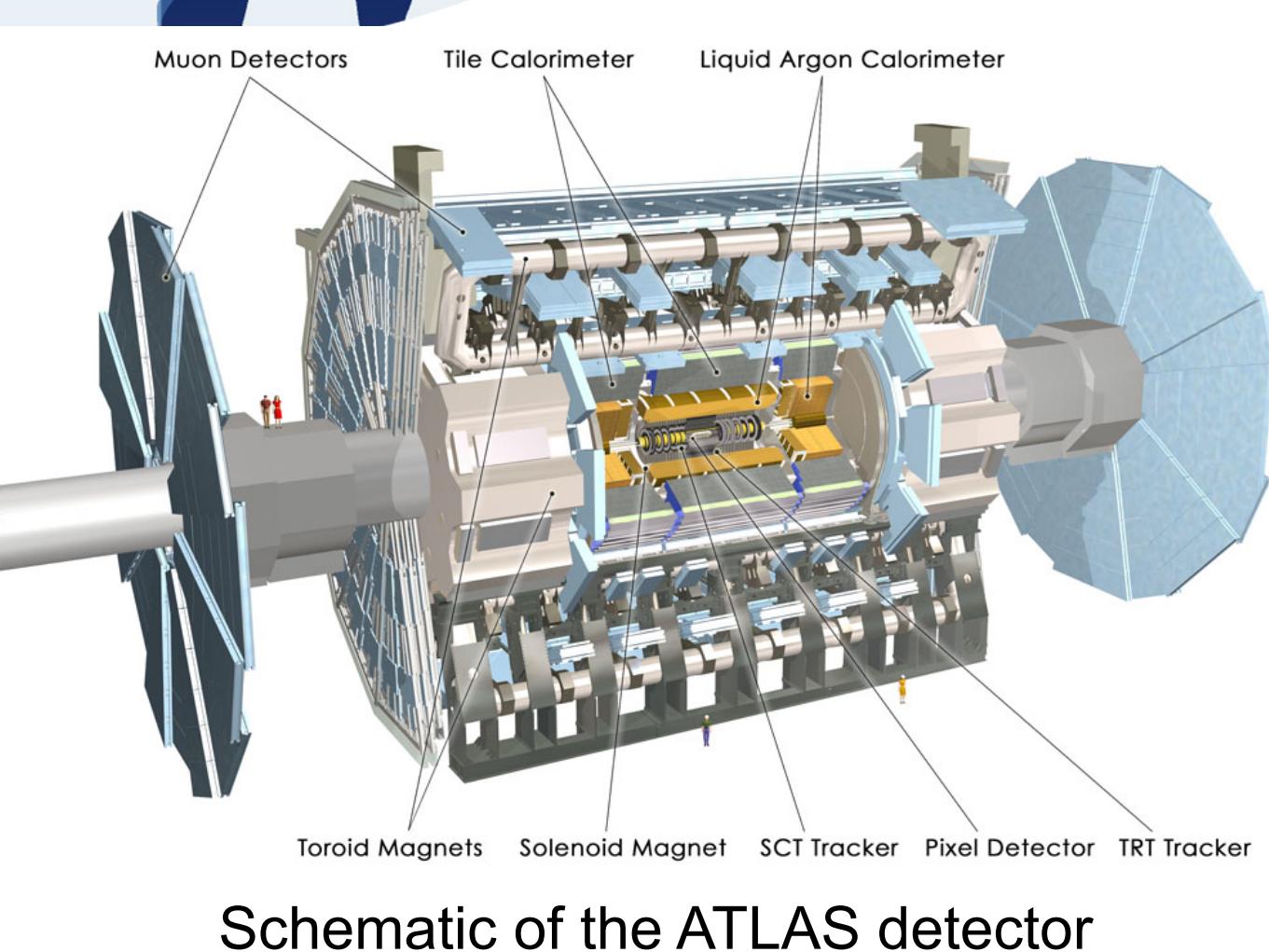


# Correlation between Inclusively Produced $\Lambda^0$ - $\Lambda^0$ , $\Lambda^0$ -anti- $\Lambda^0$ and anti- $\Lambda^0$ -anti- $\Lambda^0$ Hyperon Pairs with the ATLAS Detector

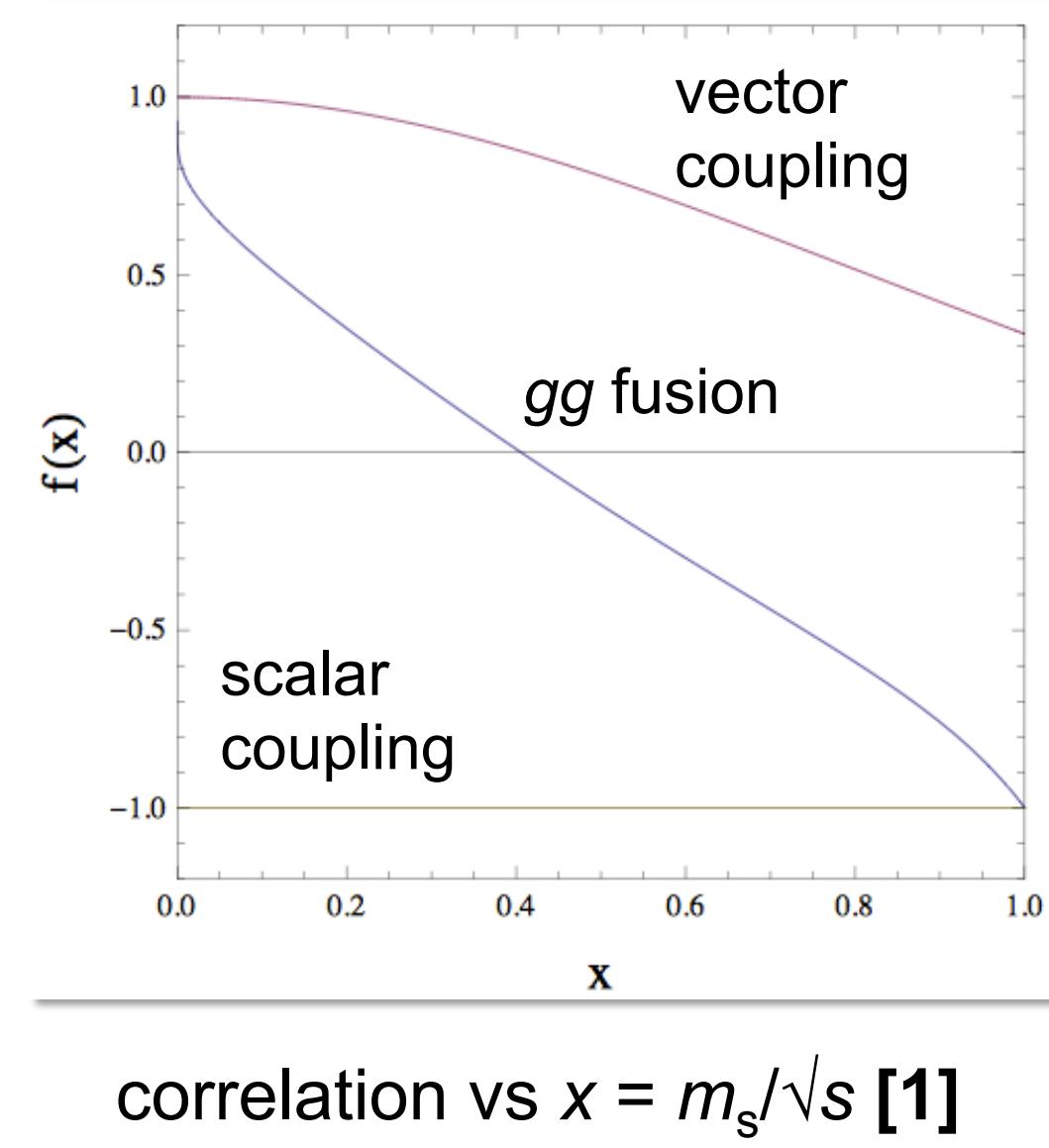
## Introduction



Schematic of the ATLAS detector

### Motivations:

- Lambda hyperon ( $u-d-s$ ) is believed to preserve the spin information when s-quark hadronizes.
- ssbar (quark-antiquark) pairs produced very closely in space-time would be constrained in their momentum, according to the initial state of the system.
- Like-type hyperon pairs produced very closely would be forbidden to carry the same quantum number by the Pauli's exclusion principle and thus follow the Fermi-Dirac statistics.
- The study of spin correlation between Lambda hyperon pairs help probe ssbar (quark-antiquark) production mechanism [1] and Fermi-Dirac effect on like-type pairs.



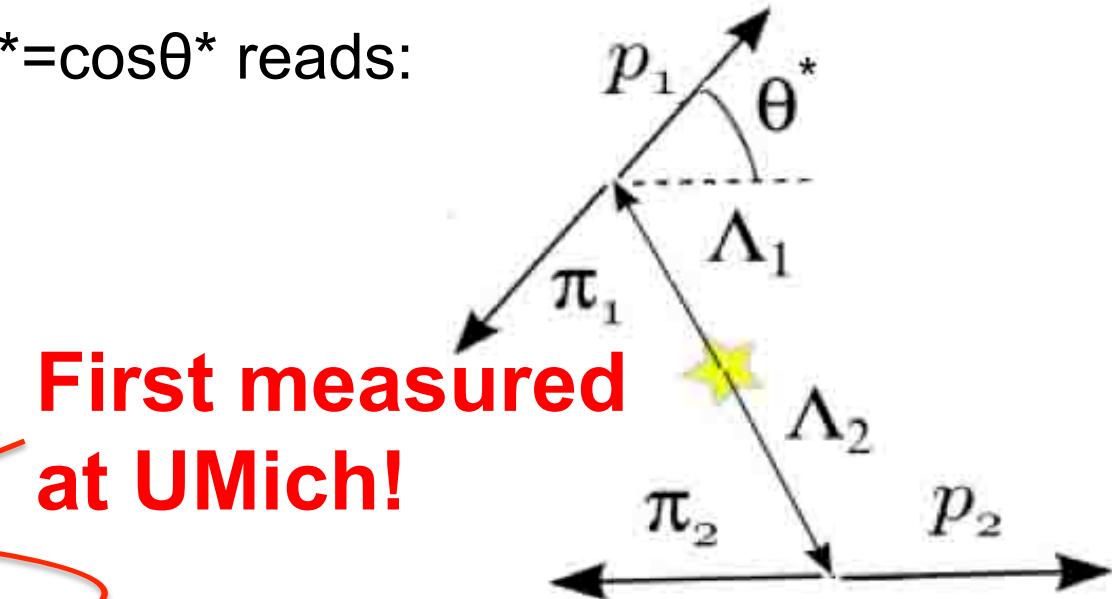
## Lambda Hyperon, Spin Correlation and Decay Angles

- The spin correlation can be measured by the decay angle between the decay protons or decay anti-protons in the center-of-mass frame of the hyperon pairs, as shown in the figure on the right.
- The PDF of the cosine of the decay angle  $y^* = \cos\theta^*$  reads:

$$w(y^*) = \frac{1}{4}(1 + A\alpha_{\Lambda_1}\alpha_{\Lambda_2}y^*)$$

where  $A = (N_{\text{aligned}} - N_{\text{antialigned}})/N_{\text{total}}$ ,

$\Lambda_1$  and  $\Lambda_2$  can be either  $\Lambda^0$  or  $\bar{\Lambda}^0$ .  
and  $\alpha_{\Lambda(\bar{\Lambda})} = +(-)0.642 \pm 0.013$  [2].



## Correlation and Kinematic Weighting

Uncorrelated templates are used as benchmarks for spin correlation extraction.

### Correlation weighting:

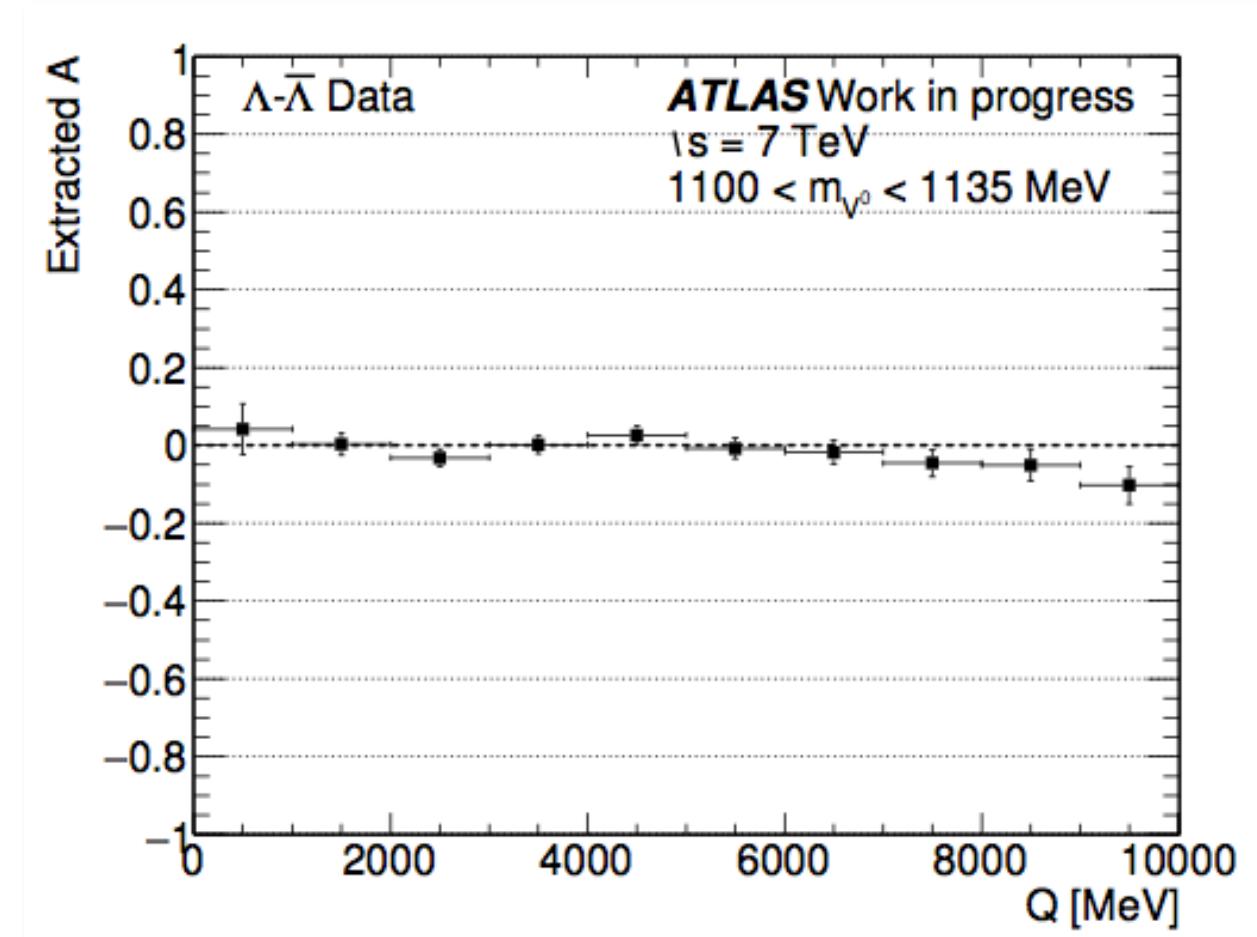
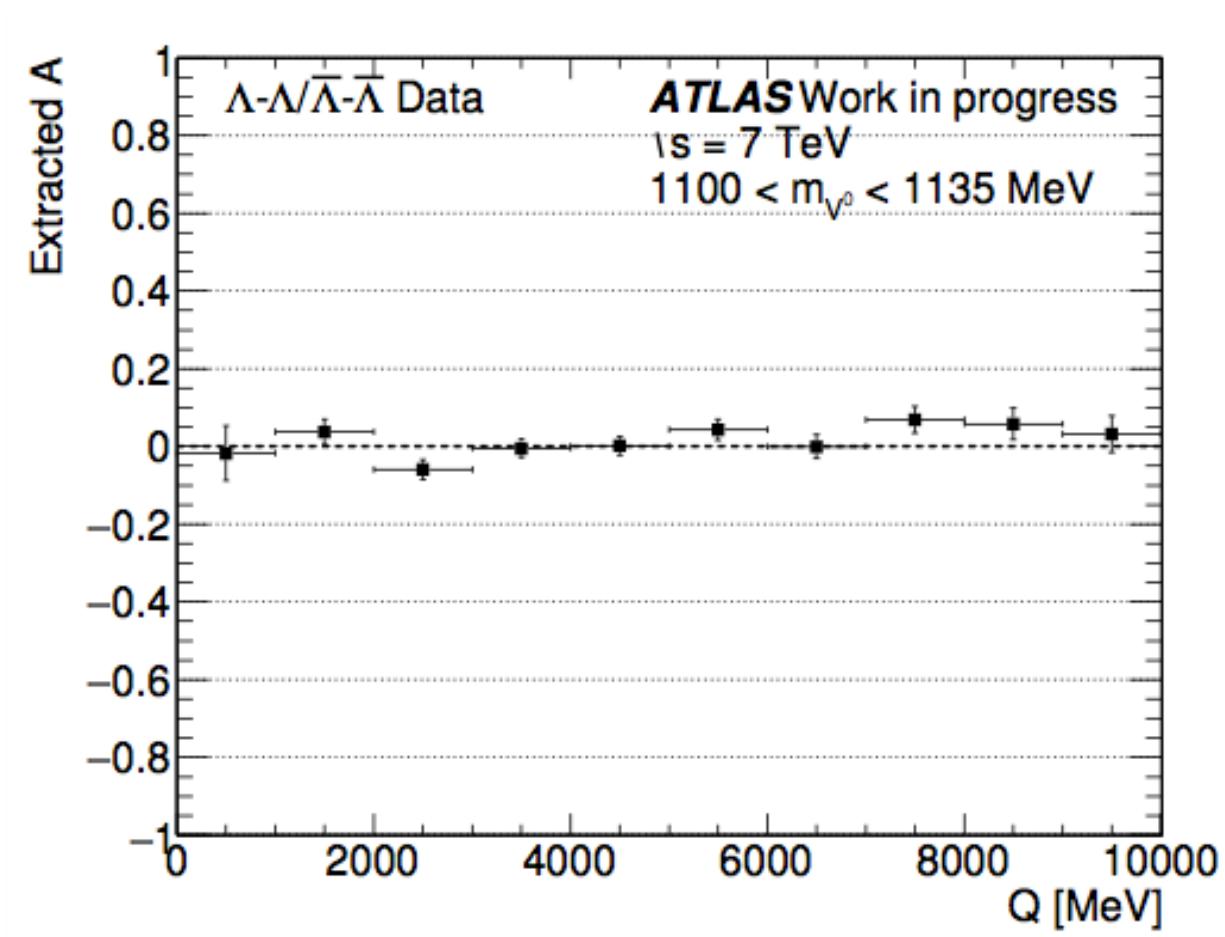
- Templates are weighed to different  $A$  values using the PDF described above. (See  $y^*$  plots on the right)

### Kinematic weighting:

- Templates are weighted iteratively to data using the kinematics of hyperon pairs and individual hyperon to account for the distortion of  $y^*$  distribution caused by detector effect which depend heavily on kinematics.

## Tentative Results

The spin correlation ( $A$ ) and the corresponding statistical uncertainties are plotted as a function of  $Q$  with bin size of 1 GeV for like-type (left) and unlike-type (right) events below. No significant deviation from zero is observed.



## References

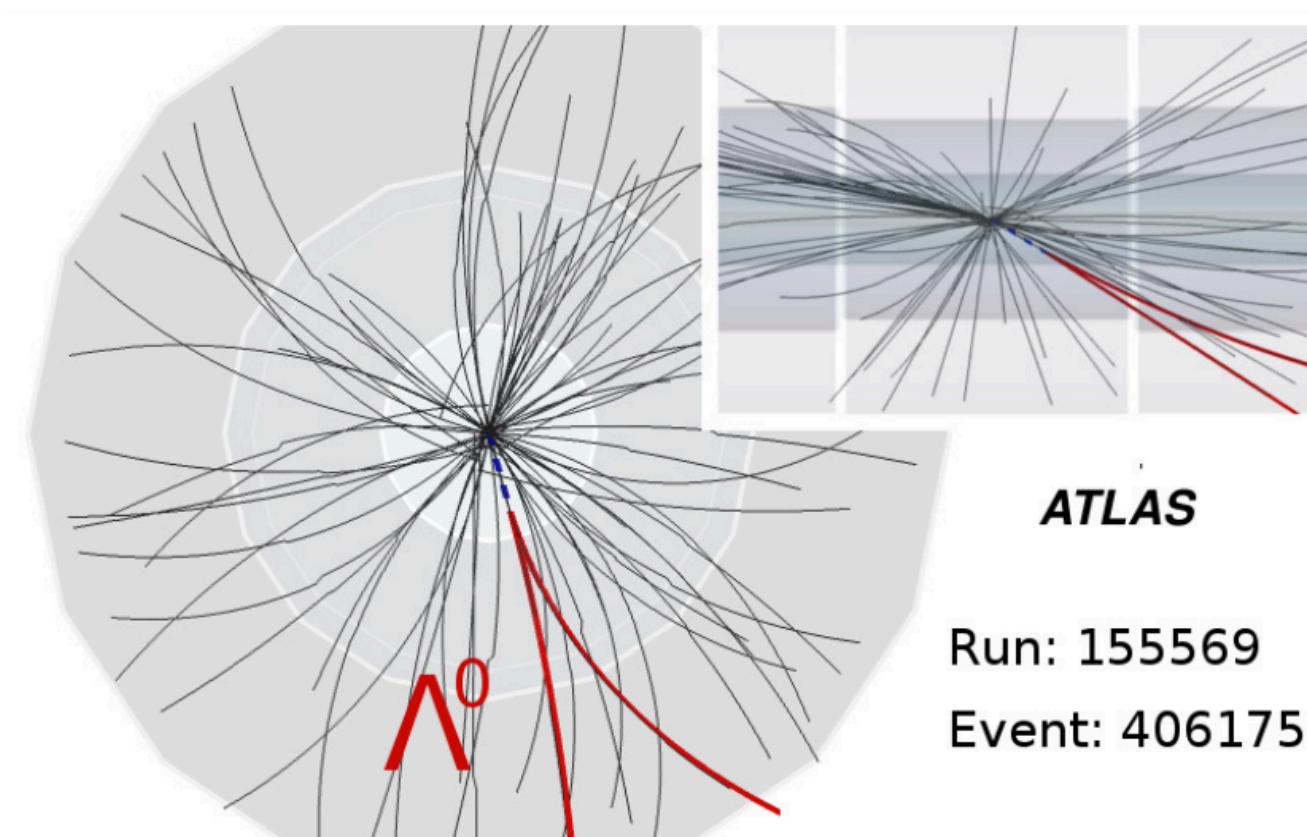
- [1] J. Ellis and D. S. Hwang, *Spin Correlations of  $\Lambda\Lambda$  Pairs as a Probe of Quark-Antiquark Pair Production*, Eur. Phys. J. C 72 (2011) no. arXiv:1108.5319. KCL-PH-TH-2011-27. LCTS-2011-13. CERN-PH-TH-2011-212, 1877. 12 p. Comments: 12 pages, 3 figures. [2] K. Nakamura et al. J. Phys. G 37 (2010) 075021.

- [3] N. D. Gagunashvili, *Comparison of weighted and unweighted histograms*, PoS(acat) 054, 2007, 2006.

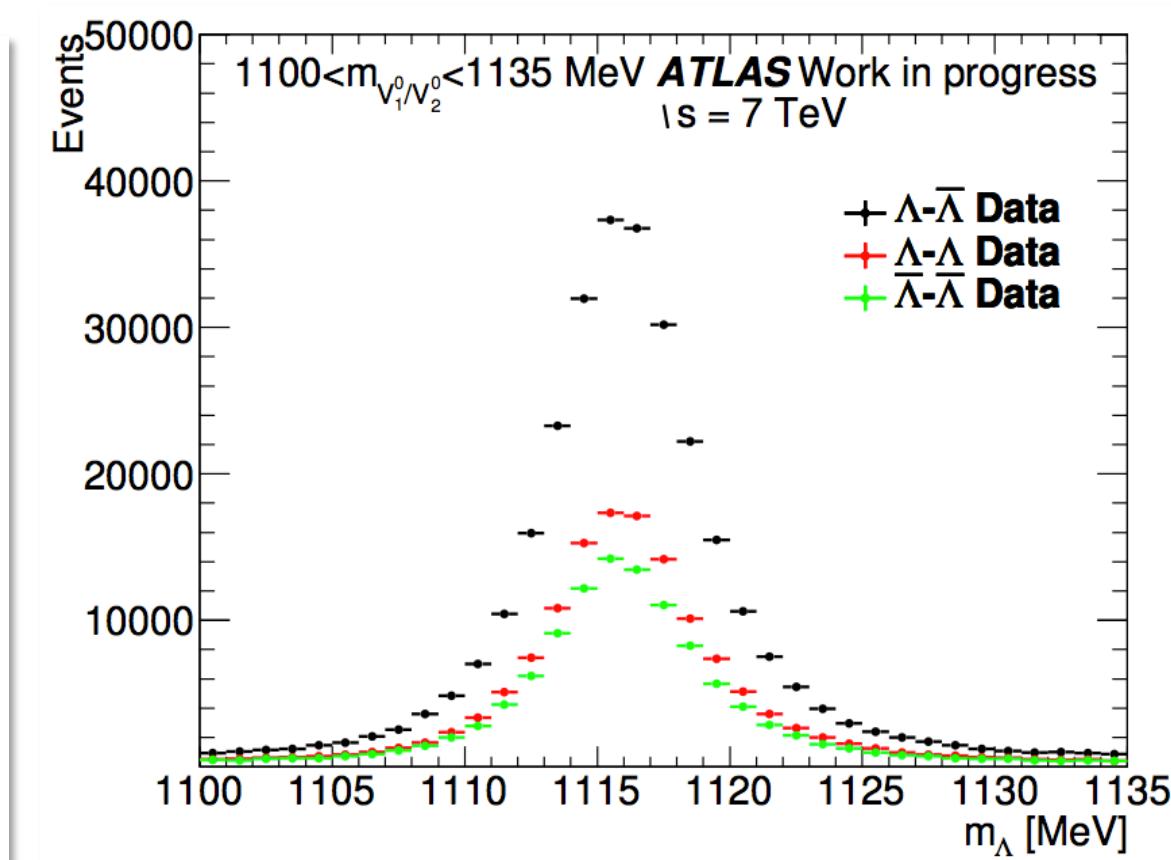
## Data, Event Selection and Yields

- Muon stream dataset from 2010 has been used with trigger selection disabled to achieve maximum statistics.
- Long-lived 2-prong decay candidates ( $V^0$ 's) are reconstructed using the standard ATLAS  $V^0$  finder package in default setting.
- A brief summary of selection criteria is listed below:

- $m(p,\pi)$  in  $(1100, 1135)$  MeV
- Vertex  $\chi^2$  probability  $> 0.05$
- Hits Pixel+SCT  $> 3$  per track
- Fraction of high threshold TRT hits  $< 0.14$
- $m(e,e)$  veto  $(0, 75)$  MeV
- $m(\pi,\pi)$  veto  $(480, 515)$  MeV
- $L_{xy} > 15$  mm
- $\sigma_{L_{xy}} > 15$
- $A_0$  significance  $< 3$



Event display of a Lambda candidate

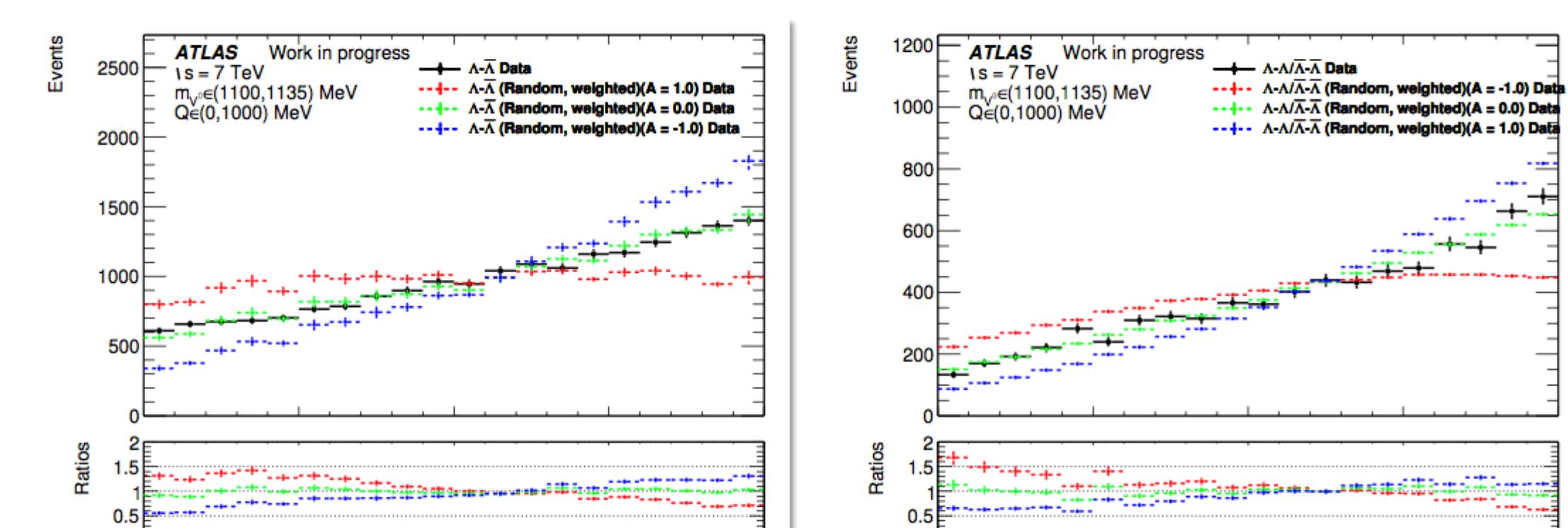


Reconstructed invariant mass of Lambda

- Uncorrelated data-driven templates are created by selecting and combining hyperon pairs from different events.

Candidates selected from	$\Lambda^0$ - anti- $\Lambda^0$	$\Lambda^0$ - $\Lambda^0$	anti- $\Lambda^0$ - anti- $\Lambda^0$
Same event	295,202	140,232	113,596
Different events	2,534,826	2,823,627	2,527,252

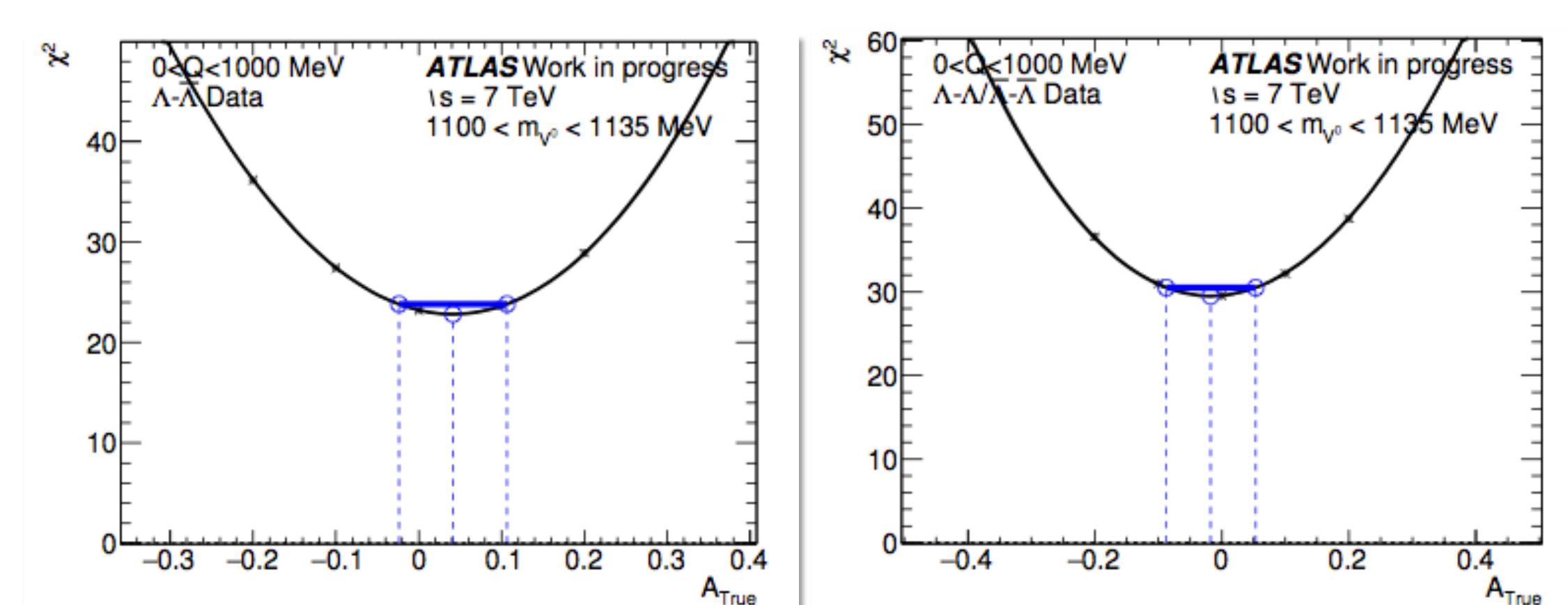
## Method of Minimum $\chi^2$



- The test statistic  $\chi^2$ , as described in reference [3], is evaluated between each template and data in bins of  $Q$ , where  $Q$  is the relative 4-momenta of each hyperon pair which represents their space-time separation:

$$Q = \sqrt{-(p_1 - p_2)^2}$$

- The position of the minimum value of  $A(\chi^2_{\min})$  is found.
- Statistical uncertainty is evaluated by  $\chi^2_{\min} + 1$ .



## Systematics

- The computation of systematics is still ongoing. Here is a list of major systematics under investigation:

- Kinematic weighting
- Decay angle resolution
- Background
- Binning
- Mass range
- Track  $p_T$  scale and resolution
- Uncertainty of decay parameter ( $\alpha$ )