Observation of isovector dibaryon resonance-like states with a mass of 2.2 GeV/c^2

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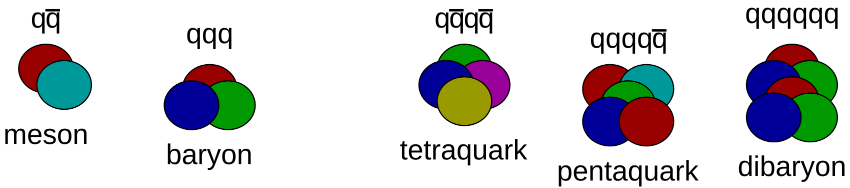
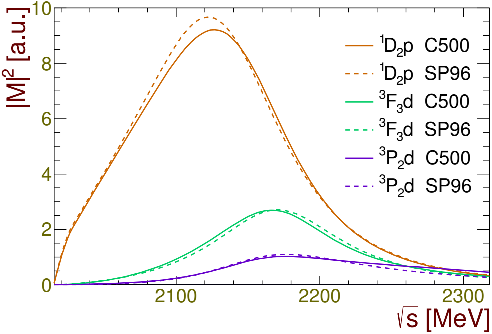
Dibaryon resonance-like states



- Resonances with baryon number $B = 2$ — "dibaryons"
- Seen in partial wave analysis (PWA) of $pp \to pp$, $pp \to d\pi^+$
- Not observed directly
- Meson-baryon models: states of the nucleon–$\Delta(1232)$ channel
- Quark-gluon models employing also π, σ-meson fields

Why $pp \to \{pp\}_s\pi^0$ channel



- Three main resonances: $^1D_2$, $^3F_3$, $^3P_2$ ($^{2S+1}L_J$ of the pp pair)
- $^1D_2$, $^3F_3$ — well defined from partial wave analysis
- $^3P_2$ — the least intensive, large uncertainties

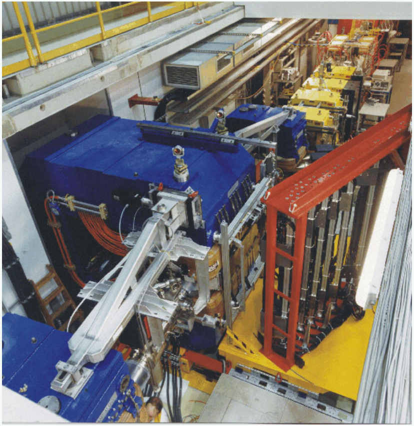
Final proton pairs in the $^1S_0$ state

- Forbidden odd (p, $f\ldots$) pion partial waves, forbidden even (S, $D\ldots$) ΔN states
- Of three dominant dibaryon resonances only the least well-defined $^3P_2$ allowed

Experimental setup

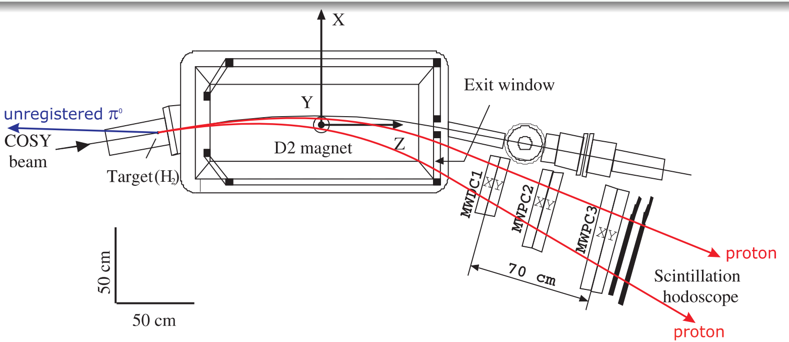
COSY synchrotron

ANKE spectrometer



Experiment

- Forward detector of the ANKE spectrometer
- Transversely polarized proton beam, internal hydrogen target



Allows measuring

- Differential cross section $d\sigma/d\Omega$
- Vector analyzing power A_y

Fitting functions

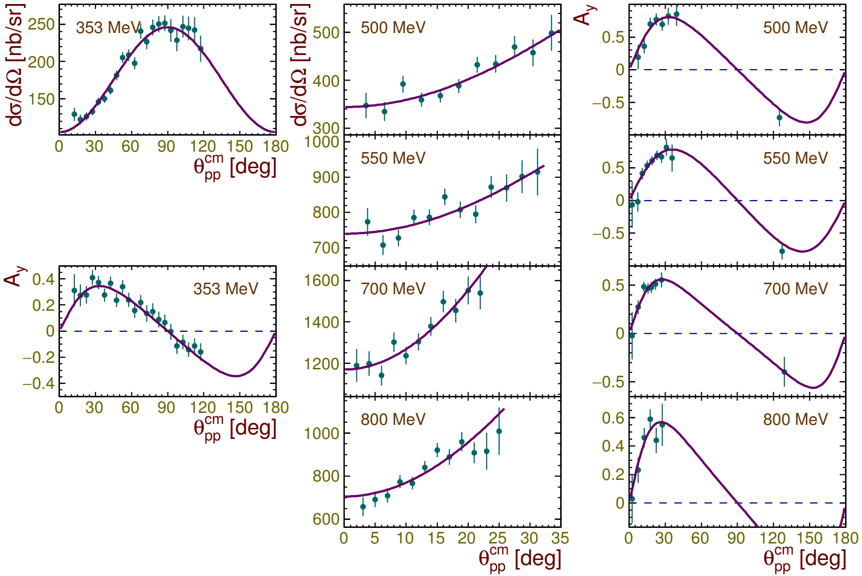
$$\frac{d\sigma}{d\Omega} = \frac{k}{4p}\left(a_0 + a_2\cos^2\theta_{pp} + a_4\cos^4\theta_{pp} + \ldots\right)$$
$$A_y\frac{d\sigma}{d\Omega} = \frac{k}{4p}\sin\theta_{pp}\cos\theta_{pp}\left(b_2 + b_4\cos^2\theta_{pp} + \ldots\right)$$

Pion orbital momenta $\ell \leqslant 2$, new parametrization

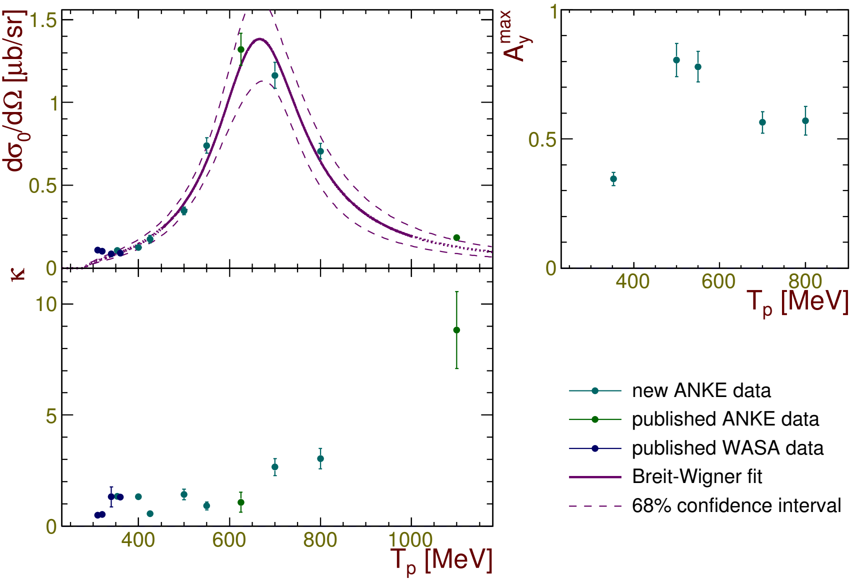
$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left(1 + \kappa\sin^2\theta_{pp}\right)$$
$$A_y = \frac{A_y^{\max}\sqrt{1+\kappa}\sin 2\theta_{pp}}{1 + \kappa\sin^2\theta_{pp}}$$

- $d\sigma_0/d\Omega$ — cross section at 0 angle
- κ — cross section angular slope
- $A_y^{\max}$ — maximal analyzing power

Measured cross section $d\sigma/d\Omega$ and analyzing power A_y



Energy dependence of fit parameters



Further analysis

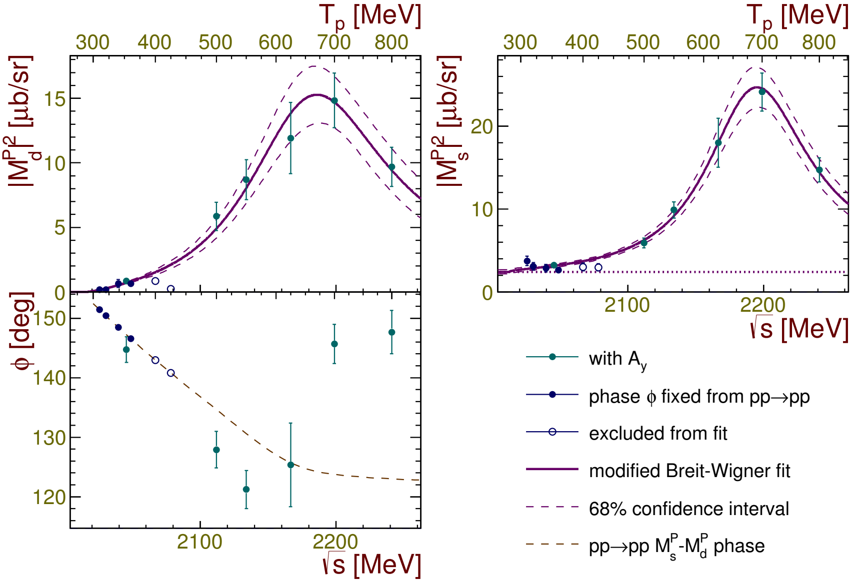
Features of the data

- Resonance peak in $d\sigma_0/d\Omega$
- $d\sigma/d\Omega$ angular dependence: minimum at zero angle
- Slowly varying angular slope parameter κ
- Large analyzing power

Partial wave analysis

- $\ell \leqslant 2$ — three possible transitions:
  ${}^3P_0 \to {}^1S_0 s, \quad {}^3P_2 \to {}^1S_0 d, \quad {}^3F_2 \to {}^1S_0 d$
- Similarity to $pp \to d\pi^+$:
  ${}^3F_2 \to {}^1S_0 d$ and momenta $\ell > 2$ neglected
- Two main transitions ${}^3P_0 \to {}^1S_0 s$, ${}^3P_2 \to {}^1S_0 d$
- $\left\{d\sigma_0/d\Omega,\ \kappa,\ A_y^{\max}\right\} \longrightarrow \left\{\left|M_s^P\right|,\ \left|M_d^P\right|,\ \phi\right\}$

Partial waves energy dependence



Summary

- Comparable ${}^3P_0 \to {}^1S_0 s$ and ${}^3P_2 \to {}^1S_0 d$ amplitudes, peak in $d\sigma_0/d\Omega$, positive slope κ and large A_y originates from their interference
- ${}^3P_2$ resonance parameters:
  $E_R = 2195 \pm 8$ MeV$/c^2$, $\Gamma = 134 \pm 22$ MeV$/c^2$
  with $\chi^2/\mathrm{ndf} = 8/6$
- Indication on resonant behaviour in ${}^3P_0 s$, parameters:
  $E_R = 2199 \pm 5$ MeV$/c^2$, $\Gamma = 94 \pm 11$ MeV$/c^2$,
  $c_{\mathrm{bg}} = 2.4 \pm 0.2\ \mu$b/sr
  with the $\chi^2/\mathrm{ndf} = 6.5/6$
- Article to be published

Thank you