Изоскалярное дибарионное состояние d*(2380): вчера, сегодня, завтра

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University of Tübingen, Germany

Модель Dyson-Xoung

Phys. Rev. Lett., v13, 815 (1964) [1]

частица	I	J	предсказание масс $A = m_d = 1876$ MeV $B \approx 47$ MeV			
D_{01}	0	1	A	=	1876	**d**
D_{10}	1	0	A	=	1876	NN(FSI)
D_{12}	1	2	A+6B	=	2160	ΔN
D_{21}	2	1	A+6B	=	2160	ΔN
D_{03}	0	3	A+10B	=	2350	**ΔΔ**
D_{30}	3	0	A+10B	=	2350	ΔΔ

D_{03} may be found in phase-shift analysis of n-p scattering [1]

Дибарион d*(2380) в эксперименте WASA-at-COSY

P. Adlarson et. al Phys. Rev. Lett. 106:242302, 2011

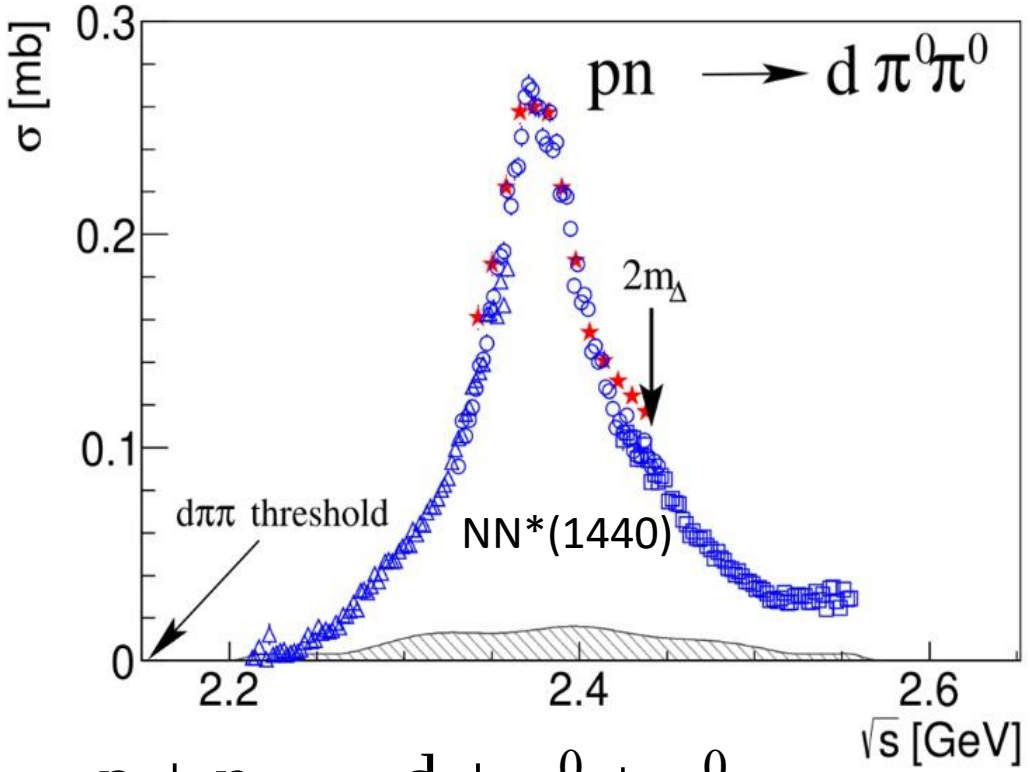
M_{d^*}=2380 МэВ Γ_{d^*}=80 МэВ

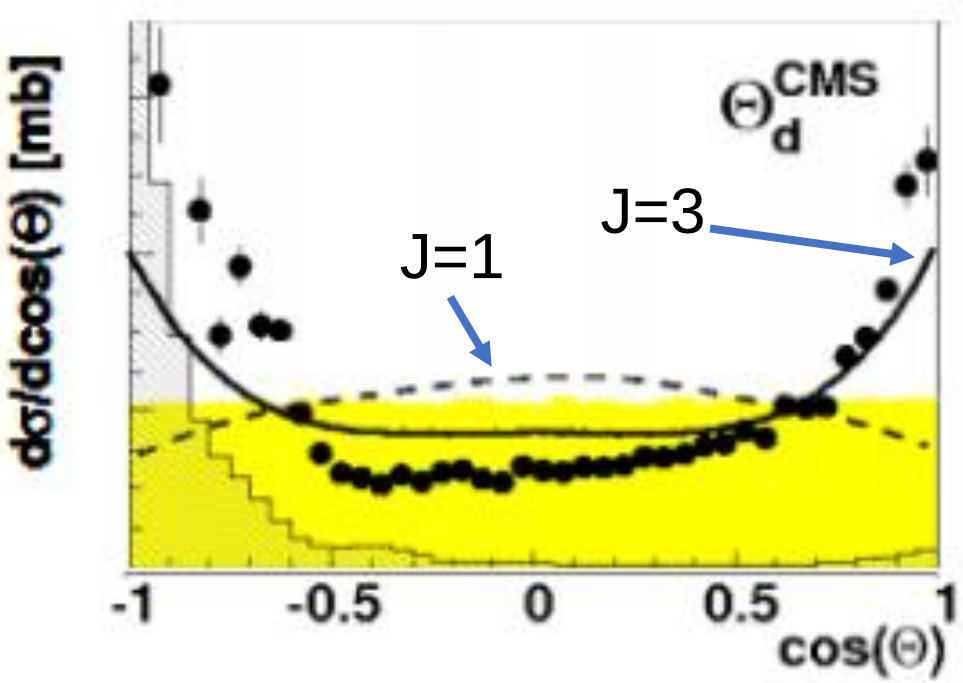
△ T_p = 1.0 ГэВ

○ T_p = 1.2 ГэВ

□ T_p = 1.4 ГэВ

* T_p = 1.2 ГэВ





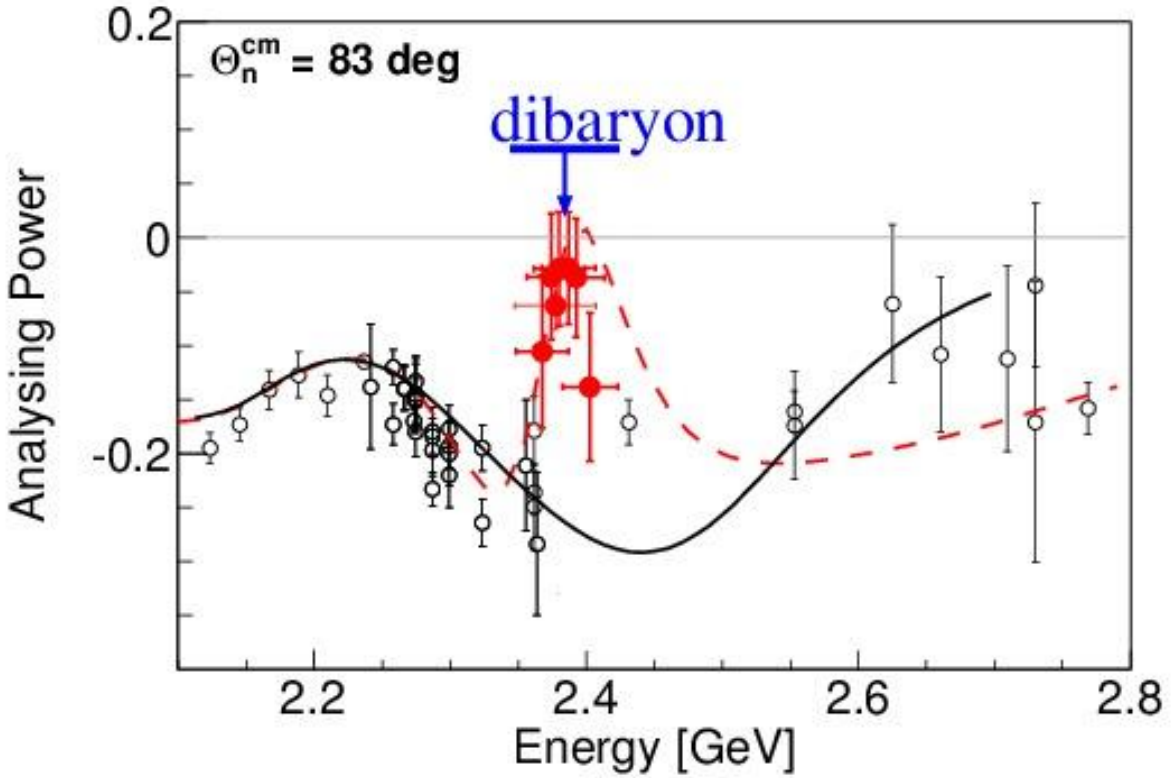
$$\underbrace{p + n}_{0,\,1} \longrightarrow d + \underbrace{\pi^0 + \pi^0}_{0,\,2}$$

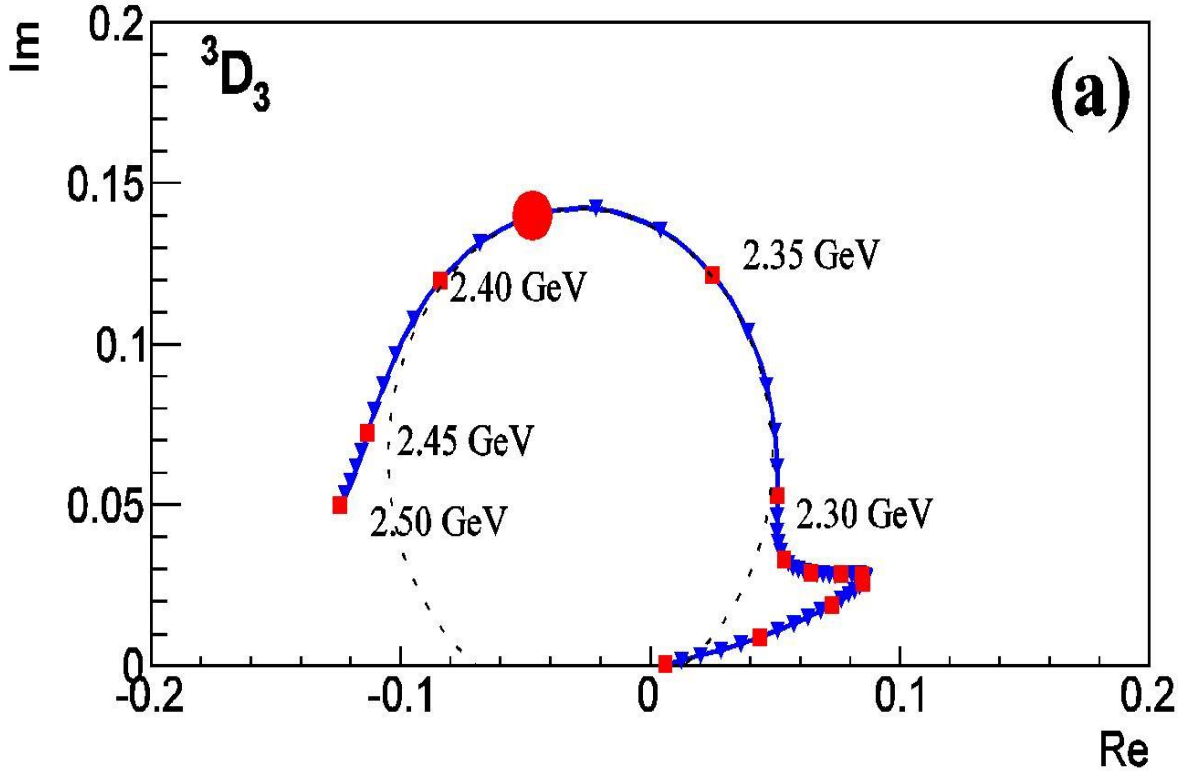
I= 0, 1 0 0, 2

$I(J^P) = 0(3^+)$

$\vec{n}p \rightarrow d^*(2380) \rightarrow pn$

PRL 112 (2014) 202301 arXiv:1408.4928





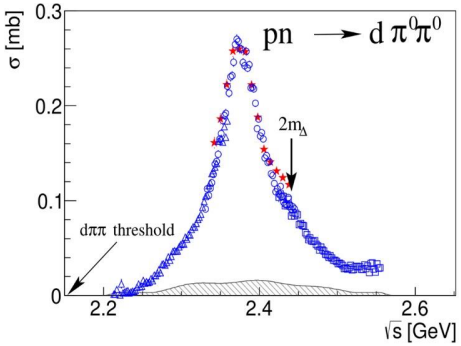
прежнее SAID SP07 решение

новое SAID SP07 решение

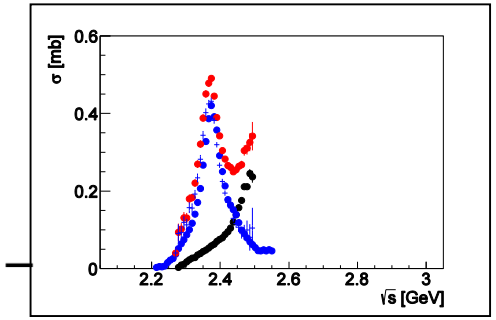
Наилучшая оценка для полюса

(2380 ± 10)МэВ $- i(40 \pm 5)$МэВ

Измеренные каналы d*



PRL 106 (2011) 242302



$$\sigma(pn \to d\pi^+\pi^-) = \frac{1}{2}\sigma(pn \to d\pi^+\pi^0) + 2\sigma(d\pi^0\pi^0)$$

PLB 721 (2013) 229

$pn \to d^*(2380)$

$d\pi^0\pi^0$

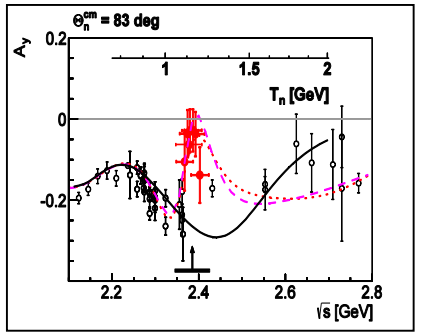
$d\pi^+\pi^-$

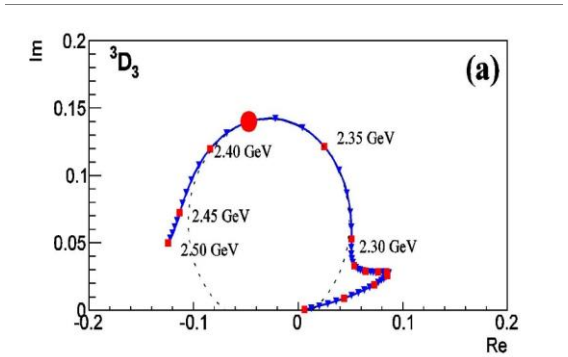
pn

$pp\pi^-\pi^0$

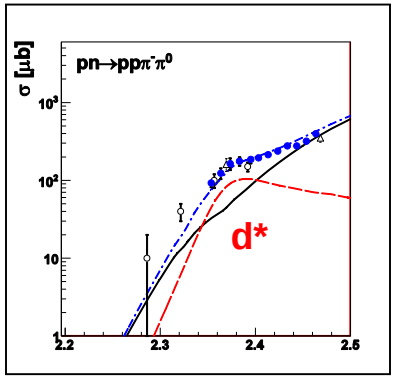
$pn\pi^0\pi^0$

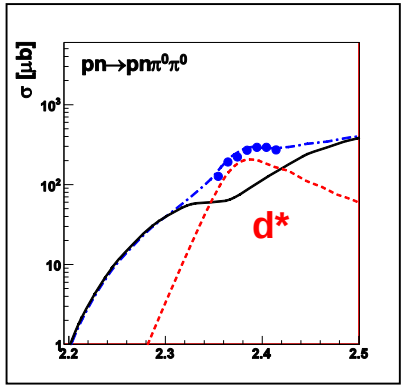
$pn\pi^+\pi^-$

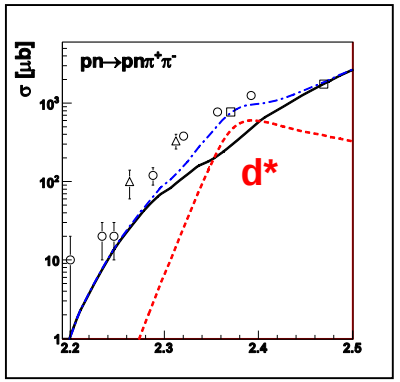




PRL 112 (2014) 202301
arXiv:1408.4928







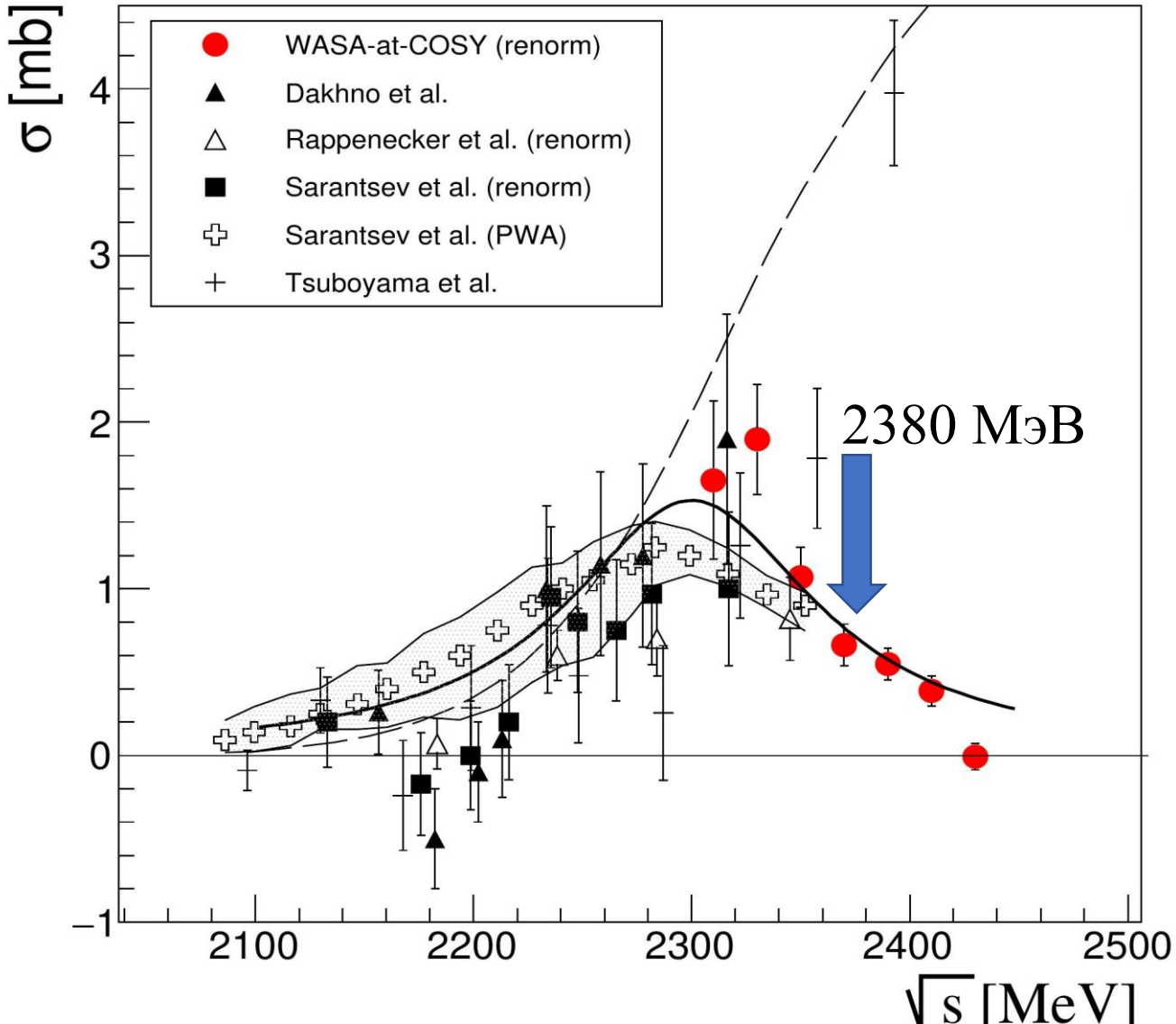
PRC 88 (2013) 055208
arXiv:1409.2659

Моды распада d*

decay channel	experiment		theory *		$NN\pi\pi$ isospin recoupling
$d\pi^0\pi^0$	14 ± 1		12.8		13
$d\pi^+\pi^-$	23 ± 2		23.4		26
$np\pi^0\pi^0$	12 ± 2	$\Delta\Delta$	13.3	$D_{12}\ \pi$	13
$np\pi^+\pi^-$	30 ± 5		28.6		32.5
$pp\pi^0\pi^-$	6 ± 1		4.9		6.5
$nn\pi^+\pi^0$	6 ± 1		4.9		6.5
$(NN\pi)_{I=0}$	< 5 (90% $C.L.$)		0.9		–
np	12 ± 3		12.1		–
$d\gamma$	≈ 0.01				
$\sum(total)$	103 ± 7		100		

*H. Huang, J. Ping, C. Deng and F. Wang, Phys. Rev. C 90 (2014) 064003
Y. Dong, F. Huang, P. Shen and Z. Zhang, Phys. Lett. B 769 (2017) 223

Изоскалярное сечение $pn \rightarrow NN\pi$ (I=0)



https://doi.org/10.1103/PhysRevC.106.065204

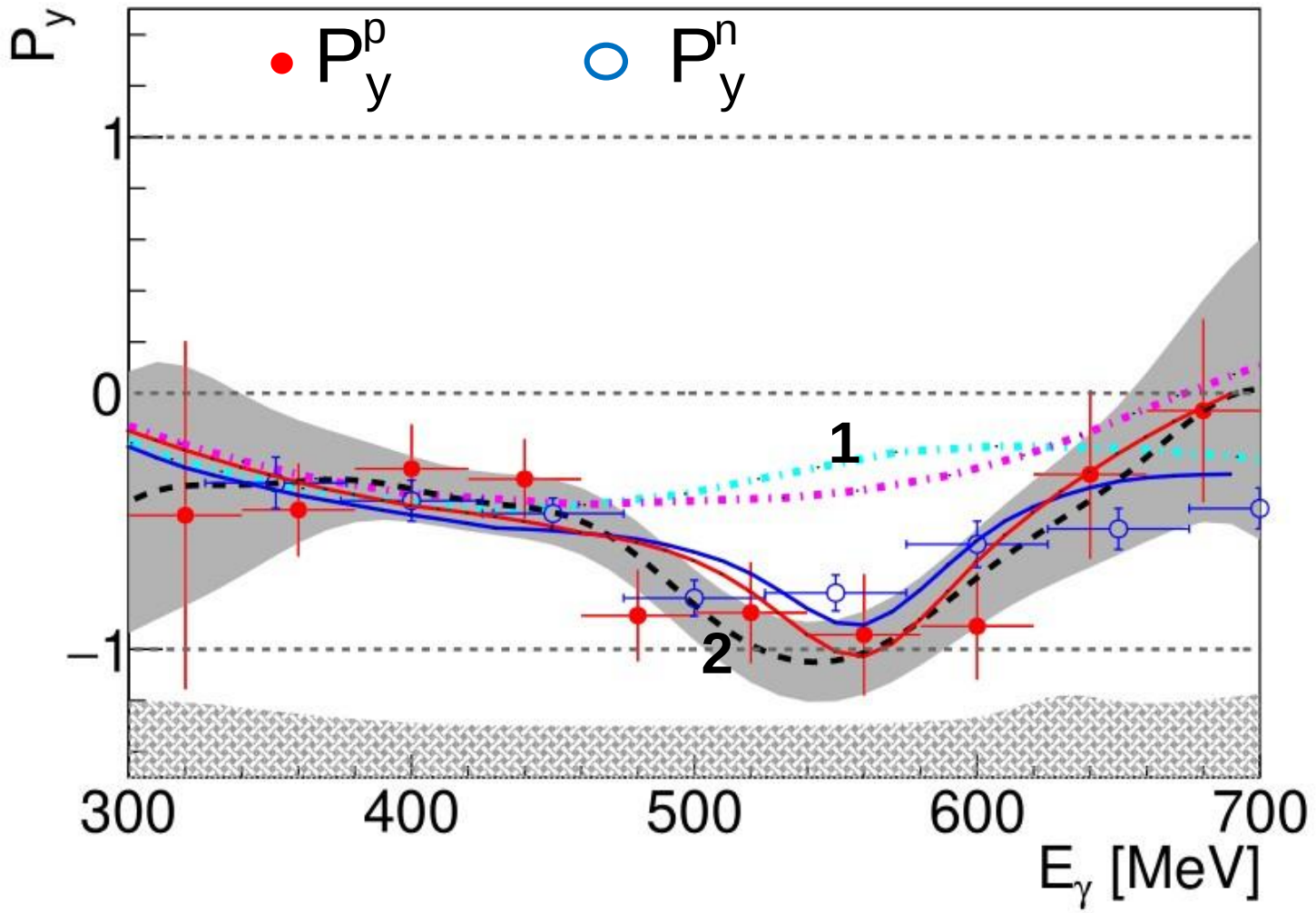
BW
M=2315 МэВ и Г=150 МэВ

t-канальное
возбуждение N*(1440)

Поиск d*(2380) A2@MAMI

https://doi.org/10.1103/PhysRevLett.124.132001

$\gamma d \rightarrow \vec{p} n$



1:

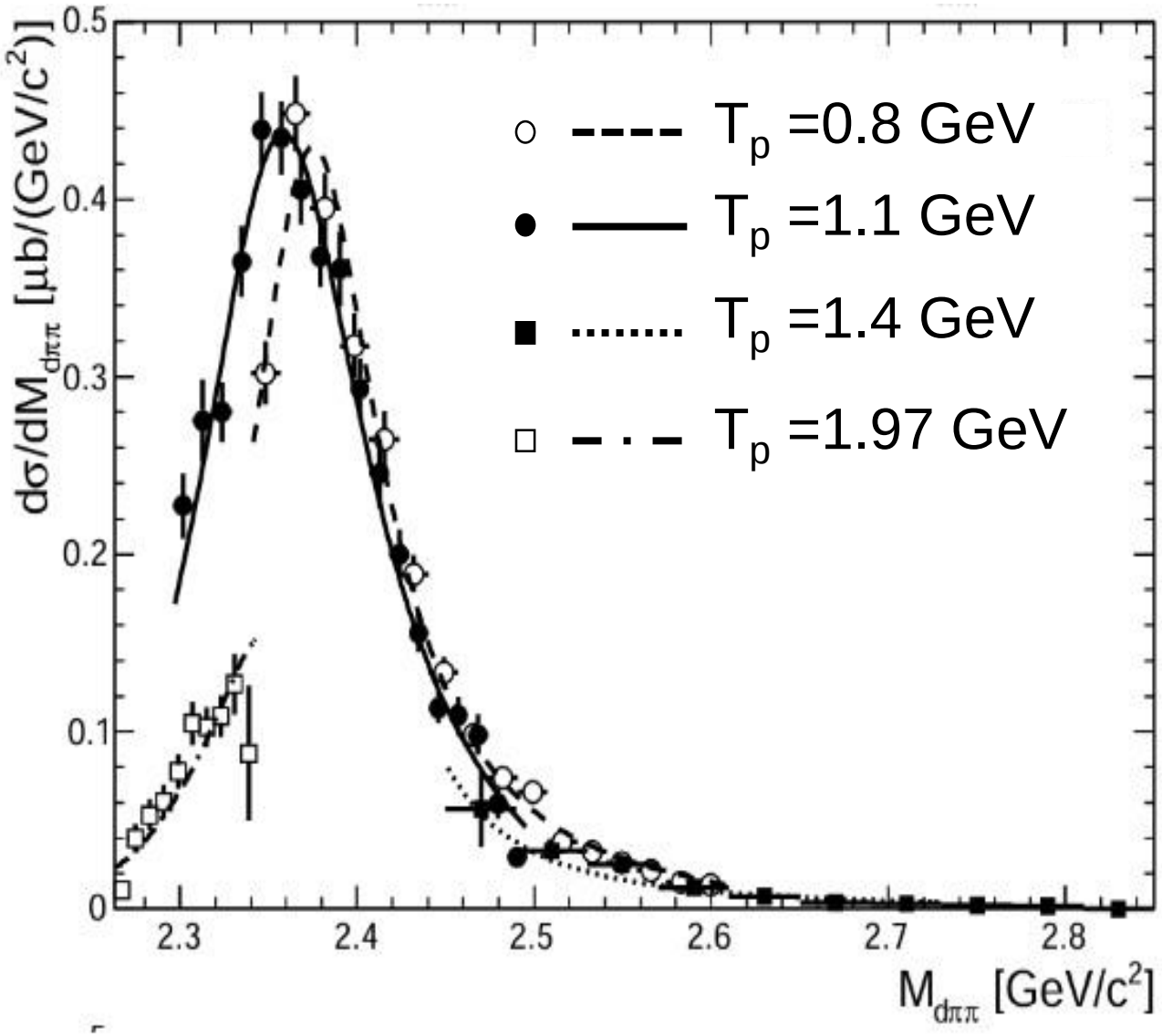
π, ρ, η, ω обмен + возбуждение «обычных» барионов

2:

1 + d*(2380)

Поиск d*(2380) ANKE@COSY

https://doi.org/10.1140/epja/i2018-12641-0



p + d → p + d + X

$$0.073\ (\mathrm{GeV}/c^2)^2 < M^2_{\pi\pi} < 0.17\ (\mathrm{GeV}/c^2)^2,$$
$$0.982 < \cos\theta_p^{\mathrm{cm}} < 1,$$
$$-1 < \cos\theta_d^{d\pi\pi} < -0.98.$$

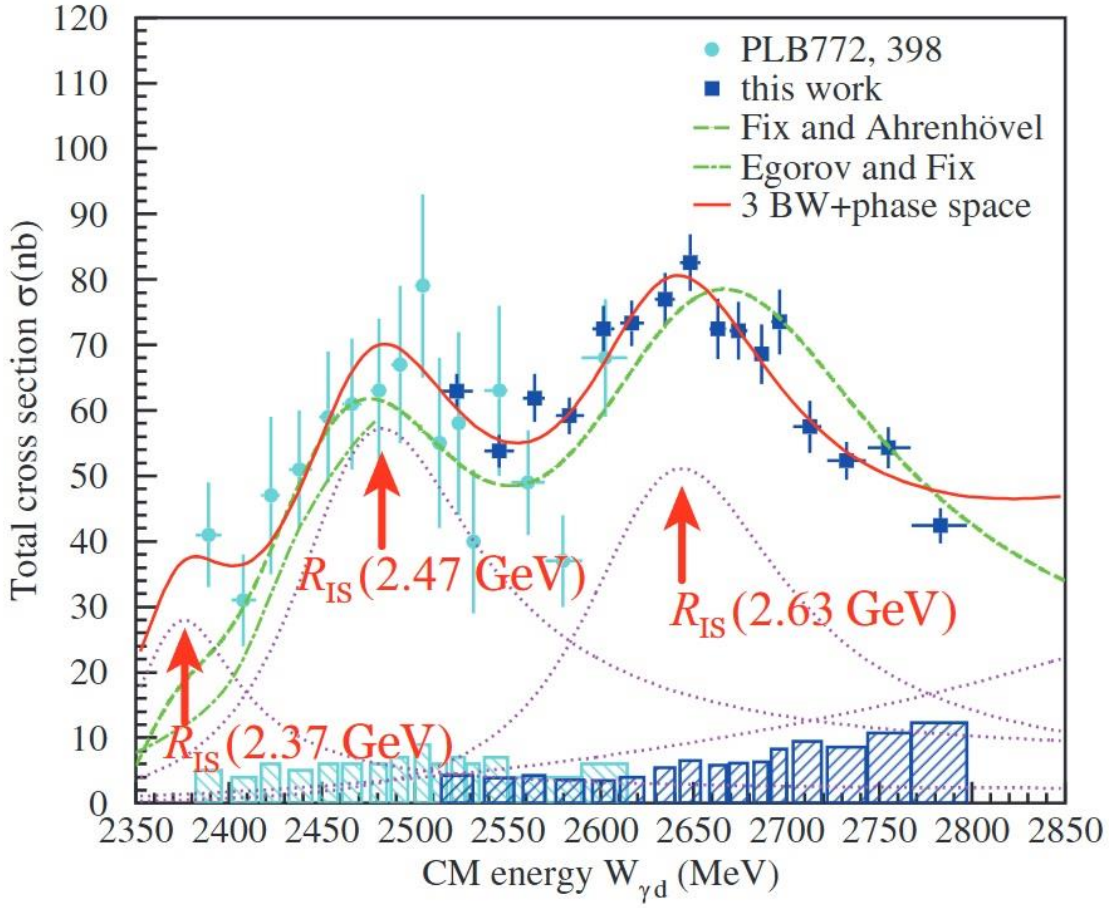
m=2.359 ± 0.007 GeV

Γ=114 ± 6 MeV

Поиск d(2380) $\gamma d \rightarrow d\pi^0\pi^0$*

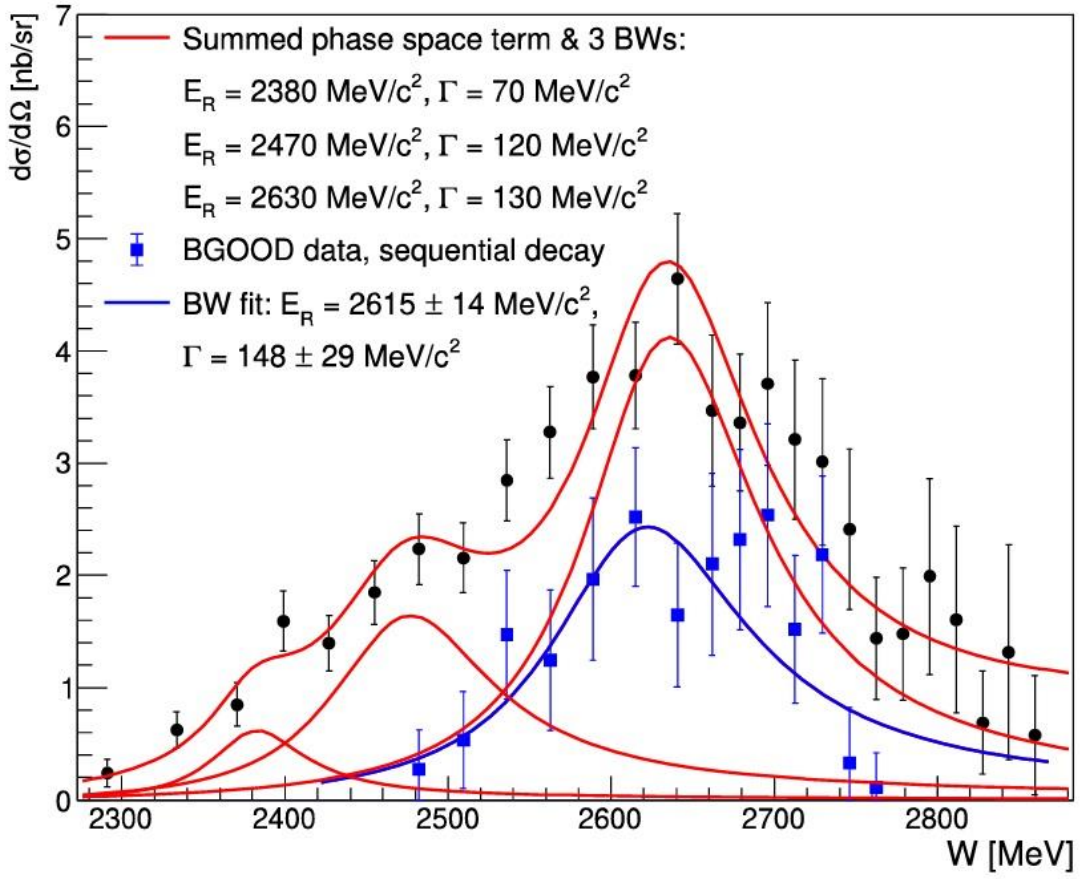
FOREST@ELPH

https://doi.org/10.7566/JPSCP.26.0220



BGOOD@ELSA

https://doi.org/10.1016/j.physletb.2022.137277



Дибарионы   S = -1

Y. Ikeda, T. Sato,
arXiv:0809.1285

резонанс в $\bar{K}NN \rightarrow \pi\Sigma N$ $m \approx 2300$ MeV $\Gamma \approx 50 \div 65$ MeV

M. Bashkanov, D.P. Watts, G. Glash, M. Mocanu, N. Nicol,   *arXiv:2308.07066*

$J^p = 3^+$ d_s (2530) $\rightarrow \Delta\Sigma^*$ $m \approx 2530$ MeV $\Gamma \approx 30$ MeV

A. Gal,   *arXiv:1011.6322*

$J^p = 2^+$ $p + p \rightarrow D^+ + K^+$

$\quad\quad\quad\quad\quad\quad\quad\quad \hookrightarrow \pi\Lambda N/\pi\Sigma N$

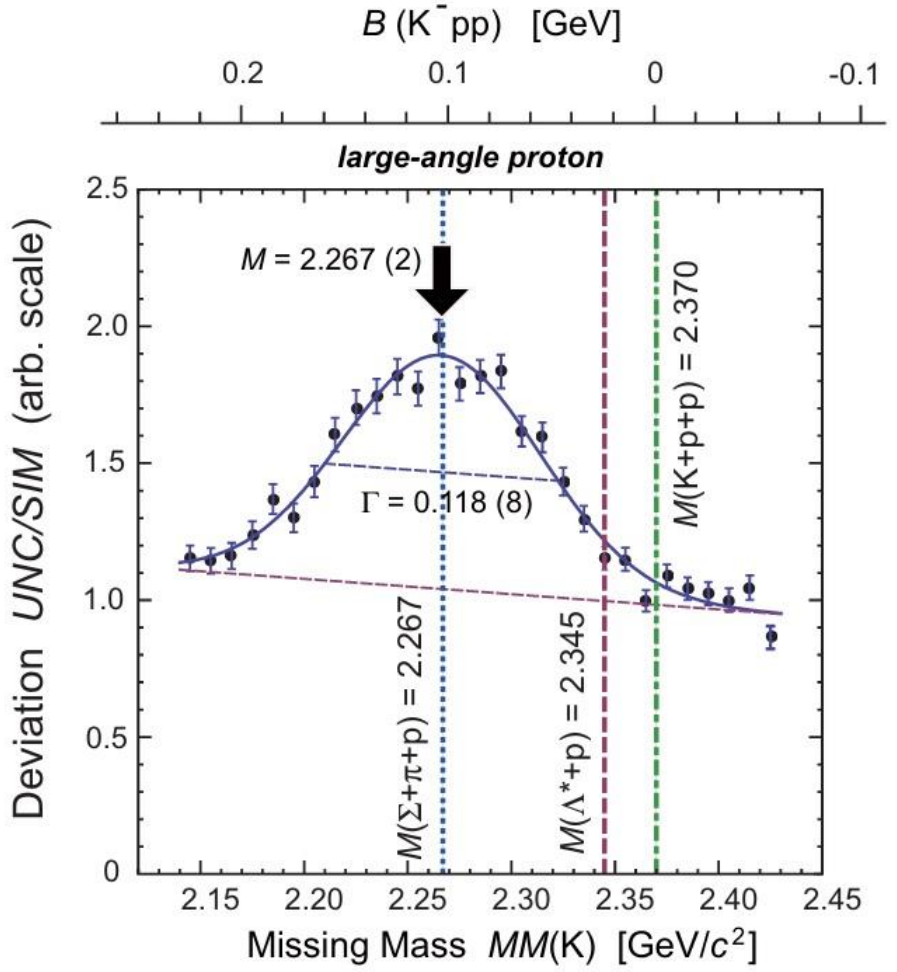
Заключение

- Измерено резонансное сечение в реакции p n → d $\pi^0\pi^0$, соответствующее D_{03} , предсказанному в работе Dyson & Xuong
- Результаты других экспериментов не противоречат существованию d*(2380)
- Для подтверждения d*(2380) необходимы новые эксперименты
- В секторе странных дибарионов существуют предсказания, требующие экспериментального подтверждения

Дибарионы с S = -1

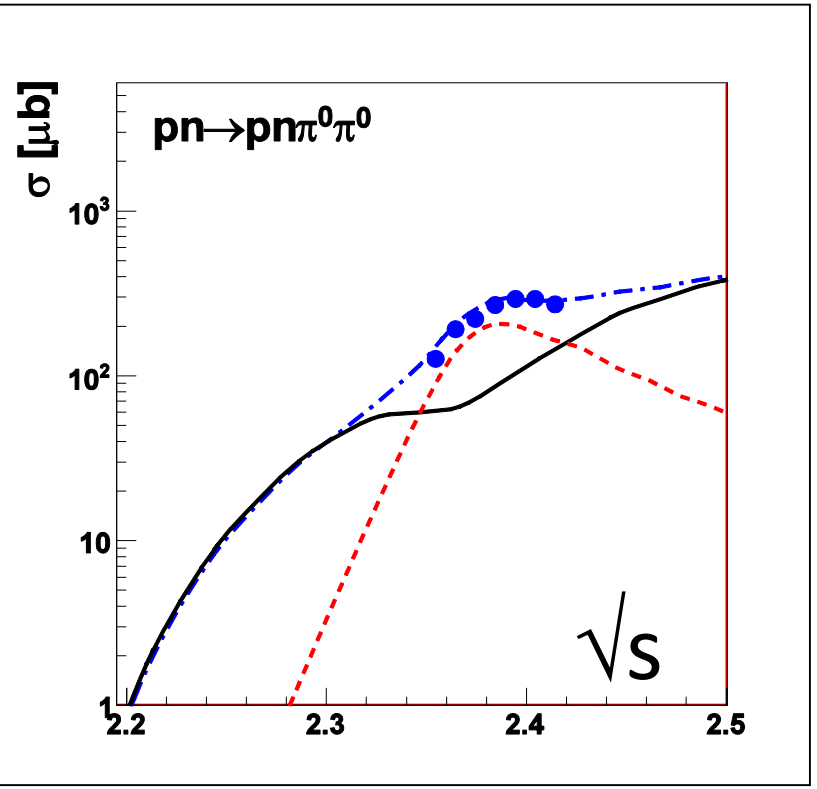
$$p + p \longrightarrow K^+ + \pi p \Lambda/\Sigma$$
$$K^+ + \Delta p \Lambda/\Sigma$$

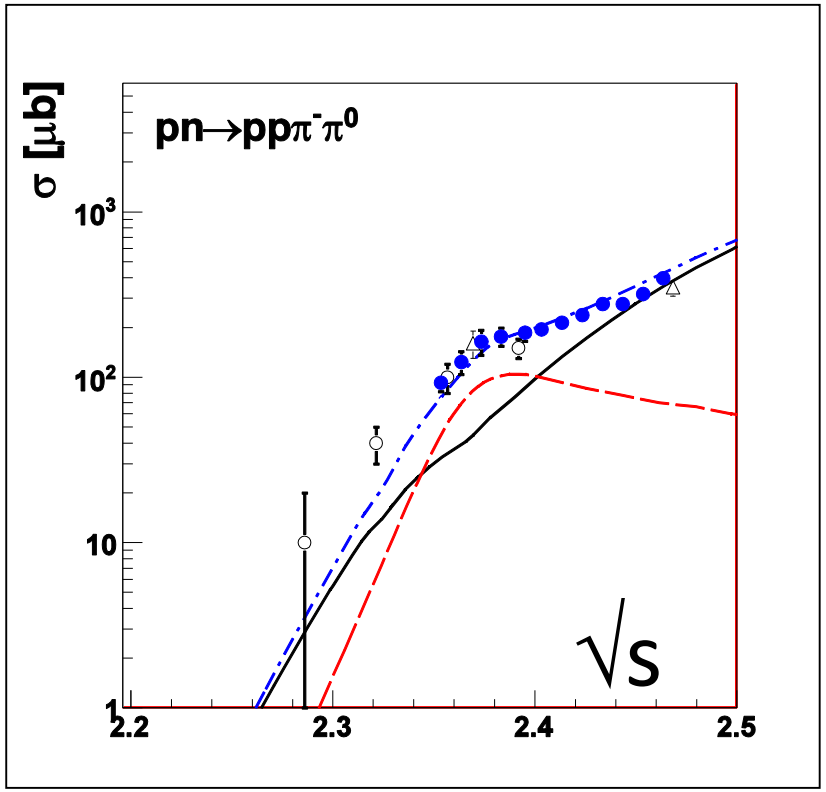
$$T_p = 3 \div 4 \text{ GeV}$$

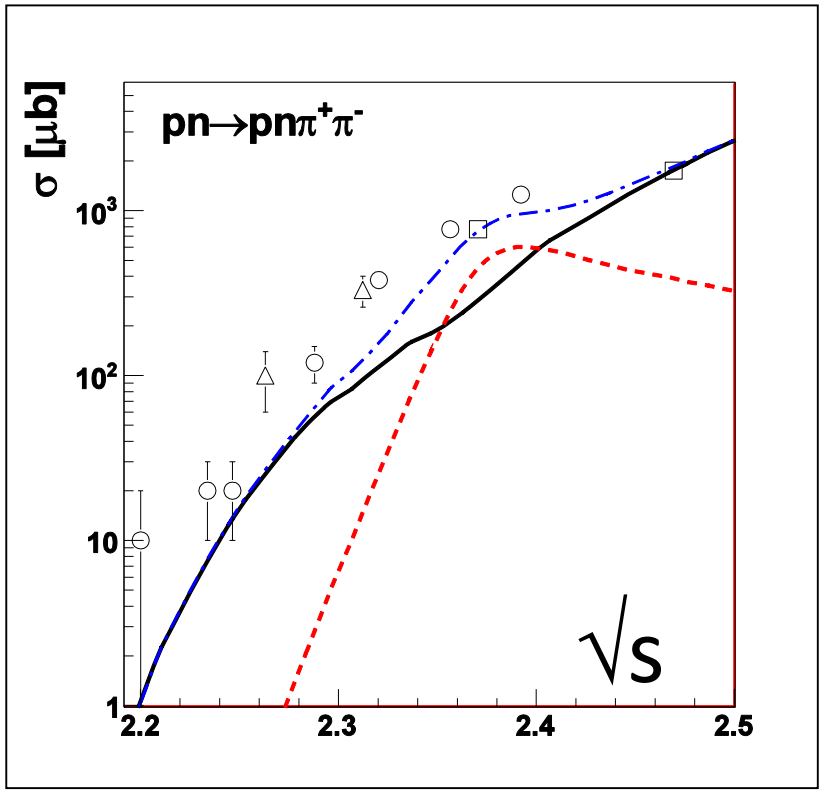


DISTO Nucl.Phys.A835:43-50,2010

Реакции $pn \to NN\pi\pi$







$\sigma_d / \sigma(NN\pi\pi) \sim 170\mu b/40mb$

PRC 88 (2013) 055208 arXiv:1409.2659

ИЗОСКАЛЯРНОЕ СЕЧЕНИЕ $NN \rightarrow NN\pi$

$$\sigma_{NN \rightarrow NN\pi}(I=0) = 3[2\sigma(pn \rightarrow pp\pi^-) - \sigma(pp \rightarrow pp\pi^0)] \qquad (1)$$

Квазисвободные реакции

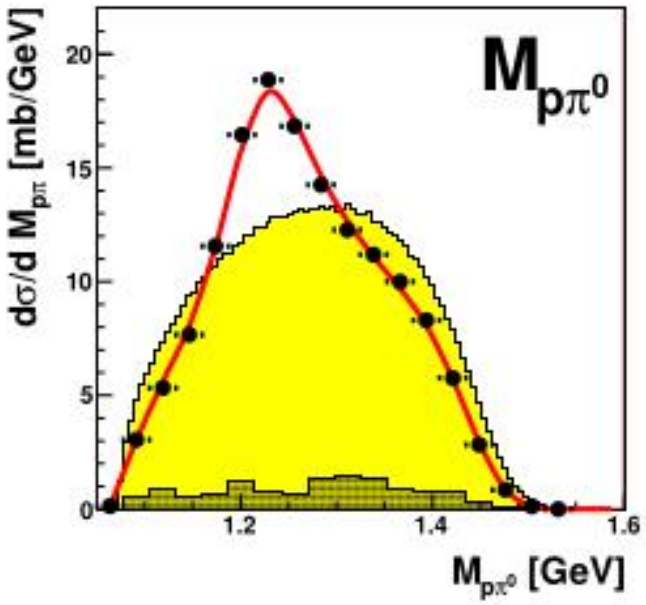
$pd \rightarrow pp\pi^0 + n_{spectator}$ $\quad I=1 \quad \Delta(1230)+p, \quad D_{12}$

$pd \rightarrow pp\pi^- + p_{spectator}$ $\quad \begin{cases} I=1 & \Delta(1230)+p, \quad D_{12} \\ I=0 & N^*(1440)+p, \quad d^*(2380) \end{cases}$

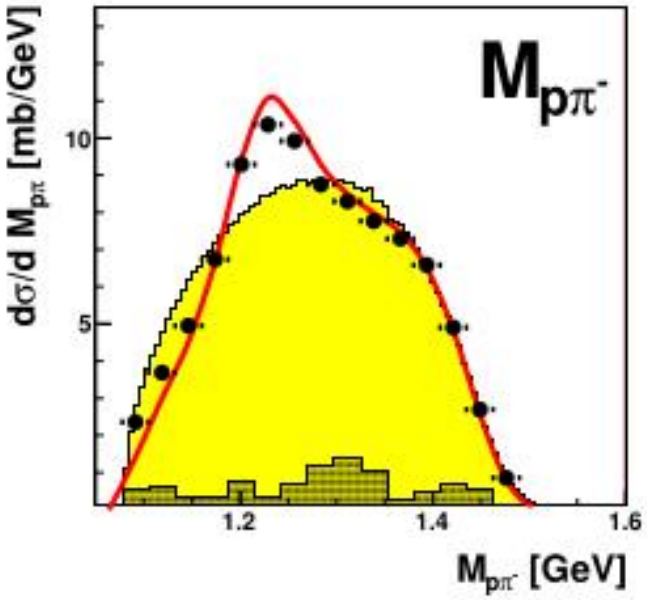
$T_p = 1200$ МэВ $\quad \sqrt{s} = 2300 - 2460$ МэВ

$p_p \sim 1600 - 2000$ МэВ/с

$M_{p\pi}$



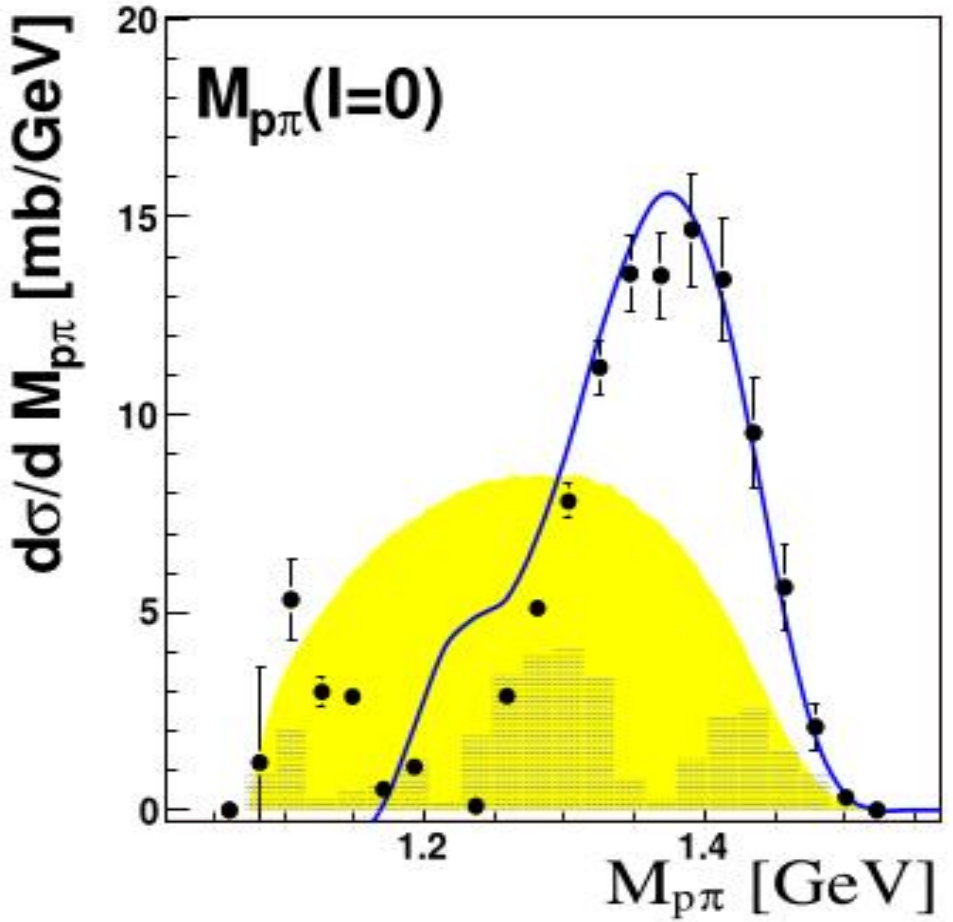
t-канальное возбуждение ΔΔ



t-канальное возбуждение ΔΔ + N*

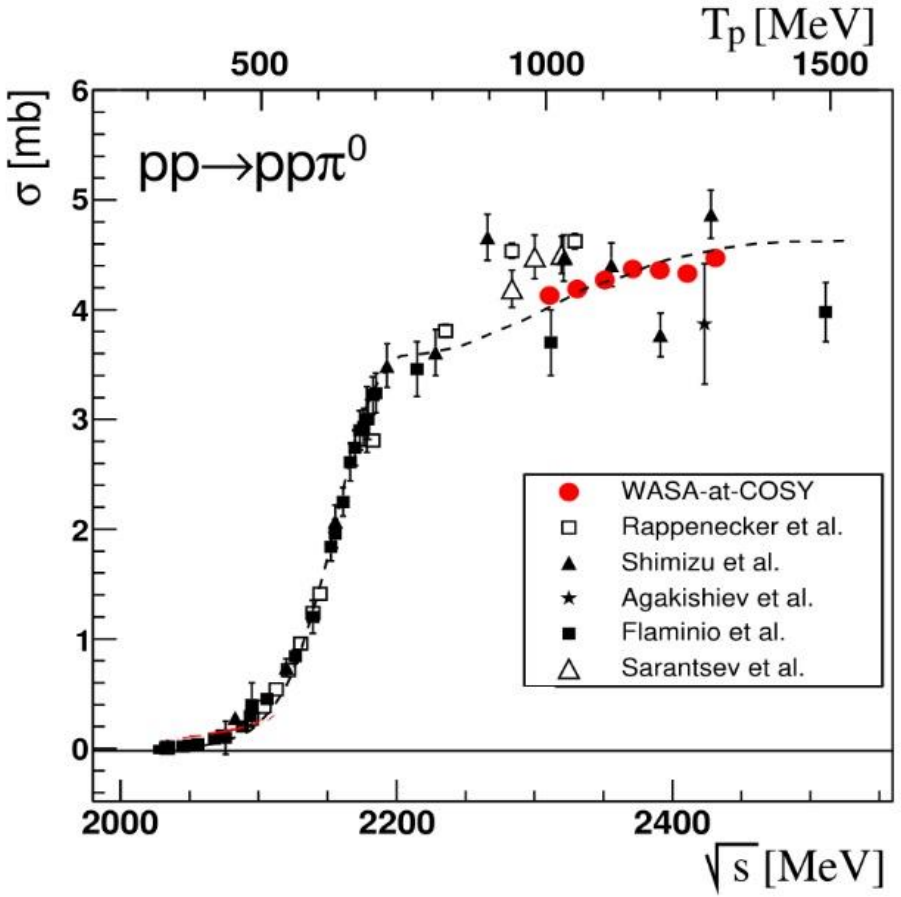
Изоскалярное сечение

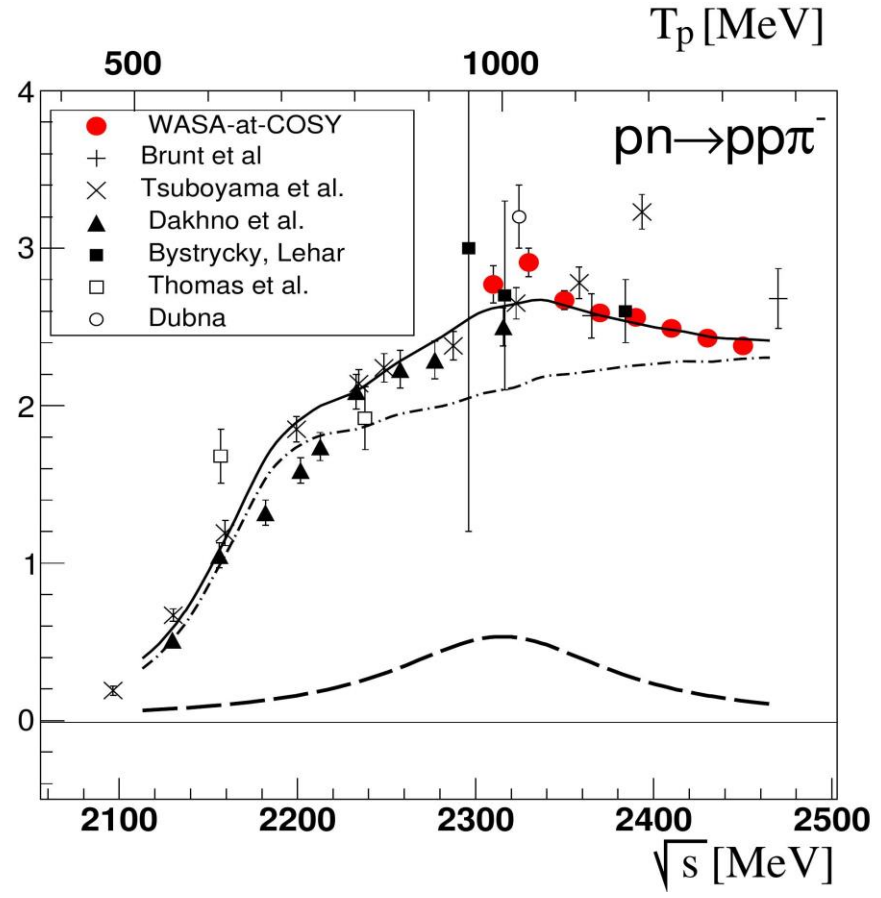
t-канал N*(1440)



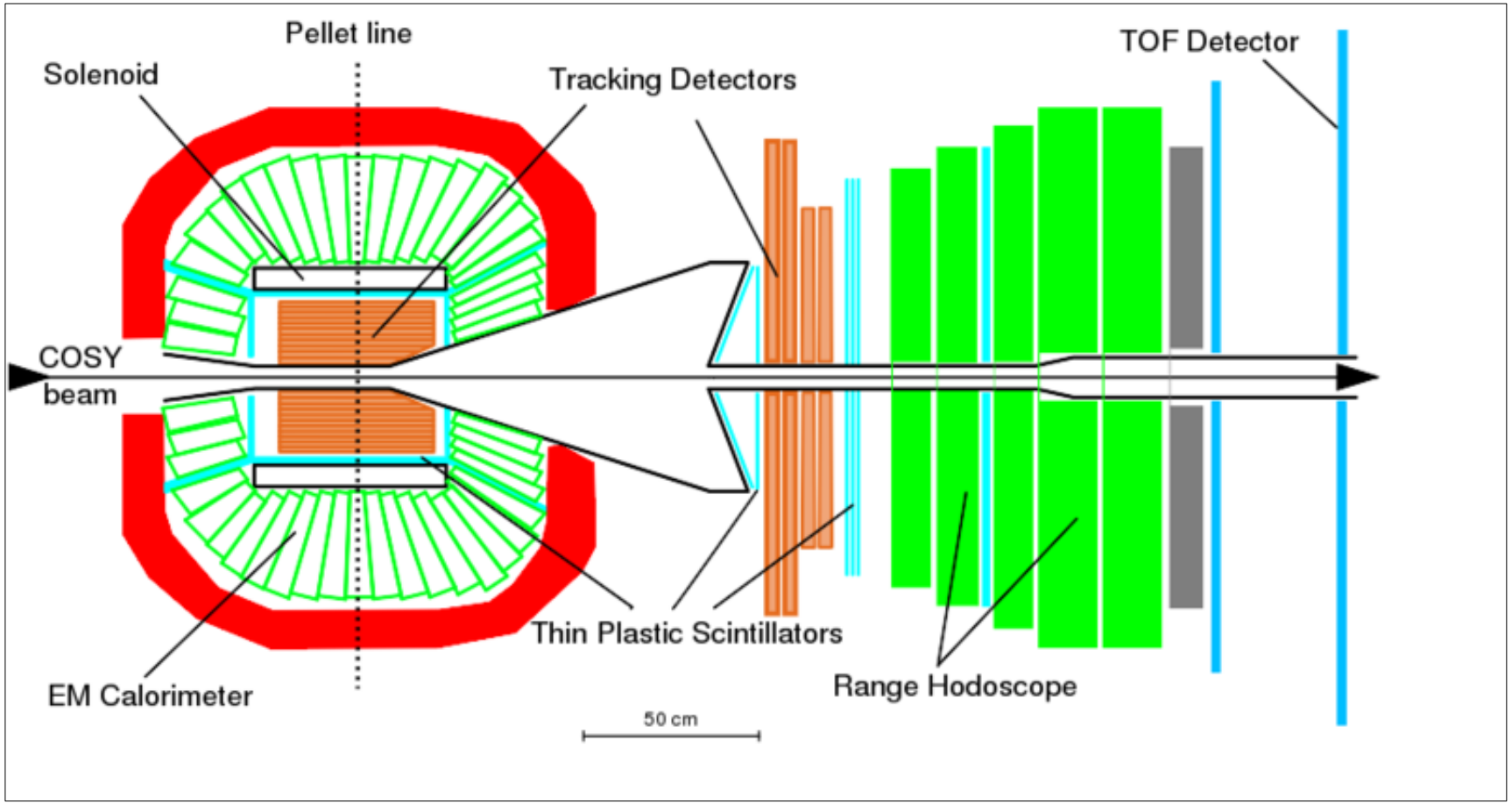
$pn \rightarrow d^*(2380) \rightarrow NN\pi(I=0)$

$$\sigma_{NN \rightarrow NN\pi}(I=0) = 3[2\sigma(pn \rightarrow pp\pi^-) - \sigma(pp \rightarrow pp\pi^0)]$$





WASA-at-COSY


Pellet line
Solenoid
Tracking Detectors
TOF Detector
COSY
beam
Thin Plastic Scintillators
EM Calorimeter
Range Hodoscope
50 cm

Альтернативные каналы

d*(2380) → π D_{12}

↳ NN

V. Kukulin, M. Platonova

Phys. Rev. C 87 (2013) 025202

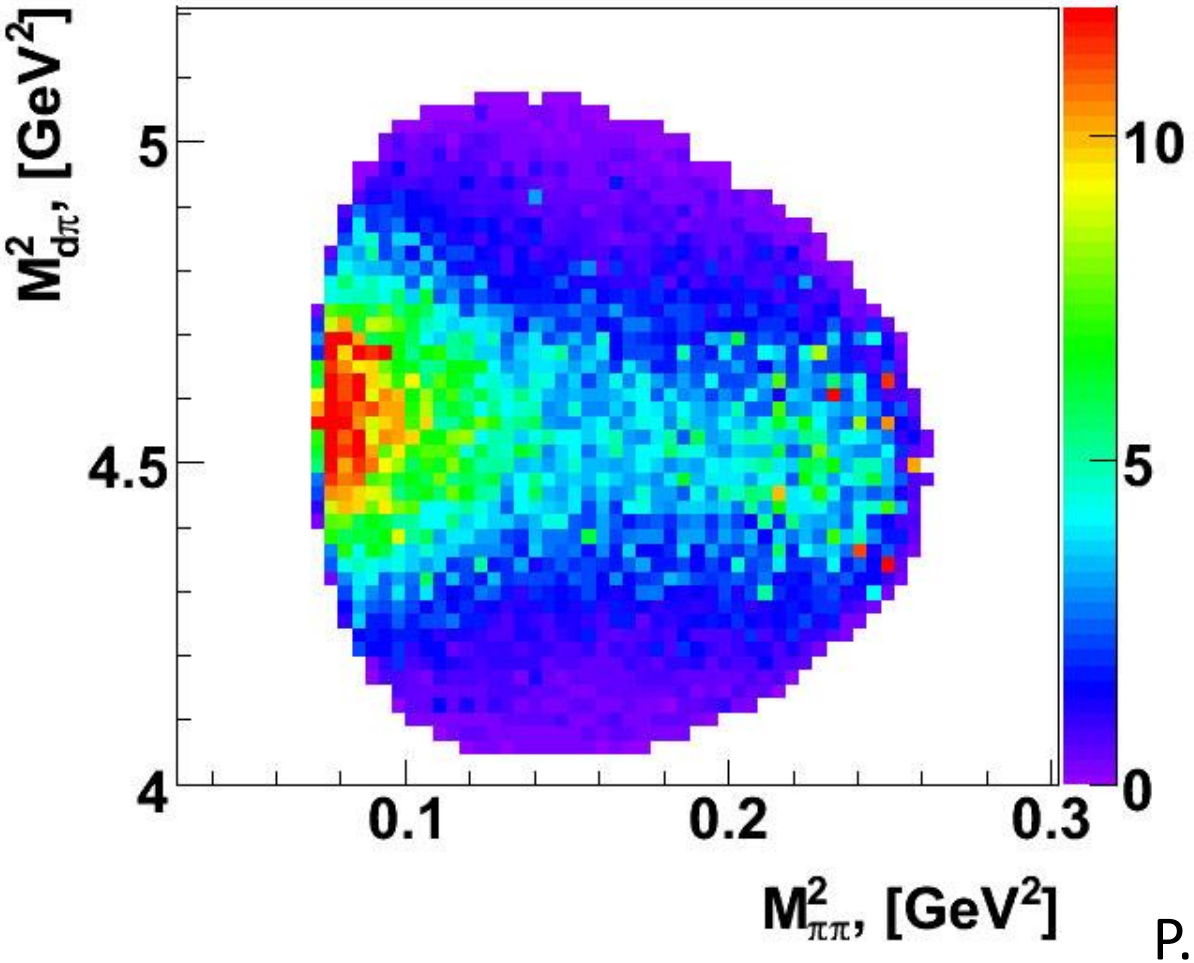
d*(2380) → NN*(1440)

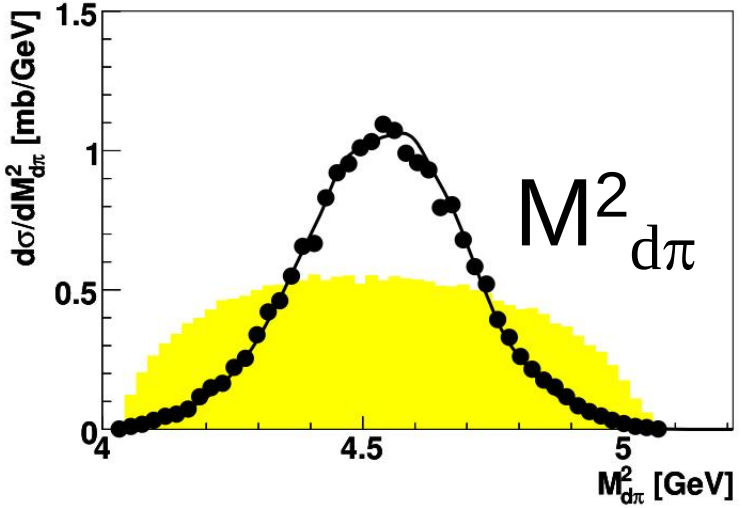
↳ Nπ

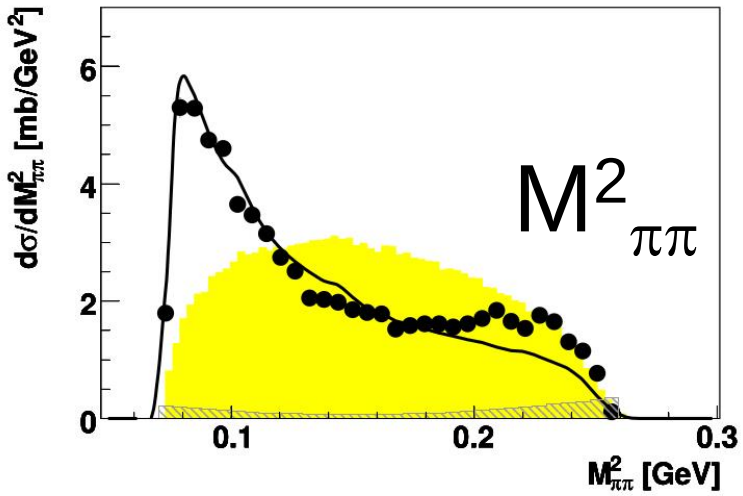
D.V. Bugg Eur. Phys. J. A50 (2014) 104

$d^* \rightarrow \Delta\Delta \rightarrow d\pi^0\pi^0$

$M^2_{d\pi}$ vs $M^2_{\pi\pi}$ at 2.38 GeV





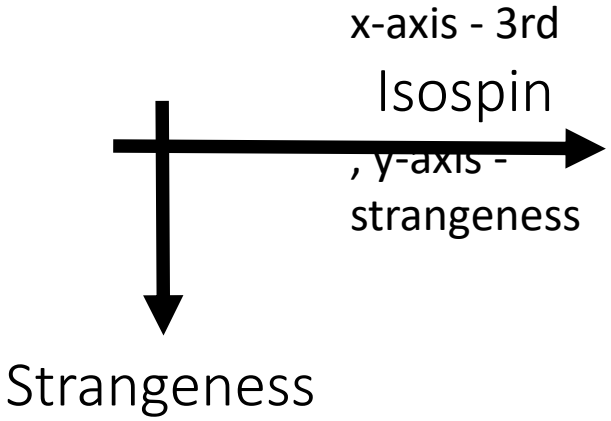


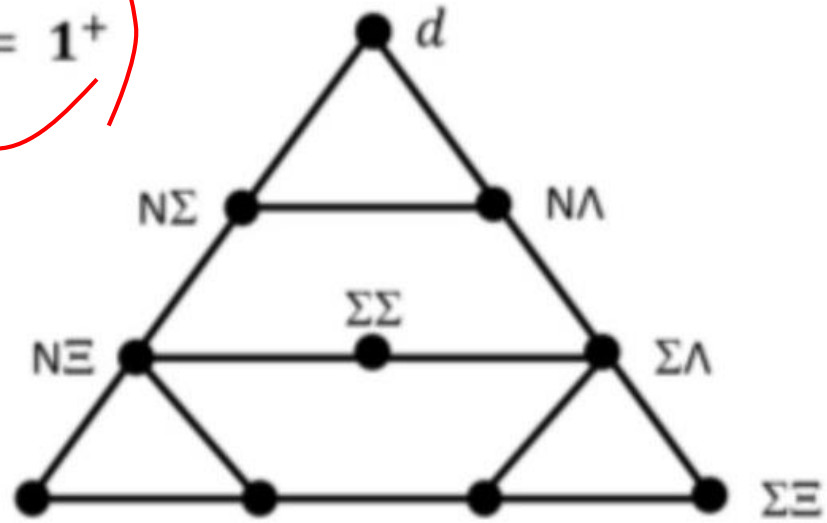
P. Adlarson et al. Phys. Rev. Lett. 106, 242302, (2011)

SU(3) ДЕКУПЛЕТ ПАР БАРИОНОВ

M. Bashkanov, D. P. Watts, G. Clash, M.Mocanu, M. Nicol
arXiv:2308.07066
Dibaryons and where to find them

$J^P = 1^+$





THE ANTIDECUPLET OF STATES BUILT ON THE SIX-QUARK

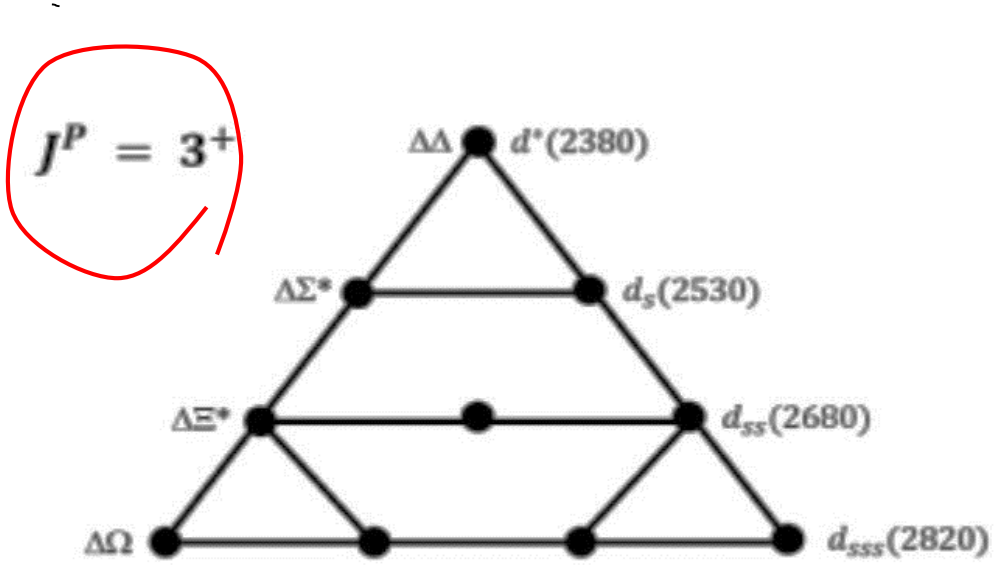


Figure 3: $d^*(2380)$ multiplet