Accuracies For Different VD(In the Search of Dibaryons with small energy excitations)

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November 21, 2023

Introduction

In June this year on monthly SPD meeting we did presentation with the title *Resolution Of Spd Detector in the Search Of Dibaryons with small energy excitations* . We also did presentations on the Conferences DSPIN23 and Baldin23, based on this document and got some feedback in the form of very useful questions and remarks.
The most serious question is: Many physicists think that such states(Dibaryons) do not exist and in their argumentation they say that if they existed the cross sections of $NN \to NN$ interactions would show some irregularites(or peaks) at some energies.
In a figure below(produced by PDG group) we show the cross section of pn interaction as a function of the energy. The region between two vertical lines in this picture corresponds to two-nucleon interaction at the energy below pion production.
On this picture the region is shown by arrow where the situation is unclear and there are chances that Dibaryons may exist.
So we think that future SPD detector could do more accurate search for Dibaryons in the questonable areas of two-nucleon mass. It is also known that VD subsystem of SPD may have three options - MVD or MAPS or DSSD. The aim of this presentation is what accuracies we may have at each of this options?

Introduction,Cross section of pn interaction

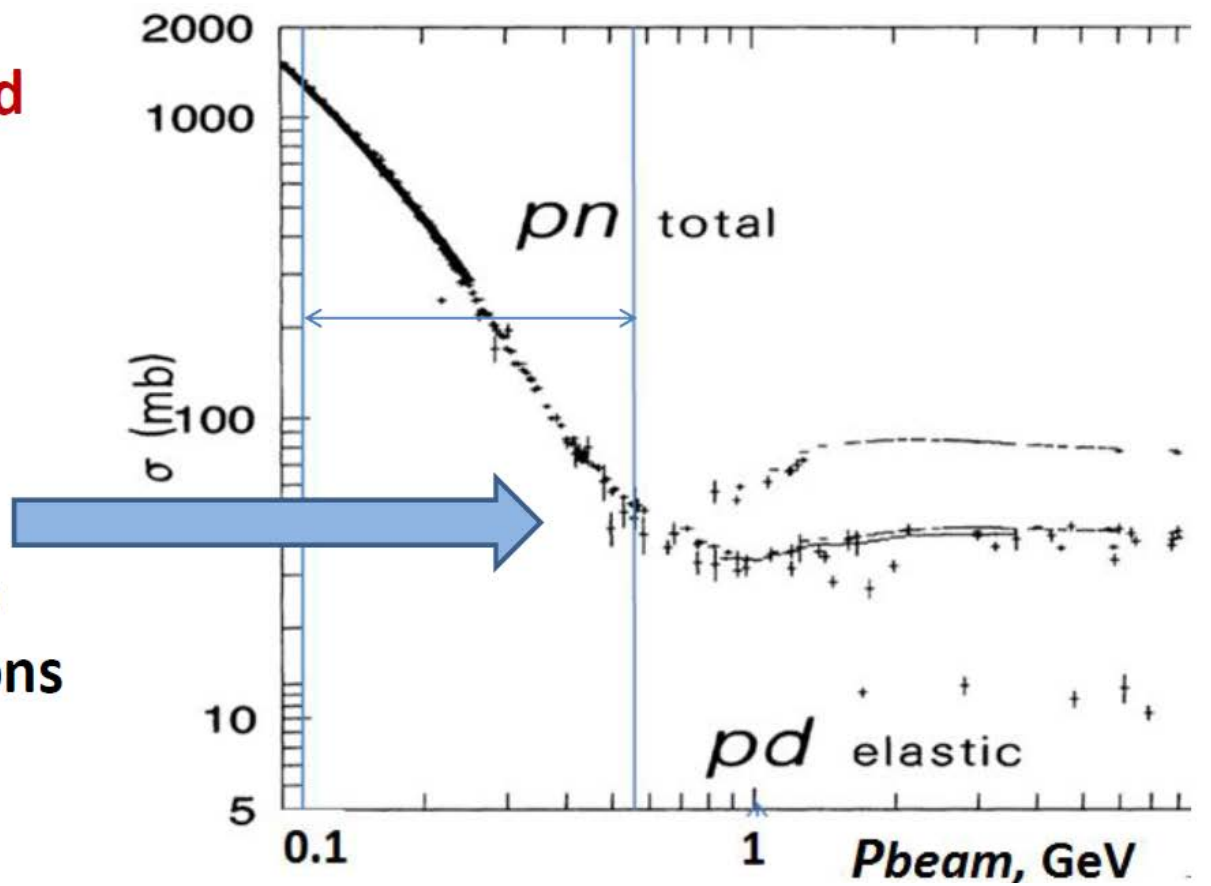
Most reliable and precise data

recommended for use by PDG in 2023

https://pdg.lbl.gov/rpp-archive/files/PhysRevD.45.S1.pdf

From gold-bearing sand to gold

For the upper energy part of spectrum some chances for the existence of light resonant dibaryons still remain.



As a reminder - Main Details of The Previous Study

As was told, previous study was done for three values of dibaryon masses(MX) and fixed deuteron momentum tranfer.In such a case unbroken deuteron has a constant momentum value in a final state and momentum of the proton distributed according to some spectrum whose range depends from MX. The bigger MX the wider its width and for biggest MX equal to 1.97685GeV it varies from $\approx 0.75 GeV/c$ to 1.8GeV/c(see low picture in the next figure).For MX equal to 1.90935GeV proton momentum varies from 1GeV/c to 1.6GeV/c(upper picture).Due to this main accuracies below have a meaning of the averages for corresponding proton spectrum. Also we have shown that appropriate resolutions in dibaryon masses may be obtained if in the processing of the data we would use kinematical fit technique.Resolutions for different dibaryon masses(MX) which were obtained in such approach are shown in a table below.

Table: The results of fitting($M_d - MX$) for all MX's. Everything in GeV

$M_d - MX$	mean $\pm\sigma$(RMS)
-0.0338	-0.0339 $\pm$ 0.0020(0.0083)
-0.0675	-0.0676 $\pm$ 0.0027(0.0126)
-0.1013	-0.1014 $\pm$ 0.0024(0.0151)

The results,shown in a table, were obtained in the assumption that VD subdetector is produced as DSSD. The aim of the current presentation is to get precisions in other realizations of Vertex Detector. We want to stress that in our conditions secondary particles are registered in End Cups of SPD Detector and all the conclusions are only for this part

Introduction, Conditions of the study

So we are talking about X systems ,produced in the reactions $d + d \rightarrow d + X$ with consequent decay $X \rightarrow p + n$,with mass $MX = M_d + E_{exc}$ and $E_{exc} < m_{\pi^0}$ mass. Conditions of the study equivalent to the experiment Baldin et al.,Communication of the JINR, Dubna 1979,1-12397

- Momenum is 2.6GeV/c,equivalent to 8.9 on fixed target
- Transferred momentum of unbroken deuteron $t = -0.5(GeV/c)^2$
- E_{exc} is taken as a fractons of π^0 mass equal to 1/4,1/2,3/4(or masses 1.90935,1.94310,1.97685 in GeV)
- All the collisions are taking place in central point of detector(coordinates $x = y = z = 0$),deuteron and proton tracks and primary vertex are reconstructed and dibaryon has zero decay width.

Proton Momentum Ranges used in this study

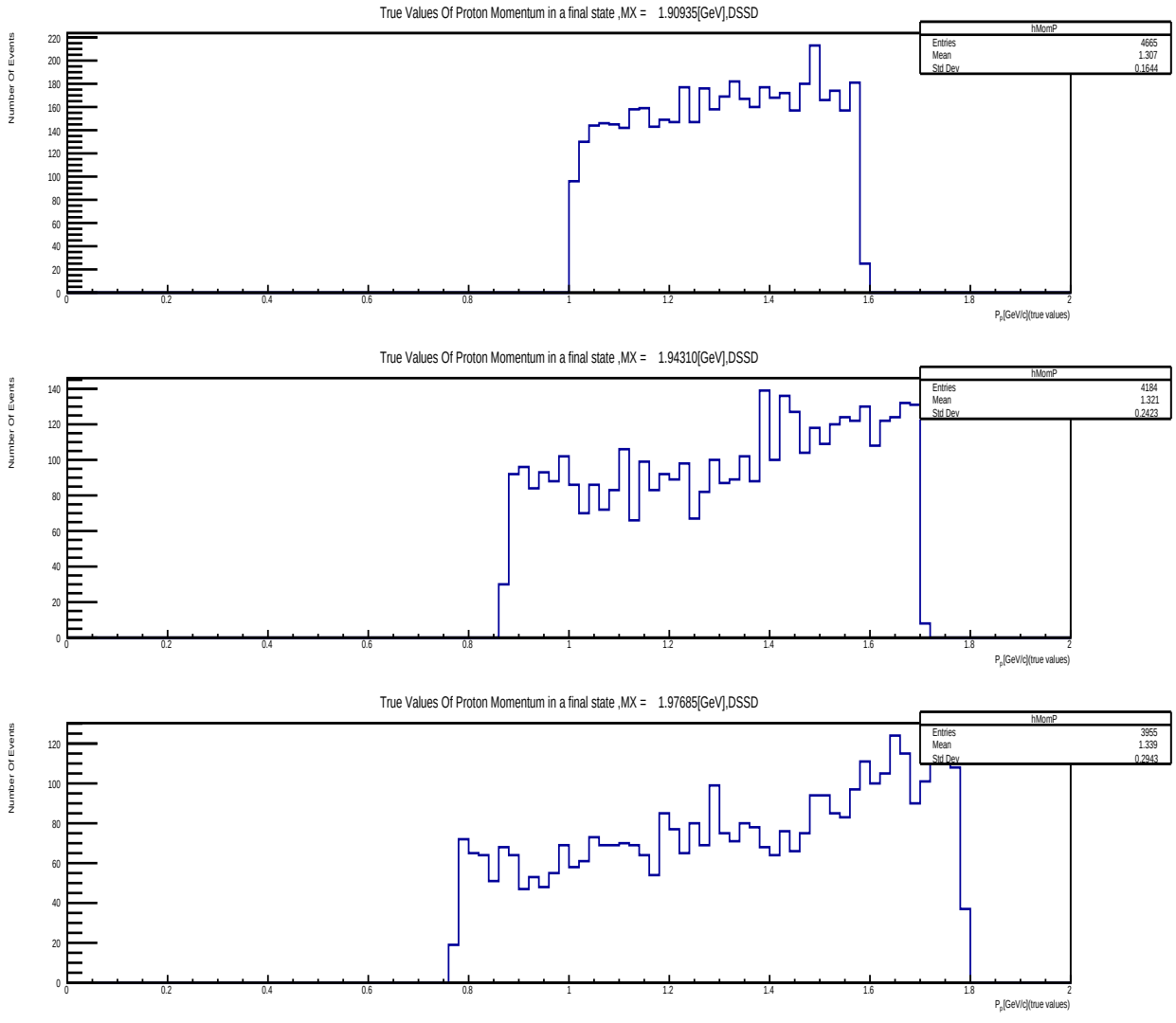


Figure: Momentum Ranges[GeV] used in this study

Accuracies of Original Momentum Reconstruction by GenFit2 code for MX=$1/4 m_{\pi^0}$(=1.90935GeV)

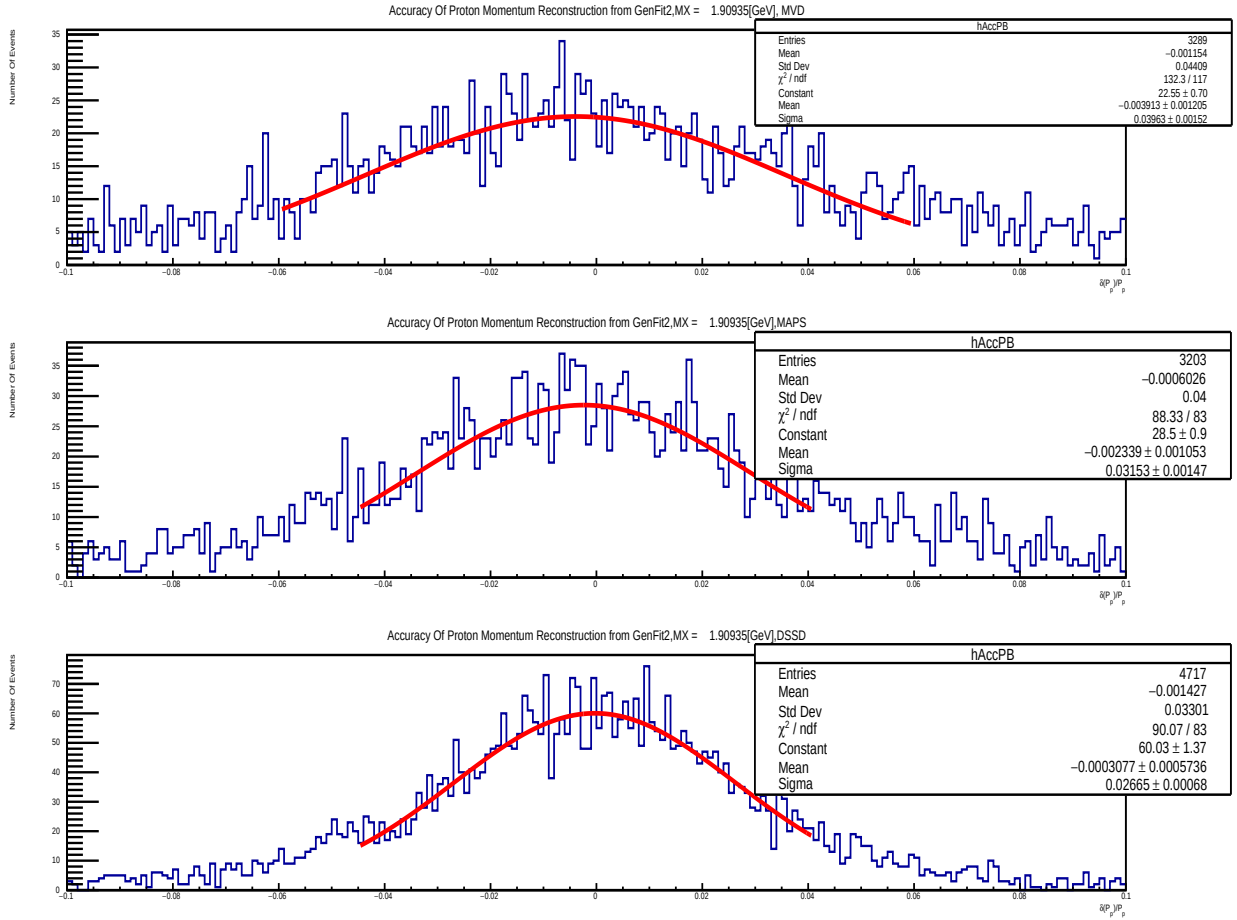


Figure: Accuracies in Momentum Reconstruction by GenFit2 code. From top to bottom - MVD,MAPS,DSSD

Accuracies of Original Momentum Reconstruction by GenFit2 code for MX=$1/2m_{\pi^0}$(=1.94310GeV)

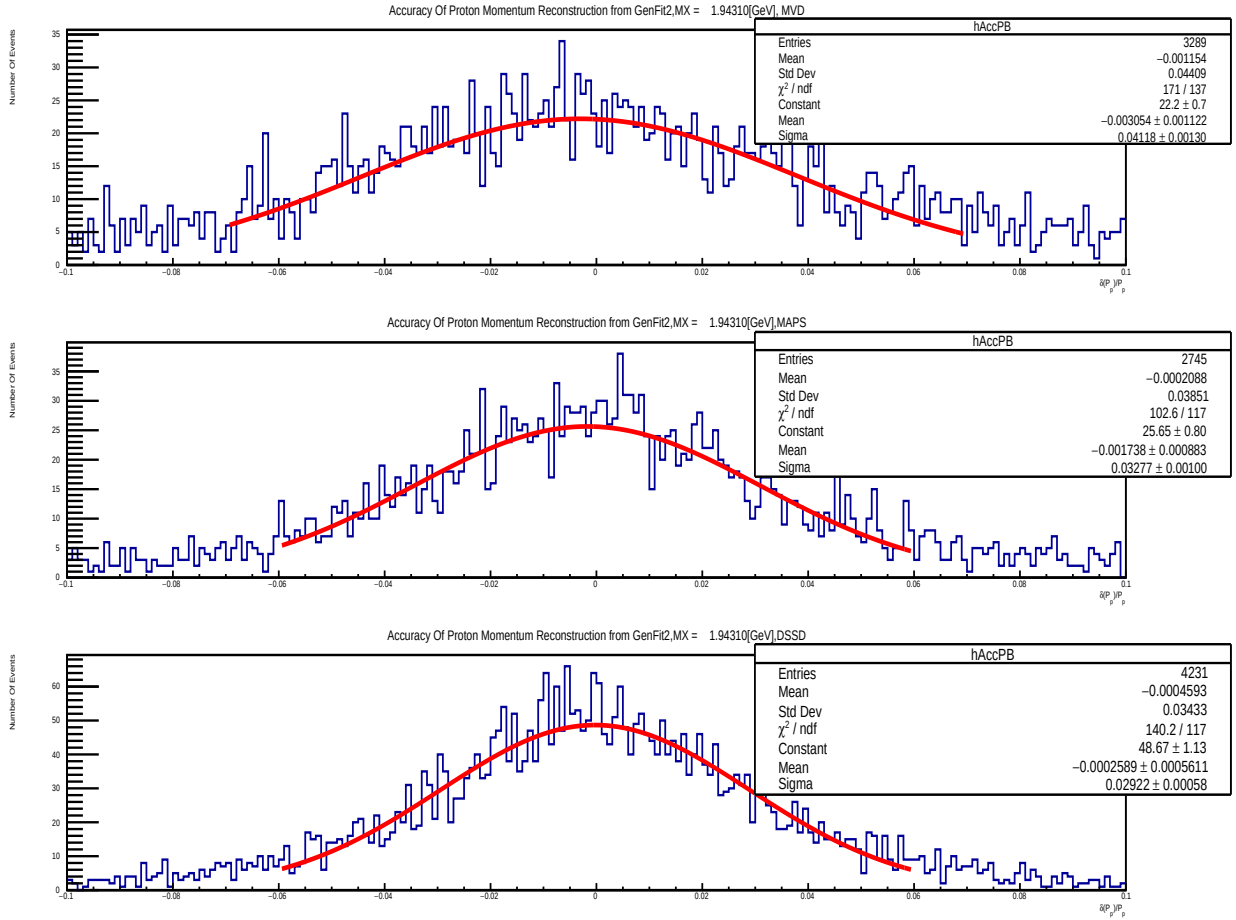


Figure: Accuracies in Momentum Reconstruction by GenFit2 code. From top to bottom - MVD,MAPS,DSSD

Accuracies of Original Momentum Reconstruction by GenFit2 code for MX=$3/4 m_{\pi^0}$(=1.97685GeV)

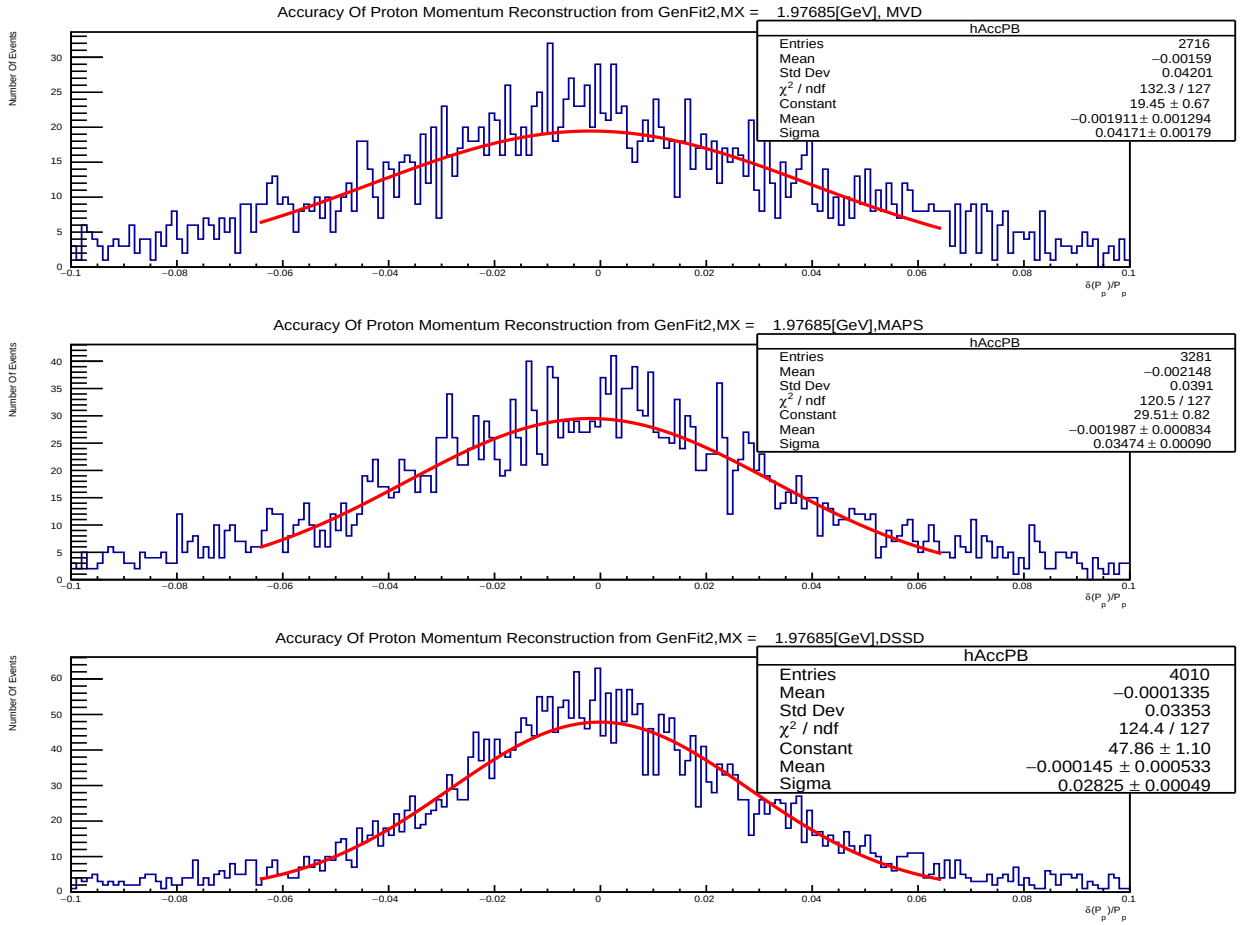


Figure: Accuracies in Momentum Reconstruction by GenFit2 code. From top to bottom - MVD,MAPS,DSSD

Conclusion about Accuracies in Proton Momentum Reconstruction by GenFit2 code for different VD's

To our knowledge such accuracies were analyzed before, but for compatibility purposes we decided to show similar values. Still we stress, that because protons in this study hit only End Cups of the SPD, it may be interesting of its own.
In a table below we show resolutions for different VD's. We can see that accuracies for DSSD are slightly better than for MAPS. Accuracies for DSSD and MAPS are remarkably better than for MVD. All of them do not change with MX

$M_d - MX$	MVD	MAPS	DSSD
-0.0338	0.040 ± 0.002	0.032 ± 0.001	0.027 ± 0.001
-0.0675	0.041 ± 0.001	0.033 ± 0.001	0.029 ± 0.001
-0.1013	0.042 ± 0.002	0.035 ± 0.0001	0.028 ± 0.001

Table: Accuracies in Proton Momentum Reconstruction by GenFit2 code for different VD's

Resolution of dibaryon mass for MX=$1/4 m_{\pi^0}$

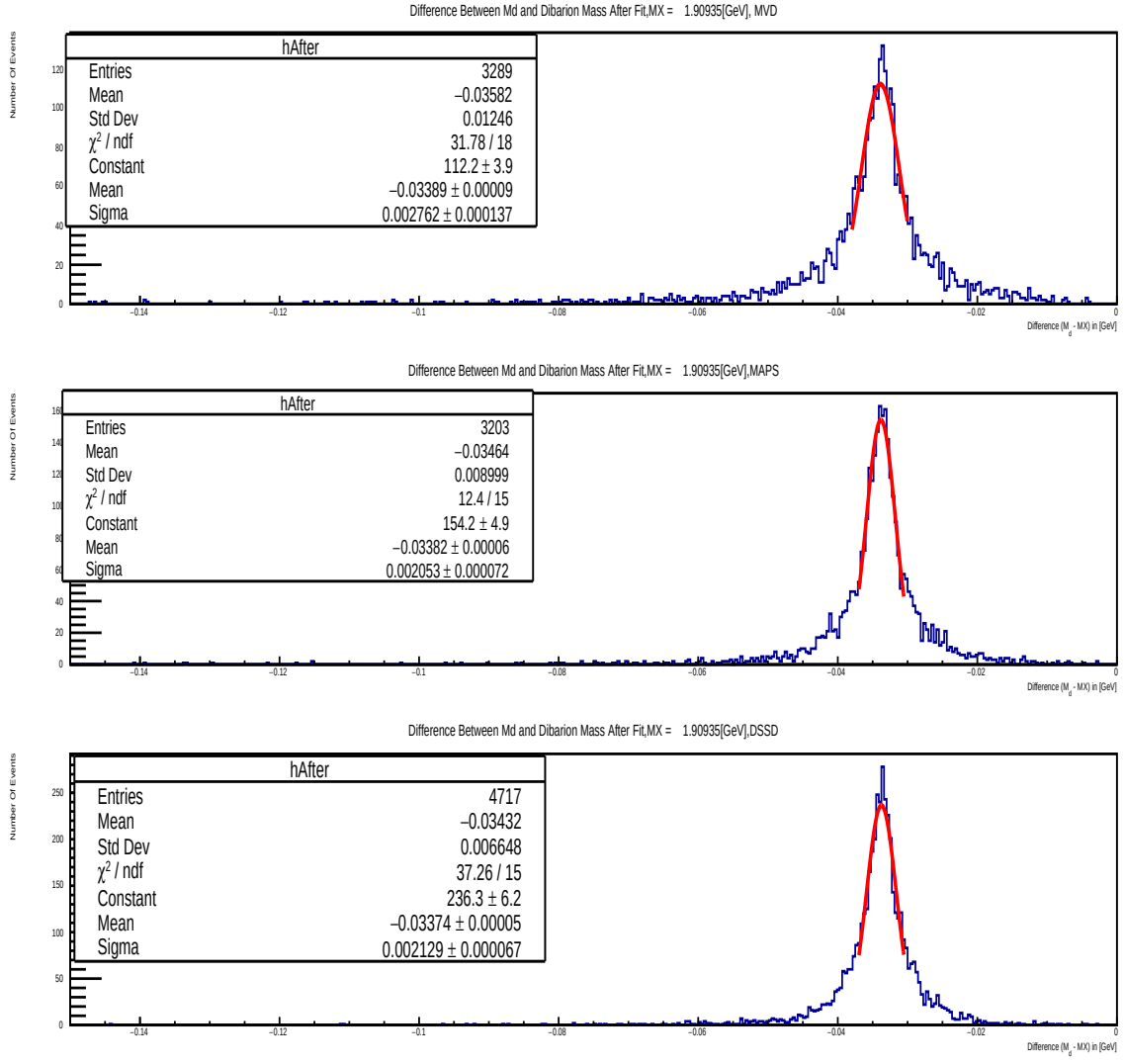


Figure: Accuracies in MX reconstruction for different VD's. From top to bottom - MVD,MAPS,DSSD

Resolution of dibaryon mass for MX=$1/2m_{\pi^0}$

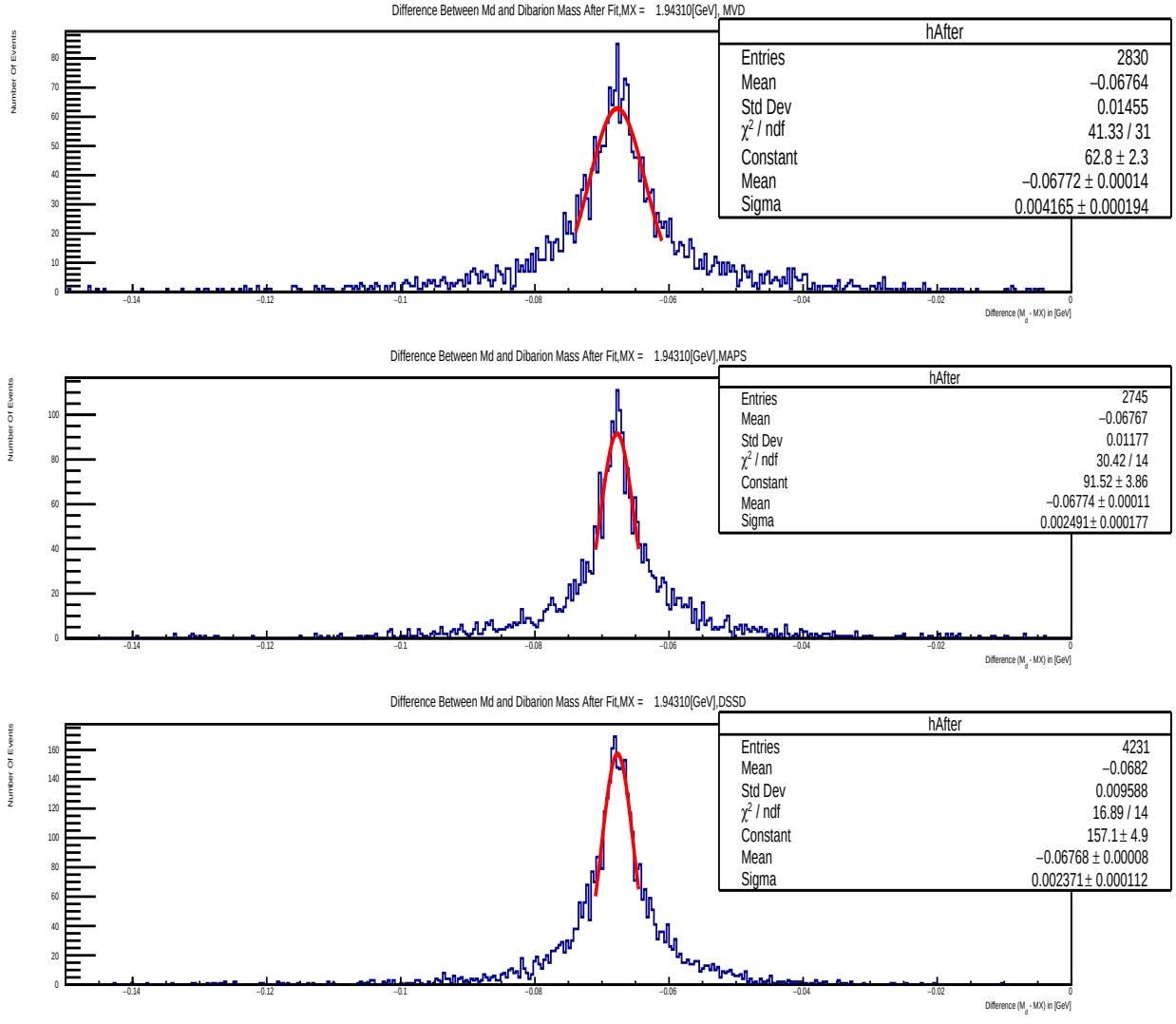


Figure: Accuracies in MX reconstruction for different VD's. From top to bottom - MVD,MAPS,DSSD

Resolution of dibaryon mass for MX=3/4m_{π^0}

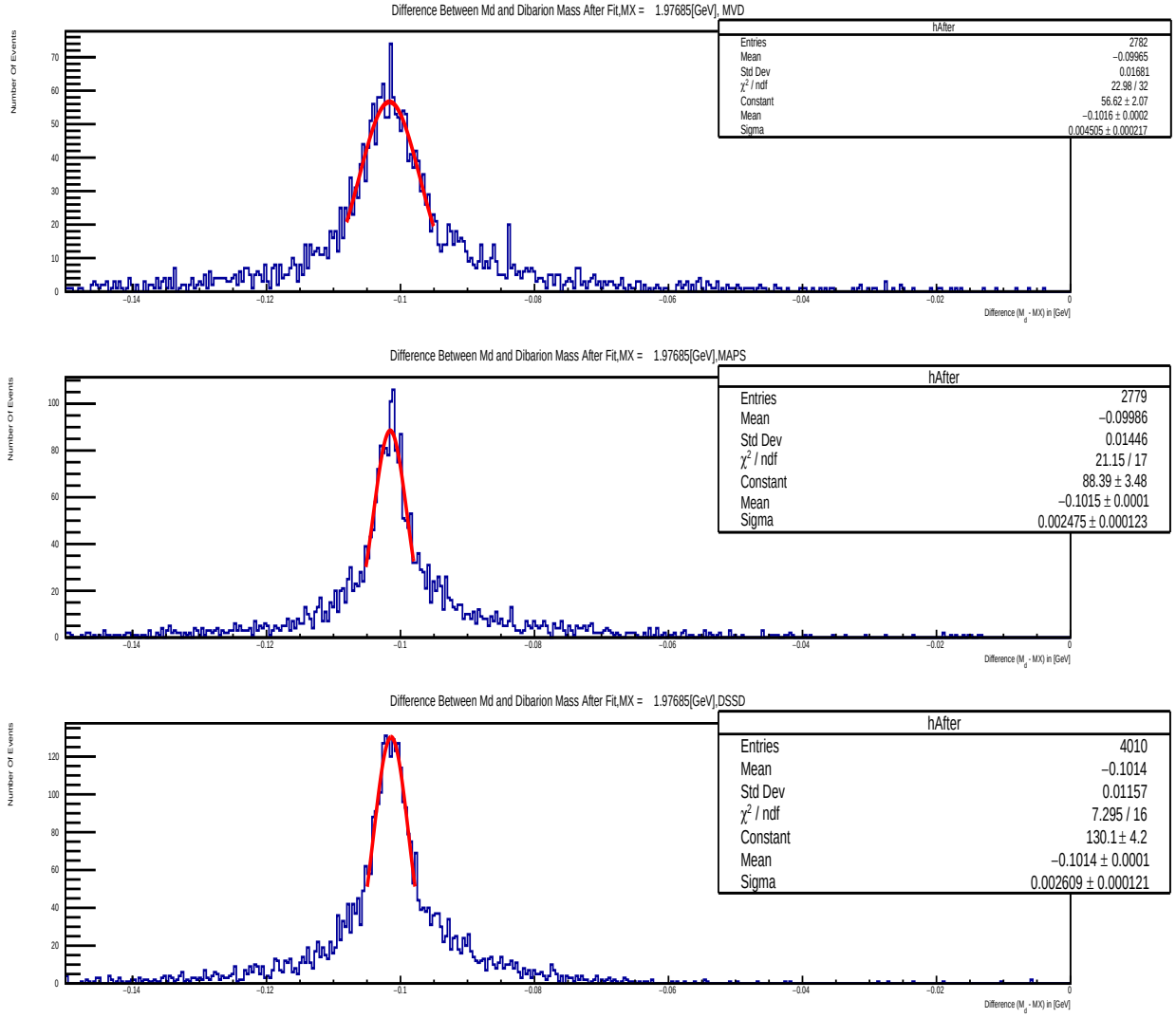


Figure: Accuracies in MX reconstruction for different VD's. From top to bottom - MVD,MAPS,DSSD

Conclusion about MX Accuracies for different VD's

In a table below we show resolutions for different VD's. We can see that for MAPS and DSSD accuracies are more or less the same. As for MVD its accuracy much worse compared with MAPS and DSSD.
For all types of VD the resolutions are worsening with the growth of MX.

$M_d - MX$	MVD	MAPS	DSSD
-0.0338	0.0028 ± 0.0001	0.0021 ± 0.0001	0.0022 ± 0.0001
-0.0675	0.0042 ± 0.0002	0.0025 ± 0.0002	0.0024 ± 0.0001
-0.1013	0.0045 ± 0.0002	0.0025 ± 0.0001	0.0026 ± 0.0001

Table: Resolution of dibaryon mass for different VD's.Everything in GeV

Summary

In a model study we obtained accuracies at the estimation of dibaryon mass at the energy range below pion production for different types of Vertex Detector(VD). It is seen that MVD type of VD is inferior to two other types. **As for MAPS and DSSD they have similar accuracies and the selection between them may be done on the base of production cost**