

# An introduction to SPEX

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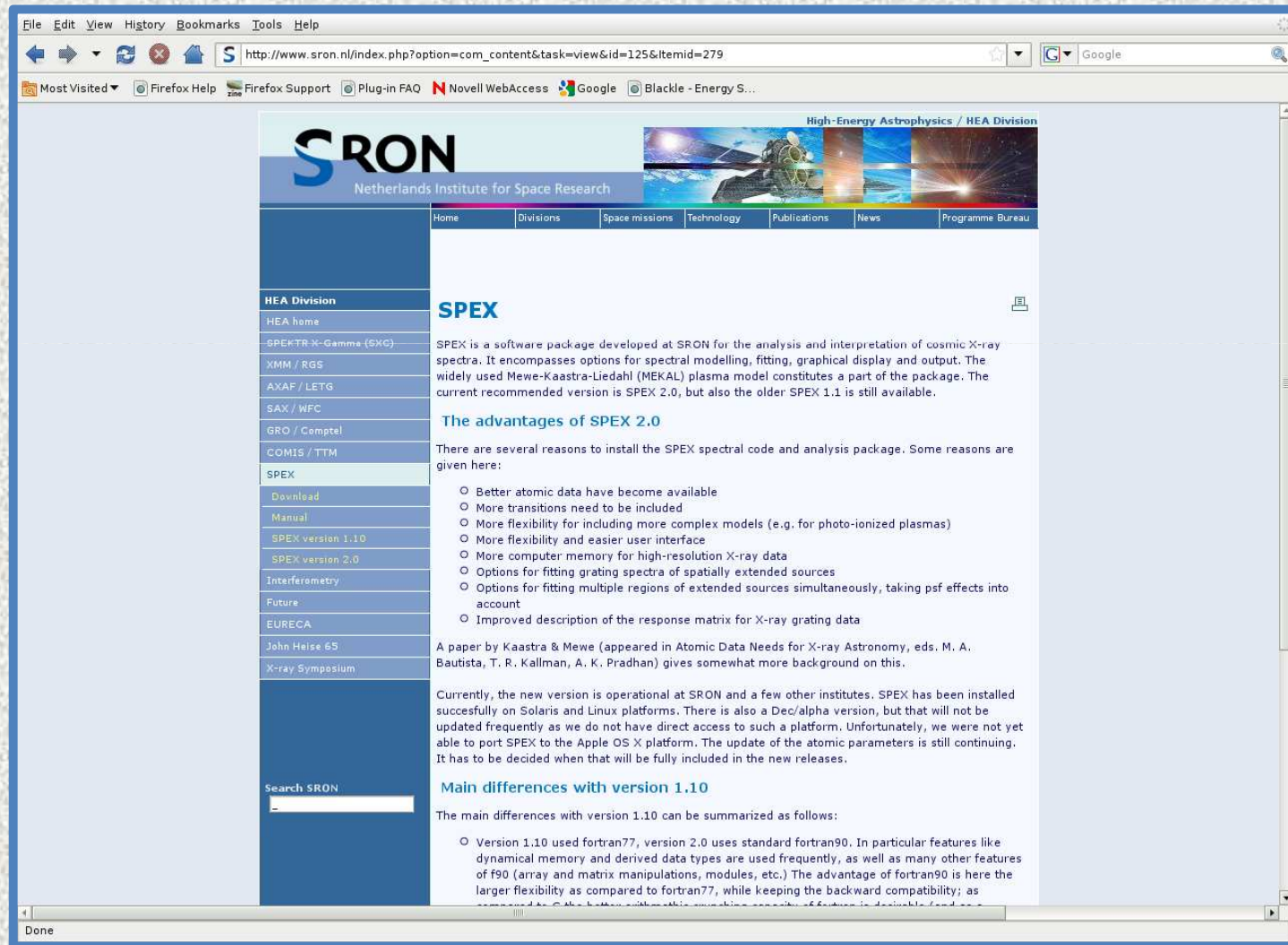
SRON

# Introducing SPEX

- SPEX is a fitting package for X-ray spectral analysis
- Similar packages: XSPEC (*Arnaud et al. 1996*), ION (*Netzer et al. 2002*), PHASE (*Krongold et al. 2003*)  
ISIS (*Houck & Denicola 2000*)
- SPEX is optimized for high-resolution spectroscopy:
  - Most updated atomic data bases
  - Several multi-parameters absorption/emission models → accurate analysis of narrow features produced by different astrophysical processes

# Where to get SPEX

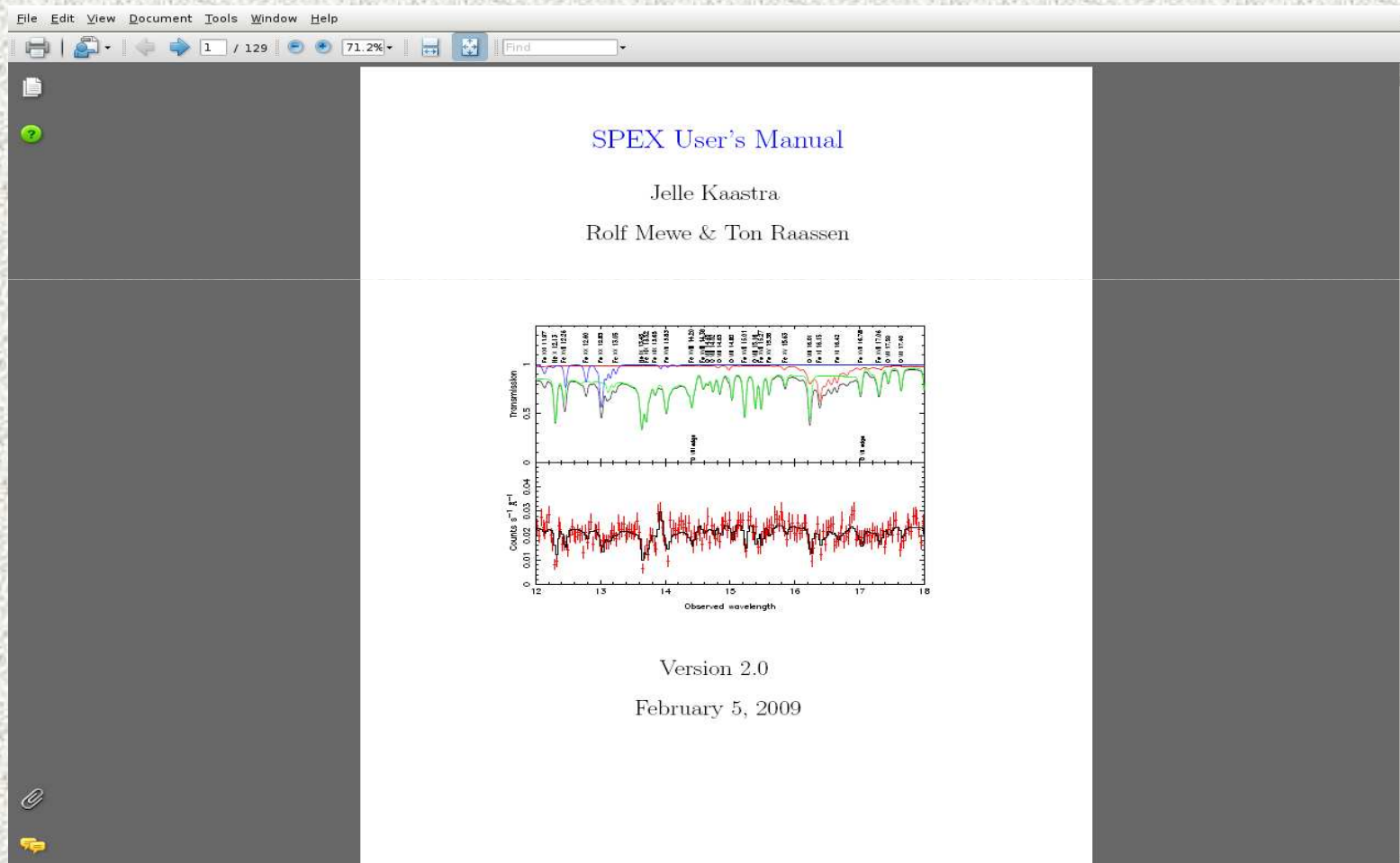
[www.sron.nl/spex](http://www.sron.nl/spex)





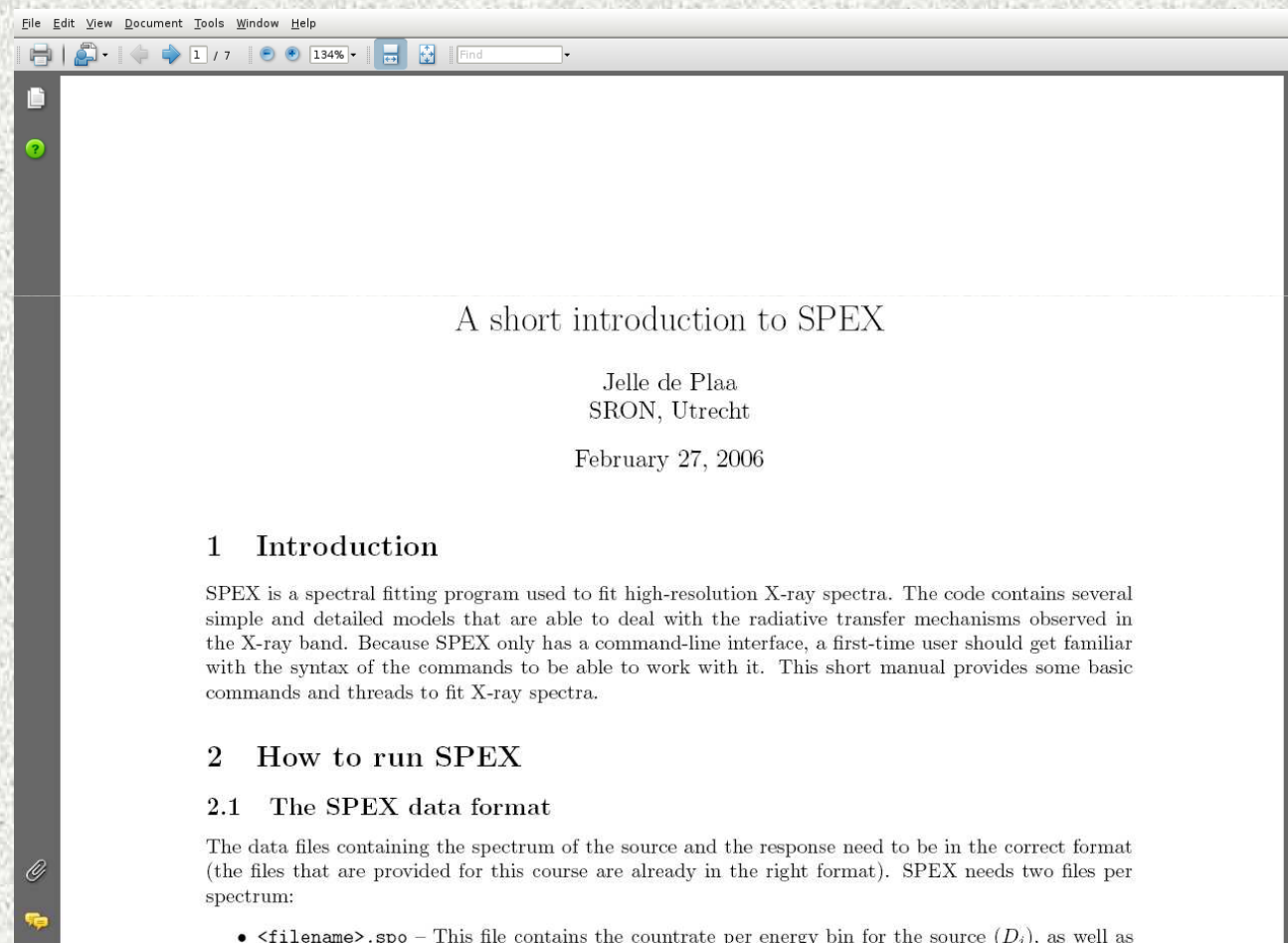
# SPEX Manual

<http://www.sron.nl/files/HEA/SPEX/manuals/manual.pdf>



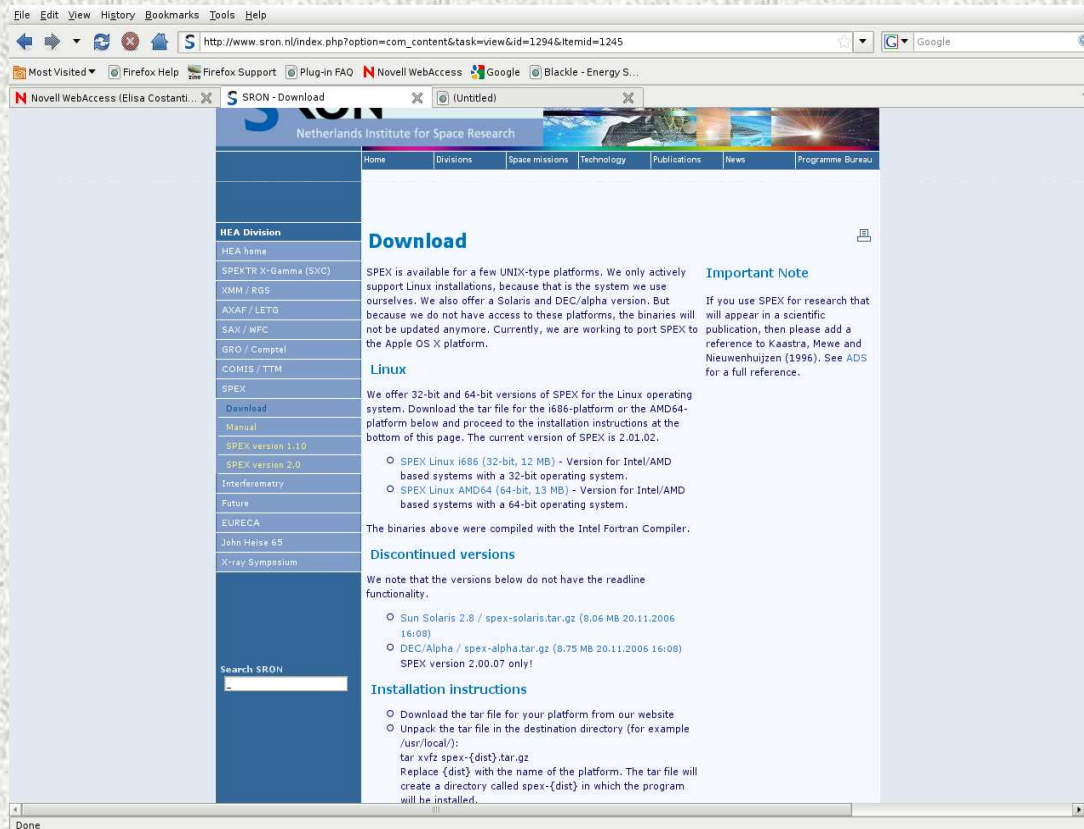
# Quick-start documents

[http://www.sron.nl/files/HEA/SPEX/manuals/spex\\_intro.pdf](http://www.sron.nl/files/HEA/SPEX/manuals/spex_intro.pdf)



# Downloading SPEX

- The latest version of SPEX is available for **LINUX** (and **MAC-OS**)
- Older version available for **SOLARIS** and **Alpha-Dec**



Easy installation: download a tar archive

Unpack the tar

Source the script  
(bash- or c-shell)

→ The environment variables are set

→  
TRAFO  
SPEX

Are ready for use!

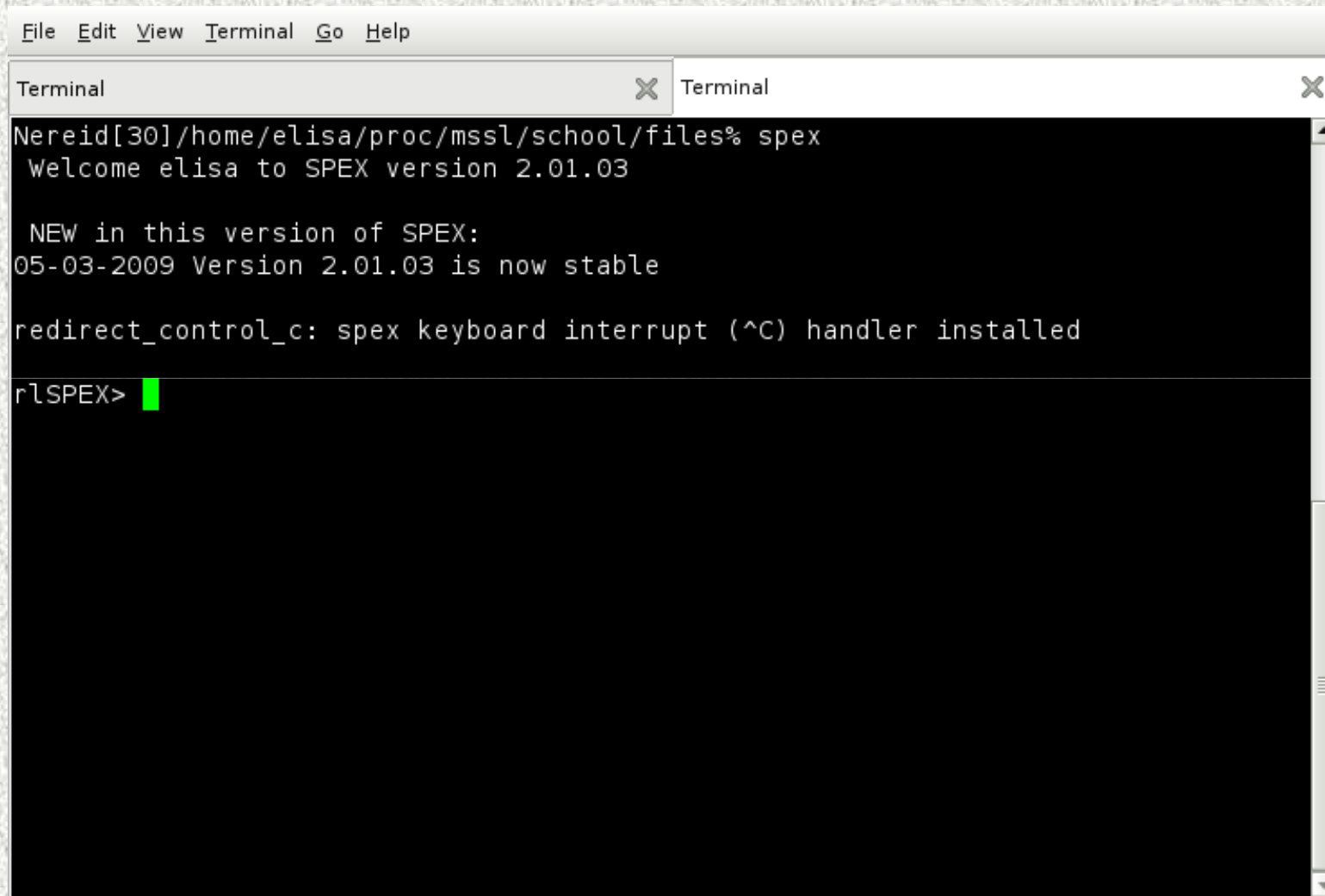
# Step 1: using TRAFO

- TRAFO converts normal fits files into SPEX format → trimmed, slimmer fits files.  
→ new spectrum & response matrix
- Inputs:
  - Original spectrum (either binned or unbinned)
  - Background
  - Effective area
  - Response matrix



# Example: AGN

## Galactic abs\*black body



The image shows a screenshot of a terminal window with a menu bar at the top containing 'File', 'Edit', 'View', 'Terminal', 'Go', and 'Help'. There are two tabs labeled 'Terminal' with close buttons. The terminal content shows the execution of the 'spex' command, which outputs a welcome message and version information. A red prompt character is visible at the end of the last line.

```
File Edit View Terminal Go Help
Terminal
Nereid[30]/home/elisa/proc/mssl/school/files% spex
Welcome elisa to SPEX version 2.01.03

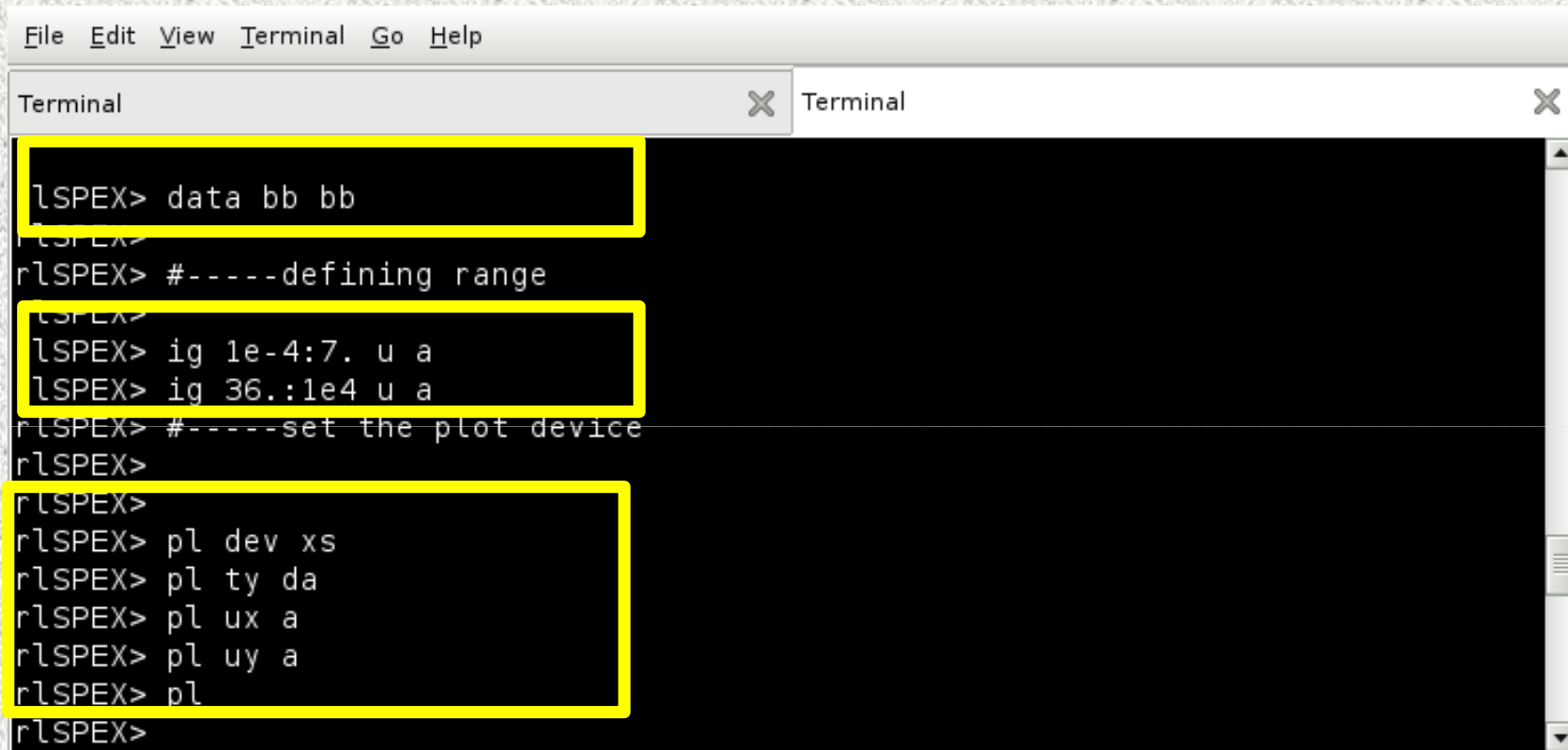
NEW in this version of SPEX:
05-03-2009 Version 2.01.03 is now stable

redirect_control_c: spex keyboard interrupt (^C) handler installed

r!SPEX>
```

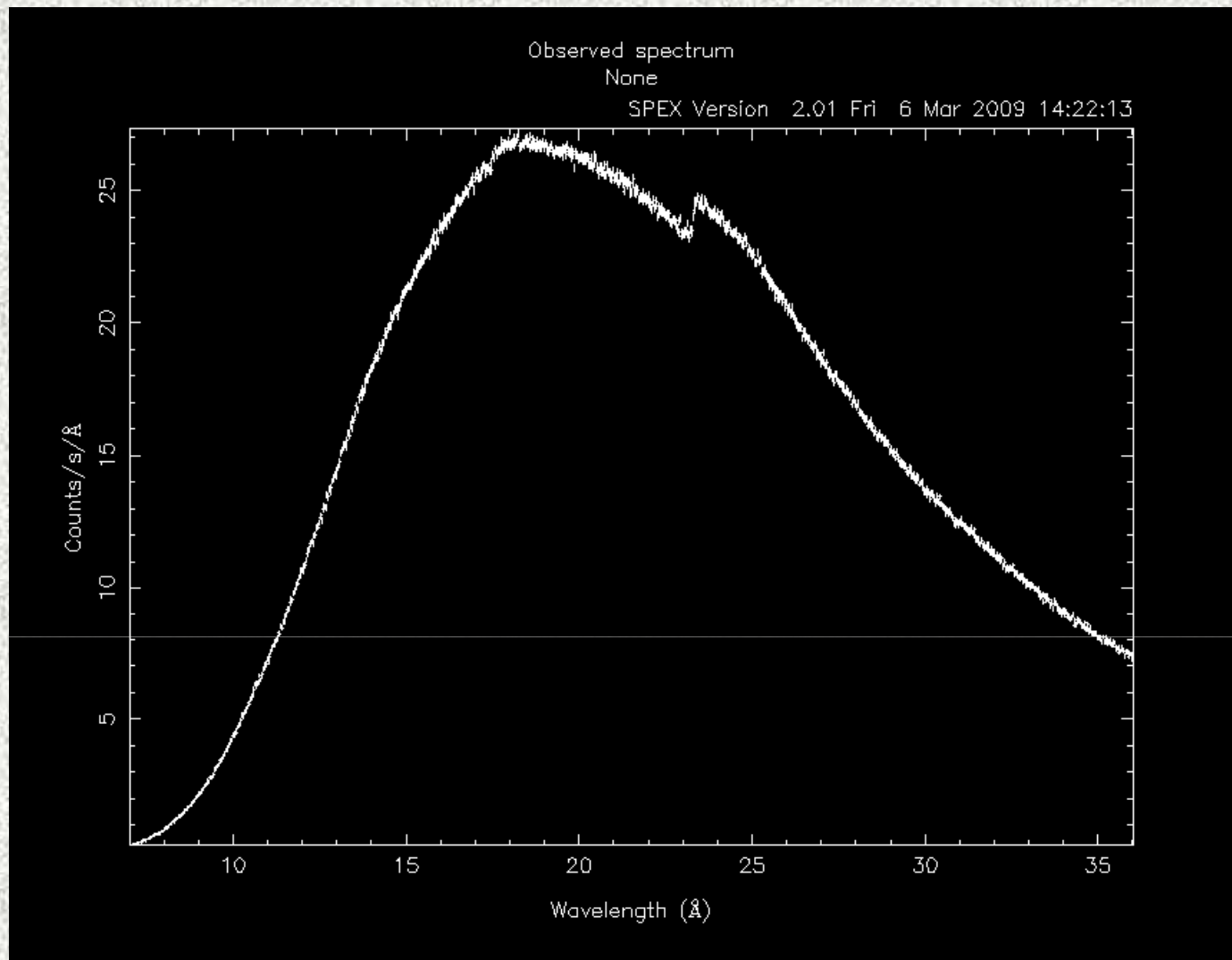


# Example 1: fitting a black body



```
File Edit View Terminal Go Help
Terminal
rlsPEX> data bb bb
rlsPEX>
rlsPEX> #----defining range
rlsPEX>
rlsPEX> ig 1e-4:7. u a
rlsPEX> ig 36.:1e4 u a
rlsPEX> #-----set the plot device
rlsPEX>
rlsPEX>
rlsPEX> pl dev xs
rlsPEX> pl ty da
rlsPEX> pl ux a
rlsPEX> pl uy a
rlsPEX> pl
rlsPEX>
```

- Spectrum and response matrix are names bb.spo and bb.res
- Use the RGS band: 7:35 Angstrom
- Display the data in Angstrom



**Save the plot:**

```
SPEX> pl x lin
```

```
SPEX> pl y lin
```

```
SPEX> plot adump data_plot
```

→ data\_plot.qdp ready for post processing with pgplot

# Fitting the spectrum

File Edit View Terminal Go Help

Terminal



Terminal



```
rlSPEX> #-----define the model
rlSPEX> dist 0.01 z
Distances assuming H0 = 70.0 km/s/Mpc, Omega_m = 0.300 Omega_Lambda = 0.700 Omega_r = 0.000
Sector      m      A.U.      ly      pc      kpc      Mpc  redshift
  cz    age(yr)
-----
1 1.332E+24 8.902E+12 1.408E+08 4.316E+07 4.316E+04 43.1582 0.0100 29
97.9 1.387E+08
-----
```

```
rlSPEX>
rlSPEX> com red
You have defined      1 component.
rlSPEX> com abs
You have defined      2 components.
rlSPEX> com bb
You have defined      3 components.
```

```
rlSPEX> #-----relate the component
rlSPEX>
rlSPEX> com rel 3 1,2
rlSPEX> #-----set known values
rlSPEX>
rlSPEX> par 1 z v 0.01
rlSPEX> par 2 nh v 1.6e-4
rlSPEX>
rlSPEX> cal
rlSPEX>
```

```

rlSPEX> elim 0.3 2
Fluxes and luminosities will be calculated between 0.300000 and 2.00000 keV

rlSPEX> cal
rlSPEX> par sho

```

```

-----
sect comp mod  acro parameter with unit      value      status      minimum      maximum lsec lco
m lpar
  1    1 reds z    Redshift                    9.999998E-03 frozen      -1.0        1.00E+10
  1    1 reds flag Flag: cosmo=0, vel=1    0.000000    frozen        0.0          1.0

  1    2 absm nh   Column (1E28/m**2)        1.5837869E-04 thawed        0.0        1.00E+20
  1    2 absm fcov Covering fraction          1.000000    frozen        0.0          1.0

  1    3 bb   norm Area (1E16 m**2)          99744.53    thawed        0.0        1.00E+20
  1    3 bb   t    Temperature (keV)          0.1400371  thawed       1.00E-04    1.00E+03

```

```

Instrument      1 region      1 has norm      1.000000E+00 and is frozen

```

```

-----
Fluxes and restframe luminosities between 0.30000 and 2.0000 keV

```

```

sect comp mod  photon flux  energy flux nr of photons  luminosity
              (phot/m**2/s)  (W/m**2)  (photons/s)  (W)
  1    3 bb      135561.      1.206483E-11  3.606857E+54  3.112619E+38

```

```

Fit method: Classical Levenberg-Marquardt
Chi-squared value :      1074.00
C-statistic      :      1073.25
Degrees of freedom: 1086
rlSPEX> █

```

SPEX> Fit meth cs

**SI units**  
**1erg=1e-7joule**



## Other useful types of plotting

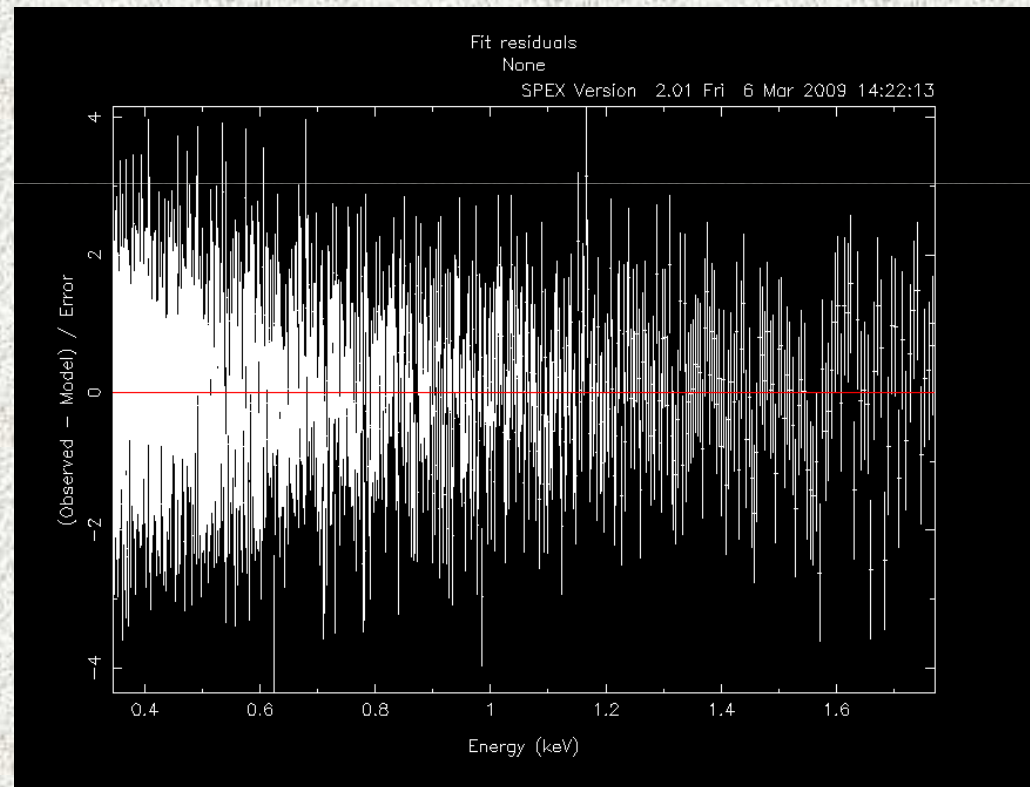
- **pl ty chi** → residuals in terms of  $\chi$ 
  - **pl uy rel** → residuals relative to the model  
(data-model)/model

- **pl ty model** → plot of the current model ( $\text{ph m}^{-2} \text{s}^{-1} \text{Ang}^{-1}$ )

- **pl ty data**
  - **pl uy fa** →  $\text{cts s}^{-1} \text{m}^{-2} \text{Ang}^{-1}$
  - **pl uy counts** → number of counts in a particular emission feature

! A useful command file is in your exercise kit: `plot_rgs.pro`

```
File Edit View Terminal Go Help
Terminal
rlSPEX> pl ty chi
rlSPEX> pl
rlSPEX>
rlSPEX>
```



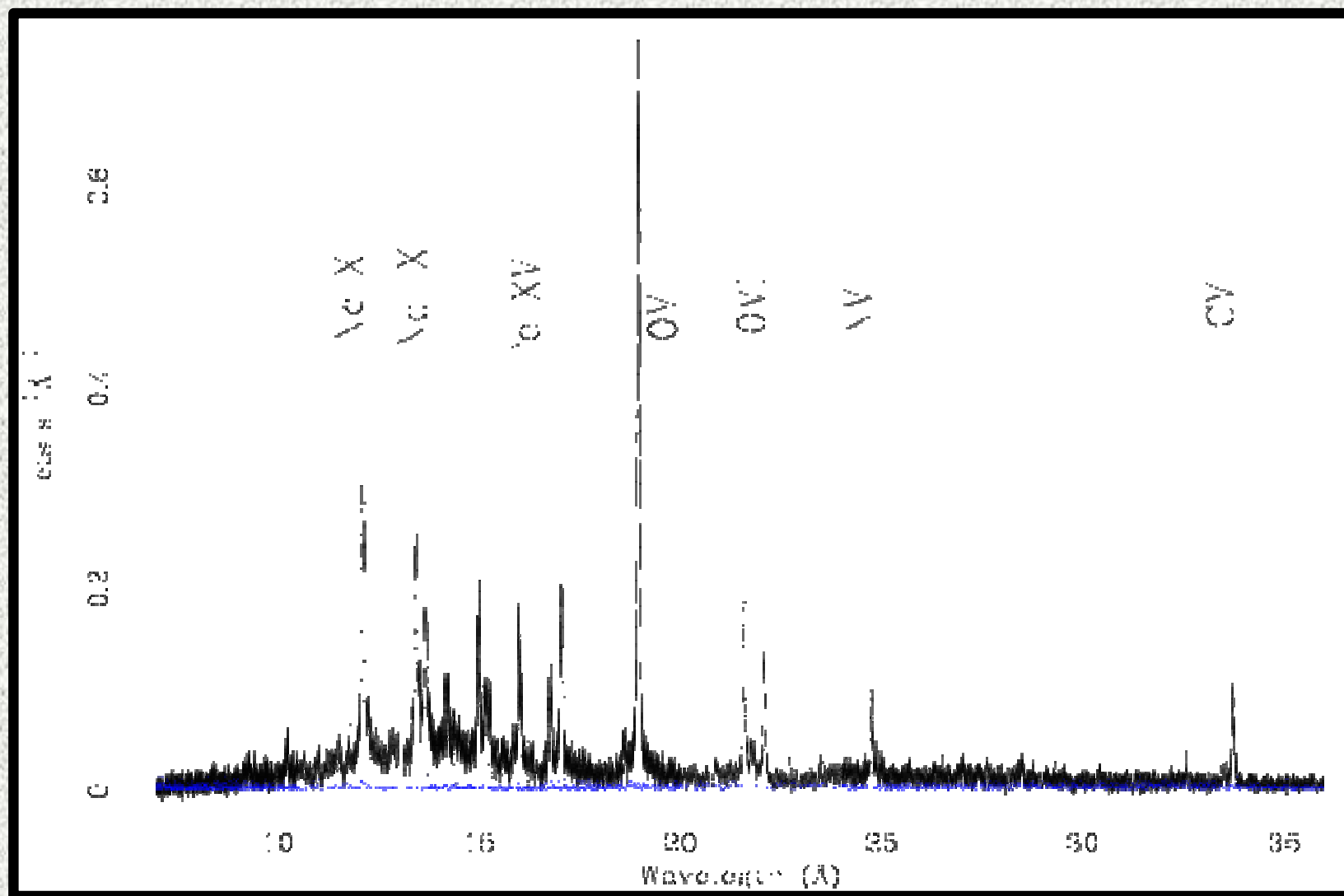
# A “live” example

## Fitting a

### star spectrum: AU Microscopii

- AU Mic is a cool nearby star (9pc), with a thermal spectrum.
  - Plasma at different temperatures (coming from different loops of the stellar corona) produces a wealth of lines in the RGS band.
- (Multiple) Collisionally ionized emission model, CIE (see also E. Behar talk)

## The RGS spectrum of AU Mic



# CIE model parameters

```
rlSPEX> com cie
You have defined      1 component.
rlSPEX> par sho
```

sect	comp	mod	acro	parameter with unit	value	status	minimum	maximum lsec
1	1	cie	norm	ne nX V (1E64/m**3)	1.000000	thawn	0.	1.00E+20
1	1	cie	t	Temperature (keV)	1.000000	thawn	5.00E-04	1.00E+03
1	1	cie	sig	Sigma (log T)	0.000000	frozen	0.	1.00E+04
1	1	cie	ed	El dens (1E20/m**3)	9.9999998E-15	frozen	1.00E-22	1.00E+10
1	1	cie	it	Ion temp (keV)	1.000000	frozen	1.00E-04	1.00E+07
1	1	cie	rt	T(balance) / T(spec)	1.000000	frozen	1.00E-04	1.00E+04
1	1	cie	vmic	Microturb vel (km/s)	0.000000	frozen	0.	3.00E+05
1	1	cie	ref	Reference atom	1.000000	frozen	1.0	30.
1	1	cie	01	Abundance H	1.000000	frozen	0.	1.00E+10
1	1	cie	02	Abundance He	1.000000	frozen	0.	1.00E+10
1	1	cie	03	Abundance Li	1.000000	frozen	0.	1.00E+10
1	1	cie	04	Abundance Be	1.000000	frozen	0.	1.00E+10
1	1	cie	05	Abundance B	1.000000	frozen	0.	1.00E+10
1	1	cie	06	Abundance C	1.000000	frozen	0.	1.00E+10
1	1	cie	07	Abundance N	1.000000	frozen	0.	1.00E+10
1	1	cie	08	Abundance O	1.000000	frozen	0.	1.00E+10
1	1	cie	09	Abundance F	1.000000	frozen	0.	1.00E+10
1	1	cie	10	Abundance Ne	1.000000	frozen	0.	1.00E+10
1	1	cie	11	Abundance Na	1.000000	frozen	0.	1.00E+10
1	1	cie	12	Abundance Mg	1.000000	frozen	0.	1.00E+10
1	1	cie	13	Abundance Al	1.000000	frozen	0.	1.00E+10
1	1	cie	14	Abundance Si	1.000000	frozen	0.	1.00E+10
1	1	cie	15	Abundance P	1.000000	frozen	0.	1.00E+10
1	1	cie	16	Abundance S	1.000000	frozen	0.	1.00E+10
1	1	cie	17	Abundance Cl	1.000000	frozen	0.	1.00E+10
1	1	cie	18	Abundance Ar	1.000000	frozen	0.	1.00E+10
1	1	cie	19	Abundance K	1.000000	frozen	0.	1.00E+10
1	1	cie	20	Abundance Ca	1.000000	frozen	0.	1.00E+10
1	1	cie	21	Abundance Sc	1.000000	frozen	0.	1.00E+10
1	1	cie	22	Abundance Ti	1.000000	frozen	0.	1.00E+10
1	1	cie	23	Abundance V	1.000000	frozen	0.	1.00E+10
1	1	cie	24	Abundance Cr	1.000000	frozen	0.	1.00E+10
1	1	cie	25	Abundance Mn	1.000000	frozen	0.	1.00E+10
1	1	cie	26	Abundance Fe	1.000000	frozen	0.	1.00E+10
1	1	cie	27	Abundance Co	1.000000	frozen	0.	1.00E+10
1	1	cie	28	Abundance Ni	1.000000	frozen	0.	1.00E+10
1	1	cie	29	Abundance Cu	1.000000	frozen	0.	1.00E+10
1	1	cie	30	Abundance Zn	1.000000	frozen	0.	1.00E+10
1	1	cie	file	File electr.distrib.				

Emission measure



# CIE model parameters

```
rlSPEX> com cie
You have defined      1 component.
rlSPEX> par sho
```

sect	comp	mod	acro	parameter with unit	value	status	minimum	maximum	lsec
1	1	cie	norm	ne nX V (1E64/m**3)	1.000000	thawn	0.	1.00E+20	
1	1	cie	t	Temperature (keV)	1.000000	thawn	5.00E-04	1.00E+03	
1	1	cie	sig	Sigma (log T)	0.000000	frozen	0.	1.00E+04	
1	1	cie	ed	El dens (1E20/m**3)	9.9999998E-15	frozen	1.00E-22	1.00E+10	
1	1	cie	it	Ion temp (keV)	1.000000	frozen	1.00E-04	1.00E+07	
1	1	cie	rt	T(balance) / T(spec)	1.000000	frozen	1.00E-04	1.00E+04	
1	1	cie	vmic	Microturb vel (km/s)	0.000000	frozen	0.	3.00E+05	
1	1	cie	ref	Reference atom	1.000000	frozen	1.0	30.	
1	1	cie	01	Abundance H	1.000000	frozen	0.	1.00E+10	
1	1	cie	02	Abundance He	1.000000	frozen	0.	1.00E+10	
1	1	cie	03	Abundance Li	1.000000	frozen	0.	1.00E+10	
1	1	cie	04	Abundance Be	1.000000	frozen	0.	1.00E+10	
1	1	cie	05	Abundance B	1.000000	frozen	0.	1.00E+10	
1	1	cie	06	Abundance C	1.000000	frozen	0.	1.00E+10	
1	1	cie	07	Abundance N	1.000000	frozen	0.	1.00E+10	
1	1	cie	08	Abundance O	1.000000	frozen	0.	1.00E+10	
1	1	cie	09	Abundance F	1.000000	frozen	0.	1.00E+10	
1	1	cie	10	Abundance Ne	1.000000	frozen	0.	1.00E+10	
1	1	cie	11	Abundance Na	1.000000	frozen	0.	1.00E+10	
1	1	cie	12	Abundance Mg	1.000000	frozen	0.	1.00E+10	
1	1	cie	13	Abundance Al	1.000000	frozen	0.	1.00E+10	
1	1	cie	14	Abundance Si	1.000000	frozen	0.	1.00E+10	
1	1	cie	15	Abundance P	1.000000	frozen	0.	1.00E+10	
1	1	cie	16	Abundance S	1.000000	frozen	0.	1.00E+10	
1	1	cie	17	Abundance Cl	1.000000	frozen	0.	1.00E+10	
1	1	cie	18	Abundance Ar	1.000000	frozen	0.	1.00E+10	
1	1	cie	19	Abundance K	1.000000	frozen	0.	1.00E+10	
1	1	cie	20	Abundance Ca	1.000000	frozen	0.	1.00E+10	
1	1	cie	21	Abundance Sc	1.000000	frozen	0.	1.00E+10	
1	1	cie	22	Abundance Ti	1.000000	frozen	0.	1.00E+10	
1	1	cie	23	Abundance V	1.000000	frozen	0.	1.00E+10	
1	1	cie	24	Abundance Cr	1.000000	frozen	0.	1.00E+10	
1	1	cie	25	Abundance Mn	1.000000	frozen	0.	1.00E+10	
1	1	cie	26	Abundance Fe	1.000000	frozen	0.	1.00E+10	
1	1	cie	27	Abundance Co	1.000000	frozen	0.	1.00E+10	
1	1	cie	28	Abundance Ni	1.000000	frozen	0.	1.00E+10	
1	1	cie	29	Abundance Cu	1.000000	frozen	0.	1.00E+10	
1	1	cie	30	Abundance Zn	1.000000	frozen	0.	1.00E+10	
1	1	cie	file	File electr.distrib.					

## Temperatures:

-- Electron  $T_e$

-- Ionic  $T_i \rightarrow$  line thermal broadening (dependence on the thermal velocity of the ions and also on ion mass)

-- equilibrium  $T_b$   
 $\rightarrow$  In CIE  $T_b/T_e=1$

Note: for non-equilibrium use the NEI model.

# CIE model parameters

```
rlSPEX> com cie
You have defined      1 component.
rlSPEX> par sho
```

sect	comp	mod	acro	parameter with unit	value	status	minimum	maximum	lsec
1	1	cie	norm	ne nX V (1E64/m**3)	1.000000	thawn	0.	1.00E+20	
1	1	cie	t	Temperature (keV)	1.000000	thawn	5.00E-04	1.00E+03	
1	1	cie	sig	Sigma (log T)	0.000000	frozen	0.	1.00E+04	
1	1	cie	ed	El dens (1E20/m**3)	9.999998E-15	frozen	1.00E-22	1.00E+10	
1	1	cie	it	Ion temp (keV)	1.000000	frozen	1.00E-04	1.00E+07	
1	1	cie	rt	T(balance) / T(spec)	1.000000	frozen	1.00E-04	1.00E+04	
1	1	cie	vmic	Microturb vel (km/s)	0.000000	frozen	0.	3.00E+05	
1	1	cie	ref	Reference atom	1.000000	frozen	1.0	30.	
1	1	cie	01	Abundance H	1.000000	frozen	0.	1.00E+10	
1	1	cie	02	Abundance He	1.000000	frozen	0.	1.00E+10	
1	1	cie	03	Abundance Li	1.000000	frozen	0.	1.00E+10	
1	1	cie	04	Abundance Be	1.000000	frozen	0.	1.00E+10	
1	1	cie	05	Abundance B	1.000000	frozen	0.	1.00E+10	
1	1	cie	06	Abundance C	1.000000	frozen	0.	1.00E+10	
1	1	cie	07	Abundance N	1.000000	frozen	0.	1.00E+10	
1	1	cie	08	Abundance O	1.000000	frozen	0.	1.00E+10	
1	1	cie	09	Abundance F	1.000000	frozen	0.	1.00E+10	
1	1	cie	10	Abundance Ne	1.000000	frozen	0.	1.00E+10	
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1	1	cie	13	Abundance Al	1.000000	frozen	0.	1.00E+10	
1	1	cie	14	Abundance Si	1.000000	frozen	0.	1.00E+10	
1	1	cie	15	Abundance P	1.000000	frozen	0.	1.00E+10	
1	1	cie	16	Abundance S	1.000000	frozen	0.	1.00E+10	
1	1	cie	17	Abundance Cl	1.000000	frozen	0.	1.00E+10	
1	1	cie	18	Abundance Ar	1.000000	frozen	0.	1.00E+10	
1	1	cie	19	Abundance K	1.000000	frozen	0.	1.00E+10	
1	1	cie	20	Abundance Ca	1.000000	frozen	0.	1.00E+10	
1	1	cie	21	Abundance Sc	1.000000	frozen	0.	1.00E+10	
1	1	cie	22	Abundance Ti	1.000000	frozen	0.	1.00E+10	
1	1	cie	23	Abundance V	1.000000	frozen	0.	1.00E+10	
1	1	cie	24	Abundance Cr	1.000000	frozen	0.	1.00E+10	
1	1	cie	25	Abundance Mn	1.000000	frozen	0.	1.00E+10	
1	1	cie	26	Abundance Fe	1.000000	frozen	0.	1.00E+10	
1	1	cie	27	Abundance Co	1.000000	frozen	0.	1.00E+10	
1	1	cie	28	Abundance Ni	1.000000	frozen	0.	1.00E+10	
1	1	cie	29	Abundance Cu	1.000000	frozen	0.	1.00E+10	
1	1	cie	30	Abundance Zn	1.000000	frozen	0.	1.00E+10	
1	1	cie	file	File electr.distrib.					

**Width** of the temperature  
(Gaussian) distribution

$\sigma_T = 0 \rightarrow$  plasma is isothermal

Line broadening due to  
**microturbulence:**

$V_{mic} = \sqrt{2} \sigma_v$  where  $\sigma_v$  is the  
Velocity dispersion along the  
line of sight

# CIE model parameters

```
rlSPEX> com cie
You have defined      1 component.
rlSPEX> par sho
```

sect	comp	mod	acro	parameter with unit	value	status	minimum	maximum	lsec
1	1	cie	norm	ne nX V (1E64/m**3)	1.000000	thawn	0.	1.00E+20	
1	1	cie	t	Temperature (keV)	1.000000	thawn	5.00E-04	1.00E+03	
1	1	cie	sig	Sigma (log T)	0.000000	frozen	0.	1.00E+04	
1	1	cie	ed	EL dens (1E20/m**3)	9.9999998E-15	frozen	1.00E-22	1.00E+10	
1	1	cie	it	Ion temp (keV)	1.000000	frozen	1.00E-04	1.00E+07	
1	1	cie	rt	T(balance) / T(spec)	1.000000	frozen	1.00E-04	1.00E+04	
1	1	cie	vmic	Microturb vel (km/s)	0.000000	frozen	0.	3.00E+05	
1	1	cie	ref	Reference atom	1.000000	frozen	1.0	30.	
1	1	cie	01	Abundance H	1.000000	frozen	0.	1.00E+10	
1	1	cie	02	Abundance He	1.000000	frozen	0.	1.00E+10	
1	1	cie	03	Abundance Li	1.000000	frozen	0.	1.00E+10	
1	1	cie	04	Abundance Be	1.000000	frozen	0.	1.00E+10	
1	1	cie	05	Abundance B	1.000000	frozen	0.	1.00E+10	
1	1	cie	06	Abundance C	1.000000	frozen	0.	1.00E+10	
1	1	cie	07	Abundance N	1.000000	frozen	0.	1.00E+10	
1	1	cie	08	Abundance O	1.000000	frozen	0.	1.00E+10	
1	1	cie	09	Abundance F	1.000000	frozen	0.	1.00E+10	
1	1	cie	10	Abundance Ne	1.000000	frozen	0.	1.00E+10	
1	1	cie	11	Abundance Na	1.000000	frozen	0.	1.00E+10	
1	1	cie	12	Abundance Mg	1.000000	frozen	0.	1.00E+10	
1	1	cie	13	Abundance Al	1.000000	frozen	0.	1.00E+10	
1	1	cie	14	Abundance Si	1.000000	frozen	0.	1.00E+10	
1	1	cie	15	Abundance P	1.000000	frozen	0.	1.00E+10	
1	1	cie	16	Abundance S	1.000000	frozen	0.	1.00E+10	
1	1	cie	17	Abundance Cl	1.000000	frozen	0.	1.00E+10	
1	1	cie	18	Abundance Ar	1.000000	frozen	0.	1.00E+10	
1	1	cie	19	Abundance K	1.000000	frozen	0.	1.00E+10	
1	1	cie	20	Abundance Ca	1.000000	frozen	0.	1.00E+10	
1	1	cie	21	Abundance Sc	1.000000	frozen	0.	1.00E+10	
1	1	cie	22	Abundance Ti	1.000000	frozen	0.	1.00E+10	
1	1	cie	23	Abundance V	1.000000	frozen	0.	1.00E+10	
1	1	cie	24	Abundance Cr	1.000000	frozen	0.	1.00E+10	
1	1	cie	25	Abundance Mn	1.000000	frozen	0.	1.00E+10	
1	1	cie	26	Abundance Fe	1.000000	frozen	0.	1.00E+10	
1	1	cie	27	Abundance Co	1.000000	frozen	0.	1.00E+10	
1	1	cie	28	Abundance Ni	1.000000	frozen	0.	1.00E+10	
1	1	cie	29	Abundance Cu	1.000000	frozen	0.	1.00E+10	
1	1	cie	30	Abundance Zn	1.000000	frozen	0.	1.00E+10	
1	1	cie	file	File electr.distrib.					

## Electron density

Lines which are sensitive to density will be adjusted in normalization



# CIE model parameters

```
rlSPEX> com cie
You have defined      1 component.
rlSPEX> par sho
```

sect	comp	mod	acro	parameter with unit	value	status	minimum	maximum	lsec
1	1	cie	norm	ne nX V (1E64/m**3)	1.000000	thawn	0.	1.00E+20	
1	1	cie	t	Temperature (keV)	1.000000	thawn	5.00E-04	1.00E+03	
1	1	cie	sig	Sigma (log T)	0.000000	frozen	0.	1.00E+04	
1	1	cie	ed	El dens (1E20/m**3)	9.999998E-15	frozen	1.00E-22	1.00E+10	
1	1	cie	it	Ion temp (keV)	1.000000	frozen	1.00E-04	1.00E+07	
1	1	cie	rt	T(balance) / T(spec)	1.000000	frozen	1.00E-04	1.00E+04	
1	1	cie	vmic	Microturb vel (km/s)	0.000000	frozen	0.	3.00E+05	
1	1	cie	ref	Reference atom	1.000000	frozen	1.0	30.	
1	1	cie	01	Abundance H	1.000000	frozen	0.	1.00E+10	
1	1	cie	02	Abundance He	1.000000	frozen	0.	1.00E+10	
1	1	cie	03	Abundance Li	1.000000	frozen	0.	1.00E+10	
1	1	cie	04	Abundance Be	1.000000	frozen	0.	1.00E+10	
1	1	cie	05	Abundance B	1.000000	frozen	0.	1.00E+10	
1	1	cie	06	Abundance C	1.000000	frozen	0.	1.00E+10	
1	1	cie	07	Abundance N	1.000000	frozen	0.	1.00E+10	
1	1	cie	08	Abundance O	1.000000	frozen	0.	1.00E+10	
1	1	cie	09	Abundance F	1.000000	frozen	0.	1.00E+10	
1	1	cie	10	Abundance Ne	1.000000	frozen	0.	1.00E+10	
1	1	cie	11	Abundance Na	1.000000	frozen	0.	1.00E+10	
1	1	cie	12	Abundance Mg	1.000000	frozen	0.	1.00E+10	
1	1	cie	13	Abundance Al	1.000000	frozen	0.	1.00E+10	
1	1	cie	14	Abundance Si	1.000000	frozen	0.	1.00E+10	
1	1	cie	15	Abundance P	1.000000	frozen	0.	1.00E+10	
1	1	cie	16	Abundance S	1.000000	frozen	0.	1.00E+10	
1	1	cie	17	Abundance Cl	1.000000	frozen	0.	1.00E+10	
1	1	cie	18	Abundance Ar	1.000000	frozen	0.	1.00E+10	
1	1	cie	19	Abundance K	1.000000	frozen	0.	1.00E+10	
1	1	cie	20	Abundance Ca	1.000000	frozen	0.	1.00E+10	
1	1	cie	21	Abundance Sc	1.000000	frozen	0.	1.00E+10	
1	1	cie	22	Abundance Ti	1.000000	frozen	0.	1.00E+10	
1	1	cie	23	Abundance V	1.000000	frozen	0.	1.00E+10	
1	1	cie	24	Abundance Cr	1.000000	frozen	0.	1.00E+10	
1	1	cie	25	Abundance Mn	1.000000	frozen	0.	1.00E+10	
1	1	cie	26	Abundance Fe	1.000000	frozen	0.	1.00E+10	
1	1	cie	27	Abundance Co	1.000000	frozen	0.	1.00E+10	
1	1	cie	28	Abundance Ni	1.000000	frozen	0.	1.00E+10	
1	1	cie	29	Abundance Cu	1.000000	frozen	0.	1.00E+10	
1	1	cie	30	Abundance Zn	1.000000	frozen	0.	1.00E+10	
1	1	cie	file	File electr.distrib.					

## Abundances

Deafult is set to solar  
(Anders & Grevesse 89)

Change abundances:  
SPEX> abu #a

Reference atom is H,  
but for spectra with  
strong lines (and weak  
continuum) it's  
better to set the ref to  
the strongest line (Fe)