Vertex parameters Study

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B2J ICPV グループとしての今後の方針

Slide in last B2JAM

1. vertex reconstructionの評価
   CP fit に必要なパラメータは問題なく出ているか（vertex error、goodness of fit、scale error etc.）
2. Control sampleの再構成（resolution function parameter、wrong tag fraction評価に必要）
   おそらく一番簡単なのは$B^+ \to J/\psi K^+$。tag-side interferenceを出すには結局semi-leptonic $B \to D^* l \nu$ は必要になる。hadronic modes B→DXをやるかは人手による
3. resolution functionのモデリングの比較
   BABAR方式（triple Gaussian） vs. Belle方式（tatami $R_{det}+R_{np}+R_k$+outlier）

(4.) 新手法の開発
nano-beamやSVDでのKs efficiencyの向上を考慮した新たなvertex reconstructionの研究開発
秋までに何か良いアイデアと実現可能性について言及できる材料が揃えば科研費申請？

1-2と同時進行でbasf2を習得してゆき、メインターゲットである3、延いては4に繋げる

Get vertex information using basf2

I start from tutorial python code for vertexing in $D^* \to D^0(\to K\pi)\pi$
analysis/examples/tutorials/B2A403-KFit-VertexFit.py

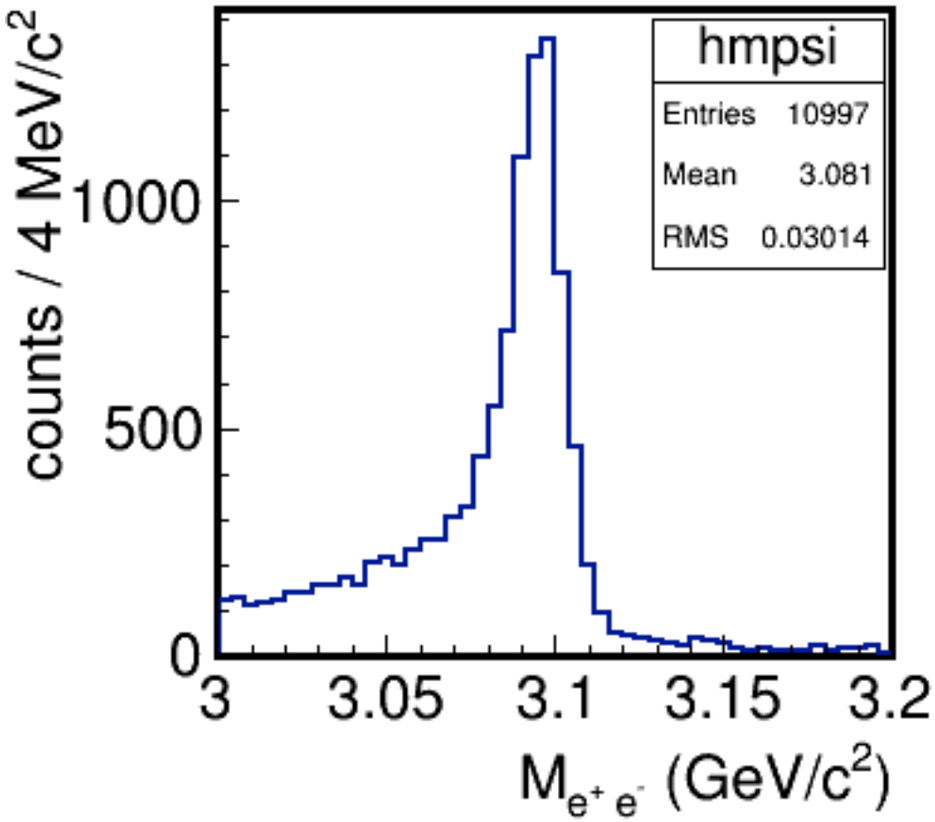
2 step vertex fit was done for D* in this script but I simplify it
to reconstruction of $J/\psi \to e^+e^-$ as first exercise.

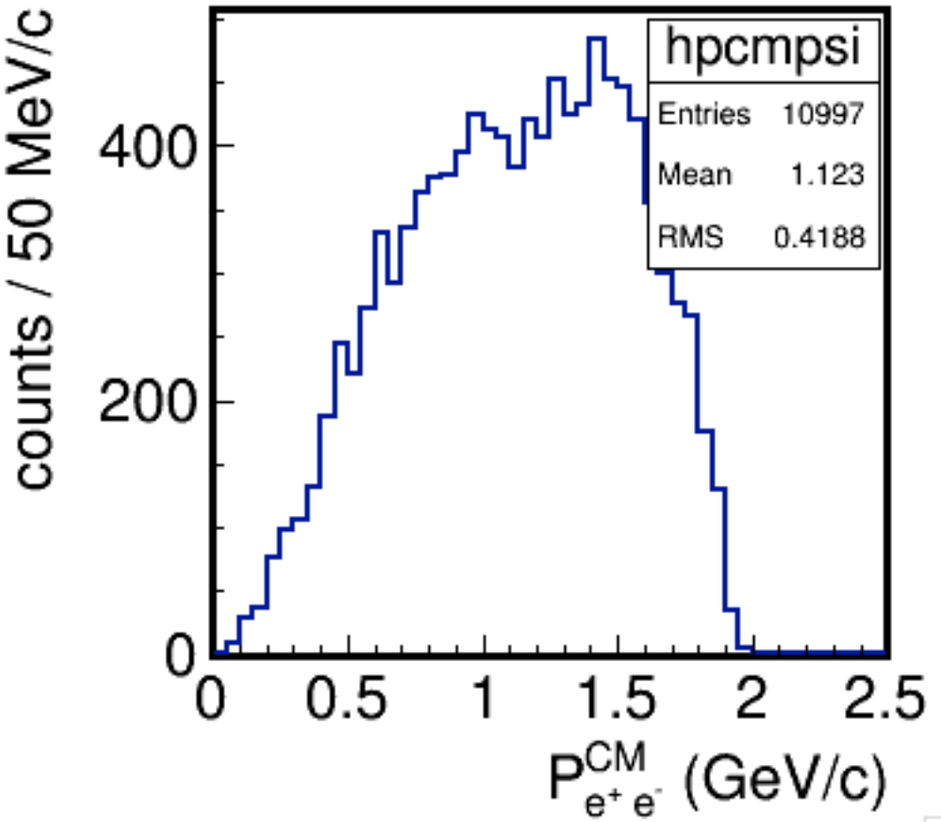
MC9 mixed MC located under following directory is used.
/ghi/fs01/belle2/bdata/MC/release-00-09-01/DB00000276/MC9/
prod00002288/e0000/4S/r00000/mixed/sub01/
1 file contains 12k events. 131 files are processed.
→ ~1.6 M events in total.

J/ψ reconstruction

e^+/e^- candidates are selected using stdCharged e+:99eff / e-:99eff

Separation	PID Cut		Efficiency	Fake Rate
e - π	electronID >	0.004	0.99	0.086(π)
	electronID >	0.597	0.95	0.017(π)





Reconstructed number events in J/ψ mass region are <u>10997 events</u>

Processed : (120k events) × (131 files) = 16M mixed MC

Branching fractions : Inclusive J/ψ from B^0 = O (10^{-2})

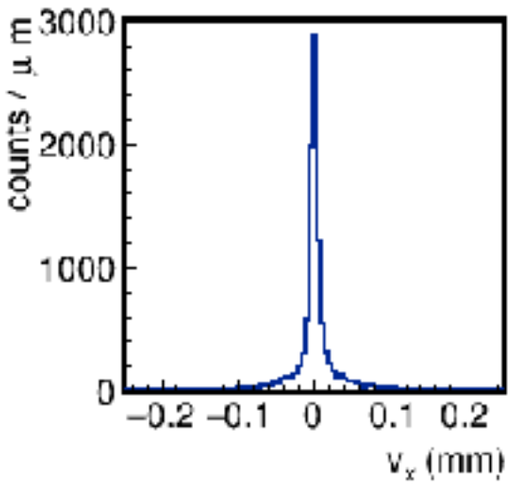
J/$\psi \rightarrow e^+e^-$ ~ 6%

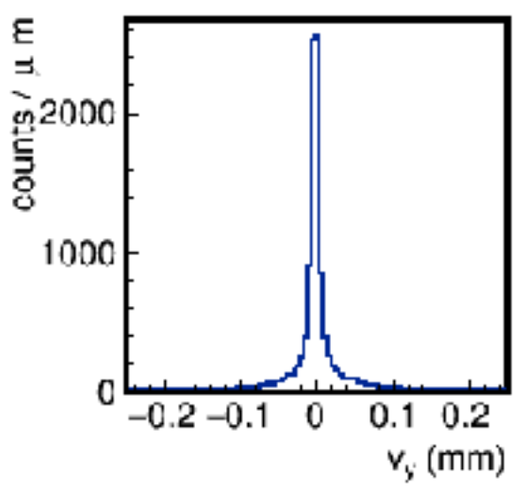
→ 2 × (1.6×10^7) × 0.01 × 0.06 = <u>19200 events</u>

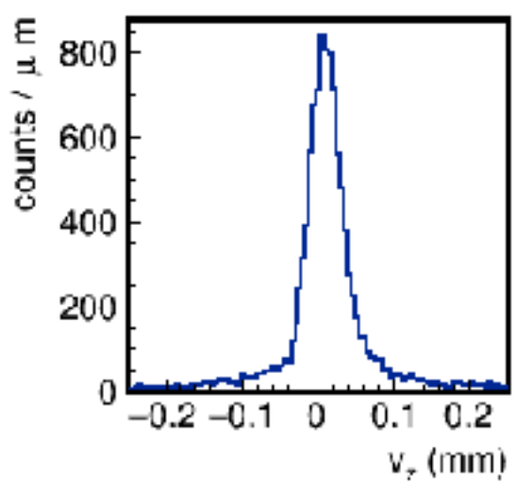
Considering reconstruction efficiency, these numbers are consistent.

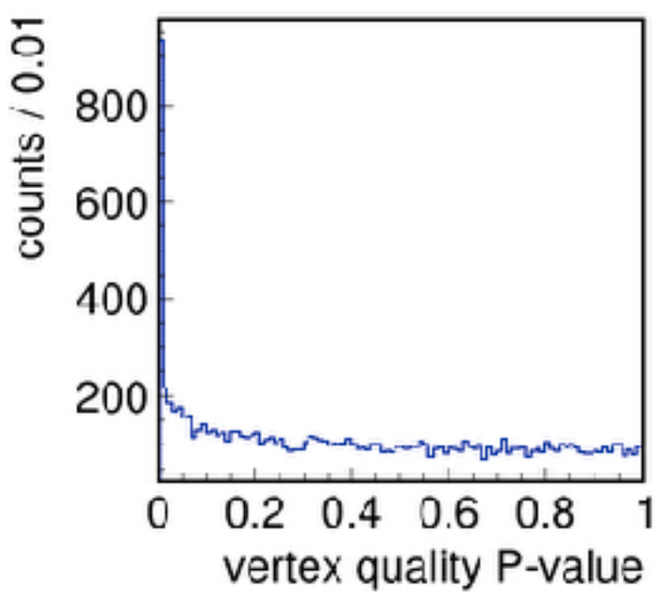
J/ψ vertex reconstruction

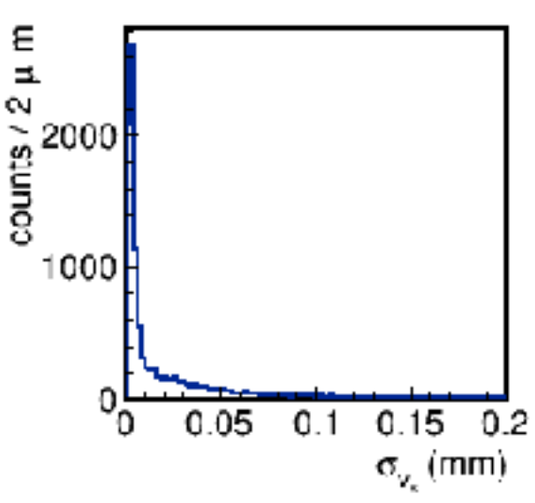
Using kfitter, vertex is reconstructed from e^+e^- tracks

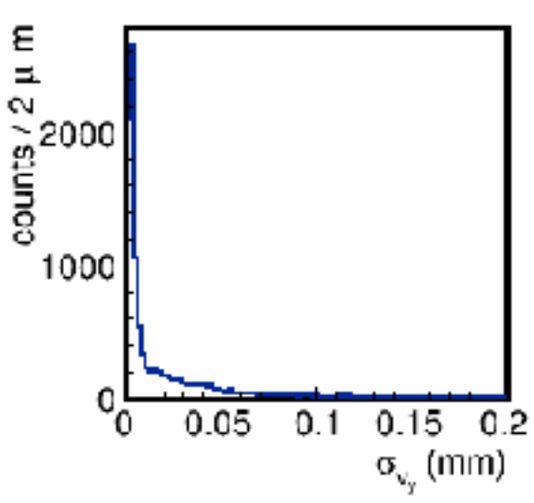


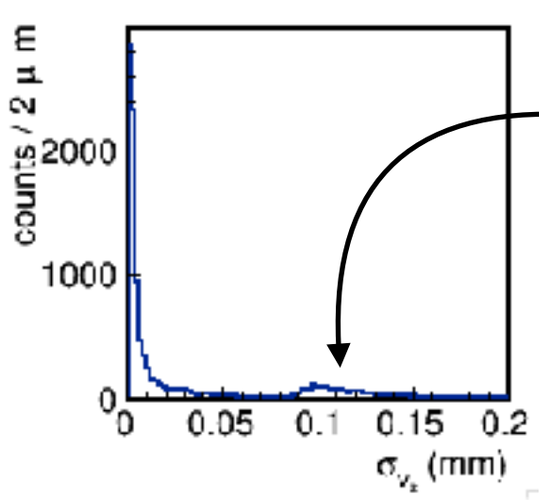










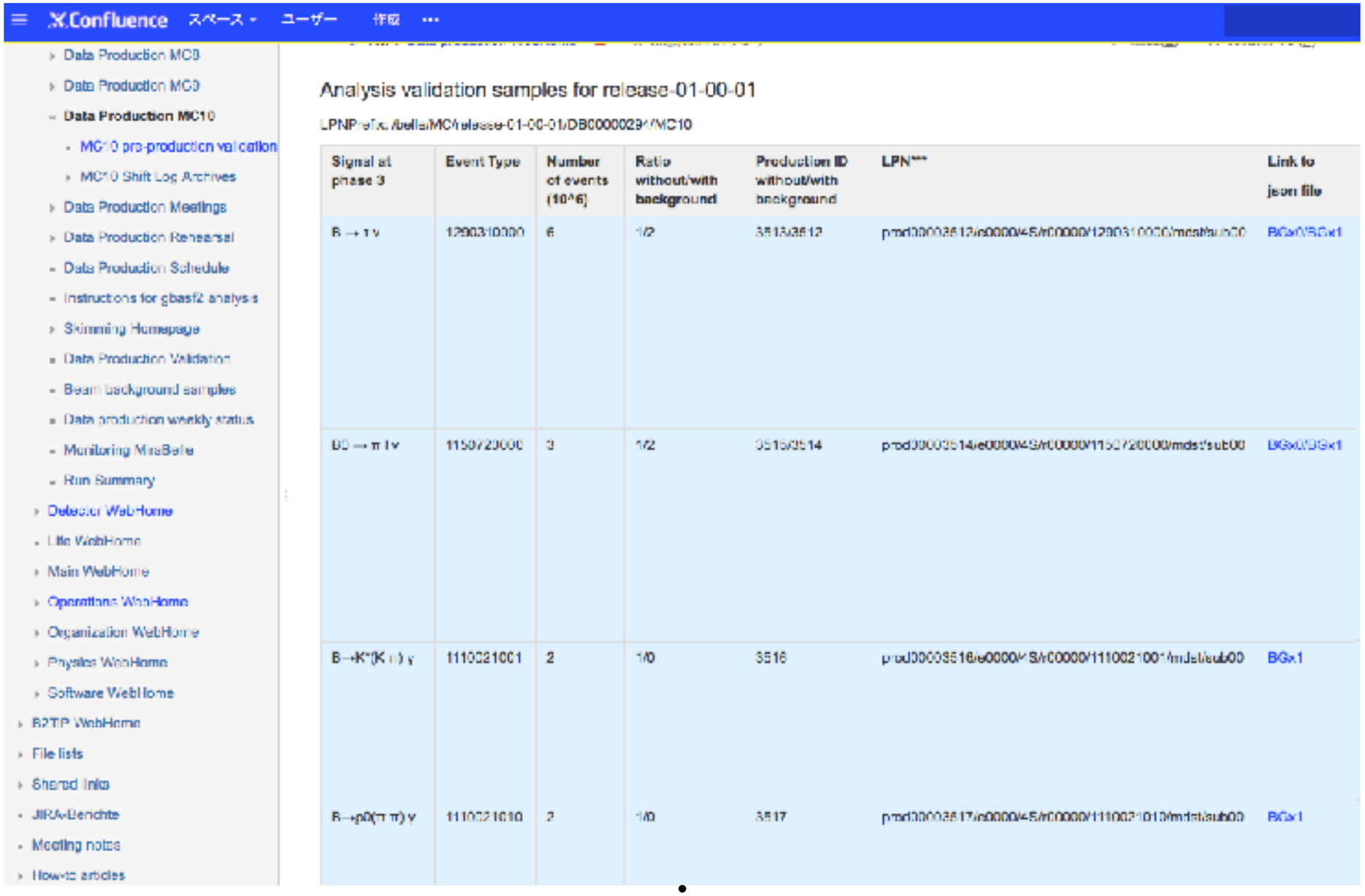


MC truth only

→ According to Luigi-san, vertex information in MC9 sample is not correct. We should wait for MC10 if we want to use correct vertex information.

MC10 sample

Small MC10 samples for validation are available on grid.

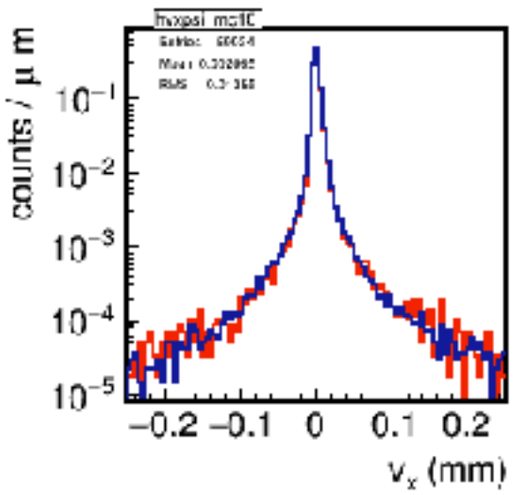


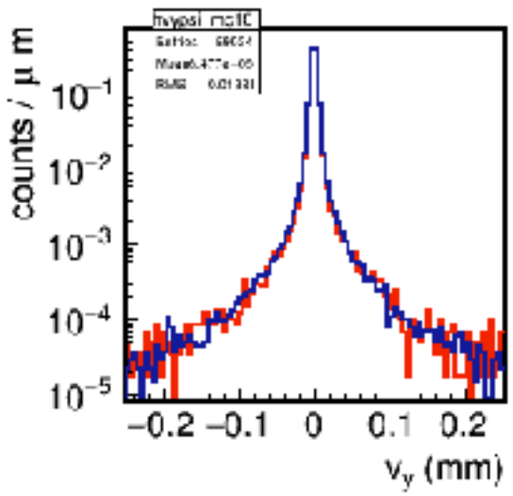
B→ J/ψ(ee) KS	1111540100	2	0.5/0.5	3521/3520	prod00003520/e0000/4S/r00000/1111540100/mdst/sub00	BGx0/BGx1	~~BIDP-262~~ - TDCPV validation sample 2 for release-01-00-00 validation CLOSED

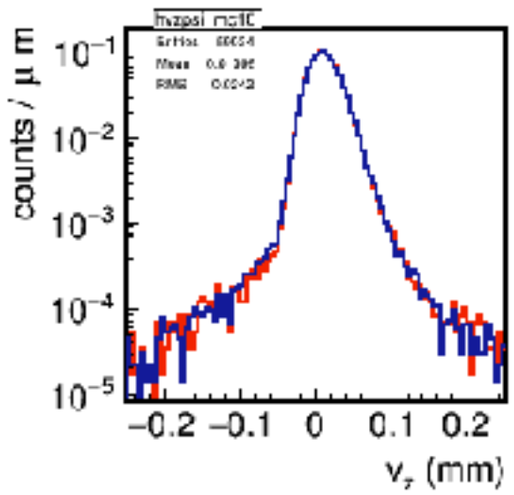
MC9/MC10 comparison

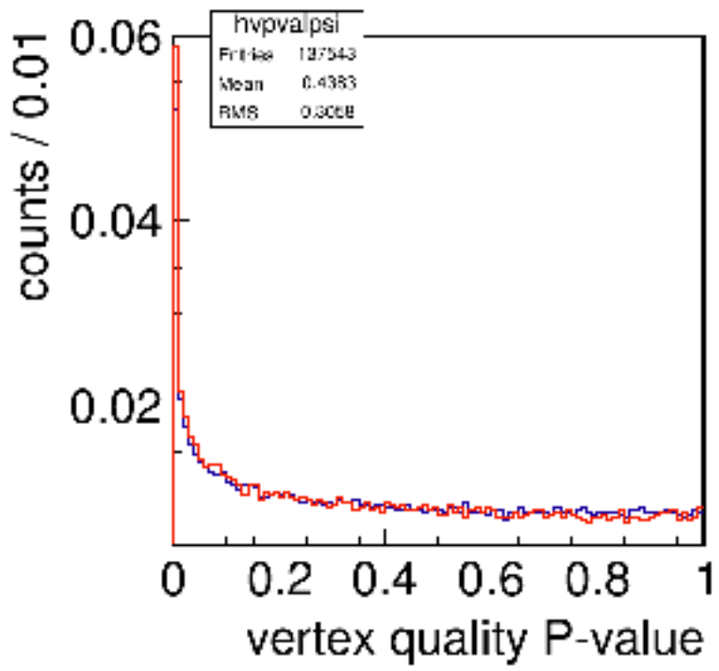
J/ψ vertex reconstruction

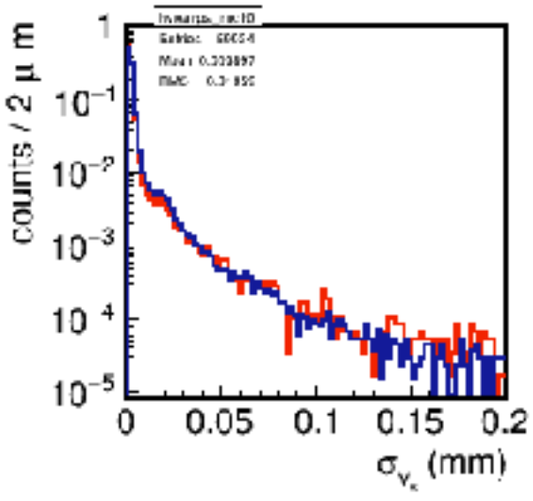
J/ψKs signal MC sample is also prepared for MC9 sample.

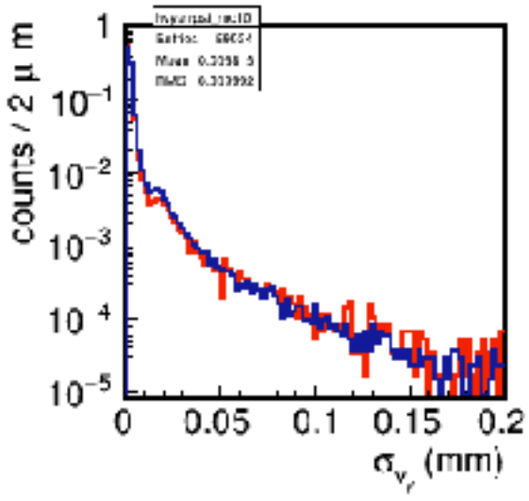


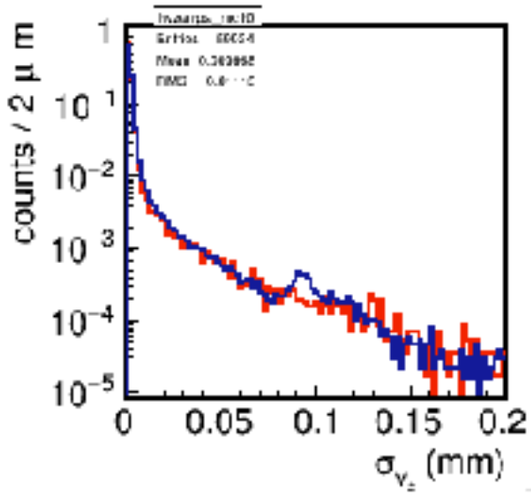












MC9 J/ψKs

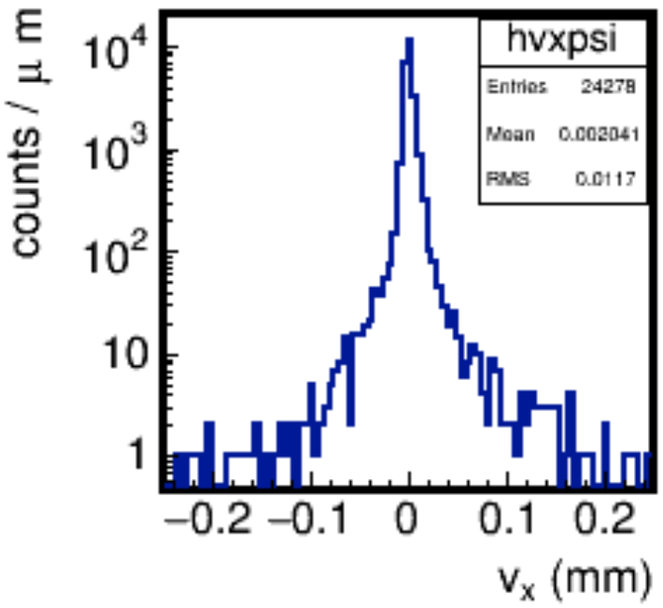
MC10 J/ψKs

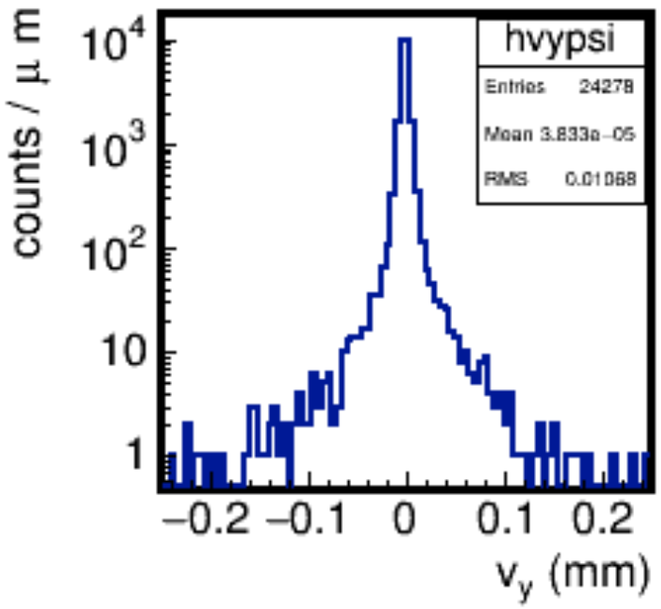
MC truth only,
All plots are
normalized to 1

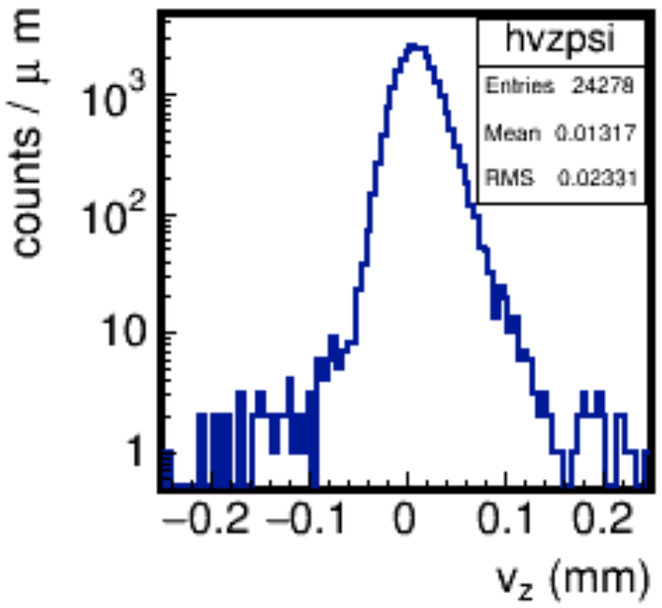
Concentration around σ_z~0.1 mm is smaller comparing mixed MC but exist in only MC9 signal MC. → modification is confirmed.

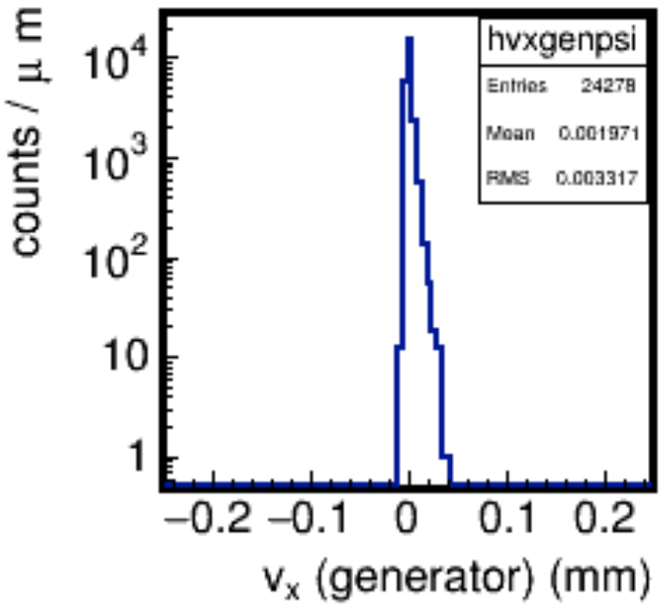
Vertex generator information

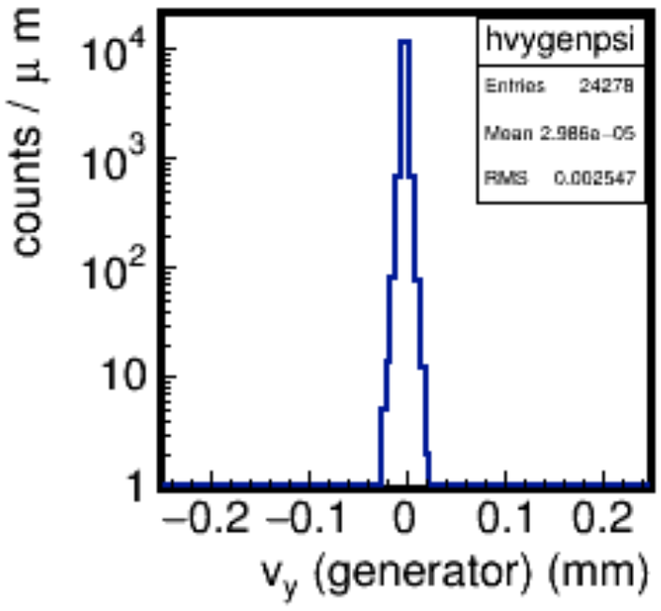
MC10 J/ψKs

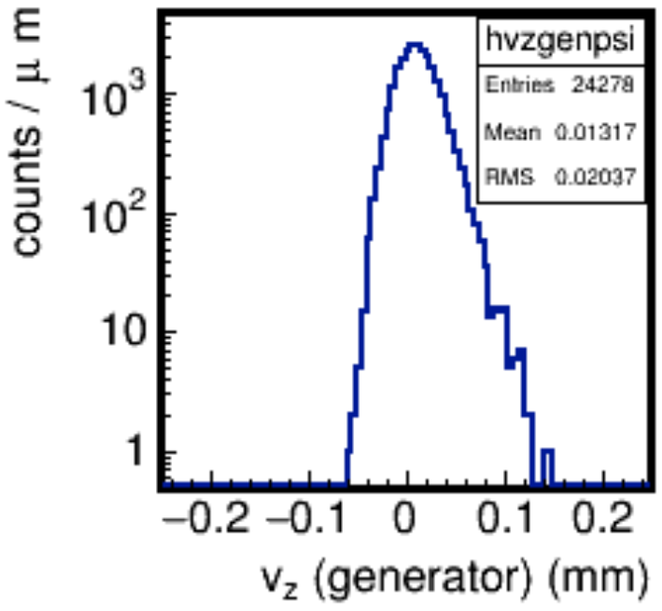










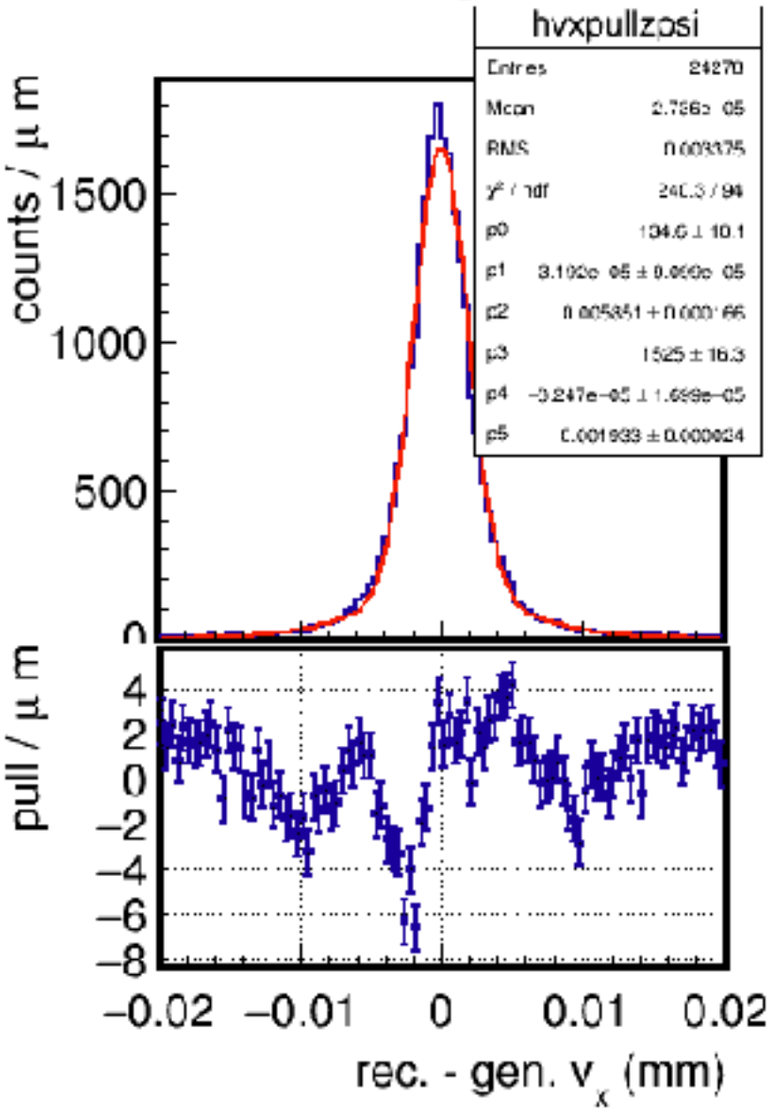


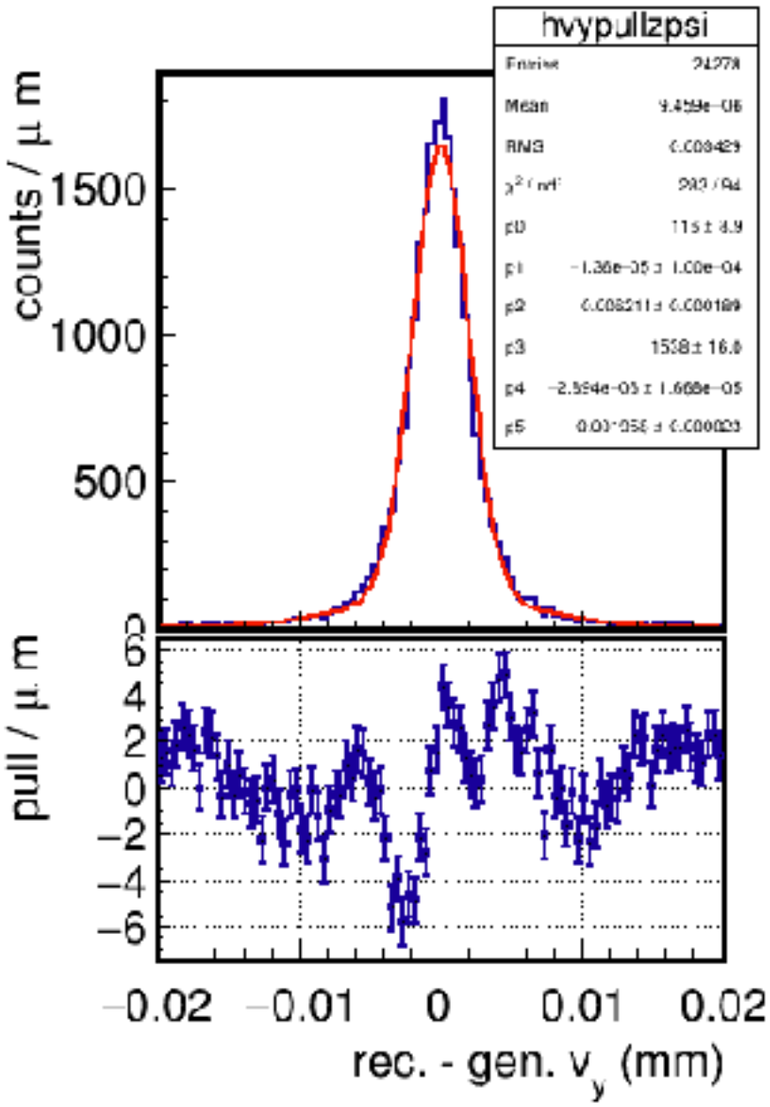
Shift in v_z (also v_x?) is seen in generator information.

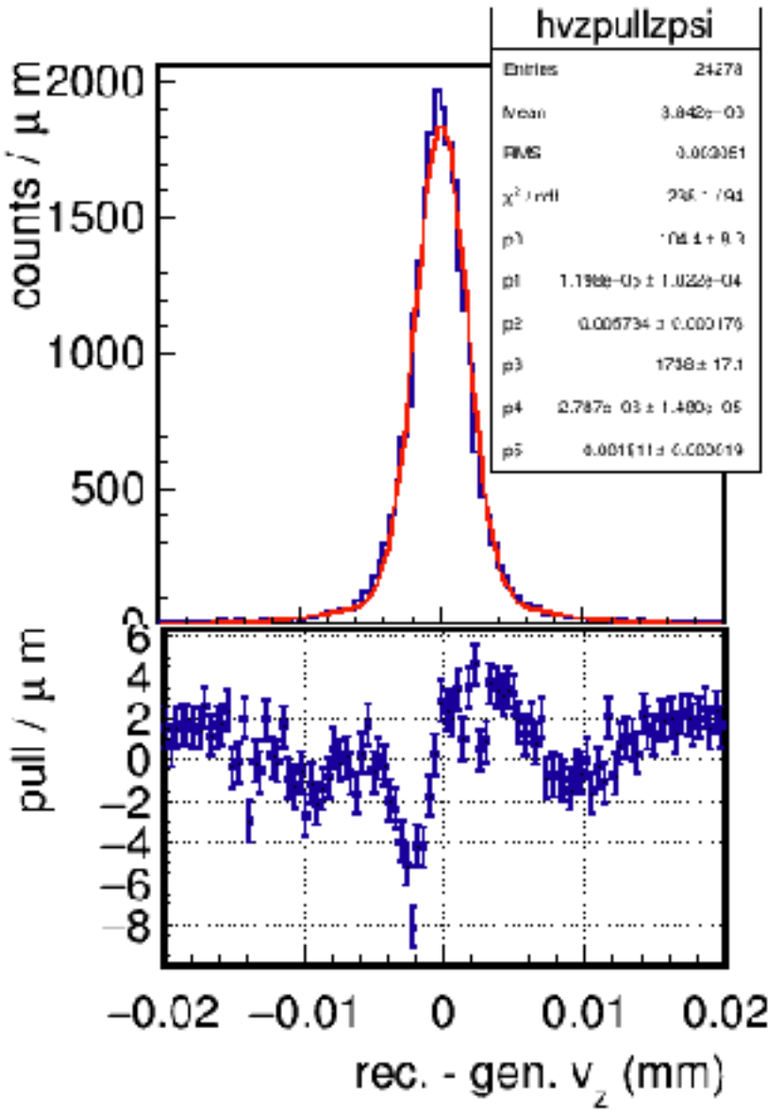
Vertex generator information

MC10 J/ψKs

(rec. vtx – gen. vtx) distribution → corresponds to $R_{det} \oplus R_k$?







Fits with double Gaussians are performed for x, y and z.

→ Obtained result is almost same.

How to get further information

By following the steps are standard flow of basf2 analysis.

1. Define daughter particle
2. Create particle list of the decay
3. Add information to the particle list
4. Define parameters written in ntuple

In step 4, NtupleTools are used. There are standard parameters are implemented. If we need further information, we should extracted from modules and add. (According to the NtupleTools confluence, “It is easy”)

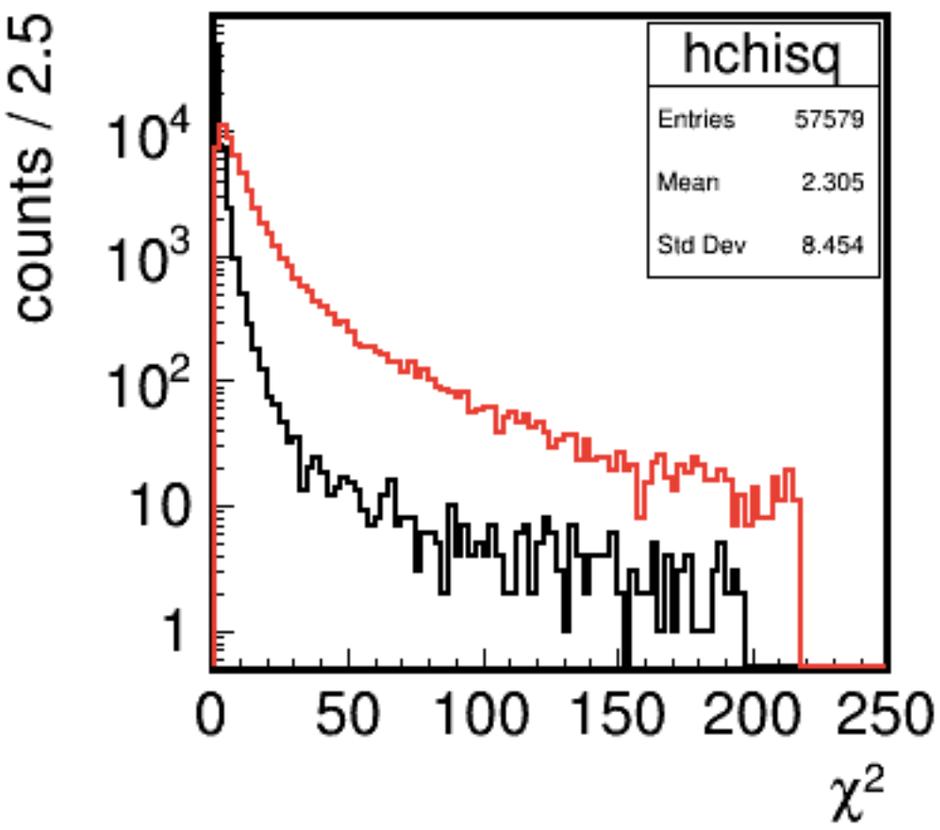
Vertex

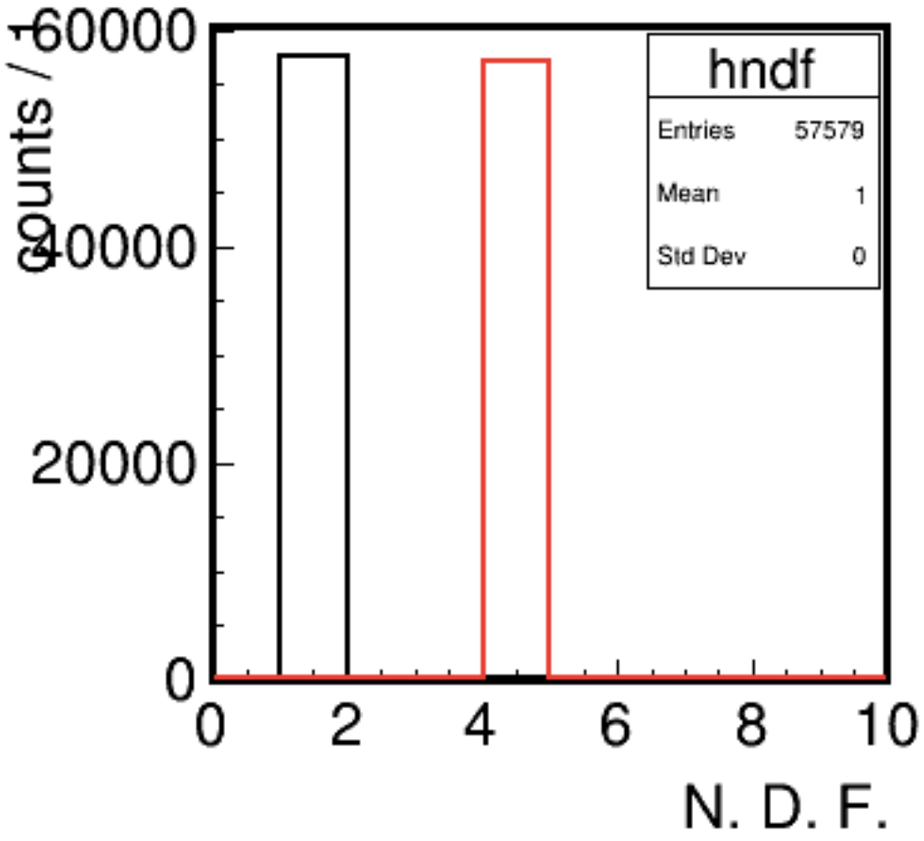
Variable	Description	Type
X, Y, Z	Vertex Position	float
ErrX, ErrY, ErrZ	Vertex Position Error	float
Rho	Sqrt(X^2+Y^2)	float
VtxPvalue	Vertex Quality	float
VtxProd	Production Vertex (X,Y,Z)	float[3]
VtxProdCov	Production Vertex Covariance	float[3][3]

Source: NtupleVertexTool.h, NtupleVertexTool.cc

Additional information distribution

Vertex fit using kfitter for MC10 $B^0 \to J/\psi(\to e^+e^-)K^0_S$





tracks only

w/ IP profile

I can not run with IP tube. It seems to be under development

[FATAL] ParticleVertexFitter: kfitter does not support yet the iptube constraint { module: ParticleVertexFitter_J/psi function: bool Belle2::ParticleVertexFitterModule::doVertexFit(Belle2::Particle*) }

Some issues for obtained plots

- Definition of N.D.F?
- No single track vertex?
- χ^2 / P-value distribution by IP information is reasonable?

Issues for obtained plots

analysis/KFit/src/VertexFitKFit.cc

```
VertexFitKFit::calculateNDF(void) {
  if (m_FlagBeam) m_NDF = 2 * m_TrackCount;
  else if (m_FlagTube) m_NDF = 2 * (m_TrackCount - 1) - 1;
  else if (m_FlagKnownVertex) m_NDF = 2 * m_TrackCount;
  else m_NDF = 2 * m_TrackCount - 3;

  return m_ErrorCode = KFitError::kNoError;
}
```

→ For tracks only: N.D.F = $2N_{track} - 3 = 1$

IP profile: N.D.F = $2N_{track} = 4$

analysis/modules/ParticleVertexFitter/src/ParticleVertexFitterModule.cc

```
bool ParticleVertexFitterModule::doVertexFit(Particle* mother)
{
   ⋮
  bool ok = false;
  // fits with KFitter
  if (m_vertexFitter == "kfitter") {
    // TODO: add this functionality
    if (m_decayString != "")
      B2FATAL("ParticleVertexFitter: kfitter does not support yet selection of daughters via decay string!");
```

Daughter selection is supported only for Rave but decision is base on decay chain, not track parameters.

Issues for obtained plots

analysis/KFit/src/KFitBase.cc

```
KFitBase::doFit2(void) {

 for (int j = 0; j < KFitConst::kMaxIterationCount; j++)   // j'th loop start
  {
        ⋮
    tmp_chisq = KFitConst::kInitialCHIsq;

      if (tmp_chisq <= chisq) {
        if (i == 0) {
          m_ErrorCode = KFitError::kBadInitialCHIsq;
        } else {
```

analysis/KFit/include/KFitConst.h

```
static constexpr double kInitialCHIsq = 1.0e+30;
```

I cannot find other selection for χ^2. According to Sumisawa-san, maximum value of vertex quality has correlation with limit of the vertex fit iteration.

→ Try to check the values in each iteration.

Summary

- Start to check vertex parameters using basf2 and MC.

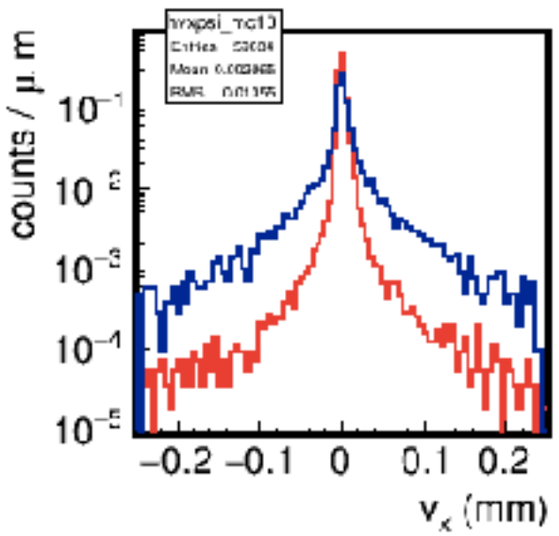
- Check plots for parameters that are already registered in ntuple tools and obtained by writing python steering file.
  → confirm modification of vertex fitter in MC10 sample.

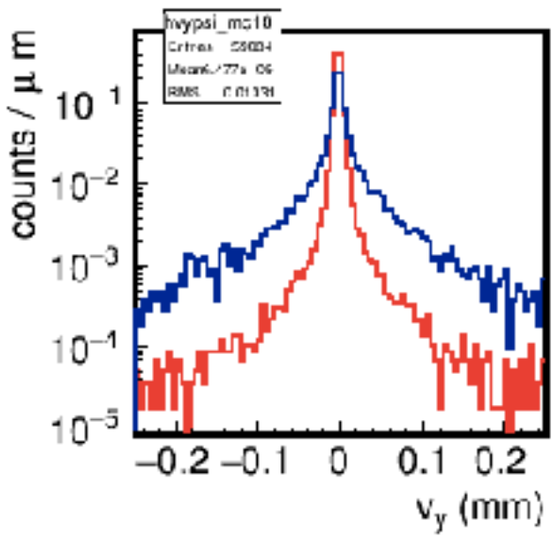
- Modification of Belle2 library has been done.
  χ^2, N.D.F are registered as additional information of mother particle.

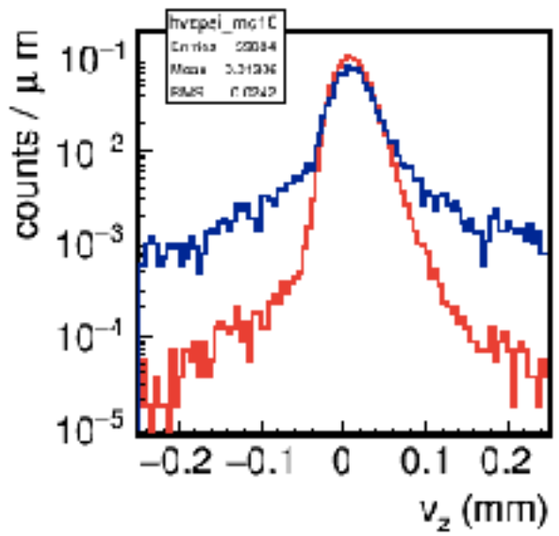
- Vertex coding is checked based on obtained distributions.
  N.D.F definition, selection for tracks and χ^2
  Some of the items are under development.
  → Try to modify the modules

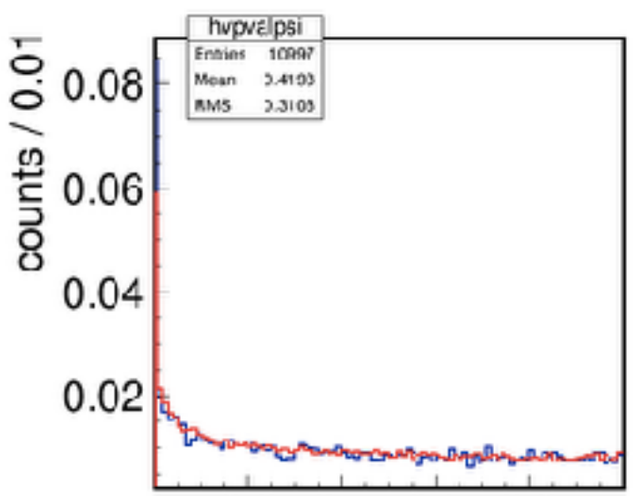
backup

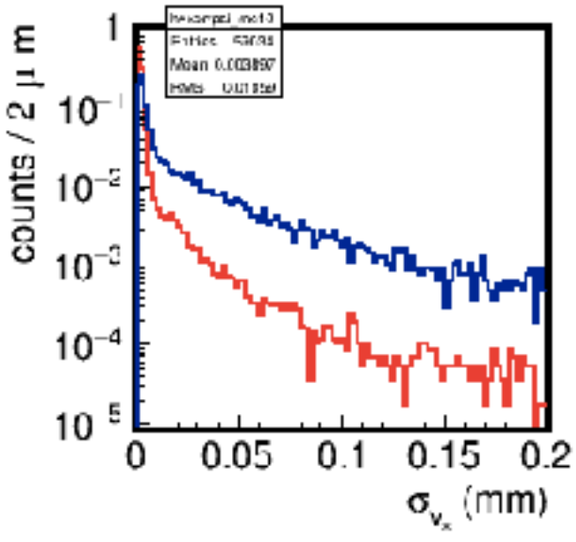
J/ψ vertex reconstruction

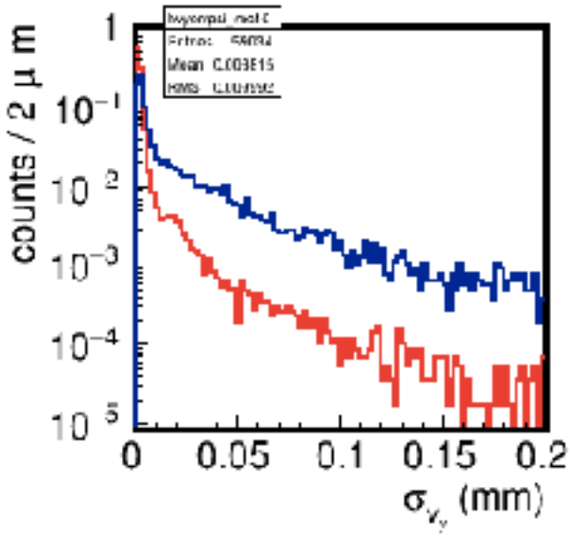


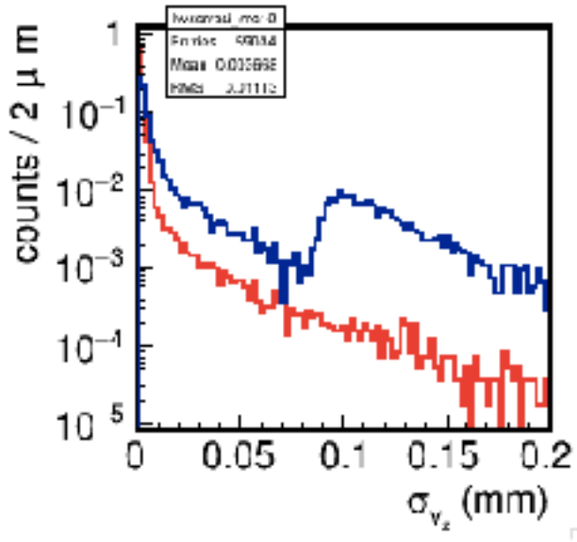












MC9 mixed

MC10 J/ψKs

MC truth only,
Normalized to 1

z error distribution seems to become normal
but whole distribution changes → effect of decay mode?