JetSeT

Jets SED modeler and fitting Tool

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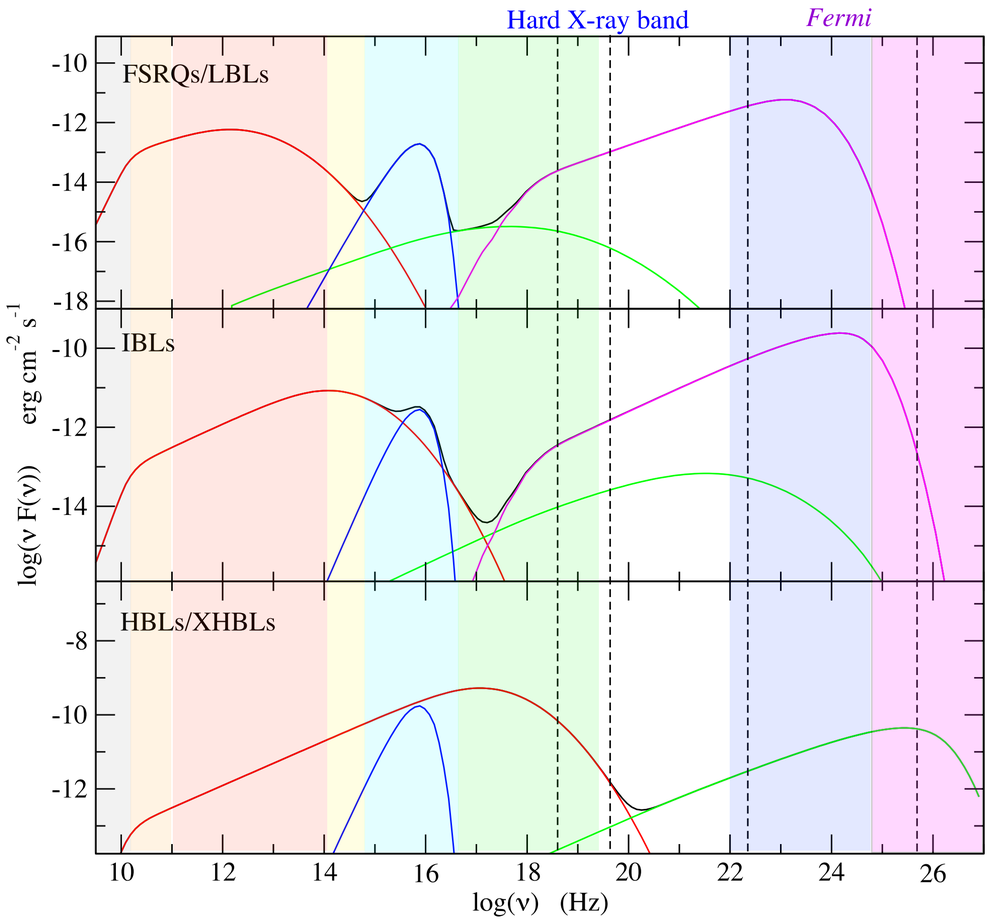
https://jetset.readthedocs.io/en/latest/
https://github.com/andreatramacere/jetset

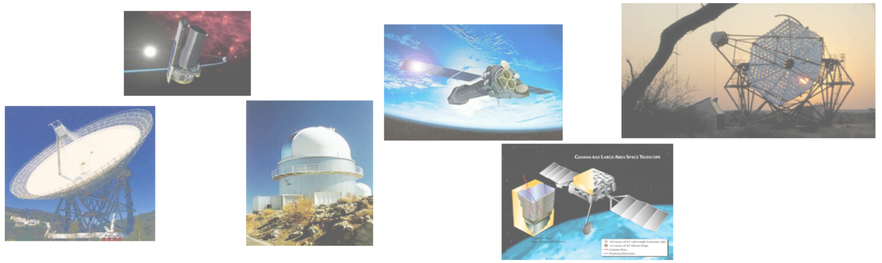
JetSeT functionalities and scope

- handling observed **data** (groping, definition of data sets, etc...)
- definition of complex radiative **models** SSC/EC IC against CMB/BLR/DT, plus analytical and template models
- **constraining** of the model in the pre-fitting stage, based on accurate and already published **phenomenological trends**
- **fitting of multiwavelength SEDs** using both **frequentist** approach (iminuit/scipy) and Bayesian **MCMC** sampling (emcee)
- reproduction of the **temporal evolution of the plasma** under the effect of **radiative and accelerative processes**. Both first order and second order (stochastic acceleration) processes.
- I started to develop the code in 2001, it became open source this year, but has been used in several publications since 2003 (Fermi/MAGIC/PLANCK, Science, ApJ,MNRAS, A&A)
- Currently used in collaboration with the MAGIC group in Padova (Michele Doro)

JetSeT :Blazars in a nutshell

data





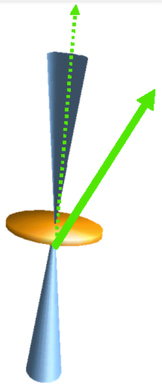
phenomenology

model fit

simulations

model

jet/disk



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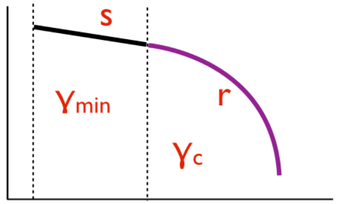
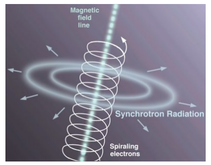
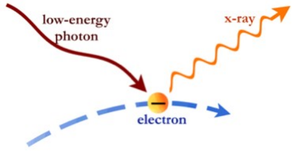
acc.



+

em.

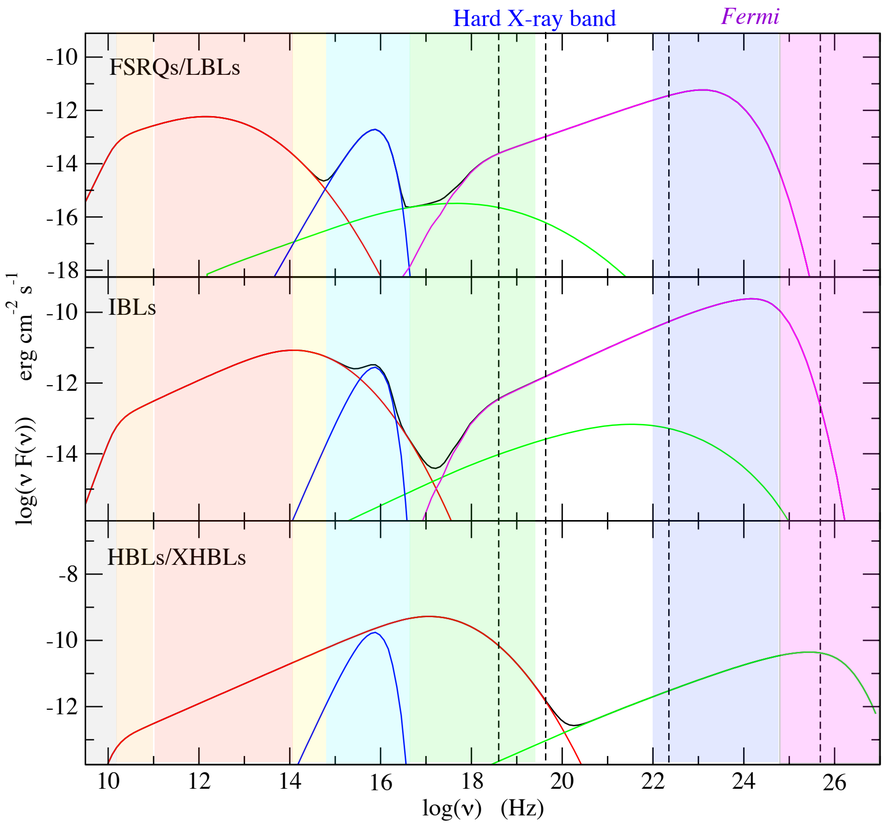




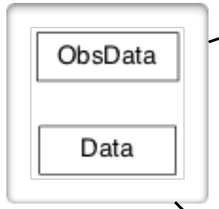
Code organization and usage

JetSeT Data Format

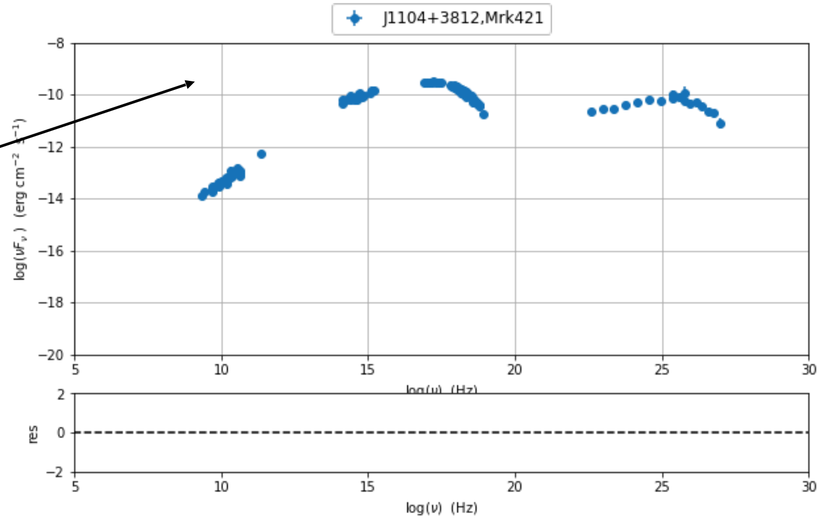
data



data loader



ObsData are built from Data, and implement several functionalities



- **grouping**
- **lin<->log**
- **UL**
- **systematics**
- **selection over T span**
- **selection over data_set**
- **rest-frame osb<->src**
- **plotting**

```
data.table
```

Table length=110

x	dx	y	dy	T_start	T_stop	UL	data_set
Hz	erg / (cm2 s)	erg / (cm2 s)	erg / (cm2 s)	MJD	MJD		
float64	float64	float64	float64	float64	float64	bool	str13
2299540000.0	0.0	1.3409e-14	3.91e-16	0.0	0.0	False	campaing-2009
2639697000.0	0.0	1.793088e-14	3.231099e-26	0.0	0.0	False	campaing-2009
4799040000.0	0.0	2.3136e-14	2.4e-16	0.0	0.0	False	campaing-2009
4805039000.0	0.0	1.773414e-14	1.773414e-15	0.0	0.0	False	campaing-2009
4843552000.0	0.0	2.77614e-14	2.615339e-26	0.0	0.0	False	campaing-2009
7698460000.0	0.0	3.696e-14	4.62e-16	0.0	0.0	False	campaing-2009
8267346000.0	0.0	2.836267e-14	2.836267e-15	0.0	0.0	False	campaing-2009
8331867000.0	0.0	3.98963e-14	3.627671e-26	0.0	0.0	False	campaing-2009
8388659000.0	0.0	3.16345e-14	1.931495e-15	0.0	0.0	False	campaing-2009
...	...	...	...	...	...	...	...

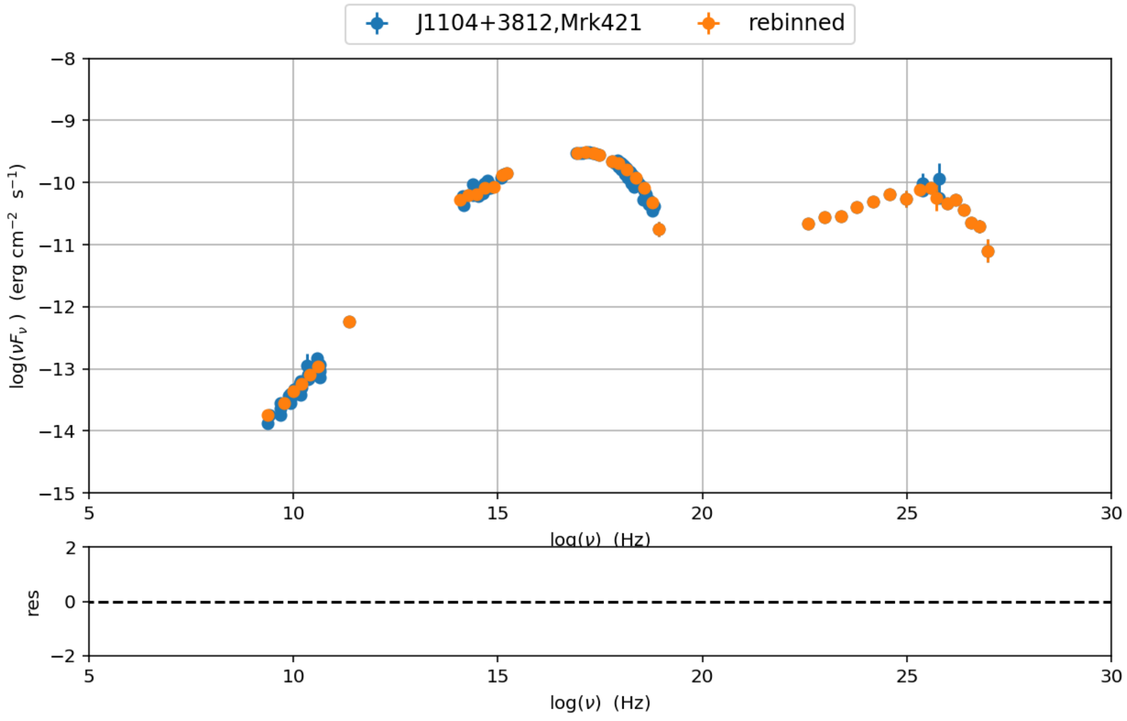
- from astropy tables
- from numpy arrays
- importer for SSDC https://tools.ssdc.asi.it/SED/

SSDC Sky Explorer

JetSeT Data Format

rebinnig(grouping)

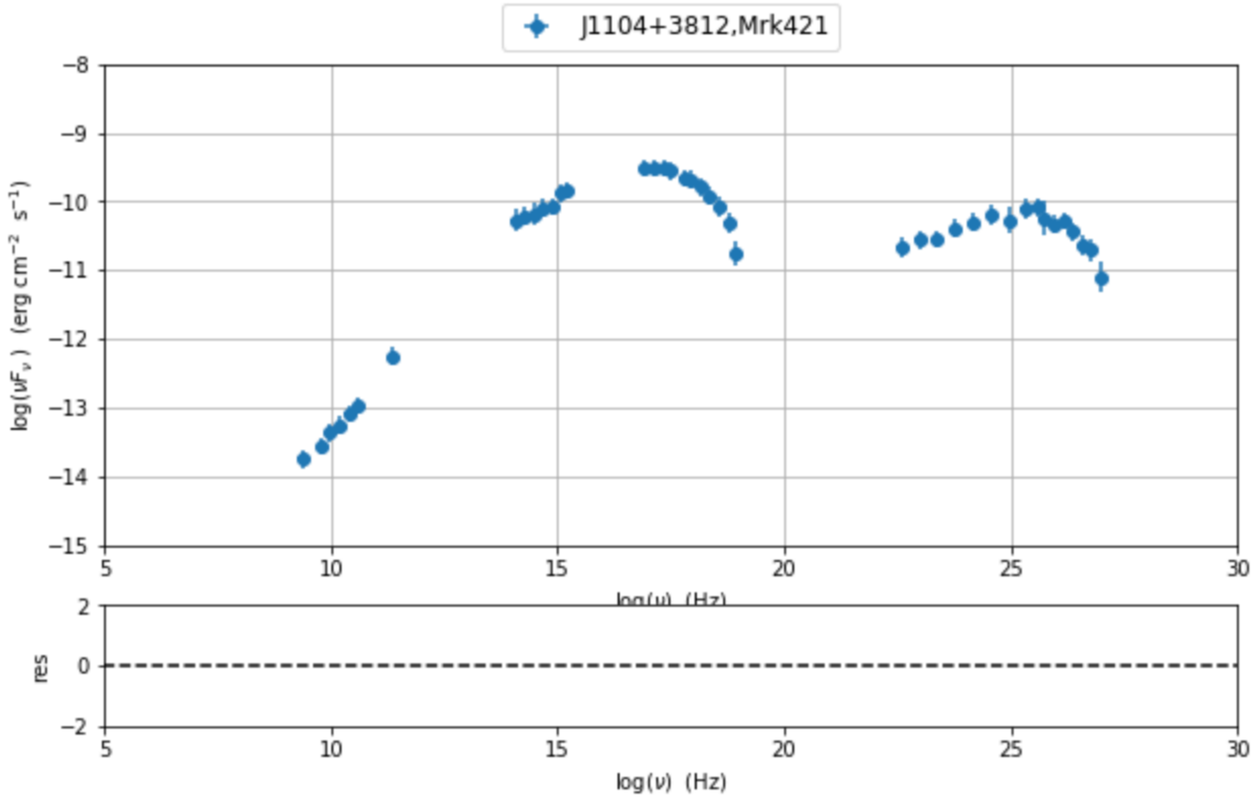
```
myPlot=sed_data.plot_sed()
myPlot.rescale(y_min=-15)
sed_data.group_data(bin_width=0.2)
myPlot.add_data_plot(sed_data,label='rebinned')
```



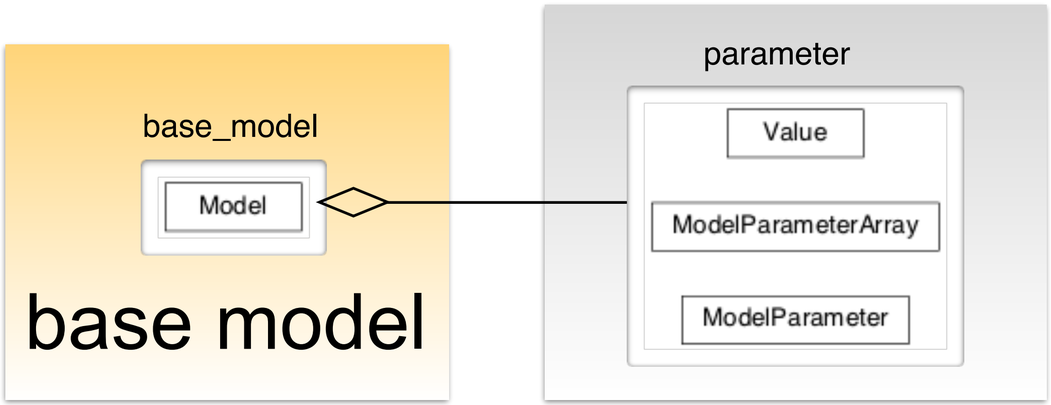

```
==============================================================================

***  binning data  ***
---> N bins= 89
---> bin_widht= 0.2
==============================================================================
```

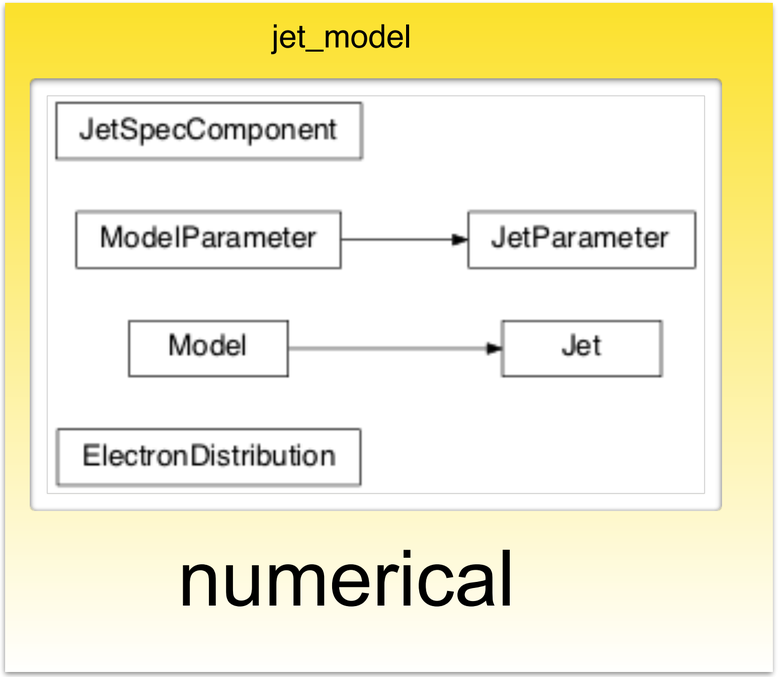
adding systematics
(**Optical vs Gamma!!!**)

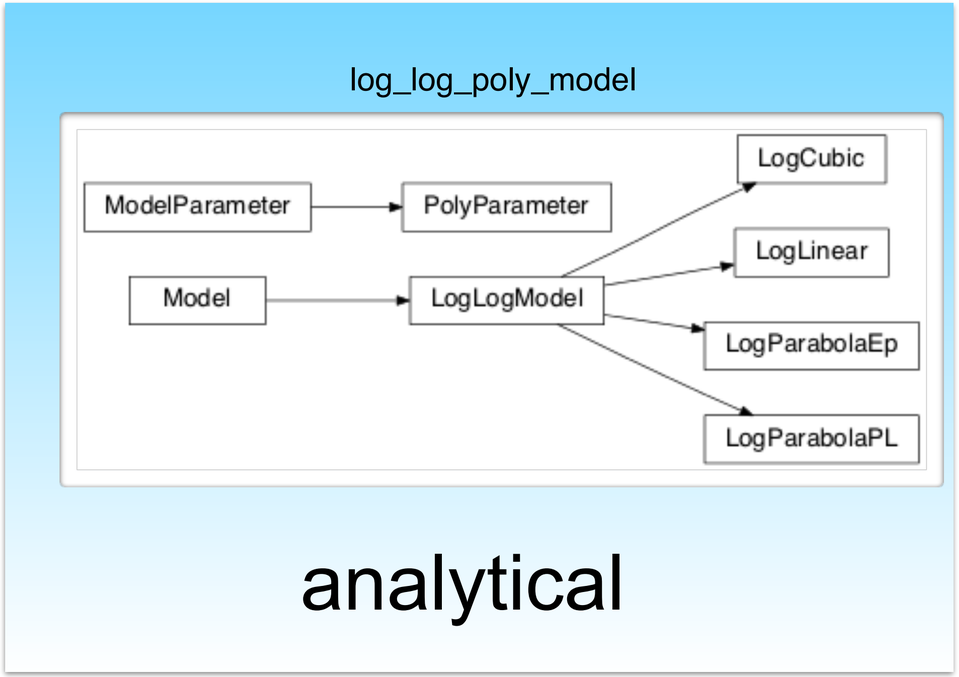
```
sed_data.add_systematics(0.2,[10.**6,10.**29])
myPlot=sed_data.plot_sed()
myPlot.rescale(y_min=-15)
```

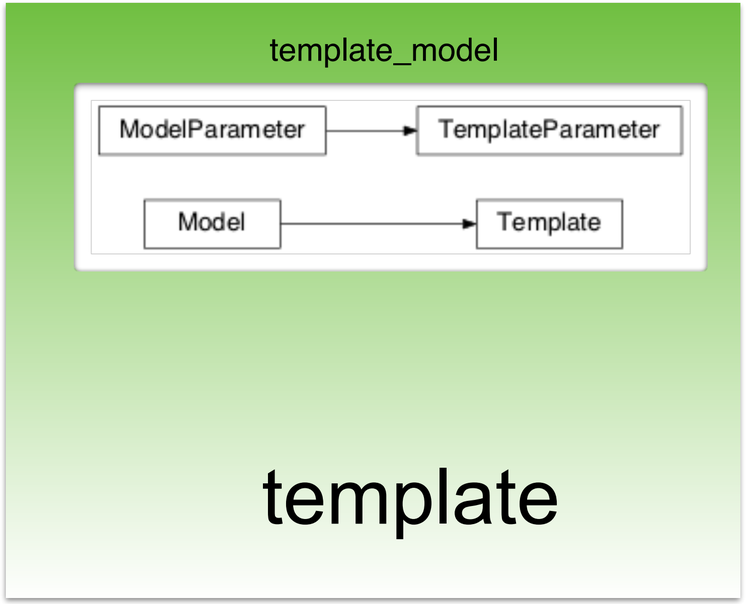


JetSeT models

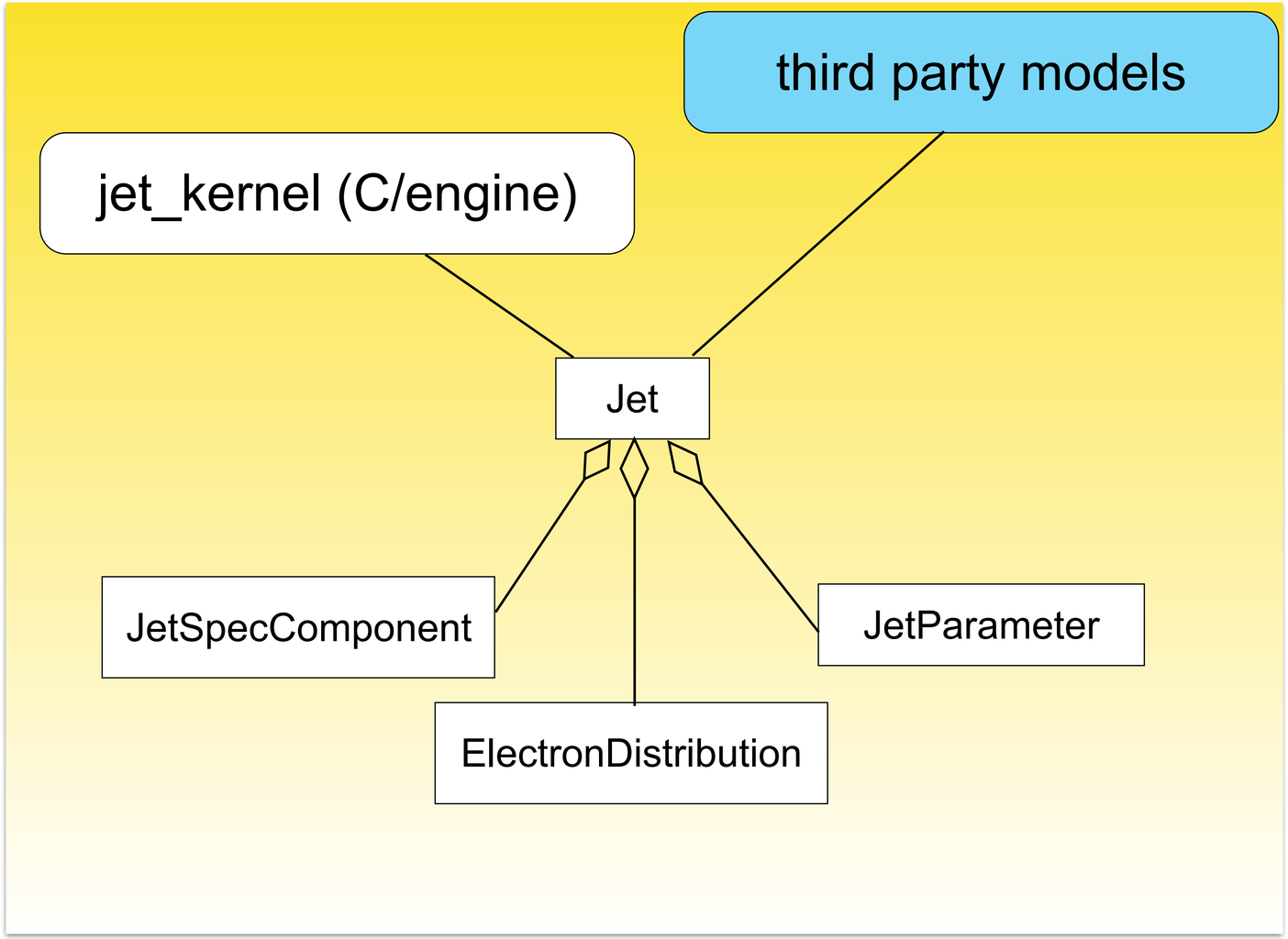






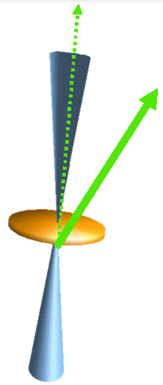


JetSeT jet model definition



model

jet/disk



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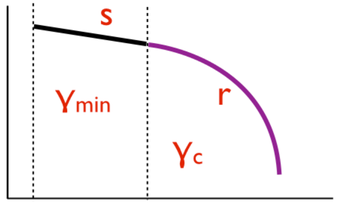

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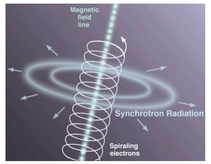
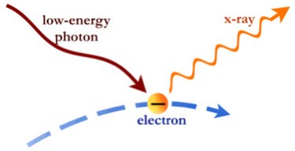
em.





JetSeT jet model creation (SSC)

```
from jetset.jet_model import Jet
my_jet=Jet(name='test',electron_distribution='lppl',)
```

model creation

```
my_jet.save_model('test_model.dat')
```

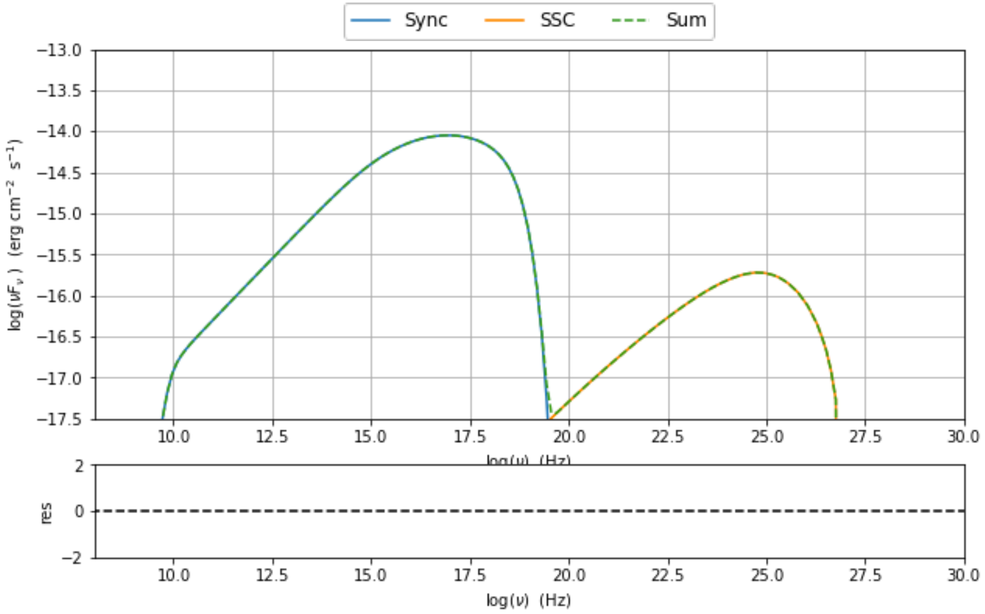
```
my_jet_new=Jet.load_model('test_model.dat')
```

model serialization
(json.dumps() model dictionary)

```
my_jet.eval()
```

```
my_jet.show_pars()
```

```
----------------------------------------------------------------------------------------------------
model parameters:
 Name              | Type                  | Units            | value          | phys. boundaries
----------------------------------------------------------------------------------------------------
 B                 | magnetic_field        | G                | +1.000000e-01  | [+0.000000e+00,No           ]
 N                 | electron_density      | cm^-3            | +1.000000e+02  | [+0.000000e+00,No           ]
 R                 | region_size           | cm               | +1.569897e+01  | [+0.000000e+00,+3.000000e+01]
 beam_obj          | beaming               |                  | +1.000000e+01  | [+1.000000e+00,No           ]
 gamma0_log_parab  | turn-over-energy      | Lorentz-factor   | +4.000000e+00  | [+0.000000e+00,+8.000000e+00]
 gmax              | high-energy-cut-off   | Lorentz-factor   | +6.000000e+00  | [+0.000000e+00,+1.500000e+01]
 gmin              | low-energy-cut-off    | Lorentz-factor   | +3.010300e-01  | [+0.000000e+00,+5.000000e+00]
 r                 | spectral_curvature    |                  | +4.000000e-01  | [-1.500000e+01,+1.500000e+01]
 s                 | LE_spectral_slope     |                  | +2.000000e+00  | [-1.000000e+01,+1.000000e+01]
 z_cosm            | redshift              |                  | +1.000000e-01  | [+0.000000e+00,No           ]
----------------------------------------------------------------------------------------------------
```



JetSeT jet model: inspection/configuration

```
my_jet.show_model()
```

model inspection

```
-----------------------------------------------------------------------------------------------------
jet model description
-----------------------------------------------------------------------------------------------------
name: test

electron distribution:
 type: lppl
 electron energy grid size:  1001
 gmin grid : 2.000000e+00
 gmax grid : 1.000000e+06

radiative fields:
 seed photons grid size:  100
 IC emission grid size:  50
 source emissivity lower bound :  1.000000e-120
 spectral components:
   name:Sum, state: on
   name:Sync, state: self-abs
   name:SSC, state: on

SED info:
 nu grid size :200
 nu mix (Hz): 1.000000e+06
 nu max (Hz): 1.000000e+30

flux plot lower bound   :  1.000000e-30

-----------------------------------------------------------------------------------------------------
model parameters:
 Name              | Type                  | Units            | value         | phys. boundaries
-----------------------------------------------------------------------------------------------------
 B                 | magnetic_field        | G                | +1.000000e-01 | [+0.000000e+00,No           ]
 N                 | electron_density      | cm^-3            | +1.000000e+02 | [+0.000000e+00,No           ]
 R                 | region_size           | cm               | +1.569897e+01 | [+0.000000e+00,+3.000000e+01]
 beam_obj          | beaming               |                  | +1.000000e+01 | [+1.000000e+00,No           ]
 gamma0_log_parab  | turn-over-energy      | Lorentz-factor   | +1.000000e+04 | [+1.000000e+00,+1.000000e+08]
 gmax              | high-energy-cut-off   | Lorentz-factor   | +1.000000e+06 | [+1.000000e+00,+1.000000e+15]
 gmin              | low-energy-cut-off    | Lorentz-factor   | +2.000000e+00 | [+1.000000e+00,+1.000000e+05]
 r                 | spectral_curvature    |                  | +4.000000e-01 | [-1.500000e+01,+1.500000e+01]
 s                 | LE_spectral_slope     |                  | +2.000000e+00 | [-1.000000e+01,+1.000000e+01]
 z_cosm            | redshift              |                  | +1.000000e-01 | [+0.000000e+00,No           ]
-----------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------
```

electron distribution

- type of distribution
- grid size
- log-lin values (γ_{min},γ_{max},γ_{cut}...)

single radiative components

- IC full KN
- Synch self-abs and different kernels
- grid size
- boundaries

full SED

- grid size
- boundaries

parameter inspection

- name
- value
- units
- physical boundaries

JetSeT jet model: electron distribution choice

```
Jet.available_electron_distributions()
```

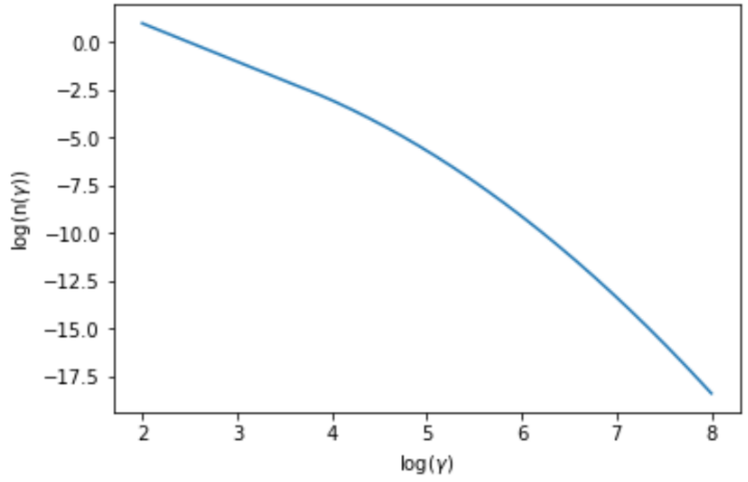
```
lp: log-parabola
pl: powerlaw
lppl: log-parabola with low-energy powerlaw branch
lpep: log-parabola defined by peak energy
plc: powerlaw with cut-off
bkn: broken powerlaw
spitkov: spitkov
lppl_pile_up: log-parabola with low-energy powerlaw branch and pile-up
bkn_pile_up: broken powerlaw and pileup
```

available electron distributions
custom distributions are possible (from array already available, from user defined models soon)

```
my_jet.show_electron_distribution()
```

```
-----------------------------------------------------------------------------------------------------------------------
electron distribution:
 type: lppl
 electron energy grid size:  1001
 gmin grid : 2.000000e+00
 gmax grid : 1.000000e+06

-----------------------------------------------------------------------------------------------------------------------
model parameters:
 Name              | Type                  | Units             | value          | phys. boundaries                | log
-----------------------------------------------------------------------------------------------------------------------
 N                 | electron_density      | cm^-3             | +1.000000e+03  | [+0.000000e+00,No            ]  | False
 gamma0_log_parab  | turn-over-energy      | Lorentz-factor    | +5.000000e+03  | [+1.000000e+00,+1.000000e+08]  | False
 gmax              | high-energy-cut-off   | Lorentz-factor    | +1.000000e+08  | [+1.000000e+00,+1.000000e+15]  | False
 gmin              | low-energy-cut-off    | Lorentz-factor    | +1.000000e+02  | [+1.000000e+00,+1.000000e+05]  | False
 r                 | spectral_curvature    |                   | +4.000000e-01  | [-1.500000e+01,+1.500000e+01]  | False
 s                 | LE_spectral_slope     |                   | +2.000000e+00  | [-1.000000e+01,+1.000000e+01]  | False
-----------------------------------------------------------------------------------------------------------------------
```

```
p=my_jet.electron_distribution.plot()
```



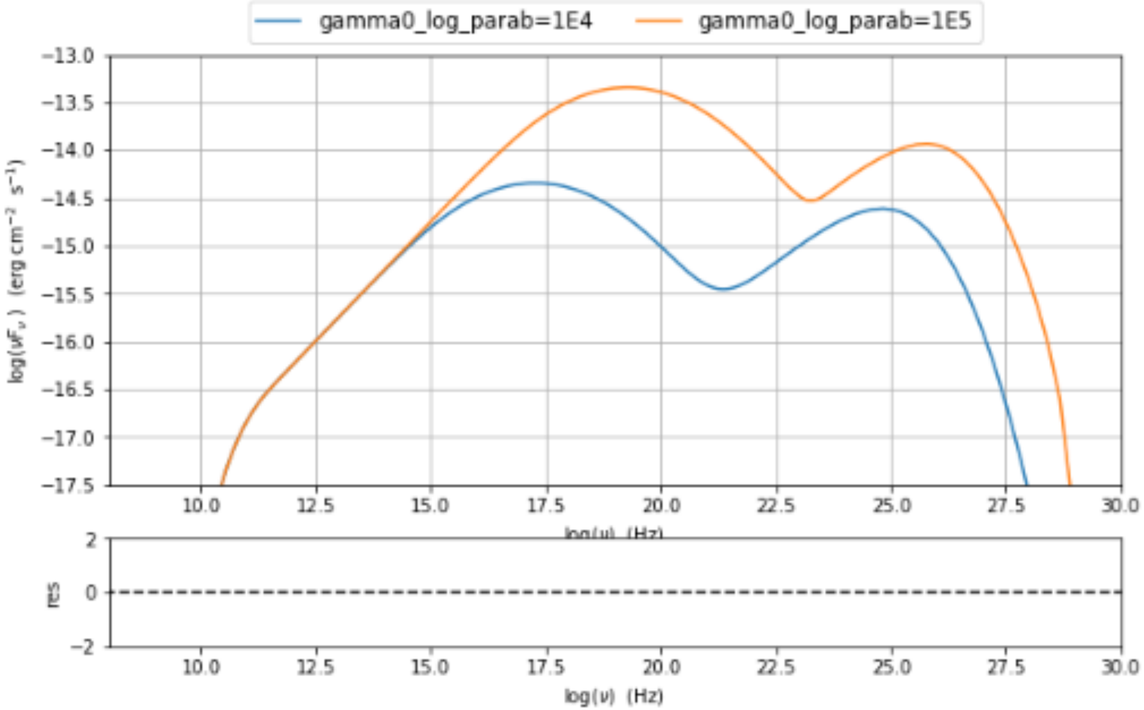
JetSeT jet model comparison and parameter setting

```
my_jet=Jet(name='test',electron_distribution='lppl',)
my_jet.set_par('B',val=0.2)
my_jet.set_par('gamma0_log_parab',val=5E3)
my_jet.set_par('gmin',val=1E2)
my_jet.set_par('gmax',val=1E8)
my_jet.set_par('R',val=14.5)
my_jet.set_par('N',val=1E3)

my_jet.parameters.gamma0_log_parab.val=1E4
my_jet.eval()
my_plot=my_jet.plot_model(label='gamma0_log_parab=1E4',comp='Sum')
my_jet.set_par('gamma0_log_parab',val=1.0E5)
my_jet.eval()
my_plot=my_jet.plot_model(my_plot,label='gamma0_log_parab=1E5',comp='Sum')
my_plot.rescale(y_max=-13,y_min=-17.5,x_min=8)
```

parameter setting: set_par()

parameter setting: accessing directly the member

plotting tools



JetSeT jet model setting N from Synch. vL(v) or vF(v)

```
my_jet=Jet(name='test',electron_distribution='lppl')
```

this is the initial value of N

```
my_jet.parameters.N.val
```

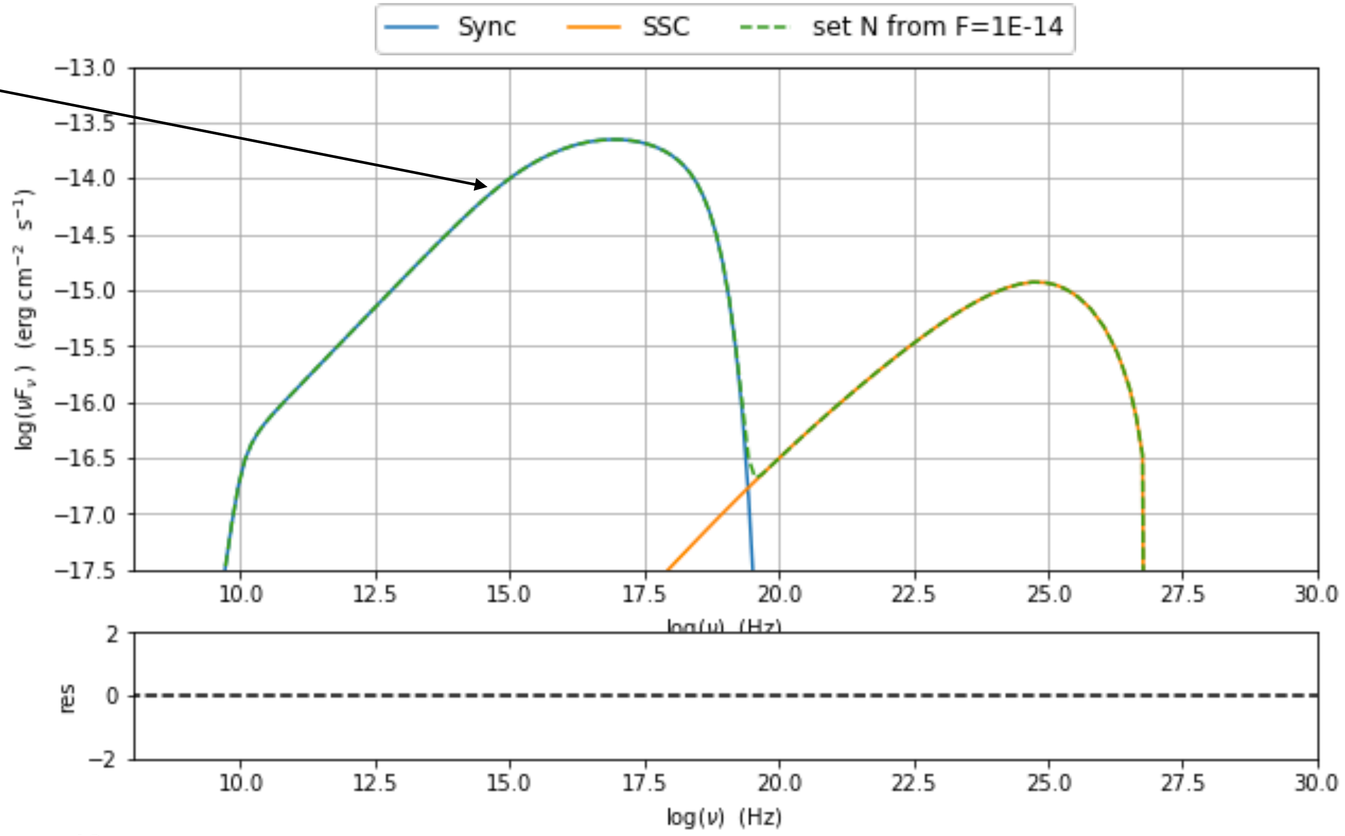
```
100.0
```

```
my_jet.set_N_from_nuFnu(nuFnu_obs=1E-14,nu_obs=1E15)
```

This is the updated value of `N`, obtained in order to match the given flux at the given frequency

```
my_jet.get_par_by_name('N').val
```

```
249.04461454958587
```



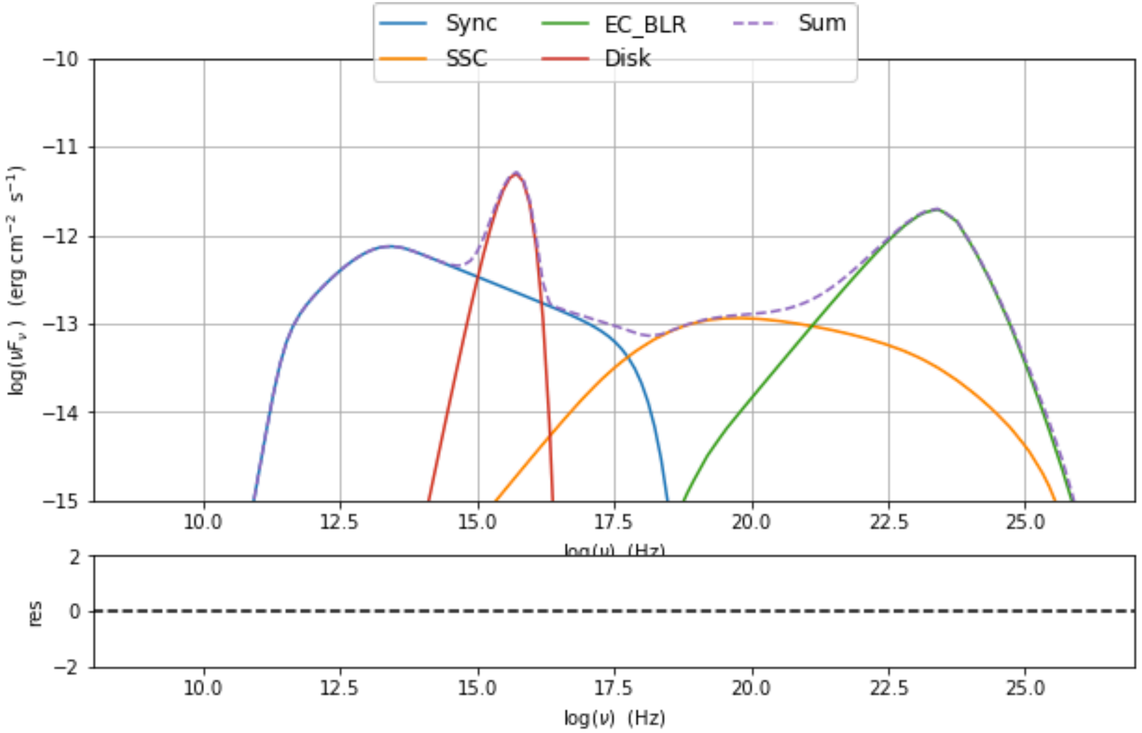
JetSeT jet model definition: EC

```
my_jet=Jet(name='BLR example',electron_distribution='bkn')
my_jet.add_EC_component('EC_BLR')
my_jet.show_model()
```

```
-----------------------------------------------------------------------------------------------------------
jet model description
-----------------------------------------------------------------------------------------------------------
name: BLR example

electron distribution:
 type: bkn
 electron energy grid size:  1001
 gmin grid : 2.000000e+00
 gmax grid : 1.000000e+06

radiative fields:
 seed photons grid size:  100
 IC emission grid size:  50
 source emissivity lower bound :  1.000000e-120
 spectral components:
   name:Sum, state: on
   name:Sync, state: self-abs
   name:SSC, state: on
   name:EC_BLR, state: on
   name:Disk, state: on

SED info:
 nu grid size :200
 nu mix (Hz): 1.000000e+06
 nu max (Hz): 1.000000e+30

flux plot lower bound   :  1.000000e-30

-----------------------------------------------------------------------------------------------------------
model parameters:
 Name              | Type                  | Units             | value          | phys. boundaries
-----------------------------------------------------------------------------------------------------------
 B                 | magnetic_field        | G                 | +1.000000e-01 | [+0.000000e+00,No            ]
 L_Disk            | Disk                  | erg/s             | +1.000000e+45 | [+0.000000e+00,No            ]
 N                 | electron_density      | cm^-3             | +1.000000e+02 | [+0.000000e+00,No            ]
 R                 | region_size           | cm                | +1.569897e+01 | [+0.000000e+00,+3.000000e+01]
 R_BLR_in          | BLR                   | cm                | +1.000000e+18 | [+0.000000e+00,No            ]
 R_BLR_out         | BLR                   | cm                | +2.000000e+18 | [+0.000000e+00,No            ]
 R_H               | Disk                  | cm                | +1.000000e+17 | [+0.000000e+00,No            ]
 R_ext_Sw          | Disk                  | Sw. radii         | +5.000000e+02 | [+0.000000e+00,No            ]
 R_inner_Sw        | Disk                  | Sw. radii         | +3.000000e+00 | [+0.000000e+00,No            ]
 T_Disk            | Disk                  | K                 | +1.000000e+05 | [+0.000000e+00,No            ]
 accr_eff          | Disk                  |                   | +1.000000e-01 | [+0.000000e+00,No            ]
 beam_obj          | beaming               |                   | +1.000000e+01 | [+1.000000e+00,No            ]
 gamma_break       | turn-over-energy      | Lorentz-factor    | +1.000000e+04 | [+1.000000e+00,+1.000000e+08]
 gmax              | high-energy-cut-off   | Lorentz-factor    | +1.000000e+06 | [+1.000000e+00,+1.000000e+15]
 gmin              | low-energy-cut-off    | Lorentz-factor    | +2.000000e+00 | [+1.000000e+00,+1.000000e+05]
 p                 | LE_spectral_slope     |                   | +2.000000e+00 | [-1.000000e+01,+1.000000e+01]
 p_1               | HE_spectral_slope     |                   | +3.000000e+00 | [-1.000000e+01,+1.000000e+01]
 tau_BLR           | BLR                   |                   | +1.000000e-01 | [+0.000000e+00,+1.000000e+00]
 z_cosm            | redshift              |                   | +1.000000e-01 | [+0.000000e+00,No            ]
-----------------------------------------------------------------------------------------------------------
```

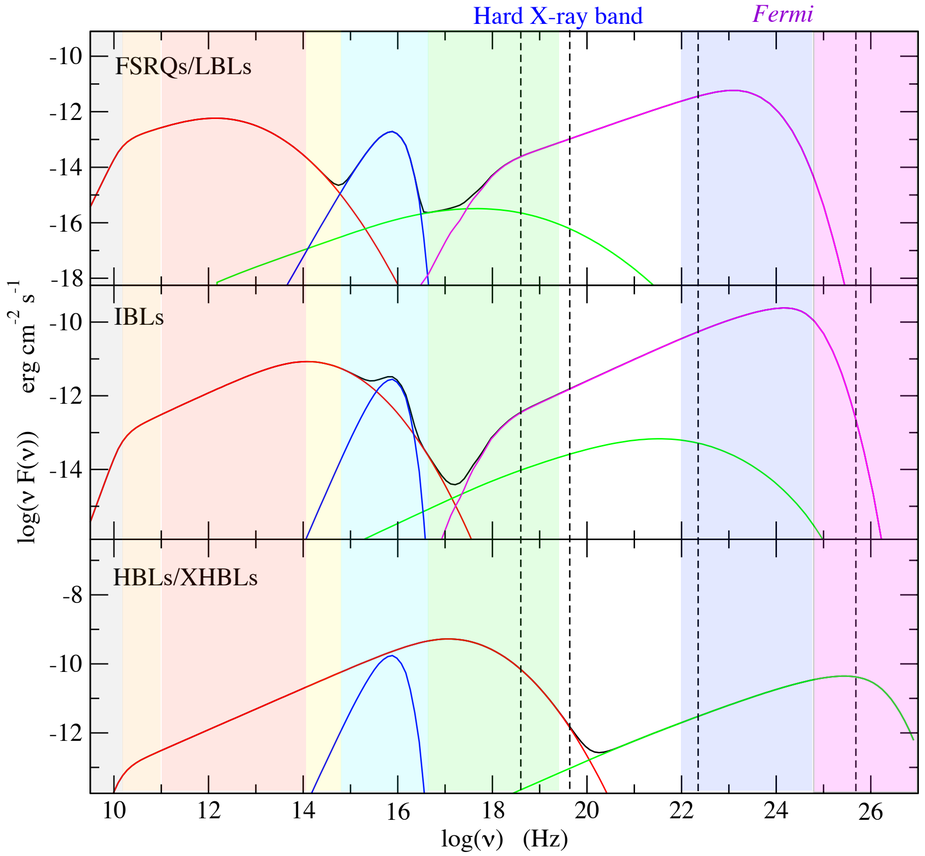
single instruction to add extenal fields

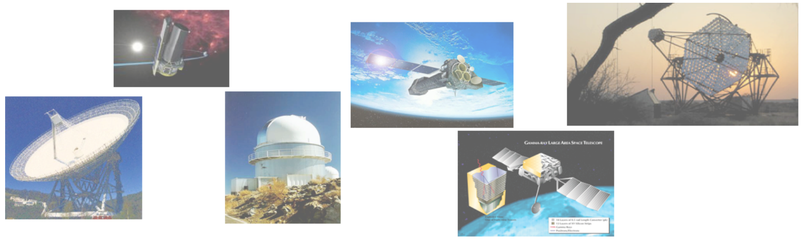
- **Disk (BB, multi T BB)**
- **EC BLR**
- **EC DT**
- **CMB**
- **Star**



JetSeT : phenomenological model constraining

data

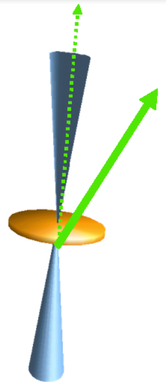




phenomenology

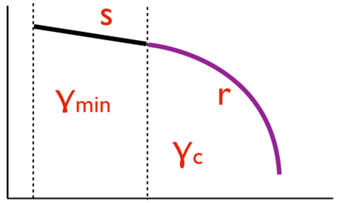
model

jet/disk



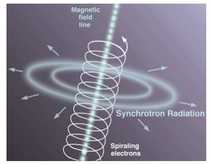
+

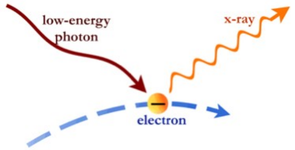
acc.



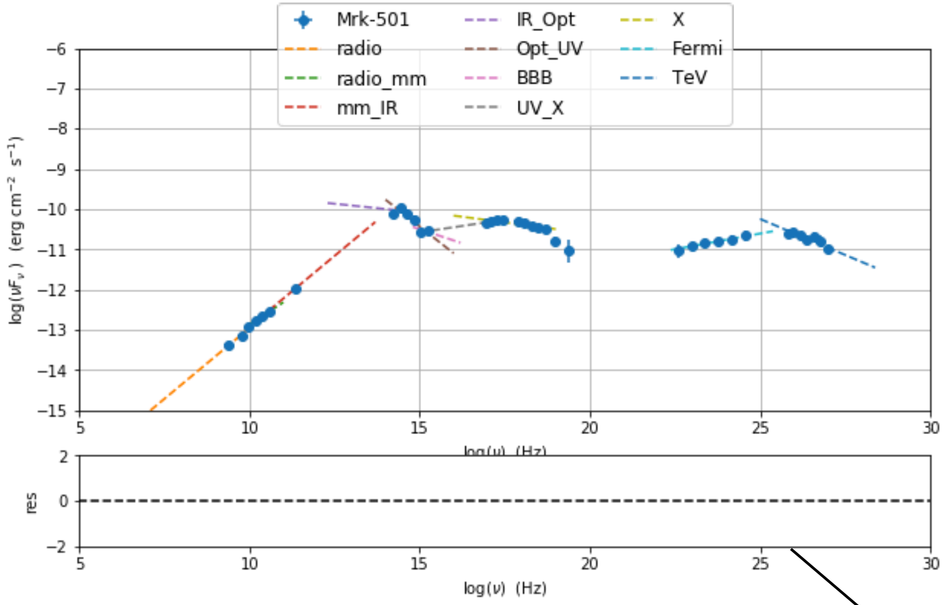
+

em.

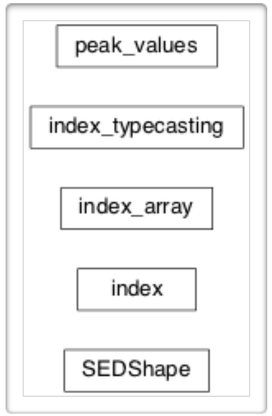




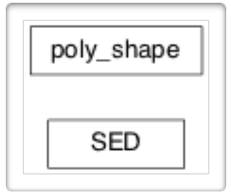
JetSeT SED shaping and model constraining (Mrk 501)

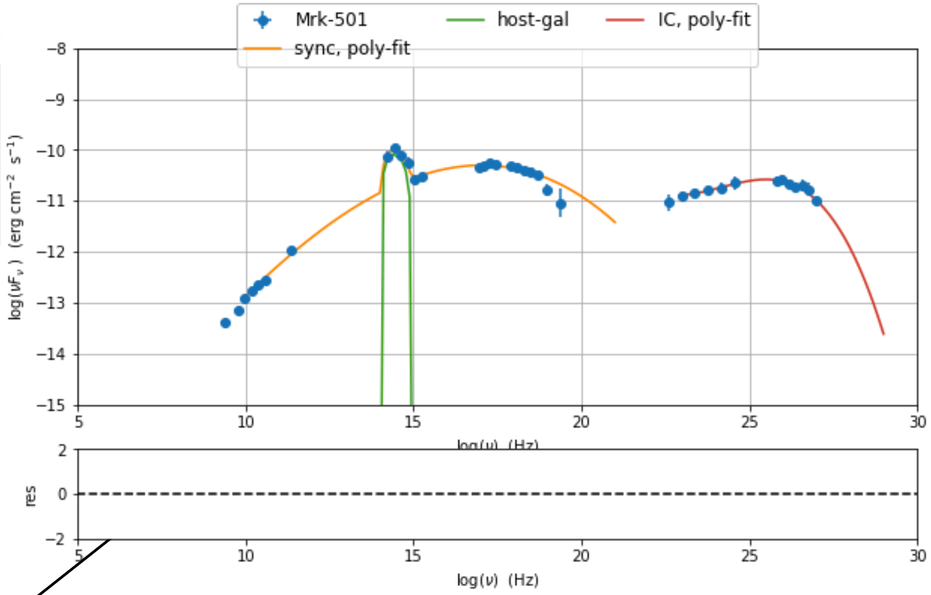


sed_shaper

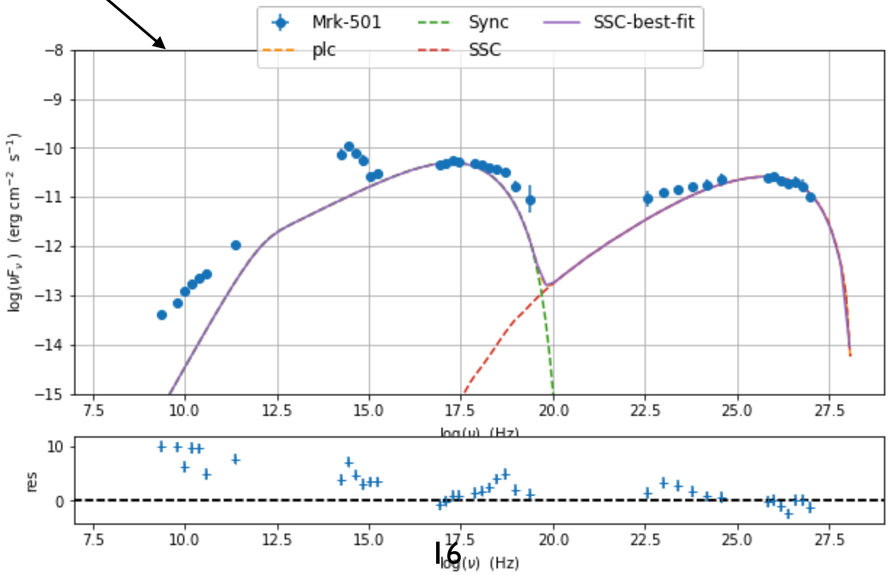


spectral_shapes

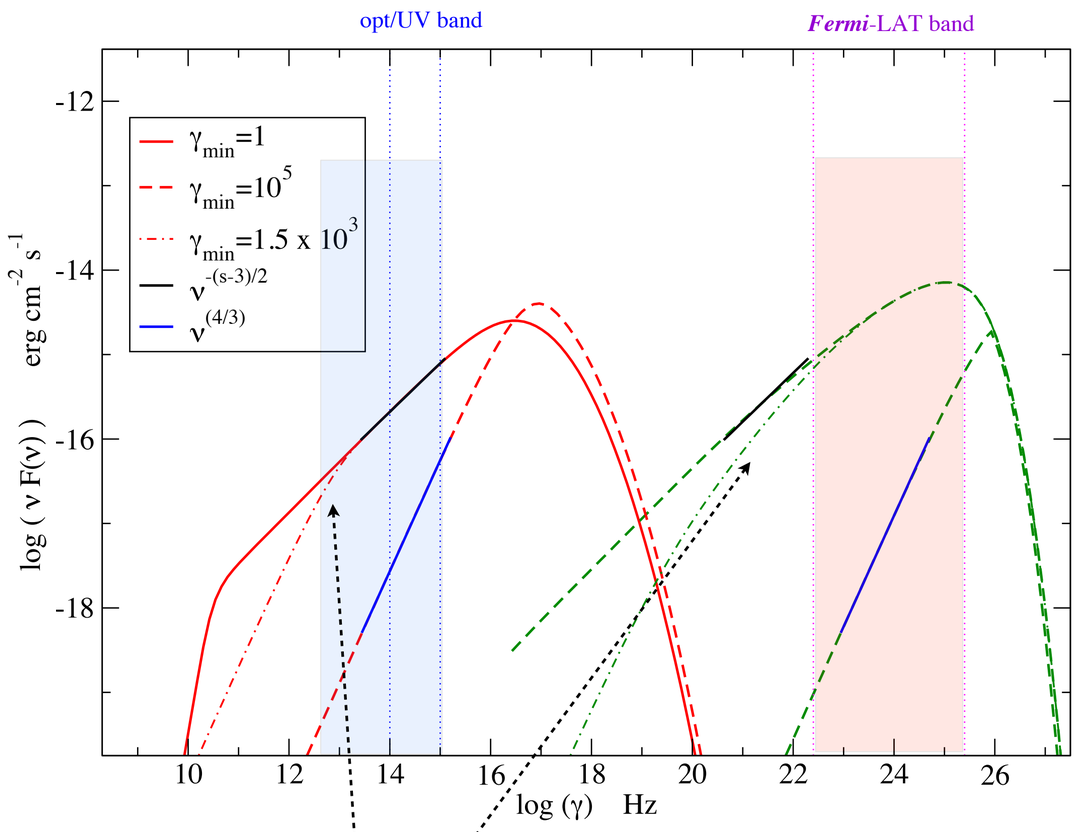


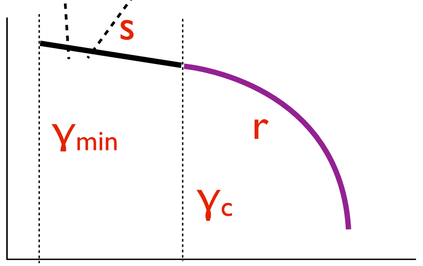


osb_constrain

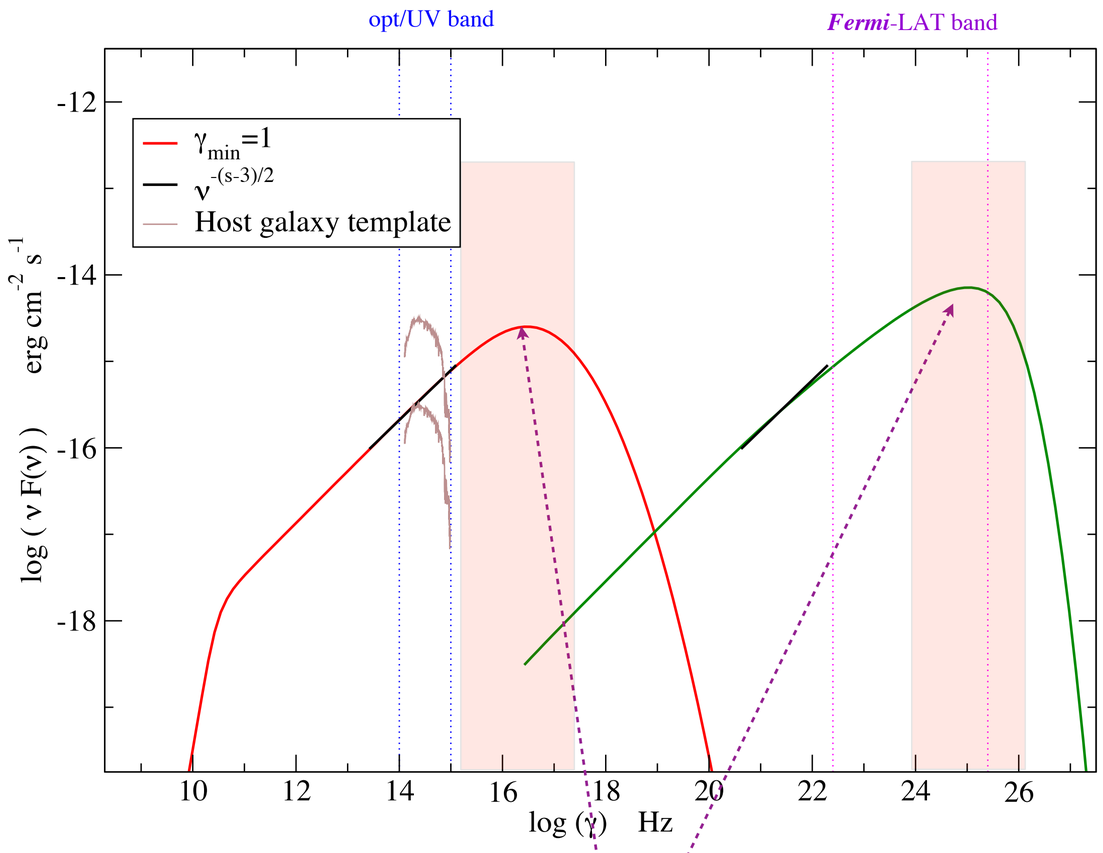


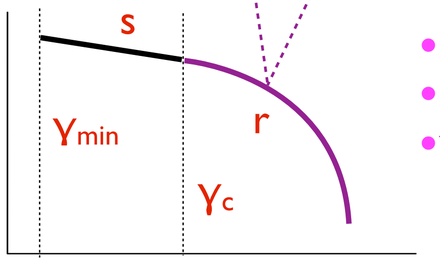
JetSeT SED shaping and model constraining





- FI+FII
- γ_{min}





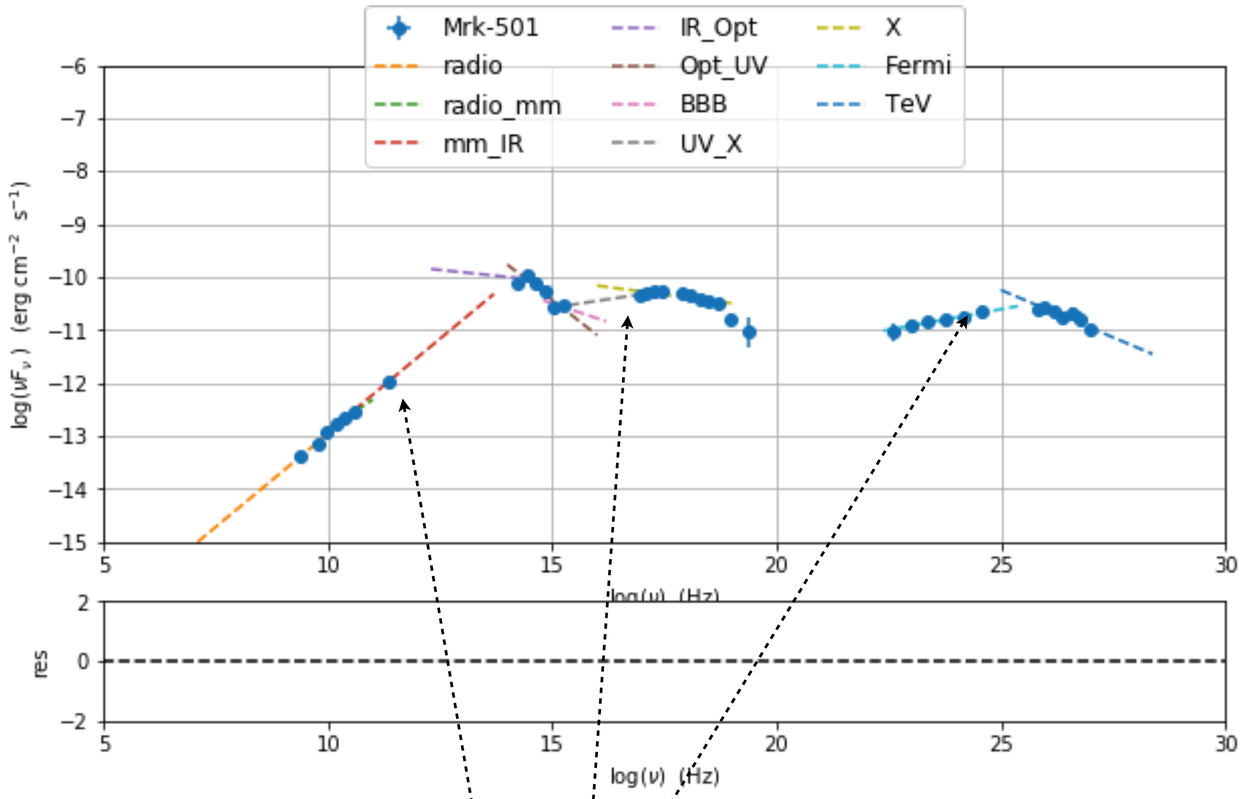
- stoch acceleration
- cooling (TH/KN)
- γ_{c} and

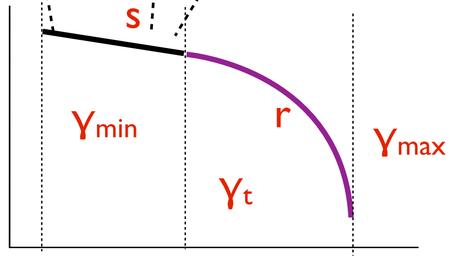
JetSeT SED shaping: spectral indices

```python
from jetset.sed_shaper import  SEDShape
my_shape=SEDShape(sed_data)
my_shape.eval_indices()
p=my_shape.plot_indices()
p.rescale(y_min=-15,y_max=-6)
```

spectral indices evaluation

```
=================================================================================================

* evaluating spectral indices for data *
---> initial range for index radio  set to [6.000000,10.000000]
---> range for index radio updated  to [6.000000,10.000000]
---> name = radio            range=[6.000 ,10.000] log(Hz)  photon.val=-1.402754e+00, err=1.250721e-01

---> initial range for index radio_mm  set to [10.000000,11.000000]
---> range for index radio_mm updated  to [10.000000,11.000000]
---> name = radio_mm         range=[10.000,11.000] log(Hz)  photon.val=-1.290348e+00, err=3.549105e-02

---> initial range for index mm_IR  set to [11.000000,13.000000]
---> range for index mm_IR updated  to [10.300000,13.700000]
---> name = mm_IR            range=[10.300,13.700] log(Hz)  photon.val=-1.109667e+00, err=5.233777e-02

---> initial range for index IR_Opt  set to [13.000000,14.000000]
---> range for index IR_Opt updated  to [12.500000,14.500000]
---> name = IR_Opt           range=[12.500,14.500] log(Hz)  photon.val=-1.778730e+00, err=8.336743e-02

---> initial range for index Opt_UV  set to [14.000000,16.000000]
---> range for index Opt_UV updated  to [14.000000,16.000000]
---> name = Opt_UV           range=[14.000,16.000] log(Hz)  photon.val=-1.621180e+00, err=4.761704e-02

---> initial range for index BBB  set to [15.000000,16.000000]
---> range for index BBB updated  to [14.800000,16.200000]
---> name = BBB              range=[14.800,16.200] log(Hz)  photon.val=-1.273282e+00, err=1.558347e-01

---> initial range for index UV_X  set to [15.000000,17.500000]
---> range for index UV_X updated  to [15.000000,17.500000]
---> name = UV_X             range=[15.000,17.500] log(Hz)  photon.val=-1.845844e+00, err=1.974302e-02

---> initial range for index X  set to [16.000000,19.000000]
---> range for index X updated  to [16.000000,19.000000]
---> name = X                range=[16.000,19.000] log(Hz)  photon.val=-2.458173e+00, err=7.557519e-02

---> initial range for index Fermi  set to [22.380000,25.380000]
---> range for index Fermi updated  to [22.380000,25.380000]
---> name = Fermi            range=[22.380,25.380] log(Hz)  photon.val=-1.795555e+00, err=1.996362e-02

---> initial range for index TeV  set to [25.000000,28.380000]
---> range for index TeV updated  to [25.000000,28.380000]
---> name = TeV              range=[25.000,28.380] log(Hz)  photon.val=-2.480131e+00, err=7.425494e-02

=================================================================================================
```



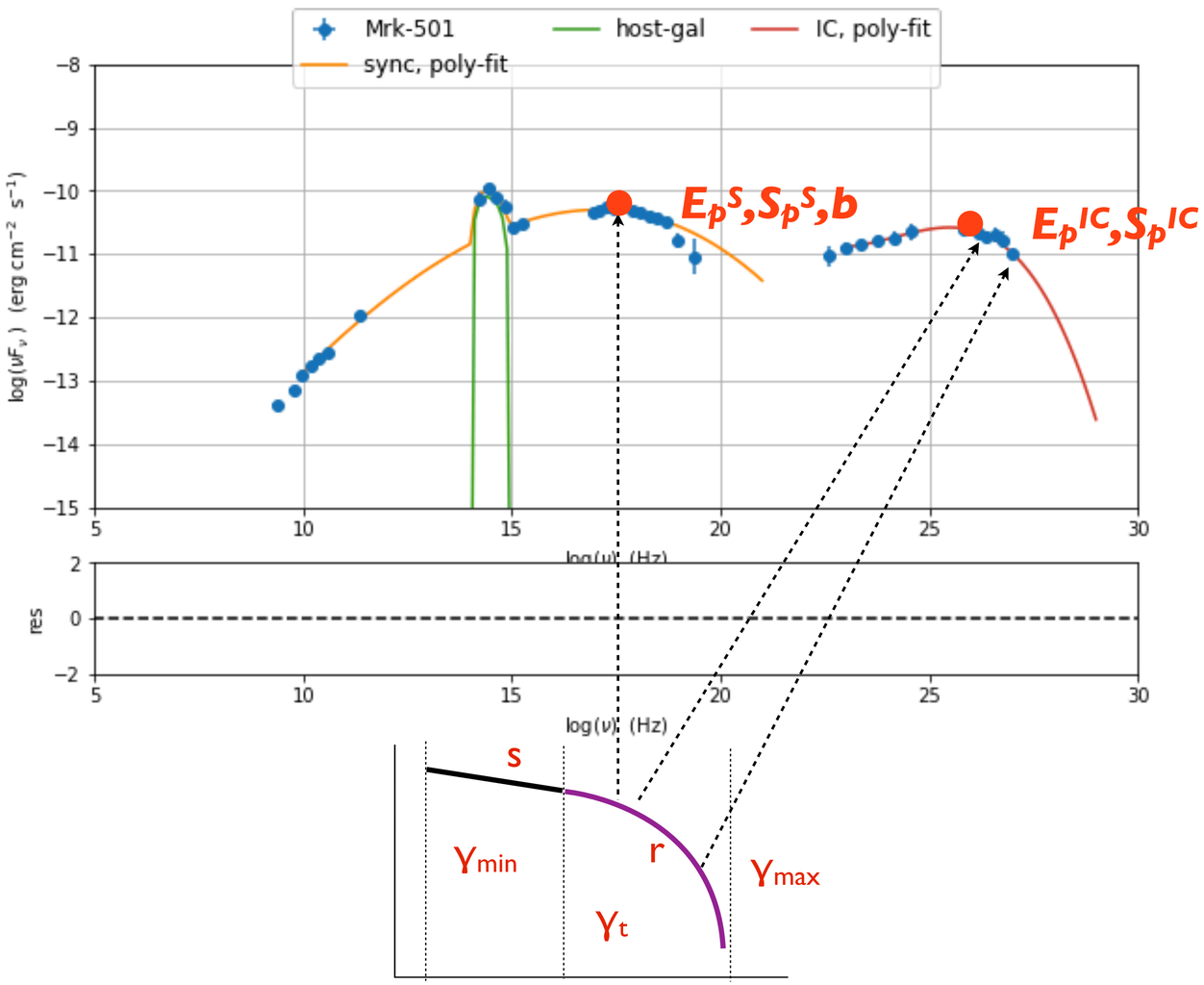


JetSeT SED shaping: log-log fit and peaks

```
mm,best_fit=my_shape.sync_fit(check_host_gal_template=True,
                              Ep_start=None,
                              minimizer='minuit',
                              silent=True,
                              fit_range=[10,21])
```

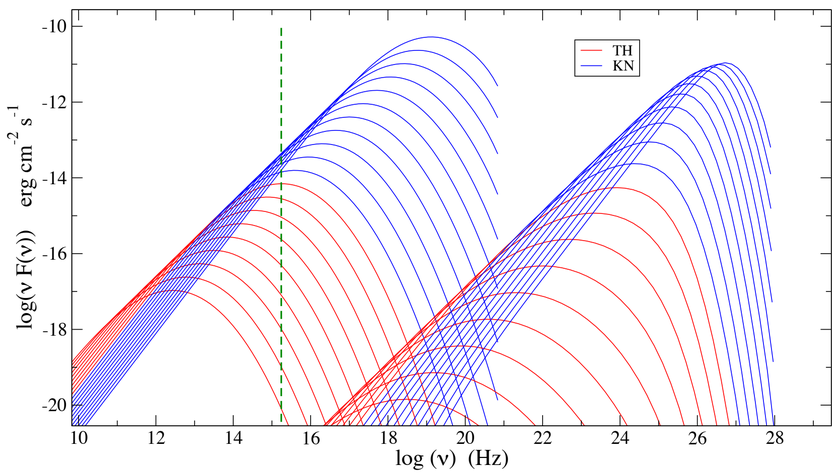
```
*****************************************************************************************
Fit report

Model: sync-shape-fit
-----------------------------------------------------------------------------------------
model parameters:
 Name              | Type                 | Units            | value         | phys. boundaries
-----------------------------------------------------------------------------------------
 b                 | curvature            |                  | -1.634633e-01 | [-1.000000e+01,+0.000000e+00]
 c                 | third-degree         |                  | -1.162221e-02 | [-1.000000e+01,+1.000000e+01]
 Ep                | peak freq            | Hz               | +1.671387e+01 | [+0.000000e+00,+3.000000e+01]
 Sp                | peak flux            | erg cm^-2 s^-1   | -9.482476e+00 | [-3.000000e+01,+0.000000e+00]
 nuFnu_p_host      | nuFnu-scale          | erg cm^-2 s^-1   | -1.121472e+01 | [-2.000000e+01,+2.000000e+01]
 nu_scale          | nu-scale             | Hz               | +2.544782e-02 | [-2.000000e+00,+2.000000e+00]
-----------------------------------------------------------------------------------------

converged=True
calls=666
mesg=
dof=16
chisq=13.064443, chisq/red=0.816528 null hypothesis sig=0.668040

best fit pars
-----------------------------------------------------------------------------------------
best-fit parameters:
  Name             | best-fit value| best-fit err +| best-fit err -|start value    | fit boundaries
-----------------------------------------------------------------------------------------
 b                 | -1.634633e-01 | +1.274060e-02 | #             | -1.616576e-01 | [-1.000000e+01,+0.00000
 c                 | -1.162221e-02 | +1.974594e-03 | #             | -1.128313e-02 | [-1.000000e+01,+1.00000
 Ep                | +1.671387e+01 | +5.617252e-02 | #             | +1.669940e+01 | [+0.000000e+00,+3.00000
 Sp                | -9.482476e+00 | +3.721763e-02 | #             | -9.480582e+00 | [-3.000000e+01,+0.00000
 nuFnu_p_host      | -1.121472e+01 | +7.347335e-01 | #             | -9.480582e+00 | [-1.148058e+01,-7.48058
 nu_scale          | +2.544782e-02 | +2.839044e-04 | #             | +0.000000e+00 | [-5.000000e-01,+5.00000
-----------------------------------------------------------------------------------------
*****************************************************************************************

---> class:  HSP
---> sync       nu_p=+1.671387e+01 (err=+5.617252e-02)  nuFnu_p=-9.482476e+00 (err=+3.721763e-02) curv.=-1.
```

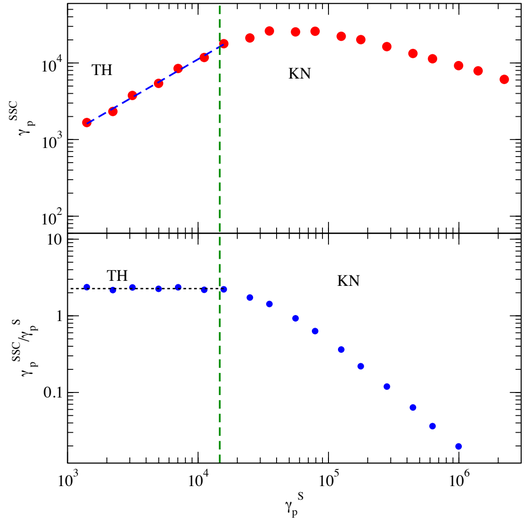
sed shaping

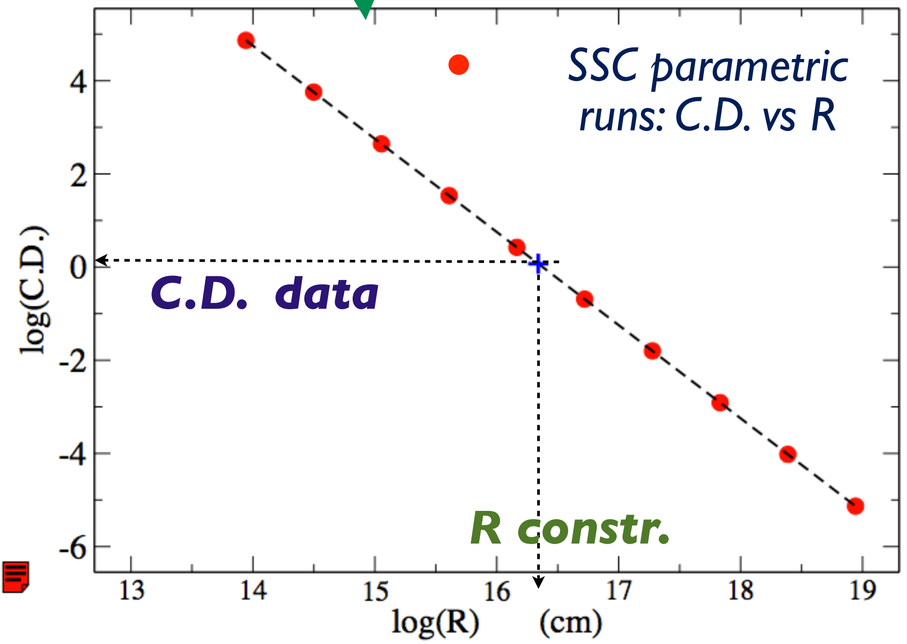


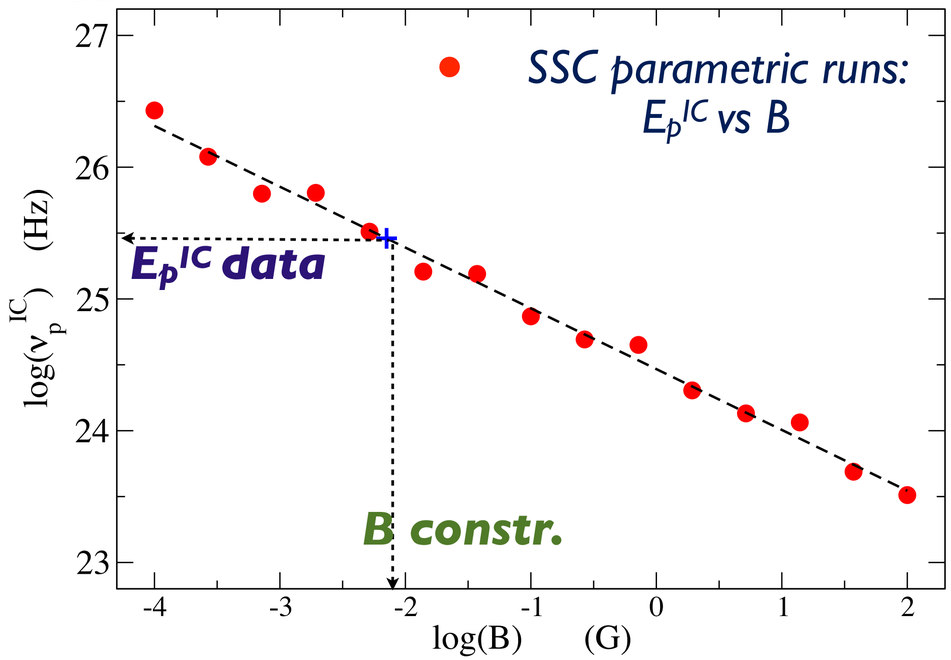
SSC constraints

- ✓ Γ=> s
- ✓ b=>r
- ✓ E_p^S,r,s=> γ_0
- ✓ t_{var},δ=> R u.l.
- ✓ N=> best S_p^S match
- ● B-> best E_p^{IC},S_p^{IC} match
- ● R -> CD







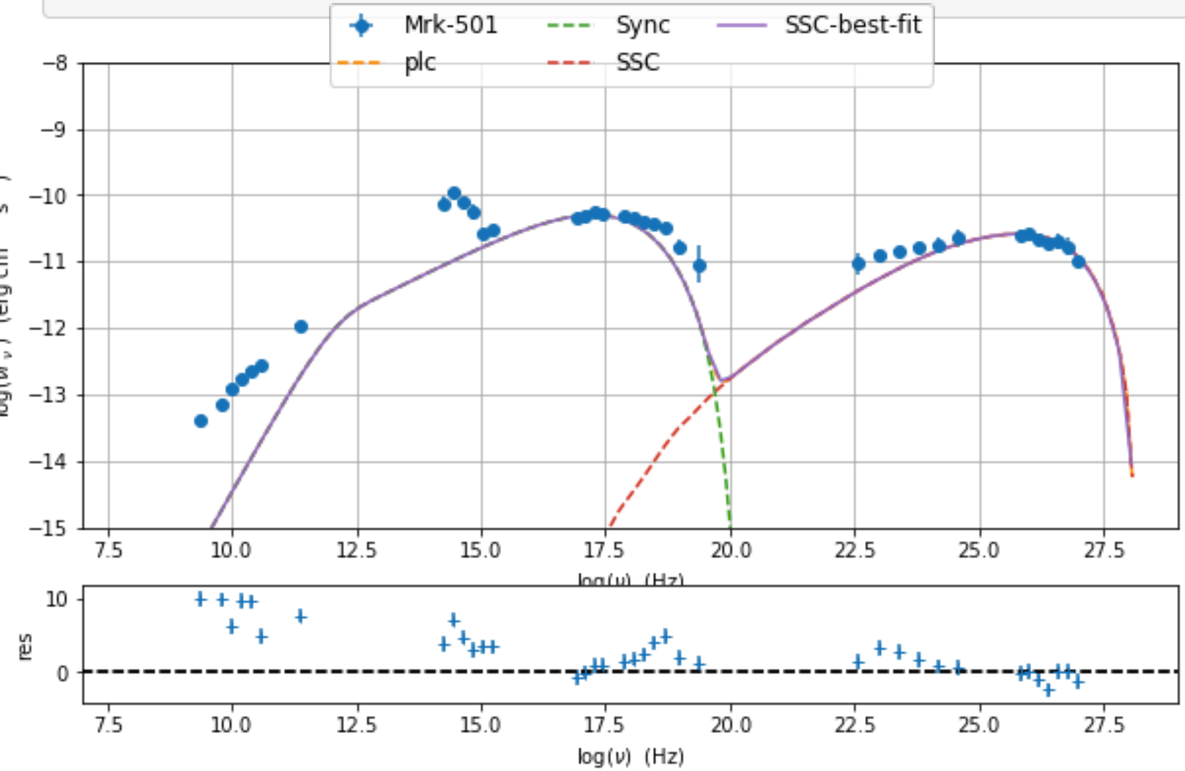


JetSeT SED model constraining: SSC

```
from jetset.obs_constrain import ObsConstrain
from jetset.model_manager import  FitModel
from jetset.minimizer import fit_SED
sed_obspar=ObsConstrain(beaming=25,
                        B_range=[0.001,0.1],
                        distr_e='plc',
                        t_var_sec=3*86400,
                        nu_cut_IR=1E12,
                        SEDShape=my_shape)


jet=sed_obspar.constrain_SSC_model(electron_distribution_log_values=False)
pl=jet.plot_model(sed_data=sed_data)
pl.rescale(y_min=-15,x_min=7,x_max=29)
```

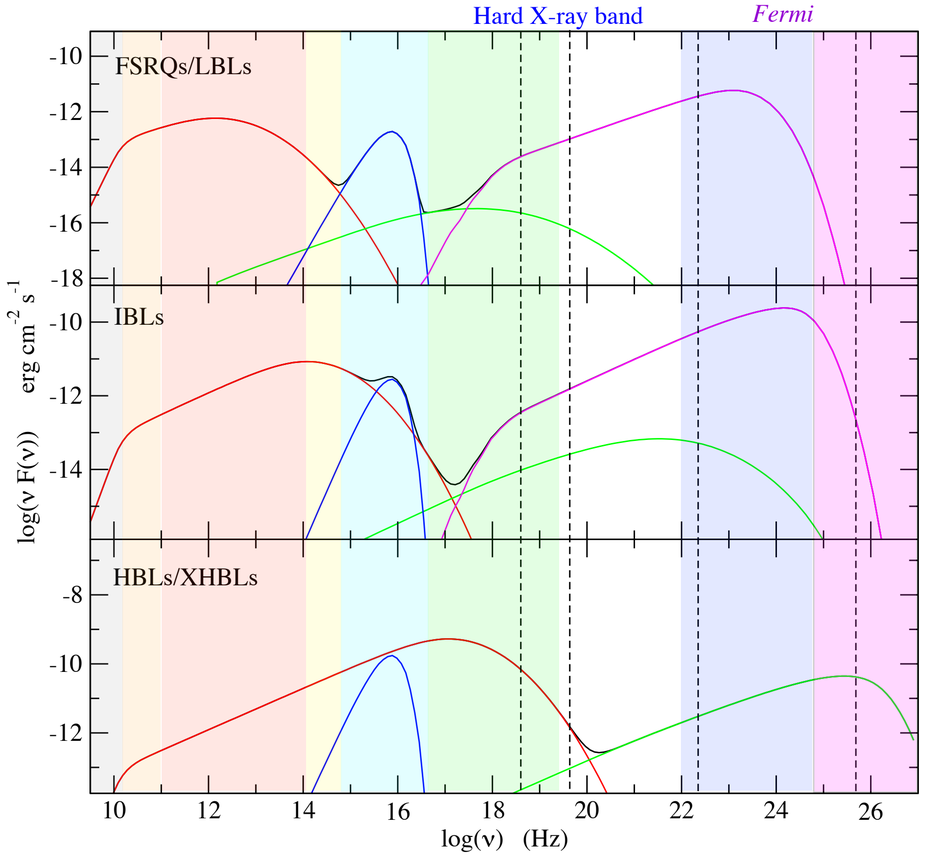
model constraining

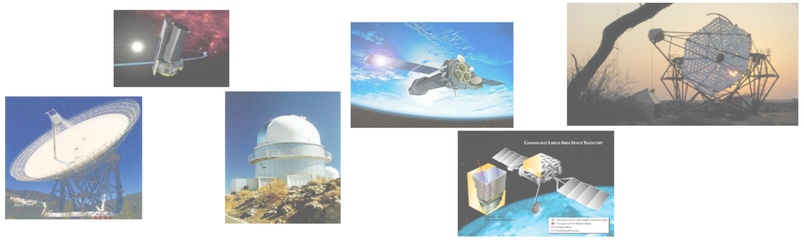
we pass the sed_shape object



JetSeT : model fit

data

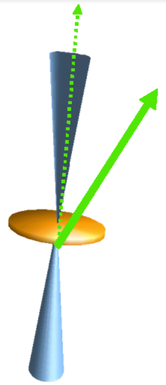




model fit

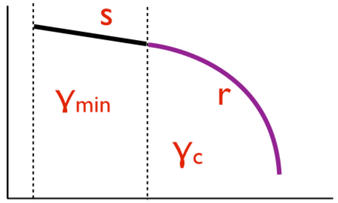
model

jet/disk



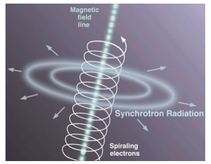
+

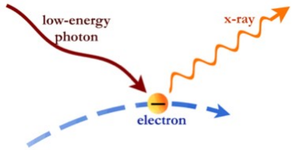
acc.



+

em.

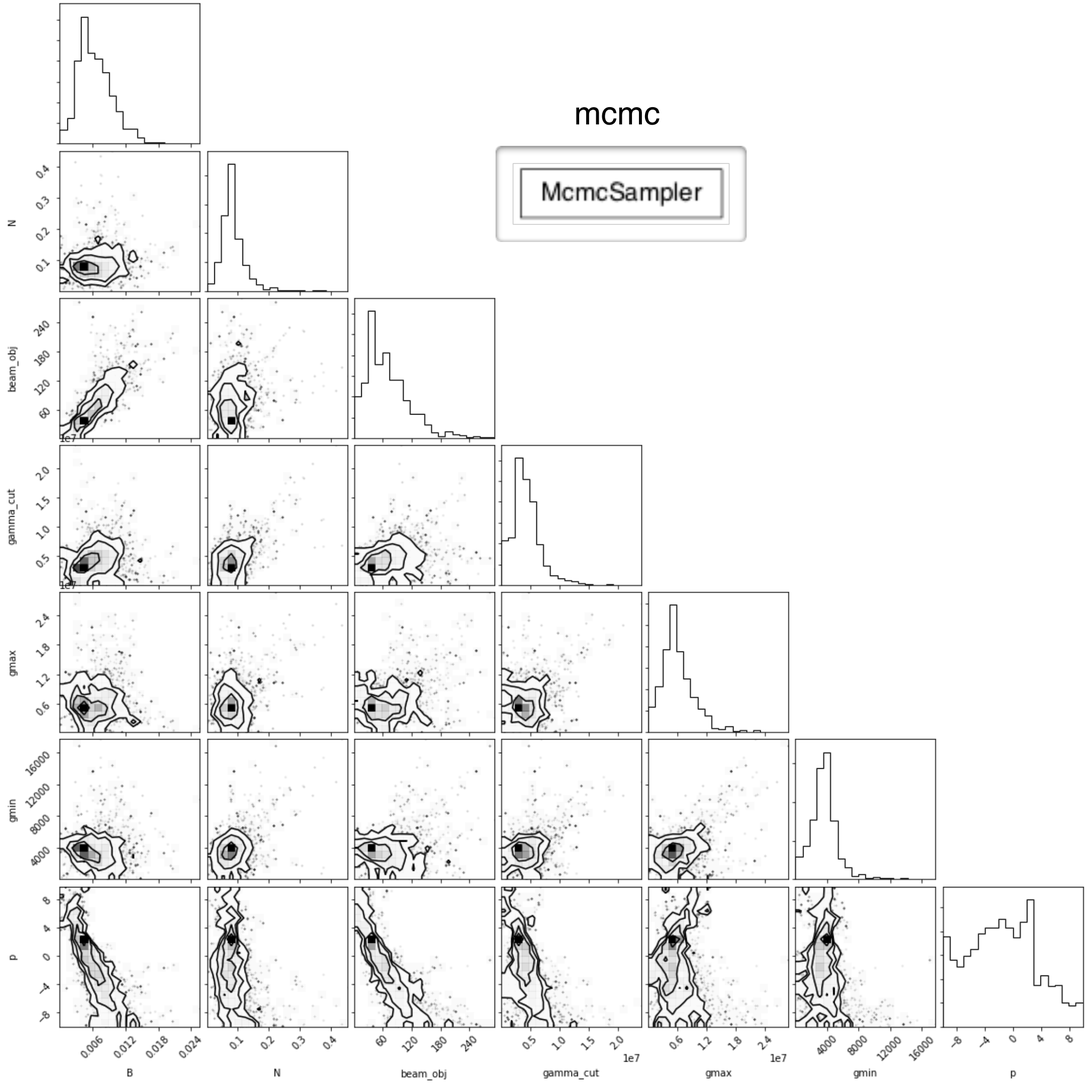




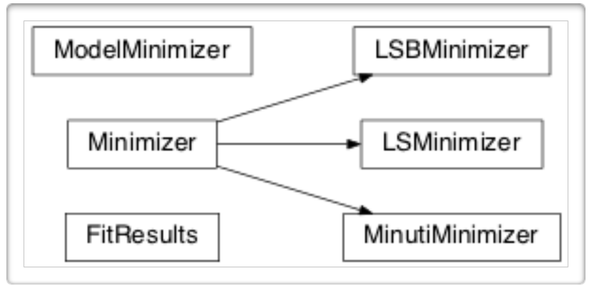
JetSeT model fitting

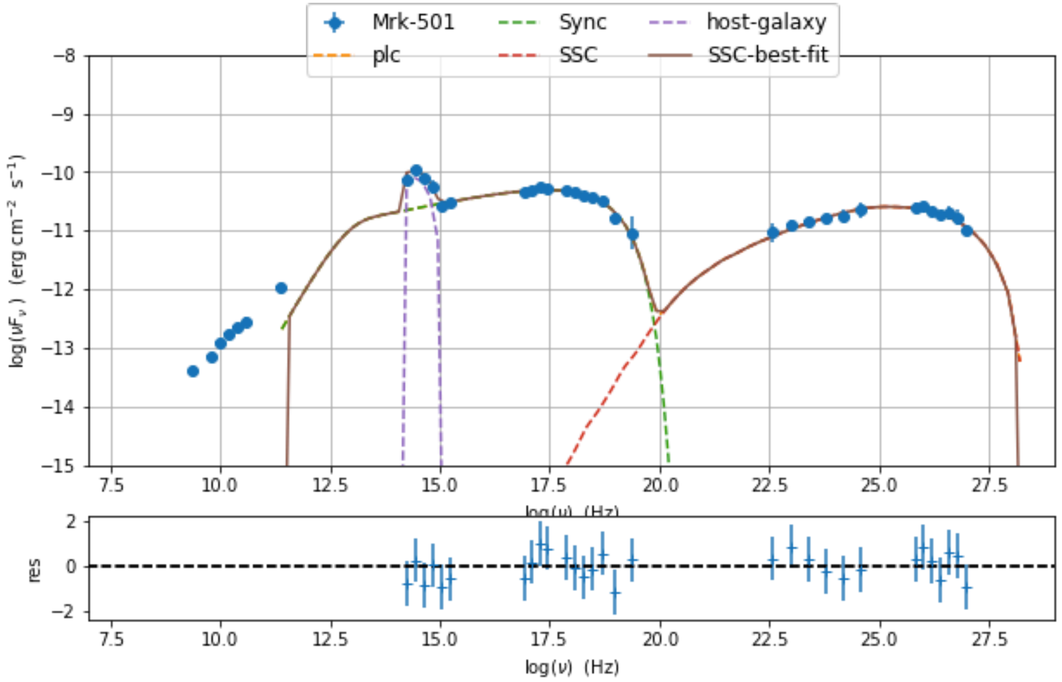
model_manager

mcmc



minimizer





JetSeT model fitting: SSC

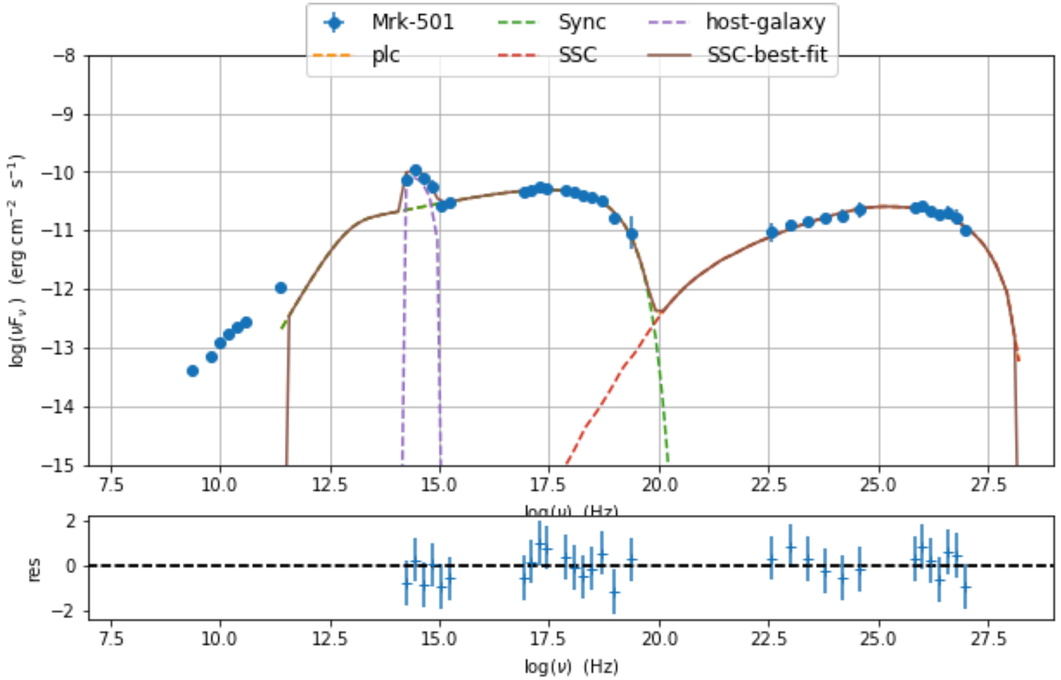
```
from jetset.model_manager import  FitModel

jet.set_gamma_grid_size(200)

fit_model=FitModel( jet=jet, name='SSC-best-fit',template=my_shape.host_gal)
fit_model.freeze('z_cosm')
fit_model.parameters.gmax.fit_range=[1E5,1E8]
fit_model.freeze('R')
fit_model.parameters.nuFnu_p_host.frozen=True
fit_model.parameters.nu_scale.frozen=True
fit_model.show_pars()
```

definition of FitModel

parameters boundaries definition and freezing

```
#lsb minimizer
model_minimizer,best_fit=fit_SED(fit_model,sed_data,10.0**11.4,10**29.0,fitname='SSC-best-fit',minimizer='lsb')

#minuti minimizer
model_minimizer,best_fit=fit_SED(fit_model,sed_data,10.0**11.4,10**29.0,fitname='SSC-best-fit',minimizer='minuit')
```

minimizer choice



JetSeT fit report

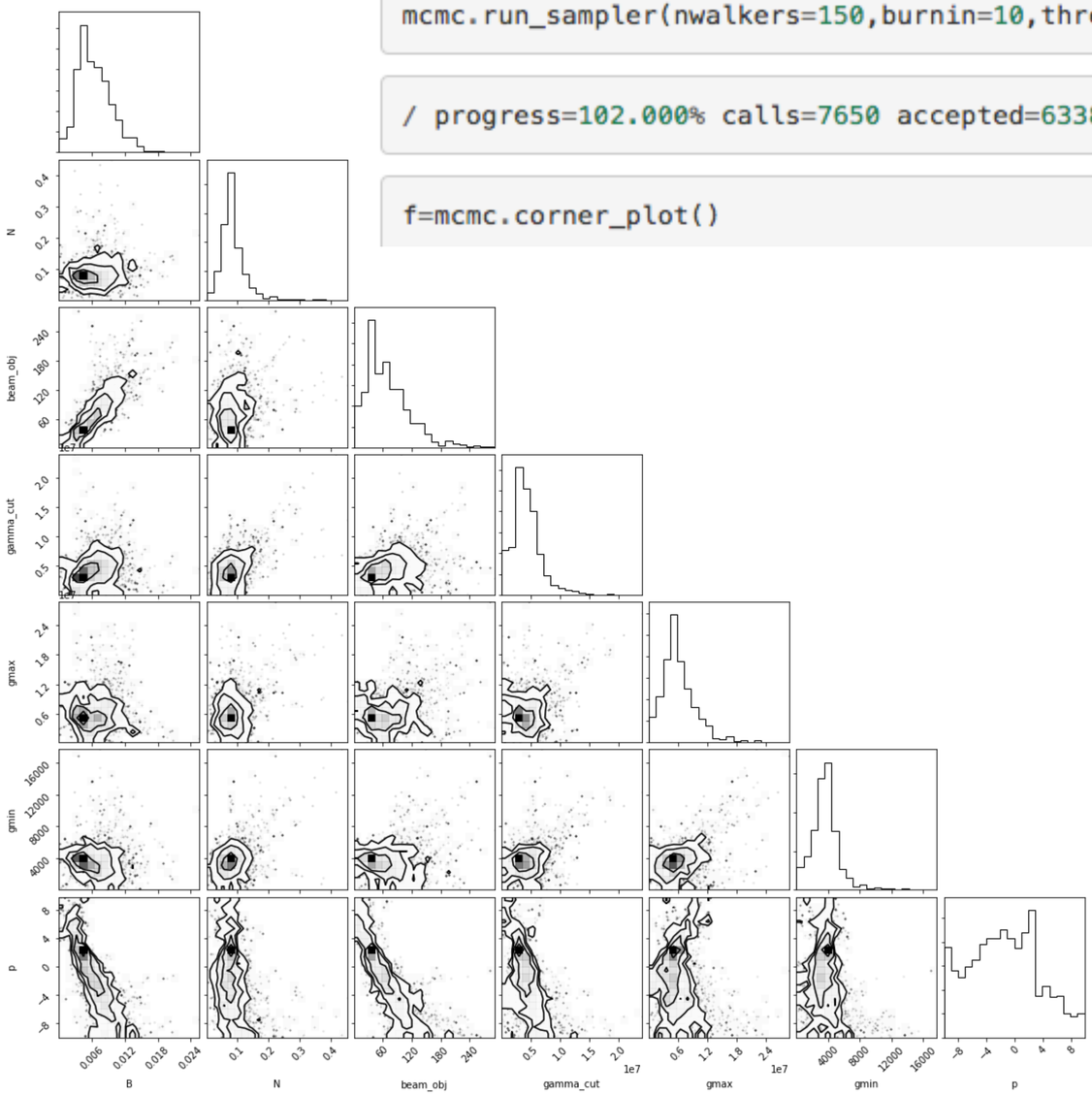
```
*****************************************************************************************
Fit report

Model: SSC-best-fit
-----------------------------------------------------------------------------------------
model parameters:
 Name              | Type                 | Units            | value         | phys. boundaries              | log
-----------------------------------------------------------------------------------------
 B                 | magnetic_field       | G                | +3.840635e-03 | [+0.000000e+00,No           ] | False
 N                 | electron_density     | cm^-3            | +7.700463e-02 | [+0.000000e+00,No           ] | False
 R                 | region_size          | cm               | +1.689721e+01 | [+0.000000e+00,+3.000000e+01] | True
 beam_obj          | beaming              |                  | +3.294741e+01 | [+1.000000e+00,No           ] | False
 gamma_cut         | turn-over-energy     | Lorentz-factor   | +3.160018e+06 | [+1.000000e+00,+1.000000e+08] | False
 gmax              | high-energy-cut-off  | Lorentz-factor   | +5.650706e+06 | [+1.000000e+00,+1.000000e+15] | False
 gmin              | low-energy-cut-off   | Lorentz-factor   | +3.655718e+03 | [+1.000000e+00,+1.000000e+05] | False
 p                 | LE_spectral_slope    |                  | +2.698452e+00 | [-1.000000e+01,+1.000000e+01] | False
 z_cosm            | redshift             |                  | +3.360000e-02 | [+0.000000e+00,No           ] | False
 nuFnu_p_host      | nuFnu-scale          | erg cm^-2 s^-1   | -1.006556e+01 | [-2.000000e+01,+2.000000e+01] | False
 nu_scale          | nu-scale             | Hz               | +1.730750e-02 | [-2.000000e+00,+2.000000e+00] | False
-----------------------------------------------------------------------------------------

converged=True
calls=155
mesg=
dof=23
chisq=11.291532, chisq/red=0.490936 null hypothesis sig=0.980012

best fit pars
-----------------------------------------------------------------------------------------
best-fit parameters:
  Name             | best-fit value| best-fit err +| best-fit err -|start value   | fit boundaries
-----------------------------------------------------------------------------------------
 B                 | +3.840635e-03 | +1.249409e-07 | #             | +3.842601e-03 | [+0.000000e+00,No           ]
 N                 | +7.700463e-02 | +6.605196e-03 | #             | +7.492553e-02 | [+0.000000e+00,No           ]
 R                 | Frozen        | Frozen        | Frozen        | +1.689721e+01 | [+0.000000e+00,+3.000000e+01]
 beam_obj          | +3.294741e+01 | +9.559399e-01 | #             | +3.285602e+01 | [+1.000000e+00,No           ]
 gamma_cut         | +3.160018e+06 | +6.406310e+05 | #             | +3.525224e+06 | [+1.000000e+00,+1.000000e+08]
 gmax              | +5.650706e+06 | +7.742767e+01 | #             | +5.650706e+06 | [+1.000000e+05,+1.000000e+08]
 gmin              | +3.655718e+03 | +5.733830e-02 | #             | +3.655704e+03 | [+1.000000e+00,+1.000000e+05]
 p                 | +2.698452e+00 | +4.055301e-02 | #             | +2.700310e+00 | [-1.000000e+01,+1.000000e+01]
 z_cosm            | Frozen        | Frozen        | Frozen        | +3.360000e-02 | [+0.000000e+00,No           ]
 nuFnu_p_host      | Frozen        | Frozen        | Frozen        | -1.006556e+01 | [-1.225412e+01,-8.254123e+00]
 nu_scale          | Frozen        | Frozen        | Frozen        | +1.730750e-02 | [-5.000000e-01,+5.000000e-01]
-----------------------------------------------------------------------------------------
*****************************************************************************************
```

JetSeT model fitting: mcmc sampling (emcee)

```
from jetset.mcmc import McmcSampler
jet.set_gamma_grid_size(100)
mcmc=McmcSampler(model_minimizer)
mcmc.run_sampler(nwalkers=150,burnin=10,threads=1,steps=50)
```

```
/ progress=102.000% calls=7650 accepted=6338
```

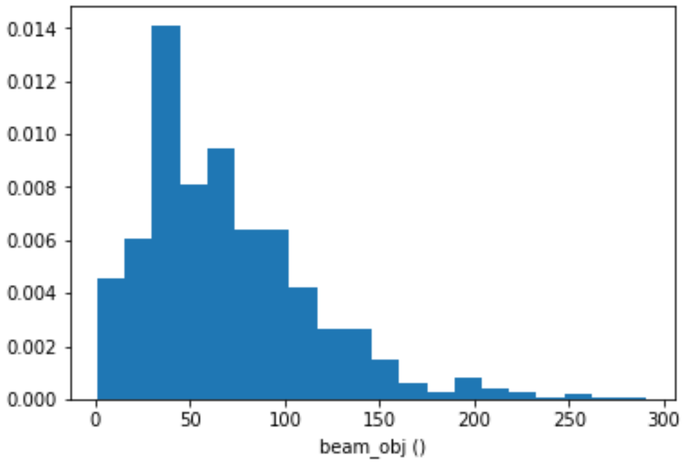
```
f=mcmc.corner_plot()
```



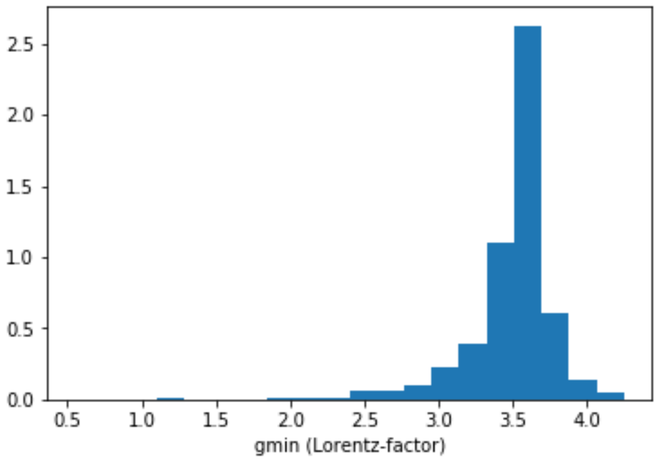

```
mcmc.seve_run('test_run')
```

```
from jetset.mcmc import SamplerOutput
s=SamplerOutput.from_file('test_run')
```

```
f=s.plot_par('beam_obj',log_plot=False)
```



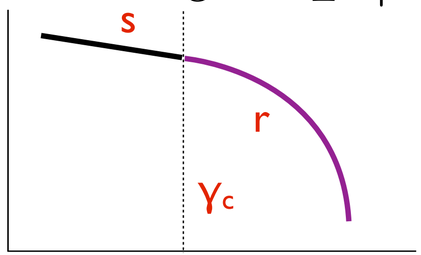

```
f=s.plot_par('gmin',log_plot=True)
```




```
f=s.plot_par('gamma_cut',log_plot=True)
```

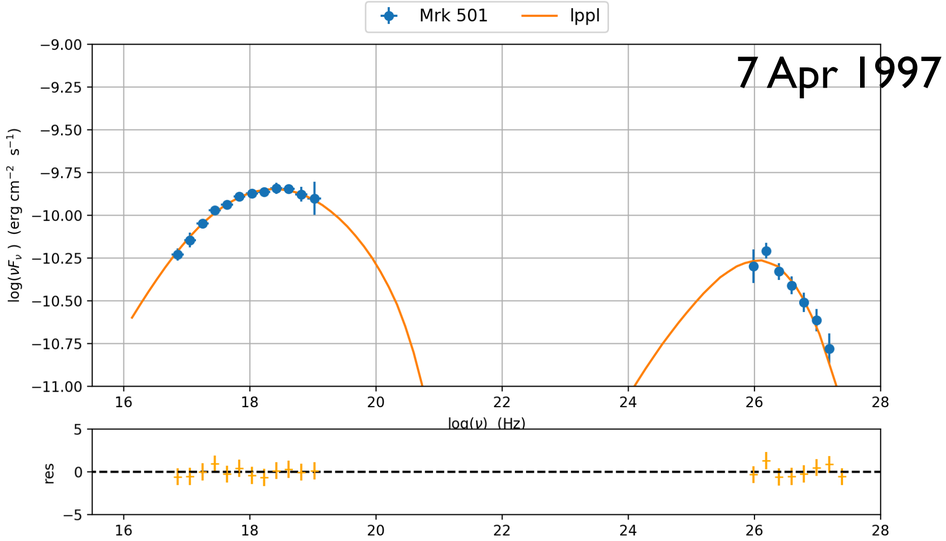
Hard spectra $s<<2.00$

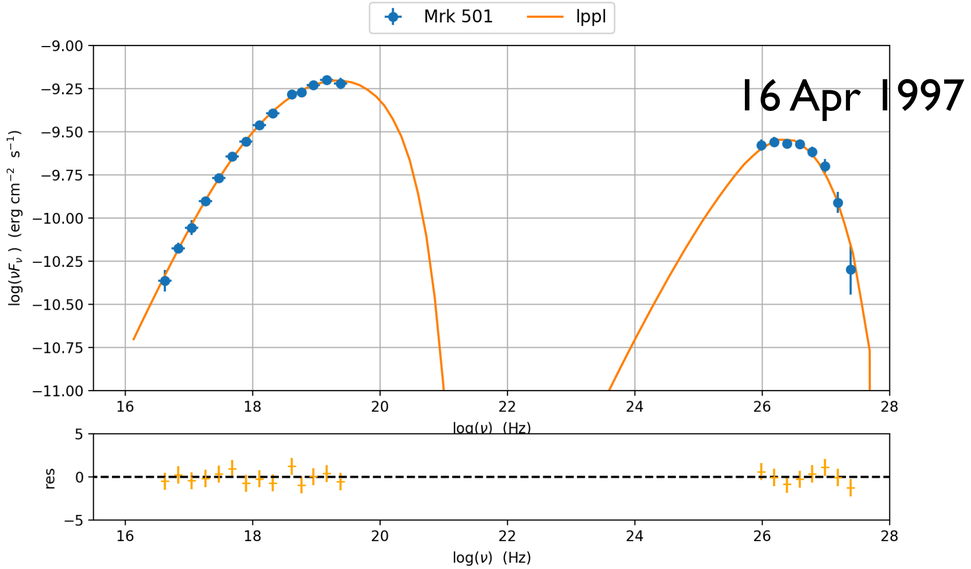
$$s = 1 + \frac{t_{acc}}{2t_{esc}}$$



Mrk 501 1997 Flare

Massaro & Tramacere +2006





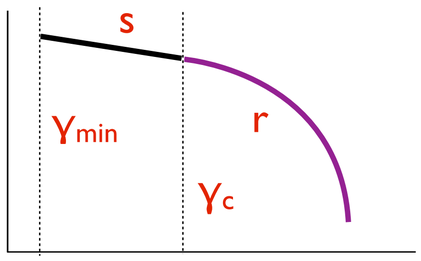

```
best fit pars
-----------------------------------------------------
best-fit parameters:
  Name              | best-fit value| best-fit err +|
-----------------------------------------------------
 B                  | +1.072178e-01 | +5.436622e-03 |
 N                  | +4.585348e+00 | +4.756569e-01 |
 R                  | Frozen        | Frozen        |
 beam_obj           | +2.450884e+01 | +7.642113e-01 |
 gamma0_log_parab   | +6.609649e+04 | +7.427709e+03 |
 gmax               | +1.860044e+14 | +5.881595e+14 |
 gmin               | +1.404527e+03 | +2.198648e+02 |
 r                  | +7.513452e-01 | +5.059815e-02 |
 s                  | +1.638026e+00 | +3.170384e-02 |
 z_cosm             | Frozen        | Frozen        |
-----------------------------------------------------
*****************************************************

=====================================================
```

```
-----------------------------------------------------
best-fit parameters:
  Name              | best-fit value| best-fit err +|
-----------------------------------------------------
 B                  | +3.065207e-01 | +1.159567e-02 |
 N                  | +1.079944e+02 | +7.375385e+00 |
 R                  | Frozen        | Frozen        |
 beam_obj           | +2.722013e+01 | +5.889626e-01 |
 gamma0_log_parab   | +6.493888e+04 | +5.410315e+03 |
 gmax               | +1.902146e+06 | +2.216666e+02 |
 gmin               | +3.003970e+02 | +5.686711e+01 |
 r                  | +6.778727e-01 | +3.526656e-02 |
 s                  | +1.321307e+00 | +1.844825e-02 |
 z_cosm             | Frozen        | Frozen        |
-----------------------------------------------------
```

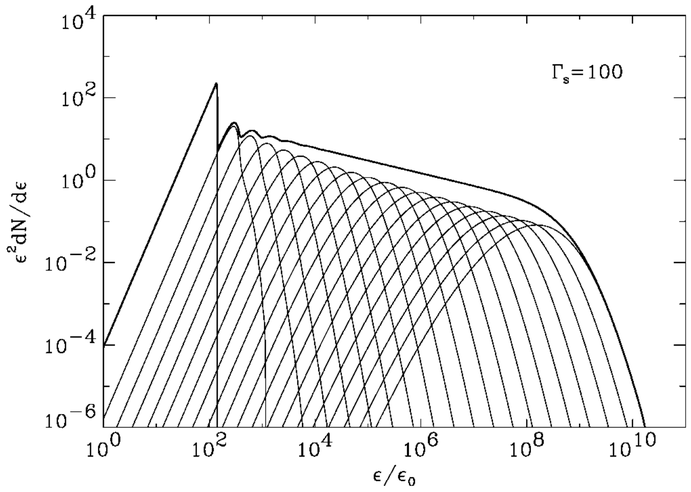
Fermi I+Fermi II Mrk 421 2006

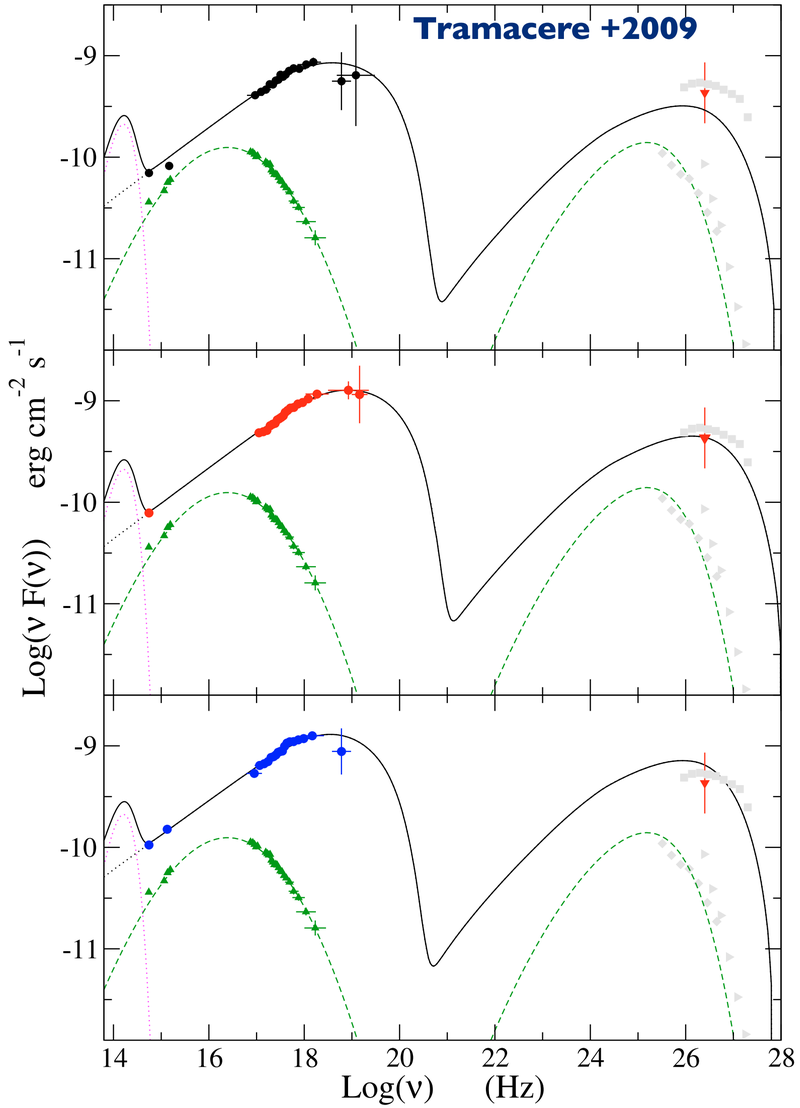
LP+PL spectra

Synch index~[1.6-1.7]=>s~[2.2-2.4]



Lemoine,Pelletier 2003





JetSeT web interface: https://www.isdc.unige.ch/sedtool

Not Secure | isdc.unige.ch/sedtool/PROD/SED.html

speed | astro | Physic | sci hub | statistics | informatica | Fotografia | astrofotografia | applications | ODA | Gmail Offline | Mon UNIGE - Portail | utili | » | Other Bookmarks

AGN SED tool
SSC/EC Simulator
author: andrea.tramacere@unige.ch

Simulator Control panel
Reset Form

- Model Menu

Jet

3e+15	R (cm)
0.1	z (red shift)
10.0	Γ (Bulk Lorentz Factor)
0.1	θ (viewing angle)
0.1	B (G)

n(γ)

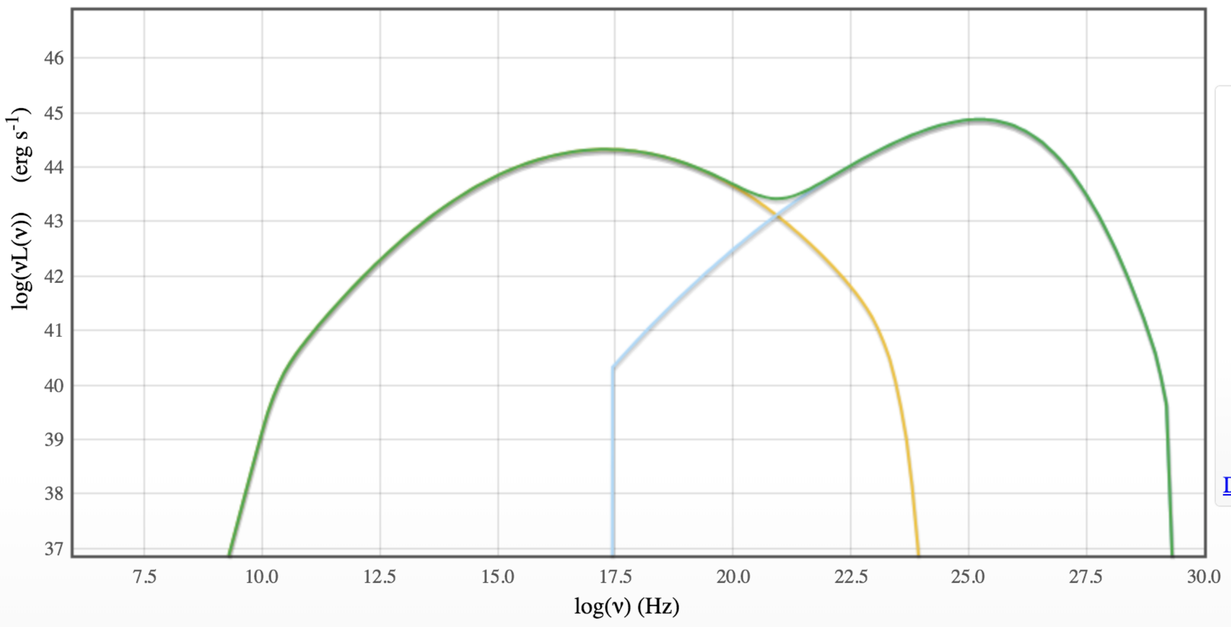
100.0	N
2.0	γ_min
100000000.0	γ_max
log-par	elec distr
0.4	r
2.0	s
10000.0	γ_0

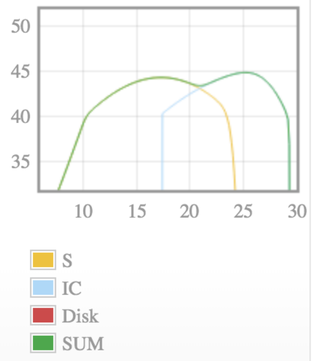
Accretion disck

1e+47	L disk
3.0	R Sw in
500.0	R Sw ext
0.1	accr_eff
1e+17	R H
100000.0	T disk max

emission scenario

Self-ab Synch





Download SED

Beaming 19.9438447326
B (G) 0.1
##
#_obs is as observed from the earth: beaming+cosmo
#_src is in the AGN rest frame :cosmo
#_blob is in the blob rest frame
---
beaming factor =1.994384e+01
Distanza rigorosa=4.548380e+02 in Mpc
Distanza rigorosa=1.403483e+27 in cm
type of distr lp
N=1.000000e+02 N/N_0 5.578788e-04
Volume for Spherical Geom. 1.130973e+47 (cm^3)

JetSeT Temporal evolution

JetSeT Temporal evolution

Tramacere +2011

injection term

$$L_{inj} = \frac{4}{3}\pi R^3 \int \gamma_{inj} m_e c^2 Q(\gamma_{inj}, t) d\gamma_{inj} \quad (erg/s)$$

systematic term

$$S(\gamma, t) = -C(\gamma, t) + A(\gamma, t)$$

cooling term

$$C(\gamma) = |\dot{\gamma}_{\rm synch}| + |\dot{\gamma}_{\rm IC}|$$

syst. acc. term

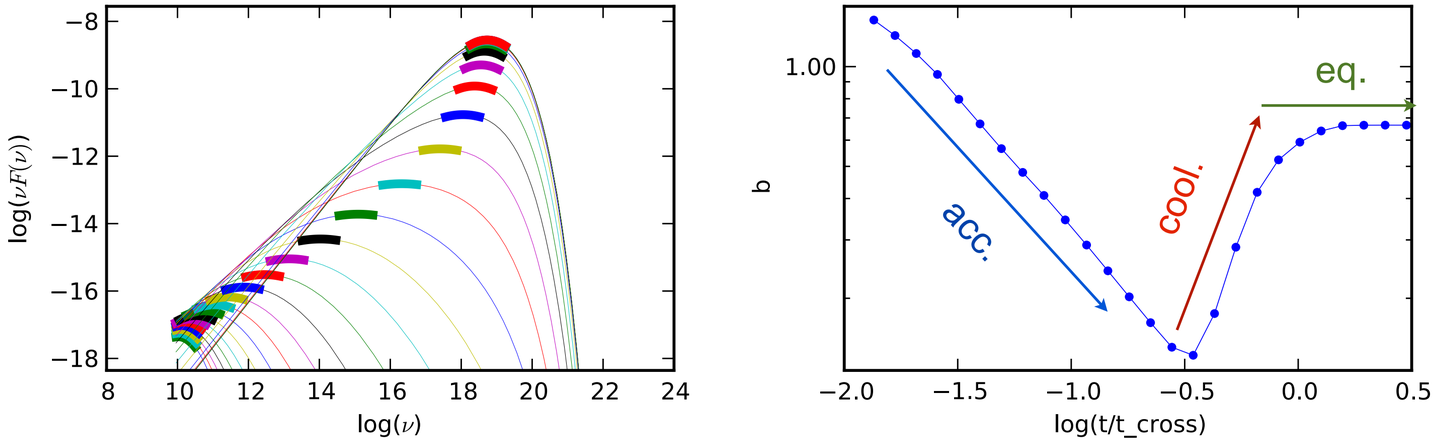
$$A(\gamma) = A_{p0}\gamma, t_A = \frac{1}{A_0}$$

$$\frac{\partial n(\gamma, t)}{\partial t} = \frac{\partial}{\partial \gamma}\left\{ -[S(\gamma, t) + D_A(\gamma, t)]n(\gamma, t) + D_p(\gamma, t)\frac{\partial n(\gamma, t)}{\partial \gamma}\right\} - \frac{n(\gamma, t)}{T_{\rm esc}(\gamma)} + Q(\gamma, t)$$

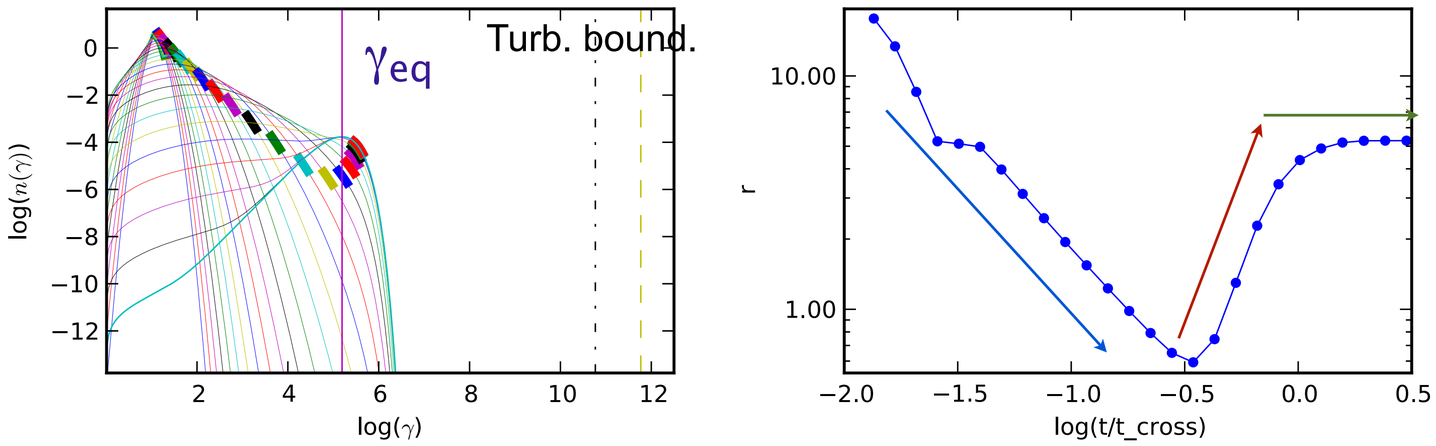
Turbulent magnetic field → momentum diffusion term

$$W(k) = \frac{\delta B(k_0^2)}{8\pi}\left(\frac{k}{k_0}\right)^{-q}$$

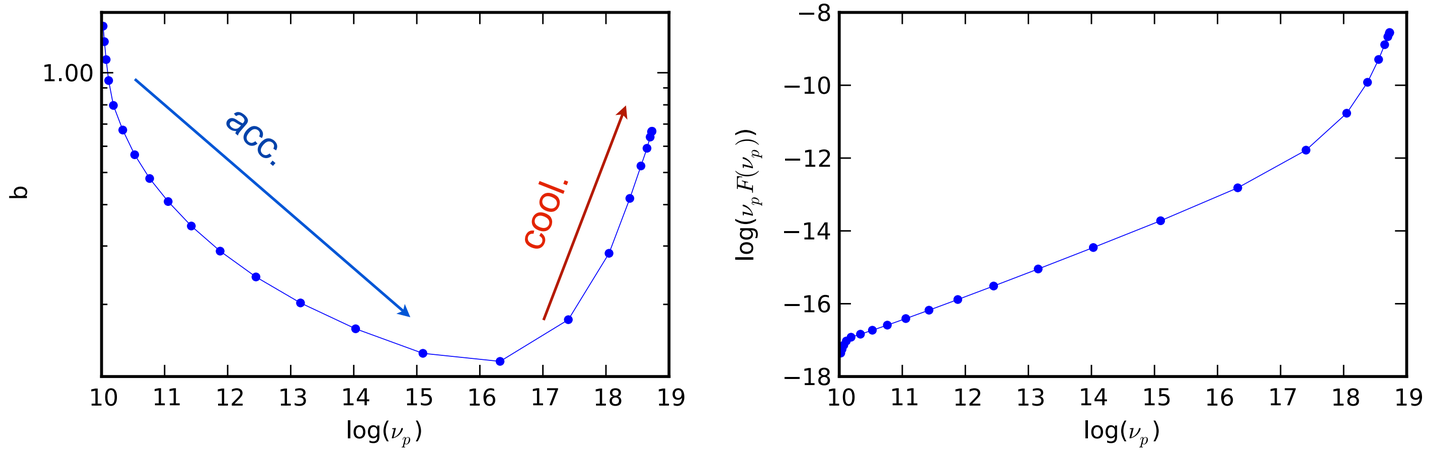
Tramacere +2011



Synchrotron



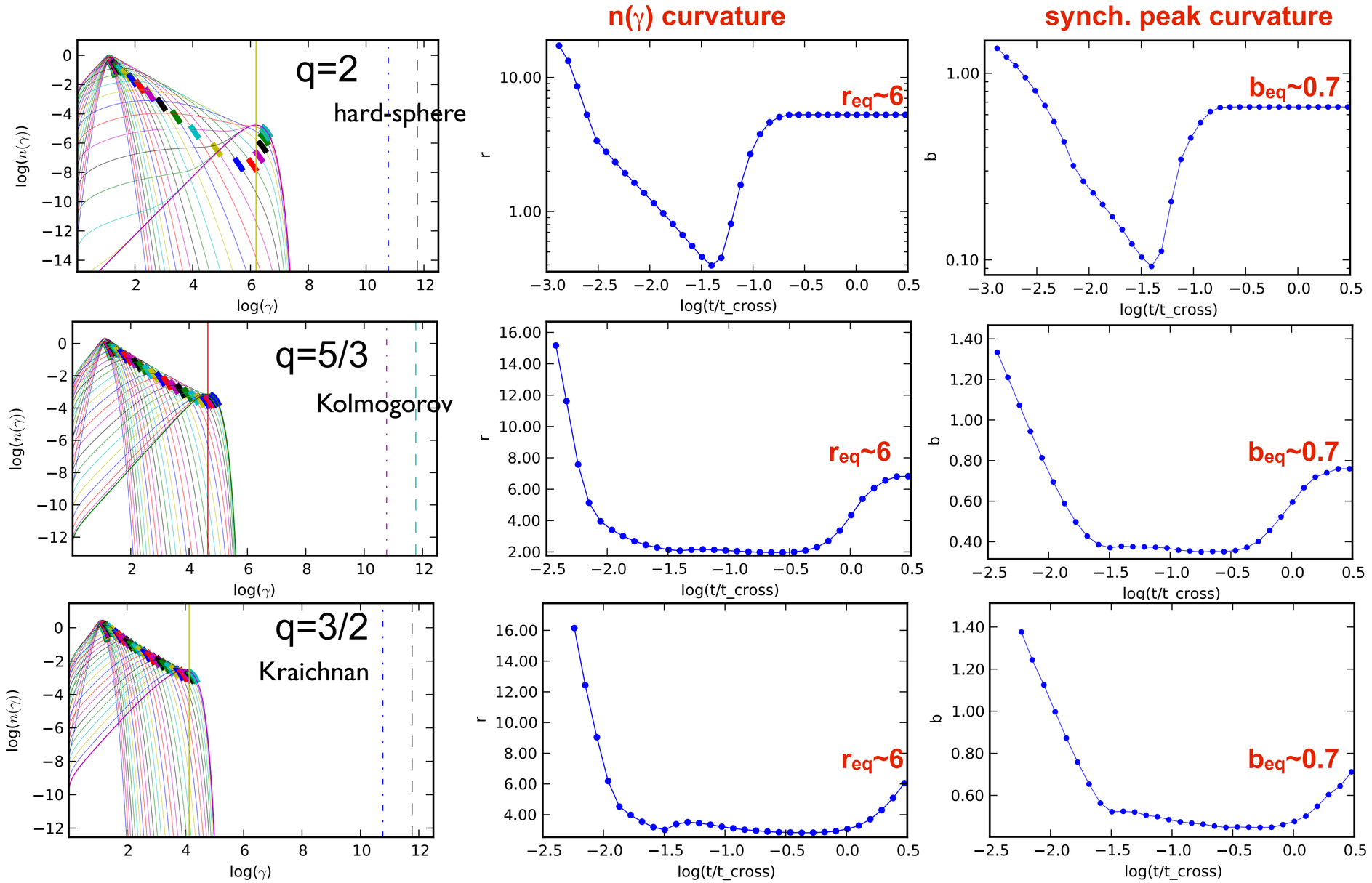
electrons



Synchrotron spectral trends

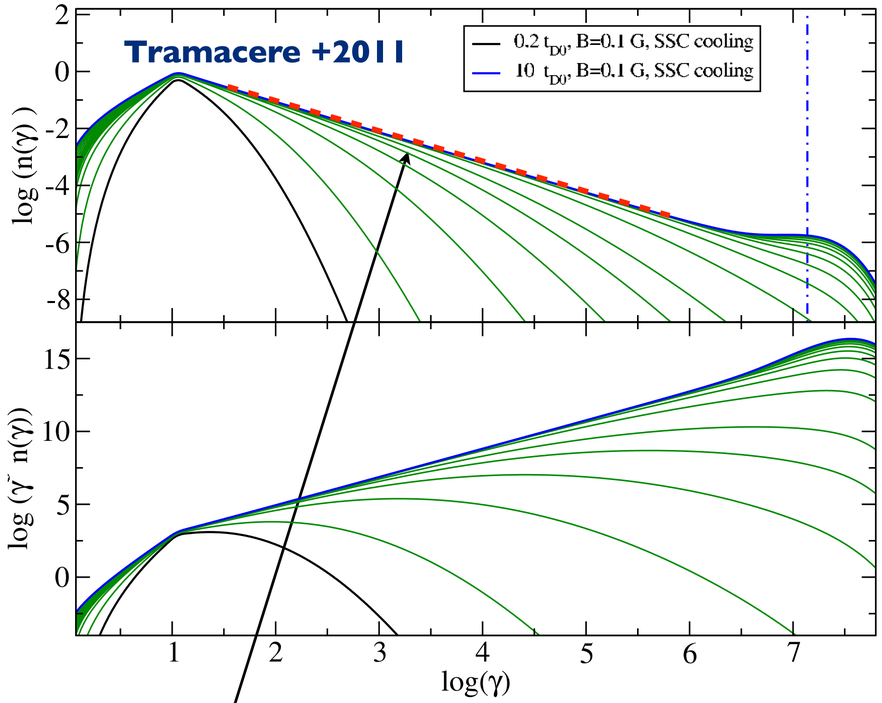
effect of the turbulence index q

B=1.0 G, $t_{D0}=10^3$, $R=5\times10^{15}$ cm



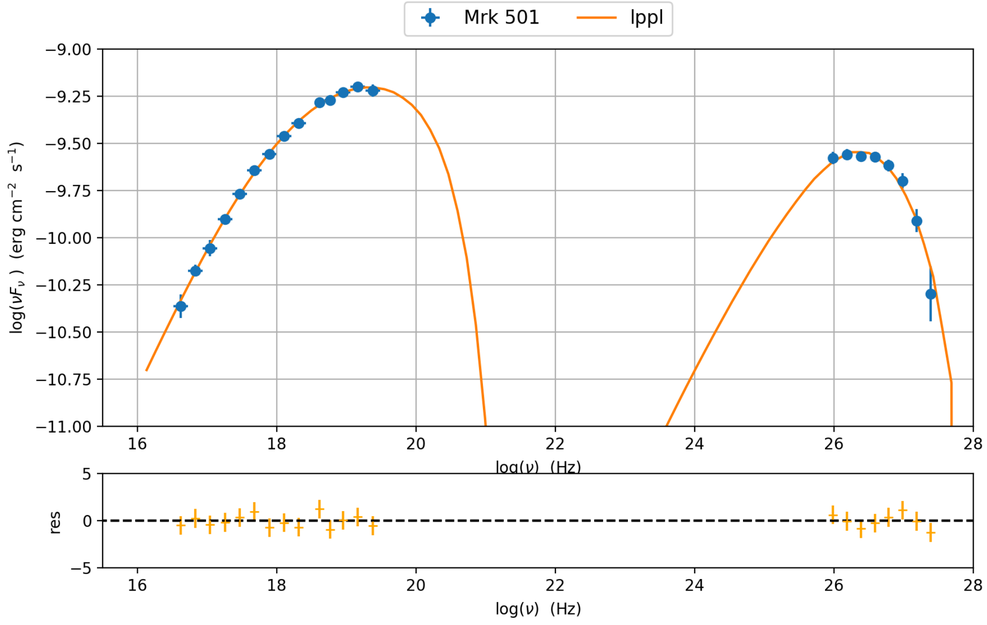
Pile-up and hard spectra

q=2, R=10^{15} cm, B=0.1 G, $t_{inj}=t_D=10^4$ s



s in agreement with $s = 1 + \frac{t_{acc}}{2t_{esc}}$

Mrk 501 1997



Massaro & Tramacere +2006

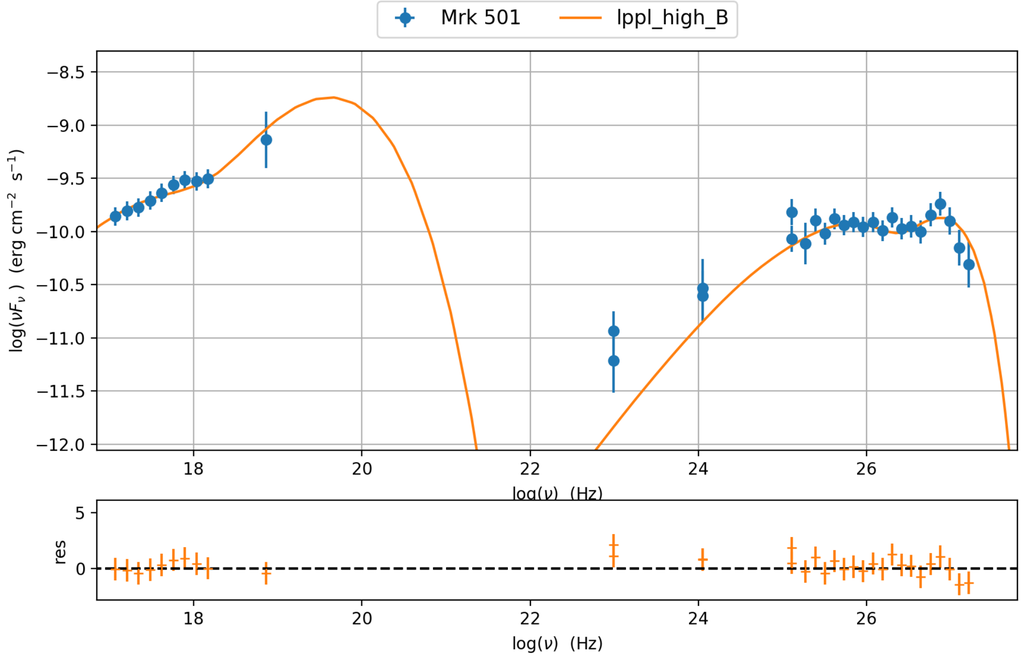
s~1.6

r~0.7-0.8<<r_{eq}~6

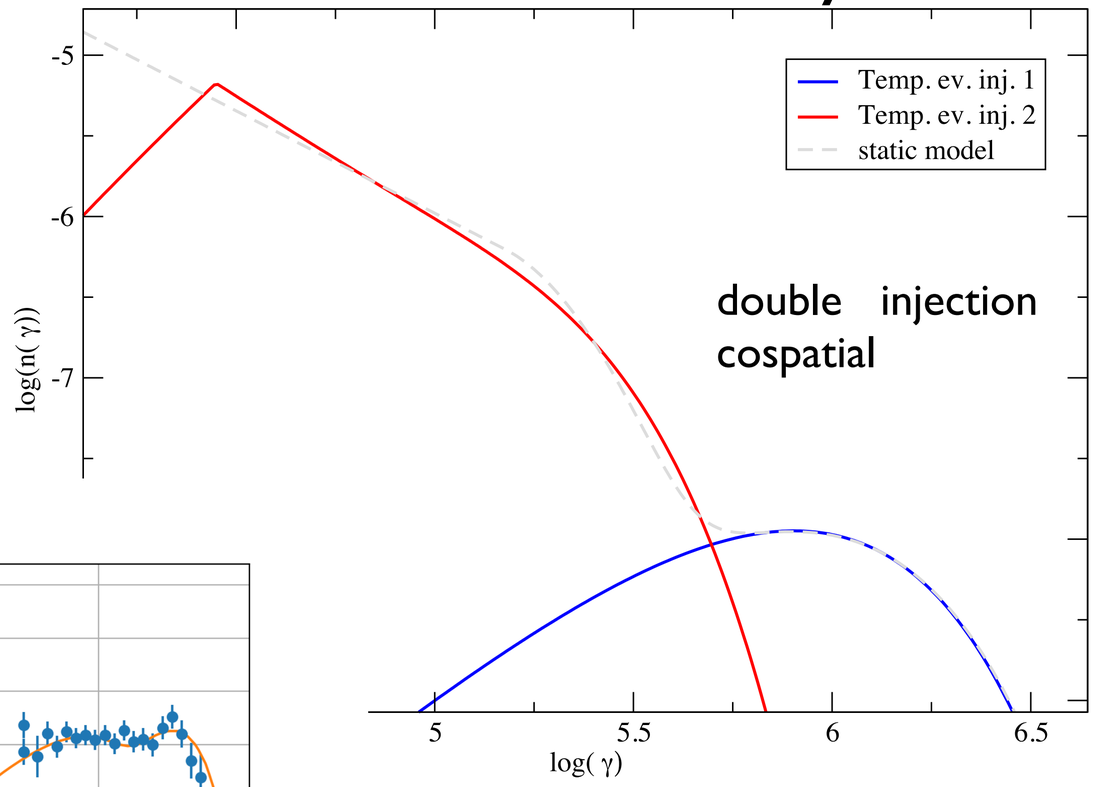
s<<s_{FI}~2.3

Pile-up and hard spectra

Mrk 501 2014 Flare
MAGIC paper
(submitted)



Preliminary!



Conclusion and outlook

- hadronic p-p is implemented no yet exposed (p-γ will come after summer, no time-ev fo hadronic modeling)
- despite the need for reproducible and numerical model fitting, eye-ball inspection is relevant to ‘understand’ how the physics models work
- plugin to threeML very soon(will build dynamically astromodels for any user designed jet model)
- model fitting for time-ev
- possibility to plug other numerical code