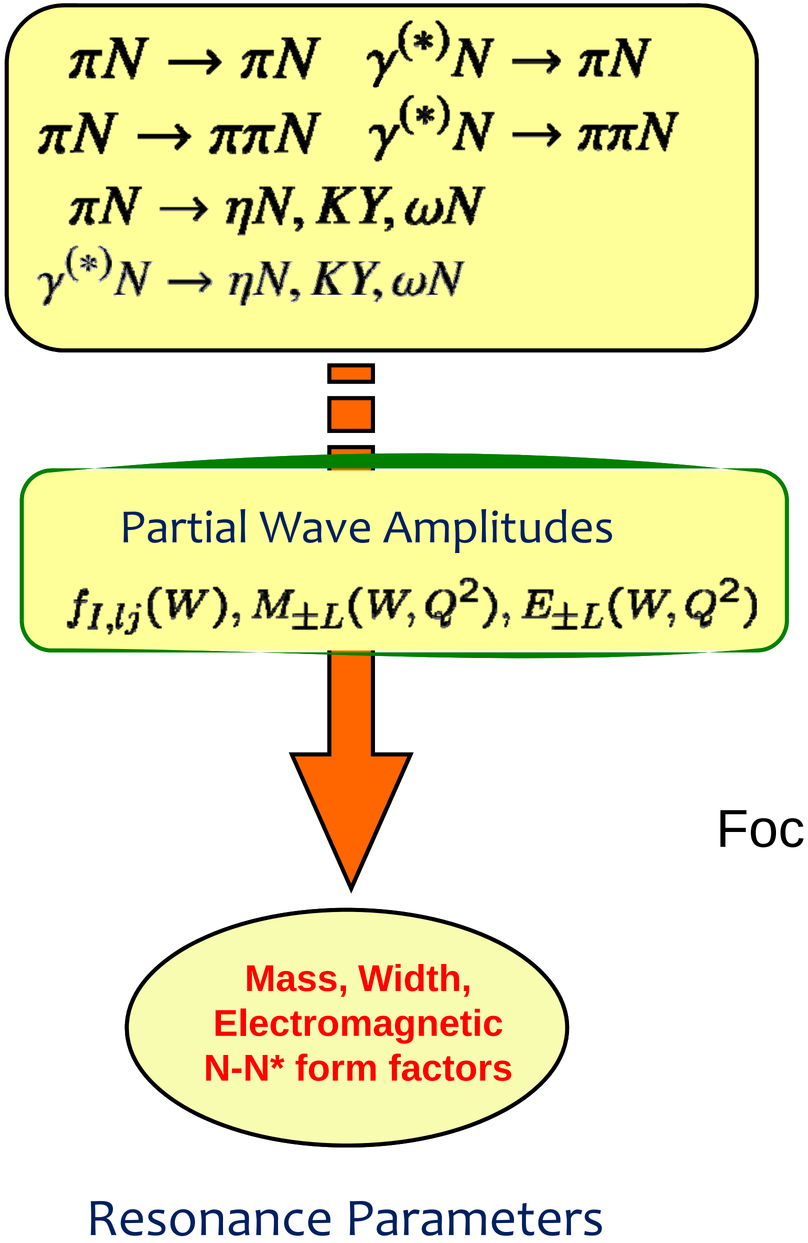
Extraction of N* Properties

-- summary of EBAC meeting--

T. Sato (Osaka U.)

Status and Plan of Jlab Experiments on N* Physics — V. Burkert

Dubna-Mainz-NTU/MAID		
	DMT model for piN scattering and pion e.m. production	S.N. Yang
	The Dubna-Mainz-Taipei model(DMT) and MAID	L. Tiator
Bonn-Gatchina	Bonn-Gatchina partial wave analysis	A. Sarantsev
IHEP(Beijing)-Saclay		
	“Quark-model” and “missing resonances” A tail-chasing game?	Q. Zhao
	eta and kaon production on the proton: results and prospectives	B. Saghai
Zagreb	Poles of PWData and PWAmplitudes in Zagreb model	A. Svarc
IHEP(Beijing)-BES	PWA of Baryon Resonances at BES	B. Zou
CLAS	Dispersion relations and unitary isobar model in single pion electro-production; Low and high Q2	I. Aznauryan
	Meson-Baryon model JM for the Nucleon Resonance Studies in Charged Double Pion Electroproduction	V. Mokeev
Julich-Georgia	Julich-Georgia	M. Doring
	Julich-UGA model for photoproduction	K. Nakayama
EBAC	Details of EBAC-DCC model	H. Kamano
	Extraction of resonances from EBAC-DCC model	S. Nakamura



Examine model dependence of resonance parameters extracted from data by different approaches

Question:How extracted resonance parameters can be used in testing various hadron structure calculations

Focus :

definition of resonance parameters

methods to extract res. param.

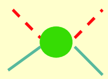
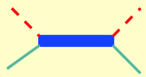
Situation on the analysis of meson production reaction

${\color{red}\pi N \rightarrow}$ ${\color{blue}\gamma N \rightarrow}$	πN	ηN	$\pi\pi N$	$K\Lambda, \Sigma$
Dubna-Mainz-NTU	${\color{red}\bigcirc}$	${\color{red}\bigcirc}$		
MAID	${\color{blue}\bigcirc}$	${\color{blue}\bigcirc}$		
Bonn-Gatchina	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}\ {\color{blue}\bigcirc}$
IHEP(Beijin)-Saclay		${\color{red}\bigcirc}{\color{blue}\bigcirc}$		
Zagreb	${\color{red}\bigcirc}$	${\color{red}\bigcirc}$		
CLAS	${\color{blue}\bigcirc}$	${\color{blue}\bigcirc}$	${\color{blue}\bigcirc}$	
Juelich-Georgia	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}$		${\color{red}\bigcirc}$
EBAC	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}{\color{blue}\bigcirc}$	${\color{red}\bigcirc}{\color{blue}\bigcirc}$

Important to study all available inelastic reactions with coupled channel analysis for both strong and em probes.

Brief summary of Reaction models

$$T = V + VG_0T$$

	V		G_0
	Non-res	'res'	
Bonn-Gatchina Zagreb DMT Julich-Georgia EBAC	'const' Meson Exc 		$< G_0 >= i\rho$ $Re(\Phi(s)) = \frac{s-s_0}{\pi}\int_{s_t}^{\infty}\frac{Im(\Phi(s')ds'}{(s'-s)(s-s_0)}$

explicit analytic form introduced

MAID

$$t^{\alpha}_{\gamma,\pi} = (Born+\omega+\rho+c.t.)(1+it^{\alpha}_{\pi N})+\sum_i t^{\alpha}_{BW}(i)e^{i\phi^{\alpha}_i}$$

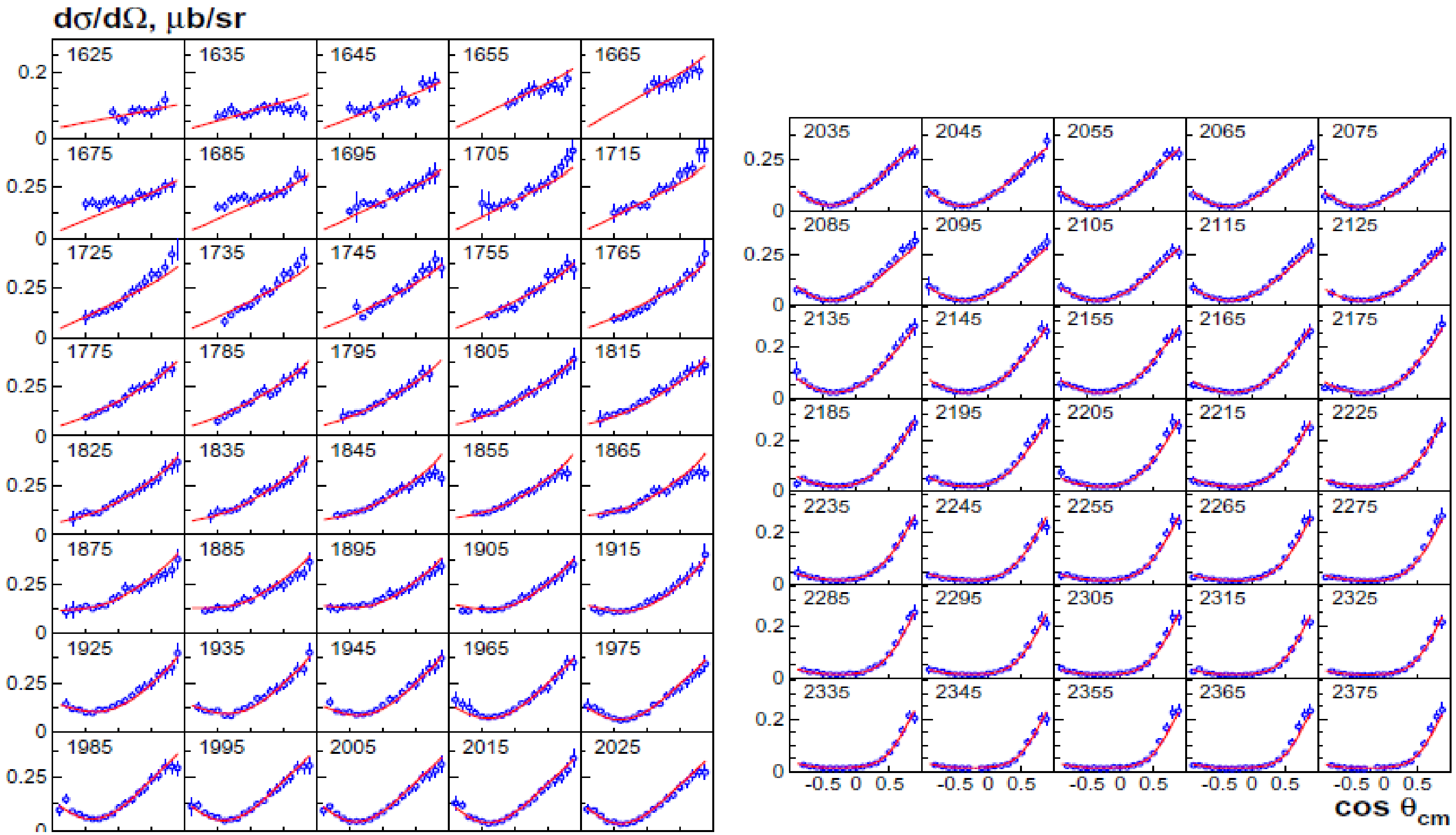
CLAS

Unitary isobar model (+Regge) , Dispersion relation for single pion production

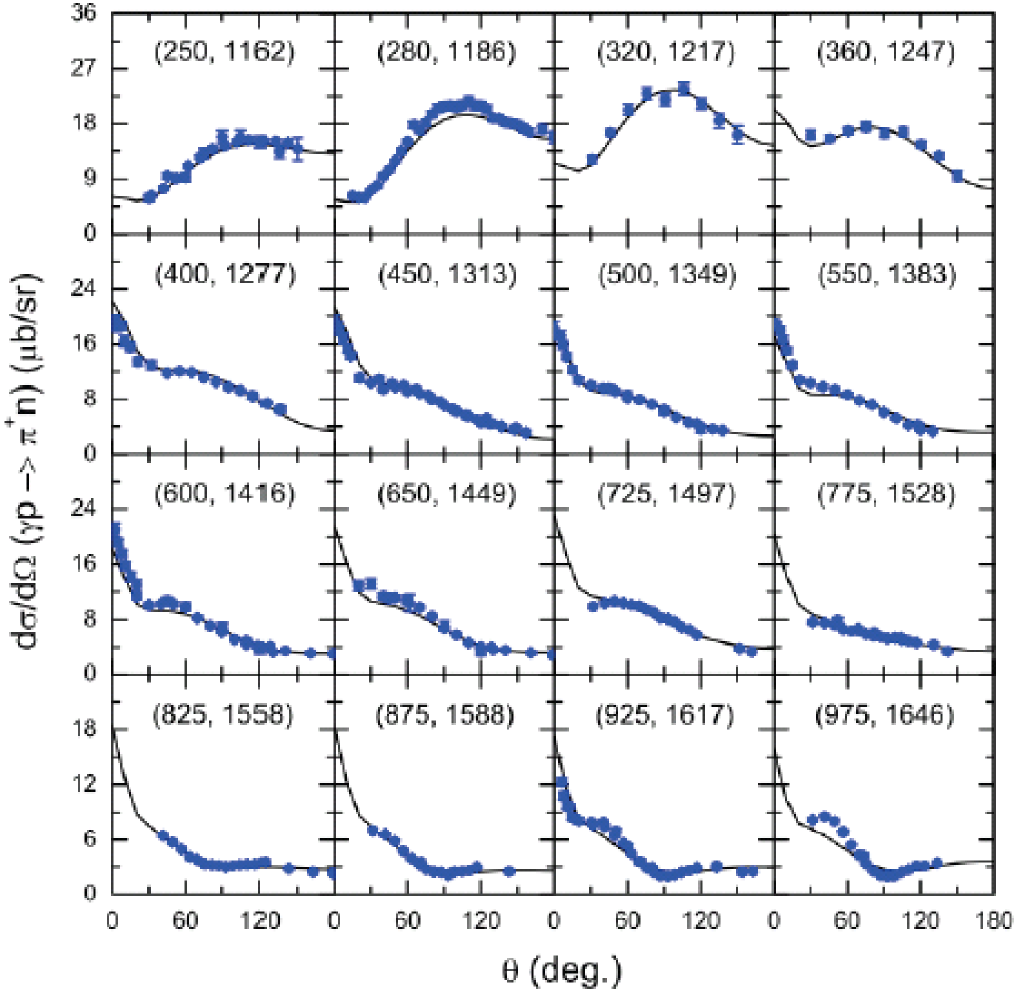
Isobar model + unitarization for $\gamma + p \rightarrow \pi^+\pi^- p$

The fit of the $\gamma p \to K\Lambda$ differential cross section

(CLAS 2009)

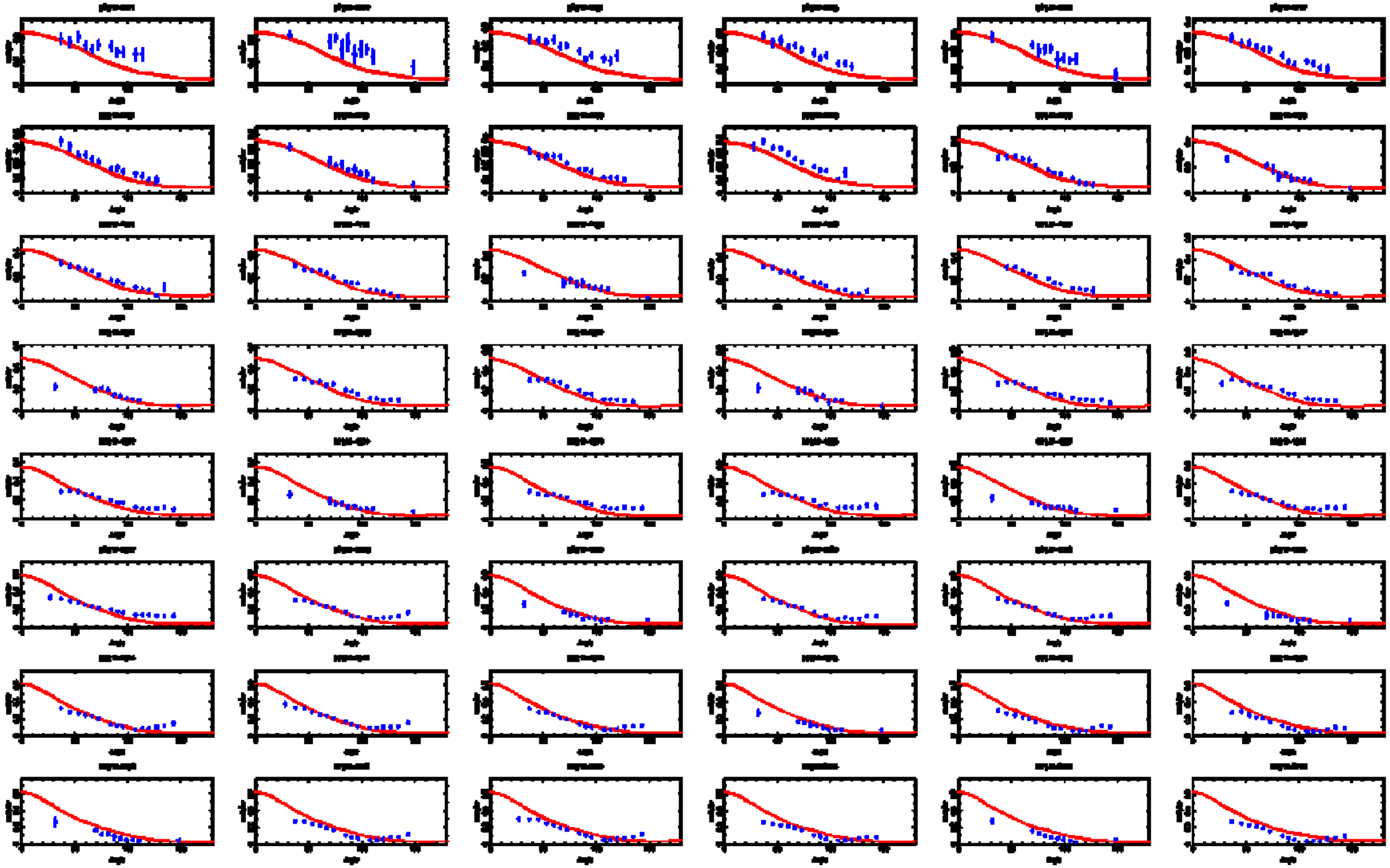


Jülich-UGA

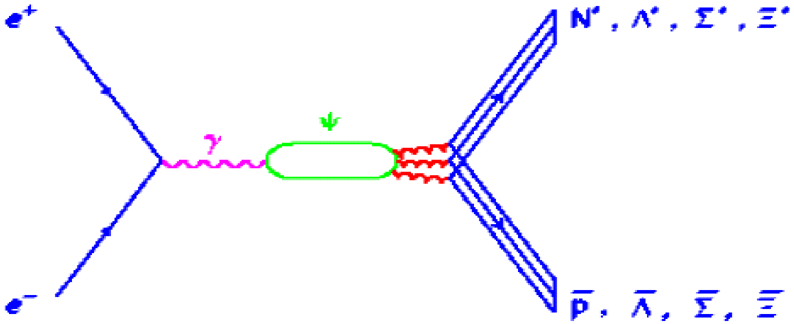

(250, 1162)
(280, 1186)
(320, 1217)
(360, 1247)
(400, 1277)
(450, 1313)
(500, 1349)
(550, 1383)
(600, 1416)
(650, 1449)
(725, 1497)
(775, 1528)
(825, 1558)
(875, 1588)
(925, 1617)
(975, 1646)
dσ/dΩ (γp -> π+ n) (μb/sr)
θ (deg.)
0
60
120
180
0
9
18
27
36
8
16
24
6
12

gamma p → K Lambda

Preliminary (EBAC)

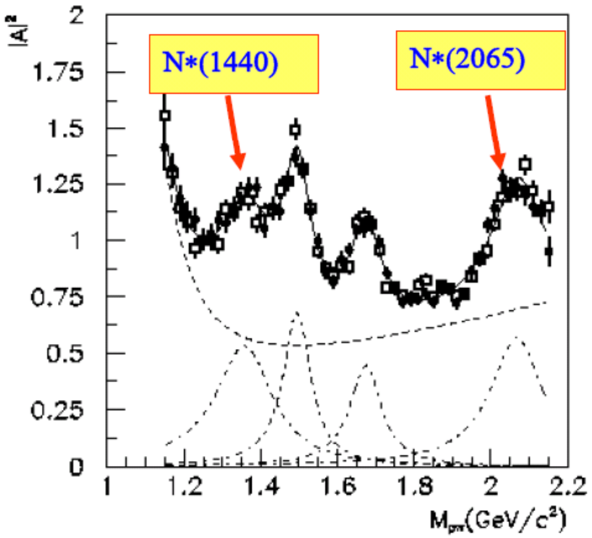


IHEP(Beijing)-BES



$$\psi, J/\psi \to \bar{B}MB$$

$J/\psi \to \bar{p}n\pi^+$ & $\bar{n}\pi^-p$



New tool for N*,Y* study : completely differrent S/N from $\pi N, \gamma^* N$

The first experiment "seeing" N*(1440) in πN mass spectrum

BESII	$M = 1358 \pm 17$,	$\Gamma = 179 \pm 56$	MeV
PDG08	$M = 1365 \pm 15$,	$\Gamma = 190 \pm 30$	MeV

IHEP(Beijin)-Saclay

$\pi N \to \eta N, K^- p \to \Sigma^0 \pi^0$ in constituent quark model

Relative signs for the N*NM couplings

$$S_{11}(1535, 1650) \to p\eta, \Lambda K^+, n\pi^+, p\pi^0, \Sigma^+ K^0$$

EBAC + chiral constituent quark model

$$T_{\gamma N \to \eta N} = (v^{NR}_{\gamma N \to \eta N} + v^{R}_{\gamma N \to \eta N})(1 + G_{\eta N} t^{NR}_{\eta N \to MB \to \eta N}) + v^{NR}_{\gamma N \to \pi N} G_{\pi N} t^{NR}_{\pi N \to MB \to \eta N}$$

Direct channel CQM

EBAC

How to characterize resonance

Scattering amplitude near resonance energy

$$F_{\beta,\alpha} = \frac{e^{i\phi_\beta}\sqrt{\Gamma_\beta/2}\,e^{i\phi_\alpha}\sqrt{\Gamma_\alpha/2}}{W - M_{pole} + i\Gamma_{pole}/2} + B_{\beta,\alpha}$$

'Breit-Wigner' parametrization

$$F_{\beta,\alpha} = \frac{e^{i\phi_\beta(W)}\sqrt{\Gamma_\beta(W)/2}\,e^{i\phi_\alpha(W)}\sqrt{\Gamma_\alpha(W)/2}}{W - M_{BW} + i\Gamma(W)/2} + B_{\beta,\alpha}(W)$$

$$\Gamma_{BW} = \Gamma(M_{BW})$$

energy dependence

$\leftarrow$ reaction model or phenomenological parametrization

'BW' parametrization

- Good fit for different non-resonant phase (MAID-DMT)

- overlapping resonances : need prescription

DMT

$$T = T^B + \sum_i T_i^{Res}$$

Bonn-Gatchina Zagreb

$$T_{ab} = \frac{B_{ab} - \delta_{ab}}{2\,i} + \sum_{cd} \frac{B_{ab}^{1/2} F_c^{1/2} \eta_c \, \eta_d F_d^{1/2} B_{bd}^{1/2}}{r - s - c \sum z_c \, \Phi_c(s)}$$

The real constants r and c are chosen so that $D(s_{pole}) = 0$.

- Pole and shadow pole near threshold (S11 Julich)

$$F_{11} \sim \frac{-ip_1\gamma_1}{W - M + ip_1\gamma_1 + ip_2\gamma_2}$$

(Kato(65),Fujii-Kato(69))

Pole of T-matrix on the unphysical sheet

- Analytic continuation

contour deformation Julich-Georgia, EBAC
Bonn-Gatchina, DMT

Pietarinen expansion Zagreb

- Regularization method DMT(Zagreb)

$$\frac{(a_N - x)^2 + b_N^2}{\sqrt[N+1]{|r_N|^2}} = \sqrt[N+1]{\frac{(N!)^2}{\left|T^{(N)}(x)\right|^2}}$$

resonance parameters of P11(1440) : Pole

resonance energy and residue of piN elastic amplitude

		Mass		Residue	
		Re	-Im	|r|	phase
DMT	Ac	1371	95	50	-79
	RM(5)	1371	95	50	-78
Bonn-Gatchina		1375	100		
Zagreb		1350	85		
Juelich		1387	74	48	-64
		1387	71		
EBAC		1356	76	37	-111
		1364	105	64	-99

Analyze same PWD/PWA using (DMT,EBAC,CMB) models (Zagreb)

→ Examine systematic error : different analytic structure of each models

study of electromagnetic form factor from residue at pole

Bonn-Gatchina

State	$P_{11}(1440)$	$P_{11}(1710)$
Re(pole)	1375 ± 6 (1365 ± 15)	1690^{+25}_{-10} (1720 ± 50)
-2Im(pole)	200 ± 10 (190 ± 30)	230^{+30}_{-20} (230 ± 150)
$g(\pi N)$	0.49 ± 0.03 / -40 ± 6^o	0.16 ± 0.06 / $-(5^{+20}_{-50})^o$
$g(\eta N)$	-0.12 ± 0.05 / 20 ± 10^o	-0.16 ± 0.05 / -20 ± 25^o
$g(K\Lambda)$		0.70 ± 0.20 / -8 ± 10^o
$g(K\Sigma)$		0.10 ± 0.05 / $(60^{+60}_{-30})^o$
$A^{1/2}(\gamma p)$	-44 ± 10 / $-37^o\pm10^o$	-65 ± 25 / $-65^o\pm20^o$

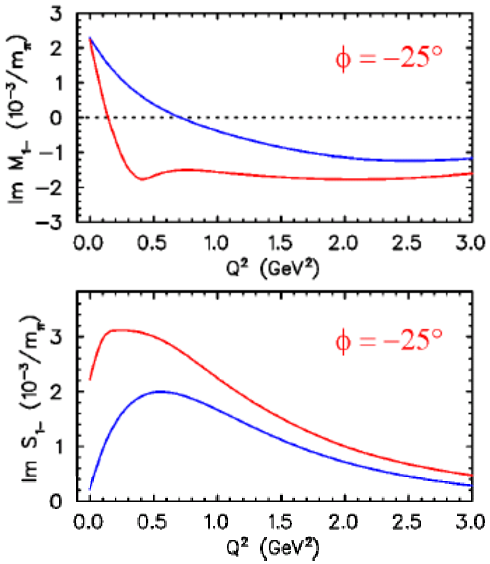
Julich-Georgia

	Pole position [MeV]	$g^{\gamma}_{1/2}$ [MeV$^{1/2}$]	$g^{\gamma}_{3/2}$ [MeV$^{1/2}$]
$P_{33}(1232)$	$1217 - 45\,i$	$0.42 - 0.11\,i$	$4.95 + 1.53\,i$
$P_{11}(1440)$	$1385 - 72\,i$	$-0.07 - 0.26\,i$	
		$-0.92 + 0.08\,i$	

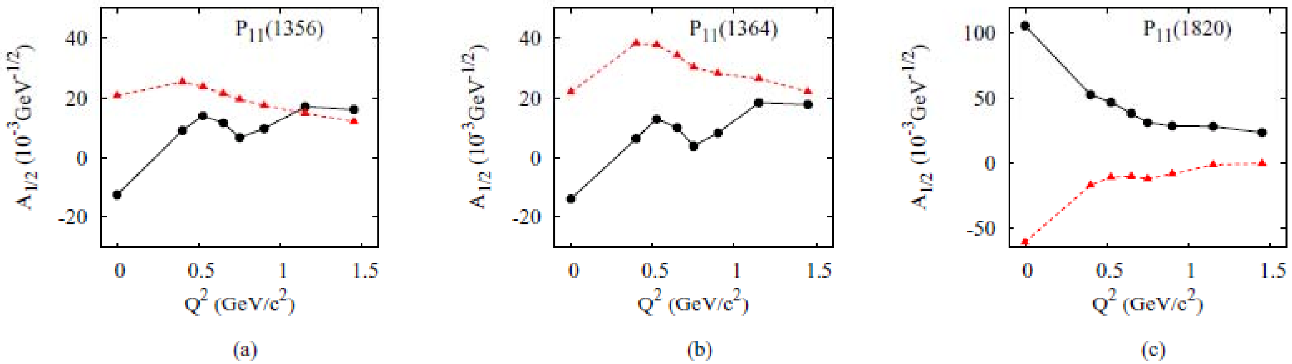
BW

MAID

SP Pole



EBAC



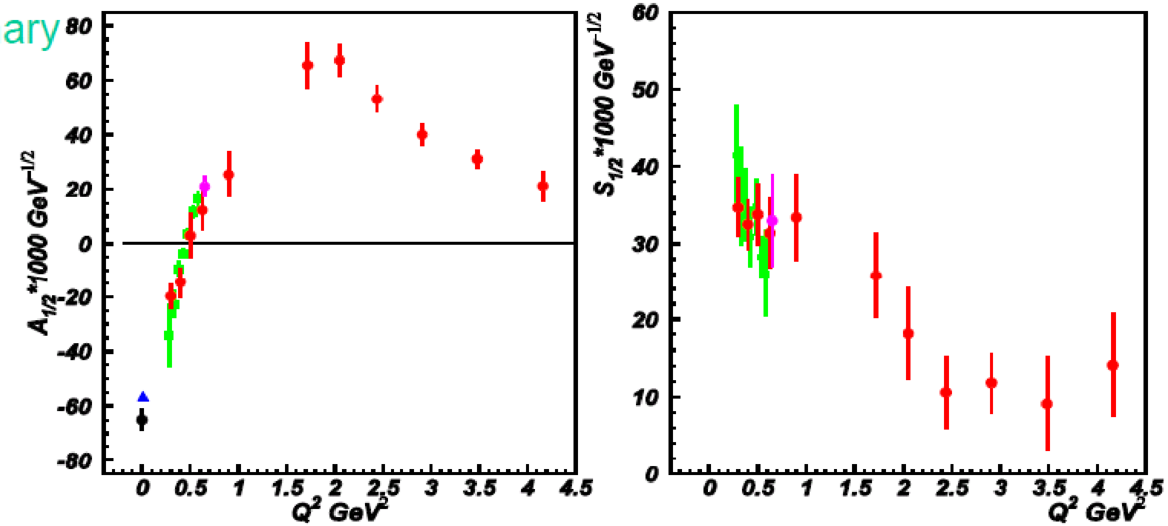
Im

RE

Nππ preliminary

Nπ

I.G.Aznauryan, V.D.Burkert et. al, CLAS Collaboration, PRC80, 055203 (2009).



Good *agreement* between the electrocouplings obtained from the *Nπ and Nππ channels*: Reliable measure of the electrocouplings with N* parameters defined within the framework of BW ansatz

Open question: how to compare these electrocouplings with obtained in cc approaches? EBAC-DCC results showed substantial Im parts.

Resonance information from the pole of S-matrix

Resonance as ‘eigenstate’ of hamiltonian with outgoing boundary condition

(A. Donnachie(72), R.H. Dalitz R. G. Moorhouse(70),Siegert(39))

$$H\psi_R = (M - i\Gamma/2)\psi_R$$

with out-going boundary condition(non-hermite) $(d\psi_R/dr - iq_R\psi_R)_{r=R} = 0$

s-matrix pole at q=q_R

Pole position mass and width

Residue at pole $F_{N^*N}(Q^2) =< \tilde{\phi}_R|j_{em}|N >$ $V \to j_{em}$

Well defined meaning :resonance mass and transition form factor determined from pole

-> meeting point with hadron structure studies