Fe K-alpha emission from the southwestern limb of SN 1006

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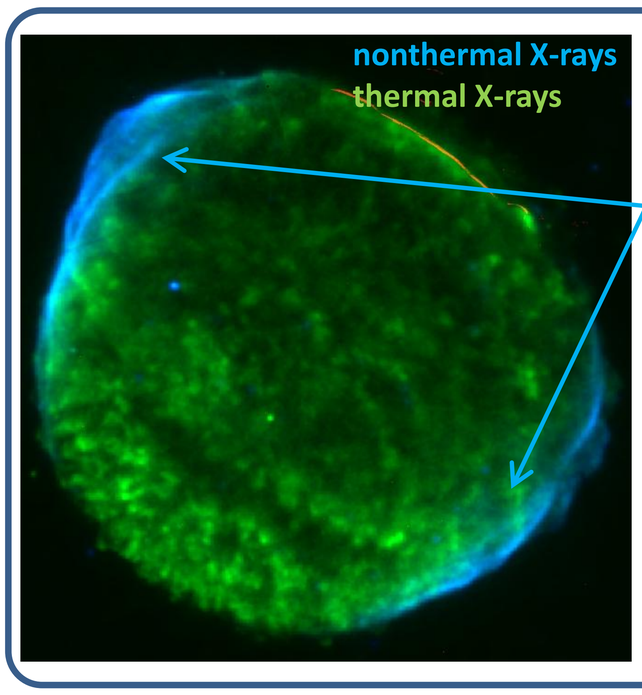
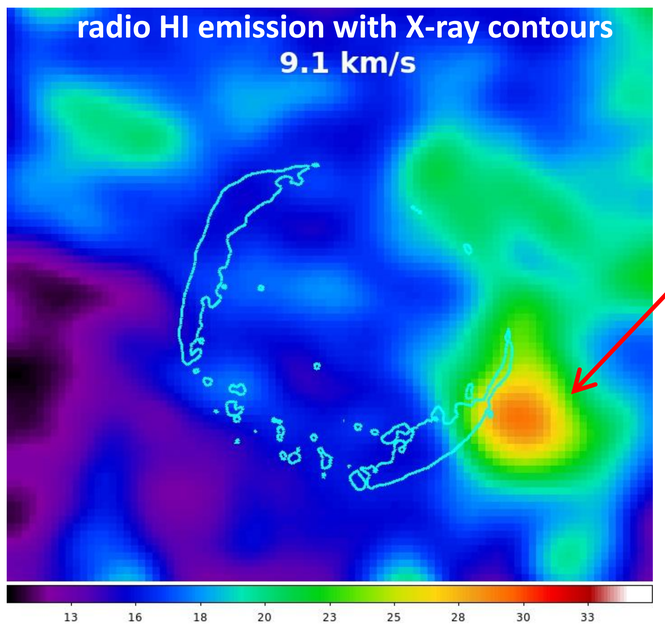
ABSTRACT

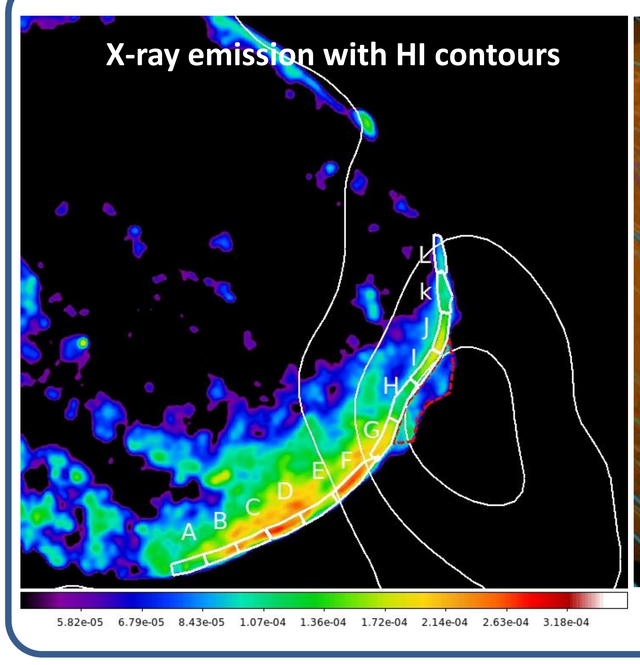
The bilateral supernova remnant **SN 1006** shows X-ray (and radio) synchrotron emission associated with ultrarelativistic electrons accelerated at its northeastern and southwestern limbs, which also emit in the GeV and TeV gamma-ray bands. **The southwestern limb is interacting with an atomic cloud** (~2 orders of magnitude denser than the ambient medium). We here present the analysis of a deep **NuSTAR** observation of the southwestern limb of SN 1006 which suggests the presence of **Fe K-alpha emission from the unshocked cloud,** likely associated with the diffusion of cosmic rays accelerated at the remnant shock front and propagating in the cloud core.

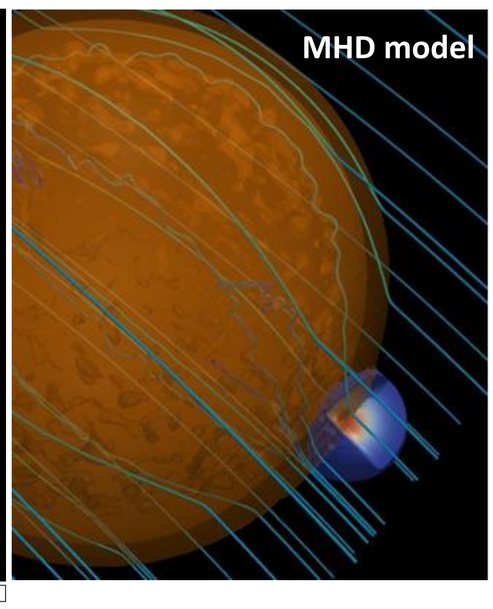


The **bilateral morphology** of **SN 1006** shows two opposed limbs which are bright in the radio band, in nonthermal X-rays, and in γ–rays, thus revealing regions with **efficient particle acceleration**, namely the northeastern and southwestern limbs

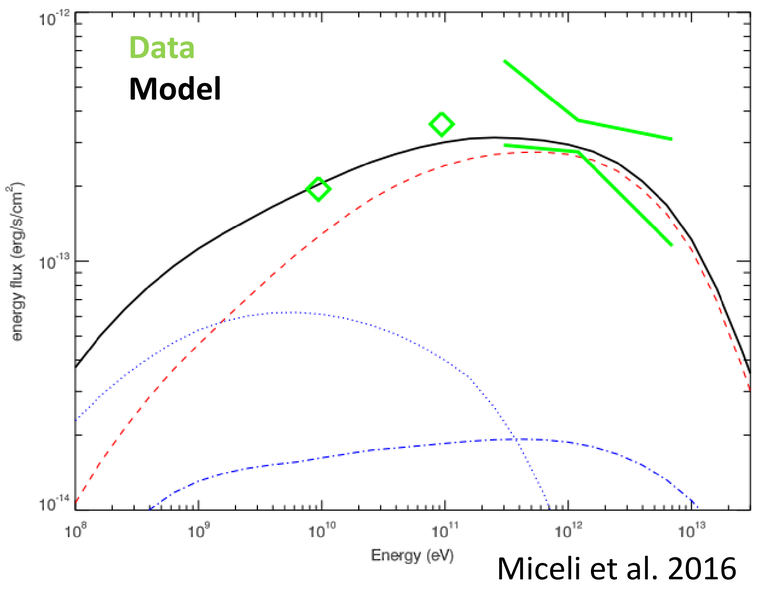


Though the remnant expands in a very tenuous environment (n~0.035 cm^{-3}, Miceli et al. 2012), it **interacts with an atomic cloud in its southwestern limb** (Miceli et al. 2014), which is a unique region with **efficient particle acceleration** and relatively **high ambient density**



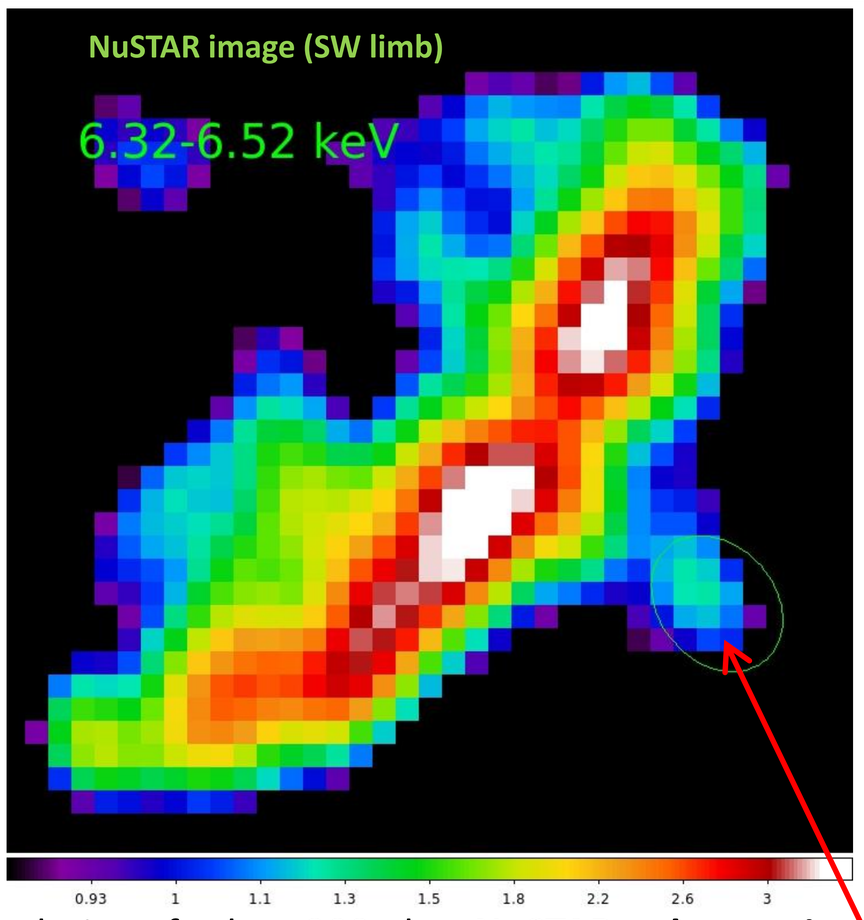


By combining **multi-λ data analysis** and dedicated **3D MHD modeling** we constrained the properties of the shock-cloud interaction **to infer its contribution to the GeV emission of the SW limb** (Miceli et al. 2016). Our predictions are in agreement with the latest Fermi-LAT results (Condon et al. 2017)

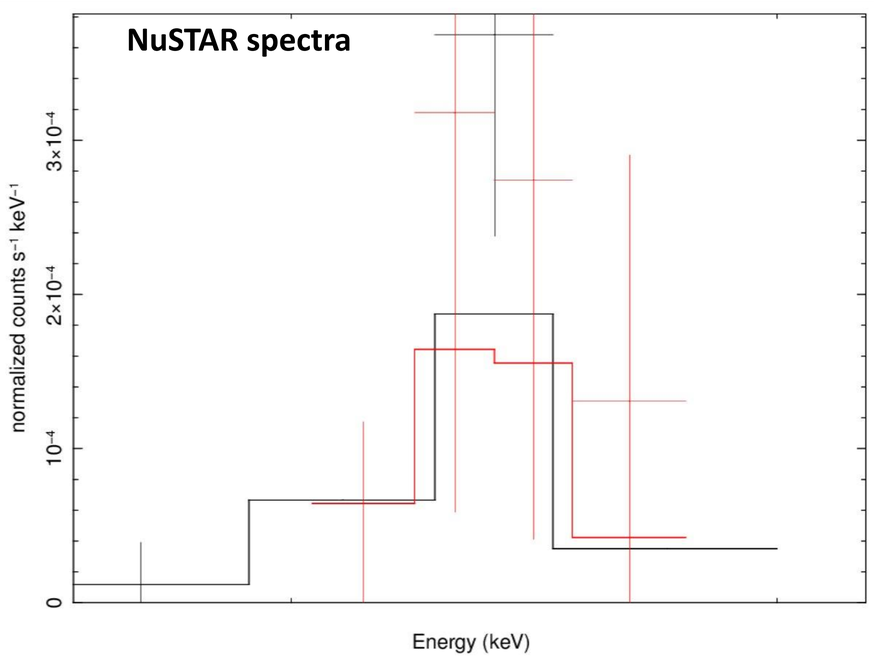


Miceli et al. 2016

Our results indicate that high energy hadrons accelerated at the SN 1006 shock front are interacting with the atomic cloud. We then expect that the low energy tail of the hadron distribution can produce the Fe fluorescence line while propagating through the cloud



The analysis of the 200 ks **NuSTAR observation** of the southwestern limb of SN 1006 reveals the presence of a **bright spot** in the Fe K-alpha energy band **at the position of the unshocked atomic cloud**



The **NuSTAR spectrum of the bright spot** shows an excess at ~6.4 keV. The combined analysis of the NuSTAR, Suzaku and XMM-Newton observations of the region provides a **detection of the Fe K-alpha emission line with a >3 σ confidence**

We verified that **the Fe K-alpha flux is that expected by assuming the hadron energy estimated in Miceli et al. 2016** for a cloud density of ~ 3 cm^{-3} (which is in agreement with HI data and our MHD simulations)

Further studies will allow us to better constrain the shape (by linking information from X-rays and γ-rays) and total energy of the distribution of hadrons accelerated at the shock front of SN 1006, to obtain information on CR acceleration in supernova remnants