Reconstruction & Efficiency

Offline studies for the Dimuon Forward Spectrometer

Alice Offline Week, October 3-7 2005

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Reconstruction & Efficiency

Outline :

- *The Dimuon Spectrometer*
- *Tracking procedure*
- *Efficiency Calculations*
- *Trigger Efficiency*
- *Vertex resolution vs Υ mass*
- *Conclusions*

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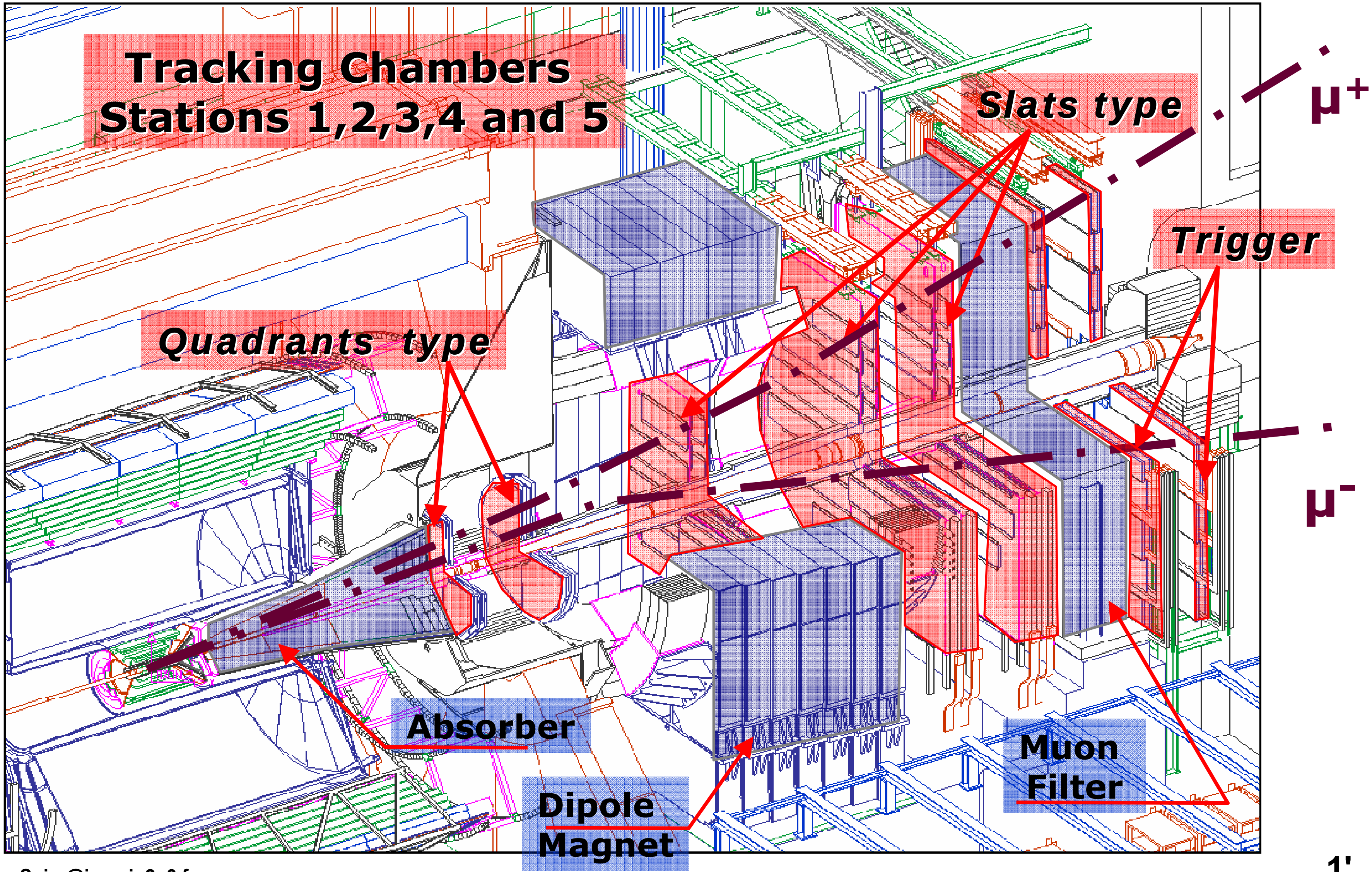
Dimuon Forward Spectrometer



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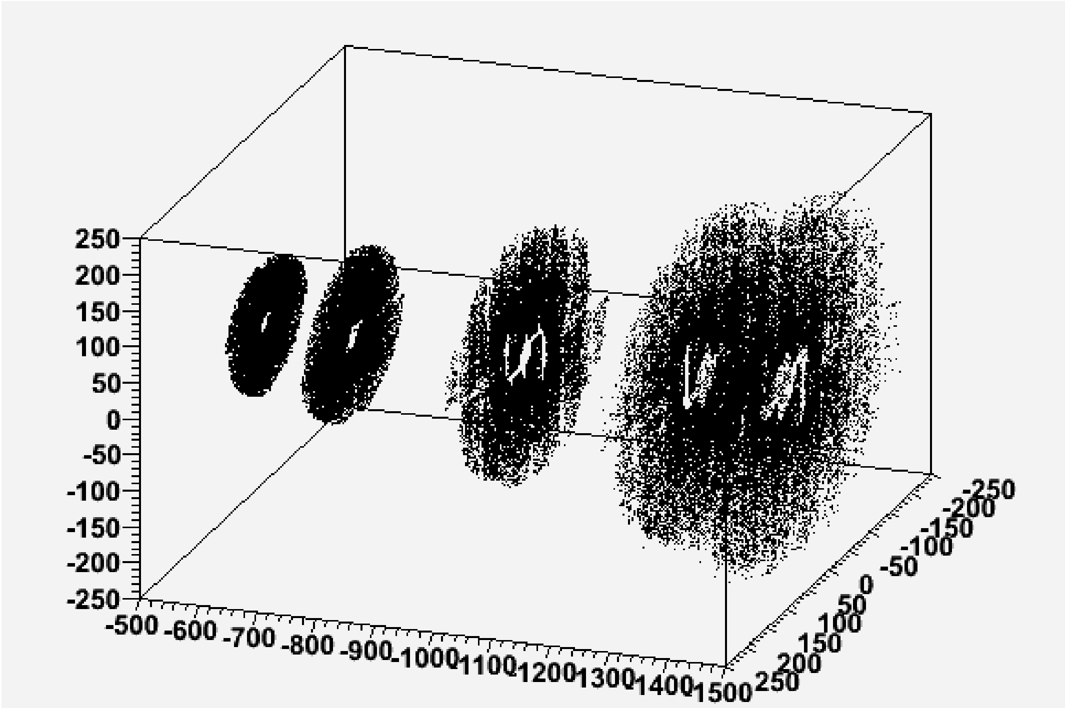
Reconstructed hits



5 tracking stations

10 detection planes

- **Station 1 & 2 :**
  - **2 planes per station**
  - **1 plane = 4 quadrants**
- **Station 3,4 & 5**
  - **2 planes per station**
  - **1 plane = 18/26 slats**
- **1 plane gives two (X,Y) coordinates :**
  - **bending plane (along x) :** X_{Const_Res} Y_{Var_Res}
  - **non bending plane (along y) :** X_{Var_Res} Y_{Const_Res}

Track Reconstruction (i)

- Segments (≡ 2 associated rec. hits in the same station) are reconstructed in all stations.

  [see AliMUONEventReconstructor::MakeTracks()]

- Station 5 : loop over all segments
  - try to find/associate a segment in station 4
  - try to find/associate a hit in station 4
  - tag if choosen
- Station 4 : loop over all segments
  - try to find/associate a segment in station 5
  - try to find/associate a hit in station 5
  - tag if choosen

with 2 segments or 1 segment+1 point, an AliMUONTrack is created

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Track Reconstruction (ii)

- **AliMUONTrack(BegSegment,EndSegment).**

in AliMUONEventReconstructor::FollowTracks()

- **FollowTracks in Stations 3, 2 and 1**
  - **Z extrapolation ($p_\perp$ estimation, helix extrapolation)**
  - **recalculate X^2 with the new segment**
  - **add the best segment to the track (X^2_{min} =5.0)**
  - **if no best segment, try with a single hit (X^2_{min} =3.0)**
  - **if no best hit, delete track**
- **Fill track parameters**
- **Vertex extrapolation (through absorber) : apply BransonCorrection on track parameters**

Tracking is done…

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Efficiency definition

- **Definition :**

1) **mc Monte Carlo Upsilons generated with decay muons in the acceptance of the Dimuon Forward Spectrometer (CutOnChild==1)**
2) **tr Tracks that satisfy software reconstruction criteria, i.e. enough hits in chambers to allow software reconstruction**
3) **rc Reconstructed Upsilons must satisfy cuts on :**
   - **the mass range $[m_{\Upsilon}^{PDG}-1; m_{\Upsilon}^{PDG}+1]$ GeV/c^2 (bad choice - corrected)**
   - **the $p_{\perp}$ reconstructed ≤ max. $p_{\perp}$ generated**

tr/mc : "detector" efficiency (dead zones)
rc/tr : "tracking code" efficiency
rc/mc : efficiency

NB : all "hardware" parameters (FEE) and chambers efficiencies are set to defaults values.

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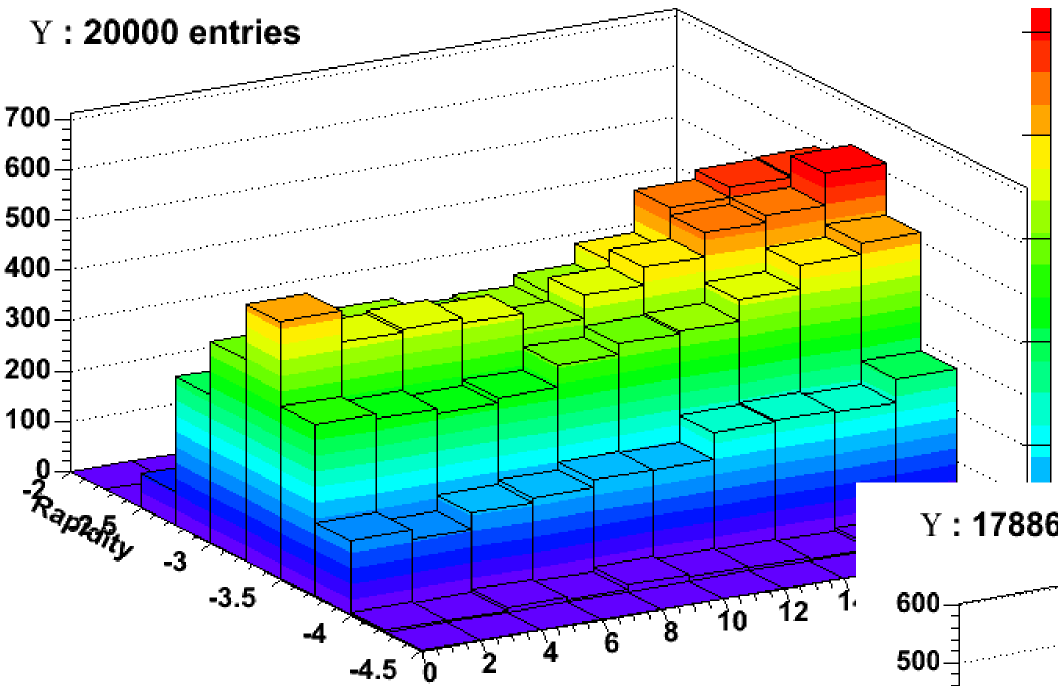
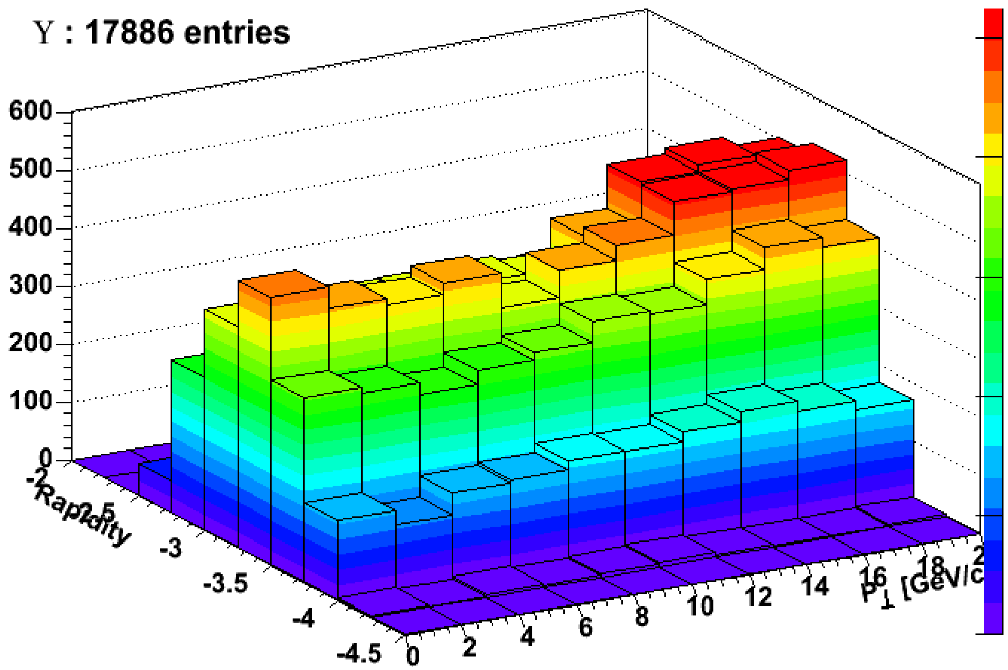
Υ Efficiency (flat [$p_\perp$,y], no backgd)



Monte Carlo Upsilons (mc)

($p_\perp$,y) distributions generated flat are not anymore : effect of the CutOnChild (≡ acceptance effect)

Reconstructed Upsilons (rc)



Integrated efficiency :
17886/20000 ≡ 89.4%

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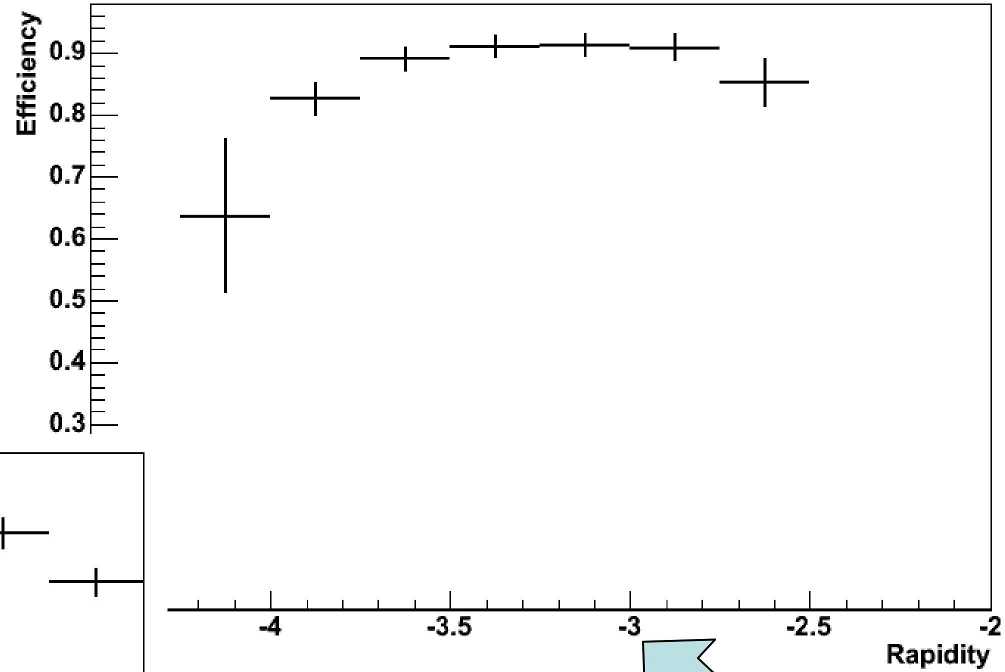
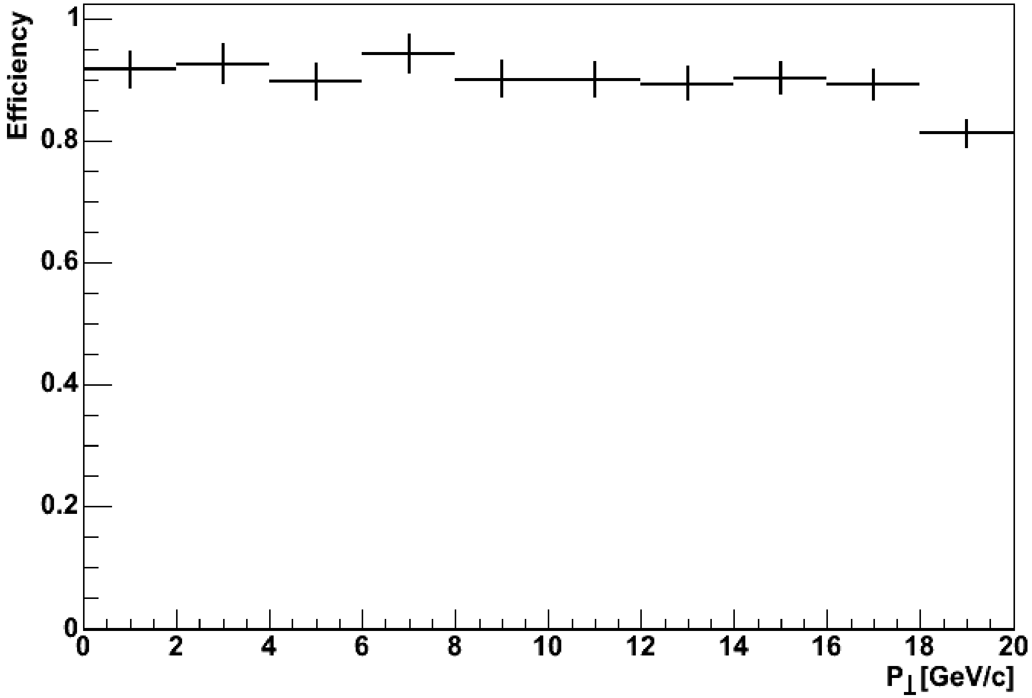
Υ Efficiency (flat [p⊥,y], no backgd)



Υ Efficiency is flat in p⊥

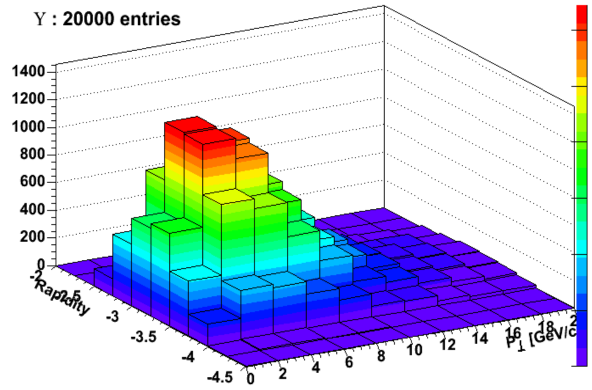


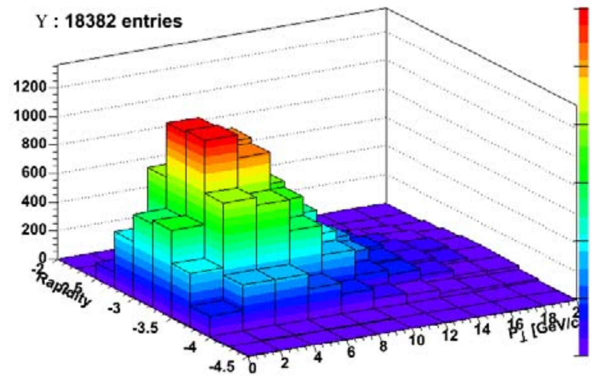
Υ Efficiency is ~ flat in Y

Υ Efficiency (realistic [p⊥,y], no background)

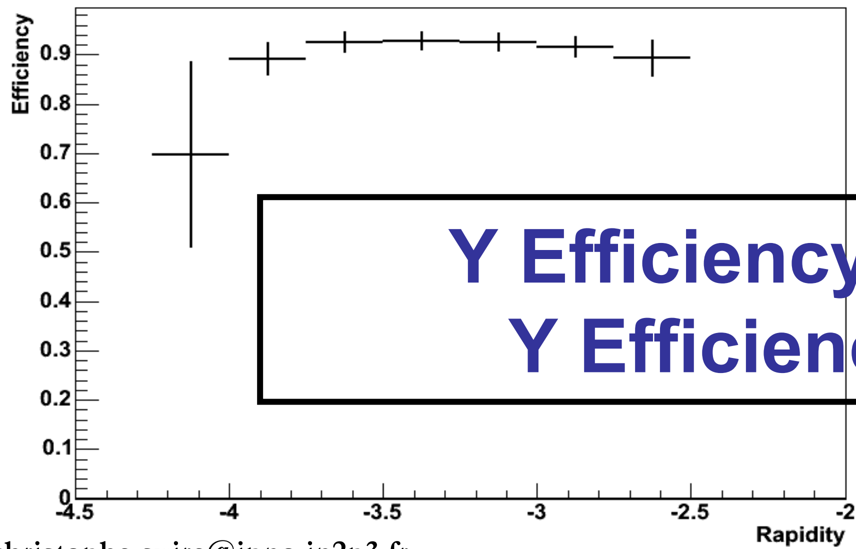
(p⊥,y) distribution are from CDF scaling

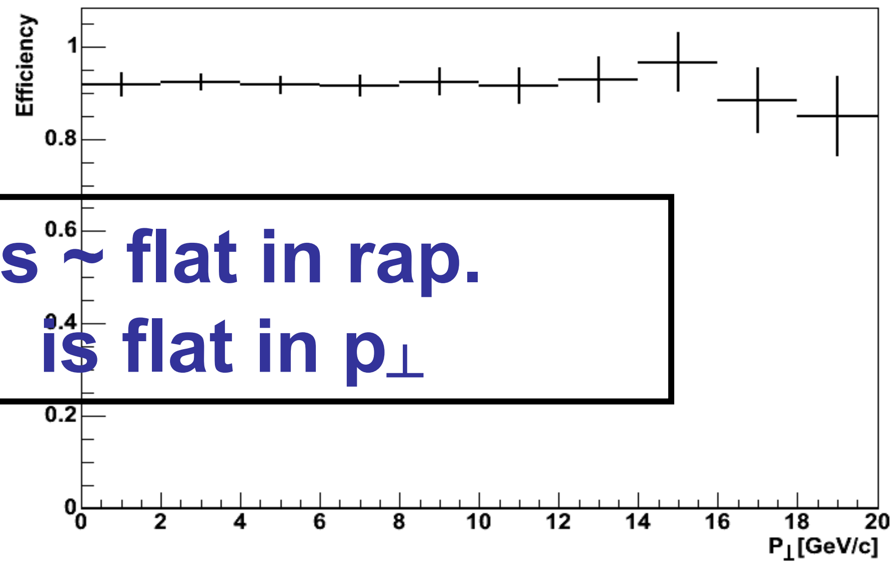
↳ **look at Pb+Pb @ $\sqrt{s_{NN}}$ = 5.5 TeV**





20000 mc
18552 rc
Eff = 92.8 %





Υ Efficiency is ~ flat in rap.
Υ Efficiency is flat in p⊥

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Υ Efficiency vs Code Version

Major change in the DFS software Old⇒New Segmentation

↳ **Υ yield is a good indicator**

Flat $(p_\perp,y)$ dist. : $Eff_{OldSeg} = 89.4\%$

CDF scaled $(p_\perp,y)$: $Eff_{OldSeg} = 91.9\%$

(from previous slides)

⇒ **Switch to new Segmentation**

Flat $(p_\perp,y)$: $Eff_{NewSeg} = 90.8\ \%$ (18157/20000)

CDF scaled $(p_\perp,y)$: $Eff_{NewSeg} = 92.8\ \%$ (18552/20000)

Small gain but a gain (up to 1.4%) is observed
→ code monitoring (same seed, same macros, same everything…)

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Trigger Efficiency : definition

- **What is the Trigger information :**
  1) All (simulated) data from the Trigger Chambers is available
  2) Hits in Trigger Chambers→pattern→Look UpTable→Trigger Type
  3) Trig. Types: SinglePlus, SingleMinus, SingleUndefined, UnlikePair,

     LikePair ⊗ LowPt (~1GeV/c), HighPt (~2Gev/c), AllPt (~1GeV/c)

[NB: logical rules like 1 undefined ⇒ 1 UnlikePair and 1 LikePair @ AllPt]

  4) DAQ is governed by these Trigger Types
- **How is define the Upsilon Trigger**
  1) As we choose ! SingleMinusHightPt, <u>UnlikePairHightPt</u>, etc…
  2) the UnlikePairAllPt seems appropriate

Trigger Efficiency : 20k Y generated (CDF Scaled param) ⇒ count UnlikePairAllPt Trigger

<u>No track reconstruction required !</u>

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Trigger type exemples

```
event 30 nglobals nlocals: 1 2
===========================================
Global Trigger output          Low pt  High pt   All
number of Single Plus      :        1       1        1
number of Single Minus     :        1       1        1
number of Single Undefined :        0       0        0
number of UnlikeSign pair  :        1       1        1
number of LikeSign pair    :        0       0        0
===========================================
```

```
event 39 nglobals nlocals: 1 2
===========================================
Global Trigger output          Low pt  High pt   All
number of Single Plus      :        0       0        0
number of Single Minus     :        1       1        1
number of Single Undefined :        1       1        1
number of UnlikeSign pair  :        1       1        1
number of LikeSign pair    :        1       1        1
===========================================
```

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Trigger type exemples

Some events can be more "exotic" !

```
event 7757 nglobals nlocals: 1 8
==========================================
Global Trigger output            Low pt  High pt   All
number of Single Plus       :       3       2       4
number of Single Minus      :       2       1       3
number of Single Undefined  :       1       1       1
number of UnlikeSign pair   :      11       5      19
number of LikeSign pair     :       9       4      16
==========================================
```

This event has 172 particles in the stack :
1 Y, 2 μ, 75 γ, 59 e- and 35 e+

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Trigger efficiency

- **Results for 20k Y in the DFS Acceptance (Y→ μ+μ-)**

Event with		SingleUndefinedAllPt trigger in the UnlikePair		
		0	**1**	**>1**
0 trigger UnlikePairAllPt	1406			
1 trigger UnlikePairAllPt	18012	**4872**	**9948**	**3192**
>1 trigger UnlikePairAllPt	582	**108**	**316**	**158**
Trigger Upsilon Ok	18594	**4980**	**10264**	**3350**

⇒ Trigger Eff = 93.0% (18594/20000)

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Rec./Trigger Tracks matching

- **Upsilon Trigger Matching conditions :**

1) Two reconstructed tracks (μ) which give an Υ at the correct mass
2) Loop over trigger tracks and calculate a χ^2 for this matching pair match if $\chi^2 < 10$ ((x,y) position and slope matching rec. tracks)
3) Count the number of reconstructed tracks matched to trigger tracks (0,1 or 2)
4) Matching vs Generated trigger word

- 20000 Υ generated (CDF scaled param)
- 18552 Υ reconstructed in the proper mass region (2 rec. tracks)
- 18594 UnlikePairAllPt triggers (2 trig. tracks)

$\Rightarrow$ Do we have a good matching ?

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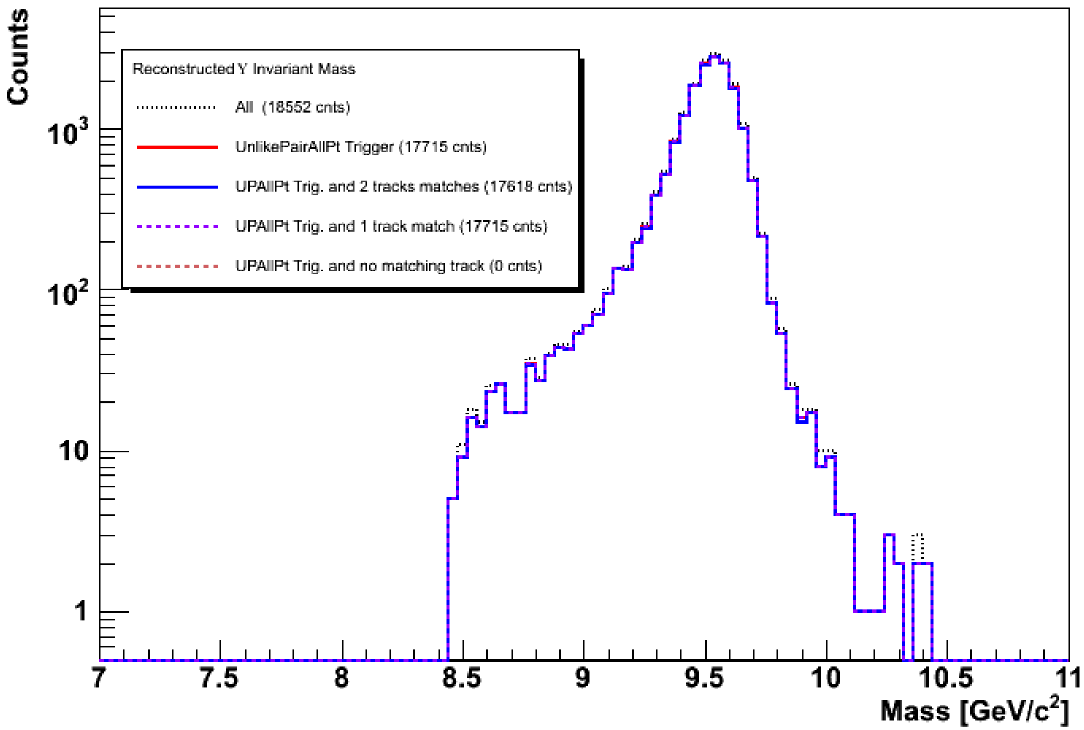
Rec./Trigger Tracks matching



- **Matching :**

1) 17715/18552 have the correct trigger word : 95.5%
2) 837 other trigger words are mostly SinglePlus/Minus
3) 2 tracks (μ) match 2 trigger tracks 17618/17715 : 99.4%

If we have an event with reconstructed Y and an UnlikePairAllPt trigger (95.5%), then :
(μ+ & μ-) matching with trigger track = 99.4 %
Single μ matching with trigger track = 100%

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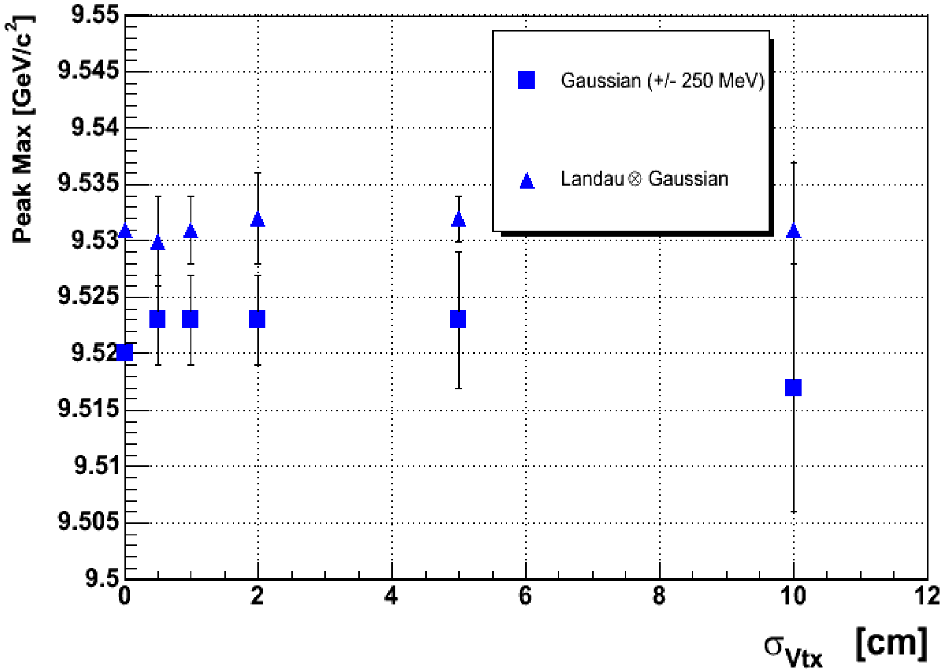
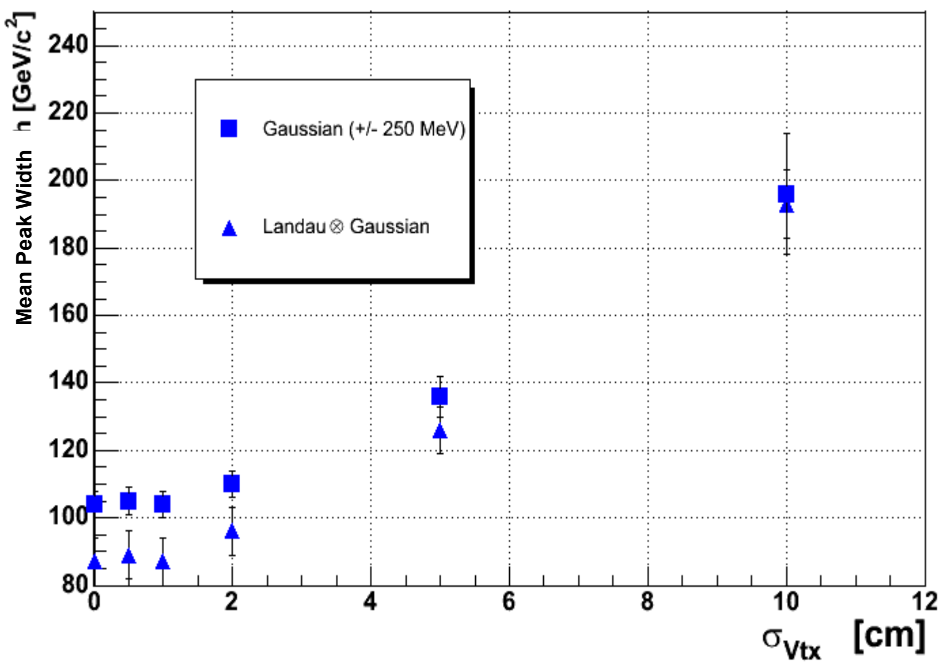
Y rec. mass vs vertex resolution

Y characterized by the mean and σ of the rec. mass peak

↳ **what is the uncertainty we can accept**





Y mass mean peak position stays rather flat

Y mass mean peak width increase if $\sigma_{vtx} \geq 2$ cm

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Conclusions

- **Efficiency for Υ (and μ tracks) under control :**
  - Efficiency ≥ 90% (97%)
    - ↳ add background, check G3 hit to rec. hit matching
- **Tiny change between old and new Segmentation**
  - Υ Efficiency gain, around 1 %
- **Trigger Efficiency for Υ : Efficiency ~ 92.8 ± 0.7 %**
- **Mass resolution vs Vertex resolution**
  - along Z $\sigma_{VTX} < 2$ cm ⇒ no effects on mass rec.

Υ efficiency : ε = Acc × BR × Track Eff. x Trig. Eff

ε = 0.05 x 0.0248 x <u>0.9 x 0.93</u> ~ 1/950

Vertex resolution must be better than 2 cm

Special Thanks to Muon Code Developers for their hard work.

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What are the ongoing studies

- **Absorber model**
  - **Multiple Scattering : Branson Model**
  - **Energy Loss : parameterization**
- **Chamber geometry**
  - **geometry of the spectrometer : alignment**
  - **geometry of the chamber itself : mapping**
- **Field inside the Dipole Magnet**
  - **correction from latest measurements**
- **Vertex reconstruction**
  - **what precision is needed on the primary vertex**
- **Monitor the Code evolution**

More Slides…

Branson Model for MS (i)

```
// initialize values for the Branson Correction
// zBP1 for outer part and zBP2 for inner part (only at the first call)
 if (first) {
   first = kFALSE;
   zEndAbsorber = -503;  // spectro (z<0)
   thetaLimit = 3.0 * (TMath::Pi()) / 180.;
   rLimit = TMath::Abs(zEndAbsorber) * TMath::Tan(thetaLimit); // = 26.3 cm ??
   zBP1 = -450; // values close to those calculated with EvalAbso.C
   zBP2 = -480;
 }

// get tracks parameters
pYZ = TMath::Abs(1.0 / fInverseBendingMomentum);
sign = 1;        if (fInverseBendingMomentum < 0) sign = -1;
pZ = Pz();  pX = Px();  pY = Py();  pTotal = TMath::Sqrt(pYZ *pYZ + pX * pX);
xEndAbsorber = fNonBendingCoor;
yEndAbsorber = fBendingCoor;
radiusEndAbsorber2 = xEndAbsorber * xEndAbsorber + yEndAbsorber * yEndAbsorber;
```

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Branson Model for MS (ii)

```
if (radiusEndAbsorber2 > rLimit*rLimit) {    zBP = zBP1;  } //particle through the absorber
else {    zBP = zBP2;  }  //particle through the beam shield
xBP = xEndAbsorber - (pX / pZ) * (zEndAbsorber - zBP);
yBP = yEndAbsorber - (pY / pZ) * (zEndAbsorber - zBP);
```

// new parameters after Branson and energy loss corrections

```
Float_t zSmear = zBP ;
pZ = pTotal * (zSmear-zVtx) / TMath::Sqrt((xBP-xVtx) * (xBP-xVtx) + (yBP-yVtx) * (yBP-yVtx)
     +( zSmear-zVtx) * (zSmear-zVtx) );
pX = pZ * (xBP - xVtx)/ (zSmear-zVtx);
pY = pZ * (yBP - yVtx) / (zSmear-zVtx);
fBendingSlope = pY / pZ;  fNonBendingSlope = pX / pZ;
pT = TMath::Sqrt(pX * pX + pY * pY);
theta = TMath::ATan2(pT, TMath::Abs(pZ));
pTotal = TotalMomentumEnergyLoss(thetaLimit, pTotal, theta);
fInverseBendingMomentum = (sign / pTotal) *    TMath::Sqrt(1.0 + fBendingSlope *
     fBendingSlope + fNonBendingSlope * fNonBendingSlope) /    TMath::Sqrt(1.0 +
     fBendingSlope * fBendingSlope);
 // set track param at vertex position at (0,0,0)  or at a smeared vertex
fBendingCoor = xVtx;  fNonBendingCoor = yVtx;   fZ= zVtx;
;
```

$P_{\perp}$ estimation at station 3 level

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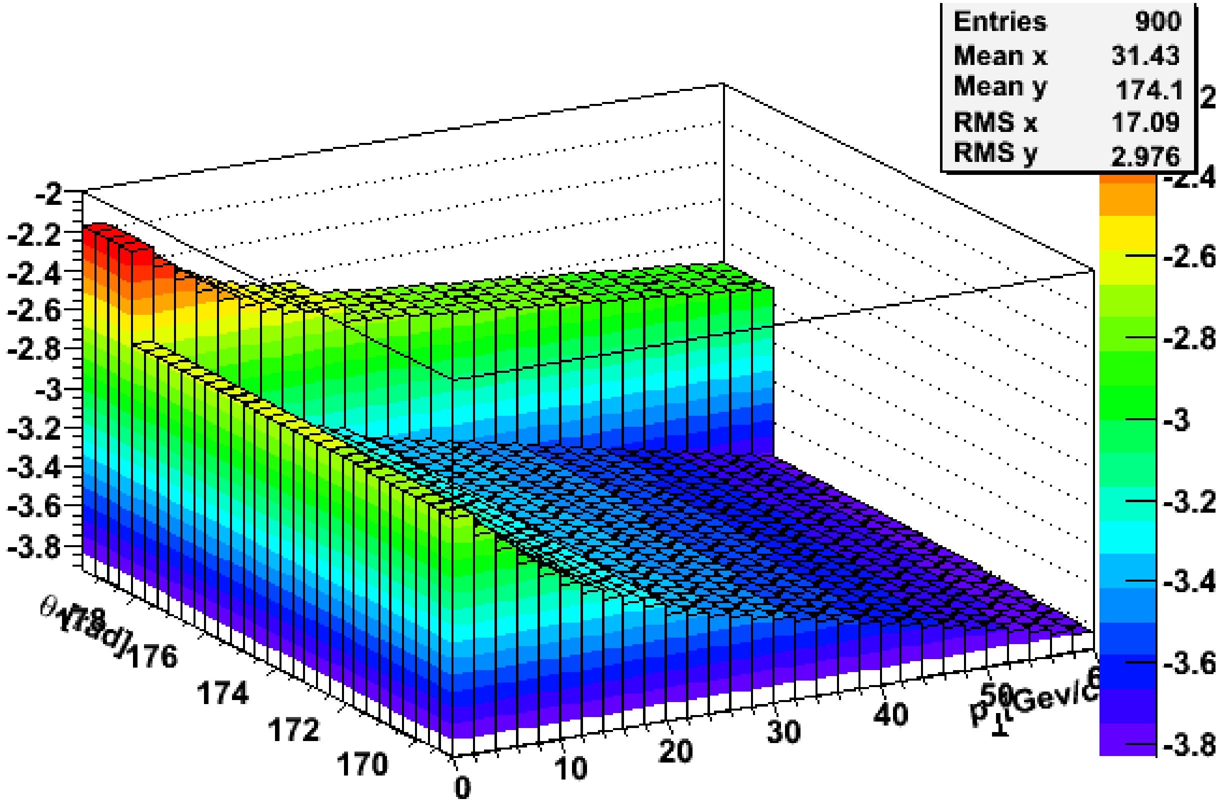
Branson model for Absorber

- **Parametrized function of the total momentum**

in AliMUONTrackParam::TotalMomentumEnergyLoss(Double_t thetaLimit, Double_t pTotal, Double_t theta)



Hard coded parameters!! Values need to be check …

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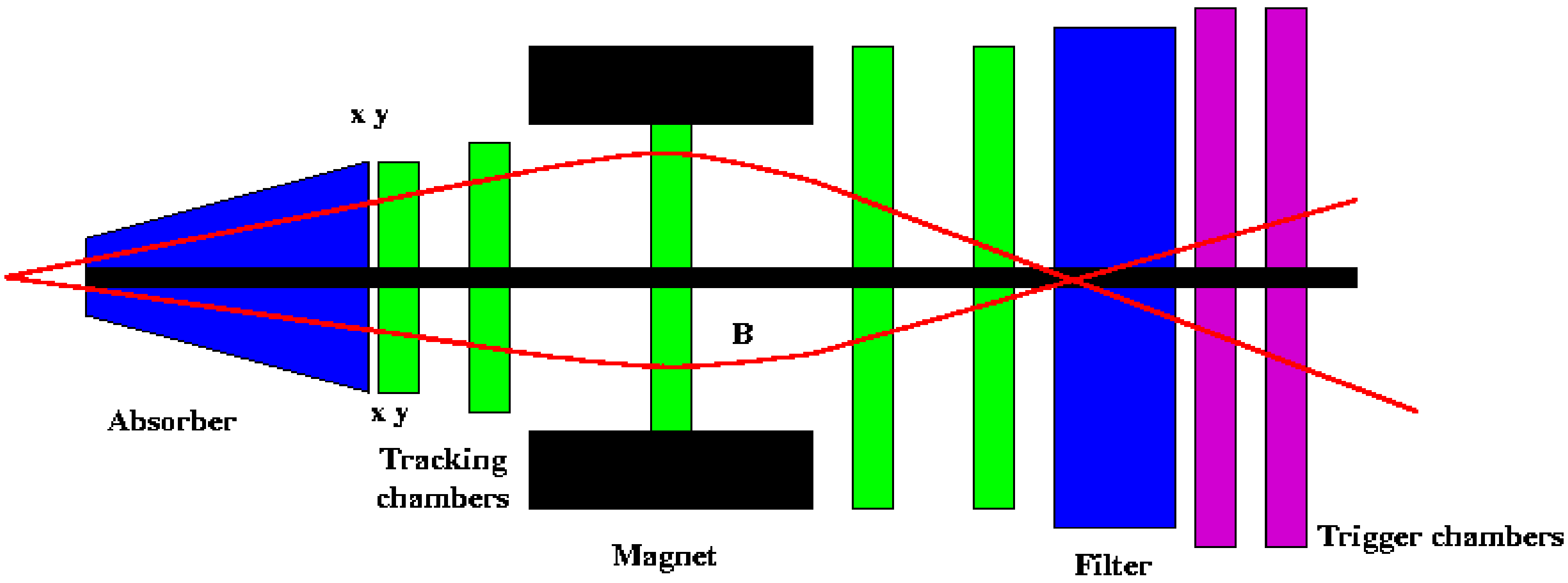
Scheme of the DFS



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Tracking : Segments

1. Segments are make individually for each station ()
2. Get a hit in one chamber and try to find one in the other chamber
    1. linear interpolation to primary vertex
3. fs

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Rec./Trigger Track matching

Trigger Word	# of Event	Meaning
0	**13**	**No trigger track**
5	**9**	**SinglePlus Lpt + Allpt**
7	**186**	**SinglePlus Lpt + Hpt + Allpt**
40	**1**	**SingleUndef + …**
56	**165**	**Single…**
448	**389**	**Single…**
16440	**3**	**LikePair + …**
20487	**4**	**LikePair + …**
20536	**5**	**LikePair + …**
28679	**46**	**LikePair + …**
28728	**35**	**LikePair + …**

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Vertex resolution and Υ width

- **Vertex resolution in ALICE :**

1) ITS can give the vertex position, ~10 μm precision (for all events ?)
2) But the fast pixels detector will be able to give almost the same resolution, ONLY if it's installed in time…
3) T0 will be present, but has a lower resolution σ_{vtx} ~ 1 cm

Need to check the reconstruction for different values of the vertex resolution σ_{vtx} [0,0.5,1,2,5,10] cm

- **How to get the Υ mass peak width :**

1) Shape is not a simple gaussian
2) Large tails, define ranges or use a "total" fit ?
3) Let's play….

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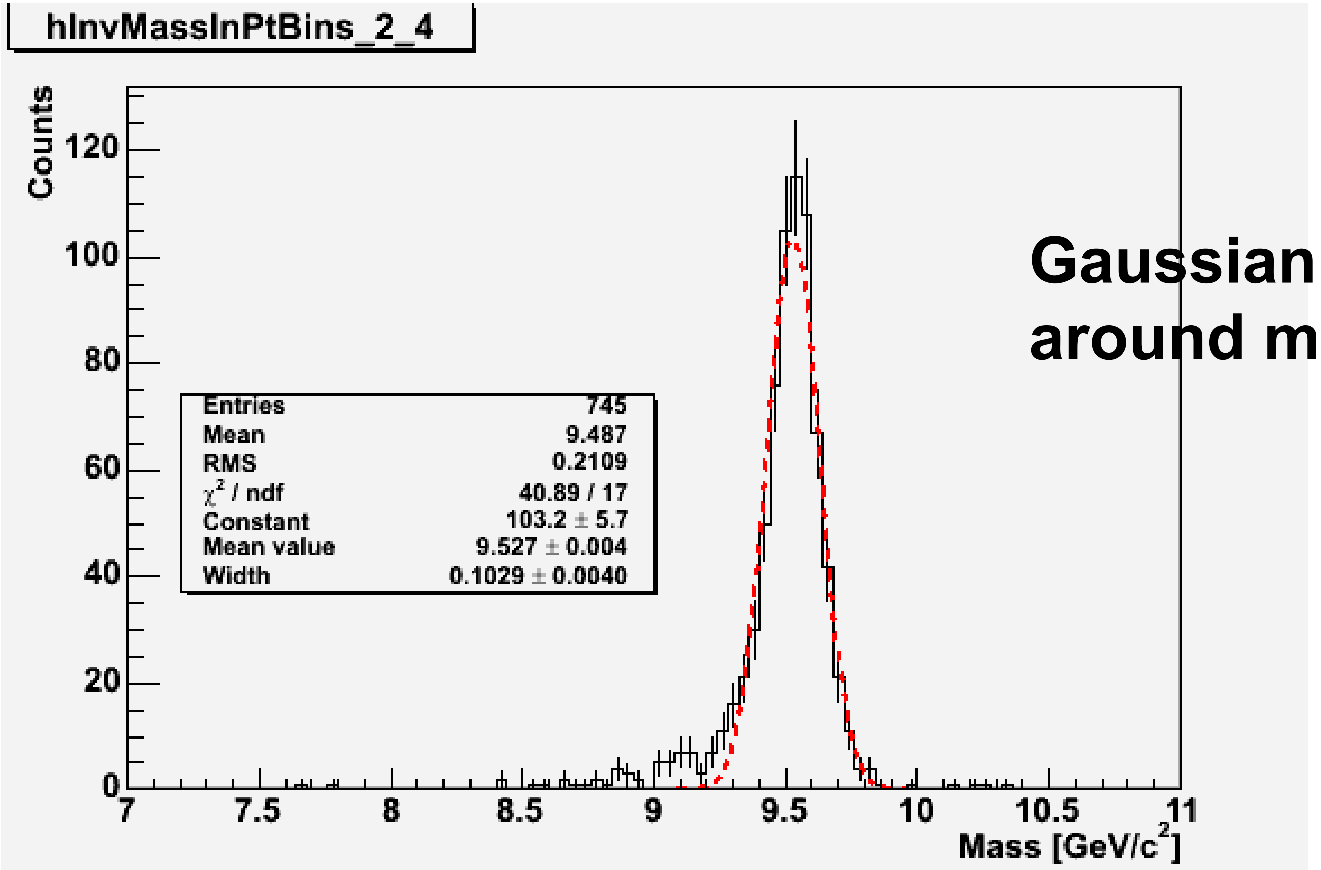
Υ mass peak fits (i)



Gaussian +/- 450 MeV around maximum value

Chi2 is not good
Tails are not taking into account
Needs (and thus depends on) a range

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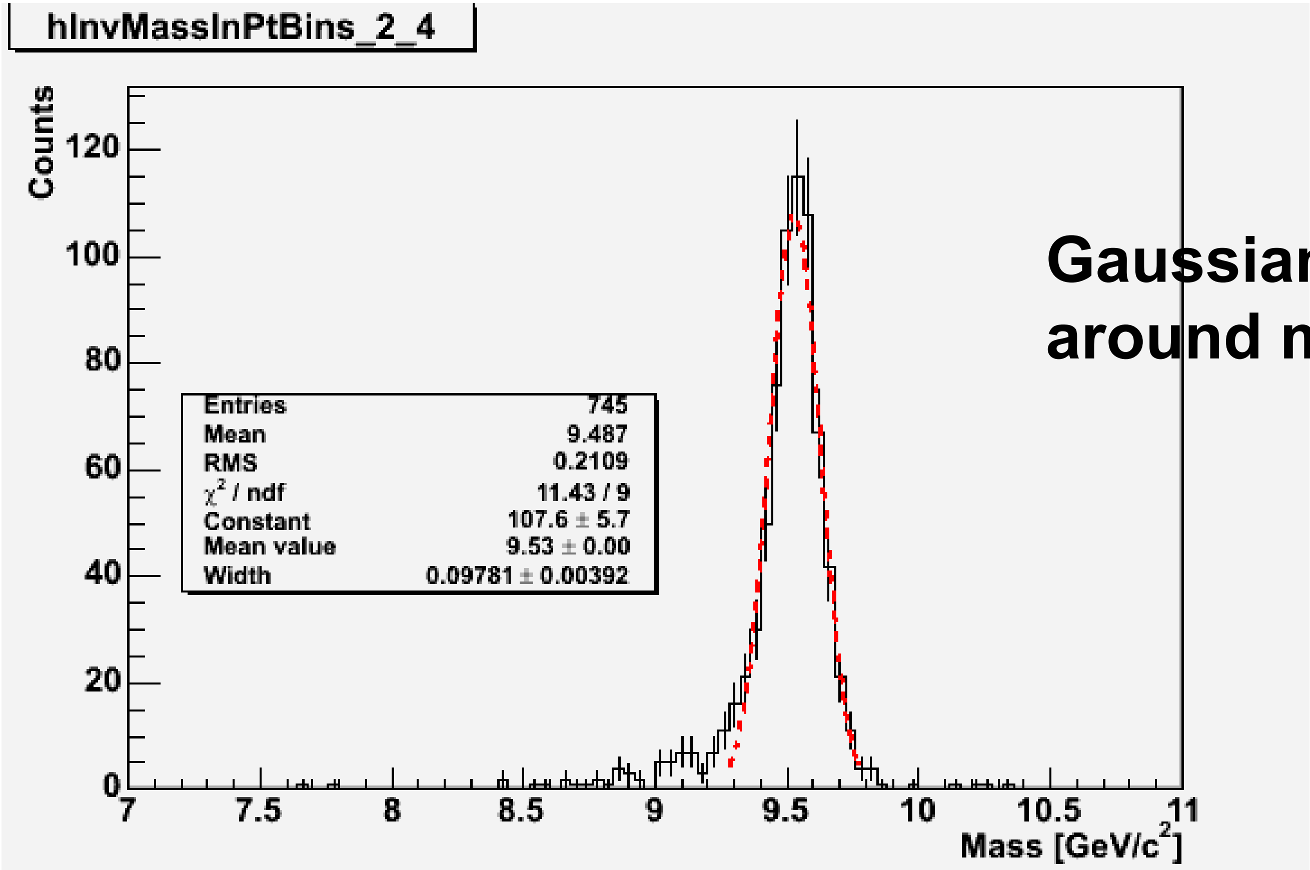
Υ mass peak fits (ii)



Gaussian +/- 250 MeV around maximum value

Chi2 is better
Tails are not taking into account
Needs (and thus depends on) a range

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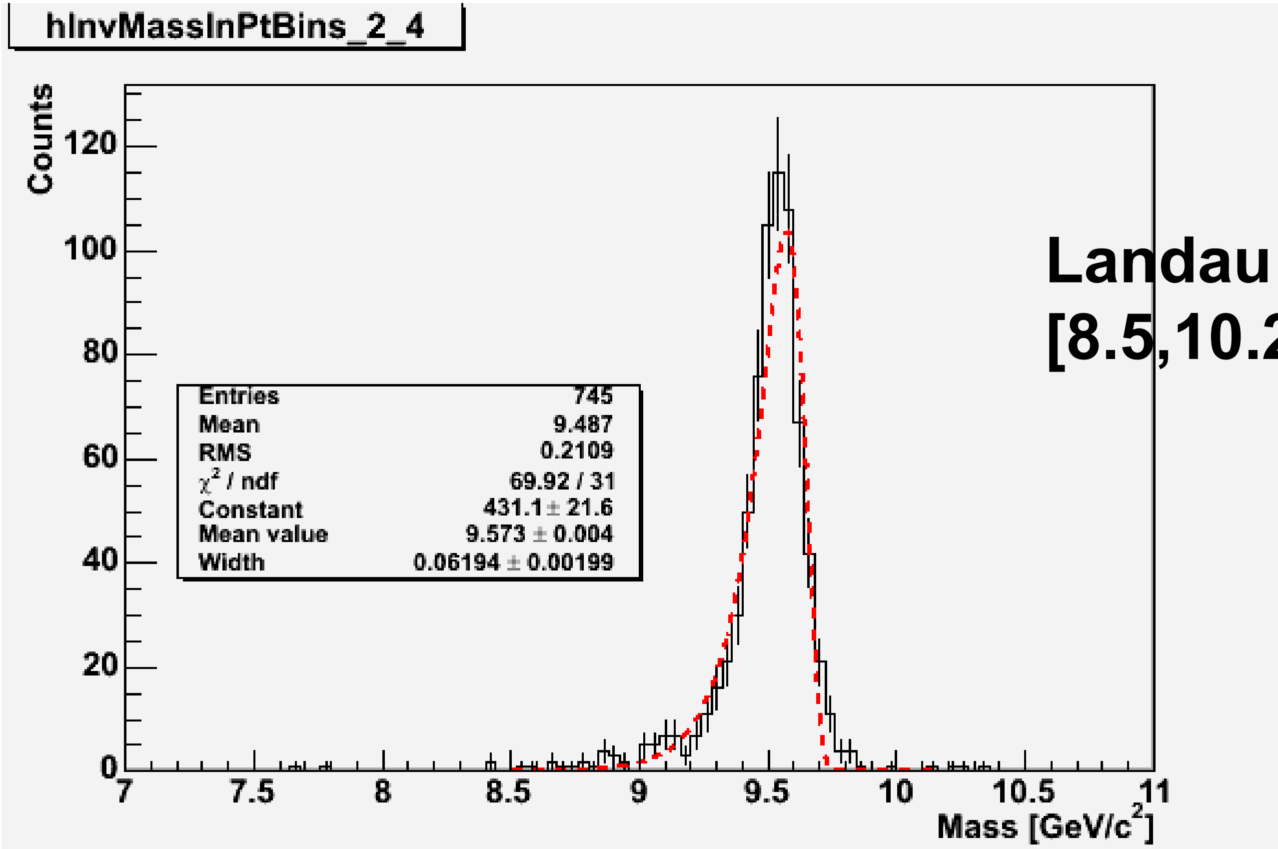
Υ mass peak fits (iii)



Landau over the range [8.5,10.2]

Chi2 is bad
Tail is here but badly fitted
Range covers the whole distribution

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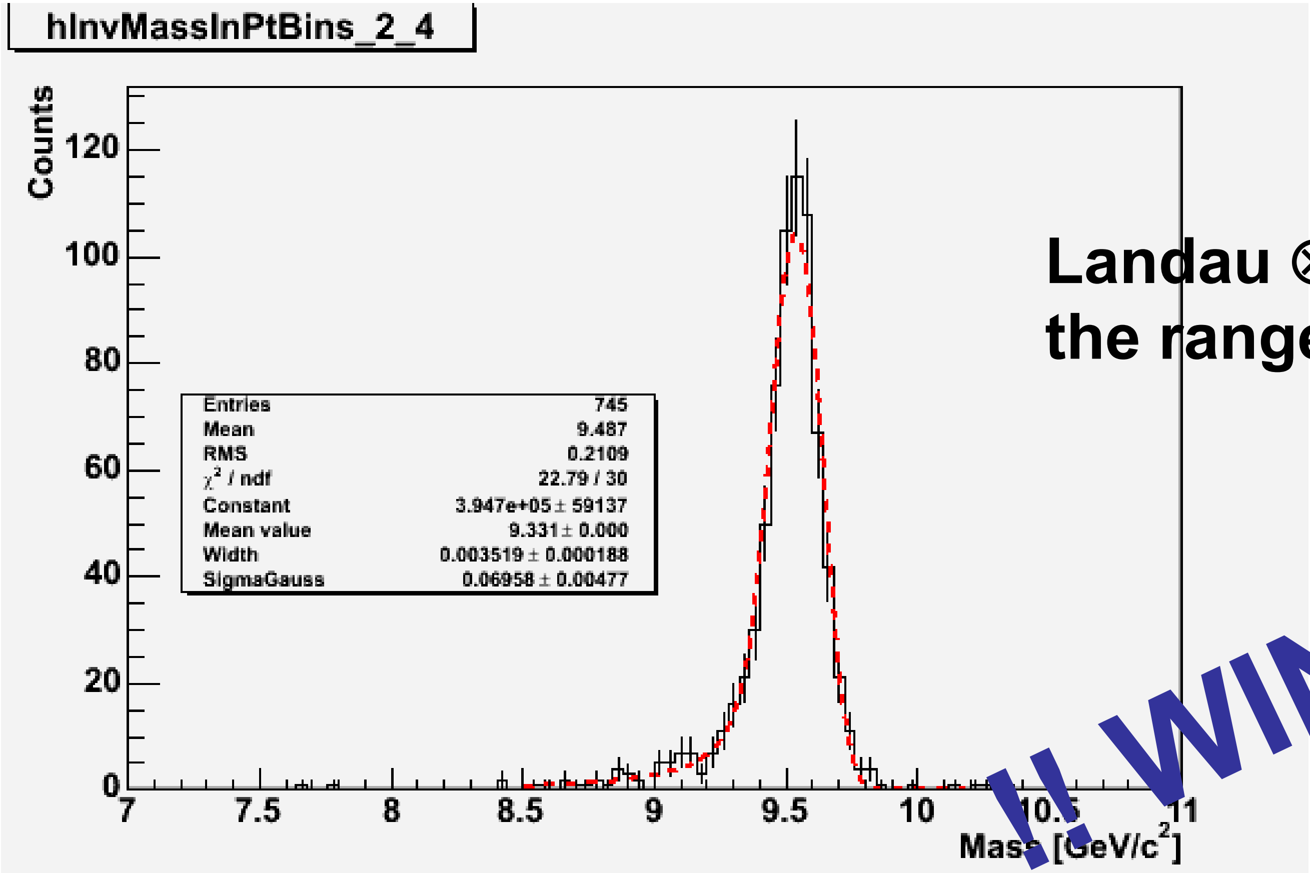
Y mass peak fits (iv)



Landau ⊗ Gauss over the range [8.5,10.2]

!! WINNER !!

Chi2 is good
Tail is here correctly fitted
Range covers the whole distribution

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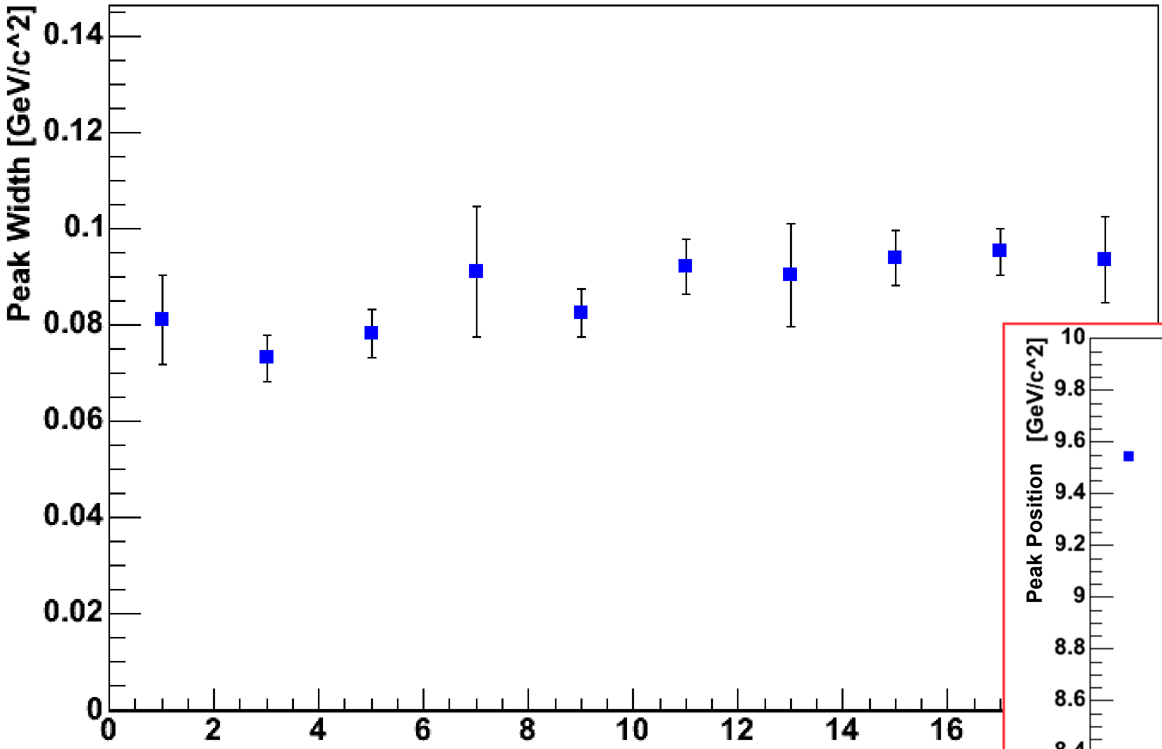
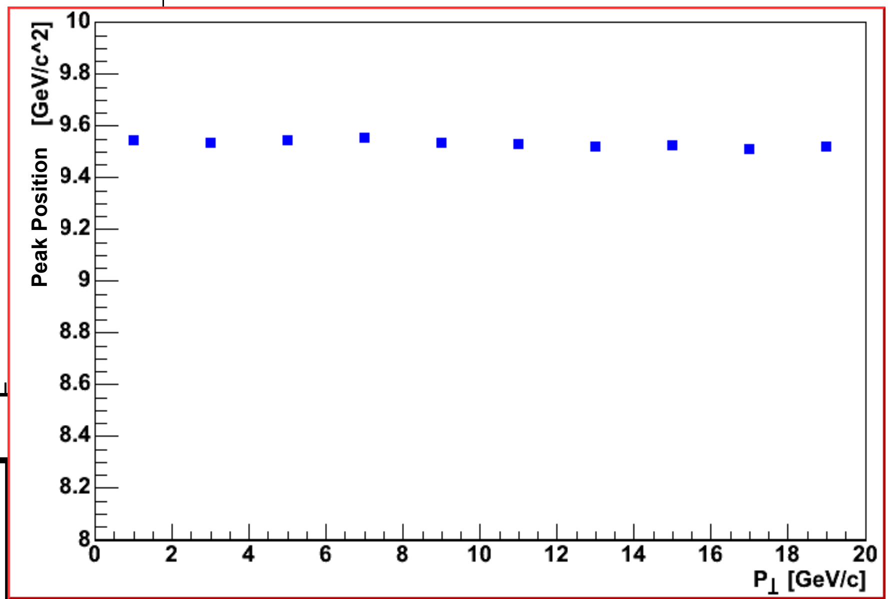
Y mass peak vs $p_\perp$

Landau ⊗ Gauss and $\sigma_{vtx} = 0$.

↳ **Look at Y Peak width and position vs $p_\perp$**





Peak width exhibits small variations
Peak position flat vs $p_\perp$

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