Heavy Flavor Meeting

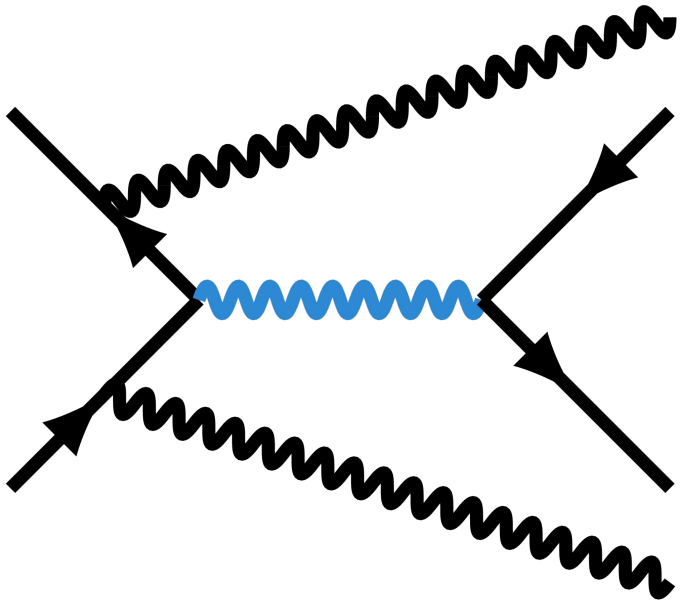
Updates on SSbar Analysis

Yuichi Okugawa
Apr 8th, 2022

ISR Suppression

ISR Suppression

- ISR effectively takes away the energy from the collision energy.
- Such phenomenon will distort the collinearity between two LPFOs. One can extract observed
  - Angle between LPFOs
    - Can jet angle do the job?
  - Visible total energy



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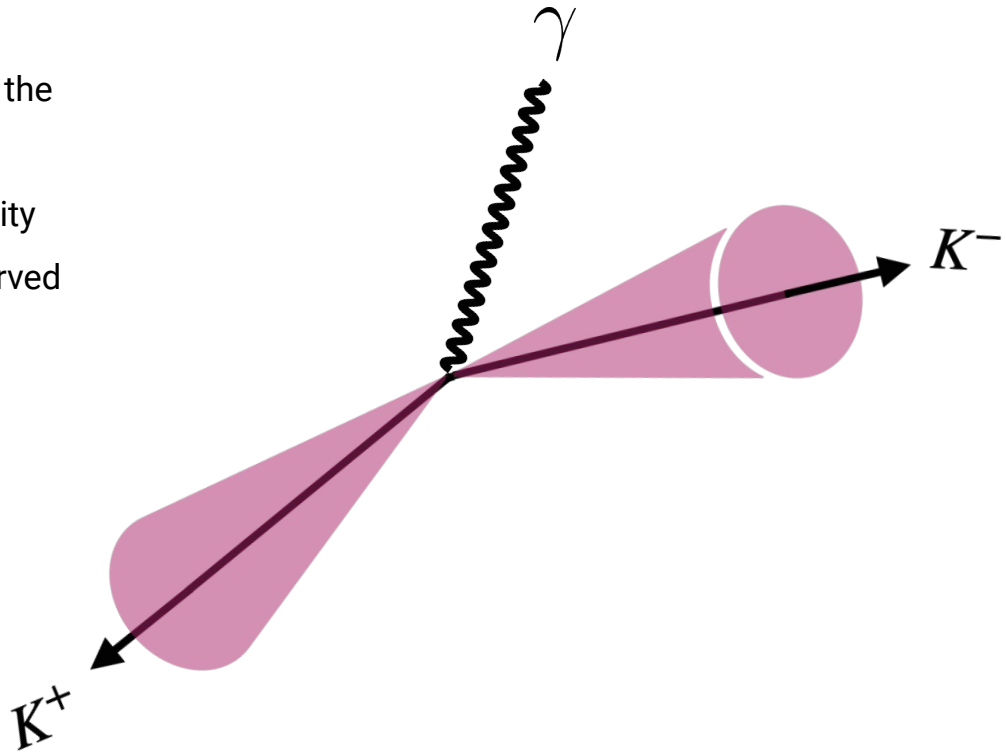


ISR Suppression

Signal Definition

- SSbar back-to-back

  $0.95 < \cos\theta_{s\bar{s}}$

- Total Energy

  $220 < E_s + E_{\bar{s}}$

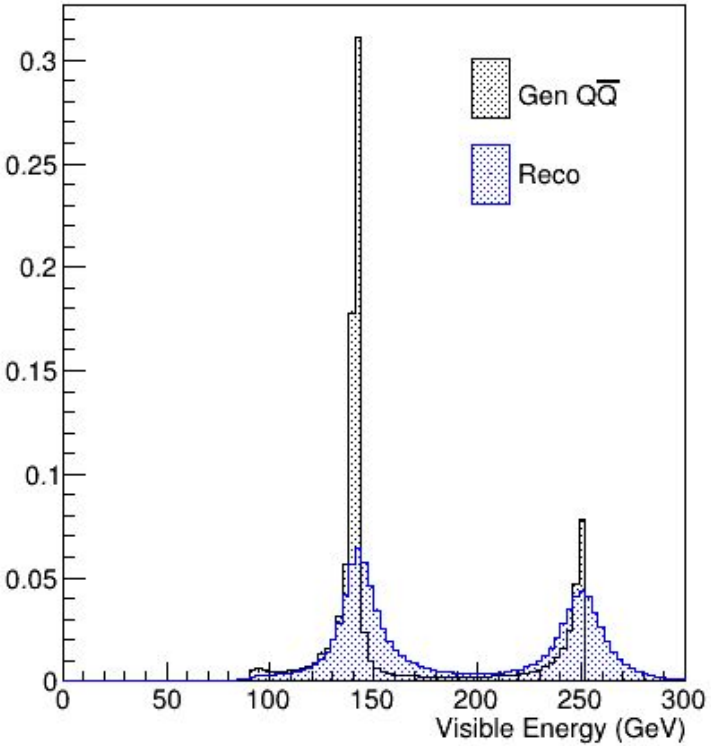
Reco ISR Removal

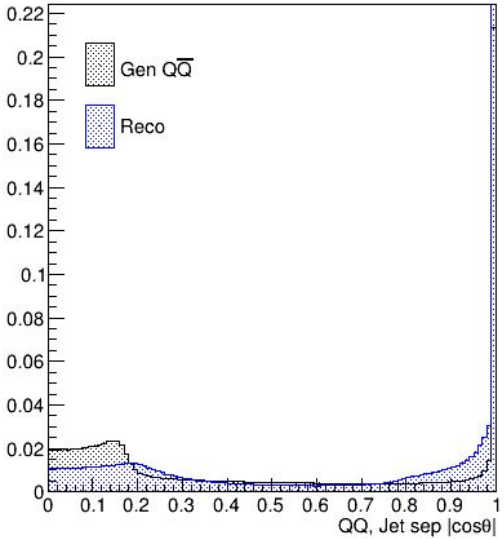
- LPFO back-to-back

  $0.95 < \cos\theta_{jets}$

- Total Energy

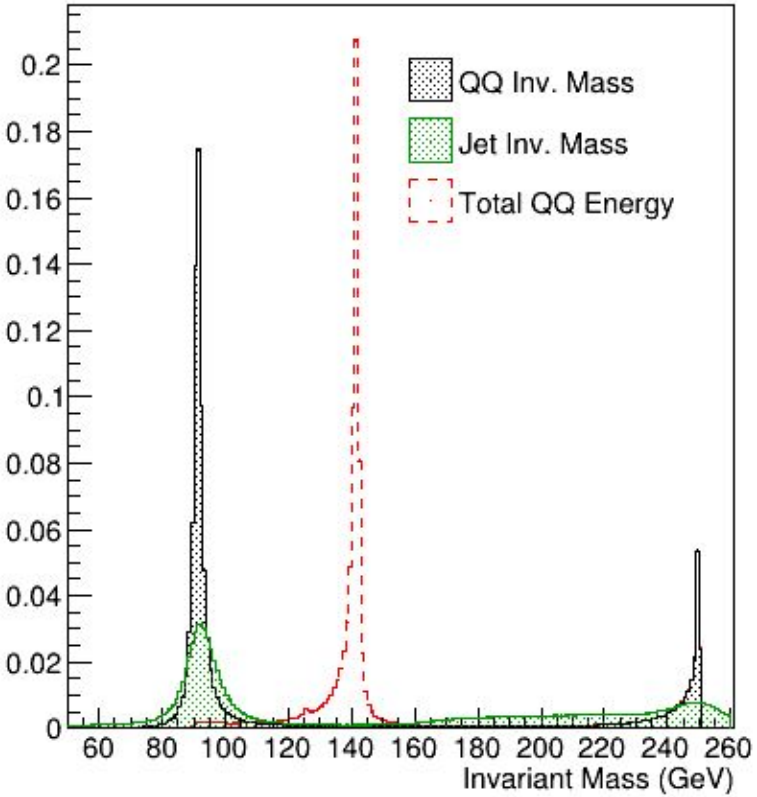
  $220 < E_{vis}$



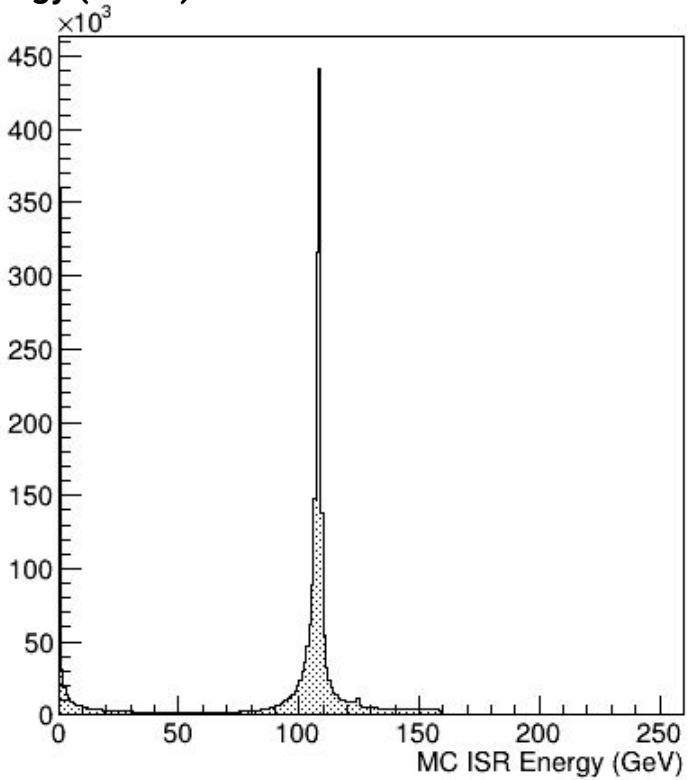


ISR Suppression

Invariant Mass

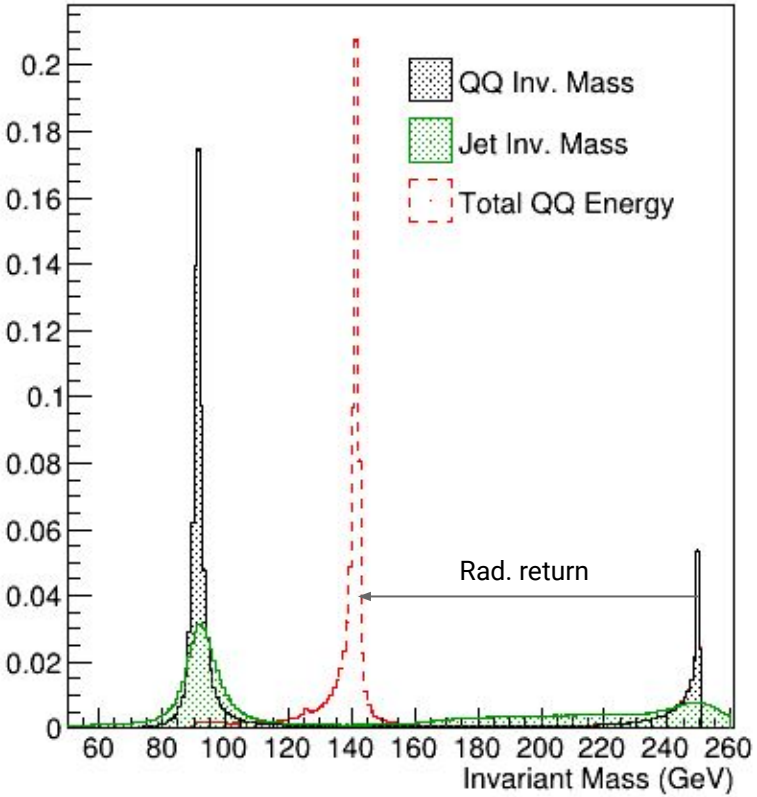


ISR Energy (Cheat)



ISR Suppression

Invariant Mass



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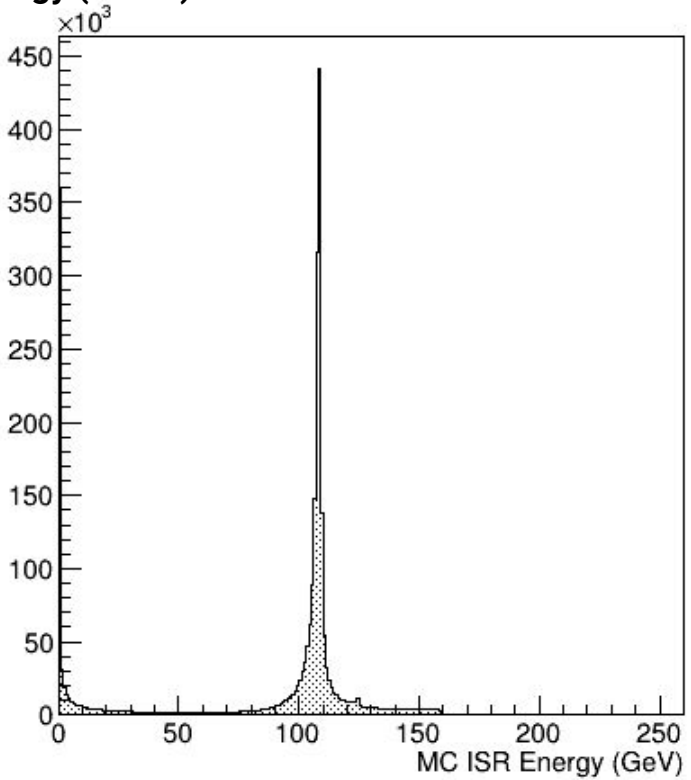

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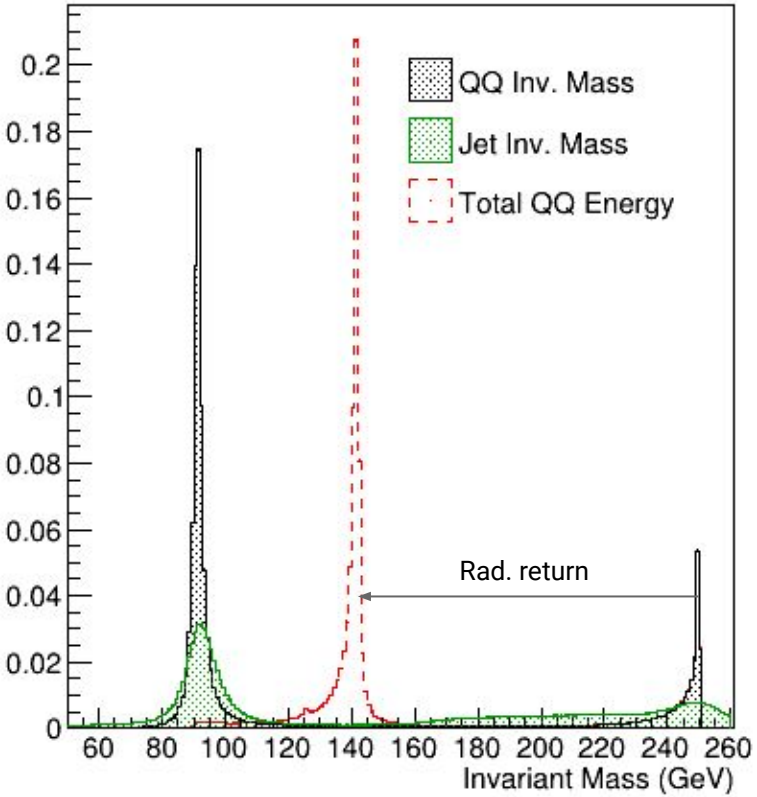

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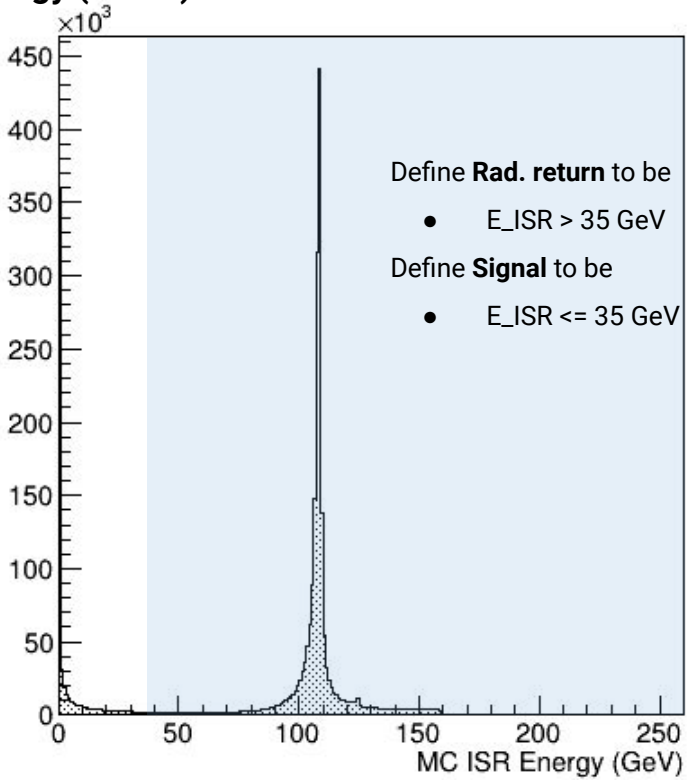
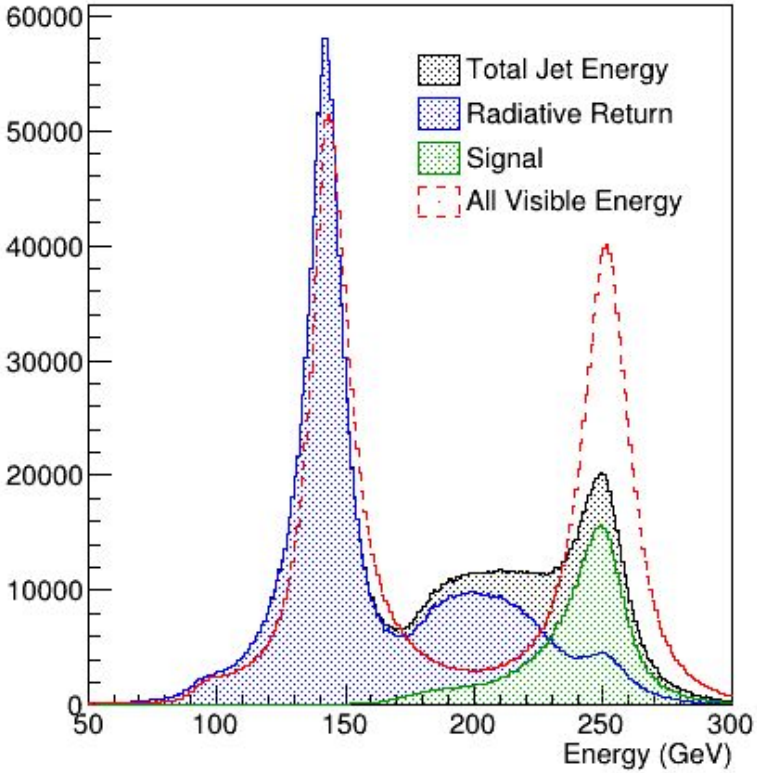
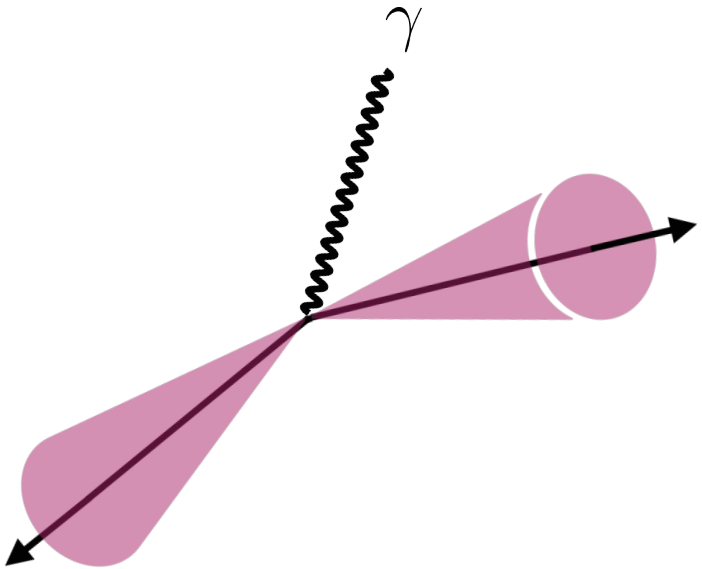


ISR Suppression

Jet Energy





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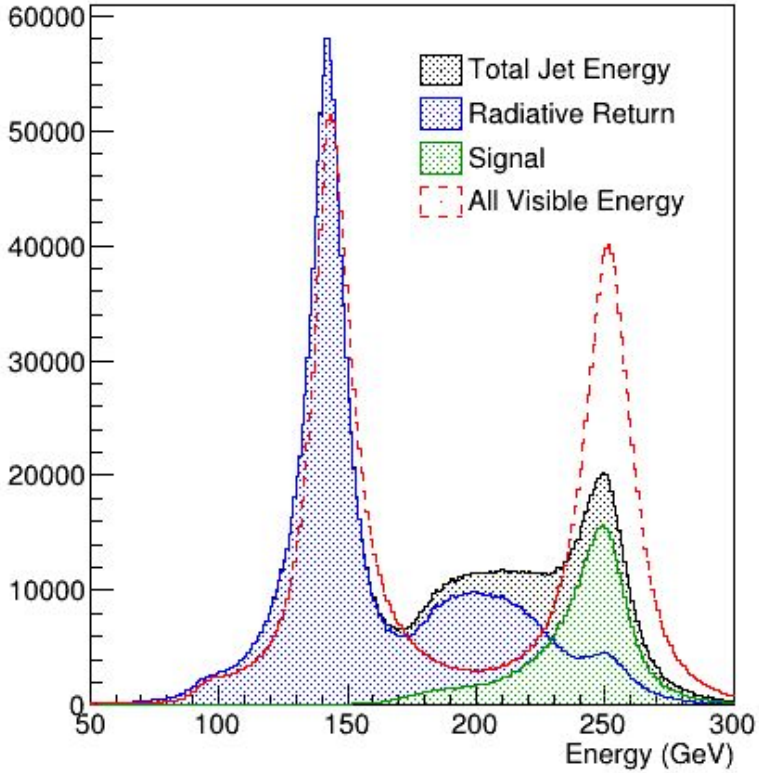
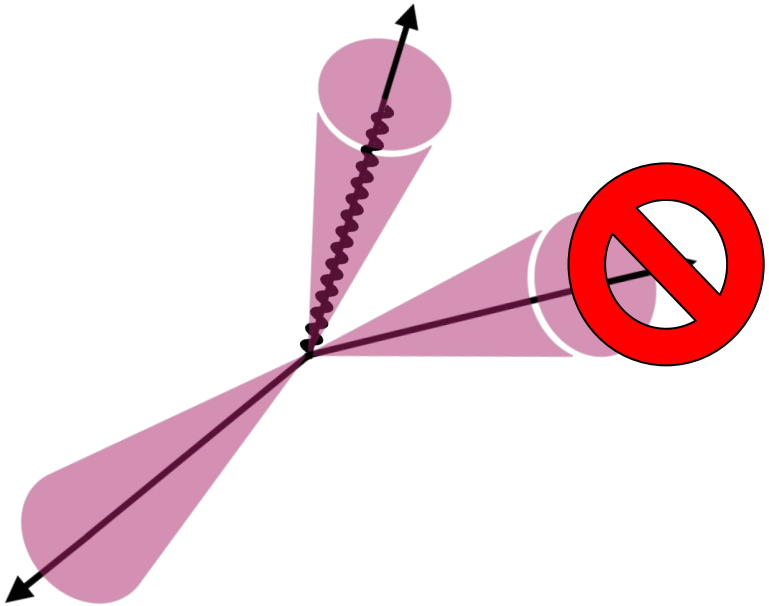
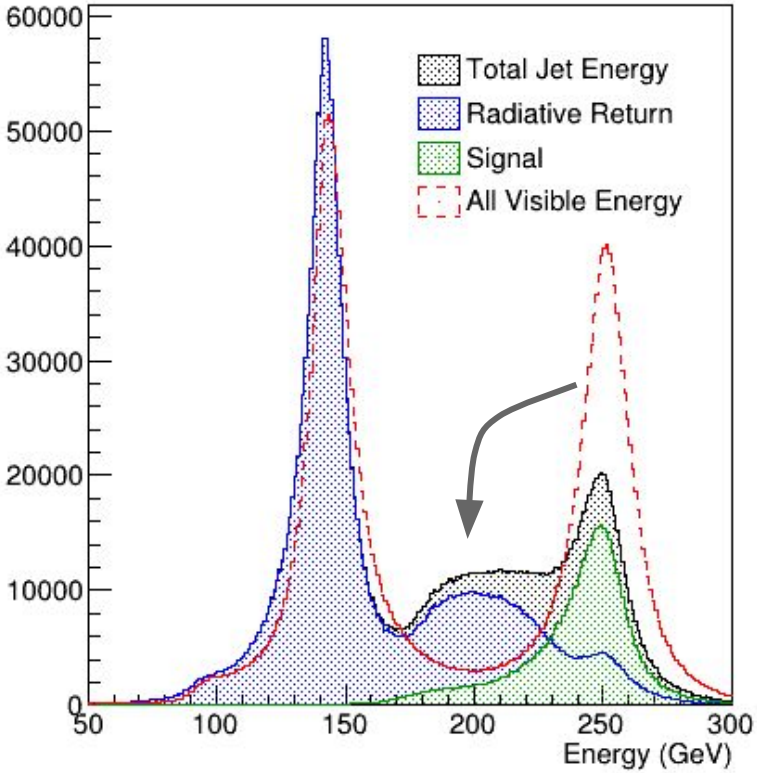
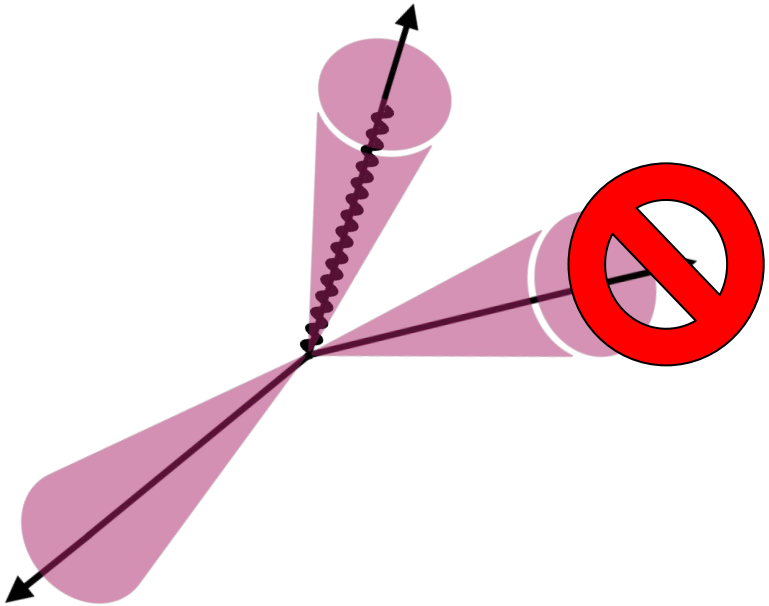




ISR Suppression

Jet Energy





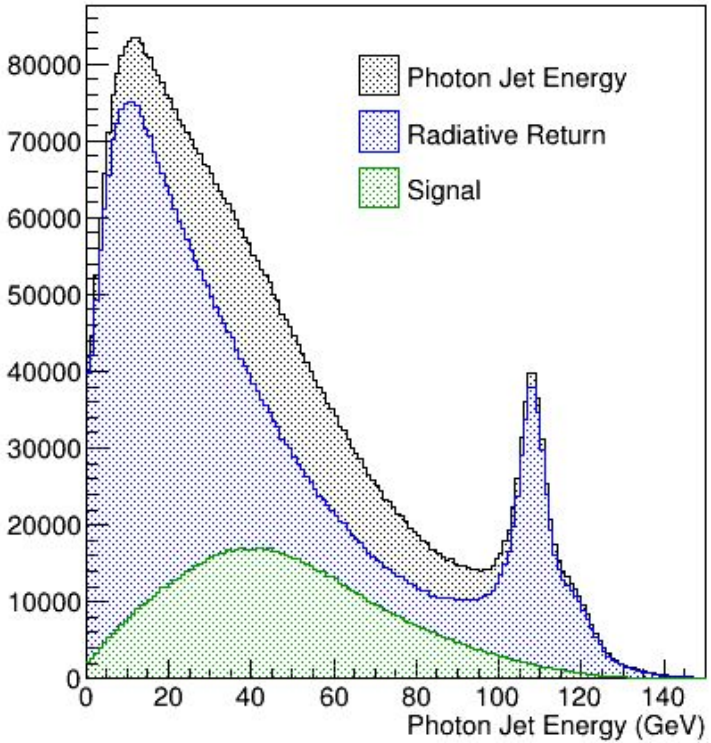
ISR Suppression

Neutral Jet Energy

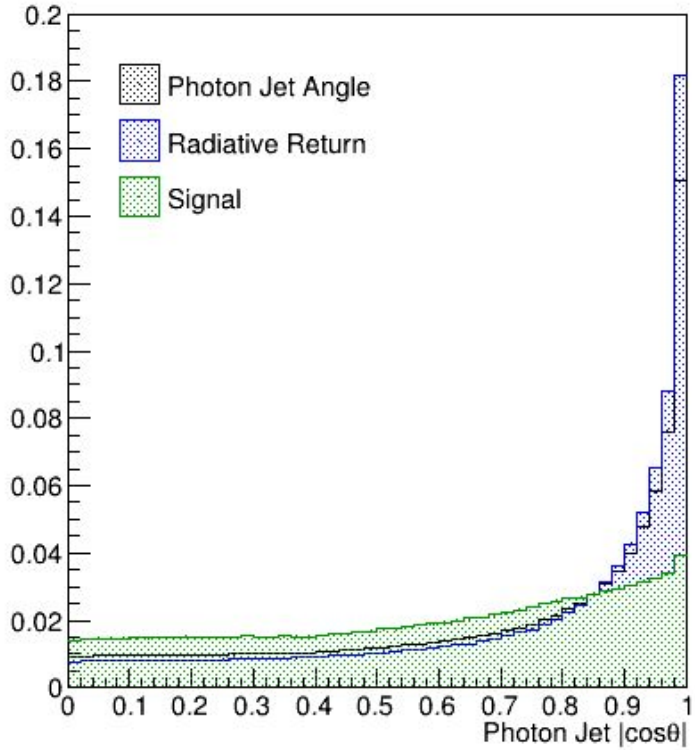
- Identify neutral pfos in a jet
  - pfo->getType() == 22 || pfo->getType() == 2112
- Add neutral pfo energy
  - Must be dominant compared to its total jet energy?
  - E_{neutral} / E_{Jet}
- Calculate neutral jet direction
  - cos theta
  - Does it go into beam pipe?

ISR Suppression

Neutral Jet E



Neutral Jet |cos| (norm)



Summary

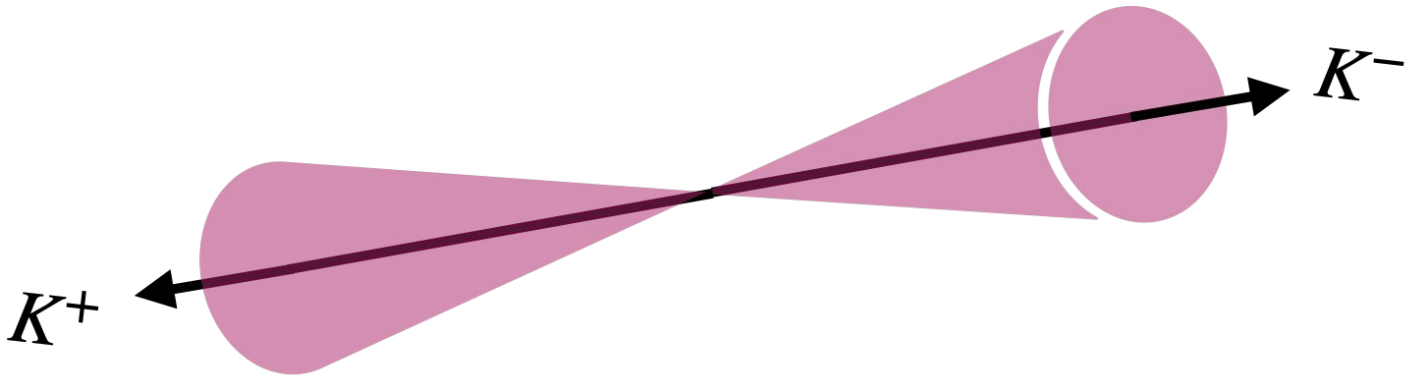
- ISR analysis was performed
- Based on Adrian's method, this still works with ssbar
  - Neutral jet energy
  - Neutral jet polar angle
- Can also implement 'Isolated Photon Finder Processor' to identify ISR photon -> eliminate from PFOs.

Backup

SSbar Analysis

SSbar Process

$e^+e^- \rightarrow s\bar{s}$



Analysis Steps

- Reconstruct SSbar process using generator information
  - Summer 2021
  - PID was performed by checking with the Generator Information.
  - Done to **explore the maximum efficiency** that can be achieved by this analysis.
  - Understanding the characteristics of the process itself.
- Reconstruct SSbar process using dE/dx distance PID
  - Fall 2021 - Winter 2022
  - PID was performed using **dE/dx distance information**.
  - Still use **Gen Info for Signal Selection**
  - Tight selection was applied to **achieve high purity**.
- Analysis Refinement
  - Winter 2022
  - Counter migration
  - Increase selection efficiencies.
  - Start of use **Reco Info for ISR removal**.

SSbar Reconstruction

Reconstruction Steps

LPFO Selection

Charge Check

Momentum Check

TPC Hit Check

IP Check

dE/dx Minimum Check

SPFO Check

Gen Signal Selection

- SSbar back-to-back

$$0.95 < \cos\theta_{s\bar{s}}$$

- Total Energy

$$120 < E_{s,\bar{s}} < 127 \text{ GeV}$$

Leading PFO

LPFO Selection

Charge Check

Momentum Check

TPC Hit Check

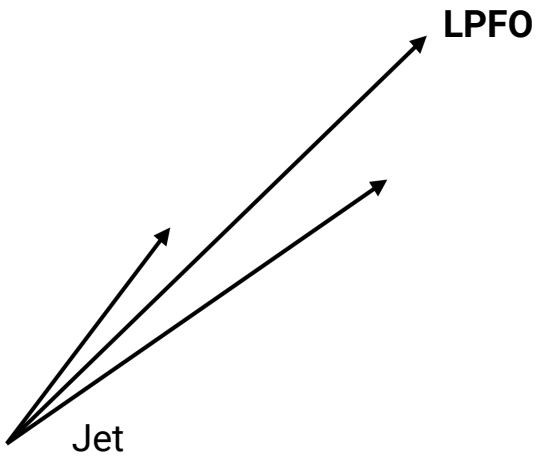
IP Check

dE/dx Minimum Check

SPFO Check

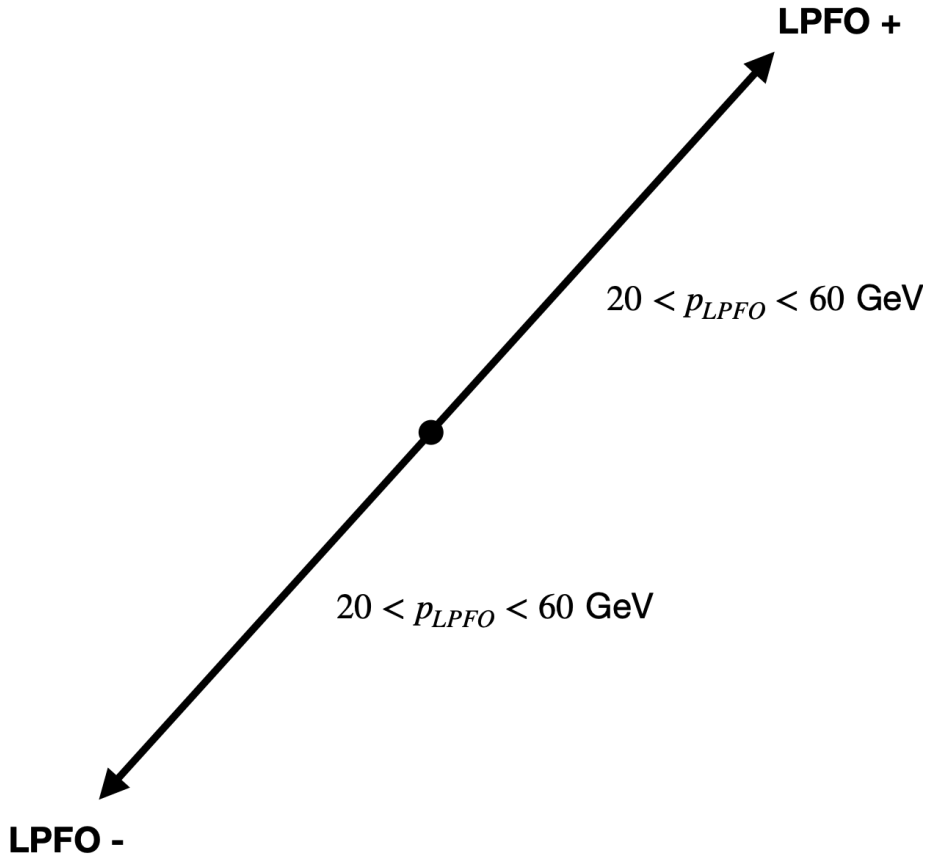
Leading PFO (LPFO)

- Particle with *highest* momentum within a Jet.
- SSbar typically disintegrate into a pair of energetic kaons.
- We choose LPFO among **charged PFOs** inside a jet.



Charge & Momentum

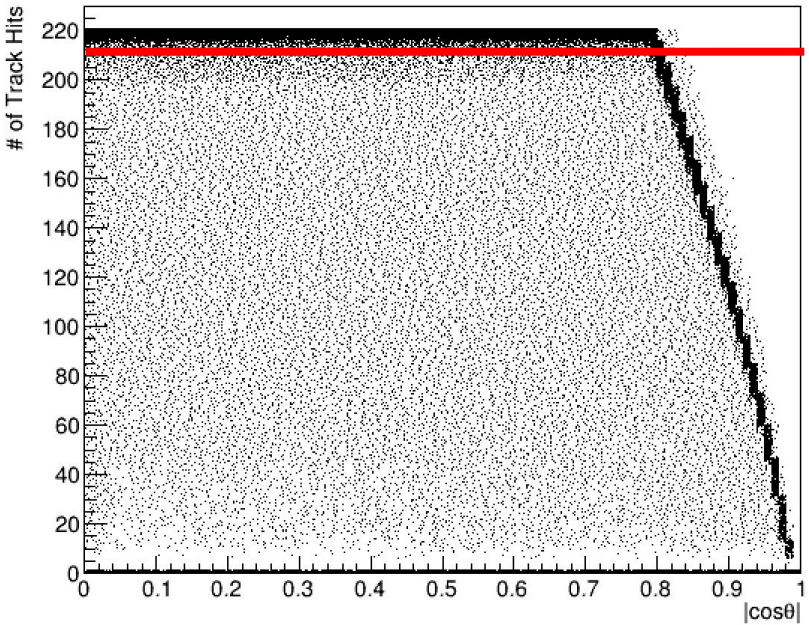
- LPFO Selection
- **Charge Check**
- **Momentum Check**
- TPC Hit Check
- IP Check
- dE/dx Minimum Check
- SPFO Check



TPC Hits

- LPFO Selection
- Charge Check
- Momentum Check
- **TPC Hit Check**
- IP Check
- dE/dx Minimum Check
- SPFO Check

$$\sigma_{dE/dx} \propto \frac{1}{\sqrt{N_{hits}}}$$

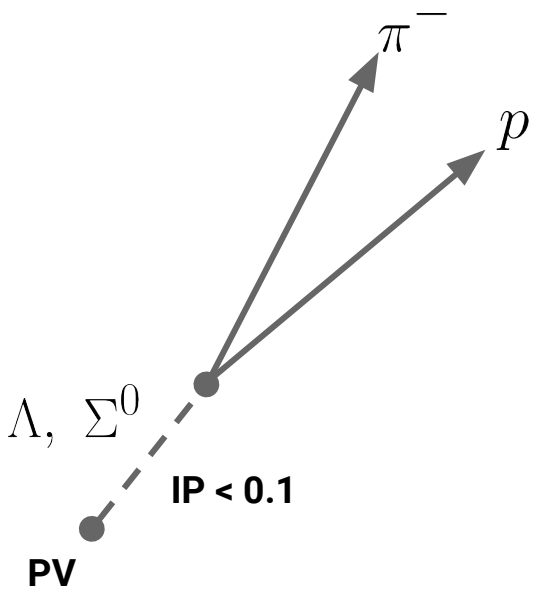


$210 < N_{hits}$

Impact Parameter

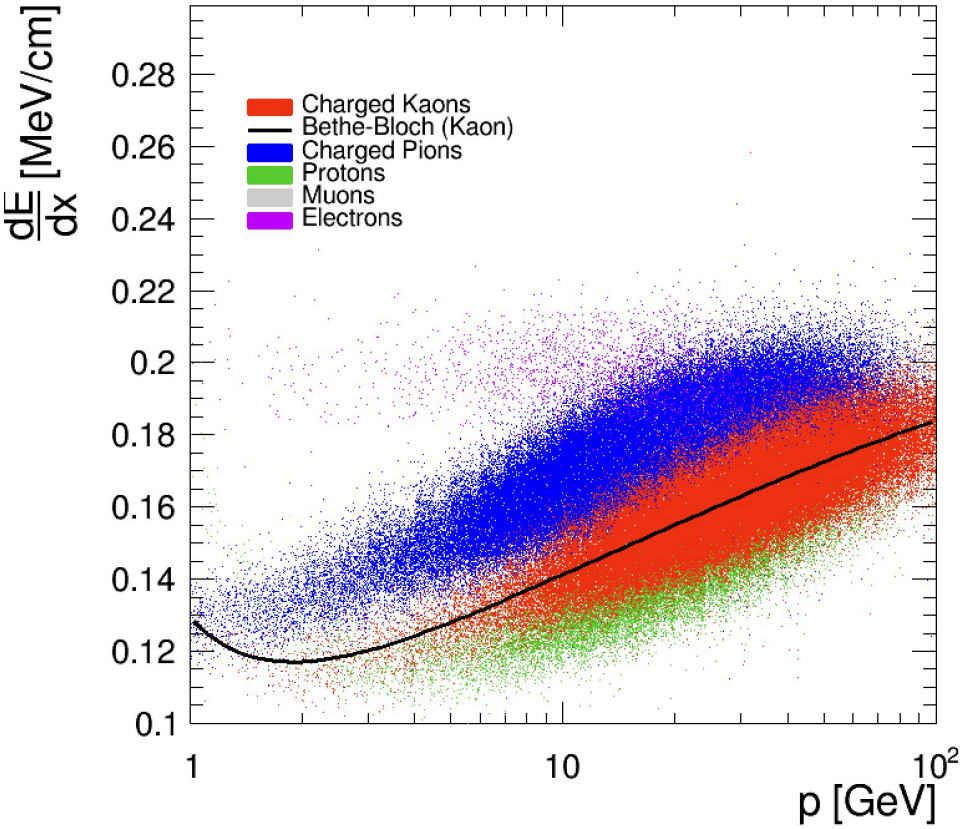
- LPFO Selection
- Charge Check
- Momentum Check
- TPC Hit Check
- **IP Check**
- dE/dx Minimum Check
- SPFO Check

Hyperon Suppression



dE/dx Minimum

- LPFO Selection
- Charge Check
- Momentum Check
- TPC Hit Check
- IP Check
- **dE/dx Minimum Check**
- SPFO Check



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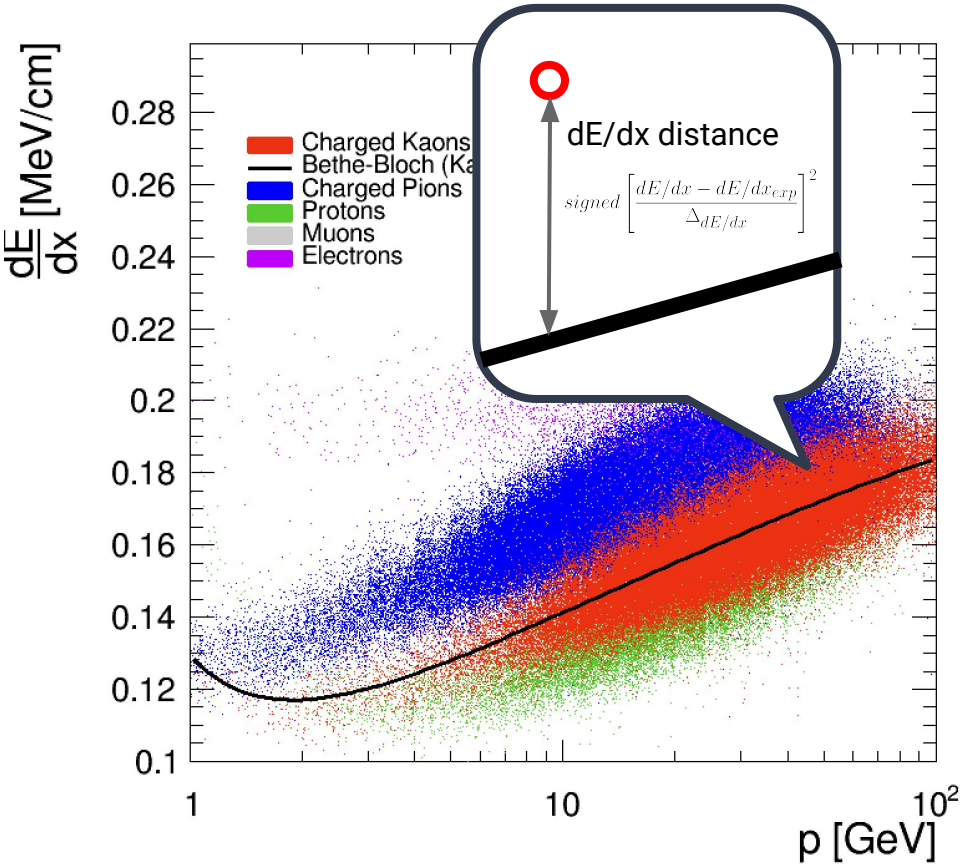

dE/dx Minimum

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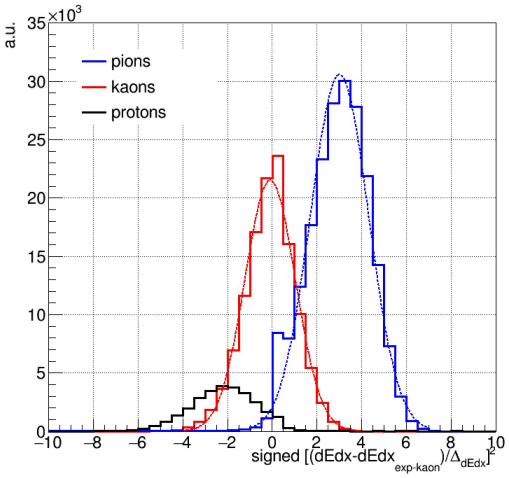
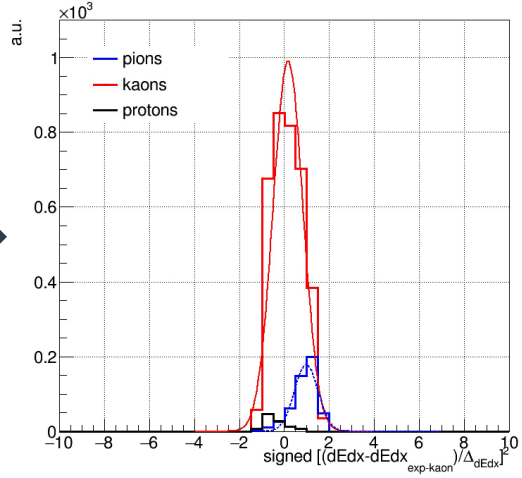
- TPC Hit Check
- IP Check
- **dE/dx Minimum Check**
- SPFO Check





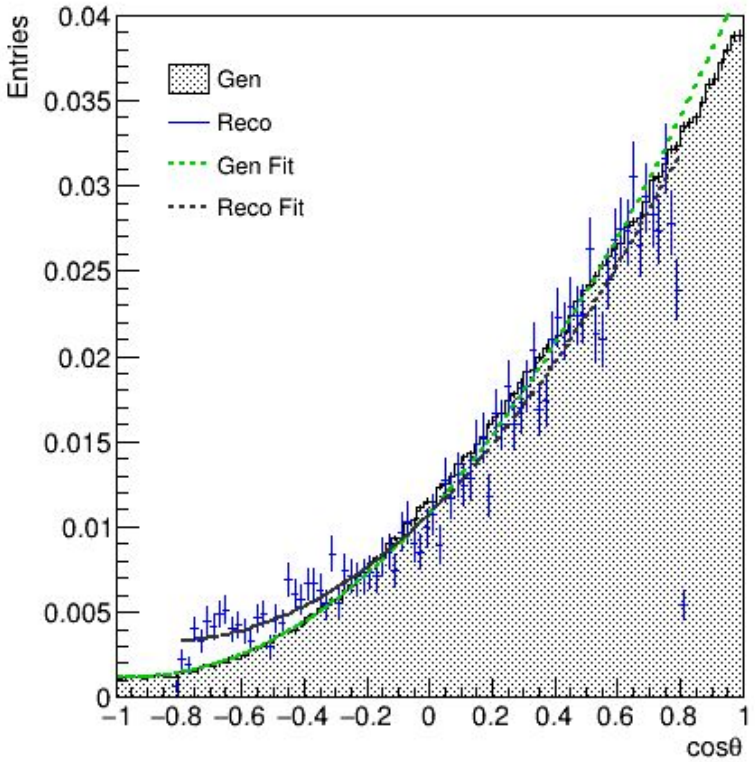
dE/dx distance minimization

- k dE/dx distance < π dE/dx distance
- k dE/dx distance < p dE/dx distance

Results I
First Attempt

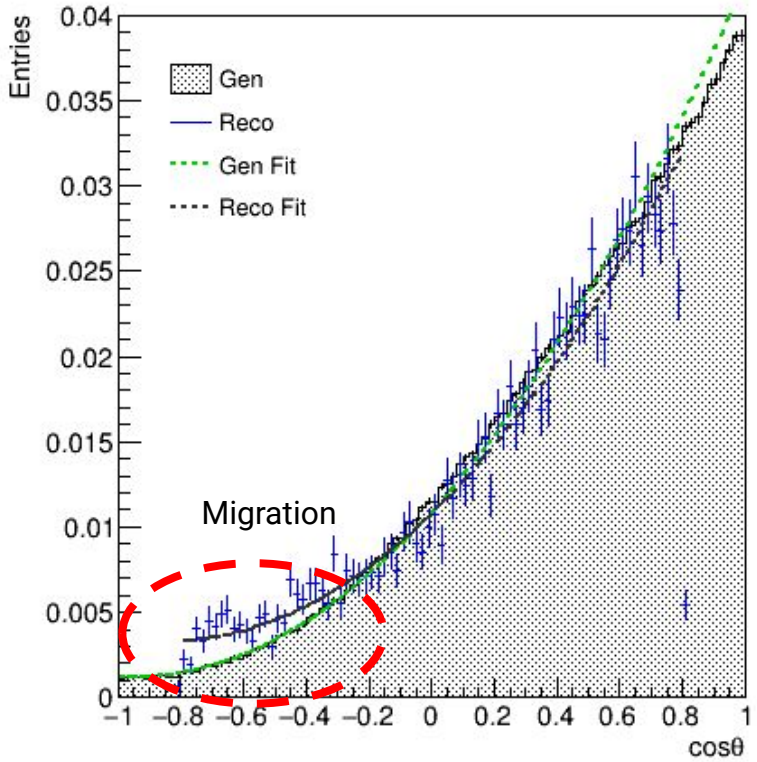
First Attempt

# Total Events (ss)	2,512,257
ISR removed (Gen)	374,399
Charge check	201,967
Momentum check	53,227
TPC hit check	27,921
Offset check	26,848
dEdx dist min check	4,211

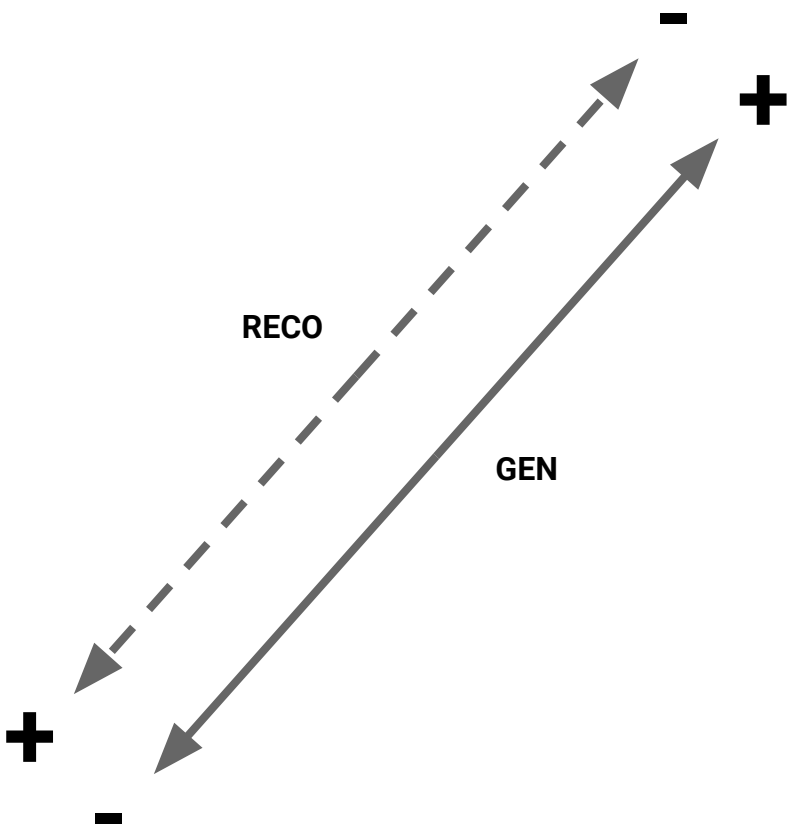


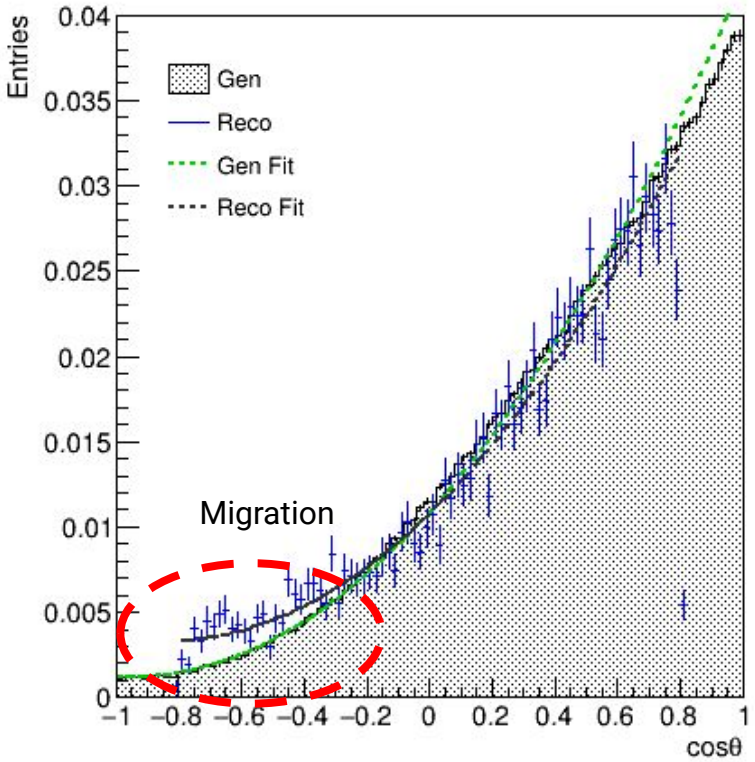
SPFO Removal

Migration


Entries
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Gen
Reco
Gen Fit
Reco Fit
Migration
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
cosθ

Migration


-
+
RECO
GEN
+
-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0.04
0.035
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0
Gen
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Migration
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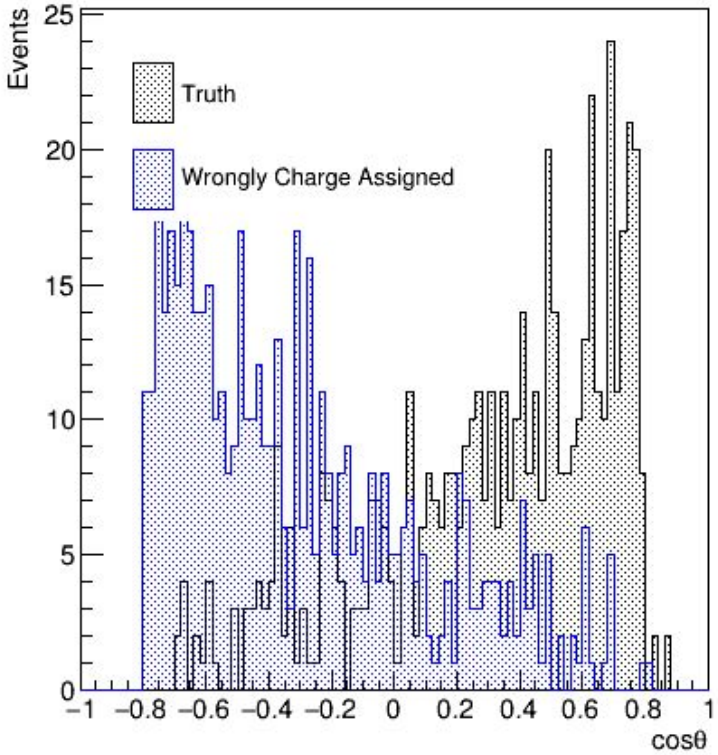
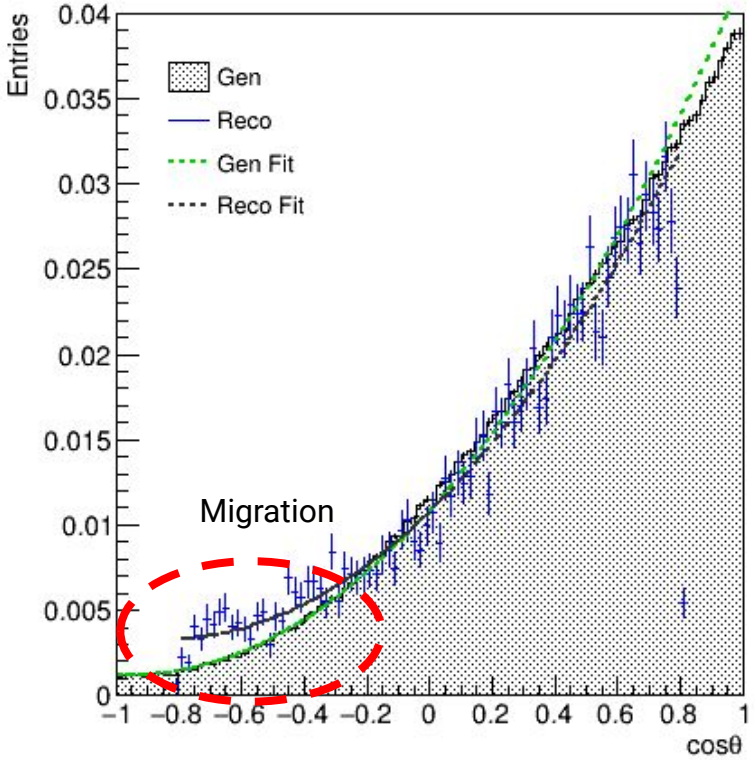
0.8
1
cosθ

Migration

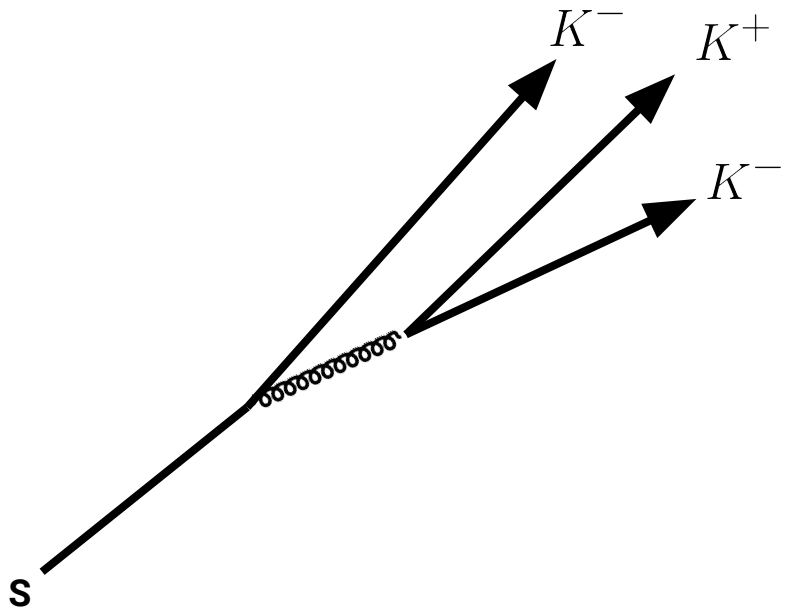

Events
Truth
Wrongly Charge Assigned
cosθ


Entries
Gen
Reco
Gen Fit
Reco Fit
Migration
cosθ

Interference

- LPFO Selection
- Charge Check
- Momentum Check
- TPC Hit Check
- IP Check
- dE/dx Minimum Check
- SPFO Check

Secondary PFO (SPFO) Check



SPFO Check

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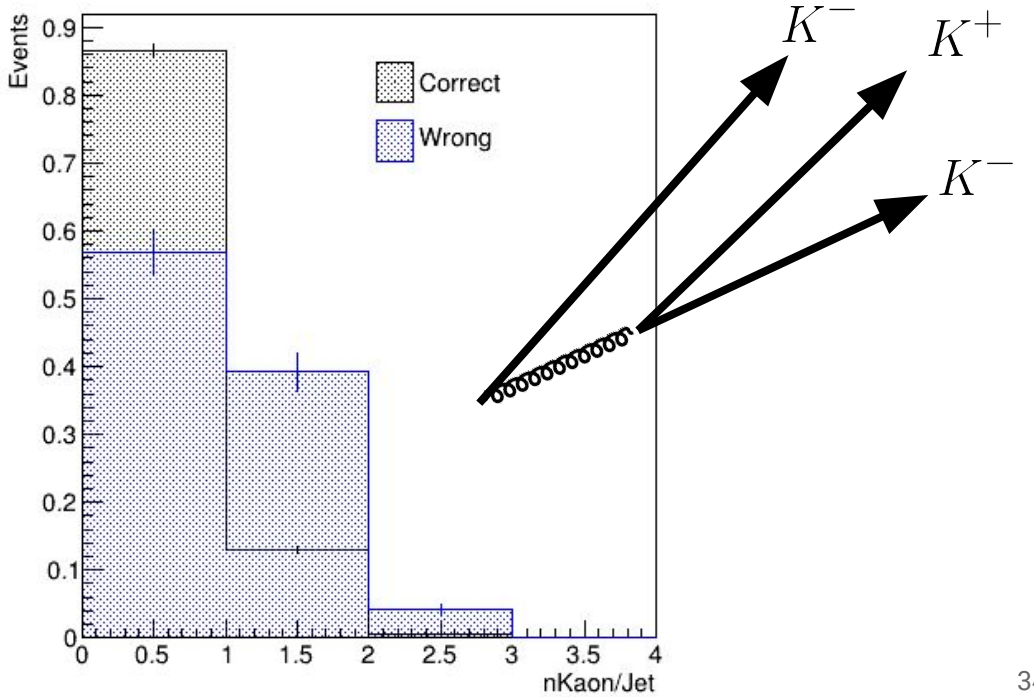
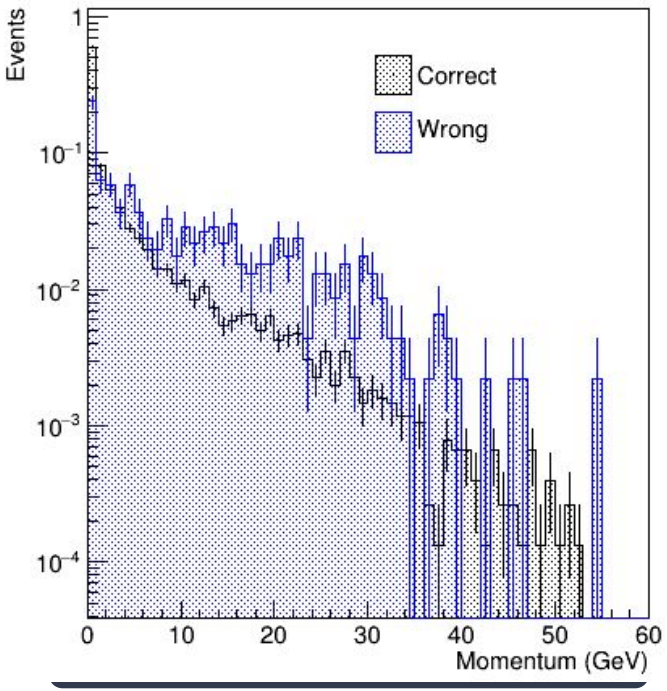
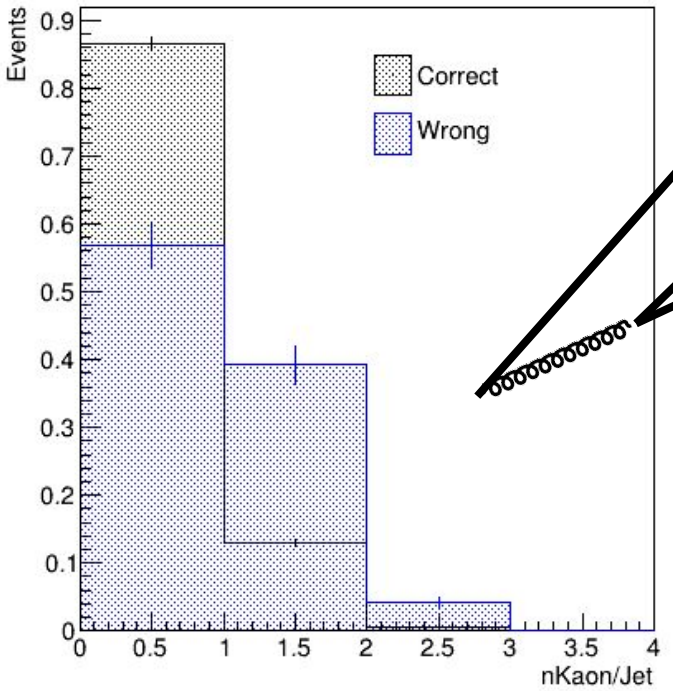


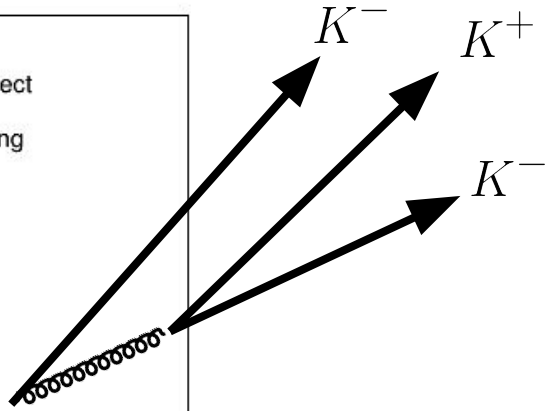
SPFO Check

LPFO Selection



Secondary PFO (SPFO) Check





SPFO Check

LPFO Selection

Charge Check

Momentum Check

TPC Hit Check

IP Check

dE/dx Minimum Check

SPFO Check

Secondary PFO (SPFO) Check

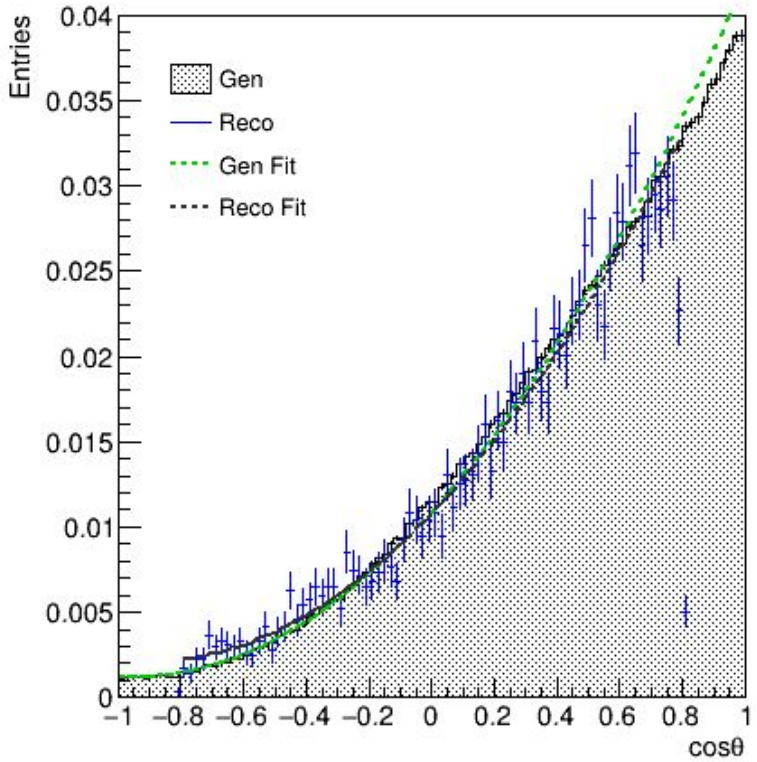
- Find SPFO such that:
  - Charged Kaon
  - Charge must be opposite to LPFO Kaon (same sign does not create confusion)
  - Must have least 10 GeV momentum
- If there is such SPFO -> veto

Results II
After SPFO Removal

After SPFO Removal

# Total Events (ss)	2,512,257
ISR removed (Gen)	374,399
Charge check	201,967
Momentum check	53,227
TPC hit check	27,921
Offset check	26,848
dEdx dist min check	4,211
Opp K SPFO check	3,036
Migration	86 (2.8%)

Purity : 97.3% **Efficiency : ~1.0%**



ISR Suppression

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ISR Suppression

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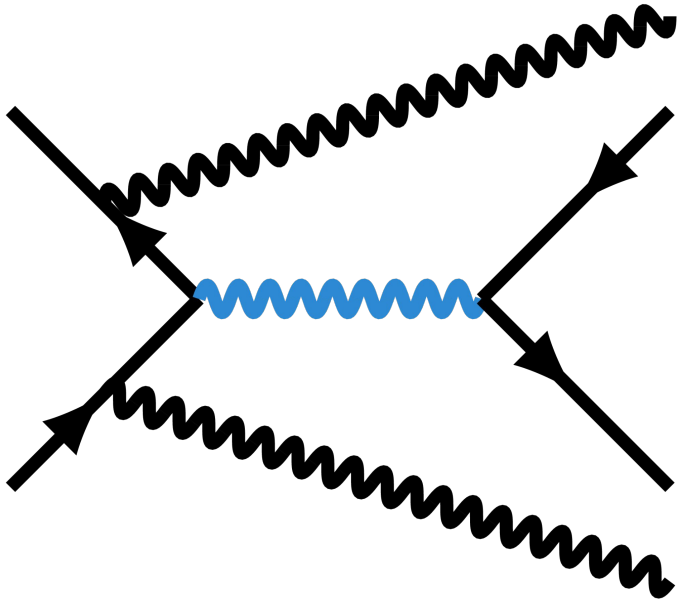
- Such phenomenon will distort the collinearity between two LPFOs. One can extract observed
  - Angle between LPFOs
    - Can jet angle do the job?
  - Visible total energy



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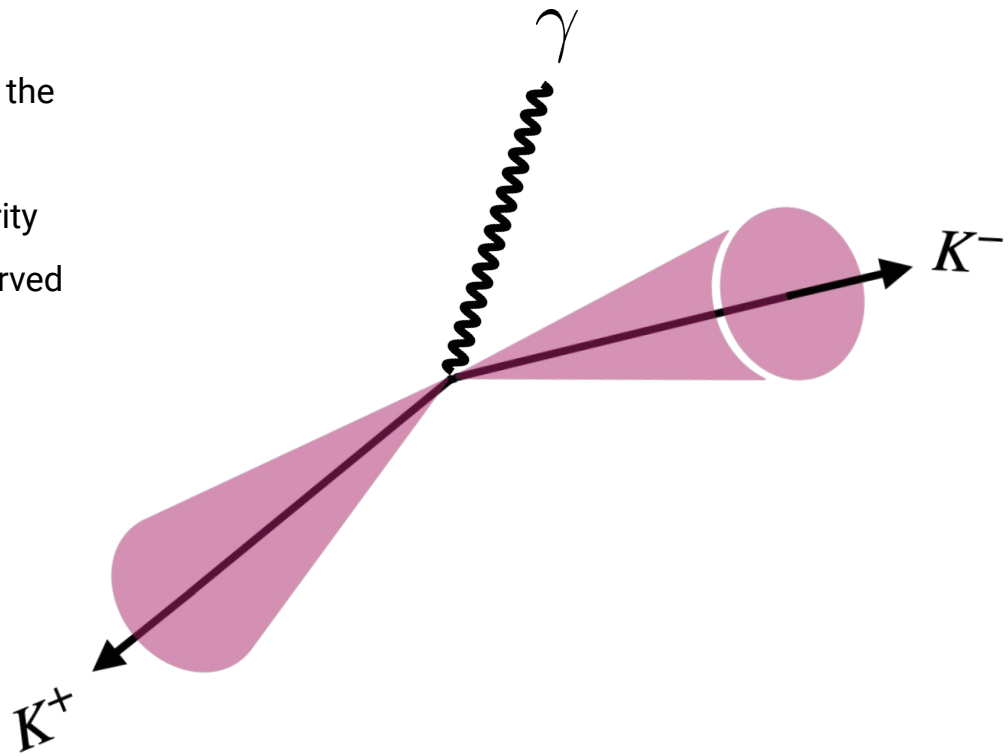


ISR Suppression

Signal Definition

- SSbar back-to-back

  $0.95 < \cos\theta_{s\bar{s}}$

- Total Energy

  $220 < E_s + E_{\bar{s}}$

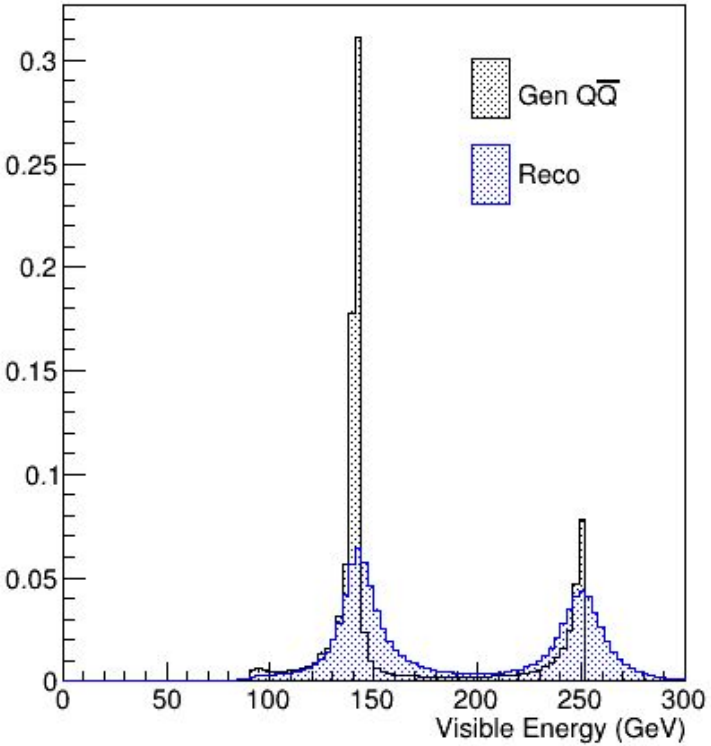
Reco ISR Removal

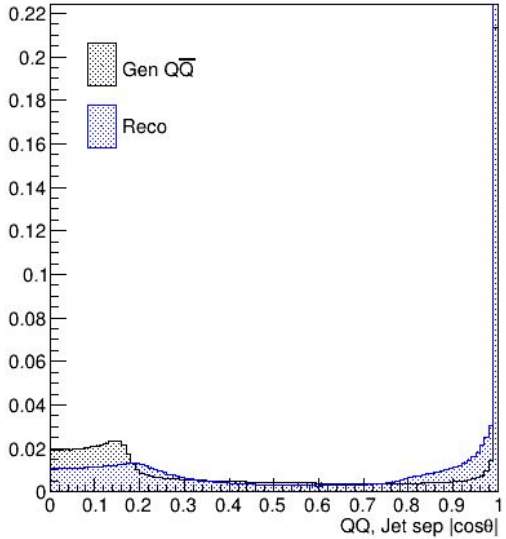
- LPFO back-to-back

  $0.95 < \cos\theta_{jets}$

- Total Energy

  $220 < E_{vis}$





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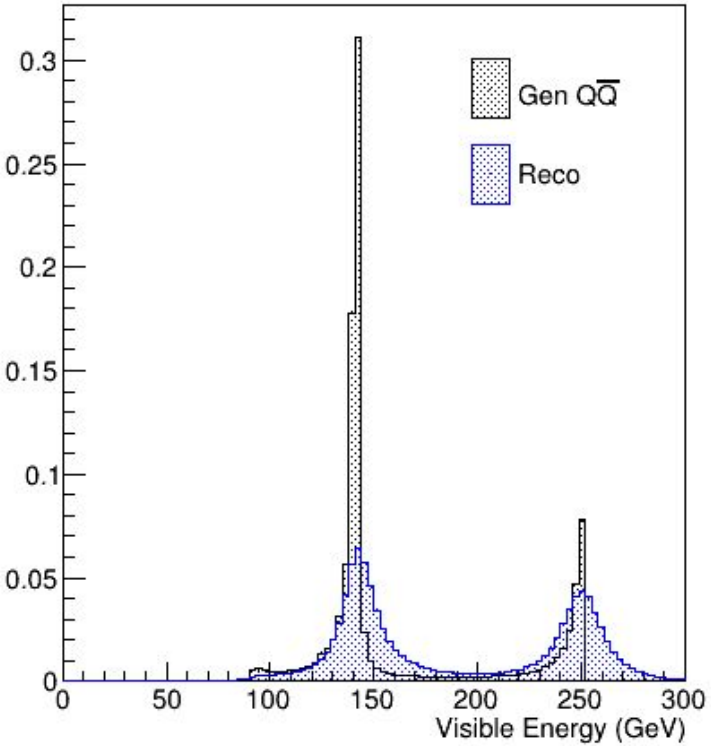
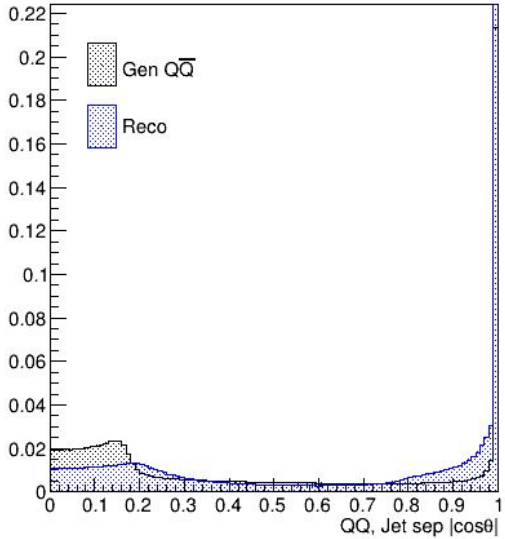


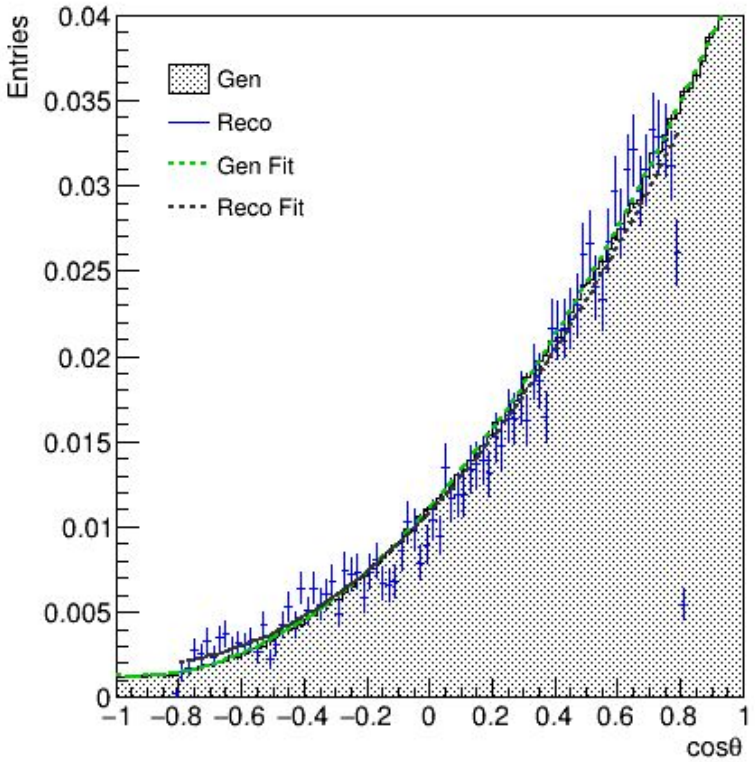


- Jet Energy Resolution
- Overlay?

Results III
After Reco ISR Removal

Polar Angle Distirbution

# Total Events (ss)	2,515,387
ISR removed	678,231
Charge check	361,681
Momentum check	71,287
TPC hit check	36,184
Offset check	34,749
dEdx dist min check	5,494
Opp K SPFO check	3,977
Migration	108 (2.7%)



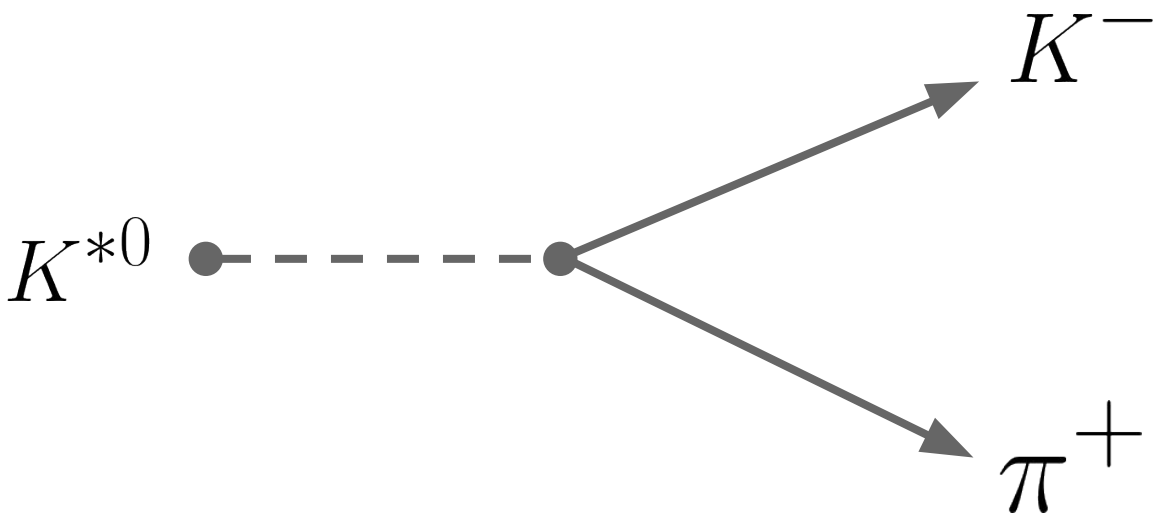
What can we do?

Efficiency Refinement

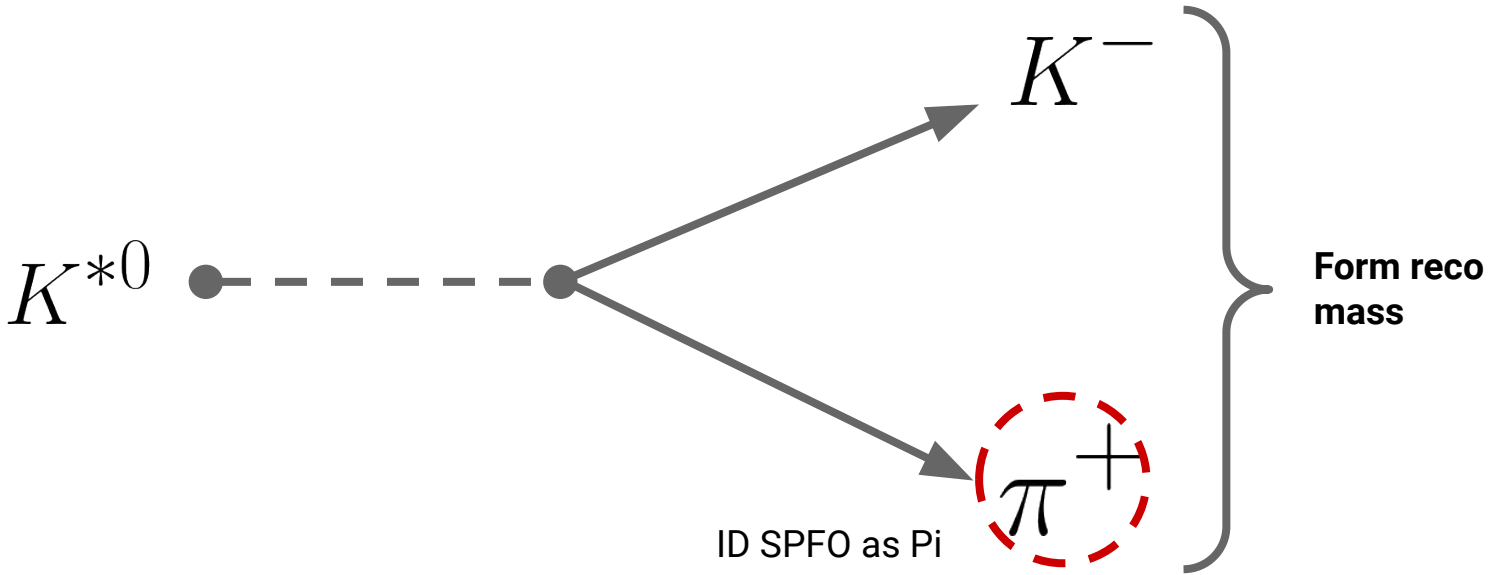
- Change in Signal Selection
  - Back-to-Back : $0.95 < \cos\theta_{s\bar{s}}$
  - Total Energy : $120 < E_{s,\bar{s}} < 127\ \mathrm{GeV}$
- Consider K*

Other Possible Leading Ks

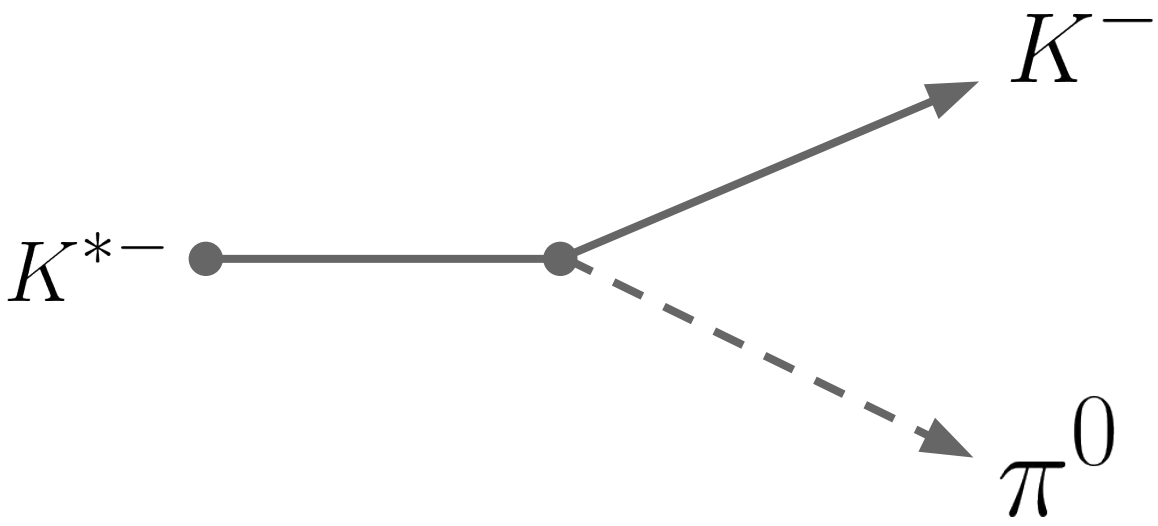
K*



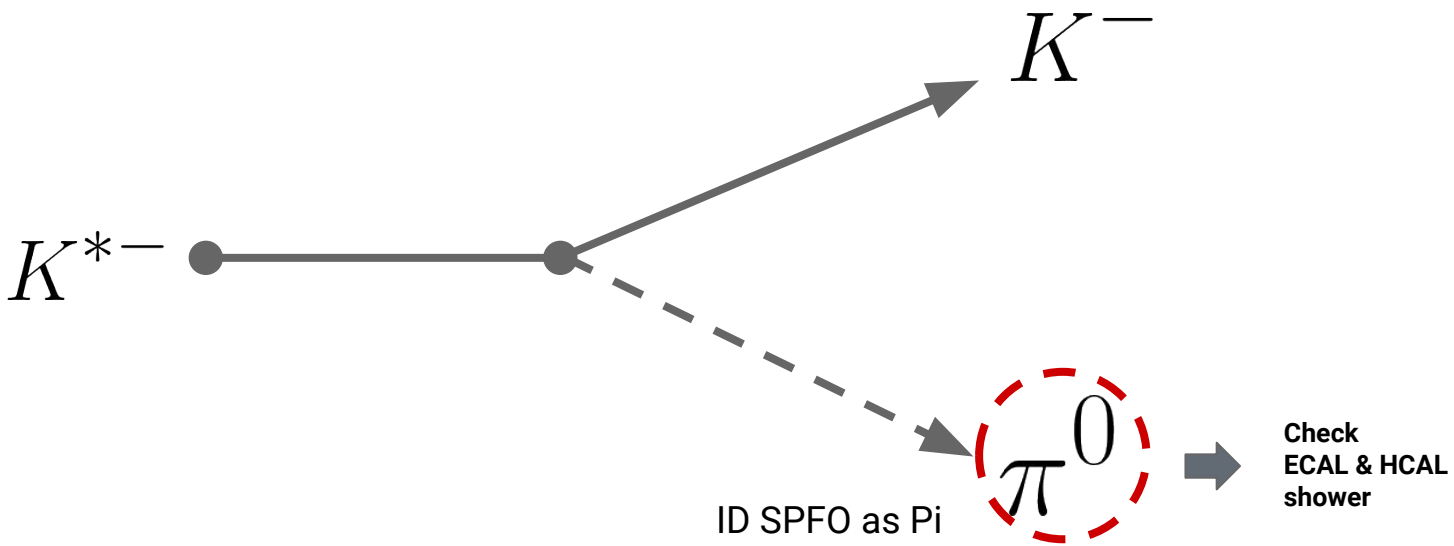
K*



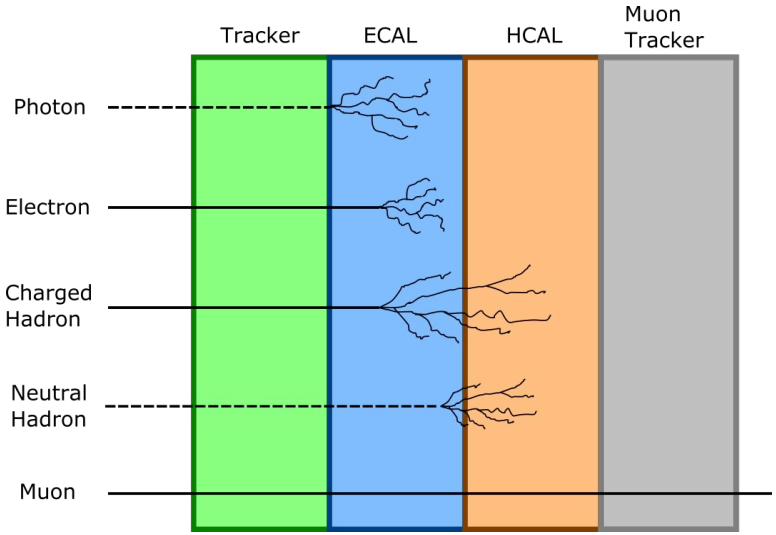
K*

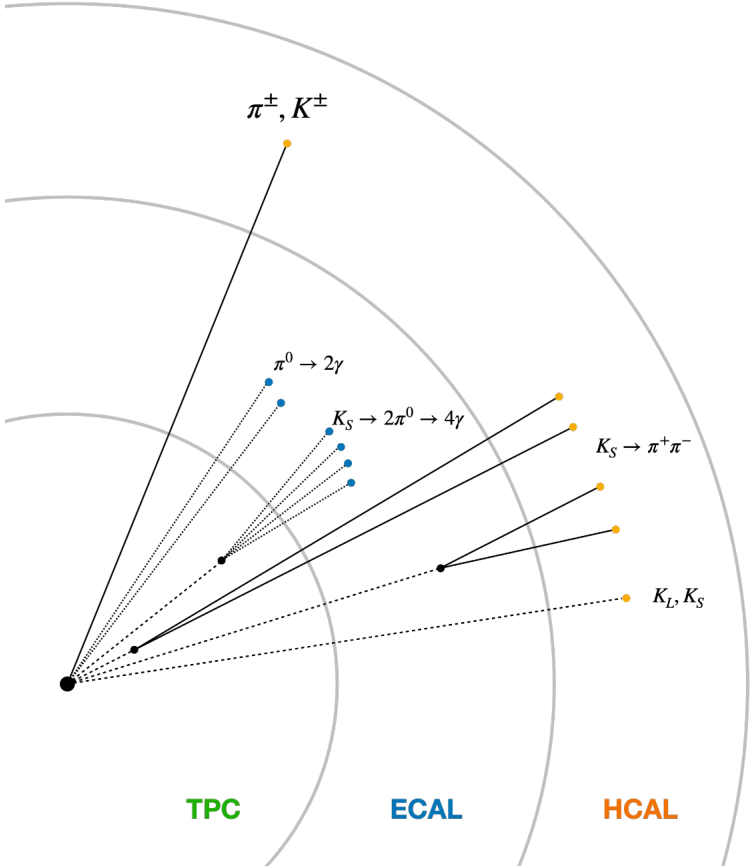


K*



Why Migration?





Summary & Prospects

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Summary

- SSbar reconstruction was performed, using dE/dx PID.
  - Kaon identification
- Purity up to 96% was achieved with current selection.
- Suffers significantly from the efficiency loss

Prospects

- Retrieve efficiency
  - Loose selection criteria (e.g. momentum)
  - Include cases with K*
  - Include neutrals using HCAL info
- ISR study
  - ISR analysis is already in progress
    - LPFO charged Kaon opening angle
    - Total visible energy