Search for the $\bar{\Theta}^-$ with PHENIX

Chris Pinkenburg for the PHENIX collaboration

Quick Pentaquark reminder

$\bar{\Theta}^-$ reconstruction with PHENIX

$\bar{n}K^-$ invariant mass distribution in d-Au

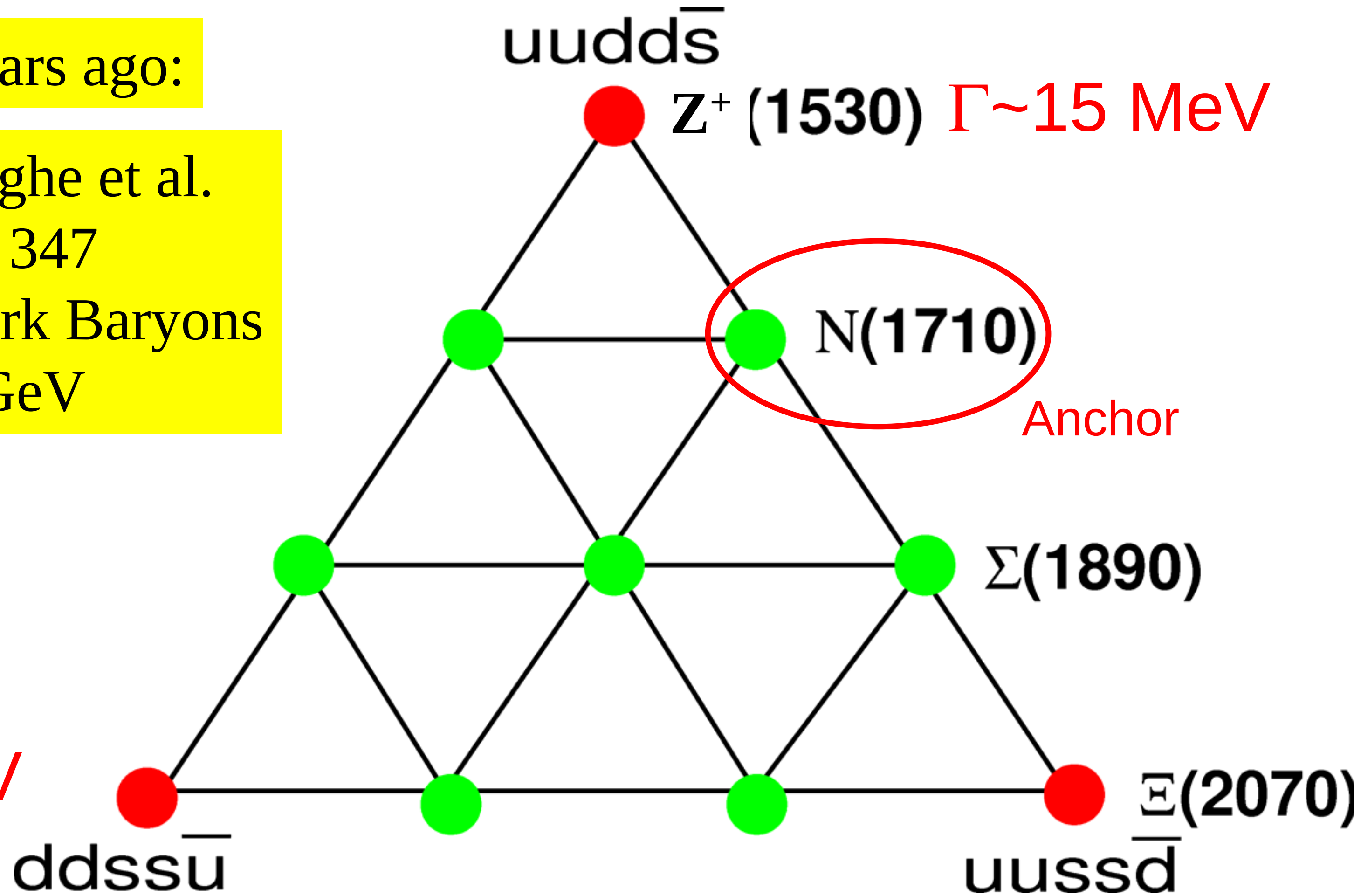
Conclusions

The Anti-decuplet predicted by Diakonov et al.

Z.Phys. A359, 305 (1997)

Almost 25 Years ago:

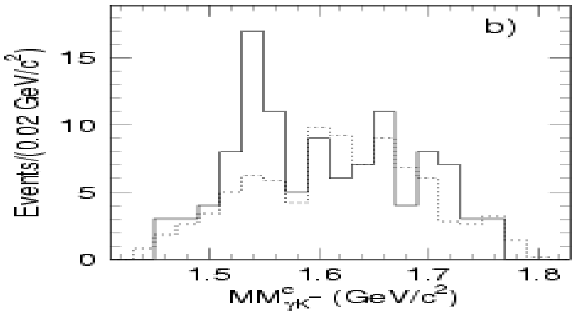
M. De Crombrugghe et al.
NPB 156 (1979), 347
Narrow Multiquark Baryons
M(uudd$\bar{s}$) = 2.5 GeV



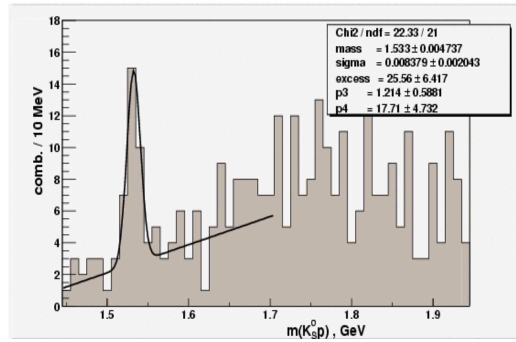
Γ~140 MeV

Θ^+ Θ^+ Θ^+ Θ^+....

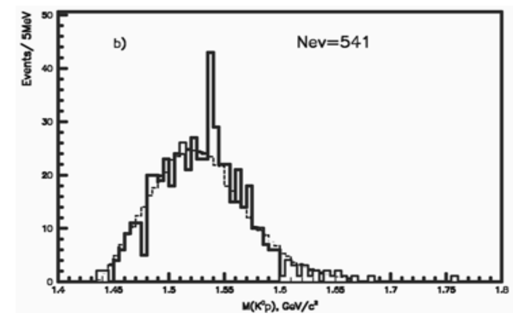
LEPS@SPring8



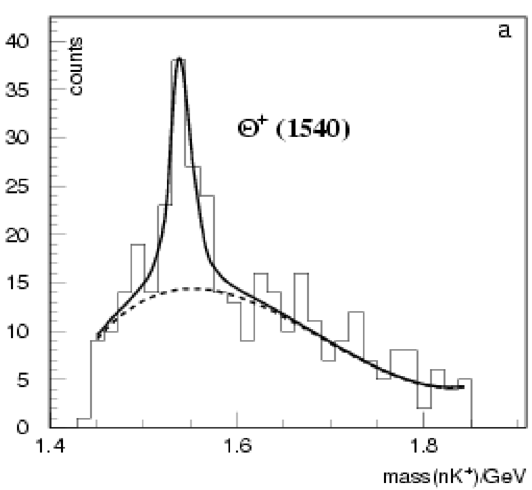
ITEP



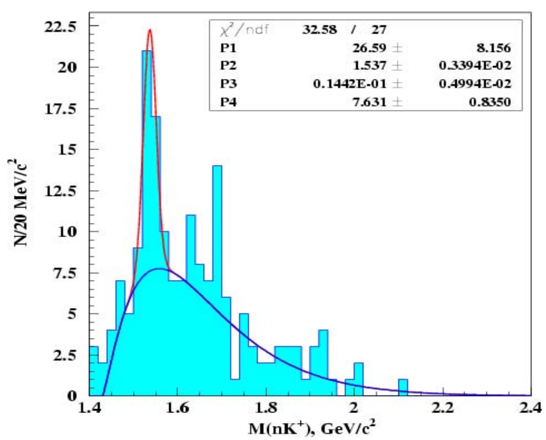
DIANA@ITEP



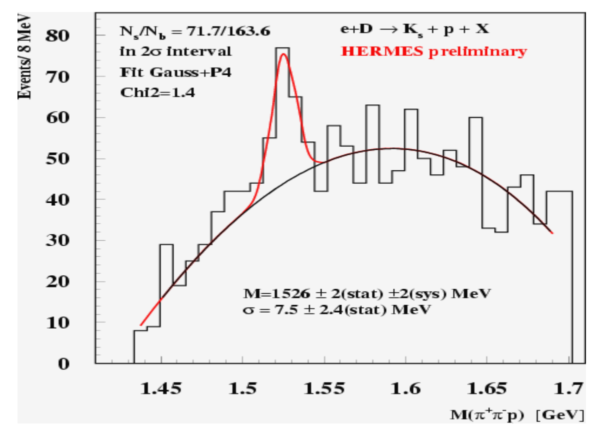
SAPHIR @ ELSA



CLAS@JLAB

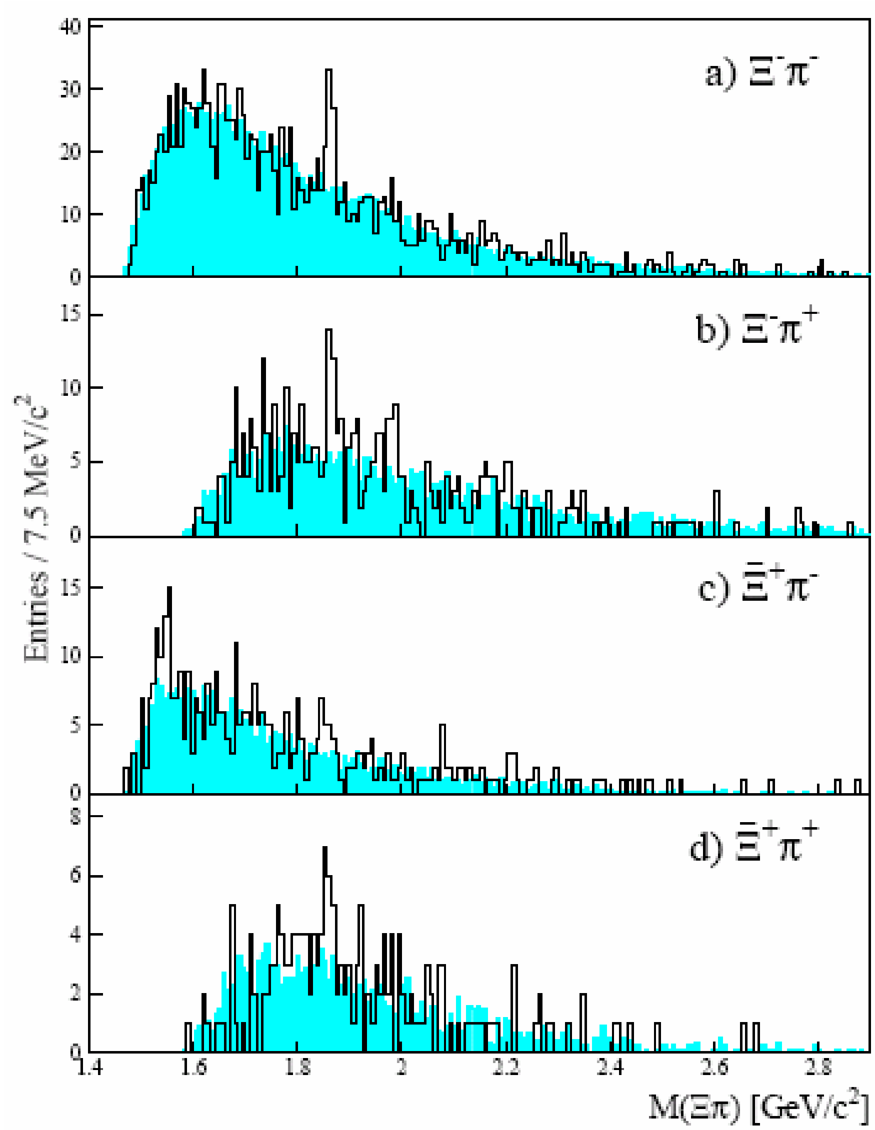


HERMES@DESY



… and the Ξ^{--}

NA49@CERN



C. Alt et al., hep-ex/0310014

Where do we stand with the Θ^+?

Experiments	Results Mass (MeV)	Width (Mev)	Significance (σ)
LEPS	$1540\pm10\pm5$	$\Gamma < 25$	4.6 ± 1
DIANA	$1539\pm2\pm$"few"	$\Gamma < 8$	4.4
CLAS	$1542\pm2\pm5$	FWhM < 21	5.3 ± 0.5
SAPHIR	$1540\pm4\pm2$	$\Gamma < 25$	4.8
ITEP (ν's)	1533 ± 5	$\Gamma < 29$	6.7
HERMES	$1526\pm2\pm2.5$	$\Gamma < 20$	5.6
World Average	**1535 ± 2.5**	Very Narrow	
Prediction	1530 $\Gamma < 15$	I=0 S=+1	$J^P=\frac{1}{2}^+$

Borrowed from Kreso.Kadija@cern.ch, talk at CERN, November 25, 2003.

What can PHENIX do?

$\Theta^+ \rightarrow K^0 + p$
Fairly hopeless due to small acceptance (three particles in small aperture)

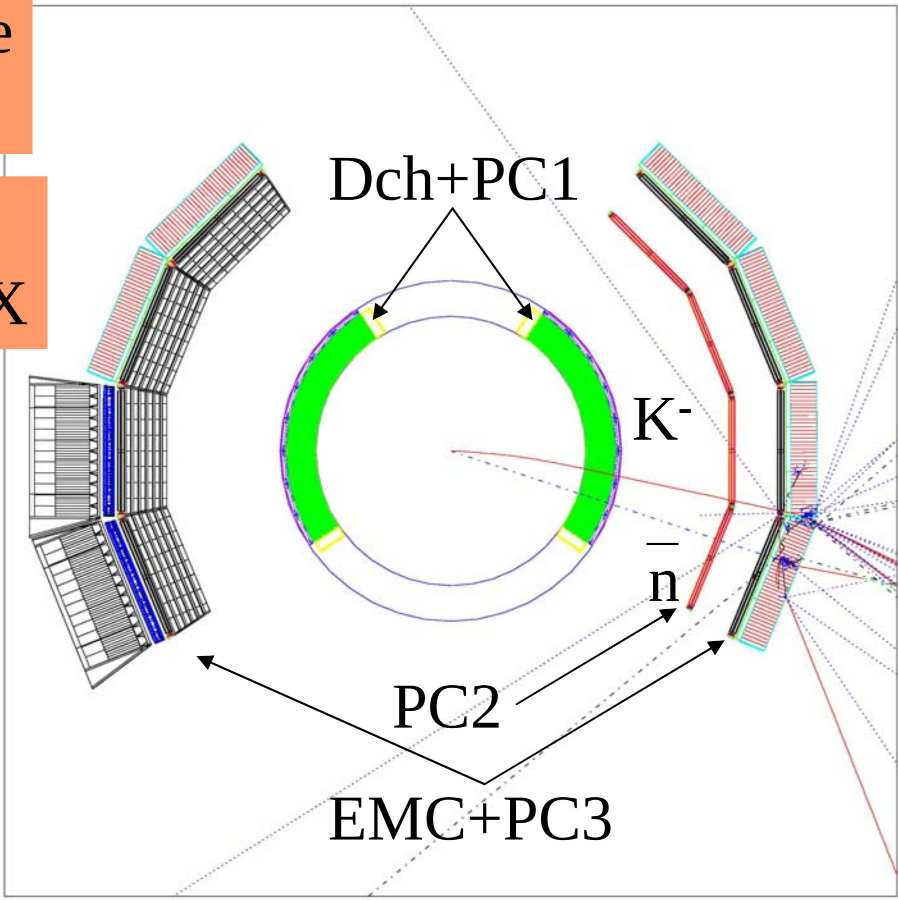
$\Theta^+ \rightarrow K^+ + n$
Neutron difficult to identify in PHENIX

But how about the Anti Particle?

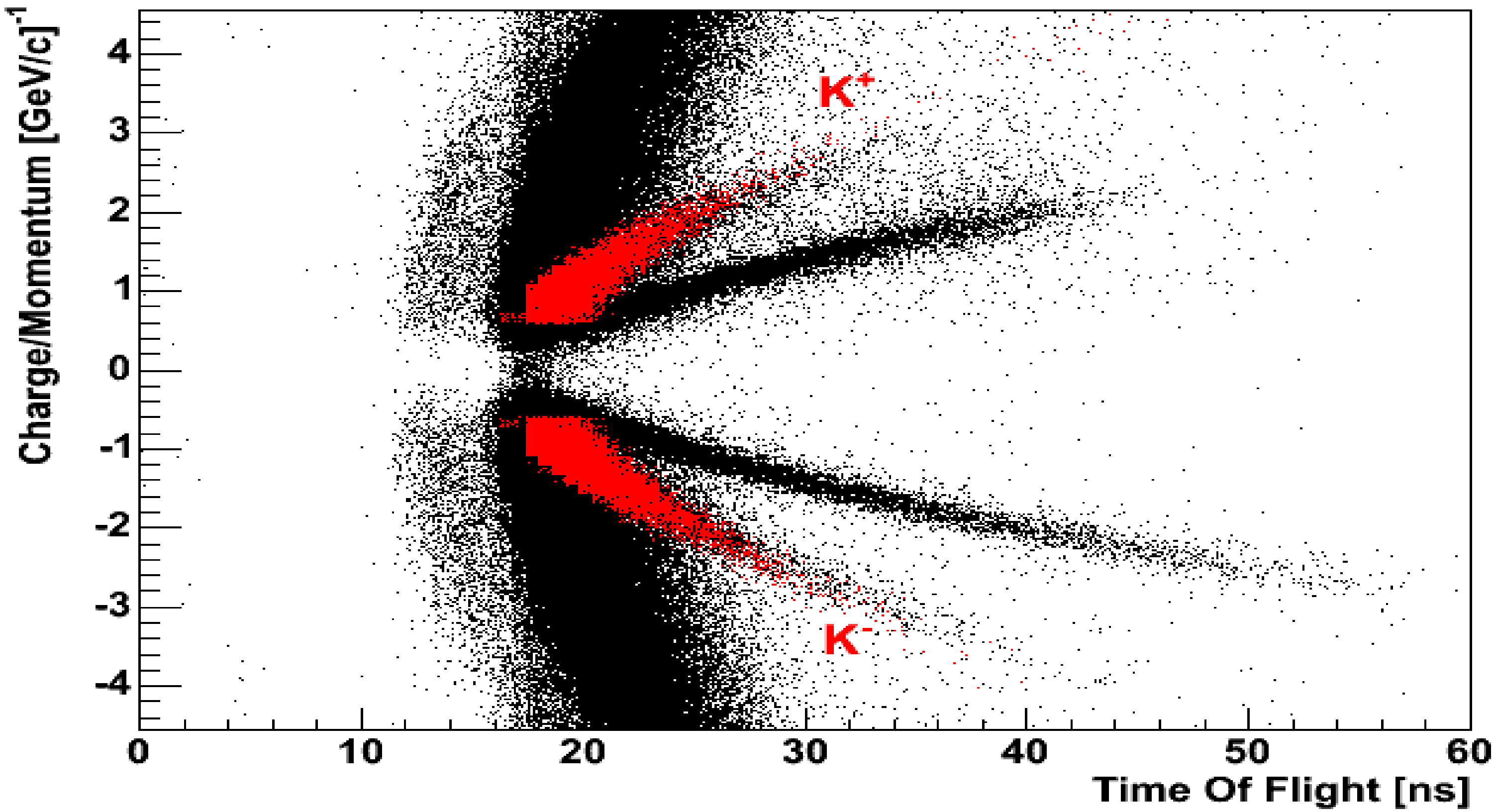
$\bar{\Theta}^- \rightarrow K^- + \bar{n}$

Looks fairly straightforward:
Search for a big cluster in the electromagnetic calorimeter caused by an $\bar{n}$ annihilation and combine it with a K^-

Simulated $\bar{\Theta}^- \rightarrow K^- + \bar{n}$



Charged Kaon Pid

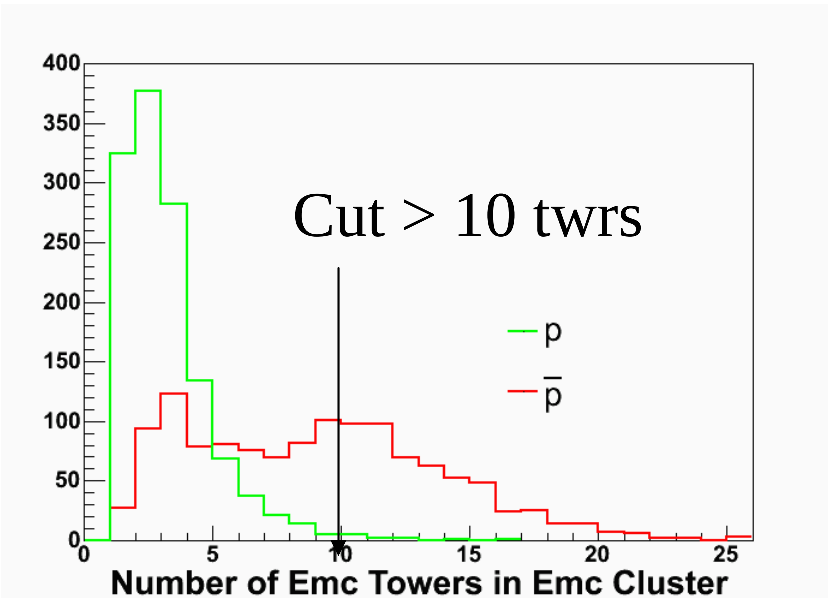


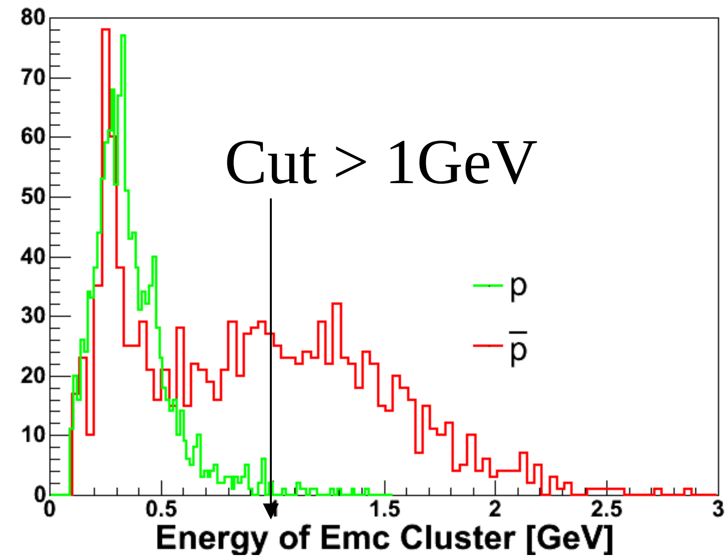
Standard Identification via Time Of Flight from the EMC and Momentum determined by Track Curvature in Magnetic Field

1.5 GeV/c Momentum cut to reduce Contamination by Pions

Anti Neutron Pid

Strategy based on Lars Ewell's initial work: Take identified Protons and Anti Protons and see how EMC-Clusters from Annihilation look like





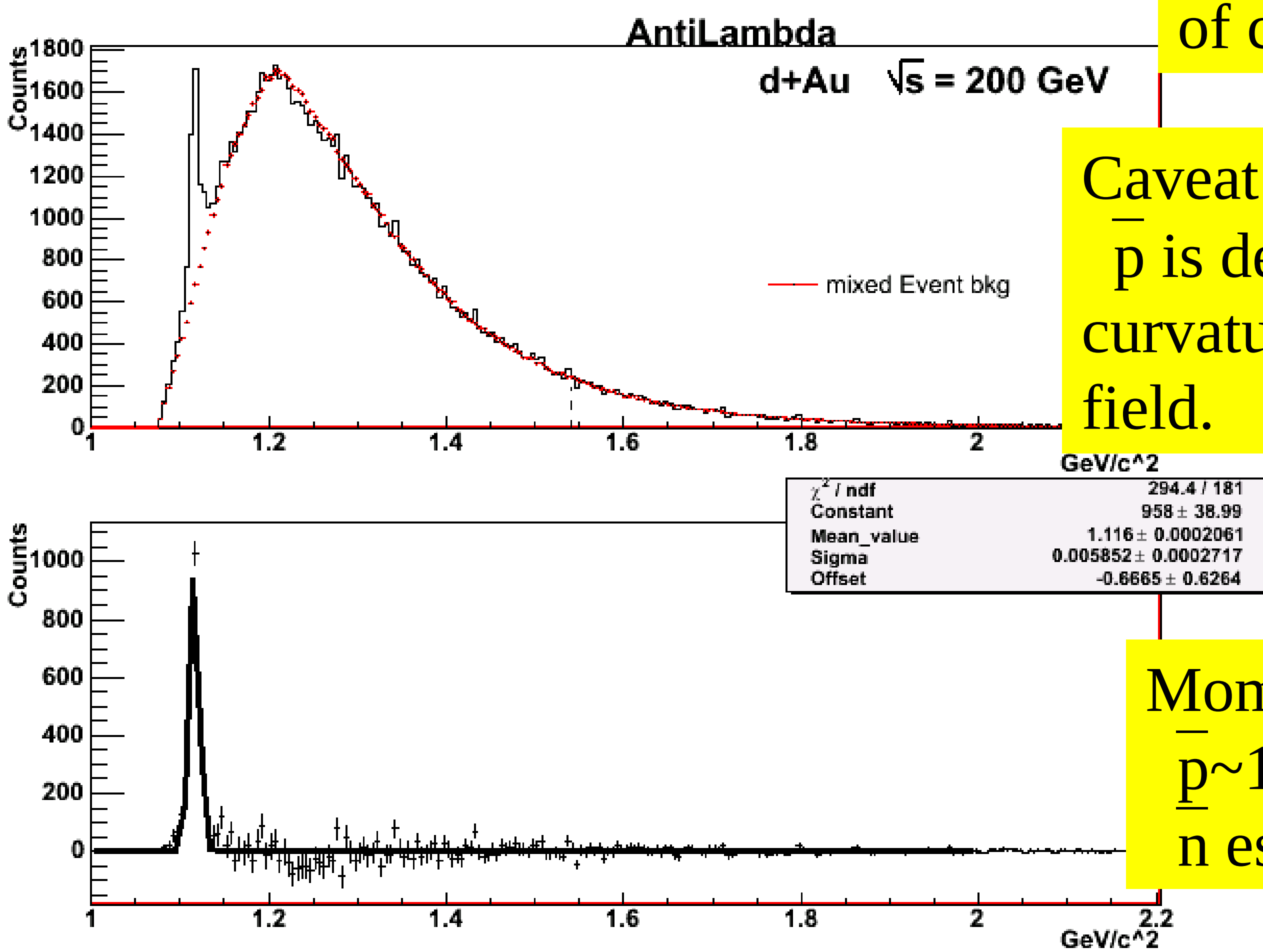
As expected the main difference is the deposited energy and the Number of towers which make up this cluster. Cut at 10 towers and 1 GeV Cluster Energy.

In addition one looks for a bad χ^2 from a fit to a photon shower shape

Timing cut of 3ns later than photons

How about the resolution?

$\bar{\Lambda} \rightarrow \bar{p} + \pi^{+}$ Invariant Mass



Reconstruction of the $\bar{\Lambda}$ shows a width of close to 6 MeV

Caveat: The momentum of $\bar{p}$ is determined by the curvature in the magnetic field.

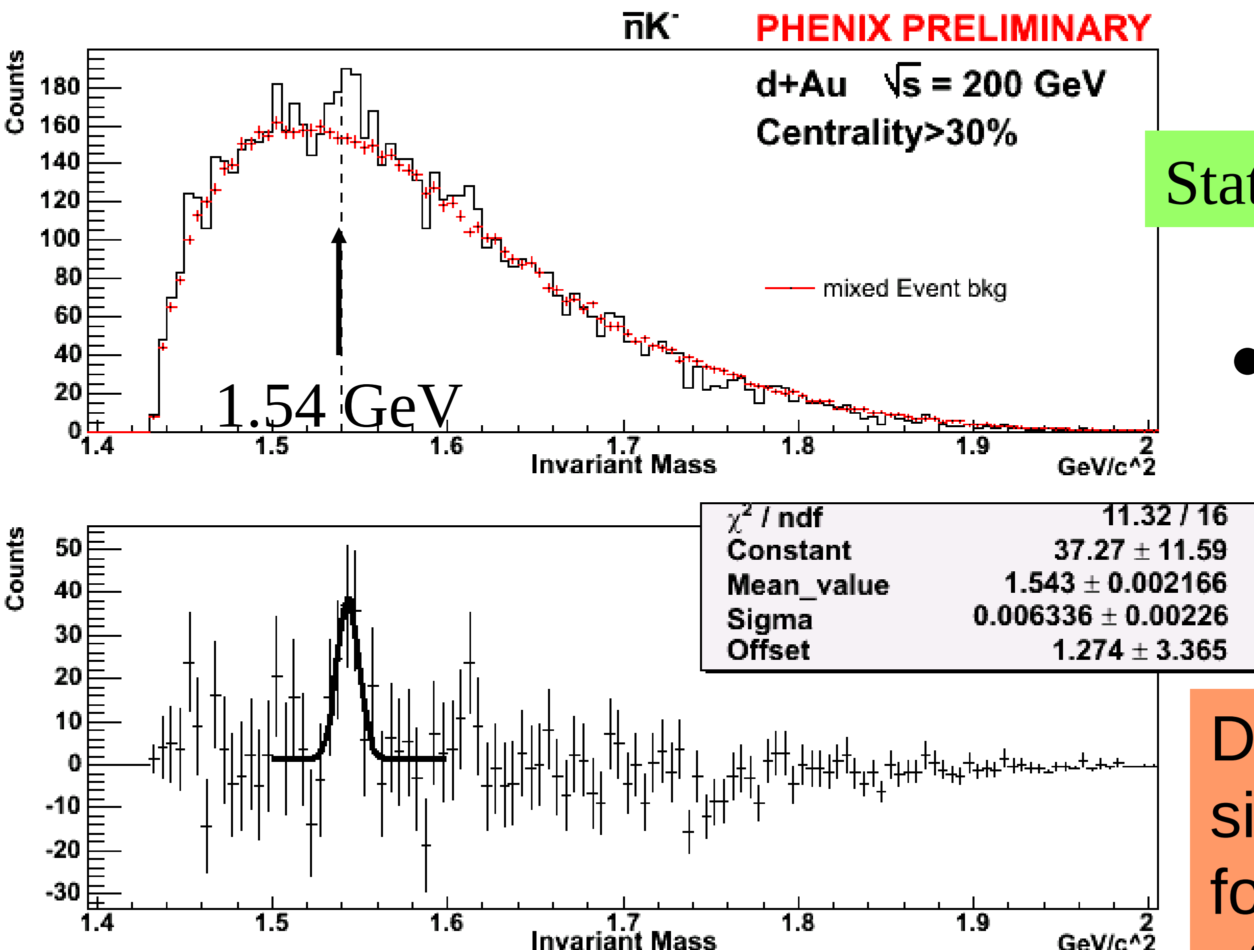
Momentum resolution:

$\bar{p}$~1% at 1GeV/c

$\bar{n}$ estimated 3%

Anti Penta Quarks with PHENIX?

$$\bar{\Theta}^- \rightarrow \bar{n} + K^-$$

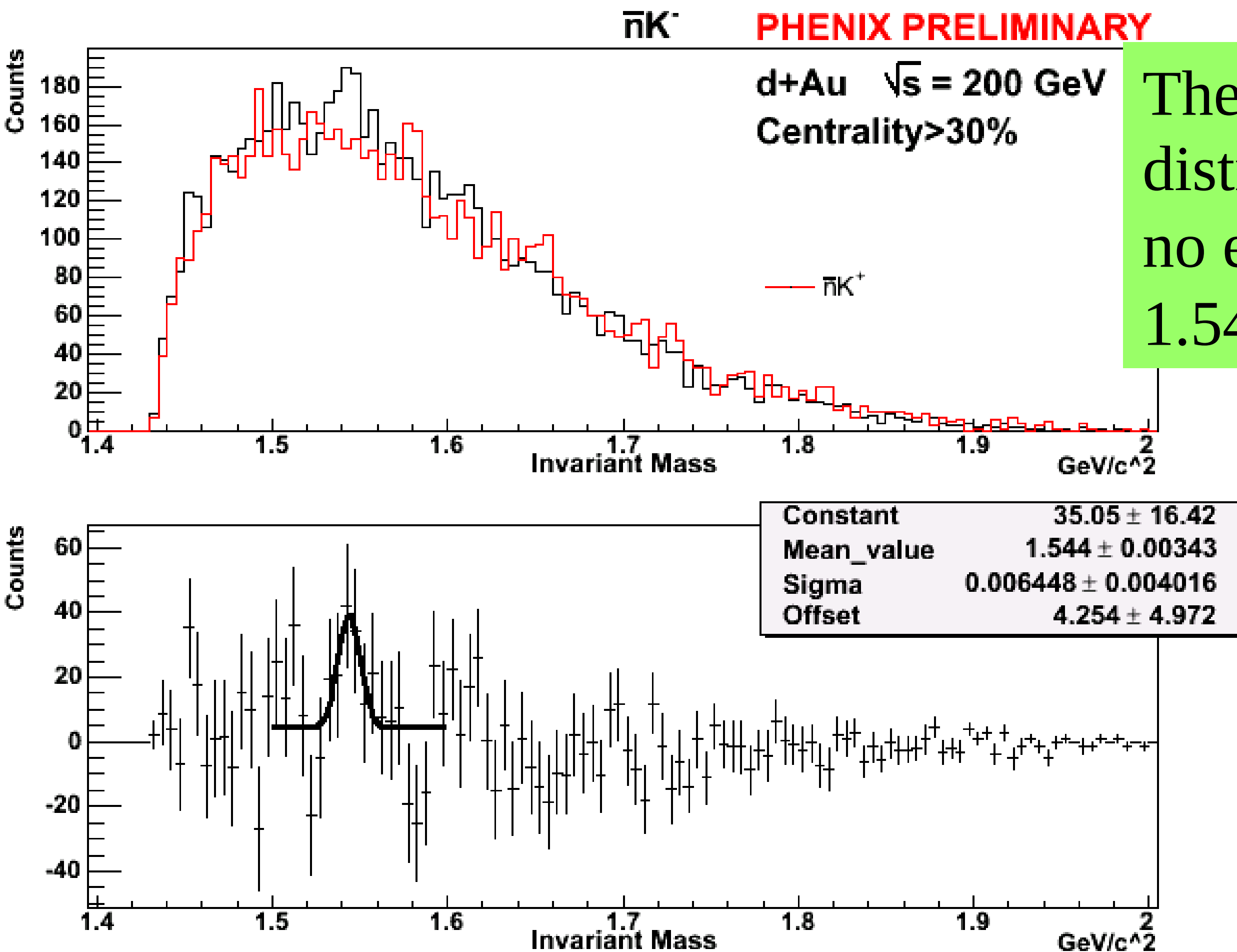


Statistically it's a 4σ effect

- No estimate of systematic Error yet
- No estimate of Efficiency yet

Determining statistical significance of peak will follow from the ongoing effort to understand the systematic errors

Control: Compare $\bar{n}K^-$ invariant mass distribution to $\bar{n}/K^+$



The $\bar{n}K^+$ invariant mass distribution (red) exhibits no enhancement at 1.54 GeV like $\bar{n}K^-$ (black)

Conclusion

Intriguing result, statistically a 4σ effect

Excess at 1.54 GeV only in $\bar{n}K^-$ invariant mass

Mass Resolution very similar to Λ, $\bar{\Lambda}$

No systematic error, or efficiencies yet, the determination of the statistical significance of the peak will follow from the ongoing effort to understand the systematic errors

Other (physics) sources of this peak?

EMC response to Anti Neutrons needs further study

Tony Frawley summed it up: We ain't saying it's there and we ain't saying it's not there.