

Searches for VHE counterparts to Fast Radio Bursts and Gravitational Waves



Fabian Schüssler (IRFU, CEA Paris-Saclay)

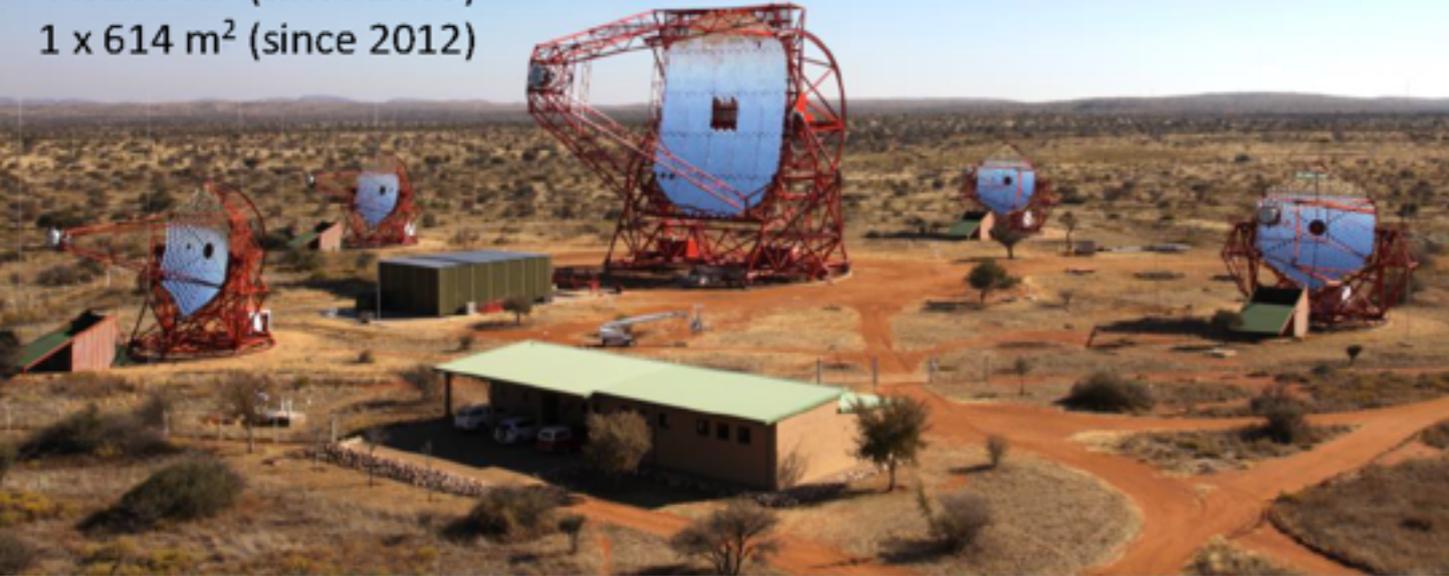


From the current IACTs to CTA

H.E.S.S. (Namibia)

4 x 108 m² (since 2003)

1 x 614 m² (since 2012)



MAGIC (La Palma)

2 x 236 m² (since 2003 / 2009)

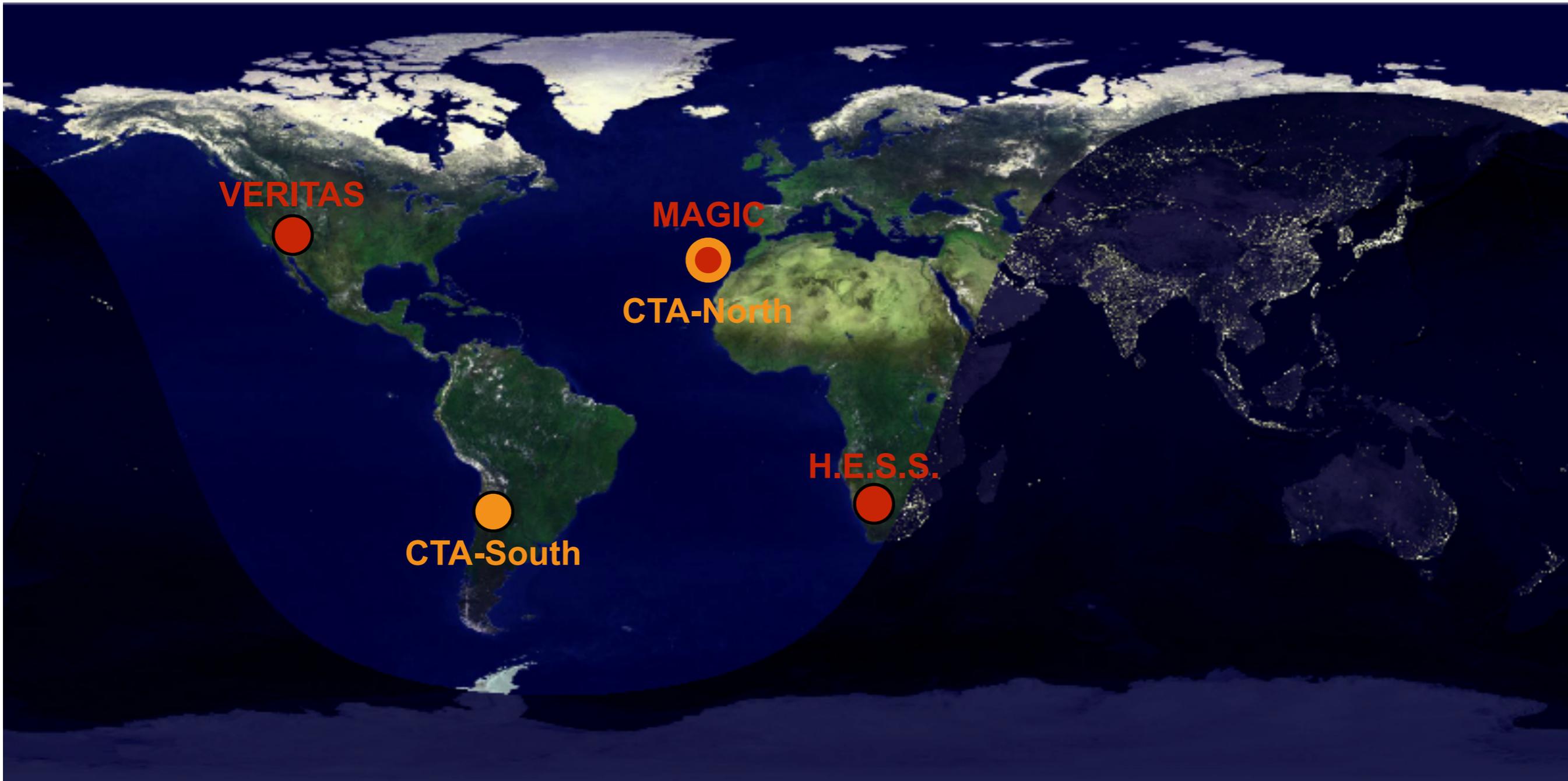


VERITAS (Arizona)

4 x 110 m² (since 2007)



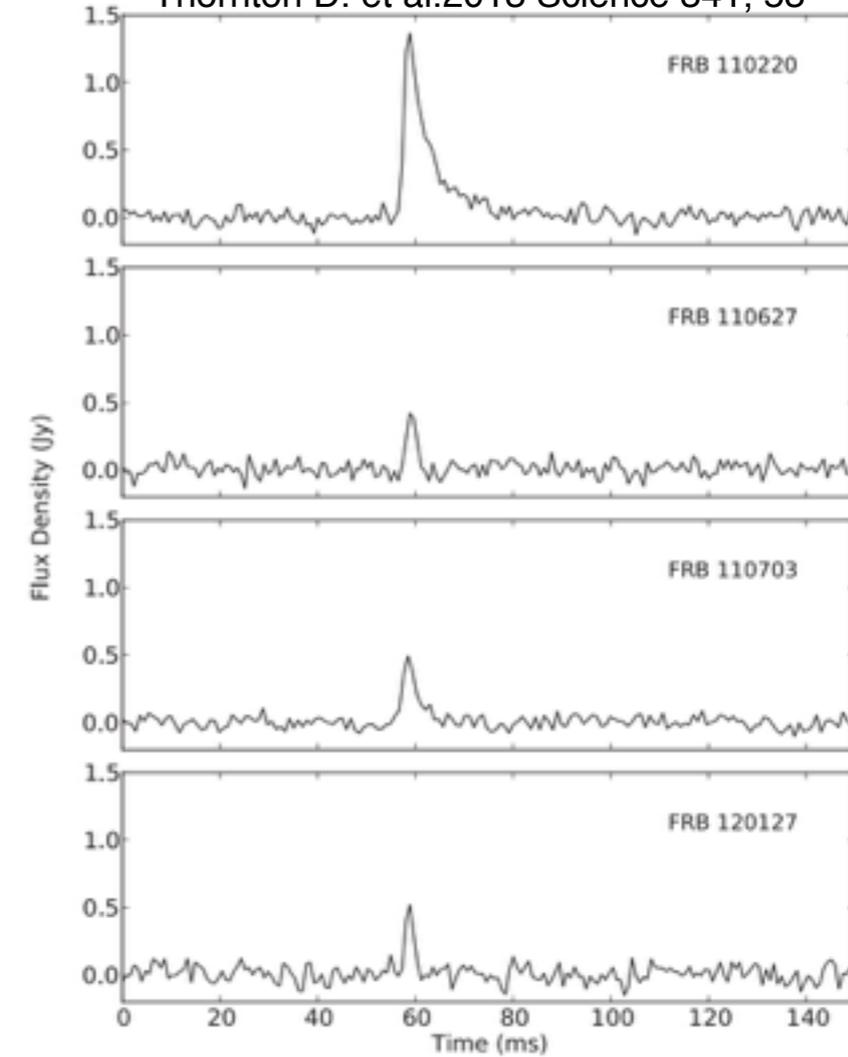
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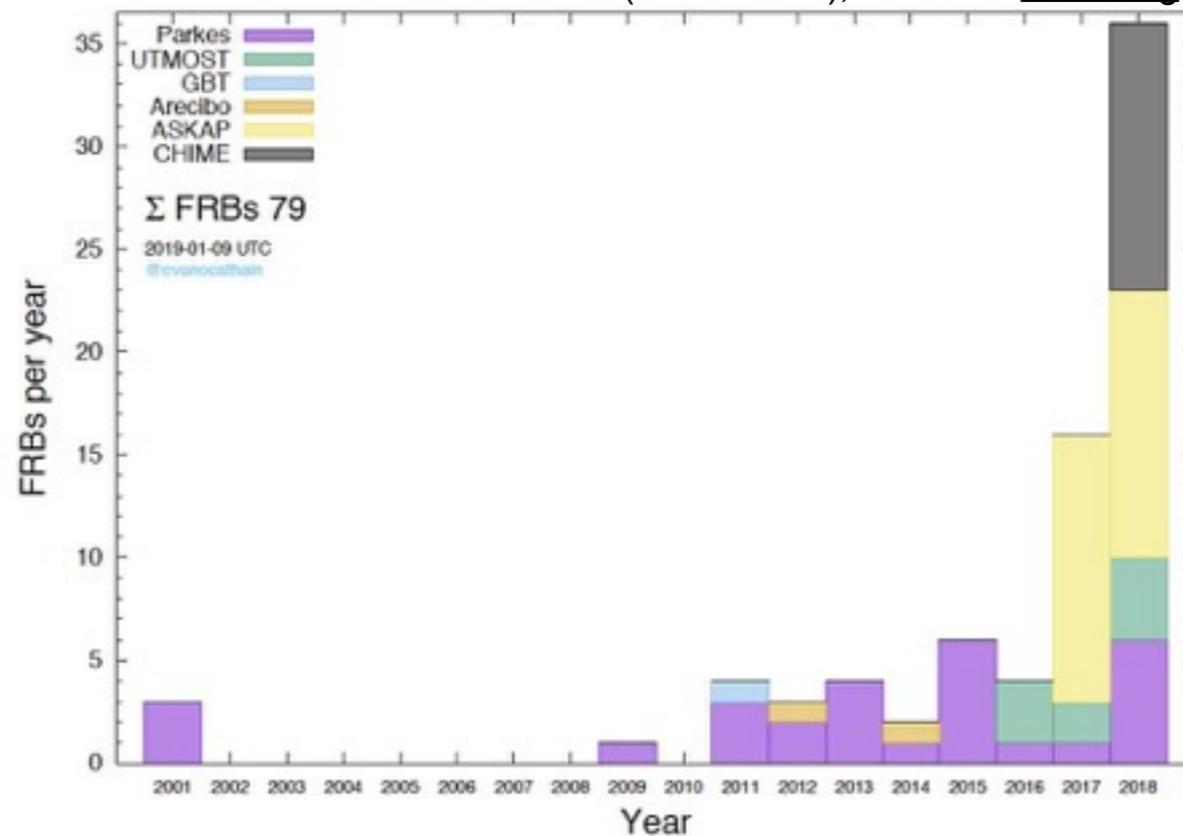
Fast Radio Bursts

- strong, millisecond radio burst of extragalactic origin
- large variety of source models (e.g. [FRBTheoryCat](#))
- significant evolutions over the last years
 - many more bursts + repeating bursts
 - large FoV instruments + rapid detection pipelines
 - ...

Thornton D. et al. 2013 Science 341, 53

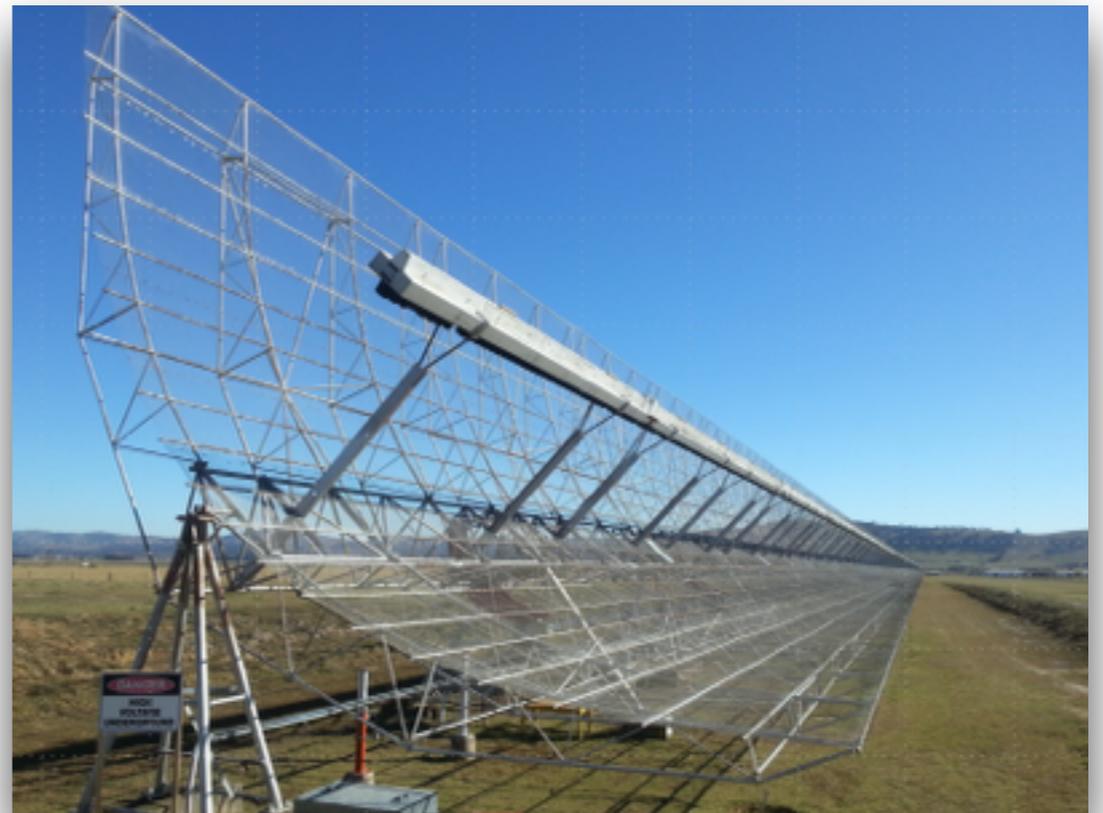


Evan Keane (2019-01-09), see also: [frbcat.org](#)



How to find a MWL counterpart?

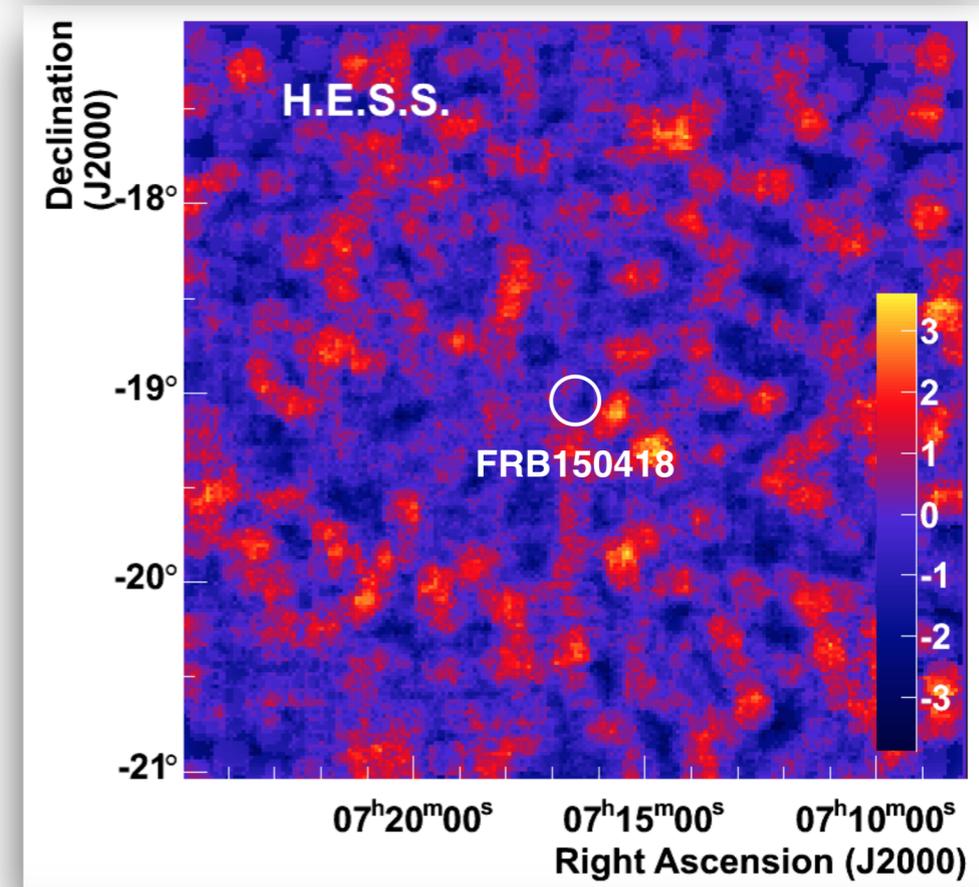
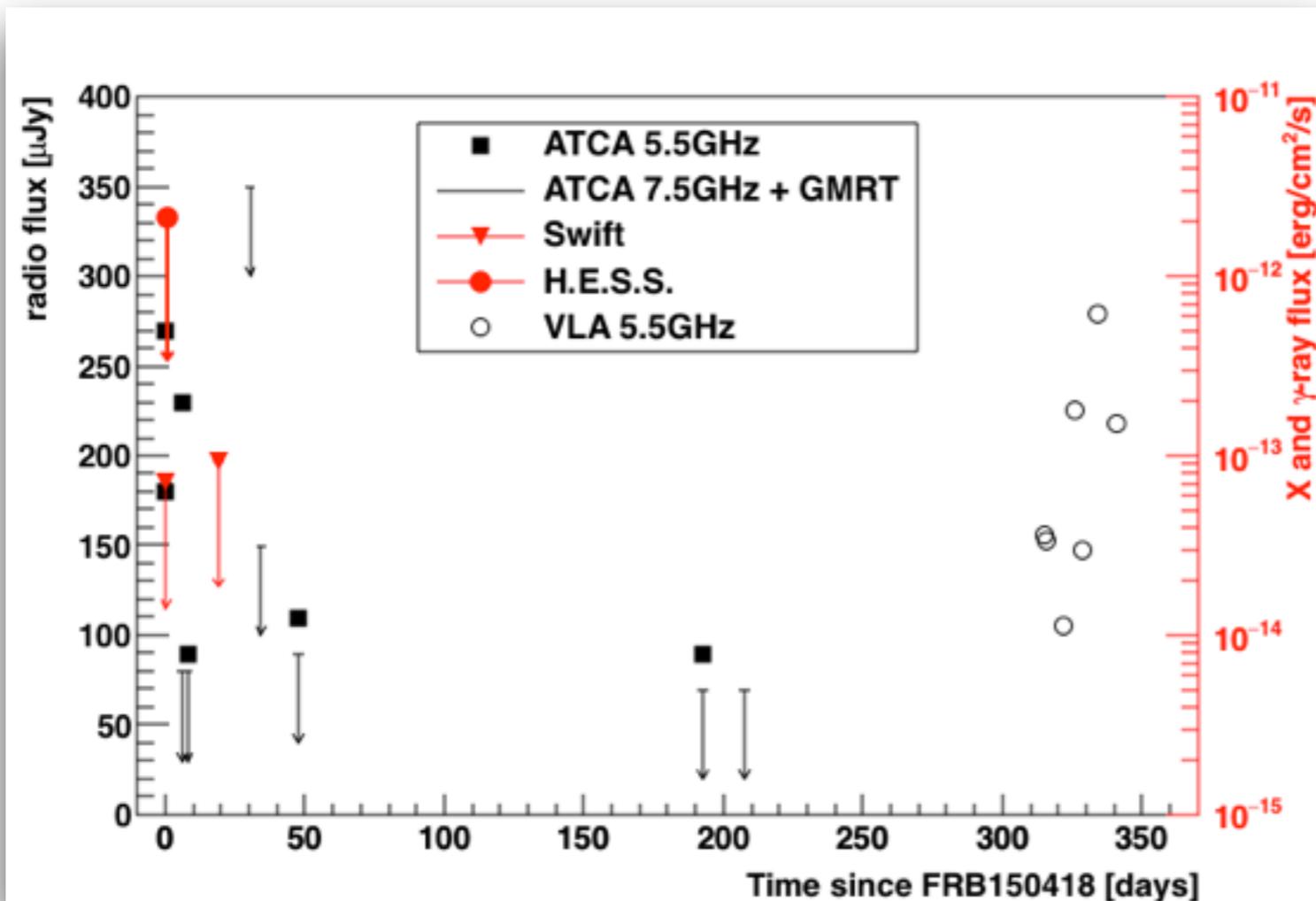
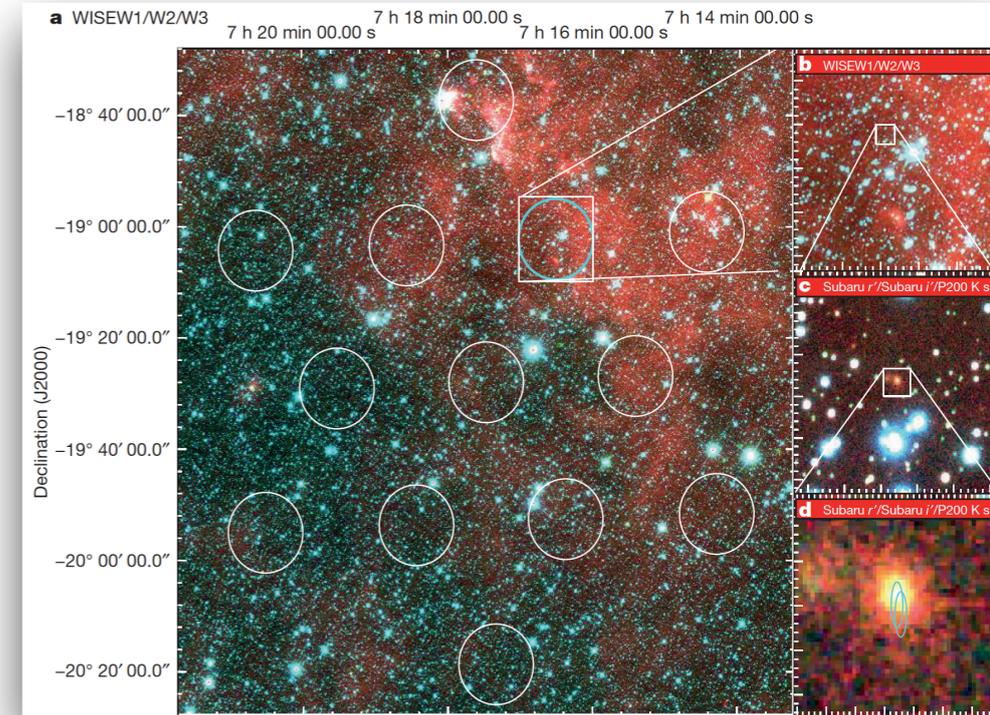
- Follow-up observations
 - physics: sensitive to "afterglow" emission only
 - technical: need rapid detection + alert emission + follow-up
 - e.g. SUPERB@Parkes -> H.E.S.S.
 - e.g. UTMOST -> H.E.S.S.



Alert follow-up: FRB150418

- detected 2015 April 18 04:29:07.056 UTC at SUPERB@Parkes
- ATCA: fading radio afterglow during ~6days
 - optical identification of galaxy at $z=0.492$
- H.E.S.S. observations the night after the burst
 - delay: ~14.5h
 - no VHE afterglow detected
 - $\Phi(E>350\text{GeV}) < 1.3 \times 10^{-8} \text{ m}^{-1} \text{ s}^{-1} (E^{-2}, 99\% \text{ C.L.})$

E. Keane et al., Nature 530 (2016)



HESS+SUPERB, A&A 597 (2017)

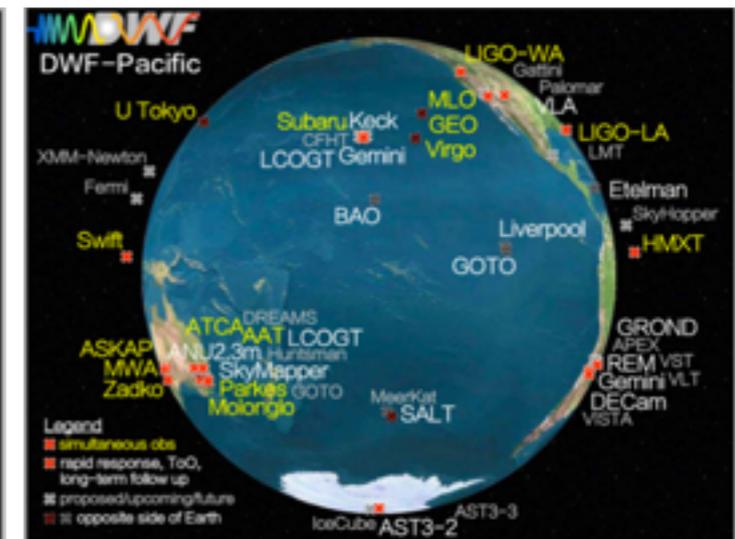
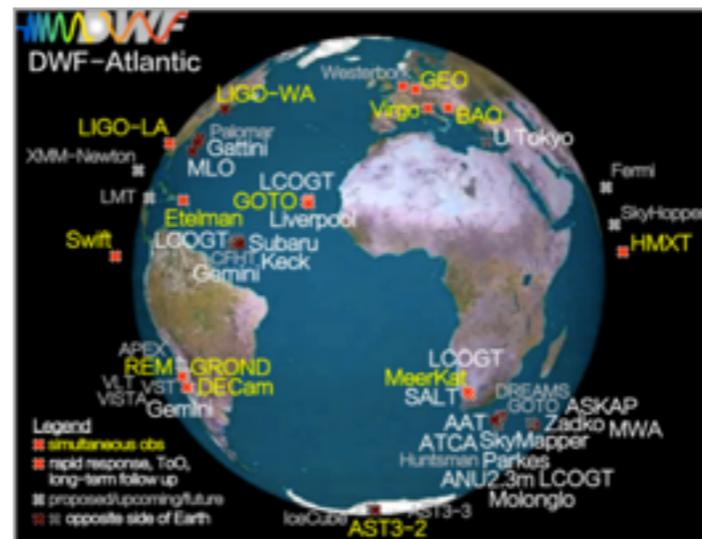
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■ Contemporaneous observations

- physics: sensitive to "precursor" + "prompt" + "afterglow" emission
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 - staring at the same field with several observatories
 - e.g. DeeperWiderFaster 2019 with H.E.S.S.



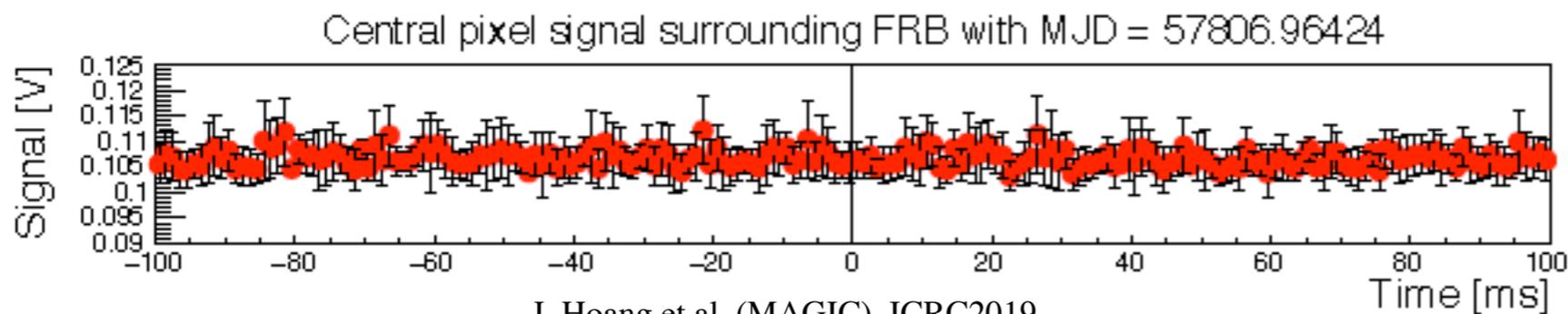
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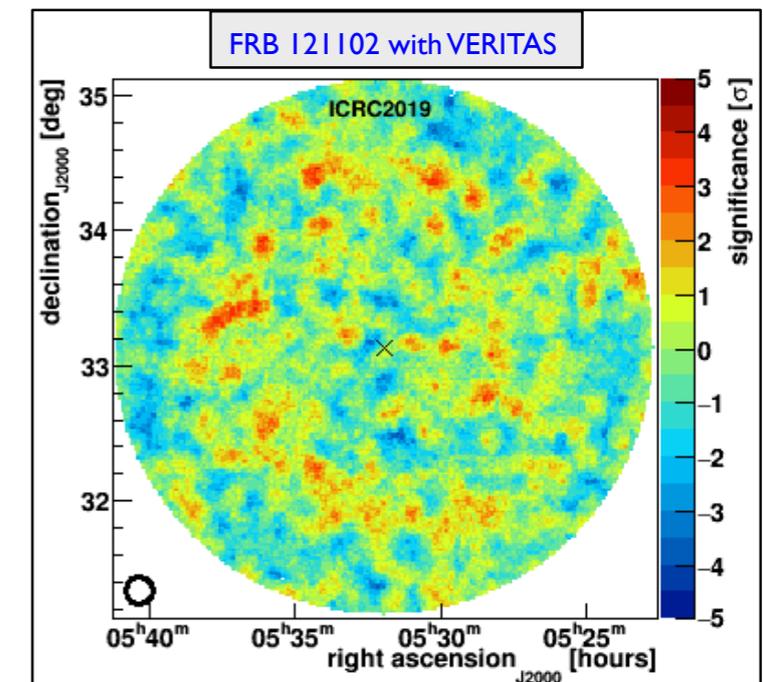
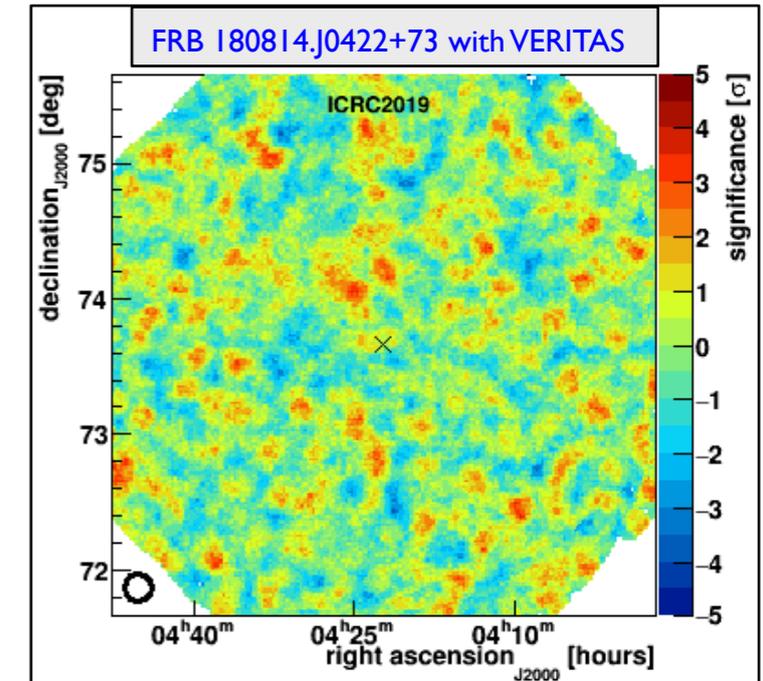
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 - staring at a repeating FRB with several observatories
 - e.g. campaigns on FRB121102 with MAGIC, VERITAS (and H.E.S.S.)

FRB 121102 and FRB 180814.J0422+73

- **VERITAS:** 12.7h + 8.2h of observations => no steady emission
- FRB 180814.J0422+73 observations overlapping with CHIME => no bursts found
 - $\Phi < 9.2 \times 10^{-13} \text{ ph cm}^{-2} \text{ s}^{-1} > 300 \text{ GeV}$ for *soft* cuts
- 115min of observations on FRB 121102 overlapping with GBT (Nov. 25, 2017) => 15 bursts found
 - dedicated analysis within 10ms around the bursts
 - $\Phi < 3.7 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1} > 200 \text{ GeV}$ for all 15 bursts
- **MAGIC:** 23h of observations (8.9h overlapping with Arecibo) on FRB 121102 => 5 bursts found



J. Hoang et al. (MAGIC), ICRC2019
arXiv: 1908.07506



J. Holder et al. (VERITAS), ICRC2019
arXiv: 1908.06471

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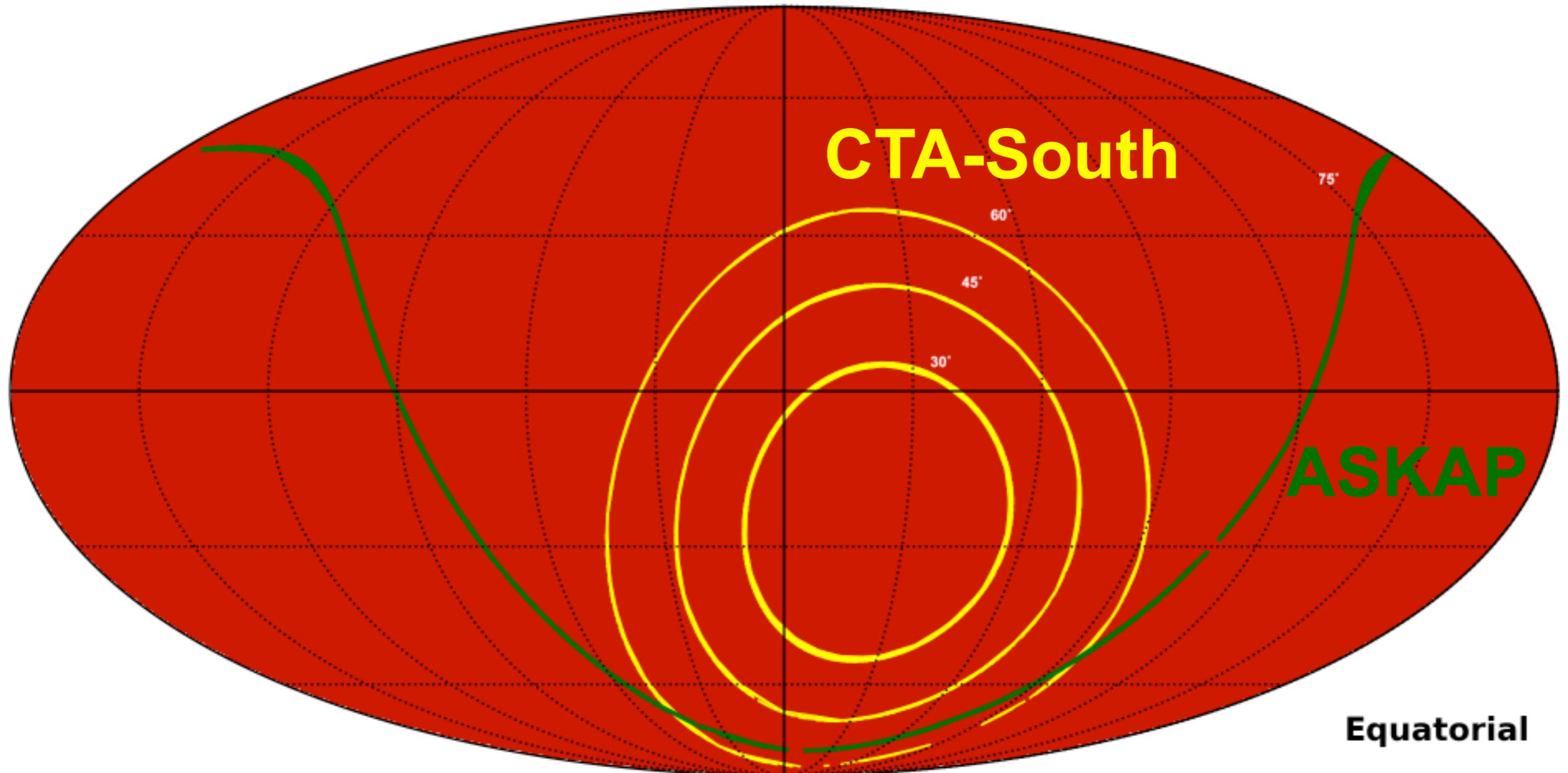
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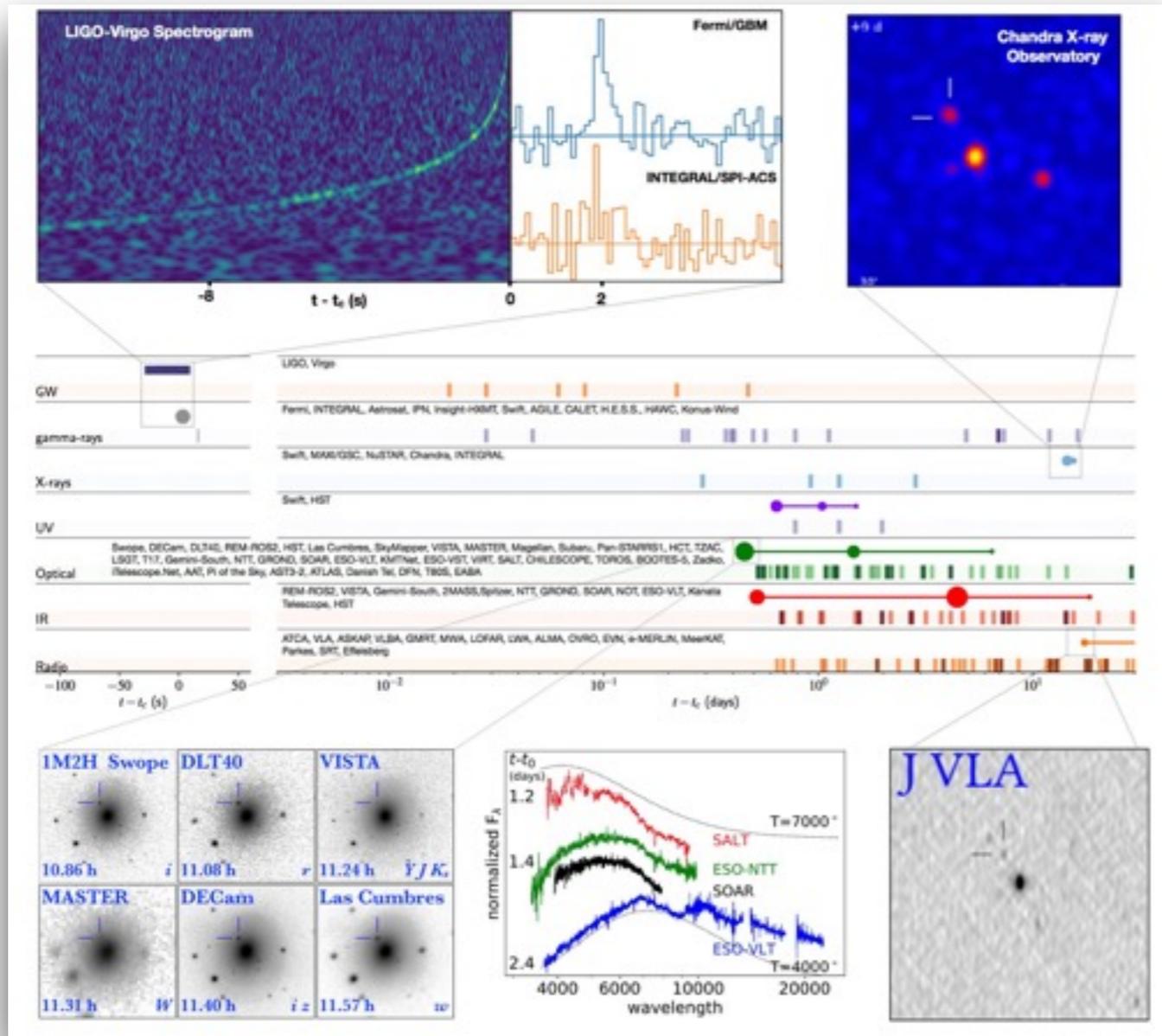
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 - **FRB171019** (ASKAP + GBT/CHIME): first repeating burst in the Southern hemisphere, stay tuned...

Opportunities for CTA



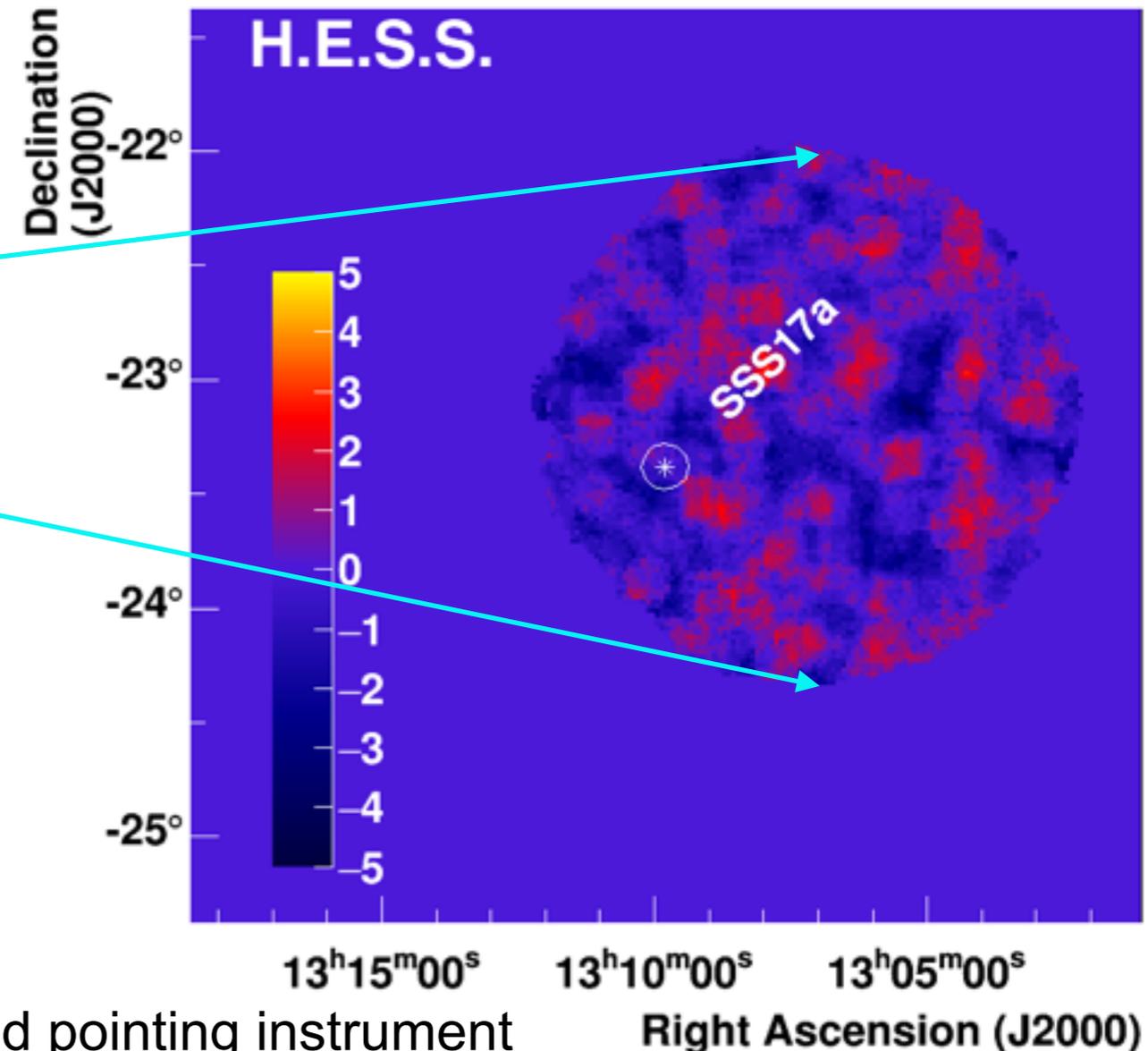
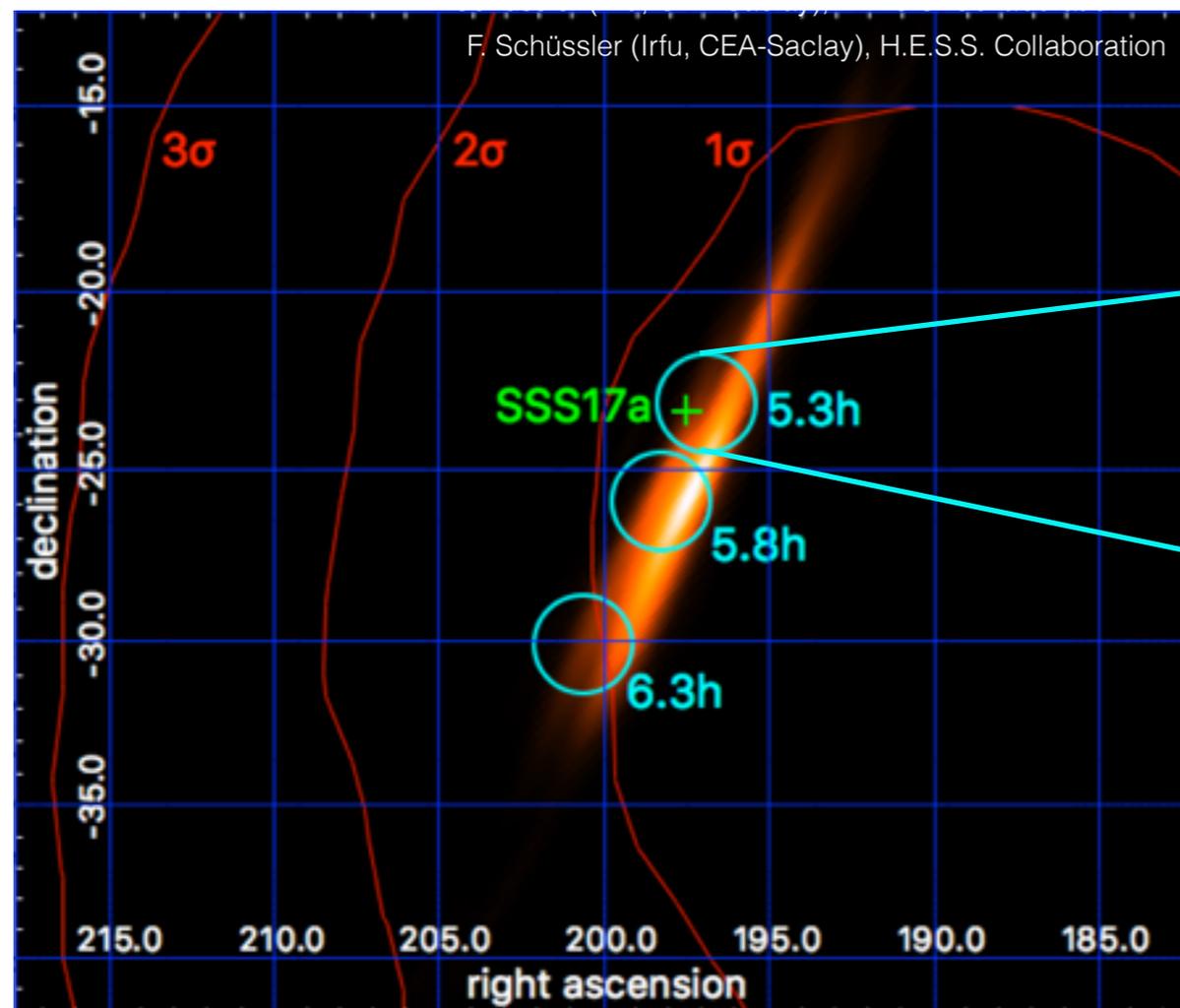
Gravitational waves



Abbott, B.P. et al 2017 ApJL 848 L12

- NS-NS mergers are sources of (short) GRBs
- GRB180720B
- GRB190114C
- GRB190829A
- GRBs emit at VHE energies
- VHE emission is strong enough for current IACTs
- VHE emission is long-lasting (GRB180729B: >10h)
- Let's detect VHE emission from NS-NS (and NS-BH) mergers...

H.E.S.S. observations of GW170817: prompt observations

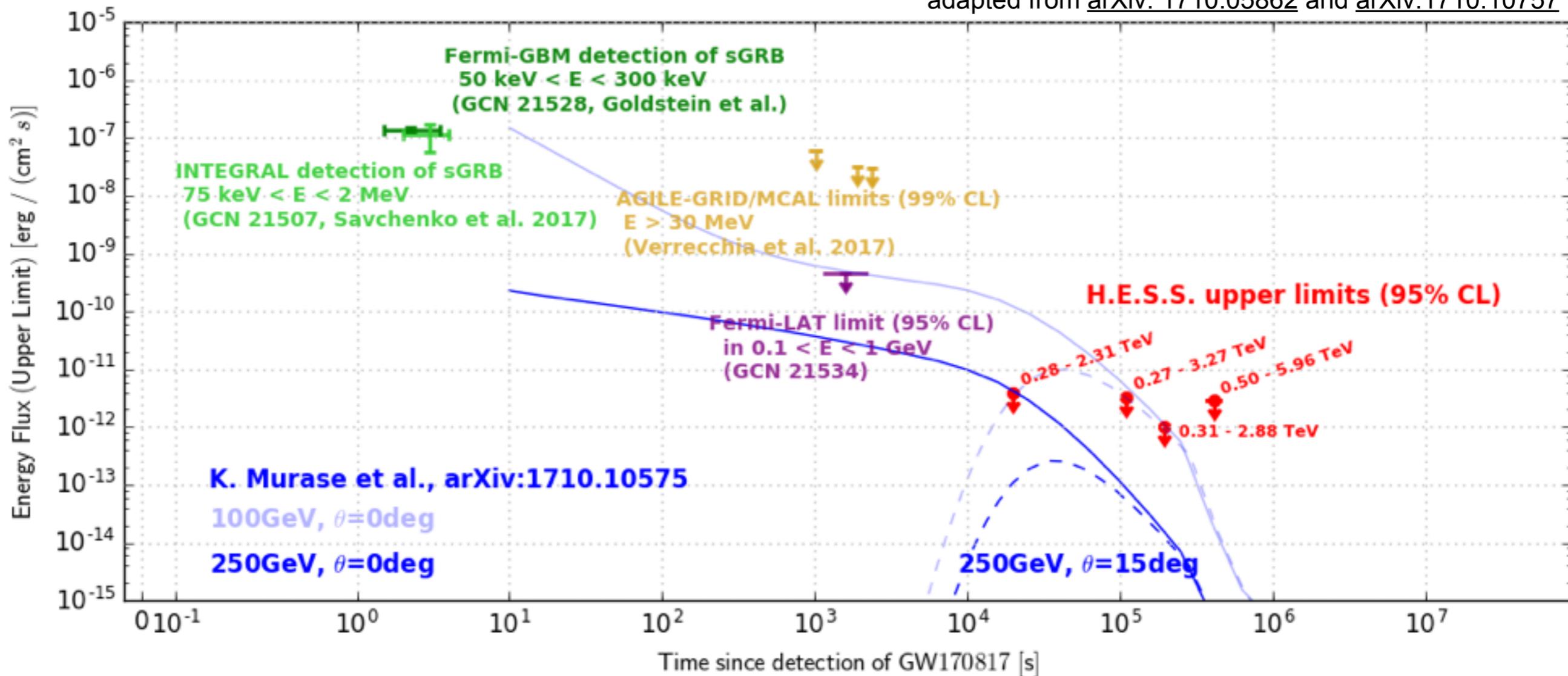


- First observations of a ground-based pointing instrument
 - 5.3 hours after GW170817
 - 5 minutes after the GCN circular announcing the Ligo+Virgo analysis
 - no significant signal: $\Phi (0.28 < E [\text{TeV}] < 2.31) < 3.9 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$
 - monitoring campaign over 5 nights

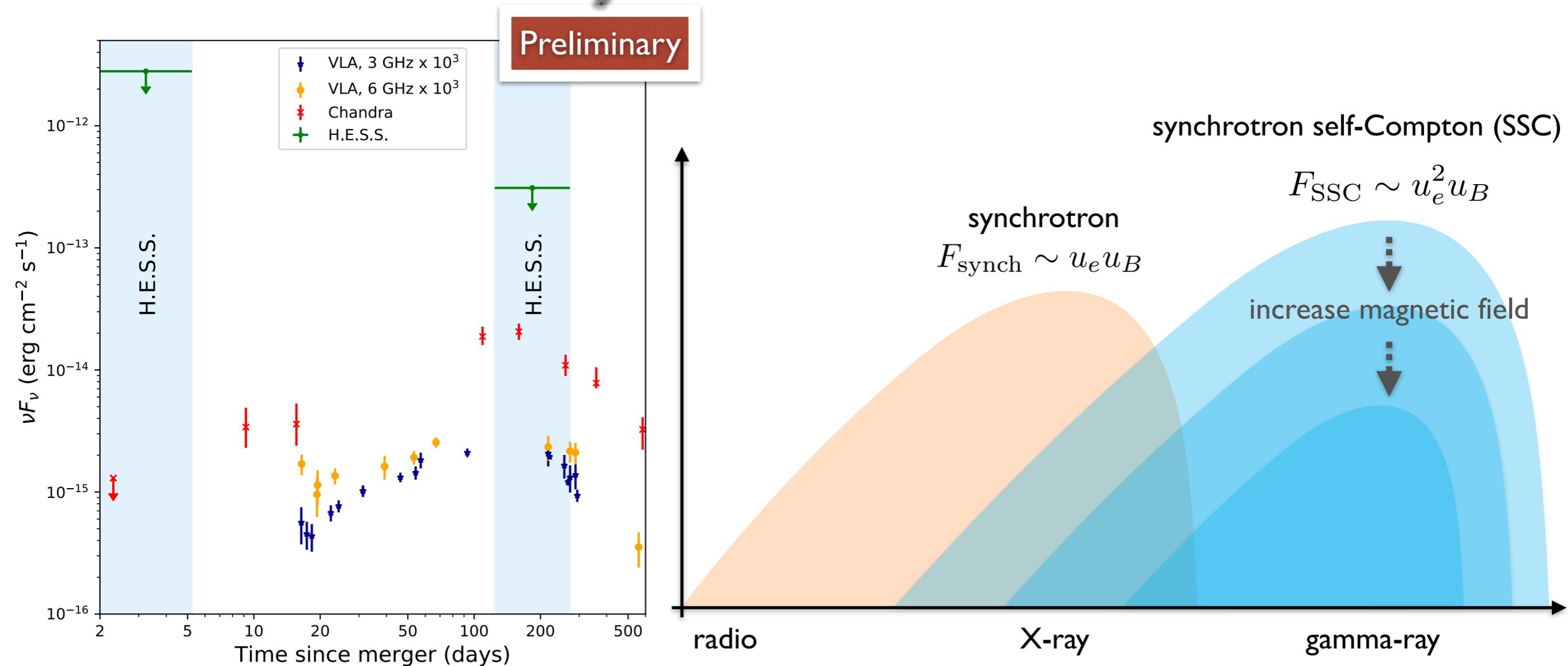
H. Abdalla et al. (H.E.S.S.), ApJL 855:L22 (2017)

H.E.S.S. observations of GW170817: prompt observations

adapted from [arXiv: 1710.05862](https://arxiv.org/abs/1710.05862) and [arXiv:1710.10757](https://arxiv.org/abs/1710.10757)

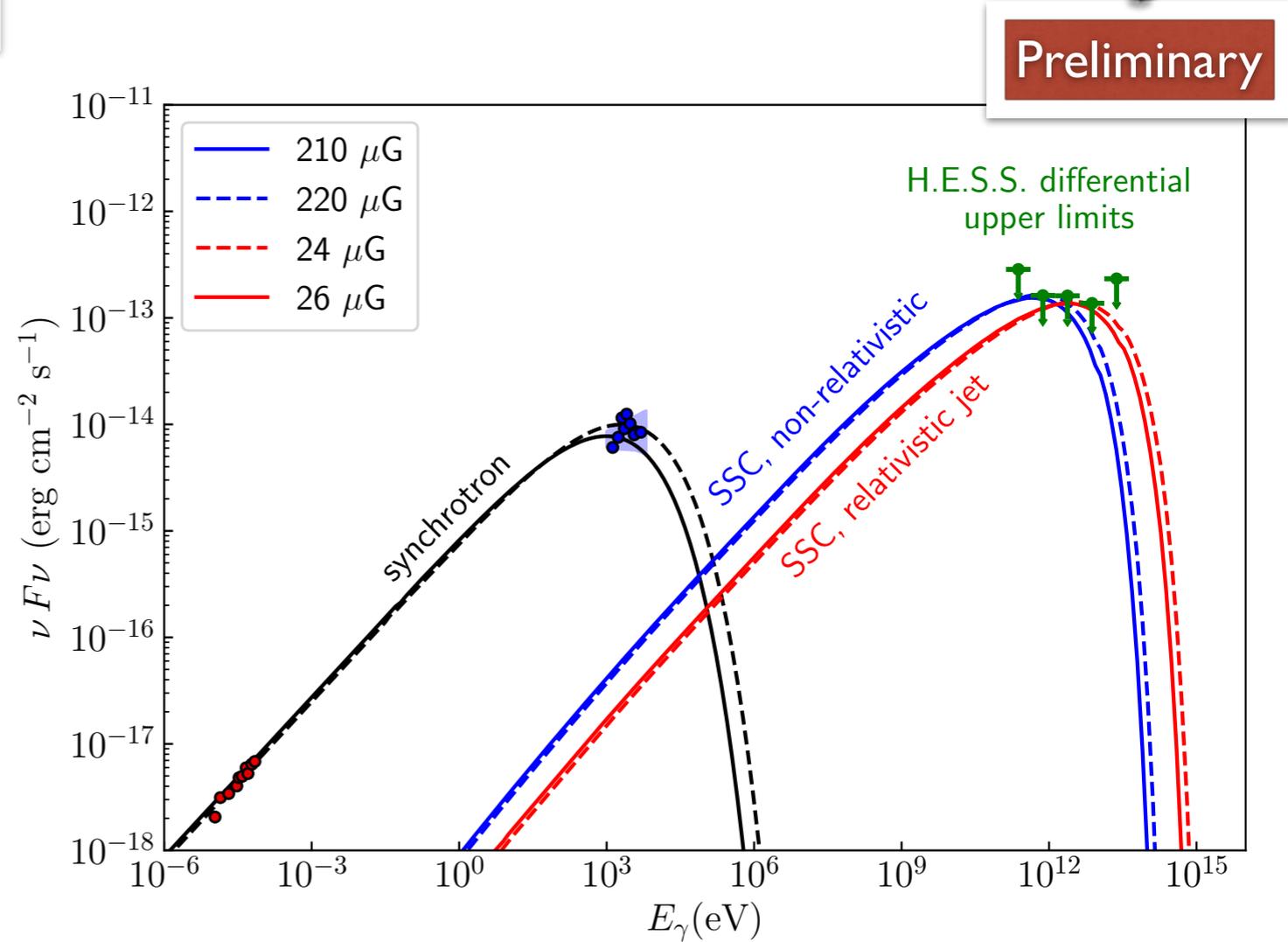
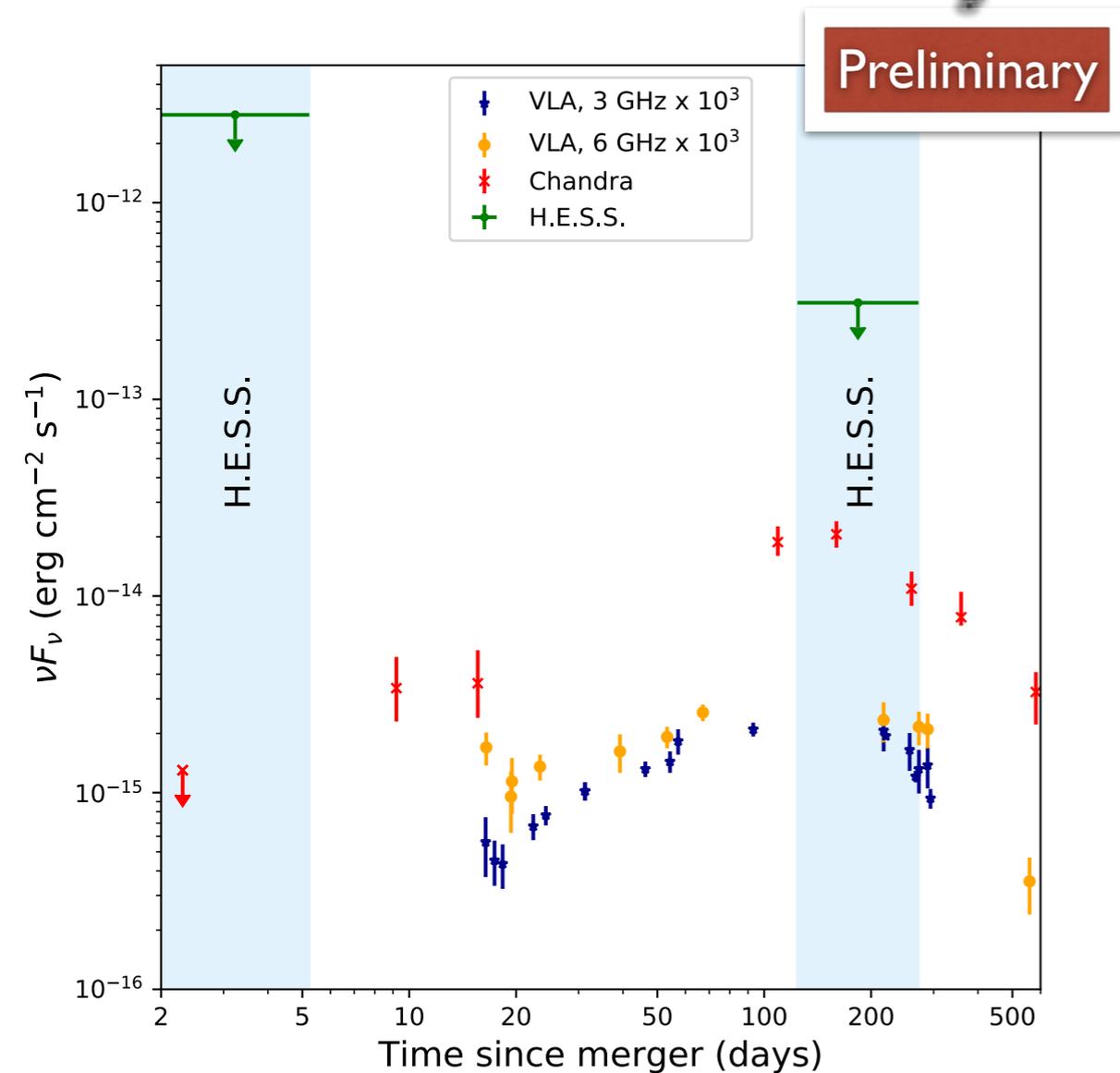


Longterm H.E.S.S. observations of GW170817



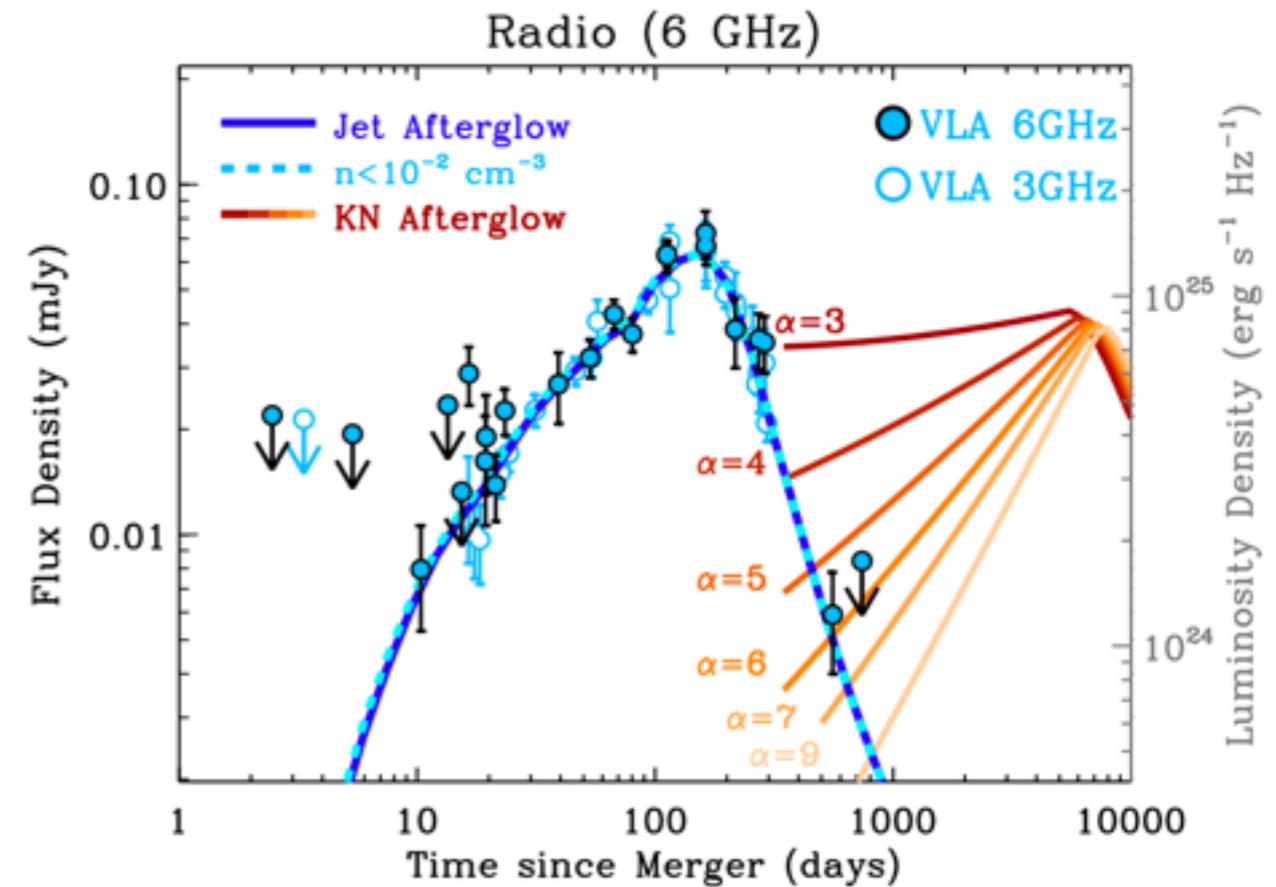
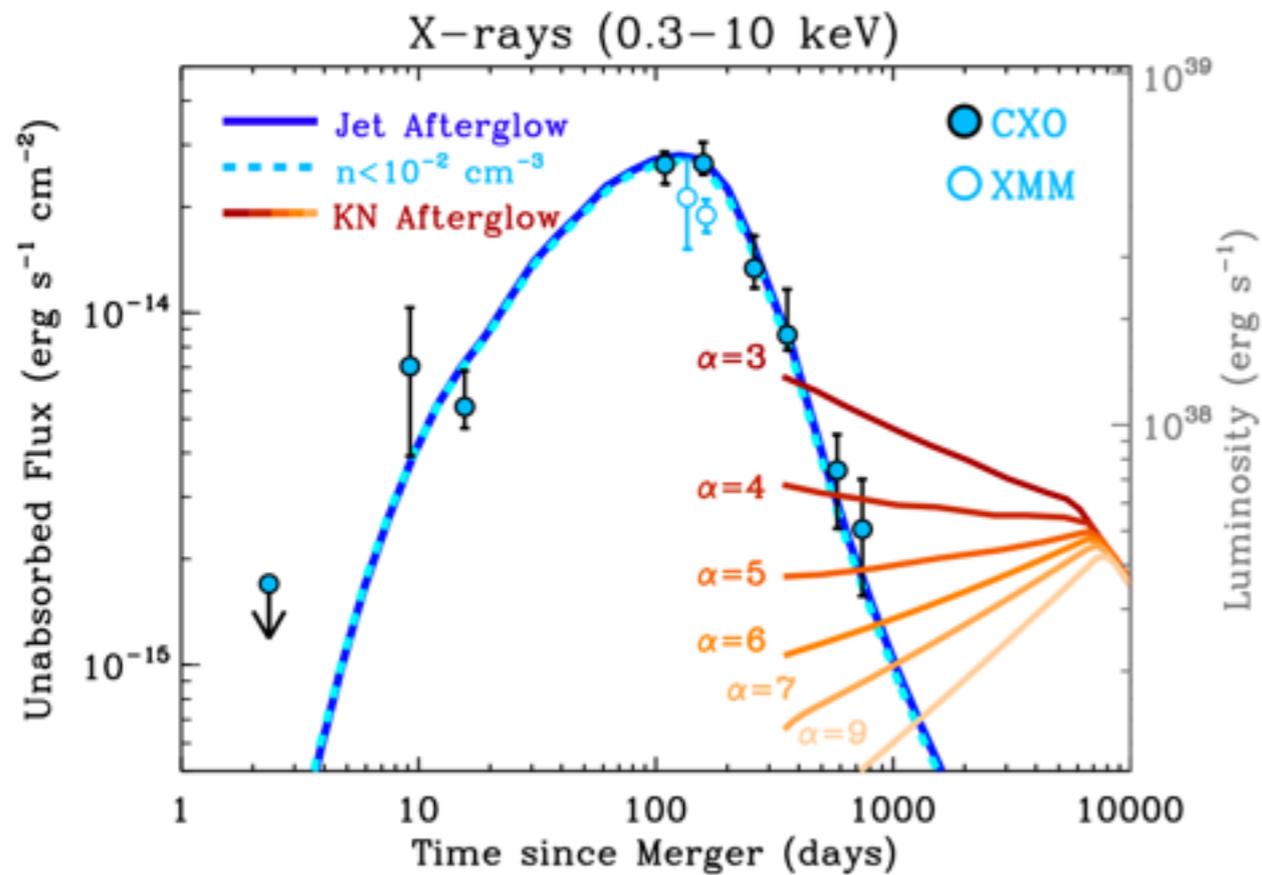
- Extensive H.E.S.S. follow-up during the peak of the X-ray+ radio emission
 - exploiting the link between synchrotron + SSC peaks to put limits on the B-field

Longterm H.E.S.S. observations of GW170817



- Extensive H.E.S.S. follow-up during the peak of the X-ray+ radio emission
 - exploiting the link between synchrotron + SSC peaks to put limits on the B-field
 - isotropic, non-relativistic outflow: $B \gtrsim 210 \mu\text{G}$
 - relativistic jet: $B \gtrsim 24 \mu\text{G}$

Continued MWL monitoring



Hajela et al., ApJ 2019, arXiv: 1909.06393

Outlook for CTA

- Fast Radio Bursts and Gravitational Waves are one of the most vibrant domains in astrophysics
- diverse and promising approaches searching for counterparts to FRBs
- (some) overlapping visibility between CTA-South and Australian radio facilities
- detection of VHE emission from GRBs boosting GW follow-up searches
 - long-lasting VHE emission possible (also for short GRBs ?)
 - deep MWL observations can provide interesting results on the remnant