ctools - Action #2721

Check stacked ctools analysis for H.E.S.S. DR1

11/07/2018 10:11 AM - Knödlseder Jürgen

Status:	Closed	**Start date:**	11/07/2018
Priority:	Normal	**Due date:**	
Assigned To:	Knödlseder Jürgen	**% Done:**	100%
Category:		**Estimated time:**	0.00 hour
Target version:	1.6.0		

Description

The stacked analysis of H.E.S.S. DR1 may already work, but it needs to be checked.

History

#1 - 11/07/2018 11:48 AM - Knödlseder Jürgen

I started with fitting a point source using a power law to the stacked data. The spatial binning was 350 x 250 pixels of 0.02 degrees in size around the Crab. No energy dispersion was considered.

Below the fit results as a function of the number of energy bins for the energy range 0.67-30 TeV. CPU time is in seconds.

Bins	logL	TS	RA	DEC	Prefactor	Index	CPU
-	98199.437	2025.108	83.623 +/- 0.002	22.025 +/- 0.002	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
20	44664.118	1714.607	83.621 +/- 0.003	22.025 +/- 0.002	5.088e-17 +/- 3.361e-18	2.759 +/- 0.077	39.5
30	48945.657	1749.936	83.621 +/- 0.003	22.025 +/- 0.002	5.295e-17 +/- 3.388e-18	2.794 +/- 0.076	53.2
40	54063.827	1866.542	83.620 +/- 0.002	22.025 +/- 0.002	5.130e-17 +/- 3.055e-18	2.765 +/- 0.073	76.7
50	56043.857	1854.033	83.621 +/- 0.003	22.024 +/- 0.002	5.273e-17 +/- 3.137e-18	2.793 +/- 0.073	84.6

The index is about 0.05 steeper in the stacked analysis compared to the unbinned analysis, the prefactor is about 3e-17 larger.

The observed number of events is 8461, for 20 energy bins the predicted number is 8454.994, giving a difference of Nobs - Npred = 6.006. Running ctmodel on the result gave 11059.5 predicted events, and inspecting the residuals it appears that there are too much events at low energies. That's the way how I run ctmodel:

```
2018-11-07T10:41:01: +=============+
2018-11-07T10:41:01: | Parameters |
2018-11-07T10:41:01: +=============+
2018-11-07T10:41:01:  inobs .....................: obs_crab_selected_stacked20.xml
2018-11-07T10:41:01:  incube ....................: [not queried]
2018-11-07T10:41:01:  inmodel ...................: crab_results_ptsrc_plaw_gauss_grad_hess_stacked20.xml
```

Note that the counts cube was not specified since the data was read from the observation definition file. This may be the problem, since a counts cube is needed to correctly take the threshold weight into account.

#2 - 11/07/2018 12:09 PM - Knödlseder Jürgen

- File crab_stacked20_resspec.png added

- File crab_stacked20_resprof.png added

- File crab_stacked20_resmap.png added

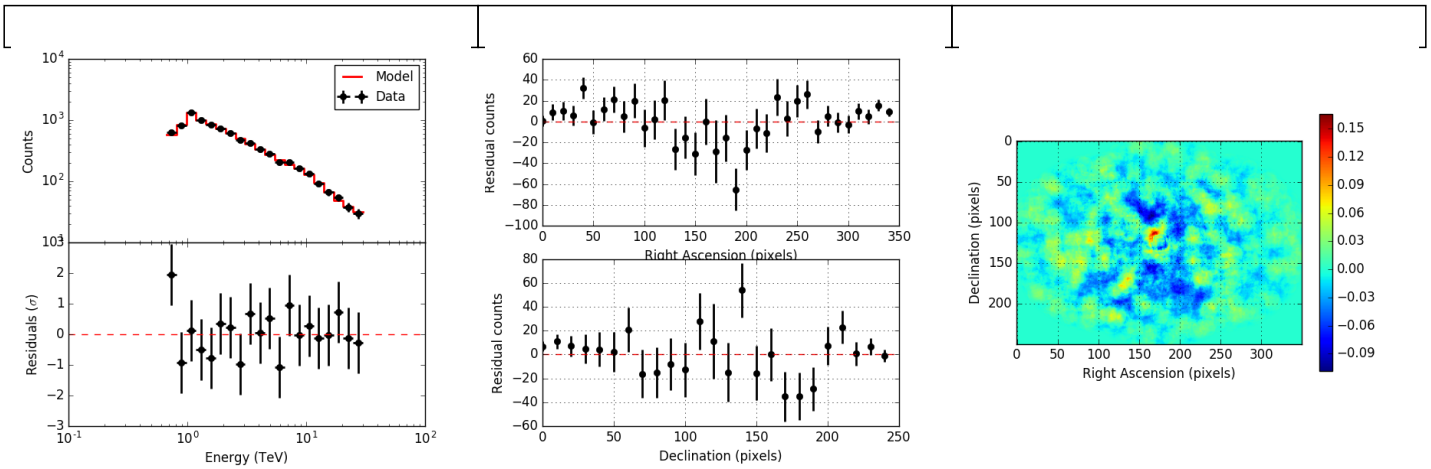
- % Done changed from 0 to 20

The issue with ctmodel was that a different computation of the model is needed for a stacked and an unbinned observation. For a stacked observation, the model value has to be weighted with the correct bin width, while for an unbinned observation this weighting needs not to be done since each observation will be evaluated using its proper IRF. I therefore implemented the following code change in ctmodel::fill_cube:

```
// Flag if the CTA observation is a counts cube
bool obs_is_cube = (obs->eventtype() == "CountsCube");
...
        // If observation is a counts cube then set the proper weight for
        // this bin
        if (obs_is_cube) {
            bin.weight(m_cube[ibin]->weight());
        }
```

This results in an expected number of counts of 8454.99, identical to the value obtained in the model fitting.

Below the residual spectrum, residual profiles in Right Ascension and Declination, and a residual map for 20 energy bins. Overall the residuals look now reasonable.



#3 - 11/07/2018 12:32 PM - Knödlseder Jürgen

- File crab_stacked20_resspec_iter1.png added

- File crab_stacked20_resprof_iter1.png added

- File crab_stacked20_resmap_iter1.png added

The background model used in ctbkgmodel was determined by fitting all observations, including the source regions. Consequently, in the ctlike fit the normalisation of the background model is reduced, as can be see in the log file, shown below for the 20 energy bins fit. In this case the background model was reduced by about 7%, the index is compatible with zero. However the shape of the background model, and the relative weighting between the backgrounds of the different observations, is preserved in a stacked analysis, introducing some bias.

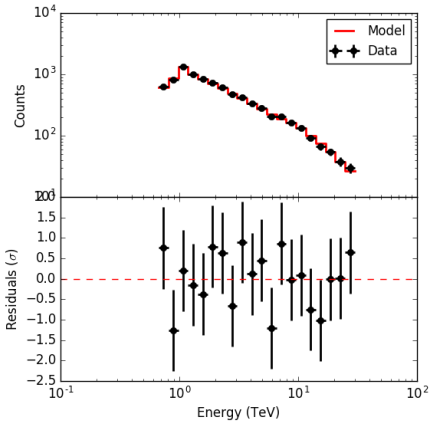
```
2018-11-07T10:30:09: === GCTAModelCubeBackground ===
2018-11-07T10:30:09:  Name .....: BackgroundModel
2018-11-07T10:30:09:  Instruments .....: CTA, HESS, MAGIC, VERITAS
2018-11-07T10:30:09:  Instrument scale factors ..: unity
2018-11-07T10:30:09:  Observation identifiers ...: all
2018-11-07T10:30:09:  Model type .....: "PowerLaw" * "Constant"
2018-11-07T10:30:09:  Number of parameters .....: 4
2018-11-07T10:30:09:  Number of spectral par's ..: 3
```

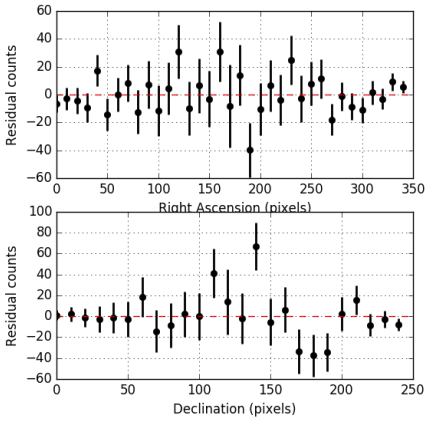
2018-11-07T10:30:09: Prefactor .....: 0.92688008398116 +/- 0.0138008183074852 [0.01,100] ph/cm2/s/MeV (free,scale=1,gradient)
2018-11-07T10:30:09: Index .....: 0.0113778958948462 +/- 0.0144446074027589 [-5,5] (free,scale=1,gradient)
2018-11-07T10:30:09: PivotEnergy .....: 1000000 MeV (fixed,scale=1000000,gradient)
2018-11-07T10:30:09: Number of temporal par's ..: 1
2018-11-07T10:30:09: Normalization .....: 1 (relative value) (fixed,scale=1,gradient)

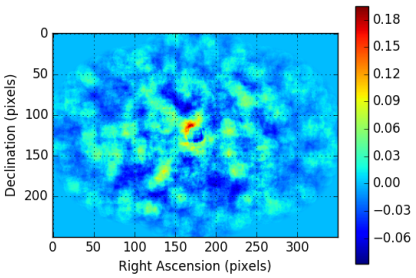
To understand the boas I therefore used the fit results of the unbinned analysis to generate an alternative background cube. Fitting this model to the data gives the following result. The background normalisation is now basically one. The Crab prefactor goes up by 0.15e-17, the spectral index is basically not affected. Hence the stacked analysis will somewhat underestimate the source fluxes, as expected.

2018-11-07T11:19:47: === GOptimizerLM ===
2018-11-07T11:19:47: Optimized function value ..: 44648.462
2018-11-07T11:19:47: Absolute precision .....: 0.005
2018-11-07T11:19:47: Acceptable value decrease .: 2
2018-11-07T11:19:47: Optimization status .....: converged
2018-11-07T11:19:47: Number of parameters .....: 10
2018-11-07T11:19:47: Number of free parameters .: 6
2018-11-07T11:19:47: Number of iterations .....: 3
2018-11-07T11:19:47: Lambda .....: 1e-06
2018-11-07T11:19:47: Maximum log likelihood ....: -44648.462
2018-11-07T11:19:47: Observed events (Nobs) ...: 8461.000
2018-11-07T11:19:47: Predicted events (Npred) ..: 8455.000 (Nobs - Npred = 5.99964775683293)
2018-11-07T11:19:47: === GModels ===
2018-11-07T11:19:47: Number of models .....: 2
2018-11-07T11:19:47: Number of parameters .....: 10
2018-11-07T11:19:47: === GModelSky ===
2018-11-07T11:19:47: Name .....: Crab
2018-11-07T11:19:47: Instruments .....: all
2018-11-07T11:19:47: Test Statistic .....: 1845.6796865592
2018-11-07T11:19:47: Instrument scale factors ..: unity
2018-11-07T11:19:47: Observation identifiers ...: all
2018-11-07T11:19:47: Model type .....: PointSource
2018-11-07T11:19:47: Model components .....: "PointSource" * "PowerLaw" * "Constant"
2018-11-07T11:19:47: Number of parameters .....: 6
2018-11-07T11:19:47: Number of spatial par's ...: 2
2018-11-07T11:19:47: RA .....: 83.6209669517135 +/- 0.00252919459519199 deg (free,scale=1)
2018-11-07T11:19:47: DEC .....: 22.0248642601462 +/- 0.00233953943144988 deg (free,scale=1)
2018-11-07T11:19:47: Number of spectral par's ..: 3
2018-11-07T11:19:47: Prefactor .....: 5.23287376743654e-17 +/- 3.38933067177766e-18 [1e-25,infty[ph/cm2/s/MeV
(free,scale=1e-17,gradient)
2018-11-07T11:19:47: Index .....: -2.75931417445264 +/- 0.0757563212467188 [10,-10] (free,scale=-2,gradient)
2018-11-07T11:19:47: PivotEnergy .....: 1000000 MeV (fixed,scale=1000000,gradient)
2018-11-07T11:19:47: Number of temporal par's ..: 1
2018-11-07T11:19:47: Normalization .....: 1 (relative value) (fixed,scale=1,gradient)
2018-11-07T11:19:47: === GCTAModelCubeBackground ===
2018-11-07T11:19:47: Name .....: BackgroundModel
2018-11-07T11:19:47: Instruments .....: CTA, HESS, MAGIC, VERITAS
2018-11-07T11:19:47: Instrument scale factors ..: unity
2018-11-07T11:19:47: Observation identifiers ...: all
2018-11-07T11:19:47: Model type .....: "PowerLaw" * "Constant"
2018-11-07T11:19:47: Number of parameters .....: 4
2018-11-07T11:19:47: Number of spectral par's ..: 3
2018-11-07T11:19:47: Prefactor .....: 0.999715699285799 +/- 0.0148947550844672 [0.01,100] ph/cm2/s/MeV (free,scale=1,gradient)
2018-11-07T11:19:47: Index .....: 0.00566705715270537 +/- 0.014450942963835 [-5,5] (free,scale=1,gradient)
2018-11-07T11:19:47: PivotEnergy .....: 1000000 MeV (fixed,scale=1000000,gradient)
2018-11-07T11:19:47: Number of temporal par's ..: 1
2018-11-07T11:19:47: Normalization .....: 1 (relative value) (fixed,scale=1,gradient)

Below the residuals for the corresponding analysis. They look a bit better than the residuals before, the impact is however not dramatic.


Model
Data
Counts
Residuals (σ)
Energy (TeV)


Residual counts
Right Ascension (pixels)
Residual counts
Declination (pixels)


Declination (pixels)
Right Ascension (pixels)

#4 - 11/07/2018 01:52 PM - Knödlseder Jürgen

- % Done changed from 20 to 30

I also checked the results obtained with a joint binned analysis. For this purpose I created for each observation a counts cube using the usepnt=yes option. Each cube had 250 x 250 spatial bins with a bin size of 0.02 deg. 20 energy bins were used. Below the results for unbinned, stacked and joint binned analysis.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98199.437	2025.108	83.623 +/- 0.002	22.025 +/- 0.002	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
Stacked	44664.118	1714.607	83.621 +/- 0.003	22.025 +/- 0.002	5.088e-17 +/- 3.361e-18	2.759 +/- 0.077	39.5
Binned	50908.047	1785.304	83.621 +/- 0.003	22.027 +/- 0.002	4.728e-17 +/- 3.006e-18	2.662 +/- 0.074	475.7

#5 - 11/07/2018 02:25 PM - Knödlseder Jürgen

Here a comparison for 50 energy bins.

Now results between unbinned and joint binned are very close. The prefactor differs by -1.7%, the index by -1%. Statistical errors on the prefactor and index are 5.7% and 2.6%, respectively.

Differences between unbinned and stacked are +7.8% in the prefactor and +3.4% in the index.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98199.437	2025.108	83.623 +/- 0.002	22.025 +/- 0.002	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
Stacked	56043.857	1854.033	83.621 +/- 0.003	22.024 +/- 0.002	5.273e-17 +/- 3.137e-18	2.793 +/- 0.073	84.6
Binned	63003.006	1938.315	83.621 +/- 0.003	22.027 +/- 0.002	4.811e-17 +/- 2.756e-18	2.675 +/- 0.069	771.6

#6 - 11/08/2018 10:09 AM - Knödlseder Jürgen

I varied some parameters of the response cube computation to see whether they impact the fit results.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98199.437	2025.108	83.623 +/- 0.002	22.025 +/- 0.002	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7

Stacked	44664.118	1714.607	83.621 +/- 0.003	22.025 +/- 0.002	5.088e-17 +/- 3.361e-18	2.759 +/- 0.077	39.5
amax=1.0	44663.161	1716.523	83.621 +/- 0.003	22.024 +/- 0.003	5.082e-17 +/- 3.350e-18	2.760 +/- 0.077	21.4
amax=1.0, abins=1000	44663.174	1716.497	83.621 +/- 0.003	22.024 +/- 0.003	5.085e-17 +/- 3.354e-18	2.760 +/- 0.077	25.3
psf=cnt(1)	44664.104	1714.636	83.621 +/- 0.003	22.025 +/- 0.002	5.088e-17 +/- 3.361e-18	2.759 +/- 0.077	28.2
psf ebins=100	44663.967	1714.910	83.621 +/- 0.003	22.025 +/- 0.002	5.095e-17 +/- 3.364e-18	2.760 +/- 0.077	15.9
exp ebins=30	44662.694	1717.457	83.621 +/- 0.003	22.025 +/- 0.002	5.210e-17 +/- 3.436e-18	2.778 +/- 0.077	19.4
exp ebins=40	44662.283	1718.278	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	23.0
exp ebins=50	44661.381	1720.082	83.621 +/- 0.003	22.025 +/- 0.002	4.904e-17 +/- 3.214e-18	2.727 +/- 0.077	20.0
exp ebins=60	44661.005	1720.835	83.621 +/- 0.003	22.025 +/- 0.002	5.036e-17 +/- 3.305e-18	2.749 +/- 0.077	20.1
exp ebins=70	44663.801	1715.242	83.621 +/- 0.003	22.025 +/- 0.002	4.807e-17 +/- 3.160e-18	2.711 +/- 0.077	24.2
exp ebins=80	44662.283	1718.278	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	24.1
exp ebins=90	44661.365	1720.115	83.621 +/- 0.003	22.025 +/- 0.002	4.907e-17 +/- 3.217e-18	2.728 +/- 0.077	19.7
exp ebins=100	44662.283	1718.278	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	23.3
exp ebins=110	44662.284	1718.277	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	24.1
exp ebins=120	44662.283	1718.278	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	24.7
exp ebins=130	44662.283	1718.279	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	23.9
exp full=300(2)	44662.283	1718.278	83.621 +/- 0.003	22.025 +/- 0.002	4.775e-17 +/- 3.128e-18	2.705 +/- 0.076	23.5

(1) psf=cnt means that the counts cube definition was used to define the PSF cube
(2) exposure cube computed over full 100 GeV - 100 TeV energy range with 300 energy bins

It turns out that the precise number of energy bins used for the exposure cube computation has an impact on the results, and with a finer energy binning the stacked analysis results get close to the unbinned analysis result. The H.E.S.S. effective area is provided for 96 bins within 100 GeV and 100 TeV, meaning that there are 24 bins per decade. The 0.67-30 TeV range used in this analysis is 1.7 decades, covering about 40 energy bins of the effective area IRF. Sampling the exposure cube with 40 bins provides indeed a result that is very close to the unbinned analysis, however increasing the number of energy bins worsens the result. Only from 100 energy bins on the result seems to converge towards a value close to the unbinned analysis result, meaning that at about a factor of 3 oversampling of the IRF is appropriate for the stacked analysis.

Since for energy dispersion a wider energy range is needed in the exposure cube, I also tried computing 300 energy bins over the full 100 GeV - 100 TeV energy range, which corresponds to about a factor of 3 oversampling in true energy. Also this works nicely, as the table shows.

#7 - 11/08/2018 10:37 AM - Knödlseder Jürgen

I now changed the Crab analysis script, computing the exposure cube, the PSF cube and the energy dispersion cube for the full energy range of 100 GeV - 100 TeV with 300 energy bins. Below the result comparison for unbinned, stacked and binned analysis. The binned analysis was redone using the new ctbin tool that now also produces multiple counts cubes. As before, 20 energy bins were used for the counts cube(s). Results are now reasonably close.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98199.437	2025.108	83.623 +/- 0.002	22.025 +/- 0.002	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
Stacked	44662.282	1718.280	83.621 +/- 0.003	22.025 +/- 0.002	4.778e-17 +/- 3.130e-18	2.706 +/- 0.076	38.7
Binned	50908.055	1785.288	83.621 +/- 0.003	22.027 +/- 0.002	4.729e-17 +/- 3.007e-18	2.663 +/- 0.074	306.0

#8 - 11/08/2018 11:46 AM - Knödlseder Jürgen

Here now the same results for energy dispersion enabled.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98196.591	2030.800	83.622 +/- 0.003	22.024 +/- 0.002	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
Stacked	44683.345	1676.155	83.620 +/- 0.003	22.025 +/- 0.003	5.859e-17 +/- 3.557e-18	3.587 +/- 0.126	3570.4
Binned	50905.009	1791.382	83.620 +/- 0.003	22.026 +/- 0.003	4.130e-17 +/- 2.271e-18	2.721 +/- 0.078	5698

The stacked results look really bad. Something is going wrong with the energy dispersion there.

#9 - 11/08/2018 02:43 PM - Knödlseder Jürgen

- Status changed from New to In Progress

- % Done changed from 30 to 40

I inspected the GCTAEdispCube::operator() interface and revised it according to the GCTAEdisp::operator() interface. Now the GCTAEdispCube::operator() takes the reconstructed and true energy in form of GEnergy objects, followed by the true sky direction.

I also corrected the GCTAEdispCube::set() method which performed some incorrect exposure weighting. This has been fixed. I added unit tests to make sure that the energy dispersion cube when integrated over reconstructed energy for a given set of true energies is unity. The tests are performed for the GCTAEdispCube::set() and GCTAEdispCube::fill() methods, hence we can be sure that the methods actually work.

#10 - 11/08/2018 03:22 PM - Knödlseder Jürgen

I now investigated different parameters for the ctedispcube tool.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98196.591	2030.800	83.622 +/- 0.003	22.024 +/- 0.002	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
max=2.0, bins=100	44683.345	1676.155	83.620 +/- 0.003	22.025 +/- 0.003	5.859e-17 +/- 3.557e-18	3.587 +/- 0.126	3570.4
max=5.0, bins=300	44659.671	1723.503	83.620 +/- 0.003	22.024 +/- 0.003	5.596e-17 +/- 3.620e-18	2.999 +/- 0.094	3177.9
max=5.0, bins=500	44659.491	1723.862	83.620 +/- 0.003	22.025 +/- 0.005	5.633e-17 +/- 3.650e-18	3.007 +/- 0.094	3287.1

Increasing the number of energy bins does not resolve the issue.

#11 - 11/09/2018 09:12 AM - Knödlseder Jürgen

I checked whether the cutting of response values where the true energy falls outside the valid reconstructed energy interval has an impact on the analysis results. Below the results. All runs were done using max=5.0 and bins=300.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98196.591	2030.800	83.622 +/- 0.003	22.024 +/- 0.002	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
Cutting	44659.671	1723.503	83.620 +/- 0.003	22.024 +/- 0.003	5.596e-17 +/- 3.620e-18	2.999 +/- 0.094	3177.9
No cut of Edisp	44659.806	1723.233	83.620 +/- 0.003	22.025 +/- 0.003	5.498e-17 +/- 3.535e-18	2.984 +/- 0.093	3732.4
No cut of Aeff and Edisp	44657.592	1727.660	83.621 +/- 0.003	22.024 +/- 0.003	3.854e-17 +/- 2.167e-18	2.689 +/- 0.080	2245.3
No cut of Aeff, PSF and Edisp	44656.980	1728.884	83.621 +/- 0.003	22.024 +/- 0.003	3.891e-17 +/- 2.184e-18	2.698 +/- 0.080	882.0

#12 - 11/09/2018 04:23 PM - Knödlseder Jürgen

It seems best to disable the true energy cut in all response cube computation tools. Here again the summary for unbinned, stacked and binned analysis using energy dispersion.

Method	logL	TS	RA	DEC	Prefactor	Index	CPU
Unbinned	98196.591	2030.800	83.622 +/- 0.003	22.024 +/- 0.002	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
Stacked	44656.980	1728.884	83.621 +/- 0.003	22.024 +/- 0.003	3.891e-17 +/- 2.184e-18	2.698 +/- 0.080	882.0
Binned	50905.009	1791.382	83.620 +/- 0.003	22.026 +/- 0.003	4.130e-17 +/- 2.271e-18	2.721 +/- 0.078	5698

#13 - 11/09/2018 04:59 PM - Knödlseder Jürgen

- File image.png added

- File screenshot_2_1541779166_image.png added

I now also redid the analysis with the new stacked response cubes without cuts. For some reason the results differs from the former result :-(Not clear what happened.

Edisp	logL	TS	RA	DEC	Prefactor	Index	CPU
No (former result)	44662.282	1718.280	83.621 +/- 0.003	22.025 +/- 0.002	4.778e-17 +/- 3.130e-18	2.706 +/- 0.076	38.7
No	44658.674	1725.497	83.621 +/- 0.003	22.025 +/- 0.002	4.555e-17 +/- 2.946e-18	2.662 +/- 0.075	44.2
Yes	44656.985	1728.874	83.621 +/- 0.003	22.024 +/- 0.003	3.890e-17 +/- 2.183e-18	2.697 +/- 0.080	1746.3

I therefore progressively put back the true energy cuts to check what's going on. Without energy dispersion, cutting in true energy should be more realistic since it avoids spill-over in energy.

Cutting	logL	TS	RA	DEC	Prefactor	Index	CPU
No	44658.674	1725.497	83.621 +/- 0.003	22.025 +/- 0.002	4.555e-17 +/- 2.946e-18	2.662 +/- 0.075	44.2
Aeff cut	44662.270	1718.304	83.621 +/- 0.003	22.025 +/- 0.002	4.793e-17 +/- 3.136e-18	2.708 +/- 0.076	39.1
PSF cut	44658.753	1725.339	83.621 +/- 0.003	22.025 +/- 0.002	4.544e-17 +/- 2.942e-18	2.660 +/- 0.075	39.2
Aeff & PSF cut	44662.066	1718.713	83.621 +/- 0.003	22.025 +/- 0.002	4.785e-17 +/- 3.132e-18	2.707 +/- 0.076	39.9
Aeff & PSF cut (former result)	44662.282	1718.280	83.621 +/- 0.003	22.025 +/- 0.002	4.778e-17 +/- 3.130e-18	2.706 +/- 0.076	38.7

The impact of the PSF cut is negligible, which is understandable since the exact weight of the PSF between the various observations should not be relevant. The important cut is the Aeff cut. Cutting on both gives similar results to the Aeff cut alone, which is expected since the PSF cut is negligible.

Still, we don't get exactly the same results are before, which may be due a different energy binning used for the PSF.

So to summarise:

- spill-over leads to a bias in the prefactor of -4.8% and in the index of -1.7% without energy dispersion
- spill-over leads to a bias in the prefactor of -6.2% and in the index of -1.3% with energy dispersion (reference = unbinned)

#14 - 11/09/2018 05:45 PM - Knödlseder Jürgen

- File deleted (screenshot_2_1541779166_image.png)

#15 - 11/09/2018 05:46 PM - Knödlseder Jürgen

- File deleted (image.png)

#16 - 11/09/2018 05:50 PM - Knödlseder Jürgen

I now also explored different number of reconstructed energy bins, since at the very beginning of this thread this also led to different spectral results. For comparison I also repeat the unbinned results.

Bins	Edisp	Clipping	logL	TS	Prefactor	Index	CPU
-	No	-	98199.437	2025.108	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
20	No	No	44658.674	1725.497	4.555e-17 +/- 2.946e-18	2.662 +/- 0.075	44.2
40	No	No	54061.014	1872.168	4.650e-17 +/- 2.731e-18	2.675 +/- 0.071	86.8
60	No	No	57605.204	1880.635	4.753e-17 +/- 2.764e-18	2.696 +/- 0.071	136.8

Bins	Edisp	Clipping	logL	TS	Prefactor	Index	CPU
-	No	-	98199.437	2025.108	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
20	No	Yes	44662.066	1718.713	4.785e-17 +/- 3.132e-18	2.707 +/- 0.076	39.9
40	No	Yes	54063.421	1867.353	5.251e-17 +/- 3.132e-18	2.785 +/- 0.073	83.8
60	No	Yes	57613.687	1863.669	5.348e-17 +/- 3.174e-18	2.806 +/- 0.073	151.3

Bins	Edisp	Clipping	logL	TS	Prefactor	Index	CPU
-	Yes	-	98196.591	2030.800	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
20	Yes	No	44656.985	1728.874	3.890e-17 +/- 2.183e-18	2.697 +/- 0.080	1746.3
40	Yes	No	54059.809	1874.578	3.932e-17 +/- 2.032e-18	2.670 +/- 0.076	3278.0
60	Yes	No	57602.555	1885.932	3.994e-17 +/- 2.040e-18	2.718 +/- 0.076	4327.9

Bins	Edisp	Clipping	logL	TS	Prefactor	Index	CPU
-	Yes	-	98196.591	2030.800	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
20	Yes	Yes	44659.671	1723.503	5.596e-17 +/- 3.620e-18	2.999 +/- 0.094	3177.9
40	Yes	Yes	54060.554	1873.088	5.833e-17 +/- 3.433e-18	3.041 +/- 0.090	6075.4
60	Yes	Yes	57609.798	1871.447	5.975e-17 +/- 3.498e-18	3.073 +/- 0.090	4520.3

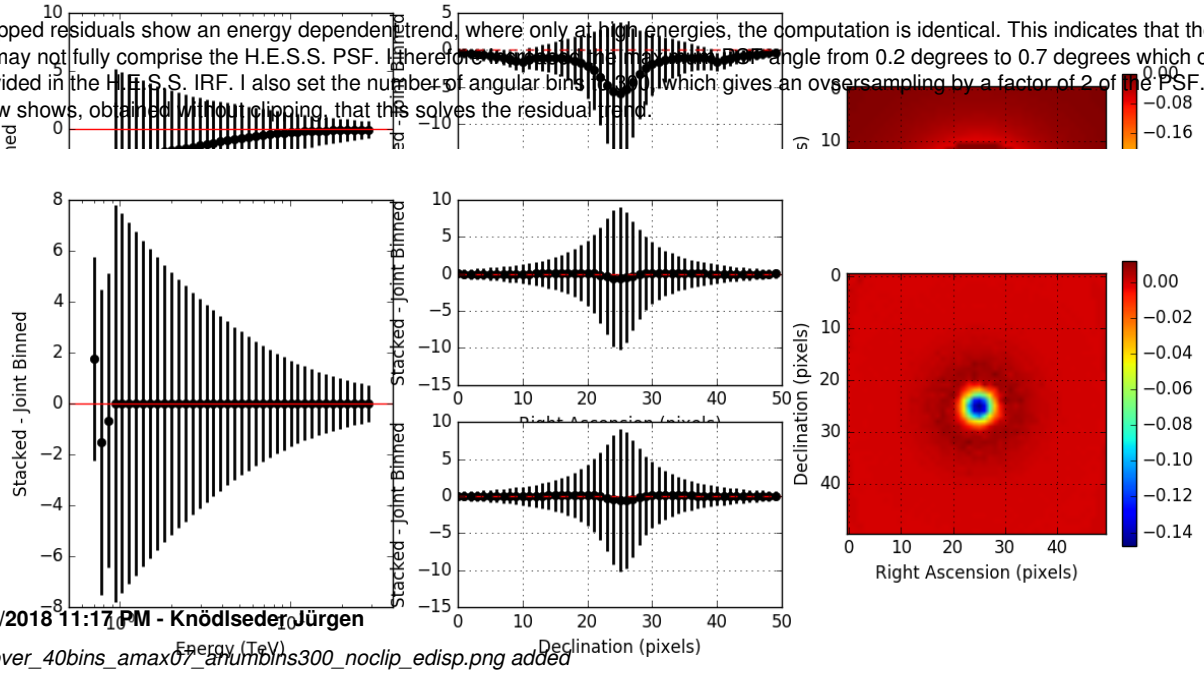
#17 - 11/09/2018 11:10 PM - Knödlseder Jürgen

- File spill-over_40bins_amax03_anumbins200_noclip.png added

- File spill-over_40bins_amax03_anumbins200_clip.png added

- File spill-over_40bins_amax07_anumbins300_clip.png added

I compared the model counts computed using an unbinned observation to the model counts computed using a stacked observation to study the effect of the spill over. The figures below show the residual of the stacked model minus the joint binned model. Left panels show the spectral residuals, central panels the spatial residual profiles in Right Ascension and Declination, and the right panels a residual map integrated over all energies. The top panels show the residuals without clipping, the bottom panel show the residuals with clipping. Obviously, clipping leads to a strong residual at low energies, near the threshold of the observations. Not clipping the stacked response is therefore strongly preferred.



The non-clipped residuals show an energy dependent trend, where only at high energies, the computation is identical. This indicates that the stacked PSF cube may not fully comprise the H.E.S.S. PSF. I therefore increased the maximum PSF angle from 0.2 degrees to 0.7 degrees which covers the angles provided in the H.E.S.S. IRF. I also set the number of angular bins to 300 which gives an oversampling by a factor of 2 of the PSF. The image below shows, obtained without clipping, that this solves the residual trend.

#18 - 11/09/2018 11:17 PM - Knödlseder Jürgen

- File spill-over_40bins_amax07_anumbins300_noclip_edisp.png added

#19 - 11/09/2018 11:17 PM - Knödlseder Jürgen

- File deleted (spill-over_40bins_amax07_anumbins300_noclip_edisp.png)

#20 - 11/09/2018 11:18 PM - Knödlseder Jürgen

- File deleted (spill-over_40bins_amax07_anumbins300_clip.png)

#21 - 11/09/2018 11:19 PM - Knödlseder Jürgen

- File spill-over_40bins_amax07_anumbins300_noclip.png added

#22 - 11/09/2018 11:25 PM - Knödlseder Jürgen

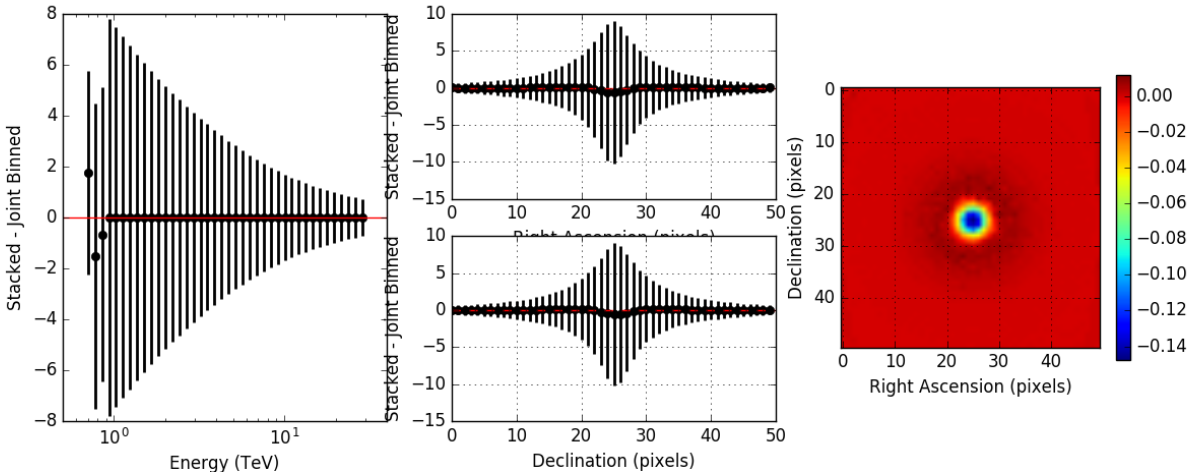
- File spill-over_40bins_amax07_anumbins300_noclip_edisp.png added

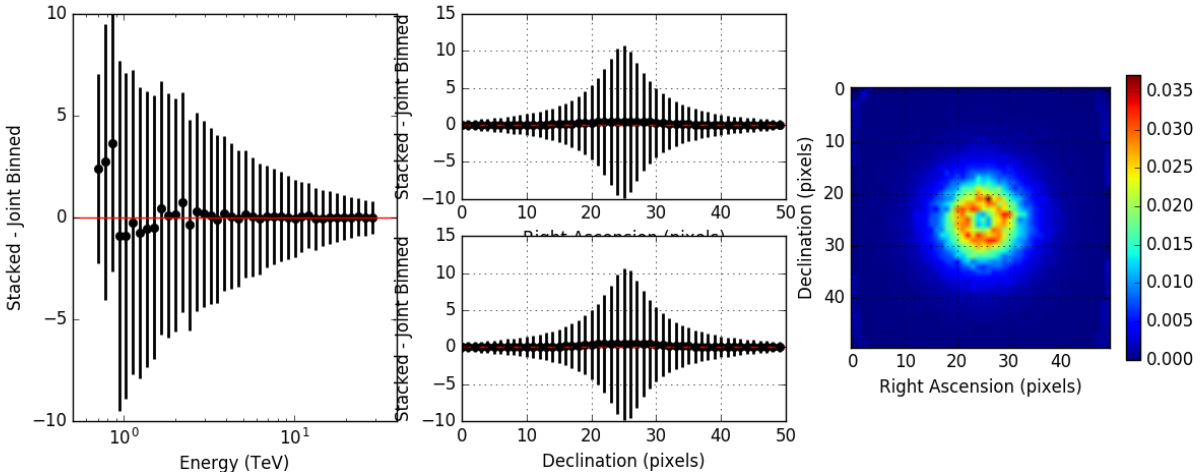
- File spill-over_40bins_amax07_anumbins300_clip.png added

- File spill-over_40bins_amax07_anumbins300_clip_edisp.png added

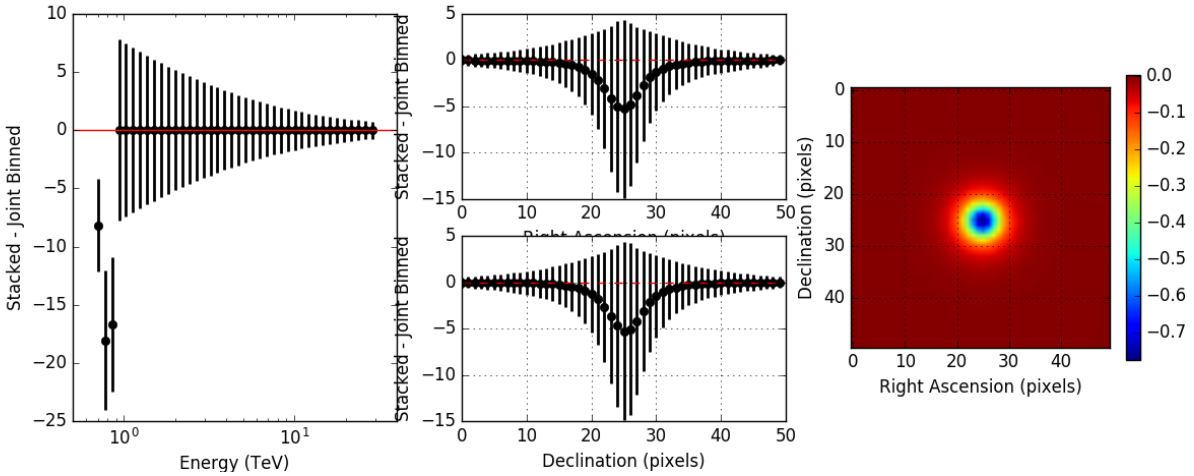
- % Done changed from 40 to 80

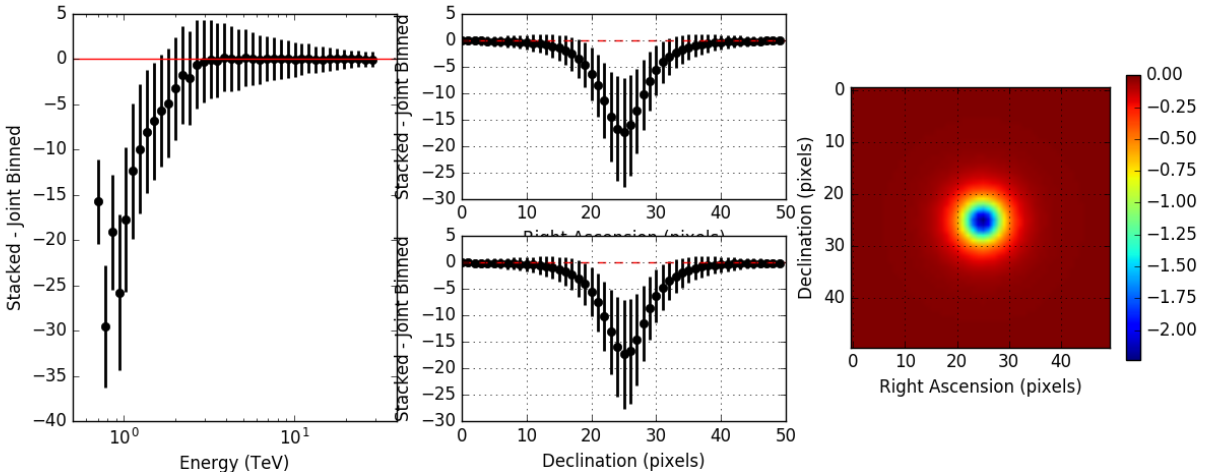
Here the plots without and with energy dispersion for no clipping:


Stacked - Joint Binned
Energy (TeV)
Declination (pixels)
Right Ascension (pixels)



And now with clipping enabled:


Stacked - Joint Binned
Energy (TeV)
Declination (pixels)
Right Ascension (pixels)


Stacked - Joint Binned
Energy (TeV)
Declination (pixels)
Right Ascension (pixels)

From these plots it is obvious that the stacked response should not be clipped. I therefore changed the code.

#23 - 11/09/2018 11:26 PM - Knödlseder Jürgen

- File show_spill_over.py added

For the record, attached the script to generate the spill over plot: attachment:show_spill_over.py

#24 - 11/10/2018 12:21 AM - Knödlseder Jürgen

Here now the final stacked results as function of the number of energy bins, in comparison to the unbinned results. The results converge for 40-50 energy bins, corresponding to about 20-25 energy bins per decade.

Bins	Edisp	logL	TS	Prefactor	Index	CPU
-	No	98199.437	2025.108	4.892e-17 +/- 2.678e-18	2.702 +/- 0.066	48.7
20	No	44658.100	1726.645	4.546e-17 +/- 2.934e-18	2.663 +/- 0.075	35.3
40	No	54060.675	1872.846	4.637e-17 +/- 2.718e-18	2.675 +/- 0.071	69.2
50	No	56036.742	1868.261	4.692e-17 +/- 2.735e-18	2.689 +/- 0.071	103.3
60	No	57604.533	1881.977	4.740e-17 +/- 2.750e-18	2.695 +/- 0.071	130.9
80	No	60446.160	1872.688	4.641e-17 +/- 2.718e-18	2.676 +/- 0.071	212.8

Bins	Edisp	logL	TS	Prefactor	Index	CPU
-	Yes	98196.591	2030.800	4.148e-17 +/- 2.005e-18	2.734 +/- 0.070	116.4
20	Yes	44656.563	1729.718	3.883e-17 +/- 2.174e-18	2.698 +/- 0.080	1423.6
40	Yes	54059.739	1874.717	3.918e-17 +/- 2.022e-18	2.698 +/- 0.076	2737.0
50	Yes	56034.364	1873.019	3.951e-17 +/- 2.022e-18	2.712 +/- 0.075	3402.5
60	Yes	57602.116	1886.812	3.985e-17 +/- 2.031e-18	2.718 +/- 0.075	3920.5
80	Yes	61382.504	1874.959	3.922e-17 +/- 2.021e-18	2.670 +/- 0.076	5192.3

#25 - 11/11/2018 04:57 PM - Knödlseder Jürgen

- File crab_sed_ptsrc_plaw_gauss_grad_hess_binned40_edisp.png added

- File crab_sed_ptsrc_plaw_gauss_grad_hess_binned40.png added

- File crab_sed_ptsrc_plaw_gauss_grad_hess_edisp.png added

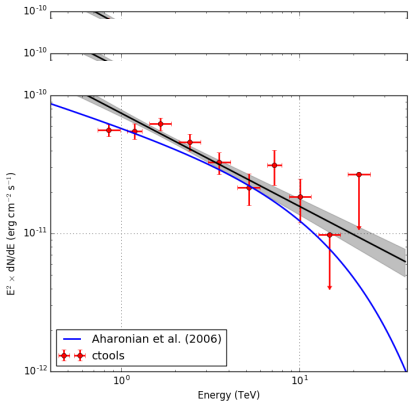
- File crab_sed_ptsrc_plaw_gauss_grad_hess_stacked40_edisp.png added

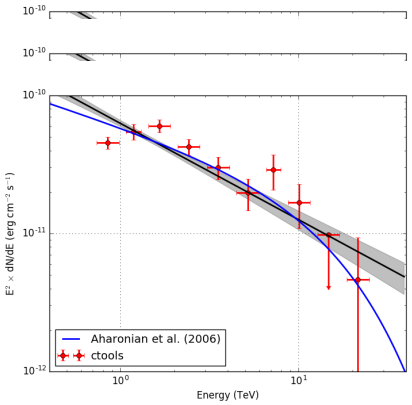
- File crab_sed_ptsrc_plaw_gauss_grad_hess_stacked40.png added

- File crab_sed_ptsrc_plaw_gauss_grad_hess.png added

Below the spectra obtained using an unbinned, joint binned and stacked analysis. Note that the energy bins for the binned and stacked analysis are not aligned with the bin boundaries of the counts cube, which explains the gaps in the spectrum. The joined binned and stacked analysis results are very similar.

Method	No energy dispersion	Energy dispersion
Unbinned		
Binned		
Stacked		





#26 - 11/11/2018 08:24 PM - Knödlseder Jürgen

- File crab_sed_ptsrc_plaw_gauss_grad_hess_binned40.png added

#27 - 11/11/2018 08:24 PM - Knödlseder Jürgen

- File deleted (crab_sed_ptsrc_plaw_gauss_grad_hess_binned40.png)

#28 - 11/11/2018 08:24 PM - Knödlseder Jürgen

- File deleted (crab_sed_ptsrc_plaw_gauss_grad_hess_binned40_edisp.png)

#29 - 11/11/2018 09:15 PM - Knödlseder Jürgen

- File crab_sed_ptsrc_plaw_gauss_grad_hess_binned40_edisp.png added

#30 - 11/12/2018 04:40 PM - Knödlseder Jürgen

I also checked the RX J1713.7-3946 observation. Below the results for unbinned and stacked analysis (40 energy bins). Energy dispersion was not applied. The stacked analysis provides a lower prefactor than the unbinned analysis, as expected due to the overestimation of the background model. The background prefactor for the stacked analysis was 0.963.

Analysis	logL	TS	Prefactor	Index	Cutoff (TeV)	Bkg. prefactor
Unbinned	537778.100	741.007	2.025e-17 +/- 1.983e-18	1.925 +/- 0.118	5.569 +/- 2.057	-
Stacked	212467.591	688.935	1.776e-17 +/- 1.483e-18	1.931 +/- 0.108	7.092 +/- 2.612	0.963 +/- 0.005

#31 - 11/12/2018 11:30 PM - Knödlseder Jürgen

- Status changed from In Progress to Closed

- % Done changed from 80 to 100

I consider that the stacked analysis is now checked.

Files

crab_stacked20_resspec.png	27 KB	11/07/2018	Knödlseder Jürgen
crab_stacked20_resprof.png	44.6 KB	11/07/2018	Knödlseder Jürgen
crab_stacked20_resmap.png	187 KB	11/07/2018	Knödlseder Jürgen
crab_stacked20_resspec_iter1.png	30.8 KB	11/07/2018	Knödlseder Jürgen
crab_stacked20_resprof_iter1.png	43.9 KB	11/07/2018	Knödlseder Jürgen
crab_stacked20_resmap_iter1.png	173 KB	11/07/2018	Knödlseder Jürgen
spill-over_40bins_amax03_anumbins200_noclip.png	129 KB	11/09/2018	Knödlseder Jürgen
spill-over_40bins_amax03_anumbins200_clip.png	109 KB	11/09/2018	Knödlseder Jürgen
spill-over_40bins_amax07_anumbins300_noclip.png	96.7 KB	11/09/2018	Knödlseder Jürgen
spill-over_40bins_amax07_anumbins300_noclip_edisp.png	114 KB	11/09/2018	Knödlseder Jürgen
spill-over_40bins_amax07_anumbins300_clip.png	87.9 KB	11/09/2018	Knödlseder Jürgen
spill-over_40bins_amax07_anumbins300_clip_edisp.png	102 KB	11/09/2018	Knödlseder Jürgen
show_spill_over.py	12.7 KB	11/09/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess_stacked40_edisp.png	59.7 KB	11/11/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess_edisp.png	59.4 KB	11/11/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess_stacked40.png	59.1 KB	11/11/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess.png	57.3 KB	11/11/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess_binned40.png	59.8 KB	11/11/2018	Knödlseder Jürgen
crab_sed_ptsrc_plaw_gauss_grad_hess_binned40_edisp.png	59.4 KB	11/11/2018	Knödlseder Jürgen