What we could learn about the Galactic nucleus with the SKA

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Fulvio Melia

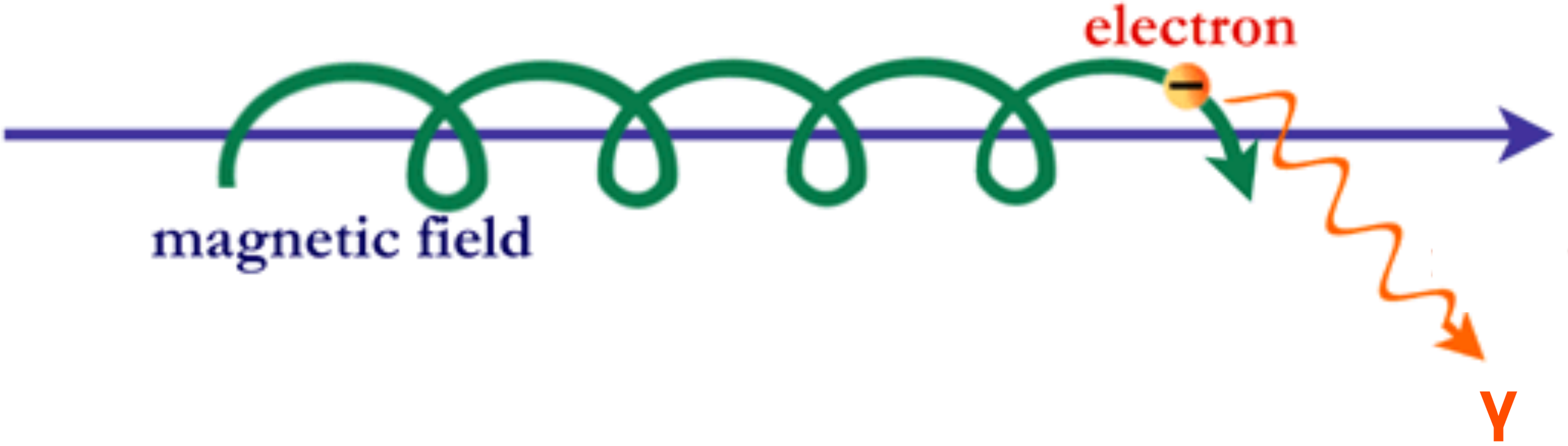
Juergen Ott

Tomo Oka

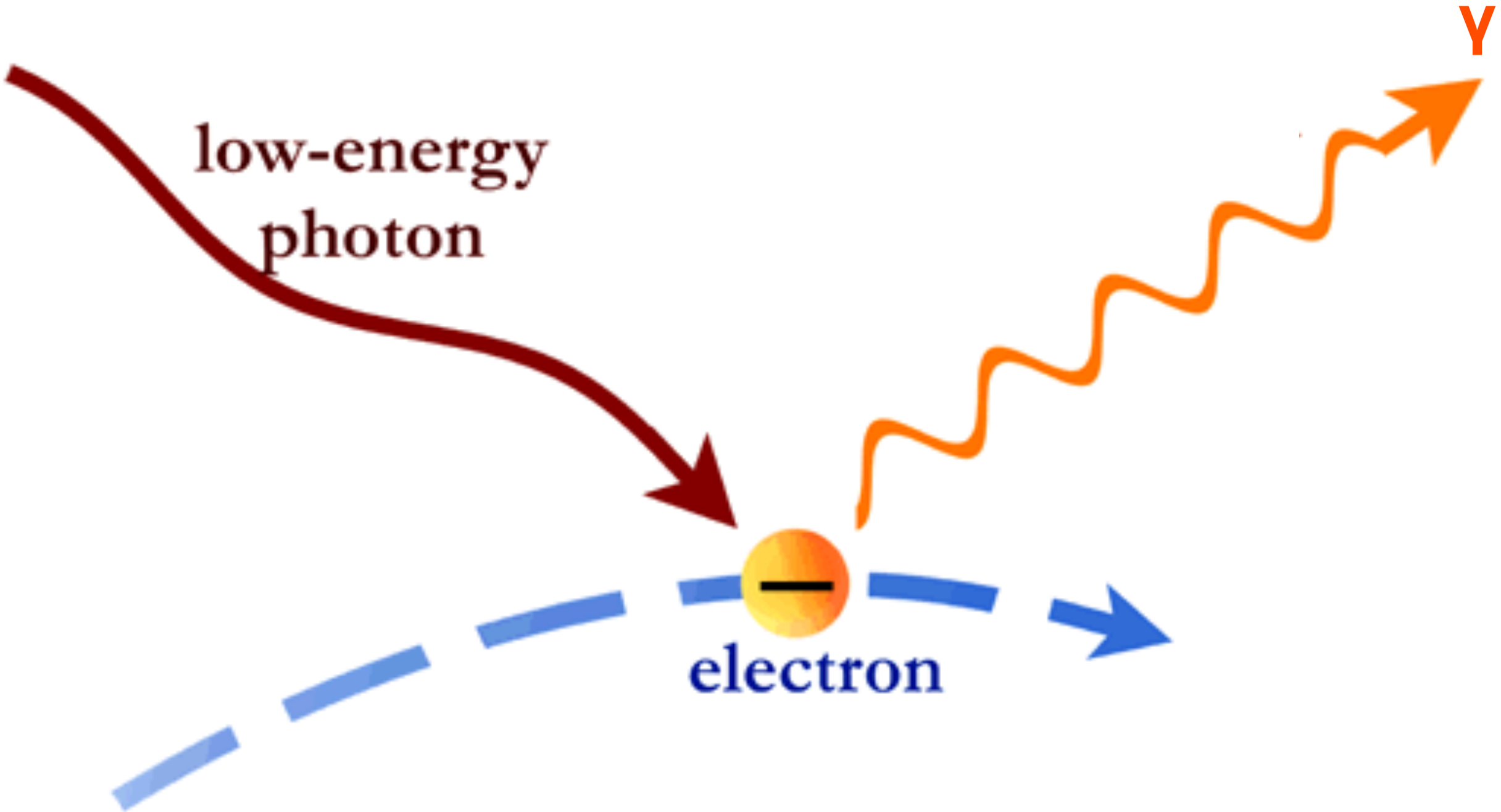
Point

- despite ~18 orders of magnitude separation in energy, there is an intimate connection between radio continuum photons and gamma-rays...

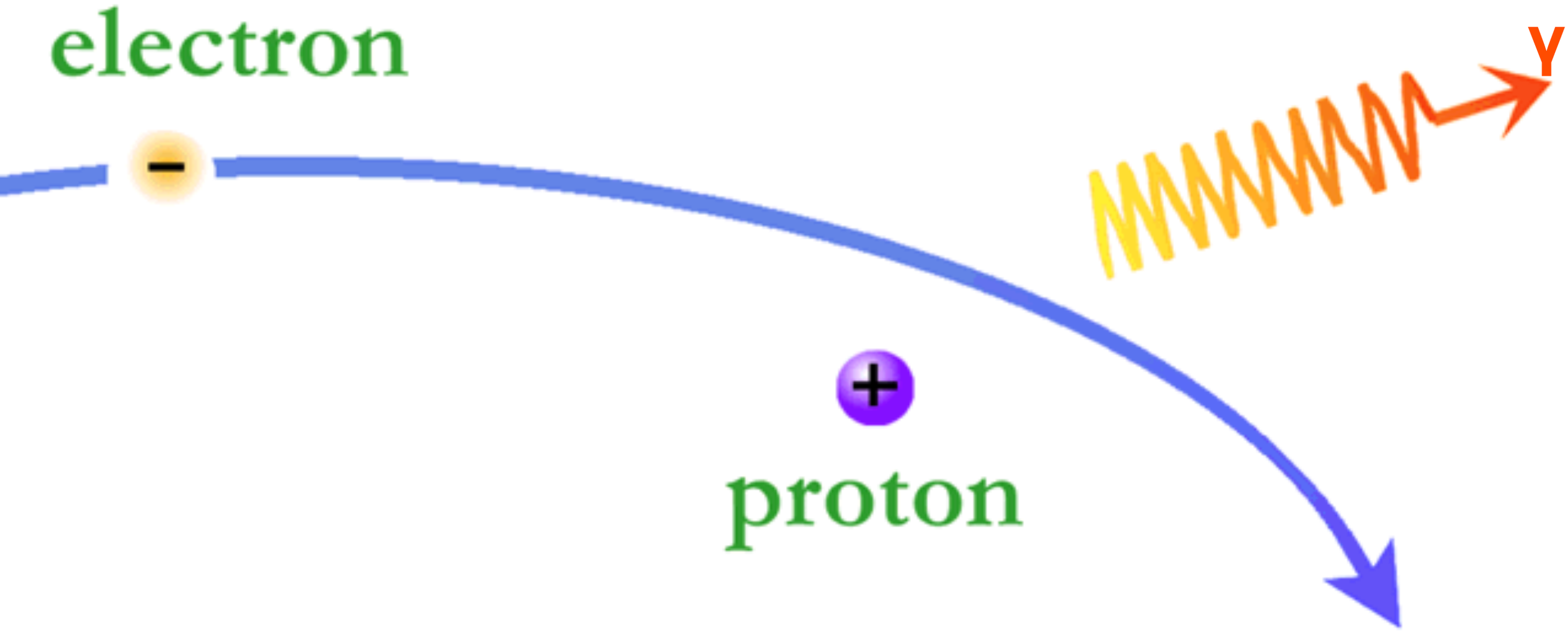
Synchrotron



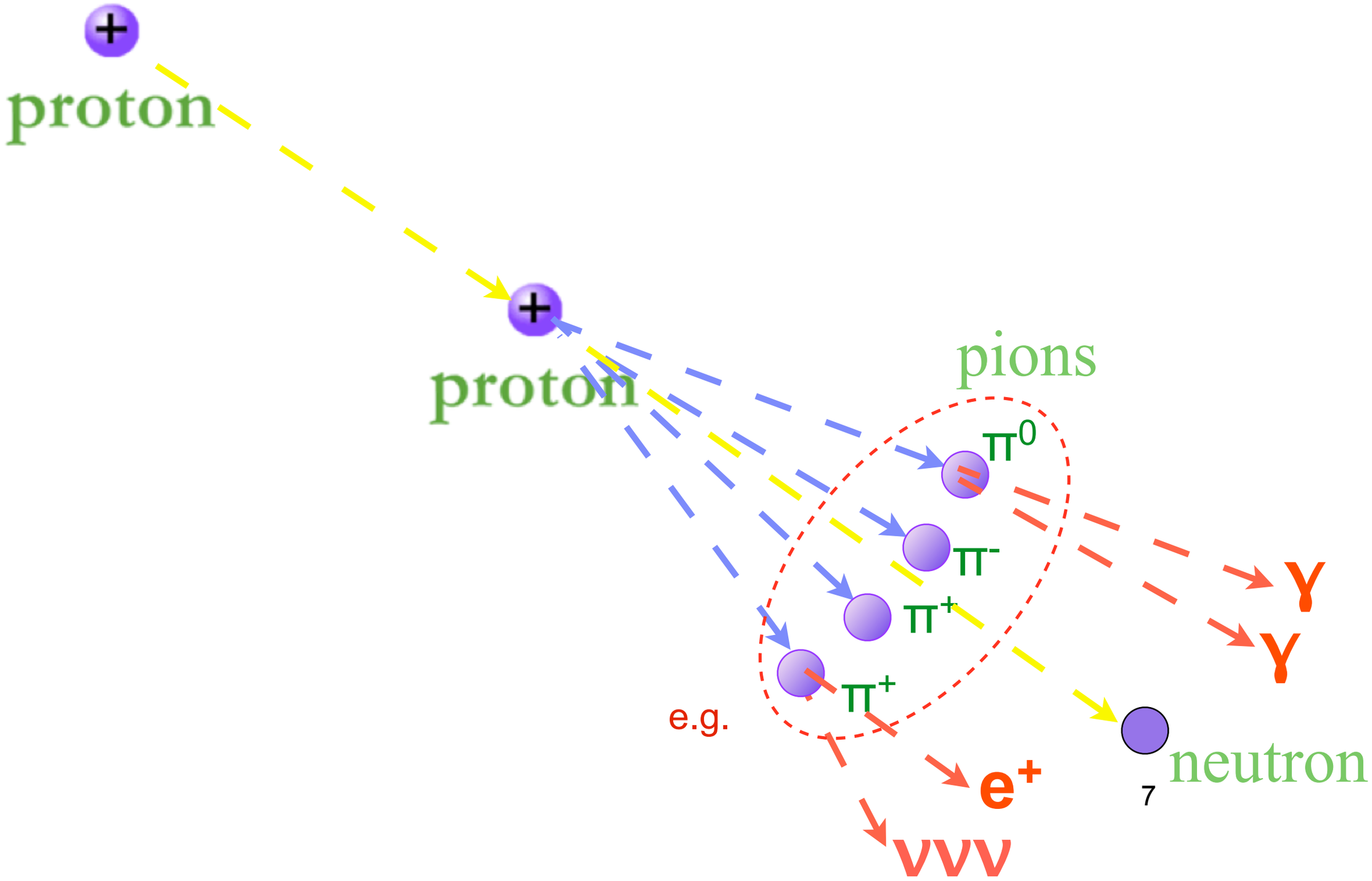
Inverse Compton Scattering



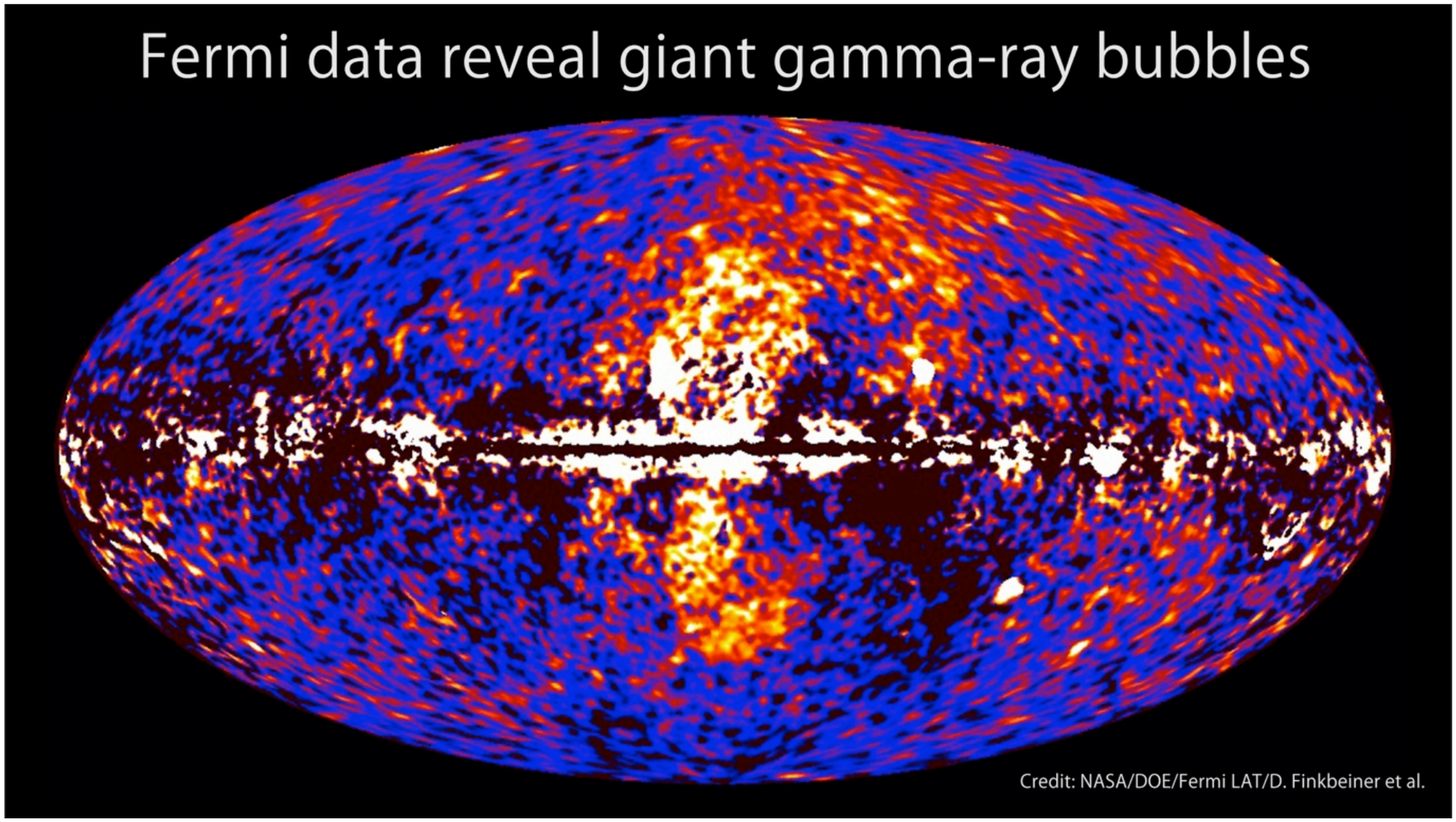
Bremsstrahlung



pp → Pion Decay → secondaries



Fermi Bubbles

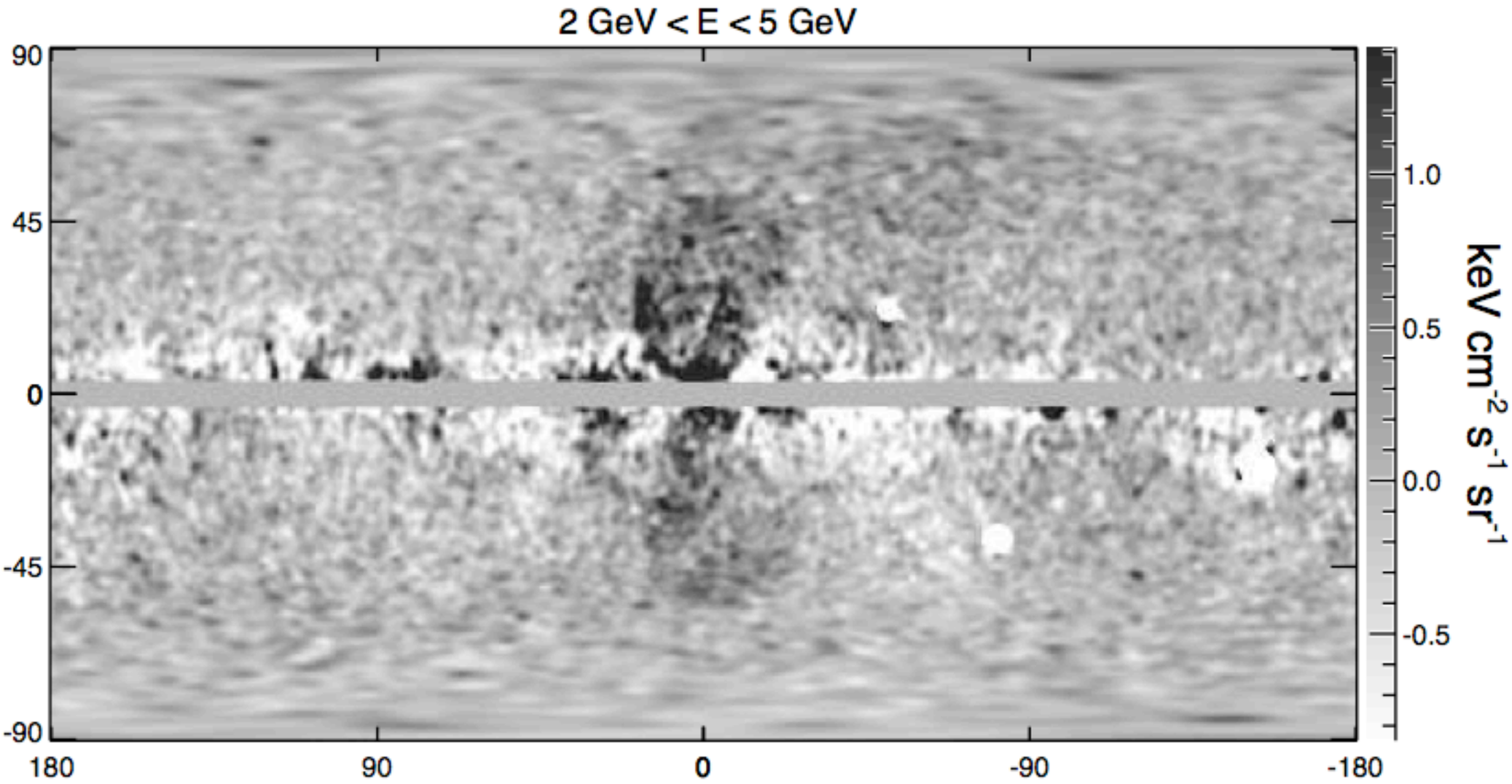


Su, Slatyer and Finkbeiner 2010 (ApJ)

Fermi Bubbles

- 4×10^{37} erg/s
- hard spectrum, but spectral down-break below ~ GeV in SED
- uniform intensity
- sharp edges
- vast extension: ~10 kpc from plane

Fermi Bubbles



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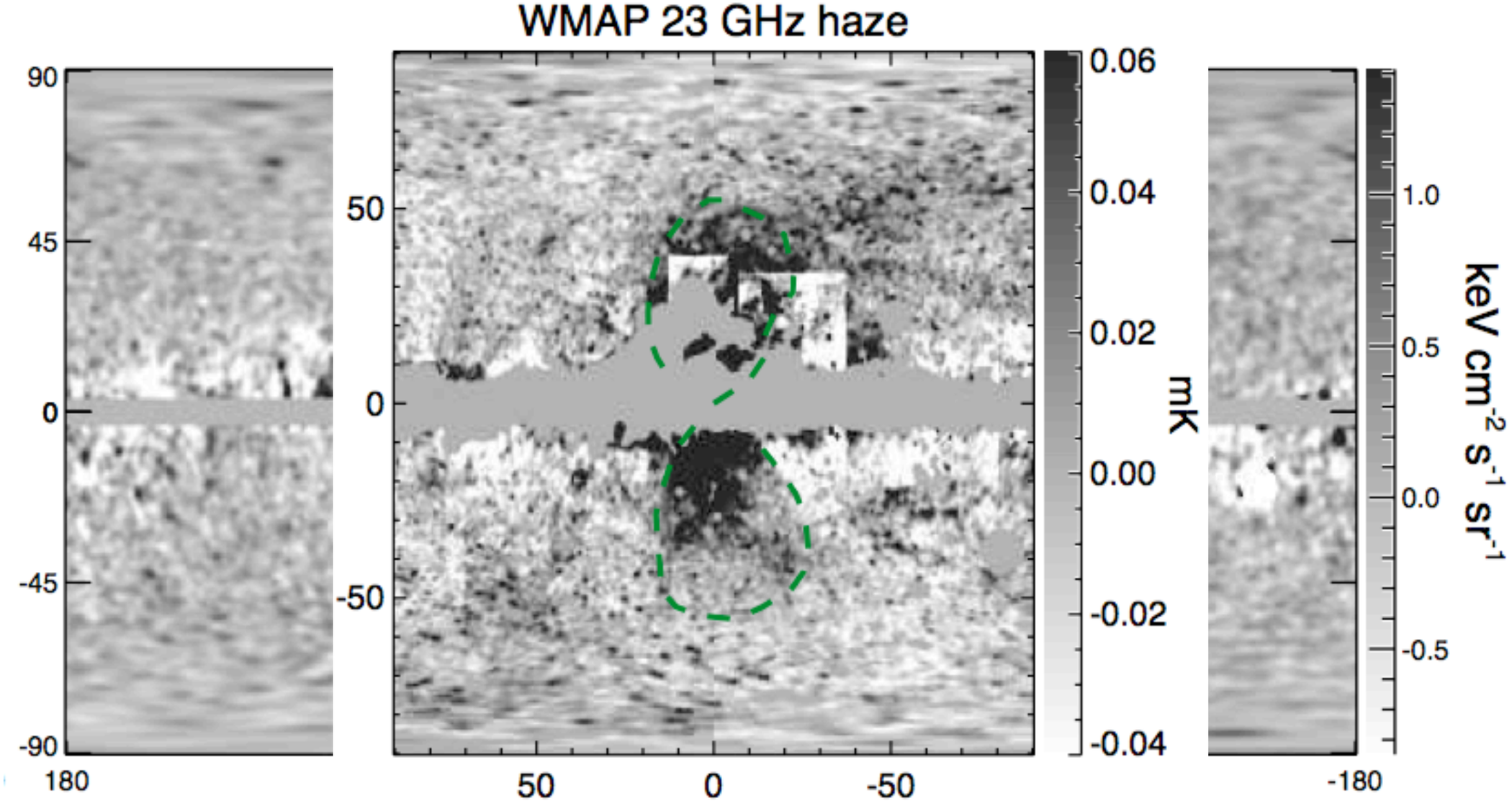
Fermi Bubbles



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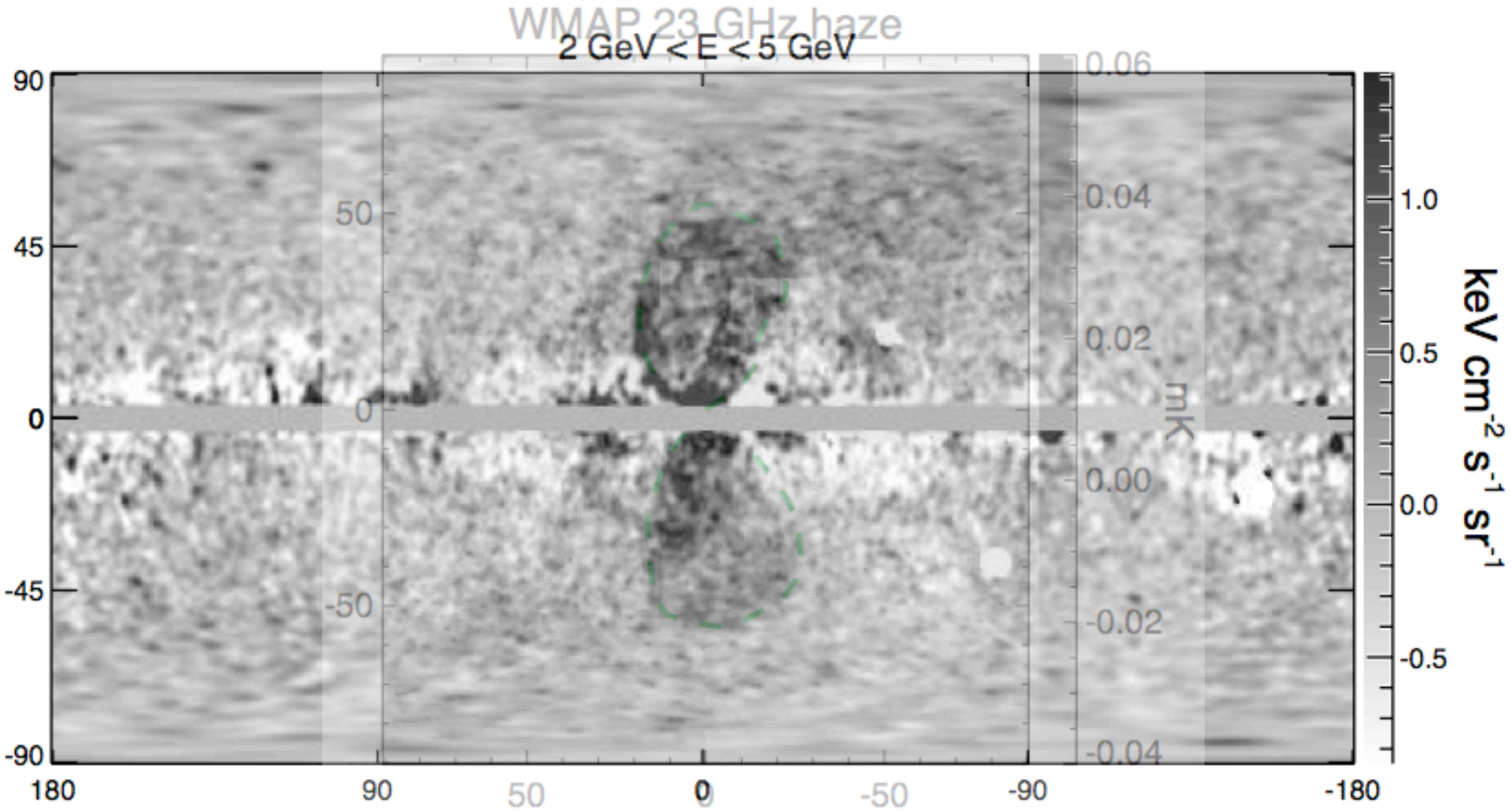
Fermi Bubbles



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‘Natural’ explanation: HE, primary electrons

- ~GeV γ-ray emission from IC by hypothesised population of hard-spectrum ~TeV electrons
- same population synchrotron-radiates into microwave frequencies

Electron scenarios

~TeV electrons ⇒ fast cooling time

(~10^6 years)

- **Very fast transport** (>3% c) ⇒

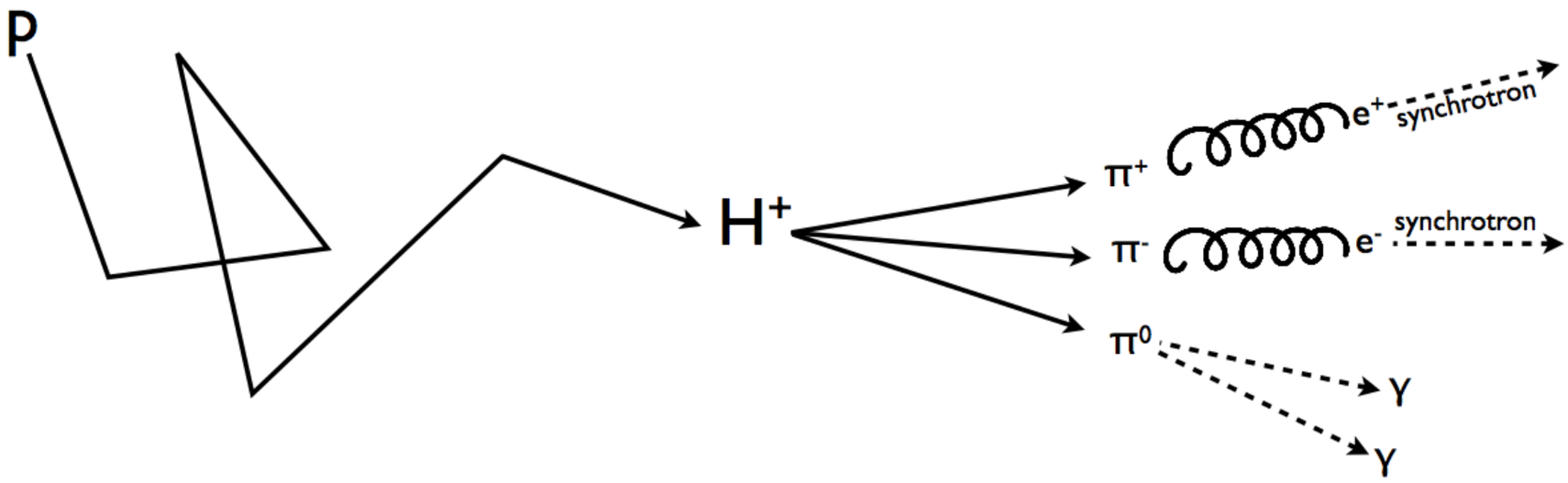
  relativistic outflow ⇒ AGN jet from Sgr A*

- **In situ acceleration**

Proton scenarios

~100 GeV protons ⇒ slow cooling time

(few 10^9 years)



Secondaries from pp collisions

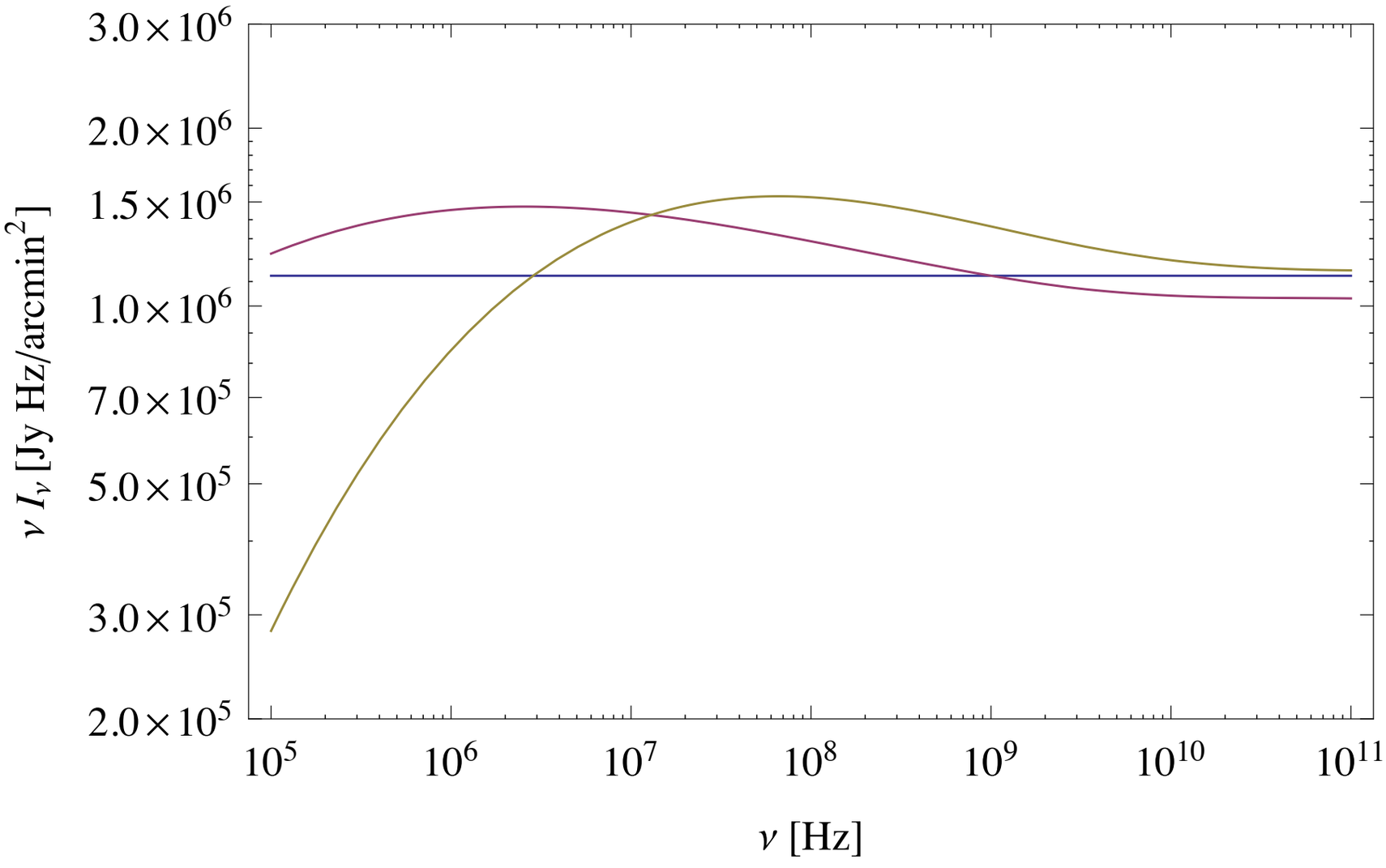
Broad questions

- Are the Fermi Bubble gamma-rays due to cosmic ray electrons or protons?
- Are these structures associated with recent AGN-like activity of Sgr A* or with GC star formation (over much longer timescales)?

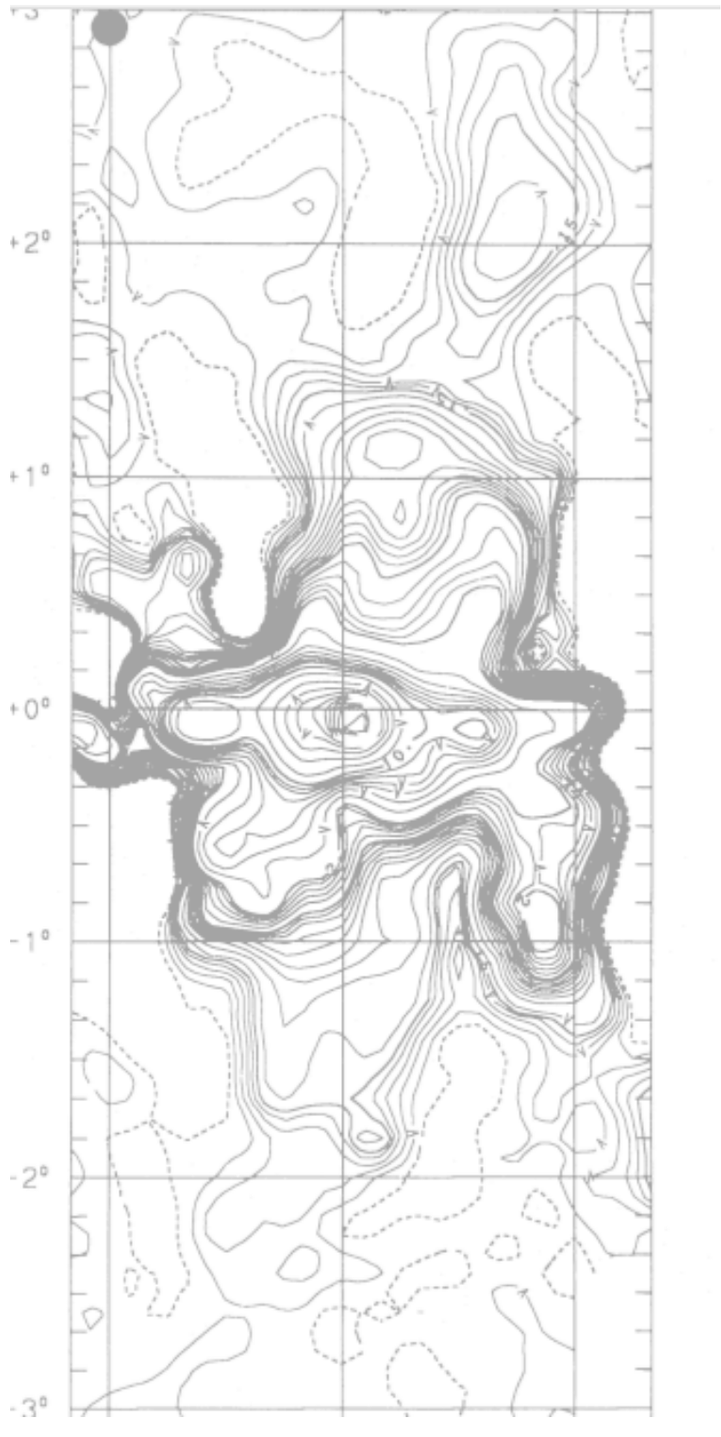
3 measurements that would help us understand the GC outflow

- Trace low surface brightness, non-thermal radio continuum spurs from the Galactic plane out into the bulge
- Measure the low-frequency spectrum of the ‘Fermi Bubbles’
- Determine magnetic field/topology of ‘Fermi Bubbles’/GC spur with RM studies of extra-galactic, polarized sources

Secondary electrons: spectral features at lf



2.7 GHz radio data
(unsharp mask)
Pohl, Reich &
Schlickeiser 1992



HESS TeV data:
Aharonian et al
2006

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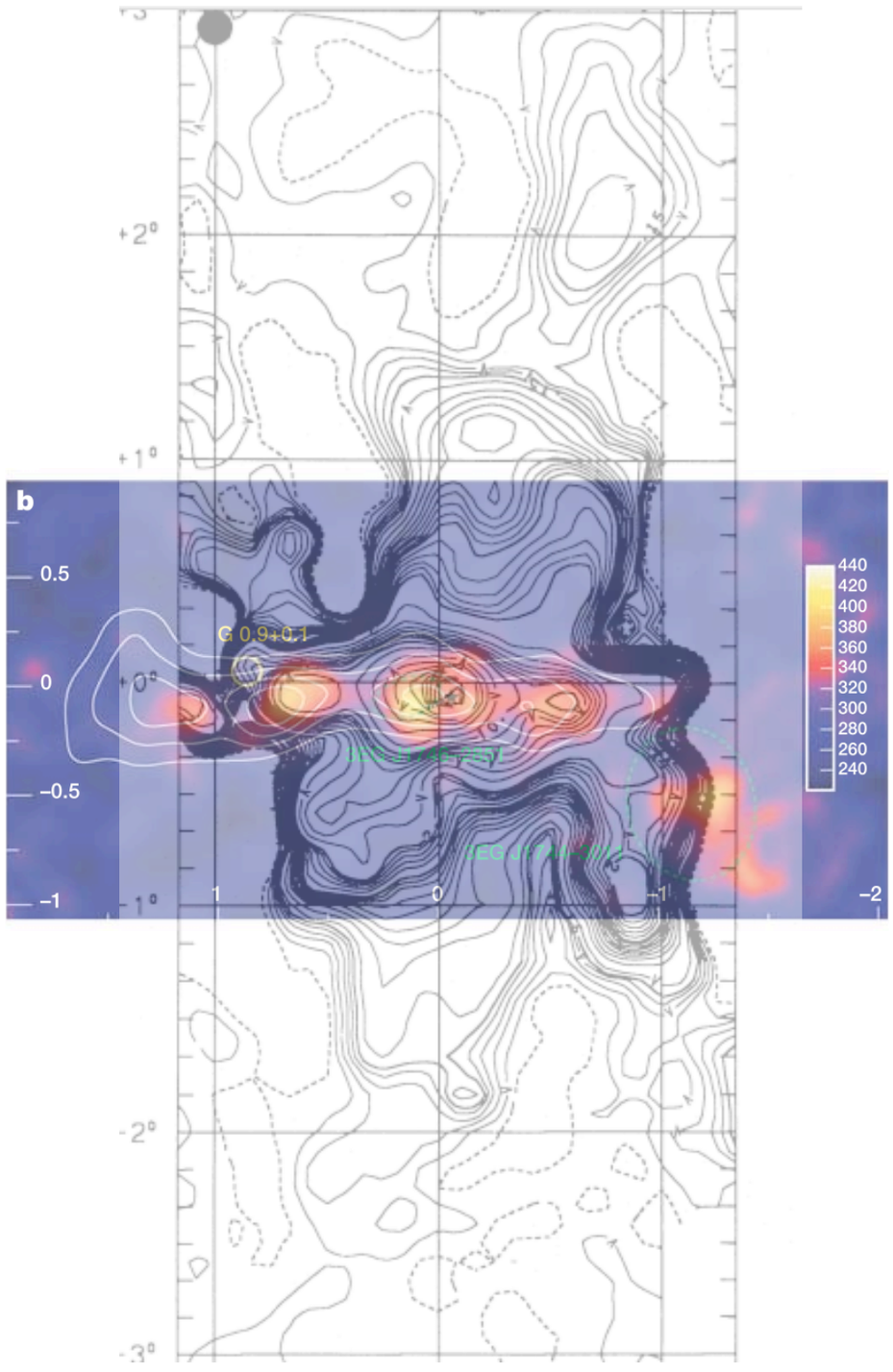

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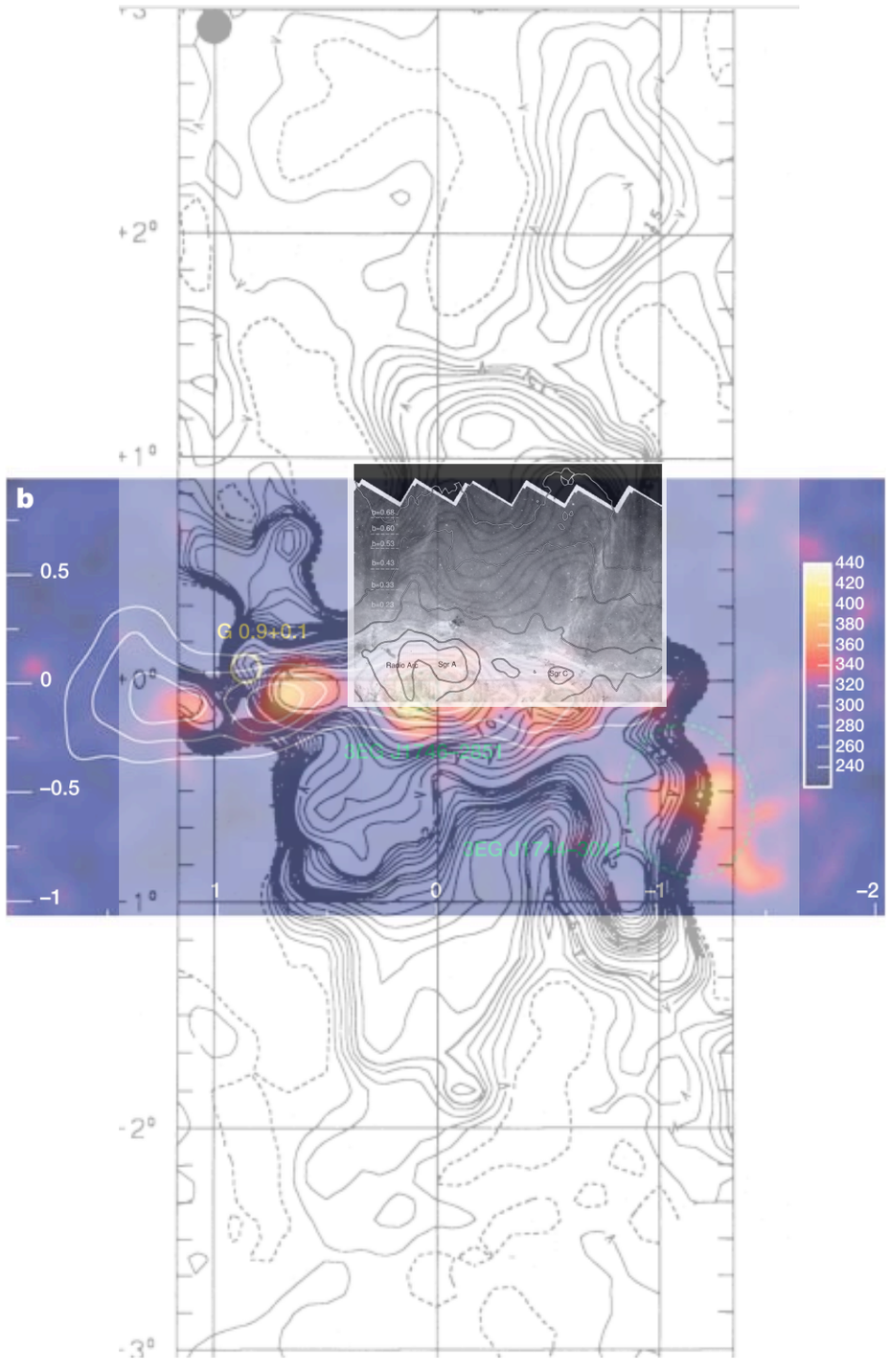
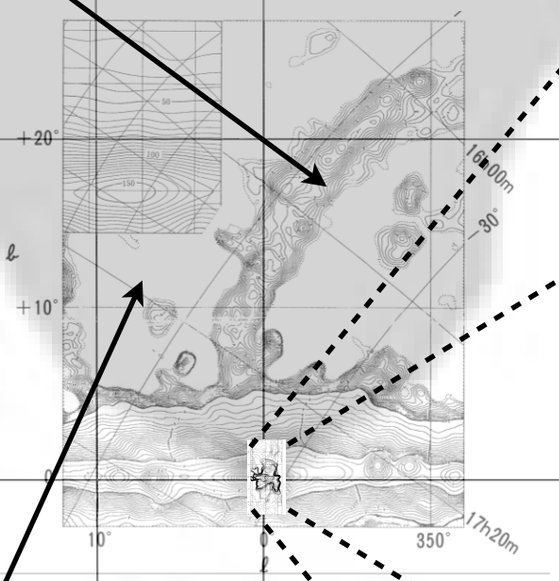
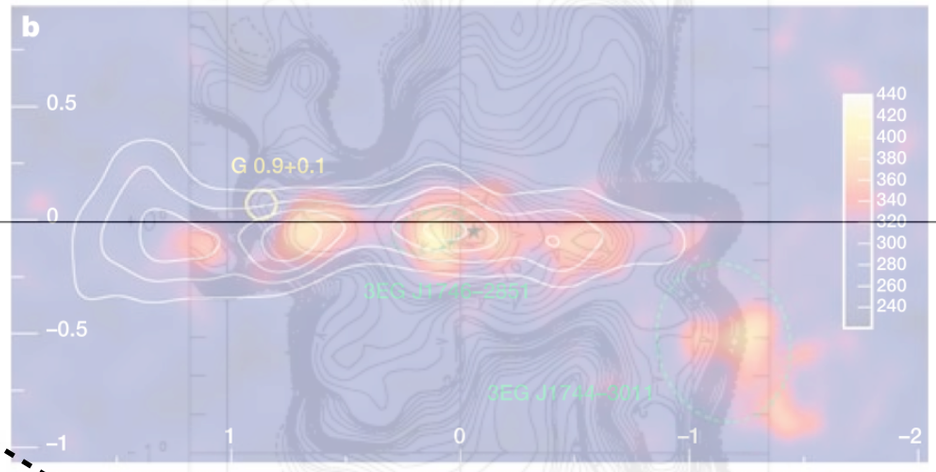


Spitzer 8 micr
Stolovy 200

"GC spur"
Sofue, Reich &
Reich 1989





Fermi Bubbles

Conclusions

- At a minimum the Fermi Bubbles represent important foregrounds to extra-galactic/ cosmological observations - predicted intensity at GHz ~10^{-19} erg/(s cm^2 Hz sr)
- More interestingly, they are likely aspects of the feedback processes that connect the activity of the Galactic nucleus to the wider Galaxy
- If they are due to cosmic ray protons, they represent a calorimetric recording of Galactic centre star-formation over the age of the Milky Way