The Dust Trail of Comet 67P/Churyumov-Gerasimenko Near Aphelion

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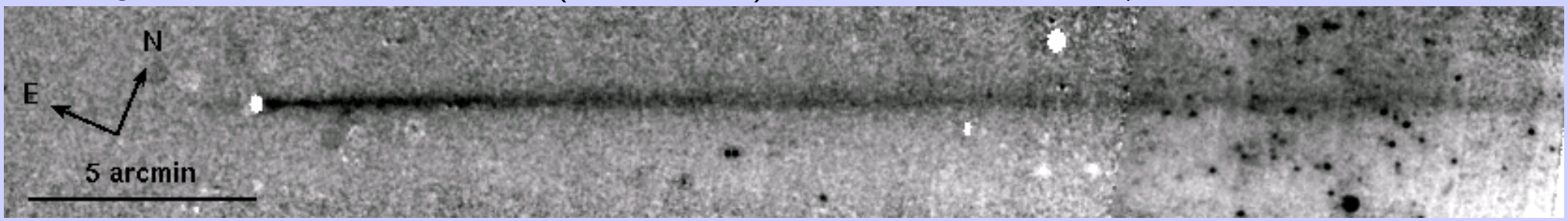
Outline

- Data
  - 3 images of dust along CG orbit (2004 – 2006)
- Simulation Method
  - Generalised Finson-Probstein Approach
- Model
  - Input
  - Free Parameters
- Results
- Applicability to other Observations
- Open Issues, Outlook

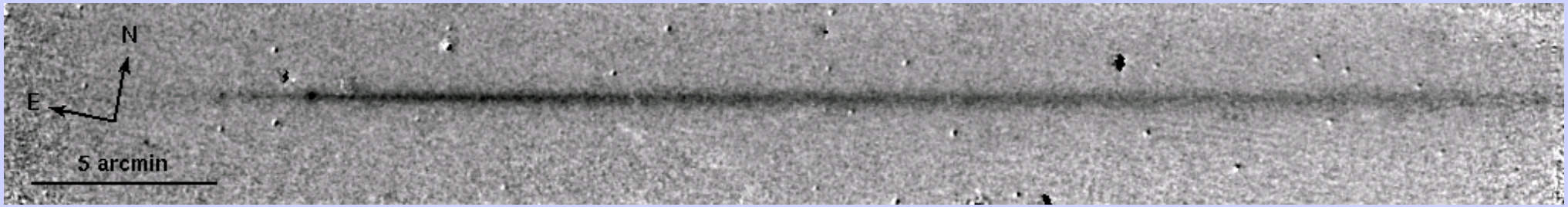
The trail of Churyumov-Gerasimenko in 2004 – 2006

20 April 2004; $r_{\rm h} = 4.7$ AU (out-bound); WFI, ESO/MPG 2.2m, full visible spectrum

29 August 2005; $r_{\rm h} = 5.7$ AU (out-bound); MIPS, Spitzer, 24 μm



9 April 2006; $r_{\rm h} = 5.7$ AU (in-bound); MIPS, Spitzer, 24 μm



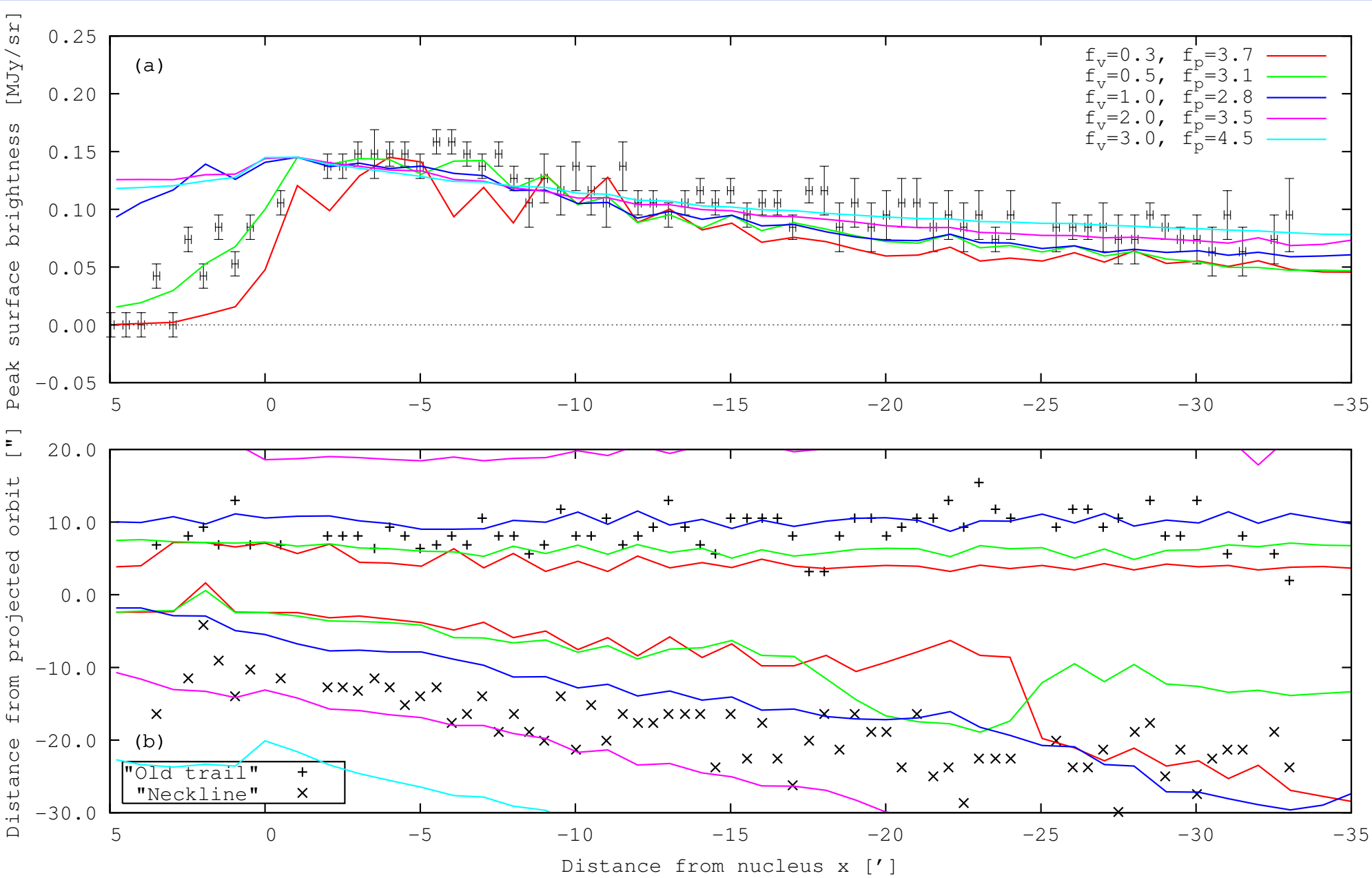
Model

- Dust emission while comet is inside 3 AU. $\rightarrow$ $\beta < 0.01$
- Scattering of visible light: geometric optics.
- Infrared emission: blackbody.
- Comet activity isotropic.
- Dust emission after 1959 (last close encounter with Jupiter).

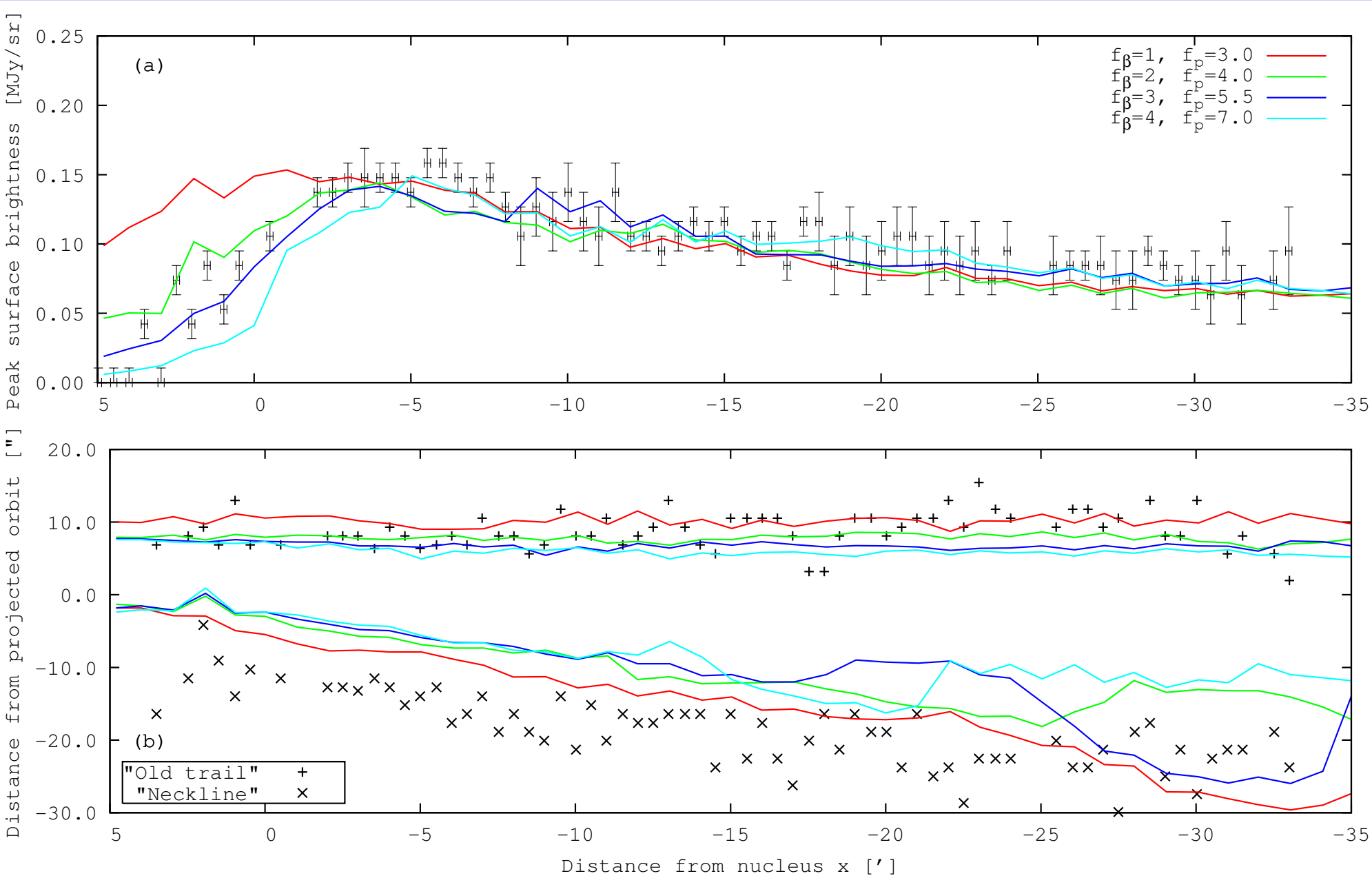
Variable Parameters

- Exponent of dust size distribution α.
- Emission speeds $v(\rho, r_{\mathrm{h}}, s) \rightarrow$ density ρ.
- Radiation pressure parameter $\beta(s) \rightarrow Q_{\mathrm{pr}}/\rho$.
- Dust production rates $Q(s, r_{\mathrm{h}})$.
- Dust albedo.

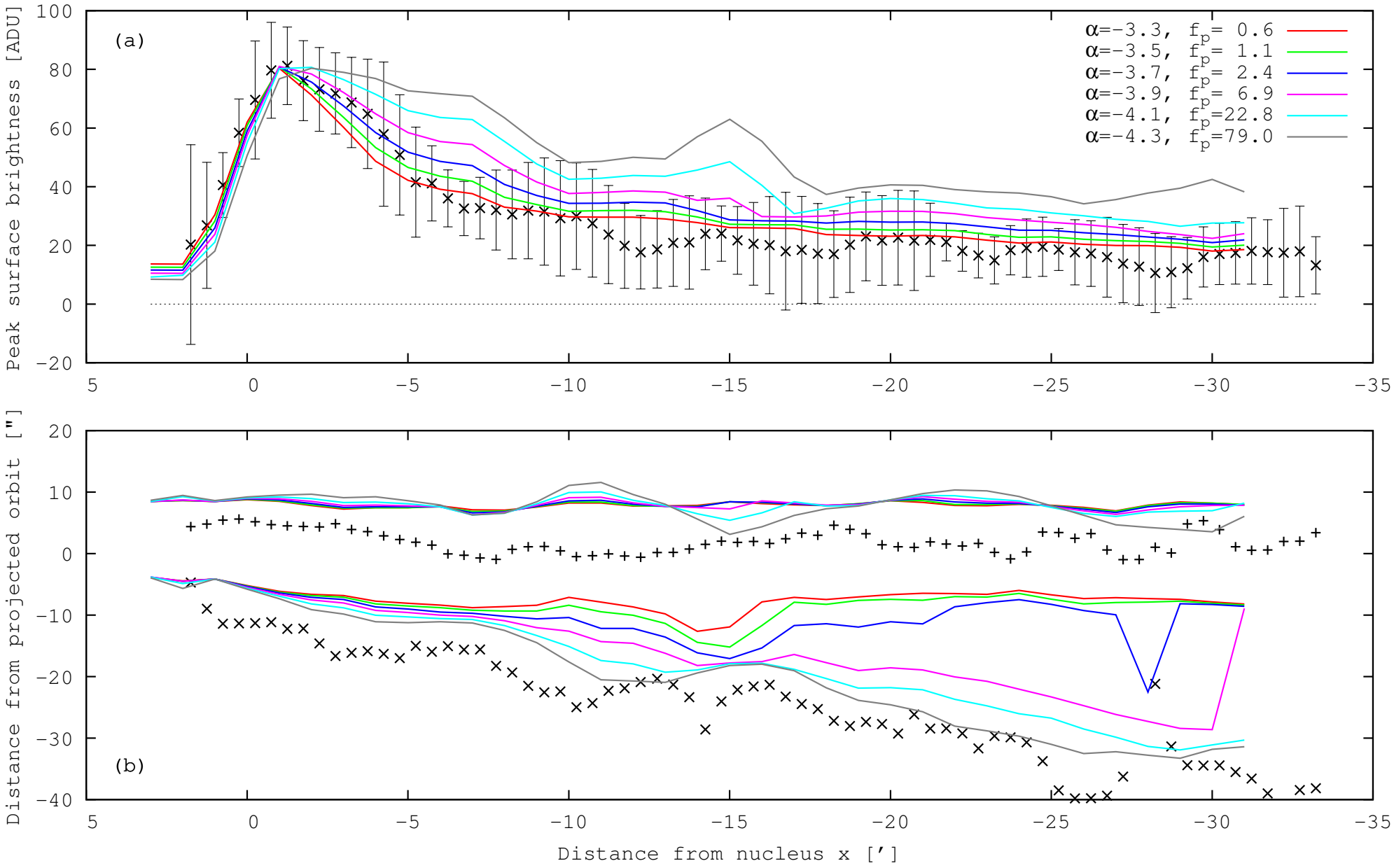
Simulation of the 2006 image – Variation of Speed



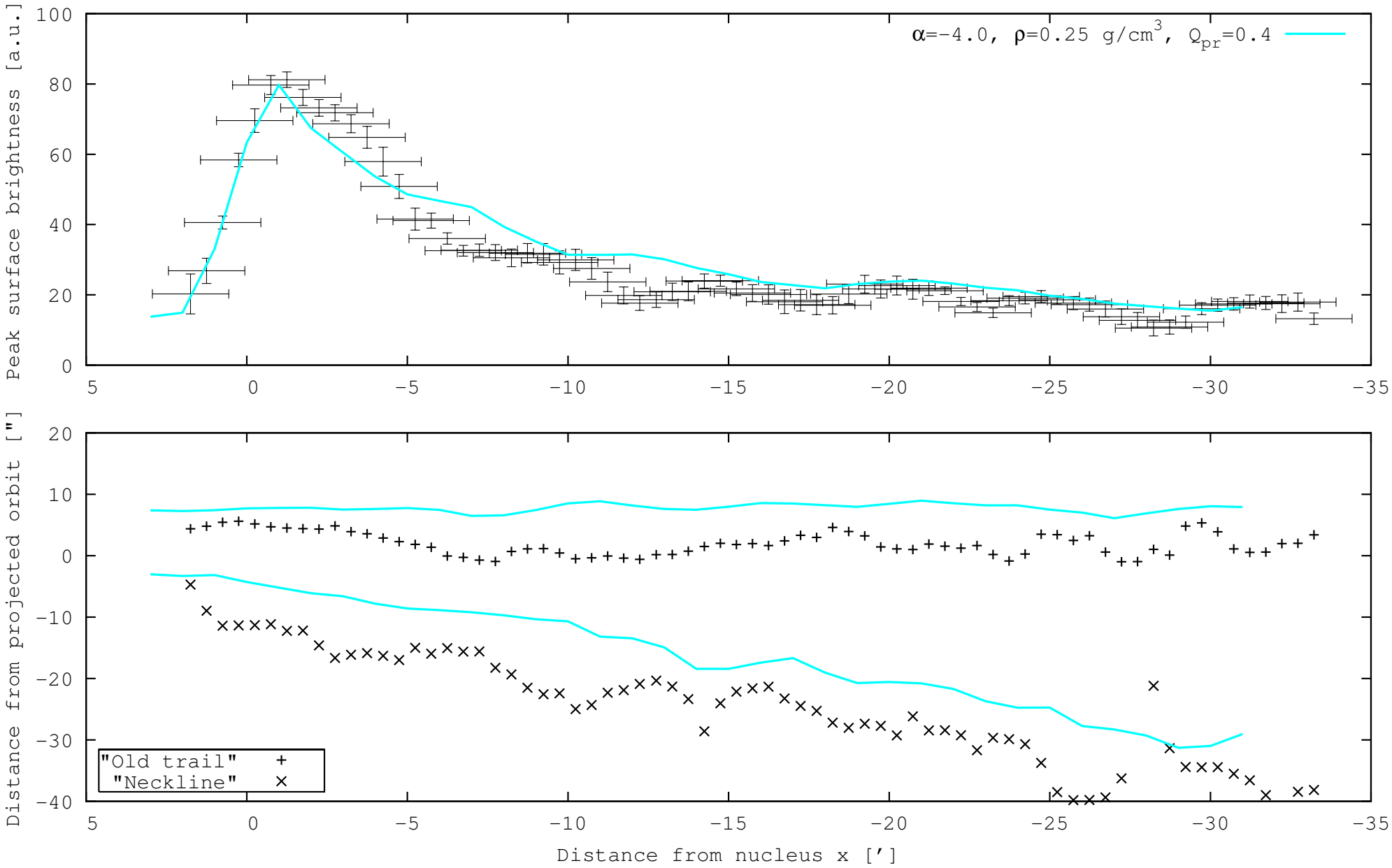
Simulation of the 2006 image – Variation of β



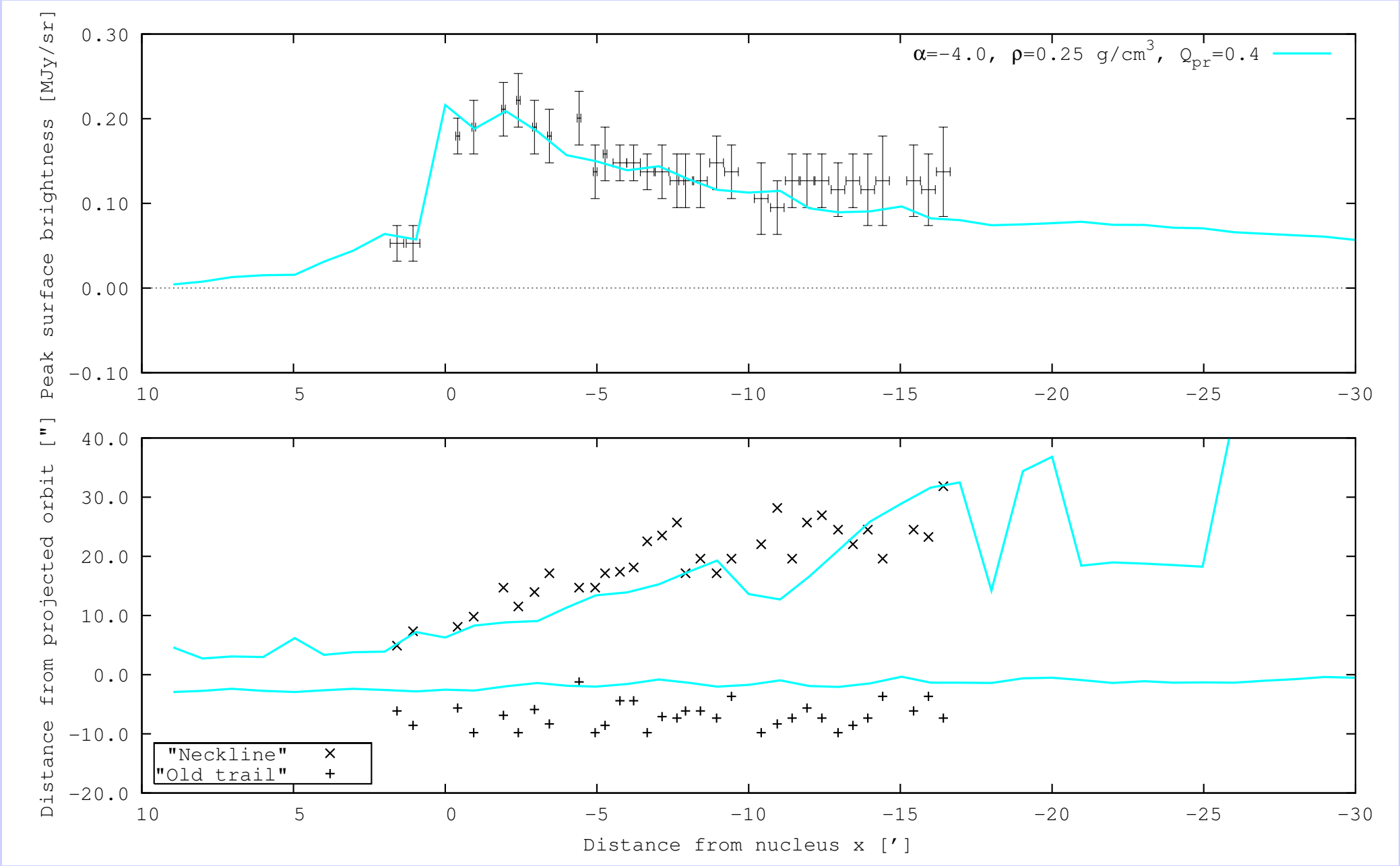
Simulation of the 2004 image – Size Distribution



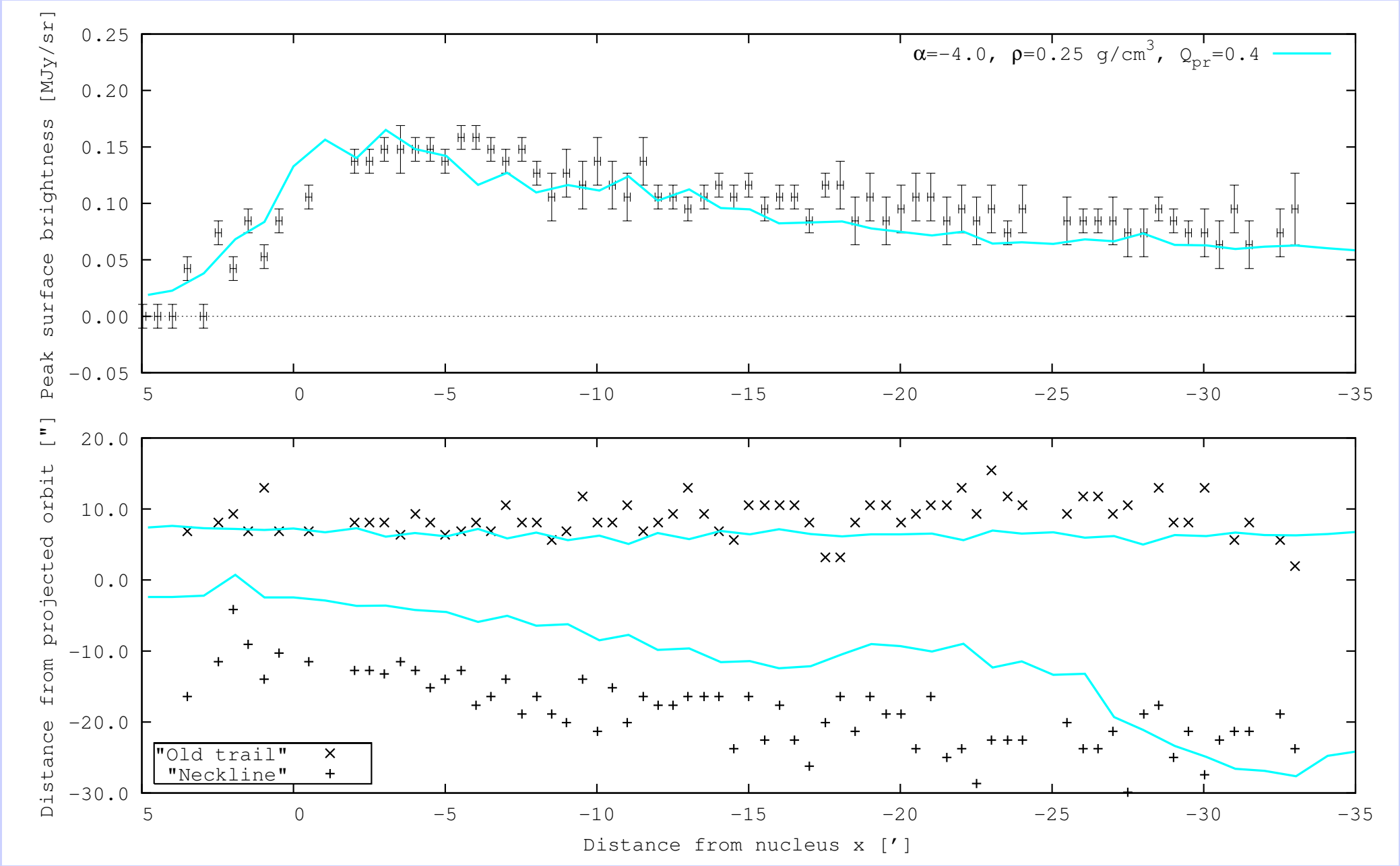
Simulation of the 2004 image



Simulation of the 2005 image



Simulation of the 2006 image



Results

- Images dominated by particles from 2002/03 apparition.
- Exponent of dust size distribution: $-4.1 < \alpha < -3.9$.
- Emission speeds $v(s) \rightarrow$ Density: $0.1\ \mathrm{g/cm^3} < \rho < 0.4\ \mathrm{g/cm^3}$.
- Radiation pressure: $0.3 < Q_{\mathrm{pr}} < 0.5$.
- Dust geometric albedo: 4% (thermal equilibrium) to 9% (IRAS temperature).
- Production rates ($s > 100\,\mu$m): >120 kg/s (perihelion), >1 kg/s (3 AU).

Application to Earlier Data

Date	Telescope	Wavelength	$r_{\rm h}$ [AU]	Reference	Model/Obs
Sep 2002	KISO	R-band	1.3	Ishiguro (2008)	1 (Old trail)
Feb 2003	KISO	R-band	2.2	Ishiguro (2008)	1 (Old trail)
Mar 2003	TNG	R-band	2.6	Fulle et al. (2004)	> 2
2004	Spitzer	24 μm	4.5	Kelley et al. (2008)	1
2004	ESO 2.2m	vis	4.7	Agarwal et al. (2007)	1-2 (definition)
2005	Spitzer	24 μm	5.7	in prep.	1 (definition)
2006	Spitzer	24 μm	5.7	in prep.	1 (definition)

Major Problems

- Visible coma would be dominated by large particles ($s > 100\,\mu$m).
- Model does not reproduce earlier observations.

Discussion

- Non-isotropic activity in the coma?
  - "Insolation-driven" model $\rightarrow$ trail even more narrow.
  - More realistic activity model not yet available.
- Disintegration of trail particles?
  - Should occur in the coma, not after many years.
- Is the coma indeed dominated by large grains?
  - Excess colour temperatures may be due to large, porous particles.
- More complicated dependence of production rate on heliocentric distance?