# Ultra-high energy Inverse Compton emission from Galactic electron accelerators

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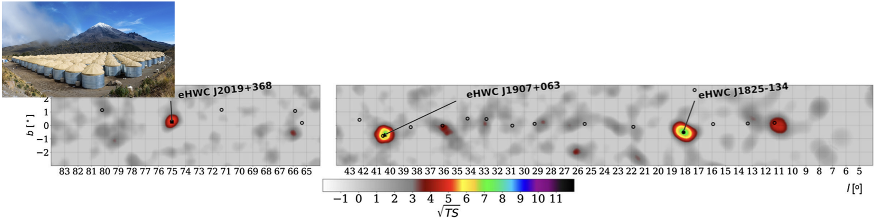
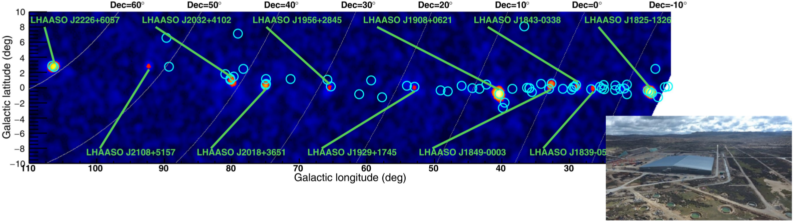
https://ui.adsabs.harvard.edu/abs/2021ApJ...908L..49B/abstract

# What is the origin of UHE $\gamma$-ray sources?



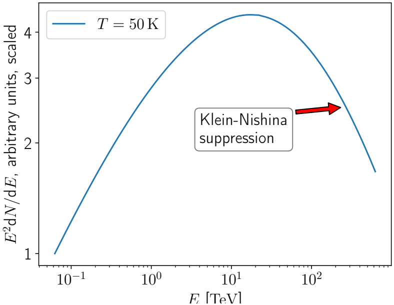

Credits: HAWC collaboration 2020




Credits: LHAASO collaboration 2021

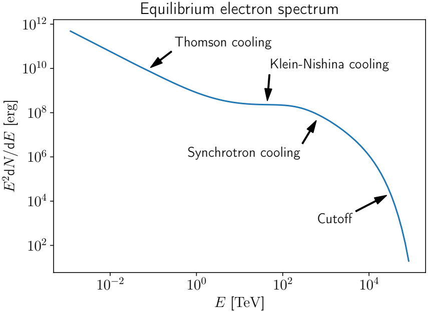
# How to get hard IC spectra at 100 TeV?

- Problem: Klein-Nishina suppression at high energies



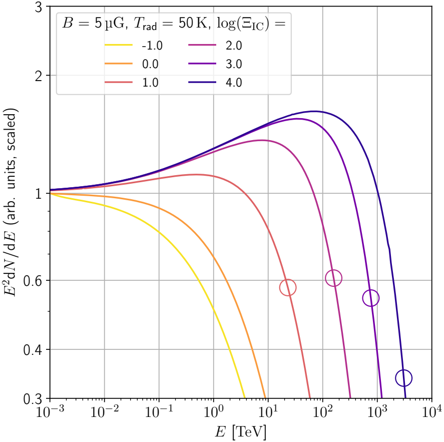

IC SED of $\propto E^{-2}$ distributed electrons and a 50 K radiation field

- Solution: Equilibrium spectra in radiation dominated environments




- From now on: $\Xi_{\mathrm{IC}} := \frac{U_{\mathrm{rad}}}{U_{\mathrm{B}}}$

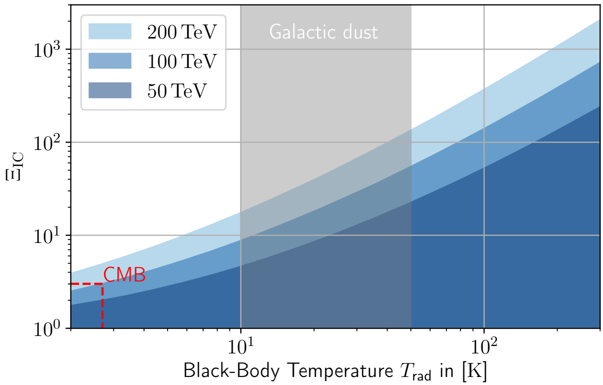
# Equilibrium spectra in radiation dominated environments




$\gamma$-ray spectra in different environments

- Low energy losses $\Rightarrow$ hard $e^-$ spectra in KN-regime $\Rightarrow$ hard $\gamma$-rays
- Need to be dominated by radiation losses until energies above 100 TeV

# Temperature influence

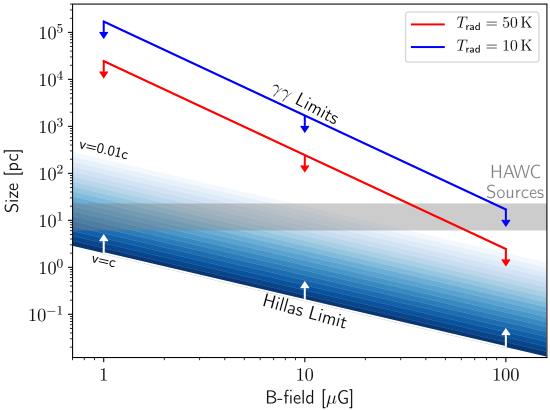



Excluded parameter space for hard UHE IC spectra

- Lower temperature $\Rightarrow$ KN-transition at higher energies $\Rightarrow$ smaller $\Xi_{\mathrm{IC}}$
- For CMB: Radiation dominance at 100 TeV for $B < 1.8\,\mu\mathrm{G}$

# System constraints

- Acceleration and confinement ⇒ Hillas limit
- Pulsars: possible accelerators
- Absorption by strong FIR field ⇒ upper limit on size
- Absorption by interstellar galactic FIR fields at 100 TeV $< 0.5$




Size limits for confinement and absorption

# Galactic Environments

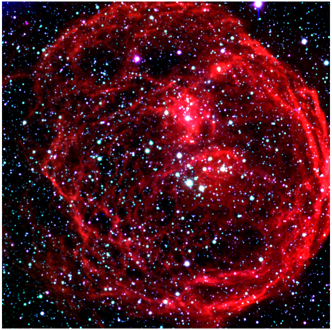
- Need special local regions with high intensity radiation fields and/or low $B$-field

**Star forming regions**

Credits: Hubble space telescope

FIR densities $\sim 100\,\mathrm{eV\,cm^{-3}}$ for tens of pc

**Superbubbles**

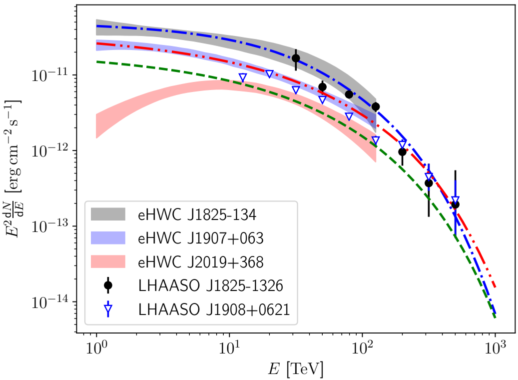


Credits: ESO

Low values of $B \lesssim 3\,\mu\mathrm{G}$

# Possible scenarios for the UHE sources detected by HAWC

- Plausibly associated pulsars: $\dot{E}_{36} = 2.8$ to $3.4$
- Emission region sizes of 6 pc to 22 pc $\Rightarrow$ fulfilment of size constraints
- Models: FIR/UV radiation from Popescu et al. 2017 enhanced by $\eta$ + CMB
- All $\eta$ compatible with data from IRAS survey




J1825-134: $\eta = 3/5$, $E_{\text{cut}} = 350$ TeV
J1907+063: $\eta = 1$, $E_{\text{cut}} = 480$ TeV
J2019+368: $\eta = 2$, $E_{\text{cut}} = 400$ TeV
All models: $B = 3\,\mu$G, $\alpha = 2$

# Conclusion

- 100 TeV hard IC spectra possible if IC losses dominate up to high energies $\Rightarrow U_{\text{rad}}/U_{\text{B}} > 1$
- High power pulsars coincident with star forming regions and superbubbles are ideal candidates
- HAWC sources can be explained with reasonable leptonic scenarios
- Redundancy in many model parameters $\Rightarrow$ Environmental conditions and multiwavelength data crucial to distinguish between leptonic and hadronic sources