Searches for stable massive particles

Philippe Mermod
Stockholm University

Nordic Workshop on LHC and Beyond
12 June 2008

- Introduction
- SMP signatures
- Towards data taking
- Backgrounds from data

What are we searching for ?

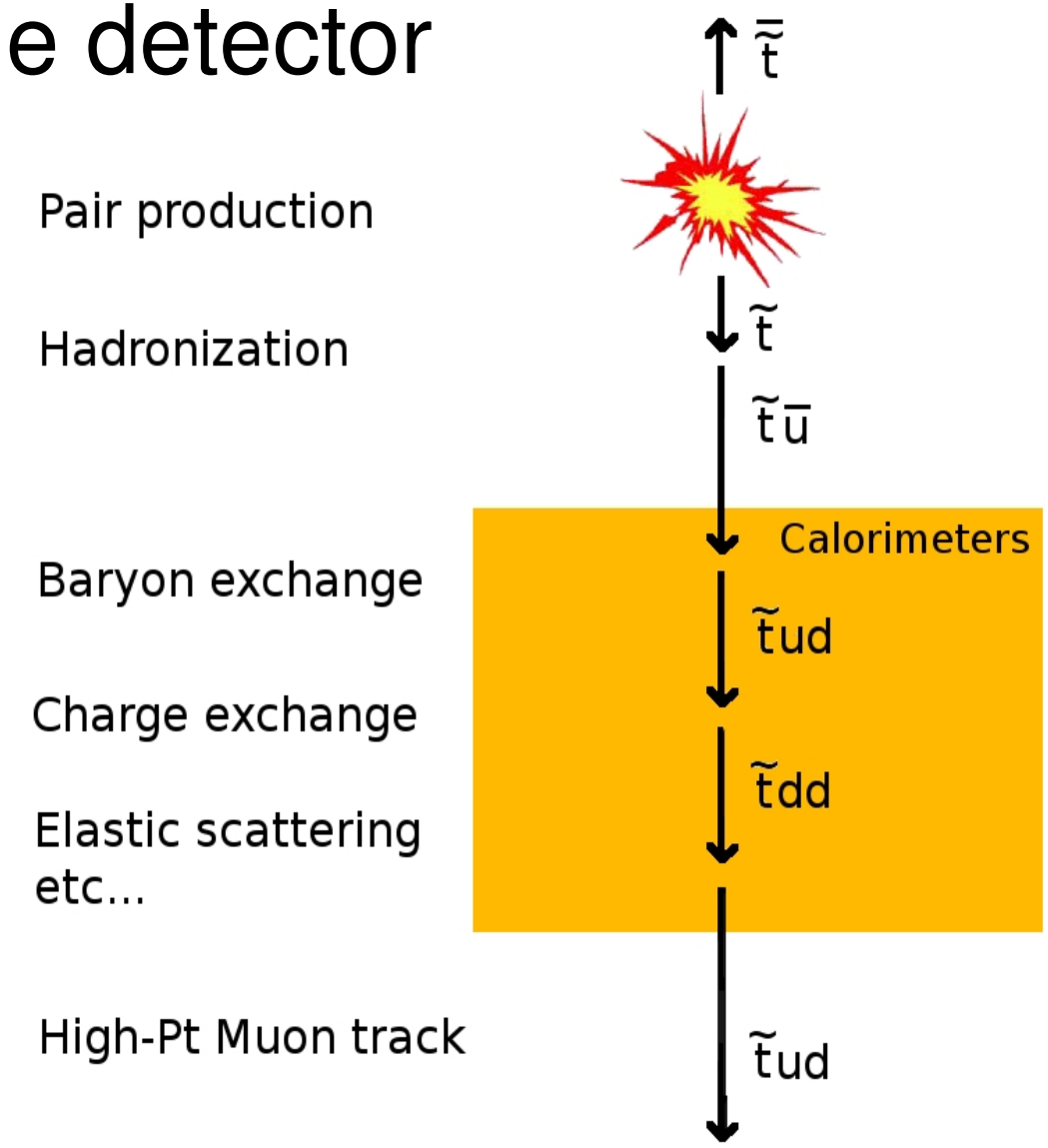
- Properties of the exotic particles :
  - Coloured
  - **Massive** (> 200 GeV)
  - *Long-lived* (> 100 ns)
- Look like **slow** muons with **high Pt**
- Let's call them R-Hadrons :
  - SUSY : stop, gluino
  - Extra-Dimension : KK-quark, KK-gluon
  - Etc...
- Generic SMPs : coloured *or* charged

Typical journey of an R-Hadron through the detector

- Hadronization in PYTHIA
- Scattering processes in Geant4

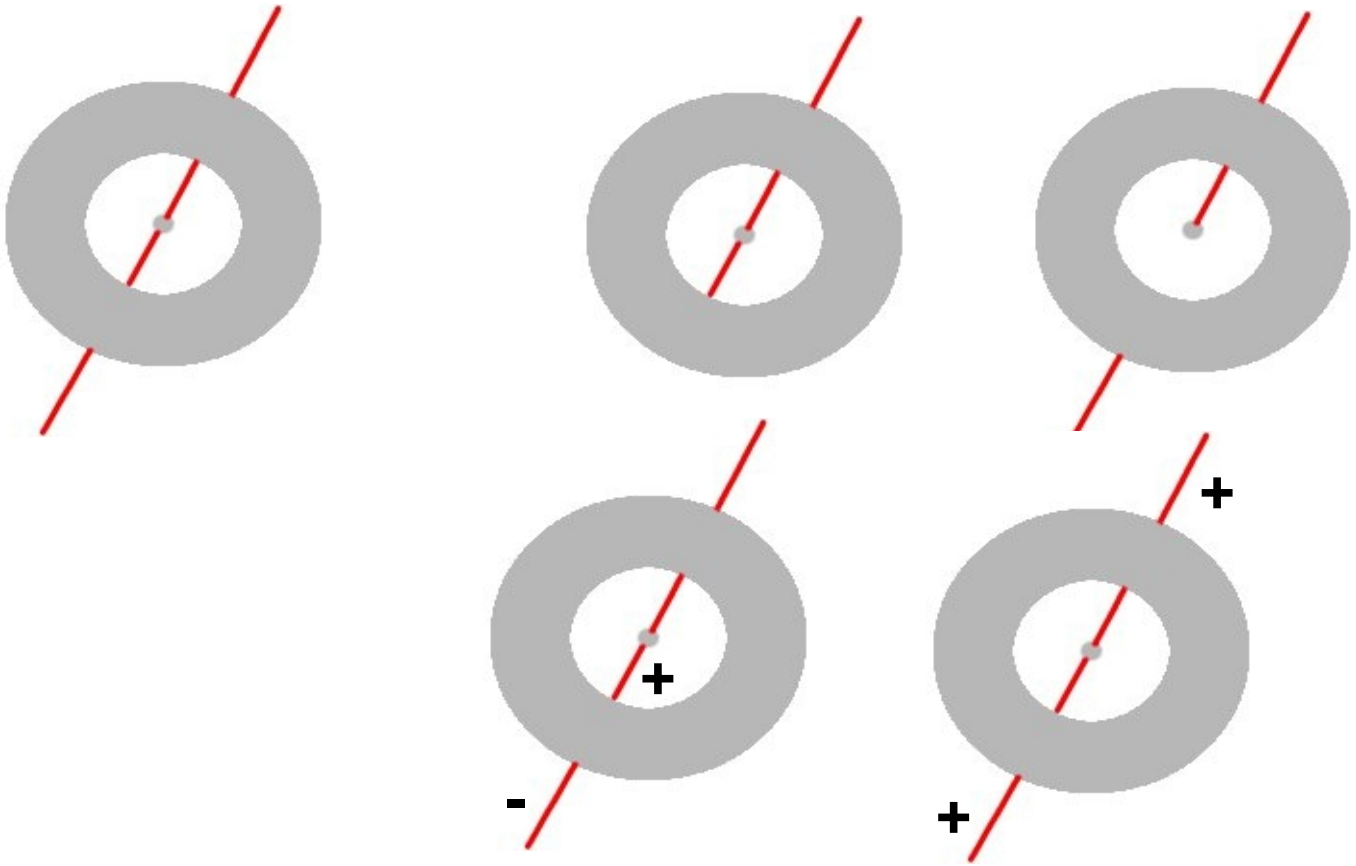
  [R.Mackeprang and A.Rizzi, Eur.Phys.J.C50, 353 (2007), A. C. Kraan, Eur.Phys.J.C37, 91 (2004)]

- Full ATLAS simulation



Signatures : High-Pt tracks

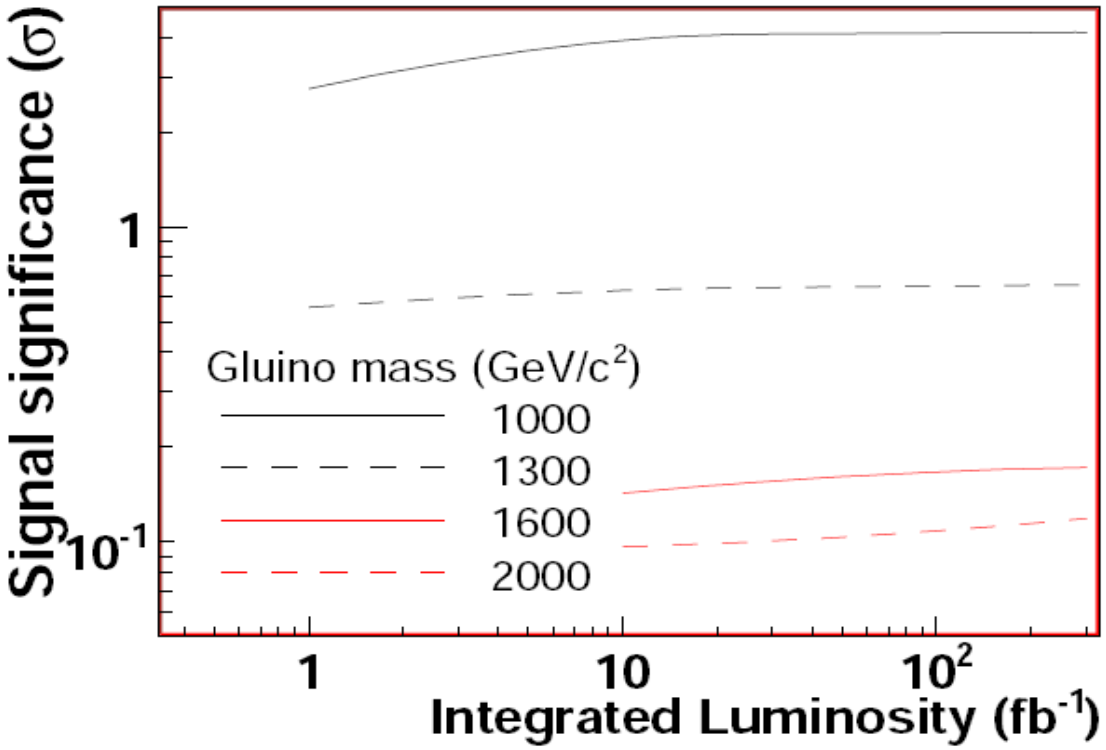
- Generic SMPs
- R-Hadrons



Gluino R-hadrons : discovery potential

- For masses below 1 TeV : feasible discovery
- For higher masses :

[ATLAS SUSY CSC note 8 (2008)]

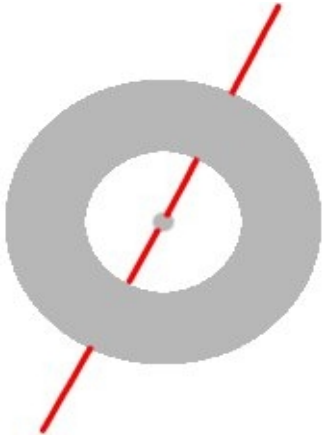


Towards data taking : detector effects

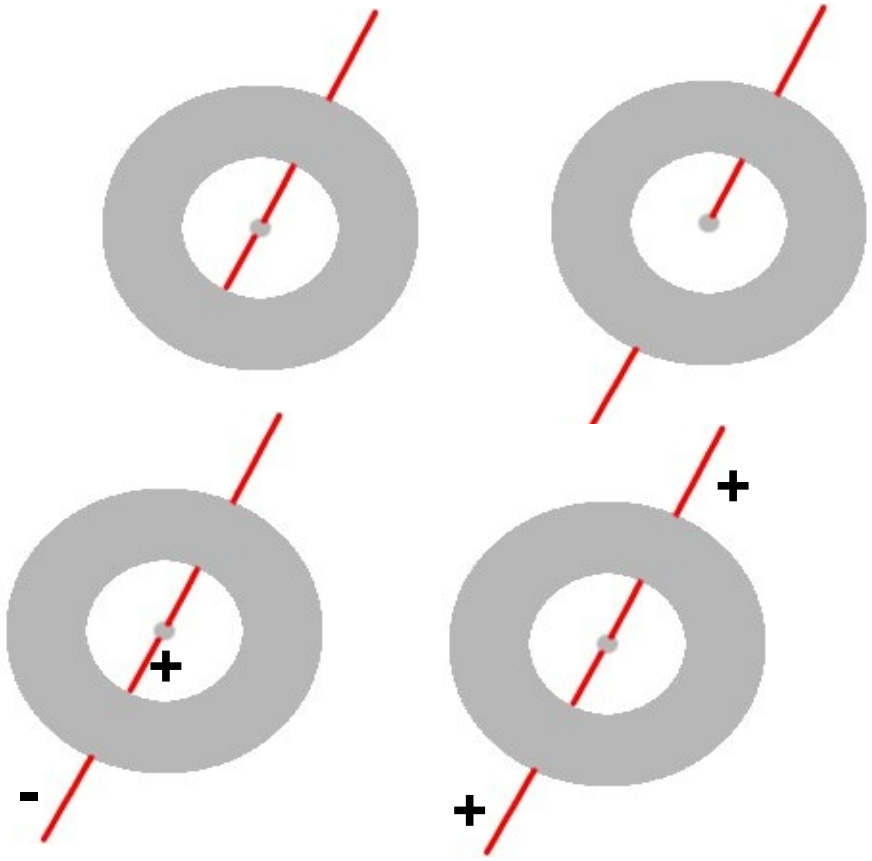
- R-Hadron propagation
  - Timing issues at low speed
  - Trigger and reconstruction efficiency
- Muon backgrounds
  - High-Pt tails from low-Pt muons
  - Efficiency of track reconstruction (faking charge exchange)
- The MC are probably not realistic
  - We need to evaluate these effects **from data**

Signatures and backgrounds

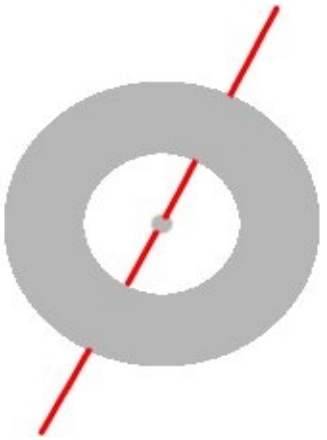
- Generic SMPs



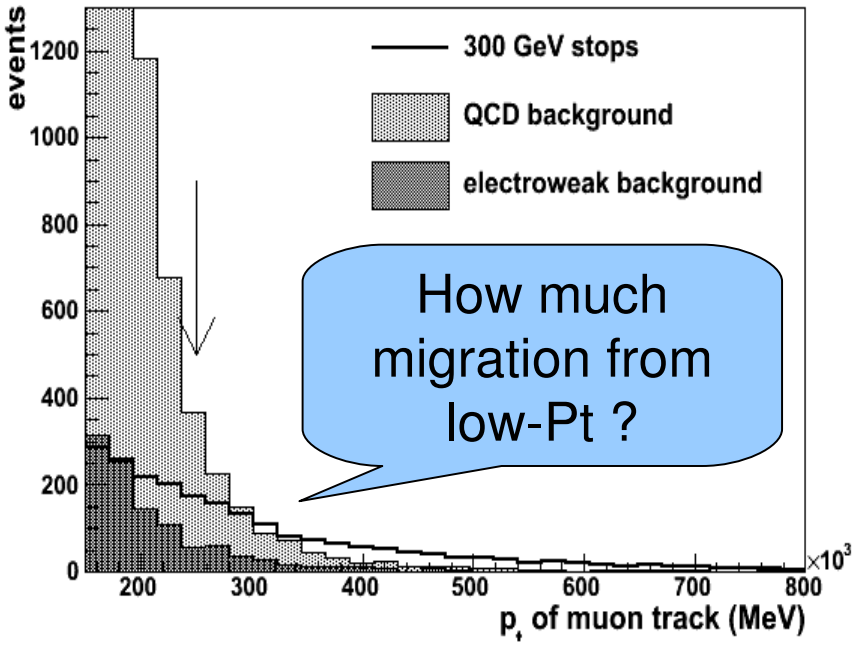
- R-Hadrons



Generic SMPs



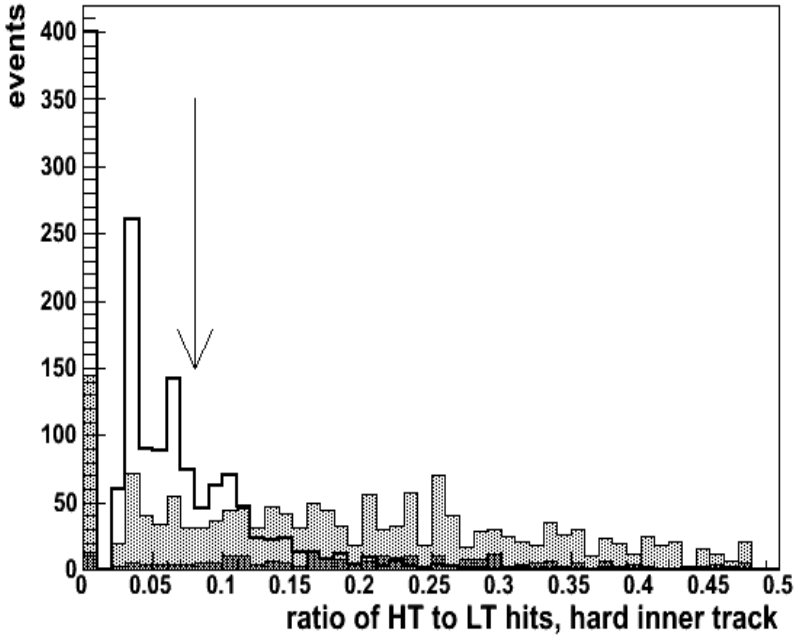
- Possible cuts :
  - One or two high-Pt muons
  - Low speed
  - Low jet activity
- The main background left :
  - High-Pt Drell-Yan muons
  - But also low-Pt muons reconstructed at high Pt

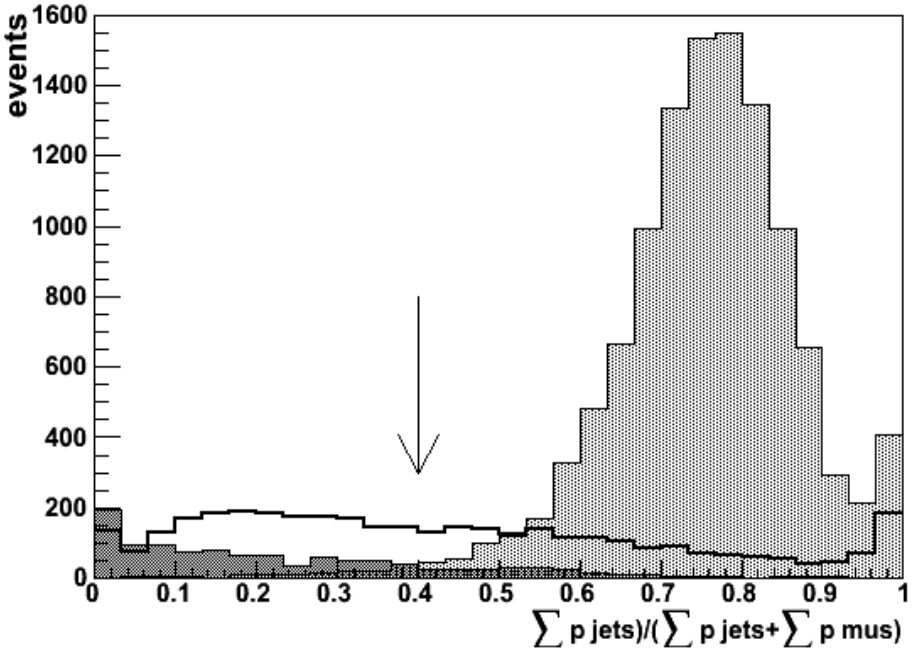


Examples of simple cuts (300 GeV stops, 1fb^{-1})

- Discovery at low luminosity
- R-Hadrons and leptons

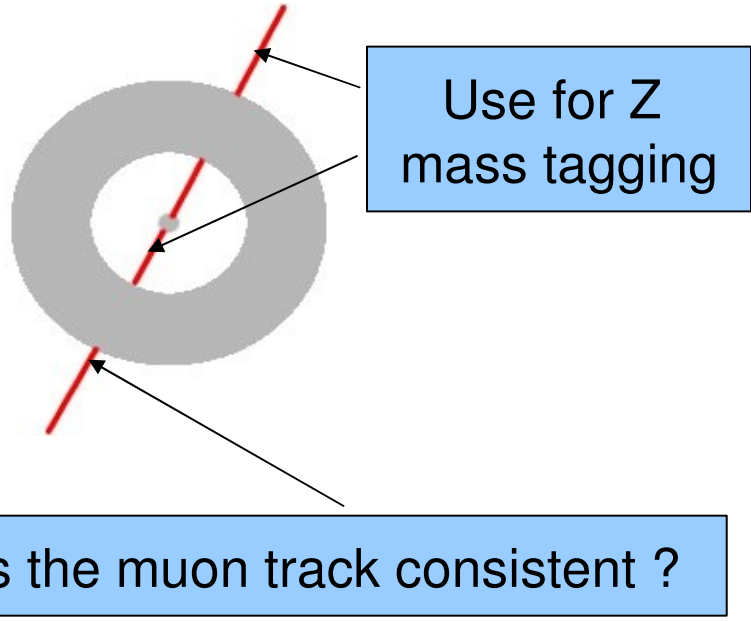
BUT : High-Pt cut at generator level...
→ incomplete bgd samples !





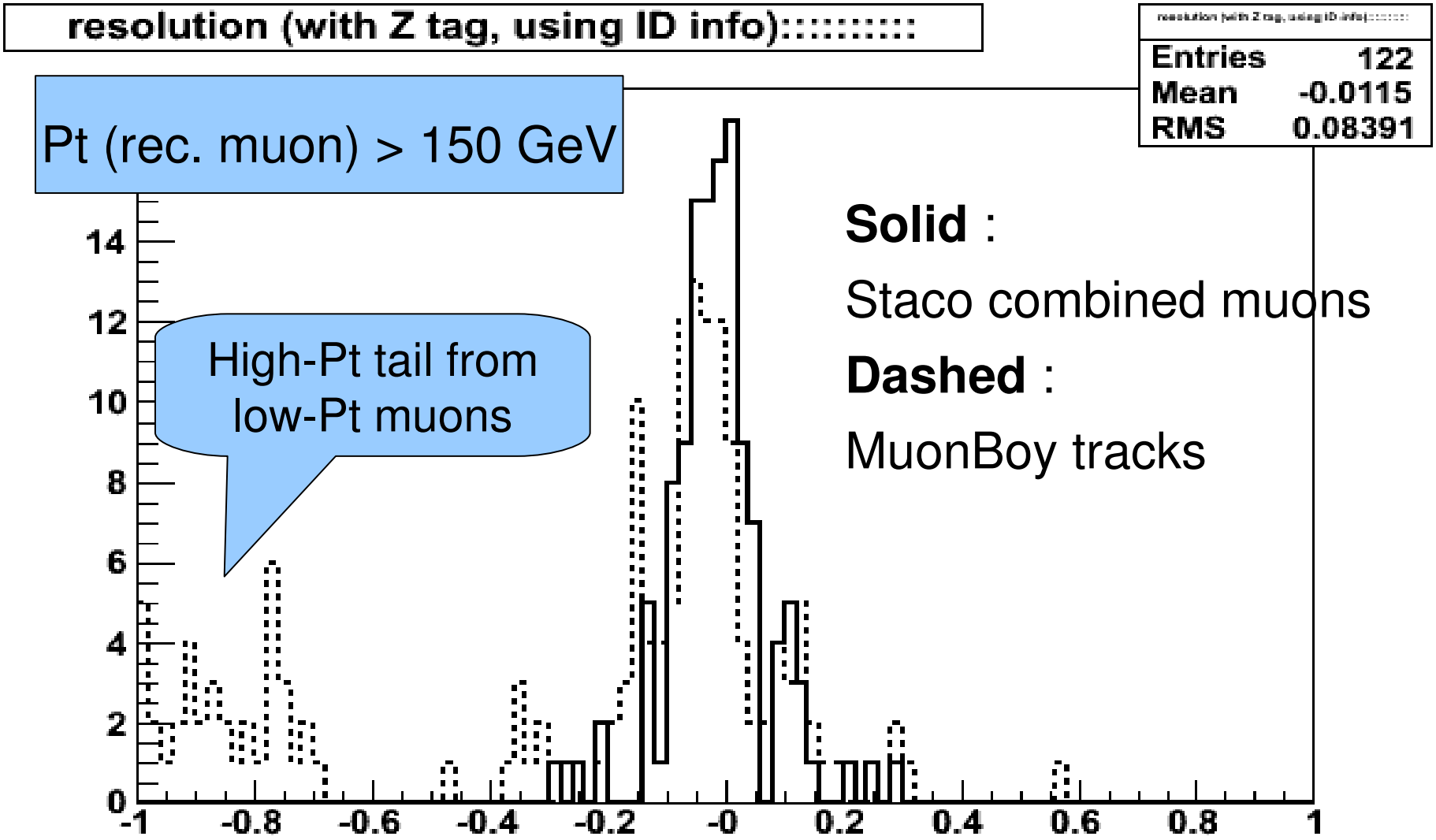
High-Pt muon tails from data

- Use Z→μμ decay
  - Tag high-Pt muon by reconstructing Z mass using inner detector information
  - Compare with muon detector information
- The method works only for standalone muon tracks
  - Dilemma : the combined muons show better performance ! (next slide)



High-Pt muon tails (0.3 fb^{-1})

(1/Ptrec-1/Ptgen)/1/Ptgen

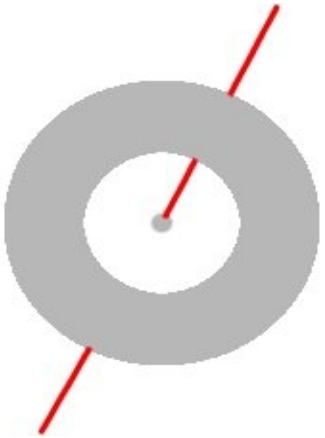


Tail fractions for standalone tracks (Z tag, MuonBoy algorithm)

	barrel	endcaps	
80<Pt<100 GeV	0.038 ± 0.009	0.10 ± 0.02	**Using truth info**
	0.038 ± 0.009	0.13 ± 0.03	**Using ID info**
100<Pt<150 GeV	0.076 ± 0.015	0.28 ± 0.05	
	0.079 ± 0.016	0.29 ± 0.05	
Pt>150 GeV	0.28 ± 0.05	1.2 ± 0.2	
	0.31± 0.06	1.1 ± 0.2	

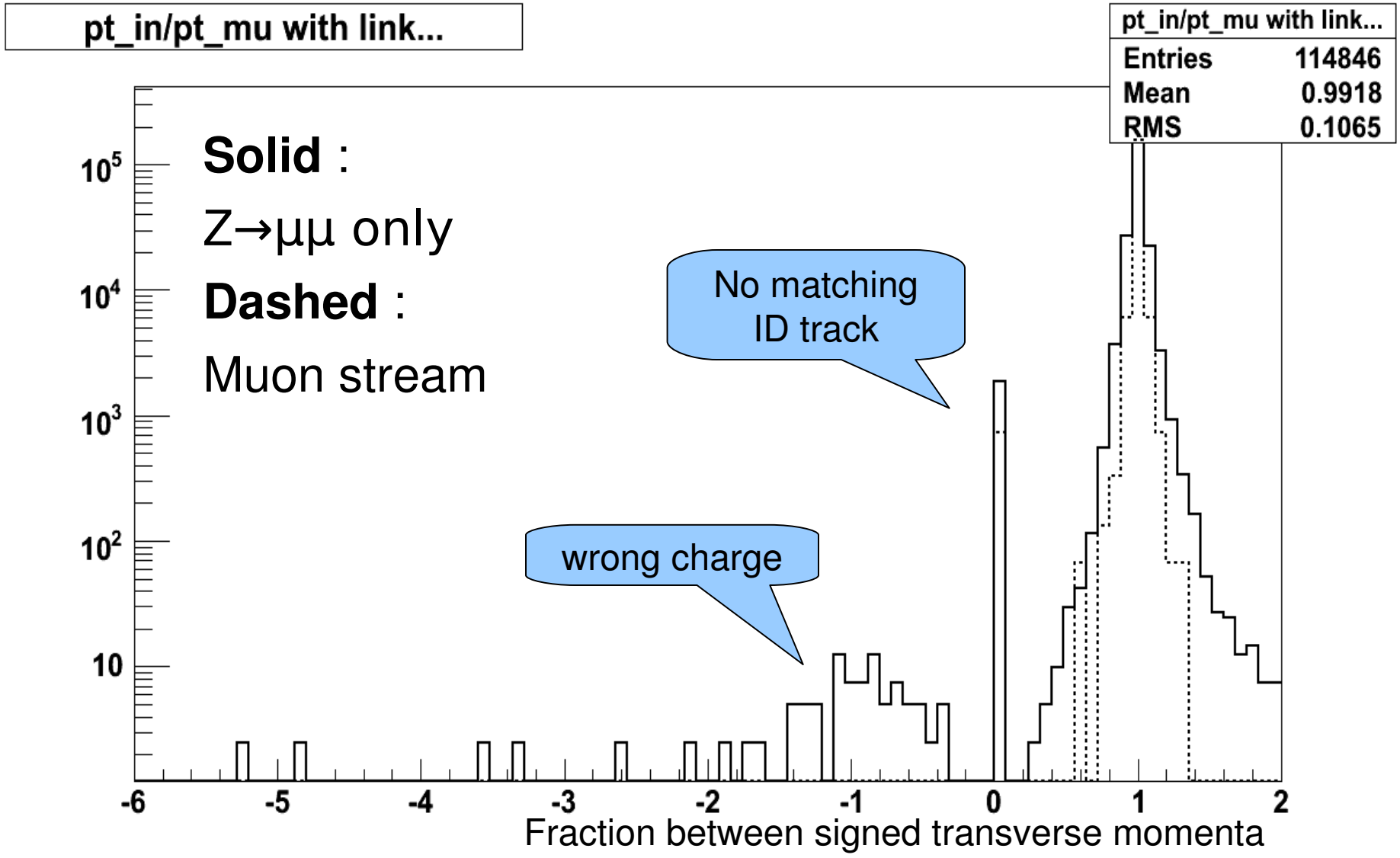
- Tail fraction increases with rec. Pt and |η|
- Experimental determination consistent with truth determination (works only for standalone tracks)

R-Hadrons



- For some specific signatures, we have to use standalone tracks anyway
- The main background left :
  - High-Pt Drell-Yan muons **and** low-Pt muon tracks reconstructed at high-Pt
  - Where no matching inner detector track is found

ID track efficiency using Z tag with muon track information (preliminary)



Summary

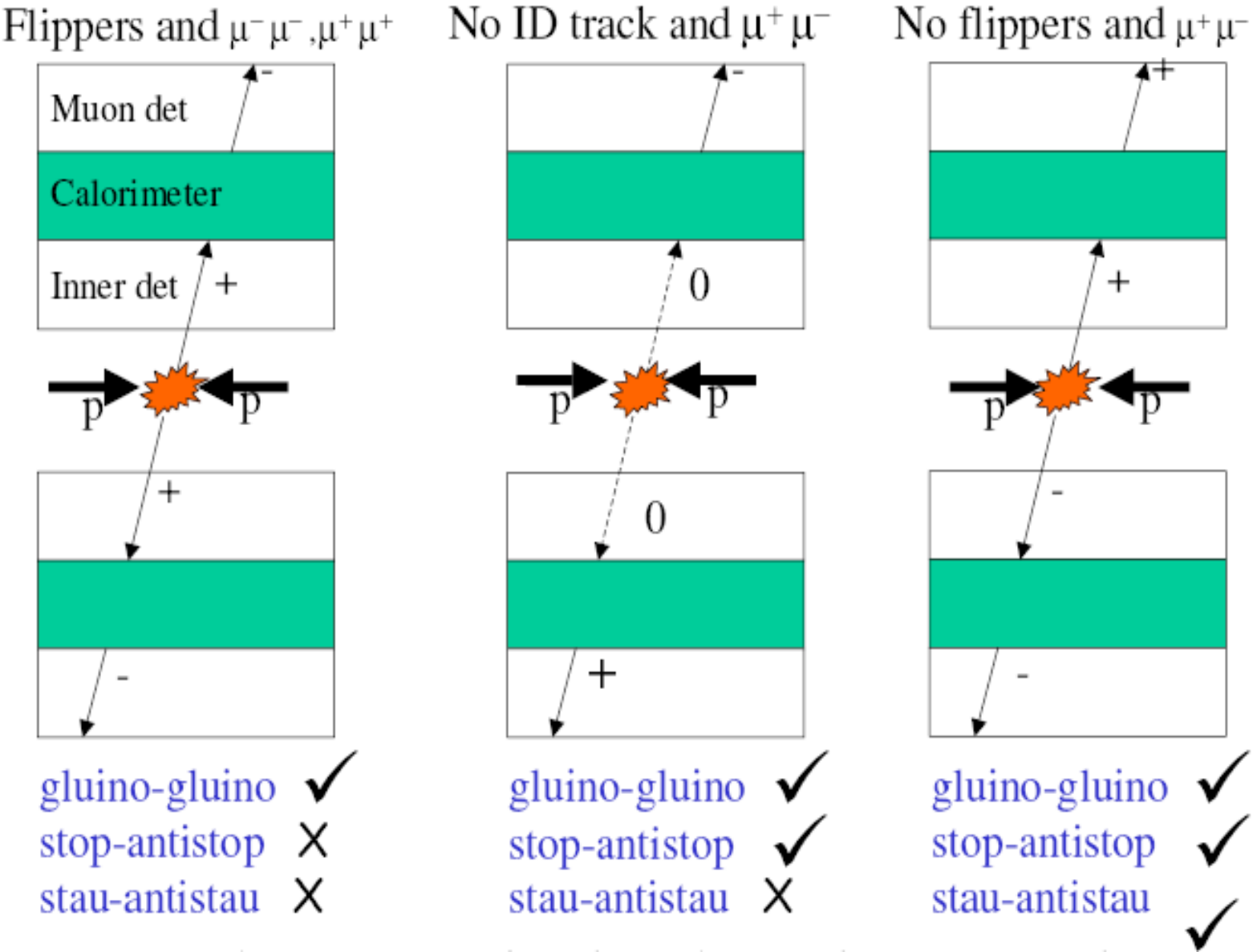
- Many exotics models predict stable massive hadrons (R-Hadrons)
- Simple event selection
  - ➔ discovery up to ~600 GeV mass
- Striking signatures
  - Can be faked due to detector effects
- Method developed to extract standalone track quality from data using Z decay
  - High-Pt tails
  - Reconstruction efficiency at high-Pt

EXTRA SLIDES

Candidate models for R-Hadrons

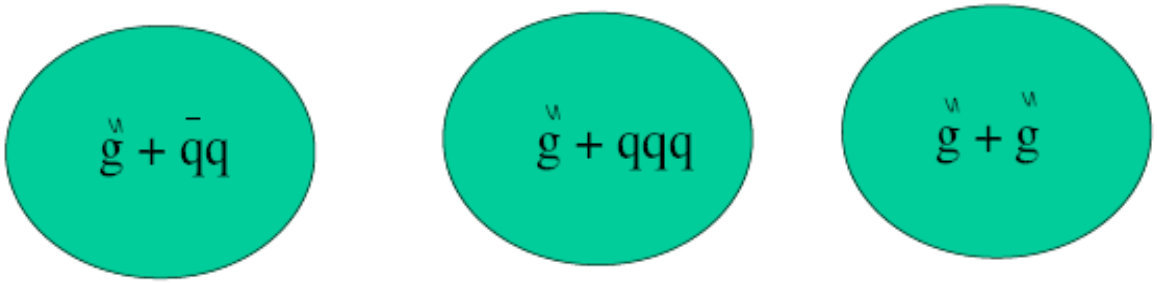
- Split-SUSY, GMSB
  - stop or gluino as LSP or NLSP
- UED
  - KK quark or gluon excitation towers
- Fourth generation quarks
  - need a mechanism to suppress decay
- Hidden Valley
  - do not feel SM strong force → like long-lived leptons

R-hadrons – Three scenarios



Implications of a stable gluino

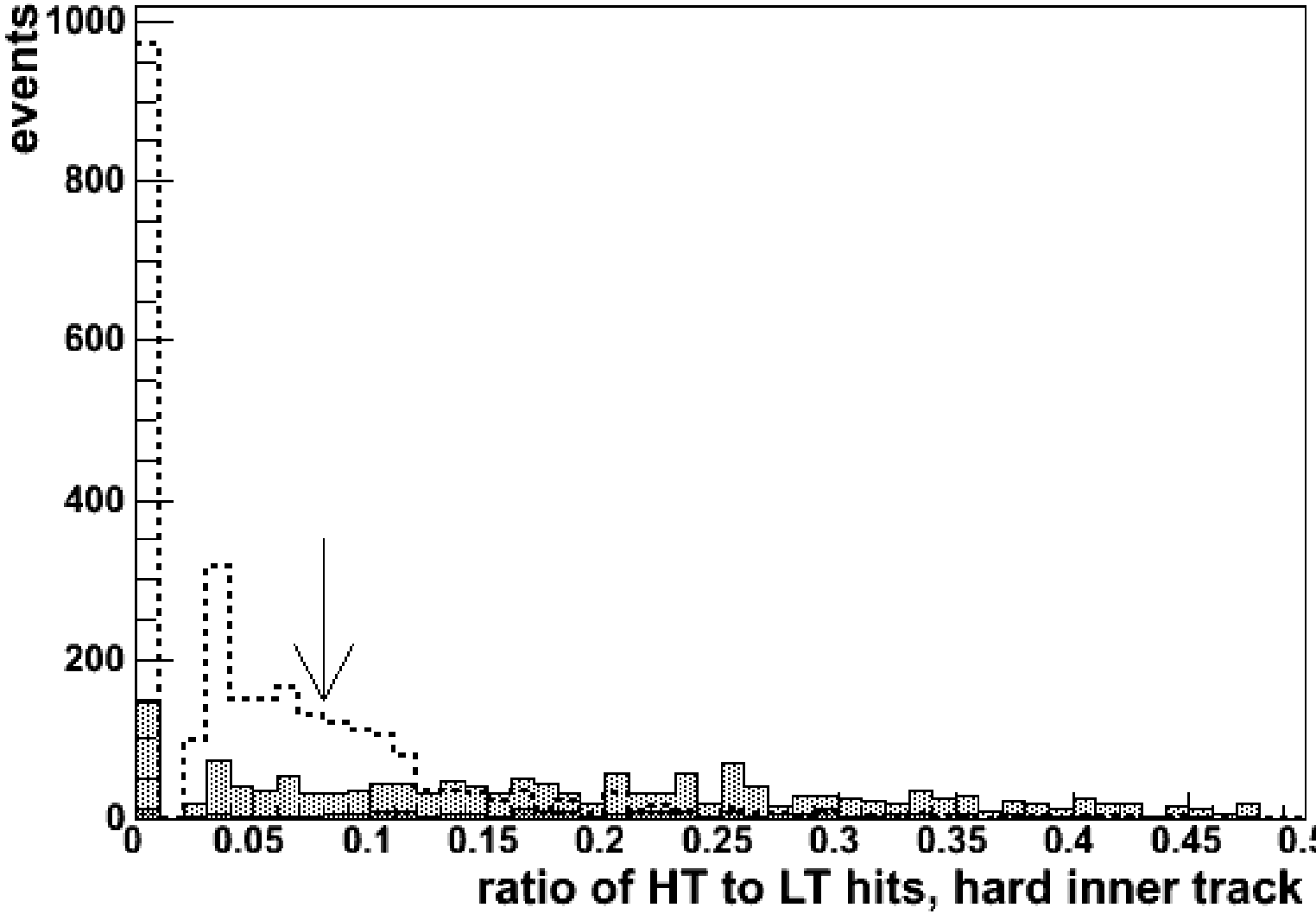
Hadronisation into bound states carrying R-parity
-R-hadrons



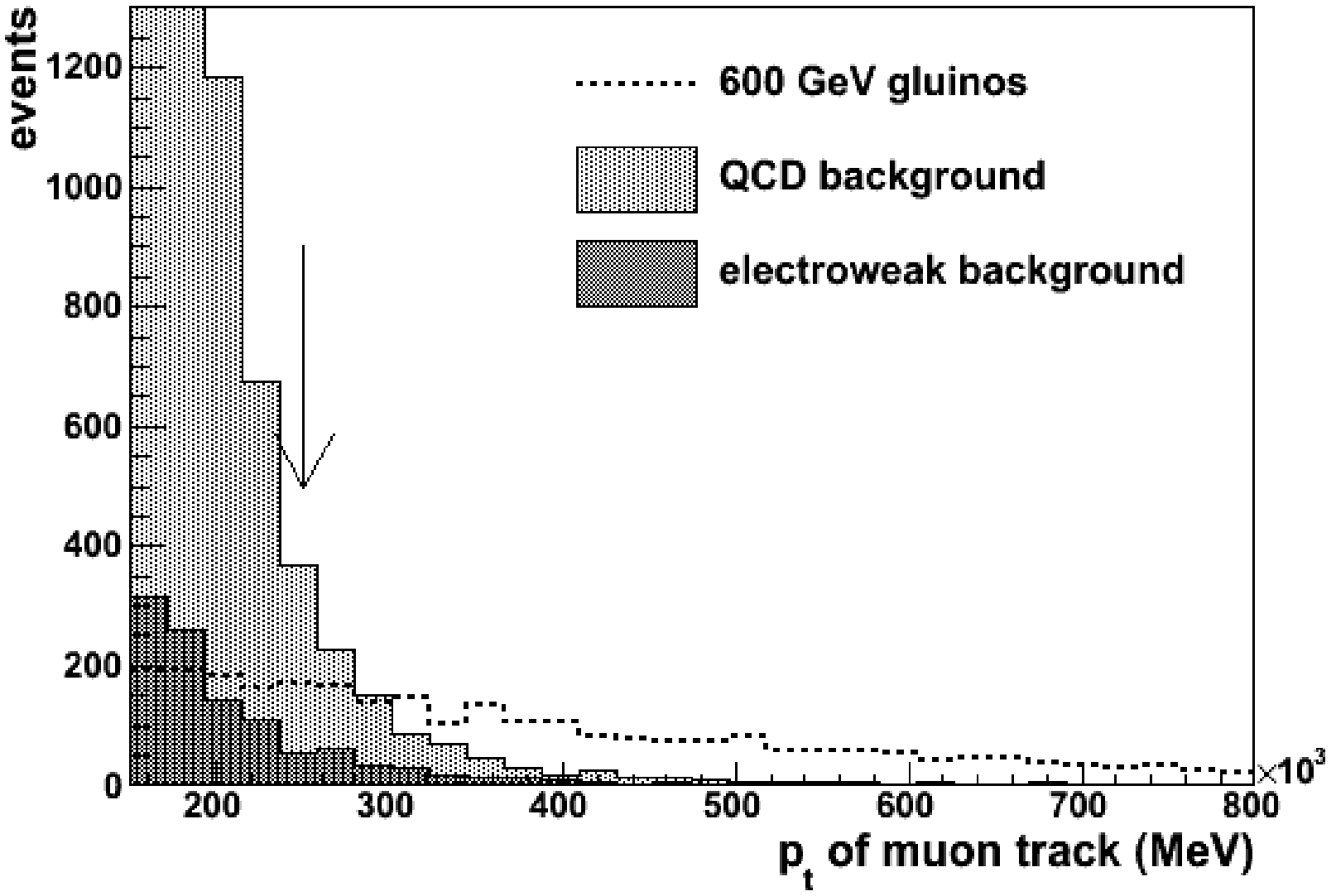
R-meson R-baryon gluino ball

→ Many possible signatures, including
flipped charge in nuclear interactions $R^+ + n \rightarrow R^- + p + \pi^+$

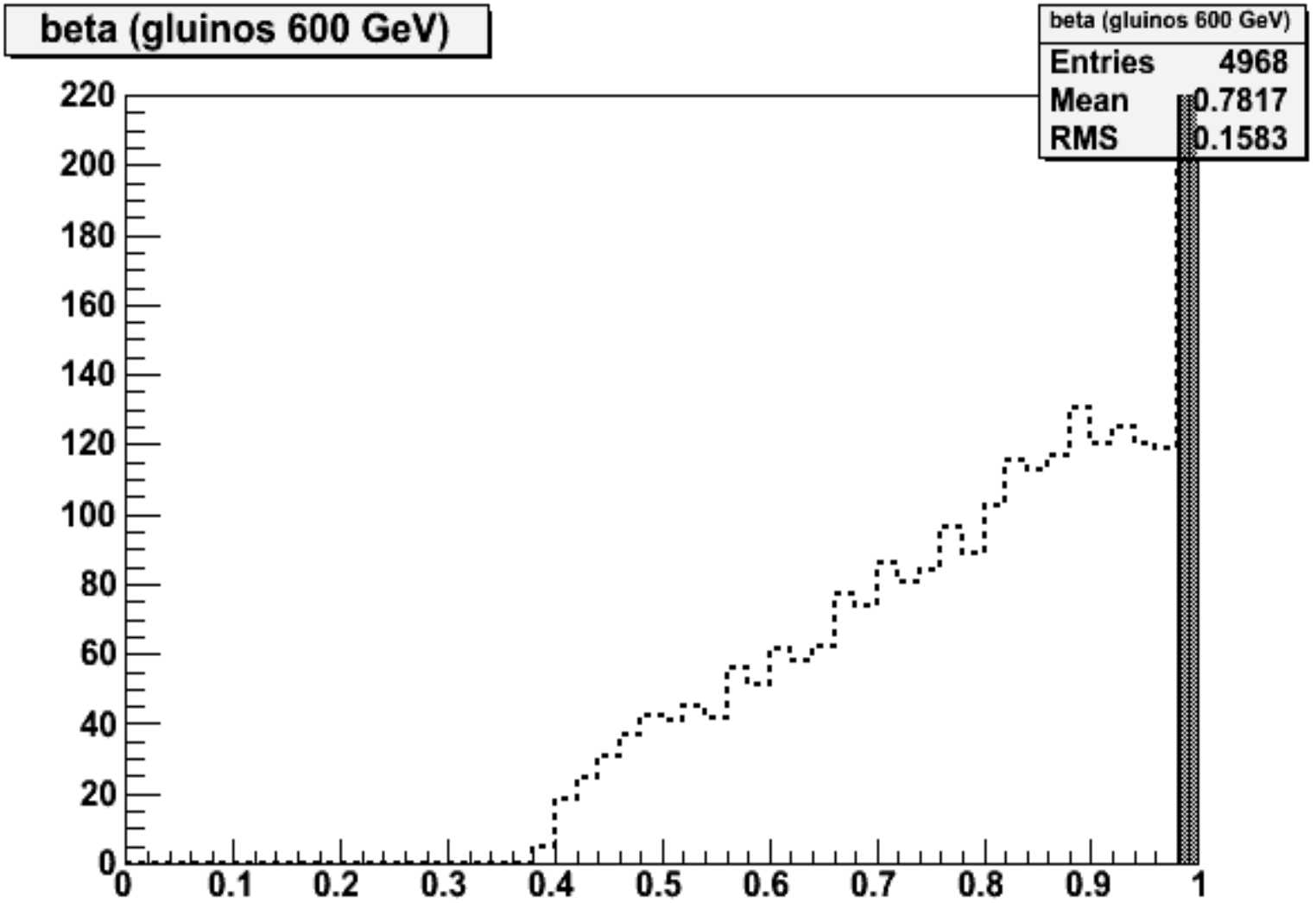
HT/LT (1fb^{-1}, no trigger) 600 GeV gluinos



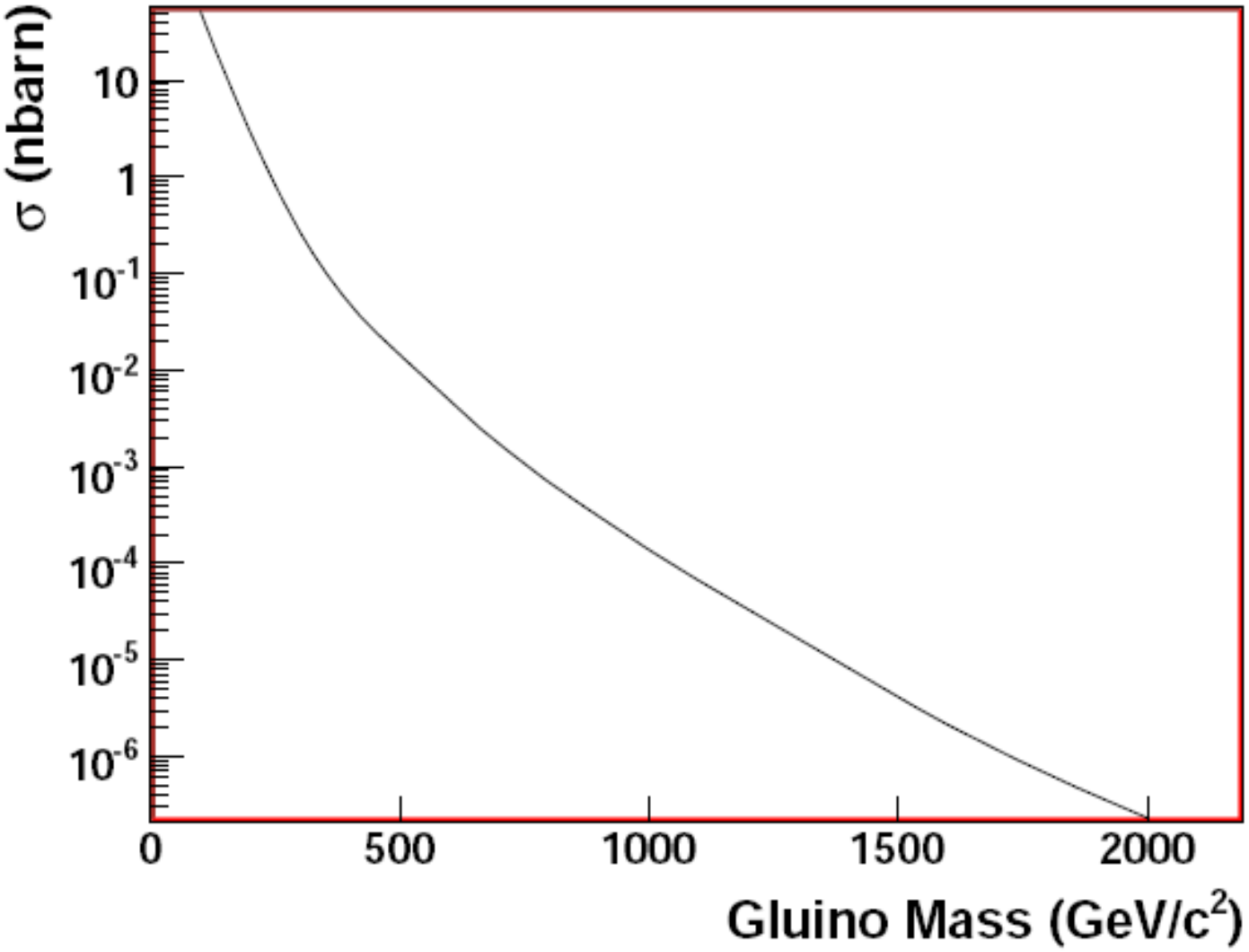
For comparison : 600 GeV gluinos



beta (hard muon track)



gluino cross section

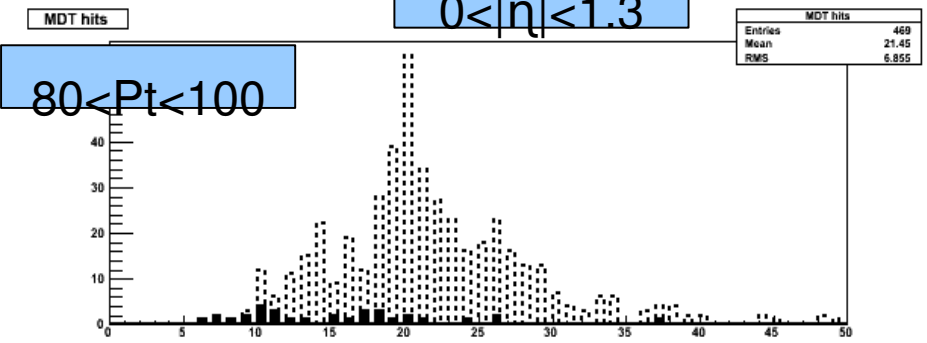


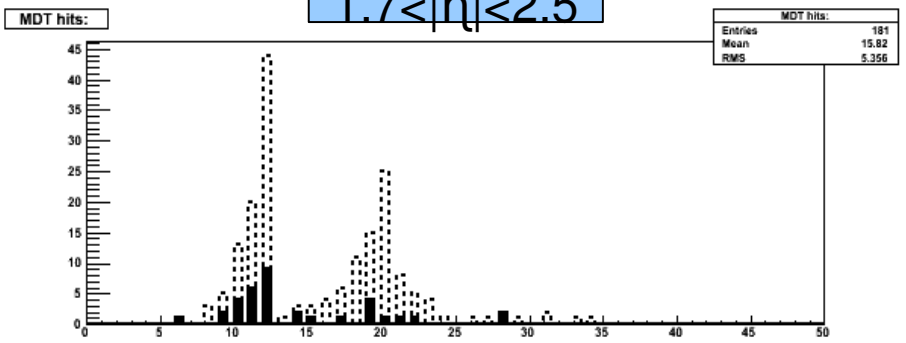
Number of hits in MDT
(unfilled = all MuonBoy, filled = tail only)

0<|η|<1.3

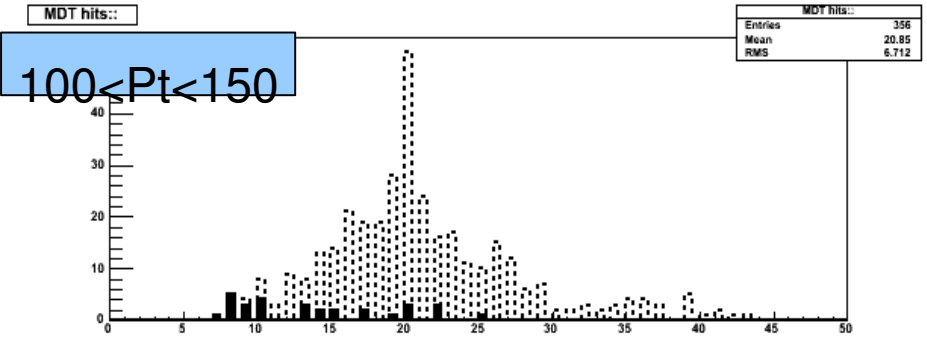
1.7<|η|<2.5

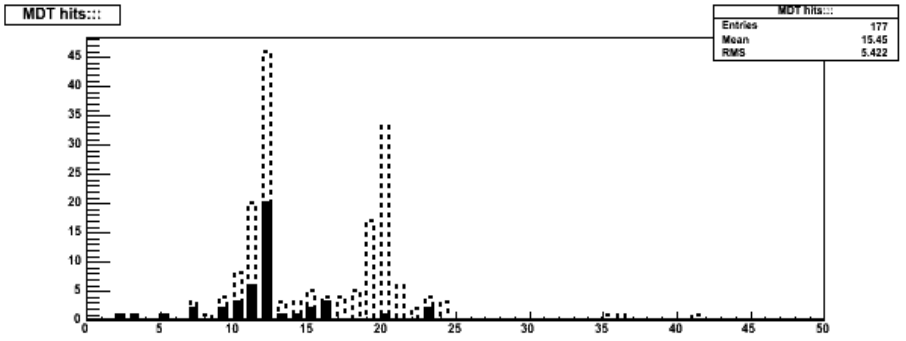
80<Pt<100



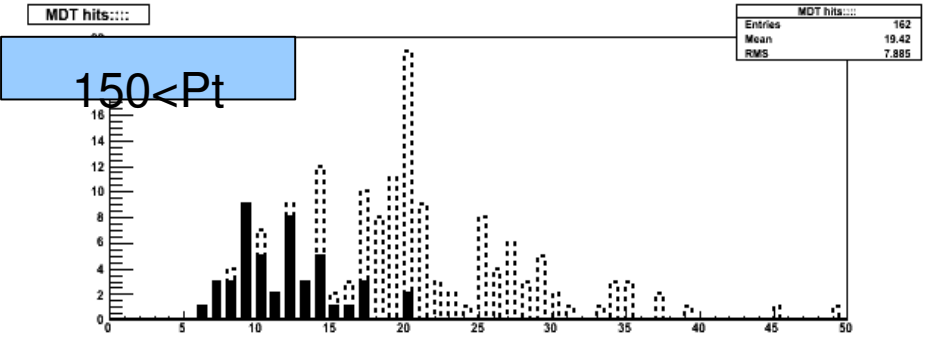


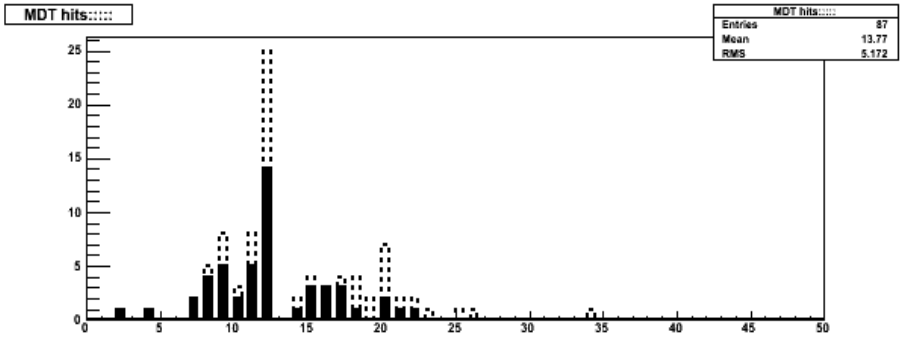
100<Pt<150





150<Pt



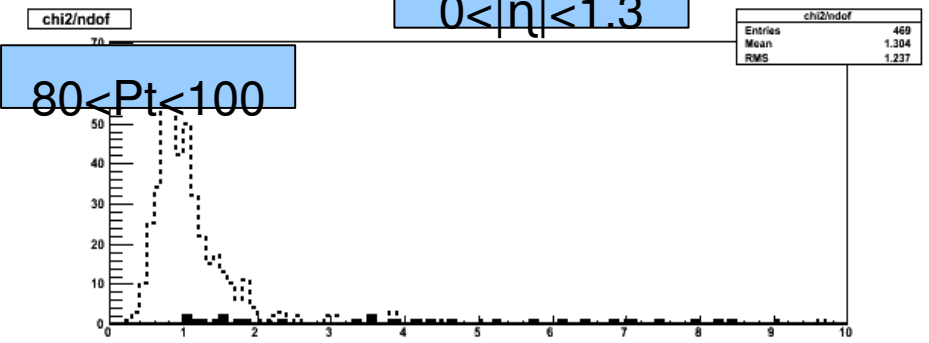


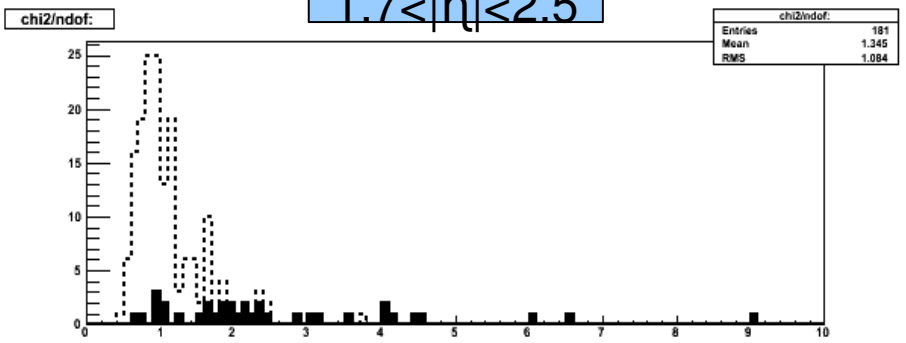
Chi2/Ndof
(unfilled = all MuonBoy, filled = tail only)

0<|η|<1.3

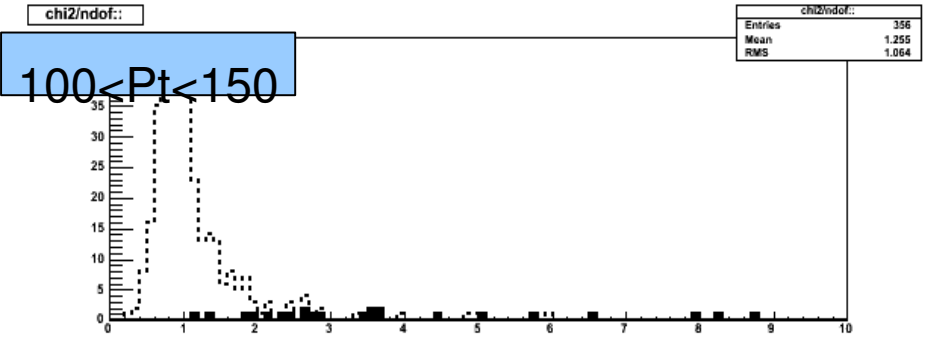
1.7<|η|<2.5

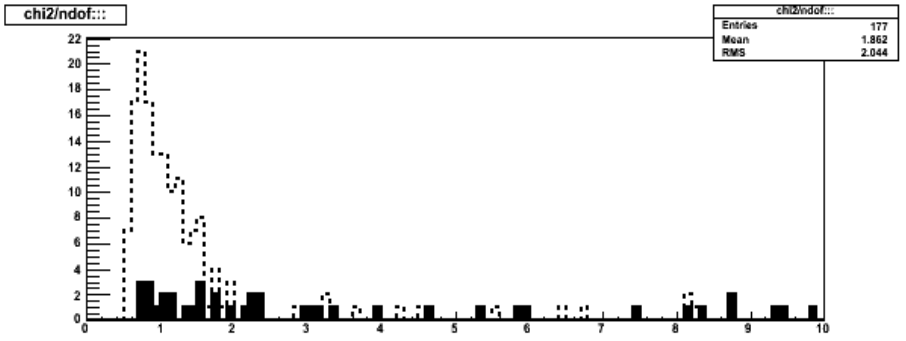
80<Pt<100





100<Pt<150





150<Pt