

GammaLib

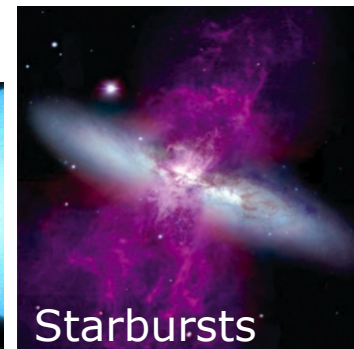
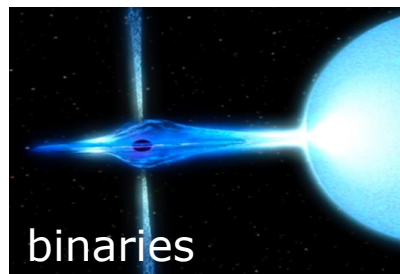
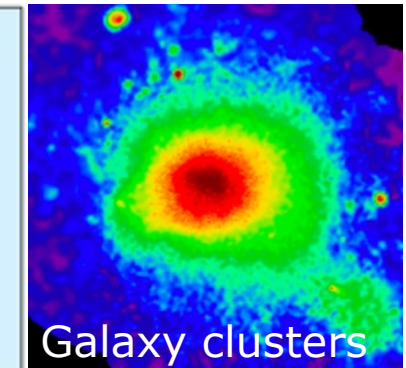
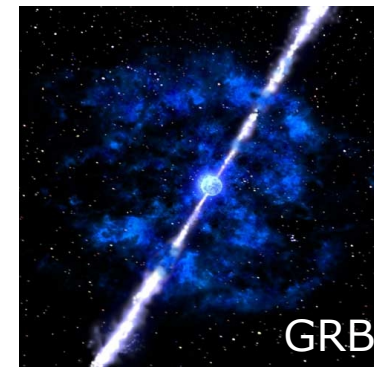
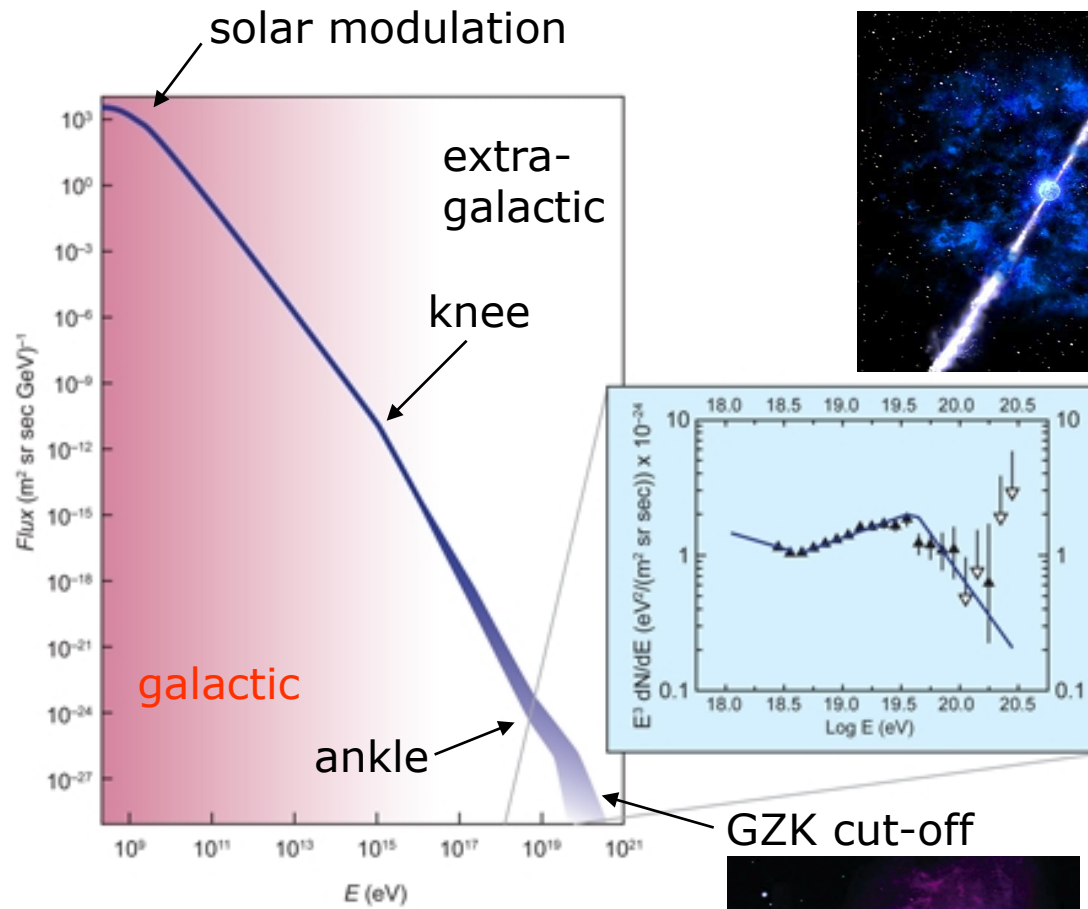
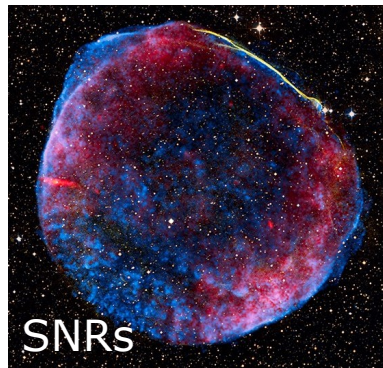
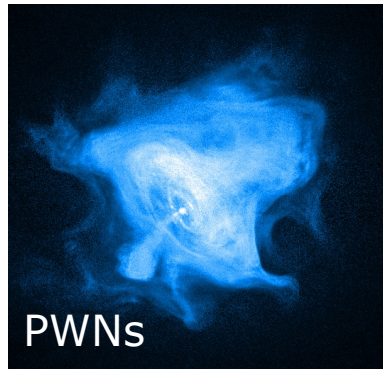
A versatile framework for the analysis of
astronomical gamma-ray data



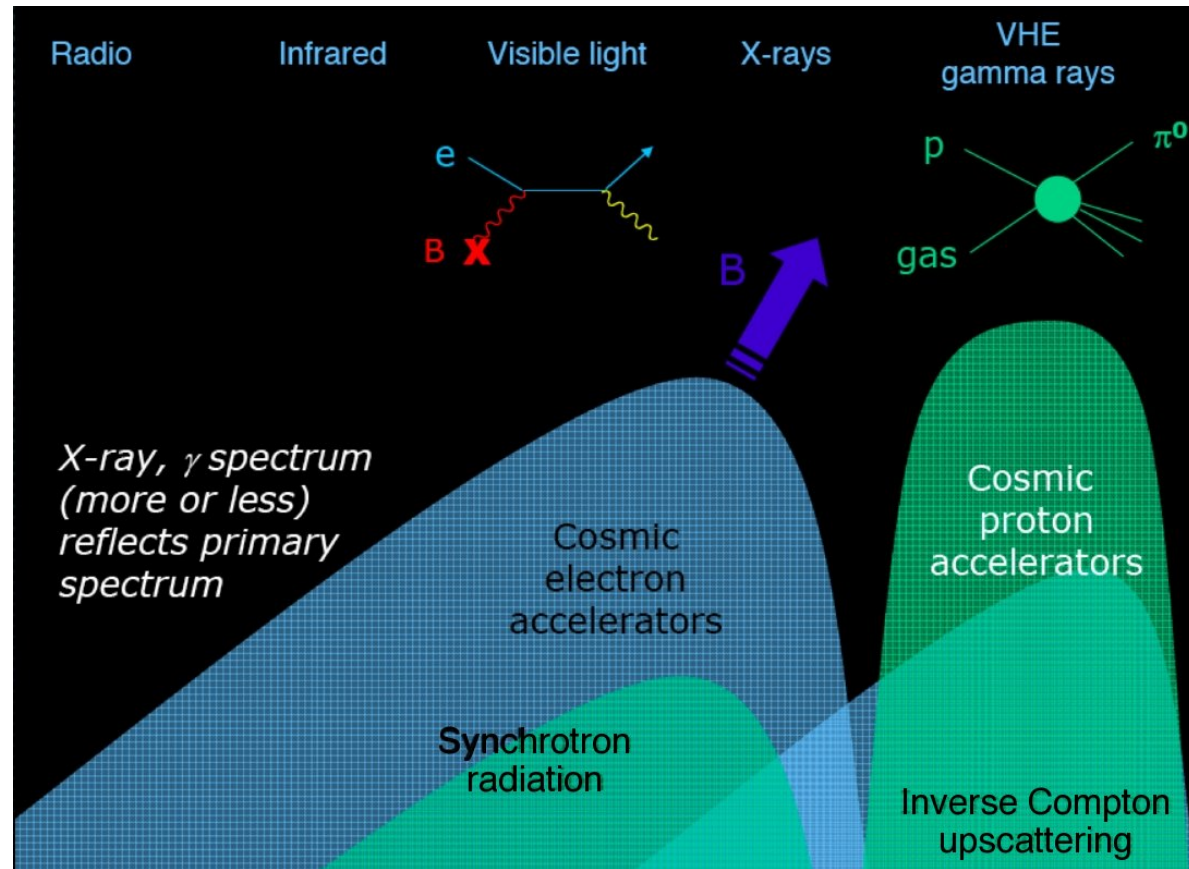
Jürgen Knödseder, on behalf of the GammaLib
development team



Understanding the non-thermal Universe

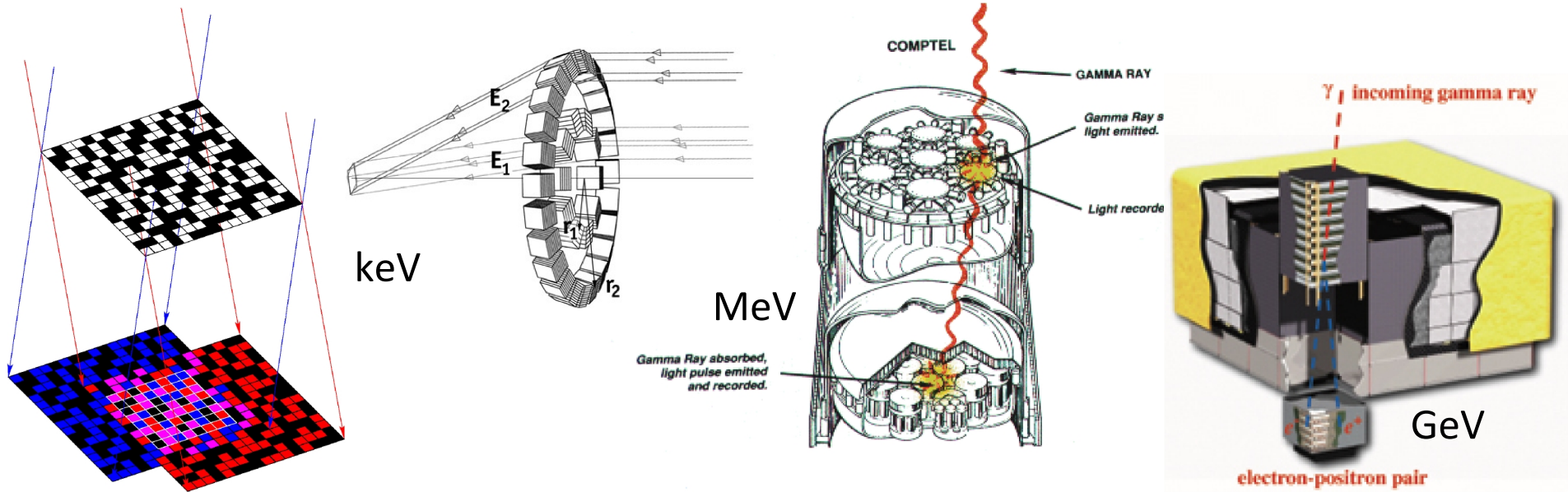


An inherent multi-wavelength endeavor

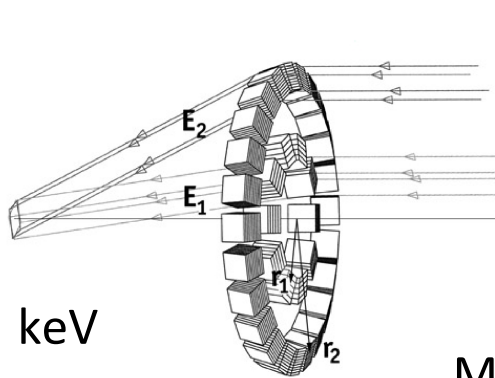
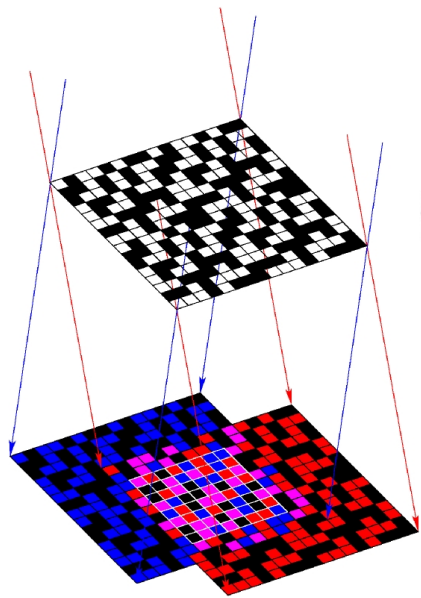


Non-thermal particles emit over the **entire** electromagnetic spectrum

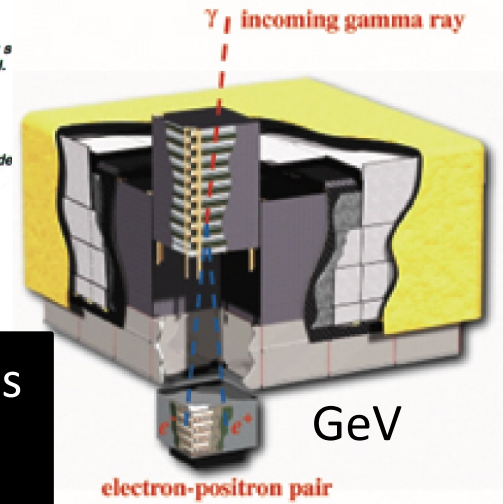
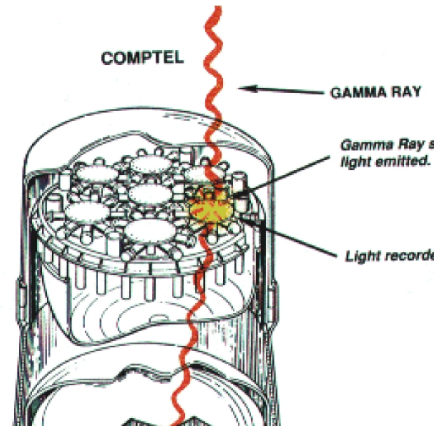
Observing gamma rays



Observing gamma rays



MeV



All instruments measure individual photons

- Localization
- Energy
- Time
- (Polarization)



Analyzing gamma-ray data today

keV

The screenshot shows the INTEGRAL Science Data Centre website. The main content area is titled 'INTEGRAL Data Analysis' and includes a 'Download INTEGRAL Software' section. Below this is a table listing software packages:

Package	Version	Download	Comments
OSA Packages			
OSA Software	10.0	<ul style="list-style-type: none">Linux: 32-bitLinux: 64-bitOS X: Snow-leopardOS X: LionDevelopers	The three binary distributions for Linux or Mac OS X are recommended. Source code compilation is possible with the "Developers" package. Please check the Known Issues and refer to the Inst. Guide.
Instrument Characteristics	10.0	Use the <code>traync</code> command	To download or update the IC files use: <code>traync -L227V</code> <code>rsync://cd11g1.ch11a20/FTP/acc_d11st1/1c_tool/prod/588F_BASIS_PROD</code>
Reference Catalogue	35.0	24 MB	Contains the general high-energy and OMC reference catalogues.
Test Data	10.0.4	0.0B	Test data files used to check the user's installation.

INTEGRAL science analysis software (OSA) and data provided by ISDC (Geneva).

MeV

The screenshot shows the CGRO Science Support Center website. The main content area is titled 'The Imaging Compton Telescope (COMPTEL)'. It features a large image of the COMPTEL instrument and a globe showing the instrument's field of view. Below the image is a 'General Information' section with links to 'COMPTEL Instrument Description', 'In-Depth Technical Information on COMPTEL', 'COMPTEL Scientific Objectives', and 'COMPTEL Specifications'. There is also a 'Public Data Archive' section with links to 'FTP Access to Public Data Archive', 'FTP Access to COMPTEL Software and Documentation', and 'Summary of Reconfigured CGRO Archive'.

COMPTEL data provided by HEASARC/GSFC (US). No public science analysis software available. **Data are unexploitable ...**

GeV

The screenshot shows the Fermi Science Support Center website. The main content area is titled 'Fermi Data'. It includes a 'Data' section with links to 'Data Policy', 'Data Access', 'Data Analysis', 'Caveats', 'Newsletters', and 'FAQ'. The 'Data Access' section is expanded, showing links to 'Data Access - the Fermi science data', 'Data Analysis - the software to analyze Fermi data', and 'Data Policy - a summary of the policies governing the release of Fermi science data'. Below this is a 'Fermi Data' section with a paragraph: 'This is the portal to the Fermi data and the software to analyze them. Before the data or software are released, they are described here.' At the bottom, there is a 'Goddard Space Flight Center' logo and contact information for the Curator, J.D. Myers, and NASA Official, Phil Newman.

Fermi science analysis software (Science Tools) and data provided by Fermi Science Support Center (HEASARC, US).

TeV: join a collaboration **(no public data and software so far ...)**

Analyzing gamma-ray data tomorrow



Data (still missing)
and VO tools



Interoperability (still missing)



Software

What is GammaLib?

A self-contained, instrument independent, open source, multi-platform C++ library that implements all code required for high-level science analysis of astronomical gamma-ray data.

Self-contained: does not depend on external libraries (except for cfitsio for FITS file access)

Instrument independent: potentially supports any high-energy astronomy instrument; enables simultaneous multi-instrument analysis

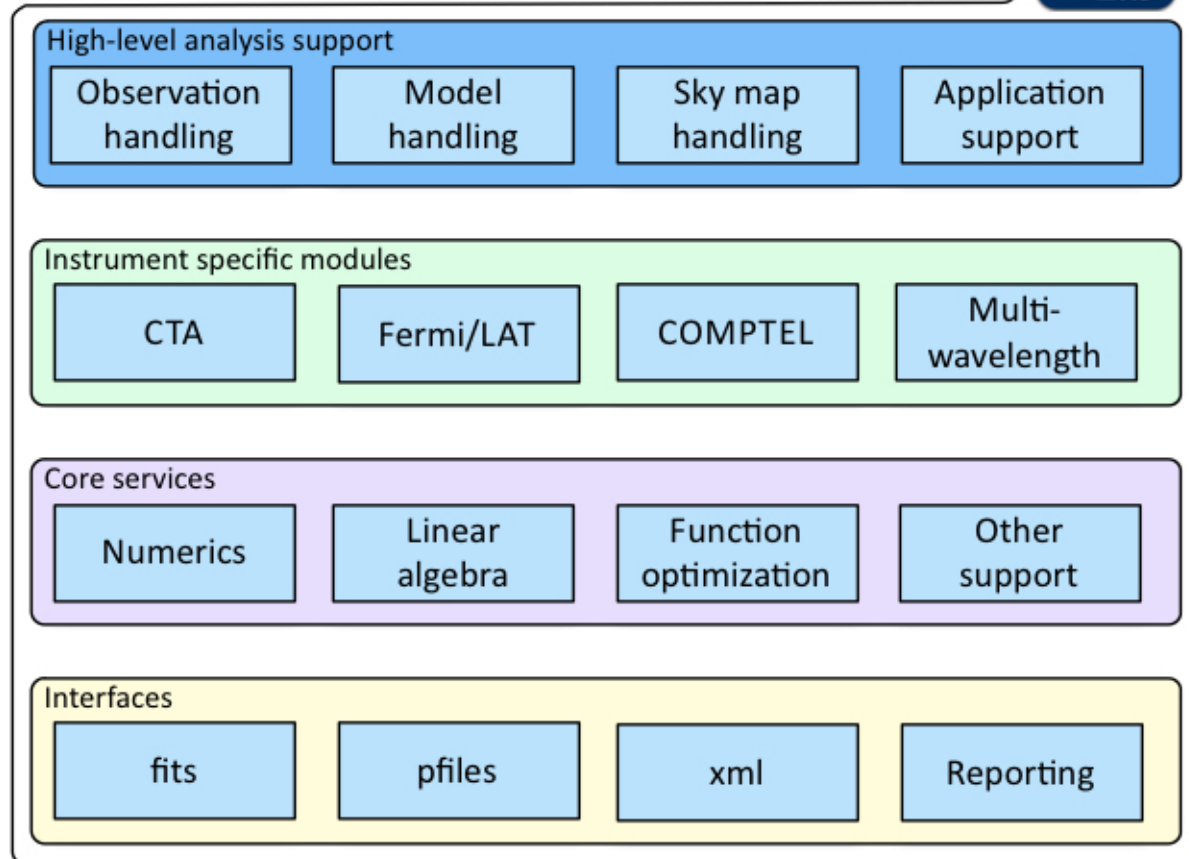
Open source: source code from <http://sourceforge.net/projects/gammlib/>

Multi-platform: compiles on any POSIX compliant Unix platform (Linux, Mac OS X, OpenSolaris, FreeBSD)

C++ library: object oriented framework, uses class abstraction for instrument independence

Python module: fully binds in Python (swig)

How is it organized?



Abstract

Extendable

Native

Compliant

How to install it?

1. Get it



2. Compile it (and check it)

```
> ./configure  
> make  
> make check
```

```
=====  
All 18 tests passed  
=====
```

3. Install it

```
> [sudo] make install
```

4. Configure it

```
> export GAMMALIB=/usr/local/gamma  
> source $GAMMALIB/bin/gammlib-init.sh
```

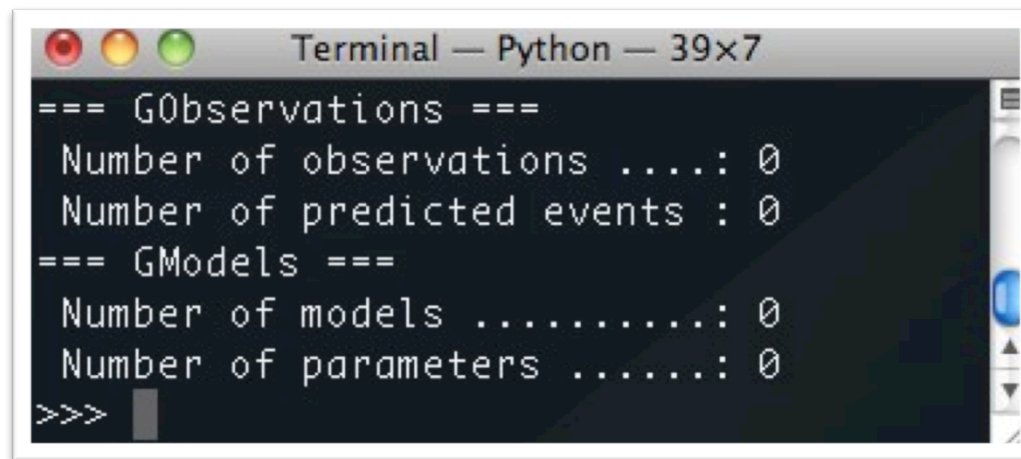
How to use it?

Build a C++ application:

```
#include <iostream>
#include "GammaLib.hpp"
int main(void) {
    GObservations obs;
    std::cout << obs << std::endl;
    return 0;
}
```

Use python:

```
$ python
>>> from gammalib import *
>>> obs = GObservations()
>>> print obs
```



A terminal window titled "Terminal — Python — 39x7" showing the output of the Python script. The output is as follows:

```
=== GObservations ===
Number of observations .....: 0
Number of predicted events : 0
=== GModels ===
Number of models .....: 0
Number of parameters .....: 0
>>>
```

A simple Use Case

Joint spectral analysis of the Crab nebula using data from COMPTEL (MeV), Fermi-LAT (GeV) and H.E.S.S. (TeV) (*credits: Marie-Hélène Grondin*)

1. Specify observation data (locally on disk)

```
<observation_list title="observation library">
  <observation name="Crab" id="vp0001_0" instrument="COM">
    <parameter name="DRE" file="/project-data/comptel/phase01/vp0001_0/m50439_dre.fits"/>
    <parameter name="DRB" file="/project-data/comptel/phase01/vp0001_0/m34997_drg.fits"/>
    <parameter name="DRG" file="/project-data/comptel/phase01/vp0001_0/m34997_drg.fits"/>
    <parameter name="DRX" file="/project-data/comptel/phase01/vp0001_0/m32171_drx.fits"/>
    <parameter name="IAQ" file="com/u47569_iaq.fits"/>
  </observation>
  <observation name="Crab" id="00001" instrument="LAT">
    <parameter name="CountsMap" file="/project-data/cta/data/fermi/crab/srcmap.fits"/>
    <parameter name="ExposureMap" file="/project-data/cta/data/fermi/crab/binned_expmap.fits"/>
    <parameter name="LiveTimeCube" file="/project-data/cta/data/fermi/crab/ltcube.fits"/>
    <parameter name="IRF" value="P7SOURCE_V6"/>
  </observation>
  <observation name="Crab" id="00023523" instrument="HESS">
    <parameter name="EventList" file="/project-data/cta/data/cta-1dc/data/hess/CTA1DC-HESS-run_1
    <parameter name="ARF" file="/project-data/cta/data/cta-1dc/data/hess/CTA1DC-HESS-run023523_1
    <parameter name="RMF" file=""/>
    <parameter name="PSF" file="/project-data/cta/data/cta-1dc/data/hess/CTA1DC-HESS-run00023523
  </observation>
</observation_list>
```

A simple Use Case

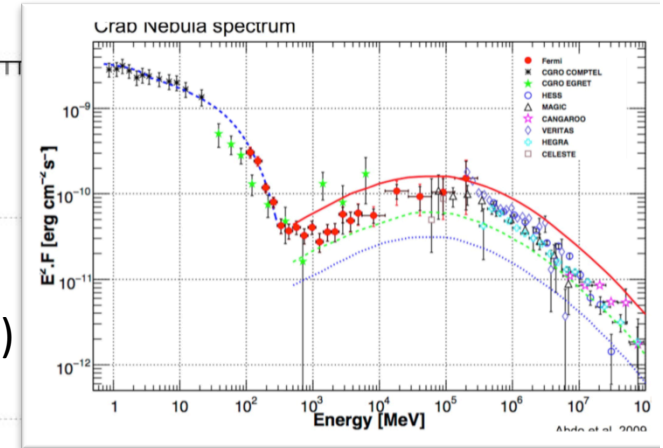
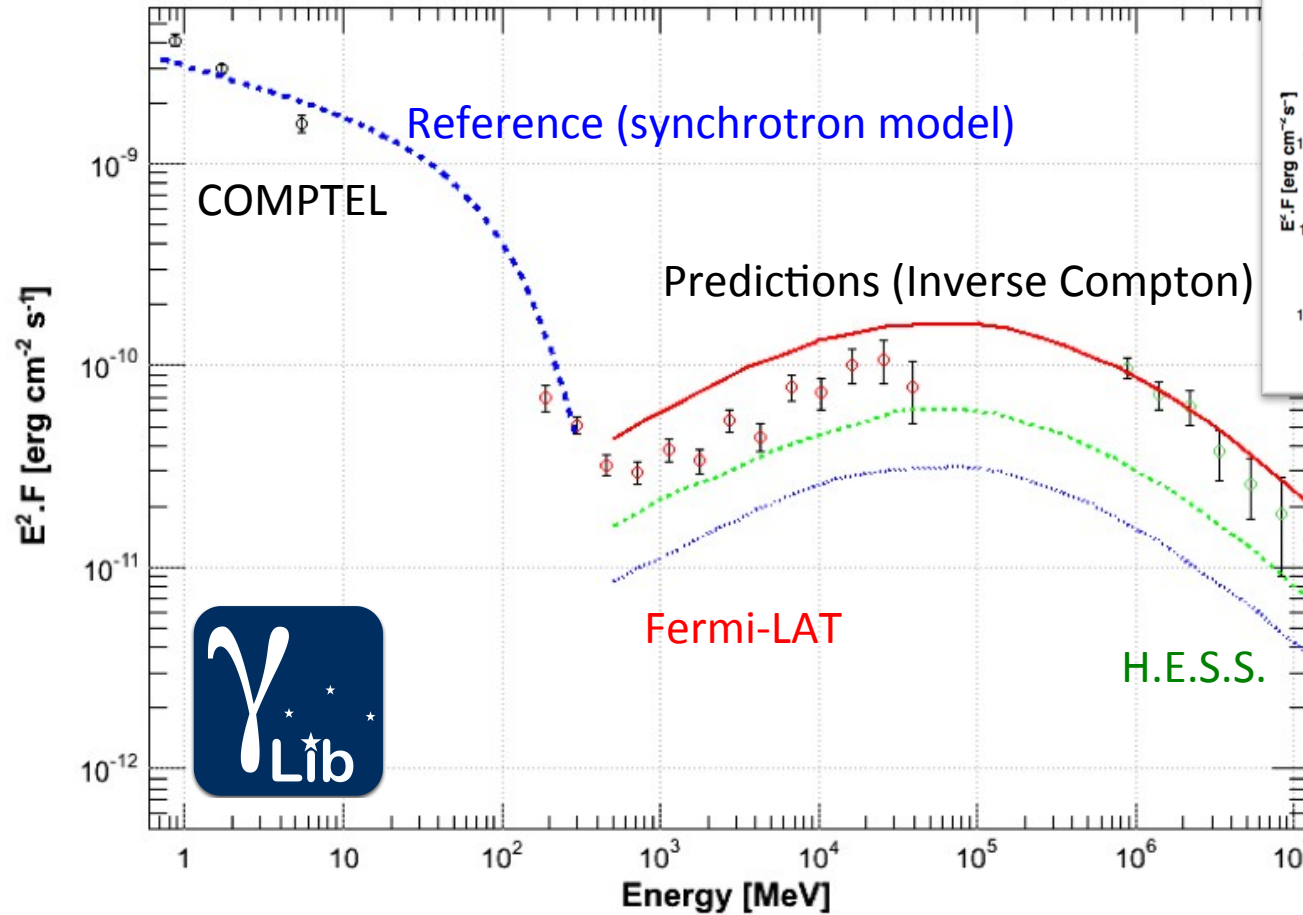


2. Specify a spatial-spectral-temporal model

```
<source_library title="source library">
  <source type="PointSource" name="Crab">
    <spectrum type="NodeFunction">
      <node>
        <parameter scale="1.0" name="Energy" min="0.866" max="0.866" value="0.866" free="0"/>
        <parameter scale="0.00378740451299" name="Intensity" min="1e-5" max="1e5" value="1.0" f:
      </node>
      ...
    <node>
      <parameter scale="1e6" name="Energy" min="20.0" max="20.0" value="20.0" free="0"/>
      <parameter scale="1.30650238384e-20" name="Intensity" min="1e-5" max="1e5" value="1.0" :
    </node>
  </spectrum>
  <spatialModel type="SkyDirFunction">
    <parameter scale="1" name="RA" min="-360" max="360" value="83.6331" free="0"/>
    <parameter scale="1" name="DEC" min="-90" max="90" value="22.0145" free="0"/>
  </spatialModel>
</source>
<source type="DiffuseSource" name="Extragal_diffuse" instrument="LAT">
  <spectrum type="FileFunction" file="/project-data/cta/data/fermi/diffuse/isotrop_2year_P76_!
    <parameter scale="1.0" name="Normalization" min="0.0" max="1000.0" value="1.0" free="1"/>
  </spectrum>
  <spatialModel type="ConstantValue">
    <parameter scale="1" name="Value" min="0" max="10" value="1" free="0"/>
  </spatialModel>
</source>
...
</source_library>
```

A simple Use Case

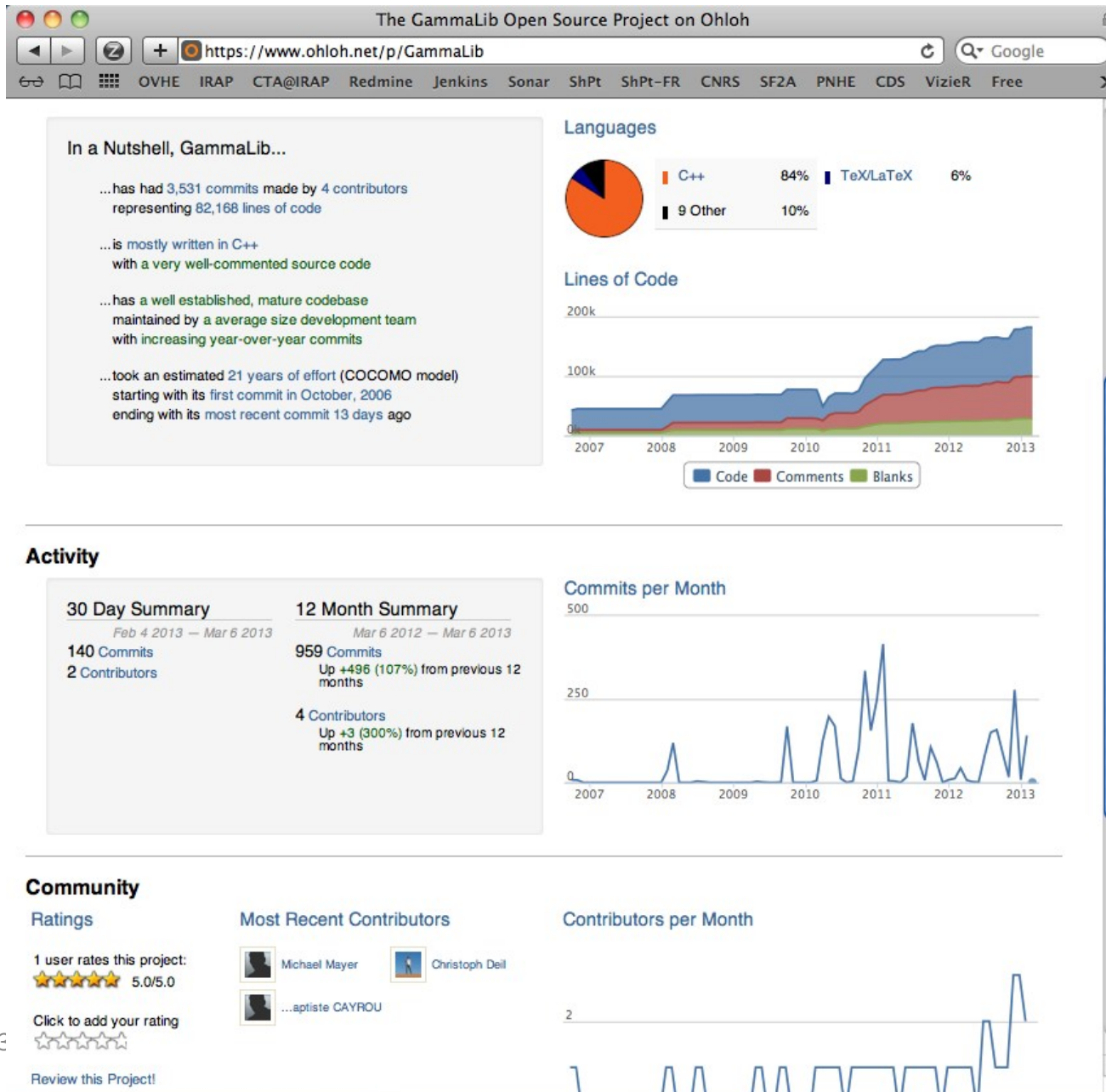
Independent analyses



Abdo et al. (2009)

Credits: Marie-Hélène Grondin

A collaborative development

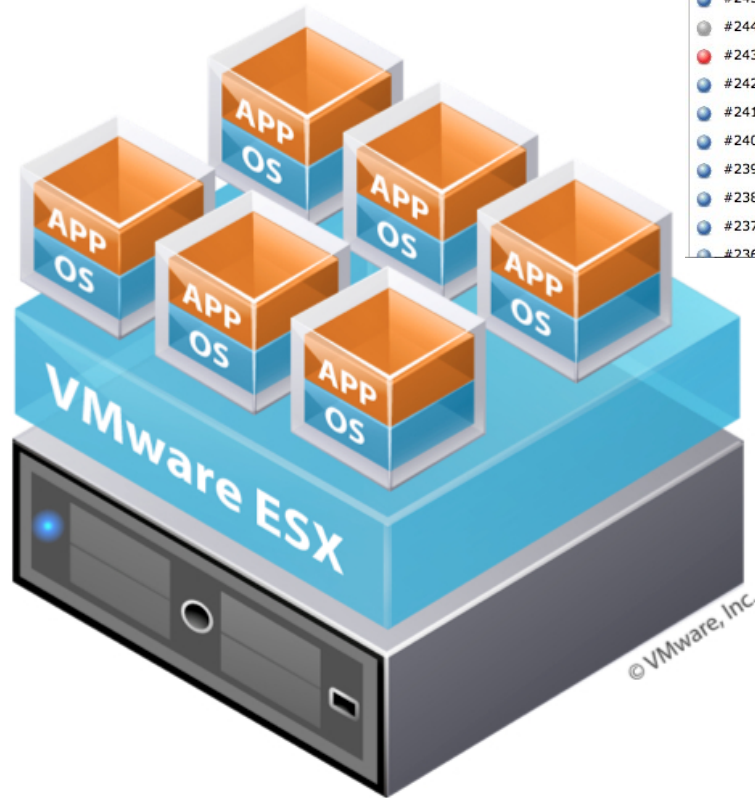


Code quality (continuous integration)



Jenkins

Continuous integration
(build, check, install, analysis)



The screenshot shows the Jenkins web interface for the 'proj et GammaLib build: Operating Systems' job. It includes a navigation menu, a search bar, and a 'Retour au tableau de bord' link. The main content area displays the 'Historique des builds' table, a 'Configurations' section with various OS links, and a 'Proj ets en aval' section. A 'Disk Usage Trend' chart is also visible, showing disk usage in MB for various builds.

Build #	Date	Size
#247	7 mars 2013 00:32:36	14KB
#246	7 mars 2013 00:00:57	14KB
#245	6 mars 2013 13:55:01	14KB
#244	6 mars 2013 12:38:09	13KB
#243	5 mars 2013 00:00:41	17KB
#242	4 mars 2013 00:01:34	14KB
#241	3 mars 2013 00:01:34	14KB
#240	2 mars 2013 00:01:34	14KB
#239	1 mars 2013 00:01:35	14KB
#238	28 févr. 2013 00:01:34	14KB
#237	27 févr. 2013 00:01:34	14KB
#236	26 févr. 2013 00:01:34	14KB

Multi-platform, multi-compiler, 32/64 Bit,
Python version, swig version, ...

Virtual box with relevant OS



Code analysis



Sonar - "GammaLib"

https://cta-sonar.irap.omp.eu/dashboard/index/1

IRAP CTA@IRAP Redmine Jenkins ShPt ShPt-FR CNRS SF2A PNHE CDS VizieR ATEL Galileo Free Jürgen Knödseder arXiv Google ADS Le Monde EVO

Home "GammaLib" Configuration Jürgen Knödseder Log out Search

Version 1.0 - 21 oct. 2012 00:17 Time changes... Configure widgets Manage dashboards

Dashboard

- Hotspots
- Reviews
- Time Machine
- Components
- Violations Drilldown
- Clouds
- Libraries

CONFIGURATION

- Manual Measures
- Action Plans
- Settings
- Exclusions
- Links
- Project Roles
- History
- Project Deletion

Lines of code
87 988 ▼
144 895 lines ▼

Files
436 ▲
27 directories
3 595 methods ▼

Violations
63

Rules compliance
99,9%

Blocker	0
Critical	0
Major	0
Minor	63
Info	0

Comments
26,3%
31 333 lines ▼
+7 528 blank
372 commented LOCs

Duplications
1,6%
2 377 lines ▼
107 blocks
47 files

Code coverage
61,3%
58,7% line coverage
70,1% branch coverage

Unit test success
100,0%
0 failures
0 errors
2 952 tests
4:35 min ▲

Complexity
2,5 /method
45,6 /file
Total: 8 946 ▼

1	2000
2	1000
4	500
6	250
8	125
10	62
12	31

● Methods ○ Classes ○ Files

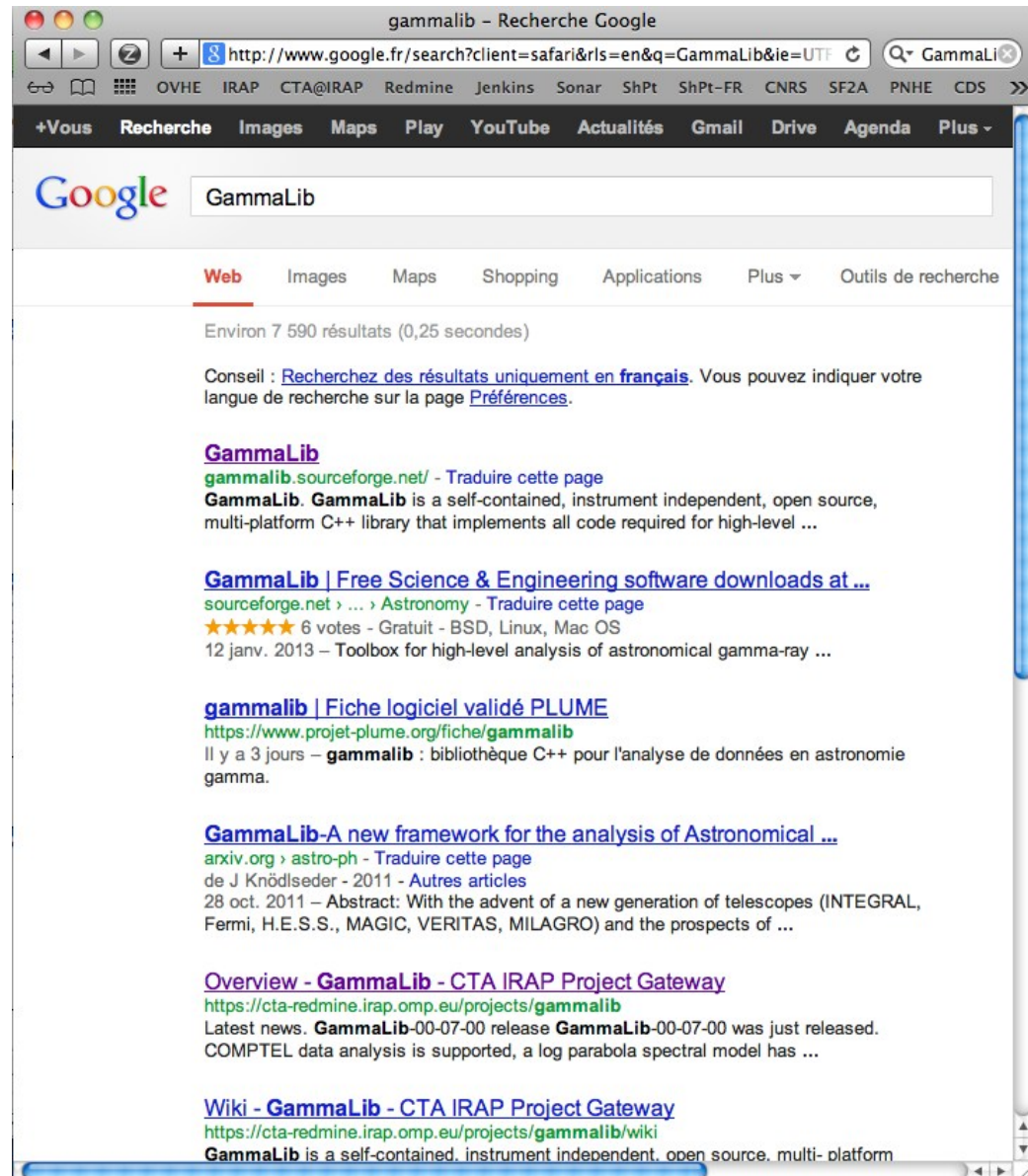
Events All

21 oct. 2012	Version	1.0	
24 juil. 2012	Profile	Default C++ Profile version 1	i
24 juil. 2012	Profile	GammaLib Profile version 1	i
23 juil. 2012	Profile	Default C++ Profile version 1	i

Key: gammalib
Language: c++
Profile: Default C++ Profile (version 1)
Alerts: [RSS Feed](#)
Links: [Continuous integration](#)
[Developer connection](#)
[Home](#)

Want to know more?

JUST
Google It!



The screenshot shows a Safari browser window with the title 'gammalib - Recherche Google'. The address bar contains the URL 'http://www.google.fr/search?client=safari&rls=en&q=GammaLib&ie=UTF8'. The search bar contains the text 'GammaLib'. Below the search bar, there are navigation tabs for 'Web', 'Images', 'Maps', 'Shopping', 'Applications', 'Plus', and 'Outils de recherche'. The search results show approximately 7,590 results found in 0.25 seconds. A message advises searching in French. The first result is 'GammaLib' from sourceforge.net, described as a self-contained, instrument-independent, open-source, multi-platform C++ library. The second result is 'GammaLib | Free Science & Engineering software downloads at ...' from sourceforge.net, with 6 stars and 6 votes, and a date of 12 Janv. 2013. The third result is 'gammalib | Fiche logiciel validé PLUME' from projet-plume.org, dated 3 days ago. The fourth result is 'GammaLib-A new framework for the analysis of Astronomical ...' from arxiv.org, dated 28 Oct. 2011. The fifth result is 'Overview - GammaLib - CTA IRAP Project Gateway' from cta-redmine.irap.omp.eu, dated 00-07-00. The sixth result is 'Wiki - GammaLib - CTA IRAP Project Gateway' from cta-redmine.irap.omp.eu, dated 00-07-00.