

Intersections between Particle and Nuclear Physics
Quebec City, May 2000

Partial Wave Analysis results from JETSET

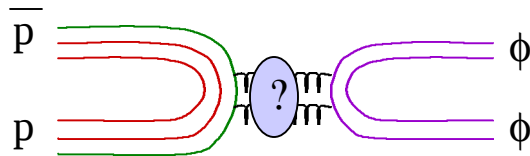
Richard Jones
University of Connecticut

representing the Jetset collaboration
with members from
Bari, CERN, Erlangen, Freiburg, Genova, Illinois, Jülich, Oslo, Uppsala

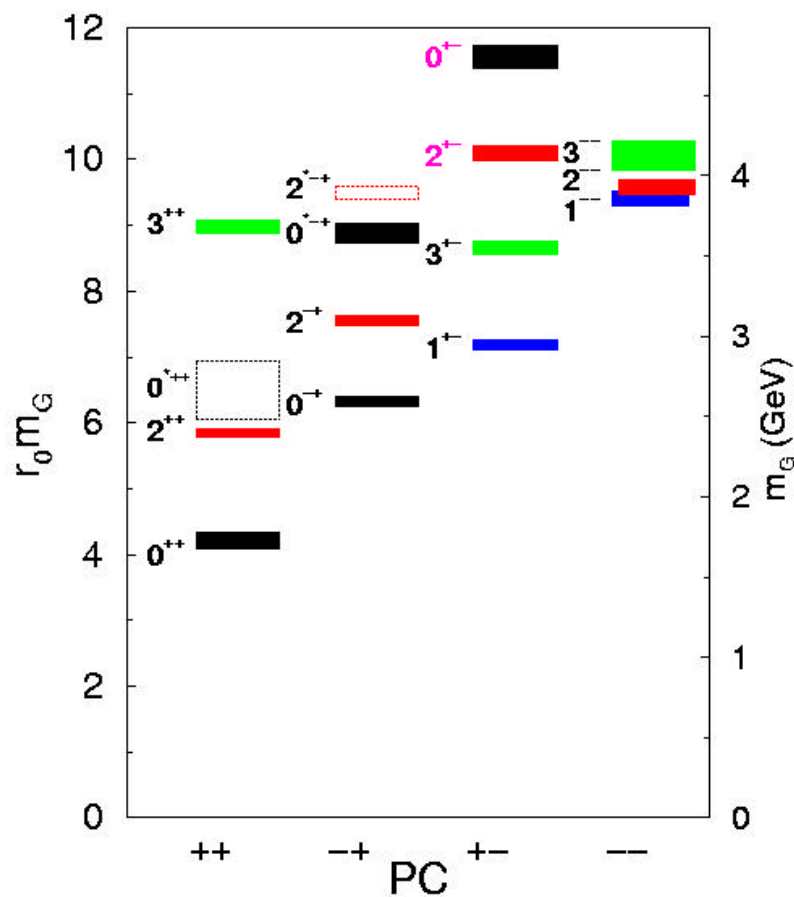
- the Jetset experiment
- PWA formalism and MC tests
- results from analysis of full data set

The Jetset Experiment

- Measures in-flight pbar annihilation: $\bar{p}p \rightarrow \phi\phi$

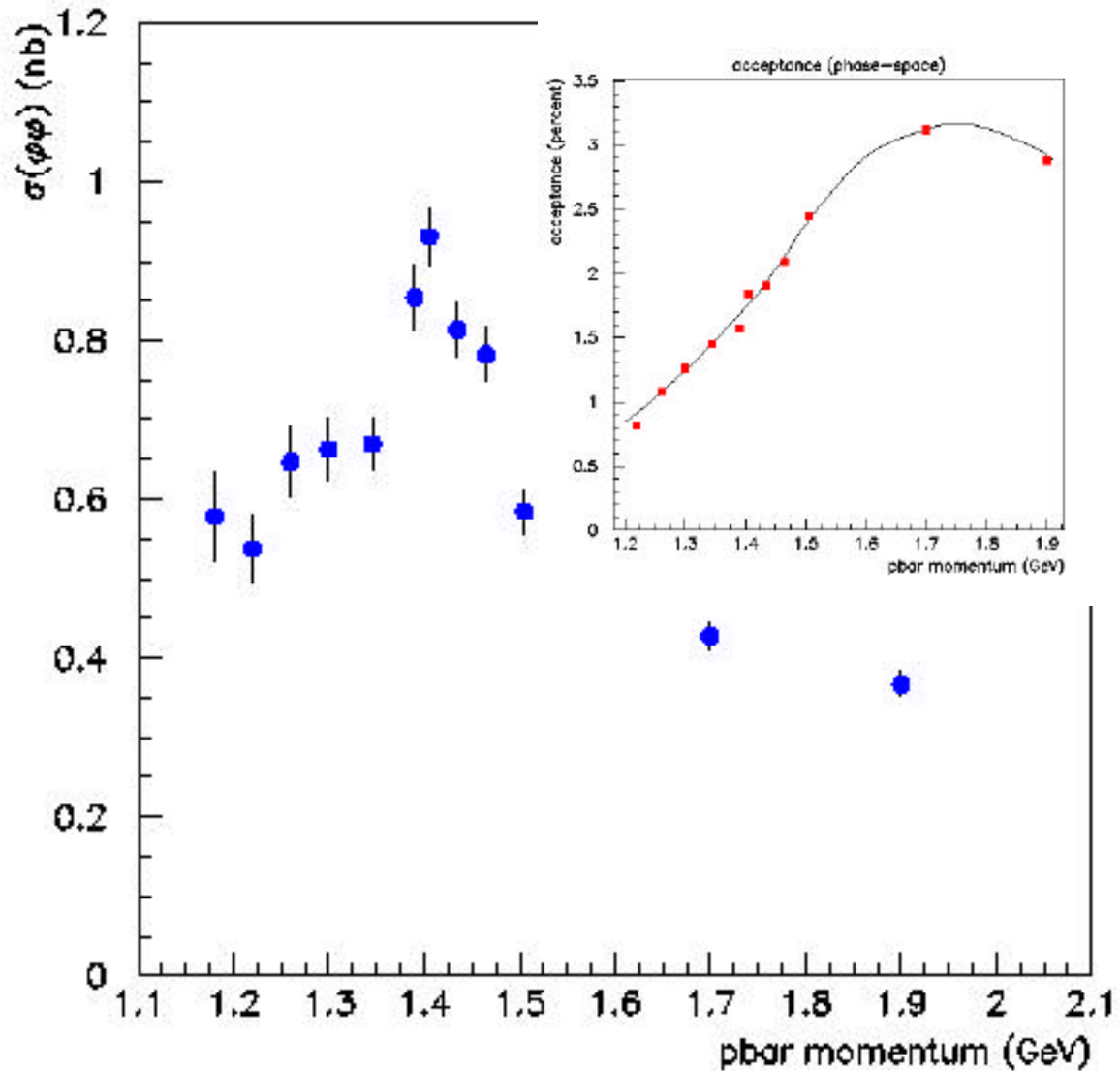


- OZI-suppressed, may form glueball resonances in s-channel



Morningstar et.al., LAT991004

Total cross section $\bar{p}p \rightarrow \phi\phi$



Complete data set from Jetset

point	N($\phi\phi$)	N(b.g.)	point	N($\phi\phi$)	N(b.g.)	point	N($\phi\phi$)	N(b.g.)
1	326	95	5	1005	589	9	1318	877
2	414	225	6	1262	585	10	1056	943
3	626	270	7	1782	886	11	936	1592
4	840	369	8	1375	868	12	707	1666

PWA Accounting

J values of the waves included in the partial wave analysis.
All waves up to J=4, L=4 in the final state were allowed.

wave	J ^{PC}	L initial	S initial	L final	S final
1	0 ^{−+}	0	0	1	1
2	0 ⁺⁺	1	1	0	0
3	0 ⁺⁺	1	1	2	2
4	1 ⁺⁺	1	1	2	2
5	2 ⁺⁺	1	1	0	2
6	2 ⁺⁺	1	1	2	0
7	2 ⁺⁺	1	1	2	2
8	2 ⁺⁺	1	1	4	2
9	2 ^{−+}	2	0	1	1
10	2 ^{−+}	2	0	3	1
11	2 ⁺⁺	3	1	0	2
12	2 ⁺⁺	3	1	2	0
13	2 ⁺⁺	3	1	2	2
14	2 ⁺⁺	3	1	4	2
15	3 ⁺⁺	3	1	2	2
16	3 ⁺⁺	3	1	4	2
17	4 ^{−+}	4	0	3	1
18	4 ⁺⁺	3	1	2	2
19	4 ⁺⁺	3	1	4	0
20	4 ⁺⁺	3	1	4	2
21	4 ⁺⁺	5	1	2	2
22	4 ⁺⁺	5	1	4	0
23	4 ⁺⁺	5	1	4	2

PWA Procedure

Getting started:

- ♦ Put all waves into the pot at once and stir
 - ✦ gives full freedom to the fit -> definition of “good fit”
 - ✦ errors on amplitudes are large, meaningless
- ♦ Put in waves a few at a time and look for the minimal set that gives a good description of the entire data set
 - ✦ gives priority to an economical description
 - ✦ adequacy judged in comparison with full fit

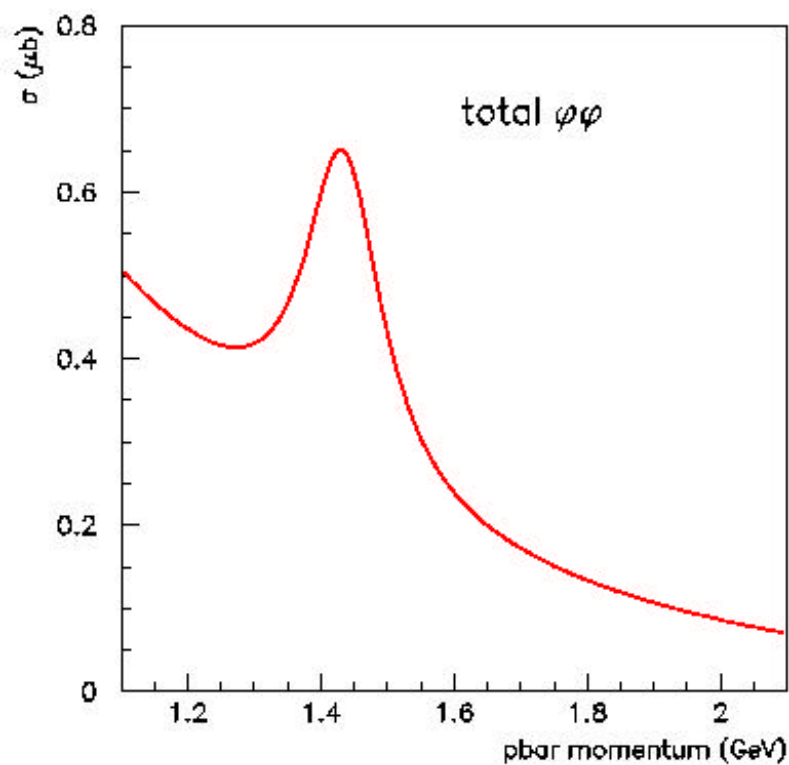
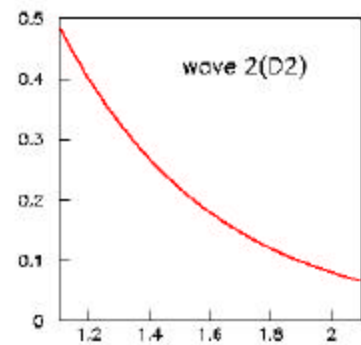
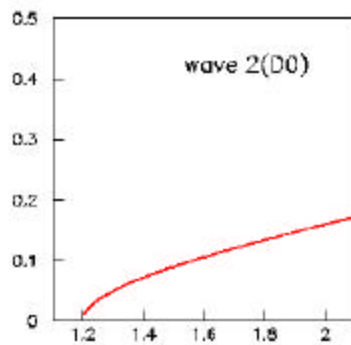
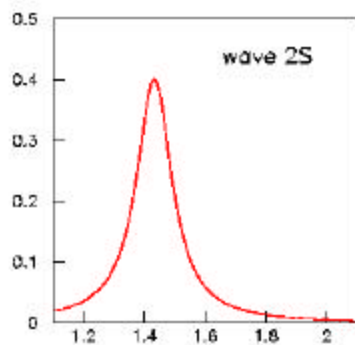
We found 3 dominant waves
all 2^{++}

Method:

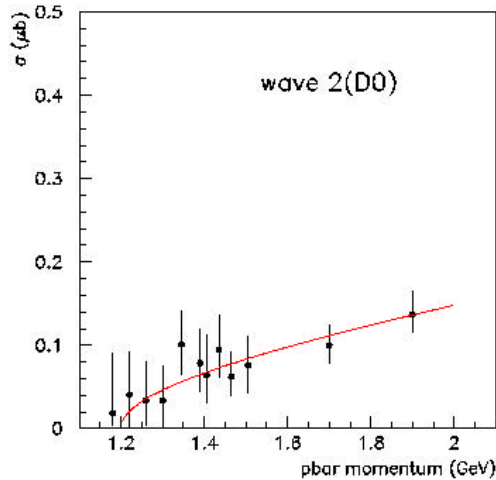
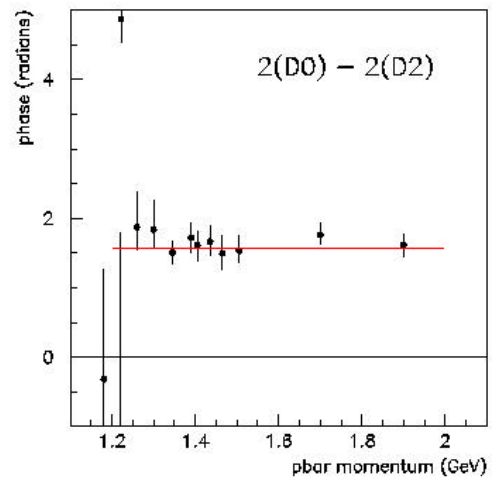
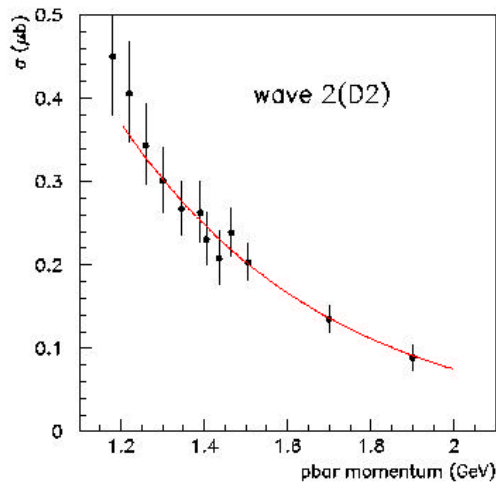
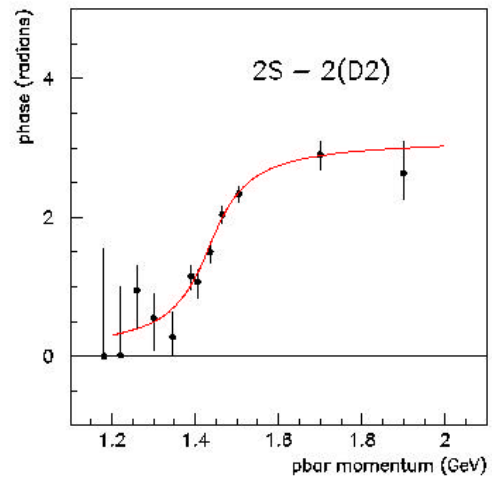
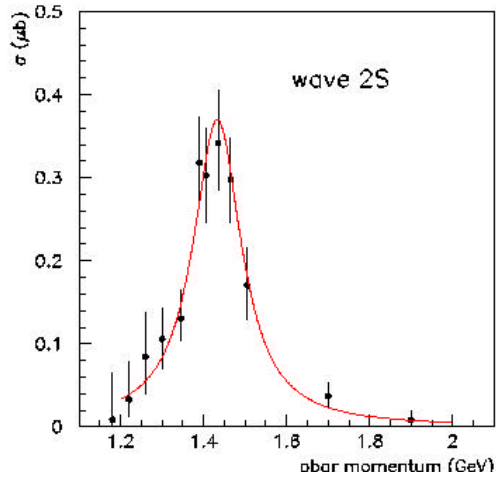
1. Group the data into large divisions for statistics
2. Try all waves one-by-one, keep best and repeat
 - ➡ Sets agreed on 3 top waves
3. Go back to beginning and put in waves two-by-two trying all pairs of waves together, then add one-by-one
 - ➡ Sets chose some pair of these 3 waves, then took the third as next choice

Monte Carlo test

- Ingredients:
- ✓ 1 resonant wave, two non-resonant
 - ✓ experimental acceptance through simulation
 - ✓ same reconstruction, analysis as for real data

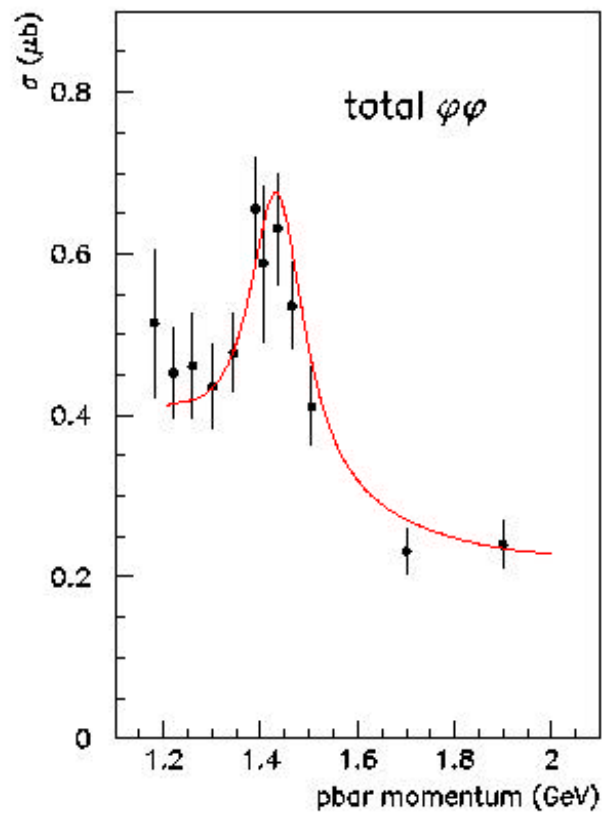
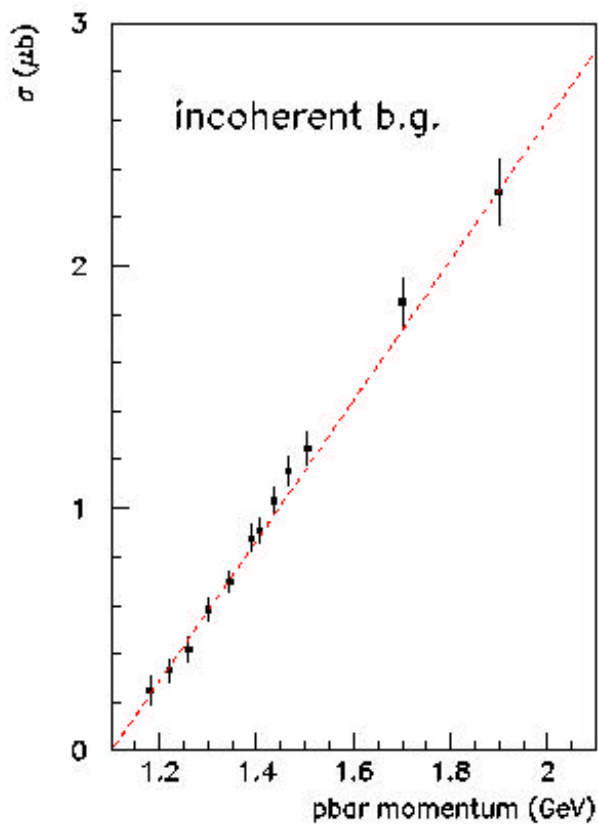


Results of Monte Carlo test

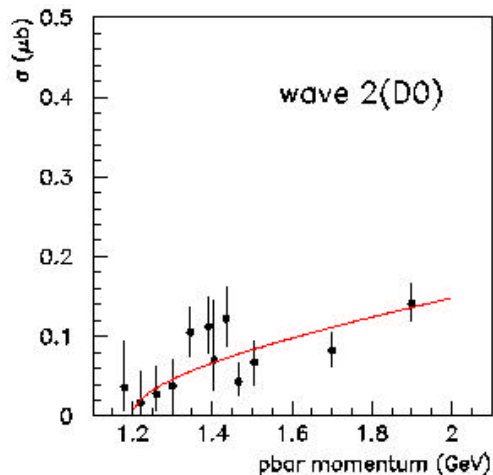
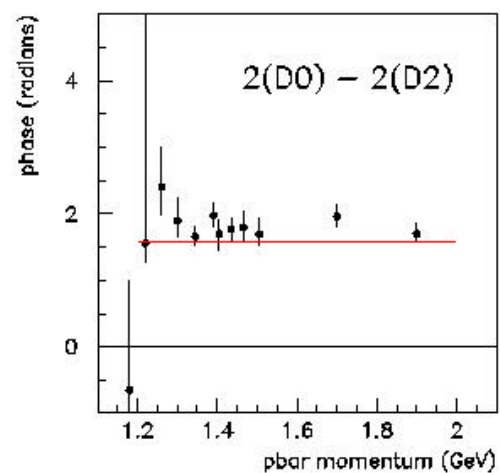
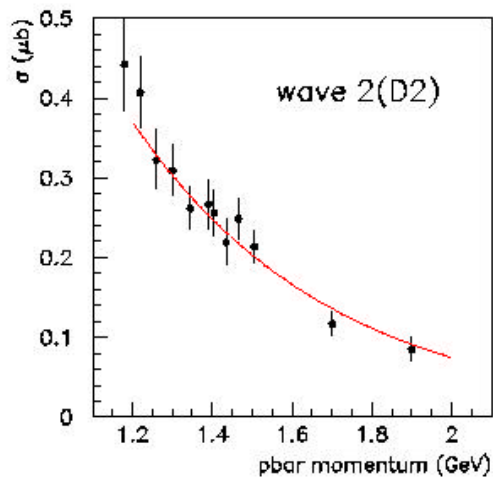
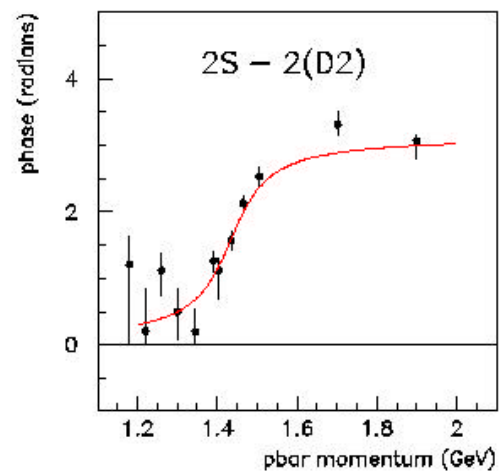
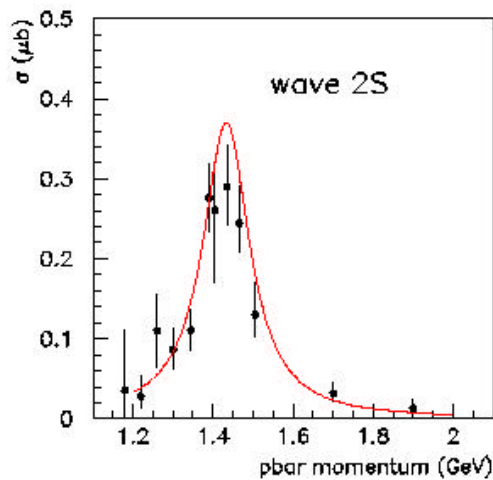


Monte Carlo test #2

- + include incoherent background
- + uniform angular distribution for background
- + not orthogonal to waves -- check for leakage

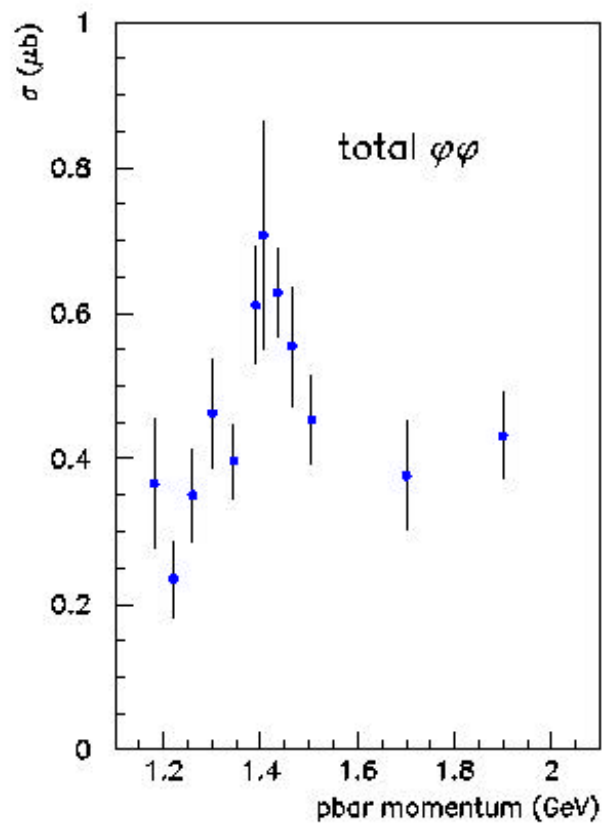
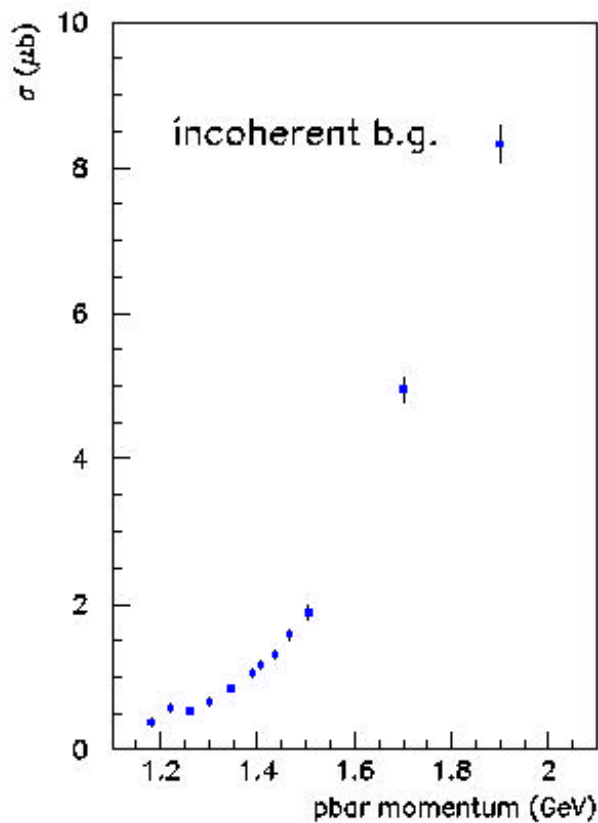


Results of Monte Carlo test #2

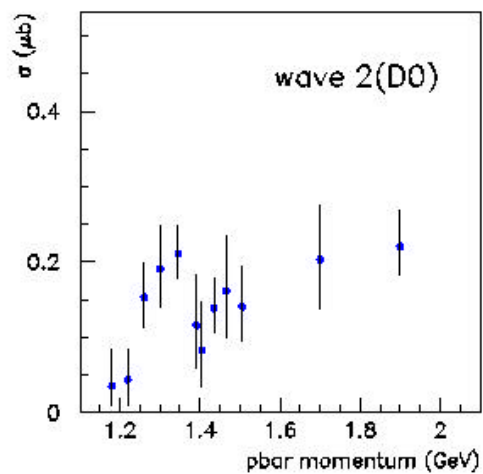
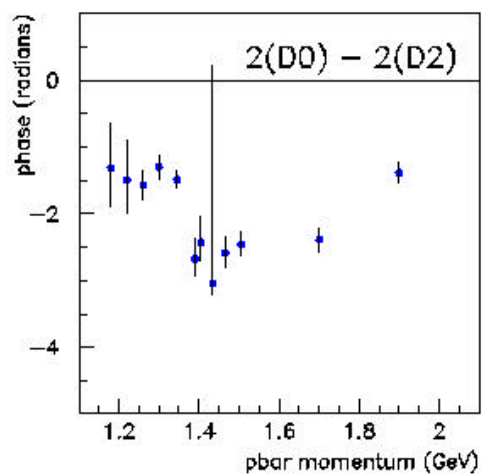
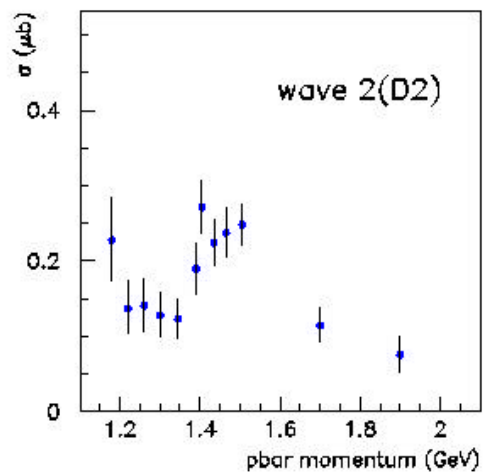
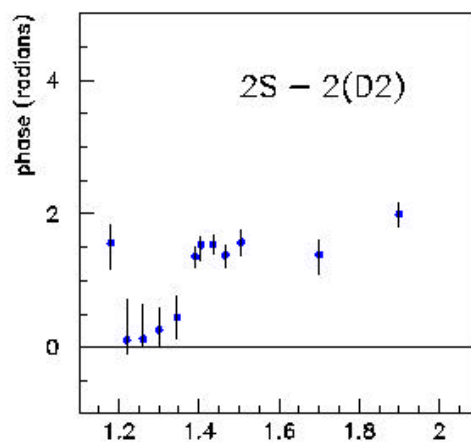
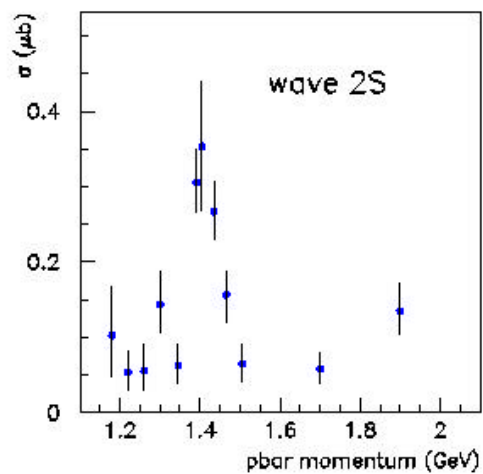


PWA Results

- ✿ 3-wave fit identical to Monte Carlo test #2
- ✿ simultaneous fit in mass and angular distributions
- ✿ $\phi\phi$ cross section now corrected for acceptance based on measured angular distribution



3-wave fit



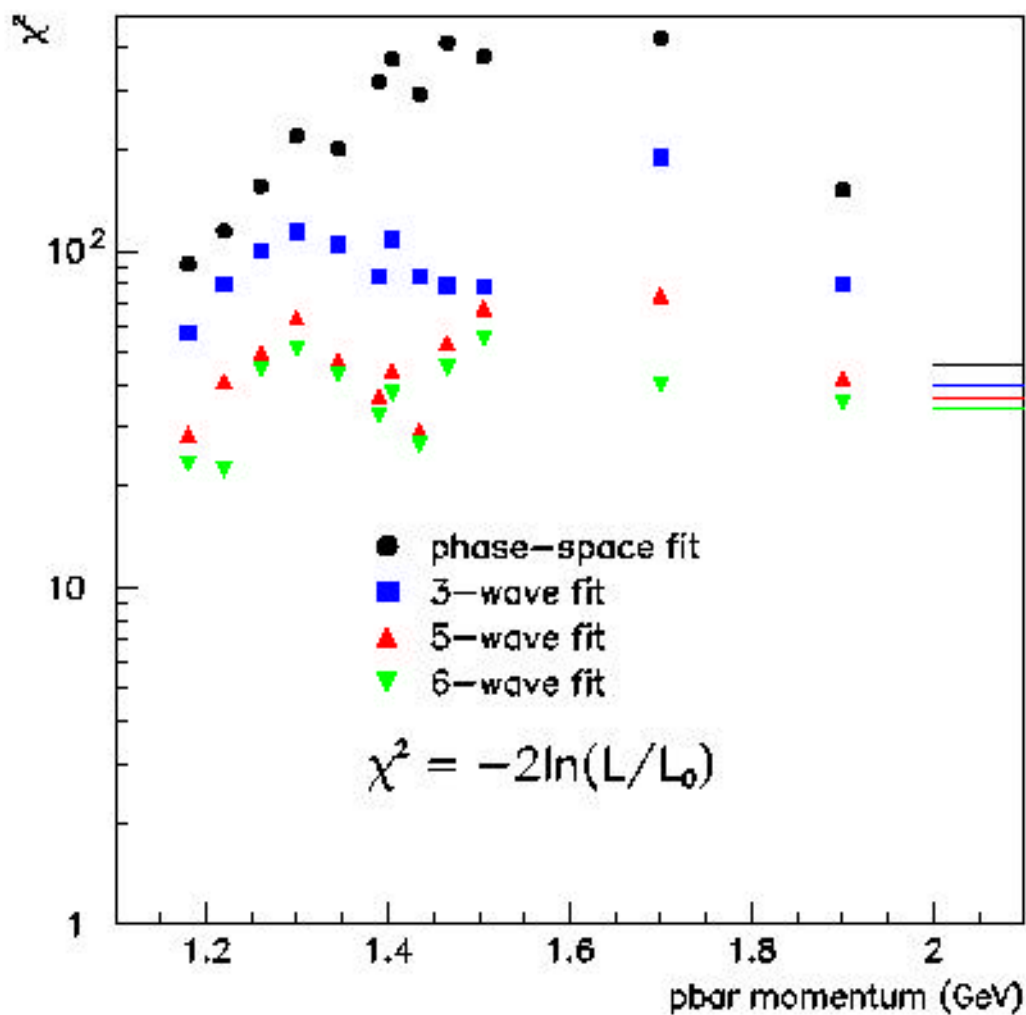
Quality of the fit

- To check goodness of fit, use likelihood ratio test

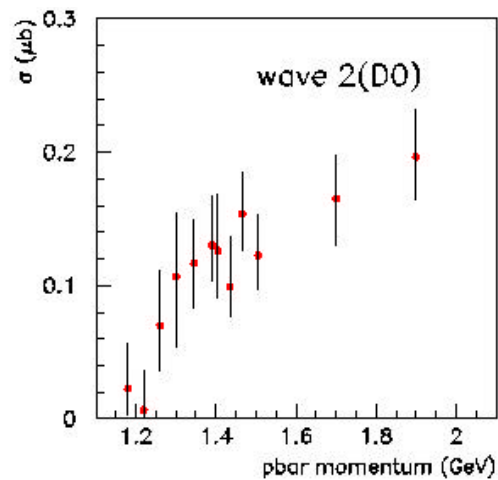
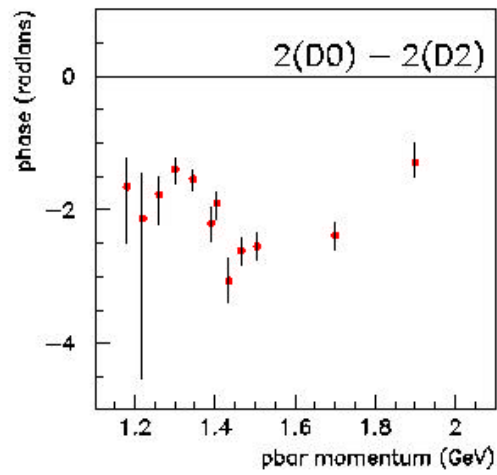
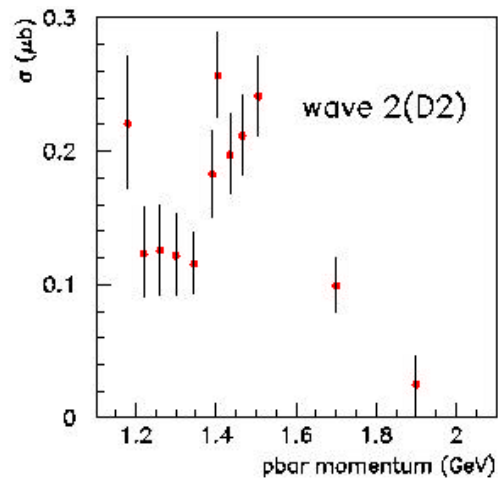
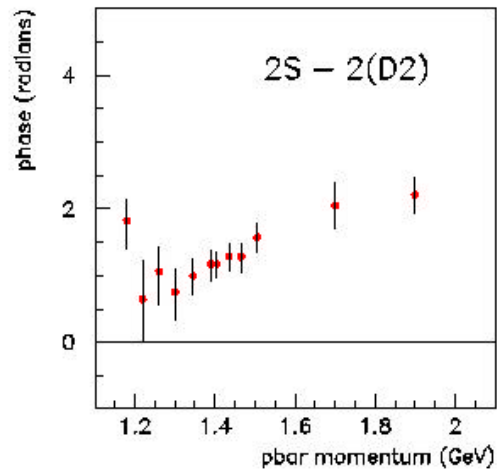
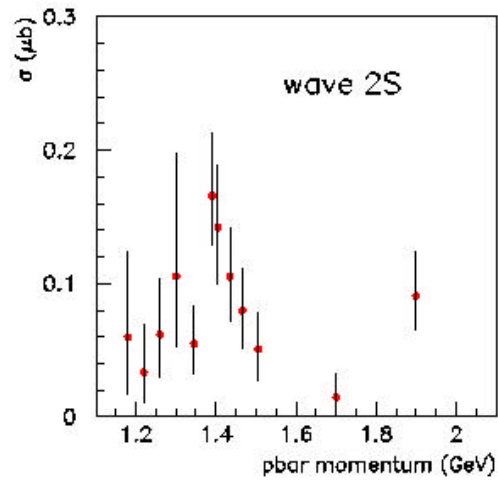
♦ Define $\chi^2 = -2 \ln \left(\frac{L}{L_0} \right)$

where L_0 is the likelihood maximum over the full parameter space
and L is the likelihood maximum over some restricted part.

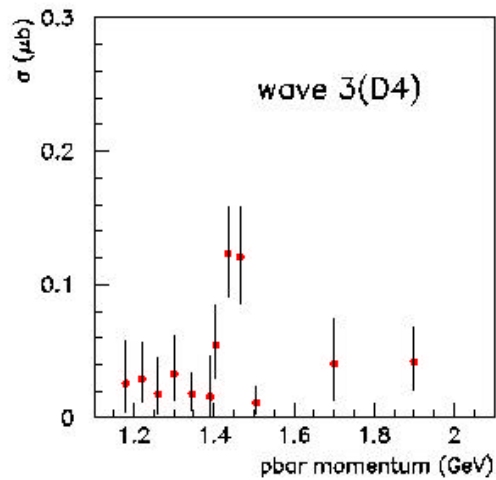
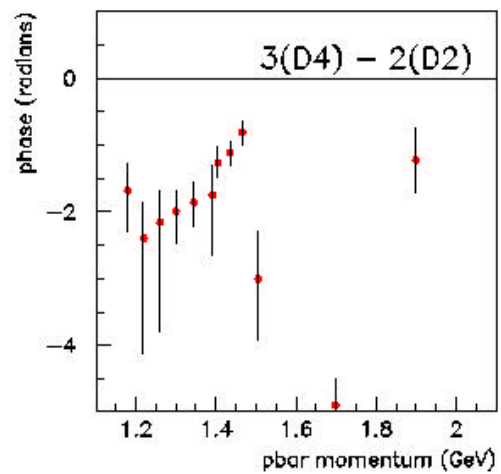
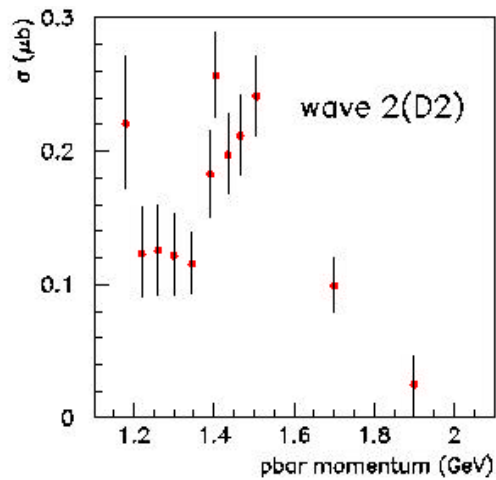
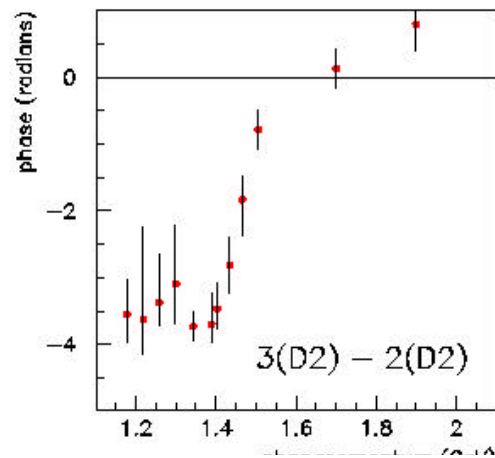
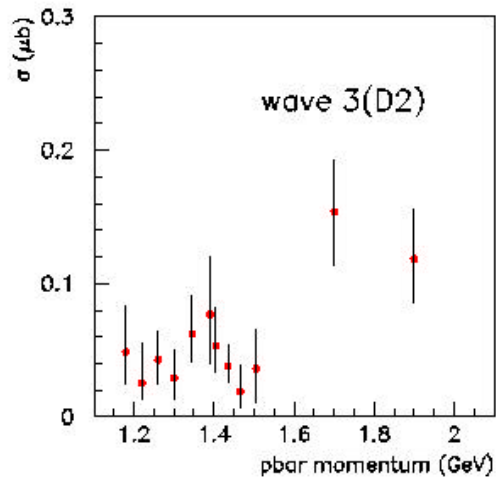
- For large N, behaves like chi-square with $N - N_0$ d.o.f.



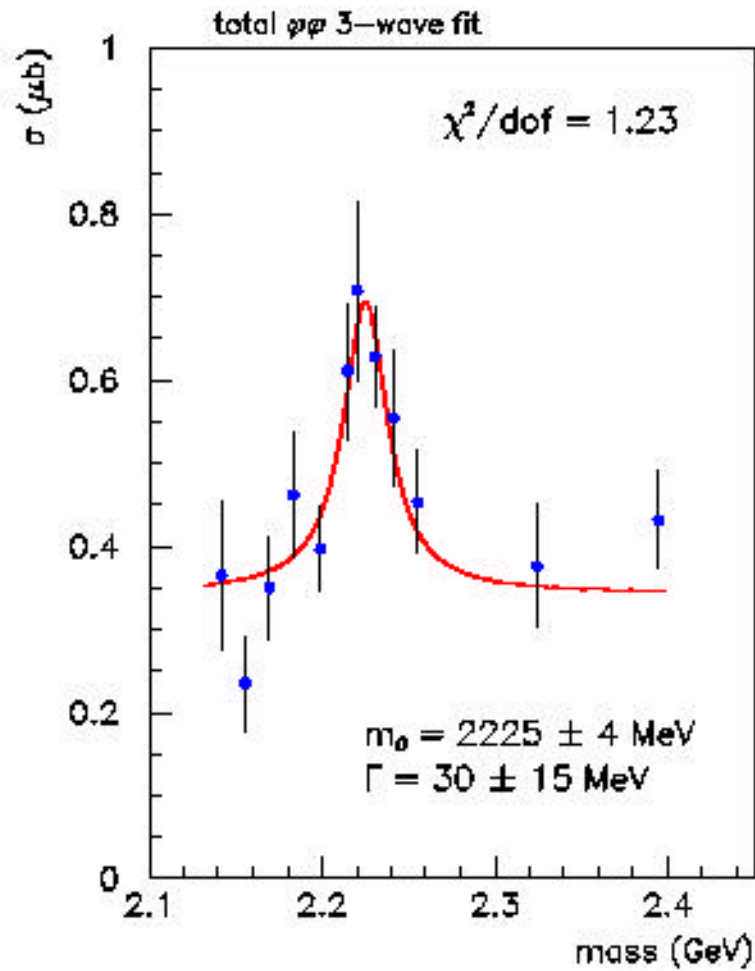
5-wave fit



5-wave fit



Conclusions



- ☆ narrow peak seen in raw cross section
- ☆ PWA reveals 3 dominant waves in 2^{++}
- ☆ rapid phase motion seen in two waves as expected for a Breit-Wigner resonance