The young supernova remnant G1.9+0.3

Robert Brose
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HELMHOLTZ ASSOCIATION

DESY

G1.9+0.3
Overview

General Properties

- Detected in radio and x-ray bands
- No detection in gamma rays yet
- Located near the galactic center
- Radius of around 2pc
- Age of about 100yrs
- Shock speed of about 14.000km/s
- Probably a type1a supernova

→ G1.9+0.3 could be an efficient particle accelerator

G1.9+0.3

Radio and X-ray observations

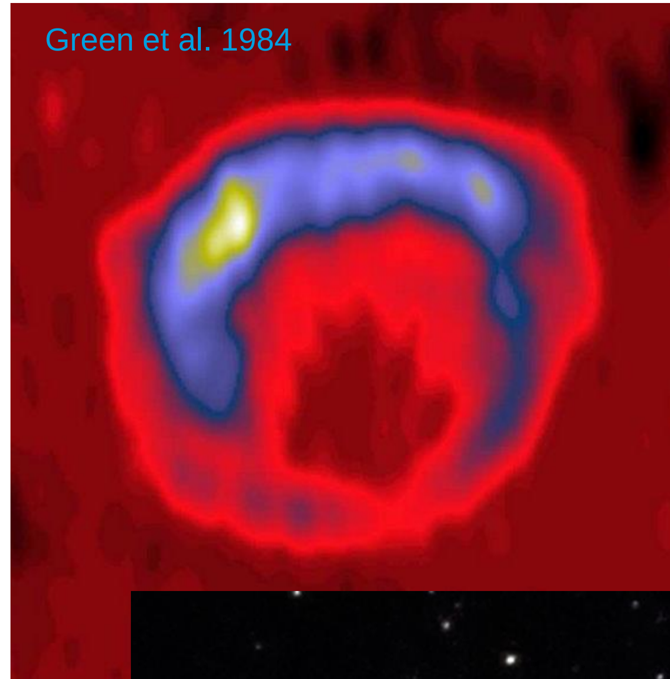
Radio observations

Detected with VLA in 1984

Asymmetric structure with bright northern rim

Measurements of the radio brightening

Radius of radio ring: 2pc



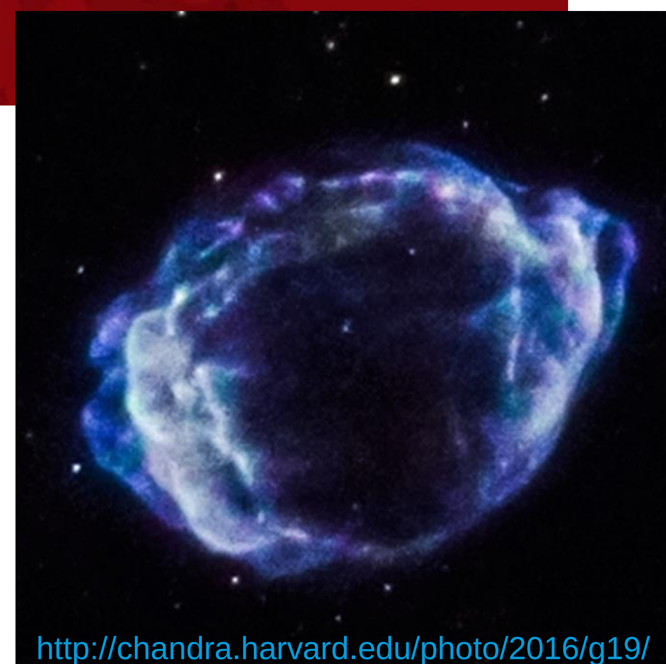
X-ray observations

Detected with Chandra and Nustar

Bipolar structure

Radius of bright x-ray features: 2.2pc

Expansion measurements possible

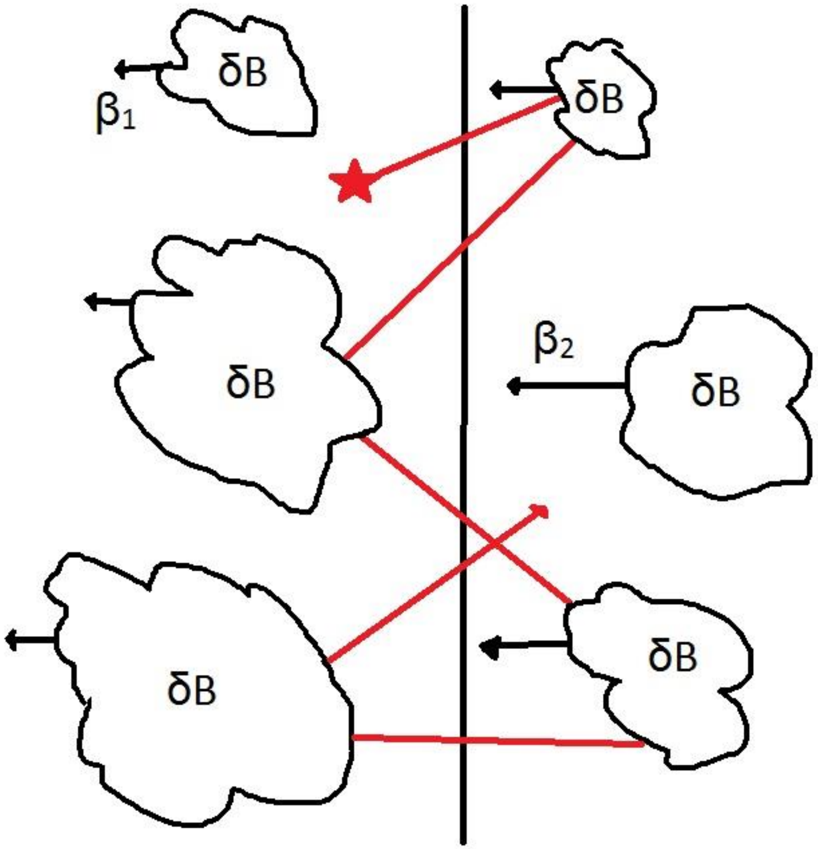


Fermi acceleration

Overview

Ingredients

- Hydro evolution of the specific SNR
- Solve the cosmic ray transport equation for protons and electrons
- Account for magnetic field amplification and magnetic turbulence



Fermi acceleration

Transport equation for cosmic rays

$$\frac{\partial N}{\partial t} = \underbrace{\nabla D_r \nabla N}_{\text{Diffusion}} - \underbrace{\nabla v N}_{\text{Advection}} - \frac{\partial}{\partial p}\Big(\underbrace{N\dot{p}}_{\text{Cooling}} - \underbrace{\frac{v}{3}Np}_{\text{Acceleration}}\Big) + \underbrace{Q}_{\text{Injection}}$$

The equation is solved:

- One dimensional
- Assuming spherical symmetry
- Including Synchrotron cooling for electrons
- On a comoving, expanding grid → no free escape boundary

Fermi acceleration

Additional ingredients

Hydro modeling:

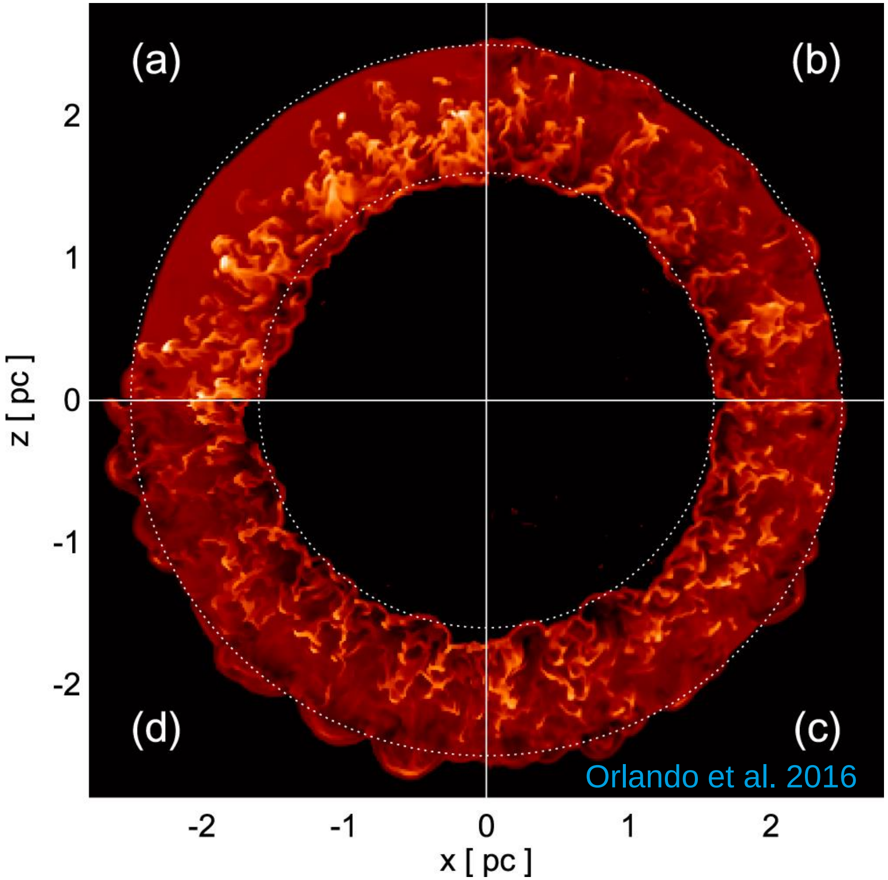
- Solving the standard gas-dynamical equations
- 1D and spherically symmetric
- Modeled as type1a-explosion in a uniform medium

Magnetic turbulence modeling:

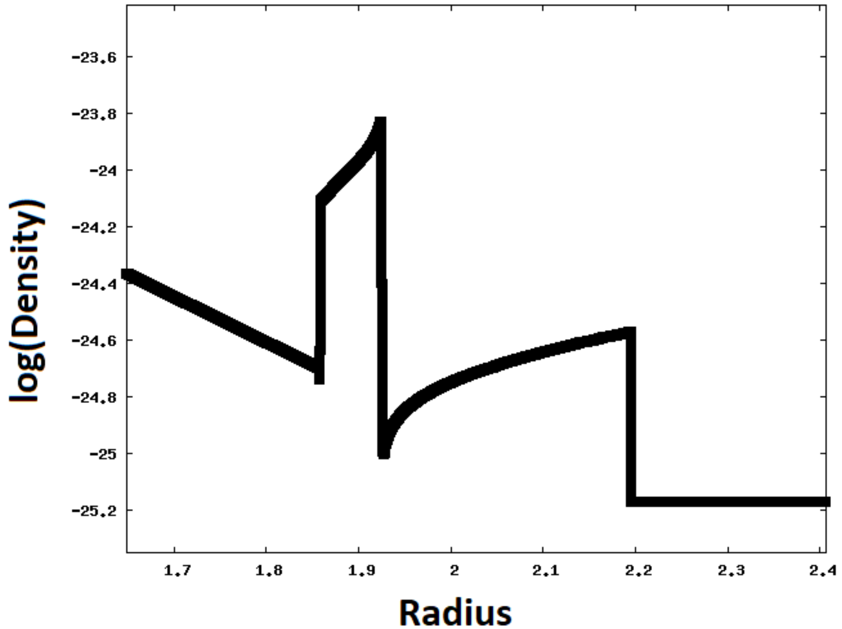
- Assuming isotropic, alfvenic turbulence
- Solving transport equation
- Processes include: Advection, cascading, amplification and damping
- 1D and spherically symmetric

Fermi acceleration

Two dimensional effects



Plasma density in 2D simulations



Plasma density in 1D simulations

Results

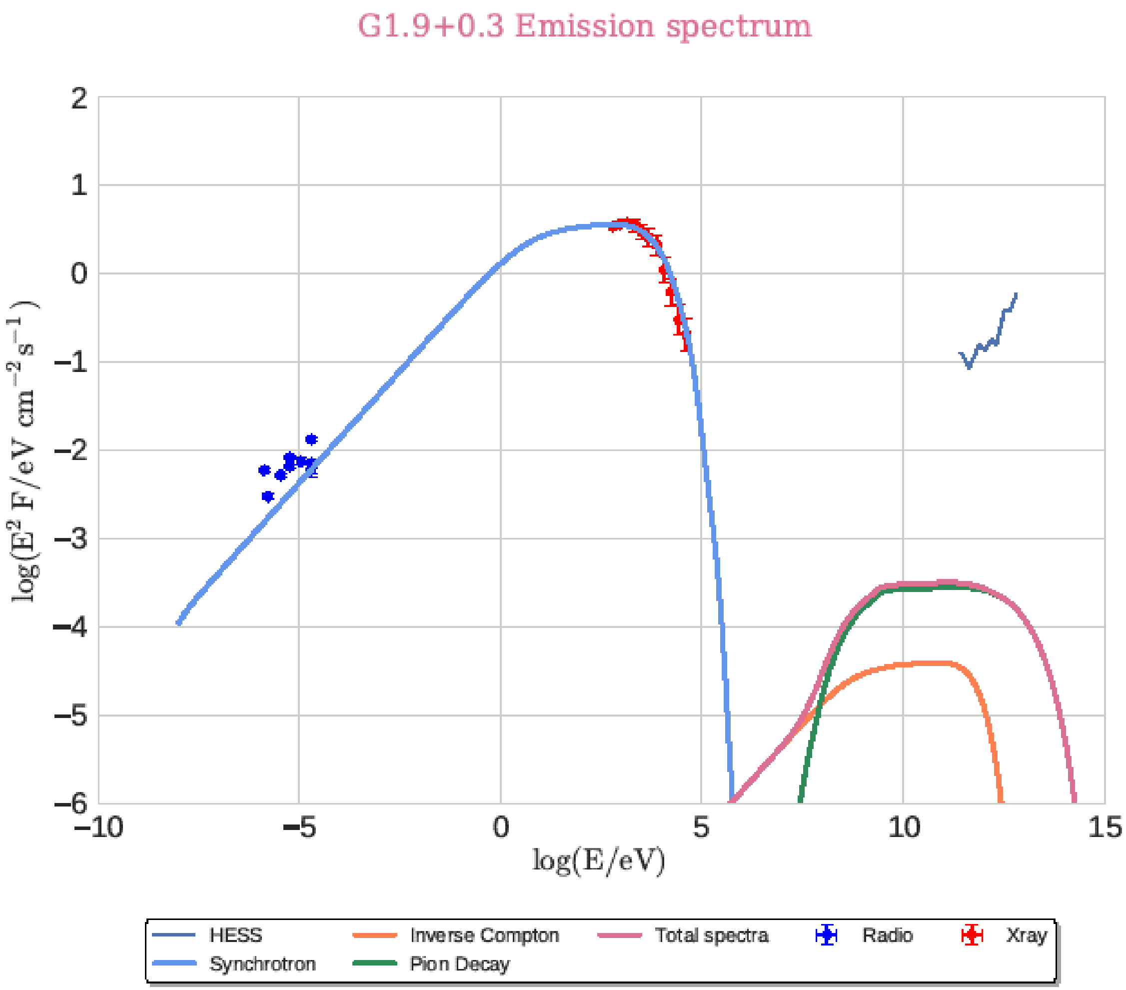
Spectral energy distribution

One shock model

B_d = 600μG → needed to generate enough synchrotron radiation

Acceleration 30 times slower than expected → indicates lower upstream field

Cosmic ray pressure well below the non-linear regime



Results

Spectral energy distribution

Forward and reverse shock model

$B_d = 175 \mu G$

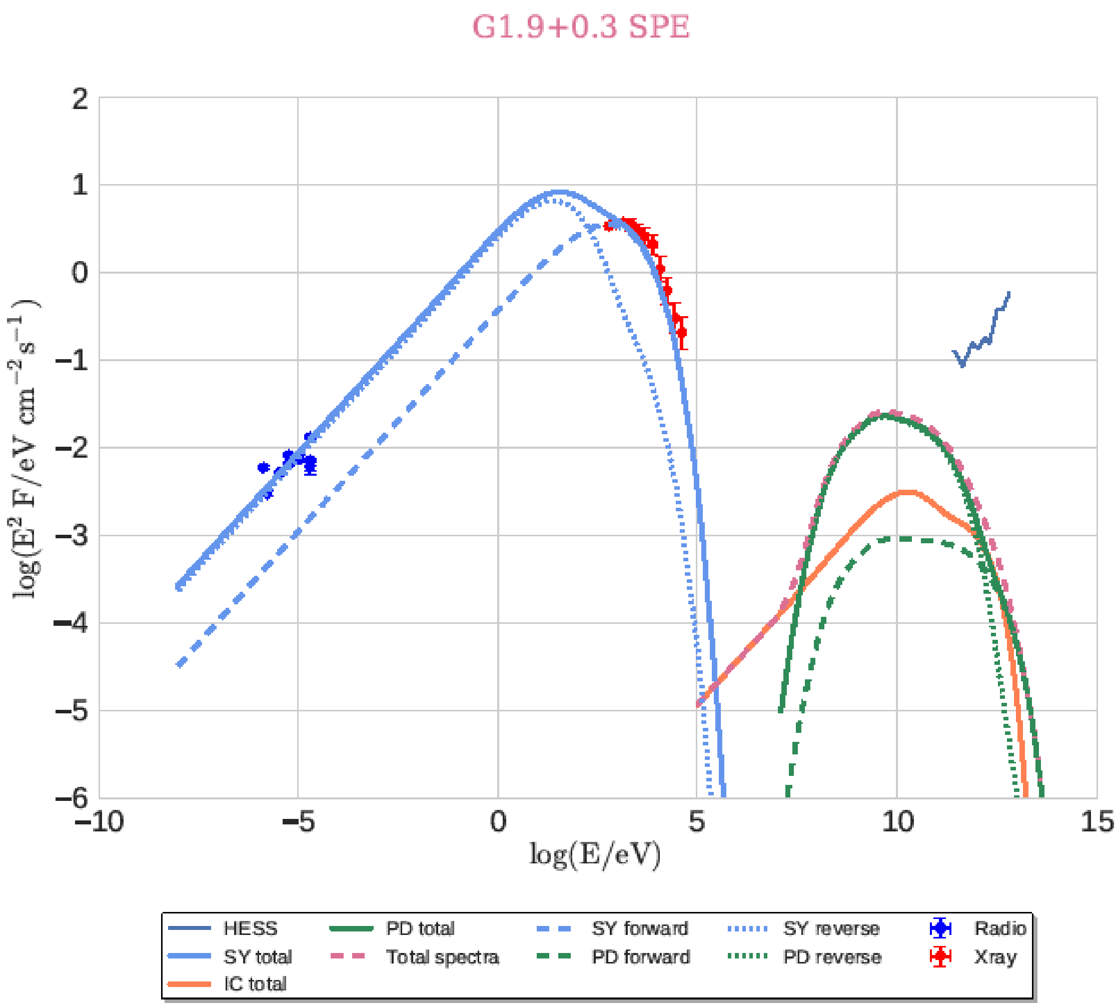
Acceleration at forward-shock now matches expectation

Acceleration at reverse shock inefficient

More relative injection at the reverse shock is needed

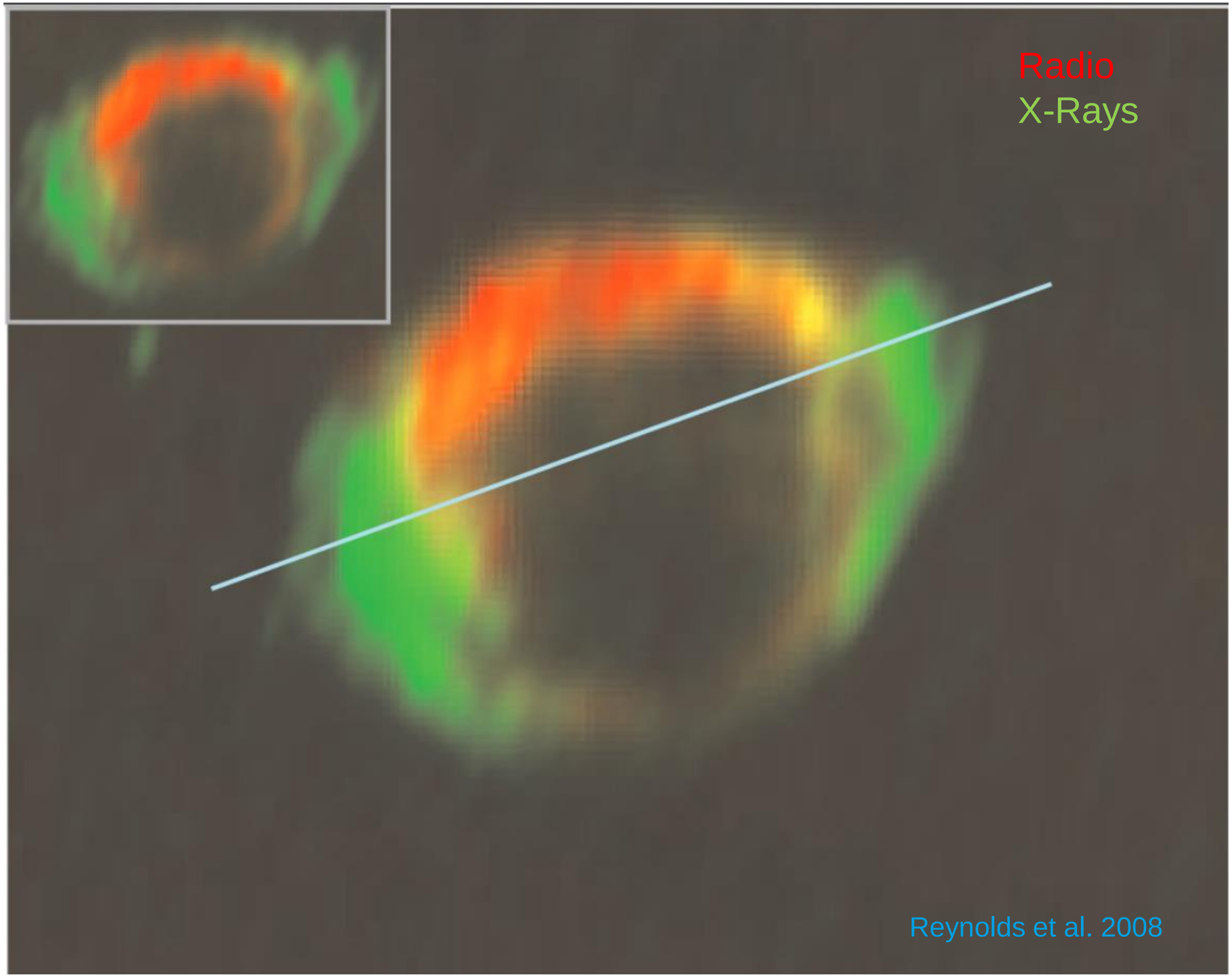
GeV emission dominated by the reverse shock

Maximum energy in agreement with self-consistent wave amplification



Results

Emission profile



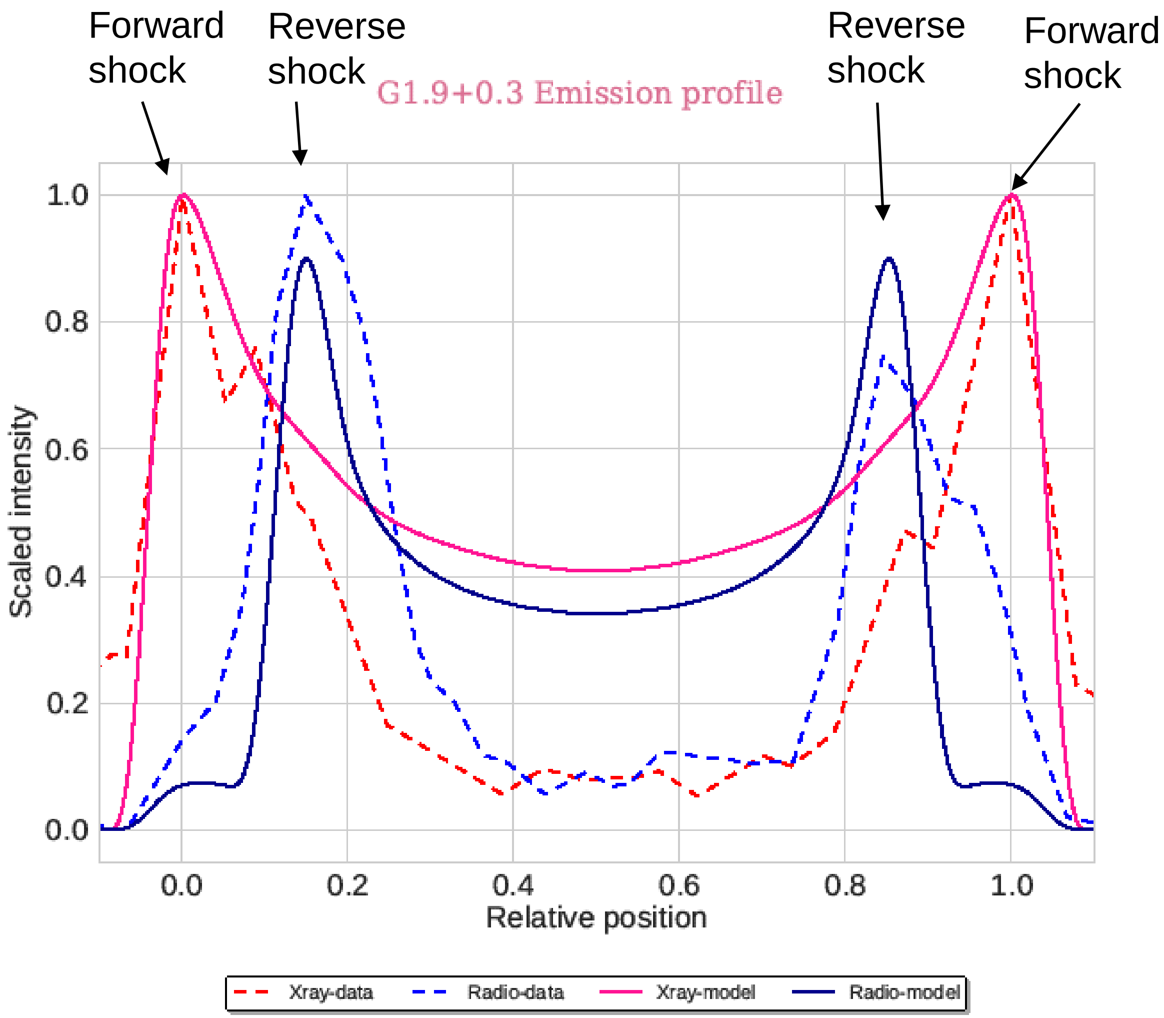
Results

Emission profile

Forward and reverse shock model

Reproducing the profile only with a two-shock model

Intensity mismatch in the center → no spherical symmetry



Summary

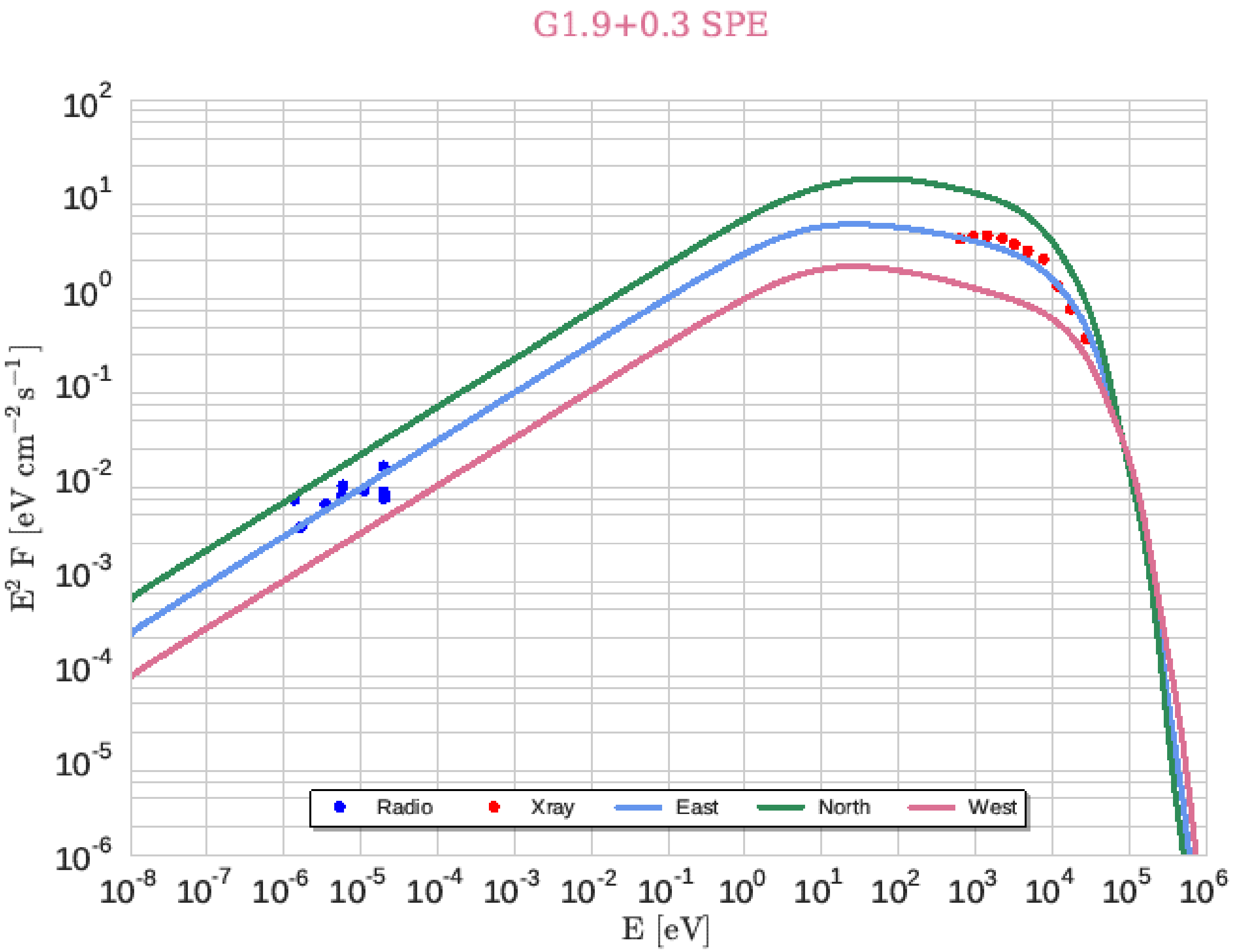
- Either cooling or two accelerating shocks can reproduce the SED
- The E-W emission profile requires the presence of two shocks
- No model requires or results in CR-modified shocks
- There are hints for additional magnetic field generation especially in the downstream of the reverse shock
- The electron-cutoff energy is consistent with the self-consistent amplification of Alfvenic turbulence

Thank you for your attention!

Backup Slides

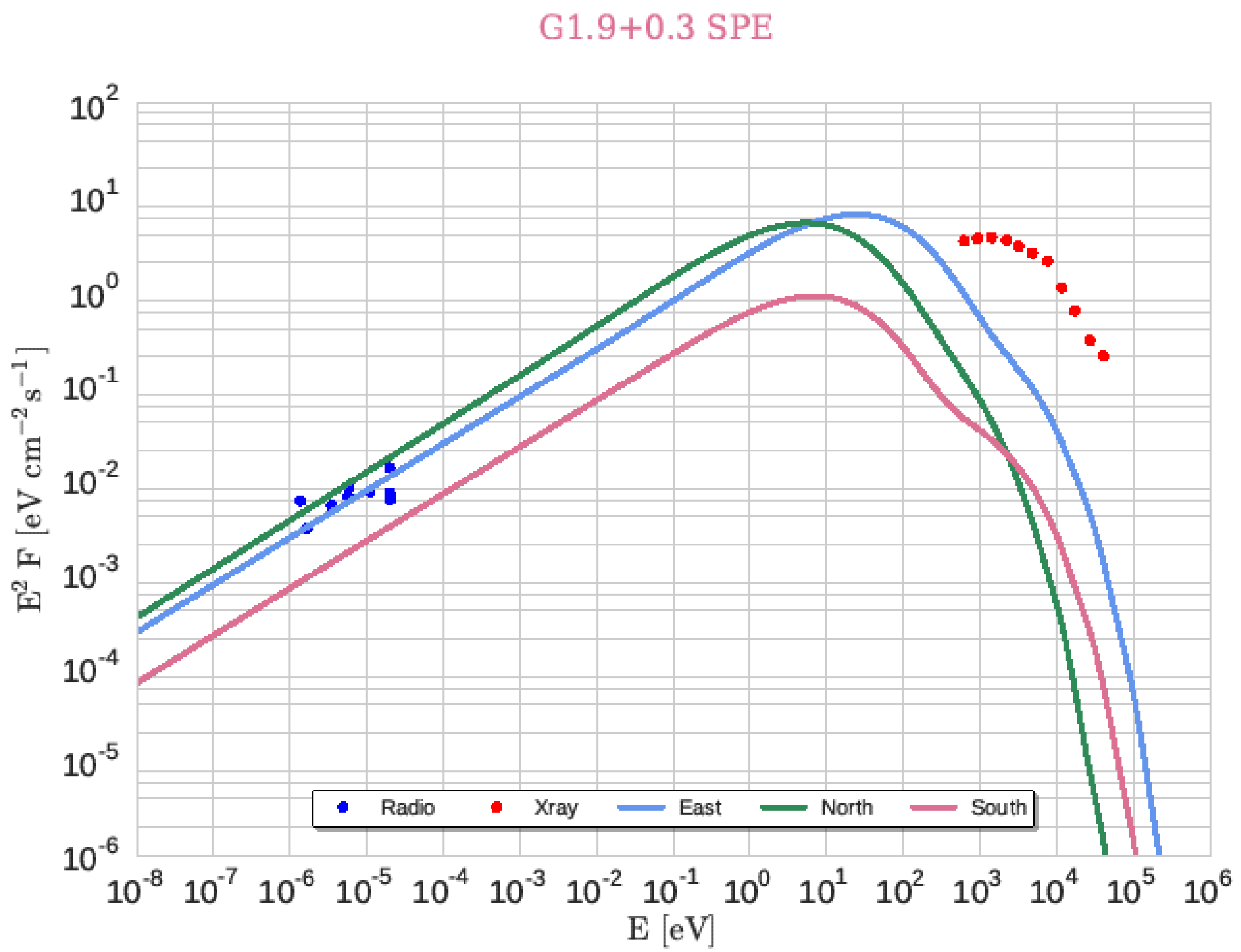
Radio asymmetry

Density effect on Radio: Forward shock



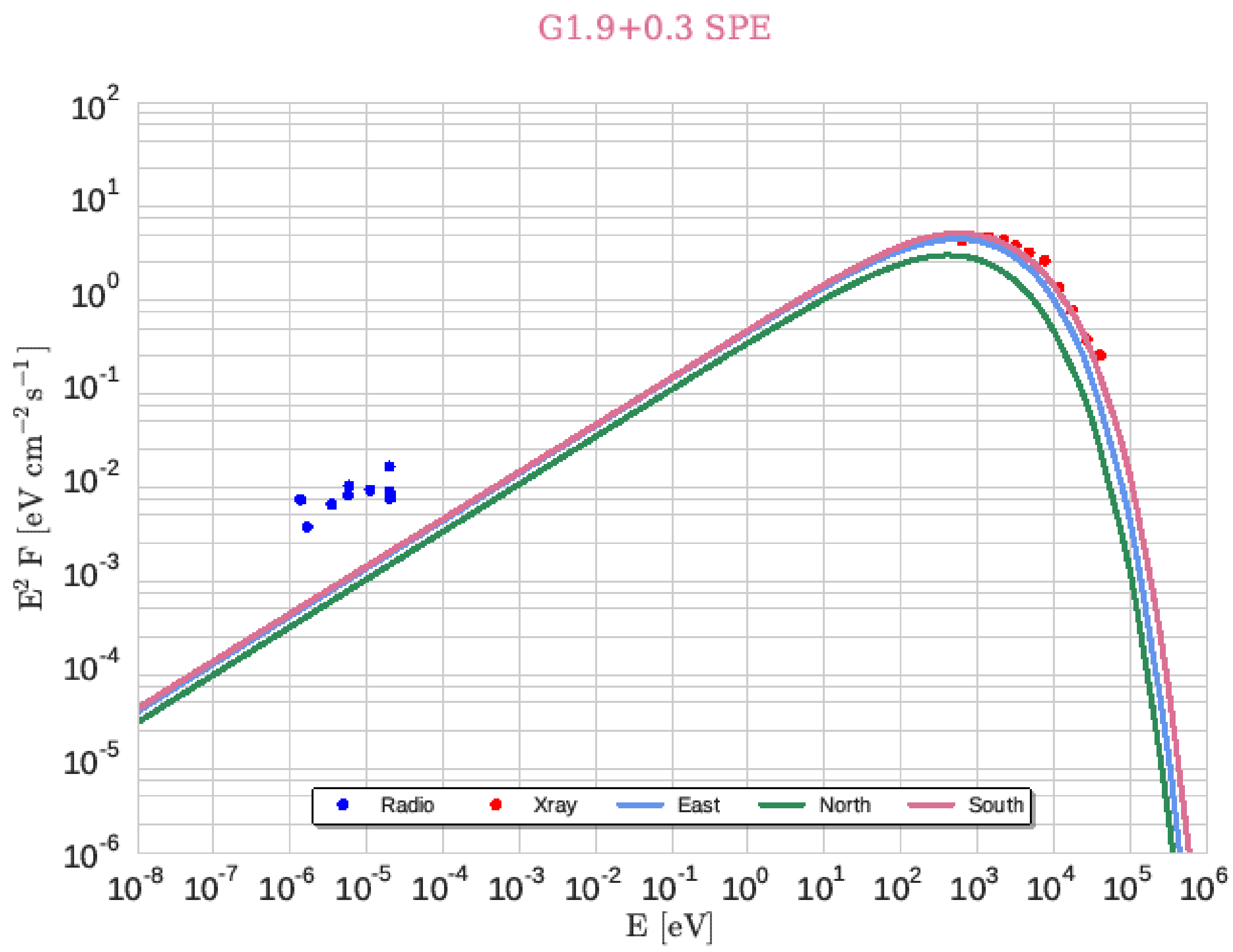
Radio asymmetrie

Expansion effect on Radio: Reverse shock



X-ray asymmetry

Asymmetric explosion energy



X-ray asymmetry

Asymmetric ejecta mass