

Fermipy, Fermitools & the FSSC

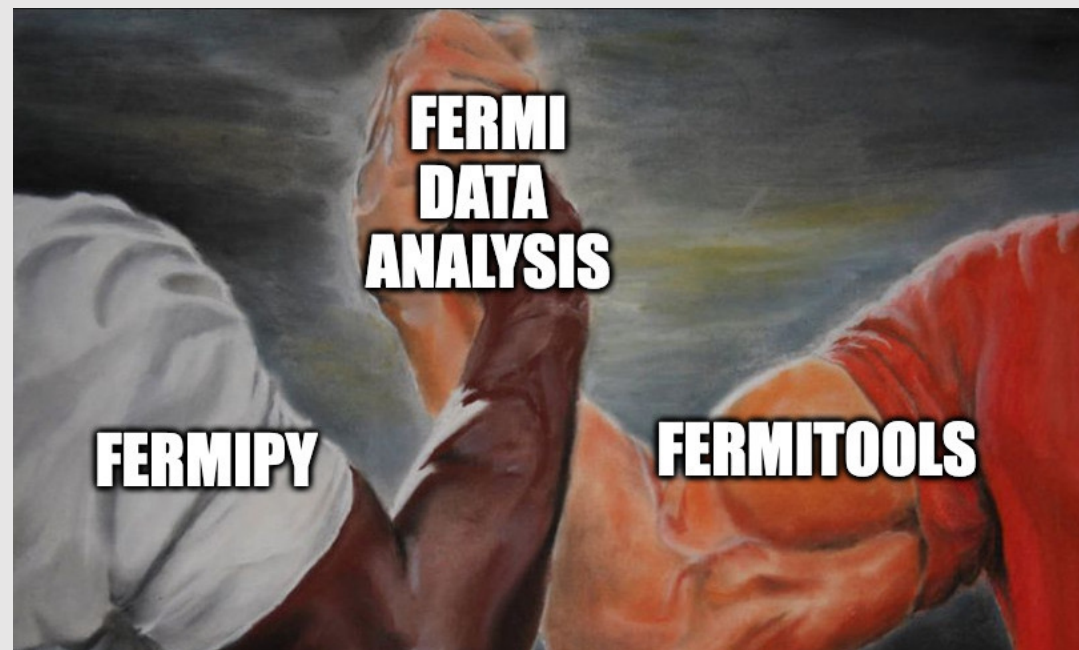
Alexander Reustle - FSSC Senior Software Engineer (NASA Goddard)

FSSC: Fermi Science Support Center

- NASA organization with teams at:
 - {Goddard, Marshall} Space Flight Center
- Analysis software tools: principally the ✨**Fermitools**✨
- User support: Fermi Guest Investigator (GI) program, Fermi-helpdesk, Fermi-summer-school.
- Mission timeline and spacecraft operations support.
- Public Dataserver and related data products: source catalogs, light curves, etc.

Fermipy & Fermitools

- Fermitools: a core dependency of fermipy
- Fermitools provides a Python interface 🐍 to key analysis packages:
 - **pyLikelihood**: maximum likelihood analysis of LAT data
 - **pyIrfLoader**: load instrument response functions
 - (Others not used by fermipy)



Fermipy



pyLikelihood



Fermitools

libLikelihood.so



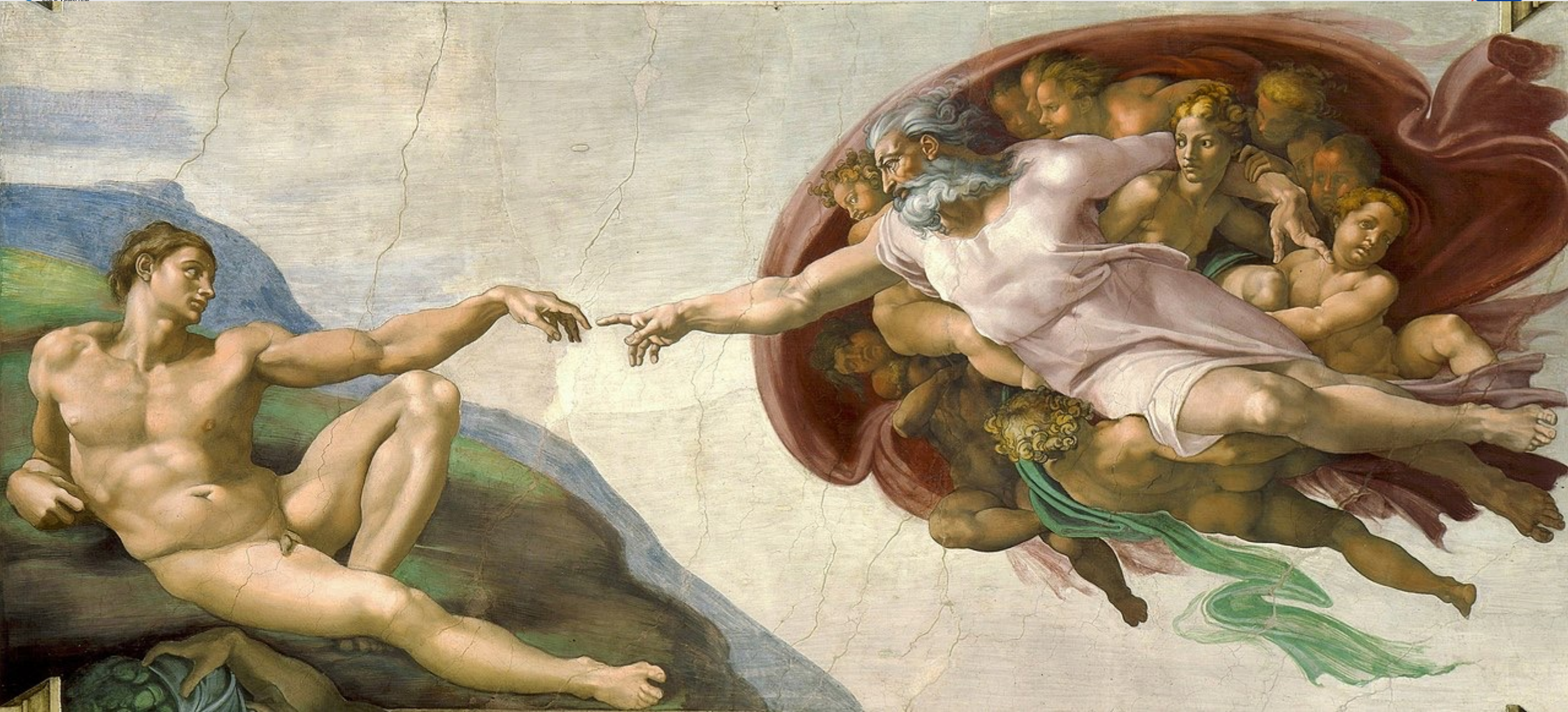
BinnedLikelihood

ModelMap

ExposureMap

PSFUtils

...



Fermitools: History

- Historically named *Fermi ScienceTools*.
- Primary development by contributors at SLAC, with support and contributions from fellow members to LAT-Collaboration.
 - Pre-launch development in the early 2000's.
 - Dual use: Public Sciencetools & GLASTRelease packages
- Currently maintained and supported by the FSSC.
- Open source on GitHub.
- Precompiled packages and dependency management with...

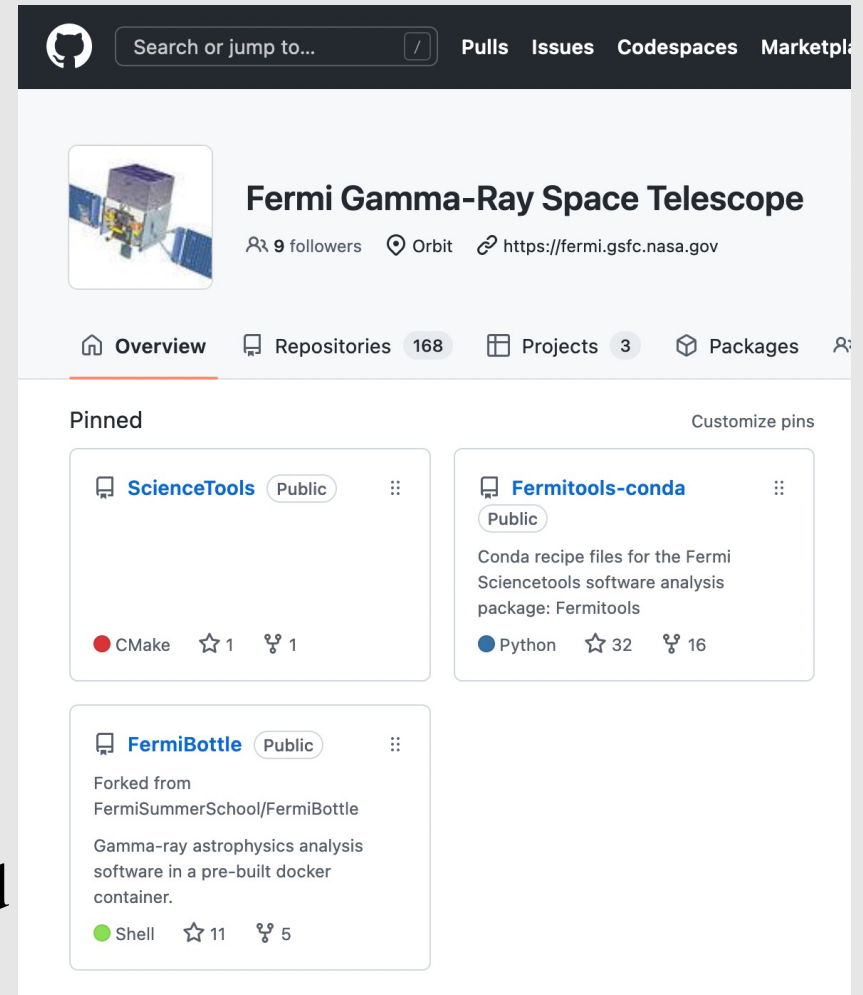
The CONDA logo, featuring the word 'CONDA' in a bold, green, sans-serif font. The letter 'C' is stylized with a green and white geometric pattern.

Fermitools LAT Data Analysis

- Command Line Tools for common data analysis types
 - Event property and GTI selection cuts: `gtselect`, `gtmktime`, `gtvcut`
 - Source analysis with BinnedLikelihood: `gtbin`, `gtexpcube2`, `gtsrcmaps`, `gtlike`
 - GRBs: `gtburst`
- Shared Object Libraries for third party applications like fermipy
- Analysis Threads:
<https://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/>
- Video Tutorials:
https://fermi.gsfc.nasa.gov/ssc/data/analysis/video_tutorials/

Fermitools: (*Open*) Source Code

- <https://github.com/fermi-lat/ScienceTools>
- C, C++ & Python legacy codebase
- Legacy Object-Oriented style
- (Git) submodules
 - Multiple Independent Repositories
 - Inherited from legacy CVS version control system.
- 2 Primary Top-Level repositories:
 - ScienceTools : Main Source Code Pkg.
 - Fermitools-Conda : Conda package build recipe and metadata.

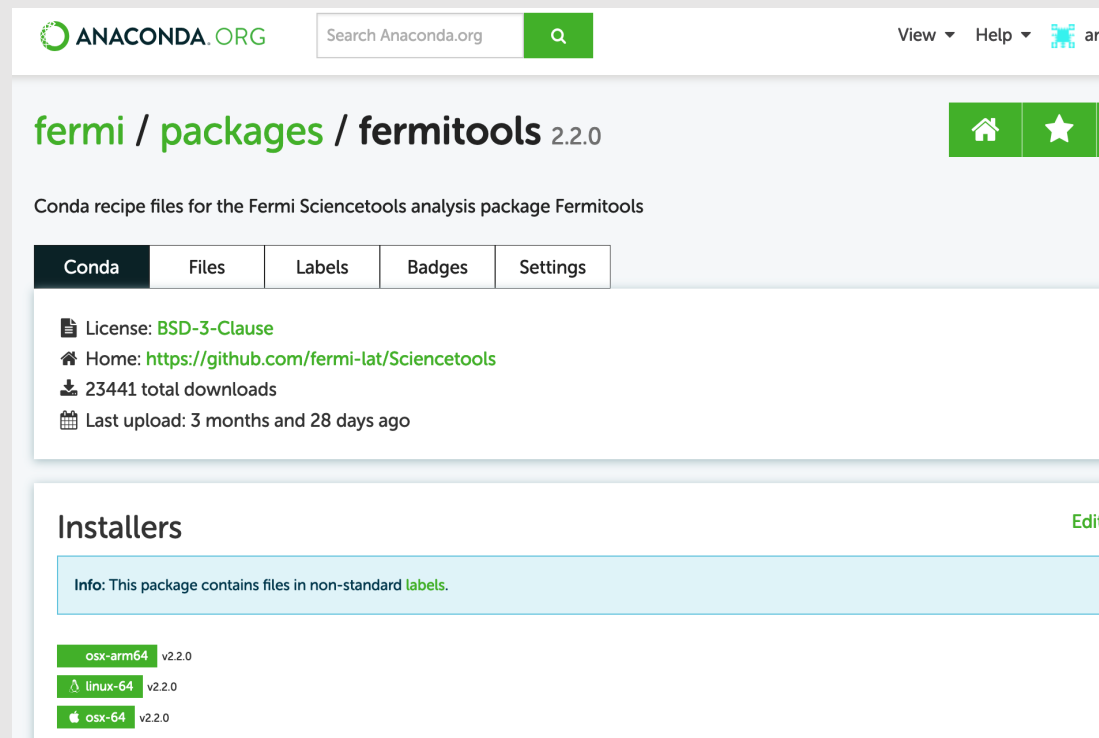


Fermitools: A Conda Package

- Package Manager & Public Cloud.
- Conflict-free versioning with isolated environments.
- Multi-platform pre-compiled “Universal” binaries:

	x86_64	arm64
Linux	✓	✓
MacOS	✓	✓

- External dependencies across all platforms.



The screenshot shows the Anaconda.org interface for the 'fermi / packages / fermitools 2.2.0' package. The page includes a search bar, navigation tabs (Conda, Files, Labels, Badges, Settings), and a section for 'Installers' with links to download the package for different operating systems and architectures.

fermi / packages / fermitools 2.2.0

Conda recipe files for the Fermi Sciencetools analysis package Fermitools

License: BSD-3-Clause
 Home: <https://github.com/fermi-lat/Sciencetools>
 23441 total downloads
 Last upload: 3 months and 28 days ago

Installers

Info: This package contains files in non-standard labels.

- osx-arm64 v2.2.0
- linux-64 v2.2.0
- osx-64 v2.2.0

Fermitools External Dependencies

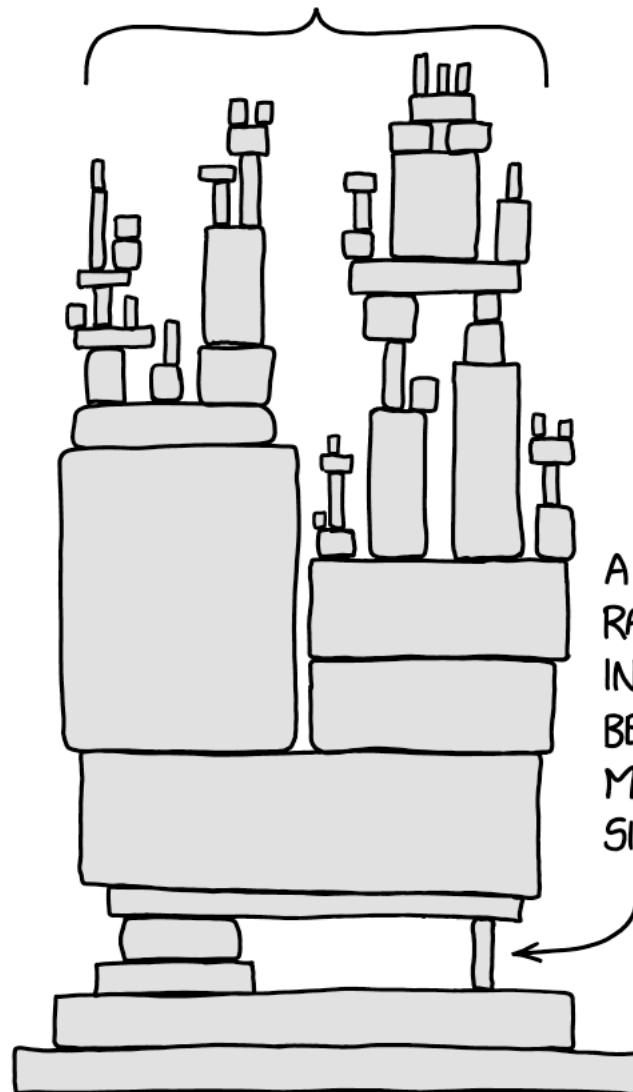
- Significant number of external dependencies, and transitive dependencies (deps of deps) managed by conda/mamba.
- Mostly require platform-specific pre-compiled binaries.

- `Python3.9`
- `Numpy`
- `Astropy`
- `Scipy`
- `Matplotlib`

Binary Dependencies:

- `CLHEP` (Common High Energy Physics functions)
- `Cfitsio` (FITS file interface)
- `f2c` (minuit optimizer dependency)
- `fftw3` (Fourier Transforms)
- `GSL` (Gnu Science Library)
- `wcslib` & `healpix` (coordinate geometry)
- `xerces-c` (XML parsing)
- ~~`CERN Root`~~ (Removed in FT version 2.2)

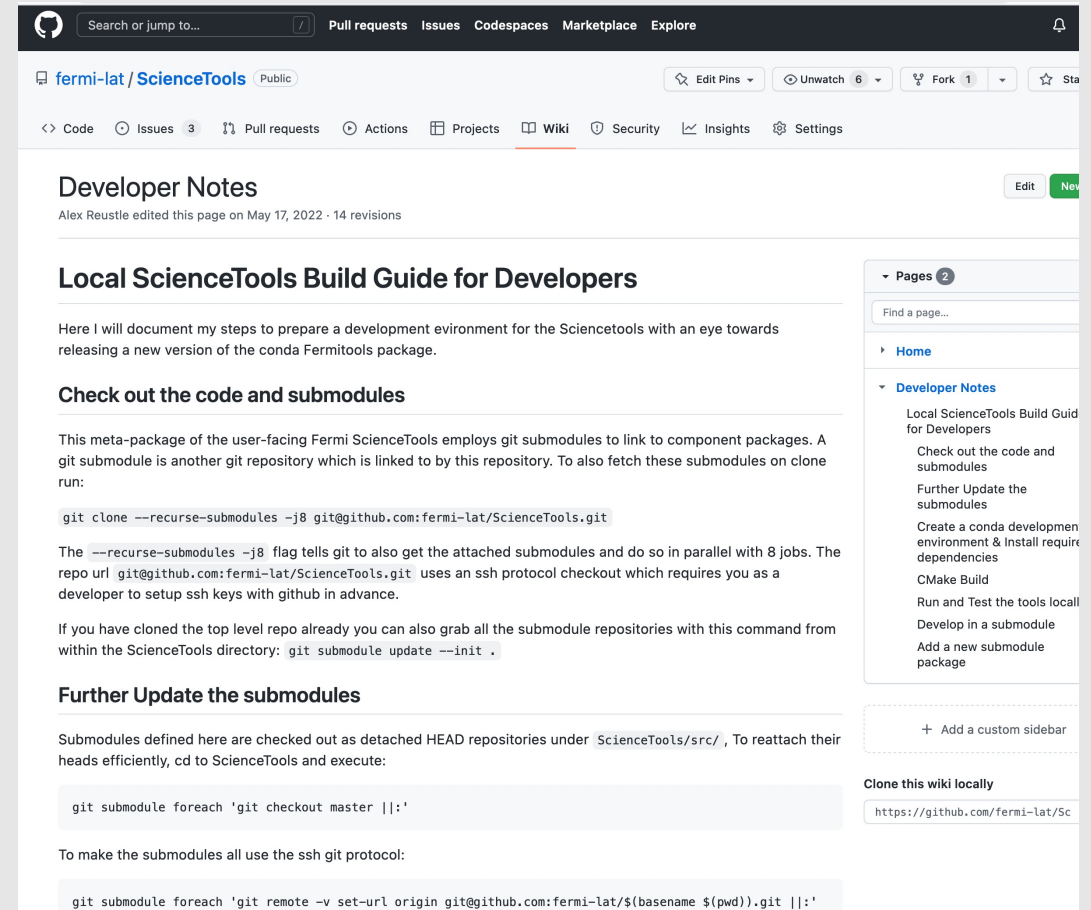
ALL MODERN DIGITAL INFRASTRUCTURE



A PROJECT SOME
RANDOM PERSON
IN NEBRASKA HAS
BEEN THANKLESSLY
MAINTAINING
SINCE 2003

Develop Fermitools Locally

1. Prepare local source code (Be careful of git submodules).
 2. Prepare Conda development environment (with build deps).
 3. CMake Build system (Legacy SCONS still available).
- github.com/fermi-lat/ScienceTools/wiki/Developer-Notes



The screenshot shows the GitHub interface for the `fermi-lat/ScienceTools` repository. The page is titled "Developer Notes" and is part of the "Wiki" section. The content includes a "Local ScienceTools Build Guide for Developers" which provides instructions on how to set up a development environment. Key steps mentioned include cloning the repository with submodules, checking out the code, and updating submodules. The page also includes a sidebar with a "Pages" section and a "Clone this wiki locally" button.

Developer Notes
Alex Reustle edited this page on May 17, 2022 · 14 revisions

Local ScienceTools Build Guide for Developers

Here I will document my steps to prepare a development environment for the Sciencetools with an eye towards releasing a new version of the conda Fermitools package.

Check out the code and submodules

This meta-package of the user-facing Fermi ScienceTools employs git submodules to link to component packages. A git submodule is another git repository which is linked to by this repository. To also fetch these submodules on clone run:

```
git clone --recurse-submodules -j8 git@github.com:fermi-lat/ScienceTools.git
```

The `--recurse-submodules -j8` flag tells git to also get the attached submodules and do so in parallel with 8 jobs. The repo url `git@github.com:fermi-lat/ScienceTools.git` uses an ssh protocol checkout which requires you as a developer to setup ssh keys with github in advance.

If you have cloned the top level repo already you can also grab all the submodule repositories with this command from within the ScienceTools directory: `git submodule update --init`.

Further Update the submodules

Submodules defined here are checked out as detached HEAD repositories under `ScienceTools/src/`, To reattach their heads efficiently, cd to ScienceTools and execute:

```
git submodule foreach 'git checkout master |:'
```

To make the submodules all use the ssh git protocol:

```
git submodule foreach 'git remote -v set-url origin git@github.com:fermi-lat/${basename $(pwd)}.git |:'
```

Fermitools Python Interface:

Or how I learned to stop worrying and love the SWIG

- SWIG: Simplified Wrapper and Interface Generator
- Provides a Foreign Function Interface (ffi) Wrapper for python
- User writes the “interface” file which swig translates into a compile-able C/C++ library matching Python’s Extension Module format
 - <https://docs.python.org/3/extending/extending.html>
- This library links into Fermitools Shared Objects, and is itself accessible by Python
- pyLikelihood.so → libLikelihood.so (.dylib on macOS)

Fermi Community!

Fermipy



Fermitools

SWIG
Generated

Fermitools Compiled

pyLikelihood.so



libLikelihood.so

BinnedLikelihood

ModelMap

ExposureMap

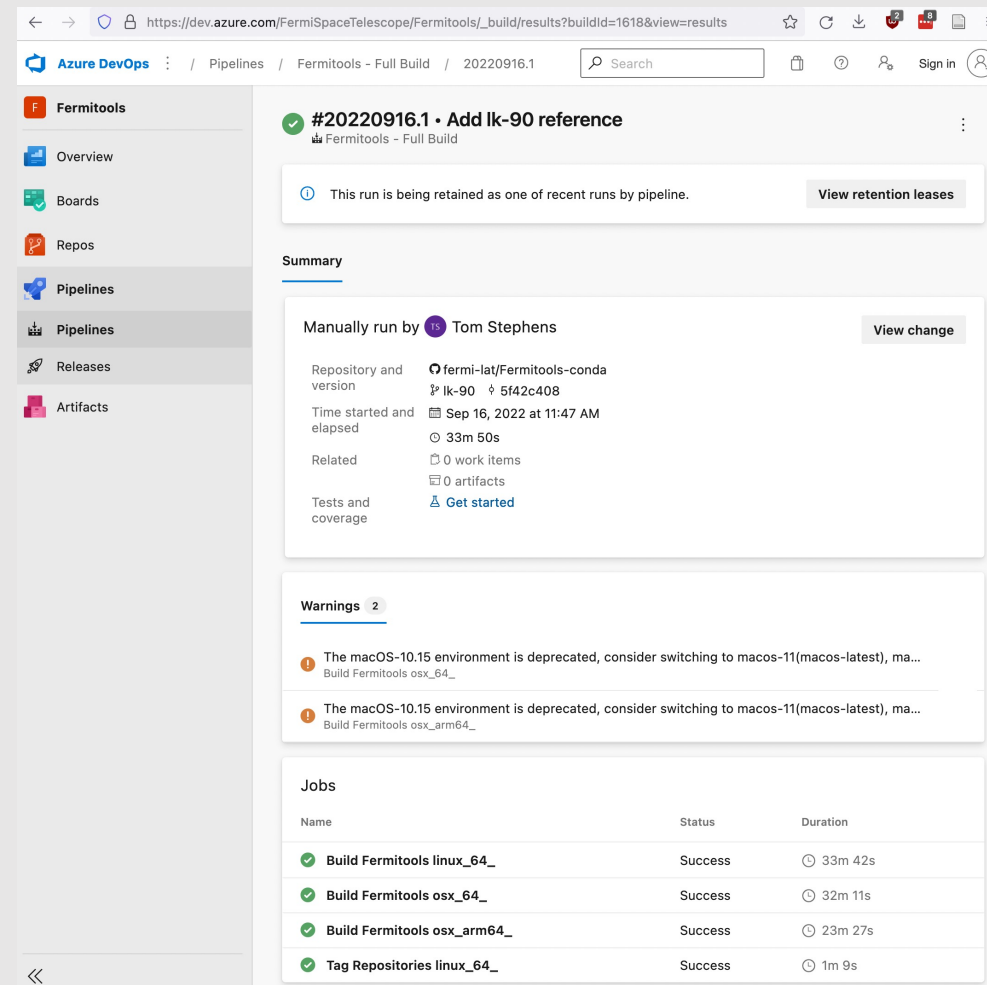
PSFUtils

...

The Fermitools CI/CD Pipeline Infrastructure

- Azure Pipelines.
- Automated Build & Test for all platforms.
- Deploy successful builds to Anaconda Cloud “dev” label

	x86_64	arm64
Linux	✓	✓
MacOS	✓	✓



The screenshot shows the Azure DevOps interface for a pipeline named 'FermiTools - Full Build'. The pipeline run #20220916.1 is shown as successful. The summary section indicates it was manually run by Tom Stephens. The repository is 'fermi-lat/FermiTools-cond' and the version is 'lk-90'. The build started on Sep 16, 2022, at 11:47 AM and took 33m 50s to complete. There are 0 work items and 0 artifacts. The jobs section lists four jobs: 'Build FermiTools linux_64_', 'Build FermiTools osx_64_', 'Build FermiTools osx_arm64_', and 'Tag Repositories linux_64_', all of which completed successfully.

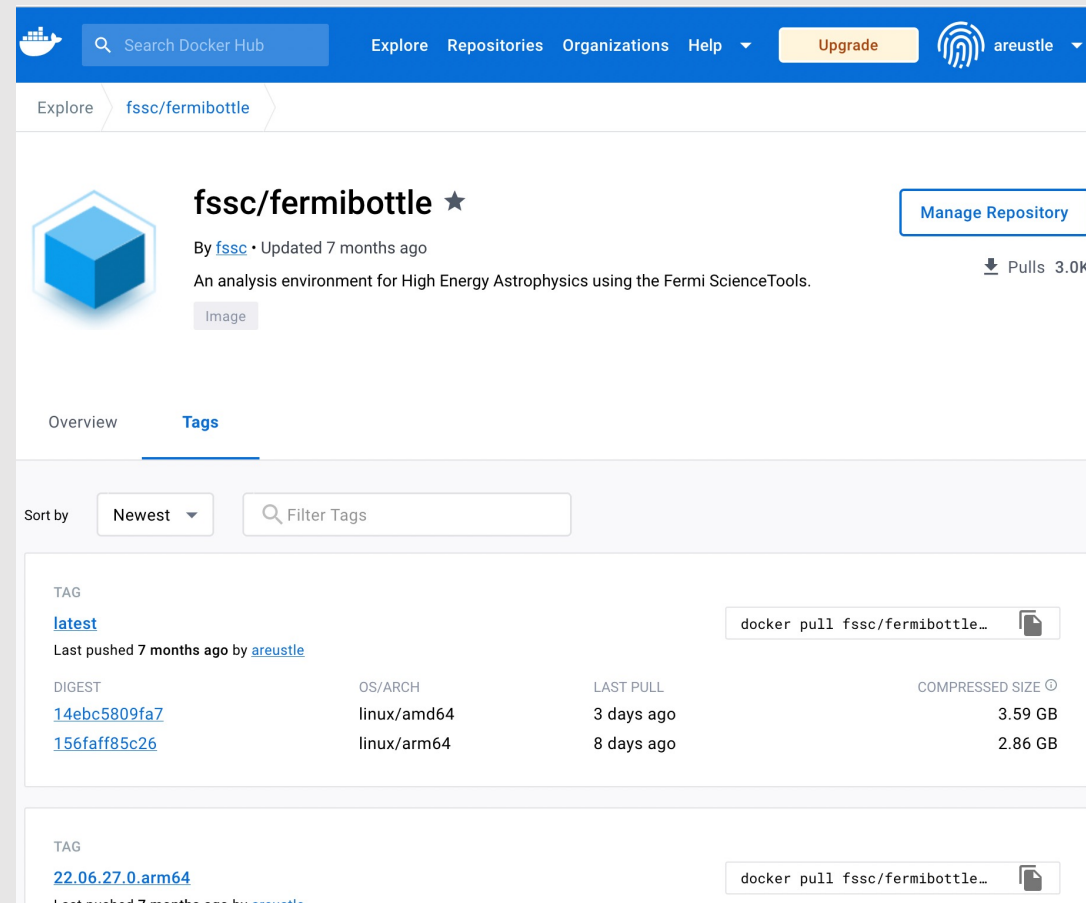
Fermitools Versioning Scheme

- Semantic versioning and release labels.
- New builds increment 3rd place “patch” version field.
- Even failed builds get a version number.
- Labels indicate a version’s status
 - `dev`: developmental, may break.
 - `rc`: release candidate, please test.
 - `main`: main release, use this!

<input type="checkbox"/>	conda	87.8 MB	linux-64/fermitools-2.2.2-py39h93a0a19_0.tar.bz2	6 months and 17 days ago	jasercion	14	dev	edit labels
<input type="checkbox"/>	conda	89.5 MB	linux-aarch64/fermitools-2.2.1-py39h216da61_0.tar.bz2	6 months and 25 days ago	fermi	1	dev	edit labels
<input type="checkbox"/>	conda	85.2 MB	osx-64/fermitools-2.2.0-py39h5f0296b_0.tar.bz2	6 months and 30 days ago	jasercion	744	main	edit labels
<input type="checkbox"/>	conda	84.0 MB	osx-arm64/fermitools-2.2.0-py39h10ad0fb_0.tar.bz2	6 months and 30 days ago	jasercion	61	main	edit labels
<input type="checkbox"/>	conda	90.0 MB	linux-64/fermitools-2.2.0-py39h93a0a19_0.tar.bz2	6 months and 30 days ago	jasercion	1652	main	edit labels
<input type="checkbox"/>	conda	85.3 MB	osx-64/fermitools-2.1.41-py39h5f0296b_0.tar.bz2	7 months and 5 hours ago	jasercion	3	dev	edit labels

FermiBottle: Containerized Fermi Analysis

- Docker container with Fermitools, Fermipy, GBM-tools and others
- Originally for the Fermi summer school
- Expanded scope and applicability
- A viable option for fermi analysis

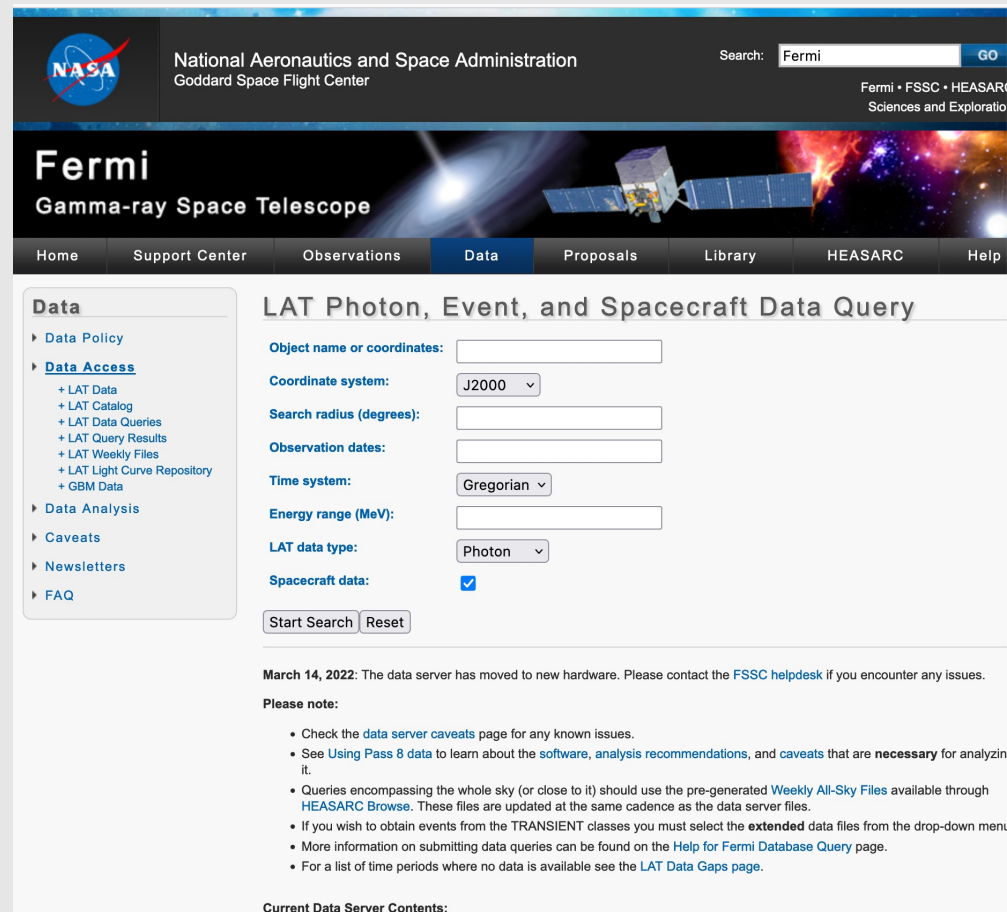


The screenshot shows the Docker Hub page for the repository **fssc/fermibottle**. The page includes a search bar, navigation links (Explore, Repositories, Organizations, Help), and a user profile for **areustle**. The repository is described as "An analysis environment for High Energy Astrophysics using the Fermi ScienceTools." and has 3.0K pulls. The **Tags** tab is selected, showing a list of tags with columns for TAG, DIGEST, OS/ARCH, LAST PULL, and COMPRESSED SIZE. The **latest** tag is highlighted, with a digest of **14ebc5809fa7** and a last pull 3 days ago. The **22.06.27.0.arm64** tag is also visible, with a digest of **156faff85c26** and a last pull 8 days ago. A **docker pull fssc/fermibottle...** command is shown in a box next to each tag.

TAG	DIGEST	OS/ARCH	LAST PULL	COMPRESSED SIZE
latest	14ebc5809fa7	linux/amd64	3 days ago	3.59 GB
22.06.27.0.arm64	156faff85c26	linux/arm64	8 days ago	2.86 GB

Fermi Dataserver

- Query-able Public access to photon, event, & spacecraft FT2 data.
- All-Sky search on {Time, Position, Energy} ranges.
- Hardware & Software upgrade enables more capabilities
- New selection cuts or pre-processing options?



The screenshot shows the Fermi Dataserver website. At the top, there is a NASA logo and the text "National Aeronautics and Space Administration" and "Goddard Space Flight Center". A search bar contains the word "Fermi" and a "GO" button. Below this, the "Fermi Gamma-ray Space Telescope" logo is displayed. A navigation bar includes links for Home, Support Center, Observations, Data (highlighted), Proposals, Library, HEASARC, and Help. The main content area is titled "LAT Photon, Event, and Spacecraft Data Query". It contains several input fields: "Object name or coordinates:", "Coordinate system:" (set to J2000), "Search radius (degrees):", "Observation dates:", "Time system:" (set to Gregorian), "Energy range (MeV):", "LAT data type:" (set to Photon), and "Spacecraft data:" (checked). There are "Start Search" and "Reset" buttons. Below the form, a notice dated March 14, 2022, states that the data server has moved to new hardware and provides contact information for the FSSC helpdesk. A "Please note:" section lists several important points for users, including checking the data server caveats page, using Pass 8 data, and selecting the extended data files. At the bottom, there is a link to "Current Data Server Contents".

Stats and Status

- Fermitool 2.2.0 released June 2022
 - ~2500 2.2.0 downloads
 - ~ 67% Linux
 - ~1000 FermiBottle (Docker) downloads in the past year
 - 3.5k over 5 years
- 2.3.0 work ongoing.
- Long-term performance improvement work ongoing.
- Data Downloads
 - ~890 TB of data downloaded.
 - ~120 TB in past year.
- LAT delivered 1.5 Billionth photon 2022-02-28
- 2022-03-14 New Dataserver hardware upgrade live!
 - Substantial backend performance improvements.
 - Forthcoming new functionality.
 - What is most worthwhile?

Questions?