The SeaTray Software Framework
SeaTray ↔ Icetray ...

- 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

- 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

- 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

- 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.
- 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?

- Service 1: DB access
- Service 2: Event reader

The diagram shows the process flow with time on the x-axis and different stages (Geometry, Calibration, Detector, Physics) on the y-axis. The Muxer combines these stages to produce the FRAME.
SeaTray: how does it work?

Service 1: DB access
Service 2: Random NG

Module 1 (Hit selection)
Module 2 (Reconstruction)
Module 3 (Writing to file)

„Eventfile“
Usage / Status in ANTARES

• 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

- 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

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

• 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

• 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

• 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