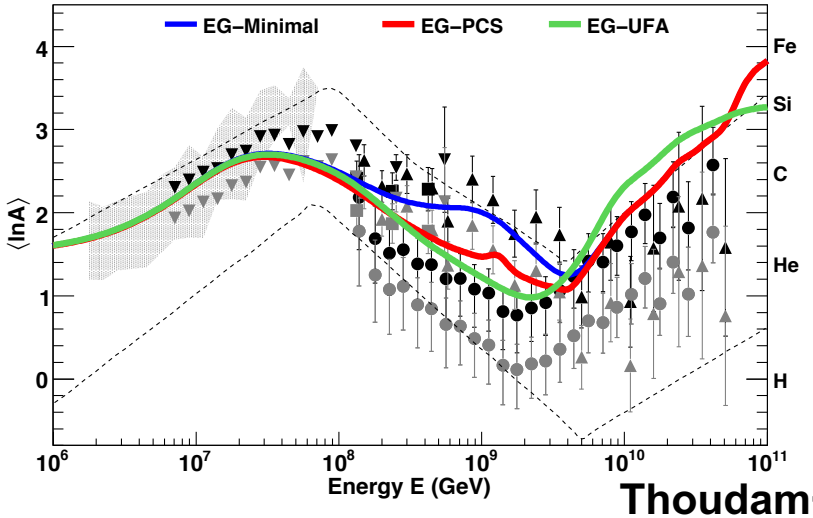
Mergers, Gammas, and FRBs

Kohta Murase (Penn State)

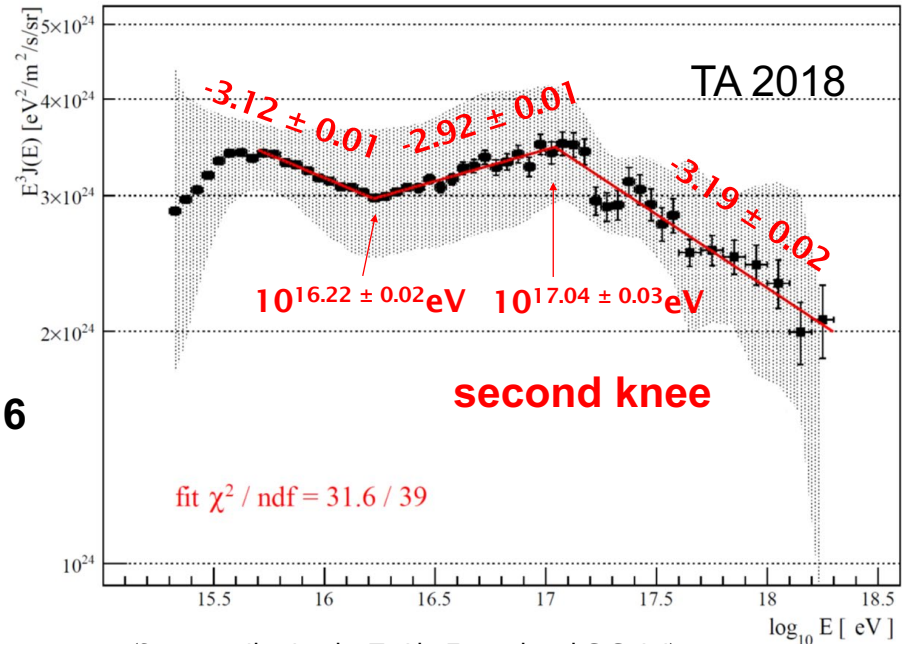
GRAND meeting

Transition Models

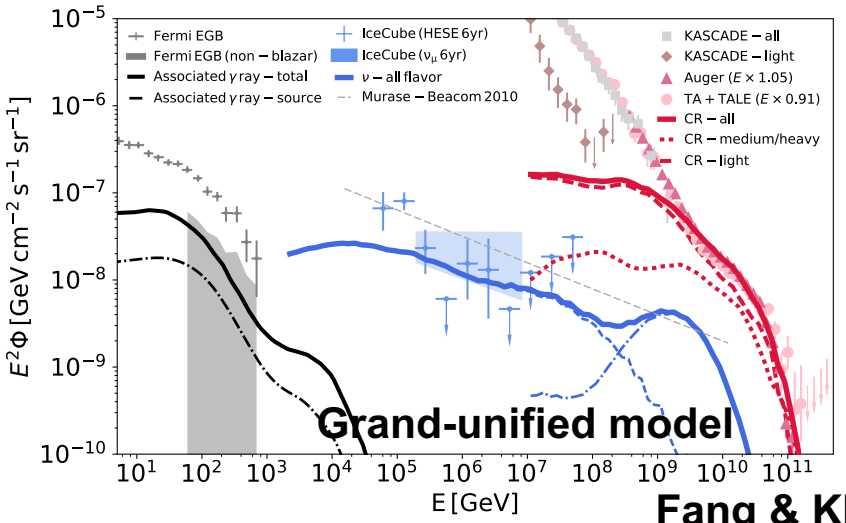
What is the B-component?
Extragalactic CRs appear around 10^{17} eV?



Thoudam+ 16

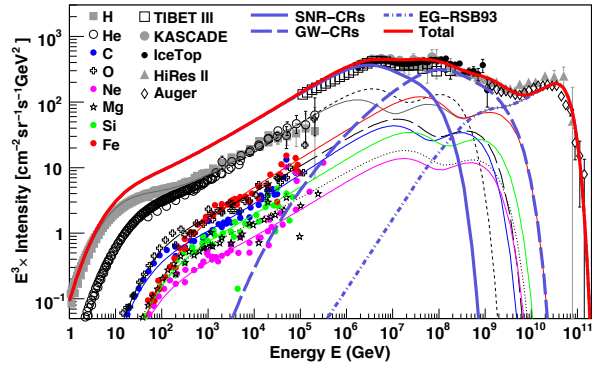


TALE spectrum:
second knee at ~10^{17} eV
break at ~$10^{16.2}$ eV

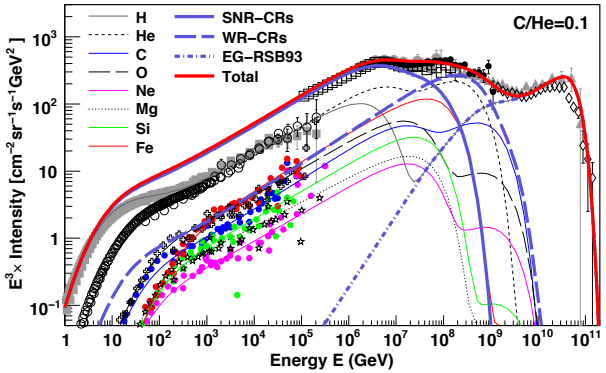


Fang & KM 18

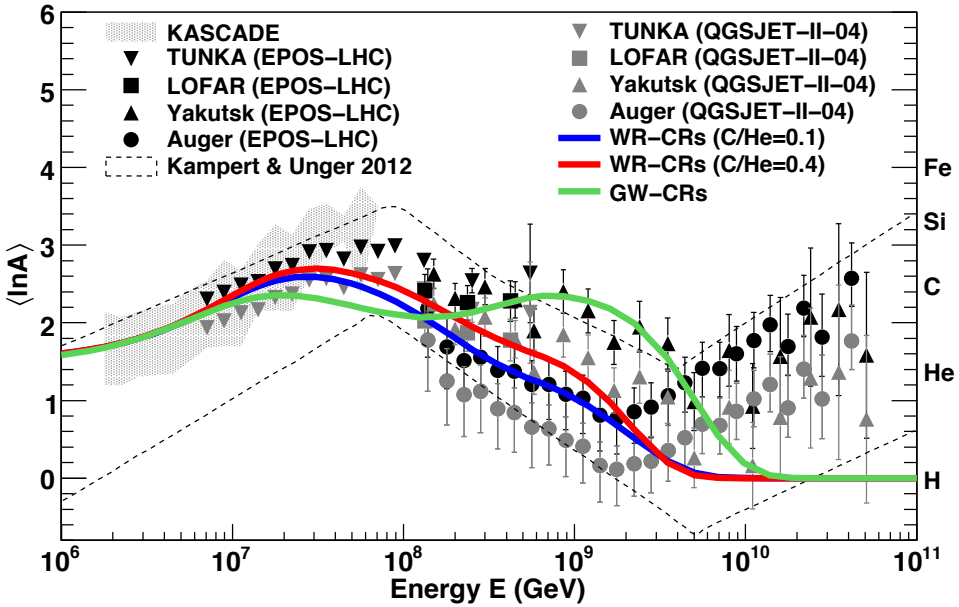
Galactic Models

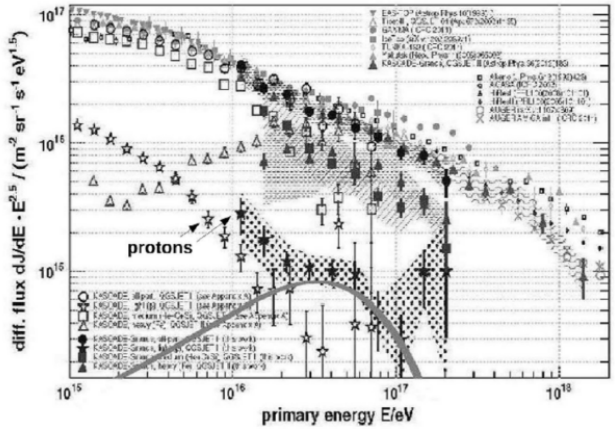


Galactic wind



SNe Ic

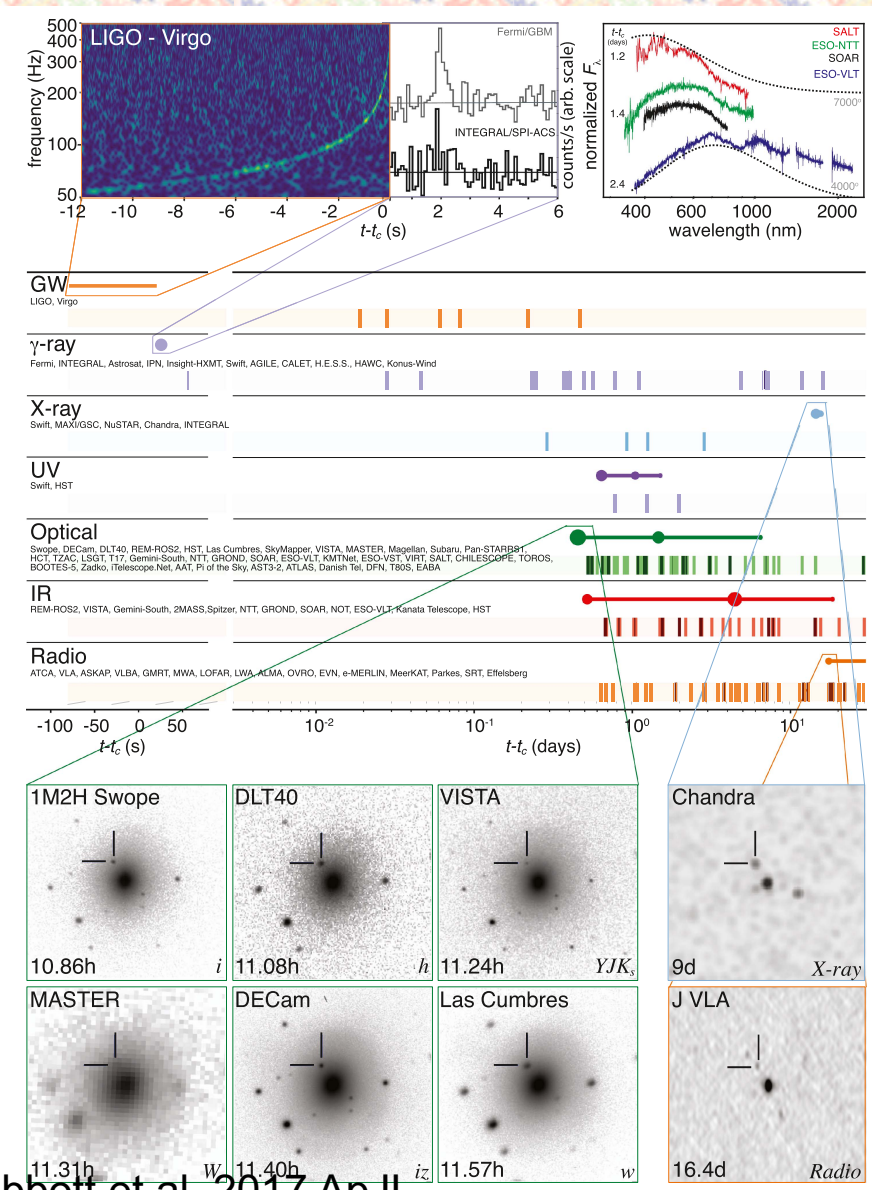


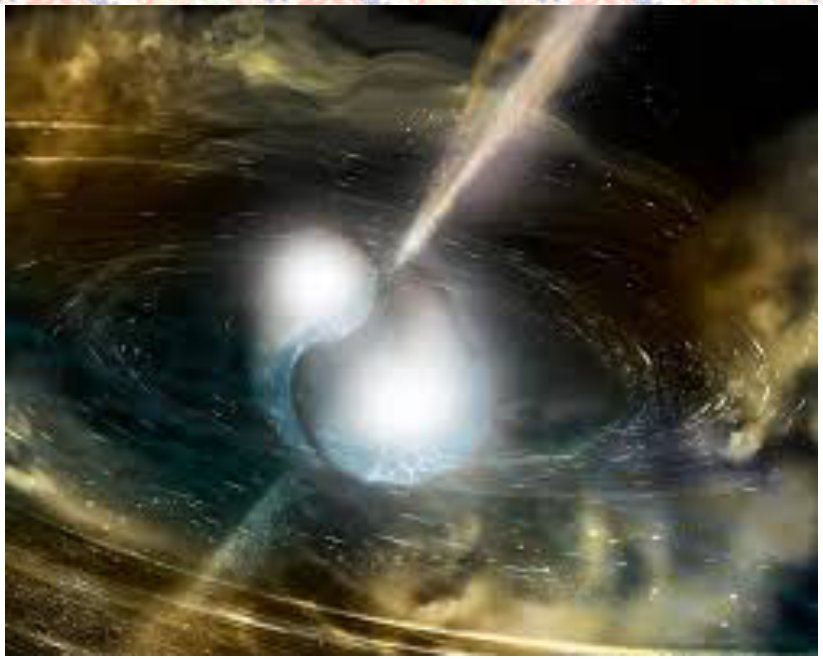


SNe IIn

Thoudam et al. 16
Zirakashvilli & Ptuskin 17

Discovery of Binary Neutron Star Merger (2017)

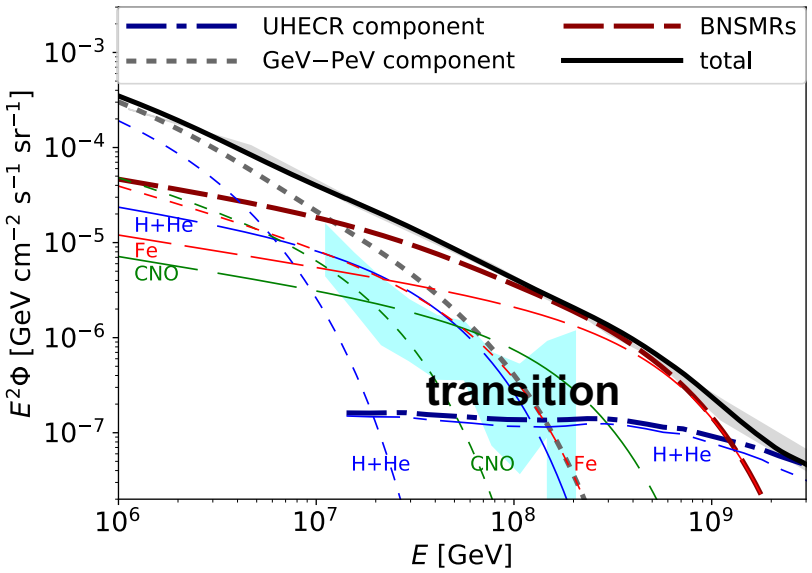


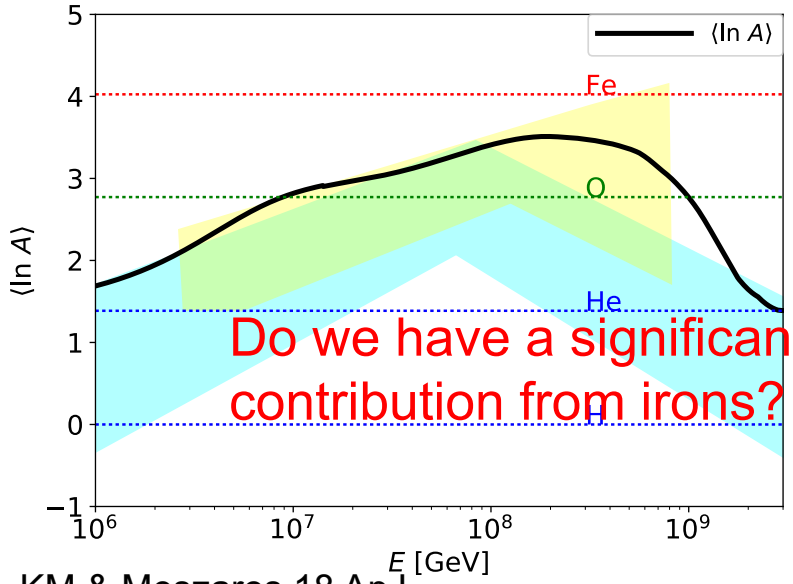


“concordance” picture
- **gravitational wave**
- **gamma-ray burst**
- **kilonova/macronova**
- **X-ray/radio afterglow**

Abbott et al. 2017 ApJL

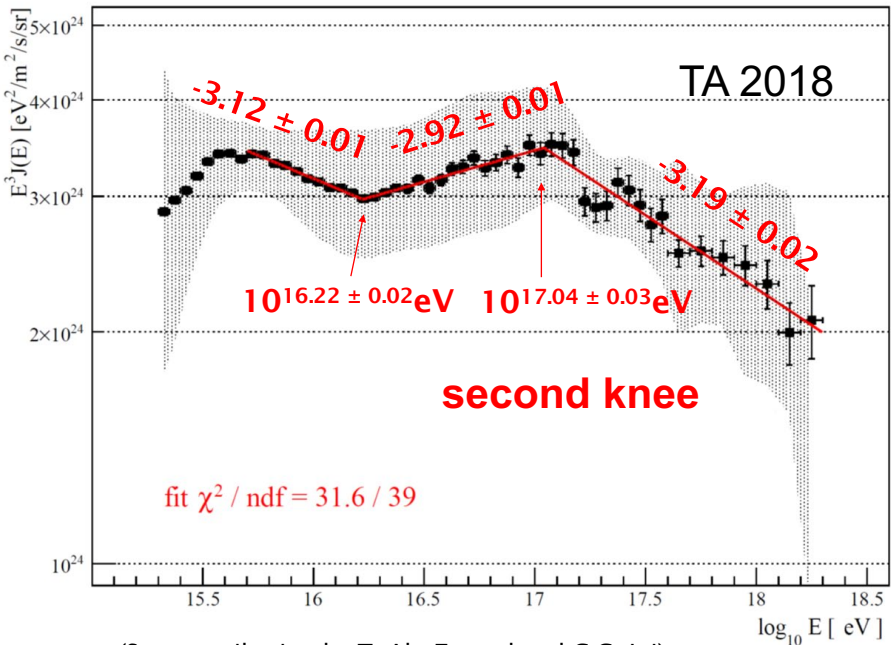
"Tale" of Past Galactic Neutron Merger Remnants?





Kimura, KM & Meszaros 18 ApJ

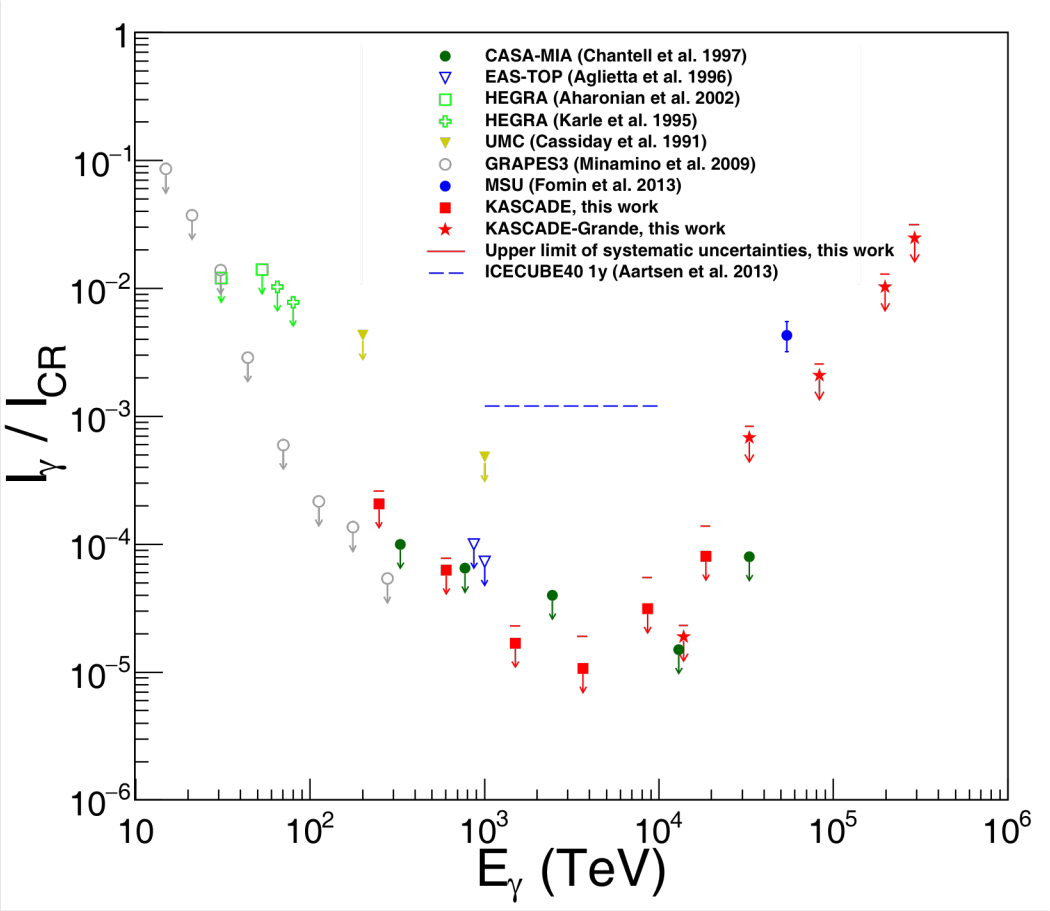
- GW170817 confirmed transrelativistic ejecta w. V~0.2-0.3c
  -> E_p^{max} ~ 30 PeV >> knee

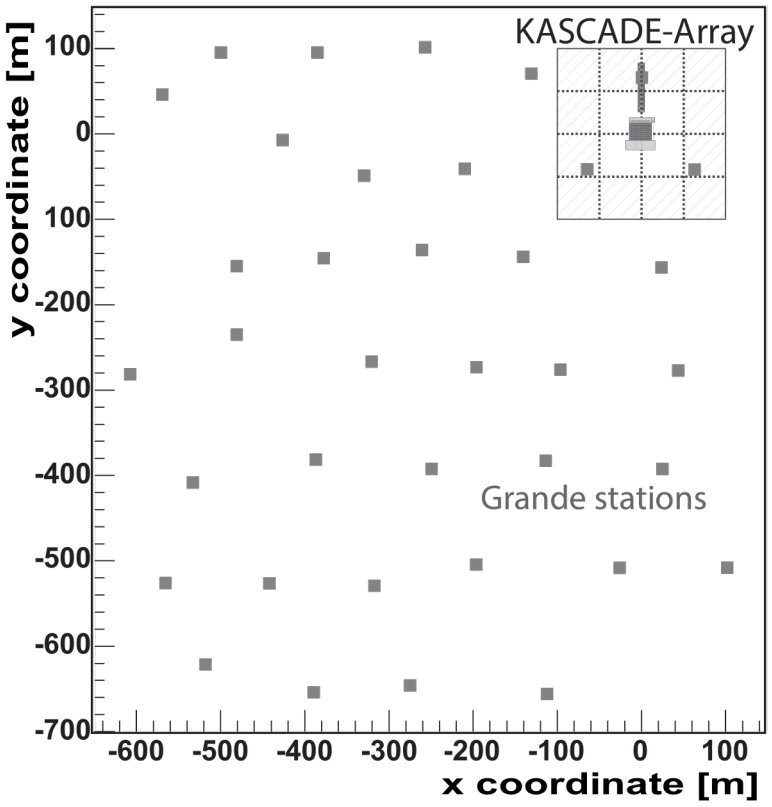


TALE spectrum:
second knee at ~10^{17} eV
break at ~$10^{16.2}$ eV

Gamma?

KASCADE-Grande 17

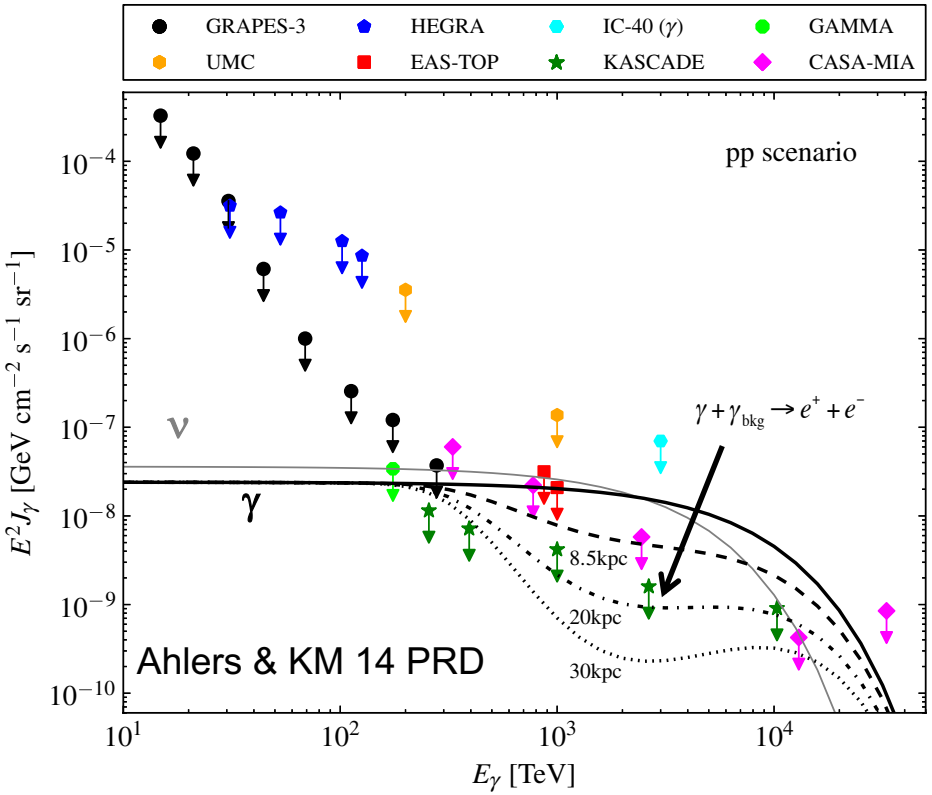


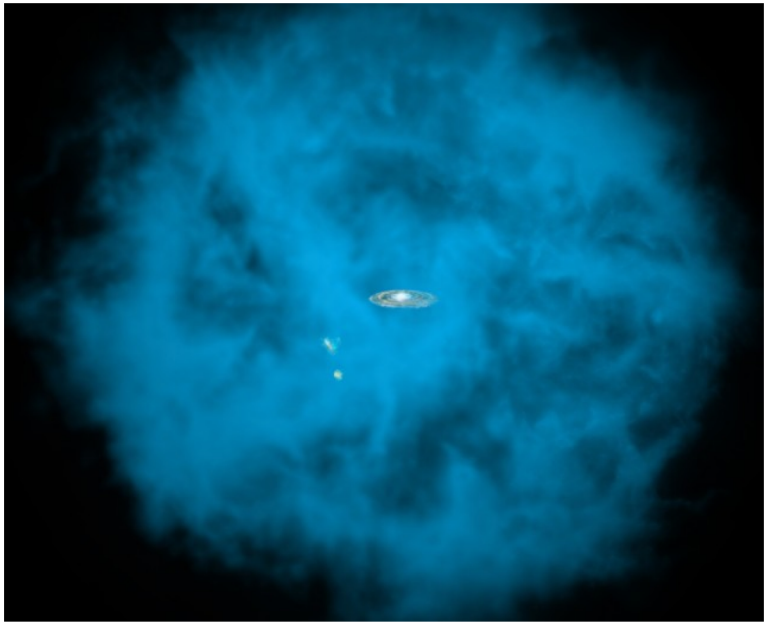


Example: Galactic Halo?

Airshower arrays have placed diffuse γ-ray limits at TeV-PeV

Isotropic limits (Galactic halo CR model)



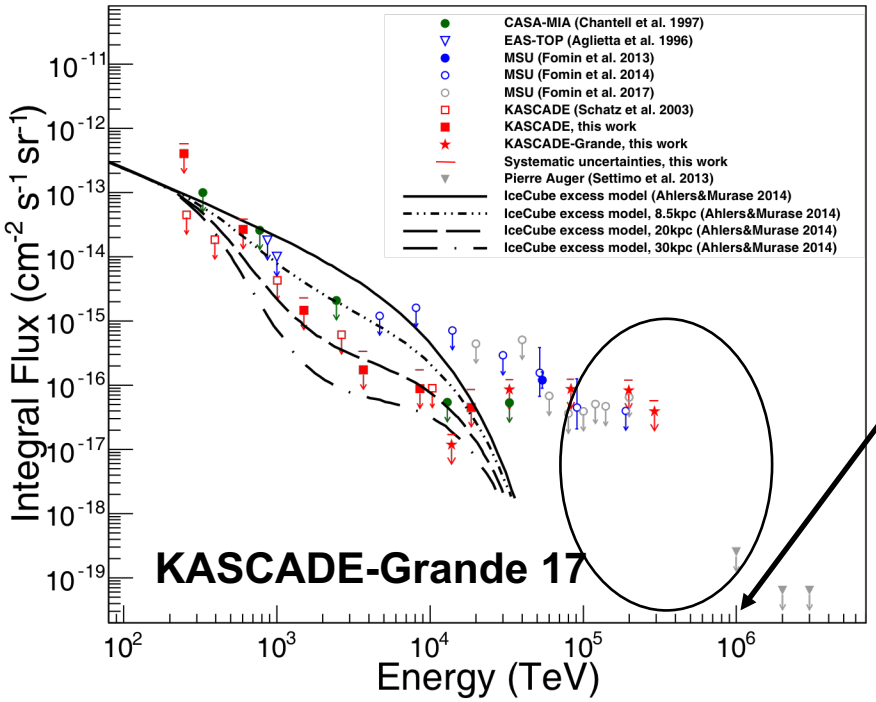


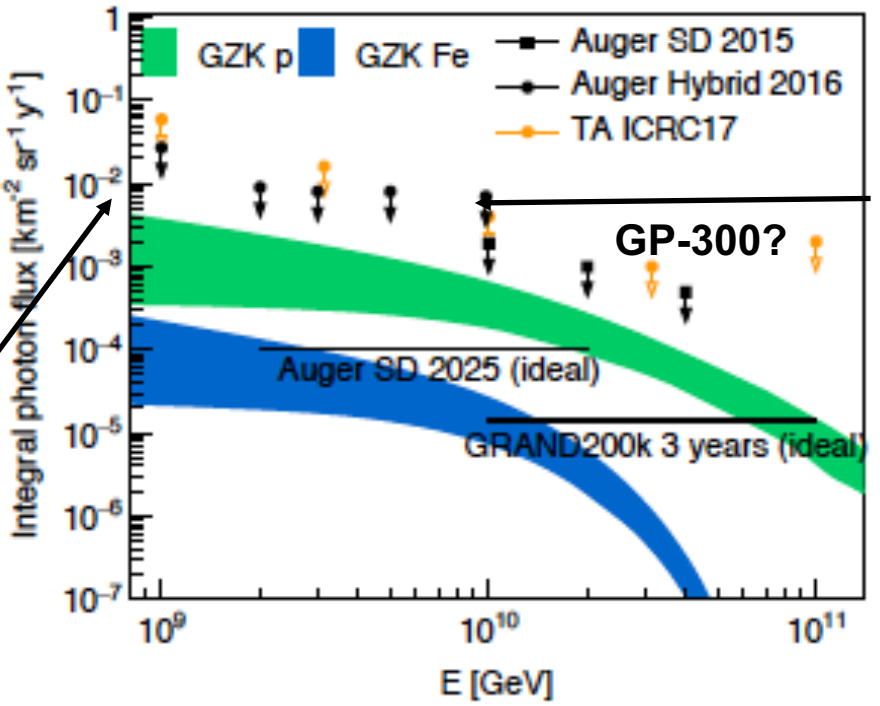
$$n_H = (10^{-4.2\pm0.25})(R/\tilde{R}_{vir})^{-0.8\pm0.3}$$

- Existing old TeV-PeV γ-ray limits are close to predicted fluxes
  → Need deeper TeV-PeV γ-ray observations (relatively not expensive)

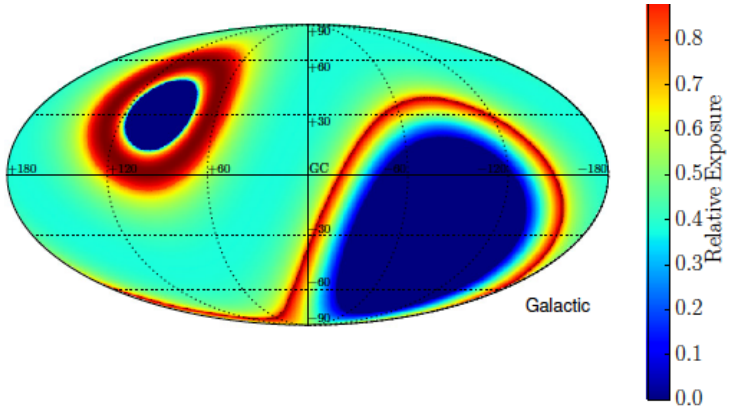
※ Fermi γ-ray data imply $s_\nu < 2.0$ → support extragalactic scenarios

Gammas?



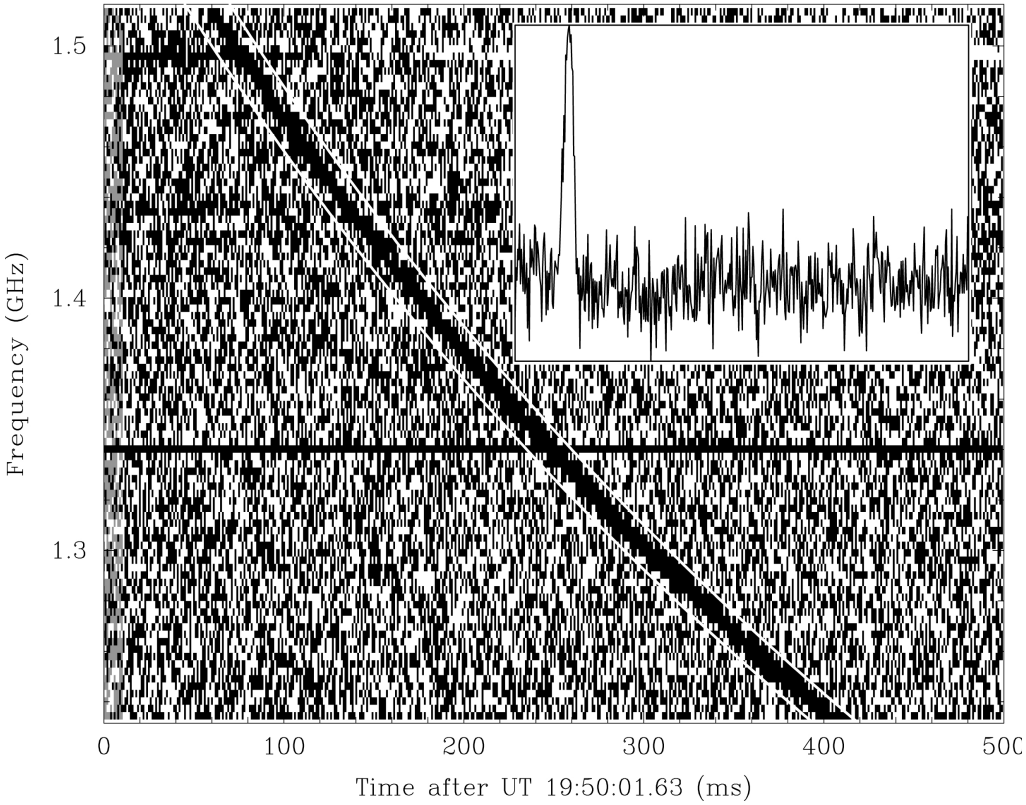


- Ideal to have surface arrays
- Important to cover 1017-1018 eV



Fast Radio Bursts

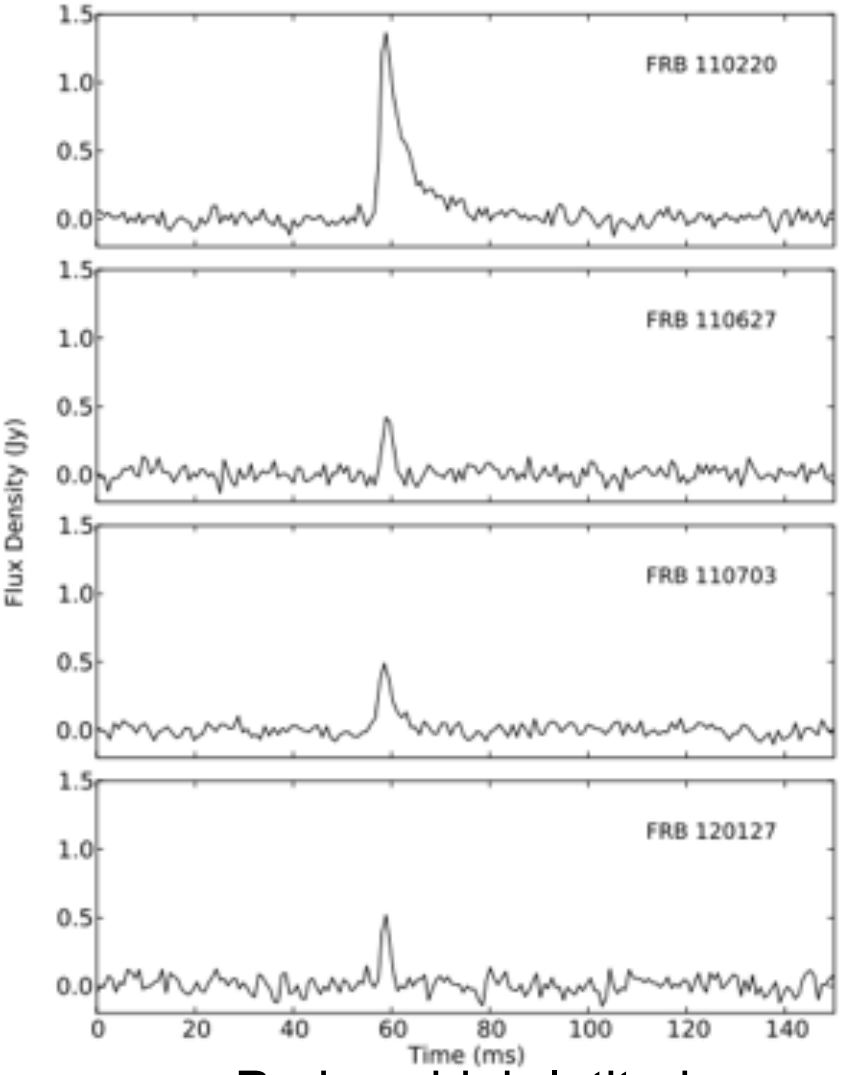
Lorimer 07 Science



$$\mathrm{DM} = \int_0^D n_\mathrm{e} dl$$

$$t_1 - t_2 \propto \mathrm{DM}\left[\frac{1}{\nu_1^2} - \frac{1}{\nu_2^2}\right]$$

Thornton et al. 13 Science



Parkes, high-latitude

FRB Characteristics

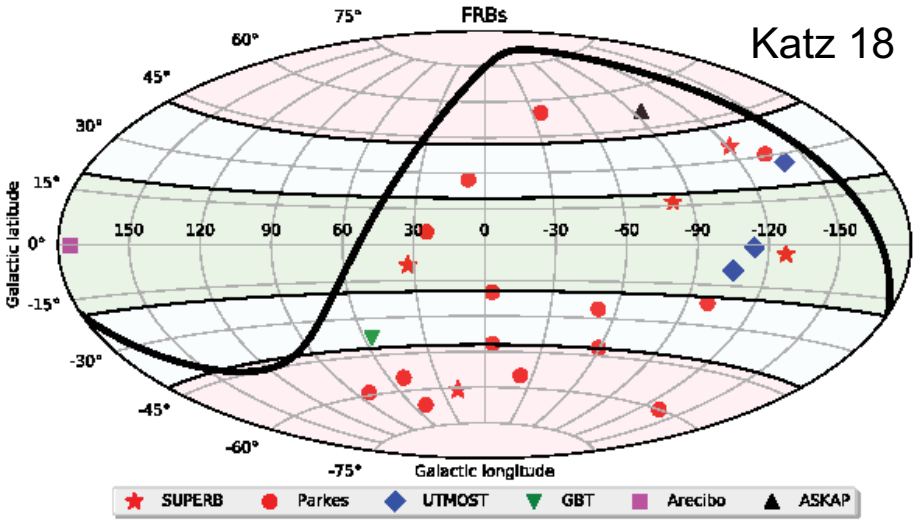
- DM~500-1000 cm^{-3} pc
  ⇒ d_L~2-6 Gpc (z~0.5-1)
  frequency-dependent DM

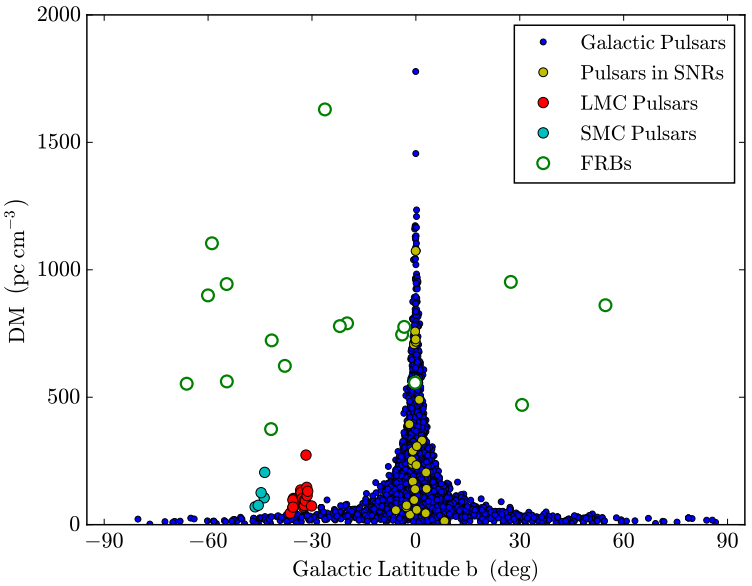
- S_ν~0.2-30 Jy ⇒ E_{iso}~$10^{39\text{-}41}$ erg

- High brightness temperature
  ⇒ coherent emission mechanism

- Observed width δt ~ 1-10 ms
  ⇒ cδt/(1+z) < 300-3000/(1+z) km

- Rate ~ 10^4/sky/day~10^{-3}/yr/gal
  ⇔ supernova rate 10^{-2}/yr/gal

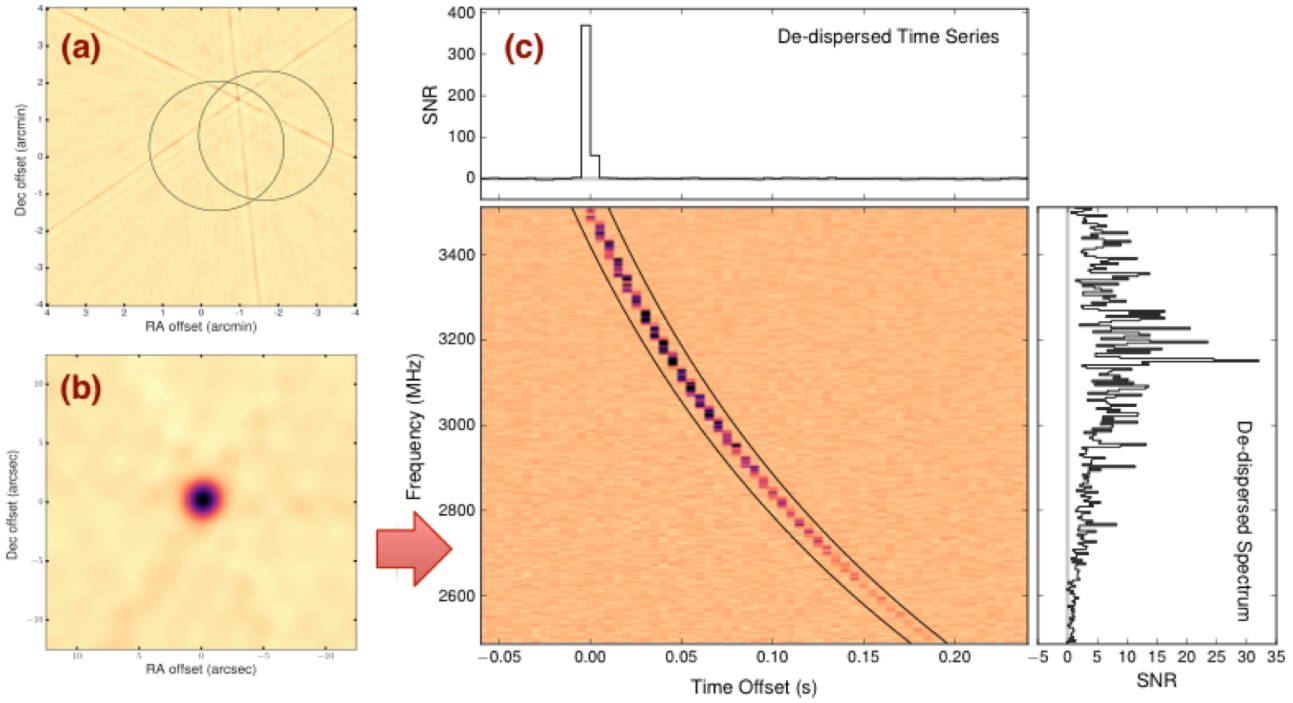




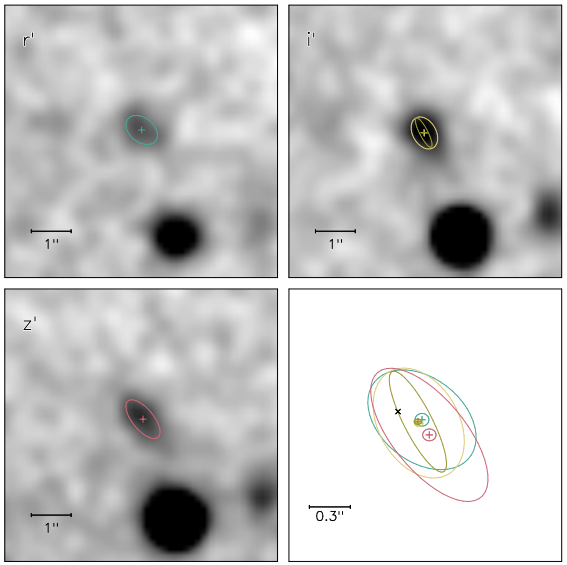
(Credit: Jim Cordes)

Discovery of Host Galaxy of FRB 121102

Chatterjee et al. 17 Nature



Tendulkar et al. 17 ApJ

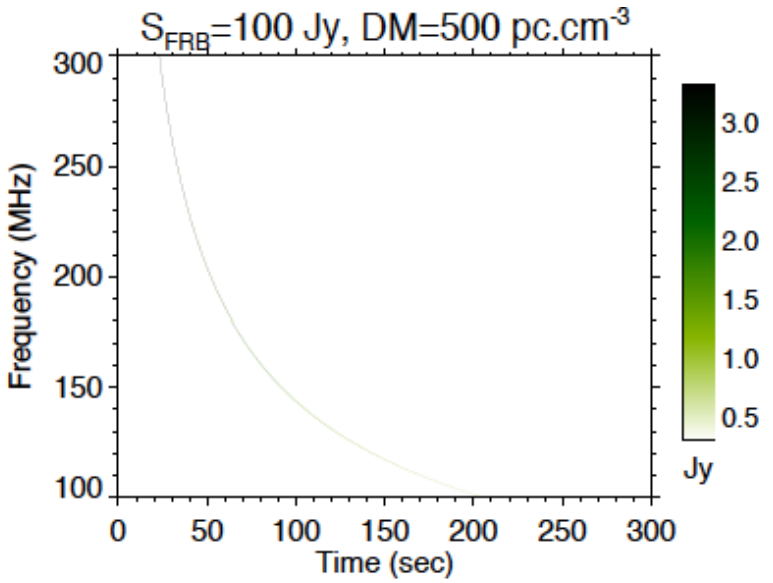


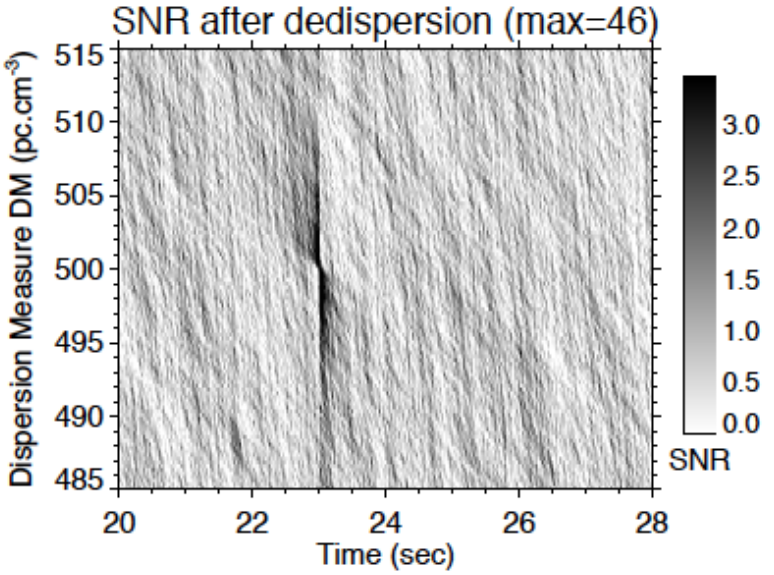
- VLA detection, ~0.1'' (w. Arecibo for one burst)
- DM=558 pc cm^{-3}, consistent w. previous report
- Keck/Gemini -> optical counterpart: dwarf galaxy (z=0.19)
- persistent radio counterpart w. ~0.15 mJy
- more… (rumor)

GRAND?

- Only brightest FRBs can be observed w. GP-300 (S>100 Jy)

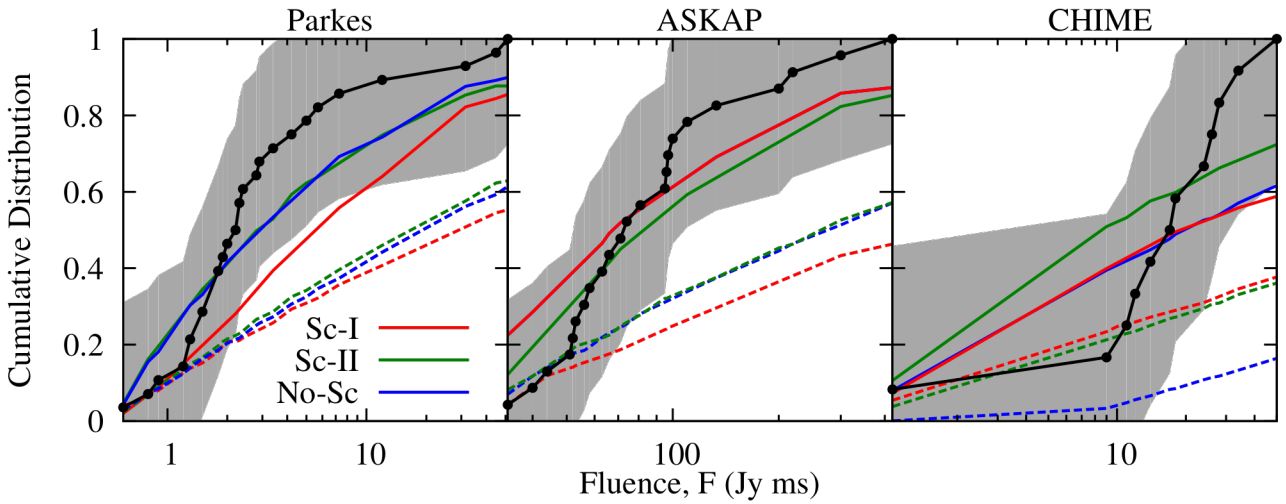
- 460 /day for α=1 at S=30 Jy

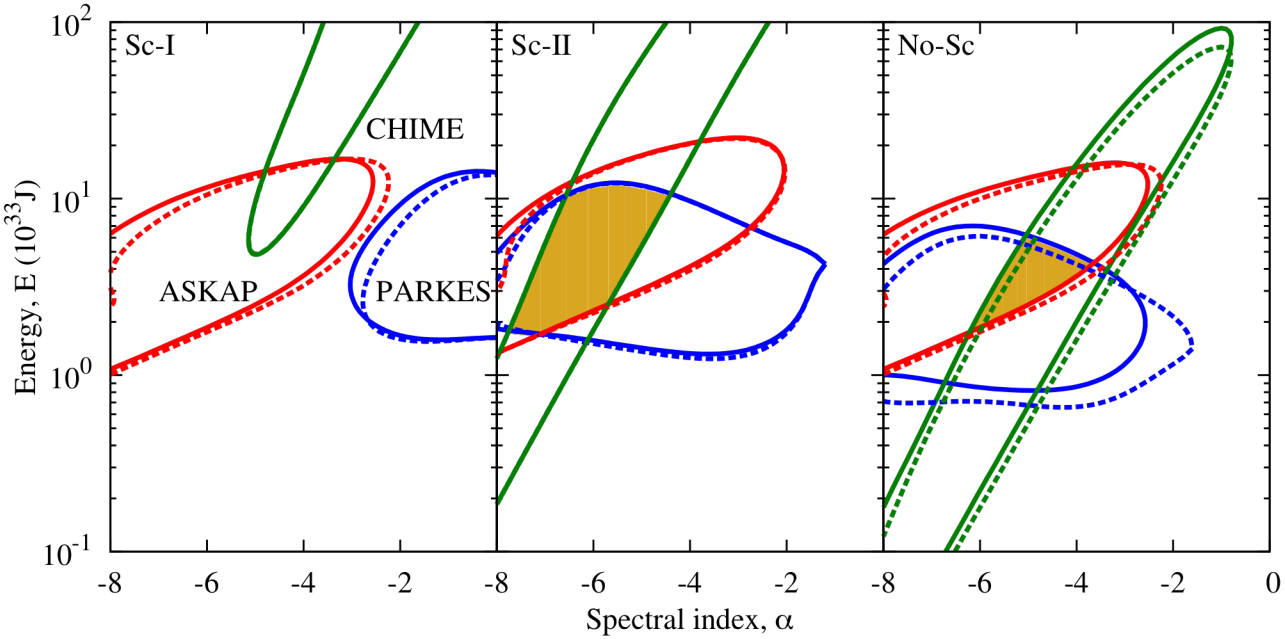




Good News

1903.12404

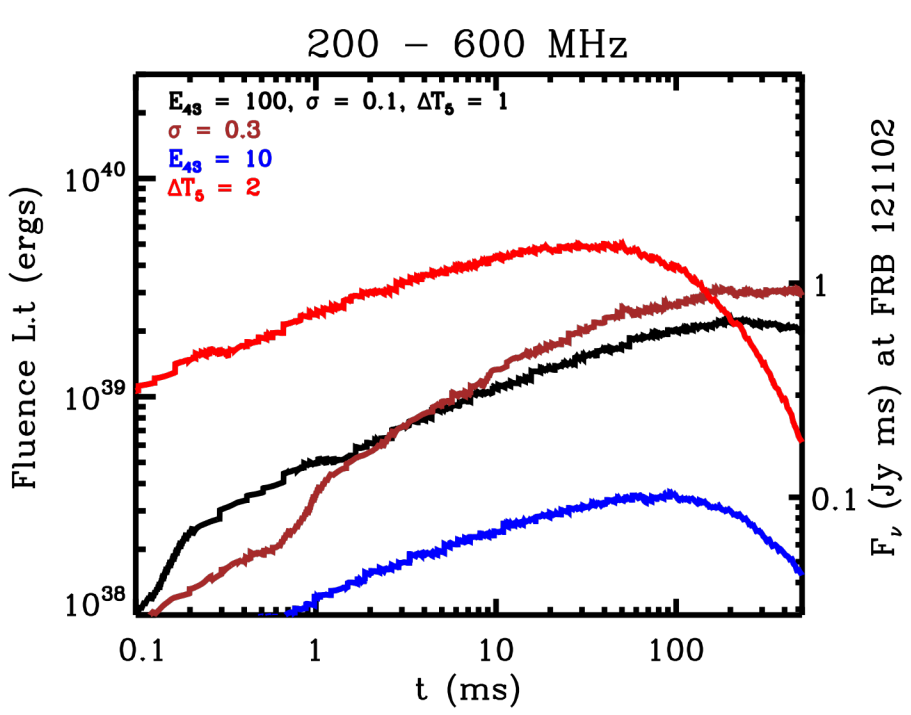


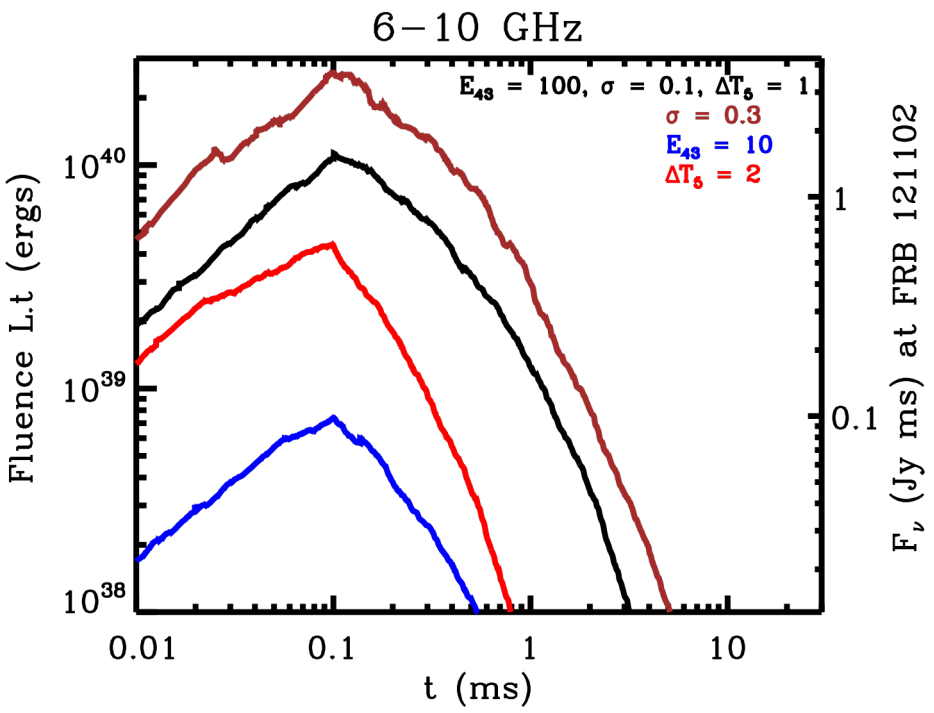


Good News II

synchrotron maser models predict emission at low frequencies

1902.01866





Summary

- Spectrum & composition
  Powerful probe of transition models

- Gamma
  worthwhile to investigate
  surface detectors?

- FRBs
  only brightest FRBs can be seen
  good prospects for low-frequency FRBs