A study of ψ(2S) to J/ψ π π in ATLAS

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IOP HEPP and APP Meeting

2^{nd} - 4^{th} April 2012

LANCASTER UNIVERSITY

ATLAS

Introduction

- This analysis is focusing on $\psi(2S) \rightarrow J/\psi(\mu^+\mu^-)\pi^+\pi^-$
- The $\psi(2S)$ is an excited state of the J/ψ, with a PDG Mass of 3686.09 ± 0.04 MeV
- Highest branching fraction of $\psi(2S)$ decays at 33.6±0.4%
- The final aim of the analysis is to produce a cross-section measurement

Analysis

- The analysis was preformed using release 17 of the ATLAS framework (Athena)
- The analysis makes use of a B-Physics data type, where di-muon events are already identified (DAOD_ONIAMUMU)
  - Using an existing Athena algorithm, the di-muon events in the J/ψ mass range are combined with 2 charged tracks
- Using 2011 ATLAS data (Periods B2 - K4) with a total luminosity of ~ 2.4 fb^{-1}

Trigger

- Trigger being used is EF_2mu4_Jpsimumu
- Which looks for di-muon events in the mass window 2.5 – 4.3 GeV
- This trigger was changed after period K, to have tighter cuts on the muons at a lower level of the trigger
- Not wanting to include 2 different triggers, data after period K was not used for this analysis

Selection

- After the di-muon events are retrieved, the following selections are applied to them

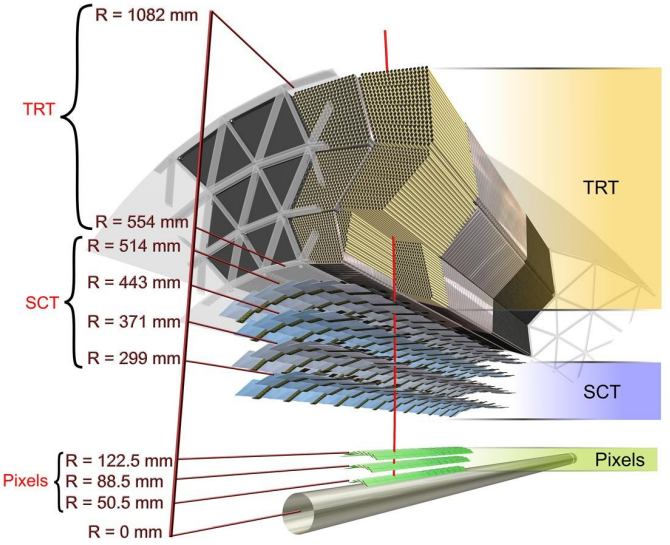
Muons	Di-Muons
pT > 4 GeV	pT > 8 GeV
|y| < 2.3	|y| < 2.0
Both Combined Muons	χ2 < 200
Oppositely Charged	PDG Mass +/- 120 MeV
MCP Cuts	

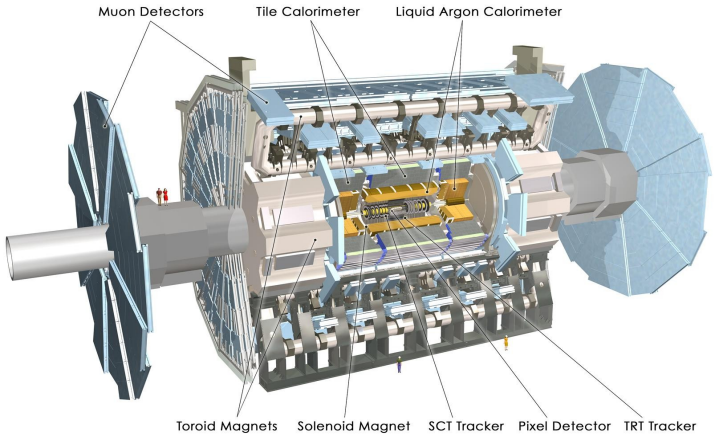
Selection (2)

- The di-muon events are combined with two charged tracks and the following selections are applied

Pion	Di-Pions	J/ψππ
pT > 0.5 GeV	pT > 0.5 GeV	Prob(χ^2) > 0.02
$\|\eta\|$ < 2.5	Mass < 2 GeV	
Oppositely Charged		

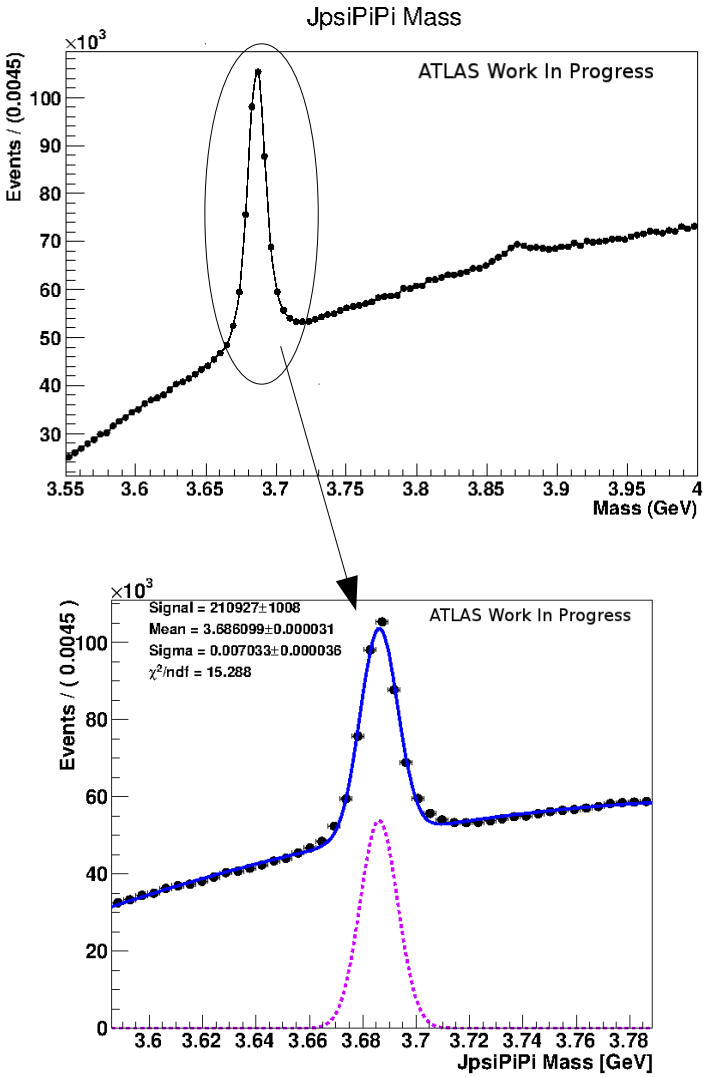
Relevant ATLAS Information





- A combine muon in ATLAS is a muon that has a combination of data from the muon detector and the inner detector (Pixel, SCT, TRT)
- MCP cuts – Muon Combined Performance group's standard cuts

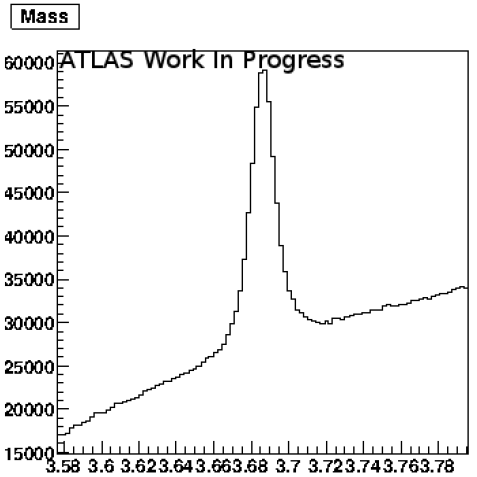
J/ψ π π Mass

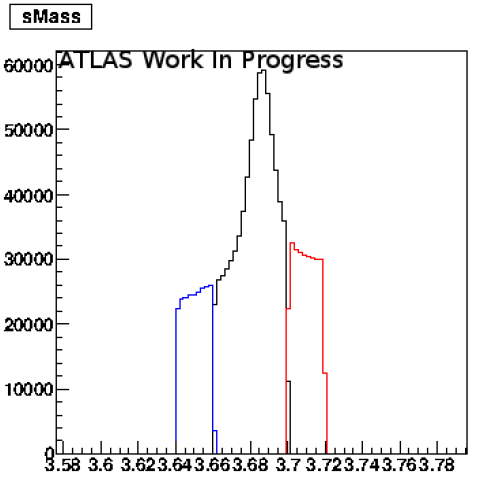


- After all the cuts are applied, the top plot for the J/ψππ mass range is obtained
- Bottom plot is a simple fit of all the events in the ψ(2S) peak

Di-Pion mass

Full ψ(2S) peak

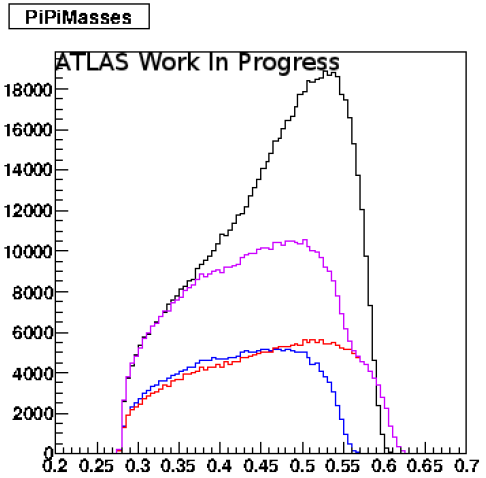


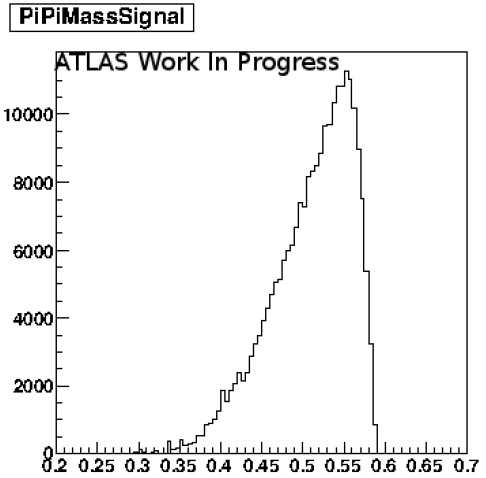


Selecting the peak and sides bands

Di-Pion mass for different regions.

Purple = both side bands

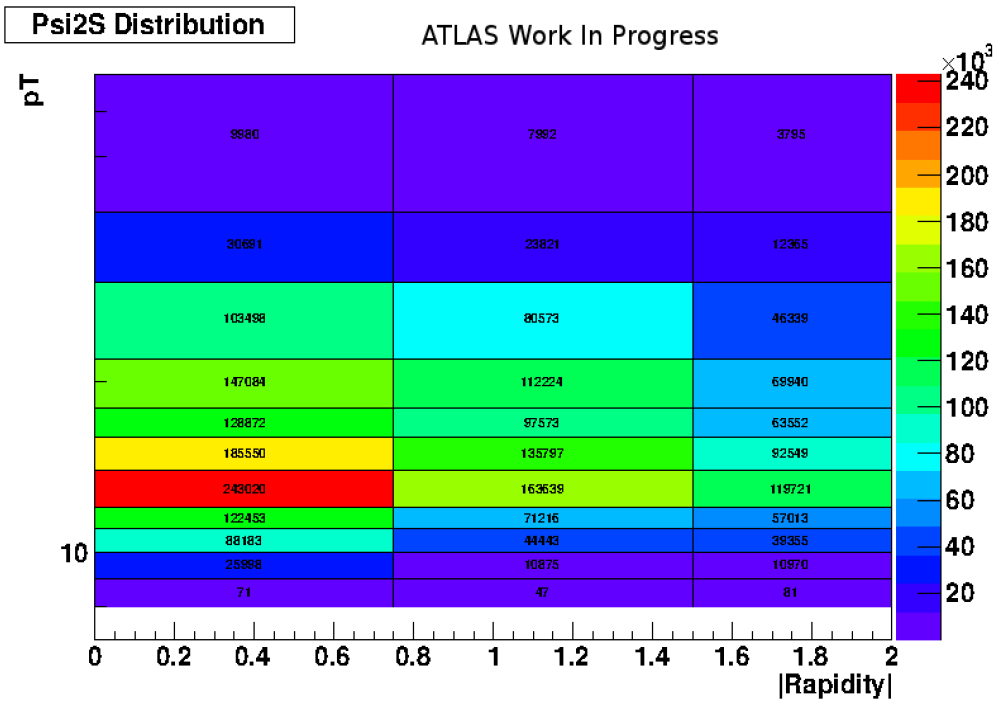




Di-Pion mass for peak minus side bands

Binning

- The mass signal was divided in pT and rapidty bins.
- pT bins are between
  - 8, 9, 10, 11, 12, 14, 16, 18, 22, 30, 40, 70 (GeV)
- Rapidity bins are between
  - 0, 0.75, 1.5, 2.0



Fitting

- The fit preformed is a 2D unbinned maximum likelihood fit using RooFit, which fits mass and lifetime simultaneously.
  - Here the lifetime is the pseudo-proper time (τ), which is define by $\tau = \frac{L_{xy} m^{\psi(2S)}}{P_T^{\psi(2S)}}$ L_{xy} is the distance from primary vertex on the xy plane
- Thus making it possible to separate particles that are directly produced and particles coming from long live parent particles
- The plots shown are 1D projection of the mass and lifetime

Fitting (2)

- Mass (prompt & non-prompt)
  - signal – single Gaussian
  - background – 2nd order polynomial
- lifetime
  - prompt signal - single Gaussian
  - prompt background - double sided exponential convoluted with a Gaussian
  - non-prompt signal - single sided exponential convoluted with a Gaussian
  - non-prompt background - 2 single sided exponential convoluted with a Gaussian

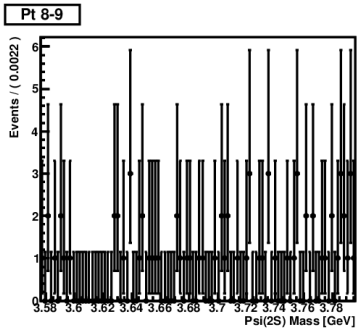
Mass Fits
(Rapidity 0.0 – 0.75)

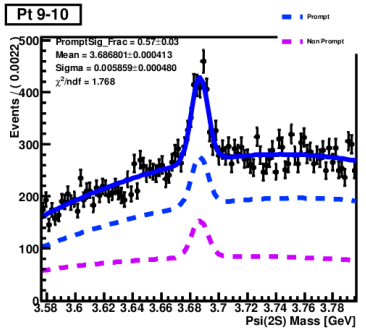
ATLAS Work In Progress

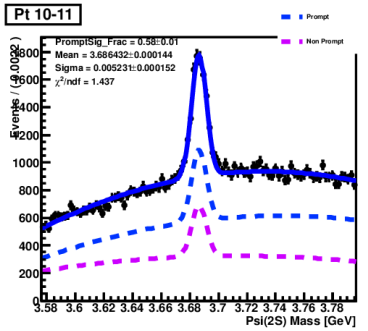
Mass Fits

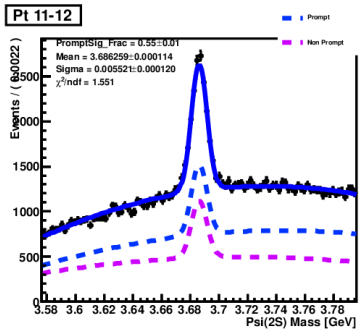
Prompt |Rap| 0 - 0.75

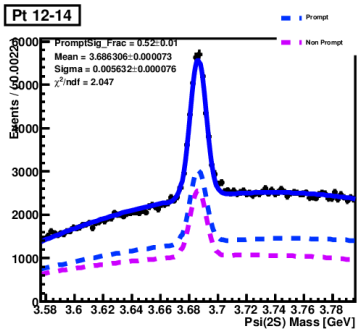
Non-Prompt

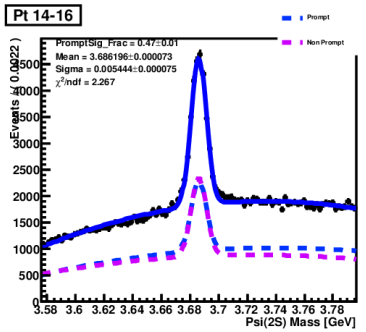


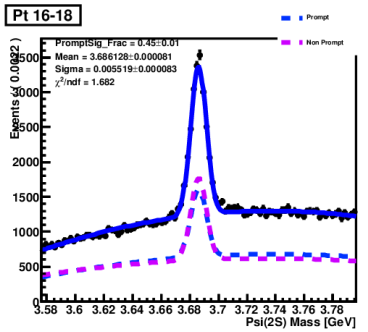


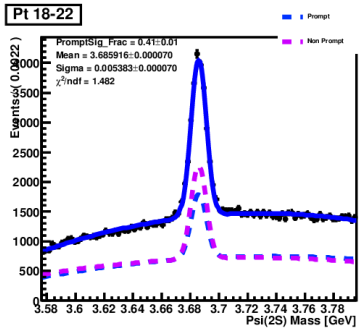


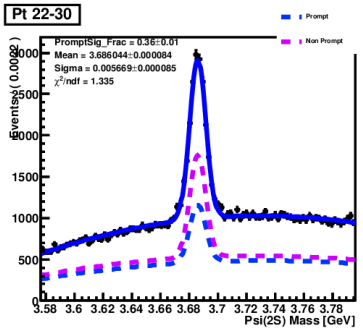


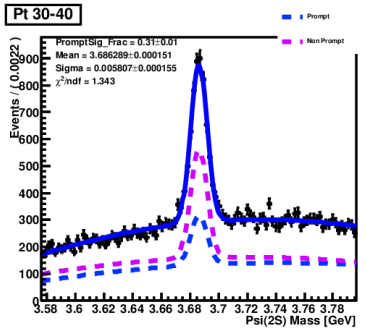


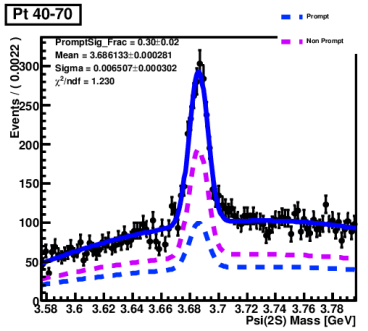










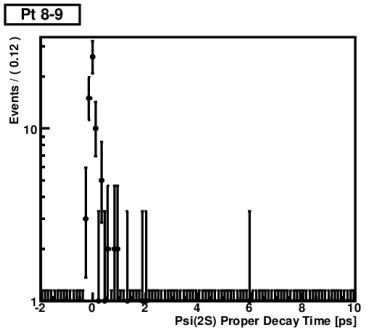


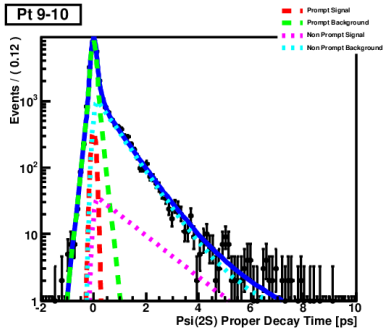
Pseudo-Proper time Fits (Rapidity 0.0 – 0.75)

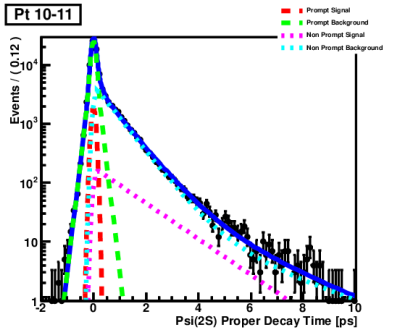
ATLAS Work In Progress

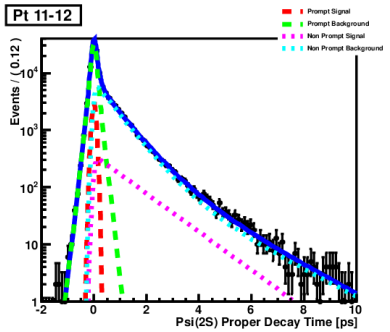
Tau Fits

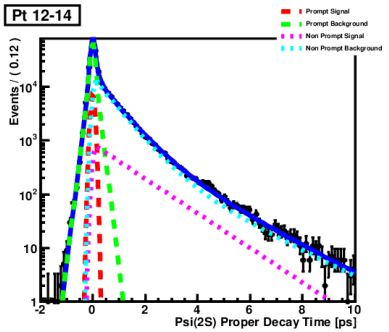
Prompt Signal |Rap| 0 - 0.75
Prompt Background
Non-Prompt Signal
Non-Prompt Background

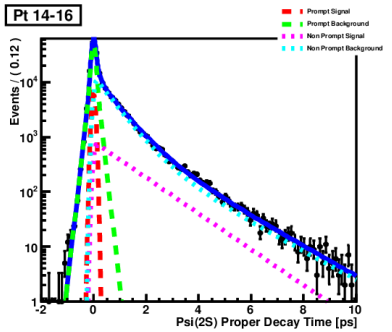


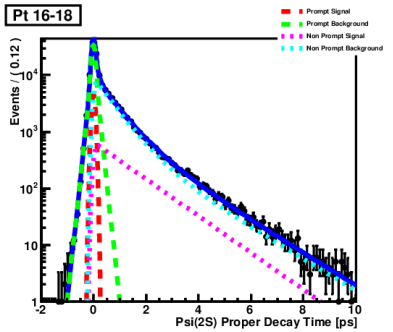


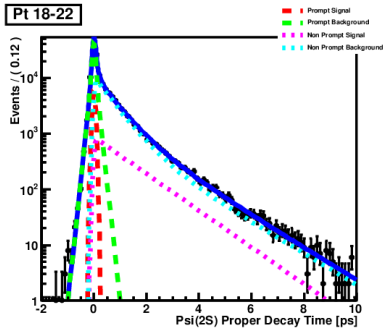


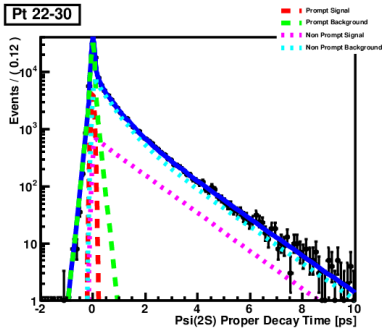


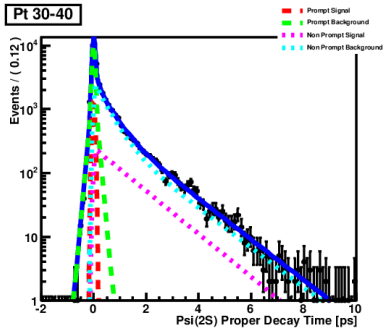


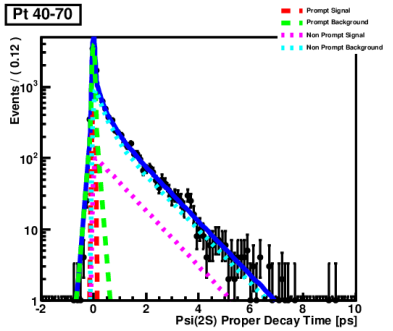




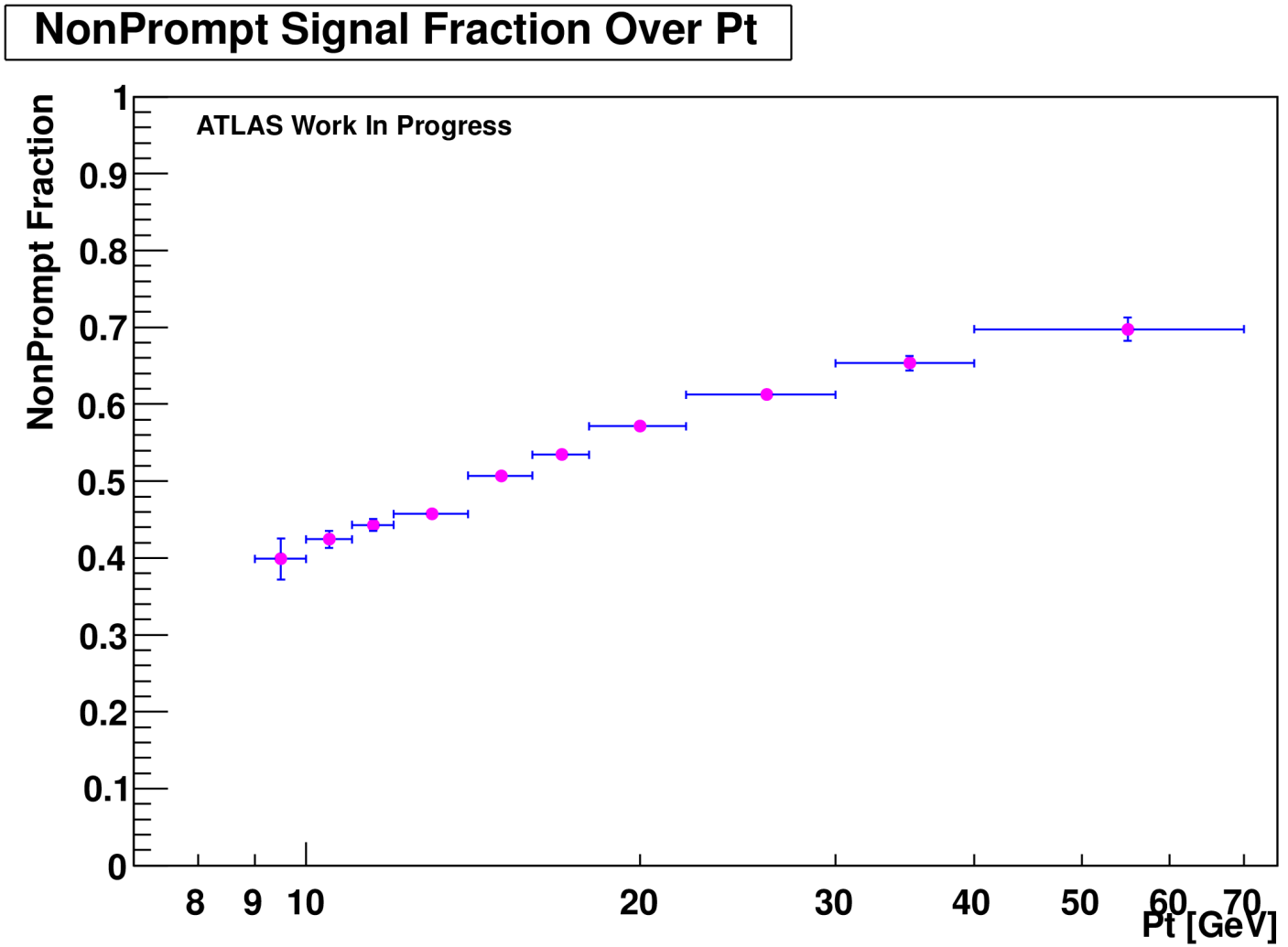








Non-Prompt fraction vs pT (All Rapidity)



Weighting

- The values from the data have to be weighted with the inverse acceptance, reconstruction and trigger efficiencies
- The weighted results shown are not the final results, as they are not using complete efficiencies maps, because they are not currently available.
  - The purpose is to show that the mechanism are working as expected.

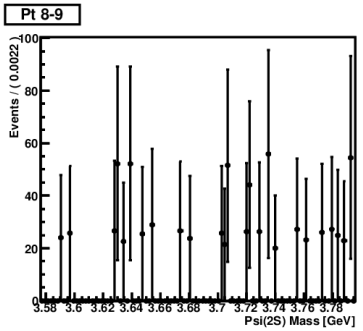
Weighted Mass Fits
(Rapidity 0.0 – 0.75)

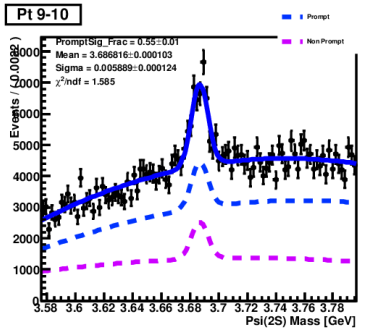
ATLAS Work In Progress

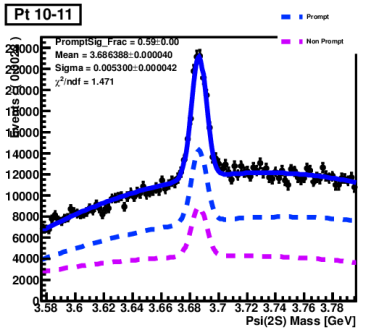
Weighted Mass Fits

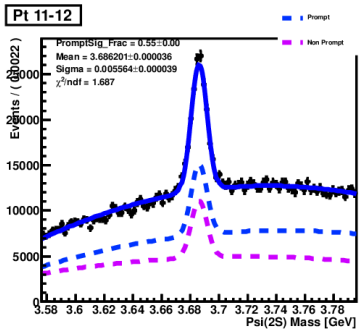
Prompt |Rap| 0 - 0.75

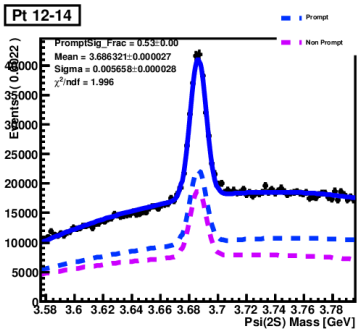
Non-Prompt

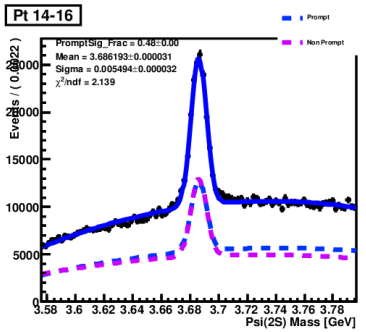


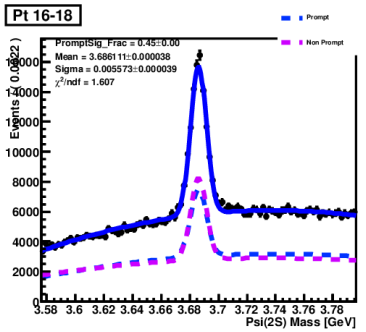


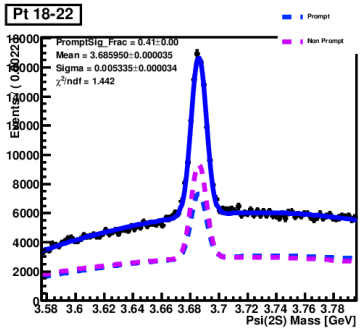


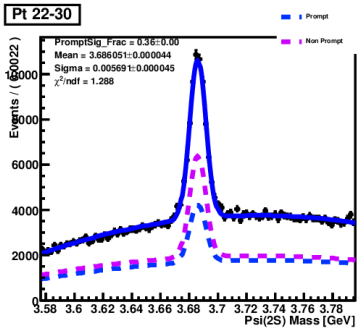


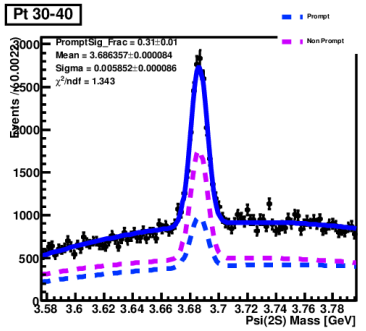


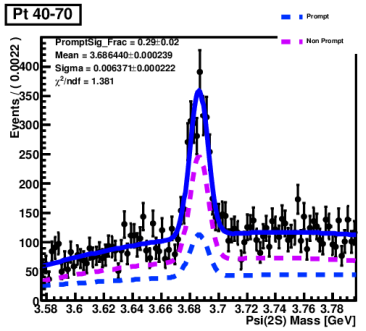










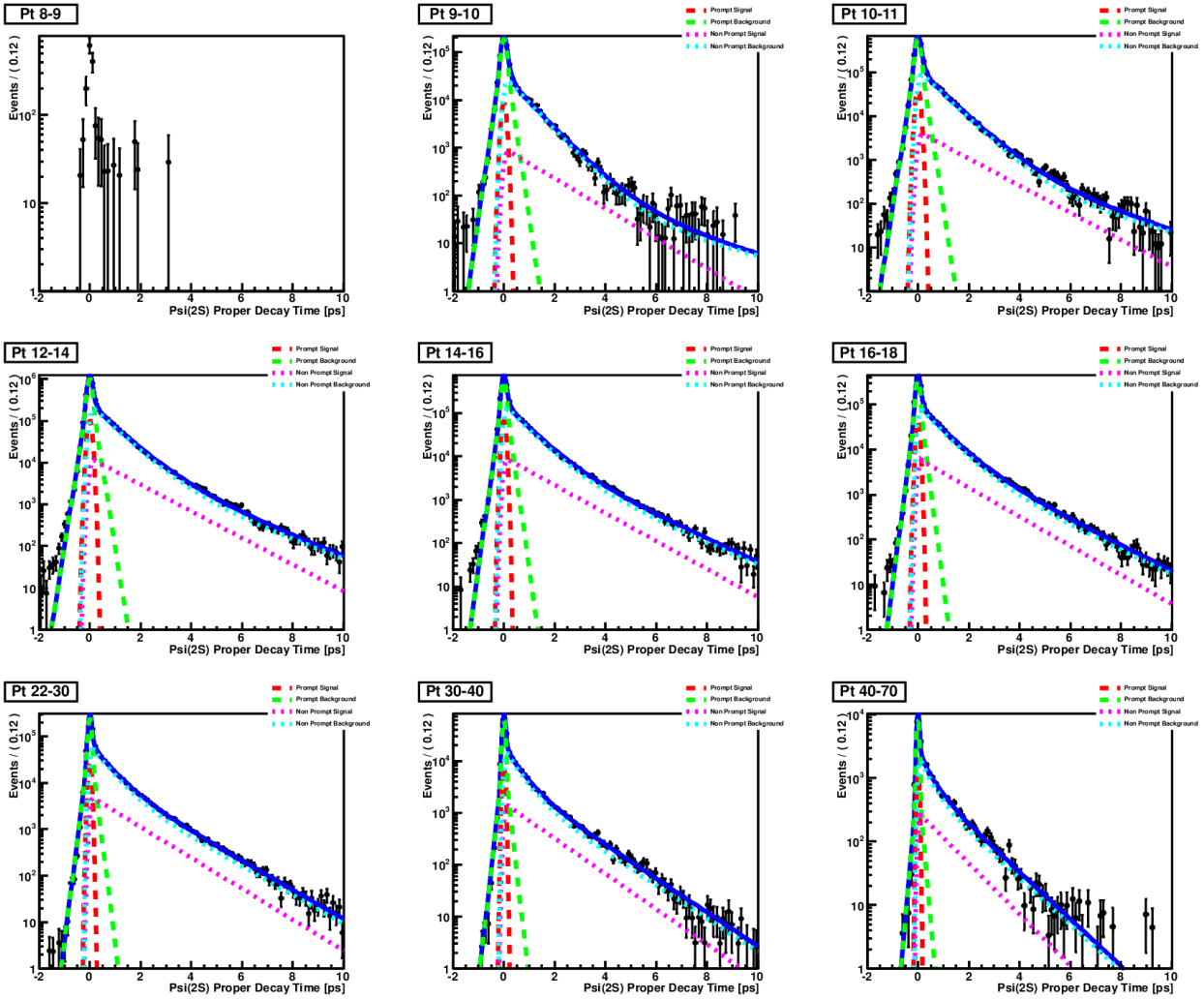


Weighted Pseudo-Proper time Fits (Rapidity 0.0 – 0.75)

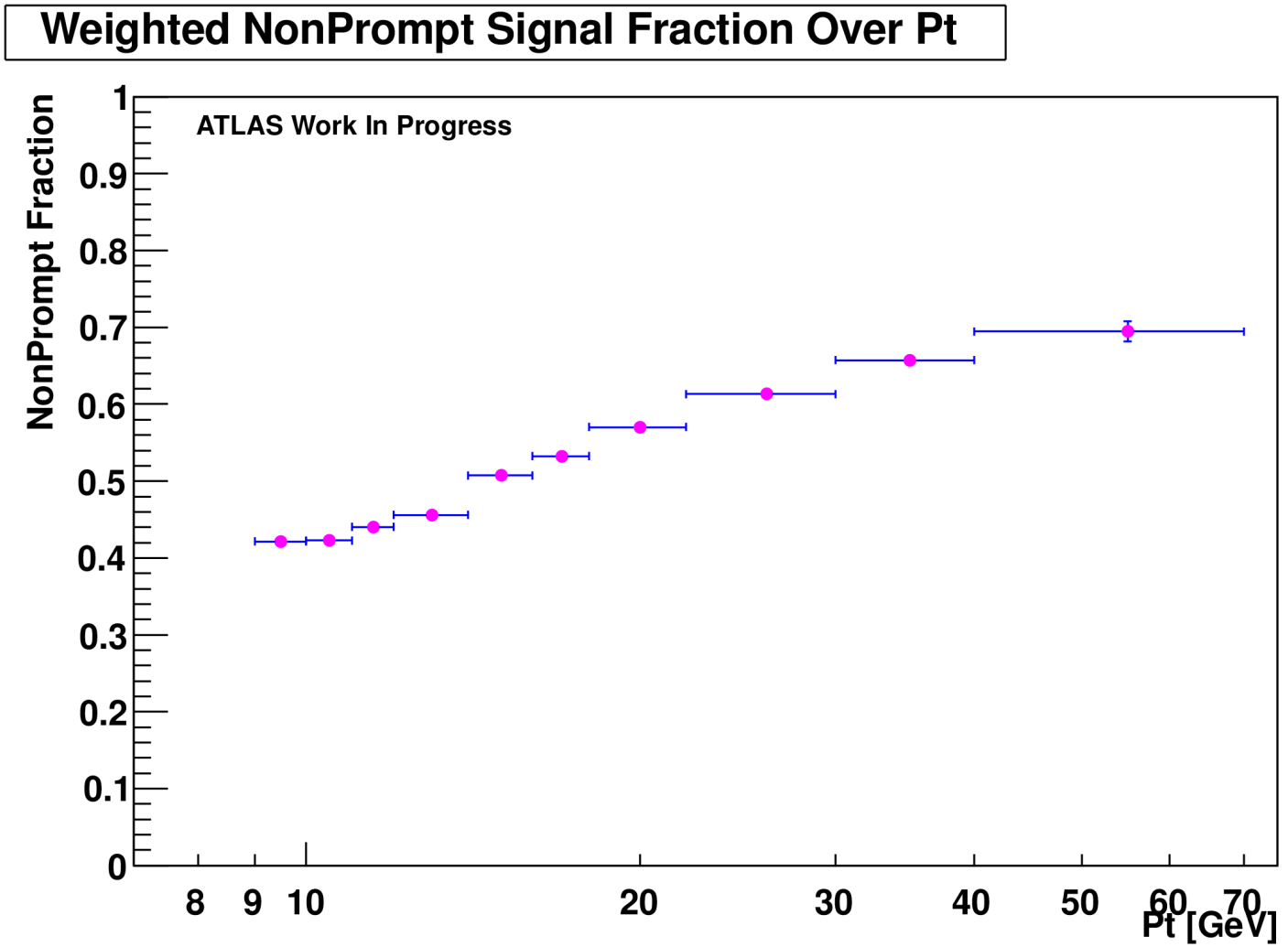
ATLAS Work In Progress

Weighted Tau Fits

Prompt Signal |Rap| 0 - 2
Prompt Background
Non-Prompt Signal
Non-Prompt Background



Weighted Non-Prompt fraction vs pT (All Rapidity)



Summary

- Have obtained a clear and easily identifiable mass peak, which is in the right place
- The di-pion mass distribution is as expected
- Using 2D fitting techniques, it is possible to distinguish prompt and not-prompt of the mass peaks

Next Steps

- Implement the complete efficiency maps, when they are ready
- Produce a cross-section measurement
- Write results up in a paper

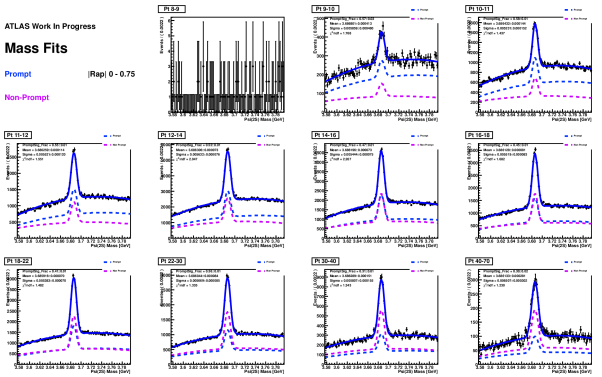
Backup slides

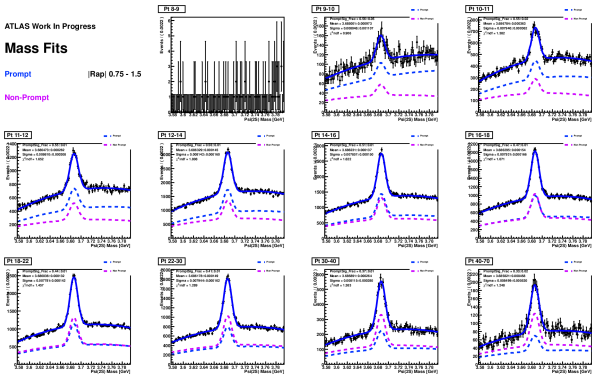
MCP Cuts

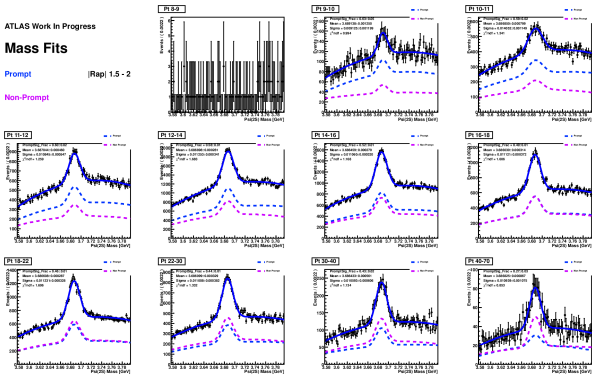
- (! expectBLayerHit) || (numberOfBLayerHits > 0)
- Number of pixel hits+number of crossed dead pixel sensors > 1.
- Number of SCT hits+number of crossed dead SCT sensors >= 6.
- Number of pixel holes + number of SCT holes < 2.

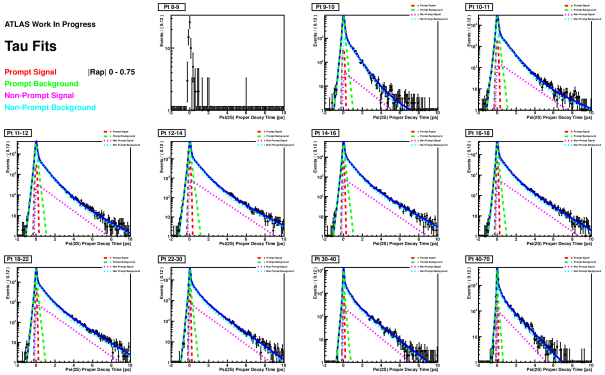
- Case 1: $|\eta| < 1.9$. Require n > 5 and nTRToutliers < 0.9 n.
- Case 2: $|\eta| \geq 1.9$. If n > 5, then require nTRToutliers < 0.9 n.
- nTRThits = number of TRT hits on the muon track
- nTRToutliers = number of TRT outliers on the muon track
- n := nTRThits + nTRToutliers

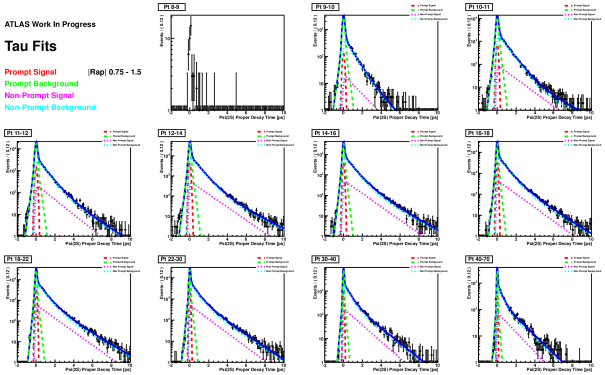
Fits in Rapidity Bins

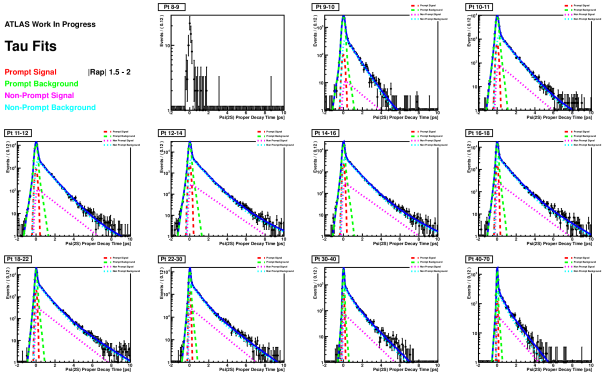












Weighted Fits in Rapidity Bins