Fermipy, Fermitools & the FSSC

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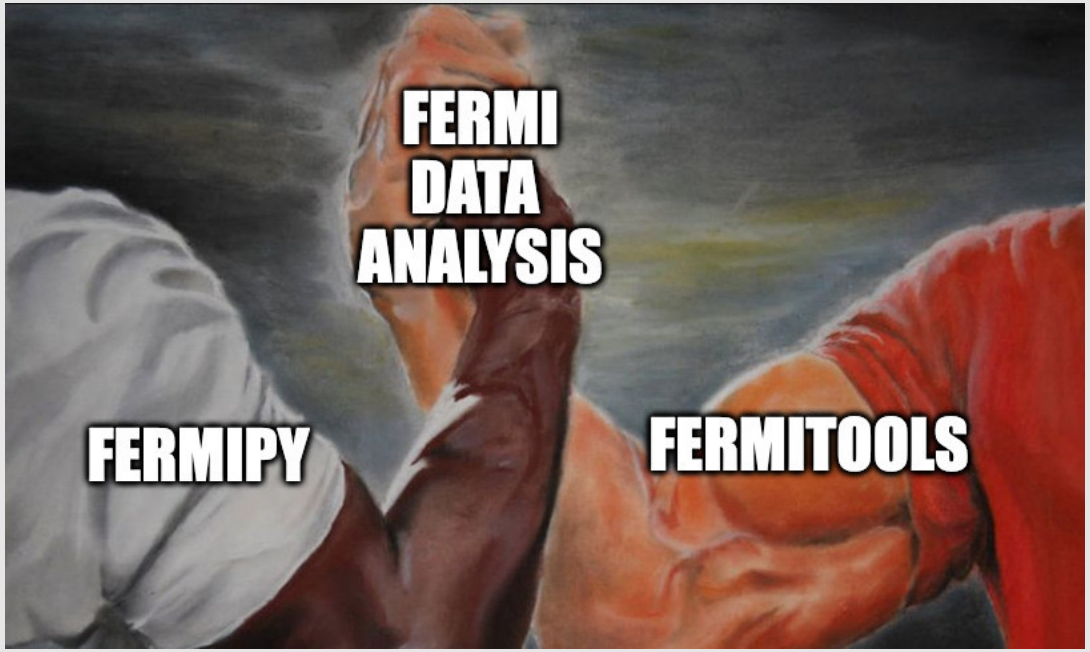
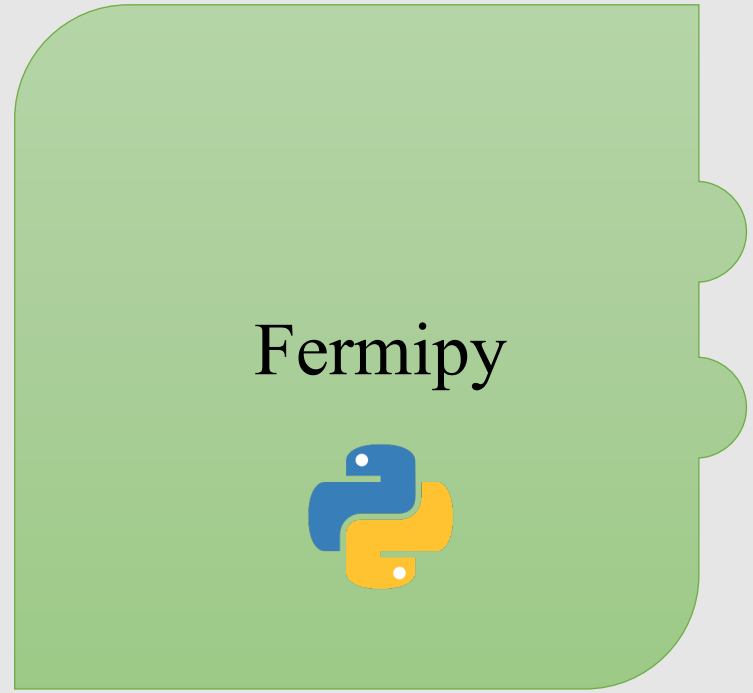
FSSC: Fermi Science Support Center

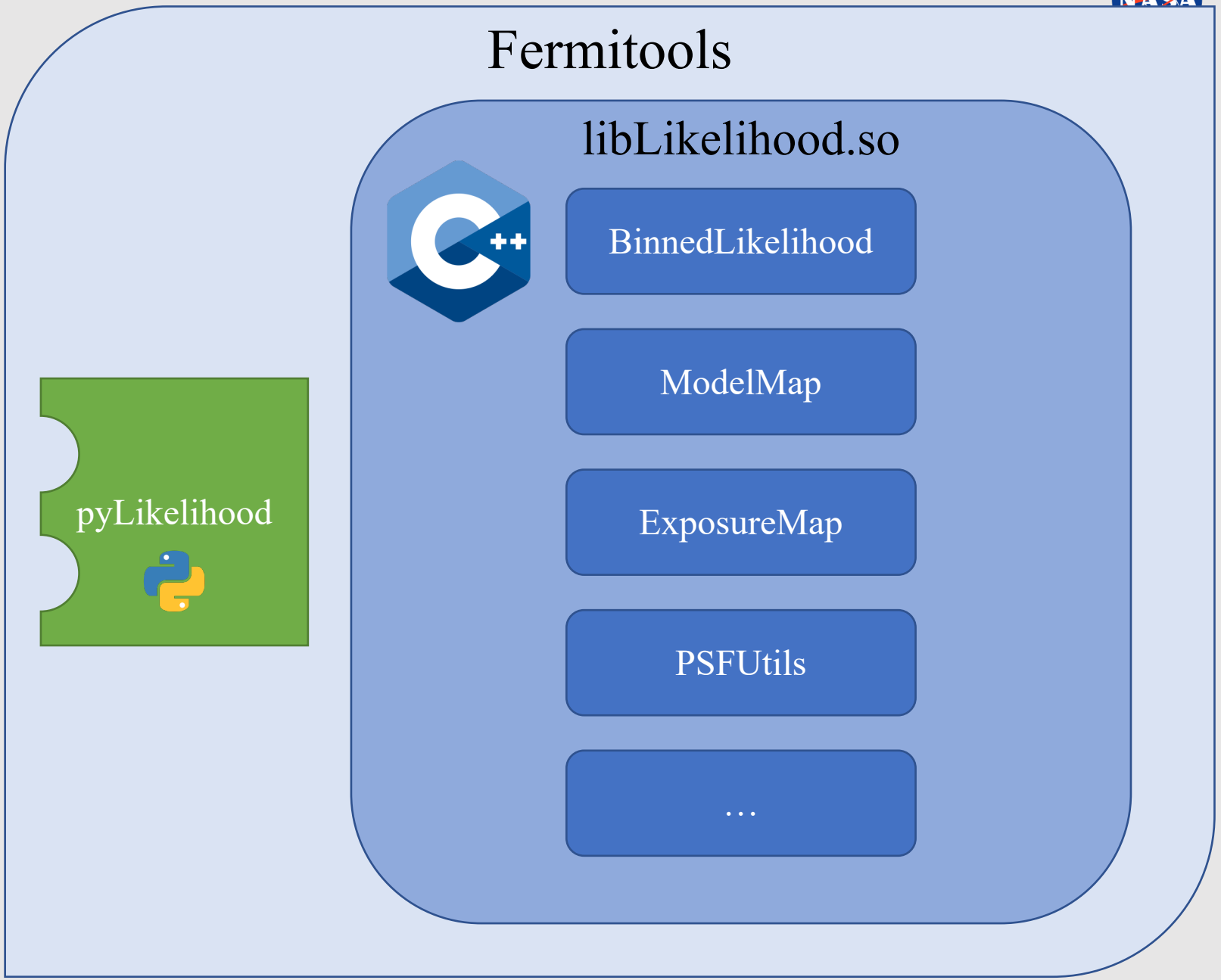
- NASA organization with teams at:
  - {Goddard, Marshall} Space Flight Center
- Analysis software tools: principally the ✨**Fermitools**✨
- User support: Fermi Guest Investigator (GI) program, Fermi-helpdesk, Fermi-summer-school.
- Mission timeline and spacecraft operations support.
- Public Dataserver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

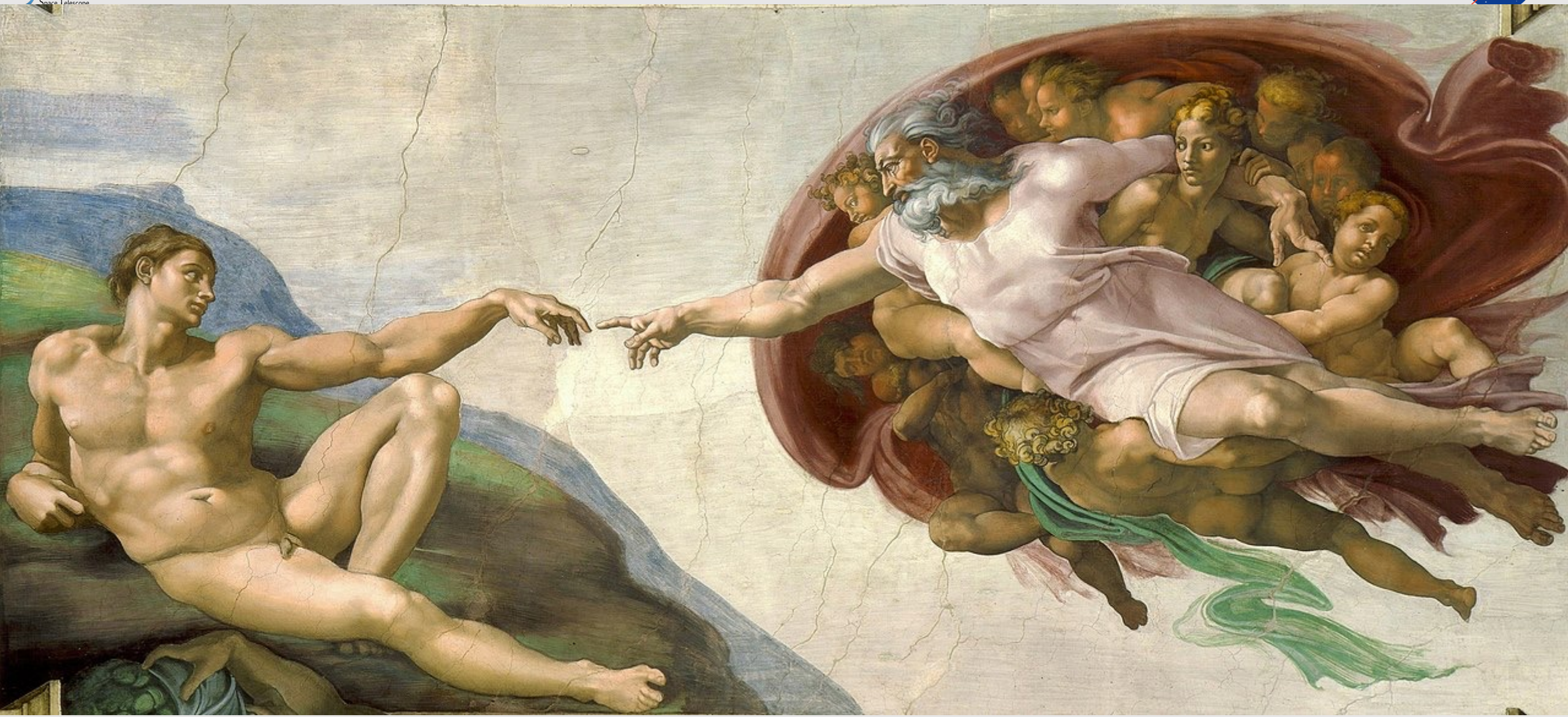
Fermipy & Fermitools

- 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


Fermitools
libLikelihood.so
BinnedLikelihood
ModelMap
ExposureMap
PSFUtils
…
pyLikelihood



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…

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

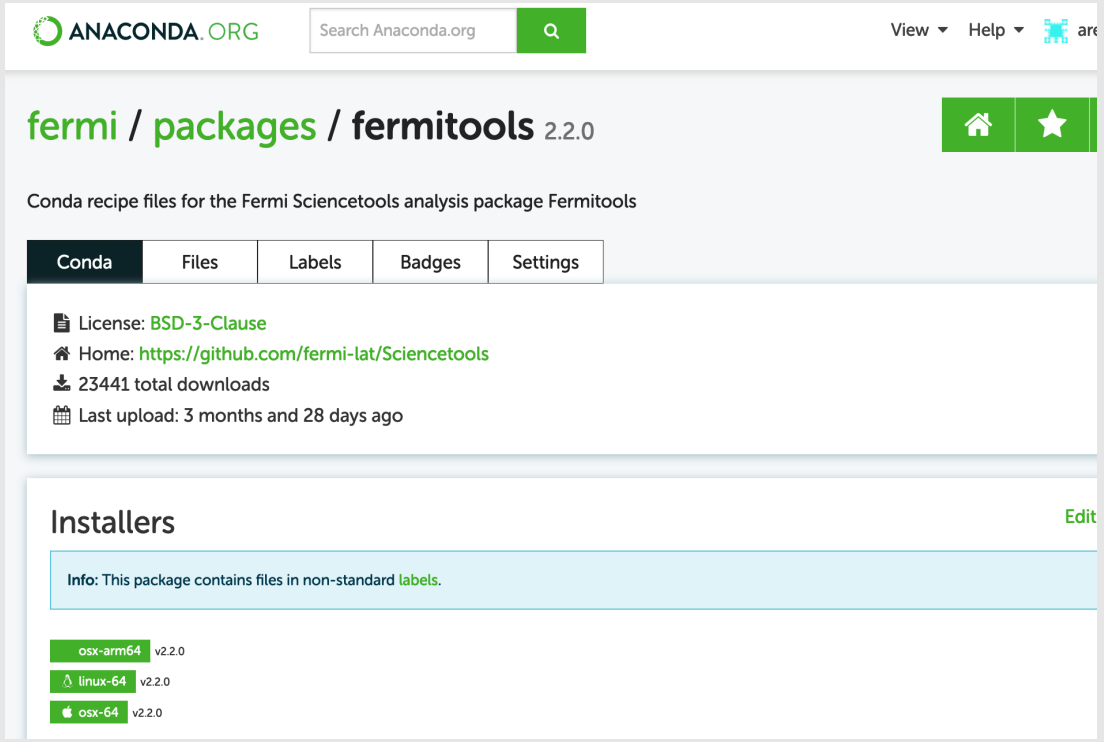
- https://github.com/fermi-lat/ScienceTools
- C, **C++** & Python legacy codebase
- Legacy Object-Oriented style
- (Git) submodules
  - Multiple Independent Repositories
  - Inherited from legacy CVS version control system.
- 2 Primary Top-Level repositories:
  - `ScienceTools` : Main Source Code Pkg.
  - `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.



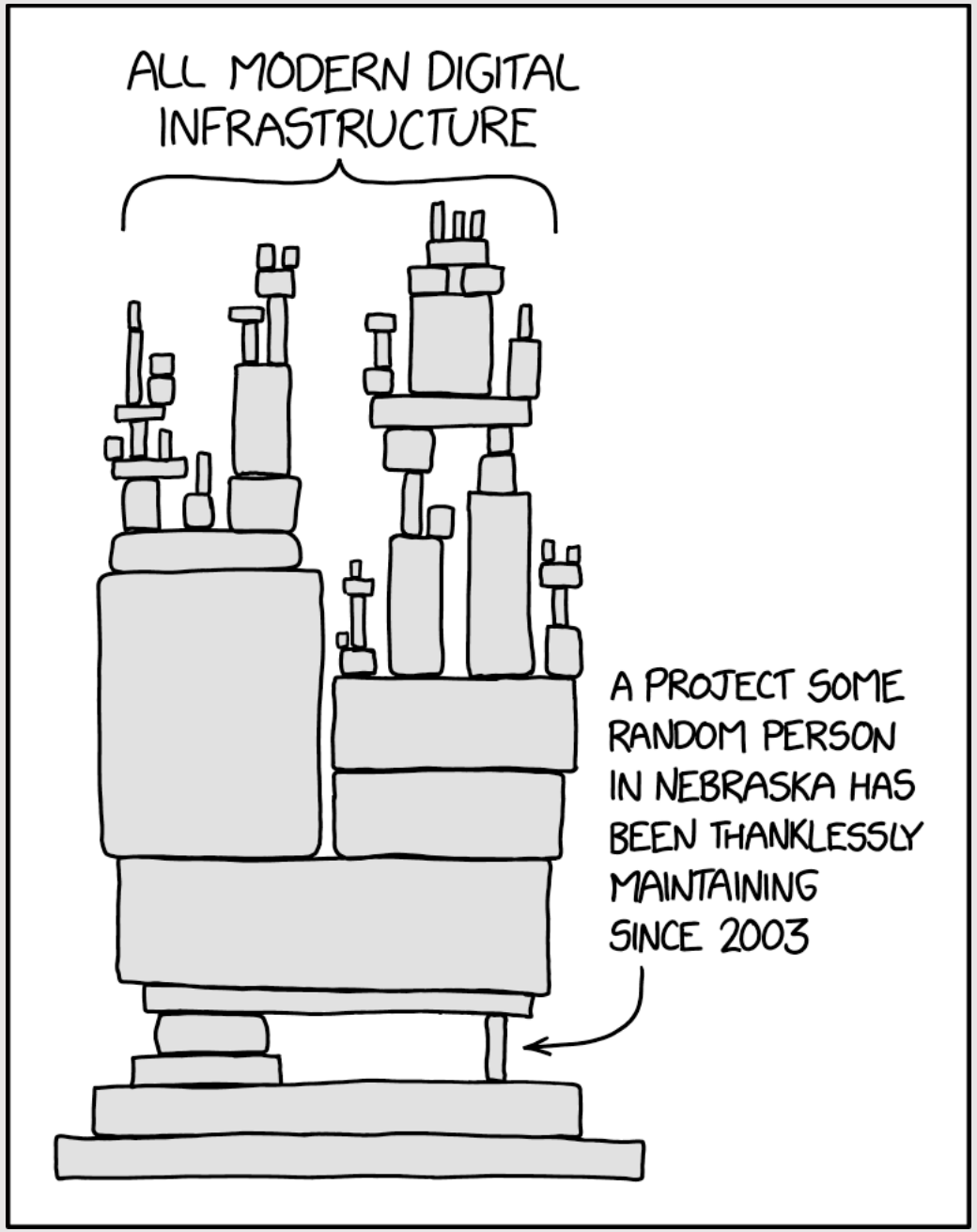
Fermitools External Dependencies

- 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:

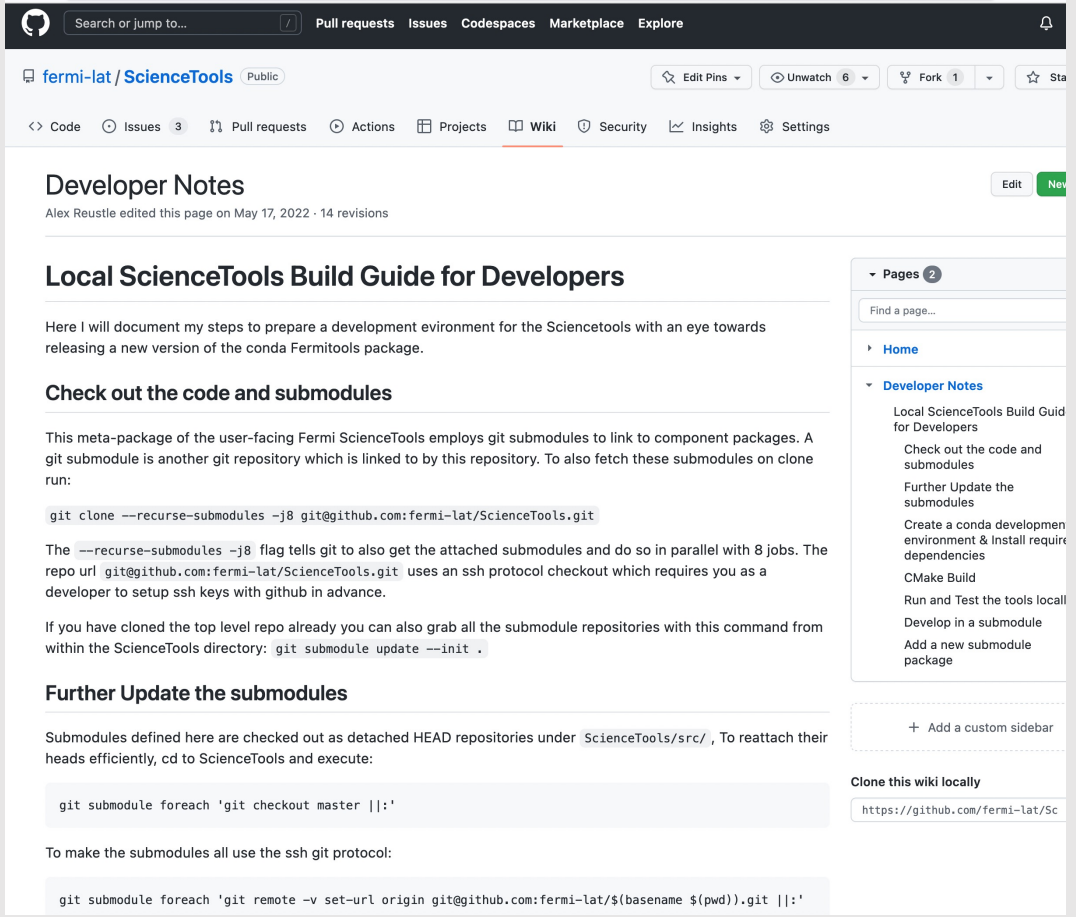
- `CLHEP` (Common High Energy Physics functions)
- `Cfitsio` (FITS file interface)
- `f2c` (minuit optimizer dependency)
- `fftw3` (Fourier Transforms)
- `GSL` (Gnu Science Library)
- `wcslib` & `healpix` (coordinate geometry)
- `xerces-c` (XML parsing)
- ~~`CERN Root`~~ (Removed in FT version 2.2)


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



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

pyLikelihood.so

Fermitools Compiled

libLikelihood.so

BinnedLikelihood

ModelMap

ExposureMap

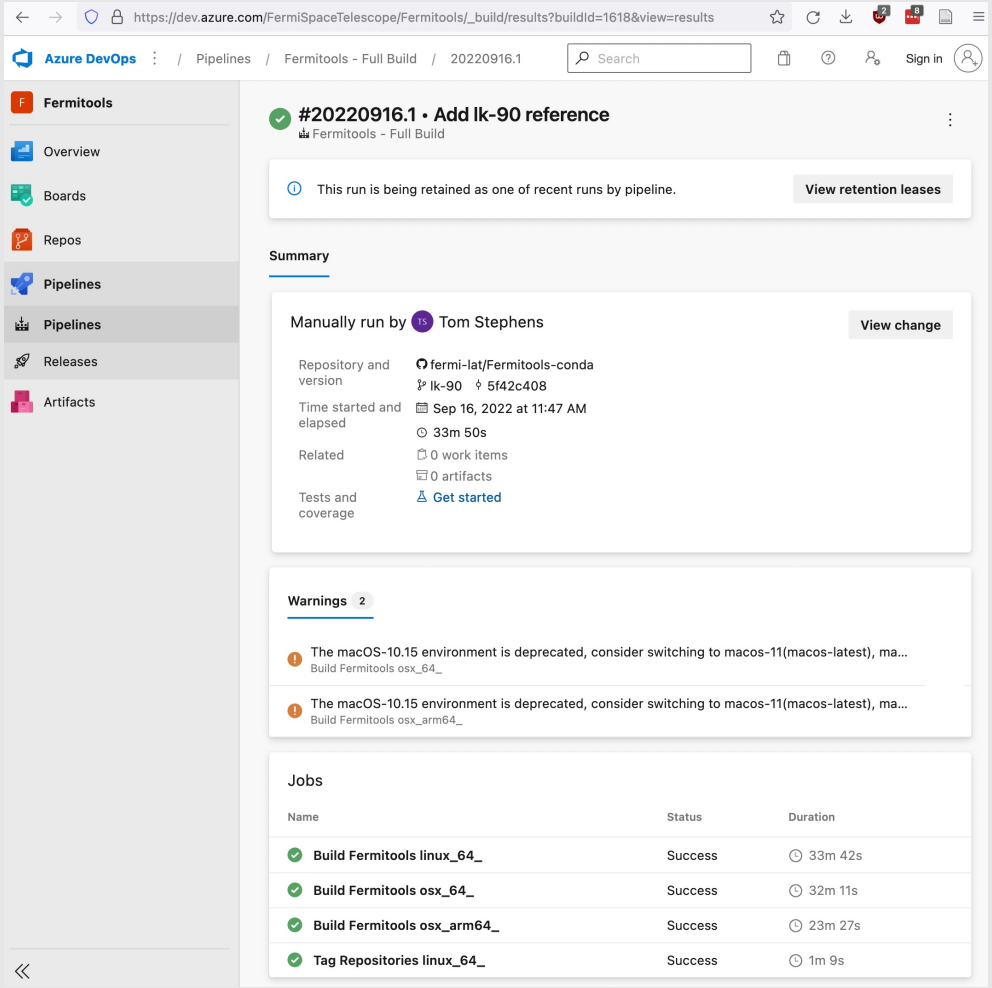
PSFUtils

…

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	✅	✅



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!

☐	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
☐	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
☐	conda	85.2 MB	osx-64/fermitools-2.2.0-py39h5f0296b_0.tar.bz2	6 months and 30 days ago	jasercion	744	main dev rc edit labels
☐	conda	84.0 MB	osx-arm64/fermitools-2.2.0-py39h10ad0fb_0.tar.bz2	6 months and 30 days ago	jasercion	61	main dev rc edit labels
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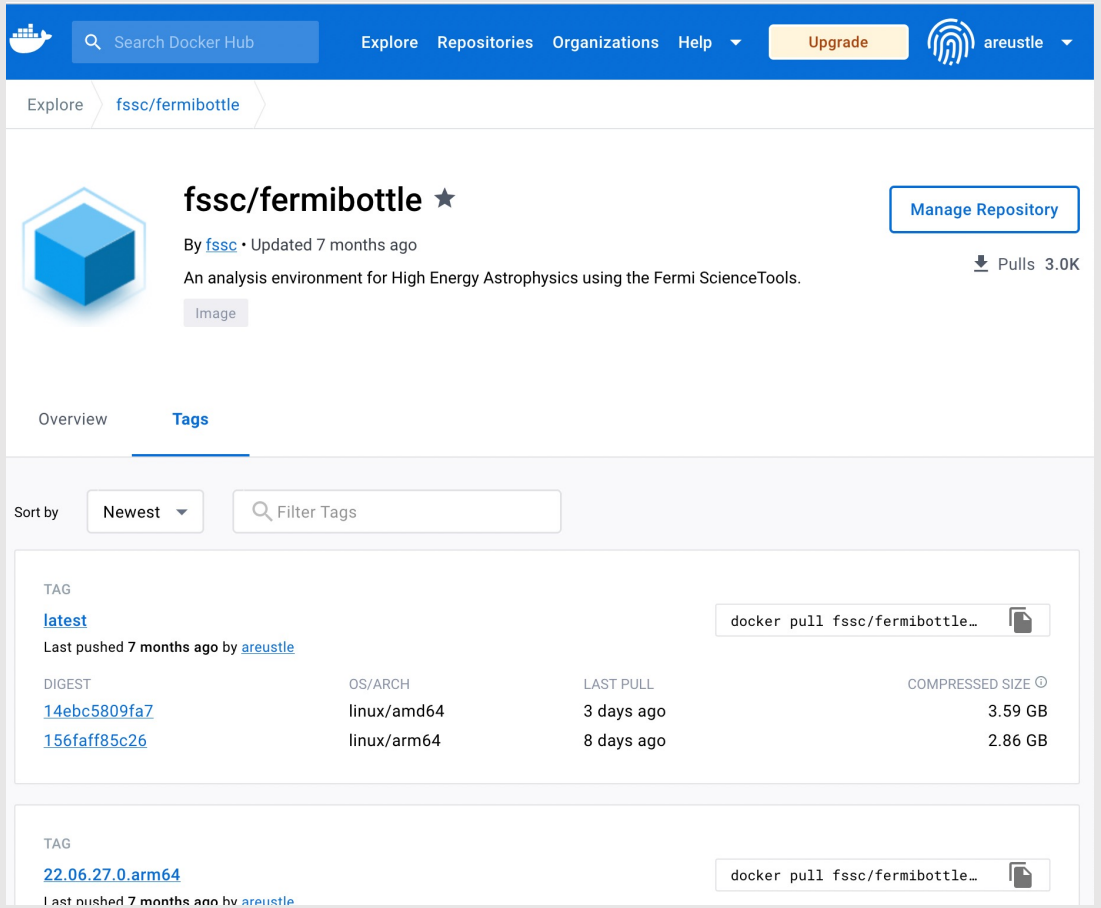
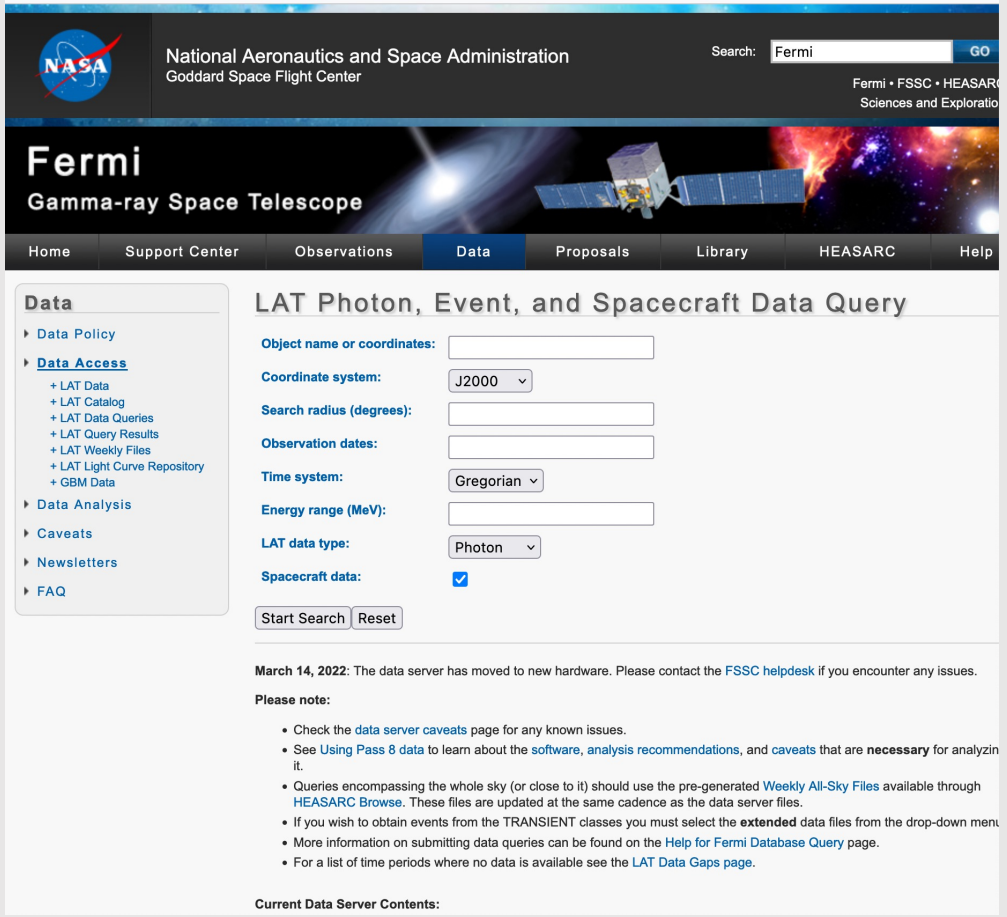
FermiBottle: Containerized Fermi Analysis

- 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



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?



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?

Fermi Gamma-ray Space Telescope

NASA

Questions?