First Tests for a PWA of Excited Ξ with PAWIAN

$\overline{\text{P}}$ANDA – Collaboration Meeting @GSI, December 7th 2016 | Jenny Pütz

Outline

- What is PAWIAN?
- What will be Tested?
- How to implement this in PAWIAN?
- Settings
- Test Results
- Summary & Outlook

What is PAWIAN?

- **PA**rtial **W**ave **I**nteractive **AN**alysis software
- Dedicated to all physics cases at $\overline{\text{P}}$ANDA
- Possible to define complicated decay trees
- Different spin formalisms and dynamics
- Event-based maximum likelihood fit (MINUIT2)
- Can be run on multi-core CPUs and computer clusters
- Generates events based on user-defined decay model or on fit results obtained with real data

https://panda-wiki.gsi.de/foswiki/bin/view/PWA/PawianPwaSoftware

What will be Tested?

- Goal: Can we reproduce the input values of the quantum numbers?
- First: focus on $J^{PC} = 1^{--}$

$$\bar{p}p \rightarrow J/\psi \rightarrow \Xi(1690)^{-} \ \bar{\Xi}^{+} \quad @ \ p_{\bar{p}} = 4.065 \text{ GeV/c}$$

- As cross reaction $\bar{p}p \rightarrow J/\psi \rightarrow \bar{\Lambda}(1890)\,\Lambda$ is chosen
- First checks are done on maximum likelihood → How strong is the fit result depending on input parameters?

How to implement this in PAWIAN?

- Configuration file
  - Definition of final state particles
  - Number of events for toy data and MC generation
  - Set beam momentum and maximal angular momentum
  - Definition of produced particles and particle decays
  - Fix different parameter
- Parameter file
  - Automatically generated
  - Defines start parameter
- Toy data and MC generation
- Fit

Settings

- Number of toy data: 30000 (generated with model)
- Number of MC data: 100000 (generated without model)
- Final state particles: $\overline{\Xi}^{+}$ Λ K^{-}
- Beam momentum: 4.065 GeV/c
- $L_{max} = 0$
- Fixed all parameters for $J^{PC} \neq 1^{--}$ to 0

Settings

Fix all parameter for $J^{PC} \neq 1^{--}$ to zero

genParams.dat

```
L0S0_J0P-1C1ToXi(1690)-_Xibar+Mag   0   0.5
L0S0_J0P-1C1ToXi(1690)-_Xibar+Phi   0   0.2
L1S1/2_Xi(1690)-ToLambda_K-Mag  1   0.5
L1S1/2_Xi(1690)-ToLambda_K-Phi  0   0.2
Xi(1690)-Mass   1.69    0.03    1.54    1.84
Xi(1690)-Width  0.02    0.004   0   0.04
L2S2_J0P-1C1ToantiLambda(1890)0_LambdaMag   0   0.5
L2S2_J0P-1C1ToantiLambda(1890)0_LambdaPhi   0   0.2
L1S1/2_antiLambda(1890)0ToXibar+_K-Mag  1   0.5
L1S1/2_antiLambda(1890)0ToXibar+_K-Phi  0   0.2
antiLambda(1890)0Mass   1.89    0.03    1.74    2.04
antiLambda(1890)0Width  0.12    0.024   0   0.24
L0S1_J1P-1C-1ToXi(1690)-_Xibar+Mag  0.7071067811865475  0.3535533905932737
L0S1_J1P-1C-1ToXi(1690)-_Xibar+Phi  0.2 0.2
L2S1_J1P-1C-1ToXi(1690)-_Xibar+Mag  0.1 0.3535533905932737
L2S1_J1P-1C-1ToXi(1690)-_Xibar+Phi  -1.2    0.2
L0S1_J1P-1C-1ToantiLambda(1890)0_LambdaMag  0.5773502691896258
  0.2886751345948129
L0S1_J1P-1C-1ToantiLambda(1890)0_LambdaPhi  1.5 0.2
L2S1_J1P-1C-1ToantiLambda(1890)0_LambdaMag  0.23    0.2886751345948129
L2S1_J1P-1C-1ToantiLambda(1890)0_LambdaPhi  -0.1    0.2
L2S2_J1P-1C-1ToantiLambda(1890)0_LambdaMag  0.156   0.2886751345948129
L2S2_J1P-1C-1ToantiLambda(1890)0_LambdaPhi  0.987   0.2
channelType1Xibar+LambdaK-Scaling   1   0.01    0   20
Iso1J0P-1C1 0.8366600265340756  0.5 0   1
Iso1J1P-1C-1    0.8366600265340756  0.5 0   1
J0P-1C1L0S0pbarpMag 0.  0.3535533905932737
J0P-1C1L0S0pbarpPhi 0   0.2
J1P-1C-1L0S1pbarpMag    0.7071067811865475  0.3535533905932737
J1P-1C-1L0S1pbarpPhi    0   0.2
```

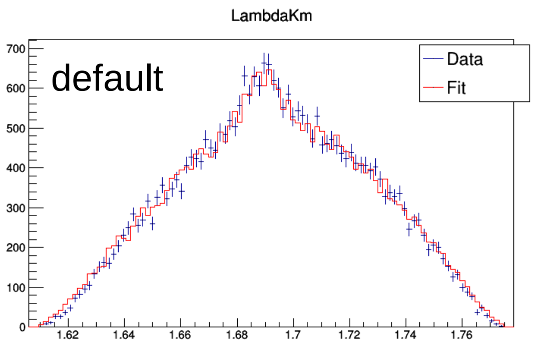
Test Results

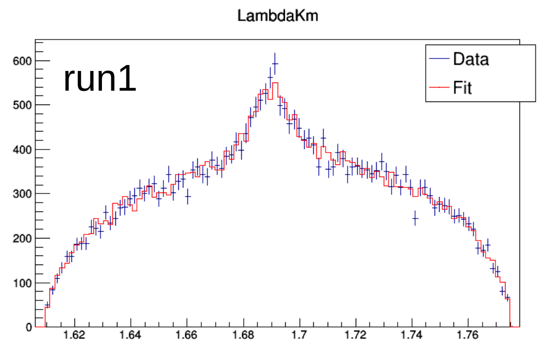
$\Xi(1690)^-$		Default Params	run1	run2	run3	run4	run5
L=0, S=1	Mag	0.707	0.707	0.2	0.9	0.7	0.3
	Phi	0	0.2	0.01	0.5	0.2	-0.2
L=2, S=1	Mag	0.707	0.1	0.01	0.1	0.7	0.7
	Phi	0	-1.2	-2	-0.5	0.2	1.5
$\bar{\Lambda}(1890)$							
L=0, S=1	Mag	0.577	0.577	0.1	0.5	0.5	0.1
	Phi	0	1.5	0.5	1.0	1.5	-1.5
L=2, S=1	Mag	0.577	0.23	0.05	0.4	0.5	0.3
	Phi	0	-0.1	-0.5	0.1	1.5	0.5
L=2, S=2	Mag	0.577	0.156	0.01	0.1	0.5	0.5
	Phi	0	0.987	-0.1	-0.5	1.5	1.5
BIC		-18336.8	-8130.28	-9324.57	-9738.29	-18187.1	-14340.7
AIC		-18444.8	-8238.28	-9432.58	-9846.3	-18295.1	-14448.7

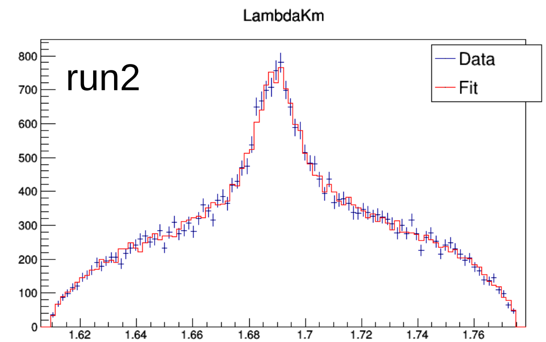
What are the different runs?

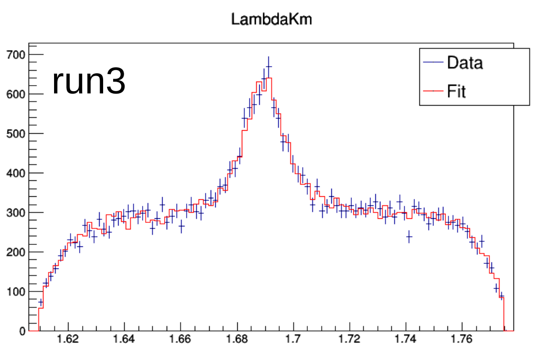
Run1: parameters randomly set by Bertram
Run2: parameters smaller than in run1
Run3: parameters bigger than in run1
Run4: parameters with equal values
Run5: parameters with „reversed“ values

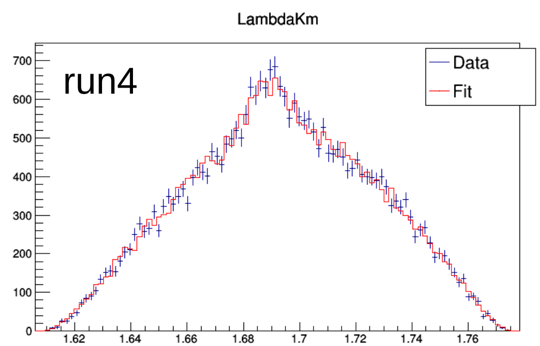
Test Results

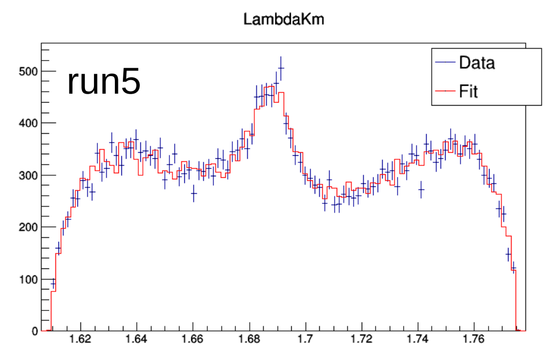




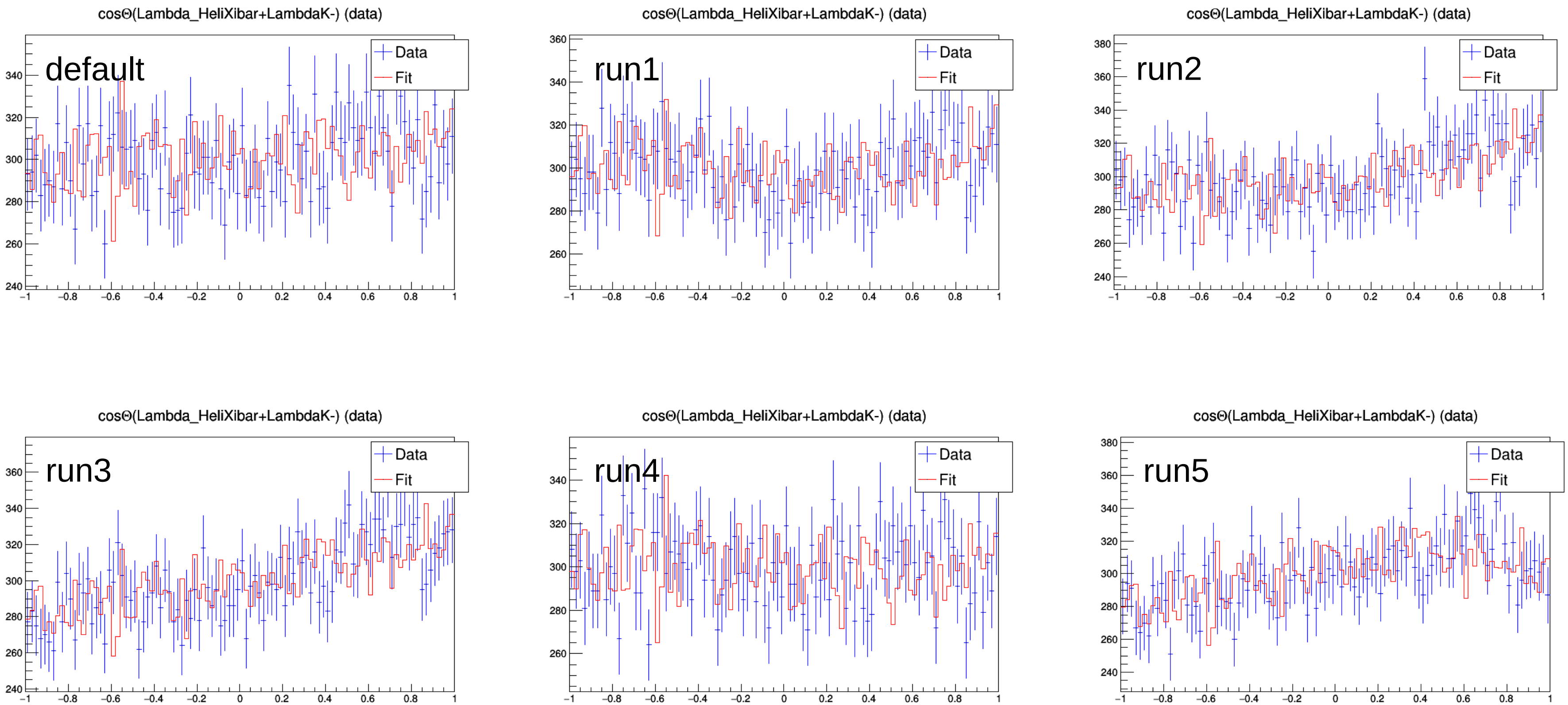








Test Results



Summary & Outlook

- ✔ Result is depending on input parameters
- ✔ “Good” result needs knowledge about which combination of L and S is “preferred/suppressed”

- ❑ Check if initial quantum numbers can be determined from fit

Thank you for your attention!

Backup

BIC and AIC

- **Bayesian information criterion (BIC):**

  is a criterion for model selection among a finite set of models; the model with the lowest BIC is preferred.

  $$\mathrm{BIC} = 2 \cdot (-\mathrm{LHH}) + k \cdot \ln(n)$$

  with LHH: maximal loglikelihood value, k: number of free fit parameters and n: number of events in the sample

- **Akaike information criterion (AIC):**

  is a measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models

  $$\mathrm{AIC} = 2k + 2 \cdot (-\mathrm{LLH})$$

LogLikelihood values

- Default: -9235.39
- Run1: -4132.15
- Run2: -4729.29
- Run3: -4401.14
- Run4: -9160.57
- Run5: -7237.37