GooFit 2.0

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UNIVERSITY OF Cincinnati

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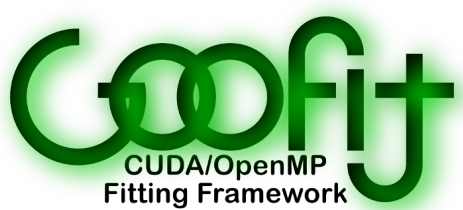


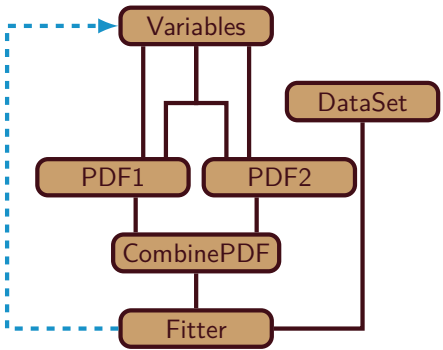
/GooFit/GooFit LGPLv3

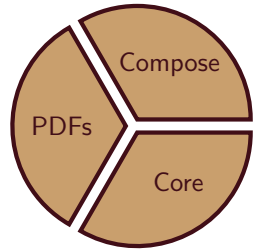
- Resembles the RooFit package
- Built for CUDA GPUs
- Also supports OpenMP on CPUs

Classic features

- PDF composition
- PDFs for amplitude analyses
- Binned and unbinned fits

Features of a fit





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Powerful composition of PDFs

- Long list of built-in PDFs
- Combination PDFs using addition, multiplication, convolution, composition, etc.
- 100+ Variables possible
- Advanced users can create new PDFs
- Expert users can extend GooFit core

Common GPUs

Classic CPUs DP

$2.7\,\mathrm{MHz} \times 2\,\mathrm{cores} \times 16\,\mathrm{FLOP/cyc} = 86.4\,\mathrm{MFLOP/s}$
$2.4\,\mathrm{MHz} \times 24\,\mathrm{cores} \times 16\,\mathrm{FLOP/cyc} = 921.6\,\mathrm{MFLOP/s}$

NVIDIA GPUs

- Programing language: CUDA
- Massively parallel identical operations (SIMD)
- Separate memory model (coprocessor)

	Name	Stream processors	Clock	TFLOPS SP	TFLOPS DP	Cost
Gamer	GTX 1050 Ti	768	1290 Mhz	1.98	0.062	$150
	GTX 1080 Ti	3,584	1596 Mhz	11.3	0.33	$850
Server	Tesla K40	2,880	745 Mhz	4.29	1.43	$3,000
	Tesla P100	3,584	1329 Mhz	9.3	4.7	$10,000

Why use GooFit?

[Phys.Rev.Lett. 111 (2013) no.11, 111801]
[Phys.Rev. D93 (2016) no.11, 112014]
[Phys.Rev. D88 (2013) no.5, 052003]
[CHEP 2013]

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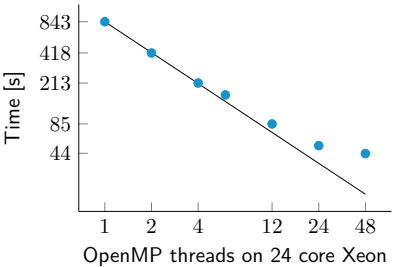

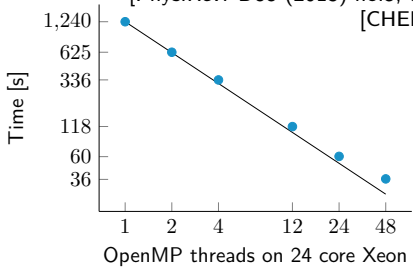

$\pi\pi\pi^0$, 16 time-dependent amplitudes

- Original RooFit code: 19,489 s single core

2 Cores	Core 2 Duo	1,159 s
GPU	GeForce GTX 1050 Ti	86.4 s
GPU	Tesla K40	64.0 s
MPI	Tesla K40 $\times 2$	39.3 s
GPU	Tesla P100	20.3 s

ZachFit: $M(D^{*+}) - M(D^0)$

- 142,576 events in unbinned fit

2 Cores	Core 2 Duo	738 s
GPU	GeForce GTX 1050 Ti	60.3 s
GPU	Tesla K40	96.6 s
MPI	Tesla K40 $\times 2$	54.3 s
GPU	Tesla P100	23.5 s

Why use GooFit? Reduce time to insight!

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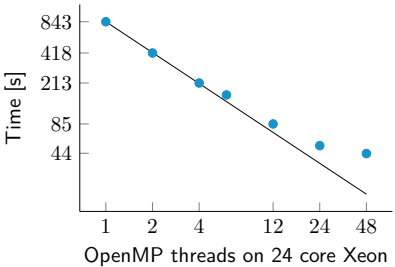

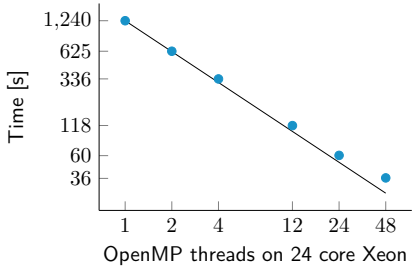

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New build features

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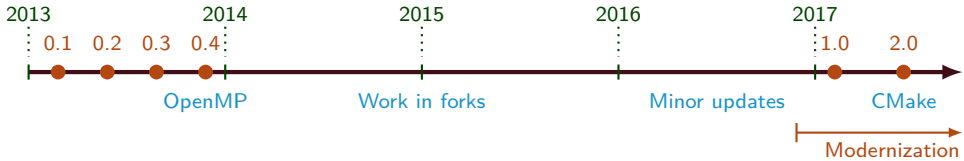


CMake enabled features

- Supports IDEs like XCode and QtCreator
- Support for macOS, CPP backend
- Datafiles auto-download (New datasets!)
- Auto-library download and discovery
- Helpers at /CLIUtils/cmake

Other build features

- Initial unit tests added
- Travis CI builds every push
- Travis powered documentation system
- Docker images available
- Example setup on new systems

It's easy to get started

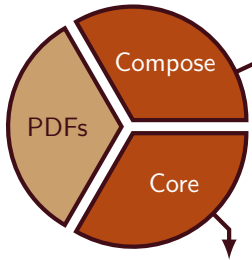

```
docker run -it ubuntu
apt-get update

apt-get install -y git cmake make g++
git clone --branch=stable https://github.com/GooFit/GooFit.git
cd GooFit
make
```

Simple installation

- More systems available on
- Or use Docker images: `goofit/goofit-omp` and `goofit/goofit-cuda`

New design features




```
./MyAnalysis generate_toy
    --params=file.ini
    --release_K892_mass
    --A12=0.3
    --plot
```

New design features

- C++11, extensive code cleanup
- Color logging, optimization warnings
- Simultaneous fit to disjoint datasets
- MPI support (GPUs or nodes)
- Optimizations for newer NVIDIA cards

/CLIUtils/CLI11 BSD

- Command line parser using C++11
- Help generation, Subcommands, validation, config files, 100% test coverage
- Designed to support toolkit customization

/GooFit/Minuit2 LGPLv2.1

- Extracted from ROOT 6.08, no changes
- Full CMake build system

New physics features

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Three body time-dependent amplitude analyses (TDAA)

- Mixing in $D^0 \to \pi^+\pi^-\pi^0$ TDAA (BaBar)
  [Phys.Rev. D93 (2016) no.11, 112014]
- Mixing and CP violation search in $D^0 \to K^0_S\pi^-\pi^+$, TDAA (LHCb)
  [CERN-THESIS-2015-348] (paper in preparation)

Four body time-integrated and time-dependent amplitude analyses

- Mixing parameters in $D^0 \to K^+\pi^-\pi^+\pi^-$ TDAA (LHCb)
  [CHEP 2016]

Toy Monte Carlo generation using /MultithreadCorner/MCBooster

- MIPWA in GooFit, such as $D^+ \to h^-h'^+h'^+$ (LHCb)
  [CHEP 2016]

GooFit 2.1: Python bindings

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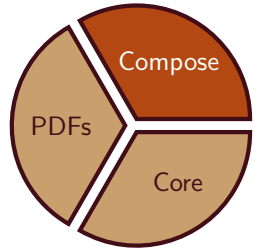
```
pip install scikit-build cmake
pip install -v goofit
```

Downloads and installs all of GooFit!



Prototype in GooFit 2.0

- Intended to be interface to composition
- All backends supported
- Only one PDF in GooFit 2.0
- Using CMake and PyBind11

Working on features 2.1 Himadri Pandey

- All PDFs added, including composition PDFs
- Install development version with `pip`
- Pythonization of objects ongoing
- Converting/adding examples/documentation

GooFit 2.1: Python bindings example


```
from goofit import *
import numpy as np

xvar = Variable("xvar", -10, 10)
xdata = UnbinnedDataSet(xvar)
npdata = np.random.normal(1, 2.5, 100000)
xdata.from_numpy([npdata], filter=True)

mean = Variable("mean", 0, -10, 10)
sigma = Variable("sigma", 1, 0, 5)
gauss = GaussPdf("gauss", xvar, mean, sigma)

exppdf.fitTo(data)

grid, values = gauss.evaluatePdf(xval)
```

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exppdf.fitTo(data)

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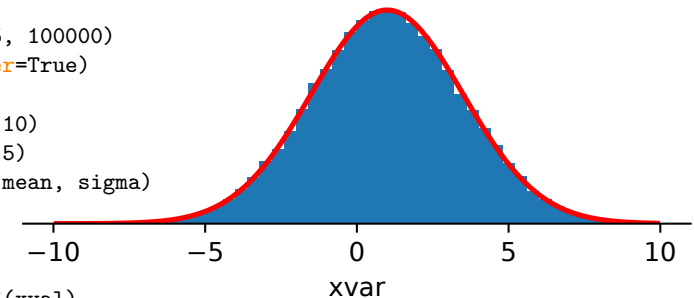
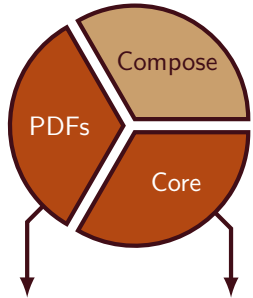
```

Data for red line PDF plot



GooFit future



New PDF indexing system

- Designed by Bradley Hittle at OSC
- Simpler PDF authoring
- We can alter core later

Other plans

- /multithreadcorner/Hydra (optional inclusion)
- GooFit 2torial: henryiii.gitbooks.io/GooFit
- Drop support for CMake < 3.8

Summary

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GooFit 2.0 — Available now

- Much easier to start using
  - Automated CMake builds
  - More supported platforms including macOS
  - Easy backend selection:
    OpenMP, CUDA, CPP, partial TBB
- More examples and PDFs
- Added example datasets
- Added MPI and performance enhancements

GooFit 2.1 — Coming soon

- Python bindings for composition
- Development releases on PyPI now

GooFit 2.x series

- Simpler PDF authoring
- Extended documentation
- Hydra inclusion
- CMake 3.8+ requirement

Acknowledgments

- A. Augusto Alves Jr.
- Rolf Andreassen
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- Bradley Hittle
- Zachary Huard
- Brian Maddock
- Himadri Pandey
- Michael Sokoloff
- Liang Sun
- Karen Tomko

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goofit.github.io

Questions?

henry.schreiner@uc.edu

Give our projects a try and a star on !

/GooFit/GooFit
/GooFit/Minuit2
/CLIUtils/CLI11
/CLIUtils/cmake
/multithreadcorner/Hydra

Running Timing Examples

General notes

- You can pick cards with the prefix: `CUDA_VISIBLE_DEVICES=0,1`

$\pi\pi\pi^0$

- `time ./pipipi0DPFit canonical dataFiles/cocktail_pp_0.txt --blindSeed=0`
- `time mpiexec -np 2 ./pipipi0DPFit canonical dataFiles/cocktail_pp_0.txt --blindSeed=0`

ZachFit

- `time ./zachFit 0 1`
- `time mpiexec -np 2 ./zachFit 0 1`

Command line parsing


```
./MyAnalysis generate_toy
       --params=file.ini
       --release_K892_mass
       --A12=0.3
       --plot
```

Recurring theme

- Analyses require 40+ options and multiple procedures
- Found a lot of duplicated code for argument parsing
- Many bugs related to parsing (usually segfaults)
- Needed powerful solution, with direct access to values

CLI11

/CLIUtils/CLI11 BSD

- No dependencies
- Compiles to single header file

Features

- Nested subcommands
- Configuration files
- 100% test coverage
- CI tests on macOS/Linux/Windows
- + GooFit's features

Use in GooFit

- Testbed for new build features

`GooFit::Application`

- Auto logging
- Optimization warnings
- GPU switches
- MPI support
- Completely optional