Measurements of the mid-rapidity parity violating spin asymmetries for $W^{\pm}$ bosons at PHENIX

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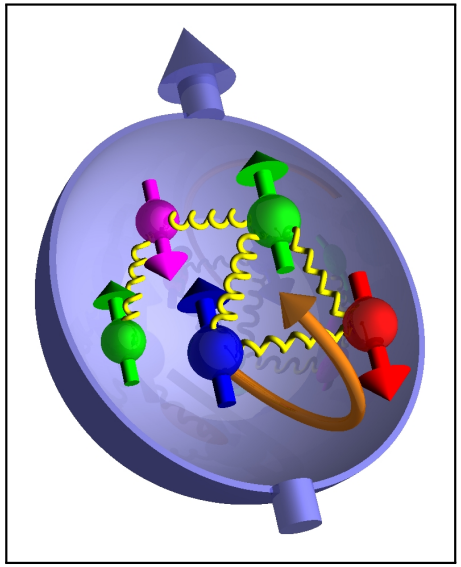
Spin Puzzle

- 20 years on we are still puzzled by the proton spin



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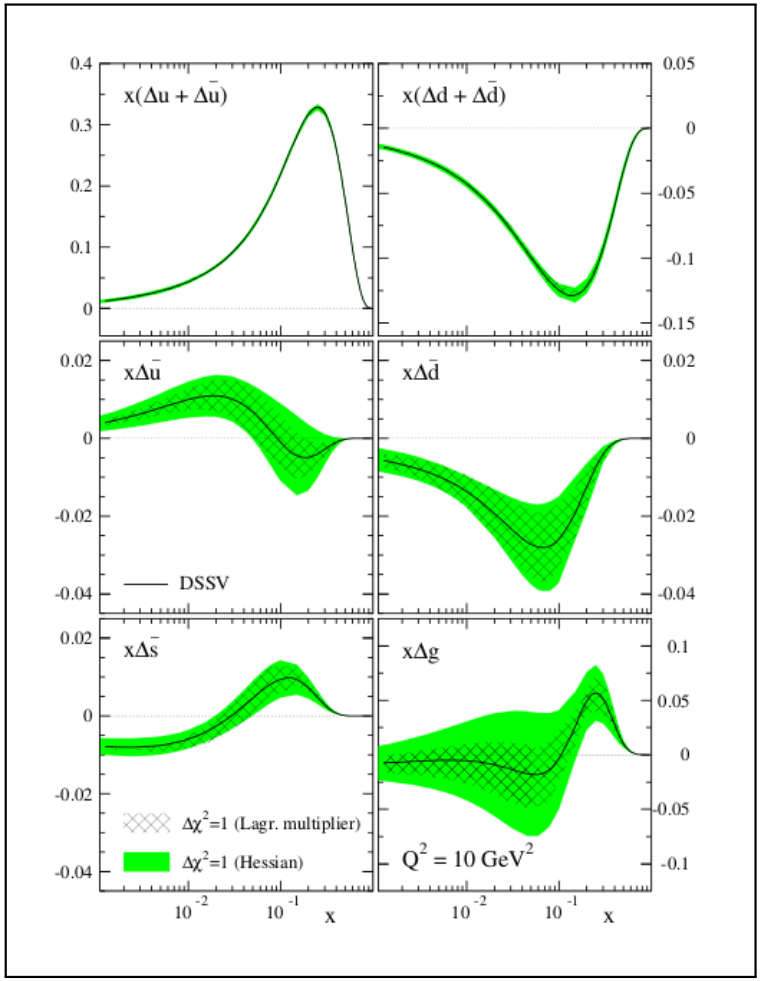
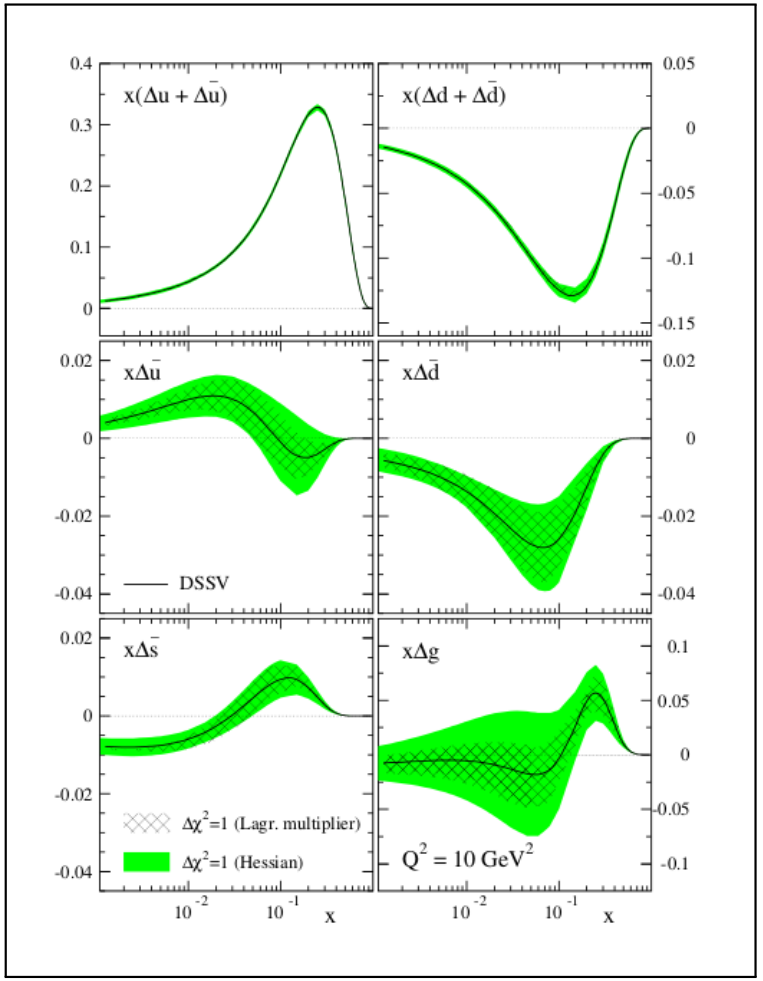


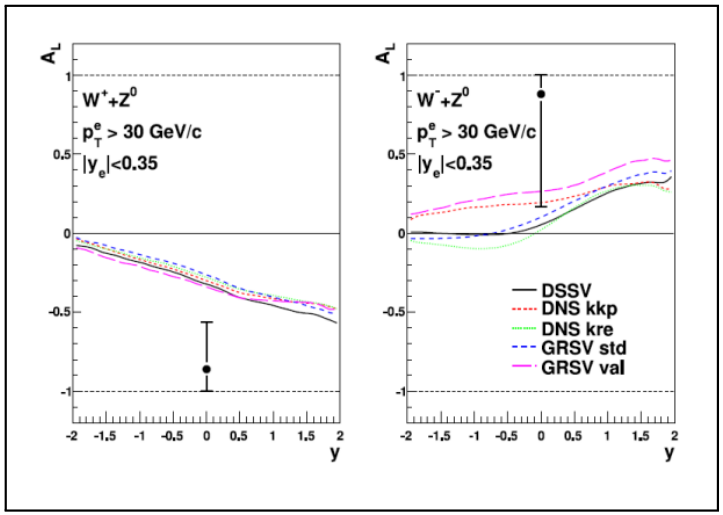
Spin Puzzle

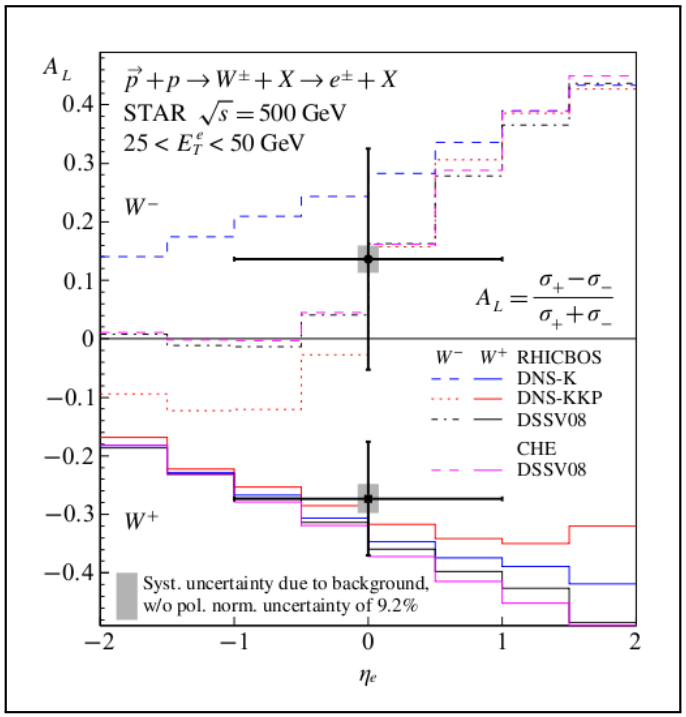
- 20 years on we are still puzzled by the proton spin
- But we are narrowing down on most of the components
- The constraints on the $\Delta\bar{u}$, $\Delta\bar{d}$ polarized parton distribution functions come from SIDIS experiments alone (mainly HERMES) and here is where the RHIC W program will bring further constraints



Current Status

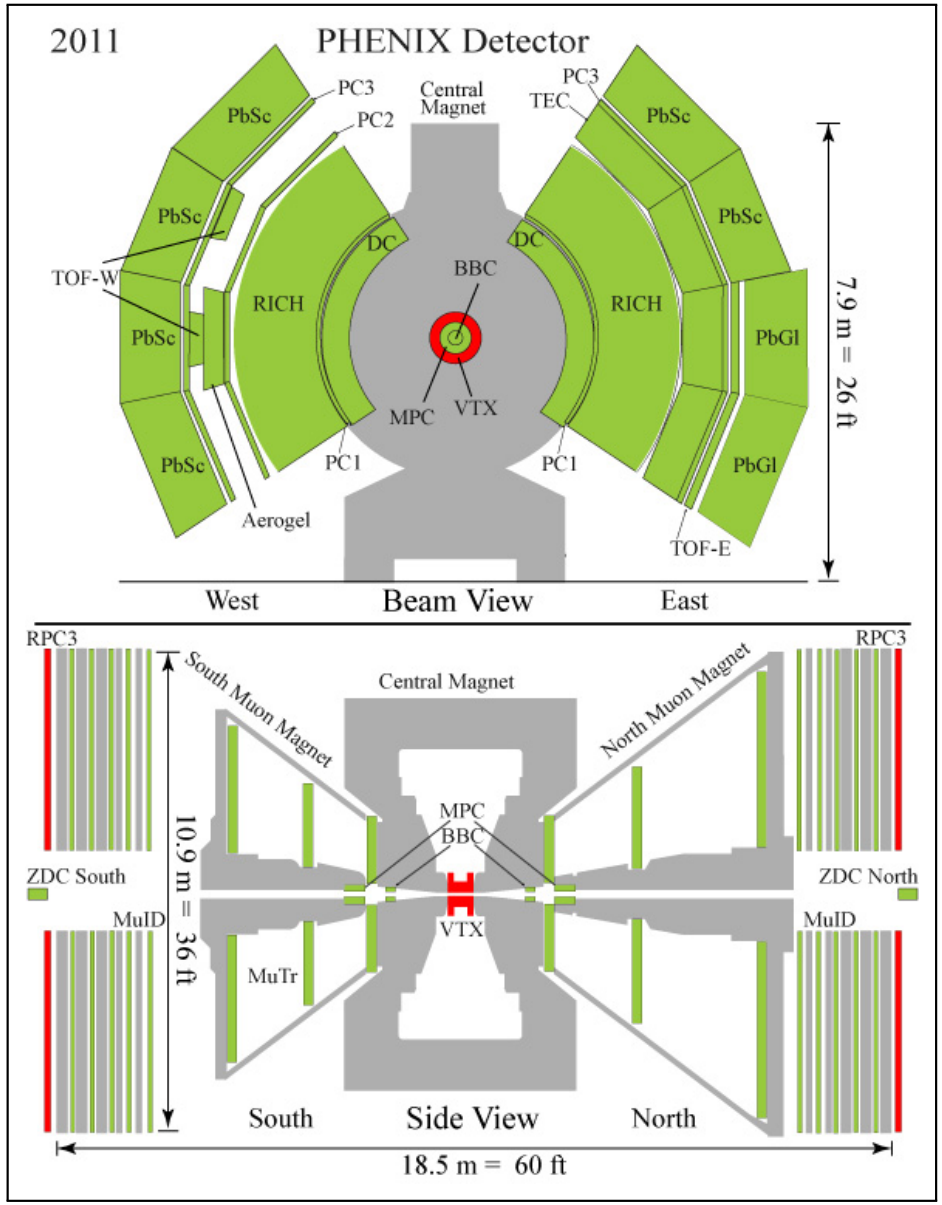
- In Run 2009 both PHENIX [1] and STAR [2] proved the feasibility of W measurements at central rapidities using the $W^{\pm} \rightarrow e^{\pm} + X$ decay channel
- Since then PHENIX has accumulated $\approx$46 pb^{-1} (Run 2011 and Run 2012)
- Polarization values for both beams have increased from $\approx$40% to $\approx$51%





PHENIX Detector

- $|\eta| < 0.35$ and $\Delta\phi = \pi$
- Electromagnetic Calorimeter (EMCal)
  $\Delta\phi \times \Delta\eta \approx 0.01 \times 0.01$
- Drift Chamber (DC) and Pad Chamber used for track matching and charge separation
- VTX Detector (commissioned during Run 2011)

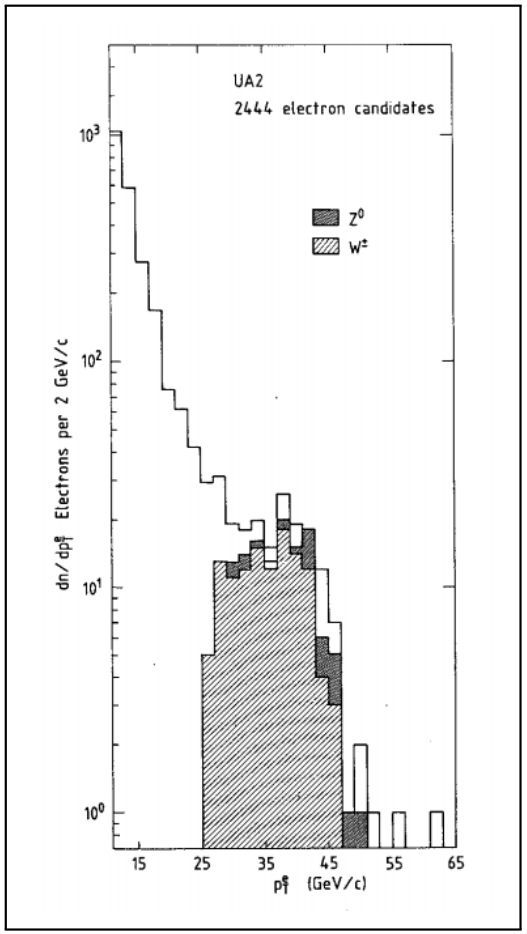


Analysis idea

- Limited ϕ coverage means we can only identify the electron/positron
- We use a similar procedure as UA1/2
- Try to reduce the background as much as possible and take the region between 30 and 50 GeV as the signal region, while using the 10 to 20 GeV region for background estimation
- Use the spin differentiated yields to construct an asymmetry:

$$A_L = \frac{1}{P}\frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$$

- For mid rapidity ($|\eta| < 0.35$):
  - W^+: A_L is a combination of $\Delta\bar{d}$ and Δu
  - W^-: A_L is a combination of $\Delta\bar{u}$ and Δd

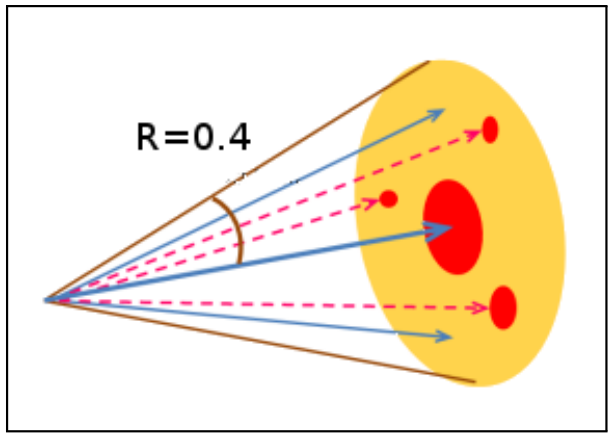


The enemy

- Reducible Backgrounds
  - π, $\eta \rightarrow \gamma\gamma$, or direct photon, followed by conversions to $e^{\pm}$
  - Cosmic rays
  - Beam related backgrounds
- Irreducible Backgrounds (pass cuts)
  - $Z \rightarrow e^{+} + e^{-}$
  - Other W decays ($W \rightarrow \tau + \nu_{\tau} \rightarrow e + \nu_{e}\bar{\nu_{\tau}}\nu_{\tau}$) (very small)
  - charm, bottom decays to $e^{\pm} + X$ (very small)

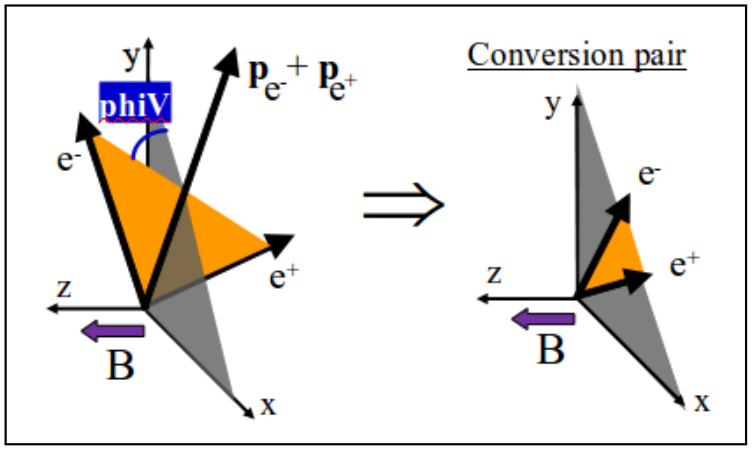
Triggering and Isolation

- High energy triggering in the EMCal (we are fully efficient at 10 GeV)
- Matching between the EMCal clusters and the DC (for charge determination)
- We use a relative isolation cut as our main background reducer (energy in a cone of $R = 0.4$ divided by the energy of the candidate electron/positron)



The VTX increases the conversion background

- phiV is a variable that describes the alignment between the plane of the electron/positron pair and magnetic field



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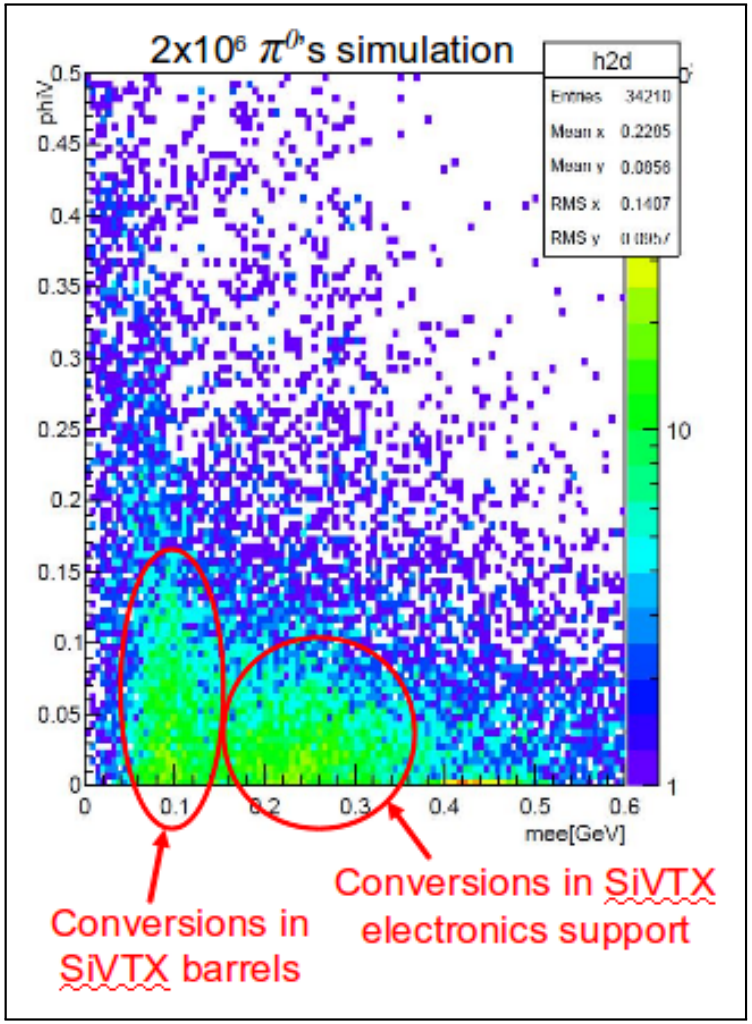
- phiV is a variable that describes the alignment between the plane of the electron/positron pair and magnetic field
- The conversions lie at small phiV (smaller than 0.15) and small invariant mass of the electron/positron pair



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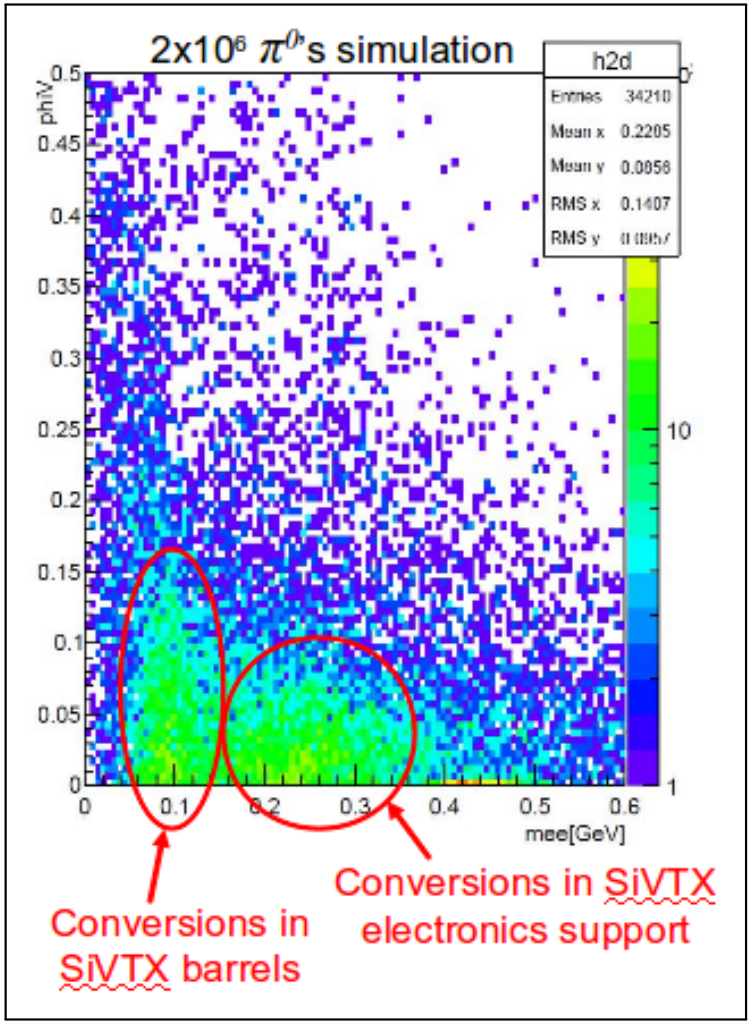
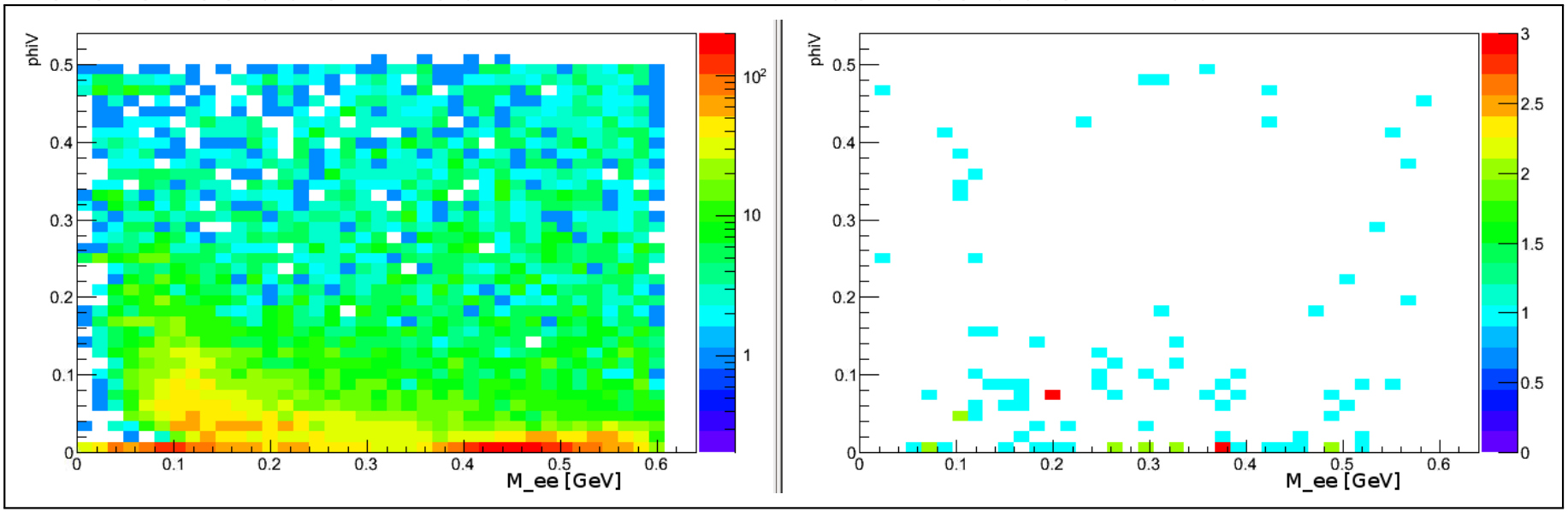
- phiV is a variable that describes the alignment between the plane of the electron/positron pair and magnetic field
- The conversions lie at small phiV (smaller than 0.15) and small invariant mass of the electron/positron pair
- We can clearly see two structures that represent the VTX barrels (active area) and electronic support structure of the VTX



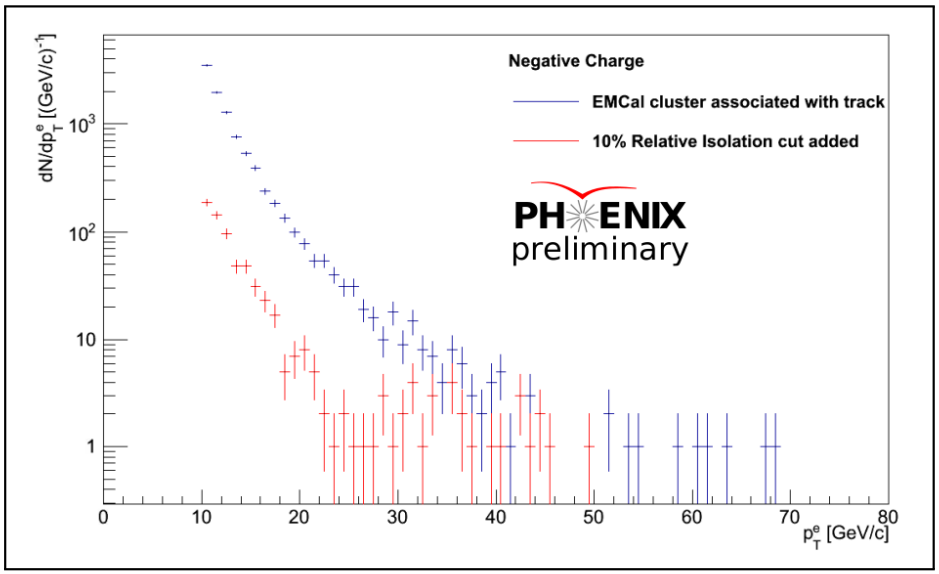
Isolation cut reduces identified conversions

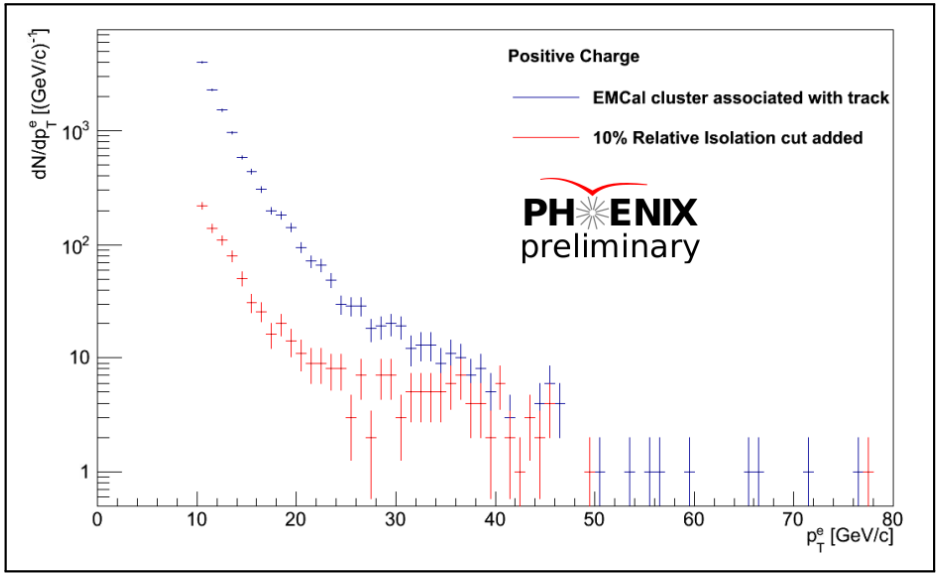
Before Isolation Cut **After Isolation Cut**



- Using the relative isolation cut we can mitigate the identified VTX effect

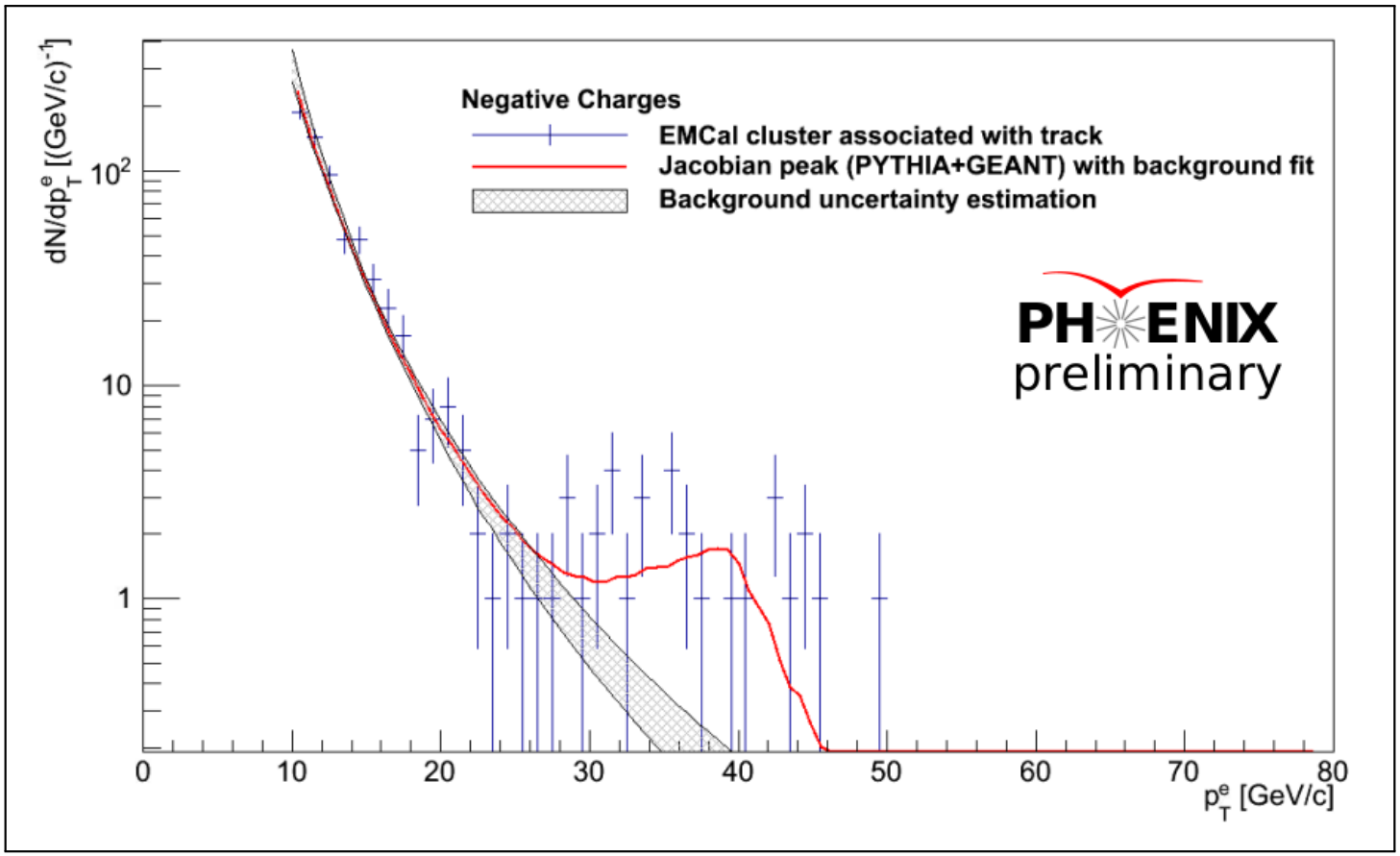
Isolation cut effect on our spectrum





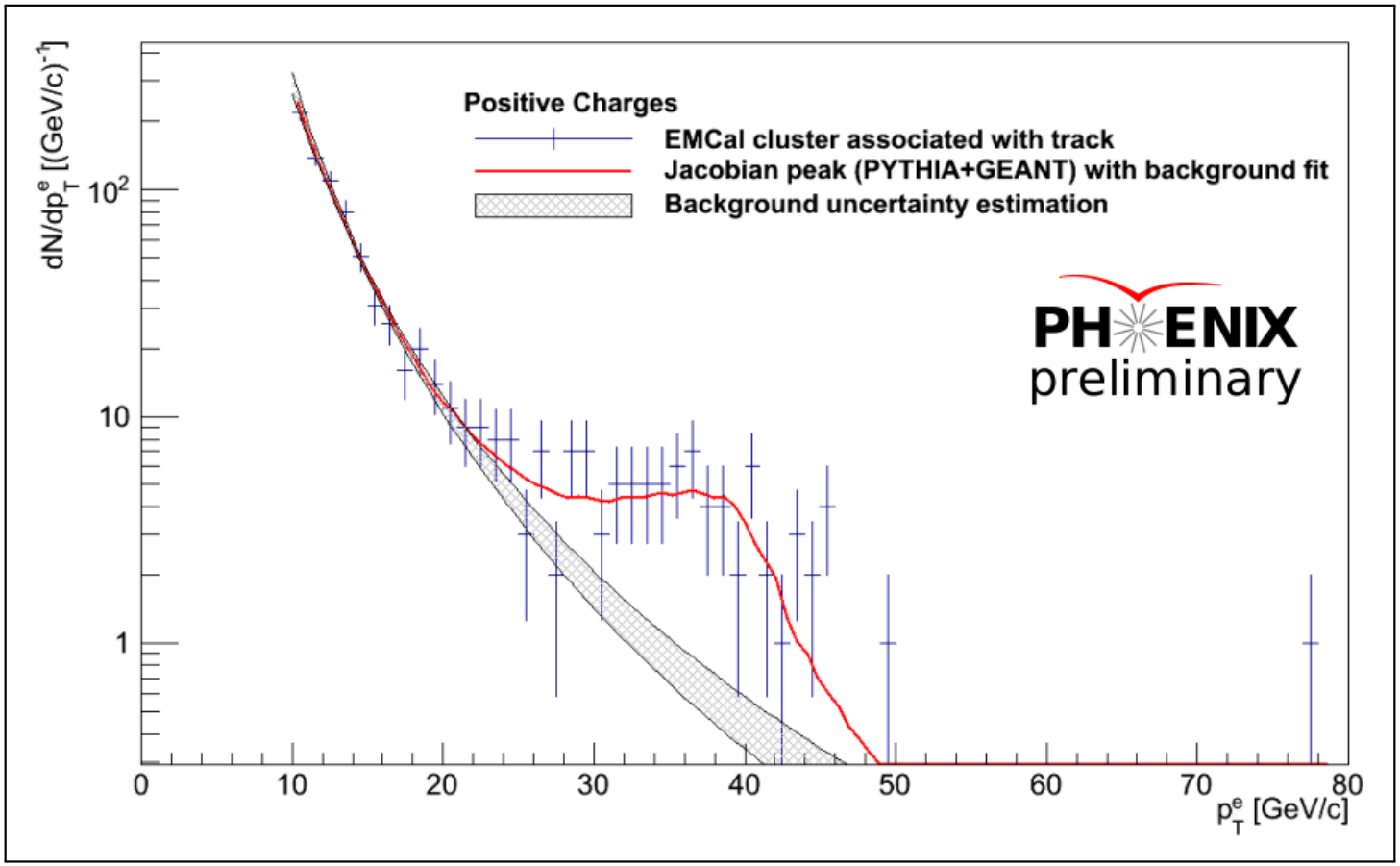
- The relative isolation cut removes more than a factor of 10 in the background dominated region (10-20 GeV) while leaving the signal region (30-50 GeV) relatively untouched

Preliminary $W^- + Z$ spectrum



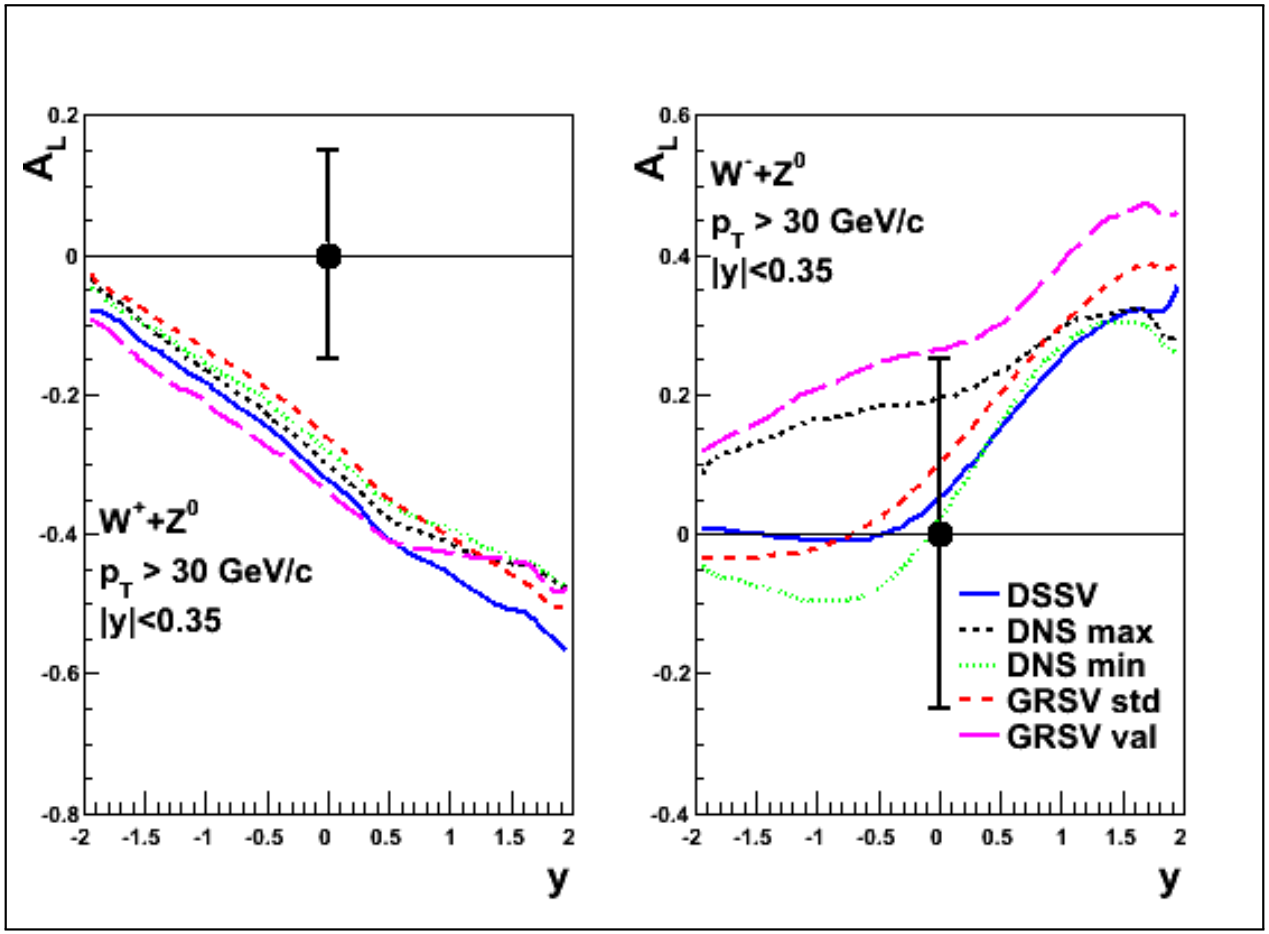
- After all of our cuts we have ≈14% background in our signal region (30 to 50 GeV)

Preliminary $W^+ + Z$ spectrum



- We achive, after all cuts, ≈17% background in our signal region (30 to 50 GeV)

Expected uncertainties for A_L



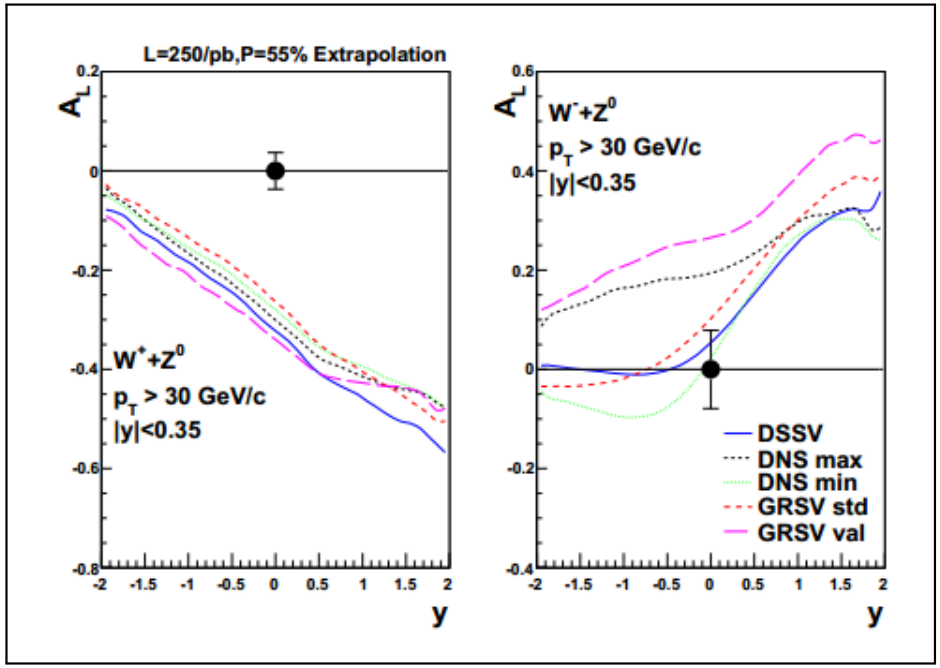
- The expected uncertainties for Run 2011 get us one (small) step closer to being able to have rejection power of theoretical curves

Summary

- From recorded data we have more than 5 times the initial (Run 2009) integrated luminosity (Run 2011 + Run 2012)
- On top of that the significant increase in polarization will help us to get an even better result
- We have performed most of the analysis (for the Run 2011 data) and have a clear Jacobian peak for both W^+ and W^- together with a background estimation
- Stay tuned for asymmetry results

Still to come

- Run 2012 brought us not only more than half of our current data but also data from the VTX which should improve our isolation cut
- The FVTX installation during Run 2012 will add more material for conversions that we need to mitigate
- The upcoming run (Run 2013) is expected to bring us ≈160 pb^{-1} of data at ≈55% polarization giving us enough data to finalize our W measurements



Refferences

- A. Adare *et al.* [PHENIX Collaboration], Phys. Rev. Lett. **106**, 062001 (2011) [arXiv:1009.0505 [hep-ex]].
- M. M. Aggarwal *et al.* [STAR Collaboration], Phys. Rev. Lett. **106**, 062002 (2011) [arXiv:1009.0326 [hep-ex]].