Update on $\Lambda(1520)$ analysis

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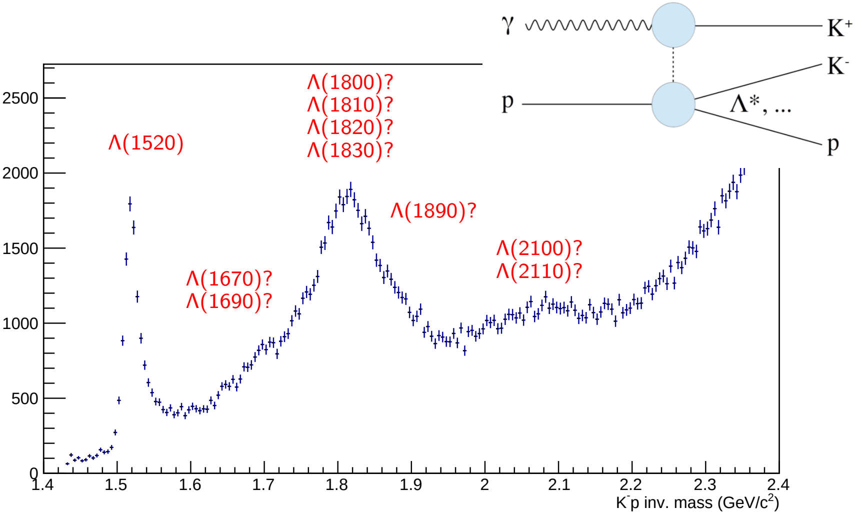
February 21, 2019

Outline

1. Reminder
2. Event selection
3. Beam asymmetry
4. SDMEs
5. Cross-sections
6. Summary and outlook

Reminder

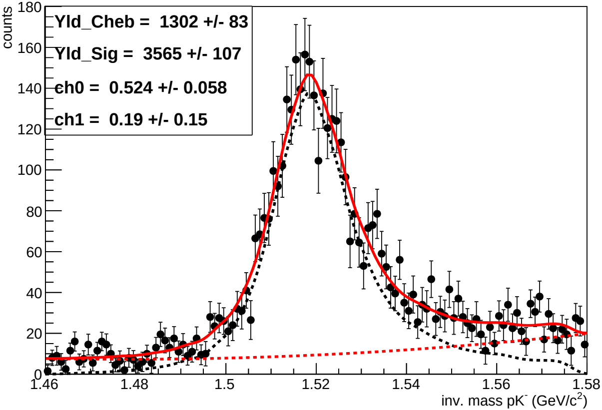

γ
p
K+
K-
Λ*, ...
p
Λ(1520)
Λ(1670)?
Λ(1690)?
Λ(1800)?
Λ(1810)?
Λ(1820)?
Λ(1830)?
Λ(1890)?
Λ(2100)?
Λ(2110)?
0
500
1000
1500
2000
2500
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
K-p inv. mass (GeV/c2)

Dataset and Cuts

- 2017 ver20 analysis launch (ver03 reconstruction)
- pKK final state (tree_kpkm__B4)
- 5σ CL (vertex and P4 fit)
- PID timing cuts
- $-0.04\,\text{GeV}^2 < \text{MM}^2 < 0.04\,\text{GeV}^2$
- vertex cuts (target cell)
- accidental subtraction

sPlots background subtraction

- simulate Λ(1520) with Breit-Wigner shape for signal shape
- use 2nd order Chebychev polynomial as background

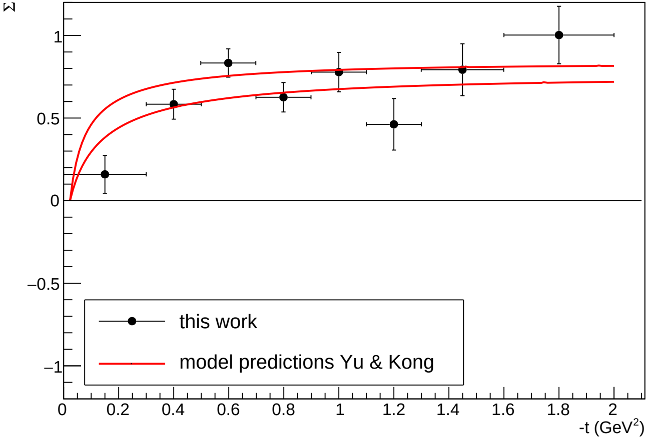


sPlot: a statistical tool to unfold data distributions, Muriel Pivk, Francois R. Le Diberder, https://arxiv.org/abs/physics/0402083

Beam asymmetry

- intensity function: $1 - P_\gamma \Sigma \cos\left(2\left(\phi - \phi_0\right)\right)$
- take ϕ_0 from Alex A.'s ρ analysis (ver02)
- take P_γ from TPol (polValsV4)
- perform extended maximum likelihood fit using RooFit within Haspect framework (same as used for sWeights)
- sum over reconstructed flat phase space Monte Carlo to perform acceptance correction (hdgeant4)

Beam asymmetry



Regge framework, reggeization of the t-channel meson exchange is applied for the $K(494) + K^*(892) + K_2^*(1430)$ exchanges in the Born amplitude. Private communication Yu, based on 10.1103/PhysRevC.96.025208

SDMEs for spin-3/2 →spin-0+spin-1/2

- parameterise the angular distribution of the $\Lambda(1520)$ decay in terms of spin density matrix elements
- evaluate K^- angle in Gottfried-Jackson frame and fit

$$W_0 = \frac{1}{4\pi}\left[3\left(\frac{1}{2}-\rho^0_{11}\right)\sin^2(\theta)+\rho^0_{11}\left(1+3\cos^2(\theta)\right)-2\sqrt{3}\left(\mathrm{Re}(\rho^0_{31})\cos(\varphi)\sin(2\theta)+\mathrm{Re}(\rho^0_{3-1})\cos(2\varphi)\sin^2(\theta)\right)\right]$$

$$W_1 = \frac{1}{4\pi}\left[3\rho^1_{33}\sin^2(\theta)+\rho^1_{11}(1+3\cos^2(\theta))-2\sqrt{3}\left(\mathrm{Re}(\rho^1_{31})\cos(\varphi)\sin(2\theta)+\mathrm{Re}(\rho^1_{3-1})\cos(2\varphi)\sin^2(\theta)\right)\right]$$

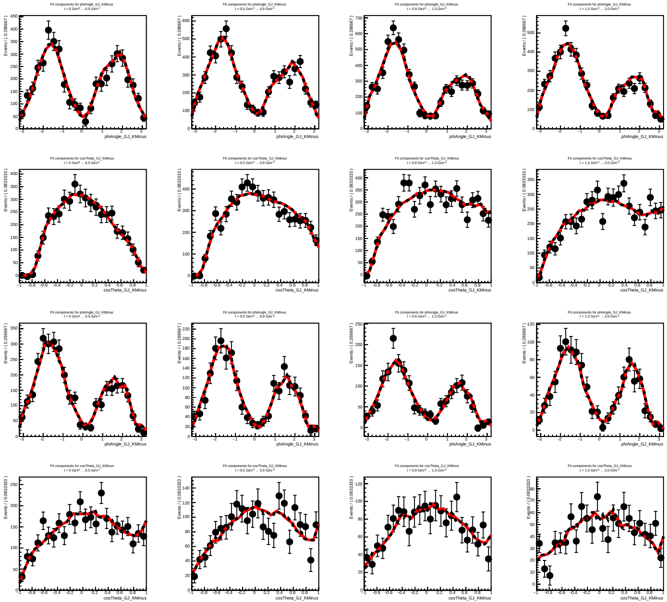
$$W_2 = \frac{1}{4\pi}\left[2\sqrt{3}\left(\mathrm{Im}(\rho^2_{31})\sin(\varphi)\sin(2\theta)+\mathrm{Im}(\rho^2_{3-1})\sin(2\varphi)\sin^2(\theta)\right)\right]$$

$$W = W_0 - P_\gamma\cos(2\Phi)W_1 - P_\gamma\sin(2\Phi)W_2$$

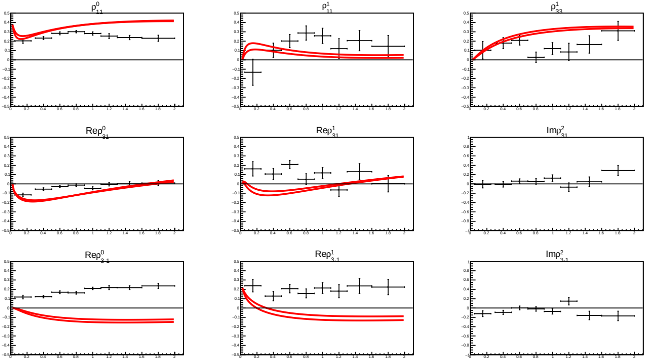
with Φ being the angle between production plane and polarisation plane.

- polarisation plane and P_γ as before
- acceptance correction done as for beam asymmetry
- 9 fit parameters and 3 fit variables, use MCMC to perform fit

Spin density matrix elements



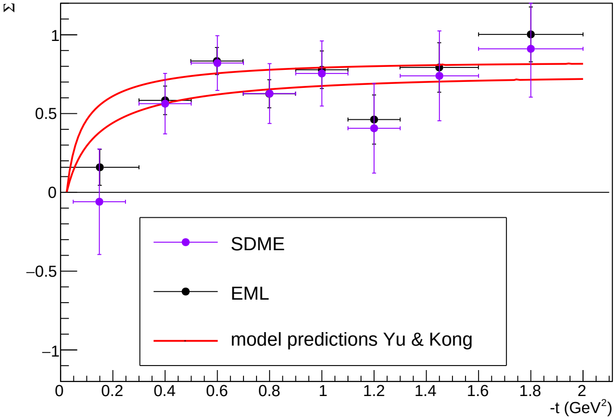
Spin density matrix elements



currently working on interpretation with help from V. Mathieu (JPAC)

Spin density matrix elements

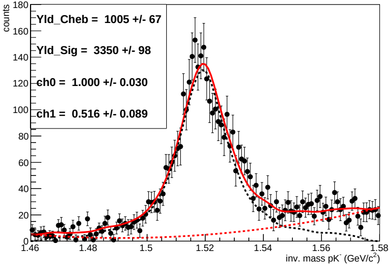
$$\Sigma = 2\left(\rho^1_{11} + \rho^1_{33}\right)$$



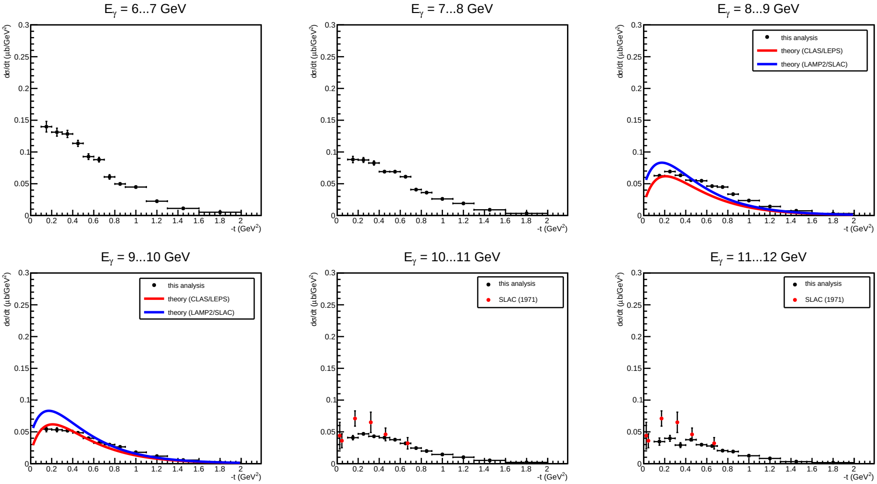
Cross-sections

- fit yield in bins of E_γ and momentum transfer $-t$
- correct for acceptance by simulating events with t-slope of $-2.5\,\text{GeV}^{-2}$ using hdgeant4
- branching fraction to $N\bar{K}$ is $(45 \pm 1)\%$

$$d\sigma/dt = \frac{\text{yield}}{\text{flux}\times\text{acc}\times\delta t\times 1.22\times 10^{-6}\times\text{branching fraction}}$$



Differential cross-sections



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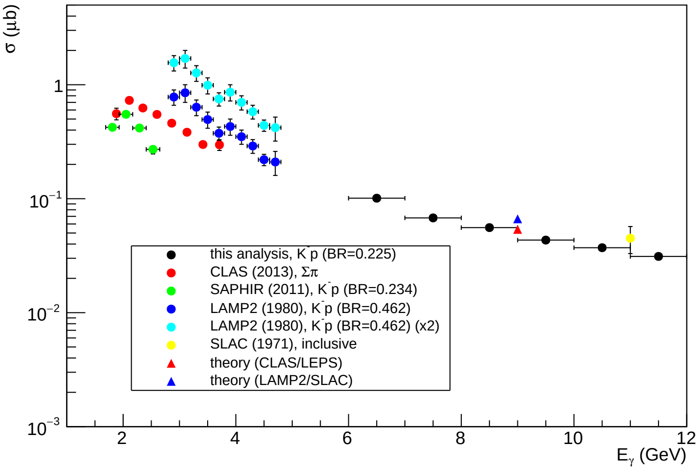
Total cross-section

in order to get total cross-section: fit $at\exp(bt)$ and integrate 0 to inf



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Summary and outlook

- beam asymmetry pretty much finalised
- SDMEs look very promising, work on interpretation under way
- first look at (differential) cross-sections very promising (for low energy results from 2018 see Sean's overview talk)

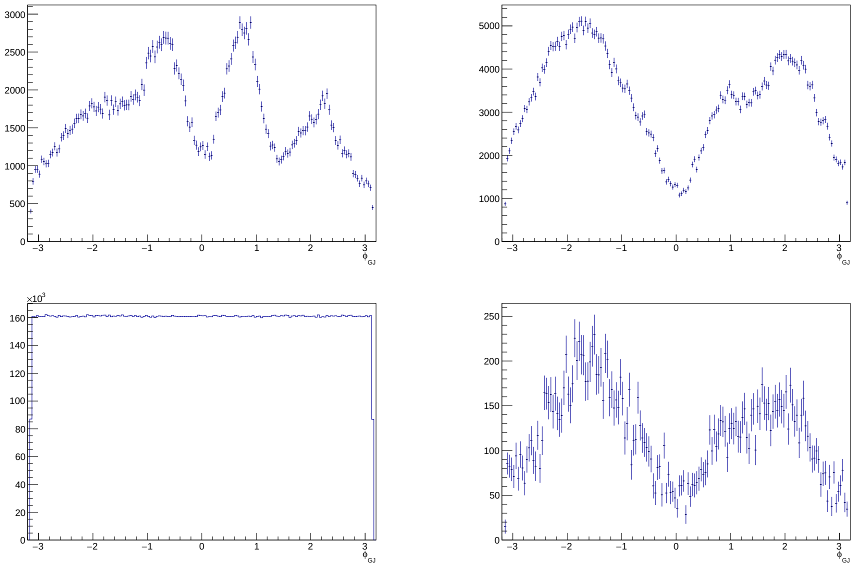
- validate errors for SDMEs
- finalise binning for (differential) cross-sections
- study systematic effects, especially acceptance
- write analysis note (started) and publish results

Thank you!

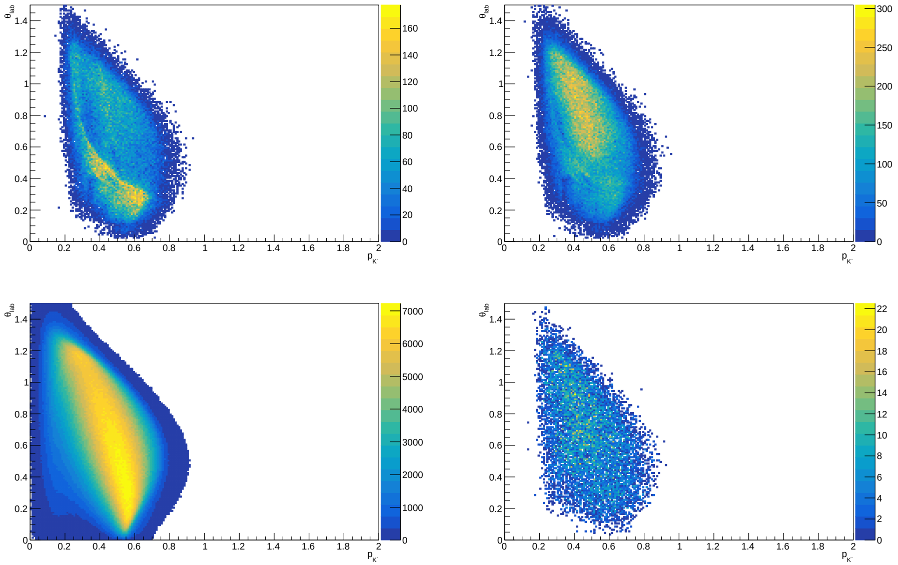
Questions? Comments? Advice?

Paper on longitudinal phase space analysis:
Mass-dependent cuts in longitudinal phase space, P. Pauli, D.I. Glazier, M. Battaglieri, A. Celentano, R. De Vita, S. Diehl, A. Filippi, J.T. Londergan, V. Mathieu, and A. P. Szczepaniak, Phys.Rev. C98 (2018) no.6, 065201
DOI: 10.1103/PhysRevC.98.065201

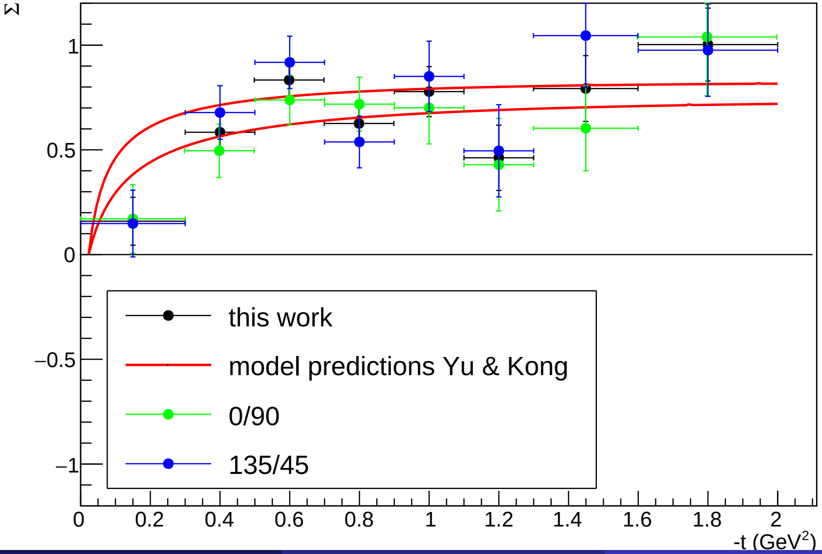
hdgeant vs hdgeant4



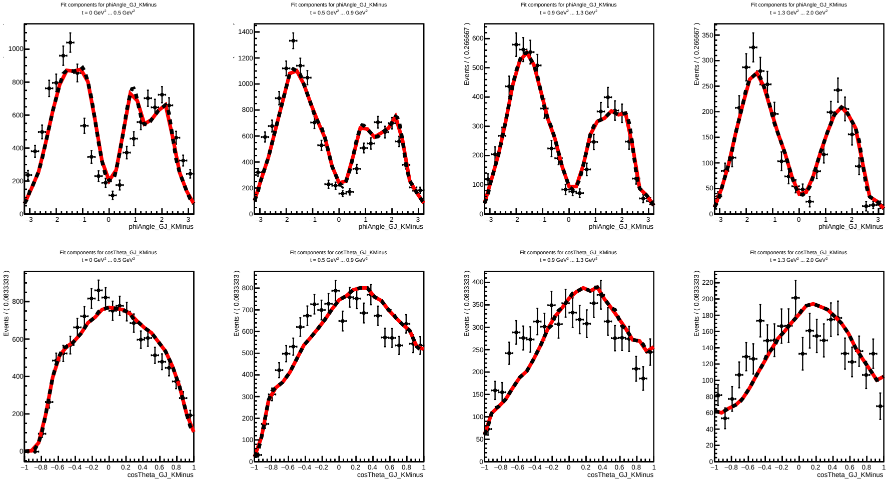
hdgeant vs hdgeant4



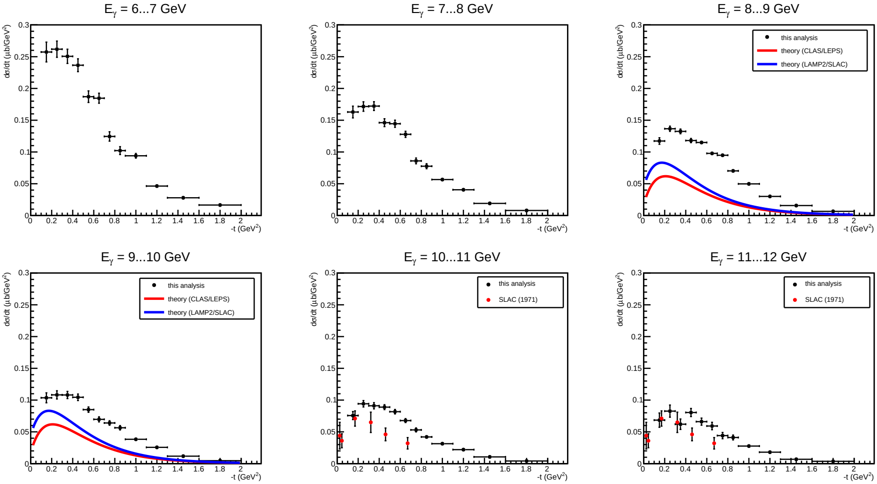
Beam asymmetry



SDMEs G3


Fit components for phiAngle_GJ_KMinus
t = 0 GeV^2 ... 0.5 GeV^2
phiAngle_GJ_KMinus
Fit components for phiAngle_GJ_KMinus
t = 0.5 GeV^2 ... 0.9 GeV^2
phiAngle_GJ_KMinus
Fit components for phiAngle_GJ_KMinus
t = 0.9 GeV^2 ... 1.3 GeV^2
Events / (0.266667)
phiAngle_GJ_KMinus
Fit components for phiAngle_GJ_KMinus
t = 1.3 GeV^2 ... 2.0 GeV^2
Events / (0.266667)
phiAngle_GJ_KMinus
Fit components for cosTheta_GJ_KMinus
t = 0 GeV^2 ... 0.5 GeV^2
Events / (0.0833333)
cosTheta_GJ_KMinus
Fit components for cosTheta_GJ_KMinus
t = 0.5 GeV^2 ... 0.9 GeV^2
Events / (0.0833333)
cosTheta_GJ_KMinus
Fit components for cosTheta_GJ_KMinus
t = 0.9 GeV^2 ... 1.3 GeV^2
Events / (0.0833333)
cosTheta_GJ_KMinus
Fit components for cosTheta_GJ_KMinus
t = 1.3 GeV^2 ... 2.0 GeV^2
Events / (0.0833333)
cosTheta_GJ_KMinus

Differential cross-sections G3



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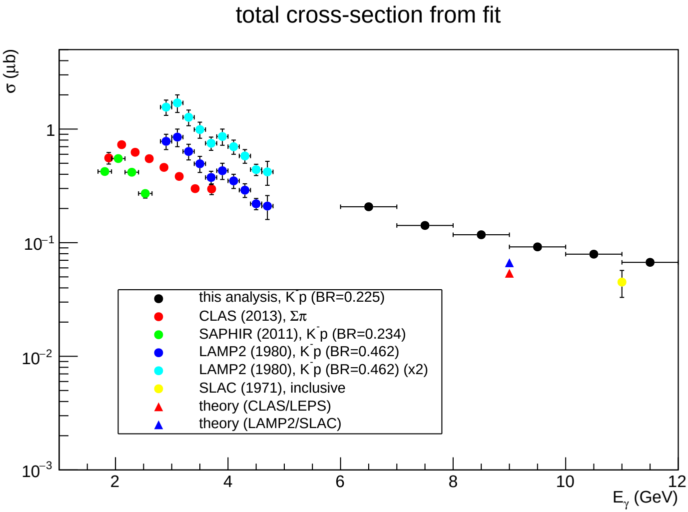

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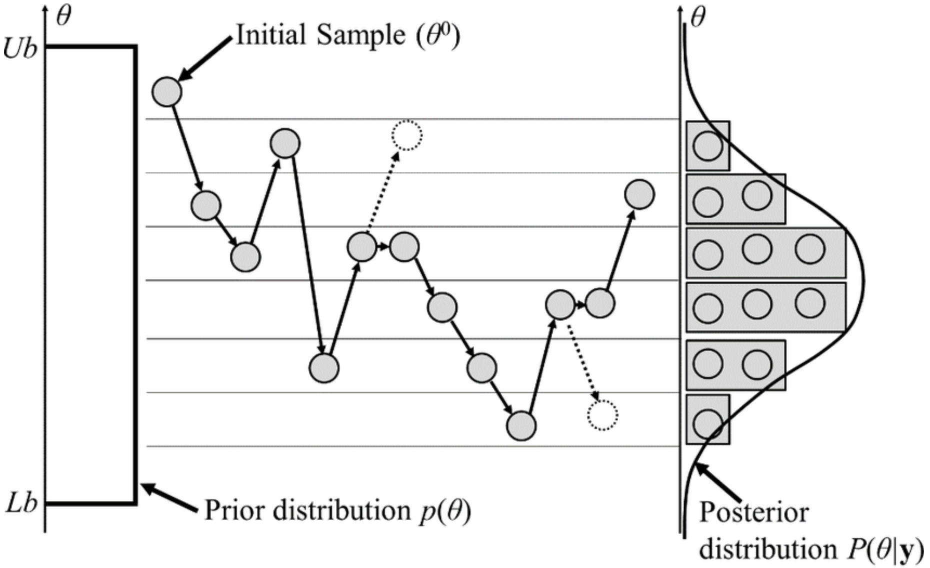
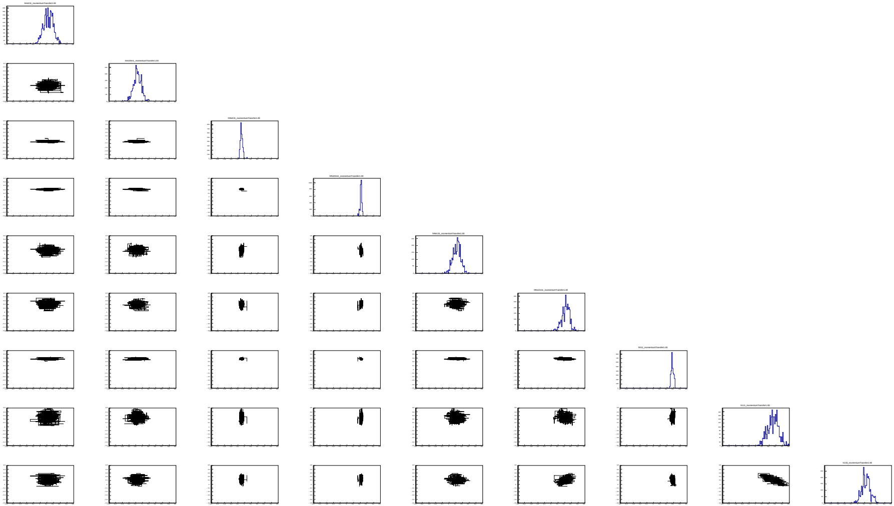
MCMC


θ
Ub
Lb
Initial Sample (θ^0)
Prior distribution $p(\theta)$
θ
Posterior
distribution $P(\theta|\mathbf{y})$

MCMC



sPlots

- use sPlot technique to remove background under the $\Lambda(1520)$ peak
- assumptions:
  - $\Lambda(1520)$ is narrow and isolated
  - no interfering background under the peak
- principle:
  - use a discriminatory variable (e.g. invariant mass) to seperate signal from background
  - need to know shape of signal and background in this variable
  - perform unbinned ML fit to extract yields
  - use yields to calculate event-by-event sWeights
  - apply sWeights to data to get 'pure' signal sample

sPlot: a statistical tool to unfold data distributions, Muriel Pivk, Francois R. Le Diberder, https://arxiv.org/abs/physics/0402083