

The CGRO/COMPTEL All-SKY Survey at MeV Energies

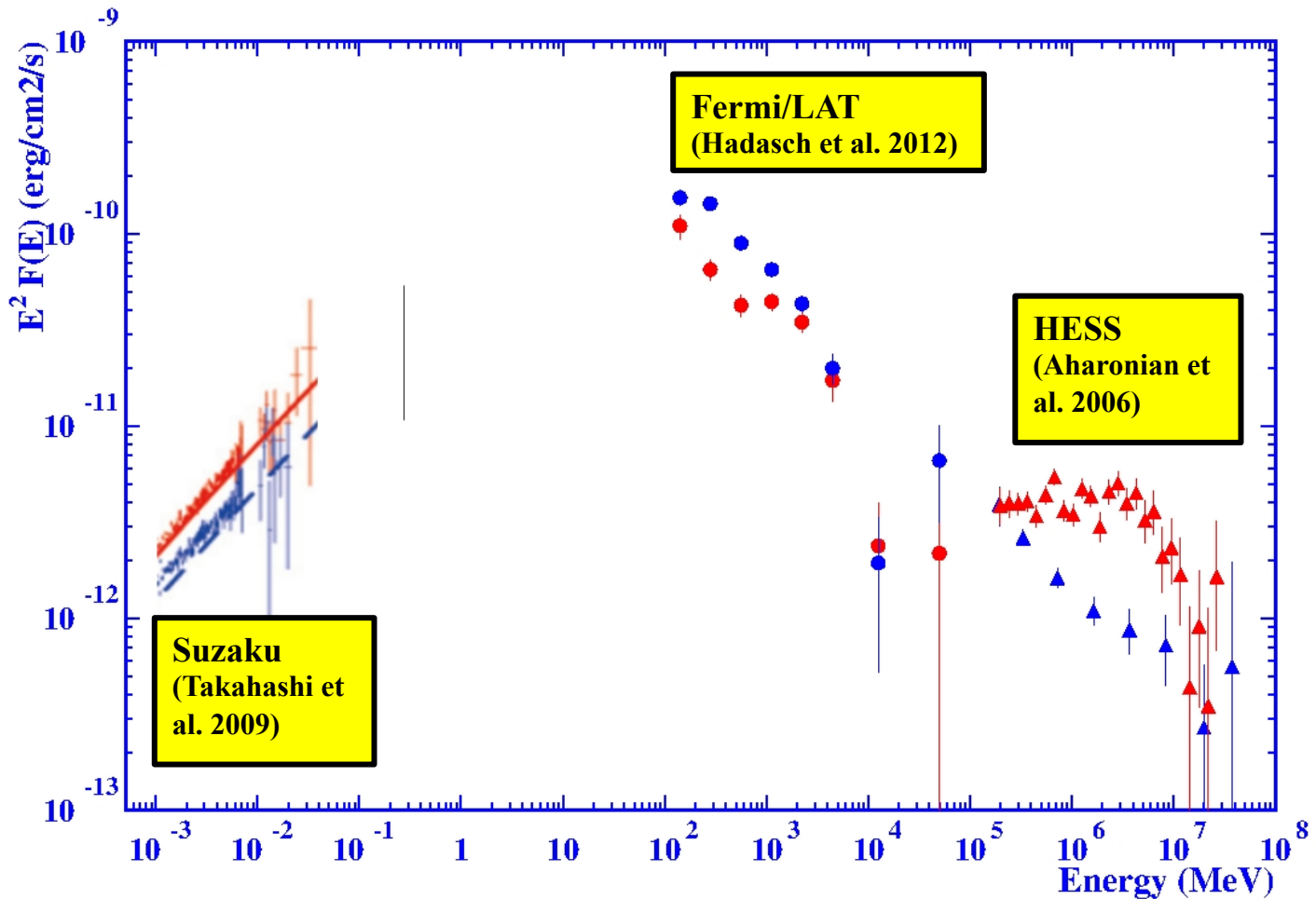
Werner Collmar & Andrew Strong

MPE Garching

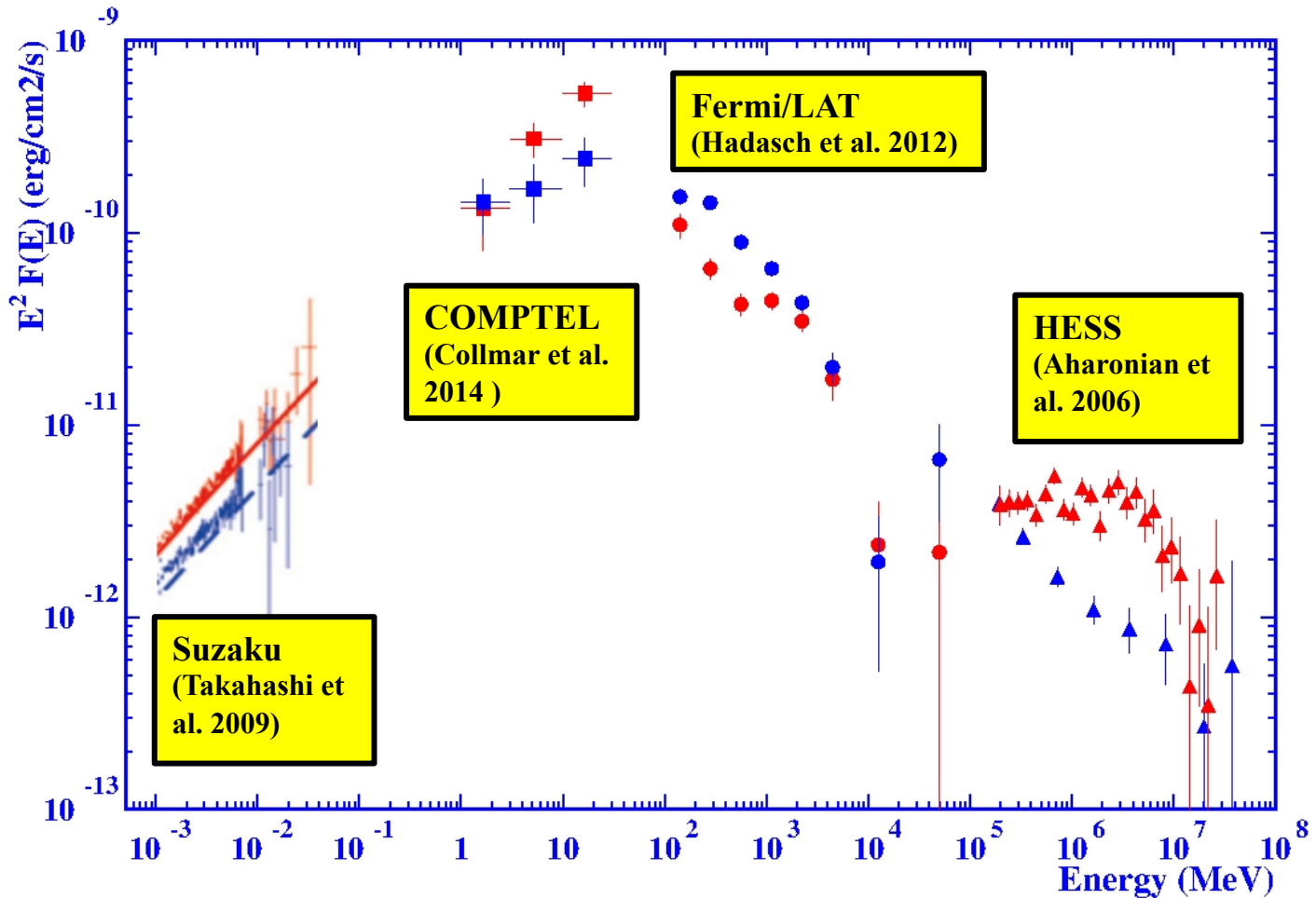
Outline

- 1) COMPTEL on CGRO**
- 2) Recent Instrumental/Software Developments**
- 3) All-Sky Imaging**
- 4) Science Perspectives**
- 5) Summary**

LS 5039 High-Energy SED



LS 5039 High-Energy SED



Current Worldwide COMPTEL Team

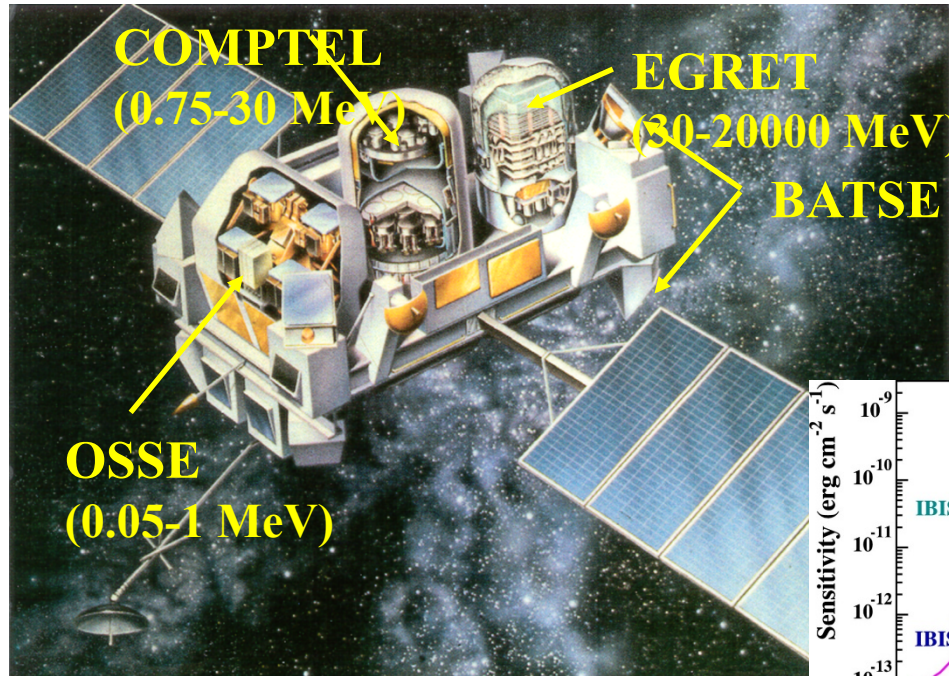


Andy: COMPTEL „Imaging“ expert (SKYMOS)

Werner: has all the COMPTEL data, software, knowledge ...

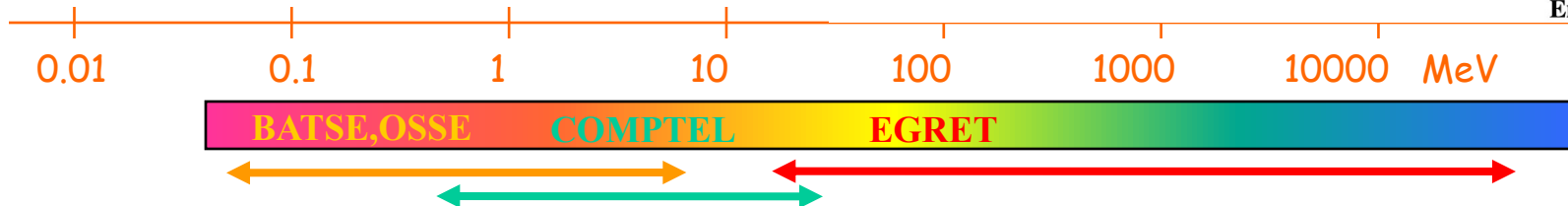
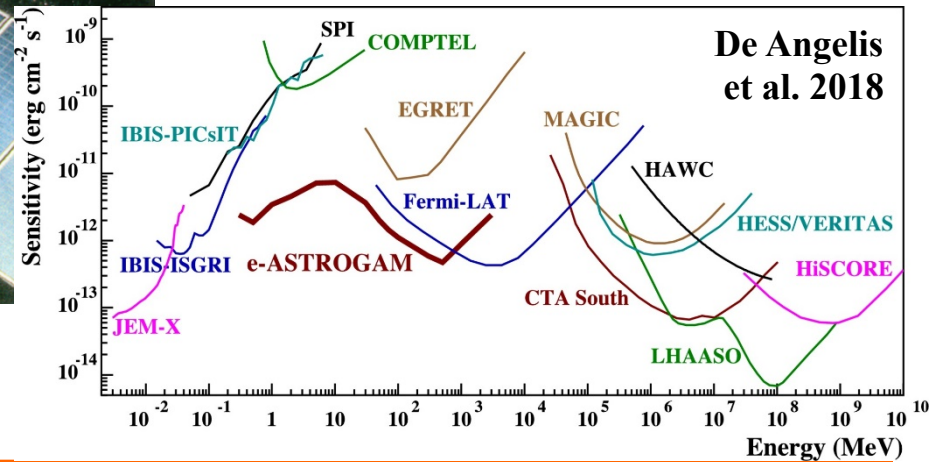
Lukas & Maxim: 2 master students (machine learning / NIFTy)

COMPTEL on CGRO

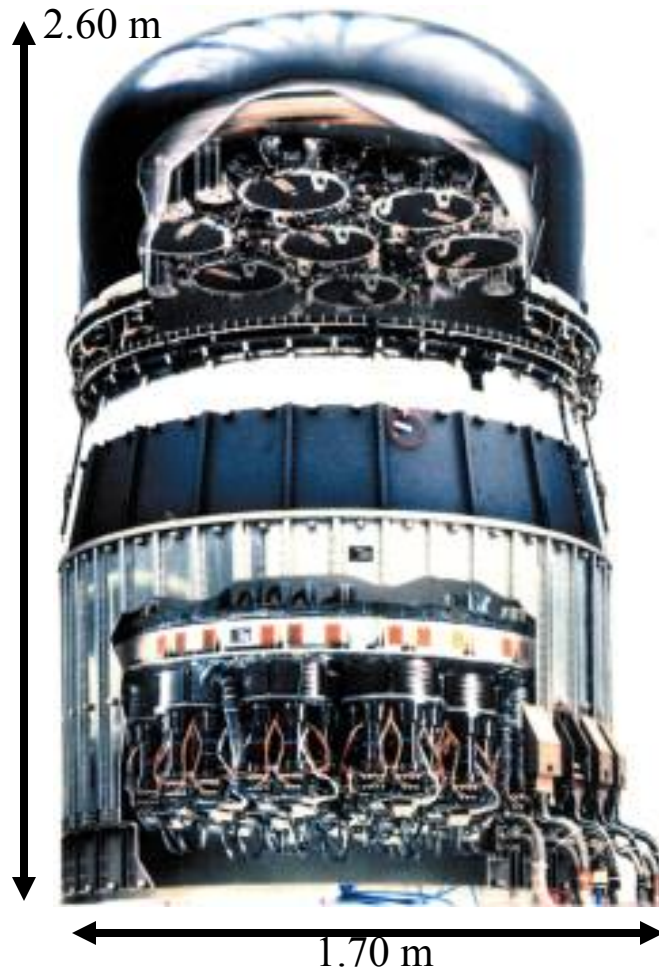


COMPTEL (Compton Telescope)

- mission: Apr. 91 – June 2000
- energy range: 0.75 – 30 MeV
- mounted parallel to EGRET
- “first-generation” experiment
- **pioneered MeV band**

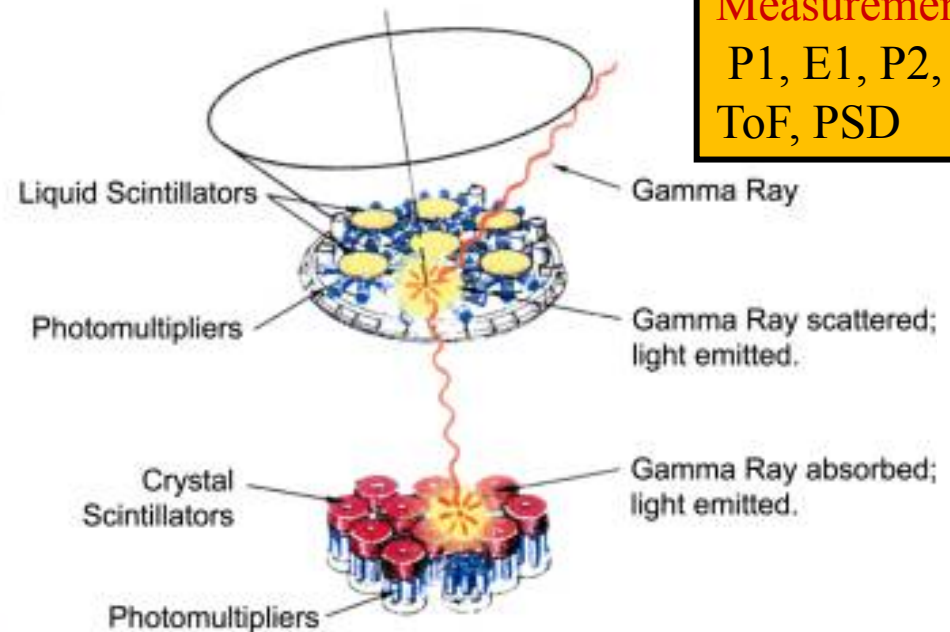


COMPton TELescope “COMPTEL”

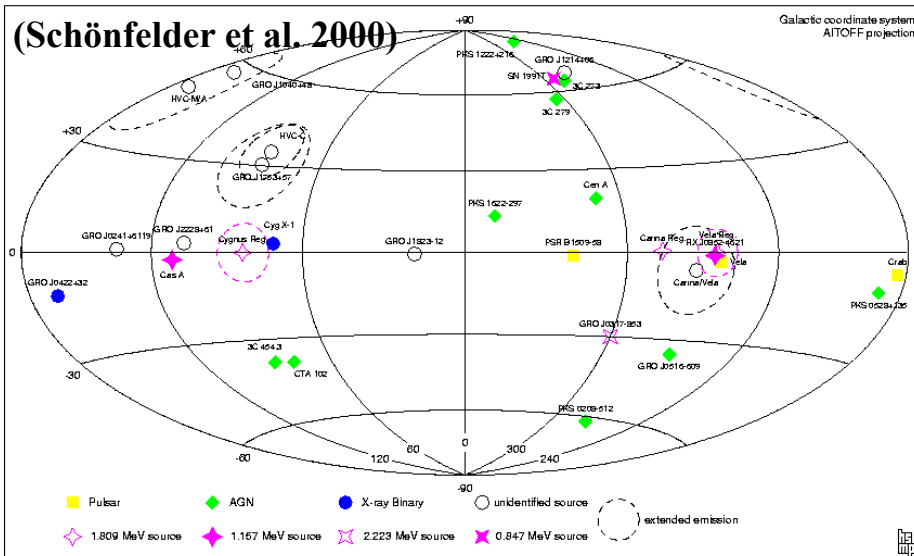


Detection Principle

Measurements:
P1, E1, P2, E2
ToF, PSD



Summary First COMPTEL Source Catalog



- contains published results of first 5.5 years (April '91 – October '96)
- 32 Sources (different nature)
- 31 GRBs / 21 solar flares
- upper limits for various types of objects (e.g. AGN, gal. BHs)

Source Type	#
Pulsars	3
Stellar Binaries	2
SNR (continuum)	1
AGN	10
Unidentified Sources	
- $ b < 10^\circ$	3
- $ b > 10^\circ$	5
γ -line sources	
- 1.809 MeV (^{26}Al)	3
- 1.157 MeV (^{44}Ti)	2
- 0.847/1.238 MeV (^{56}Co)	1
- 2.223 MeV (n-capt.)	1

Recent Developments: Analysis

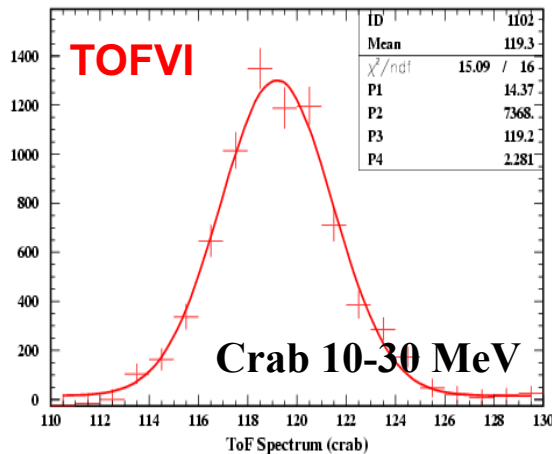
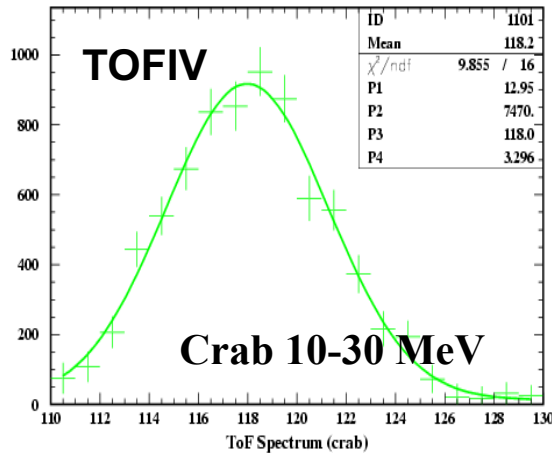
COMPTEL Energy Bands

- „Classic“ Bands („by numbers“)
0.75 – 1 MeV
1 – 3 MeV
3 – 10 MeV
10 – 30 MeV
all published results yet !
- „New“ Bands („by physics“)
0.9 – 1.7 MeV
1.7 – 4.3 MeV
4.3 – 9.0 MeV
9.0 – 30 MeV
fit better to mission and
instrumental background

Analysis Software (changes)

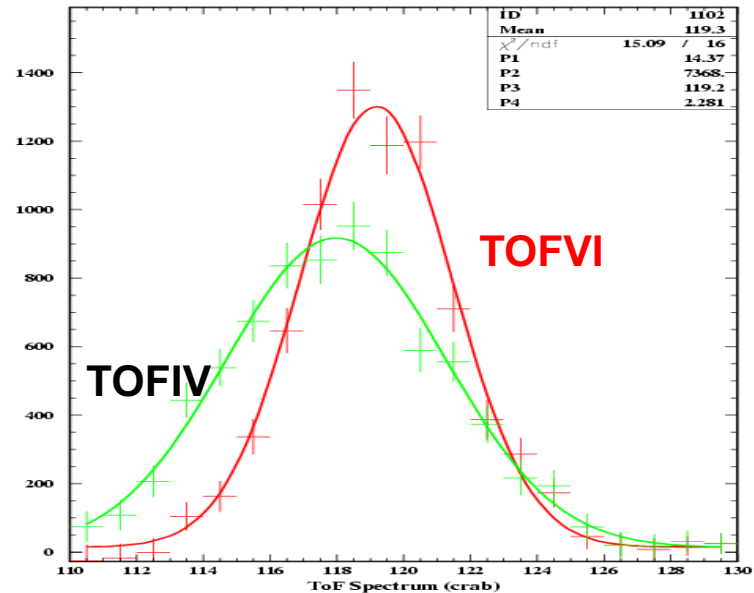
- **COMPASS Tools -> Linux**
-> fast modern computers
- **Bayesian Maximum Entropy
Deconvolution Method**
(A. Strong, M. Reineke, T. Ensslin)
 - HealPix: equal-area all-sky
projection for data and image
 - Fast convolution on sphere
 - Parallel architecture
- **PAW-System (CERN) to
display events and event
parameter**

Recent Developments: COMPTEL Data (Weidenspointner 2000)



Re-Processing of COMPTEL Data

- ToF Distributions of the Crab (10-30 MeV)
- ToF IV: Version used in COMPTEL era
- ToF VI: Reprocessing 2002 (ToF; PSD)
- > new event selections / calibrations



All-Sky Imaging CGRO Pointing Strategy

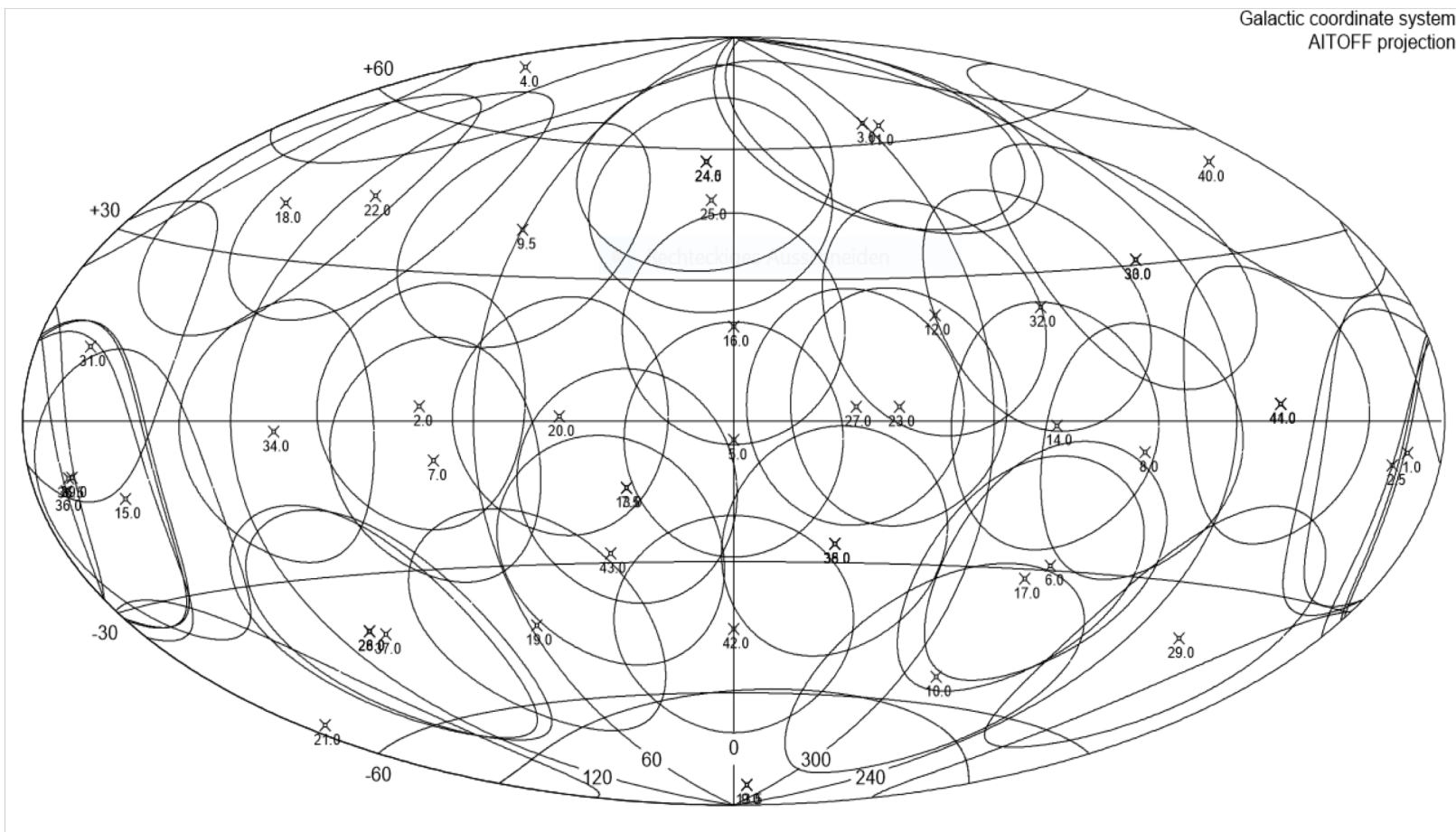
2.0	191	-5	140	38	Crab pulsar	91-05-16	to	91-05-30	
1.0	73	3	90	42	Cyg X-1	91-05-30	to	91-06-08	
2.5	195	-7	70	50	Sun	91-06-08	to	91-06-15	TOO
3.0	300	65	130	42	SN 1991T	91-06-15	to	91-06-28	
4.0	156	72	140	34	NGC 4151	91-06-28	to	91-07-12	
5.0	0	-4	140	36	Gal. Center	91-07-12	to	91-07-26	
6.0	278	-29	130	30	SN 1987A	91-07-26	to	91-08-08	
7.0	70	-8	70	50	Cyg X-3	91-08-08	to	91-08-15	TOO
7.5	25	-14	70	33	G 25.0-14.0	91-08-15	to	91-08-22	part 2 in 13
8.0	263	-6	140	33	Vela pulsar	91-08-22	to	91-09-05	
9.0	339	-84	70	35	G 338.9-83.5	91-09-05	to	91-09-12	part 2 in 13
9.5	60	40	70	42	Her X-1	91-09-12	to	91-09-19	
10.0	288	-54	140	31	FAIRALL 9	91-09-19	to	91-10-03	
11.0	294	64	140	38	3C 273	91-10-03	to	91-10-17	
12.0	311	22	140	32	Cen A	91-10-17	to	91-10-31	
13.0	25	-14	70	40	G 25.0-14.0	91-10-31	to	91-11-07	obs. 7 cont.
13.5	339	-84	70	35	G 338.9-83.5	91-11-07	to	91-11-14	obs. 9 cont.
14.0	285	-1	140	23	Eta Car	91-11-14	to	91-11-28	
15.0	153	-13	140	42	NGC 1275	91-11-28	to	91-12-12	
16.0	0	20	150	37	Sco X-1	91-12-12	to	91-12-27	
17.0	283	-32	140	29	SN 1987A rep	91-12-27	to	92-01-10	
18.0	137	40	130	39	M 82	92-01-10	to	92-01-23	CA corr.obs.
19.0	58	-43	140	39	G 58.2-43.0	92-01-23	to	92-02-06	
20.0	40	1	140	42	SS 433	92-02-06	to	92-02-20	
21.0	172	-54	140	32	NGC 1068	92-02-20	to	92-03-05	
22.0	112	44	140	32	MRN 279	92-03-05	to	92-03-19	CA corr.obs.
23.0	322	3	140	16	Cir X-1	92-03-19	to	92-04-02	
24.0	10	57	70	24	G 9.53+57.15	92-04-02	to	92-04-09	
24.5	10	57	70	25	G 9.53+57.15	92-04-09	to	92-04-16	
25.0	7	48	70	25	G 007+48	92-04-16	to	92-04-23	
26.0	109	-41	50	19	MRK 335	92-04-23	to	92-04-28	
27.0	332	3	90	19	4U1543-47	92-04-28	to	92-05-07	TOO
28.0	109	-41	70	25	MRK 335	92-05-07	to	92-05-14	
29.0	224	-40	210	21	G 224-40	92-05-14	to	92-06-04	
30.0	252	31	70	24	NGC 2992	92-06-04	to	92-06-11	
31.0	163	12	140	37	MCG +8-11-11	92-06-11	to	92-06-25	
32.0	284	23	70	20	NGC 3783	92-06-25	to	92-07-02	
33.0	252	31	140	20	NGC 2992	92-07-02	to	92-07-16	
34.0	109	-2	210	17	CAS A	92-07-16	to	92-08-06	
35.0	335	-26	50	18	ESO 141-55	92-08-06	to	92-08-11	
36.0	170	-11	10	25	GRO J0422+32	92-08-11	to	92-08-12	TOO
36.5	168	-9	80	25	GRO J0422+32	92-08-12	to	92-08-20	TOO
37.0	105	-42	70	25	MRK 335	92-08-20	to	92-08-27	
38.0	335	-26	50	20	ESO 141-55	92-08-27	to	92-09-01	
39.0	167	-9	160	25	GRO J0422+32	92-09-01	to</		

- **CGRO observed the sky sequentially in so called „Viewing Periods (VPs)“ by looking at selected positions on the sky for typically a few weeks.**
- **343 VPs during the mission (May 1991 – June 2000)**

All-Sky Imaging

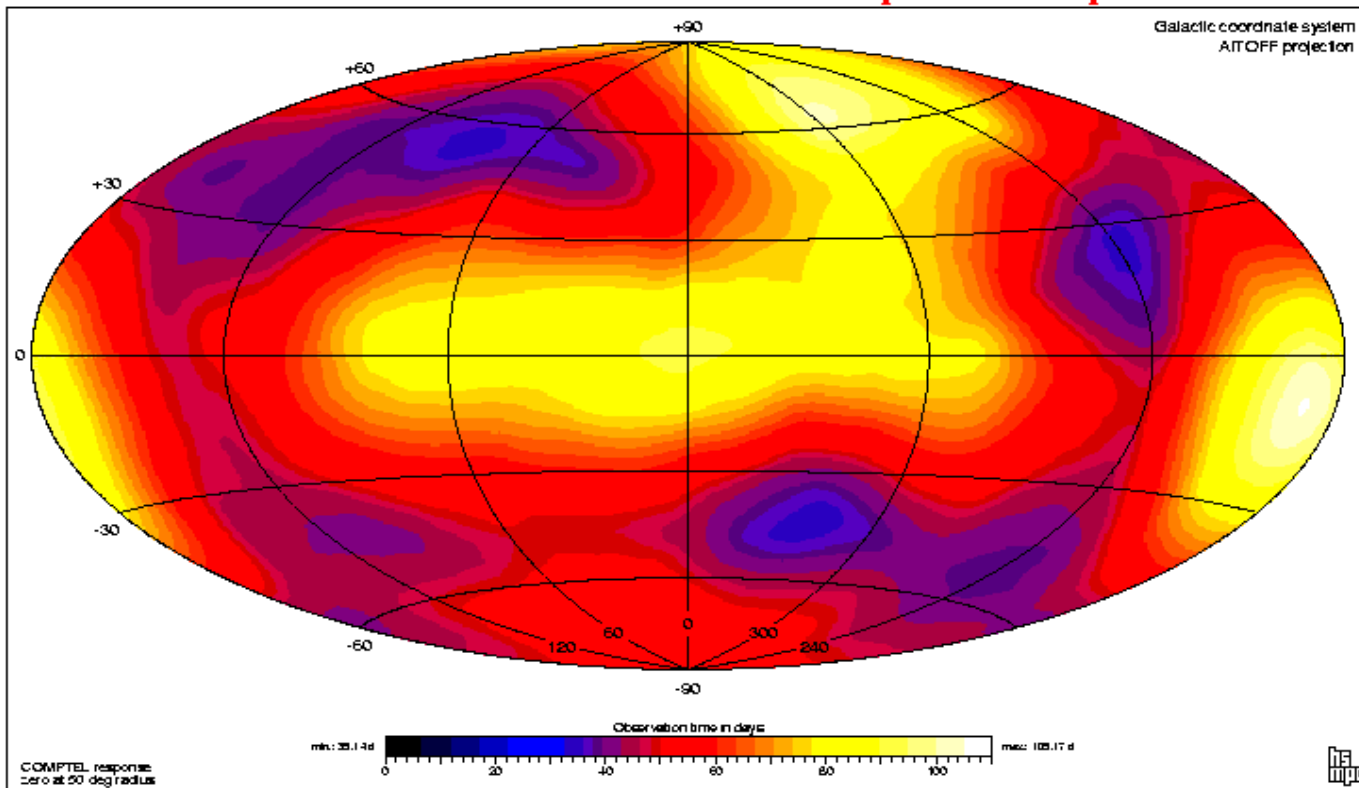
CGRO Pointing Strategy (1. Year / Phase I)

Galactic coordinate system
AITOFF projection



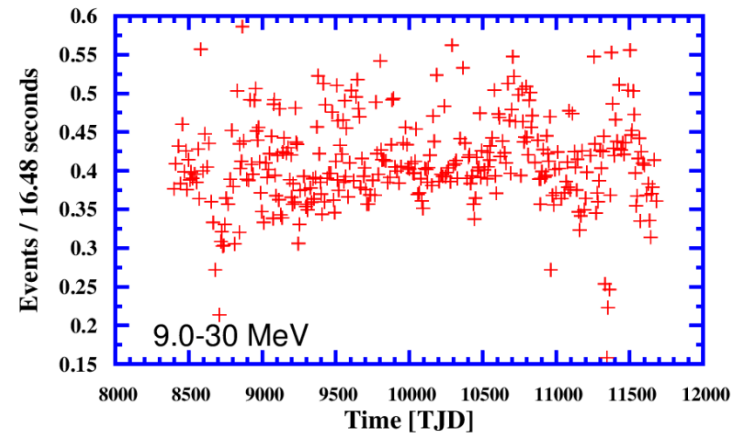
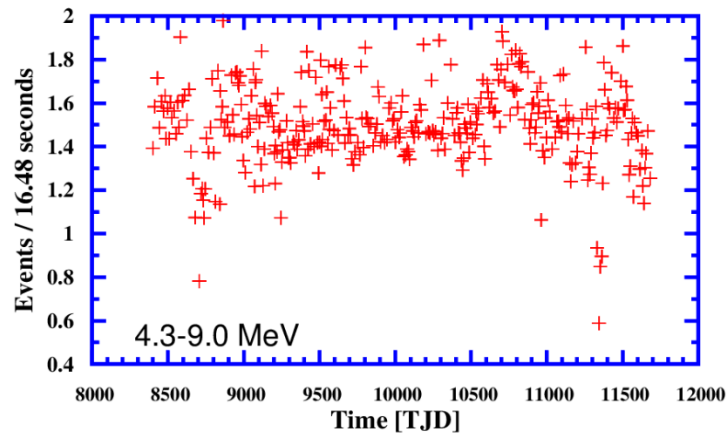
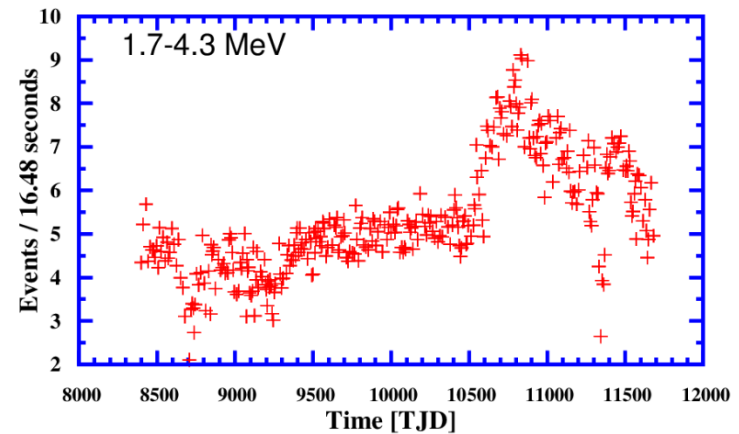
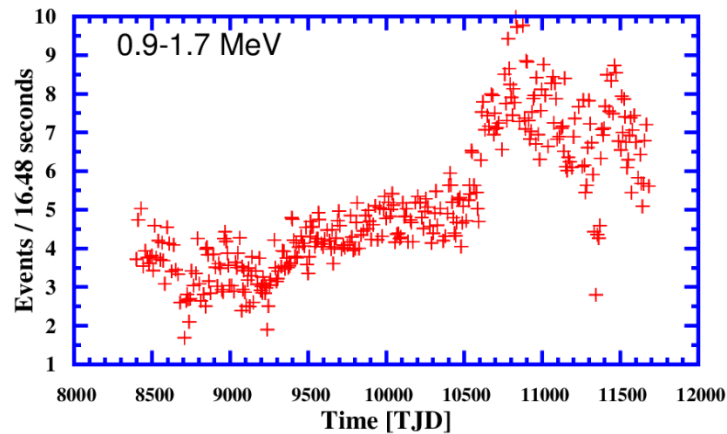
All-Sky Imaging: All-Mission Exposure

CGRO/COMPTEL All-Mission Exposure Map



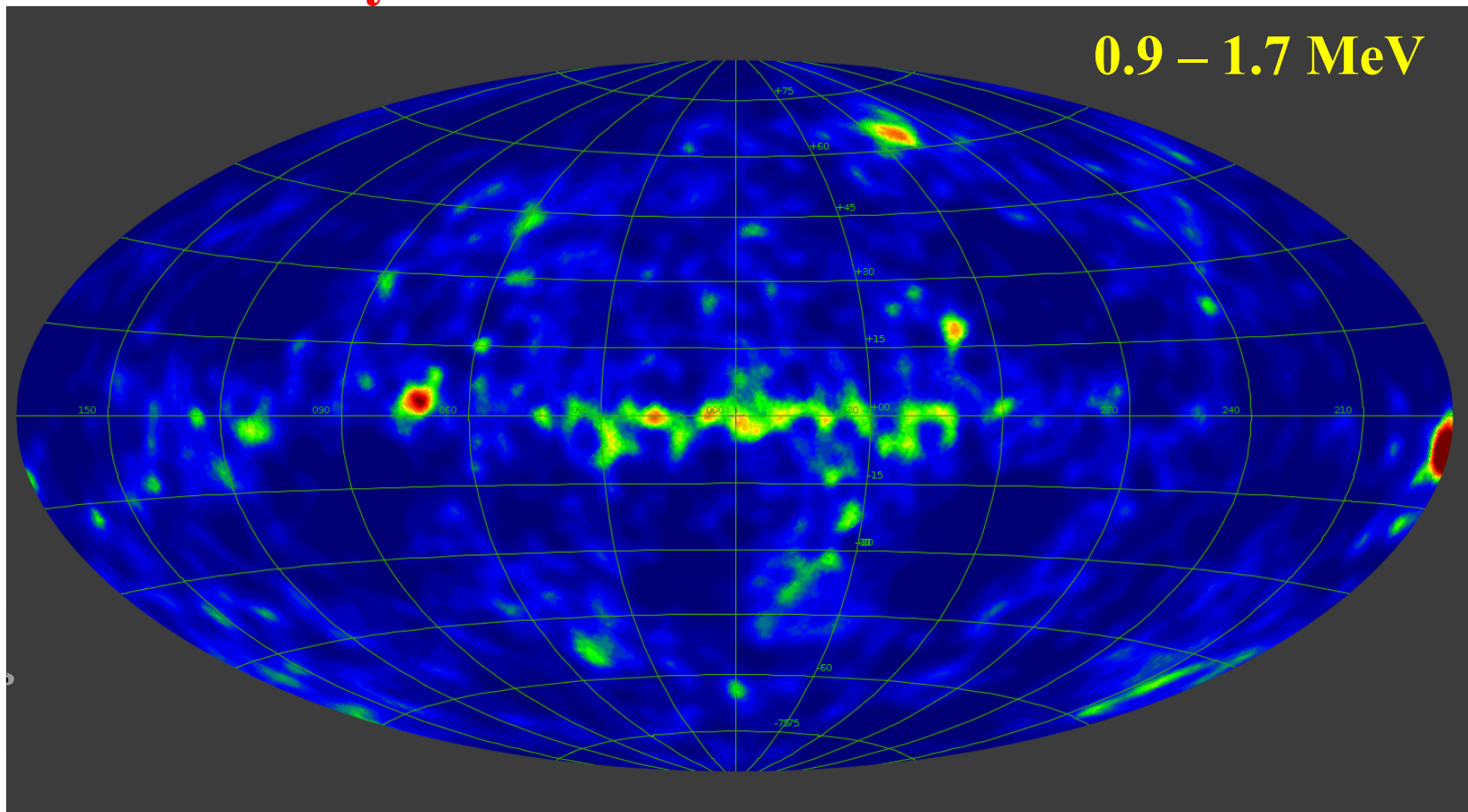
All-Sky Imaging

Average Event Rate in 4 Energy Bands (343 VPs)



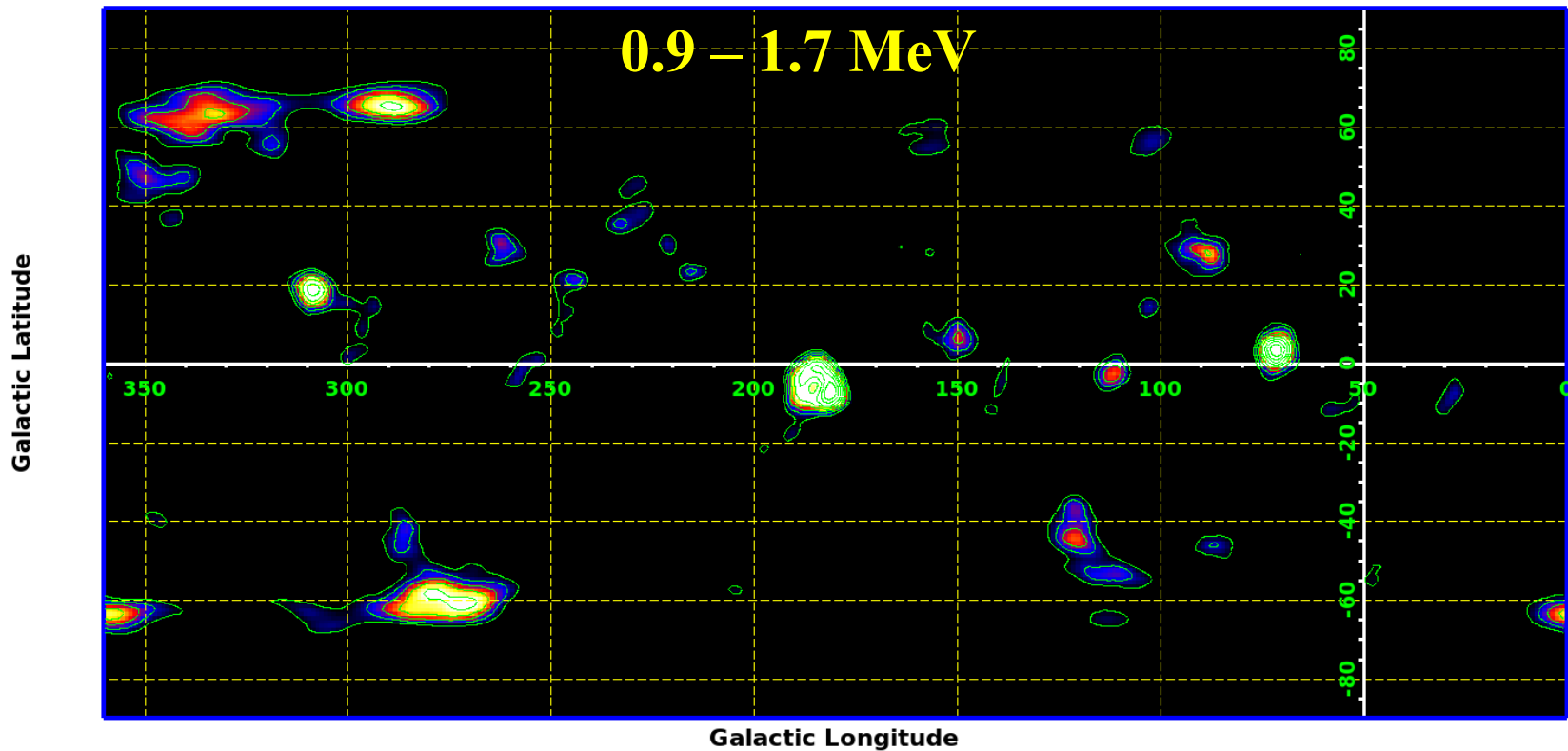
All-Sky All-Mission Imaging (Work in progress)

Preliminary



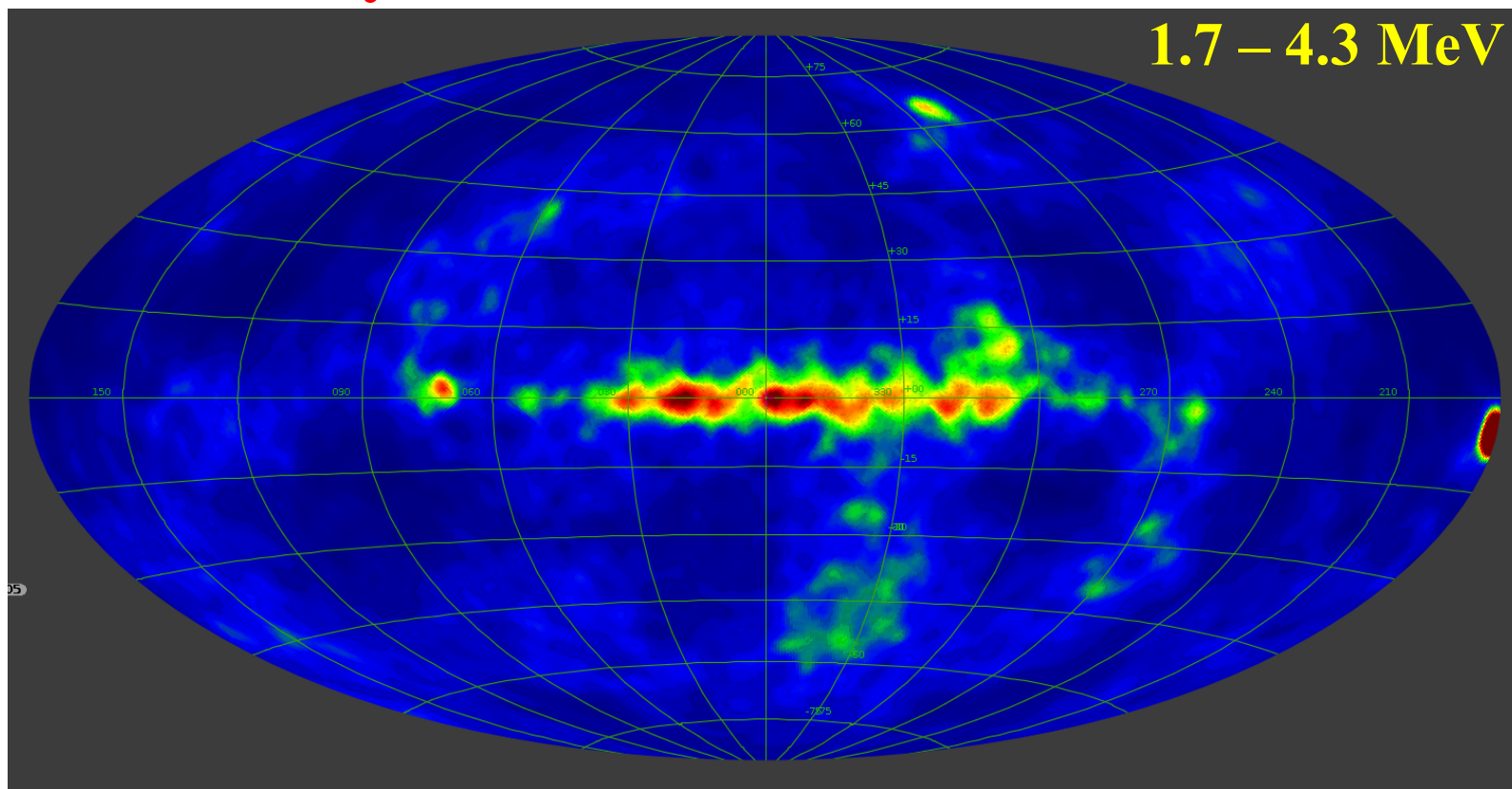
All-Sky All-Mission Point Source Maps (Work in progress)

Source Significances



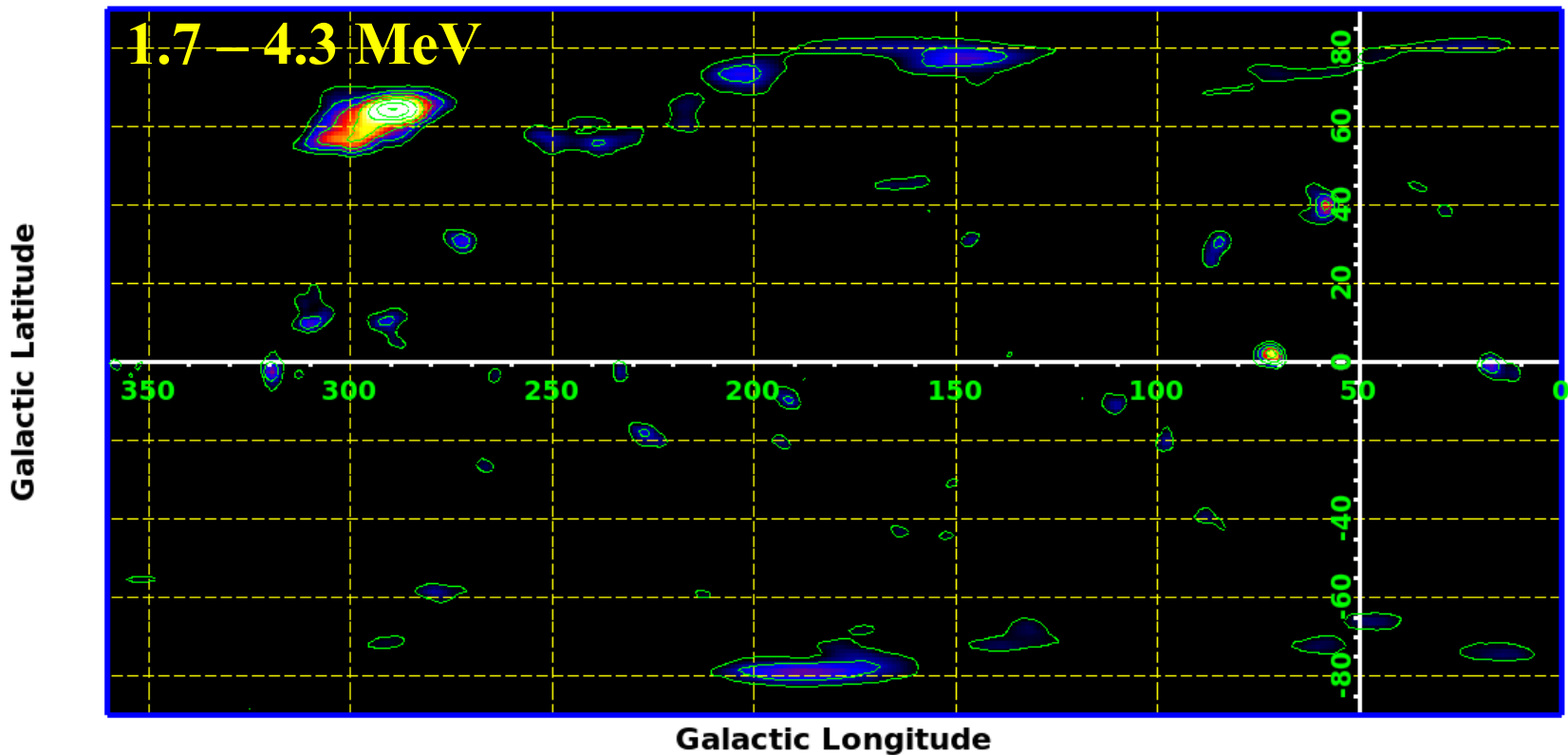
All-Sky All-Mission Imaging (Work in progress)

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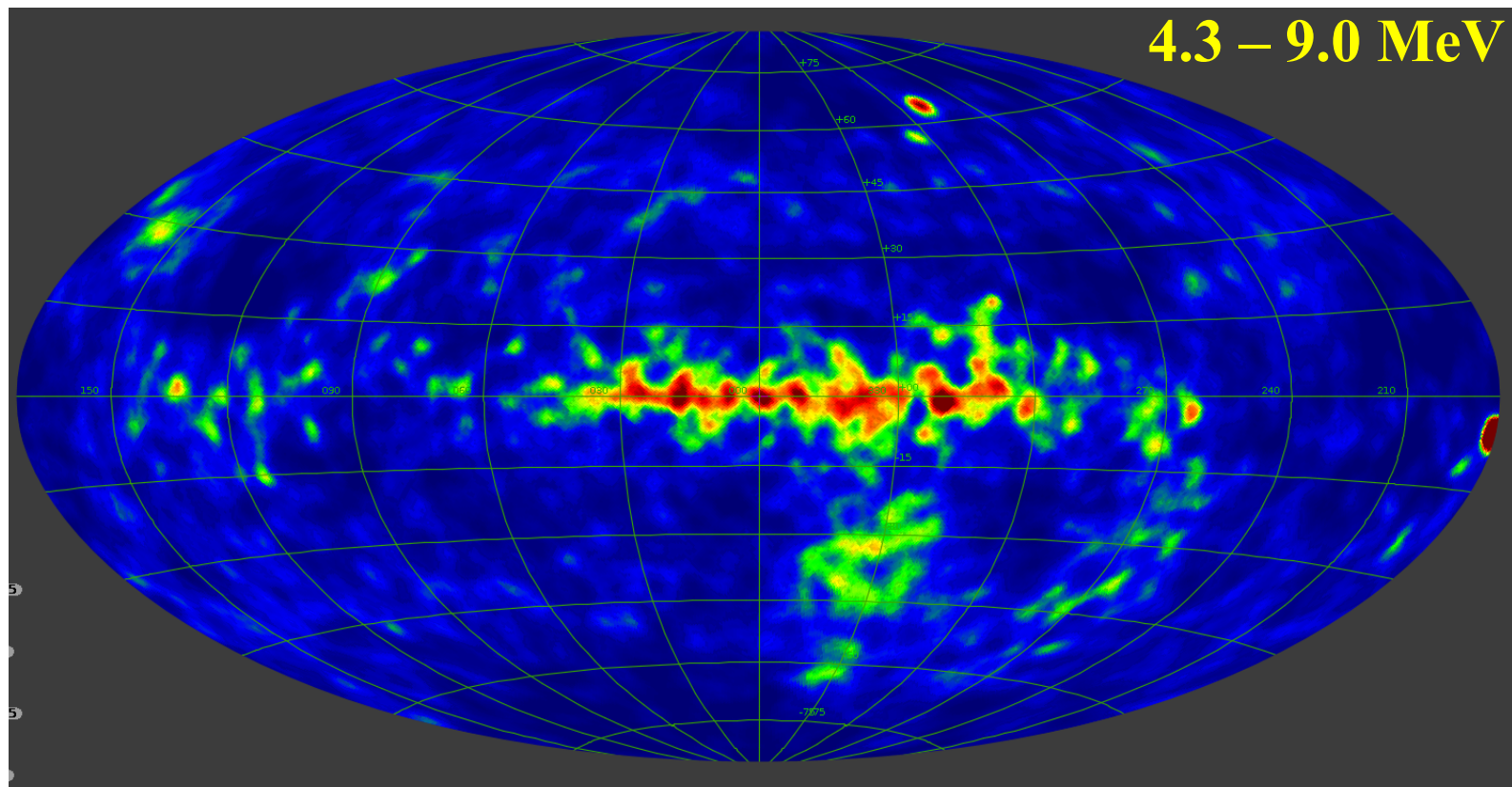
All-Sky All-Mission Point Source Maps (Work in progress)

Source Significances



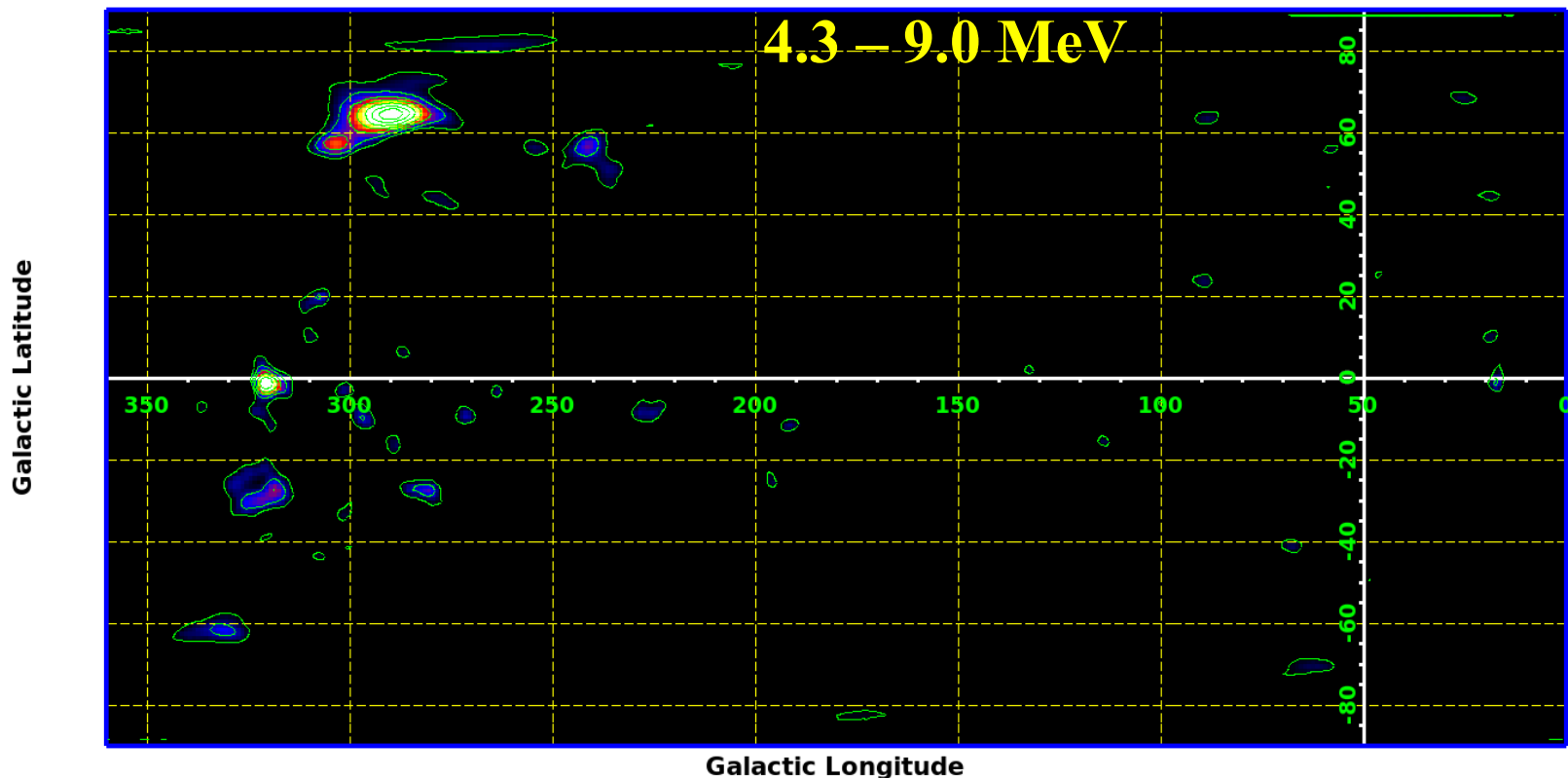
All-Sky All-Mission Imaging (Work in progress)

Preliminary



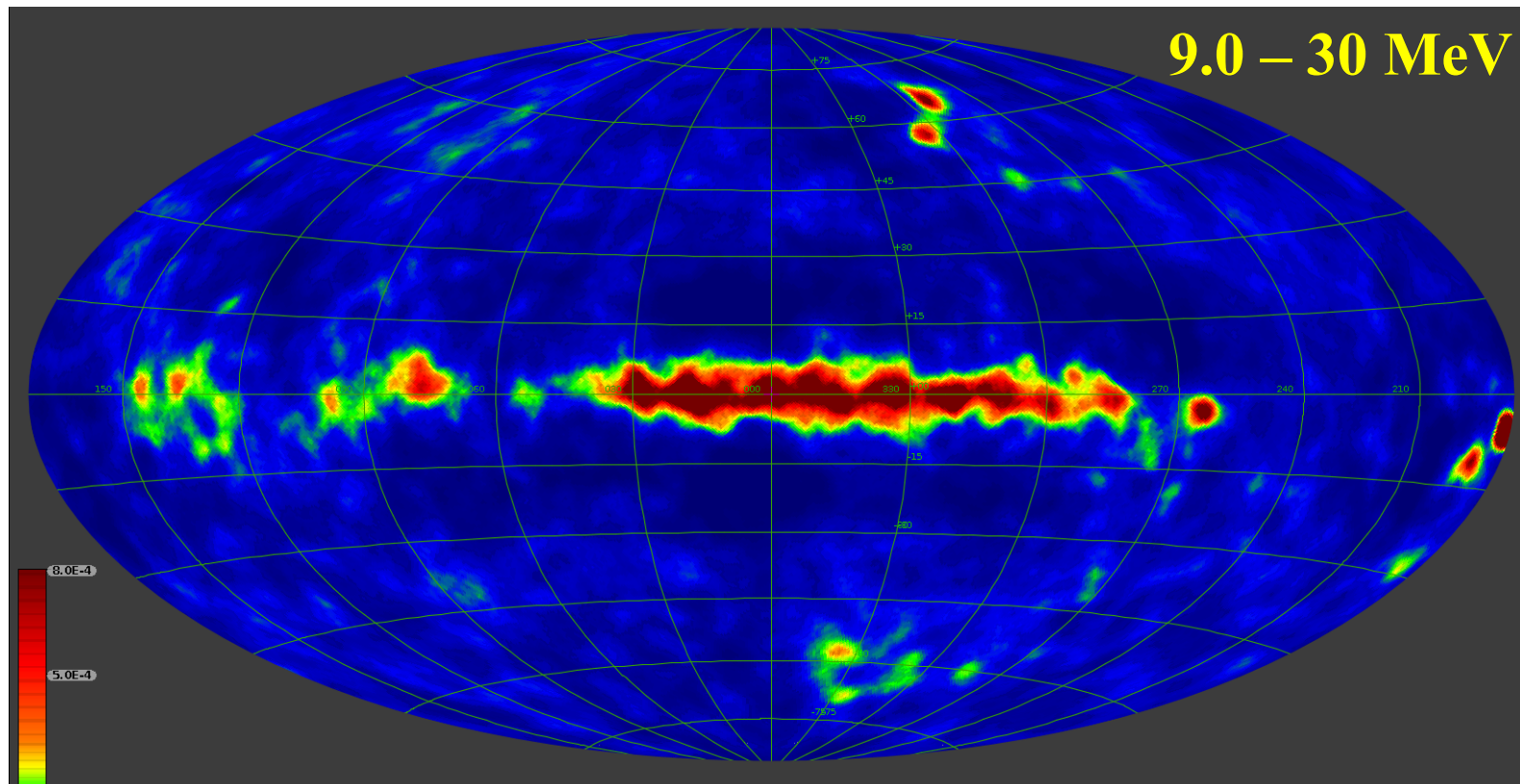
All-Sky All-Mission Point Source Maps (Work in progress)

Source Significances



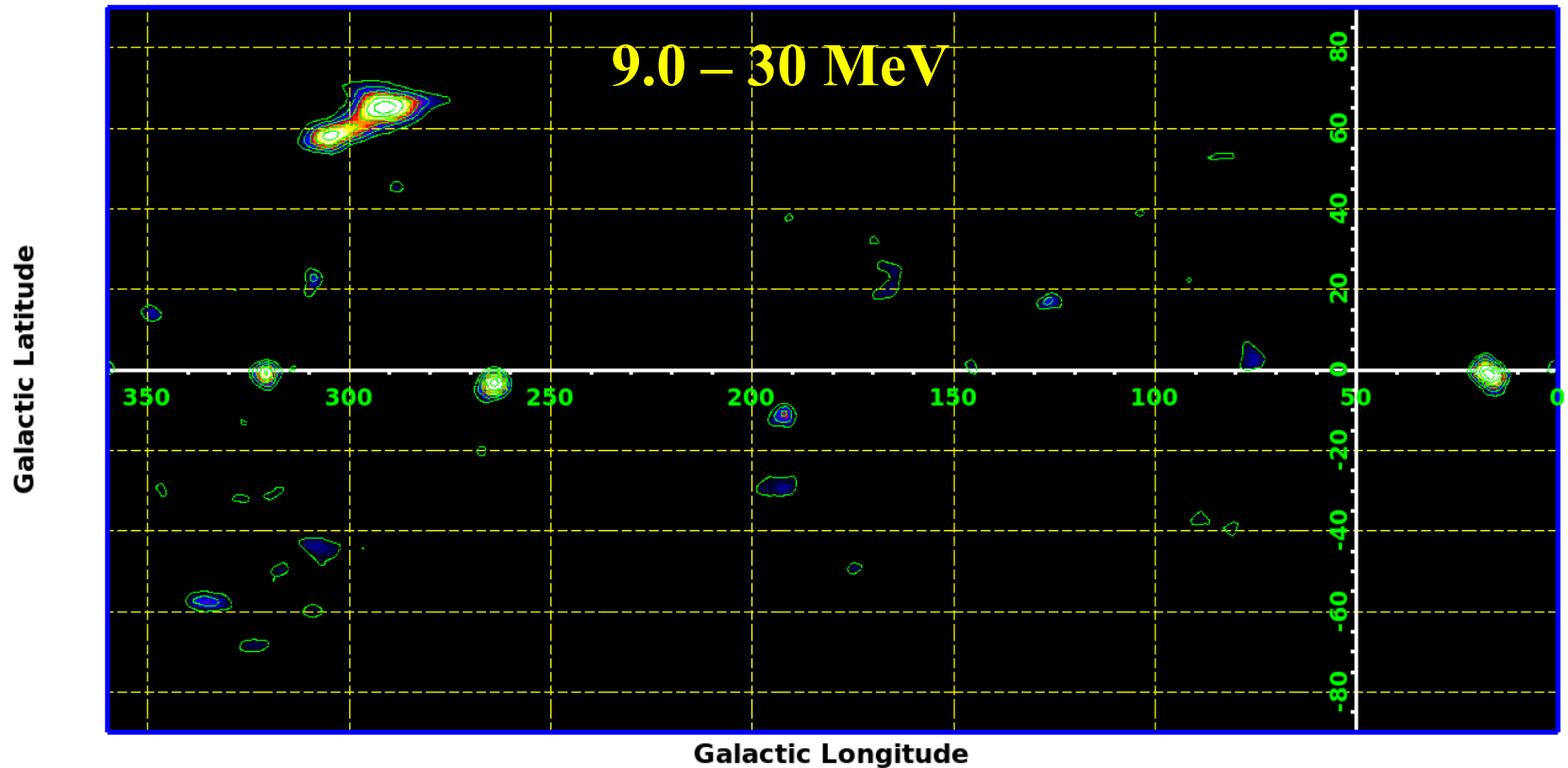
All-Sky All-Mission Imaging (Work in progress)

Preliminary

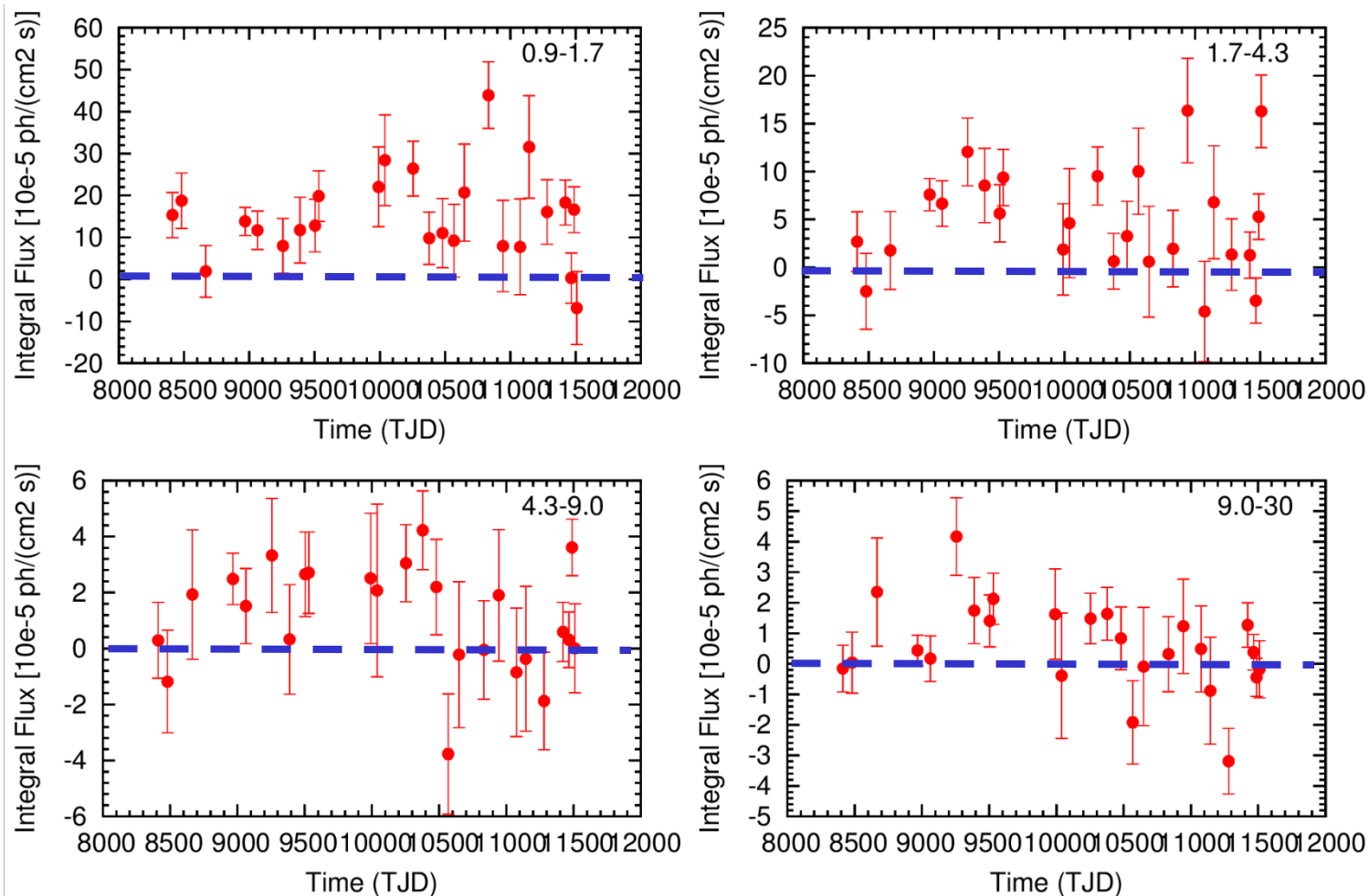


All-Sky All-Mission Point Source Maps (Work in progress)

Source Significances

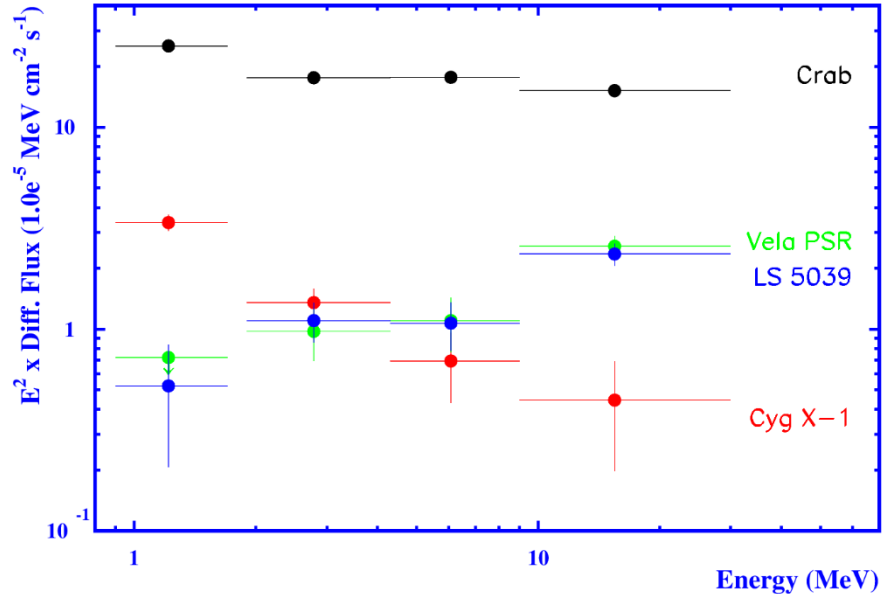


Science Perspectives: Cygnus X-1



MeV Spectra of Galactic Sources

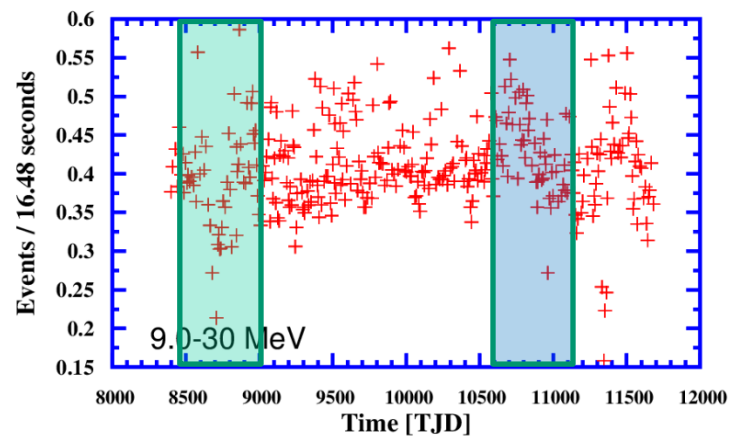
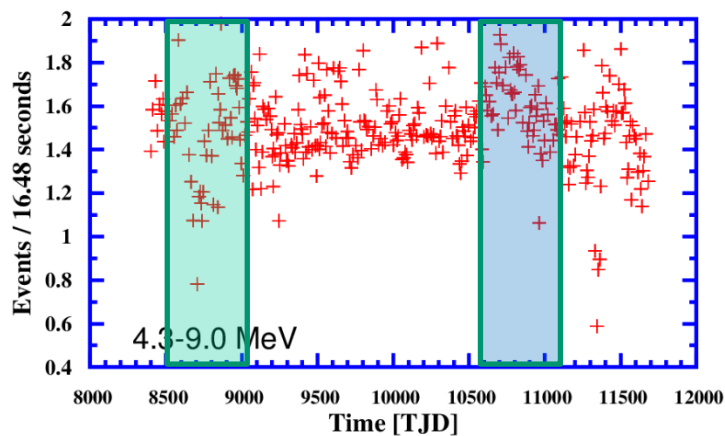
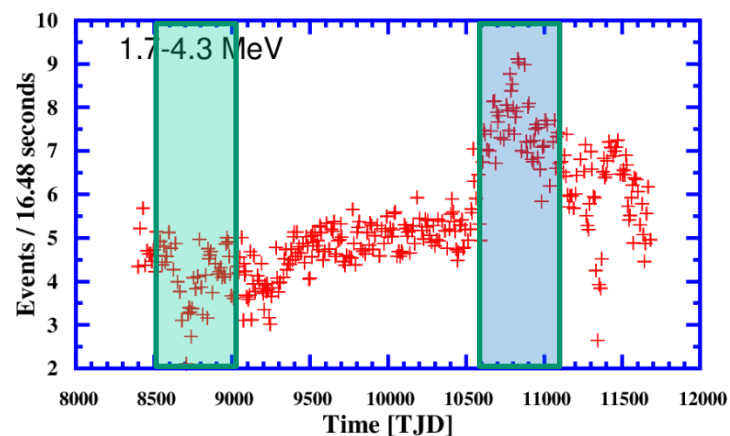
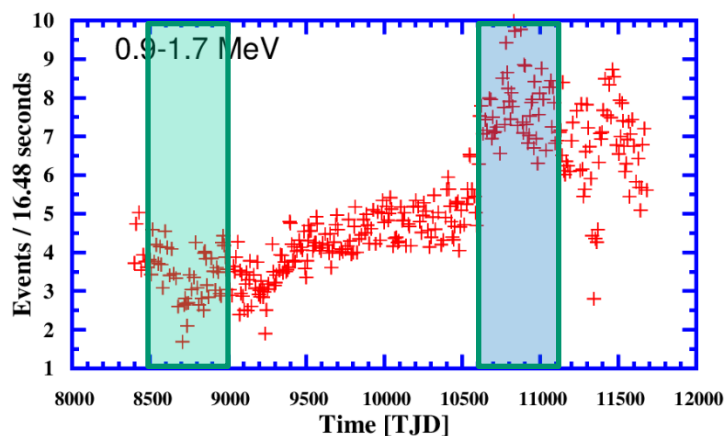
COMPTEL Galactic Sources MeV Spectra



Galactic Sources

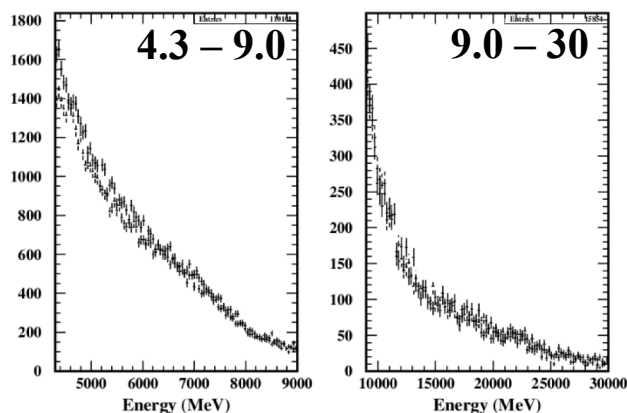
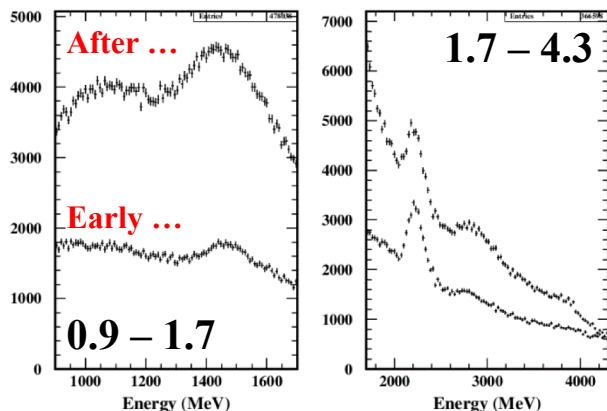
Crab (PSR)	184.6/-5.8
Vela PSR (Pulsar)	263.6/-2.8
PSR 1509-58 (Pulsar)	320.3/-1.2
LS 5039 (Binary)	18.5/-0.5
Cyg X-1 (Binary)	73.1/3.1
LSI +61 303 (Binary)	135.7/1.1
GRO J0422+32 (Binary)	165.9/-11.9
Crab Nebula (SNR)	184.6/-5.8
GRO J2227+61 (Unident.)	106.6/3.1
Cassiopeia A (Line Source)	111.7/-2.1

Science Perspectives: BGD Reductions



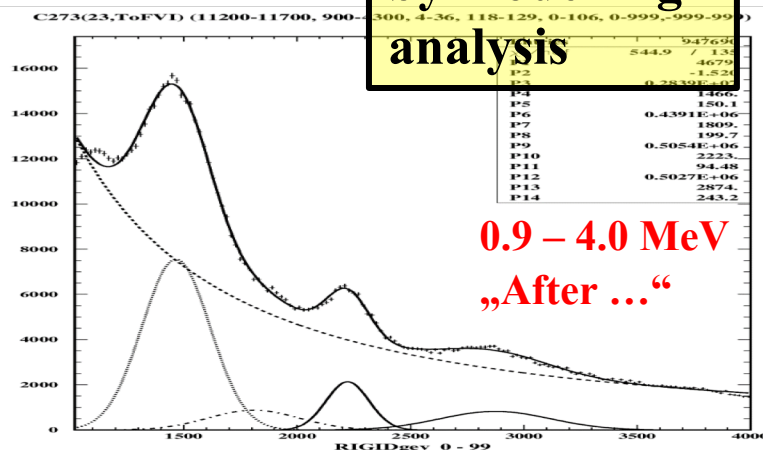
Science Perspectives: BGD Reductions

C273(29,ToFVI) (10600-11100, 9000-30000, 4-36, 116-128, 63-85, 0-999,-999-999)



by machine
learning
(Master Thesis)

by modelling
analysis



Summary/Conclusions

- **COMPTEL opened the soft γ -ray sky (0.75/0.9 – 30 MeV) for science**
- **COMPTEL data are still the most sensitive existing MeV data, though large parts (in particular late mission) are still unexplored**
- **Current activities**
 - investigate background in COMPTEL data (e.g. in time)
 - apply “modern” imaging techniques (e.g. incl. “HEALPIX”)
- **Science Goals**
 - generate a 2. COMPTEL source catalog (cur. ~45 sources)
 - supplement SED infos on sources by filling the spectral ‘MeV gap’
- **Science Perspectives**
 - analyse and publish yet unpublished data (e.g. Cyg X-1, 3C 273)
 - find more sources -> population studies (if succ. Bgd reduction)
 - gamma-ray lines (e.g. ^{26}Al , ^{44}Ti)
 - galactic & extragalactic gamma-ray background