Phi Meson Decay & Kaon Detection in the nHCal

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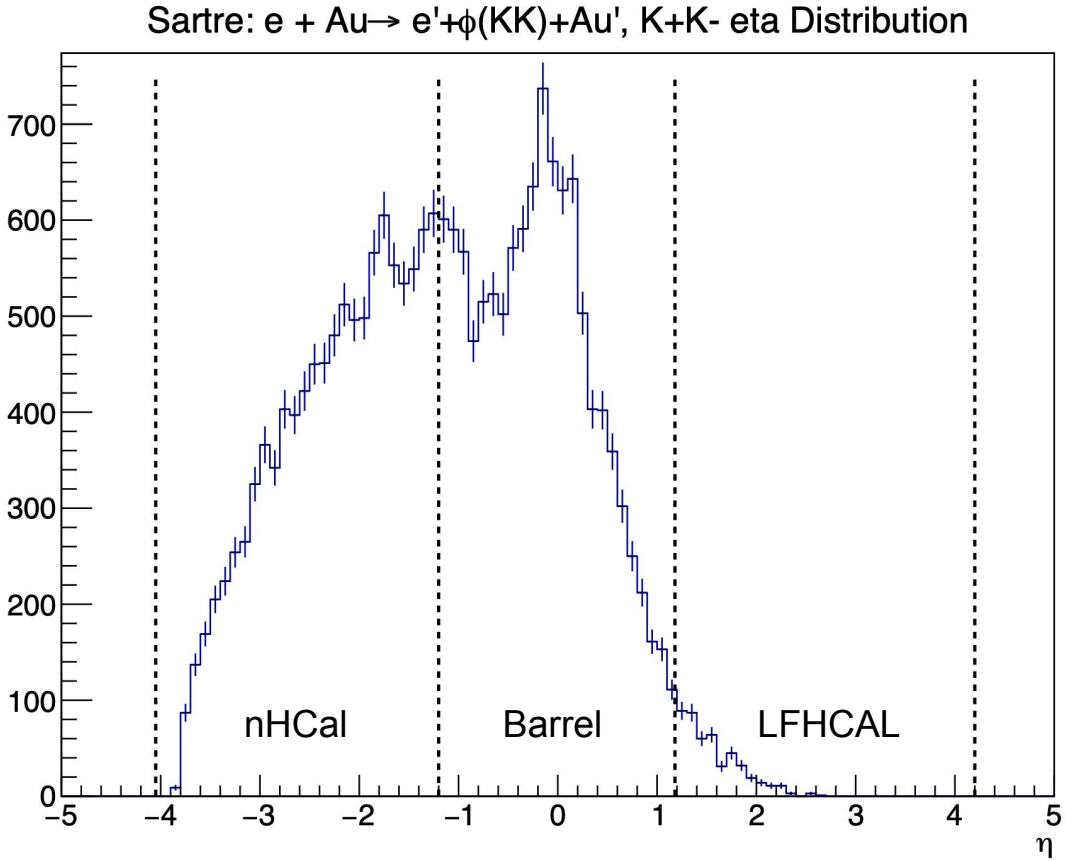
Inputs - Centrally Produced Simulation

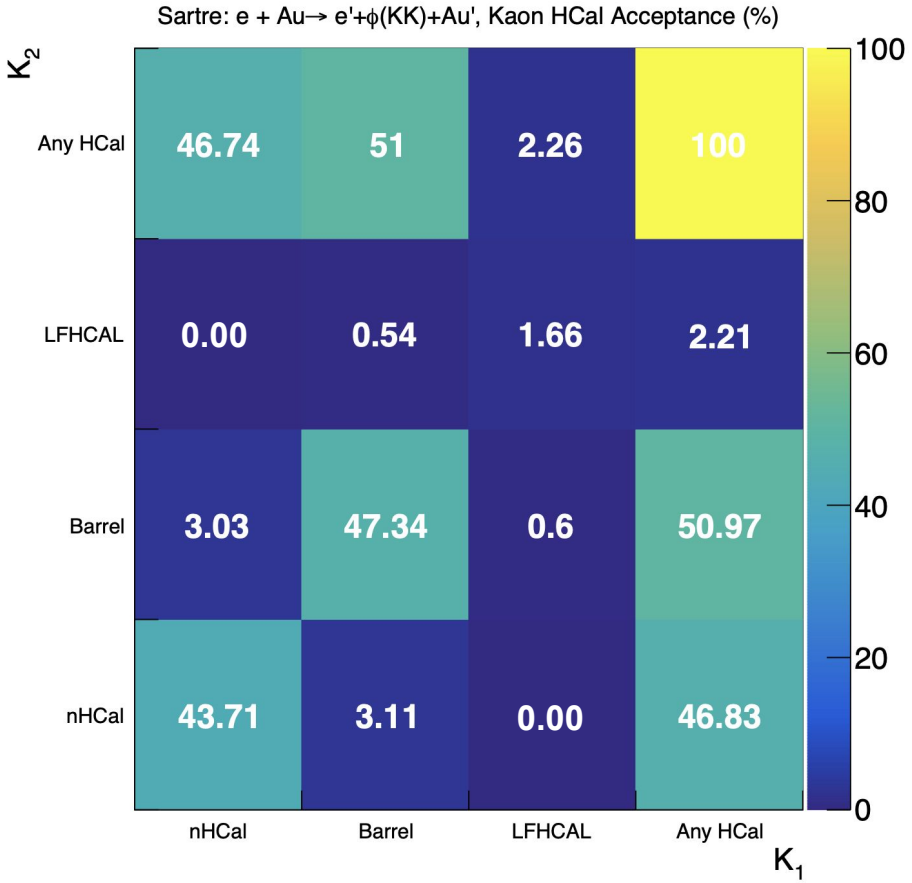
- Sartre 1.33
  - Exclusive phi meson production($e + Au \rightarrow e' + Au' + \phi$)
  - 110 GeV Au x 18GeV e
  - Analyzed data sample: 10 runs(10250 events)
- Assumed acceptances:
  - nHCal: $-4.05 < \eta < -1.2$
  - Barrel: $-1.2 < \eta < 1.18$
  - LFHCAL: $1.18 < \eta < 4.2$
- Central BNL Simulation Source:
  - https://eics3.sdcc.bnl.gov:9000/eictest/EPIC/RECO/24.07.0/epic_craterlake/EXCLUSIVE/DIFFRACTIVE_PHI_ABCONV/Sartre/Coherent/sartre_bnonsat_Au_jpsi_ab_eAu_1.*.eicrecon.tree.edm4eic.root

K+ K- Eta Distribution



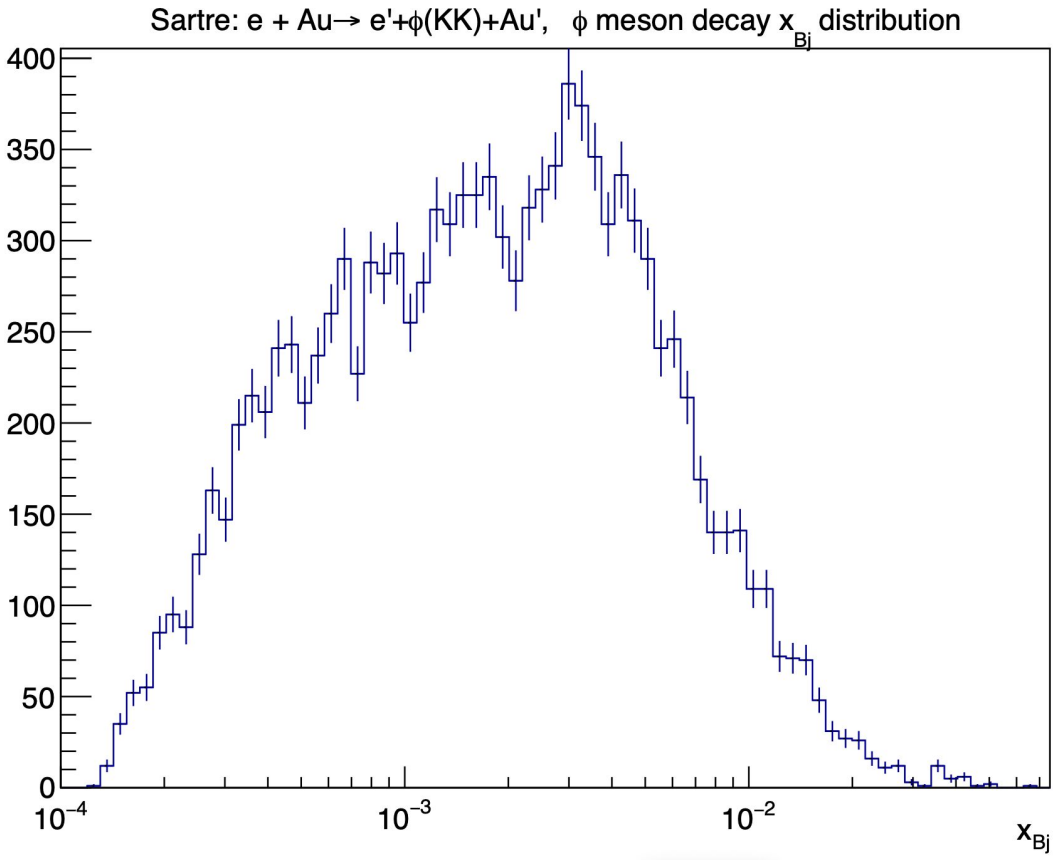
- Essentially all kaons Sartre reconstructs are in HCal range
  - “Reconstructed” = detected by tracking detectors
- 47.6% of KK within nHCal acceptance
  - Barrel Cal 50.2%
  - LFHCAL 2.23%
- Without nHCal, only 52.4% of kaons have hadronic calorimeter response

Kaon Reconstruction by Calorimeter (%)



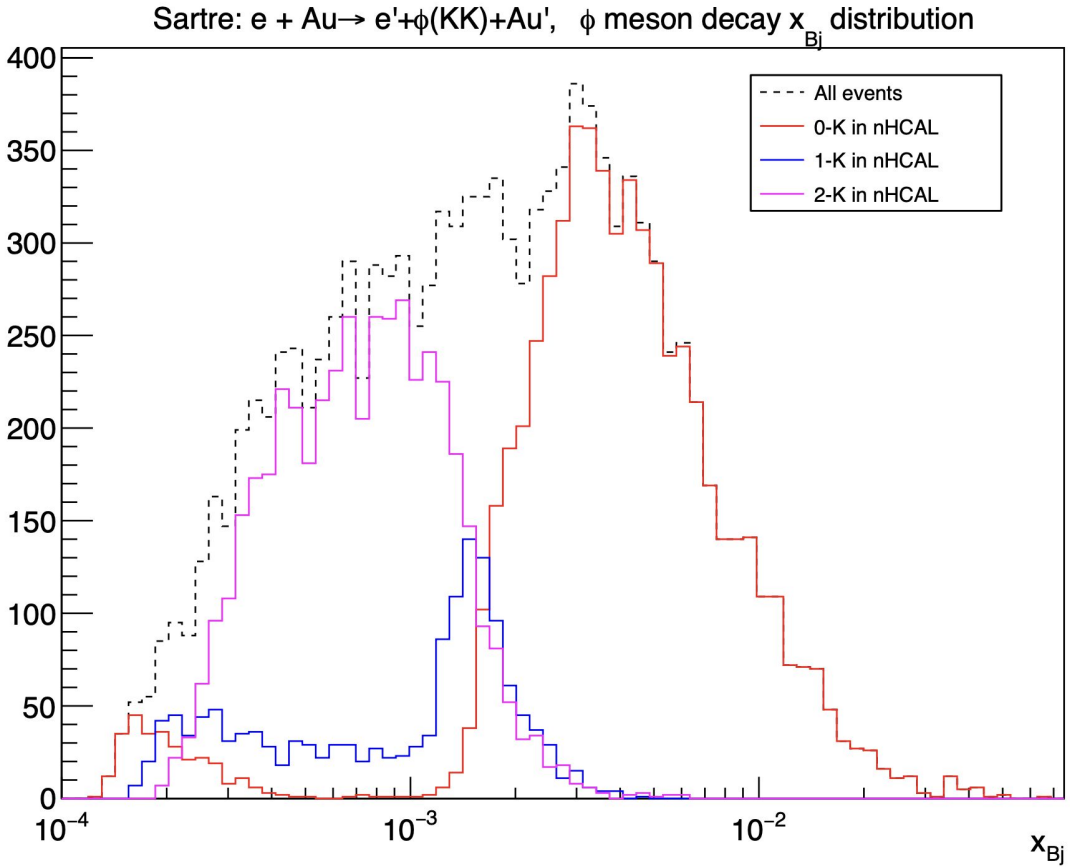
- Data normalized by number of fully reconstructed events(2 reco KK)
  - **100%** of fully reconstructed events had both kaons in “Any”
- 43.71% had both KK exclusively within nHCal acceptance
  - Without the nHCal, 49.85% of decays would be incompletely detected by HCals, if at all

$x_{Bjorken}$ Distribution



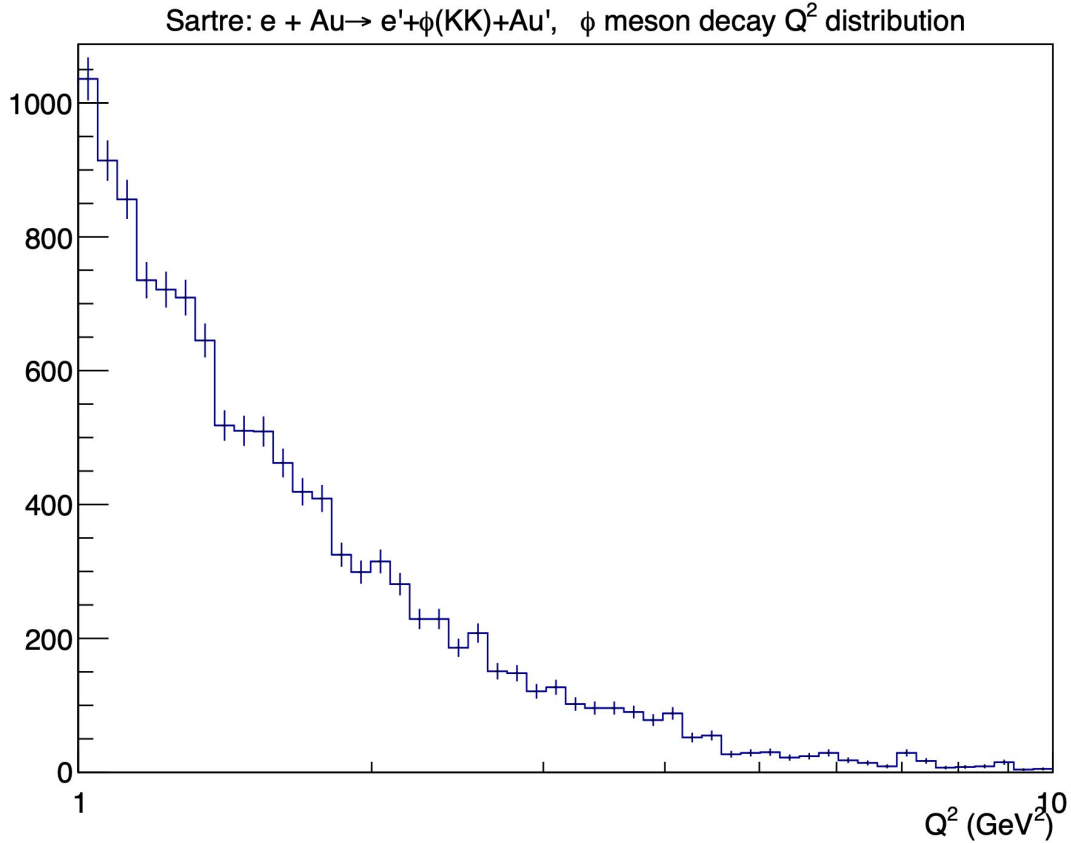
- For e + Au scatterings producing phi mesons, x_{Bj} tends to be between 10^{-4} and 10^{-2}

$x_{Bjorken}$ Distribution



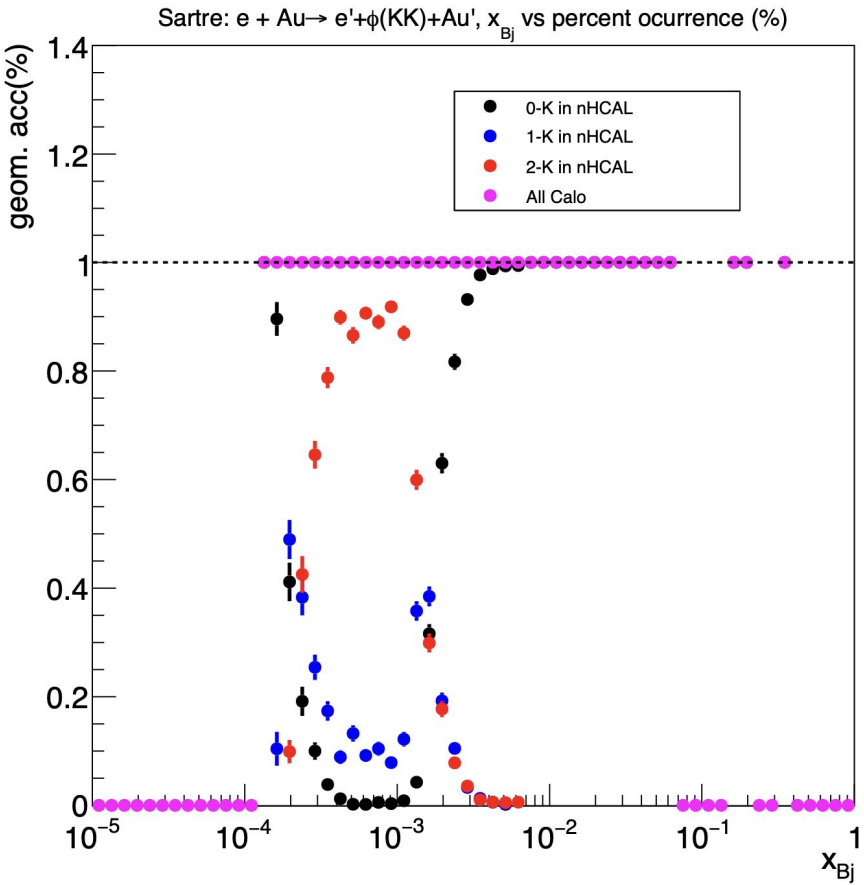
- For scatterings where both kaons within nHCal acceptance, x_{Bj} is usually lower, between 10^{-4} & 10^{-3}

Q^2 Distribution (GeV^2)



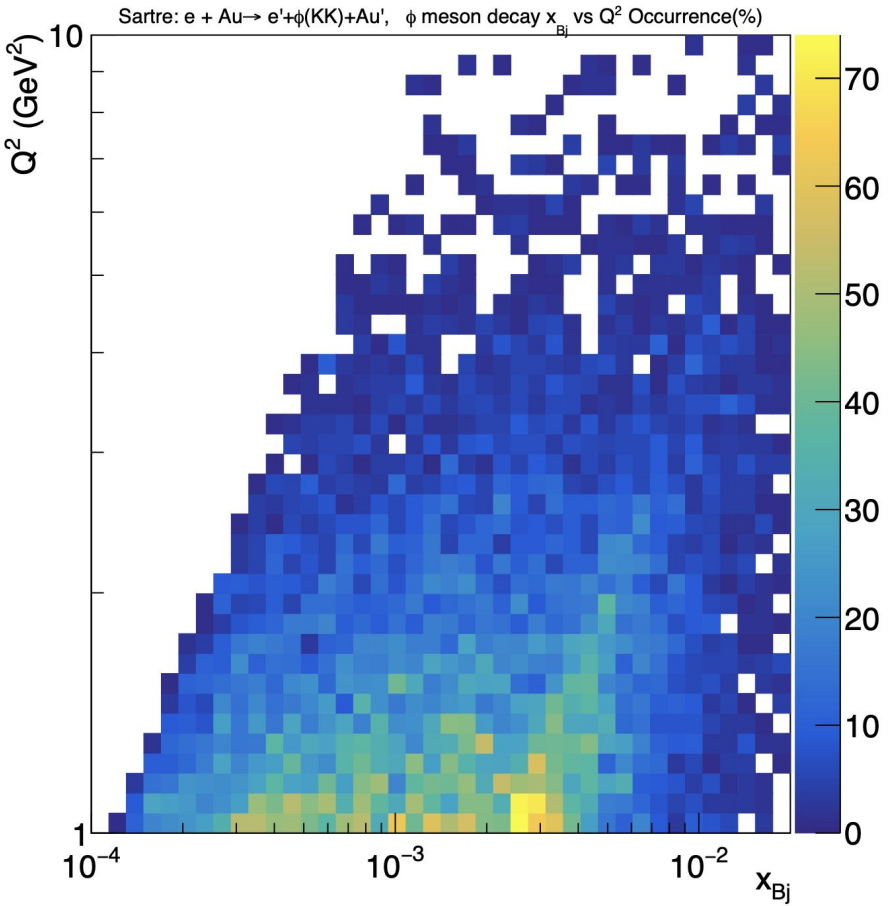
- Observe that for exclusive phi production($e + Au \rightarrow e' + Au' + \phi$), Q^2 close to 1 (mostly $1 < Q^2 < 2$)
- Q^2 relatively low since normally such collisions have higher momentum transfer

x_B vs % occurrence in nHCal



- ~100% of scatterings of all x_{Bj} values had kaons captured by some calo
- For higher x_{Bj}, nHCal struggles to capture any kaons at all
- For $3*10^{-4} < x_{Bj} < 1.5*10^{-3}$, nHCal largely successful in detecting 1 or 2 kaons for each phi decay

x_B vs Q^2 Distribution



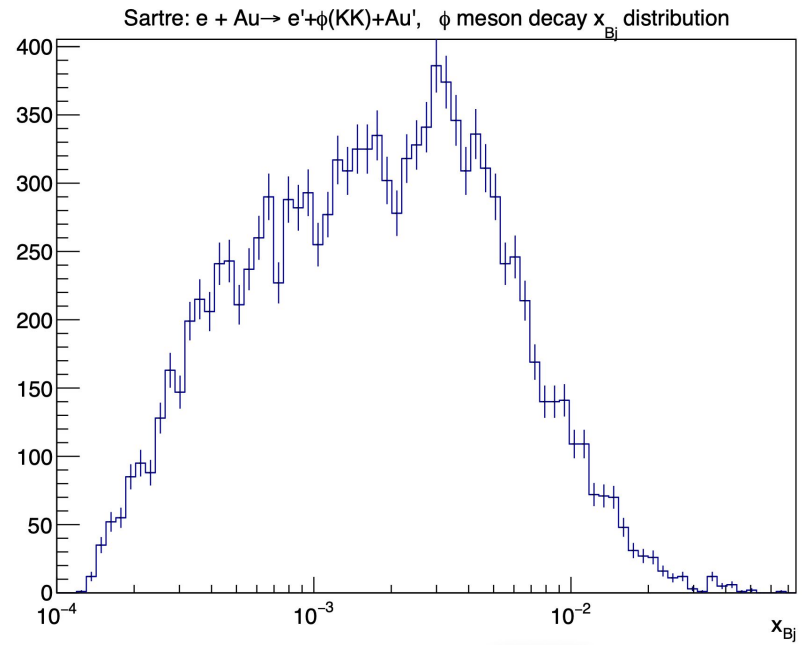
- Strong positive correlation between x_{Bj} and Q^2 values of each phi decay
- As x_{Bj}(and so Q^2) of observed scatterings lowers, nHCal becomes increasingly effective

Dhruv/Roland Comparison Slides

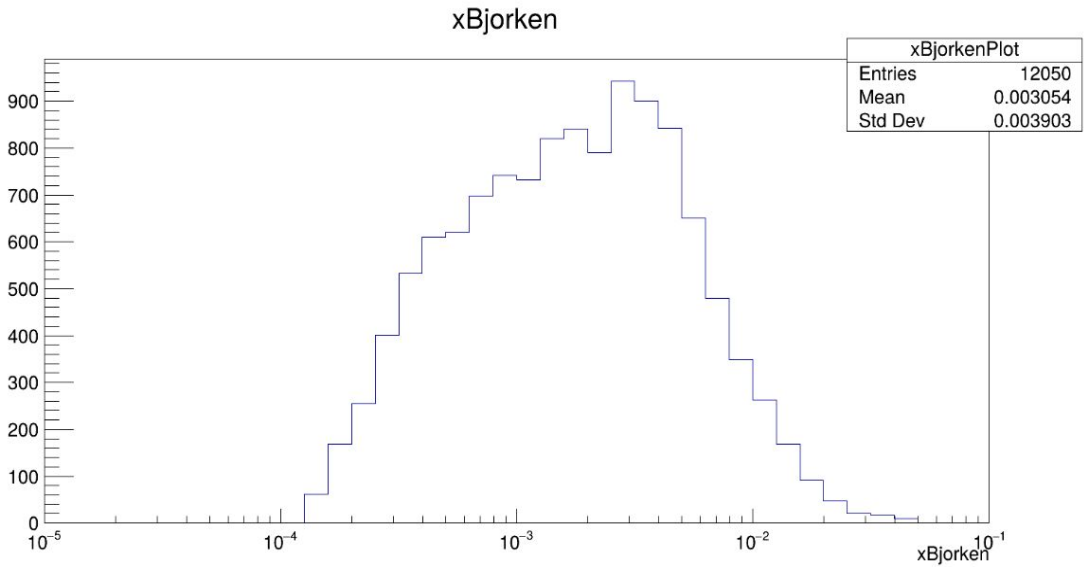
- Dhruv/Roland data: 110 GeV Au x 18GeV e
    - Centrally produced, full simulation, 12050 events

Data Comparison: $x_{Bjorken}$

Dhruv's Data:



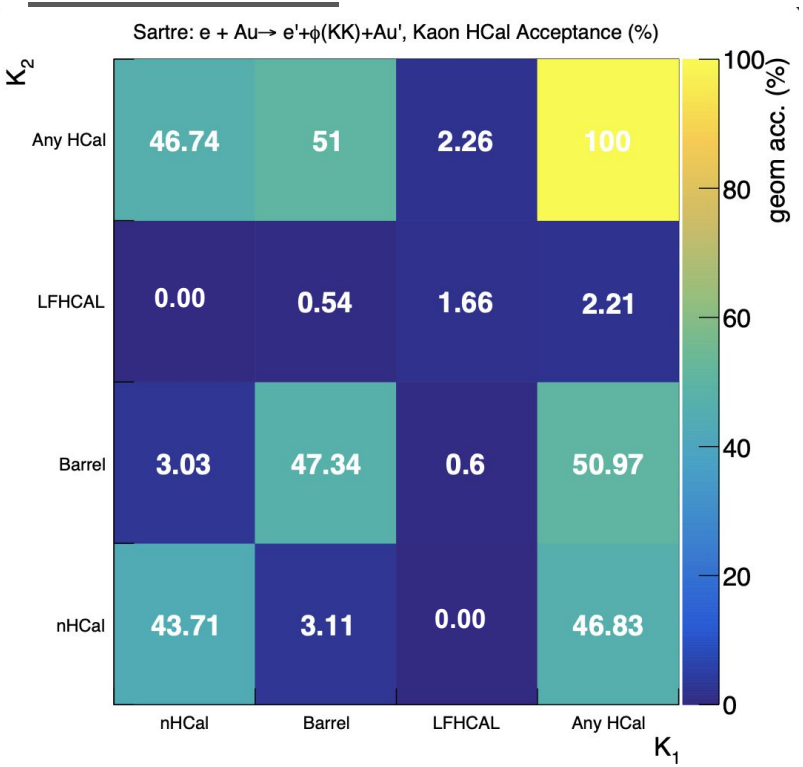
Roland's Data:



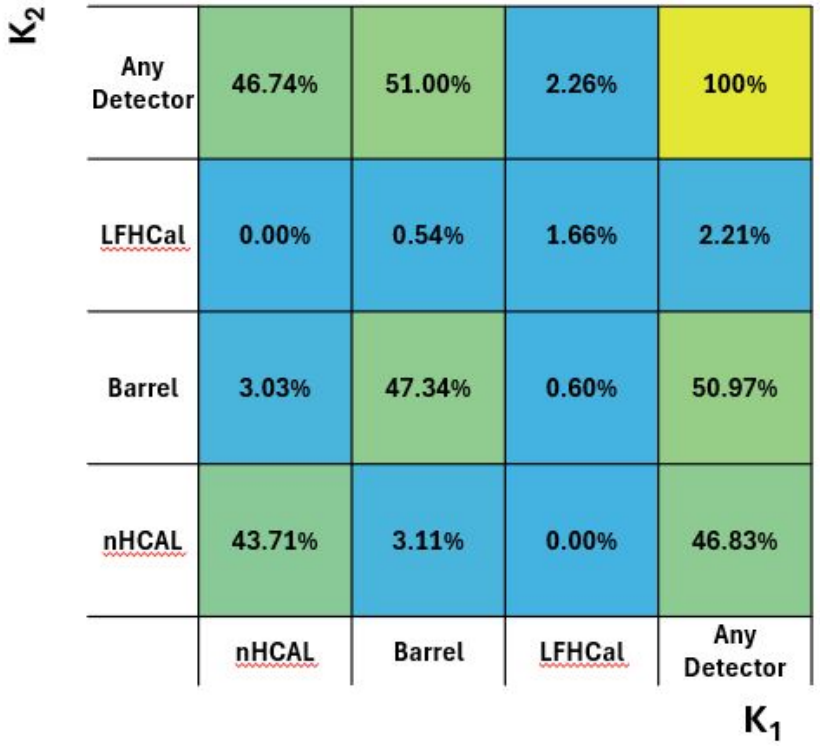
- Similar shape with most x_{Bj} between 10^{-4} and 10^{-2}
- Peaks at $x_{Bj} = 2.5*10^{-3}$ and $3*10^{-3}$

Data Comparison: Kaon Occurrence by Calorimeter

Dhruv's Data:



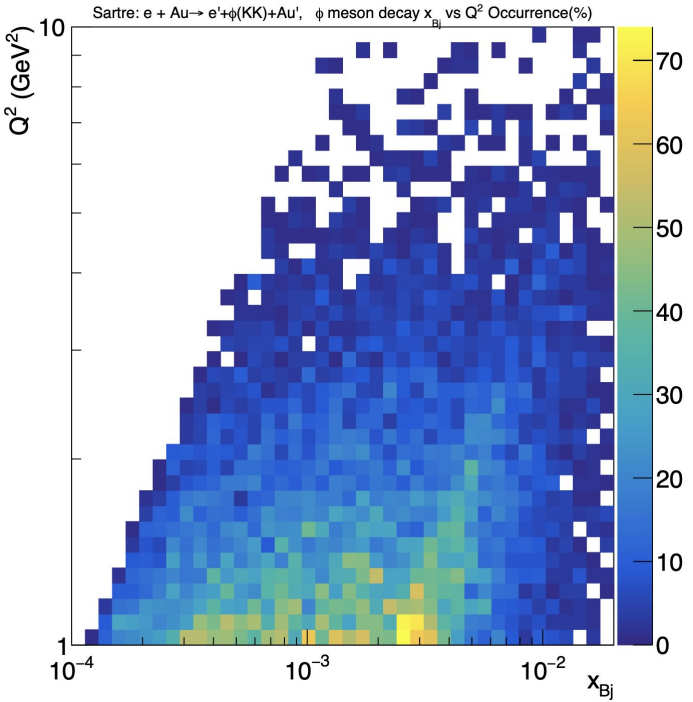
Roland's Data:



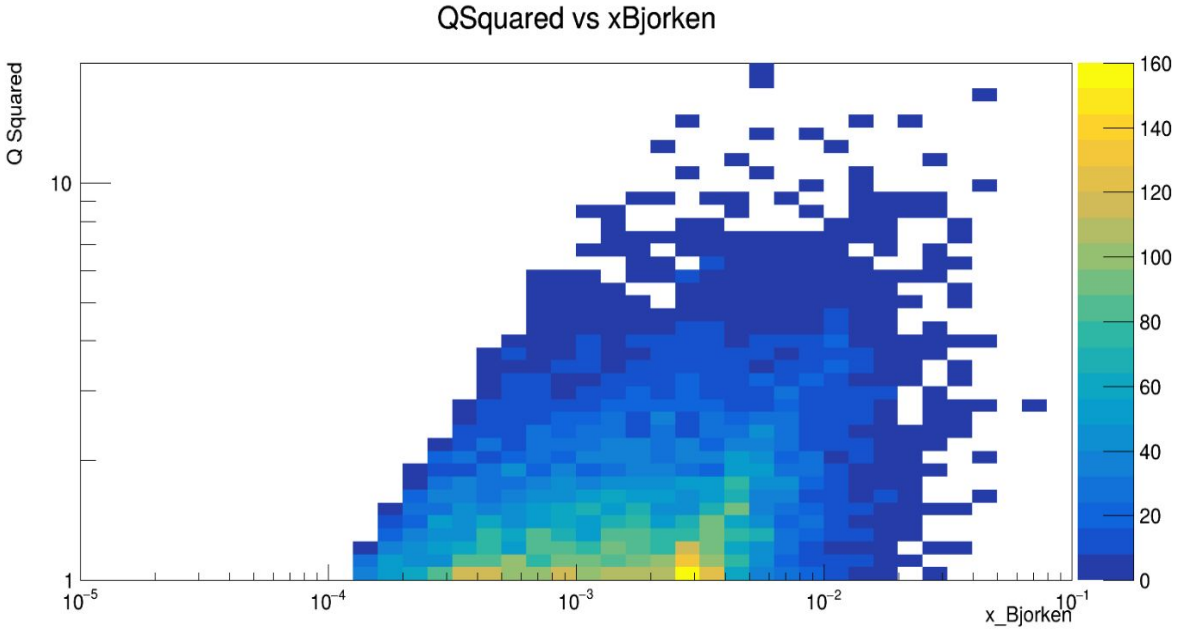
- Results identical, normalized to the number of decays where both kaons reconstructed

Data Comparison: x_{Bj} vs Q^2

Dhruv's Data:



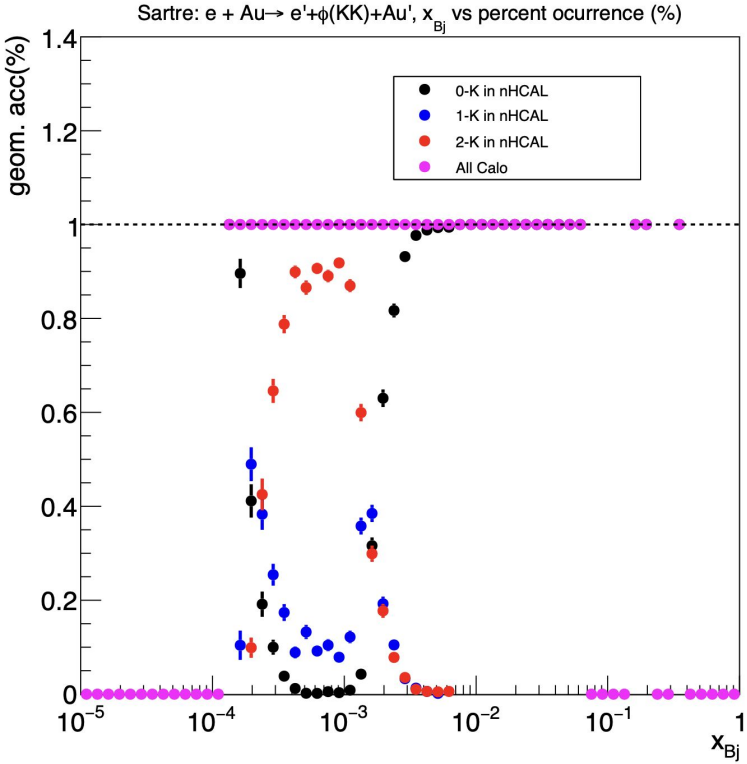
Roland's Data:



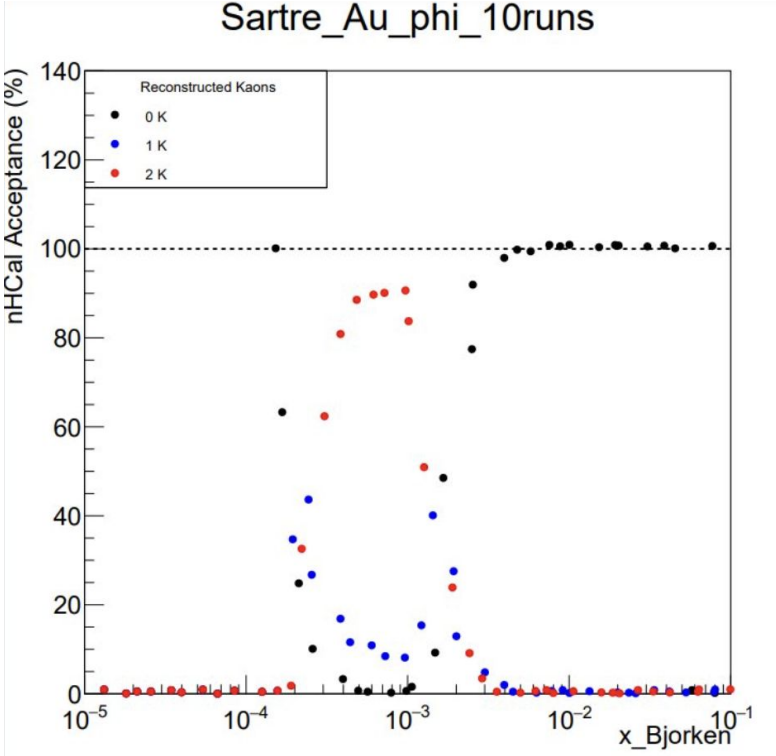
- Similar positive correlation observed between x_{Bj} and Q^2
  - Events with lower x_{Bj} tend to also have lower Q^2

Data Comparison: x_{Bj} vs % occurrence in nHCal

Dhruv's Data:



Roland's Data:



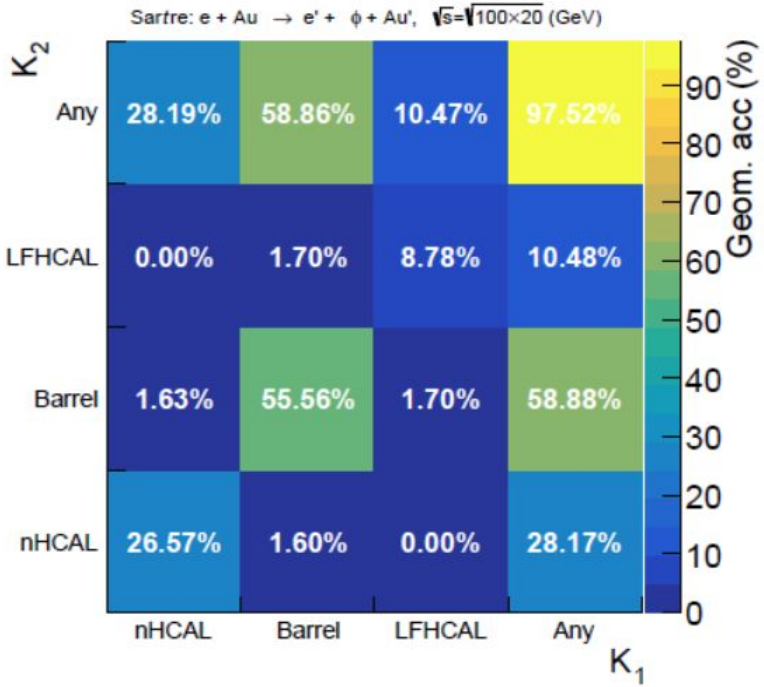
- Same trends for 0, 1, 2 Kaons in nHCal

Dhruv/Vincent Comparison Slides

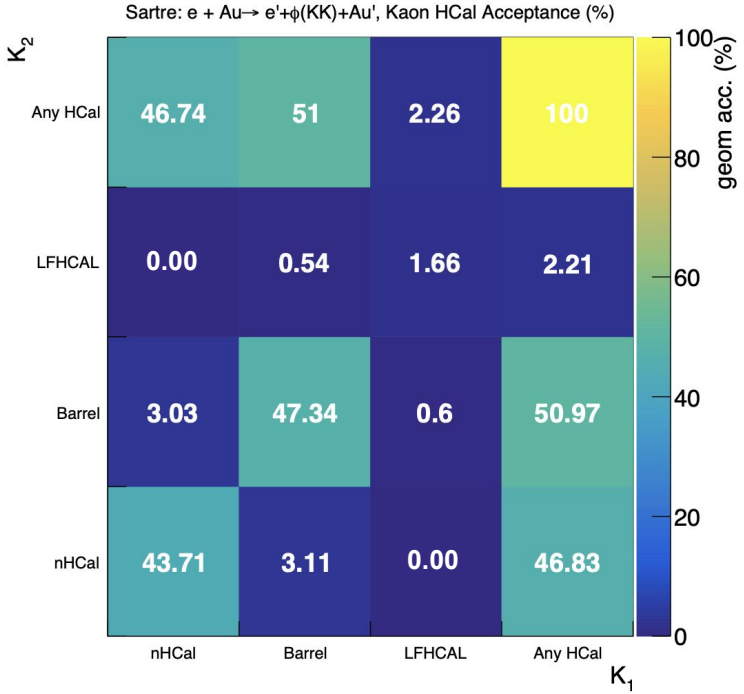
- Dhruv's data: 110 GeV Au x 18GeV e
    - Centrally produced, full simulation, 12050 events
- Vincent's data: 100GeV Au x 20 GeV e
    - Standalone Simulation without ePIC reconstruction, 1M events

Data Comparison: Kaon Occurrence by Calorimeter

Vincent's Data:



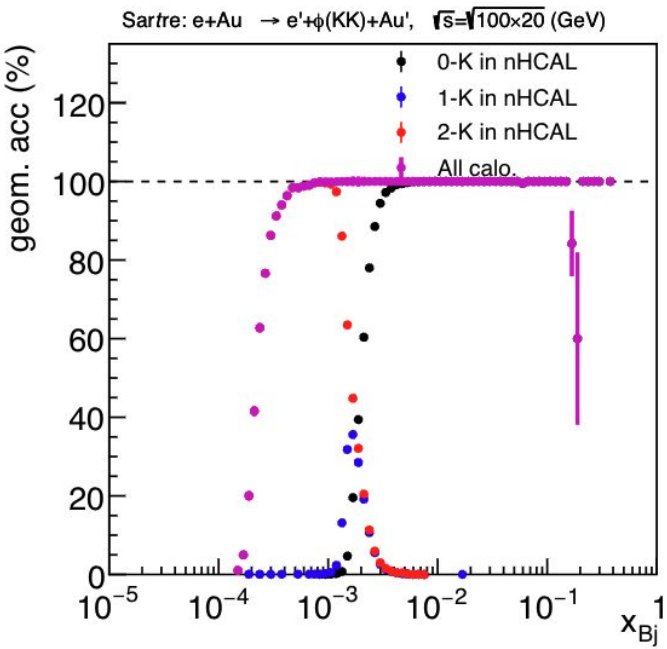
Dhruv's Data:



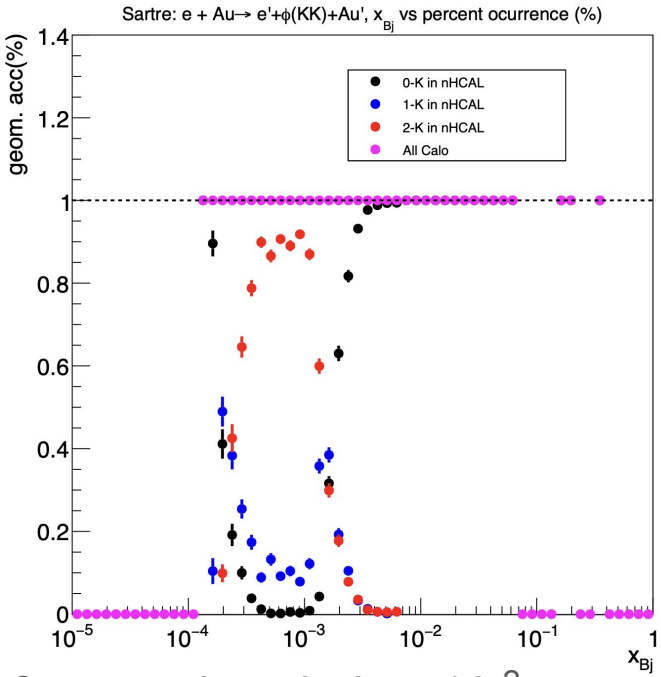
- Similar distributions between occurrence in "Any"
- Large increase in phi decay with KK only in nHCal in Dhruv's data(43.71% vs 26.57%)
- Dhruv's data shows 100% of fully reconstructed phi decay have KK within "Any"

Data Comparison: x_{Bj} vs % occurrence in nHCal

Vincent's Data:



Dhruv's Data:



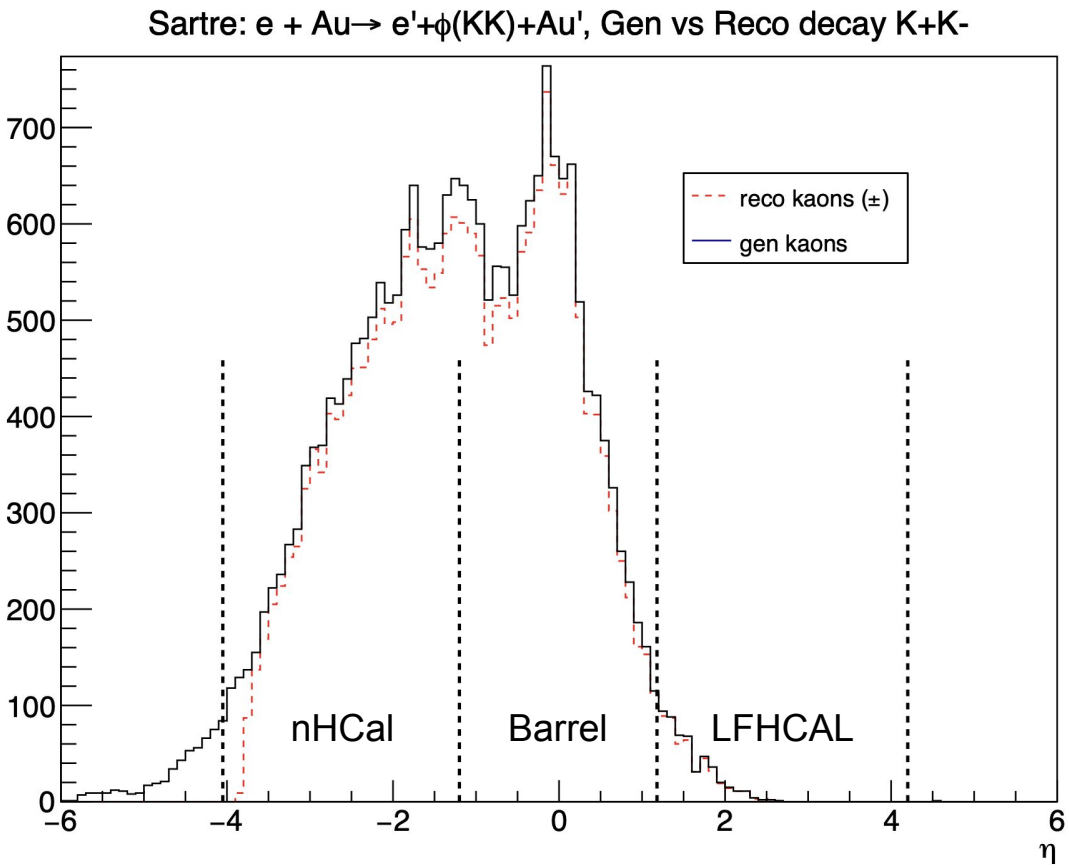
- Observe nHCal has its highest efficacy for x_{Bj} values below 10^{-2}
- Shown already that such x_{Bj} range more likely in desired exclusive scatterings
  - Thus nHCal crucial to measurements of exclusive scatterings

Possible reasons for differences between Vincent's & Dhruv/Roland's results

- Different beam energies
  - Vincent(100GeV Au x 20 GeV e) vs Dhruv/Roland(110 GeV Au x 18GeV e)
- Differences in normalization
  - Ex) all K+K- vs only reconstructed K+K-
- Subtleties in generator settings
- Simulation differences(generator-only vs. reconstruction)

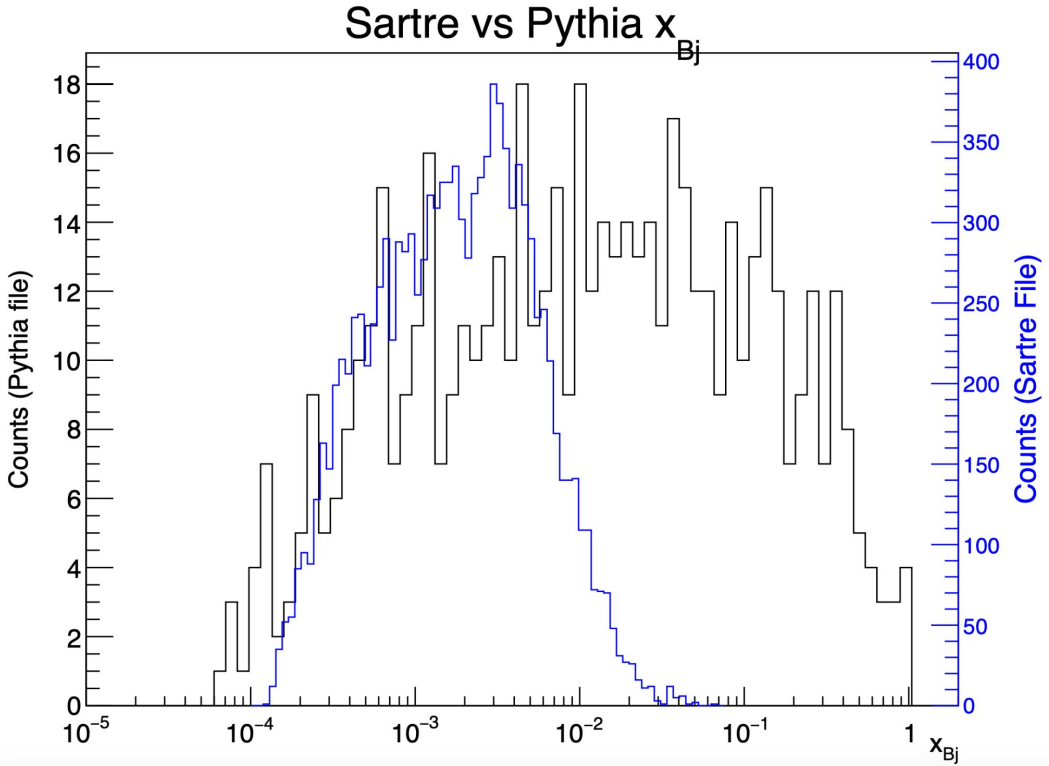
Backup

K+ K- Distribution (backup)



- Essentially all kaons Sartre reconstructs are in range
  - 91.6% of generated kaons are reconstructed
  - 85.8% of decays completely reconstructed(both kaons)

Why is this distribution important?



- Note disparity in proportion of decays with $10^{-4} < x_{Bj} < 10^{-2.8}$ between Sartre e Au file(exclusive) and a Pythia file(non-exclusive). Exclusive scatterings tend to have lower x_{Bj}, which are more often detected in the nHCal acceptance