

# LHC collimation studies in the UK, Manchester and EUCARD2

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[EUCARD2 WP11 meeting](#)  
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# LHC collimation activities

The UK (Huddersfield, Manchester, RHUL) have been active in simulations for proton collimation through EUCARD and (mainly) HiLumi-LHC for the past few years.

I'll give an overview of the UK groups in this area, some scientific outputs from the MERLIN group (Manchester + Huddersfield) and potential areas of EUCARD2 application of the work.

The RHUL effort and the engineering effort of Huddersfield will appear in dedicated talks following this one.

# The UK groups active in LHC collimation



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- Led by Rob Appleby
- Interests dominated by collimation using new simulation tools, scattering physics and novel collimation schemes
- Existing manpower : 1.2 + 1 student



Led by Stephen Gibson

Interest dominated by SixTrack/FLUKA collimation studies for HL-LHC and seamless tracking / Geant4 integration tools

Existing manpower : 2.2 + new OPAC fellow



Led by Roger Barlow

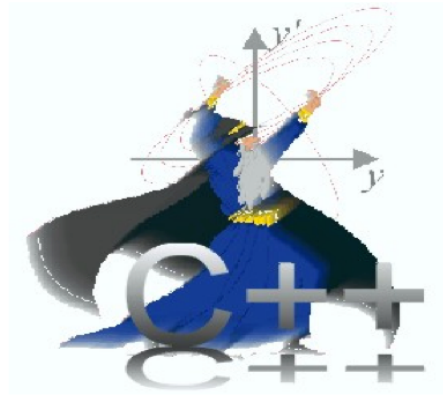
Interests dominated by simulation tools, scattering physics and collimator mechanics.

Existing manpower : 0.2 + 1 student. May add further students and engineers.

## Sixtrack, FLUKA, MERLIN and BDSIM : what they are

### **BDSIM**

A fast tracking library built with C++ and for GEANT4, allowing particle tracking in vacuum, essentially optical tracking, around the LHC lattice alongside secondary showers from G4. Under development by RHUL.



### **MERLIN**

Similar to philosophy to Sixtrack but as a flexible C++ library. Comes with more realistic scattering and parallel operation. Under development by Manchester/Huddersfield in a very modular, easily extendable, way. Tracking is currently 4D. Now gives consistent loss maps to Sixtrack for nominal and HiLumi cases. In this sense 'ready' for loss maps with enhanced scattering, novel materials and novel collimation schemes (modular design should make this easy).

The UK is primarily working on simulations



Our 'standard' halo tracking tool, with models of collimator scattering. Written in FORTRAN. Essentially 6D symplectic tracking with a K2-inspired non-inelastic scattering model.

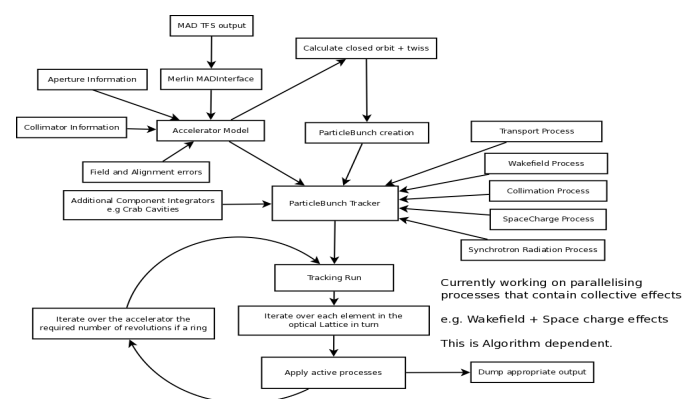
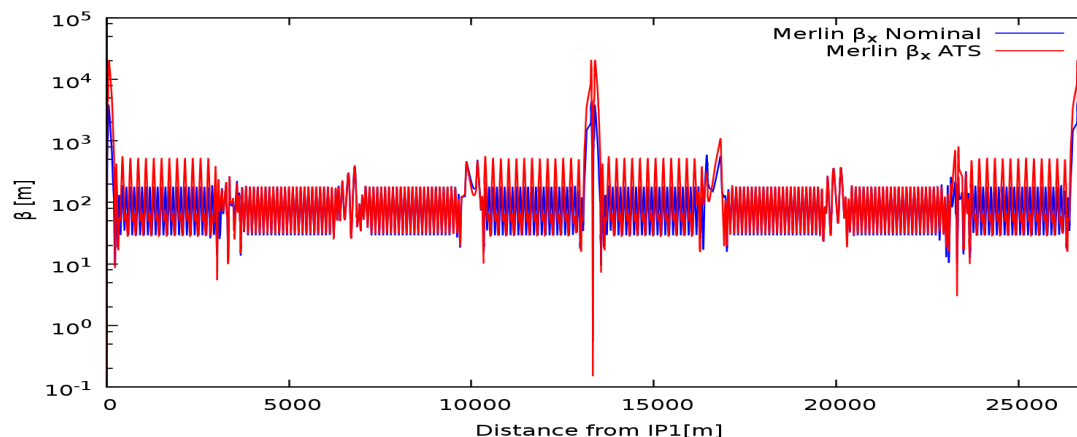
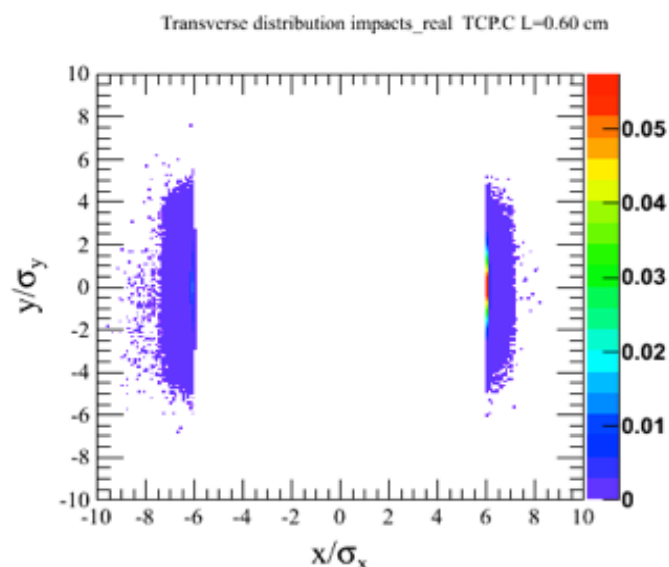


Shower code capable of tracking second showers down to low energy, and through magnetic fields. Big library of LHC components in its geometry language.

# LHC collimation with MERLIN (HiLumi-LHC and EUCARD)

As part of HiLumi LHC and (a little bit) EUCARD we've developed new tracking tools for protons, both for long term proton motion in the LHC and for understanding halo collimation in proton machines.

A key effort is the development of new collimator tracking and scattering tools (Based on MERLIN) developed originally for linear colliders, and is being adapted to study collimator loss maps, new collimation schemes and novel collimator materials and techniques.



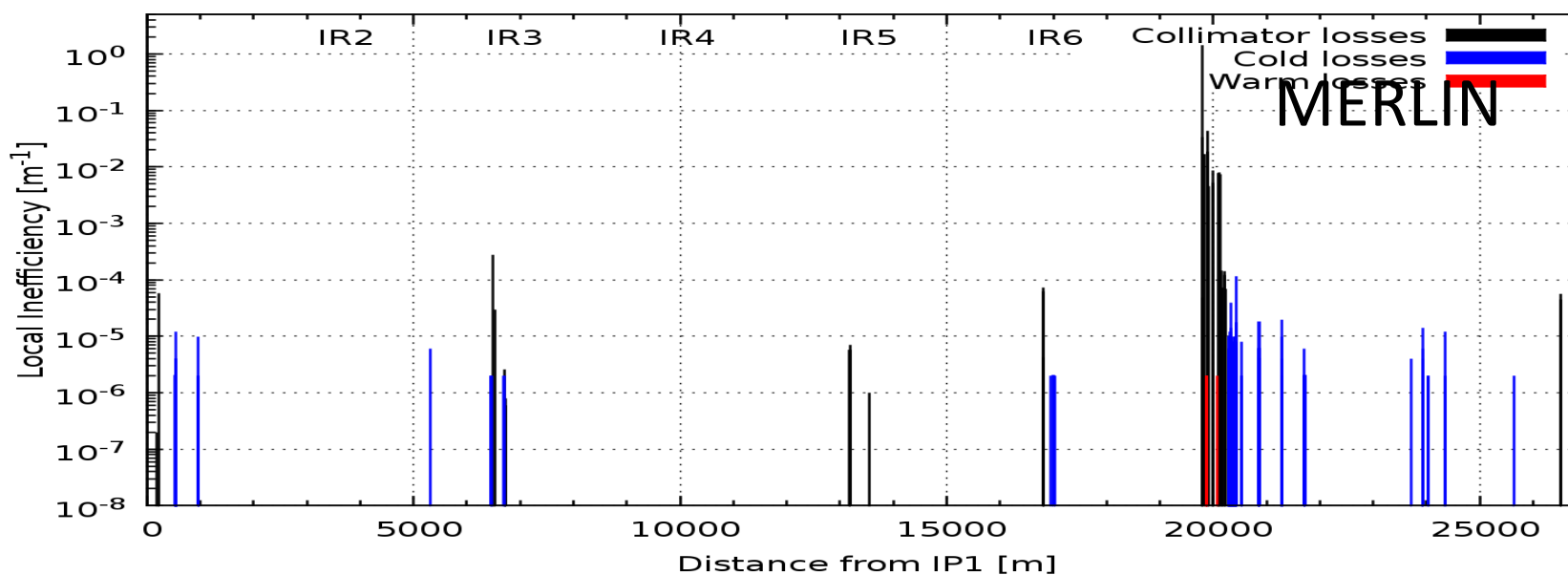
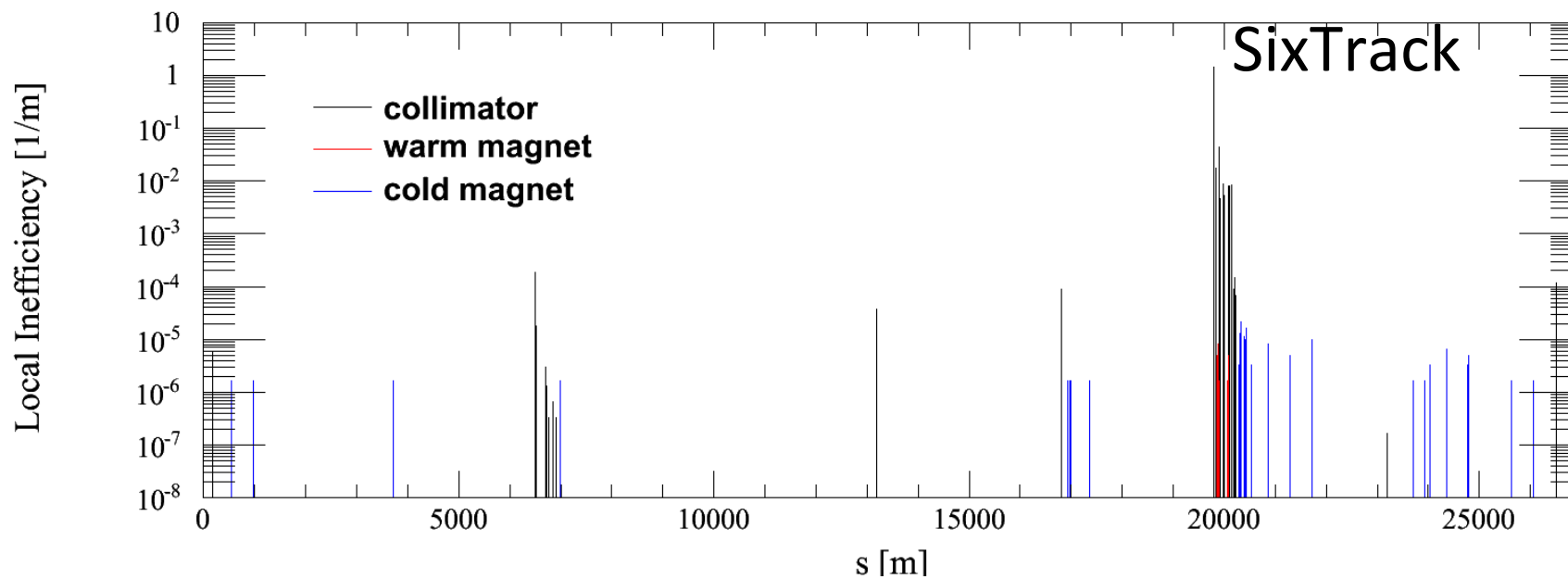
Modular design so easily extended to new composite materials.



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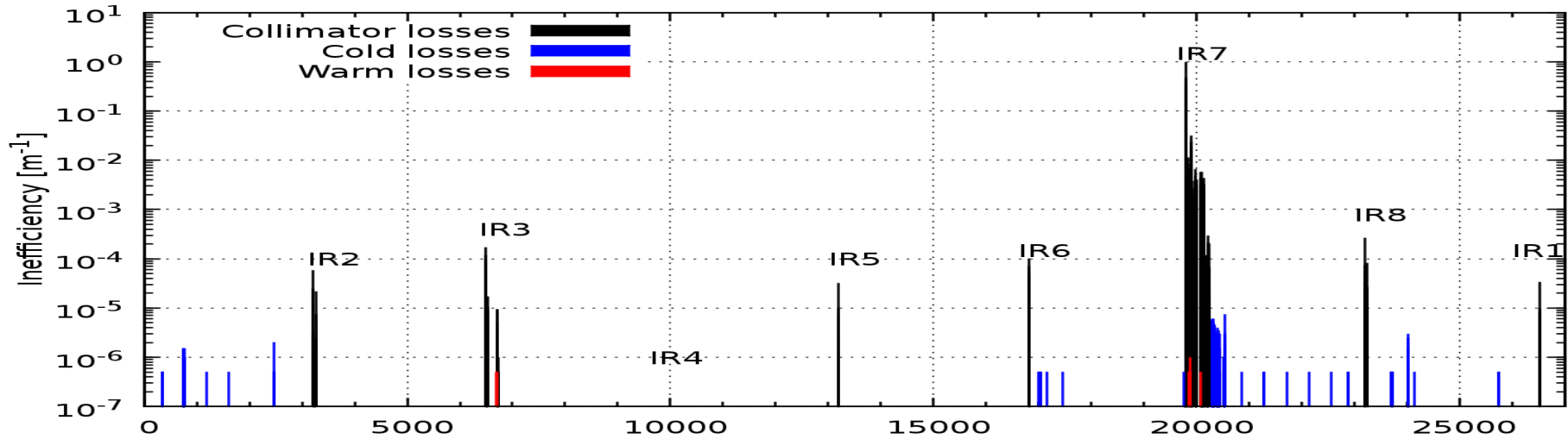
# LHC nominal loss maps with Sixtrack and MERLIN (HiLumi-LHC and EUCARD)

B1 HORIZONTAL

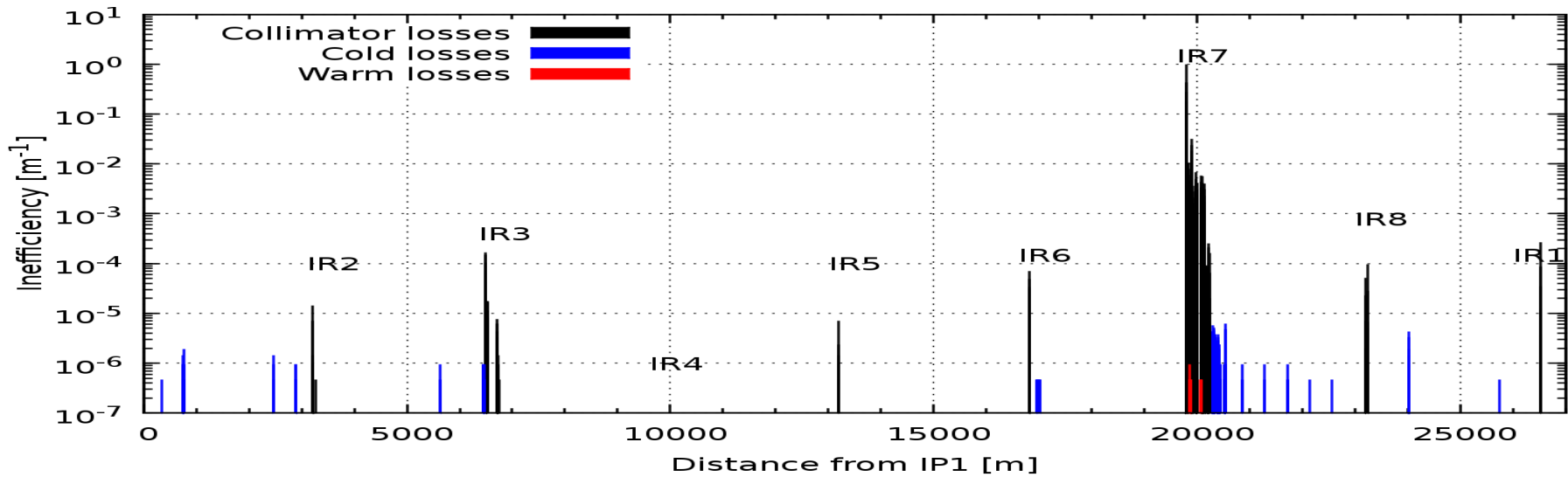


# LHC HL-LHC collimation loss maps (HiLumi-LHC and EUCARD)

Horizontal Loss map at 7 TeV - ATS B1



Horizontal Loss map at 7 TeV - PreSqueeze ATS B1



# Proton interactions in collimators (HiLumi-LHC)

We are developing new proton-collimator scattering models, based on the latest elastic and single diffractive measurements and models.

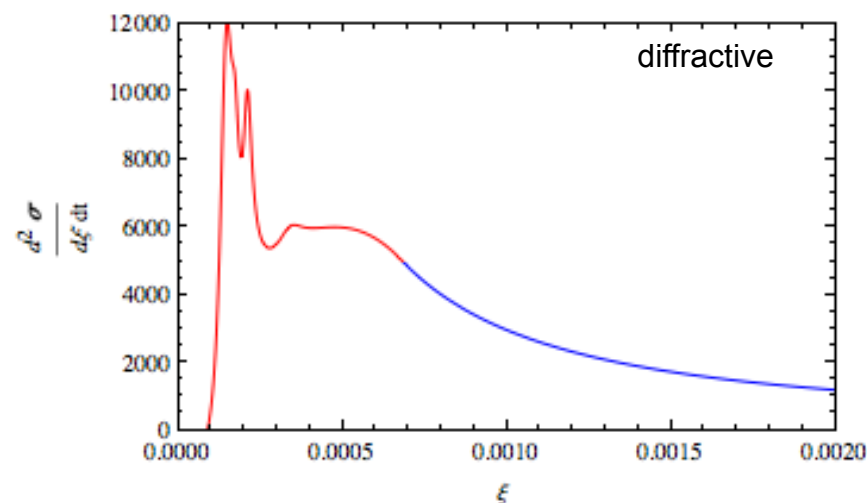
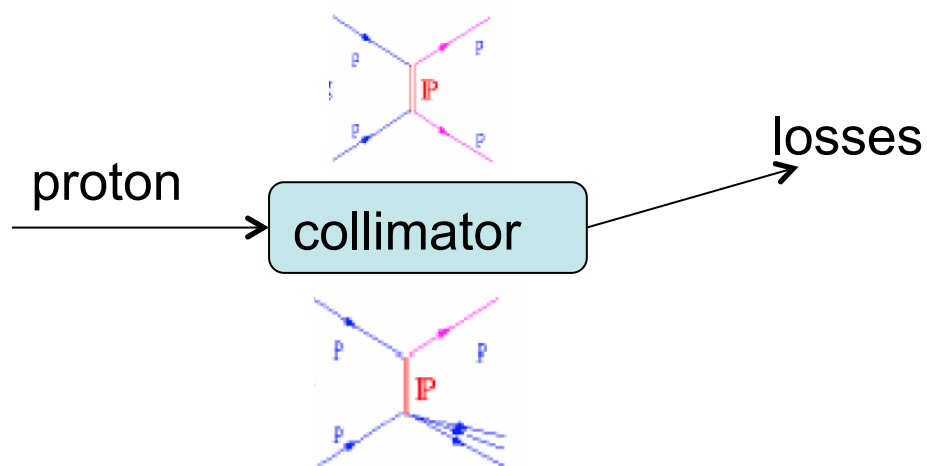
These processes in collimators drive protons losses around the LHC, particularly in the collimation regions and in the dispersive arcs around the ring.

The main idea is to model the single diffraction and elastic scattering with the Regge theory and get the parameters of the model from a fit from all the existing data for p-p and p-pbar scattering.

Sixtrack SD function:

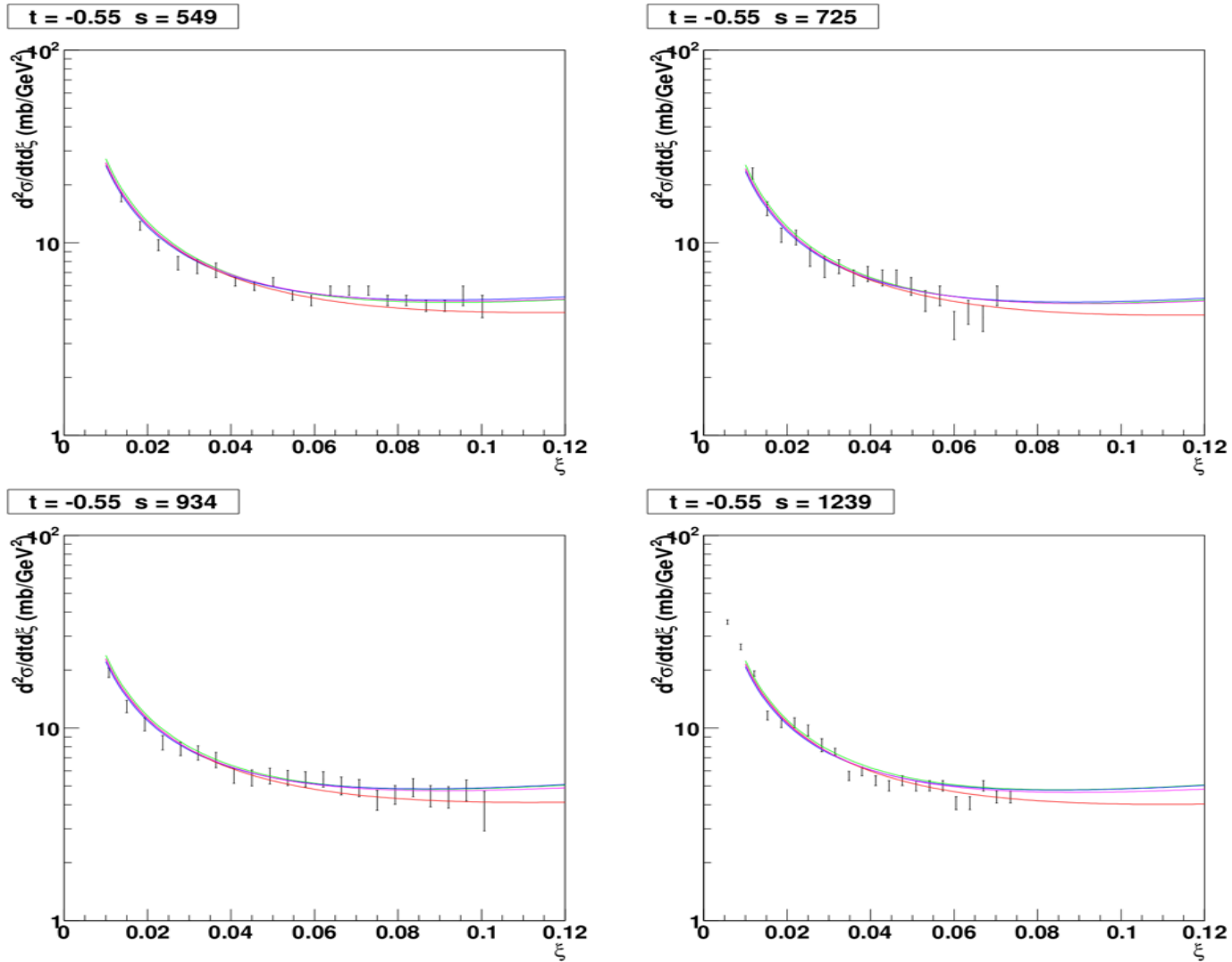
$$\frac{d^2\sigma}{dM_X^2 dt} \propto \frac{e^{-b(M_X)t}}{M_X^2}$$

In the plot is shown the double differential cross section for the exchanged momentum  $t = -0.05$ . The blue line is the fit of the Regge model and the red one is the contribution from the resonances at low missing mass  $M_X$ .





# Diffraction scattering (HiLumi-LHC)

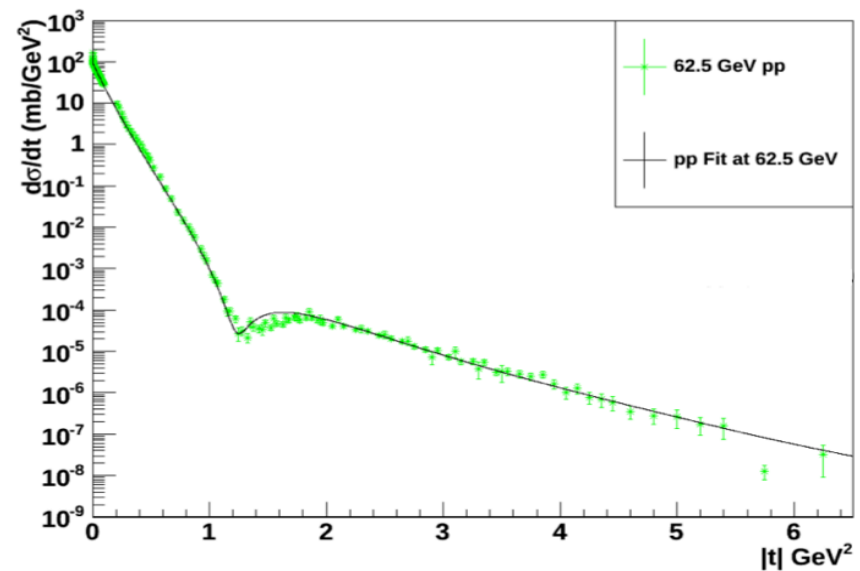
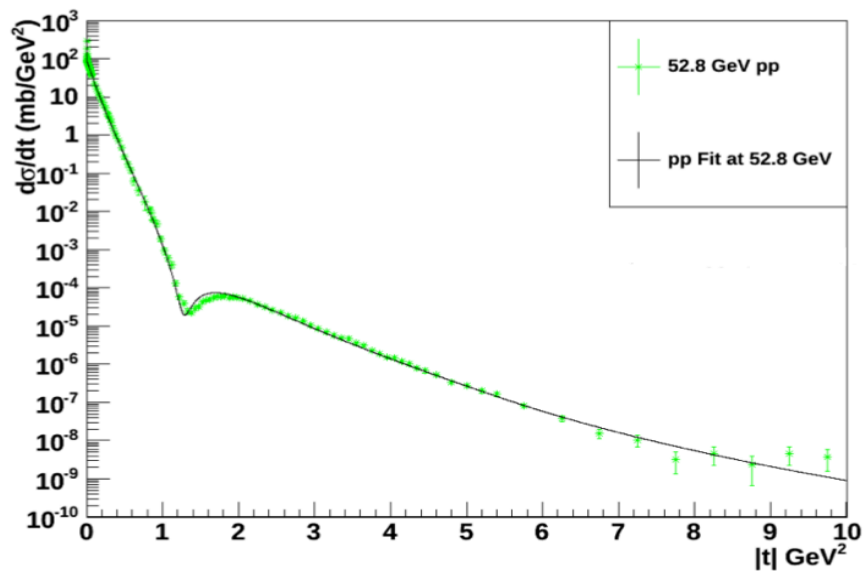
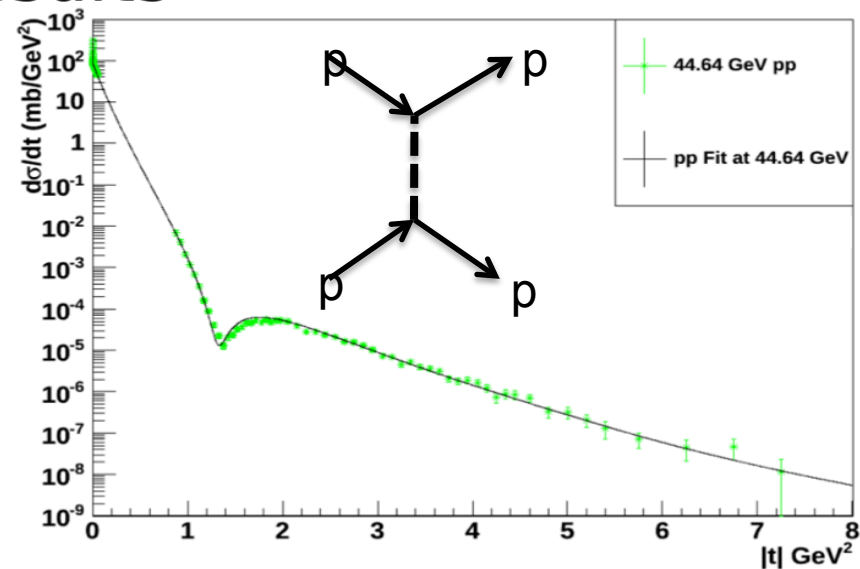
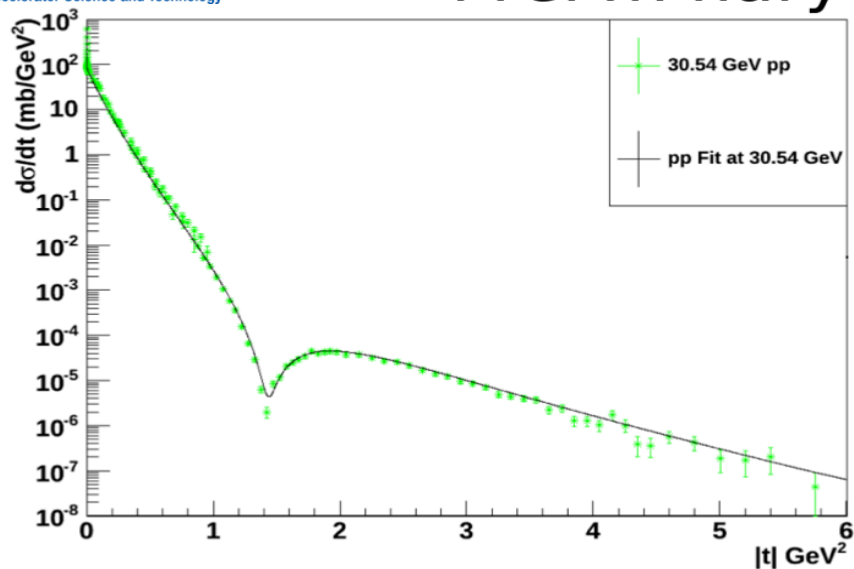




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# Elastic Scattering

## Preliminary Results





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# Potential EUCARD2 in Manchester

The MERLIN code has been developed for LHC collimation as part of the HiLumi-LHC project and EUCARD project.

The results for the LHC are very promising, and starting to bear fruit.

Potential areas of work in EUCARD2 are the following (but collaboration would be important to achieve these)

- Simulate the potential of new collimator materials like Mo-Graphite
- Comparison between, SixTrack, Merlin and FLUKA (ongoing)
- Implement cross-sections for novel materials and composites.