A first look at open charm production in Indium-Indium collisions

motivation

basic concepts of NA60

sources of background

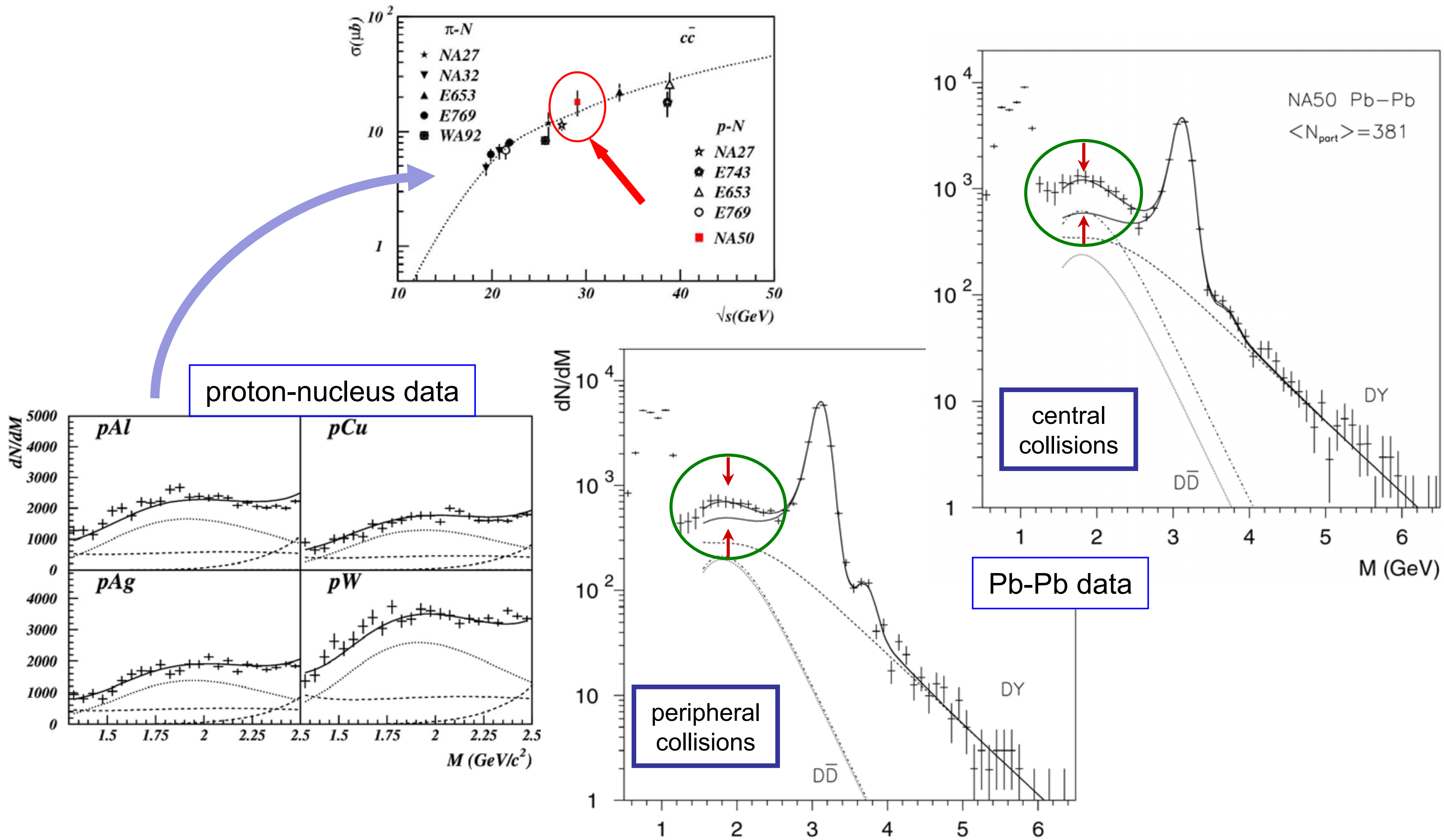
physics performance

first qualitative results

Ruben Shahoyan (IST and CERN) for the NA60 collaboration, Hard Probes 2004, 4-10 Nov.

Motivation: excess of intermediate mass dimuon production seen by NA38/NA50

The yield of intermediate mass dimuons in heavy-ion collisions (S-U, Pb-Pb) exceeds the sum of Drell-Yan and D meson decays, which describes the proton data



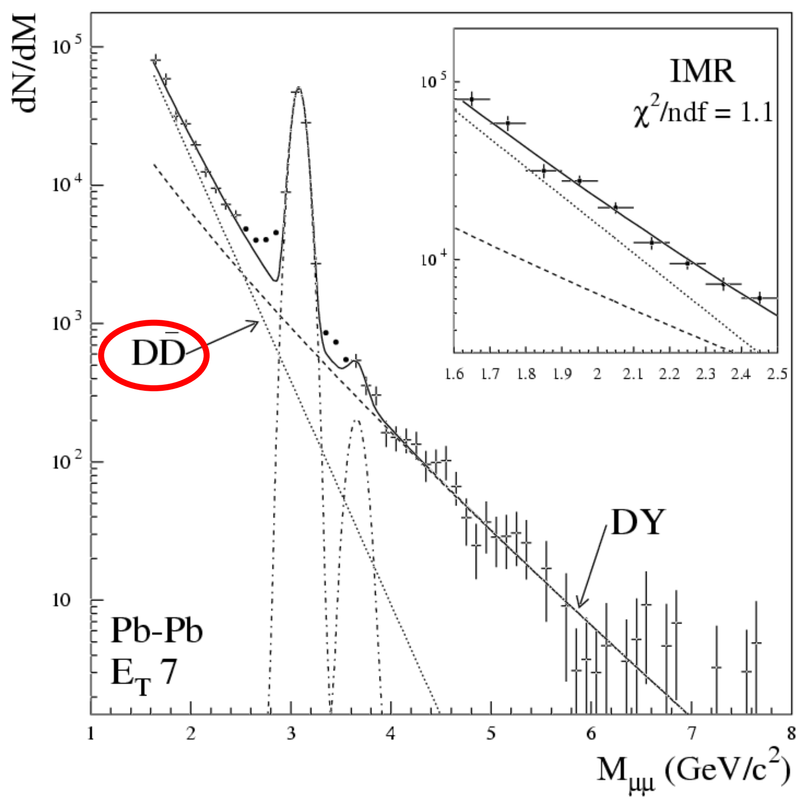
Charm enhancement or thermal dimuons ?

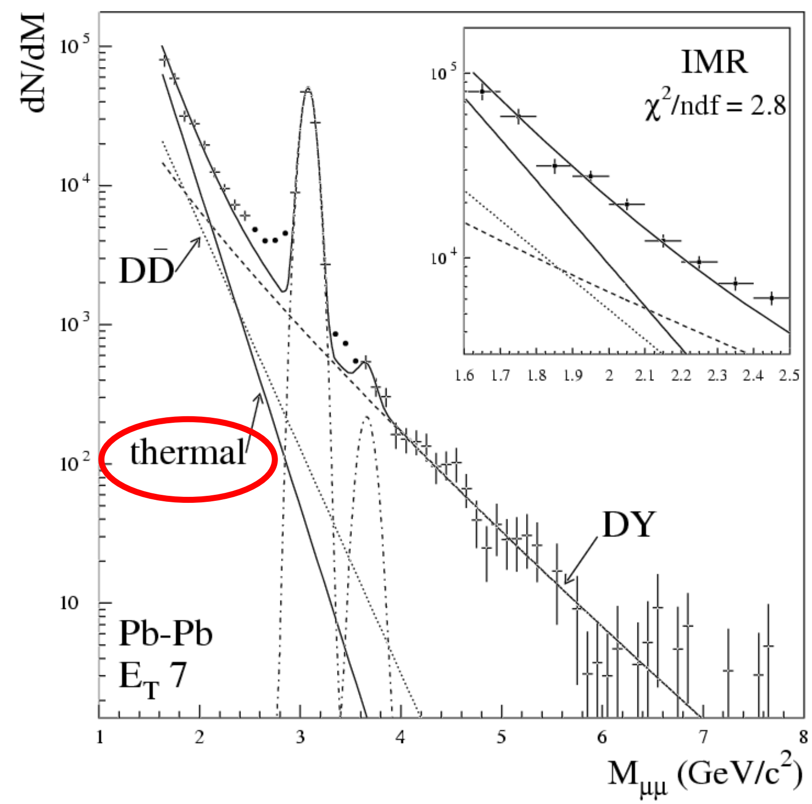
The intermediate mass dimuon yields can be reproduced :

- by scaling up the charm contribution by up to a factor of 3 (!)

  → crucial to understand J/ψ suppression: same initial state (gluons)
- or by adding thermal radiation to the DY and open charm explicitly introducing a QGP phase at T_c = 175 MeV (Rapp & Shuryak, Gale)

  → would be a direct evidence of thermalization of the pre-hadronization phase





How to measure open charm in HI ?

Explore lifetime of the D mesons:

D^+ : $c\tau$ = 312 μm

D^o : $c\tau$ = 123 μm

Select muons from $D \rightarrow \mu + X$ which do not converge to the interaction vertex.

This requires:

- precise knowledge of the vertex position
- good resolution on the track impact at the vertex

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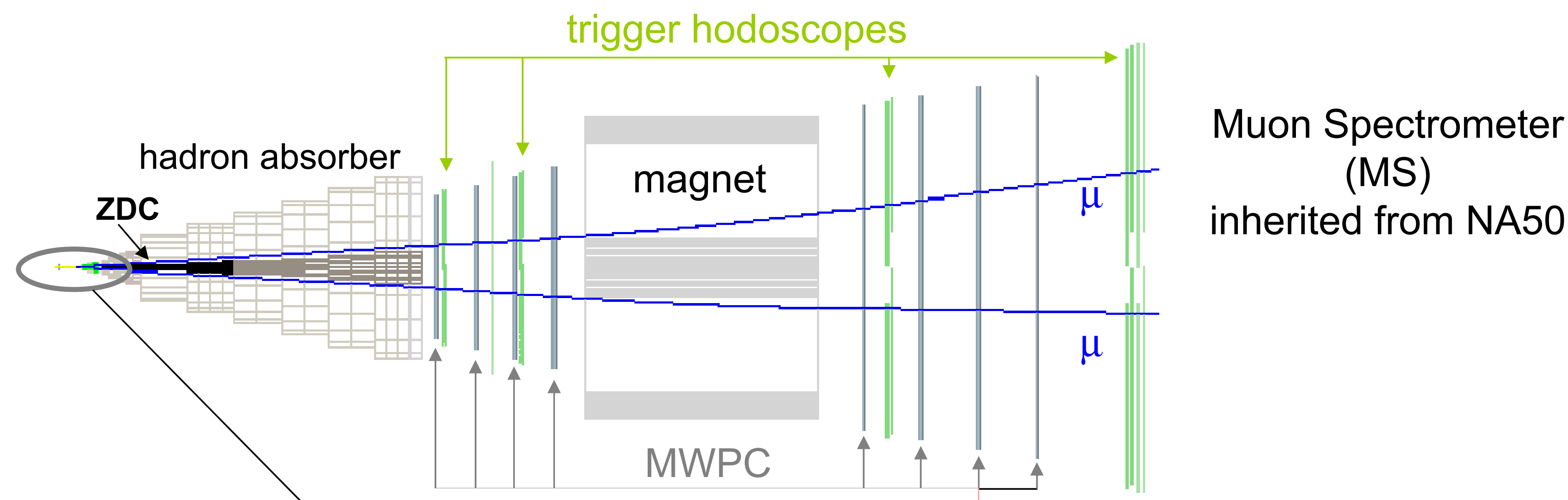
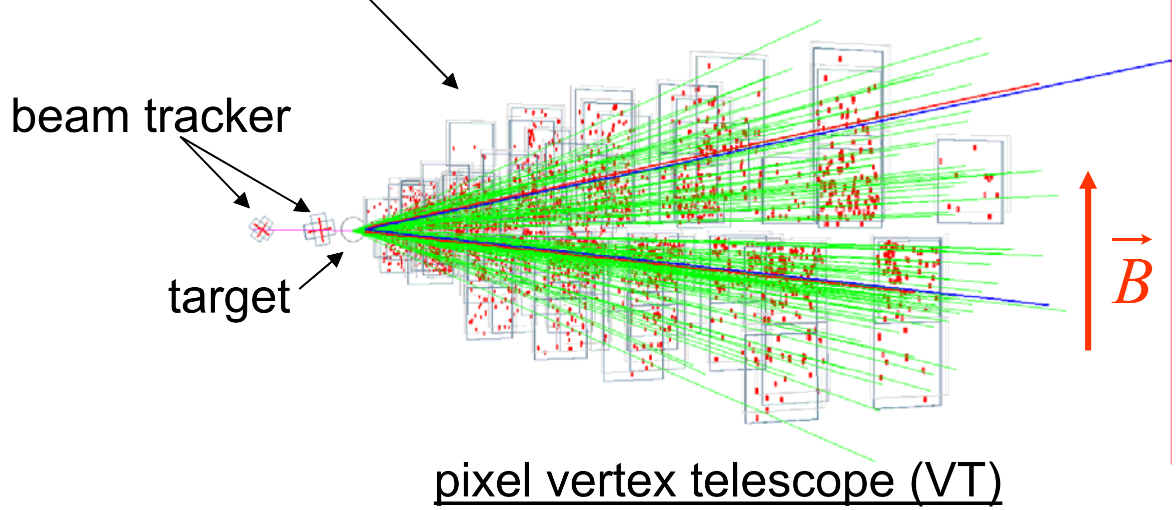
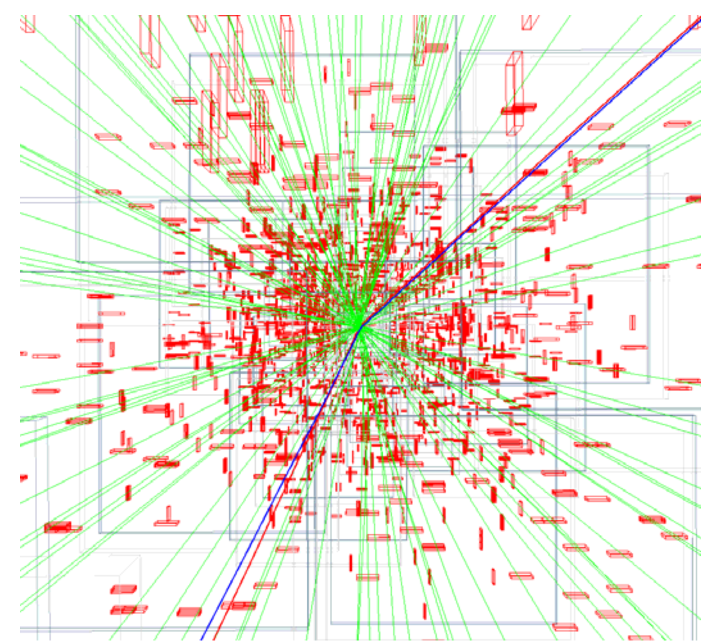
$$\sigma_{vertex} \oplus \sigma_{impact} < c\tau$$

Inverse: picking only muons strictly converging to the vertex we select prompt dimuons







16 silicon pixel planes: 50x425 μm^2 granularity
~2% X_0 per plane
9 X (bending plane, 2.5 T) and 3 Y tracking stations

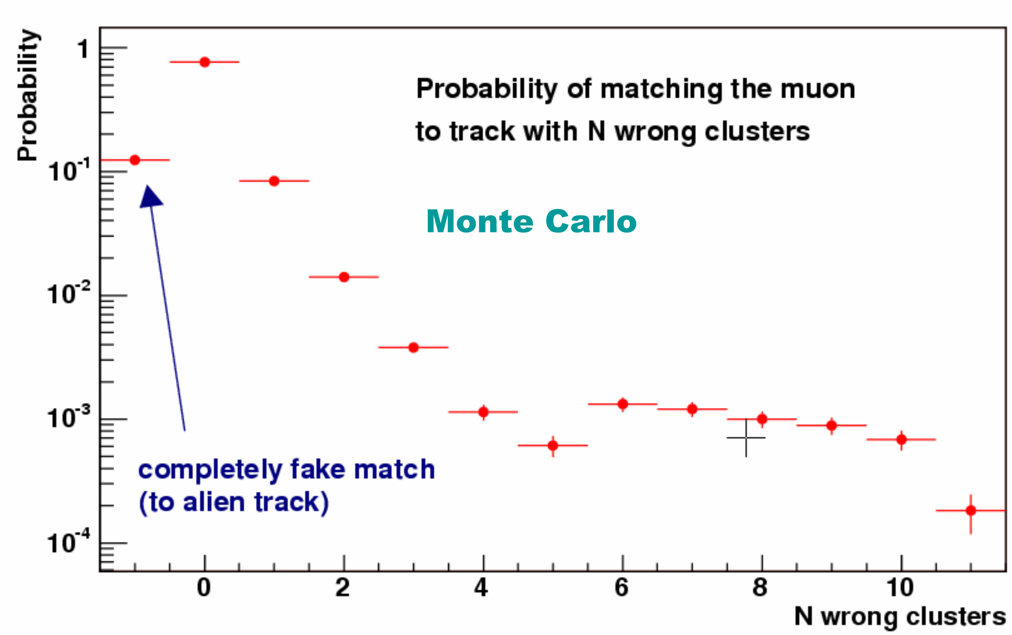
Muon track matching

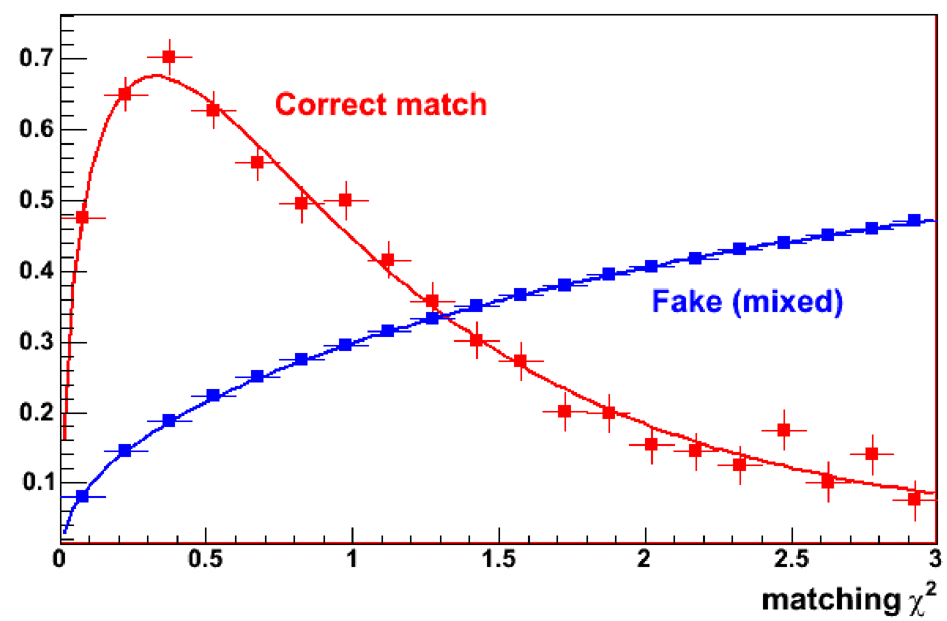
Matching between the muons in the Muon Spectrometer and the tracks in the Vertex Telescope is done using the weighted distance (χ^2) in slopes and inverse momenta. For each candidate a global fit through the MS and VT is performed, to improve kinematics

A certain fraction of muons is matched to closest non-muon tracks (fakes) ...
$\Rightarrow$ deteriorates kinematics and offset resolution.

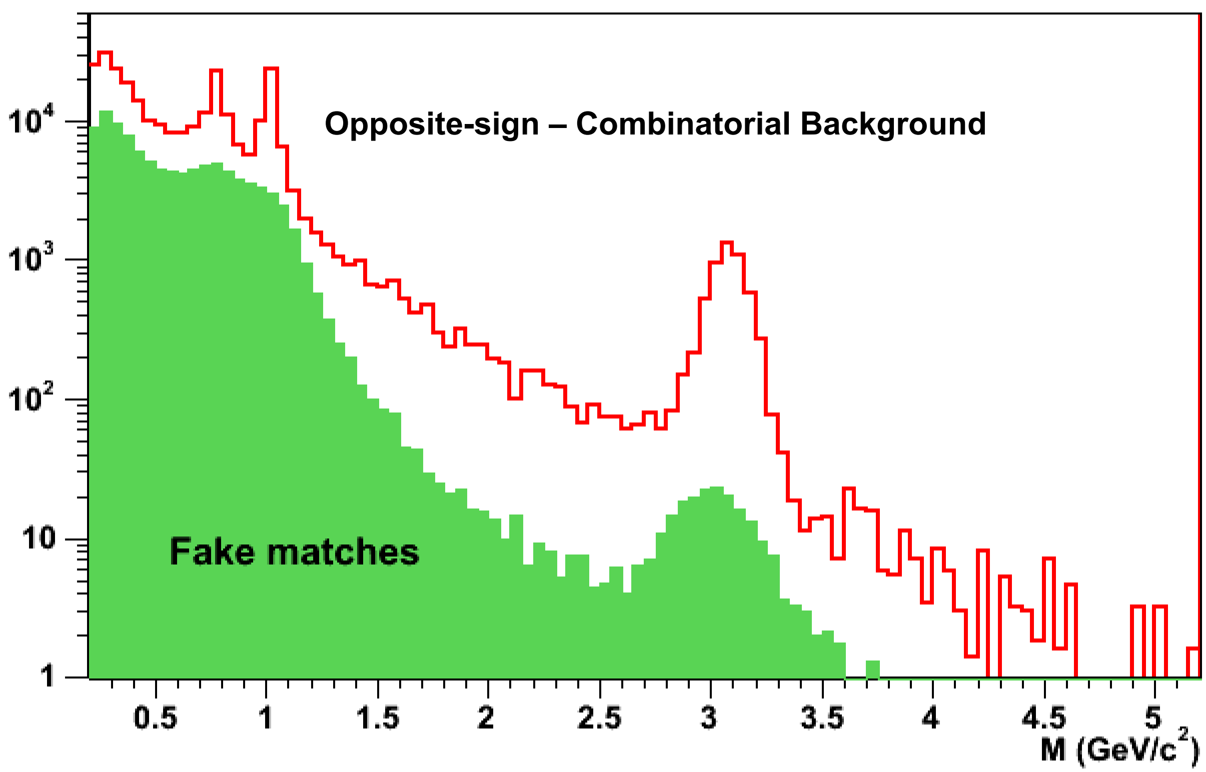
Fake matches are subtracted by a mixed events technique: the muons are matched to tracks from different events (work in progress...)

In the present study the fakes are not subtracted



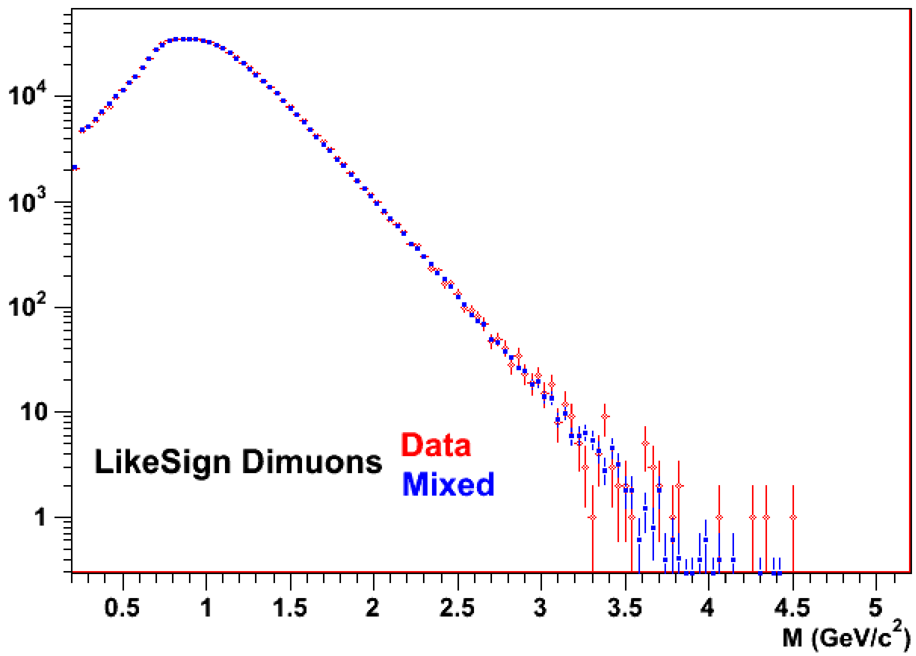


Level of fake matches

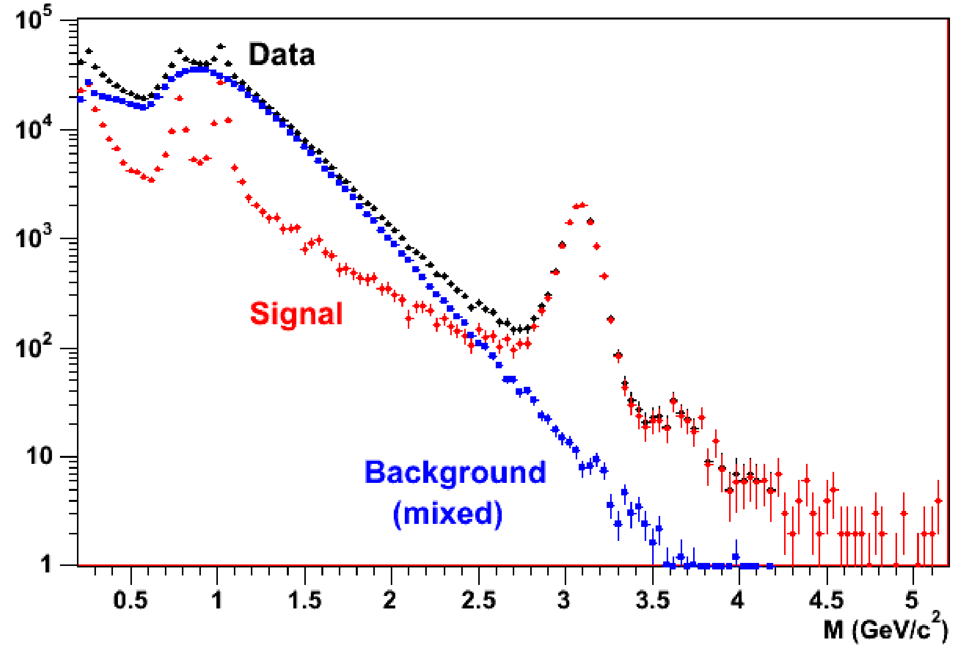


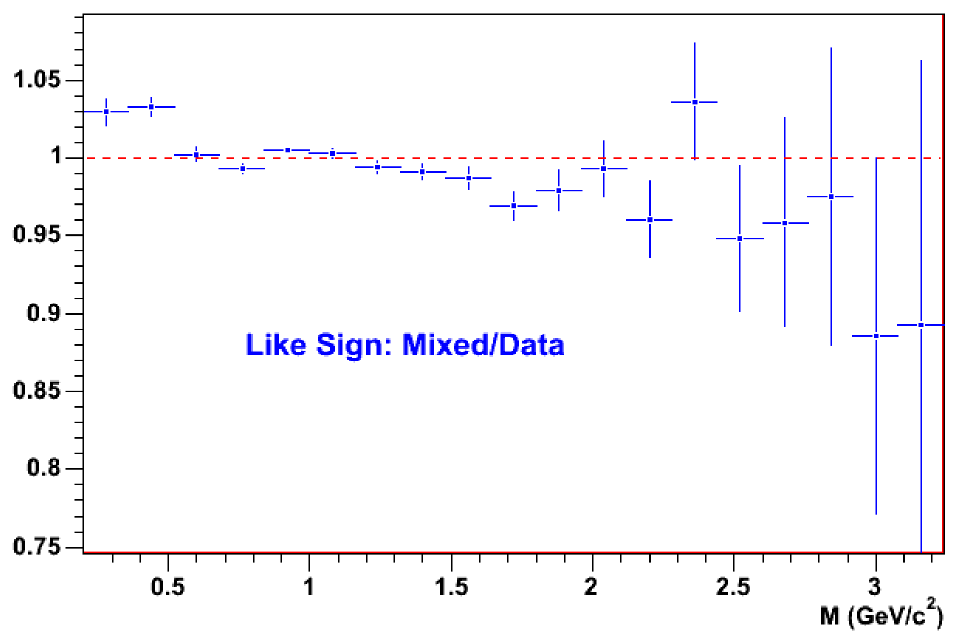
Combinatorial Background from π,K→μ decays

Subtracted by building a sample of μμ pairs using muons from different events.

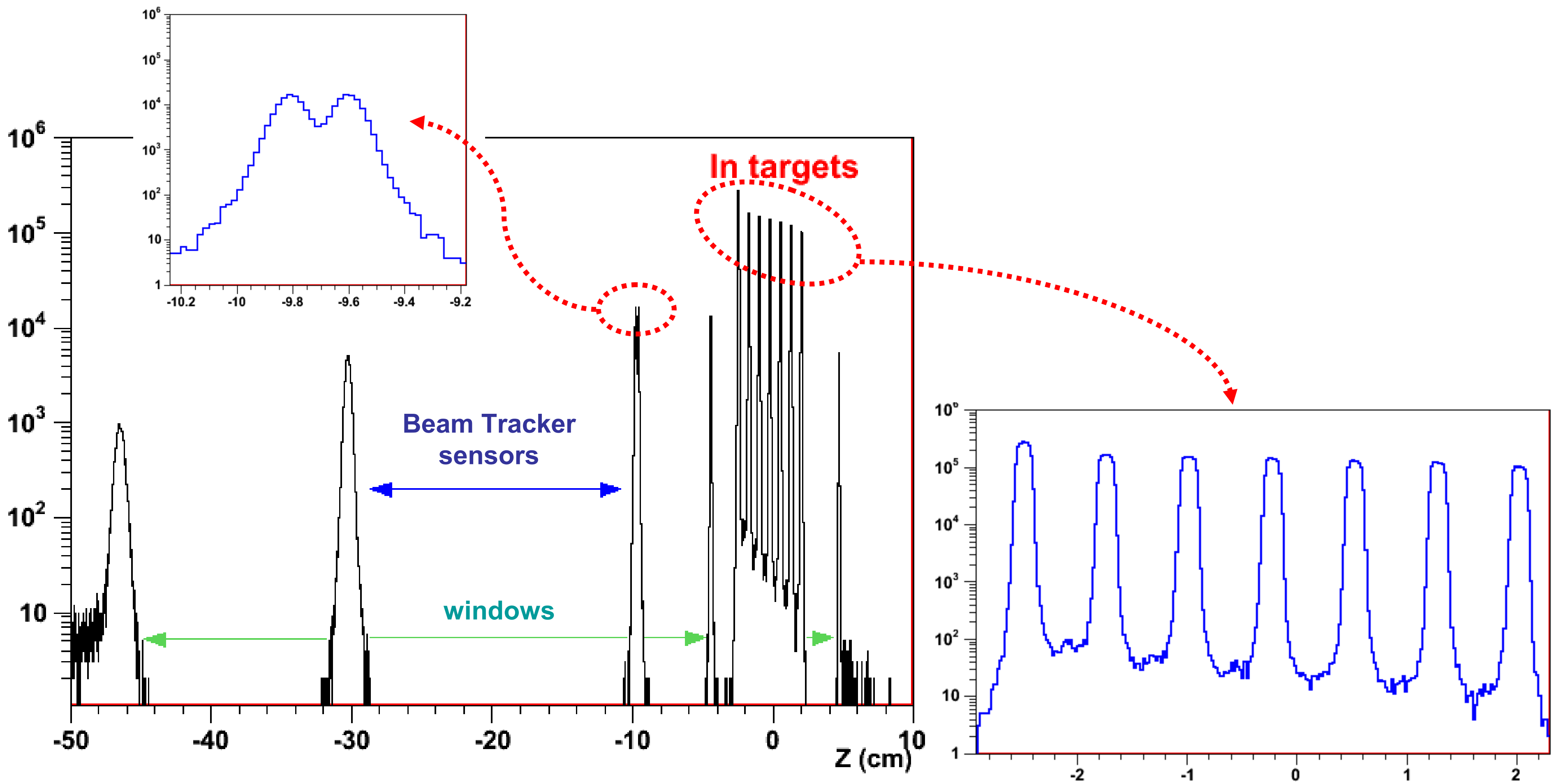


May be controlled by comparing the built **mixed** event Like Sign dimuon spectra to the corresponding measured **data**.





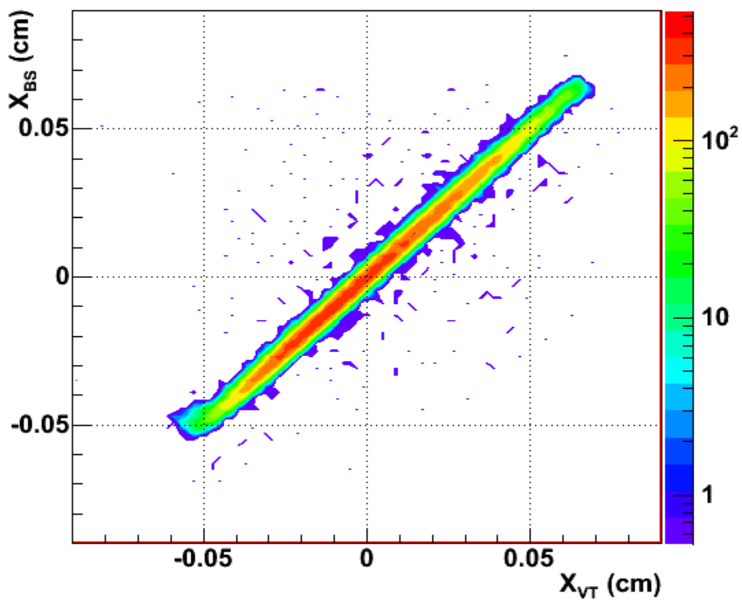
Vertexing

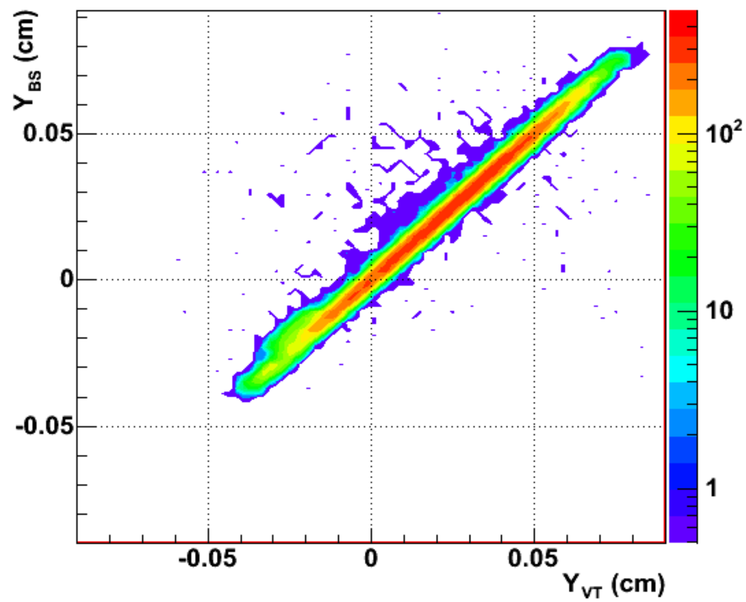


• Robust algorithm resolves multiple vertices (provided they are on different targets)

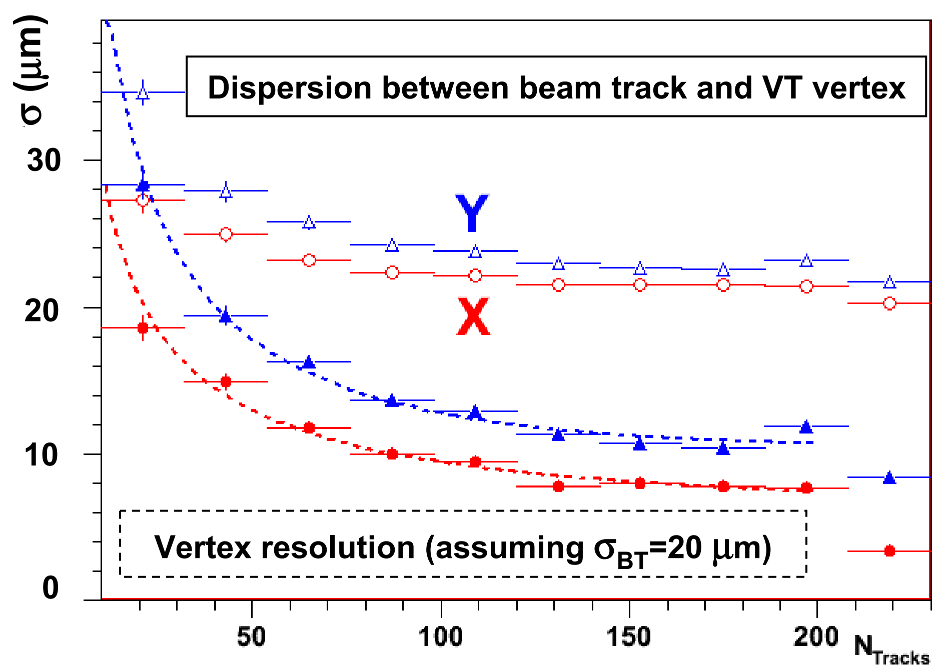
• Good target identification even for the most peripheral collisions (≥ 4 tracks)

Beam Tracker measurement vs. reconstructed vertex





Vertexing resolution and systematics are controlled using the Beam Tracker measurement (20 μm resolution for extrapolation to the target)



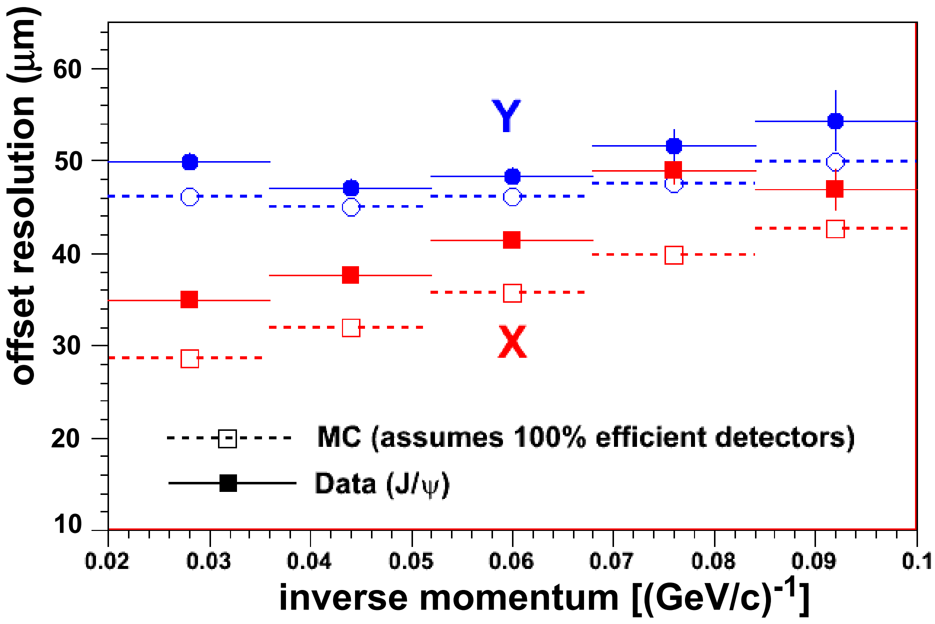
Measuring the muon track offset at the vertex

Offsets: ΔX, ΔY between the vertex and the track impact point in the transverse plane at Z_{vertex}.

Resolution depends on track momentum:

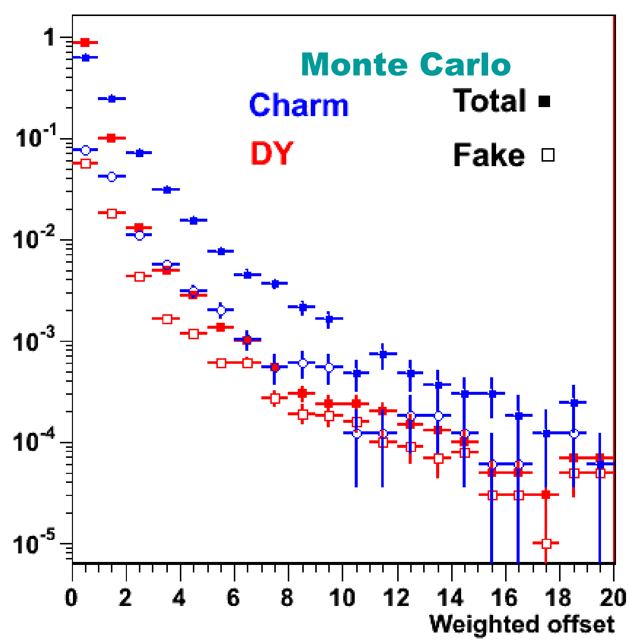
use **offset weighted** by the covariance matrices of the vertex and of the muon track

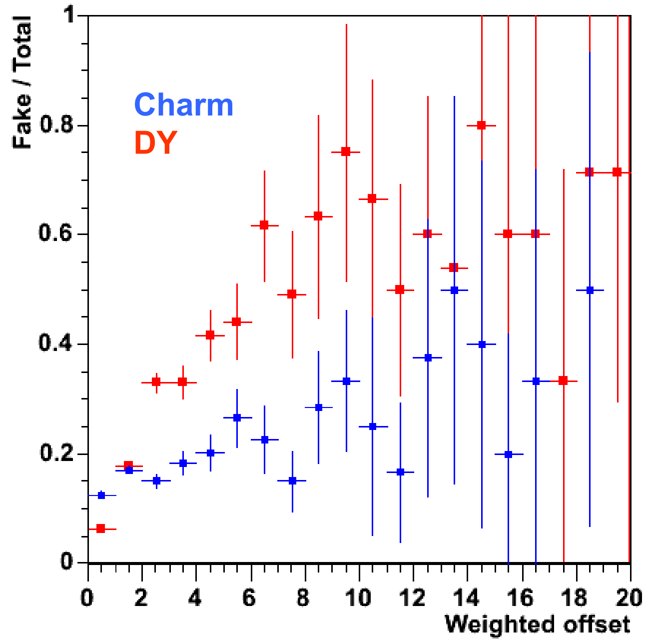
$$\sqrt{(\Delta x^2 V_{xx}^{-1} + \Delta y^2 V_{yy}^{-1} + 2\Delta x \Delta y V_{xy}^{-1})/2}$$



Fake matches tend to have large offsets:
they degrade the charm selection capability.

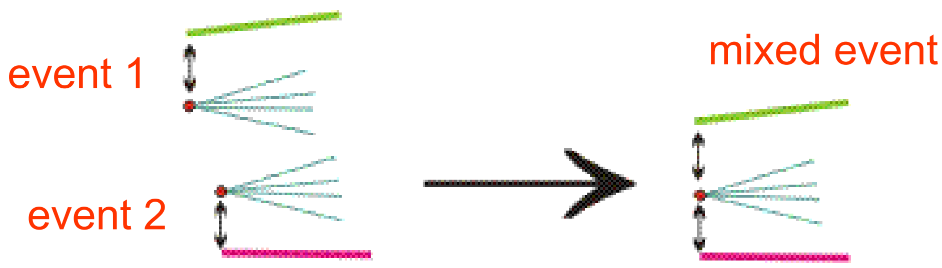
Problem will be solved once their subtraction is under control

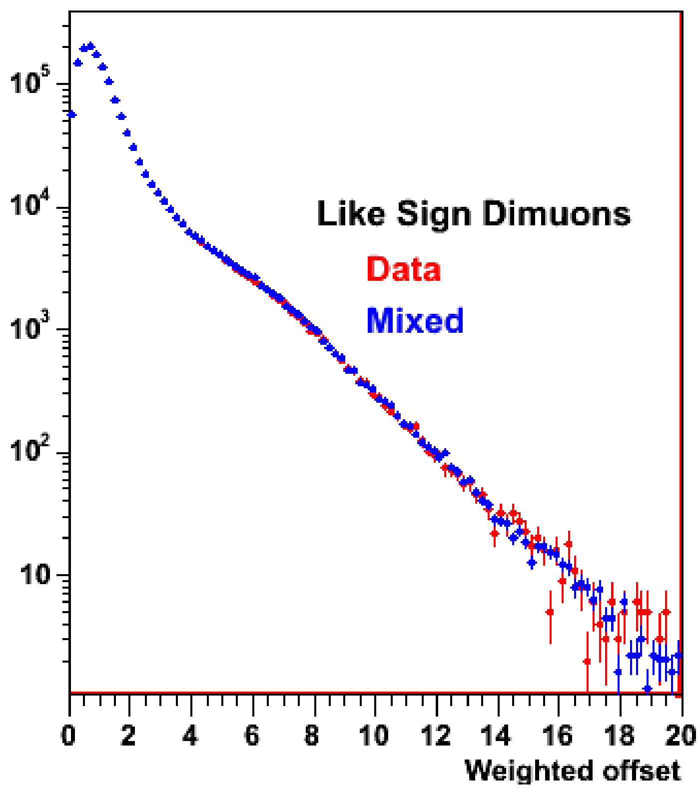


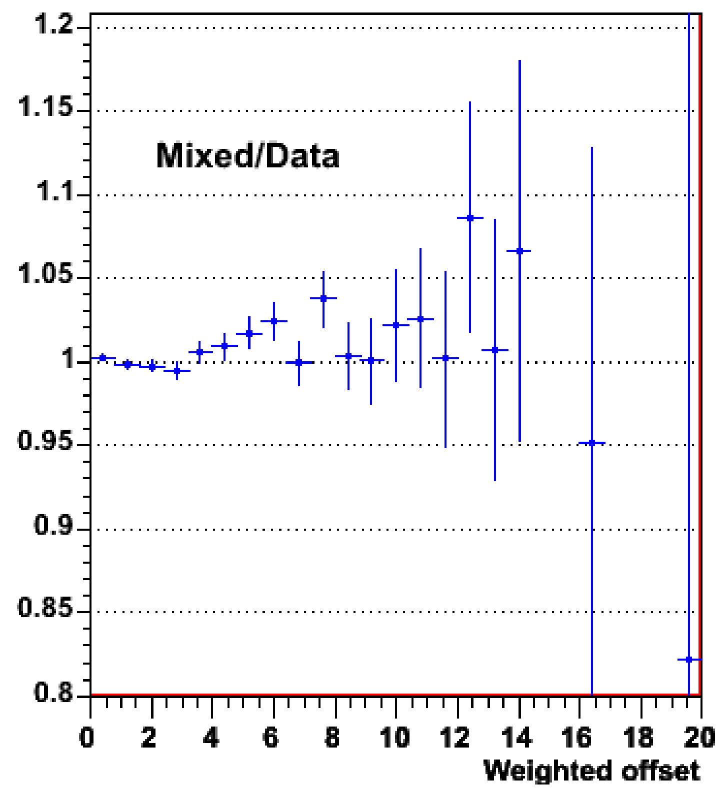


Measuring the muon track offset at the vertex

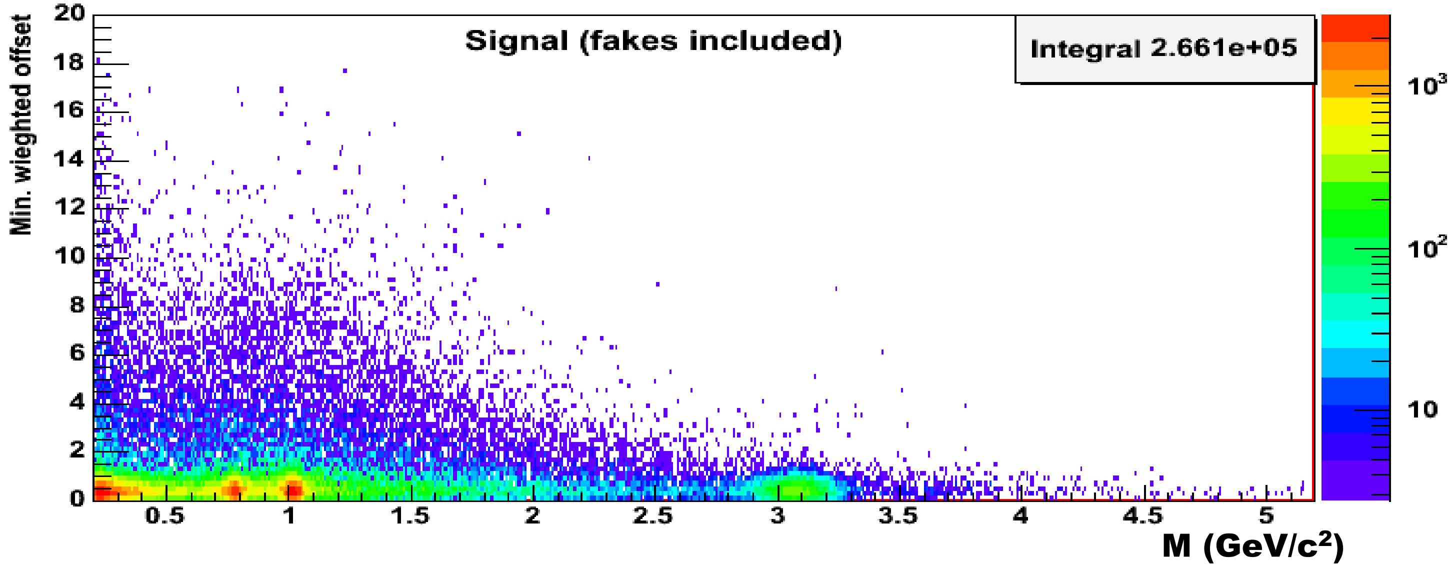
The “mixed” background sample must reproduce the offsets of the measured events: therefore, the offsets of the muons (of different events) selected for mixing must be replicated in the “mixed” event.



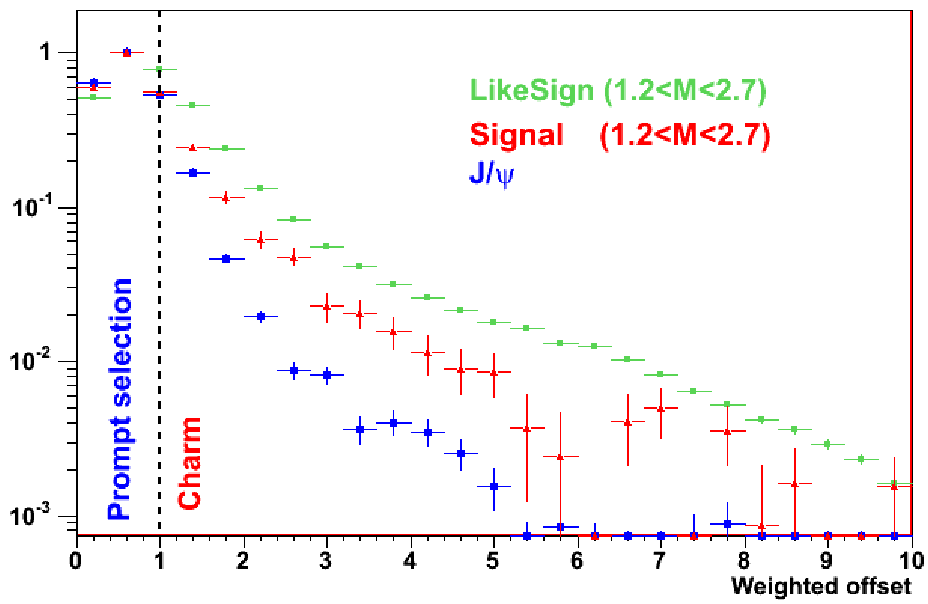




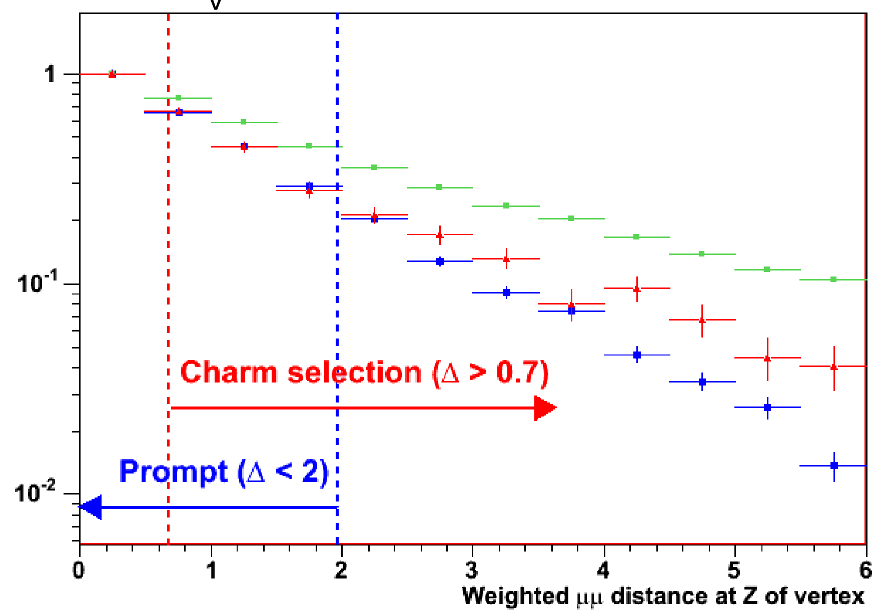
Prompt versus offsetted dimuon separation



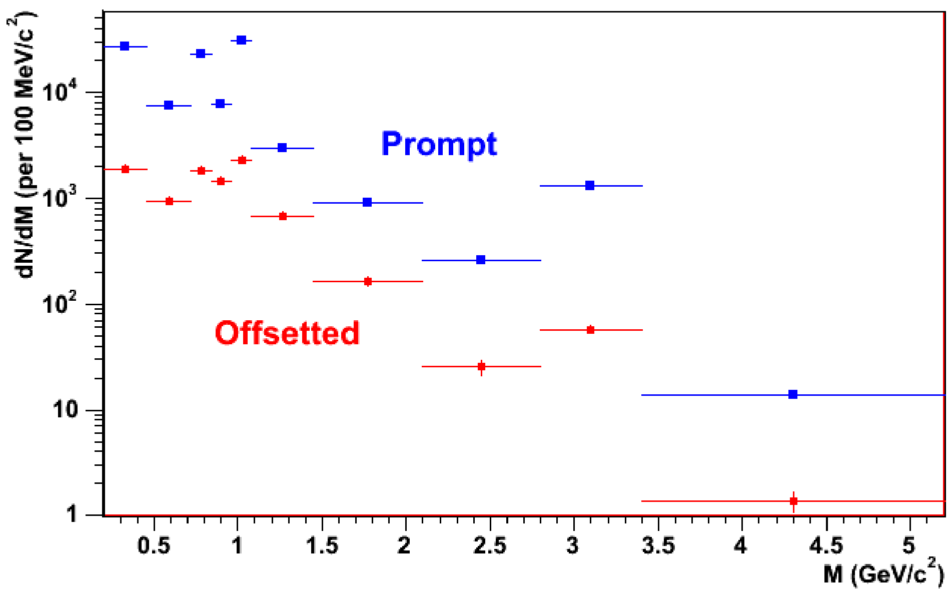
Cut on the weighted offset of the muon closest to the vertex



Additional cut on weighted distance, Δ, between muons at Z_V to reduce influence of bad vertices

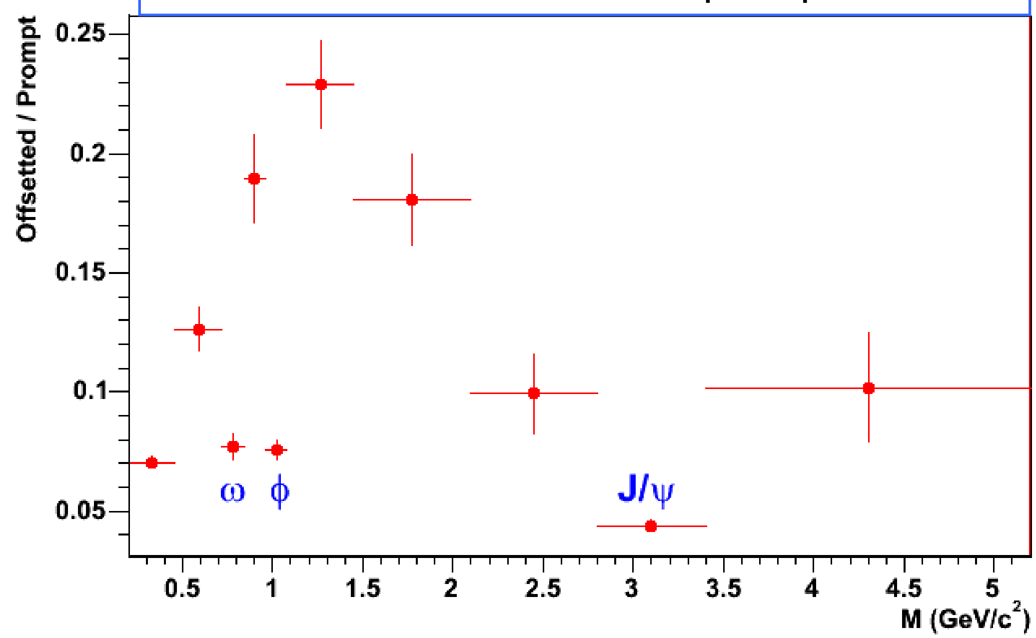


Prompt versus offsetted dimuon separation



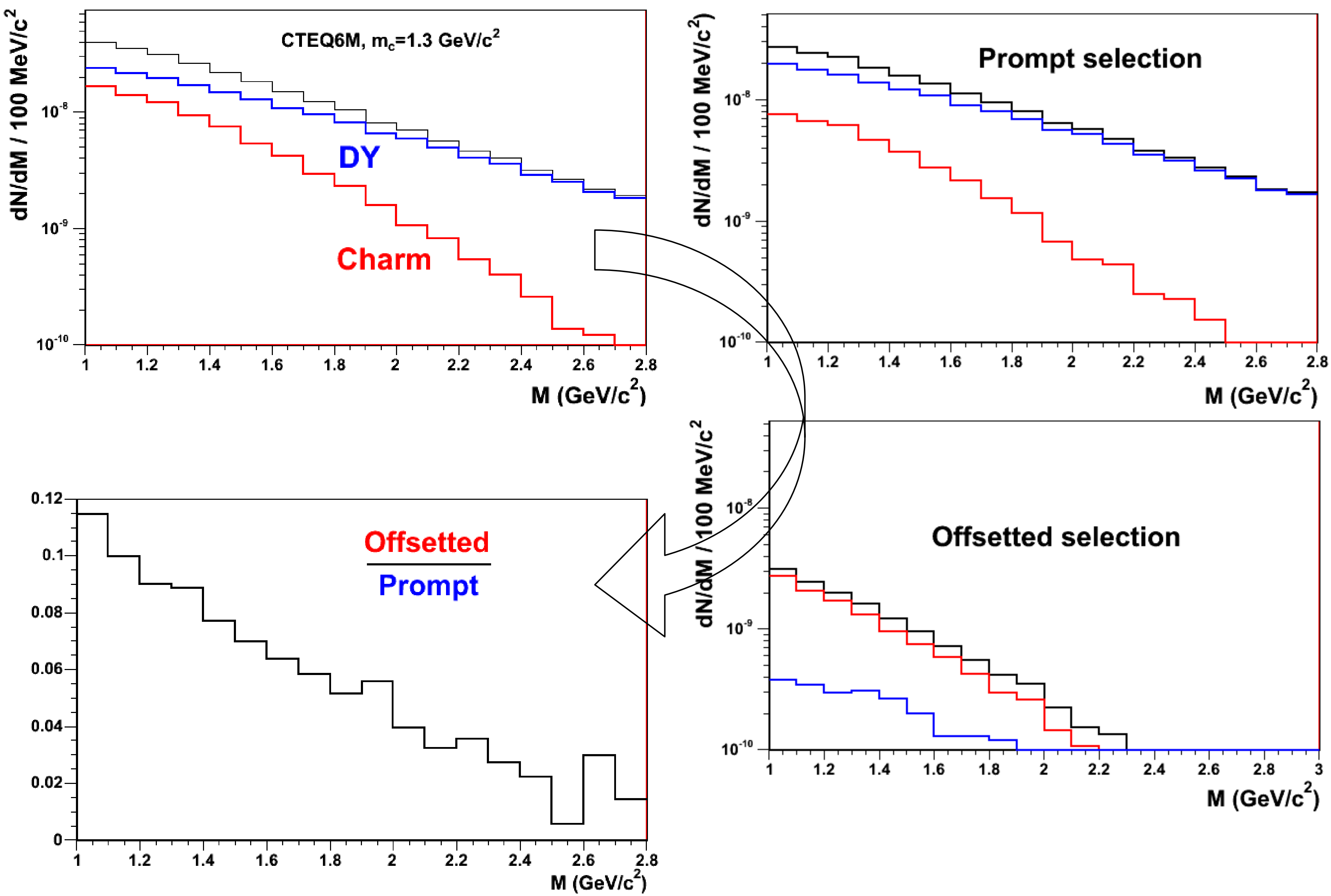
- Only ~20% of the total statistics is used
- The selection cuts are still to be optimized (once the subtraction of the fake matches is available)

Ratio between offsetted and prompt dimuons



- Strong reduction of the dimuon yield in the prompt sample, at the dimuon masses dominated by the ω, ϕ and J/ψ peaks
- Clearly visible "excess" in the offsetted dimuon sample in the mass window where the charm decays contribute the most

Very crude Monte Carlo

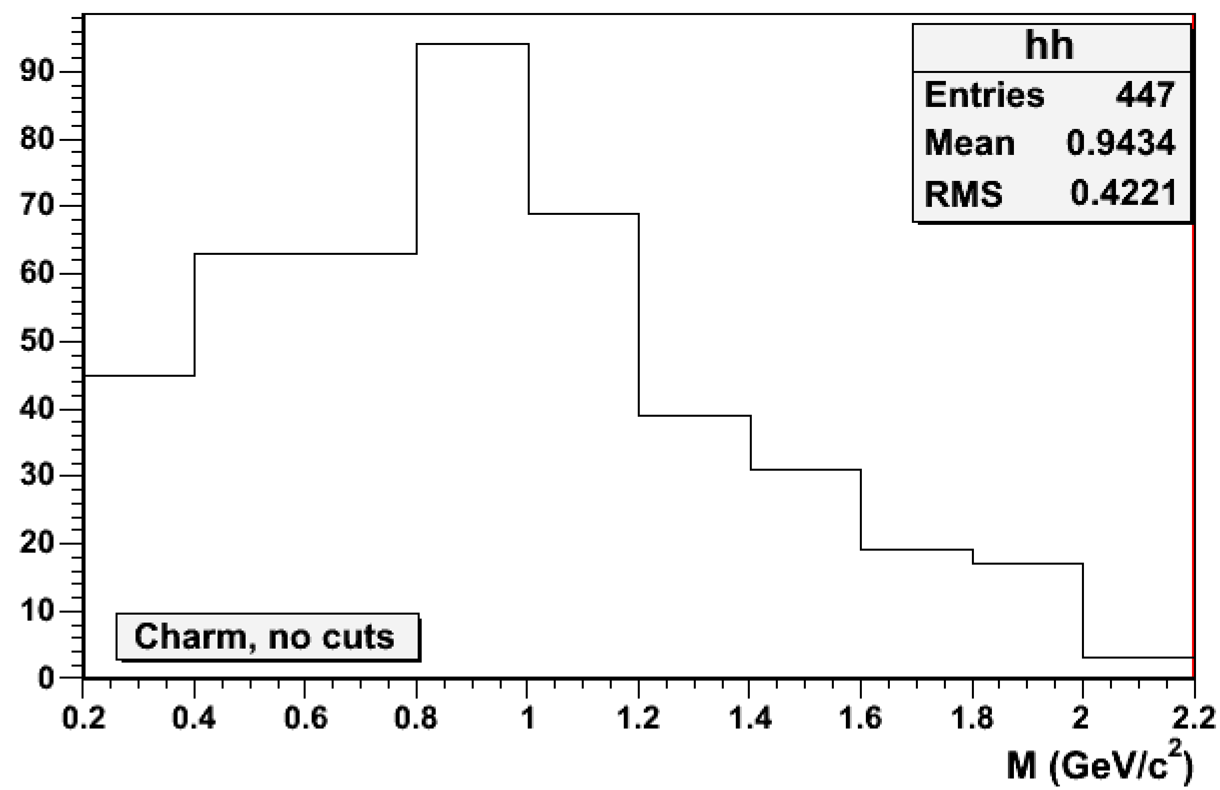


Conclusions and outlook

- ✓ Comparison with Monte Carlo should be improved (e.g. pixel's efficiencies are being evaluated)
- ✓ Fake matches background must be subtracted (work in progress)
- ✓ Nevertheless, a charm signal is already visible
- ✓ NA60 is taking data with 400 GeV/c protons on Be, Al, Cu, In, Pb, W and U targets
- ✓ Expected statistics:
  ~ 500 000 J/ψ
  similar amount of open charm at $1.2 < M < 2.7$ GeV/c^2

$\Downarrow$

reference for the studies of Indium-Indium data



hh
Entries 447
Mean 0.9434
RMS 0.4221
Charm, no cuts
0
10
20
30
40
50
60
70
80
90
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
M (GeV/c^2)