MEGS-SAM Calibration Overview

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MEGS-SAM Algorithm

- SURF Responsivity Algorithm – Individual Photon Method

$$R_S(i,j,\lambda) = \frac{N_{surf}(i,j,\lambda,E_{beam})}{F(\lambda,E_{beam}) \bullet I \bullet A_S \bullet \Delta\lambda_S \bullet \Delta t}$$

Did NOT Work
(SURF beam is too small)

- SURF Responsivity Algorithm – Total Current Method
  - Adjust filter model until scaling factor (ratio) is near unity

$$S_{pred} = f(E_{beam}) \bullet \int_0^\infty R_S \bullet F(\lambda,E_{beam}) \bullet I \bullet A_S \bullet d\lambda$$

$$S_{meas} = \int_{i,j} \frac{C_S(i,j,E_{beam})}{\Delta t} \bullet G \bullet \frac{3.65eV}{q_e}$$

$$f(E_{beam}) = \frac{S_{meas}}{S_{pred}}$$

- Solar Irradiance Algorithm + Energy Resolution Equation

$$F_{sun}(\lambda) = \frac{N_{sun}(i,j,\lambda)}{R_S(i,j,\lambda) \bullet A_S \bullet \Delta\lambda_S \bullet \Delta t}$$

$$\Delta E = 3.65 \bullet 2.36 \bullet \sqrt{\left(G \bullet \sqrt{D_S}\right)^2 + \left(\frac{340}{\lambda} \bullet F\right)}$$

MEGS-SAM Calibration Results

Parameter	Source	Flight MEGS-SAM	Rocket MEGS-SAM	Uncertainty
Current, C_S	SURF measured (dark removed from image first)	varies	varies	2%
Gain, G	Solar spectrum peak + known solar lines	2.47	2.47	10%
SURF Flux, F	Theory (calculate)	-	-	0.2%
Beam Current, I	SURF measured	-	-	1%
Area, A_S	Lab measured (but divides out)	5.3×10^{-10} m^2	5.3×10^{-10} m^2	N/A (10%)
Bandpass, $\Delta\lambda$, ΔE	Model calculated	varies	varies	10%
Scaling Factor, f_{SURF}	Calculated	0.97	0.97	8.4%
Responsivity, R_S	Calculated	-	-	17%

SAM Filter design: C 40 nm, Al 100 nm, Ti 300 nm, SiO 7 nm, 5 μm Si thick

SAM Filter results: C 80 nm, Al 200 nm, Ti 320 nm, SiO 7 nm, 5 μm Si thick

MEGS SAM SURF Scaling Factors

Table 6. Scaling Factor Results for SAM Calibration Sets.
Results are based on the calibrated responsivity model and represent different beam energies. Instances where lower currents had to be used due to lack of data at a higher current are marked with an asterisk (*).

Calibration Set	Beam Energy (MeV)	Beam Current (mA)	Original Scaling Factor	Final Scaling Factor
Rocket post-flight (January 2009)	408*	2×10^{-5}	0.6844	0.9675
	380	2×10^{-4}	0.6824	1.0224
	361*	2×10^{-5}	0.5556	0.8637
	331	2×10^{-4}	0.5616	0.9208
Rocket pre-flight (October 2007)	408	2×10^{-4}	0.7545	1.0667
	380	2×10^{-4}	0.6519	0.9767
	361	2×10^{-4}	0.6256	0.9726
	331	2×10^{-4}	0.5511	0.9036
Flight Instrument (February 2007)	408	1.6×10^{-4}	0.7602	1.0747
	380	1.8×10^{-4}	0.6934	1.0389
	361	2×10^{-4}	0.6185	0.9615
	331*	1×10^{-4}	0.4769	0.7819
Flight Instrument (August 2007)	408	1.6×10^{-4}	0.7742	1.0945
	380	1.8×10^{-4}	0.6796	1.0181
	361	2×10^{-4}	0.6289	0.9777
	331*	1×10^{-4}	0.5416	0.8852

Note systematic variation of original scaling factor as function of beam energy.
This allows estimate of how to adjust filter model as function of wavelength.

MEGS-SAM Irradiance Uncertainty

Parameter	Uncertainty
Signal, N_{sun}	1%
Responsivity, R_S	17%
Bandpass, $\Delta\lambda$, ΔE	10%
Integ. Time, Δt	0.01%
Area, A_S	(not used)
FOV Factor, f_{FOV}	(not used)
1 AU Factor, f_{1AU}	< 0.05%
Degradation, $f_{degrade}$	1%/year
Irradiance, F_{Sun}	20%

Responsivity Uncertainty

$$\sigma_{R_S}^2 = R_S^2 \bullet \left[\left(\frac{\sigma_{C_S}}{C_S}\right)^2 + \left(\frac{\sigma_F}{F}\right)^2 + \left(\frac{\sigma_I}{I}\right)^2 + \left(\frac{\sigma_{A_S}}{A_S}\right)^2 + \left(\frac{\frac{dR_S}{d\lambda}\sigma_\lambda}{R_S}\right)^2 + \left(\frac{\sigma_f}{f}\right)^2 \right]$$

Irradiance Uncertainty

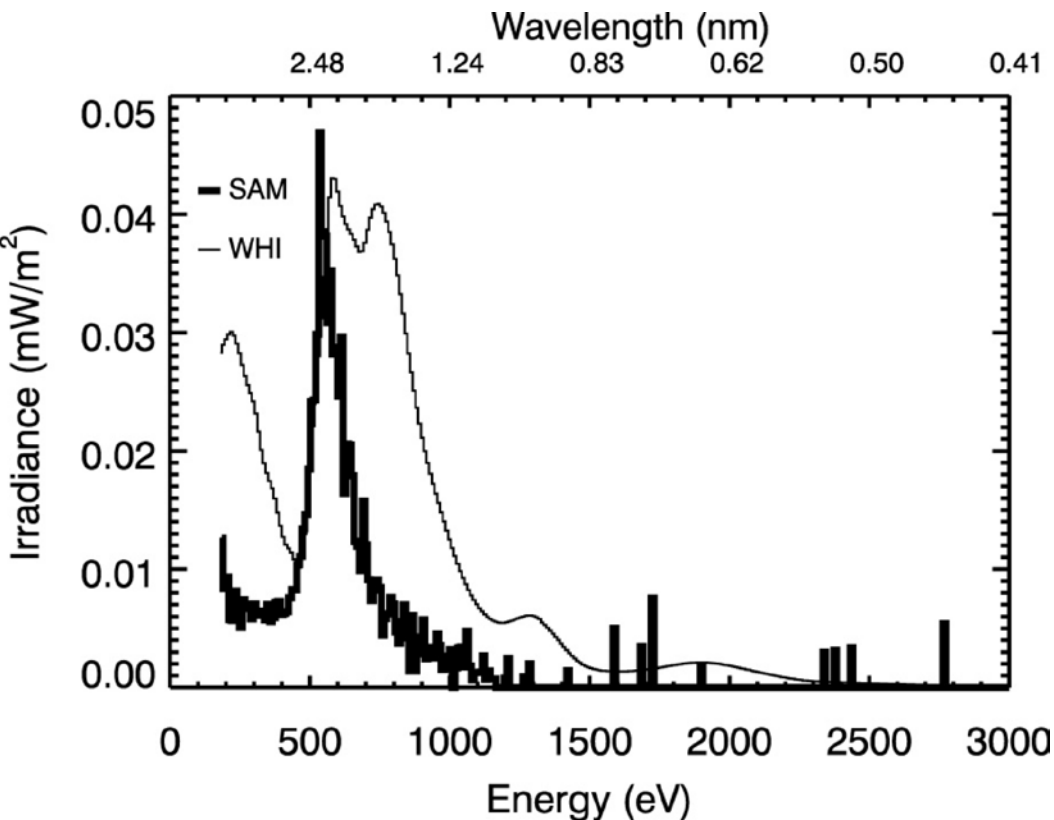
$$\sigma_{F_{Sun}}^2 = F_{Sun}^2 \bullet \left[\left(\frac{\sigma_{N_S}}{N_S}\right)^2 + \left(\frac{\sigma_{R_S}}{R_S}\right)^2 + \left(\frac{\sigma_{\Delta\lambda}}{\Delta\lambda}\right)^2 + \left(\frac{\frac{dR_S}{d\lambda}\sigma_\lambda}{R_S}\right)^2 + \left(\frac{\sigma_{\Delta t}}{\Delta t}\right)^2 + \left(\frac{\sigma_{f_{1AU}}}{f_{1AU}}\right)^2 + \left(\frac{\sigma_{f_{degrade}}}{f_{degrade}}\right)^2 \right]$$

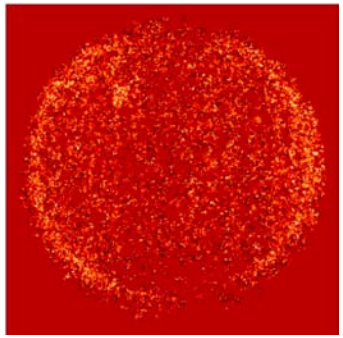
<u>SAM Calibration Challenges</u>

1) Single photon detection does not work for small SURF beam
2) Gain calibration is not consistent with different methods (10% variation)
3) Adjustment of Filter Model has large uncertainty (8%)

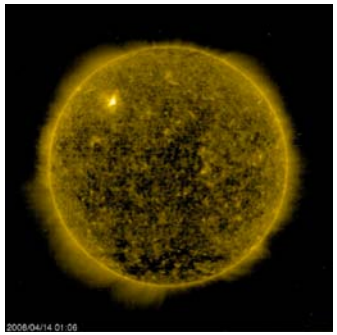
April 2008 Rocket MEGS-SAM Results

- Rocket MEGS-SAM 1-7 nm Irradiance is 57 $\mu W/m^2$
- SAM is 42% less than rocket ESP and SORCE XPS 1-7 nm irradiance (99 and 93 $\mu W/m^2$, respectively)
- SAM is 63% less than the XPS Level 4 model irradiance (WHI SIRS = 157 $\mu W/m^2$)
- Why so different?
  - Suspect double-photon events in small active region on solar disk. Note that gain with solar data was 26% more than SURF; so SAM might only be 16% less than ESP.





MEGS-SAM



EIT 28.4 nm

SDO MEGS-SAM Initial Validation Effort

- Validate MEGS-SAM irradiance with Flight ESP, Rocket EVE, TIMED SEE, and SORCE XPS
  - ESP has best accuracy
- First underflight EVE calibration is on May 5, 2010
  - Expect difference between MEGS-SAM and ESP to persist. If so, then plan to update the SDO and Rocket MEGS-SAM calibration parameters (probably Gain factor) so MEGS-SAM has same irradiance as ESP on rocket day
  - Need to implement SAM processing algorithm to just report 1-7 nm irradiance (no spectrum) and its image in this broad band
    - That is, might have to abandon the photon-detection algorithm for SAM as there appears to be too many double-photon events even in a small active region in April 2008 (solar cycle minimum !)

Long-Term Calibration Plan with MEGS-SAM

- Degradation trend for SAM will be derived using flight ESP results
  - That is, daily average difference between SAM and ESP for 1-7 nm irradiance will be assumed to be SAM degradation function
- Adjustments to trend will also be derived from the EVE underflight rocket measurements
  - Five flights planned for 5/10, 11/10, 10/11, 4/13, 4/15