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FOR ASTROPARTICLE
PHYSICS

The SeaTray Software Framework

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SeaTray ← Icetray …

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- SeaTray is based on Icetray.

- is a software framework with a high-level of abstraction intended for high-energy physics experiments.
- provides general concepts and tools to develop and run event-based reconstruction and simulation programs.
- has been developed by computer scientists and physicists working in the IceCube collaboration, mainly at U Maryland and U Wisconsin-Madison.

Icetray …

- is the underlying framework for all of IceCube's detector simulation and event reconstruction.

Nota bene:

- Icetray itself has no knowledge of a specific detector or any algorithm for simulation or reconstruction
- think of it as an 'operating system' needed to handle data structured as 'events'

IceTray

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- is written in C++ and python
- is intended to facilitate code maintenance and developer collaboration by allowing to modularize complex tasks, e.g. breaking up reconstruction strategies into logical elements.
- allows to provide clear interfaces to access data structures, e.g. calibration or hit data etc.
- minimizes programming side effects

Status of Icetray

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- well tested, stable since many years
- maintenance and development still ongoing
- very active team of O(5) persons,
  1 full-time computer scientist

Access by Antares / KM3NeT

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- A Memorandum of Understanding between IceCube and ANTARES / KM3NeT governs the use of Icetray and some simulation tools from IceCube.

- Cf. KM3NeT wiki for a link

Cooperation with IceCube

- Developers view Icetray as a software product for high energy physics experiments in general.
- Developers very open to suggestions and feedback, have repeatedly offered and given support.
- Icetray user and developer workshops in principle open to KM3NeT community.
- Icetray software repository access open to Antares / KM3NeT.

SeaTray …

- is a software package for event reconstruction and simulation for ANTARES and KM3NeT.
- builds on the Icetray framework.
- does *not* contain any event reconstruction algorithms from IceCube.
- has been developed and is in use since 2008.
- is the main tool to provide reconstructed events for physics analyses in ANTARES since 2010.
- has been used in several large-scale data and MC productions.

Availability, support, documentation

- several introductory user workshops organized
- svn repository used actively by >10 developers
- 2 - 3 tested releases per year, usually before data productions
- currently main support done by 2 – 3 people at ECAP
- documentation in KM3NeT wiki
- reference installation with several release versions available at CC Lyon
- installation on Linux relatively straightforward

SeaTray: how does it work?

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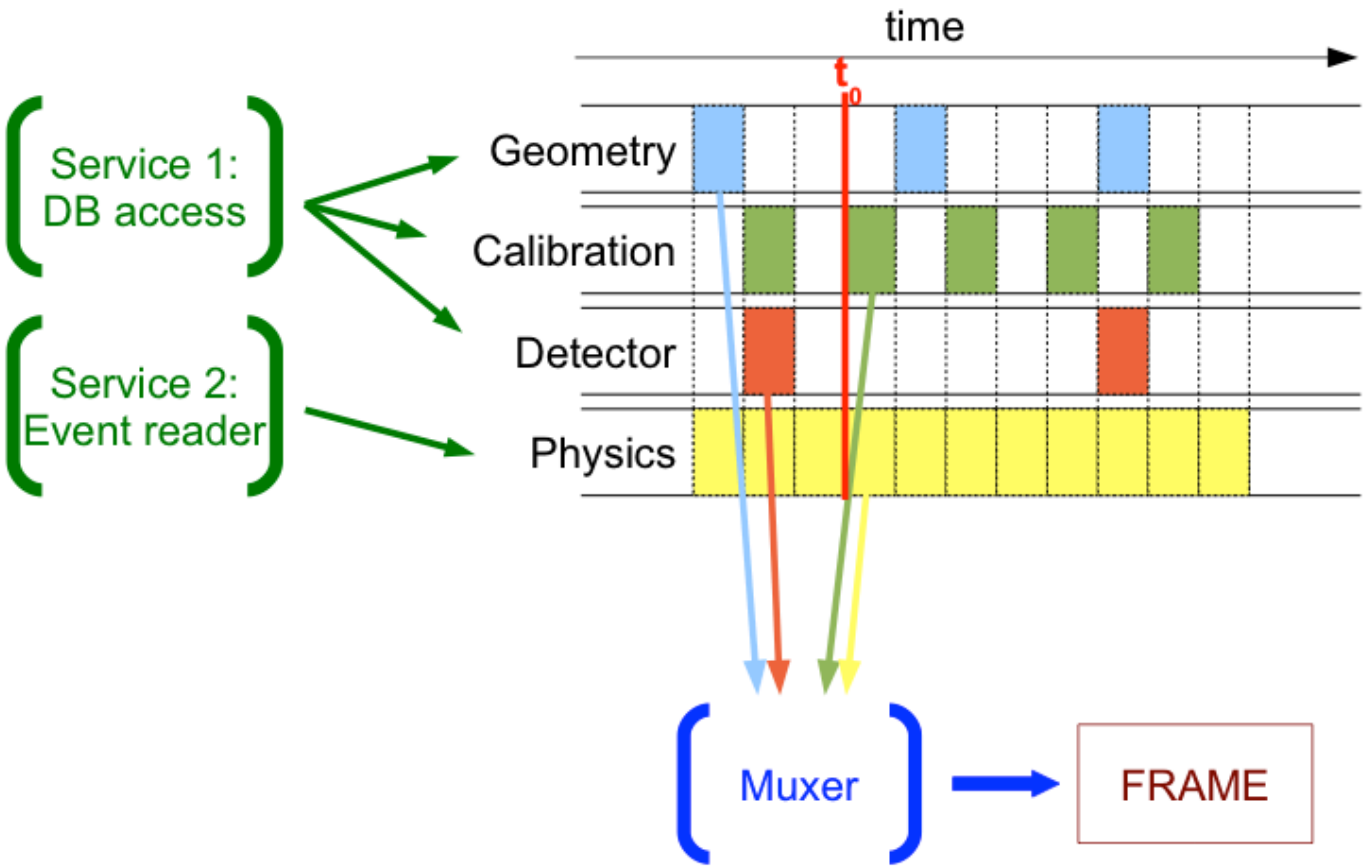

SeaTray: how does it work?

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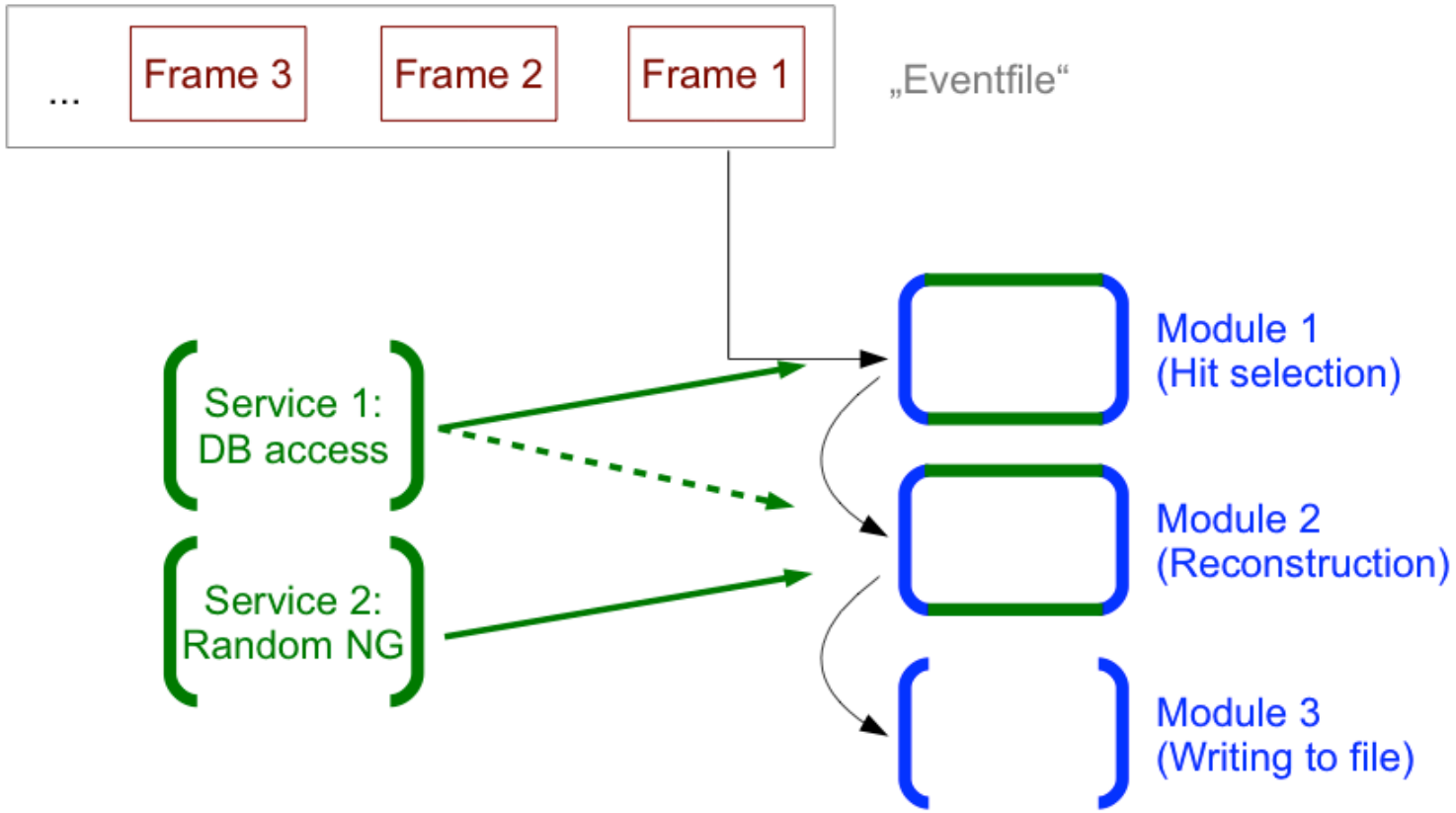

Usage / Status in ANTARES

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- reads raw data and MC at different levels
- reads calibration data from ORACLE database
- does hit charge / time and position calibration
- all relevant event reconstructions implemented
- used massively for data and MC event reconstruction
- in general not used to create MC simulations, however simulation tools, e.g. single photon propagation code are available
- provides different output formats, e.g. to create ROOT DSTs for physics analyses.
- significant amount of experience

Available track reconstructions

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- Aafit: high energy / resolution / efficiency strategy (A. Heijboer)
- BBFit: fast and robust tracking (J. Brunner)
- FilteringFit (C. Kopper), developed for KM3NeT
  2 versions under development for Antares:
  - GridFit, E. Visser
  - KrakeFit, S. Wagner
- Kalman-Filter (G.deRosa)
  - developed for KM3NeT, recently ported to SeaTray for Antares, currently under optimization and testing

Available shower reconstructions

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2 strategies which have been finalized recently:

- Dusj (F. Folger)
  - MC-generated pdf based maximum likelihood fit
  - allows to fit vertex position / time, direction and energy

- Q (Q. Dorosti)
  - fast vertex fitting and shower event recognition

Available muon energy reconstructions

- R (S. Biagi): relies on late additional hits from high energy showers along muon track
- dEdx (F. Schüssler et al.): relies on the total charge associated to the fitted muon track
- ANN (J. Schnabel): artificial neural network approach, combining information from many energy correlated variables
- ML (D. Palioselitis): a maximum likelihood approach using analytical probability density functions

Available event signature classification

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- Random Decision Forests (S. Geißelsöder):
  - powerful machine learning algorithm
  - used in pattern recognition
  - similar to neural networks, but generally better performance
  - can be trained to discriminate between different event signatures, e.g. for background suppression, identification of shower vs muon-like events, up-/down-going.
  - exploitation / investigation has started only recently

Usage / Status in KM3NeT

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- Simulation studies for TDR (ECAP, Demokritos)
  - PhD thesis C. Kopper 2010
  - FilteringFit track reconstruction algorithm
  - Detector simulation tool ‘clsim’: single photon propagator which can run on CPUs and GPUs
  - PMT simulation
- Reconstruction development for ORCA started within SeaTray (ECAP)
- Performance benchmarking needed to investigate usability for KM3NeT data rates

Summary

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- SeaTray is a software package for reconstruction (and simulation)
- SeaTray is based on IceTray, an analysis framework developed by IceCube
- Used for event reconstruction and data mass production in ANTARES
- Many reconstruction algorithms available and documented for ANTARES
- Intended to facilitate reconstruction development
- Performance needs to be investigated