Coupled-channel fit to pion-nucleon elastic and eta production data

W.J. Briscoe
R.A. Arndt, I.I. Strakovsky, R.L.Workman
GWU

N*2005 NSTAR 12 - 15 October 2005
Tallahassee, Florida

Contents

- Motivation
- New $\pi^- p \rightarrow \eta n$ data
- Effect on amplitudes
- ηn couplings
- ηn scattering length
- Conclusion

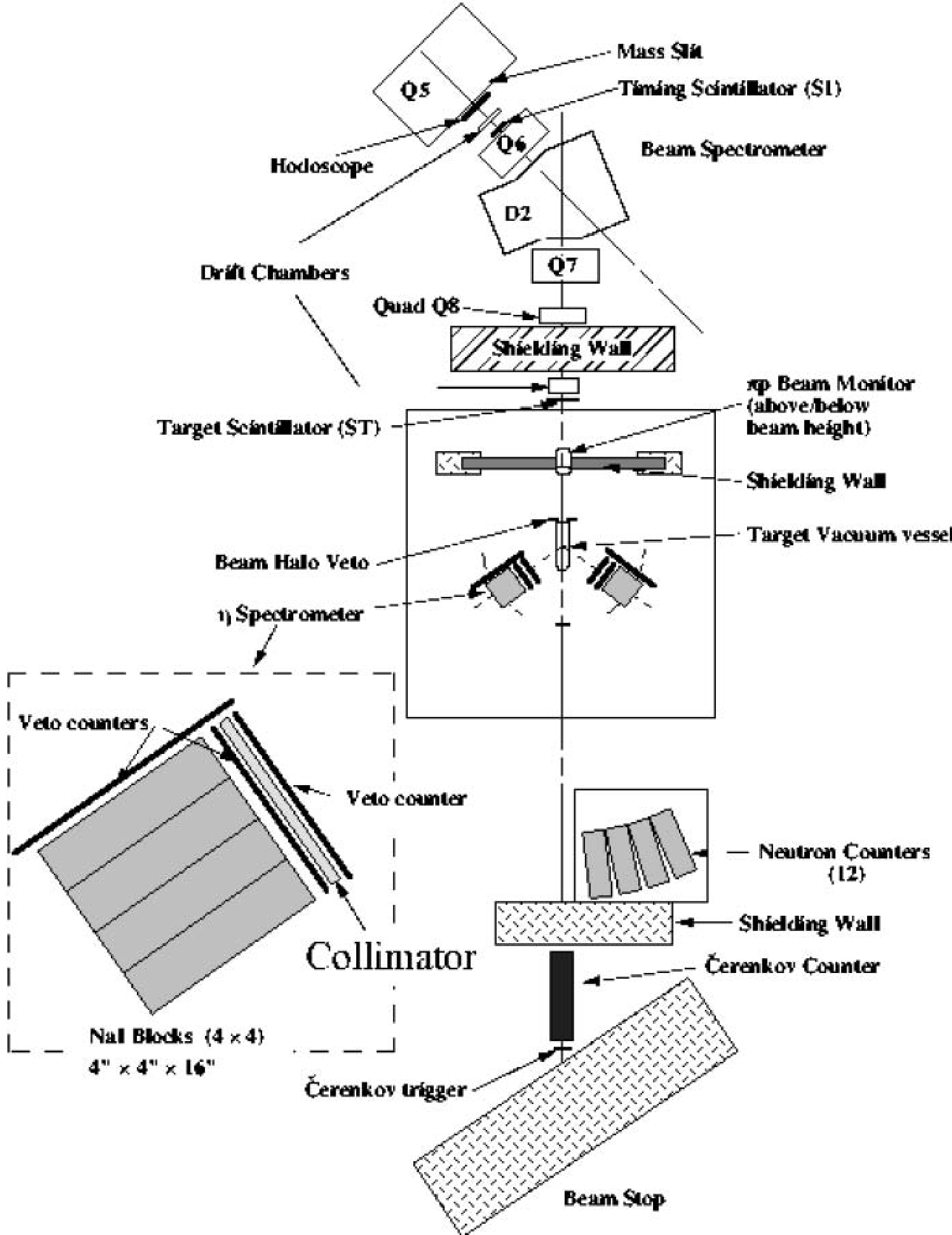
Motivation

- ηn channel vital for determination of $S_{11}(1535)$ and $D_{13}(1520)$ couplings
- Interference with (small) D_{13} signal is visible in (γ, η) and (π, η) data
- ηn SL determinations have a wide range (particularly for Re)
- New data (E909 and E913/914) are now available

New BNL $\pi^- p \rightarrow \eta n$ data

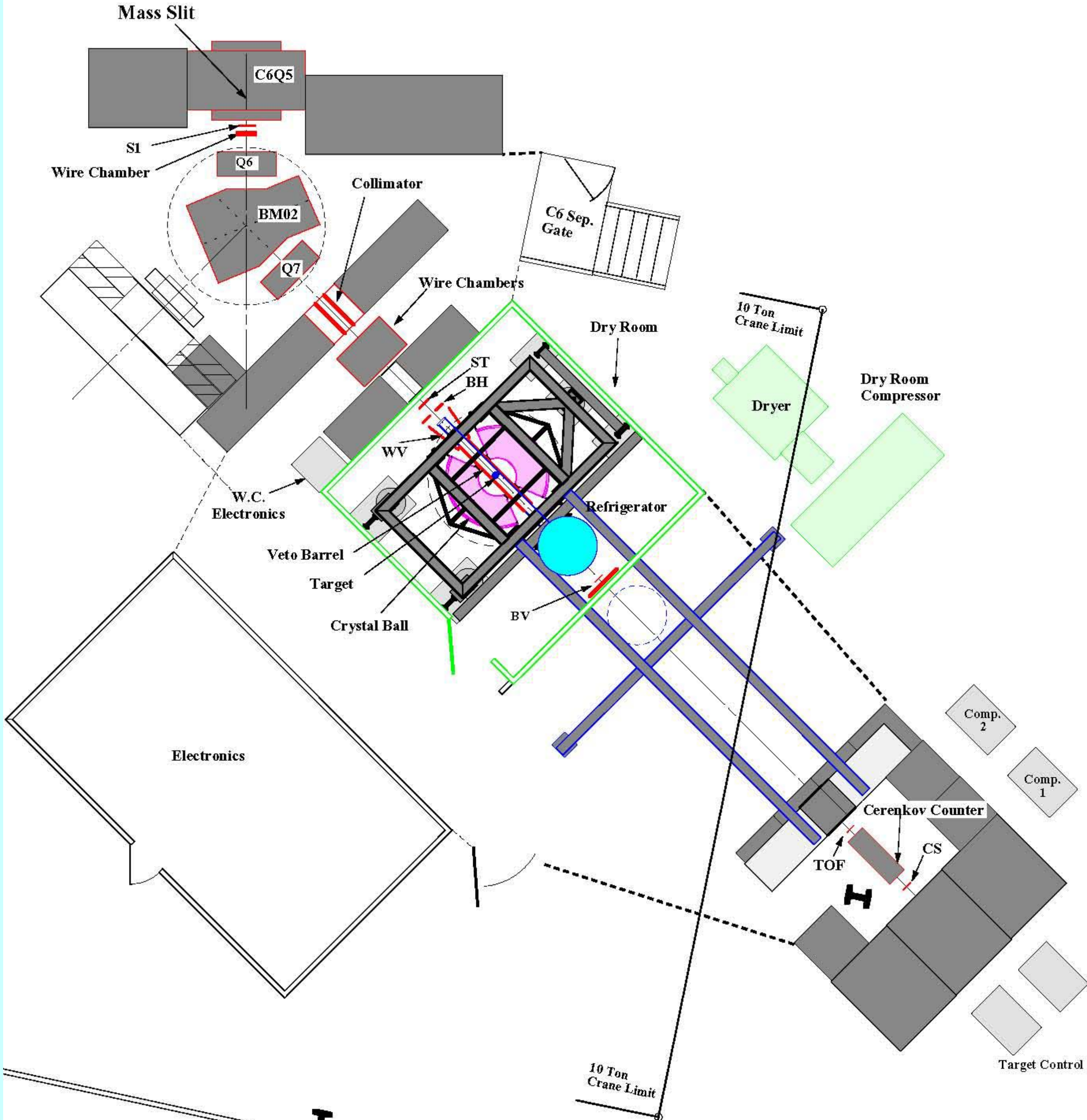
E909: 34 $d\sigma/d\Omega$	16 σ^{tot}	T=559 – 639 MeV	
Eta Spectrometer		θ= 26 – 154^o	
E913/E914: 84 $d\sigma/d\Omega$		T=561 – 620 MeV	
Crystal Ball		θ= 23 – 157^o	

E909



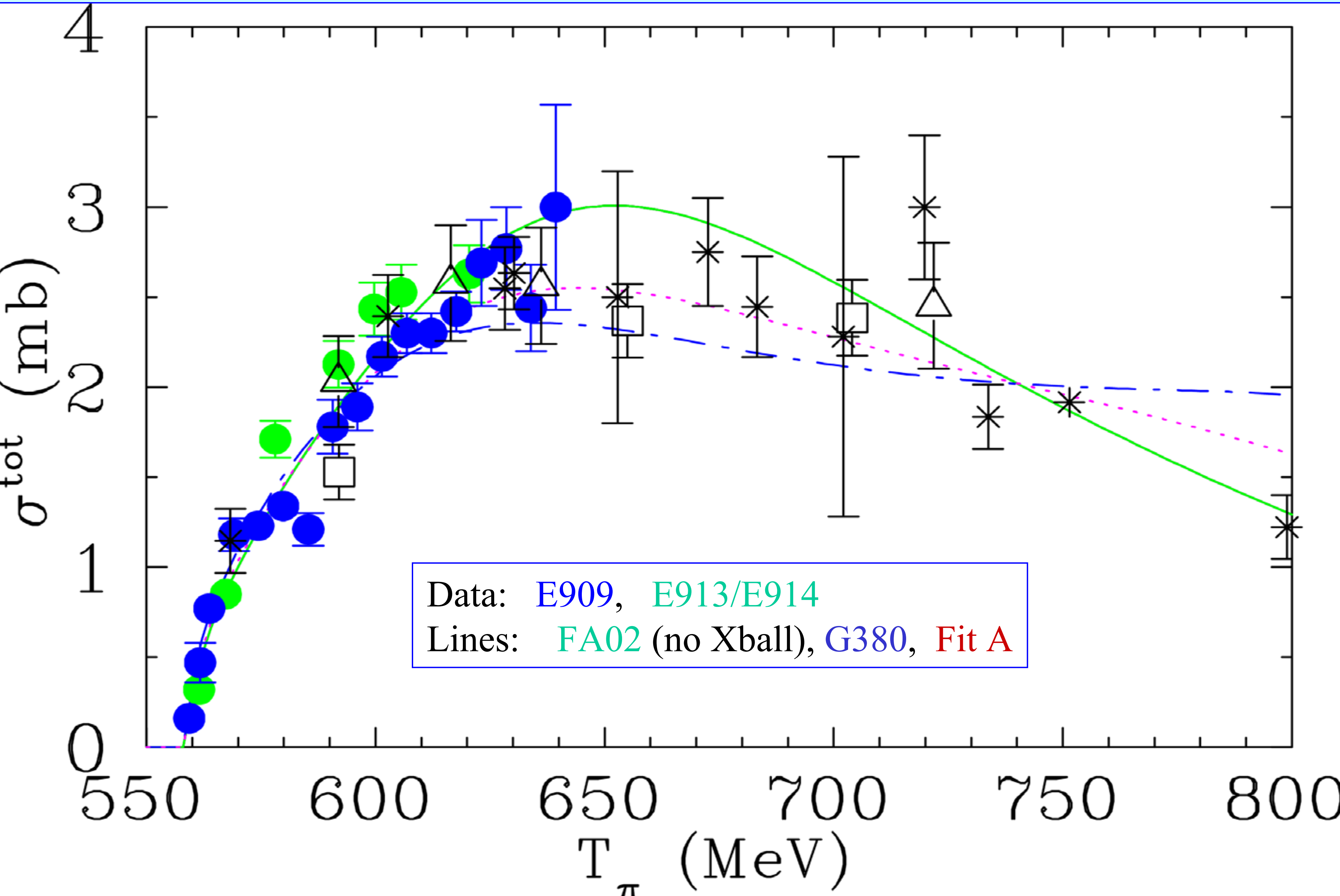
Mass Slit
Timing Scintillator (S1)
Q5
Q6
Beam Spectrometer
Hodoscope
D2
Q7
Drift Chambers
Quad Q8
Shielding Wall
πp Beam Monitor (above/below beam height)
Target Scintillator (ST)
Shielding Wall
Target Vacuum vessel
Beam Halo Veto
η Spectrometer
Veto counters
Veto counter
Collimator
NaI Blocks (4 × 4)
4" × 4" × 16"
Neutron Counters (12)
Shielding Wall
Čerenkov Counter
Čerenkov trigger
Beam Stop

913/914



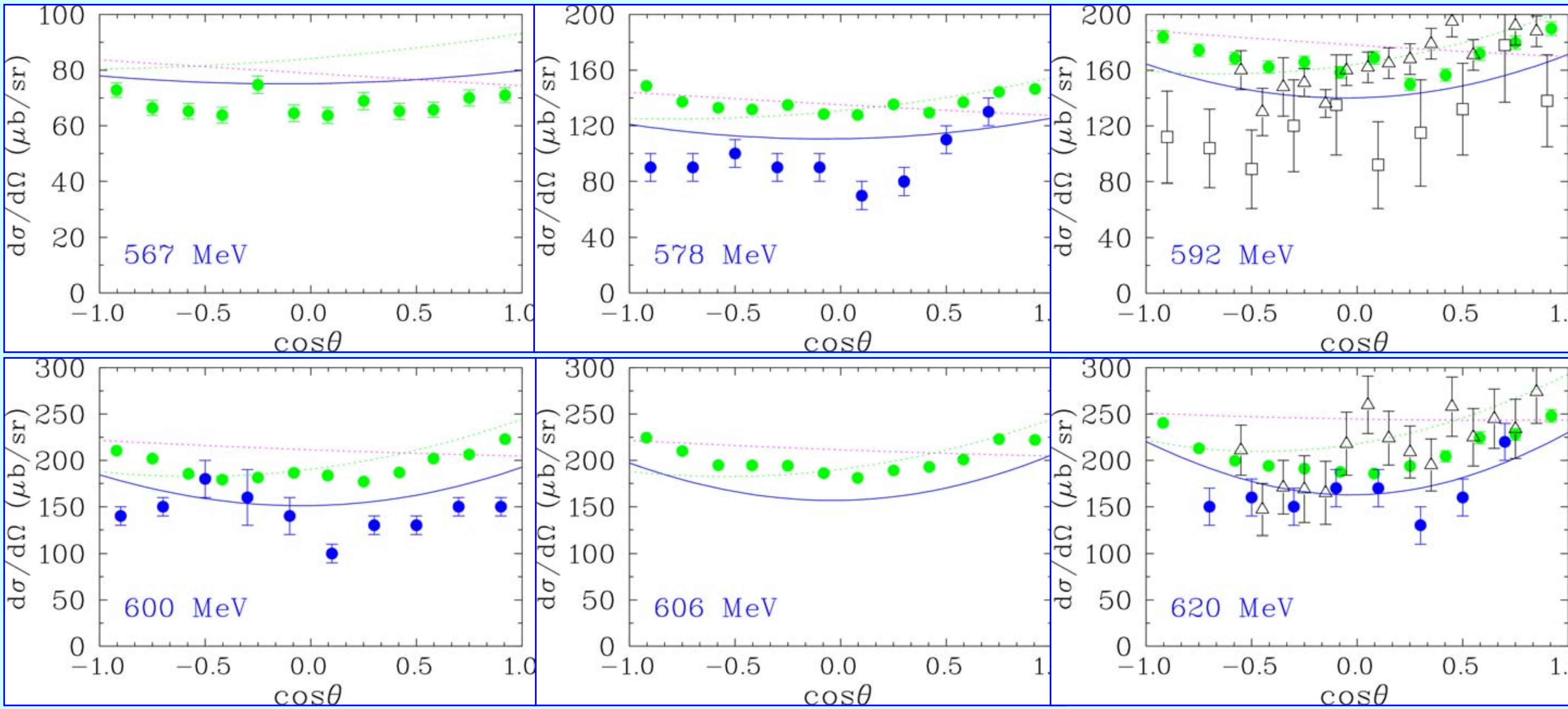
Mass Slit
C6Q5
S1
Wire Chamber
Q6
BM02
Q7
Collimator
Wire Chambers
C6 Sep.
Gate
Dry Room
10 Ton
Crane Limit
ST
BH
WV
Dryer
Dry Room
Compressor
W.C.
Electronics
Refrigerator
Veto Barrel
Target
Crystal Ball
BV
Electronics
Comp.
2
Comp.
1
Cerenkov Counter
CS
TOF
Target Control
10 Ton
Crane Limit

Total Xsection for $\pi^- p \rightarrow \eta n$



$d\sigma/d\Omega$ for $\pi^- p \rightarrow \eta n$

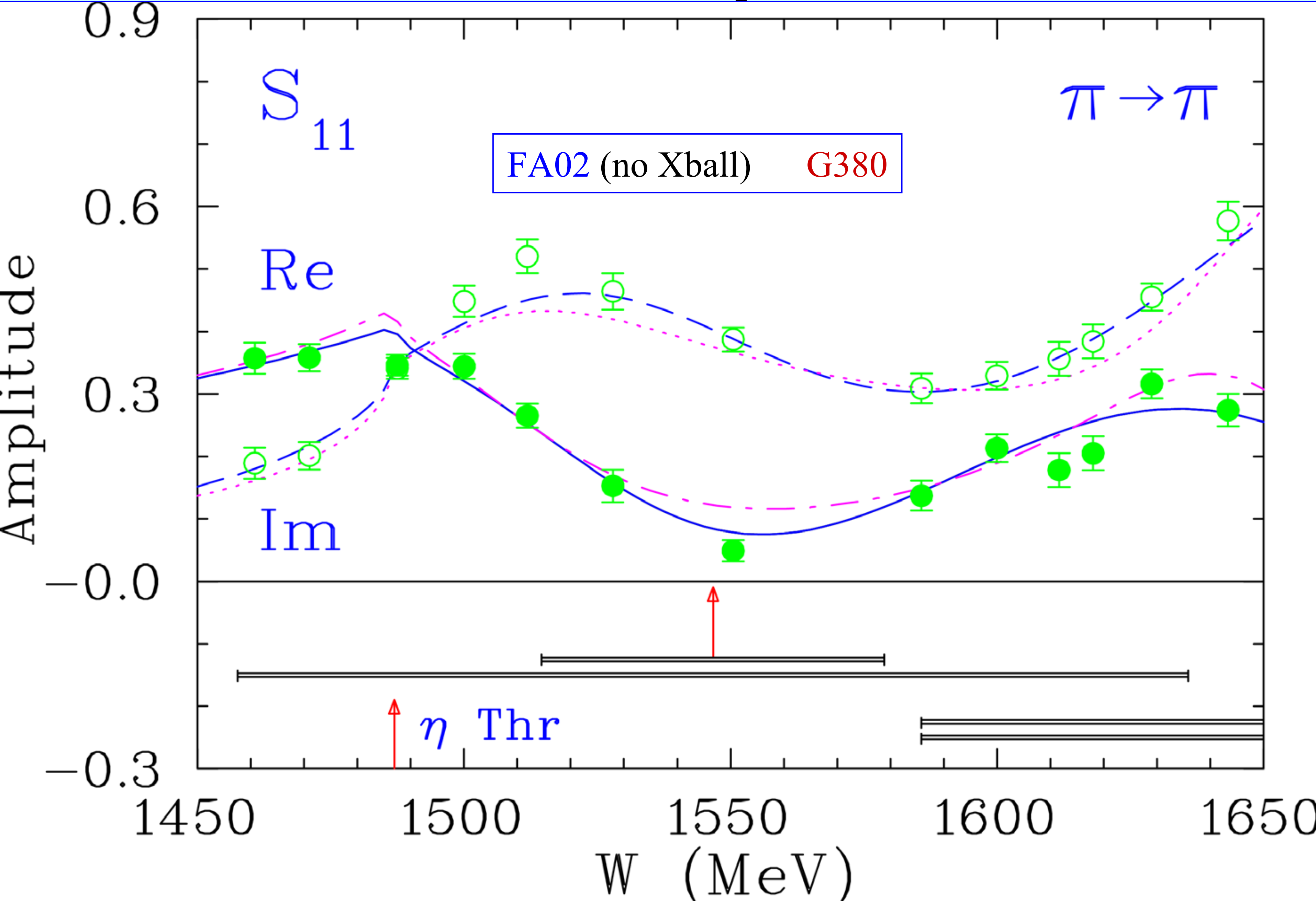
(un-norm plots)



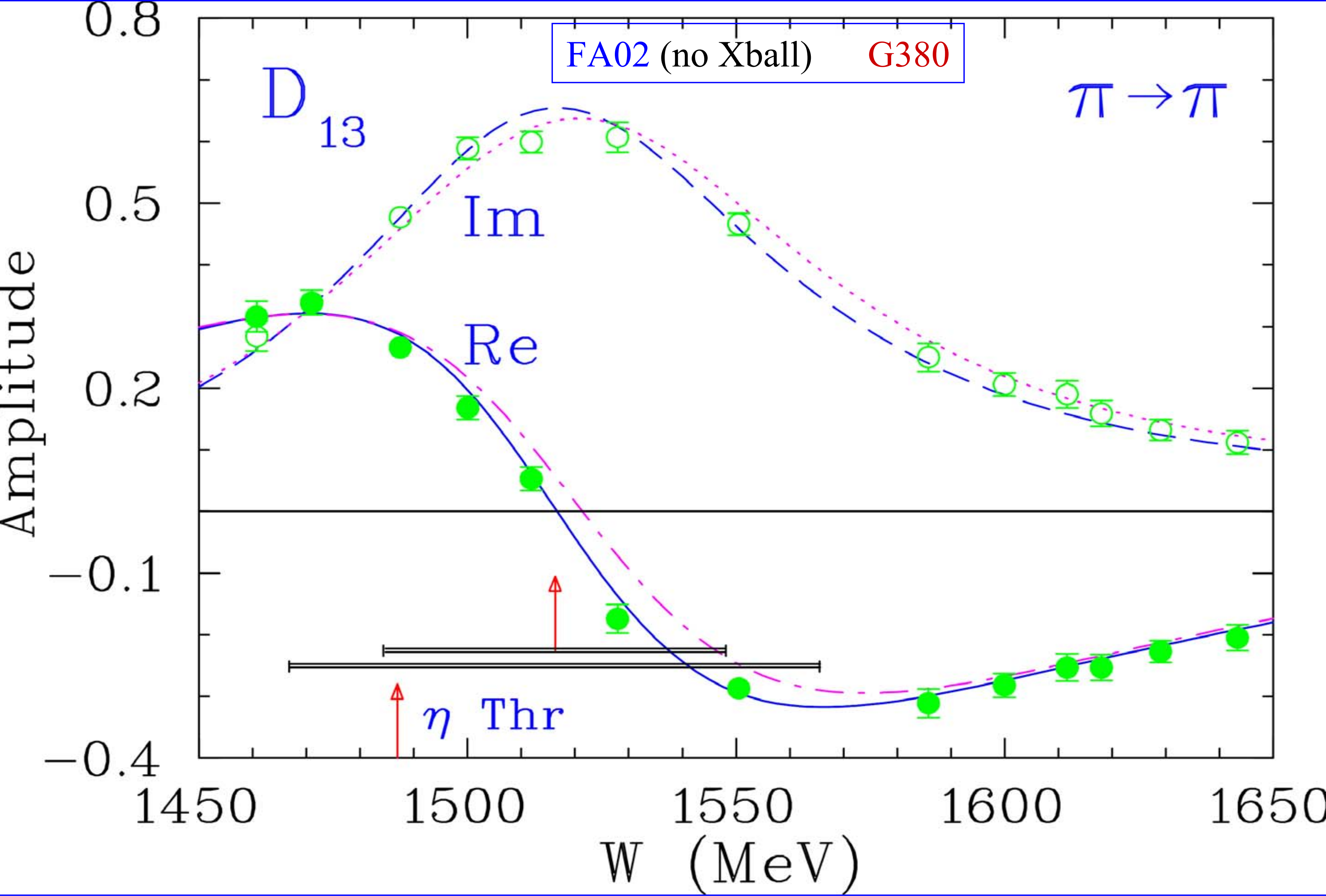
Data: E909, E913/E914

Slns: G380, Giessen multi-ch, PNPI multi-ch

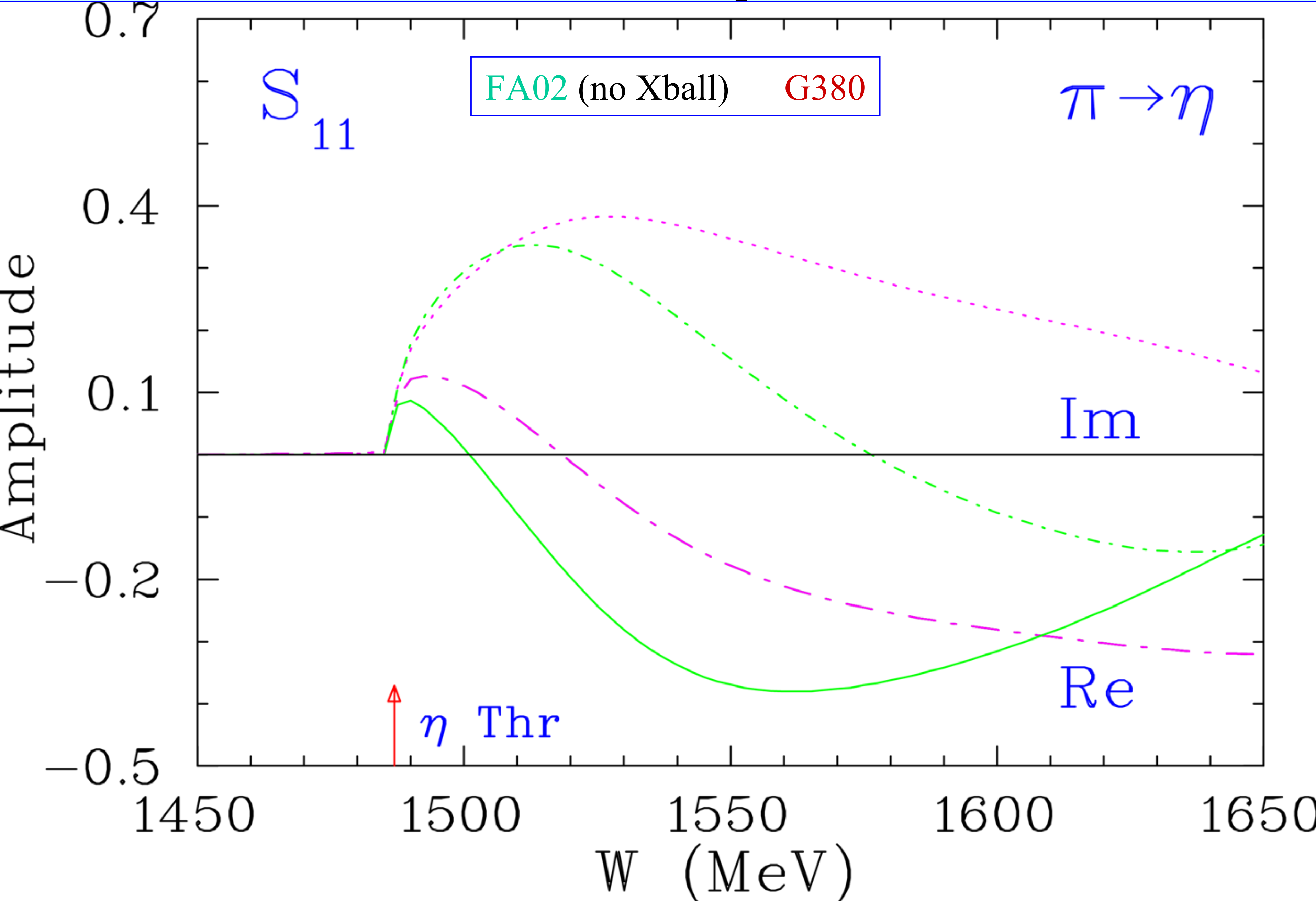
Effect on amplitudes



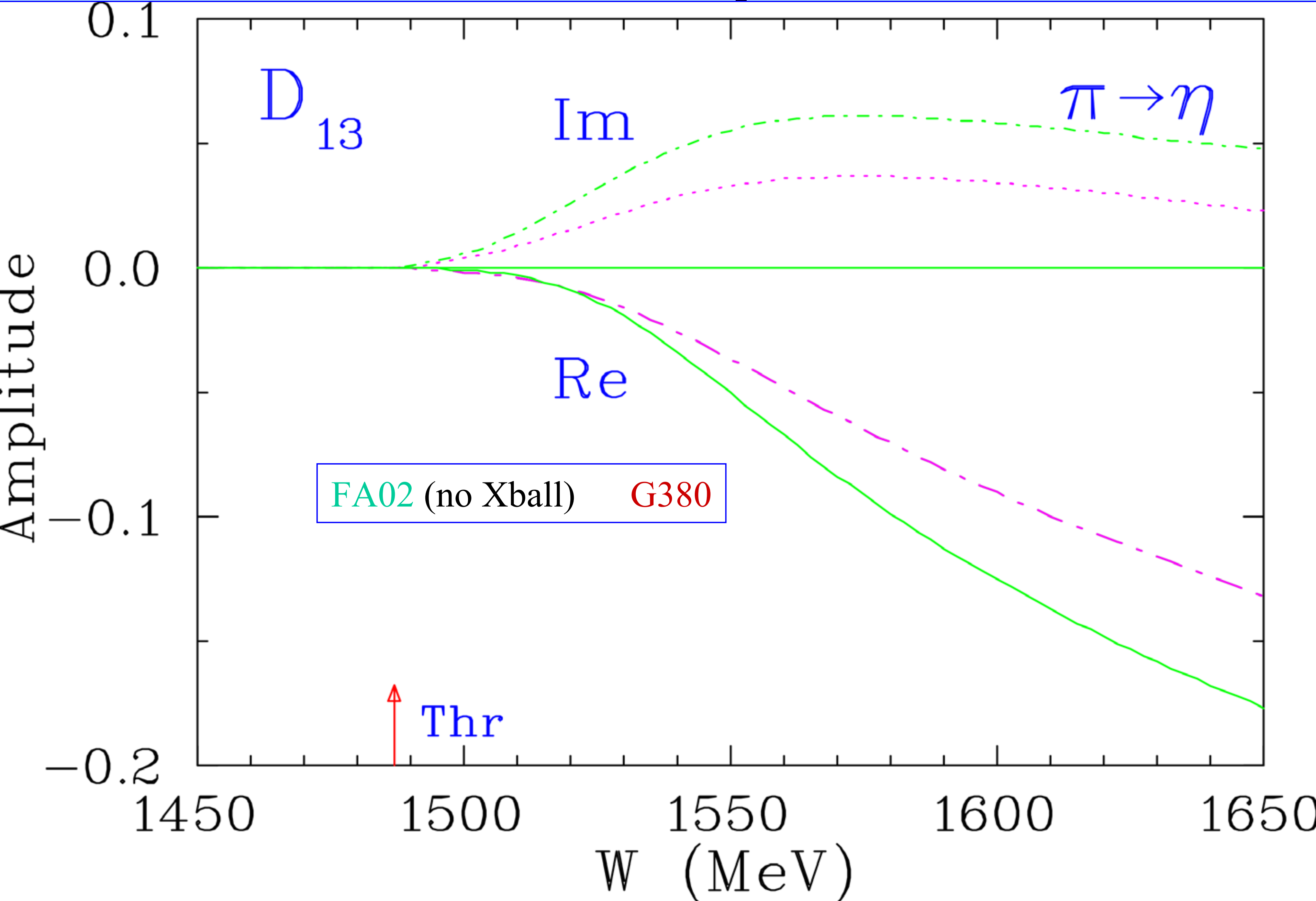
Effect on amplitudes



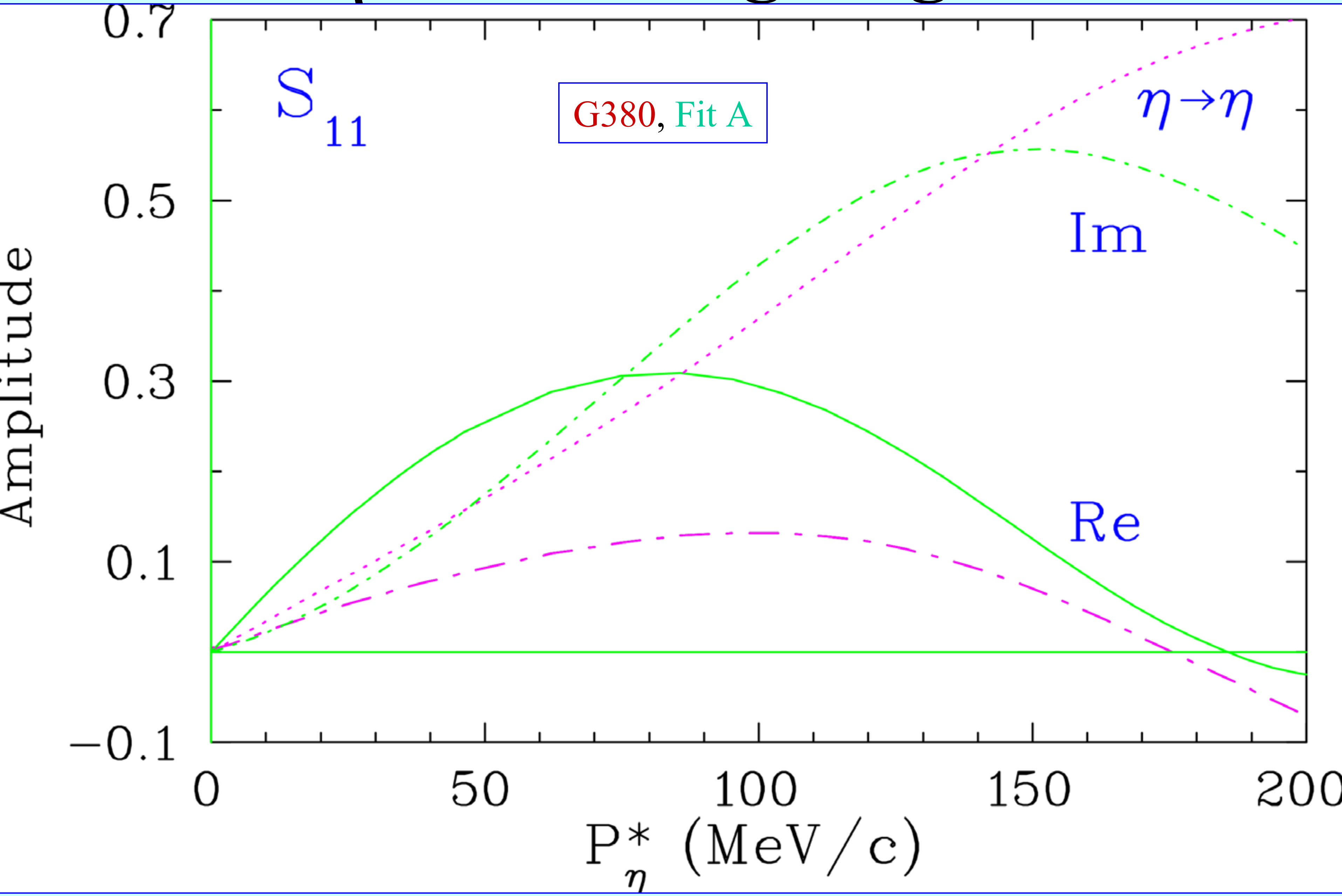
Effect on amplitudes



Effect on amplitudes



ηn scattering length



Resonance widths (MeV) and BRs

Res	Solution	Γπ	Γη	ΓπΔ	ΓρN	Γη / Γt
N(1535)	Fit A	30 ± 2	45 ± 3	15 ± 1		0.50
	Fit B	32 ± 3	45 ± 4	16 ± 1		0.48
	Fit C	39 ± 3	67 ± 4	9 ± 2		0.58
	Fit D	42 ± 6	70 ± 10	11 ± 2		0.57
N(1520)	Fit A	68 ± 1	0.12 ± 0.03	19 ± 5	19 ± 5	0.0012
	Fit B	68 ± 1	0.17 ± 0.12	19 ± 6	19 ± 6	0.0016
	Fit C	67 ± 1	0.08 ± 0.03	14 ± 4	24 ± 4	0.0008
	Fit D	67 ± 1	0.09 ± 0.07	14 ± 5	24 ± 5	0.0009

Fit A,C (include Xball)
Fit B,D (no Xball)

S_{11}(1535): Γη > Γπ

D_{13}(1520): Γη/Γt **~0.0008 – 0.0016**

D_{13} [Mainz (γ, η)]: Γη/Γt = 0.0008 ± 0.0001

D_{13} [Giessen, multi-ch]: Γη/Γt = 0.0023 ± 0.0004

Optical Theorem

The <u>optical theorem</u> leads to

$\mathrm{Im}A_{\eta N} = p_\eta/4\pi\ \sigma(\eta n)^{\mathbf{tot}}$

$= p_\eta/4\pi\ [\sigma(\eta n \rightarrow \pi N)+\sigma(\eta n \rightarrow 2\pi N)$

$+ \sigma(\eta n \rightarrow \eta N)]$

$= 3p_\pi/8\pi p_\eta{}^2 \sigma(\pi^- p \rightarrow \eta n)$

$+ p_\eta/4\pi\ [\sigma(\eta n \rightarrow 2\pi N)+\sigma(\eta n \rightarrow \eta N)$

As a result, we have

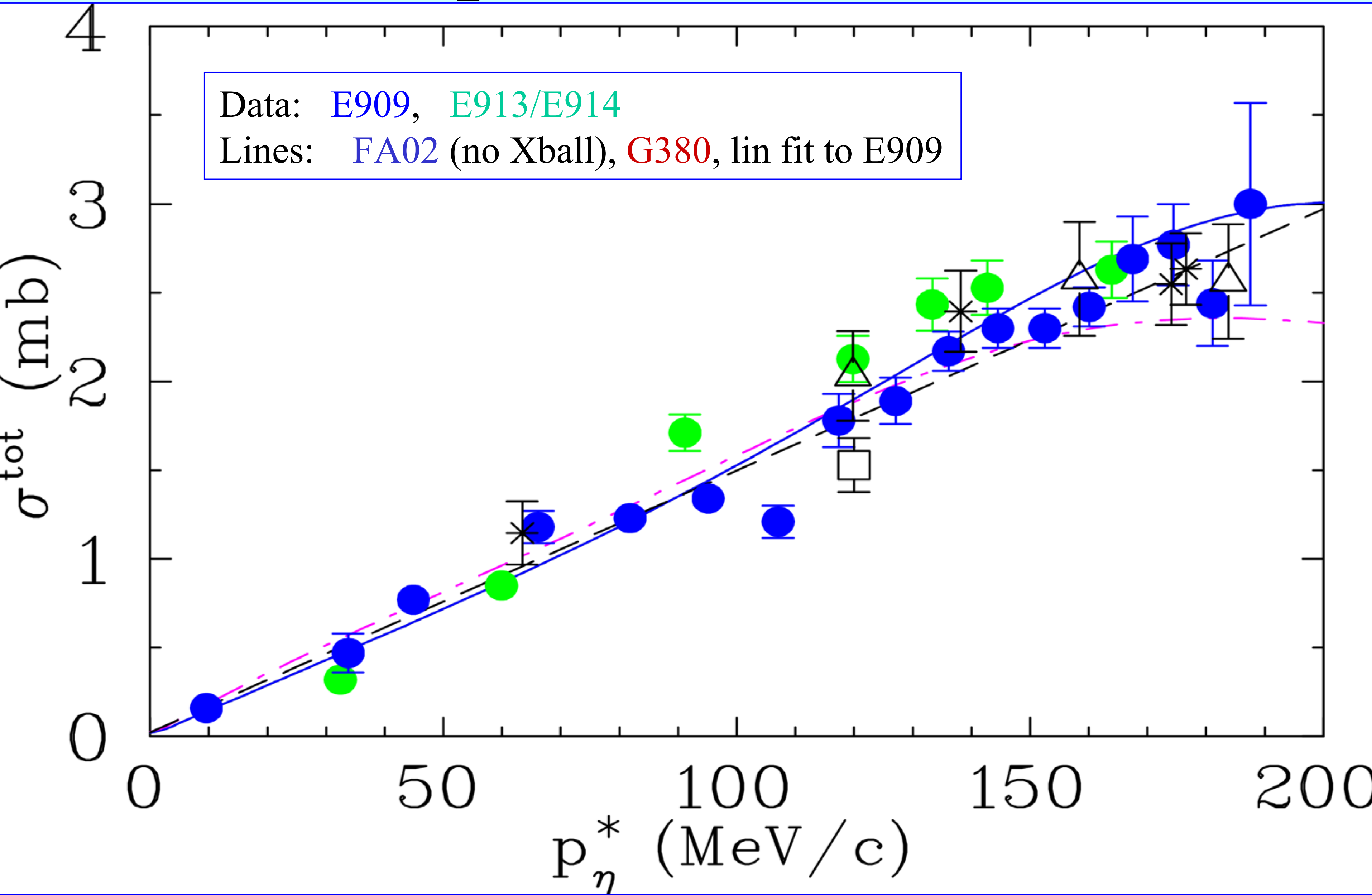
$\mathrm{Im}A_{\eta N} \geq 3p_\pi/8\pi p_\eta \sigma(\pi^- p \rightarrow \eta n)$

Using a linear fit, the recent **E909** threshold data give

$1/\ p_\eta\ \sigma(\pi^- p \rightarrow \eta n) = 15.2 \pm 0.8\ \mu\mathrm{b/MeV}$

$\mathrm{Im}A_{\eta N} \geq 0.172 \pm 0.009\ \mathrm{fm}$

Optical Theorem



ηn Scattering Length Overview

$A_{\eta N}$ (fm)		Ref	$A_{\eta N}$ (fm)		Ref
-0.15	+ i0.22	Birbrair96	0.550	+ i0.300	Sauermann95
0.20	+ i0.26	Kaiser97	0.56	+ i0.22	Birbrair96
	≥ i0.24(2)	Binnie73	0.577	+ i0.216	Feuster98
0.25	+ i0.16	Bennhold91	0.621(40)	+ i0.306(34)	Abaev96
0.27	+ i0.22	Bhalerao85	0.68	+ i0.24	Kaiser95
0.28	+ i0.19	Bhalerao85	0.734(26)	+ i0.269(19)	Batinic98
≤ 0.30		Grishina00	0.75(4)	+ i0.27(3)	Green97
0.32	+ i0.25	Ramon00	≥ 0.75		Rakityansky01
0.404(117)	+ i0.343(58)	Batinic95	0.75	+ i0.27	Fix02
0.41	+ i0.26	Gasparyan03	0.772(5)	+ i0.217(3)	Nieves01
0.42	+ i0.34	Sibirtsev02	0.83	+ i0.35	Tuan65
0.42	+ i0.32	Krehl00	0.87	+ i0.27	Green99
0.46(9)	+ i0.18(3)	Briscoe02	0.876(47)	+ i0.274(39)	Batikic95
0.476	+ i0.279	Faldt95	0.886(47)	+ i0.274(39)	Batinic95
0.476	+ i0.279	Tiator94	0.91(6)	+ i0.27(2)	Green05 ←
0.487	+ i0.171	Feuster98	0.91(3)	+ i0.29(4)	Batinic95a
0.51	+ i0.21	Sauermann95	0.968	+ i0.281	Batinic95
0.52	+ i0.25	Willis97	0.980	+ i0.37	Arima92
0.54	+ i0.49	Krippa01	0.991	+ i0.347	Penner02 ←
0.55(20)	+i0.30	Wilkin93	1.05	+ i0.27	Green99

(1.03 – 1.14) + i(0.31 – 0.41) fm (K-matrix fit)

Conclusion

Results with new $\pi^- p \rightarrow \eta n$ data consistent with other recent determinations:

- $D_{13} \rightarrow \eta n$ coupling spans previous range of values

Progress:

We are using the extracted πN and ηN amplitudes in analysis of (γ, η) data