supernova remnants
&
pulsar wind nebulae

future space-based gamma-ray observatories workshop
nasa gsfc

daniel castro (gsfc)

snrs & pwne

why?

what have we learnt with fermi-lat?

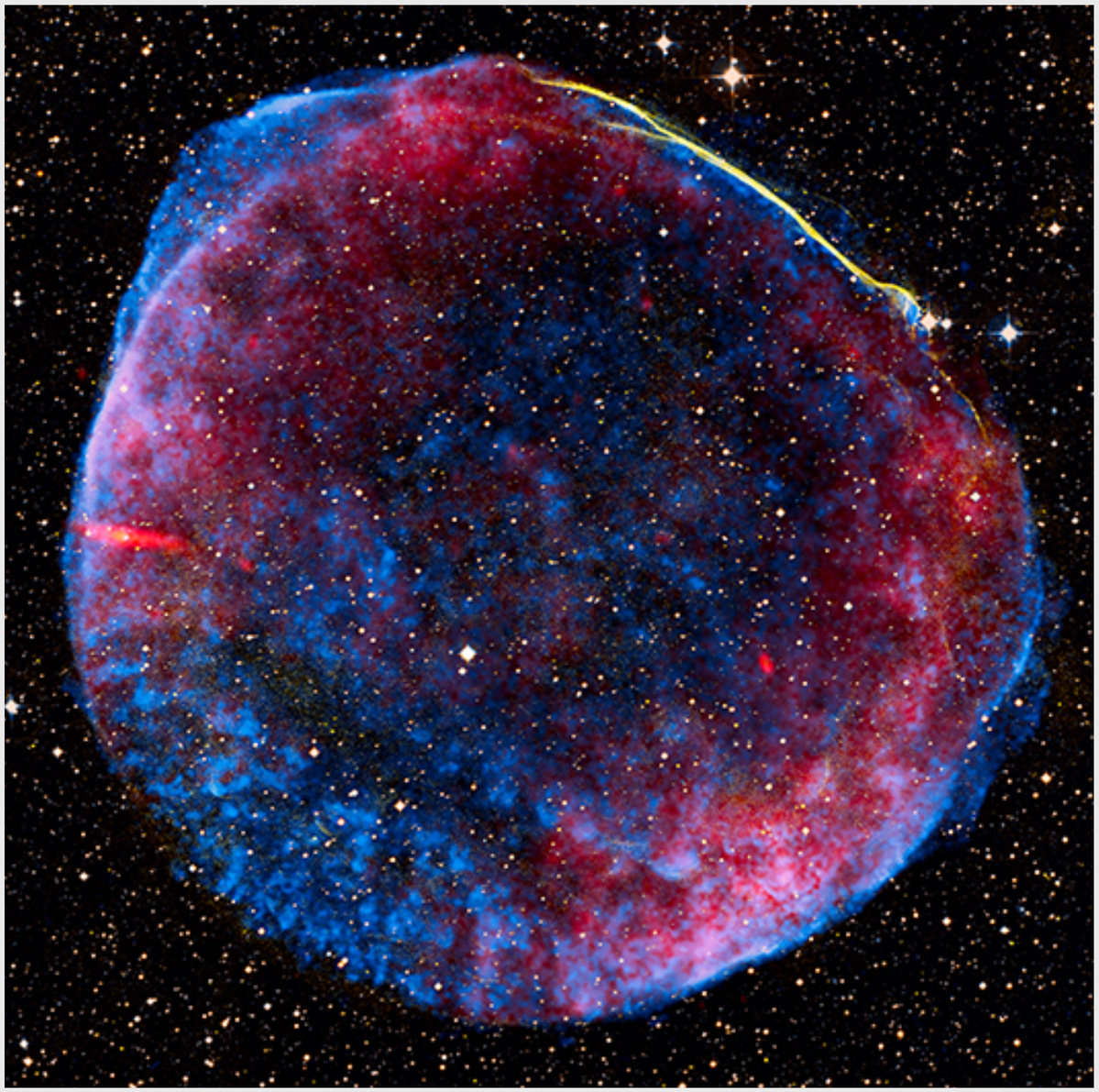
what do we need?

snrs & pwne

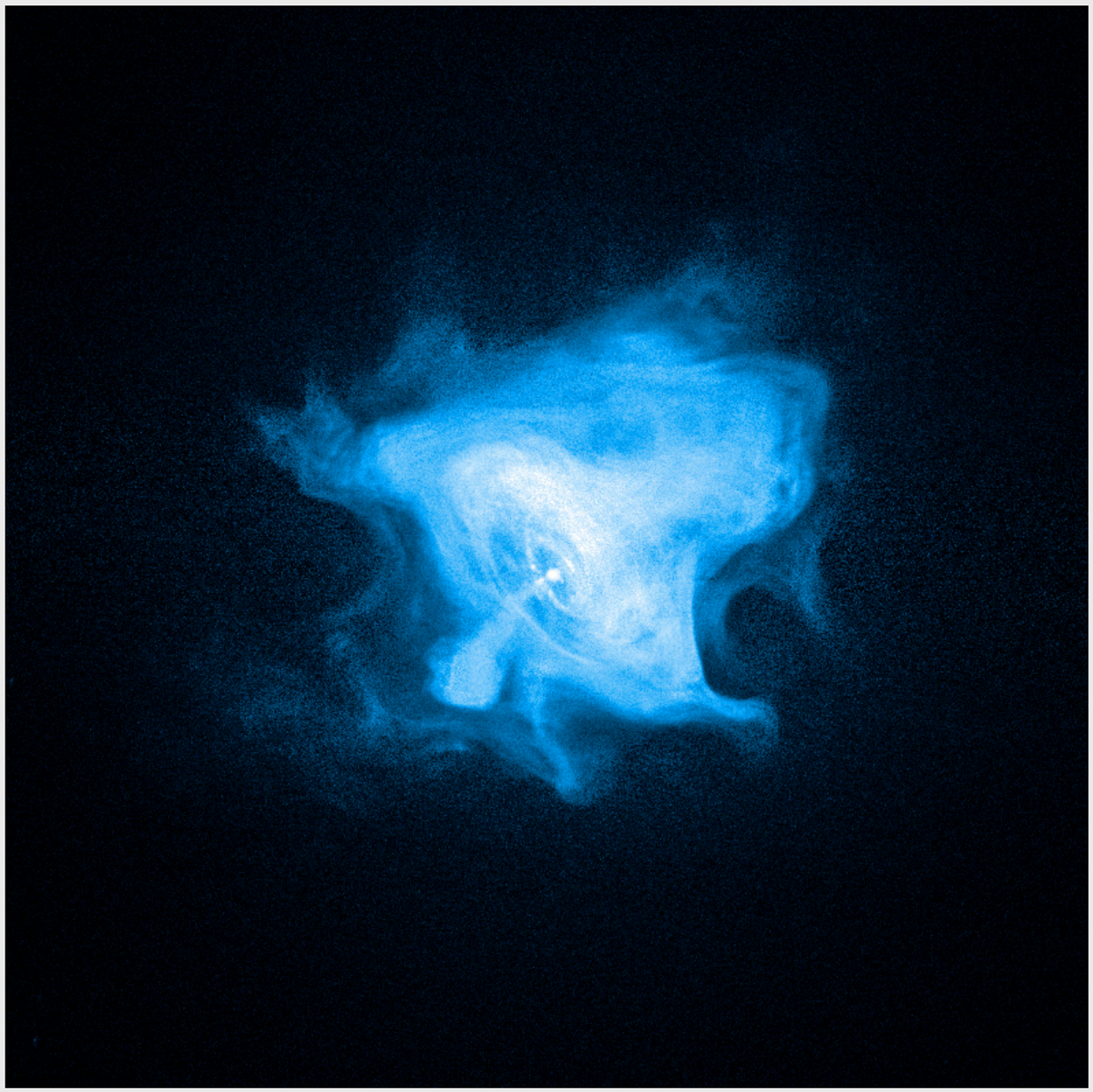
snr	pwn
supernova = explosive end of a star's evolution	rapidly rotating, highly magnetized neutron stars (pulsars)
two types: ◦ core-collapse ◦ thermonuclear	rotational energy is dissipated as particle wind
material ejected with ~10^{51} erg kinetic energy	wind = e^+e^- pairs produced by em cascades inside the pulsar magnetosphere
shock wave forms & sweeps up ism/ csm	pulsar wind is confined by the magnetic field and ambient medium
shocks compress and heat medium, and accelerate particles to rel energies	

snrs & pwne

snr



pwn



snrs & pwne

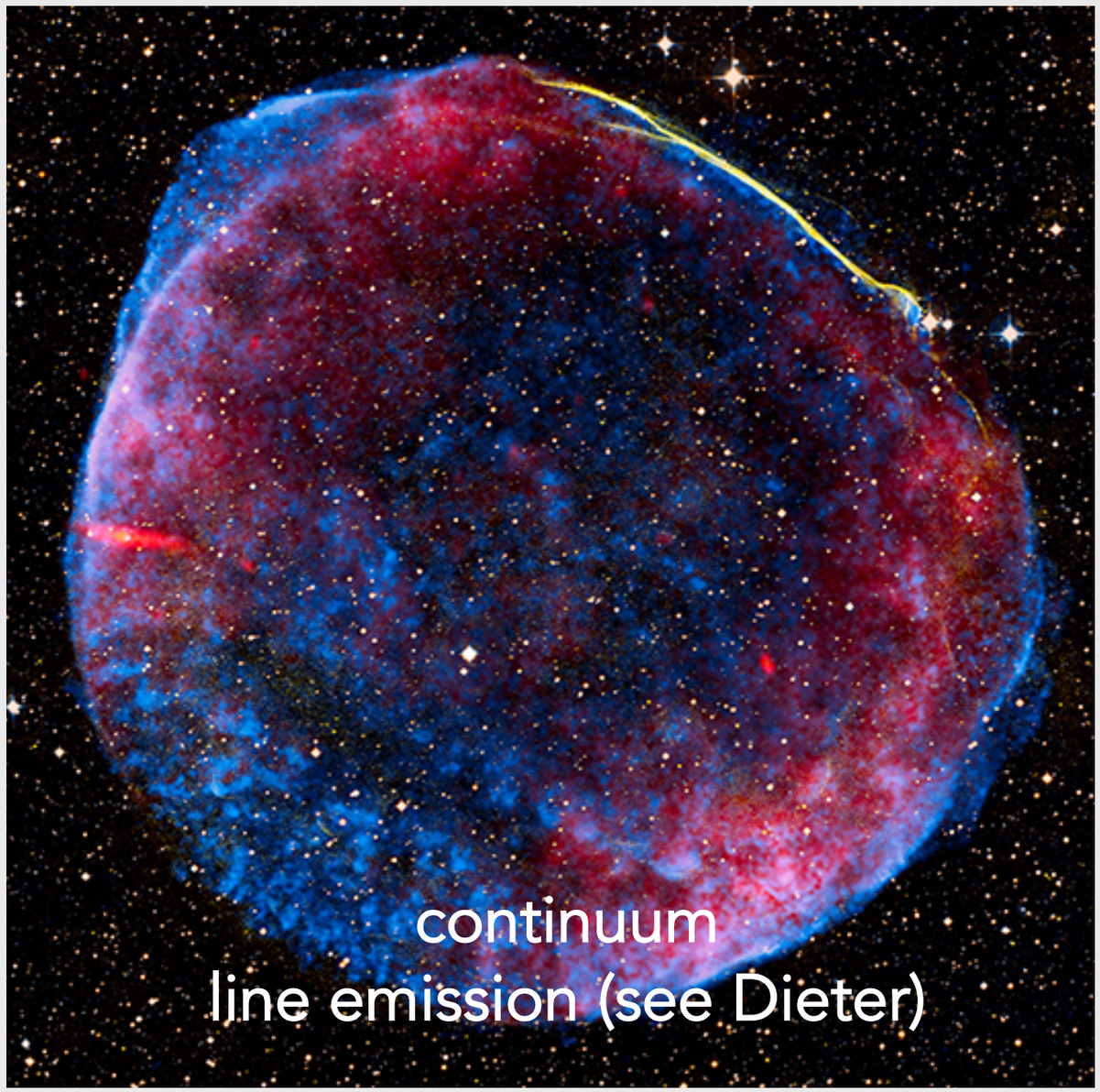
snr

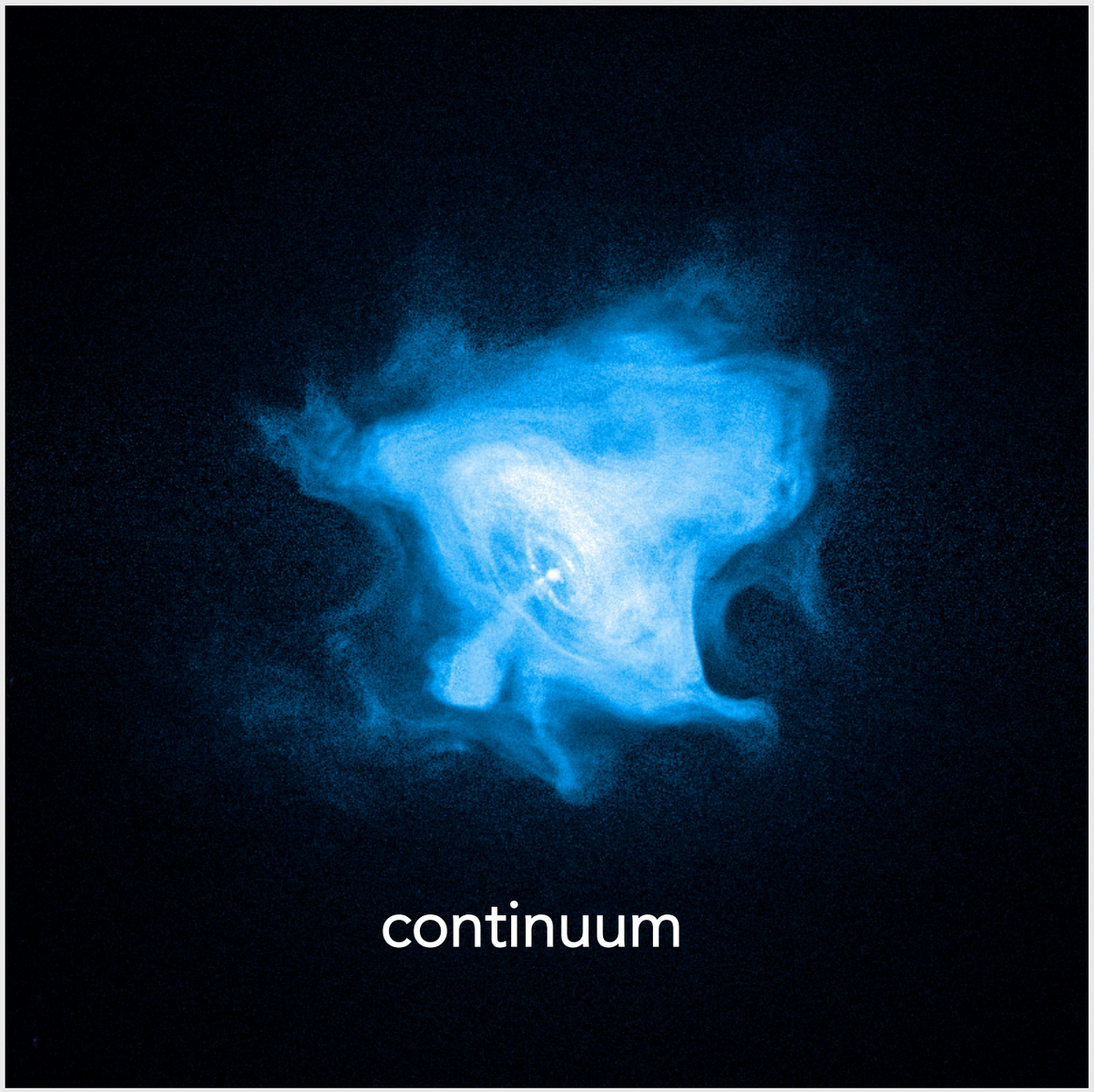
pwn

snrs & pwne in MeV

snr

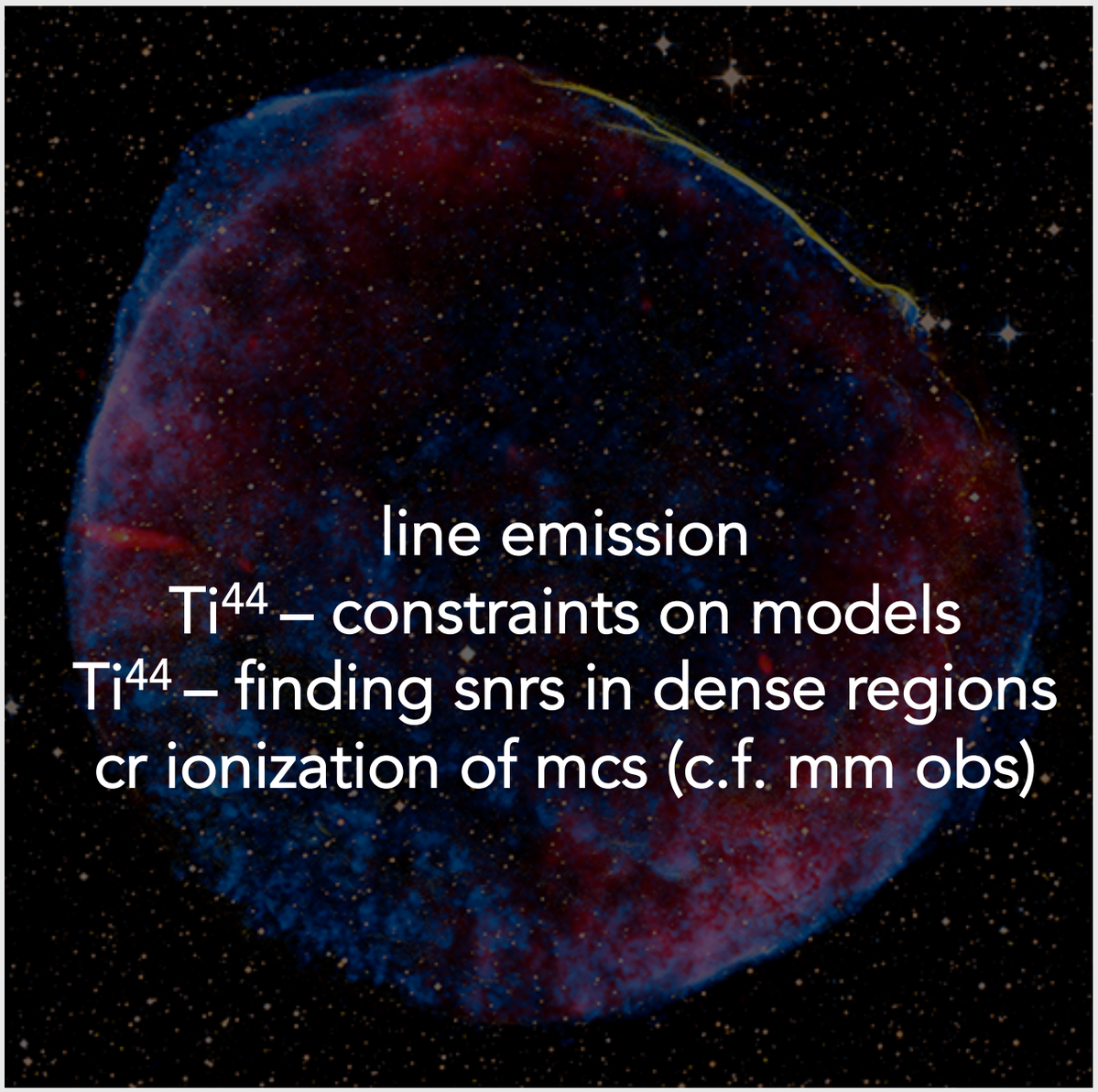
pwn





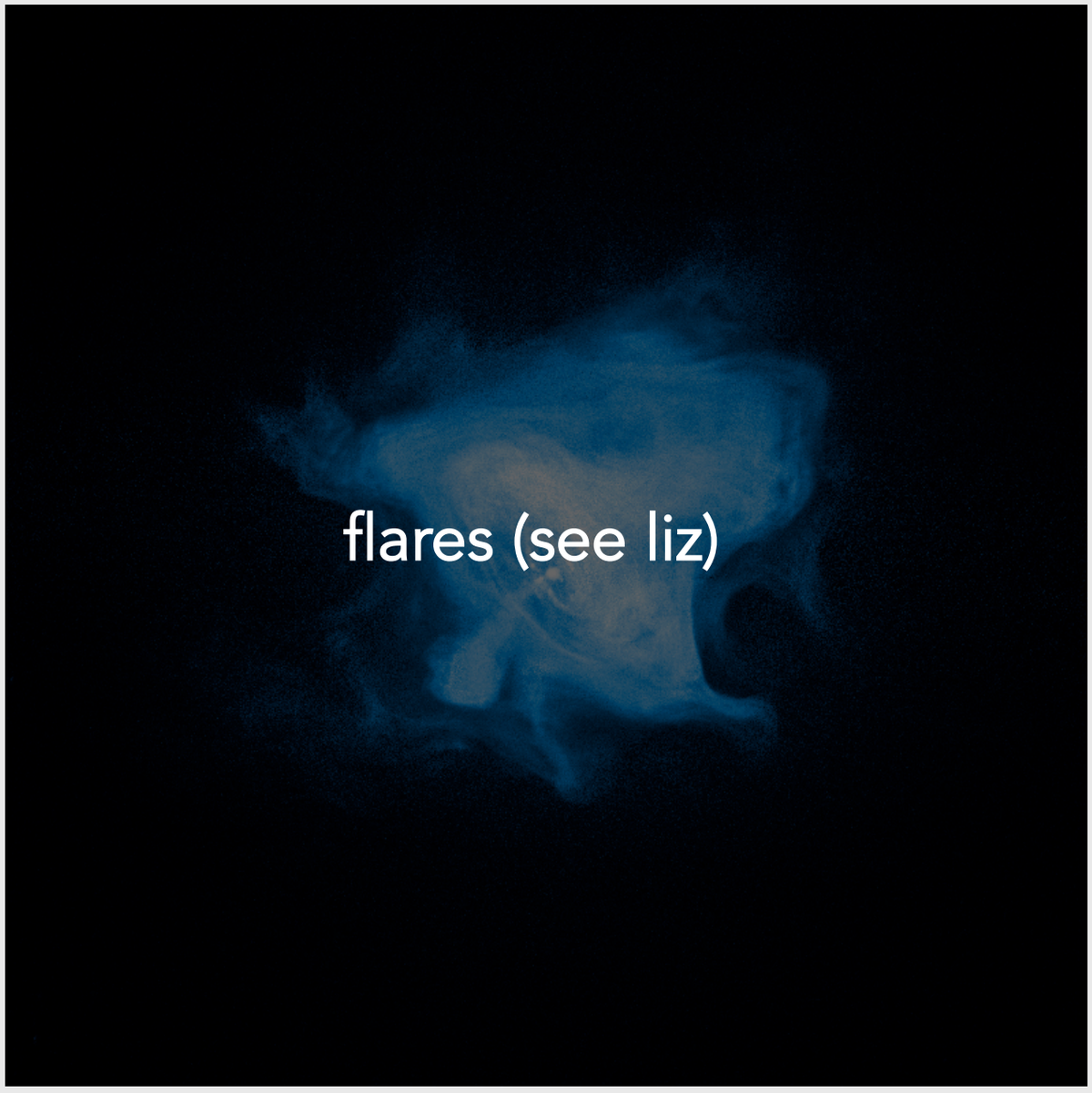
snrs & pwne in MeV

snr



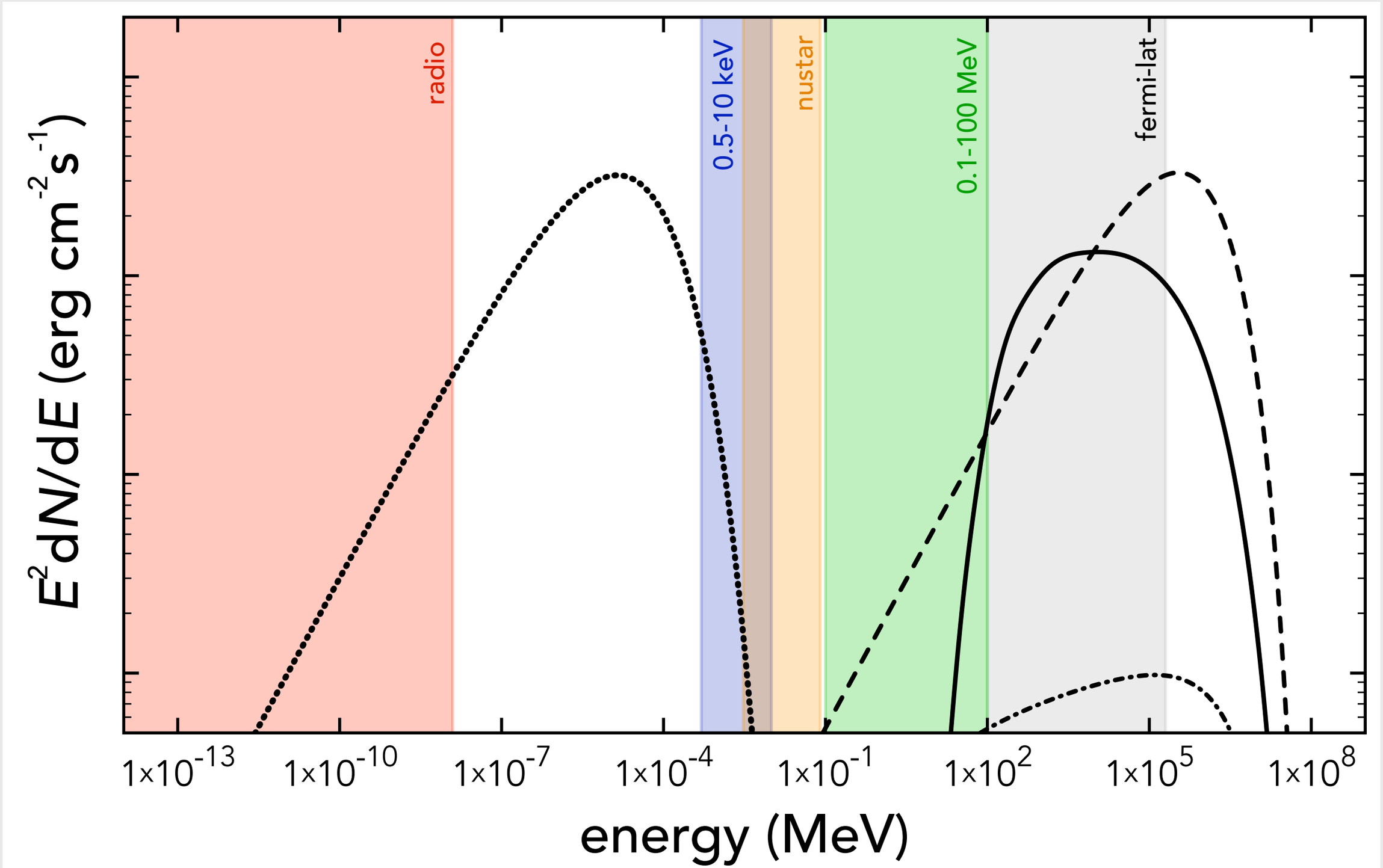
line emission
Ti^{44} – constraints on models
Ti^{44} – finding snrs in dense regions
cr ionization of mcs (c.f. mm obs)

pwn



flares (see liz)

snrs & pwne in MeV



snrs & pwne in ɣ-rays why?

snr

origin of galactic cosmic rays

particle acceleration

snr evolution

cosmic rays

- gamma-ray background
- feedback into galaxy dynamics

pwn

most of the pulsar Ė goes into pwn

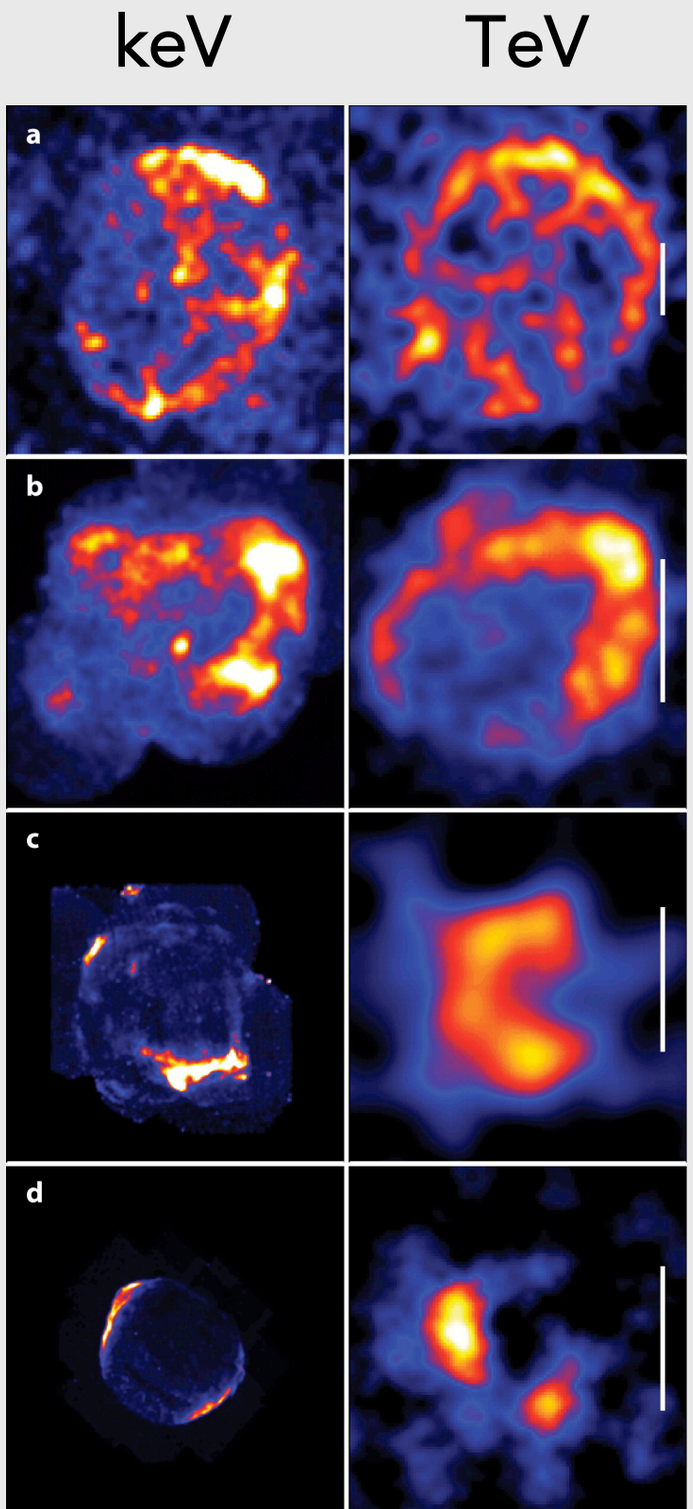
particle acceleration – relativistic flows

magnetic reconnection

pwn evolution – particle injection

finding pwne

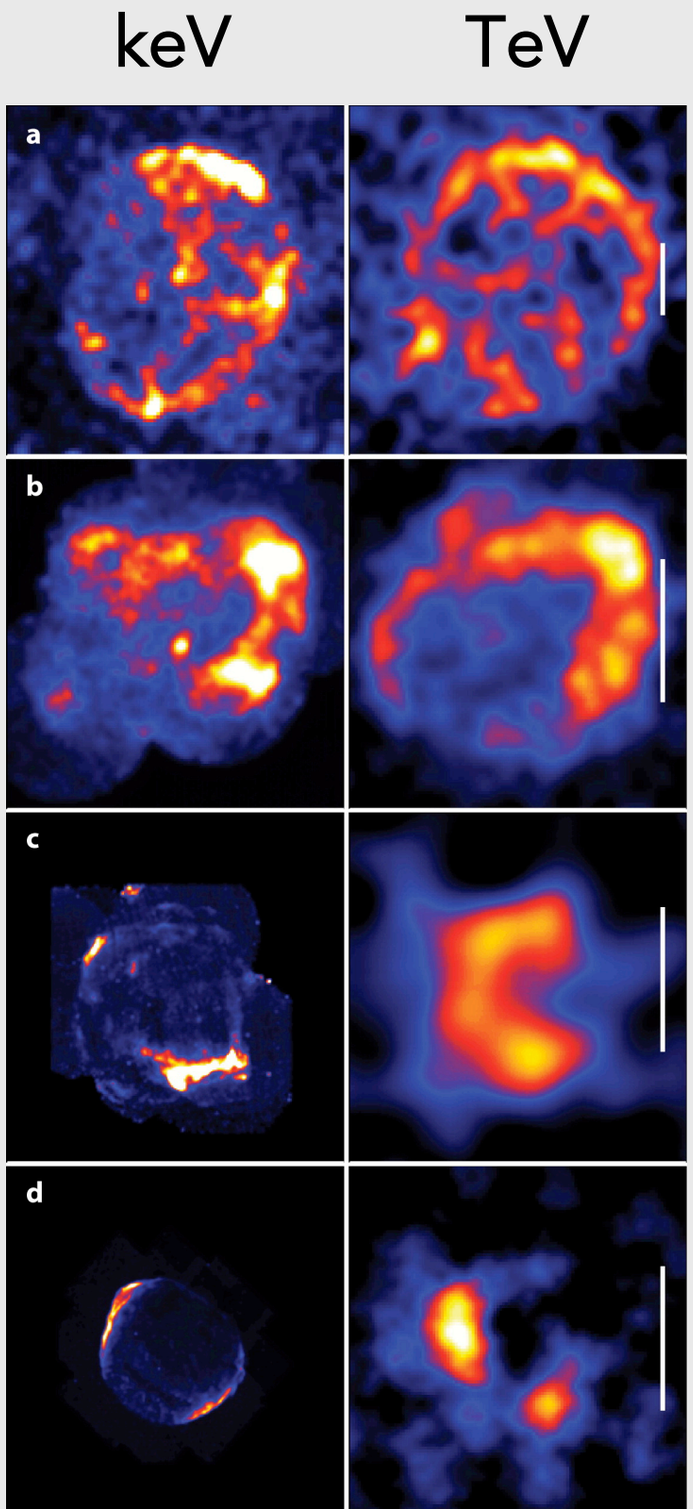
snrs in gamma-rays



uchiyama+ 2002
aschenbach 1998
vink+ 2006
aharonian+ 2006, 2007,2008
naumann-godo+ 2006

snrs in gamma-rays

what have we learnt with fermi-lat?



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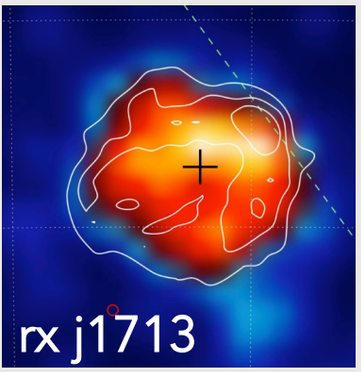
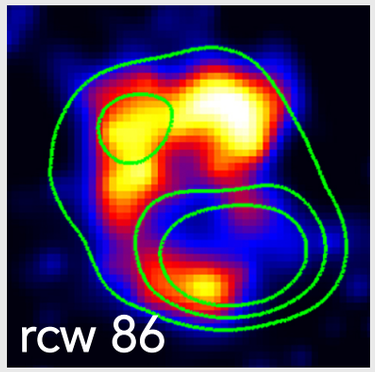
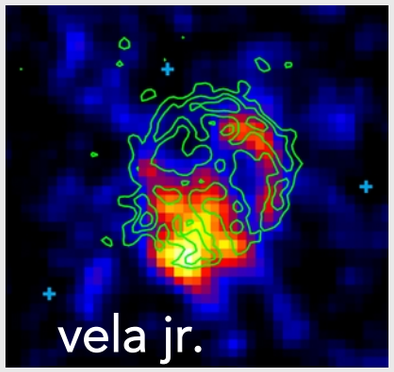
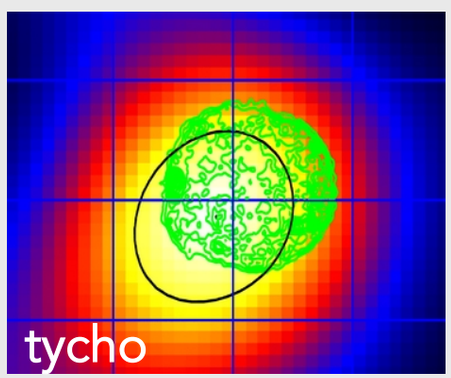
snrs in gamma-rays

dynamically young + fast shocks

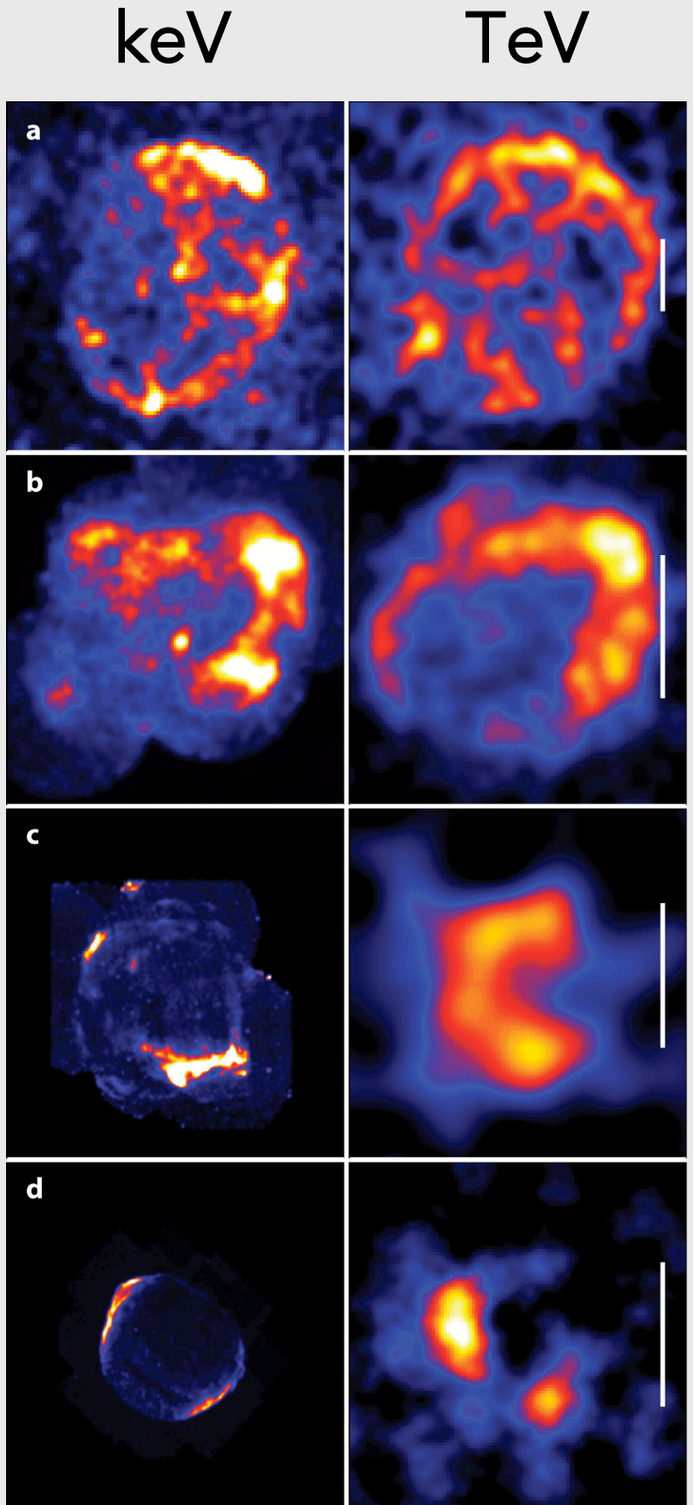






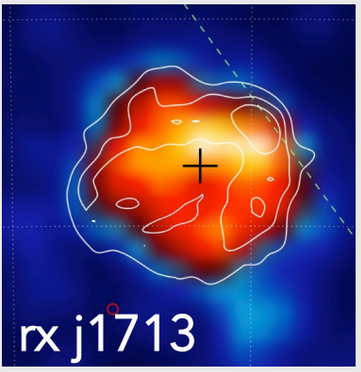


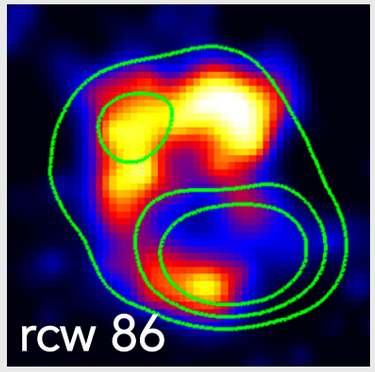
federici+ 2015
ajello+ 2016
tanaka+ 2011
abdo+ 2010
giordano+ 2012

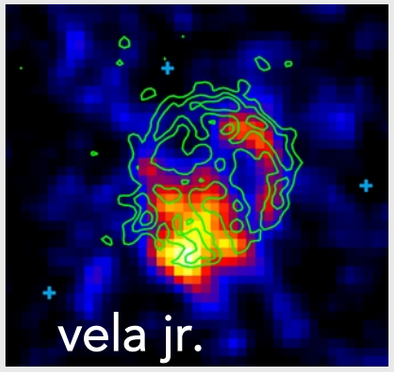


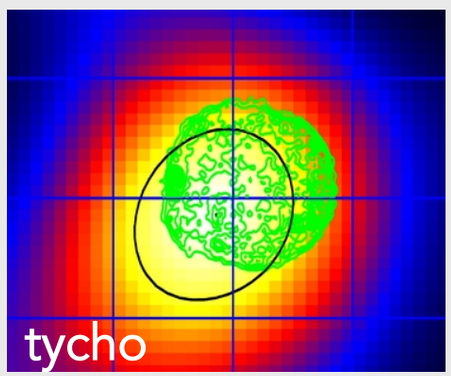
snrs in gamma-rays

dynamically young + fast shocks



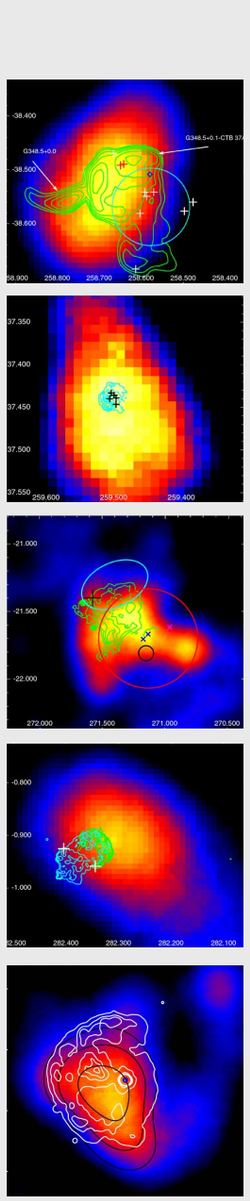


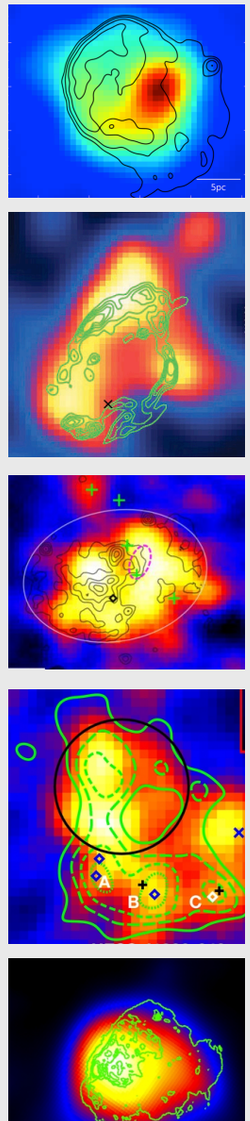


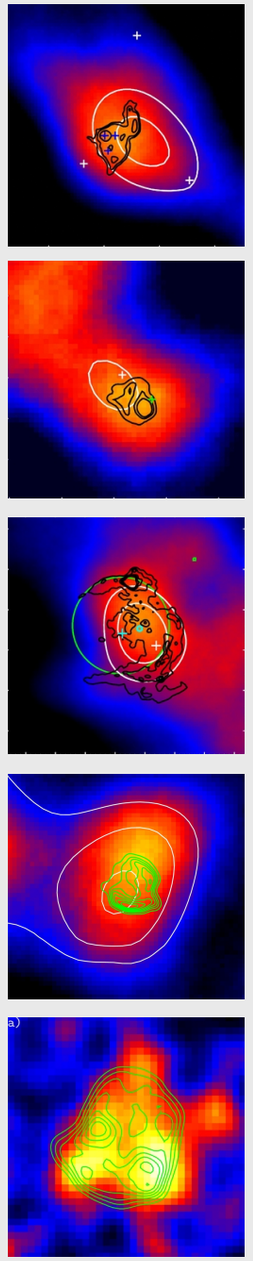


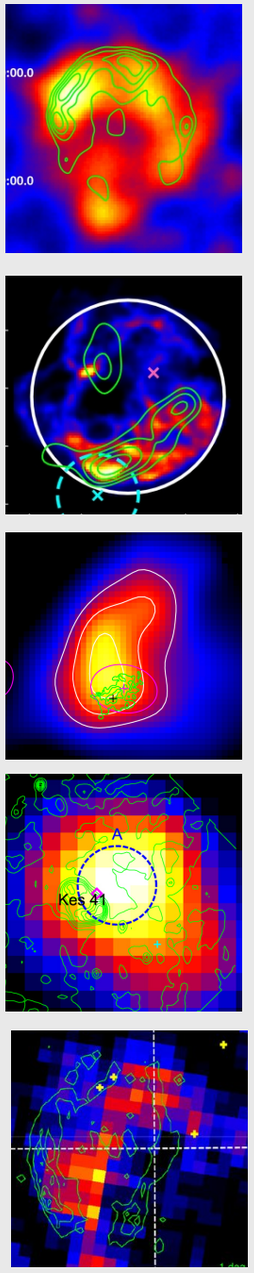
federici+ 2015
ajello+ 2016
tanaka+ 2011
abdo+ 2010
giordano+ 2012

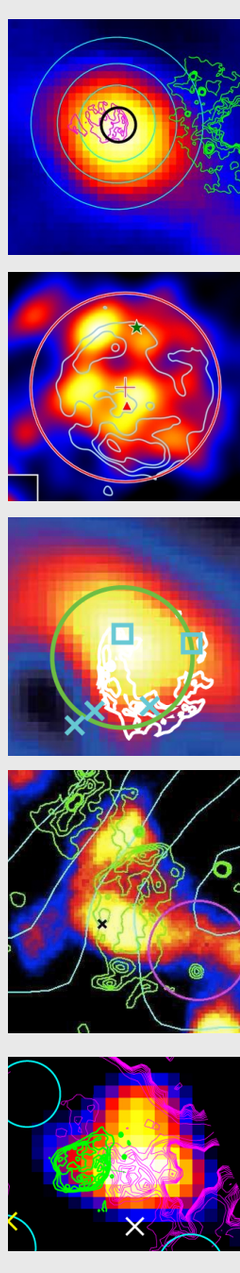
dynamically evolved + dense





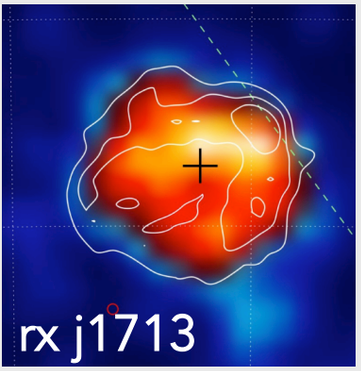


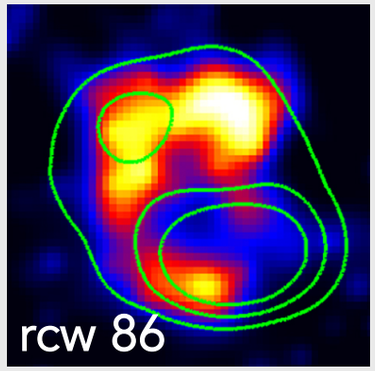


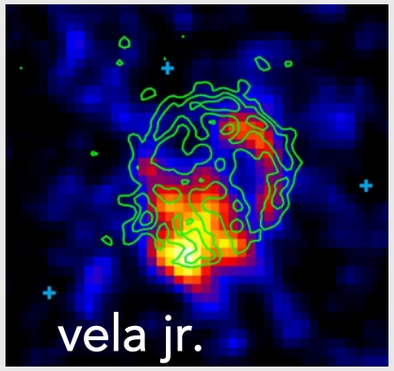


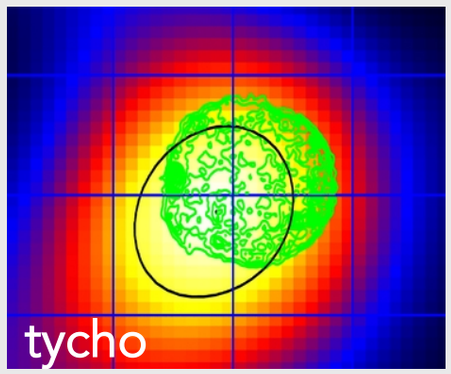
snrs in gamma-rays #1

dynamically young + fast shocks









federici+ 2015
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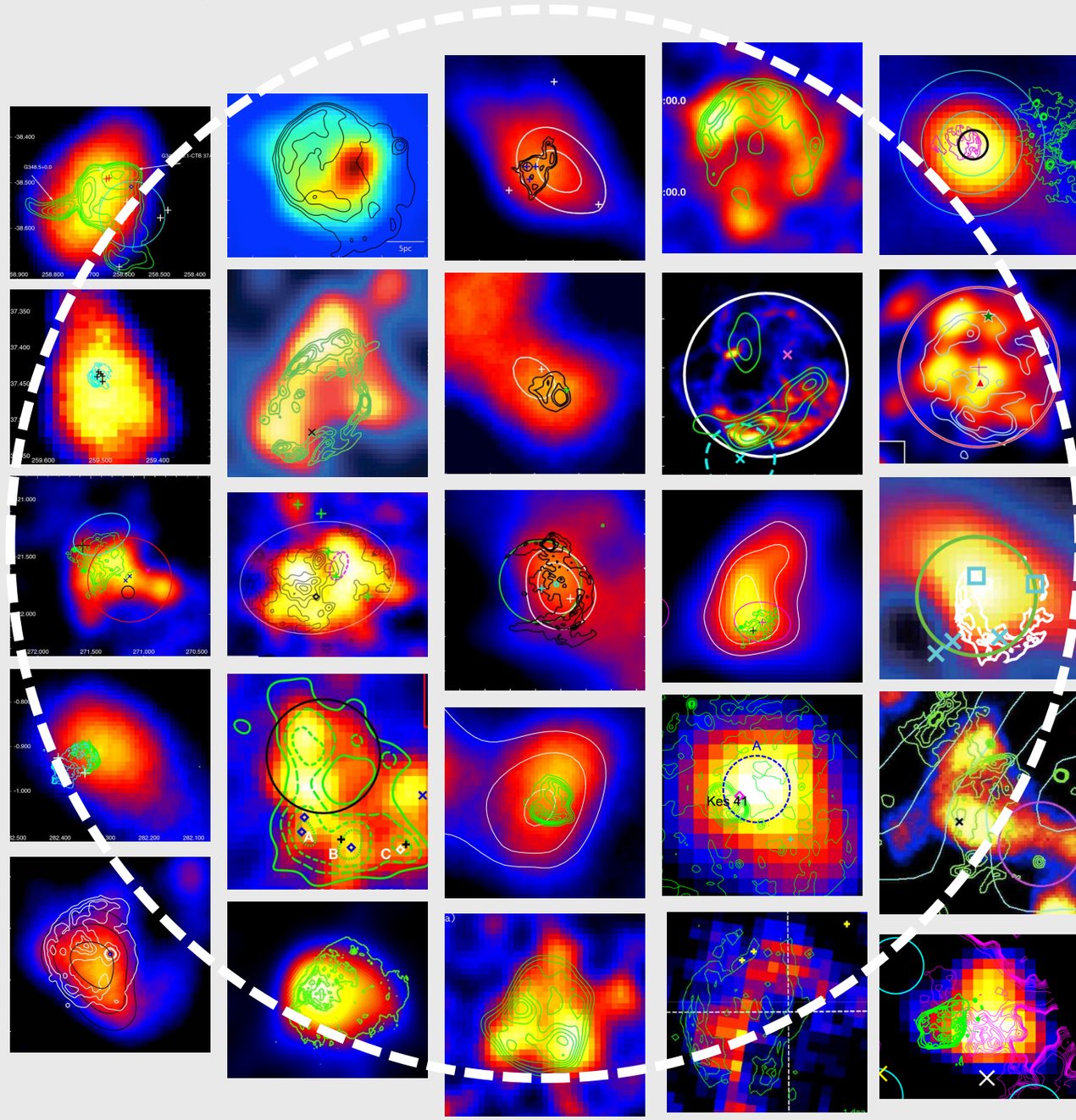
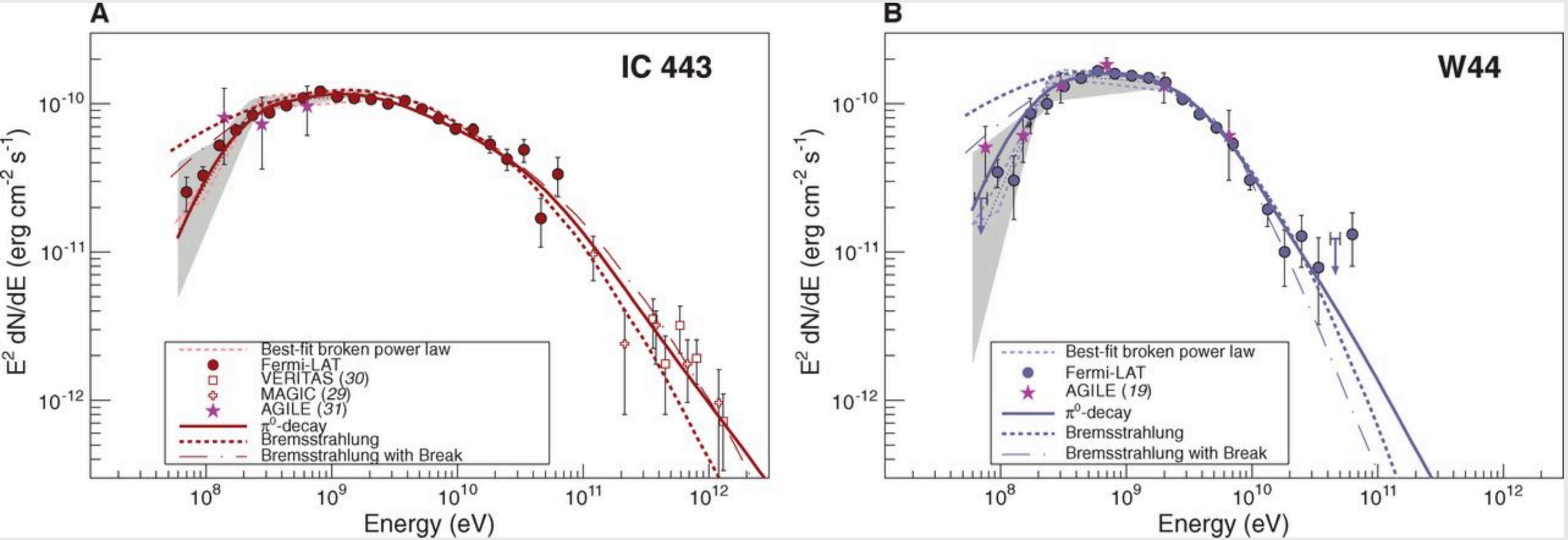
dynamically evolved + dense



snrs in gamma-rays #2

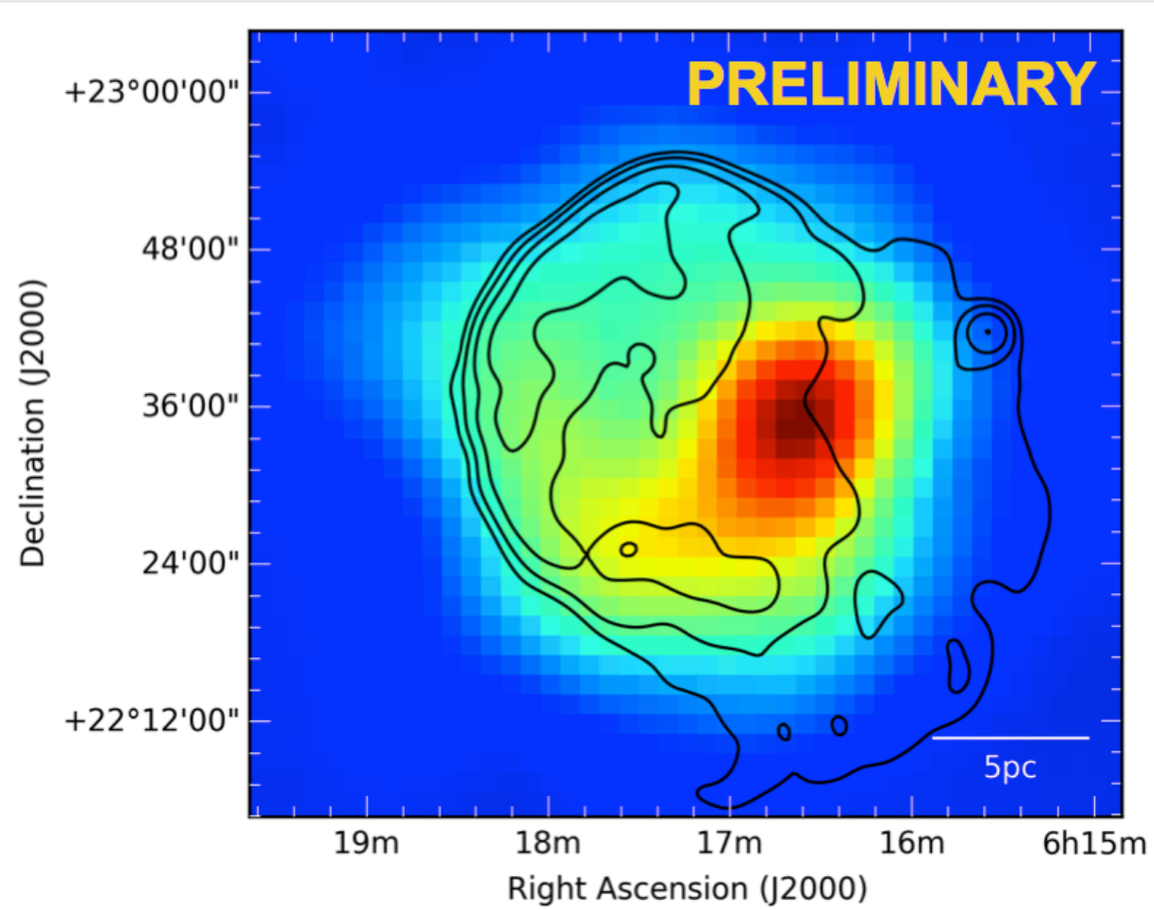
dynamically evolved + dense – pion bump



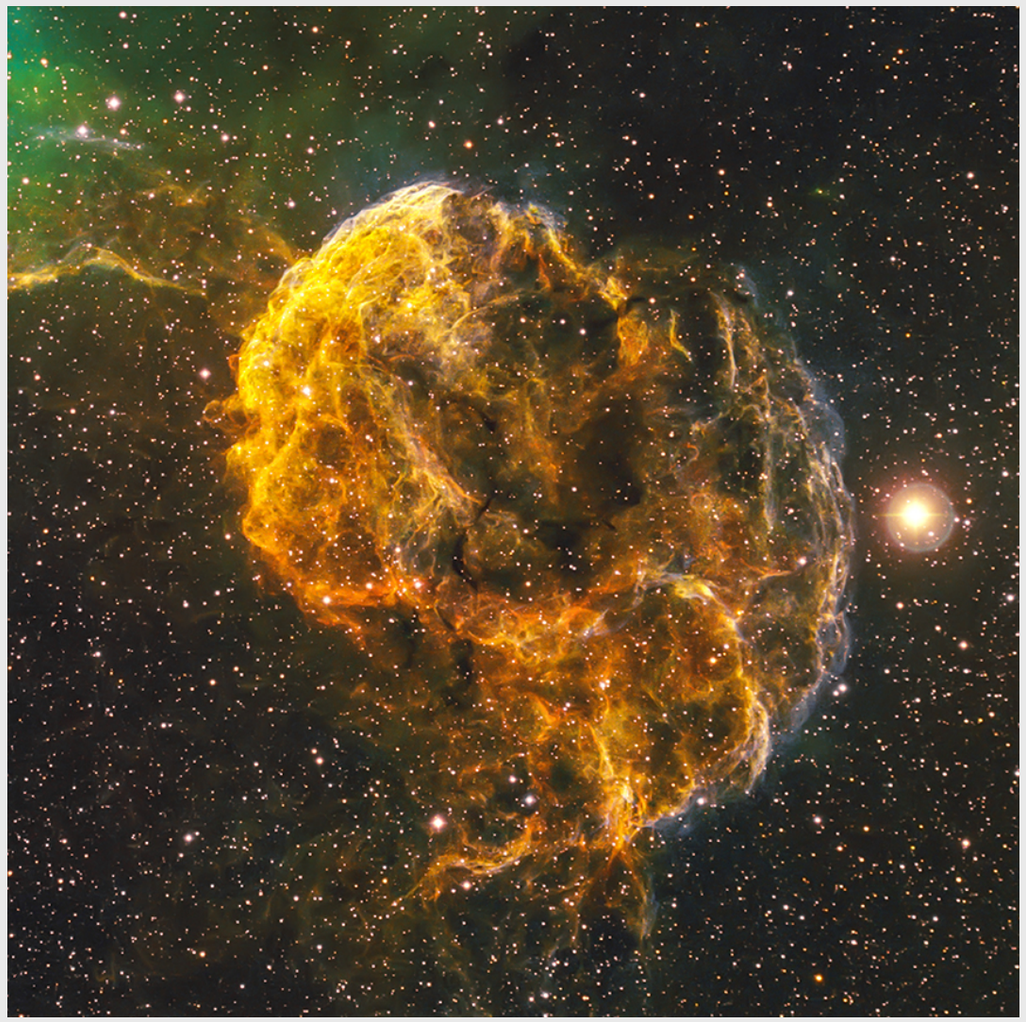
ackermann+ 2013

snrs in gamma-rays

dynamically evolved + dense – spectral break at GeV energies



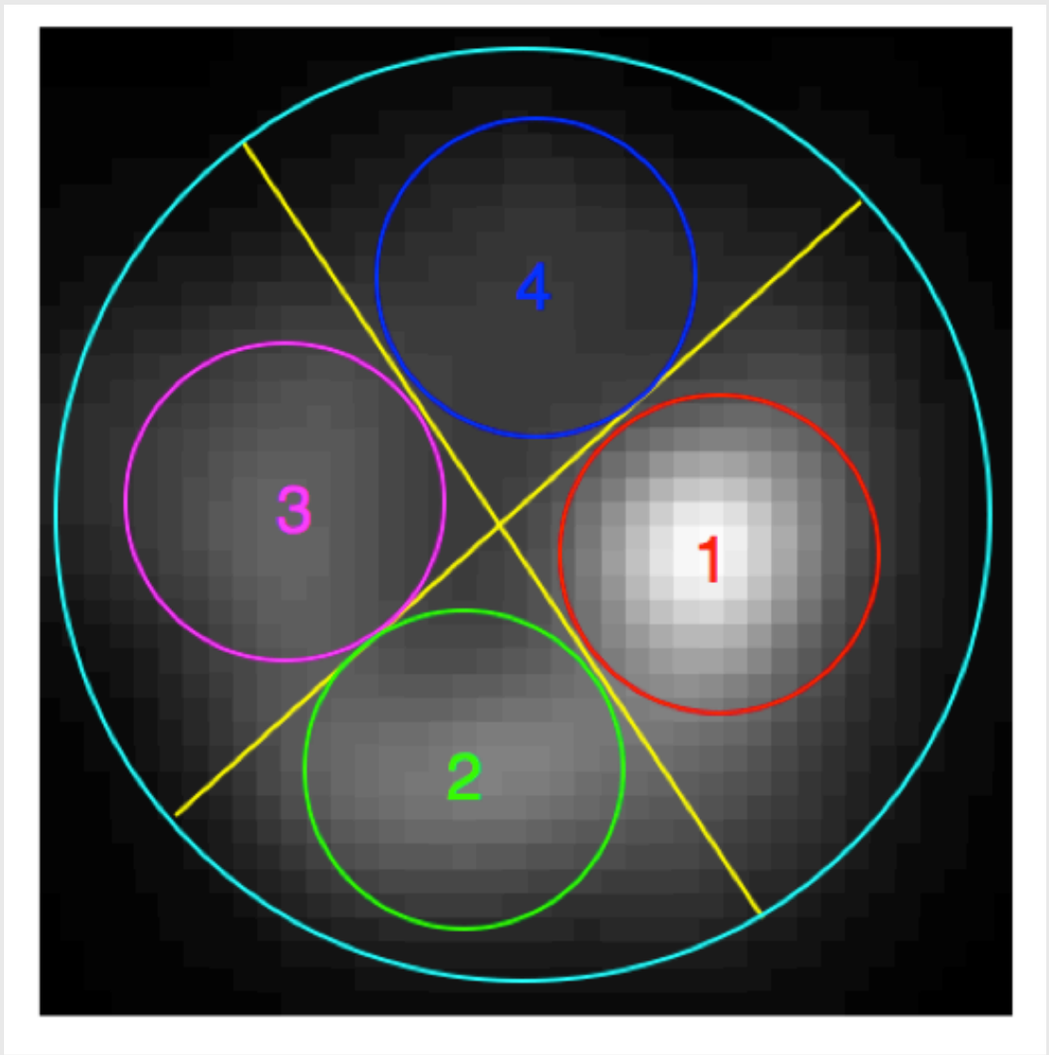
Counts Map >5 GeV (PSF23)

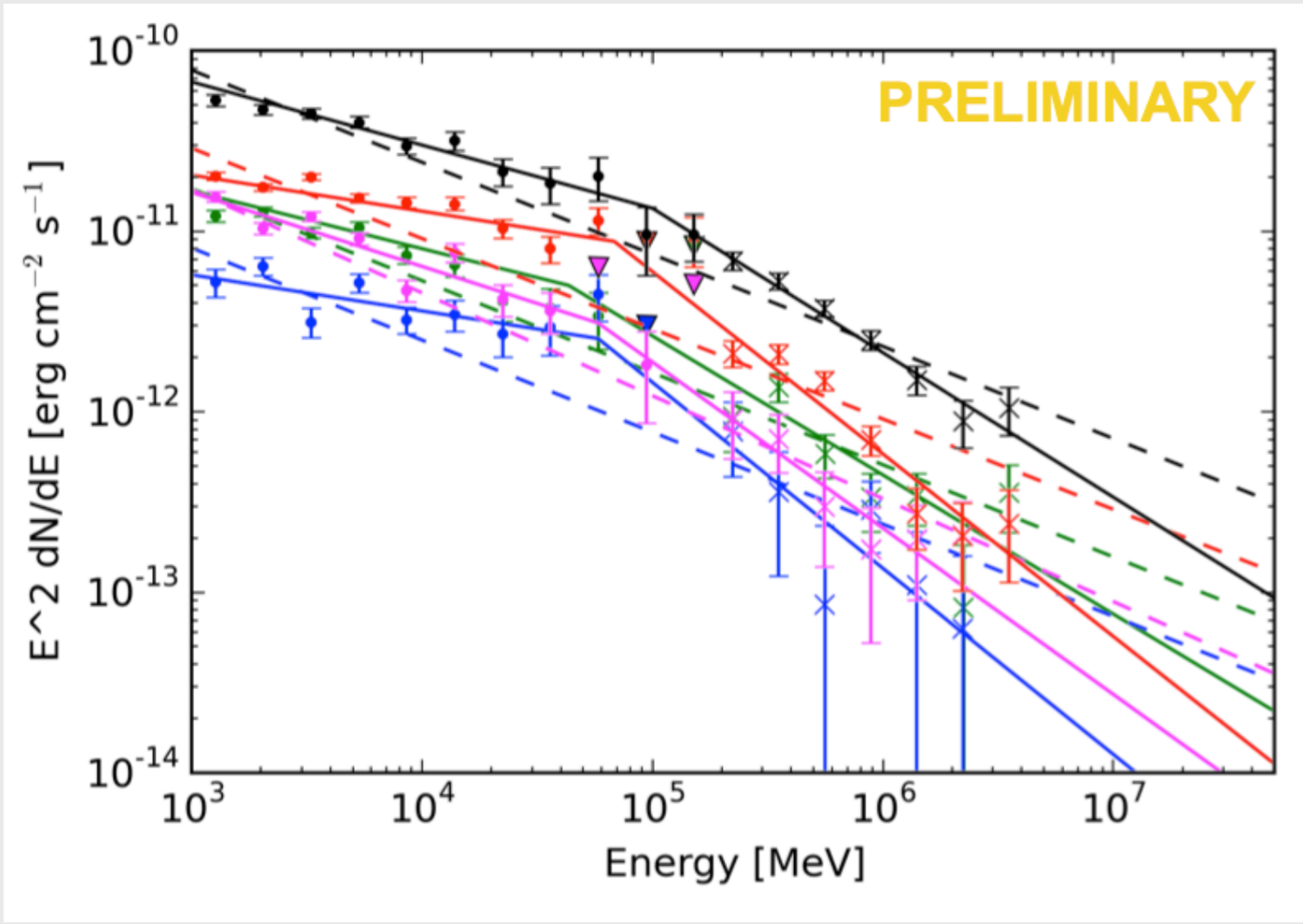


fermi collaboration (in prep)

snrs in gamma-rays #3

dynamically evolved + dense – spectral break at GeV energies

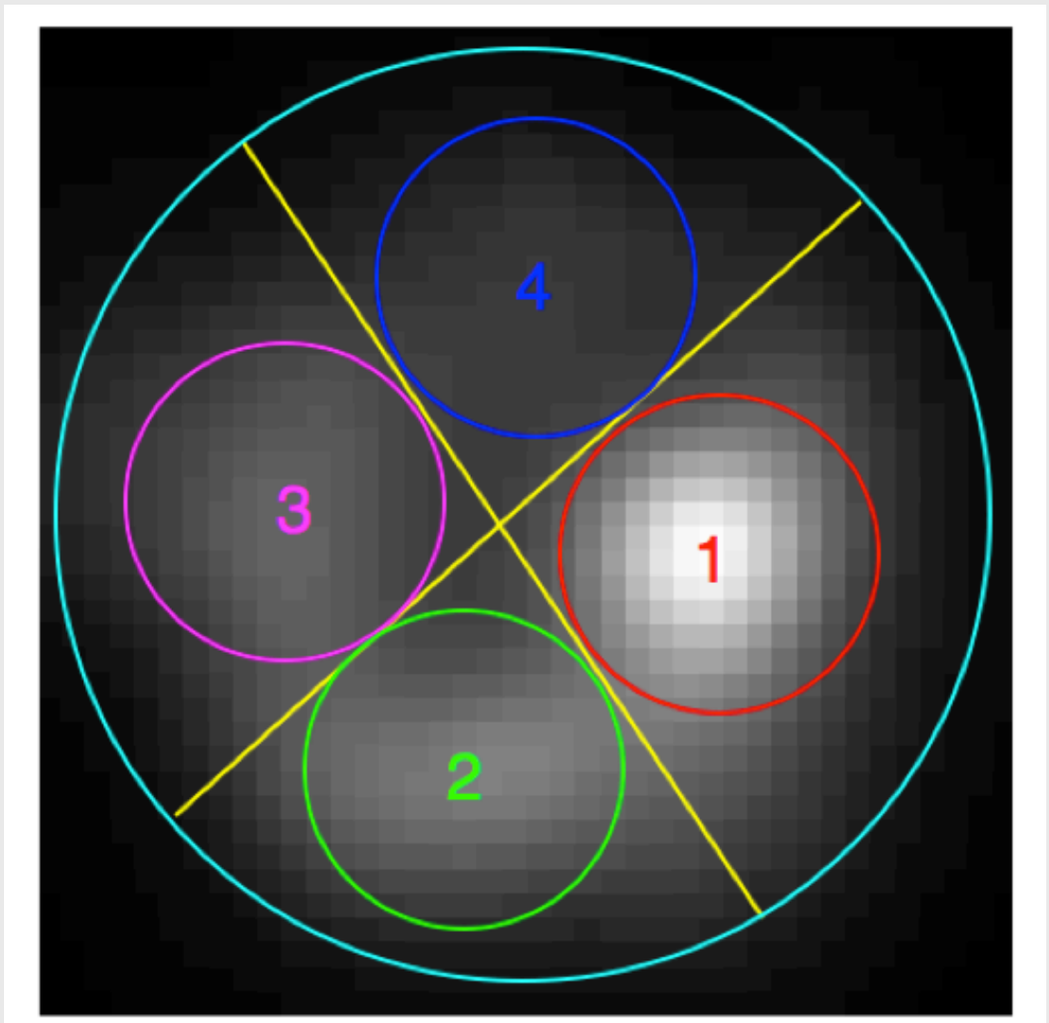


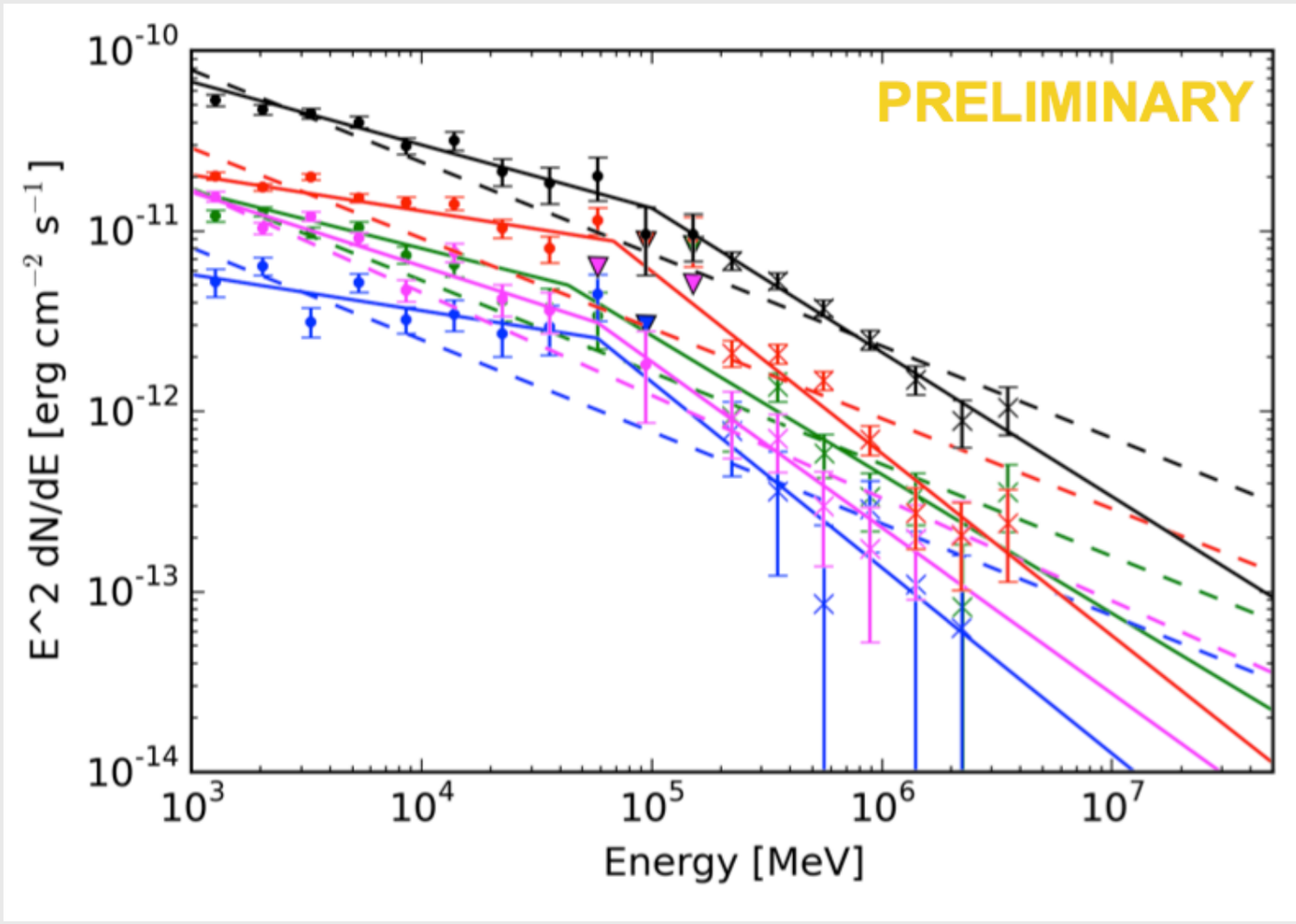


fermi collaboration (in prep)

snrs in gamma-rays #3

dynamically evolved + dense – spectral break at GeV energies
re-acceleration?



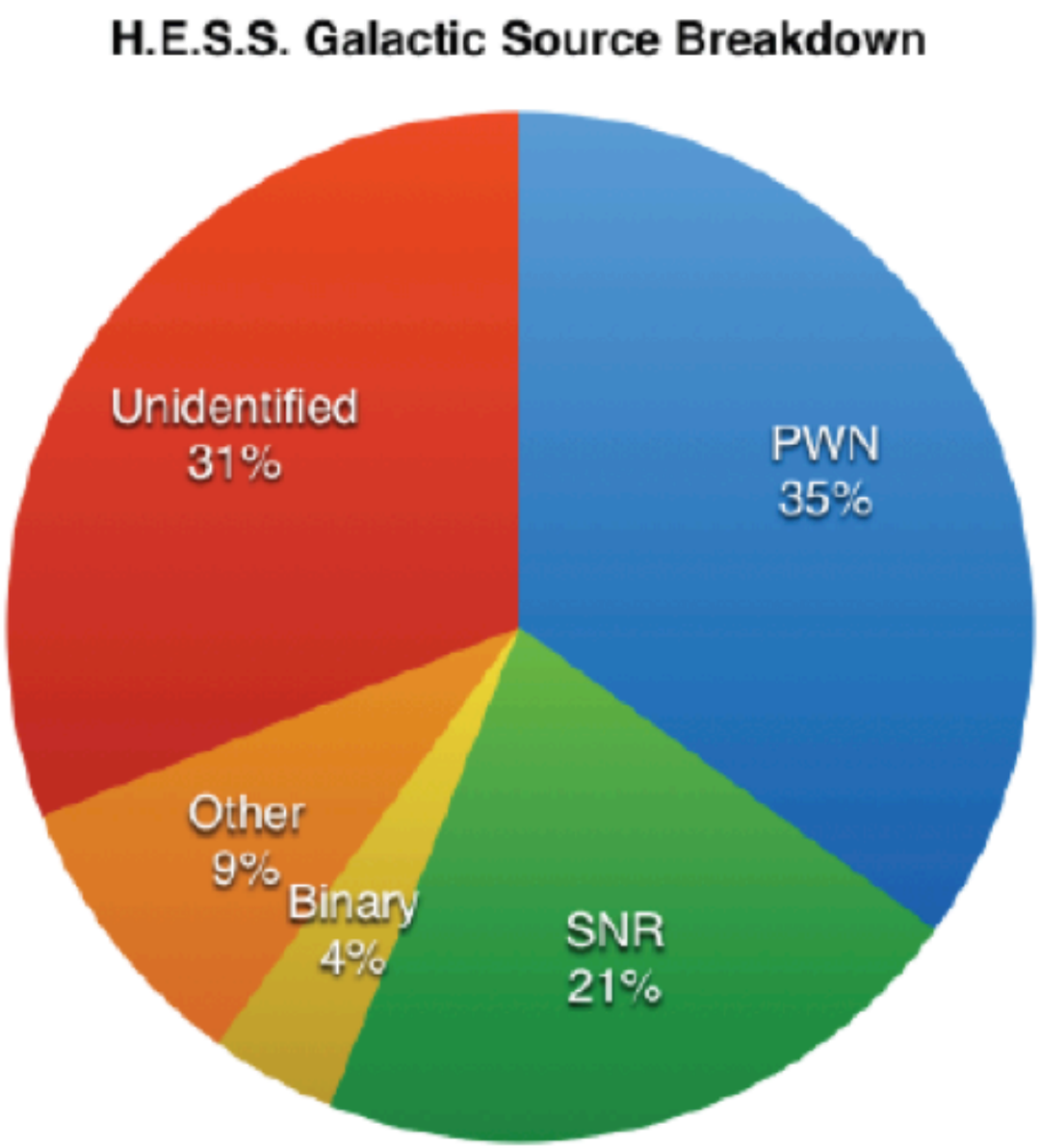


fermi collaboration (in prep)

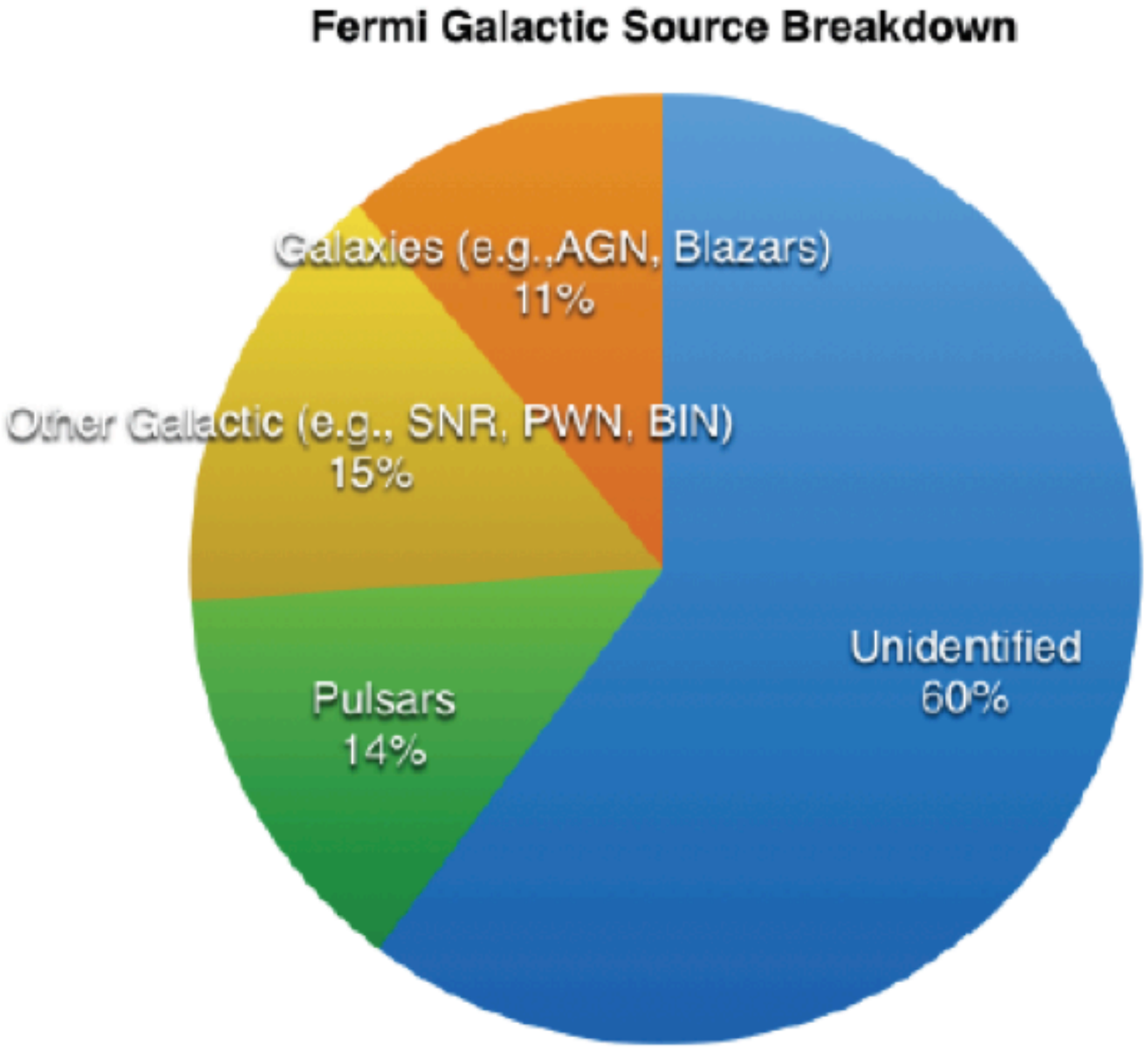
snrs & pwne in ɣ-rays why?

snr	pwn
origin of galactic cosmic rays	most of the pulsar e-dot goes into pwn
particle acceleration	particle acceleration – relativistic flows
snr evolution	magnetic reconnection
cosmic rays gamma-ray background feedback into galaxy dynamics	pwn evolution – particle injection
	finding pwne

pwne in gamma-rays

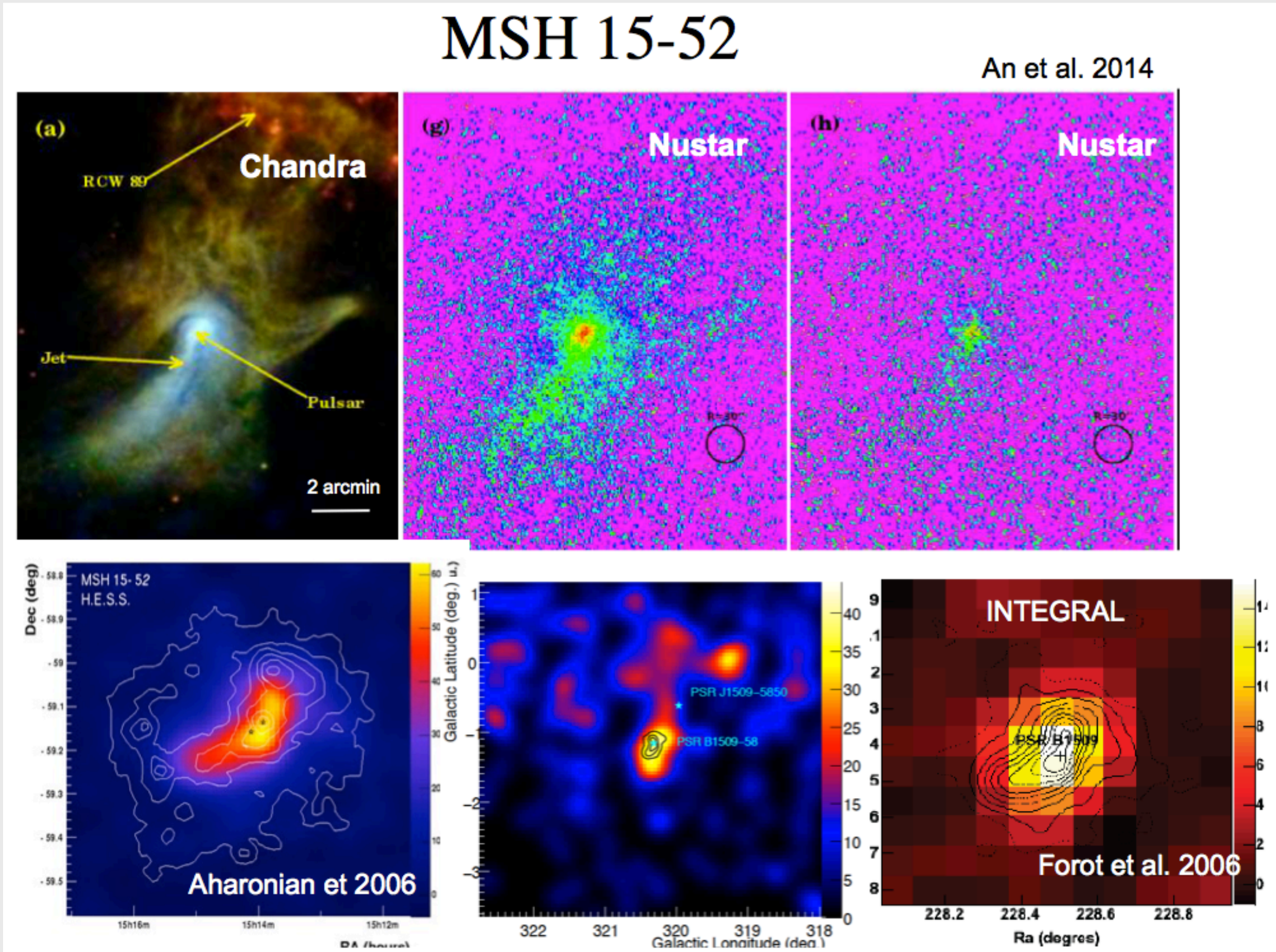


HESS collaboration

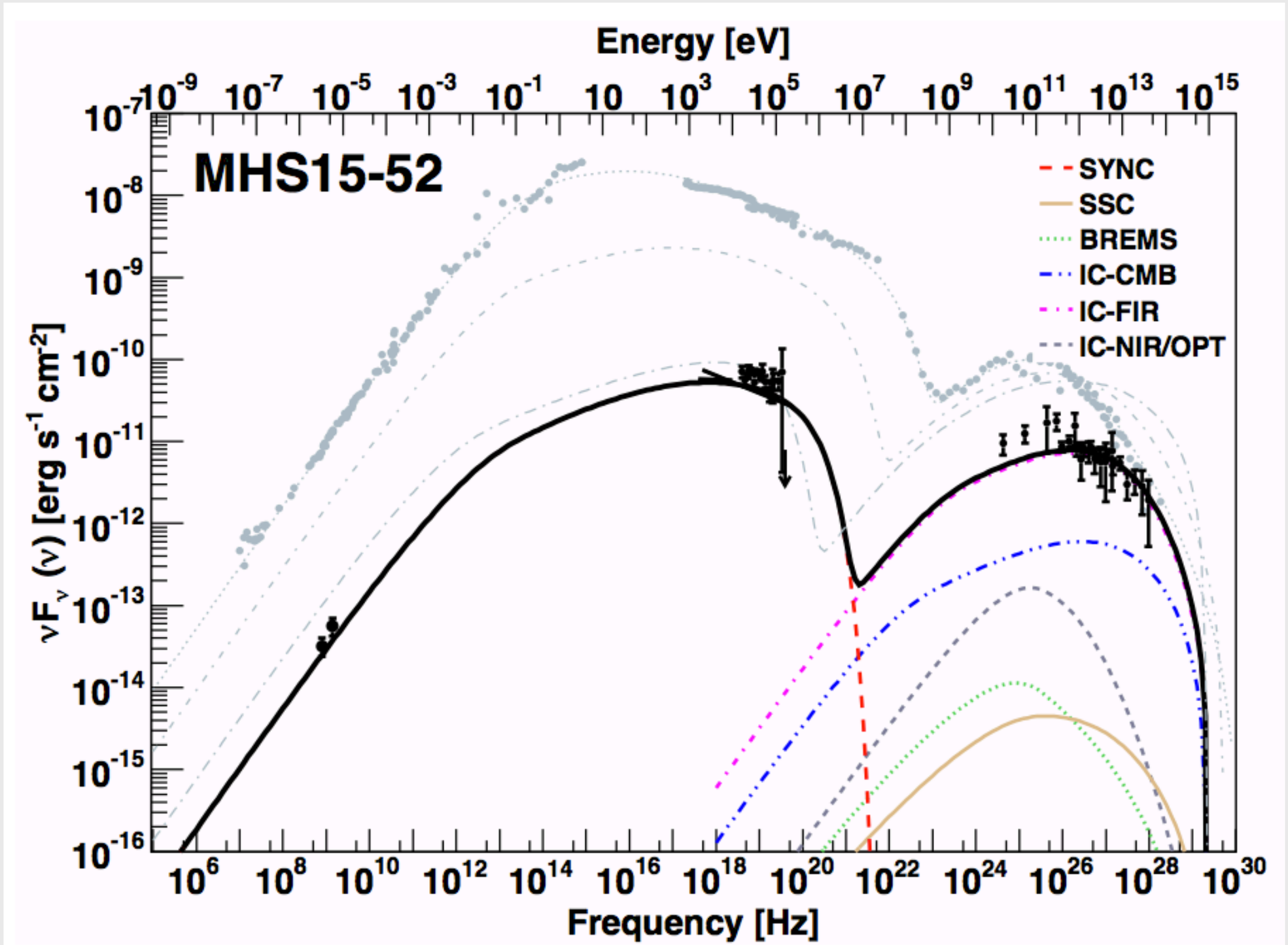


Based on 3FGL catalog
(made by Jeremy Hare)

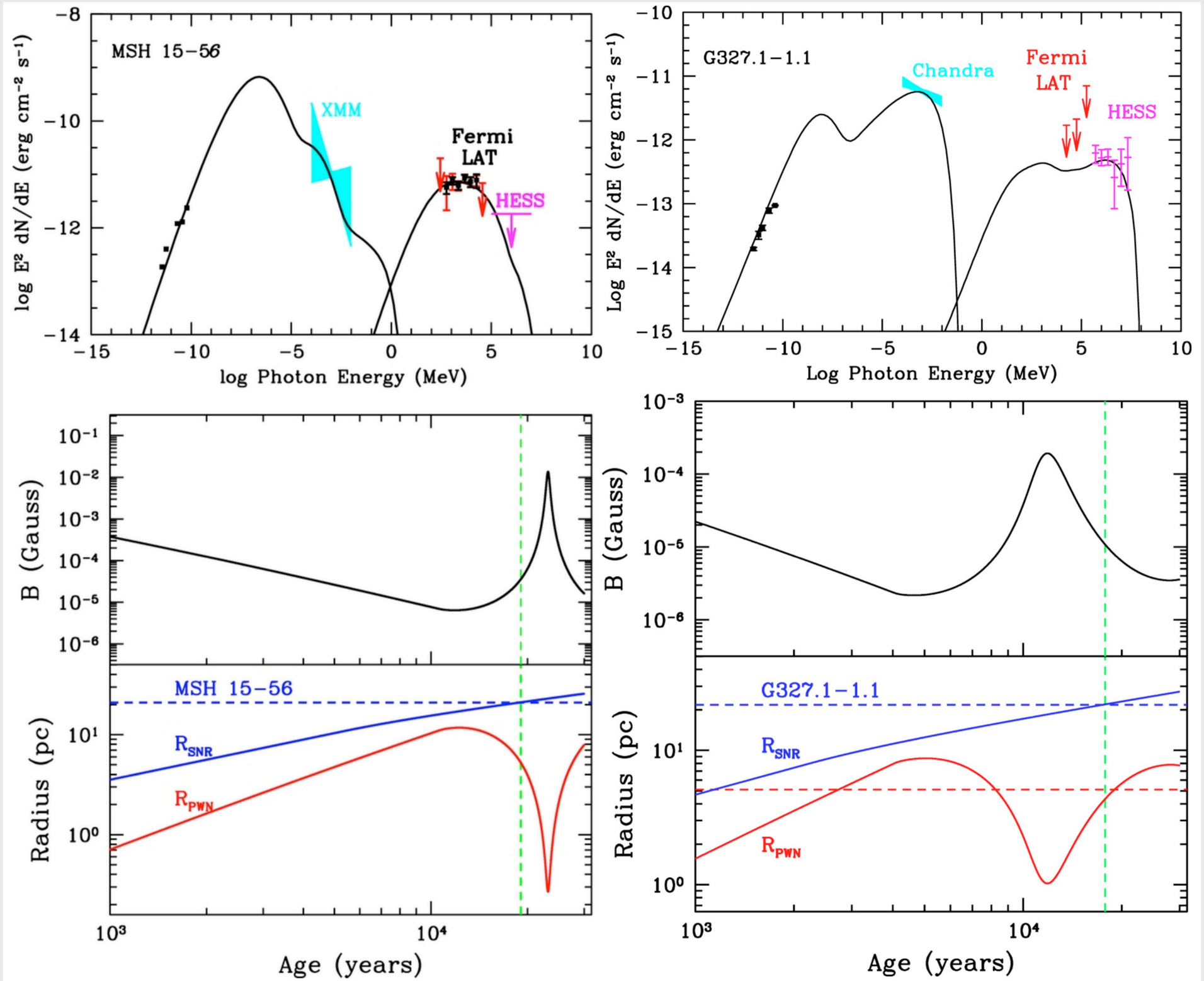
pwne in gamma-rays



pwne in gamma-rays



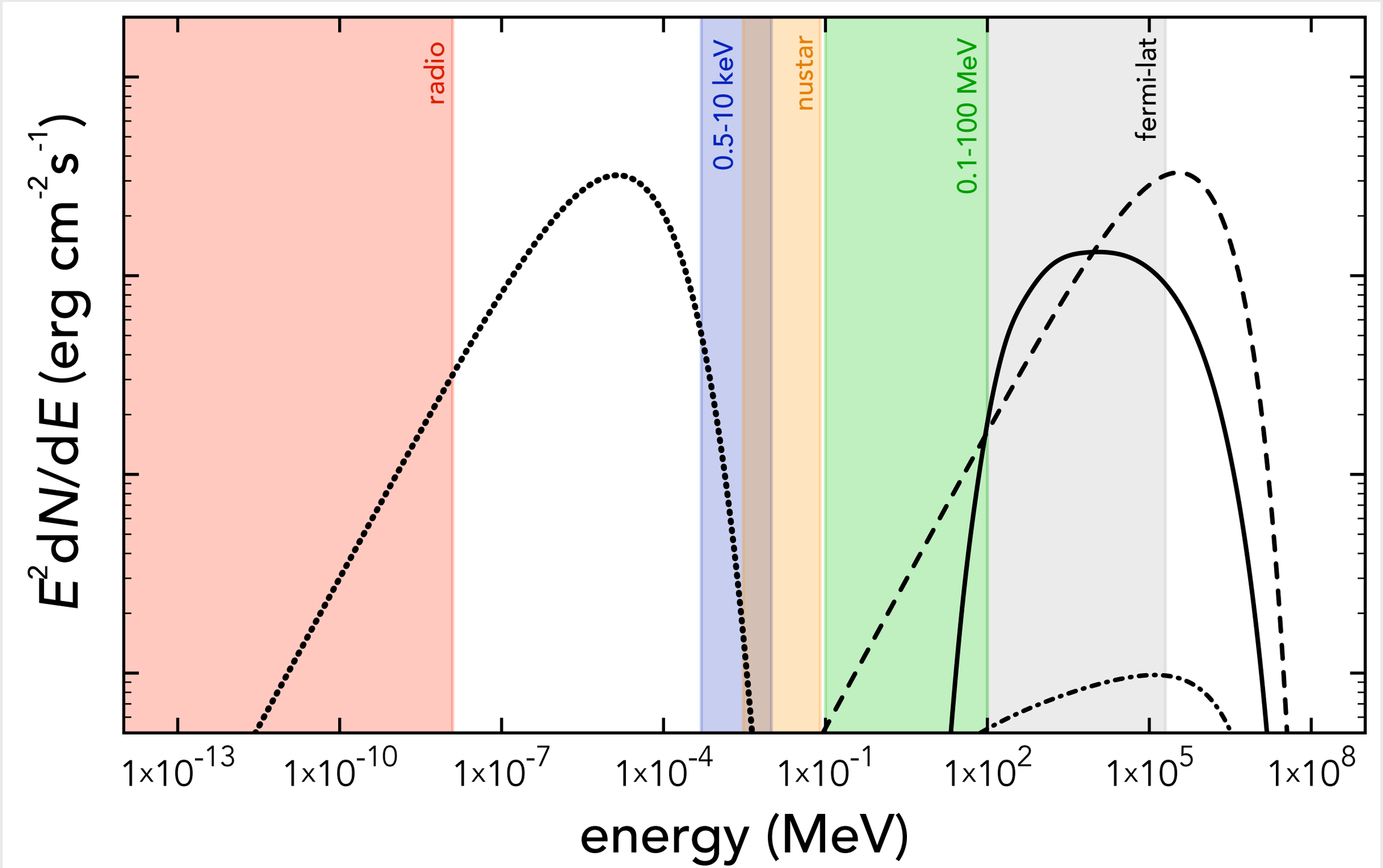
pwne in gamma-rays



temim+ 2013

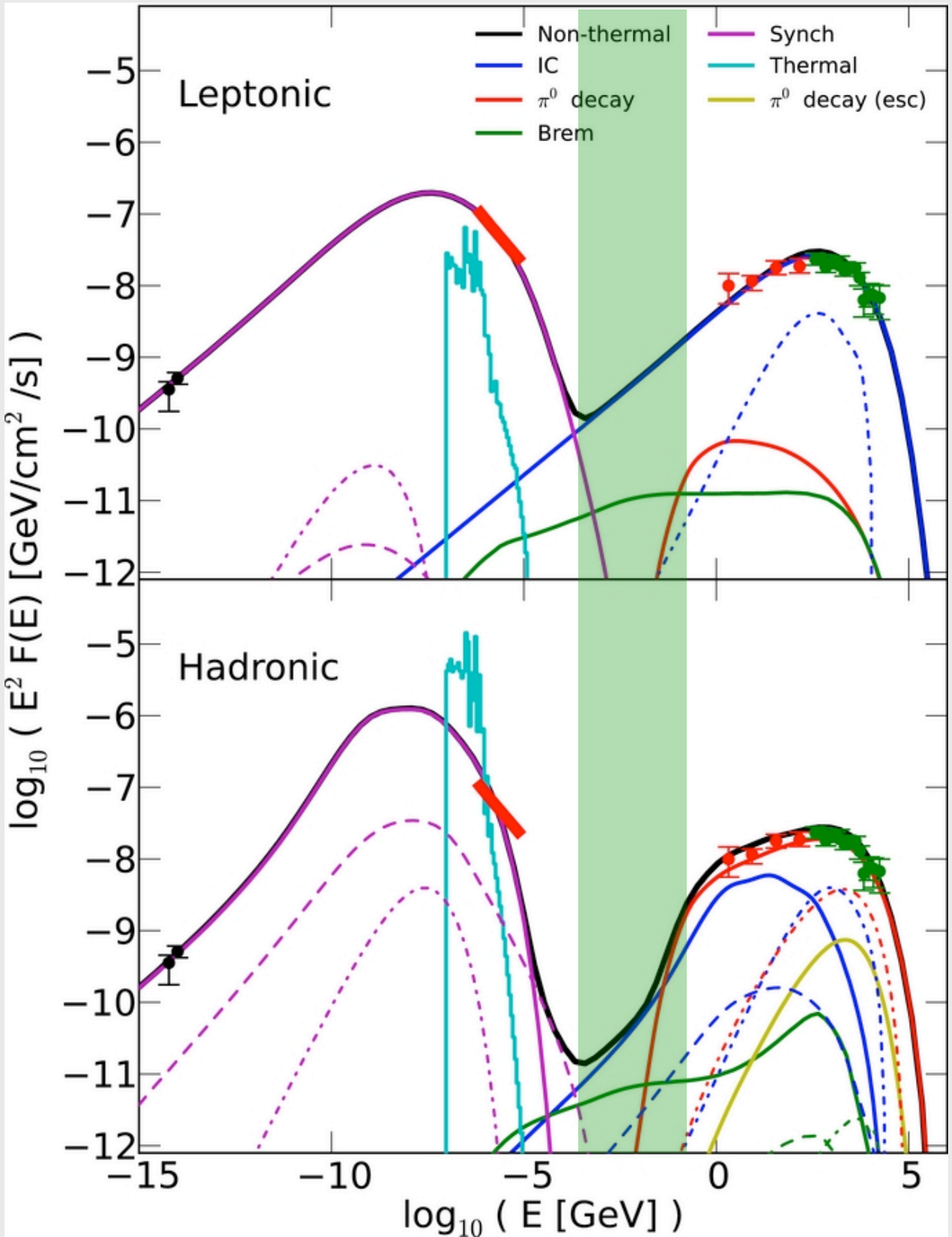
temim+ 2015

snrs 0.1-100 MeV?



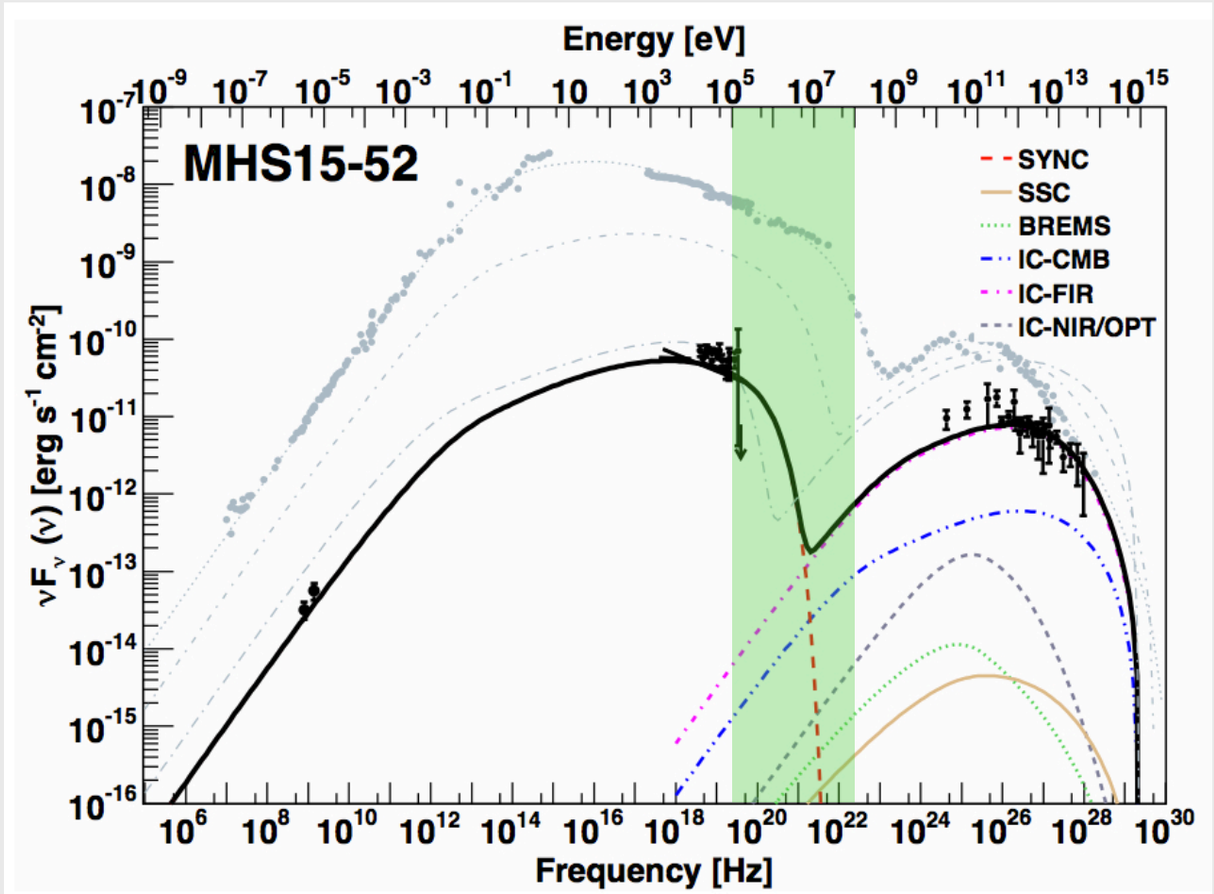
snrs 0.1-100 MeV?

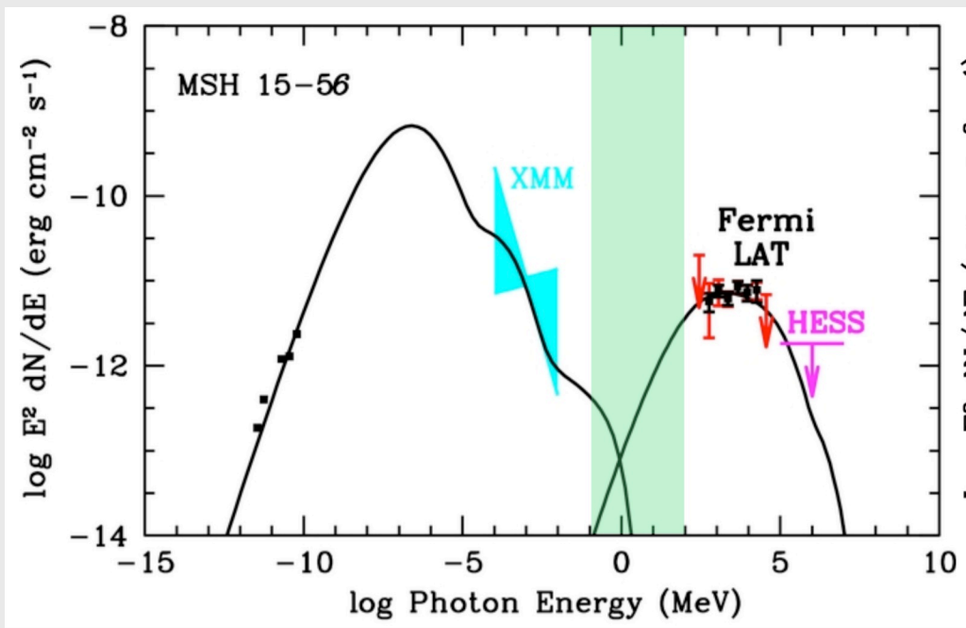
vela jr.



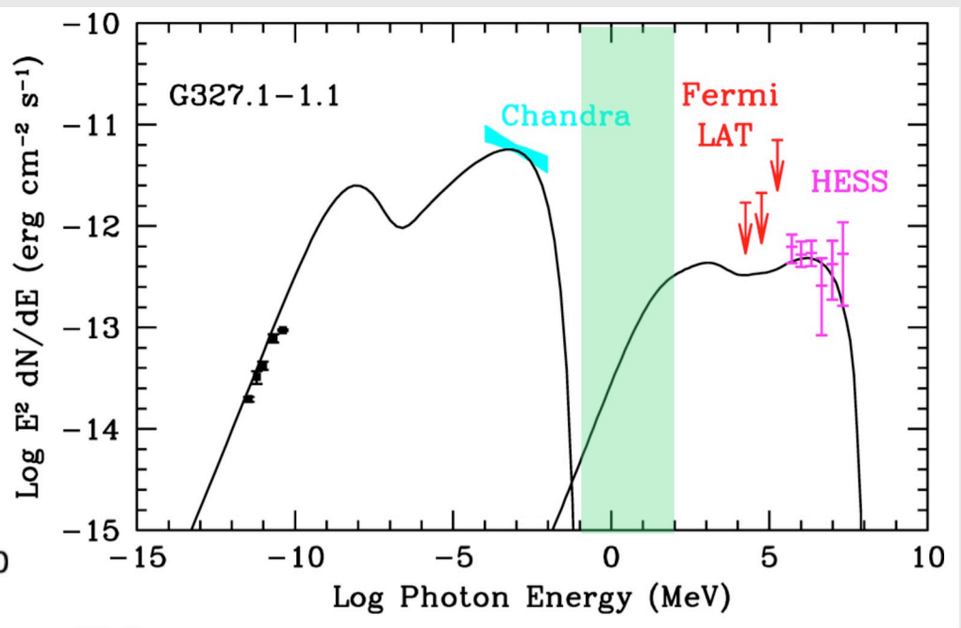
lee+2014

pwne 0.1-100 MeV?





temim+ 2013



temim+ 2015

some considerations

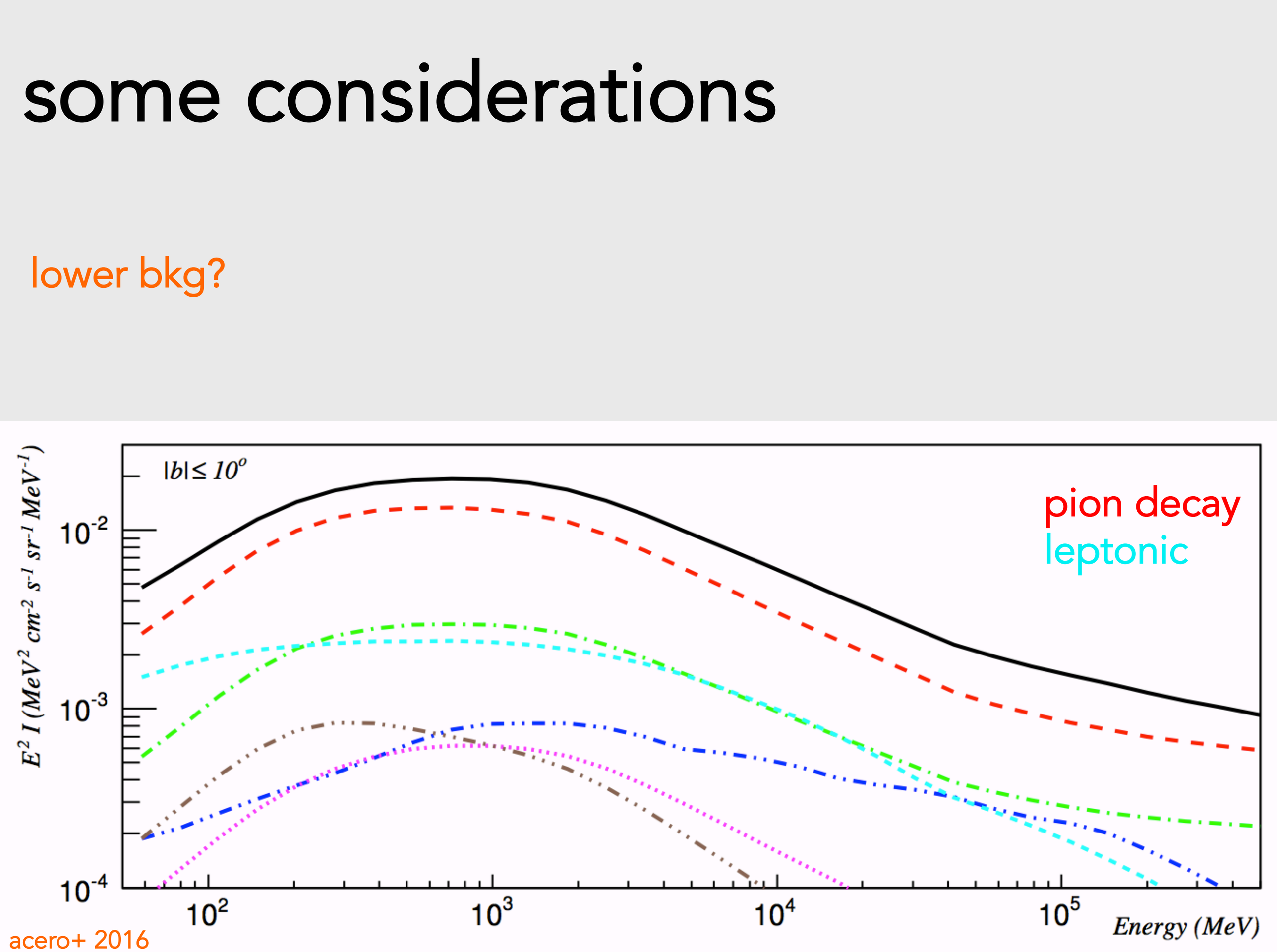
lower bkg

sizes

source confusion

some considerations

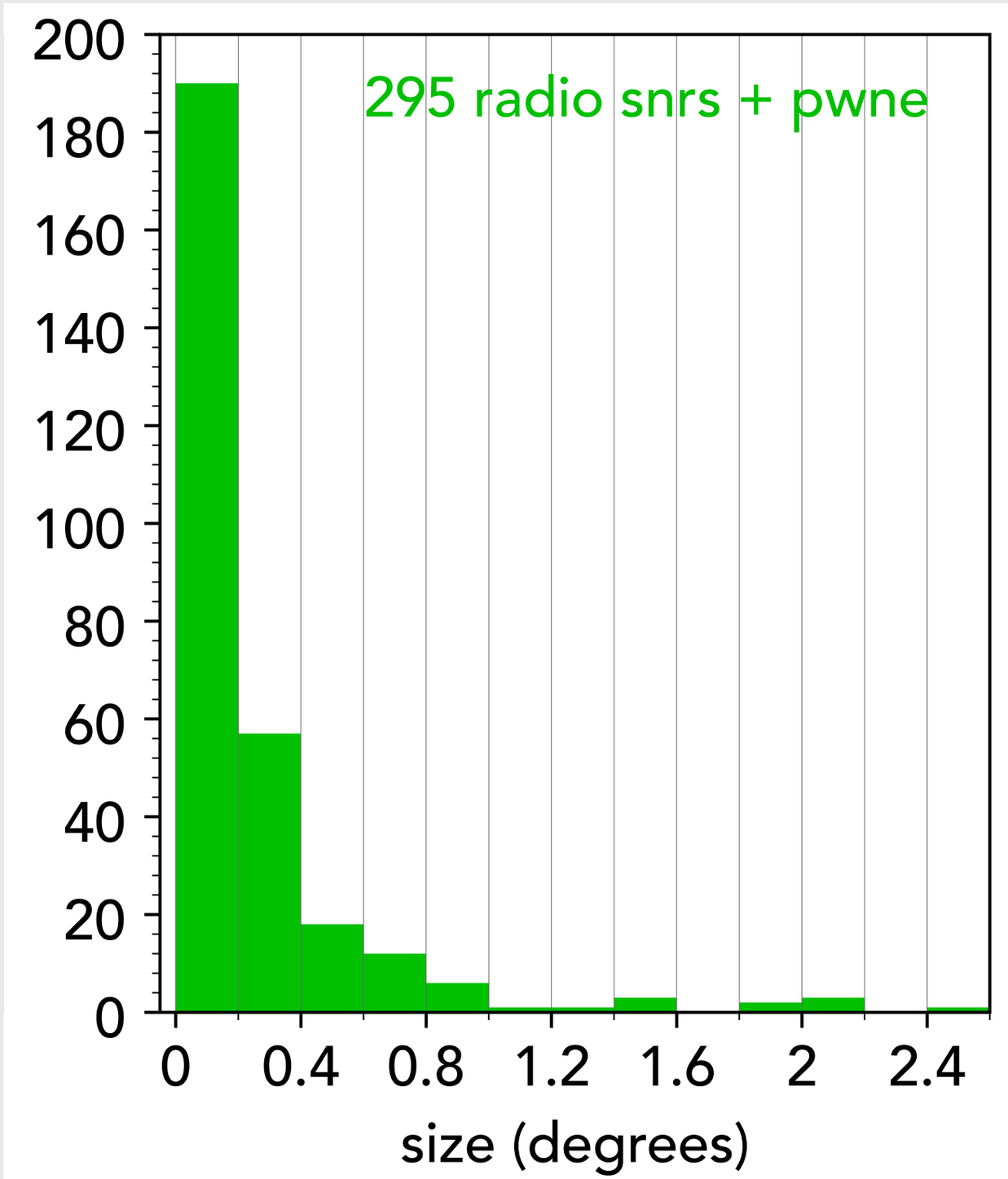
lower bkg?



acero+ 2016

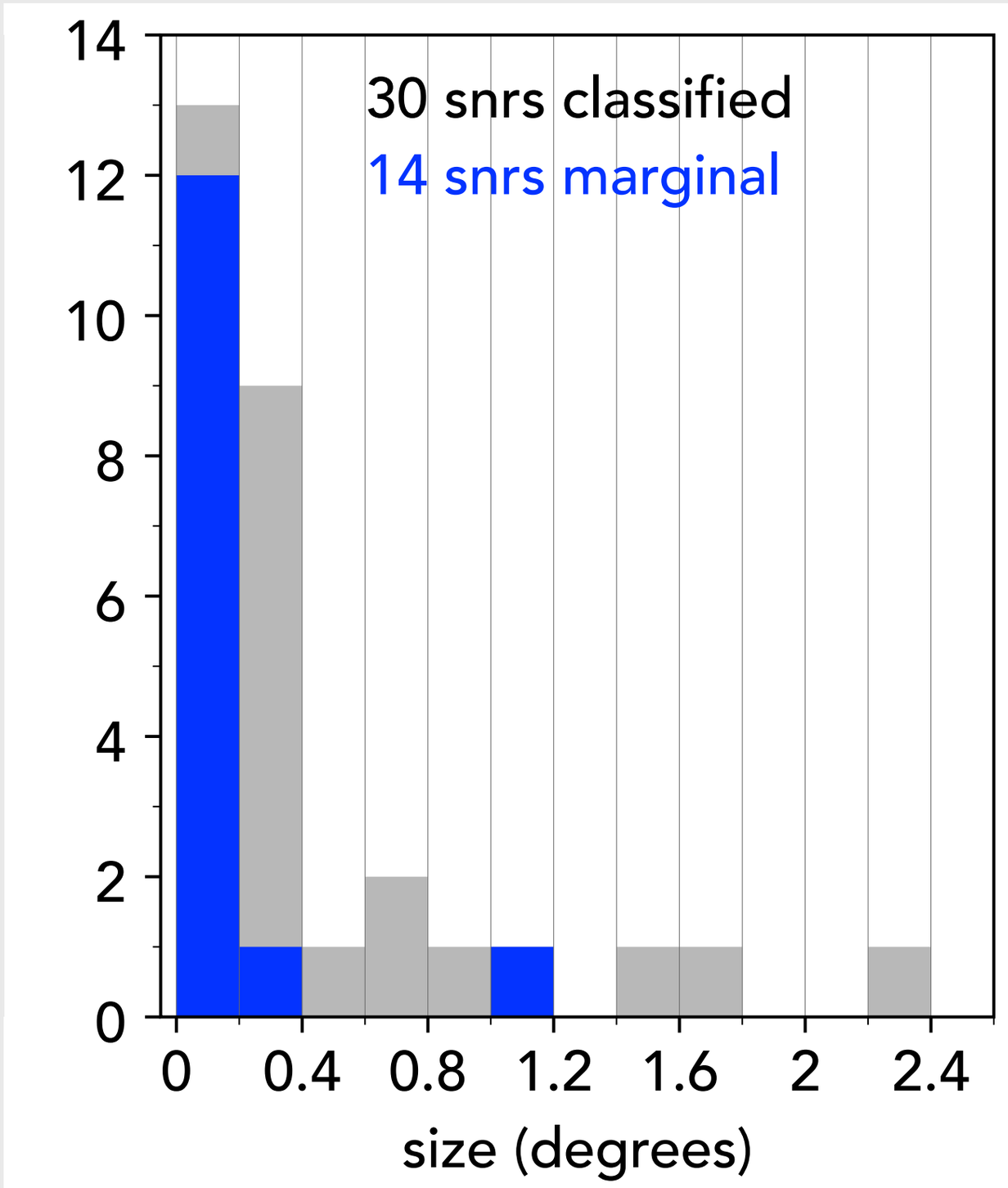
snrs in ɣ-rays

sizes



snrs in ɣ-rays

sizes



fermi snr catalog - acero+16

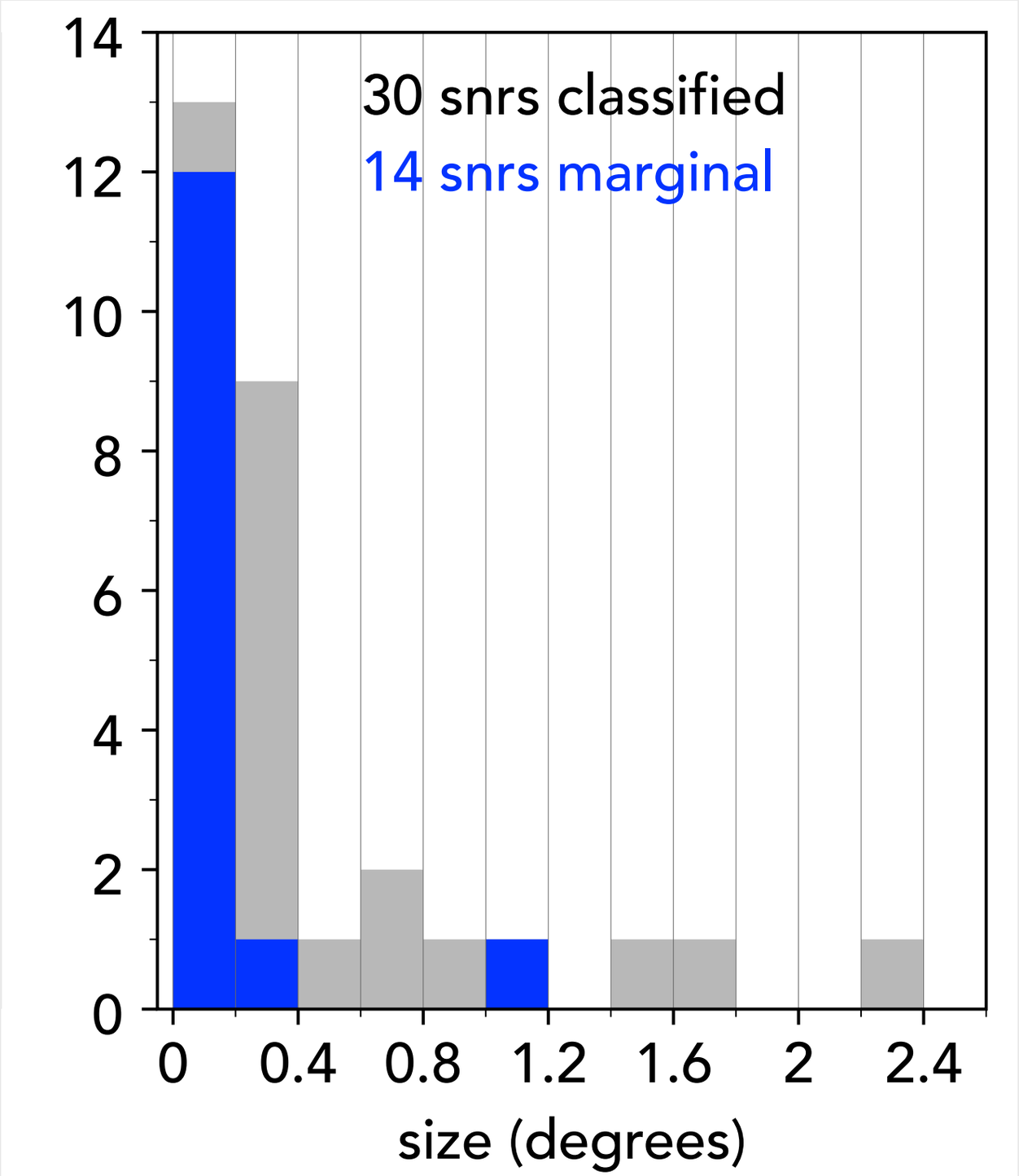
snrs in ɣ-rays

sizes

resolved studies

source confusion?

acero+16



snrs & pwn in MeV ɣ-rays

unexplored window – hadronic v leptonic

unlikely to discover new snrs or pwne (but there is always Ti^{44})

snrs & pwn in MeV ɣ-rays

questions?