Z->mumu EOM progress

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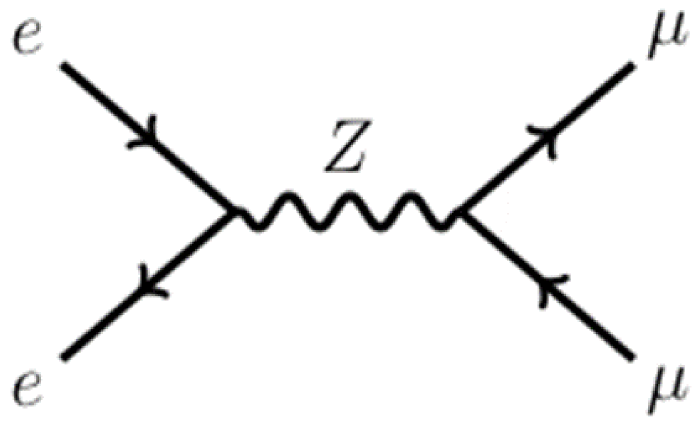
Introduction

- Analysis conducted: Z -> mumu
- 91.2 GeV CoM
- 150 ab^-1

- Forward-Backward Asymmetry
- Cross section, uncertainties, optimization



Code And Samples Used

Generators: Whizard, KKMC, RSANC

Samples of each generator:

- kkmcee_ee_mumu_ecm91p2
- rsanc_ee_mumu_ecm91p2_noBes
- wzp6_ee_mumu_ecm91p2

Cross section measurements

Describes a probability of a process, in this case Z->mumu

Has units of area [b]

$$\sigma = \frac{N_{obs} - N_{bkg}}{A \cdot \varepsilon \cdot L_{int}}$$

N_obs=number of observed events

N_bkg=number of background events

"L_{int}" =Integrated Luminosity

A=Acceptance

ε=Efficiency

Cross Section Uncertainty

$$\sigma = \frac{N_{obs} - N_{bkg}}{A \cdot \varepsilon \cdot L_{int}}$$

1. Statistical Uncertainty

   - Characteristic of the Monte Carlo

$$Statistical\ Uncertainty = \sqrt{N_{obs} + N_{Background}}$$

2. Acceptance Uncertainty

   - Possible limitations of detector

$$Acceptance\ Uncertainty = \sqrt{\frac{\frac{N_{selected}}{N_{Total}} \cdot \left(1 - \frac{N_{selected}}{N_{Total}}\right)}{N_{Total}}}$$

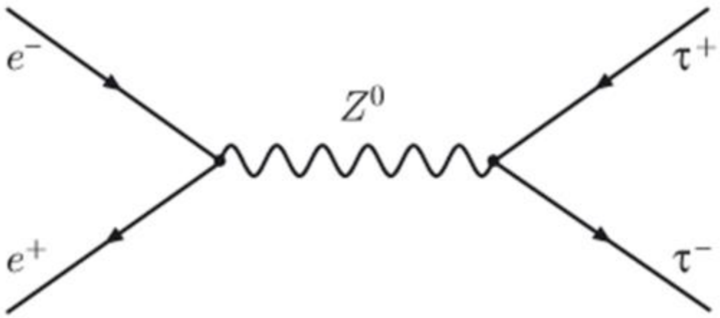
3. Luminosity uncertainty

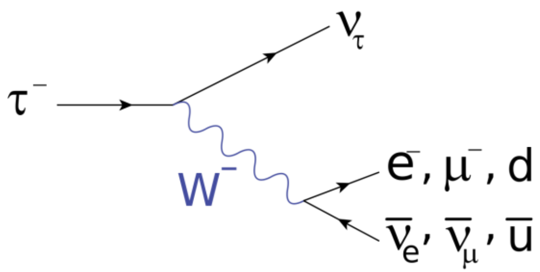
   - directly proportional to luminosity, here 0.01% of luminosity

$$Total\ Uncertainty = \sqrt{\left[\frac{\partial\sigma}{\partial N_{obs}}^{2} \cdot (\sigma_{N_{obs}} + \sigma_{N_{bkg}})^{2}\right] + \left[\frac{\partial\sigma}{\partial A}^{2} \cdot \sigma_{A}^{2}\right] + \left[\frac{\partial\sigma}{\partial L_{int}}^{2} \cdot \sigma_{L_{int}}^{2}\right]}$$

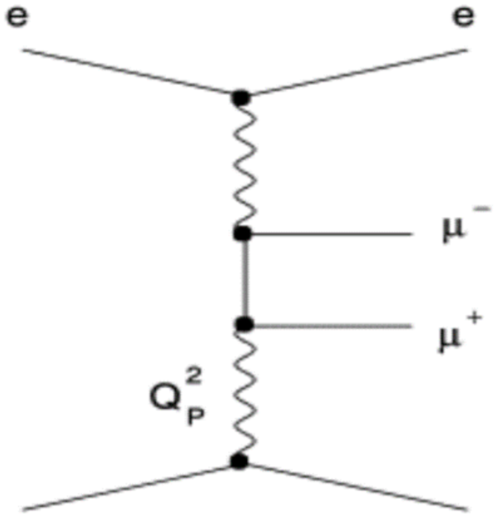
Background Events

$e^+e^- \to \tau^+\tau^-$





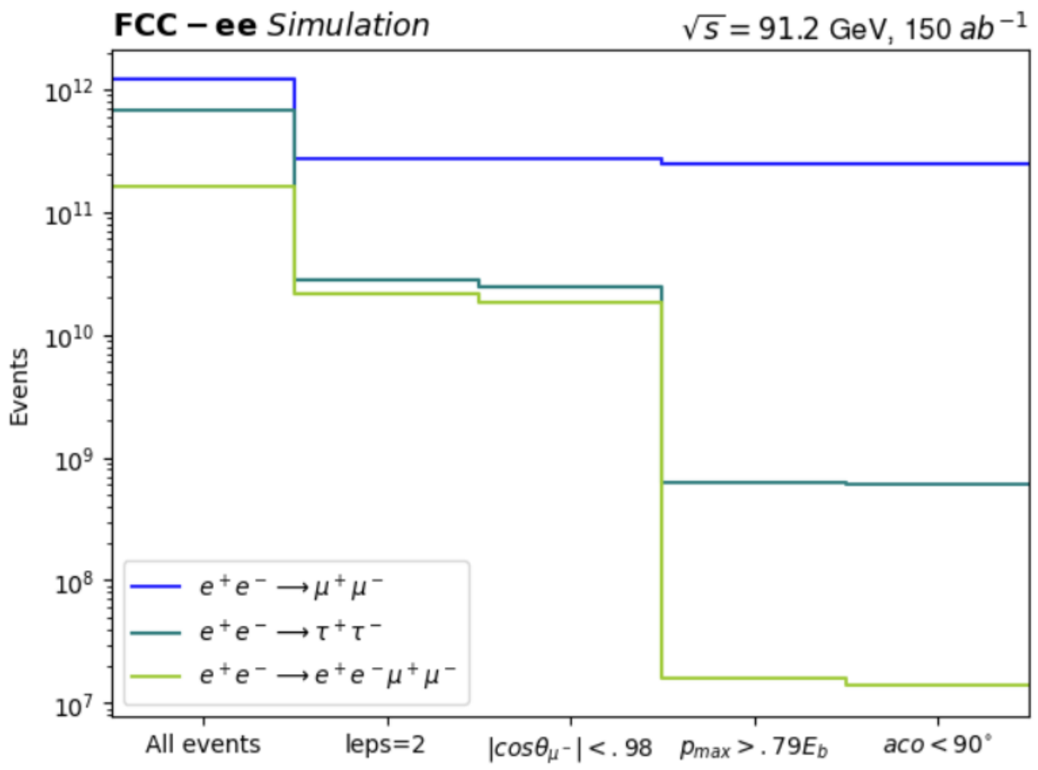
$e^+e^- \to e^+e^-\mu^+\mu^-$



Selection cuts to minimize background

1. 2 lepton event

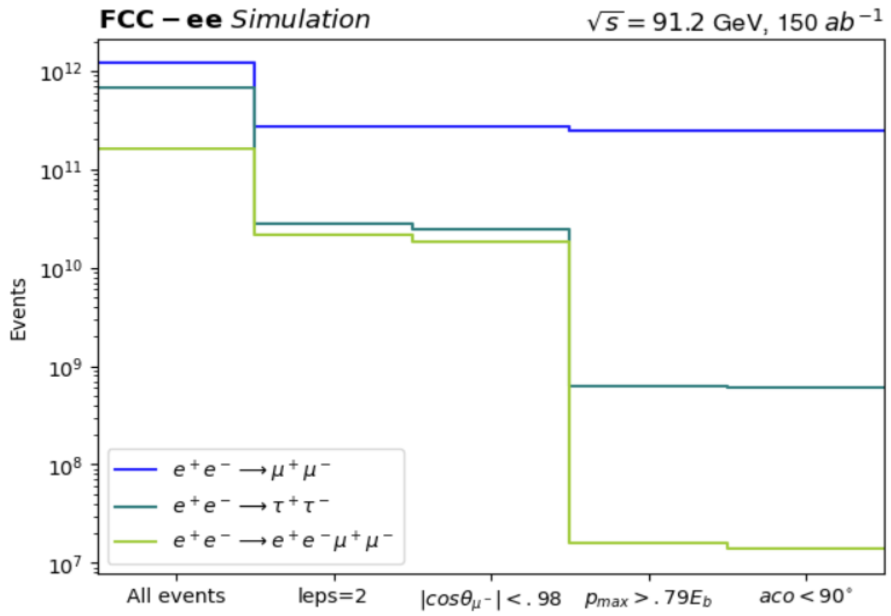
2. cos(theta) < [a certain value]
- Losing some events due to the hole
 through which the beam passes



Selection cuts to minimize background

3. Max momentum>.79 Eb
- To cut out background events of Z->tt

4. Acollinearity < 90
- To cut events where there is a possibility of neutrinos being produced from muons.



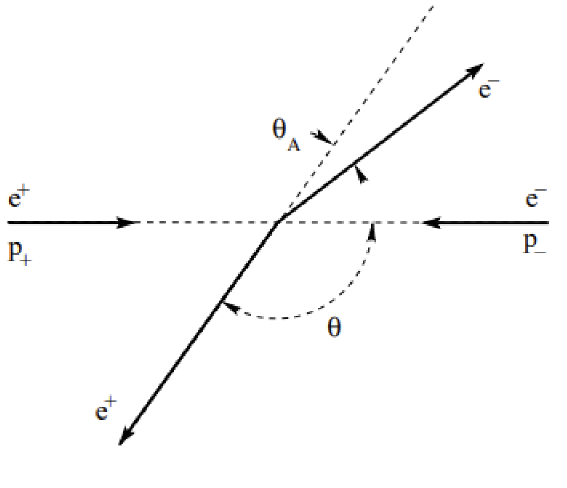
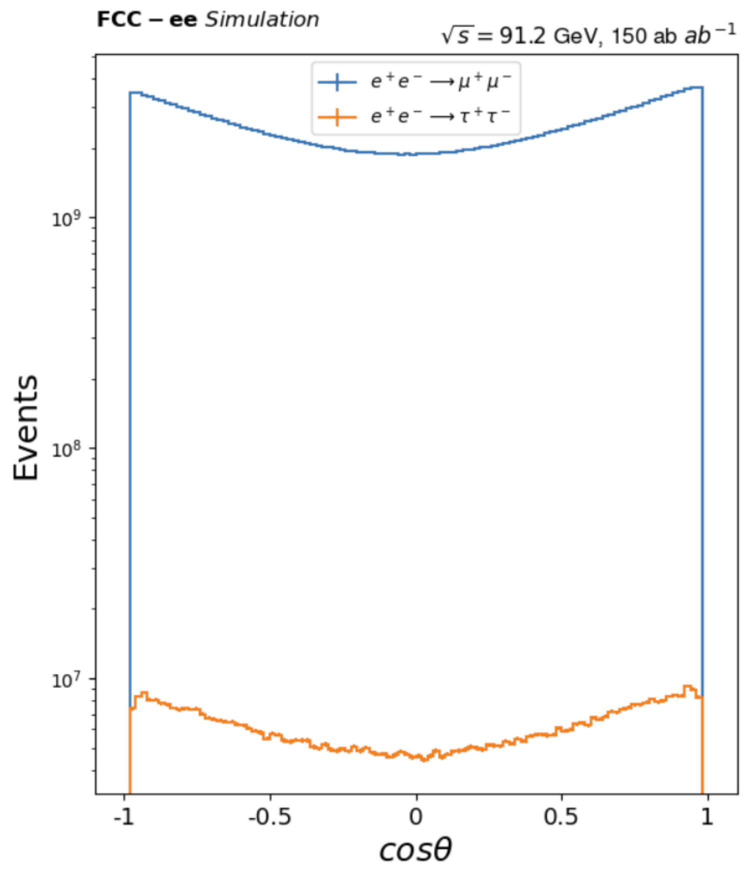


Figure 2: Definition of acolinearity angle θ_A

Hole analysis

With the cylindrical collider, there is a small hole where the beam passes through. The angle theta is measured from the axis of the beam to the hole edge.

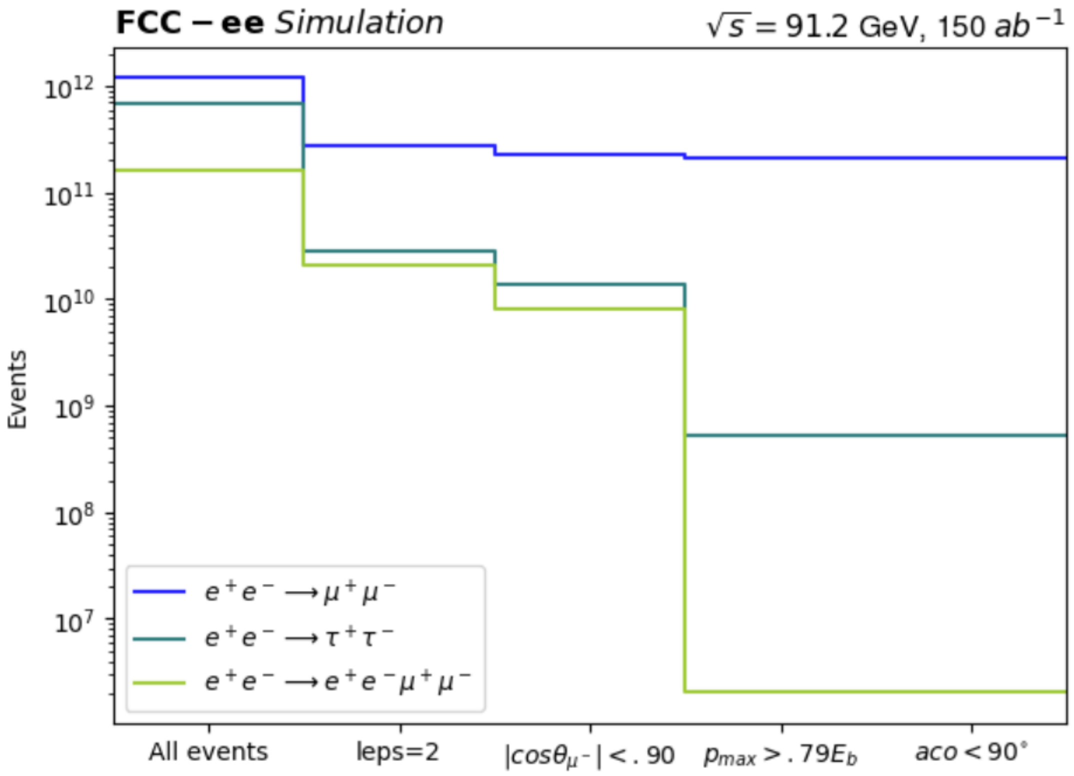
With this analysis, we try to optimize cos(theta) to lose the minimum number of mumu events.



Cos(theta)<.90

About 3.2E+10 events were cut

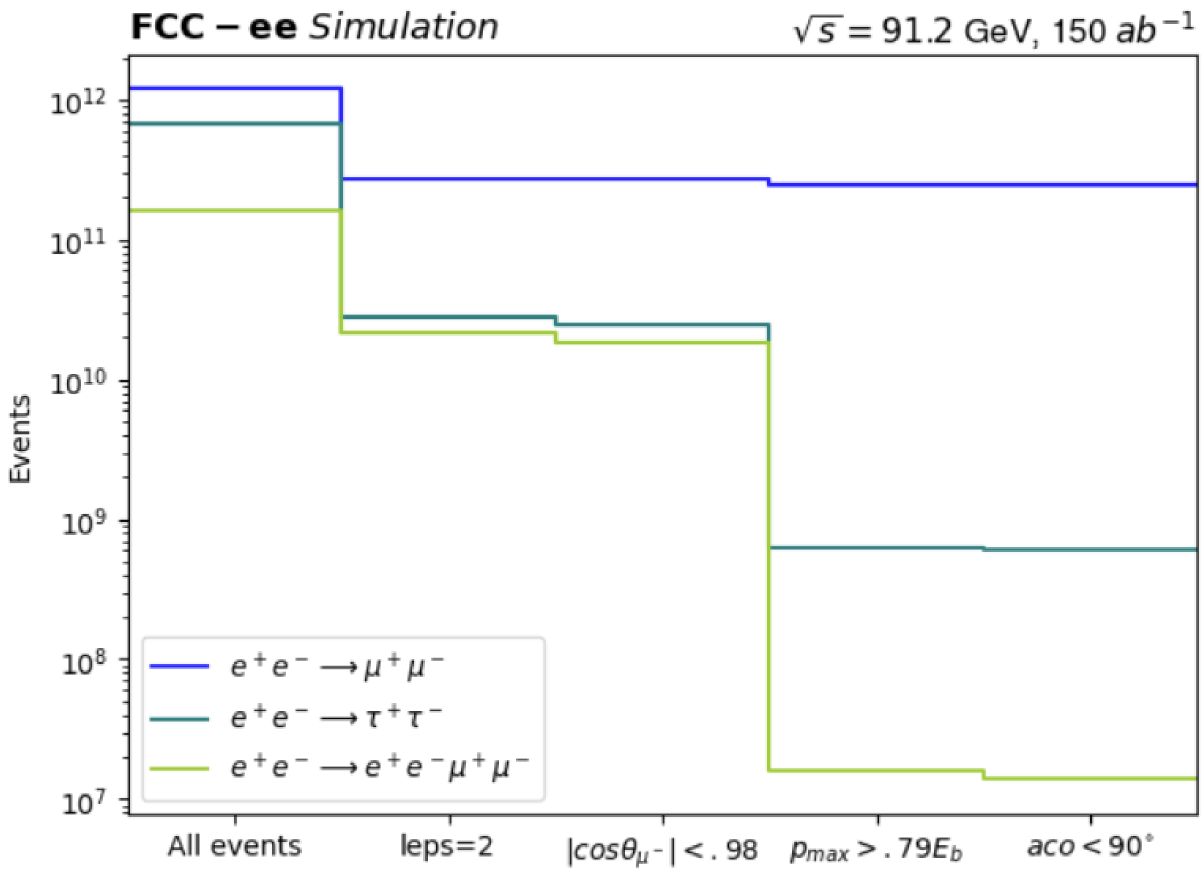
Acceptance uncertainty was 0.00839.



Cos(theta)<0.98

Events cut are 3.1E+9

- Acceptance uncertainty is 0.8%
- Acceptance of background are 0.1 (tt) and 8.6e-5 (gg)
- Therefore good cuts on background.

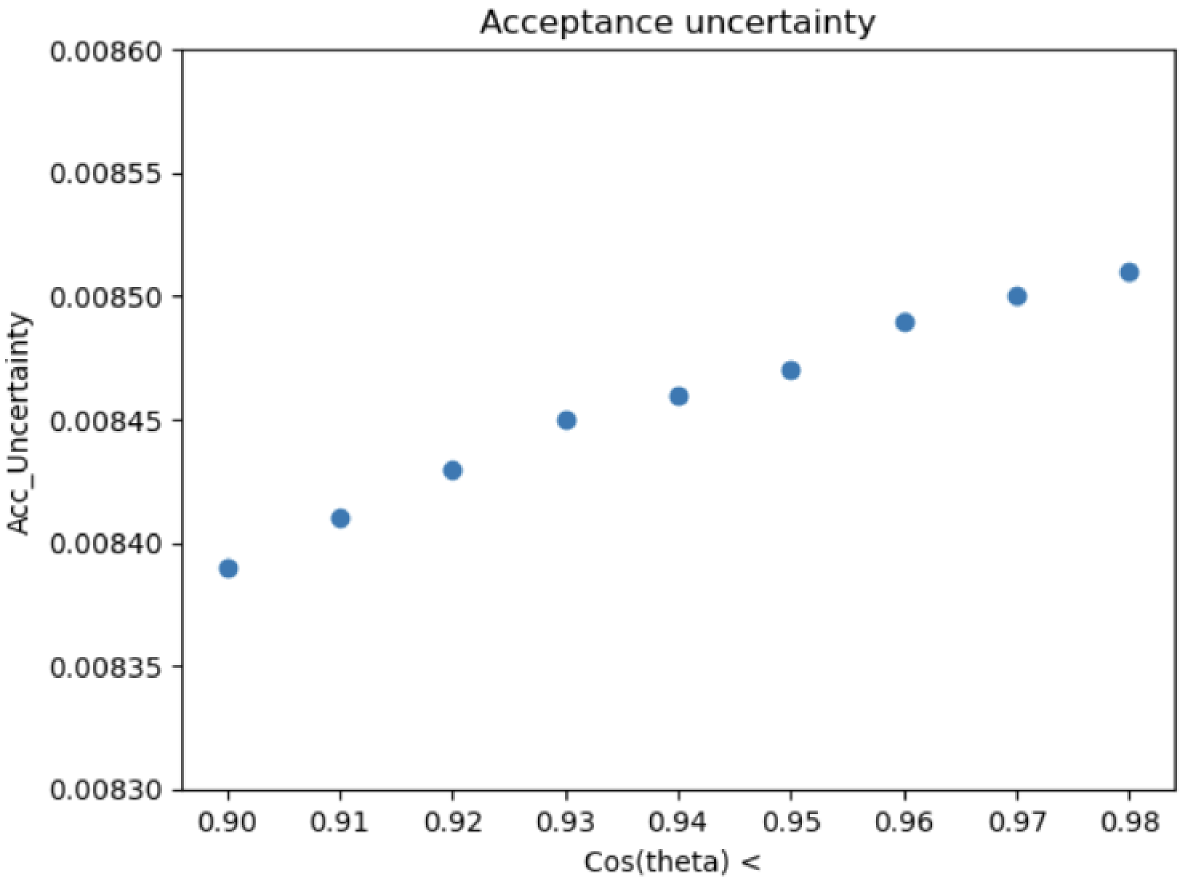


Conclusions drawn from graphs

We are able to infer that cos(theta)<0.98 is the optimal cut.

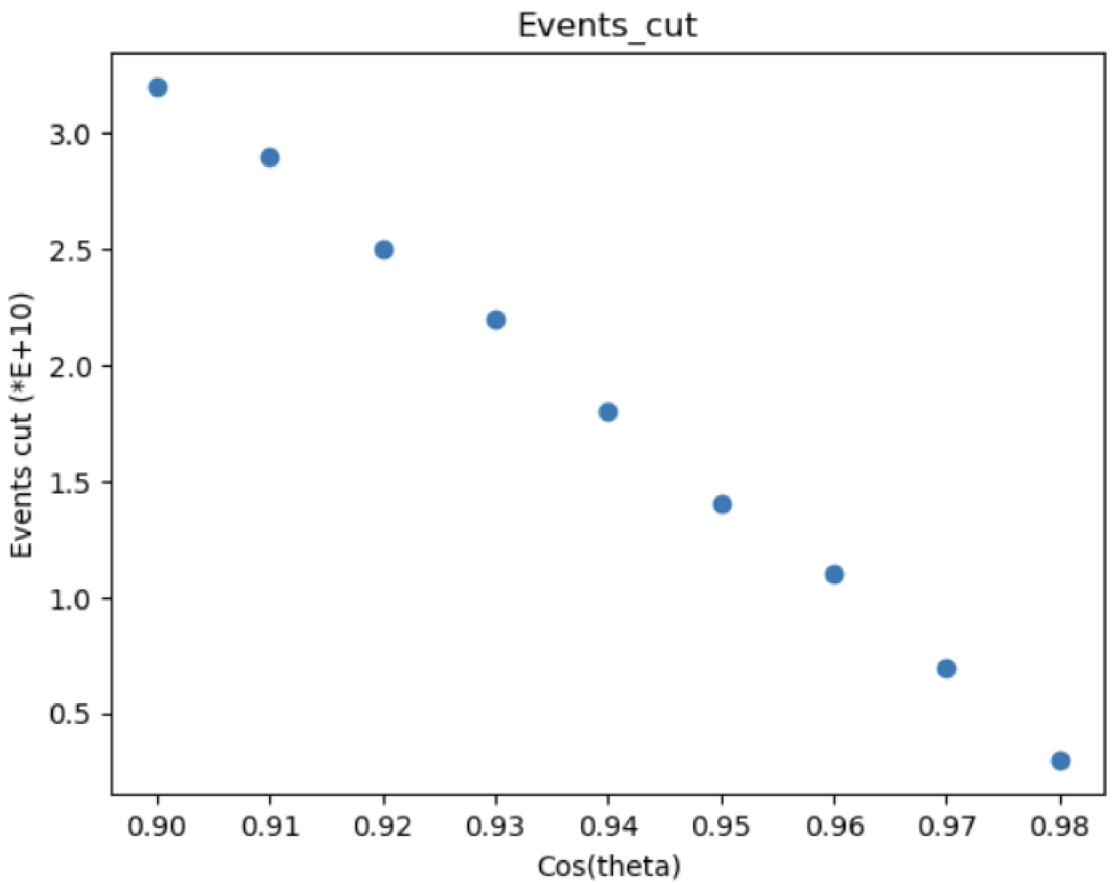
In the graph, the e+e- □ mu+mu- graph has a minimal cut at the cos(theta) juncture, but the background events are still being significantly cut.

Plotting the acceptance uncertainty with cos<x values



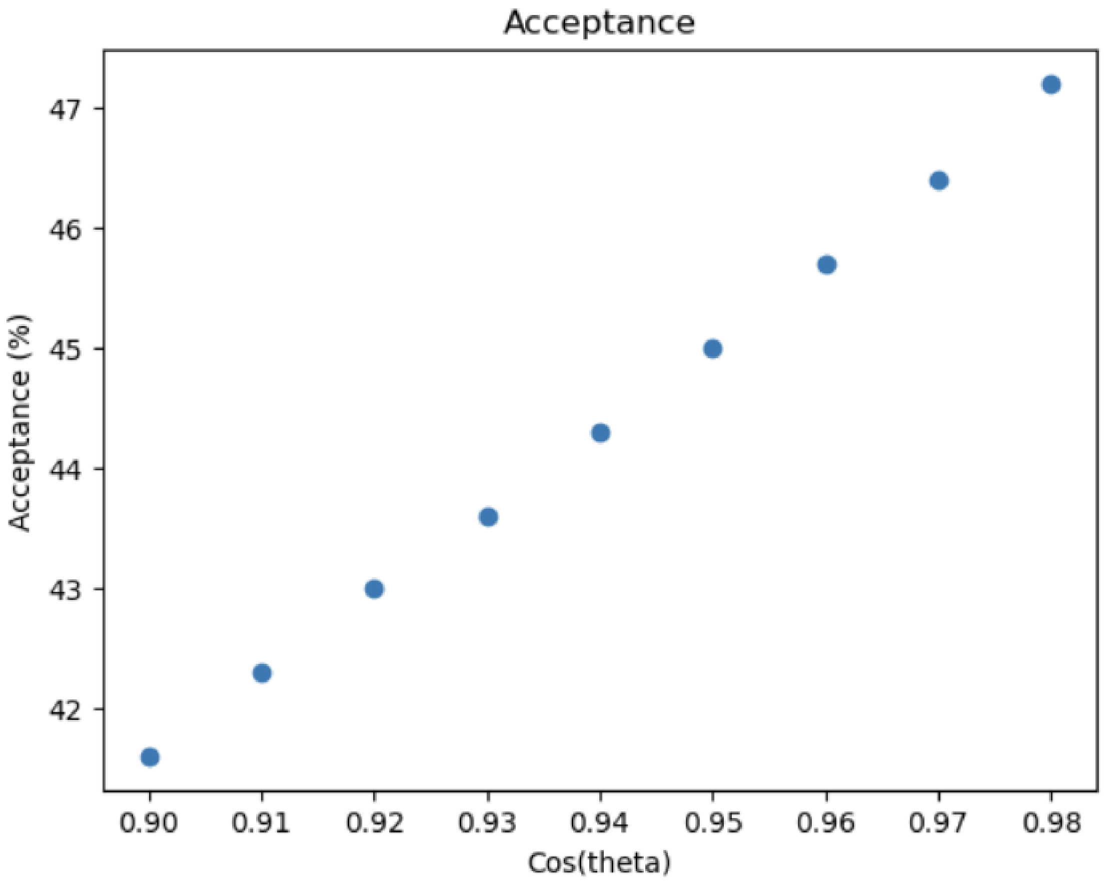
Graphing the cut events with cos(theta)

We see from the graph that the number of events cut is proportional to the value of theta.



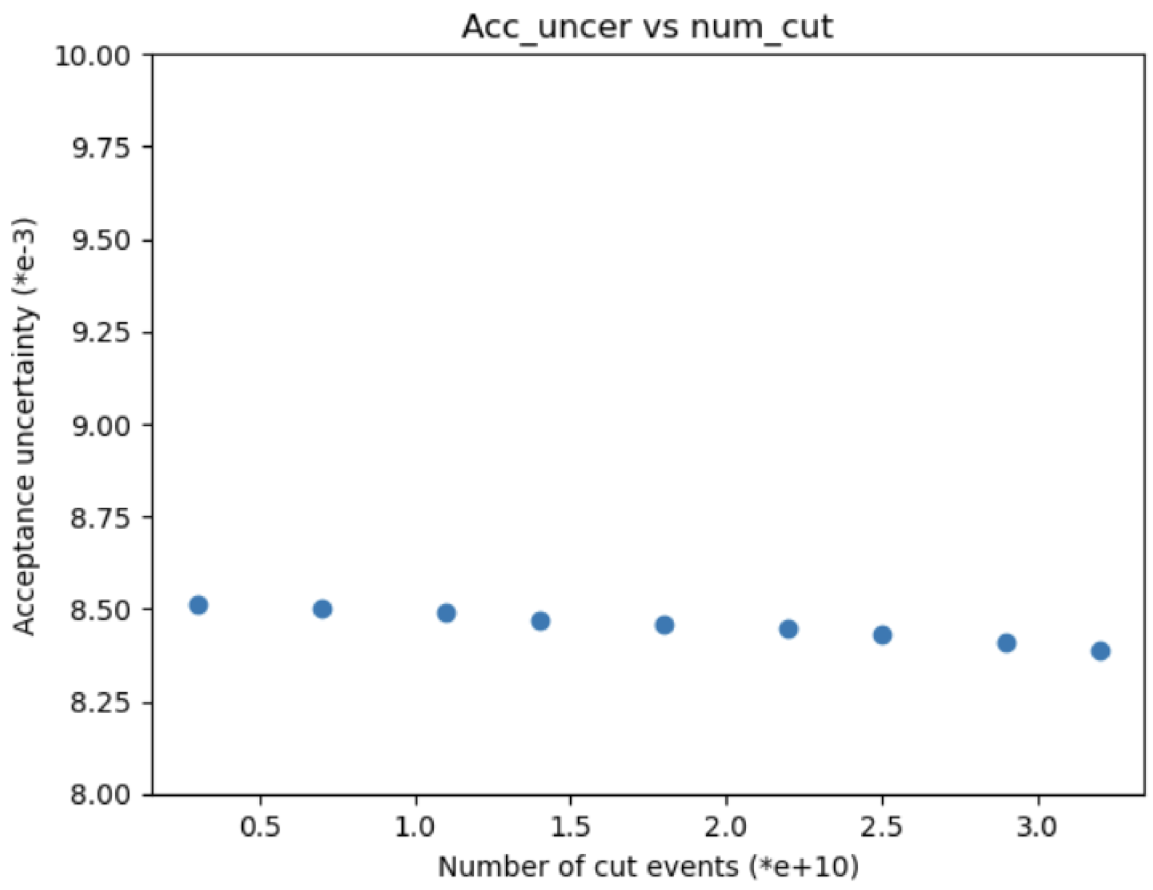
Acceptance vs cos(theta)

It follows that the acceptance increases for smaller values of theta.



Plotting acceptance uncertainty with number of events

The acceptance uncertainty decreases within magnitude of e-3 over increasing number of cut events.



Final Measurement

Cross section = 3436 b

Luminosity uncertainty = 0.01% of 150 ab^-1 = 0.015 ab^-1

Optimal cut on cos(theta) is cos(theta)<0.98

Acceptance = 46.5%

Acceptance uncertainty = 0.8%

Forward-Backward Asymmetry

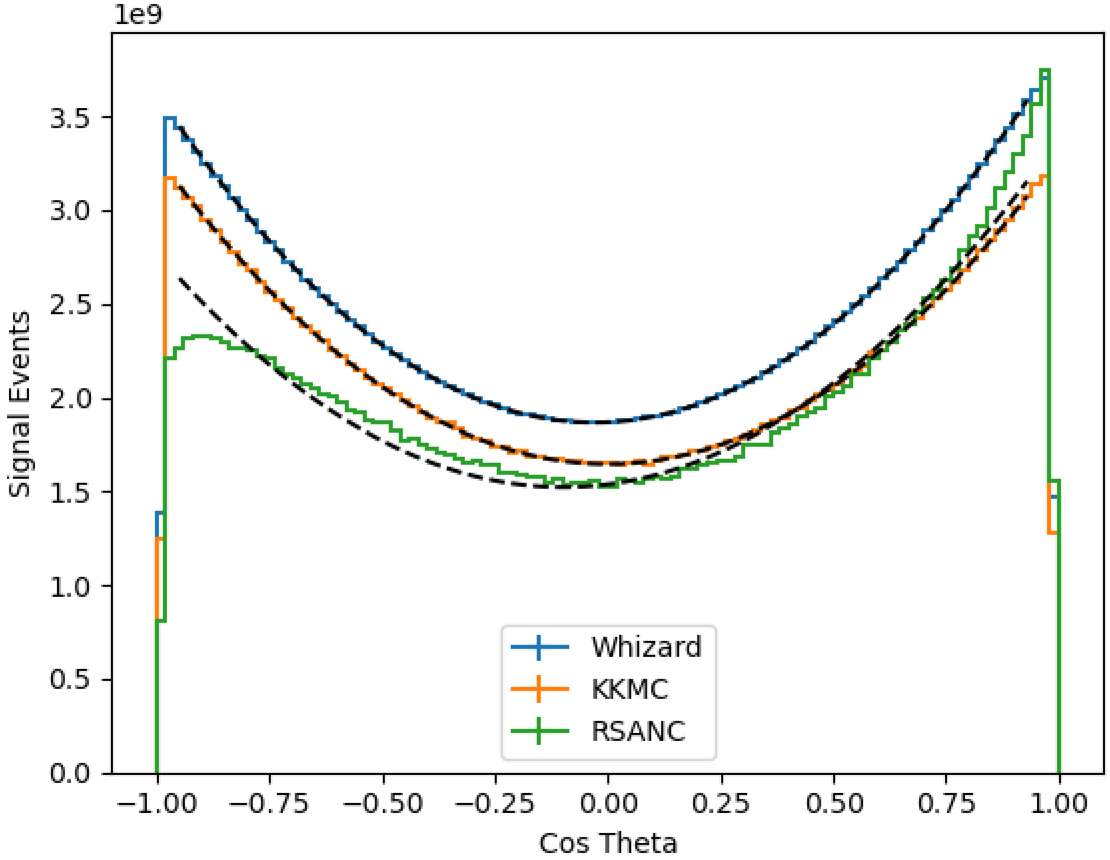
It describes an asymmetry in the distribution of particles produced in a collision when comparing their emission in the forward direction (in the direction of the incoming particles) and the backward direction (opposite to the incoming particles).Forward-backward asymmetry can arise due to various factors, such as the nature of the colliding particles and the underlying interactions. Studying such asymmetries can provide valuable insights into the fundamental forces and particles that govern the behavior of the universe.

Cos Theta

Cos Theta is the angle between the particle beam and the hole the beam is passing through to collide.

Right side of fit > Left side.

Hence, forward-backward asymmetry is present.

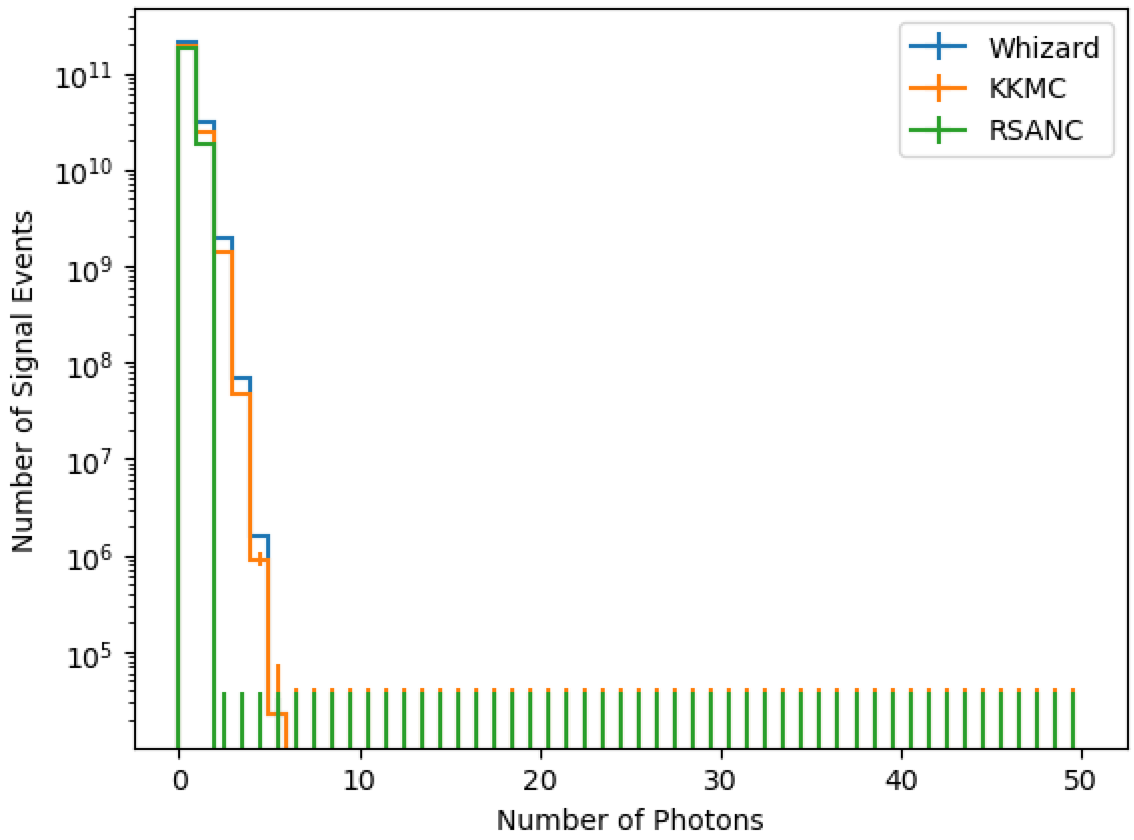


Number of photons

Not particularly relevant to AFB.

Depends on generator to generator

High Proportion of Signal Events are in 0 - 5 photon range.



Comparison of Generators

1. RSANC has the most prominent AFB.
2. Overall, Whizard is the most accurate, with 1.99e-6 statistical error.
3. [PUT REAL VALUE OF A_FB AND COMPARE]

Parameter	Whizard	KKMC	RSANC
Slope of Cos Theta Graph	-0.001	0.023	0.25
AFB	0.02229	0.0006	0.0746
Statistical Error	1.99e-6	2.12e-6	2.18e-6

Next steps

Have run the process (cos theta) with Whizard currently, would be interesting to run with kkmc and rsanc to compare.

Plot the acceptances, uncertainties with cos(theta) representing the error bar as well.

Reaffirm the confidence of advanced accuracy with the FCC Project.

Thank you

Thank you to Christoph Paus, Jan Eysermans, Luca Lavazzo and Casey Lawson.