Spin–model comparison with GWTC-3 for isolated binary black holes

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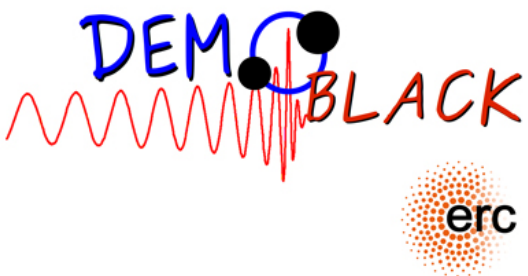
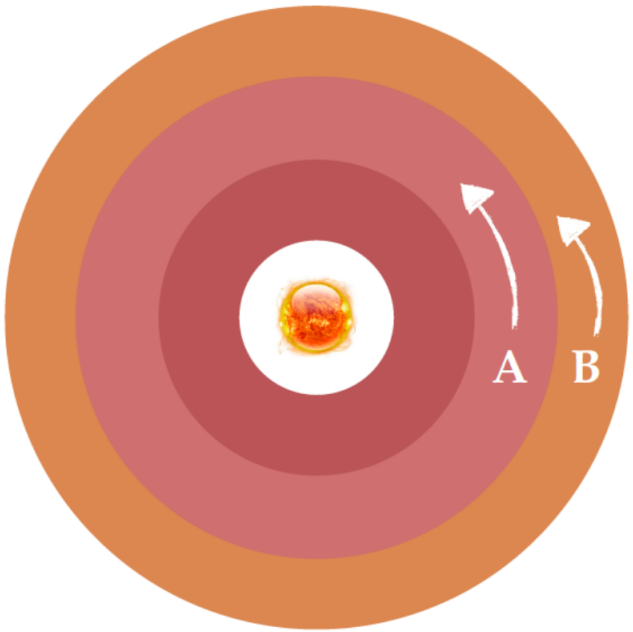
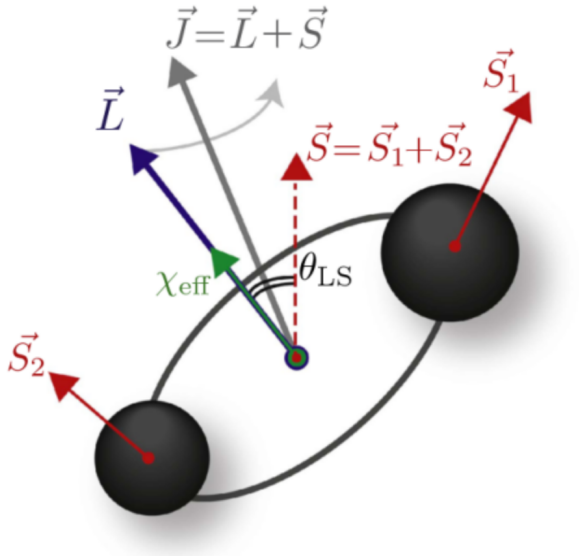


Spin measurement and models





Angular momentum transportation

- Transportation from the core of a star to outer layers.
- The angular momentum of the core is conserved during core-collapse/supernovae and become the BH spin χ

Measurements

- Spin-related quantities

$$\chi_{\rm eff} = \frac{(\vec{\chi}_1 + q\,\vec{\chi}_2)}{1+q} \cdot \frac{\vec{L}}{L},$$

$$\chi_{\rm p} = \max\left(\chi_{1,\perp},\, A\,\chi_{2,\perp}\right), A = \frac{4\,q+3}{4+3\,q}$$

- Mass-related quantities $\mathcal{M}_{\rm c}, q$
- Redshift z

Astrophysical Models

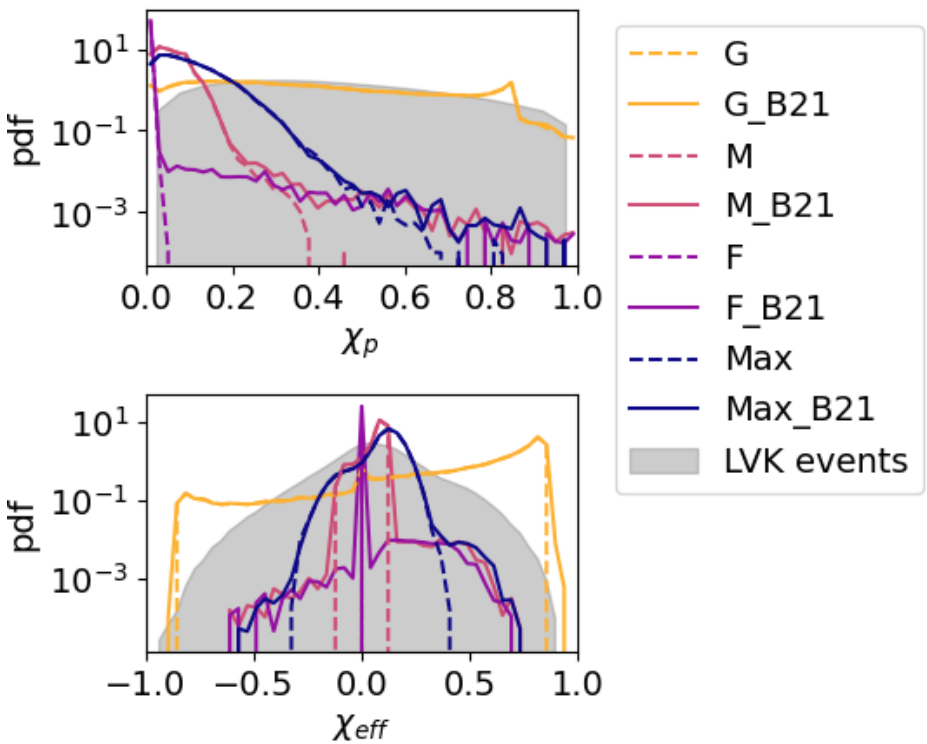
Angular momentum transportation models

Geneva (G)
- No magnetic field
- Z dependent
- Large χ distributions

MESA (M)
- Include Taylor-Spruit dynamo
- Z dependent
- Low χ

Fuller&Ma (F)
- More efficient dynamo
- Z independent
- Lower χ

Belczykski et al., 2010, ApJ



Tidal Spin-up **B_21**

- Tidal effect between BH-WR.
- Increase the angular momentum of the WR.
- Allow higher spins.

Bavera et al., 2021, A&A

Astrophysical Models

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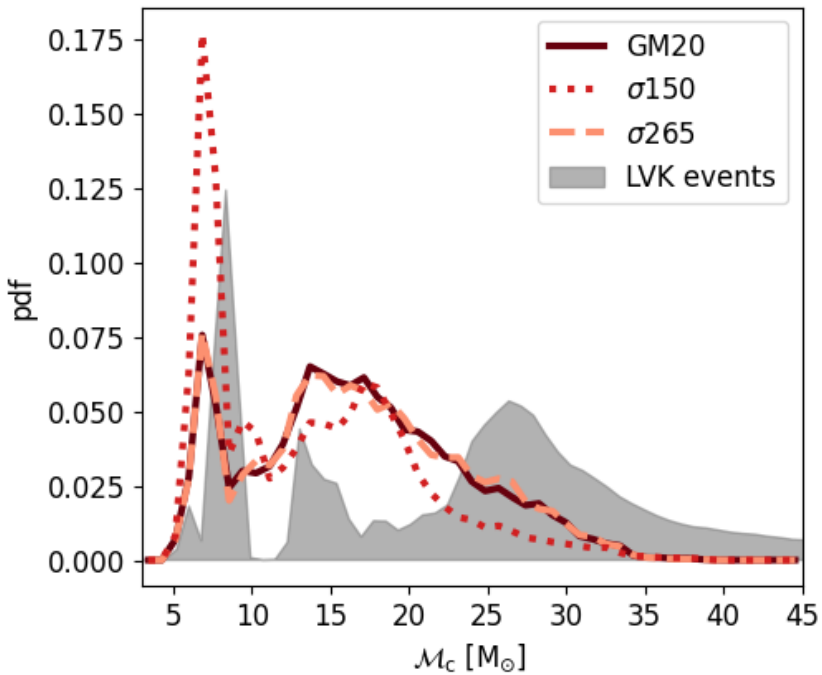
Natal kicks

Kicks of the remnant compact object during early SN phase due to asymmetric mass ejection

- **σ150**, **σ265** : Maxwellian distributions
- **GM20** : Mass dependant

Giacobbo & Mapelli, 2019, MNRAS



Bayesian analysis

Prior distributions

Gravitational-wave likelyhood of a single event

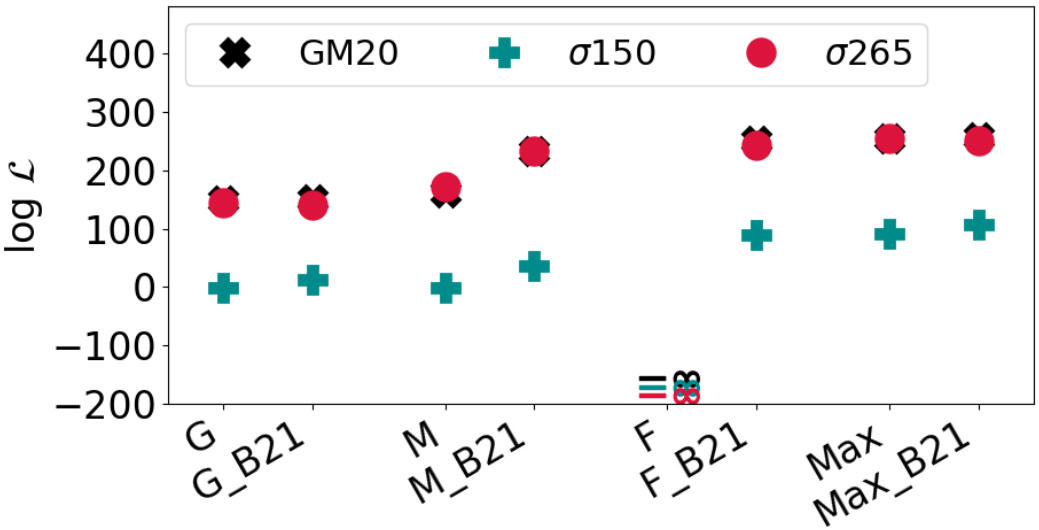
Efficiency accounts for selection effects due to detector capability

$$\mathcal{L} = \pi(\lambda) \prod_{k=1}^{N_{\rm obs}} \left[\frac{\int \mathcal{L}^k(h^k|\theta)\, p(\theta|\lambda)\, \mathrm{d}\theta}{\beta(\lambda)} \right]$$

Golden events

- $\mathrm{FAR} < 0.25 \mathrm{yr}^{-1}$
- $p_{\rm astro}^{\rm BBH} > 0.9$

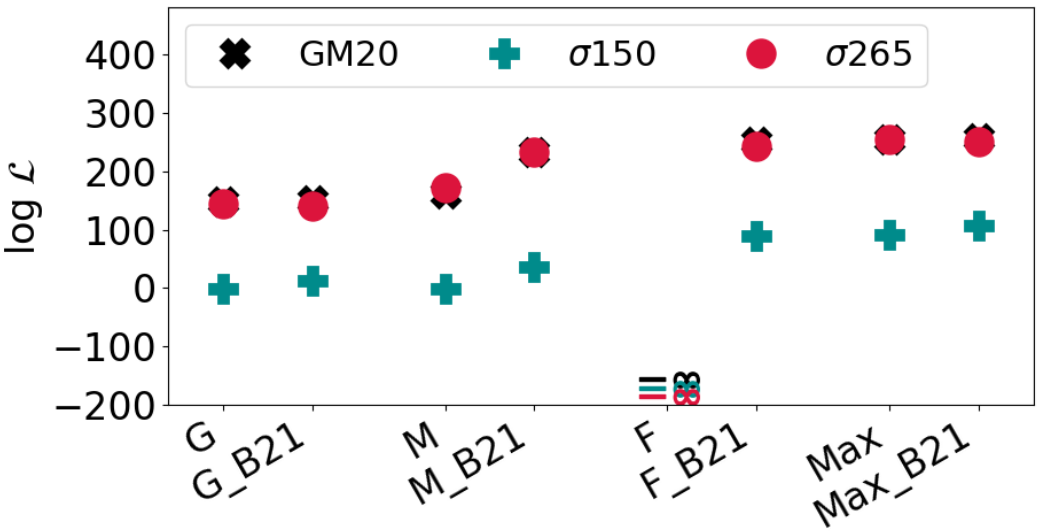
Results

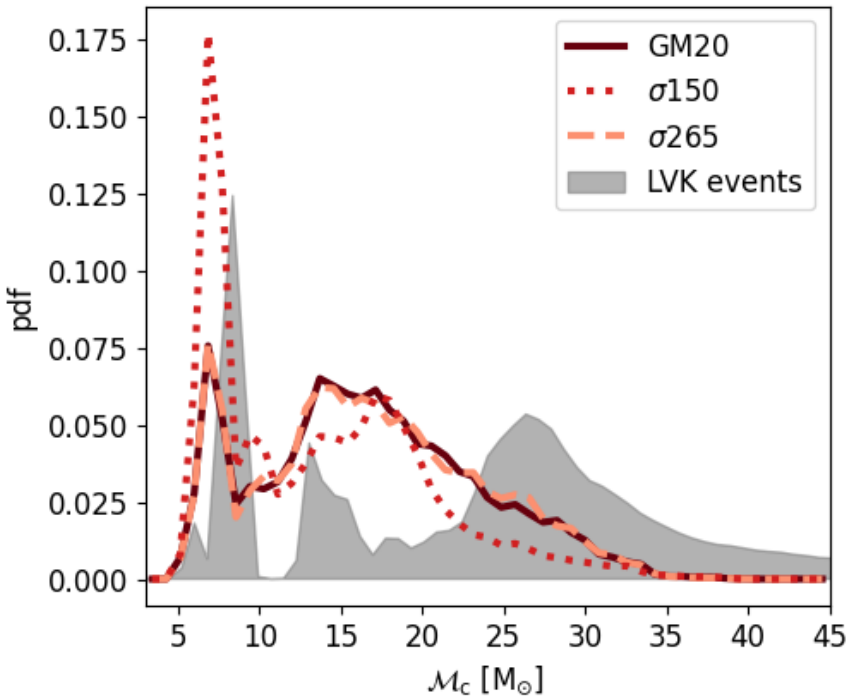


Max - Max_B21

Toy model
Spin picked in Maxwellian distribution with $\sigma = 0.1$, truncated at 1.

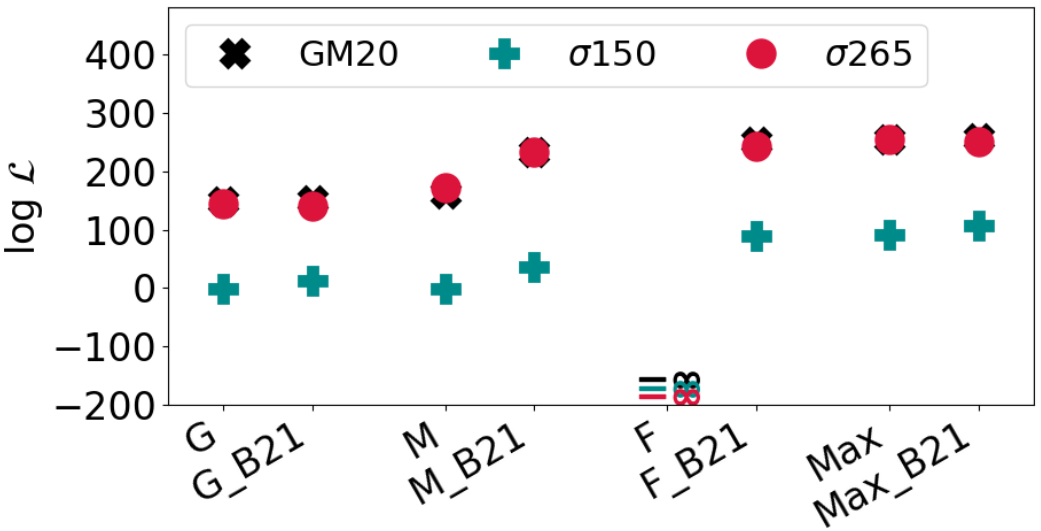
Results

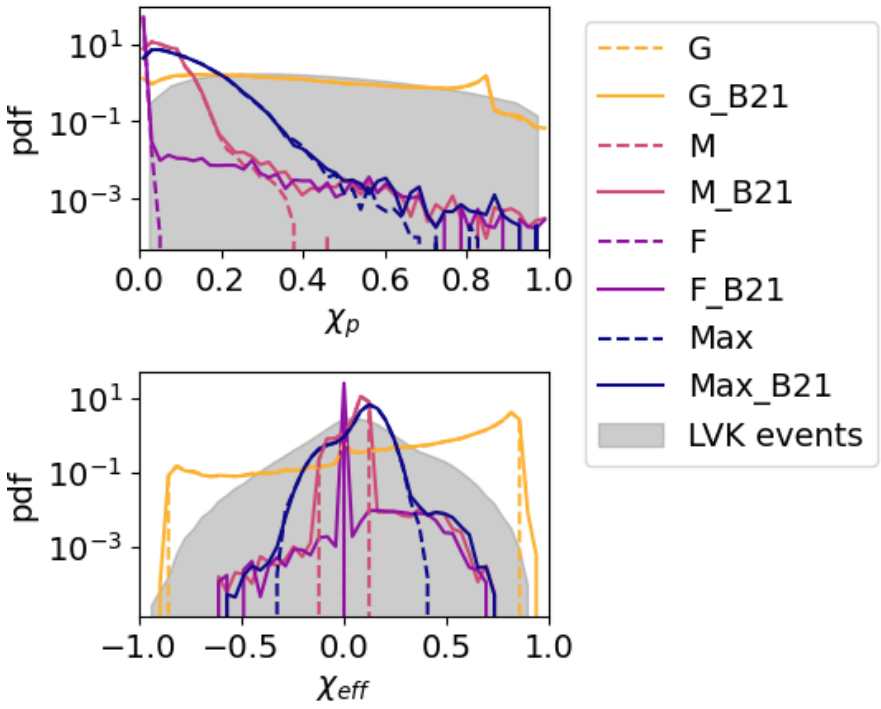




Kicks:
$\sigma 265 \sim \mathrm{GM20}$
$\sigma 265 > \sigma 150$

Results





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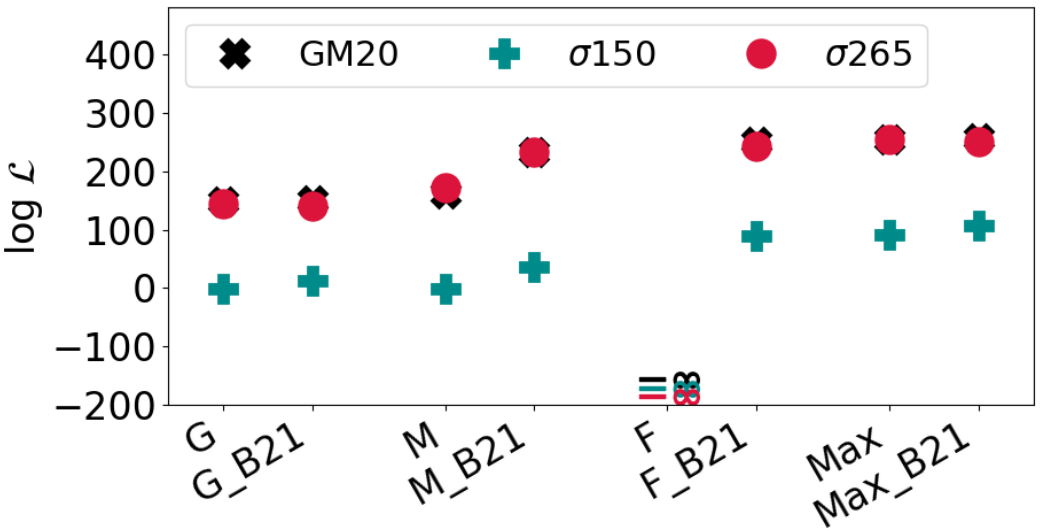
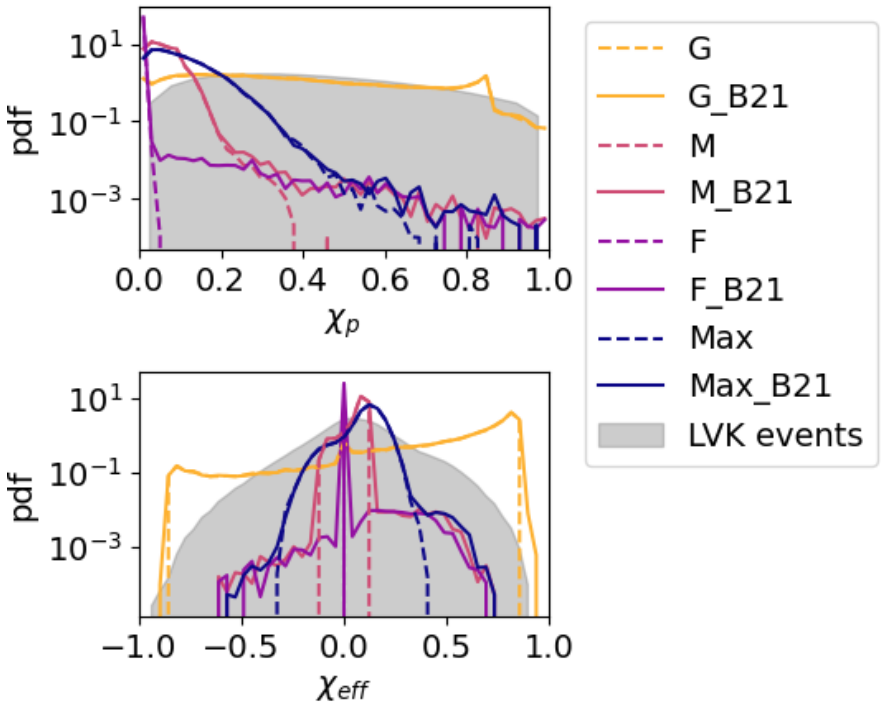
$\sigma 265 > \sigma 150$

Geneva:
(G) is not doing well
Too large
distributions

Results





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WR mechanism:
(M) and (F) good only including WR mechanism (M_B21, F_B21)

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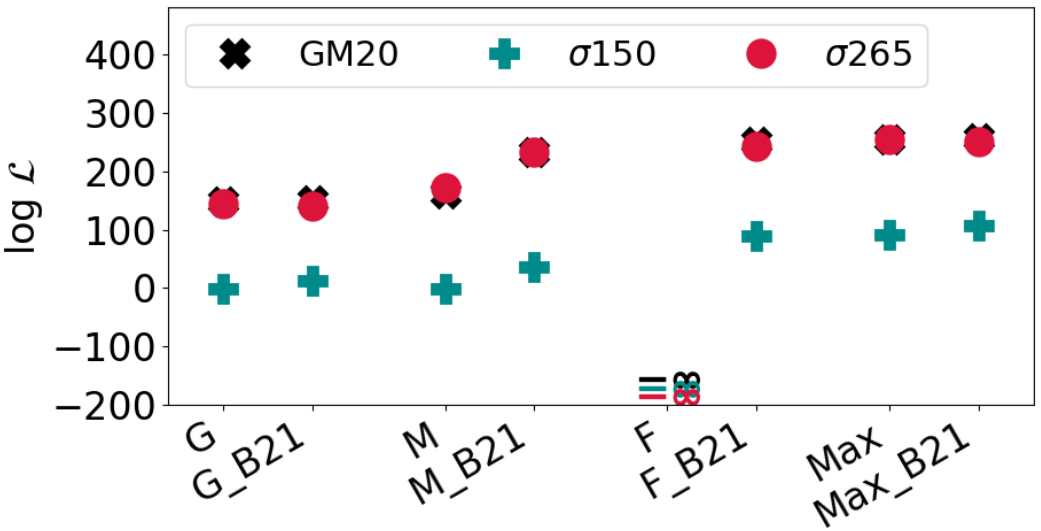

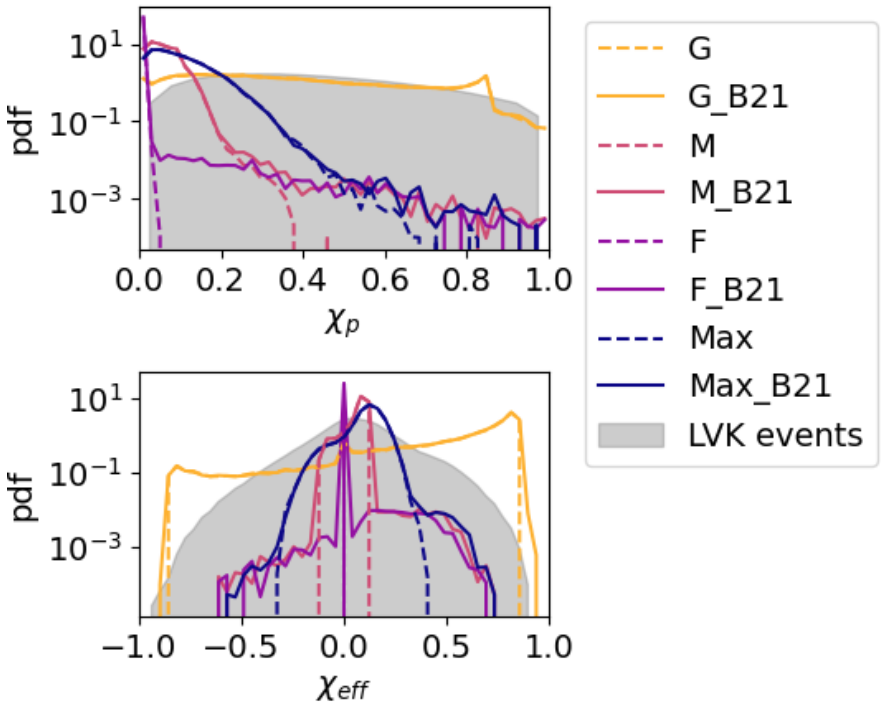

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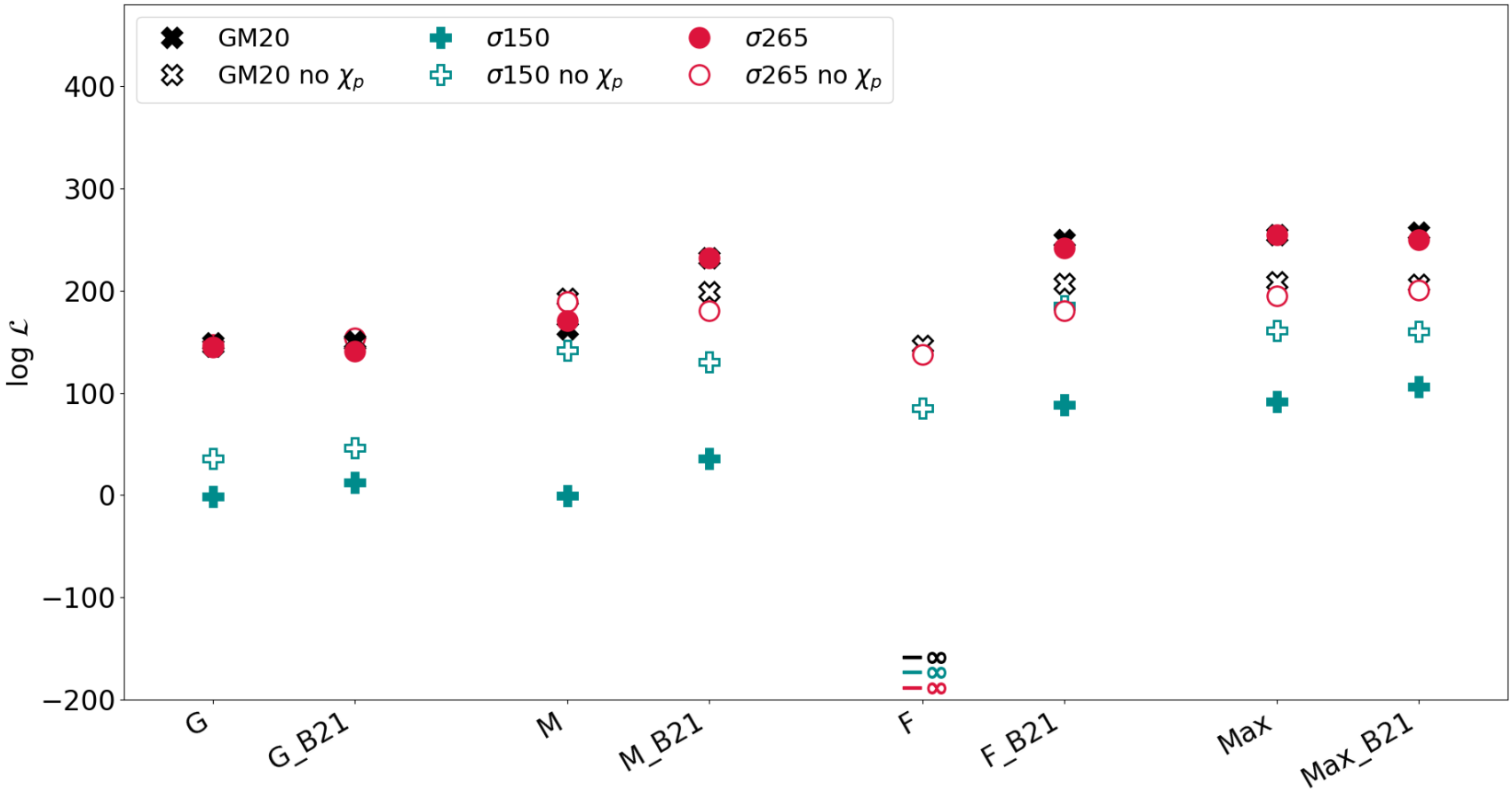
χ_{p} shows large distributions, what is its impact on the study?

Impact of $\chi_{\rm p}$



Same conclusion than without $\chi_{\rm p}$

No exclusion of (F)

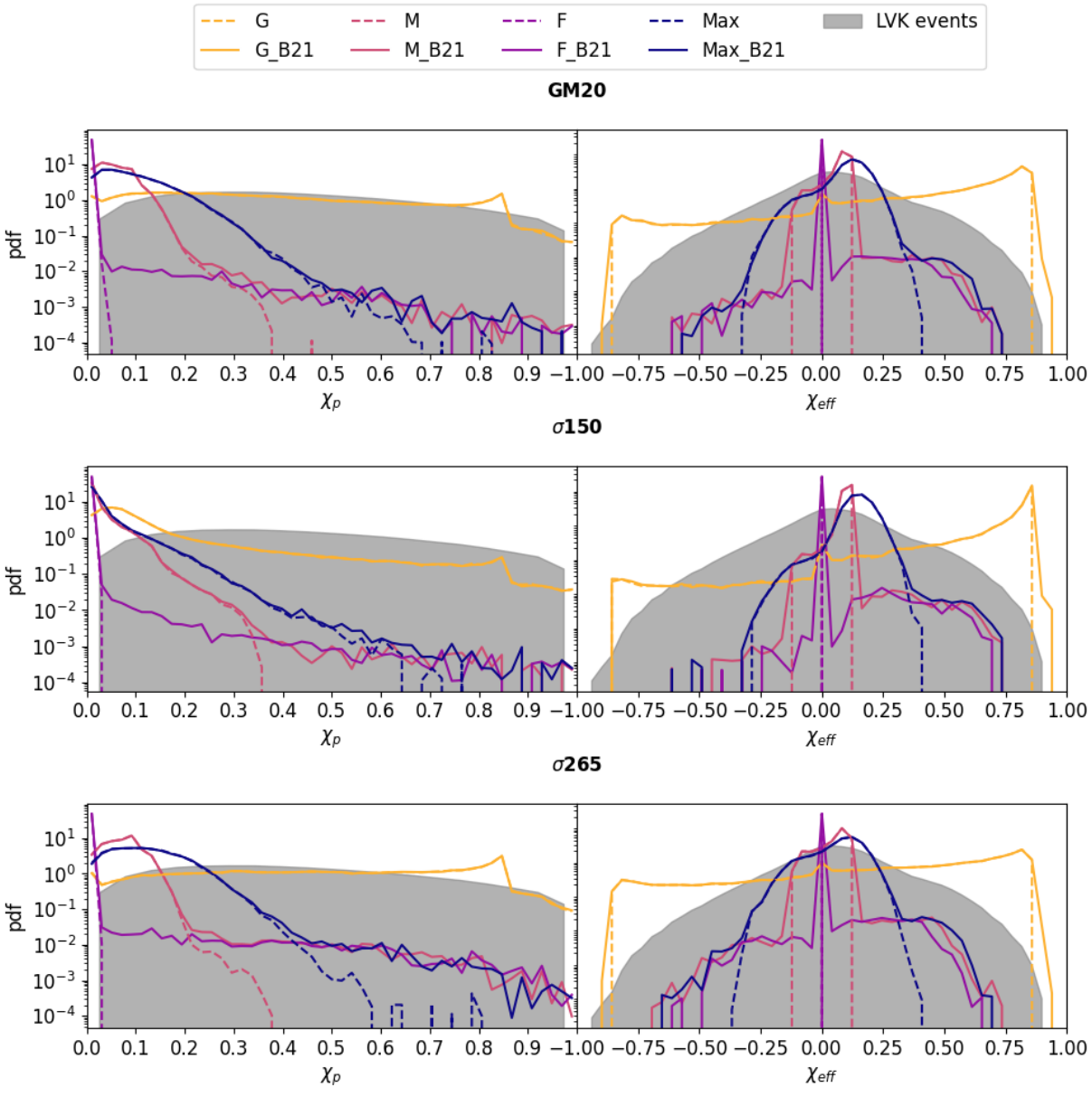
Lower difference between σ150 and σ265/GM20

Conclusion

- Gravitational waves measurement allow to exclude high efficiency angular momentum.
- The measurement of χ_{p} is relevant for angular momentum understanding.
- Public version of the code will be soon released.

Thank you for your attention :)

Spin distributions



Results tables

Table: Log-likelihood estimated with merger parameters $\theta = \{\mathcal{M}_c, z, \chi_{\rm eff}\ q, \chi_{\rm p}\}$

Model Name	GM20	σ150	σ265
G	149	-1	145
G_B21	150	-12	141
M	162	0	171
M_B21	232	36	232
F	-∞	-∞	-∞
F_B21	250	88	242
Max	255	92	254
Max_B21	257	106	250

Table: Log-likelihood estimated with merger parameters $\theta = \{\mathcal{M}_c, z, \chi_{\rm eff}\ q\}$

Model Name	GM20	σ150	σ265
G	146	35	147
G_B21	149	47	154
M	192	141	190
M_B21	199	130	180
F	146	85	138
F_B21	207	185	180
Max	208	161	155
Max_B21	206	160	200