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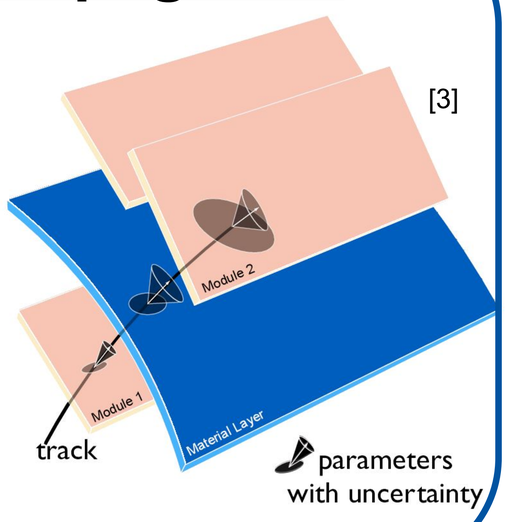
Track propagation for different detector and magnetic field setups in acts

ACTS

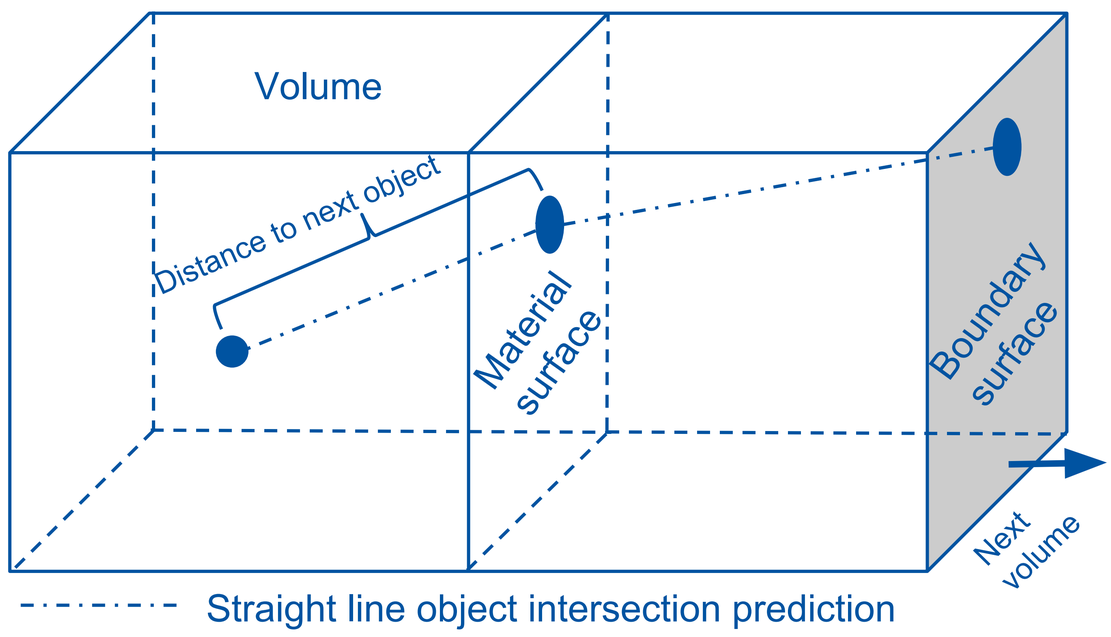
The software package ACTS[1][2] (**A** **C**ommon **T**racking **S**oftware) is a detector independent, highly parallelisable, continuously tested and documented project of contributors from different collaborations and experiments. It combines ideas, algorithms and techniques from various sources in order to provide a long term maintainable and highly performant standard for tracking software in high energy physics and beyond.

Concept of track propagation

Track propagation is a very frequent operation in the track reconstruction and describes the transport of a track parametrisation and the associated covariances through the detector geometry, taking interactions with the material and the magnetic field into account. The propagation is essential for searching hits from a particle and including the data into an estimation of the particle's properties.

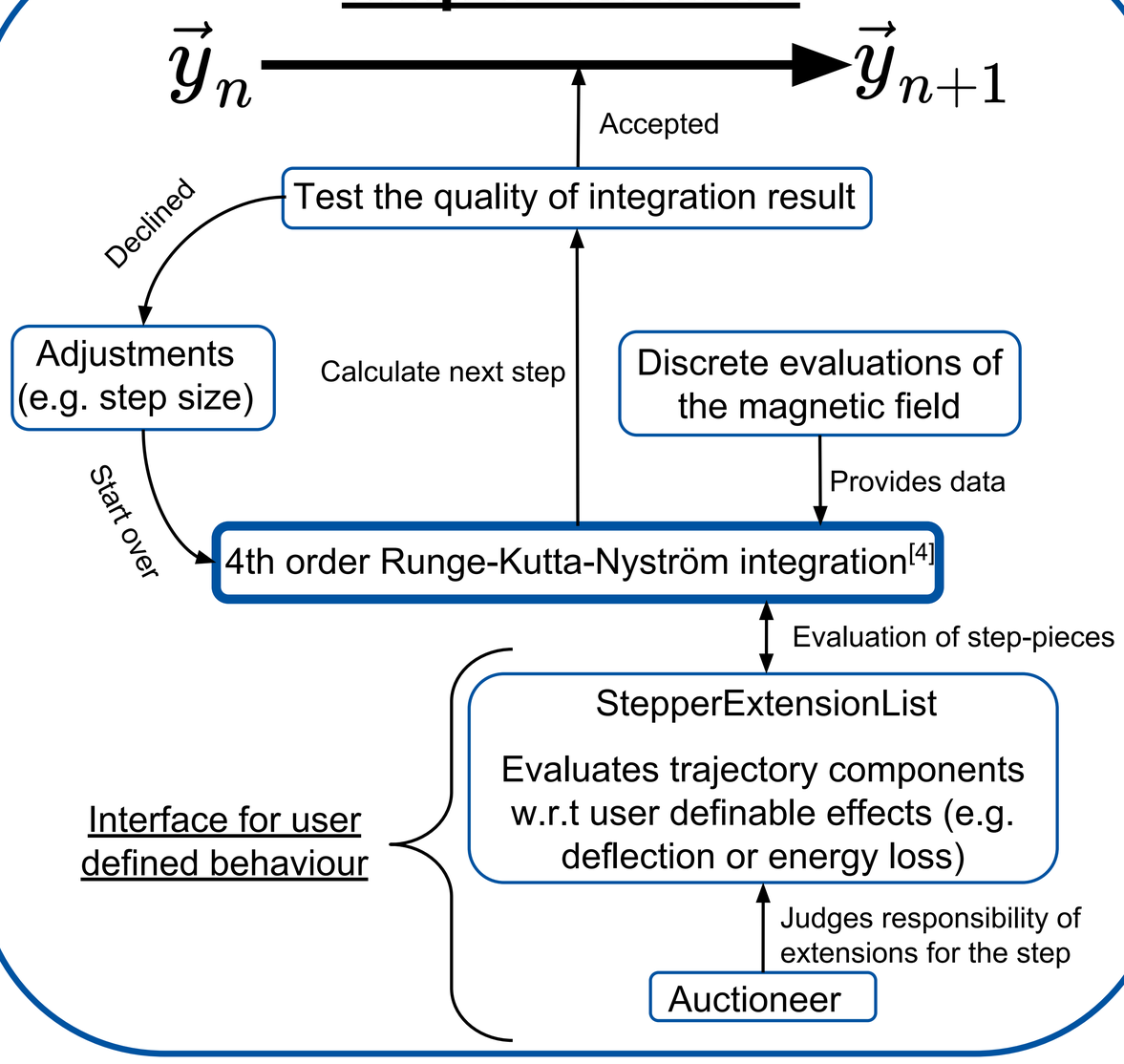


Navigation

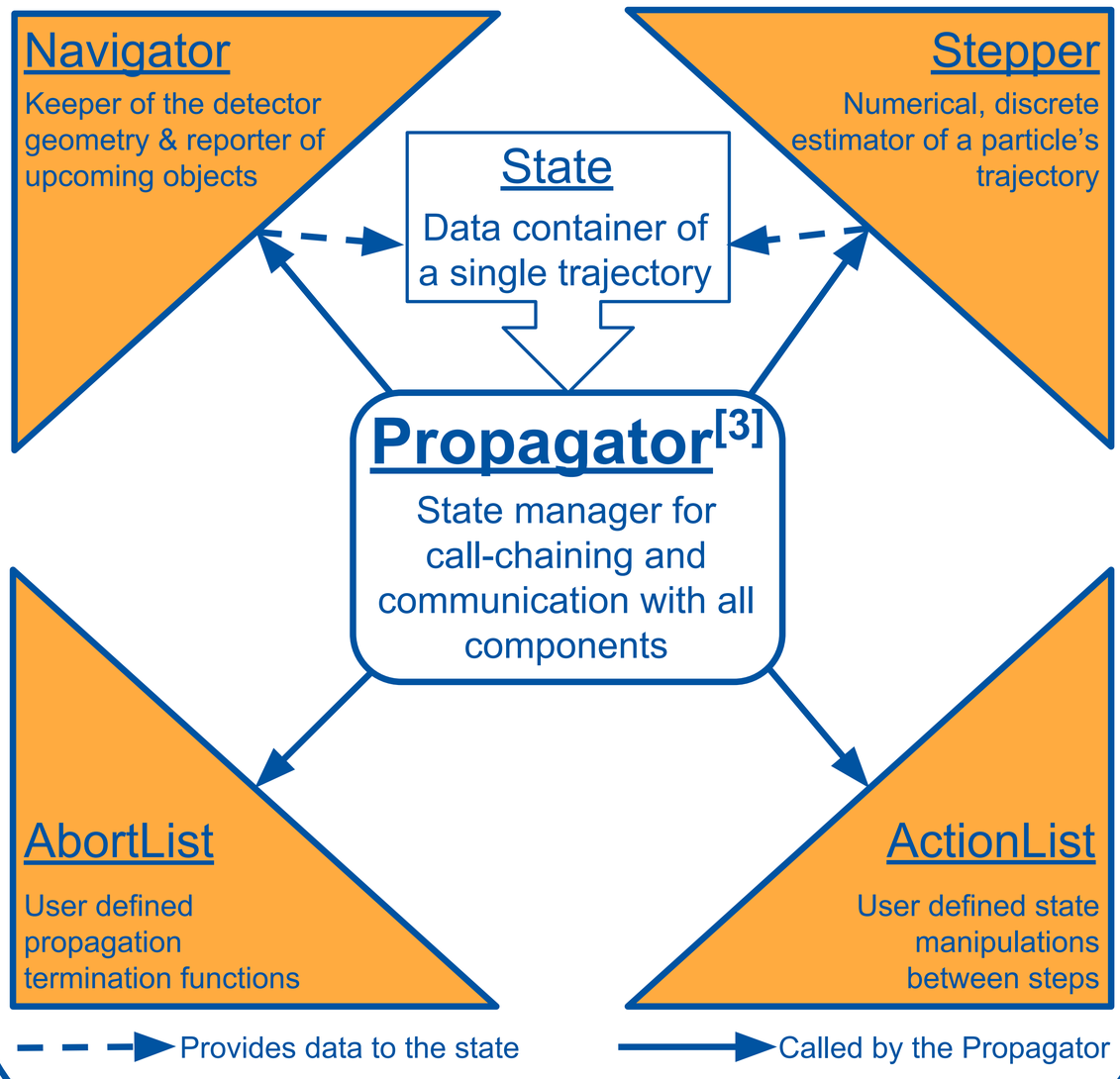


The Navigator keeps track of the detector objects, predicts objects that may be hit by the particle and reports the distance to this object. It handles the entering and leaving of objects and provides their object's properties such that they can be inquired and involved into the propagation.

Step evaluation



Propagator - design and interplay



Track parameter propagation

The reconstruction of each track in its origin is done in small steps through the detector. These include calculations of the local magnetic field, material effects and the uncertainties on track parameters. To evaluate the (n+1)th step of the track parameters $\mathbf{y}_n$ over a distance h, the RKN4 integration requires the evaluation of

$$\vec{y}\prime_{n+1} = \vec{y}\prime_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

$$\vec{y}_{n+1} = \vec{y}_n + h\vec{y}\prime_n + \frac{h^2}{6}(k_1 + k_2 + k_3)$$

which depends on the calculation of k_i[5]. These variables allow the inclusion of any physical effect on the trajectory. The propagation of the track parameter's jacobian $\mathbf{J}_n$ can be expressed via using the transport matrix[6] $\mathbf{D}_n$ such that $\mathbf{J}_{n+1}$ is given by $\mathbf{J}_{n+1} = \mathbf{D}_n \cdot \mathbf{J}_n$. This calculation is part of the STEP[5][6] propagation algorithm. In ACTS it is implemented and performed in in the StepperExtensionList.

Summary

- This structure allows a track propagation through the whole detector using a single stepper.
- The implementation provides a structure that allows the propagation of arbitrary track parameters through an arbitrary detector geometry.
- A loosely coupled structure allows a user specific implementation and replacement of components to include all required effects of the particle's trajectory.

Sources: [1] http://acts.web.cern.ch/ACTS/ [2] https://gitlab.cern.ch/acts [3] ATL-SOFT-PUB-2007-005 [4] E. J. Nyström, Acta Soc. Sci. Fenn. **50** (1925) 1–55 [5] ATL-SOFT-PUB-2009-001 [6] ATL-SOFT-PUB-2009-002

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