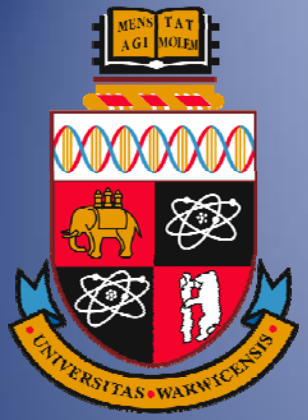
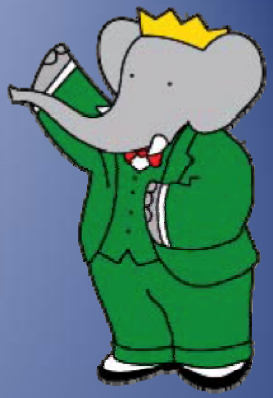




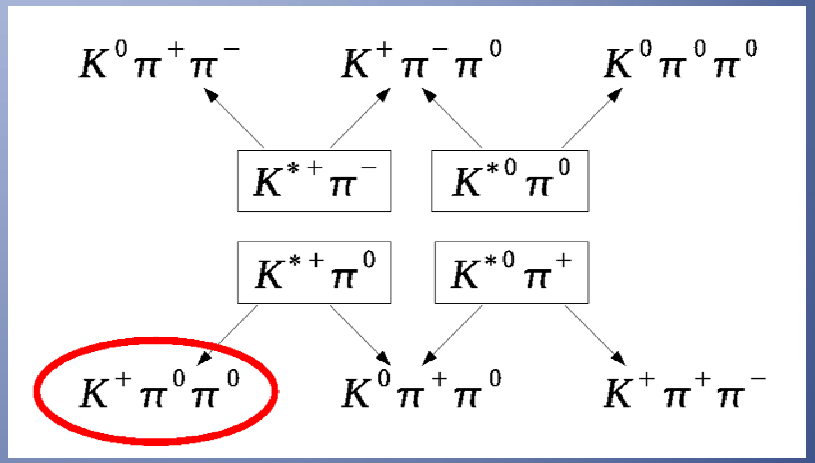
Inclusive Branching Fraction Measurement of $B^+ \to K^+\pi^0\pi^0$ at BaBar

Eugenia Puccio

University of Warwick

Motivations

- Possible hints of New Physics in measurements of rates and asymmetries in B->Kπ[1,2].
- Interesting to study related decays to final states K*π.[3]

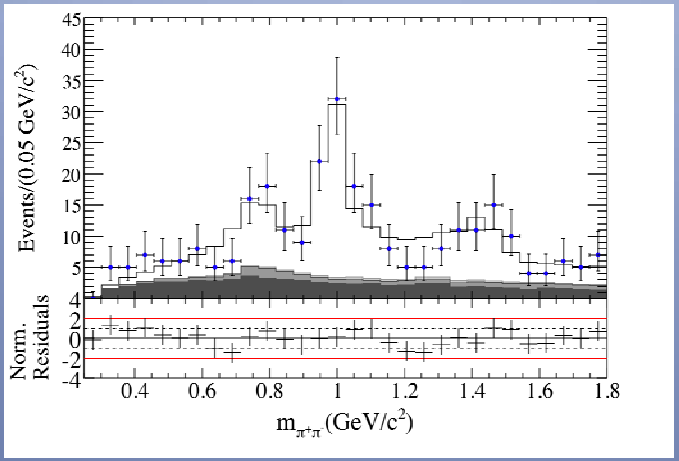


Mode	BF x 10^{-6}	A_{CP}
$K^{*+}\pi^-$	10.3 ± 1.1	-0.23±0.08
$K^{*+}\pi^0$	6.9 ± 2.3	0.04±0.29±0.05
$K^{*0}\pi^+$	9.9 + 0.8 - 0.9	-0.020+0.067-0.061
$K^{*0}\pi^0$	2.4 ± 0.7	-0.15±0.12±0.02

- Improved measurements of $K^{*+}\pi^0$ needed to reduce hadronic uncertainties.
- Only 3-body Kππ Dalitz plot not measured.

[1] B.Aubert *et al.* (BABAR), Phys. Rev. **D76**, 091102 (2007), 0707.2798
[2] Nature **452,** 332 (2008), [3] M.Gronau, D.Pirjol, and J.Zupan (2010), 1001.0702

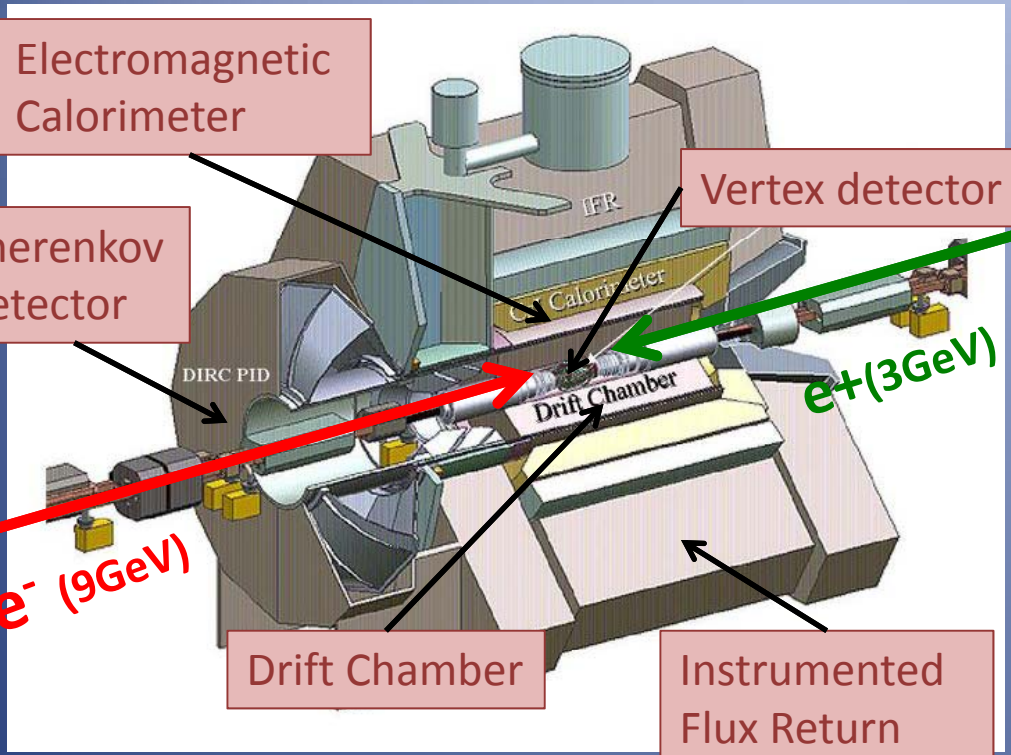
Motivations (continued)



- Structure of $f_X(1300)$ seen in $m_{\pi^+\pi^-}$ mass spectrum in DP analyses of $K^+\pi^+\pi^-$ [4] and $K_S\pi^+\pi^-$ [5].
- Check for presence of $f_X(1300)$ in $\pi^0\pi^0$ invariant mass - this will show if it is an even-spin state.

[4] B.Aubert *et al.* (BABAR), Phys. Rev. **D78**, 012004 (2008), 0803.4451
[5] B.Aubert *et al.* (BABAR), Phys. Rev. **D80**, 112001 (2009), 0905.3615

The BaBar detector

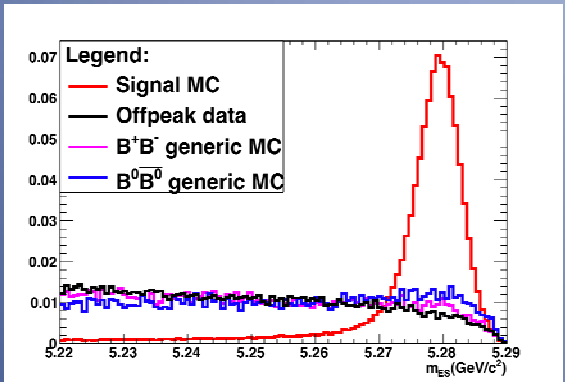


- In operation from 1999->2008
- PEP-II collided beams of e^+ and e^- with asymmetric energies.
- Collected 470M $B\overline{B}$ pairs

- This analysis makes use of 429 fb^{-1} of data taken at the Y(4S) resonance and 44.8 fb^{-1} of data taken at energies below the Y(4S).
- In addition use non resonant MC and MC for $K^{*+}\pi^0$ and f_xK^+

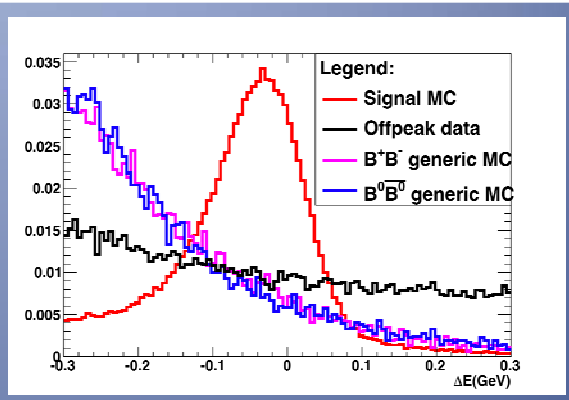
General analysis techniques

m_{ES} for MC and offpeak



$$m_{ES} = \sqrt{E^{*2}_{beam} - p^{*2}_{B}}$$

ΔE for MC and offpeak



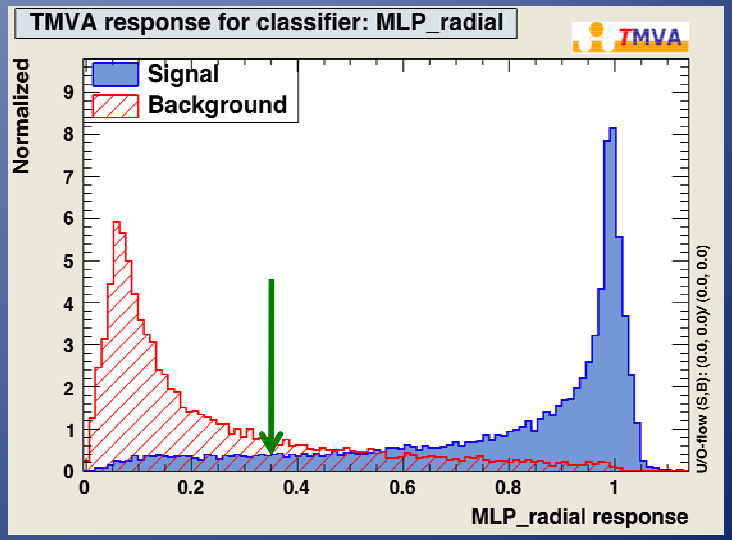
$$\Delta E = E^{*}_{B} - E^{*}_{beam}$$

- Use kinematic variables m_{ES} and ΔE to discriminate signal events from continuum and B-backgrounds.
- Also use event-shape variables combined in an MVA (ie. Fisher discriminant or neural network)

→ Insert these variables in a ML fit

Event shape variables and NN

- Ratio 2nd order momentum-weighted monomial moment to 0th order, L_2/L_0
- Absolute value of cosine of angle between B direction and beam axis.
- Absolute value of cosine of angle between B thrust and beam axis.
- Absolute value of output of flavour tagger.
- Use a "Multilayer Perceptron" NN tested and trained on signal MC and offpeak data.



Event selections

- Neutrals selections:
  - π^0 decay photons with $0.01 < LAT_\gamma < 0.6$
  - π^0 energy $E_\gamma > 0.05$ GeV
  - π^0 helicity angle:

$$\left|\cos\vartheta^{\gamma}_{helicity}\right| < 0.9$$

  - π^0 mass :

$$0.115 < m_{\pi^0} < 0.150\ GeV/c^2$$

- K_S veto:

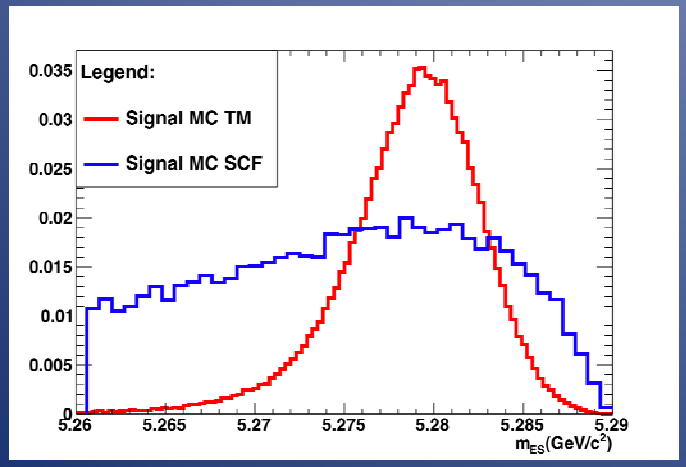
$$0.4 < m_{\pi^0\pi^0} < 0.55\ GeV/c^2$$

- Average number of B candidates found per event is 1.3.
- Select the candidate with smallest χ^2 formed from the sum of the χ^2 values of the two π^0 masses.

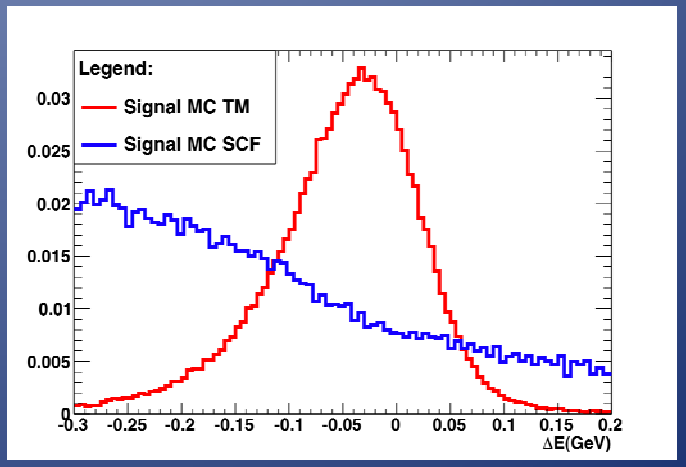
Misreconstructed Events

- Misreconstructed events are classified by setting a boundary to the following relation:
  - $\frac{p_{gen} - p_{rec}}{\sigma_{p_{rec}}} < 5$ Well reconstructed or "truth matched" event (TM)
  - $\frac{p_{gen} - p_{rec}}{\sigma_{p_{rec}}} > 5$ Misreconstructed or "self cross feed" event (SCF)

m_{ES} for NR MC



ΔE for NR MC



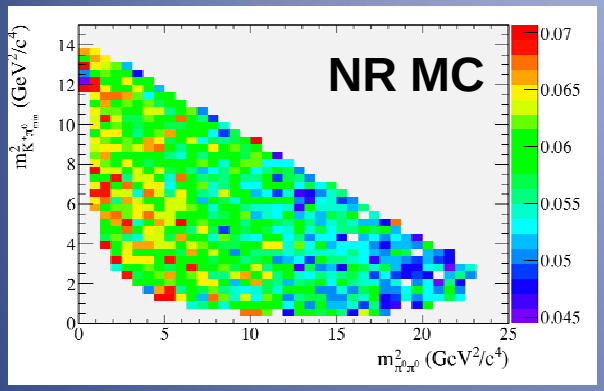
Challenges of this mode

- The main challenge of this analysis is the presence of the two π^0 mesons in the final state:
  - Expected large fraction of misreconstructed events.
  - This fraction is found to be dependent on Dalitz plot position.
  - Affects the ΔE distribution: broader shape also dependent on Dalitz plot.
- Encountered "Punzi Effect" [1] in our model which occurs when a PDF in the ML fit is dependent upon a variable, which itself does not have a PDF in the fit.

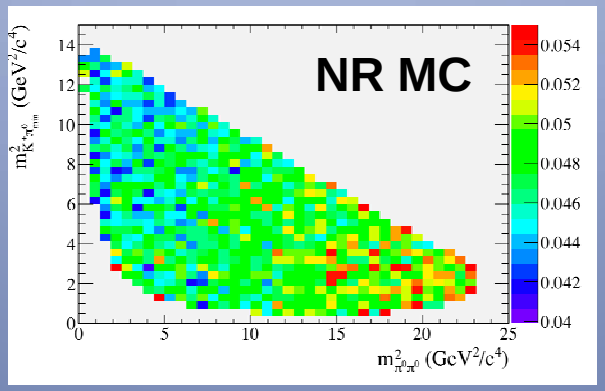
[1] G. Punzi (2004), physics/0401045

Dependences across DP

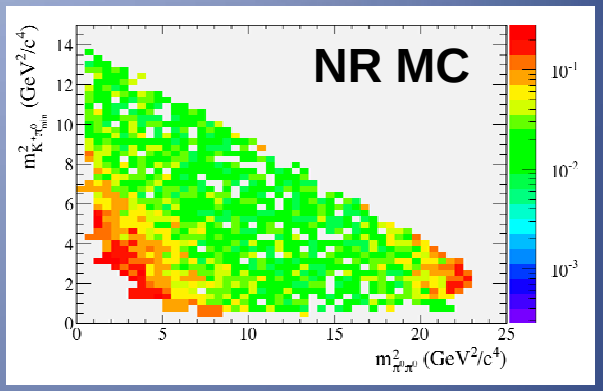
ΔE - mean



ΔE - rms



SCF fraction



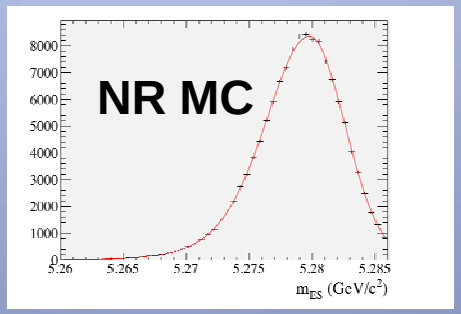
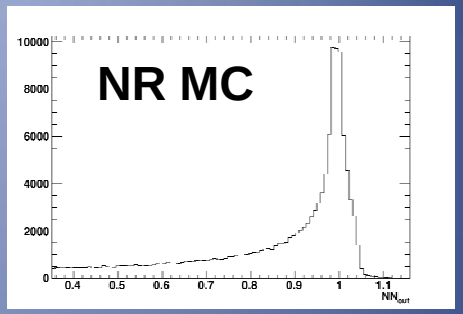
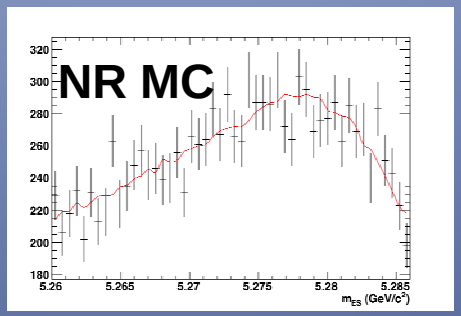
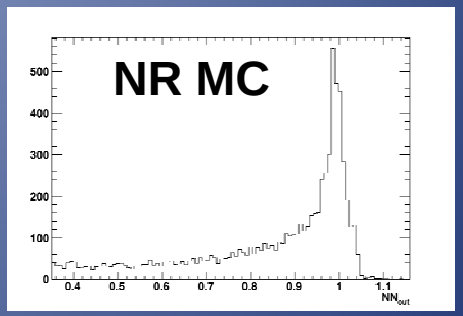
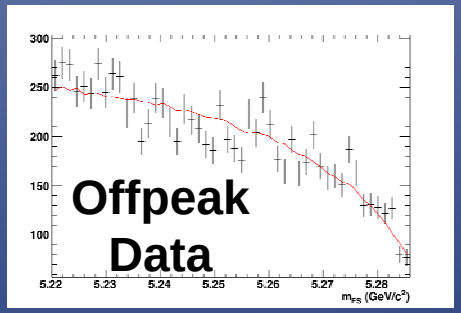
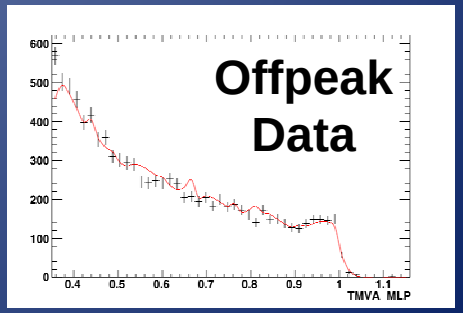
- All show strong correlations with DP, but for this measurement DP is not used in fit – Punzi biases…
- Solution:
  - Use only m_{ES} and NN PDFs. Use very tight cut on ΔE and fix $B\bar{B}$ background yields.
  - Reproduce DP from sPlot[1] and calculate SCF fraction until this converges to a definite value.

[1] Nucl. Instrum. Meth., A555 (2005), p. 356 - 369

Estimating the SCF fraction in data

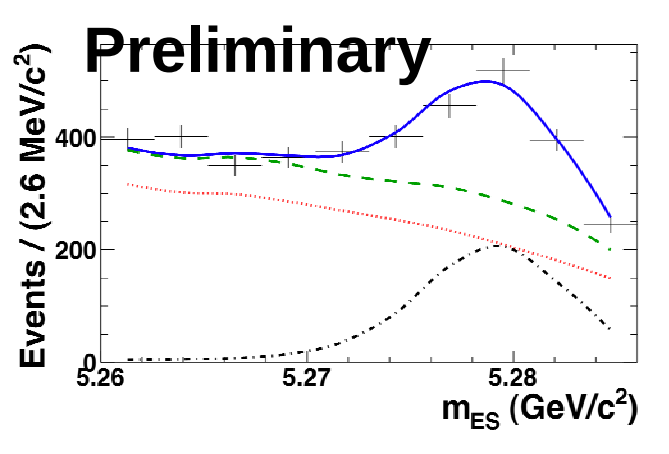
- We start with a fixed value for the SCF fraction half way between lowest and highest SCF in signal MC samples.
- Because of fixed $B\bar{B}$ backgrounds, need to use "extended" sPlots.
- The SCF fraction is then measured as: $F_{SCF} = \frac{\int (DP_{sWeights} \times DP_{SCF})}{\int DP_{sWeights}}$
- This process is iterated using the calculated SCF fraction until resultant SCF fraction and signal yield converge.

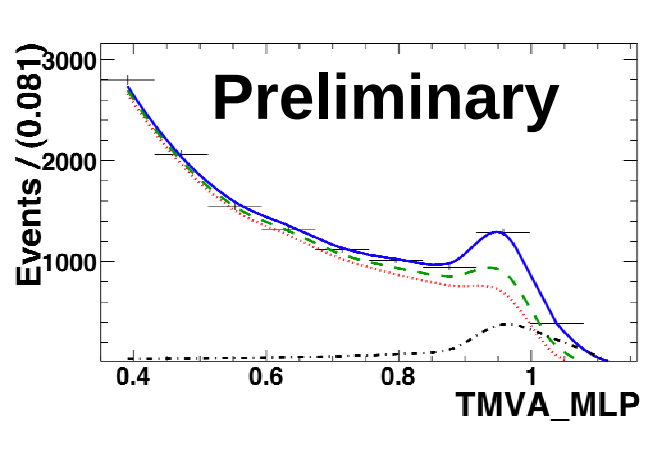
PDF studies

	m_{ES}: Cruijff	NN: histogram
TM		
Signal	**m_{ES}: 3rd order Chebychev polynomial**	**NN: histogram**
SCF		
Continuum	**m_{ES}: ARGUS**	**NN: 20 bins step function**
		

Use m_{ES} and NN histograms for $B\bar{B}$ backgrounds.

Preliminary Results





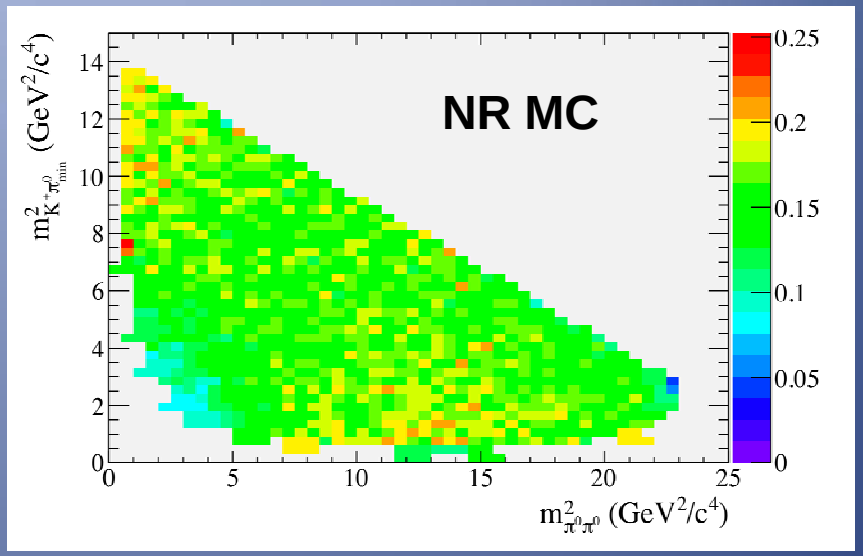
Projection plots: black points is data, blue line total fit result, red curve is continuum, green total background and black curve is the total signal contribution.

- Fit returned a total signal yield of 1220 ± 85 events and a SCF fraction of 9.7%.

Systematic Source	Preliminary estimate of uncertainty
Signal PDFs	4.6%
SCF fraction	2.5%
B background yields	1.4%
Fit bias	1.8%
Tracking efficiency	0.4%
Particle identification	1.0%
Neutral pion efficiency	6.0%
ΔE cut efficiency	4.0%
NN cut efficiency	3.0%
K_S veto	2.0%

Procedure to determine BF

- Signal reconstruction efficiency varies over the DP.
- Signal distribution over the DP is *a priori* unknown.
- Need to use *sWeights* and knowledge of variation of efficiency over the DP to correctly determine the BF.



Variation of signal efficiency over the DP determined from NR MC

Conclusion

- This is the first measurement of the branching fraction of the mode $B^+ \to K^+\pi^0\pi^0$.
- This analysis will be extended to look at some of the resonances in the Dalitz plot.
- Final results are anticipated in the summer.