SPI measurement of the Galactic diffuse soft gamma ray continuum

Galactic emission has been observed from keV to MeV by various instruments (ASCA, RXTE, OSSE, COMPTEL, CHANDRA).

The emission is interpreted as the superposition of a diffuse emission resulting from interstellar processes and point sources contribution.

Investigation of the soft gamma-ray spectrum is necessary to determine the dominant particle acceleration processes.

But : Lack of imaging and high sensitivity instruments did not allow for clear estimate of the contribution from sources relatively to diffuse

SPI has a sufficient imaging capabilities combined with a high sensitivity above 100 keV to estimate self consistently the ratio of diffuse to point sources emission.

Status on soft gamma ray continuum before INTEGRAL

- SIGMA/OSSE(Purcell et al., 1997) revealed that a few point sources accounted at least for about 50 % of the total Galactic flux.
  - **If truly diffuse**

    Inverse Compton scattering of high energy (GeV) cosmic ray electrons on the ambient photons field. The radio synchrotron emission in the Galactic magnetic field at a level much higher than the one actually observed

    Bremsstrahlung : The total power required to compensate for electrons energy losses is of the order of 10^41- 10^43 erg.s^-1 would affect interstellar-medium ionization equilibrium and give rise to an excessive dissociation of the interstellar molecules.

  - **If non-resolved sources**

    A dozen of point sources (below SIGMA sensitivity) can account for the most part of the remaining diffuse.

------- > **In the soft gamma ray domain, we are expected that diffuse emission will decrease and point sources are expected to dominate**

Present status with INTEGRAL

- Sources account for the main part of Galactic emission (> 80 %) between 100 and 200 keV leaving at most a minor role for diffuse processes(Lebrun et al, 2004, Strong et al, 2004)
- The power supply, ionization or molecule dissociation problems are alleviated.

SPI

- Advantage of SPI over previous missions
  - Imaging response that allows the sources to be explicitly accounted for, including information from other instruments on INTEGRAL in particular IBIS
  - Large coverage of the sky
  - High sensitivity

- SPI results can be compared with results from other instruments, but precise comparison is difficult because
  - Different regions observed
  - Different instrument responses
  - Different models assumed
  - Diverse ways in which results are presented (per radian, per FOV, etc.)

SPI can be used in a self consistent way to measure the ratio between Galactic diffuse and point sources emission.

Data analysis

- To measure diffuse in a self consistent way, the study requires
  - Precise sources study
    - To take into account sources variability especially at low energy
  - Heavy numerical methods
    - Including large number of data, increase the number of fitted parameters (sources position and variability, background model) to give an accurate representation of the sky

Maximizing signal-to-noise ratio

The study of sources revealed that the number of sources detected above a given significance decreased in function of the energy.

Number of sources detected above 7 standard deviations (7 std)

Data GCDE 1 +GCDE 2

Number of sources N detected above 7 std	**Associated with a known source**	**New / artefact**
N > 20 keV	**65**	**12**
N > 27 keV	**62**	**10**
N >36 keV	**48**	**2**
N > 49 keV	**19**	**0**
N >99 keV	**11**	**0**

Necessity to work separately in the different energy domains : Simplification of the number of parameters (sources) to describe the sky model in function of the energy

Modeling

Diffuse continuum

The diffuse continuum emission is modeled with a gaussian of 5.5° FWHM in latitude and extended in longitude σ= 20°

Positronium structure

The positronium is assumed to have the same distribution as the electron-positron line, a symmetric gaussian of 13° FWHM (Knodlseder et al., 2004)

Sources

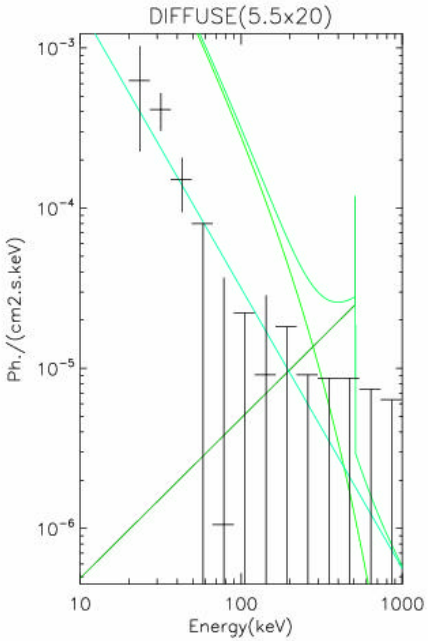
In the ideal case, we should include sources variability, but it is not possible i the case of SPI for the GCDE region for all the sources.

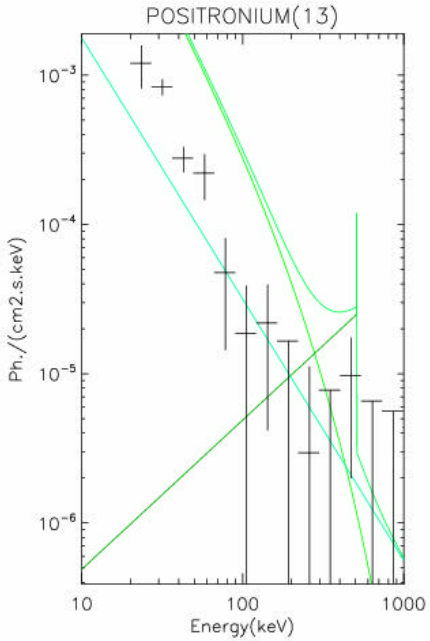
Background

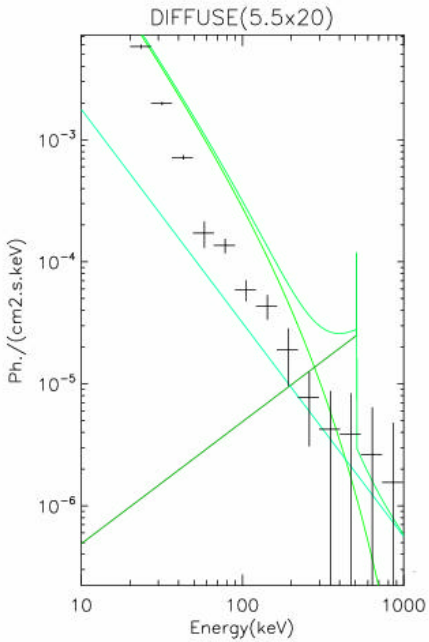
89 sources

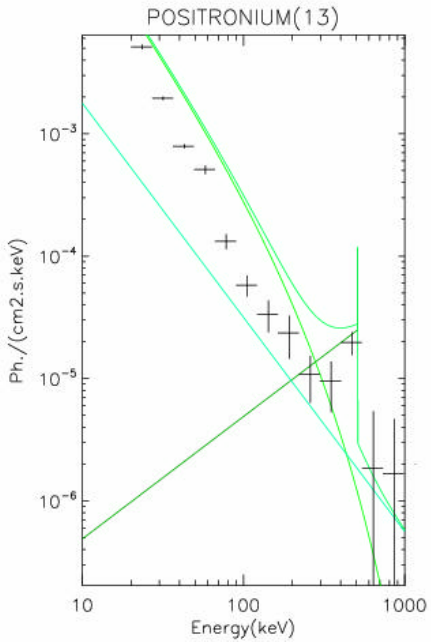
GCDE1+2

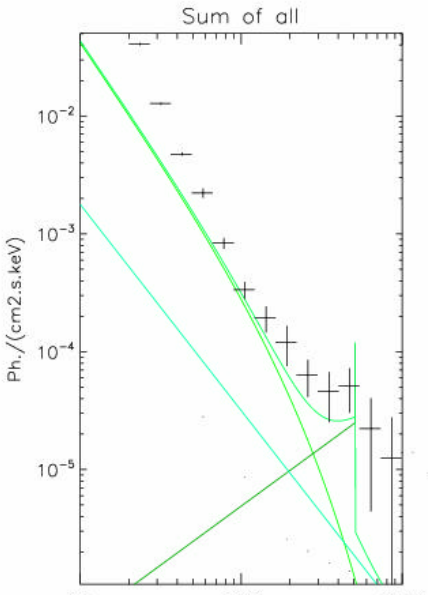
21 sources

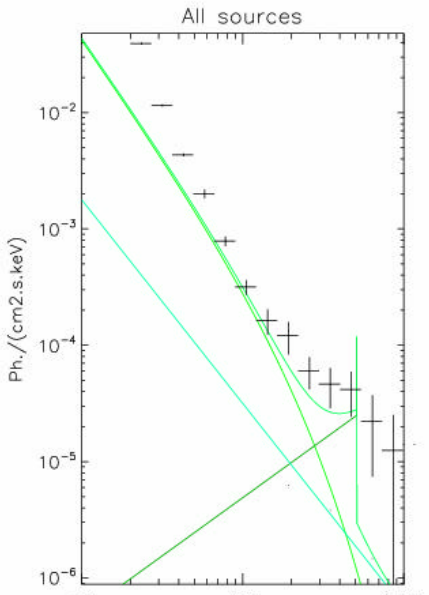


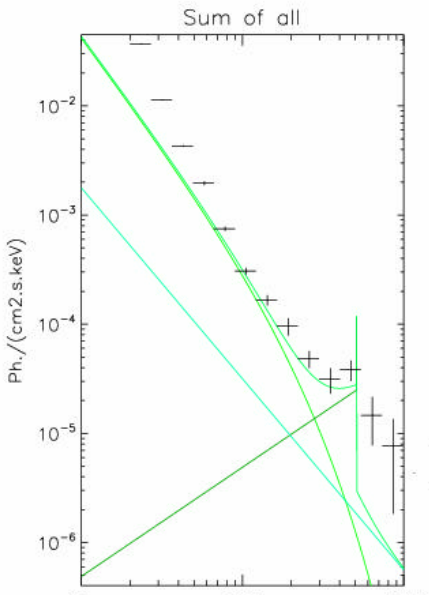


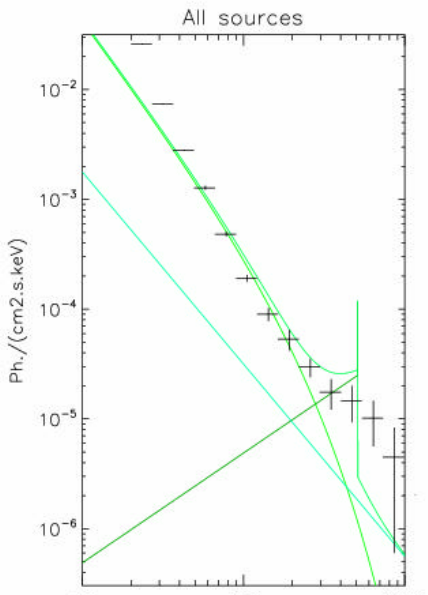




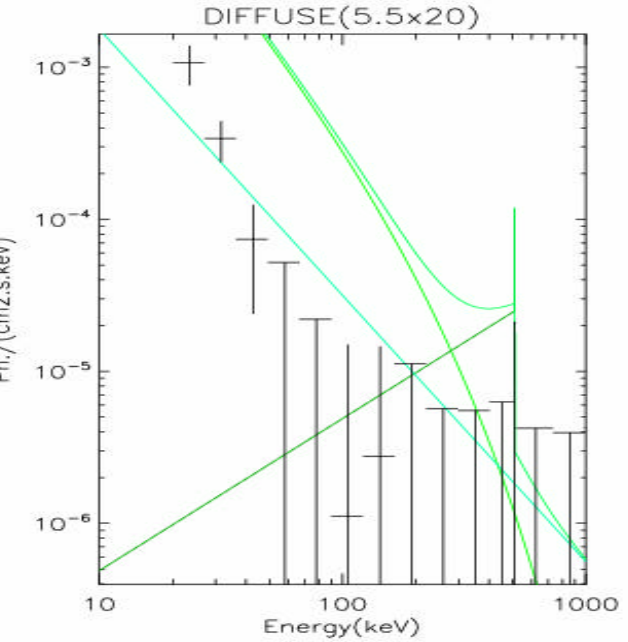


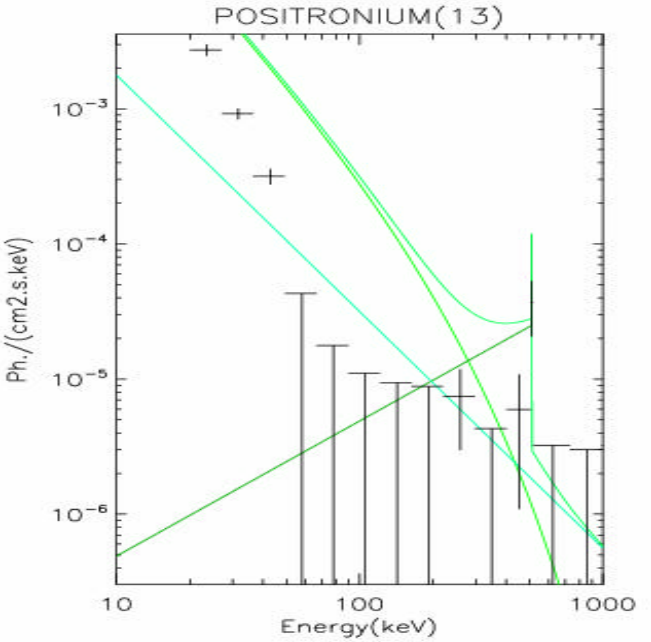




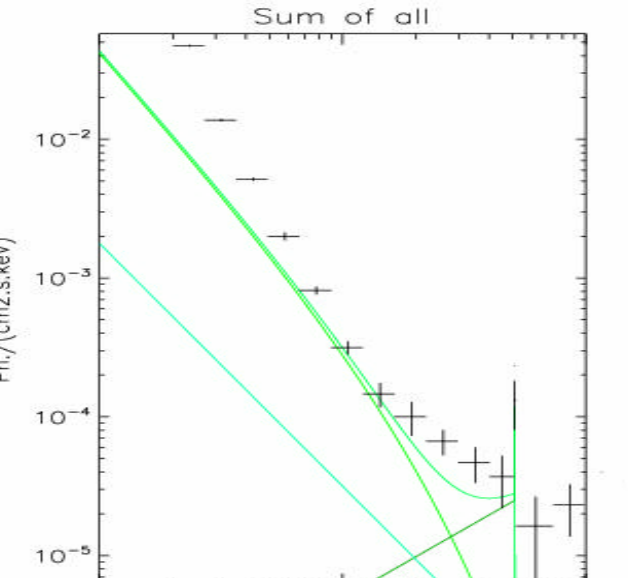


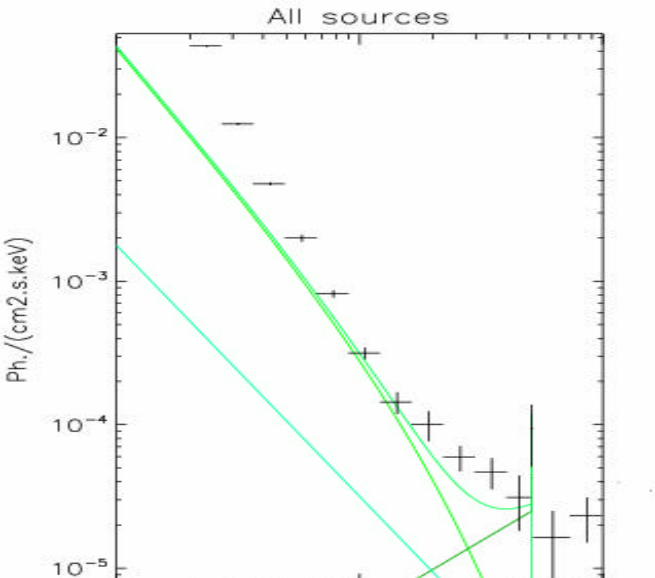
SCO X-1 variables



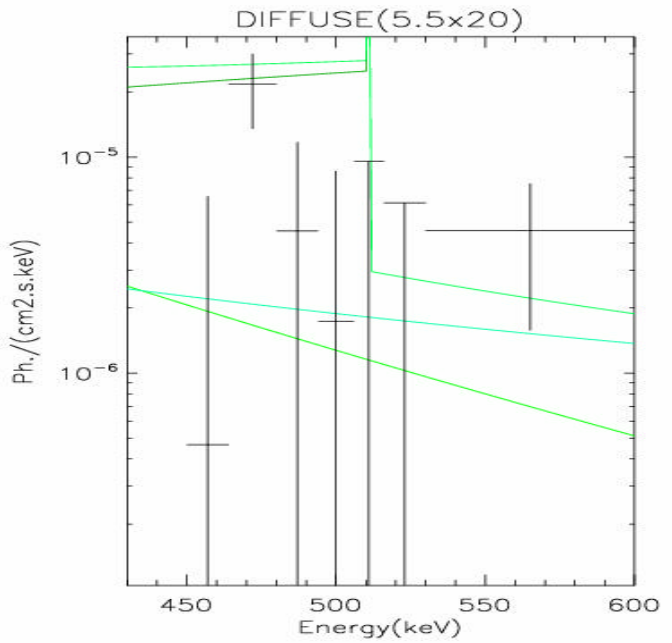


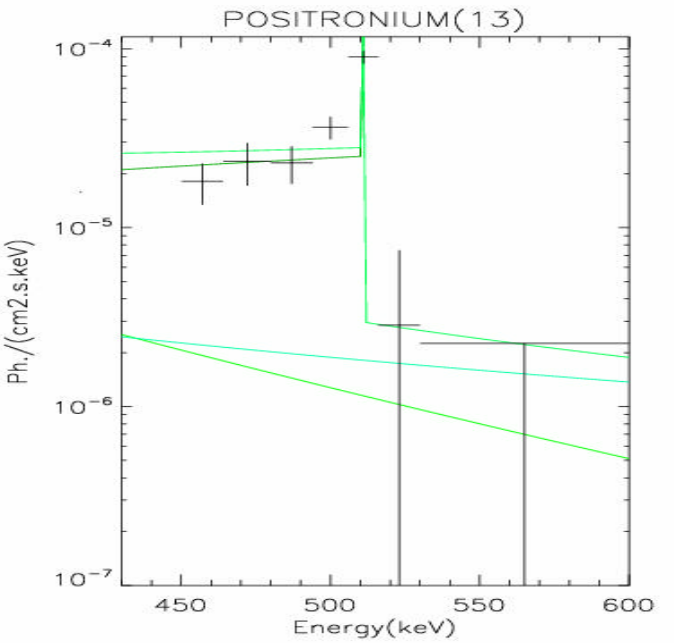
Cross-talk sources and diffuse

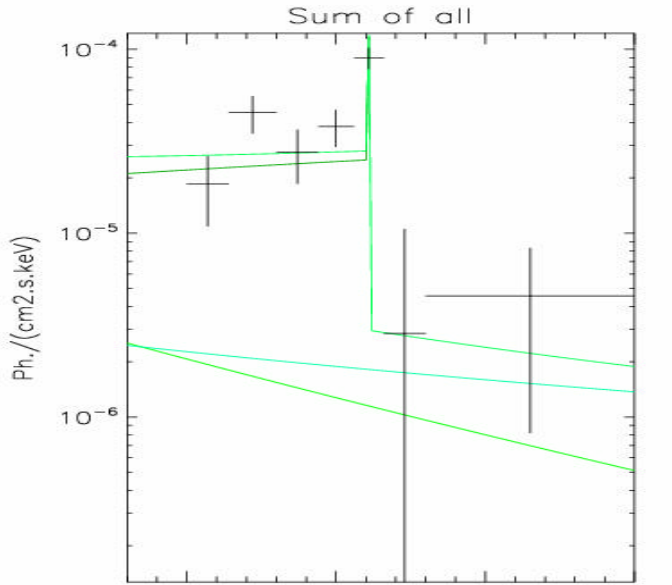


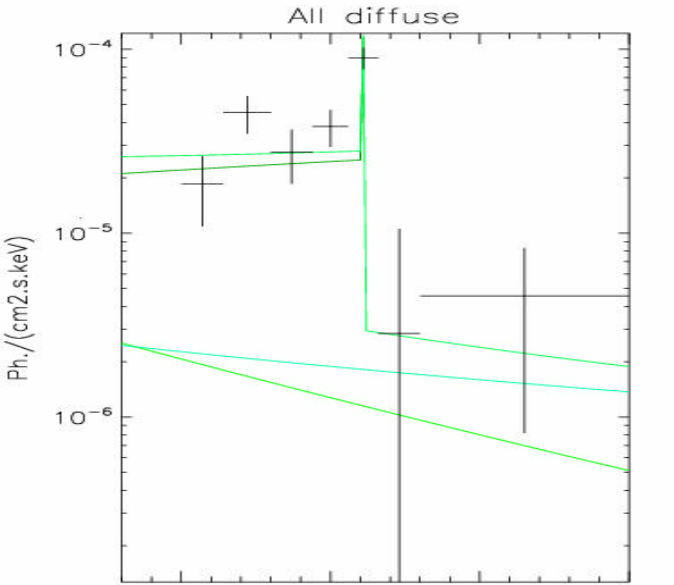


450-600 keV + 0 source









Results & Perspectives

- Main result :
  - Diffuse continuum emission (100-300 keV) represent less than ~ 20 % of the total emission.
- Study of soft gamma-ray diffuse continuum in a self consistent way with SPI required the study of sources
  - Collaboration with IBIS
- Improvement on spectral extraction software
  - Better take into account source variability
- Precise morphology of the diffuse soft-gamma ray emission in function of the energy
- Development of imaging reconstruction methods that can do both
  - Sources reconstruction in function time (variability)
  - Imaging on diffuse (true imaging)