Probing the magnetic field in the GW170817 outflow using H.E.S.S. observations

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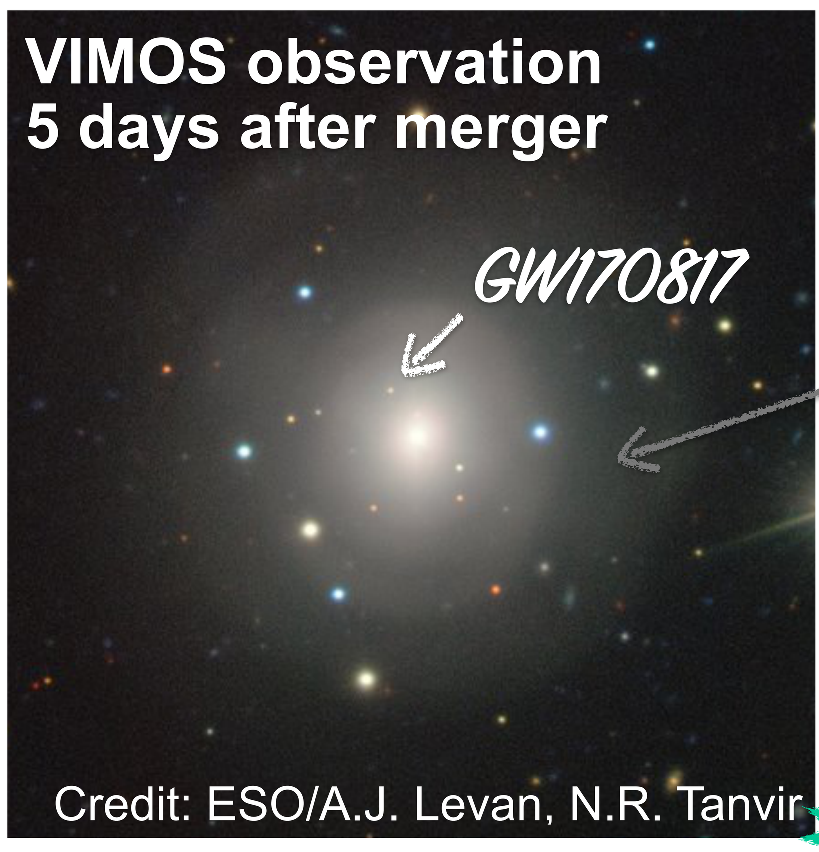
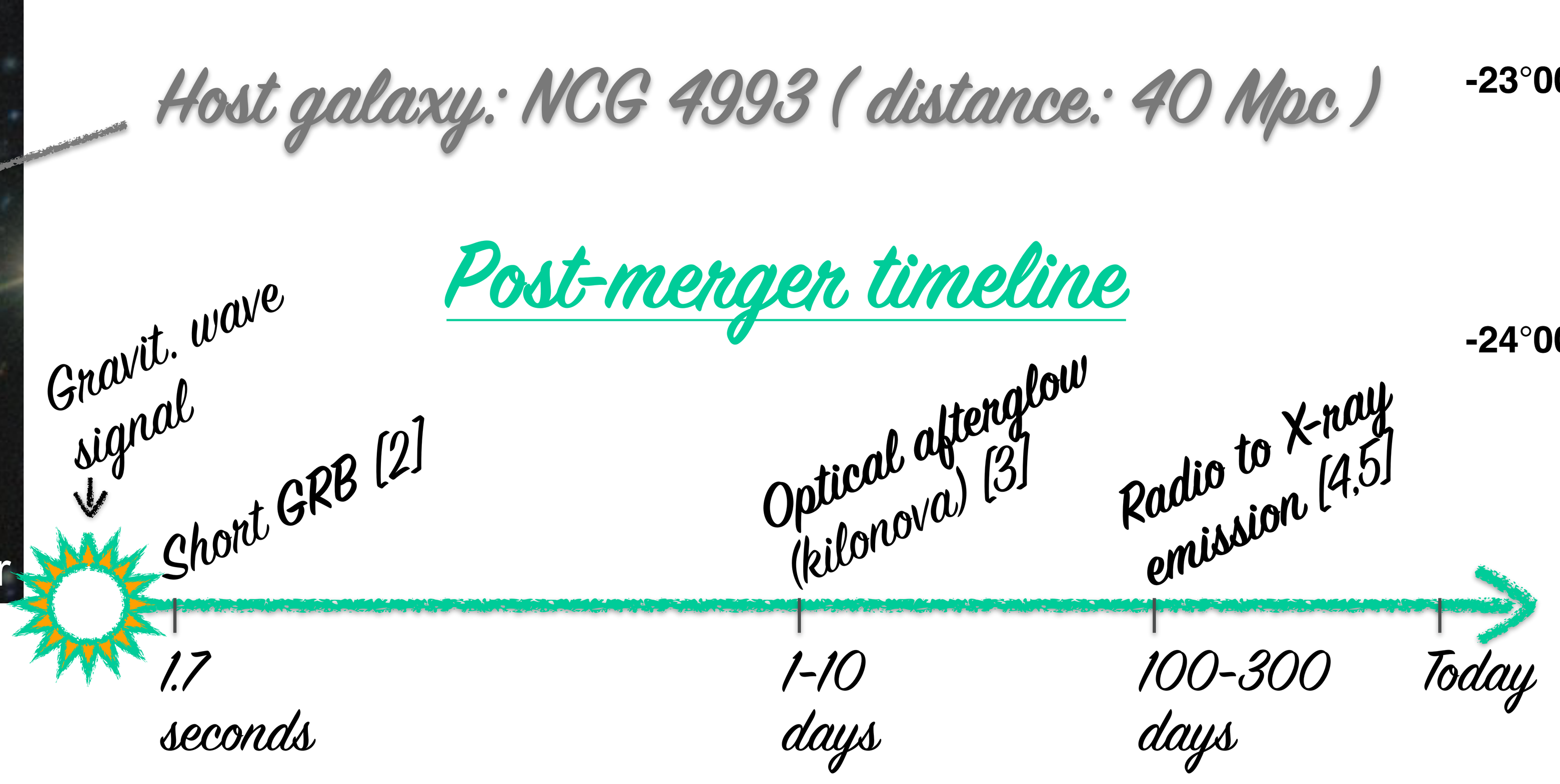
(H.E.S.S. collaboration 2019, in preparation)

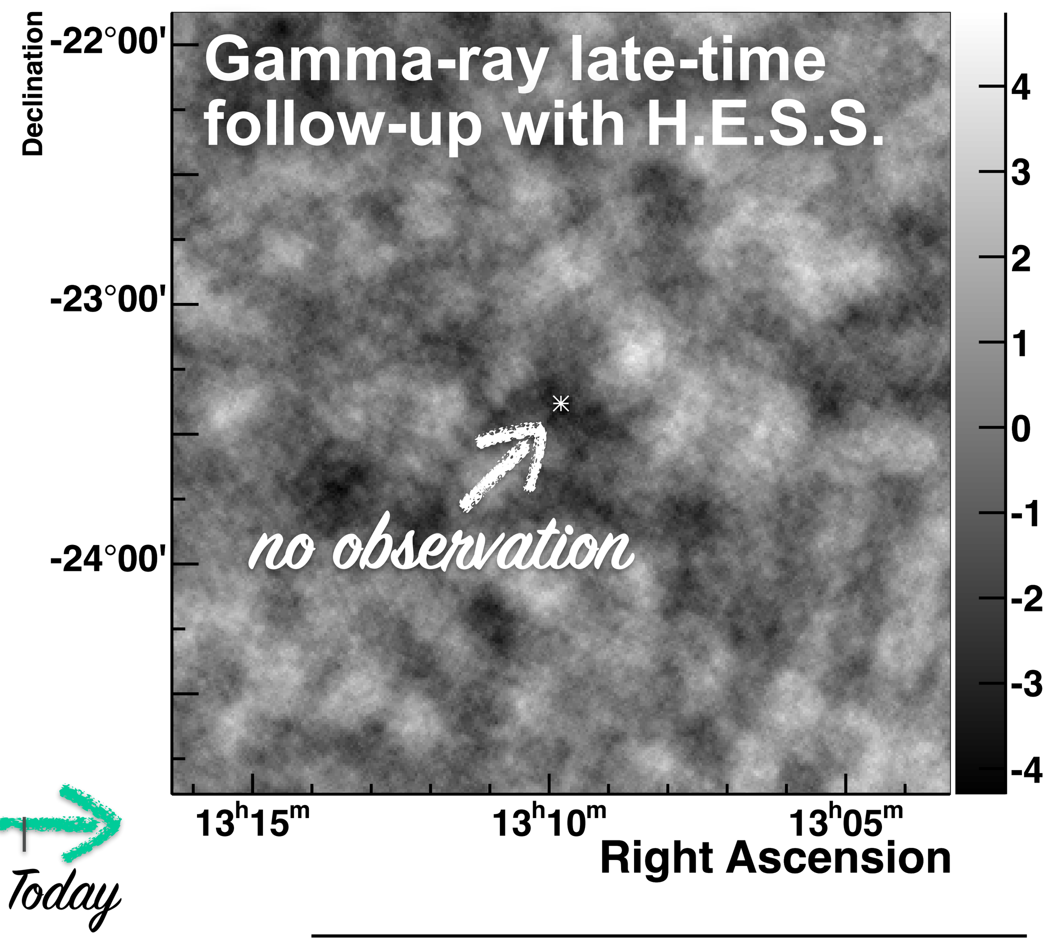
The neutron star merger GW170817



First **binary neutron star merger** ever identified

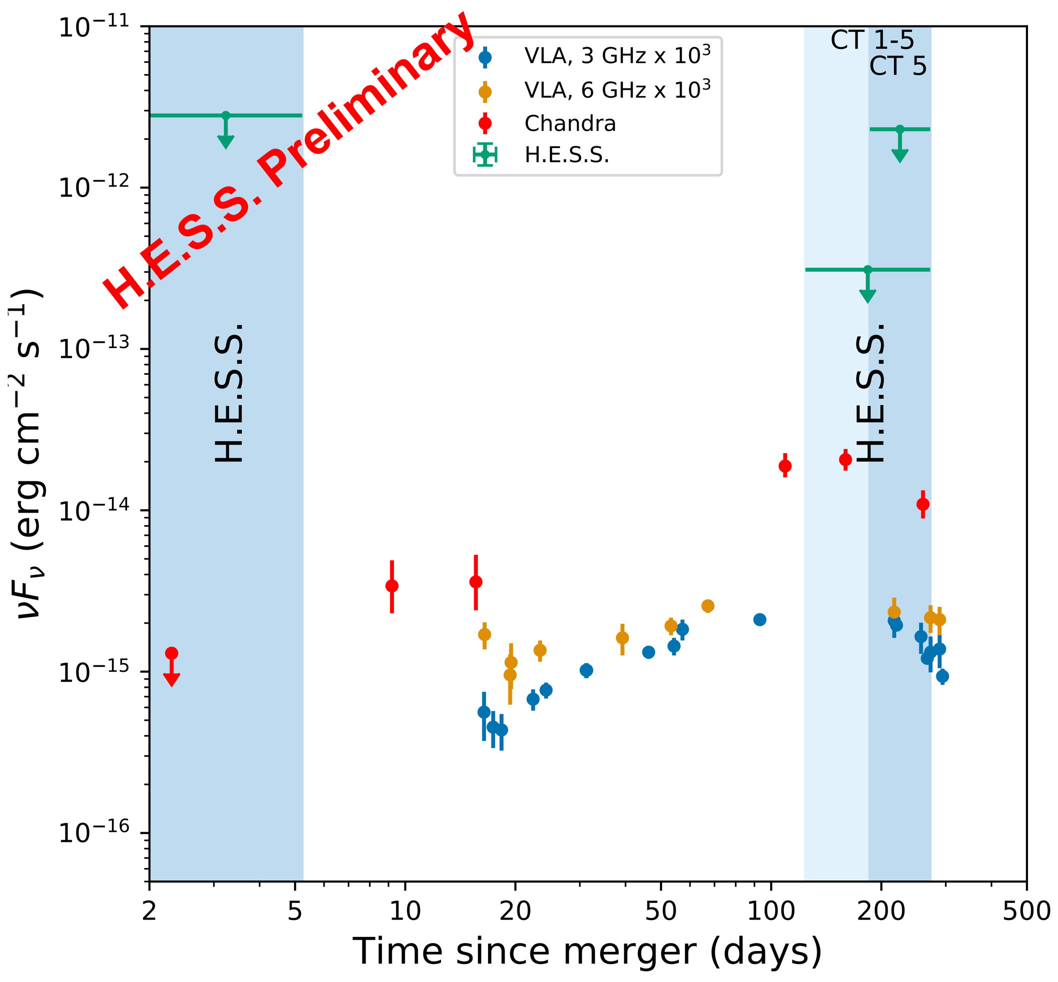
Detected in **gravitational waves** by **LIGO/Virgo**
August 17th, 2017 [1]





Long-term H.E.S.S. Results
- No detection in any data set
- No detection on month timescales
- Derive differential and integral upper limits for different data sets

Analysis and Results



[H.E.S.S. and X. Rodrigues, in preparation]

H.E.S.S. Instrument
- Operates in the **30 GeV – 100 TeV** energy range
- Has a field of view of ~ 10 deg²

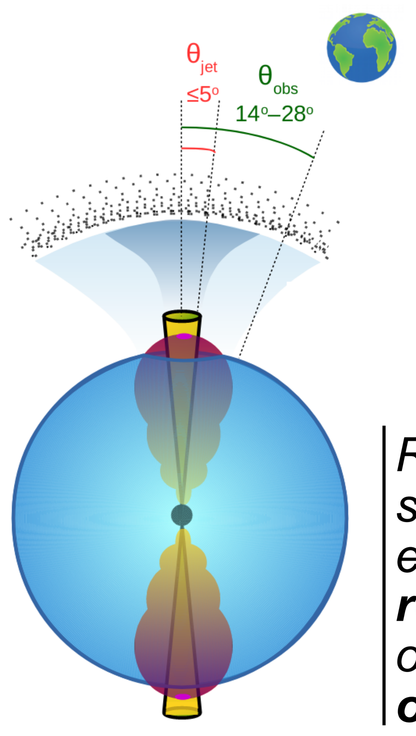
Data Set
- Observations cover **plateau and fading** of non-thermal emission (125-270 days after merger)
- 32 hours exposure with CT5 mono
- 54 hours exposure with CT1-5
- Energy **threshold of 130 GeV**

TABLE I: Properties of the H.E.S.S. data sets on GW170817 / GRB 170817A and analysis results.

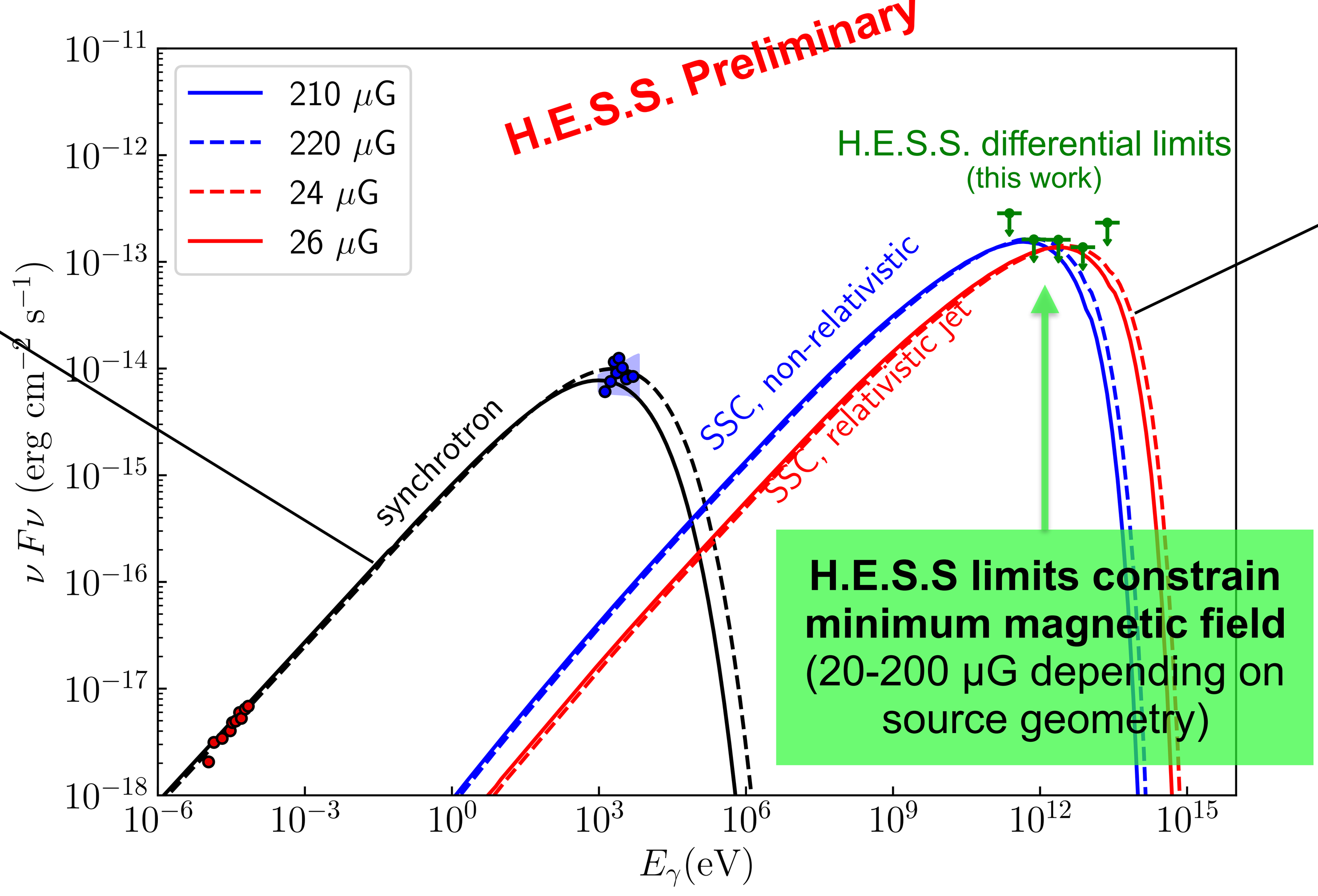
Data Set	Configuration	$T - T_0$ (days)	Exposure (hours)	$E_{\rm th}$ GeV	$F(>E_{\rm th})$ erg cm^{-2} s^{-1}	$F(1-10\,{\rm TeV})$ erg cm^{-2} s^{-1}	Zenith angle °	Reference
I	CT 5	0.22 – 5.23	3.2	270	$< 1.5 \times 10^{-12}$		58	Abdalla et al. [4]
II	CT 1–5	0.22 – 5.23	3.2	560	$< 4.7 \times 10^{-12}$	$< 2.8 \times 10^{-12}$	58	this work
III	CT 5	186 – 272	32.2	130	$< 4.1 \times 10^{-12}$	$< 1.4 \times 10^{-12}$	20	this work
IV	CT 1–5	124 – 272	53.9	130	$< 6.2 \times 10^{-13}$	$< 4.1 \times 10^{-13}$	24	this work

Interpretation of the H.E.S.S. result

Conservatively assume **synchrotron emission** that cuts off at observed X-ray energies



Radio observations suggest that the emission is from a ***relativistic jet*** *observed* ***off-axis*** *[6]*



[H.E.S.S. and X. Rodrigues, in preparation]

Synchrotron self-Compton emission expected to peak in the TeV range

	Gamma-ray luminosity
Weak magnetic field +High electron density	↑
Klein-Nishina regime	↓
Pair production	↓

Conclusions

- **H.E.S.S.** performed late-time follow-up observations of GW170817 **125-270 days** after the merger
- **No detection of gamma-ray** emission above 130 GeV energies
- We **modeled** the **radio-to-X-ray** emission of the merger remnant, consistent with **electron synchrotron**
- The **H.E.S.S. follow-up** results **constrain the magnetic field** in the remnant to the **20-200 μG** range
- This result holds for **different source geometries**, like a relativistic jet observed off-axis

References

[1] Abbott et al. 2017a, PRL 119, 16110
[2] Abbott et al. 2017b, ApJ 848:L13
[3] Smartt et al. 2017, Nature 551, 7678
[4] Alexander et al. 2017, ApJ, 848, L21
[5] Troja et al. 2017, Nature 551, 71-74
[6] Mooley et al. 2018, Nature 561, 355-359

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