Highlights of N* experiments at ELSA

Friedrich Klein
Physikalisches Institut
University of Bonn

Highlights of N* experiments at ELSA

- ELSA facility
- Selected recent data
- Projects

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JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

RUHR-UNIVERSITÄT BOCHUM

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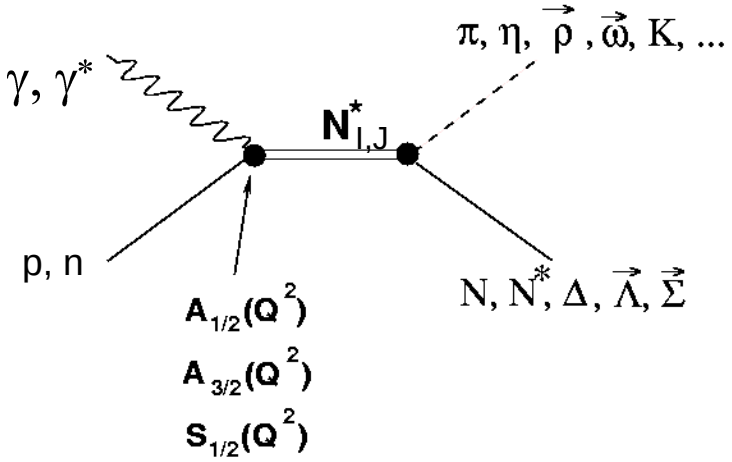
NSTAR Mission

- Find laws of nature for hadron formation
- Identify relevant degrees of freedom (constituents and fields) in hadron-spectrum
- search and characterize resonances through excitation and decay
- study and analyze meson production quanta of hadronic interaction

Electromagnetic Approach

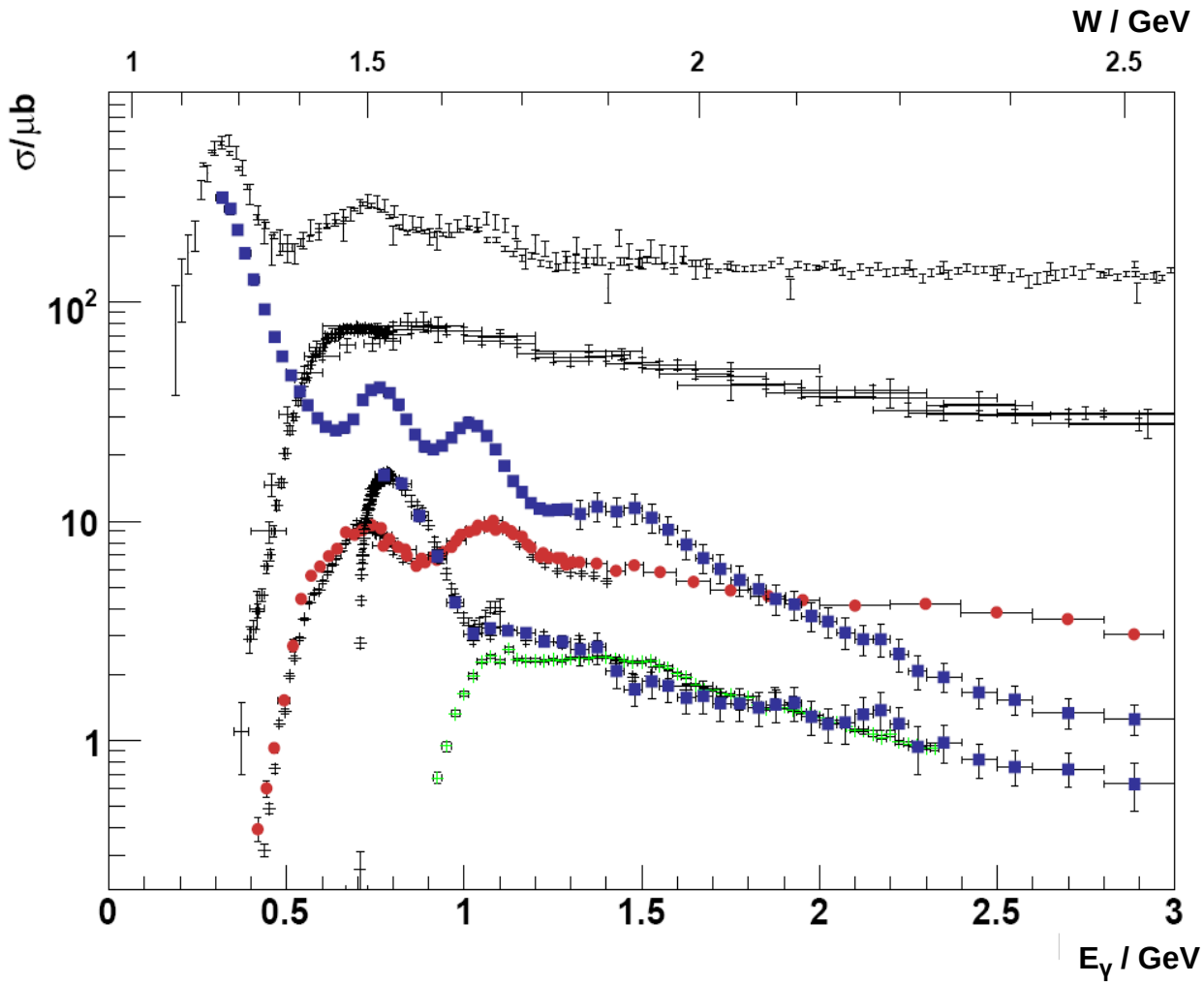
Electro-/photoproduction of mesons of various spin, flavour, …



- measure (over-)complete sets of observables
  amplitudes
  feasible for pseudoscalar mesons
  maximize constraints, minimize redundancy

- well chosen cases to get extra clues
  e.g. omega-production, -modification, -mesic nucleons, …

Meson photoproduction cross sections



$\gamma + p \rightarrow X$

$\gamma + p \rightarrow p + \pi^- + \pi^+$

$\gamma + p \rightarrow p + \pi^0$

$\gamma + p \rightarrow p + \pi^0 + \pi^0$

$\gamma + p \rightarrow K^+ + \Lambda$

$\gamma + p \rightarrow p + \eta$

Experimental Toolbox

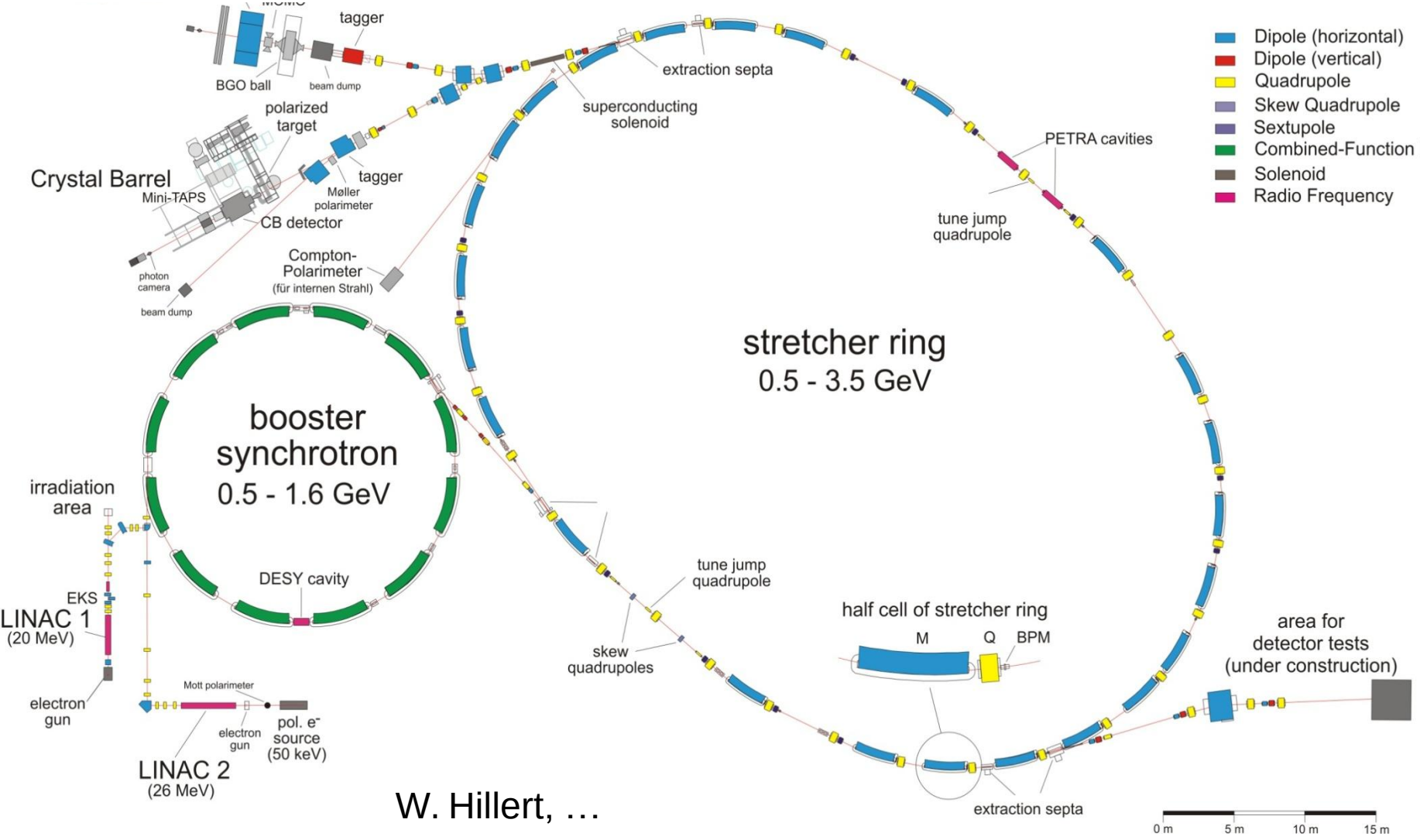
Successful efforts ➔ comprehensive toolbox for complete experiments

- pol'd e- and γ-beams in resonance region
- pol'd obstruction-less targets (longitudinal + transverse)
- High acceptance detectors w/ excellent sensitivity
  to ch's of high impact for resonance search

Available @ Jlab, MAMI, LEPS, ELSA, …

Electron Stretcher Accelerator (ELSA, Univ. Bonn)

SAPHIR,
Crystal Barrel,
now **BGO-OD**



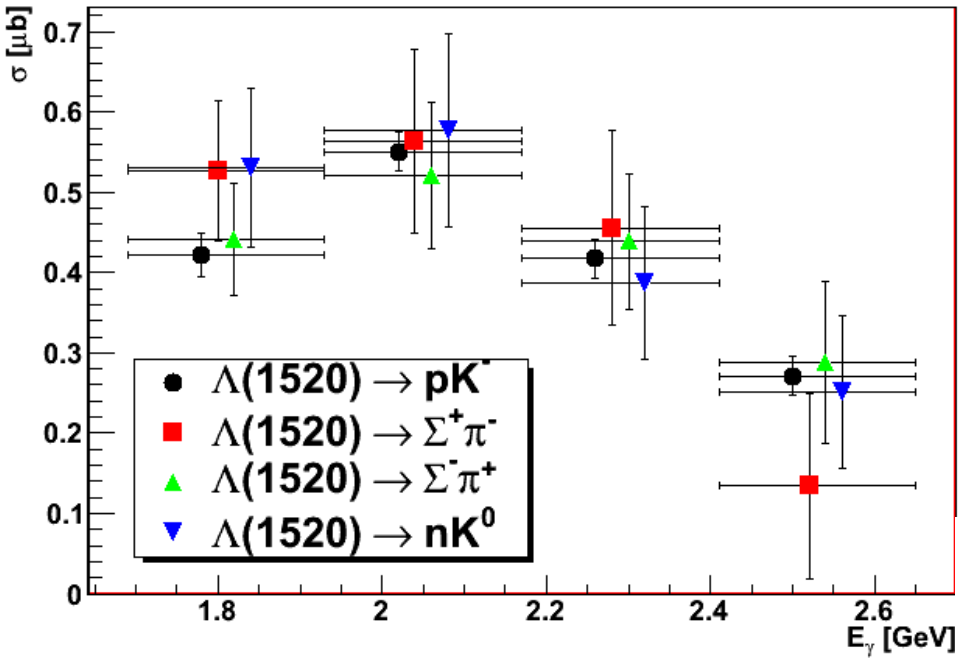
W. Hillert, …

ELSA Beam Parameters

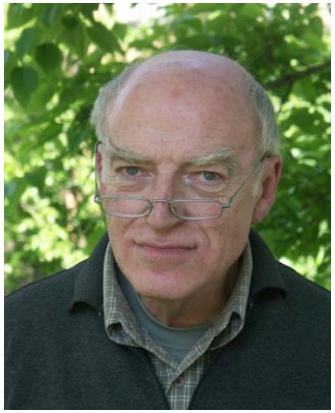
W. Hillert, …

Energy Range:	0.8 GeV < E < 3.4 GeV
Bunch Length:	1 mm < σ < 6 mm
Horizontal Emittance:	56 nm·rad < ε_h < 1 µm·mrad
Vertical Emittance:	ε_v < 0.1 · ε_h
Bunch Spacing:	Δs = 2ns
External Current:	1 fA < I < 1 nA
Duty Factor:	70% < DC < 90%
Polarization:	P > 65% @ E < 2.4 GeV

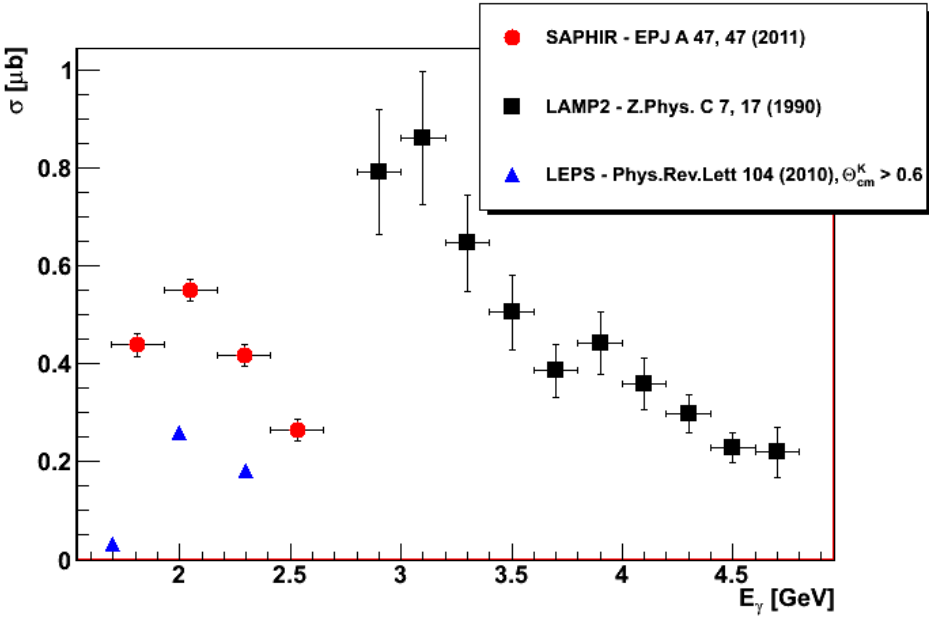
Photoproduction of $K^+ \Lambda(1520)$ @ SAPHIR



F.W. Wieland et al. EPJA (2011) **47**



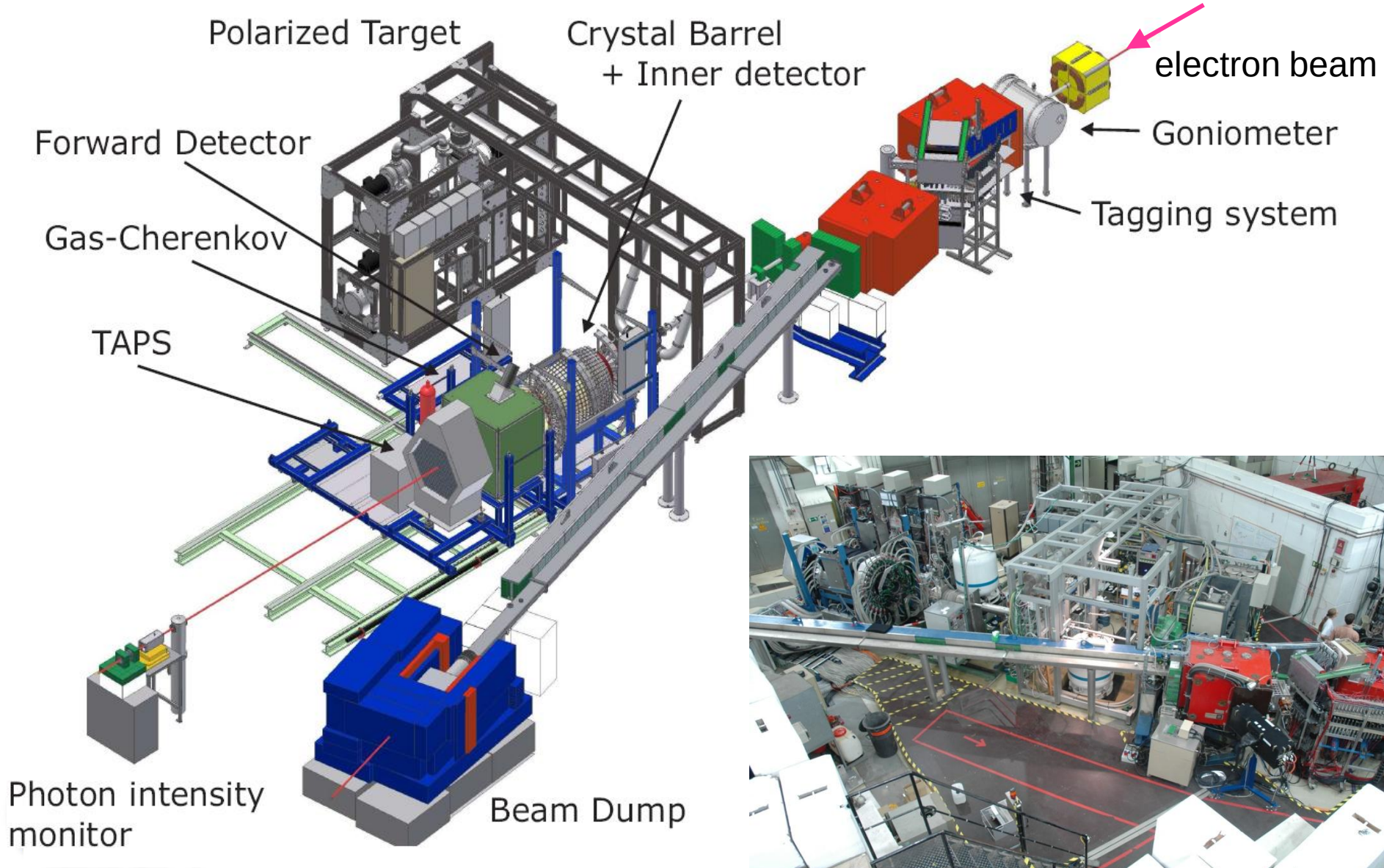
Prof. W.J. Schwille
Deceased in 2010



σ, t-distributions and
decay angular distributions determined

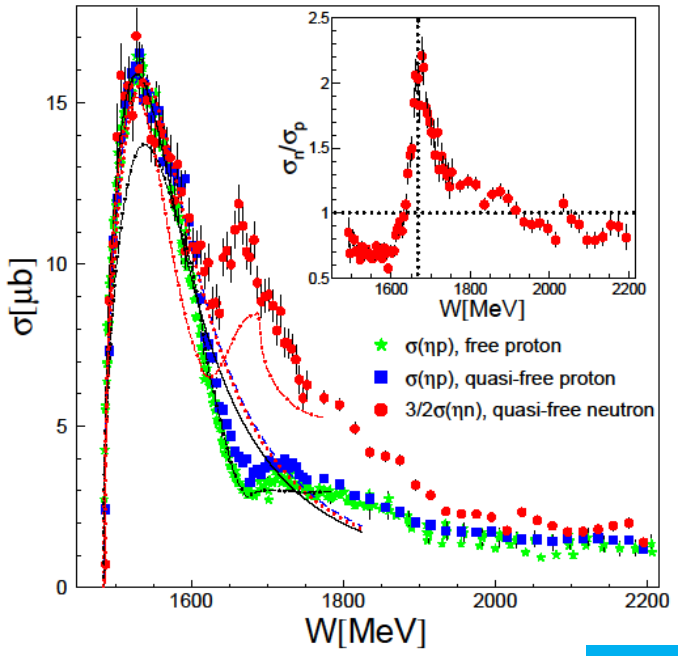
all 4 decay channels agree in σ,
but deviate from LAMP2 (1980)→
cf. Hosaka, NSTAR2009

Crystal Barrel / Taps set-up

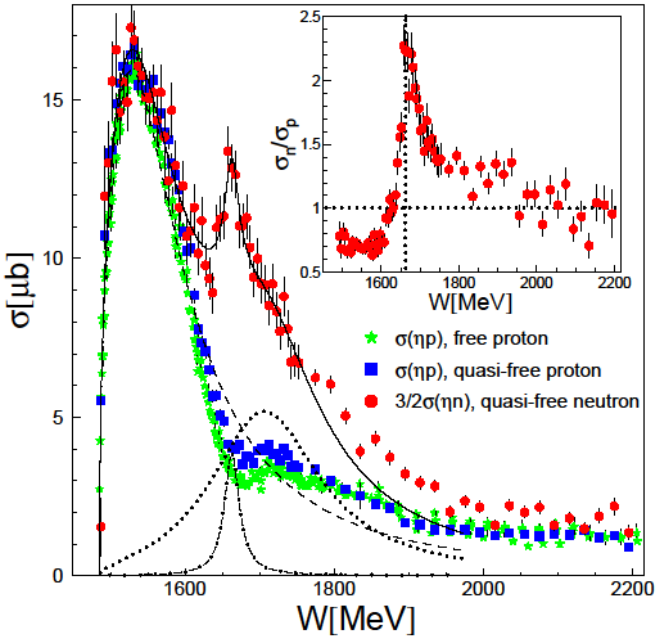


Quasi-free photoproduction of η-mesons off the deuteron

no cut on spectator momentum



spectator momenta p < 100 MeV



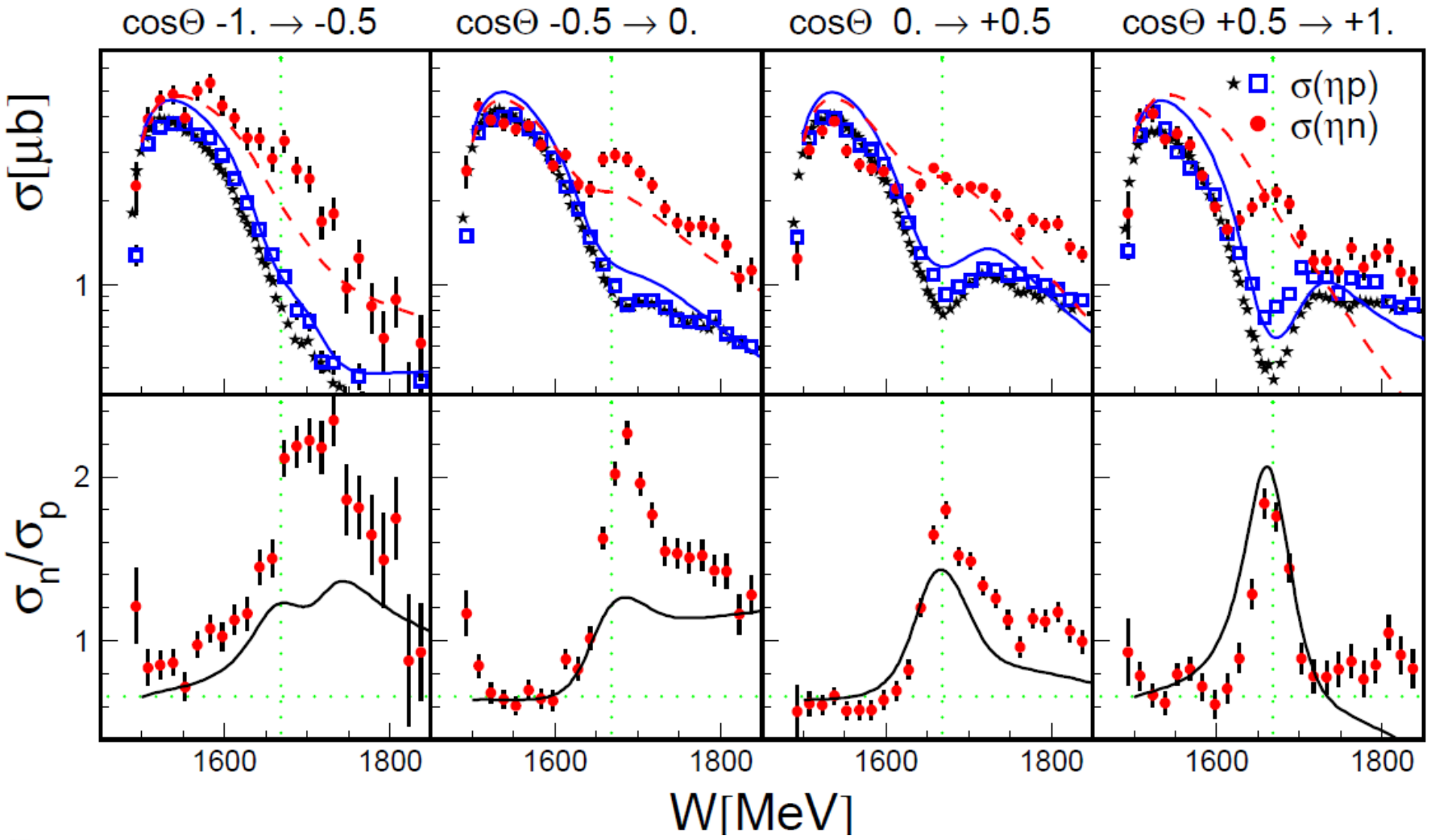
I. Jaegle et al., subm. to EPJ A

position: W≈1.67 GeV
width: σ≈25 MeV (FWHM)

narrow structure in excitation fct. of γ n → n η:

GRAAL: W ≈ 1680 MeV, Γ <30 MeV
Tohoku-LNS: W ≈ 1666 MeV, Γ <40 MeV
ELSA: W ≈ 1685 MeV, Γ <50 MeV
MAMI-C: W ≈ 1675 MeV, Γ <40 MeV

Quasi-free photoproduction of η-mesons off the deuteron



I. Jaegle et al., subm. To EPJ A

Observables in meson photo production

single pseudoscalar meson photo production

photon		**target**			**recoil**			**(target + recoil)**			
	-	-	-	-	x	y	z	x	x	z	z
	-	x	y	z	-	-	-	x	z	x	z
unpolarised	σ_0	0	**T**	0	0	**P**	0	T_x	$-L_x$	T_z	L_z
linearly pol.	**-Σ**	**H**	**(-P)**	**-G**	O_x	(-T)	O_z	$(-L_z)$	(T_z)	$(-L_x)$	$(-T_x)$
circularly pol.	0	F	0	**-E**	$-C_x$	0	$-C_z$	0	0	0	0

Knöchlein, Drechsel, Tiator Z.Phys. A 352 (1995)

Example: Longitudinally polaris. protons: $\mathbf{P_{T,z}}$

Linearly polarised photons: P_γ^{lin}

Circularly polaris. photons: P_γ^{circ}

$$d\sigma = d\sigma_0 \left[1 - P_\gamma^{lin} \left(\Sigma \cos 2\Phi - G\, P_{T,z} \sin 2\Phi \right) - E\, P_\gamma^{circ}\, P_{T,z} \right]$$

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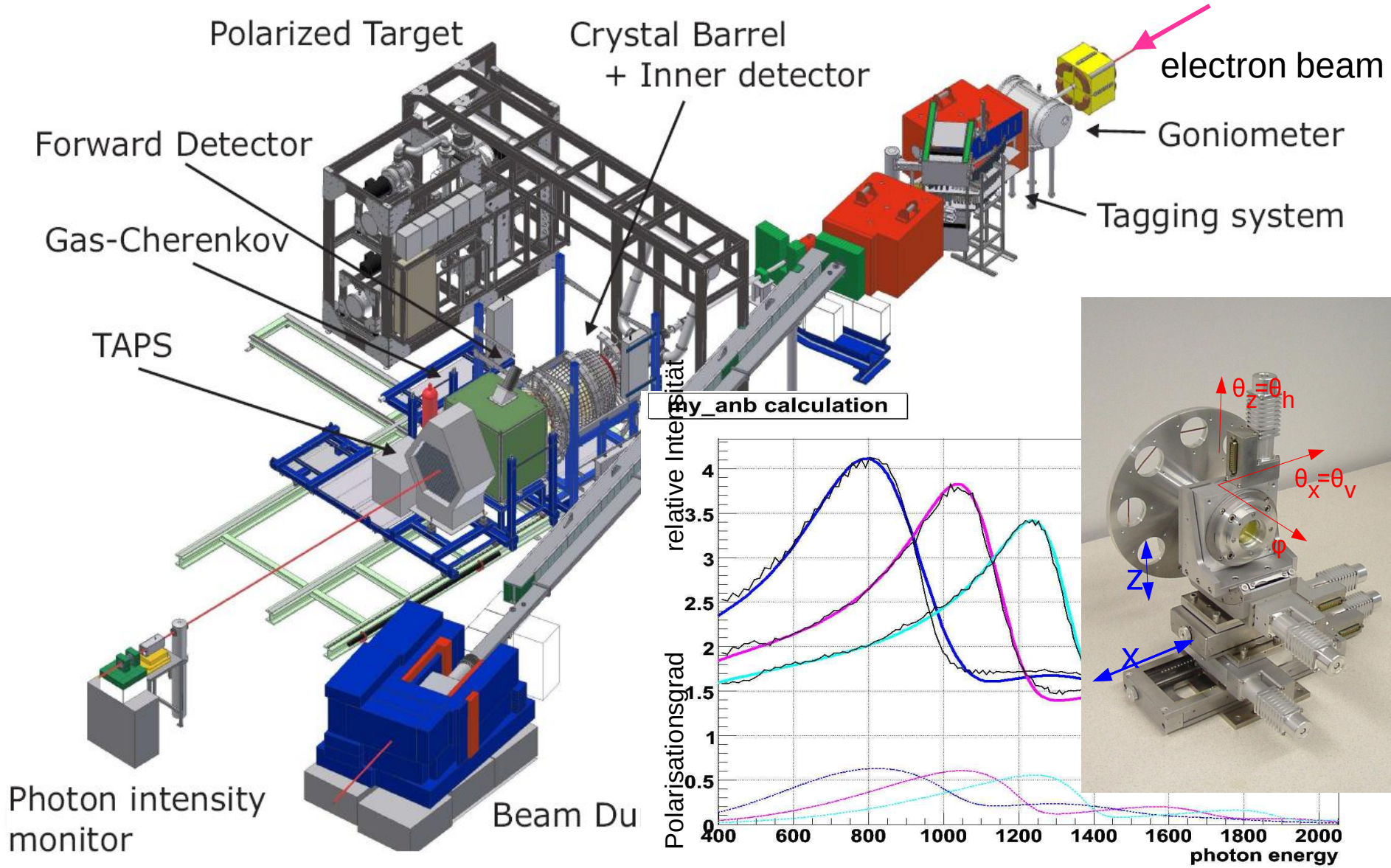
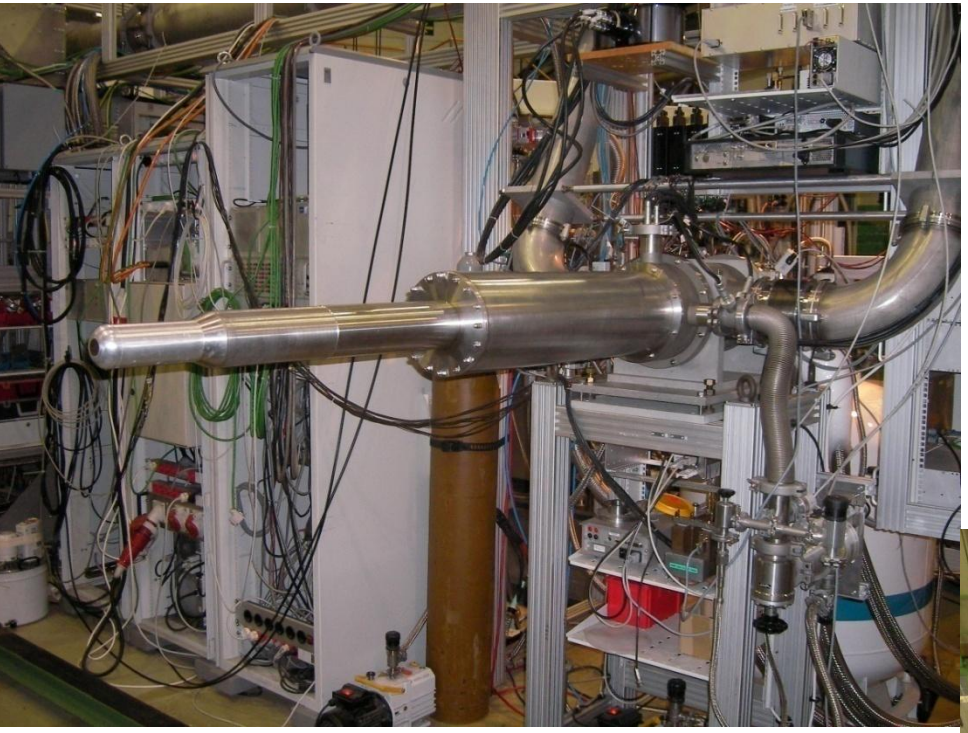
Crystal Barrel / Taps set-up



Polarized Target w/ Crystal Barrel

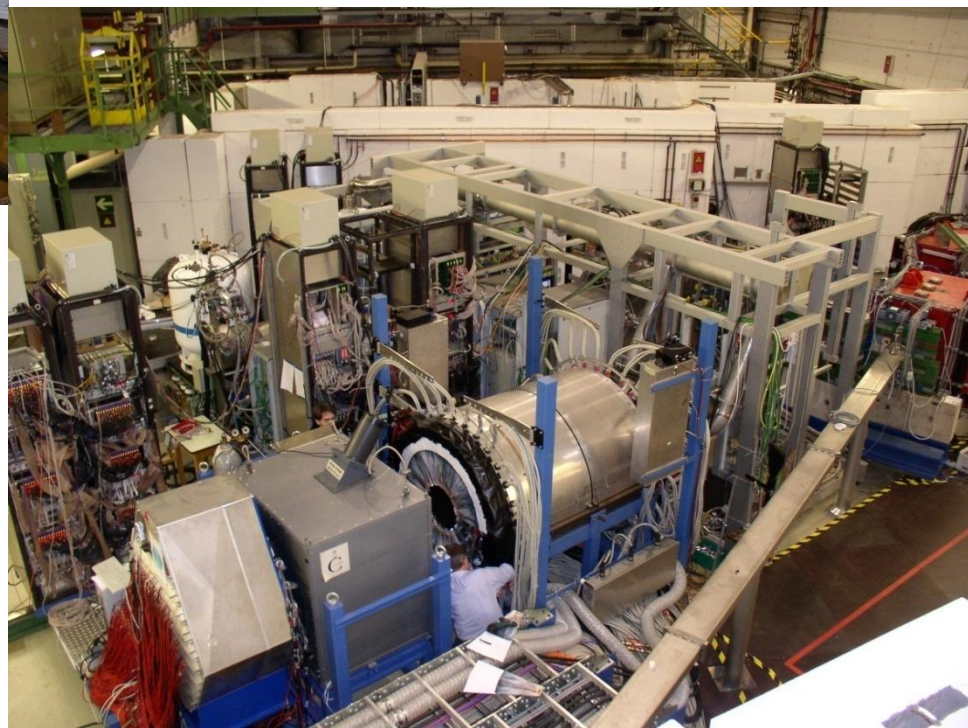


horizontal cryostat
in experimental area

data taking →

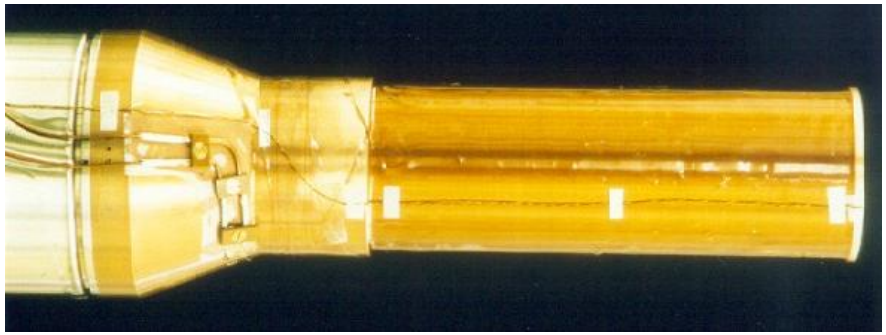
Running time over 2500 hours in year 2008
over 2200 hors in year 2009

High. polarization	P_+ = 83.4 %
	P_- = - 80.9 %
fast build-up	05h04min
(May/June)	05h39min (August)
Pol.-time	06h10min



Polarised target

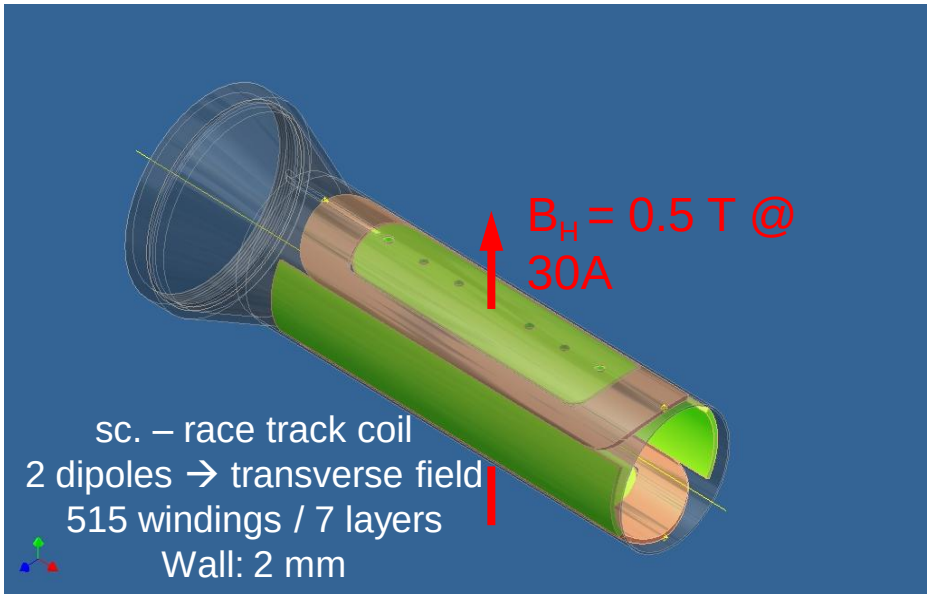
Longitudinally polarised



Solenoid with low mass layer

E, G, P data taken

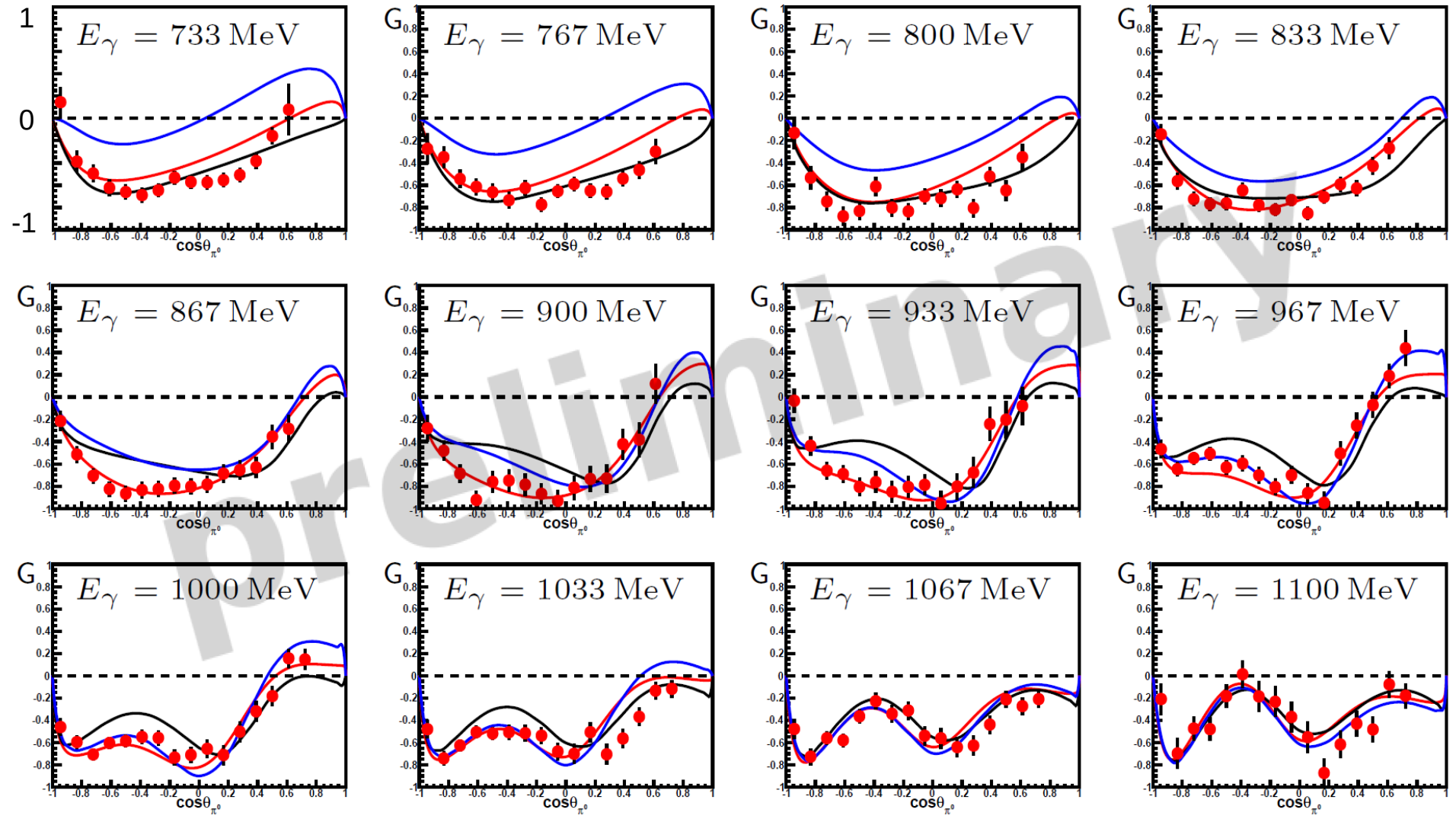
Transversely polarised



Race track coil
T, P and H data taken

H. Dutz and S. Goertz

Double polarisation Observable G in $\vec{\gamma} + \vec{p} \rightarrow p + \pi^0$

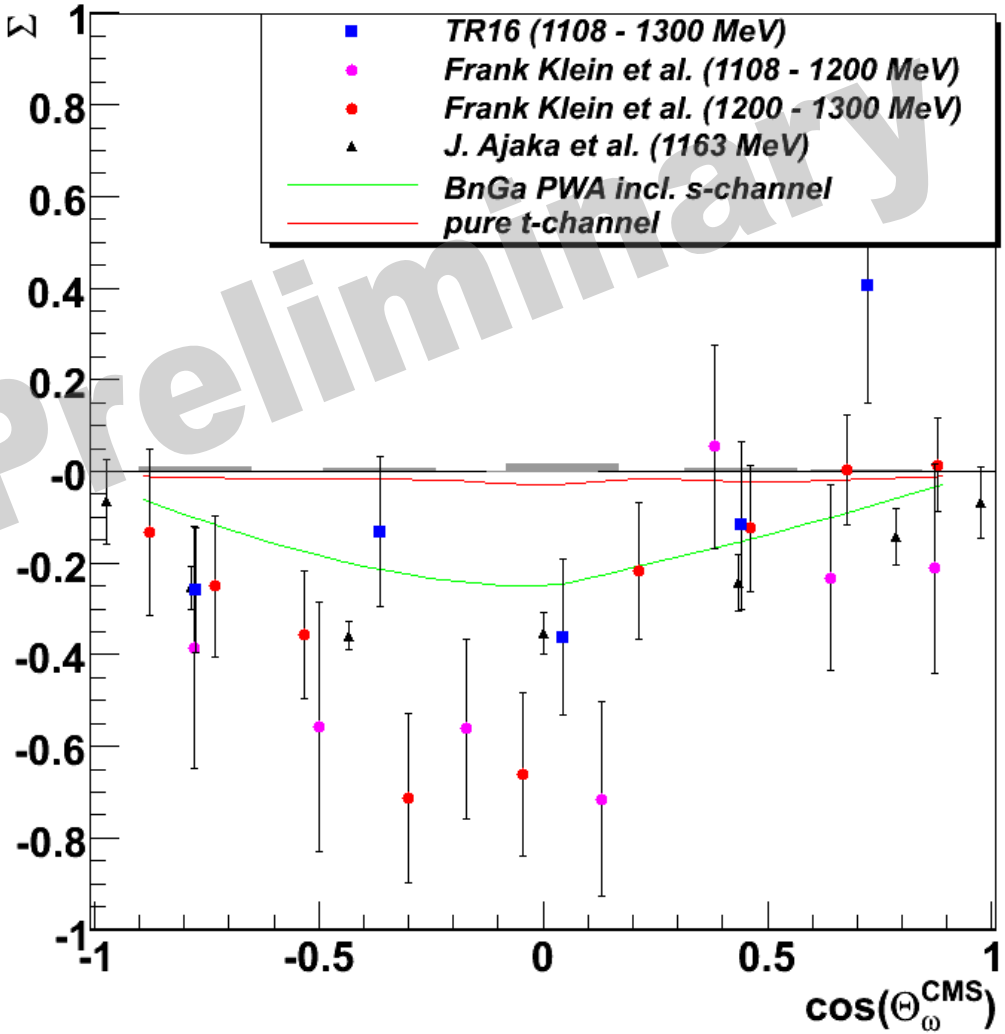


$\vec{\gamma}\vec{p} \rightarrow p\pi^0$ — Maid — Said — BnGa

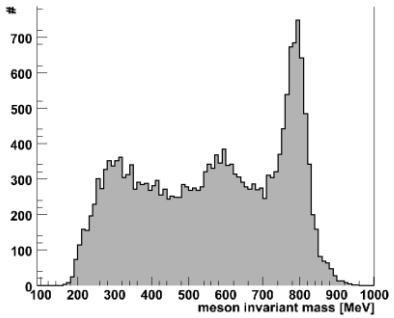
A. Thiel (Bonn)

→ contrib. H. Eberhard

Beam asymmetry Σ in $\vec{\gamma}$ + p → p + ω



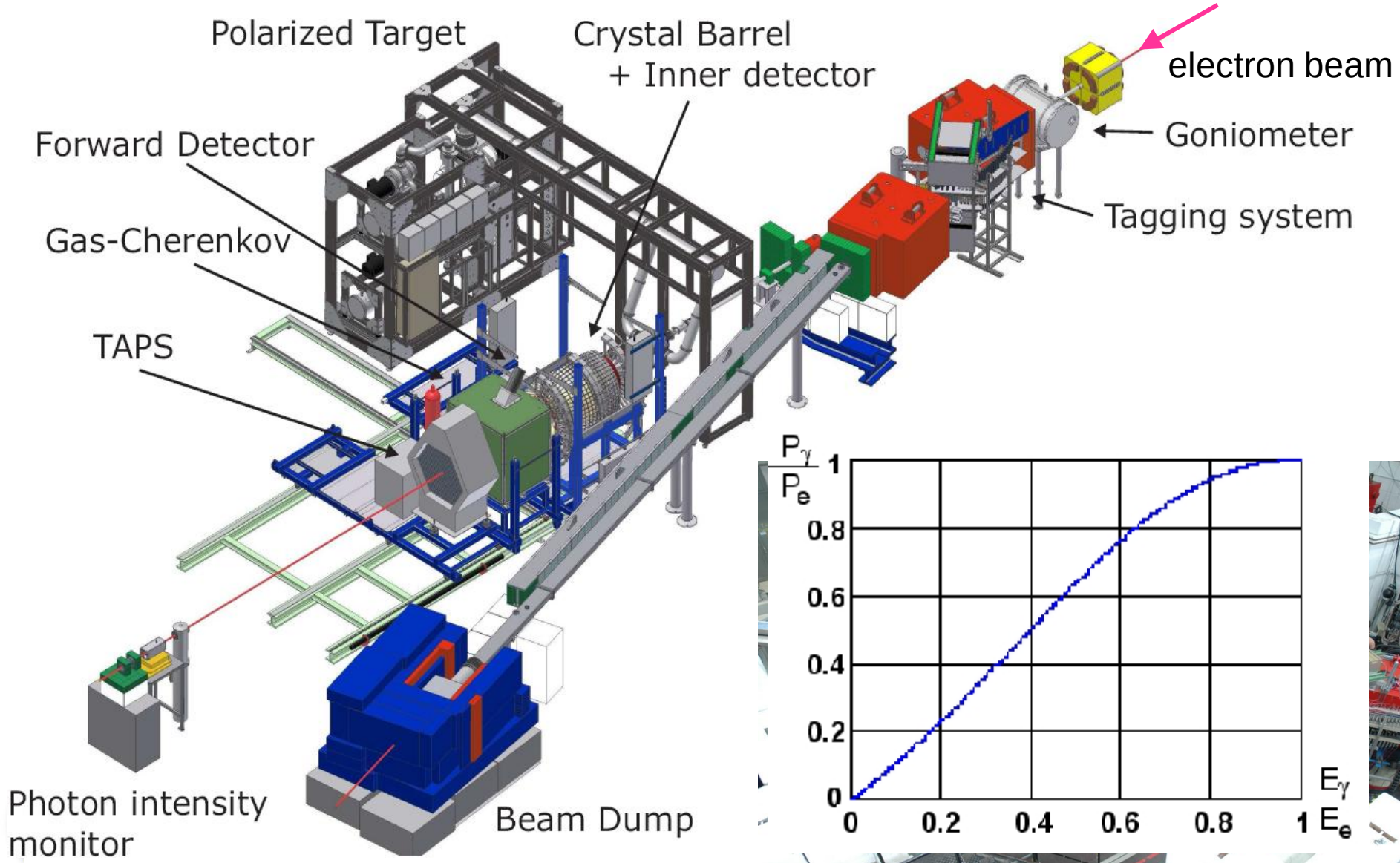
$\pi^0\gamma \rightarrow \gamma\gamma\gamma$



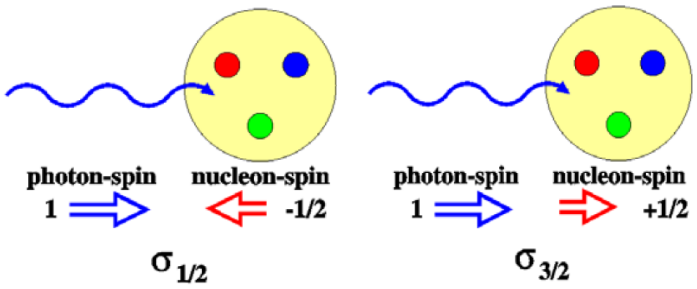
Σ, Σ_π, G, G_π

also measured

Crystal Barrel / Taps set-up



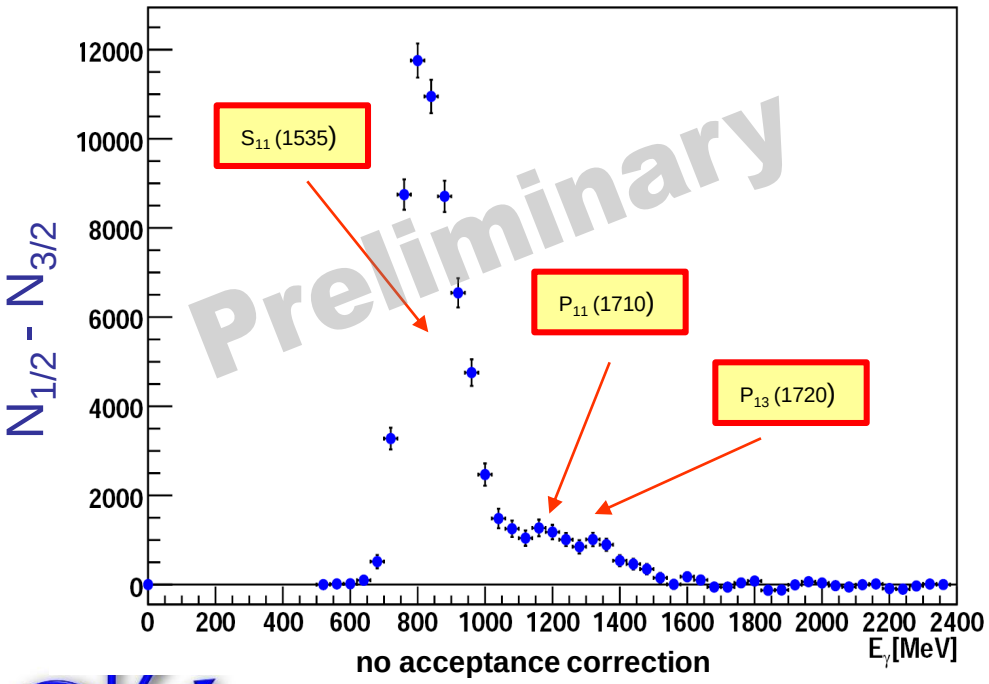
Helicity dependent total cross section $\vec{\gamma} + \vec{p} \rightarrow p + \eta$

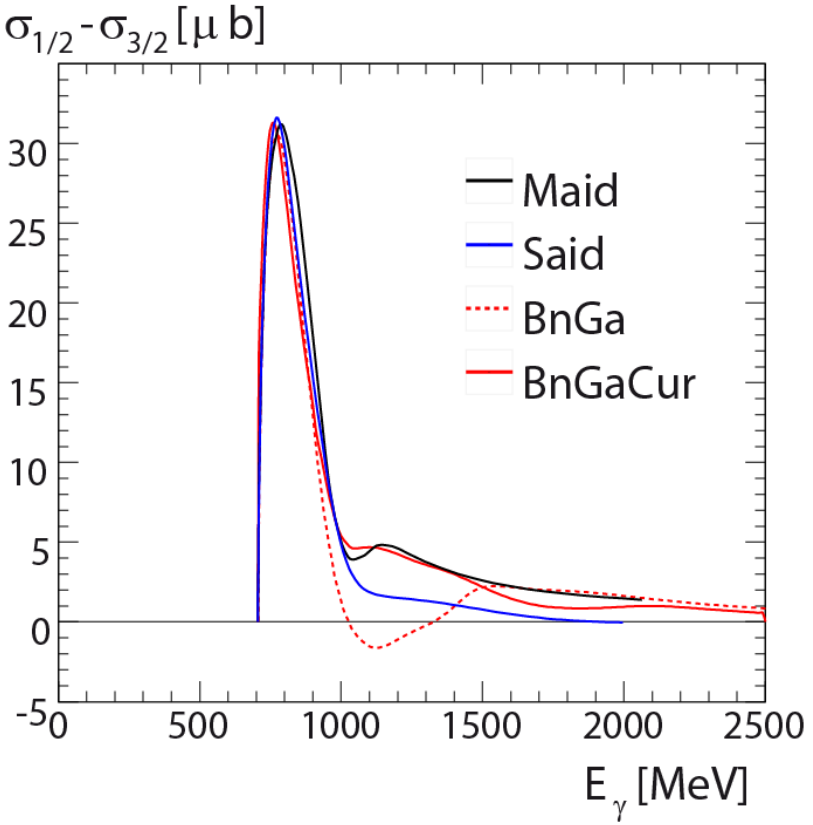


circularly polarised photon beam

longitudinally polarised proton target

Preliminary results (J. Müller)

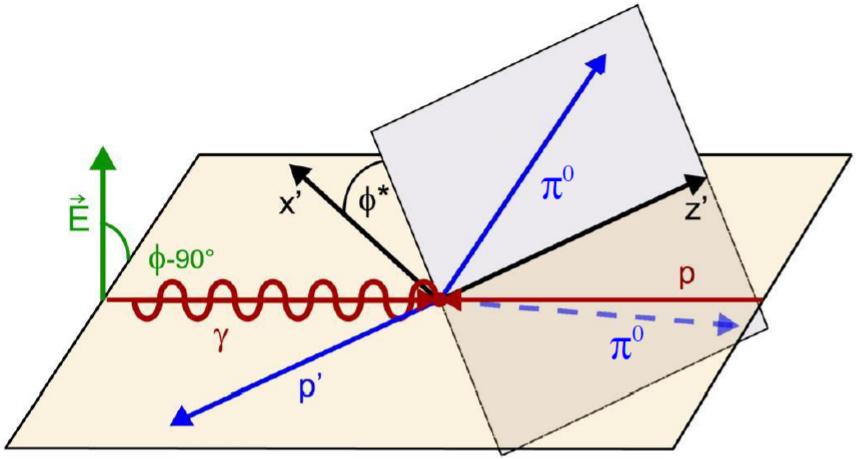




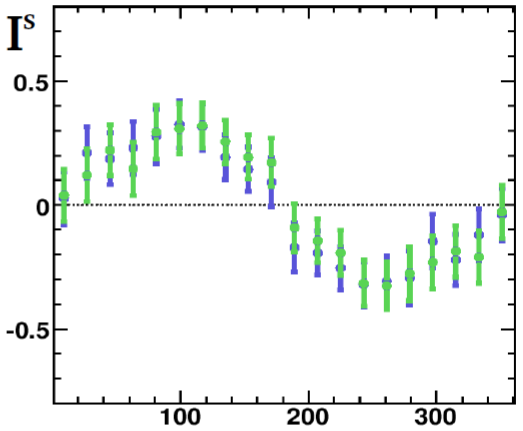
Polarization observables I^s and I^c → contr. Sokhoyan

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 \{1 + \delta_l[I^s \sin(2\phi) + I^c \cos(2\phi)]\}$$

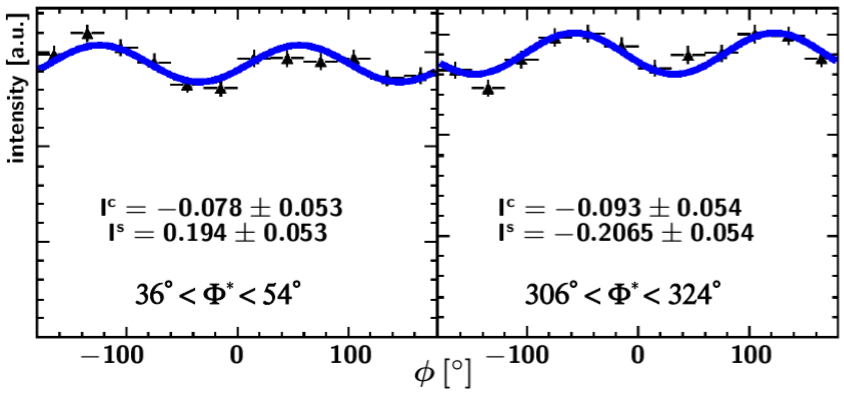
$$I^c(\Phi^*) = I^c(2\pi - \Phi^*)$$
$$I^s(\Phi^*) = -I^s(2\pi - \Phi^*)$$



π^0 in the production plane

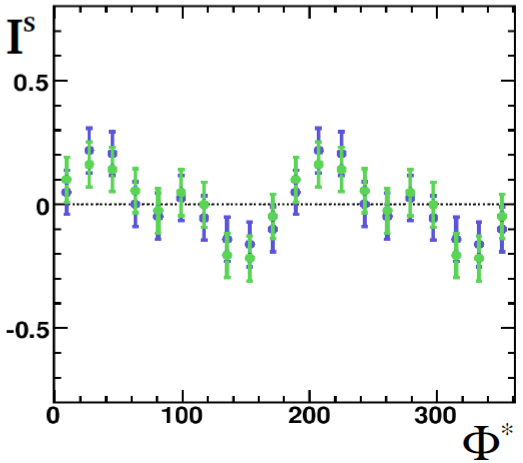


$$f(\phi) = A + B\sin 2\phi + C\cos 2\phi$$

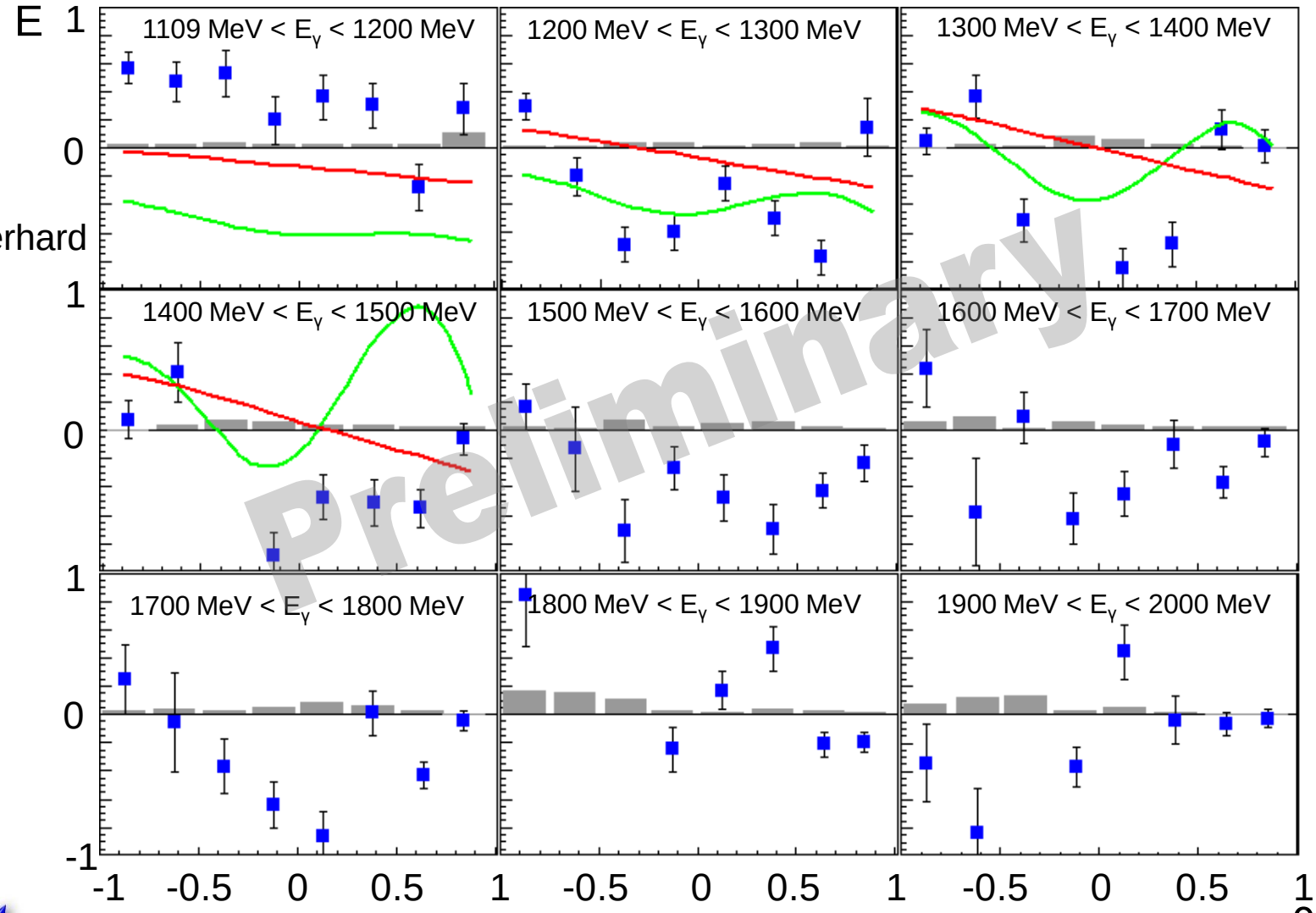


$$I^{s(c)}(\Phi^*) = I^{s(c)}(\Phi^* + \pi)$$

proton in the production plane



Double polarisation observable E in $\vec{\gamma} + \vec{p} \rightarrow p + \omega$



→ H. Eberhard

— A.V. Sarantsev et al., Eur. Phys. J. A 39 (t-Kanal)

— A.V. Sarantsev et al., Eur. Phys. J. A 39 (incl. s-Kanal)

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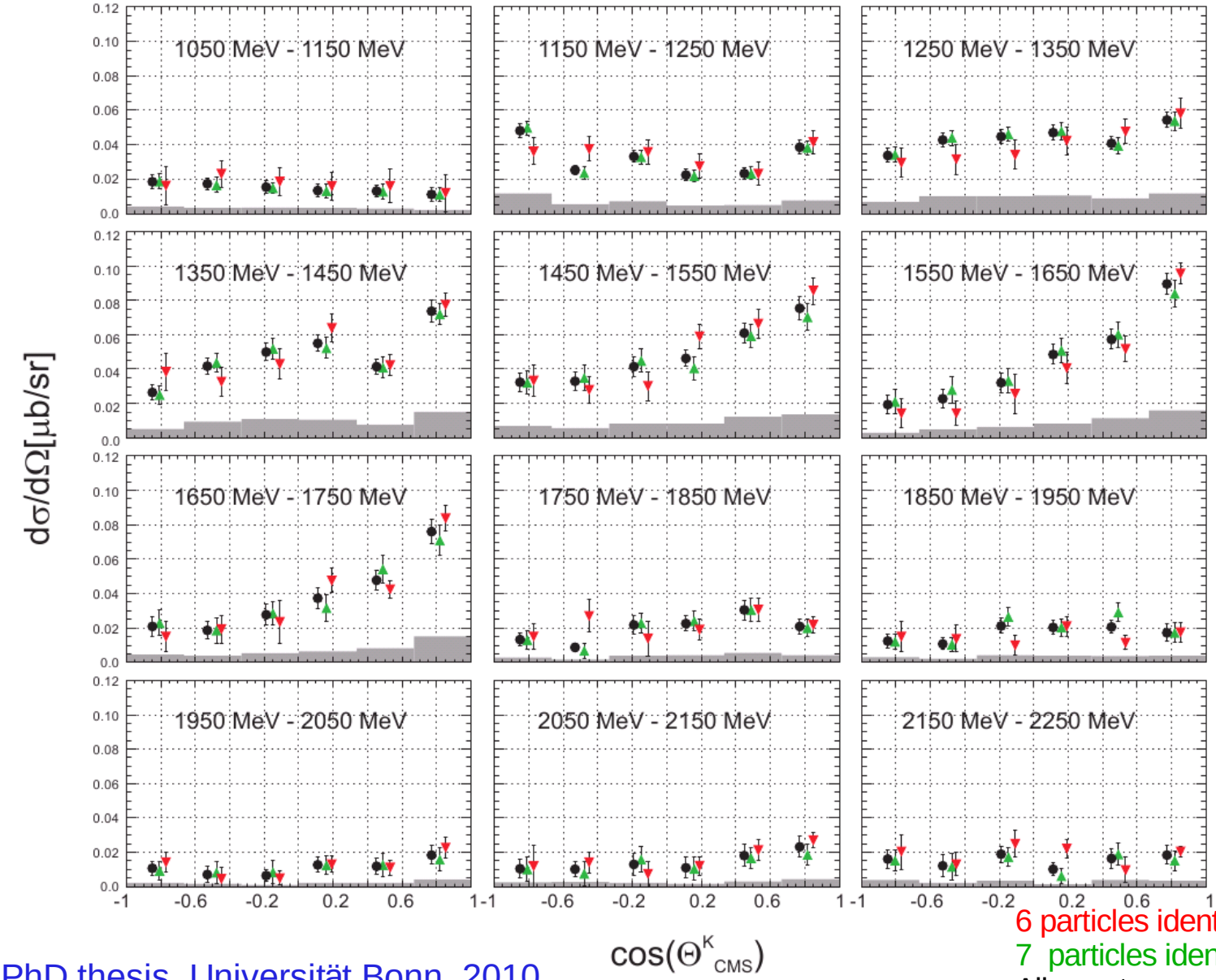
→contrib. T. Jude

Photoproduction of $K^0\Sigma^+$ @ CBELSA/TAPS



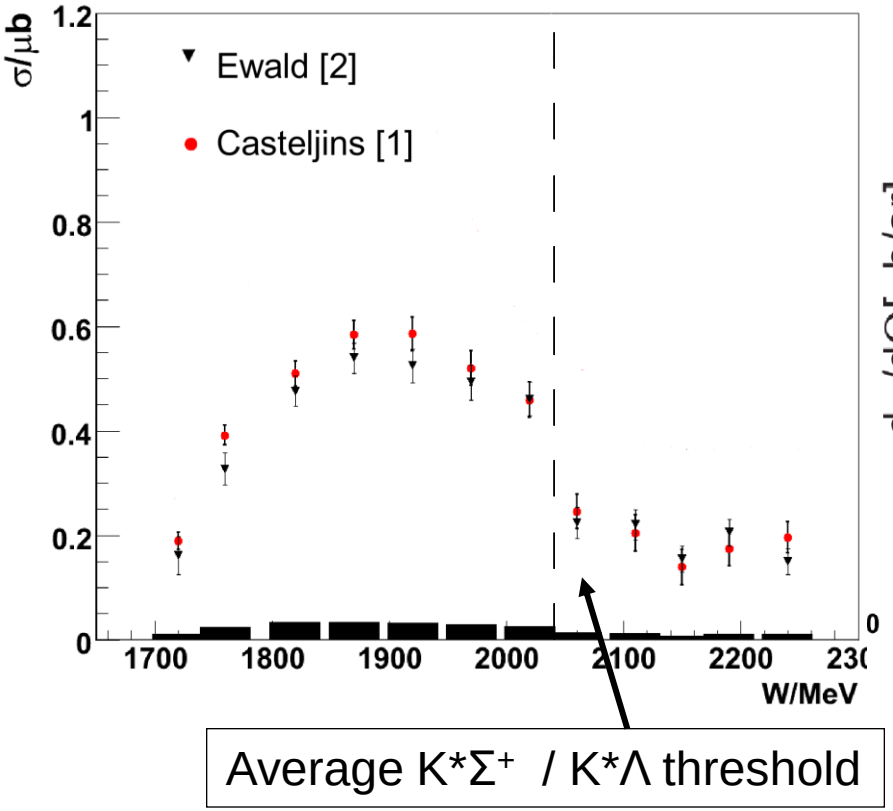
6 particles identified (red)
7 particles identified (green)
All events

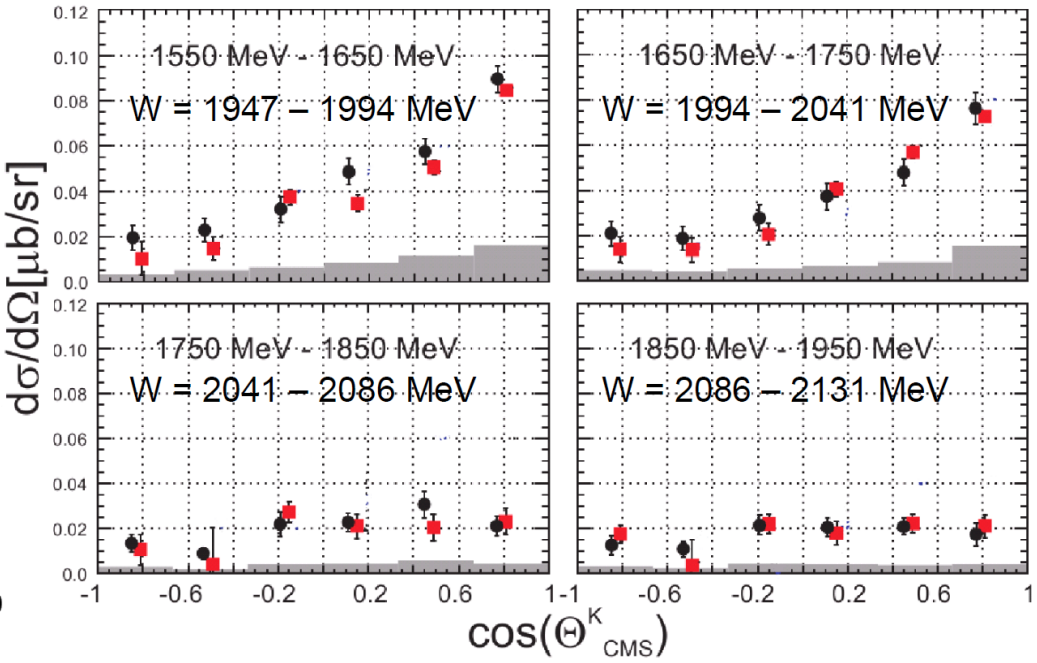
R Ewald, PhD thesis, Universität Bonn, 2010

Cross sections $\gamma p \rightarrow K^0 \Sigma^+$

→contrib. T. Jude

Cross section measurements suggest strong t-channel dependency



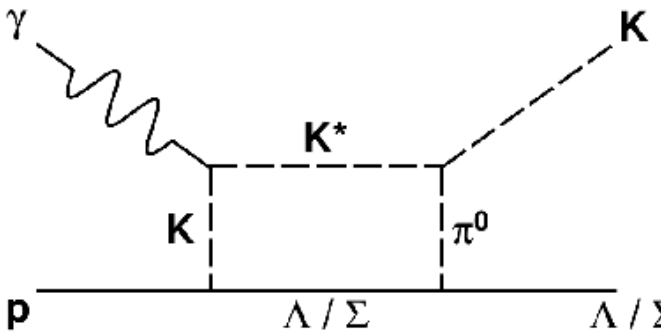


Black points: Ewald [1]
Red points: Casteljins [2]
Taken from [1]

[1] R. Ewald. PhD Thesis, Universitat Bonn (2010)
[2] R. Casteljins. Eur. Phys. J. A. 35:39 (2008)

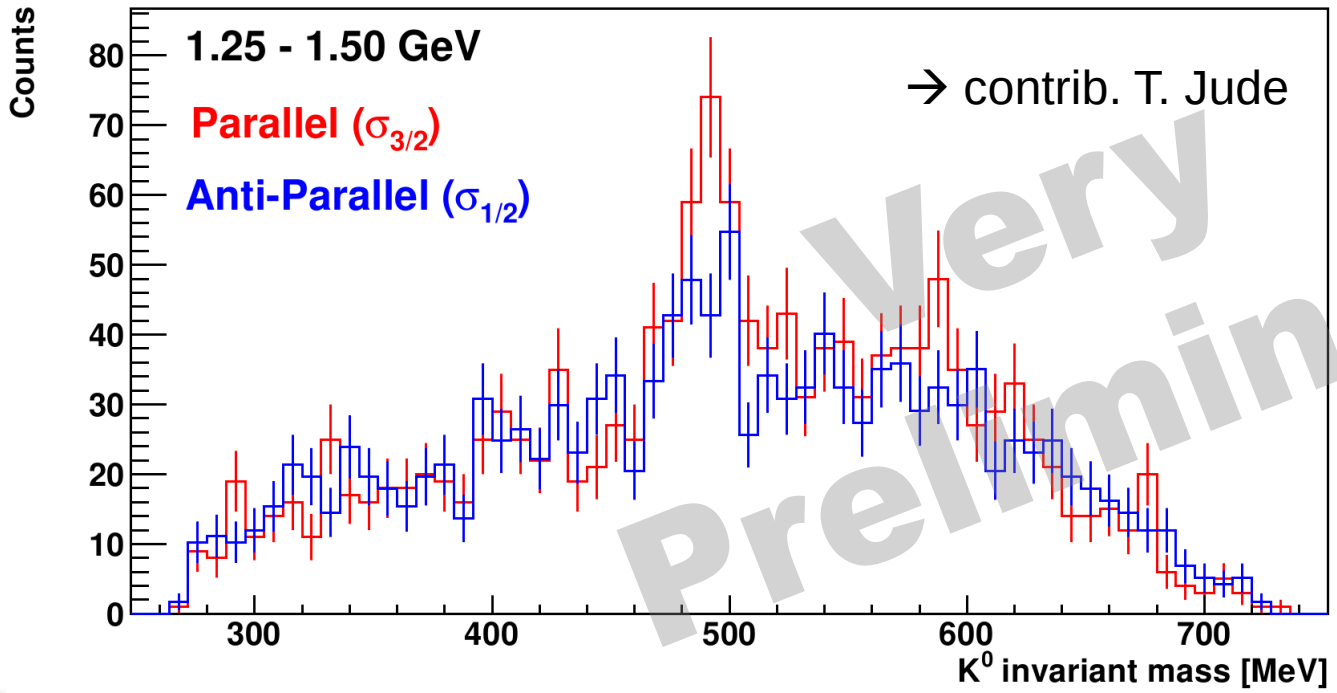
Beam-target double polarisation observable E in $K^0 \Sigma^+$

H. Schmieden: does



contribute to $K^0 \Sigma^+$???

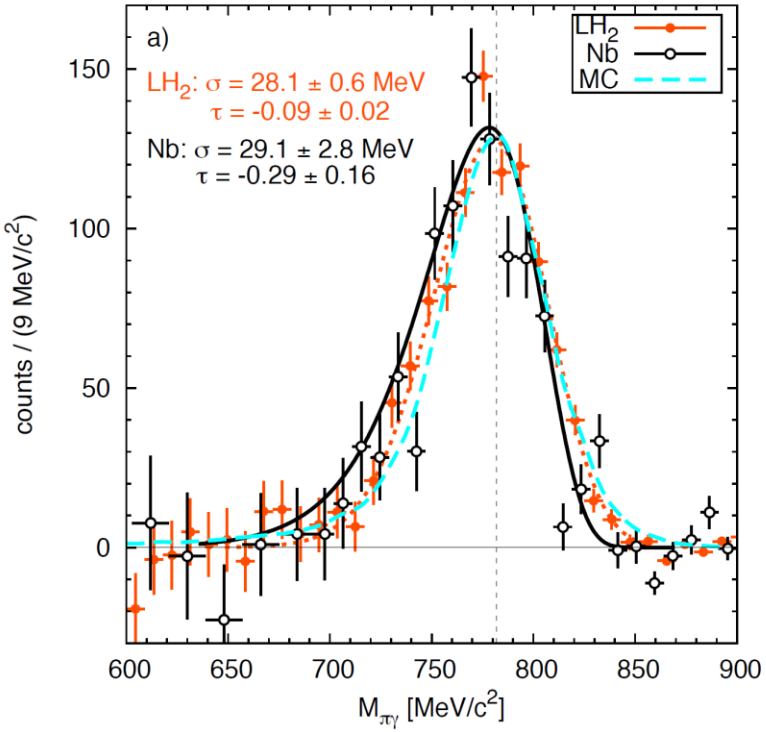
check E



ω meson line shape near the production threshold

E_γ= 900 – 1300 MeV; $E_{\gamma N}^{thr}$ =1109 MeV

M. Nanova et al., Eur. Phys. J. A 45 (2011) 16

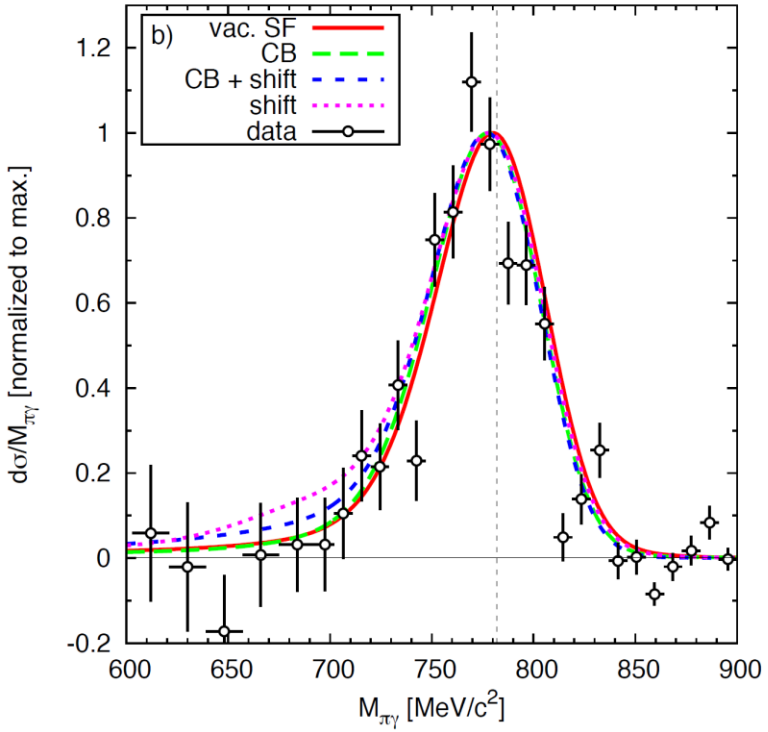


ω signal shows no significant deviation from the reference signals

higher statistics needed

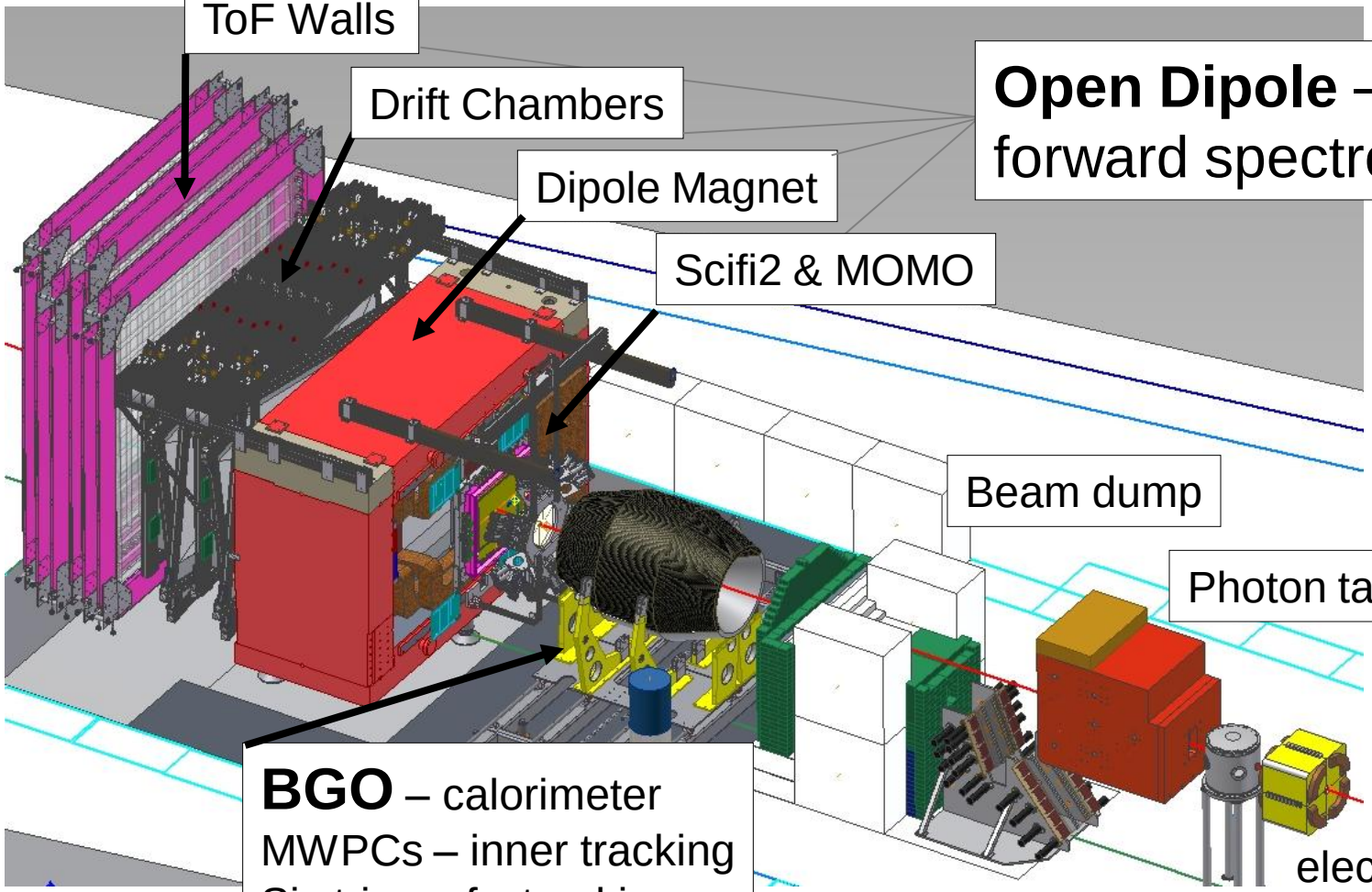
→ BGO-OD

comparison of the ω line shape to the GiBUU calculations (J.Weil)



experimental data do not allow to distinguish between the various theoretical scenarious also near threshold !

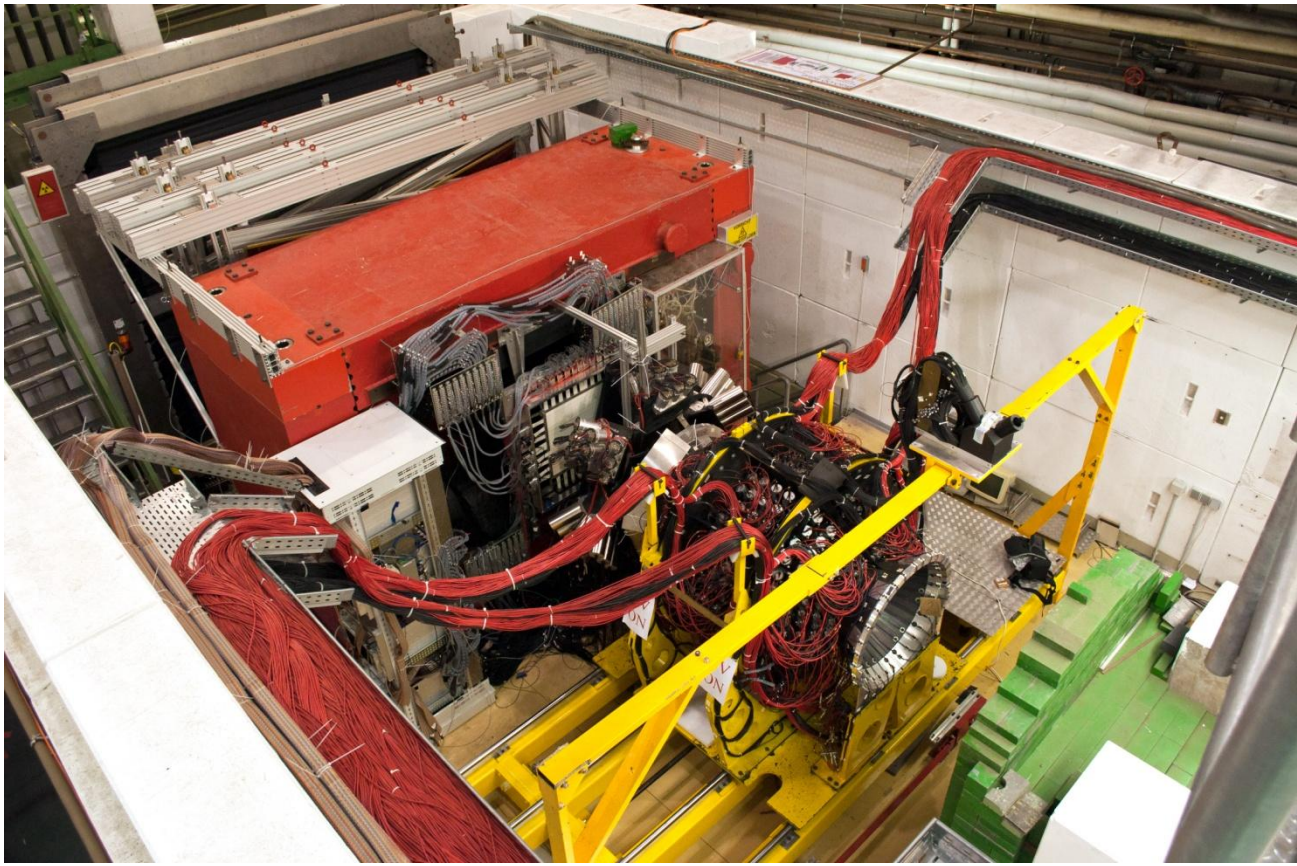
New BGO - OD set-up



Open Dipole – forward spectrometer

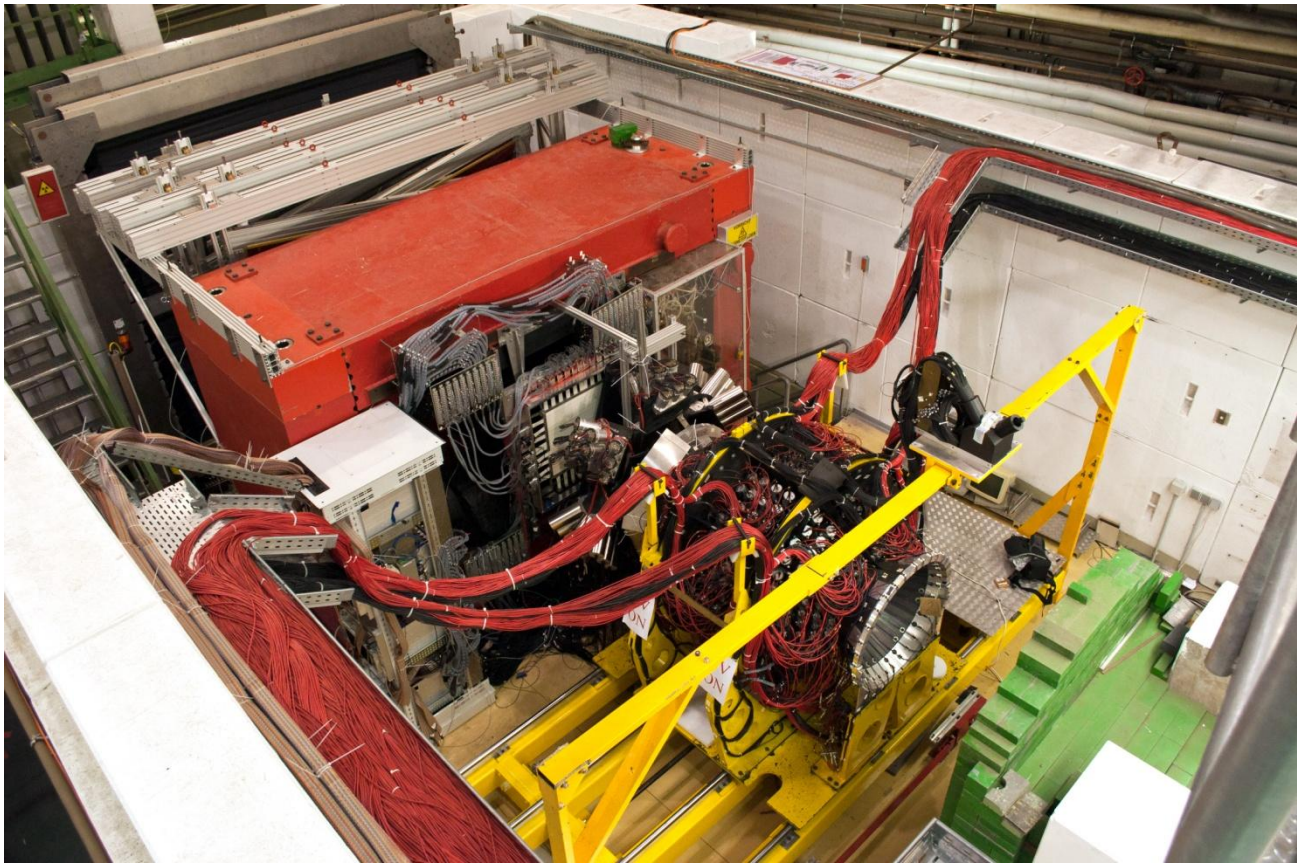
BGO – calorimeter
MWPCs – inner tracking
Si strips – fw tracking
Target system

BGO - OD experiment



Focus on
vector meson production, recoil polarisation,
strangeness photoproduction, excited hyperons, eg. $\Lambda(1405)$

BGO - OD experiment



member institutions:

Univ. of Bonn, Phys. Inst.
Univ. of Bonn, HISKP
Univ. of Messina, Italy
Univ. of Edinburgh, UK
Univ. of Moscow, Russia
INFN-LNF Frascati, Inst. Sup. di Sanità & INFN Roma1, Italy
Univ. of Pavia, INFN Pavia, Univ. of Torino & INFN Torino, Italy
Univ. of Roma „Tor Vergata“ and INFN Roma2, Italy
Nat. Sc. Center Kharkov Inst. of Phys. & Techn., Ukraine
Petersburg Nucl. Phys. Inst. (PNPI), Gatchina, Russia
Univ. of Basel, Switzerland

Contributions to NSTAR2011 from ELSA

Tue

- **T. Jude** - Double polarization asymmetry in neutral kaon production w/ CBELSA/TAPS

Wed

- **J. Hartmann** - Double polarizationn observables in meson photoproduction w/ CBELSA/TAPS
- **N. Sparks** - π^0 photoproduction off the proton at forward angles using CBELSA/TAPS

Thu

- **V. Sokhoyan** - Polarization observables Is and Ic in $\gamma p \rightarrow p\pi^0\pi^0$ with CBELSA/TAPS
- **H. Eberhard** - Measurement of polarization observables in ω-photoproduction
- **A. Wilson** - Photoproduction of π0ω meson pairs off the proton at CBELSA/TAPS
- **I. Jaegle** - Meson photoproduction off light nuclei

Summary

- tools for double polarization exp‘s w/ high acceptance for photons
- single & double meson production done w/ CBELSA/TAPS
  $d\sigma, \Sigma$, E, G, P, H, T for π and η on proton
- neutron under attack
- second complementary spectrometer BGO-OD commissioning
  better control and inclusion of charged final states
  focus on recoil polarimetry, strangeness, ω, medium effects, …

Summary

- tools for double polarization exp's w/ high acceptance for photons
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Personal wishes and hopes on N^*-activities:
avoid costly stamp collection …
theorists, help orthogonalize exp's !!

breakthrough, please come soon!