A consistent isobar analysis of cascading decays in the high-mass baryon sector

Eric Gutz

II. Physikalisches Institut
Justus-Liebig-Universität Gießen, Germany

CLAS Collaboration Meeting
Jefferson Lab, October 22, 2015

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

HIC for FAIR
Helmholtz International Center

Motivation

Volker Burkert, last Collaboration Meeting:

"What nucleon resonances teach us about nucleon structure"

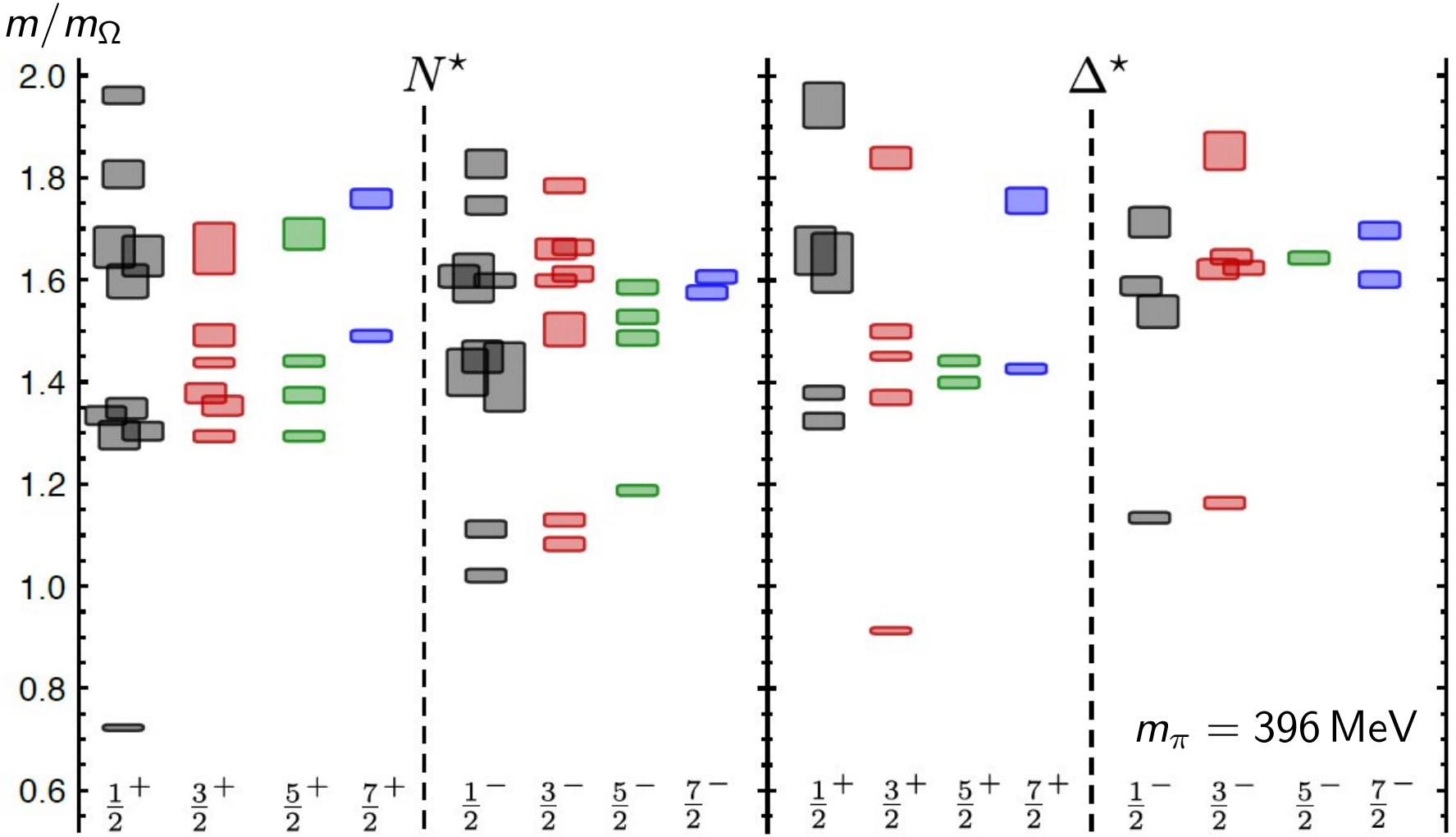
- Establish the N^* spectrum
- Identify the relevant degrees of freedom

Already on a good way, polarization observables + PWA yield many interesting results

However, questions remain, including the nature of 'excited' states

- genuine $|qqq\rangle$ states
- meson cloud effects
- dynamical generation/rescattering effects
- $|qqq\rangle$-$|q\bar{q}\rangle$ molecules
- ...

The Baryon Spectrum (on the lattice)



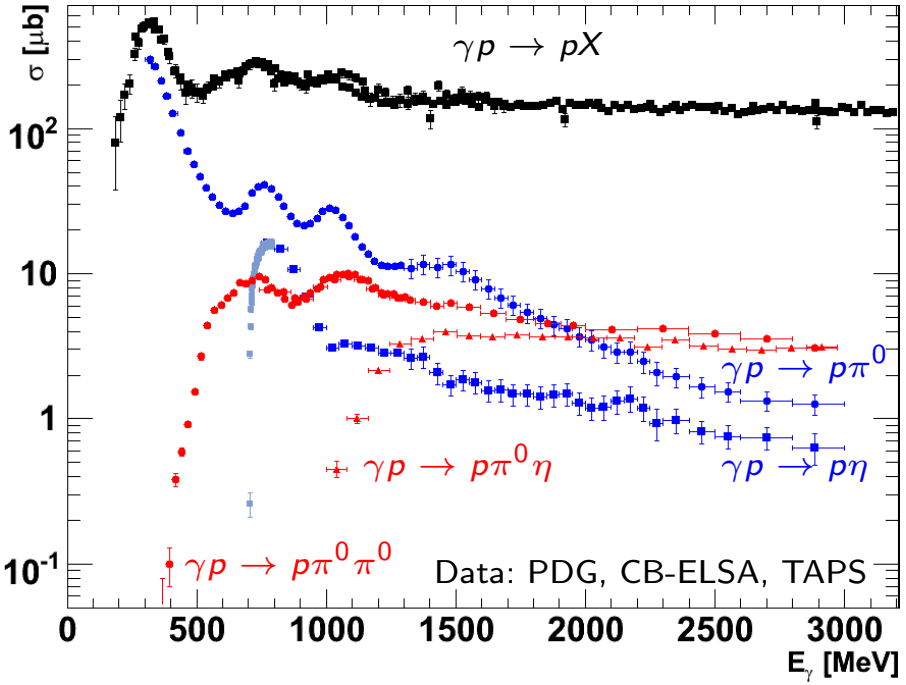
R. Edwards *et al.*, Phys. Rev. D **84** (2011) 074508

Experimental Approach

Identify states in their decays

- Bump-hunting (cross sections, invariant masses)
- Angular distributions to identify *s*-channel pocesses

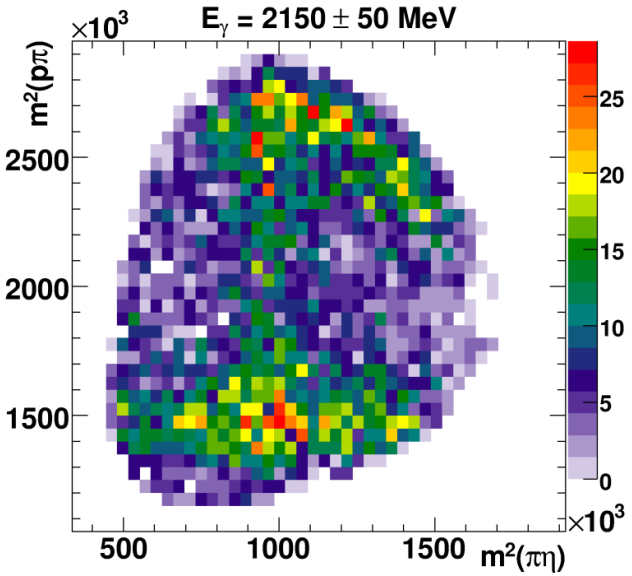
High-mass sector: Multi-meson final states gain in importance (but lose in bumps)



General question for decays:

- Does QCD invest in mass rather than momentum?
- If so, decay via high-mass mesons or excited baryons?
- How to identify (and learn from) them?

Multi-Meson Final States - Examples



$\gamma p \to p\pi^0\eta$

E.G., V. Credé, V. Sokhoyan, H. van Pee *et al.*,
Eur. Phys. J. A **50** (2014) 74

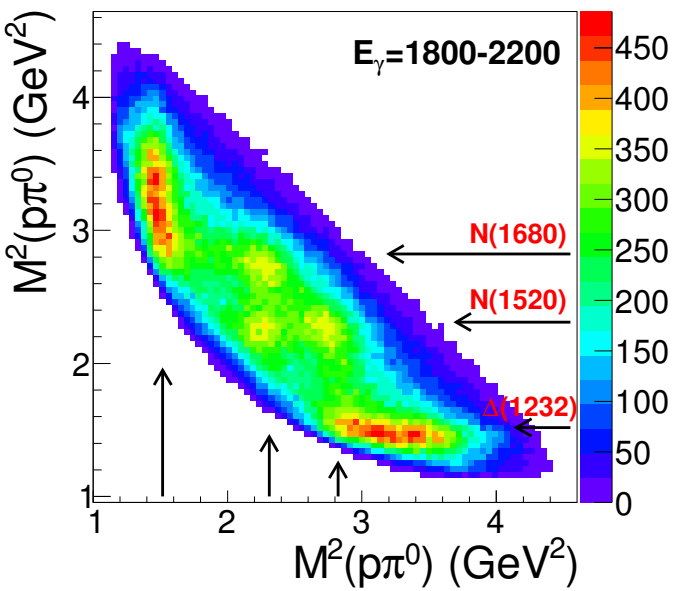
Clear evidence for isobars in the reaction:

- $\Delta(1232)\frac{3}{2}^+\eta$
- $N(1535)\frac{1}{2}^-\pi^0$
- $a_0(980)p$

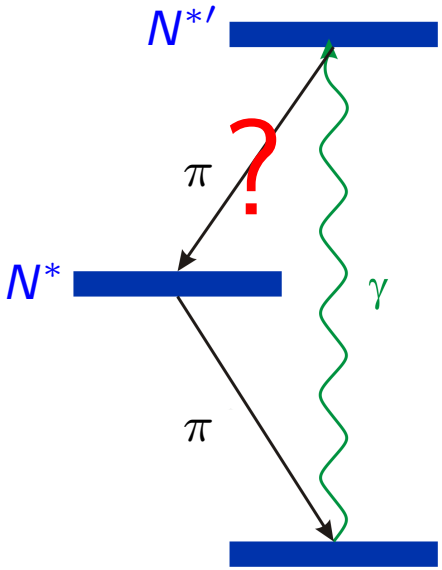
$\gamma p \to p\pi^0\pi^0$

V. Sokhoyan, E.G., V. Credé, H. van Pee *et al.*,
Eur. Phys. J. A **51** (2015) 51

- $\Delta(1232)\frac{3}{2}^+\pi^0$
- $N(1520)\frac{3}{2}^-\pi^0$
- $N(1680)\frac{5}{2}^2\pi^0$
- also seen: $N(1440)\frac{1}{2}^+\pi^0$, $f_0(980)p$, ...



Cascading decays?



Existence of isobars in the reaction does not necessitate decay chains including heavy states!

However, PWA shows this (at least for some cases), see e.g.:

"Three-Body Nature of N^* and Δ^* Resonances from Sequential Decay Chains"
A.Thiel, V. Sokhoyan, E.G., H. van Pee *et al.*, Phys. Rev. Lett. **114** (2015) 091803

"Data on I^s and I^c in $\vec{\gamma}p \to p\pi^0\pi^0$ reveal cascade decays of $N(1900)$ via $N(1520)$"
V. Sokhoyan, E.G., H. van Pee *et al.*, Phys. Lett. B **746** (2015) 127

$\Rightarrow$ QCD might indeed invest in mass rather than momentum

Nature of 'Prime' States

- PWA might confirm existence of decaying states, however, very little information about the nature of the states is given
- Idea: Consistent isobar analysis:
  - Isolate intermediate isobars (selection of heavy states from Dalitz plot)
  - Investigate excitation functions, angular distributions,...
  - Check with (non-PWA) calculations
  - Signature quantities in the decay dynamics?
- Desirable:
  - High-statistics, high-quality data at higher energies
  - Access to other isospin channels ($\pi^+\pi^-$)
  - Possibility to extend analysis to the strangeness sector

Research Interest - CLAS Data

- Check feasibility of approach with g11-/g12-run data in $\gamma p \to p\pi^+\pi^-$
- Check high-mass (scalar) meson isobars also in KK-decays
- Extension of analysis program to hyperon spectrum
- Extension of the approach to polarization observables possible

The Giessen Group

Group Prof. K-T. Brinkmann

3 staff, 4 postdocs, 12 PhD, MSc, BSc

Experimental involvement:

- $\bar{\text{P}}$ANDA at FAIR, Darmstadt
- CBELSA/TAPS, Bonn
- BGO-OD, Bonn
- ...

Main research interests:

Instrumentation

- Calorimetry (BaF_2, $PbWO_4$, new materials)
- Si detectors, tracking
- Electronics/DAQ

Physics

- Multi-meson final states in γN
- Open/hidden strangeness, charm
- In-medium physics (light mesons, J/ψ etc.)