# GENFIT 2

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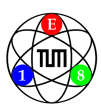
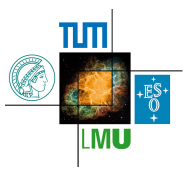








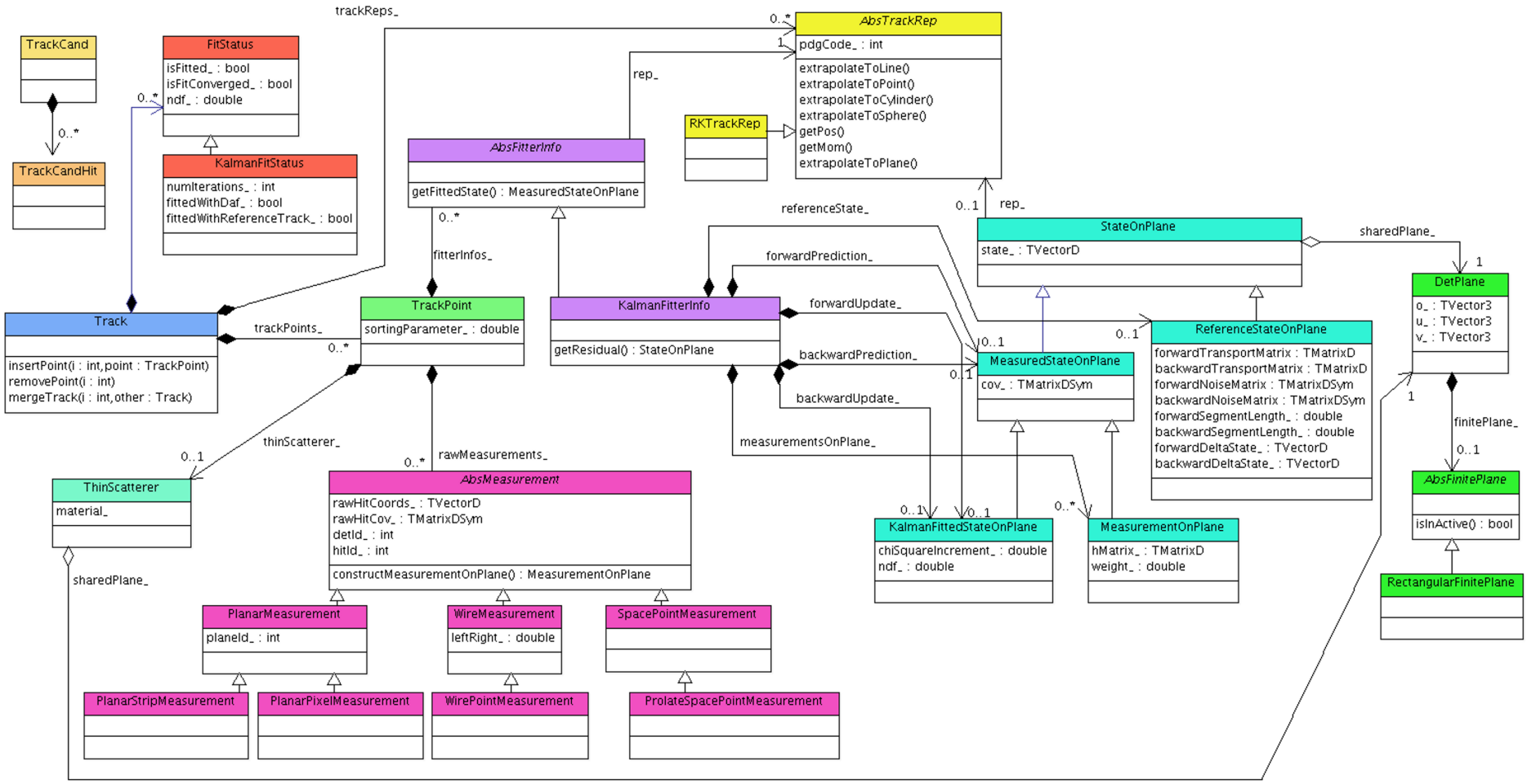
# How to get started?



- Doxygen (basf2):
  `https://belle2.cc.kek.jp/internal/software/development/namespacegenfit.html`
- Standalone version with README and several examples:
  `svn checkout svn://svn.code.sf.net/p/genfit/code/trunk`
- Tracking mailing list.
- Genfit mailing lists:
  `http://sourceforge.net/p/genfit/mailman/`
- If you want to have new features (or contribute to Genfit as a developer), please ask us!
- Overviev class diagramm:
  `genfit2/code2/UML/ClassDiagram.png`

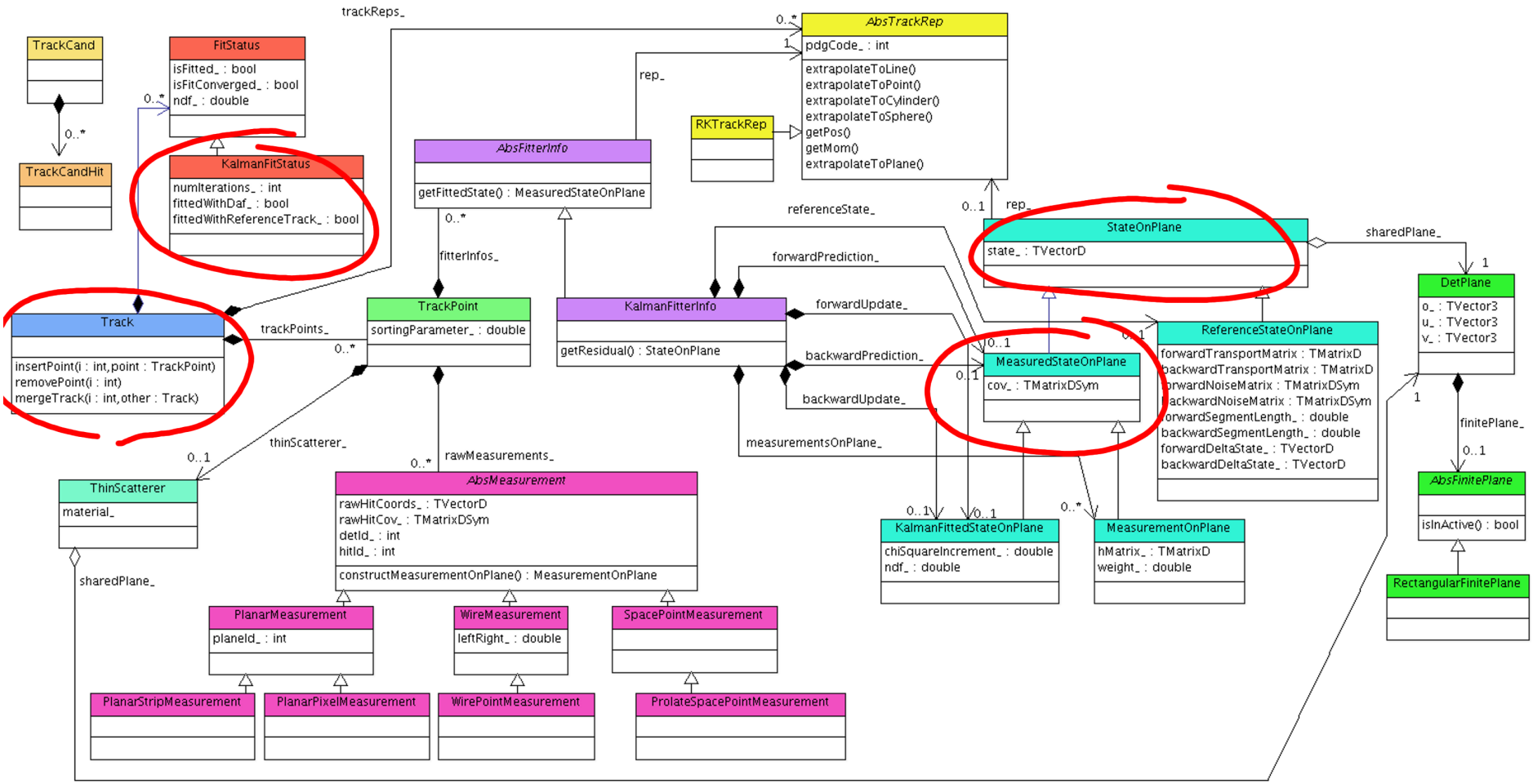
# GENFIT Track Data Structure





# GENFIT Track Data Structure





# Fitted Tracks



Getting information about the fit from a fitted track:

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```
gfTrack->getFitStatus()->isFitted()
gfTrack->getFitStatus()->isFitConverged()
gfTrack->getFitStatus()->getChi2()
gfTrack->getFitStatus()->getNdf()
gfTrack->getFitStatus()->getCharge()
```

# Get Information about the Fit



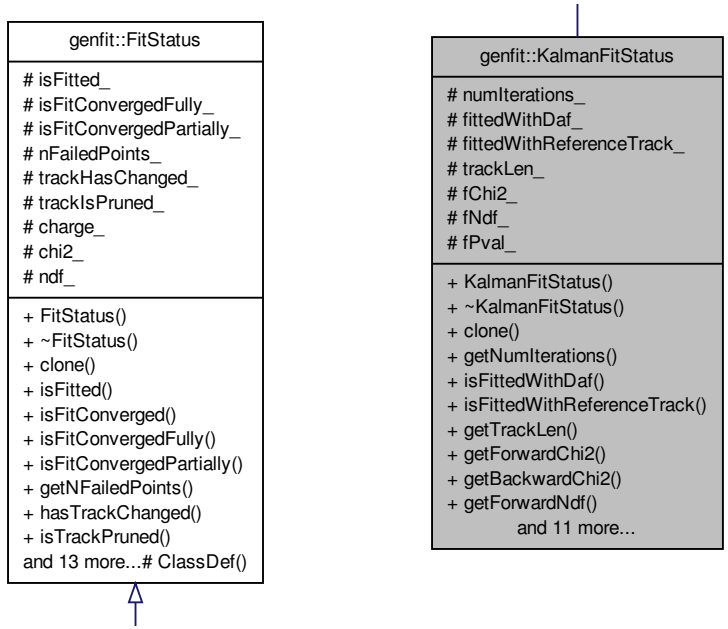
**FitStatus* genfit::Track::getFitStatus ( const AbsTrackRep * rep = NULL ) const [inline]**

Get **FitStatus** for a **AbsTrackRep**. Per default, return **FitStatus** for cardinalRep.

Definition at line **136** of file **Track.h**.

References **cardinalRep_**, and **trackReps_**.

Referenced by **genfit::GFRaveTrackParameters::getCharge()**, **genfit::AbsKalmanFitter::isTrackFitted()**, **genfit::KalmanFitterRefTrack::prepareTrack()**, **genfit::KalmanFitter::processTrackPartially()**, **genfit::KalmanFitterRefTrack::processTrackWithRep()**, **genfit::KalmanFitter::processTrackWithRep()**, and **genfit::DAF::processTrackWithRep()**.



# Getting fitted pos, mom, cov



TrackPoints contain FitterInfos contain StateOnPlane objects.

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```
const MeasuredStateOnPlane& state = gfTrack->getFittedState();
TVector3 pos = state.getPos();
TVector3 mom = state.getMom();
TMatrixDSym cov = state.getCov(); // 5x5

TMatrixDSym cov6 = state.get6DCov(); // 6x6
```

# Get Fitted State



```
const MeasuredStateOnPlane & genfit::Track::getFittedState ( int                 id = 0,
                                                             const AbsTrackRep * rep = NULL,
                                                             bool                biased = true
                                                           )                                  const
```

Shortcut to get FittedStates.

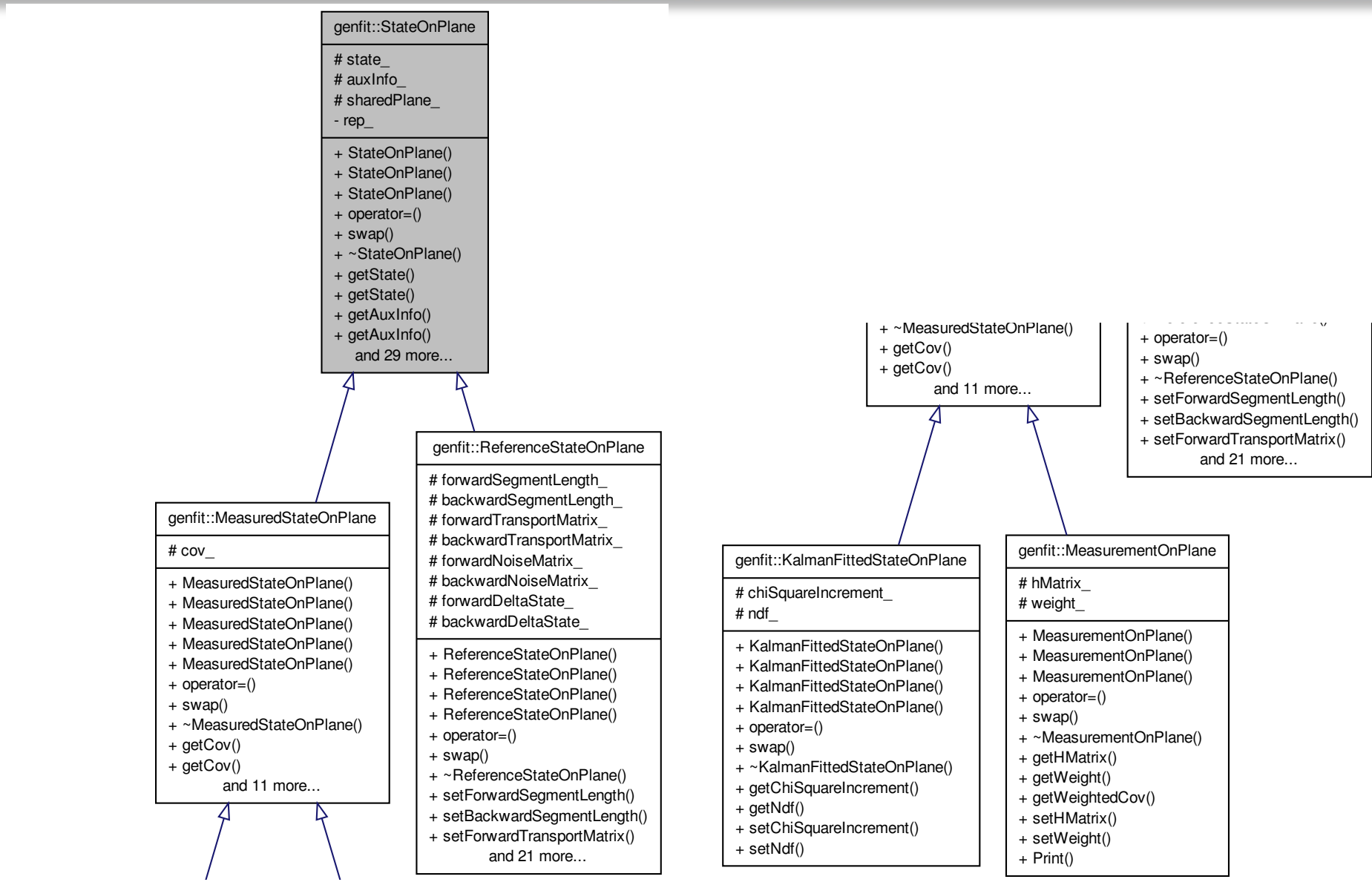
Uses getPointWithMeasurementAndFitterInfo(id, rep). Per default, the fitted state of the fitterInfo of the first **TrackPoint** with one or more **AbsMeasurement** and **AbsFitterInfo** objects is returned. If no **AbsTrackRep** is specified, the **AbsFitterInfo** of the cardinal rep will be used.

Definition at line **220** of file **Track.cpp**.

References **getCardinalRep()**, **genfit::AbsFitterInfo::getFittedState()**, **genfit::TrackPoint::getFitterInfo()**, **getPointWithMeasurementAndFitterInfo()**, and **genfit::Exception::setFatal()**.

# StateOnPlane Objects





# Extrapolating



Extrapolate fitted state, e.g. to vertex:

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```
TVector3 vertexPos, vertexMom;
TMatrixDSym vertexCov;
MeasuredStateOnPlane state = gfTrack->getFittedState(); // copy
TVector3 vertex(0,0,0);

state.extrapolateToPoint(vertex);
// or alternatively
TVector3 axis(0,0,1);
state.extrapolateToLine(vertex, axis);

state.getPosMomCov(vertexPos, vertexMom, vertexCov);
```

# TOF



Get time of flight between vertex and cylinder:

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```
TVector3 vertex(0,0,0);
double radius = 20;
double tof = gfTrack->getTOF(); // TOF from first to last hit
StateOnPlane state = gfTrack->getFittedState();
state.extrapolateToPoint(vertex);
// TOF is SIGNED!
tof -= state.getRep()->getTOF(); // + TOF from vertex to first hit

state = gfTrack->getFittedState(-1);
state.extrapolateToCylinder(radius);
tof += state.getRep()->getTOF(); // + TOF from last hit to cylinder
```

# Get Track-length and TOF



```
double genfit::Track::getTOF ( AbsTrackRep *  rep,
                               int            startId = 0,
                               int            endId = -1
                             )                              const
```

get time of flight in ns between to trackPoints

Definition at line 768 of file Track.cpp.

References genfit::AbsTrackRep::extrapolateToPlane(), genfit::AbsTrackRep::getMass(), genfit::AbsTrackRep::getMomMag(), genfit::StateOnPlane::getPlane(), and trackPoints_.

```
double genfit::Track::getTrackLen ( AbsTrackRep *  rep,
                                    int            startId = 0,
                                    int            endId = -1
                                  )                         const
```

get TrackLength between to trackPoints

Definition at line 727 of file Track.cpp.

References genfit::AbsTrackRep::extrapolateToPlane(), genfit::StateOnPlane::getPlane(), and trackPoints_.

# Insert Points



```
void genfit::Track::insertPoint ( TrackPoint *  point,
                                  int           id = -1
                                )
```

Insert **TrackPoint** BEFORE **TrackPoint** with position id, if id >= 0.

Id -1 means after last **TrackPoint**. Id -2 means before last **TrackPoint**. ... Also deletes backwardInfos before new point and forwardInfos after new point. Also sets **Track** backpointer of point accordingly.

Definition at line **263** of file **Track.cpp**.

References **deleteBackwardInfo()**, **deleteForwardInfo()**, **deleteReferenceInfo()**, **fillPointsWithMeasurement()**, **genfit::TrackPoint::hasRawMeasurements()**, **genfit::TrackPoint::setTrack()**, **trackHasChanged()**, **trackPoints_**, and **trackPointsWithMeasurement_**.

Referenced by **insertPoints()**, and **Track()**.

```
void genfit::Track::insertPoints ( std::vector< genfit::TrackPoint * >  points,
                                   int                                  id = -1
                                 )
```

Definition at line **323** of file **Track.cpp**.

References **deleteBackwardInfo()**, **deleteForwardInfo()**, **deleteReferenceInfo()**, **fillPointsWithMeasurement()**, **getNumPoints()**, **insertPoint()**, and **trackPoints_**.

Referenced by **mergeTrack()**.

# Delete Points, Merge Tracks



**void genfit::Track::deletePoint ( int id )**

Definition at line **373** of file **Track.cpp**.

References **deleteBackwardInfo()**, **deleteForwardInfo()**, **deleteReferenceInfo()**, **trackHasChanged()**, **trackPoints_**, and **trackPointsWithMeasurement_**.

**void genfit::Track::mergeTrack ( const Track * other,**
**int id = -1**
**)**

Merge two tracks.

The **TrackPoint** objects of other will be cloned and inserted after id (per default, they will be appended at the end). The other **Track** will not be altered, the **TrackPoint** objects will be (deep) copied. Only copies the **TrackPoint** objects, NOT the **AbsTrackRep**, **FitStatus**, seed state and other objets of the other track.

Definition at line **406** of file **Track.cpp**.

References **getNumPoints()**, **insertPoints()**, **genfit::Exception::setFatal()**, **trackPoints_**, and **trackReps_**.

# Questions



## How is the time / propagation reversal treated?

- Track/momentum direction is determined by state seed.
- TrackRep usually decides propagation direction.
- If propagation is in direction of momentum, momentum will be lost/TOF is positive.
- If hit resorting of Kalman is enabled, trackpoints will be sorted along momentum/flight direction.

# Questions



## Can Genfit determine whether a track was found in the wrong / reverse order?

```
const MeasuredStateOnPlane& firstState = gfTrack->getFittedState();
TVector3 firstPos = firstState.getPos();
TVector3 firstMom = firstState.getMom();
const MeasuredStateOnPlane& lastState = gfTrack->getFittedState(-1);
TVector3 lastPos = lastState.getPos();
TVector3 lastMom = lastState.getMom();
```

## Can one suggest to redo the fit with the correctly reversed track?

```
gfTrack->reverseTrackPoints(); // does NOT flip state seed

// if you want to flip the momentum direction
TVectorD stateSeed = gfTrack->getStateSeed();
stateSeed[3] *= -1; stateSeed[4] *= -1; stateSeed[5] *= -1;
gfTrack->setStateSeed(stateSeed);

myFitter.processTrack(gfTrack);
```

# Questions



## Is it possible to just say ”extrapolate to this RecoHit” directly?

If the track is already fitted, you can get the smoothed state.

```
const MeasuredStateOnPlane& state = gfTrack->getFittedState(iHit);
TVector3 pos = state.getPos();
TVector3 mom = state.getMom();
```

# Questions



## How to get track dependent info from RecoHits?

These two functions of the AbsMeasurement are overriden in the RecoHit.
The state object can be used directly to make the plane and measurement construction according to the state. But also use any other data available can be used!

```
virtual SharedPlanePtr constructPlane(const StateOnPlane& state)
virtual std::vector<genfit::MeasurementOnPlane*> constructMeasurementsOnPlane(const
```

# Questions



## How to process a track partially?

Only supported by the KalmanFitter (w/o reference track).

```
//! process only a part of the track. Can also be used to process the track only in
//! Does not alter the FitStatus and does not do multiple iterations.
void processTrackPartially(Track* tr, const AbsTrackRep* rep, int startId = 0, int
```

Thanks for your attention!

# Backup Slides

# Fitting a Track



The following descriptions and diagrams are taken from GENFIT's doxygen documentation.

```
void genfit::AbsFitter::processTrack ( Track *  tr,
                                       bool     resortHits = true
                                     )
```

Process all reps. Start with the cardinalRep and resort the hits if necessary (and supported by the fitter)

Definition at line 25 of file AbsFitter.cpp.

References genfit::Track::checkConsistency(), genfit::Track::getCardinalRep(), genfit::Track::getNumReps(), genfit::Track::getTrackRep(), and processTrackWithRep().

```
virtual void genfit::AbsFitter::processTrackWithRep ( Track *                ,
                                                      const AbsTrackRep *    ,
                                                      bool                   resortHits = false
                                                    )                                    [pure virtual]
```

Process Track with one AbsTrackRep of the Track. Optionally resort the hits if necessary (and supported by the fitter)

Implemented in genfit::DAF, genfit::KalmanFitter, and genfit::KalmanFitterRefTrack.

Referenced by processTrack().

# Get Fit Result



```
const MeasuredStateOnPlane & genfit::Track::getFittedState ( int                    id = 0,
                                                             const AbsTrackRep *  rep = NULL,
                                                             bool                 biased = true
                                                           )                                  const
```

Shortcut to get FittedStates.

Uses getPointWithMeasurementAndFitterInfo(id, rep). Per default, the fitted state of the fitterInfo of the first **TrackPoint** with one or more **AbsMeasurement** and **AbsFitterInfo** objects is returned. If no **AbsTrackRep** is specified, the **AbsFitterInfo** of the cardinal rep will be used.

Definition at line **220** of file **Track.cpp**.

References **getCardinalRep()**, **genfit::AbsFitterInfo::getFittedState()**, **genfit::TrackPoint::getFitterInfo()**, **getPointWithMeasurementAndFitterInfo()**, and **genfit::Exception::setFatal()**.

Important: The TrackReps do NOT contain the state anymore.
Instead, all states are stored in the FitterInfos in the TrackPoints.

# Get Plane



**const SharedPlanePtr& genfit::StateOnPlane::getPlane ( ) const [inline]**

Definition at line **63** of file **StateOnPlane.h**.

References **sharedPlane_**.

Referenced by **genfit::KalmanFitterInfo::addMeasurementOnPlane()**, **genfit::RKTrackRep::checkCache()**, **genfit::RKTrackRep::extrapolateBy()**, **genfit::RKTrackRep::extrapolateToCylinder()**, **genfit::RKTrackRep::extrapolateToLine()**, **genfit::RKTrackRep::extrapolateToPlane()**, **genfit::RKTrackRep::extrapolateToPoint()**, **genfit::RKTrackRep::extrapolateToSphere()**, **genfit::KalmanFitterInfo::getResidual()**, **genfit::RKTrackRep::getState5()**, **genfit::RKTrackRep::getState7()**, **genfit::Track::getTOF()**, **genfit::Track::getTrackLen()**, **genfit::KalmanFitterRefTrack::prepareTrack()**, **genfit::KalmanFitterRefTrack::processTrackPoint()**, **genfit::RKTrackRep::setPosMom()**, **genfit::RKTrackRep::setPosMomErr()**, **genfit::RKTrackRep::transformM6P()**, **genfit::RKTrackRep::transformM7P()**, **genfit::RKTrackRep::transformPM6()**, and **genfit::RKTrackRep::transformPM7()**.

# Get State



**const TVectorD& genfit::StateOnPlane::getState**`()const [inline]`

**TVectorD& genfit::StateOnPlane::getState**`()[inline]`

**const TMatrixDSym& genfit::MeasuredStateOnPlane::getCov**`()const [inline]`

Get the state (and covariance) in the parametrization of the TrackRep.
For the RKTrackRep, this is $(q/p, u', v', u, v)$.

# Get Position, Momentum, 6x6 Covariance



```
void genfit::MeasuredStateOnPlane::getPosMomCov ( TVector3 &       pos,
                                                  TVector3 &       mom,
                                                  TMatrixDSym &    cov
                                                ) const [inline]
```

Definition at line 63 of file MeasuredStateOnPlane.h.

References genfit::AbsTrackRep::getPosMomCov(), and genfit::StateOnPlane::getRep().

These and the following functions call the corresponding functions of the TrackRep connected to the StateOnPlane/MeasuredStateOnPlane.

# Get Pos etc.



**TVector3 genfit::StateOnPlane::getPos ( ) const [inline]**

Definition at line 91 of file StateOnPlane.h.

References genfit::AbsTrackRep::getPos(), and rep_.

**void genfit::StateOnPlane::getPosDir ( TVector3 & pos,**
**TVector3 & dir**
**) const [inline]**

Definition at line 95 of file StateOnPlane.h.

References genfit::AbsTrackRep::getPosDir(), and rep_.

**void genfit::StateOnPlane::getPosMom ( TVector3 & pos,**
**TVector3 & mom**
**) const [inline]**

Definition at line 94 of file StateOnPlane.h.

References genfit::AbsTrackRep::getPosMom(), and rep_.

**double genfit::StateOnPlane::getQop ( ) const [inline]**

Definition at line 100 of file StateOnPlane.h.

References genfit::AbsTrackRep::getQop(), and rep_.

# Get Various



**TVector3 genfit::StateOnPlane::getMom ( ) const [inline]**

Definition at line 92 of file StateOnPlane.h.

References genfit::AbsTrackRep::getMom(), and rep_.

**double genfit::StateOnPlane::getMomMag ( ) const [inline]**

Definition at line 97 of file StateOnPlane.h.

References genfit::AbsTrackRep::getMomMag(), and rep_.

**int genfit::StateOnPlane::getPDG ( ) const [inline]**

Definition at line 98 of file StateOnPlane.h.

References genfit::AbsTrackRep::getPDG(), and rep_.

# Get Various



**double genfit::StateOnPlane::getCharge ( ) const [inline]**

Definition at line 99 of file StateOnPlane.h.

References genfit::AbsTrackRep::getCharge(), and rep_.

**TVector3 genfit::StateOnPlane::getDir ( ) const [inline]**

Definition at line 93 of file StateOnPlane.h.

References genfit::AbsTrackRep::getDir(), and rep_.

**double genfit::StateOnPlane::getMass ( ) const [inline]**

Definition at line 101 of file StateOnPlane.h.

References genfit::AbsTrackRep::getMass(), and rep_.

# Extrapolate



```
double genfit::StateOnPlane::extrapolateBy ( double  step,
                                             bool    stopAtBoundary = false
                                           )                                  [inline]
```

Definition at line 88 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateBy(), and rep_.

```
double genfit::StateOnPlane::extrapolateToCylinder ( double              radius,
                                                     const TVector3 &    linePoint = TVector3(0.,0.,0.),
                                                     const TVector3 &    lineDirection = TVector3(0.,0.,1.),
                                                     bool                stopAtBoundary = false
                                                   )                                                  [inline]
```

Definition at line 81 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateToCylinder(), and rep_.

```
double genfit::StateOnPlane::extrapolateToLine ( const TVector3 &  linePoint,
                                                 const TVector3 &  lineDirection,
                                                 bool              stopAtBoundary = false
                                               )                                    [inline]
```

Definition at line 76 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateToLine(), and rep_.

# Extrapolate



```
double genfit::StateOnPlane::extrapolateToPlane ( const SharedPlanePtr &  plane,
                                                   bool                    stopAtBoundary = false,
                                                   bool                    calcJacobianNoise = false
                                                 )                                                  [inline]
```

Definition at line 73 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateToPlane(), and rep_.

```
double genfit::StateOnPlane::extrapolateToPoint ( const TVector3 &  point,
                                                   bool              stopAtBoundary = false
                                                 )                                          [inline]
```

Definition at line 79 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateToPoint(), and rep_.

```
double genfit::StateOnPlane::extrapolateToSphere ( double              radius,
                                                    const TVector3 &    point = TVector3(0.,0.,0.),
                                                    bool                stopAtBoundary = false
                                                  )                                             [inline]
```

Definition at line 85 of file StateOnPlane.h.

References genfit::AbsTrackRep::extrapolateToSphere(), and rep_.

# Set Position and Momentum



```
void genfit::StateOnPlane::setPosMom ( const TVector3 &  pos,
                                       const TVector3 &  mom
                                     )                        [inline]
```

Definition at line **103** of file **StateOnPlane.h**.

References **rep_**, and **genfit::AbsTrackRep::setPosMom()**