Progress Report on $\overrightarrow{\gamma} d \rightarrow K^+ \overrightarrow{\Lambda} n$ Analysis
Development of a Realistic Event Generator

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WHERE DISCOVERIES BEGIN

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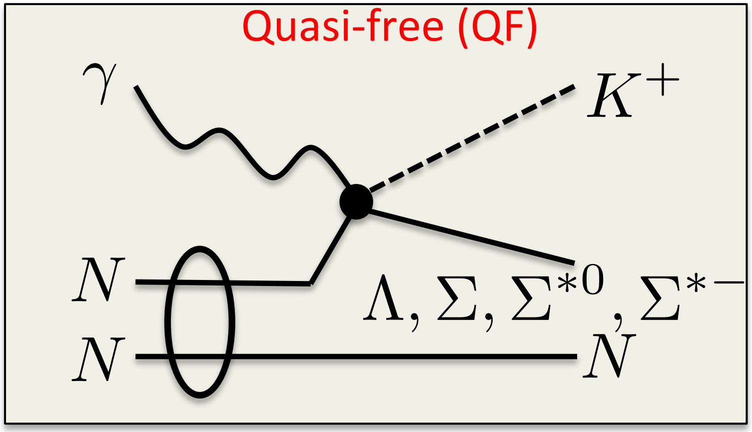
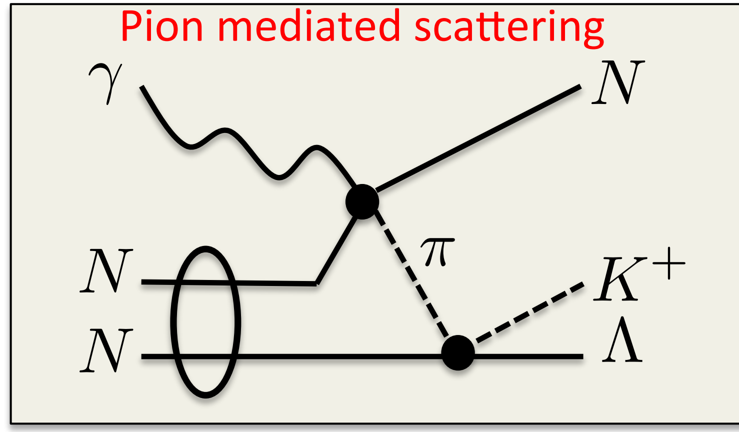
Overview of Project

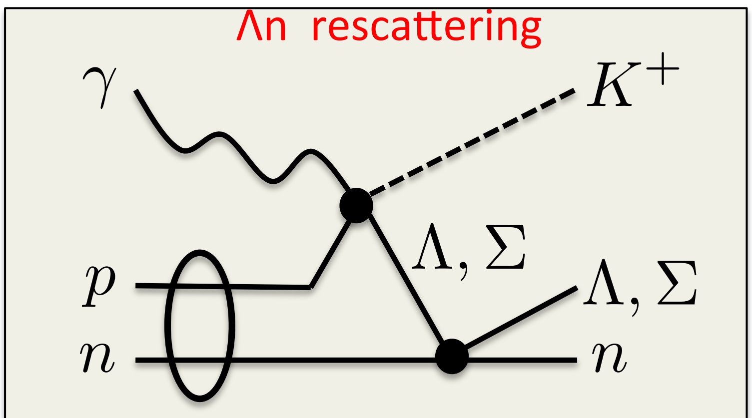
- Original motivation for development of generator
  1. Background subtraction
  2. Analysis of systematic uncertainties

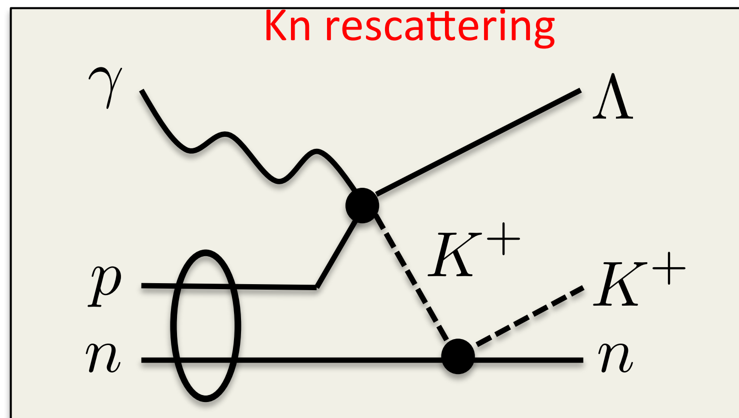
- Progress on new version and future
  1. Add more physics: Implement published unpolarized cross sections, polarization observables, etc.
  2. Offer more options aimed at diverse requirements of analysis (study of background mechanisms)

Reaction Mechanisms and Background Channels









Channels in Generator

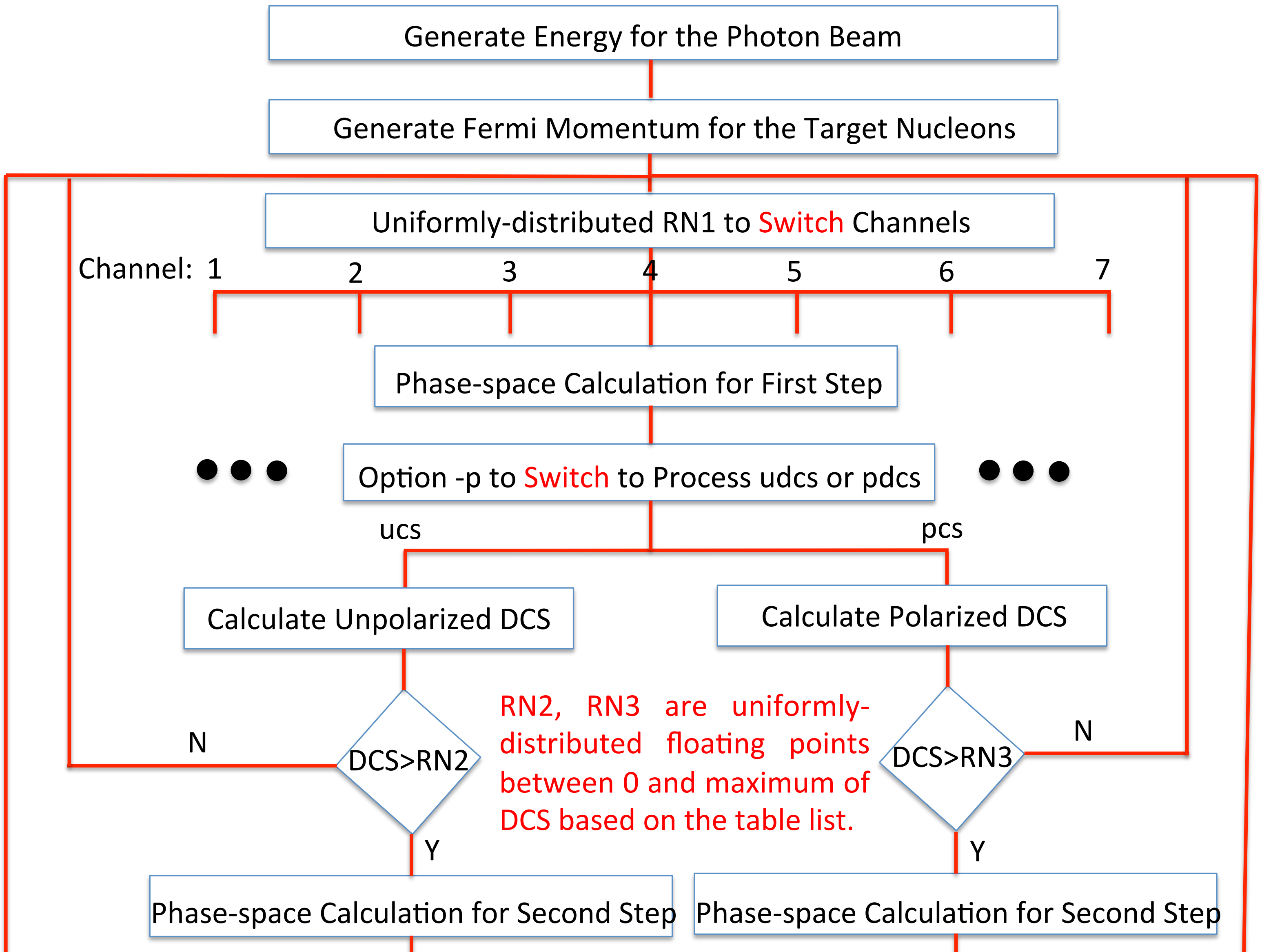
Generator

Channel Number	Channel Name	First step	Second step
1	π^0 mediated for signal	$\gamma n \to \pi^0 n$	$\pi^0 p \to K^+\Lambda$
2	Kn re-scattering for signal	$\gamma p \to K^+\Lambda$	$K^+ n \to K^+ n$
3	Λn re-scattering for signal	$\gamma p \to K^+\Lambda$	$\Lambda n \to \Lambda n$
4	Σn re-scattering for Σ production	$\gamma p \to K^+\Sigma$	$\Sigma n \to \Sigma n$
5	π^+ mediated for signal	$\gamma p \to \pi^+ n$	$\pi^+ n \to K^+\Lambda$
6	Quasi-free for Σ^{*0} production	$\gamma p \to K^+\Sigma^{*0}$	$\Sigma^{*0} \to \Lambda\pi$
7	Quasi-free for Σ^{*-} production	$\gamma n \to K^+\Sigma^{*-}$	$\Sigma^{*-} \to \Lambda\pi^-$

Additionally, two other channels are processed in the next process of conversion from root-file to BOS-file.

- Channel 8: quasi-free for Λ production, using the first step information of the channels 2 and 3
- Channel 9: quasi-free for Σ production, using the first step information of the channel 4

Flow Chart of Generator



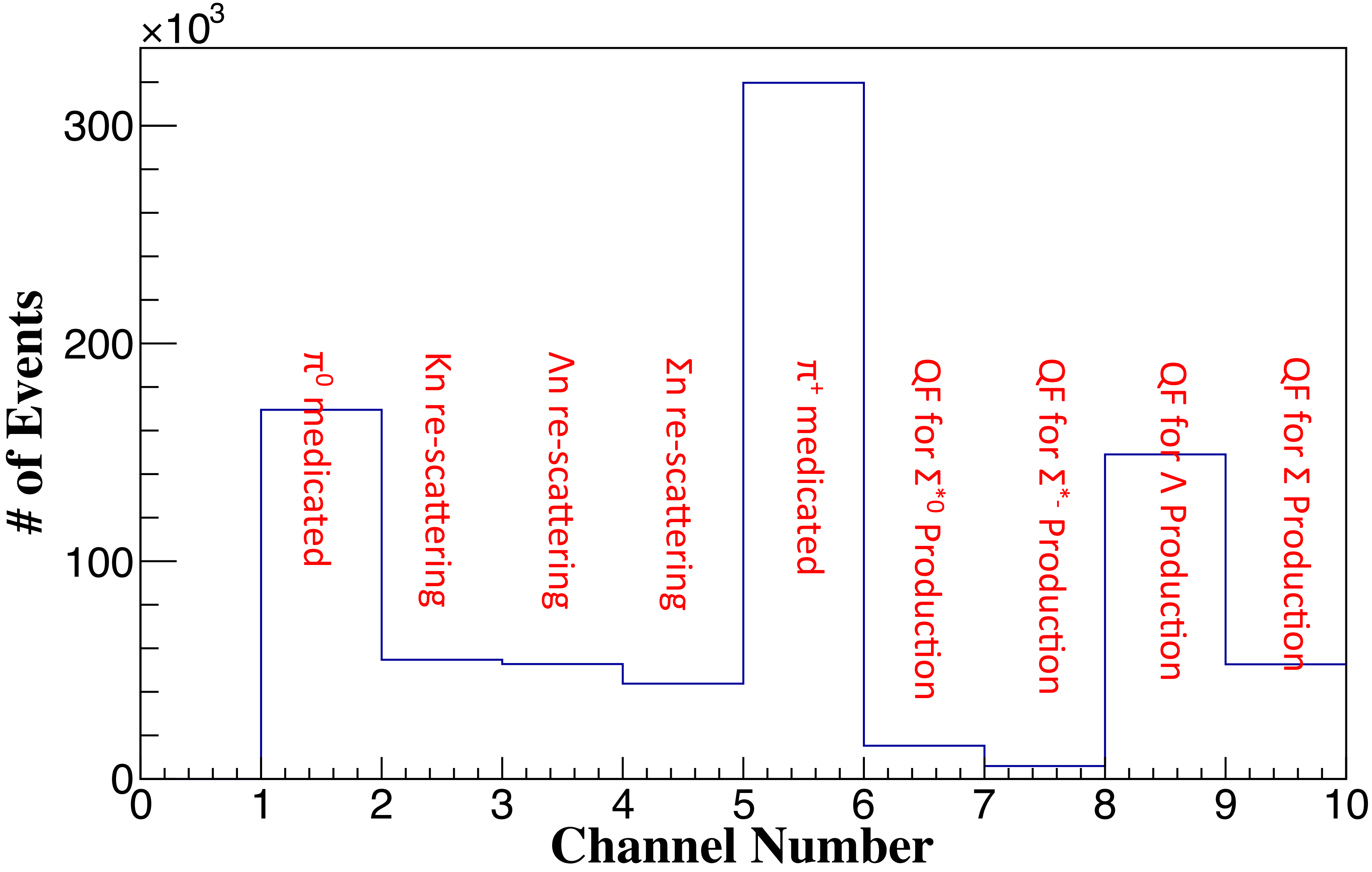
How to Run

- After compiling, the executive file called “gendpi0” is produced.
- Example of how to run:

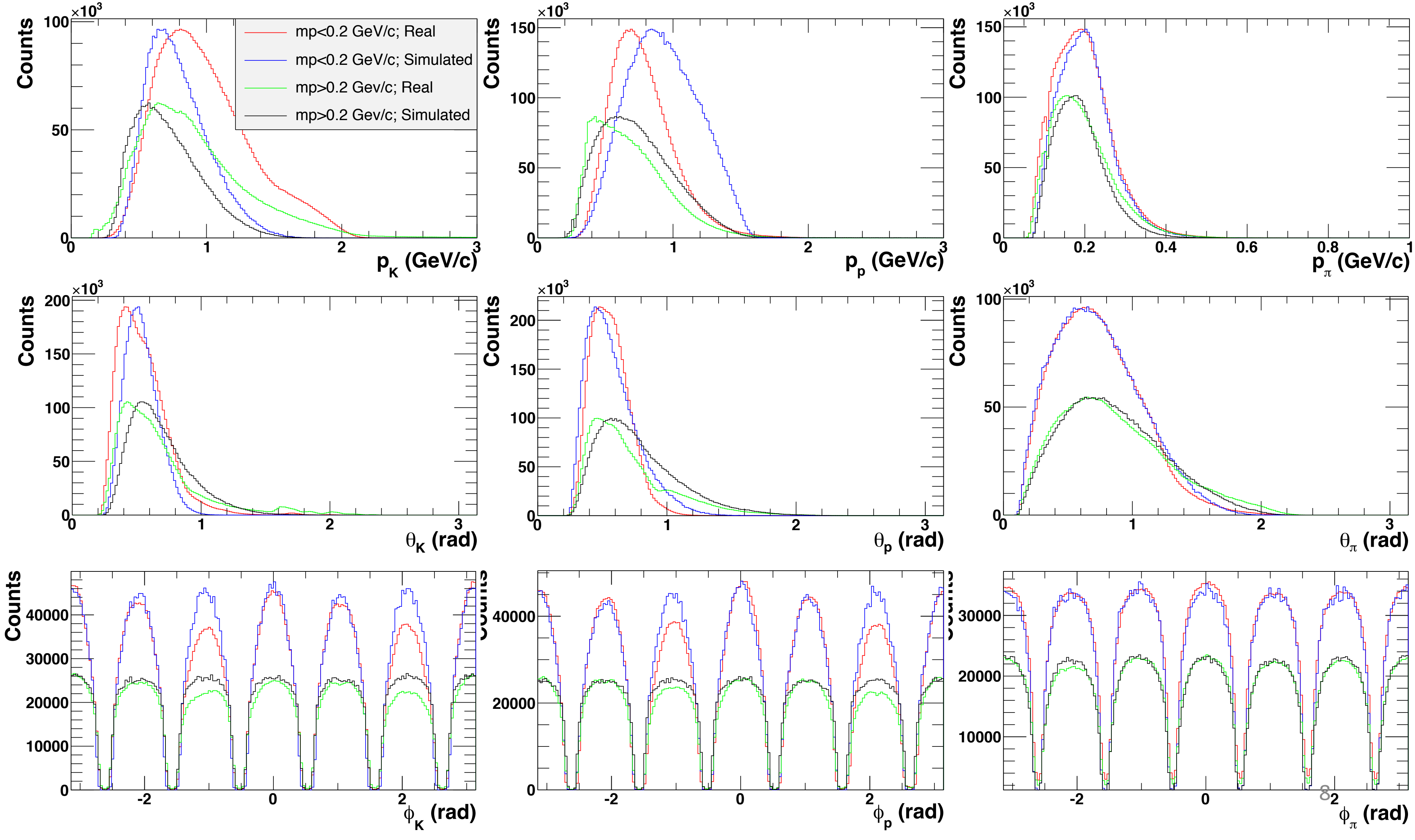
  ./gendpi0 -R example.root -M 50000 -E 0.9:2.6 -p pcs -n 3 -c 246

  - Option R: Output file name
  - Option M: Number of events to be generated.
  - Option E: Photon beam energy range
  - Option p: Choice of unpolarized or polarized differential cross section in the first step
  - Option n: Number of reaction channels to be processed
  - Option c: List of the reaction channels according to numbering scheme on p. 3

Number of Events for Different Channels



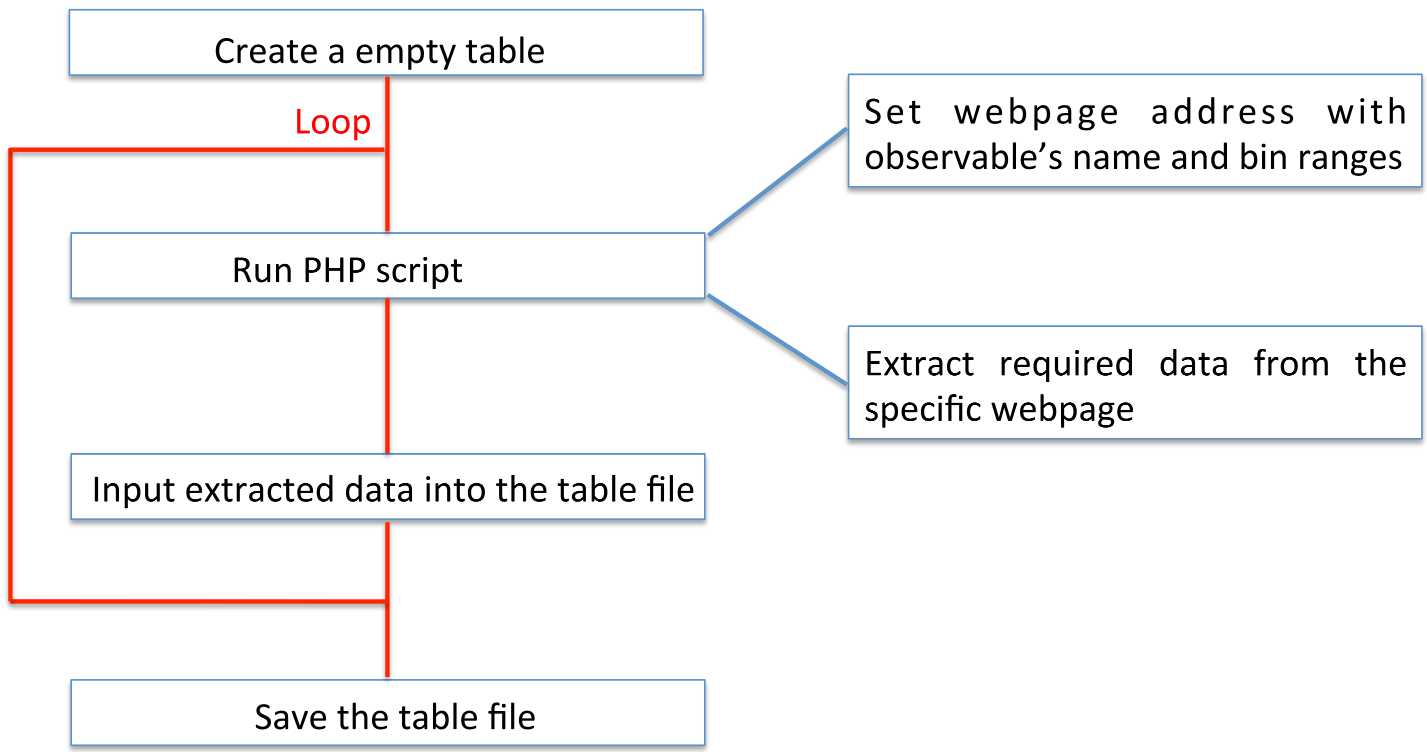
Compare Kinematics Between Real Data and Simulated Data



How to Extract Cross-Section Values from Online Databases, Such as SAID

A batch program was developed to quickly create a table in the format required by the generator using PHP script and C++.

Flow Chart



Unpolarized Cross Section of the Second-Step Channels

- There are no available results for unpolarized cross section of second-step $\pi^0 p \to K^+\Lambda$ and $\pi^+ n \to K^+\Lambda$ channels.
- Data and model predictions are published for the closest channels, such as $\pi^- p \to K^0\Lambda$, $\pi^- p \to K^0\Sigma^0$, $\pi^- p \to K^+\Sigma^-$, and $\pi^+ p \to K^+\Sigma^+$.
- The technique of isospin couplings for $\pi N \to KY$ is used to calculate unpolarized cross section of the second-step channels.

Hadron	p	n	π^+	π^0	π^-	K^+	K^0	Λ	Σ^+	Σ^0	Σ^-
I	$\frac{1}{2}$	$\frac{1}{2}$	1	1	1	$\frac{1}{2}$	$\frac{1}{2}$	0	1	1	1
I_3	$\frac{1}{2}$	-$\frac{1}{2}$	1	0	-1	$\frac{1}{2}$	-$\frac{1}{2}$	0	1	0	-1

Technique of Isospin Couplings

- In the strong interaction, iso-multiplets are indistinguishable.
- For a reaction, the initial and final states of isospin can be obtained through Clebsch-Gordan coefficients.
- Cross section is proportional to square of magnitude of amplitude.

$$\sigma = C|\langle f|H|i\rangle|^2$$

$\pi N \to K\Lambda$

- Channel a: $\pi^- p \to K^0\Lambda$

$$\sigma_a = C| -\sqrt{\frac{2}{3}}\langle\frac{1}{2} - \frac{1}{2}|H|\frac{1}{2} - \frac{1}{2}\rangle|^2$$

- Channel b: $\pi^0 p \to K^+\Lambda$

$$\sigma_b = C| -\sqrt{\frac{1}{3}}\langle\frac{1}{2}\frac{1}{2}|H|\frac{1}{2}\frac{1}{2}\rangle|^2$$

- Channel c: $\pi^+ n \to K^+\Lambda$

$$\sigma_c = C|\sqrt{\frac{2}{3}}\langle\frac{1}{2}\frac{1}{2}|H|\frac{1}{2}\frac{1}{2}\rangle|^2$$

$$\sigma_a : \sigma_b : \sigma_c = 2 : 1 : 2$$

$\pi N \to K\Sigma$

- Channel a: $\pi^- p \to K^0 \Sigma^0$

$$\sigma_a = C|\frac{\sqrt{2}}{3}\langle\frac{3}{2} - \frac{1}{2}|H|\frac{3}{2} - \frac{1}{2}\rangle - \frac{\sqrt{2}}{3}\langle\frac{1}{2} - \frac{1}{2}|H|\frac{1}{2} - \frac{1}{2}\rangle|^2$$

- Channel b: $\pi^- p \to K^+ \Sigma^-$

$$\sigma_b = C|\frac{1}{3}\langle\frac{3}{2} - \frac{1}{2}|H|\frac{3}{2} - \frac{1}{2}\rangle + \frac{2}{3}\langle\frac{1}{2} - \frac{1}{2}|H|\frac{1}{2} - \frac{1}{2}\rangle|^2$$

- Channel c: $\pi^+ p \to K^+ \Sigma^+$

$$\sigma_c = C|\langle\frac{3}{2}|H|\frac{3}{2}\rangle|^2$$

- Channel d: $\pi^+ n \to K^+ \Sigma^0$

$$\sigma_d = C|\frac{\sqrt{2}}{3}\langle\frac{3}{2}\frac{1}{2}|H|\frac{3}{2}\frac{1}{2}\rangle - \frac{\sqrt{2}}{3}\langle\frac{1}{2}\frac{1}{2}|H|\frac{1}{2}\frac{1}{2}\rangle|^2$$

- Channel e: $\pi^0 p \to K^+ \Sigma^0$

$$\sigma_e = C|\frac{2}{3}\langle\frac{3}{2}\frac{1}{2}|H|\frac{3}{2}\frac{1}{2}\rangle + \frac{1}{3}\langle\frac{1}{2}\frac{1}{2}|H|\frac{1}{2}\frac{1}{2}\rangle|^2$$

$$\sigma_d = \sigma_a \qquad \sigma_e = \frac{\sigma_b + \sigma_c - \sigma_a}{2}$$

Summary and Outlook

- Source files about the generator can be found in the ifarm directory /u/home/caot/simulation. To be uploaded to the standard CLAS repository.

- Unpolarized differential cross sections of the second-step channels are in process to be added into the generator.

- More polarization observables will be implemented to calculate comprehensive polarized differential cross sections of the first-step channels.

- Additional options will be offered for the convenience of user applications.