

OBLIQUITY DEPENDENCE OF CR ACCELERATION IN SHOCKS

*MATTEO PAIS,
CHRISTOPH PFROMMER,
KRISTIAN EHLERT -
LEIBNIZ INSTITUT FÜR
ASTROPHYSIK POTSDAM (AIP)*

*RÜDIGER PAKMOR -
HEIDELBERG INSTITUTE FOR
THEORETICAL STUDIES (HITS)*

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SUPERNOVA REMNANTS (SNRs)

Types of SNRs:

- * shell SNRs;
- * composite (with a pulsar);
- * mixed-morphology remnants
(thermal X-ray enclosed in radio shell);

Phases of SNRs:

- * *(depend on the density of the ISM)*
- * free expansion (0 - 400 yrs);
- * **Sedov-Taylor phase (self-similar)
(400 - 30000 yrs);**
- * snowplough phase (30K yrs and beyond)



Image of SN 1006 (X-ray + optical + radio)

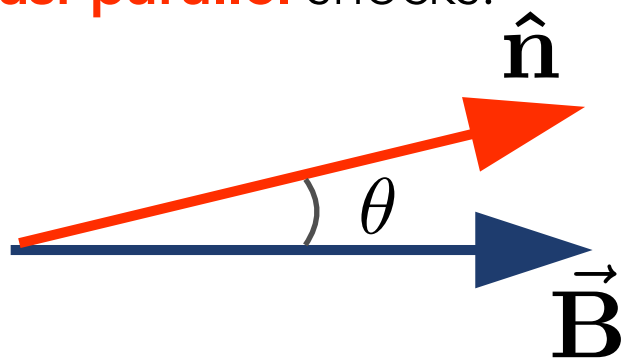
OBLIQUITY DEPENDENT SHOCK ACCELERATION

Diffusive shock acceleration (DSA) enables a small fraction of particles to gain energy:

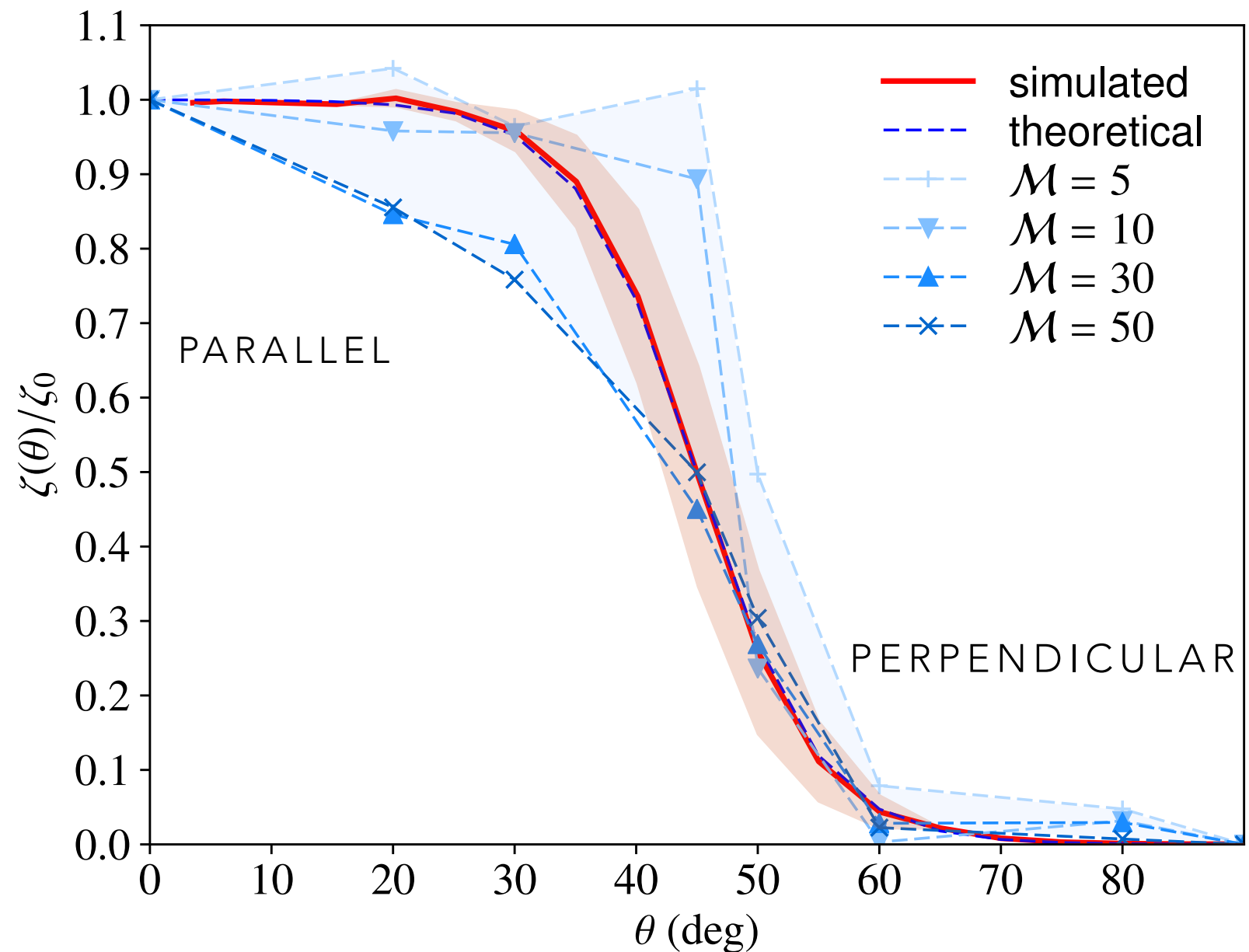
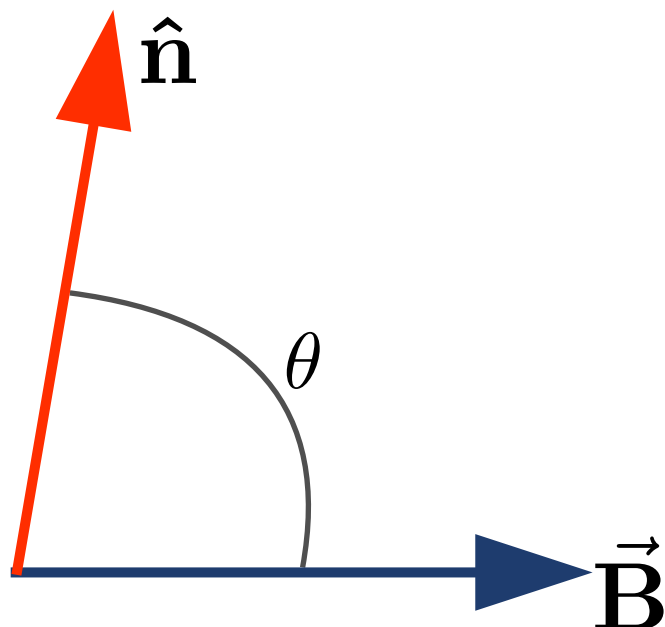
Efficiency:

$$\zeta = \frac{\epsilon_{\text{cr}}}{\epsilon_{\text{th}}}$$

Quasi-parallel shocks:

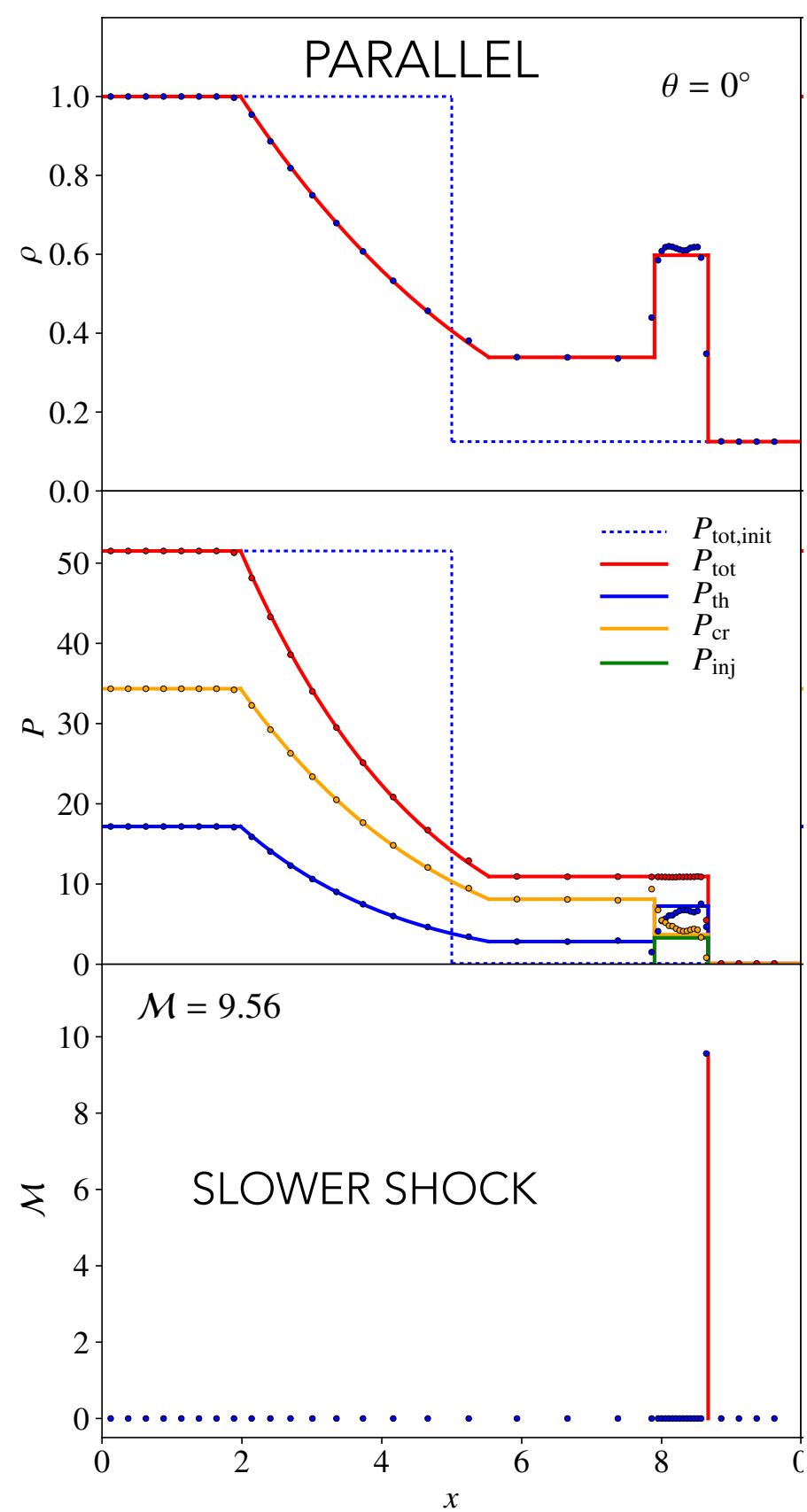


Quasi-perpendicular shocks:

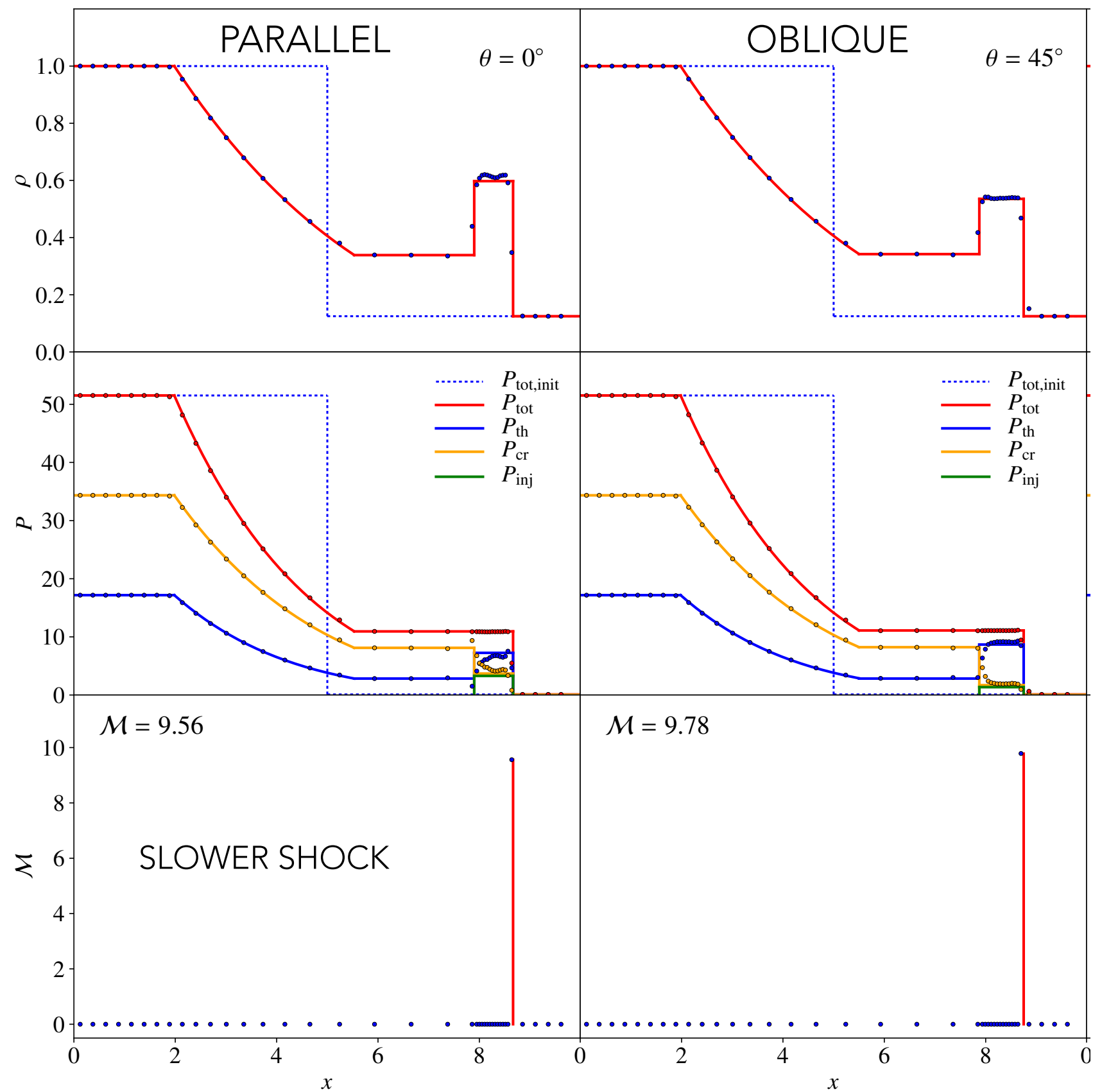


Modelled after Caprioli and Spitkovski (2014b)

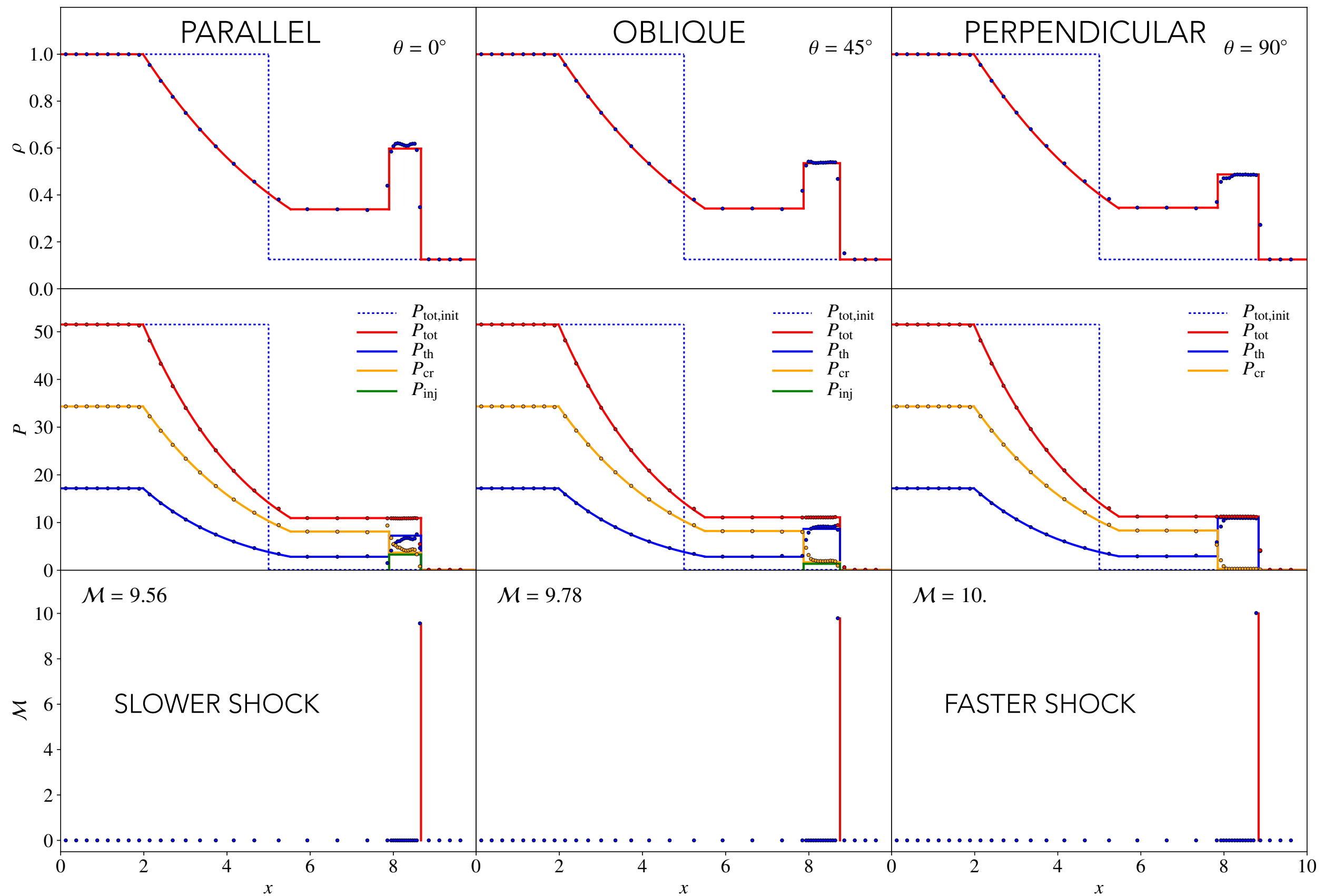
SHOCK-TUBE TESTS FOR OBLIQUITY-DEPENDENT DSA



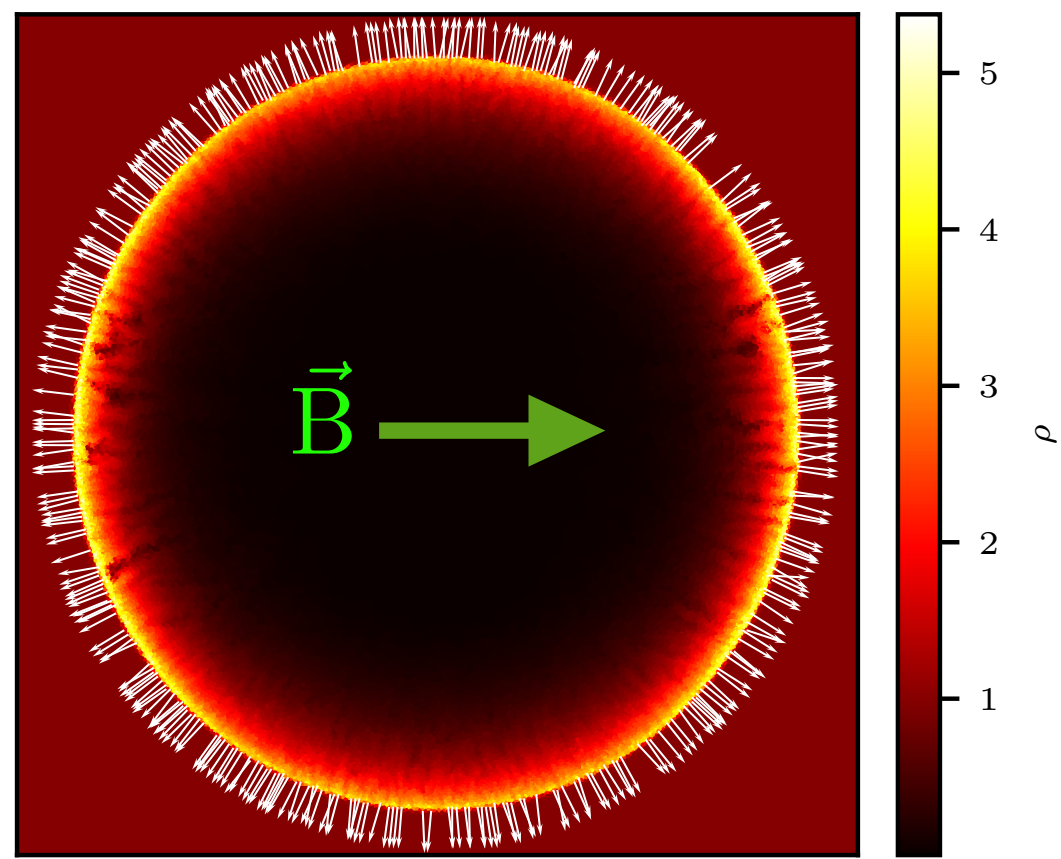
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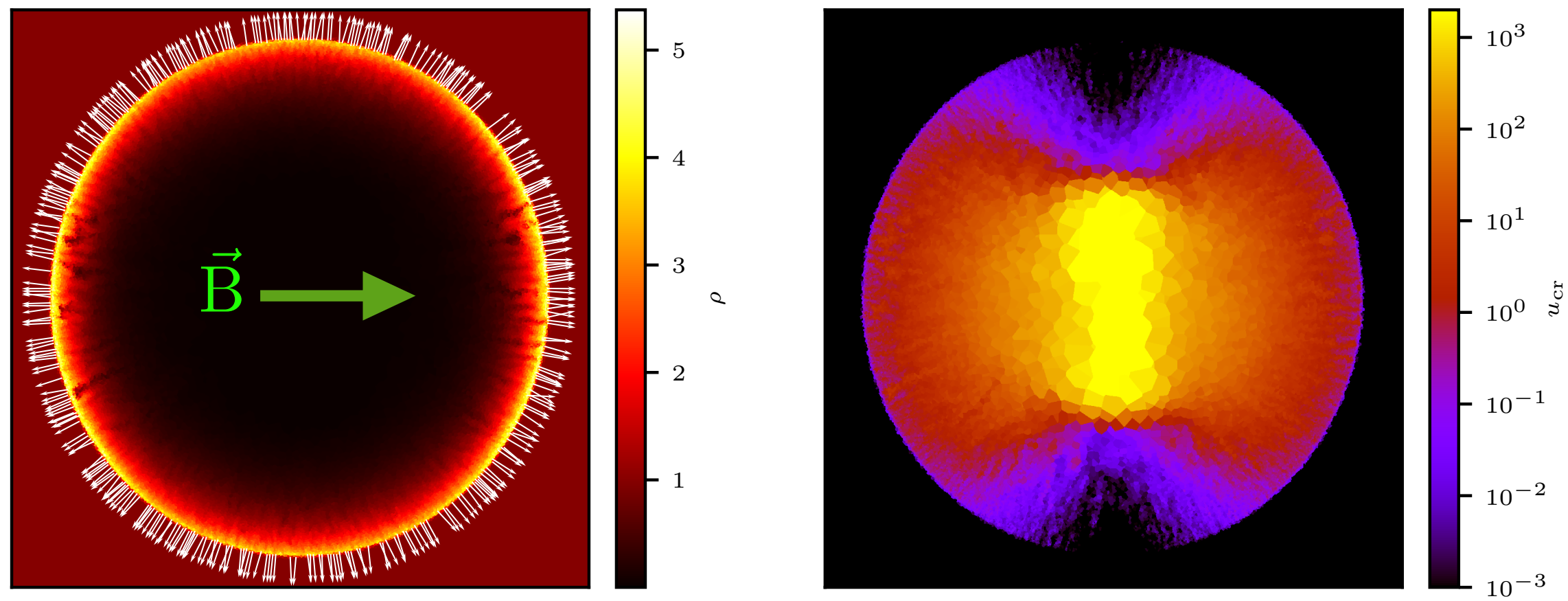
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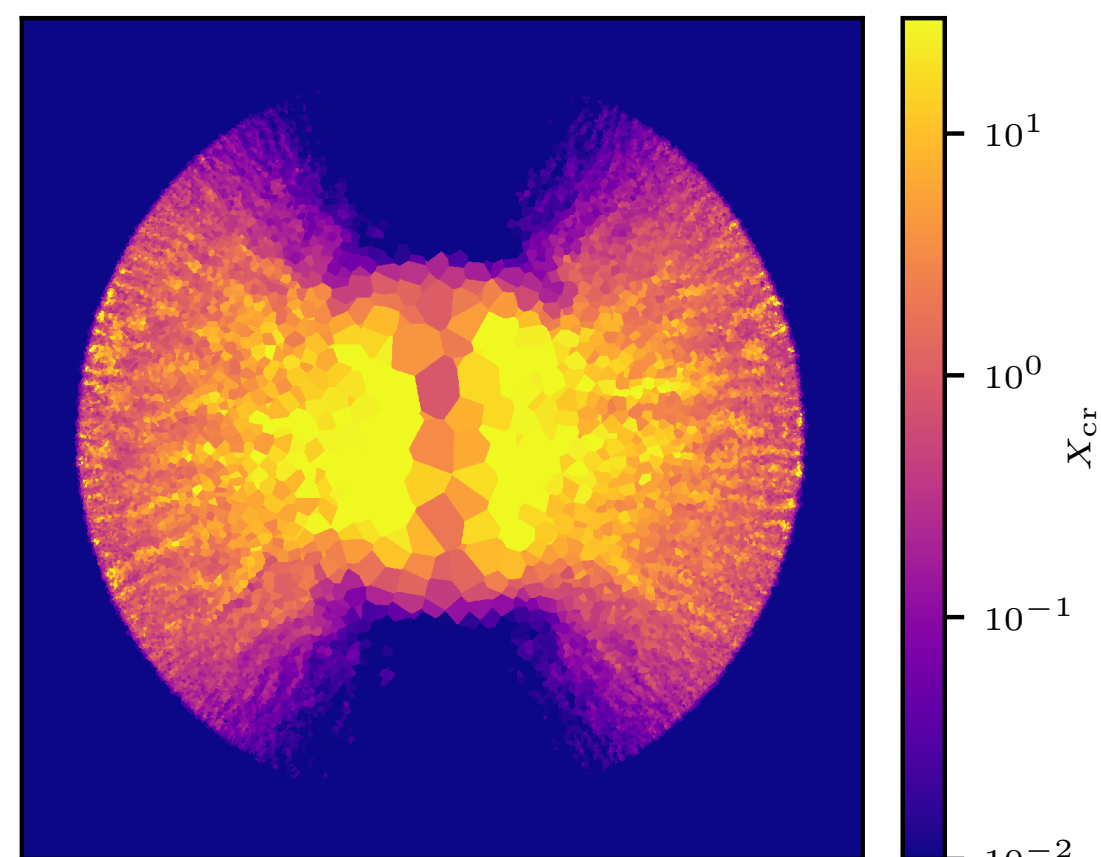
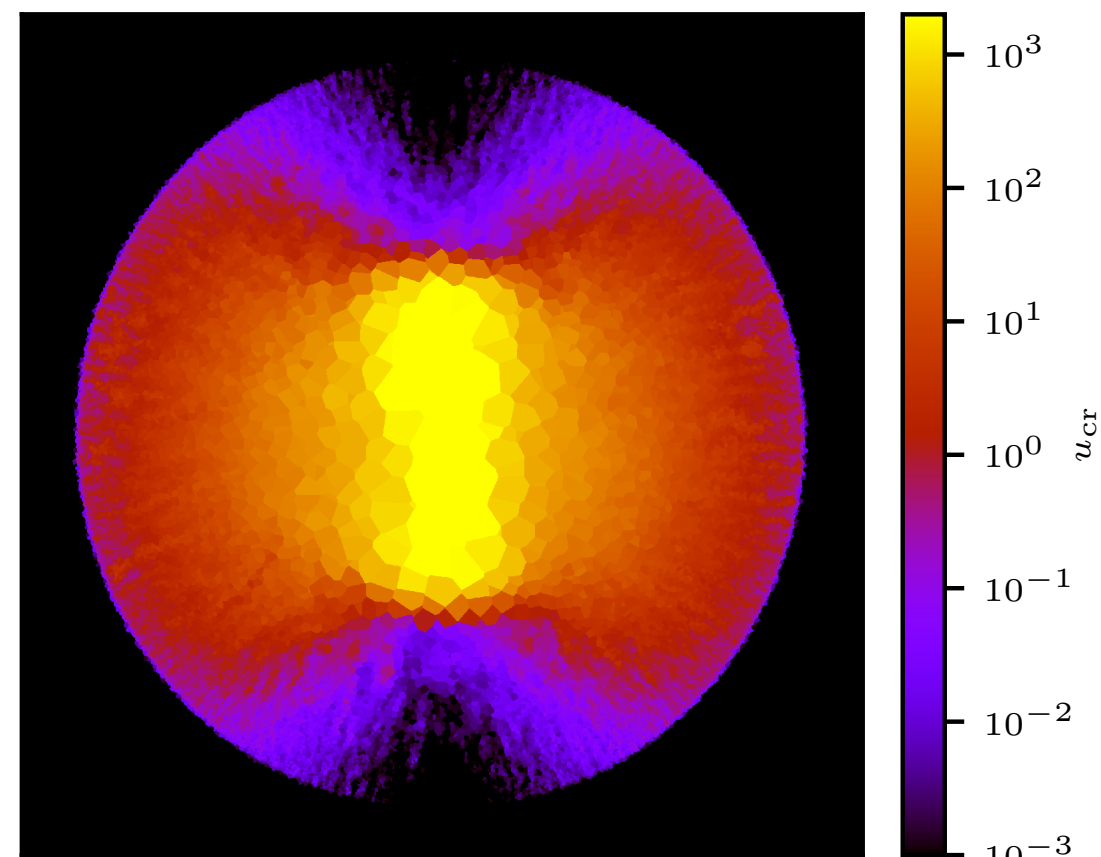
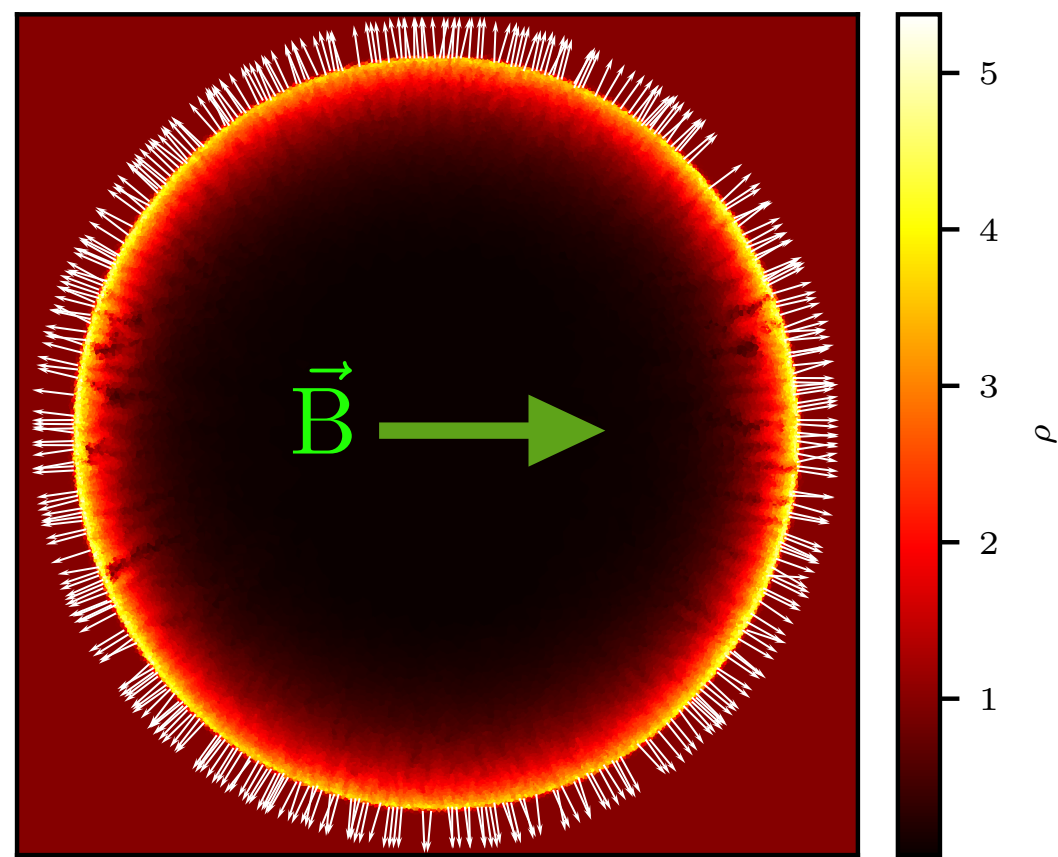
SNR - HOMOGENEOUS B FIELD (MAPS)



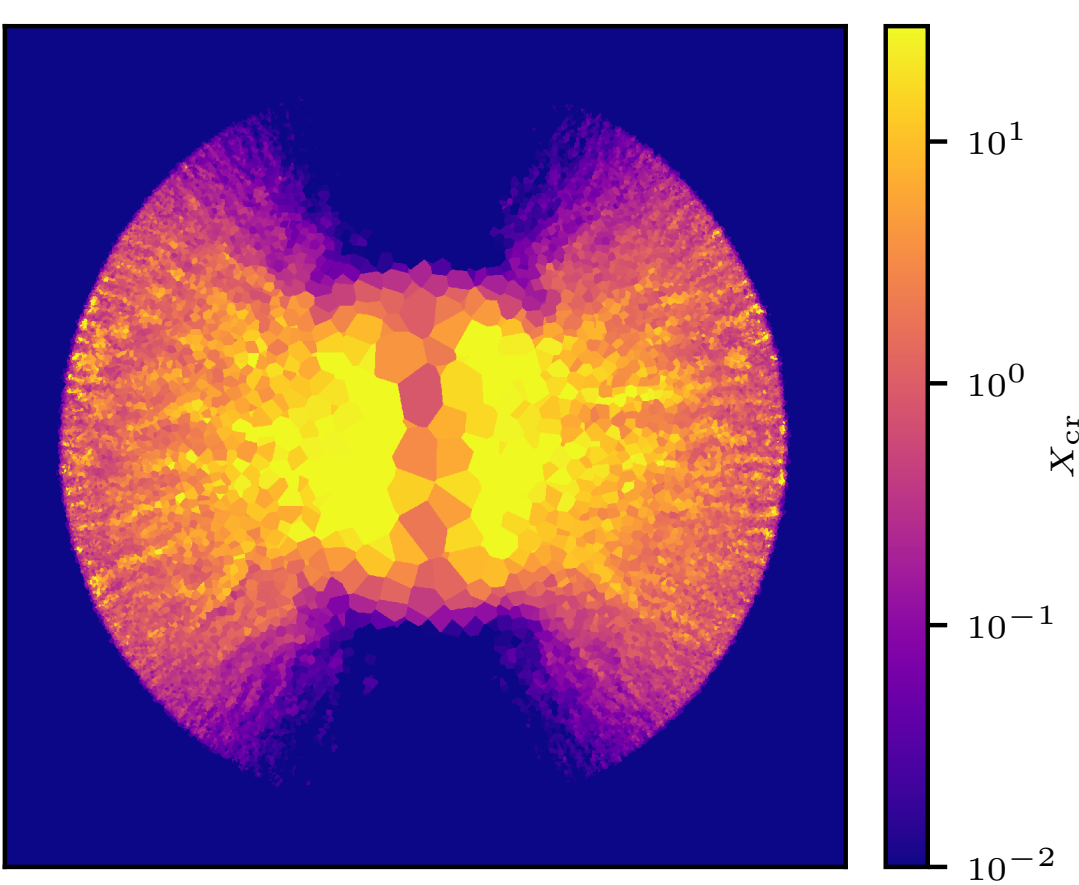
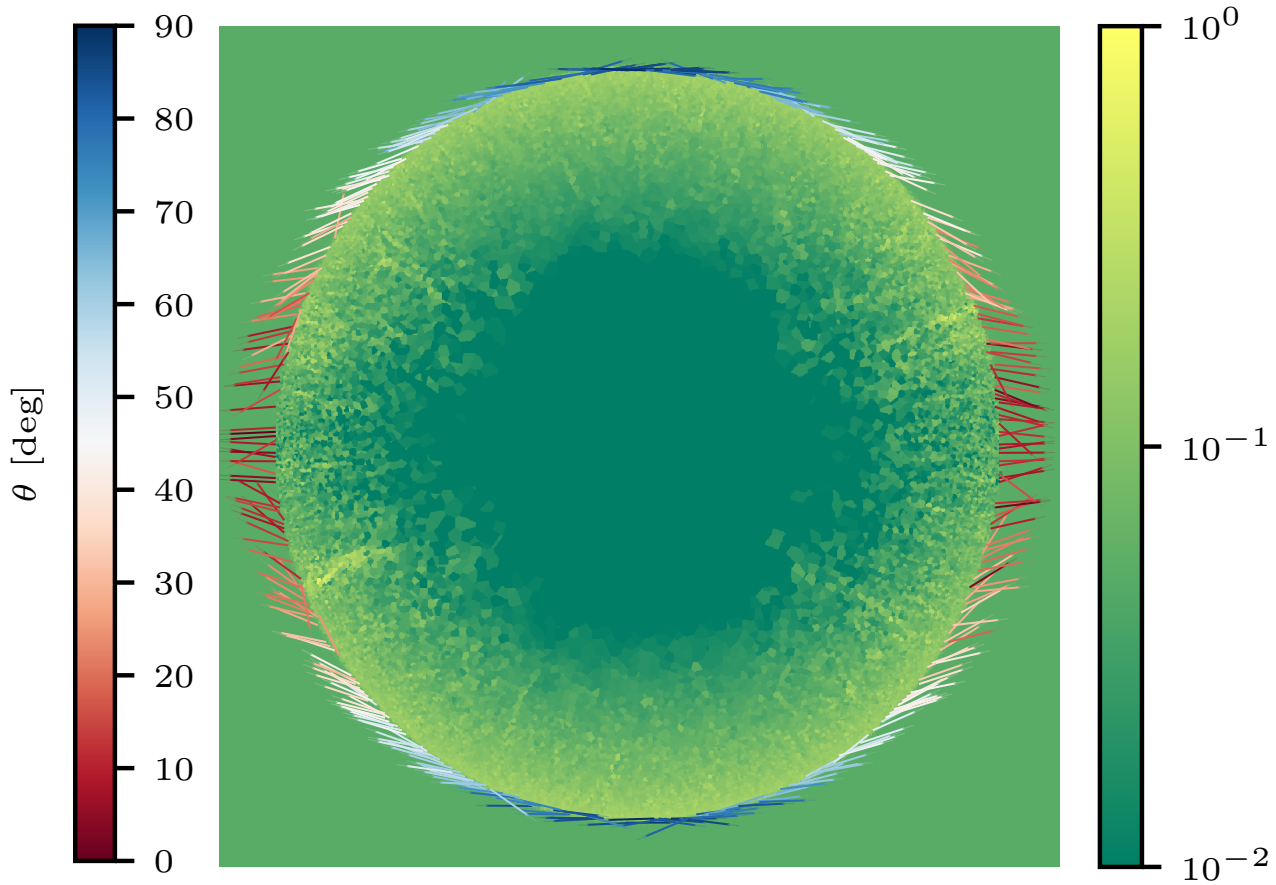
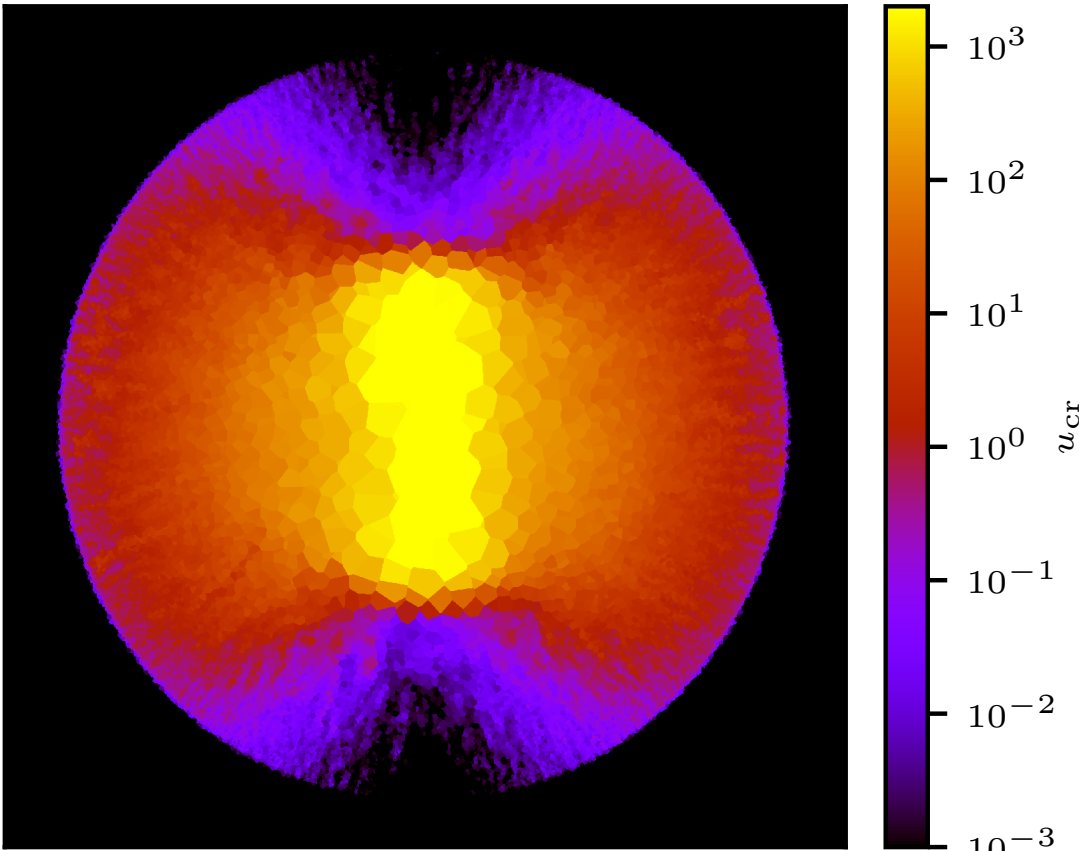
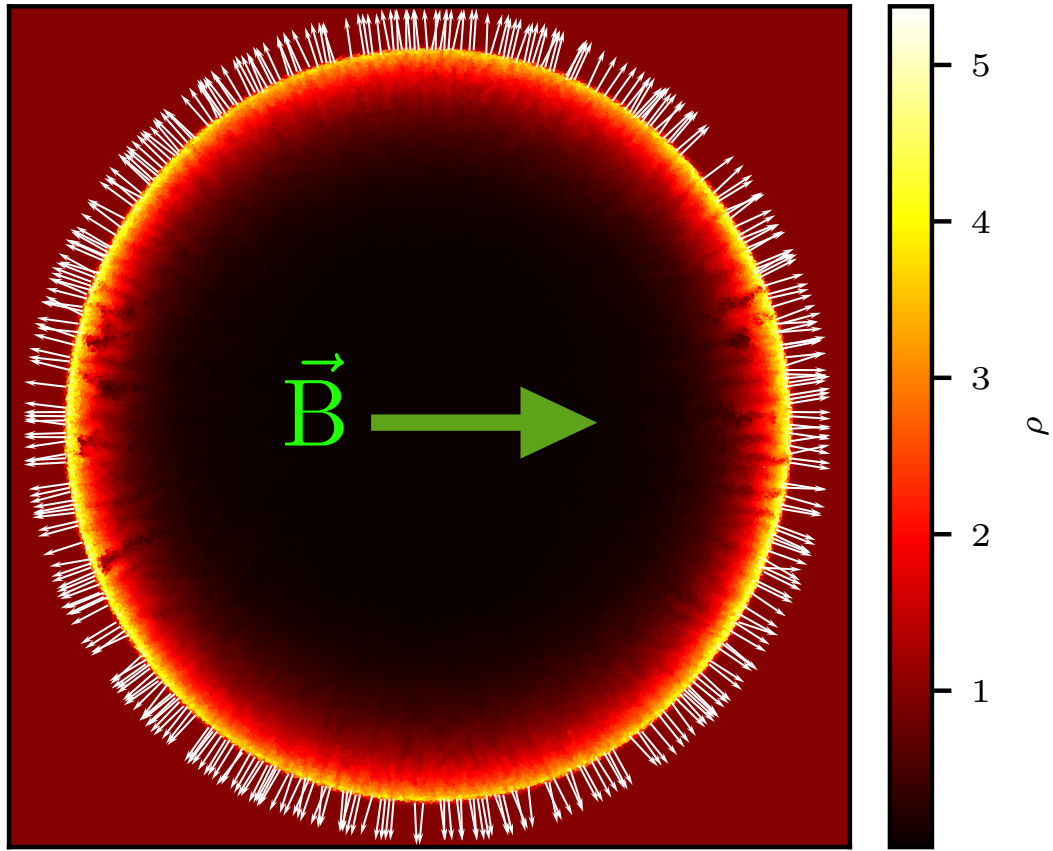
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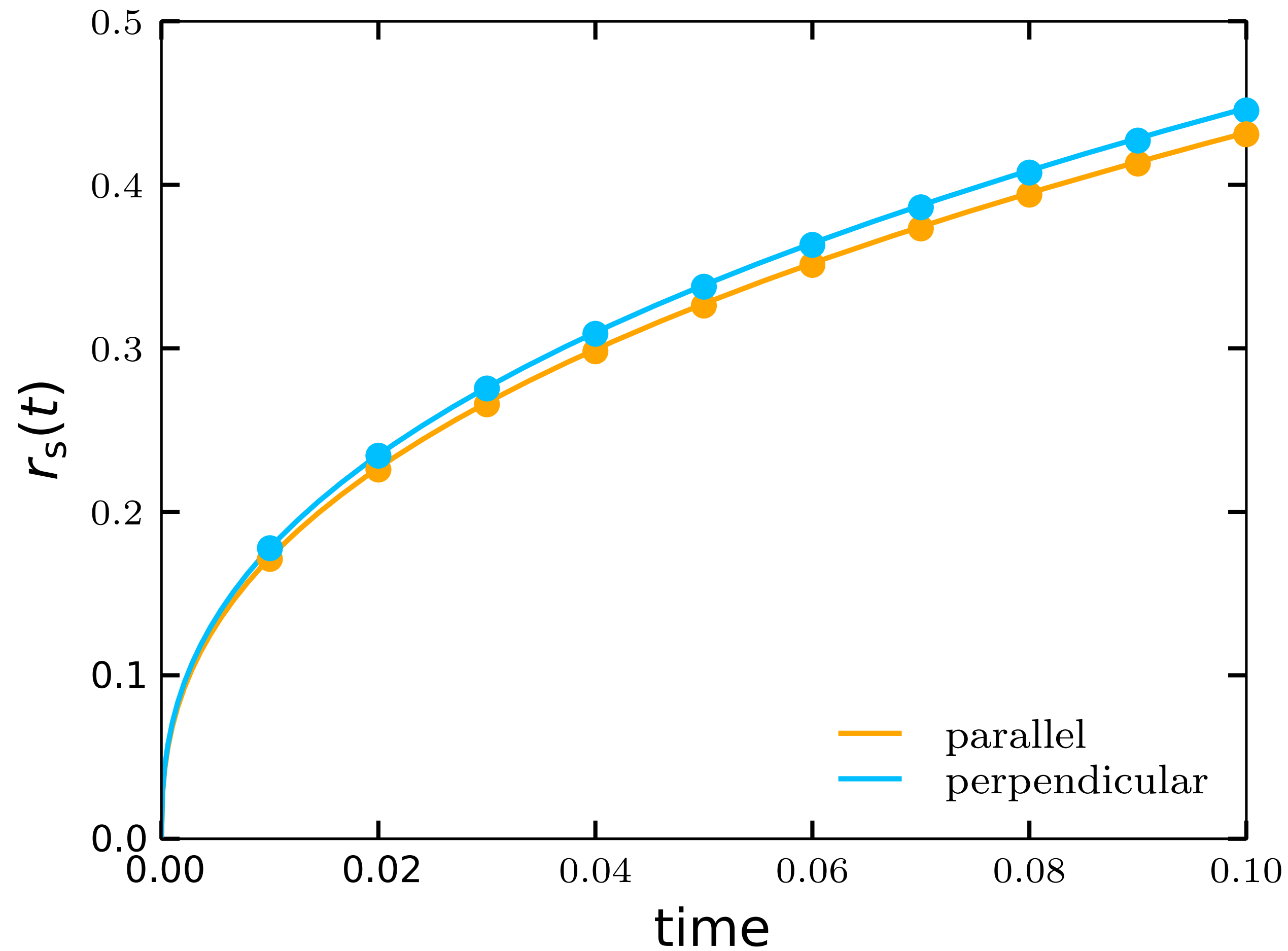
SNR - HOMOGENEOUS B FIELD (MAPS)



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SNR - RADIAL PROFILES AND EVOLUTION

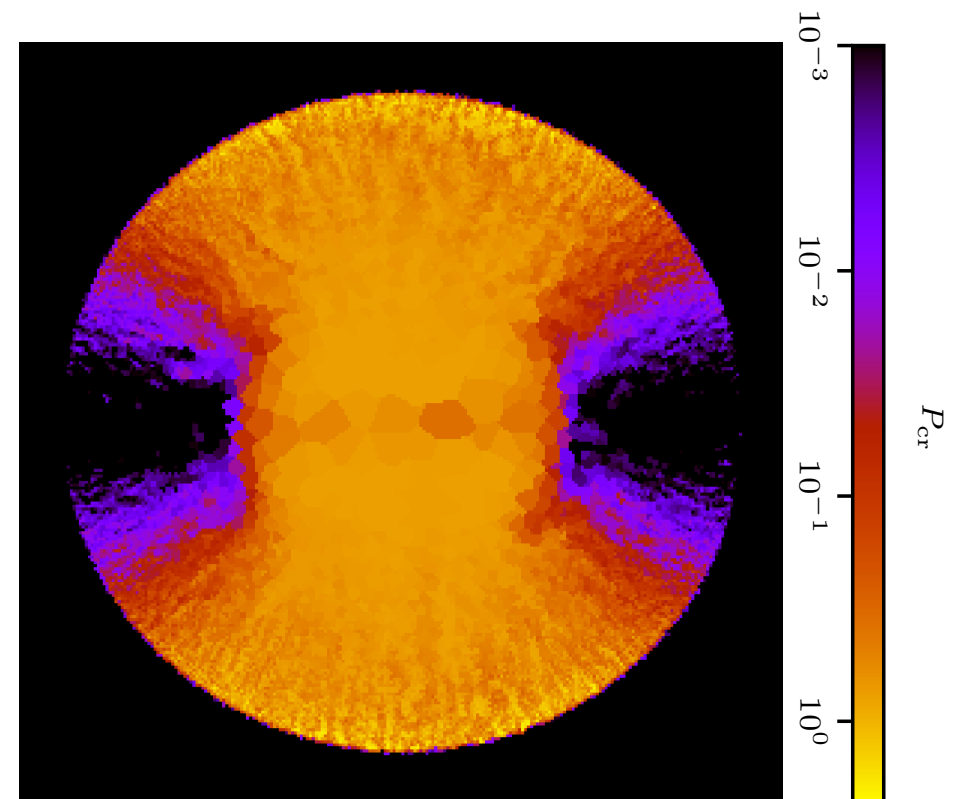
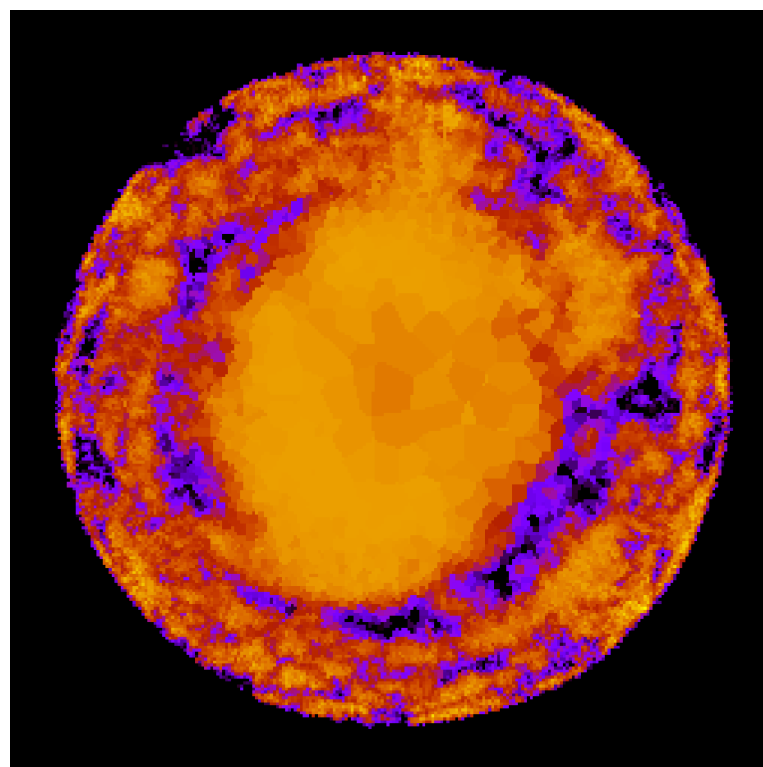
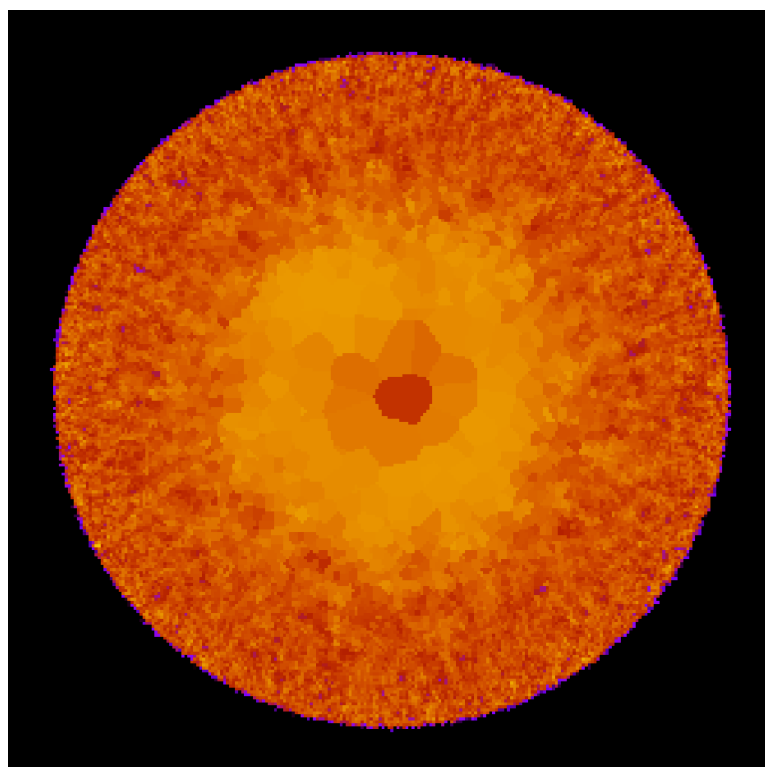
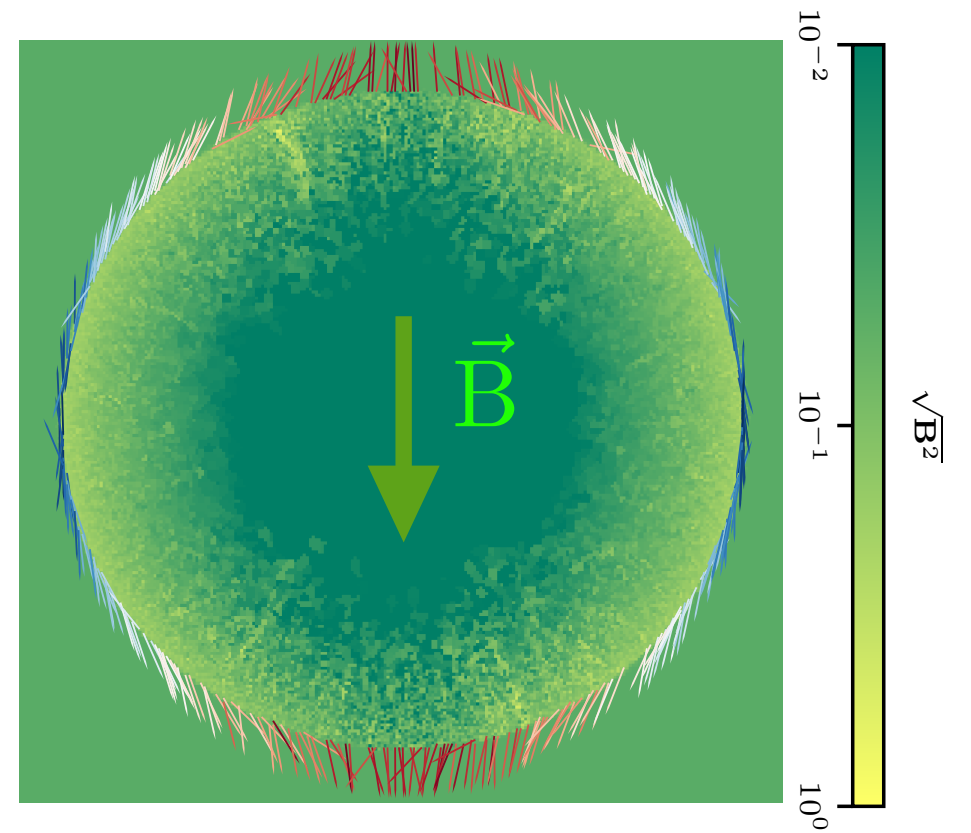
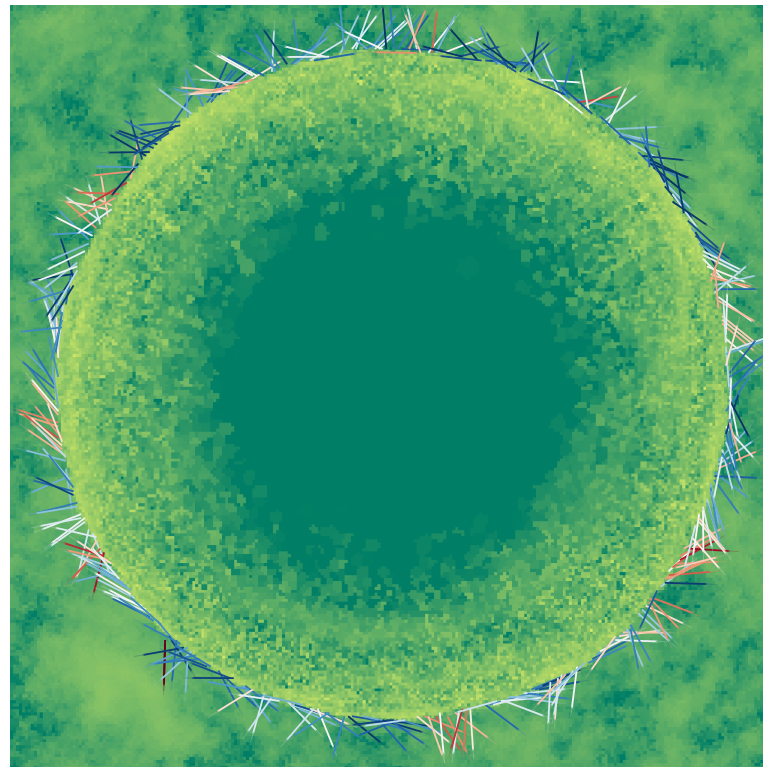
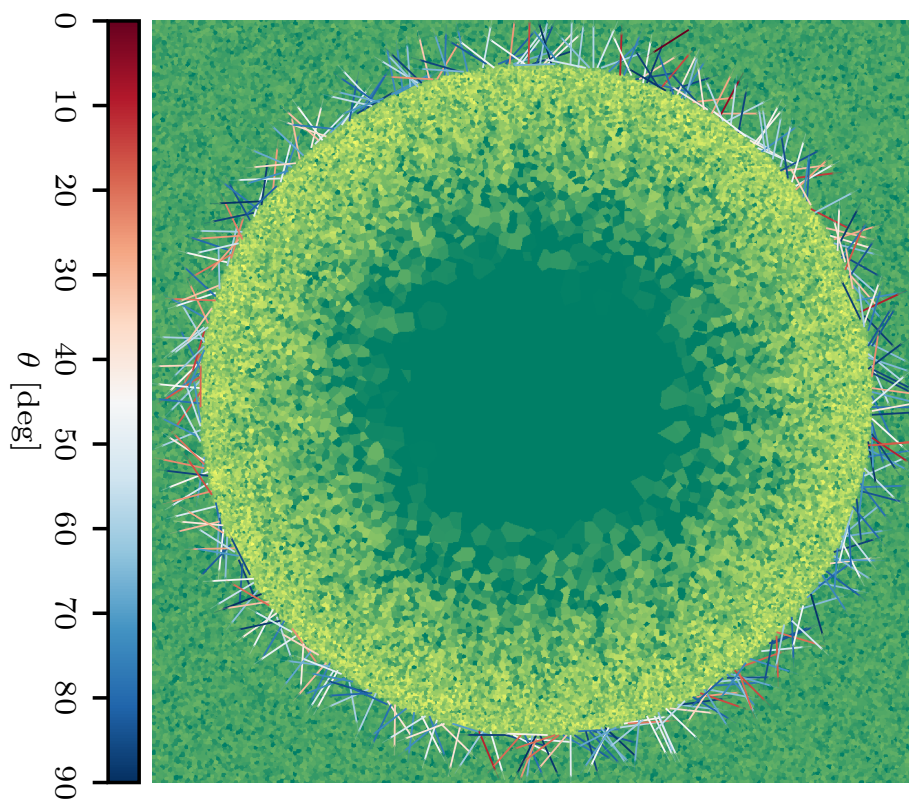


SNR - TURBULENT FIELD (MAPS)

$$\lambda_B = L/100$$

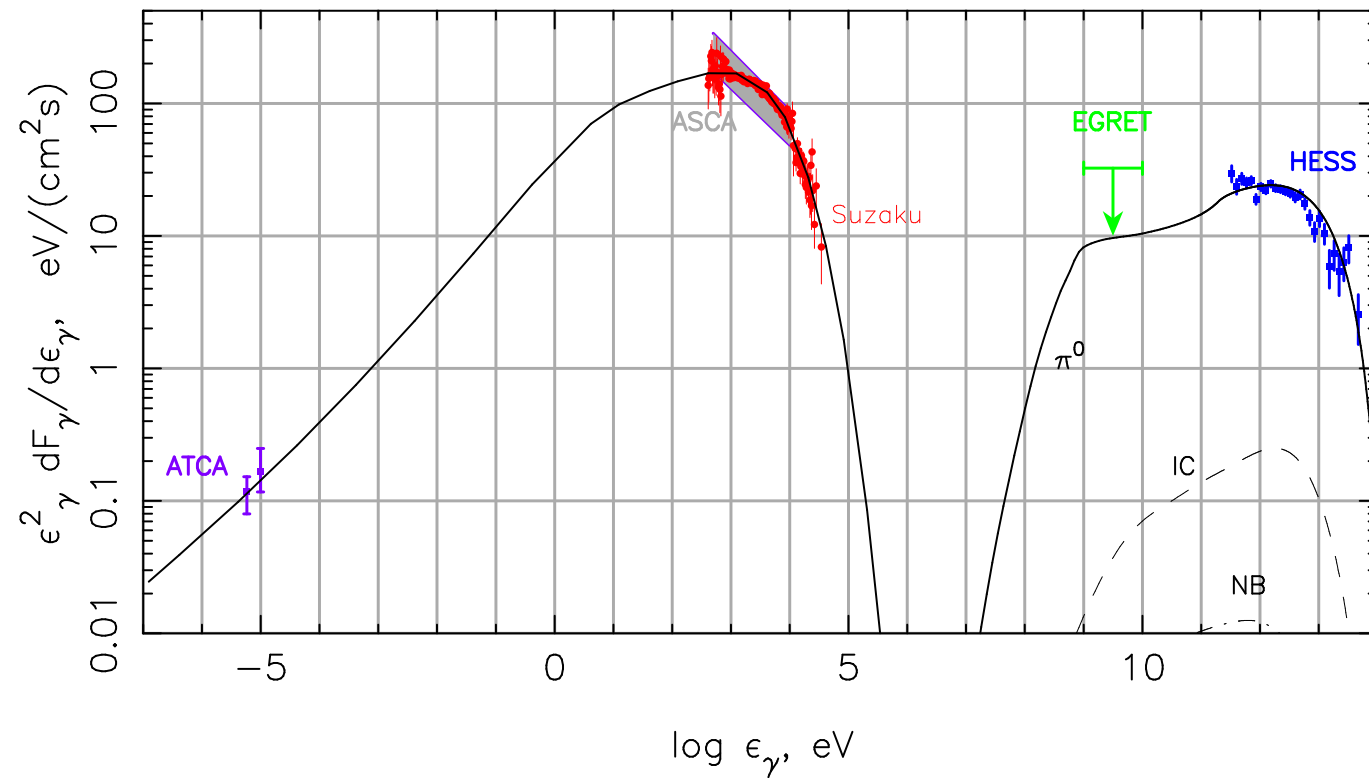
$$\lambda_B = L/2$$

homogeneous

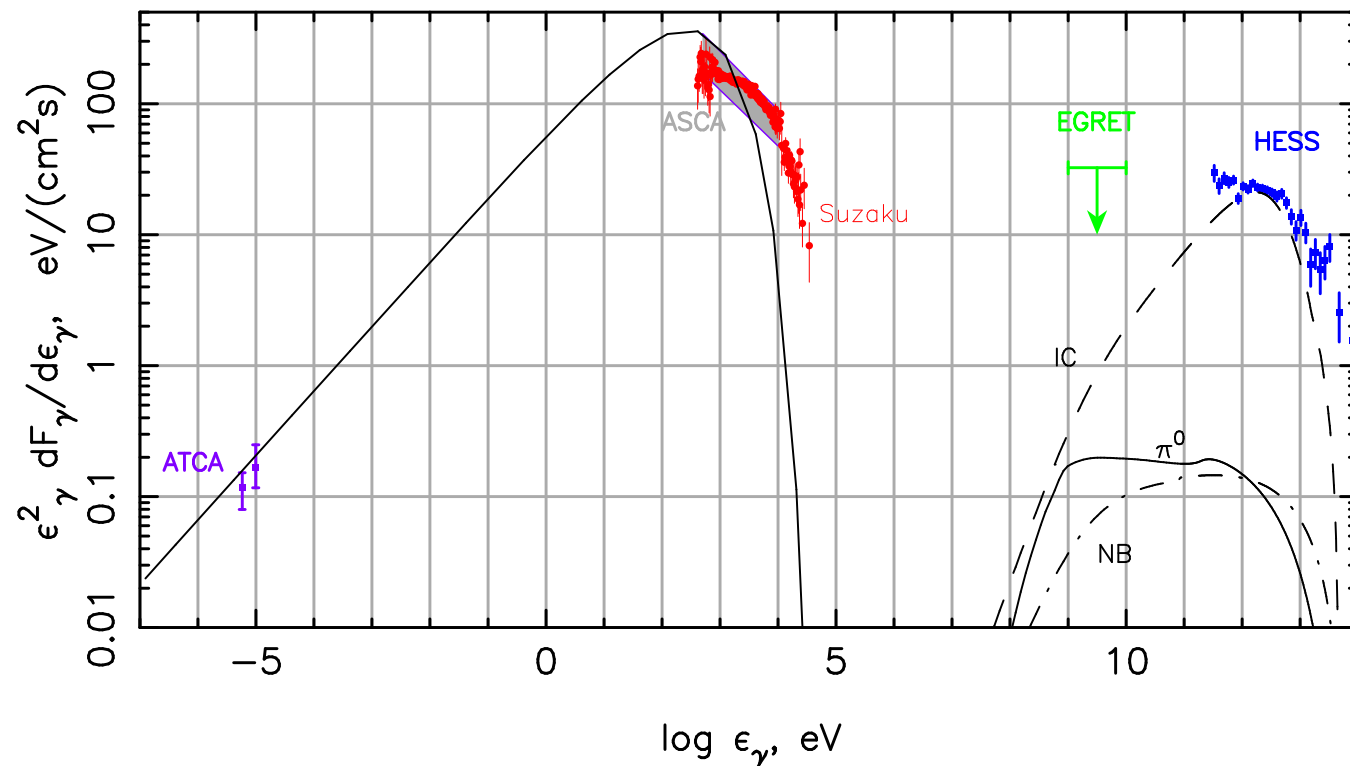
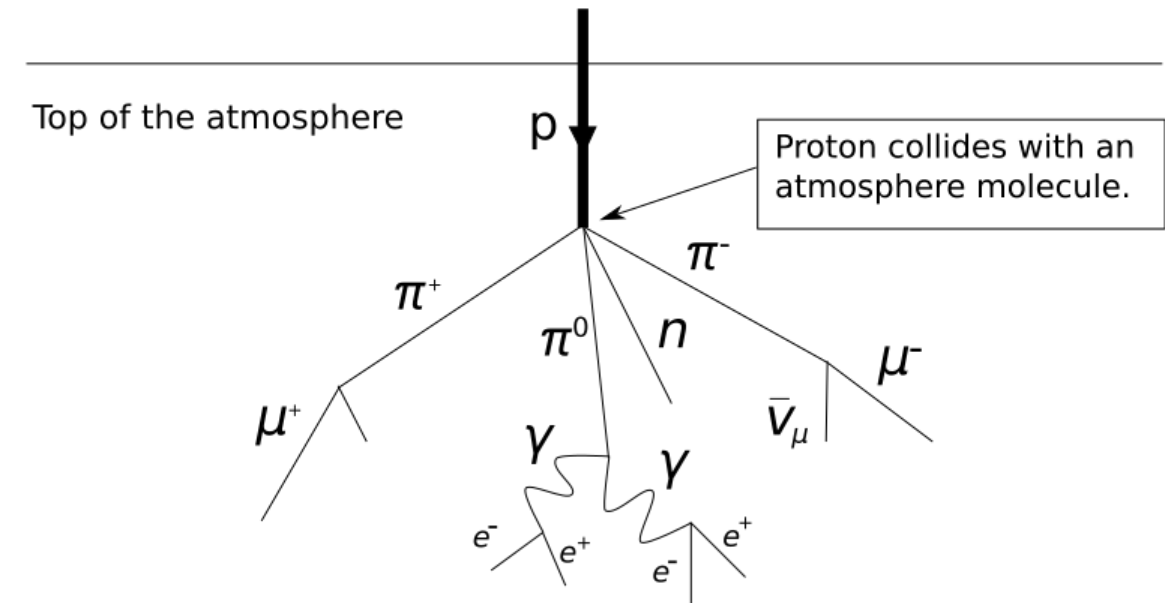


HADRONIC EMISSION FROM SNRs - γ -RAY MAPS

Two scenarios to describe the γ -ray emission from SNRs:



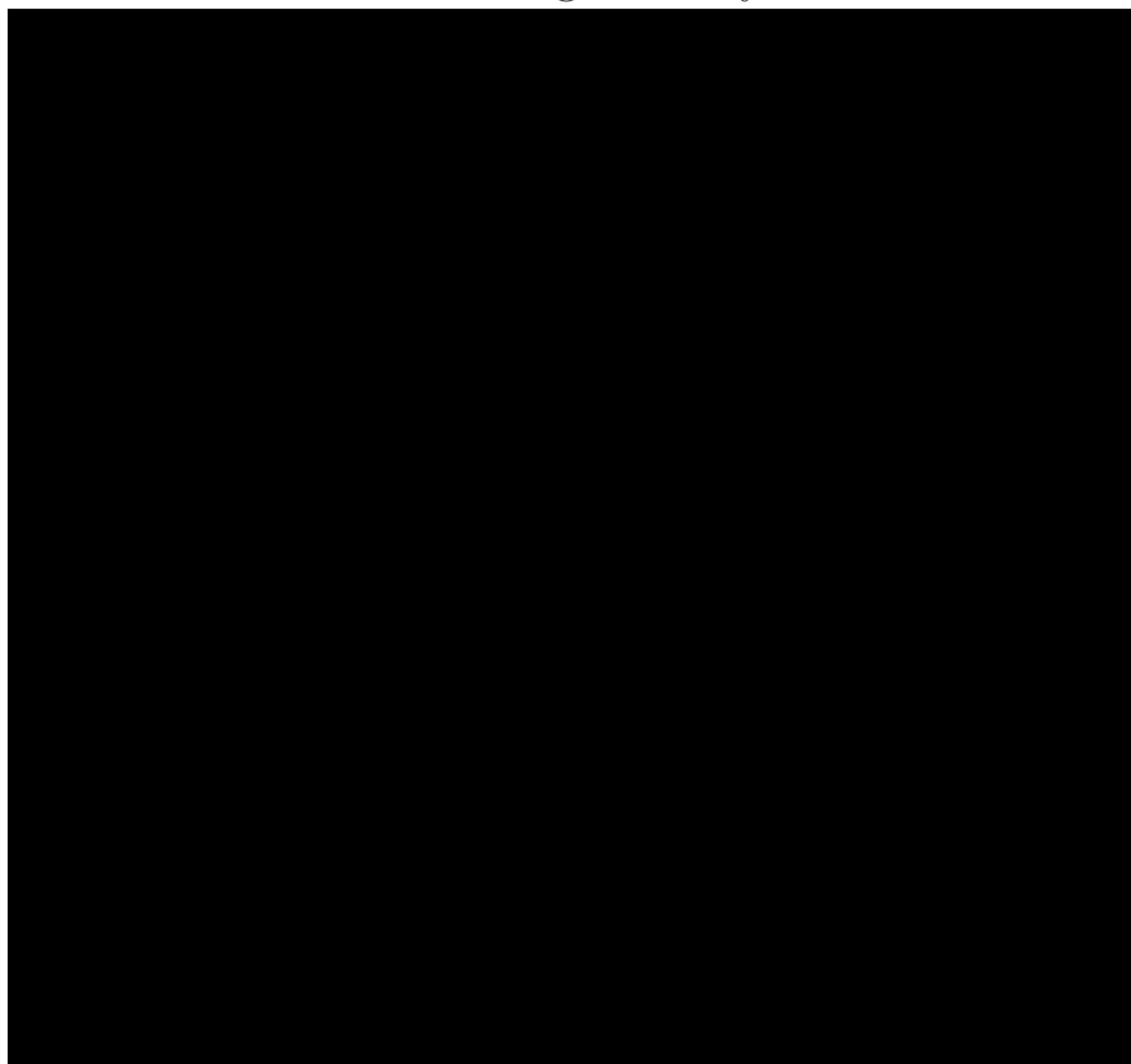
* Hadronic scenario (pion decay)



* Leptonic scenario (ICS + Bremsstrahlung)

credits: E.G. Berezhko and H.J. Völk (2008)

SN 1006 - Age: 0000 years

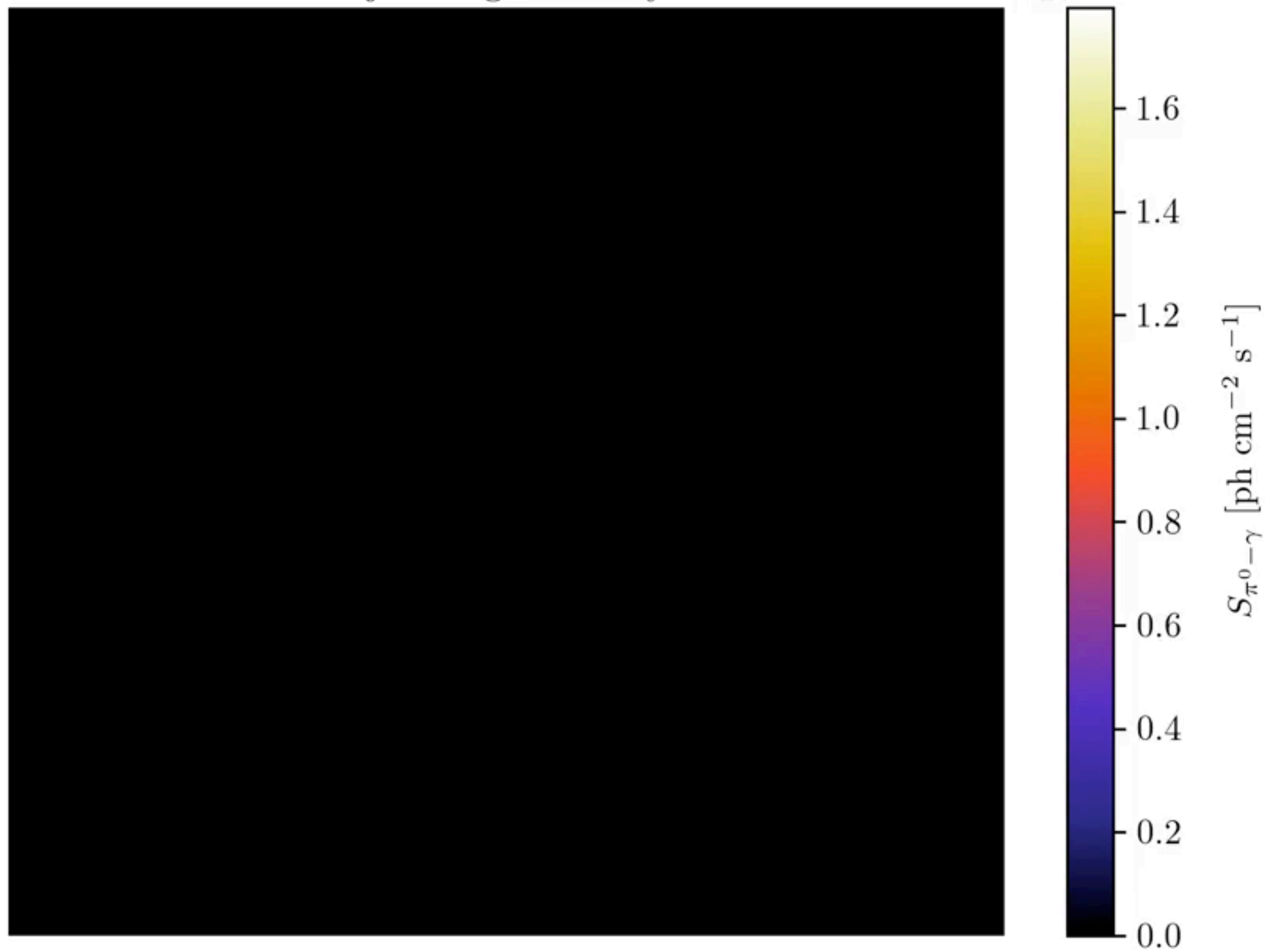


$\times 10^{-10}$

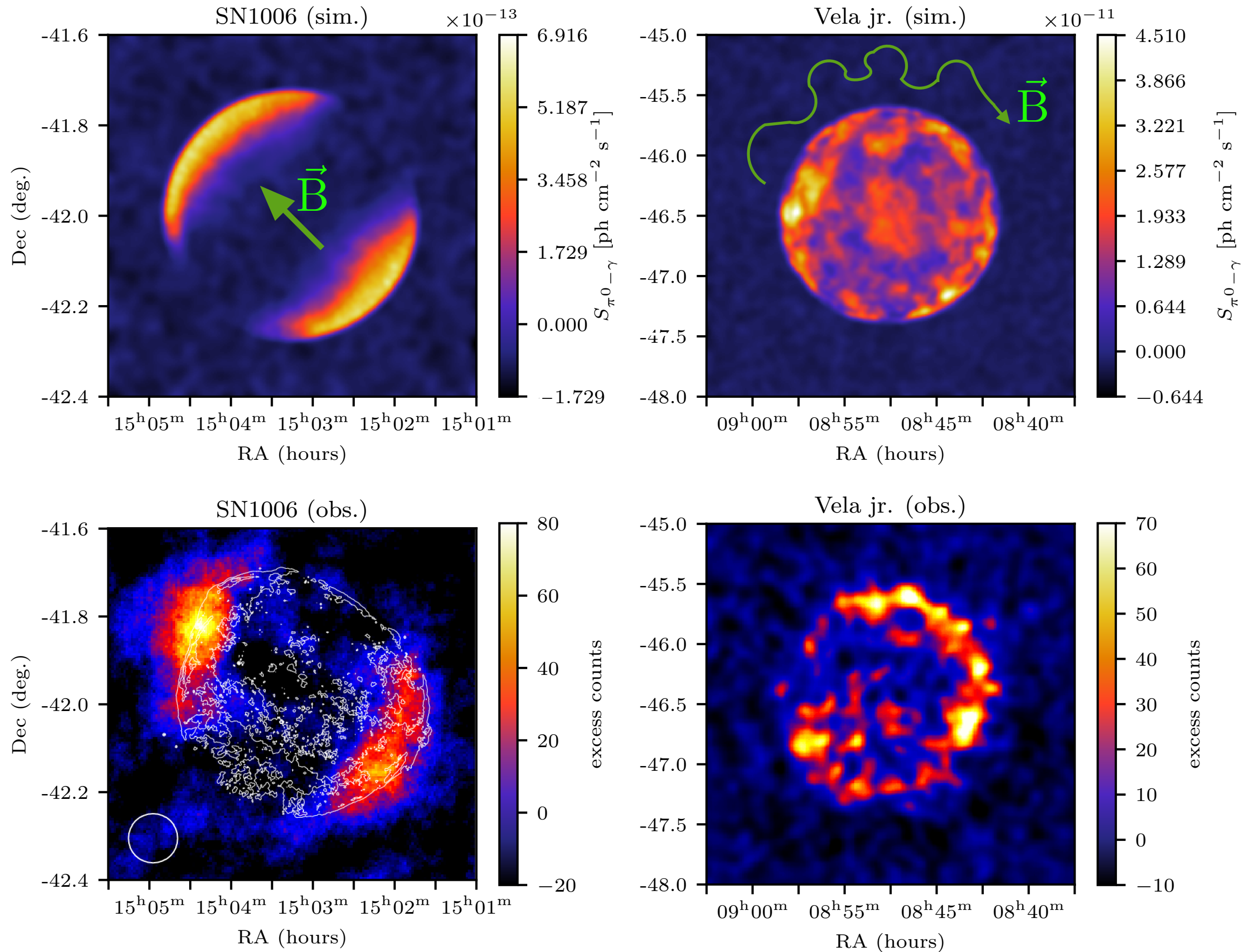
$S_{\pi^0-\gamma}$ [ph cm⁻² s⁻¹]

9
8
7
6
5
4
3
2
1
0

Vela jr. - Age: 0000 years



HADRONIC EMISSION FROM SNRs - γ -RAY MAPS



SUMMARY:

OBLIQUITY DEPENDENT SHOCK ACCELERATION:

- * average acceleration efficiency for SNRs is **~30%** of the maximum given efficiency;
- * **Morphology of gamma-ray emission** for SNR reproduced with obliquity-dependent DSA;
- * **Estimation of the magnetic correlation length λ_B from TeV gamma-ray maps.**

FUTURE:

- * more realistic model including density fluctuations and gradients for the ISM;