"Search of Dibaryons with small energy excitations" - *as a first possible experiment on SPD*

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Cross section of pn interaction

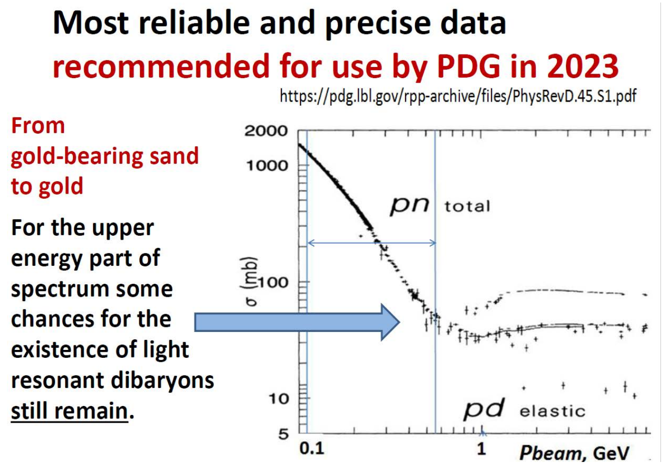

Figure 1: Cross section of *pn* interaction. Two vertical lines limit the region below pion production

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 excitation* . 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 irregularities(or peaks) at some energies.
In a fig.1(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.

Missing Mass from Baldin experiment (Baldin et al.,Communication of the JINR, Dubna 1979,1-12397)

In a figure 2 we show the results of Baldin experiment where on fixed target dd interaction at 8.9GeV/c was studied. . You may see two pronounced peaks,left one is dd elastic scattering,next is (according to authors) the scattering of incident nucleon(inside broken euteron) on deuteron. Detailed structure of this peak is also very interesting and deserves detailed consideration

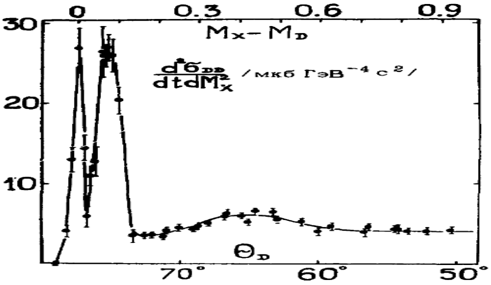

Рис.2. Зависимость двойного дифференциального сечения $\frac{d\sigma}{dt\,dM_X^2}$ процессов D + D → M_X+D и N + D → ND от угла эмиссии дейтрона отдачи при t =0,5 (ГэВ/с)^2.

On monthly SPD meeting in November we presented the report with the title *Accuracies For Different VD (In the Search of Dibarions with small energy excitation)*.
In all of them we estimated dibarion mass resolution at very simplified assumptions- we assumed
that dd collisions take place in the same point at the center of SPD detector with fixed transfer momentum to unbroken deuteron. At that time our purpose was to show the principal possibility to reach reasonable resolutions in dibarion masses.It was shown that for dibarion massess, corresponding to three excitation energies(1/4,1/2,3/4) of π^0 mass the resolution was less than 3MeV.(see
'https://indico.jinr.ru/event/3914/contributions/22175/attachments
/16173/27606/Dibarion.pdf')

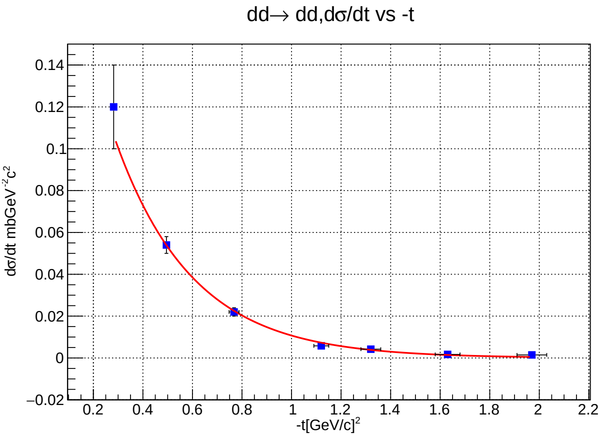

Figure 3: Transfer momentum distribution from Baldin experiment

Conditions of the simulation

In the current presentation we are estimating dibarion mass resolution omitting these restrictions. So the conditions of the study:

- Mass of the dibarion X in the reaction $d + d \rightarrow d + X$ was taken as $M_X = md + E_{exc}$,where md is deuteron mass, E_{exc} is the excitation energy equal to $E_{exc} = 3/4 m_{\pi^0}$ and m_{π^0} is the π^0 mass
- The width of dibarion X was equal zero(this was done specially to estimate resolution)
- Momentum of deuteron in dd collisions 2.6GeV/c
- The distribution of Transfer momentum for unbroken deuteron is taken from Baldin experiment obtained for dd elastic scattering , see fig. 3
- Cooridinates of primary vertex were generated by Gaus - for Z with $\sigma = 40cm$,for X,Y with $\sigma = 0.08cm$
- For the analysis only the events with $-35cm < Z < 35cm$ were selected

Few details of data processing

In a previous presentations we gave detailed description of data processing. Shortly, it is chain of steps, consisting from simulation,reconstruction and analysis, aimed on getting dibarion mass resolution. In the analysis we used kinematical fit technique, which gave dramatic improvement in the accuracy of mass reconstruction.
Such a procedure was made twice for two types of VD detectors - for Micromegas-based Tracker(here called MVD) and Double-Sided Silicon Detector (DSSD)
In both cases by 10000 $d + d \to d + X$ events were generated and went through all the suitable steps in a processing.Mass of dibarion was equal to 1.97685GeV. Resolutions were estimated as σ's of Gauss fitting in the maxima of the suitable distributions. The results are shown in the two following pictures.

Resolution for MVD option

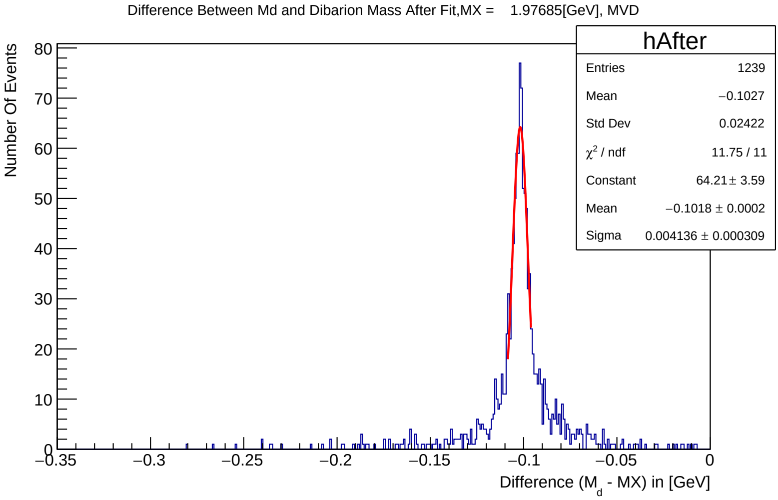

Figure 4: Difference $M_d - M_X$ in GeV, M_d, M_X are deuteron and dibarion masses respectively

Resolution for DSSD option

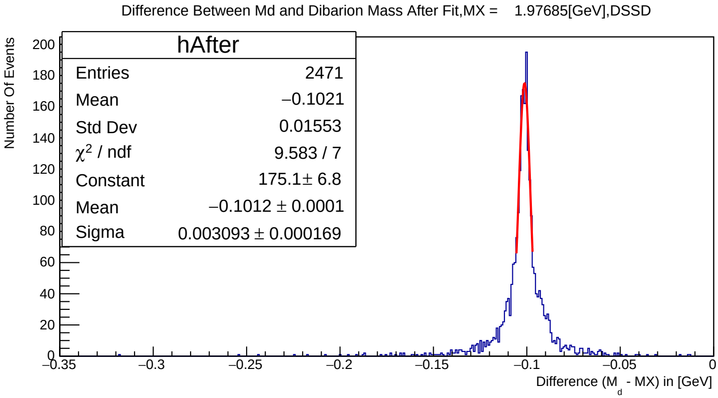

Figure 5: Difference $M_d - M_X$ in GeV, M_d, M_X are deuteron and dibarion masses respectively

Luminosity of dd collisions

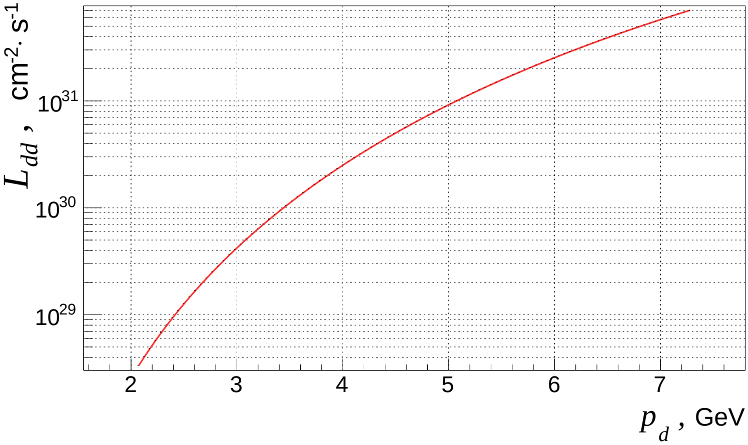

Figure 6: Luminosity of deuteron beam in a symmetric mode

Counting rate.May this process be a candidate for first SPD experiments?

Factors for the estimation of Counting Rate:

- Luminosity of dd for Collider Momentum $2.6 GeV/c$ is $\approx 1.7 \cdot 10^{29} cm^{-2} sec^{-1}$
- Cross section of $d + d \rightarrow d + X$ for $(0.282 < -t < 1.97)(GeV/c)^2$ is $0.033 mb$
- Fraction of the Luminosity corresponding to the probability of having primary vertex in the selected region is 0.382

Counting rate $\approx 2.1 sec^{-1}$

Comparison of the resolutions

when	MVD	DSSD
prevous	0.0045$\pm$ 0.0002	0.0026 $\pm$ 0.0001
now	0.0041$\pm$ 0.0003	0.0031 $\pm$ 0.0002

Table 1: Resolution of dibaryon mass for different VD's.Everything in GeV. Here "prevous" means the estimate for simulation with fixed vertex at the center of detector and momentum transfer $t = -0.5(GeV/c)^2$;"now" is for the conditions of current simulation

In a table 1 we compare the resolutions of SPD detector for two variants of the simulation.
So called "prevous" and "now" in the left column of table 1 are explained in the caption of the table. Errors shown in the table are from fit by root and we may say that the resolutions are practically the same taking into account the fit errors.

Summary and Acknowledgments

We think that process analyzed by us may be a good candidate for the very first runs of future SPD detector. Accuracies,counting rates look very optimistic and simplicity of the process is very appealing!

The other interesting investigation which can be performed simultaneously with the current one is the study of the scaling behaviour of exclusive reactions $2 \to 2$ or so called CCR rule(Preprint of JINR,Abramov et al V.V. Abramov et al E2-2021-12).According to this rule $d\sigma/dt$ of such processes follow the law $\sim s^{n-2}f(t/s)$, where n is the sum of constituent quarks. The reactions to be studied are $dd \to^3 Hp, dd \to^3 Hen, dd \to^4 He\pi^0$.

We would like to thank A.Philippov(staff member of LPHE) for his calculations of the Luminosity and our colleague V.Andreev(member of SPD collaboration) for useful suggestions about running SpdRoot.