Feedback from LHCb

27th G4 Technical Forum

Issues from Experiments and Users

30th March 2010

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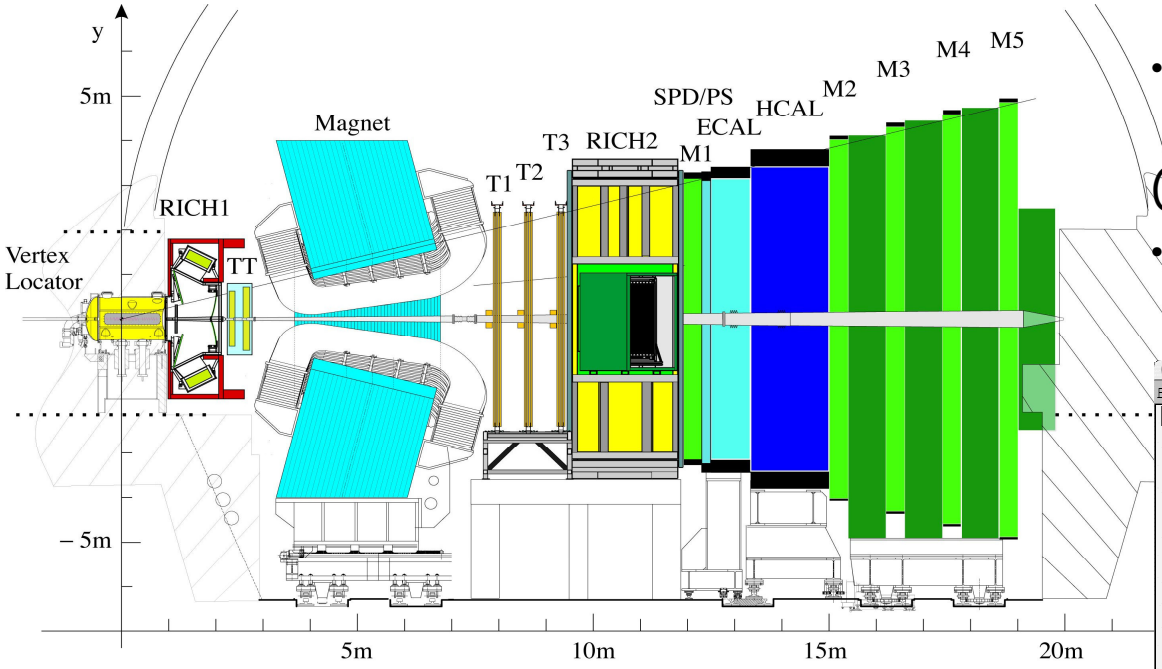
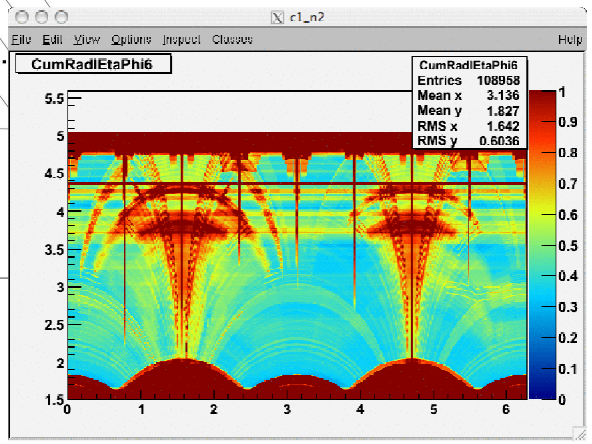
Physics tuning studies



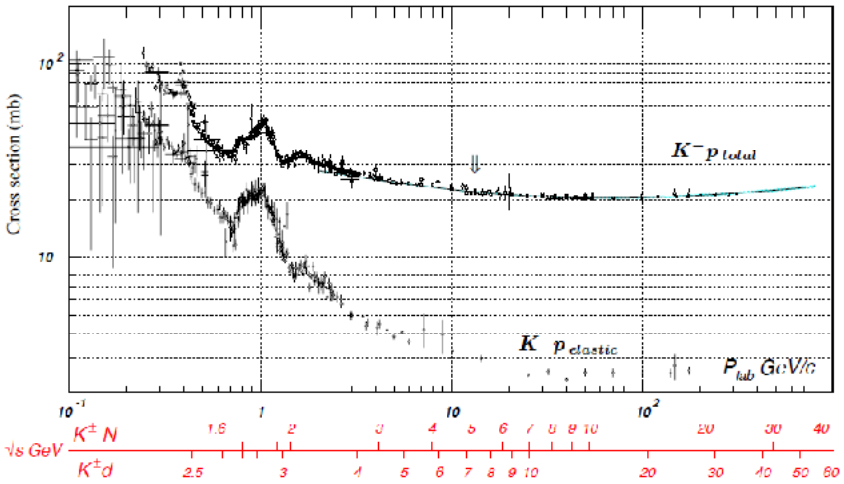
- Amount of material in tracker area kept as low as possible ($0.6X_0$ up to RICH2)
- HCAL used mainly for trigger purpose

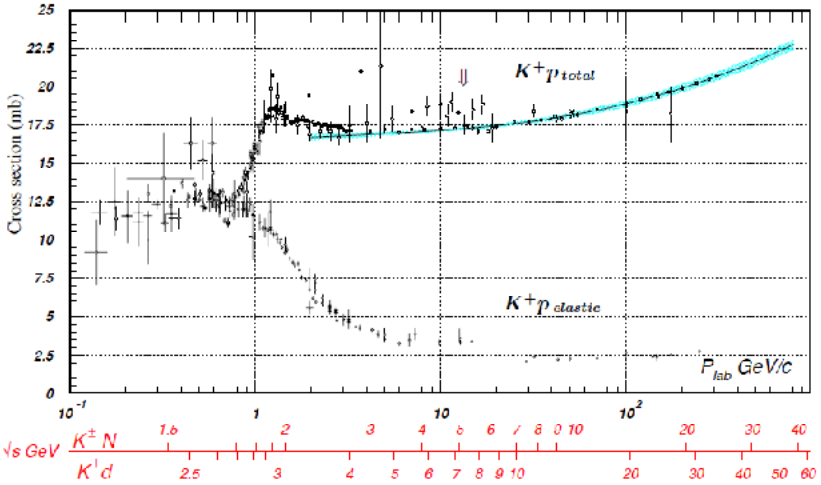


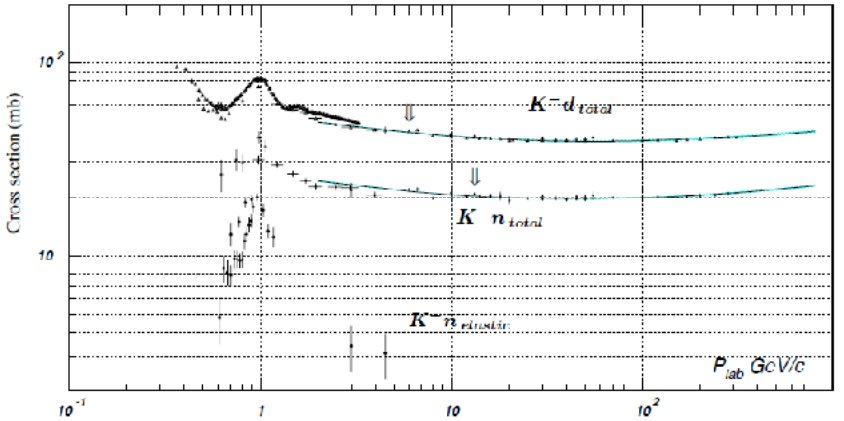
Main issues:

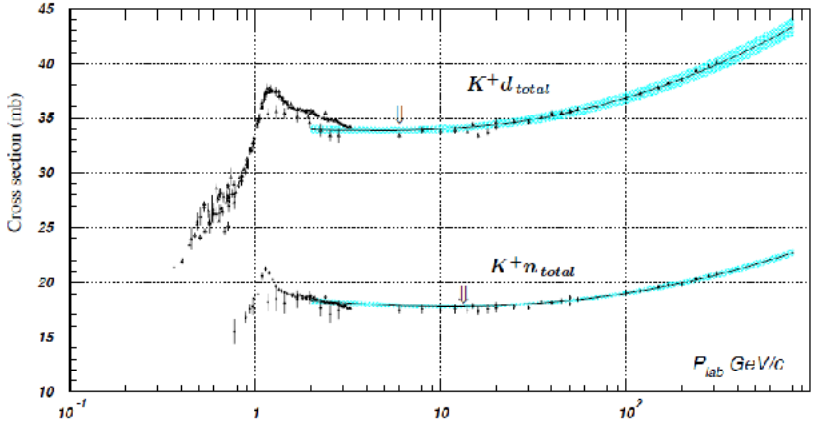
- G4 description of dE/dx in thin Si detectors
- G4 Multiple Coulomb Scattering simulation in case of large step sizes and dense material
- Particle multiplicities in hadronics interactions for thin layers
- Interaction asymmetries
- Kaon interactions

PDG cross sections

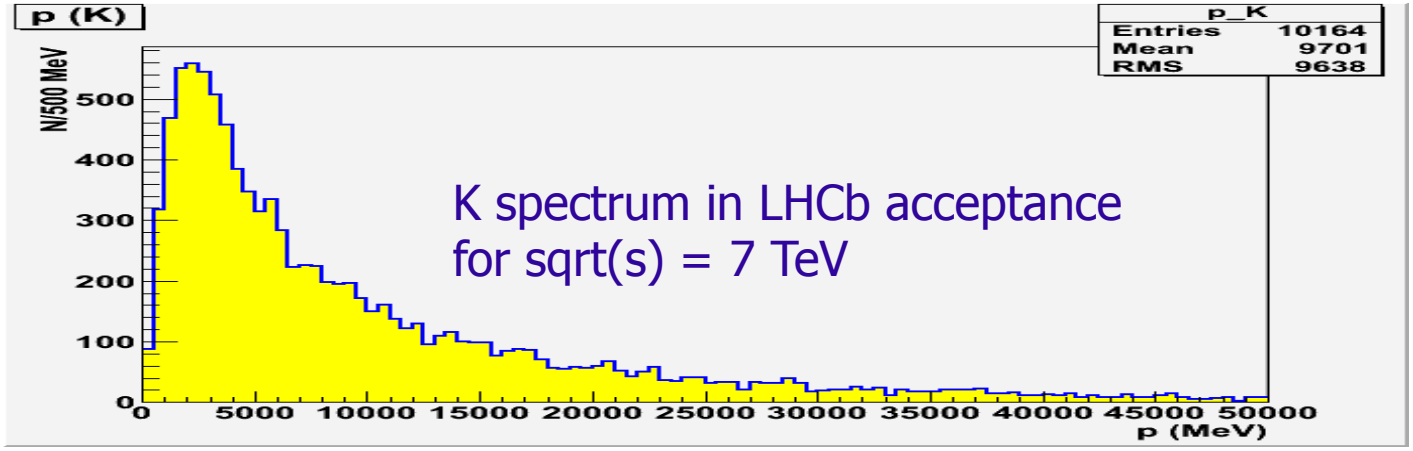




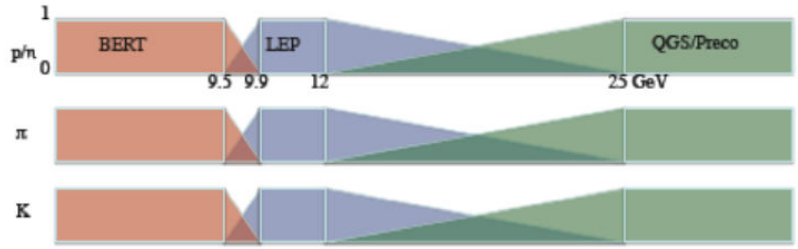




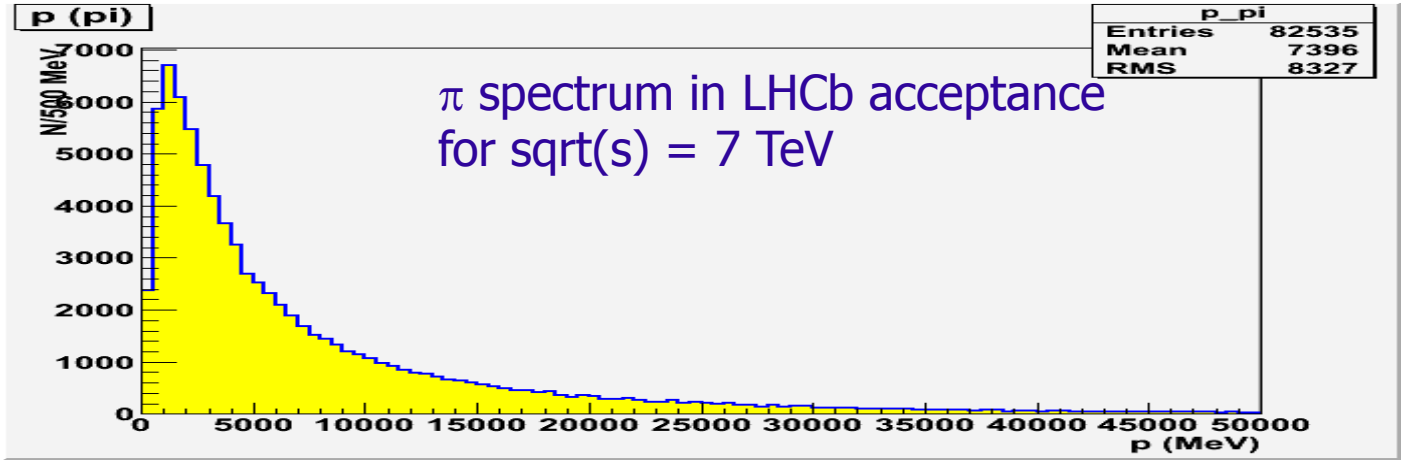
G4 Physics Lists - LHCb K and π range



K spectrum in LHCb acceptance
for sqrt(s) = 7 TeV



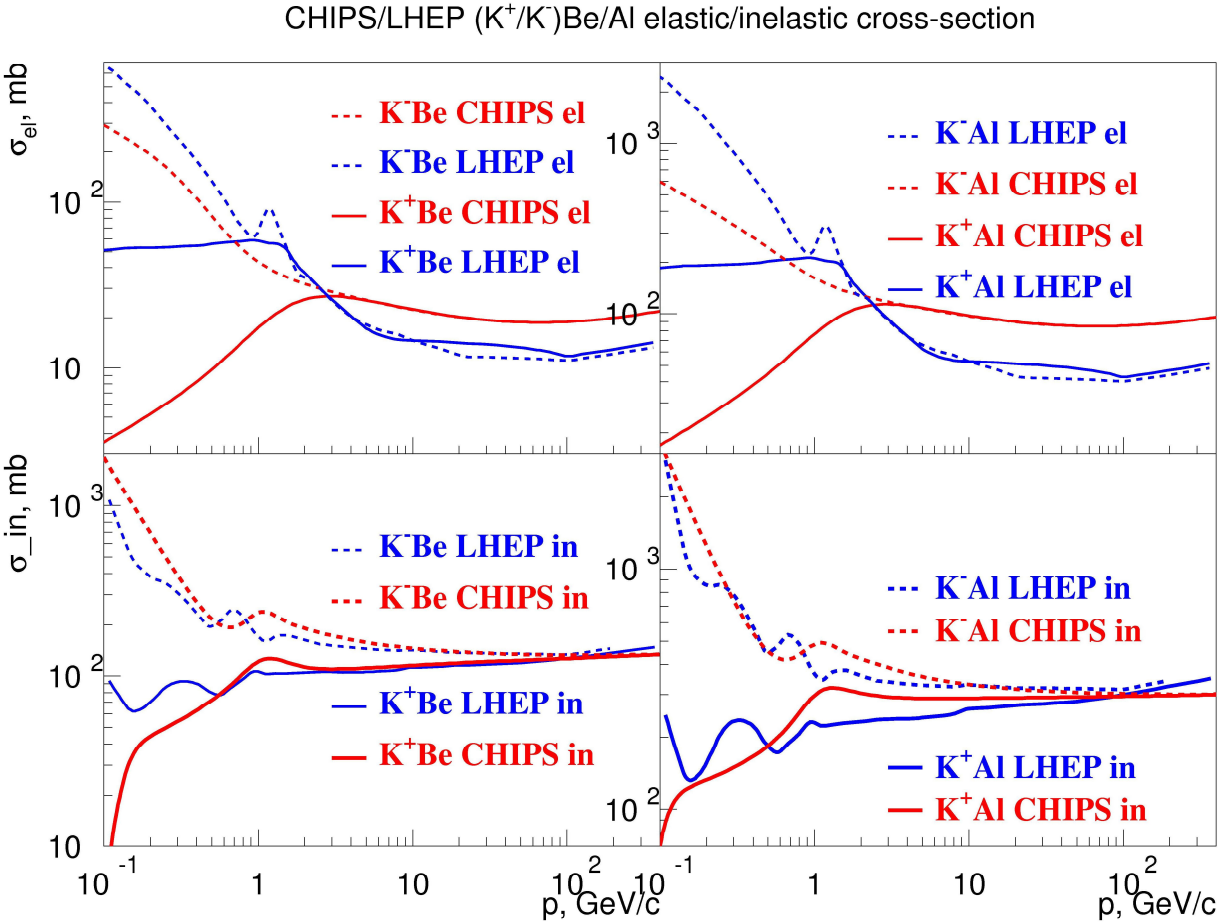
So far used LHEP
Looking into QGSP_BERT and FTFP_BERT



π spectrum in LHCb acceptance
for sqrt(s) = 7 TeV

K+/- interactions

Kaons are not only present in B signal decays but are also an essential ingredient in flavor tagging



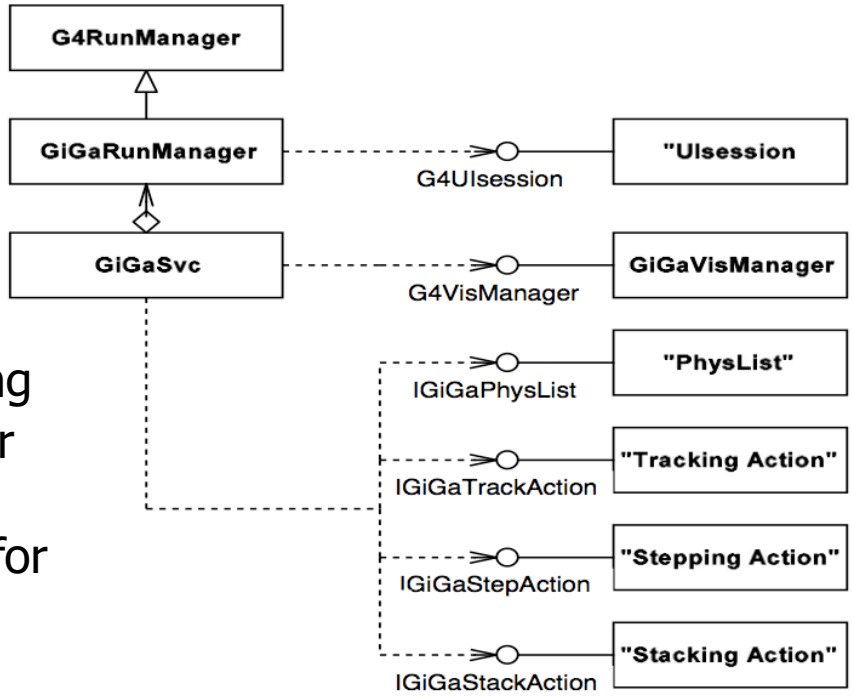
Need an hadronic physics builder with well modeled Kaon interactions

courtesy of Mikhail Kosov

G4 Physics Lists Constructors

- Need to study different PLs performances for future MC productions to tune and validate w. r. to data (LHEP used so far).
- LHCb frameworks communicates with G4 through the GiGa (Geant4 Interface for Gaudi Application).
- A PL instantiated via a templated wrapper (GiGa tool GiGaExtPhysics) around **G4VPhysicsConstructor.**

```
GiGa.PL.PhysicsConstructors += [
  GiGaExtPhysics<G4HadronElasticPhysics>
  ... ]
```



- The PL is defined at run time configuring the list of builders to be used. They mirror the templated list set up in G4 with the addition of LHCb physics processes (e.g. for the RICH)

G4 Physics Lists Constructors

- The constructors were always called with their default arguments. Only name and verbose level could be accessed via methods of **G4VPhysicsConstructor.**

```
template <class PHYSCONSTR>
class GiGaExtPhysics : public GiGaPhysicsConstructorBase
{
  ...
public:
  G4VPhysicsConstructor* physicsConstructor ()  const
  {
      m_phys =  new PHYSCONSTR() ;
      m_phys -> SetPhysicsName( name() );
...
    }
    return m_phys ;
  };
```

- a helper class (GiGaExtPhysicsExtender) was introduced to allow customized initializations through template specialization

G4 Physics Lists Constructors

- Specialized extensions to templated class were implemented to allow the proper set of G4 constructors arguments to be passed :

(example for **G4HadronElasticPhysics**):

Method to declare extra arguments to pass to the constructor

in QGSP_BERT_HP set to true
in QGSP_BERT set to false

```
template <>
class GiGaExtPhysicsExtender<G4HadronElasticPhysics> {
public:
  inline void addPropertiesTo(AlgTool *tool) {
    tool->declareProperty("HighPrecision", m_highPrecision = false,
                          "Parameter 'HighPrecision' for the constructor of G4HadronElasticPhysics");
    tool->declareProperty("Glauber", m_glauber = false,
                          "Parameter 'Glauber' for the constructor of G4HadronElasticPhysics");
  }
  inline G4HadronElasticPhysics *newInstance(const std::string &name, int verbosity) const {
    return new G4HadronElasticPhysics(name, verbosity, m_highPrecision, m_glauber);
  }
private:
  bool m_highPrecision;
  bool m_glauber;
};
```

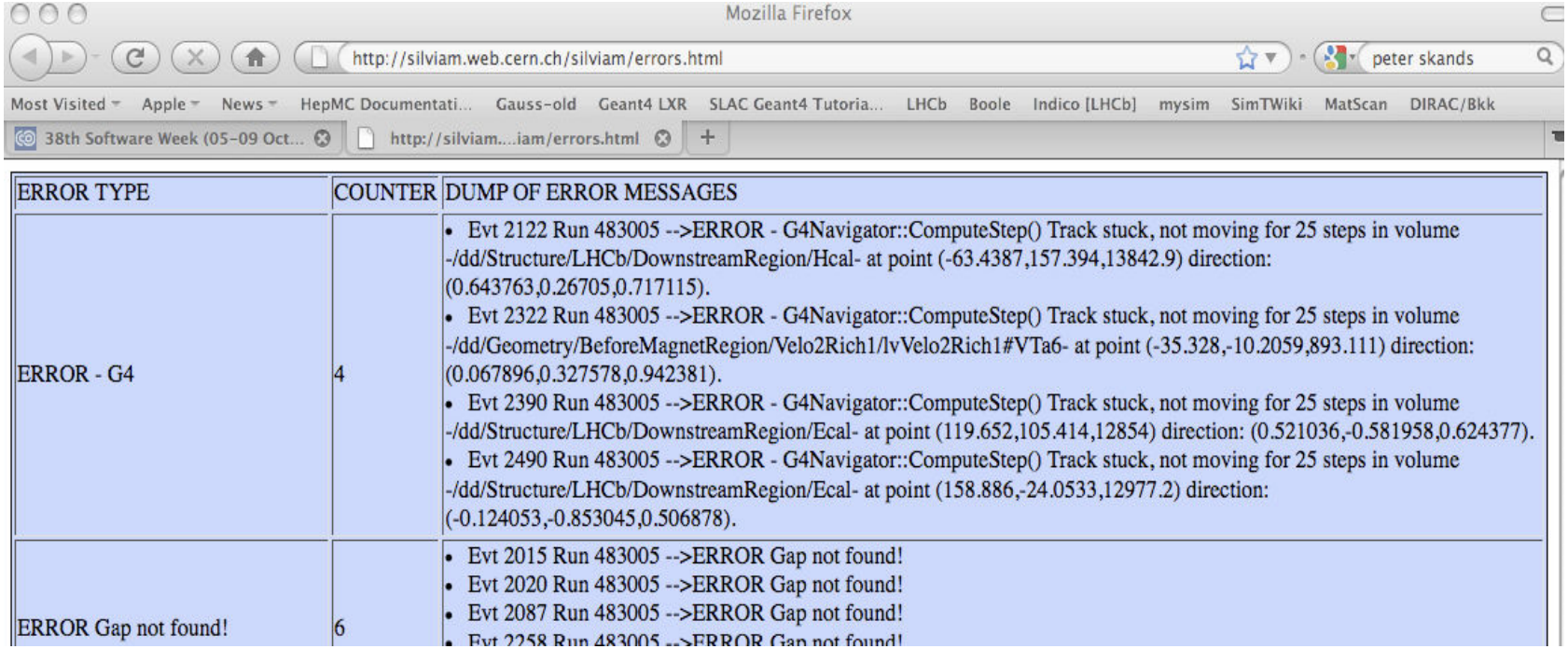
G4 Physics Lists Constructors

Suggestions/proposals

- rationalize the constructors of the PL builders
- create an extender of **G4VPhysicsConstructor** to allow the setting of class arbitrary parameters

Debugging Gauss in production

- Important to trace back reason of crashes and problems not leading to crashes (event aborted) during production:
  - impossible to look trough 45000 job log files /day
  - G4 errors detected at job level during production and combined for a given sample
  - dump of error messages together with RunNr,EventNr -> full reproducibility of event (random seed reset every event)



ERROR TYPE	COUNTER	DUMP OF ERROR MESSAGES
ERROR - G4	4	• Evt 2122 Run 483005 -->ERROR - G4Navigator::ComputeStep() Track stuck, not moving for 25 steps in volume -/dd/Structure/LHCb/DownstreamRegion/Hcal- at point (-63.4387,157.394,13842.9) direction: (0.643763,0.26705,0.717115). • Evt 2322 Run 483005 -->ERROR - G4Navigator::ComputeStep() Track stuck, not moving for 25 steps in volume -/dd/Geometry/BeforeMagnetRegion/Velo2Rich1/lvVelo2Rich1#VTa6- at point (-35.328,-10.2059,893.111) direction: (0.067896,0.327578,0.942381). • Evt 2390 Run 483005 -->ERROR - G4Navigator::ComputeStep() Track stuck, not moving for 25 steps in volume -/dd/Structure/LHCb/DownstreamRegion/Ecal- at point (119.652,105.414,12854) direction: (0.521036,-0.581958,0.624377). • Evt 2490 Run 483005 -->ERROR - G4Navigator::ComputeStep() Track stuck, not moving for 25 steps in volume -/dd/Structure/LHCb/DownstreamRegion/Ecal- at point (158.886,-24.0533,12977.2) direction: (-0.124053,-0.853045,0.506878).
ERROR Gap not found!	6	• Evt 2015 Run 483005 -->ERROR Gap not found! • Evt 2020 Run 483005 -->ERROR Gap not found! • Evt 2087 Run 483005 -->ERROR Gap not found! • Evt 2258 Run 483005 -->ERROR Gap not found!

Debugging Gauss in production

Specific errors are not that frequent

G4 problems encountered during production:

1) jobs hanging in production (~ several%)

- ν or n of few MeV ping-ponging between Universe and an upstream volume

(protection has been introduced to kill these particles)

- charged particles of zero steps (G4 pushing them) in the same volume (protection introduced)

```
WARNING - G4PropagatorInField::ComputeStep():
 Zero progress for 51 attempted steps.
```

2) in ~0.5% of events aborted by G4 due to:

```
G4Exception : StuckTrack issued by : G4Navigator::ComputeStep()
Stuck Track: potential geometry or navigation problem
```

- track stuck message but G4 returning "no overlaps found" in check

Need to know which errors to look for…. that do not cause a crash…

It would help to have a unique way of messaging errors/warnings to have a generic script to find ALL of them

Or/and an error message summary

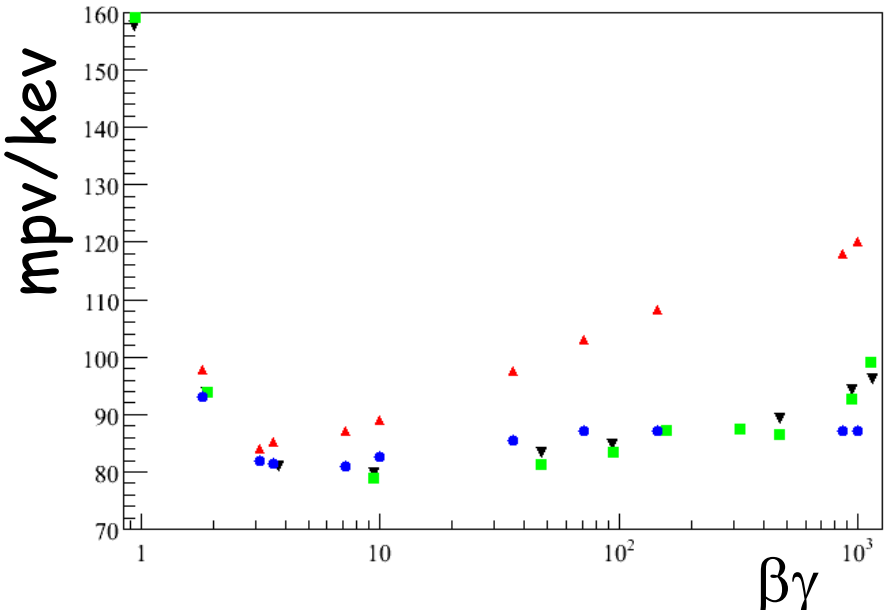
Backup for EM physics

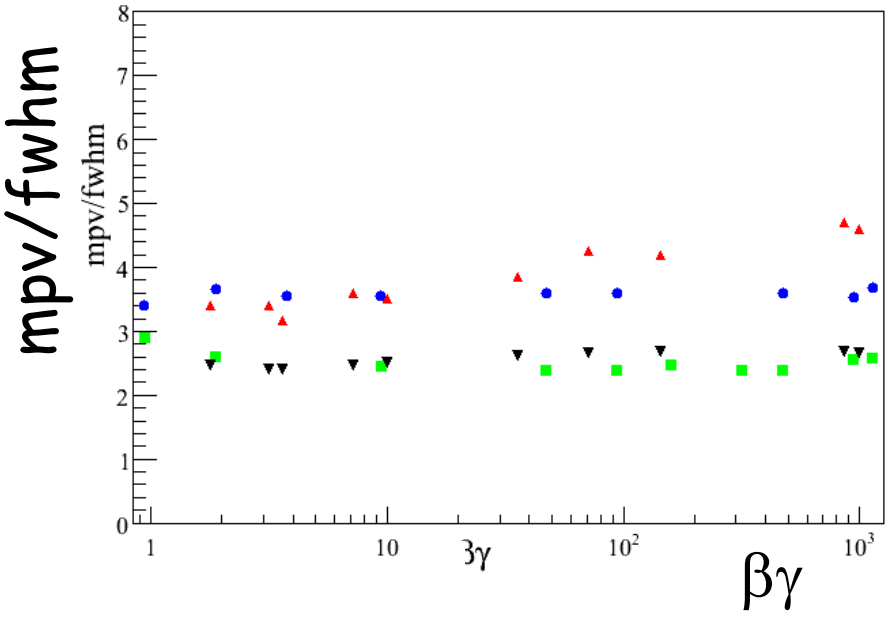
dE/dx in thin Si Detectors

- 3 detectors in LHCb use Si of different thickness (220μm,400μm, 600μm)
- Particle guns (50k muons at fixed Energy) studies performed
- Results of simulation compared to simple model describing data

Recent G4 versions -> much better agreement

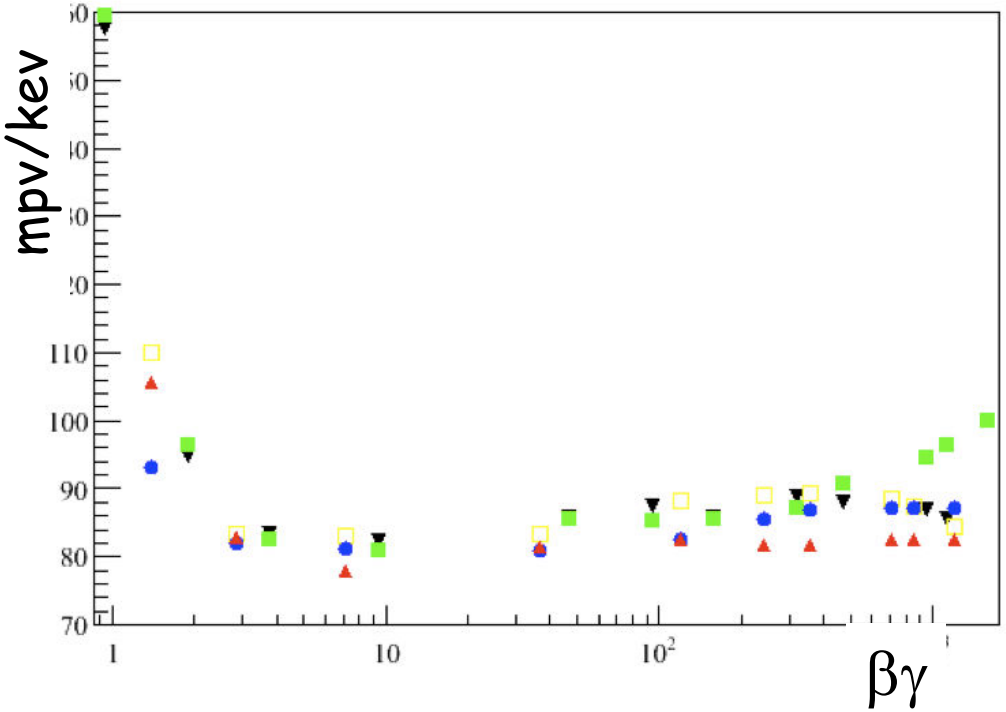
- **Landau + smearing for atomic binding**
- **G4 7.1.p03 (DC06)**
- **G4 8.3.p01 + EMOpt1**
- **G4 9.1.p01/p02/p03 + EMOpt1 (MC09)**





dE/dx in thin Si Detectors

- in G4 7.1.p03 the dE/dx intrinsic width was too small (atomic binding correction was missing) -> in digitization phase smearing was applied
- in G4 9.1 the atomic binding is simulated (width is close to expectation) -> correction no longer needed.
- the width seems to be a bit overestimated w.r.t. theory (~5% for 400μmSi)
- still remain problem in vertex detector (220μm Si) simulation: Landau width too wide w.r.t. test beam data



- better agreement with δ-rays on
  - still problem at high βγ for muons
- unphysical differences between muons and pions?

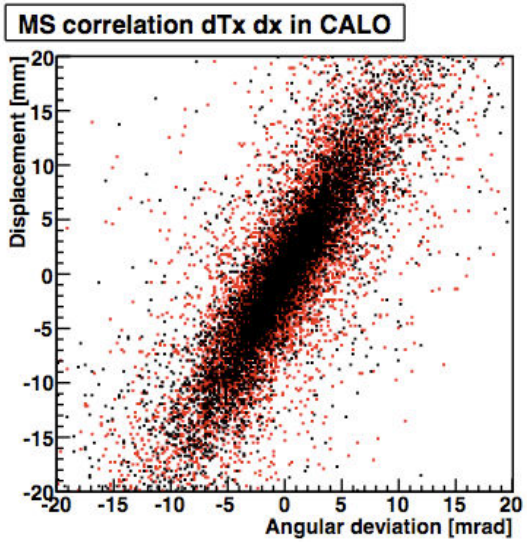
- **Landau + smearing for atomic binding**
- **G4 9.1.p01/p02/p03 (pions)**
- **G4 9.1.p01/p02/p03 (mu with δ-rays ON)**
- **G4 9.1.p01/p02/p03 (muons)**
- **G4 9.1.p01/p02/p03 (pions with δ-rays ON)**

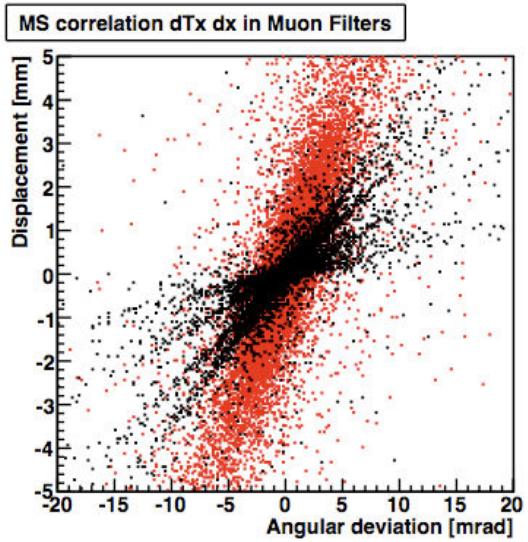
MCS in LHCb MUON system

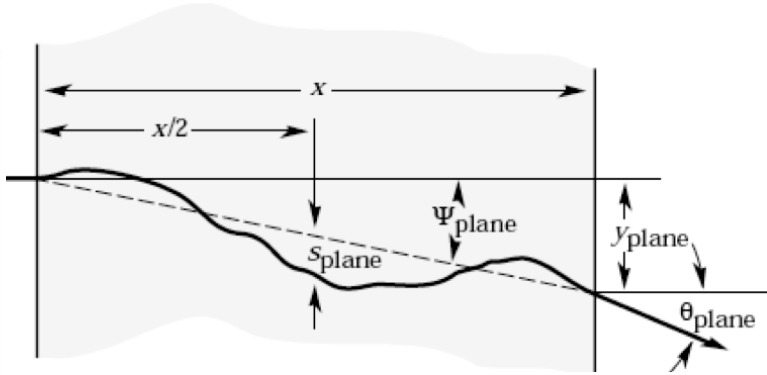
- Muon trajectories are dominated by multiples scattering interactions in the Calorimeters and Muon Filters

- The MCS in G4 is not correctly simulated in case of dense material and large step sizes (MUON Filters are a perfect example!) -> correlation between displacement and angular deviation not maintained.

- Step size not constrained by other factors (no B field simulated in that region)







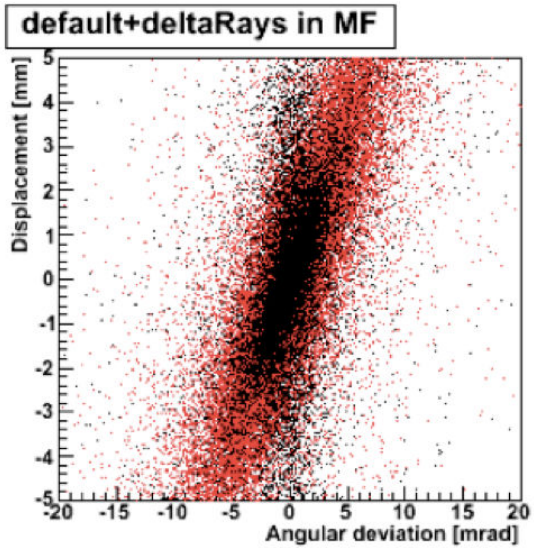
- G48.0
- PDG

- MCS problem may affects also the momentum measurement in the track fit when propagation of track over large distances (e.g. Magnet) -> poor q/p parameter pull.

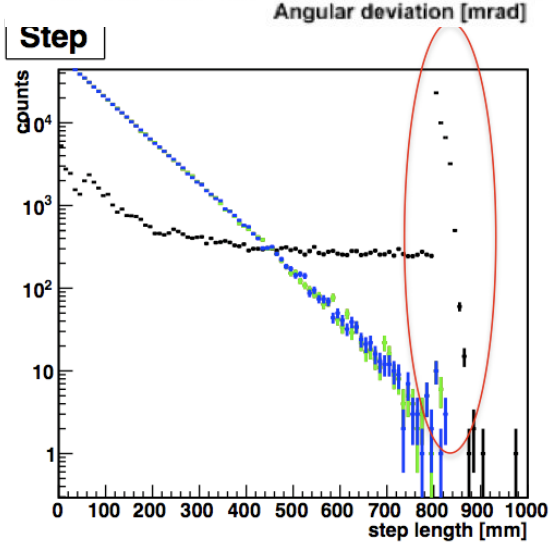
- Situation improved in current production but still the q/p pull is worse than the other track parameters.

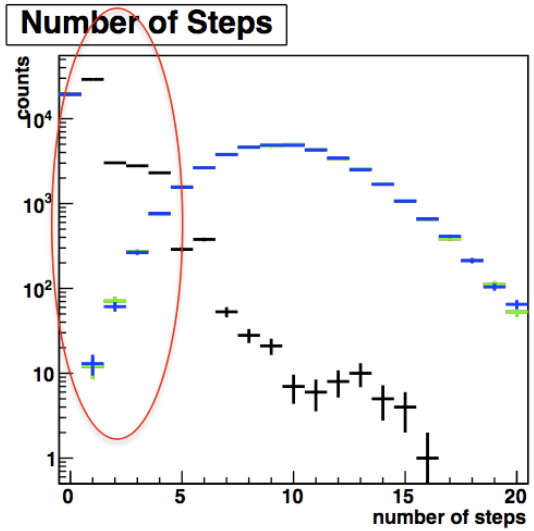
MCS in LHCb MUON system

• in future productions activation of δ-rays. Side effect G4 reduces the step length -> correct description of correlation (still slightly differences with PDG)



• G49.1p03
• PDG

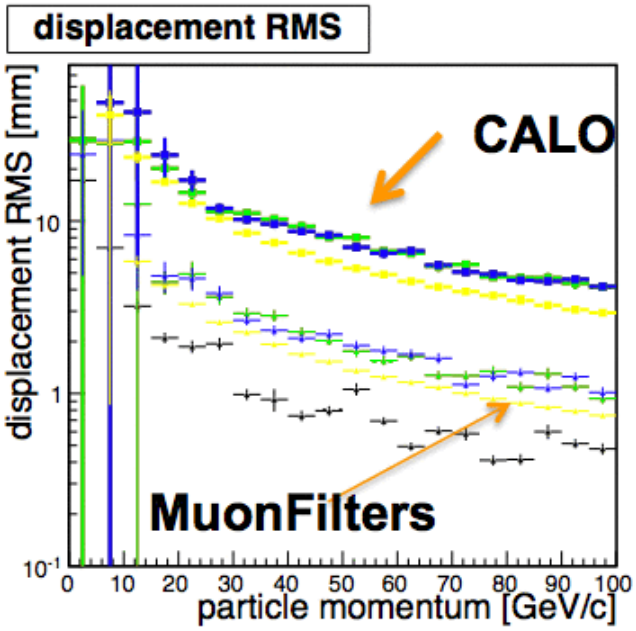


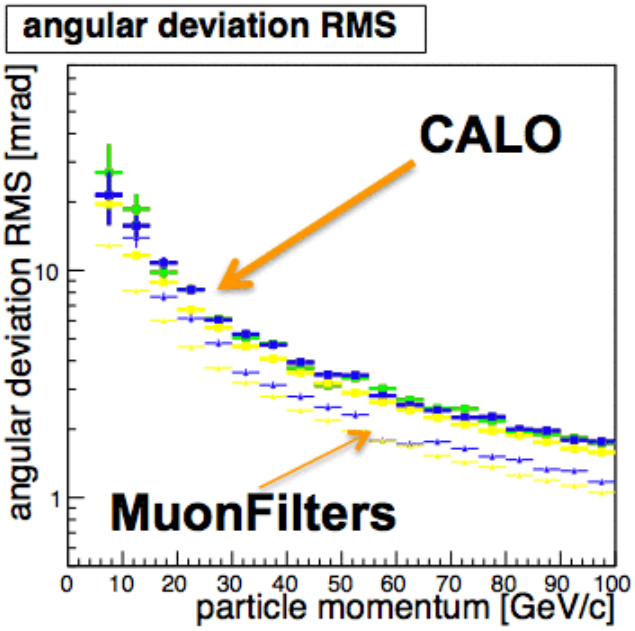


• default (δ-rays OFF)
• with δ-rays ON

MCS in LHCb MUON system

- MCS description in G49.1p03 (G4MuMscModel) slightly improved w.r.t. G4 8.2 (G4MuMultipleScattering), independently of δ-rays.
- Still slight differences with PDG
- Set up monitoring plots specific for MCS, to be investigated with Gauss based on G49.2p2 (being commissioned)





- Default
- δ-rays in ALL LHCb
- δ-rays in MUON Filters
- PDG