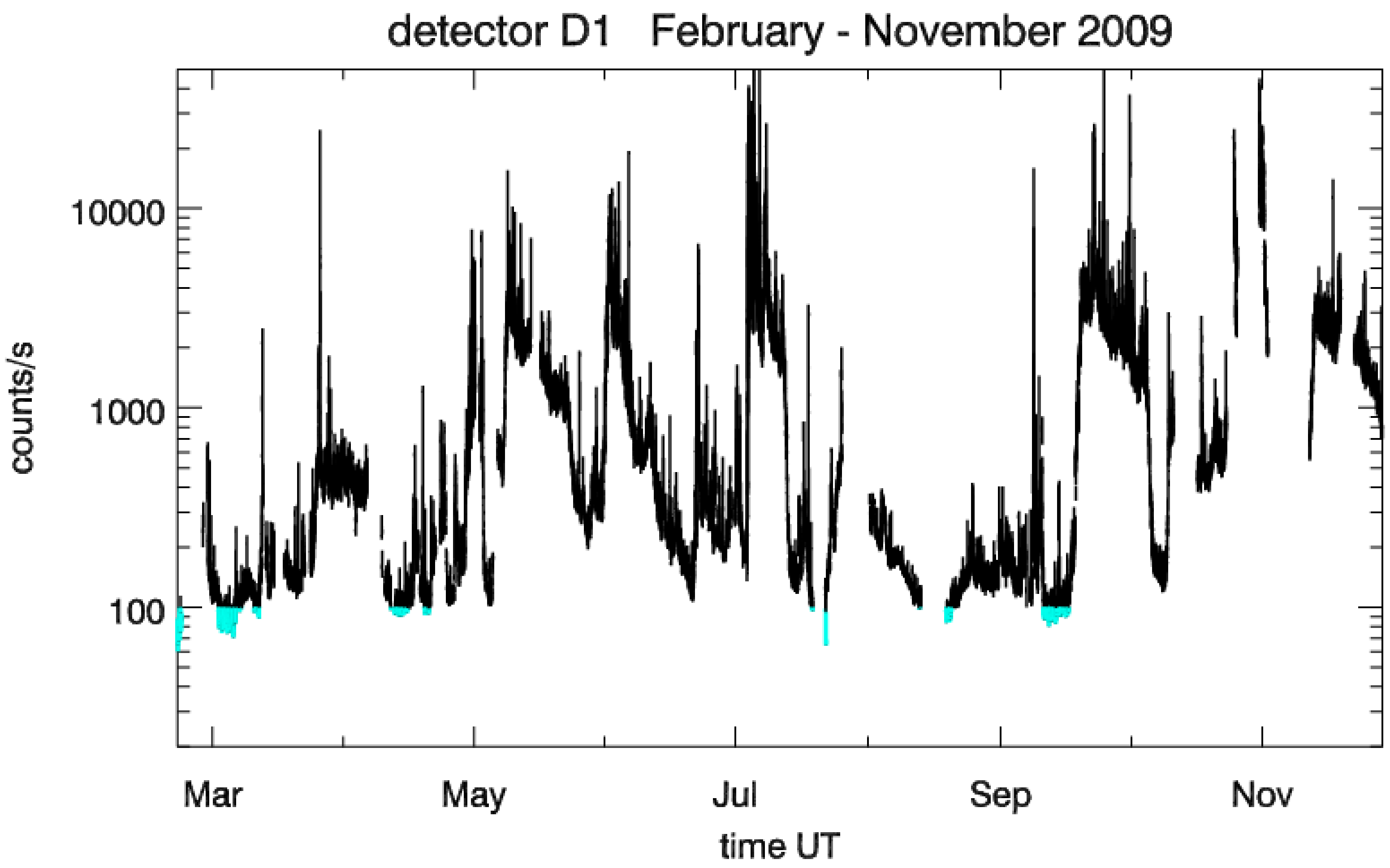
Rozkłady temperatury i gęstości w koronie w okresie minimum aktywności II

Marek Siarkowski

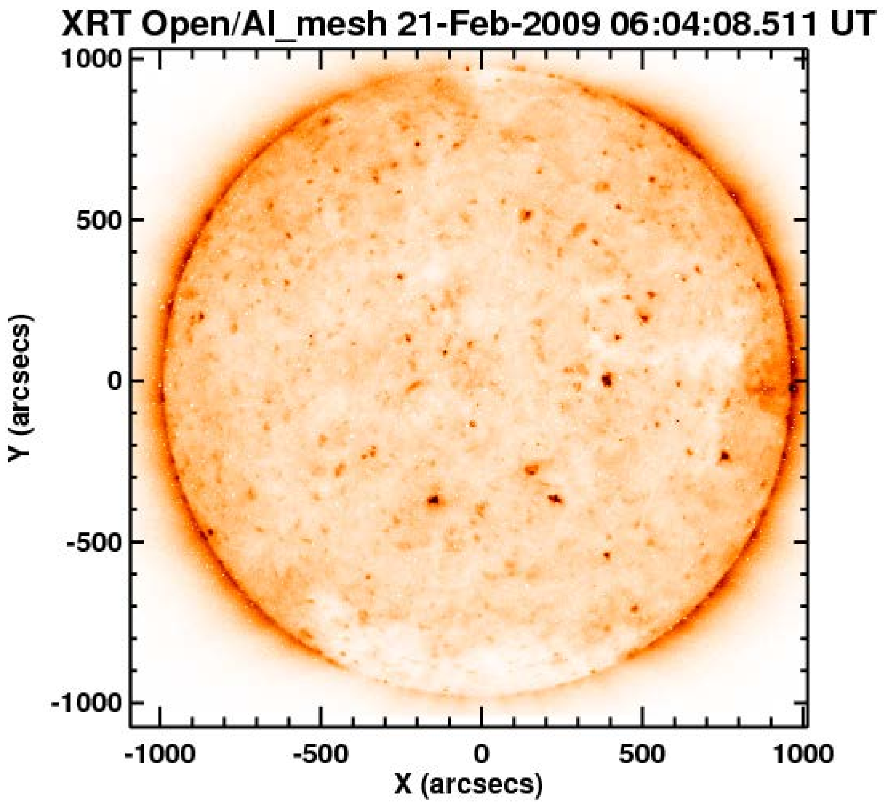
Wrocław 02-mar-2015

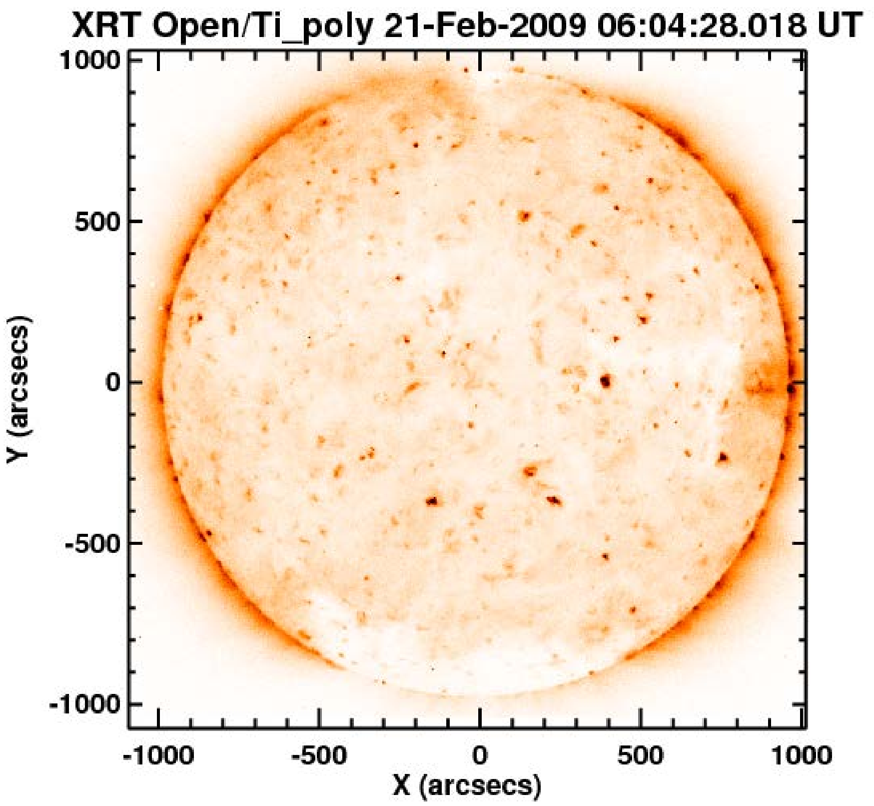
SphinX D1 daily averages



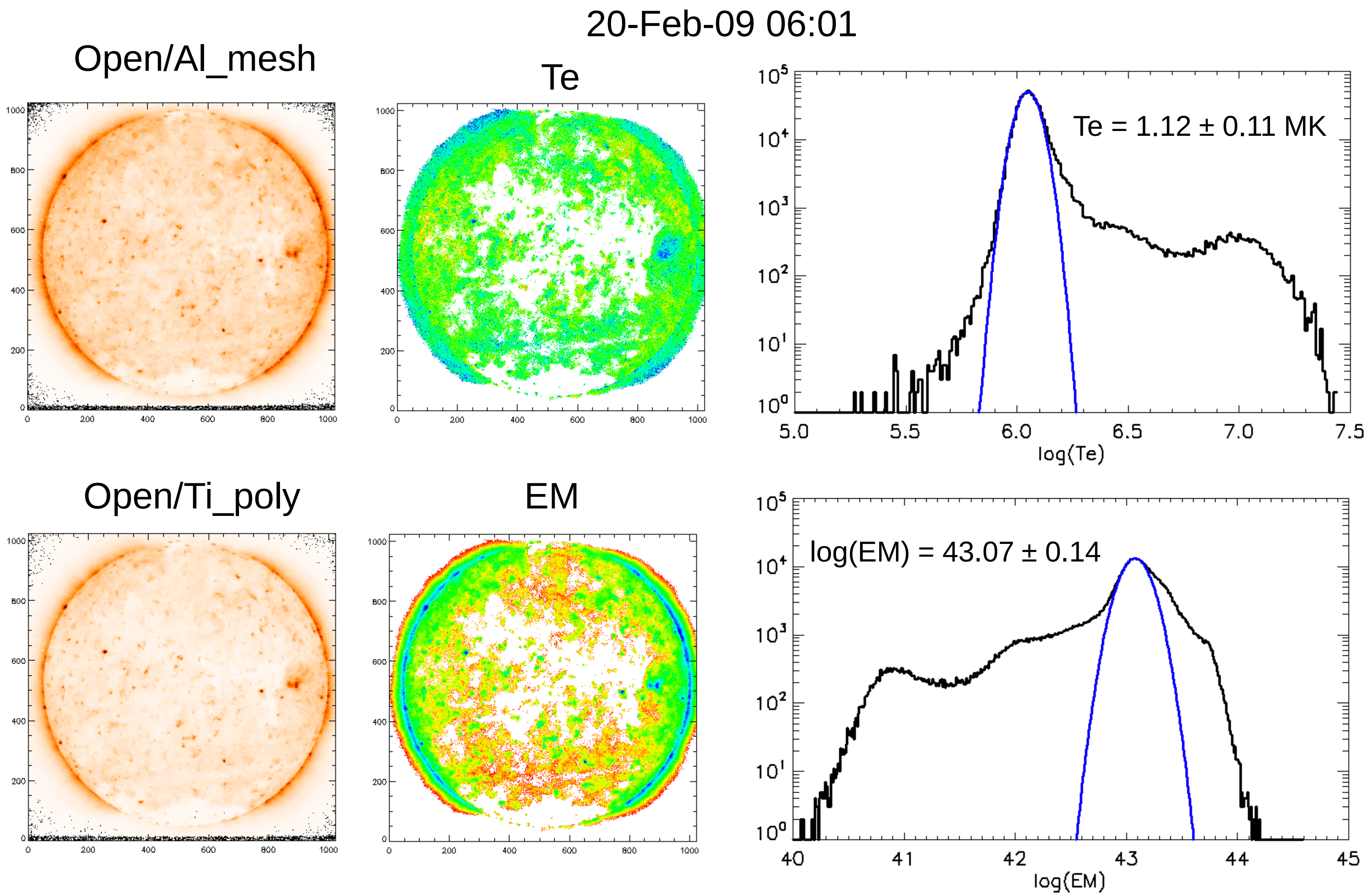
J. Sylwester et al., ApJ, 751:111 (5pp), 2012

QS from Hinode/XRT



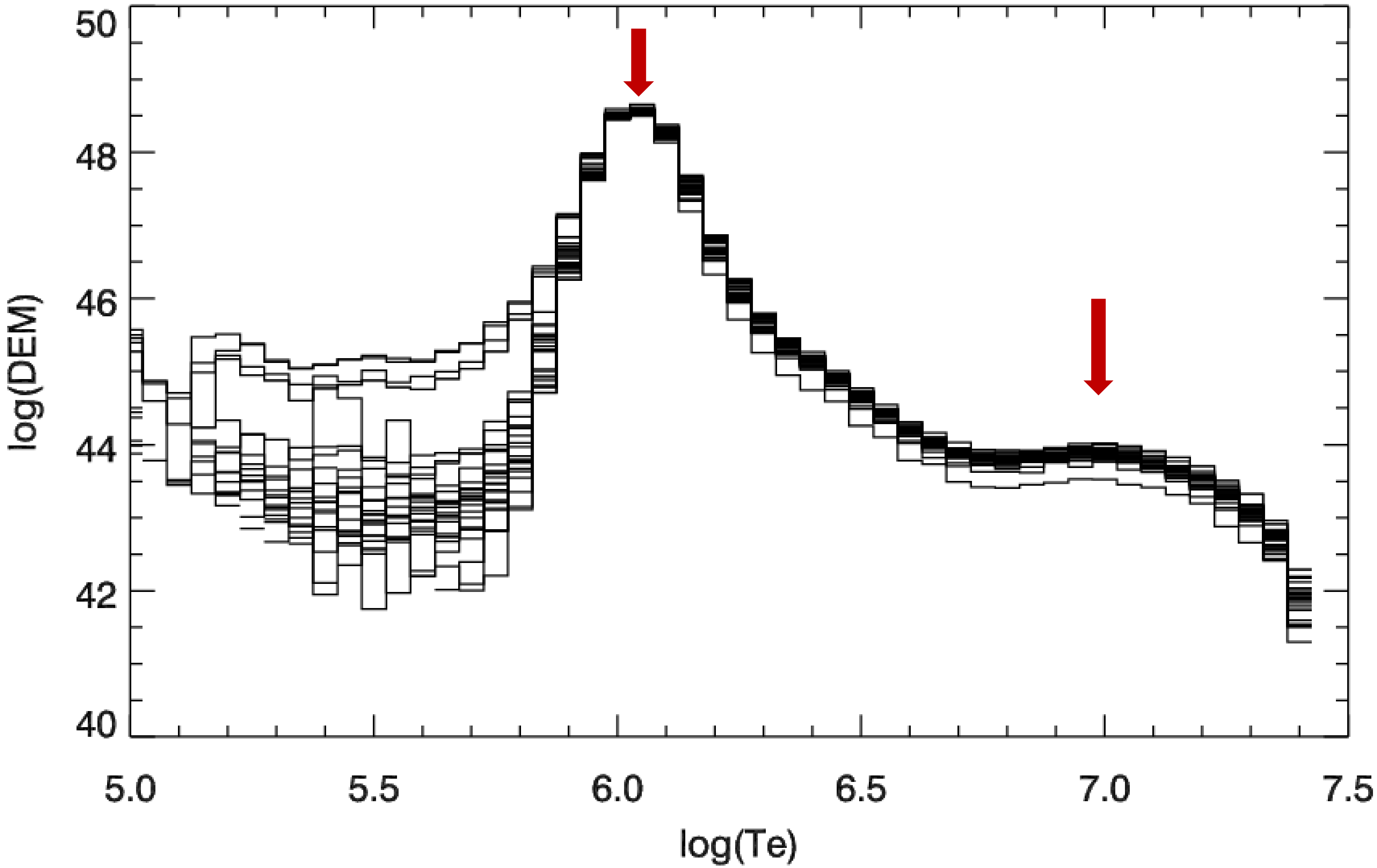


QS from Hinode/XRT

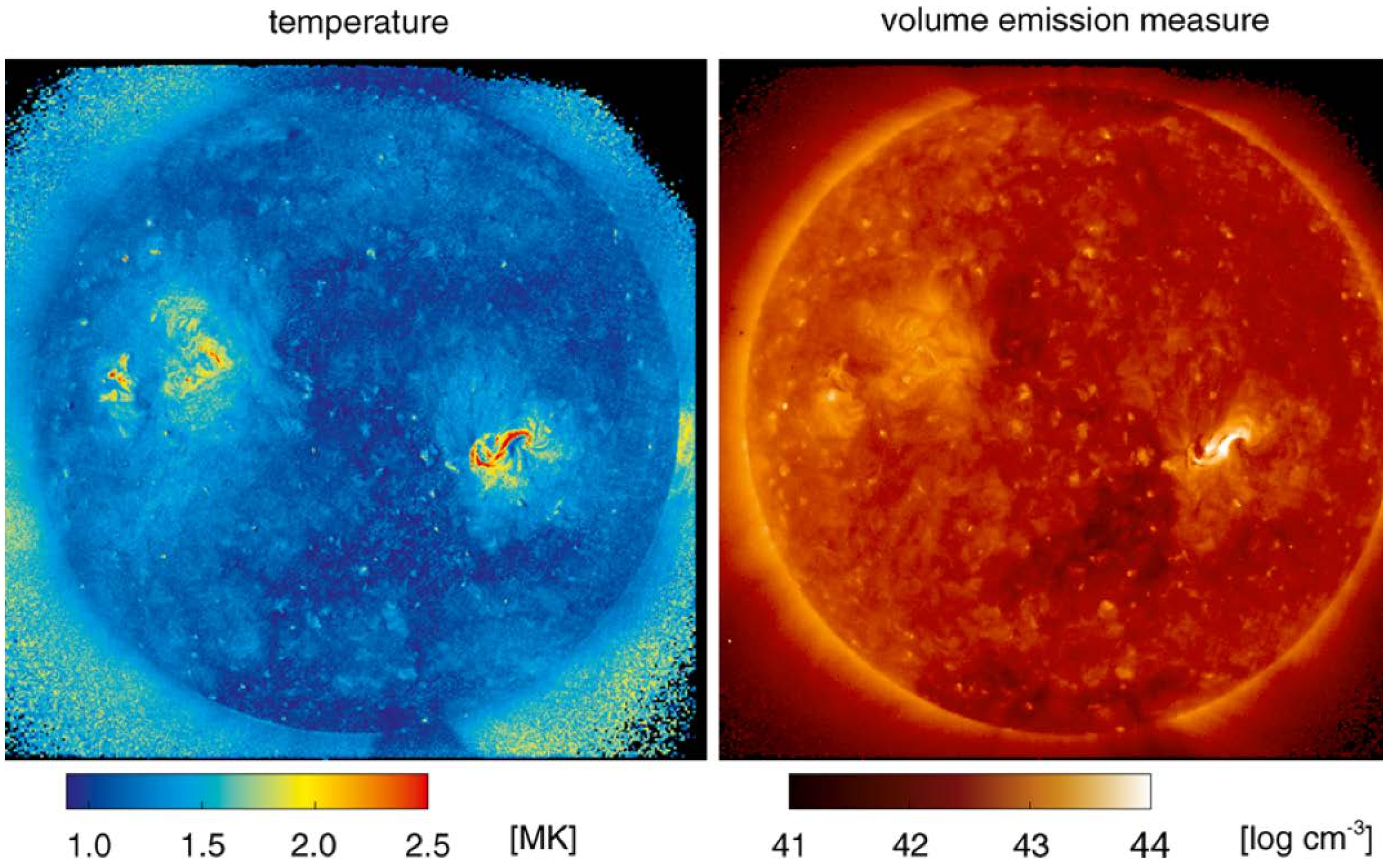


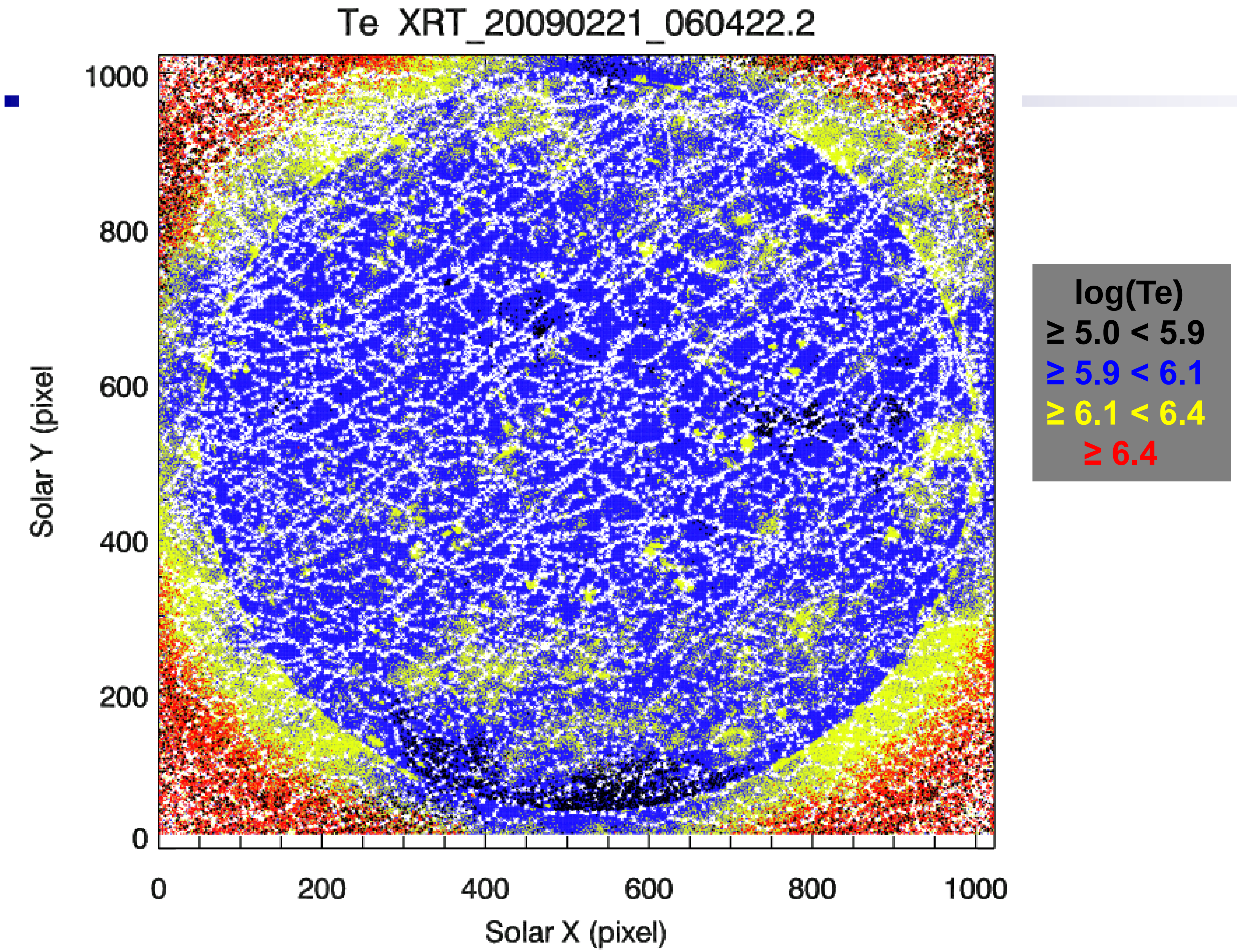
quasi DEM from XRT

27 periods of very low activity from February to Sepember 2009

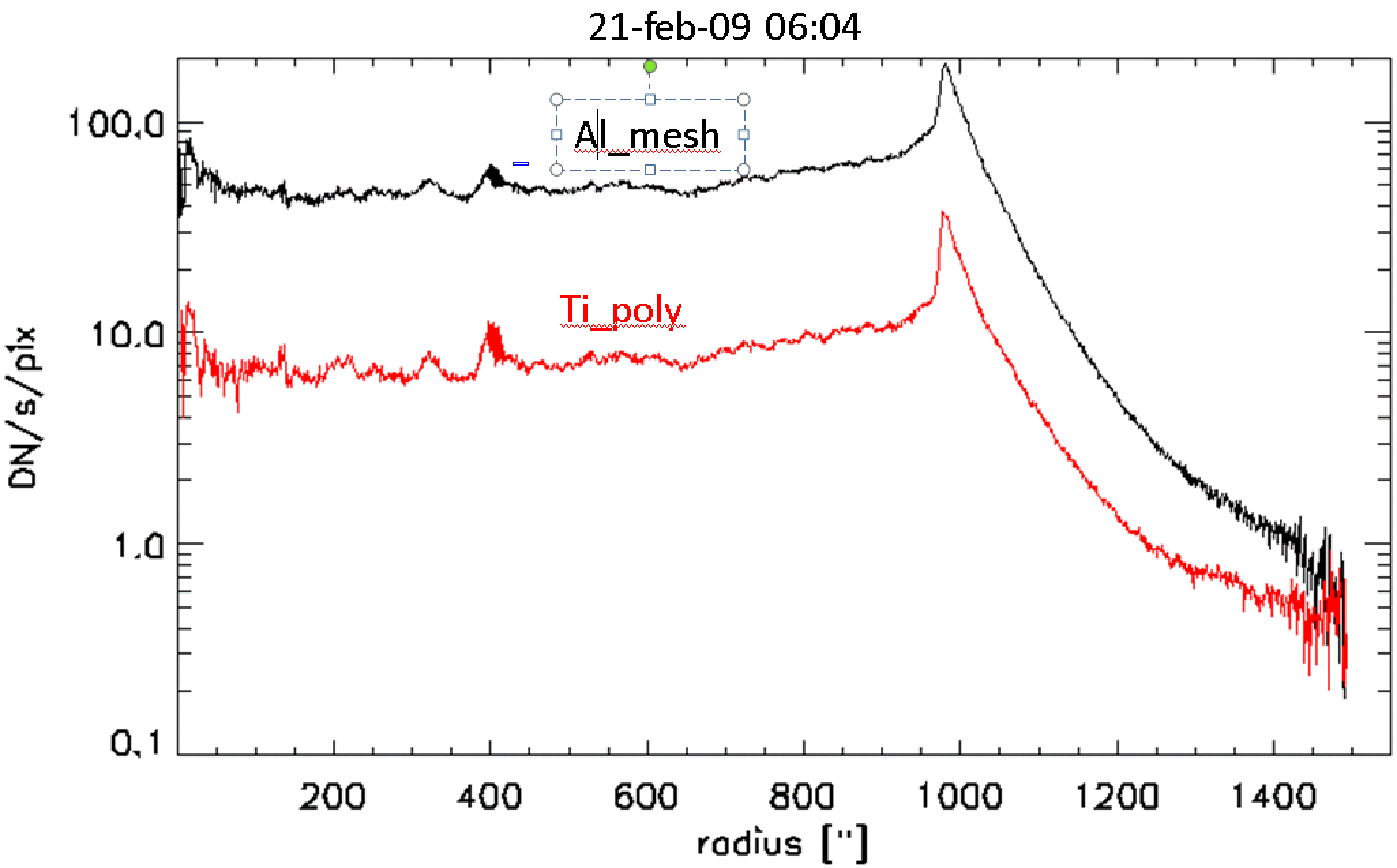


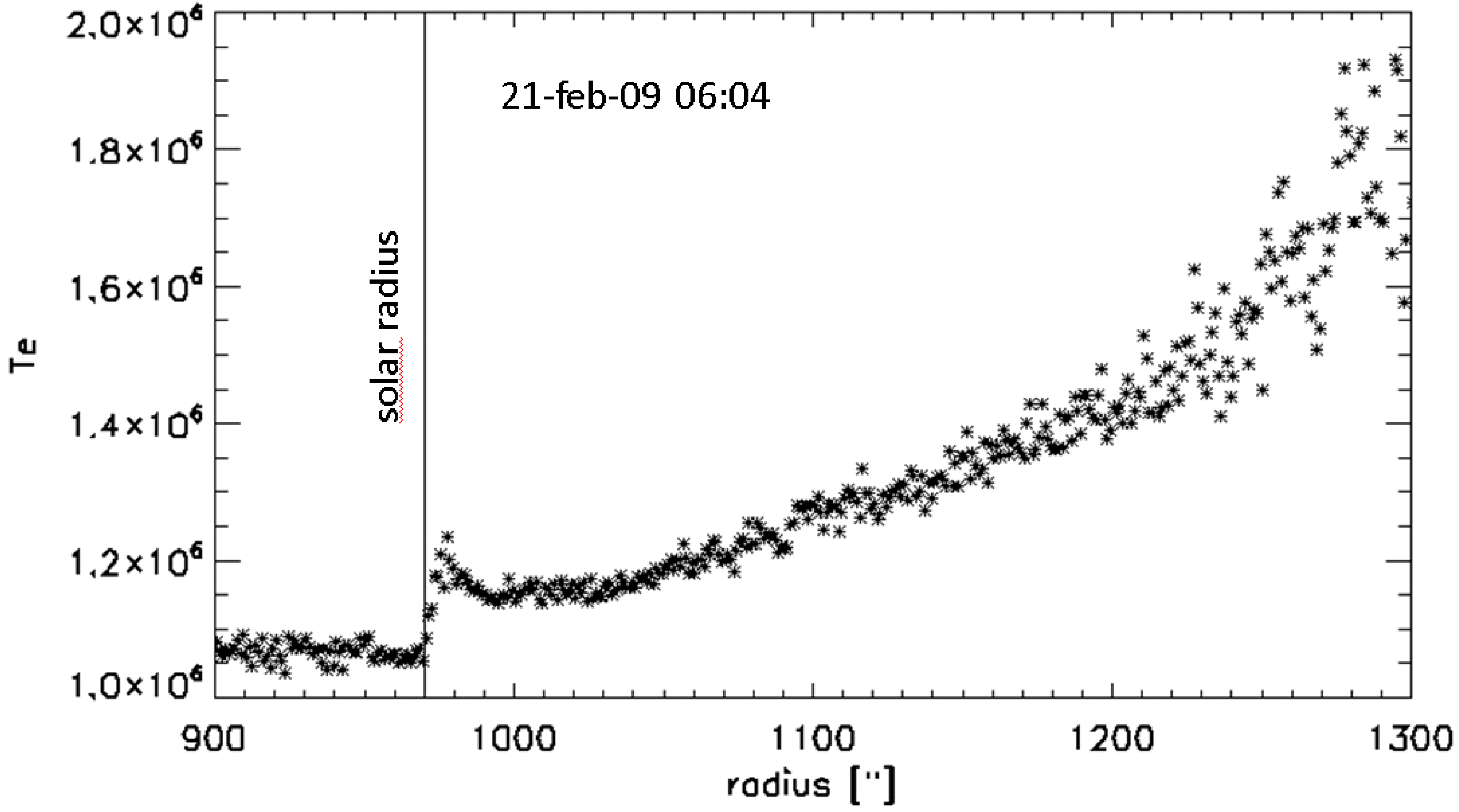
Narukage et al., Sol. Phys 269 169 2011



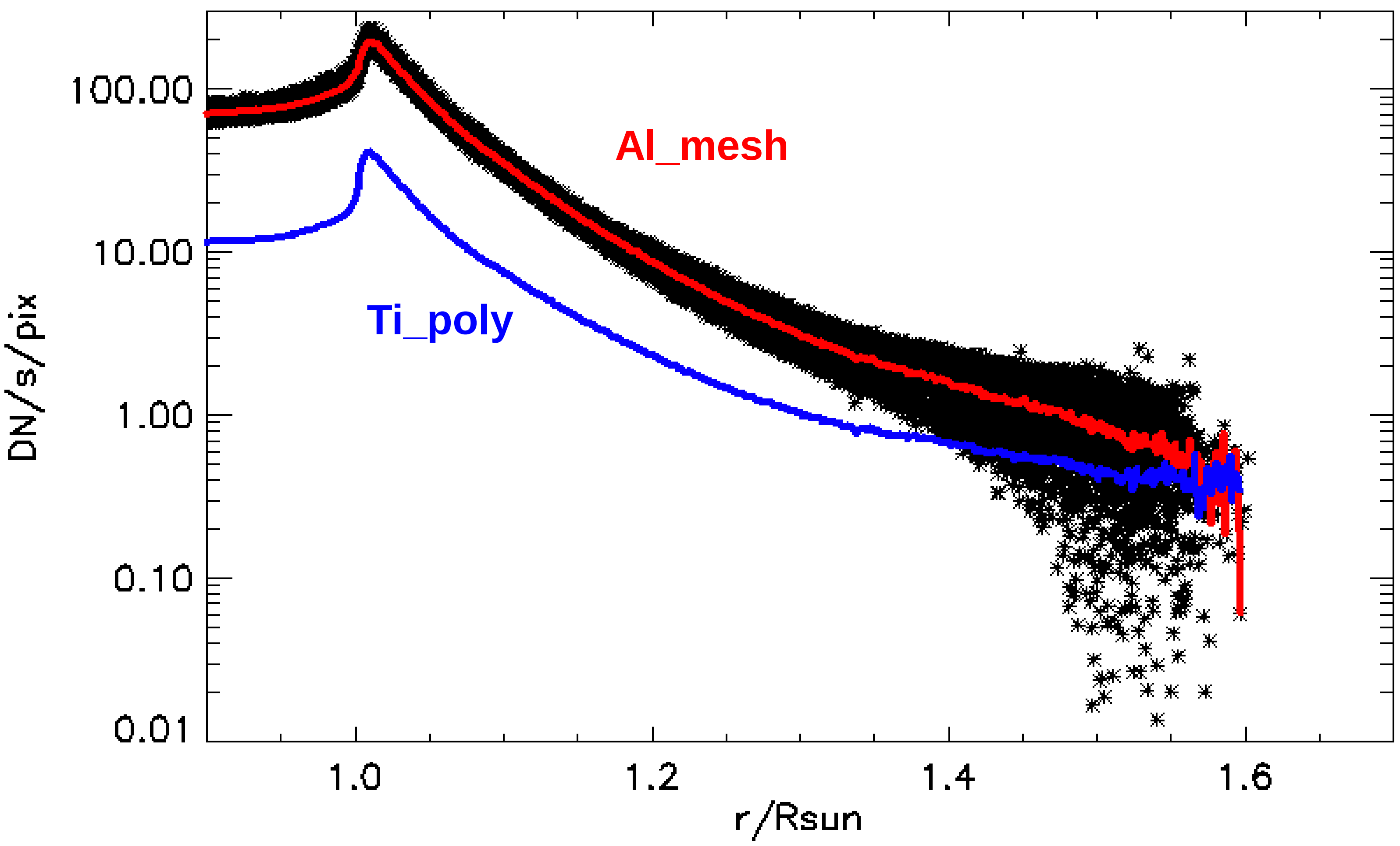

Te XRT_20090221_060422.2
1000
800
600
400
200
0
Solar Y (pixel
0
200
400
600
800
1000
Solar X (pixel)
log(Te)
≥ 5.0 < 5.9
≥ 5.9 < 6.1
≥ 6.1 < 6.4
≥ 6.4

observed distribution of emission

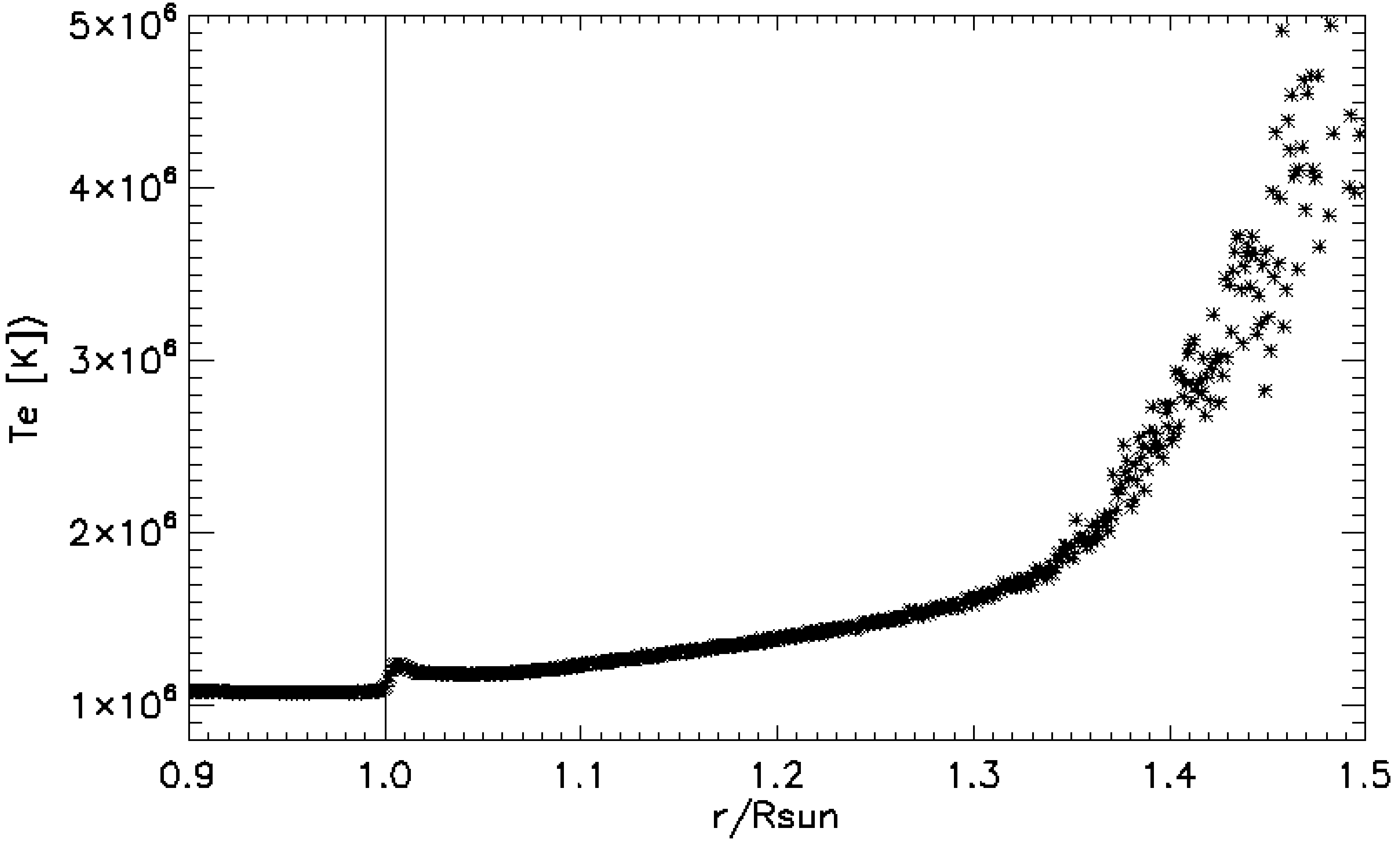




21-feb-09 06:04
solar radius
Te
2,0×10^6
1,8×10^6
1,6×10^6
1,4×10^6
1,2×10^6
1,0×10^6
900
1000
1100
1200
1300
radius ['']

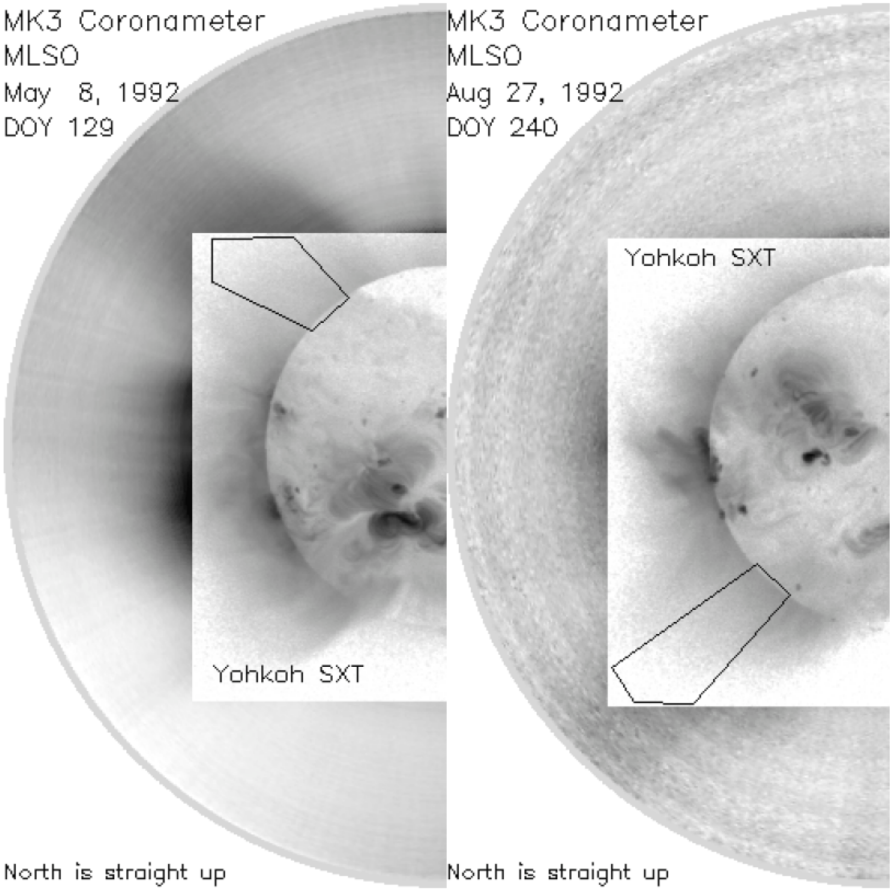


100.00
10.00
1.00
0.10
0.01
DN/s/pix
1.0
1.2
1.4
1.6
r/Rsun
Al_mesh
Ti_poly



Te [K])
5×10^6
4×10^6
3×10^6
2×10^6
1×10^6
0.9
1.0
1.1
1.2
1.3
1.4
1.5
r/Rsun

Wheatland, Sturrock and Acton, ApJ 482,510, 1997



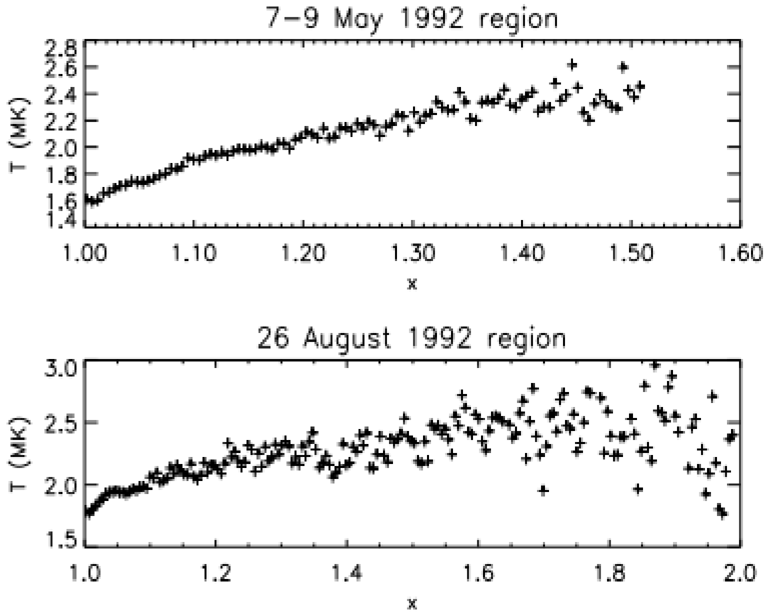
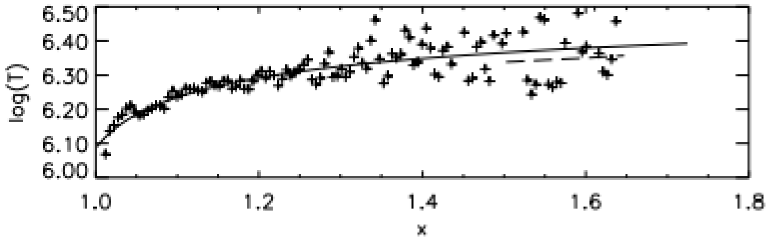
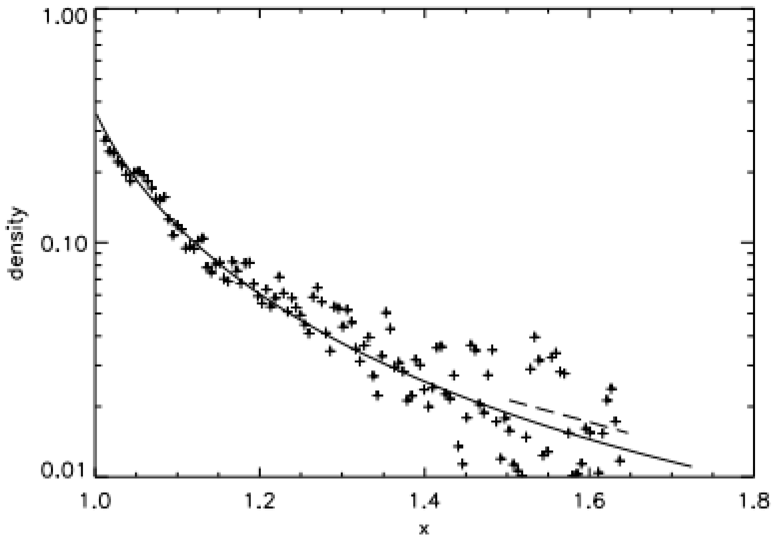


FIG. 3.—Mean temperatures derived for each region by the filter-ratio technique.

Wheatland, Sturrock and Acton, ApJ 482,510, 1997





conserved inward heat flux model

$$F = F_o\, x^{-2} = a\, T^{5/2}\, \frac{dT}{dr} \qquad x = r/R_\odot$$

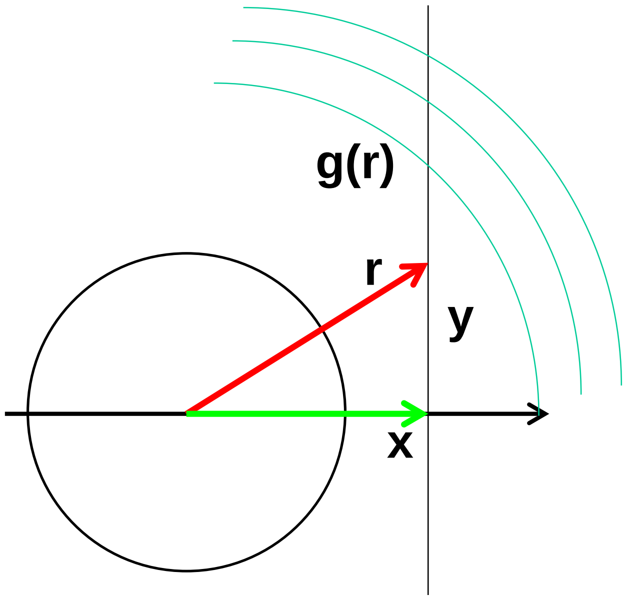
$$T(x) = \left[T_0^{7/2} + \frac{7\, R_\odot\, F_0}{2a}\left(1 - \frac{1}{x}\right)\right]^{2/7}$$

$$\frac{dp}{dr} = -\frac{GM}{r^2}\,\rho \qquad p = \psi\, n\, k_B\, T \quad \rho = \mu\, n\, m_p$$

$$n(x) = \frac{n_0\, T_0}{T} exp\left[-\frac{\alpha}{F_0}\left(T^{5/2} - T_0^{5/2}\right)\right]$$

$$\alpha = \frac{2\,\mu\, G\, M\, m_p\, a}{5\,\psi\, k_B\, R_\odot^2}$$

Inversion of Abel's Integral Equation



f(x)

$$f(x) = \int_{-\infty}^{\infty} g(y)\,dy = 2\int_{0}^{\infty} g(y)\,dy$$

$r^2 = x^2 + y^2 \qquad r\,dr = y\,dy$

$$f(x) = 2\int_{r=x}^{\infty} \frac{g(r)\,r\,dr}{\sqrt{r^2 - x^2}}$$

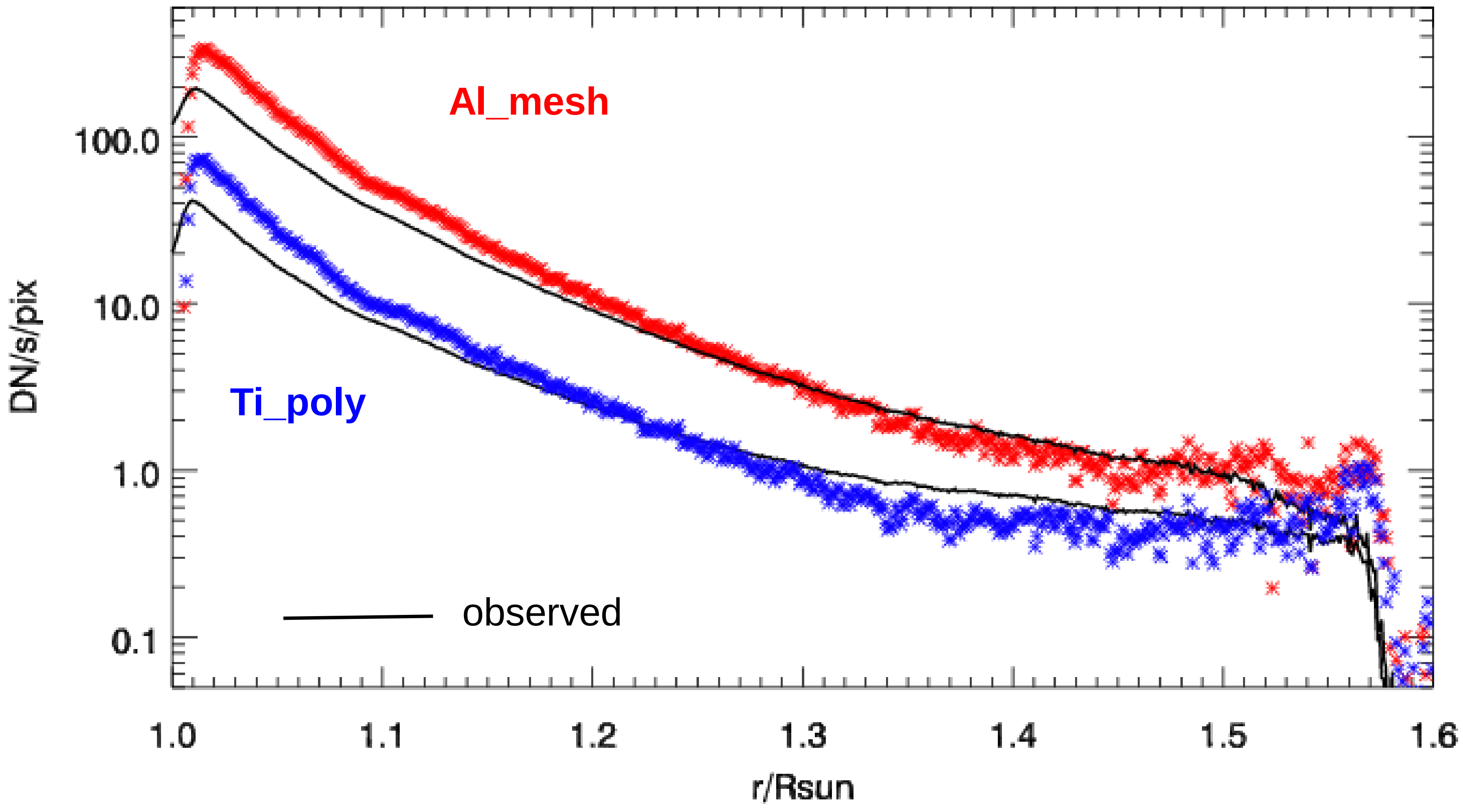
$$g(r) = -\frac{1}{\pi}\int_{x=r}^{\infty} \frac{f'(x)\,dx}{\sqrt{x^2 - r^2}}$$

$y^2 = x^2 - r^2 \qquad x\,dx = y\,dy$

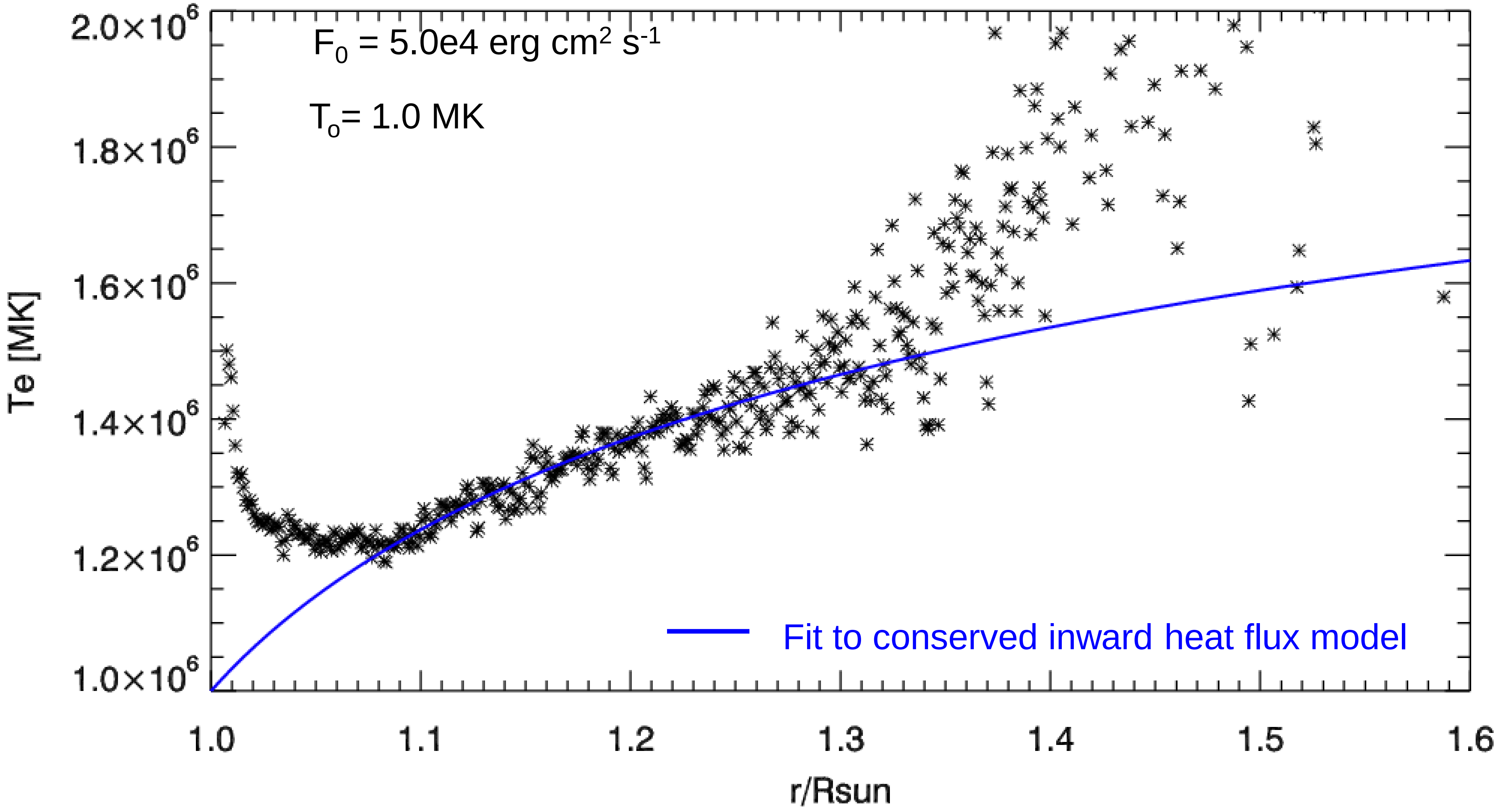
$\infty \rightarrow r_c,\ y_c,\ x_c$

$$g(r) = -\frac{1}{\pi}\int_{0}^{\infty} \frac{f'(y)\,dy}{\sqrt{y^2 + r^2}}$$

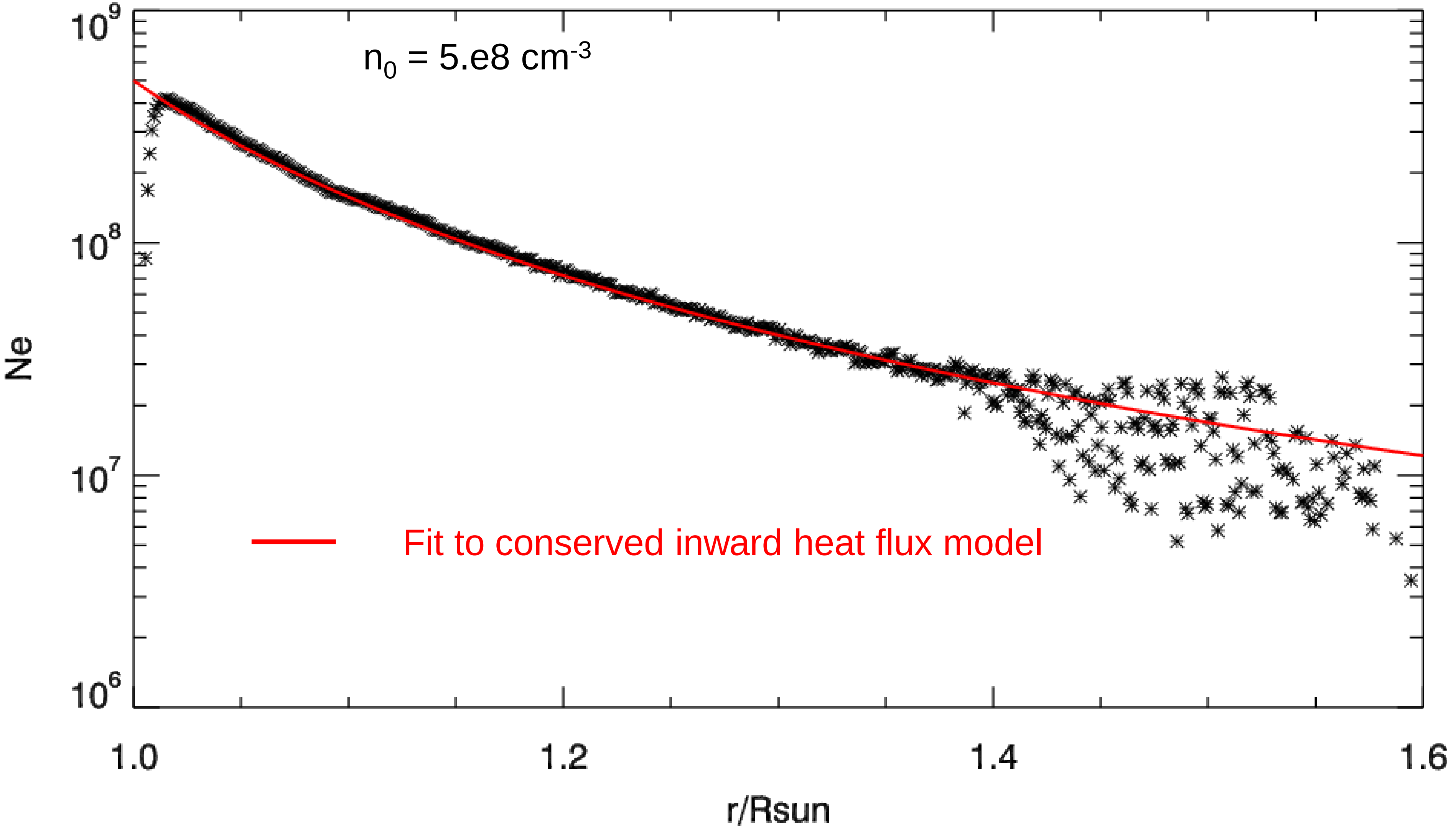
„True” radial emission distribution after Abel Inversion



„True" radial temperature distribution after Inversion of observed emission distributions

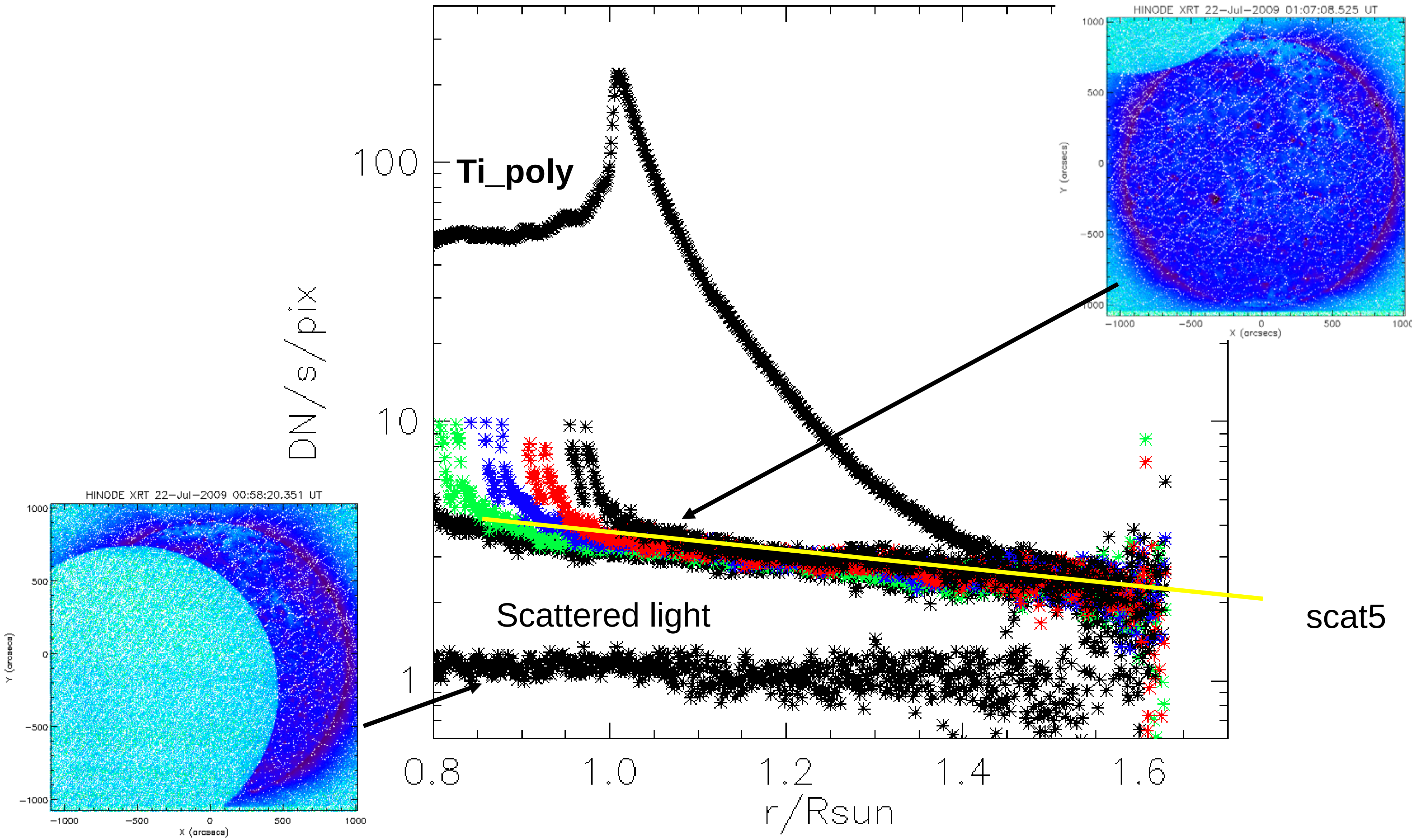


density

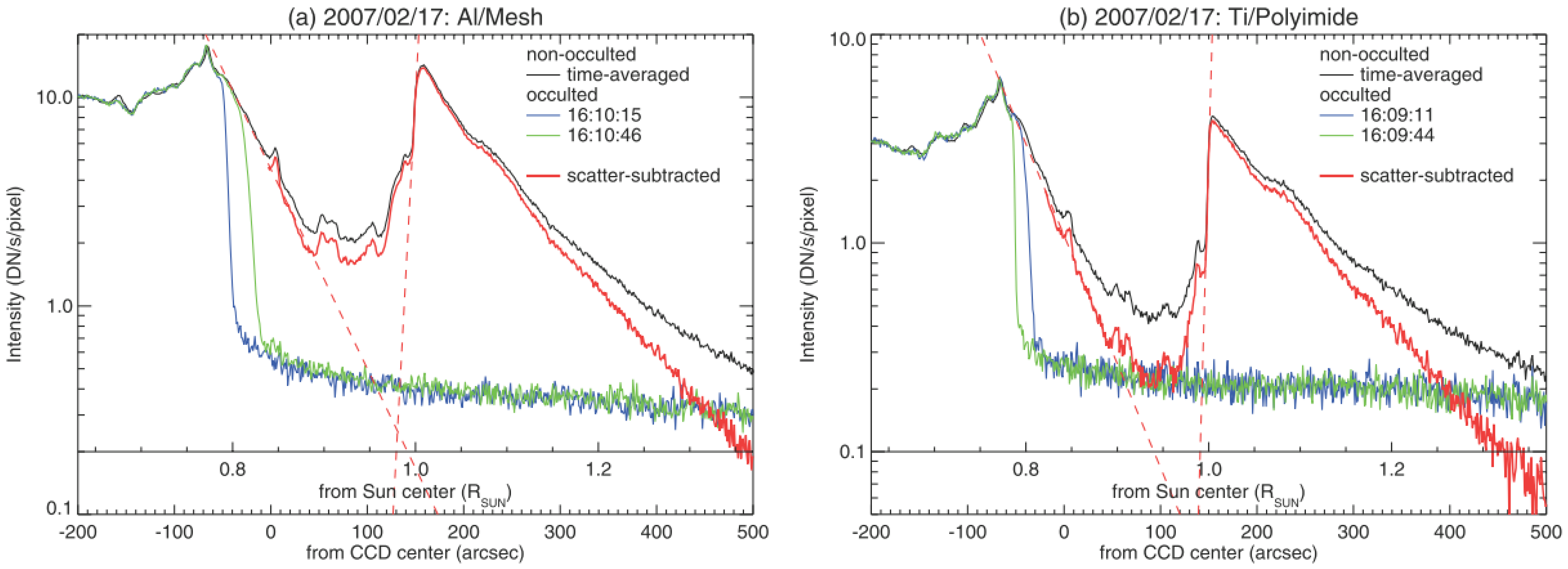


n_0 = 5.e8 cm^{-3}
10^9
10^8
10^7
10^6
Ne
Fit to conserved inward heat flux model
1.0
1.2
1.4
1.6
r/Rsun

solar eclipse 22-Jul-2009

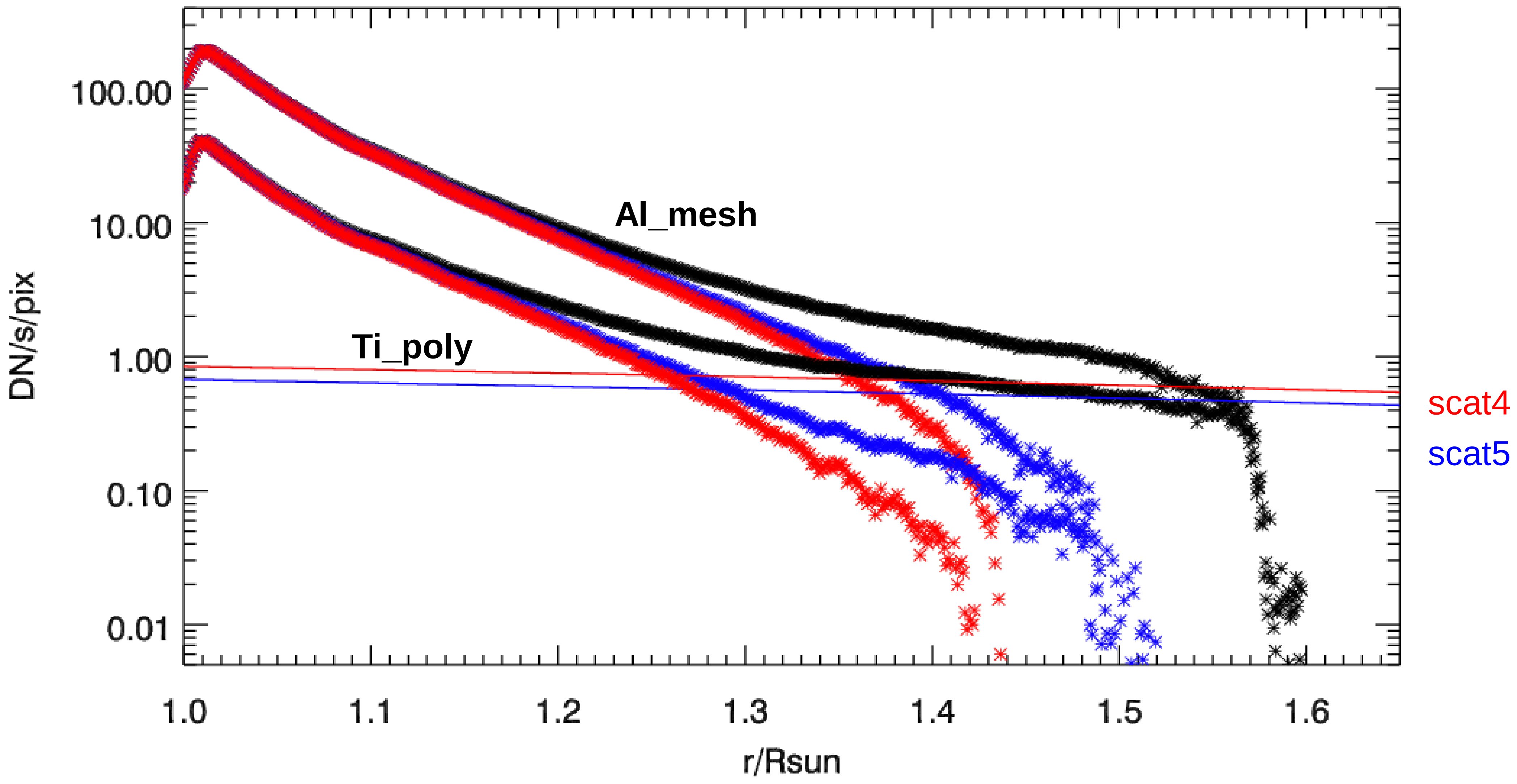


Kano et al., Publ. Astron. Soc. Japan 60, 827–834, 2008



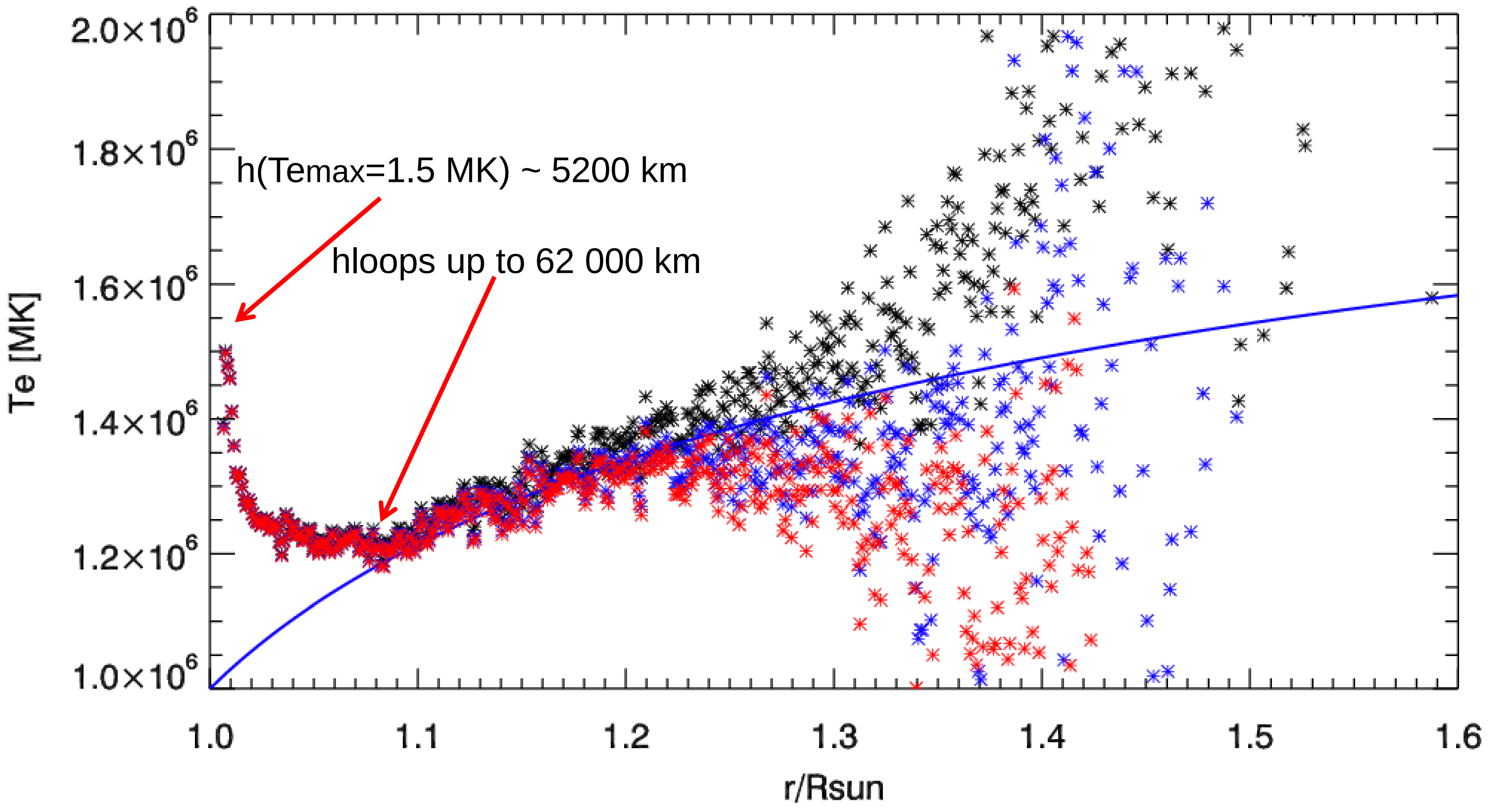
scat (Al_mesh) ~ 2 * scat (Ti_poly)

scattered light

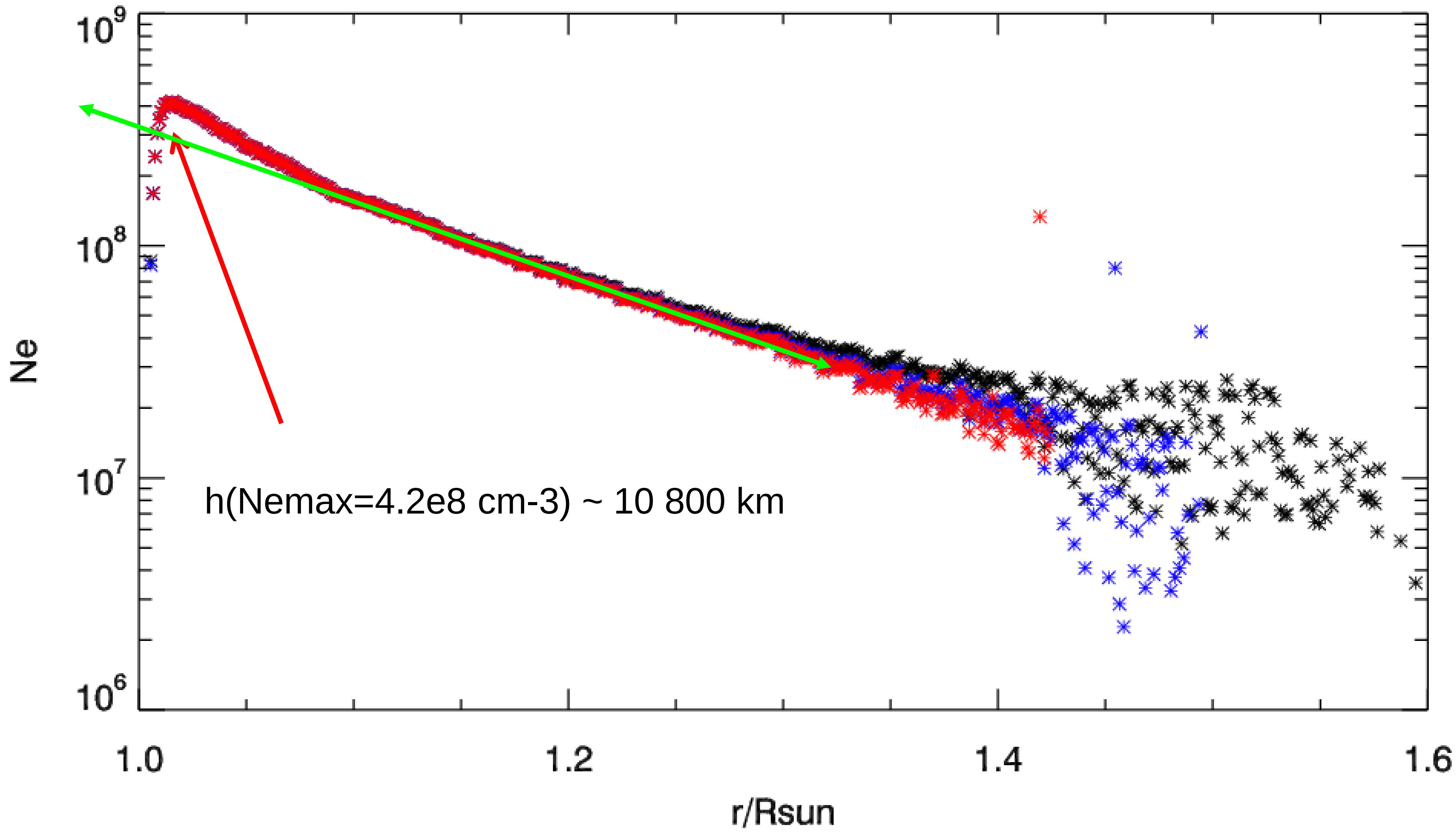


scat (Al_mesh) ~ 2 * scat (Ti_poly)

F_0 = 4.3e4 erg cm^2 s^{-1} T_o= 1.0 MK

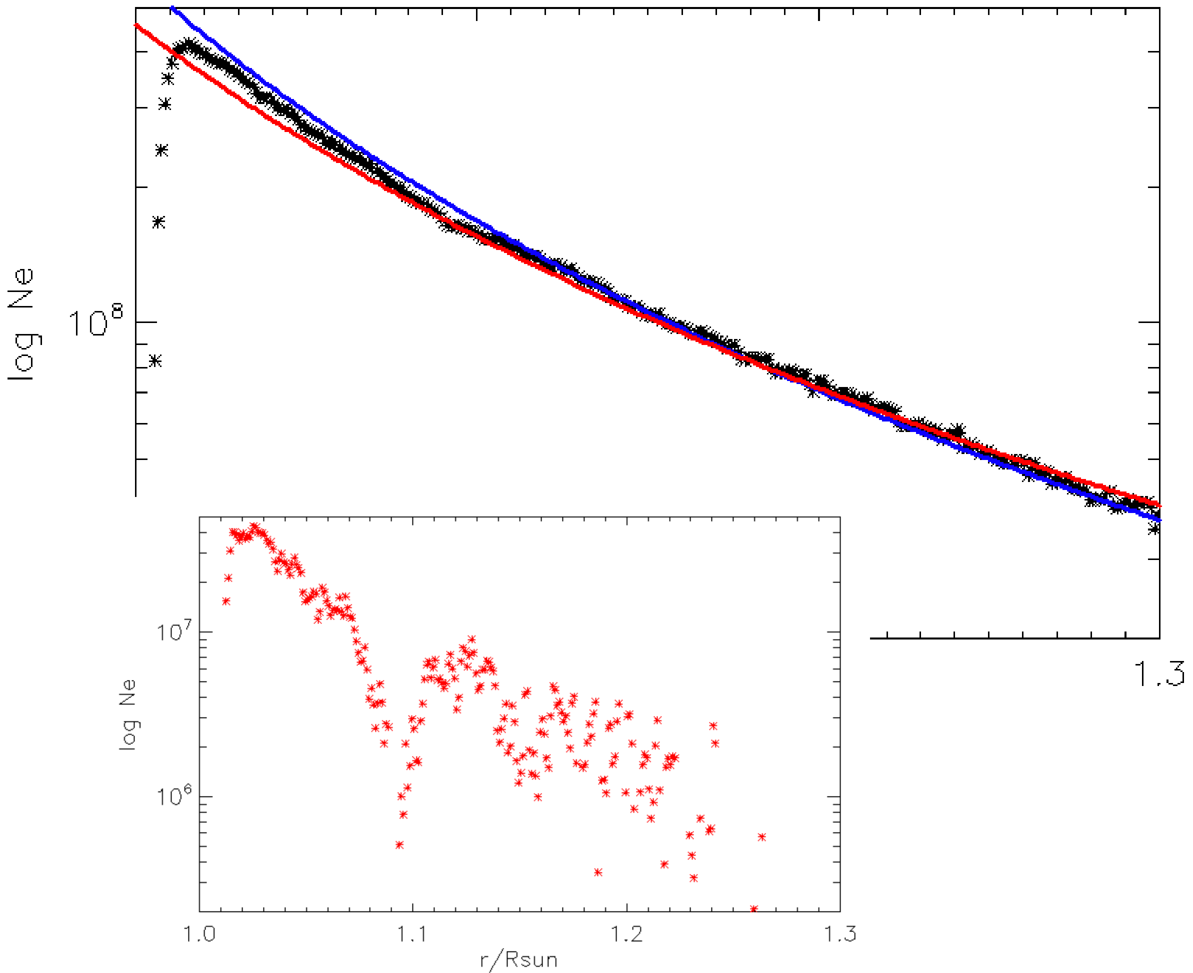


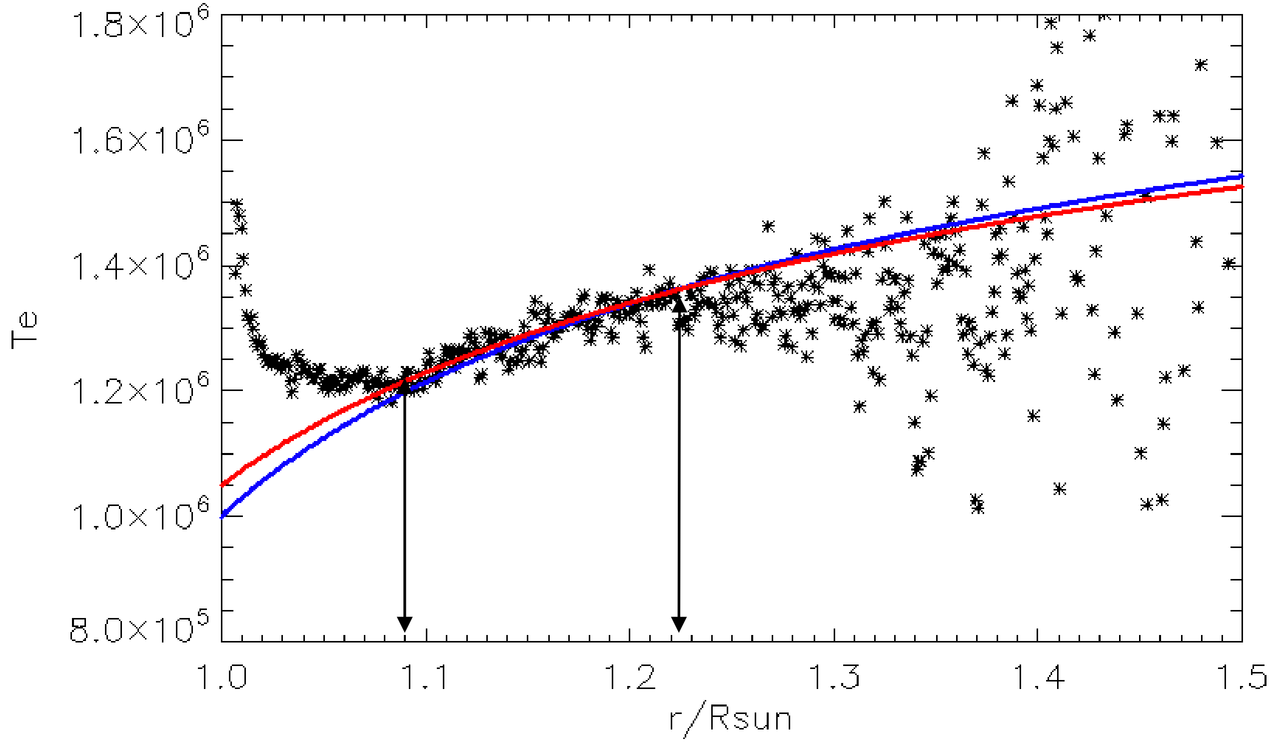
n_0 = 5.9 e8 cm^{-3}

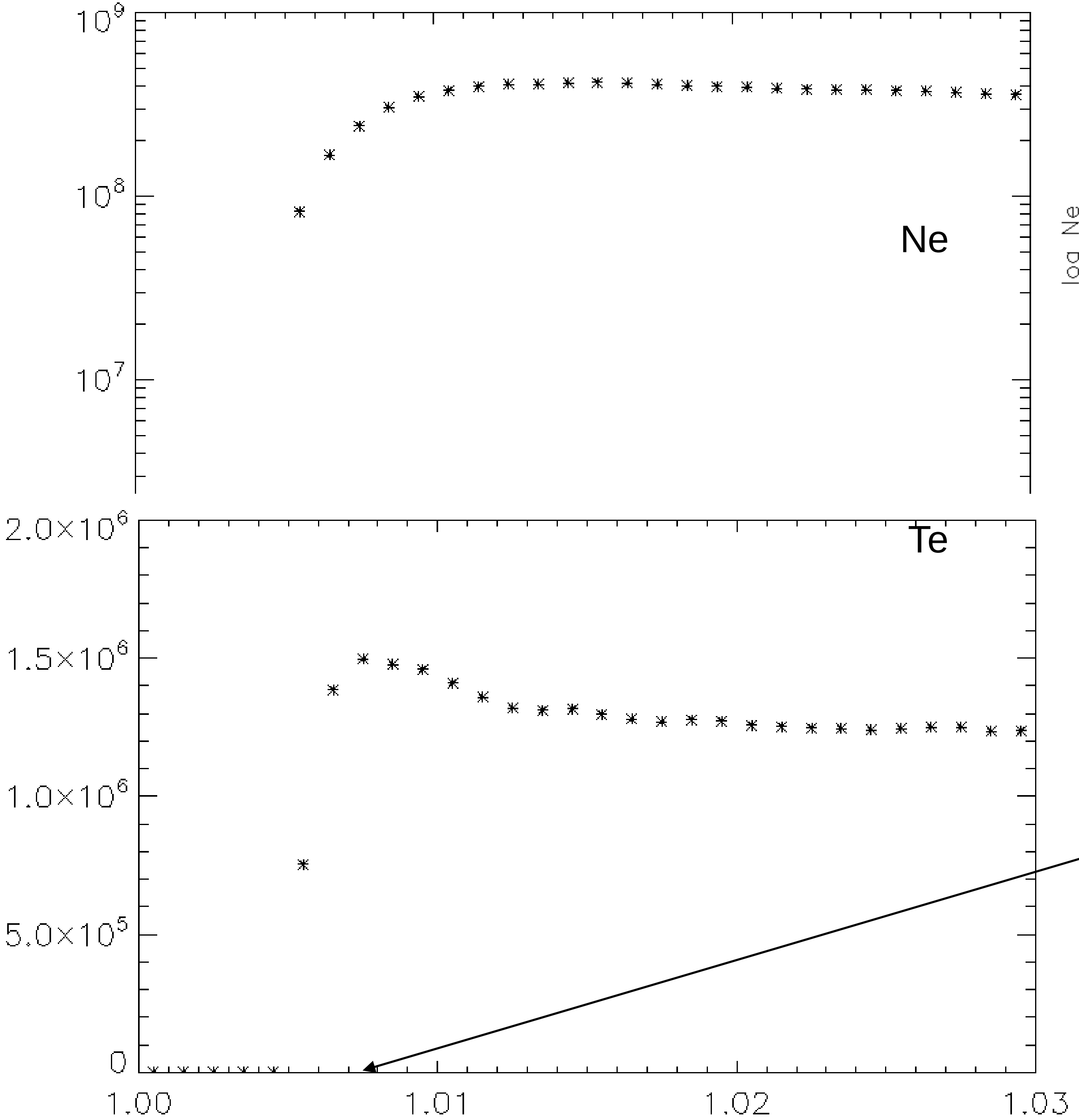


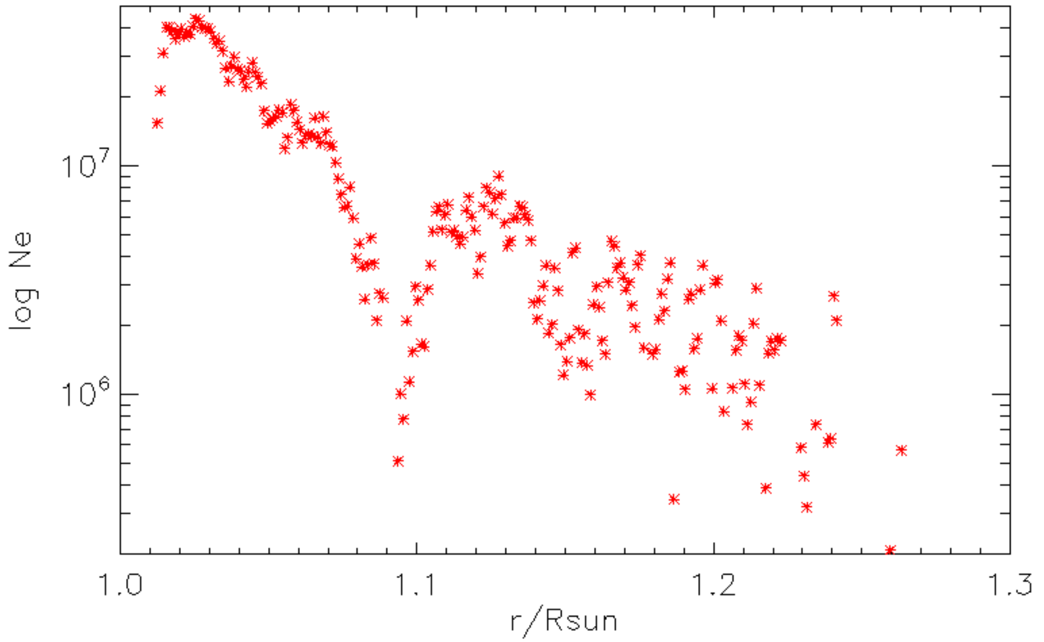
F_0 = 3.9e4 erg cm^2 s^{-1} T_o= 1.0 MK n_0 = 5.9 e8 cm^{-3}

F_0 = 3.9e4 erg cm^2 s^{-1} T_o= 1.05 MK n_0 = 4.6 e8 cm^{-3}







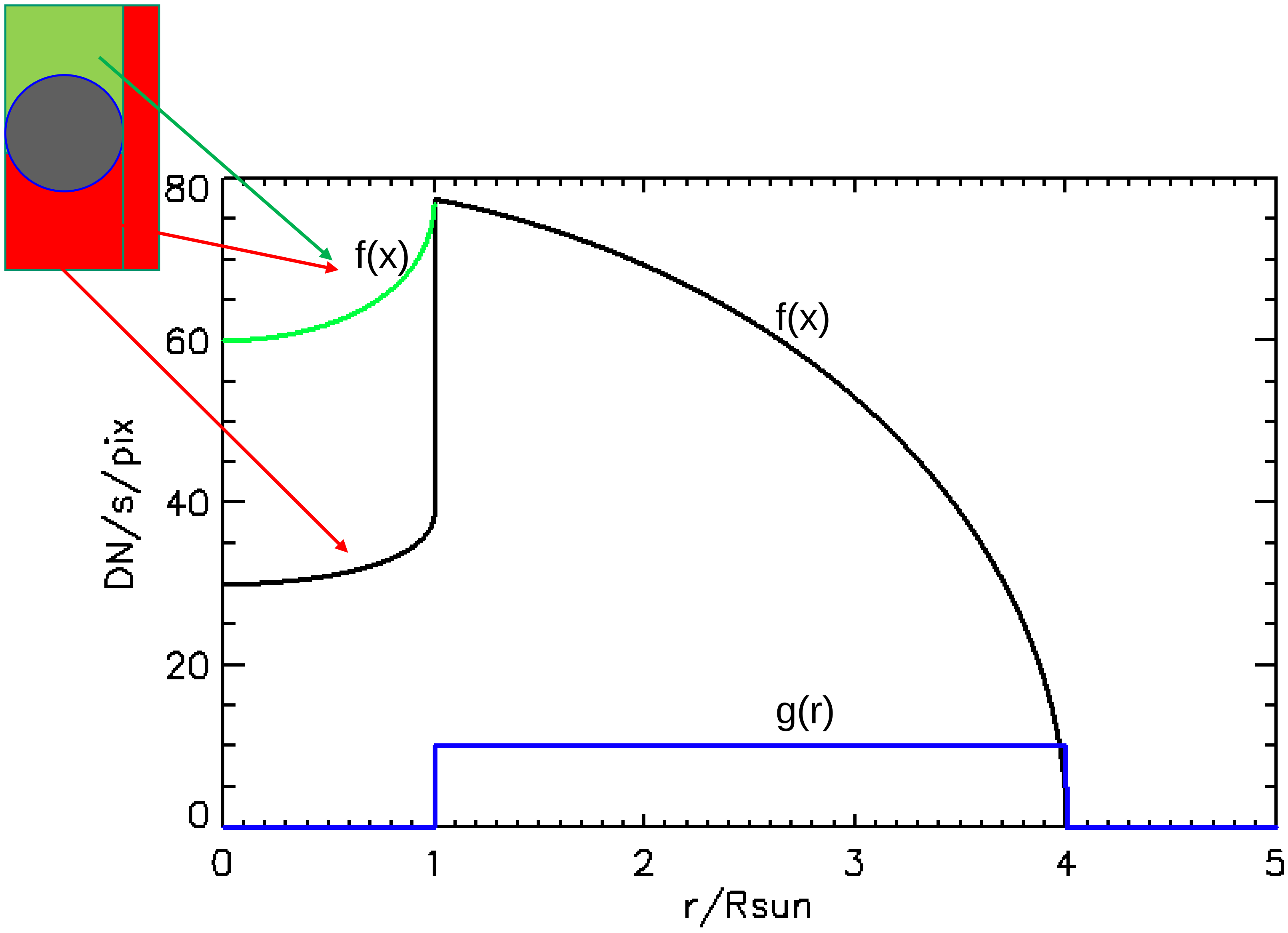


Scaling law Tm~(pL)^1/3

L=5.2 e8 cm   Tm=1.5e6 → Ne=5.7 e9

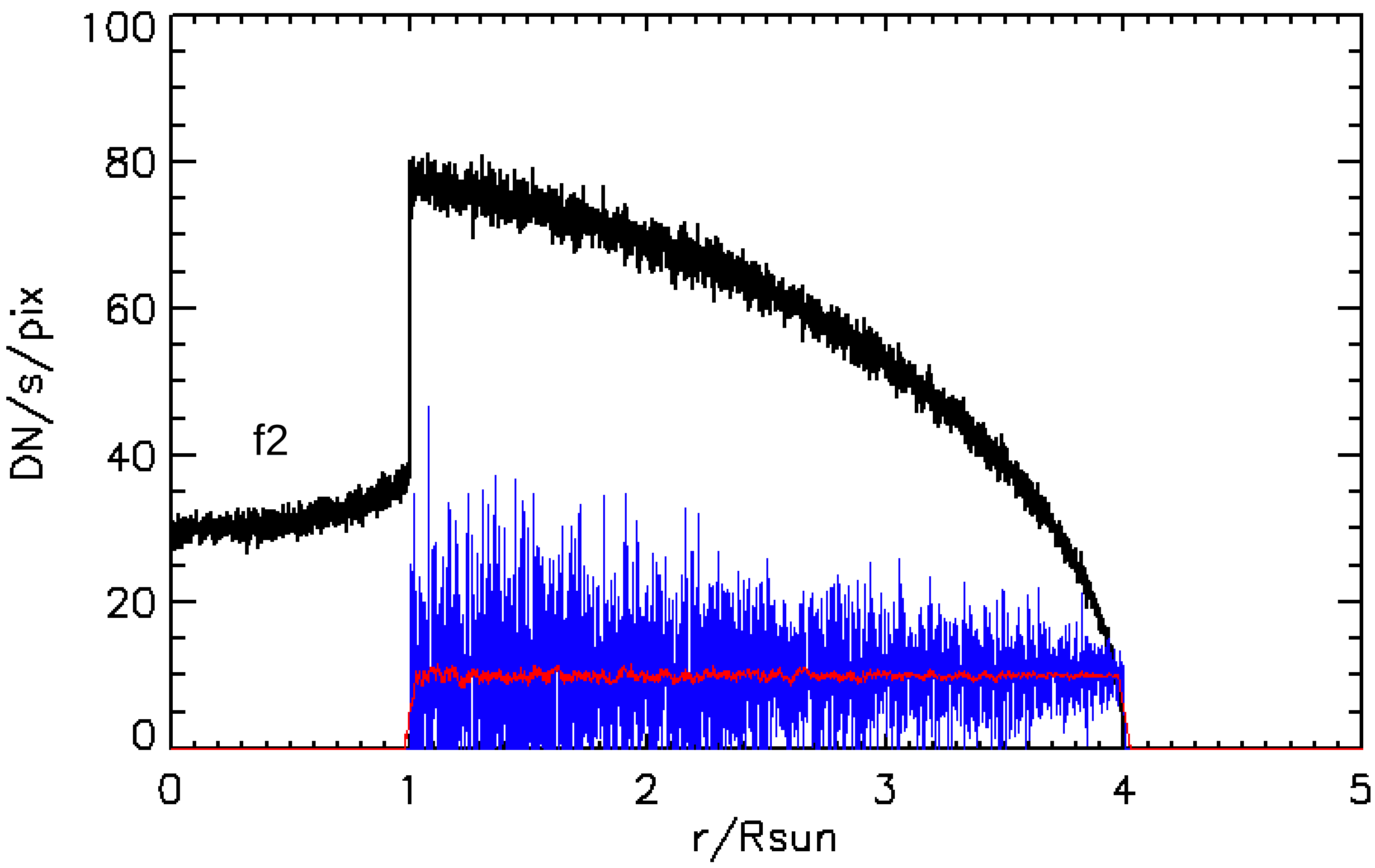
→(?) filling factor ~ 4.e7/5.e9 ~ 0.008 ~ 0.01
~ 4.e8/5.e9 ~ 0.08 ~ 0.10

inversion test



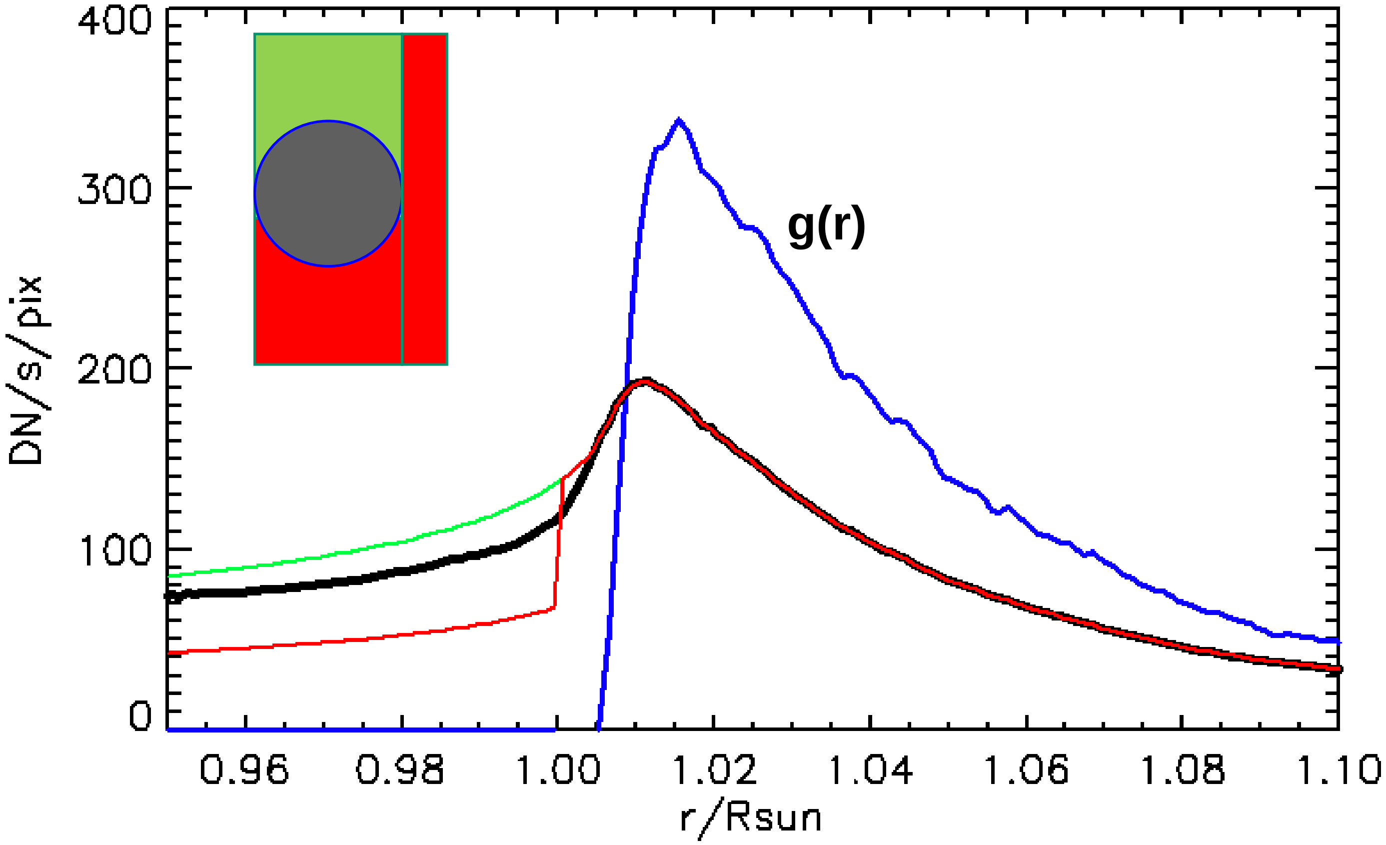
$$\mathbf{f(0)} = \int_0^\infty \mathbf{g}(\boldsymbol{r})\,\mathbf{dr}$$

inversion test

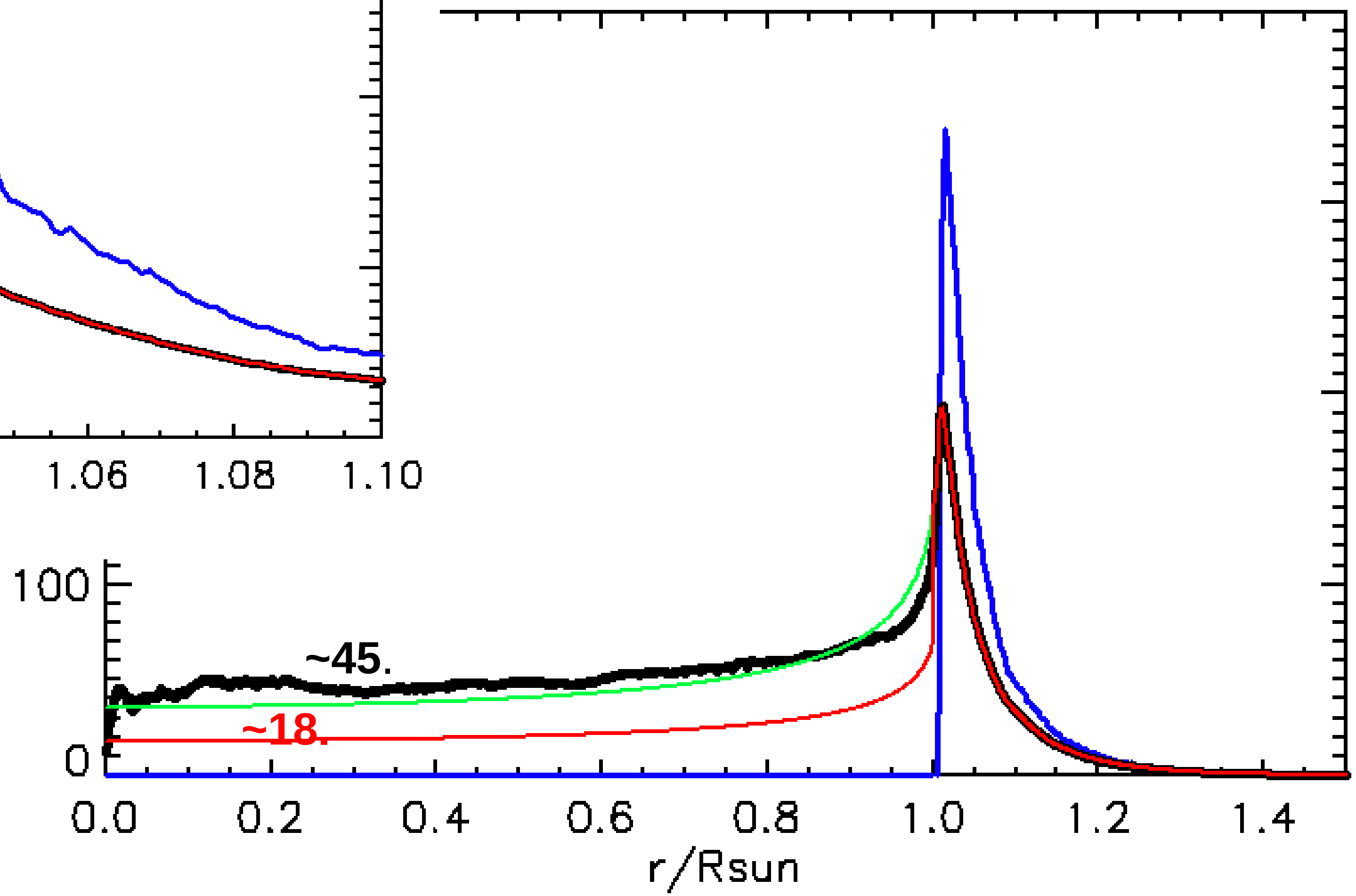



```
average(g3(1000:4000)) = 9.988
g3s = smooth (g3,51,/edge_truncate)
```

inversion

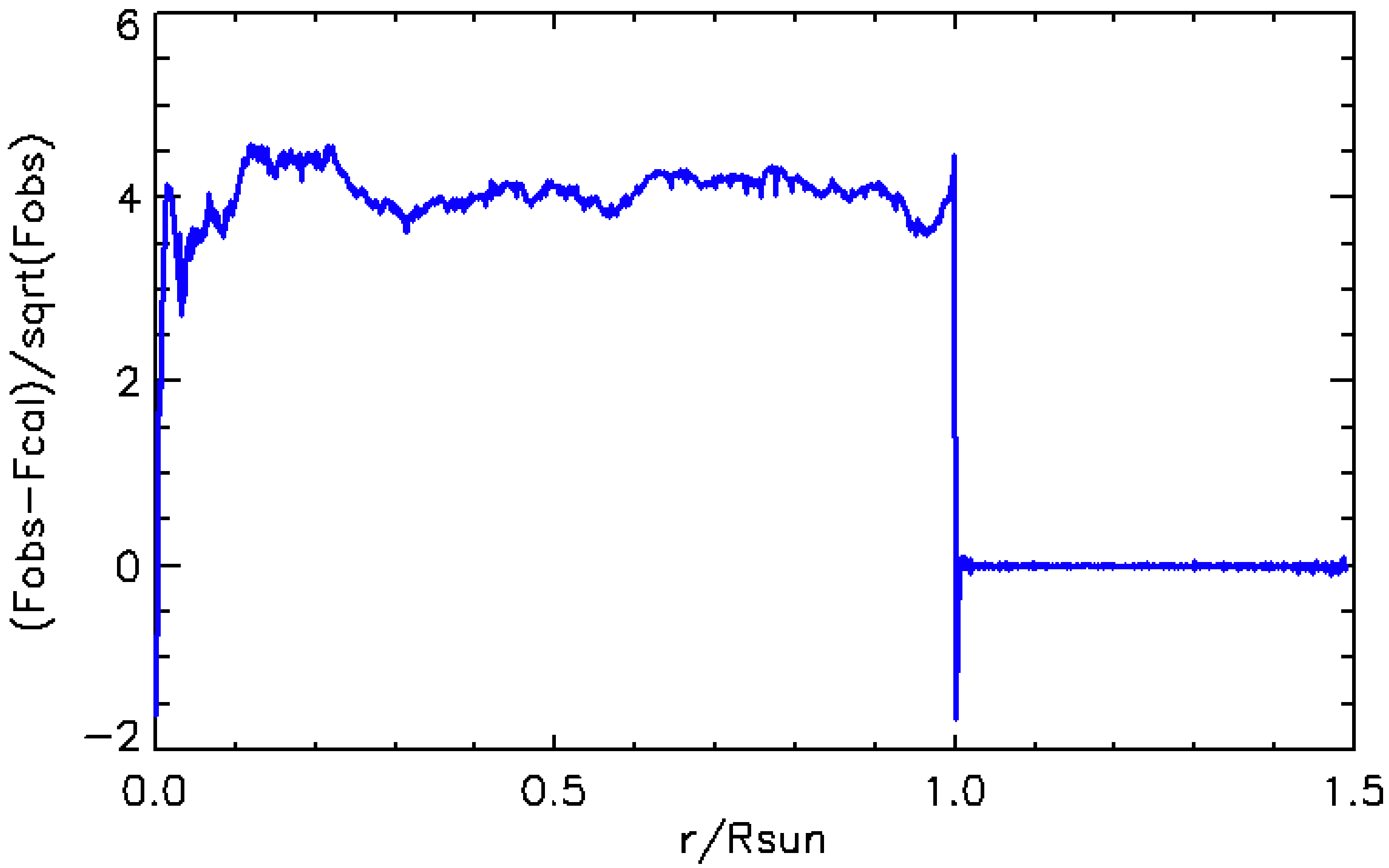


400
300
200
100
0
DN/s/pix
g(r)
0.96
0.98
1.00
1.02
1.04
1.06
1.08
1.10
r/Rsun

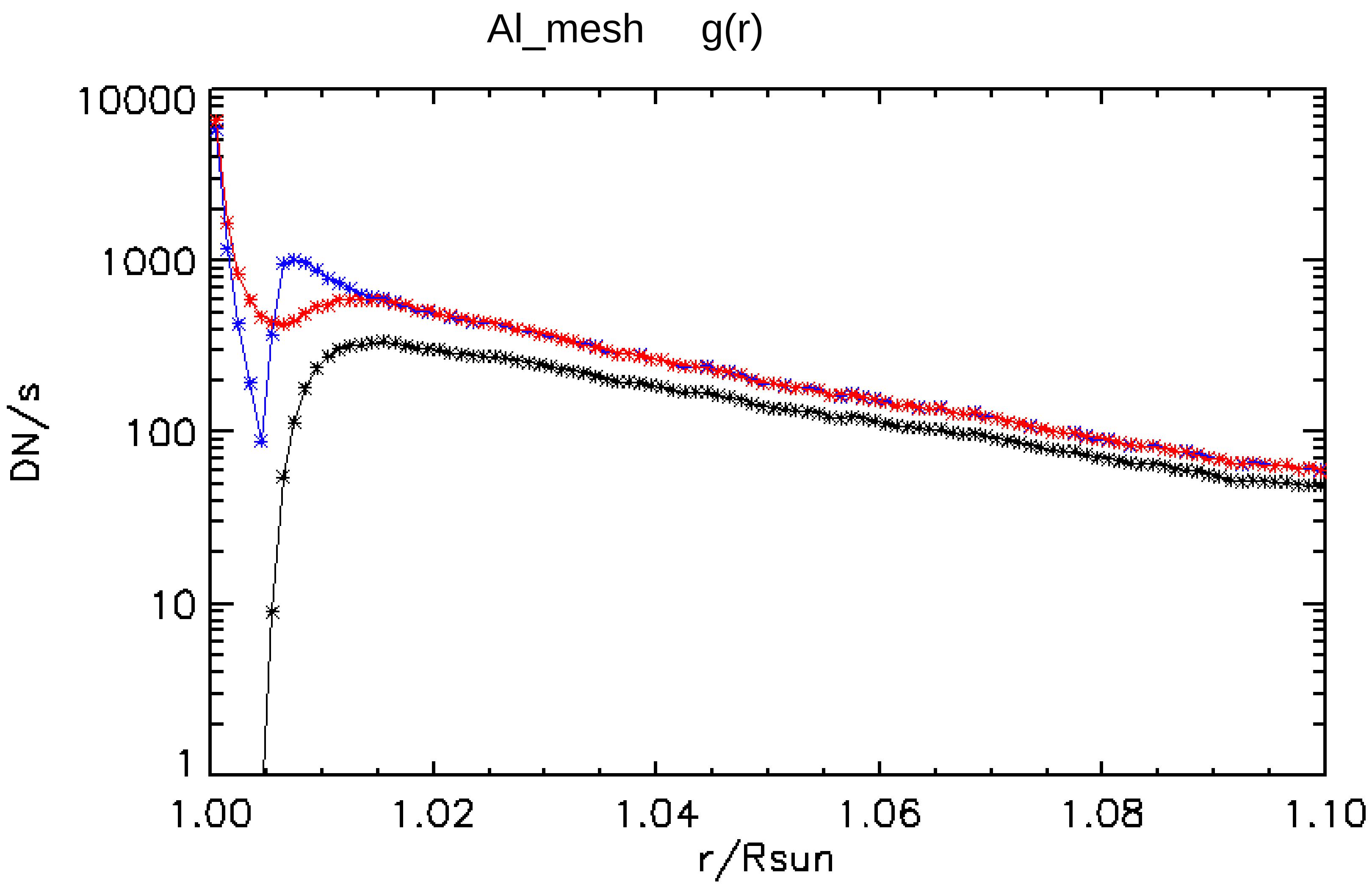


100
0
~45.
~18.
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
r/Rsun

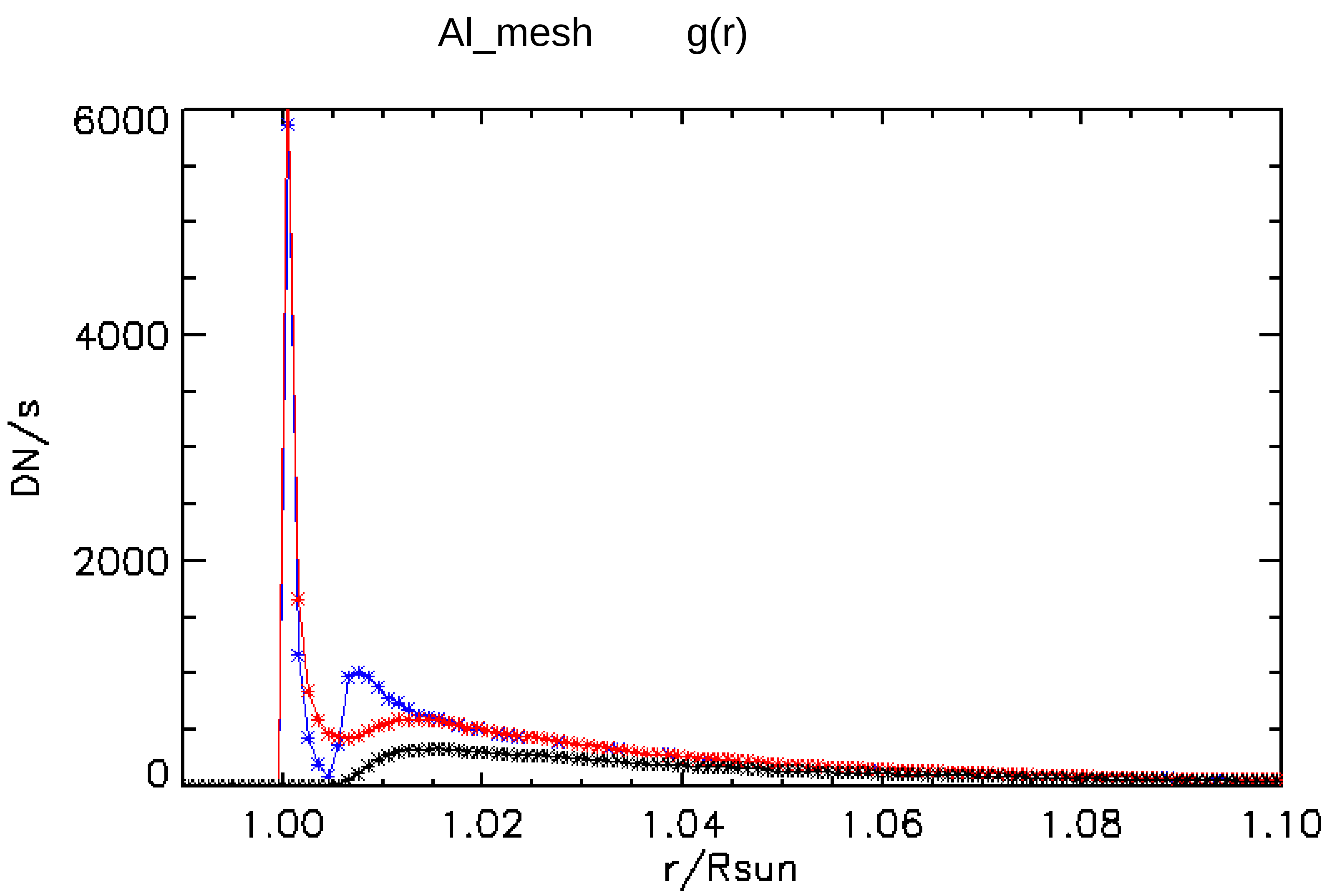
goodness of fit



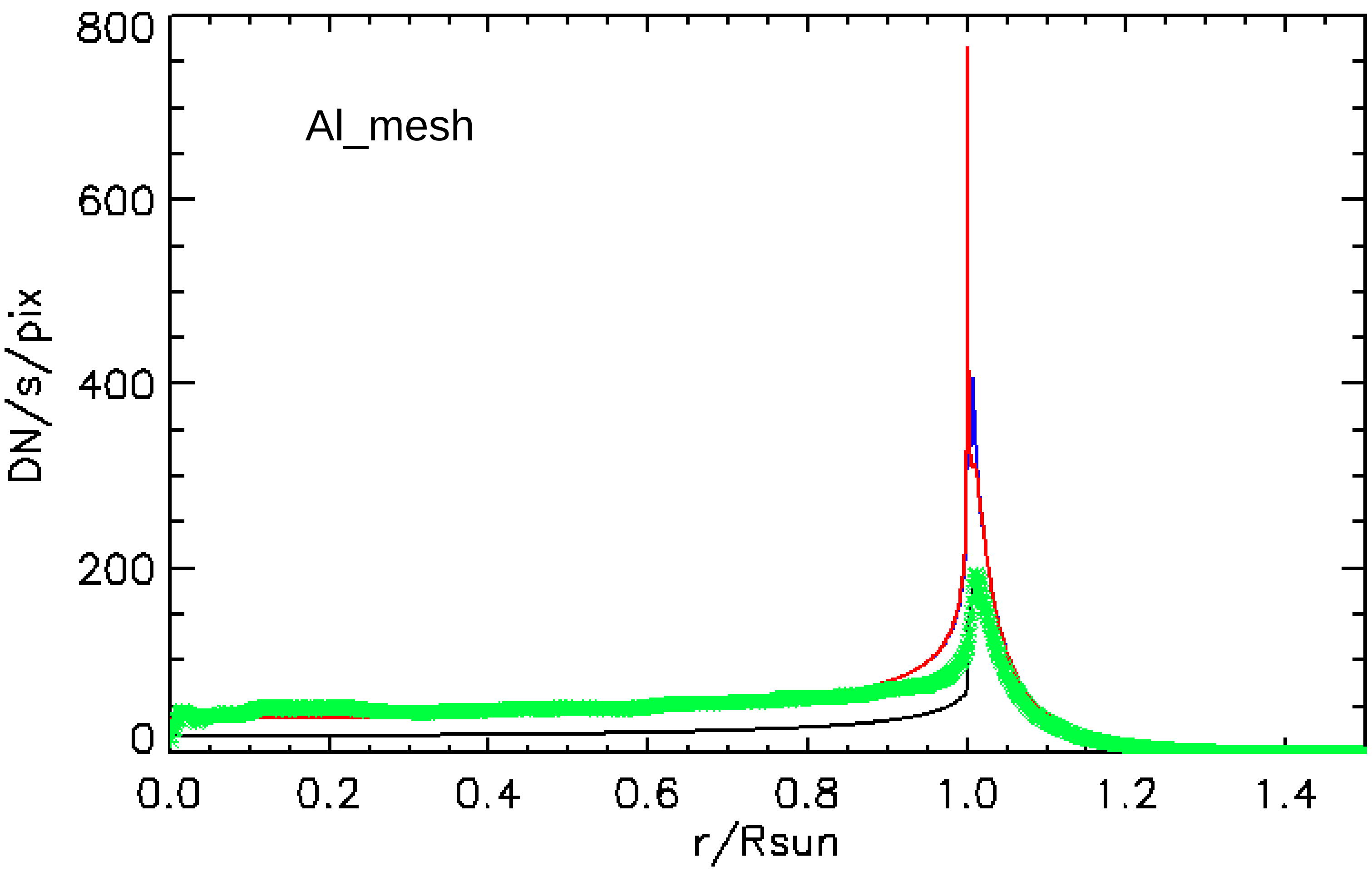
g(r) distribution



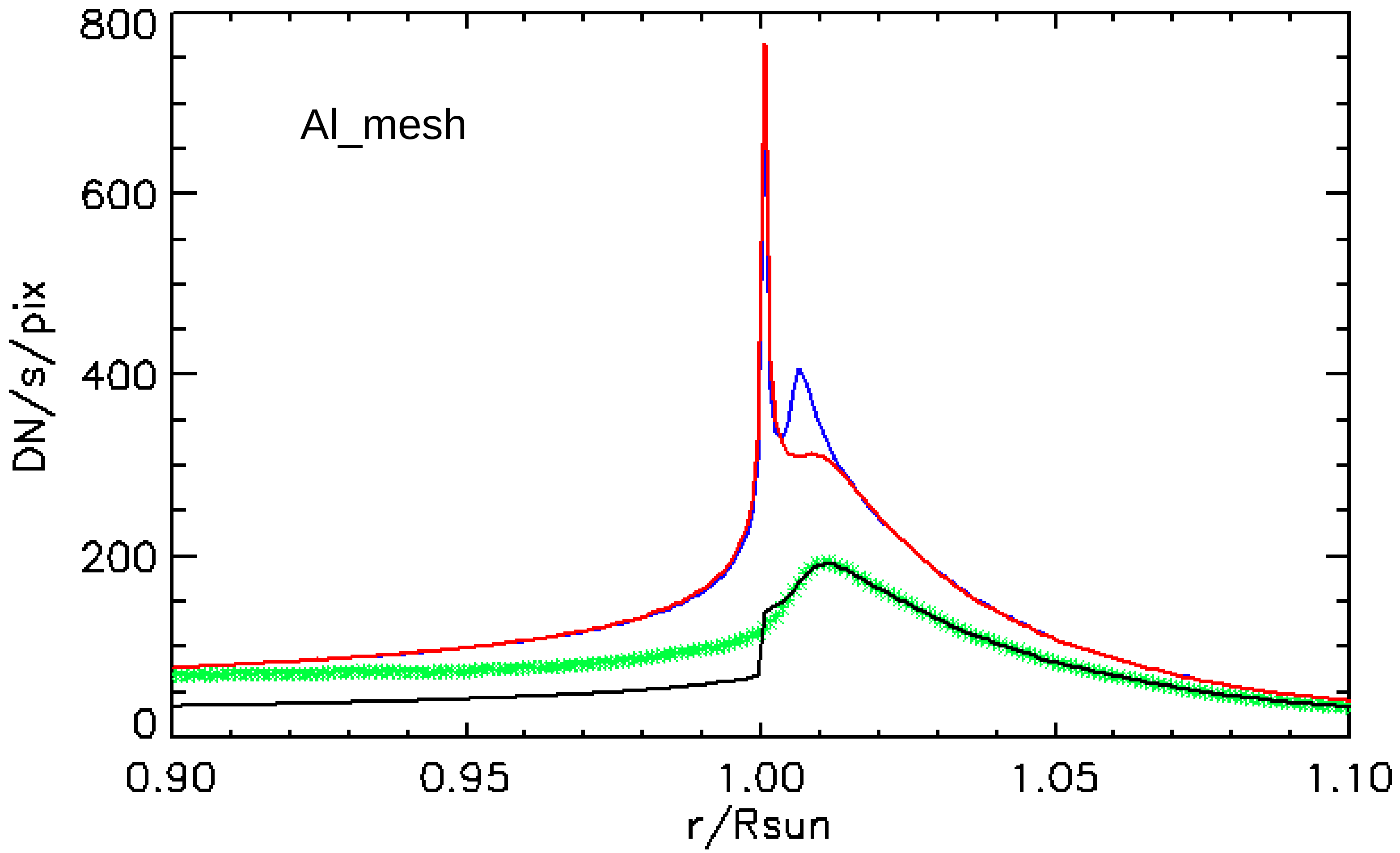
g(r) distribution



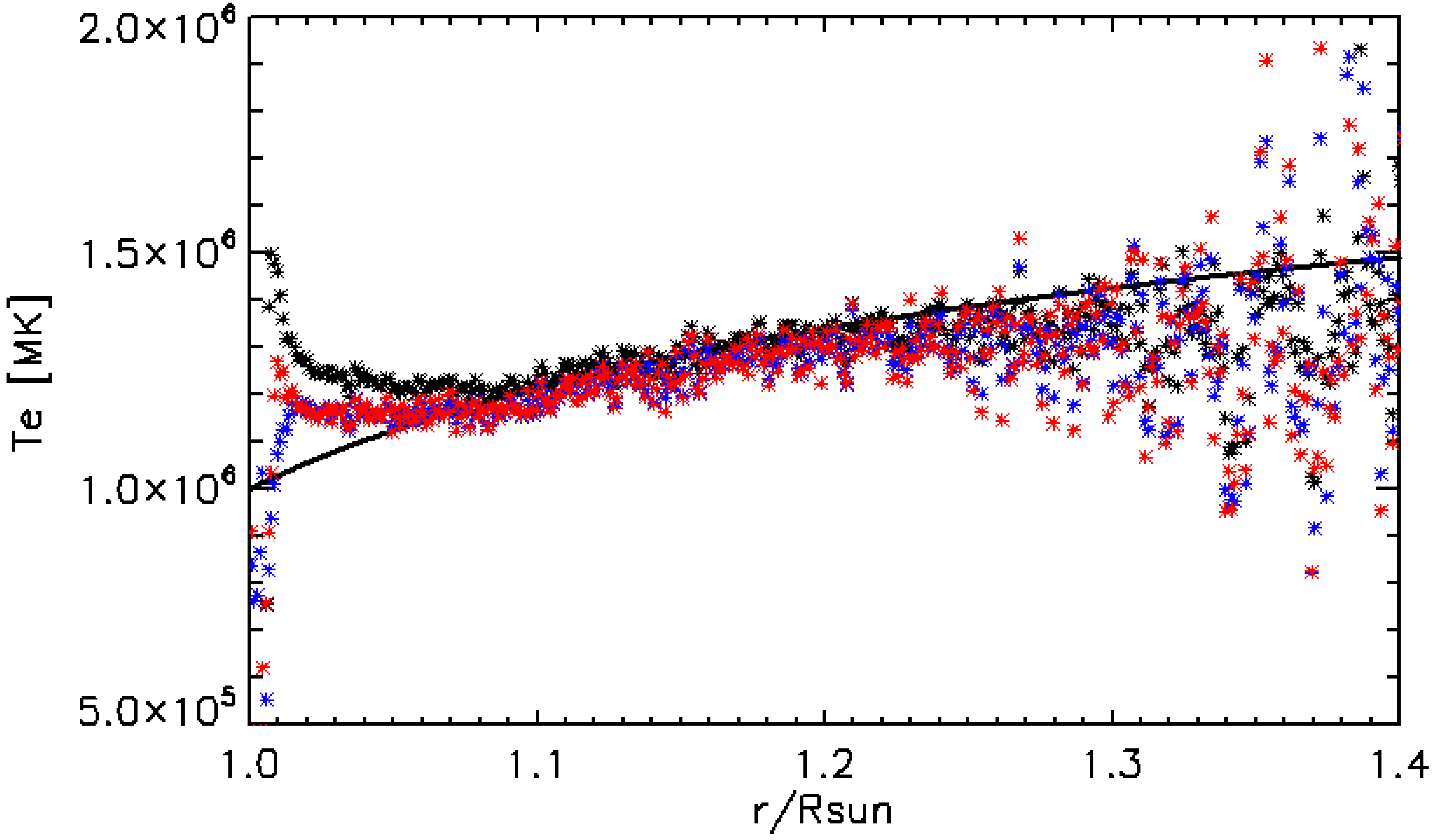
fit to observed profile



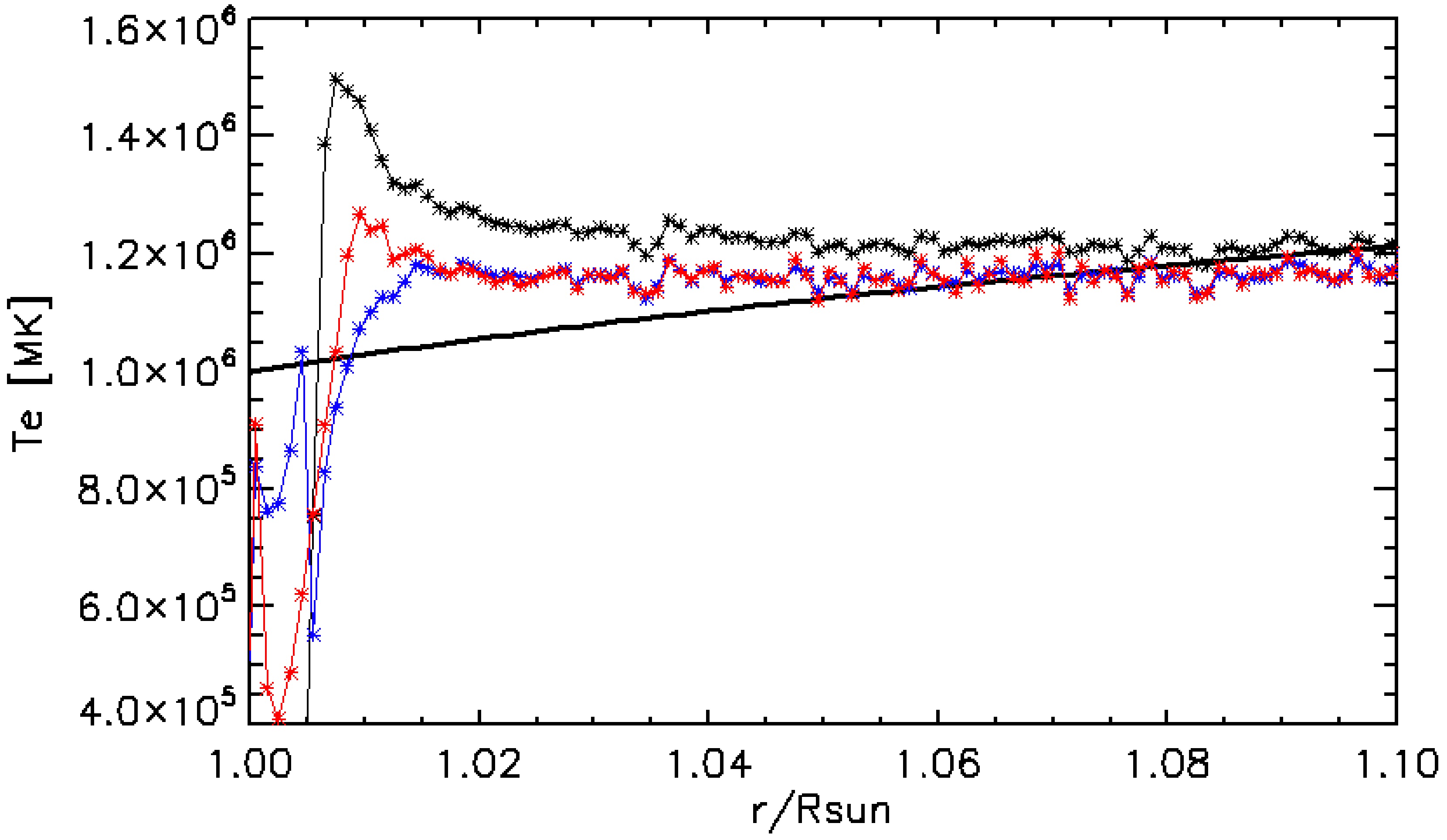
fit to observed profile



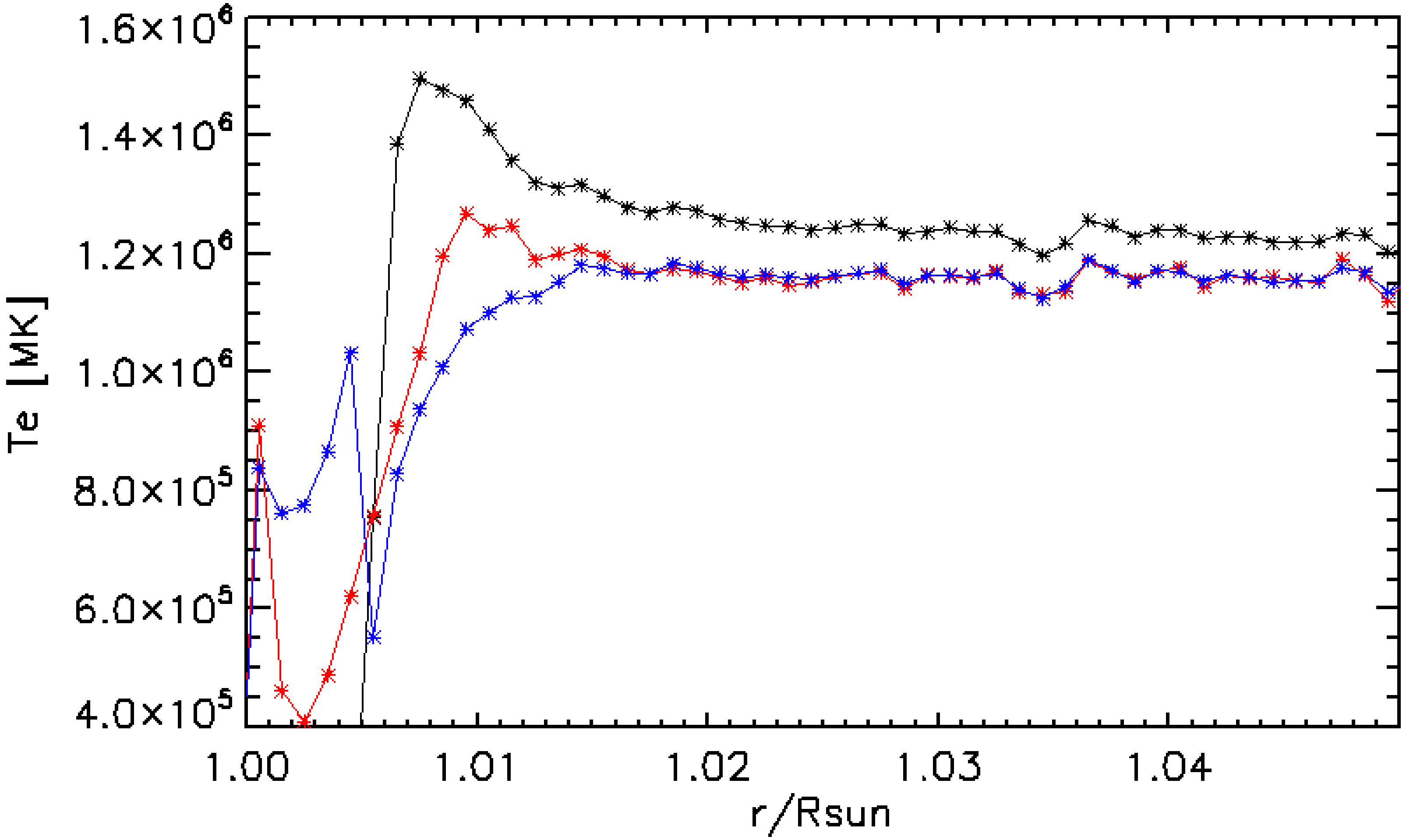
$T_e(r)$ distribution



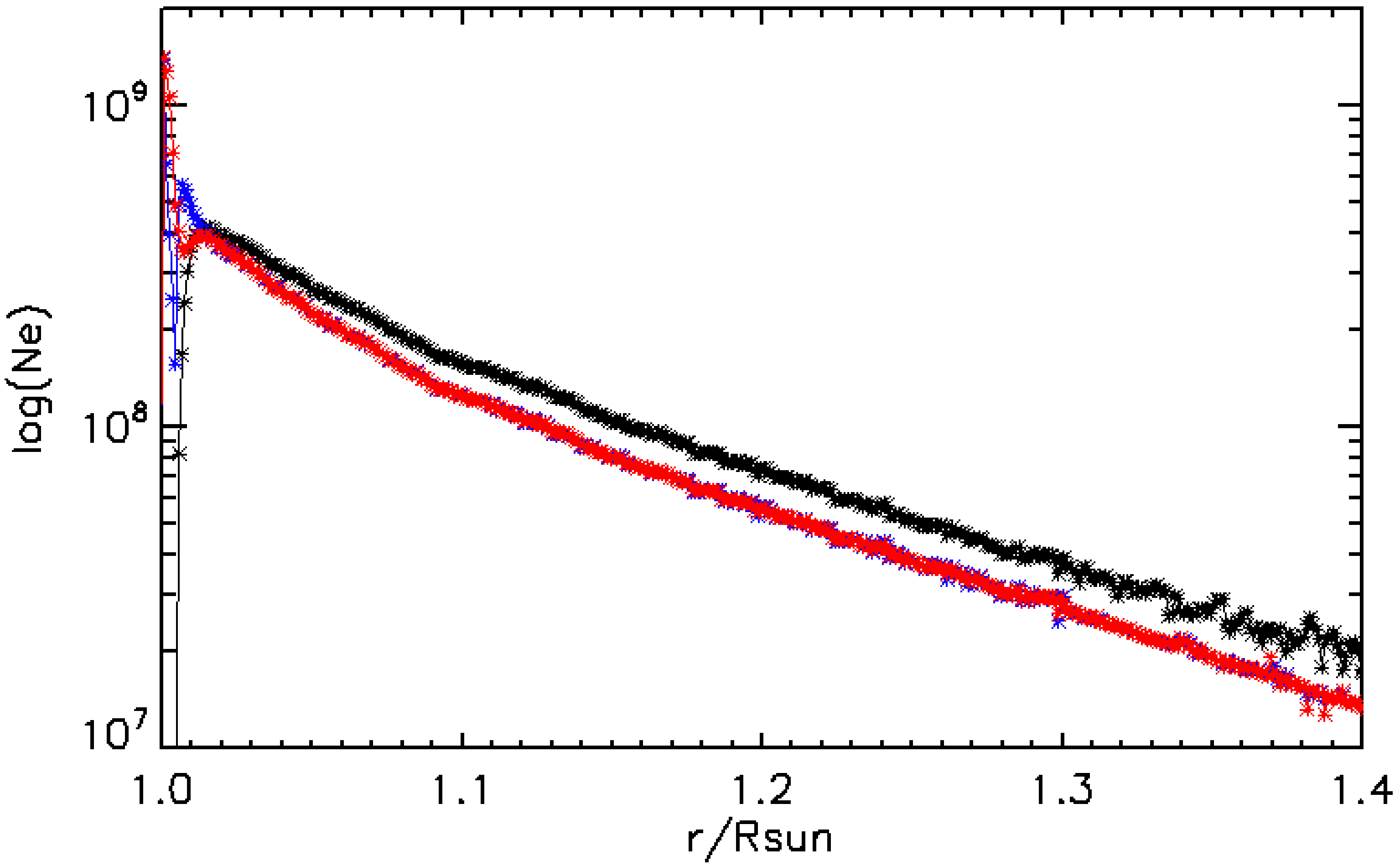
$T_e(r)$ distribution



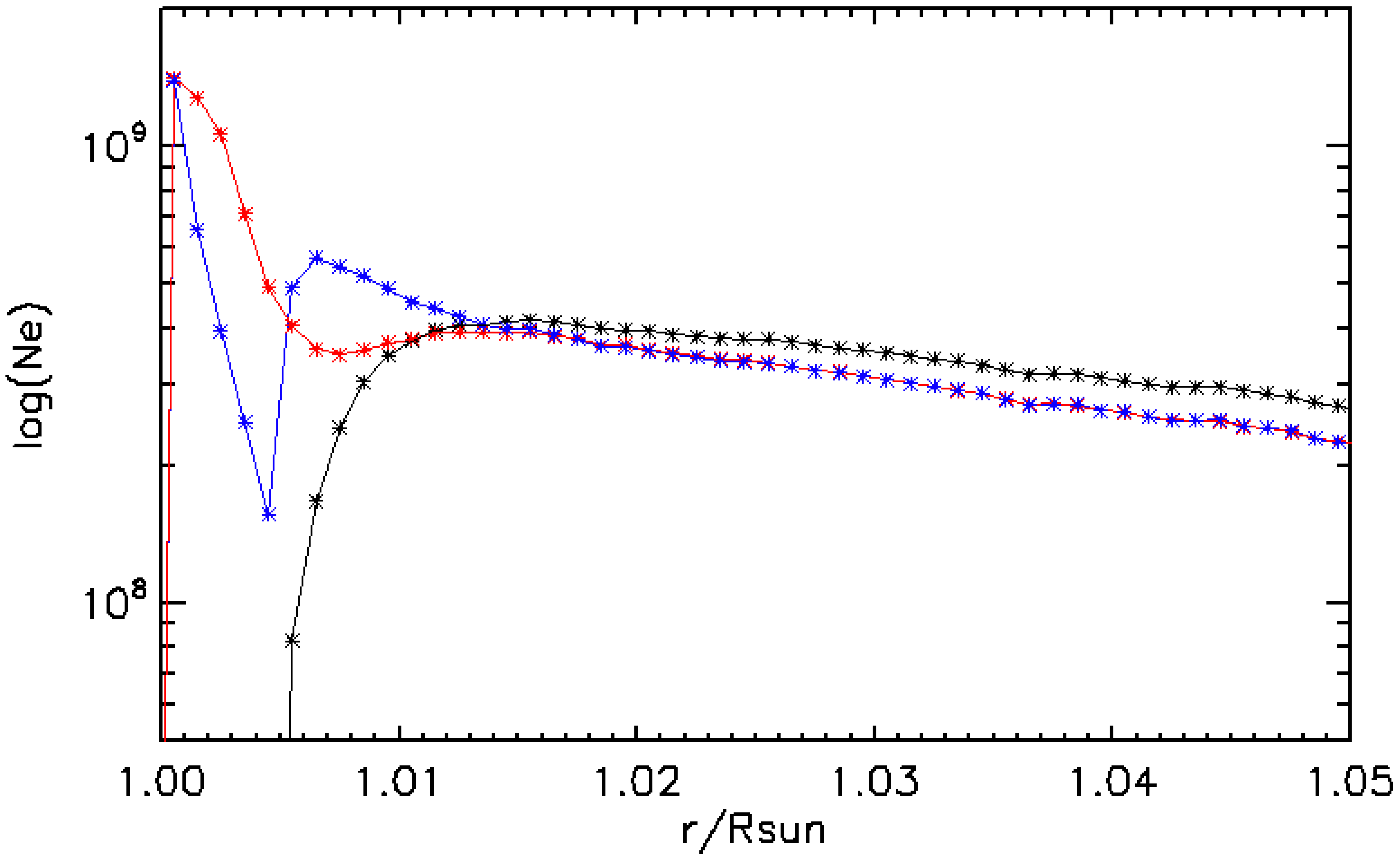
$T_e(r)$ distribution



$N_e(r)$ distribution



$N_e(r)$ distribution



Total Solar Eclipse 2009

Kobelski_2013_XRT_calibration.pdf

The grazing incidence mirror used by XRT is a source of scattered light. This scattered light requires a model dependent and non-trivial deconvolution to correct, and is thus not performed by xrt prep.pro. Estimates of the uncertainties due to scattered light are similarly difficult to estimate, and as such are not considered.

0 tehXRT20090221_060422.2.fits.sav
1 tehXRT20090303_075650.0.fits.sav
2 tehXRT20090304_080521.2.fits.sav
3 tehXRT20090305_055520.6.fits.sav
4 tehXRT20090414_055900.8.fits.sav
5 tehXRT20090420_060731.5.fits.sav
6 tehXRT20090719_063216.6.fits.sav
7 tehXRT20090812_195641.2.fits.sav
8 tehXRT20090812_200541.3.fits.sav
9 tehXRT20090812_201441.5.fits.sav
10 tehXRT20090812_202341.7.fits.sav
11 tehXRT20090812_203241.9.fits.sav
12 tehXRT20090812_204142.0.fits.sav
13 tehXRT20090812_205042.2.fits.sav
14 tehXRT20090813_060744.5.fits.sav
15 tehXRT20090819_060345.3.fits.sav
16 tehXRT20090820_053544.8.fits.sav
17 tehXRT20090820_120531.3.fits.sav
18 tehXRT20090820_121431.4.fits.sav
19 tehXRT20090820_122331.6.fits.sav
20 tehXRT20090820_123231.8.fits.sav
21 tehXRT20090820_132532.3.fits.sav
22 tehXRT20090820_133432.5.fits.sav
23 tehXRT20090912_061242.6.fits.sav
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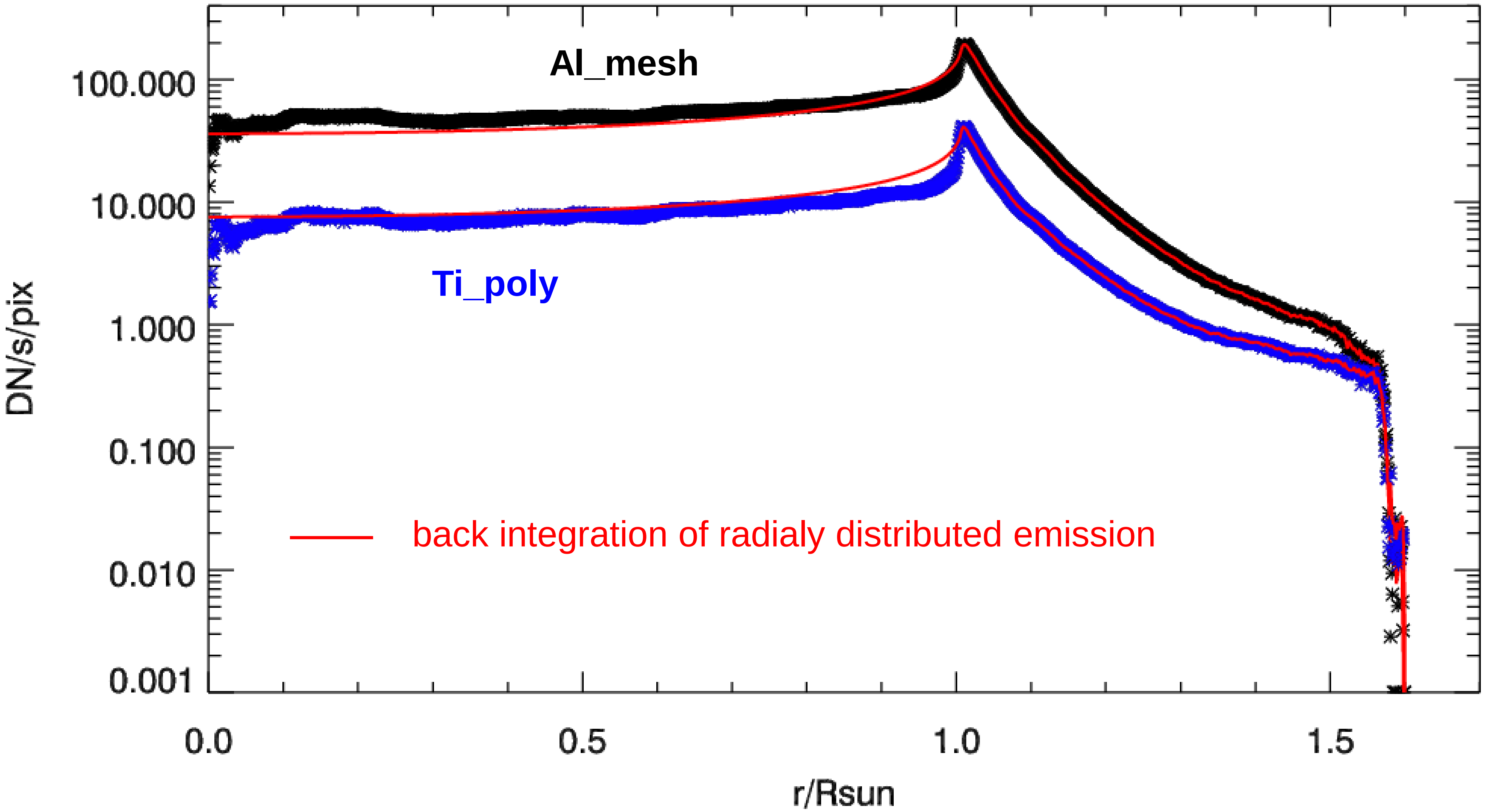
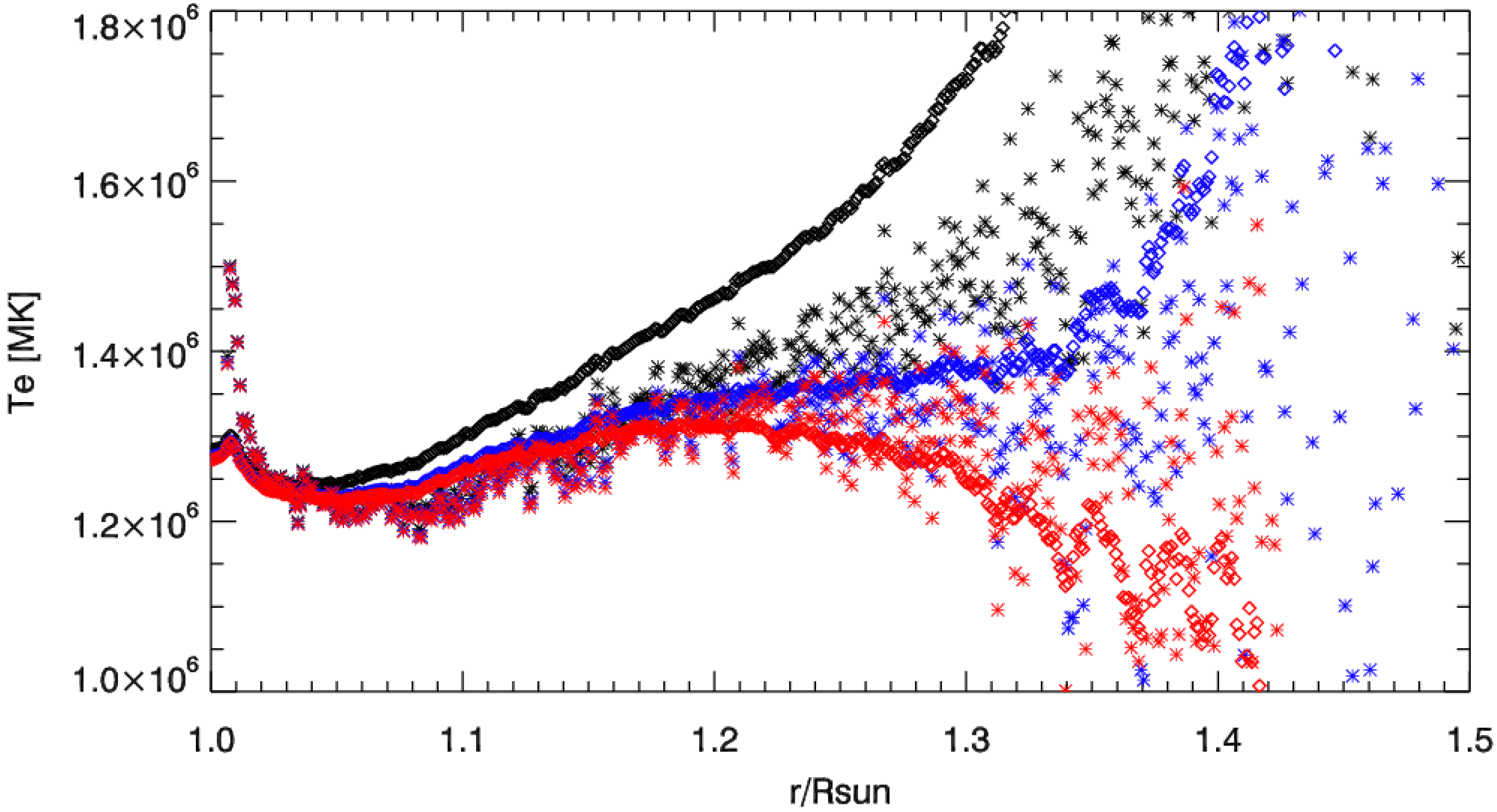


Al_mesh
Ti_poly
back integration of radialy distributed emission
DN/s/pix
100.000
10.000
1.000
0.100
0.010
0.001
0.0
0.5
1.0
1.5
r/Rsun

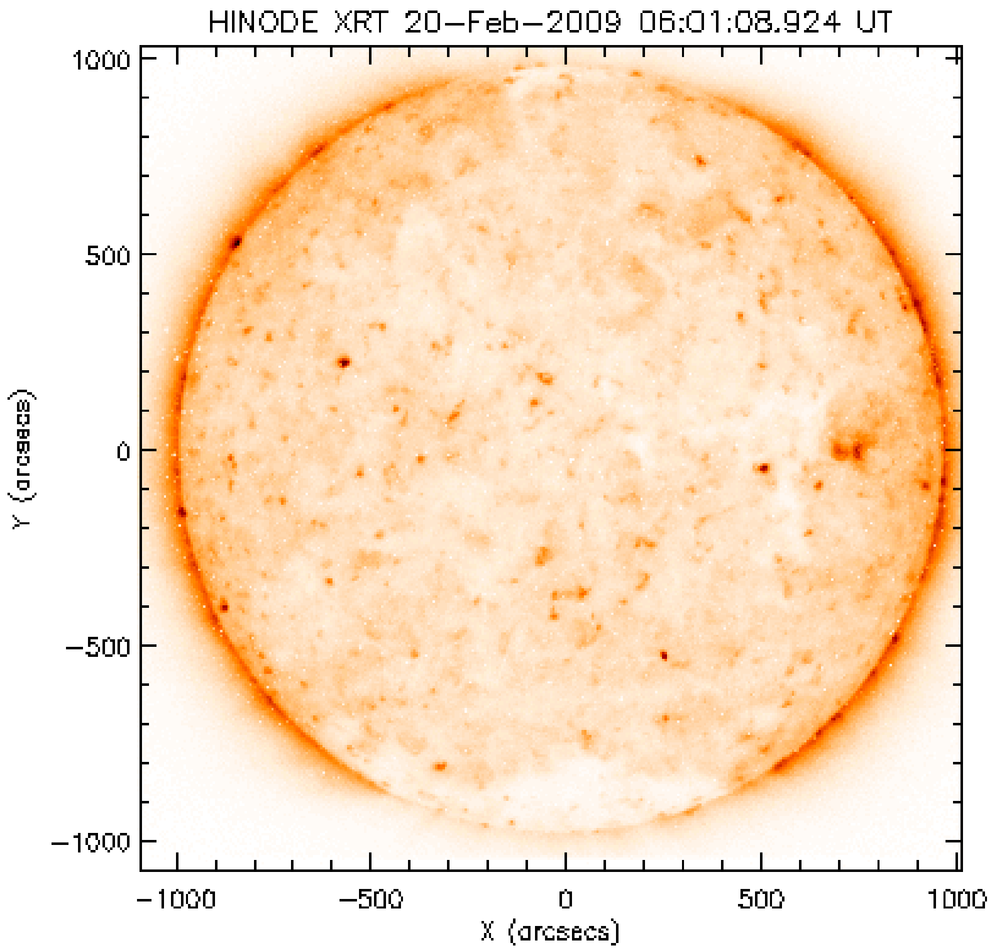


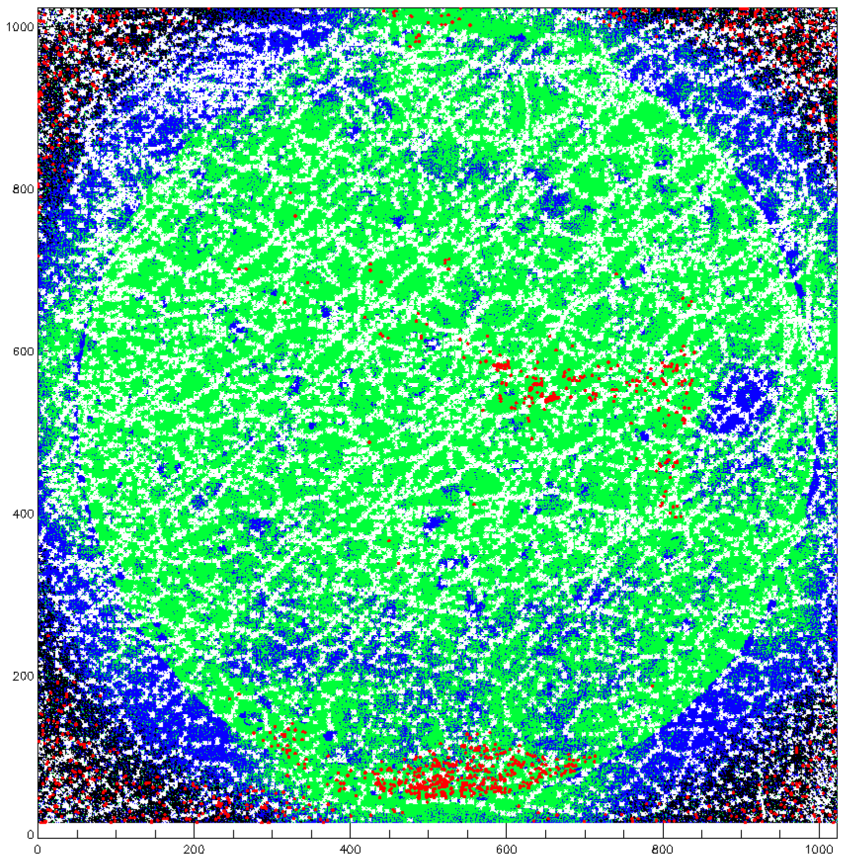
1.8×10^6
1.6×10^6
1.4×10^6
1.2×10^6
1.0×10^6
Te [MK]
1.0
1.1
1.2
1.3
1.4
1.5
r/Rsun

wnioski

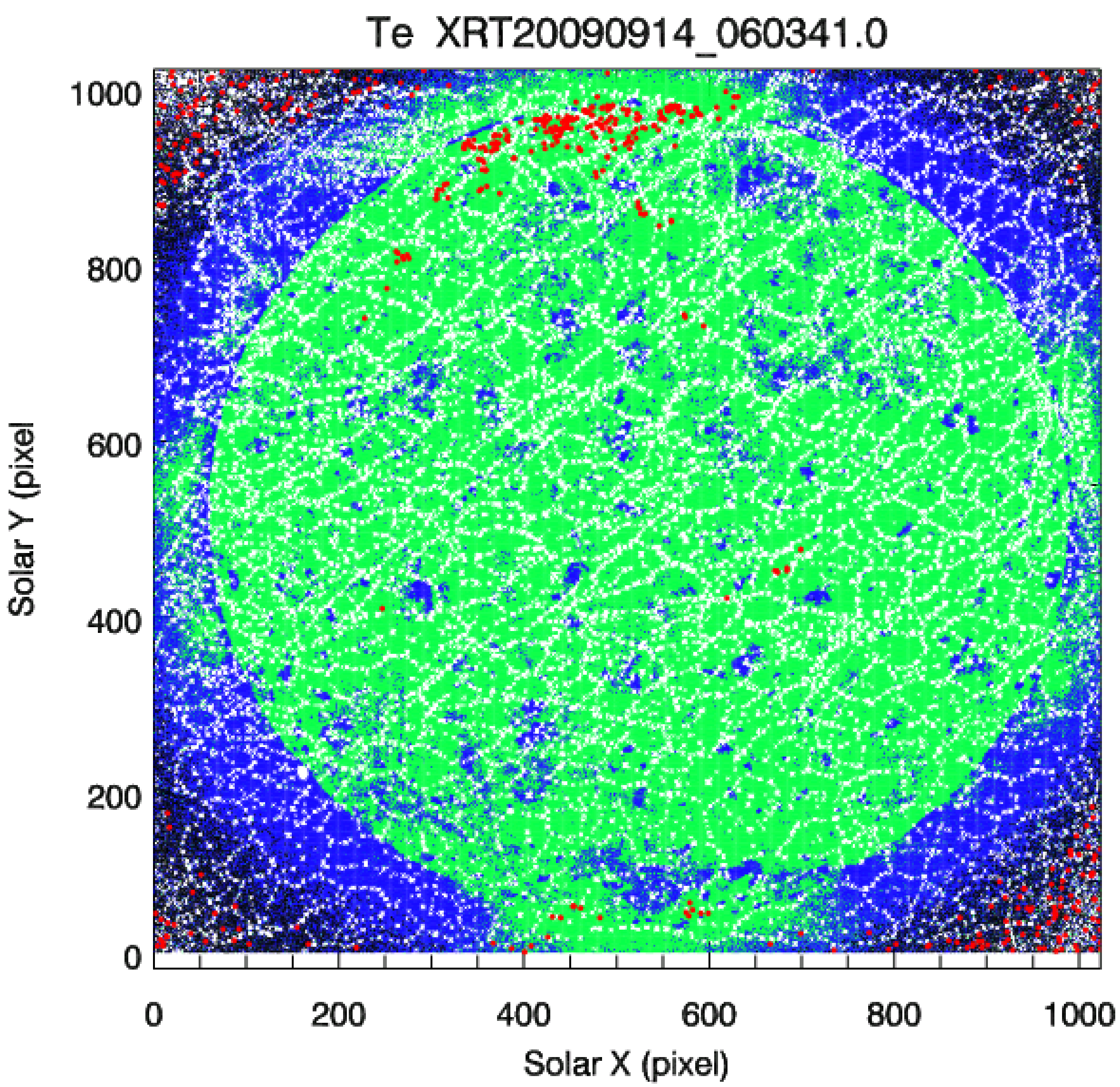
- Powyżej $r/R_{\odot}$ = 1.2 wpływ światła rozproszonego jest istotny
- Korona podczas minimum ma 2 składowe:
  - pętle o Te do ~1.5 MK i wysokościach ~5000 km
  - składowa „radialna” gdzie temperatura rośnie z wysokością od Te ~1.0 MK

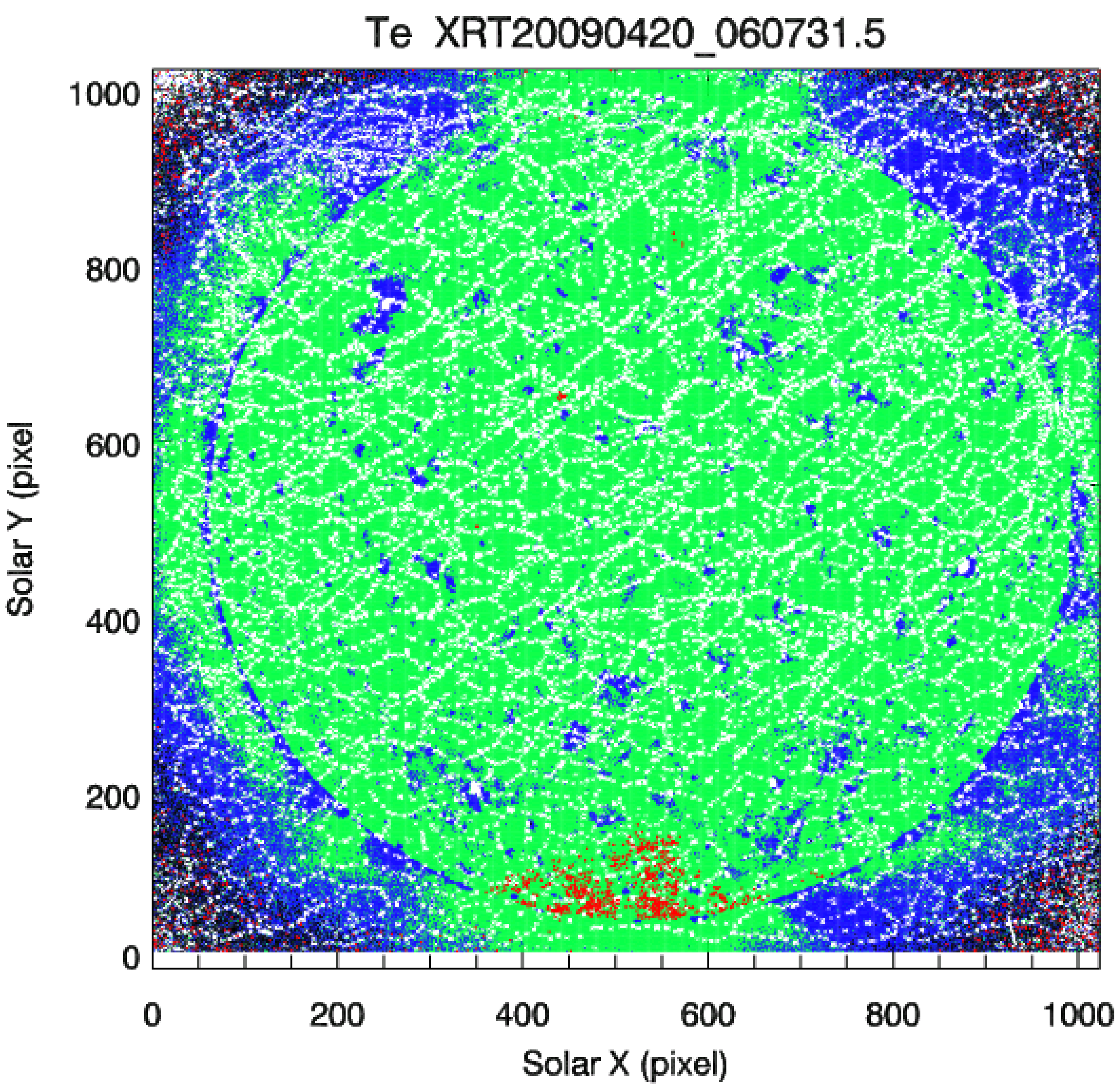
Where is cold and hot component ?

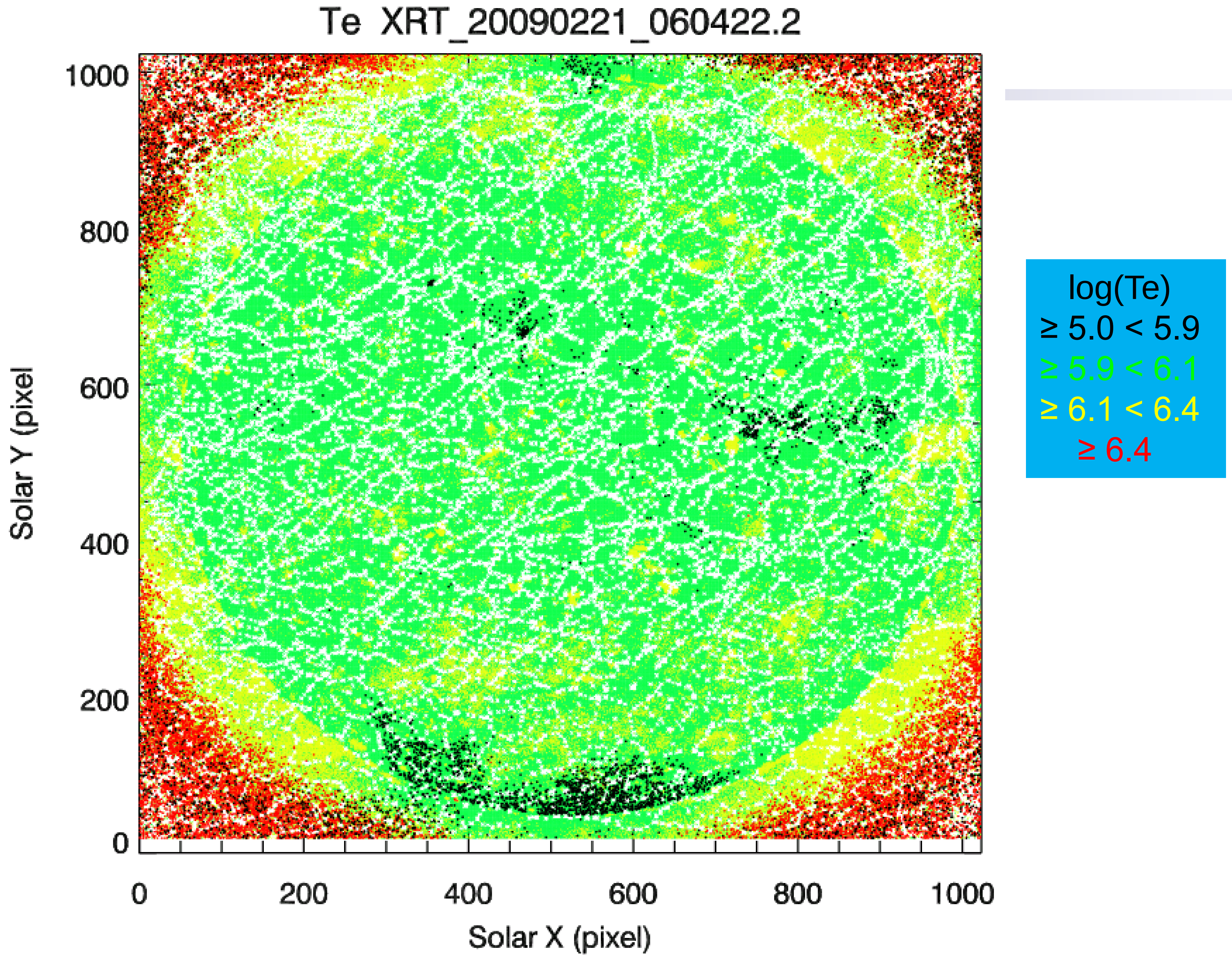




Where is cold and hot component ?







Te XRT_20090221_060422.2
Solar Y (pixel)
Solar X (pixel)
0
200
400
600
800
1000
log(Te)
≥ 5.0 < 5.9
≥ 5.9 < 6.1
≥ 6.1 < 6.4
≥ 6.4