An accuracy of 5-point Hα (pseudo)spectroscopy of the solar chromosphere observed by a Lyot filter

Background: Pit's serious objection against the use of the 4th-order polynomial in fitting of (pseudo)spectroscopic data

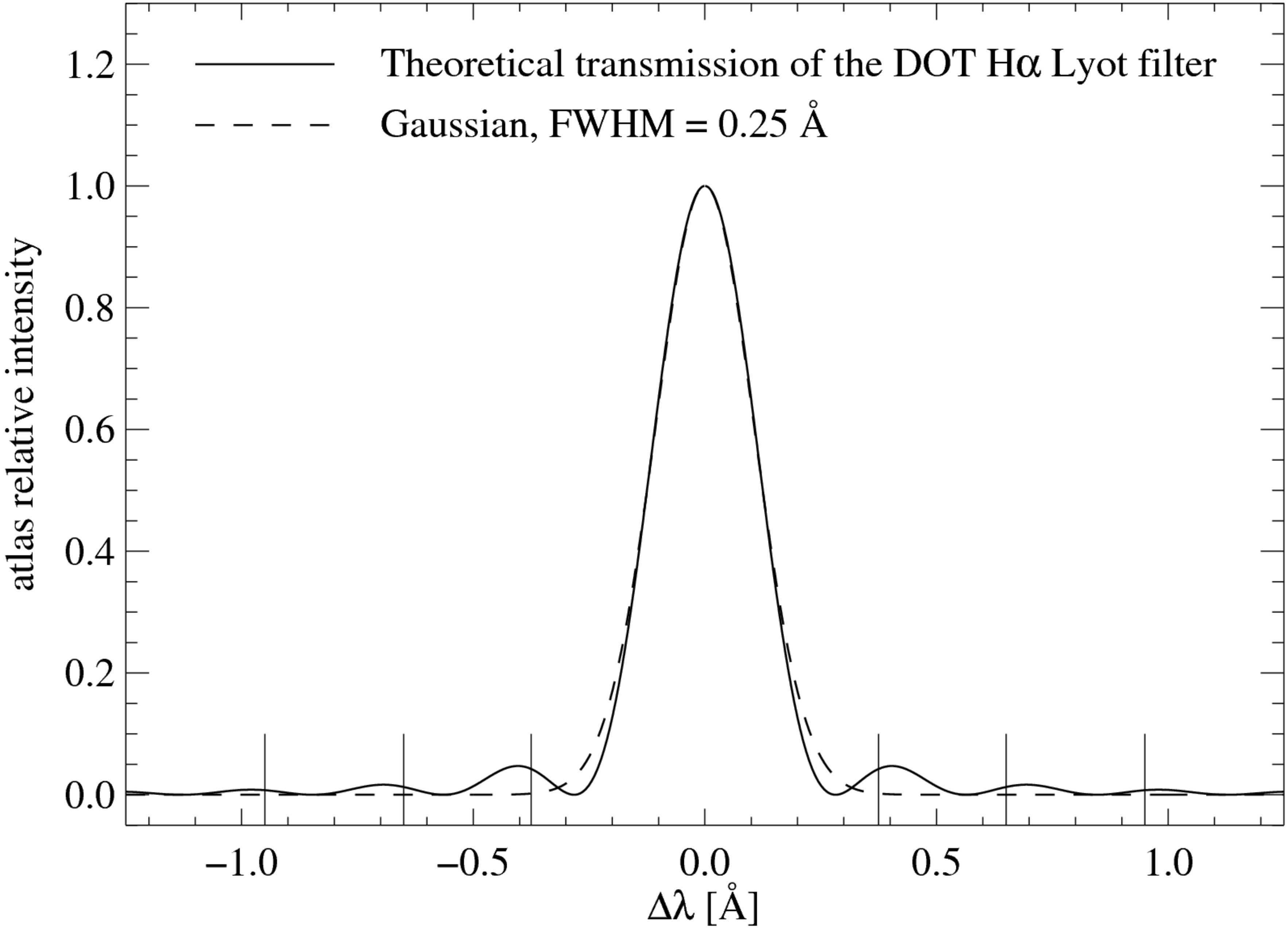
Aim: to react on the objection estimating an accuracy of the spectral characteristics core Dopplershift, intensity, and width derived from 5-point sampling of the Hα spectral line using:

- Gaussian, parabolic, and the 4th-order polynomial fit of the data
- theoretical transmission profile of the Lyot filter in the form $\sin^2 x/x^2$
- atlas Hα profile shifted about known velocities

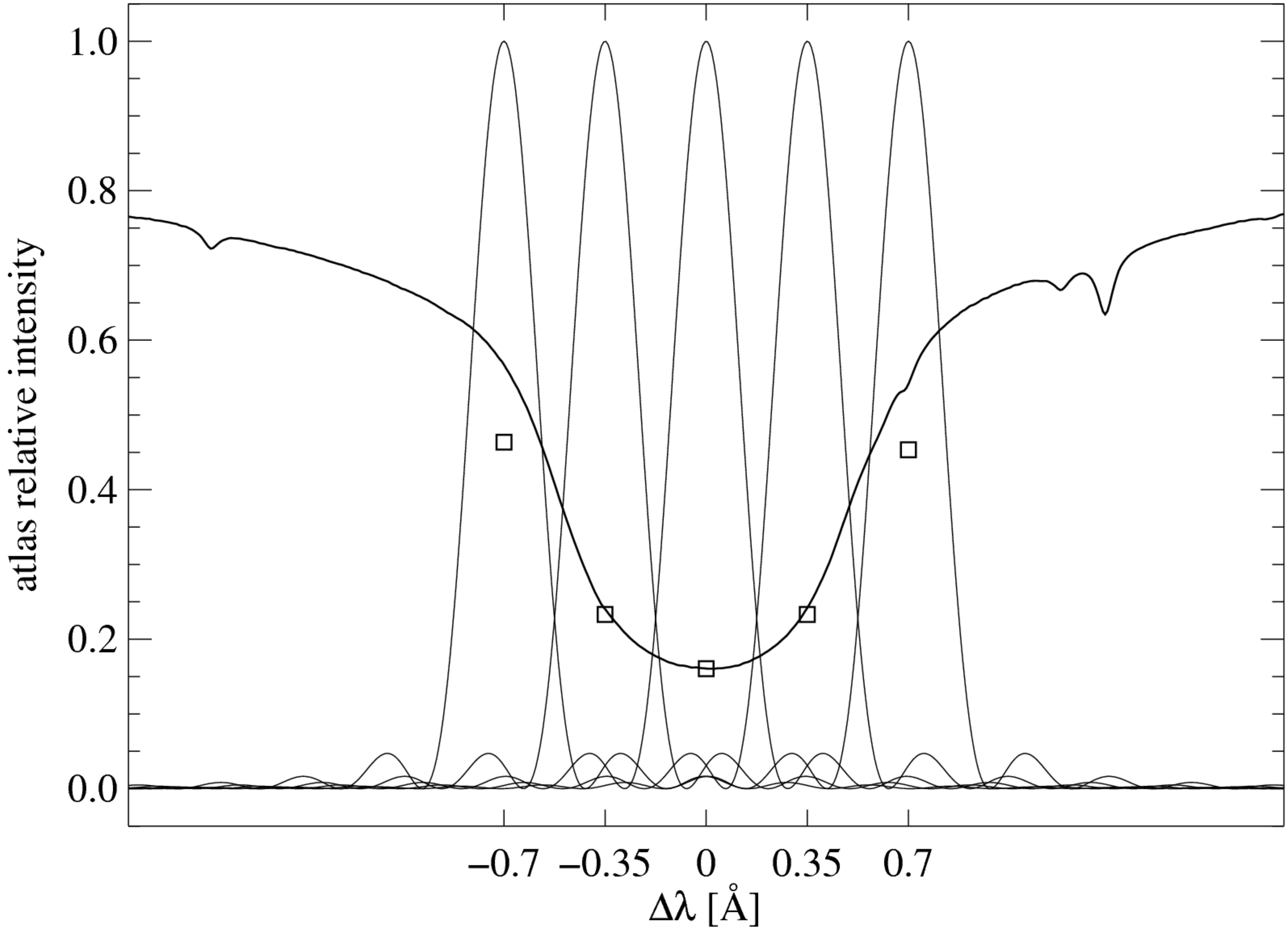
Future improvement: synthetic NLTE Hα profile instead of the atlas profile computed by Rybicki Hummer (RH) code - Han Uitenbroek

Open problem: disagreement between wing-to-core ratios derived from the atlas Hα profile and spatio-temporal mean of the DOT data

Considered transmission profiles



Why (pseudo)spectroscopy ?
5-point sampling !

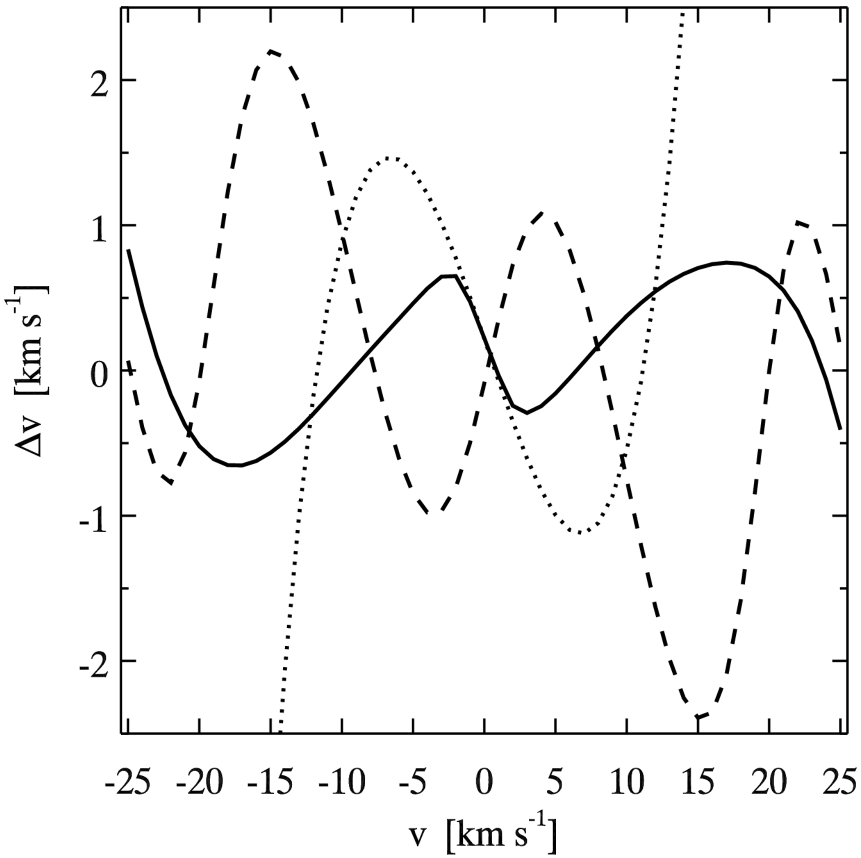


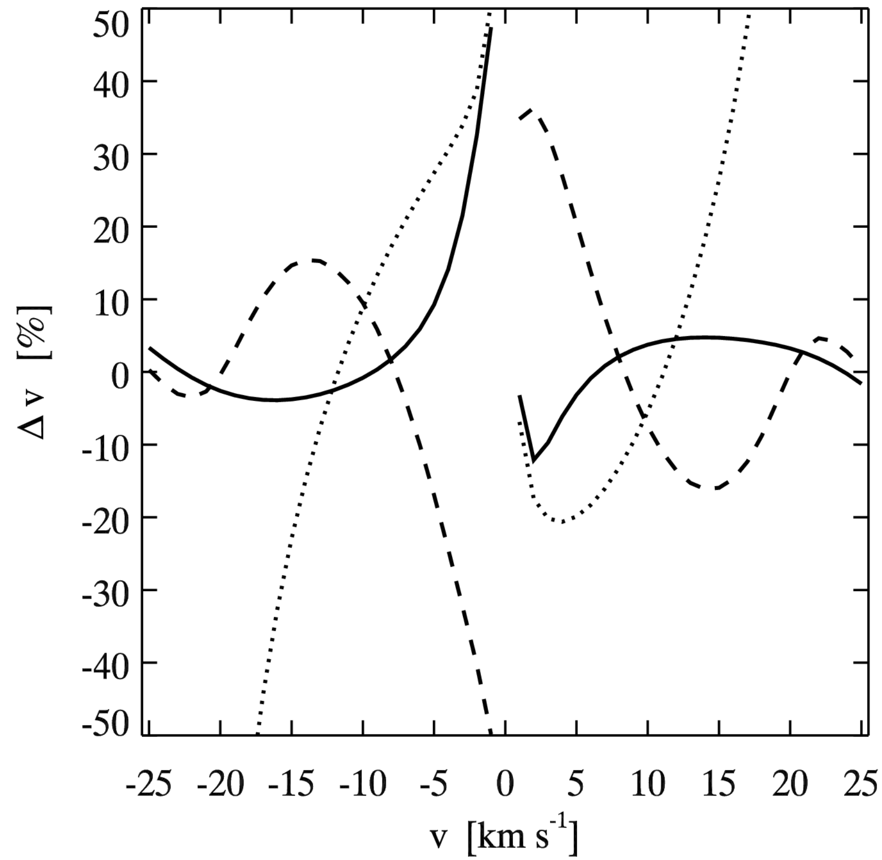
Displays

- data - movie launched by the launcher “1-mosaic”

- polynomial fitting of the data and spectral characteristics
  IDL demo launched by the launcher “2-view-fitting”

- shifting and fitting of the atlas Hα profile
  IDL demo - fig2-sinc.pro

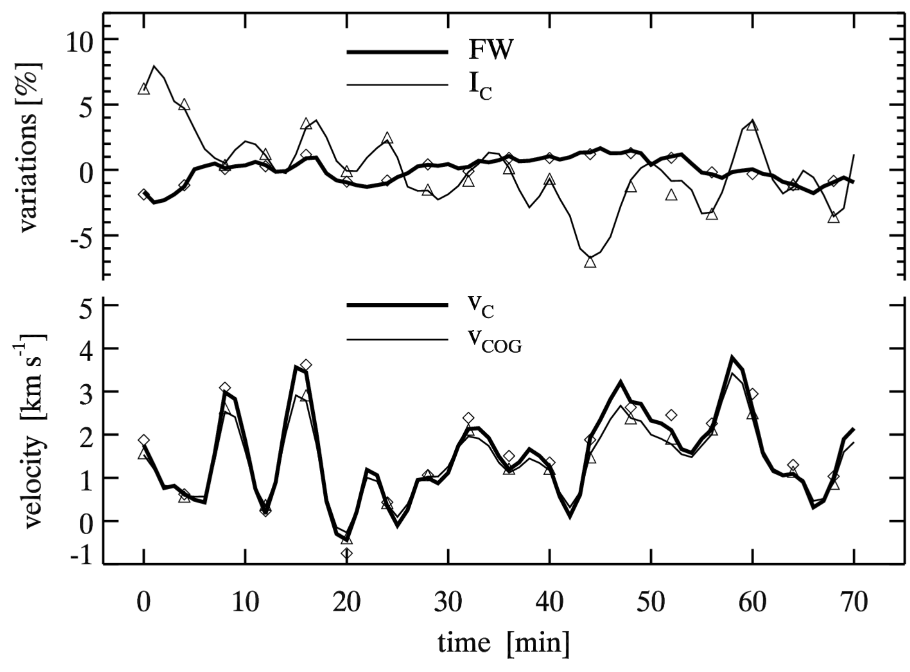




Gaussian

the 4th-order polynomial

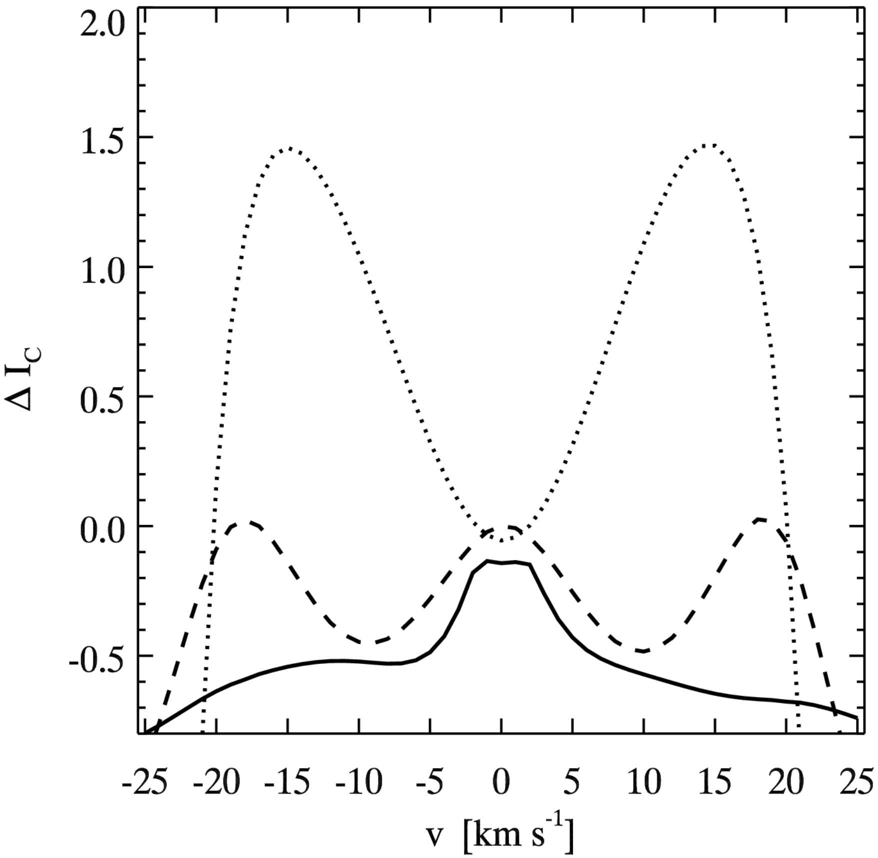
parabola

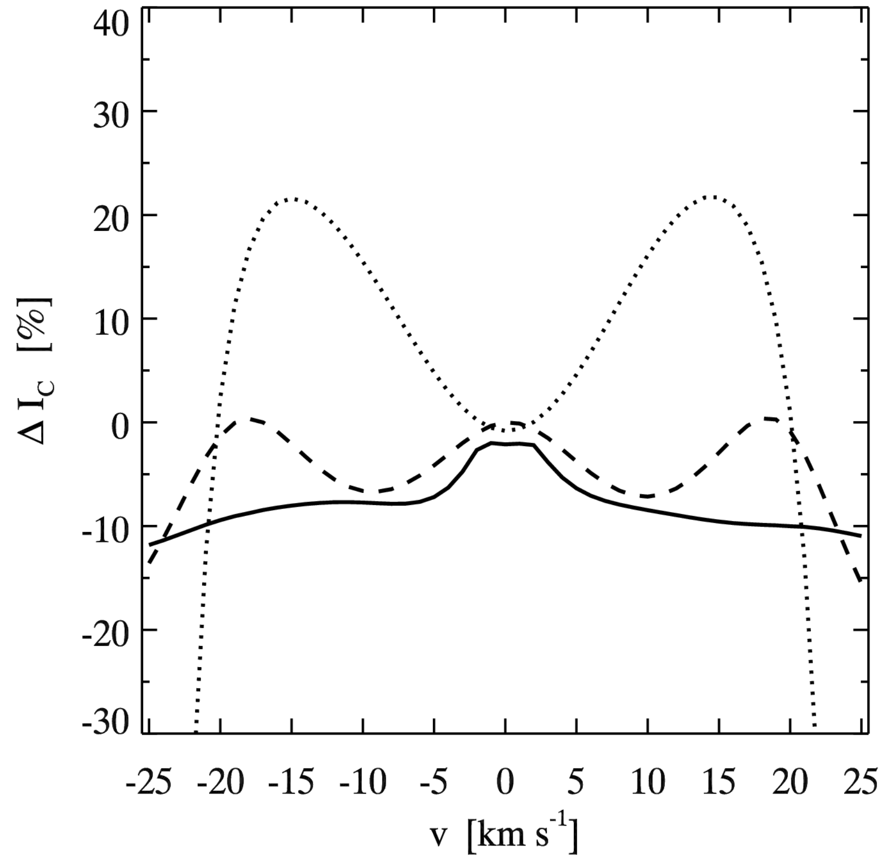


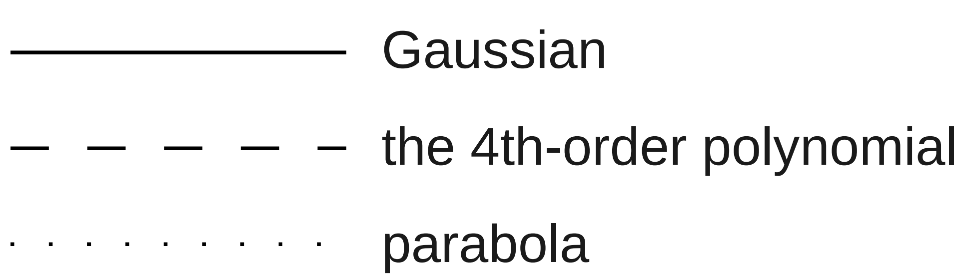
Why I didn't use Gaussian sooner ?

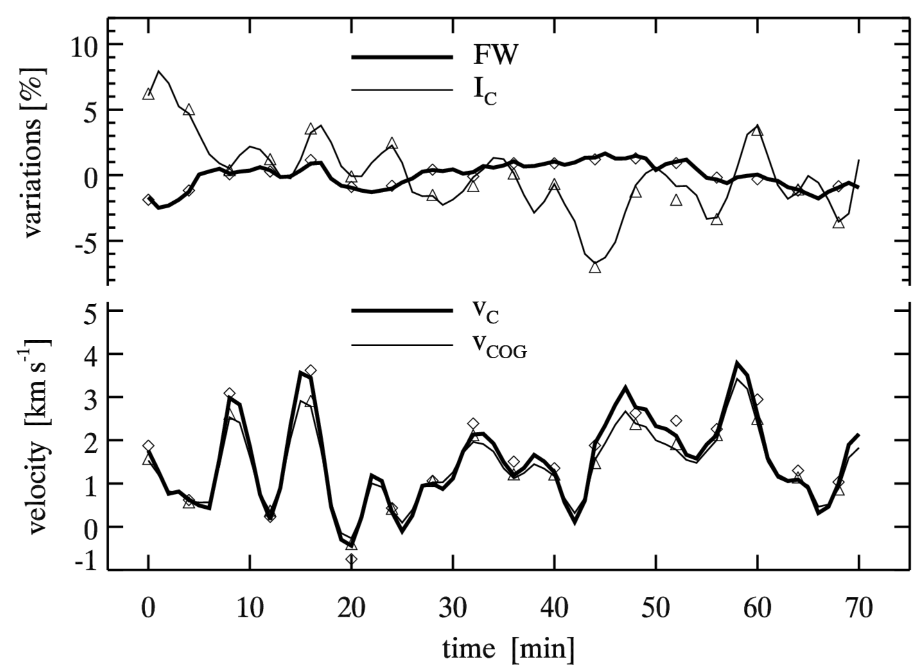
GAUSSFIT.PRO

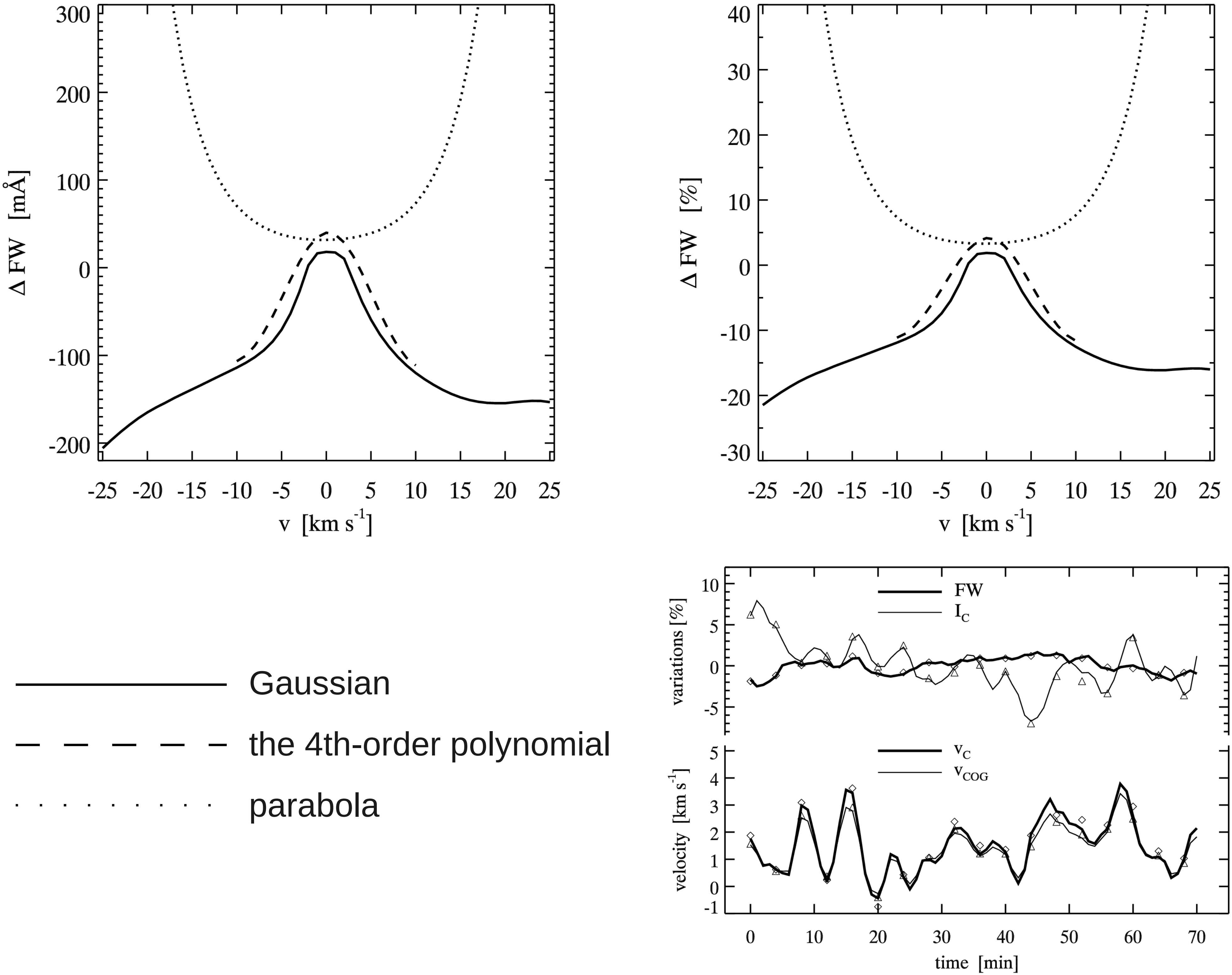
- failed very often when applied on real data without defining an estimated solution
- unclear how to deal with its possible failure and whether GAUSSFIT.PRO has an error mechanism to proceed without crash
- in the network many spots with wild data clearly incompatible with Gaussian


Δ I_C
v [km s^-1]


Δ I_C [%]
v [km s^-1]


Gaussian
the 4th-order polynomial
parabola


FW
I_C
variations [%]
v_C
v_COG
velocity [km s^-1]
time [min]



300
200
100
0
-100
-200
Δ FW [mÅ]
-25 -20 -15 -10 -5 0 5 10 15 20 25
v [km s^-1]
40
30
20
10
0
-10
-20
-30
Δ FW [%]
-25 -20 -15 -10 -5 0 5 10 15 20 25
v [km s^-1]
Gaussian
the 4th-order polynomial
parabola
FW
I_C
variations [%]
10
5
0
-5
v_C
v_COG
velocity [km s^-1]
5
4
3
2
1
0
-1
0 10 20 30 40 50 60 70
time [min]

Some results and consequences

Velocity

- **Gauss, polynomial, parabola:** large and rapid changing errors in the range ±5 km/s
- **Gauss, polynomial:** both deliver plausible results out of the range ±5 km/s with relatively small errors.
- **Gauss:** seems to perform slightly better than polynomial with errors less than ±1 km/s and with much smaller error variations than polynomial.
- **parabola:** rapidly increasing errors at velocities larger than ±15 km/s but these are very rare in the network. These seemingly large errors might be due to the behavior of the $I_{\pm 0.7}$ points of the oversimplyfing atlas profile at large velocities. This behavior not seen in real data at large velocities.

Upshot: safer to focus on large velocities determined either by polynomial or Gaussian suffering smaller errors and error variations.

Answer to Pit: polynomial performs at least as good as parabola in velocity measurements but Gaussian is a better choice.

Some results and consequences

Core intensity I_C

- **Gauss:** underestiamtes I_C systematically; error mostly less than 10%. Large error variations in the range ±5 km/s, error almost constant out of this range.

- **polynomial:** also underestimates systematically with error mostly less than 10%. Large error variations over the whole range of velocities.

- **parabola:** overestimates I_C up to 20%. Unclear behavior at velocities larger than ±15 km/s do to the same reason explained in previous slide. Large error variations in the range ±5 km/s.

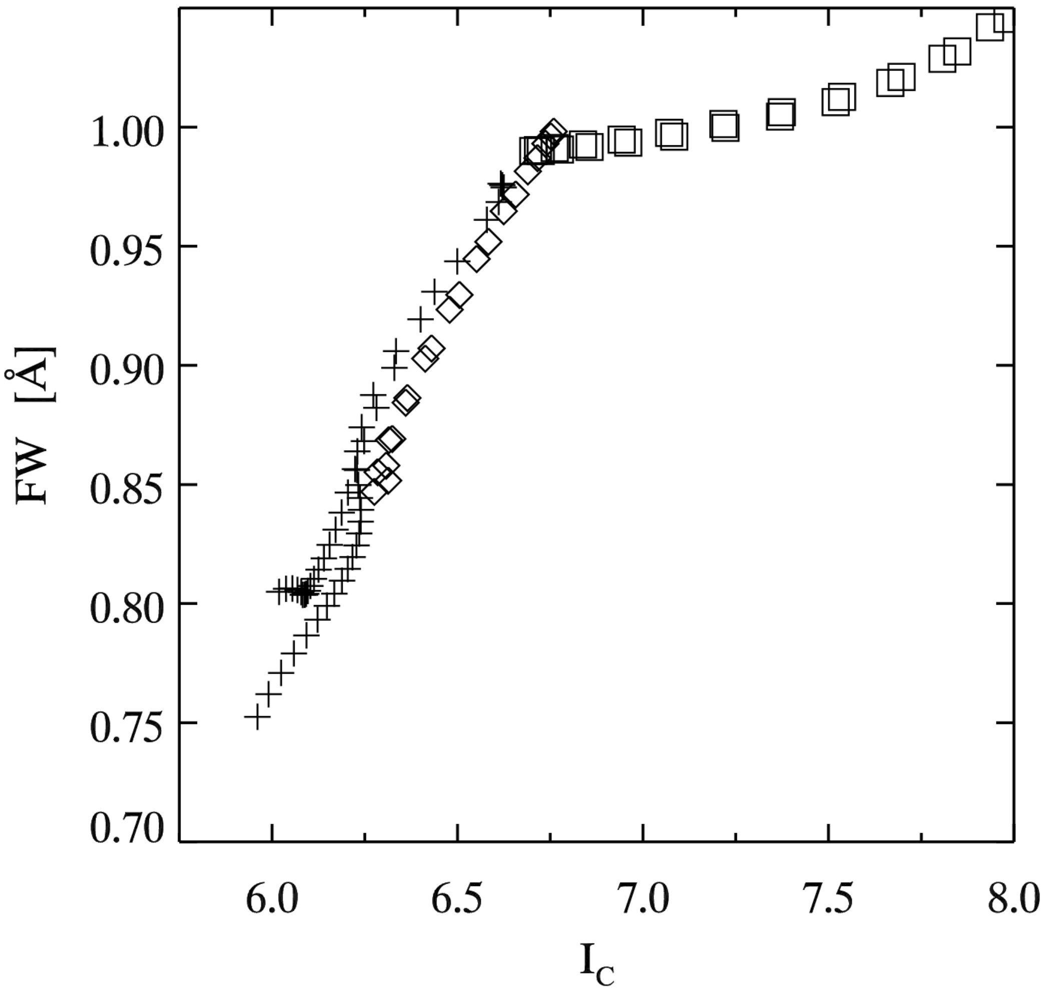
Answer to Pit: polynomial can be safely used in determination of the core intensity in broad range of velocities but Gaussian would be a better choice.

Some results and consequences

Core with *FW*

- **Gauss:** underestimates *FW* systematically; error up to 20%. Again, large error variations in the range ±5 km/s.
- **polynomial:** also underestimates systematically with large error variations in the range ±5 km/s. Unclear behavior at velocities larger than ±10 km/s due to undulation of polynomial fit at the $I_{\pm 0.7}$ points at large velocities.
- **parabola:** overestimates I_C systematically. Unclear behavior at velocities larger than ±15 km/s do to the same reason explained previously.

Consequence: artificial FW-Ic correlation



plus - Gaussian

diamond - polynomial

square - parabola

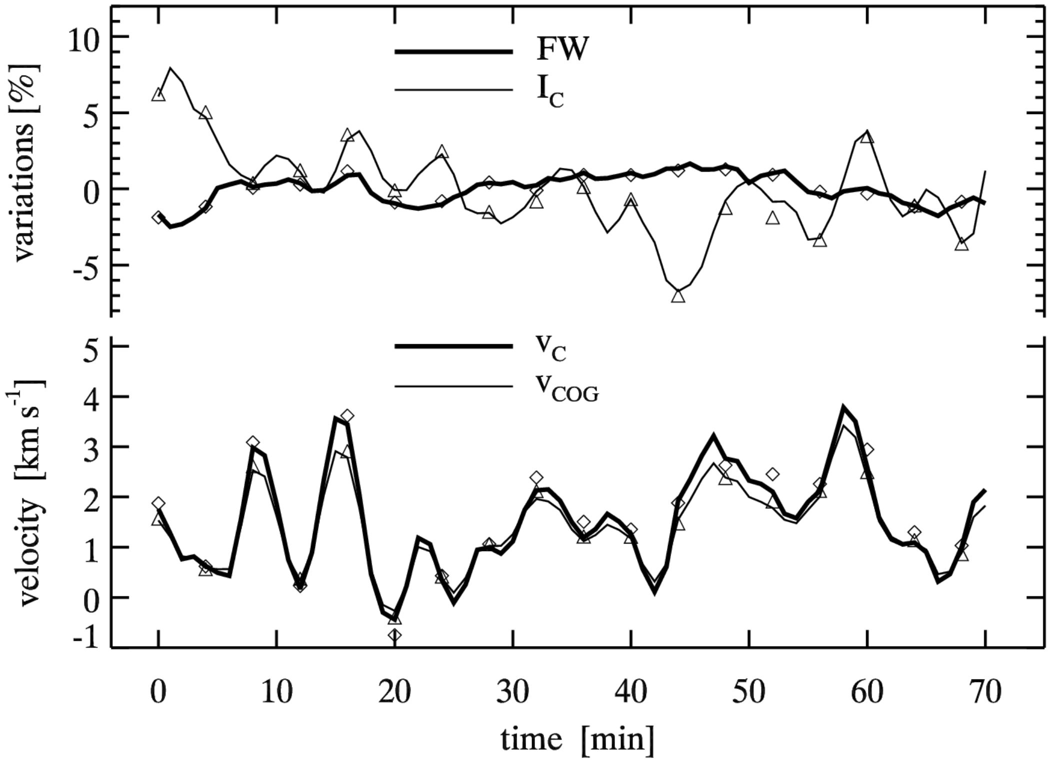
General upshots

- in a given velocity range, spectral characteristics of a target should display variations significantly larger than error variations of the method itself in the same velocity range. Otherwise, one can not be sure whether variations are real or just artificial due to the method.

- the velocity range ±5 km/s is a very problematic, since errors of all characteristics vary much in this range.

- Gaussian displays small error variations at velocities larger than ±5 km/s

- large velocities suffer much smaller methodic errors than the small one



What next

- the RH (Rybicki-Hummer) code is ready to use (demo)
- RH knows NLTE polarized radiative transfer
- grid of synthetic NLTE Hα profiles in the range of velocities $\pm$25 km/s added to the FALC model
- redo plots, consider asymmetry (one-point bisector, center of gravity) and their errors
- an attempt to answer:
  Can be used the 4th order polynomial fitting of the Hα (pseudo)spectroscopy in determination of Hα asymmetry through one-point bisector and the center of gravity
- paper – CAOSP or some other journal ?

spatio-temporal means of intensities over large areas of internetwork	DOT Hα data 19 October 2005 (28 September 2007)	Atlas Hα profile + Gaussian transmission profile	Atlas Hα profile + Sinc^2 transmission profile
$<I_{\pm 0.7}> / I_{center}$	2.35 (2.34)	3.28	2.86
$<I_{\pm 0.7}> / <I_{\pm 0.35}>$	1.73 (1.75)	2.10	1.97
$<I_{\pm 0.35}> / I_{center}$	1.36 (1.34)	1.56	1.45

/home/koza/idl/pub/2012/ceab-internetwork/internetwork/internetwork.pro
/home/koza/idl/dot/2005-10-19/ha-atlas+filter.pro

Possible explanation:

Possible non-linearity of the older DOT Hα camera ? NOT !
Problem persists also with the new camera.

Characteristic of the transmission profile of the DOT Hα Lyot filter given in its source paper (Gaizauskas 1976) **differs** from the real transmission profile, which may be broader than 0.25 Å with sidelobes having larger amplitudes and shifted farther from the central peak and thus transmitting more parasitic light.

Consult the problem with the Dutchmen ? Write about it in Discussion ?

APVV

- two emails - no answer yet from Nikola Vitas
- ValMez seminar v Horní Bečve – Anatómia Slnka