Status of the *'Nucleosynthesis'* Field

by Roland Diehl
MPE Garching

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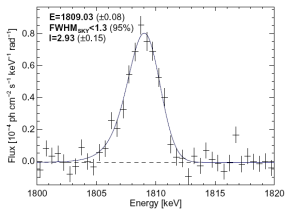
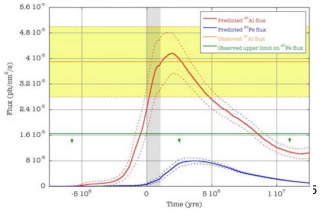
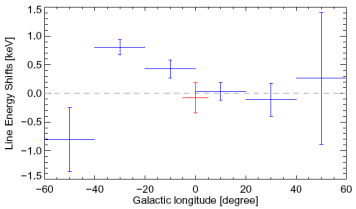
Status of the *Nucleosynthesis* Field - Overview

☆ ^{26}Al in the Galaxy

- ☞ Spatially-Resolved Spectra
- ☞ Line Width Constraint
- ☞ Galactic ^{26}Al versus Models
- ☞ Cygnus-Region ^{26}Al versus Models

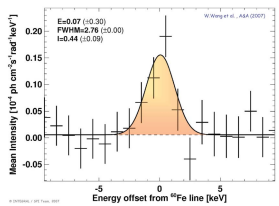


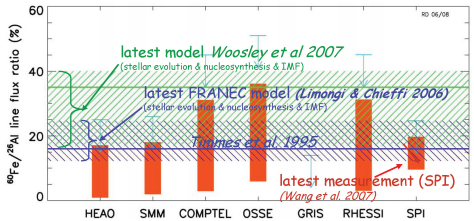




☆ ^{60}Fe in the Galaxy

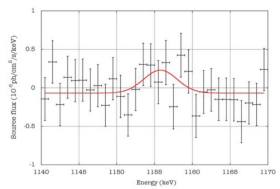
- ☞ Clear Detection
- ☞ ^{60}Fe/^{26}Al Ratio: New Models & Theory
- ☞ ^{60}Fe Lifetime Re-Determined/Revised

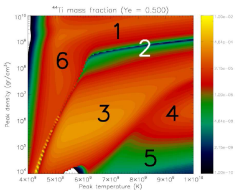




☆ ^{44}Ti from Supernovae

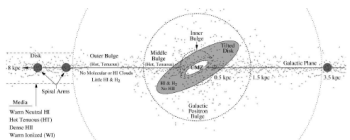
- ☞ Cas A Constraints from all 3 ^{44}Ti Lines
- ☞ New Models for cc-SNe

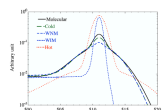




☆ Positrons in the Galaxy

- ☞ Spatially-Resolved Spectra
- ☞ Line Shape Constraints
- ☞ Bulge/Disk Ratio: New Models & Theory

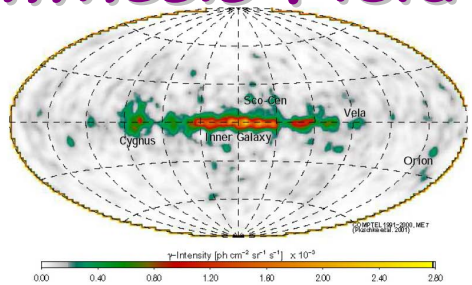


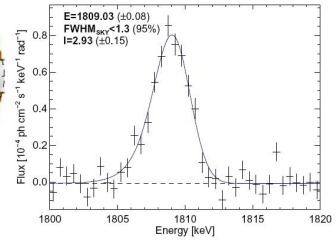


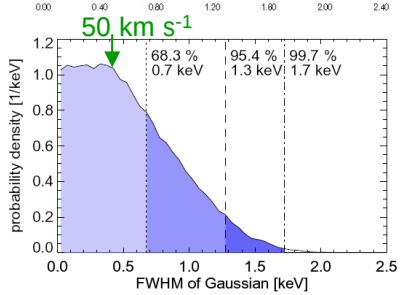
Status of the *Nucleosynthesis* Field - ^{26}Al

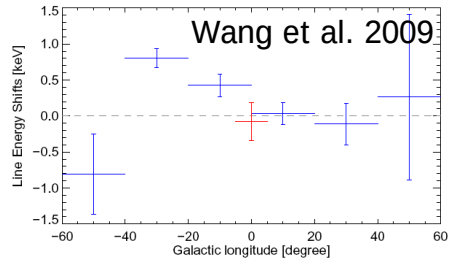
☆ ^{26}Al Observation Results

- ☞ Spatially-Resolved Spectra
- ☞ Line Width Constraint
- ☞ Galactic ^{26}Al versus Models
  - **Wang et al., A&A (2009)**
- ☞ Cygnus-Region ^{26}Al versus Models
  - **Martin et al., submitted to A&A**



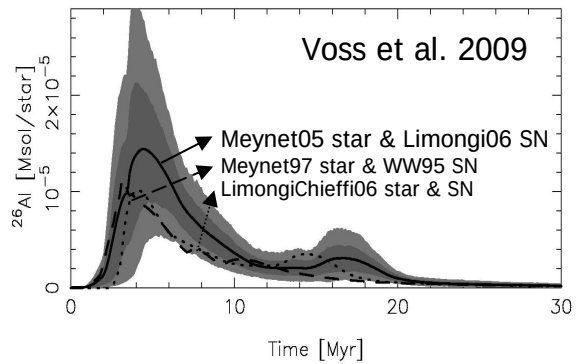






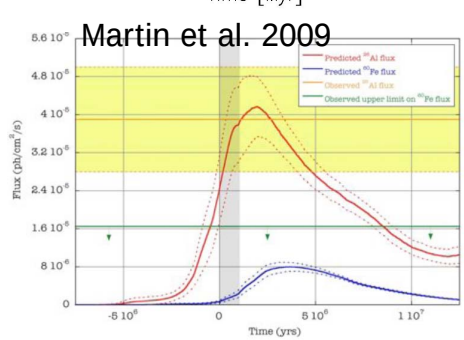
☆ ^{26}Al Nucleosynthesis Models

- ☞ Stellar Evolution from MS through Collapse
  - **Limongi & Chieffi, A&A (2006)**
- ☞ Stellar Evolution Including Effects of Stellar Rotation
  - **Palacios et al., A&A (2005)**
- ☞ Updates of WW95 Model with new Nuclear Physics
  - **Woosley & Heger, PhysRep (2007)**



☆ ^{26}Al in Massive-Star Regions: Predictions

- ☞ Population Synthesis for Massive-Star Groups
  - **Voss et al., submitted to A&A**
- ☞ Massive-Star Groups in the Cygnus Region
  - **Martin et al., submitted to A&A**



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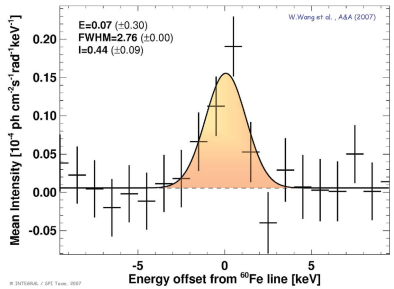
Status of the *Nucleosynthesis* Field - ^{60}Fe

☆ ^{60}Fe in the Galaxy

☞ Clear Detection

- Wang et al., A&A 2007; Lang et al., in prep.

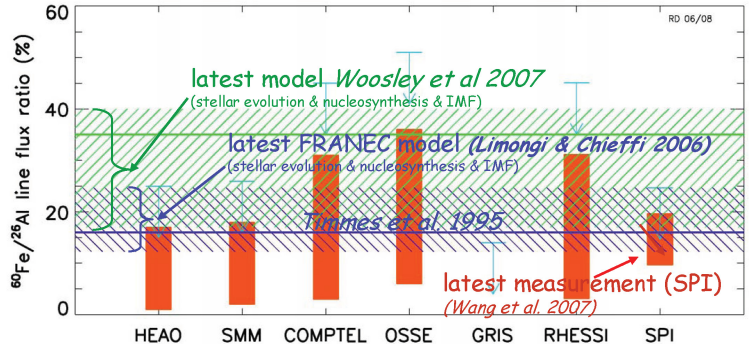


☞ Limits for Cygnus, Vela

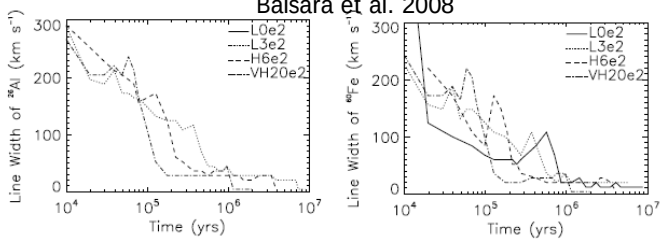
- Wang et al., A&A 2007; Martin et al., submitted to A&A

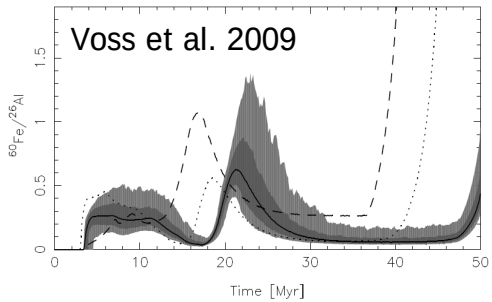
☞ ^{60}Fe/^{26}Al Ratio: New Models & Theory

- Updates & Variants on Stellar & SN Models
  - » Limongi & Chieffi, A&A 2006
- Review/Re-Measurements of Nuclear Rates
  - » First-Ever Measurement of ^{60}Fe (n,γ)^{61}Fe (10.2 ±3 mb) (Reifarth et al. 2009)
  - » First Measurements of ^{59}Fe (n,γ)^{60}Fe in preparation
- Simulations for ISM-Massive-Star Groups
  - » Balsara et al. 2008
  - » Voss et al. 2009



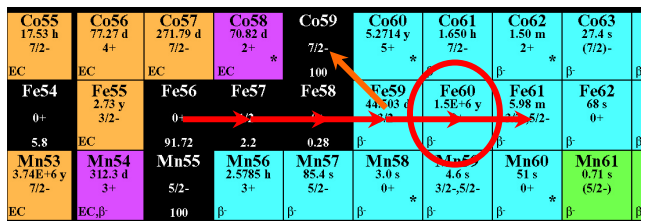
Balsara et al. 2008





☞ ^{60}Fe Lifetime Re-Determined/Revised

- » 'old' value: τ=(2.15 ±0.3) My (Kutschera et al 1984)
- » 'new' value: τ=(3.78 ±0.06) My (Rugel et al 2009) based on ^{60}Fe from PSI beam dump and AMS
- » Implications for Young Regions (not 'steady-state')



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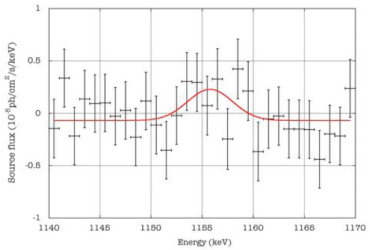
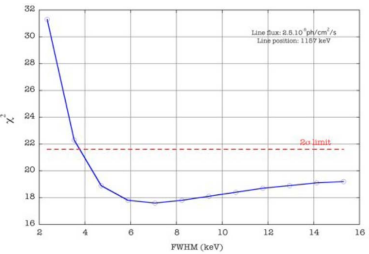
Status of the *Nucleosynthesis* Field - ^{44}Ti

☆ ^{44}Ti from Supernovae





- Cas A Constraints from 3 Lines
  - IBIS provided best total-flux measurement (2.5 ±0.3) 10^{-5} ph cm^{-2} s^{-1} (Renaud+ 2006)
  - Compatible Velocities >500 km/s (SPI 1157 keV line limit); Martin+ 2009

☆ New Radioactivity Constraints for SNe

- Cas A Echo Spectrum, Krause+ 2008
- Cas A ^{56}Ni Yield from Reddening, Ericson+ 2008
- New SNR G1.9+0.3 with ~100 yrs age
  - Reynolds+ 2008
  - No Hint for ^{44}Ti Emission found in SPI nor IBIS

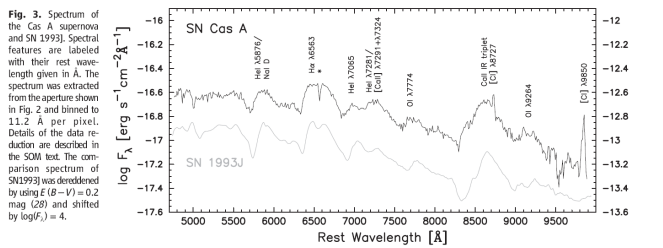
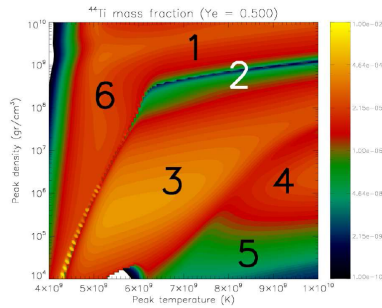


Fig. 3. Spectrum of the Cas A supernova and SN 1993J. Spectral features are labeled with their rest wavelength given in Å. The spectrum was extracted from the aperture shown in Fig. 2 and binned to 11.2 Å per pixel. Details of the data reduction are described in the SOM text. The comparison spectrum of SN1993J was dereddened by using $E(B-V) = 0.2$ mag (28) and shifted by $\log(F_\lambda) = 4$.

☆ New Model Yields & their Variabilities

- First 2.x-dimensional Parametrized Simulations
  - Strong Y_e Dependency; Fryer+ 2008, Magkotsios+ 2008
- Re-Measurements of Key Nuclear Reaction Rates
  - ^{40}Ca(α,γ)^{44}Ti being measured; ^{44}Ti(α,p)^{47}V to be done (RIB); others?
- Nuclear-Network Studies
  - e.g. NARF, Parikh+ in prep.



Model Name and citation	Model Charact. E_{exp} 10^{51} erg	M_{rem} $M_\odot$	Yields ^{28}Si $M_\odot$	^{45}Sc 10^{-5} $M_\odot$	^{44}Ti 10^{-5} $M_\odot$	^{60}Co 10^{-5} $M_\odot$	^{56}Ni $M_\odot$
WW-S22A[8]	1.47	2.02	0.356	1.20	6.15	2.43	0.205
WW-S25A[8]	1.18	2.07	0.315	0.228	3.04	5.36	0.129
23e-1.5[7]	3.2	1.5	0.303	0.082	0.513	1.03	0.0013
23e-2.0[7]	2.6	2.0	0.461	0.080	6.95	1.04	0.283
d0.2-1.5[7]	2.6	1.5	0.463	0.081	2.62	0.99	0.240
d0.7-1.5[7]	2.3	1.5	0.482	0.091	10.0	1.01	0.216
23p-1.2[7]	3.2	1.2	0.362	0.080	0.655	0.992	0.0066
23p-1.6[7]	2.4	1.6	0.439	0.079	23.5	0.996	0.613
CL-20[9]	1.6	-	0.156	0.542	4.03	1.13	0.10
CL-25[9]	1.8	-	0.245	1.26	2.19	2.44	0.10

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Status of the *Nucleosynthesis* Field: e^+ Annihilation

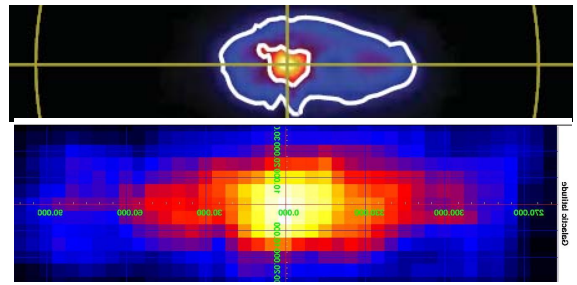
☆ Positrons in the Galaxy

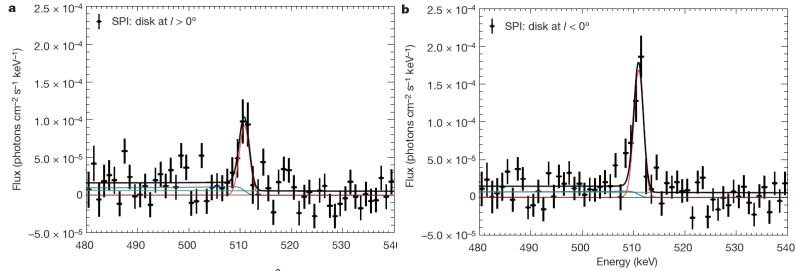
☞ Imaging Studies -> Asymmetry

- Weidenspointner et al., Nat 2008
- Bouchet et al., ApJ 2008
- Skinner et al., PoS 2009 -> 1.60 $^{+0.49}_{-0.16}$

☞ Spatially-Resolved Spectra

- Weidenspointner et al., Nat 2009



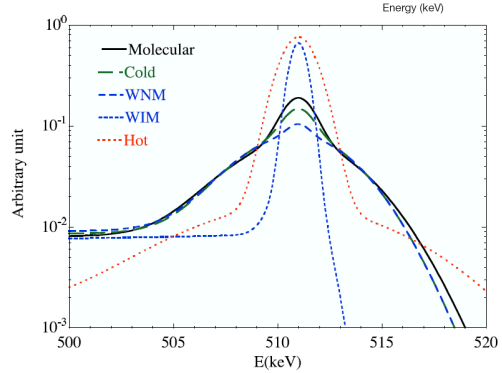


☆ Models and Simulations

- Prantzos et al., in prep for RevModPhys (from 2007/2008 ISSI workshops)
- Studies & Discussion on Cosmic-Ray Propagation, on Positron Production by Different Sources, on Positron Annihilation Physics, on Dark Matter

☞ Annihilation Physics and Site

- Guessoum et al., A&A 2006

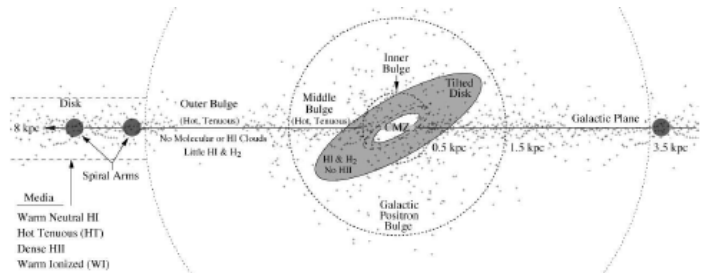


☞ Sources: SgrA; Pulsars; Binaries; DM; ...

- Cheng; Wang; Guessoum, Skinner; Boehm, Hooper;...

☞ Positron Propagation in ISM

- Gillard et al., ESA-SP 2007



☞ Bulge/Disk Ratio: New Models & Theory

- Higdon et al.; Lingenfelter, submitted to ApJ

Nucleosynthesis Science Meetings

- since last IUG Meeting
- a subjective list of conferences with "nucleosynthesis" as a main/major theme

- ☆ Gas & Stars in Galaxies, Jun 2008, Garching/Germany
- ☆ Cosmic Odysee of Elements, Jul 2008, Crete/Greece
- ☆ Astrophysics with ^{60}Fe, Jul 2008, Garching/Germany
- ☆ Chemical Evolution of Dwarf Galaxies, Jul 2008, Garching/Germany
- ☆ High-Energy Gamma-Ray Symposium, Jul 2008, Heidelberg/Germany
- ☆ Nuclei in the Cosmos X, Aug 2008, Michigan/USA
  - invited INTEGRAL nucleosynthesis-result talk
- ☆ INTEGRAL Science Workshop, Sep 2008, Copenhagen/Denmark
  - invited INTEGRAL nucleosynthesis-result talk
- ☆ Particles & Nuclei in the Cosmos (PANIC), Nov 2008, Eilat/Israel
  - invited INTEGRAL nucleosynthesis-result talk
- ☆ Origin of Elements Heavier than Iron, Sep 2008, Torino/Italy
  - invited INTEGRAL nucleosynthesis-result talk
- ☆ Simbol-X Workshop, Dec 2008, Paris/France
- ☆ Astrophysics with ^{44}Ti, Jan 2009, Garching/Germany
- ☆ VISTARS Workshop, Mar 2009, Russbach/Austria
  - invited INTEGRAL nucleosynthesis-result talk

and upcoming:

- ☆ Nucleosynthesis - Making the Elements in the Universe, Jun 2009, Bad Honnef/Germany
- ☆ Nuclear Physics in Astrophysics IV, Jul 2009, Gran Sasso/Italy
- ☆ Chemical Abundances IAU265, Aug 2009, Rio de Janeiro/Brazil
- ☆ Light Elements in the Universe, Nov 2009, Geneva/Switzerland
- ☆ Nuclei in the Cosmos XI, Jul 2010, Heidelberg/Germany

Science Quality Monitoring by IUG

- ☆ Tracking of Advances in INTEGRAL's Science Areas
  - ☞ Monitor Papers & Plans per **Science Area**
- ☆ Tracking of Success and Science Impacts for
  - ☞ **Observing Time, and Proposals**

  with respect to
    - » resources invested, results obtained
    - » science appreciation, contribution to science advance
  - – Action for one/two IUG Members per Area? Rotating?
- ☆ Report & Discussion at IUG Mtgs
    - » TAC Guidelines Developped from there?
- ☆ Prerequisite: (and Side-Effects)
  - ☞ Define quality criteria for INTEGRAL proposals and observing time

    e.g.:
    - » stated goals were (xx%) achieved
    - » xx scientists with xx personmonths were involved
    - » result received xx credits among experts, and xx credits among adjacent / broader community
  - ☞ Define relative merits of science areas of INTEGRAL
  - ☞ Guide future proposal evaluations, and observation scheduling

  ☞ **IUG (rather than external bodies & committees) defines quality criteria**

My suggestions, IUG Meeting Jun 2008

'Nucleosynthesis' with INTEGRAL: Targets

☆ Core Program

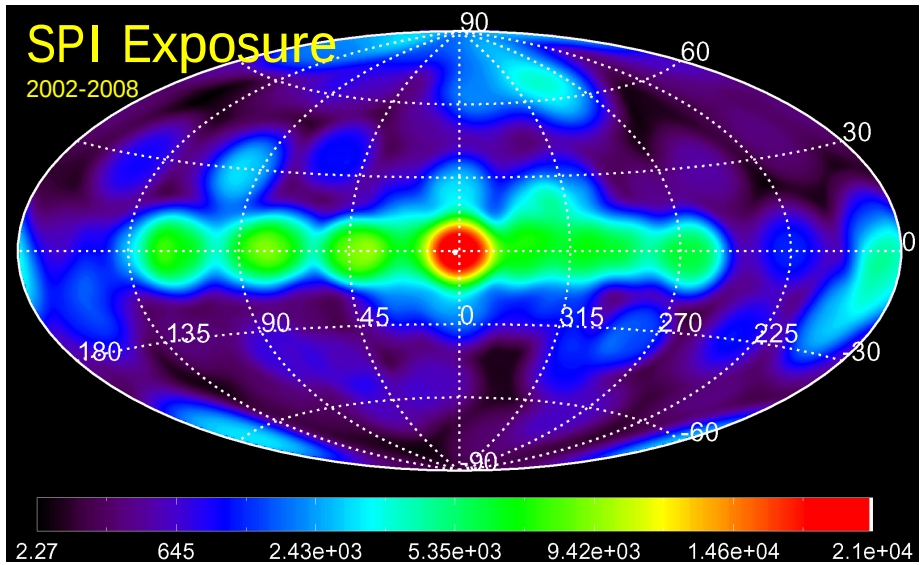
☞ Galactic Plane

- Diffuse Radioactivities (^{26}Al, ^{60}Fe), Positron Annihilation, ^{44}Ti Sources
- Vela Region (^{26}Al, ^{60}Fe, Positron Annihilation)
- Cygnus Region (^{26}Al, ^{60}Fe, Positron Annihilation)

☆ Open Program in the AO Cycles

☞ Specific Source Regions

- SN1987A/LMC
- Cas A
- Tycho
- SN1006
- Cygnus
- Carina
- Vela
- Orion
- Perseus
- Galactic Bulge
- Galactic Ridge
- Scutum Spiral Arm Region



☆ Key Programs

☞ Galactic Plane (511 keV; ^{26}Al, ^{60}Fe; ^{44}Ti)

☞ High-Latitude Region (511 keV reference)

☞ Special Pointing Strategies (511 keV)

Remarks: Judging the "Nucleosynthesis" Field

☆ Progress and Status Measurements are Difficult and Subjective

☞ Choices of Objects and their Units

- observation seconds / numbers of proposals / numbers of scientists & time / ???
- publications / citations / invited talks / N&V / ???

☞ Choices of Normalizations / References

- all absolute numbers merely measure the size of a community
- compare to peer groups: other missions (CGRO / ASCA, XMM... / UVES-VLT / ???)
- compare to other INTEGRAL science objectives (uuuuuuhhhh....)
- compare different epochs / times / AO's

☆ My Choices

☞ Questions Asked

- how do different nucleosynthesis projects compare?
- how did the return on investment evolve over the INTEGRAL mission?
- how does nucleosynthesis compare to other INTEGRAL science objectives?

☞ INTEGRAL Investments

- observing time per AO and nucleosynthesis proposals

☞ Science Return

- refereed-journal publications
- refereed-paper citations

☆ Annotations and Caveat's

☞ This addresses Core Program only Indirectly (-> Proposals on same targets)

☞ Others may take a different (and maybe better) approach

Accepted *Nucleosynthesis* Proposals

☆ *AO's 1-6*

Prop_ID	PI	Title	ksec	Cat
120125	Vink	To the bottom of the explosion forming Cas A: observing 44Ti and the hard X-ray emission	1500	A
120148	Knoedlseder	Probing core collapse: 44Ti and 60Co nucleosynthesis in SN 1987A	1500	A
120154	Knoedlseder	Identification and study of nucleosynthesis sources in the Carina region	1000	B
120158	Hartmann	Mapping Galactic 60Fe synthesis in Centaurus-Circinus	2000	B
220021	Knoedlseder	Identification and study of nucleosynthesis sources in the Carina	2000	A
220027	Knoedlseder	A deep exposure of the Cygnus X region	2000	A
220030	Jean	Positron annihilation in the galactic disk	2000	A
220142	Vink	Ti-44 and hard X-ray continuum diagnostics of Cas A:	1500	A
220023	Kienlin	Deep exposure on GRO J0852-4642 "Vela Junior"	2000	B
220103	Ballet	Hidden supernovae in the Carina arm	2000	B
220112	Bykov	Observations of IC 443 with INTEGRAL: a Supernova Remnant	400	B
220116	Diehl	Massive Stars of Orion OB1 and the ISM	3000	B
220122	Kretschmer	Locating 26Al Sources in the Galaxy	2000	B
220126	Decourchelle	Gamma-ray observations of Cas A and Tycho supernova	1500	B
220150	Schanne	Deep survey of the Vela region for nucleosynthesis studies	2000	B
320004	Schanne	Deep survey of the Vela region for nucleosynthesis studies	2000	A
320011	Weidenspointner	Low-mass X-ray binaries as sources of 511 keV line emission:	1500	A
320013	Weidenspointner	Galactic positron annihilation radiation: discriminating bulge, halo,	2000	A
320056	Vink	Probing the nature of Cas A's and Tycho's supernova explosions	2500	A
320062	Milne	Detecting Positron Annihilation Radiation and Hard X-ray Emission from Type Ia Supernova Remnan	2500	A
430000	Winkler	GC Region Key Program	2000	K
420008	Diehl	Massive Stars of Orion OB1 and the ISM	2500	A
420021	Weidenspointner	Galactic positron annihilation radiation: proving the existence of	1500	A
420073	Sunyaev	Dissecting the Milky Way: Stellar Ridge, Cosmic Rays, Annihilation	4000	A
430012	Weidenspointner	Key project proposal: positron annihilation radiation from the Galactic center region	0	KA
430045	Diehl	Nucleosynthesis Lines from the Inner Galaxy : 26Al,60Fe & 44Ti lines	0	KA
532000	Knoedlseder	Nucleosynthesis and Annihilation Emission from Cygnus X	2000	K
520026	Weidenspointner	Determining the Galactic distribution of positron annihilation radiation by mid-latitude	2000	A
520064	Terrier	X-ray and gamma-ray counterpart of the observed spallation activity in the Per OB2	1500	A
520071	Sunyaev	Dissecting the Milky Way II: Stellar Ridge, Cosmic Rays, Annihilation Radiation,	2000	A
520008	Iyudin	Gamma-Ray Line Emission from the Superbubble	2000	B
520067	Kienlin	A possible 44Ti excess in the Perseus OB 2 association?	1500	B
530018	Weidenspointner	Key programme proposal: positron annihilation radiation from the...	0	KA
530042	Renaud	Search for young supernova remnants with INTEGRAL in the Galactic Centre regions	0	KA
531003	Weidenspointner	Key programme proposal: positron annihilation radiation from...	0	KA
600000	Weidenspointner	Confirming the assymmetry of the positron annihilation emission from the inner disk of the Galaxy	2000	K
632000	Knoedlseder	Nucleosynthesis and Annihilation Emission from Cygnus X	2000	K
620059	Sunyaev	Dissecting the Milky Way III: Stellar Ridge, Cosmic Rays, Annihilation Radiation, Nucleosynthesis	2000	A
630010	Weidenspointner	Positron annihilation radiation from the Galactic bulge region	0	KA
630036	Renaud	Search for young supernova remnants with INTEGRAL in the Galactic Center region	0	KA
630046	Terrier	G1.9+0.3: constraining particle acceleration and nucleosynthesis in the youngest known Galactic S	0	KA
631002	Weidenspointner	Positron annihilation radiation from the North Ecliptic Pole region	0	KA
632022	Renaud	Search for young supernova remnants with INTEGRAL in the Cygnus X region	0	KA
633035	Renaud	Search for young supernova remnants with INTEGRAL in the inner Galactic disk	0	KA
635004	Weidenspointner	Positron annihilation radiation from the Virgo region	0	KA

Nucleosynthesis Proposals: The Outcome

☆ **Accumulated Observing Time**

☆ **Papers on Proposal's Science** with PI as Co-Author, Refereed

Prop_ID	PI	Title	ksec	Cat	ksec observed	Papers specific	Papers context	Ref1: Author	Ref1: Journal	Ref1: Year	Prop: Year
120125	Vink	To the bottom of the explosion forming Cas A: observing 44Ti and the hard X-ray emission	1500	A	1500.40	1	2	Martin	NAR	2008	2002
120148	Knoedlseder	Probing core collapse: 44Ti and 60Co nucleosynthesis in SN 1987A	1500	A	1500.40	0	0				2002
120154	Knoedlseder	Identification and study of nucleosynthesis sources in the Carina region	1000	B	0.00	0	0				2002
120158	Hartmann	Mapping Galactic 60Fe synthesis in Centaurus-Circinus	2000	B	509.65	0	0				2002
220021	Knoedlseder	Identification and study of nucleosynthesis sources in the Carina	2000	A	2000.46	0	0				2003
220027	Knoedlseder	A deep exposure of the Cygnus X region	2000	A	2000.13	1	1	Martin	A&A	2009	2003
220030	Jean	Positron annihilation in the galactic disk	2000	A	1981.30	2	13	Jean	A&A	2006	2003
220142	Vink	Ti-44 and hard X-ray continuum diagnostics of Cas A:	1500	A	1500.06	3	10	Renaud	ApJ	2006	2003
220023	Kienlin	Deep exposure on GRO J0852-4642 "Vela Junior"	2000	B	0.00	0	0				2003
220103	Ballet	Hidden supernovae in the Carina arm	2000	B	2000.46	0	0				2003
220112	Bykov	Observations of IC 443 with INTEGRAL: a Supernova Remnant	400	B	691.00	0	2	Bykov	ApJ	2005	2003
220116	Diehl	Massive Stars of Orion OB1 and the ISM	3000	B	0.00	0	0				2003
220122	Kretschmer	Locating 26Al Sources in the Galaxy	2000	B	2576.60	1	8	Kretschmer	AdvSpRes	2006	2003
220126	Decourchelle	Gamma-ray observations of Cas A and Tycho supernova	1500	B	1500.06	2	2	Renaud	ApJ	2006	2003
220150	Schanne	Deep survey of the Vela region for nucleosynthesis studies	2000	B	0.00	0	0				2003
320004	Schanne	Deep survey of the Vela region for nucleosynthesis studies	2000	A	2936.96	0	0				2004
320011	Weidenspointner	Low-mass X-ray binaries as sources of 511 keV line emission:	1500	A	2374.70	1	6	Knödlseder	A&A	2005	2004
320013	Weidenspointner	Galactic positron annihilation radiation: discriminating bulge, halo,	2000	A	1729.06	1	6	Knödlseder	A&A	2005	2004
320056	Vink	Probing the nature of Cas A's and Tycho's supernova explosions	2500	A	2161.06	3	10	Renaud	ApJ	2006	2004
320062	Milne	Detecting Positron Annihilation Radiation and Hard X-ray Emission from Type Ia Supernova Remnan	2500	A	2374.70	1	3	Kalemci	ApJ	2006	2004
430000	Winkler	GC Region Key Program	2000	K	2005.58	0	0	(several...)			2005
420008	Diehl	Massive Stars of Orion OB1 and the ISM	2500	A	2500.26	0	8	Diehl	NAR	2004	2005
420021	Weidenspointner	Galactic positron annihilation radiation: proving the existence of	1500	A	1500.25	1	6	Knödlseder	A&A	2005	2005
420073	Sunyaev	Dissecting the Milky Way: Stellar Ridge, Cosmic Rays, Annihilation	4000	A	3991.84	12	4	Sazonov	ExpAst	2005	2005
430012	Weidenspointner	Key project proposal: positron annihilation radiation from the Galactic center region	0	KA	0.00	0	6	Knödlseder	A&A	2005	2005
430045	Diehl	Nucleosynthesis Lines from the Inner Galaxy : 26Al,60Fe & 44Ti lines	0	KA	0.00	4	12	Diehl	Nat	2006	2005
532000	Knoedlseder	Nucleosynthesis and Annihilation Emission from Cygnus X	2000	K	1698.00	1	1	Martin	A&A	2009	2006
520026	Weidenspointner	Determining the Galactic distribution of positron annihilation radiation by mid-latitude	2000	A	1782.64	0	6	Knödlseder	A&A	2005	2006
520064	Terrier	X-ray and gamma-ray counterpart of the observed spallation activity in the Per OB2	1500	A	1306.10	0	0				2006
520071	Sunyaev	Dissecting the Milky Way II: Stellar Ridge, Cosmic Rays, Annihilation Radiation,	2000	A	1372.41	0	12				2006
520008	Iyudin	Gamma-Ray Line Emission from the Superbubble	2000	B	1983.03	0	0				2006
520067	Kienlin	A possible 44Ti excess in the Perseus OB 2 association?	1500	B	1306.10	0	0				2006
530018	Weidenspointner	Key programme proposal: positron annihilation radiation from the...	0	KA	0.00	0	0	Knödlseder	A&A	2005	2006
530042	Renaud	Search for young supernova remnants with INTEGRAL in the Galactic Centre regions	0	KA	0.00	0	3	Renaud	ApJ	2006	2006
531003	Weidenspointner	Key programme proposal: positron annihilation radiation from...	0	KA	0.00	1	3	Weidenspointn	Nat	2008	2006

☞ up to AO-5 (which is complete); Status Apr'09, Obs up to Rev 778 / Feb'09

Nucleosynthesis ToO's: No Luck yet

- SN2003gs
- SN2004dj
- SN2008S
- (M. Leising)

Summary							Mpc	
	Date	Exposure	Target	Type	Host	ref	Distance	Peculiarities
	Aug.03	300048	SN 2003gs type Ia	Ia-p	NGC 936	IAU 8171	16.6	Si lines weak, 11000 km/s; subluminous
	Aug.04	200032	SN 2004dj	II-P	NGC 2403	IAU 8377	3.1	
	Feb.08	552000	SN 2008S	II-n?	NGC 6946	CBET 1234	5.6	

INTEGRAL/SPI Science Contributions

☆ "Nucleosynthesis and Gamma-Ray Line Spectroscopy" is a Major Science Field where SPI Results Contribute

☞ Citation Status Snapshot for SPI Publications

(ADS Paper Database)

- Weekly Status Update, Fri Apr 17 05:11:22 2009
- Complete Citation History till Apr'09

+SPI, INTEGRAL - Most Cited

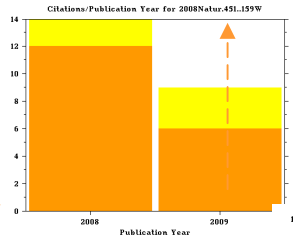
2008Natur.451..159W: Weidenspointner,+: An asymmetric distribution of positrons in the Galactic disk revealed by gamma-rays

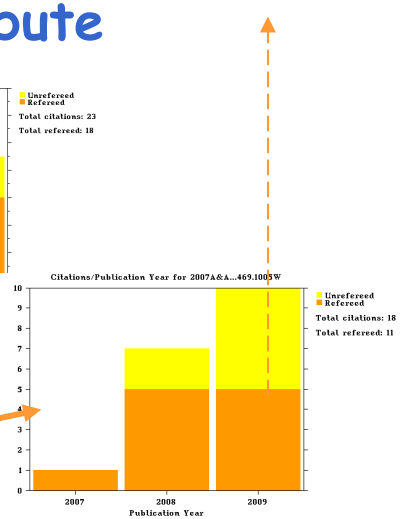
2007A&A...469.1005W: Wang,+: SPI observations of the diffuse ^{60}Fe emission in the Galaxy

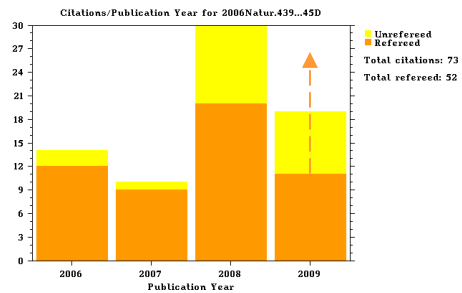
2006ApJ...647..483L: Limongi,+: The Nucleosynthesis of ^{26}Al and ^{60}Fe in Solar Metallicity Stars Extending in Mass from 11 to 120 M_{solar}: The Hydrostatic and Explosive Contributions

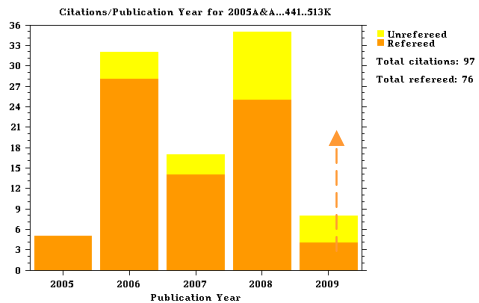
2006Natur.439...45D: Diehl,+: Radioactive ^{26}Al from massive stars in the Galaxy

2005A&A...441..513K: Knödlseder,+: The all-sky distribution of 511 keV electron-positron annihilation emission

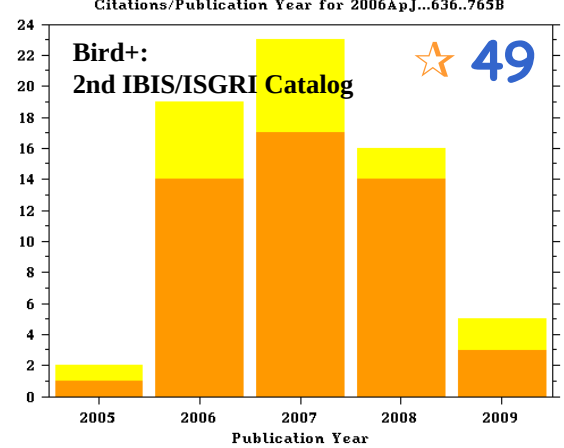


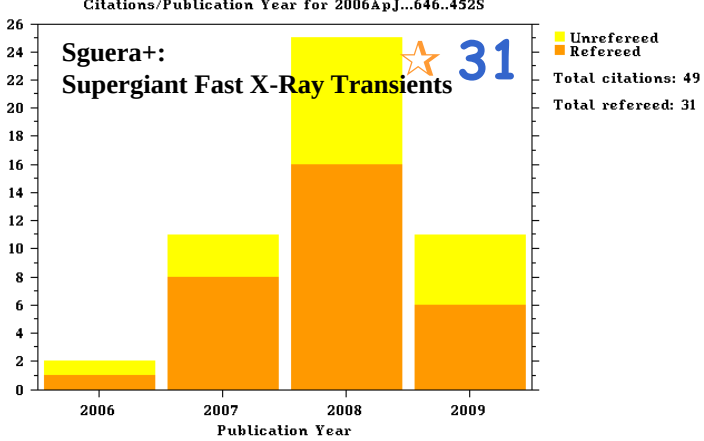


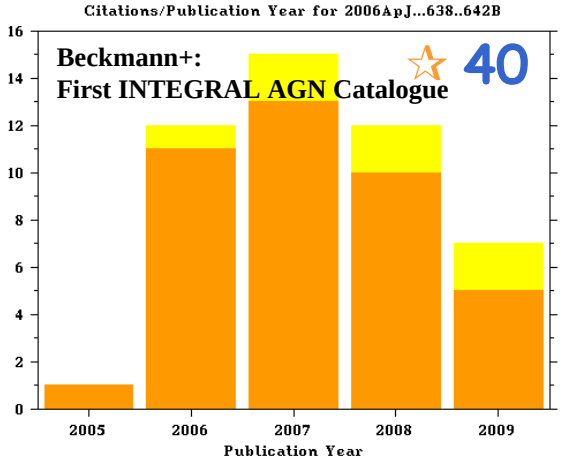




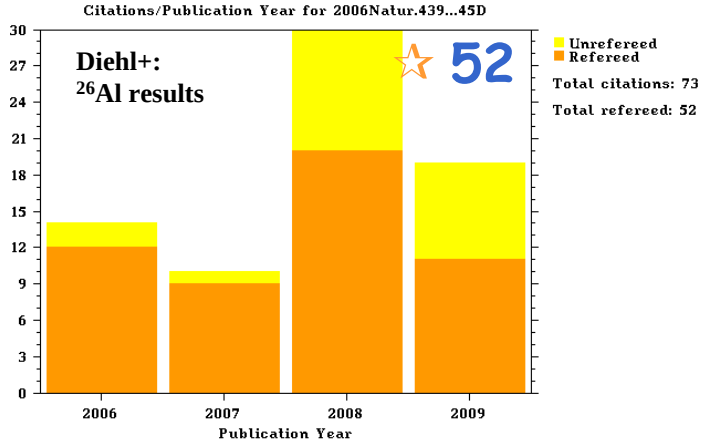
An "Impact" Comparison

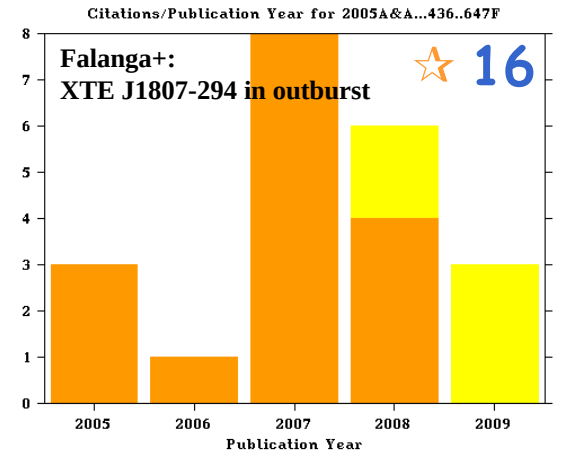


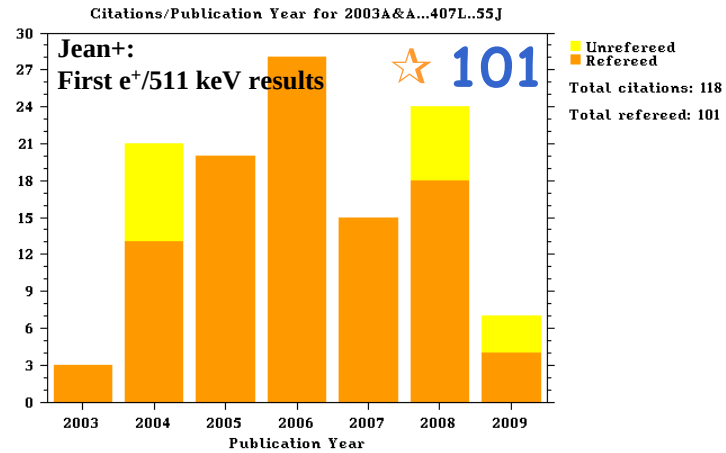




Well-Cited INTEGRAL Papers in Different Core Science Areas with Some Citation History





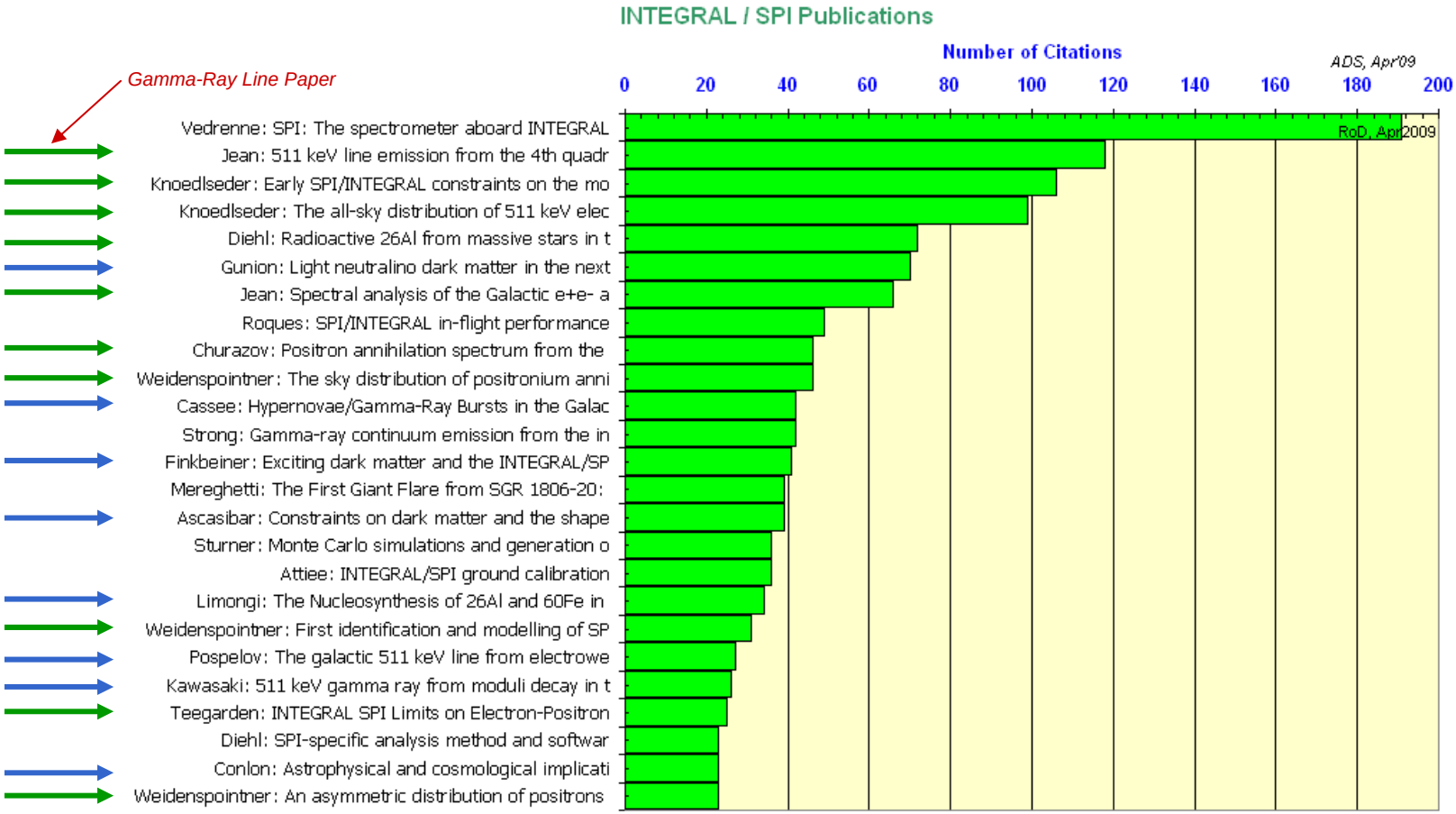


INTEGRAL/SPI Science Contributions

☆ "Nucleosynthesis and Gamma-Ray Line Spectroscopy" is a Major Science Field where SPI Results Contribute

☞ Citation Status for SPI Publications

(ADS Paper Database; Apr 2009)



Status of *Nucleosynthesis* with INTEGRAL

- ☆ **Nucleosynthesis is a Key Science Turf for INTEGRAL**
  - ☞ Unique Observations and Data
  - ☞ Diversity of Objects & Objectives
- ☆ **INTEGRAL's Nucleosynthesis Results Have Major Impact**
  - ☞ Fewer Papers than other INTEGRAL Science Areas
  - ☞ Among the Most-Cited INTEGRAL Papers
  - ☞ External Community Attention Obtained after ~3 years
- ☆ **Large Observing Investments Appear Justified**
  - ☞ Several Hallmark Publications, Nucleosynthesis-Line Legacy Results
  - ☞ Broad Interests
- ☆ **Typical Results Appear after ~3 Years or More**
  - ☞ Major Discoveries Have Been Reported
  - ☞ Refinement Studies Will Address More Subtle Astrophysics Issues
    - Spatially-Resolved Spectroscopy for Diffuse Emissions -> Line Astronomy...
    - Upper Limits for Key/Candidate Sources/Regions -> Constrain Model Space...
    - Expect Future Papers to Address Expert-Community
  - ☞ Some Observations Have Not Yet Been Summed Up (and Should)

other Recent Science from SPI's AntiCoincidence

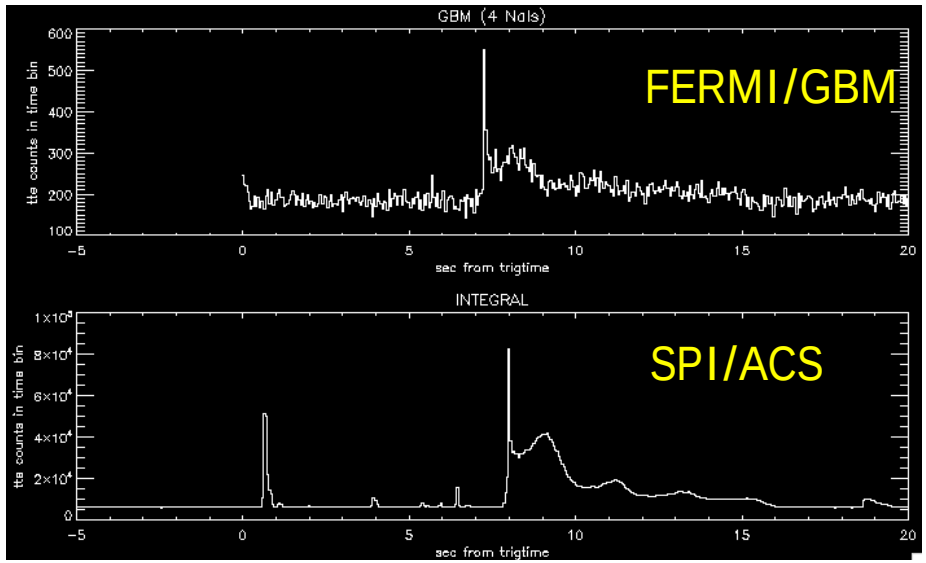
☆ 512 kg of BGO Detector (!)

- ☞ Most-sensitive ~MeV gamma-ray detector for all-sky monitoring

☆ AXP 1E1547.0-5408

- GCN 8841, Mereghetti+ Jan 22 2009

- ☞ ACS recorded two bright and long bursts on from the recently reactivated AXP 1E1547.0-5408.
- ☞ Pulsations at NS period (2.1 s) are clearly visible



☆ GRB 080916C

- Abdo+ Science 2009; Greiner+ A&A 2009

- ☞ Brightest-Ever GRB (~4 10^{52} erg in gamma-rays) at z=4.35, with GeV Emission
- ☞ ACS recorded time variability at <100ms time scale
  -> Lorentz Factor Γ>1000 (in conflict with afterglow-derived Γ~80-200)