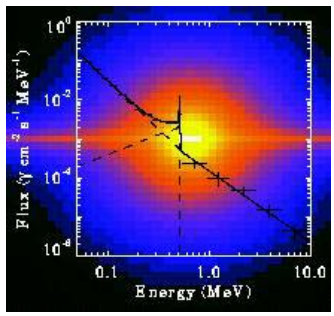
e^+ Annihilation in the Galaxy

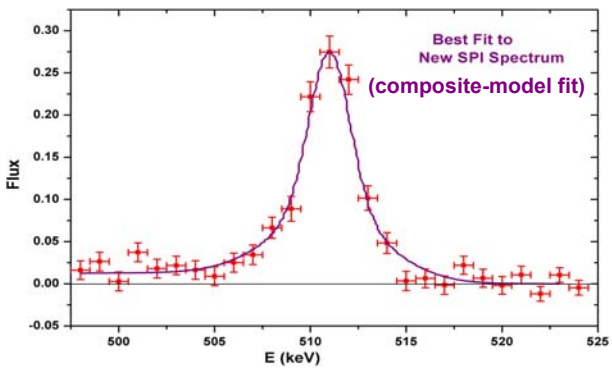
The annihilation of positrons ejected from various sources into the interstellar medium occurs under unknown conditions of temperature and density. These, however, translate into the shape of the gamma-ray emission spectum. INTEGRAL/SPI can resolve spectral detail and thus help clarify e^+ transport from its sources and the conditions of annihilation.

The sources of positrons in the Galaxy are a composite of nucleosynthesis events (novae, supernovae) and compact sources such as pulsars and microquasars. After ejection from their sources, positrons preferentially annihilate only after they have been slowed down and thermalized, colliding with electrons either bound in atoms, or on grain surfaces, or free within the ISM. These different reactions paths for annihilation involve different momentum balance within the final annihilation process, hence different shapes of the 511 keV line emitted from the two-photon annihilations. In comparison, the three-photon annihilations carry a less specific signature through their broad continuum, extending downward from 511 keV over several hundred keV, although the line-to-continuum ratio provides an important diagnostic.

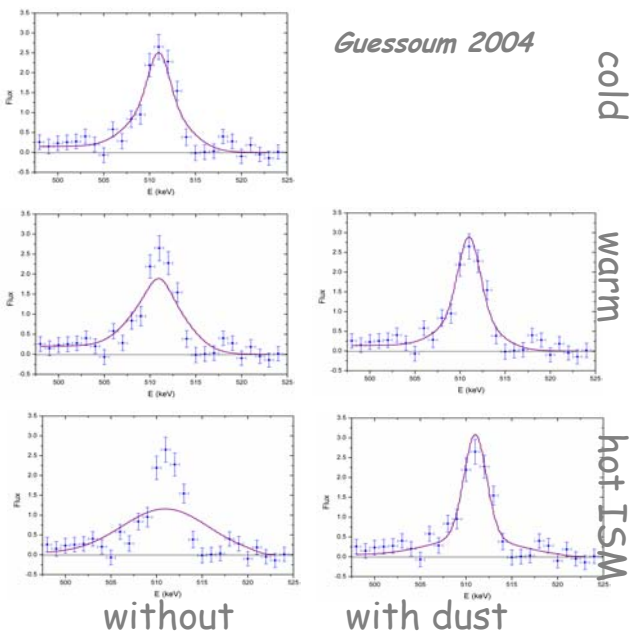


Annihilation emission spectrum, as known before INTEGRAL from OSSE on the Compton Observatory (superimposed onto their best-fitting image, color)

The expected different shapes of the annihilation lines for the different processes, i.e., in hot, intermediate, and cold interstellar medium environments, and with free atoms or on the surface of interstellar dust grains, have been determined from simulations. None of the single processes can produce a line shape as observed. When a multi-component model is adapted to the measurements, it is evident that dust grains play a significant role. No clear statement on the temperature of the environment is possible yet.



With INTEGRAL/SPI, the shape of the 511 keV line has been measured with great precision, even from the first year of observing (the mission will last >6 years). The line is clearly broadened beyond the instrumental resolution. Its shape does not represent any known or obvious profile, in particular no simple Gaussian.



References:
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• Jean P., Knödlseder J., Lonjou V., et al.: A&A 407, L55 (2003)
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