Preliminary Statistics

S. Walker, L. Lista

Toy MC to Generate Events

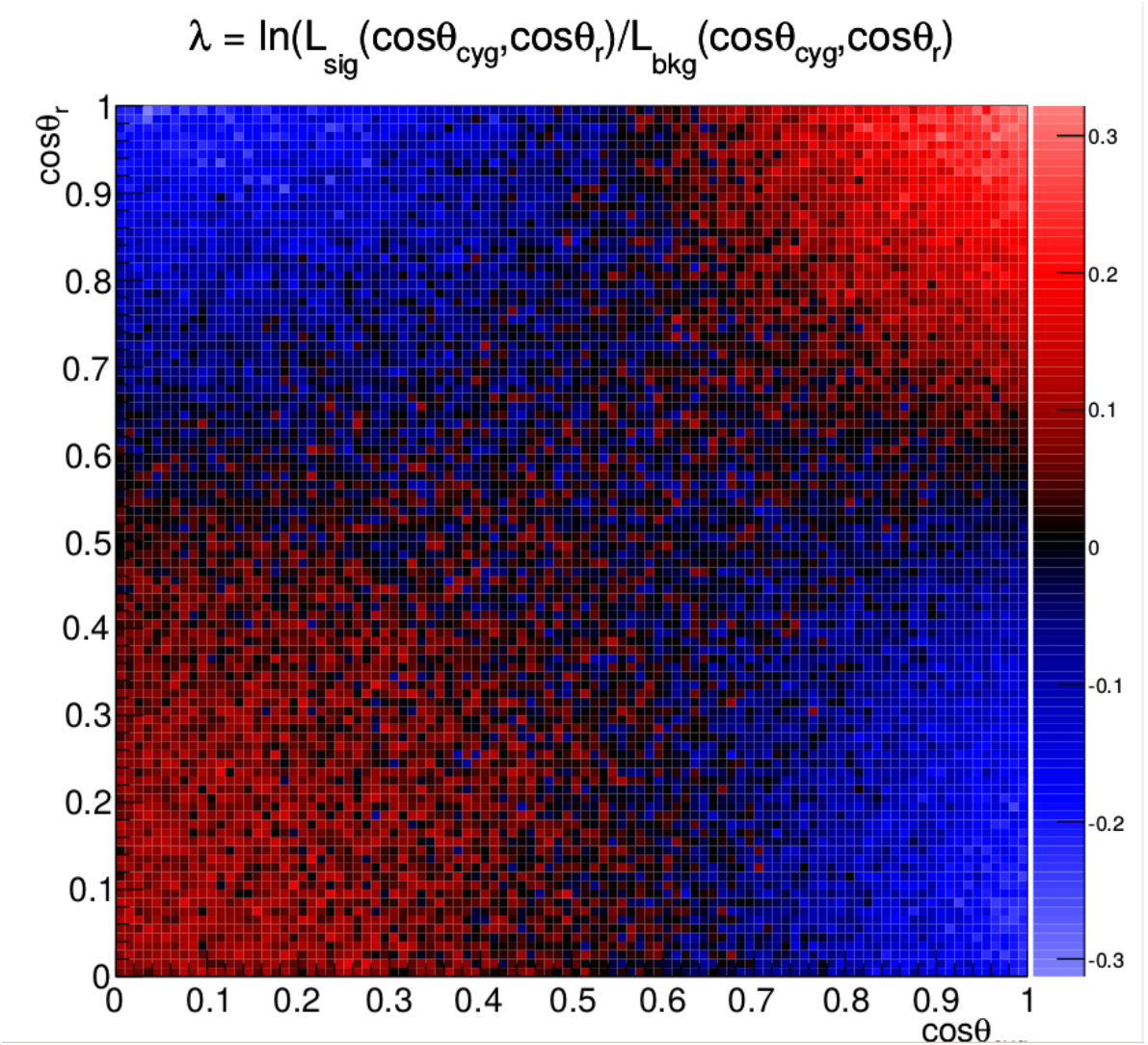
- Time is drawn from a uniform distribution from 0 to 24
- Cygnus angle is calculated
- Velocity components of the WIMP in the rest frame of the galaxy are chosen from a 3-dimensional Gaussian with sigma= 220,000/sqrt(2) (while scalar velocity<560,000km/s)
- The velocity of the SS motion through the galaxy is added to the z component to have the incident velocity components in a frame where the z-axis points in the direction of Cygnus (direction of SS motion)
- Coordinates are rotated to the detector frame
- A recoil energy is chosen from a uniform distribution from 0 to maximum possible recoil energy (rE_{WIMP}, where r is kinematic factor)
- The velocity of the recoiling nucleus, and sin(α) and cos(α) (where α=angle between incident WIMP and recoil track) are calculated . A vector is defined perpendicular to the WIMP vector and an algorithm is used to rotate it at random from 0 to 2π radians. This chooses a recoil vector in the detector frame. The cosine of the polar angle of the recoil in the detector frame can then be calculated.
- Absolute value of the $Cos(\Theta_r)$ is used to fold events at the same angle above and below the x-y plane of the detector

Process for Statistics

- A high statistics (10 million events right now) 2D histogram for Cygnus angle versus $\cos(\Theta_r)$ is created to be used as the signal probability density function (pdf).
- A histogram for a background pdf is created with the same number of events, but isotropic in $\cos(\Theta_r)$
- A 2D lamba histogram is made where the value in a bin is the log of the ratio signal/background for the same bin.
- 10,000 sets of N number of events are generated from the signal MC, and for each event the lambda value is retrieved from the corresponding bin of the lambda histogram. A new histogram of the lambda values of events is created.
- This is repeated the background distribution to generate events, and a histogram is made of the lamba values of events.

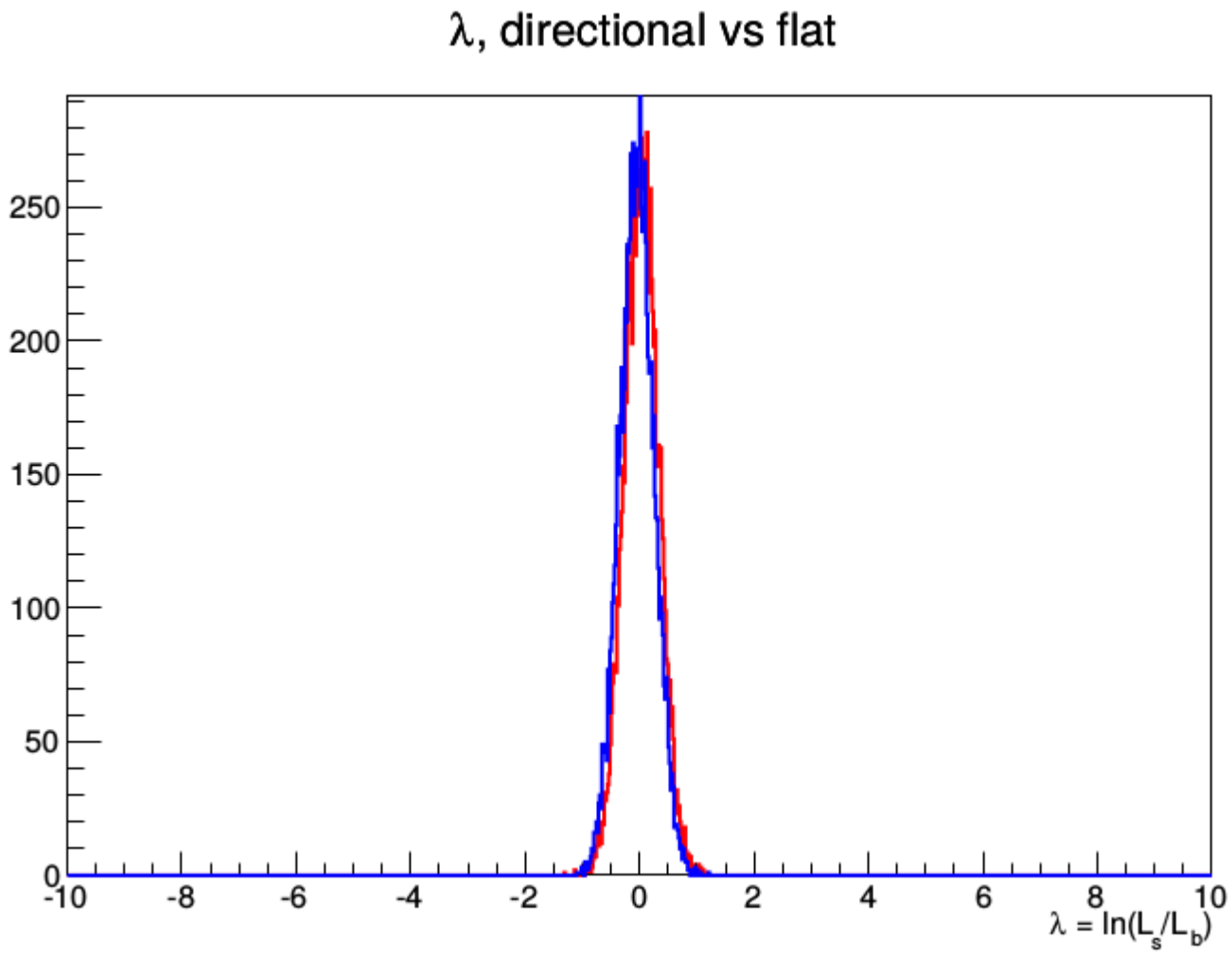
Lambda as a function of $Cos(\Theta_{rec})$, $Cos(\Theta_{cygnus})$

- A 2D lamba histogram is made where the value in a bin is the log of the ratio signal/background for the same bin.
- Lamba=0 indicates a ratio of 1, meaning that the probability of events at that $cos(\Theta_r)$, $cos(\Theta_{cyg})$ is equal for signal and background, as represented by black in the histogram. For red bins, events from signal have a higher probability of occurring than in background, while in blue bins it is the opposite.

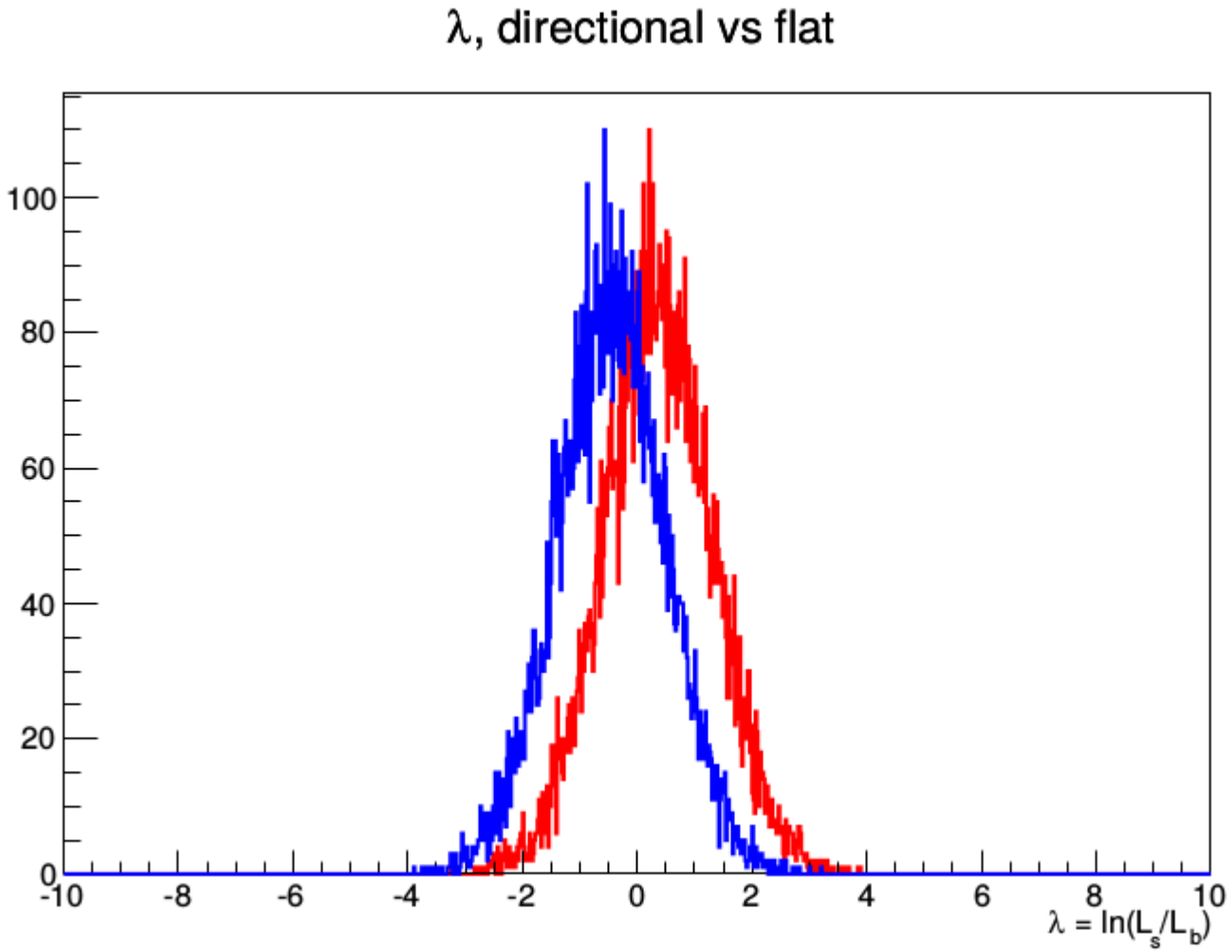


Resolution: 10 events

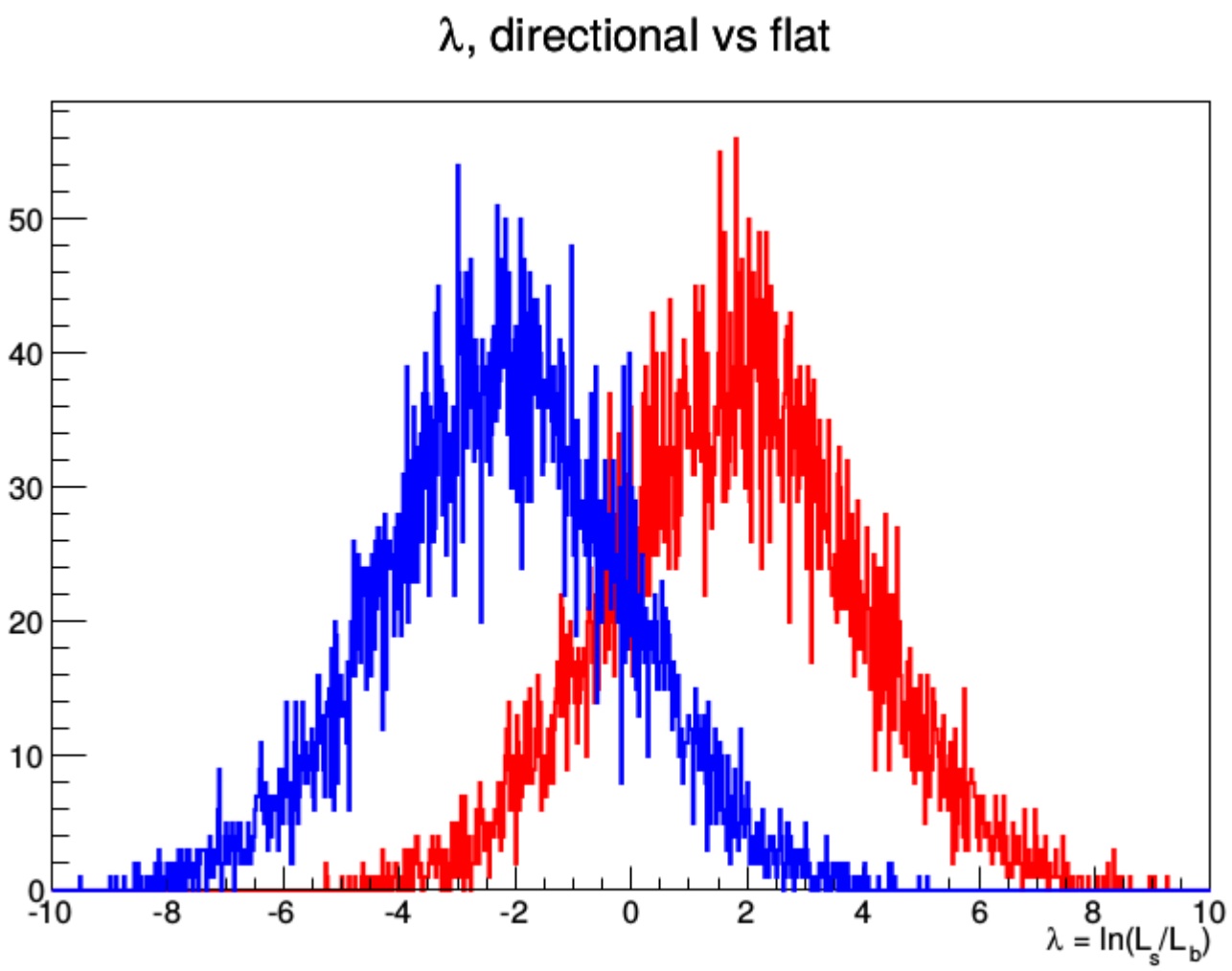
- $\lambda = \ln(\frac{L_{sig}(\cos(\theta_{cyg}),\cos(\theta_r))}{L_{bkg}(\cos(\theta_{cyg}),\cos(\theta_r))}$, where $L(\cos(\theta_{cyg}), \cos(\theta_r)) = \prod_{i=j=0}^{n} L(\cos(\theta_{cyg})_i, \cos(\theta_r)_j)$
- Red is a histogram of the lamba found for 10,000 10 event data sets from the signal MC.
- Blue is the same, but taking the lamba for background data sets
- The greater the separation between the two the easier it is to distinguish signal from background



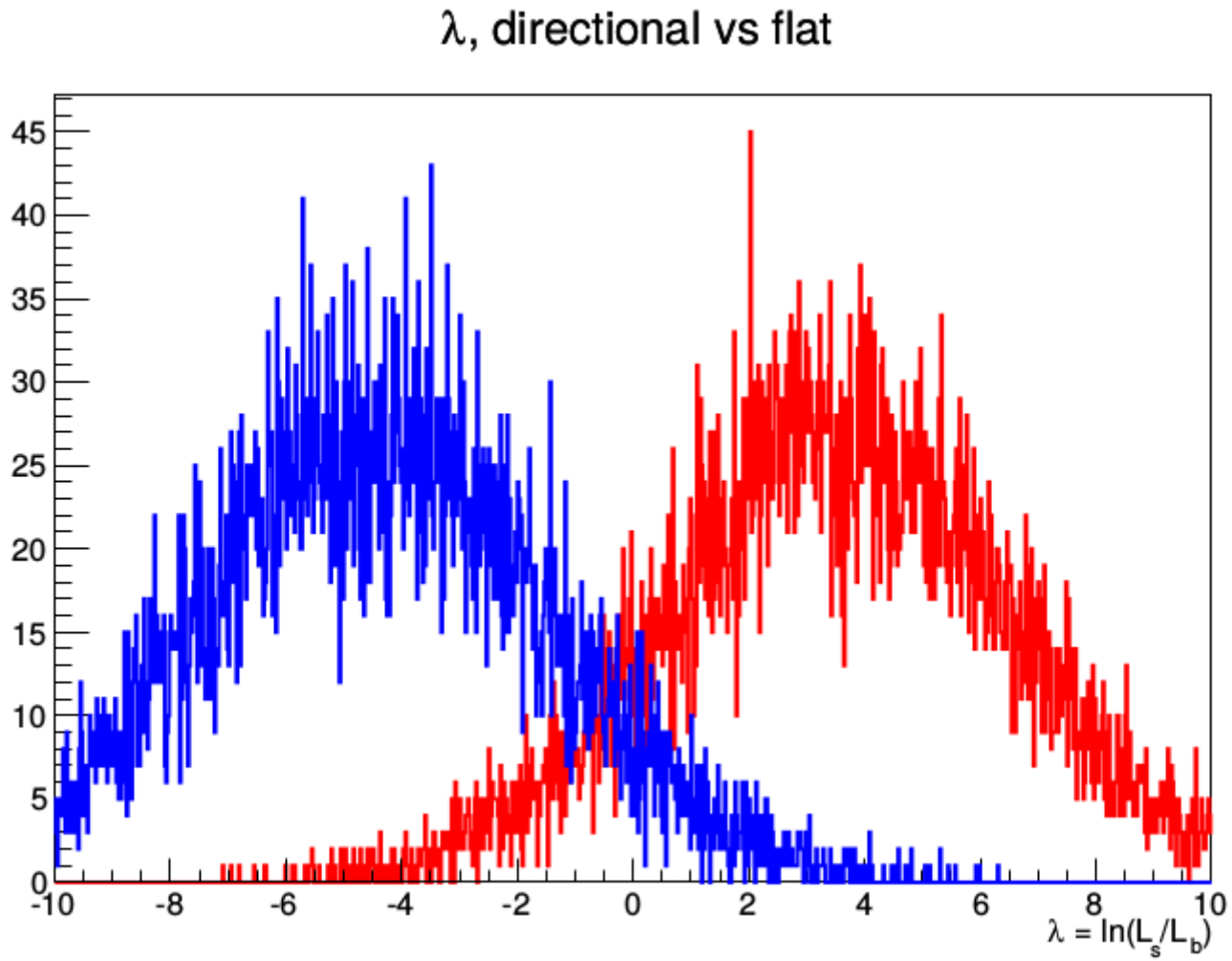
100 events


λ, directional vs flat
100
80
60
40
20
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
λ = ln(L_s/L_b)

500 events



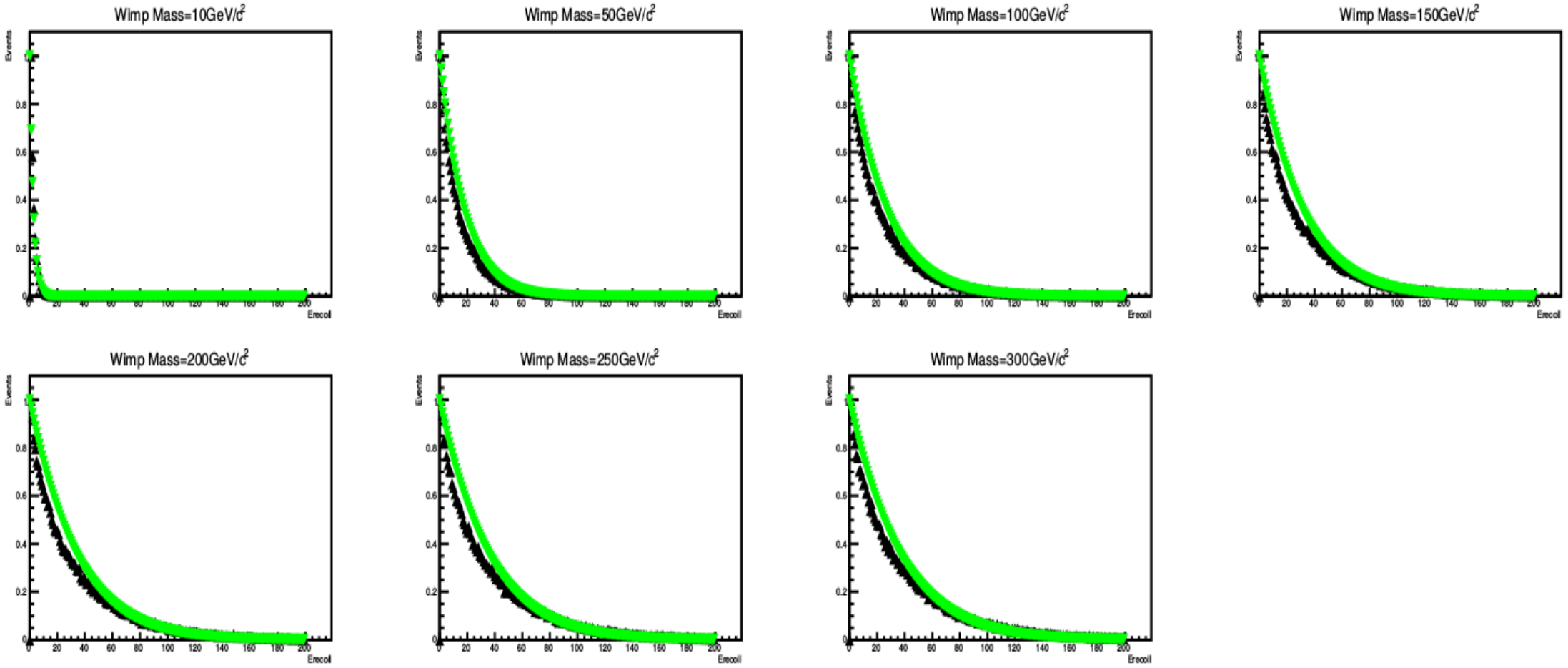
1000 events


λ, directional vs flat
45
40
35
30
25
20
15
10
5
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
λ = ln(L_s/L_b)

Next Steps

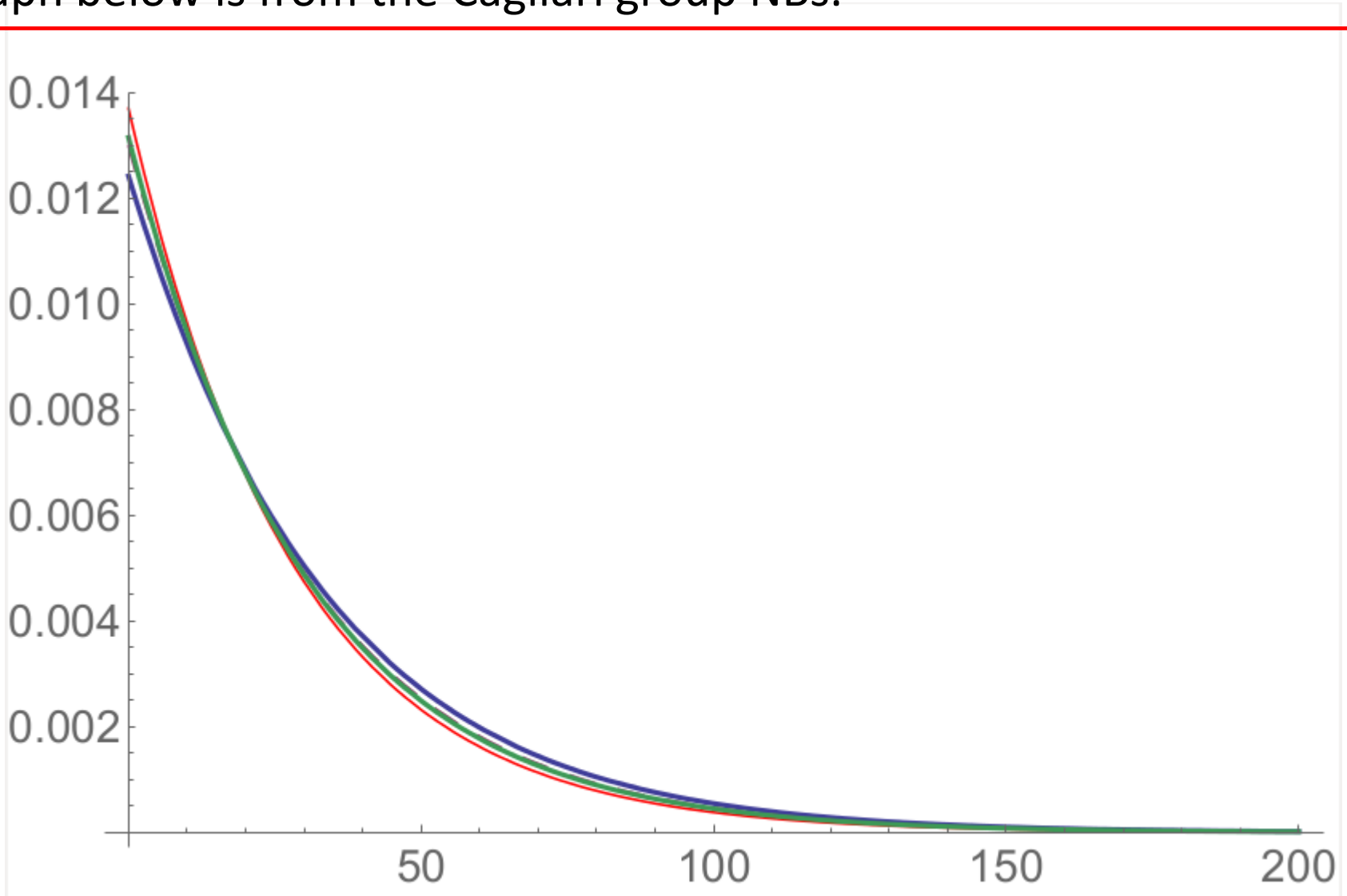
- Comparison between my MC results and those of the Cagliari group (see next slides)
- Add form factor and annual modulation to the MC
- Comparisons between this MC and the old one to check for errors
- 3D statistics (polar angle of recoil, Cygnus angle, recoil energy)
  - The higher the energy of an event the more restricted the possible polar angles
  - 3D likelihood will be more sensitive, allowing better discrimination for less events
- Discuss other various “background” models (co-moving WIMP gas, point sources, surface contamination in the detector, galactic sources etc)
- Explore the effects of energy threshold in the detector
- Explore the impact of different WIMP masses

Comparison between recoil spectra from my MC and Cagliari calculations



Black is Susan's MC. Green is from the notebooks of the Cagliari group. Various WIMP masses are investigated. I still need to add the form factor for my graphs, but the trends are close.

We should also add how the recoil curves change with the time of the year.
The graph below is from the Cagliari group NBs.



Comparison between polar recoil angle from spectra from my MC (left) and Cagliari group (right)