

The BGOOD experiment at ELSA

Exotic structures in the light quark sector?

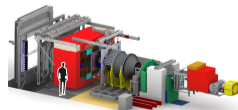
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programme, grant agreement no. 824093

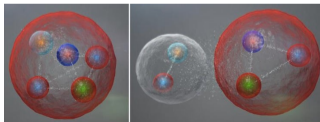


Exotic structure in the light quark sector?



Relevant degrees of freedom?

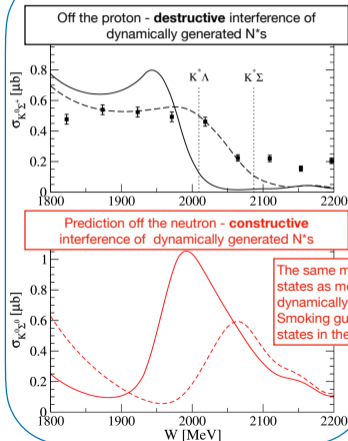
- Constituent quark models - “Missing resonance” problem persists in N^* & Δ spectra
- 3 quark states only?
- Molecule-like states, meson-baryon degrees of freedom? Glazman & Riska, Phys. Rep. 268 (1996) 263, Garcia-Recio et al., PLB 582 (2004) 49, Lutz & Kolomeitsev, PLB 585 (2004) 243
- $\Lambda(1405)$ - dynamically generated by meson-baryon interactions? Nacher, Oset, Toki, Ramos, & Meißner, NPA725 (2003)181, Hall et al., PRL 114 (2015) 132002, Molina & Döring, PRD 94, 056010 & 079901 (2016)



$\gamma p \rightarrow K^0 \Sigma^+$ @ CBELSA/TAPS

Ewald et al, PLB 713(2012) 180

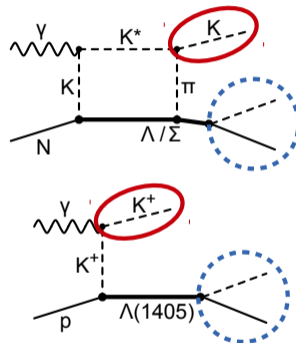
Ramos & Oset, PLB 727, (2013) 287



Experimental requirements in photoproduction



- Charged particle identification at extremely forward angles - reaction dynamics at very low momentum exchange
- High forward momentum resolution
- Reconstruction of complicated, mixed charge final states - eg $K^+\Lambda(1405) \rightarrow K^+(\pi^0\Sigma^0) \rightarrow K^+\pi^0\gamma p\pi^-$
- Unique & complementary to existing experiments (eg CBELSA-TAPS neutral particle reconstruction, CLAS charged particle reconstruction).



BGOOD at the ELSA facility, Bonn

The BGOOD experiment

Eur. Phys. J. A 56:104 (2020)

Spokespersons: H. Schmieden (Bonn)
& P. Levi Sandri (Frascati)

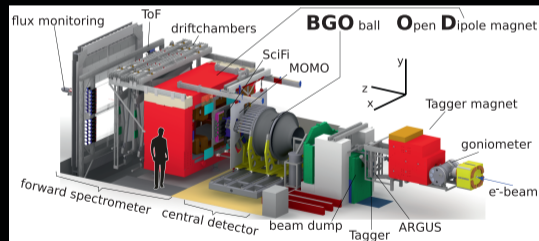
- The BGOOD Collaboration - 32 members in Germany, Italy, Russia & USA
- BGO calorimeter (central region) & Forward Spectrometer combination
- High momentum resolution, excellent charged & neutral particle ID

EPJ A



Recognized by European Physical Society

Hadrons and Nuclei



Overview of the BGOOD (BGOball Open Dipole magnet) experiment at the ELSA Facility dedicated to study meson photo-production

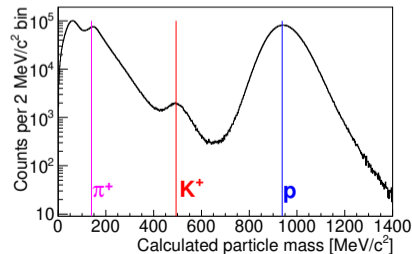
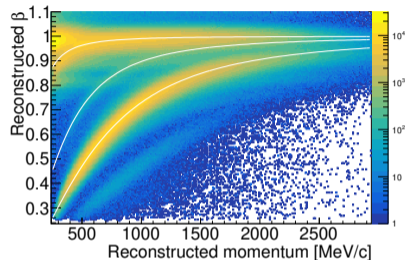
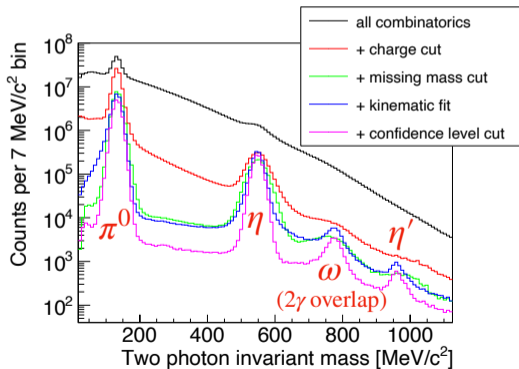
From: T. C. Jude and P. Levi Sandri et al. on "The BGOOD experimental setup at ELSA"



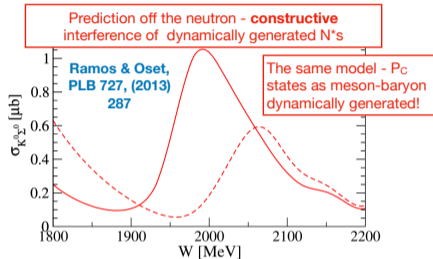
The BGOOD experiment, Eur. Phys. J. A 56:104 (2020)



- BGO Rugby Ball (central region) - charged & neutral particle ID
- Charged particle identification at forward angles



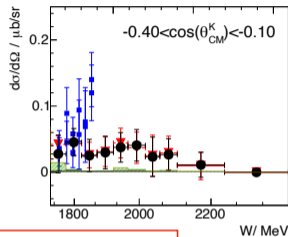
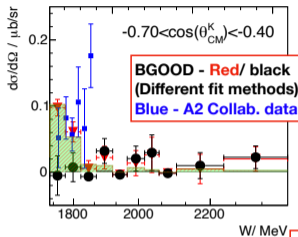
$\gamma n \rightarrow K^0 \Sigma^0$ K. Kohl et al. arXiv:2108.13319 (2021)



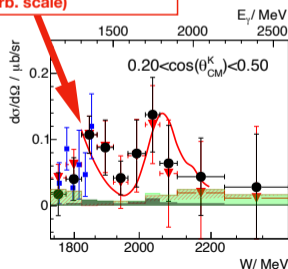
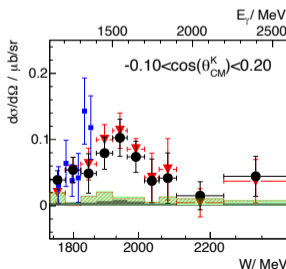
- $K^0 \rightarrow 2\pi^0$ in the BGO Rugby Ball
- Identify $\Sigma^0 \rightarrow \gamma \Lambda$ & angle cut on $\Lambda \rightarrow p\pi^-$
- Consistent with model prediction!
- More data required (& planned) for definitive statement

blue squares - Akondi et al. (A2) EPJA 55 11, 202 (2019)

Tom Jude (University of Bonn)



Ramos & Oset prediction (arb. scale)



$\gamma p \rightarrow K^+ \Lambda(1405) \rightarrow K^+ (\Sigma^0 \pi^0)$ G. Scheluchin et al. arXiv:2108.12235 (2021)

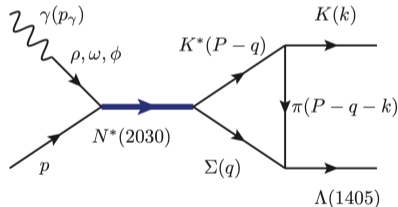


Total cross section for $\gamma p \rightarrow K^+ \Lambda(1405) \rightarrow \Sigma^0 \pi^0$ (line shape also measured)

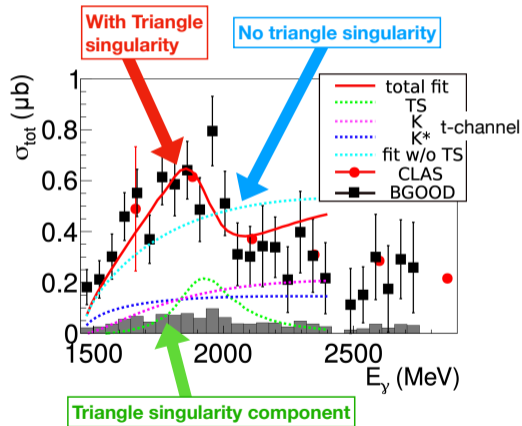
Triangle singularity in $\gamma p \rightarrow K^+ \Lambda(1405)$

Wang et al. PRC 95, 015205 (2017)

- $N^*(2030)$ proposed for cusp in $K^0 \Sigma^+$!



- $N^*(2030)$ close in mass & strong coupling to $K^* \Sigma$
- $K^* \Sigma$ molecular component?

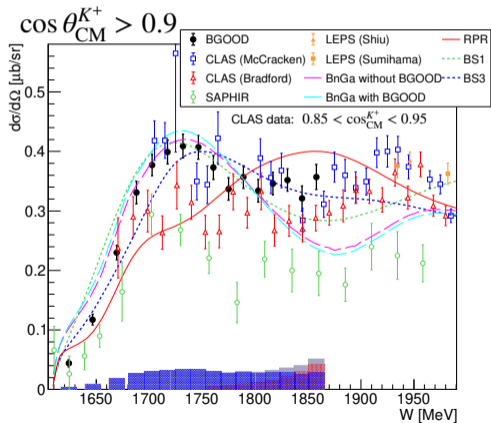


[CLAS: Moriya, PRC 87, 035206 (2013)]

Forward $\gamma p \rightarrow K^+ \Lambda$ Eur. Phys. J. A (2021) 57:80



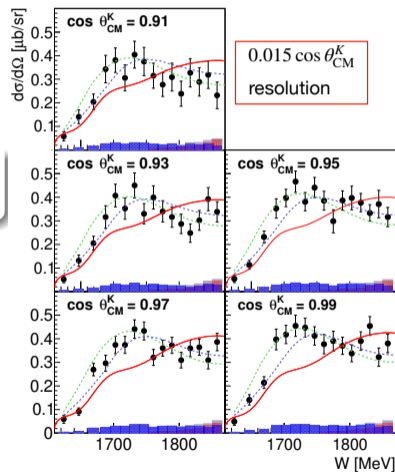
- Low t data - constraint on hypernuclei electroproduction
- Forward angles - sensitive to high spin N^*



CLAS data:

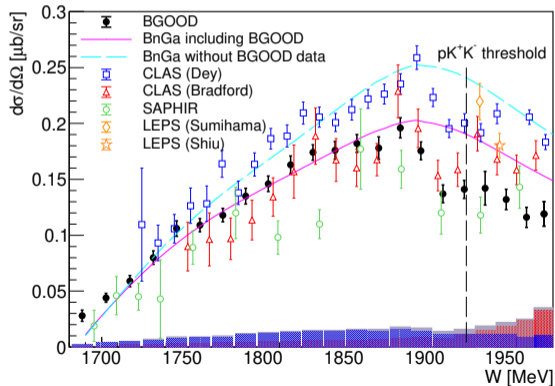
$$0.85 < \cos \theta_{CM}^{K^+} < 0.95$$

BnGa: EPJA 50:74 (2014)
 RPR: Skoupil & Bydžovský, PRC, 100:035202 (2019)
 BS1 & BS3: Skoupil & Bydžovský, PRC, 97:025202 (2018)
 Bradford, PRC 73:035202 (2006)
 McCracken, PRC 81:025201 (2010)
 SAPHIR, EPJA 19:251 (2004)
 LEPS: PRC 73:035214 (2006) & 97:015208 (2018)

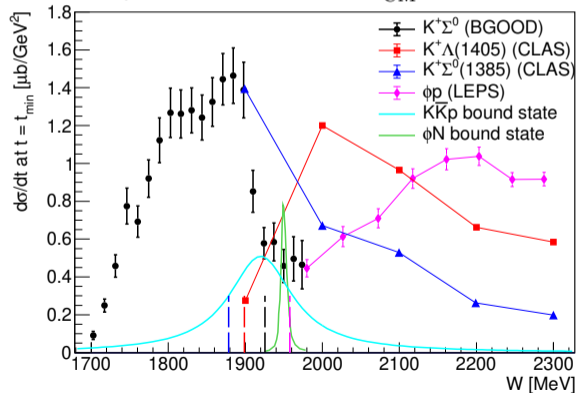




- High statistics for $\cos \theta_{CM}^K > 0.9$ (CLAS: $\cos \theta_{CM}^K$ 0.85 to 0.95)
- Reveals “cusp” at $W \sim 1900$ MeV



Data extrapolated to t_{min} & $\cos \theta_{CM}^K = 1$

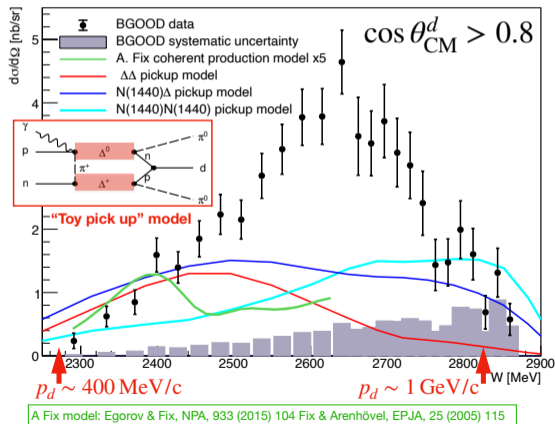


Dibaryons at BGOOD? TJ, paper in preparation

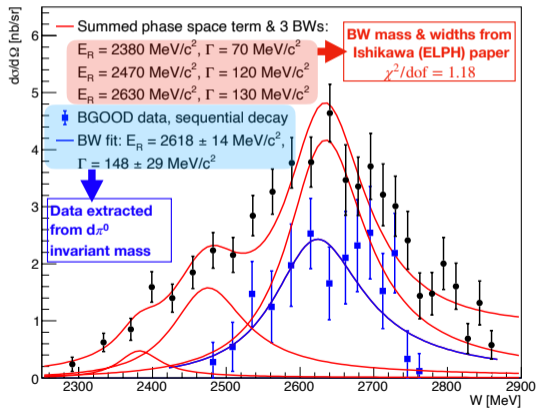
Coherent reaction - $\gamma d \rightarrow \pi^0 \pi^0 d$, deuterons in the forward spectrometer!



Not described by coherent production or FSI



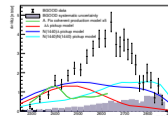
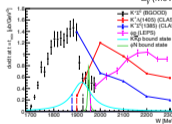
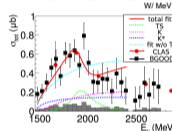
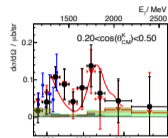
Supports proposed dibaryon spectrum



The BGOOD experiment at ELSA - The story so far



- **BGOOD** - photoproduction at forward angles & low momentum transfer
Eur. Phys. J. A 56:104 (2020)
- $\gamma n \rightarrow K^0 \Sigma^0$ - dynamically generated meson-baryon resonance contributions? (parallels to P_C states) K. Kohl et al. arXiv:2108.13319 (2021)
- $\gamma p \rightarrow K^+(\Lambda(1405) \rightarrow \Sigma^0 \pi^0)$ - triangle diagram mechanism?
G. Scheluchin et al. arXiv:2108.12235 (2021)
- **Cusp** in $\gamma p \rightarrow K^+ \Sigma^0$ - at thresholds & bound state predictions
TJ et al. Phys. Lett. B 820 (2021) 136559, $K^+ \Lambda$ paper: Eur. Phys. J. A (2021) 57:80
- **Coherent** $\gamma d \rightarrow \pi^0 \pi^0 d$ - proposed dibaryon spectrum TJ, paper in preparation



Molecular-like structures in the uds sector?

The BGOOD experiment at ELSA - What's next?

Square brackets indicate TNA projects to be discussed later



- Data taking currently underway! Detector development & improvement - [TA4-1,4,5,6]
- [TA4-5] Aerogel Cherenkov - forward K^+/π^+ separation Detector development by Moscow group
- Higher statistics study in the strangeness sector
 - [TA4-3] $K^0\Sigma$ channels & different $\Lambda(1405)$ decay modes
 - [TA4-3] $K^+\Sigma^-$ J. Groß, PhD analysis, Uni Bonn
 - [TA4-4] $K^*\Sigma$ A. Figueiredo, Bachelor thesis 2020, Uni Bonn
- Dibaryon searches in coherent reactions
 - $\gamma d \rightarrow 3\pi^0 p$ A. Stirner, Masters thesis 2021, Uni Bonn
 - $\gamma d \rightarrow \pi^0 \eta p$ TJ, proof of principle tests
- [TA4-2] η' near threshold S. Alef, PhD thesis 2021, Uni Bonn
- $\gamma p \rightarrow \pi^0 \eta$: a_0 & a_2 studies at low p transfer A. Sonnenschein, Masters thesis 2021, Uni Bonn