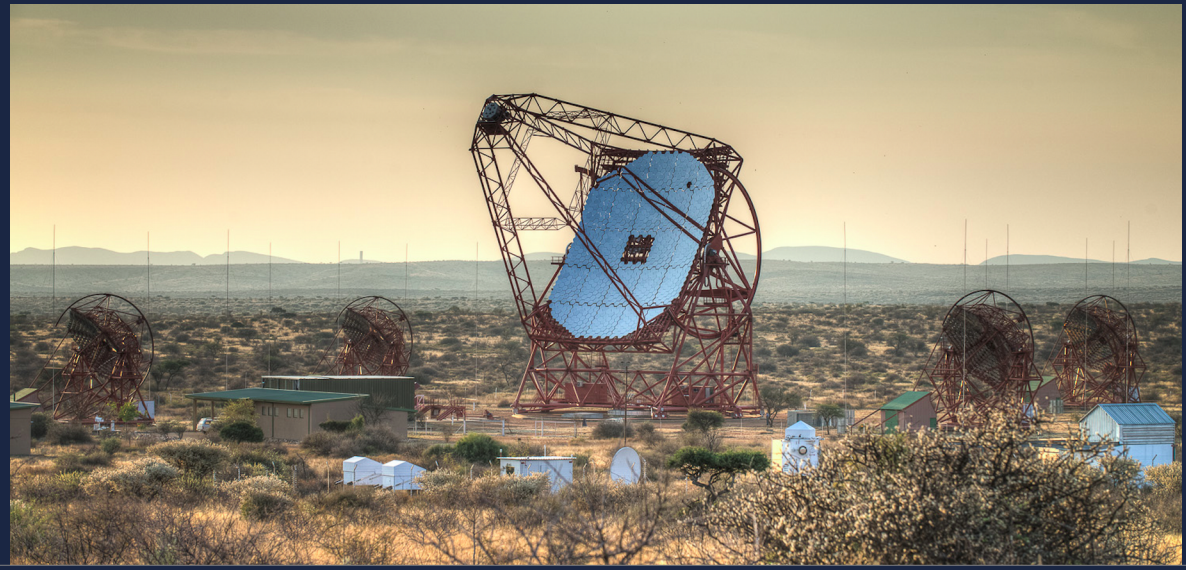
The H.E.S.S. Experiment: Current Status and Future Prospects

Heike Prokoph (DESY)
for the H.E.S.S. Collaboration



H.E.S.S.

The High Energy Stereoscopic System (H.E.S.S.)

Imaging Atmospheric Cherenkov Telescope Array in Namibia

- Sensitive to gamma-ray energies from ~30 GeV to 100 TeV
- Regular observation time ~1000h/year (astronomical darkness)

Phase I (2002)

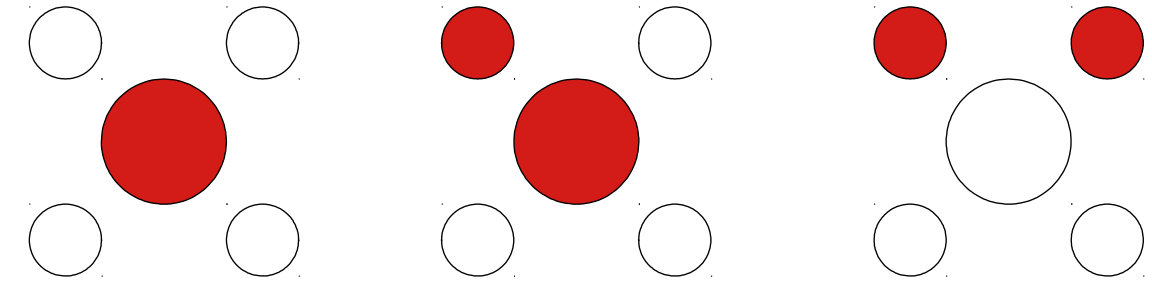
- 4x 12m telescopes
- 960 PMTs/camera
- 5 degree field of view (FoV)
- Energy threshold ~100 GeV
- Angular resolution ~0.1deg

Phase II (2012)

- Additional 28m telescope (CT5) with 2048 PMTs
- 3.2 degree FoV
- Energy threshold ~30 GeV
- Angular resolution 0.1-0.4 deg

H.E.S.S. Phase II: The Hybrid Array

- Operation of a mixed system of Cherenkov telescopes
- Running three different trigger configurations simultaneously
  - CT5 mono (80%)
  - CT1-5 hybrid (15%)
  - CT1-4 stereo (5%)
- Further improvement on the array performance through camera upgrade in 2016/17
  - Goal: Increase overlap between CT1-4 and CT5



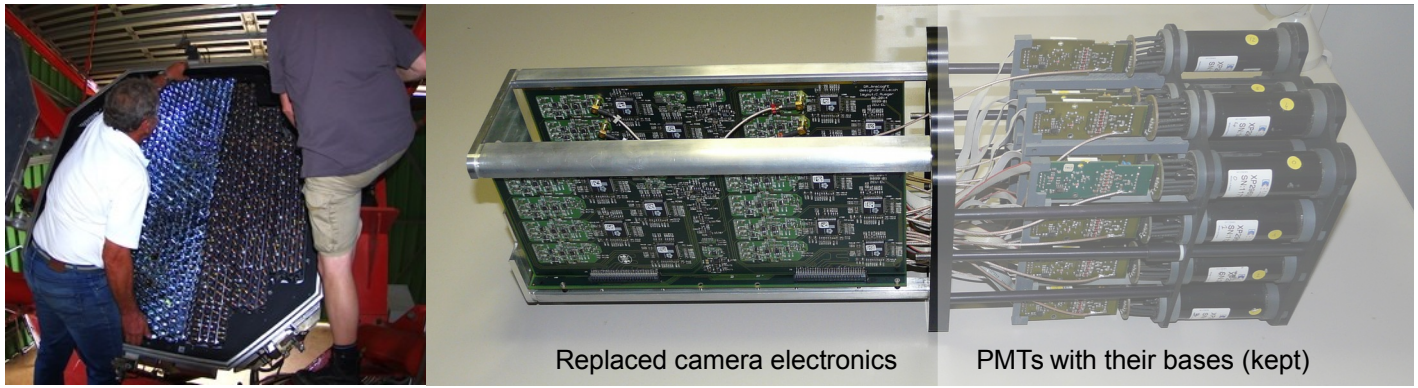
Systematics limited
Low energy threshold

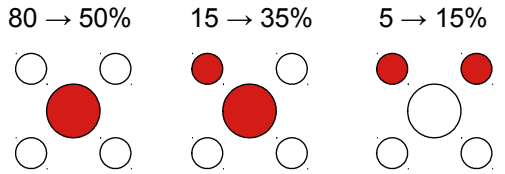
Statistics limited
Stereoscopic reconstruction

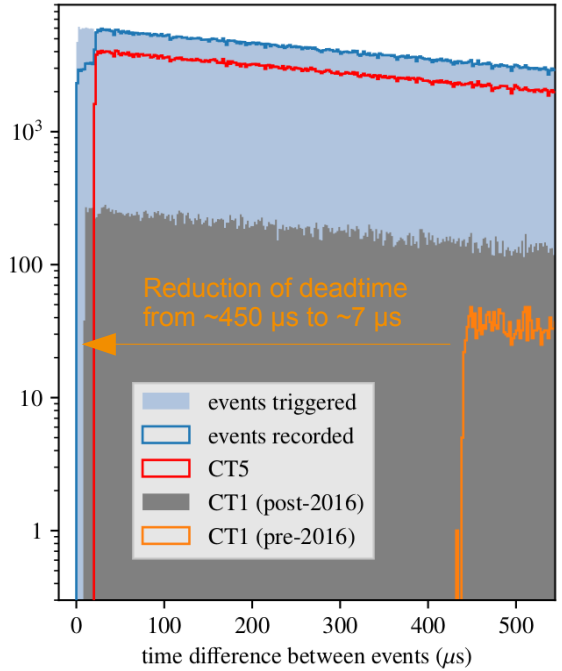
H.E.S.S.-I Camera Upgrade in 2016/17

- Replacement of the backend electronics in the 14-years old HESS-I cameras using NECTAr chip technology
  - Deadtime reduced to ~zero
    → increased overlap with CT5 at trigger level
  - Full waveform readout now possible
    → improve low- & high-energy performance

J. Zorn et al. (**PS3-90**)







H.E.S.S. DAQ Cluster Upgrade in Summer 2019

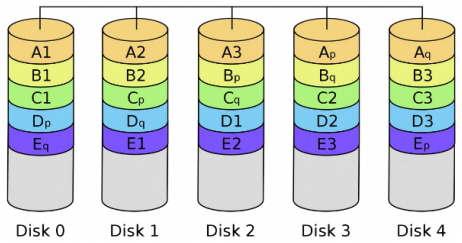
Replacement of the IT infrastructure onsite needed for prolongation of H.E.S.S. operations

- Many systems face end-of-lifetime support after >15 years of H.E.S.S. operation
- High risk of critical failures of central IT

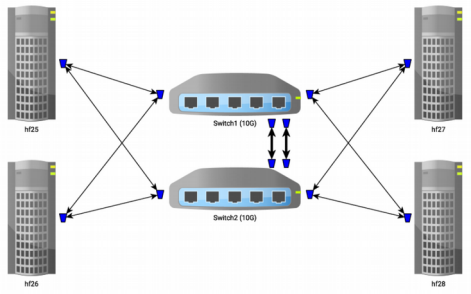
Main goals of the upgrade

- Increase reliability, stability and future maintenance of IT infrastructure
- Prepare network infrastructure for planned CT5 camera upgrade at the end of 2019

Redundant data storage using RAID6



Redundant network infrastructure, incl. upgrading from 1GB/s to 10GB/s and change towards CentOS7



Keeping as much of the existing DAQ software as possible unchanged

Scientific Highlights

H.E.S.S.

H.E.S.S.-I Legacy Data Sets

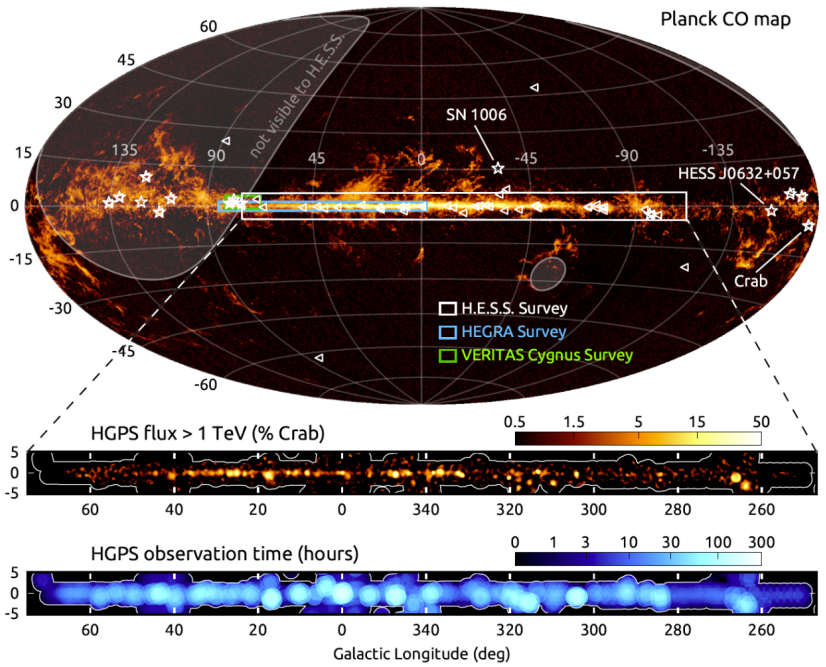
Galactic Plane Scan

- Release of >2500 hours of observations of the Galactic Plane by H.E.S.S. (2004 – 2013)
  - A&A special issue (2018)
  - Source associations and catalogs, population studies, diffuse emission, …
  - All data products available as fits files
- Further investigations
  - Detailed comparison to HAWC sky maps and source associations
  - Search for gamma-ray emission from pulsars

A. Jardin-Blicq et al. (**GAl2h**)

M. Spir-Jacob et al. (**GAl2a**)

N. Komin et al. (**GAl4a**)



H.E.S.S.-I Legacy Data Sets

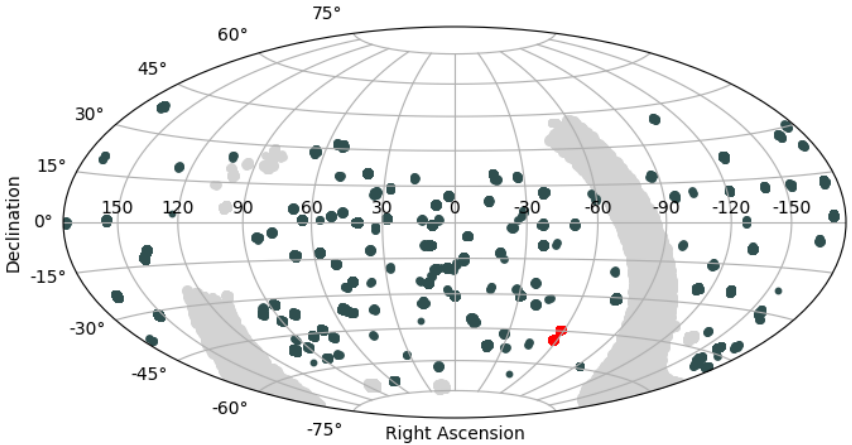
Galactic Plane Scan

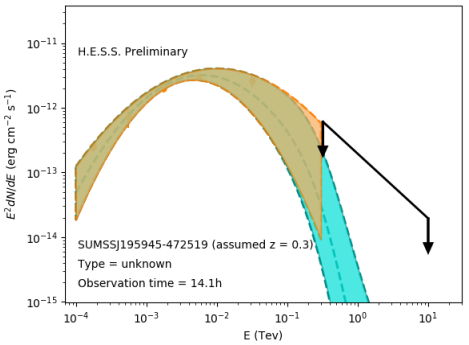
- Release of >2500 hours of observations of the Galactic Plane by H.E.S.S. (2004 – 2013)
  - A&A special issue (2018)

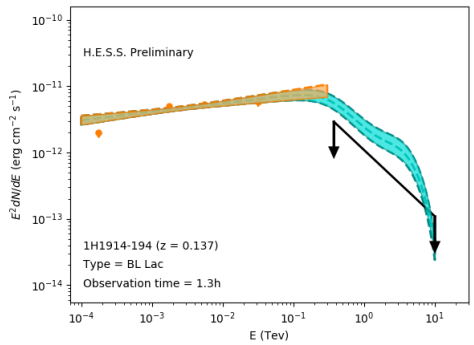
Extragalactic „Survey“

- Planned release of >2500 hours of H.E.S.S. extragalactic observations (2004 – 2013) covering about 6% of the sky
  - Systematic search for variability
  - Comparison with known Fermi-LAT sources
- Further investigations on long-term variablity and deep exposure data sets (>100h)
- Search for primordial black holes

T. Tavernier et al. (**GAl11a**)

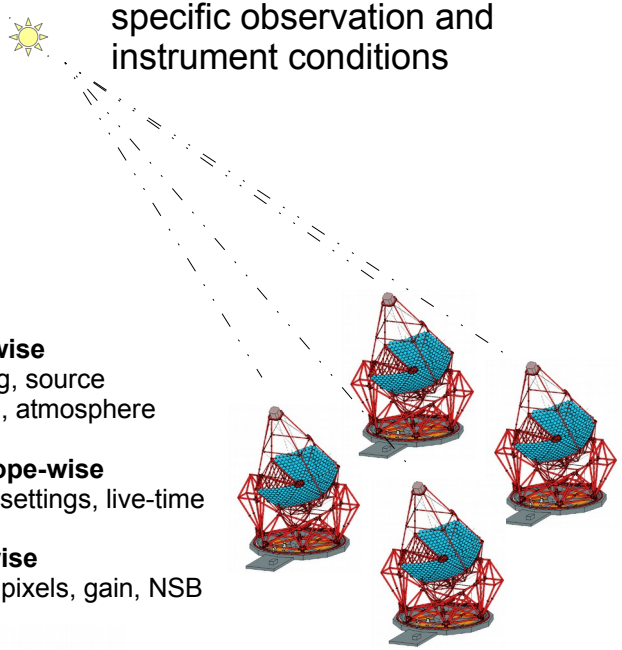






H.E.S.S.-I Precision Measurements

- Improved reconstruction using run-wise simulations (ICRC2017)
  - Taking into account source-specific observation and instrument conditions



Array-wise
Tracking, source position, atmosphere

Telescope-wise
Trigger settings, live-time

Pixel-wise
Broken pixels, gain, NSB

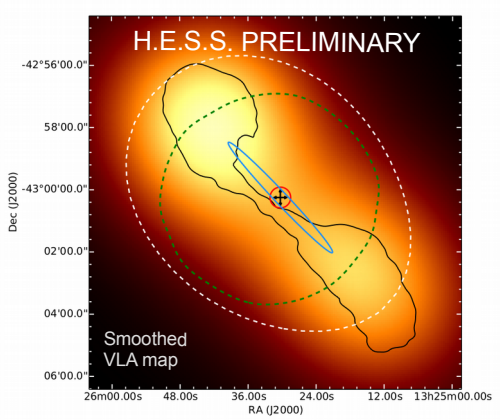
M. de Naurois et al. (**GAI5e**)

VHE extension measurements by H.E.S.S.

- **Crab Nebula** extension
  → accepted by Nature Astronomy (2019)

Centaurus A extension (nearby radio galaxy)

- 13.1sigma detection in 202 hours live-time
- VHE morpology analysis favors elliptical shape



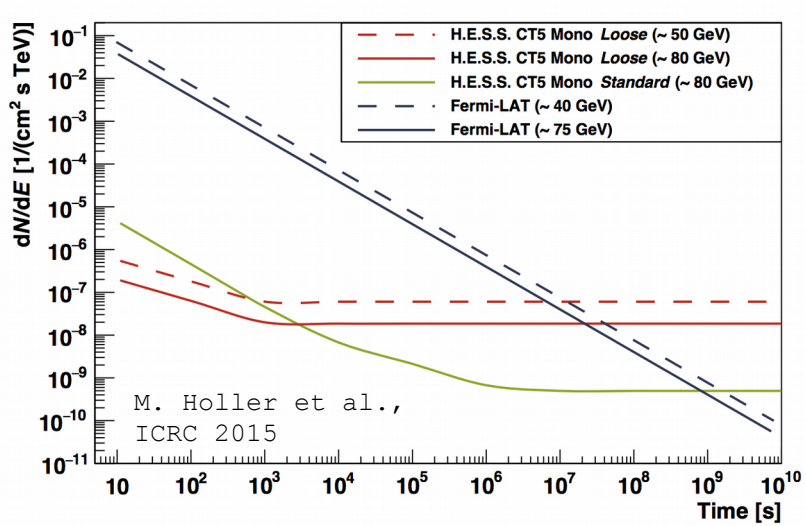
PRELIMINARY

- Gaussian width of semi-major axis (blue contours): 0.044 ° +/- 0.012° (2.8 kpc)
- Point-Like in the transverse direction
- Aligned with radio jets

H.E.S.S.-II activities in the multi-messenger context

H.E.S.S. is very well suited to follow-up transient alerts

- Excellent gamma-ray sensitivity paired with a large FoV
- Rapid follow-up response time (~30 seconds) thanks to fully automatic online transient alert system



Q. Piel **GAI10a**

F. Schuessler **PS2-81**

M. Seglar-Arroyo **GAI10d**

G. Emery **PS2-55**

S. Ohm **GAI10b**

G. Emery **GAI5b**

Search for electromagnetic counterparts of transients in the VHE gamma-ray regime

- Prompt follow-up of multi-messengers alerts
  - Gamma-ray bursts
  - Fast Radio Bursts
  - Neutrino events
  - Gravitational wave events
  - AGN flares
- Long-term follow-up of electromagnetic counterparts
  - GW counterparts
  - Monitoring of AGN

GRB observation program and detection of GRB180720b

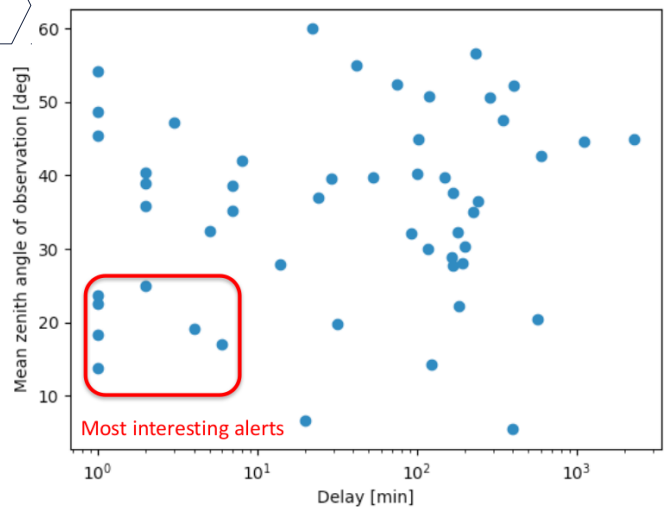
H.E.S.S. observes regulary gamma-ray bursts (~1/month)

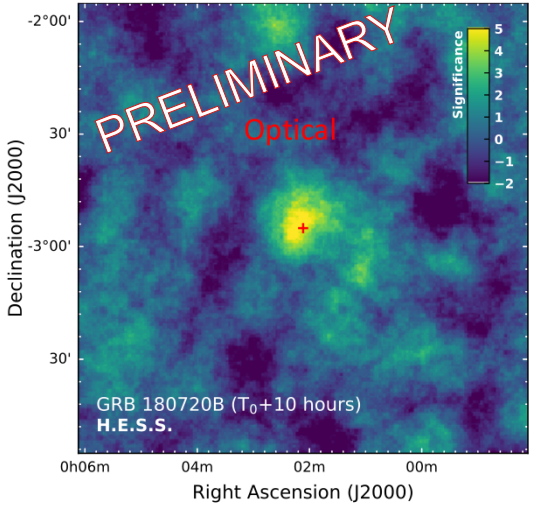
- Follow-up of *Fermi* and *Swift* alerts for usually 2 hours
- In past ~10 years, H.E.S.S. observed 68 GRBs (39 with CT5)
  - No detection in prompt nor afterglow phase until Aug 2018

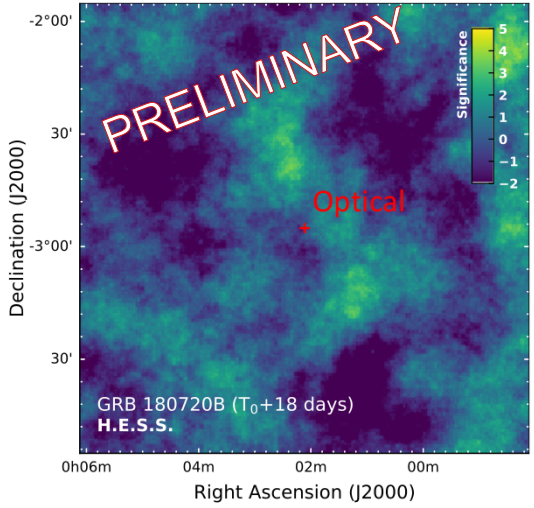
GRB180720b

- 10h after Swift alert
- Redshift z = 0.653 (ESO-VLT/X-shooter)

Q. Piel
GAI10a







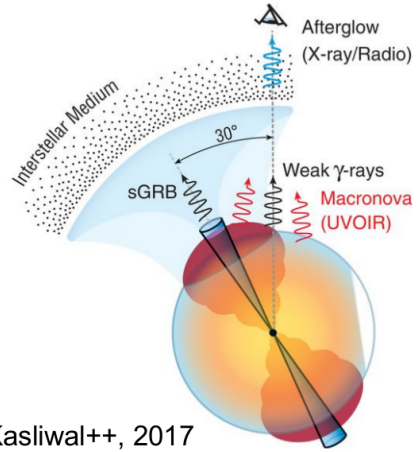
GW170817 – Prompt & long-term follow-up observations

GW170817/GRB170817a trigger

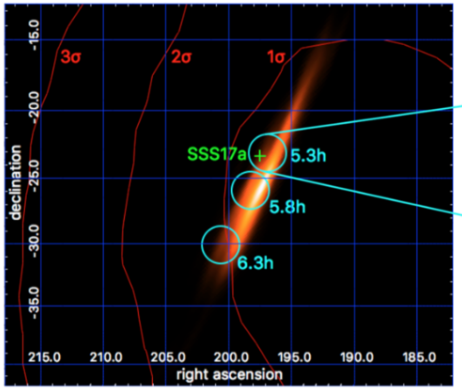
- First detection of gravitational waves from a NS Merger
- First coincidence detection of the GW and EM signatures

H.E.S.S. observations were first pointed observations

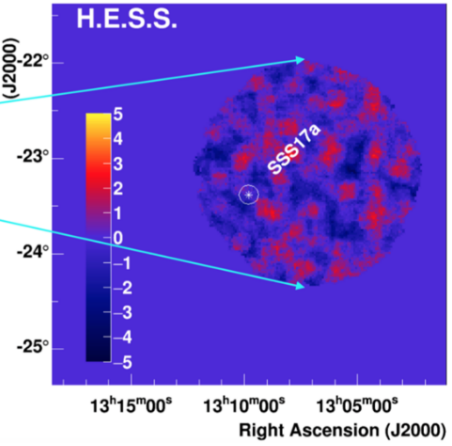
- Scan of error region during the first night (3 pointings)
- Follow-up campaign during the next nights on target (~8h)
- No signal: Φ (0.27<E[TeV]<8.55) < 1.5 x 10^{-12} erg cm^{-2} s^{-1}

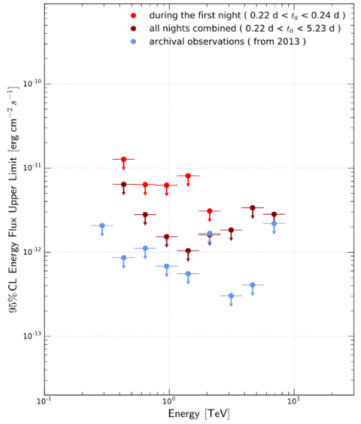


Kasliwal++, 2017



H.E.S.S. Collaboration, ApJL 855 (2017)





(a) SSS17a: H.E.S.S. limits

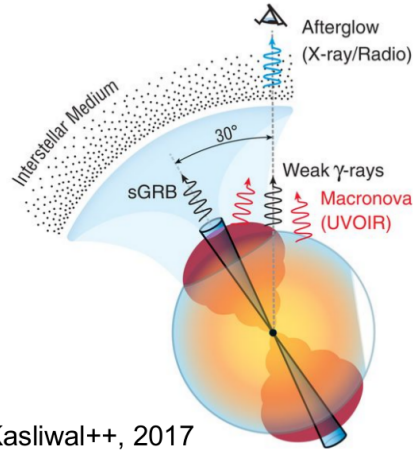
GW170817 – Prompt & long-term follow-up observations

GW170817/GRB170817a trigger

- First detection of gravitational waves from a NS Merger
- First coincidence detection of the GW and EM signatures

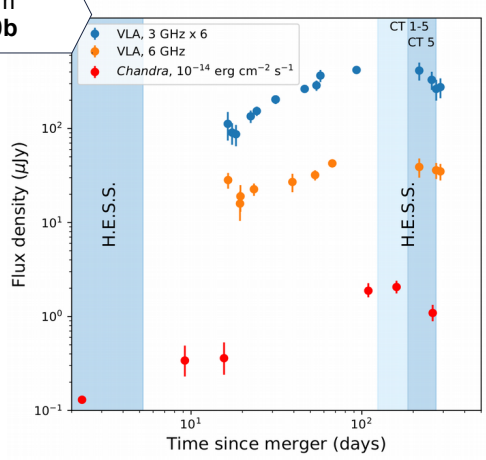
Long-term follow up to probe the magnetic field in the remnant

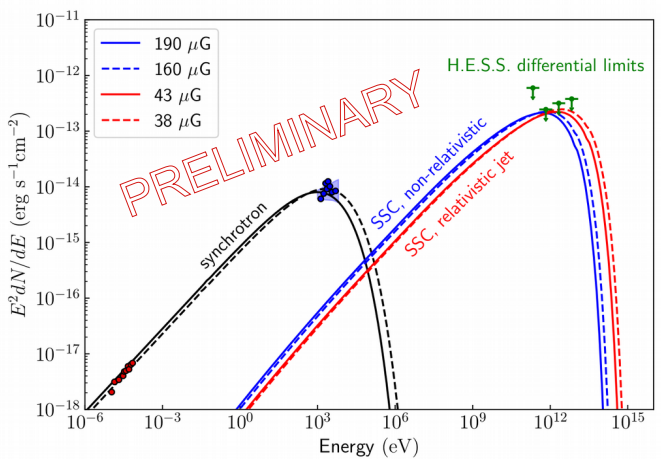
- Non-thermal X-ray + radio emission in remnant (electrons are accelerated efficiently → good condition for gamma-ray production using synchrotron self-Compton)
- VHE observations can be used (together with radio & X-ray) to break the ambiguity and constrain magnetic field



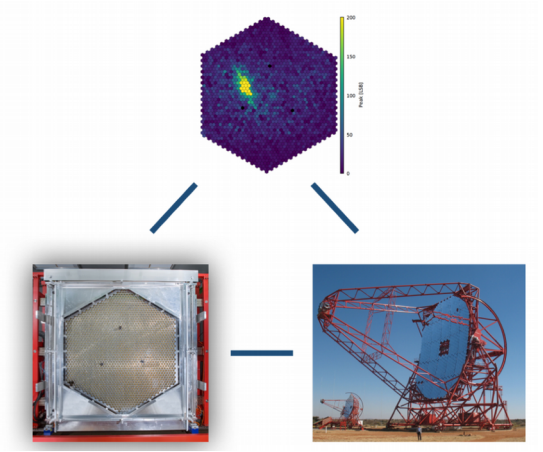
Kasliwal++, 2017

S. Ohm
GAI10b





Summary & Outlook



H.E.S.S. instrumental upgrades proceeding well (future proven)

- Successfully upgraded the CT1-4 cameras and IT infrastructure onsite
- Extension of H.E.S.S. operations for the next 3 years approved
  - Operation under low- to moderate moonlight conditions under investigation
  - Upgrade of the CT5 camera (end of 2019) with advanced FlashCam

H.E.S.S. covers a broad science program (many topics could not be addressed here)

- Strong focus on key science projects (>100 hours) for precision measurements
  - Source morphology, Pevatrons, variable (pulsed) emission, dark matter searches, …
- Increasing involvement in transient phenomena following the MWL/MM approach
  - Prompt follow-up searches for high-energy gamma-ray counterparts of neutrino and GW alerts
  - Long-term follow-up of electromagnetic counterparts in the multi-messenger era

Thank you for your attention.

H.E.S.S.