

Run 169226, Event 379791
Time 2010-11-16 02:53:54 CET



ATLAS

EXPERIMENT

Measurement of the centrality dependence of the J/ψ yields and observation of Z production in lead-lead collisions with the ATLAS detector at the LHC

Niels van Eldik

On behalf of the ATLAS collaboration



Measurement goals

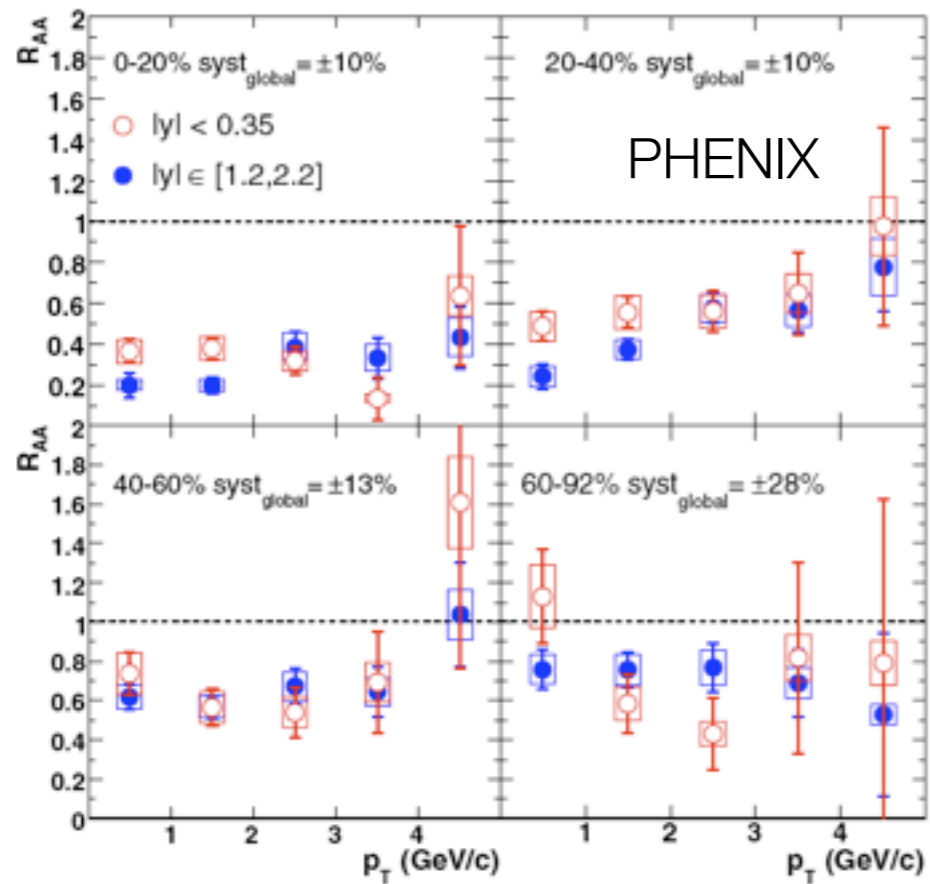


FIG. 3 (color online). J/ψ R_{AA} versus p_T for several centrality bins in Au + Au collisions. Mid (forward) rapidity data are shown with open (solid) circles. See text for description of the errors and Ref. [21] for data tables.

$$R_{AA} = \frac{d^2 N_{J/\psi}^{AA} / dp_T dy}{N_{\text{coll}} d^2 N_{J/\psi}^{pp} / dp_T dy}$$

- Colour screening is expected to prevent the formation of quarkonium states in deconfined matter
- J/ψ suppression in HI collisions as a function of centrality already observed in past experiments
 - PHENIX measurement in Au-Au collisions @ $\sqrt{S_{NN}}=200$ GeV
 - NA50, $\sqrt{S_{NN}}=17.3$ GeV
- Measurements at higher energies needed to understand the underlying mechanism
- Z bosons, only accessible at the LHC, are not expected to be affected by the deconfined matter
 - can serve as a reference for the J/ψ analysis

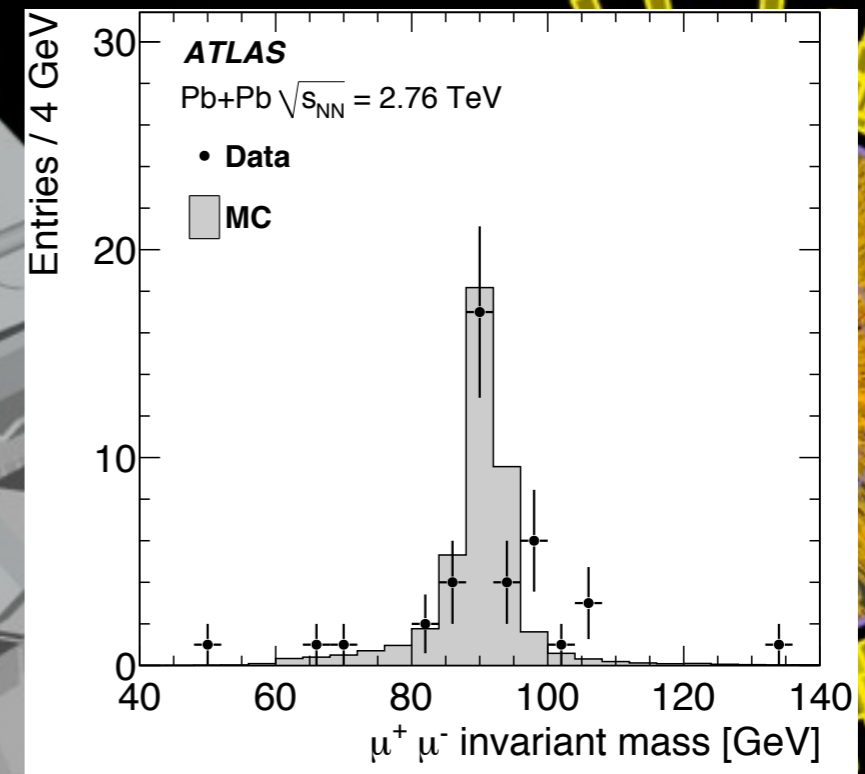
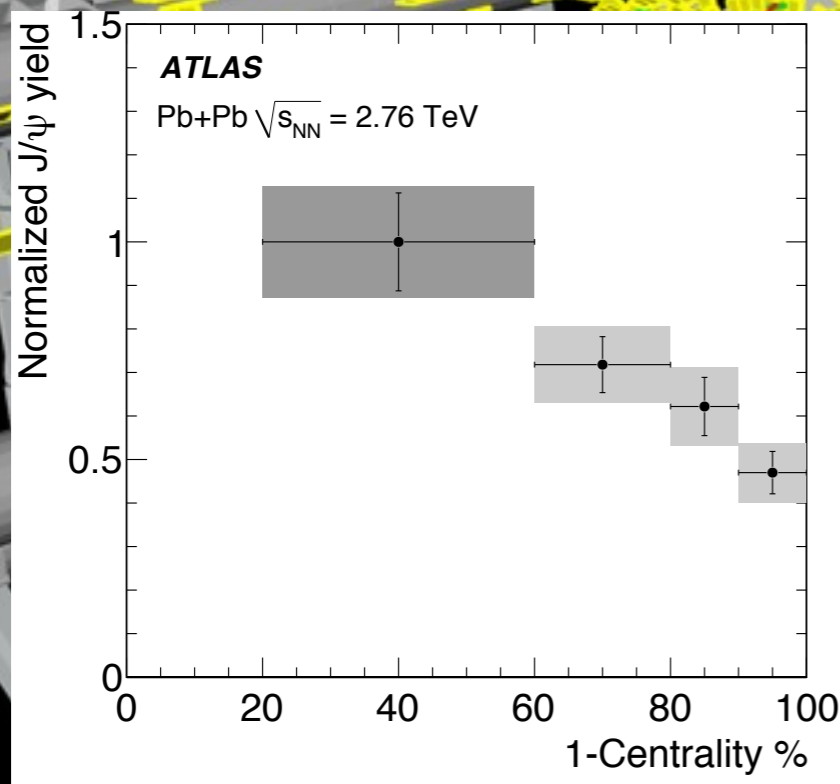
Measurement of the centrality dependence of J/ψ yields and observation of Z production in lead-lead collisions with the ATLAS detector at the LHC

G. Aad *et al.* (The ATLAS Collaboration),

Abstract

Using the ATLAS detector, a centrality-dependent suppression has been observed in the yield of J/ψ mesons produced in the collisions of lead ions at the Large Hadron Collider. In a sample of minimum-bias lead-lead collisions at a nucleon-nucleon centre of mass energy $\sqrt{s_{NN}} = 2.76$ TeV, corresponding to an integrated luminosity of about $6.7 \mu\text{b}^{-1}$, J/ψ mesons are reconstructed via their decays to $\mu^+\mu^-$ pairs. The measured J/ψ yield, normalized to the number of binary nucleon-nucleon collisions, is found to significantly decrease

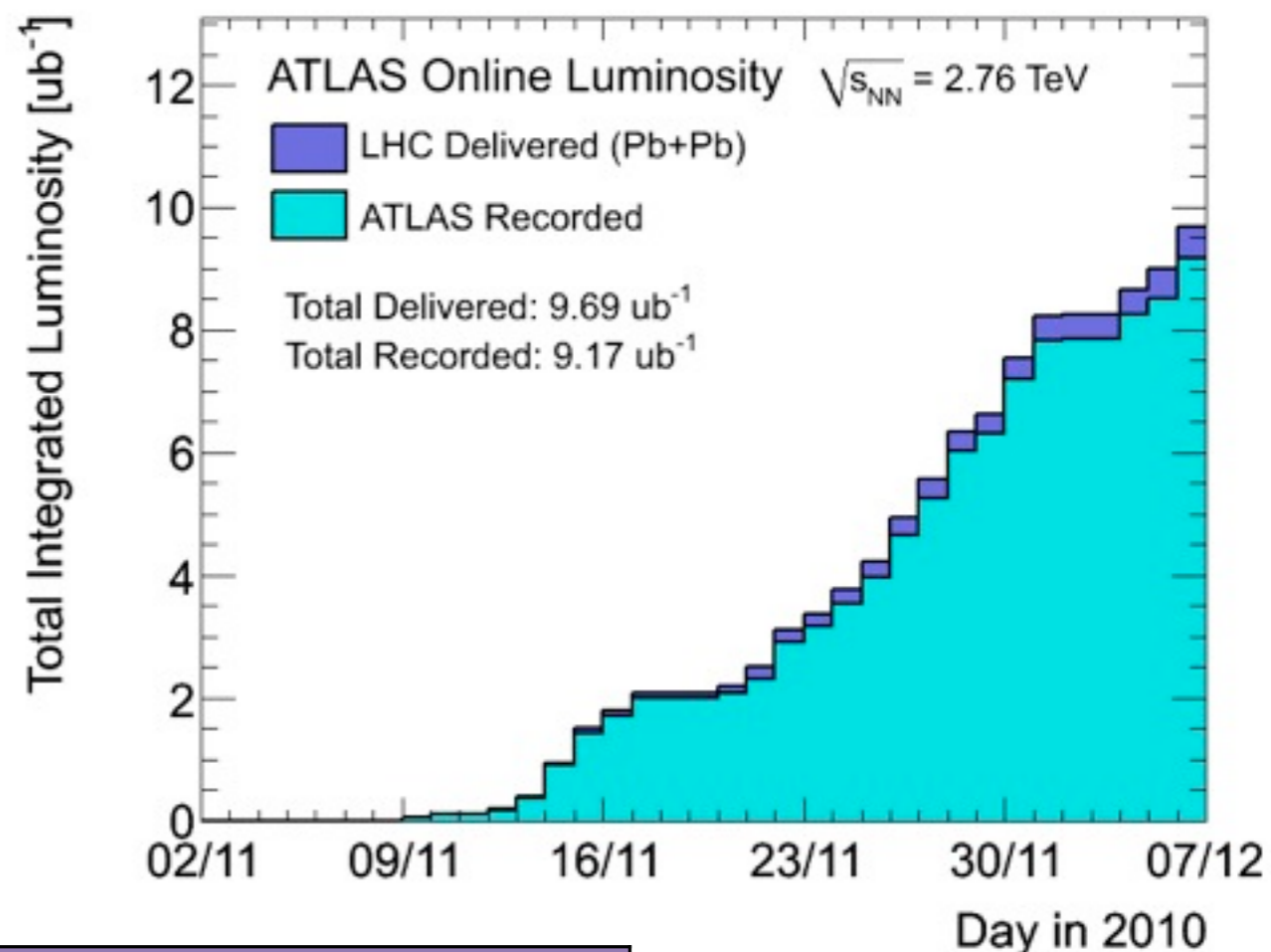
[arXiv:1012.5419v1](https://arxiv.org/abs/1012.5419v1)





Atlas luminosity, data-taking

- ATLAS luminosity profile vs day
 - data taking efficiency > 95%
- Paper used runs corresponding to $6.7 \mu\text{b}^{-1}$

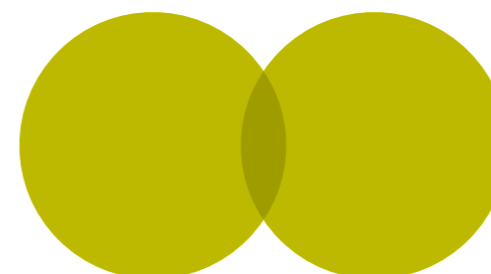
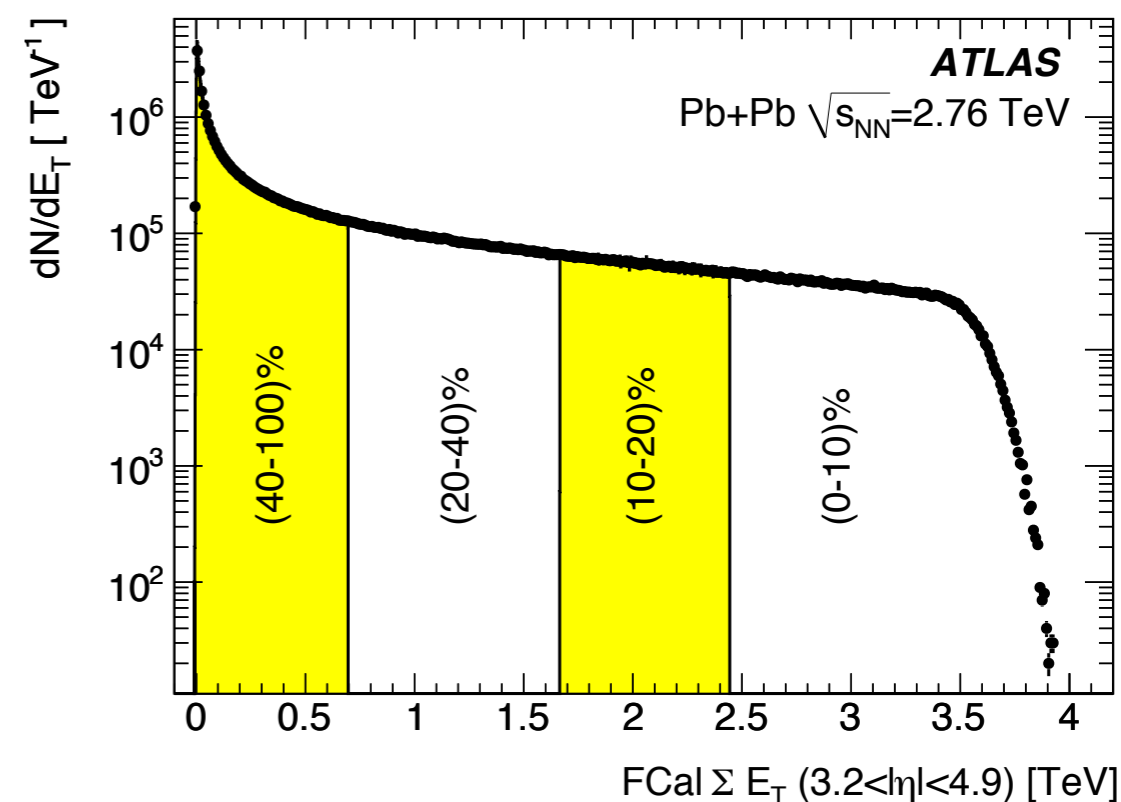


Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.7	100	100	99.2	100	100	100	100	99.6	100	100

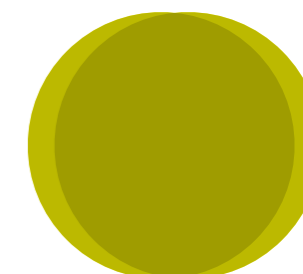
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in PbPb collisions at $\sqrt{s_{\text{NN}}}=2.76 \text{ TeV}$ between November 8th and 17th (in %).

Trigger, centrality

- Triggers:
 - minimum bias scintillator triggers
 - Zero Degree Calorimeters (ZDC)
- Centrality
 - characterised by percentage of total cross-section using the forward calorimeter FCal ΣE_T ($3.2 < |\eta| < 4.9$)
 - four centrality bins: 0-10%, 10-20%, 20-40%, 40-80%
 - range between 80-100% excluded due to larger systematics in determining R_{coll}



Peripheral



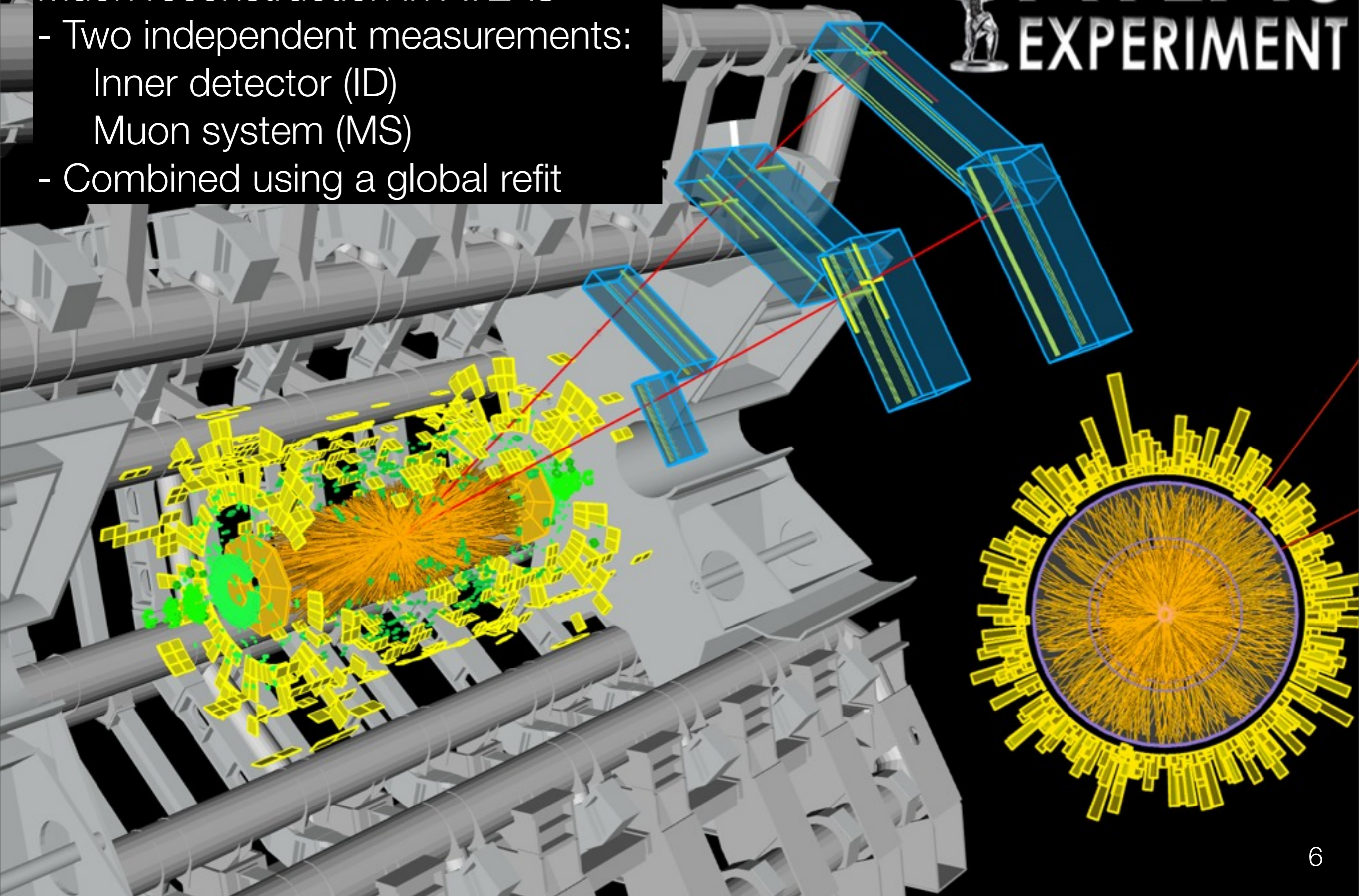
Central



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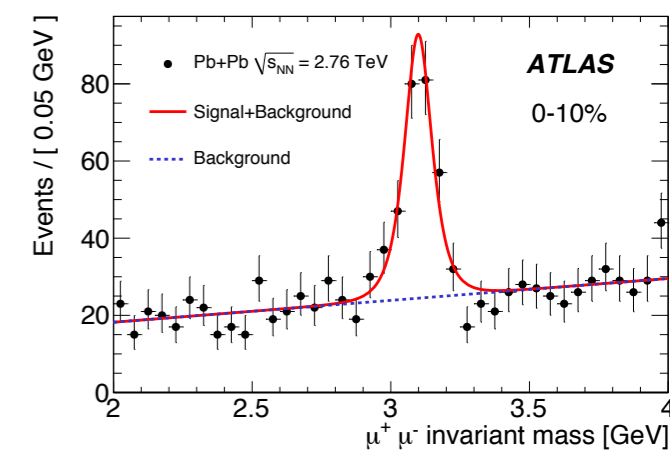
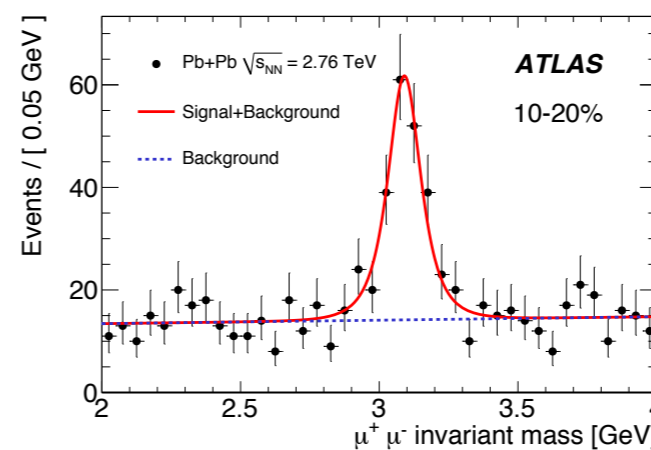
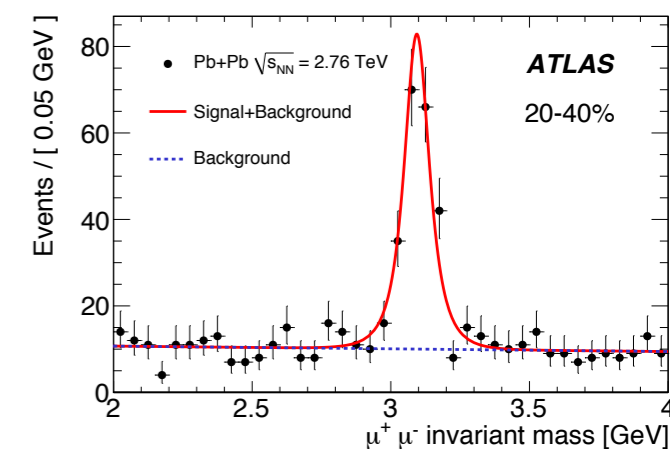
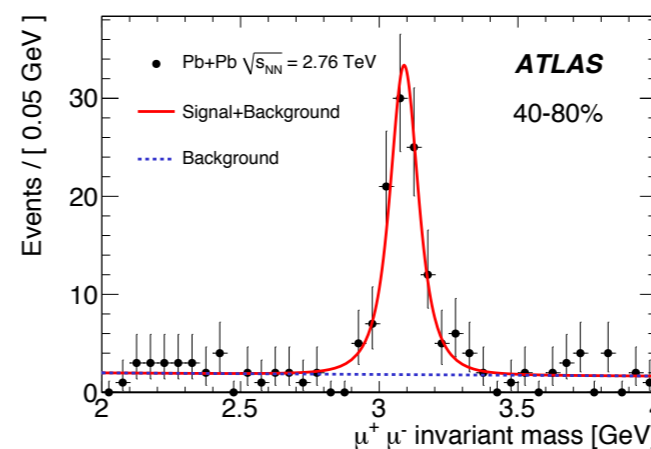
Muon reconstruction in ATLAS

- Two independent measurements:
 - Inner detector (ID)
 - Muon system (MS)
- Combined using a global fit



Extracting the J/ψ signal from the data

- Event selection:
 - 2 combined muons with opposite sign
 - $p_T > 3$ GeV
 - $|\eta| < 2.5$
- Use sideband subtraction technique to extract the J/ψ counts
- Mass windows
 - signal [2.95, 3.25] GeV
 - sidebands [2.4, 2.8], [3.4, 3.8] GeV



Determining the J/ψ reconstruction efficiency as a function of centrality



- J/ψ reconstruction efficiency as a function of centrality extracted from Monte Carlo
 - no data-driven methods available at low p_T
 - centrality dependence parametrized as a function of the total number of hits in the first pixel layer
- Overall reconstruction efficiency was found to drop by 8% for the most central collisions compared to the most peripheral collisions
- Monte Carlo samples:
 - PYTHIA J/ψ and Z events superimposed onto lead-lead events generated with HIJING
 - HIJING was run with effects of jet quenching disabled
 - elliptic flow imposed subsequent to generation tuned with RHIC data
 - detector response simulated with GEANT4

Systematics

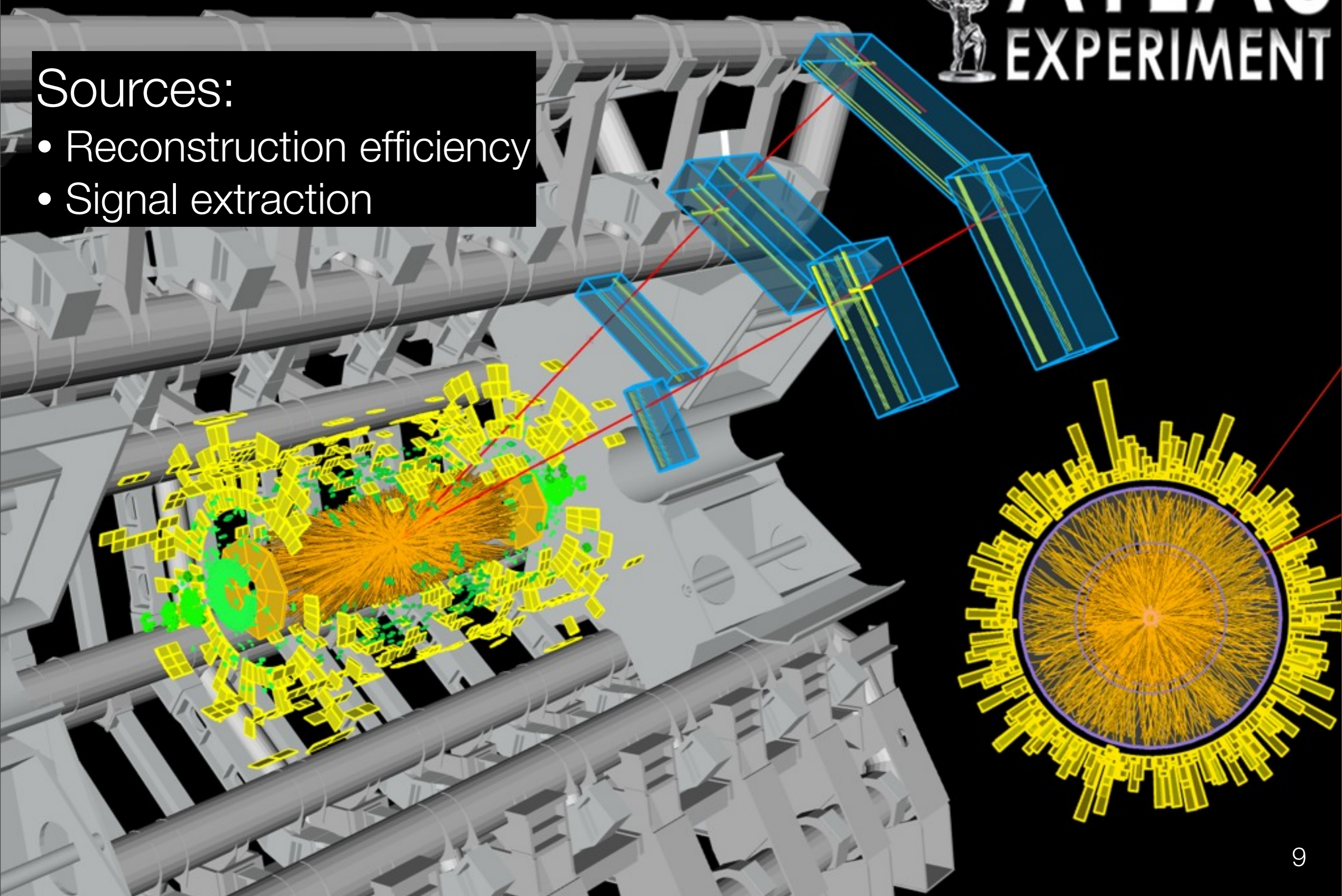


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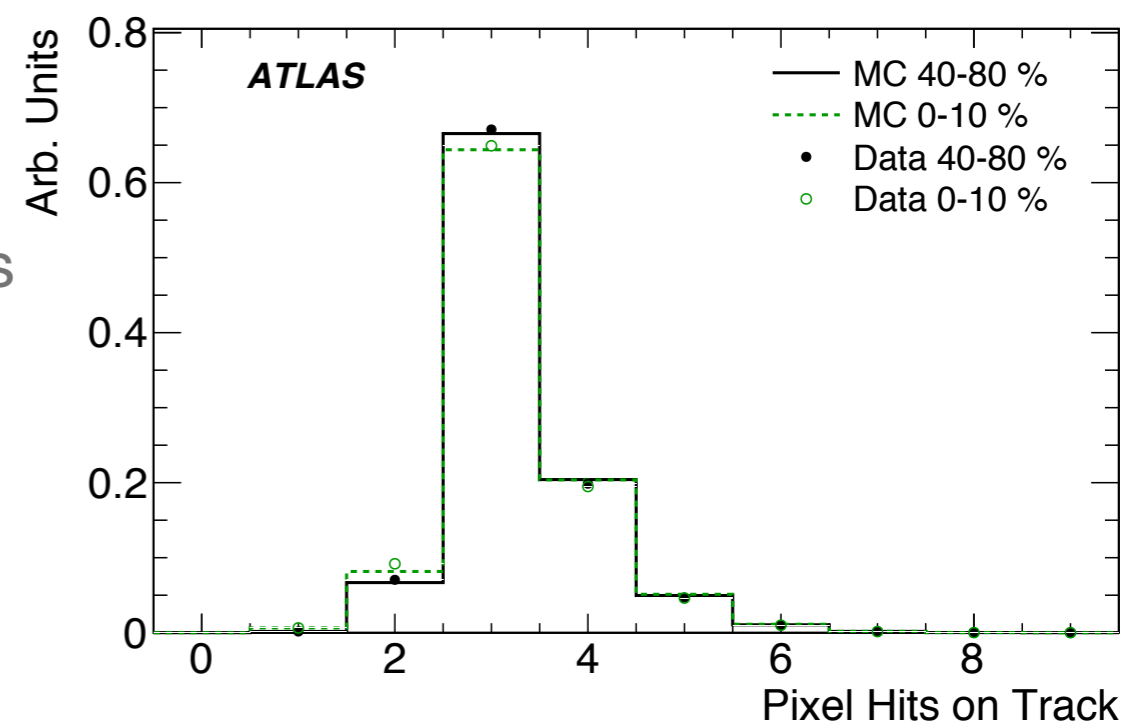
- Reconstruction efficiency
- Signal extraction





Systematics: Monte Carlo driven efficiency determination

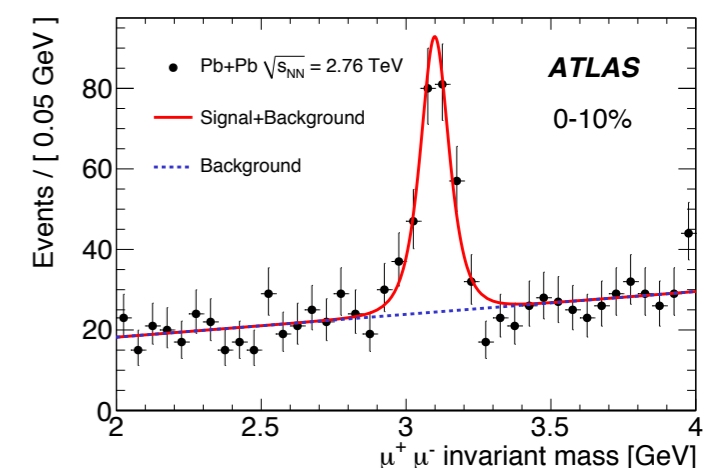
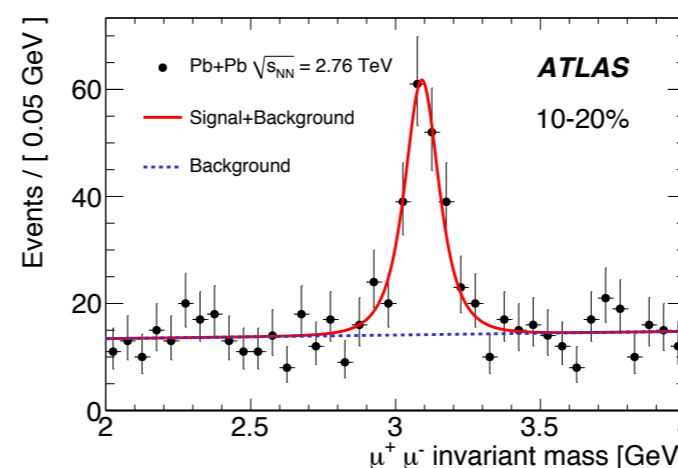
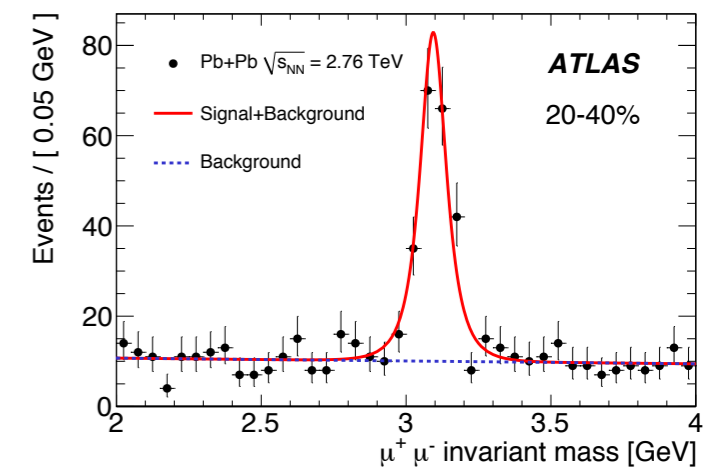
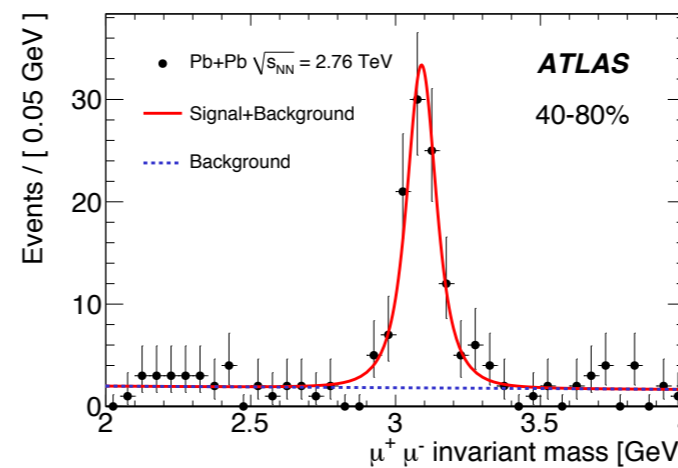
- Most of the efficiency dependence from centrality is coming from ID
 - occupancy effects causing good tracks to fail our track selection cuts
- Estimate systematics by comparing differences between data and MC on the selection threshold
- Studied as a function of centrality
 - maximum deviation of 3% found in the most central bins
 - 2 muons \rightarrow 6% maximum total systematics



Systematics: Signal extraction



- Cross-check yields using a maximum likelihood fit with the mass resolution left as free parameter
- Two different background models were used: first and second order polynomial
- Maximum deviation of the fitted yield compared to the sideband subtraction method taken as systematic error





The J/ψ result: Final numbers

Centrality	$N^{\text{meas}}(J/\psi)$	$\epsilon(J/\psi)_c / \epsilon(J/\psi)_{40-80}$	Systematic Uncertainty		
			Reco. eff.	Sig. extr.	Total
0-10%	190 ± 20	0.93 ± 0.01	6.8 %	5.2 %	8.6 %
10-20%	152 ± 16	0.91 ± 0.02	5.3 %	6.5 %	8.4 %
20-40%	180 ± 16	0.97 ± 0.01	3.3 %	6.8 %	7.5 %
40-80%	91 ± 10	1	2.3 %	5.6 %	6.1 %

- Correct for “average” J/ψ efficiency RATIOS vs centrality from MC
- Relative yield: everything normalised to most peripheral bin



This measurement must be interpreted as a relative yield within experimental acceptance: 2 muons with $p_T > 3$ GeV and $|\eta| > 2.5$

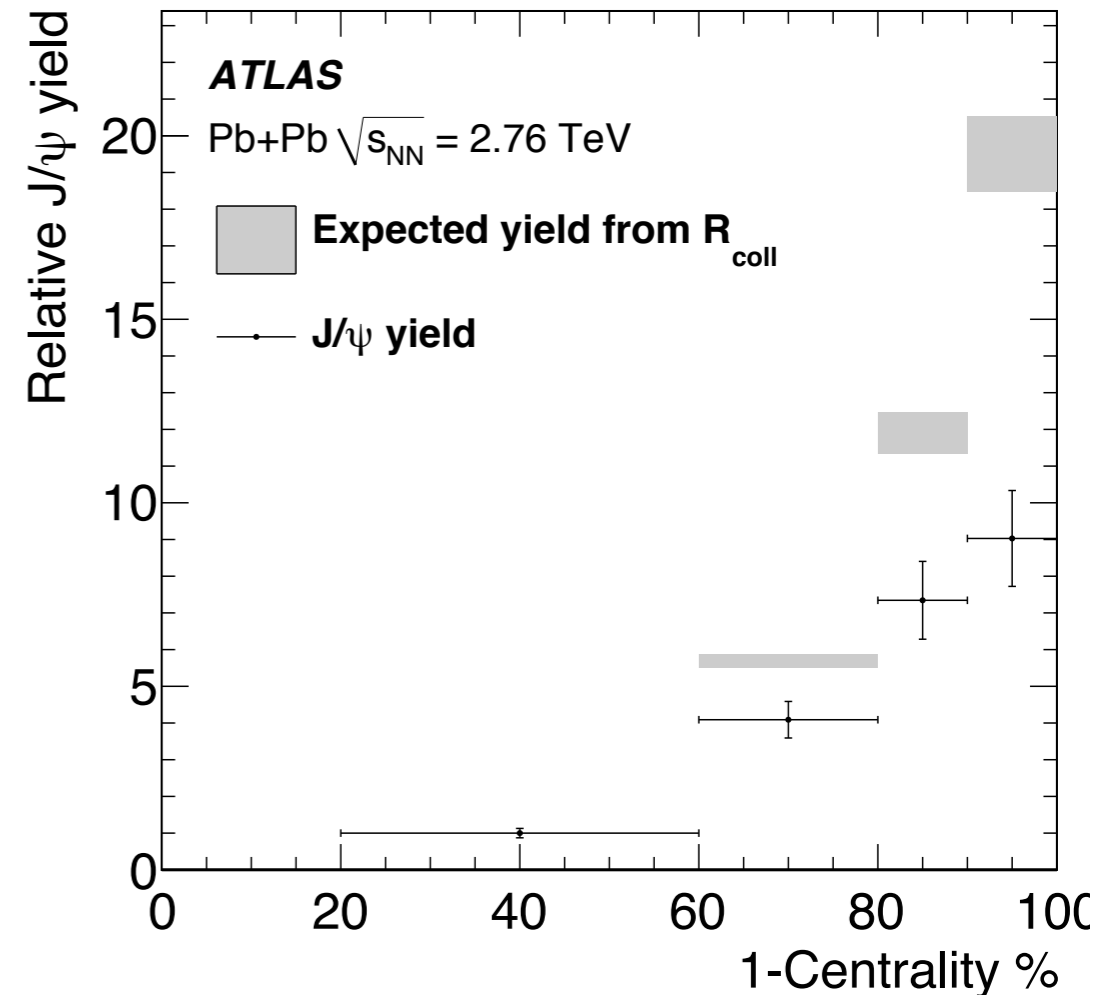


80% of the reconstructed J/ψ 's have a $p_T > 6.5$ GeV



The J/ψ result: Normalised yields

- Normalising yields:
 - correct for difference in relative cross-section due to differences in bin sizes
- Note: the uncertainties in the 40-80% bin are not propagated into the ratio for the more central bins
- Compare to: mean number of binary collisions calculated using a Glauber Monte Carlo (R_{coll})
 - uncertainty estimated by varying the input parameters of the Glauber MC by 1σ
 - impact of trigger bias was estimated to be very small. Accounted by a 2% systematic error.
- The result including statistical and systematical errors

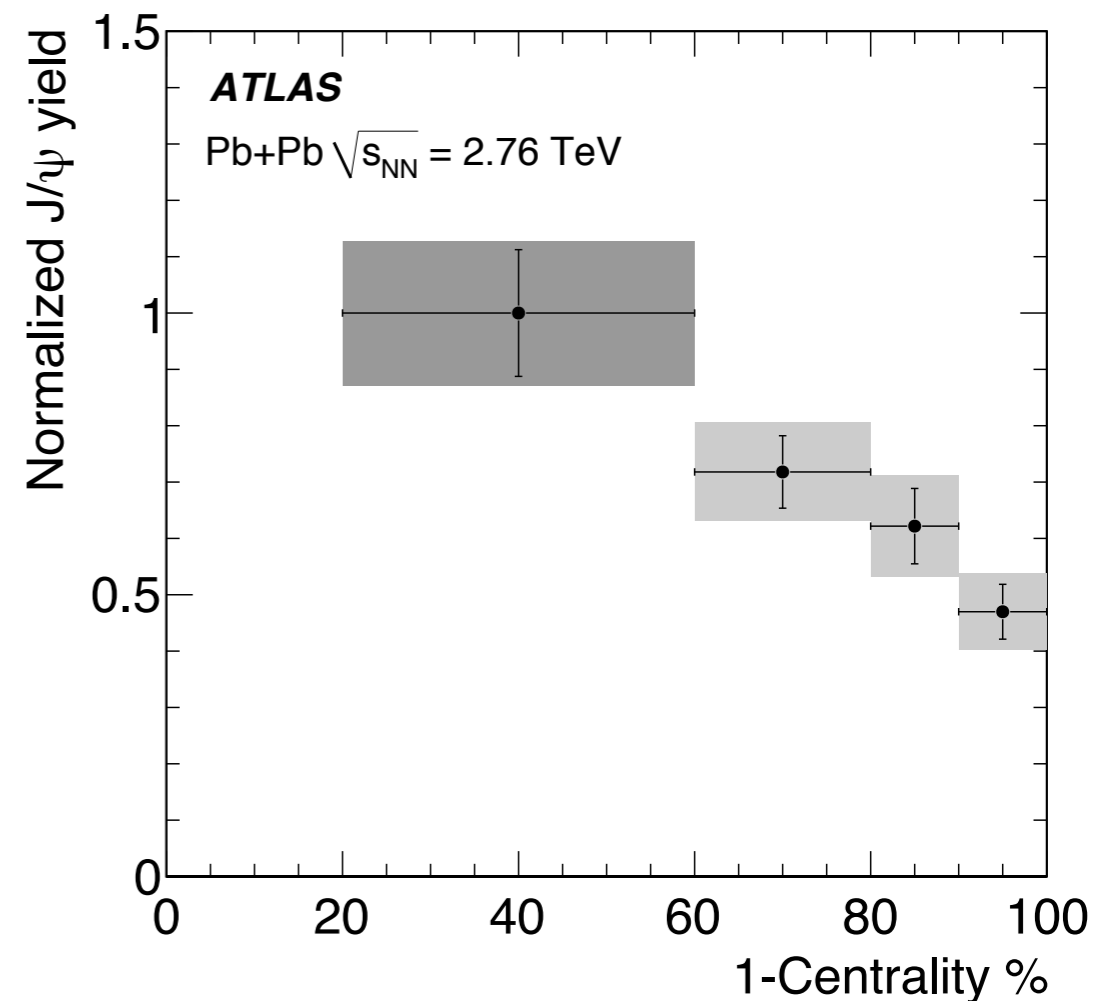


Centrality	R_{coll}	Uncertainty
0-10%	19.5	5.3 %
10-20%	11.9	4.7 %
20-40%	5.7	3.2 %
40-80%	1.0	—

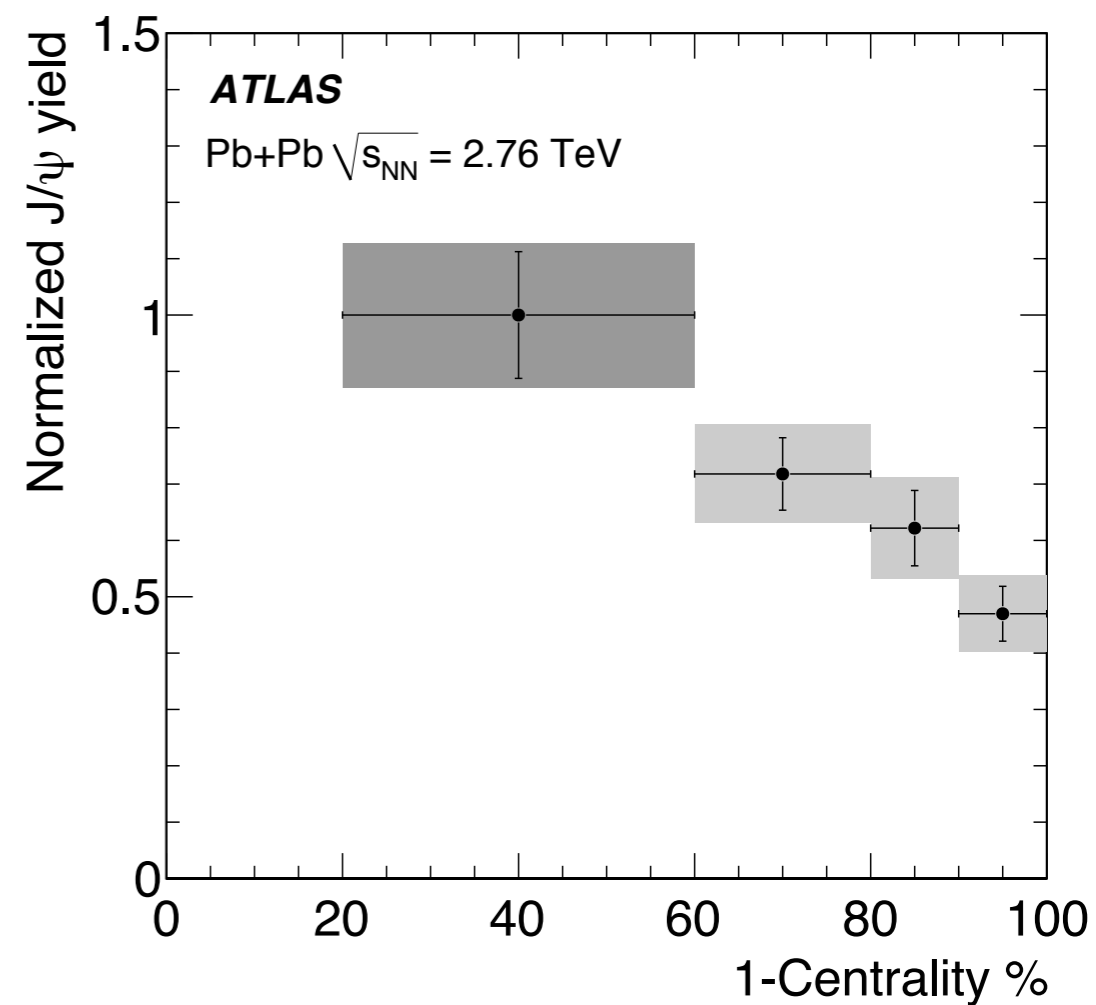
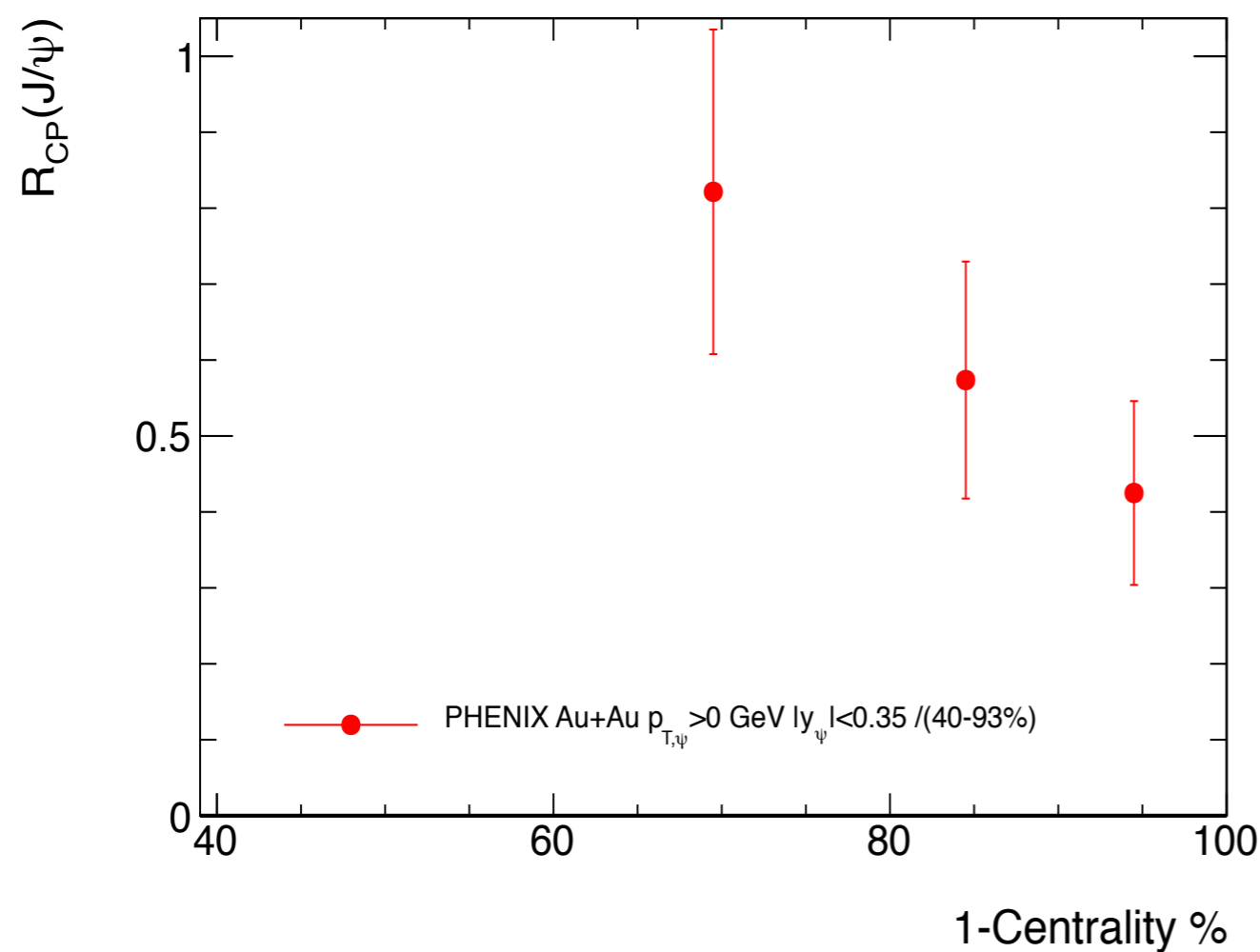


The J/ψ result: Normalised yields (2)

- Finally: yield normalised to mean number of binary collisions in each centrality bin
- Uncertainties on R_{coll} included as systematical errors on the points
- We observe a centrality dependent suppression of the J/ψ yield
 - probability that the data points are consistent with their average
 - $P(\chi^2, ndof) = 0.11\%$



The J/ψ result: ATLAS vs PHENIX



- PHENIX result: obtained by integrating previously shown result over p_T
- Similar trend observed as in ATLAS data
 - momentum ranges very different

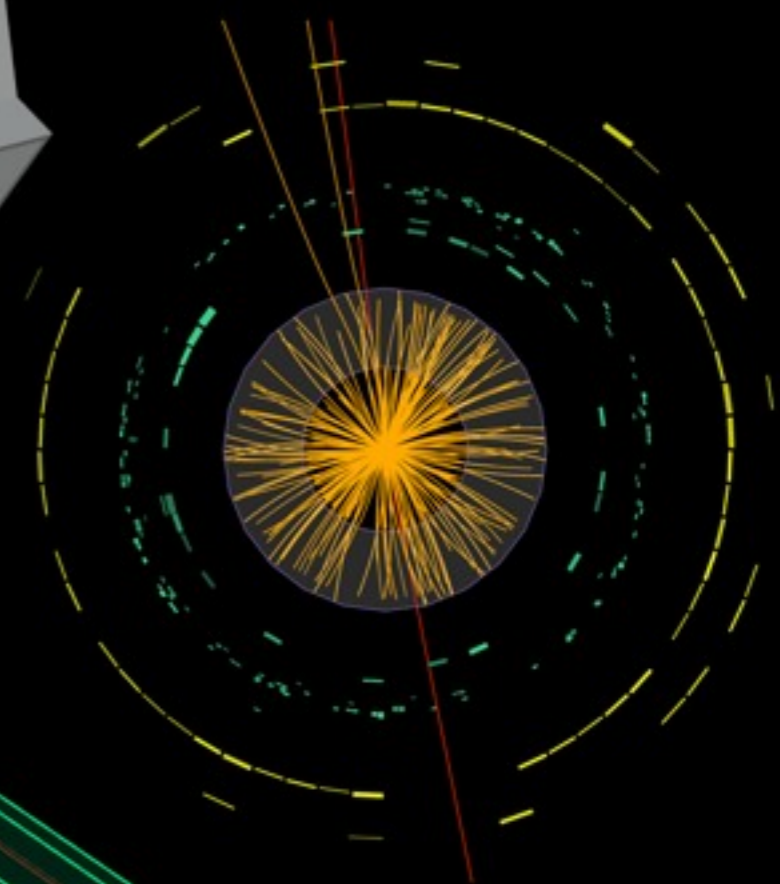
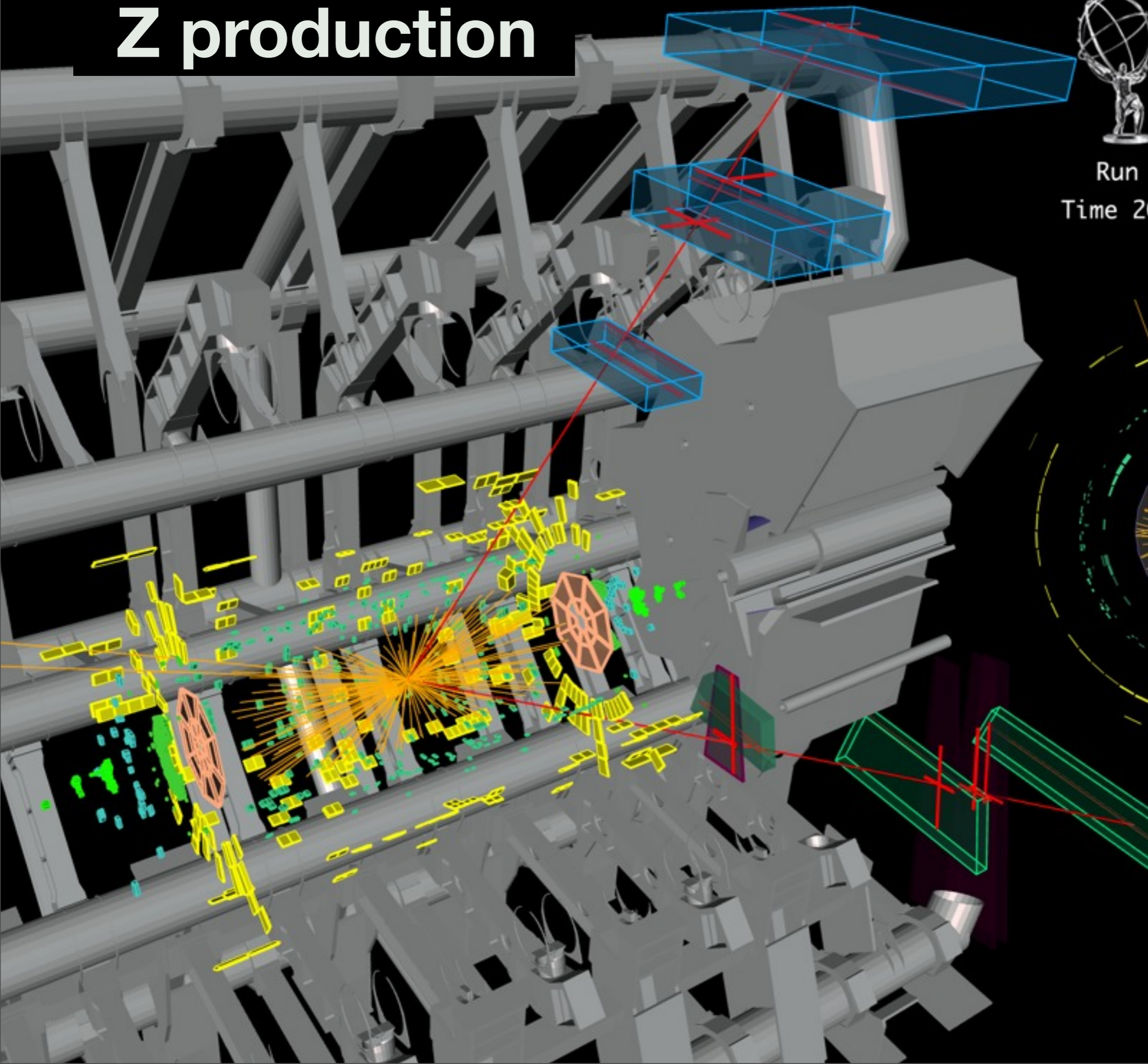
Z production



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Run 169045, Event 728772

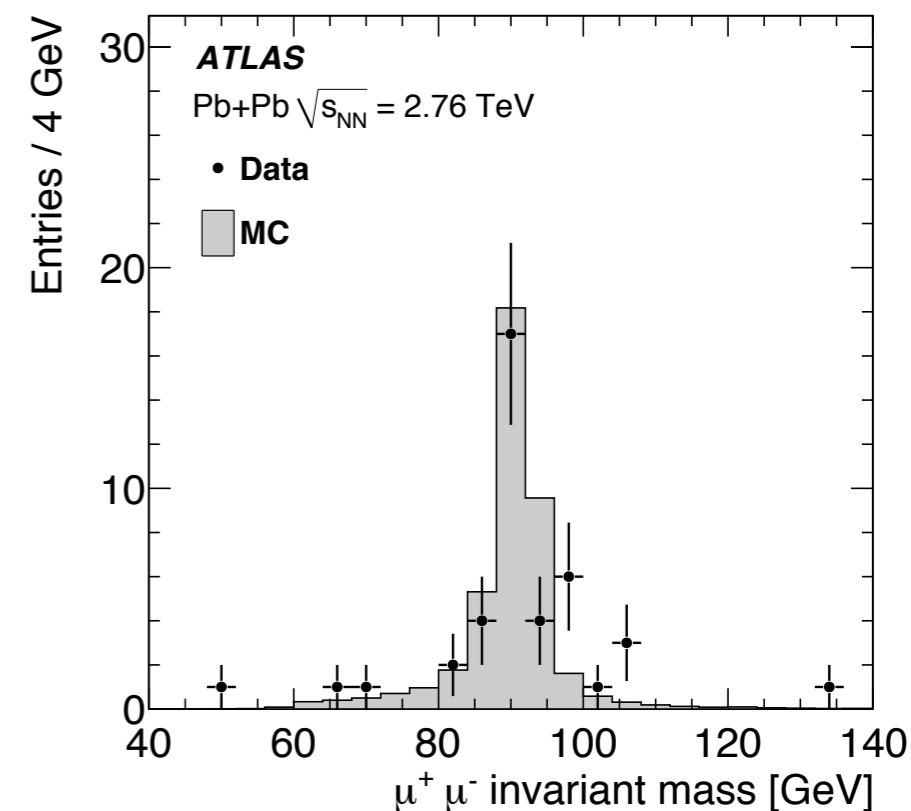
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Heavy Ion
Collision with
a $Z \rightarrow \mu\mu$
Candidate

Z production in lead-lead collisions: event selection

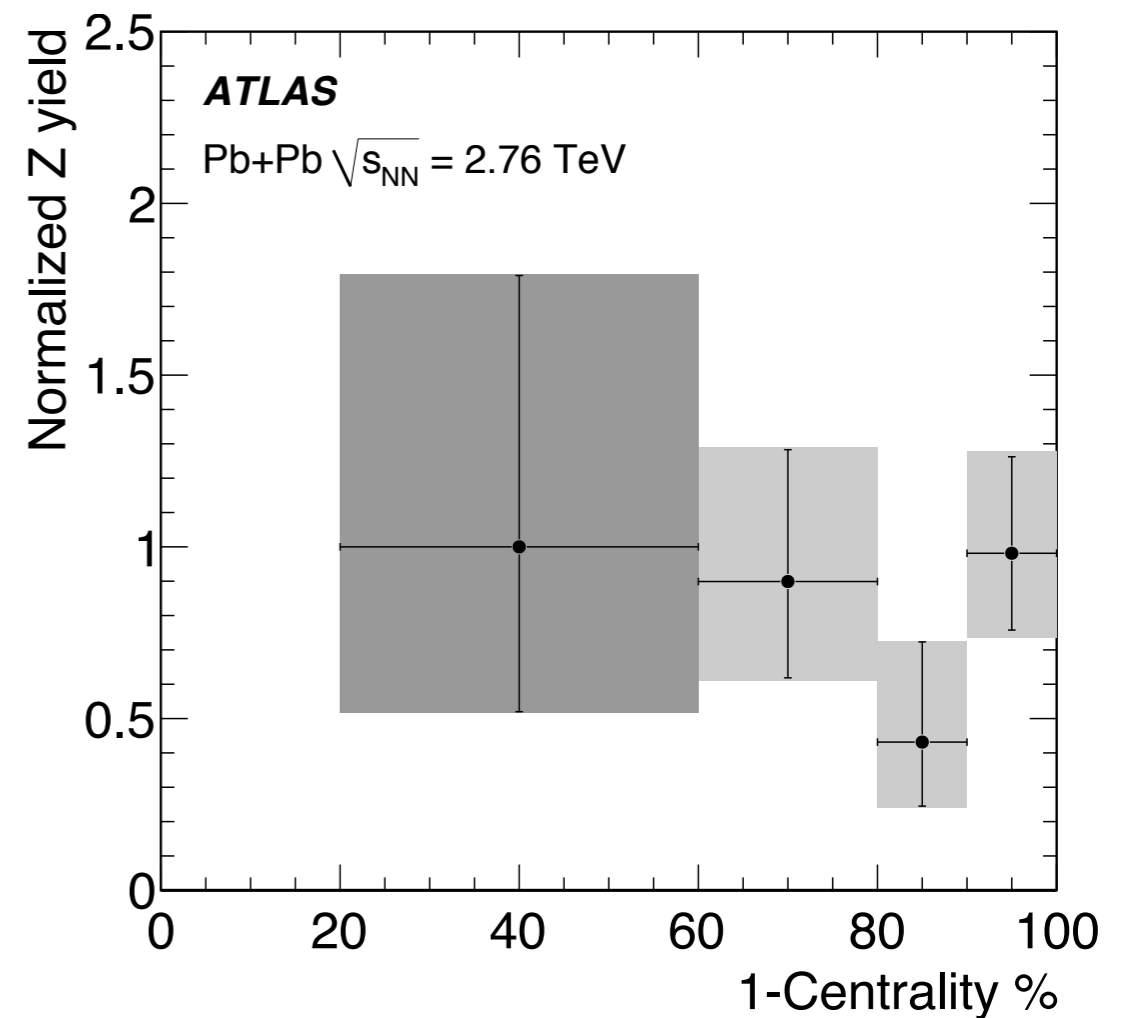
- Event selection:
 - two combined muon with opposite charge
 - $p_T > 20$ GeV
 - $|\eta| < 2.5$
 - $|\eta_1 + \eta_2| > 0.01$ (cosmic rejection)
 - mass window [66, 116] GeV
- 38 Z candidates observed
- Relative yield calculation
 - same method applied as for the J/ ψ
 - systematics have been assumed to be the same as for the J/ ψ (conservative estimate)



Z production in lead-lead collisions: centrality dependence



- Relative Z boson yield found to be compatible with a linear scaling with the number of binary collisions
- Low statistics precludes any definite conclusions



Conclusions

- First results on the J/ψ and the Z relative yields in lead-lead collisions obtained with the ATLAS detector
- We observe a centrality dependent suppression in the normalised J/ψ yield
- The relative yield of the 38 observed Z candidates as a function of centrality is presented
 - no definite conclusions for the Z bosons can be inferred given the current statistics
 - the distribution is compatible with a flat distribution

