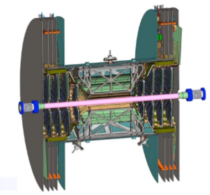
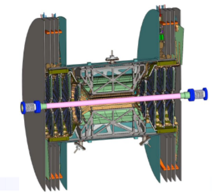


FVTX Simulation and Analysis Software

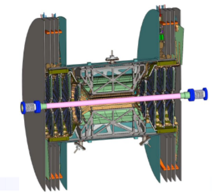
Zhengyun You
Los Alamos National Laboratory
Nov-17-2010



Outline

- Physics Motivation;
- Detector Performance;
- Charm / Beauty Separation (Blind Analysis);
- Verify DCA Distribution with Real Data;
- Di-muon Measurements Improvement;
- Summary and Future Work;

Physics Motivation



Measurement in p + p, d + Au and Au + Au Collisions

Single Muons measurements:

- Precision heavy flavor and hadron measurements.
- Separation of c and b in semi-leptonic decays via decay kinematics.
- Improve W background rejection.

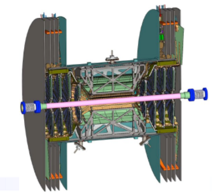
Dimuons measurements:

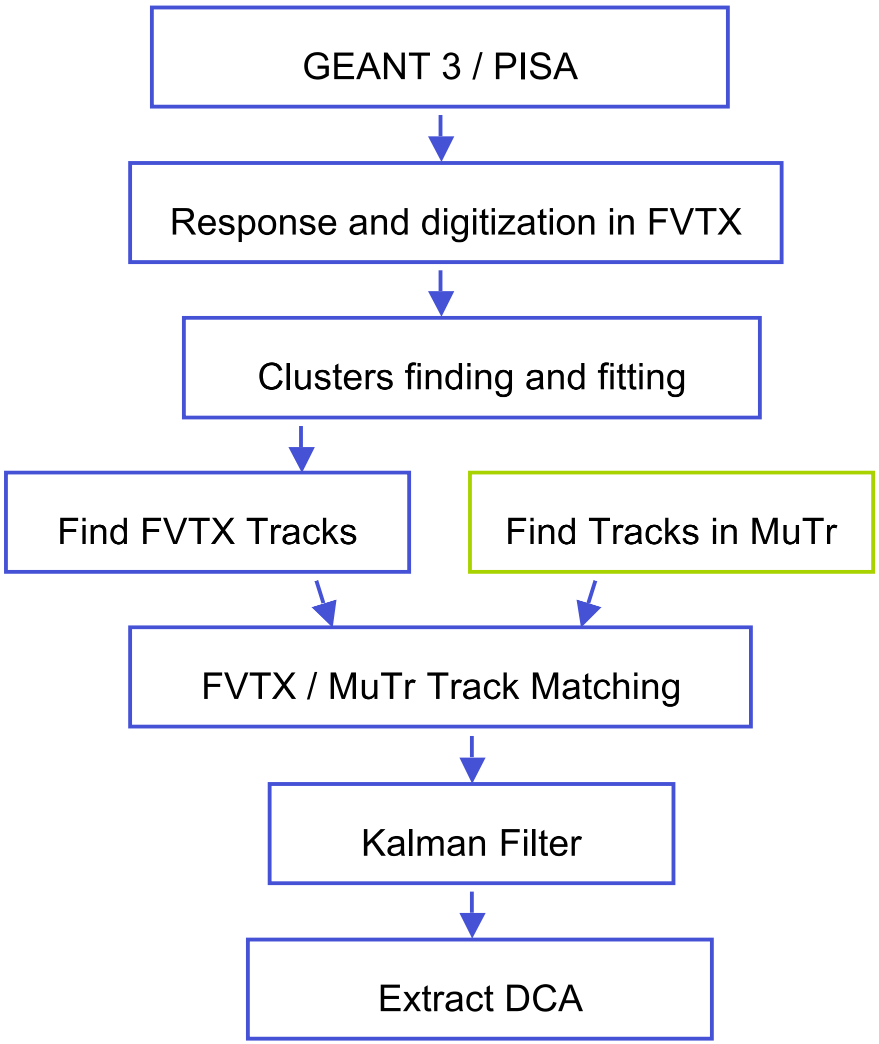
- Separation of ψ' from J/ψ at forward rapidity.
- B$\rightarrow$J/ψ, golden channel to measure B cross section.
- First Drell-Yan measurement at RHIC.

Physics FVTX Can Access:

- Energy loss mechanism in hot dense medium (Heavy flavor $R_{AA,}$ v_2)
- Cold nuclear effects (Heavy flavor R_{dAu})
- Gluon polarization $\Delta G/G$ (Heavy flavor A_{LL})
- Sivers function, higher twist (Heavy flavor A_N)
- Crucial test of QCD universality (Drell-Yan A_N)

FVTX Software Status

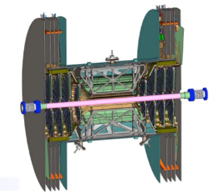




Current status

- ✓ In GEANT3, Geometry **re-organized** with real detector structure and allow **alignment** corrections;
- ✓ Geometry in root framework of offline code is changing with GEANT3 correspondingly;
- ✓ Detector response includes noise and digitization;
- ✓ Cluster finding and Fitting
- ✓ Track finding and fitting

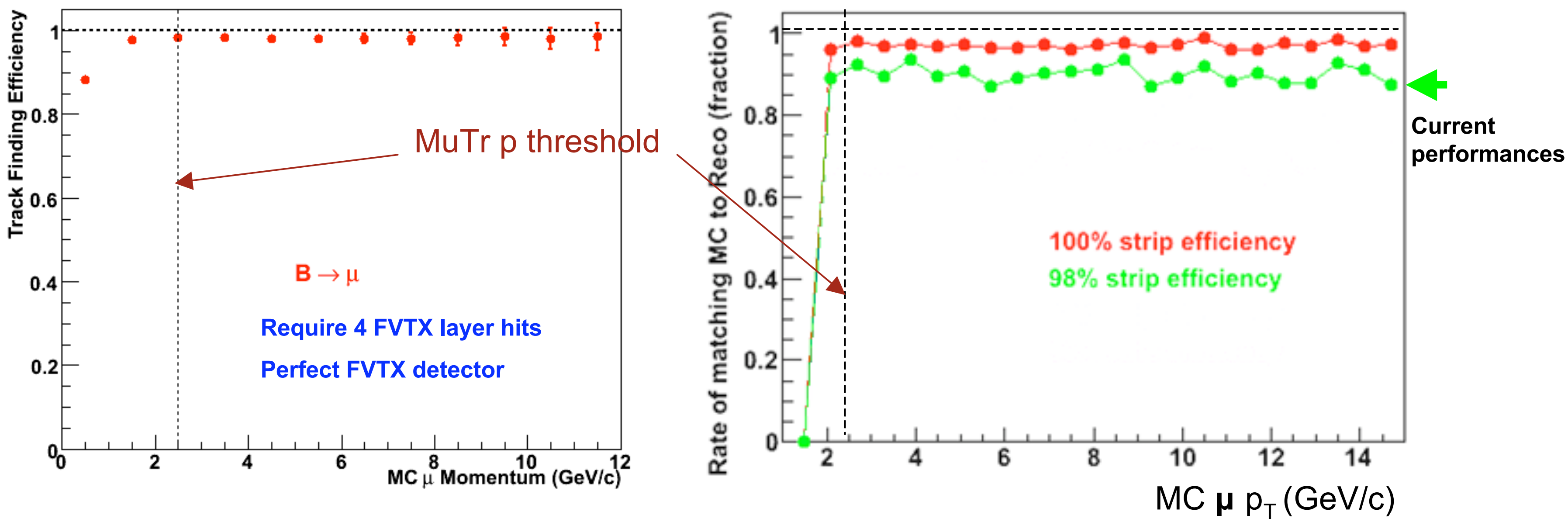
FVTX Track Finding Efficiency



$$\varepsilon_{TrackFinding} = \frac{N_{\mathrm{Re}co}}{N_{\mathrm{Re}constructible}}$$

μ from B decay (PYTHIA).

Single μ embedded in MB HIJING



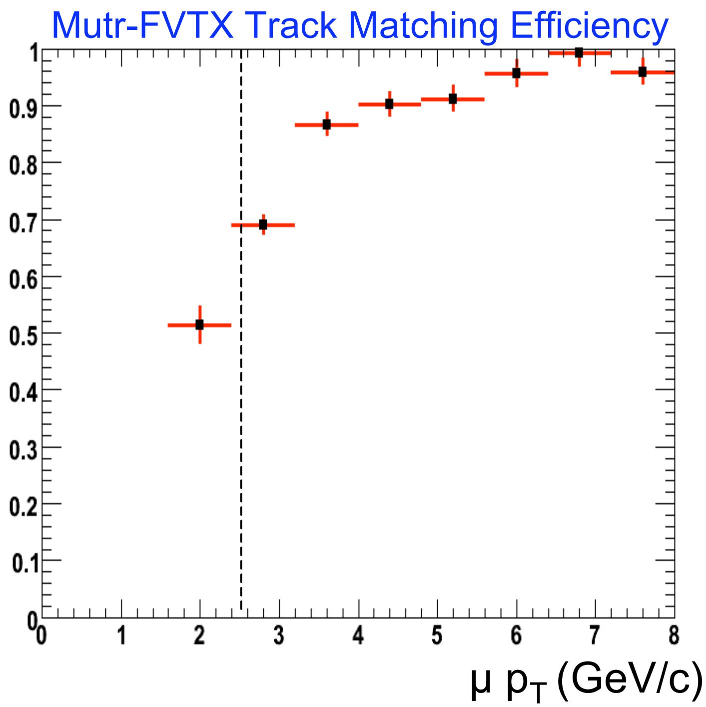
No underlying event

Full multiplicity in MB Au + Au

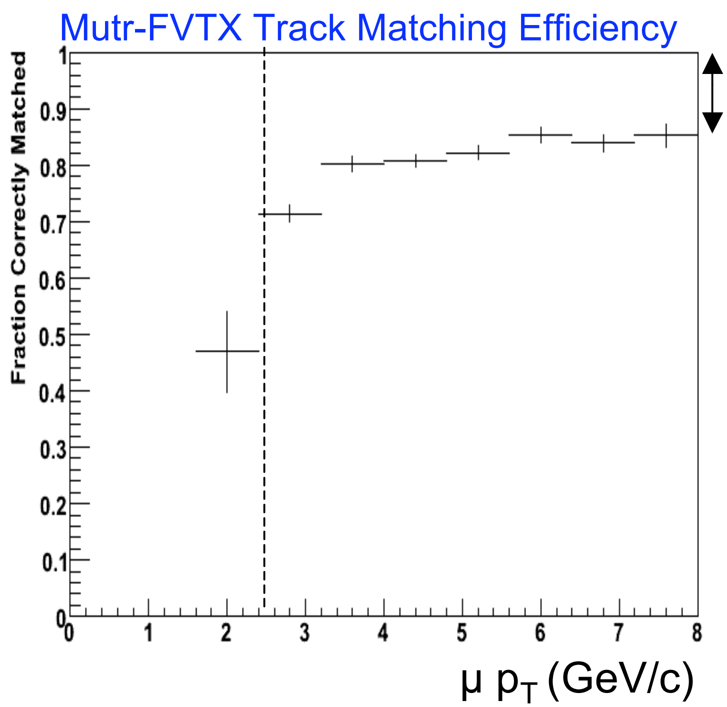
FVTX Track Matching Efficiency

$$\varepsilon_{Matching} = \frac{N_{FVTX+MuTr\_matched}}{N_{reco\_MuTr\&\&reco\_FVTX}}$$

p + p event



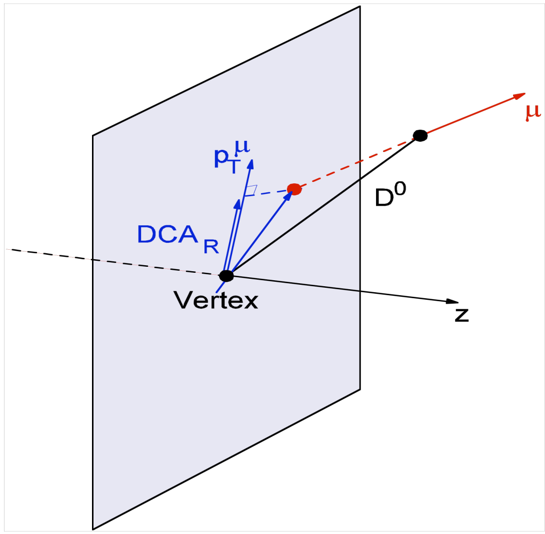
Central Au + Au event

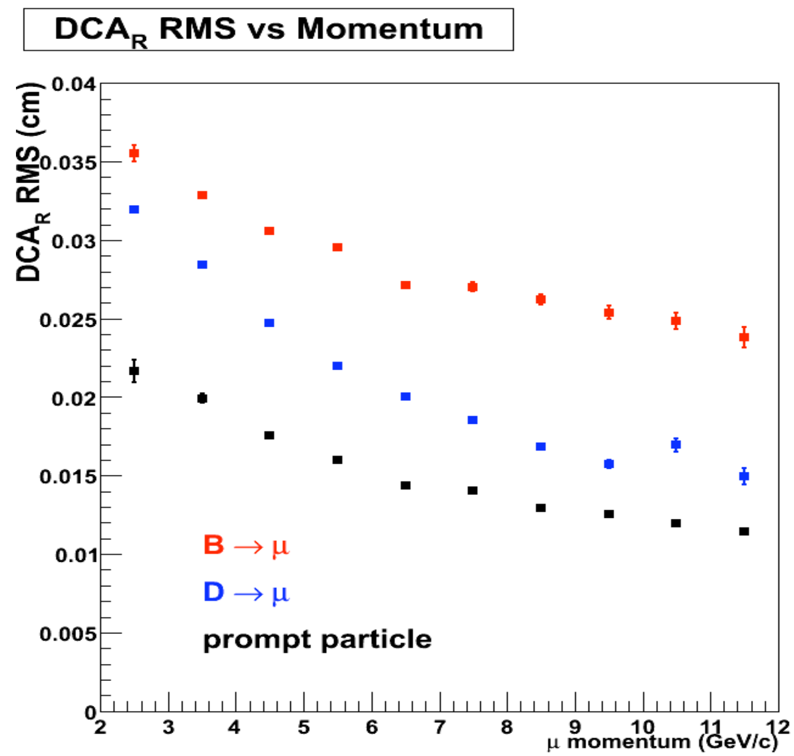


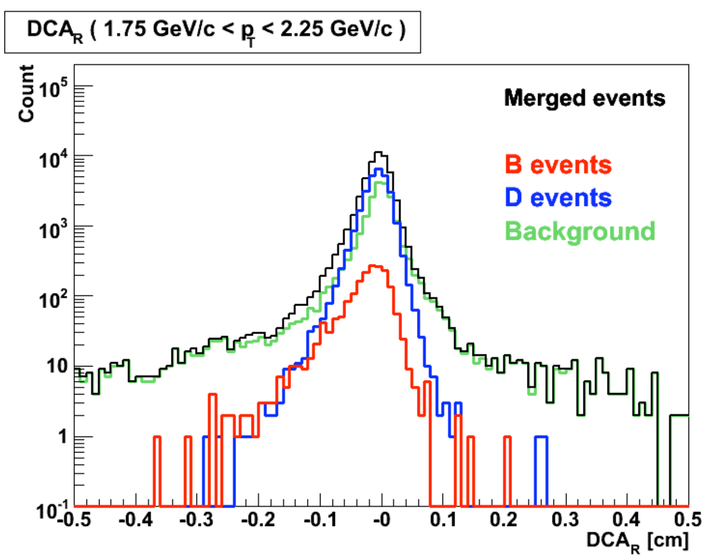
About 15% efficiency lose due to incorrect tracking matching in high multiplicity environment.

DCA_R

DCA_R = impact parameter projected onto μ p_T.

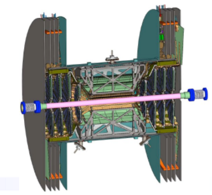






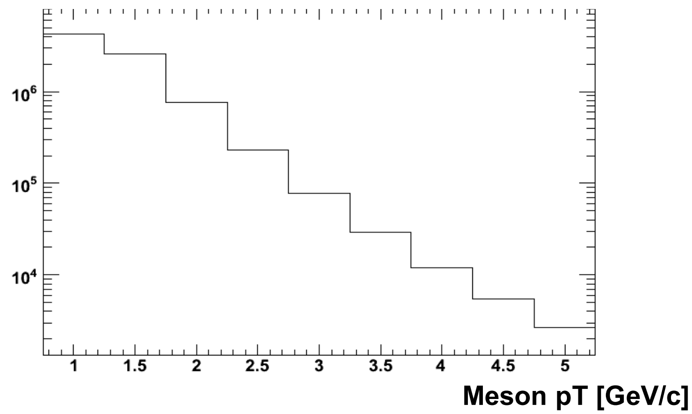
μ decay from D, B and hadrons have different DCA_R shapes in a given μ p_T bin

Charm / Beauty Separation



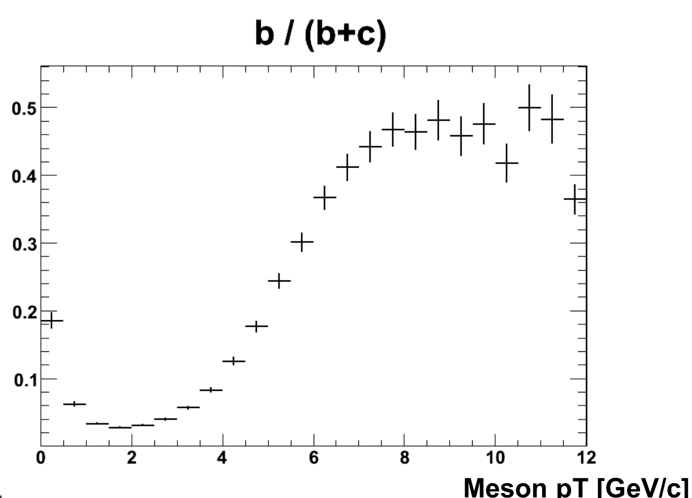
From

A blind (D+B+Background)
"Real Data" (PYTHIA) sample



…

Extract b ratio



Blind testing samples

Training sample (D, B, Bkgnd)

Pisa, Response, Reco …

DCA shape for fixed μp_T

μ_D DCA

μ_B DCA

Bkgnd DCA

Fit and extract

D/B/Bkgnd ratio for fixed μ p_T

Transform μ p_T to Meson p_T

D/B meson p_T spectra

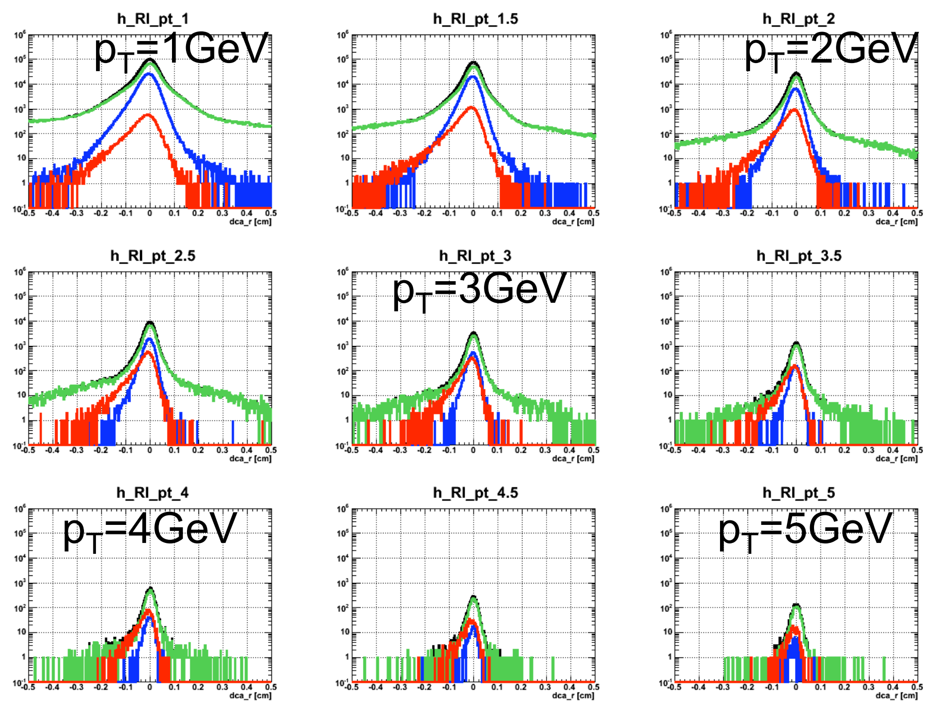
Statistics and DCA_R shape

Event Type	Testing Statistics N_{event} ($10pb^{-1}$)	Training Statistics
D Event (All D meson)	4.25 Billion	10 Billion
B Event (All B meson)	24 Million	100 Million
BG Event	240 Billion	500 Billion

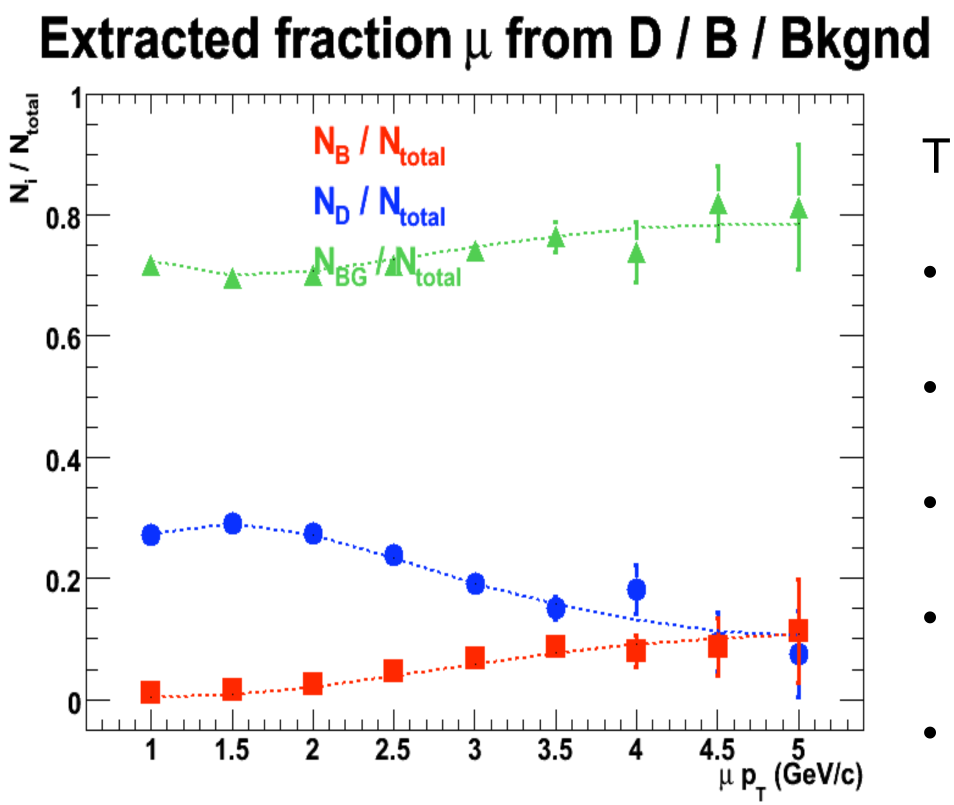
Mixed using ratios consistent with the cross sections measured by PHENIX.

DCA_R shape for different μ p_T

D, B, Background, Merged



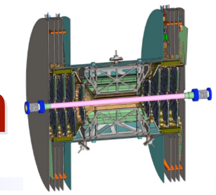
Fraction Extraction



The Fitting method has been carefully tuned :

- Select appropriate bins / range on DCA fit;
- Fitting Method (χ^2, -log f);
- DCA shape smooth;
- Option for un-bin Roofit;
- Fraction extraction value / error is improved;

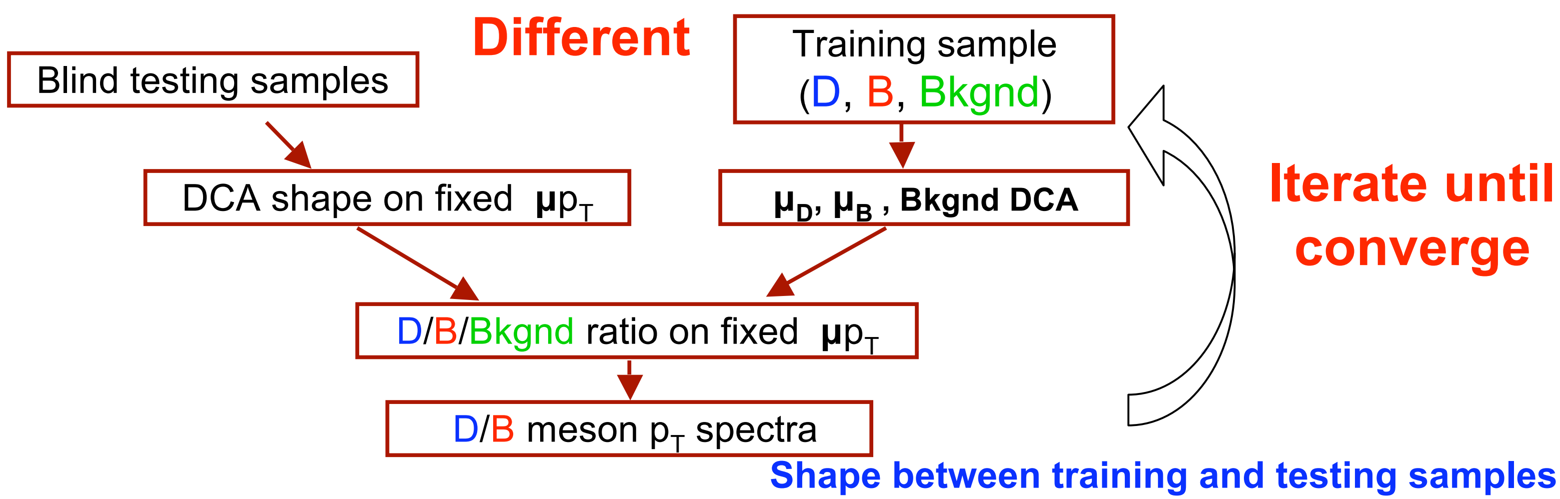
Q 1 : When meson p_T shape is uncertain



Q : If the training sample's meson p_T spectra is uncertain (different from testing sample), Can we still get correct D / B ratio vs meson p_T ?

A :
1. Different meson p_T spectra in training sample will affect D / B fraction extraction on fixed μ p_T, and output different meson p_T spectra after transformation.
2. Re-weight training samples with the output meson pT spectra and start new round of training.
3. Iterate until the difference between input training sample and output meson p_T spectra converges to zero.

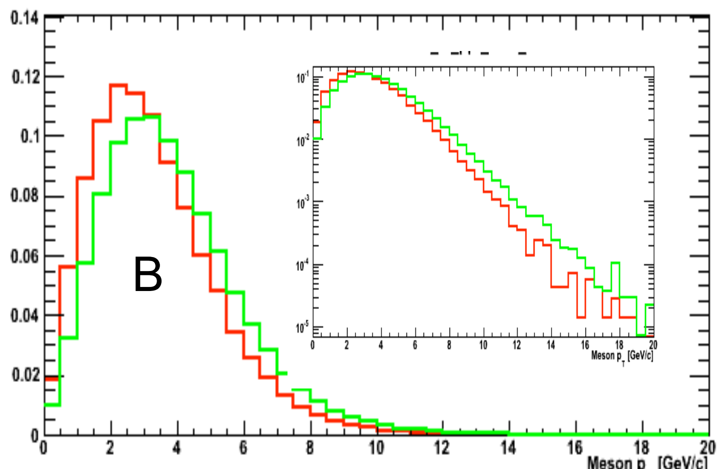
Then we get the correct D / B meson pT spectra and b / (c+b) ratio in testing sample.



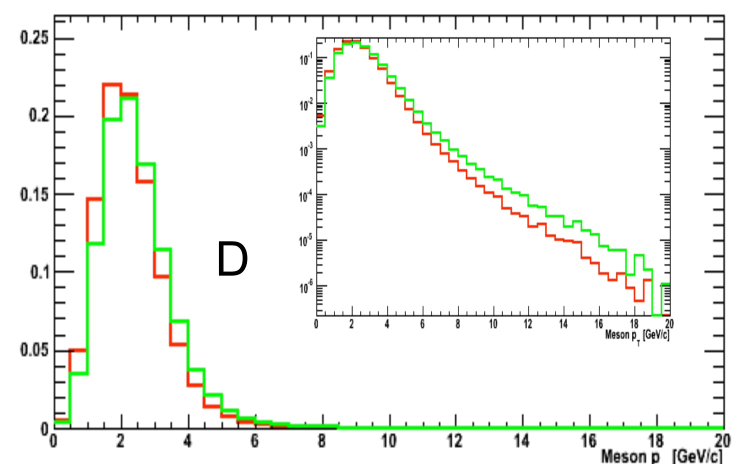
Different meson p_T in training sample

Change training sample's meson p_T slope by **30%,** on first iteration

Normalized meson p_T spectra



Meson p_T [GeV/c]

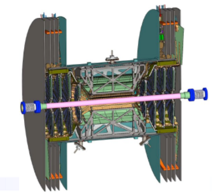


Meson p_T [GeV/c]

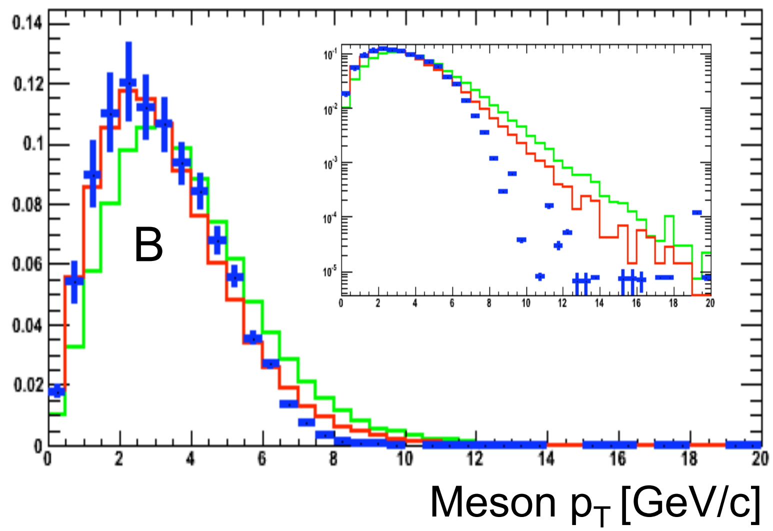
True meson pT in testing

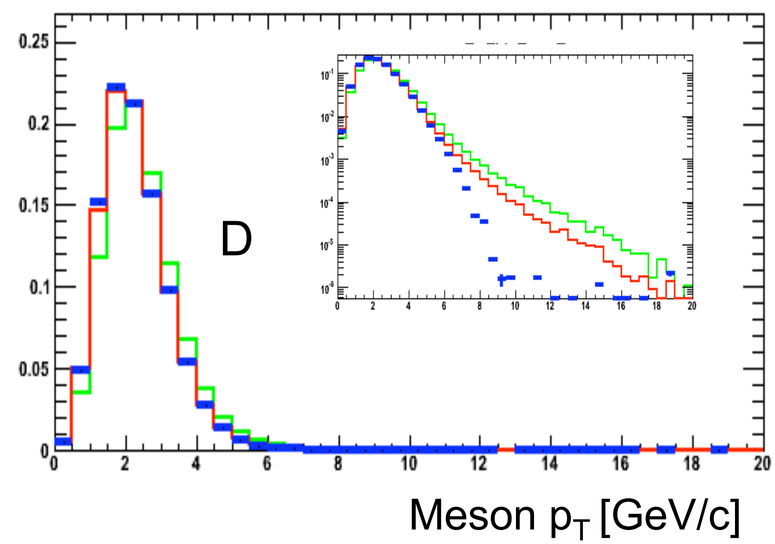
meson pT of initial training

After 30 iterations



Normalized meson p_T spectra



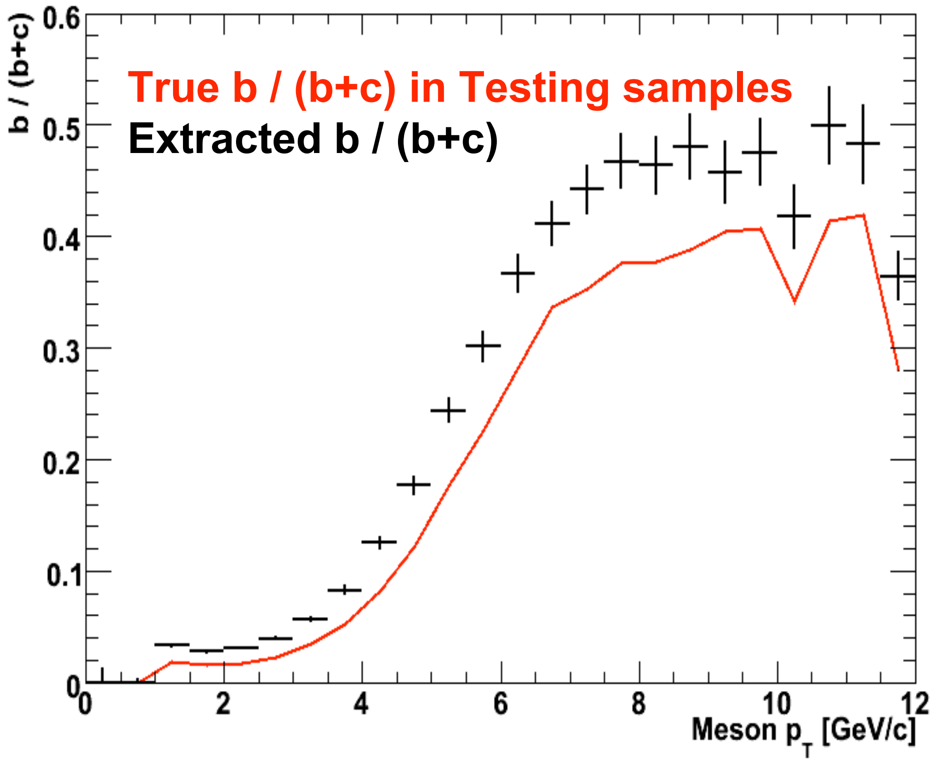


True meson p_T in testing
meson p_T of initial training
Output meson p_T after iteration

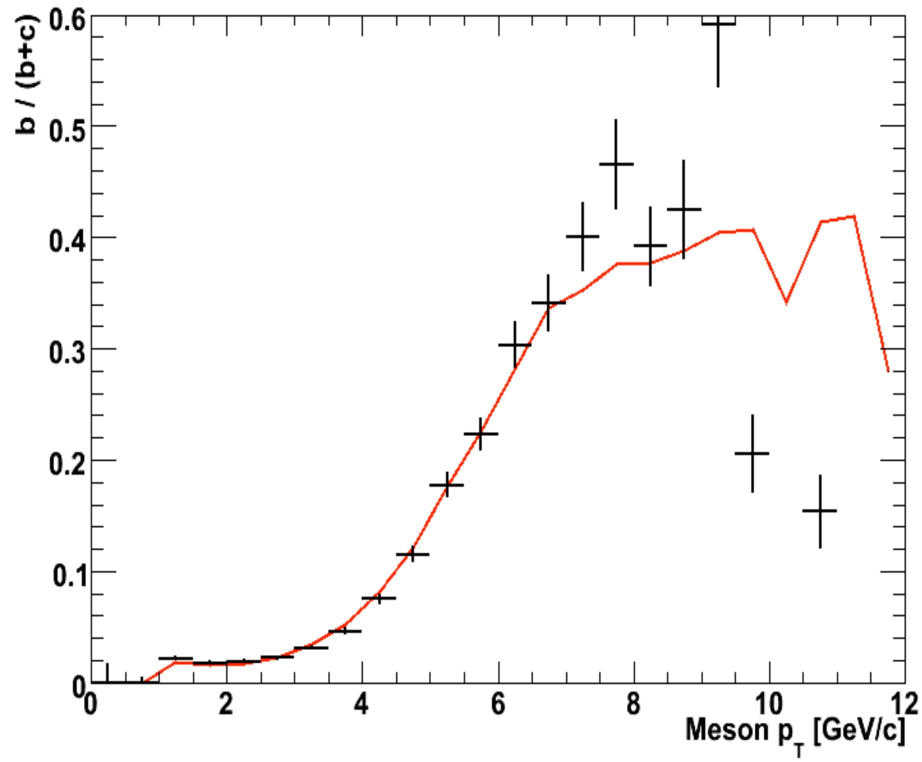
For high p_T (>7GeV/c) meson,
match not good enough,
due to not enough statistics in Training samples

b / (b+c) ratio

Before iteration



After 30 iterations

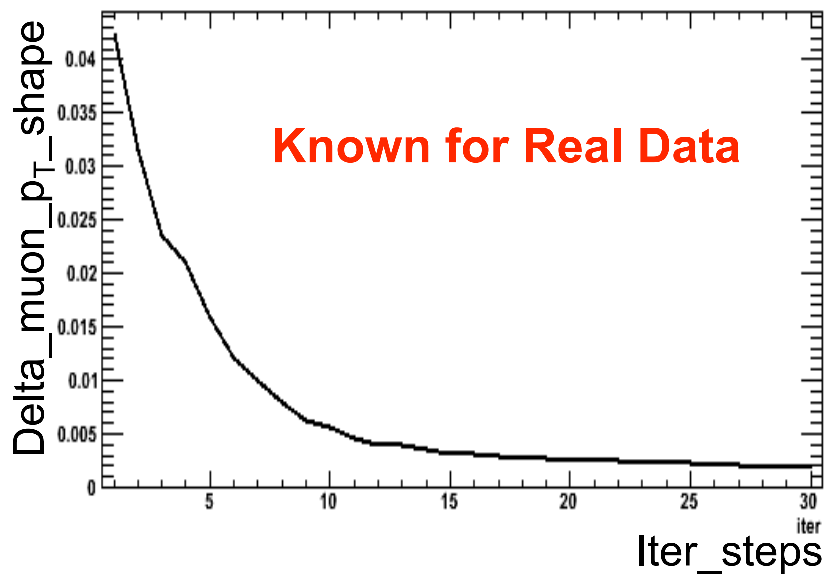


*** Training samples' statistical error not included**

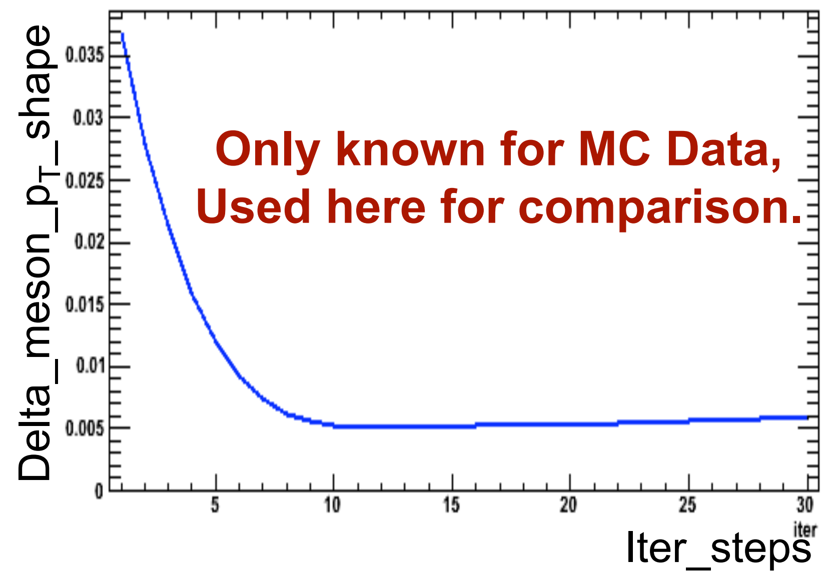
Criteria for convergence

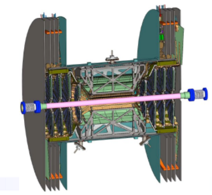
When converged, training sample and testing sample's
μ p_T spectra (known for Real Data) and
meson p_T spectra (only known for MC Data)
should be consistent

Extracted μ p_T spectrum in testing sample - μ p_T spectrum in training sample



Extracted meson p_T spectrum in testing sample - True meson p_T spectrum in testing sample





Q 2 : Verify DCA distribution

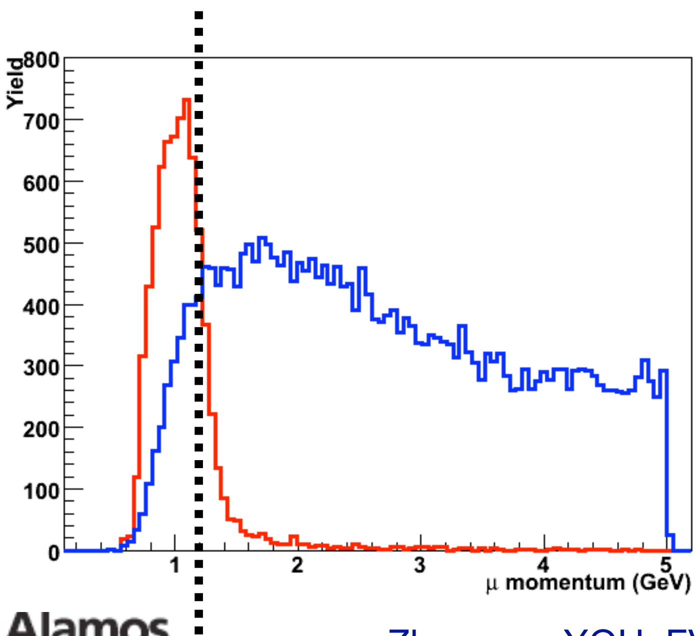
Q : How to verify the DCA distribution from Monte-Carlo is correct ?

A : Will use other detectors like Muon Identifier to verify DCA distribution.

1. Use single **μ** from J/ψ peak to verify prompt **μ**'s DCA distribtuion.
2. Hadron decay **μ** and stopped hadrons selected with MuID, compare with background distributions and extract ratio.

Momentum of MuID Gap2/3 tracks

(= Hadron decay μ + Stopped Hadron)

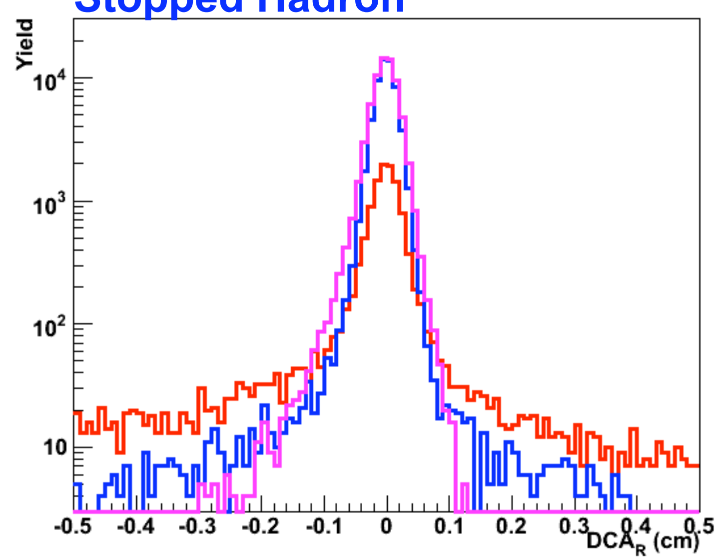


DCA_R Distribution

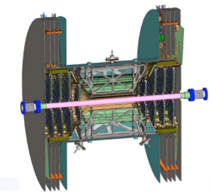
J/ψ decay μ : Prompt μ + B→J/ψ→μ

Hadron decay μ

Stopped Hadron

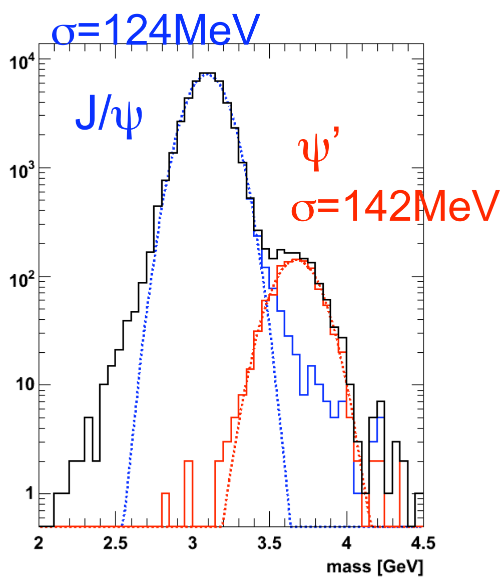


Di-muon improvement

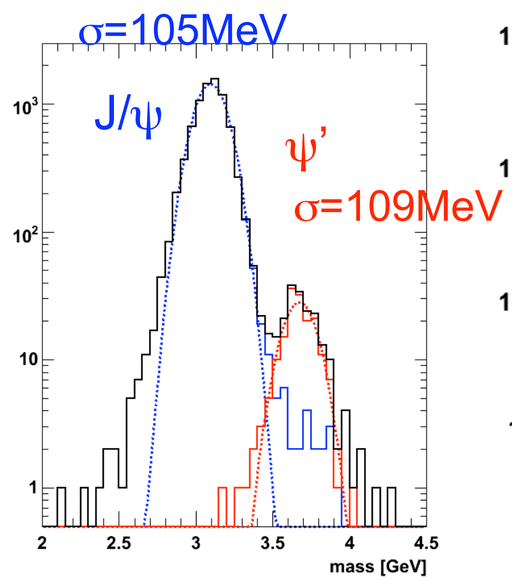


J/ψ and ψ' resolution improved

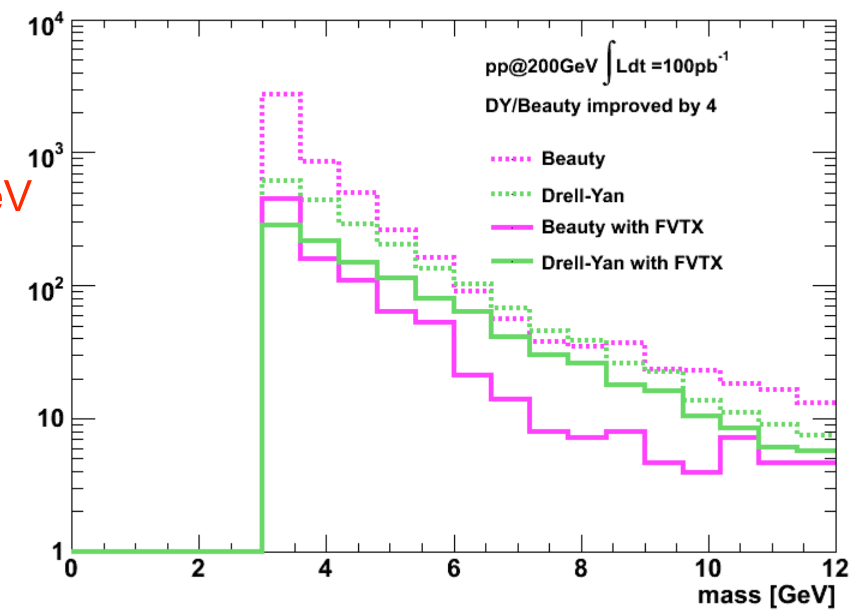
No FVTX



With FVTX

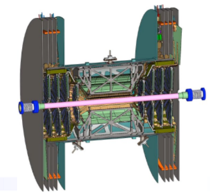


b-bbar background rejection with FVTX
In Drell-Yan process



Improve Signal / Background Ratio by factor ~4

Software for Commissioning



Alignment Software :

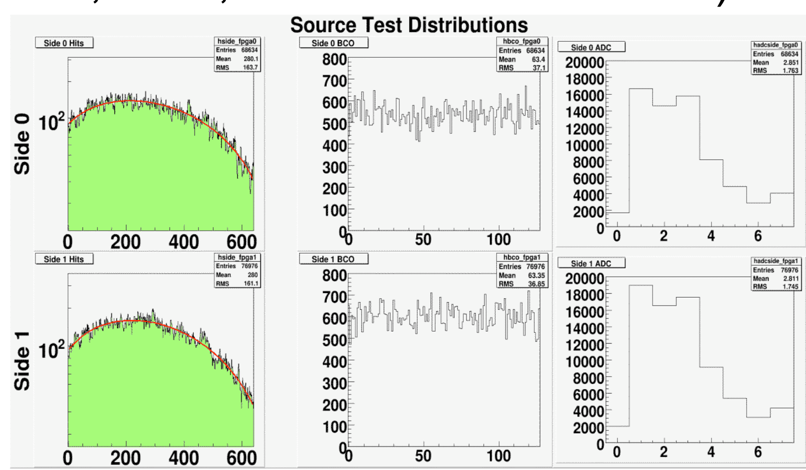
Mechanical alignment, allows corrections for each wedge in both of simulation and offline reconstruction.

Offline alignment, an algorithm (Millepede) which uses zero-field events to align detectors. The algorithm has been working well in PHENIX MuTr system, is now being implemented in FVTX.

Online Monitoring :

Scripts / Macros being developed by Columbia.

(Monitoring Multiplicity, Hits distribution, ADC, Hot/Dead channels …)



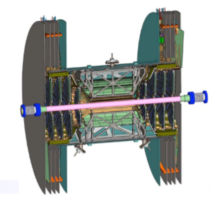
Database Interface :

In Progress.

PRDF (Phenix Raw Data Format) :

In Design.

Preparation for Real Data Analysis



-- *manpower*

LANL: Zhengyun You, Cesar Luiz da Silva, Hubert van Hecke, Melynda Brooks, Ming Liu, Mike Leitch, Pat McGaughey, Xiaodong Jiang, 1 or 2 new postdocs.
NMSU: Xiaorong Wang, Feng Wei, Elaine Tennant, Abraham Meles.
UNM: Imran Younus, Douglas E. Fields, Jeongsu Bok, Aaron Key.
Columbia University: Dave Winter, Aaron Veicht.

*** student**

-- *Institutes now working on Muon Arm analyses*

BNL, Colorado, GSU, ISU, Korea U., RIKEN, SUNYSB, UCR, UIUC …
Will continue muon related analyses with FVTX, like W measurement.

Software Leader
H. v Hecke (LANL)
X. Wang (NMSU)

GEANT Simu.
LANL

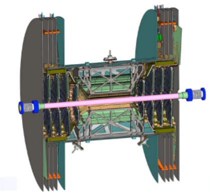
Offline Software
LANL
NMSU
Columbia

Analysis
LANL, NMSU, UNM, Columbia, SUNYSB, BNL, …

Alignment
NMSU
LANL

Database
Columbia

Online Monitoring
Columbia
LANL



Summary and Work to do

- FVTX software is close to ready for real data analysis.
- FVTX provides high reconstruction efficiency and matching efficiency in p + p and Au + Au collisions.
- Blind analysis demonstrates that FVTX provides sufficient DCA resolution for c / b separation, and has the ability to get correct b / (c+b) ratio when meson p_T shape is uncertain.
- Have a plan to verify Signal / Background’ DCA distribtuion with real data.
- Preparation work towards real data analysis will continue.