Measurement of Reverse Emittance Exchange with KDE

Tanaz A. Mohayai

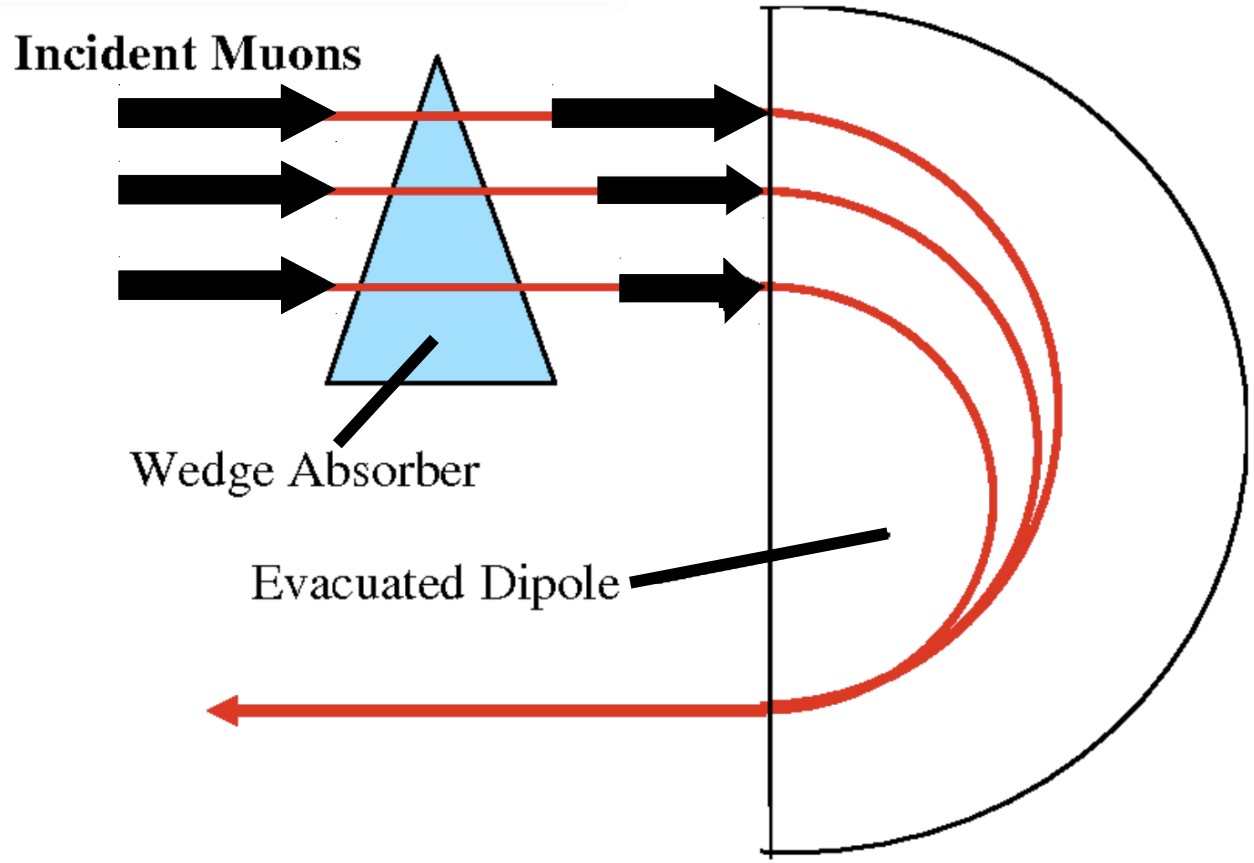
CM 51

June 27, 2018

ILLINOIS INSTITUTE OF TECHNOLOGY

Motivation

- Measure reverse emittance exchange using MICE wedge data
  - ★ Small natural dispersion in MICE beam not enough for emittance exchange (longitudinal cooling in exchange of transverse heating)
  - ★ Possible to demonstrate reverse emittance exchange → longitudinal heating and transverse cooling



- Wedge data and MC specifications: 6 mm input emittance and 140 MeV/c reference momentum

Cut Specifications

Data Type	Cut Variable	Cut Value
Recon (data and MC recon)	ToF [ns]	28 < ToF < 32
	ToF0 Spacepoint	Single
	ToF1 Spacepoint	Single
	P [MeV/c], TKU	130 < P < 150
	Tracker Track, TKU	Single
	P [MeV/c], TKD	120 < P < 200
	Tracker Track, TKD	Single
MC	PID	-13
	Fiducial Area [mm^2]	150
	Recon, TKU reference plane	Keep only TKU MC events that are reconstructed in TKU

Cut Specifications

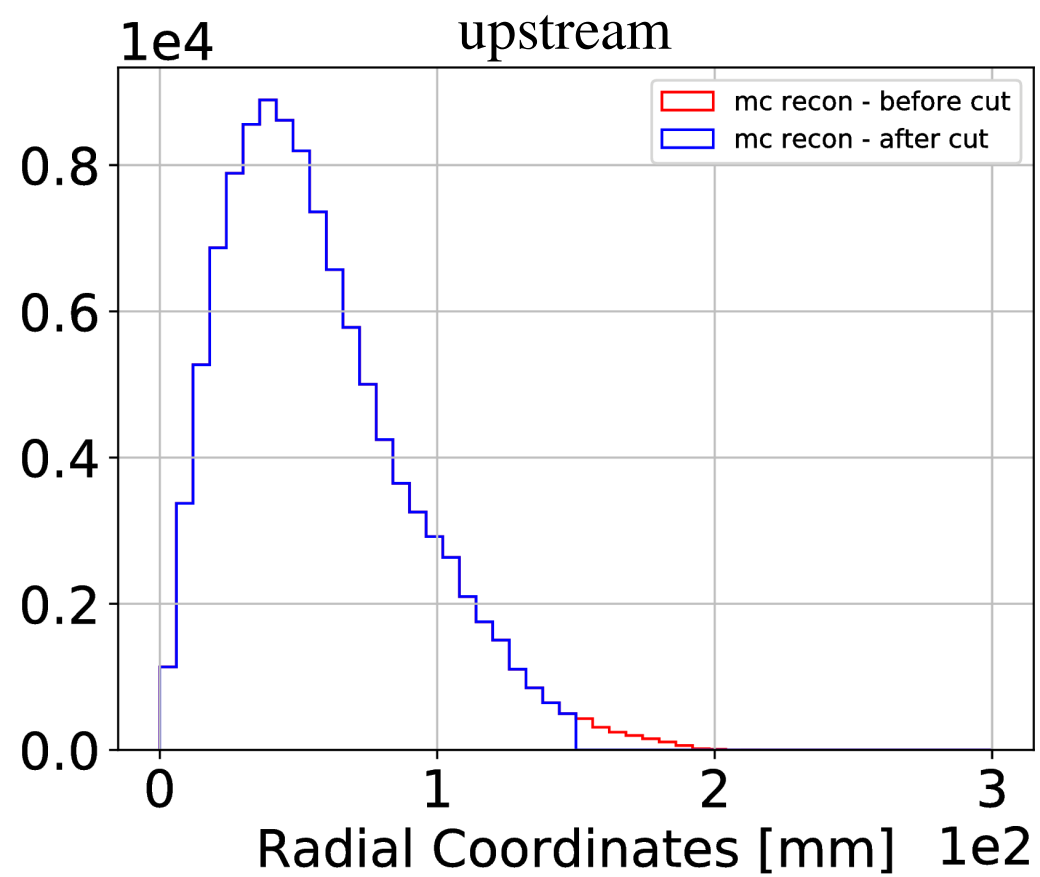
Data Type	Cut Variable	Sample Size Before Cut	Sample Size After Cut
MC Recon	ToF0 SP	1,135,500	1,105,890
	ToF1 SP	1,105,890	1,073,095
	ToF	1,073,094	715,174
	Single Track, TKU	403,639	403,259
	P, TKU	403,259	225,886
	Single Track, TKD	311,534	311,119
	P, TKD	311,119	198,697
MC	PID	8,431,890	5,974,561
	Fiducial Area	5,974,561	5,754,757
	Recon, TKU reference plane	108,670	46,817

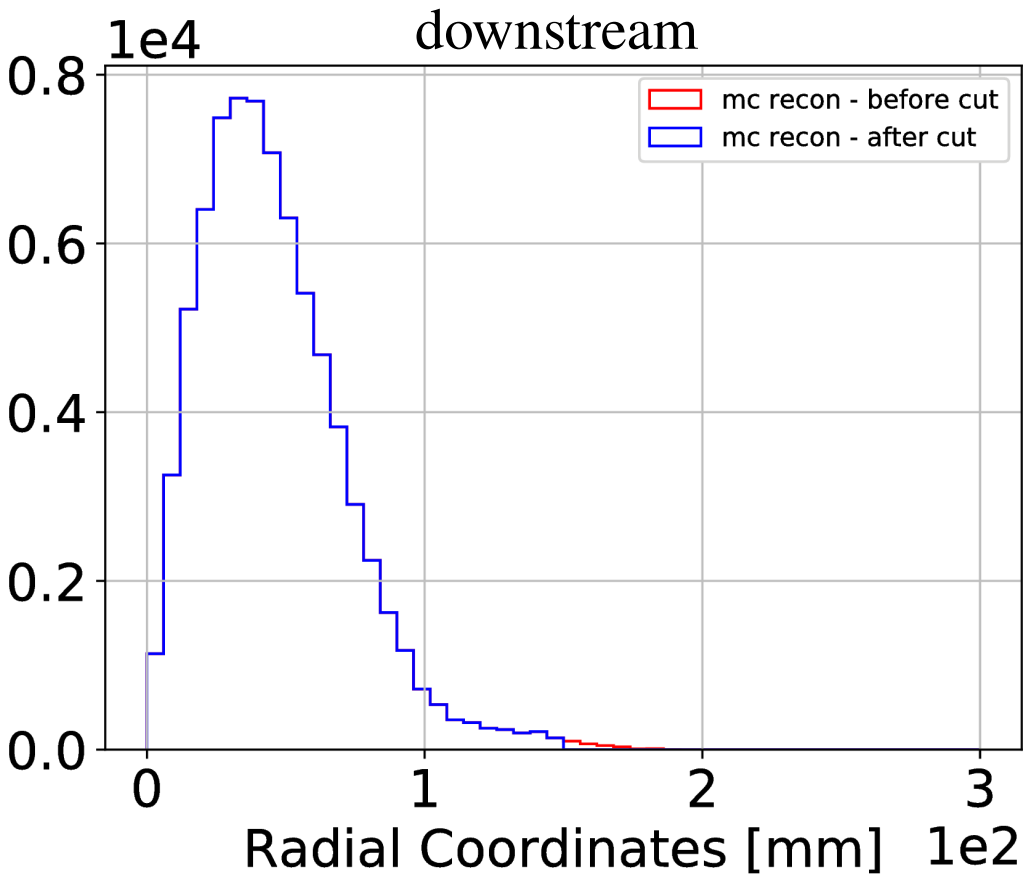
Cut Specifications

Data Type	Cut Variable	Sample Size Before Cut	Sample Size After Cut
Data	ToF0 SP	2,518,964	1,659,729
	ToF1 SP	1,659,729	1,615,614
	ToF	1,615,614	970,379
	Single Track, TKU	526,664	523,489
	P, TKU	523,489	356,778
	Single Track, TKD	443,714	441,359
	P, TKD	441,359	258,106

Cut Variable Plots – MC

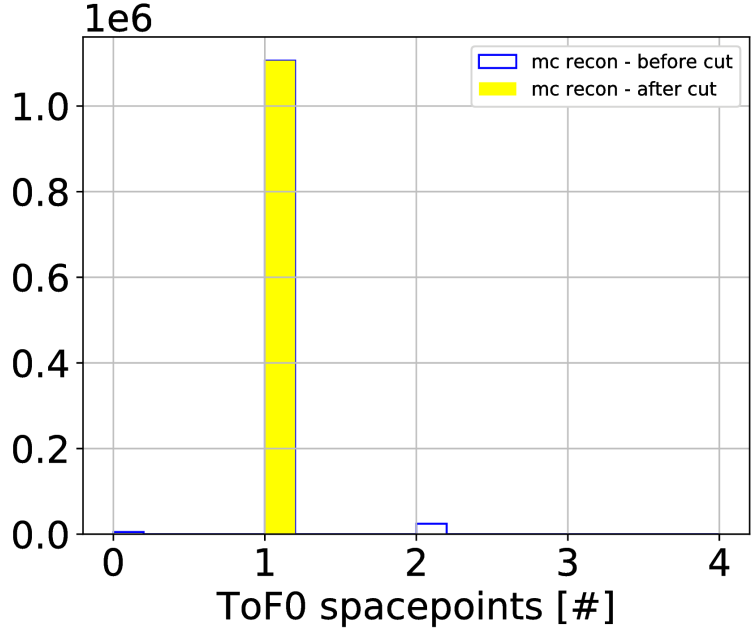
- **MC cut variable**: upstream, downstream fiducial area before and after fiducial cut



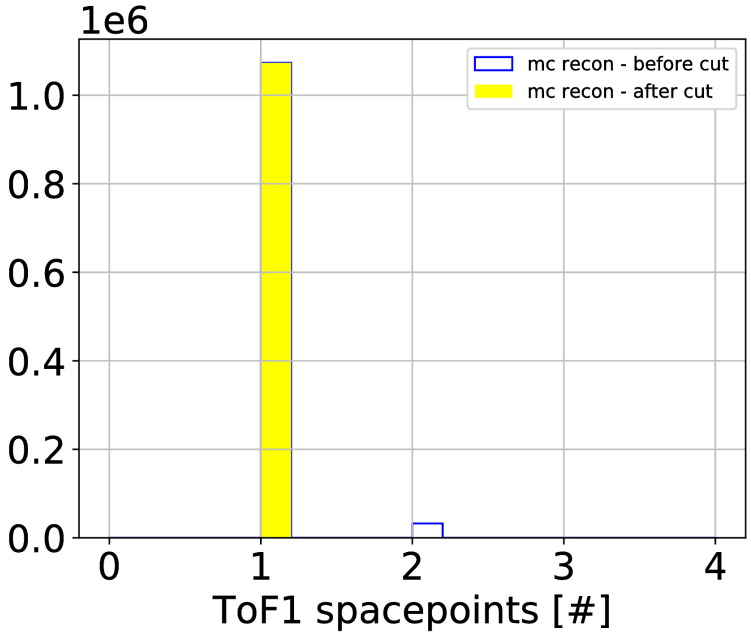


Cut Variable Plots – MC Recon

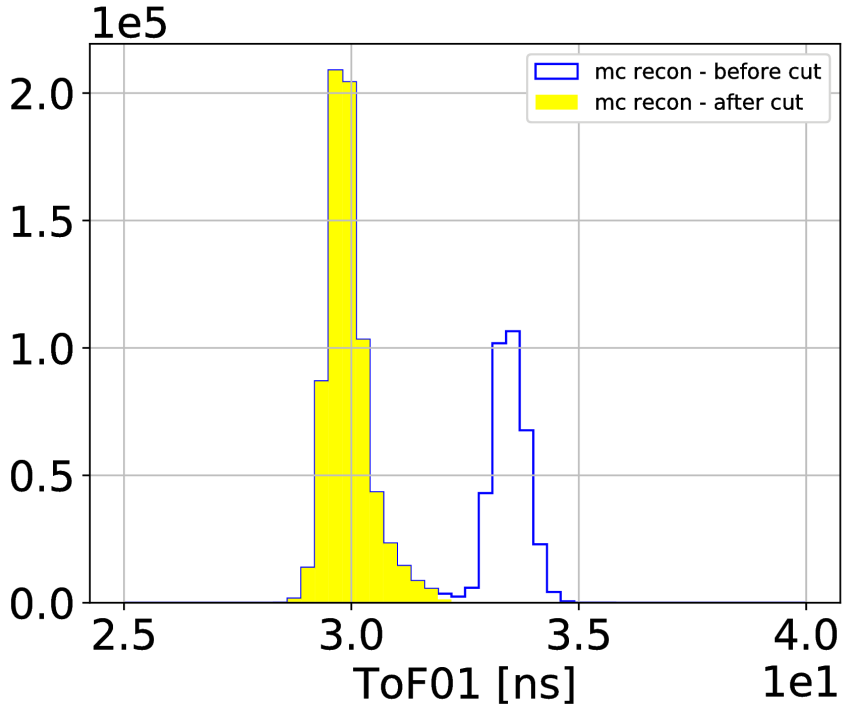
- **MC Recon ToF cut variables:**



- ToF0,1 spacepoint distributions before and after cut

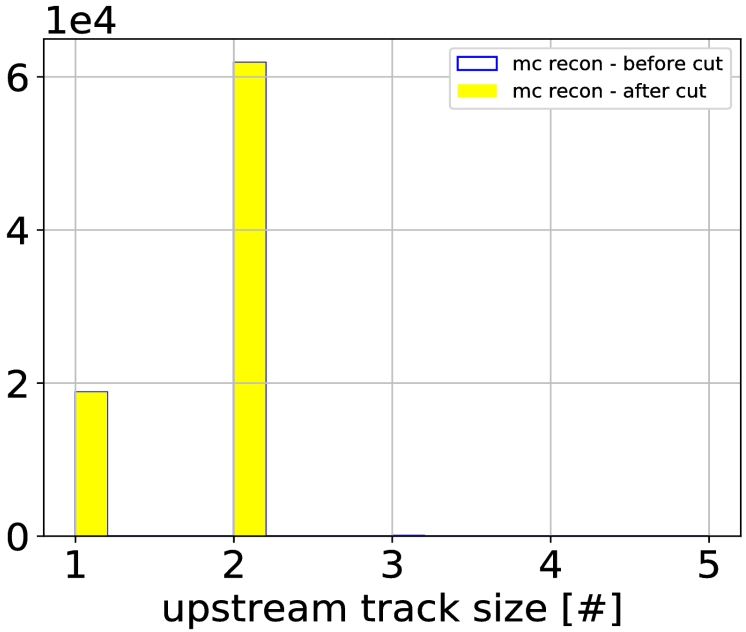


- Time distribution between ToF0 and ToF1 before and after cut

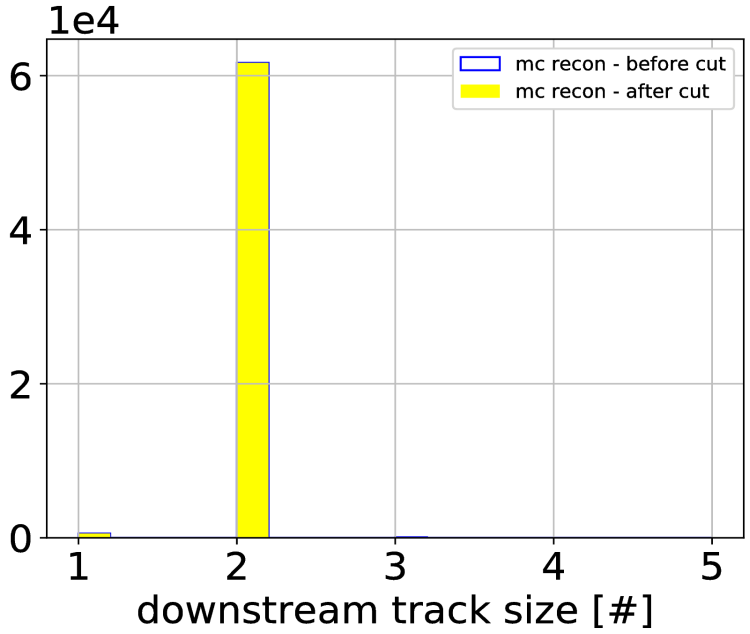


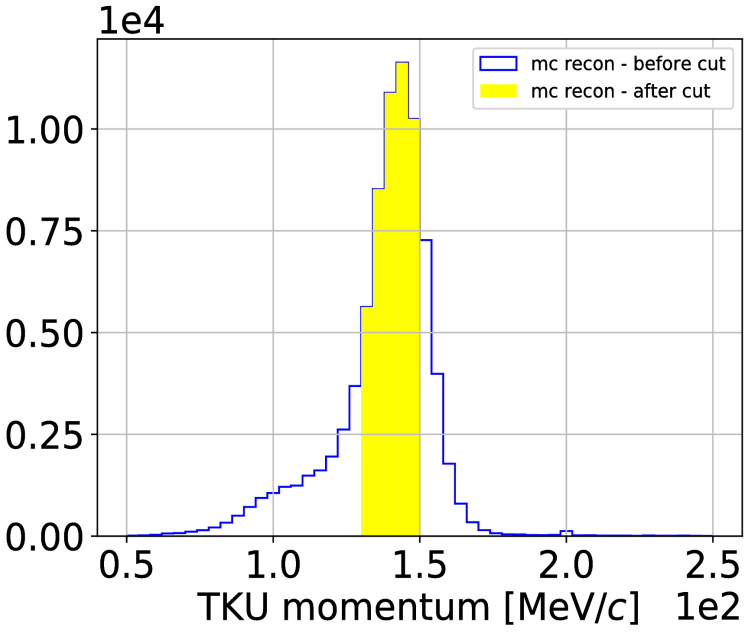
Cut Variable Plots – MC Recon

- **MC Recon tracker cut variables:**

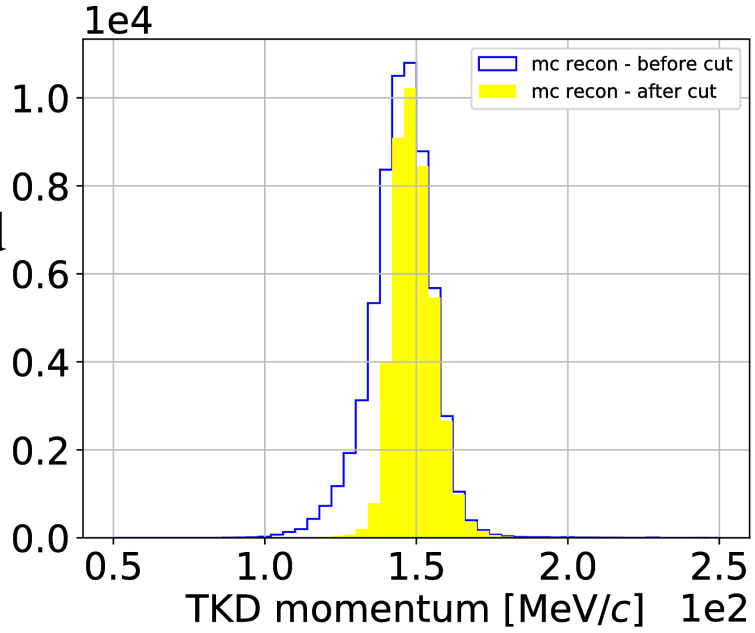


★ TKU and TKD tracker track distributions



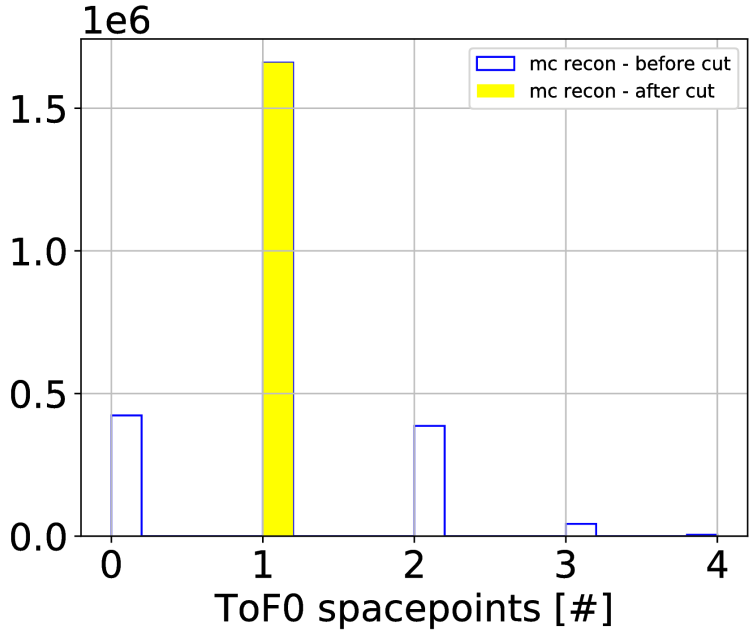


★ TKU and TKD reconstructed momentum before and after cut

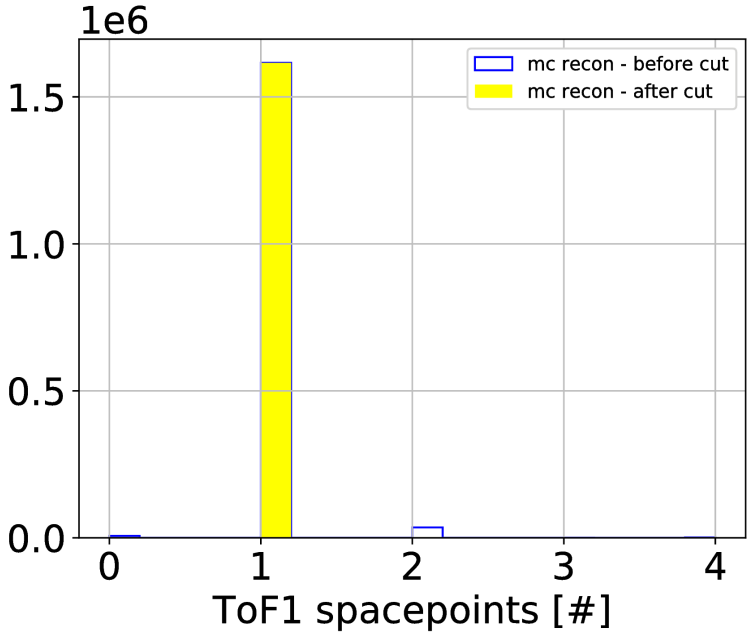


Cut Variable Plots – Data

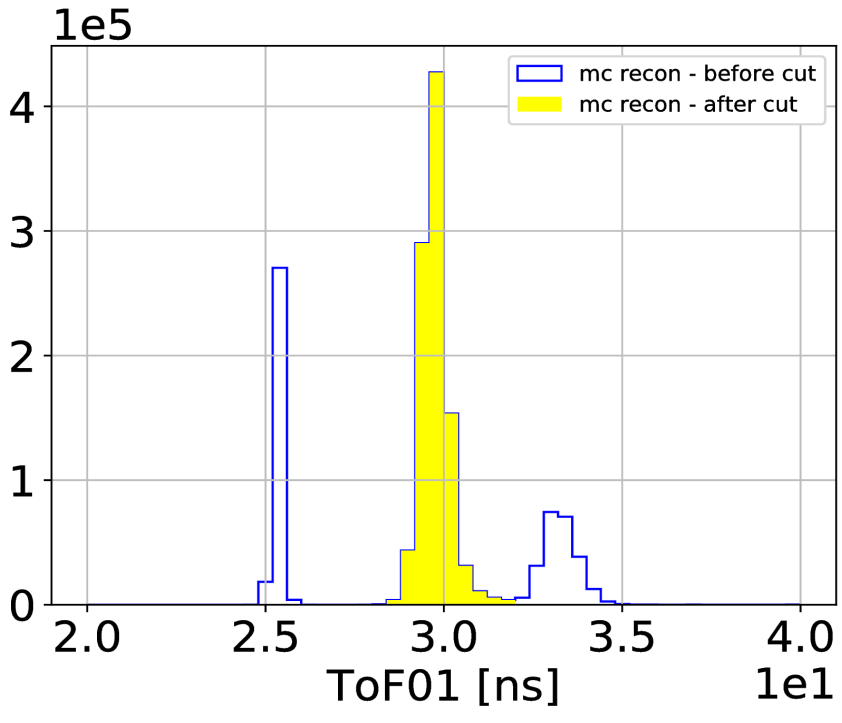
- **Data cut variables**:



- ToF0,1 spacepoint distributions before and after cut

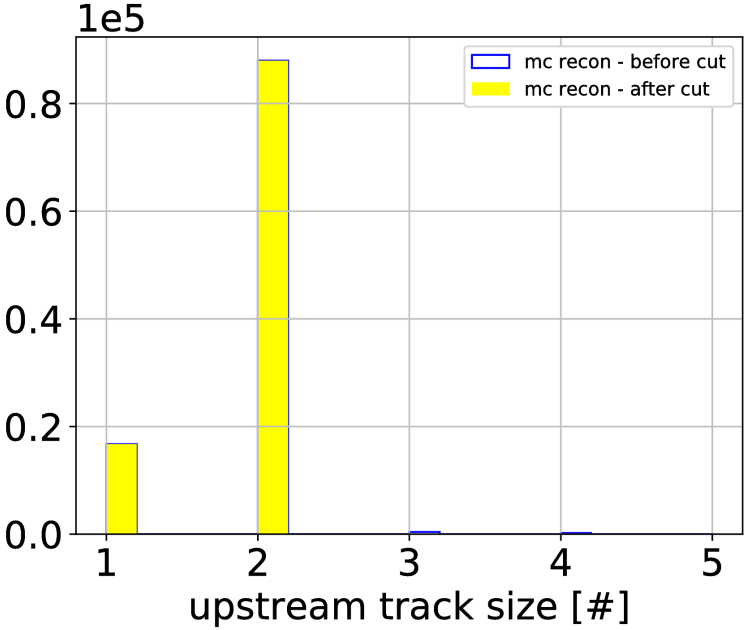


- Time distribution between ToF0 and ToF1 before and after cut

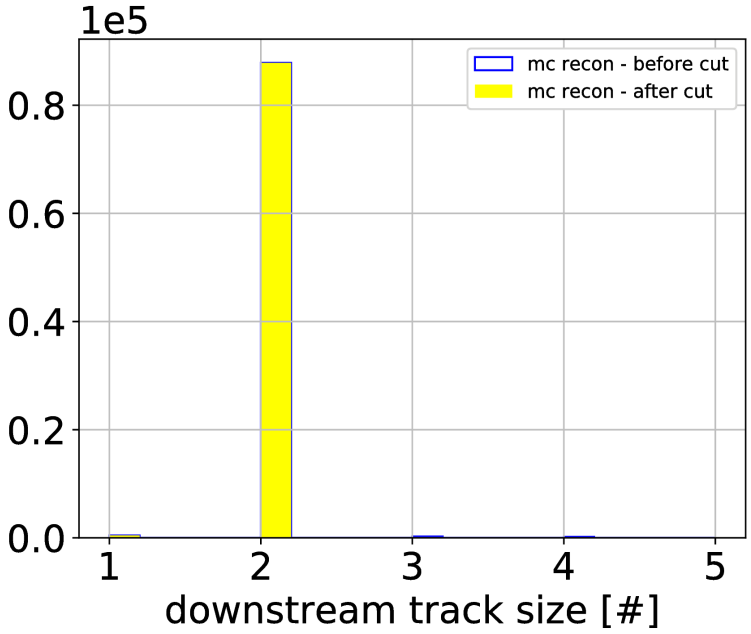


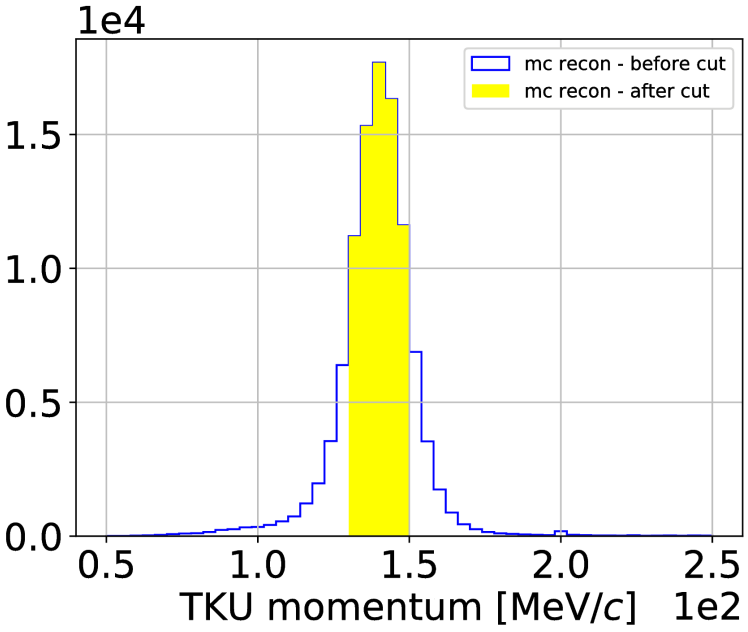
Cut Variable Plots – Data

- **Data cut variables**:

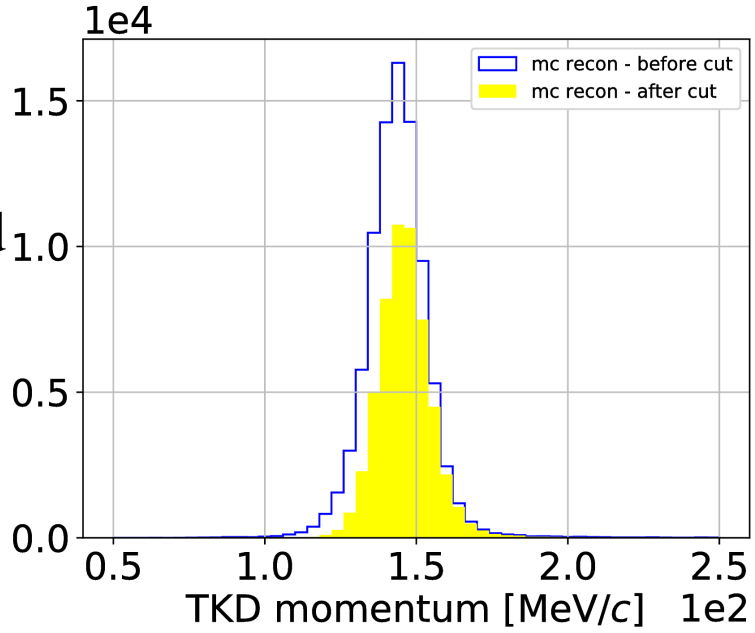


★ TKU and TKD tracker track distributions



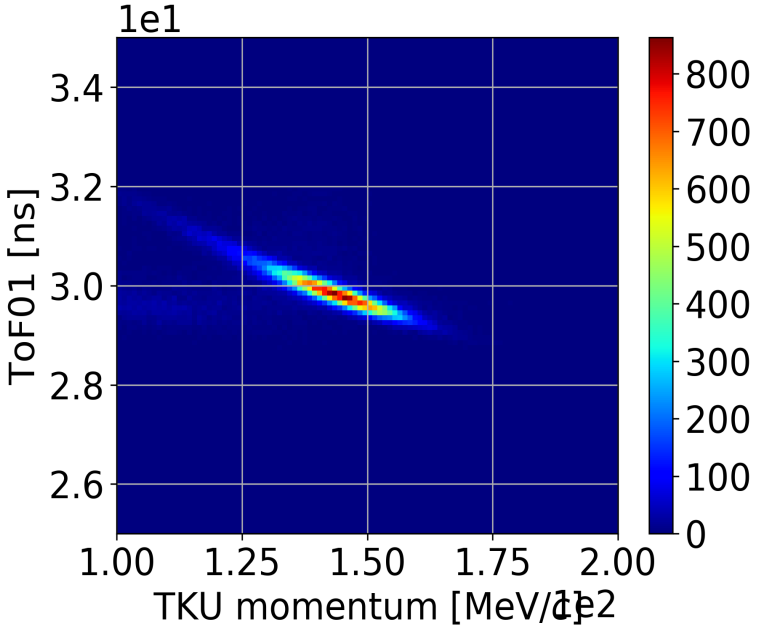


★ TKU and TKD reconstructed momentum before and after cut

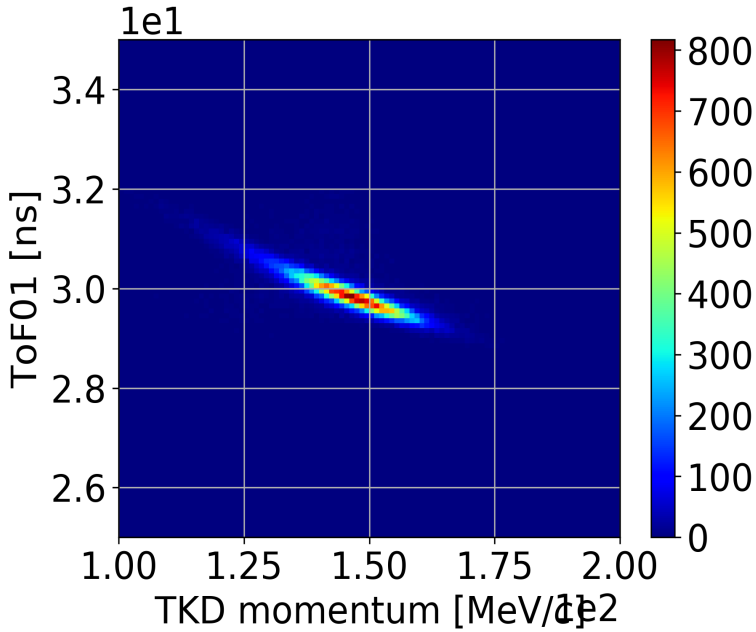


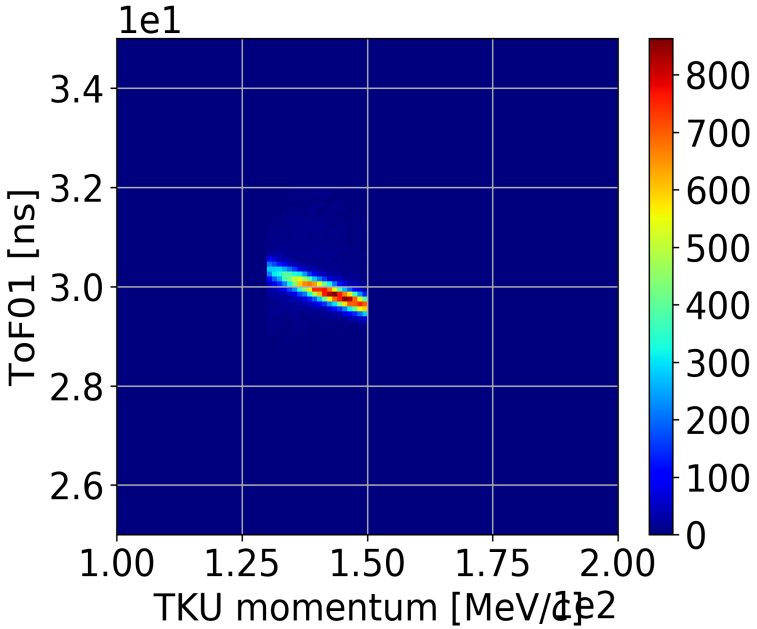
Cut Variable Plots – MC Recon

- **MC Recon tracker cut variables:**

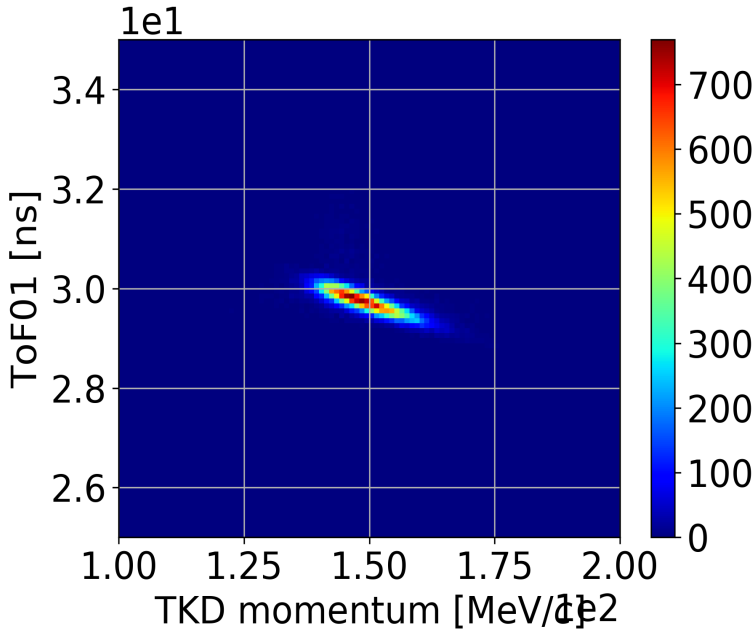


★ ToF versus TKU and TKD momenta, **before cut**



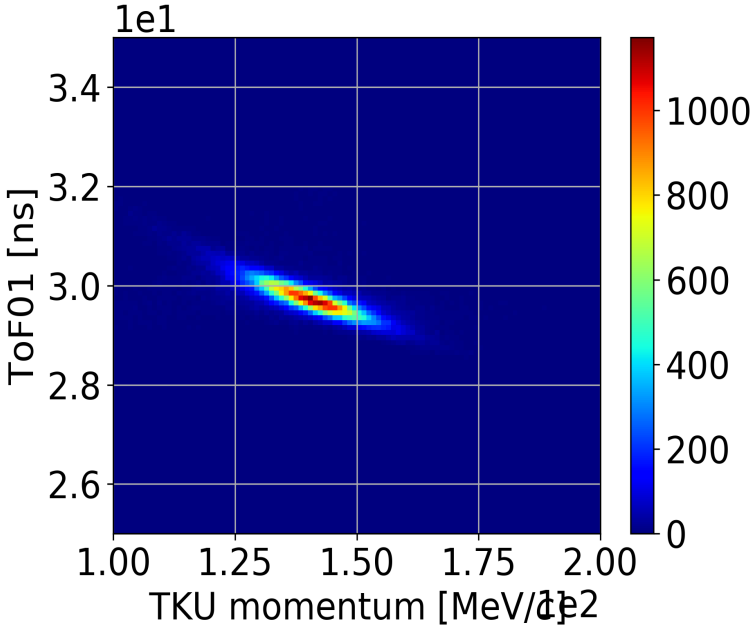


★ ToF versus TKU and TKD momenta, **after cut**

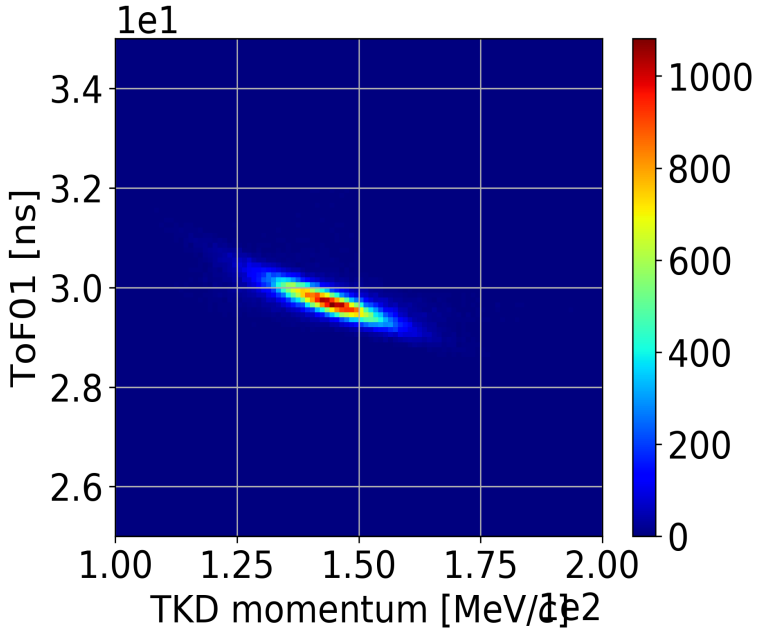


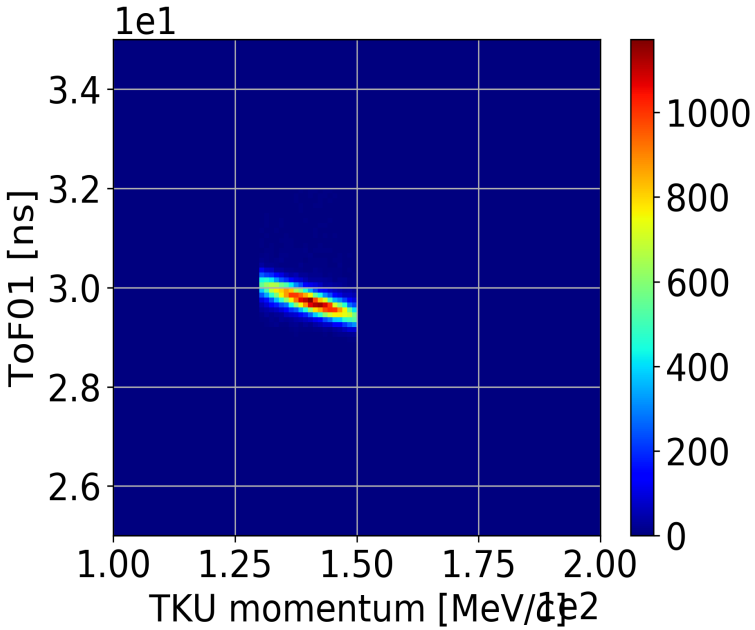
Cut Variable Plots – Data

- **Data cut variables**:

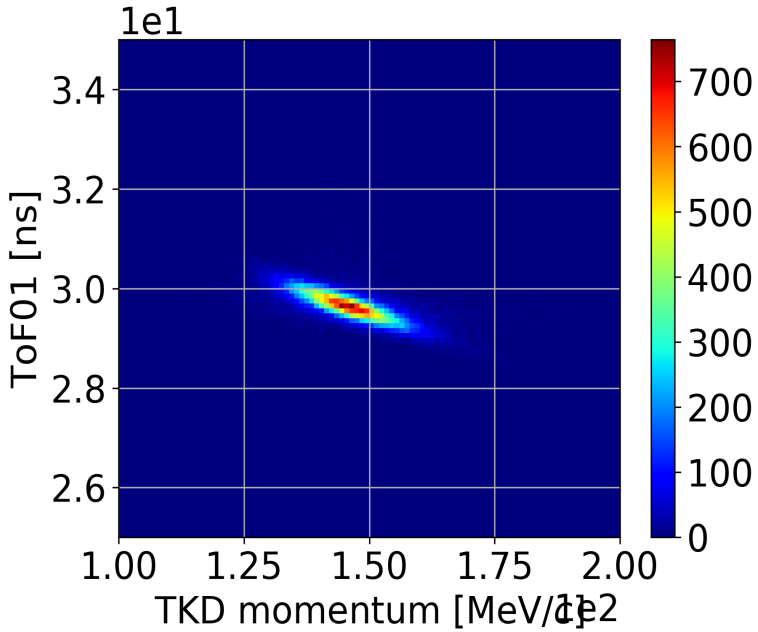


★ ToF versus TKU and TKD momenta, **before cut**



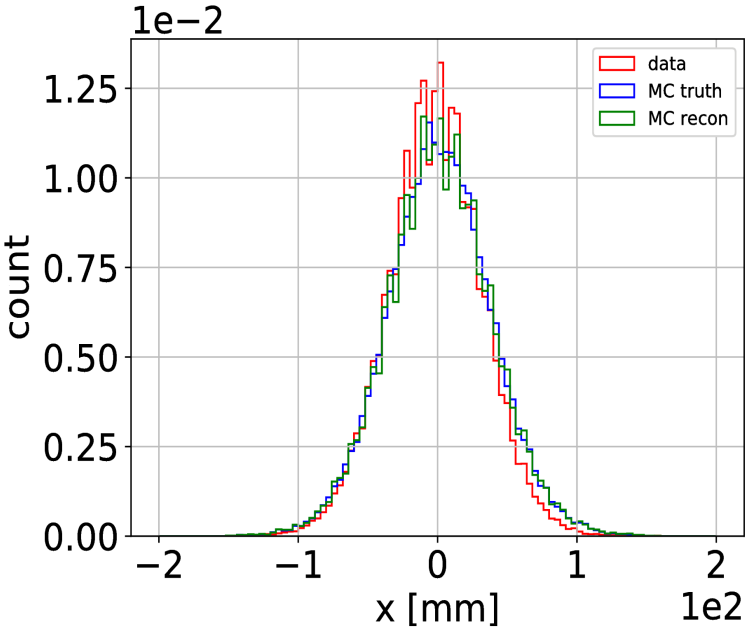


★ ToF versus TKU and TKD momenta, **after cut**

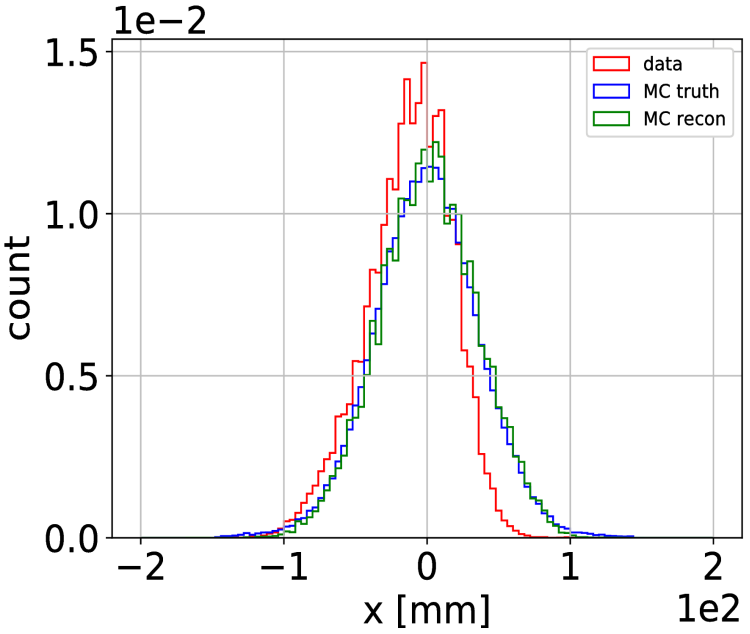


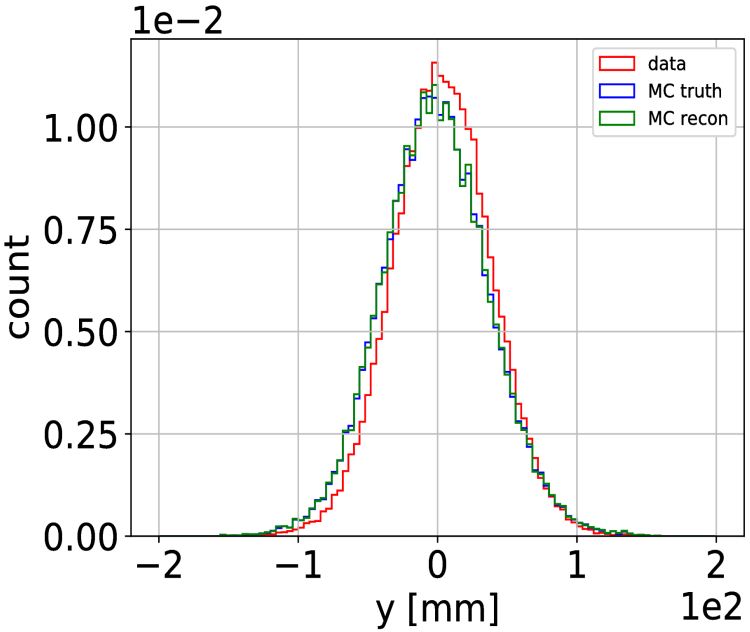
Phase-space Plots

- **Position phase spaces**:

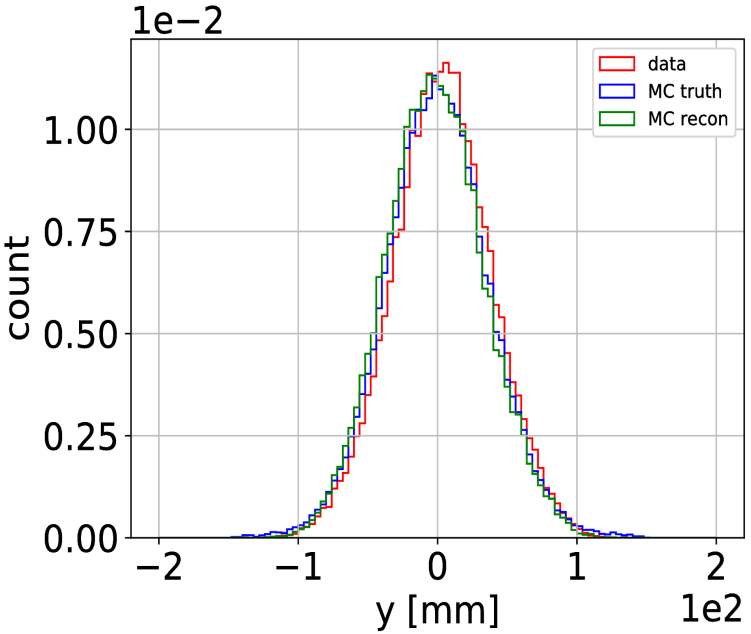


★ **x** from **TKU (left)** to **TKD (right)** reference planes



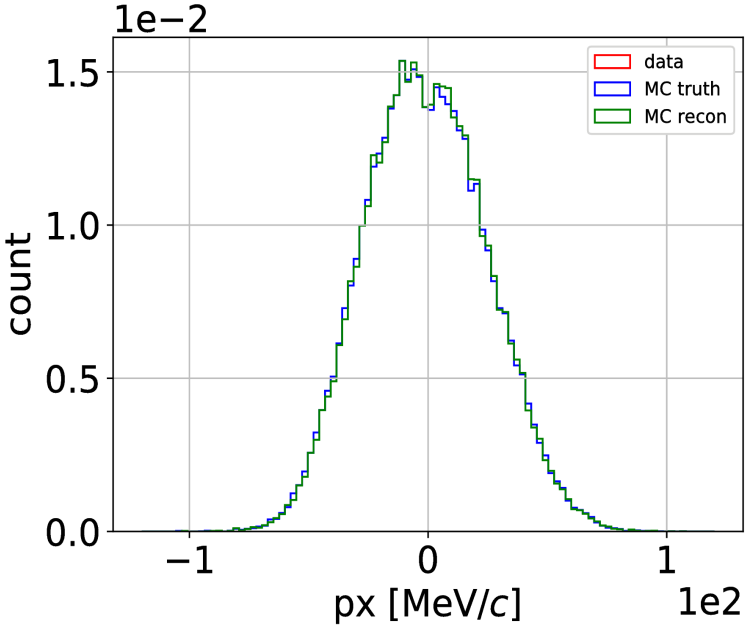


★ **y** from **TKU (left)** to **TKD (right)** reference planes

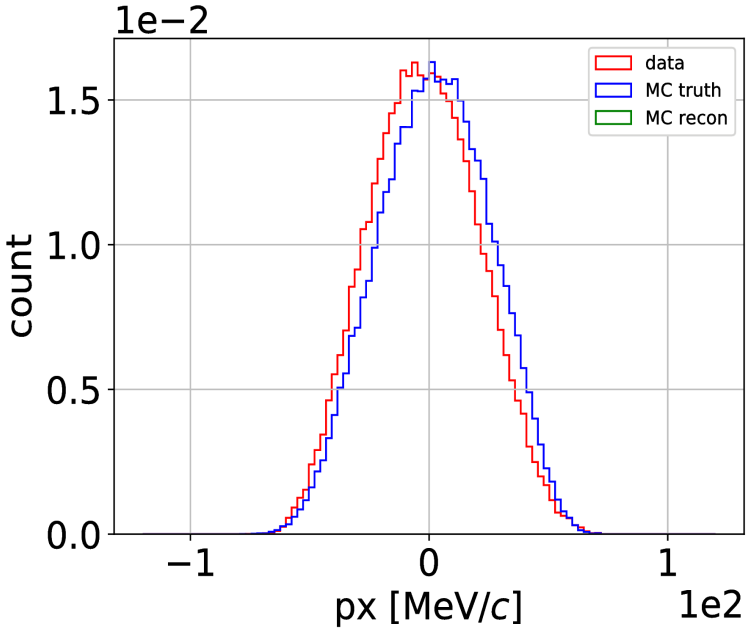


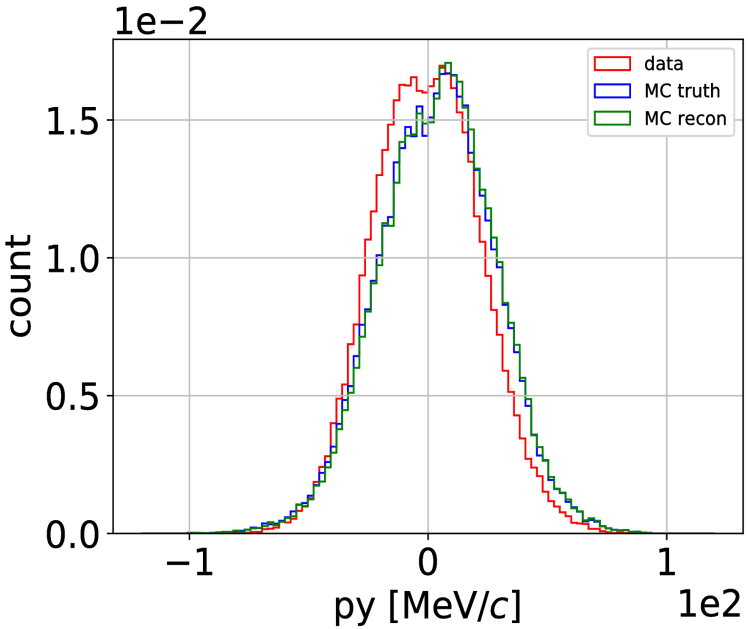
Phase-space Plots

- **Momentum phase spaces:**

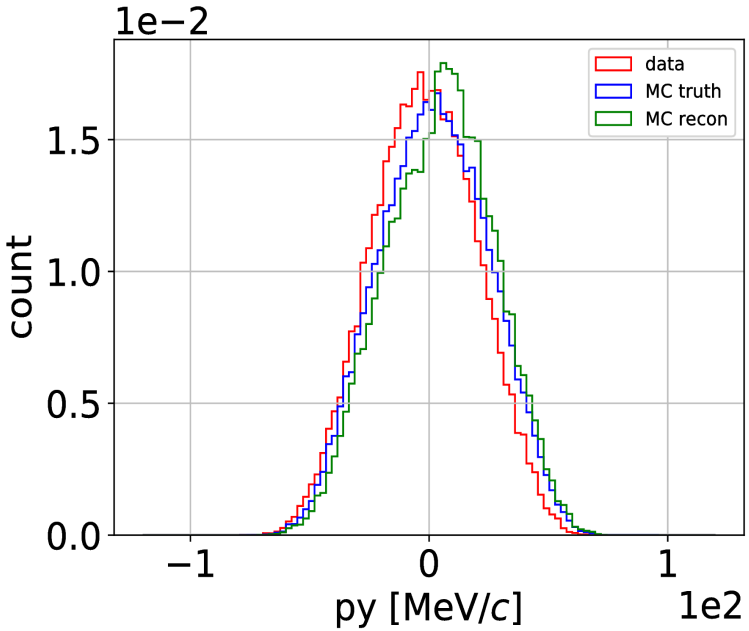


★ **px** from **TKU (left)** to **TKD (right)** reference planes



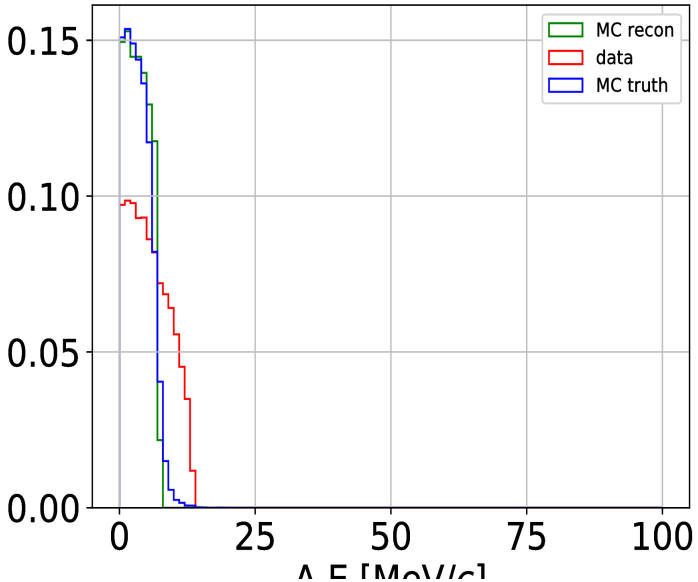


★ **py** from **TKU (left)** to **TKD (right)** reference planes

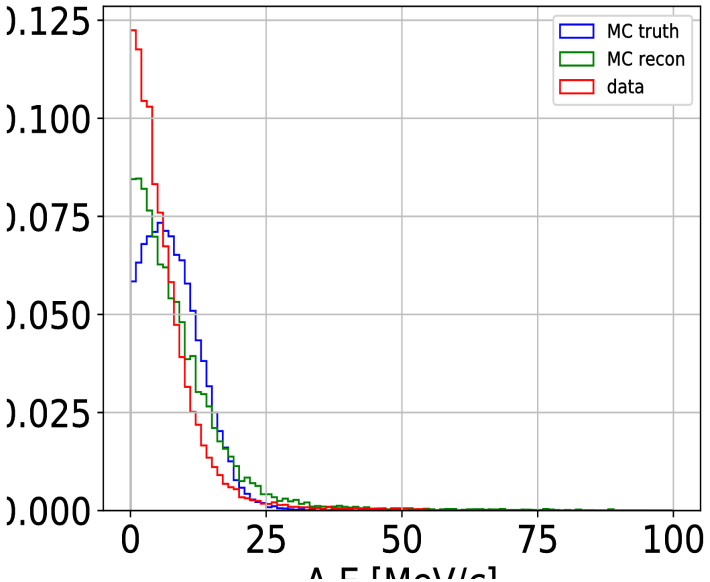


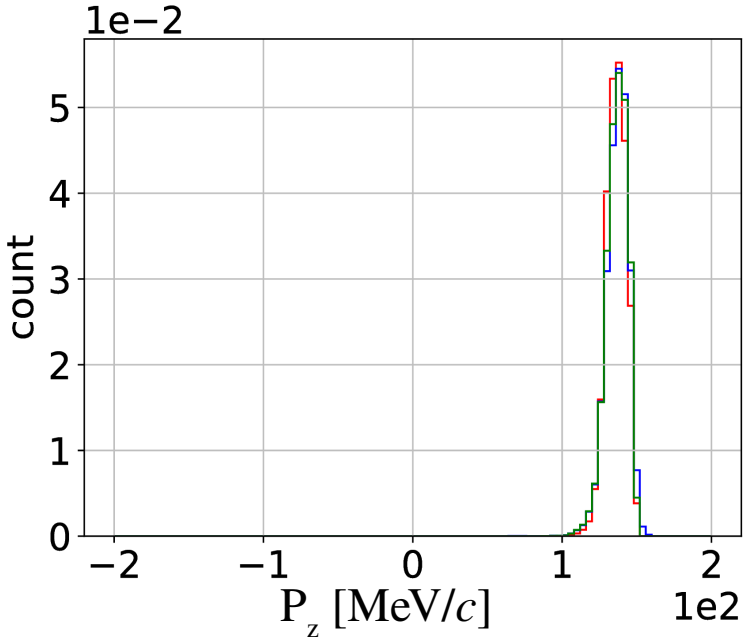
Phase-space Plots

- **Energy Coordinate**:

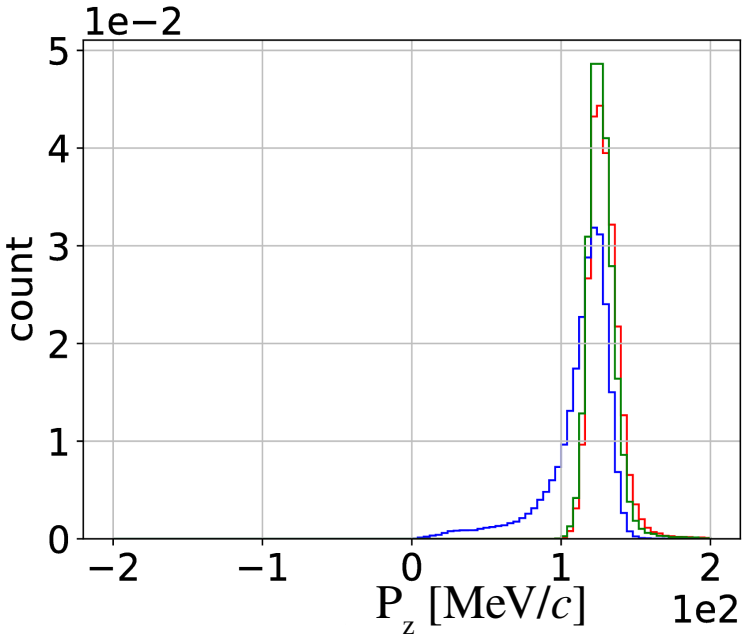


★ **ΔE** from **TKU (left)** to **TKD (right)** reference planes



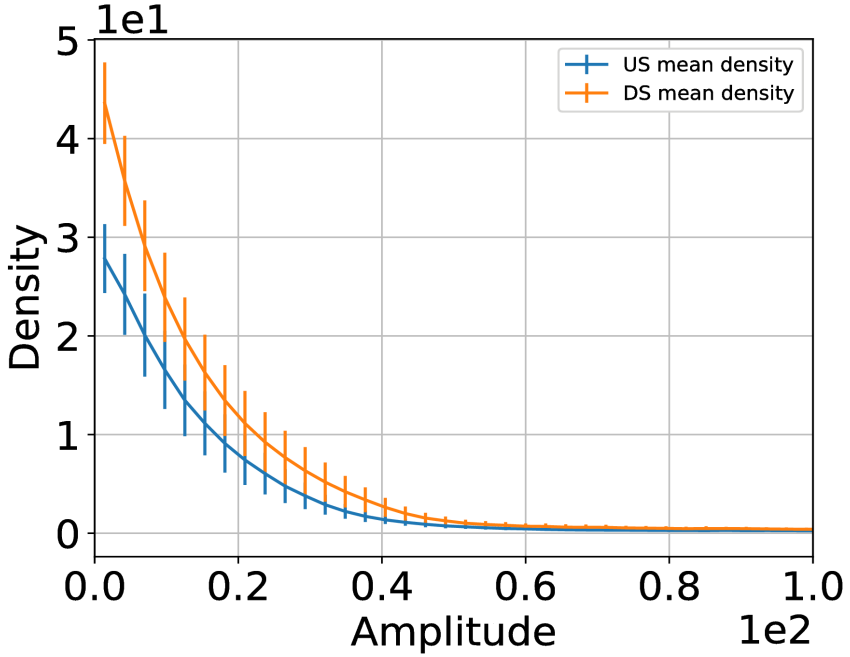


★ **pz** from **TKU (left)** to **TKD (right)** reference planes

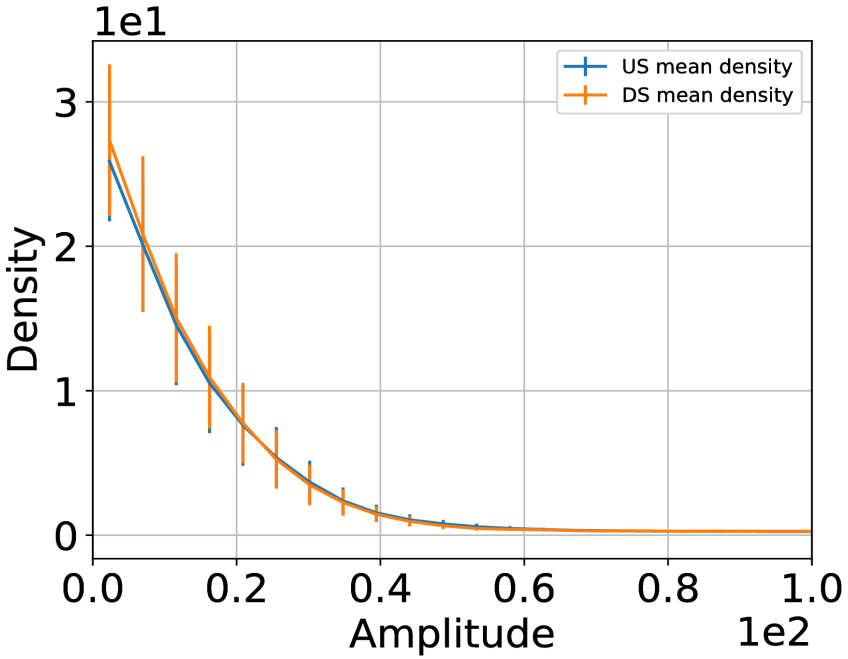


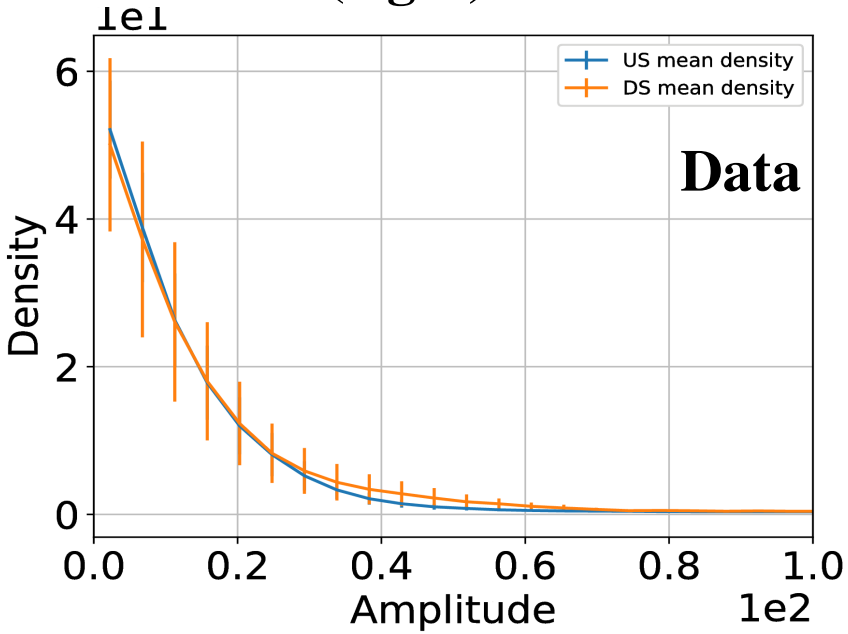
KDE Density vs Volume – Transverse

- Density versus the amplitude enclosed



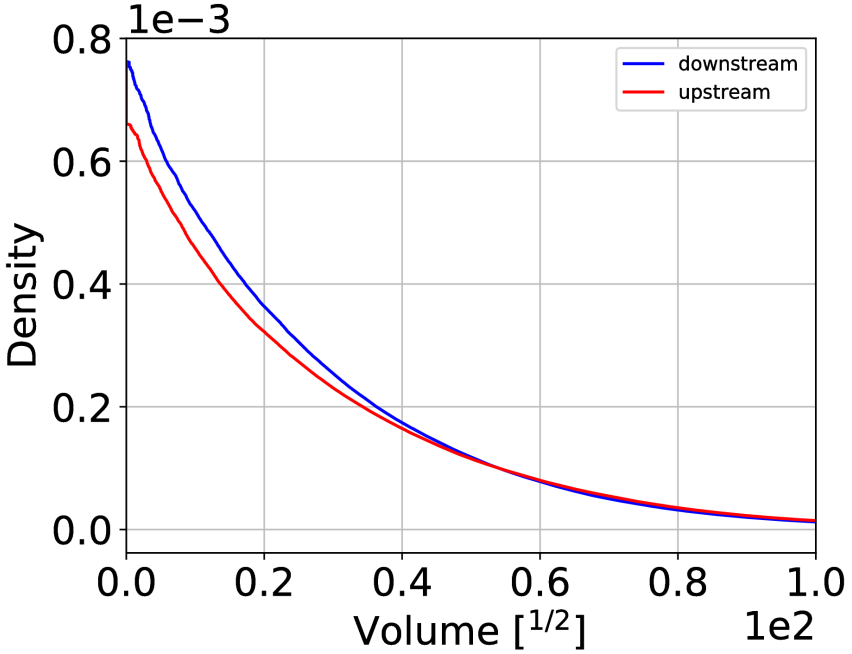
★ Similar trends in upstream distributions in **MC (left)** and **MC recon (right)**



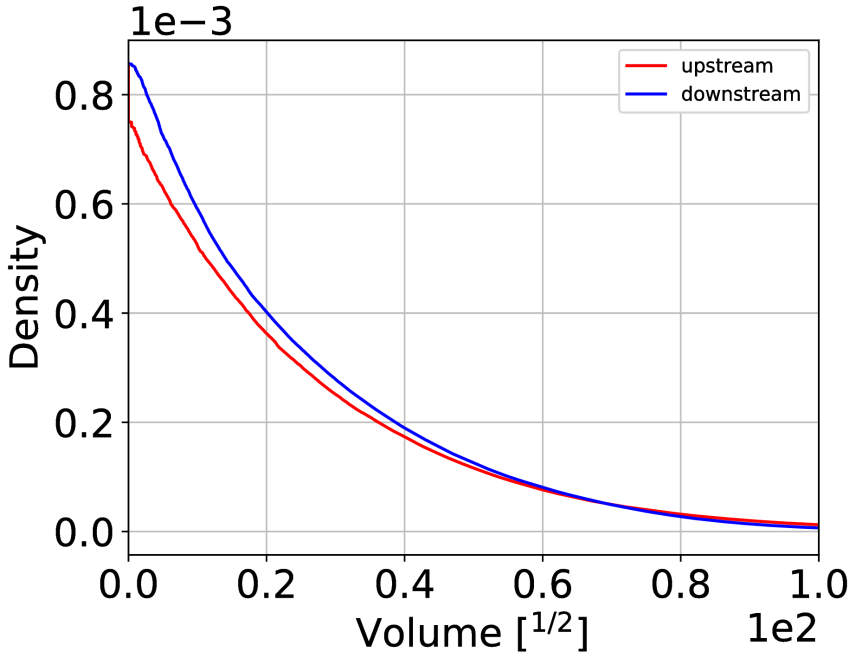


KDE Density vs Volume – Transverse

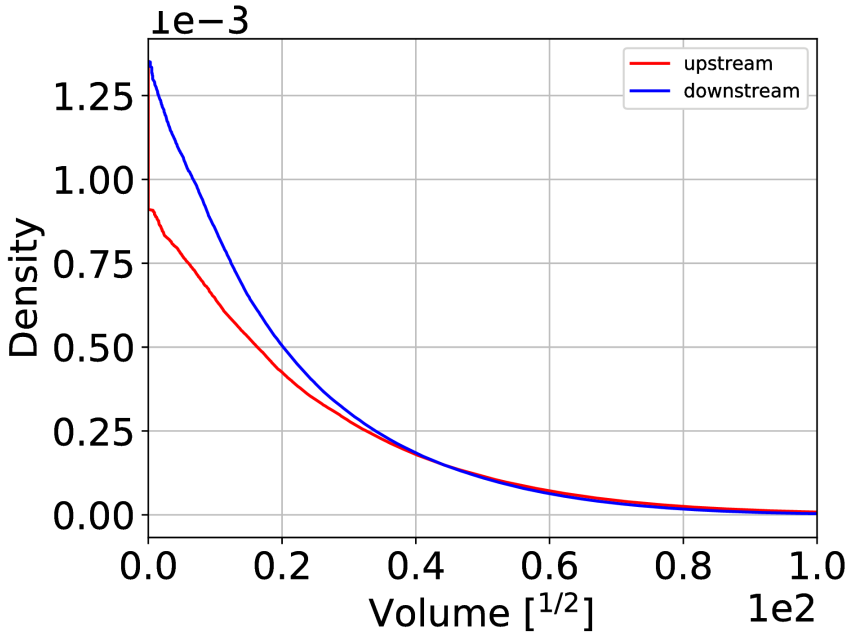
- Density of the contour versus the contour volume enclosed



★ Similar trends in **MC (left)** and **MC recon (right)**



★ Data displays larger cooling effects



Conclusions

- Preliminary reverse emittance exchange observed; further studies underway to verify it.
- Improvements:
  - Compare with empty absorber channel
  - Cut high amplitude particles (similar to evolution plots)
  - Obtain time distribution using global reconstruction for longitudinal studies
  - Add statistical and systematic uncertainties
  - Understand lack of electrons in the simulated ToF distribution