Tracking Software.

Progress Report

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ATLAS ID Week Common Day
28/10/13

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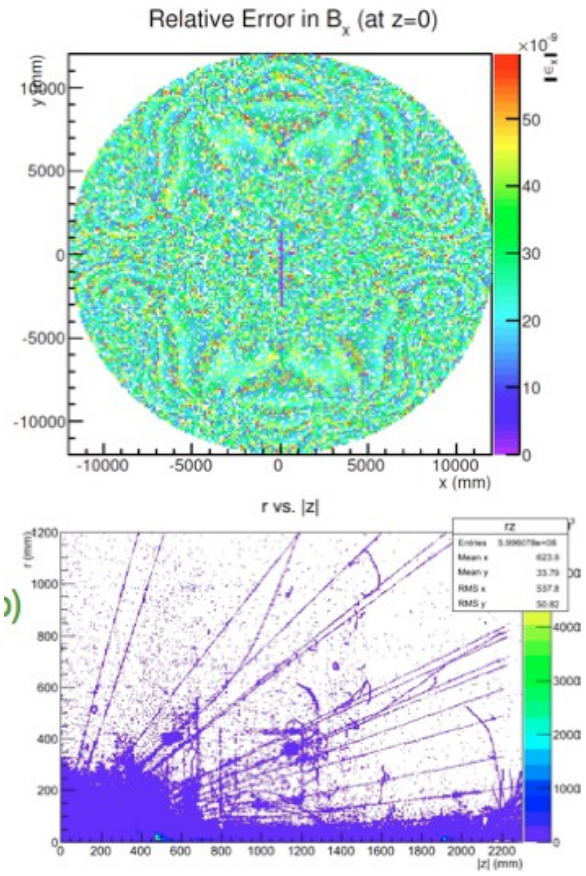
DESY

Introduction

- Tracking constitutes a significant fraction of total reconstruction time
  - LS1 was earmarked as an opportunity to make significant (and necessary) improvements ahead of Run 2
- Several activities have been ongoing recently in the domain of Tracking software:
  - New Magnetic Field Service
  - New Flat Track EDM
  - New Maths Library: CLHEP->Eigen
- Will outline the motivation, consequences and progress in each of these items
  - Also, the next steps that face the tracking software

New Magnetic Field

- Moving from previous FORTRAN90 version of magnetic field service to C++ implementation
  - Joint project between Tracking and Simulation developers
  - Overall, move to new Mag Field ~90% complete
- Several improvements with respect to old implementation
  - For example, cacheing of last look-up, avoiding unit conversion...
  - Also some simplified fields available for use where appropriate
- New service has been in devval for sometime
  - Wrapper to old service available
  - Plan for future is to use new service directly throughout



New Track EDM

- Flattening of TrackParameters EDM
  - Now just two template class implementations remain, ParametersT and CurvilinearParametersT

```
namespace Trk {

    typedef ParametersBase<5, Charged>                  TrackParameters;
    typedef CurvilinearParametersT<5, Charged>          CurvilinearParameters;
    typedef ParametersT<5, Charged, ConeSurface>        AtaCone;
    typedef ParametersT<5, Charged, CylinderSurface>    AtaCylinder;
    typedef ParametersT<5, Charged, DiscSurface>        AtaDisc;
    typedef ParametersT<5, Charged, PerigeeSurface>     Perigee;
    typedef ParametersT<5, Charged, PlaneSurface>       AtaPlane;
    typedef ParametersT<5, Charged, StraightLineSurface> AtaStraightLine;

}
```

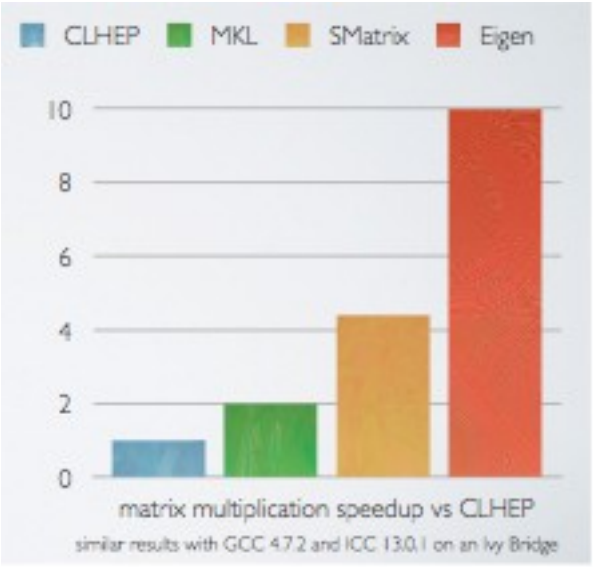
  - Above example from TrackParameters.h; dimension changes from 5->6 for ExtendedTrackParameters
  - Charged->Neutral for NeutralParamters

New Track EDM

- Change reduces lines of code by 98%
  - 9180 lines of code over 11 files collapsed to 277 lines in 4 files
  - Factor 4 speed-up in stand-alone creation/access/deletion tests
- Some consequences
  - Removal of Trk::ErrorMatrix: now just access to the covariance matrix, to be inverted if weight matrix is required
  - Removal of MeasuredTrackParameters; just check for existence of pointer to covariance
  - Mostly avoids the previously large number of dynamic memory allocations and dynamic_casts (can create TrackParameters from Trk::Surface to get the correct type instead)
- Migration largely complete for Tracking/ID/MS
  - Next, propagate these changes through to CombinedReconstruction

Eigen Migration

- Why Eigen?
  - Simply, most performant option
  - Aside: xAOD prototype provides Smatrix and Eigen interfaces in Athena, but only SMatrix within ROOT
- Amg Interface developed to provide interface similar to CLHEP
  - Also some optimisations such as macros for fixed size & symmetric matrices
- Some consequences
  - Removal of LocalParameters/GlobalParameters, use Amg::Vector2D or Amg::Vector3D
  - Amg::Vector3D used both for vectors and points; care must be taken when applying transform to which type an Amg::Vector3D represents!
  - CLHEP has two methods, (x,y) and [x][y] which count from 1 and 0 respectively, Eigen access always counts from 0
  - Unlike CLHEP, uninitialised matrices do not contain identity or zeros; must be set explicitly



Eigen Migration: Consequences for Geometry

- Tracking/ID/Muon domain is being migrated, GeoModel is not planned to be
  - InDet/MuonReadoutGeometry packages 'bridge' these two domains
  - Currently, both Eigen/Amg and CLHEP used within ReadoutGeometry
  - Amg contains helper classes to convert transforms CLHEP<->Eigen which are very useful here
  - Aside: plan for future to split InDetReadoutGeometry into separate Si and TRT packages, with an eye towards Upgrade layouts
- TrkDetDescr has been migrated
  - Also massive code clean-up at the same time; for example now a single BinUtility class in place of ~20

Mig5 Status

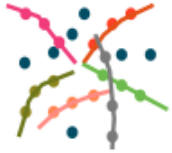
Status as of today (Monday, 28/10/2013)

AtlasEvent	x86_64-slc6-gcc47-opt	rel_1	2013-10-27 23:22	45 (60)	10/27 23:53	N/A	N/A				10/27 23:36 F	79 (76)	10/28 0:15	tags
AtlasReconstruction	x86_64-slc6-gcc47-opt	rel_1	2013-10-27 23:58	159 (186)	10/28 0:40	N/A	N/A				10/28 0:09 F	20 (10)	10/28 1:06	tags

- Just a handful of Tracking/ID/Muon packages still failing in AtlasEvent
  - More in AtlasReconstruction, but number is coming down every day
  - Progress can be followed in Jira; can see that a relatively small number of people have migrated a large number of packages: http://goo.gl/hFcfOD (ID) http://goo.gl/Cu9OqF (Tracking/Muons)
  - Also a lot of work in providing new Amg functionality, and release coordination (thanks to R. Langenberg and L. Caminada)
- Full track fits are running in mig5, as is MS segment finding
  - Soon, can start thinking about validating these in detail (more later...)
- Plan is to merge into devval soon

DESY

Mig5 Status

	stage	migration status	ID CPU time	comments
	space point formation	done	-1%	fully validated
	space point seeded track finding	done	-20%	slightly increased track finding efficiency
	ambiguity solving & track fitting	done	N/A	**biggest relative CPU saving potential,** debugging phase
	vertex reconstruction	ongoing	N/A	bound together with **xAOD** via xAODParticle design, prototype in preparation
	particle creation	ongoing	M/A	

Next Steps: How to Validate

- Now that bulk of tracking is running, validation tools become very urgent
  - Validation of some individual aspects (e.g. geometry-related packages) via stand-alone 'Unit Tests has already been performed
  - Good progress has been made in migrating Muon D3PDMaker code
  - TrackD3PDMaker ~finished; package itself compiles, some of the tools it uses still need to be migrated
  - Such packages have significant opportunities for streamlining; do not want to change functionality at this stage otherwise we will not be able to 'validate the validation'
- Another form of validation: Peer review of code
  - Various pitfalls that can escape attention first time around
  - Catch bugs at an early stage
  - Aim to use Jira to track which packages have been reviewed: Packages change status from 'Resolved' to 'Closed' after successful peer review, or are move back to 'In Progress' if problems found
  - Especially useful if original author/maintainer can do this (they are not always the ones doing the migration)

Next Steps: xAOD

- Many talks this week about xAOD development
  - See talk from A. Krasznahorkay in ASG session of S&C WS on Tuesday: http://goo.gl/IzdoHL
  - New task force (AMSG TF4) formed this week for migrating code to use xAOD
- Prototype xAOD::TrackParticle has been developed
  - See talk from E. Moyse in Tracking Software session on Thursday: http://goo.gl/3HkOMX
- xAOD::Vertex design is also now in pipeline
  - K. Prokofiev is working on this
- Also a good opportunity to clean up TrackSummary class
  - Grew 'organically' with things simply added when requested; much of the information contained may no longer be needed

Summary and Conclusions

- Migration of Tracking/ID/Muon software is progressing well
  - More help is always appreciated in this to finish the remaining packages, especially from those with some familiarity with tracking software
  - Once complete, merge into devval, and propagate changes to other domains
  - People need not necessarily wait until then; can use mig5 to start migrating
- Next urgent priority is to be able to properly validate the tracking
  - Dedicated effort to make sure the necessary tools are in place soon
- Hope to soon be able to see the performance improvements brought by these changes
  - Results of testing some specific elements in isolation are promising; soon we will have the complete picture
  - Can then begin to look again at what are the new hotspots, and iterate on how to improve them
- Tracking Workshop this week
  - Hopefully many new ideas for the immediate/short/medium/long term will result