THE CALIBRATION LAB AT UNIS

Auroral All-Sky Camera Calibration

Fred Sigernes [1*], Drummond Biles [2], Henrik Bjørklund [1], Dag Lorentzen [1], Trond Trondsen [2], Urban Brändström [3], Espen Trondsen [4], Bjørn Lybekk [4], Jøran Moen [4] , Sergey Chernouss [5] and Charles Deehr [6]

[1] The University Centre in Svalbard (UNIS), N-9171 Longyearbyen, Norway
[2] Magnetosphere Ionosphere Research Lab, University of New Hampshire, USA
[3] Keo Scientific Ltd., Calgary, Alberta, Canada
[4] Swedish Institute of Space Physics, Kiruna, Sweden
[5] Department of Physics, University of Oslo, Oslo, Norway.
[6] Polar Geophysical Institute, Murmansk Region, Apatity, Russia
[7] Geophysical Institute, University of Alaska, Fairbanks, USA

* Birkeland Center for Space Science

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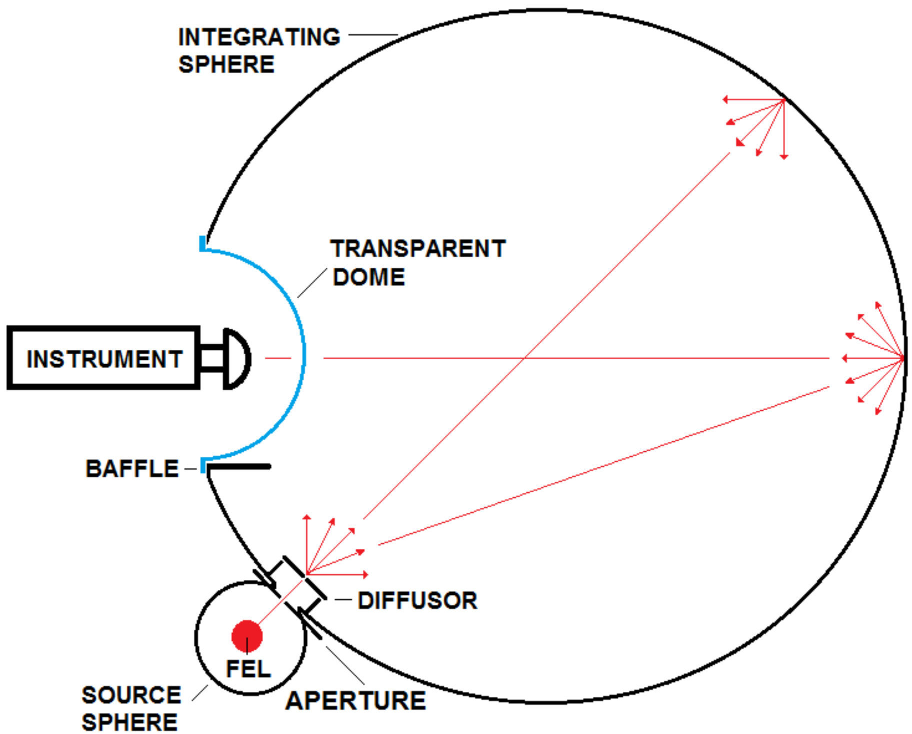
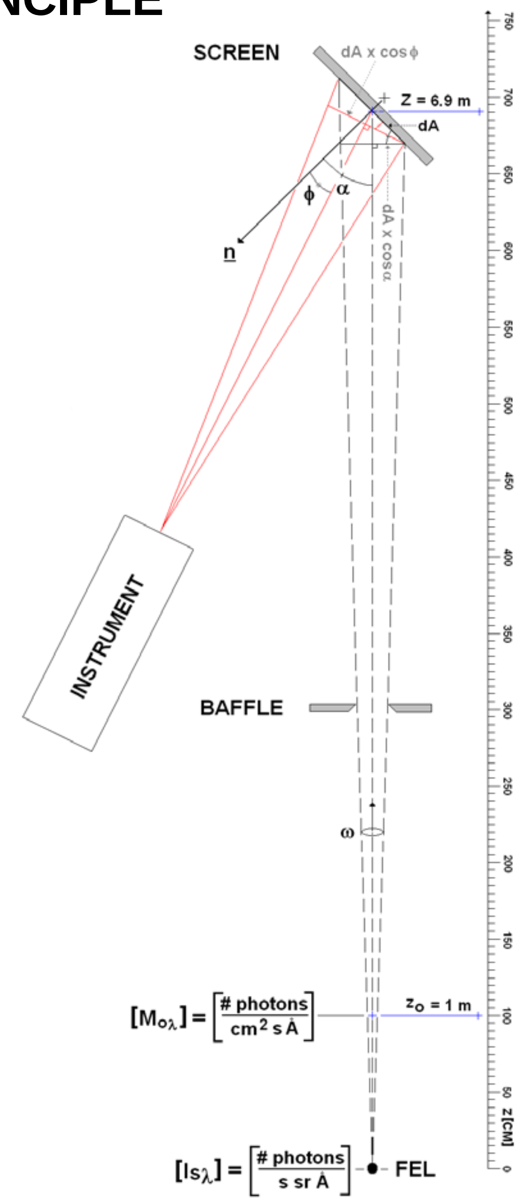
1. BASIC PRINCIPLE

$$B(\lambda) = \frac{M_o(\lambda)}{\pi}\rho\left(\frac{z_o}{z}\right)^2 \times \cos\alpha \quad \left[\frac{\#\,photons}{cm^2 s \mathring{A} sr}\right]$$

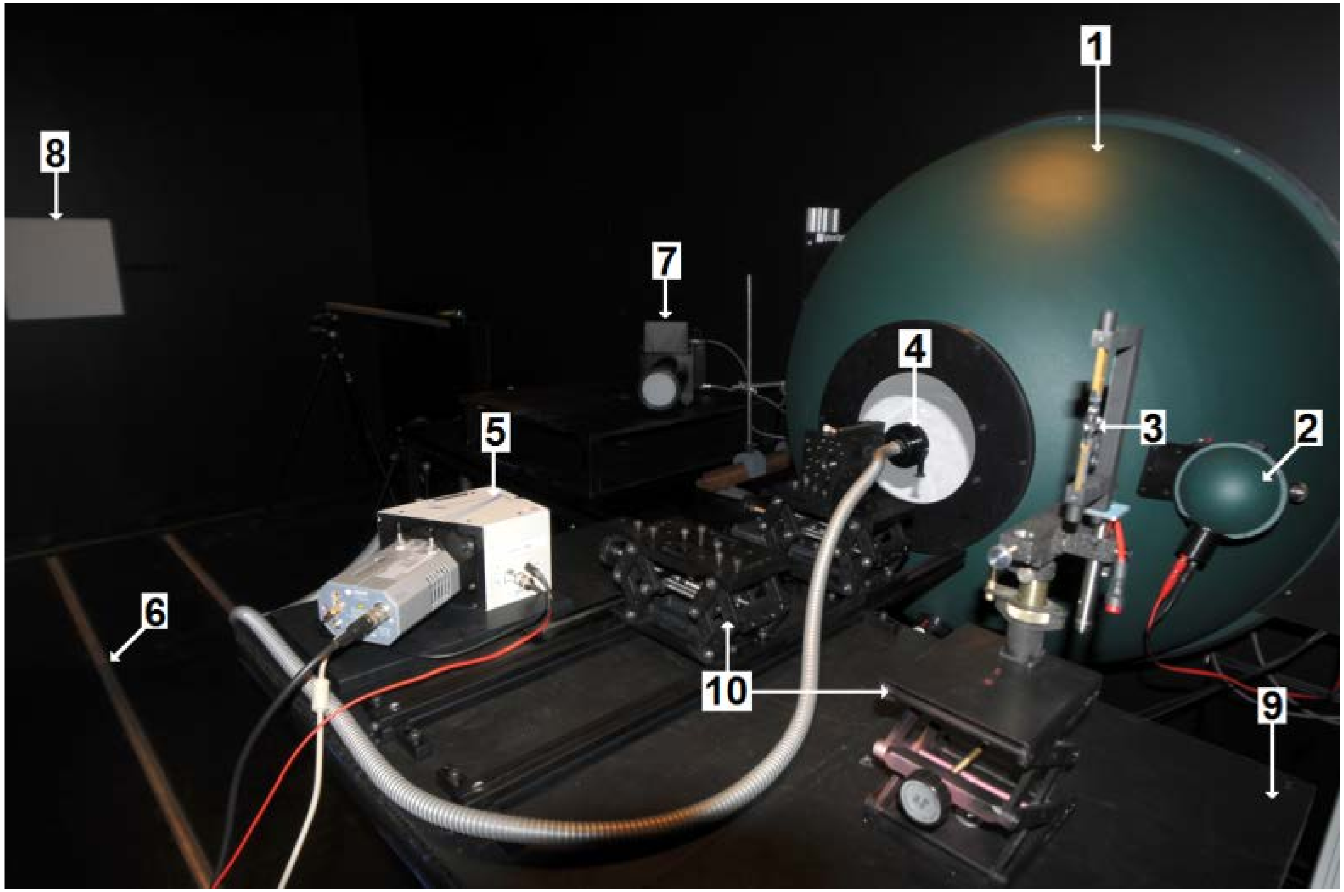
$$= \left(\frac{4\rho}{10^6}\right) M_0(\lambda)\left(\frac{z_0}{z}\right)^2 \times \cos\alpha \quad [R/\mathring{A}]$$





$$1R \equiv (1/4\pi)\times 10^6\,\#\,photons\ \ cm^{-2}\sec^{-1} sr^{-1}$$

2. EXPERIMENTAL SETUP



Experimental setup at UNIS optical lab: (1) Labsphere 1m diameter integrating sphere, (2) source lamp sphere, (3) Oriel 45W tungsten Lamp (FEL), (4) fiber bundle probe, (5) Oriel FICS 77443 spectrograph, (6) rail road, (7) Keo Alcor-RC lamp, (8) Lambertian screen, (9) adjustable table on rails, and (10) table jacks.

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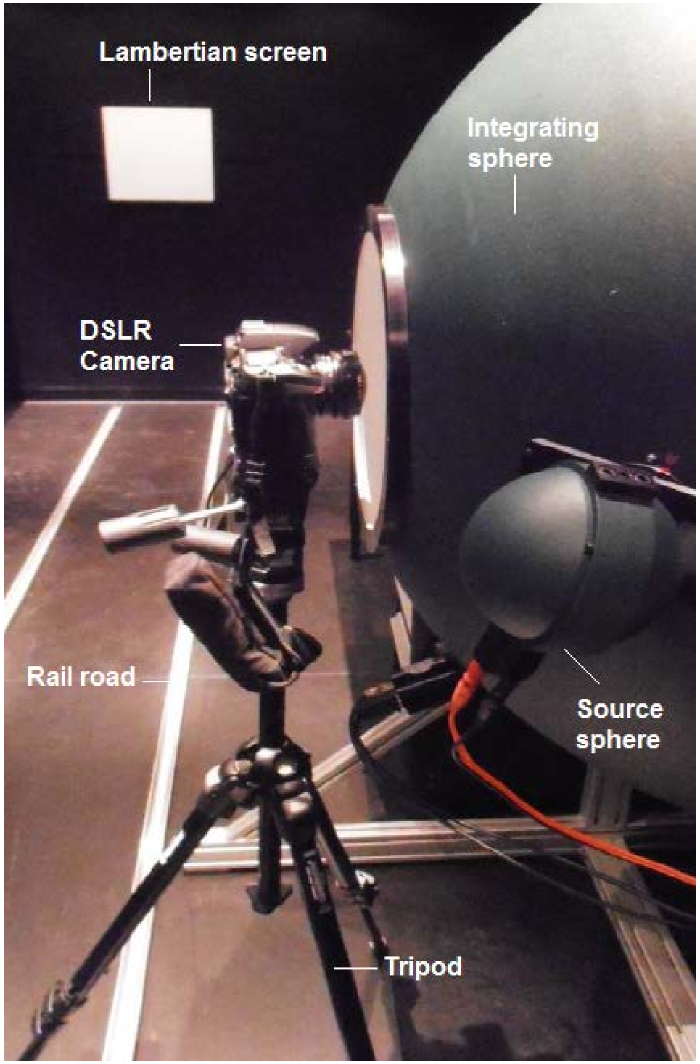
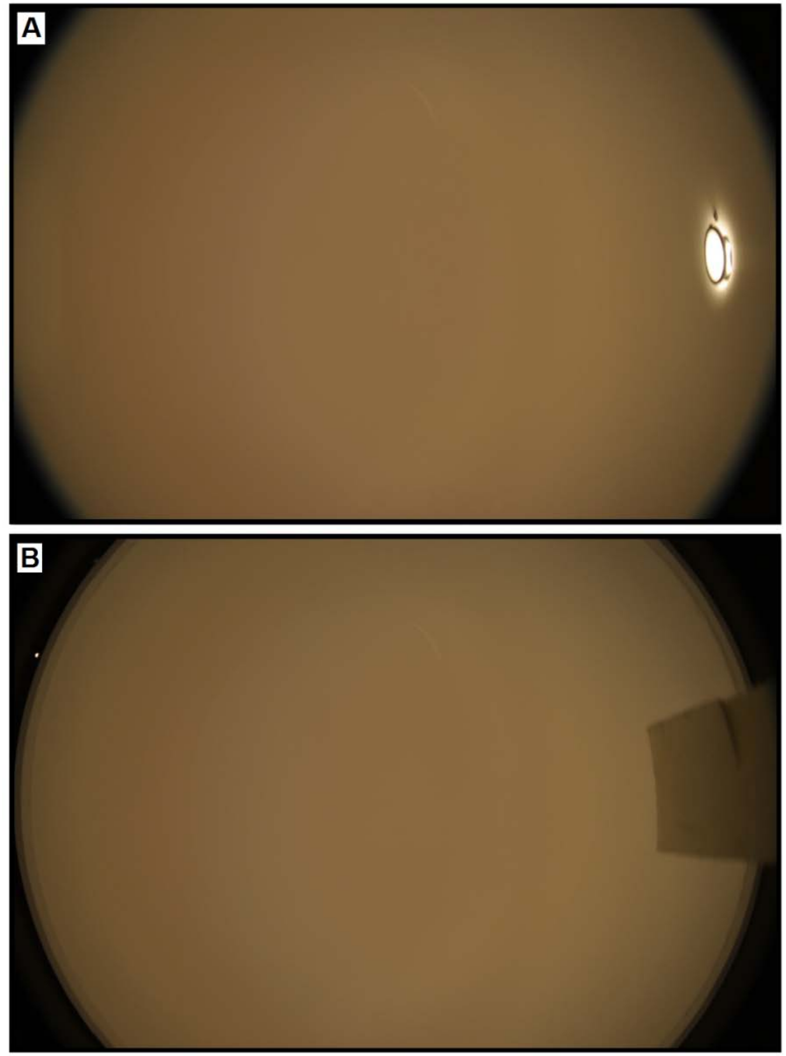
2. EXPERIMENTAL SETUP

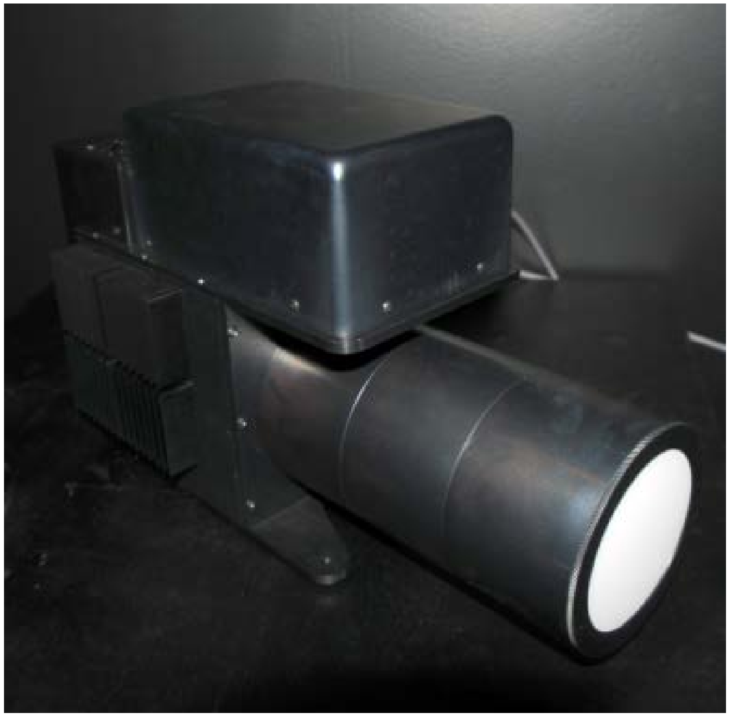


Integrating sphere camera setup.



Sphere images. (A) No source block and (B) moon block.

3. TEST OF CALIBRATION



Keo Alcor-RC. Remote Controlled Low Brightness source from Keo Scientific (head unit).

Keo User Manual:

«It consists of the lamp, aperture wheels, various diffusing elements, and electronics required to remotely control the system.»

In addition:

1) Agilent E3633A power supply
2) Alcor-RC power supply
3) Control software
4) Calibration Certificate (NRC)
5) HP mini PC (not included)

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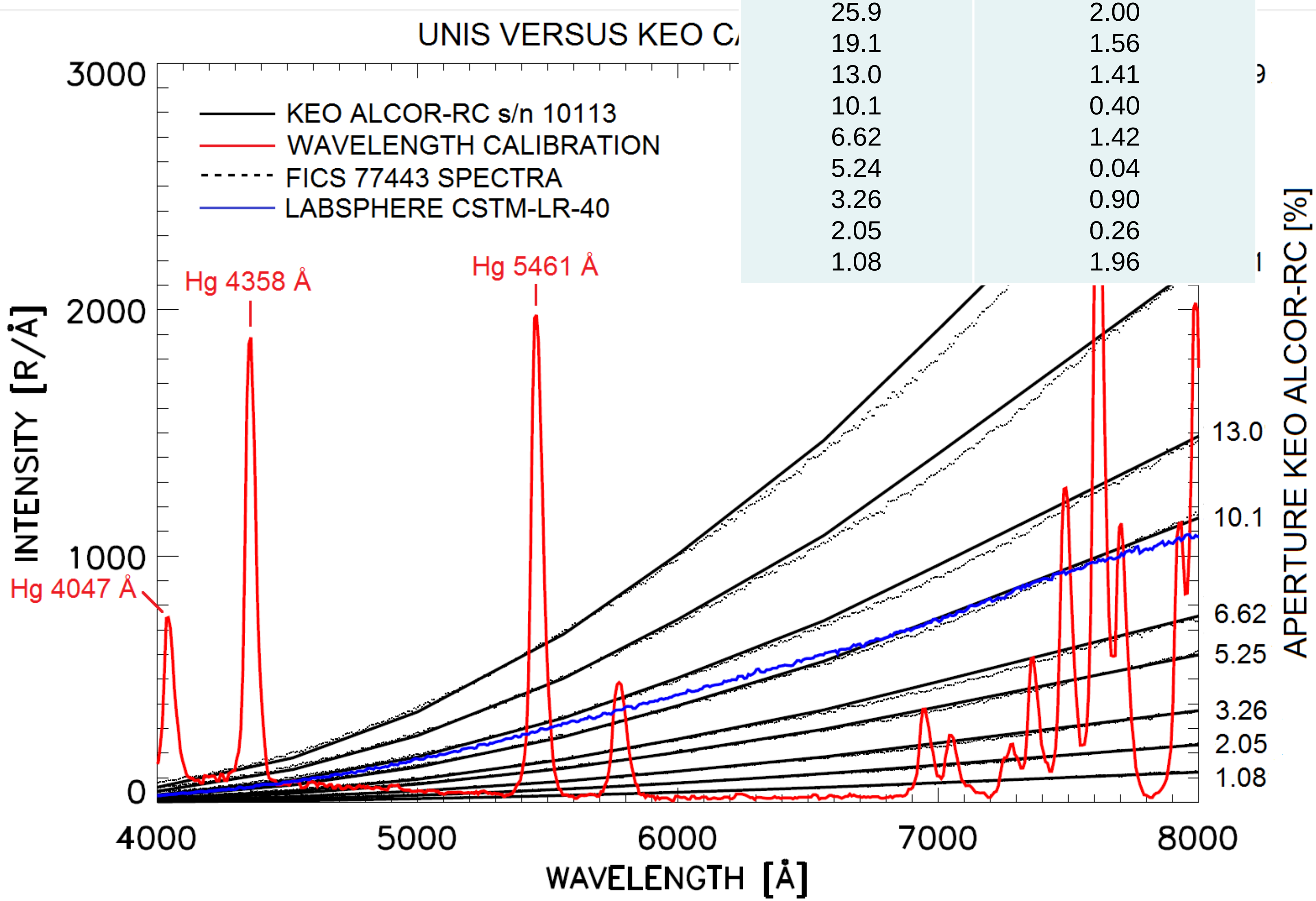
Keo Alcor RC Aperture [%]	Relative Integrated Percentage Error Keo & FICS[%]
25.9	2.00
19.1	1.56
13.0	1.41
10.1	0.40
6.62	1.42
5.24	0.04
3.26	0.90
2.05	0.26
1.08	1.96



F. Sigernes et al., Auroral All-Sky Camera Calibration, 40 AM

4. CAMERA EQUATIONS

Camera raw counts (x,y) of screen

$$u = \int B(\lambda) \cdot S(\lambda) d\lambda \quad [cts]$$

$$B(\lambda) = \left(\frac{4\rho}{10^6}\right) \times M_0(\lambda) \times \left(\frac{z_0}{z}\right)^2 \times \cos\alpha \quad [R/Å]$$

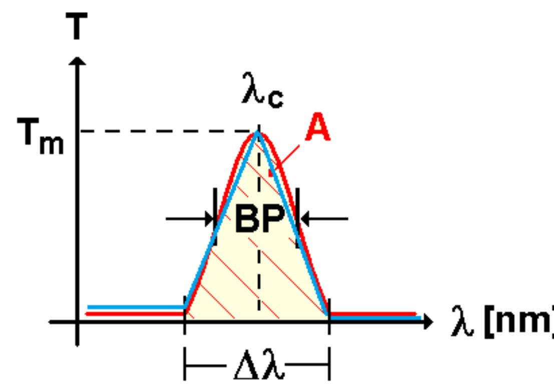
$$S(\lambda) \approx \varepsilon \cdot T(\lambda) \quad [cts/R]$$

$$u = B(\lambda_c) \cdot \varepsilon \cdot \int T(\lambda) d\lambda = B(\lambda_c) \cdot \varepsilon \cdot A$$

$$A = \int T(\lambda) d\lambda \approx T_m \cdot BP$$

Assumes that the source *B*, lens transmissions and detector sensitivity varies slowly in the wavelength interval $\Delta\lambda$

FILTER TRANSMISSION



For auroral emissions

$$J_a(\lambda) \equiv J \cdot \delta(\lambda - \lambda_c)$$

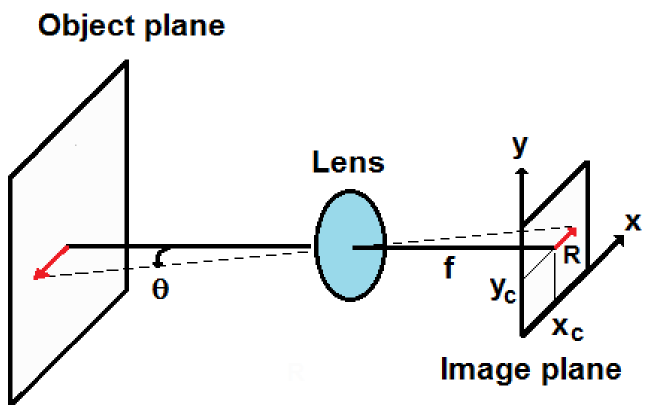
$$u_a = \int J_a(\lambda) \cdot S(\lambda) d\lambda = \int J \cdot \delta(\lambda - \lambda_c) \cdot \varepsilon \cdot T(\lambda) d\lambda$$

$$= J \cdot \varepsilon \cdot \int T(\lambda) \cdot \delta(\lambda - \lambda_c) d\lambda = J \cdot \varepsilon \cdot T_m$$

$$J = u_a \times \left[\frac{B(\lambda_c) \cdot BP}{u}\right] \quad [R]$$

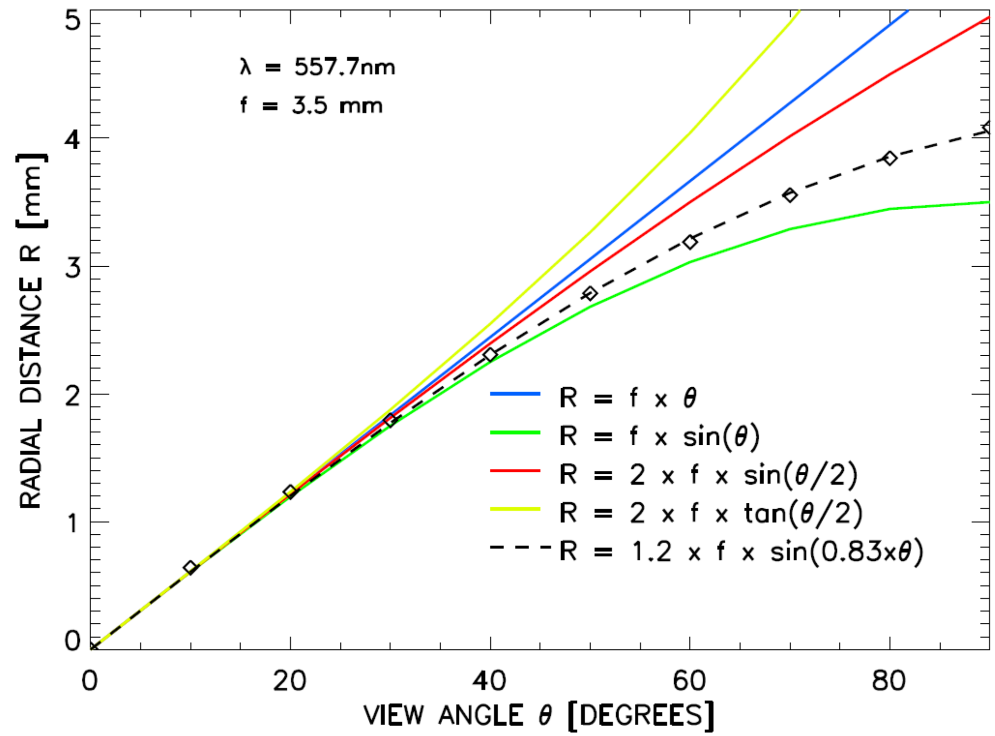
4. CAMERA EQUATIONS

Transform from (x,y) to (R,θ)



$$R \equiv \sqrt{(x-x_c)^2 + (y-y_c)^2}$$

$$R = k_1 \cdot f \cdot \sin(k_2 \cdot \theta)$$

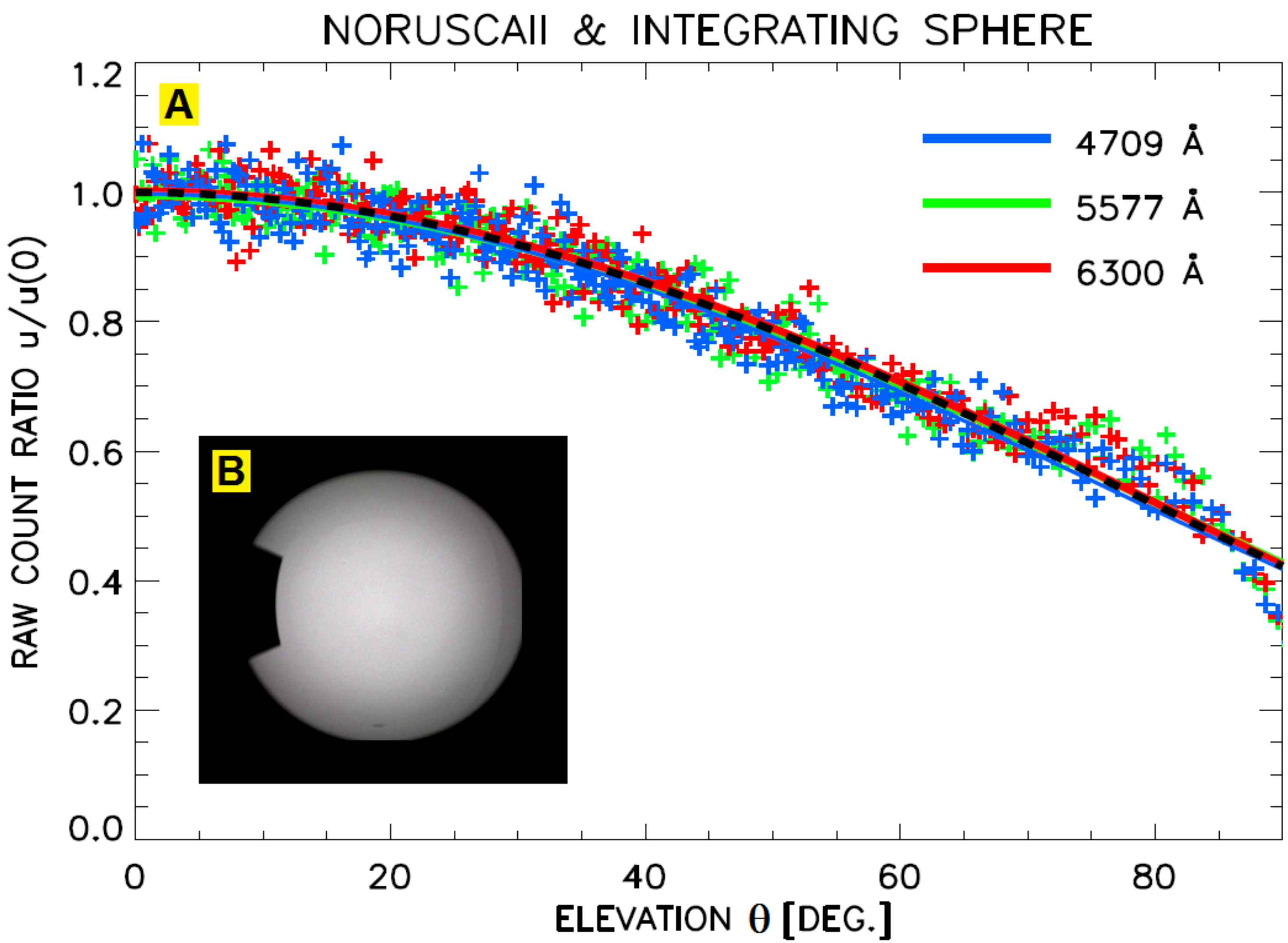


Due to uniform *B* and symmetry, a functional fit $u = u(\theta)$ should work

$$u = u(\theta) \approx u(0) \cdot [a_0 \cos(a_1 \cdot \theta) + a_2]$$

$$J = u_a \times \left[\frac{B(\lambda_c) \cdot BP}{u(0)}\right] \times \left[\frac{1}{a_0 \cos(a_1 \cdot \theta) + a_2}\right]$$

4. RESULTS


NORUSCAII & INTEGRATING SPHERE
A
B
4709 Å
5577 Å
6300 Å
RAW COUNT RATIO u/u(0)
ELEVATION θ [DEG.]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80

4. CONCLUSION

A two-step method to calibrate and flat-field correct an all-sky camera is outlined:

1. The center pixel spectral sensitivity is obtained and tested by a traditional method including a flat Lambertian screen and a 45*W* tungsten lamp.
2. Flat-field correction or off-axis response is conducted by the use of a modified l *m* diameter integrating sphere.

The net result is that it is sufficient with only 6 parameters per channel to calibrate an all-sky camera.