

# **COSIpy updates**

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**COSI workshop, JMU Mainz**

# COSI Data challenges

- Released on a yearly basis
- Facilitate the development of the COSI data pipeline and analysis tools
- Provide resources to the astrophysical community to become familiar with COSI data
- First DC released in March 2023 and focused on the 2016 COSI balloon flight data
- DC2 released in 2024, also the first release of cosipy (high-level analysis tools)
- DC2 focused on simulated datasets using different science input models for different objectives
- DC3 to be released later this year

## Tutorials

### Data format and handling

Spacecraft file: attitude and position

Detector response and signal expectation

TS Map: localizing a GRB

Fitting the spectrum of a GRB

Fitting the spectrum of the Crab

Extended source model fitting

Image deconvolution

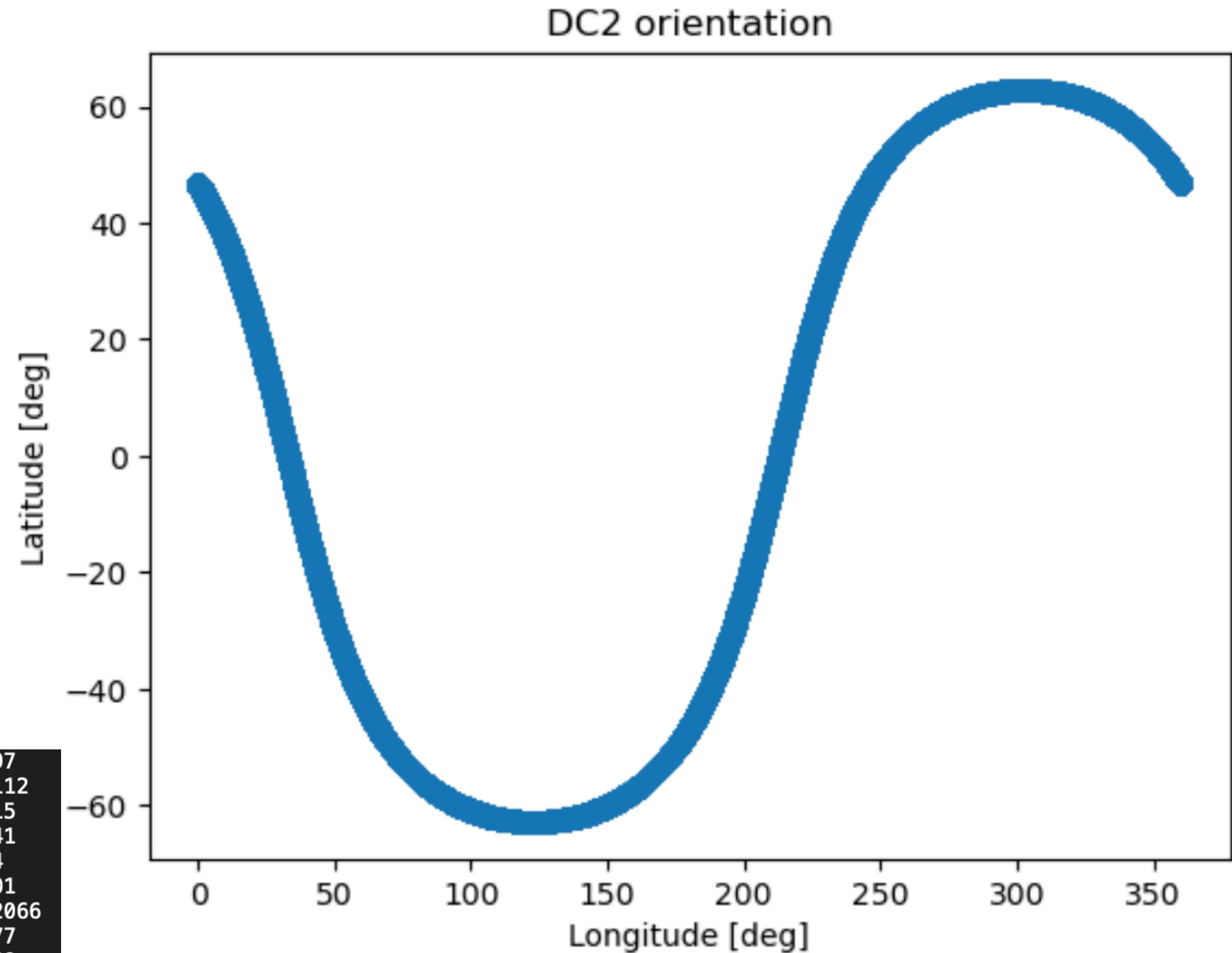
# **1- COSI orientation and pointing**

# DC2 orientation

- 0 deg inclination
- 550 km orbit
- Always pointing zenith
- Galactic latitude between (-62.87, +62.87) deg

Time      b\_x      l\_x      b\_z      l\_z

```
OG 1835487302.0 68.3380787943012 44.67309722321497 -21.661921205698793 44.67309722321497
OG 1835487303.0 68.28695666554313 44.70409195030112 -21.713043334456863 44.70409195030112
OG 1835487304.0 68.2358402243372 44.73510829054615 -21.764159775662804 44.73510829054615
OG 1835487305.0 68.18472949353415 44.76614632621641 -21.81527050646584 44.76614632621641
OG 1835487306.0 68.13362449598479 44.79720613957824 -21.8663755040152 44.79720613957824
OG 1835487307.0 68.08252525453989 44.82828781289802 -21.91747474546011 44.82828781289801
OG 1835487308.0 68.0314317920502 44.859391428442066 -21.968568207949804 44.859391428442066
OG 1835487309.0 67.98034413136648 44.89051706847677 -22.01965586863351 44.89051706847677
OG 1835487310.0 67.92926229533954 44.92166481526848 -22.07073770466045 44.92166481526848
OG 1835487311.0 67.87818630682014 44.952834751083564 -22.12181369317986 44.95283475108356
OG 1835487312.0 67.82711618865903 44.984026958188345 -22.172883811340967 44.984026958188345
OG 1835487313.0 67.776051963707 45.01524151884921 -22.223948036292995 45.01524151884921
OG 1835487314.0 67.72499365481482 45.04647851533251 -22.275006345185172 45.04647851533251
OG 1835487315.0 67.67394128483326 45.07773802990459 -22.326058715166734 45.07773802990459
OG 1835487316.0 67.62289487661309 45.109020144831824 -22.377105123386904 45.109020144831824
OG 1835487317.0 67.57185445300509 45.14032494238055 -22.428145546994912 45.14032494238055
```

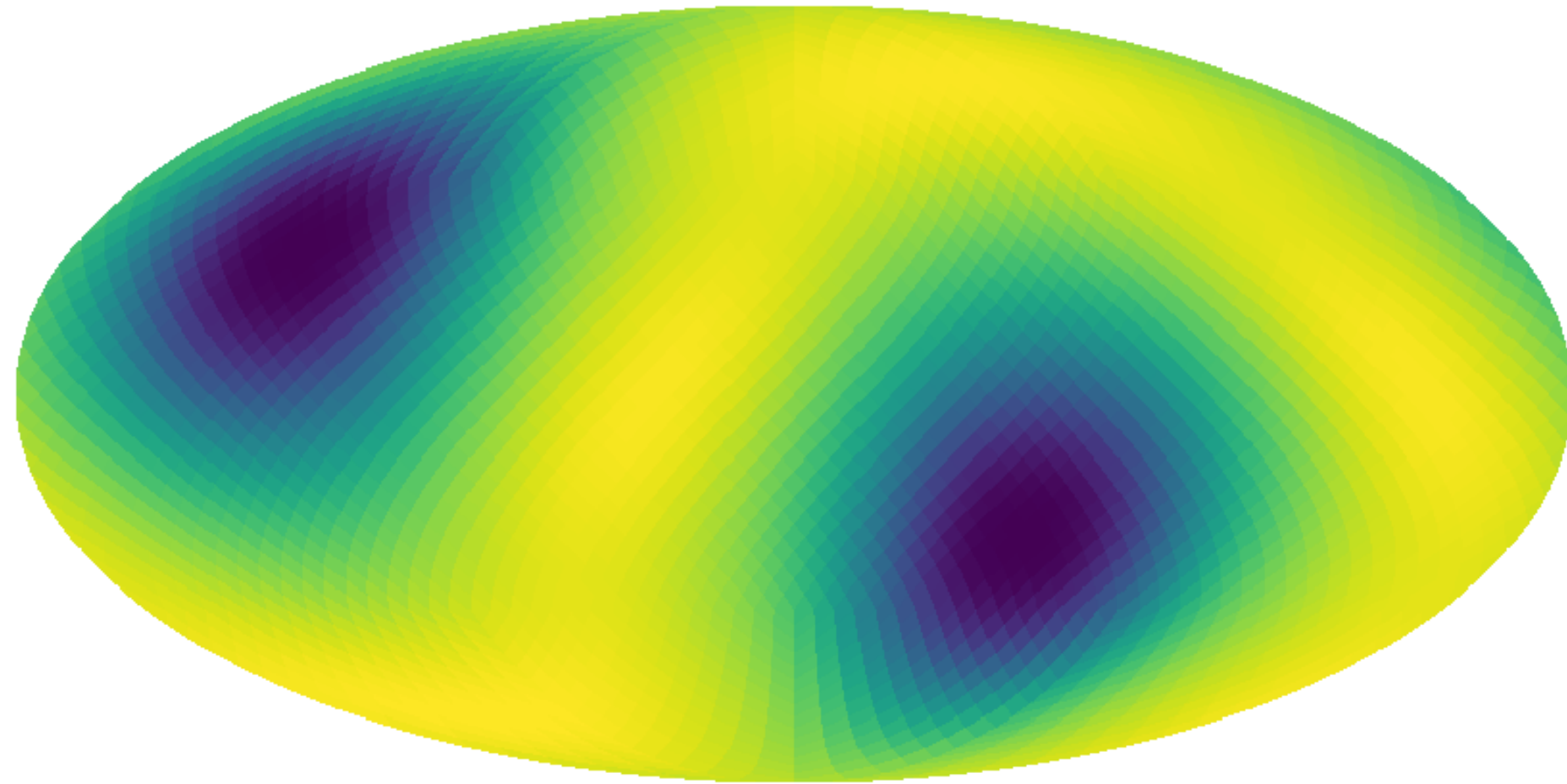


Can be used with SpacecraftFile class



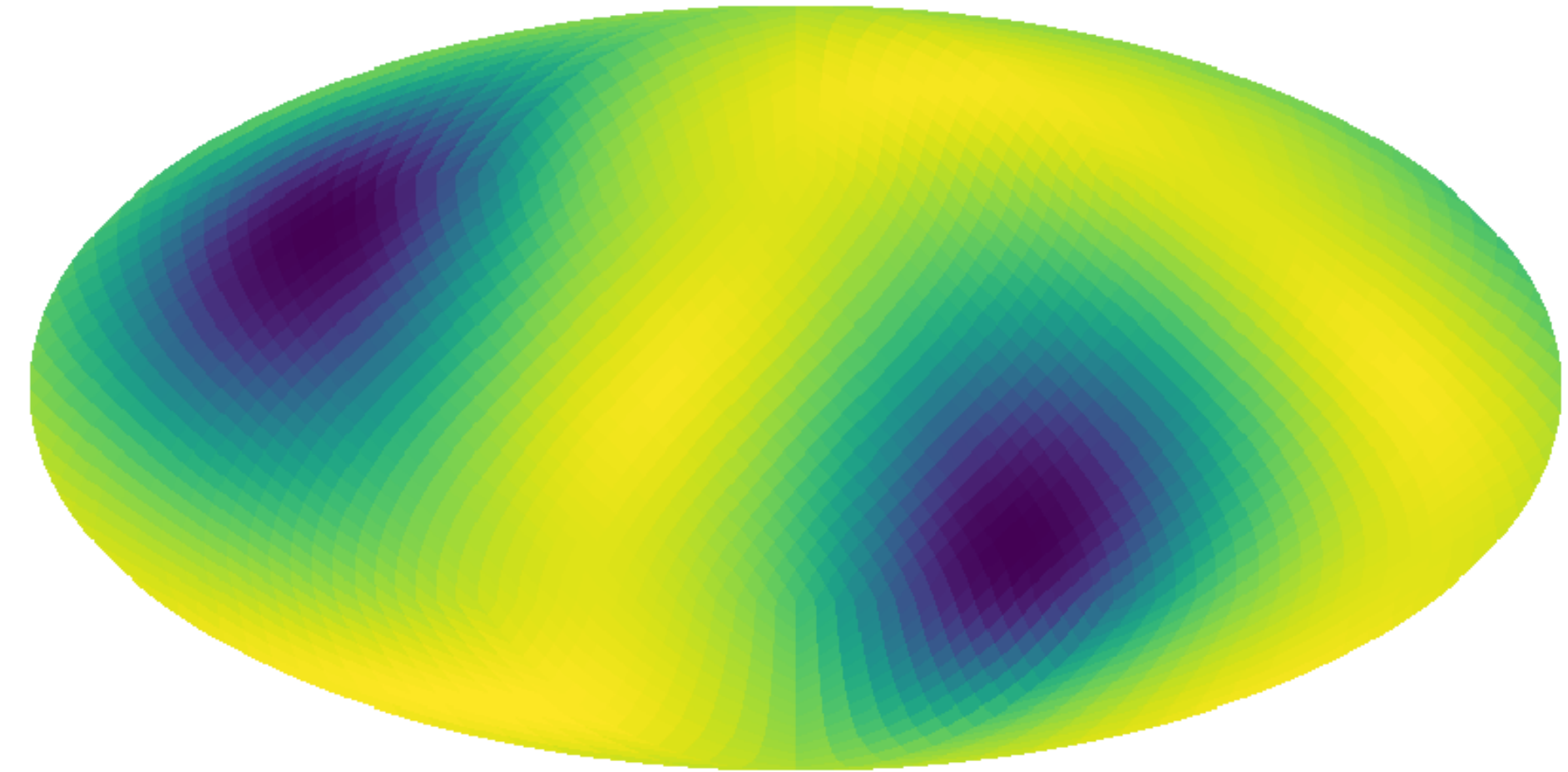
# DC2 orientation exposure maps

Energy bin = 0 (100.0 keV - 158.489 keV)



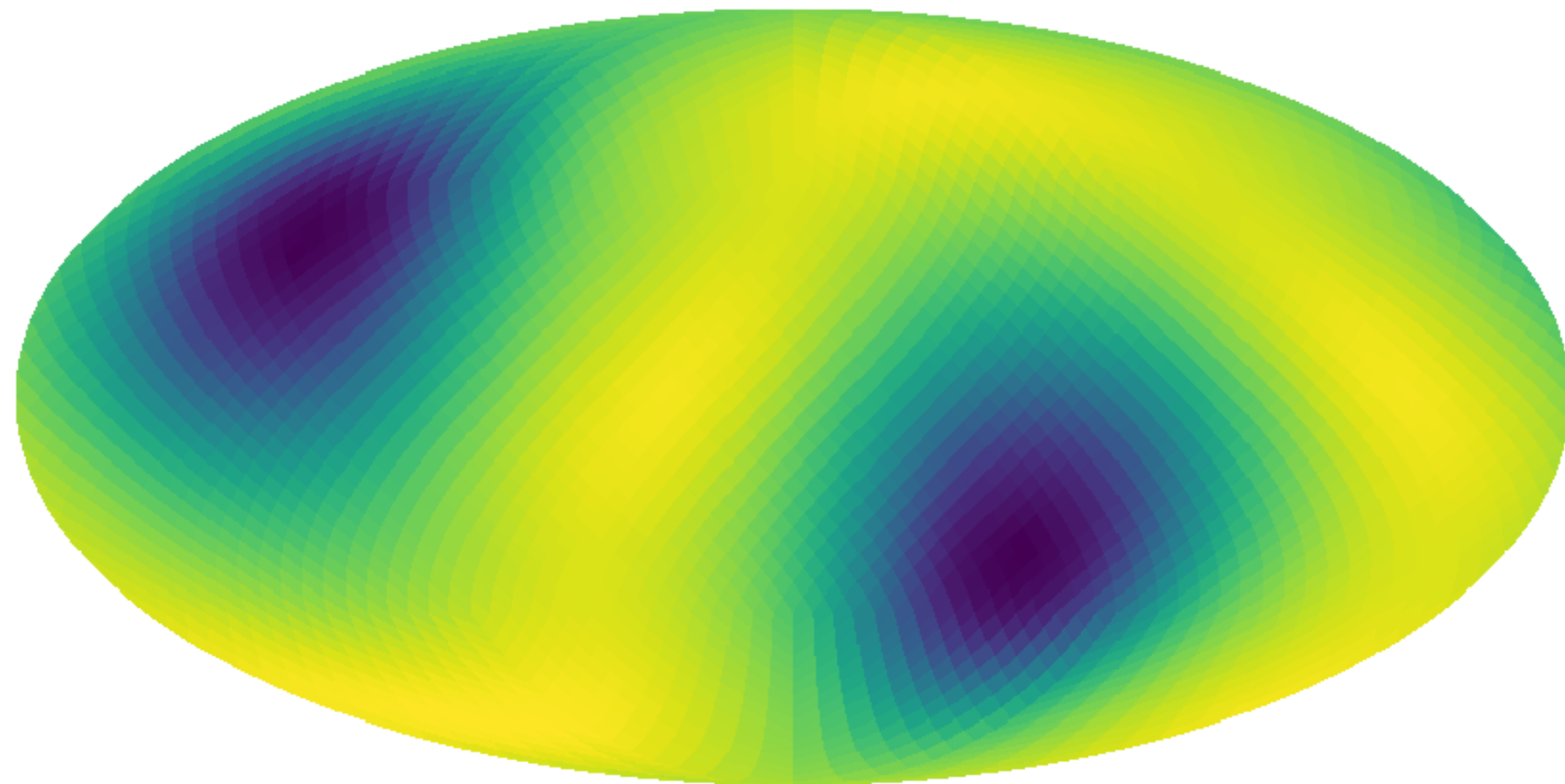
632501 cm2 s 5.37381e+07

Energy bin = 3 (398.107 keV - 630.957 keV)



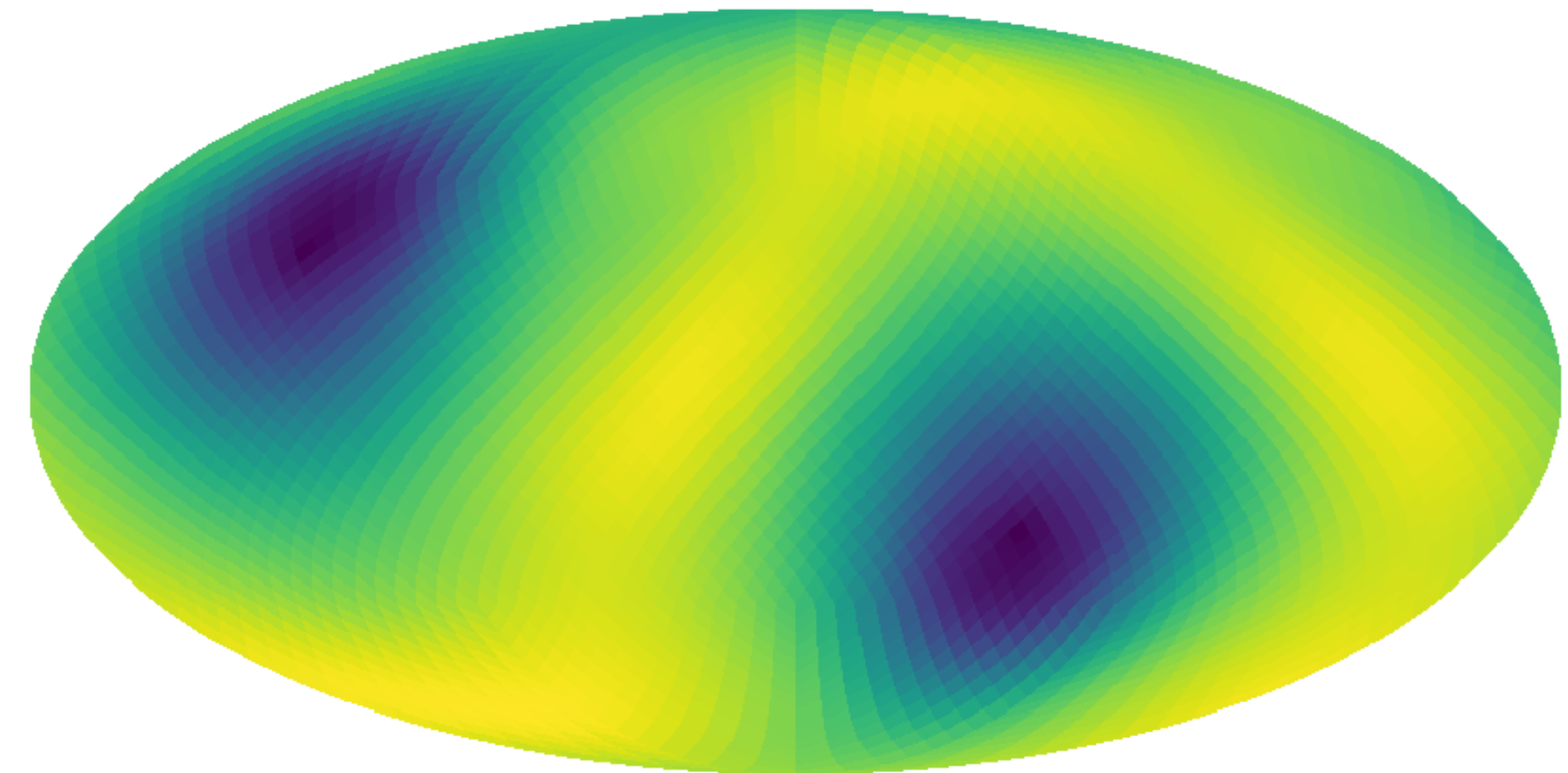
4.33058e+07 cm2 s 3.13867e+08

Energy bin = 4 (630.957 keV - 1000.0 keV)



8.51967e+07 cm2 s 3.14657e+08

Energy bin = 6 (1584.89 keV - 2511.89 keV)



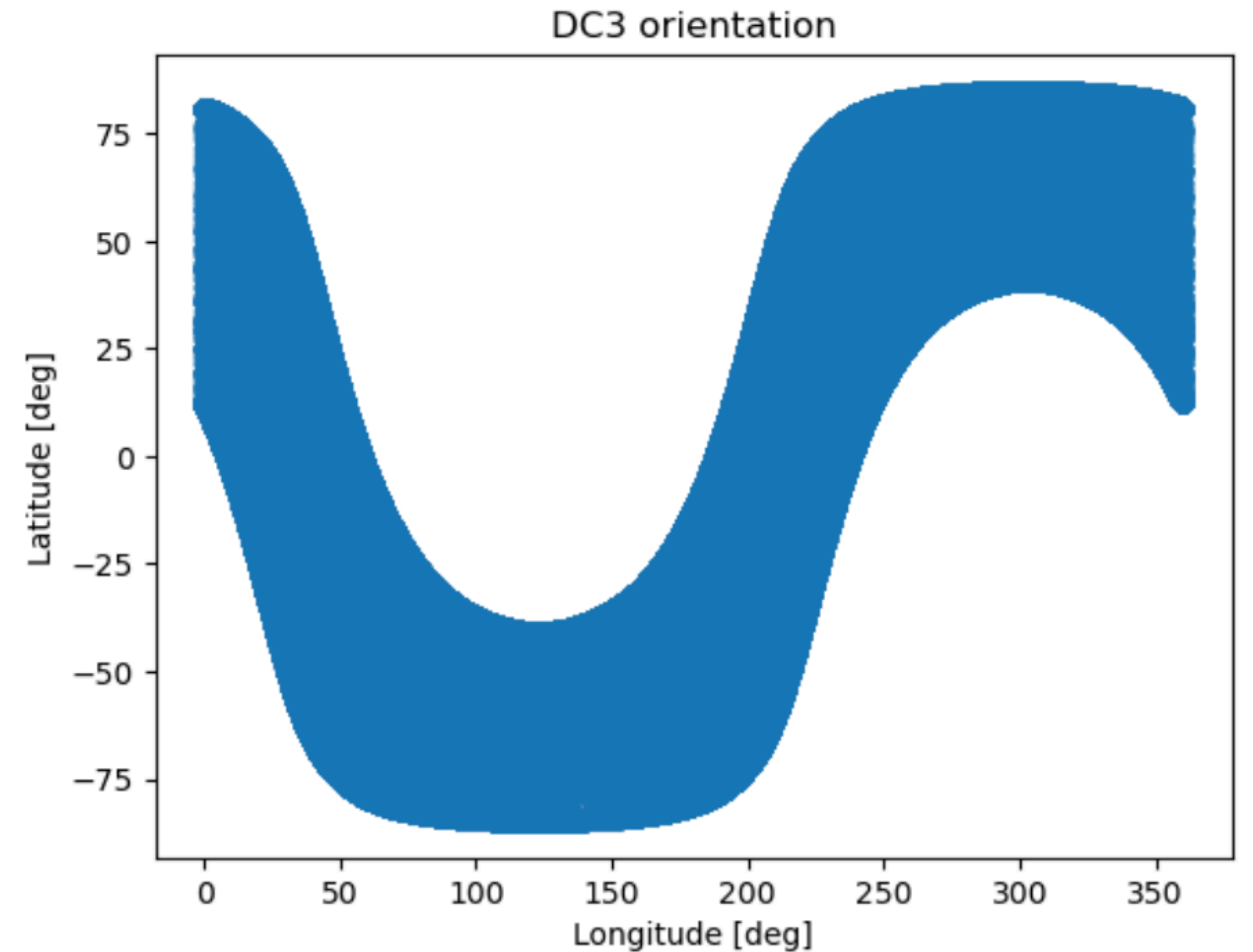
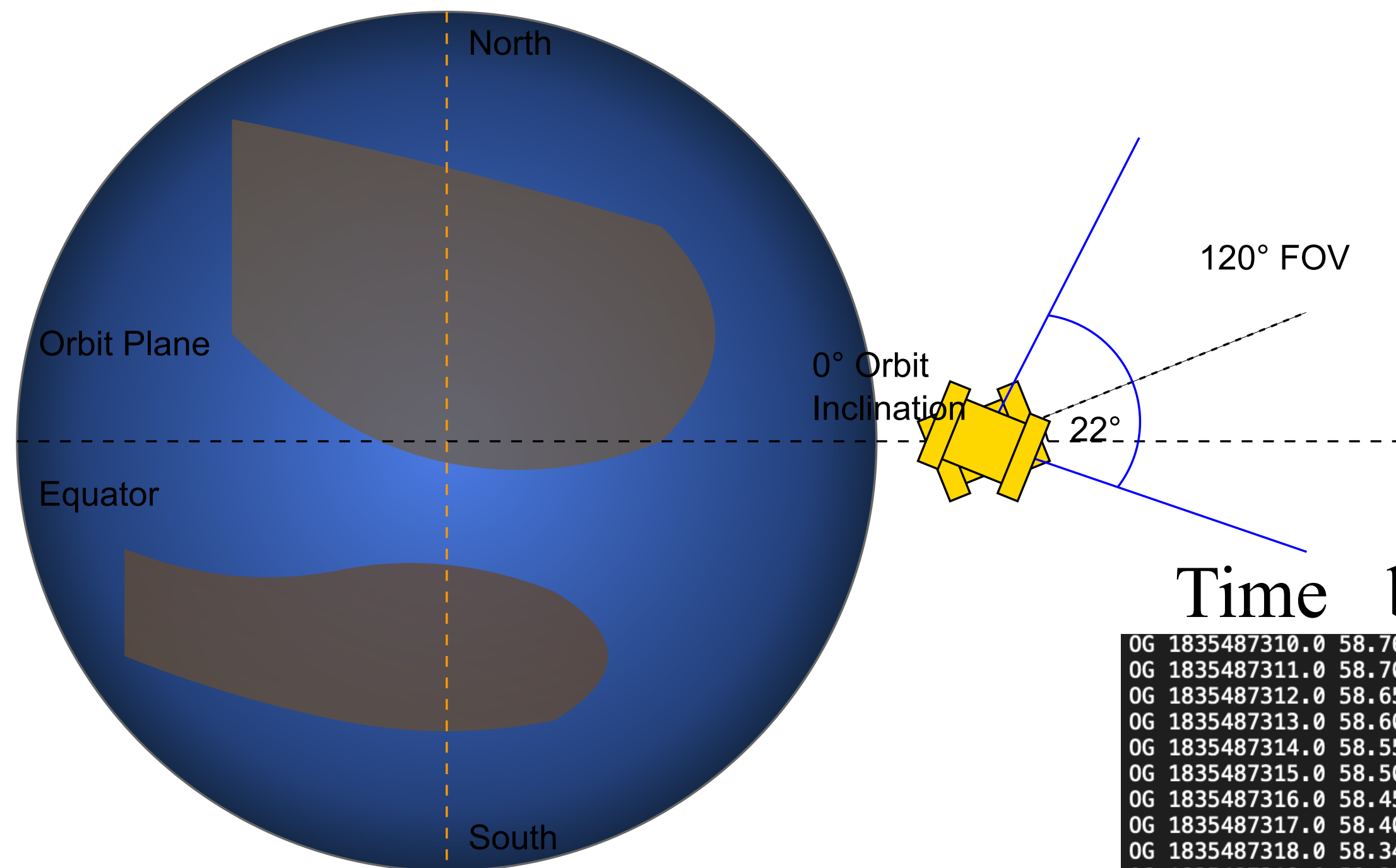
1.28991e+08 cm2 s 2.65301e+08



# DC3 orientation

- 0 deg inclination
- 530 km orbit
- Rocking between  $\pm 22$  deg
- Galactic latitude between  $(-84.75, 84.75)$  deg

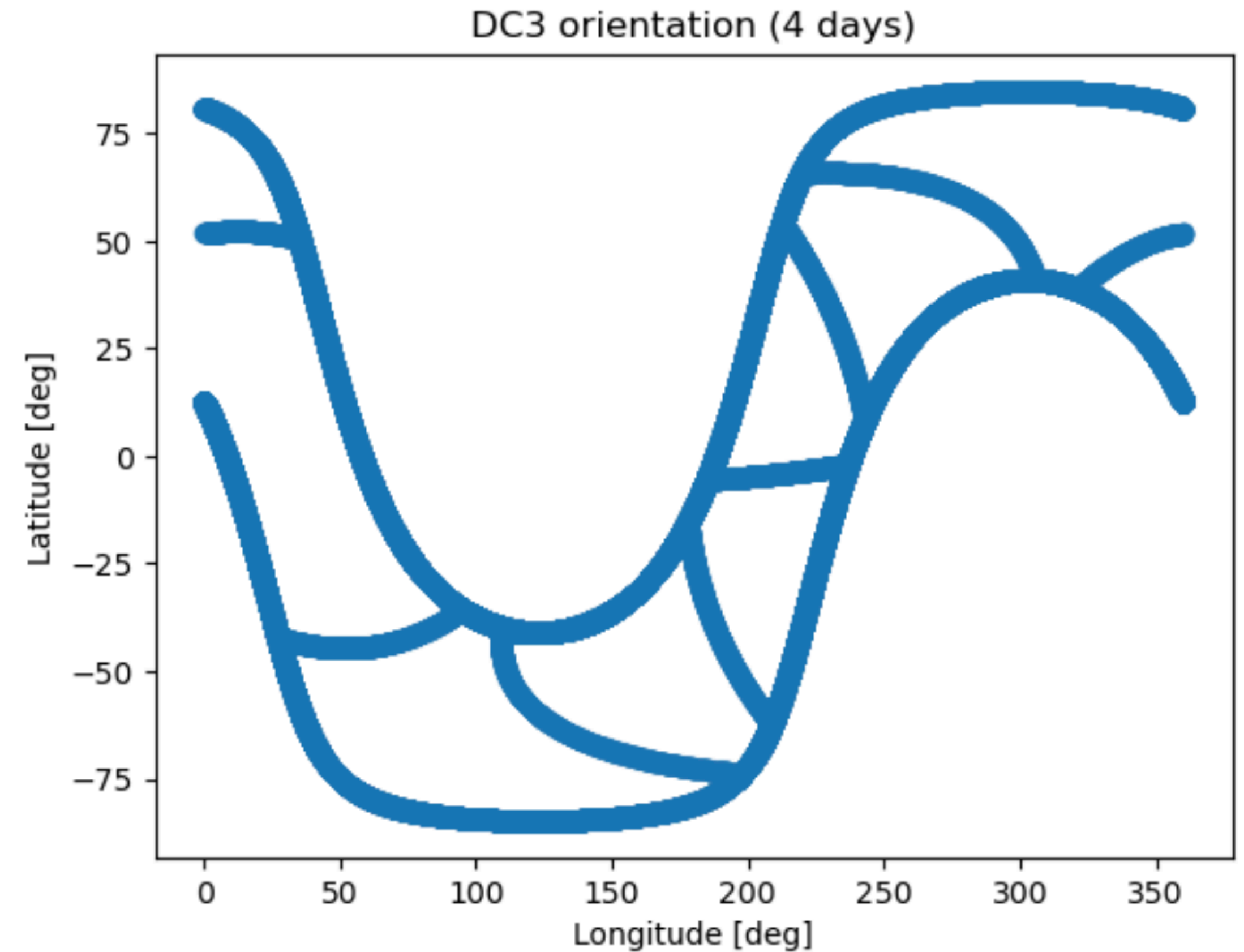
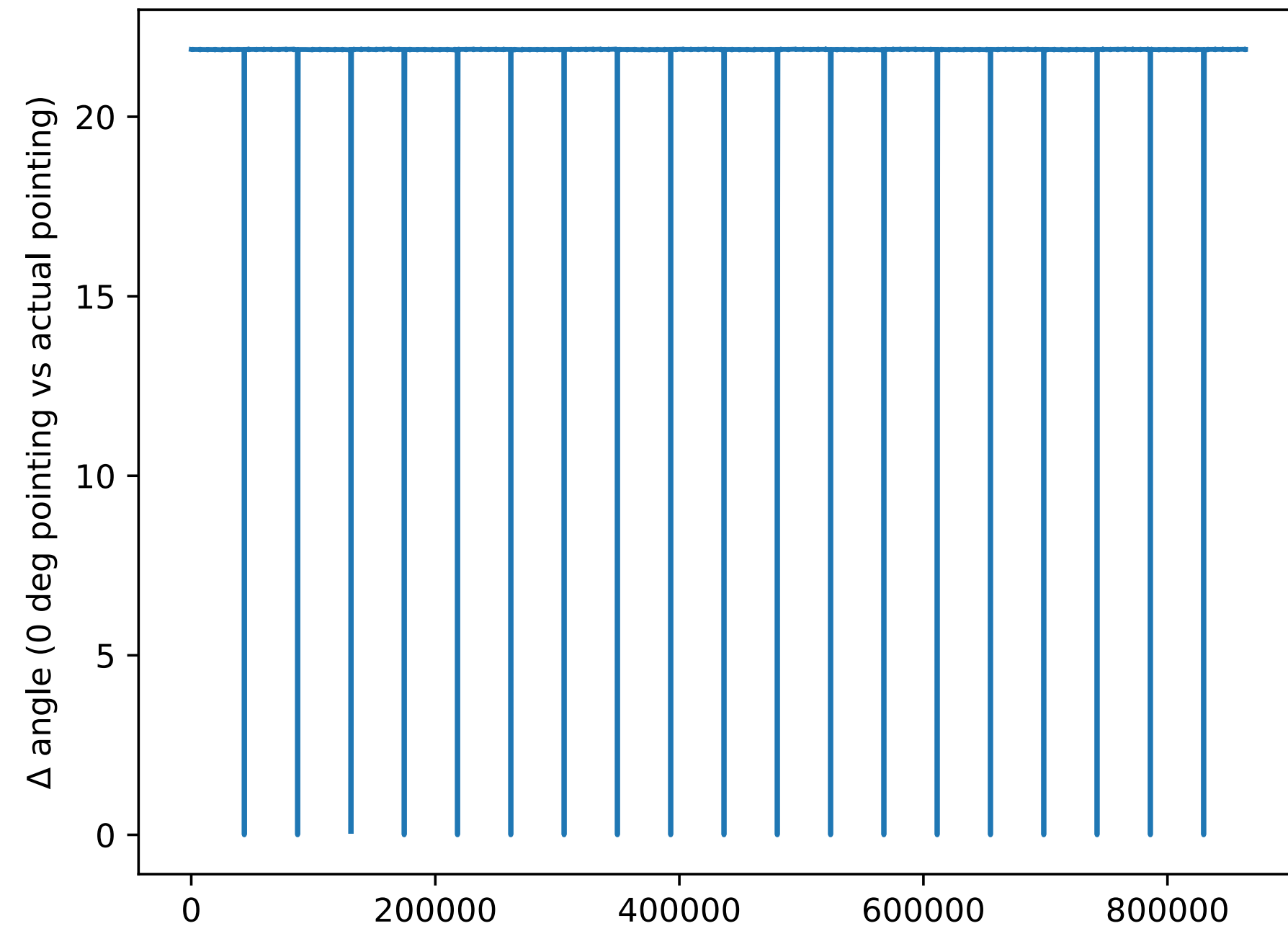
22° North-South Repointing



	Time	b_x	l_x	b_z	l_z	Altitude	Earth Zenith b	Earth Zenith l
OG	1835487310.0	58.760934289859065	22.62686287259092	-31.239065710140935	22.62686287259092	530.2208016301391	-22.070752486112152	44.92161800609016
OG	1835487311.0	58.70955612310303	22.647957904080666	-31.29044387689698	22.647957904080666	530.2206491226293	-22.121829359976452	44.952785141770924
OG	1835487312.0	58.658174575672085	22.669052823541133	-31.341825424327915	22.669052823541133	530.2204924481392	-22.172900269822435	44.98397484568608
OG	1835487313.0	58.606789654323336	22.69014767009757	-31.393210345676664	22.69014767009757	530.2203316068582	-22.223965196186146	45.015187189314524
OG	1835487314.0	58.55540136581383	22.711242482875235	-31.444598634186175	22.71124248287523	530.2201665989807	-22.275024119558644	45.04642224427994
OG	1835487315.0	58.50400971690064	22.732337300999372	-31.495990283099363	22.732337300999372	530.219997424706	-22.32607702038621	45.07768008235157
OG	1835487316.0	58.45261471434083	22.753432163595235	-31.54738528565917	22.753432163595235	530.2198240842389	-22.377123879069863	45.10896077544455
OG	1835487317.0	58.40121636489147	22.774527109788085	-31.598783635108532	22.774527109788085	530.2196465777888	-22.42816467596544	45.14026439562056
OG	1835487318.0	58.34981467530963	22.795622178703162	-31.650185324690373	22.795622178703162	530.2194649055702	-22.479199391383357	45.17159101508837
OG	1835487319.0	58.29840965235237	22.81671740946572	-31.70159034764763	22.81671740946572	530.219279067803	-22.53022800558822	45.20294070620408

# DC3 orientation

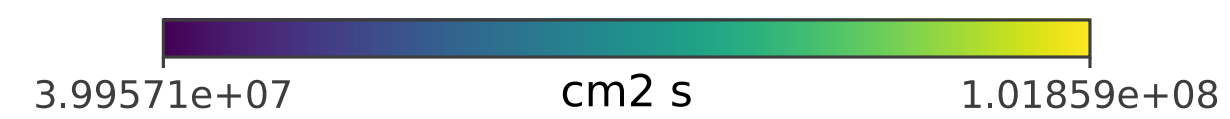
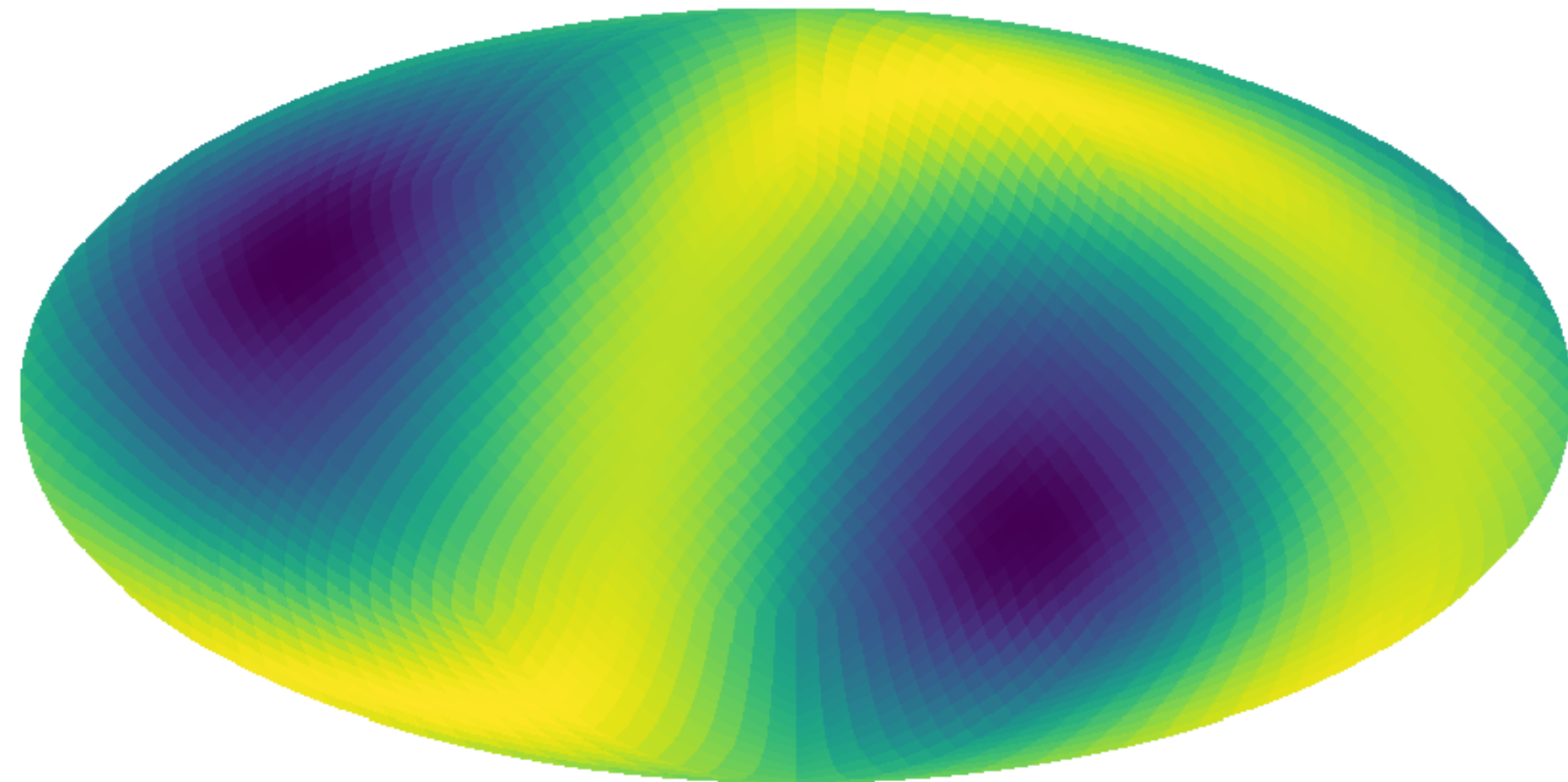
- Few days zoomed in
- 12 hours observing North sky, 8 minute slewing time on average, 12 hours observing south sky and so on.



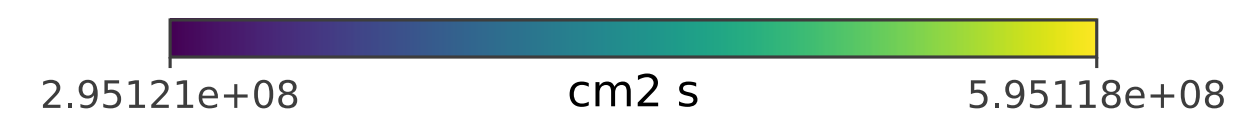
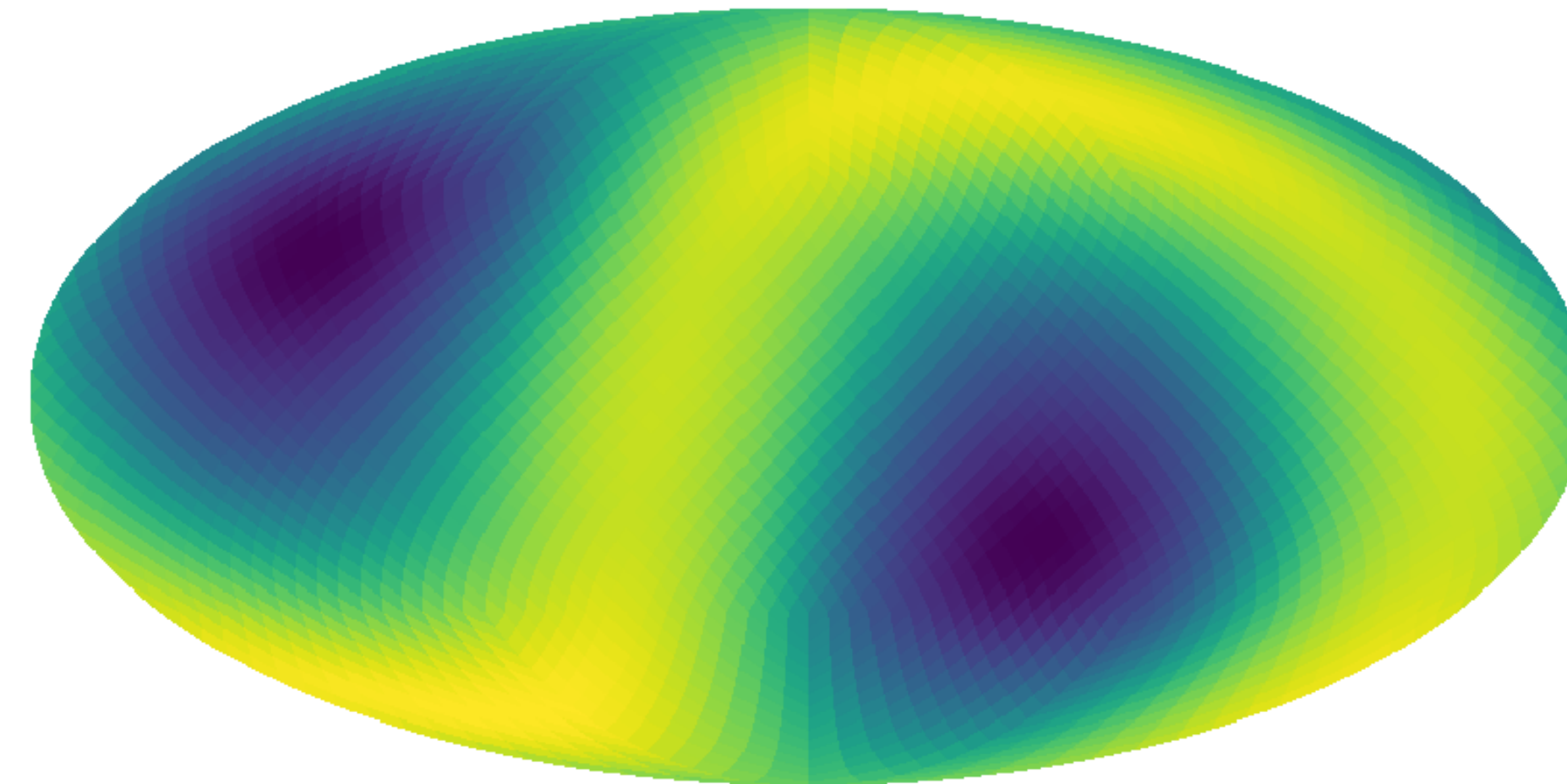


# DC3 orientation exposure maps

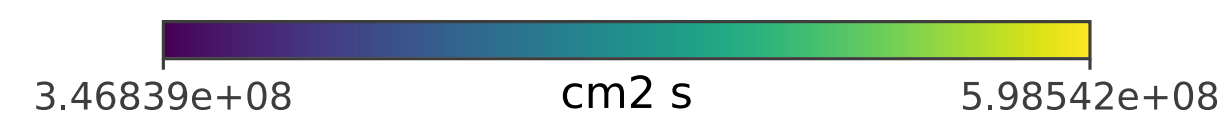
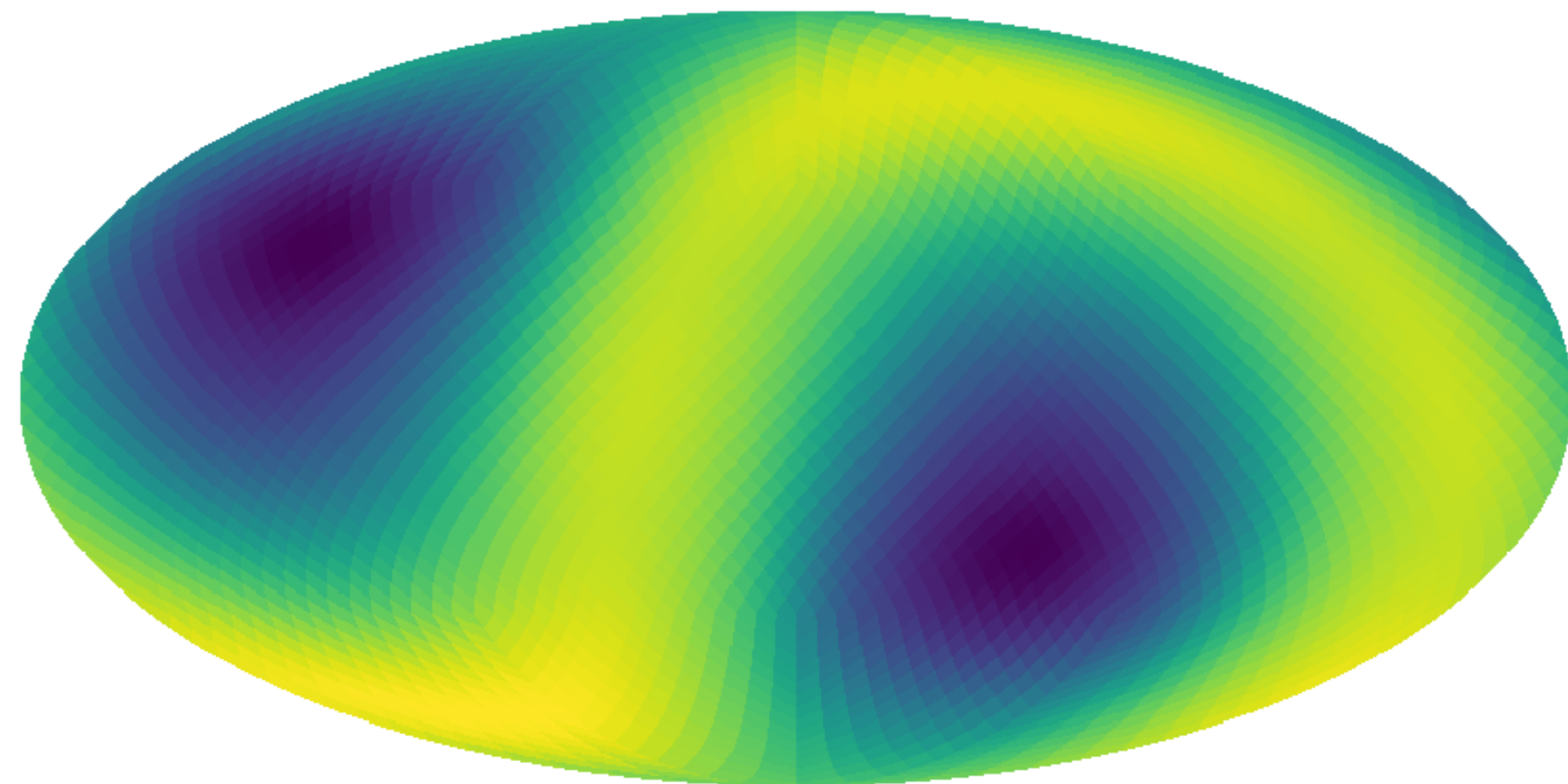
Energy bin = 0 (100.0 keV - 158.489 keV)



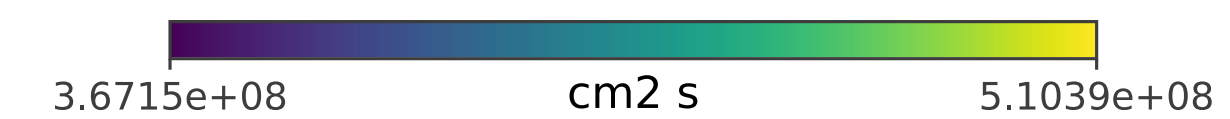
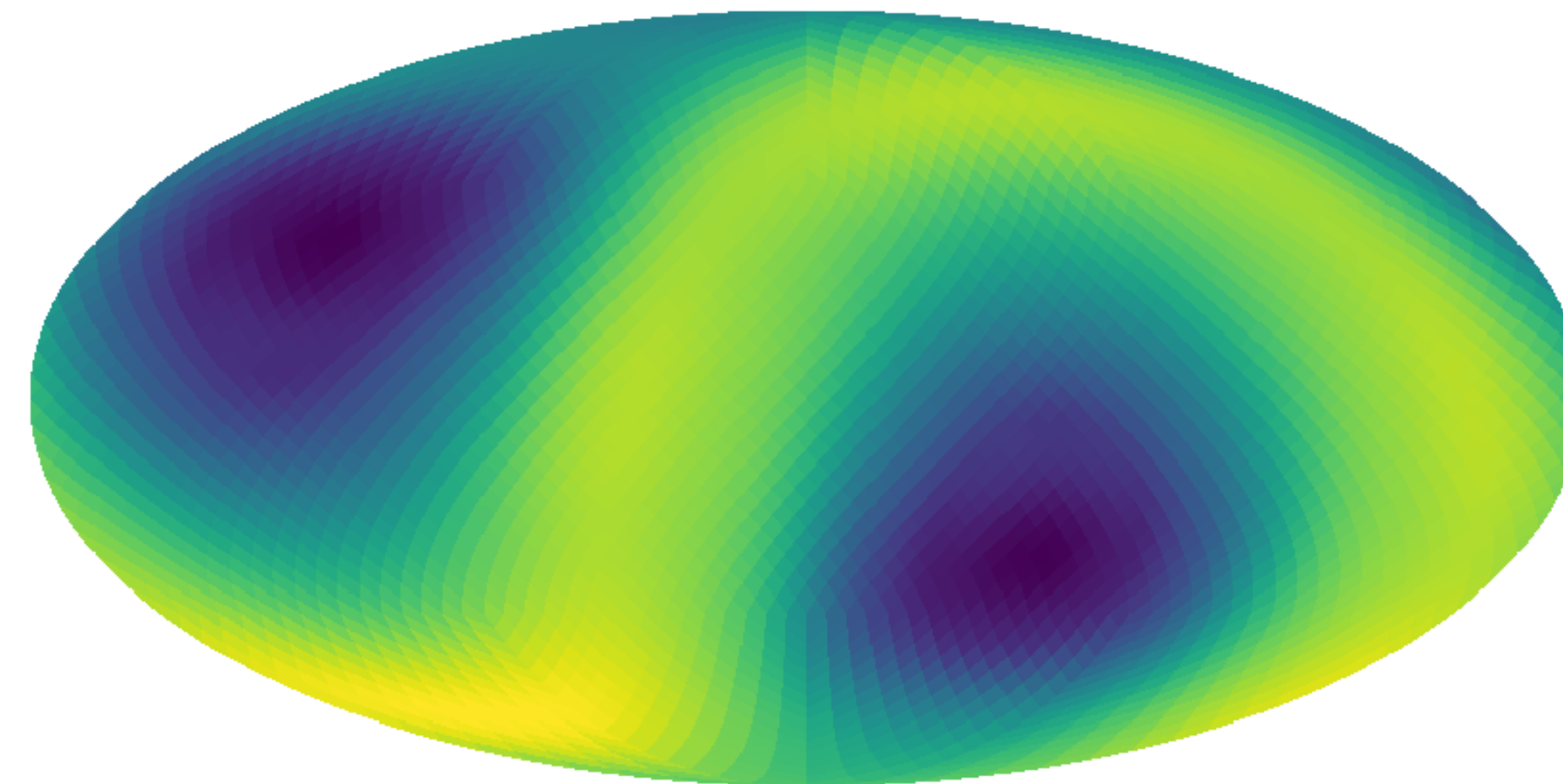
Energy bin = 3 (398.107 keV - 630.957 keV)



Energy bin = 4 (630.957 keV - 1000.0 keV)



Energy bin = 6 (1584.89 keV - 2511.89 keV)





## **2- COSI time series builder**

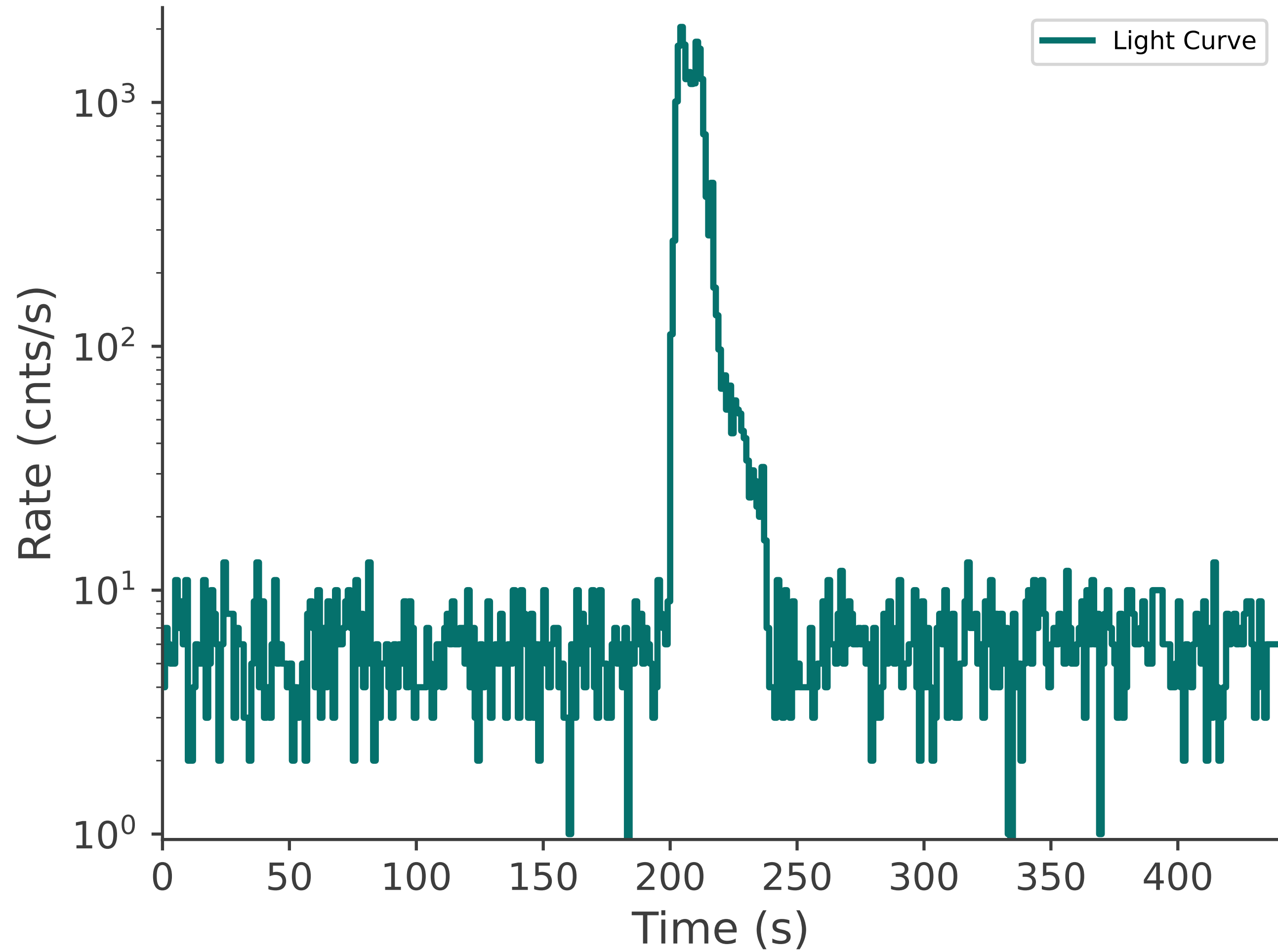
# Time series builder

```
tsb_cosi = TimeSeriesBuilderCOSI.from_cosi_grb_data(  
    name = 'COSI_GRB',  
    yaml_file="inputs-GRB.yaml",  
    cosi_dataset= (.hdf5 file),  
    response_file= response_file (COSI response file or OGIP compatible),  
    ori_file = (optional if response is OGIP compatible) ,  
    l = (optional if response is OGIP compatible),  
    b= (optional if response is OGIP compatible),  
    poly_order=0 (optional),  
    verbose=True  
)
```

```
•[21]: tsb_cosi = TimeSeriesBuilderCOSI.from_cosi_grb_data(  
    name = 'COSI_GRB_090206620_testing',  
    yaml_file="../bkg_estimation_line/inputs.yaml",  
    cosi_dataset='grb_bkg_GRB090206620.hdf5',  
    response_file= "COSI_GRB_090206620_testing.rmf",  
    # ori_file="/scratch/astrohome/smittal/wasabi_cosi/20280301_3_month.ori",  
    # l = 93.,  
    # b= -53.,  
    # poly_order = 0 (optional)  
    verbose=True  
)
```

# Time series builder

```
tsb_cosi = TimeSeriesBuilder(
    name = 'COSI_GRB090206620',
    yml_file="inputs/cosi_dataset.yml",
    response_file="response_file.yml",
    ori_file = (optional if response_file is provided),
    poly_order=0 (optional if response_file is provided),
    verbose=True
)
```

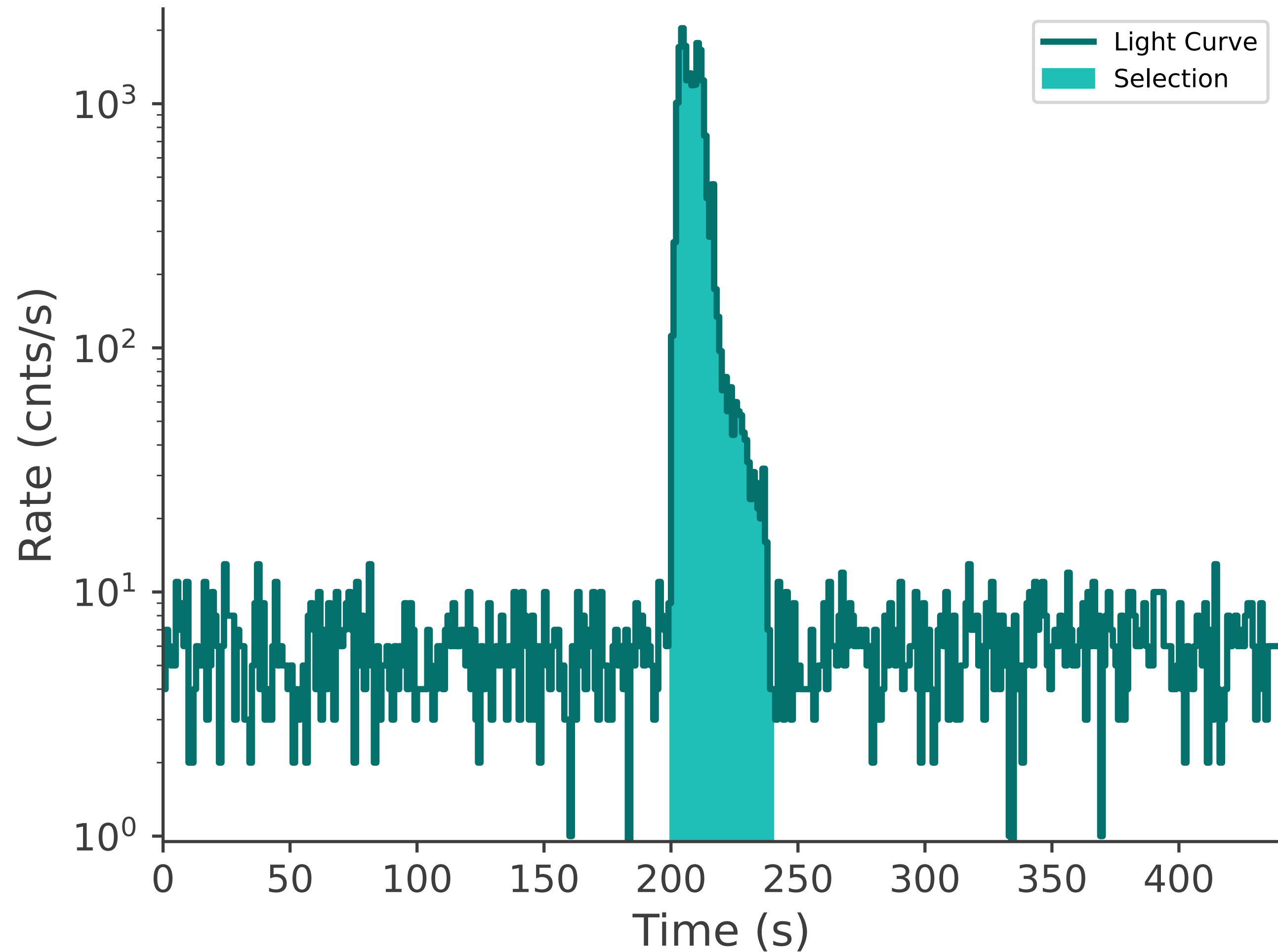


DC2 simulated GRB:  
GRB090206620



# Time series builder

```
tsb_cosi = TimeSeriesBuilder(
    name = 'COSI_GRB090206620',
    yml_file="inputs/cosi_dataset.yml",
    response_file="response_file",
    ori_file = (optional if response_file),
    b = (optional if response_file),
    poly_order=0 (optional if response_file),
    verbose=True
)
```

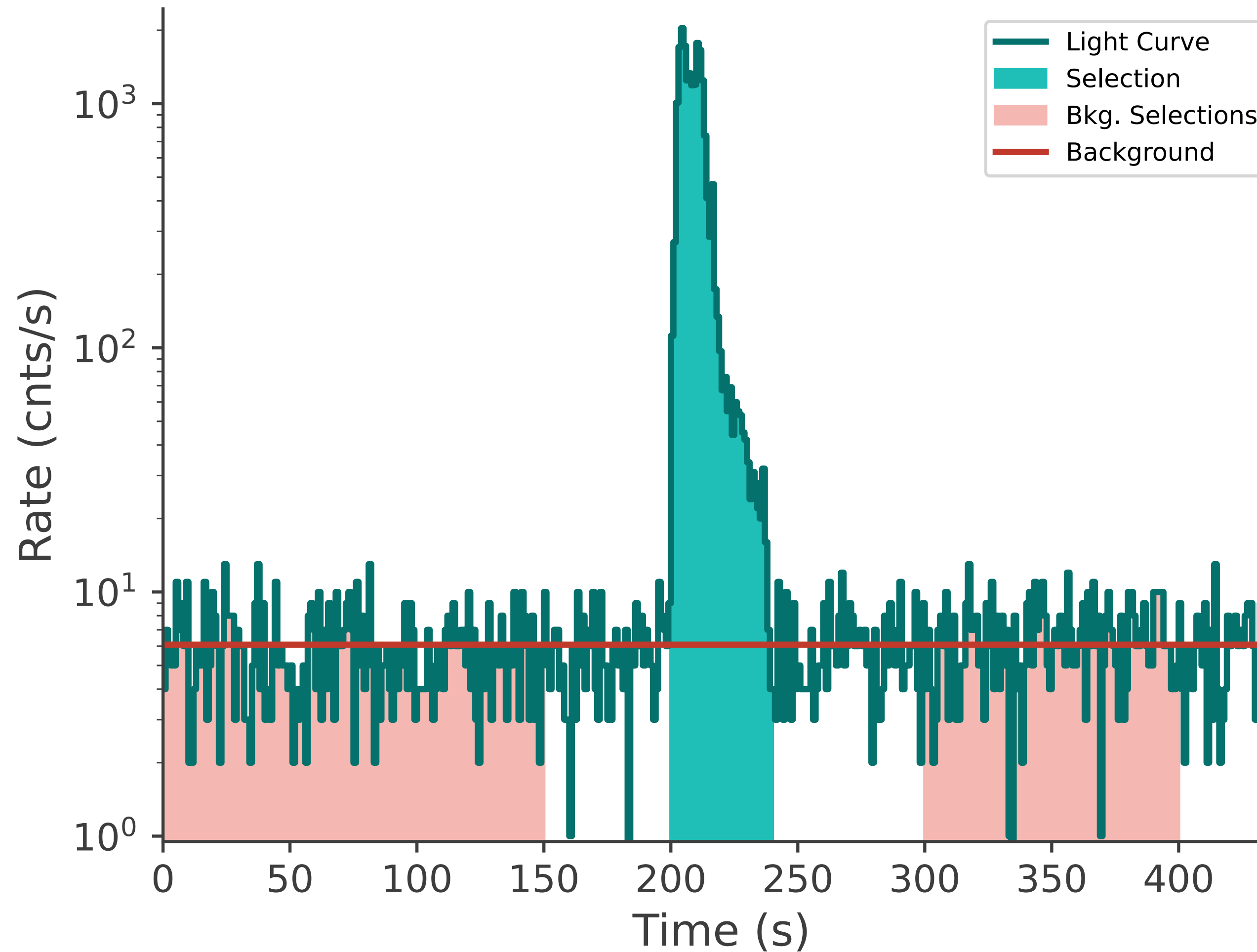


DC2 simulated GRB:  
GRB090206620

Can select active time  
interval

# Time series builder

```
tsb_cosi = TimeSeriesBuilder(
    name = 'COSI_GRB090206620',
    yml_file="inputs/cosi_dataset.yml",
    response_file="response_file",
    ori_file = (optional if response_file),
    l = (optional if response_file),
    b = (optional if response_file),
    poly_order=0 (optional),
    verbose=True
)
```

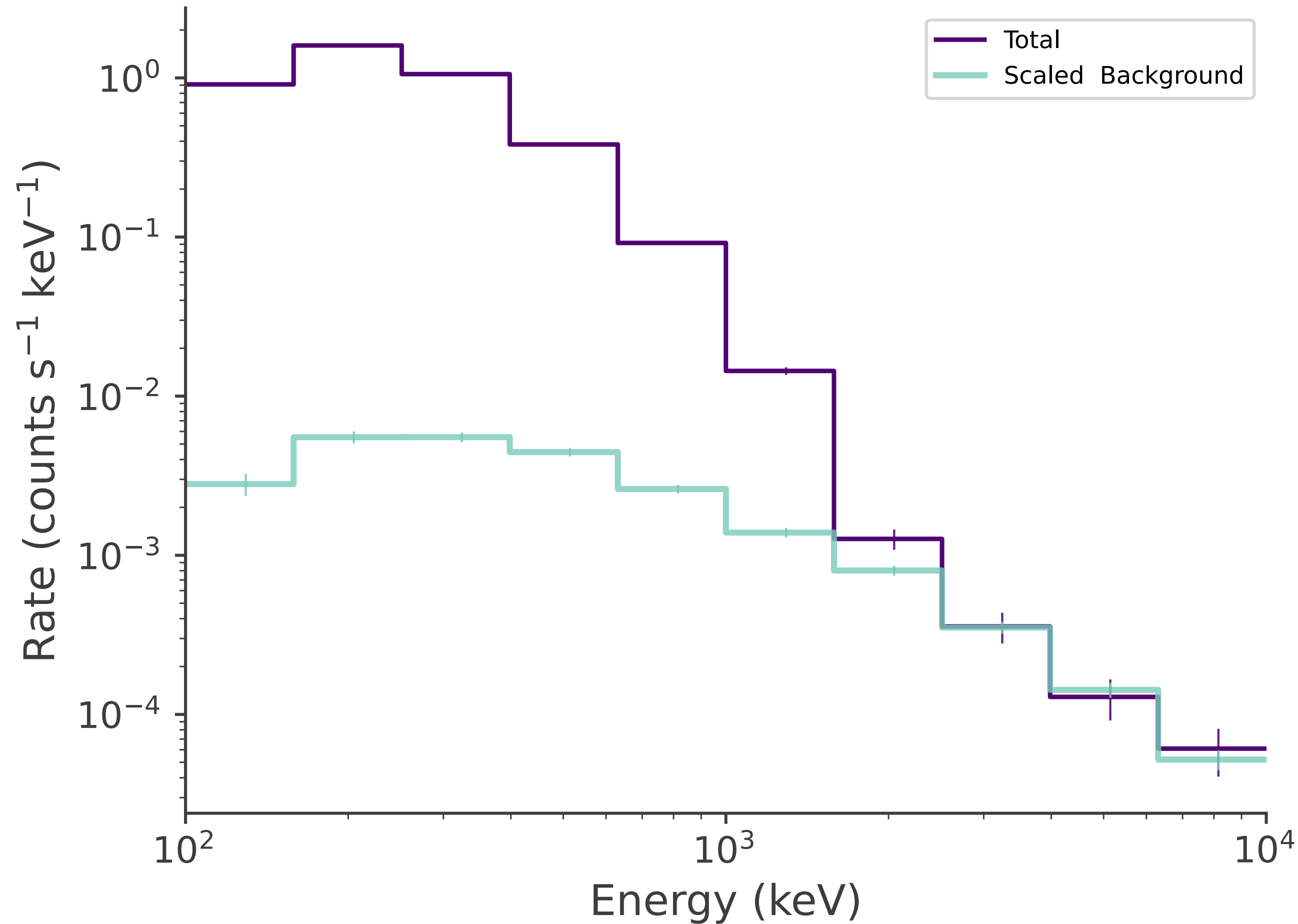


DC2 simulated GRB:  
GRB090206620

Bkg time interval to  
estimate bkg rate during  
the event

# Time series builder

```
tsb_cosi = TimeSeries  
name = 'COSI_G  
yaml_file="inputs  
cosi_dataset= (.hc  
response_file= res  
ori_file = (optiona  
l = (optional if res  
b= (optional if res  
poly_order=0 (op  
verbose=True
```



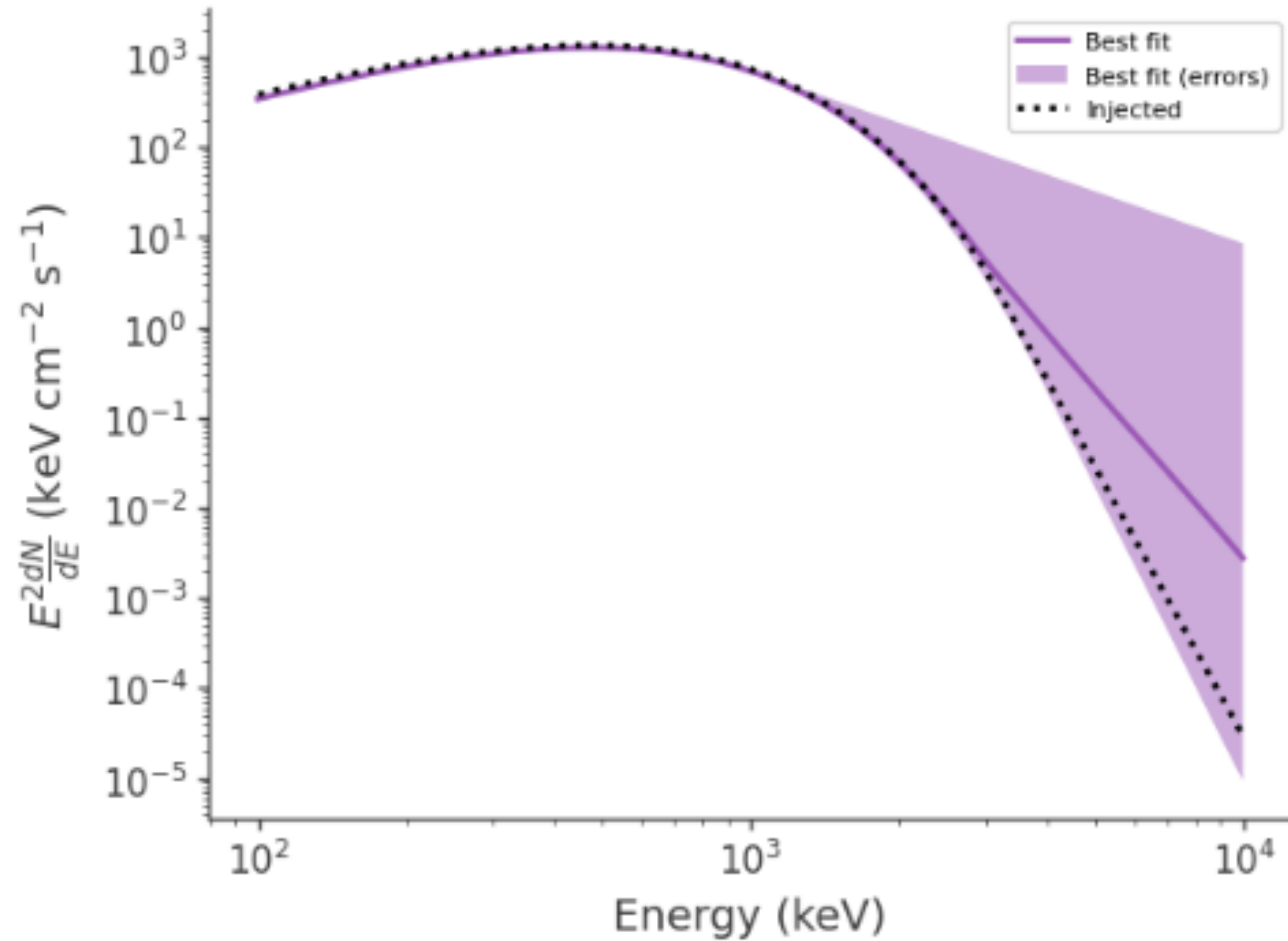
DC2 simulated GRB:  
GRB090206620

See what the spectrum  
looks like

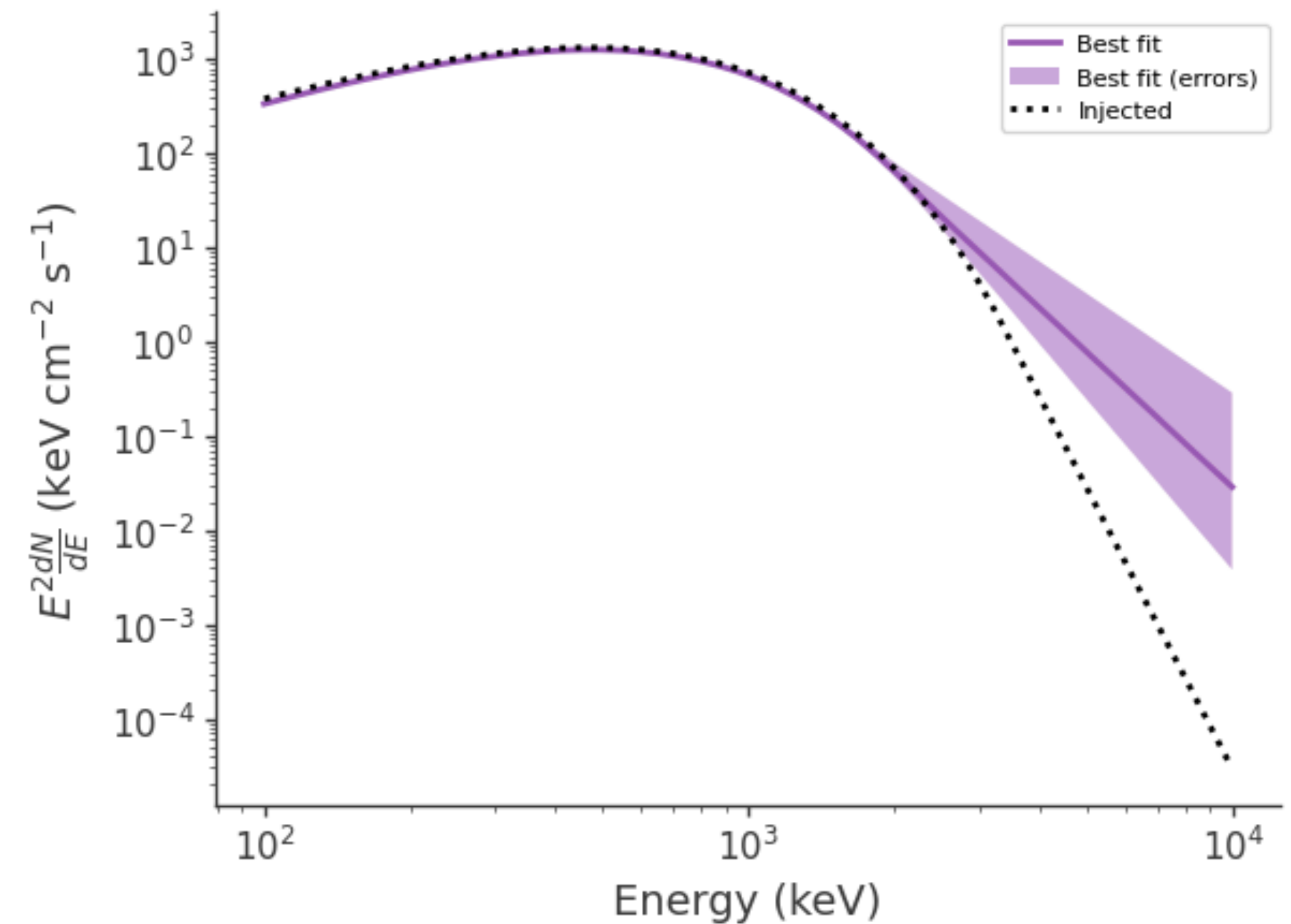
Create plugin for the fit



# GRB090206620

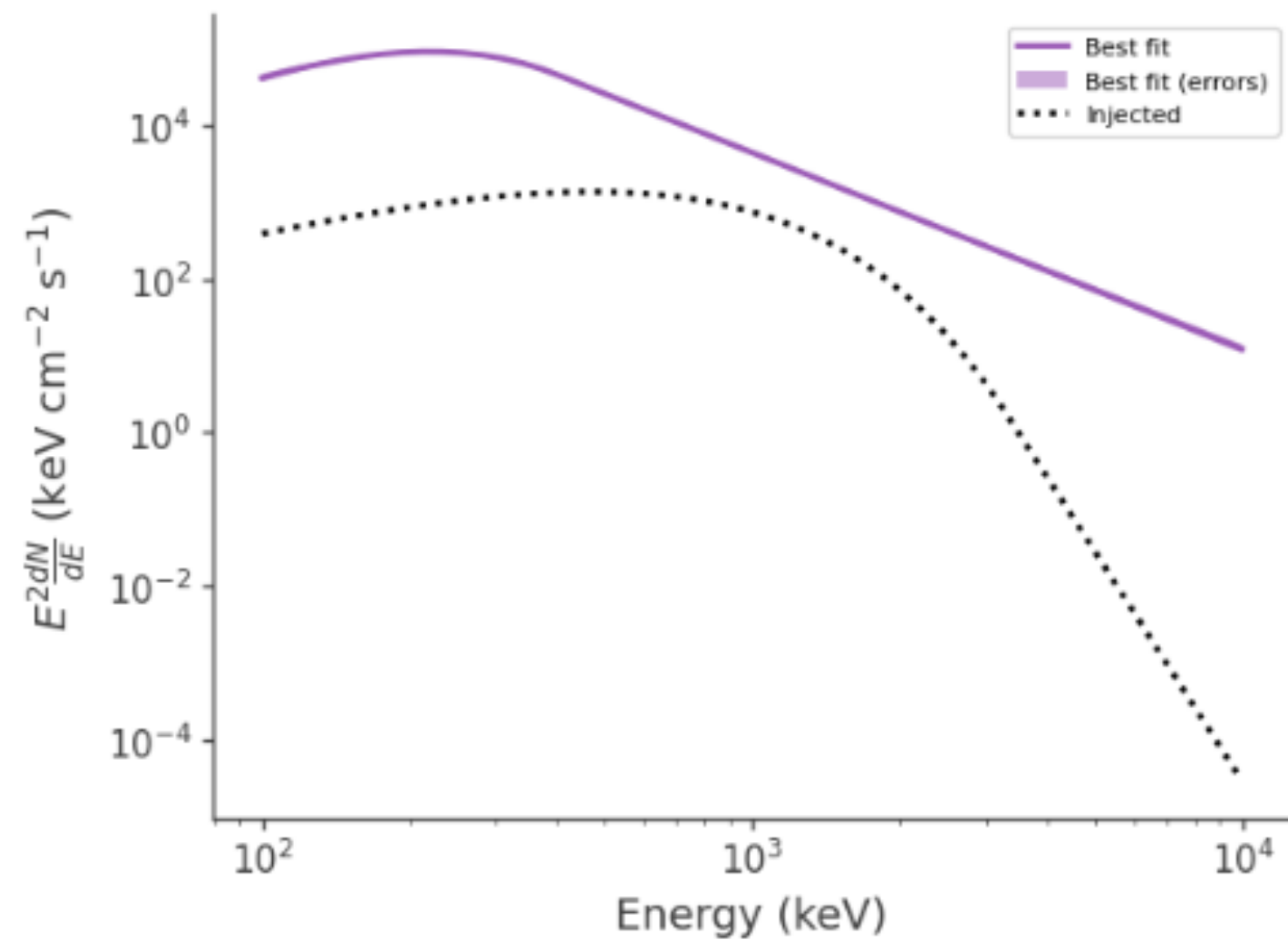


Fit using time series builder

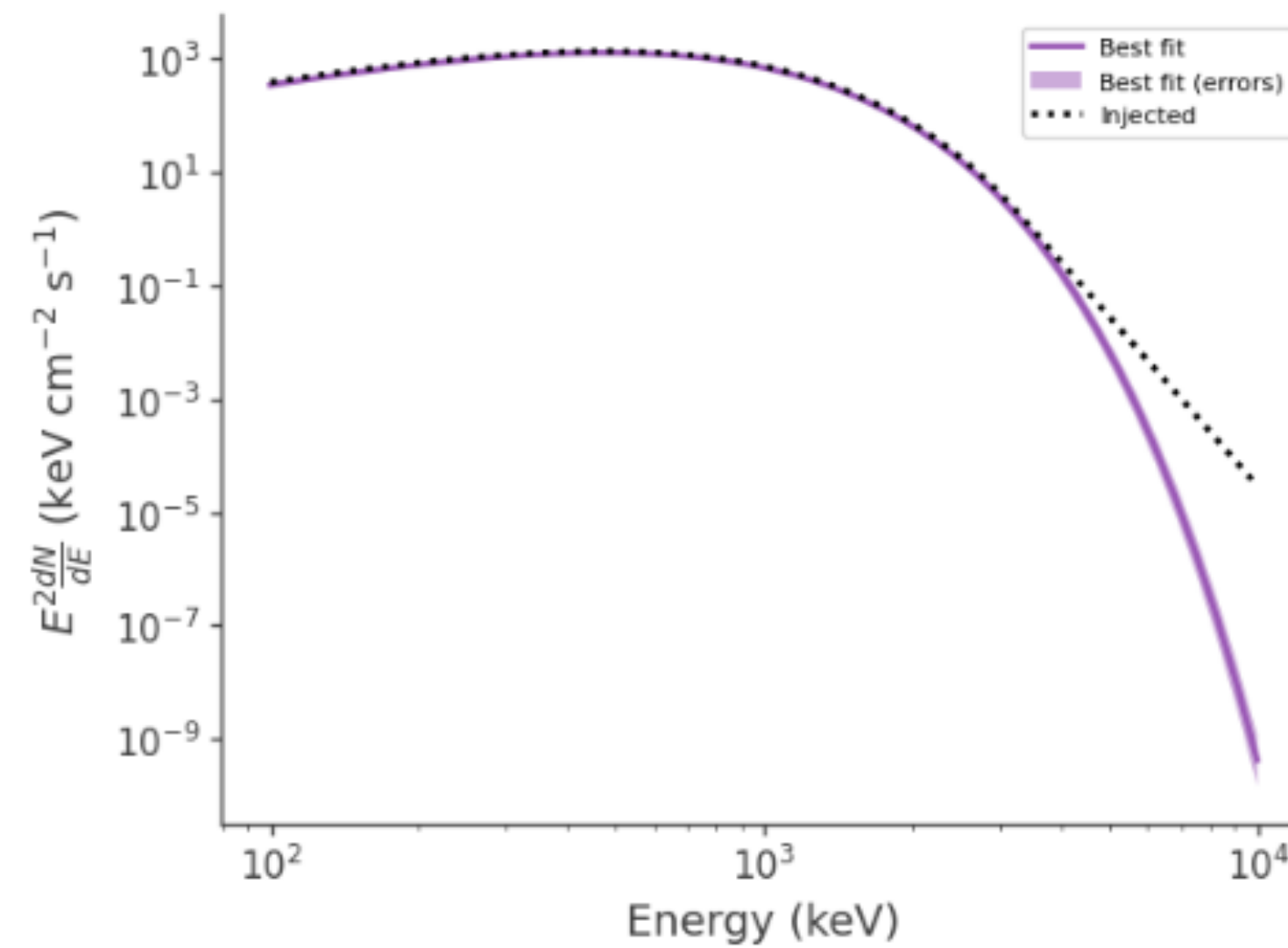


DC2 spectral\_fit\_GRB notebook

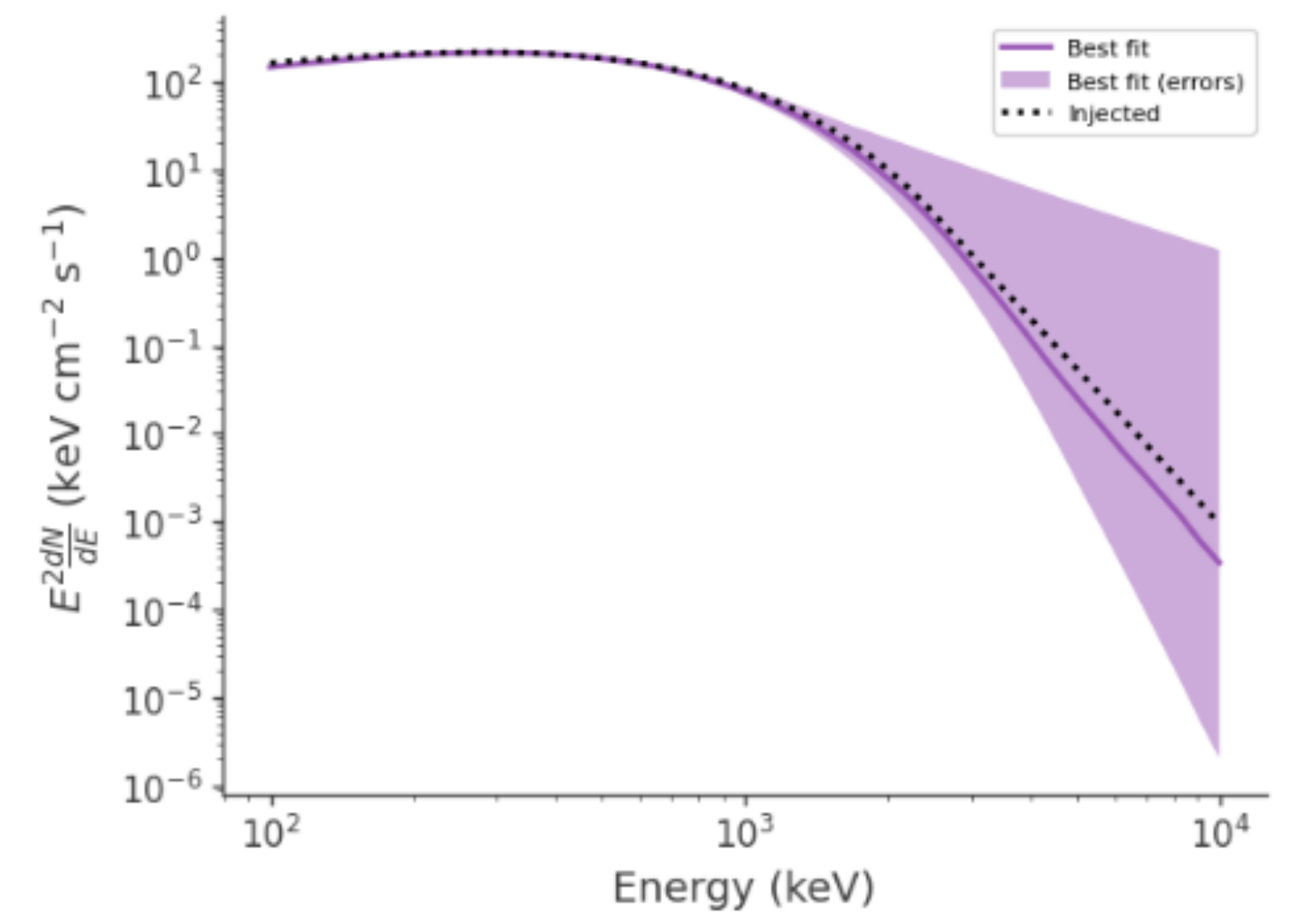
Uses COSIlike: a COSI 3ML  
plugin



Applying incorrect response



Incorrect model (broken power-law)



Different source:  
GRB130425327

# Next steps for TSB

- Make it fits file compatible
- Take full CDS into account (right now only time and energy so allows for simple ON/OFF analysis)

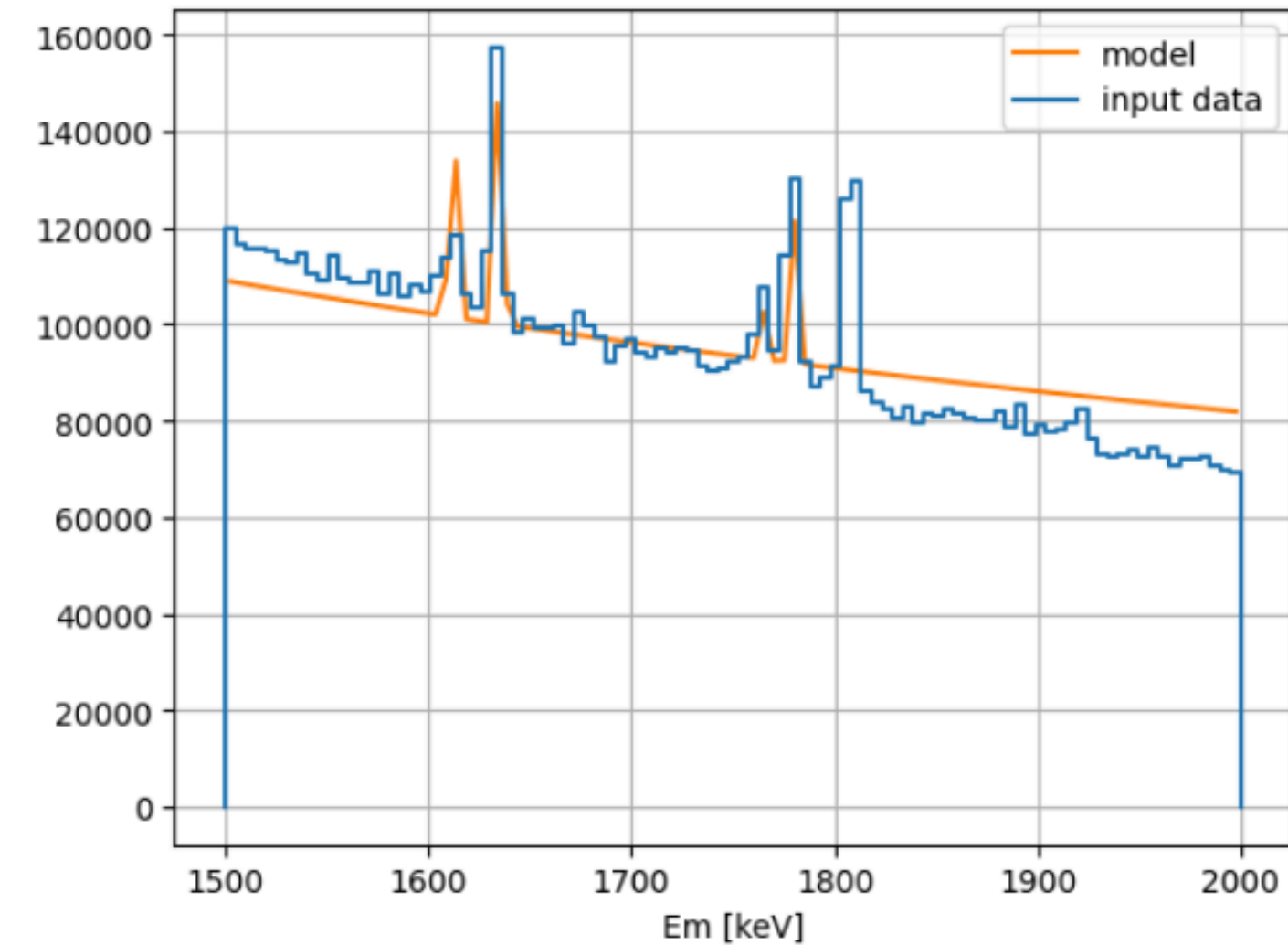


# **3- COSI line background estimation**

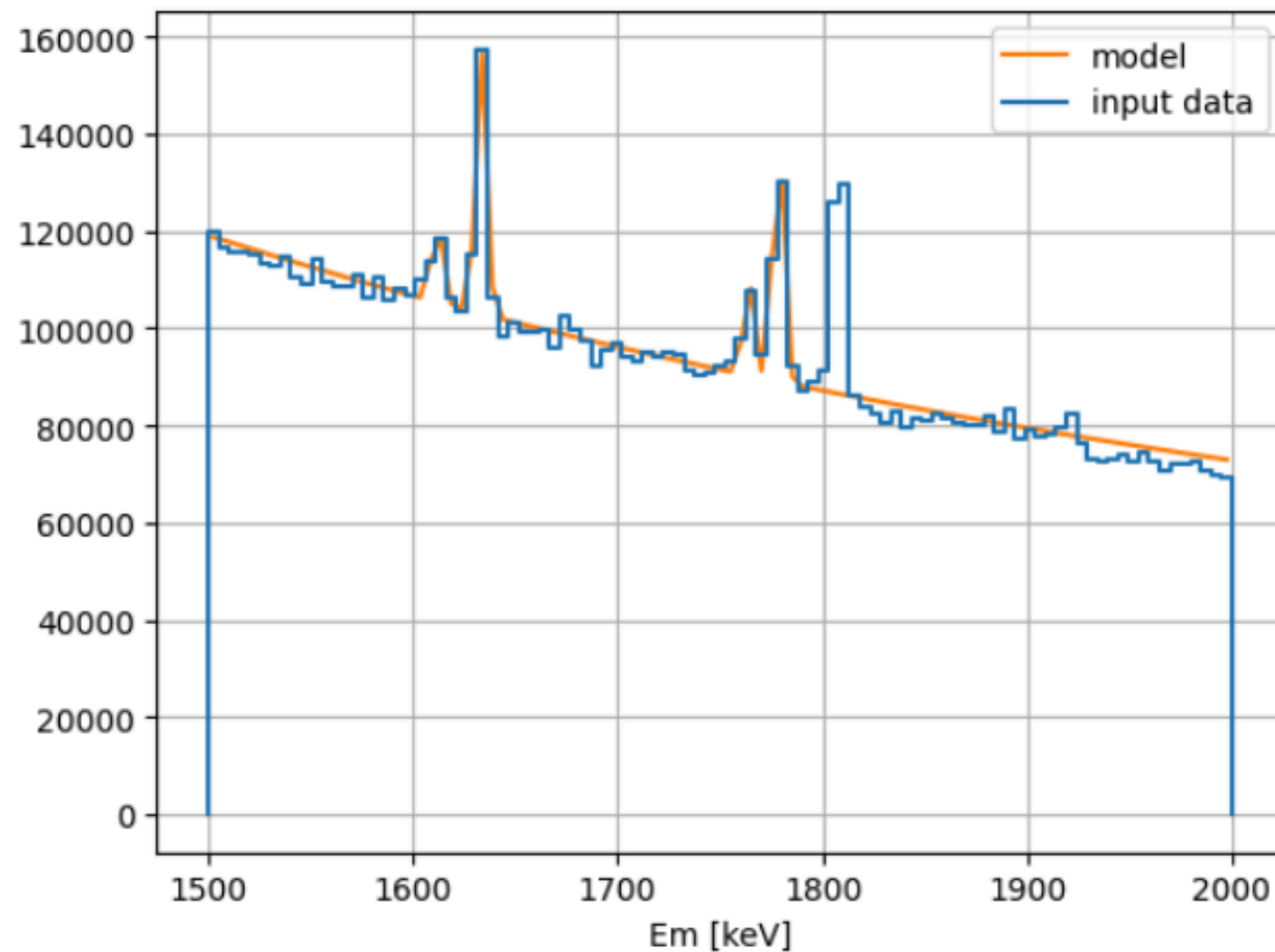
# Background modeling from adjacent energy bins

```
instance.set_bkg_energy_spectrum_model(bkg_model, [18000.0, -1.0, 40000.0, 1612, 50000.0, 1635, 10000.0, 1765, 30000.0, 1780, 1.0])  
instance.plot_energy_spectrum()
```

(<Axes: xlabel='Em [keV]'->, <ErrorbarContainer object of 3 artists>)

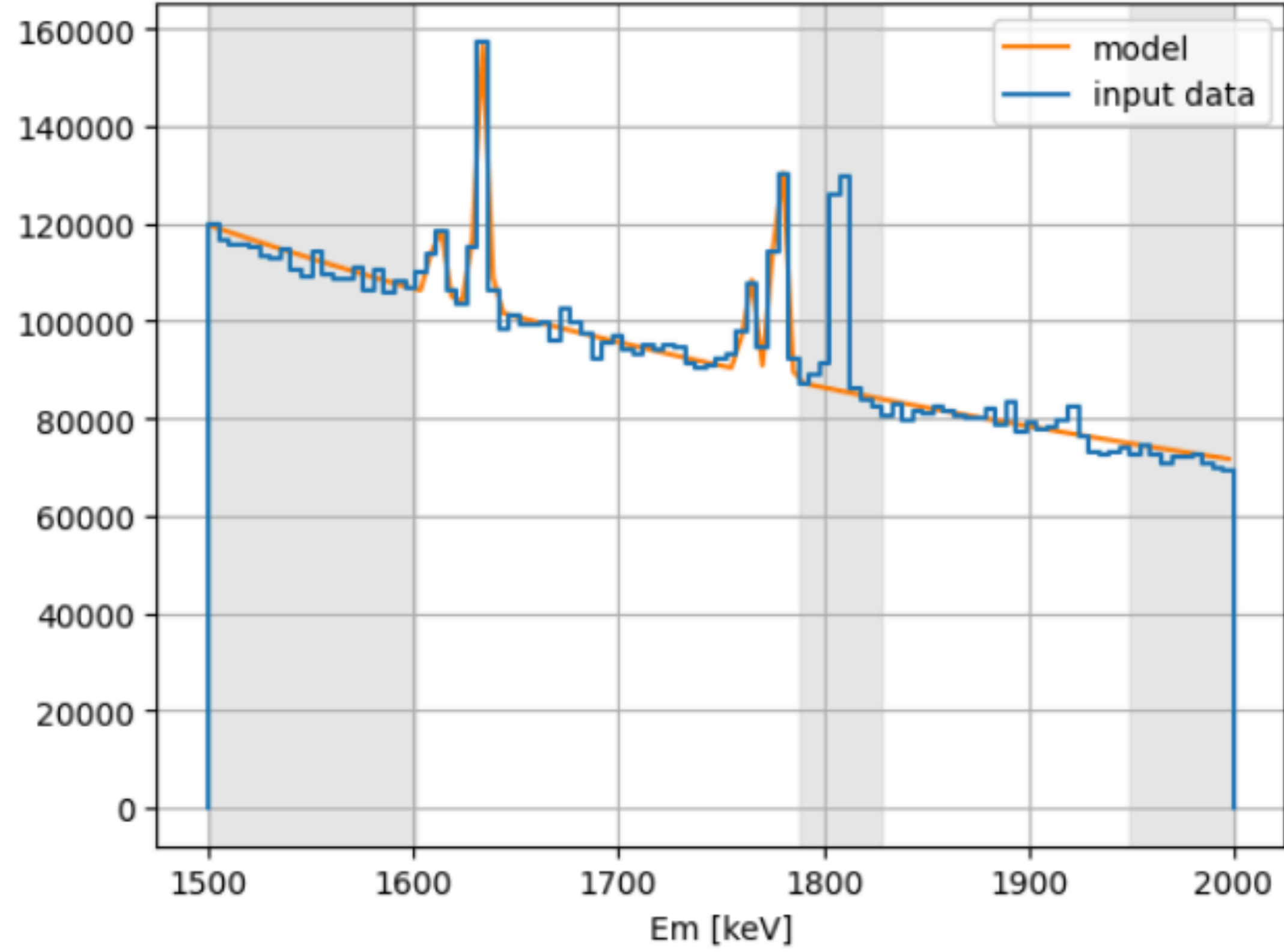


Bkg model: power law +  
4 gaussian

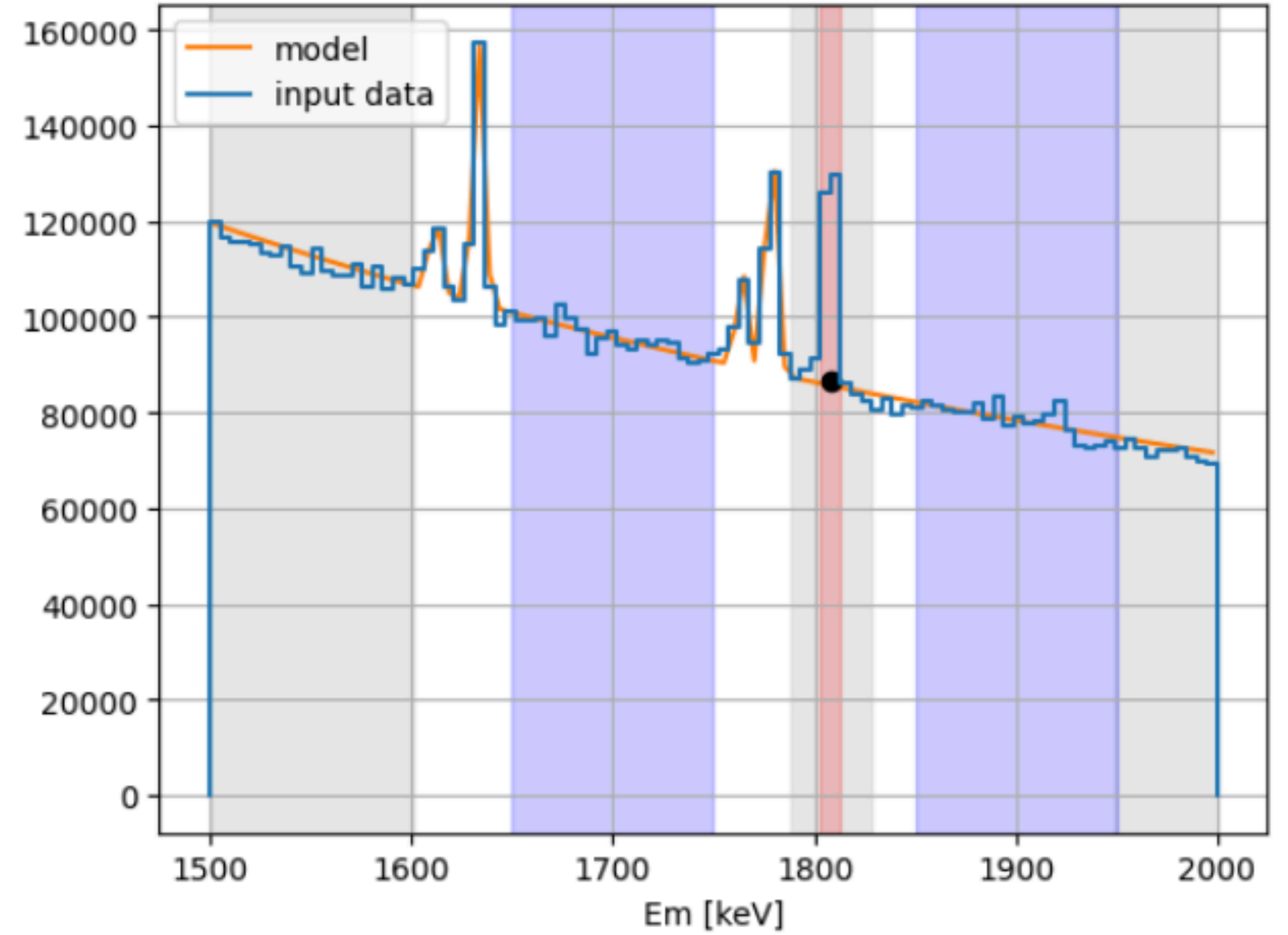


Fitted background

- LineBackgroundEstimation class
- Requires a full dataset (background + signal)
- User can define a background model and fit it to the dataset



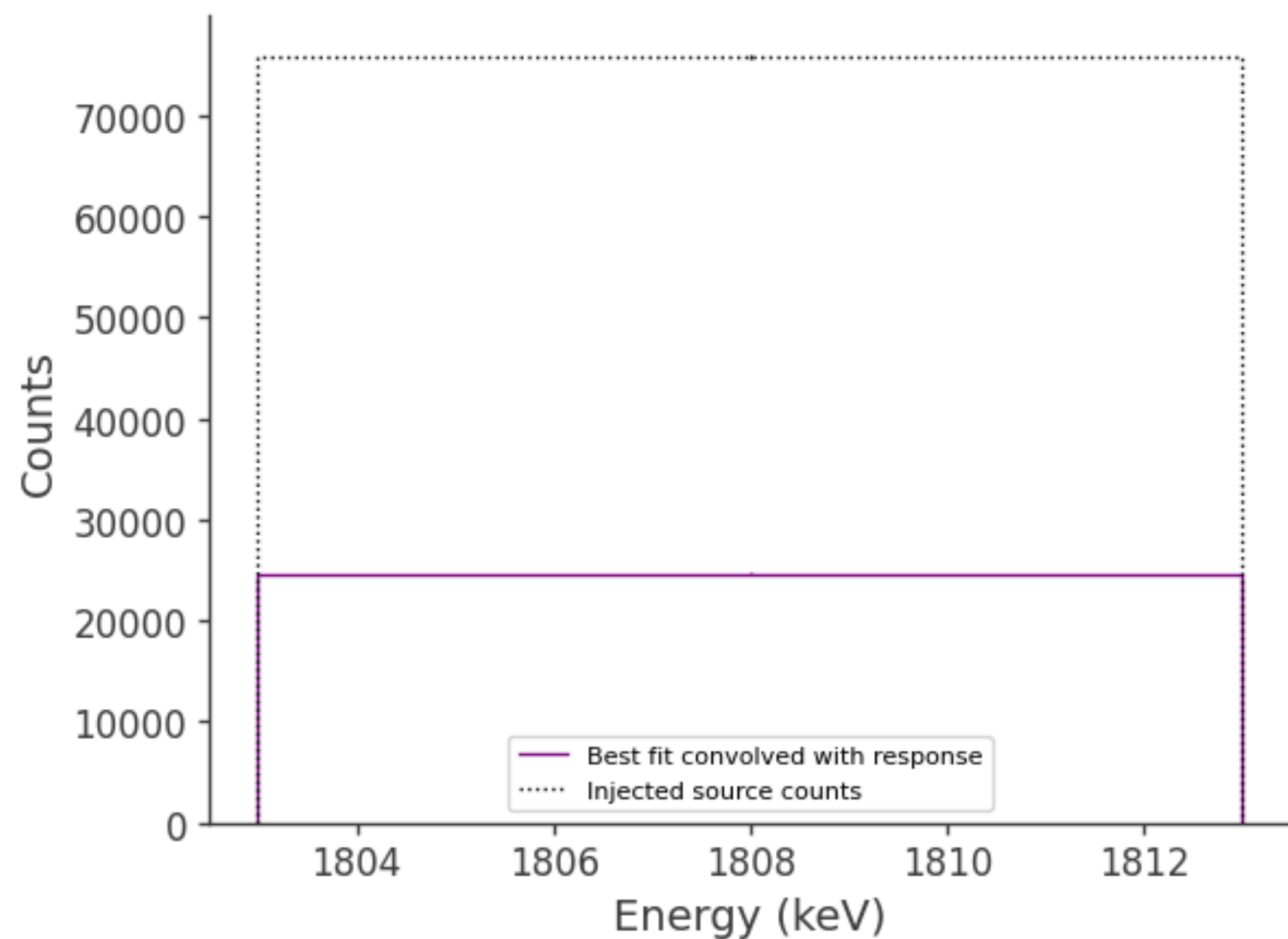
Mask regions (shown in grey) to exclude from the fit



Generate bkg model histogram for the source region (shown in red) based on fitted model and provided bkg energy range (shown in blue)

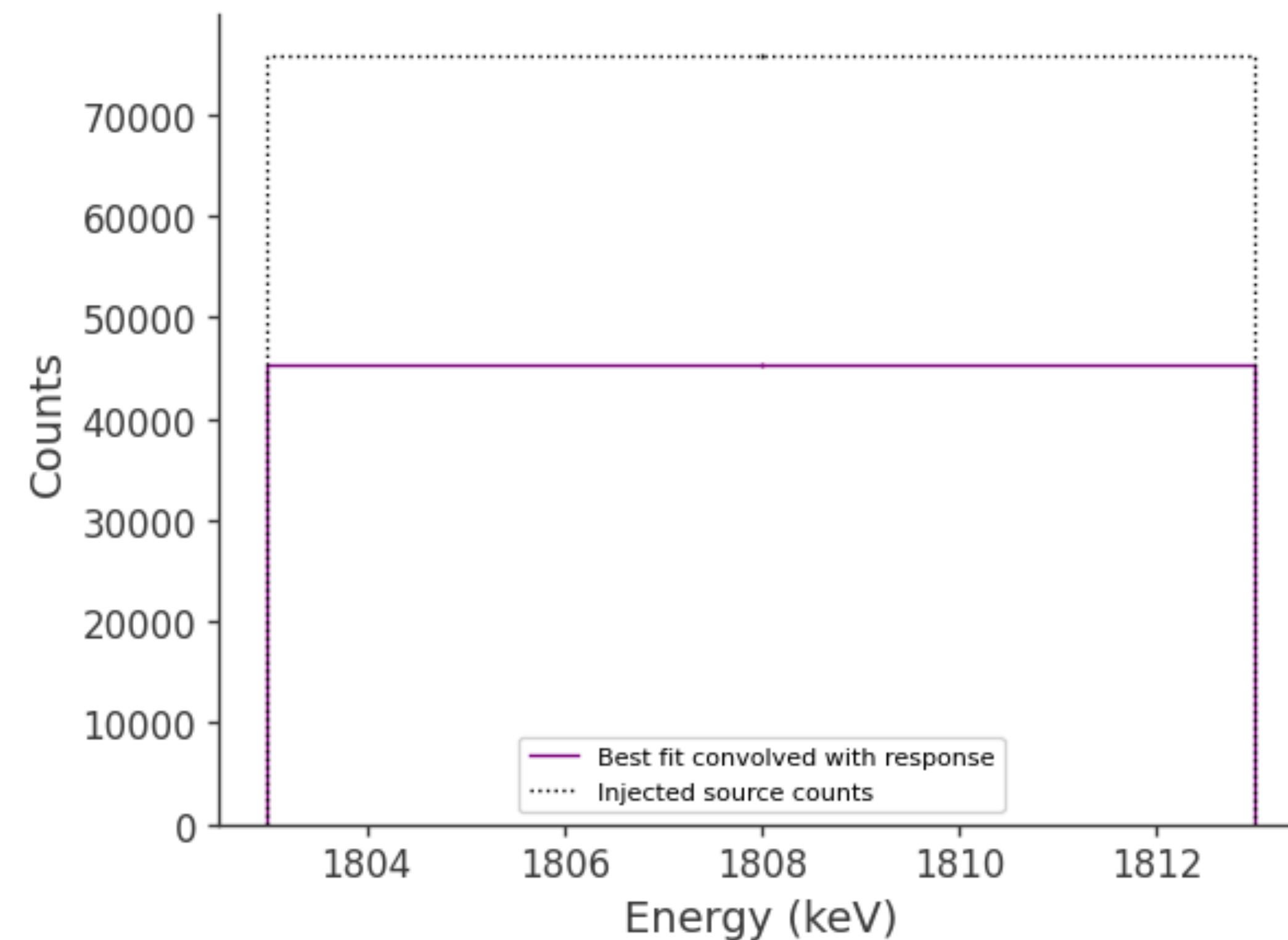


# DC2 extended source fit notebook



Bkg param free

Bkg over predicted by around a factor of 3



Bkg param forced to  
a smaller value

**Thank you!**