snewpy

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Photo: NNN 2023 in Procida, Italy

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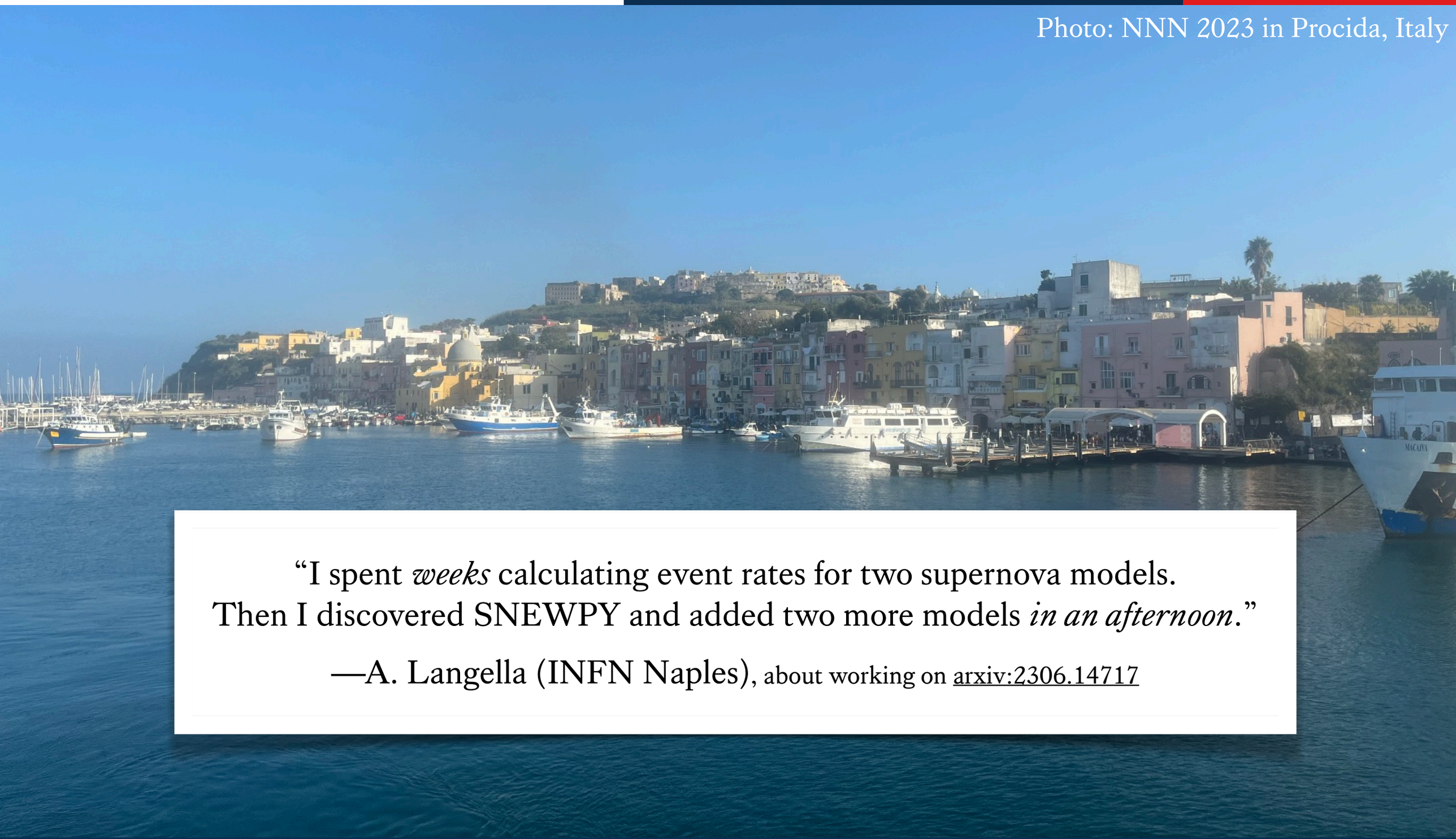


"I spent *weeks* calculating event rates for two supernova models.
Then I discovered SNEWPY and added two more models *in an afternoon*."

—A. Langella (INFN Naples), about working on arxiv:2306.14717

About Me

- 10 years on Hyper-K & 5 years on SNEWS 2.0
- Have dabbled in ...
  - Liquid Argon (DUNE)
  - Liquid Scintillator (LSC@Yemilab, arxiv:2309.13435)
  - WbLS (Theia)
- Now Senior Research Software Engineer at KCL
  - Maintainer of SNEWPY, SNOwGLoBES & sntools

That input file contains the flux of ν_μ *or* ν_τ and *not* the sum of both!

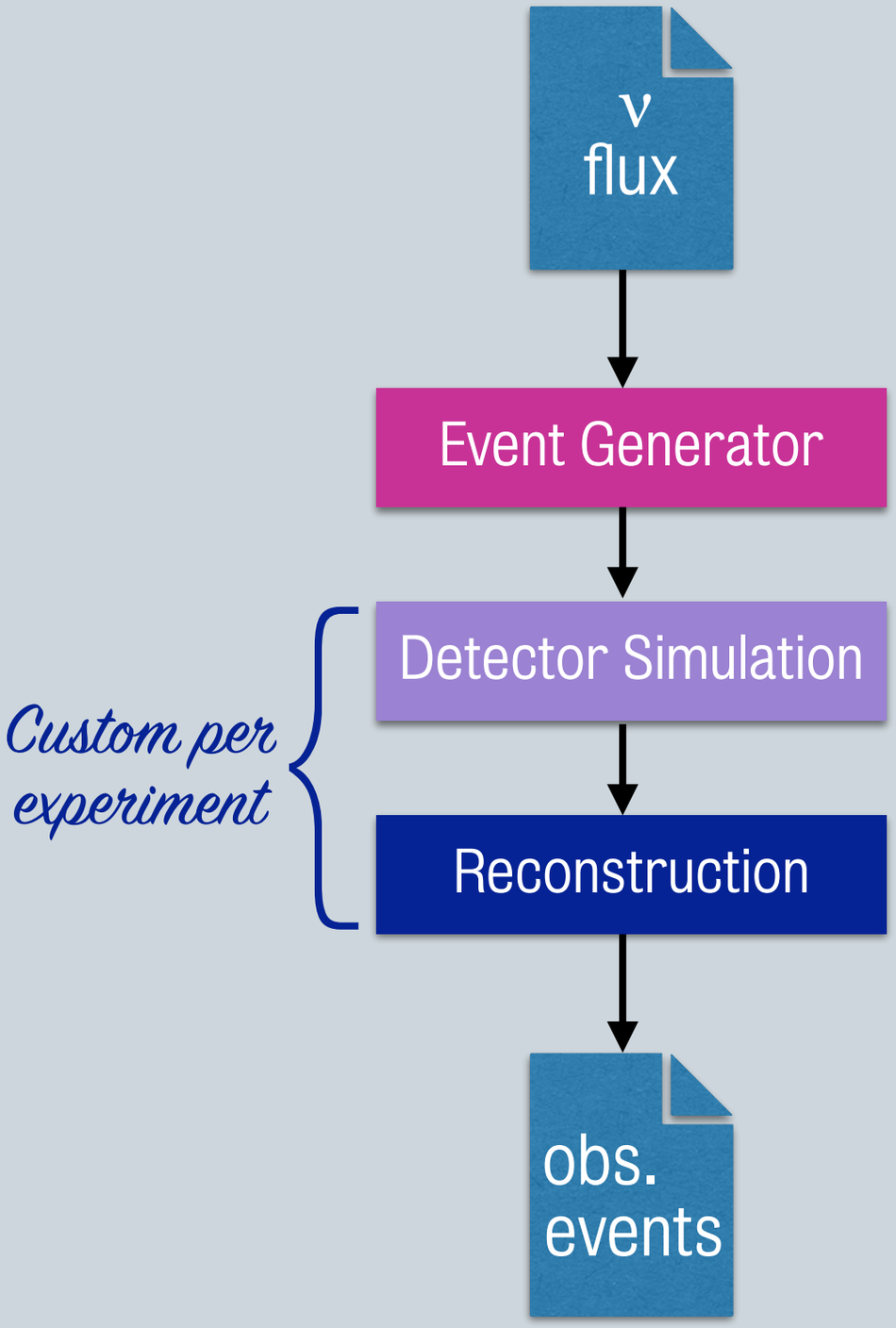
Software matters!

We had a bug in the script that produced the tabulated values in the paper.

Our previous event generator implemented an old cross section that was off by ~30%

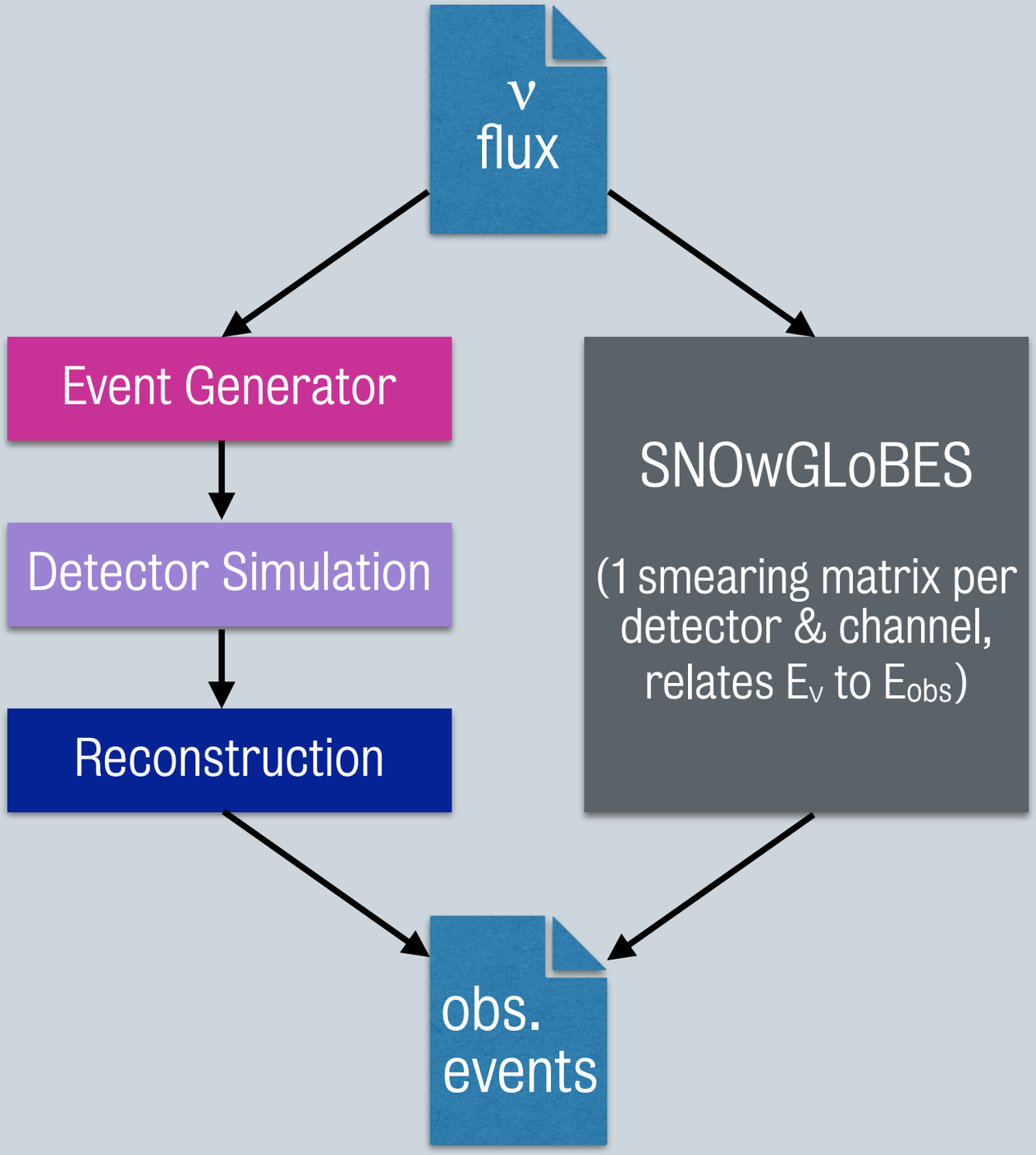
Based on three real examples I have witnessed.

Determining the Detector Response



- Event generators implement the cross sections, energy & angular distribution of outgoing particles, and more
  - MARLEY (mainly Ar)
  - sntools (H_2O, LS, WbLS)
  - *… and some proprietary ones*
- Problem: Steep learning curve, inaccessible for external groups, computationally expensive

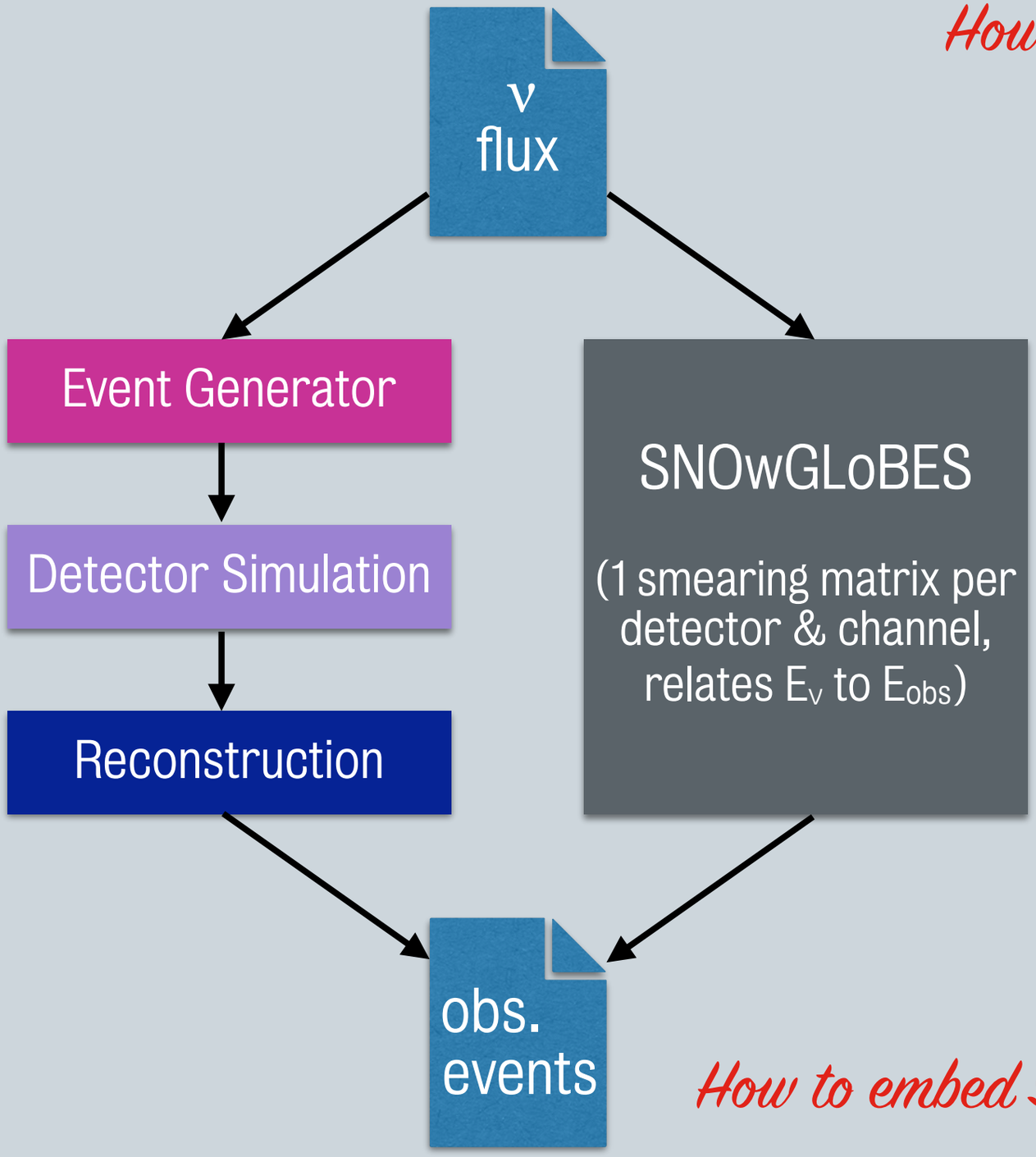
Determining the Detector Response



- github.com/SNOwGLoBES/snowglobes
- Orders of magnitude faster & covers *many* use cases
- Still need event generator for advanced studies (e.g. directionality, n capture)

Determining the Detector Response

Where to get fluxes from different SN models?



How to apply transformations to ν flux before reaching the detector?

- github.com/SNOwGLoBES/snowglobes
- Orders of magnitude faster & covers *many* use cases
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How to embed SNOwGLoBES in a Python-based workflow?

SNEWPY Offers ...

Where to get fluxes from different SN models?

- ... a simple and unified interface to hundreds of supernova simulations.

How to apply transformations to ν flux before reaching the detector?

- ... a large library of flavor transformations that relate neutrino fluxes produced in the supernova to those reaching a detector on Earth.

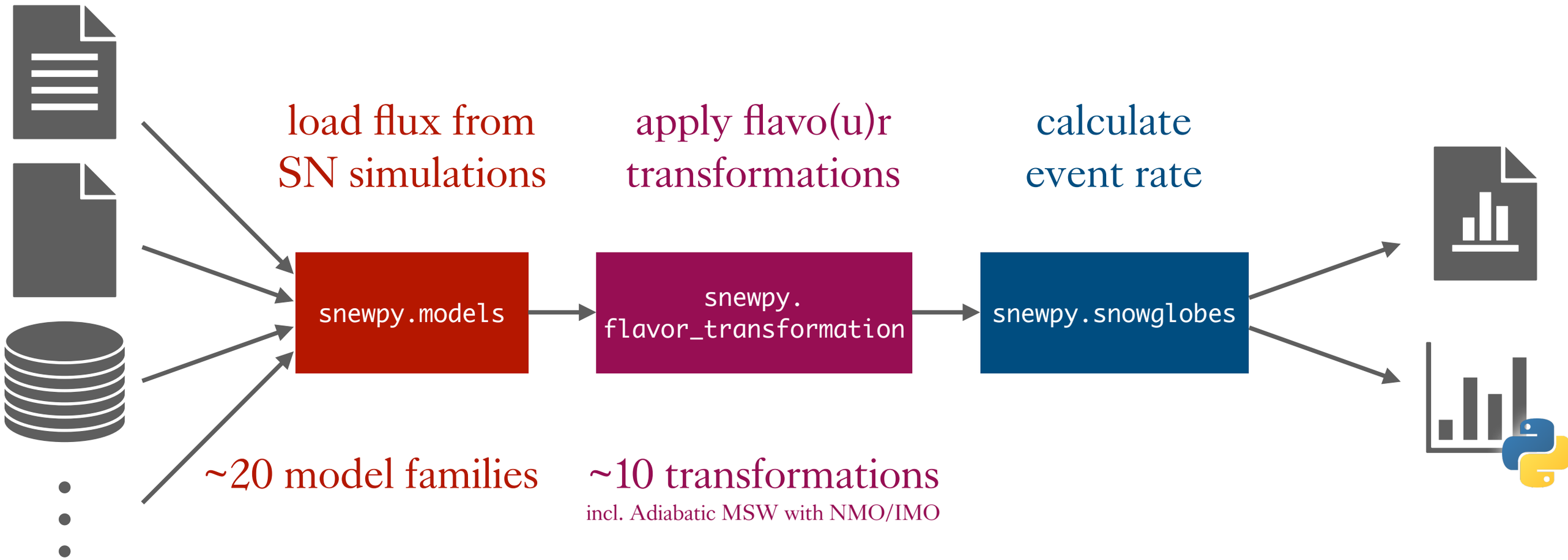
How to embed SNOwGLoBES in a Python-based workflow?

- ... and a Python interface to SNOwGLoBES to integrate into your existing workflows.

ApJ 925 (2022) 107
JOSS 6 (2021) 03772
github.com/SNEWS2/snewpy

Design of SNEWPY

snewpy



Modular design makes it easy to contribute!

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github.com/SNEWS2/snewpy

Selected Papers Using SNEWPY

SNEWPY is used by many groups across our field(s)

Exploiting synergies between neutrino telescopes for the next galactic core-collapse supernova

DOI:10.1051/epjconf/202328005002

Meriem Bendahman[1,3], *Anne-Cécile* Buellet[2], *Matteo* Bugli[2], *Joao* Coelho[1], *Alexis* Coleiro[1], *Gwenhaël* de Wasseige[1], *Sonia* El Hedri[1,*], *Thierry* Foglizzo[2], *Davide* Franco[1], *Isabel* Goos[1], *Yahya* Tayalati[3], *Alessandra* Tonazzo[1], *Cristina* Volpe[1]

Neutrino Echos following Black Hole Formation in Core-Collapse Supernovae

Samuel Gullin,[1] Evan P. O'Connor,[1] Jia-Shian Wang,[2] and Jeff Tseng[2]

arXiv:2109.13242

[1] *The Oskar Klein Centre, Departmen … Stockholm University, AlbaNova, SE-106 …*

[2] *Department of Physics, Oxford University, Oxfor…*

Detectability of hadron-quark phase transition in neutrino signals of failing core-collapse supernova

arXiv:2203.05141

Zidu Lin,[1] Shuai Zha,[2] Evan P. O'Connor,[3] and Andrew W. Steiner[1,4]

[1] *…d Astronomy, University of Tennessee Knoxville*

…nghai Jiao Tong University, Shanghai 200240, China

…in Centre, Department of Astronomy, …, AlbaNova, SE-106 91 Stockholm, Sweden

…ion, Oak Ridge National Laboratory

(Dated: March 11, 2022)

Uncovering the neutrino mass ordering with the next galactic core-collapse supernova neutrino burst using water Cherenkov detectors

arXiv:2210.11676

César Jesús-Valls[1,*]

[1] *Kavli IPMU (WPI), UTIAS, The University of Tokyo, Kashiwa, Chiba 277-8583, Japan*

Earth tomography with supernova neutrinos at future neutrino detectors #17

Rasmi Hajjar (Valencia U., IFIC and SSM, Naples), Olga Mena (Valencia U., IFIC), Sergio Palomares-Ruiz (Valencia U., IFIC) (Mar 16, 2023)

Low- and High-energy Neutrinos from SN 2023ixf in M101 #14

2303.09369 [hep-ph]

Dafne Guetta (Ariel U. Ctr., Samaria), Aurora Langella (Nap… and INFN, Naples), Silvia Gagliardini (Ariel U. Ctr., Samaria and INFN, Rome), Massimo Della Valle (Ariel U. Ct…

Published in: *Astrophys.J.Lett.* 955 (2023) 1, L9 • e-Print: …

Physics Potential of a Few Kiloton Scale Neutrino Detector at a Deep Underground Lab in Korea #5

Seon-Hee Seo (IBS, Daejeon, CUP), Jose Alonso (MIT, Cambridge, Dept. Phys.), Pouya Bakhti (Jeonbuk Natl. U.), Janet Conrad (MIT, Cambridge, Dept. Phys.), Steve Dye (U. Hawaii, Honolulu) et al. (Sep 23, 2023)

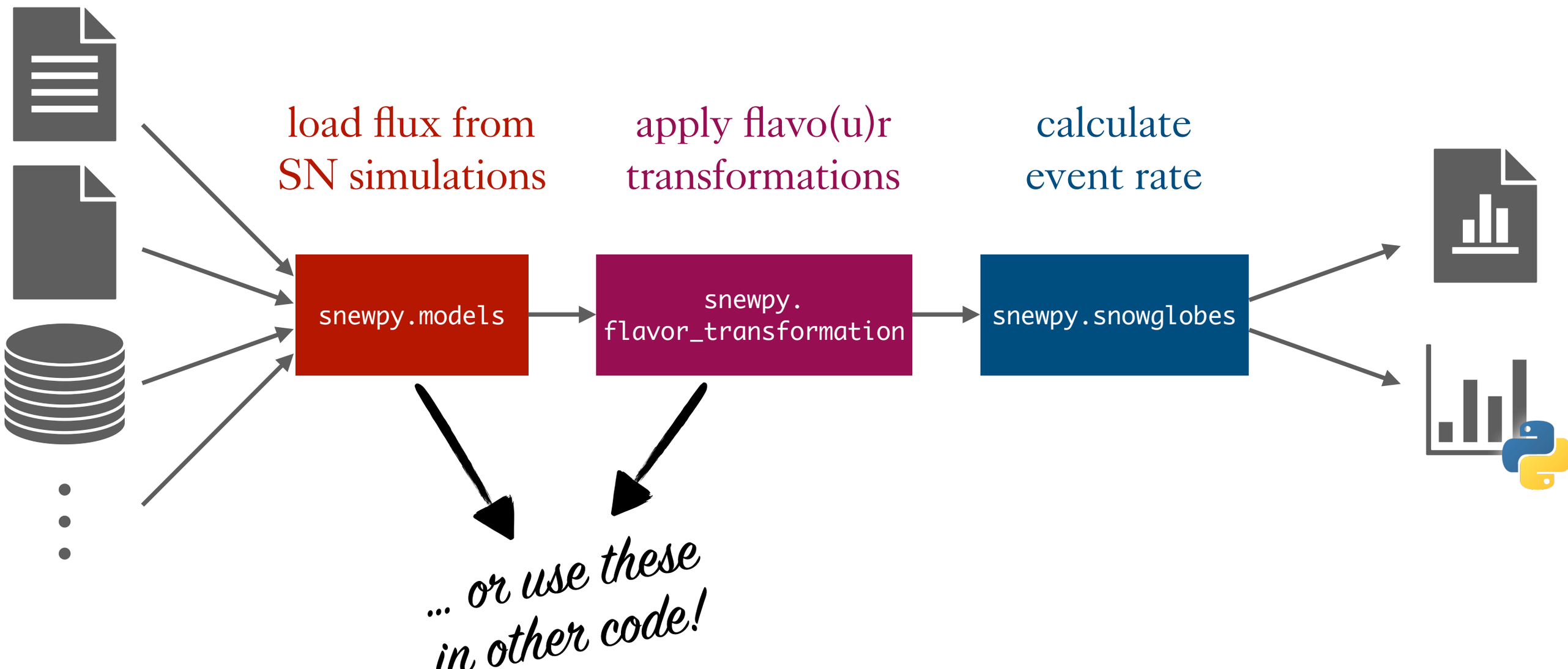
e-Print: 2309.13435 [hep-ex]

Imagine if each group had to write this boilerplate code themselves!

Modular Design Enables Reuse

snewpy

Can use SNEWPY as a complete analysis pipeline ...



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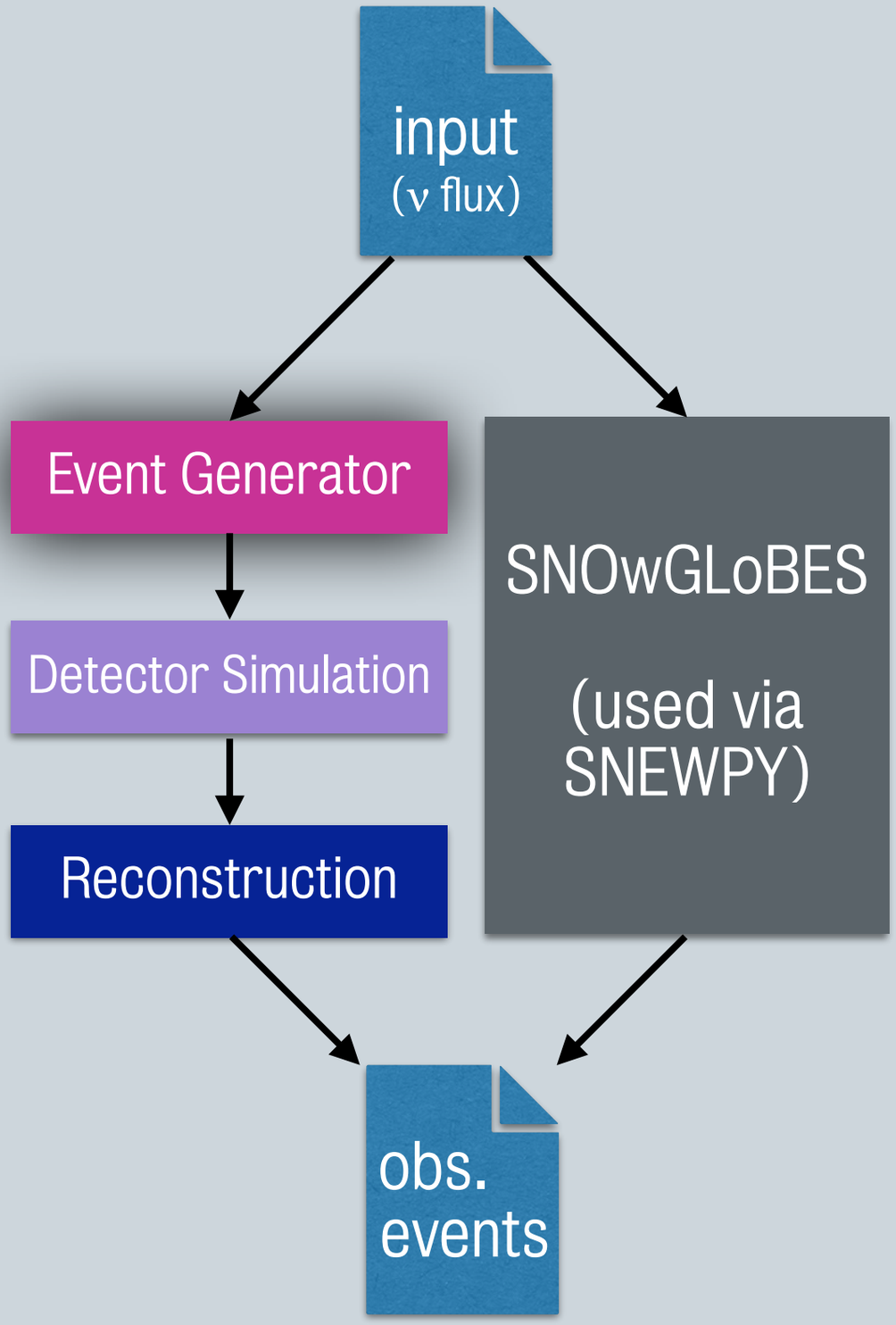
Integrating SNEWPY in sntools



- sntools: open-source event generator for HK, SNO+, JUNO, Theia, ...
  - github.com/JostMigenda/sntools
  - JOSS paper: DOI:10.21105/joss.02877
- Integrates SN models & flavour transformations from SNEWPY
  - For devs: Save work & eliminate major source of bugs
  - For users: Smooth transition from quick estimates (SNOwGLoBES) to advanced analyses (sntools)

Also used by other event generators, e.g. IceCube's ASTERIA: DOI:10.5281/zenodo.3926834

Conclusions

Generic problems

Domain-specific problems

Solve with SNEWPY!

Solve with research!

SNEWPY saves time & avoids bugs–enabling more (and more reliable) research!

❤️ to all the fantastic SNEWPY contributors!

Conclusions

Generic problems

Domain-specific problems

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❤️ to all the fantastic SNEWPY contributors!

Part 2: SNEWPY & the DSNB

SNEWPY is Under Active Development

May 3

github-actions

v1.5

69f3172

Compare

v1.5

DOI 10.5281/zenodo.11110204

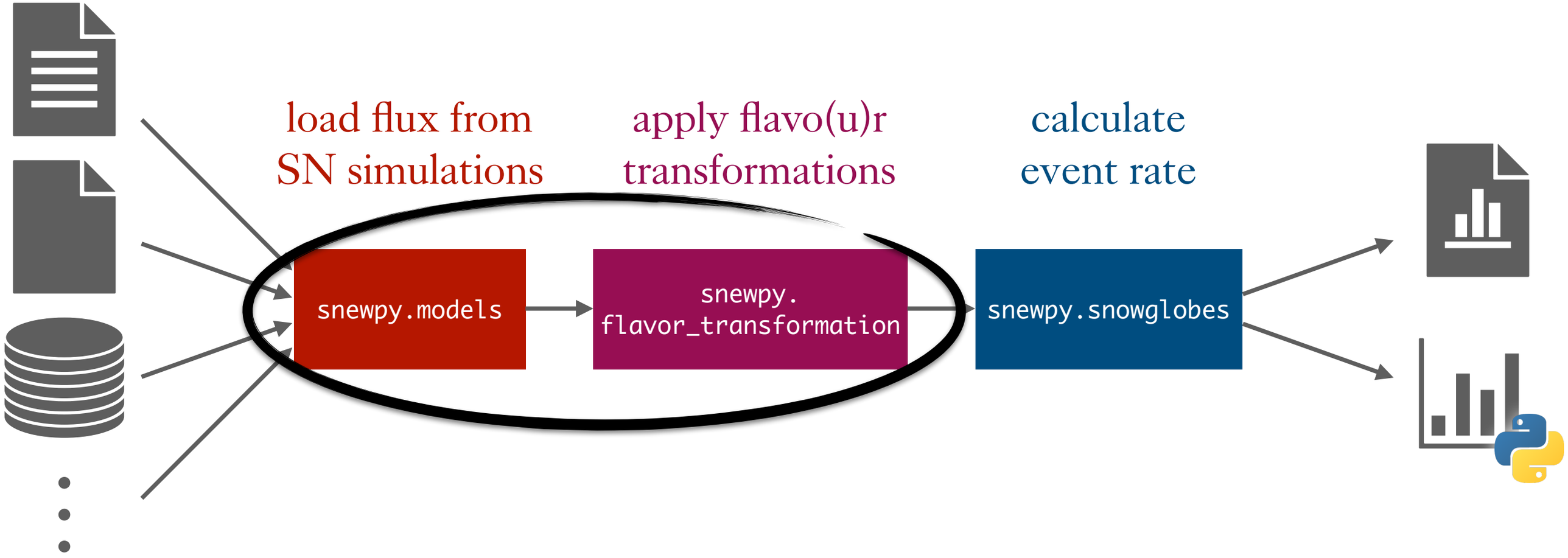
What's Changed

- **Added support for pre-supernova models**
- **Added two new core-collapse supernova model families**:
  - `Fornax_2022` contains 100 long-duration 2D simulations (from arXiv:2307.08735)
  - `Mori_2023` contains 14 simulations of axion-like particle production in 2D simulations (from arXiv:2304.11360)
- **Added new Quantum Decoherence flavor transition** based on arXiv:2306.17591
- Updated SNOwGLoBES dependency to v1.3.2. This fixes an issue where SNEWPY did not find detector efficiency files for the `ar40kt` detector configuration. After applying correct efficiencies, the event rate for `ar40kt` is reduced by ~5%.
- Fixed issue where the function `Fornax_2021.get_initial_spectra()` would raise an error when given an array of times as an argument.
- Fixed issue where `get_initial_spectra()` would return incorrect luminosity if the energy argument was not in units of MeV
- The bulk model downloader (`snewpy.get_models()`) now uses the same download location as the on-demand download on model initialisation.
- Various minor bugfixes, performance, documentation and other improvements

- v1.6 later this year:
  - adds Yoshida_2016 preSN model, Fischer_2020 and Bugli_2021 ccSN models
  - extended cooling tails (Li+ arXiv:2008.04340; Ekanger+ arXiv:2206.05299)

SNEWPY and the DSNB

- Initially focussed on ccSN
- Recently added preSN model support
- No explicit DSNB features (yet!), but already used by Ando+ (arXiv:2306.16076; https://github.com/shinichiroando/PyDSNB)



SNEWPY and the DSN…

- Initially focussed on c…
- P…
- … used by Ando+ (…ichiroando/PyDSNB)

How can we help YOU study the DSNB?