



Institute of Accelerating Systems and Applications
University of Athens



Calibrating Solar Proton Data - Experience from ESA SEPEM & SEPCALIB Projects

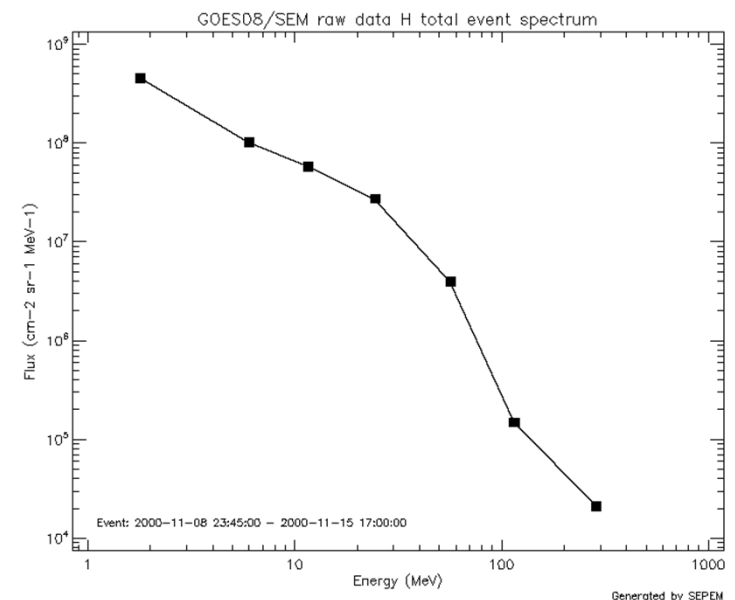
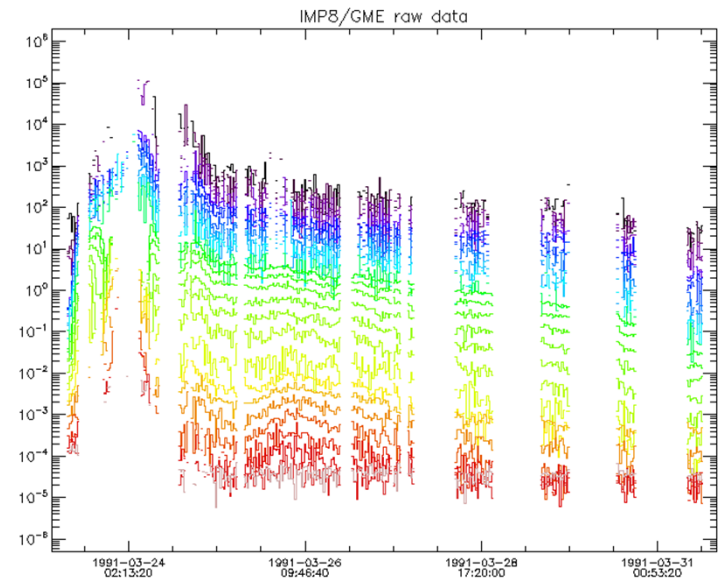
Piers Jiggins & Ingmar Sandberg (and Daniel Heynderickx)
Space Weather Workshop, Boulder, Colorado
11/04/2014



Recognised Instrument Issues and Caveats



1. Datasets have different issues/caveats
2. "Science class" data tends to be vulnerable to saturation and dead time effects
 - e.g. IMP-8/GME (top right)
 - Same for IMP-8/CPME and others
3. Monitor data has poorer En. res. (bottom right)
 - Instruments aren't 'science' calibrated
 - Unknown mean energy of bins
4. All data can have spikes and other issues
 - Sometimes hard to code corrections
 - Some manual cleaning necessary
 - Algorithms available on SEP-EM
5. Env. Modelling the timespan is a major issue
 - Need a sample as broad as possible
 - Requires combining different data

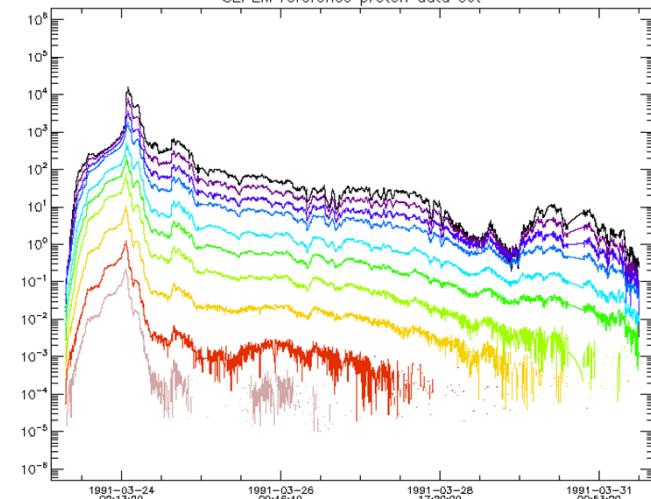
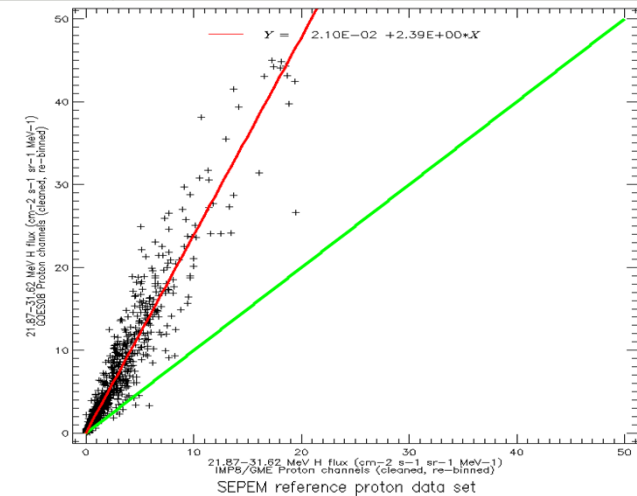


Original Procedure for Combining Fluxes in the SEP-EM Project



IMP-8*	GOES-5	GOES-7	GOES-8	GOES-12	GOES-11	GOES-13
1973-11-01	1984-01-01	1987-03-06	1995-03-01	2003-06-01	2003-06-21	2011-03-01
1984-01-01	1987-03-05	1995-02-28	2003-05-31	2003-06-20	2011-02-28	2013-03-31

1. Data (5-200 MeV) baseline instruments in table
2. Manual removal of bad data and very small gaps linearly interpolated
 - Same for GME & GOES SEM(-2)
 - Algorithms can be tested against results
3. Data is re-binned to 10 logarithmically-spaced energy bins (SEP-EM reference energies)
 - Purposefully not any specific instrument energies
4. Cross-Calibrate SEM(-2) to GME
 - Excluding data gaps in either dataset
 - Considering different time resolutions

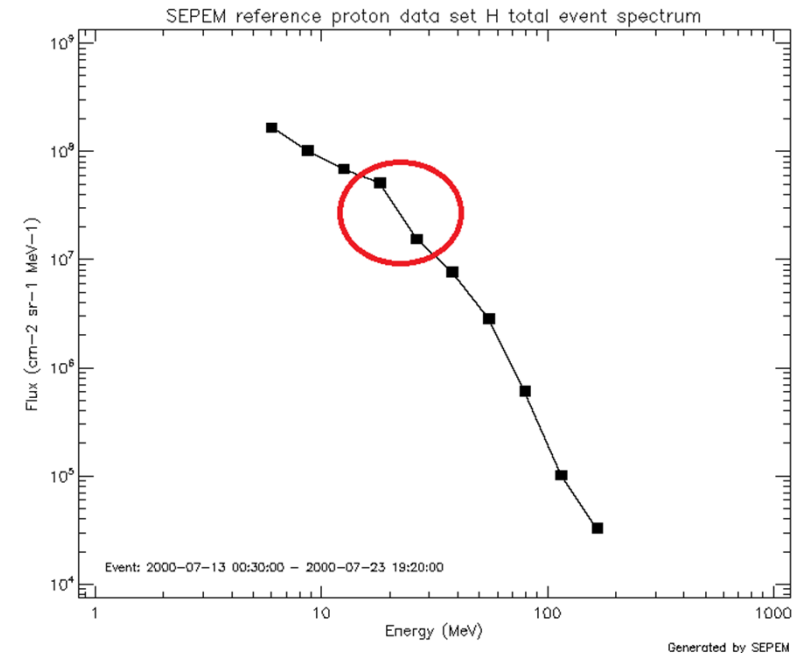


Outstanding Issues and concerns with the calibration procedure



E (MeV)	6.01	8.70	12.6	18.2	26.3	38.0	55.0	79.5	115	166
GOES-5	0.86	0.92	1.14	1.52	3.46	2.01	1.81	1.50	1.67	1.60
GOES-7	0.73	0.79	0.90	0.90	1.83	1.35	1.38	1.34	1.48	1.23
GOES-8	0.84	0.98	1.08	1.08	2.39	1.79	1.89	1.44	1.62	2.61
GOES-11	0.70	0.74	0.85	0.86	1.74	1.50	1.86	1.51	1.57	2.44

1. The approach taken corrects the wrong thing!
 - Problem is with (knowing) the energy
 - We correct the flux (channel is proxy)
2. Many scaling factors at SEPTEM energies are very high as a result (see table)
3. There is a jump seen the SEPTEM SPE spectra
 - Seen in (almost) all SPEs
4. Remaining caveats and different approaches needed to be studied
 - => SEPCALIB Project



SEPCALIB project

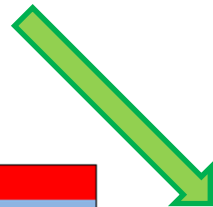
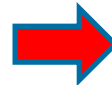
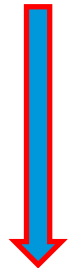


- Understand the source of caveats in SEPEM database
- Update & develop calibration schemes of NOAA GOES/SEM(-2) using IMP8/GME measurements.

Characteristics of target data: GOES

Wealth of reference data: IMP8

Cross-calibration procedure



GOES05-07/SEM		
Our notation	Channel name	Energy range
#0	P2	4.2-8.7
#1	P3	8.7-14.5
#2	P4	15.0-44.0
#3	P5	39.0-82.0
#4	P6	84.0-200.0
#5	P7	110.0-500.0

GOES08-12/SEM-2		
Our notation	Channel name	Energy range
#0	P2	4.0-9.0
#1	P3	9.0-15.0
#2	P4	15.0-40.0
#3	P5	40.0-80.0
#4	P6	80.0-165.0
#5	P7	165.0-500.0

IMP8/GME/LED		
Our notation	Channel name	Energy range
#0	DIntn_1	0.88-1.15
#1	DIntn_2	1.15-1.43
#2	DIntn_3	1.43-1.79
#3	DIntn_4	1.79-2.27
#4	DIntn_5	2.27-3.03
#5	DIntn_6	3.03-4.20
#6	DIntn_7	4.20-4.94
#7	DIntn_8	4.94-5.96
#8	DIntn_9	5.96-7.25
#9	DIntn_10	7.25-8.65
#10	DIntn_11	8.65-11.10
#11	DIntn_12	11.10-13.60
#12	DIntn_13	13.60-16.10
#13	DIntn_14	16.10-18.70
#14	DIntn_15	18.70-22.50

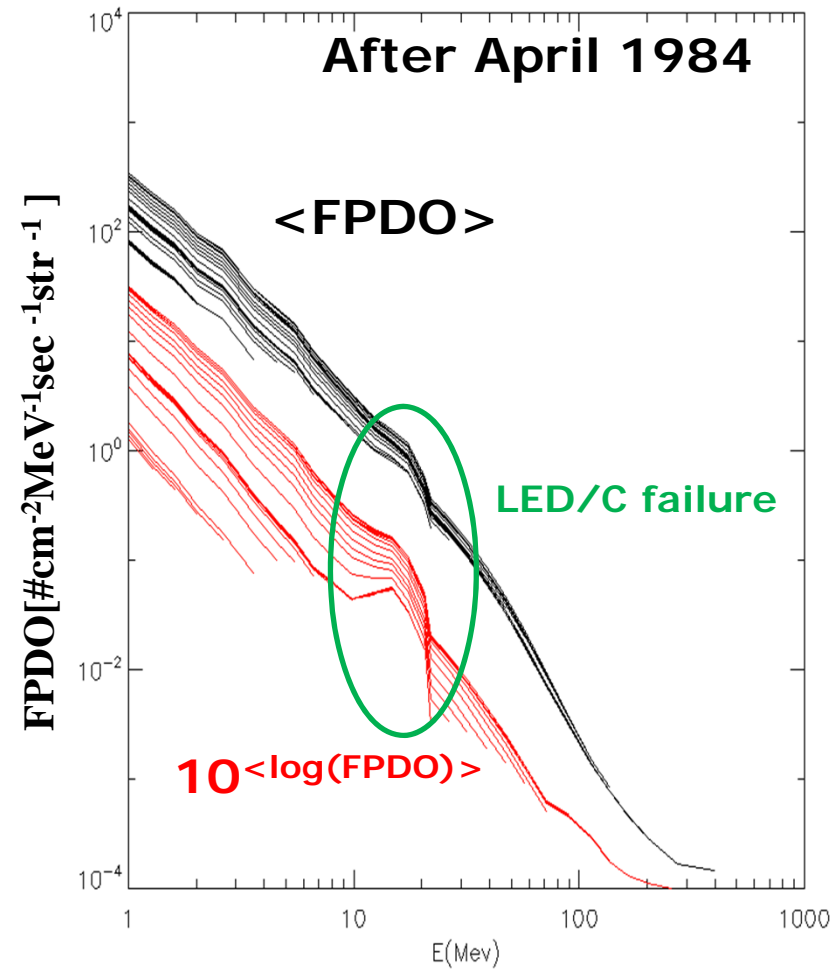
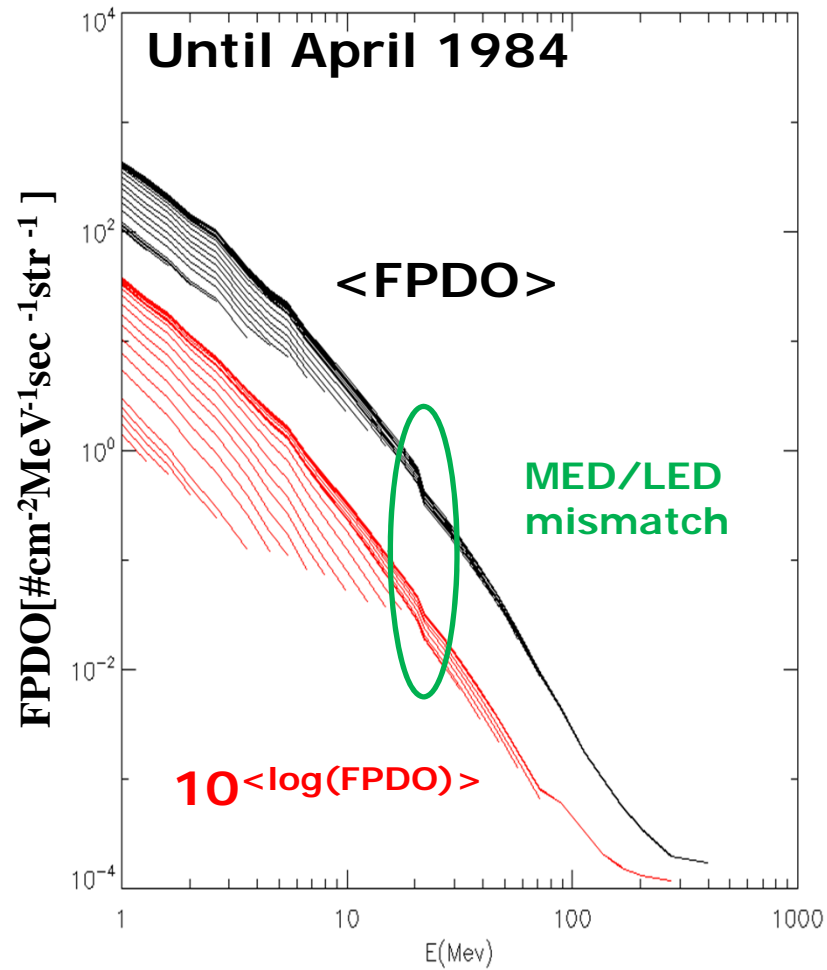
IMP8/GME/MED		
Our notation	Channel name	Energy range
#15	DIntn_16	19.80-24.20
#16	DIntn_17	24.20-28.70
#17	DIntn_18	28.70-35.20
#18	DIntn_19	35.20-42.90
#19	DIntn_20	42.90-51.00
#20	DIntn_21	51.00-63.20
#21	DIntn_22	63.20-81.00
#22	DIntn_23	87.00-92.50
#23	DIntn_25	107.0-121.0
#24	DIntn_26	121.0-154.0
#25	DIntn_27	154.0-178.0
#26	DIntn_28	178.0-230.0

ORIGINAL PROCEDURE:

- Interpolate data at SEPEM bins
- Linear regression fit
- Calibrate using fit coefficients

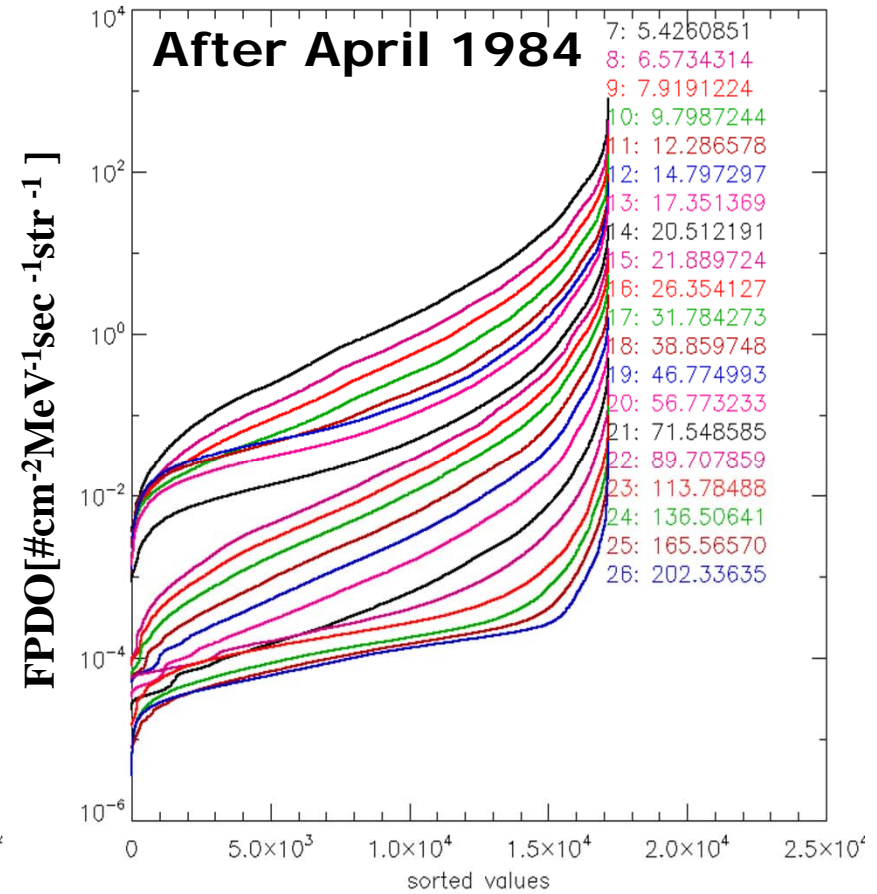
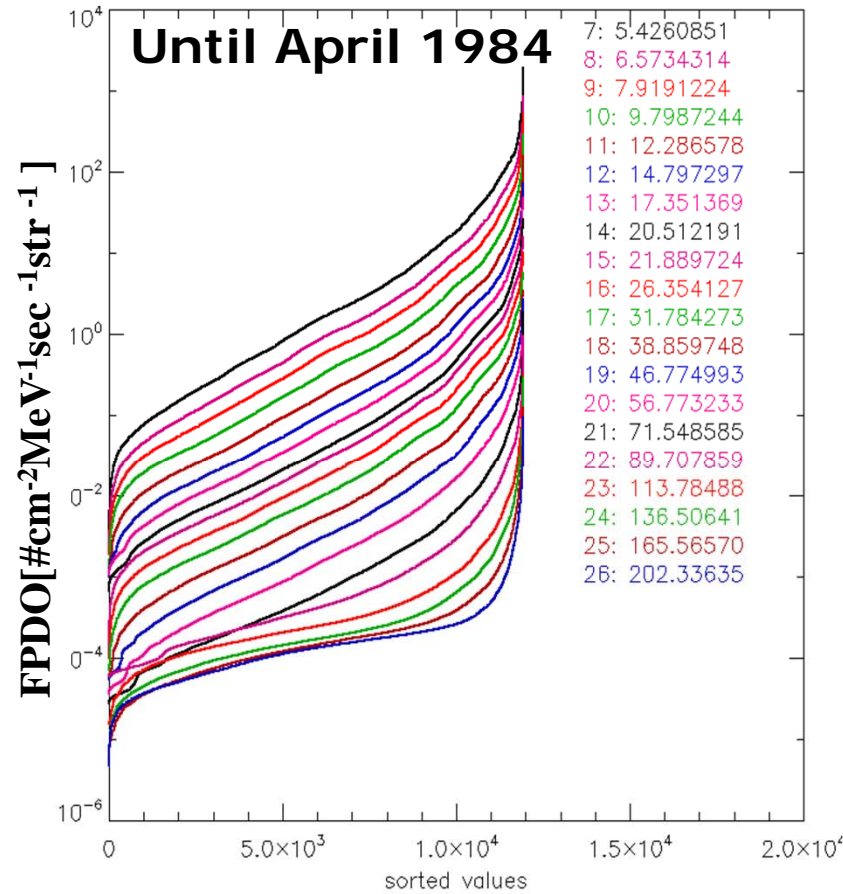


Mean spectra of concurrent measurements

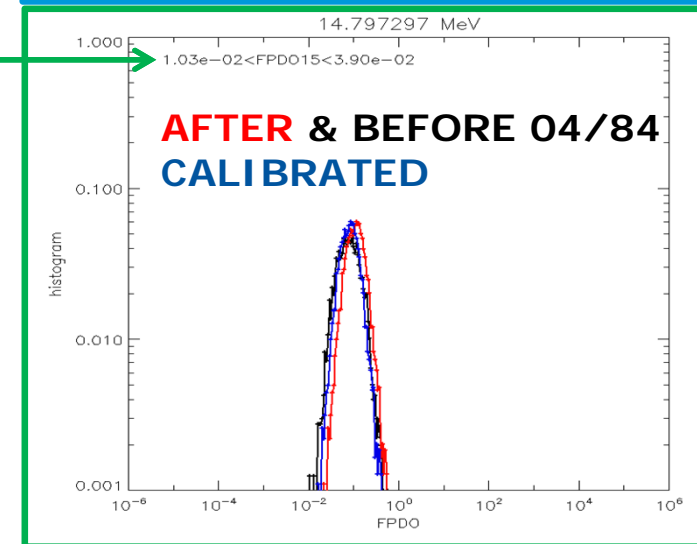
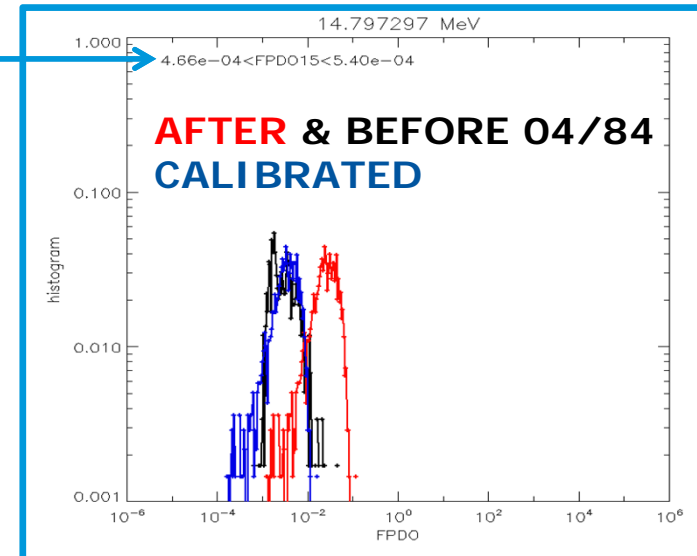
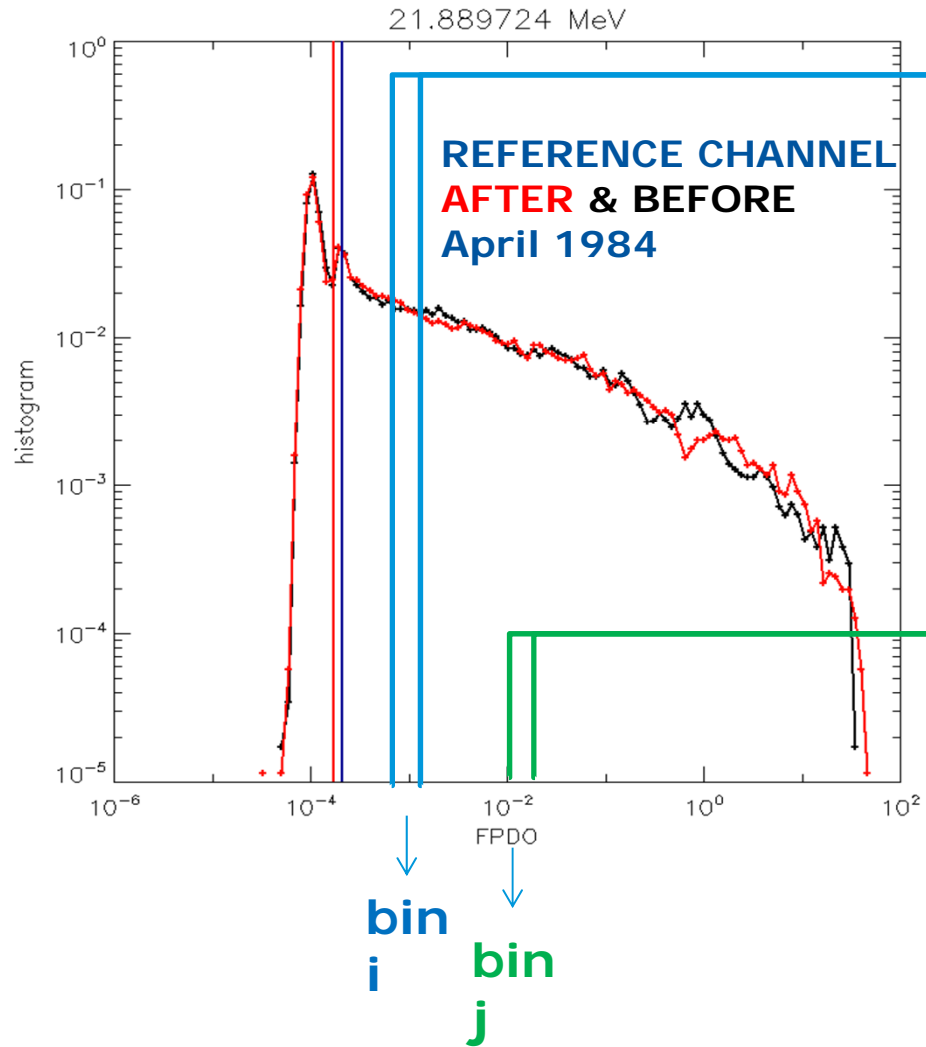




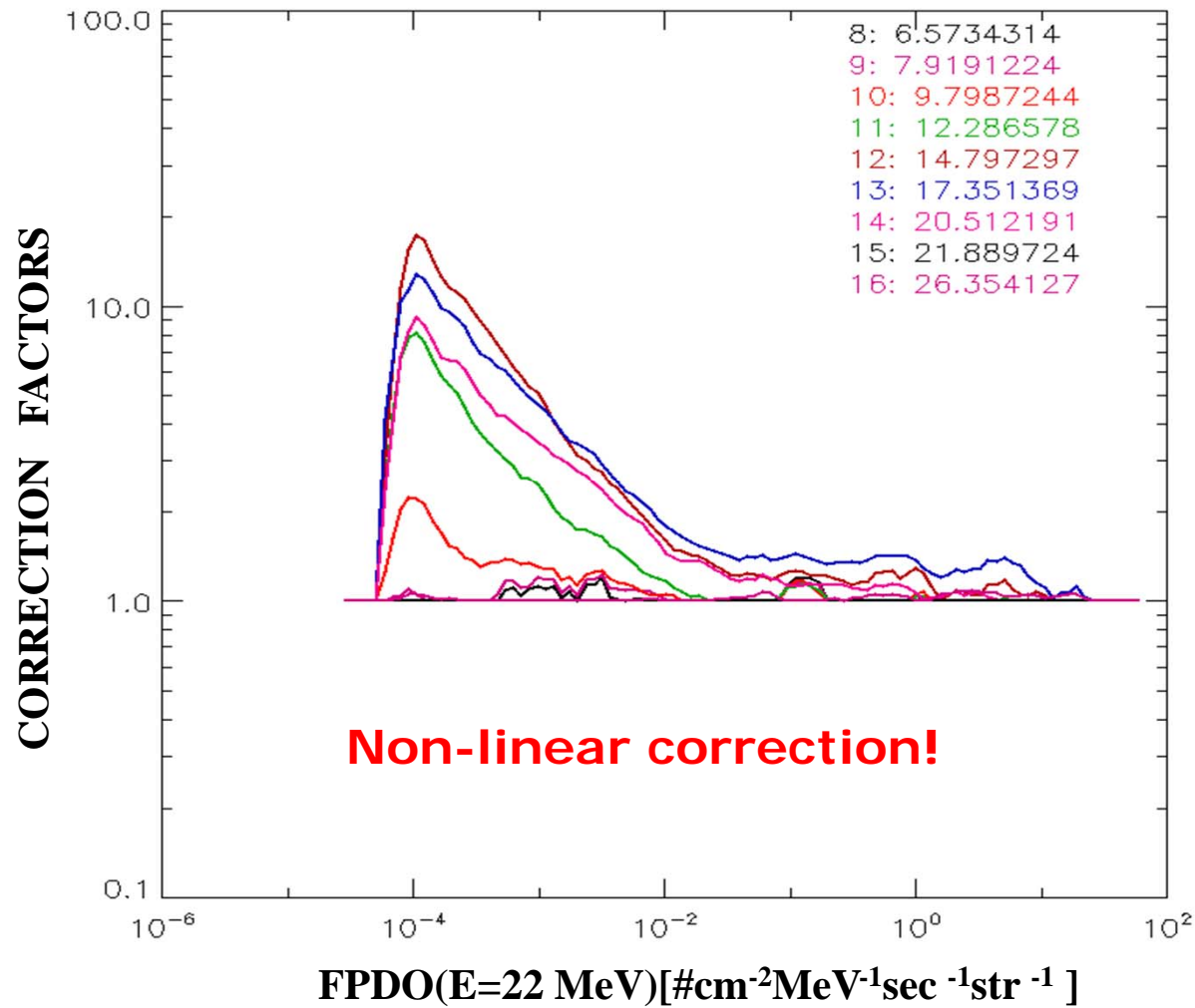
Sorted values of concurrent measurements



Correct IMP8/GME/LED data

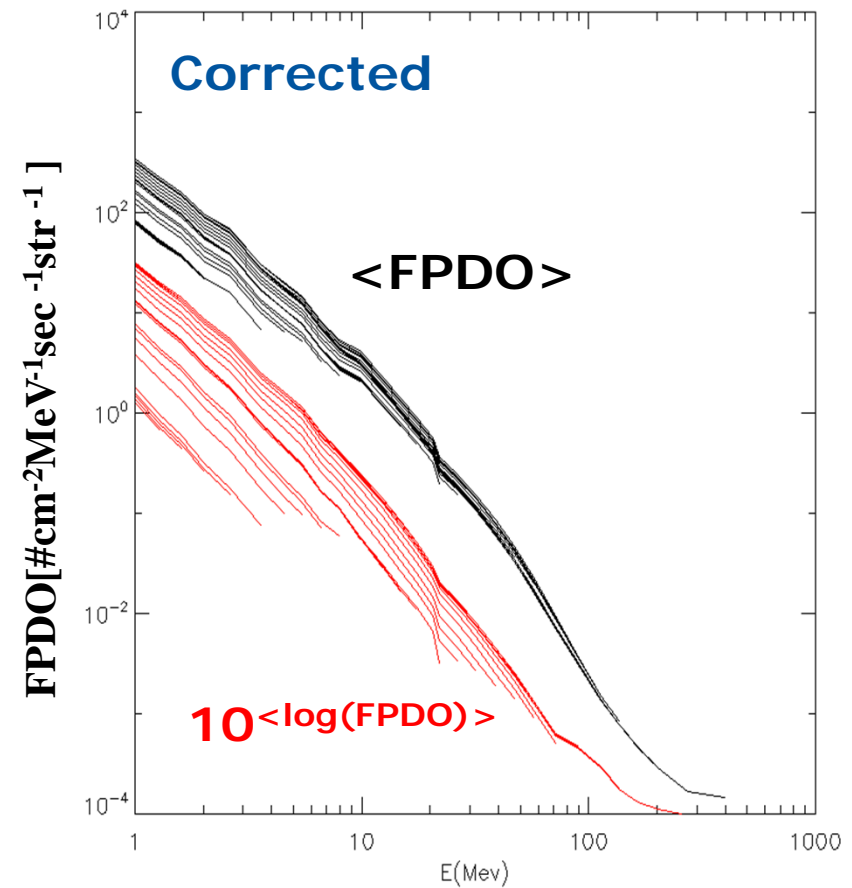
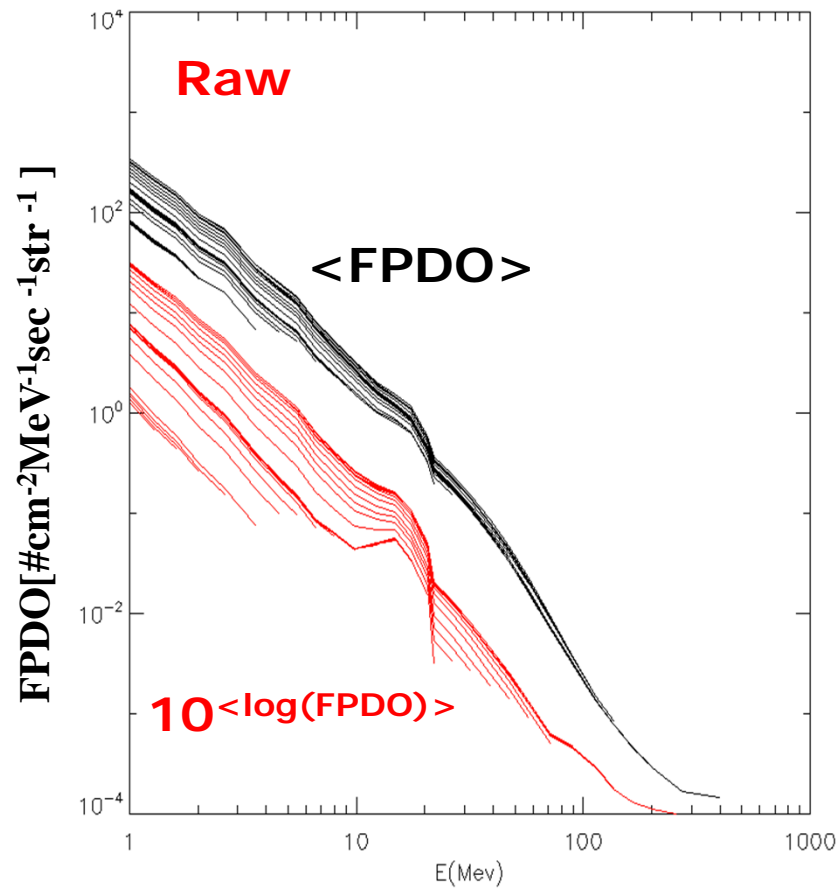


IMP8/GME/LED Inter-calibration factors



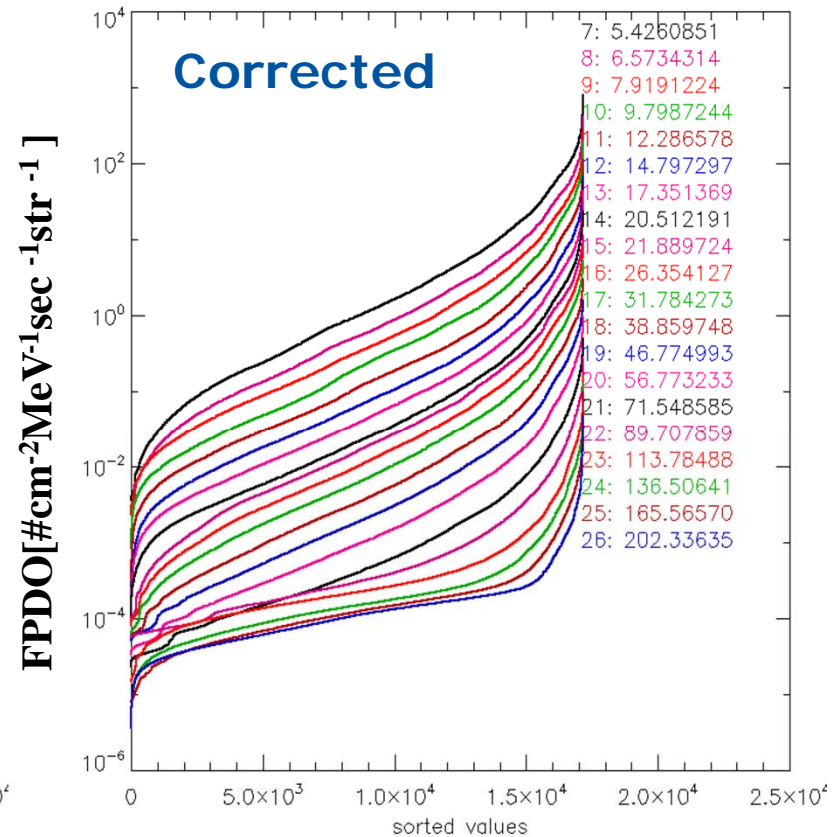
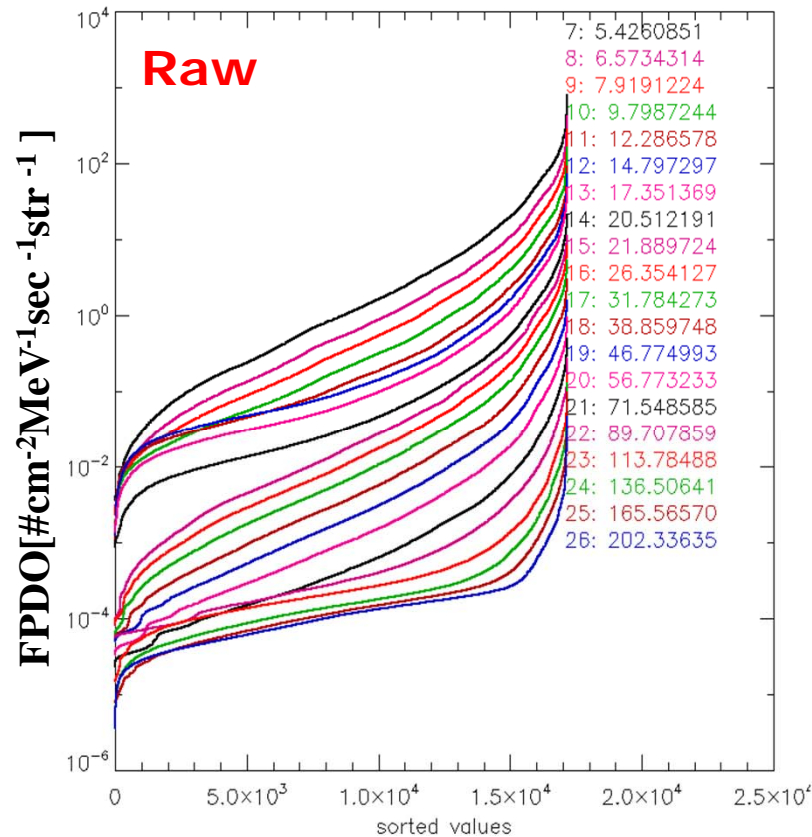


Mean spectra of concurrent measurements





Sorted values of concurrent measurements



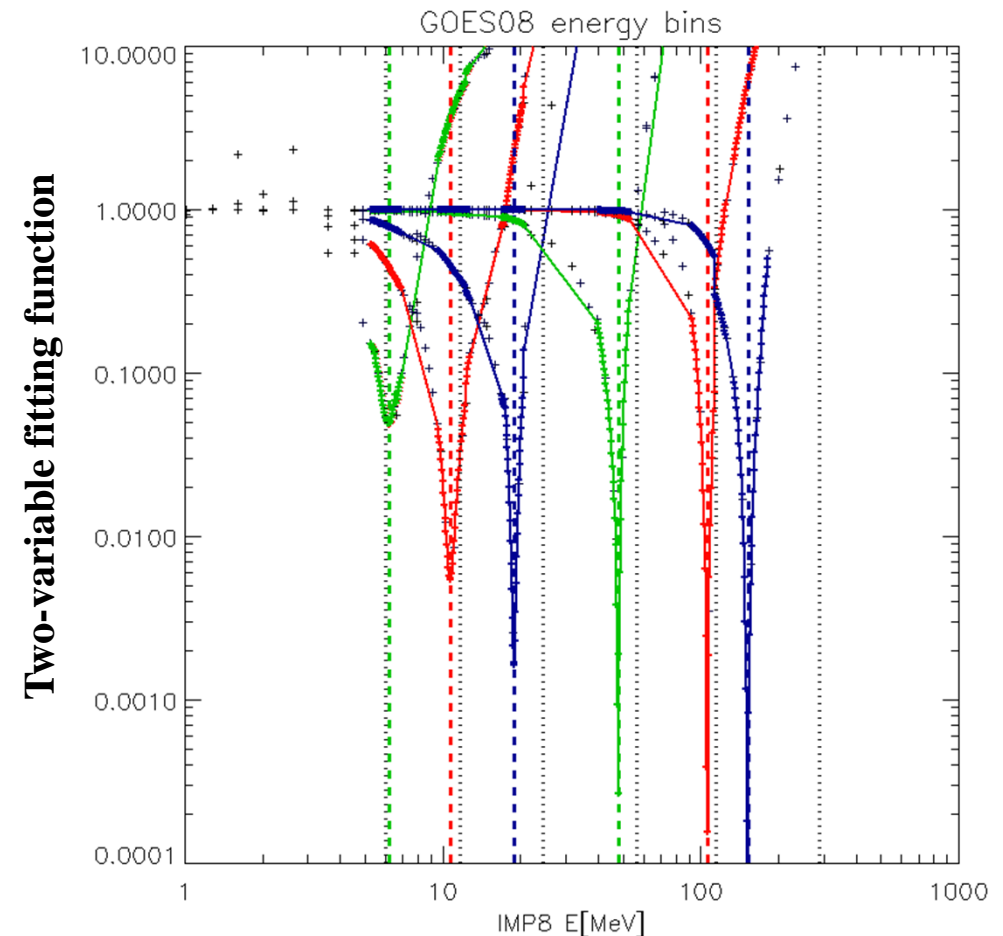
Determine GOES/SEM effective energies



- Time-average GOES datasets in order to match cadence & time-stamps with IMP8/GME.
- Iterative energy re-binning of IMP8/GME fluxes within GOES/SEM energy ranges E_i
- Determination of linear fitting coefficients

$$FLX_{GOES} = A_i(E) + B_i(E_i)FLX(E_i)_{IMP8}$$

- Mapping: $E_i \rightarrow (A_i, B_i) \rightarrow C_i$
- Effective energy: the value that optimizes fitting coefficients; $A=0$ and $B=1$

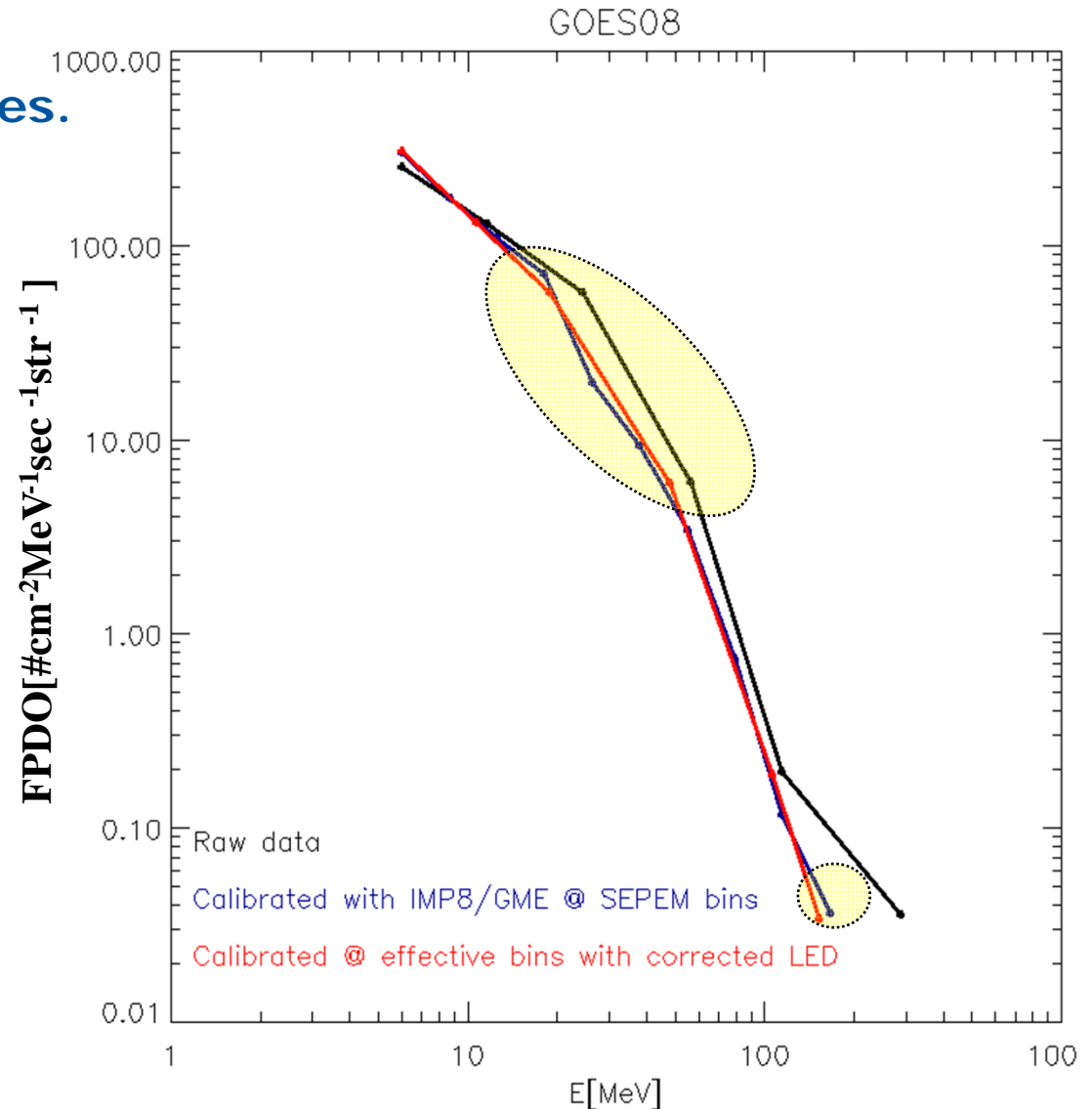


- **SEM : GOES05, GOES07**
- **SEM-2 : GOES08, GOES11**

New Calibration Scheme for SEP-EM



- Determine effective energies.
- Calibrate GOES/SEM:
"just change the energy values tagged with each GOES/SEM channel!"
- Re-bin @ SEP-EM energies





- **A method for correcting IMP8/GME/LED data**
- **Determination of GOES/SEM(-2) effective energies**
- **Calibrate at the effective energies of target dataset**
- **Future update of ESA SEPEM database and processing algorithms**



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