Line-Strength Indices in Globular Clusters of NCG 3585

Joana Ascenso
Boriana Ivanova
Lucia Ballo
Jose Luis Cervantes
Nicolas Cardiel

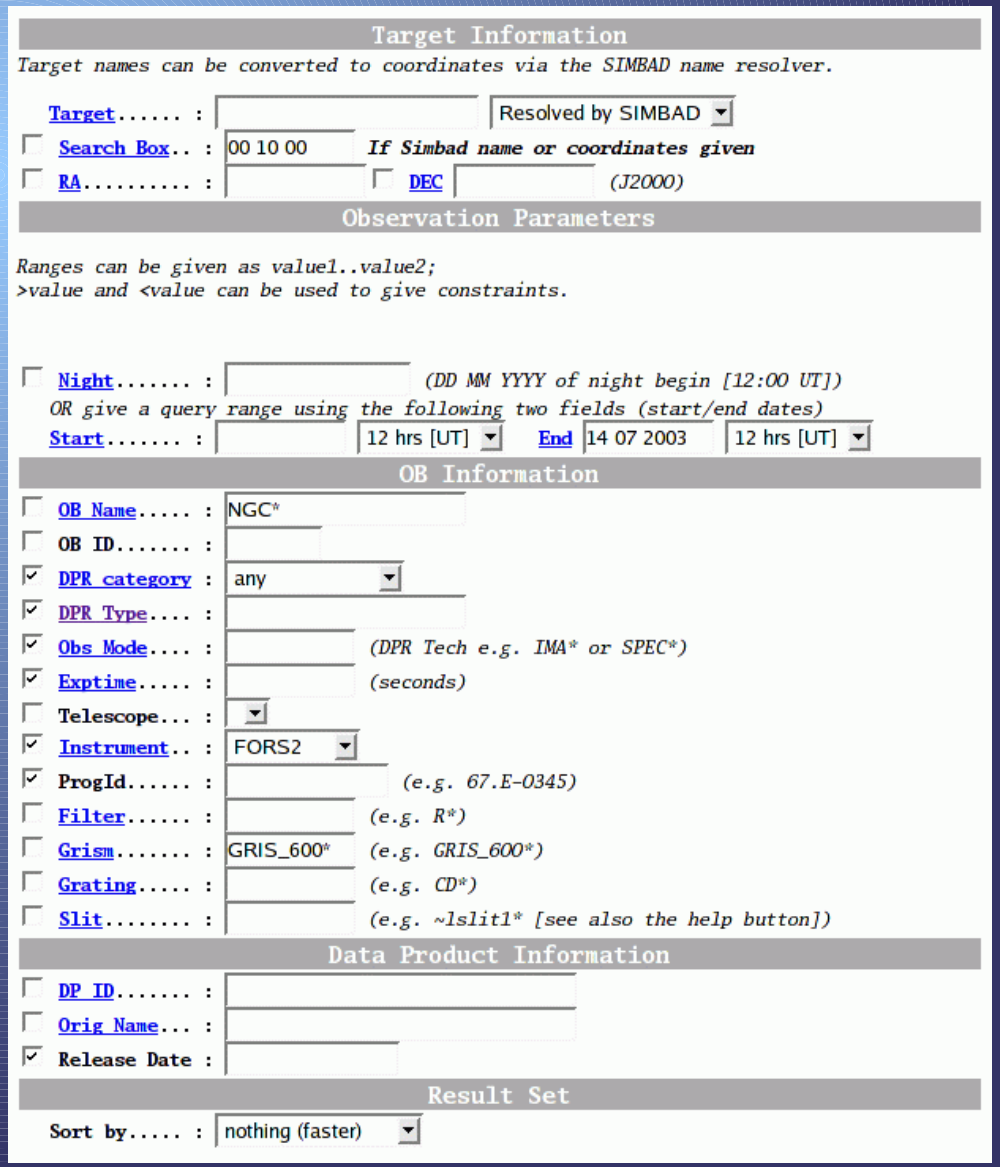
Outline

- Introduction
- General ideas about the computation of random errors in data processing
- Data reduction
- Analysis

Our work...

- Measure line-strength indices (absorption features) in spectra of extragalactic globular clusters
  - Metallicity and age indicators (from models)
  - Star formation history of the host galaxy
- Searched the ESO archive for spectra of early type objects (old stellar populations)
  - Bright (NCG) VLT, FORS2 spectroscopic data

Query



Target Information

Target names can be converted to coordinates via the SIMBAD name resolver.

Target..... : [ ] Resolved by SIMBAD

☐ Search Box.. : 00 10 00 *If Simbad name or coordinates given*

☐ RA..... : [ ] ☐ DEC [ ] *(J2000)*

Observation Parameters

Ranges can be given as value1..value2;
>value and <value can be used to give constraints.

☐ Night..... : [ ] *(DD MM YYYY of night begin [12:00 UT])*

OR give a query range using the following two fields (start/end dates)

Start..... : [ ] 12 hrs [UT] End 14 07 2003 12 hrs [UT]

OB Information

☐ OB Name..... : NGC*

☐ OB ID..... :

☑ DPR category : any

☑ DPR Type.... :

☑ Obs Mode.... : *(DPR Tech e.g. IMA* or SPEC*)*

☑ Exptime..... : *(seconds)*

☐ Telescope... :

☑ Instrument.. : FORS2

☑ ProgId..... : *(e.g. 67.E-0345)*

☐ Filter..... : *(e.g. R*)*

☐ Grism..... : GRIS_600* *(e.g. GRIS_600*)*

☐ Grating..... : *(e.g. CD*)*

☐ Slit..... : *(e.g. ~lslit1* [see also the help button])*

Data Product Information

☐ DP ID..... :

☐ Orig Name... :

☑ Release Date :

Result Set

Sort by..... : nothing (faster)

Identified one project from the archive

ESO Observing Programmes

Archive Facility HOME | ESO HOME | Form INFO

Define new query

67.B-0034(B) on 25 May 2001, VLT-Kueyen

Period	67
Mode	Visitor
Nights	4
Instrument	FORS2
Observer	Puzia
PI/CoI	Kissler-Patig/ Bender/ Maraston/ Puzia/ Saglia/ Thomas
Remarks	
Title	*The chemistry of extra-galactic globular clusters and its link to the star-formation history of early-type galaxies*

ESO HOME | ST-ECF HOME | Help | Search

wdb 1.9c - 7-Jan-2004 ..... Send

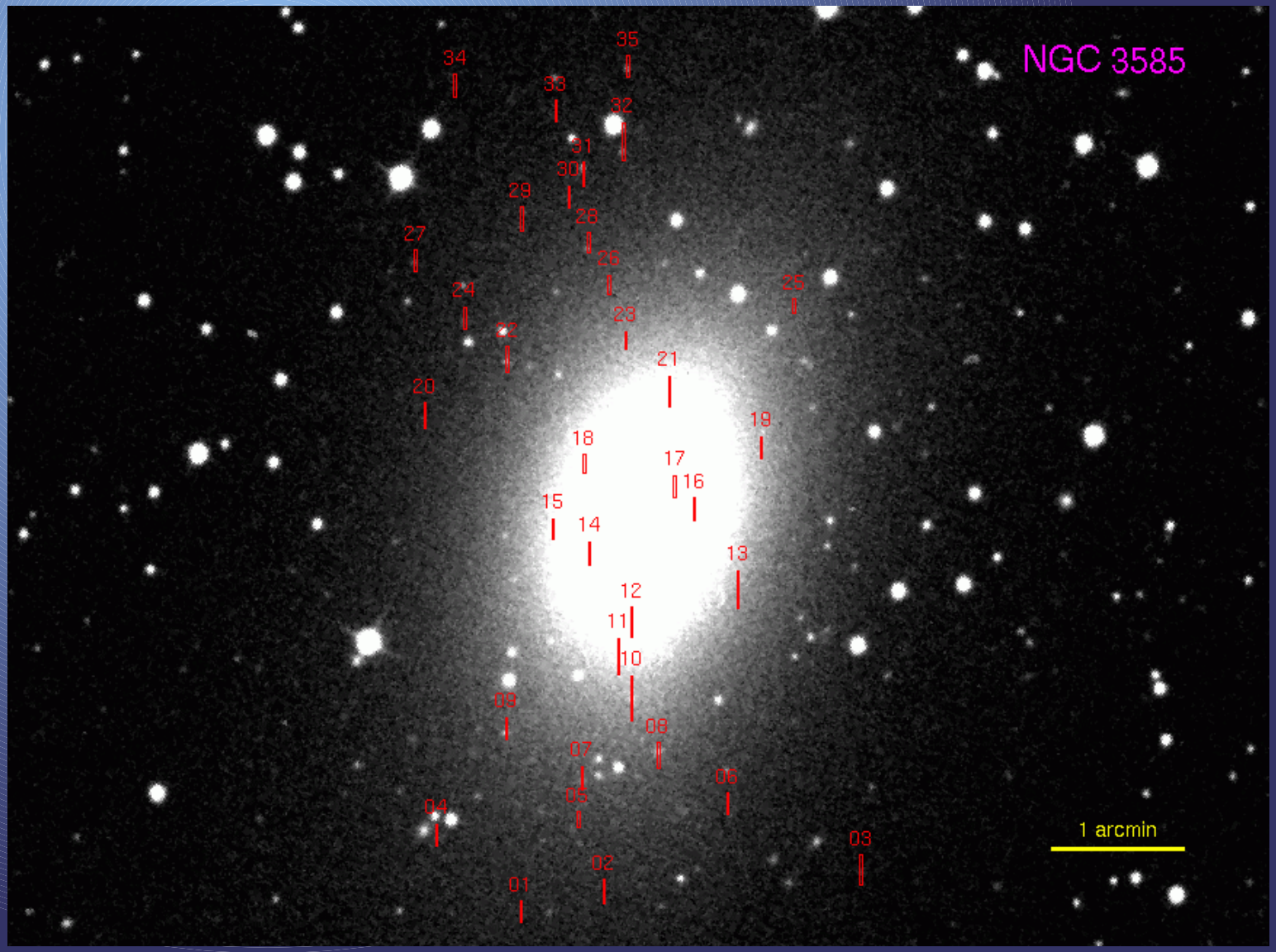
comments to visas@eso.org

Data

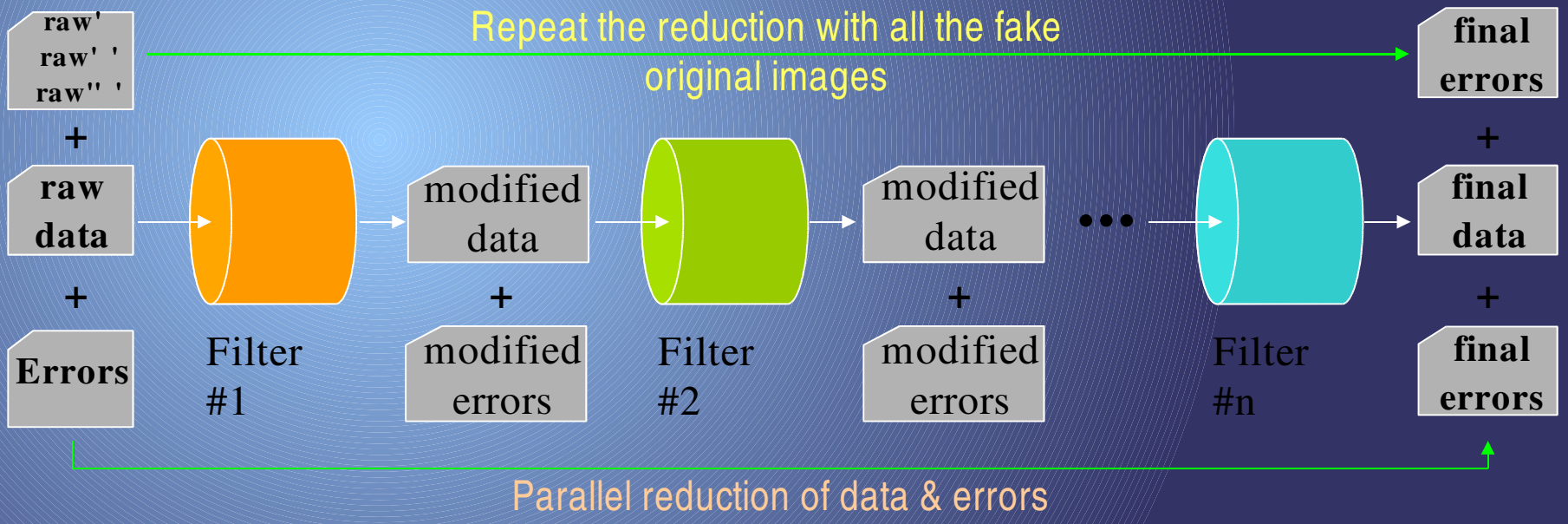
- Searched ADS for publications with the data from the project (Puzia et al. 2004, A&A, 415, 123)
- Retrieved data from archive for one of the galaxies in the project
  - NGC 3585 – elliptical galaxy (E7)
  - Radial velocity ~ 1500 km/s (z = 0.0047)
  - 35 candidates to globular clusters

⌋ mask with 35 slits

Targets


NGC 3585
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
09
08
07
06
05
04
03
02
01
1 arcmin

Typical data reduction



How to quantify random errors?

- Comparison of several (many if possible) independent measurements — **Expensive!**
- First principles (gain, readout noise), generate several fake original images, and repeat the reduction many times — **Expensive!**
- First principles and a parallel reduction of data and errors. However one needs an appropriate software. Here we have used **REDUCEME**

Computing random errors

- The arrival of photons to the detector follows a Poissonian distibution

$$\sigma_\gamma = \sqrt{N_\gamma}$$

- The photo-electrons generated in the detectors do also follow a similar distribution

$$\sigma_\mathrm{e} = \sqrt{N_\mathrm{e}}$$

- The expected error in the number of counts is then

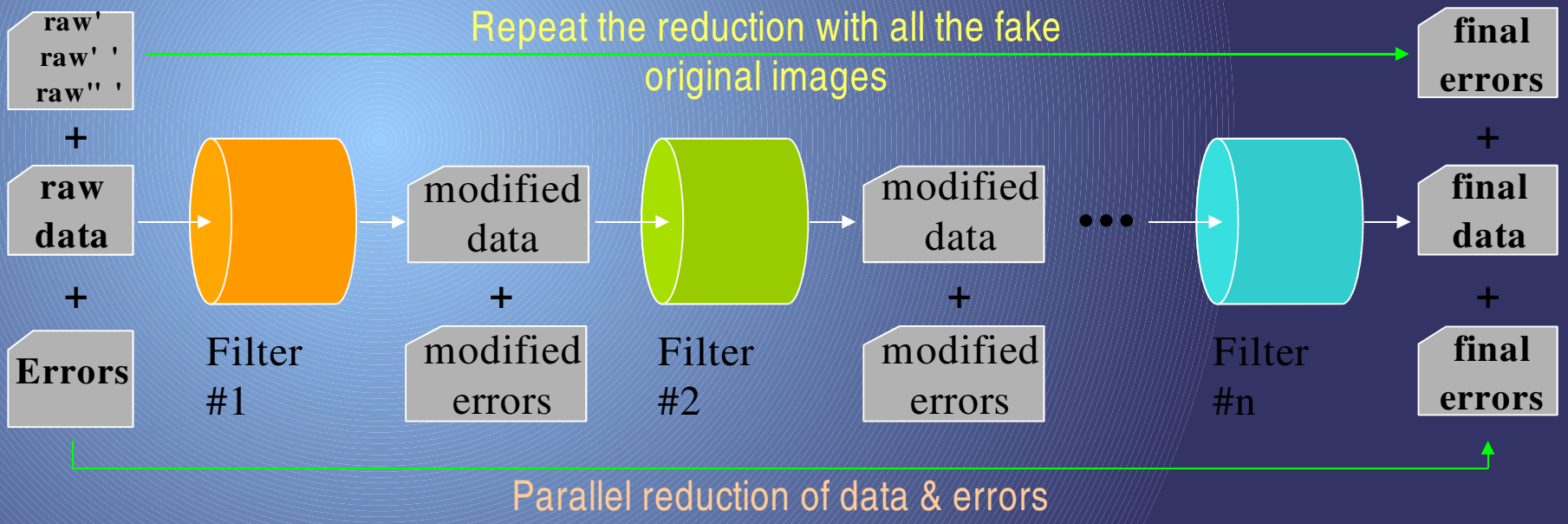
$$\sigma_\mathrm{c} = \sqrt{\frac{1}{g} N_\mathrm{c}}$$

where g is the gain (electrons/ADU).

- In the presence of readout noise, the total error in the number of counts is

$$\sigma_\mathrm{c} = \sqrt{\frac{1}{g} N_\mathrm{c} + \mathrm{RN}^2}$$

Typical data reduction



How to quantify random errors?

- Comparison of several (many if possible) independent measurements — **Expensive!**
- First principles (gain, readout noise), generate several fake original images, and repeat the reduction many times — **Expensive!**
- First principles and a parallel reduction of data and errors. However one needs an appropriate software. Here we have used **REDUCEME**

Data Reduction

- Basic reduction
  - Bias
  - Dark
  - Flatfielding
- Wavelength calibration
- Correction of geometric distortions
- Atmospheric extinction
- Sky subtraction
- Flux calibration
- Spectra extraction

Methodology

The analysis has been performed using the REDUCE package; in the last few days we wrote 53 scripts, because....

"We don't want to type the same command more than once"

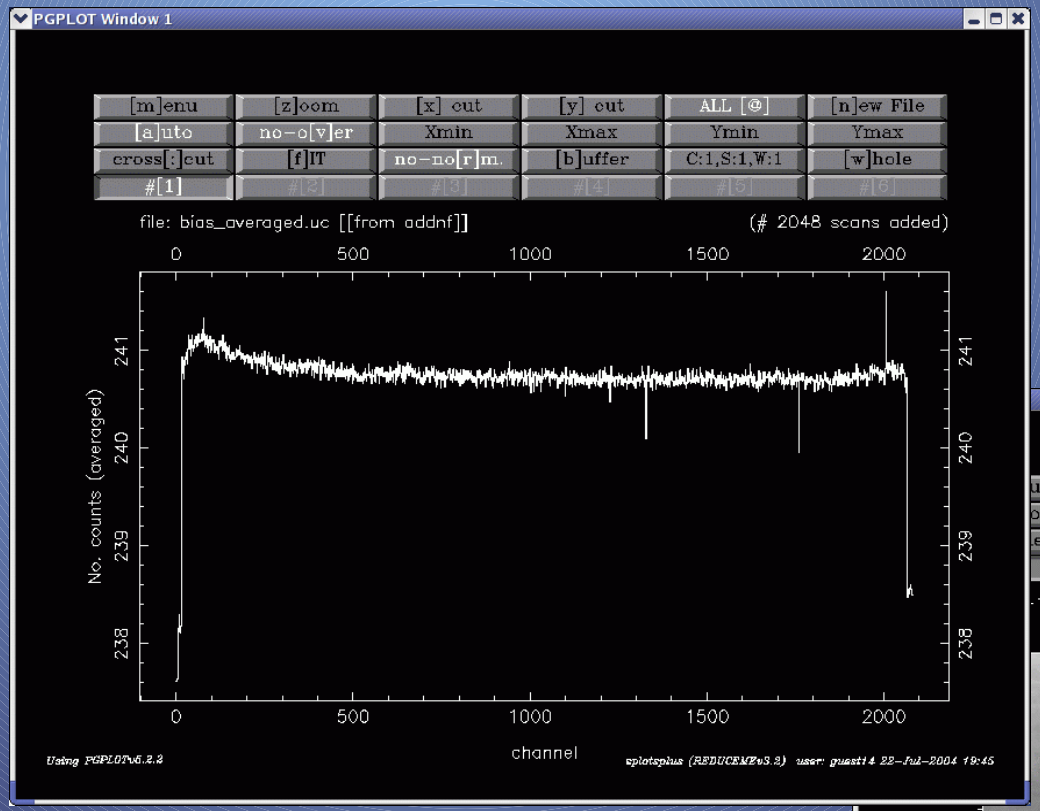
(Nicolas, 2004)

pippo.txt - /export/diska/ngc3585/

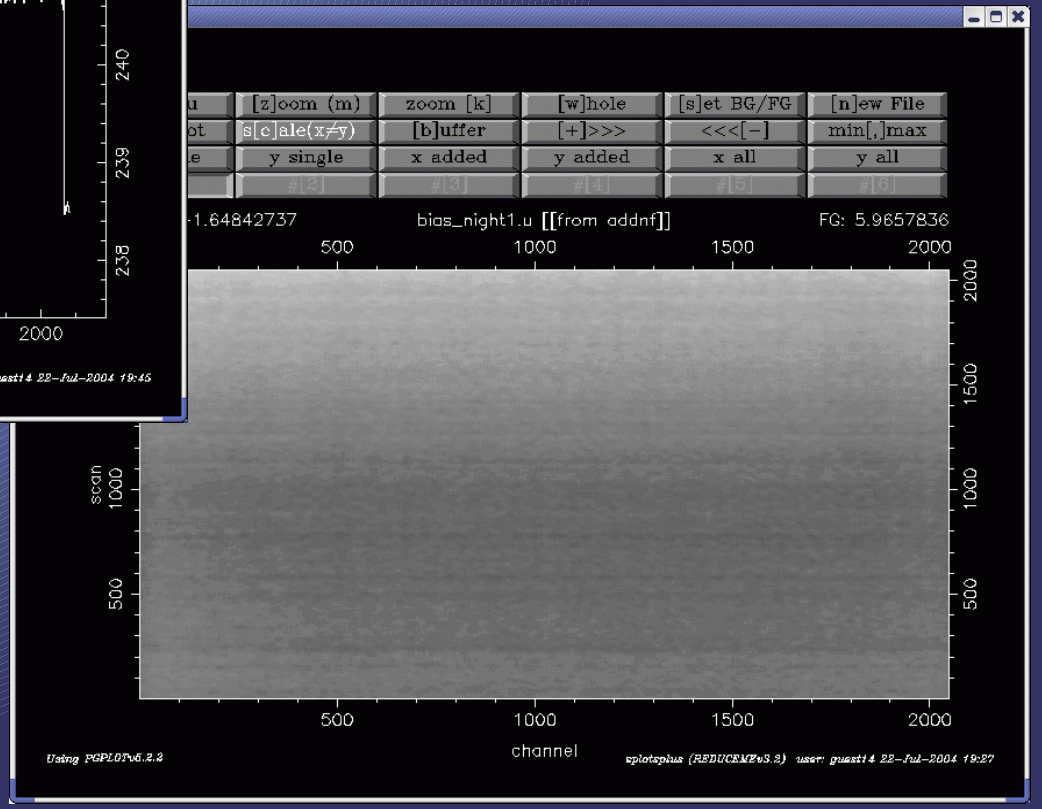
File Edit Search Preferences Shell Macro Windows Help

```
 1 night0/enlarge_std.tcsh                 night4/basicred_science.tcsh
 2 night0/extrapolate_std.tcsh             night4/reduce_bias_night4.tcsh
 3 night0/reduce_dark.tcsh                 night4/rename_night4.tcsh
 4 night0/reduce_std.tcsh                  nightn/addnf_science.tcsh
 5 night0/resample_std.run                 nightn/cleanest.tcsh
 6 night0/resample_std.tcsh                nightn/clean_science_sky.run
 7 night1/basicred_science.tcsh            nightn/clean_science_sky.tcsh
 8 night1/reduce_bias_night1.tcsh          nightn/corrext.tcsh
 9 night1/rename_night1.tcsh               nightn/create_bigslit_noerrors.
10 night2/basicred_flatfield.tcsh          nightn/create_bigslit.tcsh
11 night2/basicred_science.tcsh            nightn/create_slit.tcsh
12 night2/basicred_wave.tcsh               nightn/flux_calibrate.tcsh
13 night2/calambda.tcsh                    nightn/index.tcsh
14 night2/calibrate_slit_1st.tcsh          nightn/interpcol.tcsh
15 night2/calibrate_slit_2nd.tcsh          nightn/measure_z.run
16 night2/calibrate_slit.run               nightn/measure_z.tcsh
17 night2/clean_flat.tcsh                  nightn/rebincw_science.run
18 night2/clean_wave.tcsh                  nightn/rebincw_science.tcsh
19 night2/collagee.tcsh                    nightn/resample_k0III.run
20 night2/collage.tcsh                     nightn/resample_k0III.tcsh
21 night2/normalise_flat.tcsh              nightn/sdistor_science.run
22 night2/preflat.tcsh                     nightn/sdistor_science.tcsh
23 night2/reduce_bias_night2.tcsh          nightn/skysubm_science.run
24 night2/rename_night2.tcsh               nightn/skysubm_science.tcsh
25 night3/rename_night3.tcsh
```

Bias Frame

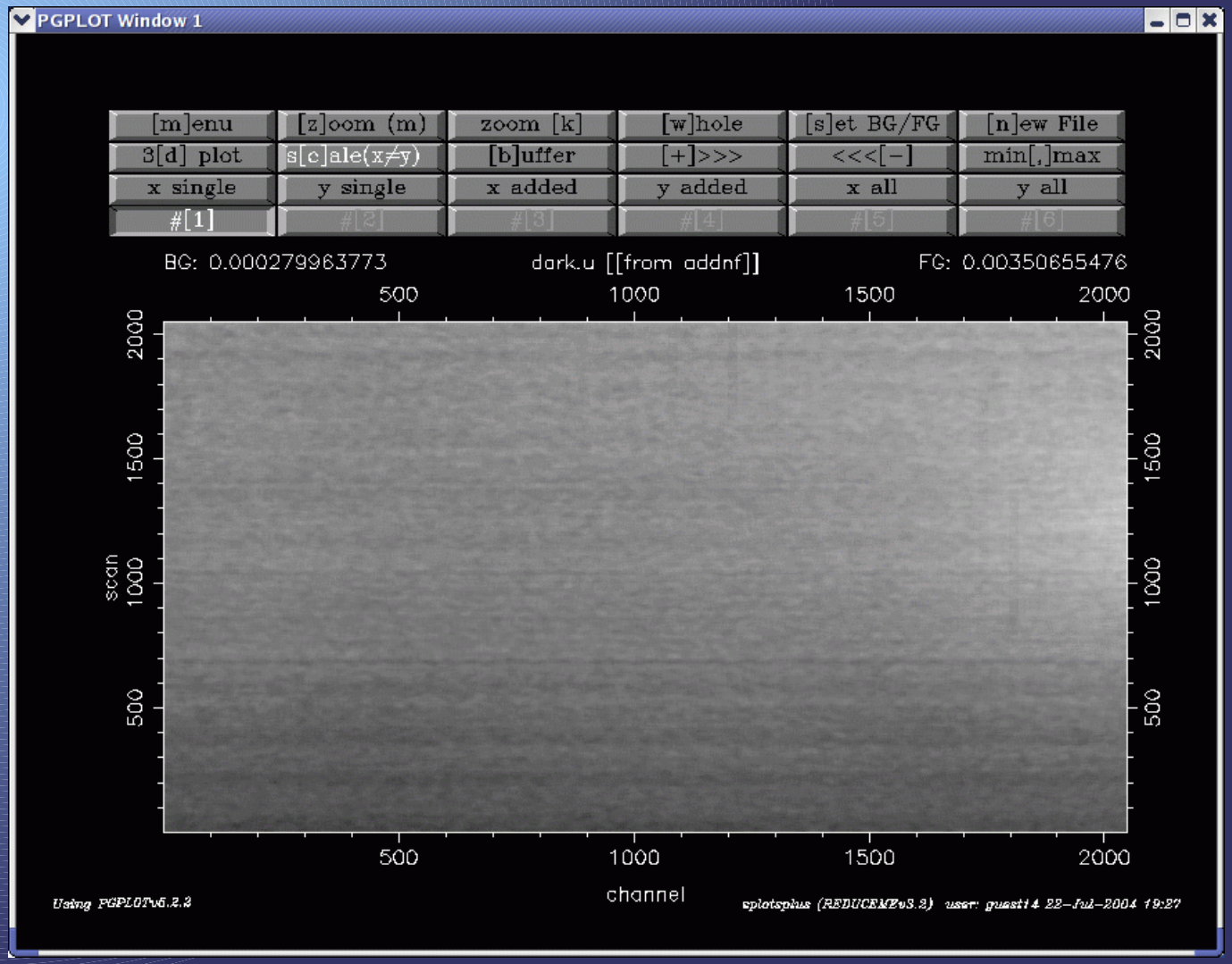


1. Cleaning
2. Average
3. Subtract overscan
4. Extract useful region
5. Smoothing

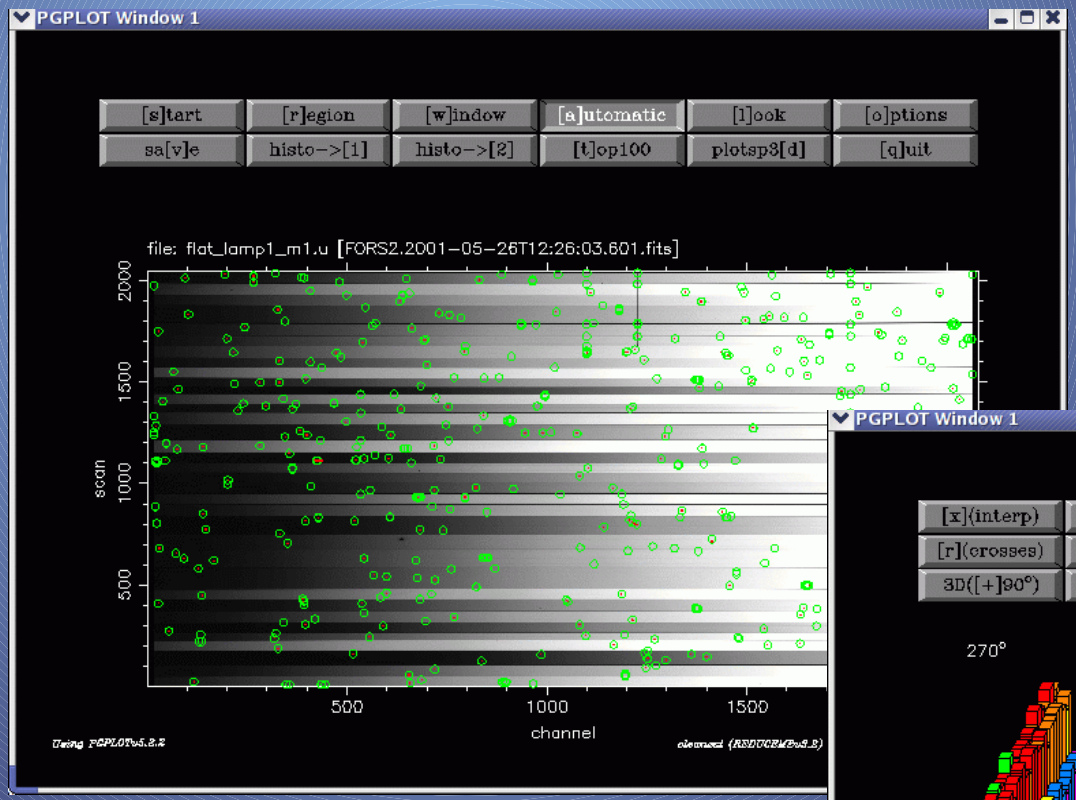


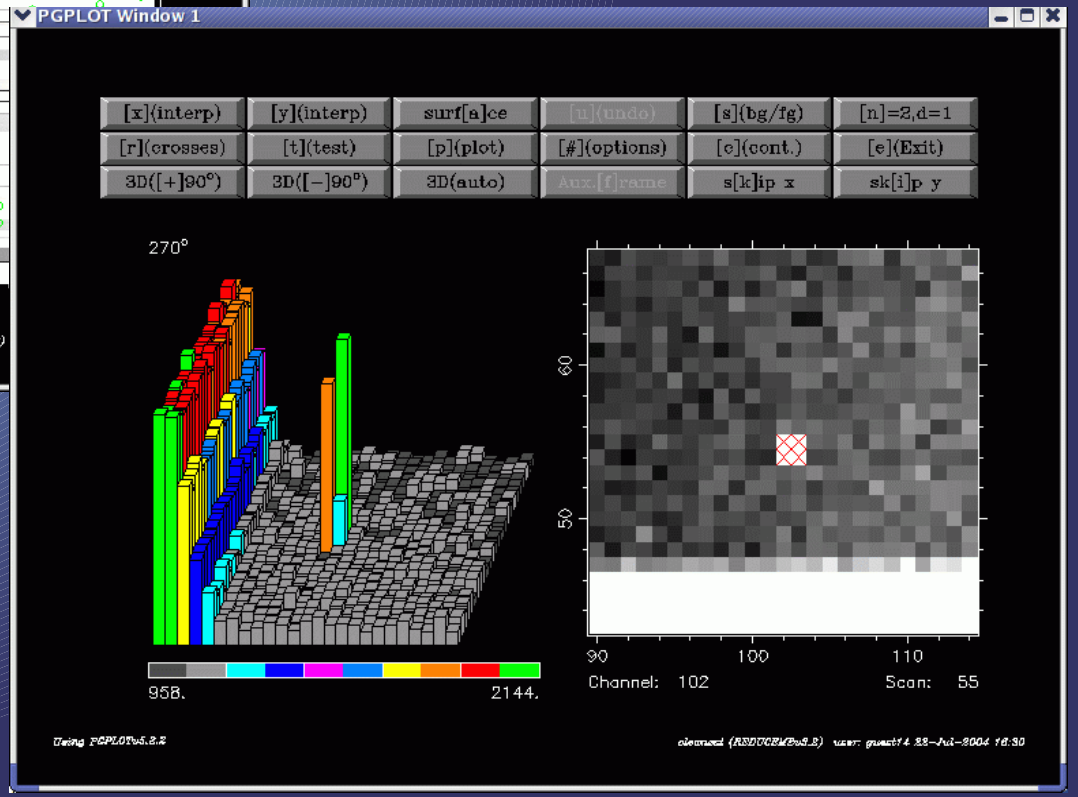
Dark Frame

1. Average
2. Smoothing
3. Normalization



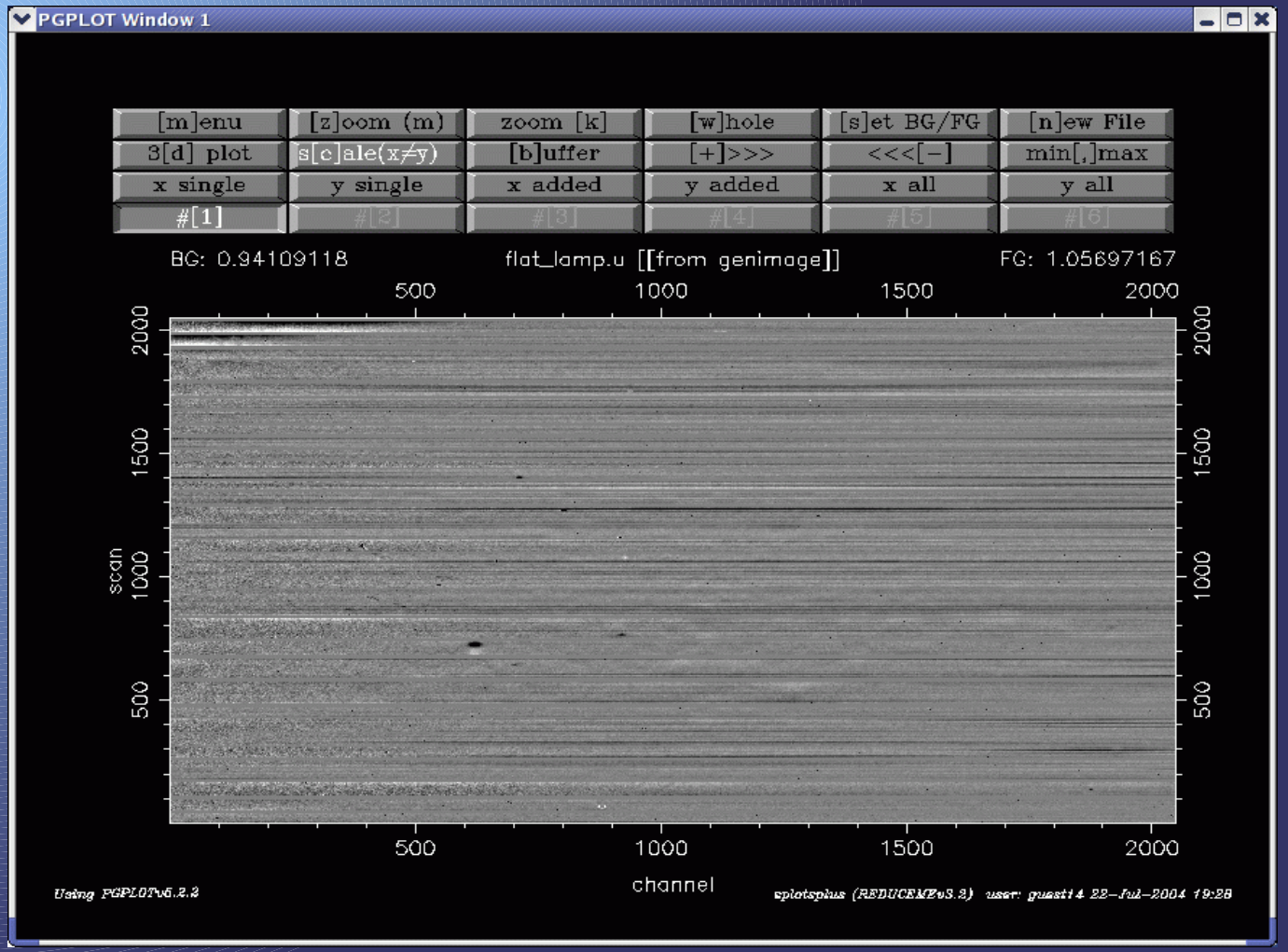
Flatfielding: Cleaning Cosmic Rays



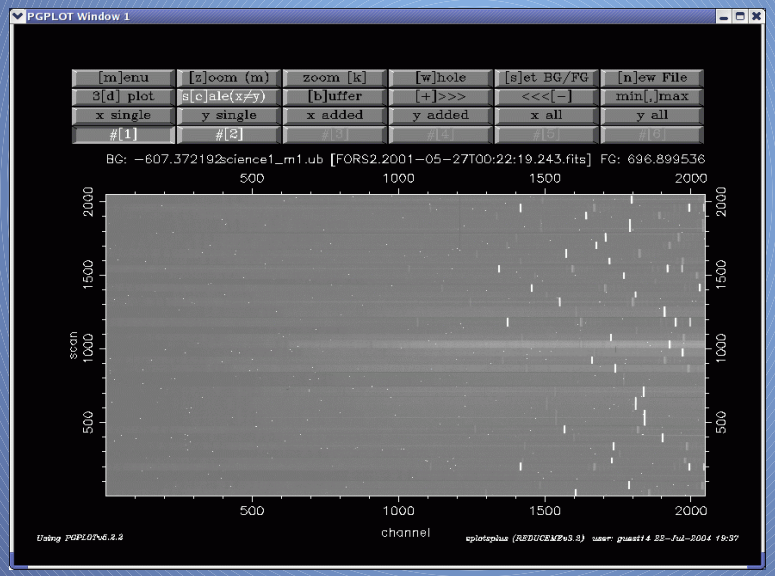


Flatfielding: Final Frame

1. Add individual frames
2. Extract and normalize each slit
3. Reconstruct the whole mask frame

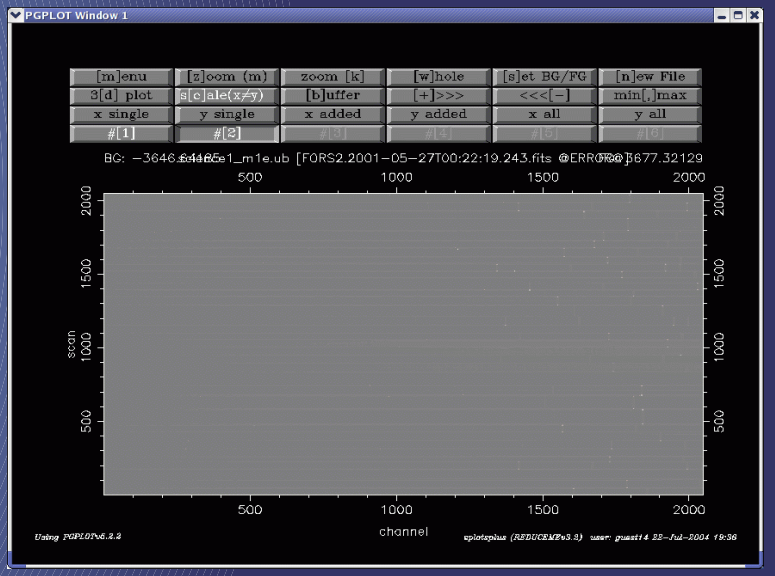


Basic Reduction of the Science Frames



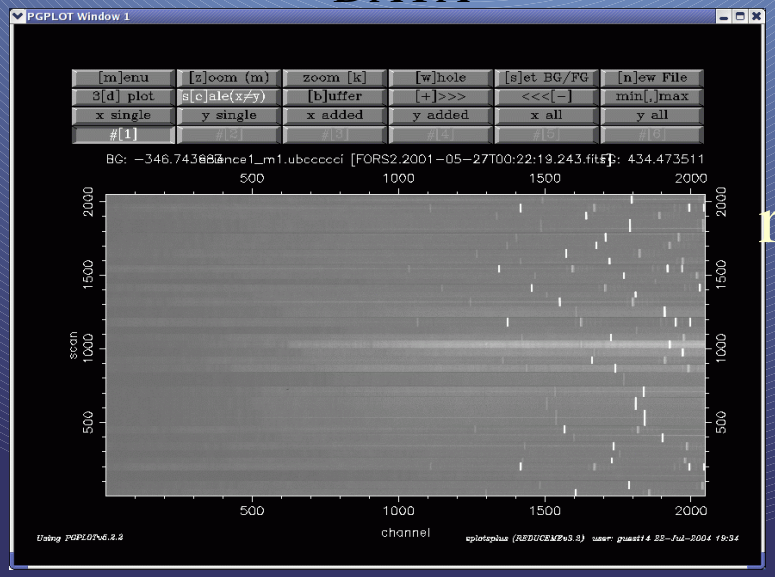
DATA

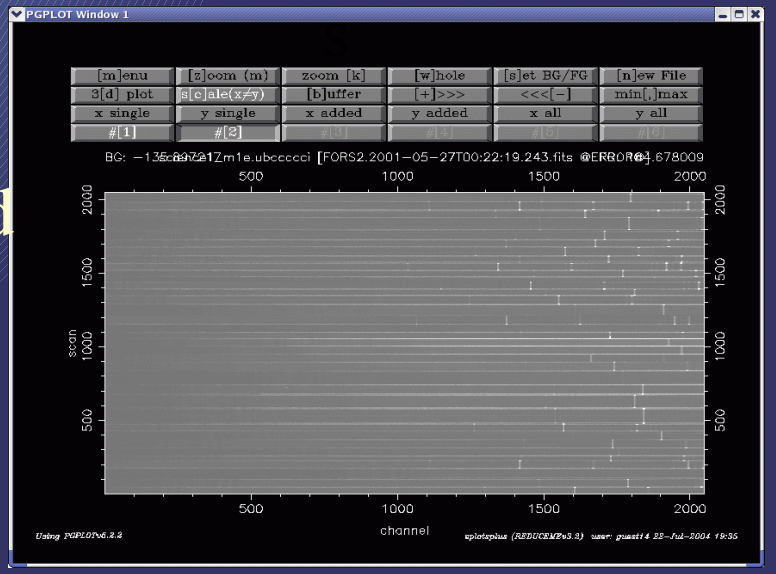
Before cleaning



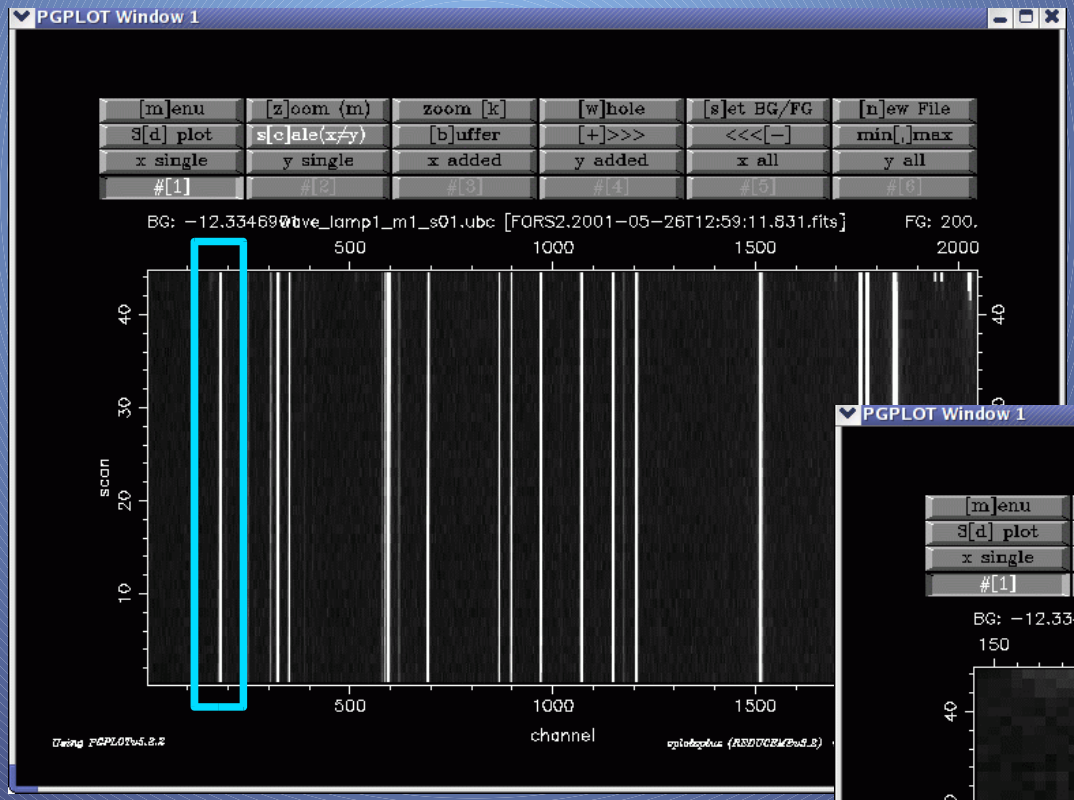
ERROR

After cleaning and removing bad columns

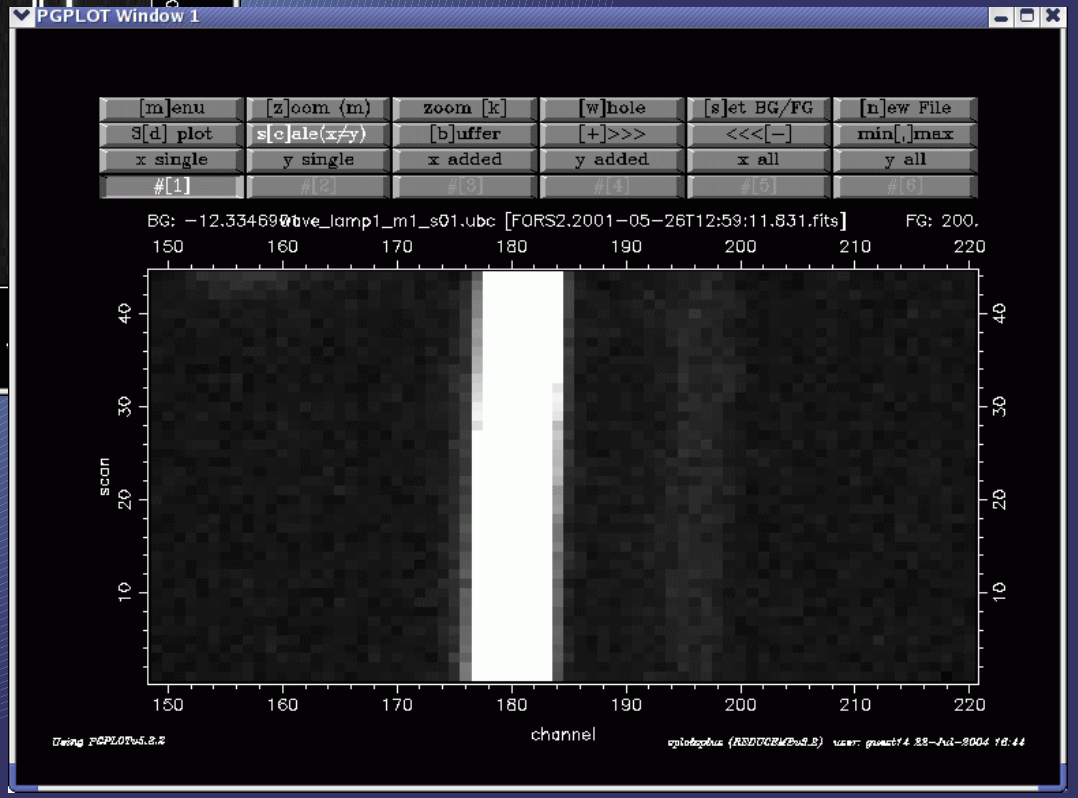




Wavelength Calibration (I)

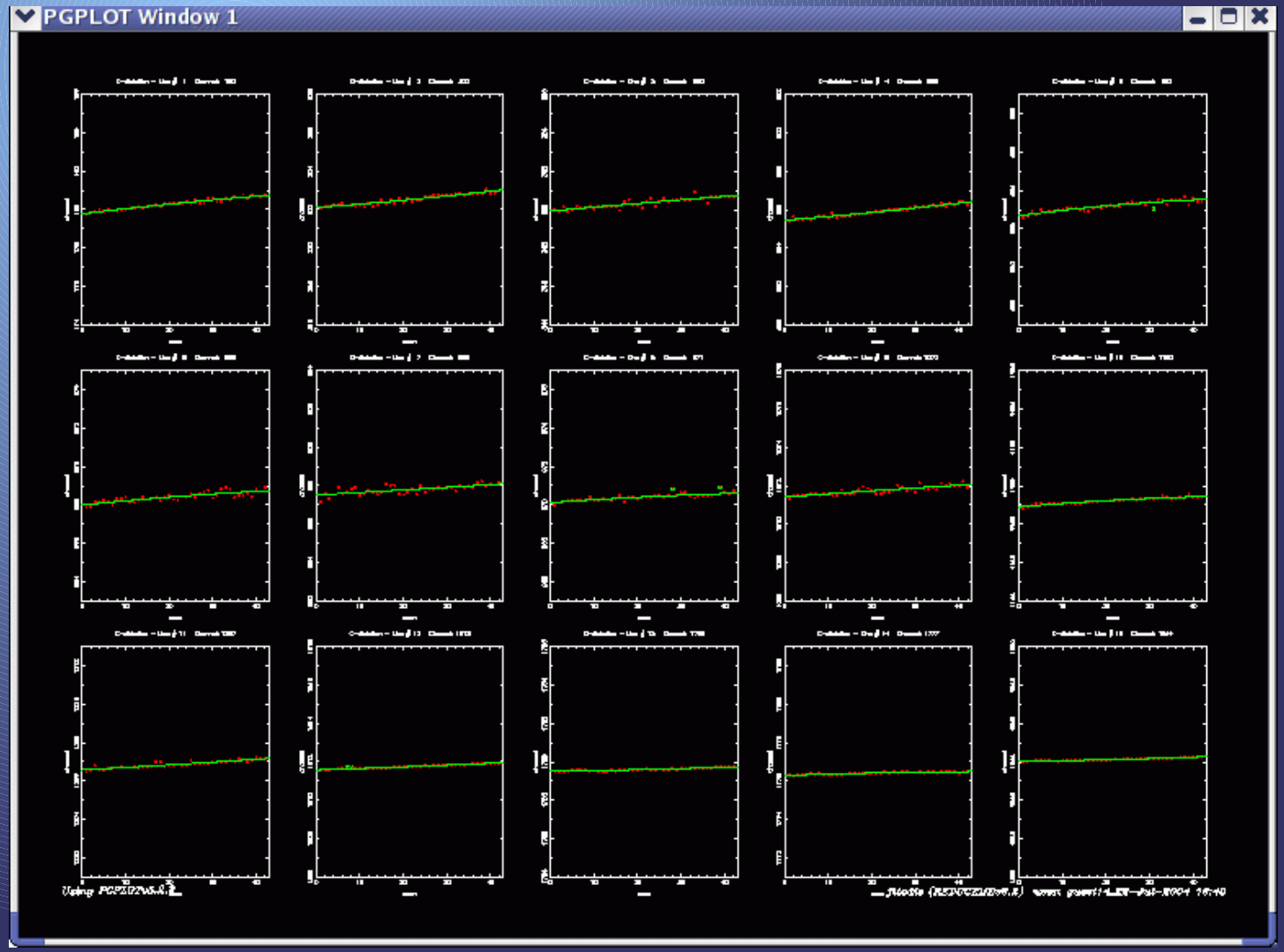


Vertical distortion...



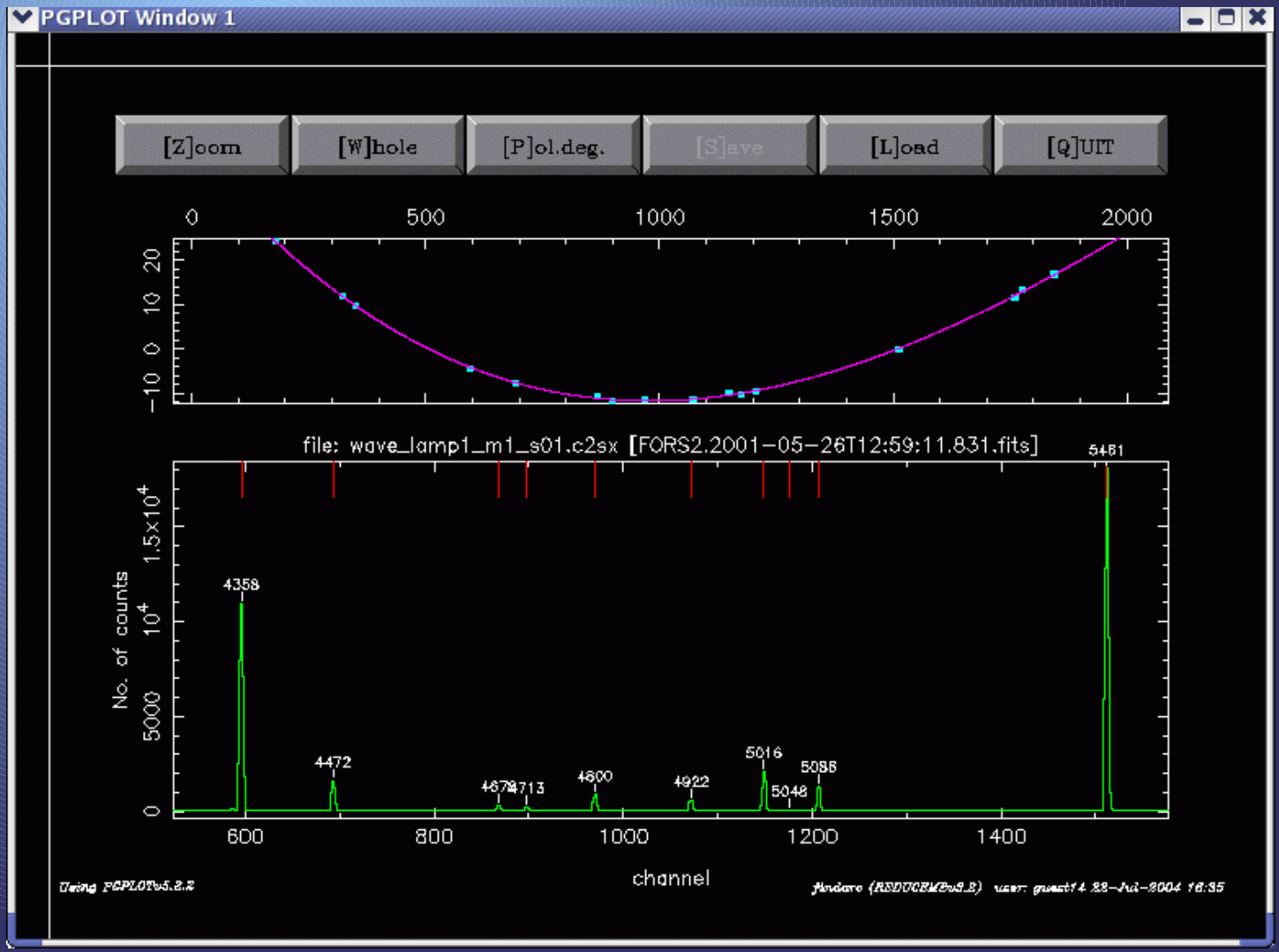
Wavelength Calibration (II)

... and correction for vertical distortion

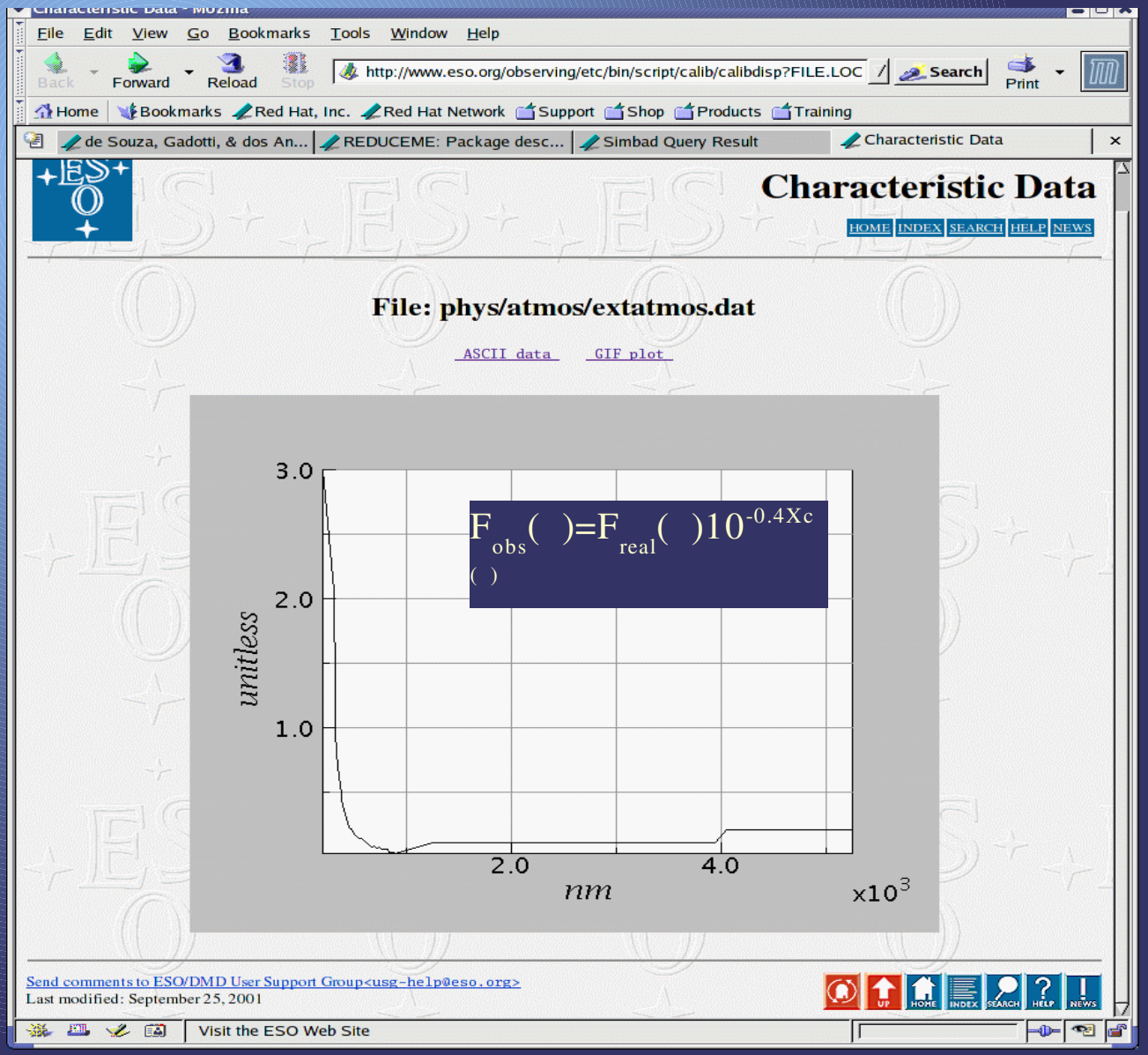


Wavelength Calibration (III)

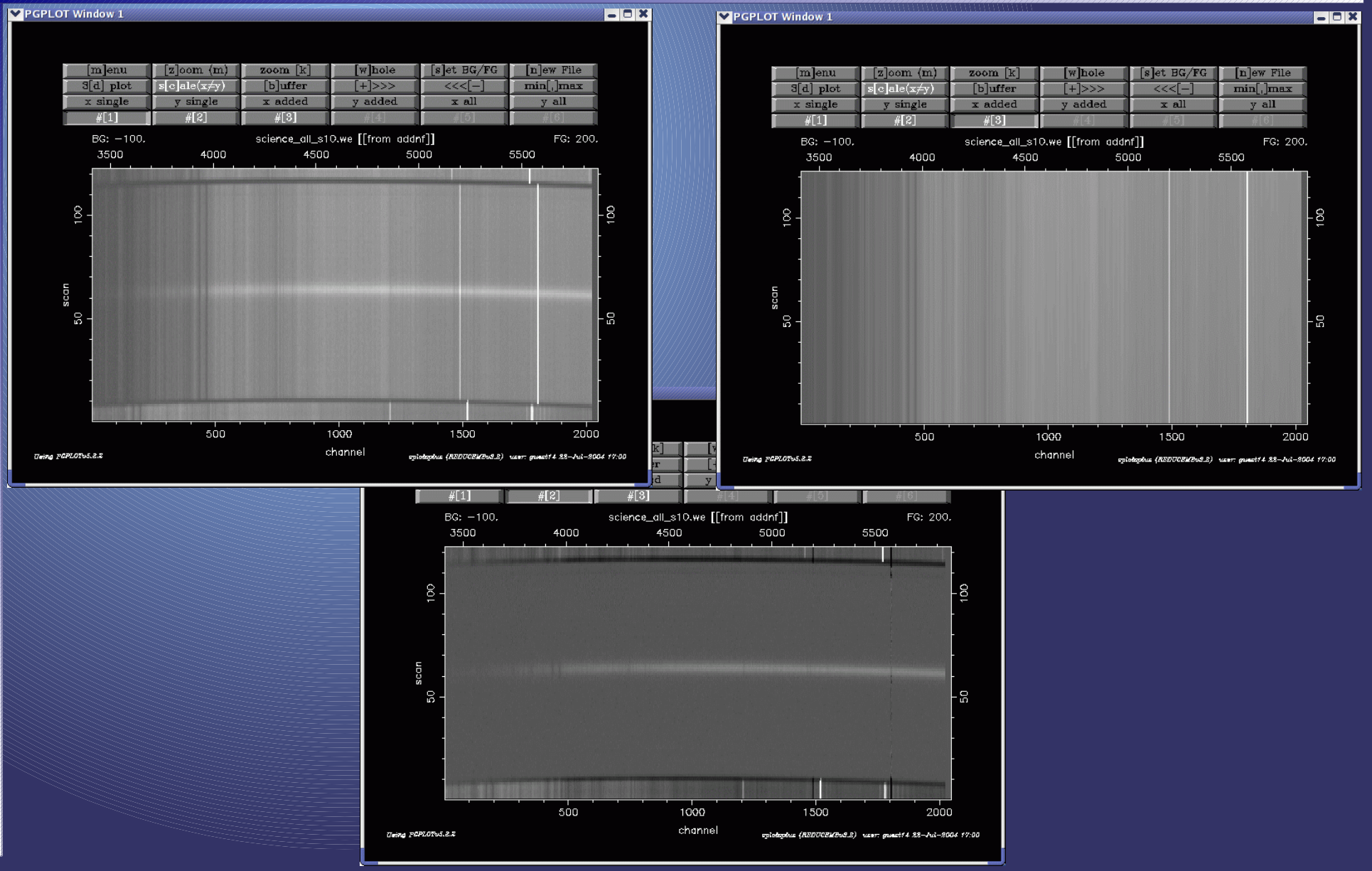
Line identification and polynomial fitting



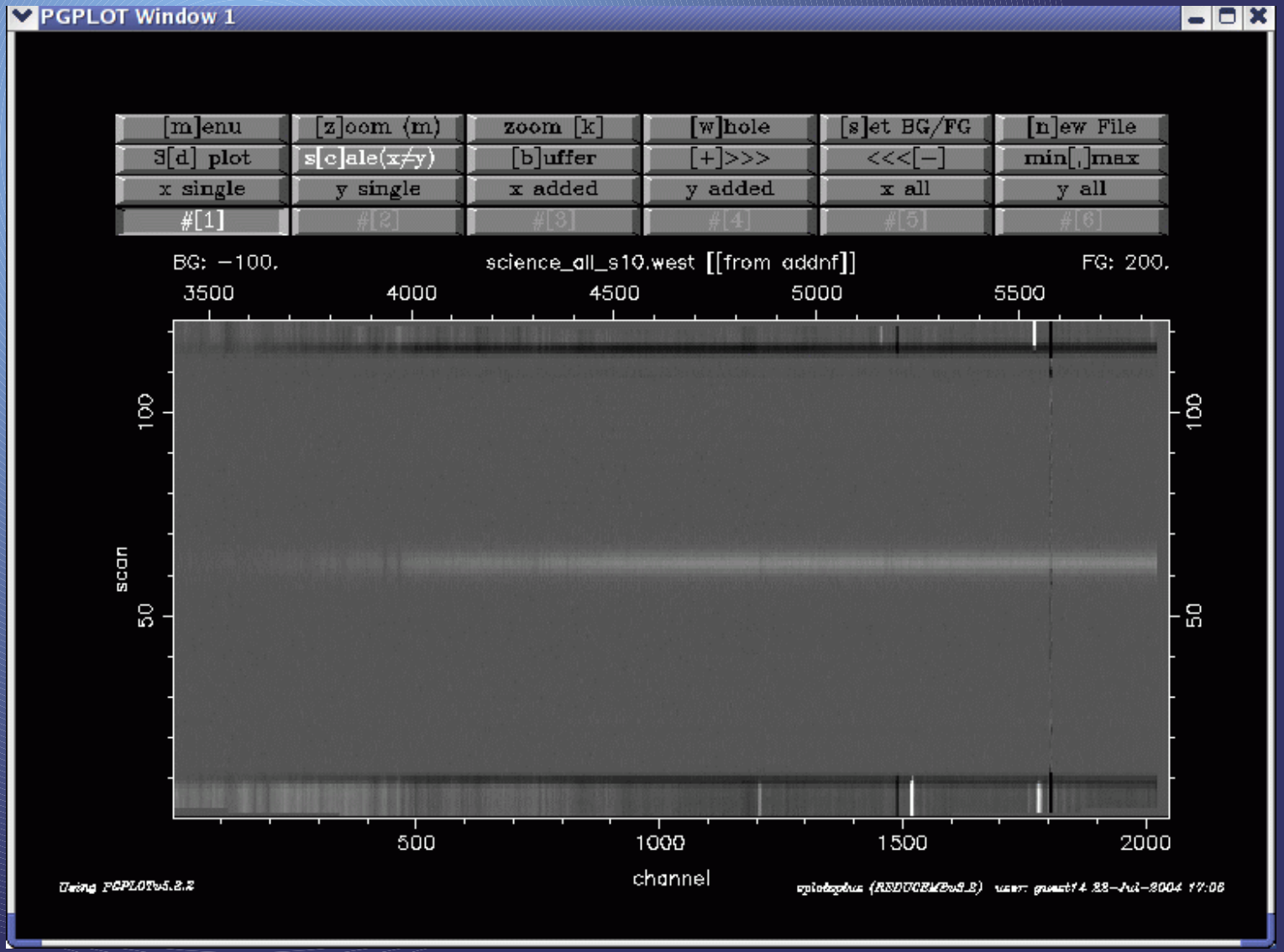
Atmospheric Extinction



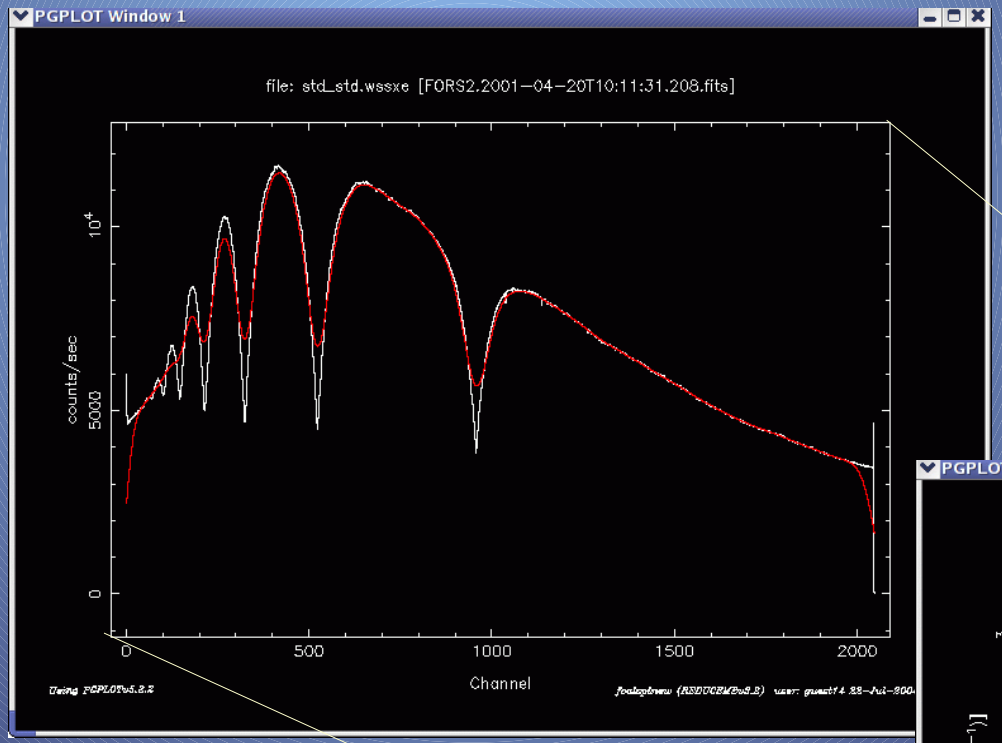
Sky Subtraction...

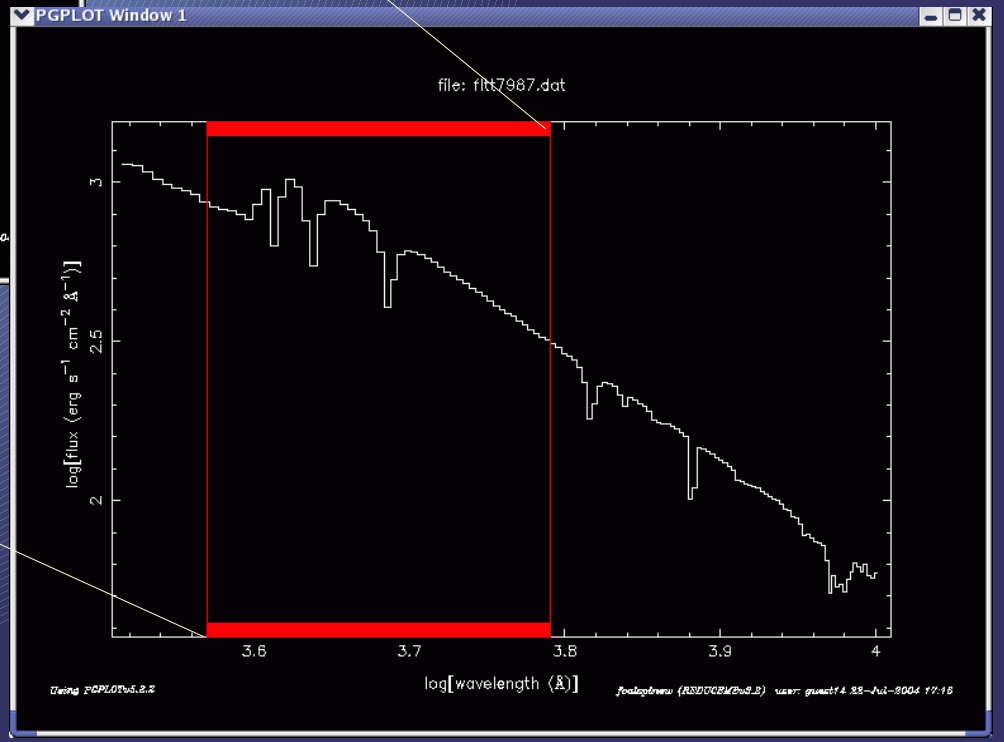


...and distortion correction



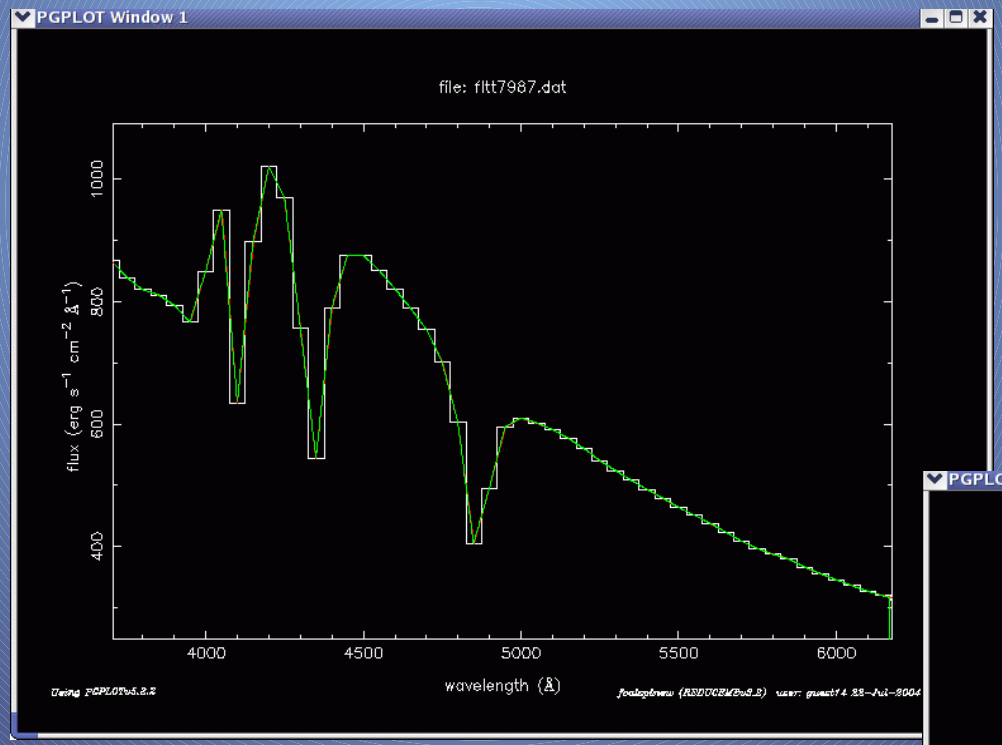
Flux calibration curve (I)

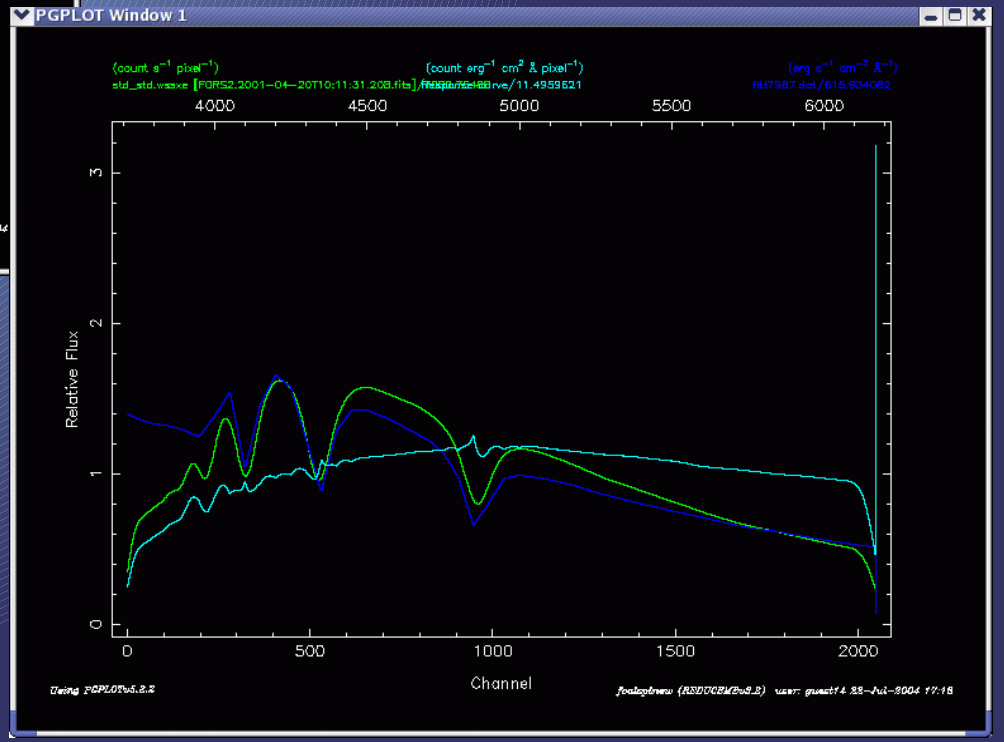




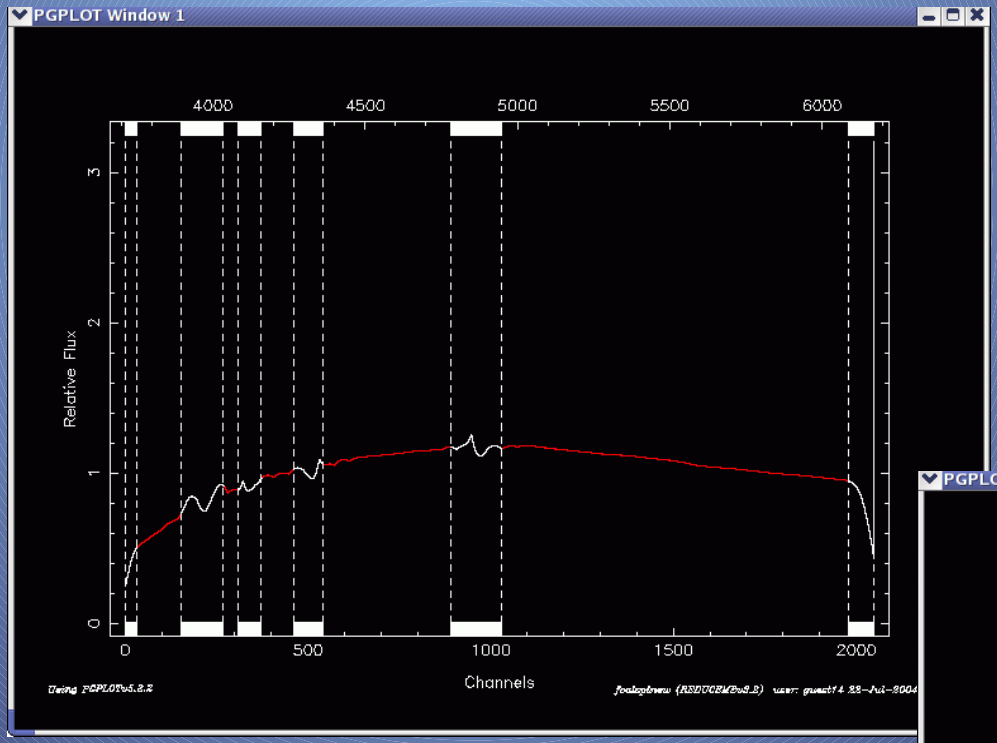
Spectrophotometric standard LTT7987

Flux calibration curve (II)

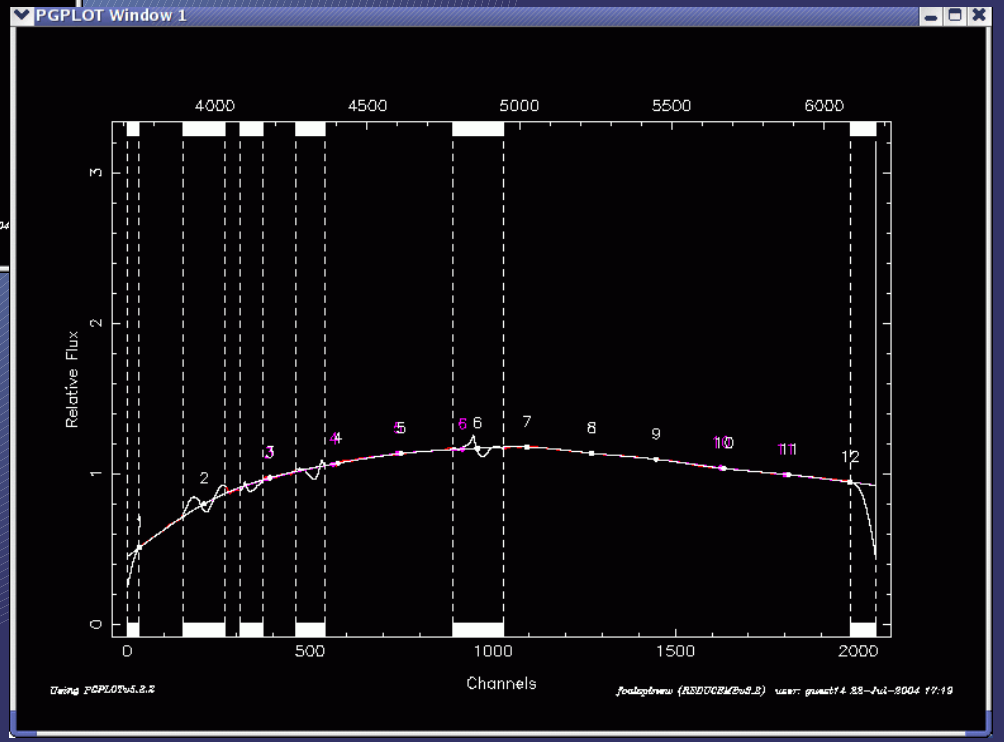




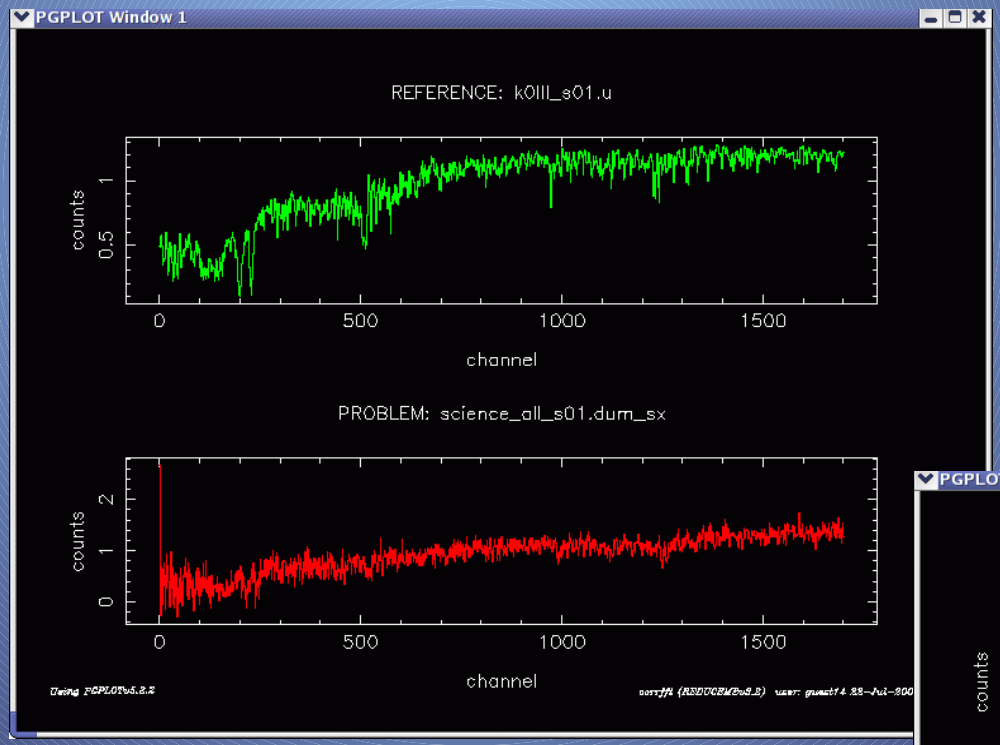
Flux calibration curve (III)



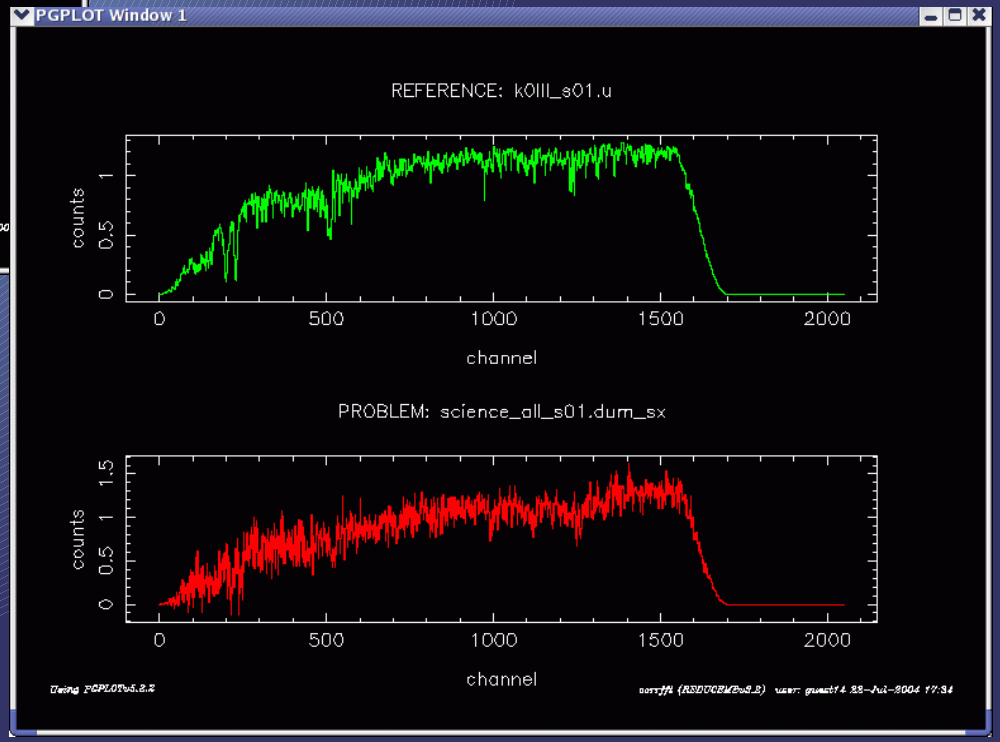
Fit with cubic splines



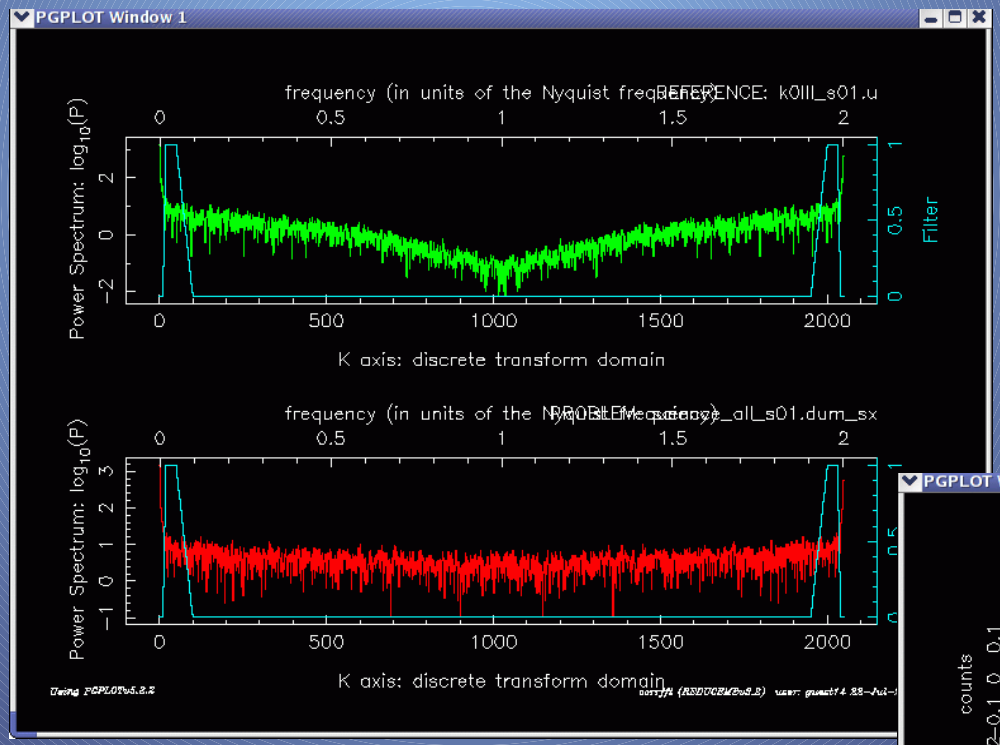
Radial Velocity



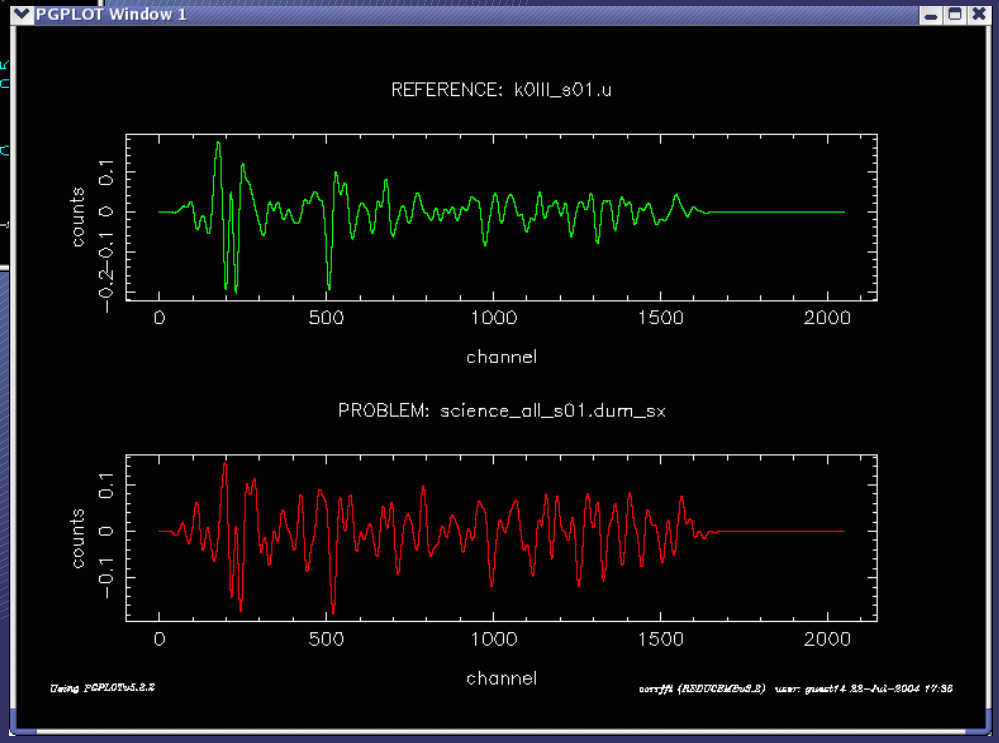
Cross-correlation with a K0III star



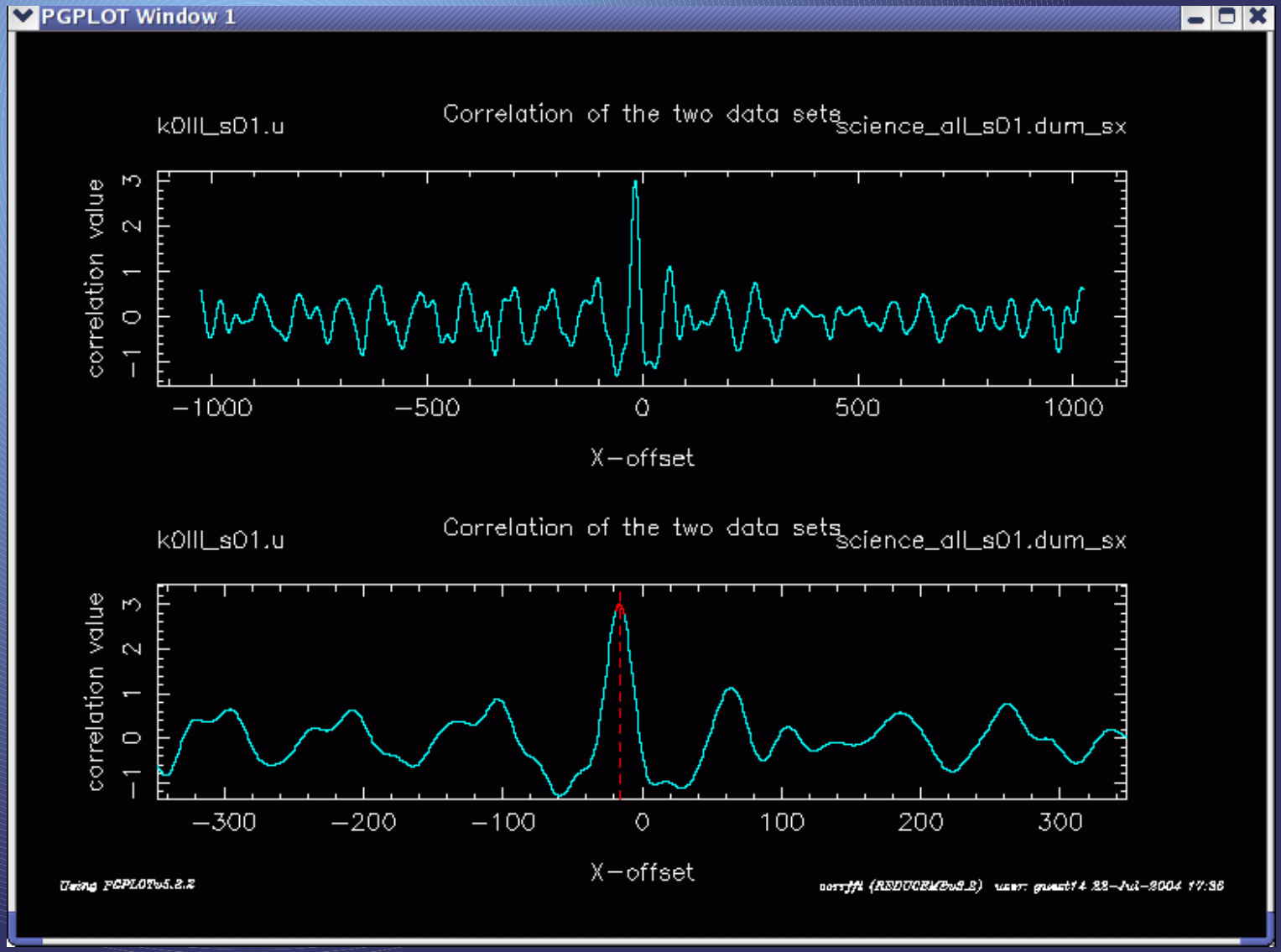
Radial Velocity



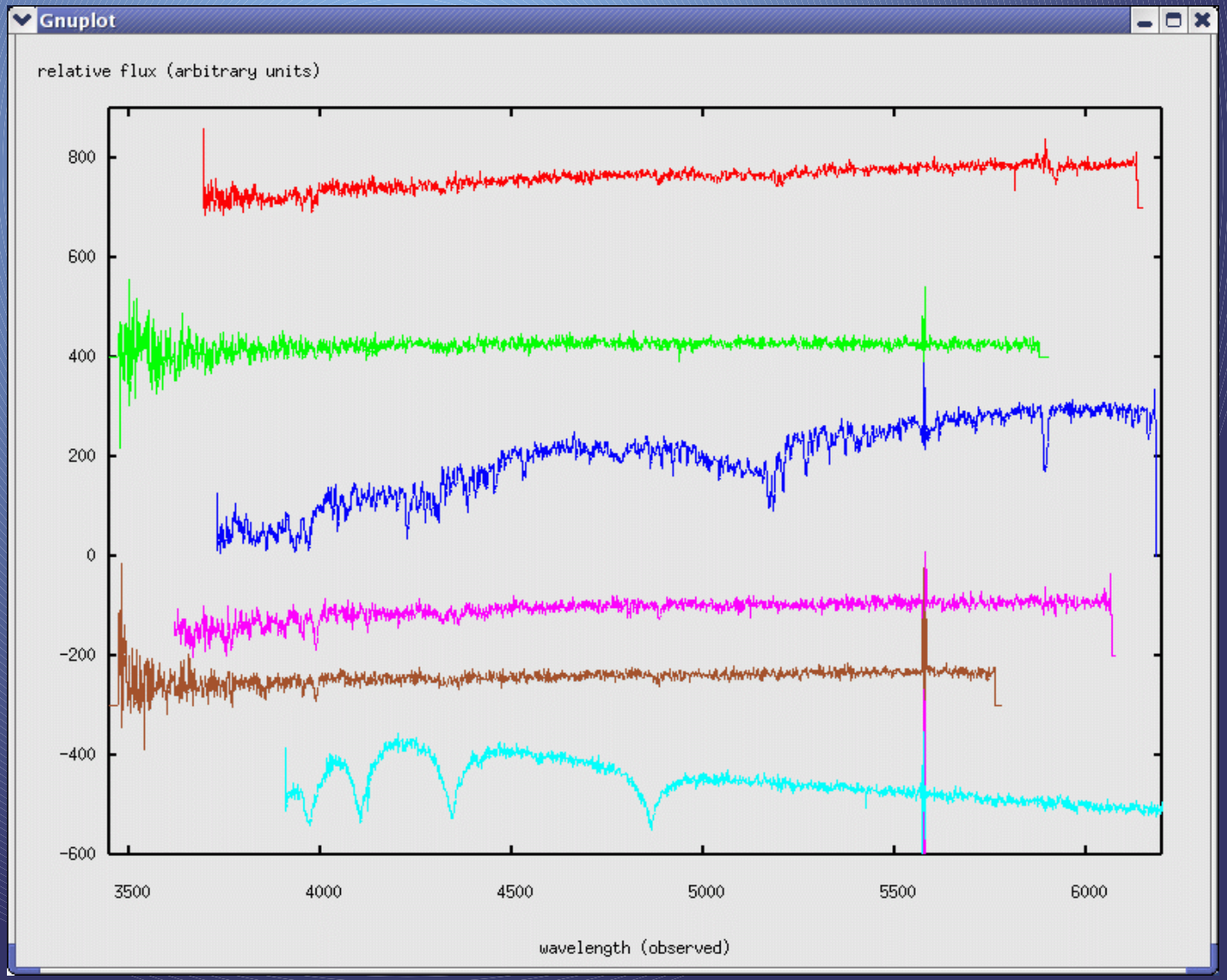
Cross-correlation with a K0III star



Radial Velocity



Some Spectra Examples



GC

GC – noisy spectrum

Milky Way STAR

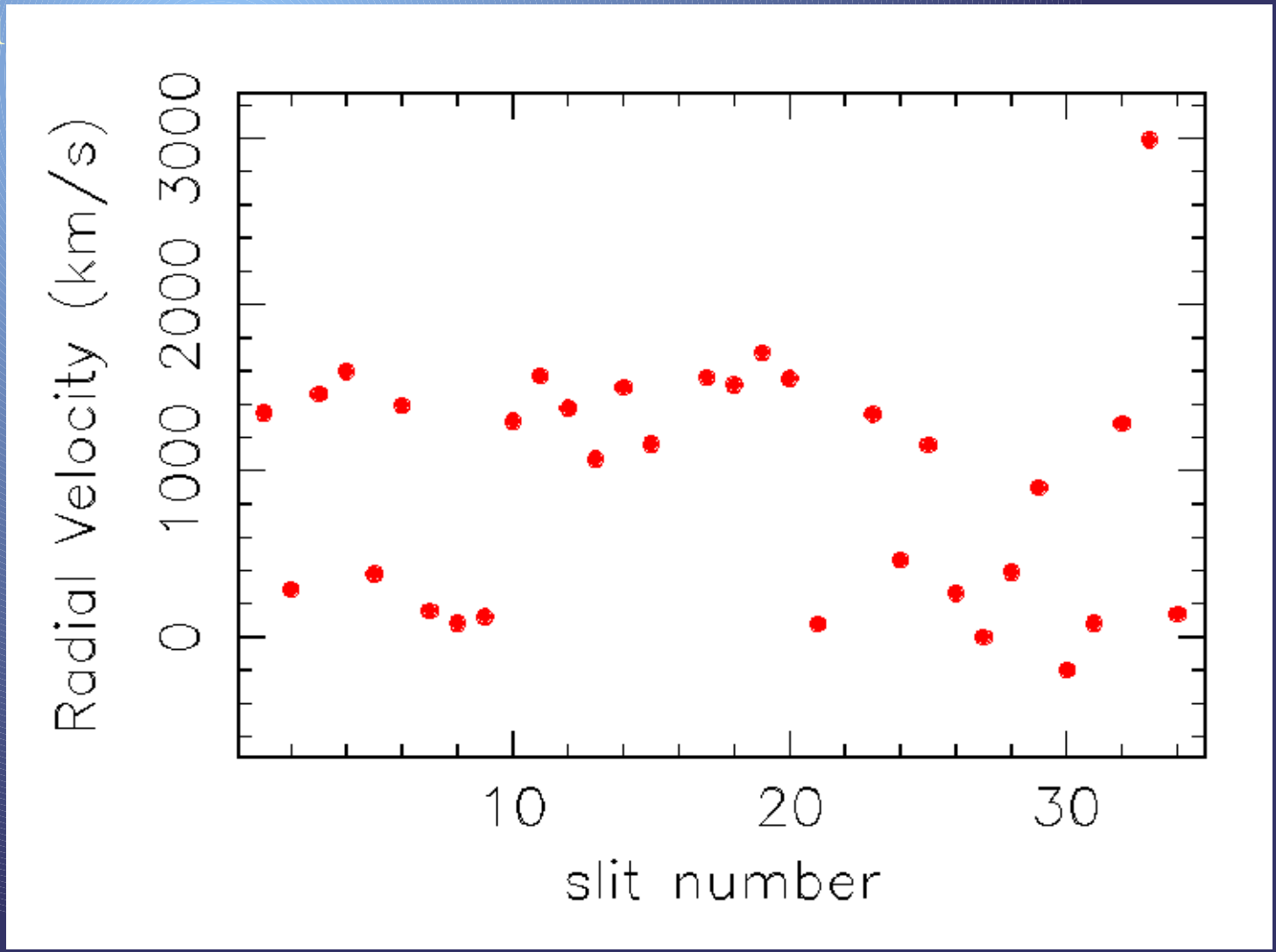
GC

GC

HOT STAR

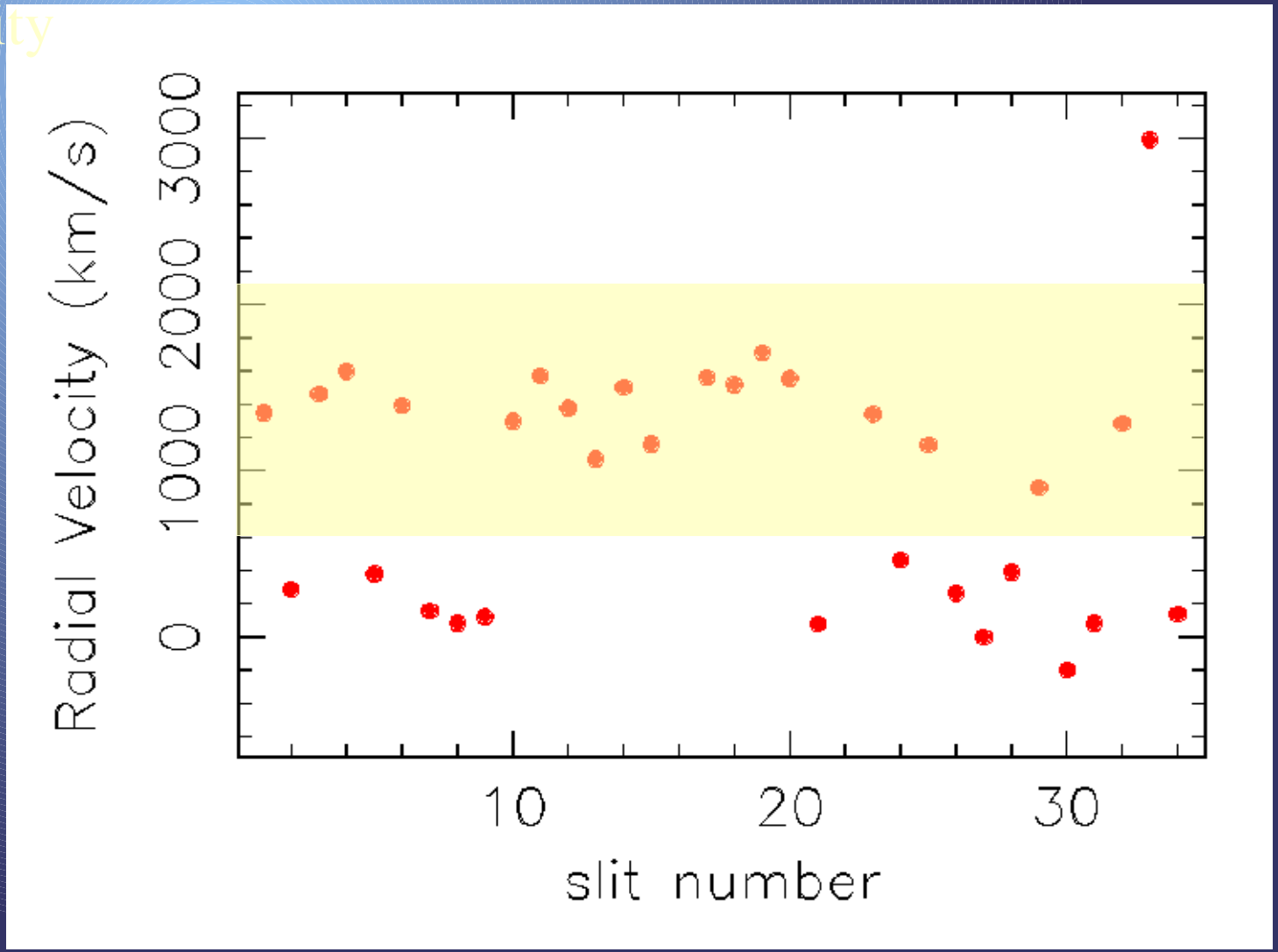
Spectra

We select the globular clusters according to their radial velocities



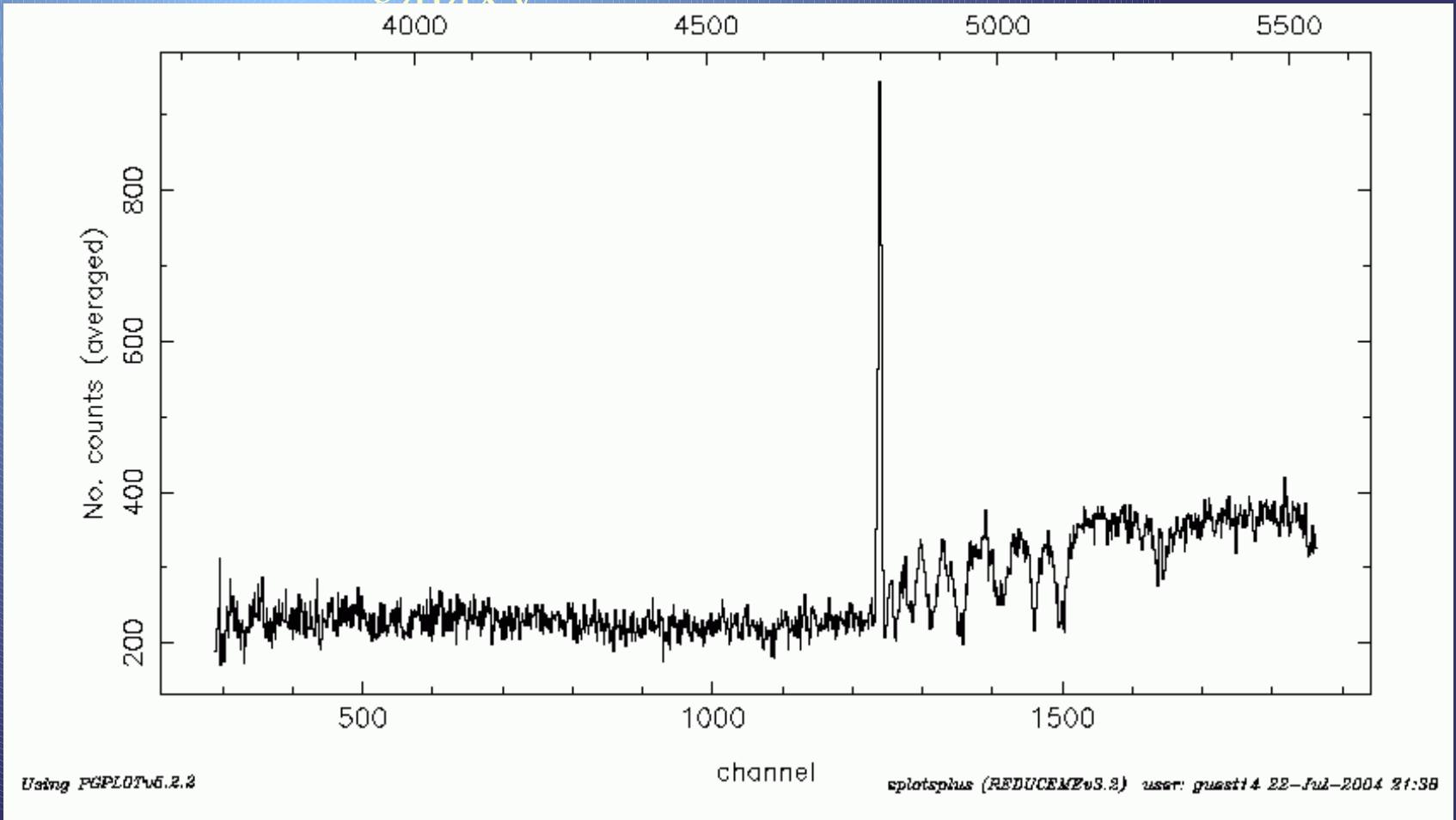
Spectra

We select the globular clusters according to their radial velocity



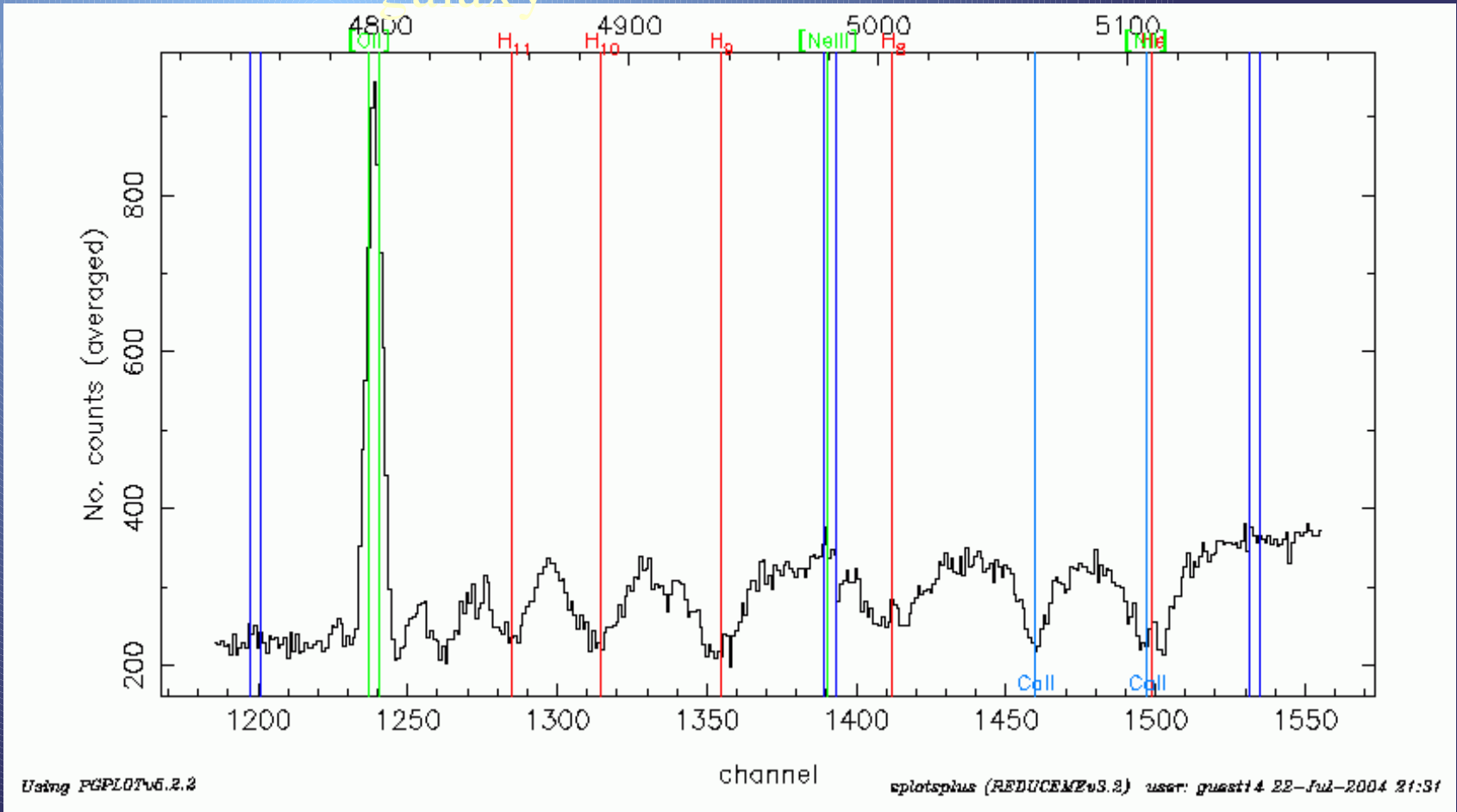
Spectra

We found a starburst galaxy



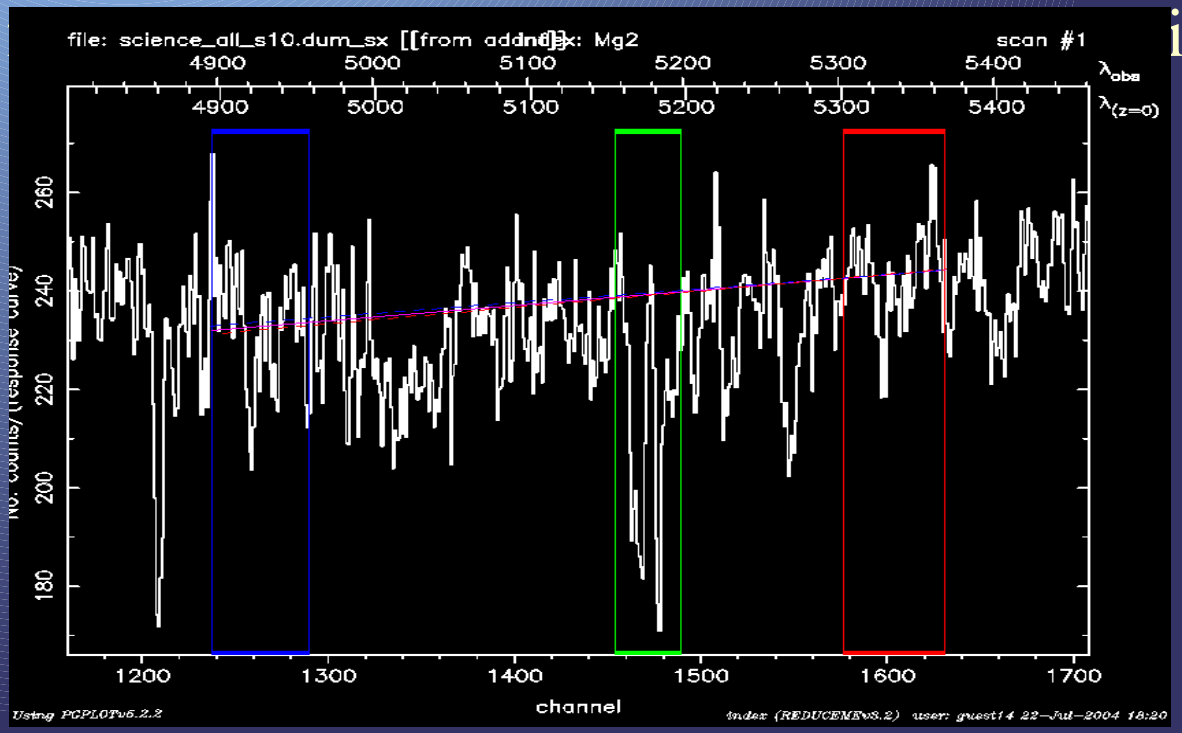
Spectra

We found a starburst galaxy

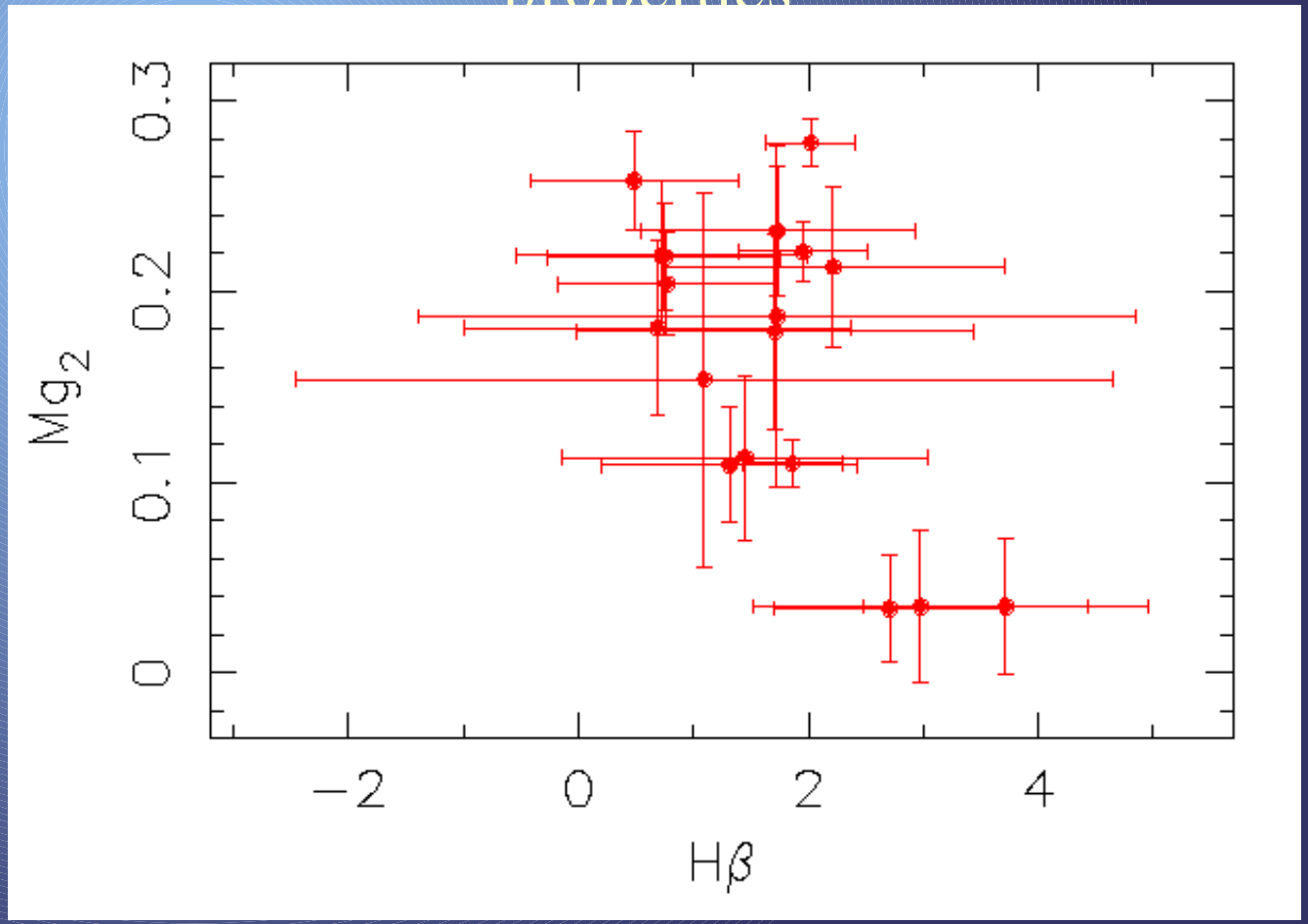


Line-Strength Absorption Lines

- Globular clusters are simple stellar structures – SSP models
- Its ages, metallicities and compositions detailed the formation of its host galaxies
- Lick system of absorption line indices measures the absorption ies

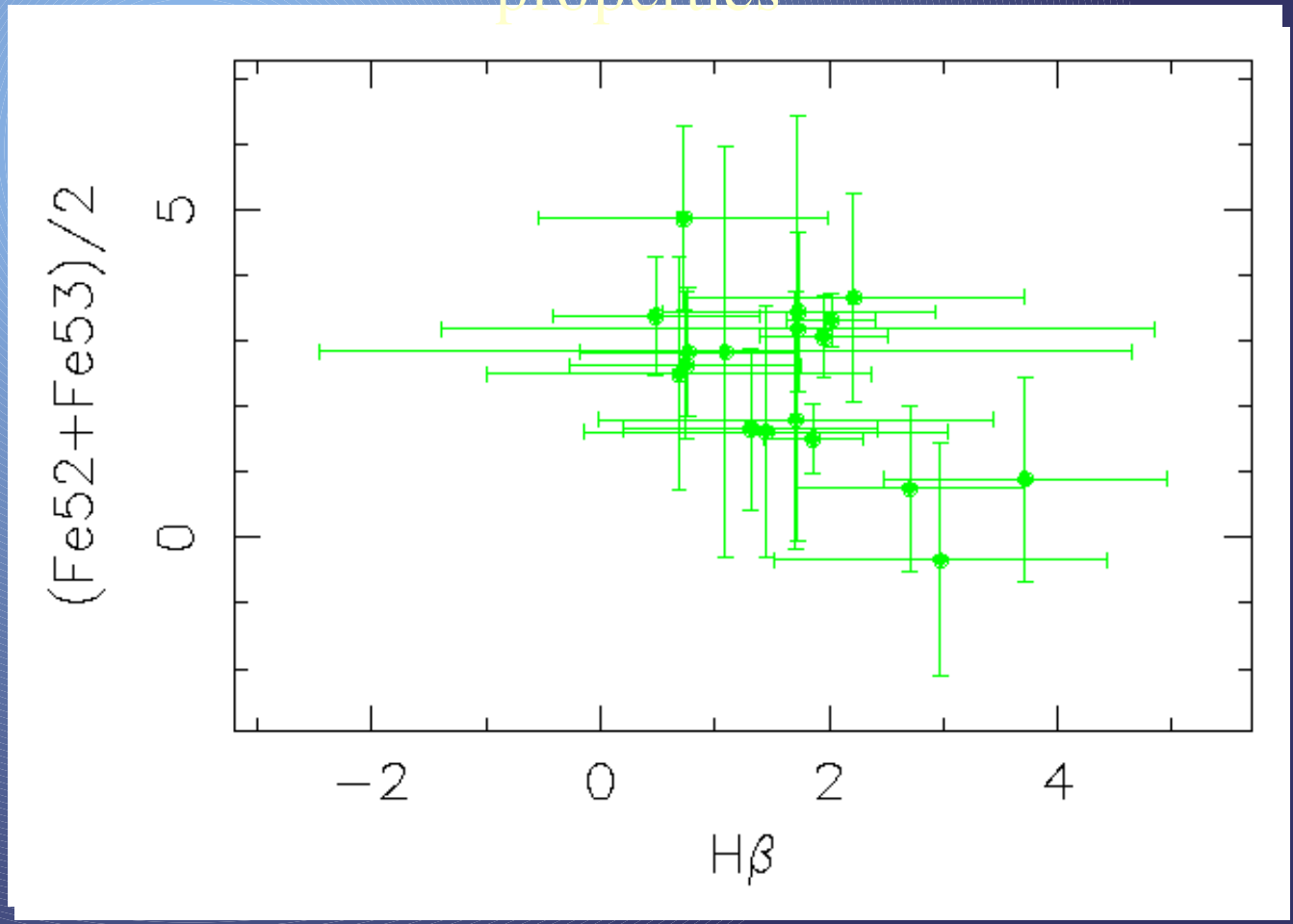


Comparing indices we extract conclusions about globular clusters properties



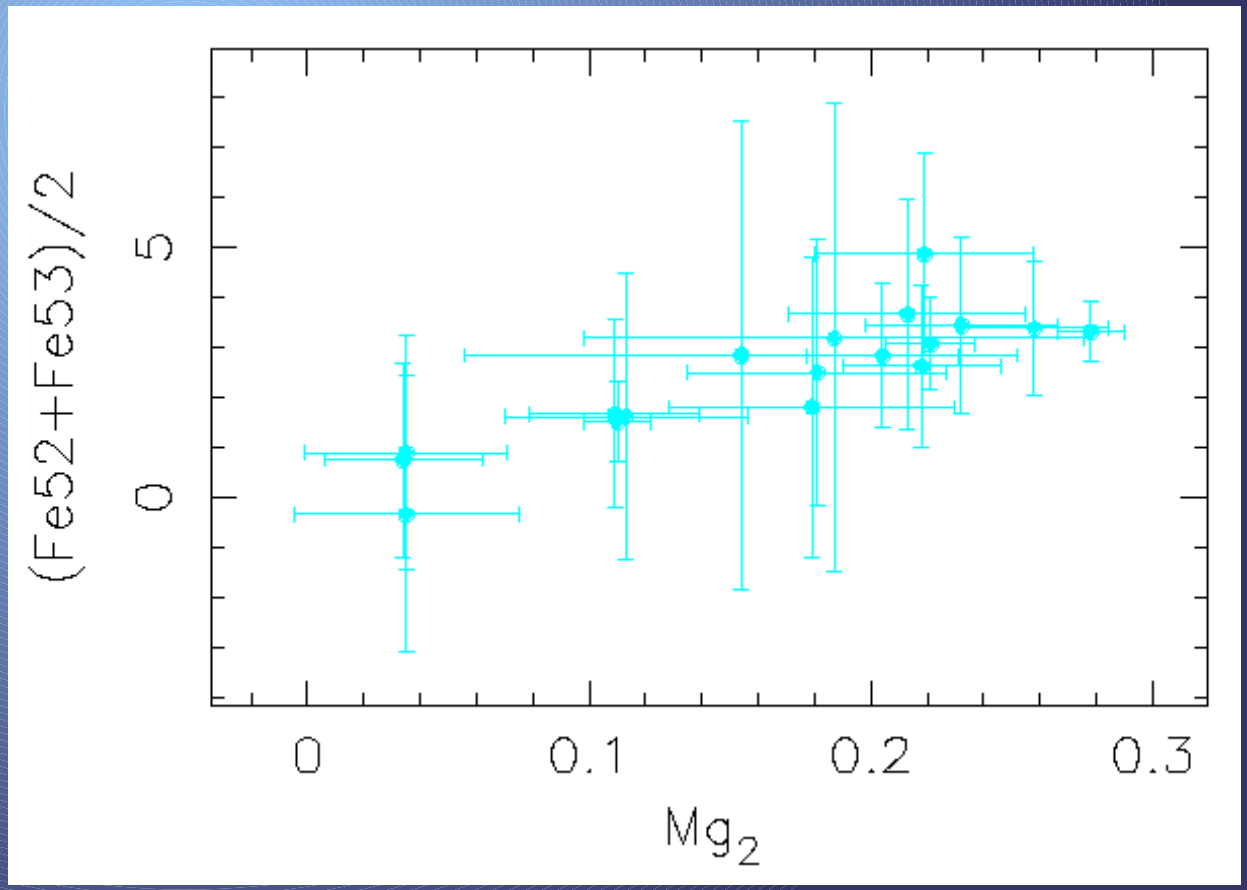
Time scale

Comparing indices we extract conclusions about globular clusters properties

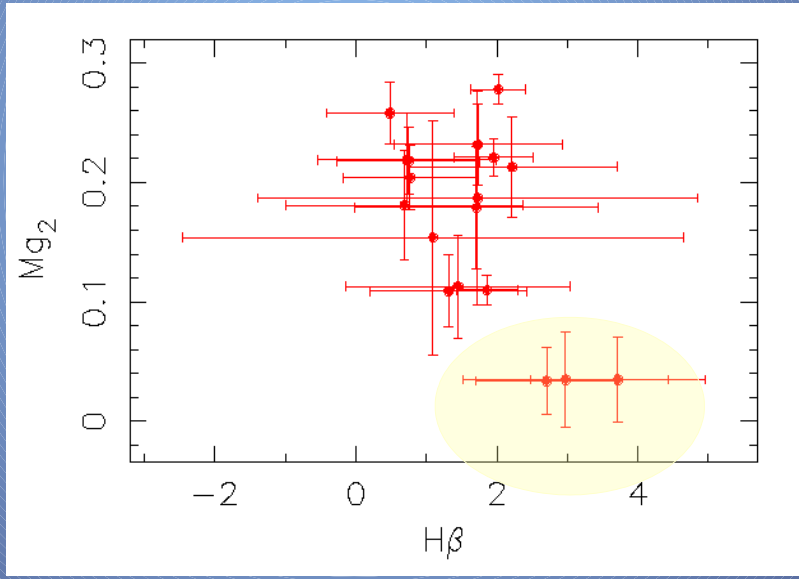


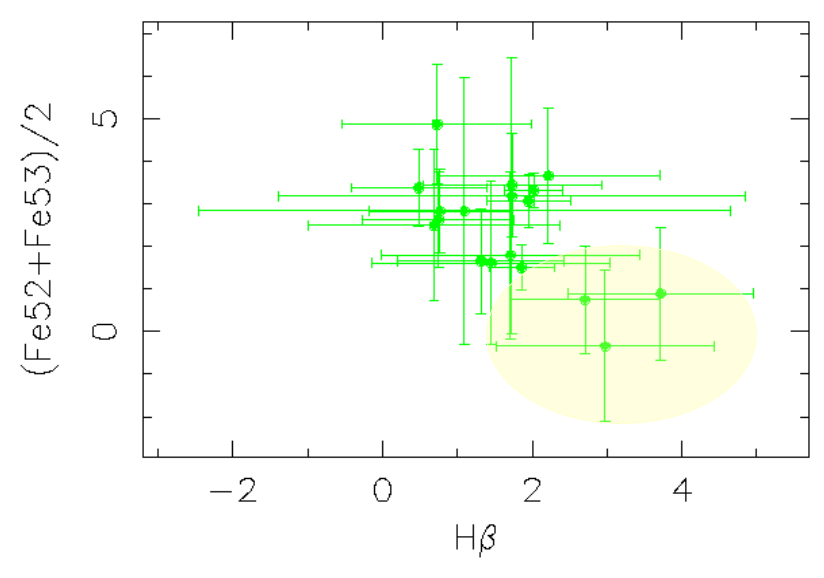
Time scale

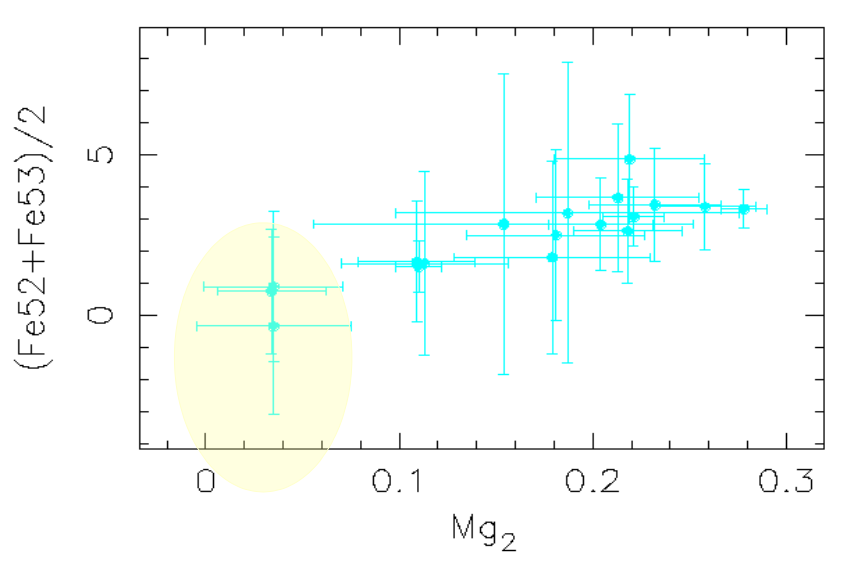
Comparing indices we extract conclusions about globular clusters properties



Cluster Populations







Fin *(Spanish)*

Fim *(Portuguese)*

The End *(English)*

Fine *(Italian)*

Привършване
(Bulgarian)