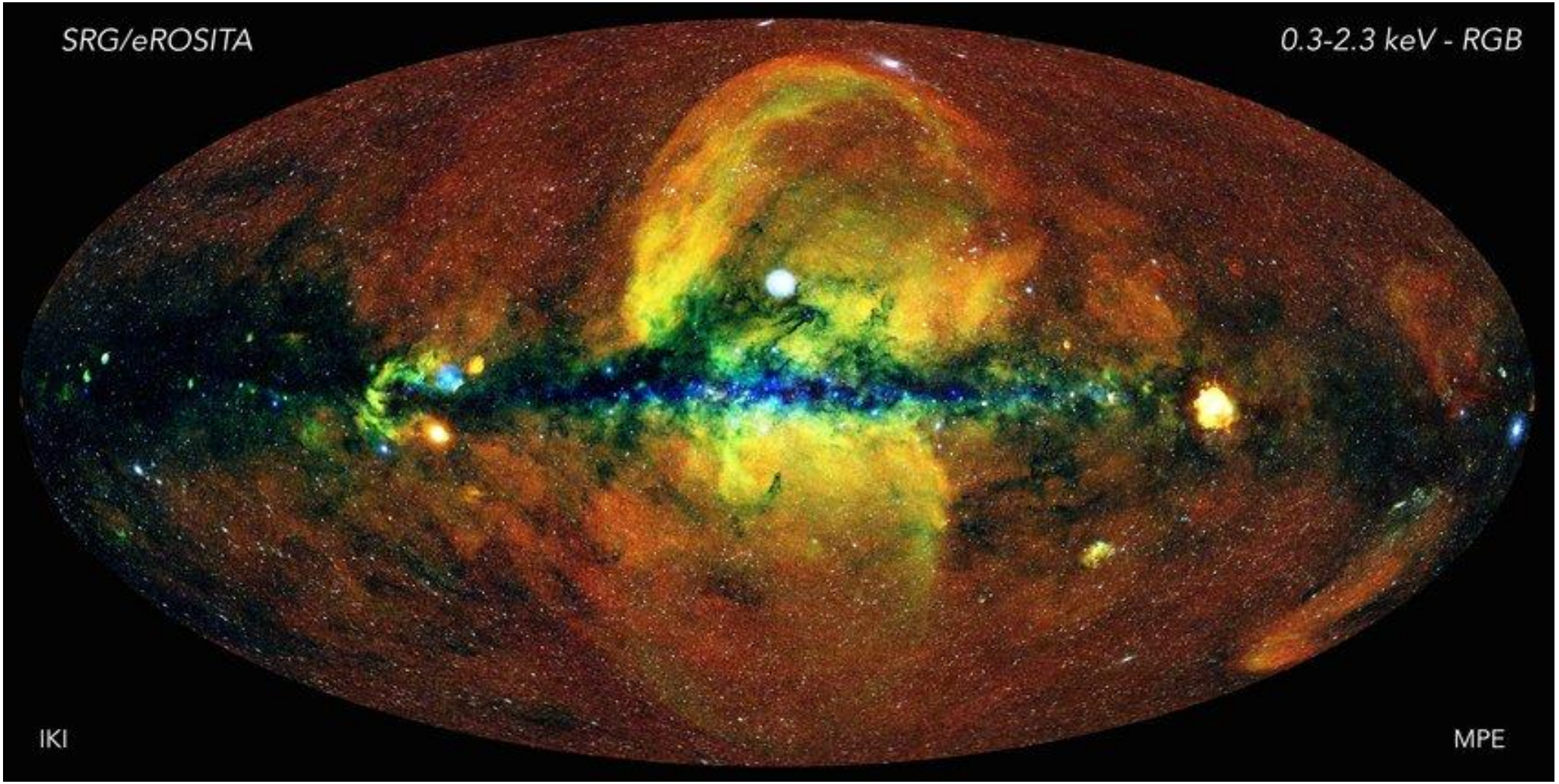
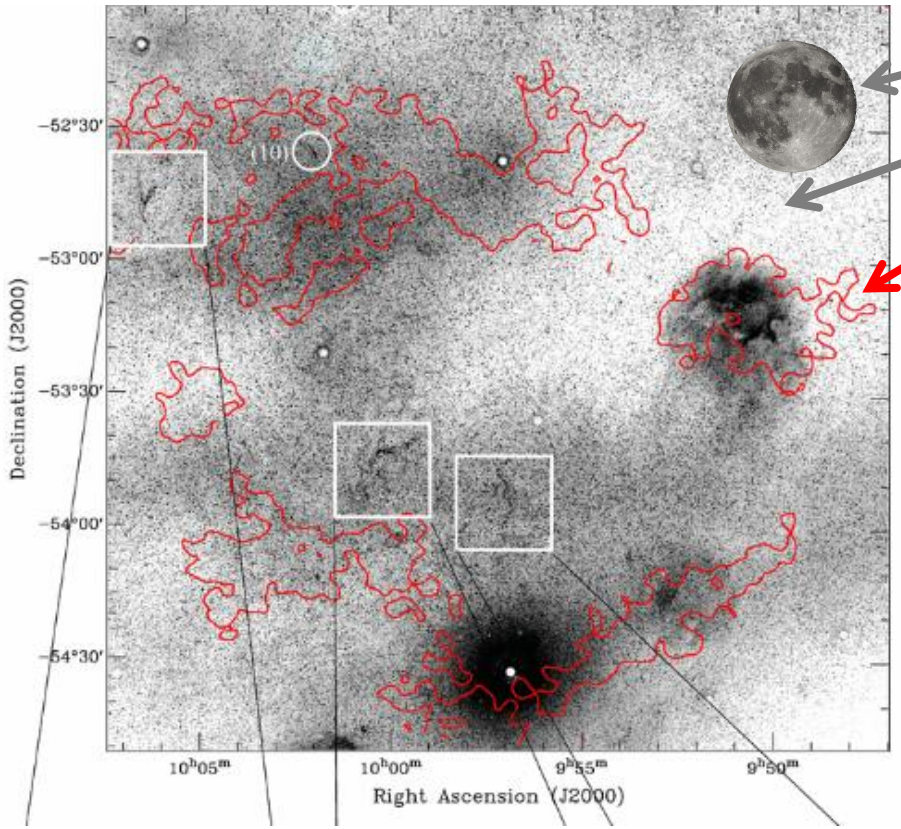
Studies of SNRs with eROSITA and more...

The eROSITA view of non-thermal SNRs



The SNR G279.0+01.1: Introduction

Stupar et al. 2009



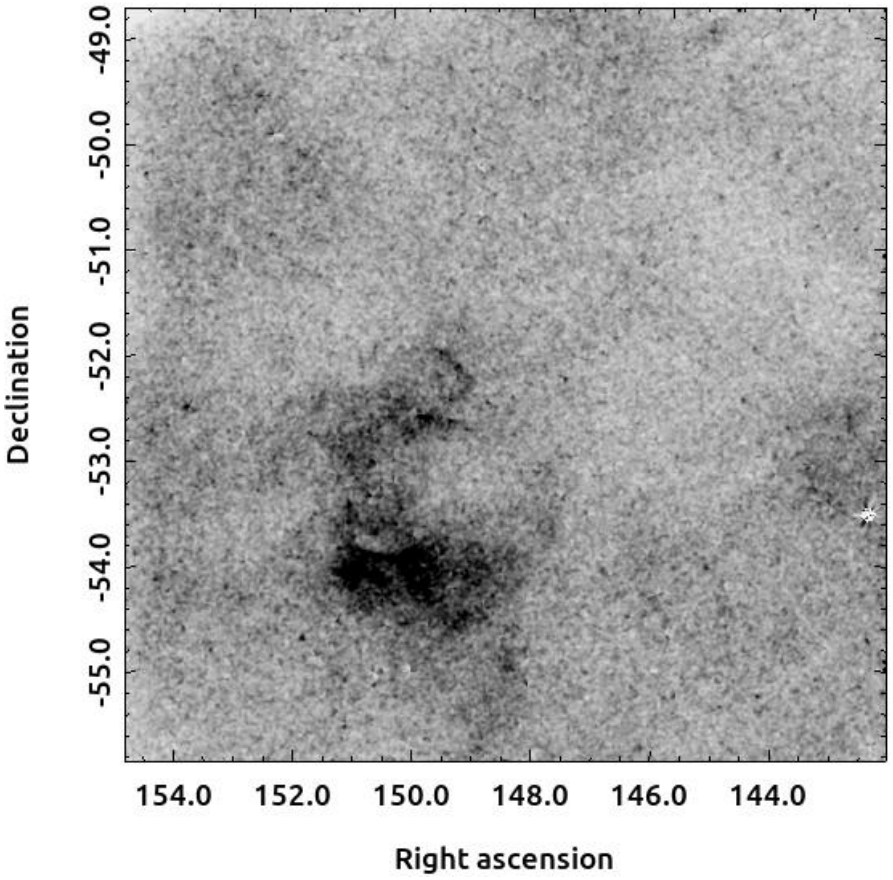
Size of XMM-Newton field of view

Grey scale: optical - Hα (SHS survey data)

Red contours: radio continuum (PMN data)

- Angular size: ~3°
- Distance: ~2.7 kpc (from literature)
  - ➔ Largest Galactic SNR ever detected?
- Age: ~10^6 years (from literature)
- **No X-ray counterpart reported in the literature**

The SNR G279.0+01.1: eROSITA view



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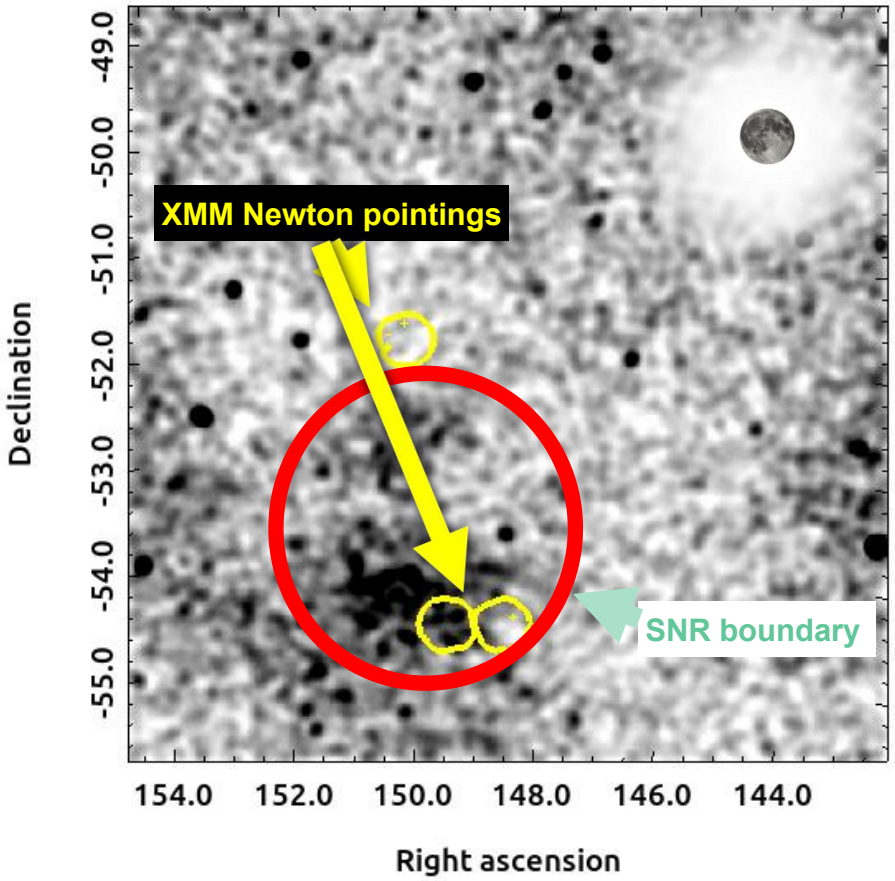
[3] **~100000 counts to work with**

The SNR G279.0+01.1: X-ray knowledge without eROSITA

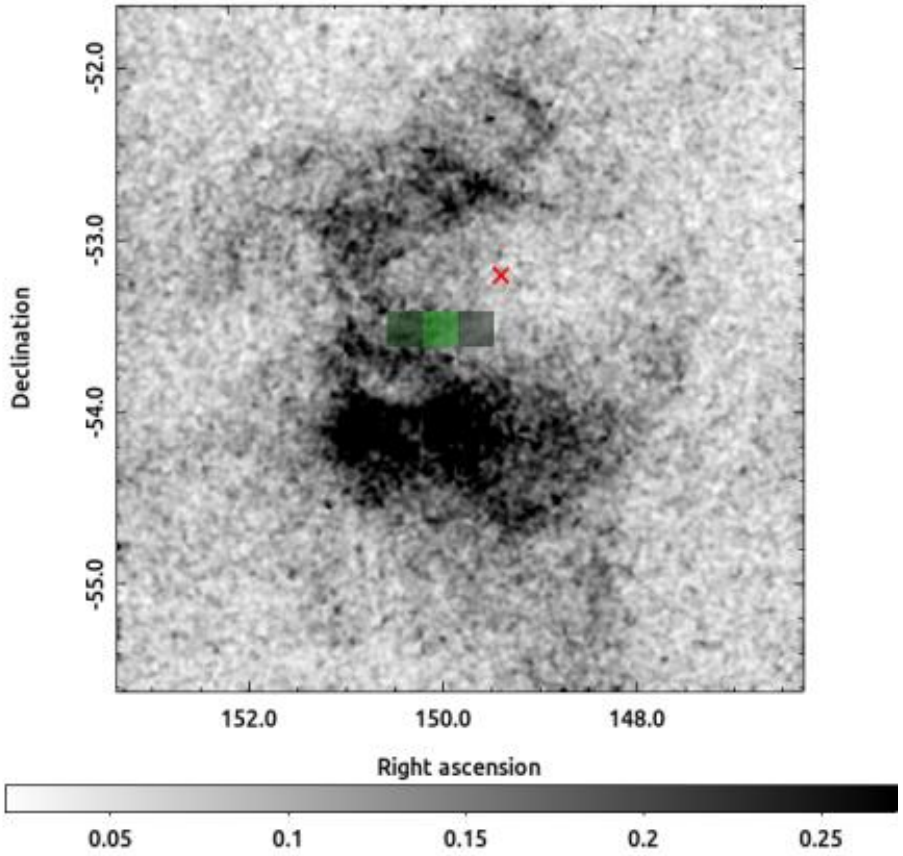


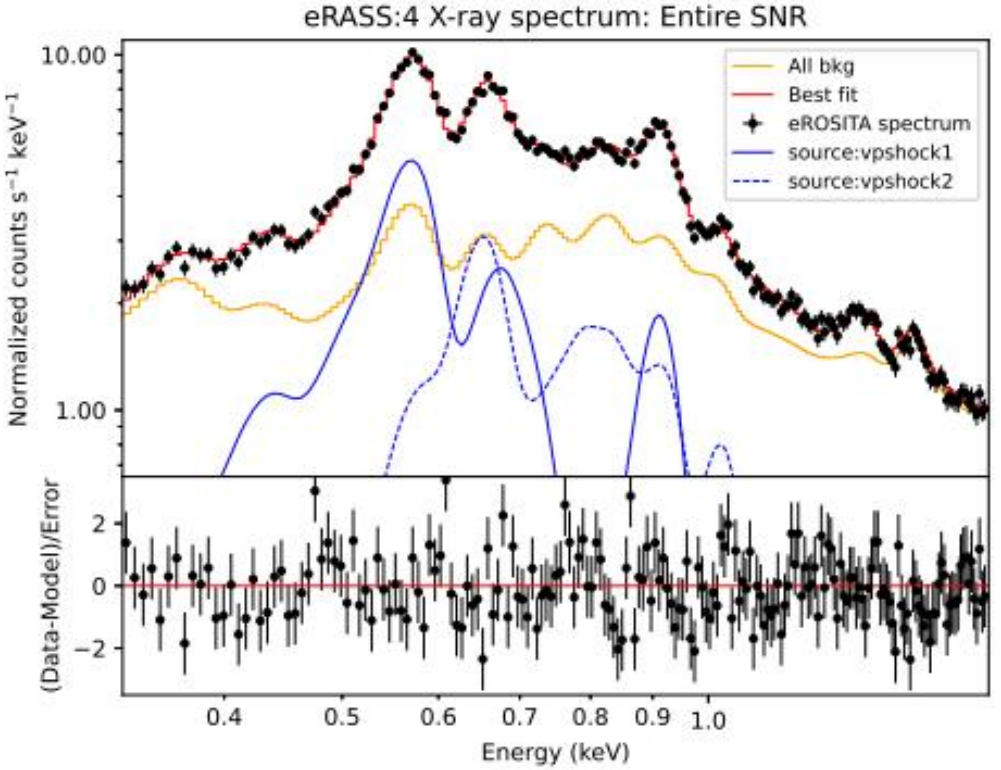
An aposteriori detection of the remnant with ROSAT:

- Grey scale: **ROSAT** All-Sky Survey (image optimized after eROSITA findings; no point sources subtracted)
- **1100** counts, no source discovery in literature
- Yellow circles: XMM-Newton pointings

The SNR G279.0+01.1: eRASS:4 imaging and spectra

eRASS:4, 0.3-1.1 keV exposure-corrected intensity sky map





The SNR G279.0+01.1: eRASS:4 imaging and spectra

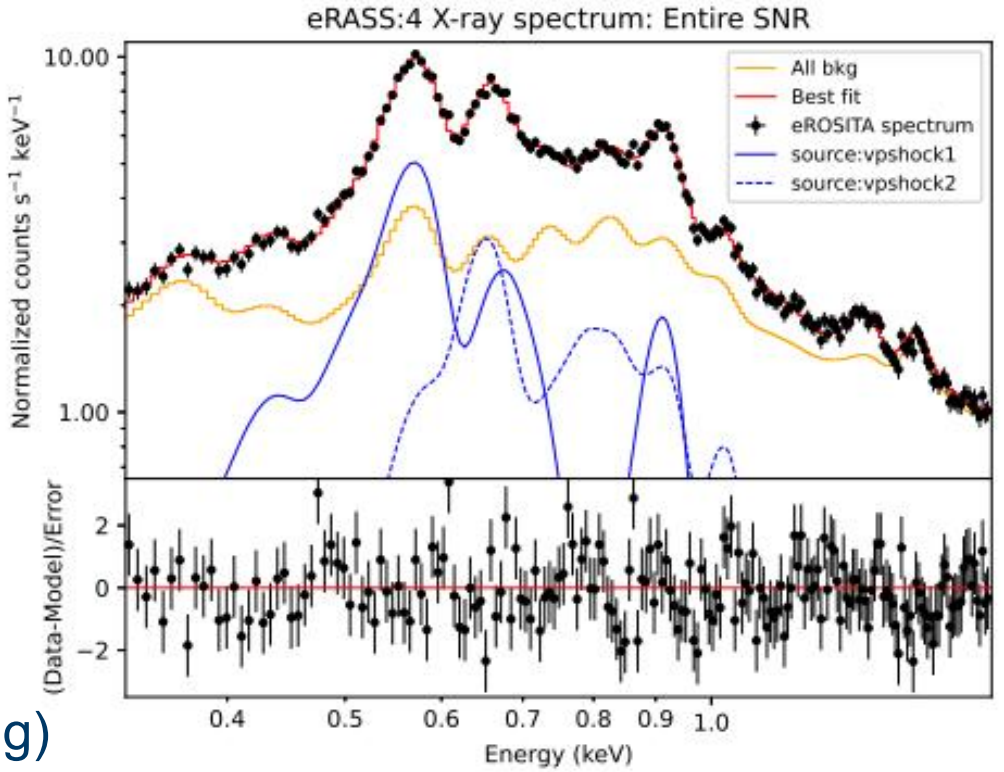
eRASS:4:

- Two-temperature plasma in non-equilibrium

ionization (NEI) (blue model)

NEI+NEI model

$kT_{(keV)}$	$0.60^{+0.07}_{-0.05}$ $0.34^{+0.03}_{-0.07}$
$N_{H(10^{22}cm^{-2})}$	$0.31^{+0.04}_{-0.02}$
O	$4.47^{+1.30}_{-0.84}$ $0.66^{+0.04}_{-0.05}$
Ne	$2.52^{+0.38}_{-0.39}$ $1.48^{+0.26}_{-0.22}$
Mg	1.0 $5.85^{+4.27}_{-1.43}$
Ionization time $(10^{11}s/cm^3)$	$2.34^{+0.97}_{-0.69}$ $0.06^{+0.02}_{-0.01}$
χ^2/dof	1.19



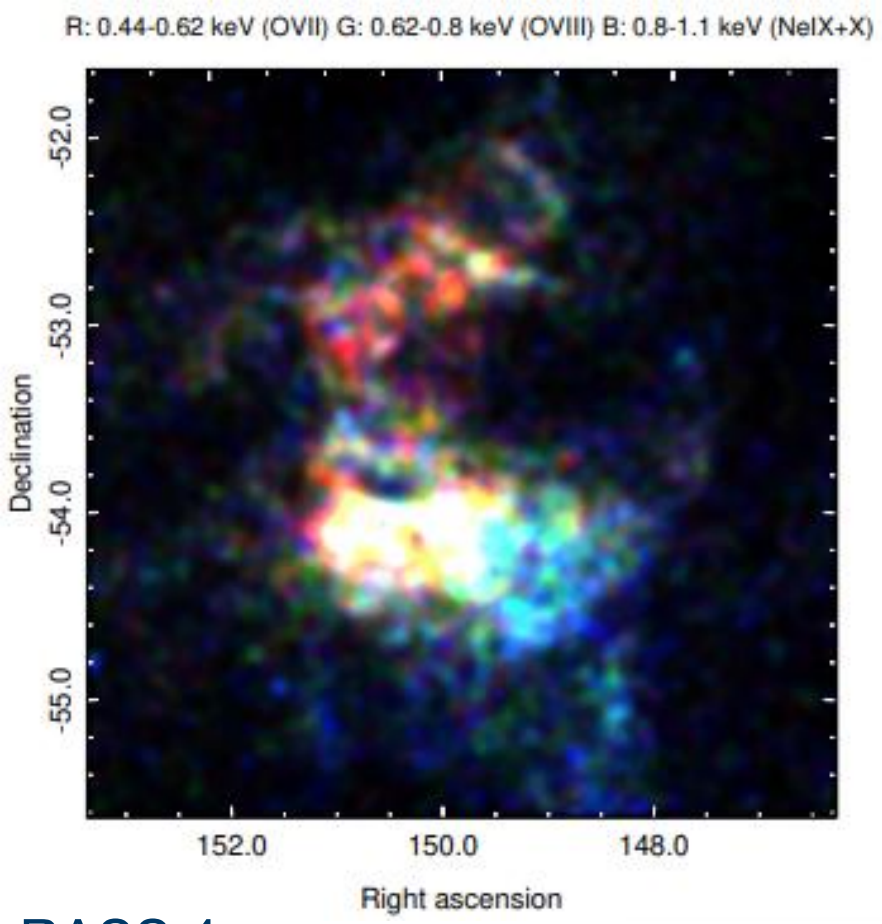
➔ Several temperatures (not surprising)

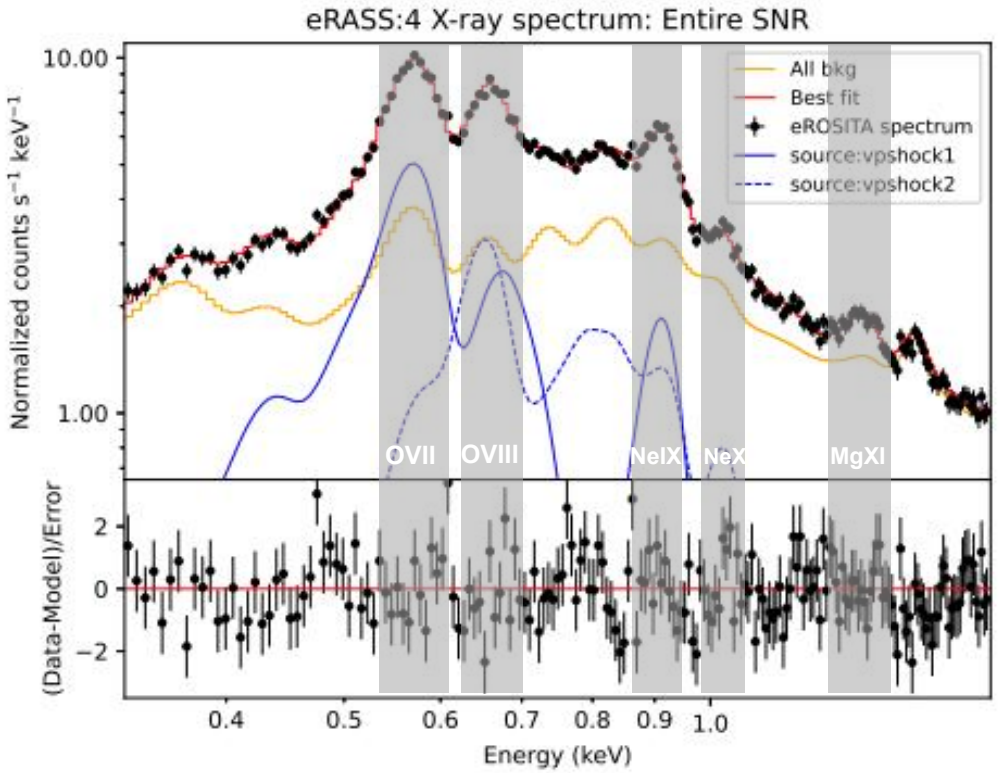
➔ Ejecta (O, Ne, Mg)

➔ Non-equilibrium

→ still compatible with usual old-age SNR

The SNR G279.0+01.1: eRASS:4 imaging and spectra





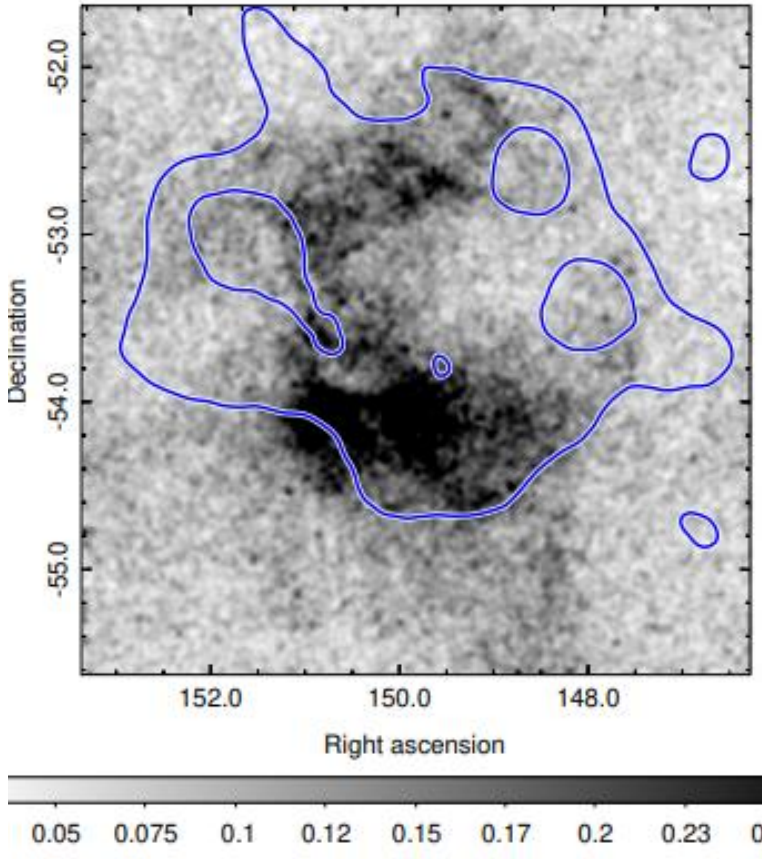
eRASS:4:

- High spectral resolution (OVII, OVIII, NeIX+X)

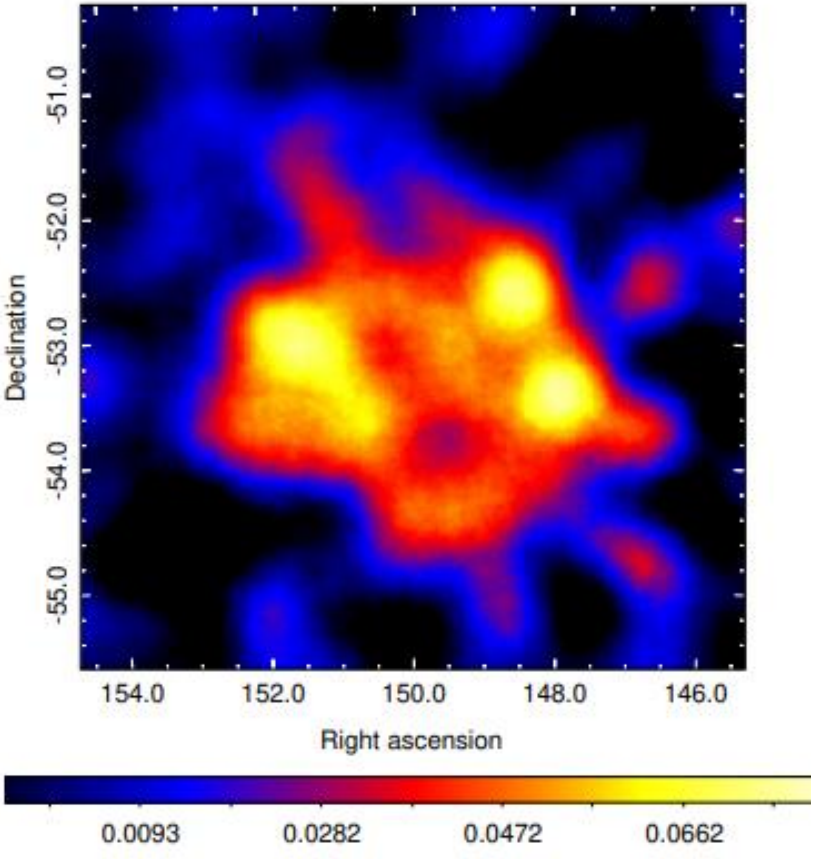
➔ typical composition for core-collapse [7]

γ-ray emission: the connection to cosmic-ray physics

Fermi-LAT contours on top of eRASS:4



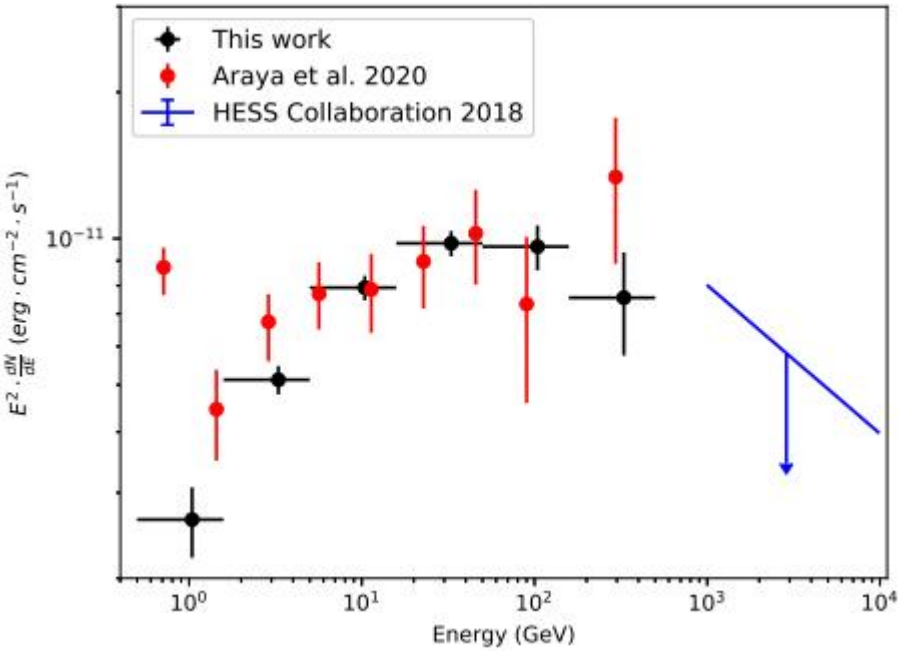
Fermi-LAT residual count map >5 GeV



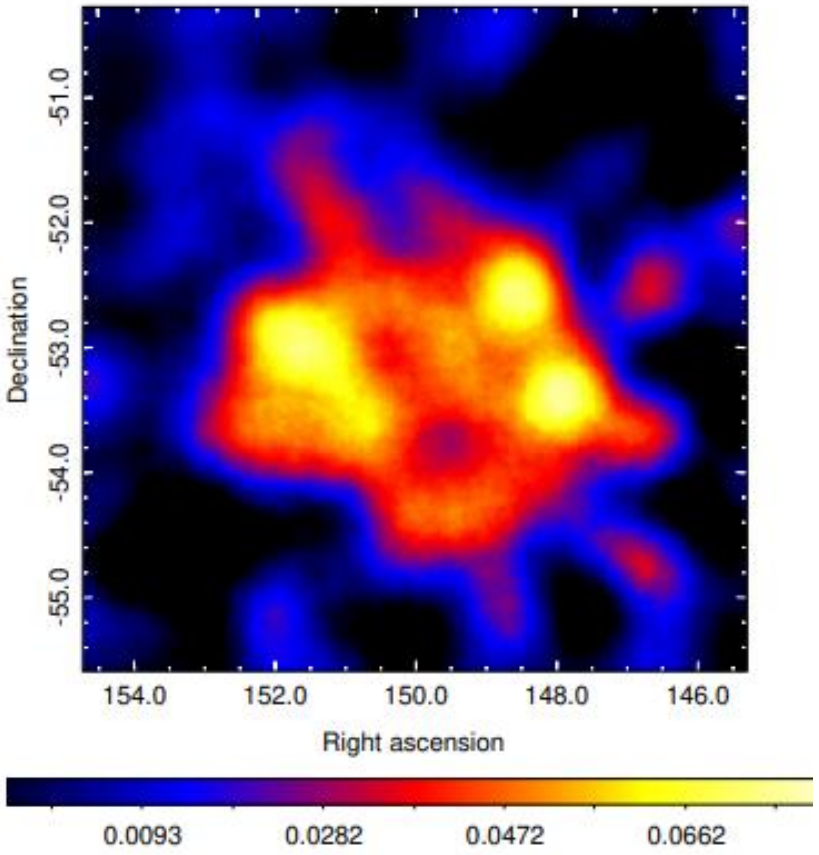
- **Fermi-LAT → "commonly" interpreted as hadronically γ-ray emission**
- **High density of cosmic ray particles** because of
  - ➔ (past or present) **acceleration in the SNR**
    or
  - ➔ **interaction of "sea" CRs** with **high-density gas?**

γ-ray emission: the connection to cosmic-ray physics

GeV/TeV SED



Fermi-LAT residual count map >5 GeV



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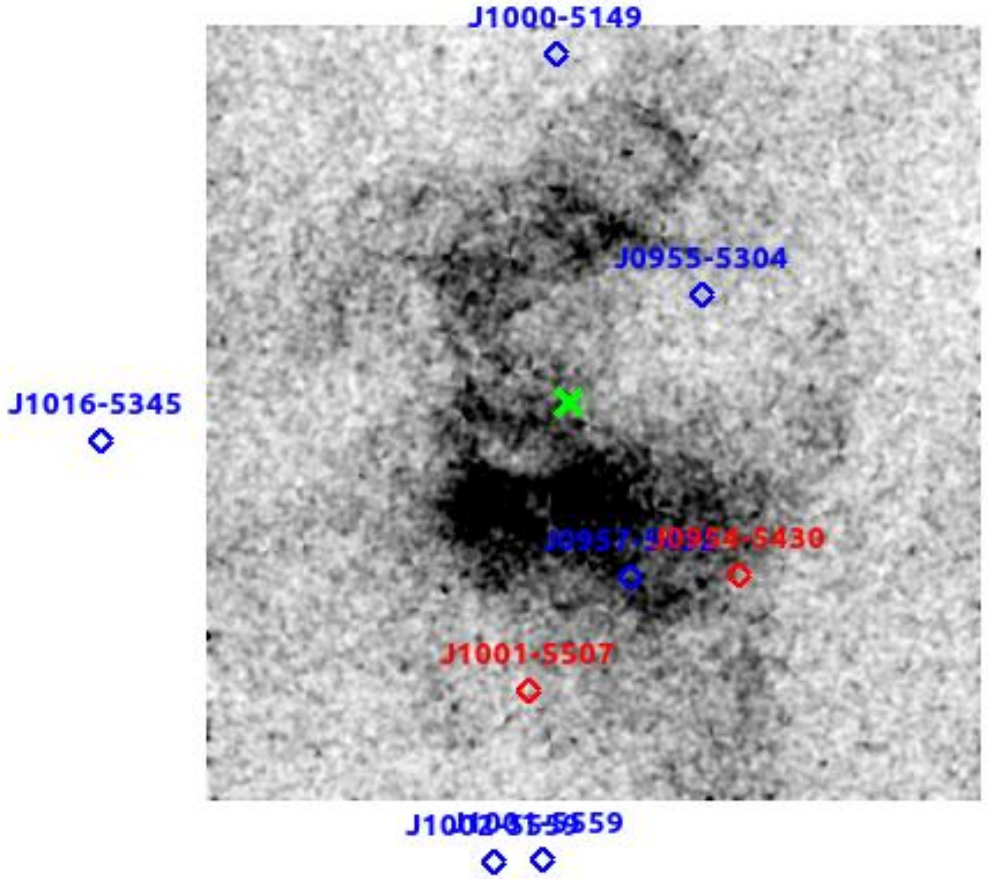
Modeling

- Application of standard hydrodynamic model (Leahy & Williams (2017)). Homogeneous circumstellar medium, kinetic explosion energy 10^{51} erg
- Main parameters: distance and density of the circumstellar medium
- Adopting literature value for distance (2.7 kpc, supported by measured X-ray absorption) and density of $0.4\ \mathrm{cm}^{-3}$:
  - ➔ age ~10^6 years
  - ➔ linear size ~140 pc

- Odd: Gamma-ray emission, X-ray emission from non-equilibrium ionisation plasma
- Check the pulsar association (used in the literature to confirm the 2.7 kpc distance)
  - ➔ pulsar association plausible, since X-ray spectra dominated by light elements (O, Ne, Mg)
    → Core-Collapse SNR

New scenario: smaller distance→smaller age



Updated distances

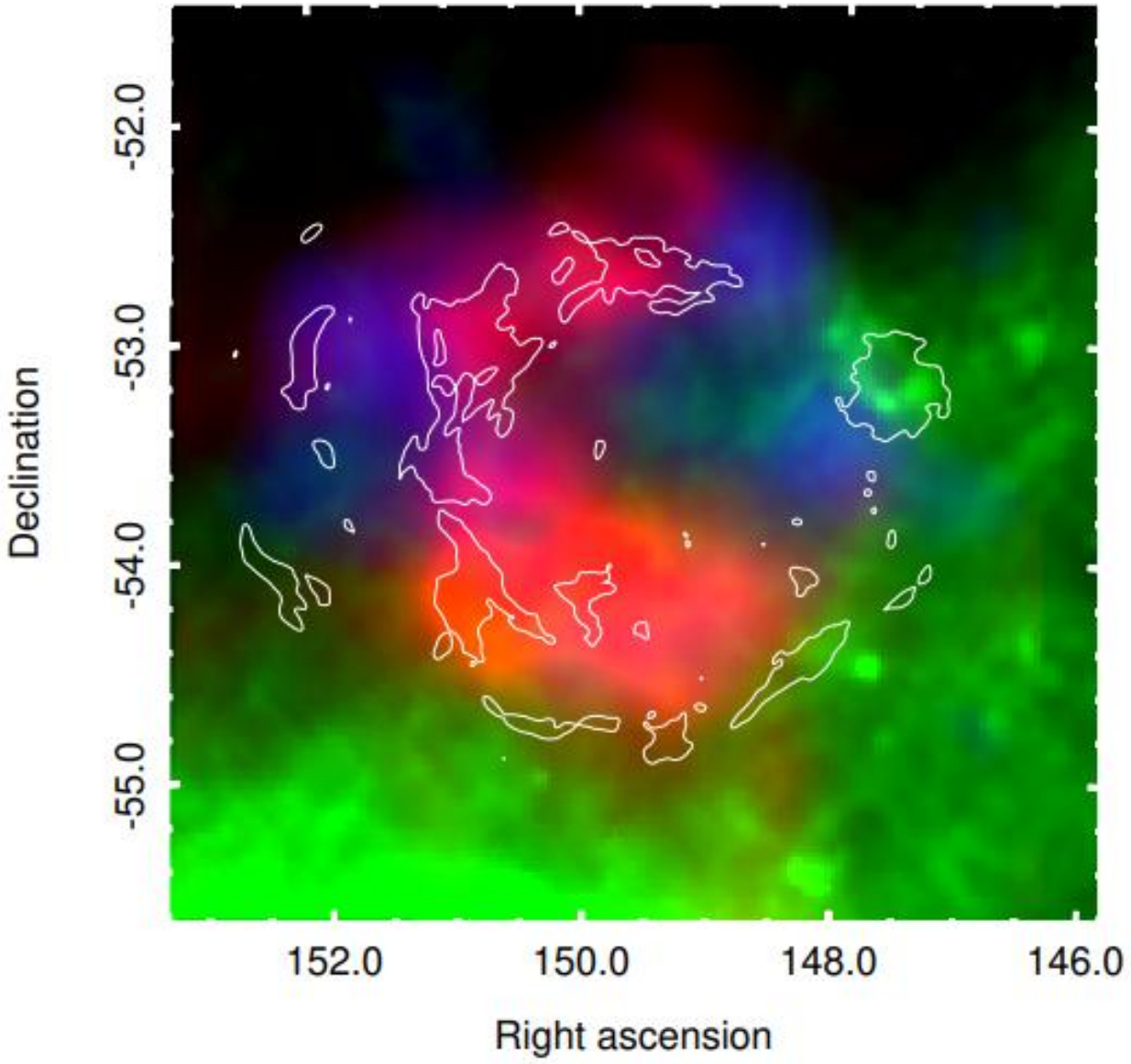
Pulsar	D (NEW!) kpc	D (old) kpc	Age Myr	v_{transv} km · s^{-1}
J0955-5304	0.40	3.31	3.87	1.5
J0957-5432	0.45	4.33	1.66	4.1
J0954-5430	0.43	3.96	0.17	48.8
J1001-5507	0.41	2.78	0.44	23.5
J1000-5149	0.13	1.93	4.22	1.0
J1001-5559	0.43	3.32	30.6	0.6
J1002-5559	3.27	9.83	7.84	16.9
J1016-5345	0.12	1.94	6.33	0.8
J0941-5244	0.40	3.14	9.17	2.1
J0940-5428	0.38	2.95	0.04	455.5

ATNF pulsar catalog:

Results:

- Likely associations: **J0954-5430, J1001-5507, or J0940-5428**
- **Distance: 0.4 kpc!**
- **SNR Age: $10^4 - 5 \cdot 10^5$ yrs** (linear size: ~20 pc)
- Better consistency with observations

A multiwavelength view of G279.0+01.1



R: 0.3-1.1 keV eRASS:4,

G: 100 μm IRAS,

B: >5 GeV Fermi-LAT.

White contours: radio continuum (ASKAP)

Conclusions: Detection of G279.0+01.1 in X-rays

- X-ray counterpart detection with eROSITA (confirmed with ROSAT and XMM-Newton), ~3 deg size
  - ➢ Soft thermal X-rays (two temperature plasma) in the 0.3-1.1 keV energy band
- GeV counterpart (confirmed, refined, updated GeV SED)
- Radio counterpart (refined → larger size consistent with X-rays)
- Updated remnant's center
- Modelling:

NEW!!

No1 scenario (old and distant):

Dist:	2.7 kpc
Size:	141 pc
Age:	$> 7 \cdot 10^5$ yrs
Pulsar:	No association
NEI model:	questionable
GeV emission:	questionable

No2 scenario (young and adjucent):

Dist:	**0.4 kpc**
Size:	**20 pc**
Age:	$\mathbf{10^4 - 7 \cdot 10^5}$**yrs**
pulsar:	**J0954-5430, J1001-5507, J0940-5428**
NEI model:	**better fit**
GeV emission:	**better fit**