CGRO/COMPTEL Observations of Relativistic Jet Sources at MeV Energies for 9 Years

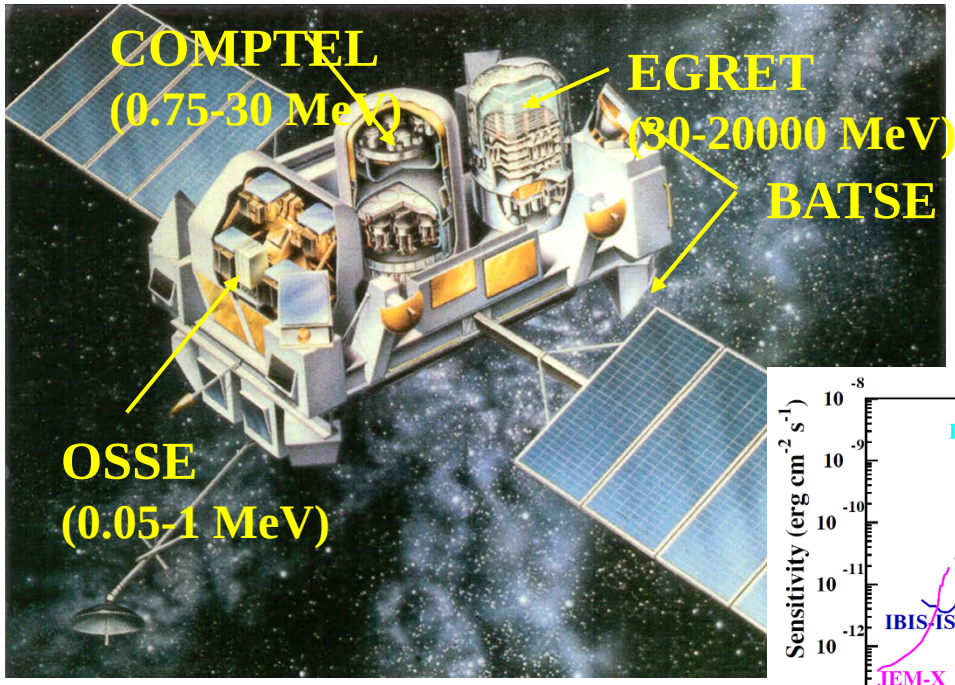
Werner Collmar

MPE Garching

Outline

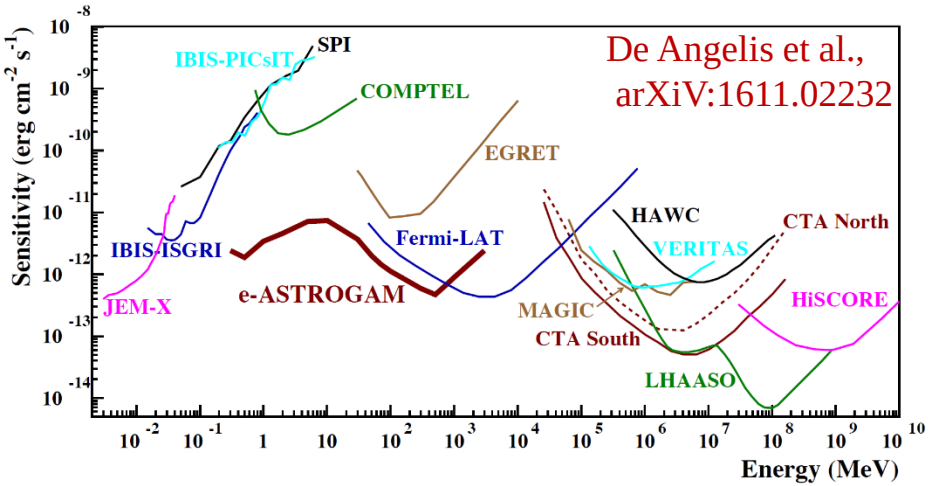
1) **COMPTEL on CGRO**
2) **All-Sky Imaging (work in progress)**
3) **Status and Perspective of Gamma-Ray Binaries**
4) **Summary (incl. current Developments)**

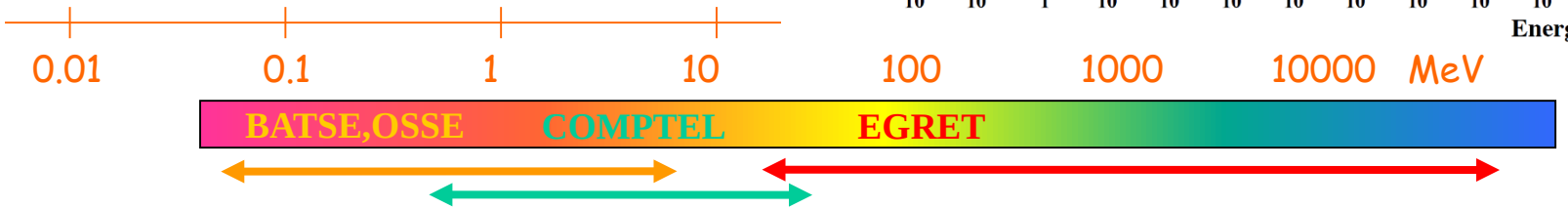
COMPTEL on CGRO



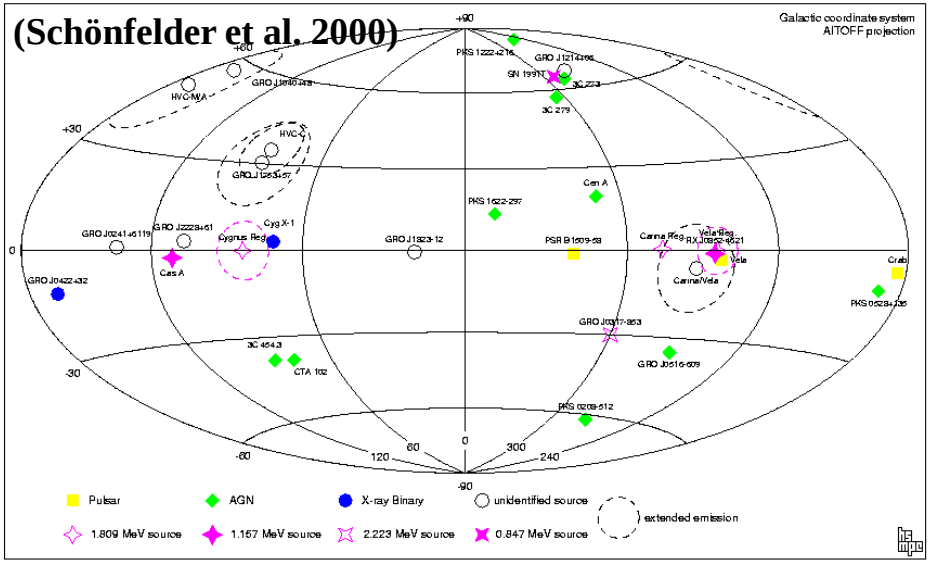
COMPTEL (Compton Telescope)

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





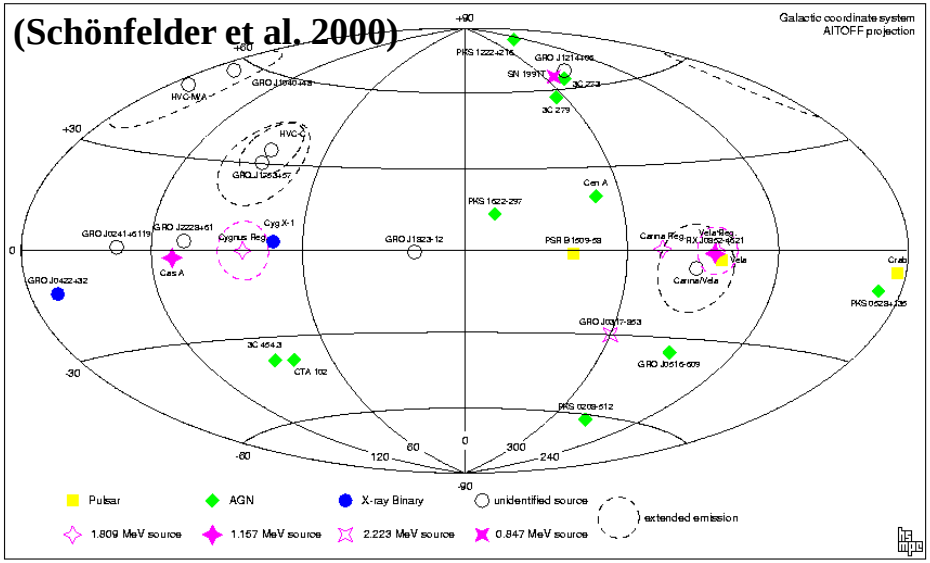
Summary First COMPTEL Source Catalog



- 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	
- $\|b\| < 10°$	3
- $\|b\| > 10°$	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

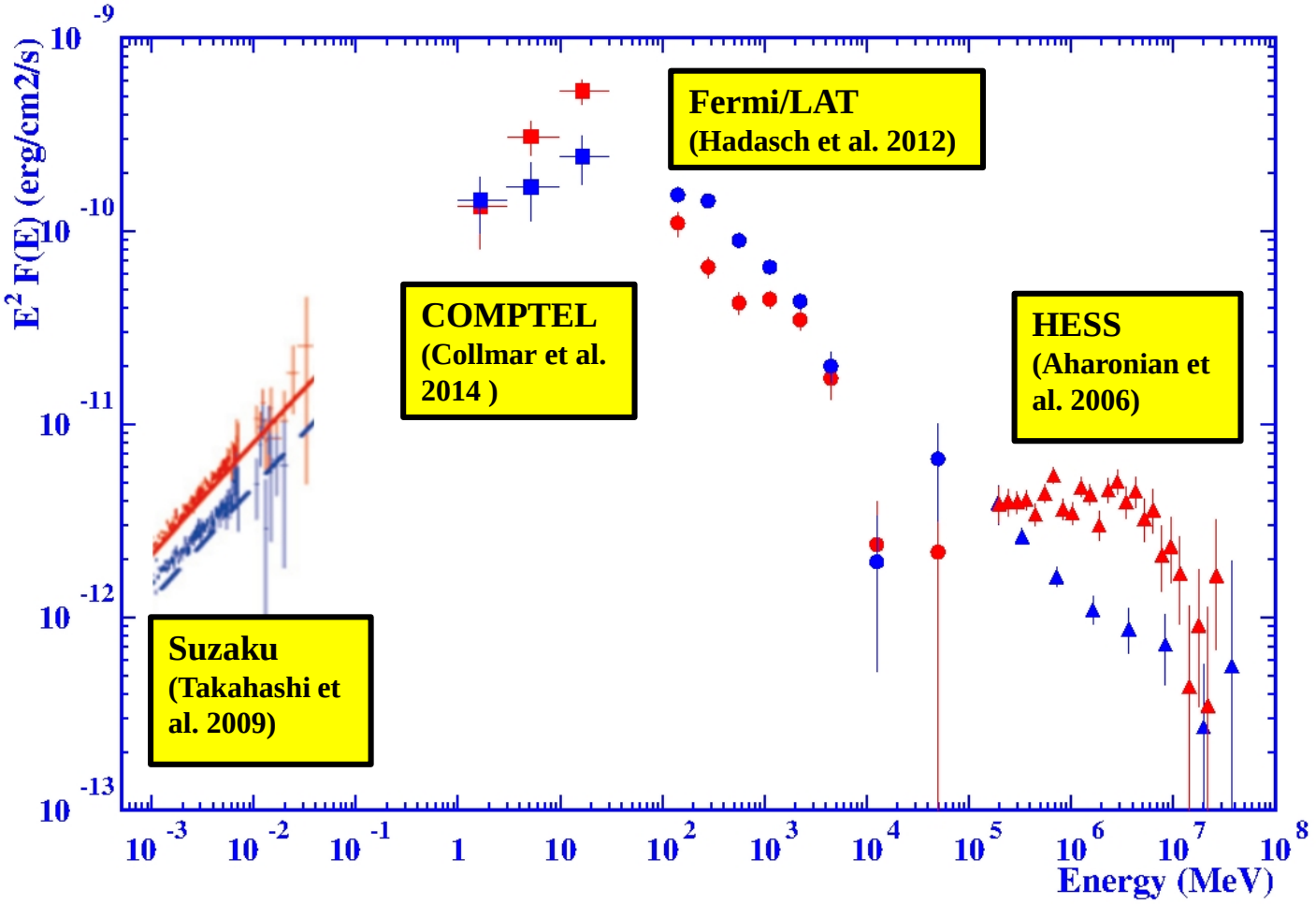
Summary First COMPTEL Source Catalog



Galactic Sources (|b| < 10°)	
GRO J1823-12 (LS 5039)	18.5/-0.5
Cygnus X-1	73.1/3.1
GRO J2227+61	106.6/3.1
LSI +61 303	135.7/1.1
GRO J0422+32	165.9/-11.9
Crab	184.6/-5.8

- 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)

Gamma-ray Binaries: LS 5039



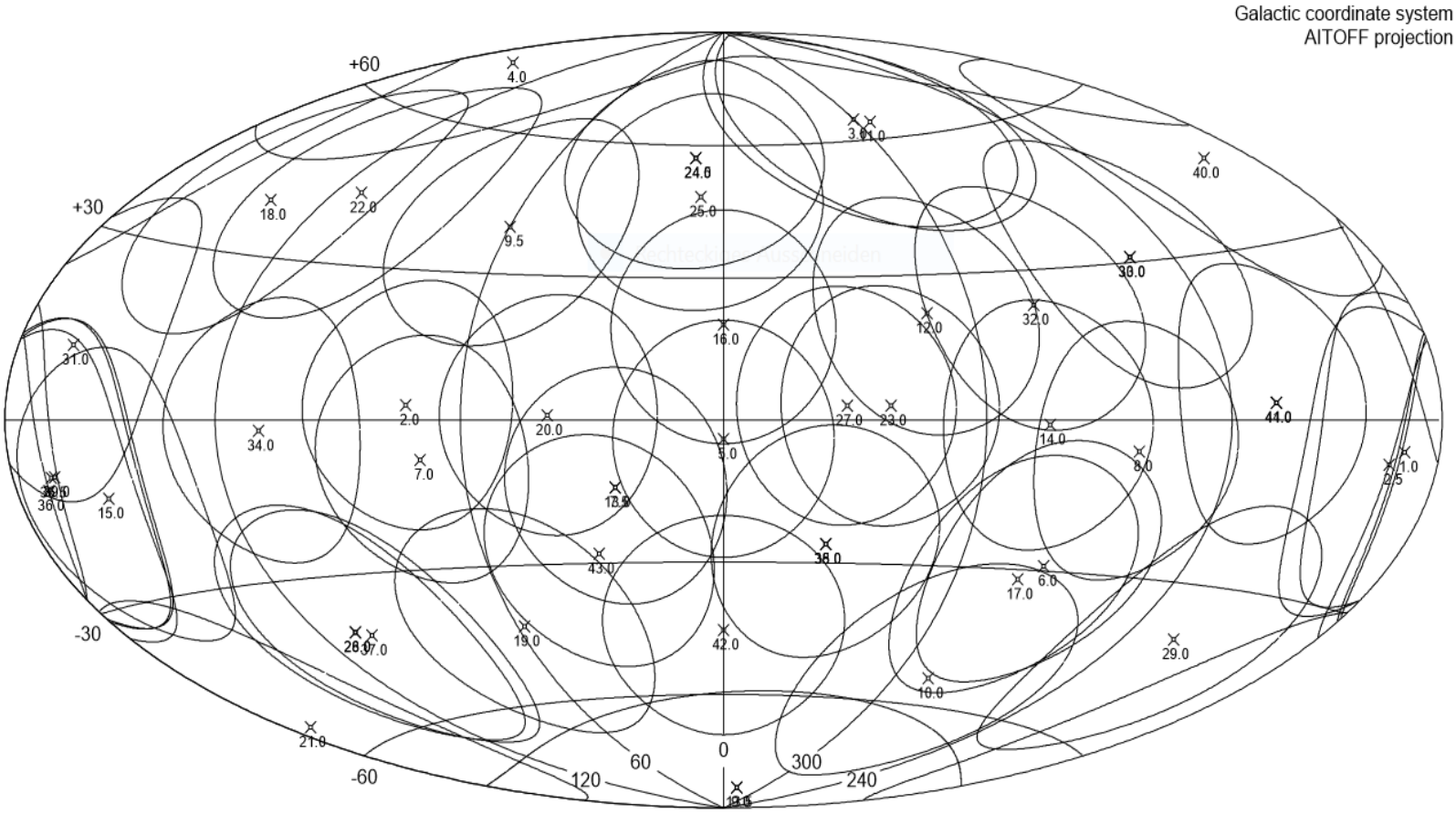
All-Sky Imaging
CGRO Pointing Strategy

1.0	191	-5	140	38	Crab pulsar	91-05-16 to 91-05-30	
2.0	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	MKN 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 92-09-17	TOO
40.0	196	45	210	25	MCG +5-23-16	92-09-17 to 92-10-08	
41.0	228	3	70	22	G 228+03	92-10-08 to 92-10-15	
42.0	0	-45	140	17	PKS 2155-304	92-10-15 to 92-10-29	
43.0	31	-28	50	23	MRK 509	92-10-29 to 92-11-03	
44.0	228	3	140	23	G 228+03	92-11-03 to 92-11-17	
0.0	0	0	0	0	---------- end ----------		

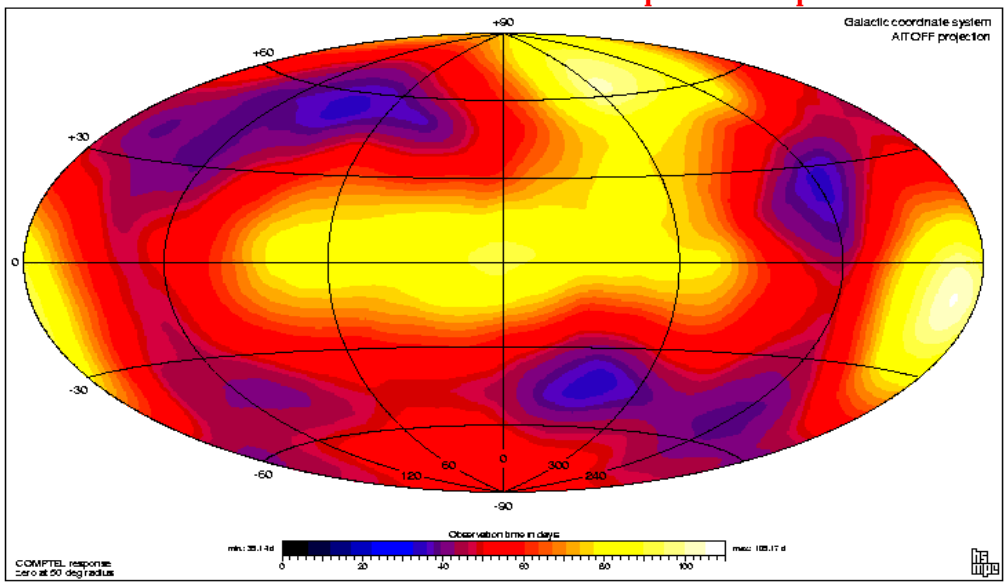
- **CGRO observed the sky sequentially in so called „Viewing Periods (VPs)“ by looking at selected positions on the sky for typically a few weeks.**

- **343 VPs during the mission (May 1991 – June 2000)**

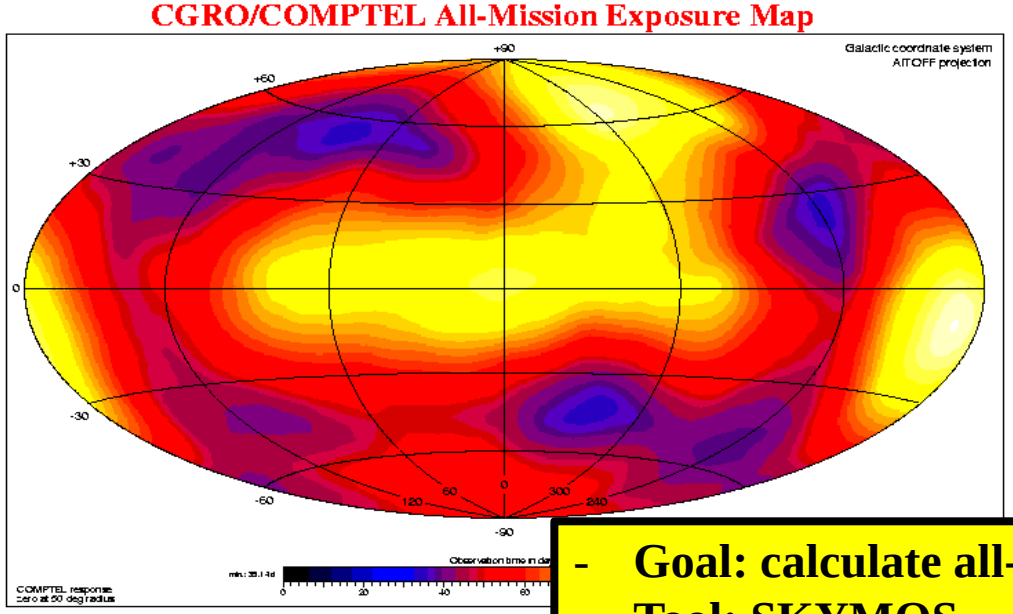
All-Sky Imaging
CGRO Pointing Strategy

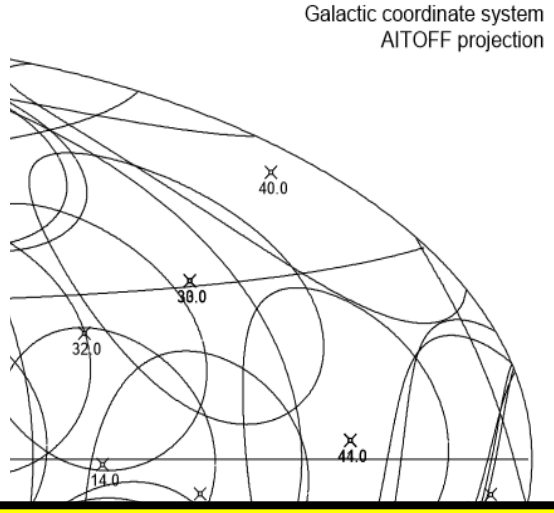


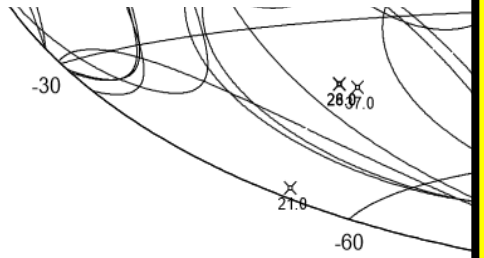
All-Sky Imaging
CGRO Pointing Strategy



All-Sky Imaging
CGRO Pointing Strategy

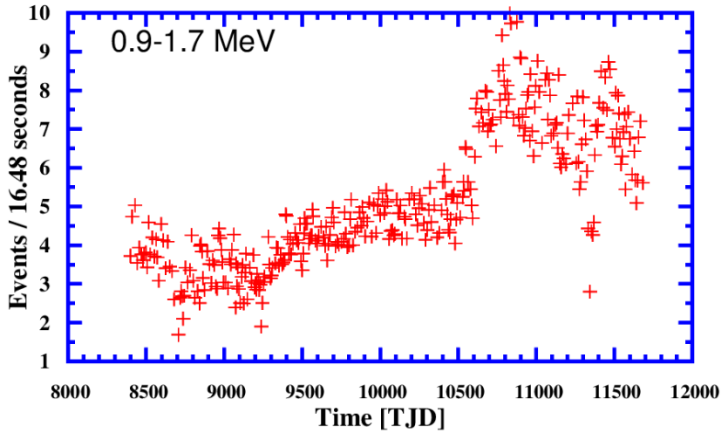


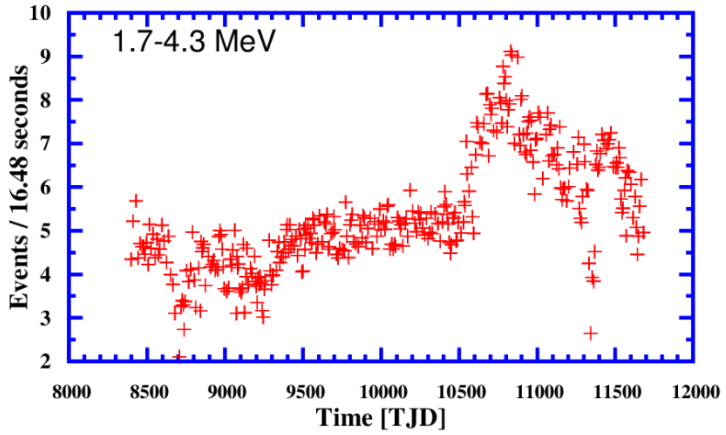


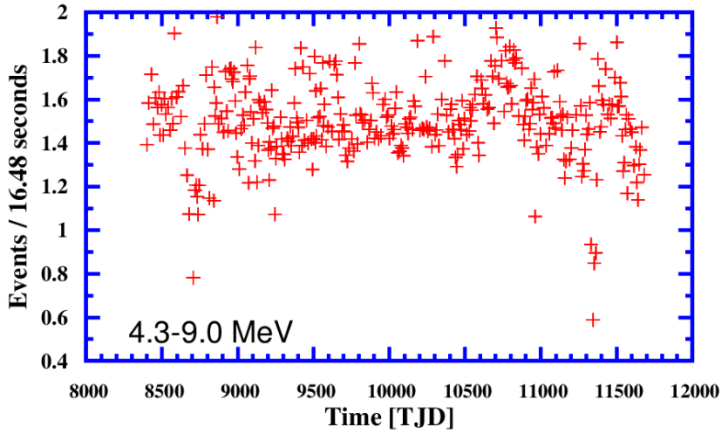


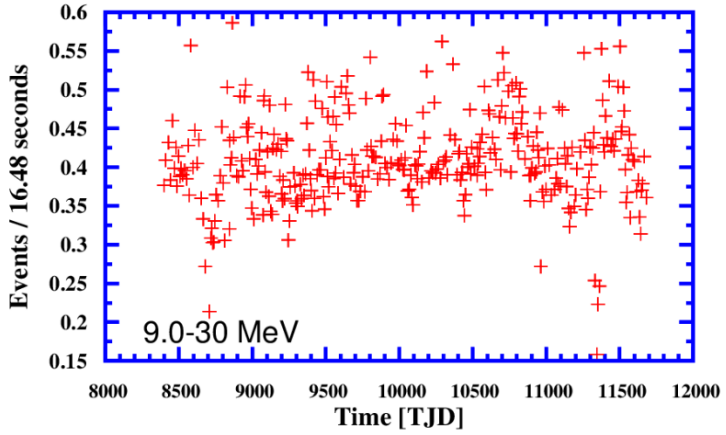
- **Goal: calculate all-sky maps**
- **Tool: SKYMOS**
  - **A. Strong (MPE); M. Reineke, T. Ensslin (MPA)**
  - **Bayesian Maximum Entropy Deconv.**
  - **provide data for certain time periods, energies, and selections (W. Collmar)**

All-Sky Imaging
Data in 4 Energy Bands



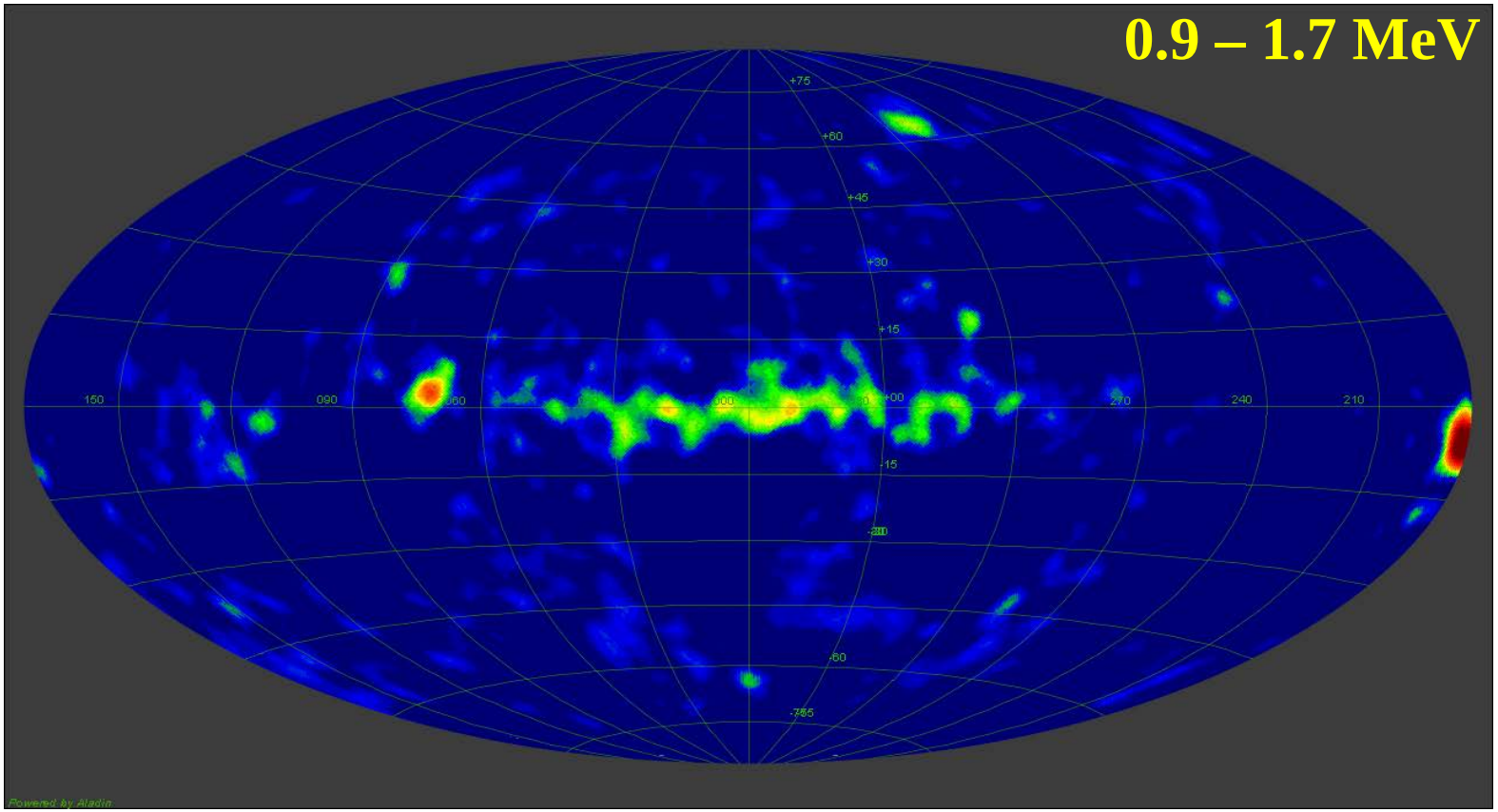






All-Sky All-Mission Imaging
(Work in progress)

Preliminary



All-Sky All-Mission Imaging
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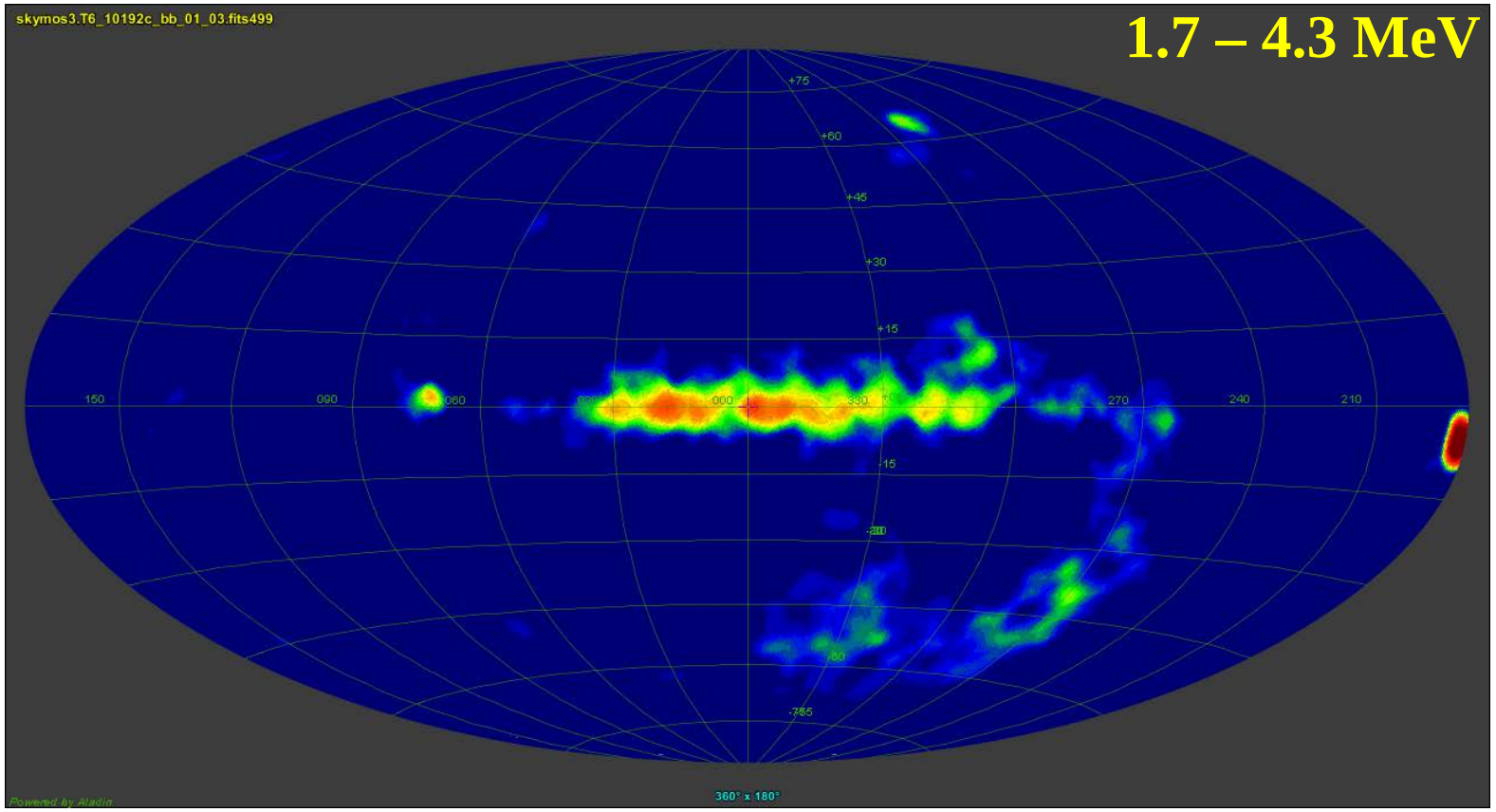
Preliminary



All-Sky All-Mission Imaging
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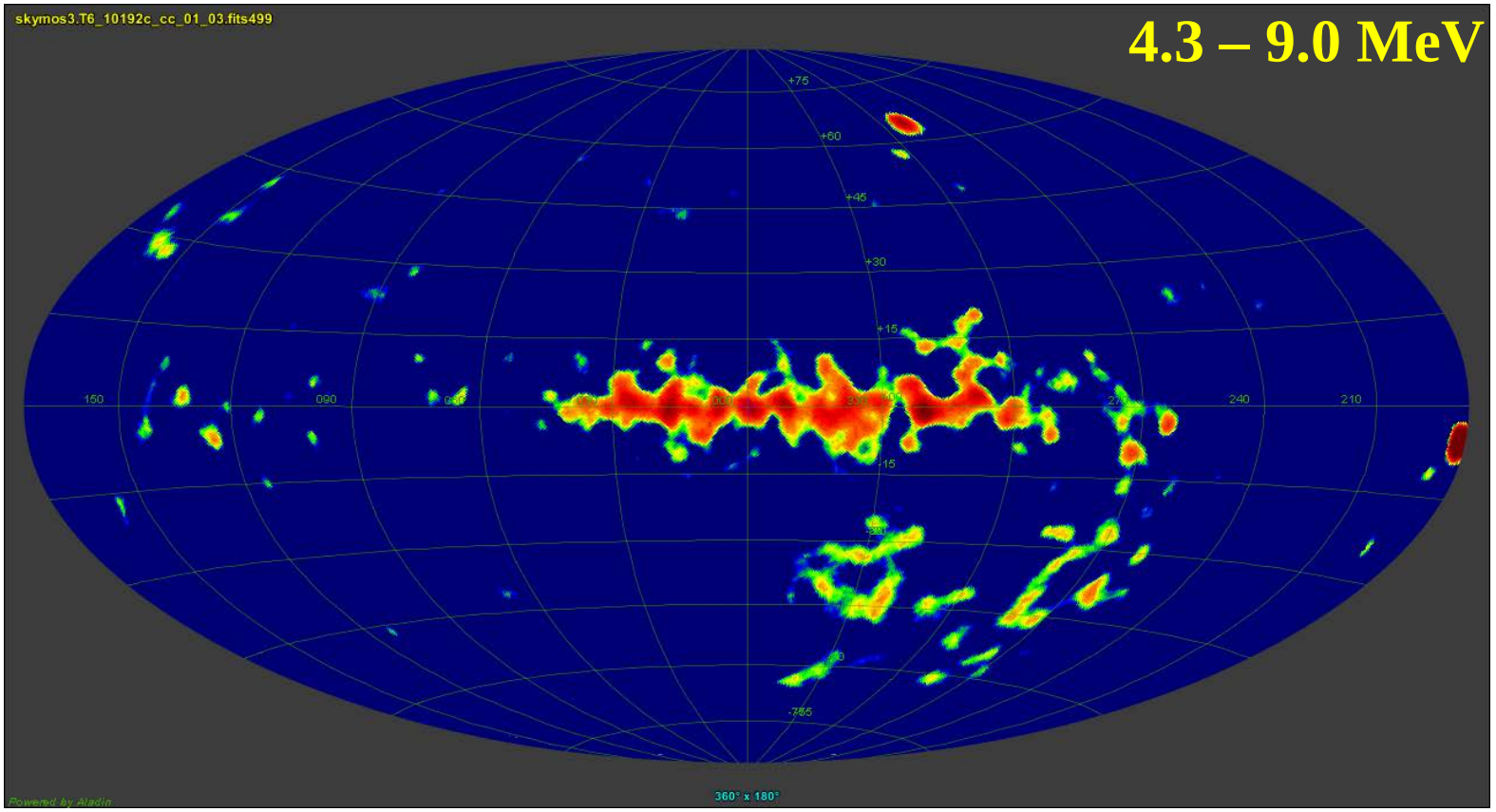
Preliminary



All-Sky All-Mission Imaging
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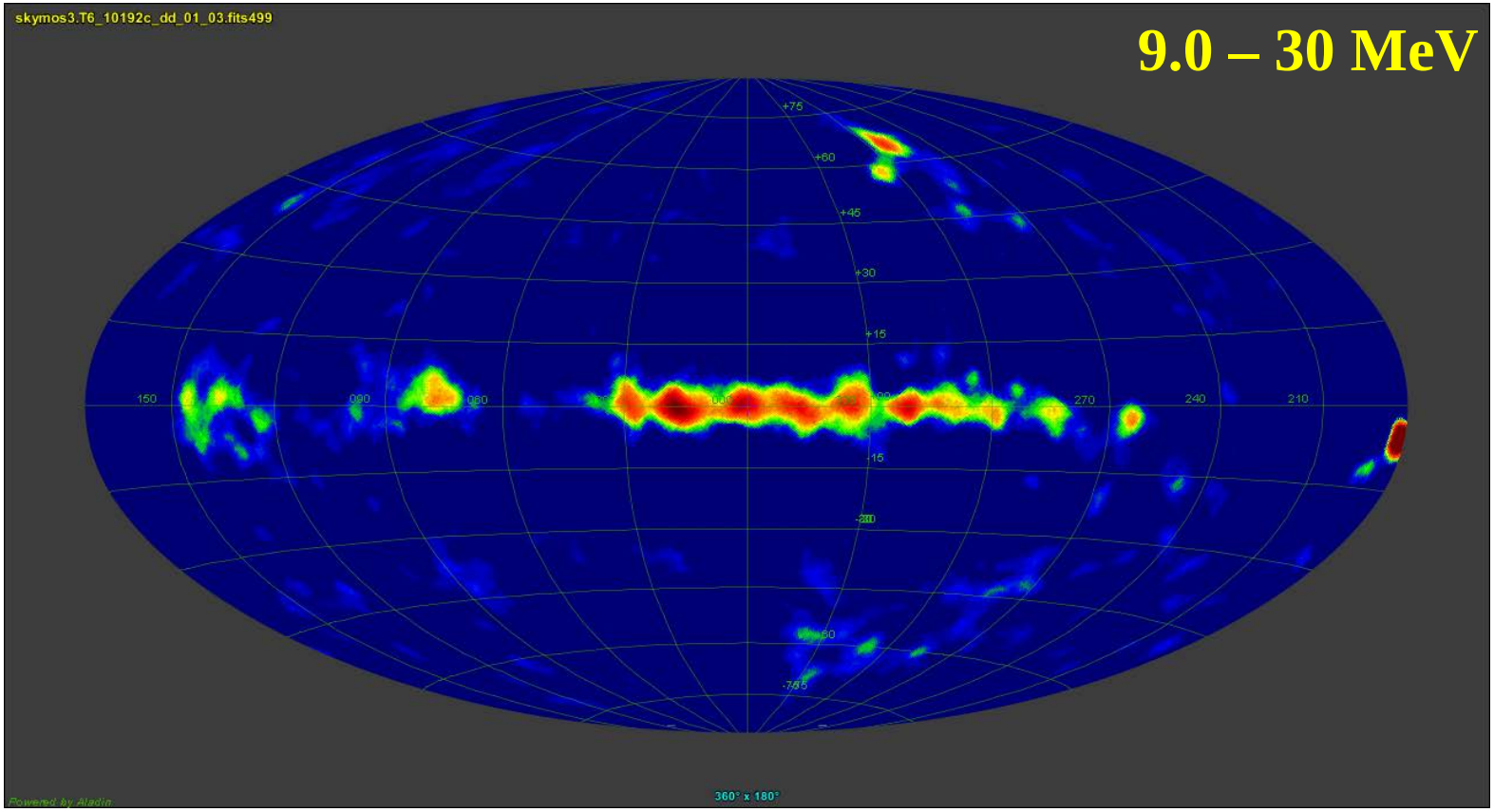
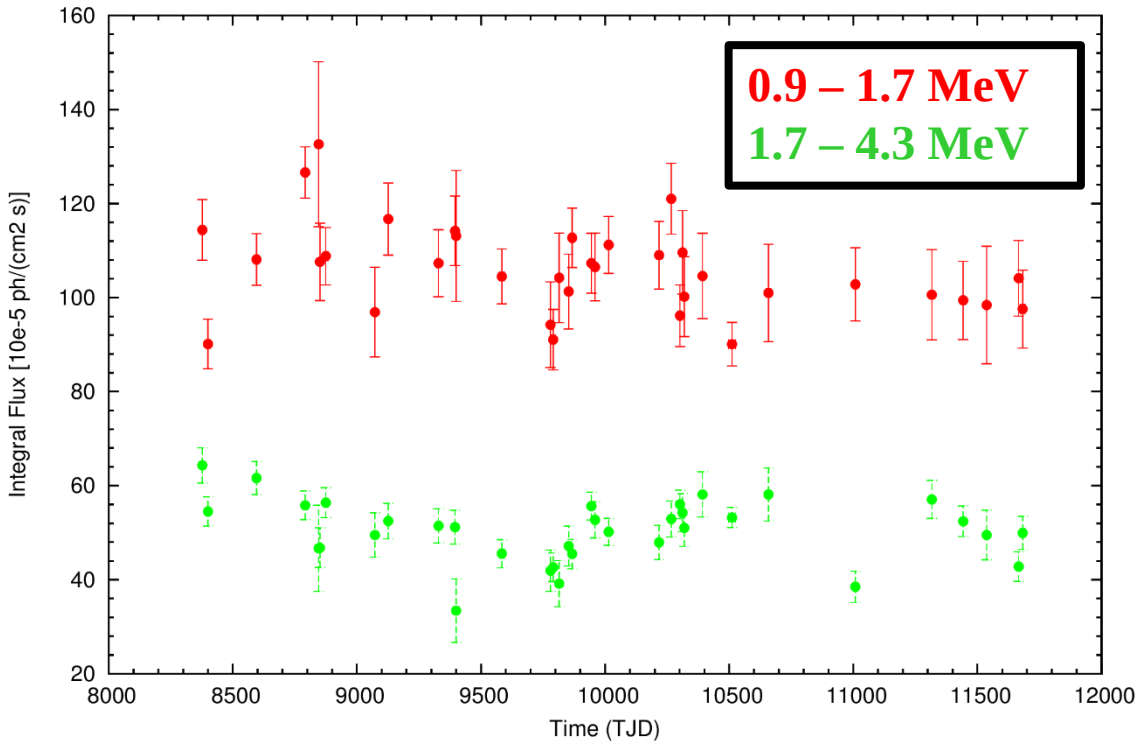
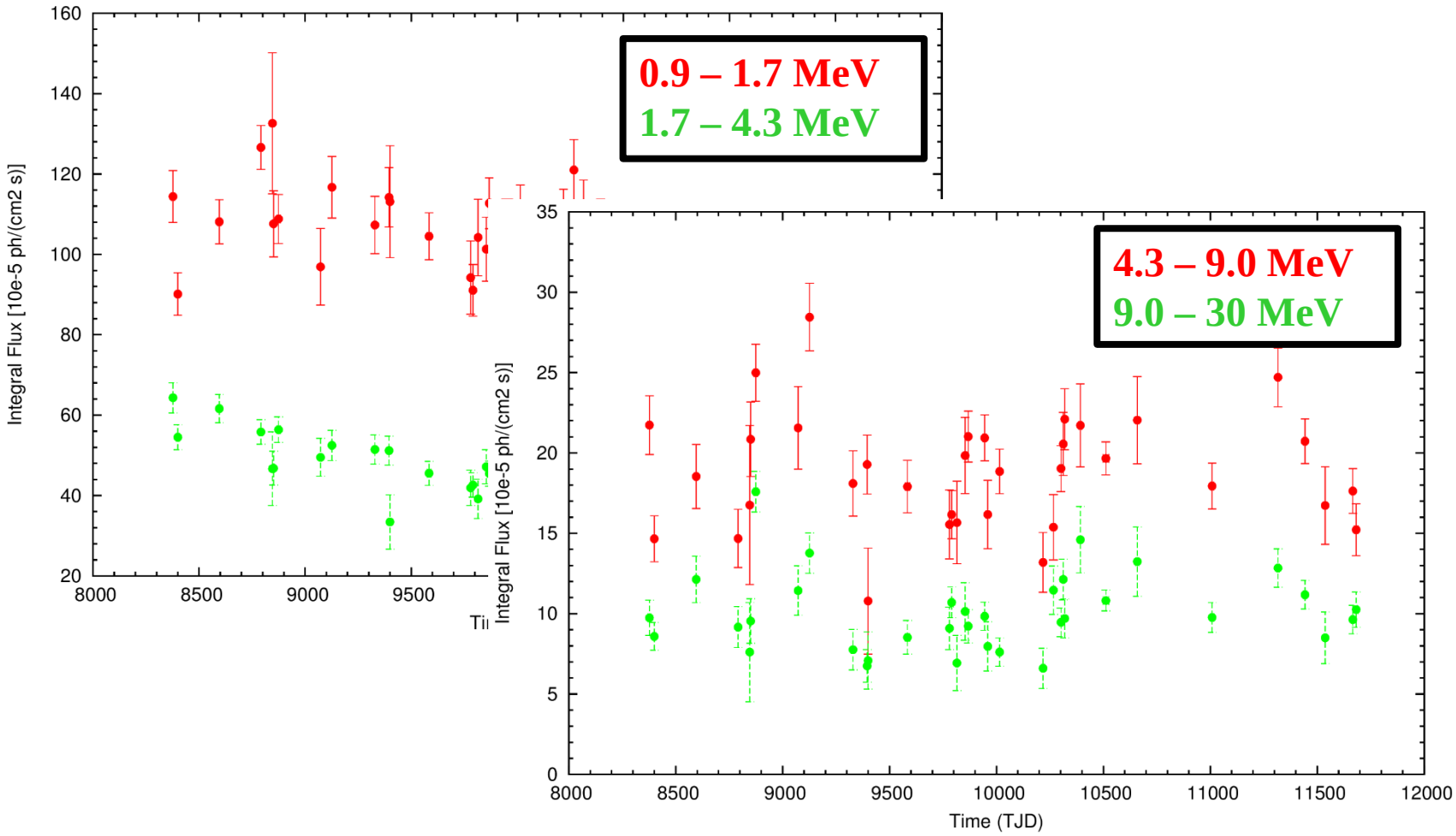
Preliminary



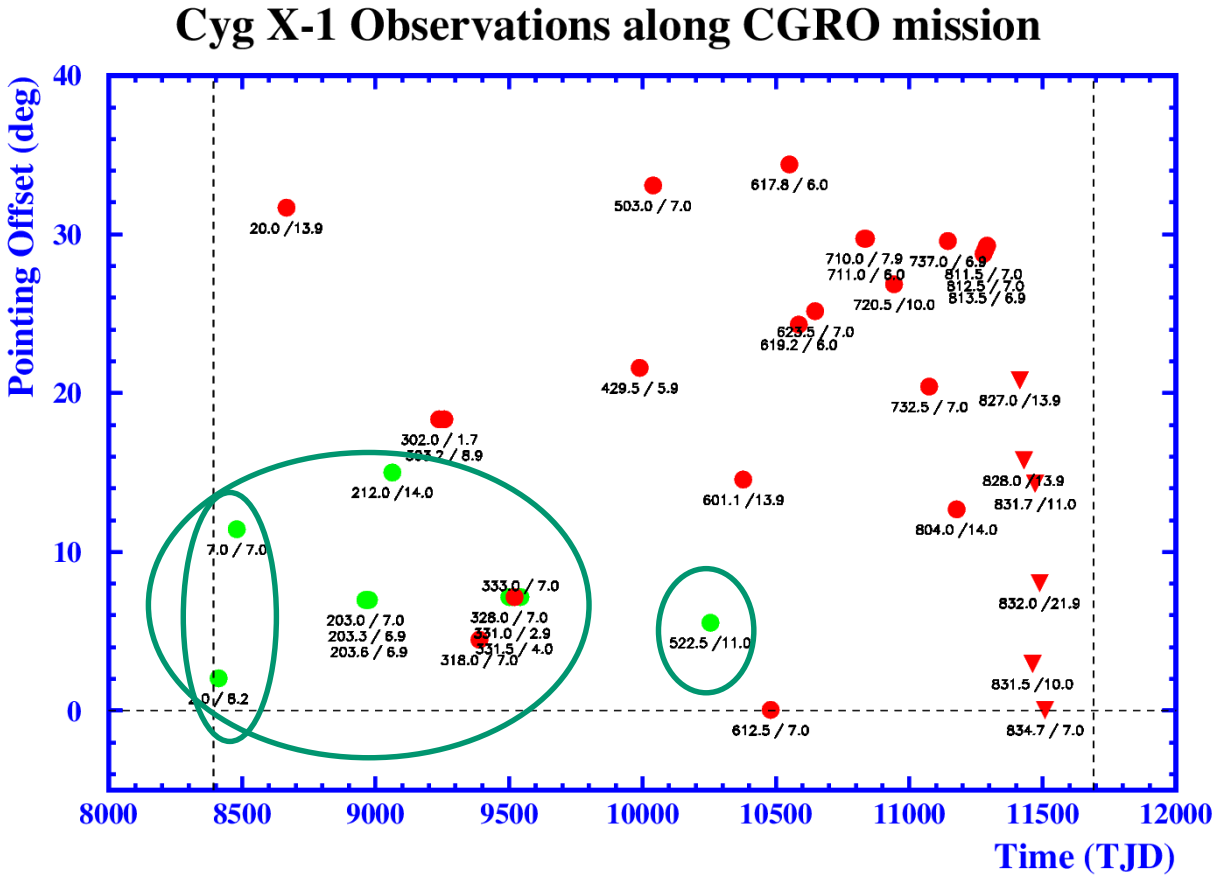
Monitoring Sources: Crab (total)



Monitoring Sources: Crab (total)



Cygnus X-1

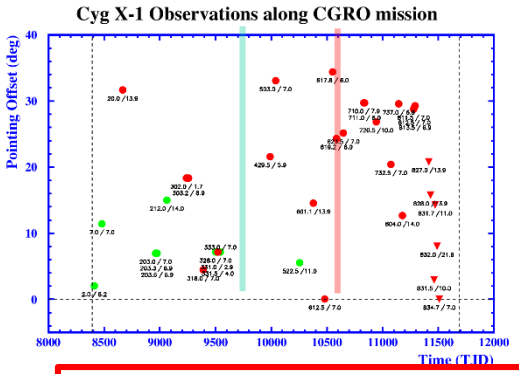


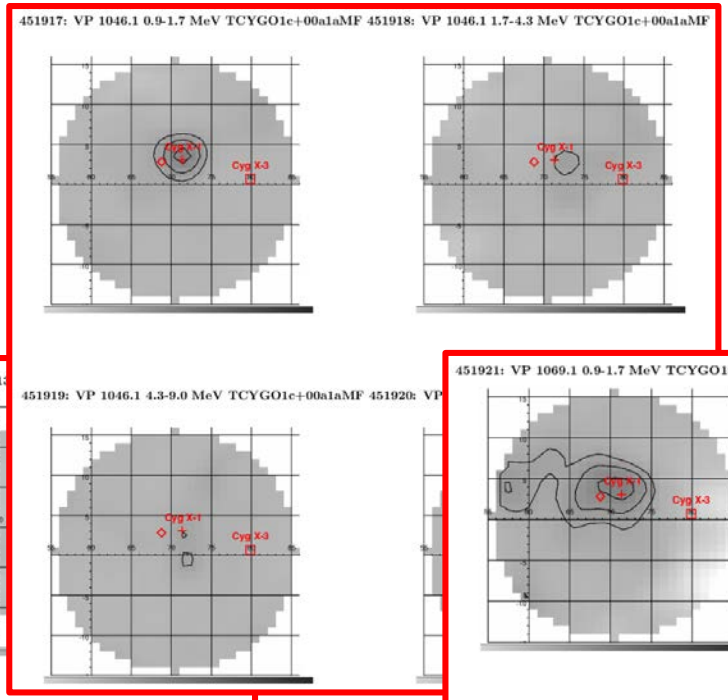
McConnell et al. 1994

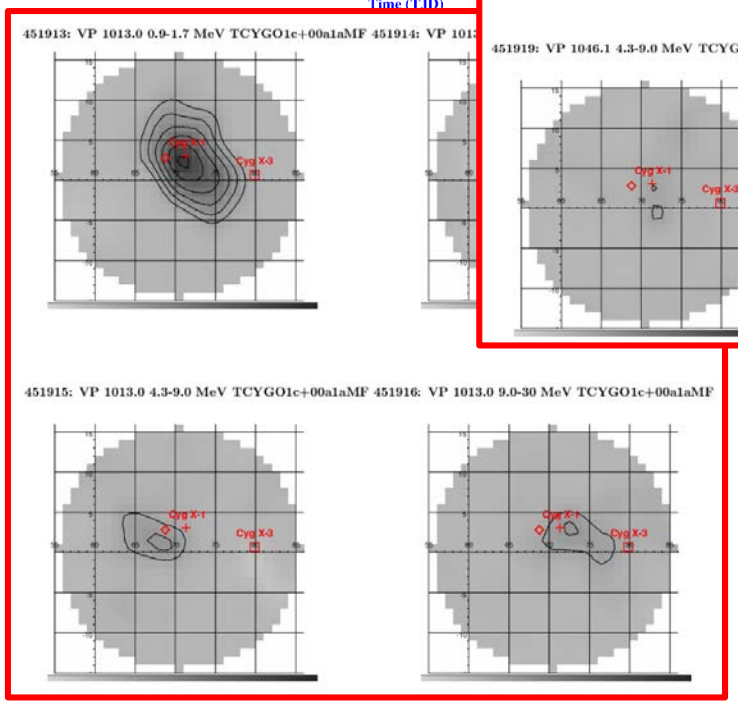
McConnell et al. 2000

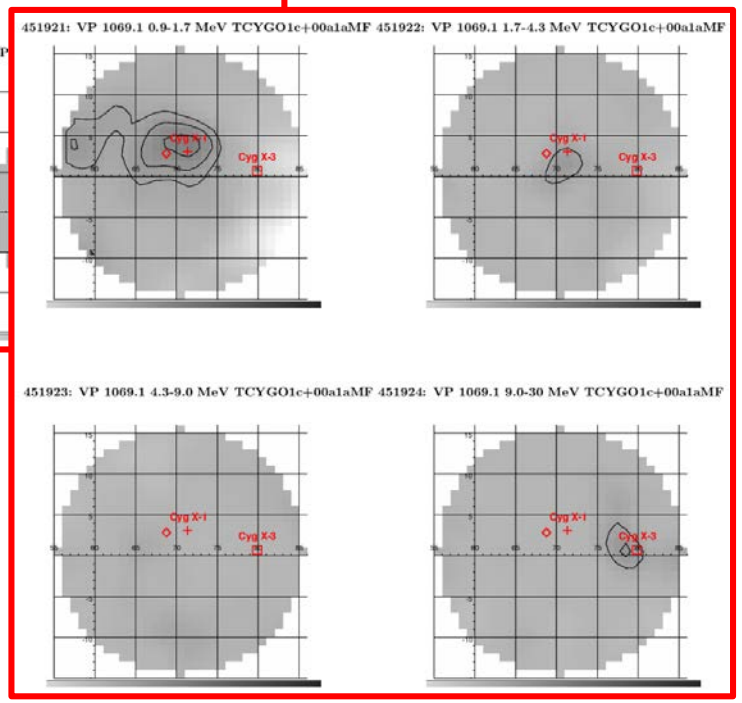
McConnell et al. 2002

Cygnus X-1: Images

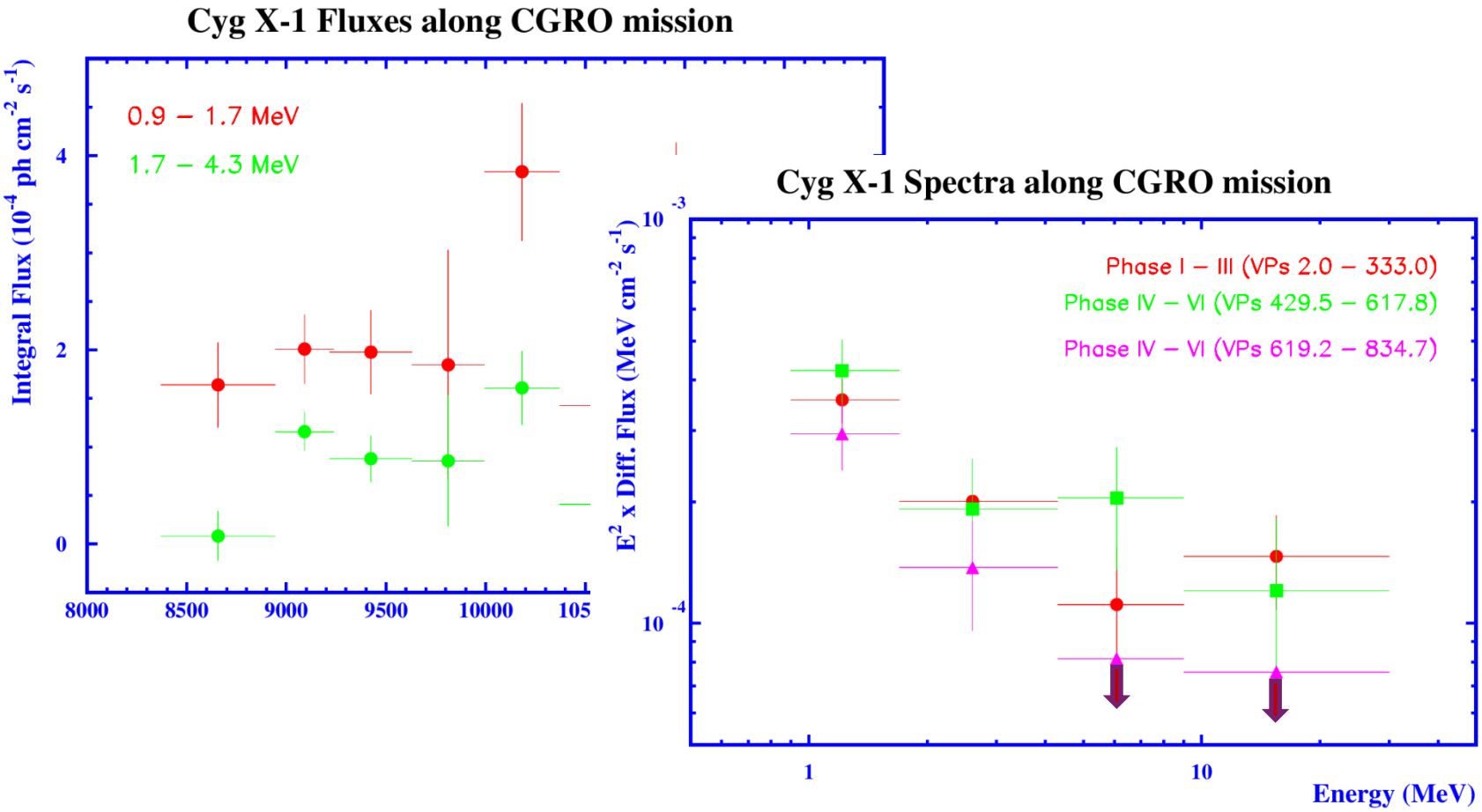




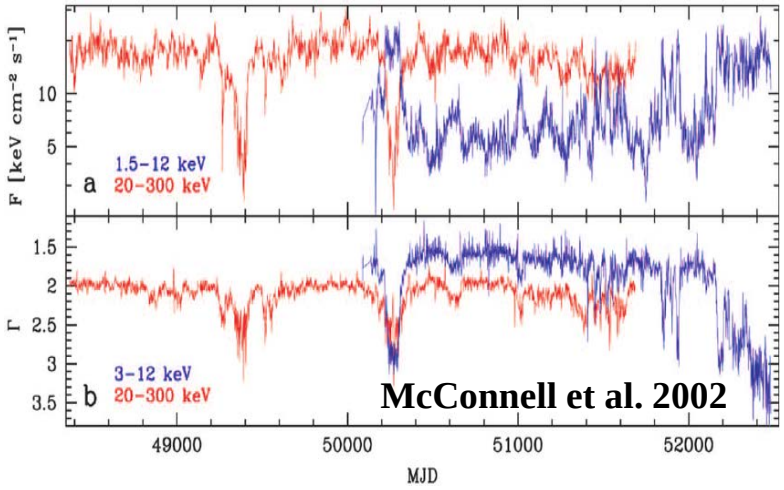


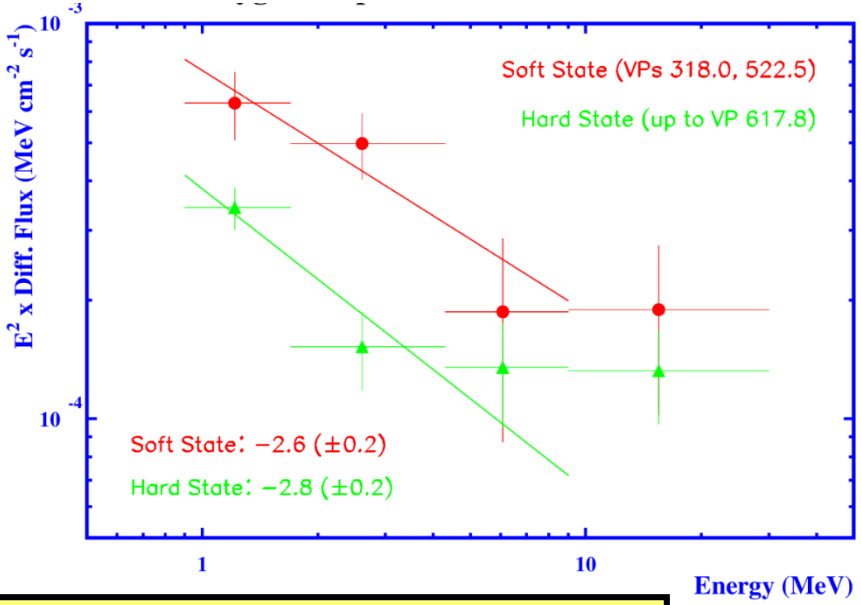


Cygnus X-1: Light Curves & Spectra



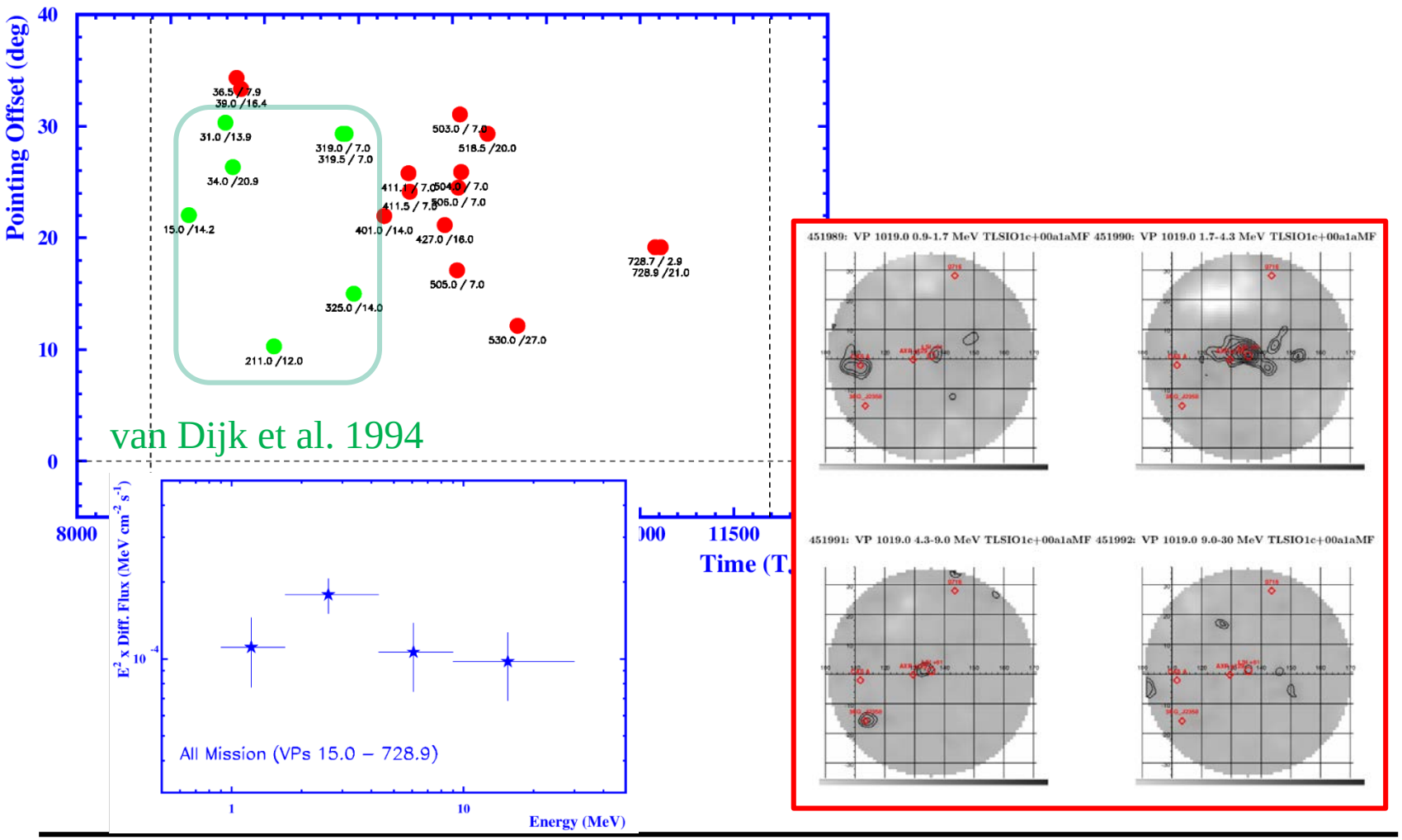
Cygnus X-1: hard / soft State



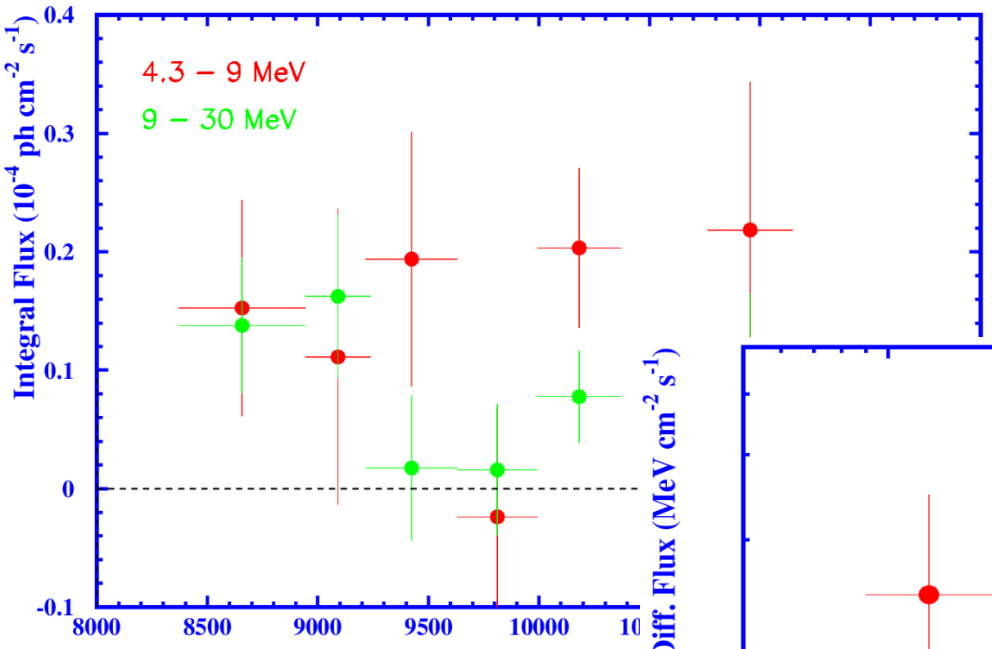


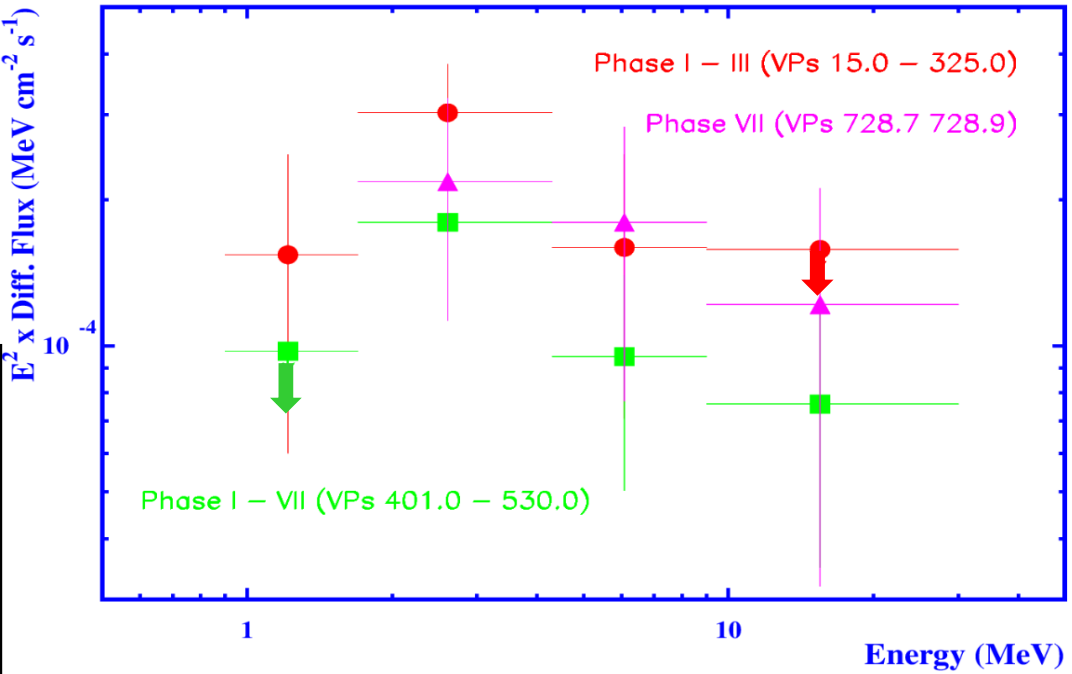
- **Cyg X-1 "visible" for COMPTEL throughout CGRO Mission, in particular (< 4.3 MeV)**
- **> 4.3 MeV: sources to be disentangled for accurate flux measure**
- **variable flux (0.9 – 4.3 MeV)**
- **spectral change: hard / soft state**
- **evidence for Cyg X-3 (9 – 30 MeV) in late misson**

LSI +61° 303: Observations & Sky Maps



LSI +61° 303: Fluxes & Spectra





- **LSI +61° 303 is detected by COMPTEL**
- **1.7-4.3 MeV: sources to be disentangled**
- **evidence flux variability**
- **spectral index: ~ 2.0**

Summary

- **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**
- **Crab (total) by far brightest MeV source (others at most at 10% level)**
- **Current activities**
  - **investigate background in COMPTEL data (e.g. in time)**
  - **apply "modern" imaging techniques (e.g. incl. "HEALPIX") by using modern computer power**
- **Science Goals**
  - **generate a 2. COMPTEL source catalog**
  - **supplement SED infos on sources by filling the spectral 'MeV gap'**
  - **checking on source polarization (e.g. Crab, GRBs, solar flares)**
- **Good News: COMPTEL data are still there …**
  … and ready to be looked at
  … and even somebody is doing that