Semianalytic modeling of galaxy spectra

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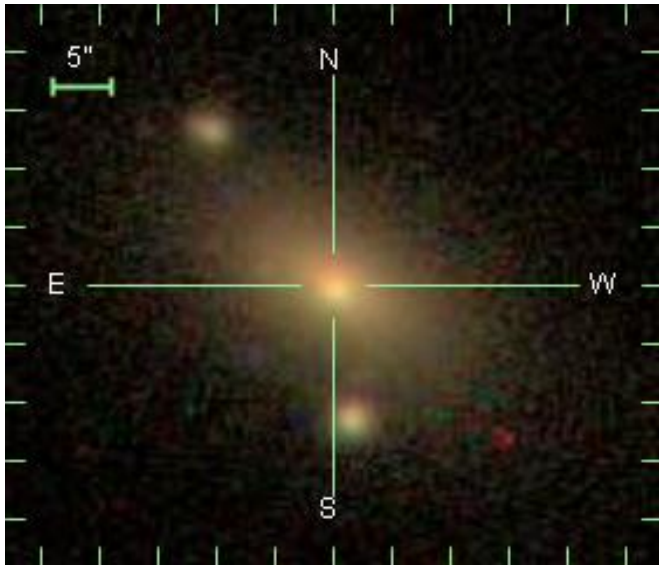
Spectral Energy Distribution (SED) of galaxies



Studying distant galaxies:

- Structure is not resolved
  - Not much information in 2D pictures
  - Especially the very distant ones
    - the more distant, the more interesting
    - galaxy picture here

Spectral Energy Distribution (SED) of galaxies

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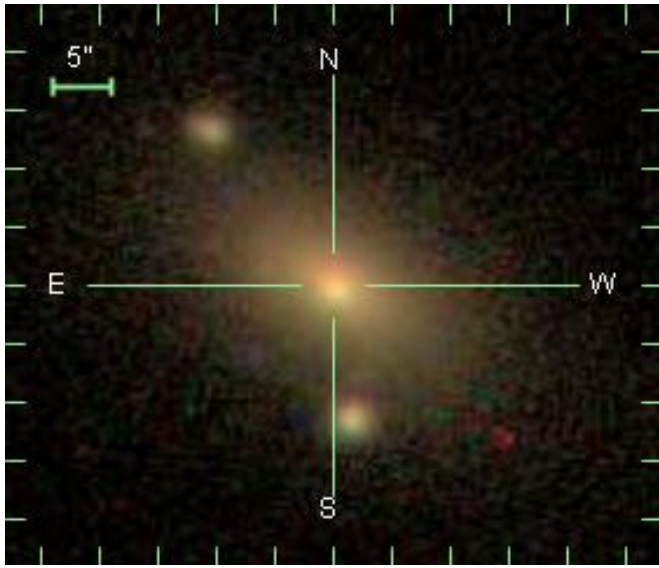

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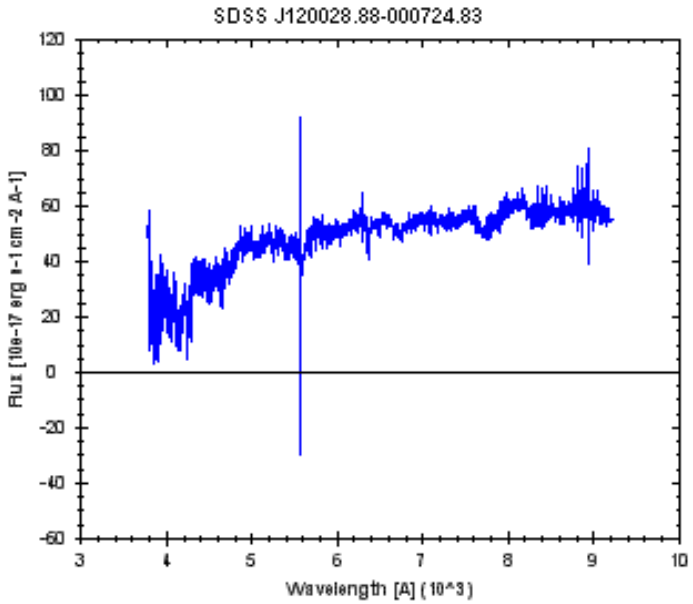


- More information in SEDs!
  - e.g.: redshift (distance)

Spectral Energy Distribution (SED) of galaxies

- The origin of galaxy SED:
  - Integrated light of all objects in the galaxy
    - stars
    - active nucleus
    - emission, and absorption of interstellar matter (ISM)

- Information in galaxy SED:
  - redshift
  - age
  - velocity dispersion of stars
  - amount of ISM
  - more?

Stellar Population Synthesis model (SPS)

Assumptions:

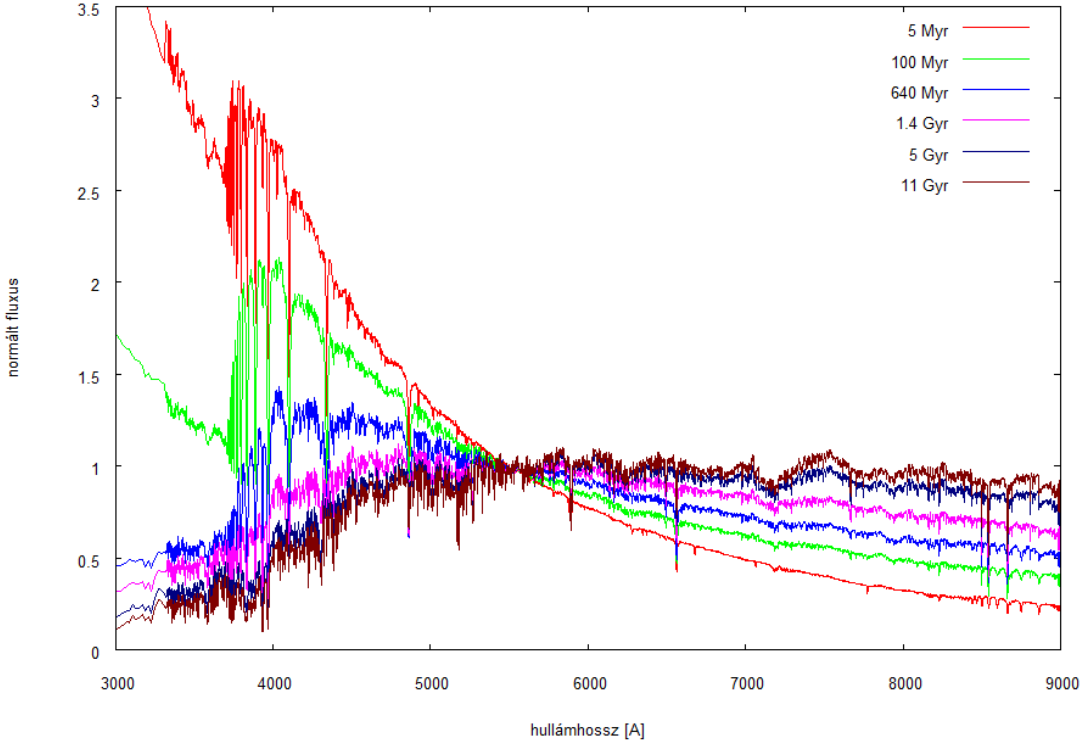
- SED of a star is given if we know:
  - initial mass
  - initial chemical composition
  - age
  - SED is given by stellar evolution models

- universal Initial Mass Function (IMF)
  - the most important
  - and debated

Stellar Population Synthesis model (SPS)

Stellar Population:

- SED of stars + IMF : Population of stars
  - variables: age, chemical comp.



Stellar Population Synthesis model (SPS)

Stellar Population:

- SED of stars + IMF : Population of stars
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Stellar Population Synthesis:

- Multiple populations - > GALAXY
  - variables:
    - ages of populations (star formation history)
    - chemical composition

Stellar Population Synthesis model (SPS)

Other factors:

- redshift

- velocity dispersion
  - convolution of spectra with Gauss

- Interstellar matter simple model
  - simple model is needed
    - there are very complicated ones, there is not enough information in the spectra to account for these complicated models

Computation

Isochrone synthesis:

- Convolution of SSP-SEDs, and SFH
  - ~4000 wavelengths, ~200 timesteps

- Age dependent effect of ISM
- Velocity distribution: convolution with a Gaussian
- Interpolation in chemical composition

Computation on GPU:

- ~4000 (almost) independent points
  - massive parallelization
- Interpolation between original models, convolution in time, convolution in wavelengths all can be done in parallel:

Performance:

- GALAXEV: seconds
- SPS-FAST (c++, OpenCL):
  - GTX 670: 0.3 ms
  - Intel core i7-2600: 2.5 ms

Fitting

- 5-8 parameters
- Degenerate parameter space (age-chemical composition)
- Model needs refinement

Fitting methods

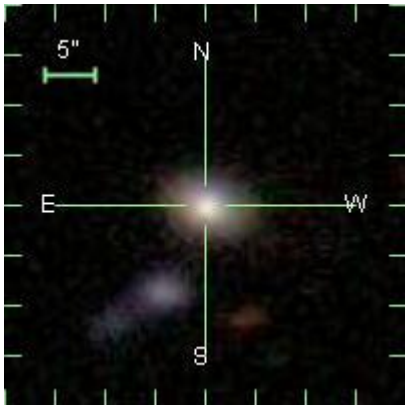
- In practice now:
  - with pre-generated sample galaxies
    - small discrete grid
  - only reduced parameters used (spectral indices)
  - approximation: MOPED

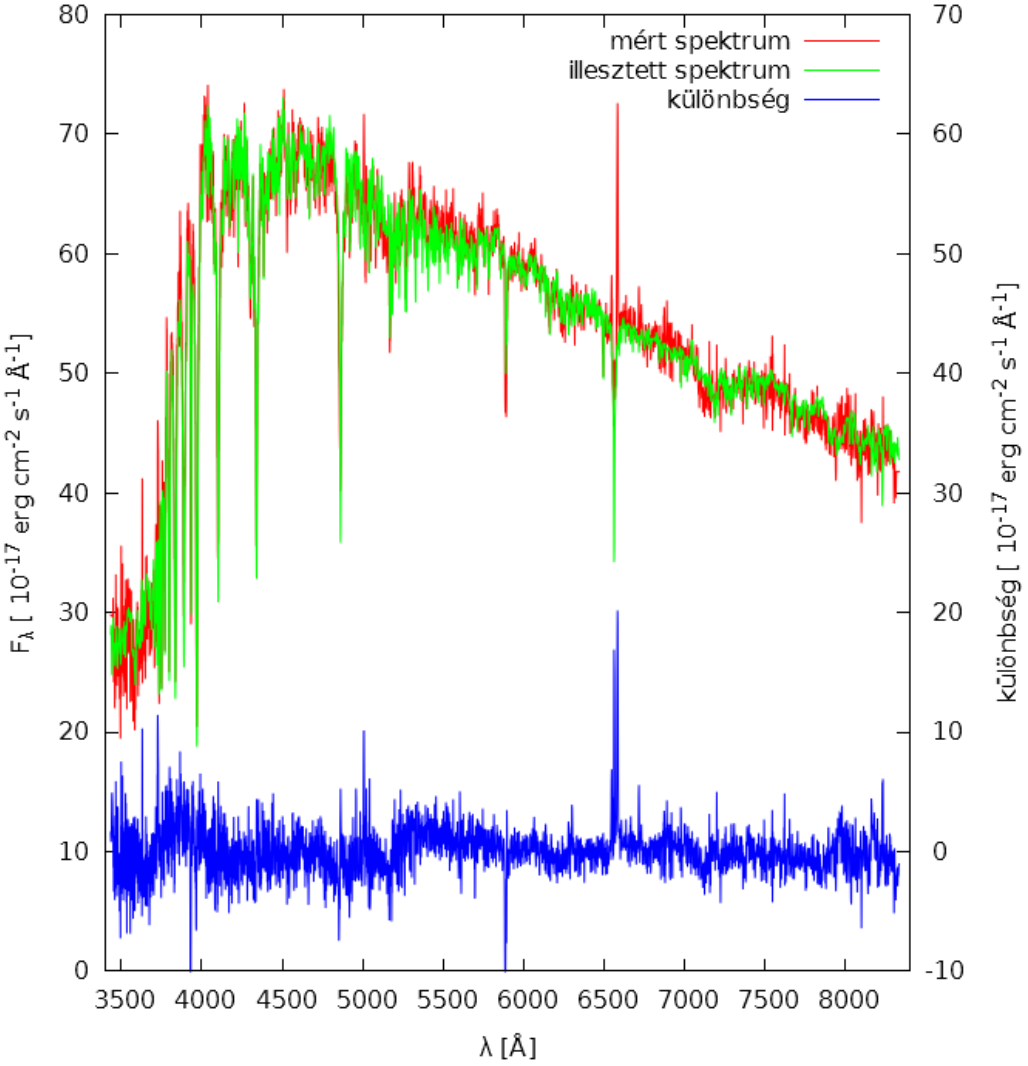
- MCMC fitting:
  - Explores the parameter space
  - Robust
  - Shows degenerations, and other problems
  - ~50000 points needed, (~15 seconds)

MCMC SPS model fitting example

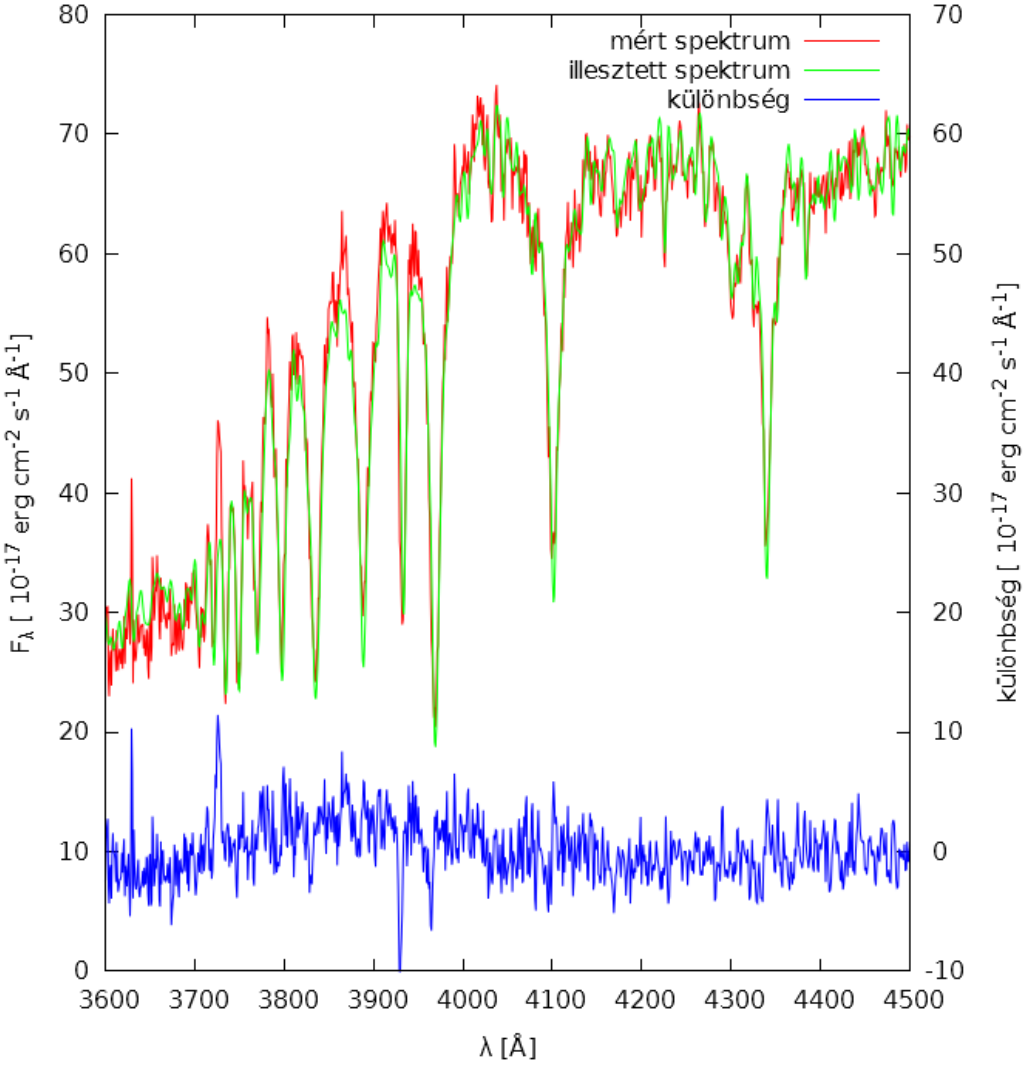
- Based on GALAXEV:
  - Bruzual and Charlot models
  - Exponential decay in SFH
  - 2 component Charlot and Fall ISM model
  - Random high SNR galaxy from SDSS spectral survey
  - 50000 iterations

Results

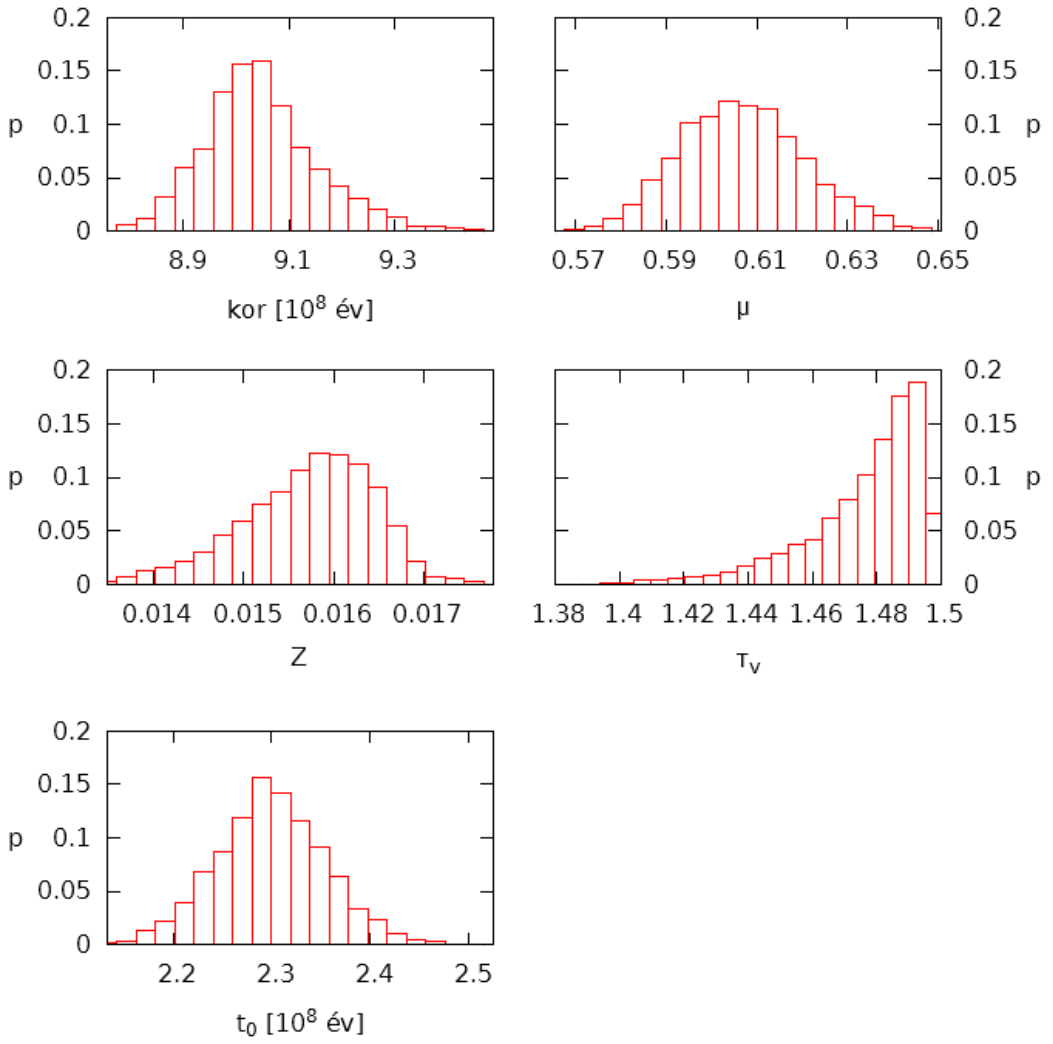

5"
N
E
W
S


mért spektrum
illesztett spektrum
különbség
Fλ [10-17 erg cm-2 s-1 Å-1]
különbség [10-17 erg cm-2 s-1 Å-1]
λ [Å]
80
70
60
50
40
30
20
10
0
-10
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000

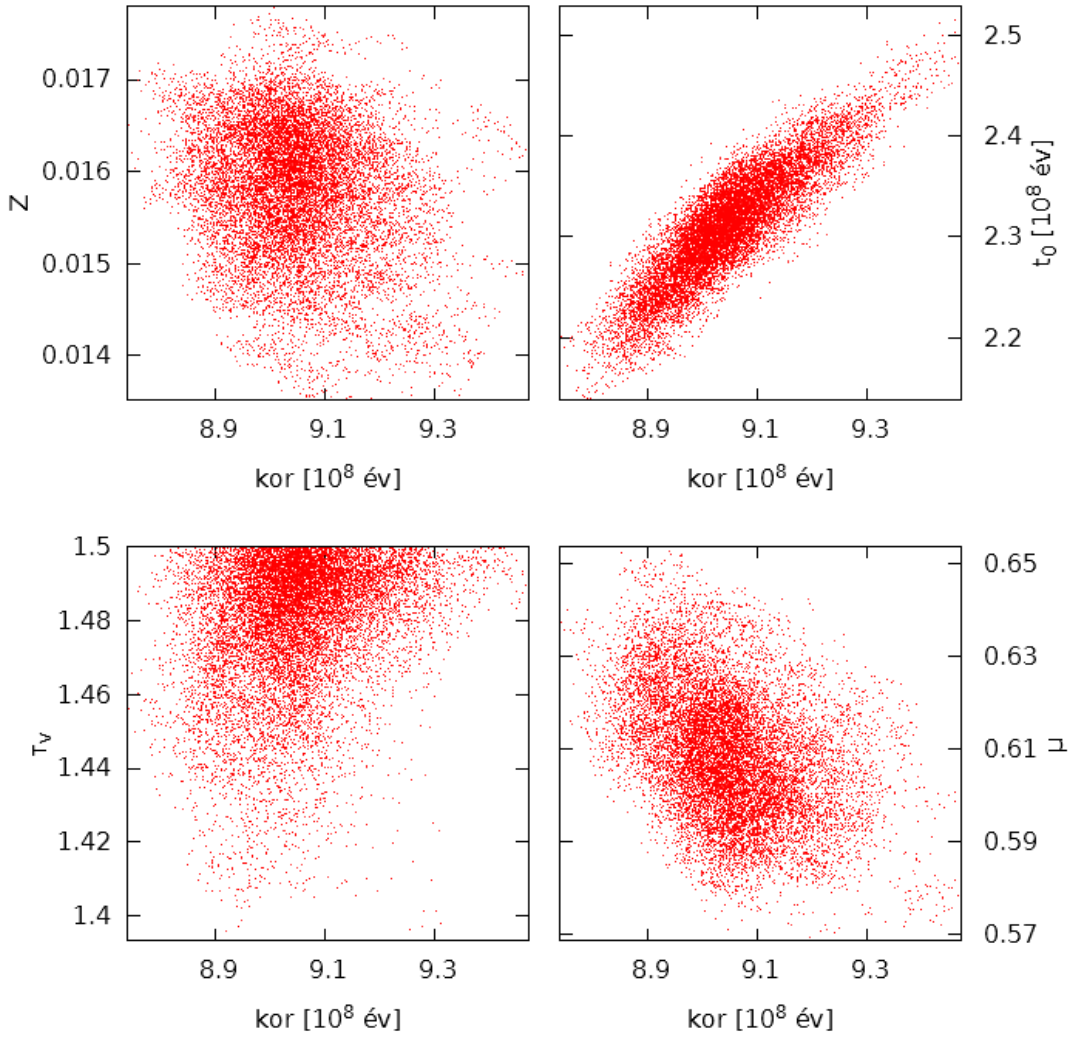
Results


mért spektrum
illesztett spektrum
különbség
F_λ [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]
különbség [10^{-17} erg cm^{-2} s^{-1} Å^{-1}]
λ [Å]
0
10
20
30
40
50
60
70
80
-10
0
10
20
30
40
50
60
70
3600
3700
3800
3900
4000
4100
4200
4300
4400
4500

Results


0.2
0.15
0.1
0.05
0
p
8.9
9.1
9.3
kor [10^8 év]
0.57
0.59
0.61
0.63
0.65
μ
0.014
0.015
0.016
0.017
Z
1.38
1.4
1.42
1.44
1.46
1.48
1.5
τ_V
2.2
2.3
2.4
2.5
t_0 [10^8 év]

Results


Z
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8.9
9.1
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kor [10^8 év]
t0 [10^8 év]
2.5
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τv
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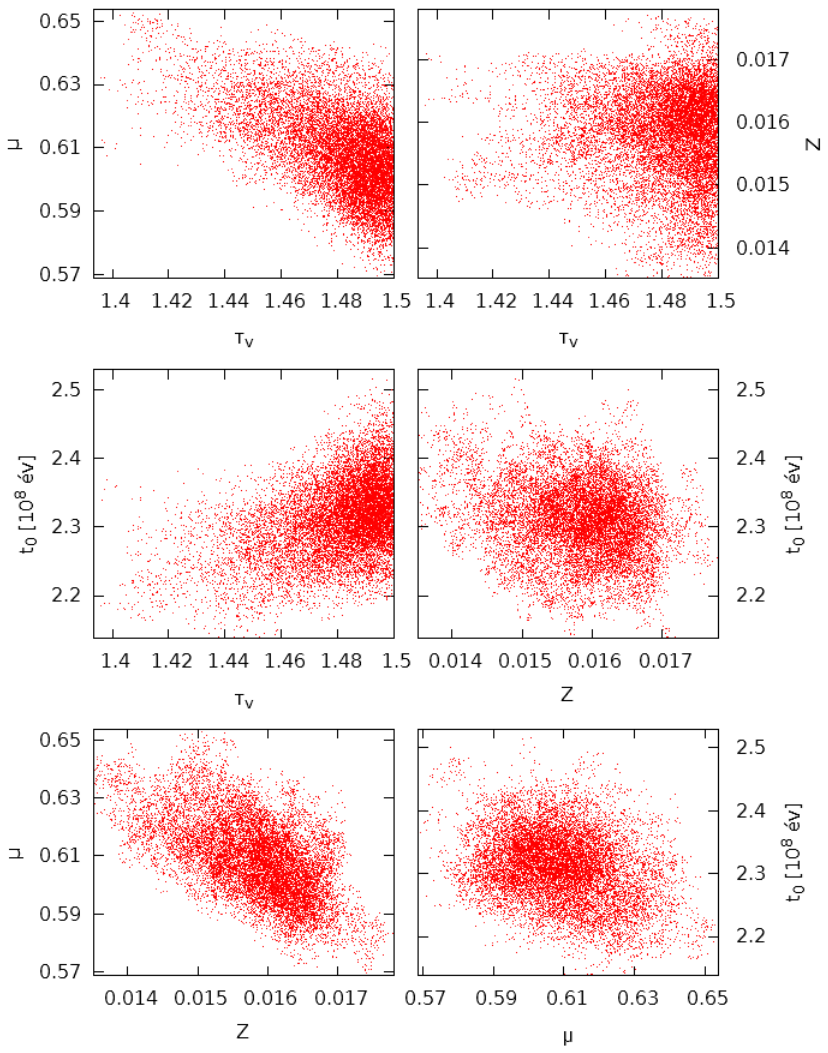
μ
0.65
0.63
0.61
0.59
0.57
1.4 1.42 1.44 1.46 1.48 1.5
τv
Z
0.017
0.016
0.015
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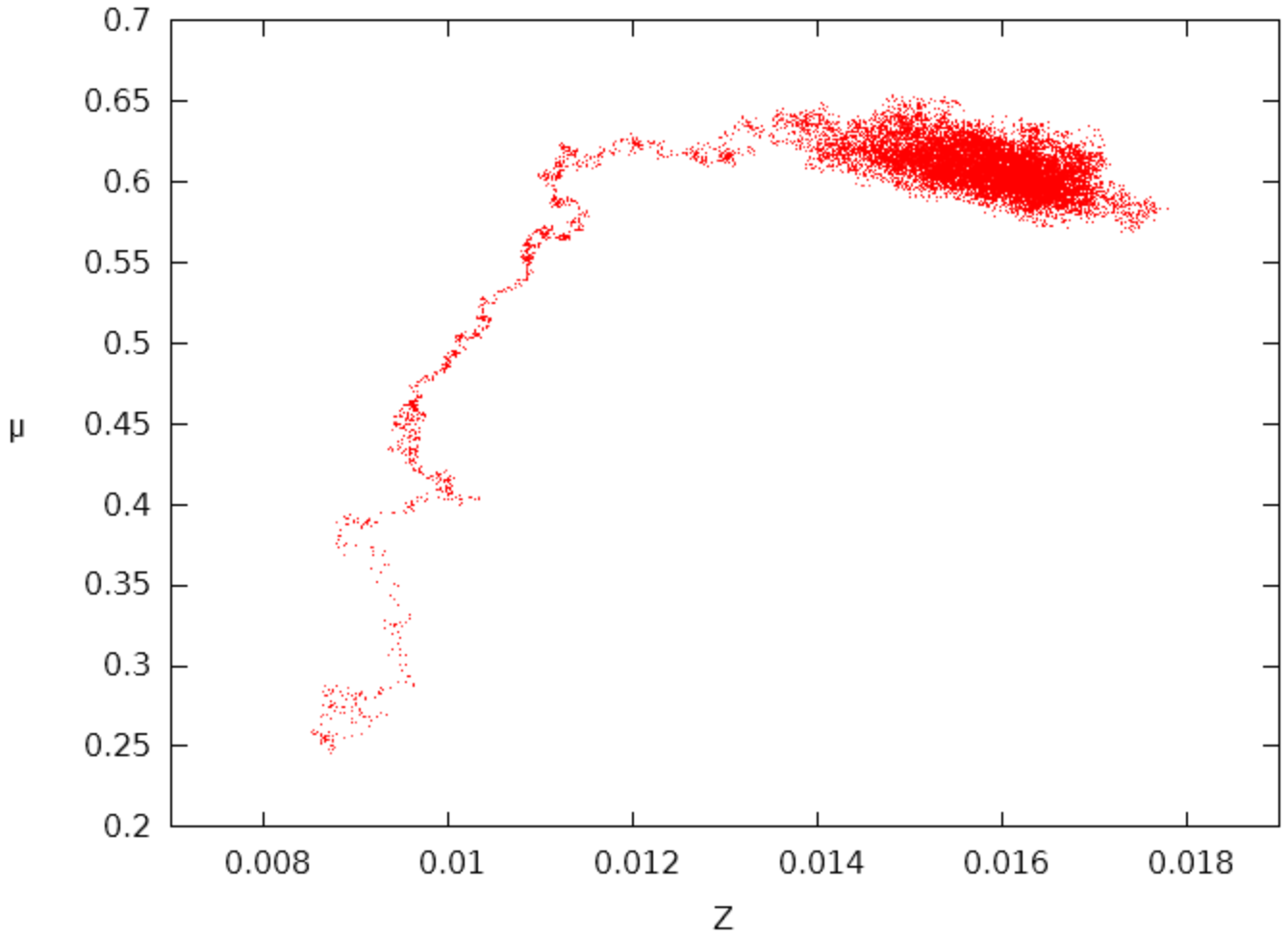
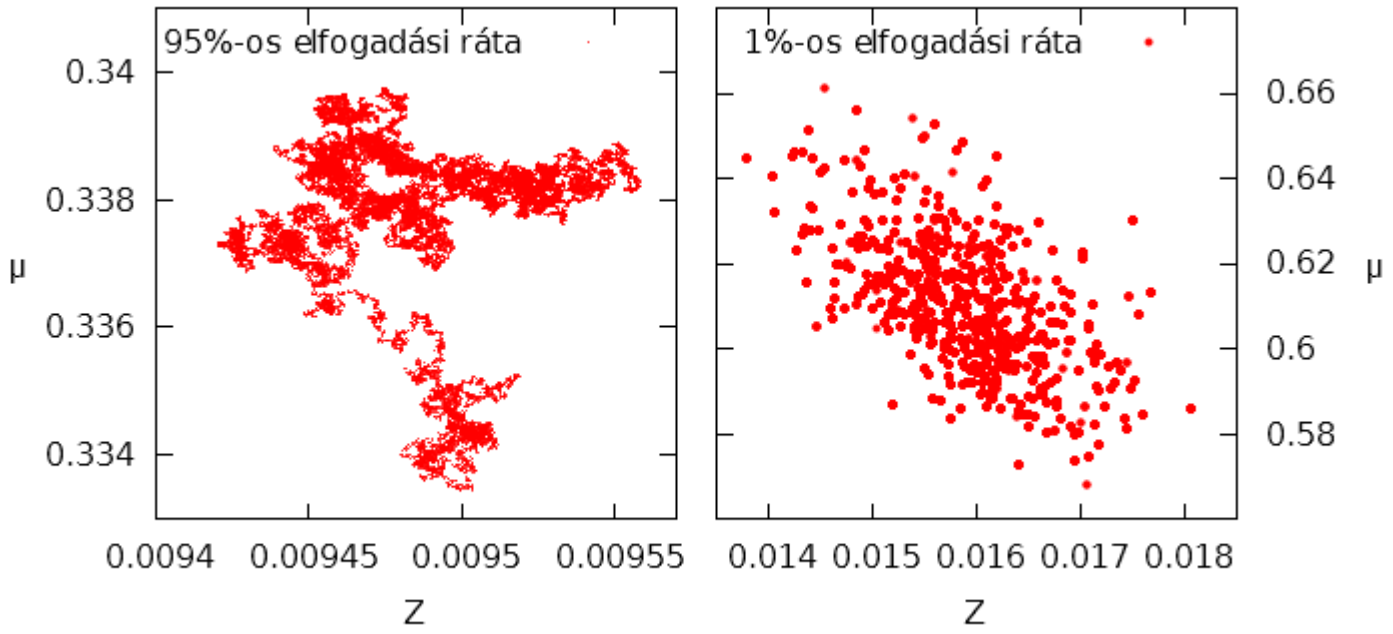
t0 [10^8 év]
2.5
2.4
2.3
2.2
0.014 0.015 0.016 0.017
Z
0.57 0.59 0.61 0.63 0.65
μ

MCMC

Burn-in


0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
μ
0.008
0.01
0.012
0.014
0.016
0.018
Z

MCMC


95%-os elfogadási ráta
1%-os elfogadási ráta
μ
0.34
0.338
0.336
0.334
0.66
0.64
0.62
0.6
0.58
μ
0.0094
0.00945
0.0095
0.00955
Z
0.014
0.015
0.016
0.017
0.018
Z

Usage, goals

Usage:

- Analysis of big databases
- improvement of SPS models
- detailed inspection of a galaxy in seconds

Goals:

- introduce it to the researches of the field
- incorporate different SPS models

Thank you for your attention!

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