Extraction of resonance parameters from meson production reactions

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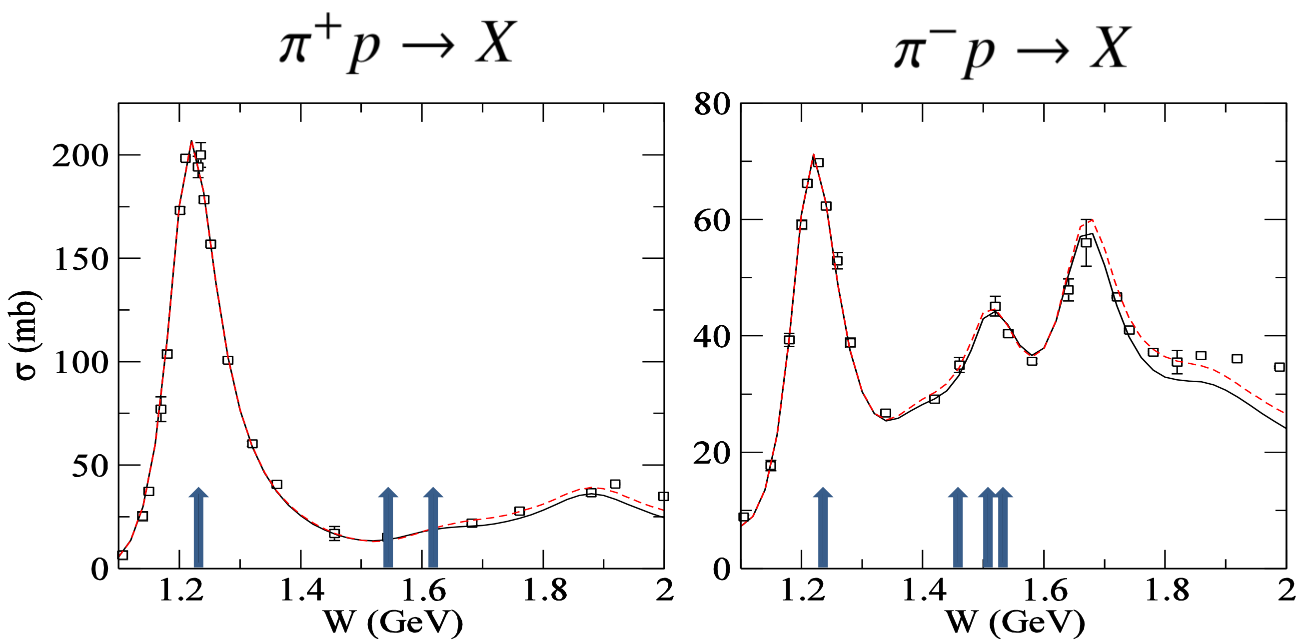
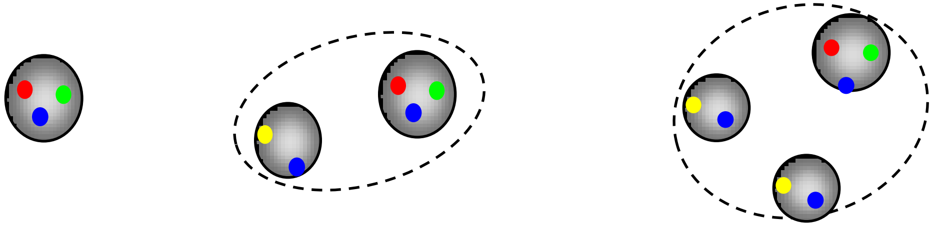
[Suzuki, Sato, Lee PRC 79 (2009) 025205]

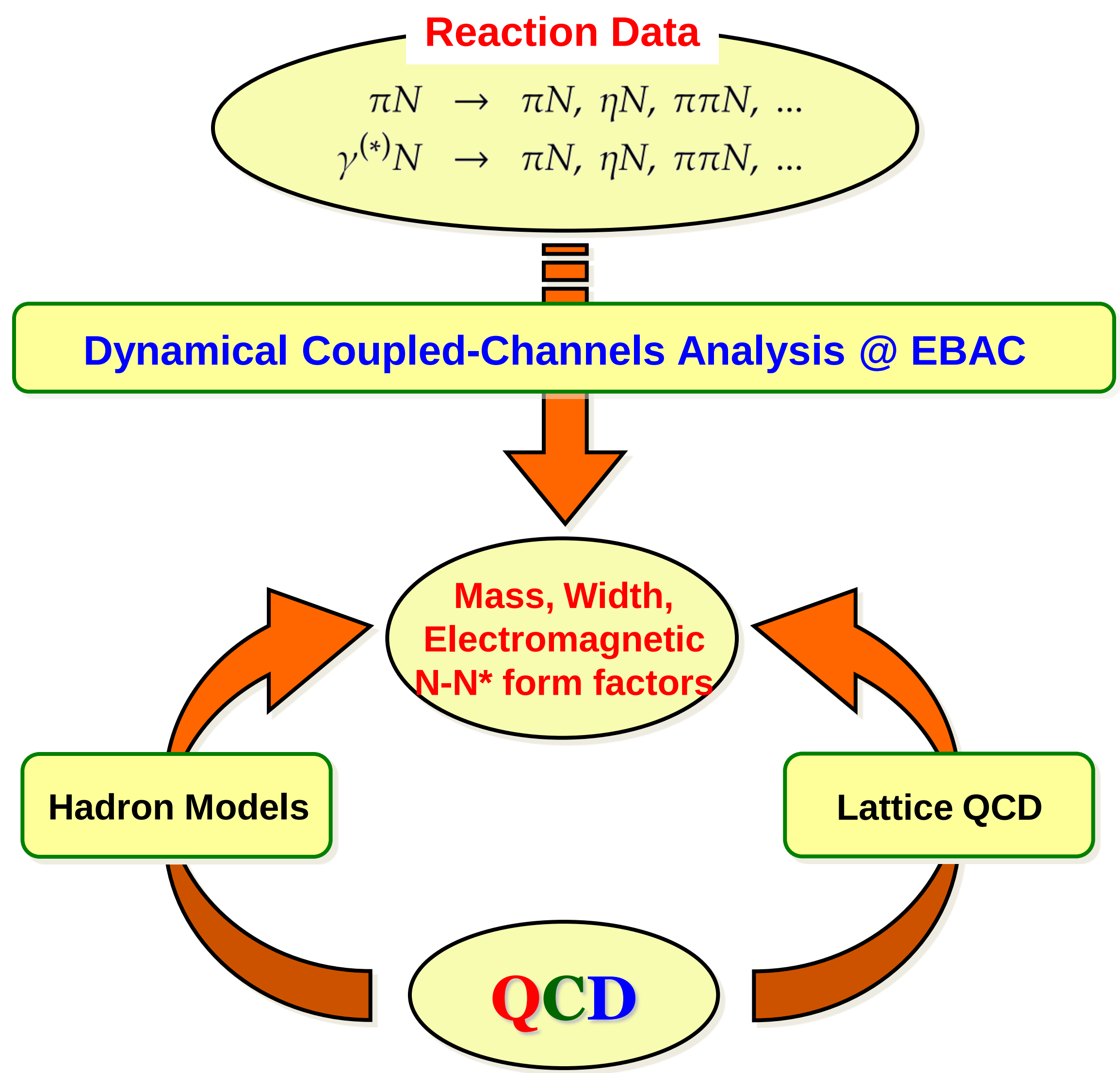
- motivation
- dynamical model of meson production reaction
- extraction of resonance parameters, (analytic continuation of scattering amplitudes)
- P33 and P11 from current EBAC model
- summary



Excited baryon → resonance in πN, γ *N reactions



Structure of resonance : mass, form factor, branching ratio


Reaction Data
$\pi N \rightarrow \pi N, \eta N, \pi\pi N, \ldots$
$\gamma^{(*)} N \rightarrow \pi N, \eta N, \pi\pi N, \ldots$
Dynamical Coupled-Channels Analysis @ EBAC
Mass, Width, Electromagnetic N-N* form factors
Hadron Models
Lattice QCD
QCD

Resonance

- Resonances: poles of the scattering amplitudes

$$< f|T(W)|i >\sim \frac{< f|V|\phi_R >< \tilde{\phi}_R|V|i >}{W - M + i\Gamma/2}$$

- characterize resonances

Pole position → mass, width   Residue → Form factors

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

Extraction of Resonance Parameters

	πN	γ*N
VPI/GW	BW,Pole(AC)	BW
CMB,Pitt-ANL	BW,Pole(AC)	
Bonn-Gatchina	BW,Pole(AC)	BW,Pole(AC)
Giessen	BW,Pole(SP)	BW
Jlab/Yerevan		BW
MAID		BW
DMT	BW,Pole(SP)	
Juelich	Pole(AC)	
EBAC	Pole(AC)	BW,Pole(AC)

} Dynamical model (DMT, Juelich, EBAC)

BW Breit-Wigner, SP speed-plot, AC Analytic continuation

Dynamical Model of meson production reaction

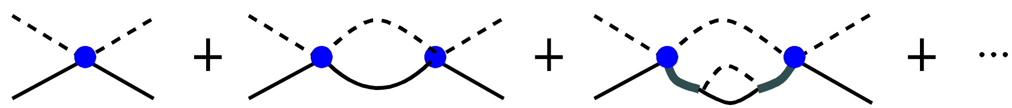
Coupled channels model with ππN three-body unitarity

$$\pi N, \eta N, \pi\pi N(\pi\Delta, \sigma N, \rho N)$$

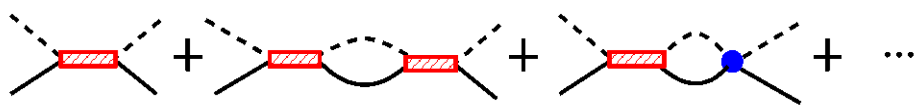
$$T_{\alpha,\beta}(W) = t^{nr}_{\alpha,\beta}(W) + \sum_{i,j} \bar{\Gamma}_{\alpha,i}(W)[\frac{1}{W - m_0 - \Sigma(W)}]_{ij} \bar{\Gamma}_{\beta,j}(W)$$

α, β Meson-Baryon channel i, j Resonances

$t^{nr}(W) =$



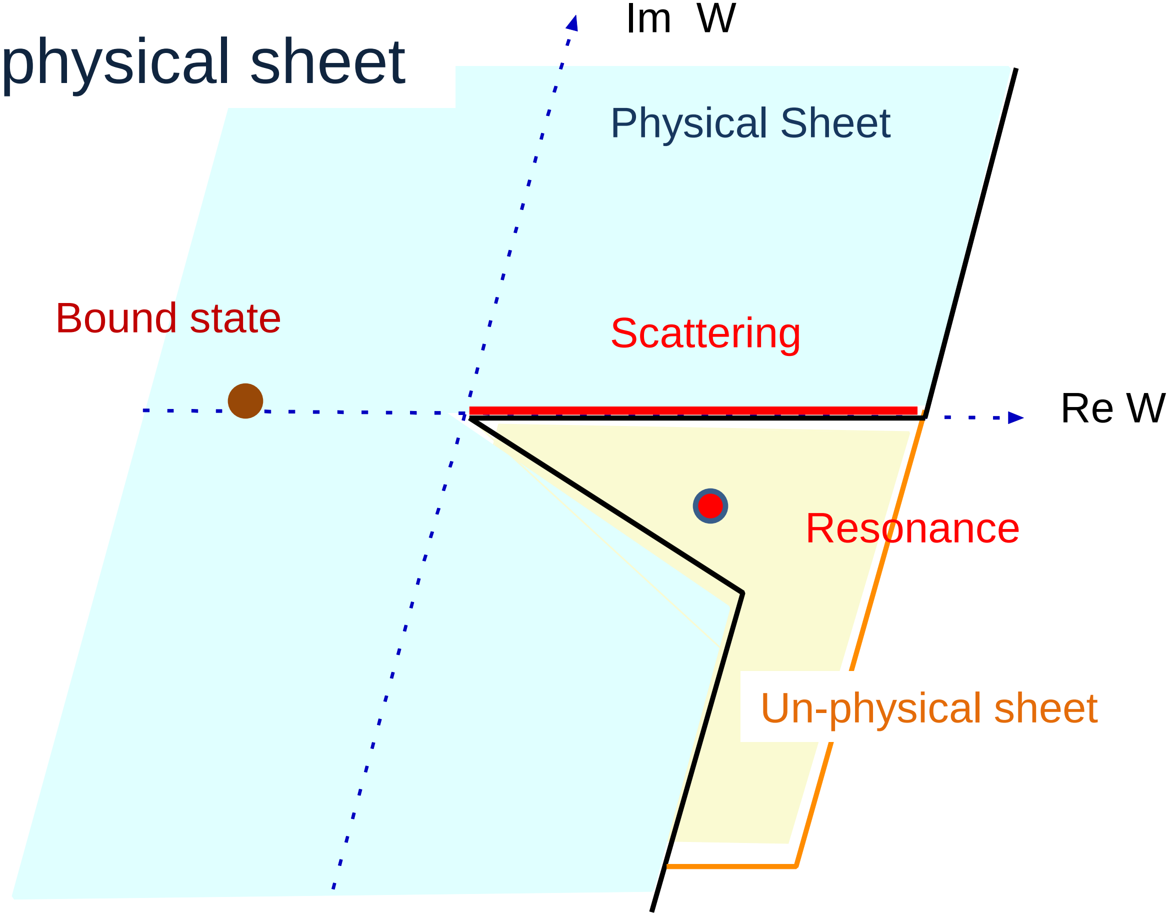
$t^{res}(W) =$



$\Sigma(W) = \bar{\Gamma}(W) G^0 \Gamma$ $\bar{\Gamma}(W) = (1 + t^{nr}(W) G^0(W))\Gamma$

- $G^0(W)$: MB Green function
- N* Green function: mass
  N* vertex : form factor

Resonance Pole on unphysical sheet



- Need to examine T(W) for complex W, un-physical sheet
- Multi-sheets for coupled channel

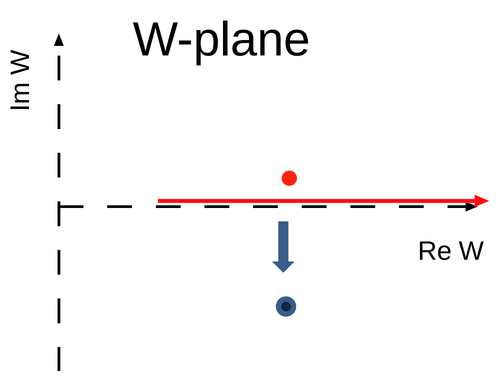
Ex: 2ch pp uu up pu (Kato 65,..)

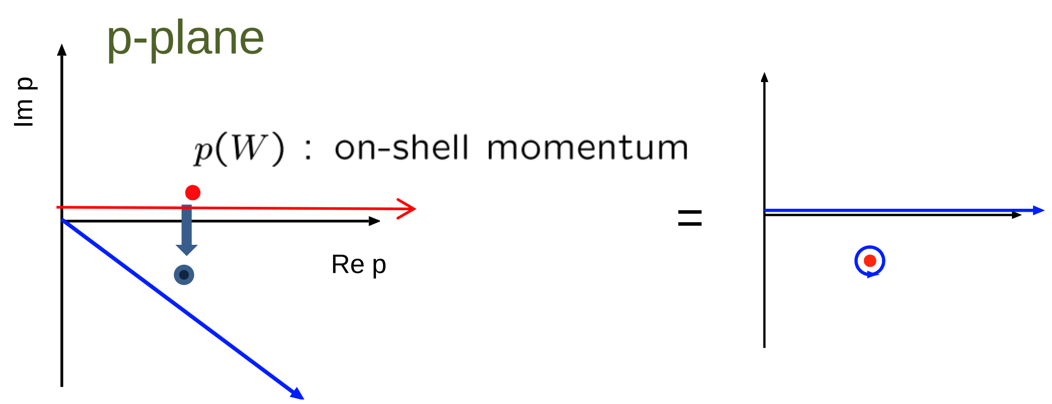
Resonance

Analytic continuation of T(W)

T(W) : obtained by solving Lippman-Schwinger Equation

$$< p_\alpha|T(W)|p_\beta > = < p_\alpha|V|p_\beta > + \sum_\gamma \int dp_\gamma^2 p_\gamma^2 \frac{< p_\alpha|V|p_\gamma >< p_\gamma|T(W)|p_\beta >}{W - E_M(p_\gamma) - E_B(p_\gamma) + i\epsilon}$$





Example: T for un-physical sheet above threshold

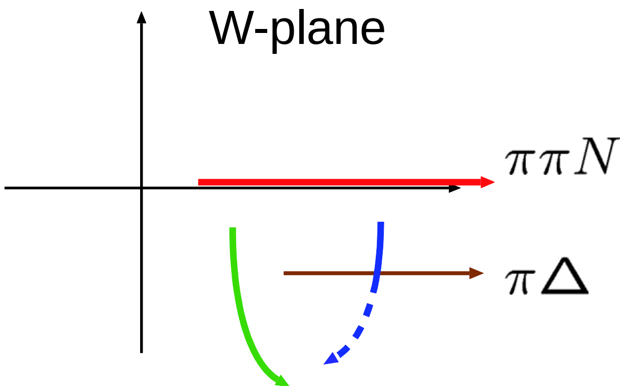
- Choose appropriate path for phys/un-phys sheets (Pearce-Gibson ‘89)
- V(p’,p) must be analytic in the region of path deformation

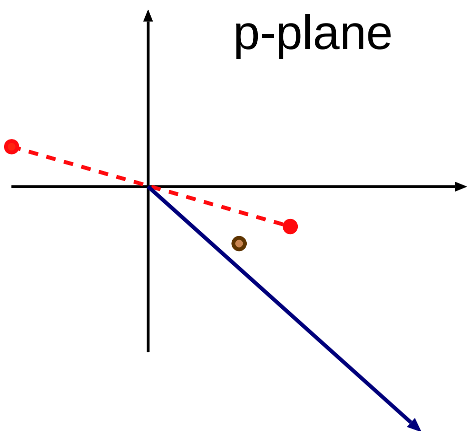
Green functions with unstable particle $(\pi\Delta, \rho N, \sigma N)$

$$G_{\pi\Delta}(W,p) = \frac{1}{W - E_\pi(p) - E_\Delta(p) - \Sigma_\Delta(W,p)}$$

Example:

for un-phys $\pi\pi N$ and $\pi\Delta$





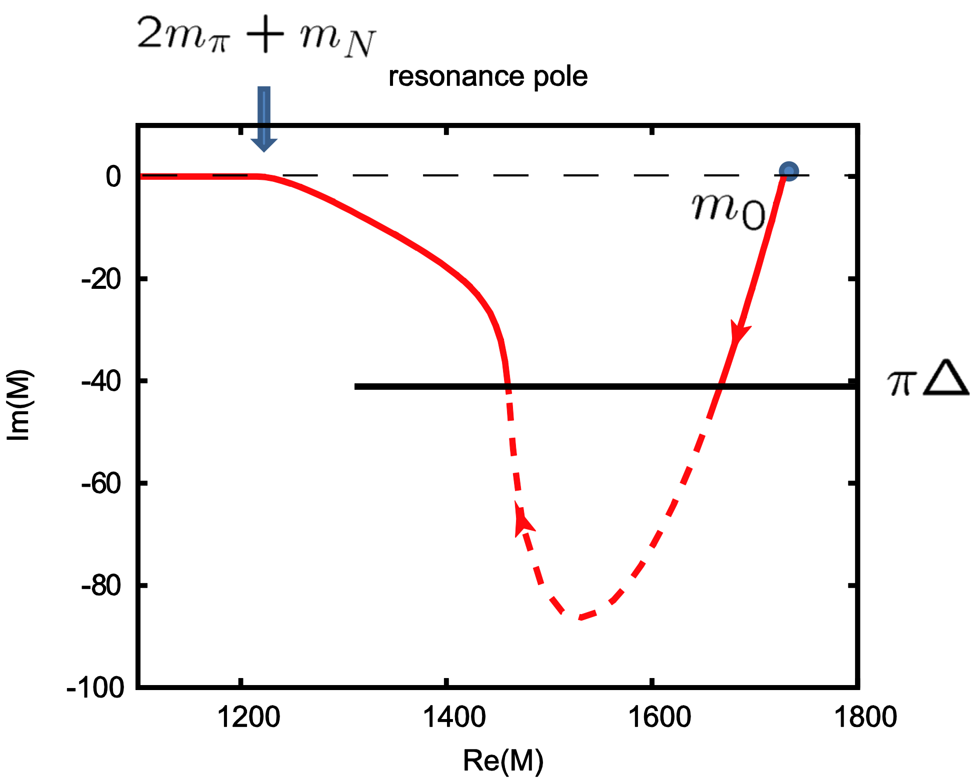
(Pearce Afnan '84)

Toy model

- N* couple with only πΔ
- S-wave, non-rela : 'analytic' solution

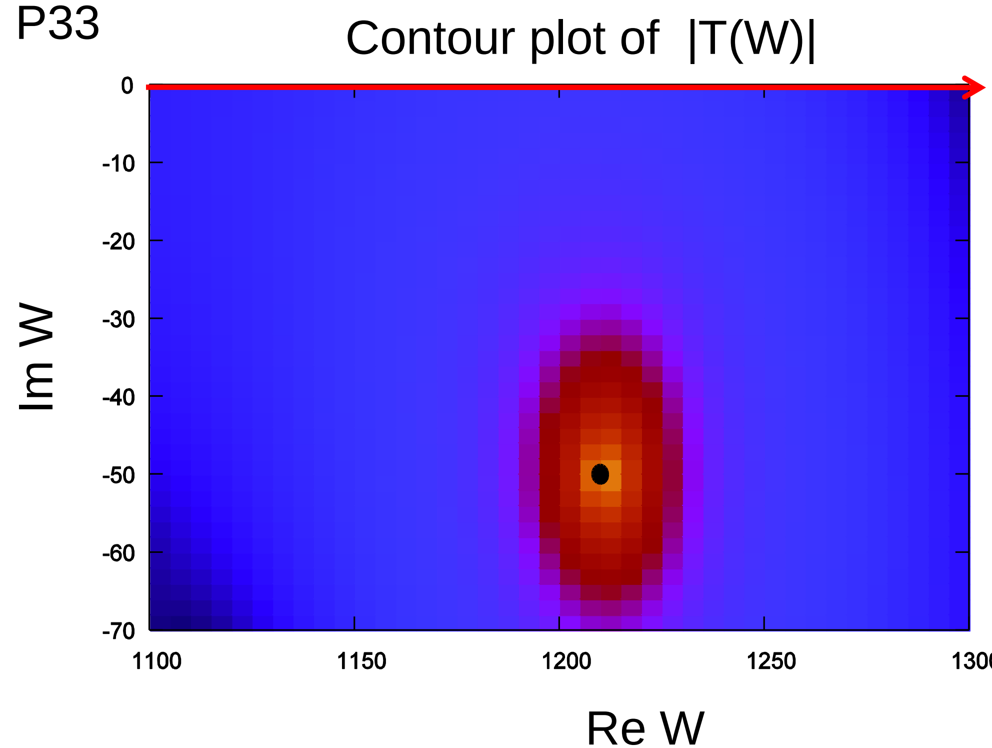
$$M_{N*} = m_0 + \Sigma_{\pi\Delta}(M_{N*})$$

$$\Sigma_{\pi\Delta}(W) = \int dp p^2 g^2_{N*\to\pi\Delta}(p) G_{\pi\Delta}(W,p)$$



Results from EBAC model (preliminary)

P33



	M	width	R	phi
Arndt06	1211	99	52	-47
Hoehler93	1209	100	50	-48
Cutkosly80	1210	100	53	-47
Doring09	1218	90	47	-37

$$T \sim \frac{Re^{i\theta}}{W - M_{res}}$$

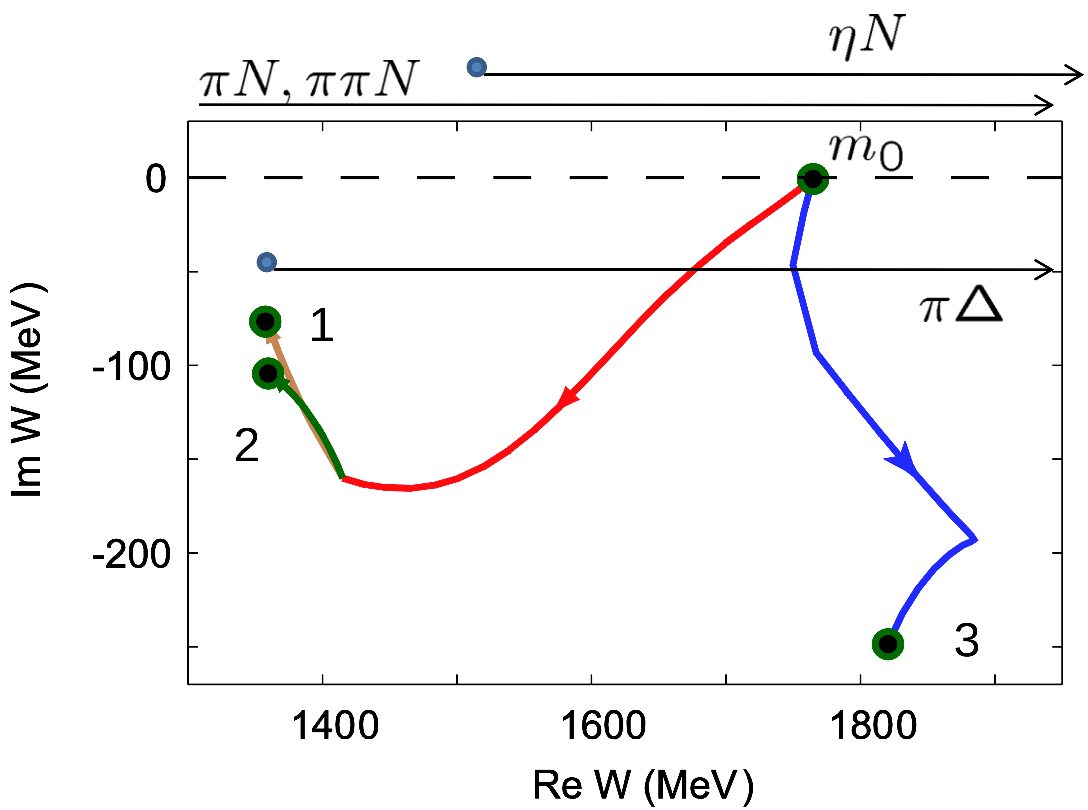
$$M_{res} = 1211 - 50iMeV$$

$$R = 52MeV, \phi = -46^0$$

P11

Pole trajectory

preliminary



	ηN	$\pi\Delta$
1	p	u
2	p	p
3	u	u

Multi-poles associated with single resonance in coupled channel

	poles	
ours	1357 - i 76	1364 - i 105
R. A. Arndt et al.	1359 - i 82	1388 - i 83
M. Doring et al.	1387 - i 147/2	1387 - i 71

Summary

- Pole of T matrix gives resonance information
  Mass and width from pole position, form factors from residue

- A method to extract resonance parameters using analytic continuation of the scattering amplitude is developed.

- Applied for πN scattering amplitude of EBAC current model
  P33, P11 resonance poles are extracted

- Extracting resonance form factor is in progress.