UCB Space Sciences Laboratory

SPI Instrument Team Activities

Prof. Steven Boggs (PI)

Dr. Cornelia Wunderer (SPI CoI)

Dr. Andreas Zoglauer (postdoc)

Jason Bowen (student)

Mark Bandstra (student)

Prof. Emrah Kalemci (collabrator, Sabanci U.)

Sirin Caliskan (student, Sabanci U.)

INTEGRAL Users Group Mtg. November 27, 2007

UCB Science Activities:

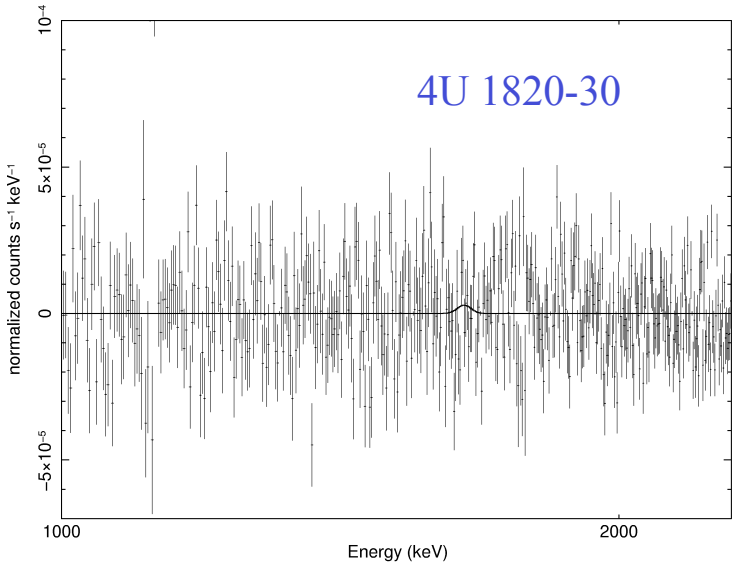
- Redshifted 2.2 MeV search – NS gravitational redshift
- Positrons annihilation in Type Ia SNRs
- Polarization sensitivity and measurements
- Joint SPI/RHESSI ^{26}Al, ^{60}Fe analysis for diffuse component

w/ full or partial GOP support for specific sources:

- SN1006 (w/ Reynolds, Milne)
- GRB timing – probe energy scales at the Planck mass (Wunderer)
- GRB polarization (w/ Kouveliotou)
- Redshifted 2.2 search, 4U 1820-30

Neutron Capture

We are actively involved in the study of redshifted 2.223 MeV neutron capture emission from the surface of accreting neutrons stars. Measurement of a known emission line from the surface of a neutron star will provide a direct measure of the gravitational redshift of the star, which in turn will provide a strong constraint on the neutron star equation of state. While researchers in many wavebands are searching for such lines, the gamma-ray neutron capture line has the potential of being bright enough for SPI to measure, as well as coming unambiguously from the surface itself. We are currently implementing the spectral algorithms we have developed to search for rotationally-broadened, redshifted lines from known sources that are good candidates, in the archival and core program data from our Core Program funding, as well as Key Program data through the GO program. Mark Bandstra, a graduate student, is performing this study as part of his Ph.D. thesis. In collaboration with E. Kalemci and S. Caliskan.



(M. Bandstra, in progress)

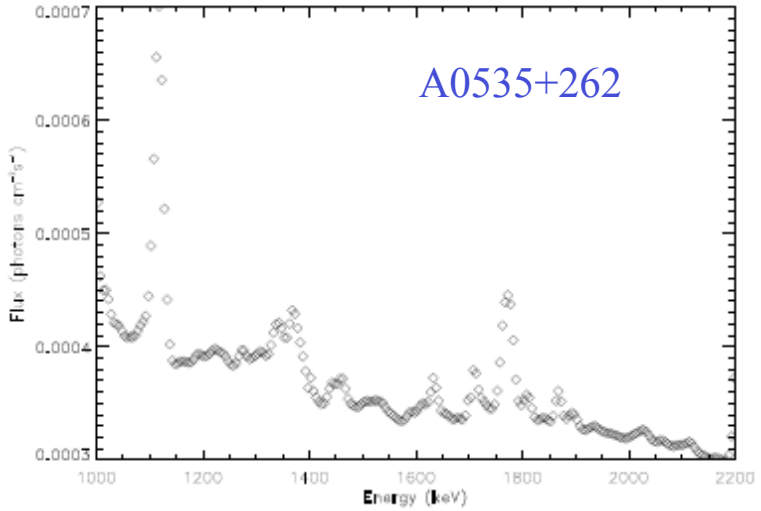


FIG. 5.— The 3 σ upper limits of A0535+262 using single, multiple and PSD events, GEDSAT for background subtraction and fitting a Gaussian with 22keV FWHM.

(S. Caliskan et al., ready for submission)

Prof. Steven Boggs

Positrons from Supernova Remnants

We are actively involved in the search for annihilation emission from Type Ia supernova remnants, one of the prime candidates from positron production in our Galaxy. We have published the first limits on such a source, SN 1006, which was partly funded through the GO program. As part of our Core Program studies, we are helping to extend this study to other historical SN Ia remnants as part of a systematic survey. This work was begun by Emrah Kalemci as a postdoc here at SSL, and has evolved into a primary Ph.D. thesis topic for one of our graduate students, Jason Bowen, in collaboration with CESR/Toulouse and E. Kalemci.

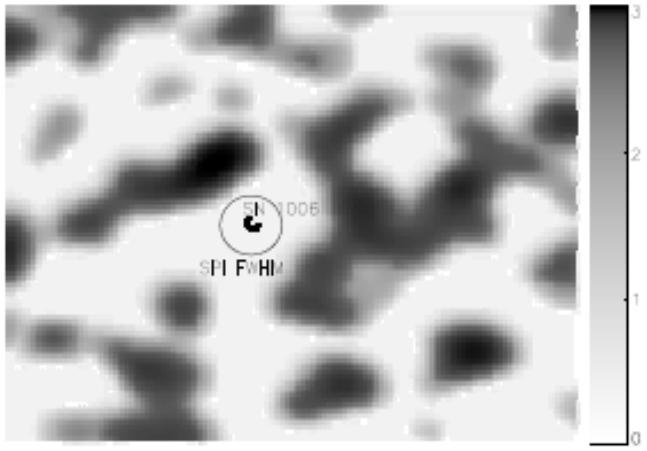


FIG. 1.— SPI significance image in 508.5–513.5 band of the fully coded field of view. The *ASCA* contours of SN 1006 is overlaid to indicate the extent and position of the source. The 3° FWHM of the imaging resolution of SPI is shown for comparison. The significance scale is plotted on the right.

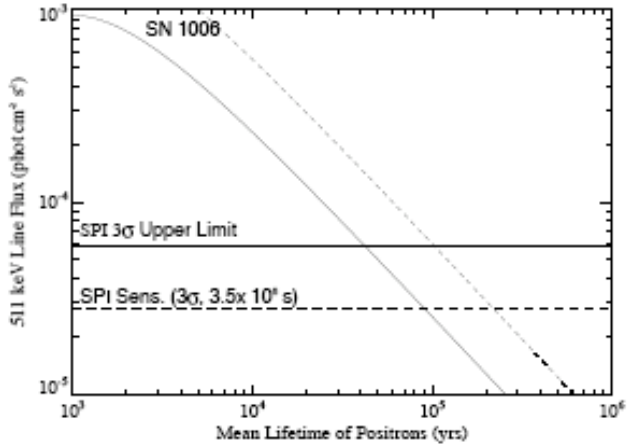


FIG. 2.— Predicted 511 keV line fluxes from SN 1006 as a function of positron mean lifetime. The solid and dotted curves are for 5% and 12% escape fractions, respectively. The expected SPI (5σ) sensitivity to the 511 keV line for 3500 ksec, and the current SPI 3σ upper limits for the emission from the SNRs are shown for reference.

(E. Kalemci et al., 2006)

Prof. Steven Boggs

Polarization

As a large array of individual detectors, SPI is potentially sensitive to gamma-ray polarization through the systematic study of photons which scatter in one detector before depositing their remaining energy in a second detector. Polarized photons will preferentially scatter at right-angles relative to their polarization direction; therefore, systematic study of the photon scatter-angle distribution in the ME events can potentially reveal the polarization of the source. This is especially promising in SPI for bright events, like gamma-ray bursts. We have characterized the expected scatter-angle distribution for polarized sources, and studied the background distribution and potential systematic biases in these measurements with SPI. These efforts, as part of the Core Program, were crucial in our successful attempt to constrain polarization from gamma-ray bursts, partly funded through the GO program. S. Boggs in collaboration with E. Kalemci.

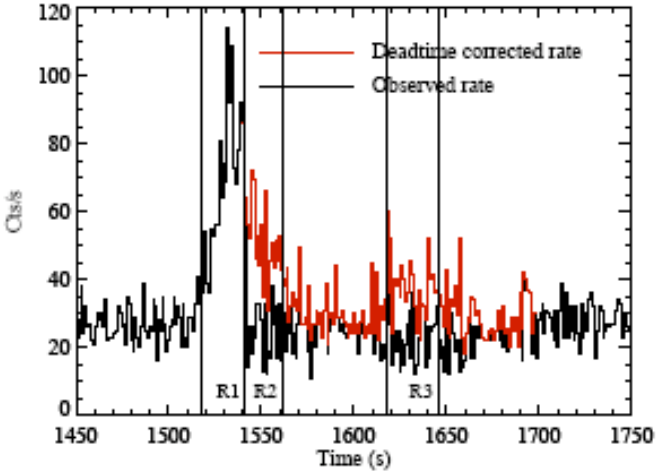


FIG. 3.— The observed (black histogram) and the reconstructed (red histogram) light curve of ME events in 100–500 keV band. The gaps are treated as dead-time. The vertical solid lines separate R1, R2, R3 regions (see text).

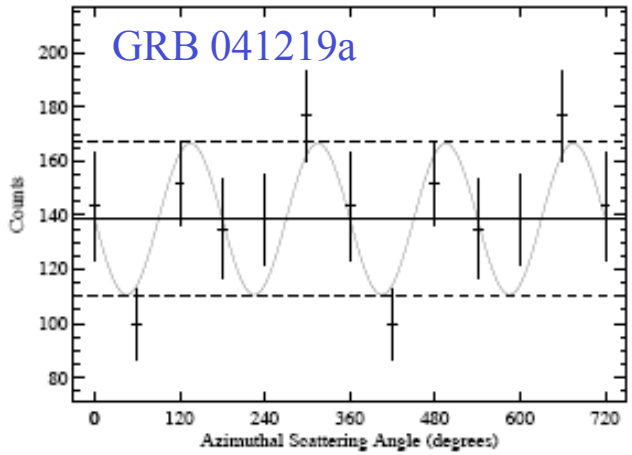
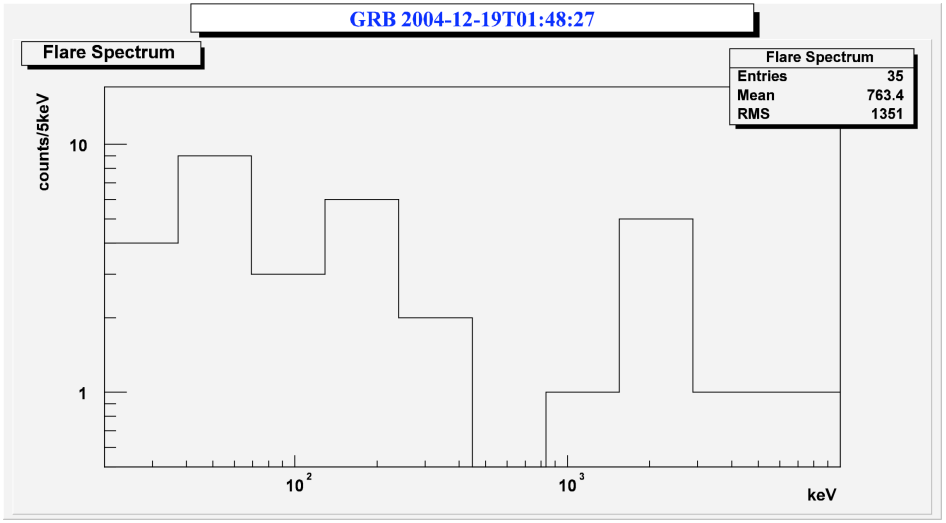


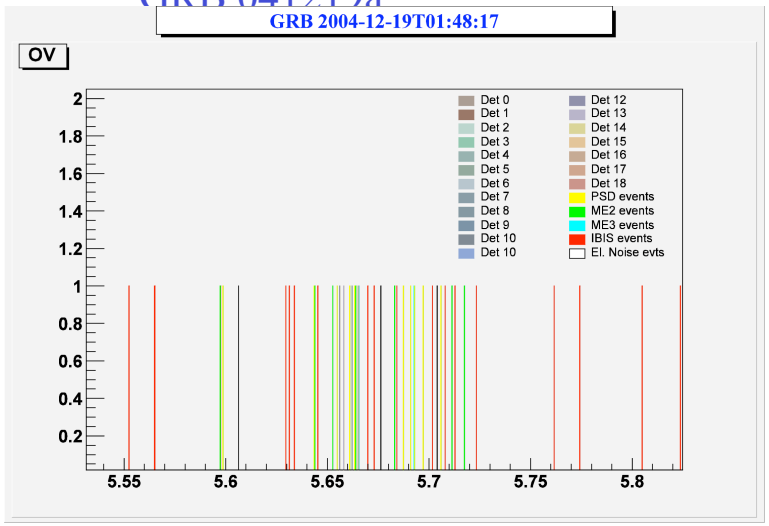
FIG. 11.— The azimuthal scattering angle distribution of events in Regions 1, 2 and 3 and a $\cos 2(\phi - \eta)$ fit to the data. The solid line is the average (no polarization) and the dashed lines show the maximum and the minimum modulation for a 100% polarization fraction.

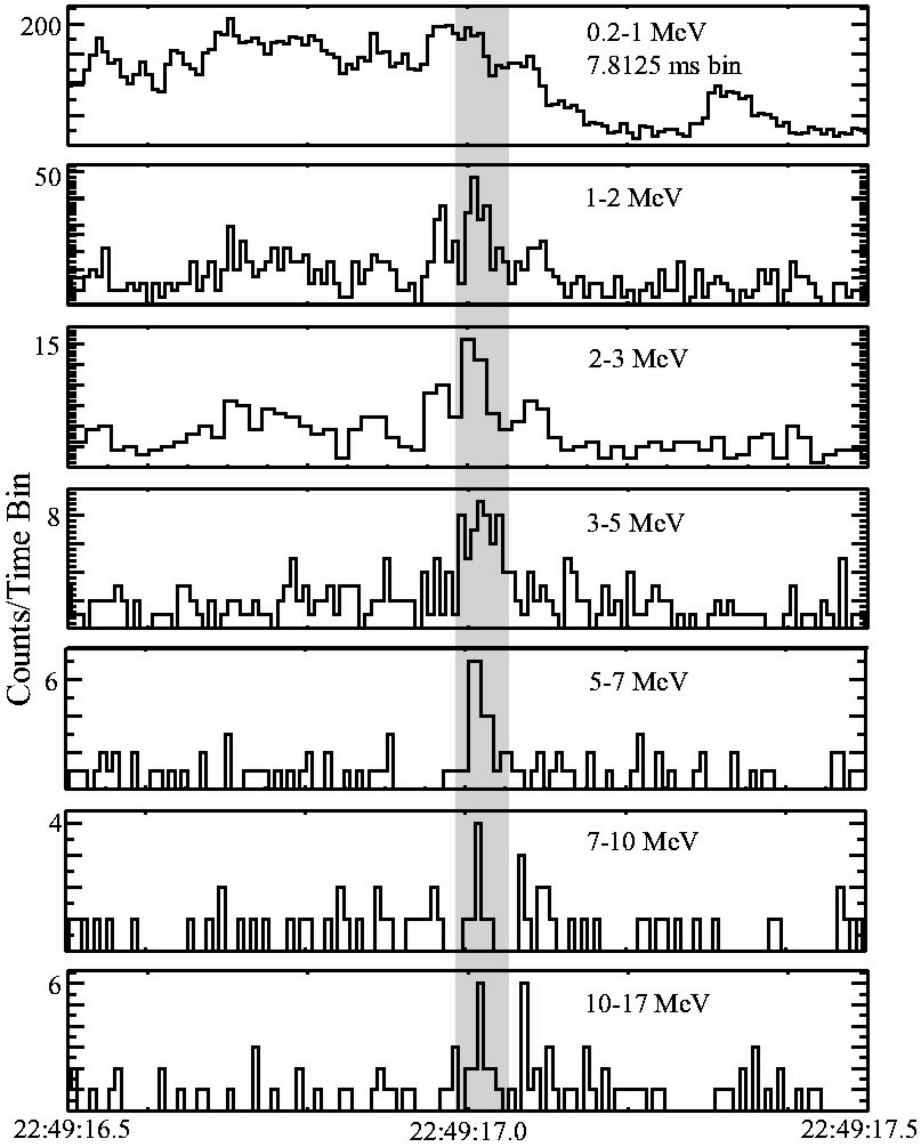
(E. Kalemci et al., 2007)

GRB Timing

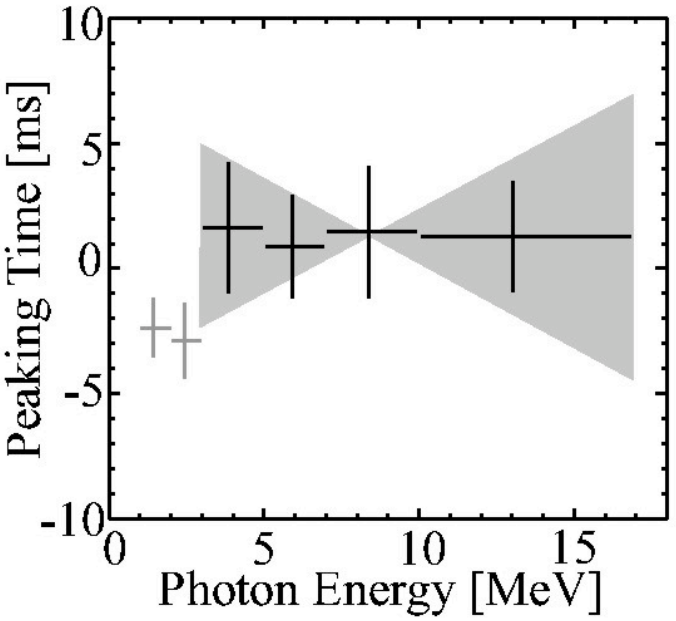
Since the discovery of the cosmological origin of GRBs there has been growing interest in using these transient events to probe the Quantum Gravity energy scale in the range 10^{16}-10^{19} GeV, up to the Planck mass scale. This energy scale can manifest itself through a modification in the electromagnetic radiation dispersion relation, specifically, an energy-dependence of the velocity of light. We have searched INTEGRAL-observed GRBs for suitable flares, requiring a 5 sigma trigger on a 2ms, 10ms, or 100ms time scale using only photons above 1 MeV. This search has been made more difficult by false triggers from the SPI electronic noise component evident in single-event spectra at 1.4 – 1.6 MeV. Led by C. Wunderer.







$E_{QG} > 1.8 \cdot 10^{17}$GeV



(Boggs et al., 2004)

Prof. Steven Boggs

UCB Instrument Activities:

• Implement the use of PSD information to characterize and correct for radiation damage in SPI spectral response.

• Study the characteristics and rejection techniques for the spurious 1.4-1.6 MeV background ‘lines’ due to electronic noise

• Understand SPI multiple-detector background (ME) for background and polarization studies.

• Characterize the SPI sensitivity to polarization and determine systematics affecting potential measurements.

• Characterize the RHESSI background using the MGGPOD suite (GSFC/CESR) to further understand the SPI background. Help maintain and update simulation tools.

Proceedings/Publications

1. L. Bouchet, et al., "SPI/INTEGRAL observation of the Cygnus region," Astronomy and Astrophysics, Vol. 411, pp. L377-L382 (2003).
2. P. Jean, et al., "SPI Instrumental background characteristics," Astronomy and Astrophysics, Vol. 411, pp. L107-L112 (2003).
3. J.P. Roques, et al., "SPI/INTEGRAL in-flight performance," Astronomy and Astrophysics, Vol. 411, pp. L91-L100 (2003).
4. G. Vedrenne, et al., "SPI: The spectrometer aboard INTEGRAL," Astronomy and Astrophysics, Vol. 411, pp. L63-L70 (2003).
5. Wunderer, C.B., et al., "A Preliminary Exposure-Map Based Comparison of SPI and RHESSI 26Al Flux Measurements" , Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 909 (2004).
6. Wunderer, C.B., Smith, D., Weidenspointner, G., "Modelling of the Detector Background Spectrum for the Low-Earth Orbit Ge Spectrometer RHESSI with MGGPOD," Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 913 (2004).
7. Kalemci, E., Boggs, S., Wunderer, C., Jean, P., "Background in the multiple events (ME) of INTEGRAL/SPI" , Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 855 (2004).
8. Kalemci, E., Boggs, S., Wunderer, C., Jean, P., "Measuring polarization with SPI on INTEGRAL," Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 859 (2004).
9. Diehl, R., et al., "Al(26) Studies with INTEGRAL's Spectrometer SPI," Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 27 (2004).
10. Knoedlseder, J., et al., "Search for gamma-ray line emission from the radioactive decay of 60Fe with SPI," Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 123 (2004).
11. Knoedlseder, J., et al., "SPI/INTEGRAL observation of 1809 keV gamma-ray line emission from the Cygnus X region," Proc. 5th INTEGRAL Workshop, Eds. , ESA SP-552, ISBN , 33 (2004).

(continued)

Proceedings/Publications (cont.)

12. Diehl, R., Halloin, H., Kretschmer, K., Lichti, G. G., Schönfelder, V., Strong, von Kienlin, A., A. W., Wang, W., Jean, P., Knödlseder, J., Roques, J.-P., Weidenspointner, G., Schanne, S., Hartmann, D. H., Winkler, C., Wunderer, C., "Radioactive 26-Al and massive stars in the Galaxy," Nature, Vol. 439, pp. 45-47 (2006).
13. Diehl, R., Halloin, H., Kretschmer, K., Strong, A. W., Wang, W., Jean, P., Lichti, G. G., Knödlseder, J., Roques, J.-P., Schanne, S., Schönfelder, V., von Kienlin, A., Weidenspointner, G., Winkler, C., Wunderer, C., "26-Al in the inner Galaxy: large-scale spectral characteristics derived with SPI/INTEGRAL," , Astronomy and Astrophysics, Vol. 449, pp. 1025-1031 (2006).
14. Kalemci, E., Boggs, S. E., Milne, P. A., Reynolds, S. P., "Search for annihilation radiation from SN 1006 with SPI on INTEGRAL," Astrophysical Journal, Vol. 640, pp. L55-L57 (2006).
15. Kalemci, E.; Reynolds, S. P.; Boggs, S. E.; Lund, N.; Chenevez, J.; Renaud, M.; Rho, J., "X-ray observations of SN 1006 with INTEGRAL", Astrophysical Journal, Vol. 644, pp. 274-278 (2006).
16. Matthieu, R., Gros, A., Lebrun, F., Terrier, R., Goldwurm, A., Reynolds, S., Kalemci, E., "Imaging extended sources with coded mask telescopes: Application to the INTEGRAL IBIS/ISGRI instrument", Astronomy and Astrophysics, Vol. 456, pp 389-394 (2006).
17. Joinet, A., Jourdain, E., Malzac, J., Roques, J. P., Corbel, S., Rodriguez, J., Kalemci, E., "Hard X-ray emission of the microquasar GX 339-4 in the low/hard state", Astrophysical Journal, Vol. 657, pp. 400-408 (2007).
18. Kalemci, E., Boggs., S. E., Kouveliotou, C., Finger, M., Baring, M. G., "Search for Polarization from the Prompt Gamma-Ray Emission of GRB 041219a with SPI on INTEGRAL", Astrophysical Journal Supplement Series, Vol. 169, pp. 75-82 (2007).
19. Wang, W., Harris, M. J., Diehl, R., Halloin, H., Cordier, B., Strong, A. W., Kretschmer, K., Knödlseder, J., Jean, P., Lichti, G. G. , Roques, J. P., Schanne, S., Kienlin, A. v., Weidenspointner, G., Wunderer, C. B., "SPI observations of the diffuse Fe emission in the Galaxy," Astronomy and Astrophysics, Vol. 469, p.1005-1012 (2007).
20. Wunderer, C. B., Bellm, E., Boggs, S. E., Hurley, K., "Search for millisecond flares in INTEGRAL and RHESSI GRBs," Proc. 1st GLAST Symposium, AIP Conference Proceedings, Vol. 921, pp. 512-512 (2007).
21. Wunderer, C. B., Boggs, S.E., Coburn, W., Hurley, K., "Searching for MIllisecond Flares in INTEGRAL GRBs -- towards constraining Lorentz Invariance and Quantum Gravity with INTEGRAL GRBs," Proc. 6th INTEGRAL Workshop, ESA SP-XXX, in print (2007).

Posters/Presentations

1. C. Wunderer, et al., “An Exposure-Map Based Comparison of the 26Al Fluxes Measured by SPI and RHESSI,” 5th INTEGRAL Workshop, Munich, Germany, February 2004.
2. C. Wunderer, et al., “Modelling of the Detector Background Spectrum for the Low Earth Orbit – Ge Spectrometer RHESSI with MGGPOD,” 5th INTEGRAL Workshop, Munich, Germany, February 2004.
3. E. Kalemci, et al., “Background in the Multiple Events (ME) of SPI/INTEGRAL,” 5th INTEGRAL Workshop, Munich, Germany, February 2004.
4. E. Kalemci, et al., “Measuring Polarization with SPI on INTEGRAL,” 5th INTEGRAL Workshop, Munich, Germany, February 2004.
5. E. Kalemci et al., "Measuring Polarization with the INTEGRAL Observatory", X-Ray Polarimetry Workshop, SLAC, Stanford, CA, February 2004.
6. C. Wunderer, et al., "A systematic study of GRB millisecond flares at MeV energies aiming to constrain Quantum Gravity, " HEAD Meeting, New Orleans, September 2004.
7. E. Kalemci, et al., "Hard X-rays observations of SN 1006 with INTEGRAL", 2004, HEAD Meeting, New Orleans, September 2004.
8. C. Wunderer, "Unraveling our Origins through Gamma-Ray Astronomy," MIT Astrophysics Colloquium, February 2005.
9. C. Wunderer, "Unraveling our Origins through Gamma-Ray Astronomy," UC Berkeley Astrophysics Seminar, February 2005.
10. E. Kalemci et al., "INTEGRAL Observations of SN1006", 205th AAS Meeting, San Diego, January 2005.
11. C. Wunderer, "Unraveling our Origins through Gamma-Ray Astronomy," KIPAC, Stanford University, April 2005.
12. C. Wunderer, et al., “ Searching for ms Flares in INTEGRAL GRBs,” 6th INTEGRAL Workshop, Moscow, July 2006.
13. E. Kalemci et al., “Search for polarization in the prompt emission of GRB 041219 using SPI,” 6th INTEGRAL Workshop, Moscow, July 2006.
14. E. Kalemci et al., “SN 1006 with INTEGRAL,” 6th INTEGRAL Workshop, Moscow, July 2006.
15. S. Caliskan, E. Kalemci, S.Boggs, “Search for redshifted 2.2 MeV line from 4U 1820-30,” 6th INTEGRAL Workshop, Moscow, July 2006.
16. C. Wunderer ,"(Snapshots of) The MeV View of the Gamma-Ray Sky," Stanford/SLAC/KIPAC - ACKS Seminar, February 2007.
17. C.B. Wunderer, E. Bellm, S.E. Boggs, K. Hurley, "Searching for millisecond flares in INTEGRAL and RHESSI GRBs - toward probing quantum gravity with gamma-ray bursts," GLAST Symposium (Palo Alto, CA), February 2007.

SPI Team Meeting Presentations

1. E. Kalemci, S. Boggs, "Characterization of radiation damage before and after the annealing using the PSD", SPI Scientific Team Meeting, MPE, Garching, Germany, April 2003.
2. E. Kalemci et al., "The distribution of SPI background events in lines and continuum for the singles and the multiples", SPI Scientific Team Meeting, CESR, Toulouse, France, June 2003.
3. C. Wunderer, et al., Paris, "Combining SPI and RHESSI Measurements to constrain the spatial distribution of 26Al," Paris, Oct. 8-9, 2003.
4. E. Kalemci, S. Boggs, "Characterizing the effects of radiation damage before and after the second annealing using the PSD information", SPI Scientific Team Meeting & SPI/IBIS Joint Meeting, IAP, Paris, France, October 2003.
5. E. Kalemci, S. Boggs, C. Wunderer, "Polarization capabilites of SPI & IBIS instruments", SPI Scientific Team Meeting & SPI/IBIS Joint Meeting, IAP, Paris, France, October 2003.
6. C. Wunderer, et al., "Millisecond Time Structures of GRBs," Toulouse, June 7-9, 2004.
7. C. Wunderer, et al., "Light Bucket/ Exposure Map - Approach to 26Al with SPI," Toulouse, June 7-9, 2004.
8. E. Kalemci et al., "Search for gravitationally red-shifted 2.2 MeV line from selected neutron stars", SPI Scientific Team Meeting, CESR, Toulouse, France, June 2004.
9. E. Kalemci et al., "Study of coincidence lines in ME", SPI Scientific Team Meeting, CESR, Toulouse, France, June 2004.
10. C. Wunderer & S. Boggs, "The electronic noise background feature at 1.4-1.6 MeV, " Munich, Oct. 2004.
11. E. Kalemci et al., "INTEGRAL Observations of SN1006", INTEGRAL Internal Meeting at ESTEC, Noordwijk, Netherlands, January 2005.
12. C. Wunderer & S. Boggs, "Further characterization of the electronic noise feature at 1.4-1.6 MeV," Rome, March 2005.
13. E. Kalemci et al., "Search for polarization in the prompt emission of GRB 041219 using SPI," Toulouse, November 2005.
14. C. Wunderer & S. Boggs, "Update on 1.4-1.6 MeV noise features," SPI Scientific Team Meeting, MPE, Garching, Germany, March 2006.
15. E. Kalemci et al., "Search for polarization in the prompt emission of GRB 041219 using SPI, the end", Toulouse, October 2007.
16. S. Caliskan, E. Kalemci, S.Boggs, "Search for redshifted 2.2 MeV line from accreting neutron stars", Toulouse, October 2007 .
17. E. Kalemci, "SPI related activities at Sabanci University", MPE, Garching, March 2007.
18. S. Caliskan, E. Kalemci, S.Boggs, "Search for redshifted 2.2 MeV line from A0535+26 during an outburst", Garching, March 2007.
19. C. Wunderer "GRB Millisecond Flares ... an update ..." SPI Scientific Team Meeting, MPE Garching March 2007.