

Efficienza di ricostruzione di muoni e risoluzione con $J/\psi \rightarrow \mu\mu$



Stefania Spagnolo

INFN Lecce e Dipartimento di Fisica, Università del Salento



Misura in situ dell'efficienza di ricostruzione di muoni di basso impulso

- ☐ Efficienza di ricostruzione dei muoni nelle prime misure di ATLAS
- ☐ Misura in situ dell'efficienza di identificazione di muoni di basso impulso
 - ☐ Tag and Probe con $J/\psi \rightarrow \mu\mu$
 - ☐ InsituMuonPerformance (contributo italiano)
 - ☐ altri gruppi di lavoro
- ☐ Stima della risoluzione in massa con $J/\psi \rightarrow \mu\mu$



Risultati per le conferenze estive

- nota del Muon Combined Performance w.g.: ATLAS-CONF-2010-064
- **goals: studi di performance**
 - il confronto delle efficienze delle due catene di ricostruzione di muoni
 - Chain 1 = STACO (Saclay); Chain 2 = MUID (Nikhef, UMass,)
 - misura dell'efficienza (relativa) di diverse procedura di ricostruzione
 - **efficienza di ricostruzione combinata (CB) rispetto a muoni segment tagged (ST)**
 - ✓ segment tagged = traccia dell'ID estrapolata al MS che incontra segmenti in una o piu' stazioni
- **non una misura un-biased dell'efficienza utilizzabile immediatamente per misure di fisica**

	Data	Min. Bias MC	MC Purity
$p_T > 4 \text{ GeV}$			
Chain 1	$(80.6 \pm 0.1)\%$	$(82.9 \pm 0.5)\%$	$(45.8 \pm 0.6)\%$
Chain 2	$(89.4 \pm 0.1)\%$	$(88.7 \pm 0.4)\%$	$(45.8 \pm 0.6)\%$
$p_T > 6 \text{ GeV}$			
Chain 1	$(88.5 \pm 0.2)\%$	$(89.2 \pm 0.7)\%$	$(50.9 \pm 1.2)\%$
Chain 2	$(90.2 \pm 0.2)\%$	$(90.2 \pm 0.7)\%$	$(50.9 \pm 1.2)\%$

Table 1: Relative efficiencies of the combined reconstruction algorithms with respect to calorimeter tagged muons with trigger chamber hits in the region of the calorimeter tagged muons. The purity reported in the third column is defined as the fraction of selected muons in the (minimum bias) Monte-Carlo data which can be matched to muons generated close to the interaction point within a cone of $\Delta R < 0.1$. The purity reported in the third column is defined as the fraction of the calorimeter-tagged muon sample in the minimum bias Monte-Carlo which can be matched to muons.



Risultati che dipendono dall'eff. di ricostruzione di muone a basso p_T

- ☐ nota del B-Physics w.g.: ATL-CONF-2010-062
- ☐ Inclusive double differential $J/\psi \rightarrow \mu\mu$ production cross section in bins of J/ψ transverse momentum and rapidity with $\mathcal{L}_{int} = 9.5 \text{ nb}^{-1}$
 - ☐ i candidati $J/\psi \rightarrow \mu\mu$ sono selezionati usando coppie di muoni (uno combinato, l'altro CB o Segment Tagged; in ogni caso la cinematica è misurata dall'ID) di $p > 3 \text{ GeV}$ per $|\eta| < 2$. ($p > 8 \text{ GeV}$ per $2 < |\eta| < 2.5$)
 - ☐ nessun taglio in p_T
 - ☐ lo spettrometro utilizzato come strumento di "identificazione" non di misura
- ☐ per event weight: $w_i^{-1} = \mathcal{A}(p_T, y) \times \epsilon(p_{T\mu+}, \eta_{\mu+}) \times \epsilon(p_{T\mu-}, \eta_{\mu-}) \times \epsilon_{trg}(p_T, y)$
- ☐ la misura richiede una stima granulare dell'eff. di ricostruzione vs p_T e η
 - ☐ utilizzata la predizione MC per produzione prompt di J/ψ (alta statistica)
 - ☐ primo tentativo di produrre una misura di efficienza di identificazione di muoni con il metodo del tag and probe basato su $J/\psi \rightarrow \mu\mu$ basato sull'analisi dei dati del periodo A-B-C-D ($\sim 300 \text{ nb}^{-1}$); binning minimale dei dati
 - ☐ problemi: statistica ancora limitata e periodi D2-D6 con condizioni di trigger di muone piuttosto instabili che rendono complicata l'analisi.
 - ☐ errore sistematico sulla eff. di ricostruzione 7% (massima deviazione tra MC e la preliminare misura data driven)



Tag and Probe in InsituMuonPerformance



- InsituMuonPerformance logica e software sono progettati per la misura di sezione d'urto per qualche processo [thanks to C. Bini, S. Borroni, S. Rosati]
- efficienza di ricostruzione per la selezione di muoni utilizzata nell'analisi di fisica X rispetto a tagli di accettazione
- efficienza di trigger relativa a muoni della medesima selezione
 - oppure efficienza di trigger assoluta rispetto ai tagli di accettazione
- i muoni selezionati soddisfano a criteri dettati dall'analisi (in generale non sono tutti quelli di un container standard di muoni ricostruiti)
- **Metodo:** risonanza Z o J/ψ , (Υ) - sulla stream di muoni
 - per evento si selezionano tutti i muoni che soddisfano a criteri di qualità stringenti (Tag) e hanno prodotto il trigger di muone: N_{tag}
 - per ogni tag si cerca un muone Probe tra tutte le tracce dell'ID che abbia un buon fit del vertice con la Tag e tale che M_{inv} (dopo il refit del vertice) sia nel range 2-4 GeV o 2.6-3.6 GeV: $N_{\text{probe}} = N_{\text{tagAndProbe}}$
 - l'efficienza è la frazione di $\sum N_{\text{probe}}$ (su tutti gli eventi) che risultano identificati come muoni



Tag and Probe con $J/\psi \rightarrow \mu\mu$ InsituMuonPerformance



☐ Persone coinvolte:

- ☐ Bachas K, Hassani S., Mountricha E., Nicolaidou R., Petridou C.,
 - ☐ CERN, Saclay, Tessaloniki
- ☐ Chiodini G., Orlando N., Spagnolo S.
 - ☐ INFN Lecce + Univ. del Salento

☐ Attività:

- ☐ integrazione del software per TP con $J/\psi \rightarrow \mu\mu$ in InsituMuonPerformance
- ☐ analisi dei dati
 - ☐ produzione di mappe di efficienze per la pubblicazione (in preparazione) della misura della sezione d'urto inclusiva e doppio differenziale di J/ψ
 - ☐ produzione di una nota (in preparazione) con descrizione del metodo e risultati sulla performance di ricostruzione data driven basati su $\sim 3 \text{ pb}^{-1}$



Tag and Probe con $J/\psi \rightarrow \mu\mu$

- preselezione: Period B-C-D I (LI_MU0), E (EF_MU4 || EF_MU6), F (EF_MU4 || EF_MU6 || EF_MU10)
- Tag-Trigger matching requested in all periods based on TrigEffJpsiTools (uses extrapolator)

Cuts on Tag

- $p_T > 4$ GeV CB muon
- Hits: SCT ≥ 6 , Pixel ≥ 1 , TRT ≥ 10 and TRTOutliers < 10 (in $|\eta| < 2$)
- d0(perigee) < 2 mm, d0,z0(vtx) $< 0.3, 1.5$ mm
- d0,z0(vtx) significance $< 3, 3$

Cuts on Probe

- $p > 3$ GeV
- $|\eta| < 2.5$
- $p_T > 1$ GeV
- Hit quality as for Tag

accettanza per la
misura di sezione
d'urto di J/ψ

Cuts on Tag+Probe

- Tag and Probe ID tracks should come from a common vertex
- χ^2 of the vertex fit < 6
- Separation in $\Delta R < 3.5$

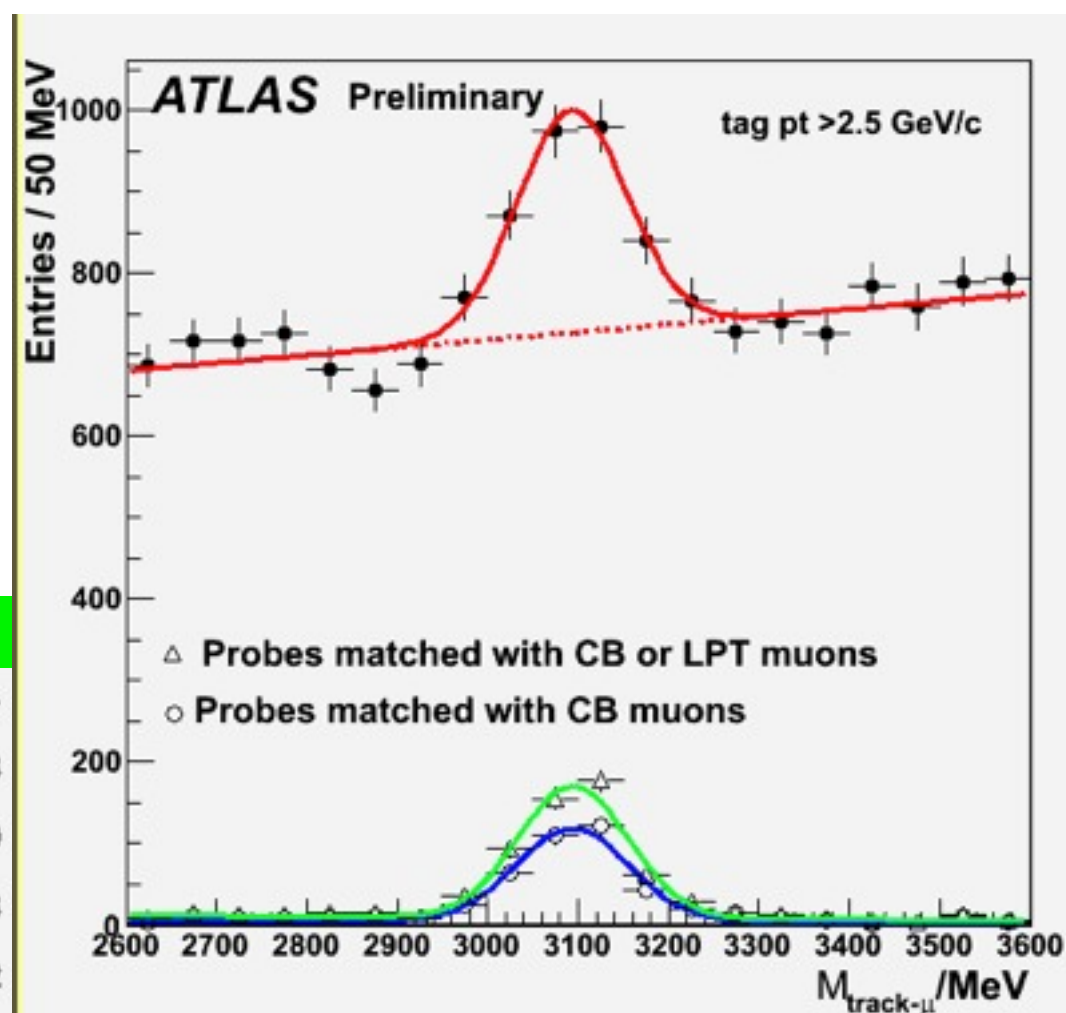
□



Tag and Probe con $J/\psi \rightarrow \mu\mu$

- problemi specifici del metodo Tag and Probe con J/ψ
 - background subtraction & errors on the efficiency measurement
 - fit indipendente delle distribuzioni di M_{inv} per tutte le coppie TP e per il sottoinsieme delle coppie TP in cui la probe è identificata come muone
 - gaussiana + polinomio di I grado
 - estrazione dei muoni di segnale da ciascuna distribuzione
 - $\text{Efficiency} = N_{\text{signal}}(\text{probe}=\mu) / N_{\text{signal}}(\text{all probes})$
 - errore sull'efficienza ?

	all Tag and Probes	Probe=CBorST μ	Probe=CB μ
χ^2 / ndf	13.07 / 15	25.88 / 15	33.66 / 14
Prob	0.5969	0.03933	0.002313
Nbkg	5299 ± 511.2	66.94 ± 5.95	35.43 ± 4.59
Bkg slope	0.09465 ± 0.02126	-0.00636 ± 0.00233	-0.004257 ± 0.001723
Nsignal	832.3 ± 85.9	492.2 ± 23.9	354 ± 20.2
Mass	3093 ± 6.3	3094 ± 3.1	3094 ± 3.7
Width	60.74 ± 6.04	60.74 ± 3.17	62.13 ± 3.50



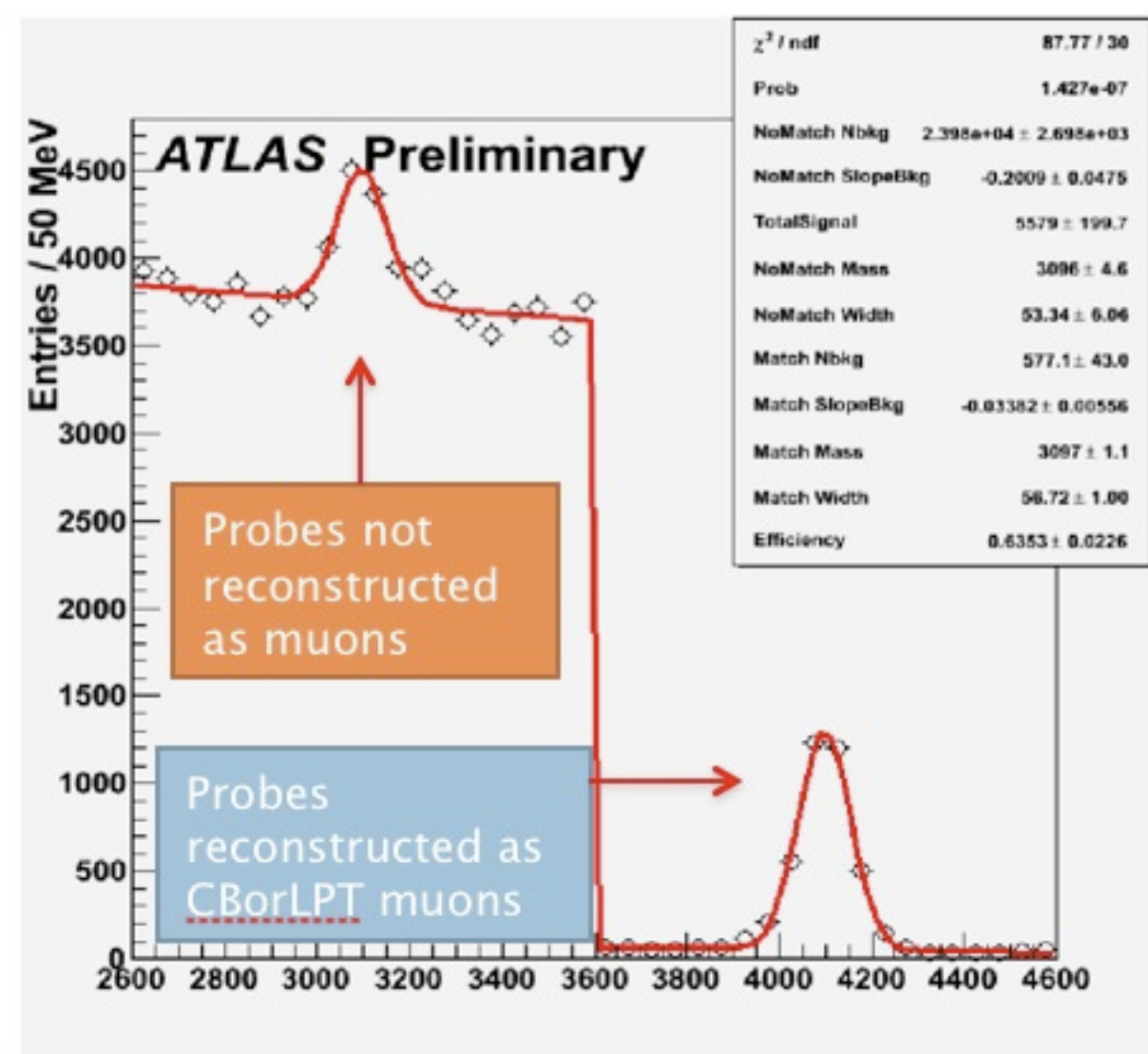


Tag and Probe con $J/\psi \rightarrow \mu\mu$



□ Il metodo di estrazione dell'efficienza

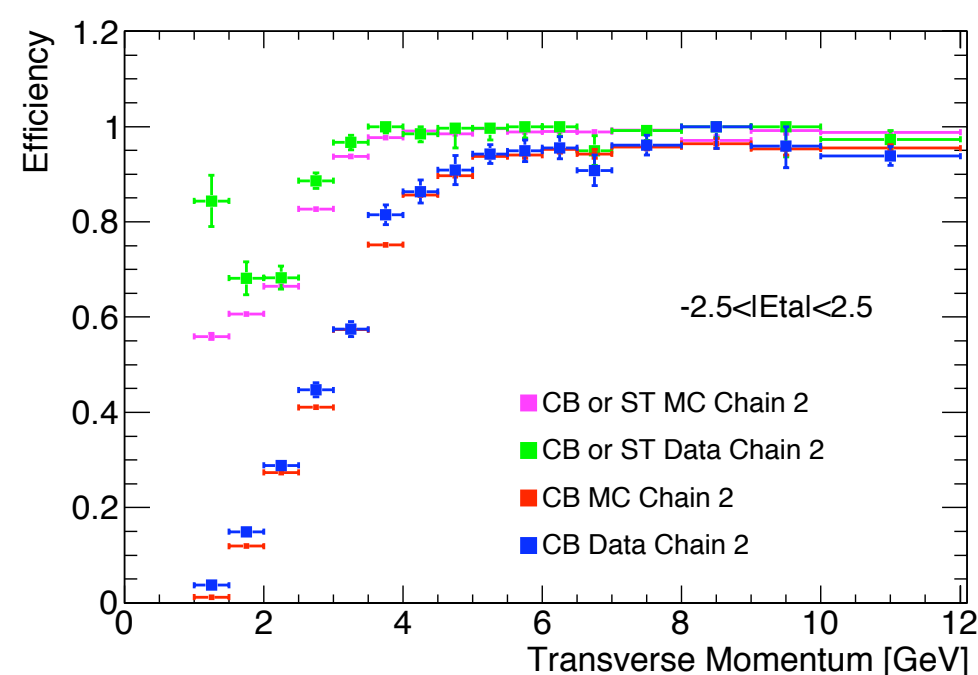
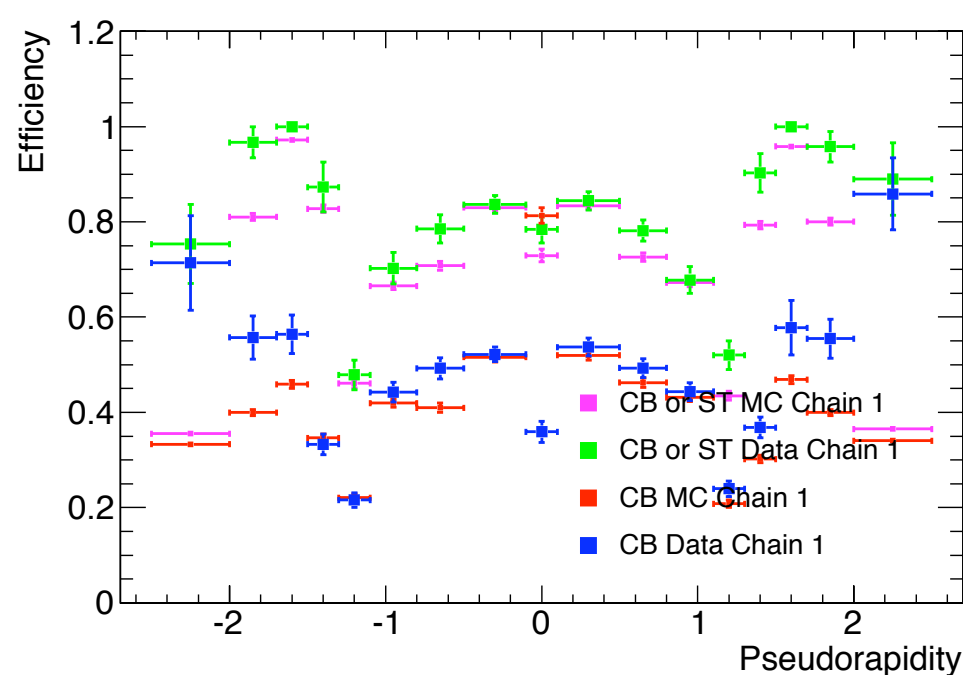
- Separate all T&P pairs in 2 independent samples
 - probes that are matched to a reconstructed muon
 - probes not matched to a reconstructed muon
- Fit at the same time the 2 distributions with linear (background) + Gaussian
- Efficiency is then extracted from the fit and signal yield directly
- Statistical error on the efficiency accounts for uncertainty on signal and background
- Fit method used as baseline for main result





Confronto dei risultati con il MC

- Confronto con il MC - MC09
- MC prompt $J/\psi \rightarrow \mu^0 \mu^0$ processed with TP analysis (no muon trigger in preselection applied and no tag-trigger matching requested)
 - solo segnale (minimo fondo combinatorio)
 - solo produzione diretta di J/ψ
 - distribuzione cinematica delle probe selezionate diversa nei dati e nel MC (il confronto deve essere fatto su una mappa eta x pT assumendo la dipendenza da phi minima)





Confronto dei risultati con il MC: Pt of the signal probes in data vs pt of the signal probes in MC(directJPsi->mu0mu0)



MC / DATA (period EF)

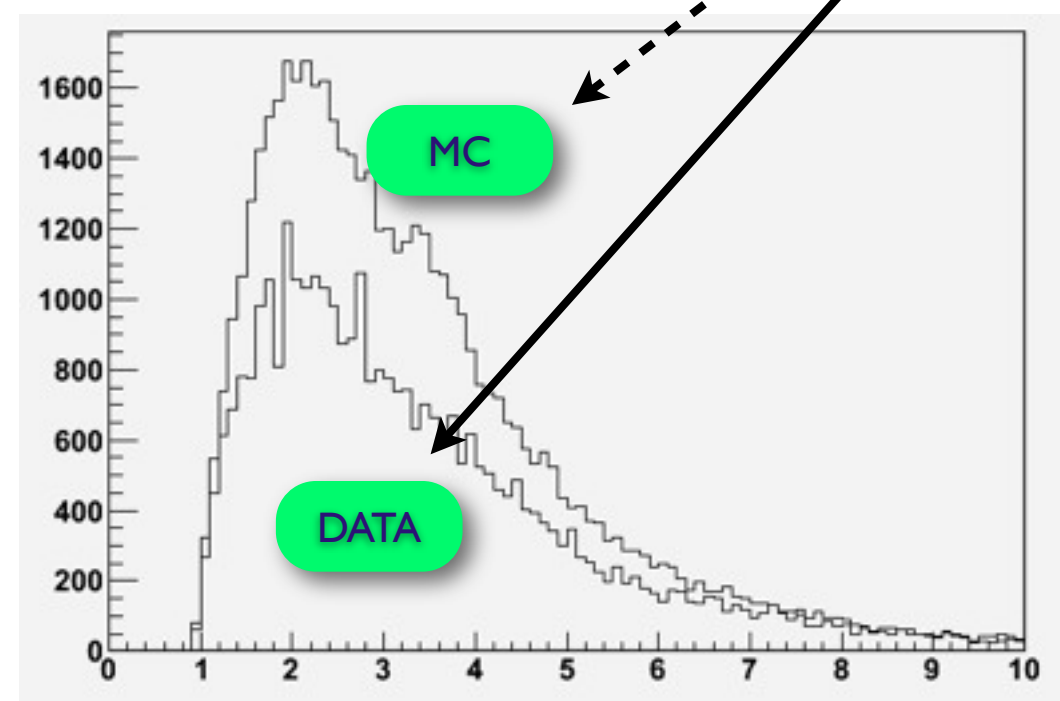
method:

consider probe Pt distribution
consider probe Pt in the side bands (out or +/- 3 sigma)
Renormalize to PtSB_Integral + Bkg_underPeak
subtract PtSB(renormalized) to Pt $\rightarrow$ Pt signal

conclusion:

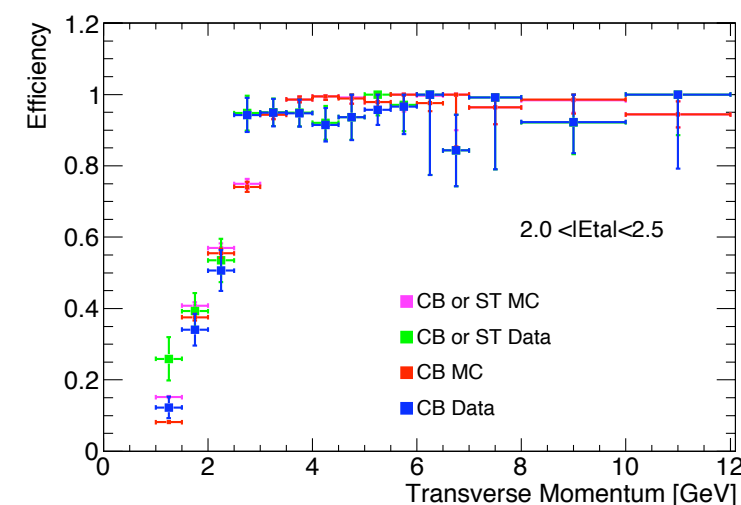
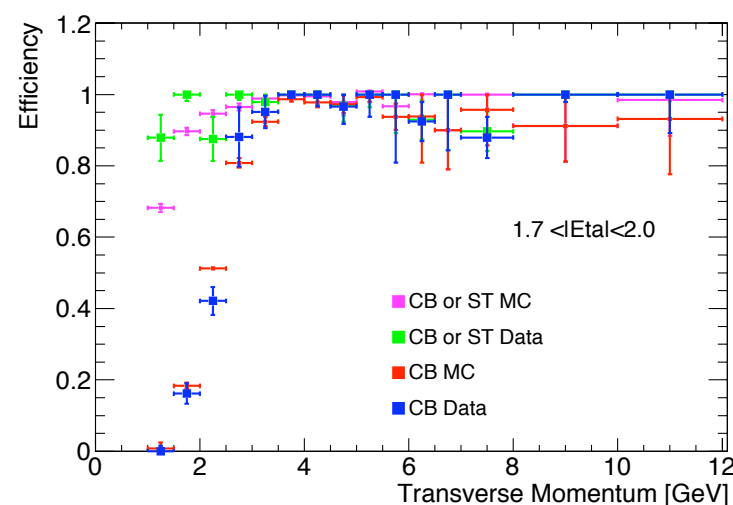
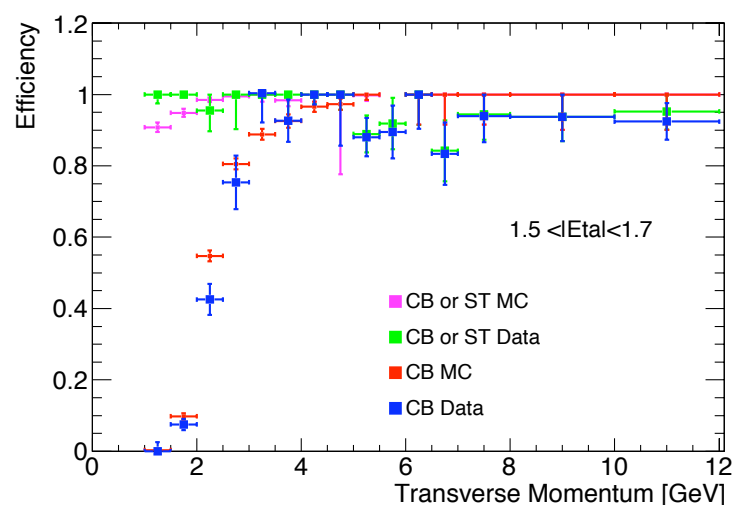
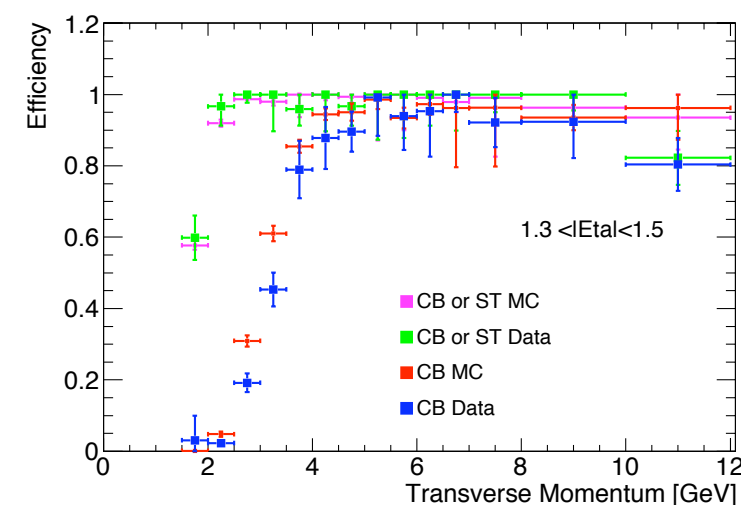
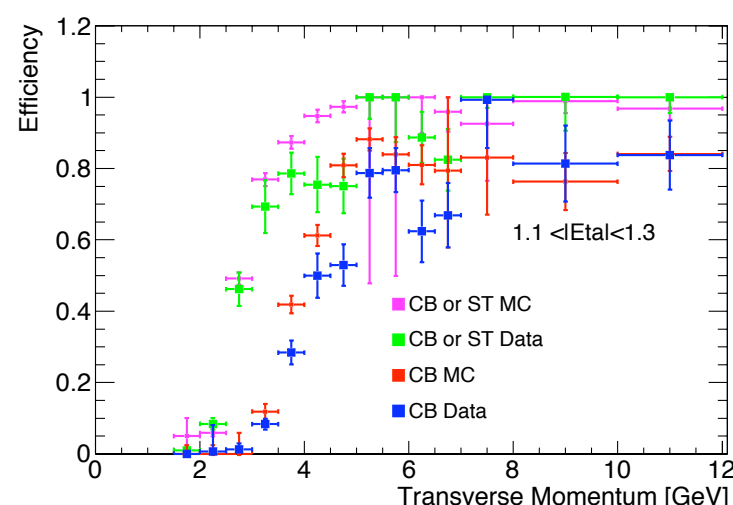
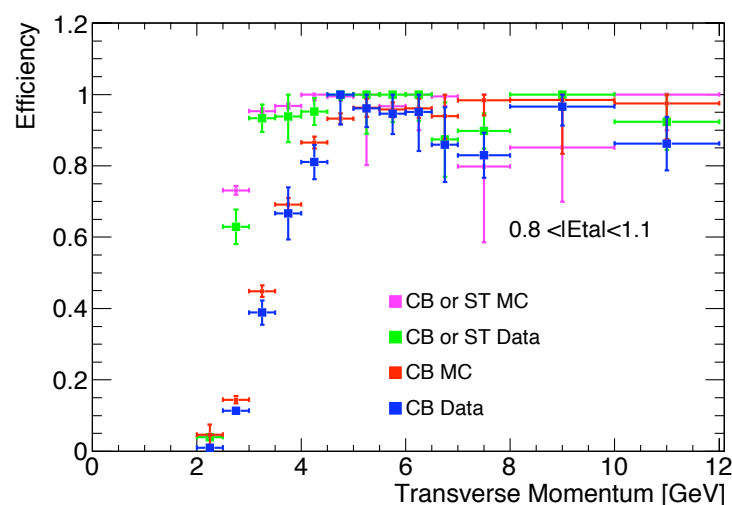
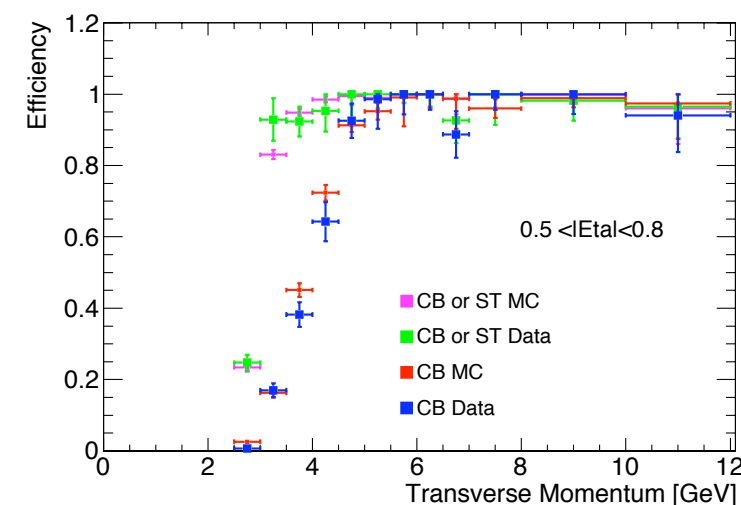
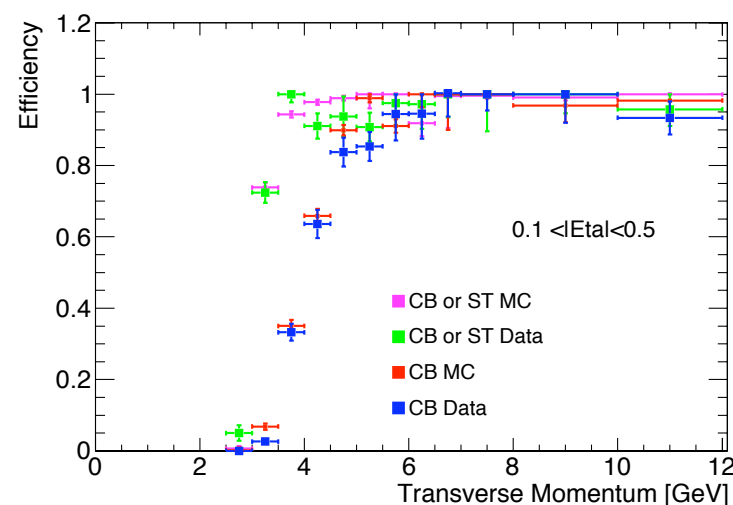
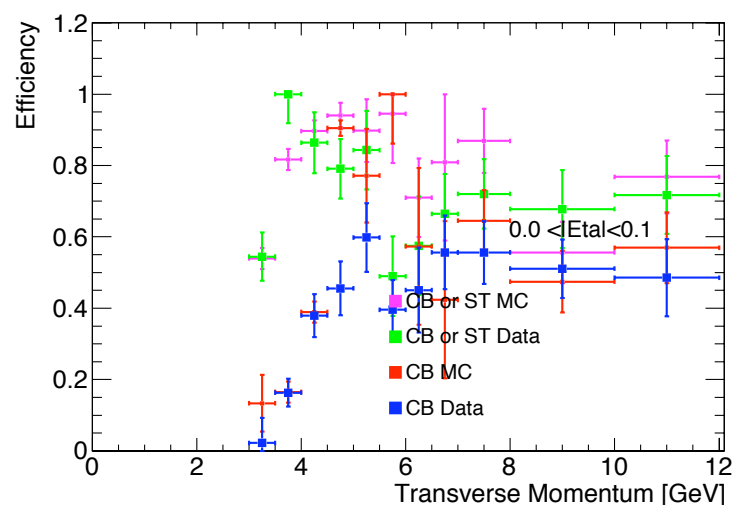
eff. vs pt $\sim$ ok in data and MC

average eff. or eff. vs phi overall higher in data since pt spectrum of signal probes in data is harder than in MC sample



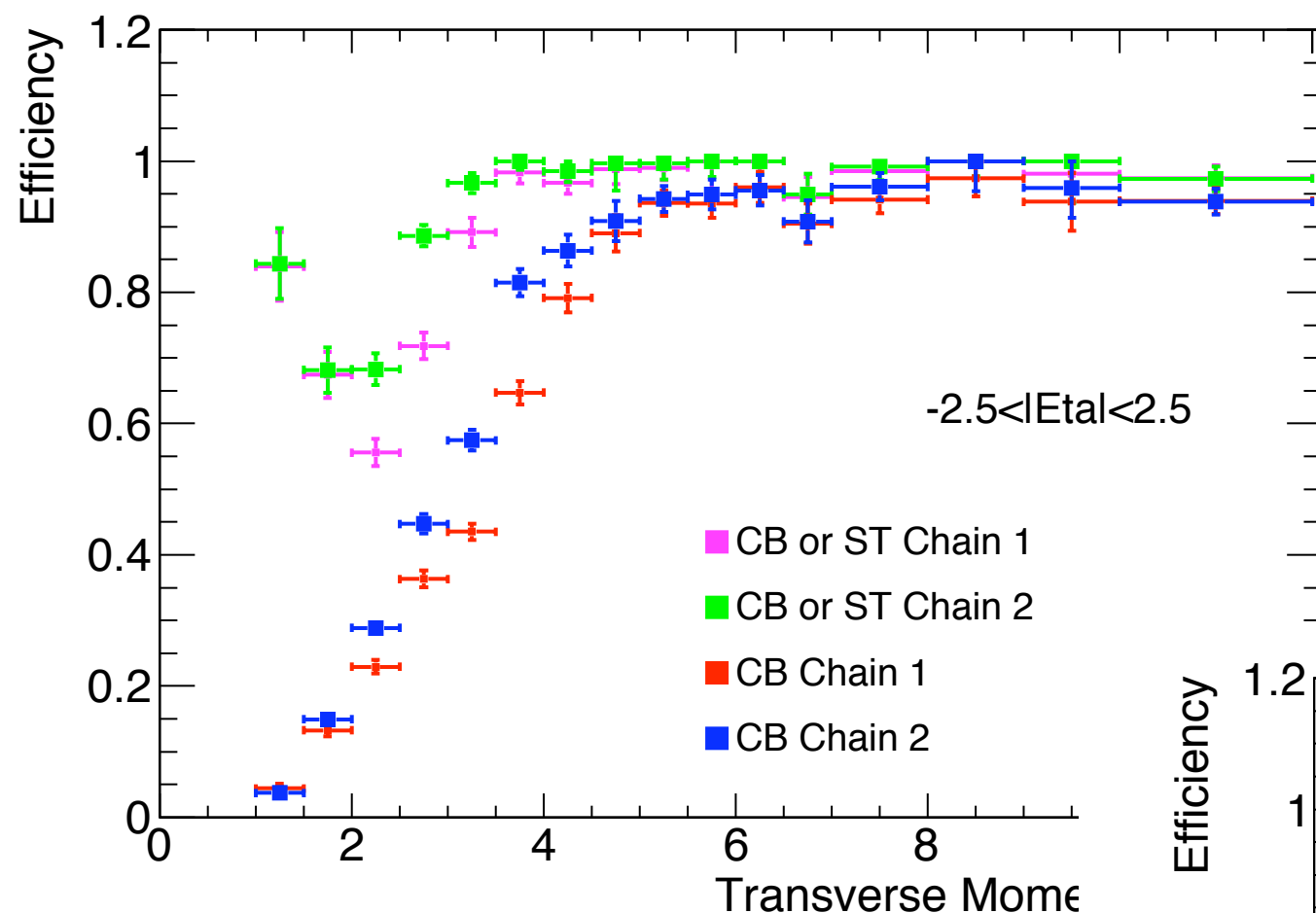


Mappa di efficienza preparata per la misura della sezione d'urto di produzione inclusiva di J/ψ



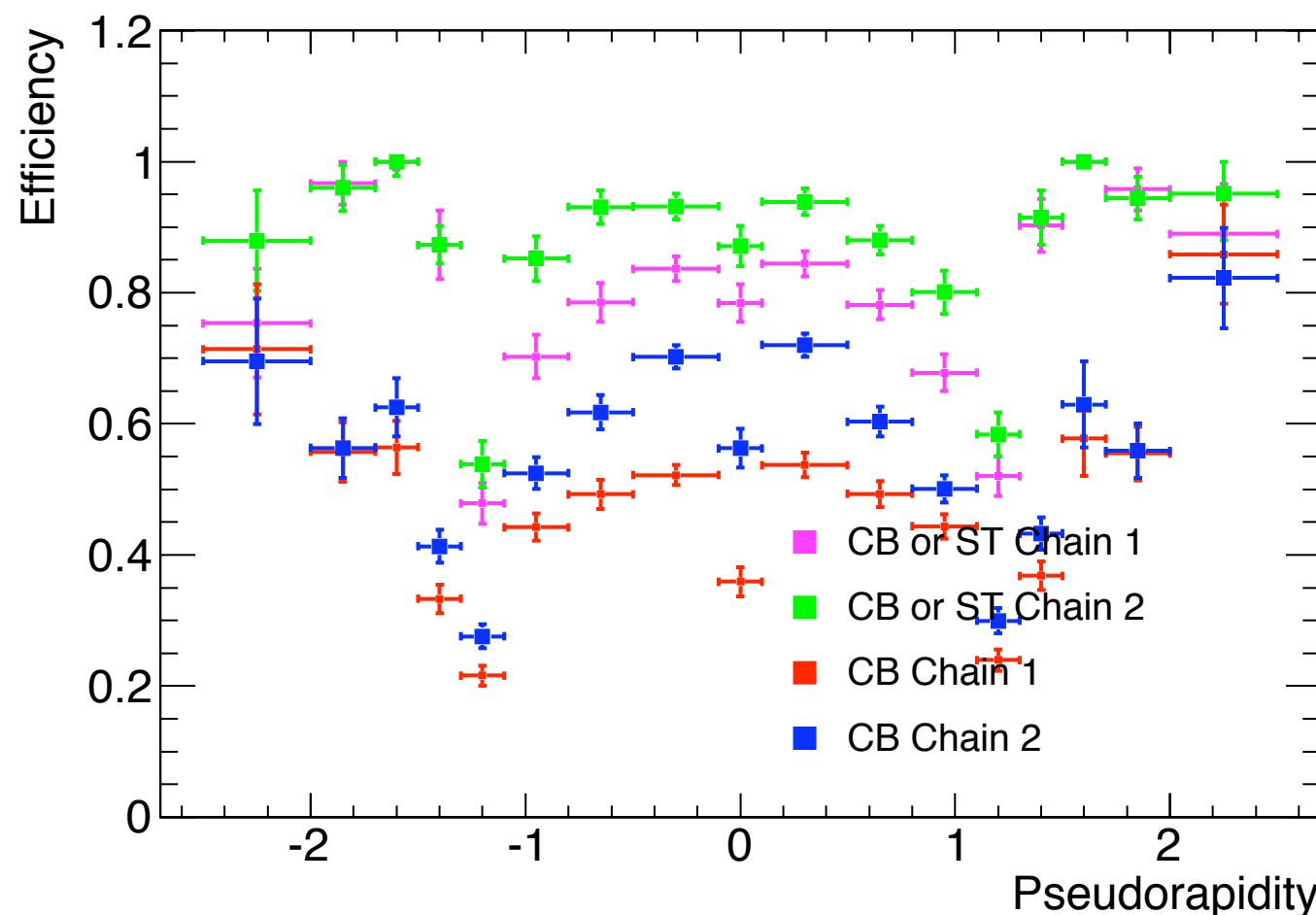


Risultati: Staco vs Muid



In generale efficienza piu' alta per Muid, a basso p_T (che si riflette sulla eff. integrata in p_T vs η)

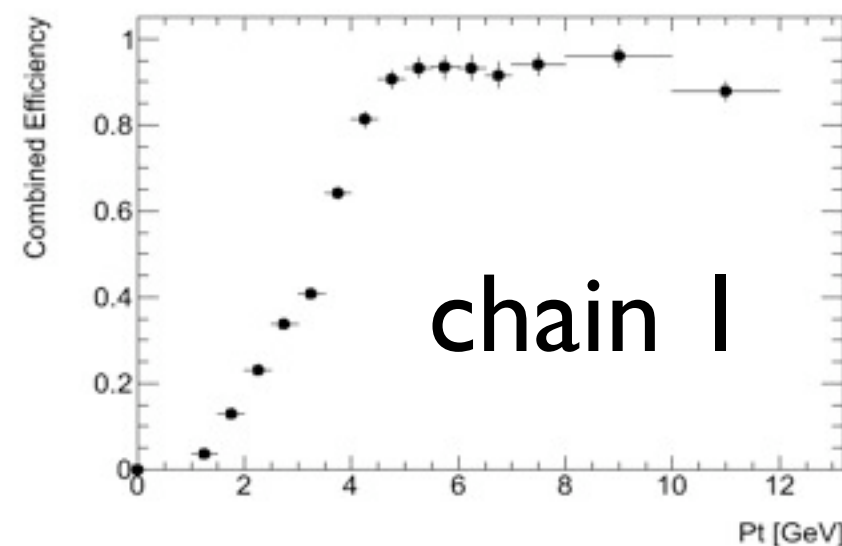
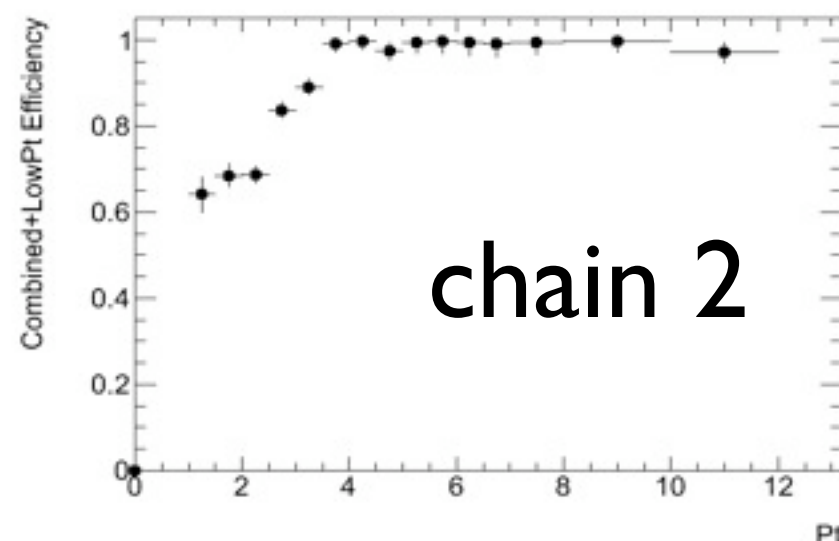
Il prezzo e' una maggiore impurezza (misurata nei dati ed attesa nelle simulazioni)





Un'altra tecnica per la misura dell'efficienza

- ☐ Likelihood based analisi: **sPlot**
 - ☐ dettagli in : <http://arxiv.org/abs/physics/0402083>
- ☐ Si utilizza una variabile discriminante (invariant mass) per effettuare un unfolding delle componenti di segnale e fondo in distribuzioni di variabili di controllo (eta, phi, pt)
- ☐ le variabili di controllo devono essere non correlate con la variabile discriminante
 - ☐ Correlation is less than 11% for pt and 2% for eta, phi
- ☐ risultati in buon accordo con il fit delle distribuzioni di massa invariante





Incertezze sistematiche

- ☐ 2 categorie
 - ☐ stabilita` dell'efficienza rispetto alle condizioni del detector e di trigger: confronto tra period E e period F
 - ☐ variazioni sulla procedura di fit (metodo baseline):
 - ☐ shape del fondo: lineare vs quadratico
 - ☐ livello di background:
 - ☐ tagli su quantita` di energia (core energy) depositata attorno alla muon probe estrapolata nei vari strati del calorimetro [riduzione del fondo $\sim 1/2$]



Altri studi dell'eff. di ric. offline di muone con J/ψ



- studio molto simile per strumenti, procedure, definizioni all'analisi con InsituMuonPerformance TP J/ψ (COM-note)

1 Muon efficiency measurements using $J/\psi \rightarrow \mu^+ \mu^-$ decays in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

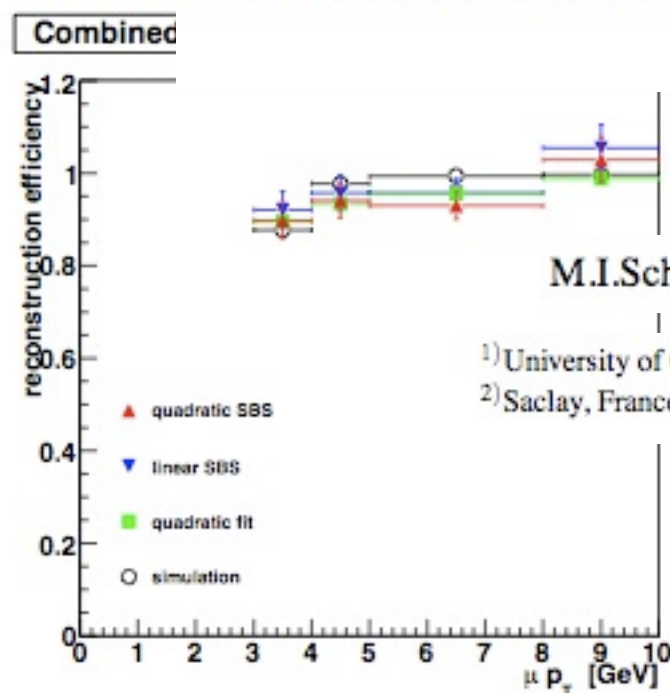
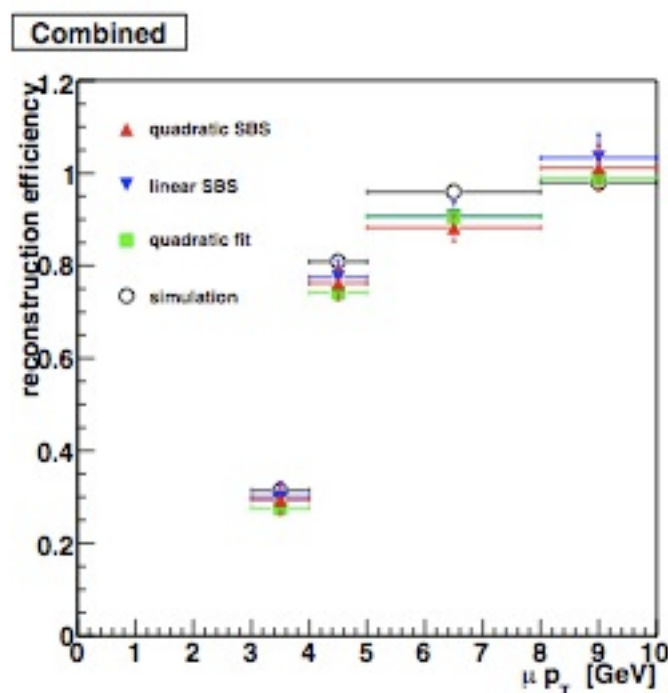
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3

K. Kessoku¹, T. Matsushita², S. Oda¹, H. Sakamoto¹

¹International Center for Elementary Particle Physics, The University of Tokyo, Tokyo, Japan

²Kobe University, Graduate School of Science, Kobe, Japan



Determination of Muon Reconstruction Efficiencies Using the Method of Tag and Probe with J/ψ s

M.I.Scherzer¹, L. Chevalier,² B. Heinemann¹, S.C. Hsu¹, A. Korn¹

¹University of California, Berkeley and Lawrence Berkeley National Laboratory, USA

²Saclay, France

Figure 6: Muon reconstruction efficiency in the barrel region ($0.1 < |\eta| < 1.1$) versus p_T . Shown are the data with the default (quadratic) sideband subtraction, the linear sideband subtraction and the simulation.



ID tracking performance study with a $J/\Psi \rightarrow \mu\mu$ sample

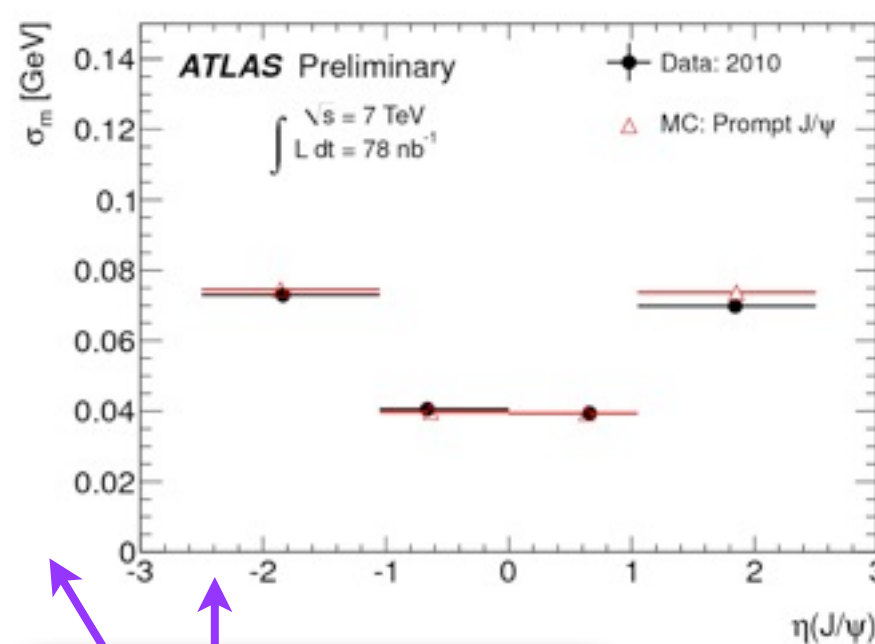
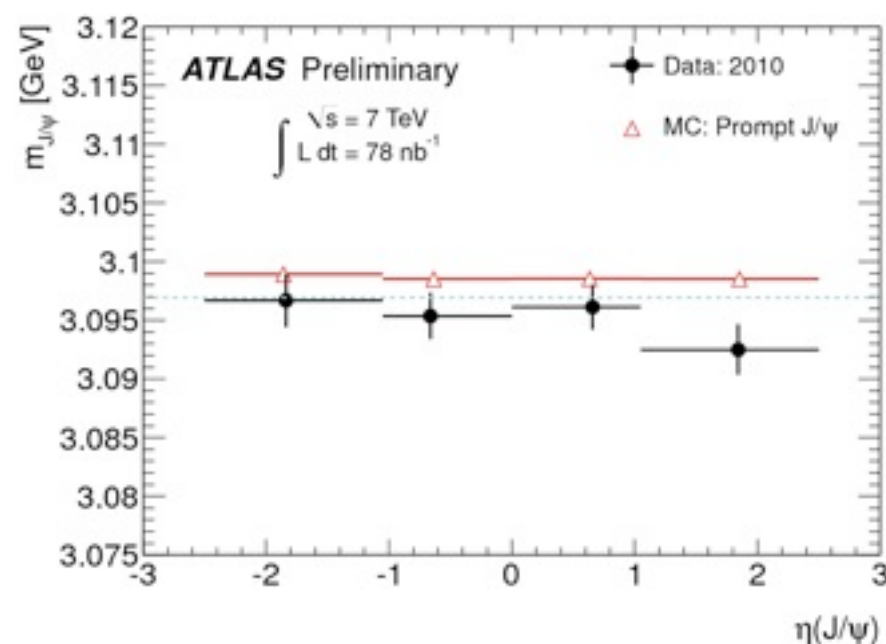
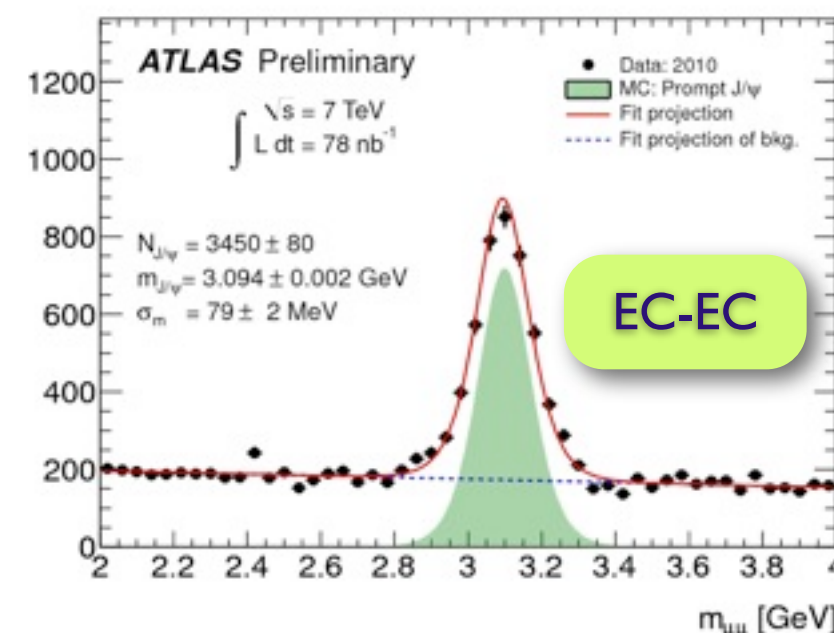
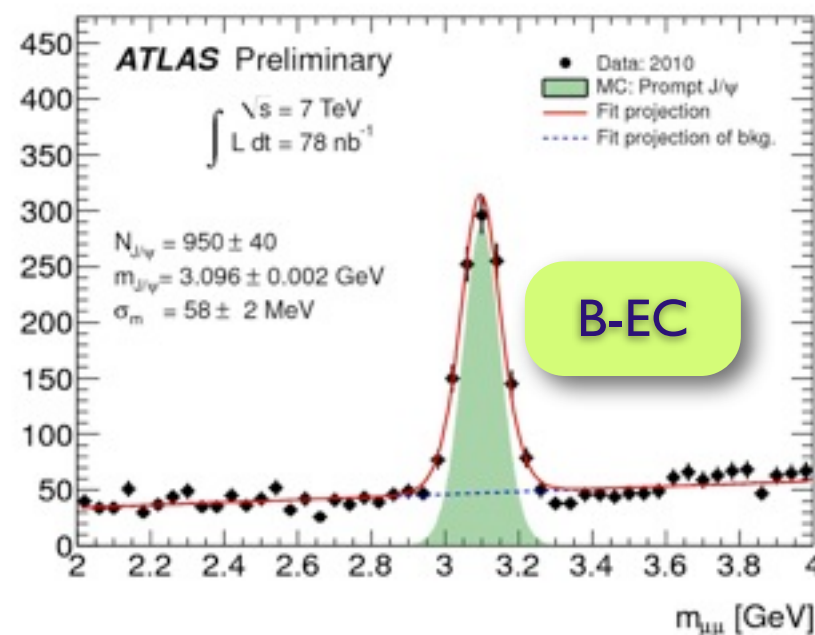
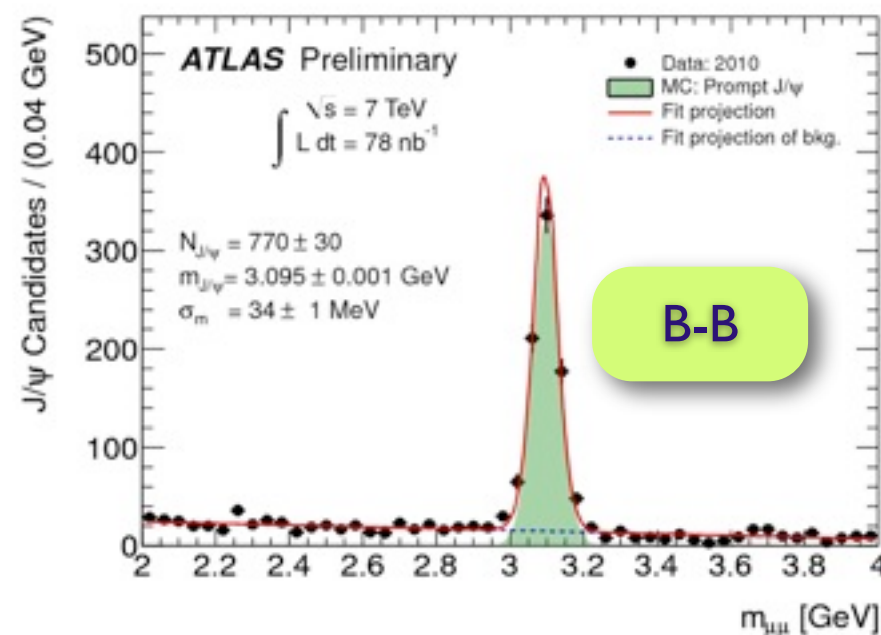


from *Inner Tracking Combined Performance Group*

- ☐ ATLAS-CONF-2010-078
- ☐ Event and J/ψ candidate selection
 - ☐ muon pairs can be **CB-CB, CB-ST or ST-ST**
 - ☐ **muon kinematic parameters from ID reconstruction used**
 - ☐ cut on $p < 3$ GeV (no explicit p_T cut but ID reconstruction starts for $p_T > 0.5$ GeV)
- ☐ same analysis applied to MC
 - ☐ Pythia (MC09 ATLAS tune and MRST LO parton pdf's) with J/ψ prompt production implemented according to NRQCD Color Octet Model
- ☐ **mass and mass resolutions** are derived from an unbinned maximum likelihood fit to the candidate invariant mass (signal is modeled with a gaussian and background by a first order polynomial)
 - ☐ results are compared with MC in different detector regions



ID tracking performance study with a $J/\Psi \rightarrow \mu\mu$ sample



J/ψ pseudo-rapidity

Mass in agreement with PDG in all regions of pseudo-rapidity

Scale and resolution in data well described by the simulation

mass scale max. deviation $(0.2 \pm 0.1)\%$



Di-Muon mass resolution study $J/\Psi \rightarrow \mu\mu$

MS Muon Pair Selection for J/ψ

- 2 Opposite Charge **ComBined** muons with:
 - **MS muon** quality CUTS applied to BOTH muons:
 - $\text{Nhmdt} > 8 \ \&\& \ \text{nhcsc} > 1 \ \&\& \ \text{nhtgcphi} > 0$ IF $|\text{eta}| > 2.0$
 - $\text{nhmdt} > 15 \ \&\& \ \text{nhtgcphi} > 1$ IF $|\text{eta}| > 1.05 \ \&\& \ |\text{eta1}| < 2.0$
 - $\text{nhmdt} > 15 \ \&\& \ (\text{nhrcphi} > 1$ IF $|\text{eta}| < 1.05$
 - P and Pt cut = $P_t^{\text{MS}} > 6. \text{ GeV} \ \&\& \ P^{\text{MS}} > 10. \text{ GeV}$
 - $|\delta d0| < 1. \text{ mm} \ \&\& \ |\delta z0| < 5. \text{ mm}$
 - J/ψ mass from ID loose cut = $\text{massID} > 2.4 \ \&\& \ \text{massID} < 3.6 \text{ GeV}$
 - **MS** J/ψ invariant mass computed with:
 - [ID directions] + [MS-SA|P|] measurements

ID Muon Pair Selection for J/ψ

- 2 Opposite Charge **CB** muons with:
 - Quality CUTS ID tracks:
 - $\text{nhtrt} > 10 \ \&\& \ \text{nhpix} > 1 \ \&\& \ \text{nhsct} > 4$ IF $|\text{eta}| < 2.0$
 - $\text{nhpix} > 1 \ \&\& \ \text{nhsct} > 4$ IF $|\text{eta}| > 2.0$
 - P and Pt cut = $P_t^{\text{ID}} > 3. \text{ GeV} \ \&\& \ P^{\text{ID}} > 4. \text{ GeV}$
 - $|\delta d0| < 1. \text{ mm} \ \&\& \ |\delta z0| < 5. \text{ mm}$

F. Cerutti, LNF

Invariant mass Fit

- 3 regions taken into account for **ID**
 - R1 both muons $\rightarrow |\eta| < 1.05$
 - R2 both muons $\rightarrow |\eta| > 1.05 \ \&\& \ |\eta| < 2.0$
 - R3 both muons $\rightarrow |\eta| > 2.0$
- 4 regions taken into account for **MS**
 - R1 both muons $\rightarrow |\eta| < 1.05$
 - R2 both muons $\rightarrow |\eta| > 1.05 \ \&\& \ |\eta| < 1.7$
 - R3 both muons $\rightarrow |\eta| > 1.7 \ \&\& \ |\eta| < 2.0$
 - R3 both muons $\rightarrow |\eta| > 2.0$
- Fit with **Gauss** + 1st order **pol.** in limited mass range



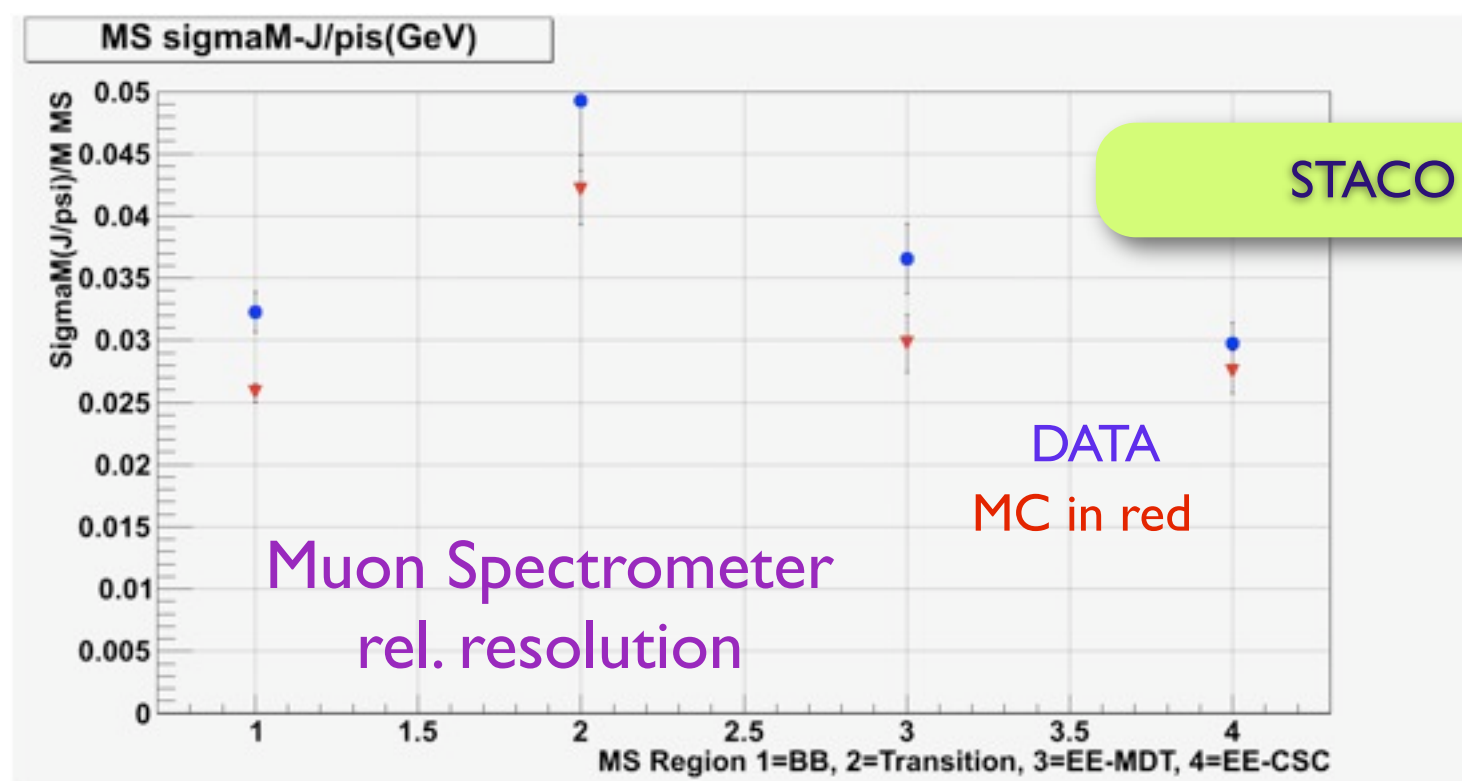
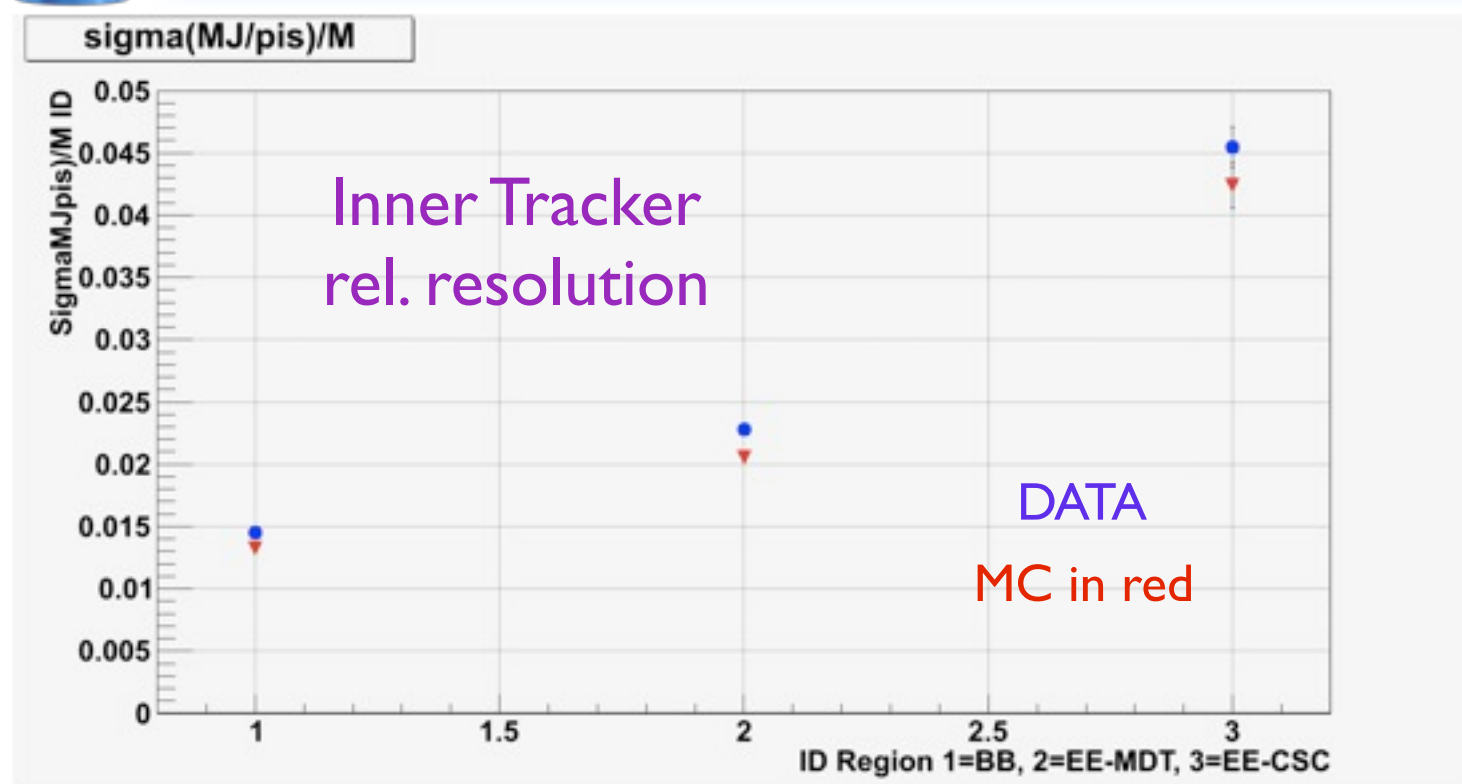
Di-Muon mass resolution study $J/\Psi \rightarrow \mu\mu$



F. Cerutti, LNF

$$\sigma(P_t)/P_t \sim \sigma(M)/M \times \sqrt{2}$$

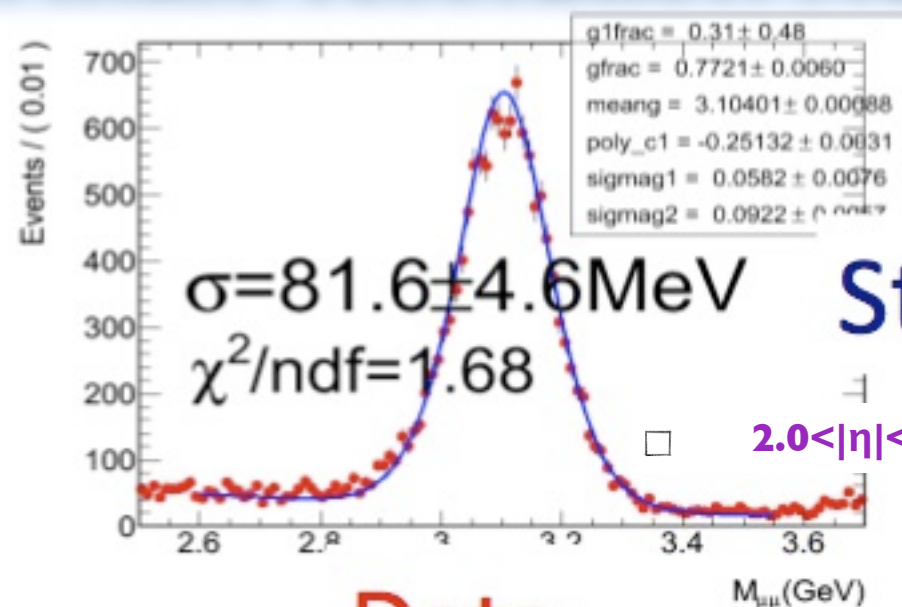
- Resolution **DT**/**MC** agreement at **~10%**





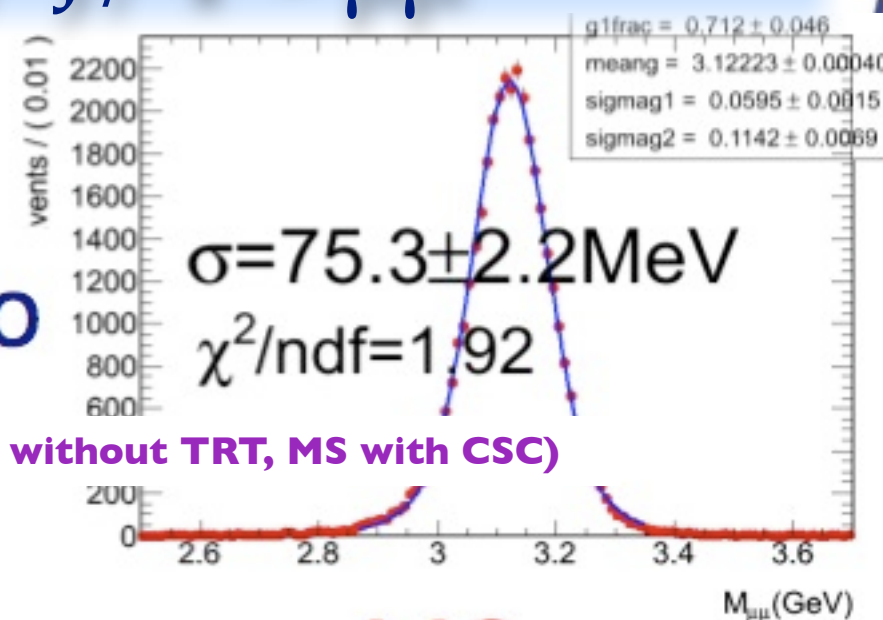
Altri studi:

Di-Muon mass resolution study $J/\Psi \rightarrow \mu\mu$



Staco

2.0 < |η| < 2.5 (ID without TRT, MS with CSC)



Data

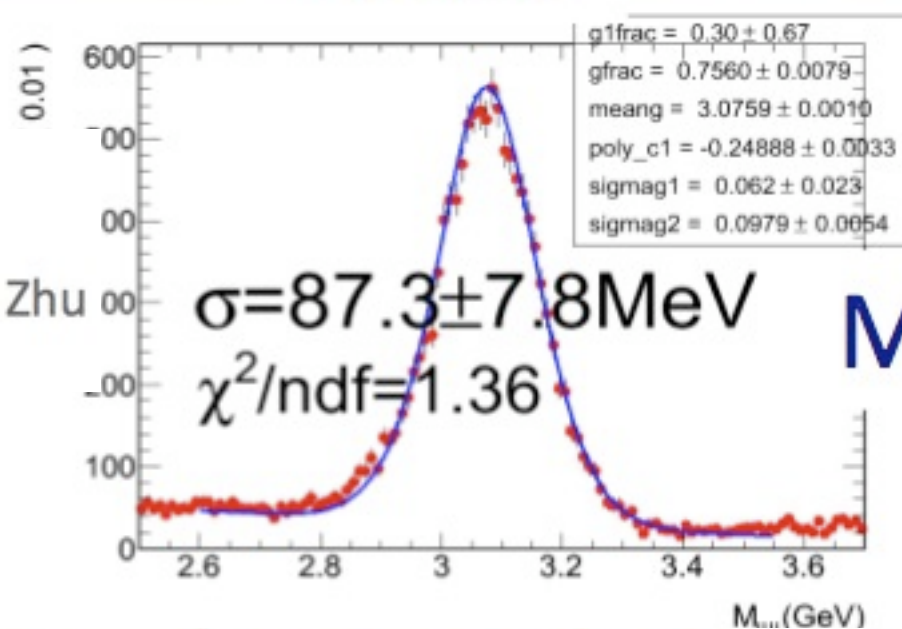
MC

Liu Jianbei

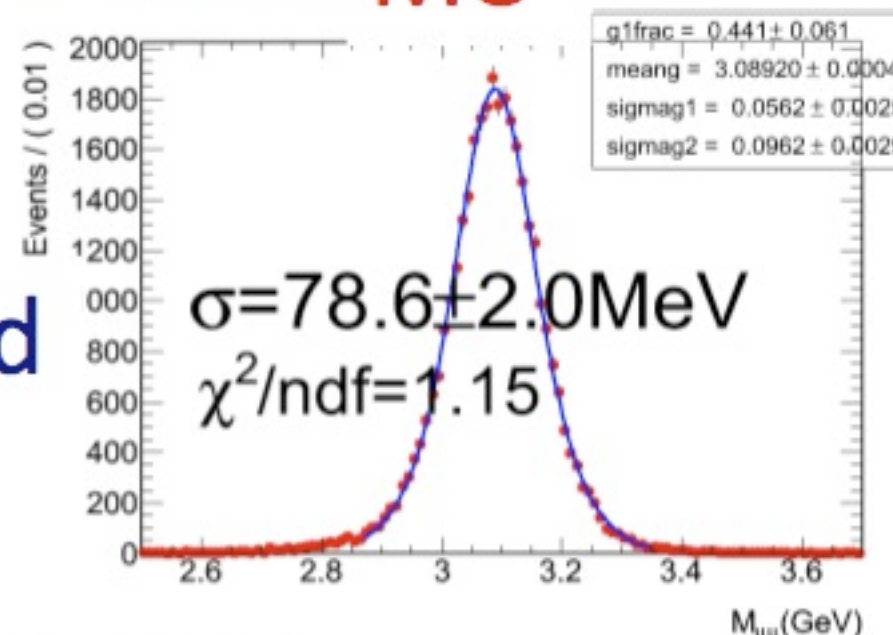
With

Li, Y. Wu, H. Yang, B. Zhou, J. Zhu

University of Michigan



Muid



	$ \eta < 1.05$	$1.05 < \eta < 1.4$	$1.4 < \eta < 2.0$	$2.0 < \eta < 2.7$
STACO	8.5%	13.6%	11%	8.4%
MUID	16%	19%	7.4%	11%

$|data - MC| / MC$



Conclusioni

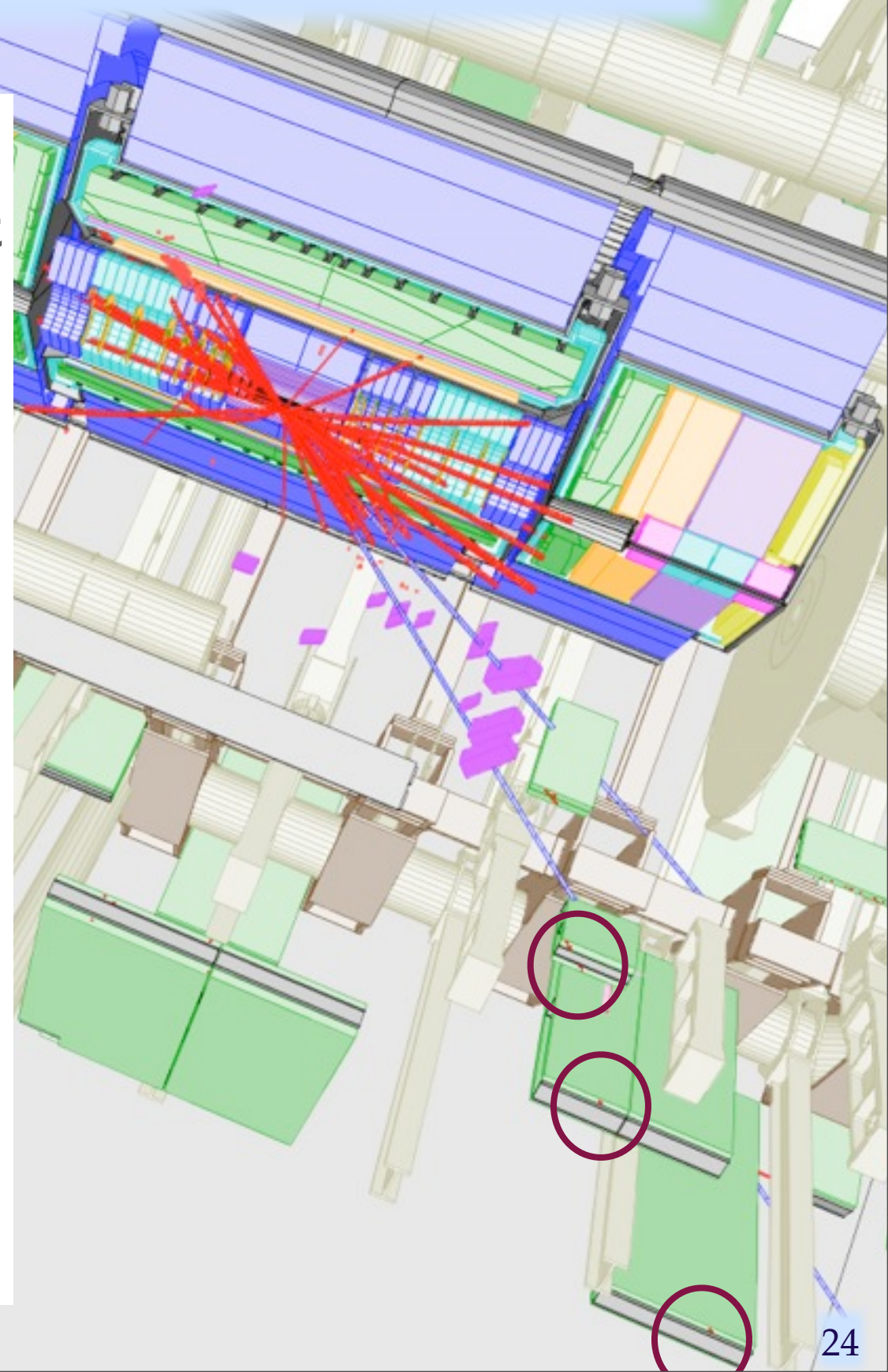
- ☐ Tag and Probe con $J/\psi \rightarrow \mu\mu$ ampiamente utilizzato per misure di eff. di ricostruzione offline di muoni a basso p_T
 - ☐ prossima una CONF-NOTE che raccoglierà i risultati e contributi dei vari working groups sui primi 3 pb-I
- ☐ $J/\psi \rightarrow \mu\mu$ utilizzato di pari passo per controllare la risoluzione in massa con muoni combinati 7 pb-I
 - ☐ preceduto da uno studio a bassa statistica 80nb-I ristretto alla risoluzione in massa dell'ID
- ☐ Contributo italiano ben integrato
- ☐ ...
- ☐ Tag and Probe con $J/\psi \rightarrow ee$ usato per misure di efficienza e tuning degli algoritmi di identificazione di elettroni di bassa energia
- ☐ Il monitoraggio a lungo termine della misura di efficienza di ricostruzione di muoni / trigger / etc con TP basato su $J/\psi \rightarrow \mu\mu$ richiede probabilmente un trigger dedicato
 - ☐ soglia dei trigger di muone singolo non prescalati cresce rapidamente $\Rightarrow$ riduzione dell'accettanza per $J/\psi \rightarrow \mu(\text{MS+ID})\mu(\text{ID})$

Backup



Muon reconstruction in ATLAS

- Muon Reconstruction in ATLAS starts from local segments in 3 (typically) measurement stations of the **Muon Spectrometer (MS)** fitting to a common track
 - **Rel. sagitta resolution $< 10\%$ for $p_T < 1$ TeV**
 - **coverage $|\eta| < 2.7$**
- extrapolated to IP, if matching an Inner Detector (ID) track the statistical combination of the ID and MS extrapolated tracks is a *Combined Muon [CB]* (typical muon reconstruction mode for intermediate-high p_T)
- an ID track extrapolated to the MS and matching one or more muon segments is a *Segment Tagged Muon [ST]* (low p_T muons are reconstructed with higher efficiency as ST Muons if $|\eta| < 2$)



η bin	p_T bin	Source of systematic - CB efficiency						
		NL BG	Calo cut	D0 cut	BG+cuts	Period	Tot. Syst.	Stat.
-2.5 to -1.5	0.5 - 2.0	0.19	0.13	0.07	0.2	0	0.2	0.08
	2.0 - 4.0	0.04	0.05	0.0001	0.03	0	0.03	0.03
	4.0 - 6.0	0.0003	0.02	0.02	0.02	0.04	.044	0.02
	6.0 - 8.0	0.01	0.01	0.0019	0.01	0	0.01	0.05
	8.0 - 10.0	0.0	0.02	0.03	0.02	0	0.02	0.06
	>10.0	0	0.05		0.03	0	0.03	0.05
-1.5 to -0.5	0.5 - 2.0	0.02	0.006	0.01	0.01	0	0.01	0.03
	2.0 - 4.0	0.02	0.02	0.004	0.02	0	0.02	0.02
	4.0 - 6.0		0.02		0.02	0	0.02	0.01
	6.0 - 8.0	0.03	0.02	0.004	0.03	0.04	0.05	0.03
	8.0 - 10.0	0.002	0.03		0.02	0	0.02	0.08
	>10.0	0.02	0.02	0.02	0.01	0	0.01	0.07
-0.5 to 0.5	0.5 - 2.0							
	2.0 - 4.0	0.007	0.005	0.006	0.01	0	0.01	0.02
	4.0 - 6.0	0.007	0.005	0.002	0.007	0	.007	0.02
	6.0 - 8.0	0.003	0.001	0.0003	0.002	0	.002	0.03
	8.0 - 10.0	0.001	0.01	0.002	0.008	0	.008	0.04
	>10.0	0.05	0.004	0.005	0.04	0.06	0.07	0.04
0.5 to 1.5	0.5 - 2.0	0.02	0.004	0.01	0.02	0	0.02	0.03
	2.0 - 4.0	0.01	0.001	0.01	0.02	0	0.02	0.02
	4.0 - 6.0	0.003	0.02	0.004	0.01	0.02	0.02	0.02
	6.0 - 8.0	0	0	0	0	0	0	0.01
	8.0 - 10.0	0	0	0	0	0	0	0.04
	>10.0	0.02	0.01	0.01	0.02	0	0.02	0.04
1.5 to 2.5	0.5 - 2.0	0.14	0.09	0.02	0.1	0.1	0.14	0.08
	2.0 - 4.0	0.002	0.01	0.008	0.01	0	0.01	0.03
	4.0 - 6.0	0	0.01	0	0.009	0	.009	0.03
	6.0 - 8.0	0	0	0	0	0	0	0.02
	8.0 - 10.0	0	0.03	0	0.02	0	0.02	0.06
	>10.0	0.036	0.03	0.004	0.04	0	0.04	0.07



Electron performance with $J/\psi \rightarrow e^+e^-$



- Electron performance of the ATLAS detector using $J/\psi \rightarrow e^+e^-$ decays
 - ATL-COM-PHYS-2010-518 based on $\mathcal{L}_{int} = 78 \text{ nb}^{-1}$
 - calorimeter momentum scale (and uniformity) through J/ψ reconstructed mass
 - performance of bremsstrahlung recovery in track refit



Electron performance with $J/\Psi \rightarrow e^+e^-$ bremsstrahlung recovery, calorimeter mass scale and uniformity



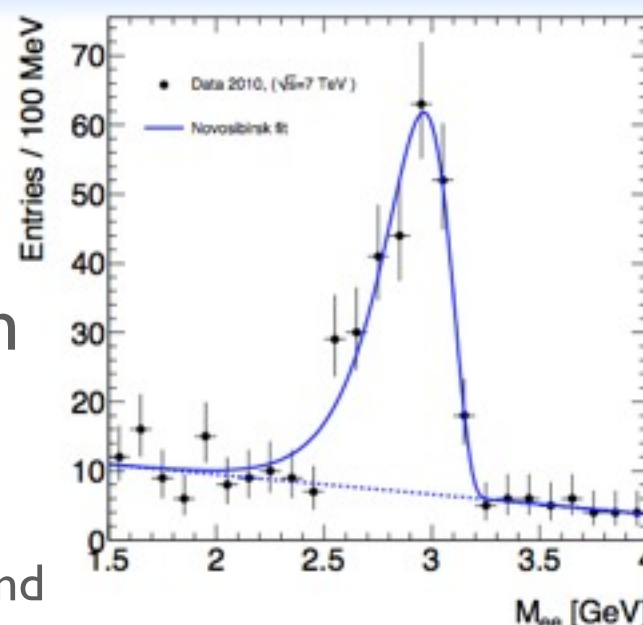
- electron selection for e^+e^- invariant mass reconstruction

□ Calorimeter discriminants

- Lateral containment in η in the 2nd LAr layer: $R_\eta < 0.85(0.9)$ for $|\eta| < 1.5(> 1.5)$
- fraction of EM energy in the 1st compartment w.r.t. total: $f_1 > 0.15$
- $E_{ratio} > 0.07$,

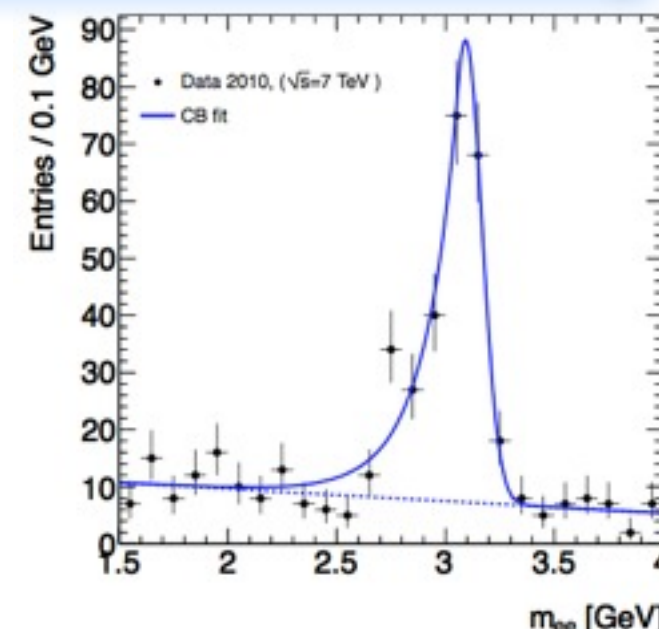
□ Tracking variables:

- fraction of TRT highThr hits > 0.12 ,
- track $p_T > 2$ GeV, 1 b-layer hit (removes γ conversions), 1 pixel hit, 7 SCT hits, unbiased d0 significance w.r.t. primary vertex < 5



Mass from tracks

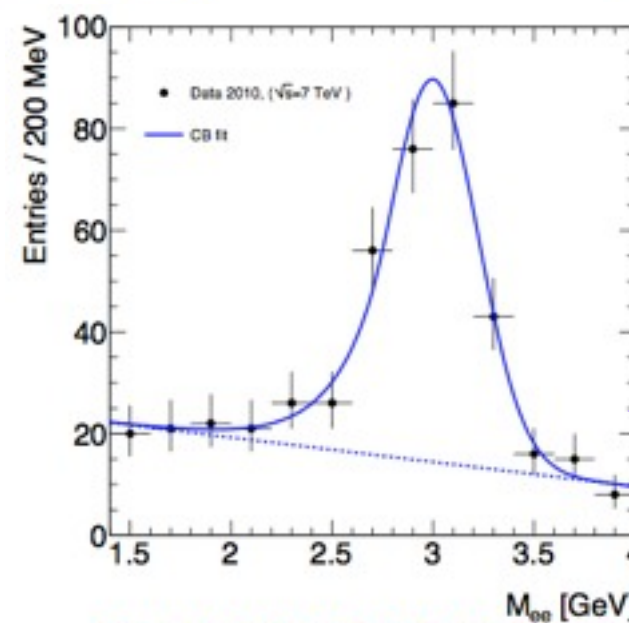
mean = 2.96 ± 0.01
sigma = 0.16 ± 0.01
signal = 234 ± 20
bkg = 57 ± 18



Mass from tracks - GSF

mean = 3.09 ± 0.01
sigma = 0.07 ± 0.01
signal = 222 ± 11
bkg = 28 ± 2

Gaussian Sum
Filter for
bremsstrahlung
recovery



Mass from calo energy/track direction

mean = 3.00 ± 0.03
sigma = 0.22 ± 0.03
signal = 229 ± 24
bkg = 96 ± 22

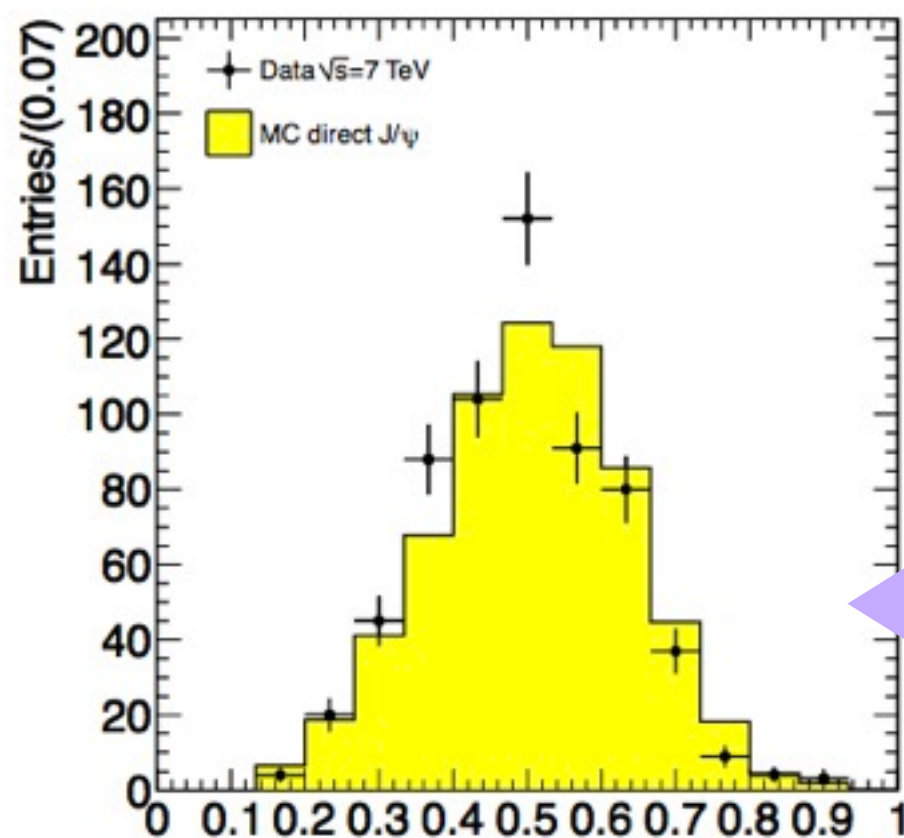
by measuring the
mass from the
calorimeter energy
as a function of
Energy & η the
uniformity can be
probed



Electron performance with $J/\Psi \rightarrow e+e^-$ shower shape at low E_T with J/Ψ tag and probe

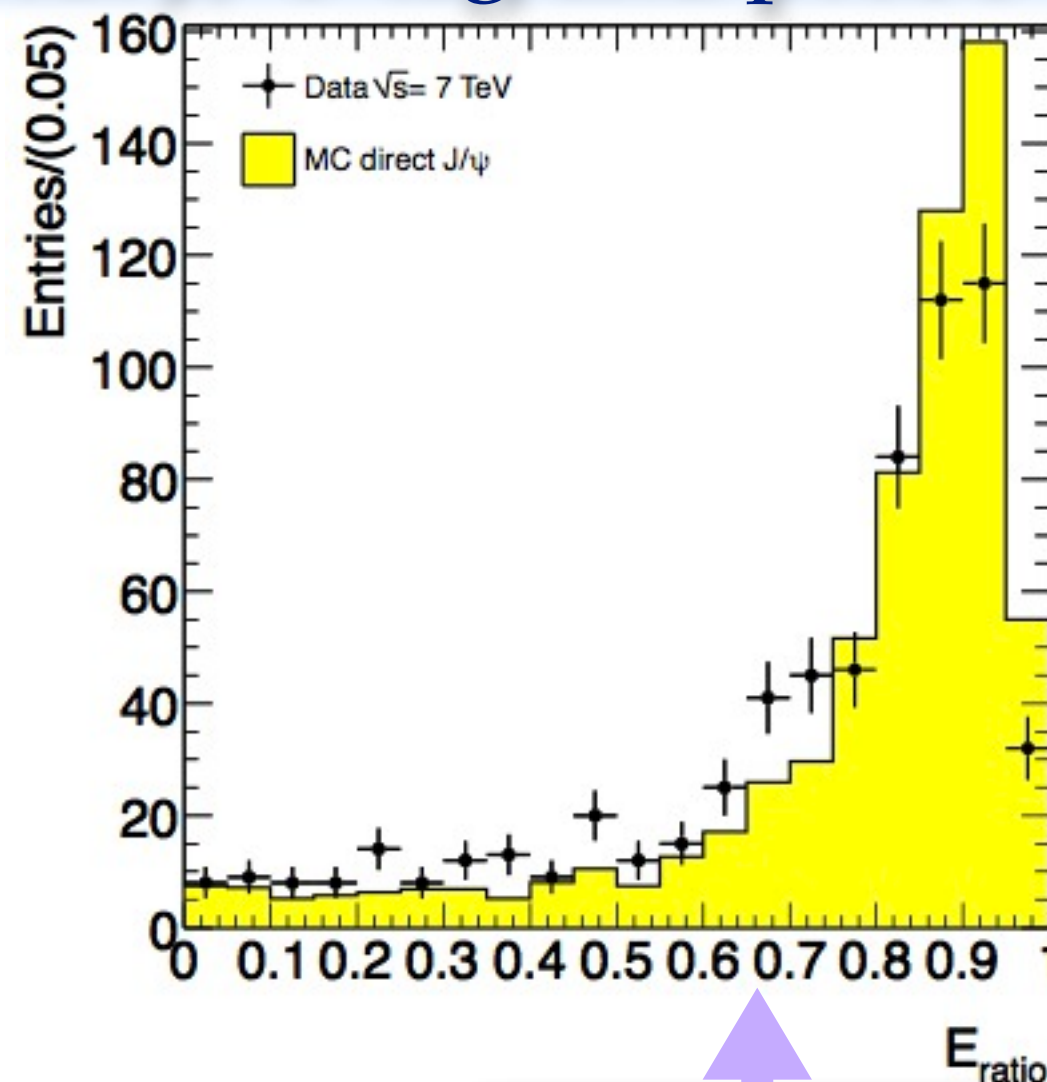


- tighter electron selection for the tag
 - $p_T > 4$ GeV, fraction of TRT highThr hits > 0.18 , raw cluster energy > 2.5 GeV
- electron probe identification
 - Calorimeter discriminants cuts are fully released
 - Tracking variables as in standard $J/\Psi \rightarrow ee$ selection but fraction of TRT highThr hits > 0.15
- tag-and-probe selection: $2.7 < M_{\text{inv}} < 3.2$ GeV (15% bkg under the peak not subtracted)



f_1

Energy fraction in the first EM calo compartment **for electrons identified with tracking criteria + tag&probe**



Ratio of the energy difference between largest and second largest energy deposits over the sum of them in the 1st calo compartment **for electrons identified with tracking criteria + tag&probe**



Di-Muon mass resolution study $J/\Psi \rightarrow \mu\mu$

Liu Jianbei

With

X. Li, Y. Wu, H. Yang, B. Zhou, J. Zhu
University of Michigan

- **2 Combined** muons with opposite charge

- $|\eta| < 2.5$ && $|Z(\text{, PV})| < 10\text{mm}$

- $n_{\text{Pix}} \geq 1$ && $n_{\text{Sct}} \geq 6$

- Requirements on TRT hits ($n_{\text{Trt}} = \text{TRT hits on track} + \text{TRT outliers}$)

- If $|\eta| < 1.9$

- $n_{\text{Trt}} > 5$ && $n_{\text{Trt}}(\text{outliers})/n_{\text{Trt}} < 0.9$

- Else if ($n_{\text{Trt}} > 5$)

- $n_{\text{Trt}}(\text{outliers})/n_{\text{Trt}} < 0.9$

- Cuts specifically for STACO

- $X^2_{\text{match}} < 150$

- $|P_{\text{MS}} - P_{\text{ID}}|/P_{\text{ID}} < 0.2$ if $P_{\text{MS}} < 20\text{GeV}$

- **$P > 10\text{GeV}$ && $P_{\text{T}} > 2.5\text{GeV}$** (to be compared with 2.5GeV P_{T} cut in MC)

mc09_7TeV.108494.Pythia_directJpsimu2p5mu
2p5_e524_s765_s767_r1302_r1306

- Mass fitting

- Data (signal + background)

- Gauss + 1st order Polynomial

- MC (signal only)

- Gauss

- Note: double gauss is needed to well describe the mass distributions in the forward region ($|\eta| > 2.0$). Other than that, single gauss is used throughout.

- Resolution extraction

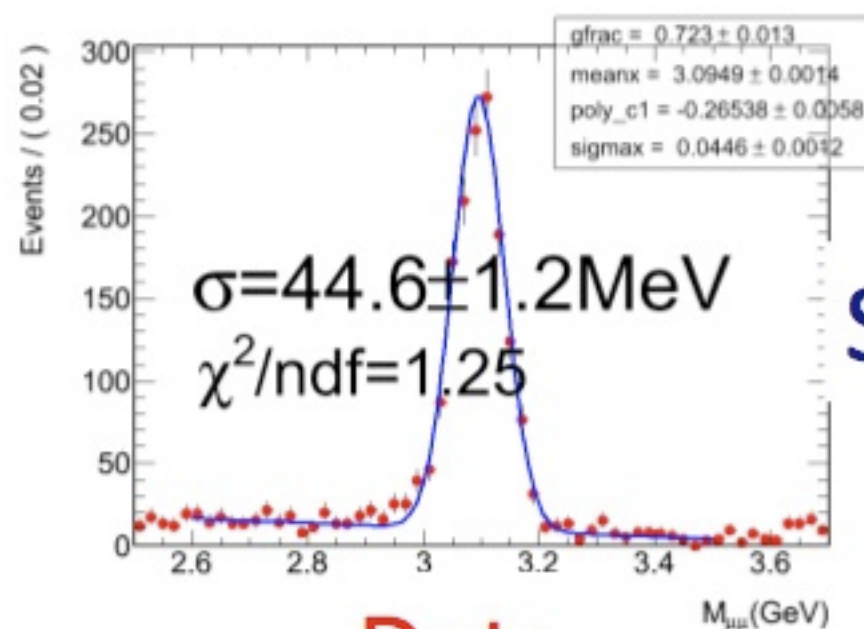
- Mass resolution = $\sigma(\text{Gauss})$



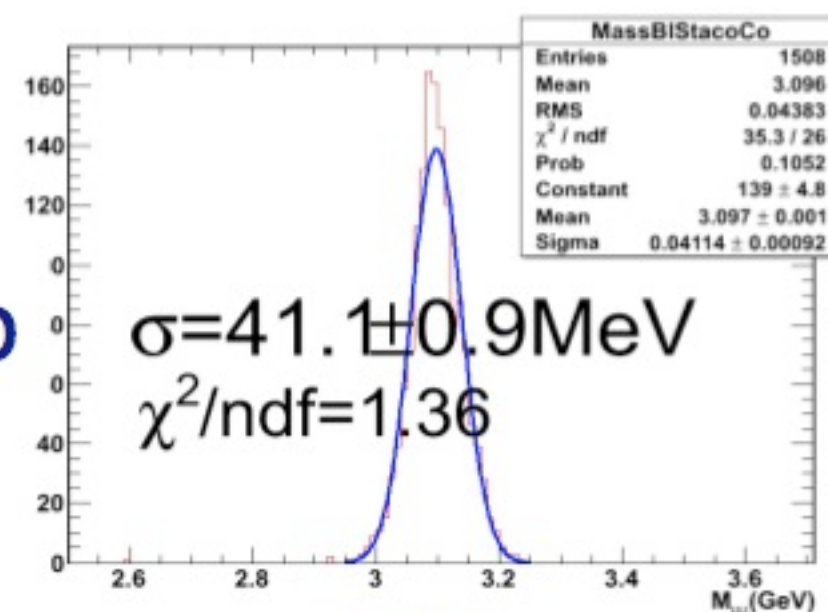
Di-Muon mass resolution study $J/\Psi \rightarrow \mu\mu$



□ Barrel

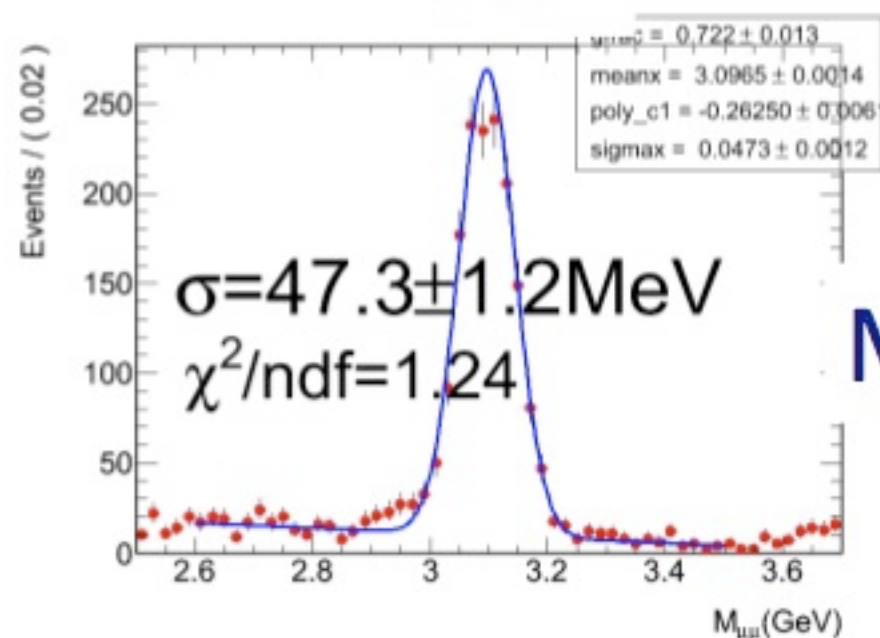


Staco

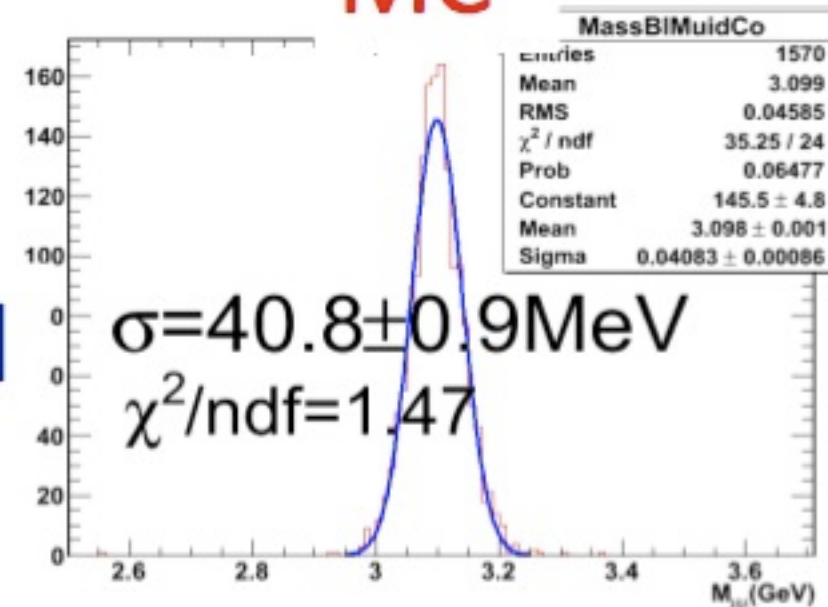


Data

MC



Muid



□