# Status of the Tracking Event Model

Jose A. Hernando, E. Rodrigues

*The plan,*

*In the Step I*

*"Looking at the bright side of life..."*

*In the Step II*

*Conclusion, plans*

# Plan

- **Motivation:**
  - Revisit the tracking code to try to improve the design
  - Unify code on/off line and define an interface for the clients
    - Define a Track! (for on/off line)
  - Define base classes (data and tools) for and tracking developers
- **Method:**
  - Modify the current code adiabatically
  - Reusing almost all the code: “adapting” and not “replacing”
- **Organization:**
  - Task Force (G. Raven) to:
    - ‘define the classes, requirements and implementation constrains’
- **Plan:**
  - Step I: Interfaces for clients
    - Track, State, ITrackExtrapolator
  - Step II: Tracking interfaces
    - Measurement, Node, FitTrack, ITrackProjector, ITrackFitter
- **Scale:**
  - 6 months

# Step I: The classes, current view


**A TRACK:**

**flag (bitField) TYPE, HISTORY, FLAG**

**chi2/ndof, ndof (quality)**

**physics State = "The persistent State"**

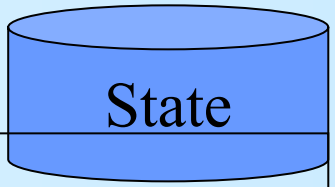
**<States*> = "the *transient* states"**

**<LHCbID> = list of LHCbID**

**Methods:**

Access to physics state: *p,pt, slopes, position*

Access states: *at z, plane, LOCATION*



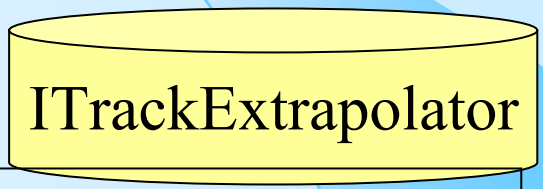

**A STATE:**

**flag (bitField) TYPE, LOCATION**

**vector-state, covariance, z**

**Methods:**

Access to physics contents: pt(),p()




**A Extrapolator: extrapolate a Track/State**

**Main method: propagate(State, z)**

**Methods:**

*propagate the track*

*get directly physics values:*

*i.e momentum(track,z)*

*transportMatrix() (F)*

# Status, Step I

- **Define the client Interfaces**
  - Track, State, ITrackExtrapolator
  - After long discussions, many compromises, *Dec 04*
    - Track finally 'controlled' by persistency, a skeleton of a track
  - A complex and powerful bitfield class
- **Having some Tracks**
  - Converters: Jan 05
    - *Tr/TrConverters,* TrStoredTrack -> Track
    - *Trg/TrgConverter* TrgTracks -> Track
- **Extrapolators**
  - Interface:
    - *Kernel/LHCbInterfaces,* Jan 05
  - Implementations: in
    - *Tr/TrackExtrapolators*; base tool : TrackExtrapolator
    - Linear: TrackLinearExtrapolator Jan05
    - Others: Parabolic, FastParabolic, Herab, FirstClever, **Mar05**
  - Propagators work, but more testing needed
  - Intersection with a plane temporally simplified
- **Saving the Tracks:**
  - In progress, we got some problems with persistency, need some help with custom DSTs

# Status, Step I (cont)

- **Making the Tracks, Tracks!**
  - In private area:
    - *Event/TrgEvent*, TrgTrack inheriting from Track, **Mar05**
    - A TrgTrack now is Track!, TrgState is in fact just a State
  - As an exercise:
    - *Trg/TrgVelo* using the new TrgTrack, Mar05
  - *In the yellow light*, waiting the green light: (end Mar 05)
    - Commit the new TrgTrack, update the Trg Packages
  - Implications:
    - Trg will get a new version
    - I see no particular problems…, just a delicate work
      - We use a Python tool to help us (see next transparency)
    - It will require revisiting/fixing LHCbID to do:
      - The linking with MC:
      - The Buffer Tampering
- **Using the new Tracks:**
  - Ideal Pattern Recognition
    - *In Tr/TrackIdealPR* If we can not do it here, forget it!
    - Minor changes to make independent of old TEM
  - In Panoramix
    - In Vis/SoEvent (SoTrackCnv) **Mar05**
    - Of course we need to draw Tracks, (one for all?)

# Status, Step I (and cont)

- **Migrating**
  - Updating/replacing Clients code: TrCheck, ParticleMaker, Calorimeter, Rich…
- **With a Python tool**

```
python translate_to_new_tracking.py –f *.cpp *.h –r False
```

  - Create new cpp and header files
  - Replacing the old Trg/TrStored code to the new Tracking
  - It works quite nice ☺ but of course do not expect a miracle
  - We tuned the tool with Trg.
  - We need a guinea-pig (some client code) to be replaced and to tune the tool
  - When the tool is tuned up, we advertise it, you run the tool in your package, try to compile…
    - If still too many complicated errors show up…
    - Just contact us and we will try to make the compilation
    - You check them later…
  - It is a general tool to replace any work for another in files

```
translate_to_new_tracking.py –f *.cpp *.h –i red –o green –r False
```

- **Idea:**
  - All code that uses the Track interface is valid for any type of Track!
  - Ie. Drawing in Panoramix

# Interactive reconstruction

*"Reconstruction sans frontières"*

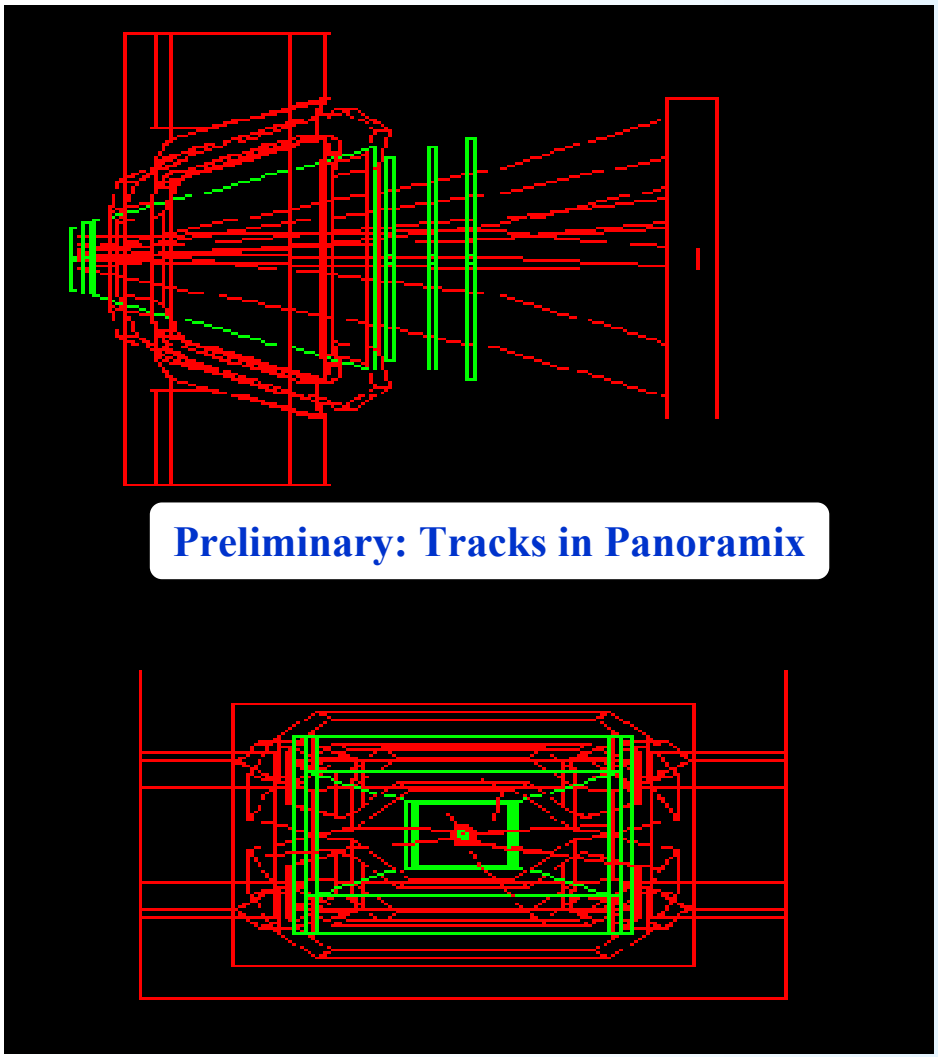
- **How to make the reconstruction interactive?: via Python**
  - From Python you can execute and use C++ code
  - Python is an interactive language, has introspection
    - >> dir(track)
  - Other pros: Python is very intuitive, dynamically typed, no pointers, heterogenic containers, dictionaries…
  - One develop code ~4 times faster than in C++
- **GaudyPython and Bender**
  - Pere already exposed Gaudi framework to Python
    - >> gaudi.run(1)
  - Vanya has exposed most of DaVinci tools/data for analysis, including his 'meta-language' LoKI in Python
- **Idea:**
  - Expose the base track data classes and interfaces tracking tools to Python
  - The base tracking classes allow to write code in a base level for reconstruction
    - You will be able to do this code in Python and check it ***interactively***
  - You can debug/test and develop tracking code with the Base classes in Python
    - That is what we are doing already!

# Looking at the bright side of life…

- **Already done:**
  - Expose ITrackExtrapolator, Track/State to Python, thanks to Vanya and Pere, Mar 05
  - Example:
    - pol = extrapolator("TrackParabolicExtrapolator")
    - state = track.physicsState().clone()
    - pol.propagate(state,z=1000.)
- **And Panoramix?:**
  - Panoramix has methods exposed to Python (Guy also was in the business :)
    - So we can 'use' Panoramix from Python
  - The other direction is needed (and can be made), nice requirement
    - If you click in a Track in Panoramix you can get the Object in your Python prompt!
- **In the future:**
  - We will expose to Python:
    - Measurement and ITrackProjector, Measurement/FitTrack and IFitter
  - Some things that will be possible to do *interactively* :
    - Pattern Recognition algorithms:
      - extrapolate this track to 'here', get the best measurement, update the track
    - Refitting
      - Replace/Remove this measurement and refit
      - Change the fitter and refit, change the extrapolator (this has better error estimate…) and refit
    - Alignment:
      - I want to try this new set of parameters, replace the Projector, refit the track or the Event

# Interactive and with display

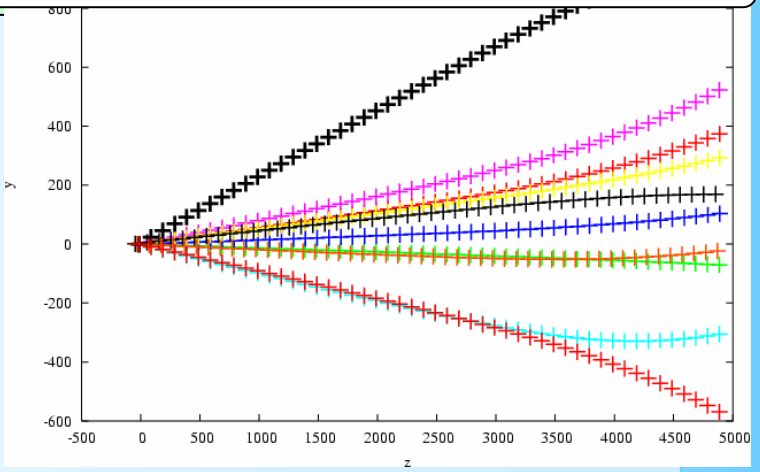
- **Python:**
  - Just import modules: PyROOT, Hippys



**Preliminary: Tracks in Panoramix**

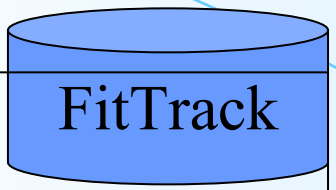
```
pol = extrapolator("TrackParabolicExtrapolator")
state = track.physicsState().clone()
z = state.z(), xx = [], zz = []
for i in range(50):
    z = z + 10
    pol.propagate(state,z)
    xx.append(state.x())
    zz.append(z)
hxy(z,x)
```

**A scatter plot from a Python prompt**



# Step II: The clases

A DRAFT VERSION




A FitTrack:

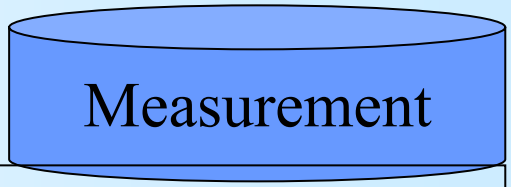
<Measurement*>

<Nodes*>

Methods:

Add/remove measurements

Nodes are the 'Transient' state of the Track while fitting it

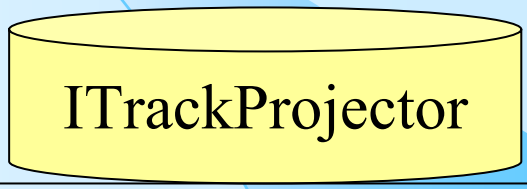


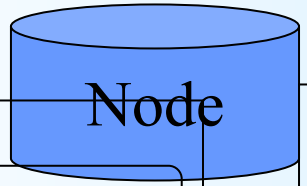

A Measurement:

type (I.e RVelo)

z, measure, error (double)

LHCbID




A Node:

type (I.e RVelo)

Measurement* ("refined")

State*

residual, error

Methods:

chi2(), …

Internal?…

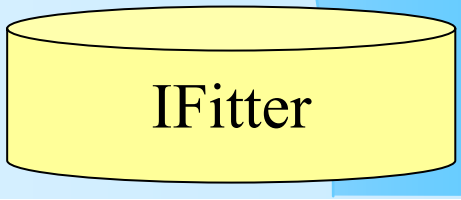
A Projector: Project a state into a measurement

Main method: project(State, Measurement)

*Internally deals with the Alignment/Calibration*

Methods:

*residual, chi2, node, ProjectionMatrix (H)*



# Step II, Status and Plans

- **Define the client Interfaces:**
  - Measurement, Node, FitTrack, ITrackProjector, Ifitter
    - http://cern.ch/eduardo.rodrigues/lhcb/tracking
  - Please contact us if you want to discuss them…
  - A draft version in:
    - *Event/TrackEvent* and *Event/FitTrackEvent*
- **Next steps:**
  - Creating Measurements from Clusters
  - Coding the projectors
  - Expose them to Python
  - Check how they work…
  - Make the Kalman Filter work with Projectors and Extrapolator
    - The present code already has almost the ‘same’ philosophy.
    - A delicate work from *Tr/TrFitter* to *Tr/TrackFitter*
  - Study of how to refit the Track starting only from Track
    - It could imply to write in persistency some extra info (Marcel, Matt)

# Conclusions and Plans

- **Status:**
  - Steady work, many fronts, small forces (E.R,JAH, Edwin Bos –Nikhef-)
  - Guide by G. Raven as a Task Force.
- **In the Plans**
  - Step I
    - TrgTracks to be Track
    - Tune the Python tool to migrate code to the new tracking
    - To have Ideal Pattern Recognition
  - Step II
    - Code Measurement, Projectors,
    - Adapt Fitter package
    - PR packages will follow accordingly with Task Force
  - In the Python front:
    - Expose the base classes inside ***Bender***
      - "Bender": exposing LHCb code (DaVinci, LoKi, Brunell) into Python
    - Interact with Panoramix
- **This A C++ chirurgic operation:**
  - For the moment the patient behaves fine, no anesthesia applied yet