Muon Backgrounds

by Helmut Burkhardt,

with Grahame Blair and Lawrence Deacon

short introduction + reminder - news on recent details in next presentation by Lawrence Deacon

- **Muon backgrounds came as a bad surprise in the SLC**
- **High energy muons go very far, tripping ALICE and LHCb detectors in the LHC before we had any beam in the LHC**

a full simulation chain was set up and is working and files were made available for detector studies :

- **HALO generation using HTGEN, integrated with full tracking of core + halo using PLACET and more recently**
- **detailed generation and follow up of secondaries using BDSIM**
- **this should be used to make sure that the CLIC machine and the detector design is such that muons will not be a major problem**

Halo generation, HTGEN

There are many potential processes and effects which can generate and enhance halo (see HTGEN list of 16 candidate processes), many of which are absent in the ideal machine.

One component which will always be there and which we use as basis for predictions is beam-gas scattering.

Assumptions, input for simulation :

Gaussian beams without halo (cleaned) at the beginning of the LINAC

LINAC section 10 nTorr CO equivalent at room temperature (300 K)

BDS section 10 nTorr CO equivalent at room temperature (300 K)

Particle flux estimate on spoilers and secondary muons

Analytical estimate (main parameters from clictable2010.html)

3.72×10^{9} e/bunch

312 bunches

1.16×10^{12} e/train

2×10^{-4} fraction hitting spoilers, determined with HTGEN tracking

2.3×10^{8} e/train on spoilers

~ 10^{-4} fraction resulting in secondary muons at QD0 (BDSIM)

~ 2×10^{4} muons / train end of BDS at QD0

depends critically on vacuum and spoiler layout

All details with absolute predictions from full simulation, on web JAI/ClicMuon

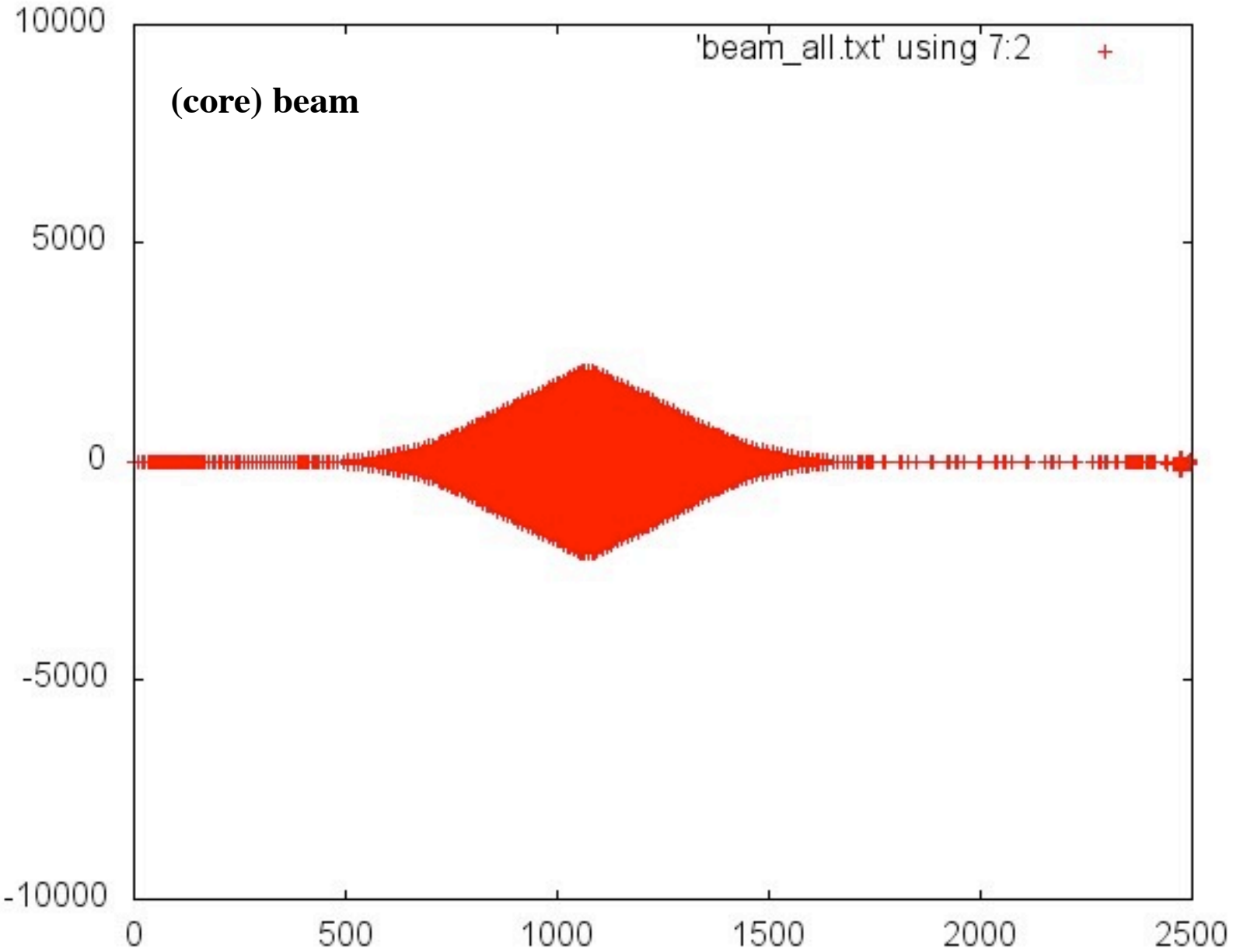
Energy and spatial distributions - mostly geometry depended

Caution : halo from HTGEN based on beam gas alone (~ lower limit)

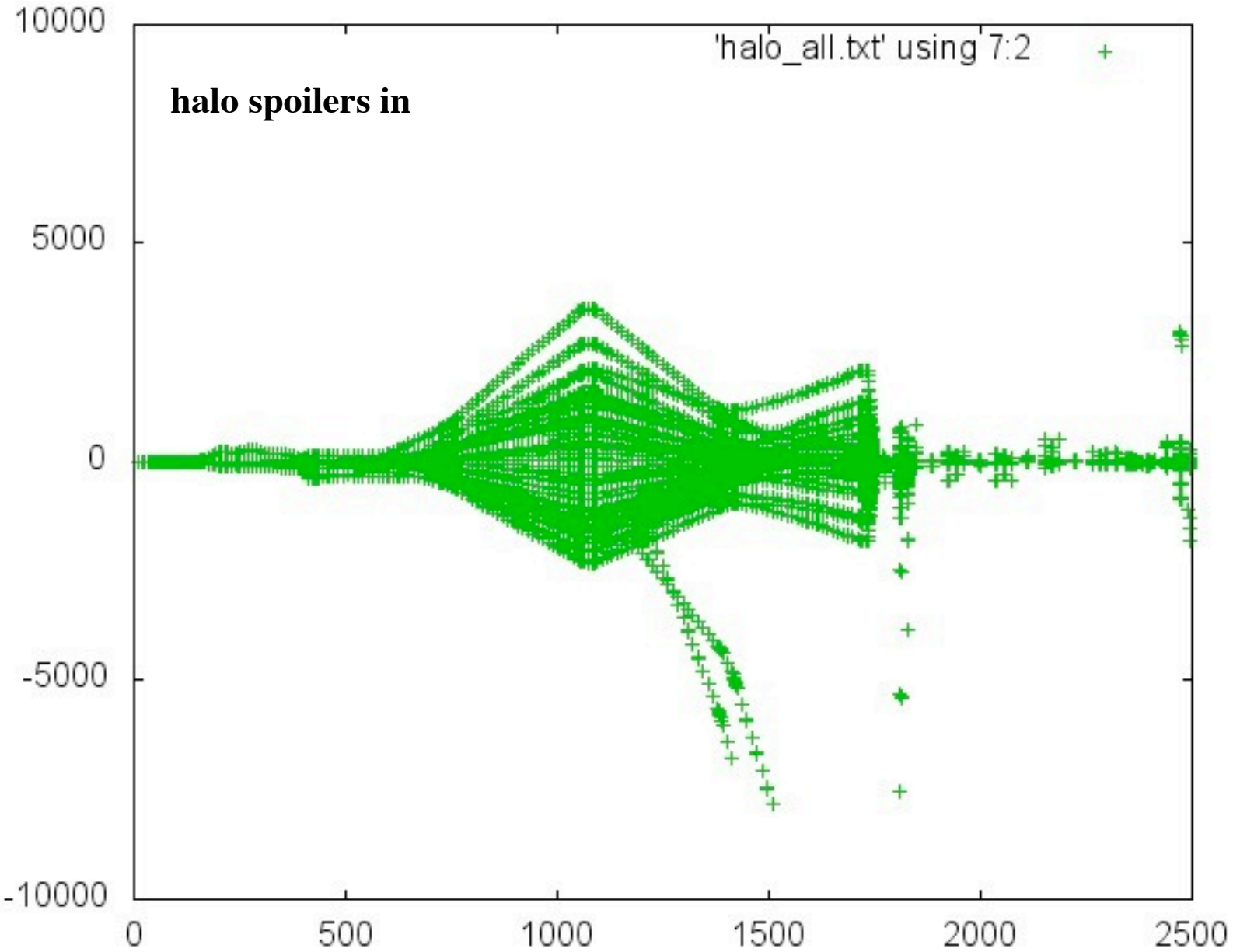
and tracking currently done for the ideal machine

Need for a large safety factor in overall rates

PLACET-HTGEN tracking



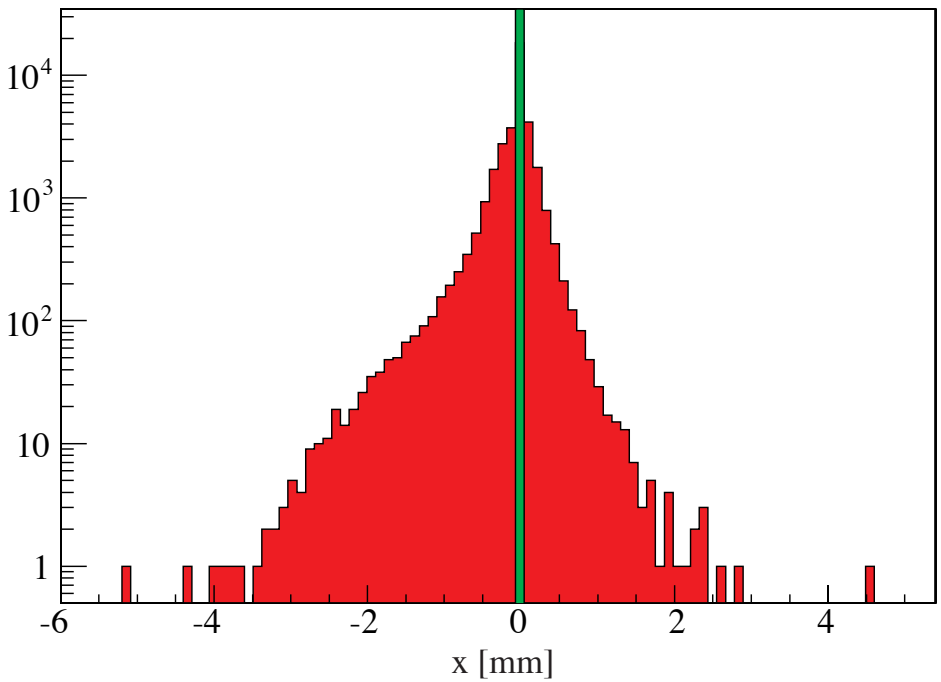
PLACET-HTGEN tracking

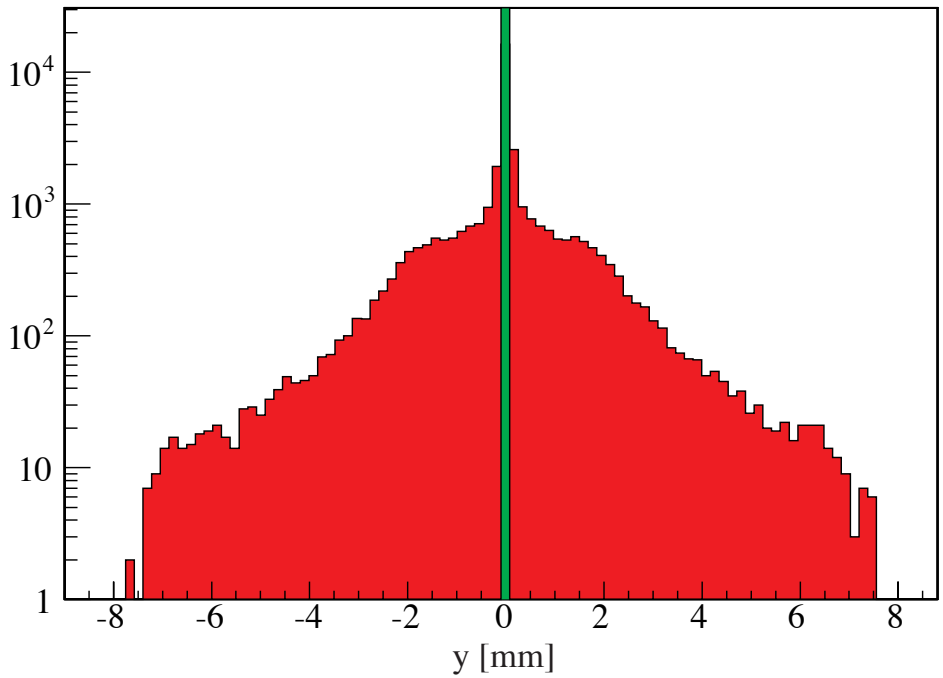


v_09_04_01/bds.name.aperture.FixedSR.collaper

Projection at the 1st spoiler

HTGEN + PLACET, at XSP1, YSP1





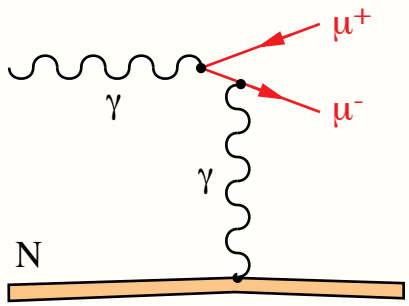
Interaction in the spoiler, tracking of secondaries ---> BDSIM

Muon production, Geant4

Muon production processes :

1. Monte Carlo Generator for Muon Pair Production, by Burkhardt, Kelner, Kokoulin, CLIC-Note-511, 2002

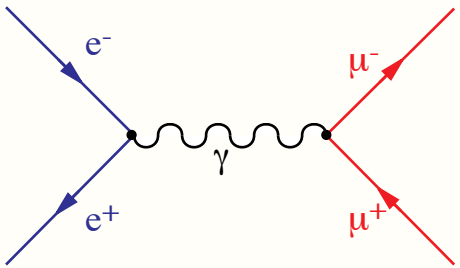
G4 process **GammaToMuPair**



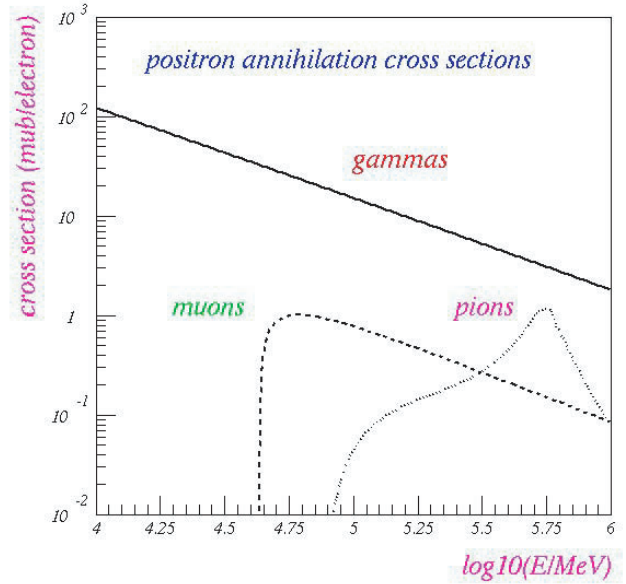
Bethe-Heitler

2. Production of muon pairs in annihilation of high-energy **positrons** with **resting electrons** by Burkhardt, Kelner, Kokoulin, CLIC-Note-554

G4 process **AnnihiToMuPair**

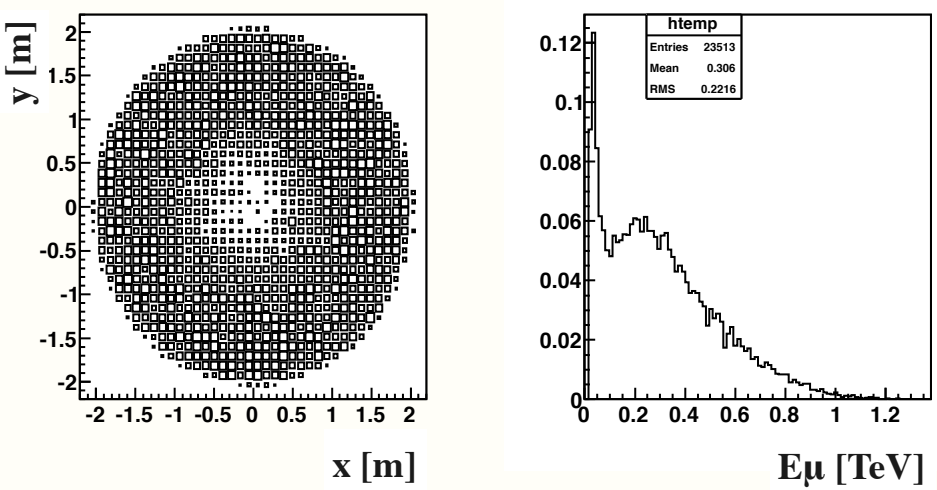


Equivalent for hadrons
1st version of eeToHadrons.cc exists, implemented in 2004 in G4 by V. Ivanchenko
based on M. Maire + M. Benayoun
We now started to also include this.
Broad peak of π production at ϱ for Ee+ ≈ 570 GeV

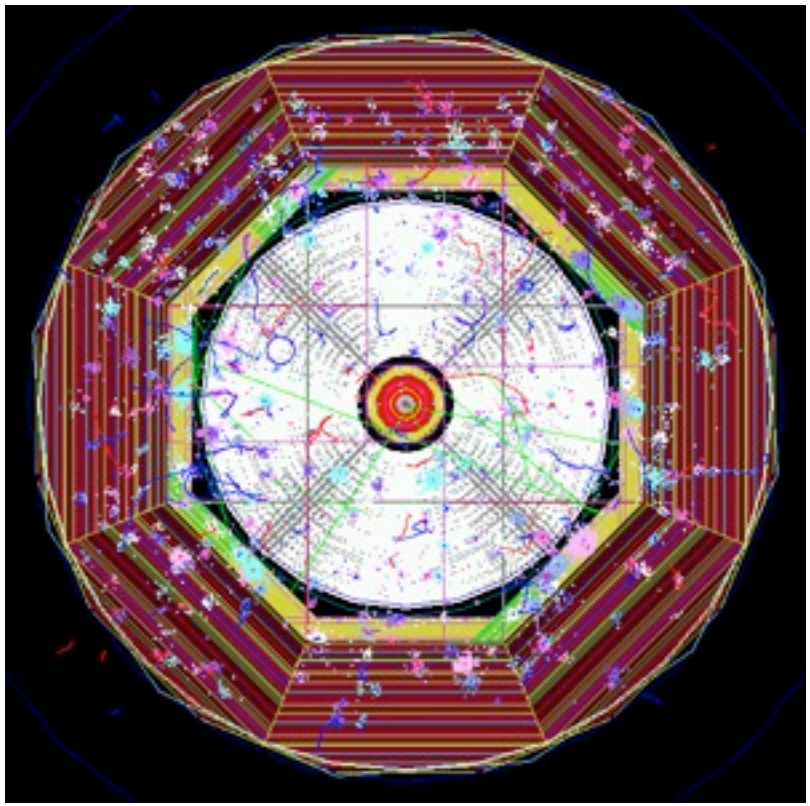


BDSIM --> Detector

Lawrence Deacon + Grahame Blair : Geometry for BDSIM with
all magnets, spoilers, absorbers, beam-pipe and concrete tunnel at r = 2m
magnets simulated as iron cylinders of 25 cm radius
beam pipe r = 8.21 mm, 2mm thick, inside void
tunnel filled with Air at ntp



Distributions of muons at the front of QD0



Input : 600 muons from BDSIM, used as input for the ILC detector simulation, from Macro Battaglia, 19 February 2010

Conclusion

- **We have a working full simulation of halo production, tracking of core + halo, production of secondaries**
- **This allows to get a fairly good picture of how the muon background looks like and a rough idea on the overall rate**

For recent developments see Lawrence Deacon presentation :

- **swapping to 1. betatron collimation, 2. off-momentum would only bring a rather modest gain**
- **extra magnetized shielding could help a lot - would be good to reserve the space and add shielding later if needed**

recent status of muon background studies, documented for IPAC'2010 THPD014