“Hadron Spectroscopy”
involving KVI

J.G. Messchendorp, November 2005
Hadron Spectroscopy

Electromagnetic probes
MAMI ELSA CEBAF GRAAL LEGS KEK LNS SPRING8 DESY ...

Hadronic probes
COSY IUCF CELSIUS GSI RHIC CERN PSI ...

Key questions
Nucleon structure?
Spin?
Mass?
Confinement?
Chiral Symmetry breaking?
Role of strangeness
In-medium effects?
...
Nucleon excitations

Complex excitation spectrum of the nucleon

Broad and overlapping resonances

Meson production important tool to study specific resonances
Meson Photoproduction from the Proton
\( \gamma + p \)

Compilation: S. Schadmand

SAPHIR (Bonn)  
CBELSA (Bonn)  
DAPHNE, TAPS (Mainz)  
GRAAL (Grenoble)

\( E_\gamma (\text{GeV}) \)
Hyperon Photoproduction: $\gamma + p \rightarrow K^0 + \Sigma^+$

Requires photon spectrometer with large acceptance
Hyperon Photoproduction: $\gamma + p \rightarrow K^0 + \Sigma^+$

Data: R. Casteljins
Calc.: A. Usov & O. Scholten (coupled channel)

All known resonances + $P_{13}$ (1830)
Hadrons in the nucleus:
The role of chiral symmetry breaking
and dynamic generation of mass

Chiral symmetry = Fundamental symmetry of QCD for massless quarks

Chiral symmetry is broken on hadron level

\[ \frac{1}{2}^\pm, \frac{1}{2}^- \]

\[ \chi\text{-sym.} \quad \text{nature} \]

\[ \frac{1}{2}^- (1535) \]
\[ \approx 600 \text{ MeV} \]

\[ \frac{1}{2}^+ (938) \]

Can we observe a (partial) restoration of chiral symmetry at finite nuclear densities?

\[ \rightarrow \text{Study hadron masses in the nuclear medium} \]
photon-induced $\omega$-mesons in nuclei

(CBELSA-TAPS collaboration)

D. Trnka et al., PRL 94 (2005) 192303

$\sim 8\%$ mass drop at $0.6 \rho_0$
Future Perspectives for Hadron Physics Group at KVI

Charmed hybrids and glueballs (exotics) searches using anti-proton facility at FAIR
Future Perspectives for
Hadron Physics Group at KVI

PANDA (anti-Proton ANnihilation at DArmstadt)
“Hadron spectroscopy” involving KVI

KVI team:

J. Bacelar, R. Castelijns, H. Loehner, J. Messchendorp, S. Shende (experiment)

O. Scholten, R. Timmermans, A. Usov (theory)
QCD: Existence of gluon-rich states

LQCD glueball predictions

η, ω, γ, φ → γ’s

LQCD: Hybrid state
M~4.2-4.5 GeV
Hadrons in the nucleus

nuclear photoabsorption cross section per nucleon

\( \gamma + p \) total
\( \gamma + A \) total
(average nucleus)

ELSA

No resonance structure above 0.6 GeV

V. Muccifora et al., PRC 60 (1999) 064616