Analysis of the $K^+K^-\pi^+$ final state with MesonEx

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Introduction

- The reaction is $\gamma p \rightarrow K^+ K^- \pi^+ n$
- The three final state hadrons are all detected in the forward detector
- The neutron is considered missing in this analysis
- The electron is detected at small angles in the FT (2.5 - 4.5^o) and in the energy range 0.5 - 4.5 GeV.
- Takes place at low Q^2: 0.007 - 0.3 GeV^2, the photon is called quasi-real for this reaction

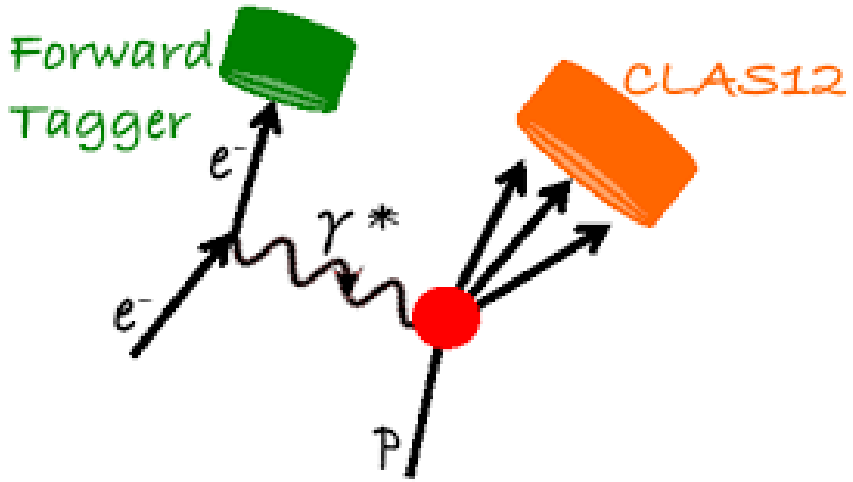


Figure: The Forward Tagger and CLAS12

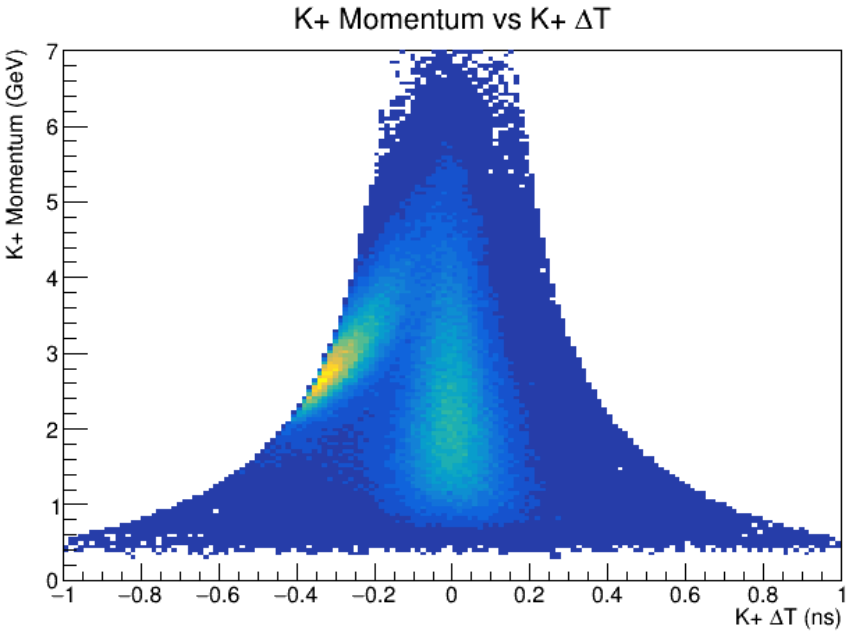
Data Processing

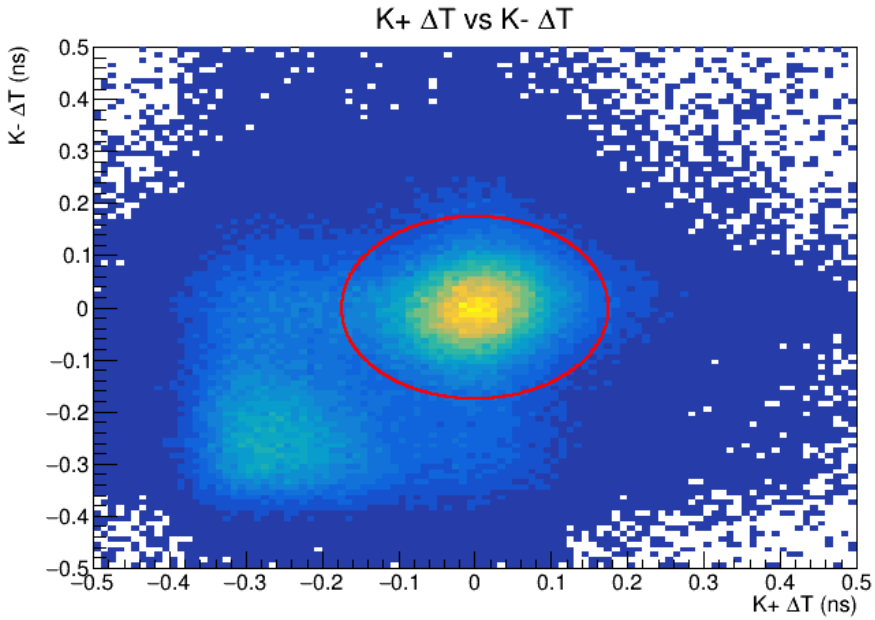
- All the available Pass 1, fall 2018 skim 3 data is being analysed - using both the inbending and outbending configuration (the plots below are using inbending data).
- Data in hipo files is analysed using chanser that is built upon clas12root to produce root trees.[1]
- An sPlot fit is performed around the dependent variable - the missing mass in this case. This is done using brufit.[2]
- Forward Tagger energy correction is applied to electrons.
- Start time correction found from e^- candidates in the FT.

[1] https://github.com/dglazier/chanser
[2] https://github.com/dglazier/brufit

Data Processing

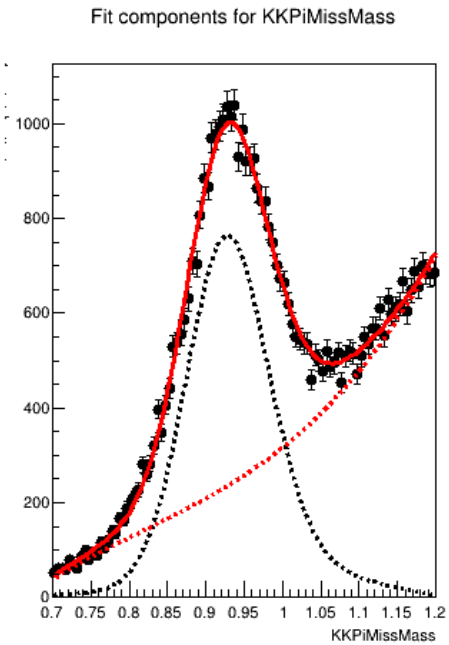
- Only pions/kaons detected in the Forward Detector are considered
- Events are required to have passed conditions of the mesonex trigger
- Relevant RG-A analysis note conditions: DC Fiducial cuts on the hadrons
- Momentum-dependent delta time cuts are applied as shown (bottom left)
- Further cuts placed on kaon delta time removes background pion events (bottom right)

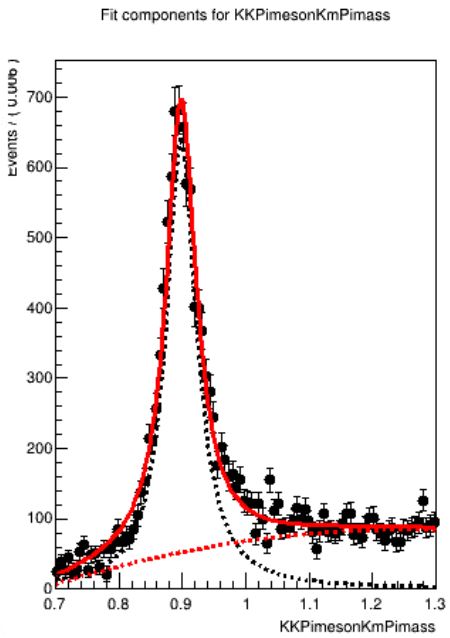


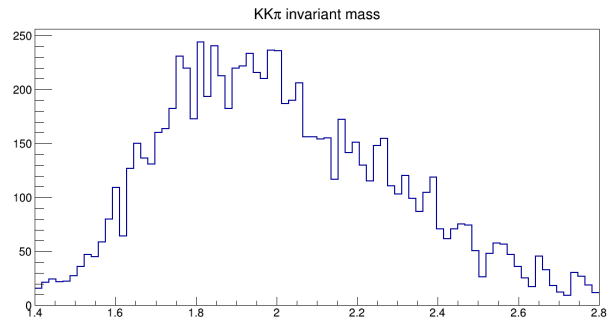


Data Processing

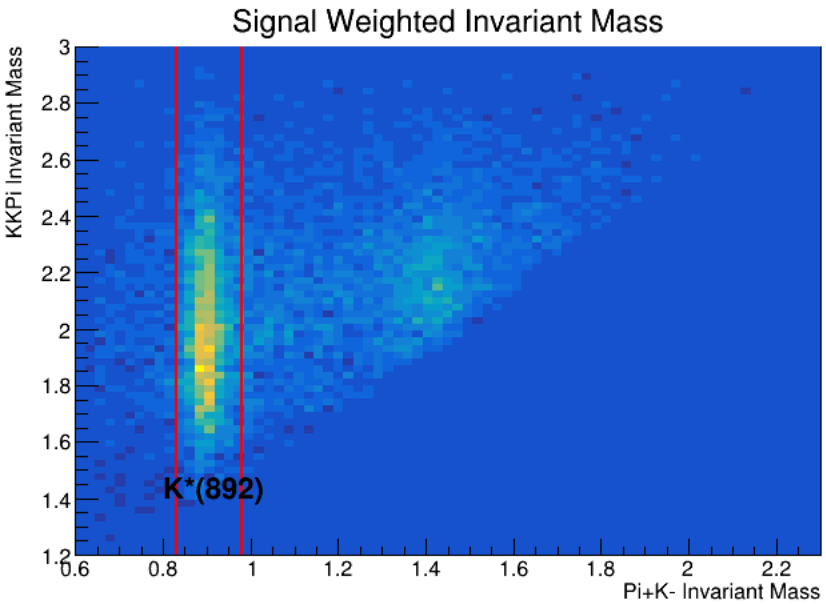
- Signal events are extracted from the data sample that passes the above mentioned cuts using the sPlot background subtraction technique performed in 'brufit'
- The fit is performed in this case by fitting a Gaussian distribution as the missing mass signal atop a second order Chebychev background for the $K^+K^-\pi^+$ final state (22,333 signal events)
- A second fit is used to extract weights for isolation of the K^* isobar events (9,048 signal events)

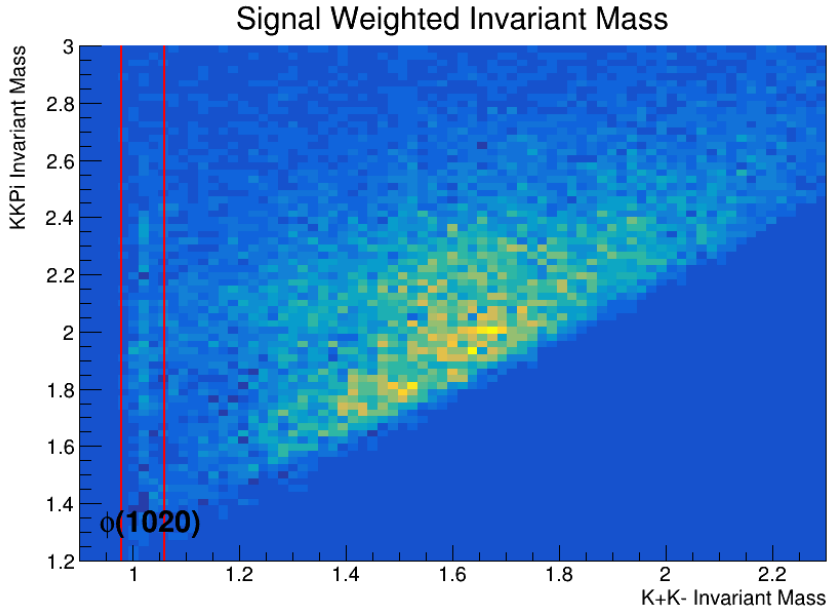


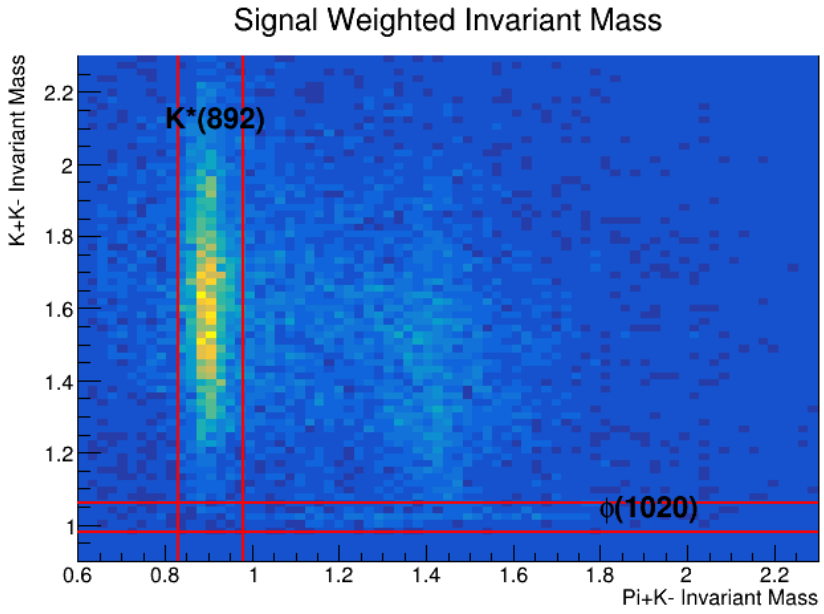




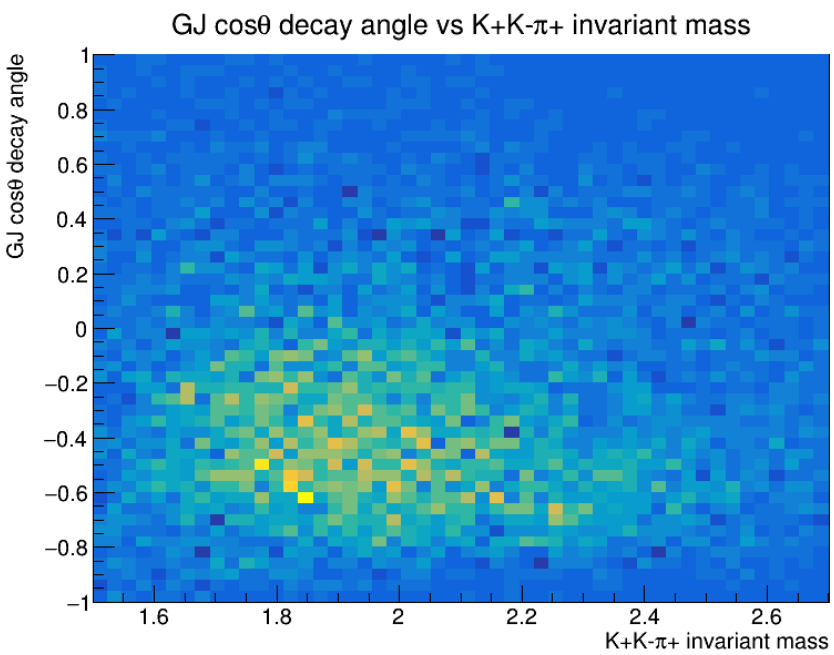
The Signal Weighted Data

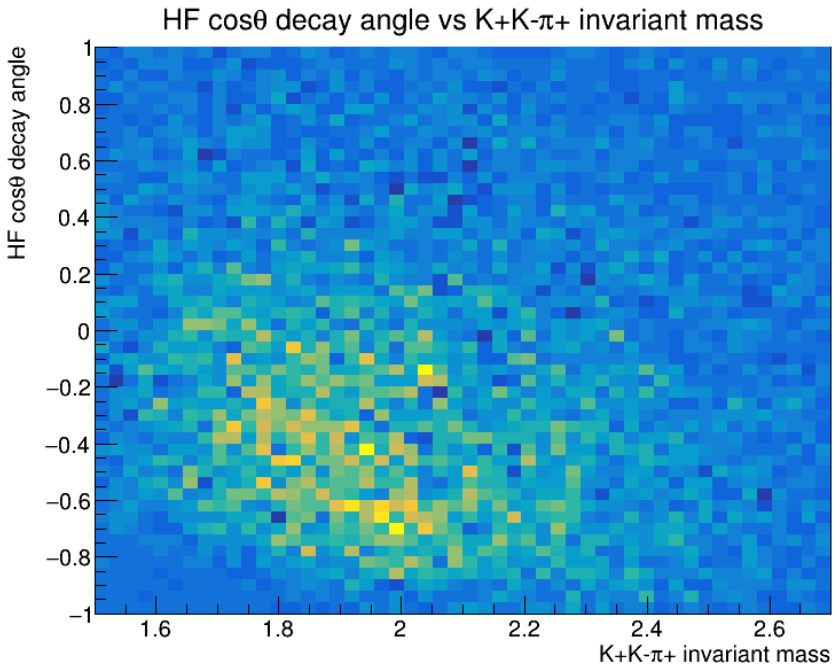


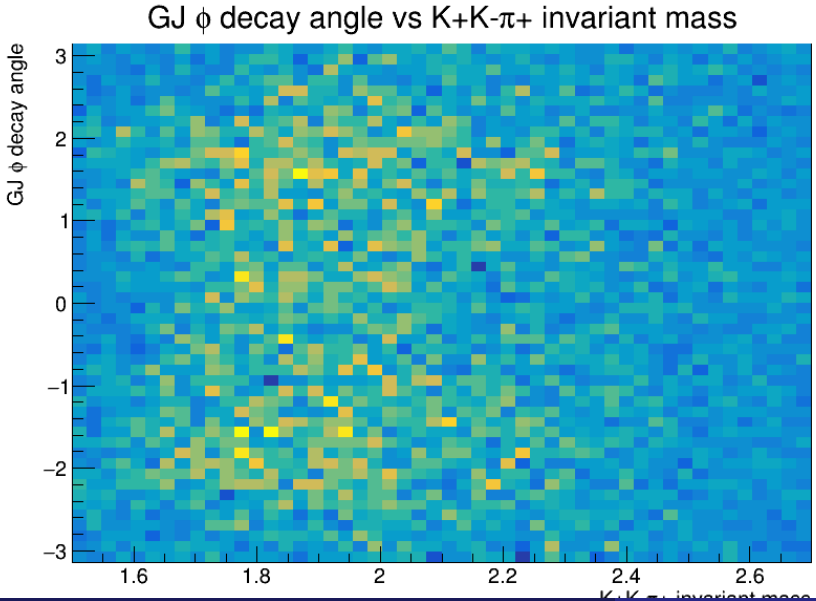


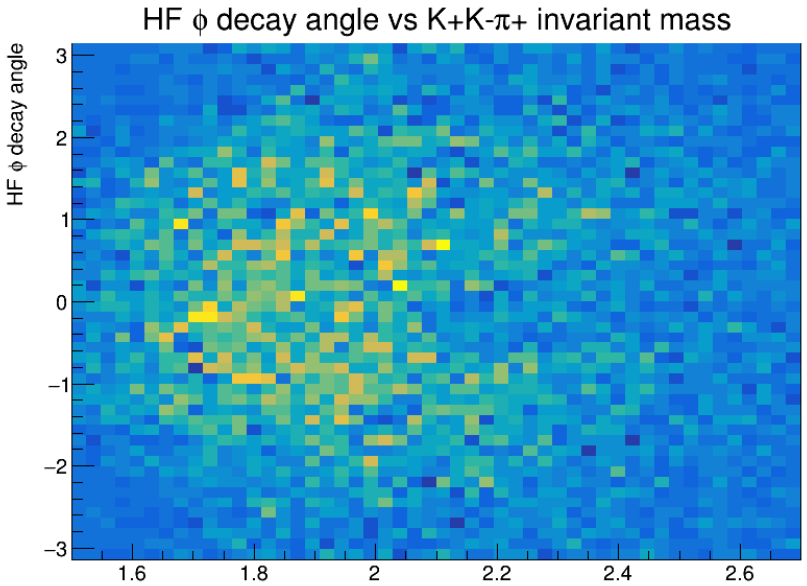


The Decay Angles









Moments Calculation

- We want to extract the moments are calculated as fit parameters of the intensity:

$$\mathcal{I}(\Omega) = \sum_{JMS\Lambda} \left(\frac{2J+1}{4\pi}\right)\left(\frac{2S+1}{4\pi}\right) H(JMS\Lambda) \times D^{J*}_{M,\Lambda}(\phi_{GJ}, \theta_{GJ}, 0) D^{S*}_{\Lambda,0}(\phi_{HF}, \theta_{HF}, 0), \quad (1)$$

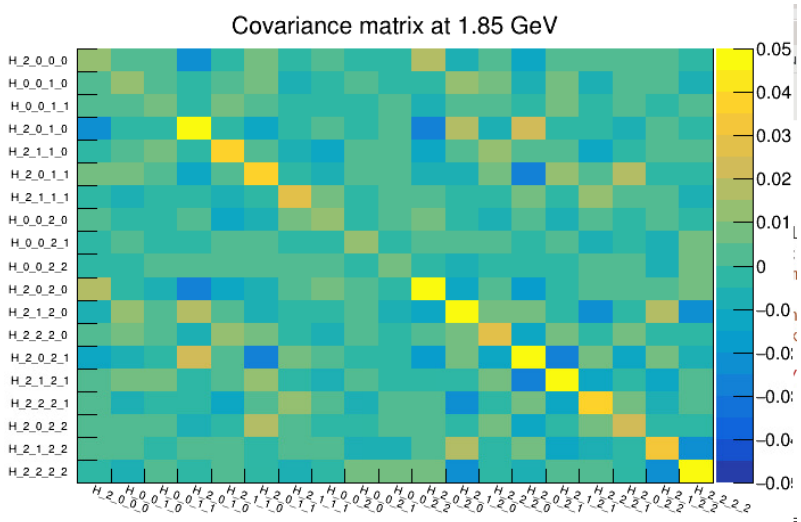
- The moments relate to partial waves:

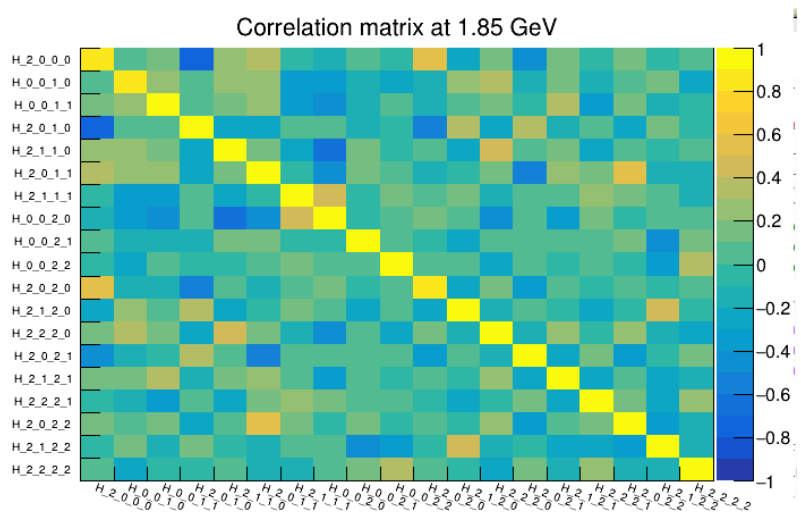
$$H(JMS\Lambda) = \sum_{b,b'} \sum_{\lambda,\lambda'} \left(\frac{\sqrt{(2l'+1)(2l+1)}}{2j'+1}\right)\left(\sqrt{\frac{2s+1}{2s'+1}}\right)(l,0;s,\lambda|j,\lambda) \times (l',0;s',\lambda'|j',\lambda')(s,\lambda;S,\Lambda|s',\lambda')(s,0;S,0|s',0) \times (j,m;J,M|j',m')(j,\lambda;J,\Lambda|j',\lambda') \times \rho_{bb'}. \quad (2)$$

Approach to fit the moments

Moments fits to three body decays can have >100 parameters (depending on the generality of the fit), MCMC was found to be more robust that Minuit fits

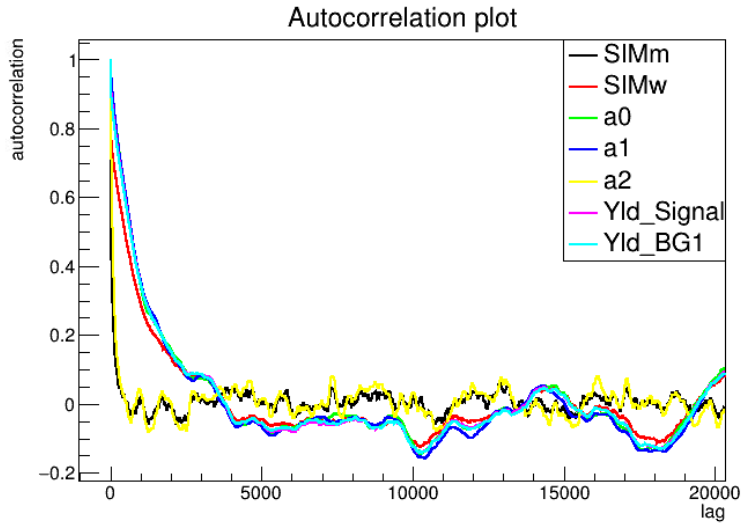
1. Run a standard sequential proposal Metropolis-Hastings algorithm
2. Calculate the covariance matrix from this chain
3. Use the covariance matrix as part of a step proposal function for the MCMC
4. The acceptance is calculated every 1000 steps and automatically adjusts the step size parameter if the acceptance falls outside an optimal window.

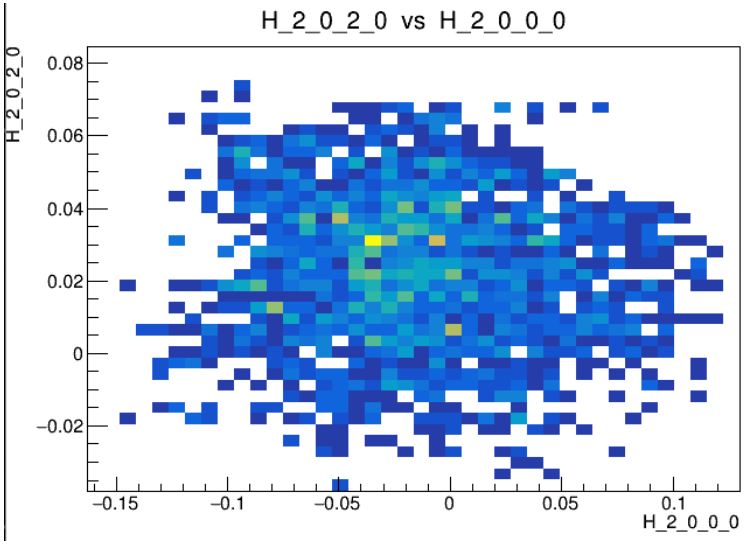




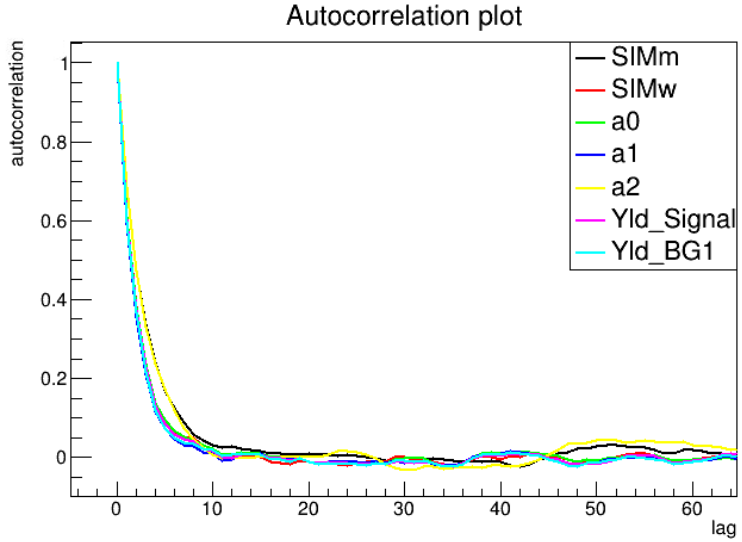
Approach to fit the moments

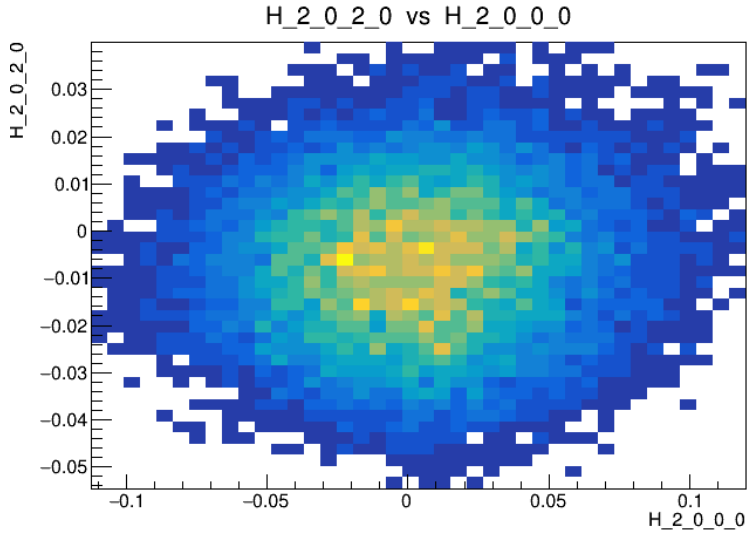
Using just a sequential proposal MCMC



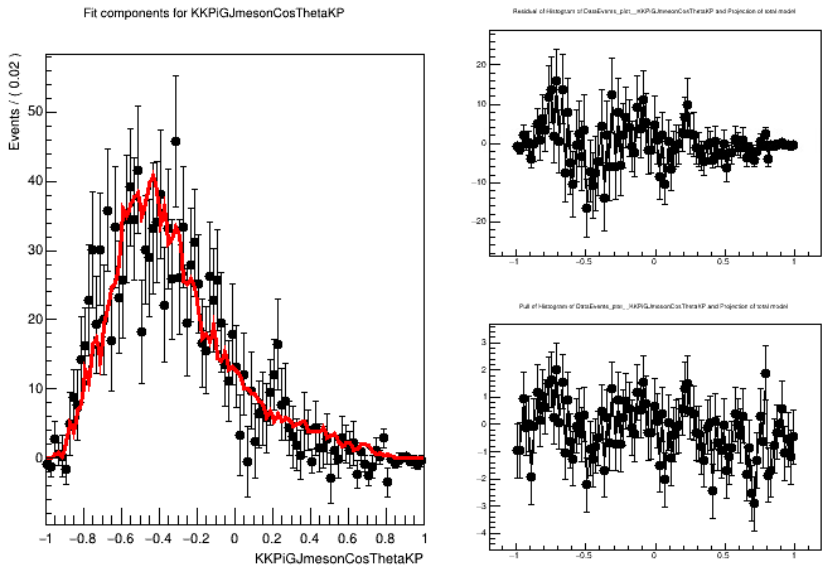


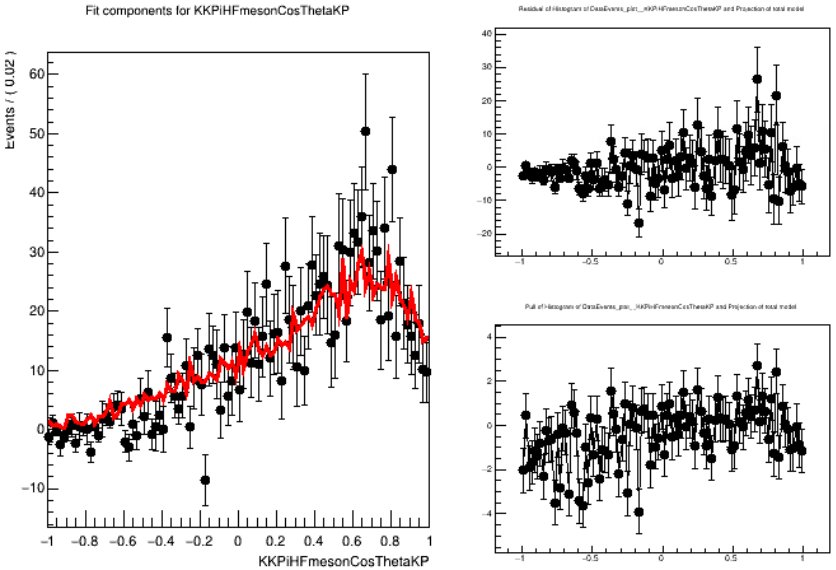
Including the covariance matrix step proposal

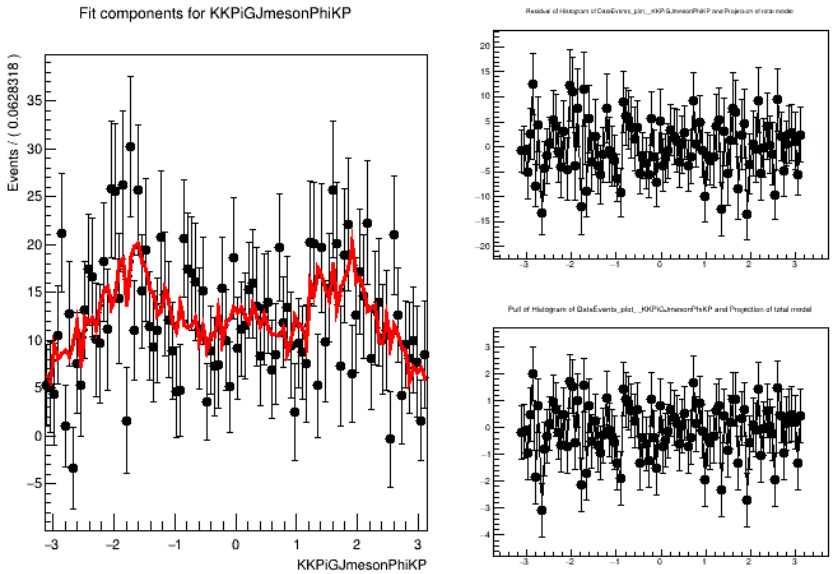


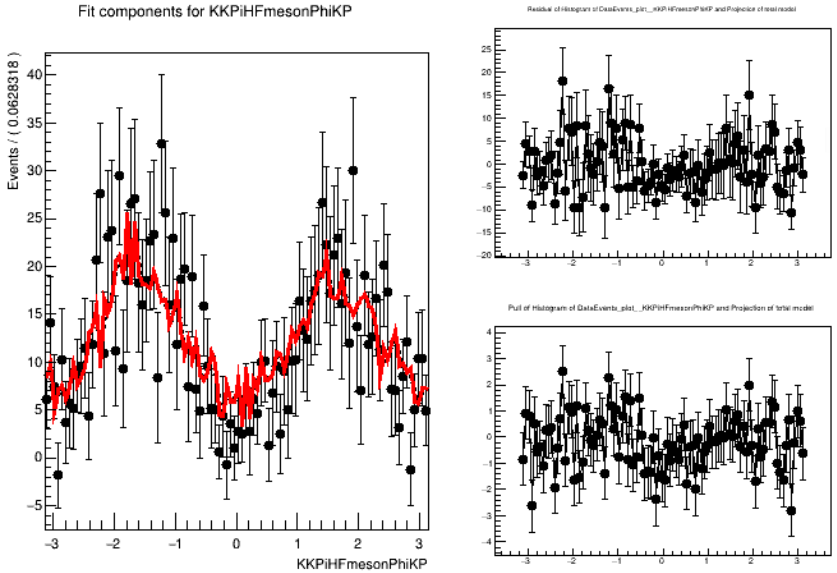


Fits of the Decay Angles



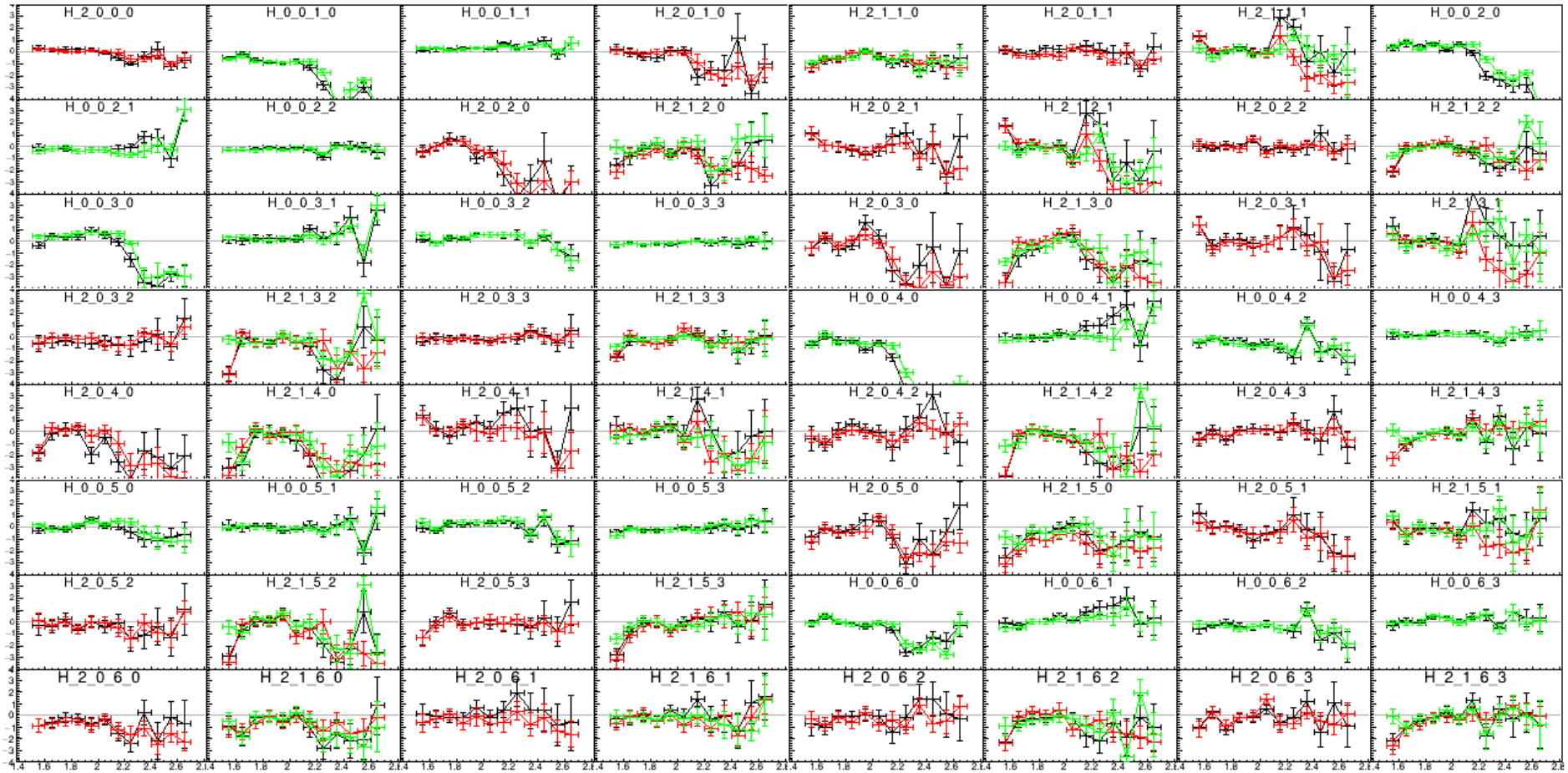






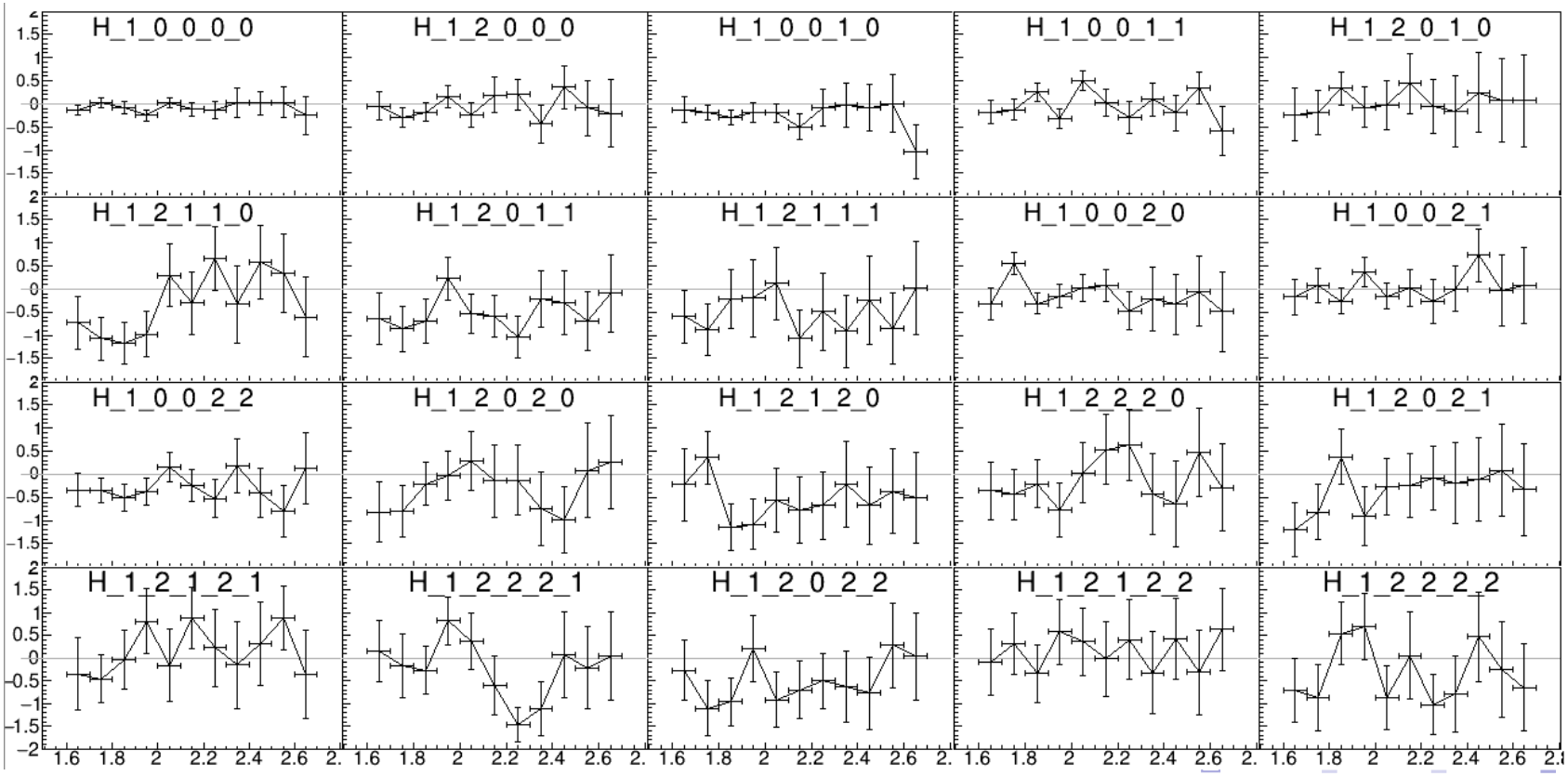
Moments Fitting

- Provisional moments results here are given in the form H_S_Λ_J_M
- Each colour represents a different moments set used for fitting



Polarised Moments Fitting

- Using a linearly polarised beam, it is possible to extract the polarised moments also
- These give us more information about the wave content
- The plot below shows an example of a subset of polarised moments that can be extracted from the data



Summary and ongoing work

- The workflow is largely in place to extract clean events for the K^*K^+ final state using kinematical cuts and sPlots
- Final studies are being done on acceptance and other systematic effects
- Work is ongoing on validating these results using toy generators - generating simulated data and using the fit on known moment values
- As well as working on a method by which the waves can be extracted from the moments