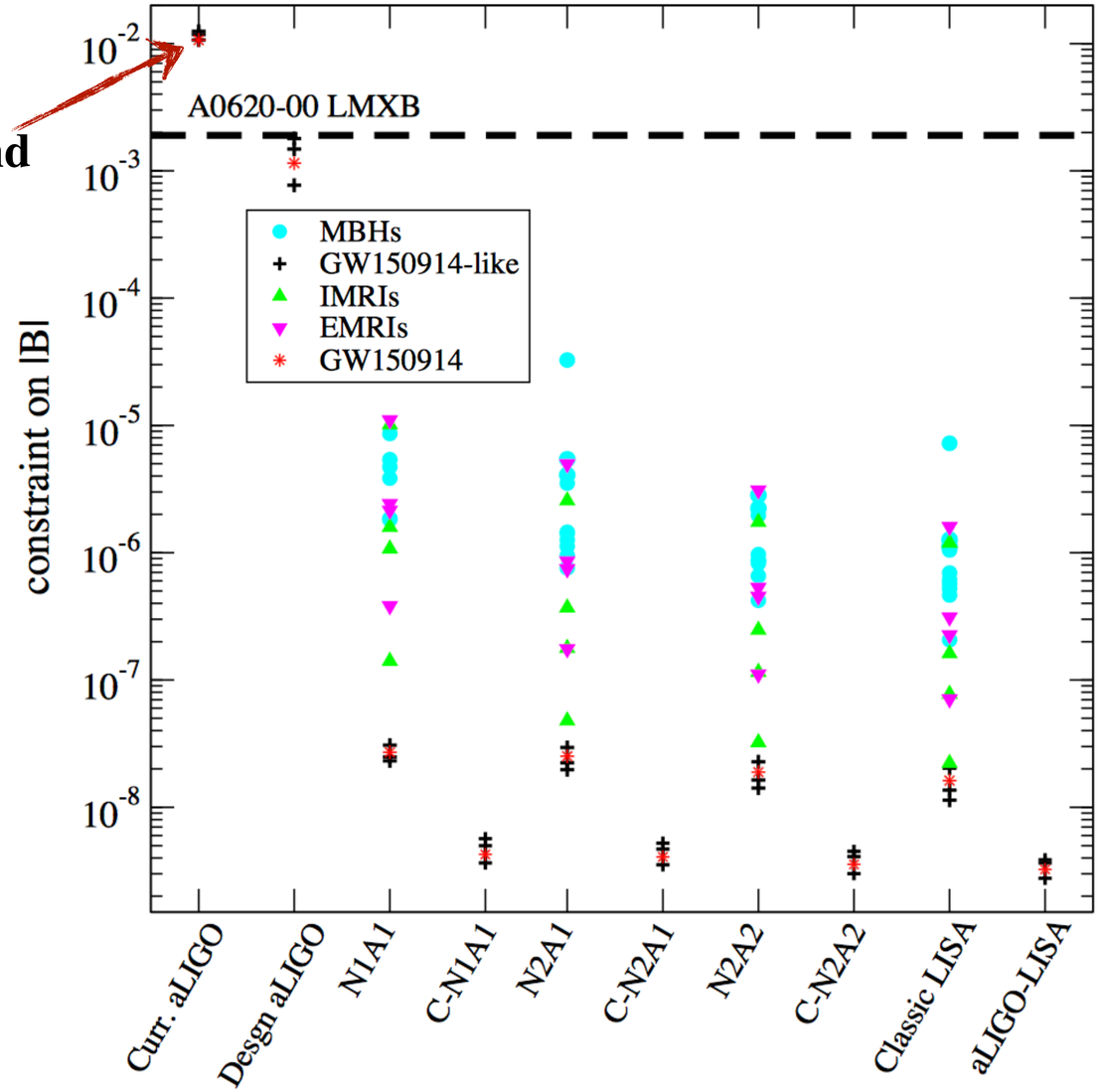

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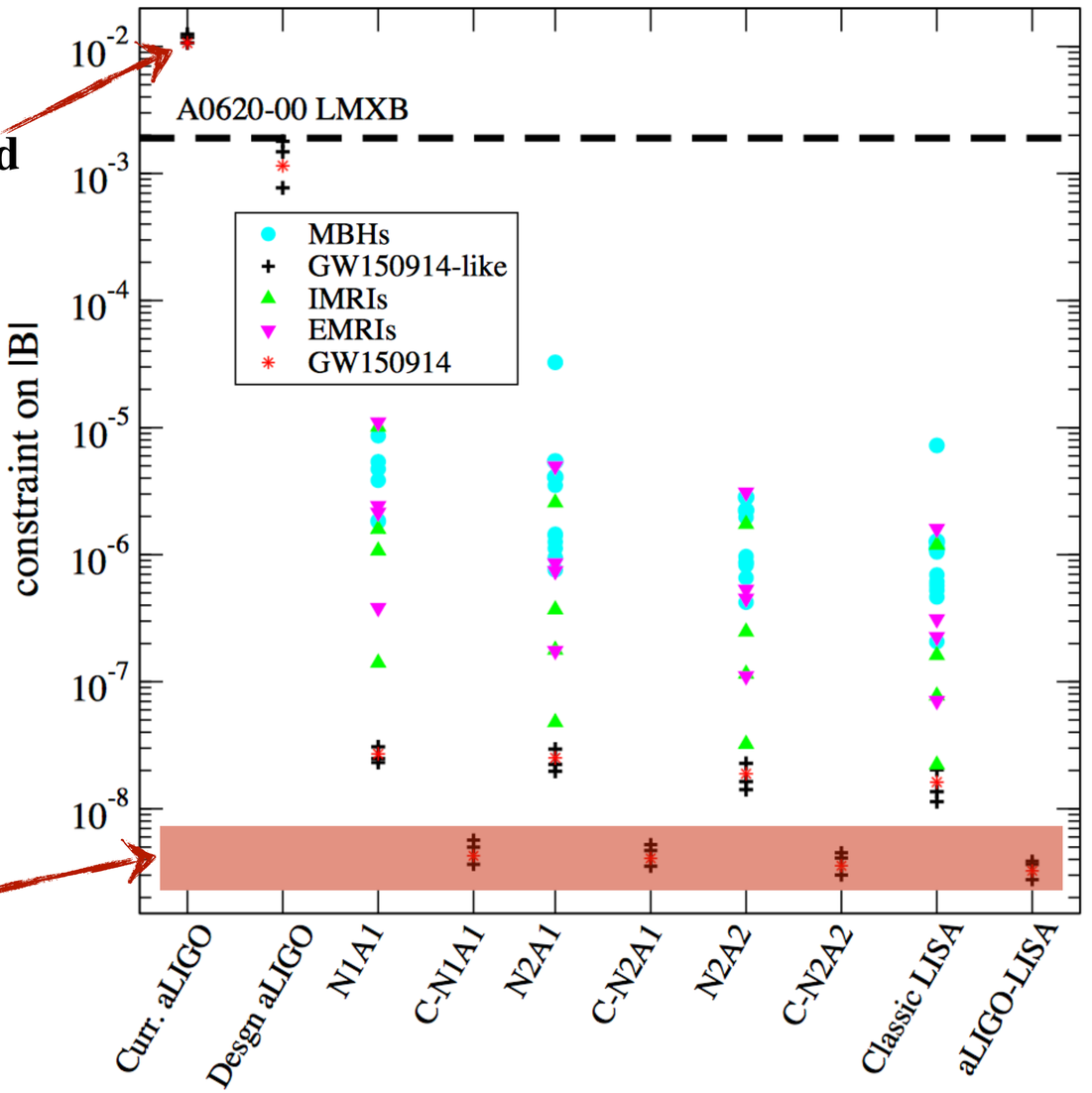

10^6 times better than current bounds!!

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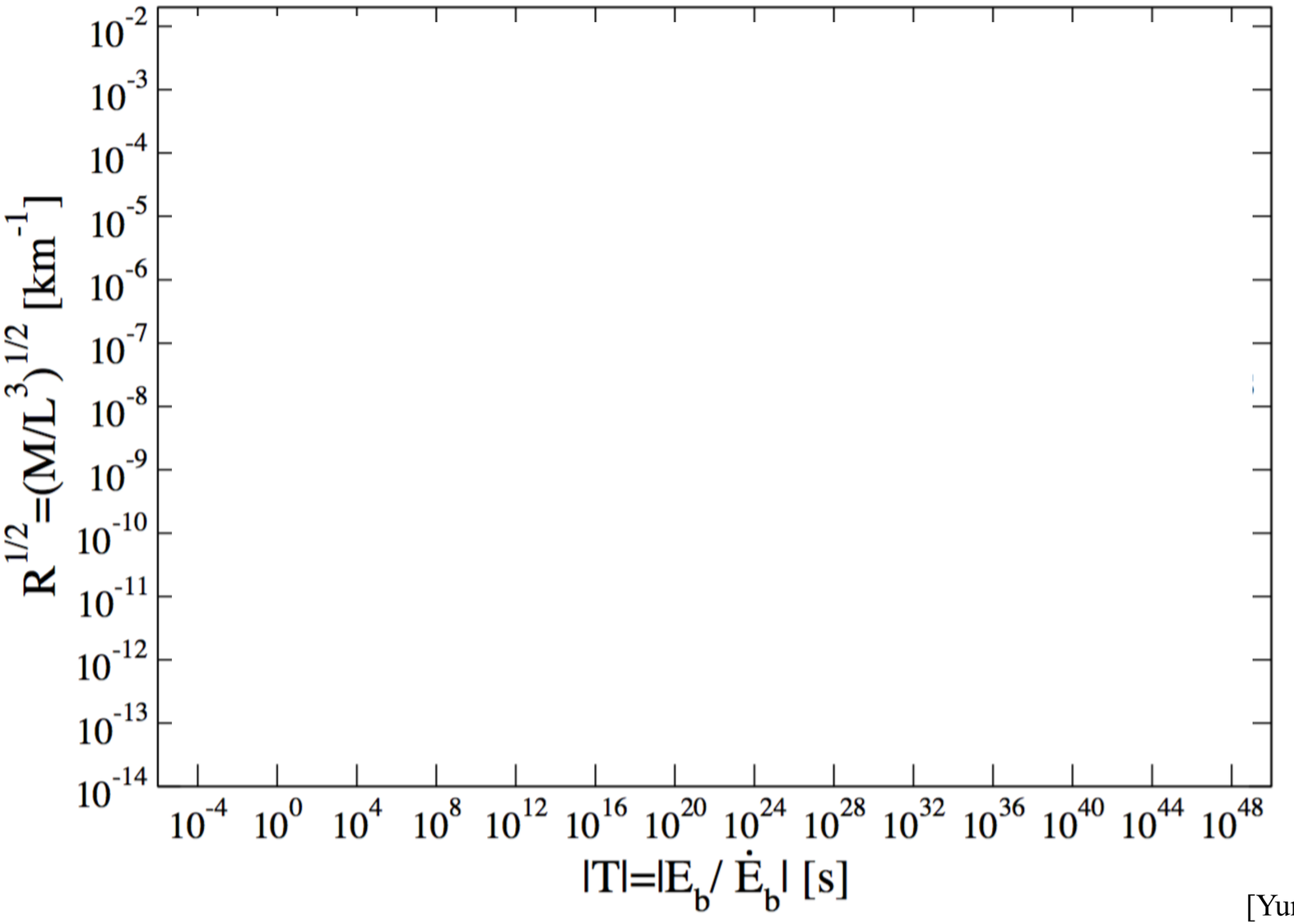

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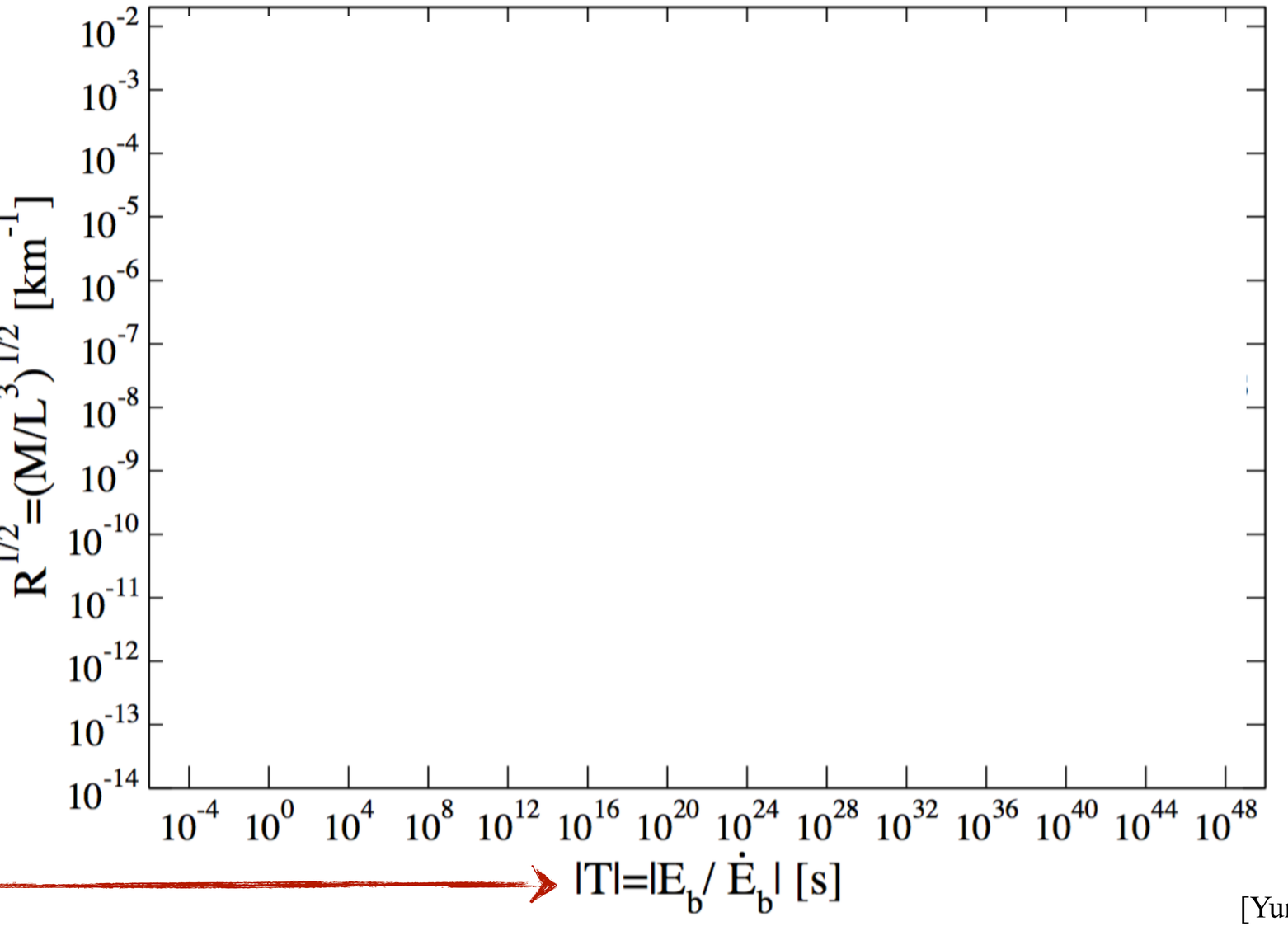

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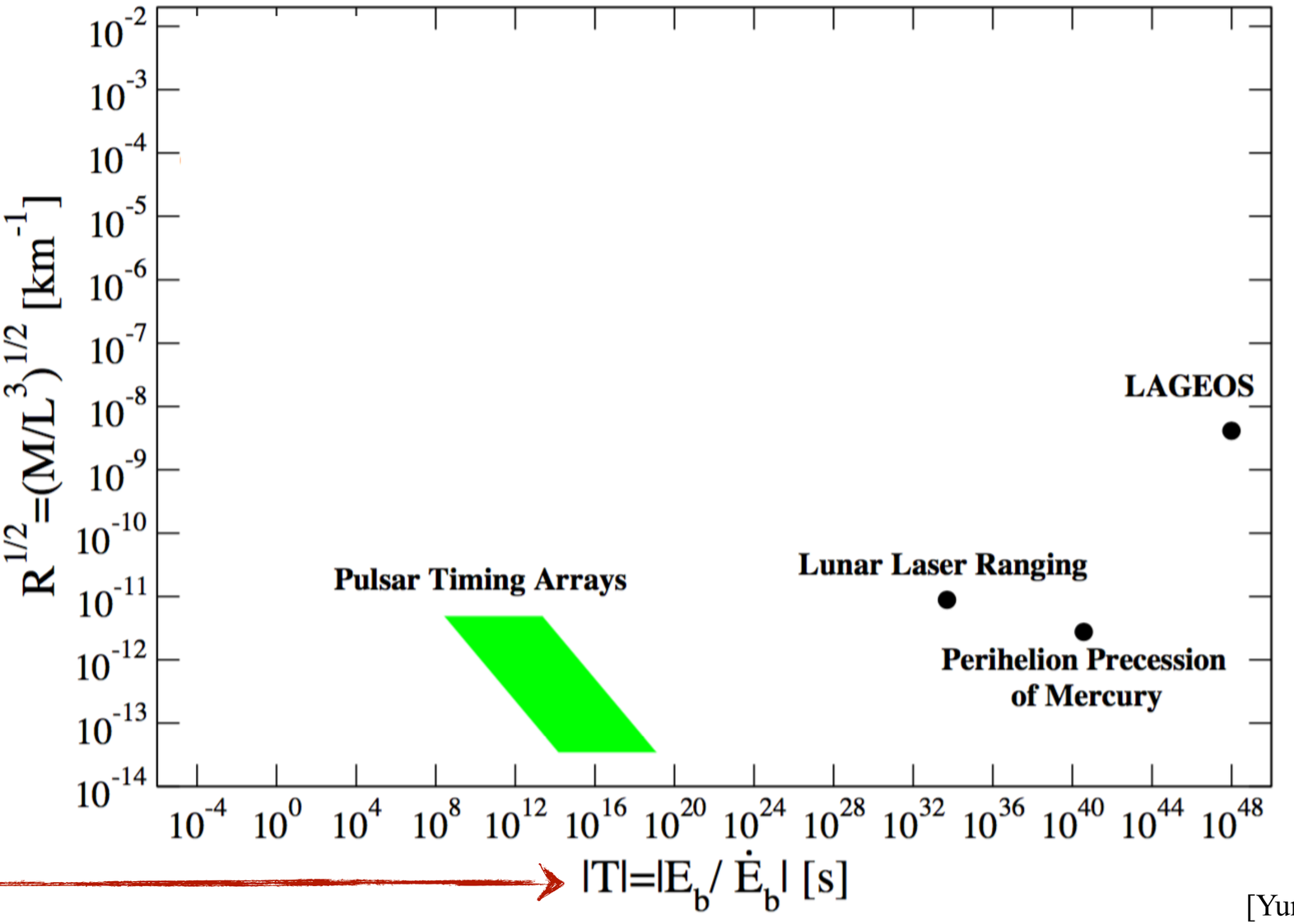

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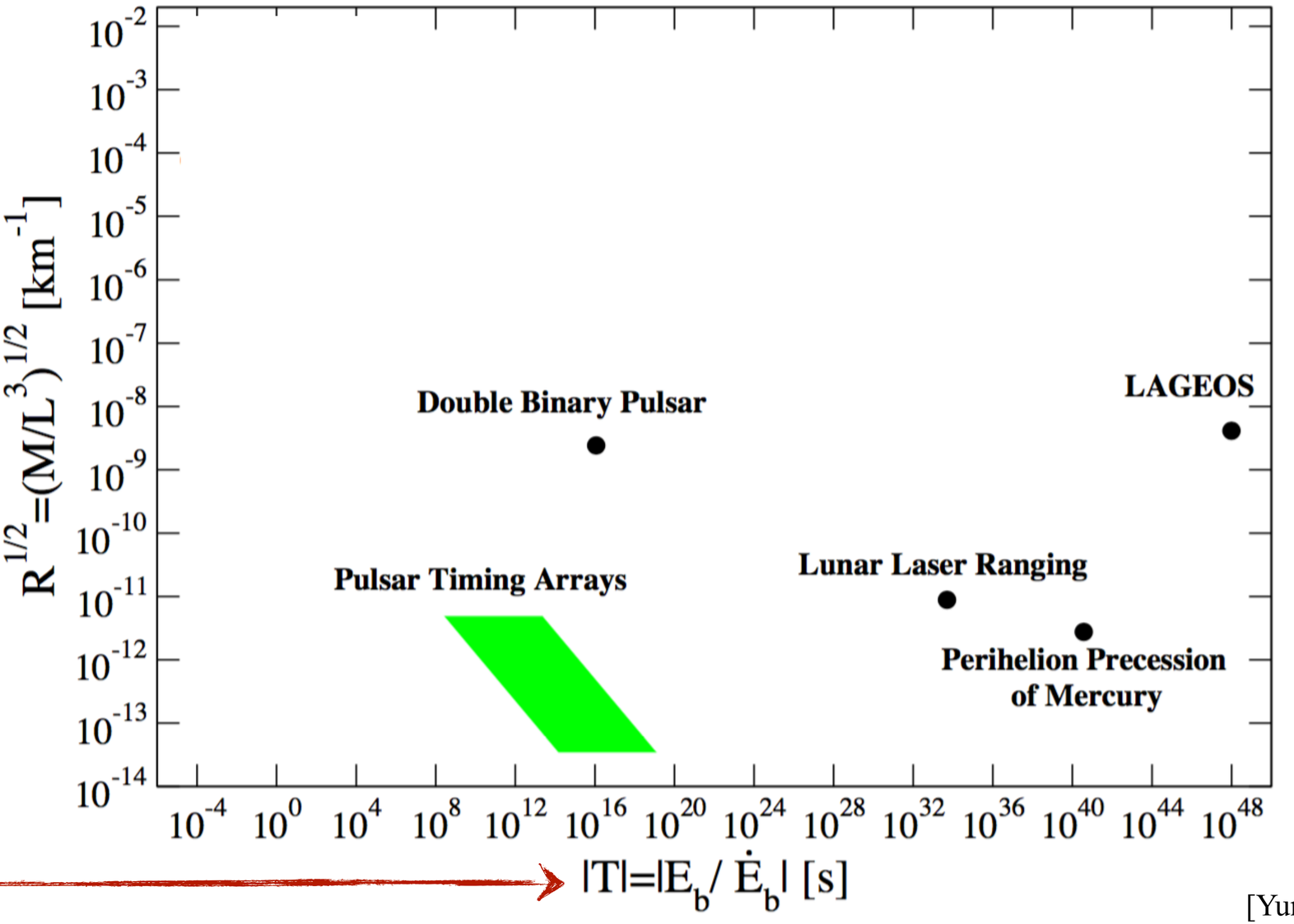

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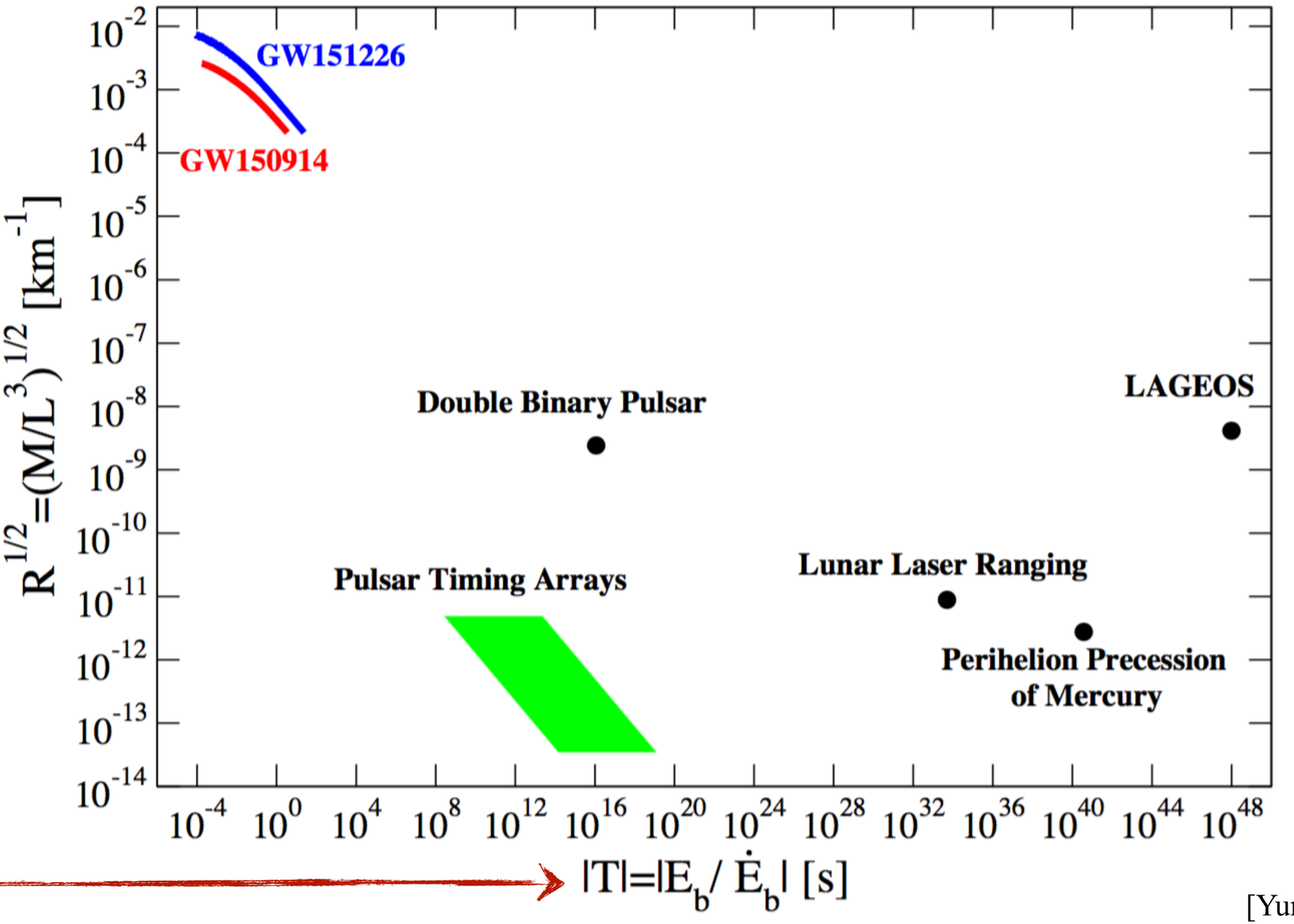

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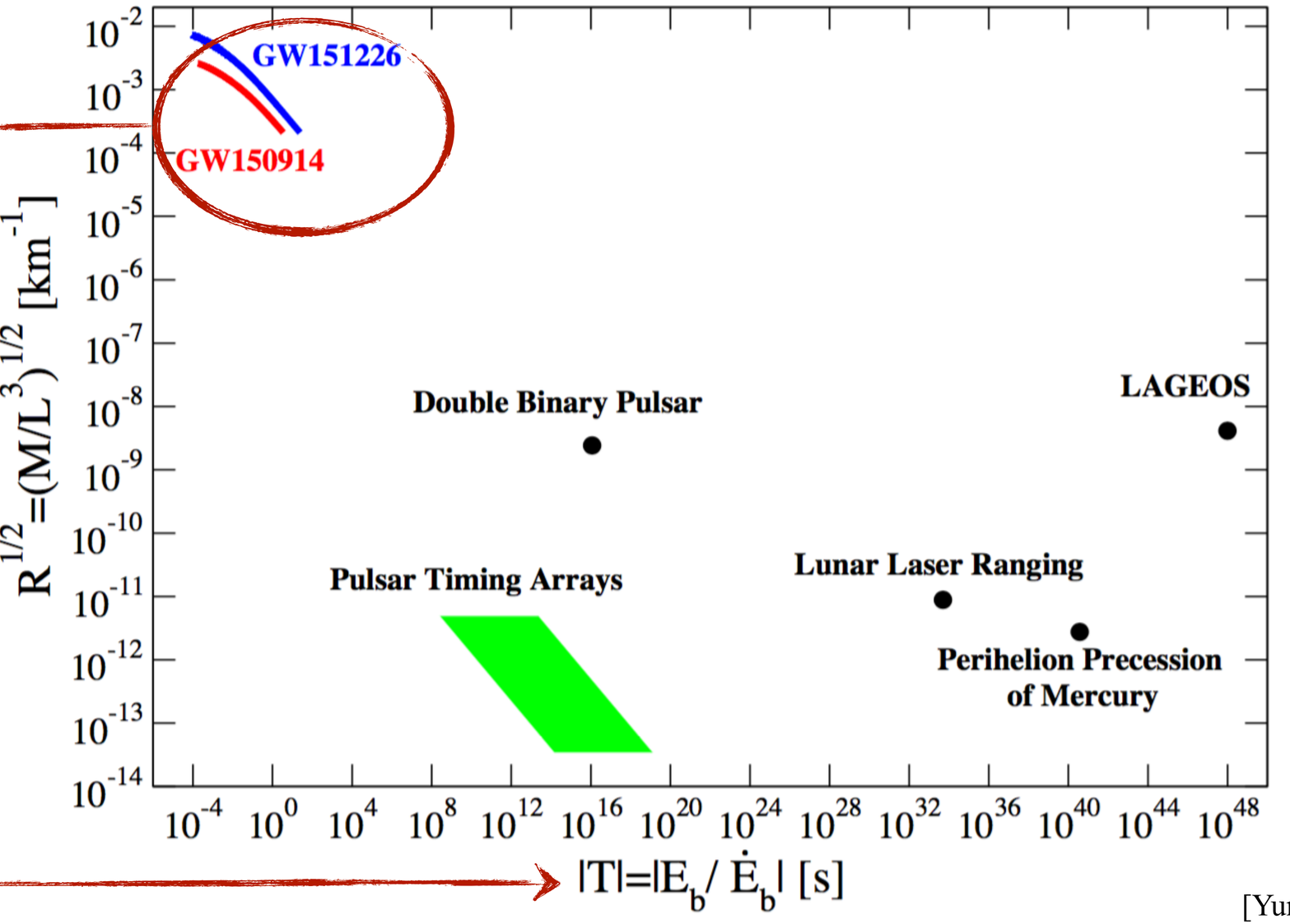
Extreme Gravity Tests



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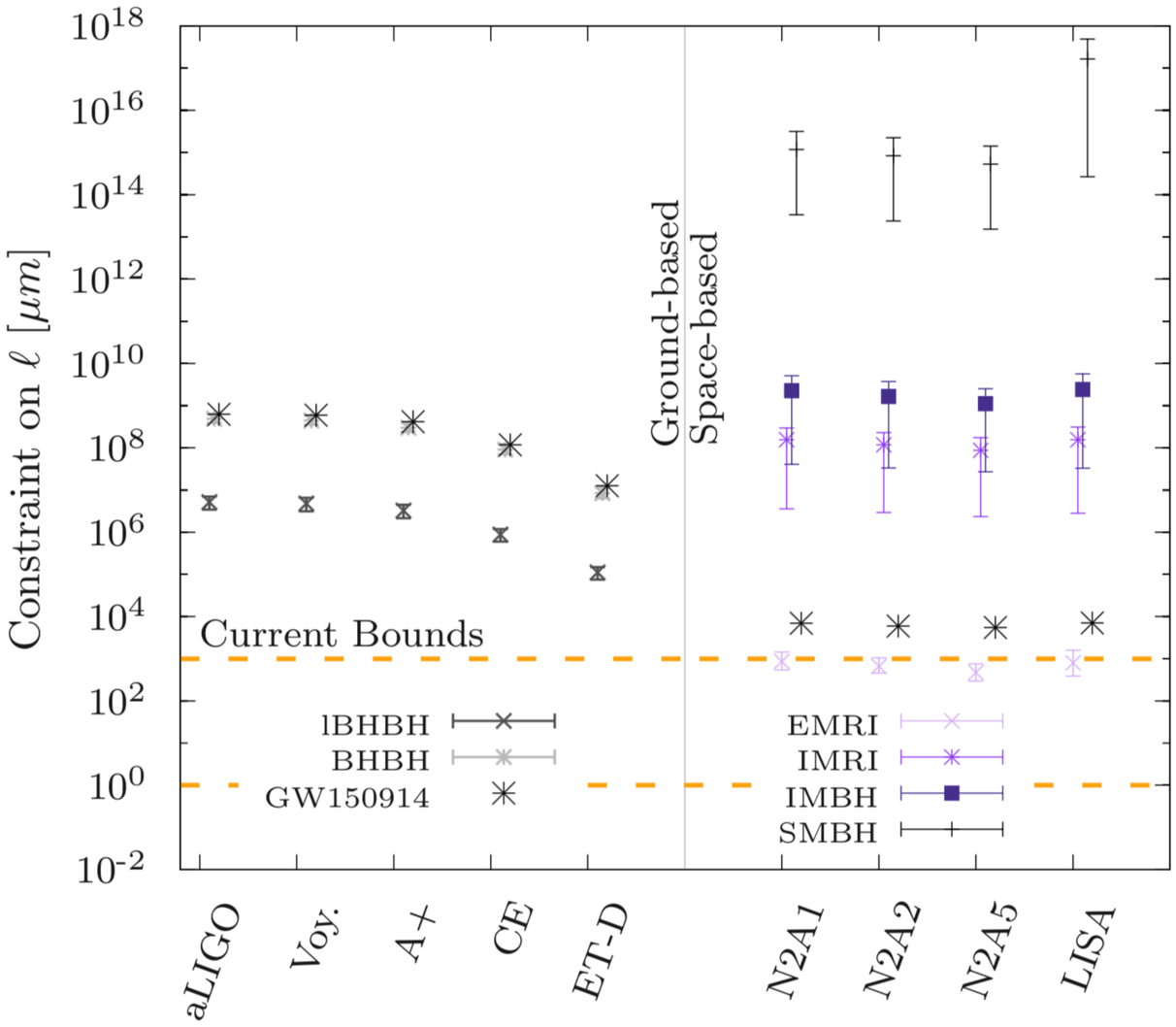

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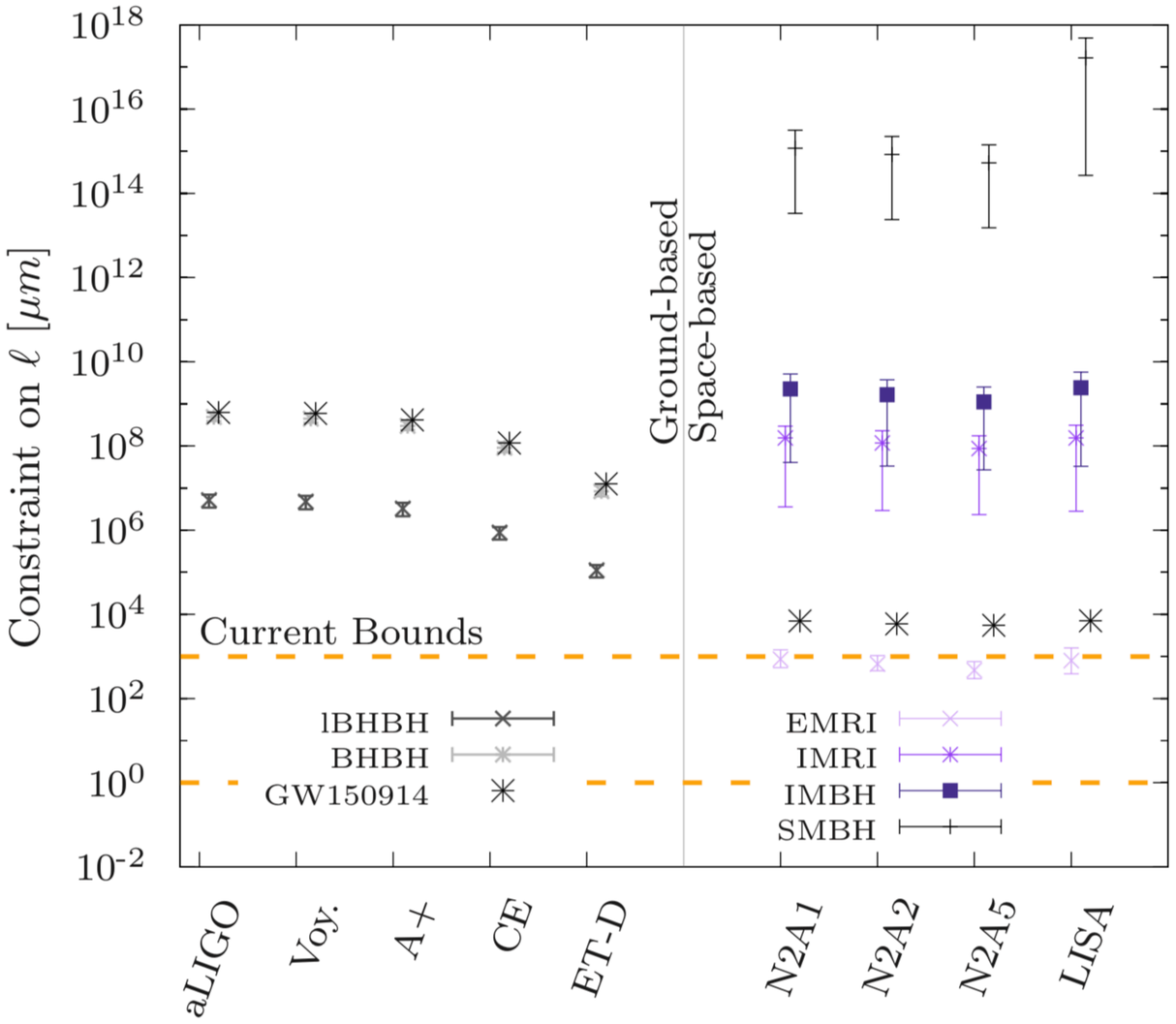

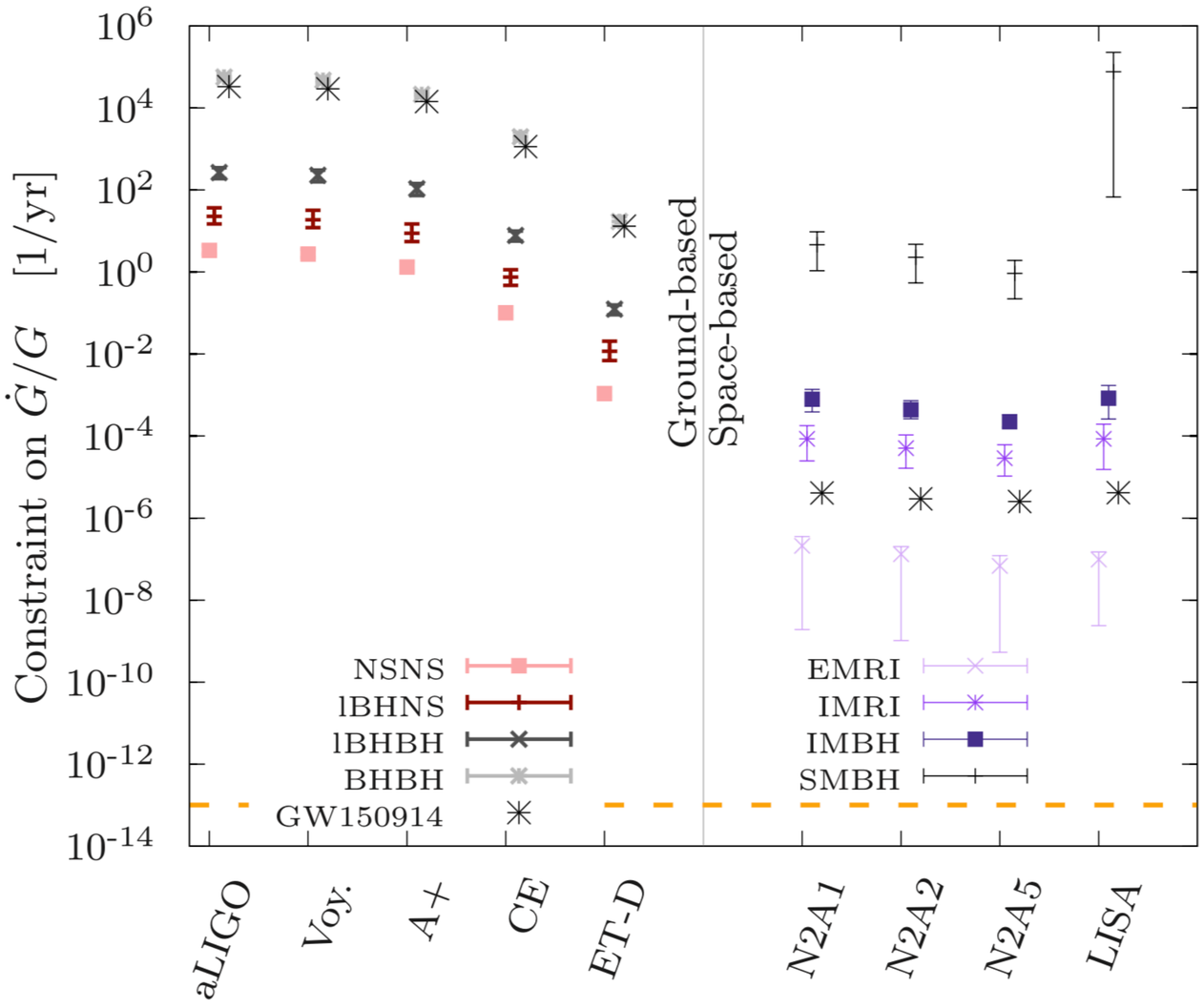

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