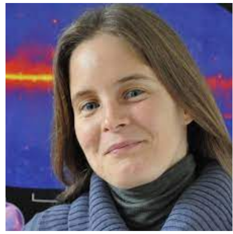
Fermi Gamma-ray Space Telescope anr université de BORDEAUX LP2i Bordeaux

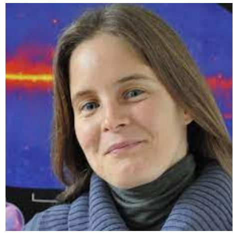


Characterization of the GeV emission from the Kepler supernova remnant

Fabio Acero
Marianne Lemoine-Goumard
Jean Ballet

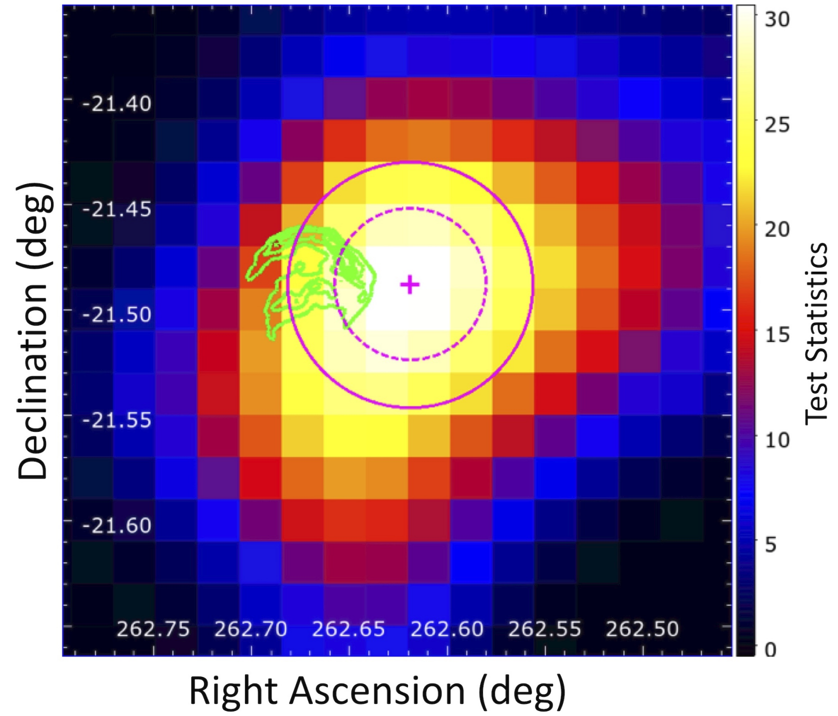
Acero et al. A&A 660, A129 (2022)

Fermi Gamma-ray Space Telescope

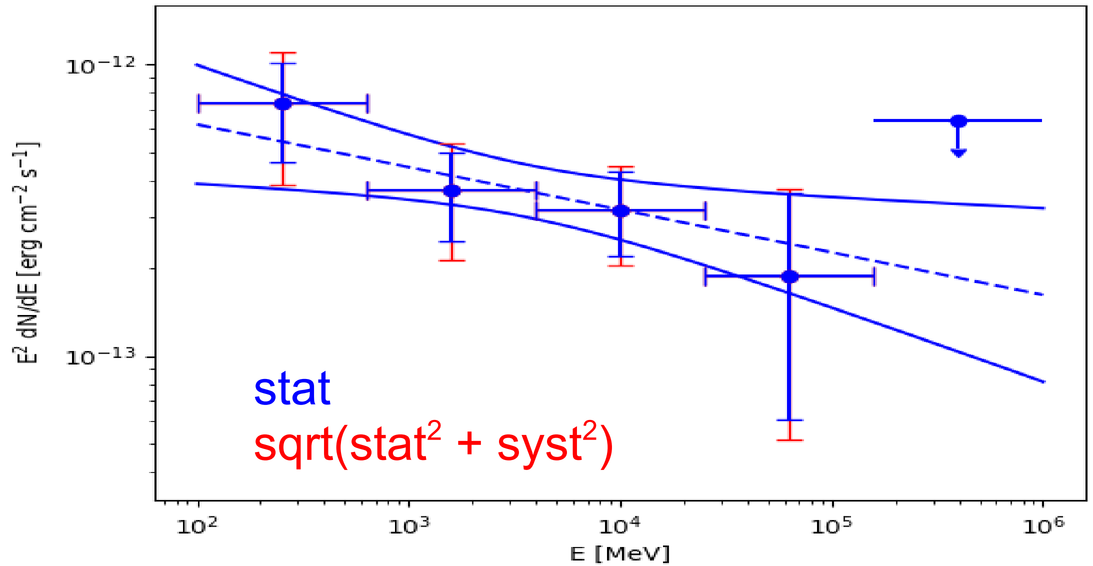


Fermi-LAT detection of the Kepler SNR

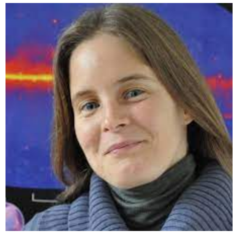
- Clear detection (TS=38.3 above 100 MeV)
- No significant differences between best-fit point-source and MWL templates
- Emission not significantly extended
- Hard power-law spectrum :
  - Index = $2.14 \pm 0.12_{stat} \pm 0.15_{syst}$



Fermi-LAT TS map at the Kepler SNR position above 1 GeV. Green contours from the infrared 24 µm Spitzer map. The plus symbol and circles illustrate the best-fit position and the 68%/95% confidence contours



Fermi-LAT spectral energy distribution of the Kepler SNR using the IR spatial template.



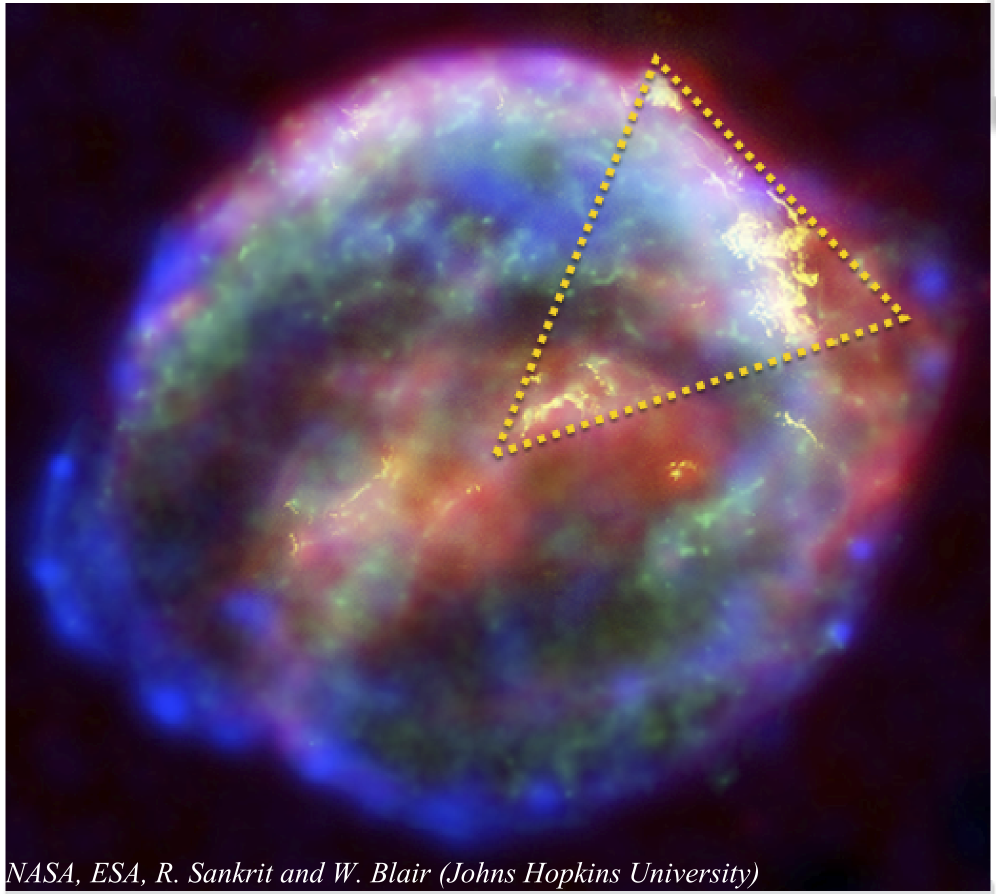
Modeling of the Kepler SNR

- Well measured distance: 5.1 ± 0.8 kpc (Sankrit et al. 2016)
- Rationale : Gamma-ray stems from the NW interaction region where density is high (n_0~8 cm^{-3} from optical)

Synchrotron + IC

Electron emission coming from fast shocks (Southern hemisphere)

V_{shock} ~5000 km/s
n_0~10^{-2} cm^{-3}



NASA, ESA, R. Sankrit and W. Blair (Johns Hopkins University)

IR (24 µm Spitzer) **Hα (HST)** **synchrotron (X) (CXT)**

Hadronic emission

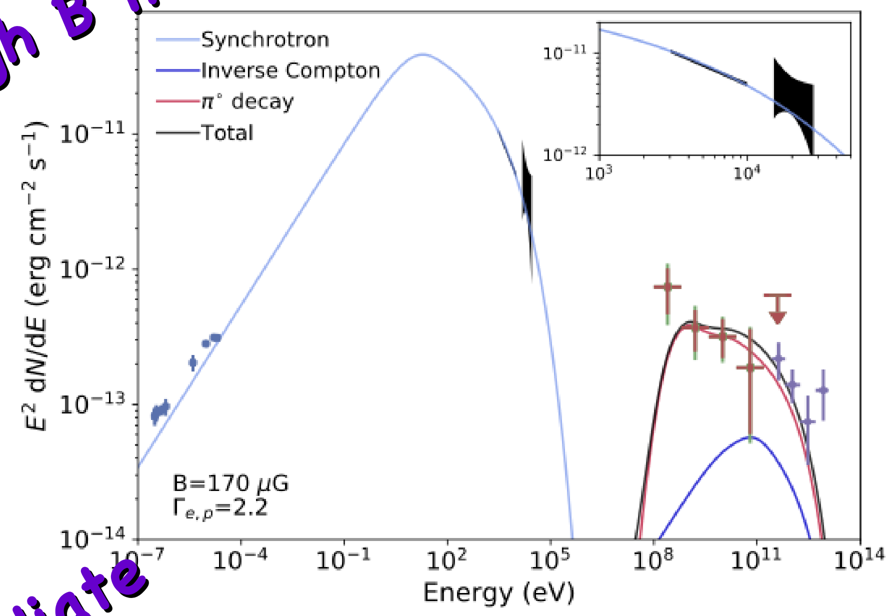
Interaction with the CSM with ~8 cm^{-3}
Lower shock speed ~1700 km/s

Fermi Gamma-ray Space Telescope

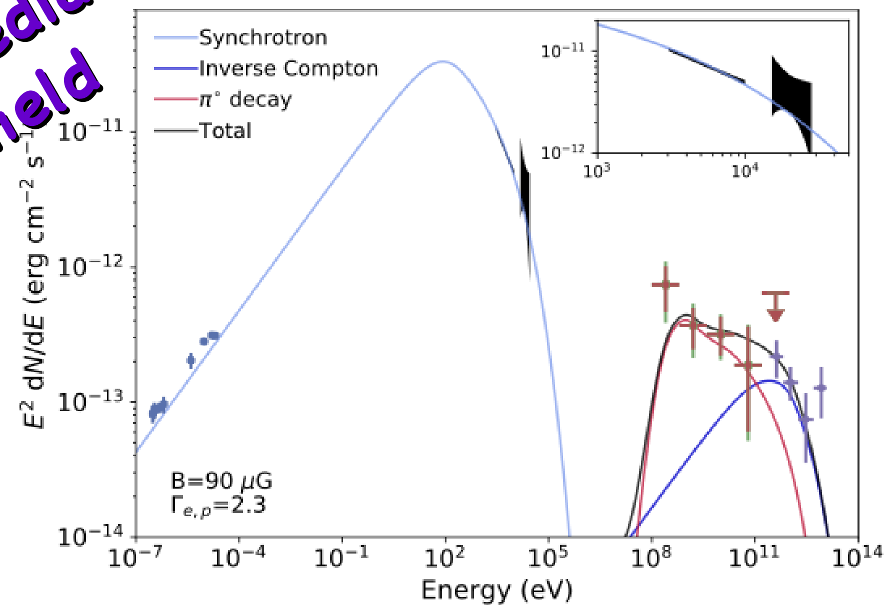
Fermi-LAT spectrum & Kepler's modeling

- Only 4 degrees of freedom: B field and injection
- Most parameters are fixed from theory or literature
- $V_{sh,e}$ from Chandra X-ray synchrotron rims motion
- $V_{sh,p}$ from Hubble Hα motion
- Density from Hα
- Electrons are cooling limited => $E_{max,p}$ & E_{break}
  - Exponentially Cutoff BrokenPowerLaw with a change of slope after E_{break} to $\Gamma_2=\Gamma_1+1$
- Proton acceleration is age limited =>$E_{max,p}$
- With an opening angle of 45° (filling factor 15%):
  - Local proton budget ~ 4% of E_{51}

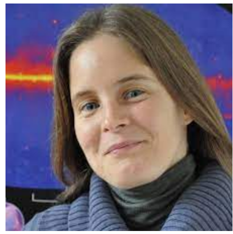
High B field



Intermediate B field



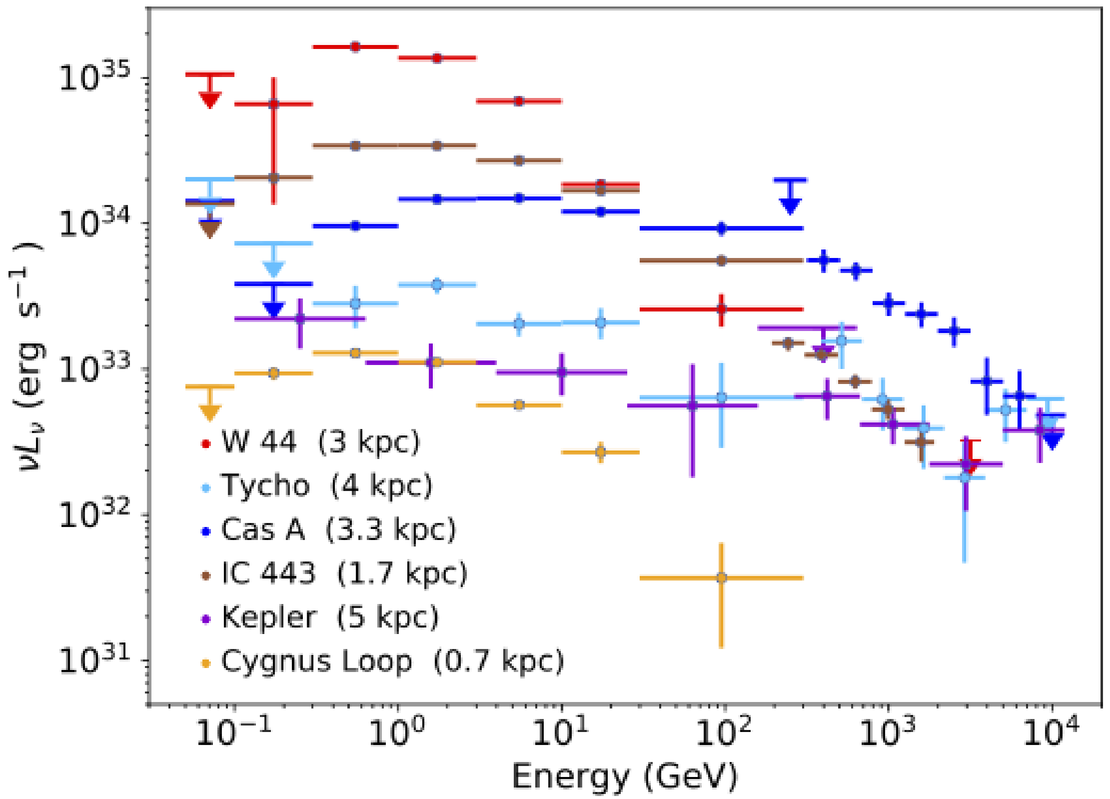
MWL observations used : radio fluxes from Castelletti et al. (2021), X-ray data from the Suzaku XIS + HXD instruments (Nagayoshi et al. 2021), H.E.S.S. flux points from Prokhorov et al. (2021, H.E.S.S. Collaboration) + our Fermi points



Conclusions on our Fermi-LAT results

- Significant detection
- SED modeling assuming pp interaction from NW for Fermi
  - Requires a steep injection of 2.2-2.3
  - Compatible with new H.E.S.S. Data
- Depending on magnetic field, TeV are located :
  - ~100muG: IC dominated and TeV should arise from Southern fast shocks
  - > 150 muG : pp interaction and TeV should arise from NW region
- Tycho, Kepler, and Cassiopeia A exhibit a nearly flat spectrum (TeV/GeV=0.2-0.4) while the curvature is stronger for IC 443 (TeV/GeV=0.015) and W 44 (TeV/GeV < 2 x 10^{-3})

Different acceleration and emission mechanisms between young and middle-aged SNRs



Luminosity spectral energy distributions of a selection of SNRs for which the distance is well constrained and the γ-ray emission is likely dominated by hadronic emission. References for the distances and data used are given in Acero et al. (2022)