Physics Studies for the PXD Optimisation

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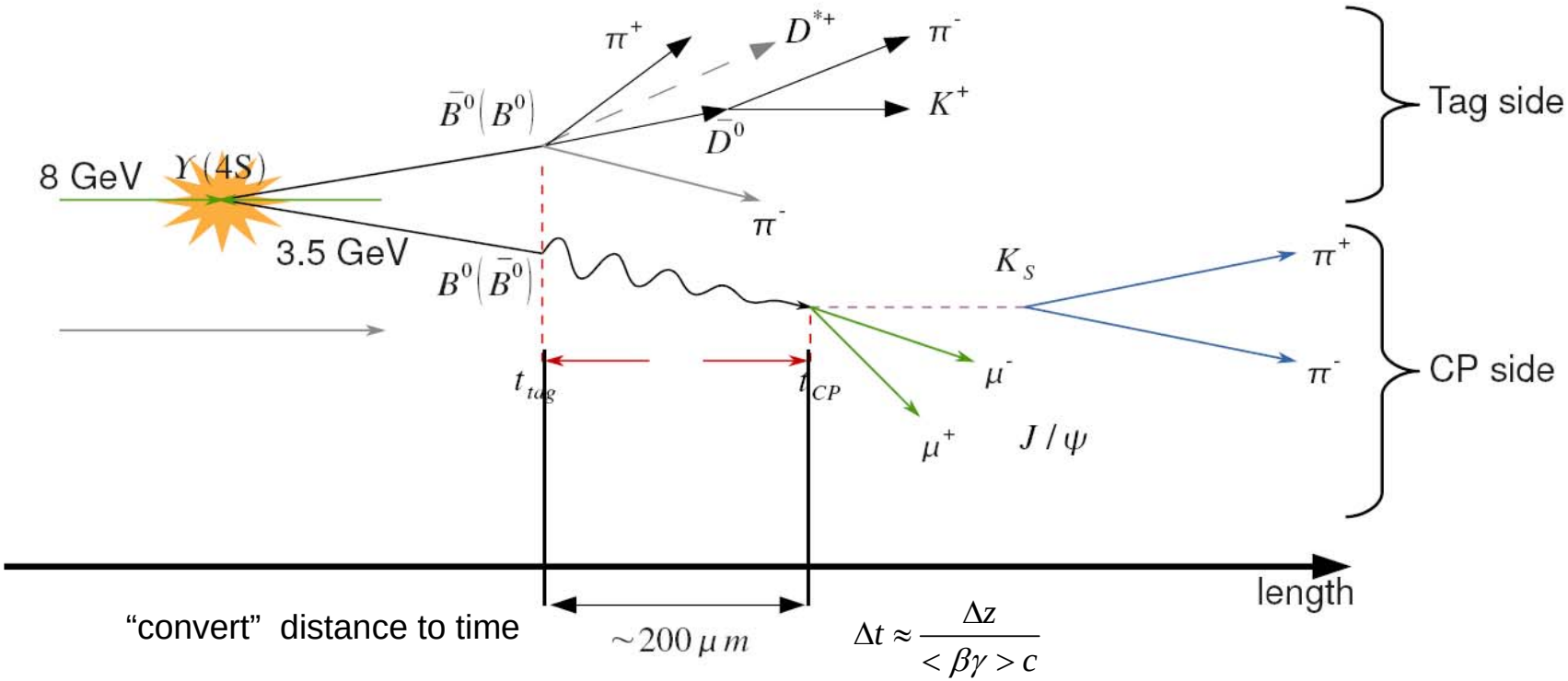
Content

- Introduction: Physics Channel
- Master plan for optimization study
- Benchmark plots
- Model of resolution function
- Summary and Outlook

Introduction

- Aim: Evaluate PXD options with realistic physics benchmark process
- Vertex resolution key to all CP violation measurements

➔ Study “Golden Channel”:



High precision vertexing essential for this type of measurements

Master Plan for Optimization Study

A.) Establish analysis chain in Belle framework: BASF

well-proven tool box for Physics analysis in Belle

1. Generate events (EvtGen)
2. Simulate events (Belle Geometry)
3. Analyze events (BASF / ROOT)

B.) Implement analysis in ILC framework: Mokka/Marlin

tool box for detector optimization studies

1. Interface EvtGen output
2. Simulate events with ILC framework setup for Belle geometry
3. Reconstruct vertices using MarlinRave as Vertex fitter

Comparison of A and B establishes baseline for optimization study

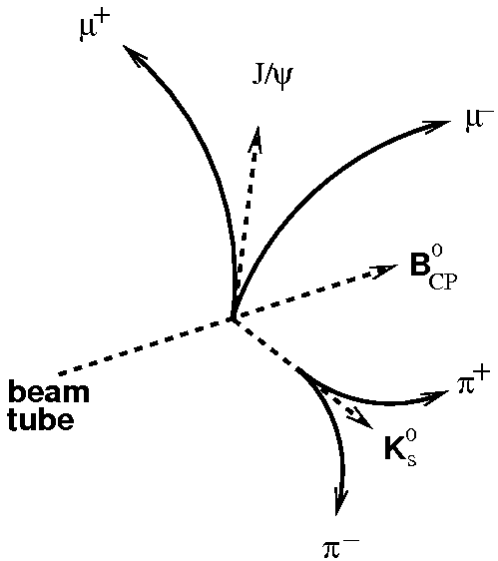
C.) Rerun B.) for various Belle II detector (and beam) scenarios

Event Reconstruction

- EvtGen: Generate 100 000 entangled $B^0\,\overline{B}^0$ pairs
- Force "golden" decay modes:

CP side:

$(\overline{B}^0) \rightarrow J/\psi K^0_s \rightarrow \mu^+\mu^-\,\pi^+\pi^-$

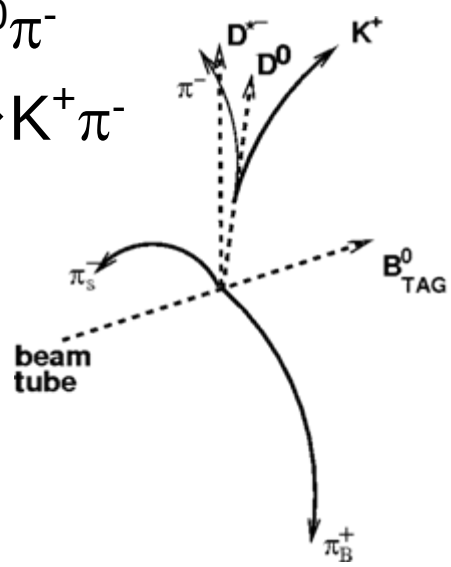


Tag side (+c.c.):

$\overline{B}^0 \rightarrow D^{*-}\pi^+$

$\rightarrow \overline{D}^0\pi^-$

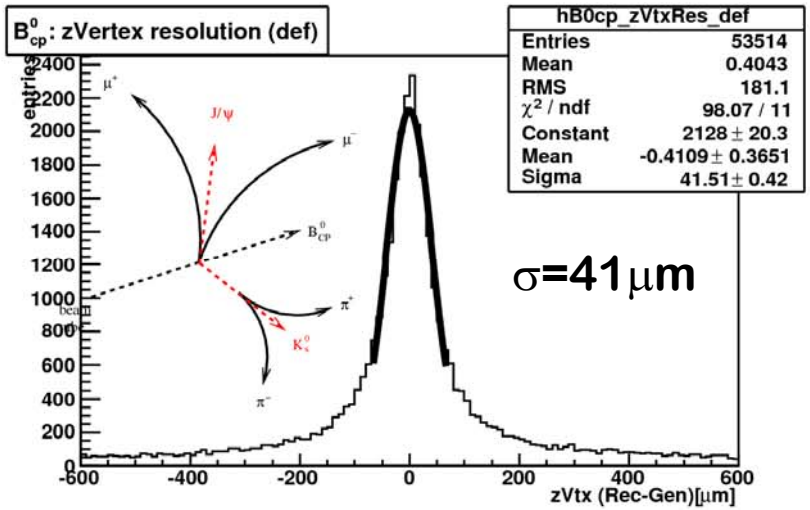
$\rightarrow K^+\pi^-$



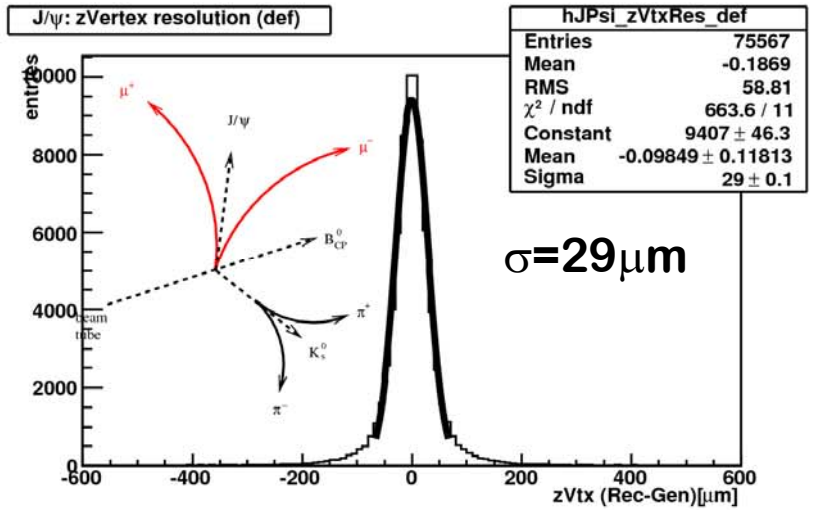
- Match generator level to reconstructed candidates by hit fraction requirement on all daughter tracks

Methods to reconstruct CP side vertex

Reco B decay vtx from J/ψ & K^0_s

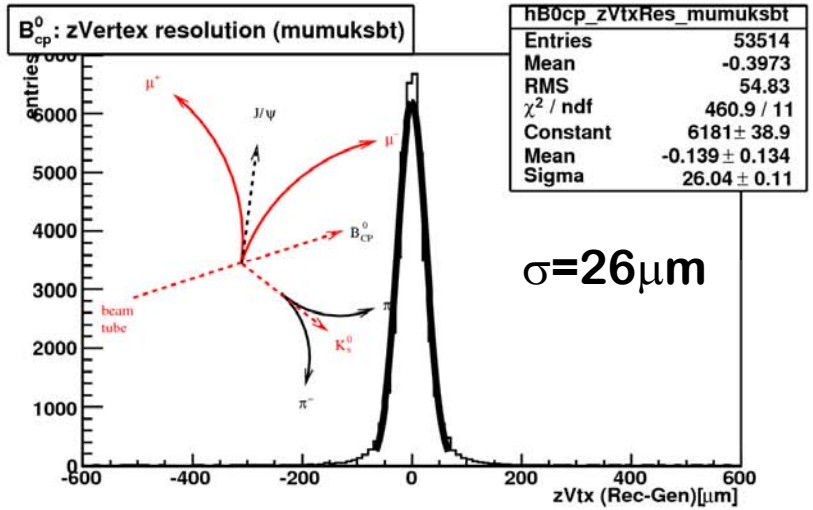


Reco B decay vtx from $\mu^+\mu^-$



B0 vtx from two muon vertex fit
- Almost as good as best reco
-simplest model to implement in ILC software

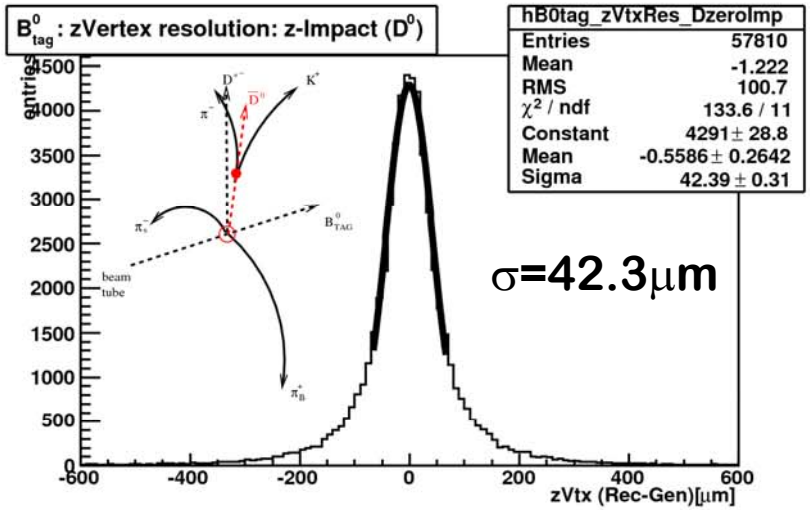
Fit: here single Gauss, binned log-likelihood, range ±66.6μm
improved fit model, see later



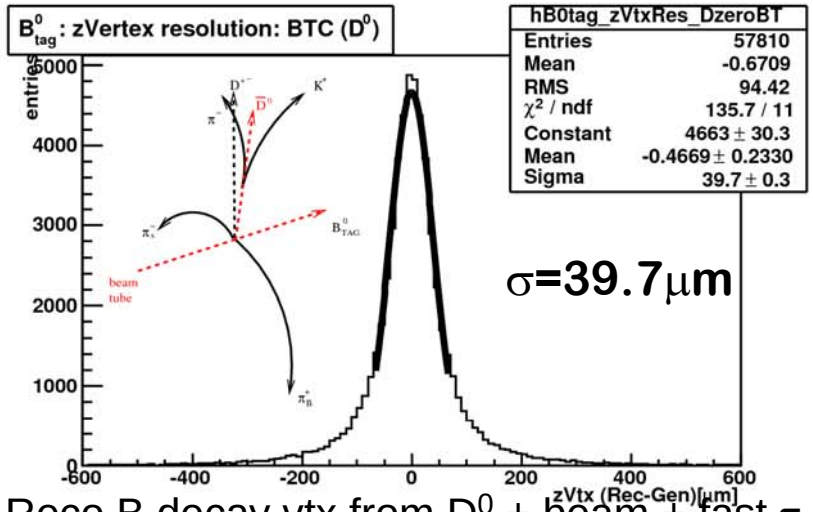
Reco B decay using $\mu^+\mu^-$ K^0_s+beam constr.

Methods to reconstruct Tag side vertex

Reco B decay vtx from D^0 (4-mom + vtx)



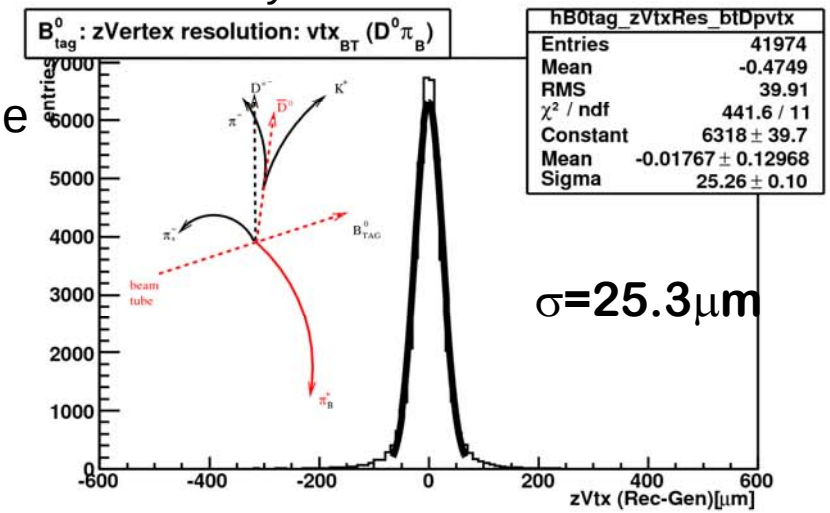
Reco B decay vtx from D^0 +beam



Reconstruct D^0 vertex and 4-mom from Kπ, back extrapolate to beam line
-simplest model to implement in ILC software

Fit: here single Gauss, binned log-likelihood, range ±66.6μm
improved fit model, see later

Reco B decay vtx from D^0 + beam + fast π



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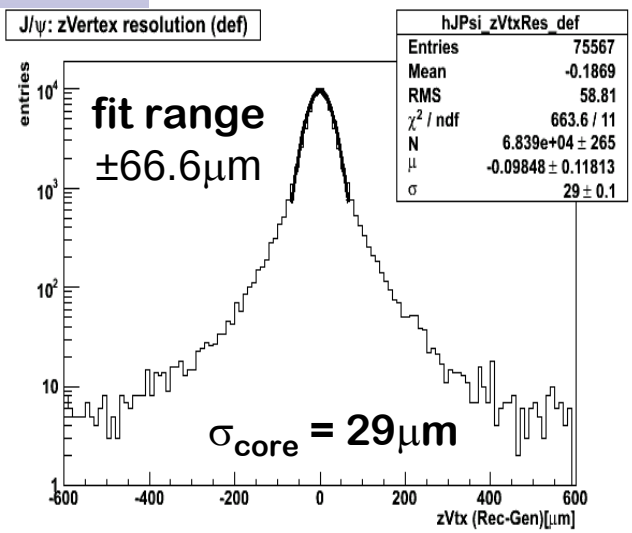
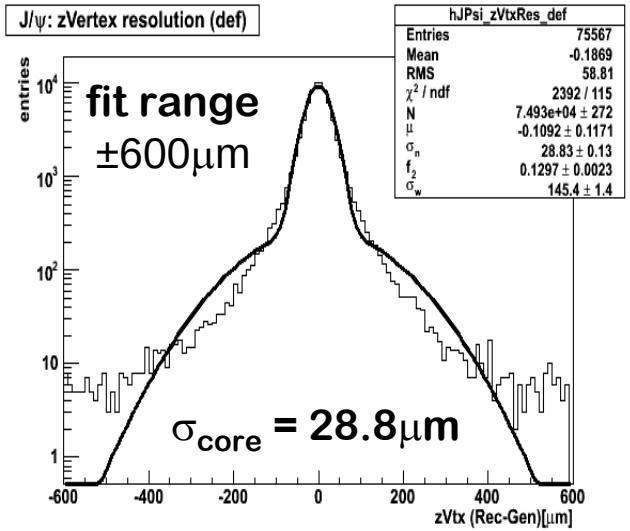
Fit Model for Resolution

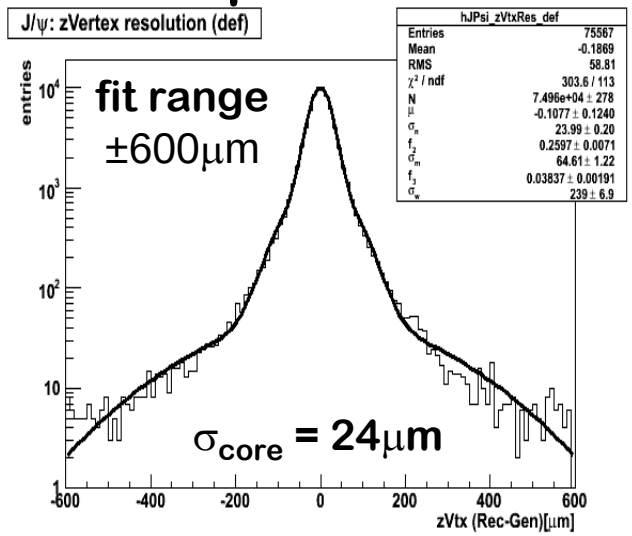
Gauss



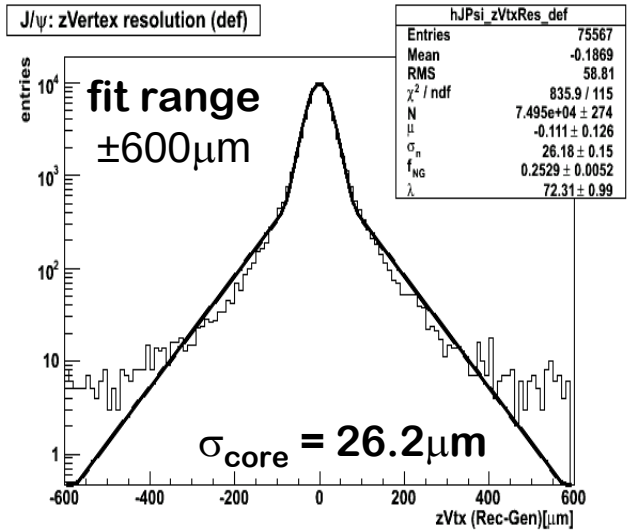
Double Gauss



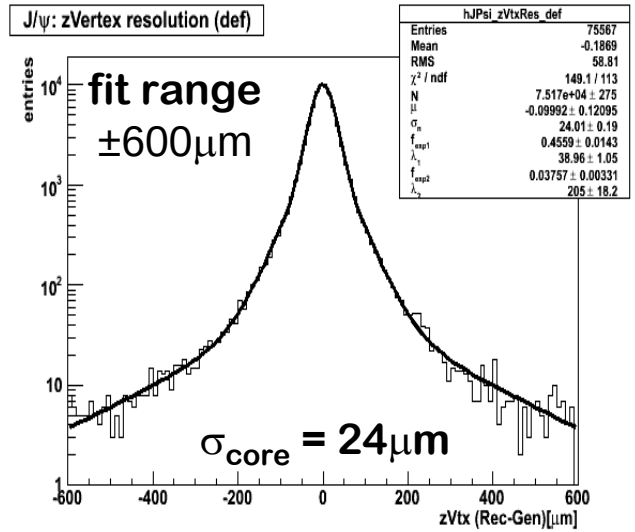
Triple Gauss



Gauss + Exp



Gauss + two Exp



Aim: Quantify Gaussian core and non-Gaussian tails

(all fits are binned log-likelihood fits)

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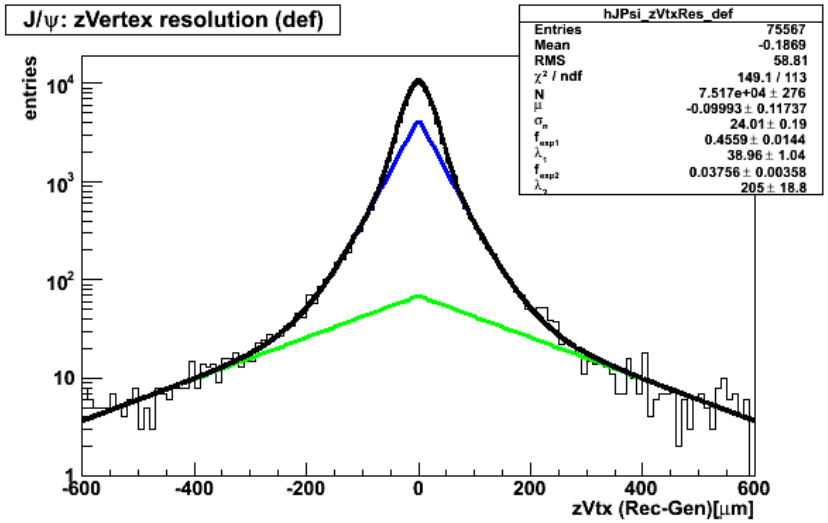
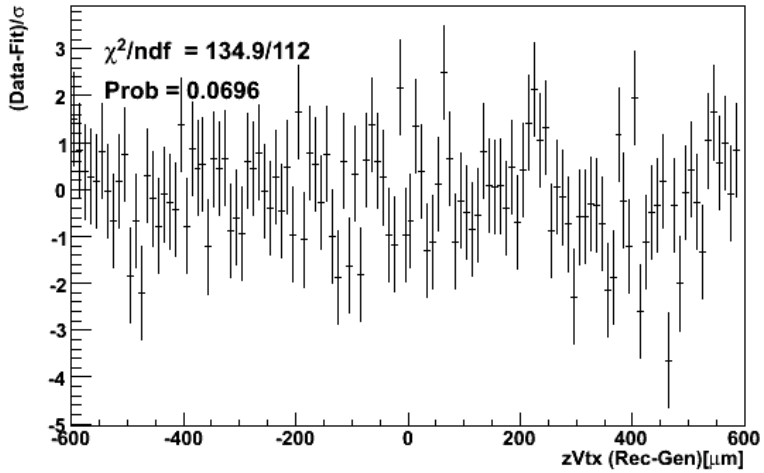
Best Fit:

$$\sigma_{vtx} = N\left\{\frac{(1-f_1-f_2)}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)+\frac{f_1}{2\lambda_1}\exp-\frac{|x-\mu|}{\lambda_1}+\frac{f_2}{2\lambda_2}\exp-\frac{|x-\mu|}{\lambda_2}\right\}$$

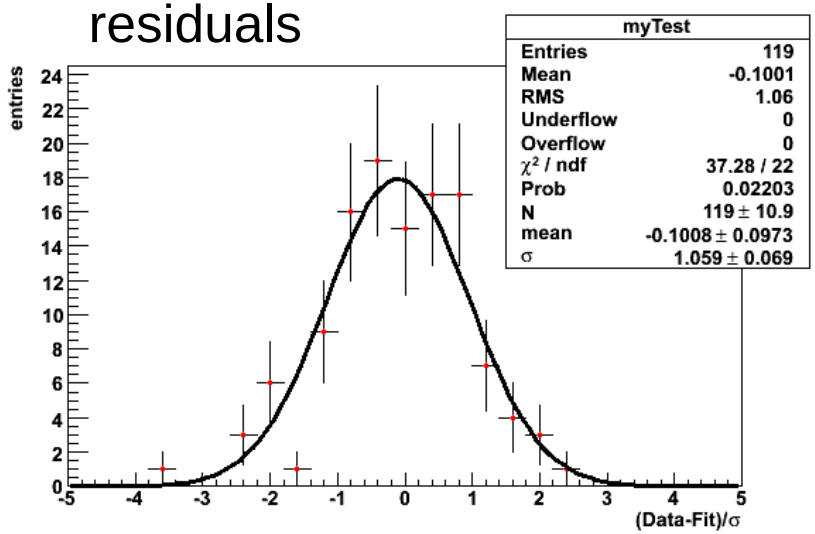
Gauss + two exponentials



ratio



residuals



Resolution is characterized by

-Core: width of Gaussian
(e.g. σ=24μm)

-Tail: fraction of histogram entries outside 3σ-window, independent of fit details on tail.
fraction on histrogram: 9.88%
(fraction evaluated by fit: 9.96%)

➔excellent fit

Mokka/Marlin Progress

- Work started to implement physics benchmark in Mokka/Marlin
- No results yet, the devil is in the details

  e.g.:

  - Loss of (some) Generator level information (B0 vtx set to zero) when interfacing EvtGen with Mokka/Marlin, B^0B^0 no longer entangled when decayed by Geant4
  - ILC framework not tuned for low momentum tracks
    → fake tracks, multiple reconstruction of loopers
  - Learning how to use MarlinRave vertex fitter, compiling the package at MPI larger effort than expected
  - Discovered differences when running local jobs (at MPI) on batch jobs on farm (at Rechenzentrum Garching)
- Will cut some corners to quickly get to some results on J/ψ vertex resolution

Summary

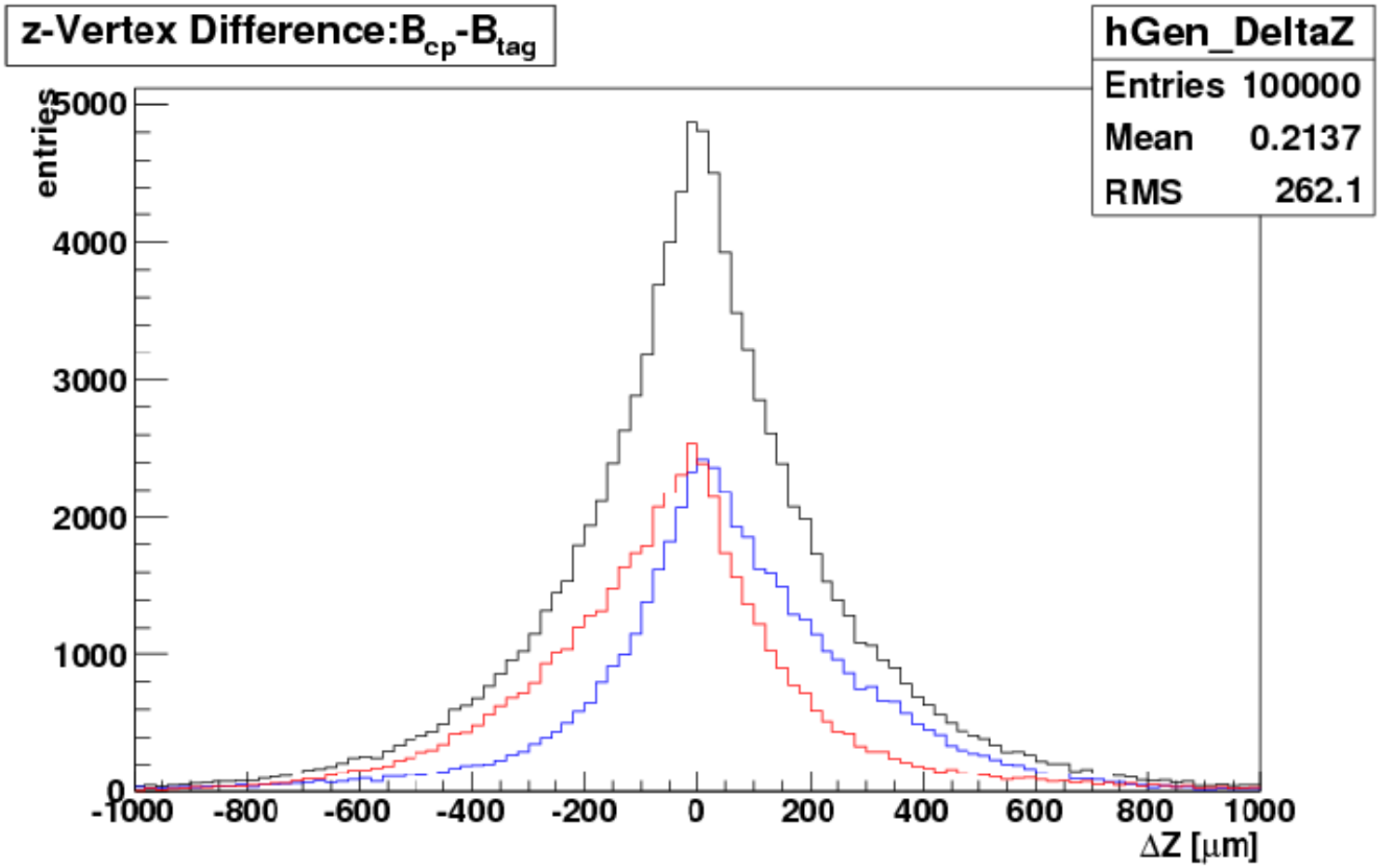
- Benchmark analysis in the Belle framework (BASF/ROOT) is running
- Characterization of vertex resolution presented
- Work on implementing benchmark analysis in Marlin/Mokka framework has started

Outlook

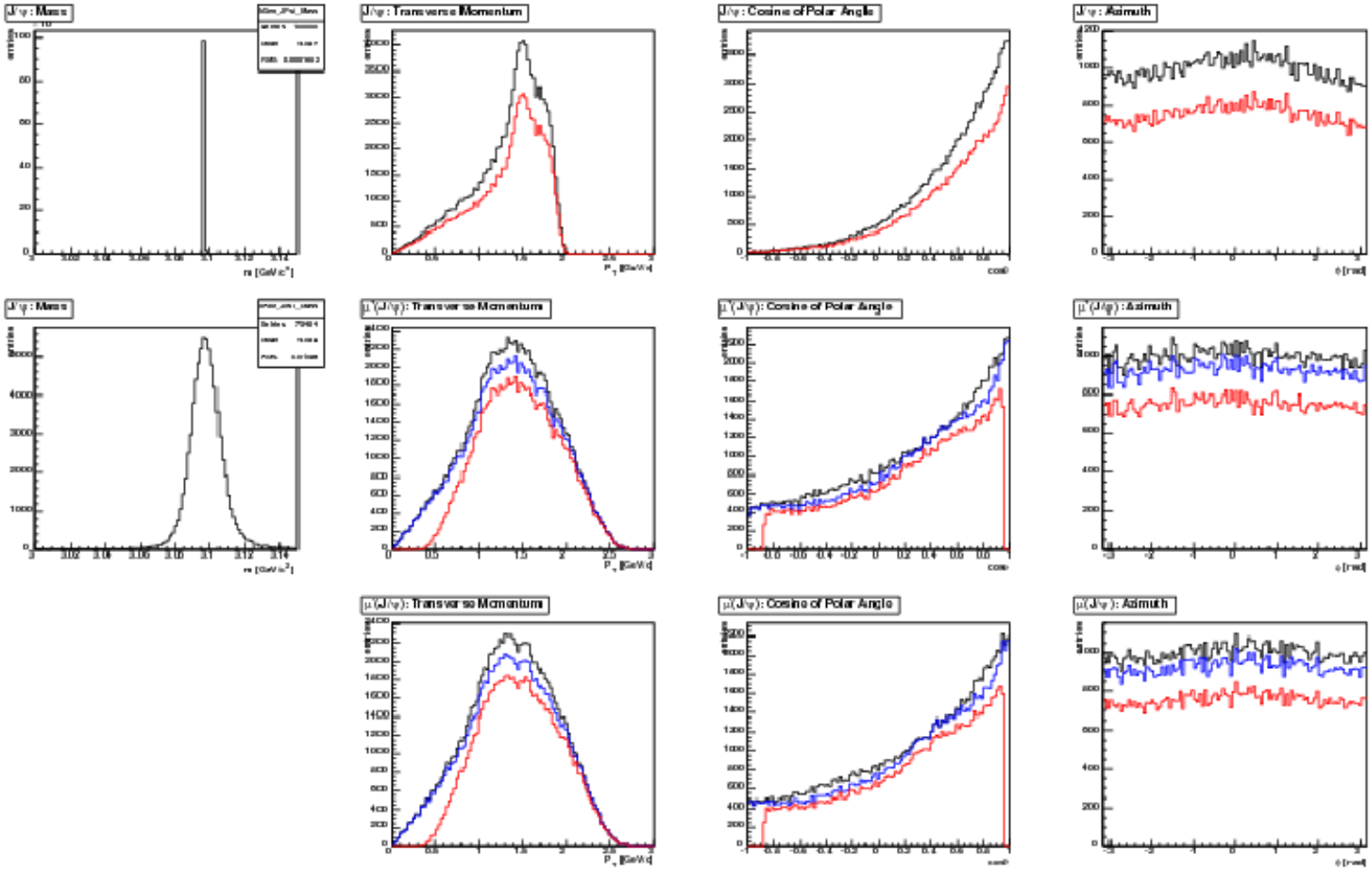
- Plan to present first comparison of BASF and Marlin/Mokka on B2GM in November
- Will try hard to also present first studies of the PXD geometry for Belle II

Backup Slides

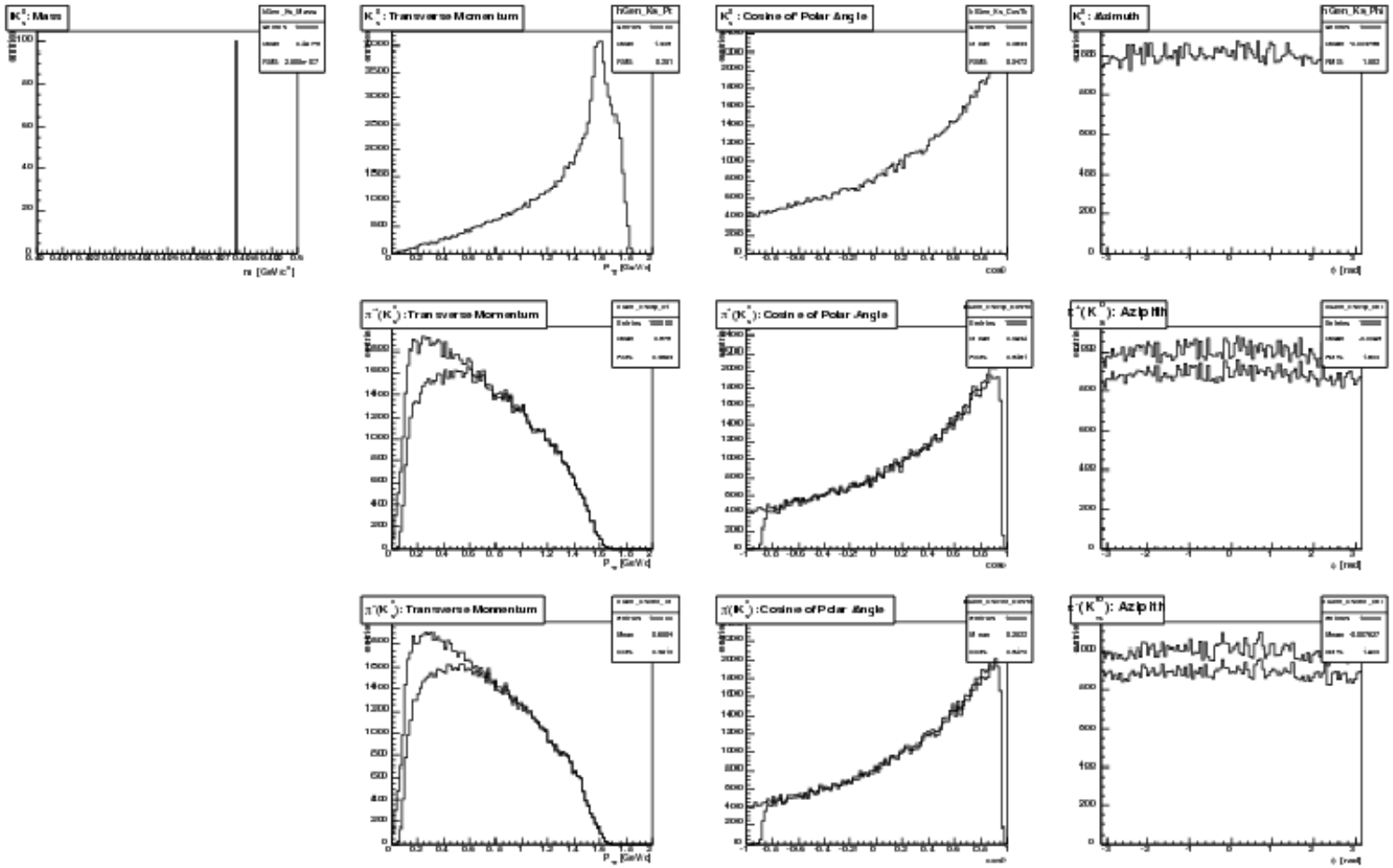
- Characterize events on generator level
  - DeltaZ
  - JPsi→mumu
  - Ks→pipi
  - Fast pi, D*, slow pi
  - D^0→Kpi


z-Vertex Difference:B_cp-B_tag
hGen_DeltaZ
Entries 100000
Mean 0.2137
RMS 262.1
entries
5000
4000
3000
2000
1000
0
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
ΔZ [μm]

Gen: J/Psi→mumu



Gen: K0s→pipi



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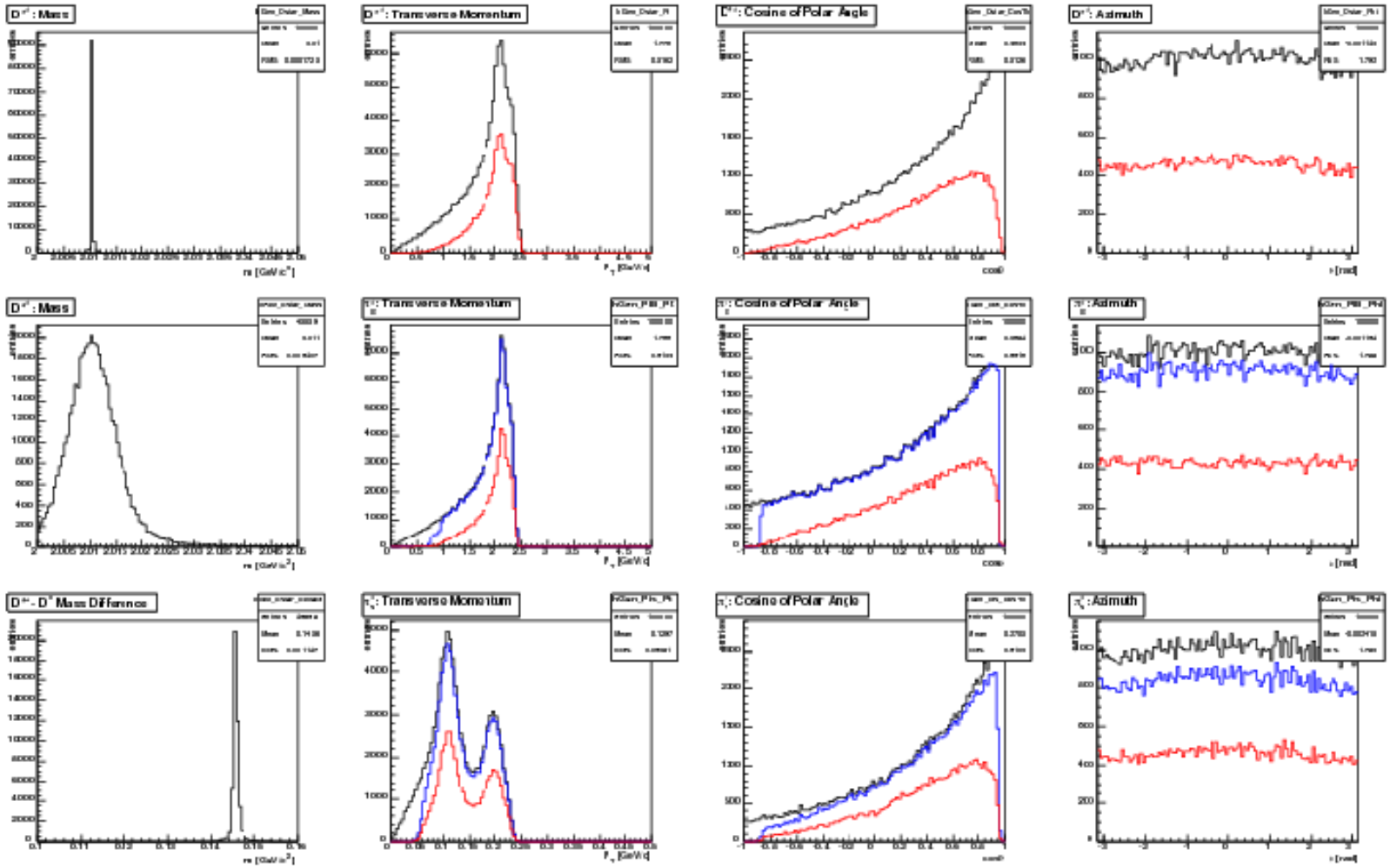
Gen: fast pi, Dstar, slow pi



Gen: $D^0 \rightarrow K\pi$