Composite Models

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Use case I

- Source morphology more complicated than single (asym) Gaussian
- e.g. Vela X (radio nebula + cocoon)
- Want to model complicated source with one spectrum (but several spatial components)
- Avoid using detour using FITS templates

Use case II

- Source spectrum more complicated than single component
- e.g. Crab in Fermi (PSR + nebula)
- Want to model source with several spectral components
- Avoid using detour using Ascii File templates

Feature #1706



ctmapcube

Model XML File

- k?xml version="1.0" encoding="UTF-8" standalone="no"?>
 <source_library title="source library">
 <source_name="E0" type="LogdexBolue">
 <spectrum type="LogdexBolue">
 </spectrum type=
 </se

 - </spectrum> <spatialModel type="GaussFunction"> cspatialModel type="GaussFunction"> cparameter name="RA" value="80.0" scale="1" min="27.898" max="137.898" free="0" /> cparameter name="DEC" value="c68.0" scale="1" min="-81.4065" max="-50" free="0" /> cparameter name="DEC" value="3.8" scale="1" min="0.0001" max="10" free="0" /> c/spatialModel>

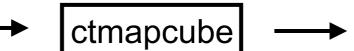
- //Suituruous/ /Suituruous/ /Suituruous/ /Suituruous/ cparameter name="Integral" value="2.05" scale="1e=08" min="le=09" max="1e+06" free="1" /> cparameter name="Integral" value="2.05" scale="1" min="0" max="5" free="1" /> cparameter name="lowerLimit" value="100" scale="1" min="0.0001" max="1000000" free="0" /> /cparameter name="lowerLimit" value="loo" scale="1" min="0.0001" max="1000000" free="0" /> /cparameter name="lowerLimit" value="loo" scale="1" min="0.0001" max="1000000" free="0" />
- c/spectrum> <spatialModel type="GaussFunction"> <patialModel type="GaussFunction"> <patianter name="DEC" value="-68.85" scale="1" min="27.898" max="137.898" free="0" /> <patianter name="Sigma" value="68.85" scale="1" min="8.8081" max="18" free="0" /> </spatialModel>

- (source)
 (source)
 (source name="E2" type="ExtendedSource">
 (source name="Integral" value="1.6" scale="1e-8" min="le-80" max="le+86" free="1" />
 (parameter name="Integral" value="2.6" scale="1" min="0" max="5" free="1" />
 (parameter name="LowerLimit" value="100" scale="1" min="0.8001" max="10000000" free="0" />
 (parameter name="LowerLimit" value="16" scale="1" min="0.8001" max="10000000" free="0" />
- </spectrum> <spectrum> <spec

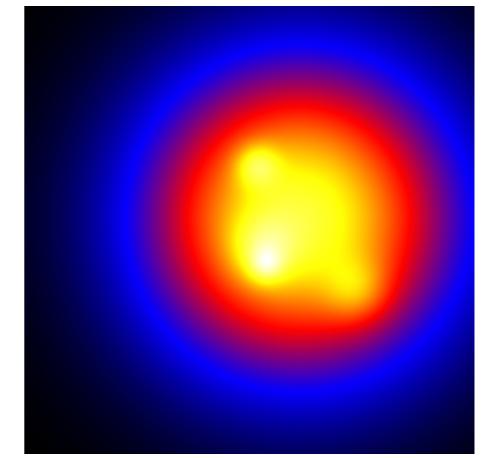
- </spectrum>
- c/spectrum> <spatialModel type="GaussFunction"> <patiantModel type="GaussFunction"> <patianter name="DEC" value="40,25" scale="1" min="27.898" max="137.898" free="0" /> <patianter name="Sigma" value="60,25" scale="1" min="8.4065" max="-60" free="0" /> </patialModel>

- (/spacialroute_ (source name="E4" type="ExtendedSource"> <spactrum type="PowerLaw2"> <parameter name="Integral" value="1.85" scale="1e=8" min="le=09" max="1e+06" free="1" /> <parameter name="Integral" value="2.13" scale="1" min="0" max="5" free="1" /> <parameter name="LowerLimit" value="100" scale="1" min="0".0001" max="10000000" free="0" /> <parameter name="LowerLimit" value="le6" scale="1" min="0".0001" max="10000000" free="0" /> //sectrum>
- </spectrum>
 <

</source> </source_library>



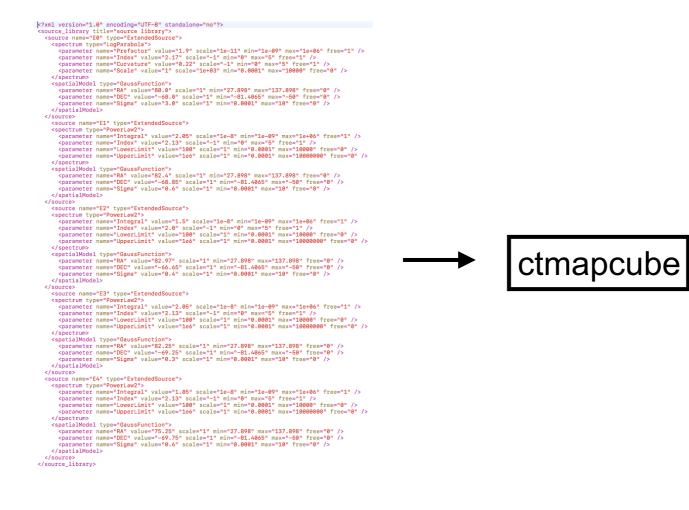
FITS Cube template



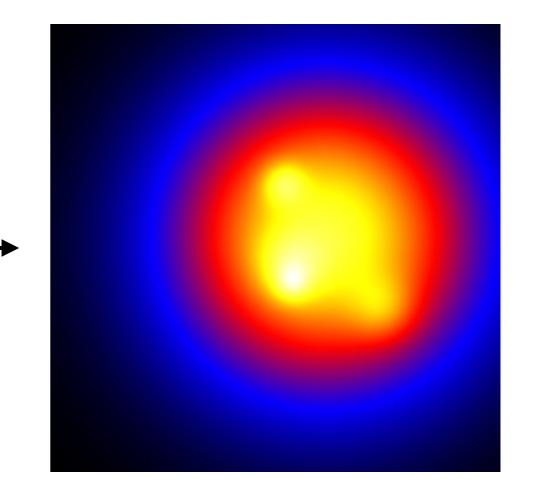


ctmapcube

Model XML File



FITS Cube template



- Requires knowledge of spectrum of each component
- Need to reproduce template if you want to change a component



Proposal I - Linked Parameters

```
<?xml version="1.0" standalone="no"?>
<source library title="source library">
   <source name="Crab pulsar" type="PointSource">
        <spectrum type="PowerLaw">
          <parameter name="Prefactor" scale="1e-16" value="5.7" min="1e-07" max="1000.0" free="1"/>
          <parameter name="Index"</pre>
                                      scale="-1"
                                                   value="2.48" min="0.0"
                                                                                          free="1"/>
                                                                             max="+5.0"
          <parameter name="Scale"</pre>
                                      scale="1e6" value="0.3" min="0.01" max="1000.0" free="0"/>
        </spectrum>
       <spatialModel type="SkyDirFunction">
           <parameter max="360" min="-360" name="RA" scale="1" value="83.6331" free="1" />
           <parameter max="90" min="-90" name="DEC" scale="1" value="22.0145" free="1" />
       </spatialModel>
    </source>
   <source name="Crab nebula" type="PointSource">
        <spectrum type="PowerLaw">
          <parameter name="Prefactor" scale="1e-16" value="5.7" min="1e-07" max="1000.0" free="1"/>
          <parameter name="Index"
                                      scale="-1" value="2.48" min="0.0" max="+5.0"
                                                                                          free="1"/>
          <parameter name="Scale"</pre>
                                      scale="1e6" value="0.3" min="0.01" max="1000.0" free="0"/>
       </spectrum>
       <spatialModel type="SkyDirFunction">
           <parameter max="360" min="-360" name="RA" scale="1" value="83.6331" free="1" />
           <parameter max="90" min="-90" name="DEC" scale="1" value="22.0145" free="1" />
       </spatialModel>
    </source>
    ink>
       <source name="Crab pulsar" parameter="RA">
        <source name="Crab nebula" parameter="RA">
        <parameter max="360" min="-360" name="RA" scale="1" value="83.6331" free="1" />
    </link>
</source library>
```



Proposal I - Linked Parameters

- Add the <link> information to Model container
- Fix all linked parameters automatically
- Introduce a new (more global) parameter
- Need to figure out how to resolve parameters in model evaluation

Advantages:

Very flexible Can link across sources Keep XML source definition

Drawbacks:

More complicated XML file Difficult to implement?



Proposal II - New XML model definitions (GModelSpectralComposite, GModelSpatialComposite)

```
<source name="Crab" type="PointSource" tscalc="1">
  <spectrum type="Composite">
      <spectrum type="PowerLaw" component="PSR">
          <parameter name="Prefactor" value="5" scale="1e-16" min="0.1" max="10" free="1" />
          <parameter name="Index" value="-2.2" scale="1" min="-6" max="-1" free="1" />
          <parameter name="Scale" value="1" scale="1e+06" free="0" />
      </spectrum>
      <spectrum type="PowerLaw" component="Nebula">
          <parameter name="Prefactor" value="8.0" scale="1e-16" min="0.1" max="10" free="1" />
          <parameter name="Index" value="-2.5" scale="1" min="-6" max="-1" free="1" />
          <parameter name="Scale" value="1" scale="1e+06" free="0" />
      </spectrum>
  </spectrum>
  <spatialModel type="SkyDirFunction">
      <parameter name="RA" value="83.6331" scale="1" min="0" max="260" free="0" />
      <parameter name="DEC" value="22.01" scale="1" min="-90" max="90" free="0" />
  </spatialModel>
</source>
```



Proposal IIa - Multiple spectra per source

```
<source name="Crab" type="PointSource" tscalc="1">
  <spectrum type="PowerLaw" component="PSR">
      <parameter name="Prefactor" value="5" scale="1e-16" min="0.1" max="10" free="1" />
     <parameter name="Index" value="-2.2" scale="1" min="-6" max="-1" free="1" />
     <parameter name="Scale" value="1" scale="1e+06" free="0" />
  </spectrum>
 <spectrum type="PowerLaw" component="Nebula">
      <parameter name="Prefactor" value="8.0" scale="1e-16" min="0.1" max="10" free="1" />
     <parameter name="Index" value="-2.5" scale="1" min="-6" max="-1" free="1" />
     <parameter name="Scale" value="1" scale="1e+06" free="0" />
  </spectrum>
 <spatialModel type="SkyDirFunction">
     <parameter name="RA" value="83.6331" scale="1" min="0" max="260" free="0" />
     <parameter name="DEC" value="22.01" scale="1" min="-90" max="90" free="0" />
  </spatialModel>
</source>
```



Could think of adding a "weight" attribute

```
<source name="Source" type="ExtendedSource" tscalc="1">
  <spectrum type="PowerLaw">
    <parameter name="Prefactor" value="5" scale="1e-16" min="0.1" max="10" free="1" />
   <parameter name="Index" value="-2.2" scale="1" min="-6" max="-1" free="1" />
   <parameter name="Scale" value="1" scale="1e+06" free="0" />
  </spectrum>
  <spatialModel type="GaussFunction" weigth="0.8">
    <parameter name="RA" value="83.6331" scale="1" min="0" max="360" free="0" />
   <parameter name="DEC" value="22.01" scale="1" min="-90" max="90" free="0" />
   <parameter name="Sigma" value="0.2" scale="1" min="0" max="1" free="0" />
  </spatialModel>
 <spatialModel type="GaussFunction" weigth="0.2">
    <parameter name="RA" value="83.6331" scale="1" min="0" max="360" free="0" />
   <parameter name="DEC" value="22.01" scale="1" min="-90" max="90" free="0" />
   <parameter name="Sigma" value="0.6" scale="1" min="0" max="1" free="0" />
 </spatialModel>
</source>
```



Proposal II - Change XML source definition

- Implement new composite spatial and spectral model
- allow multiple spectral and spatial (or temporal) components per model
- Model evaluation is just the sum of model components (normalisation has to be worked out)
- Should work straight-forward (in my mind)

Advantages:

Intuitive Easy to use Keep XML files clean

Drawbacks:

Some sensible changes to the code Work out normalisation

