Modeling the Deep Impact ejecta plume

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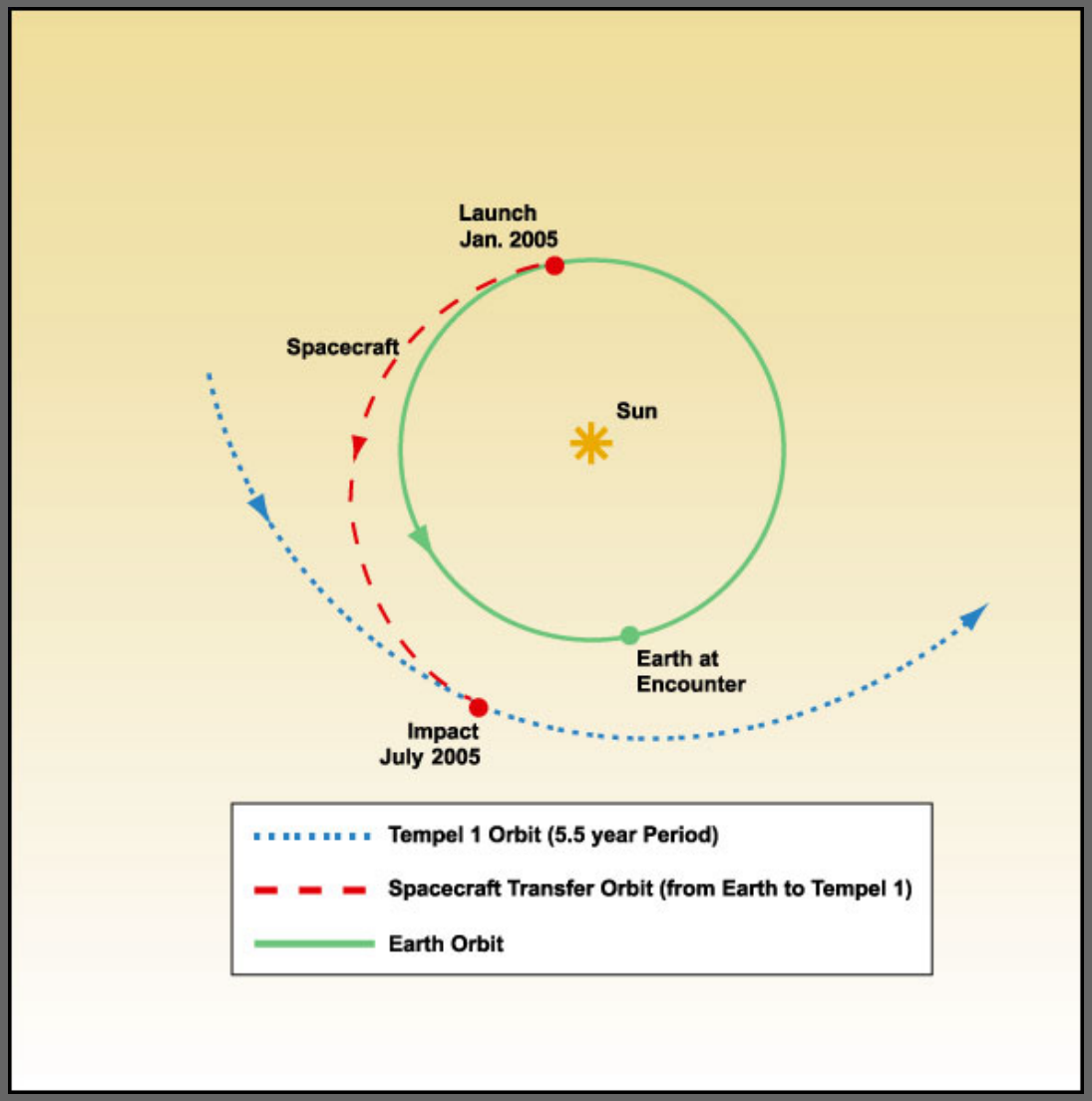
In - house meeting April 12-13 2007

The Deep impact mission by NASA



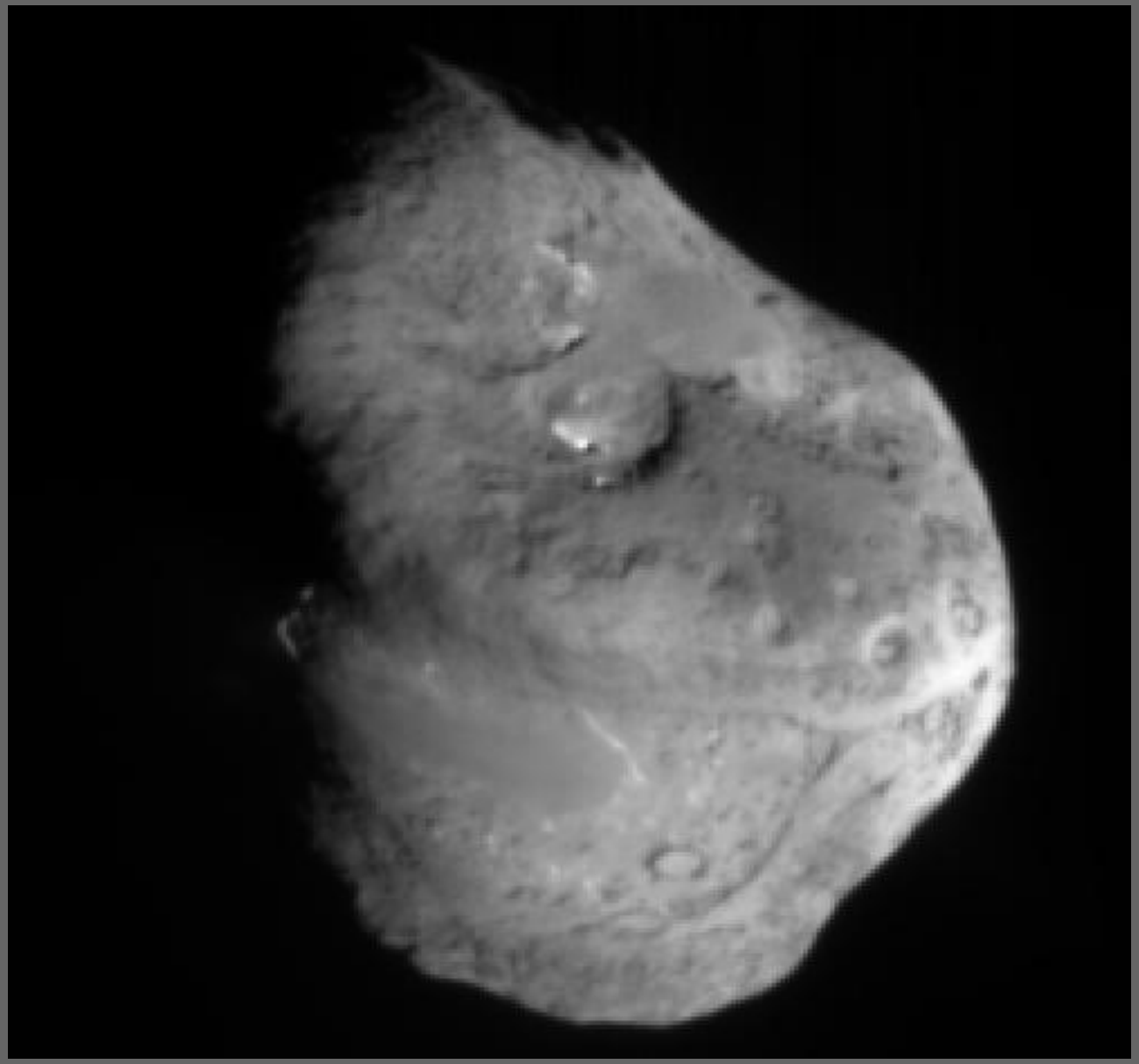
Heliocentric distance

=1.5 AU

Geocentric distance

=0.89 AU

Image of comet Tempel 1 by the Impactor Targeting System Camera



6 km

The impact sequence imaged by the High Resolution Instrument Camera aboard the DI Flyby Spacecraft

International Campaign

- Observations were attempted from IAO and VBO during July 01 – 08 July, 2005
- Imaging in R band
- Collaborators: U.S. Kamath, G.Maheswar, S. Muneer, S.K. Pandey, T.P. Prabhu, D.K. Sahu, R. Vasundhara

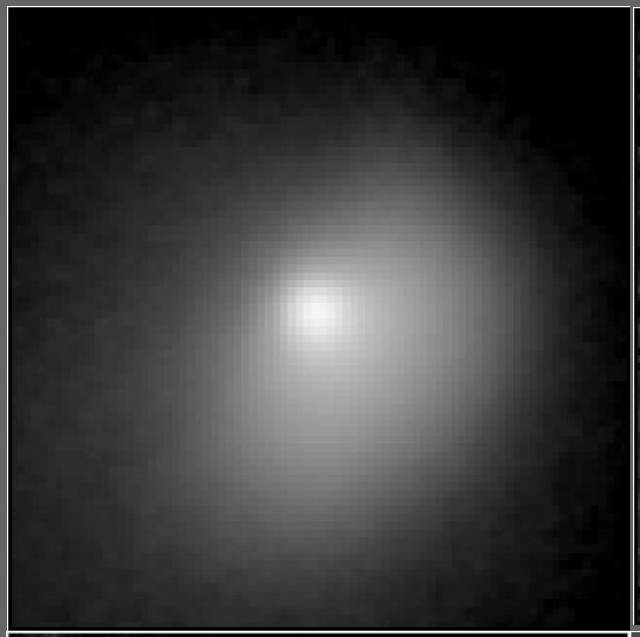
Preliminary results in Meech et al.2005 Science 310, 265-269

The impact plume was imaged successfully at the

Field : 31“ x 31"

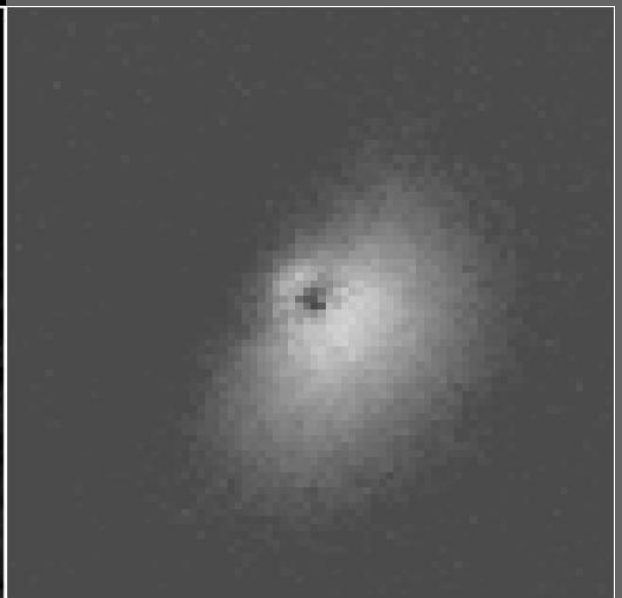
102 cm telescope at VBO through R filter, on 03 & 04 July

Original Image of 04 July



03 July

4July/ 1/ρ coma



04 July - scaled 03 July

Assumptions in the model :

1. Instantaneous ejection of the plume material

2. The grains were ejected with a size dependent initial velocity

3. The trajectory of the grains – shape of the plume was modified by solar radiation pressure over the next few days

4. The ejecta cone (curtain) is of finite thickness

Parameters modelled: Cone width, thickness, initial grain velocity, grain size distribution

•Grain size distribution:

n(s) ds = [(1–so/s)**M] *(so/s)**N

(Hanner, 1985, Adv. Space. Res. 4(9), 189)

so = minimum grain size

Intensity of light scattered by the grains = $\Sigma\, I_{(s)}\, n(s)\, ds$

where,

$I(s, \theta, \lambda) = I_o(\lambda) \,.\, \lambda^{**2}\, (I \parallel + I \perp) \;/\; 8.\pi.r^{**2} \,.\, \Delta^{**2}$

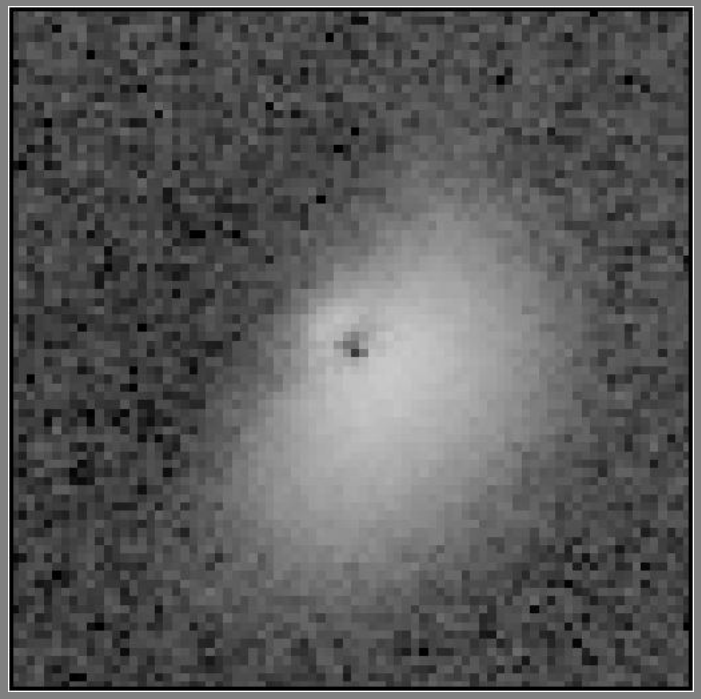
Further possibilities (not used in the present work) :

Polarization : $P(s, \theta, \lambda) = (I \parallel - I\perp) / (I \parallel + I \perp)$

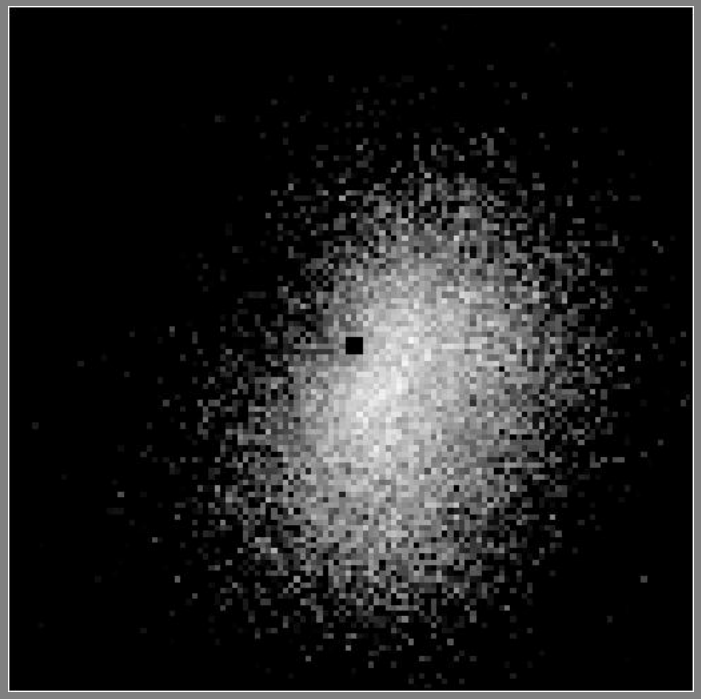
Normalized reflectivity gradient (Jewitt & Meech, 1986) :

$S'(\lambda 1 , \lambda 2) = (dS/d\lambda) \times 1000/S_{mean}$

4 July, 2005 Observations from the VBO

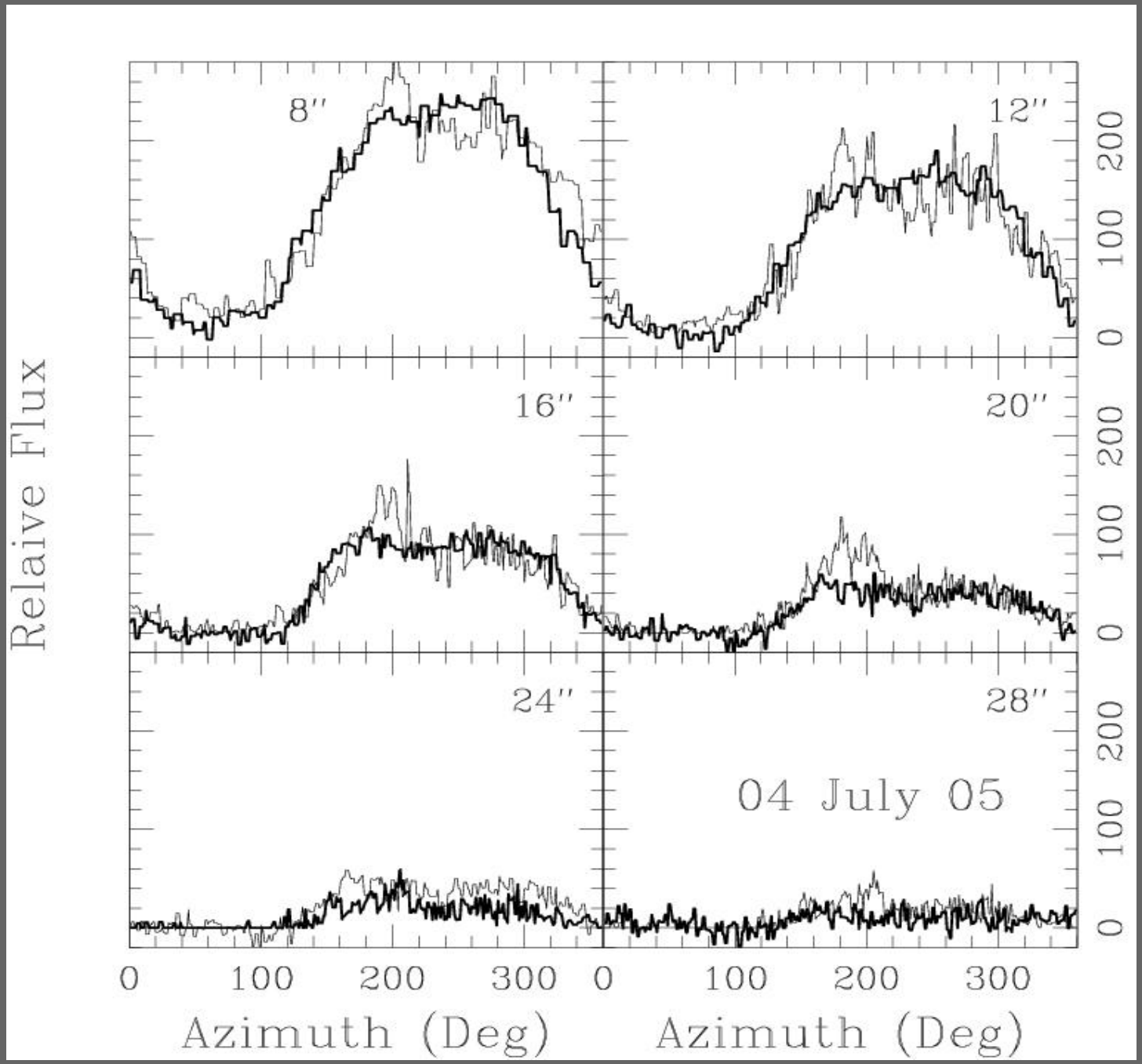


July 4 - July 3(S)



Simulated image

Field : 31" X 31 "


8″
12″
16″
20″
24″
28″
04 July 05
Relaive Flux
0
100
200
300
Azimuth (Deg)
Azimuth (Deg)

Evolution of the ejecta plume

Collaboration with Stephen Lowry and Alan Fitzsimmons, Queen's University, Belfast.

The Data:

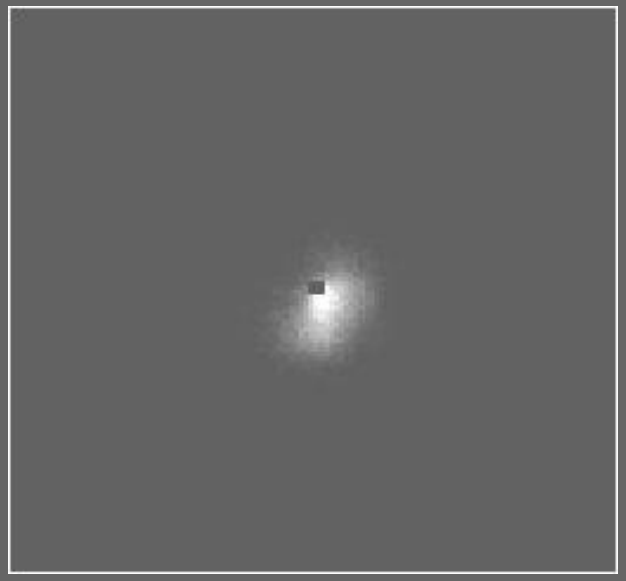
Images obtained at the 2.5 m Isaac Newton Telescope at La Palma

at the prime (f/3) focus through Sloan r filter

Dates: 04 July – 07 July

Observed image

Simulated image

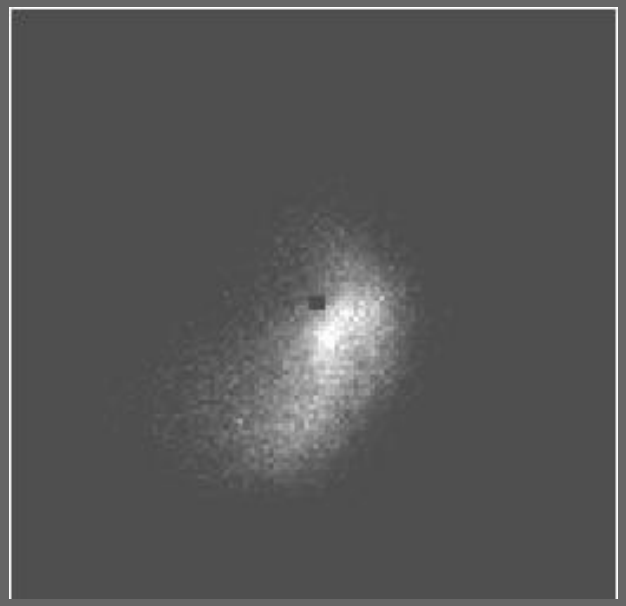


Impact time:

05:52:02 UT

04 July

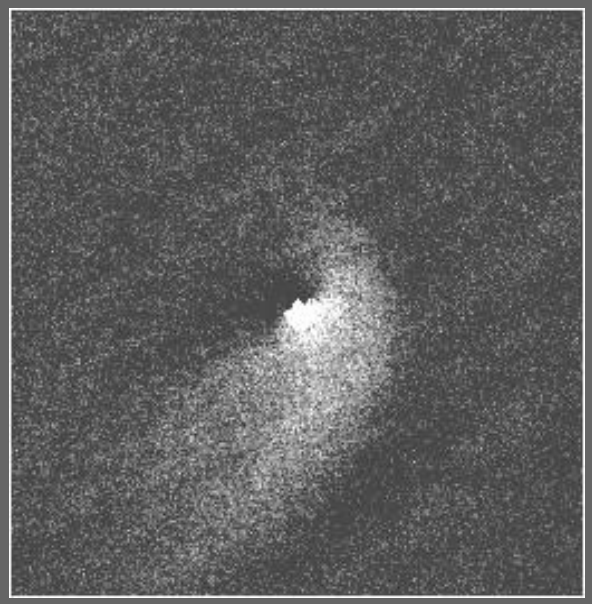
22:08:35 UT

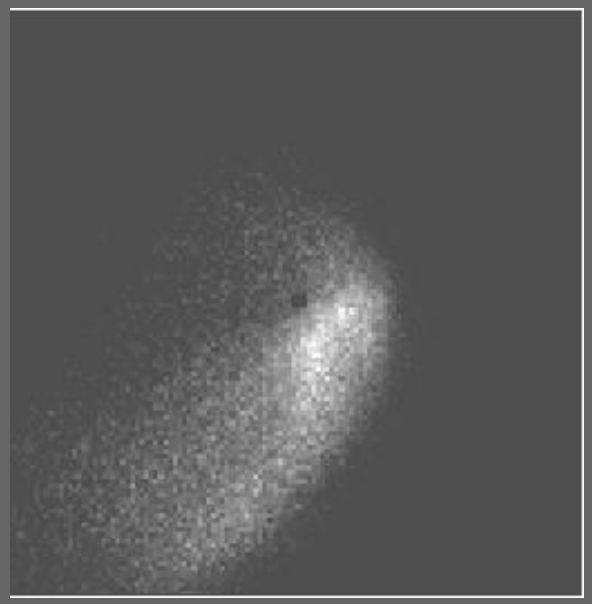


05 July

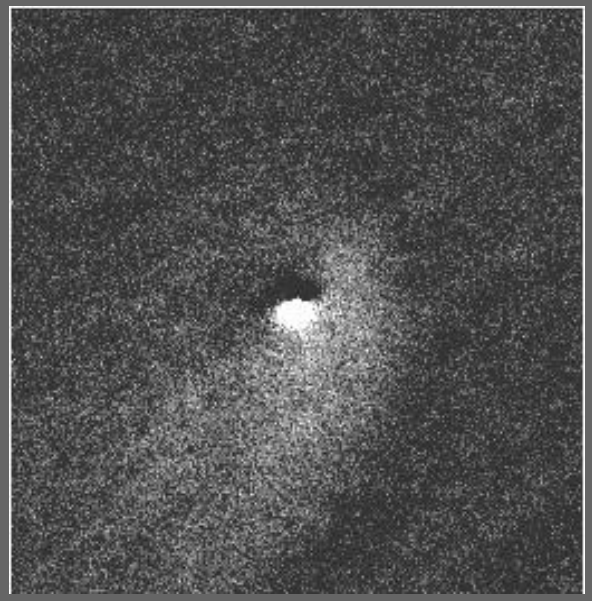
Observed image

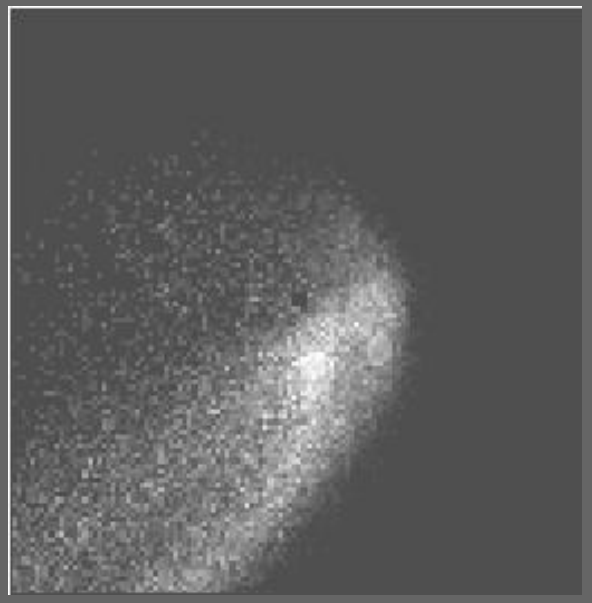
Simulated image



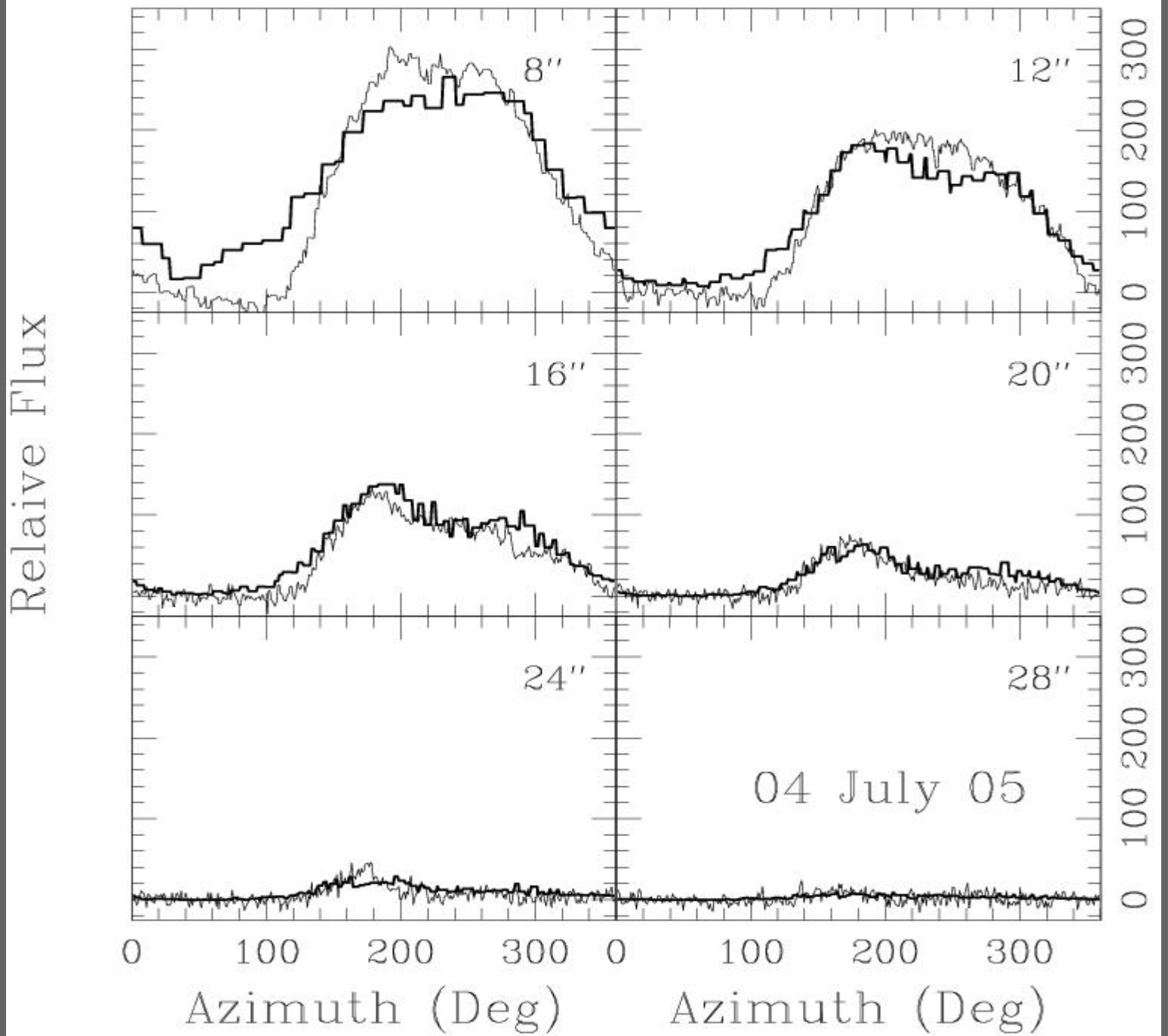


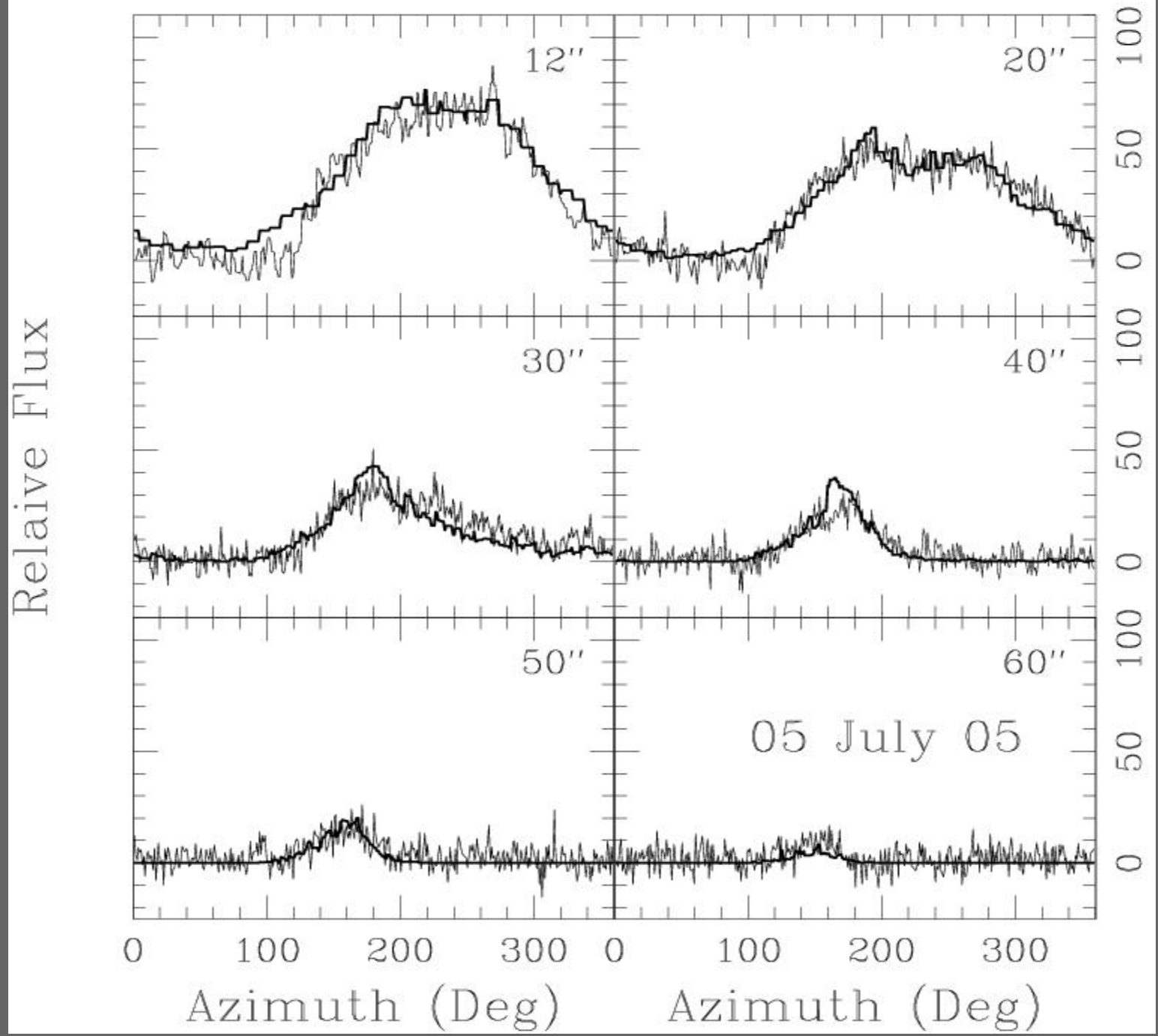
06 July

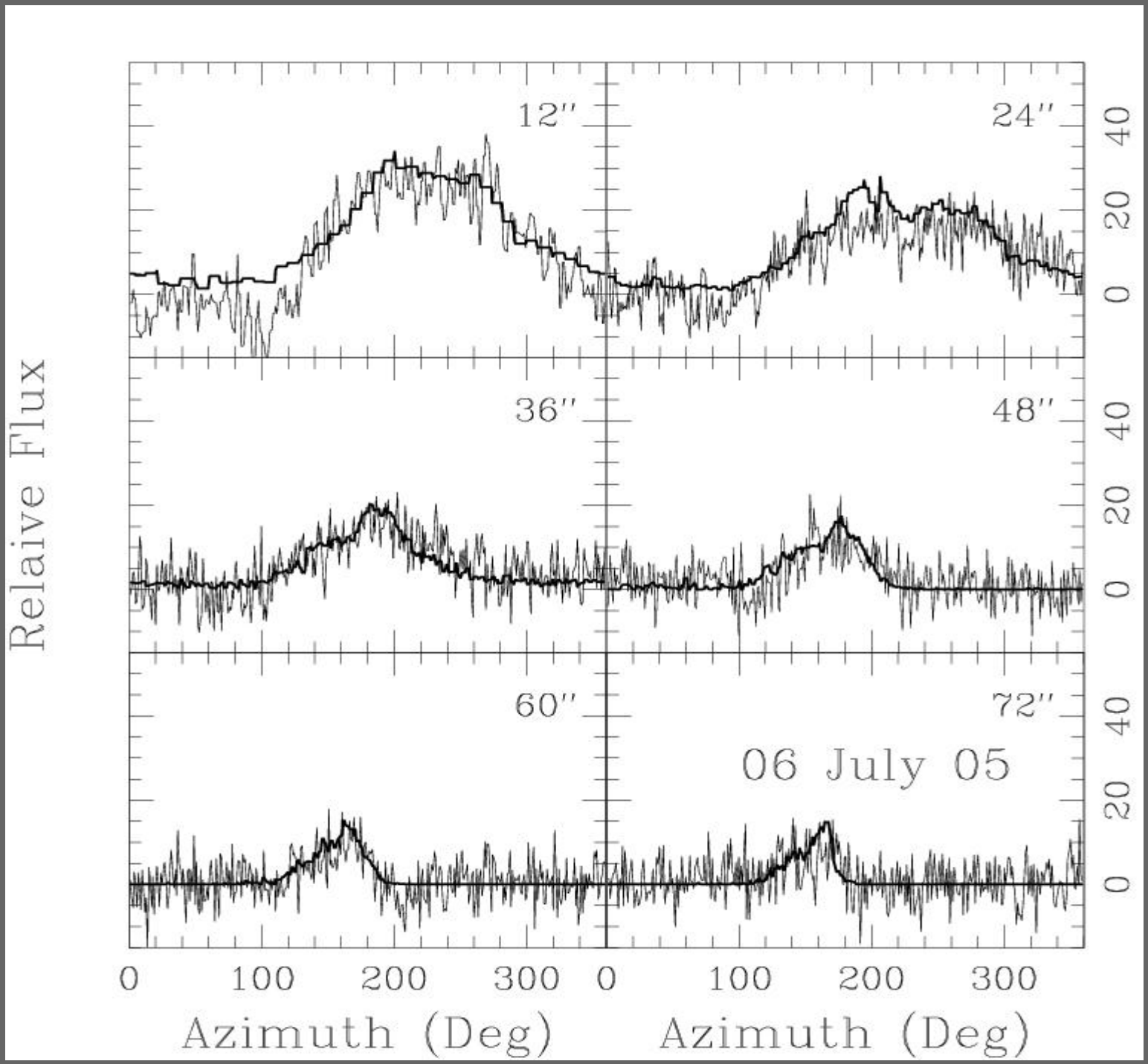


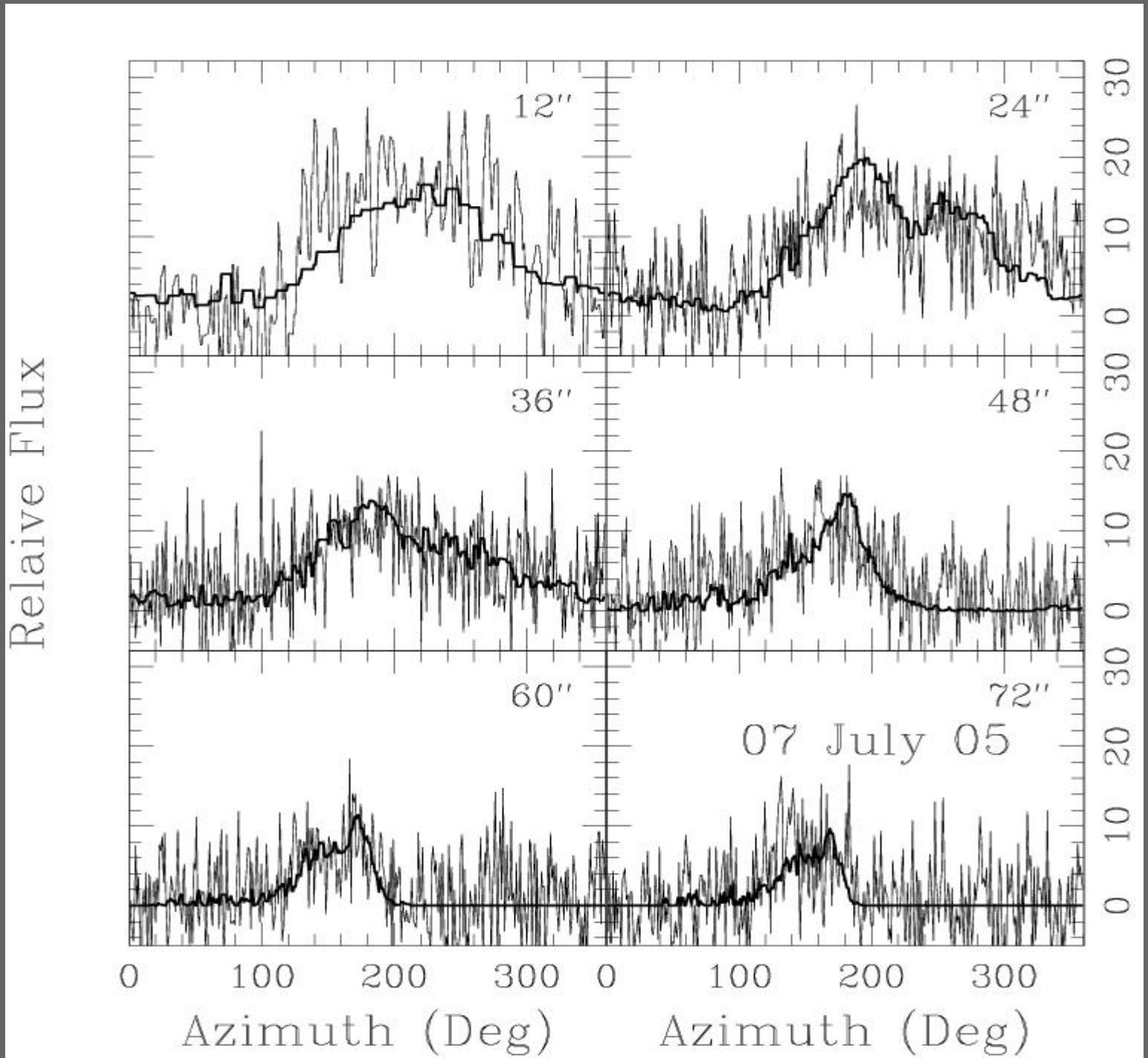


07 July


Relaive Flux
8''
12''
16''
20''
24''
28''
04 July 05
0
100
200
300
Azimuth (Deg)
Azimuth (Deg)

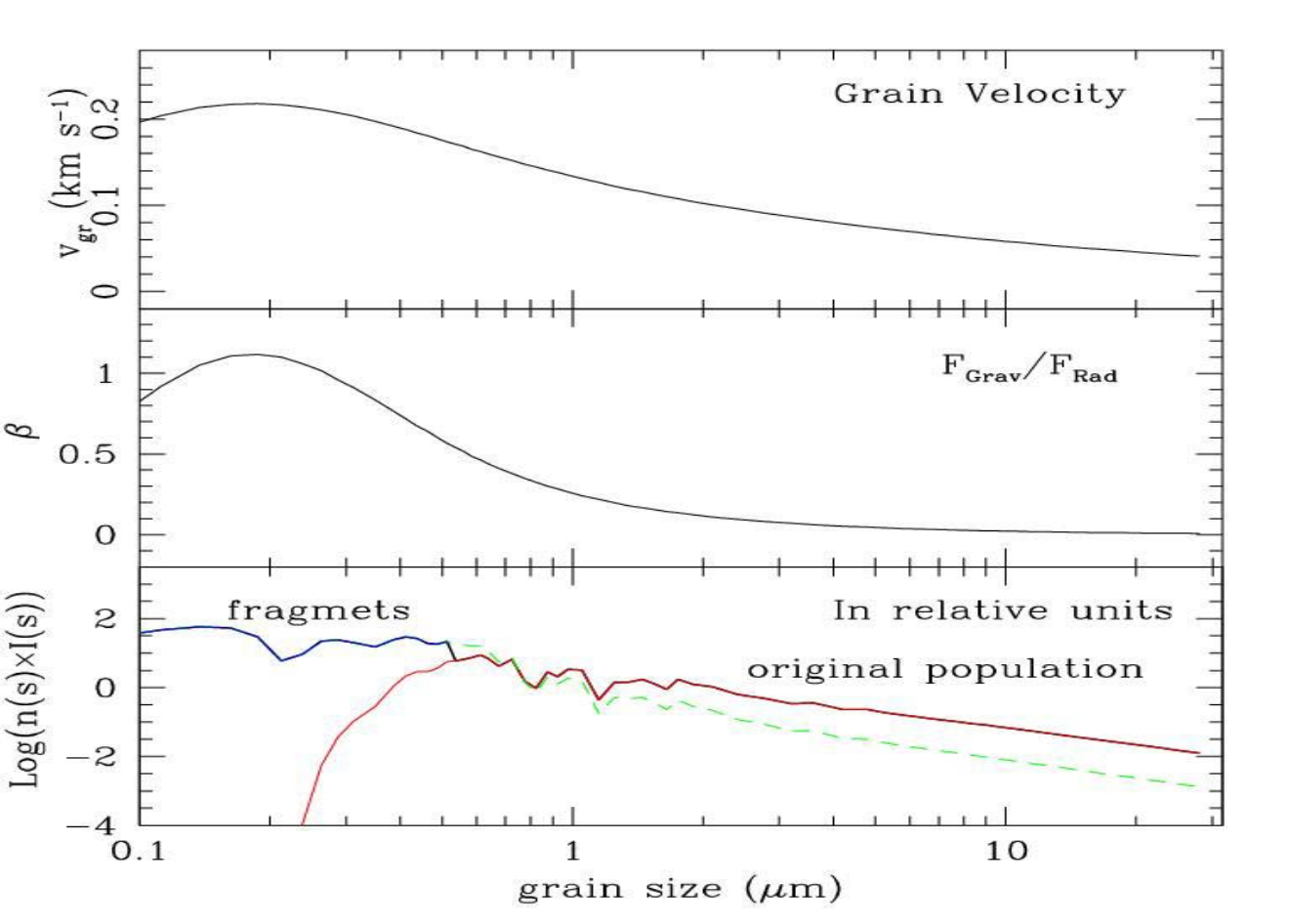

12″
20″
30″
40″
50″
60″
05 July 05
Relaive Flux
0
100
200
300
Azimuth (Deg)
Azimuth (Deg)
0
50
100


12″
24″
36″
48″
60″
72″
06 July 05
Relaive Flux
0
20
40
0
100
200
300
Azimuth (Deg)
Azimuth (Deg)


Relaive Flux
12″
24″
36″
48″
60″
72″
07 July 05
0
100
200
300
Azimuth (Deg)
Azimuth (Deg)
0 10 20 30

Results:

Grain velocities, Radiation pressure parameter and size distribution used in the fit



Results:

Adjusted parameters :	fits:
•Opening half angle of the ejecta cone	45°
•Thickness of the cone (Gaussian)	FWHM:20°
• velocity range	0.06– 0.23 km/s
•Hour angle of the earth as seen by the impact location at the time of impact	50° ± 10°
•Cometo-centric declination of the impact location using the derived pole location	–60° ± 10 °
•Zenith distance of the Earth with respect to Impact location	71° ± 10°
•Position angle of the ejection cone axis	232°±10°

The fits were better if grain fragmentation is taken into account

Future Plans

The model has the potential to simulate colour and polarization maps, which can be exploited to investigate the grain properties.

Thank you