

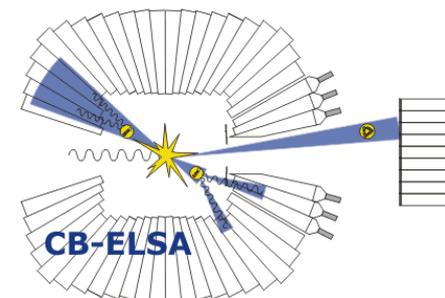
Experiments at ELSA (Bonn) and MAMI (Mainz) Electron Accelerators

- *Physics*
- *Accelerators*
- *Detectors*
- *Results*
- *Outlook*

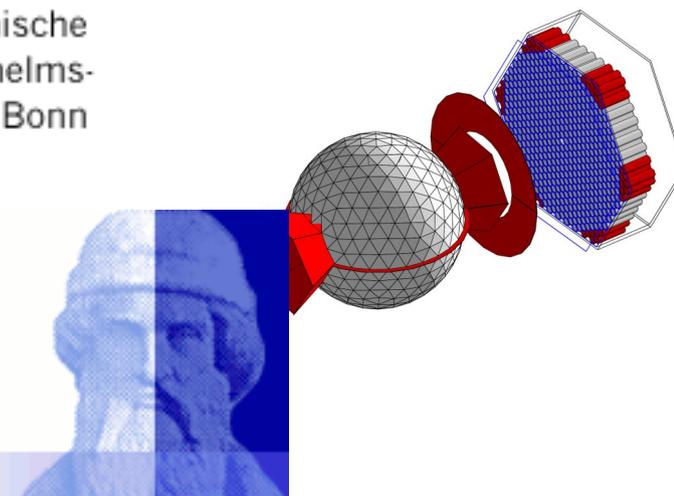


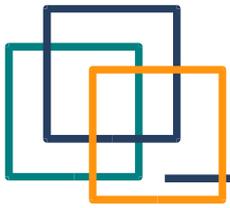
universität**bonn**

Rheinische
Friedrich-Wilhelms-
Universität Bonn



JOHANNES GUTENBERG
UNIVERSITÄT MAINZ

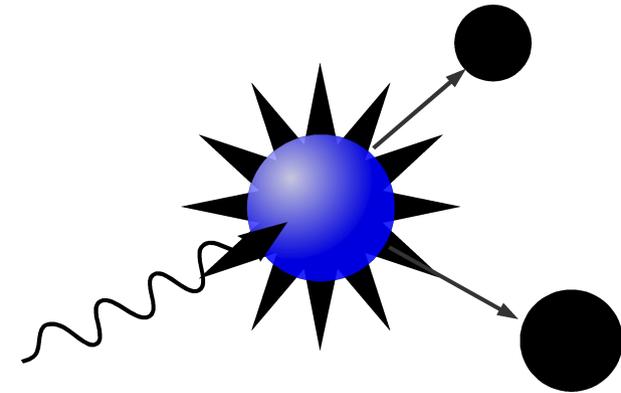
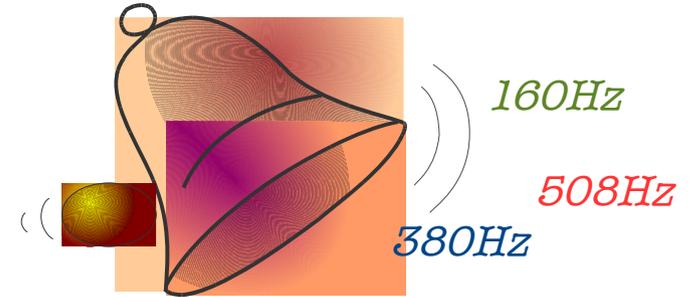
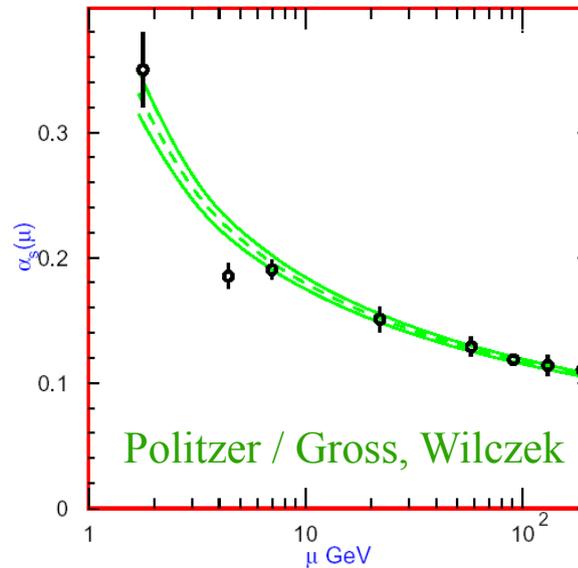
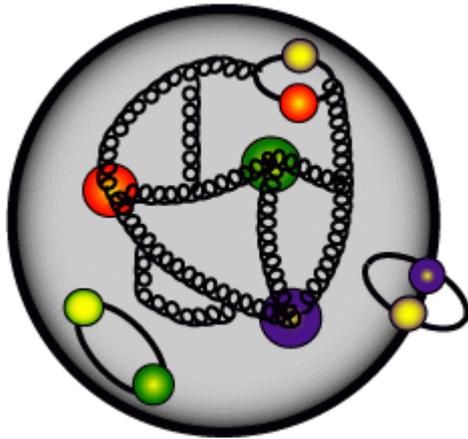
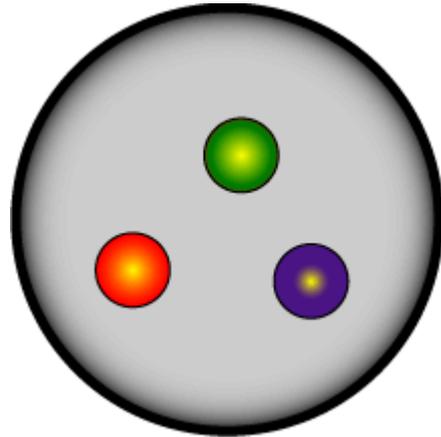


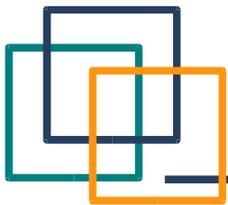


Nucleon Structure

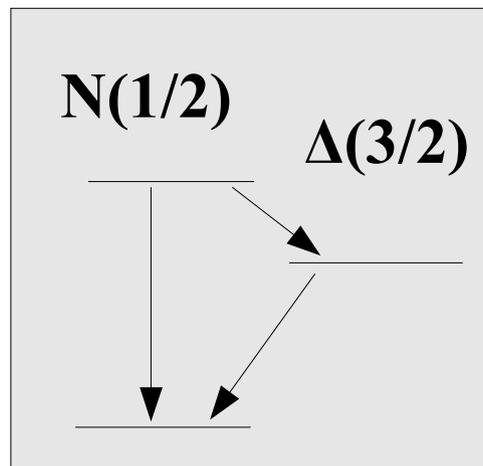
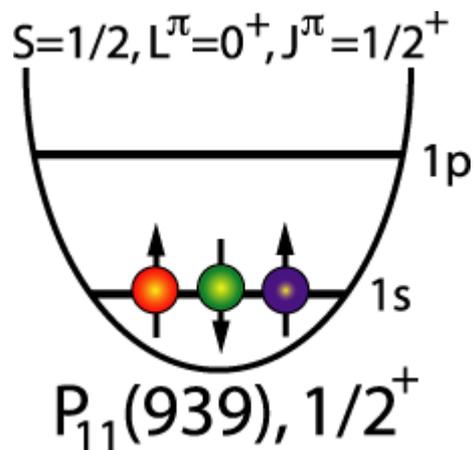
complex system

- ▶ valence quarks
- ▶ sea quarks
- ▶ gluons





Change of internal structure



▶ change of internal structure

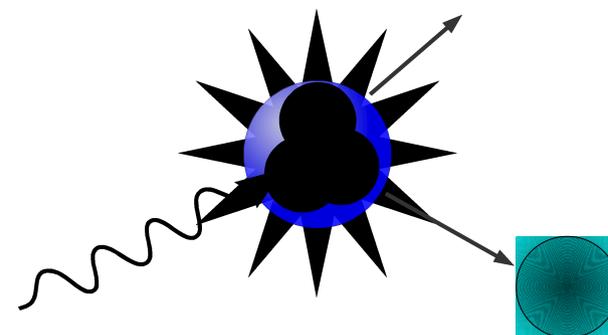
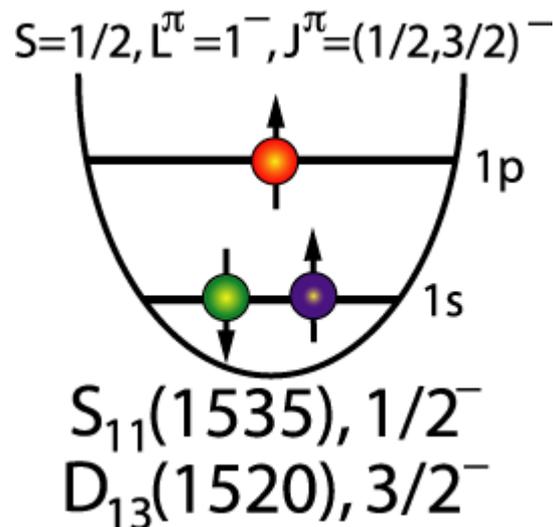
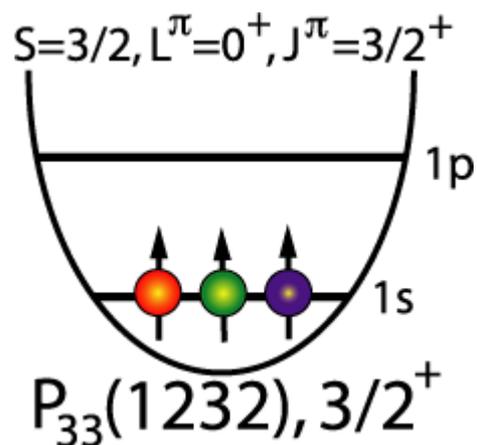
$N \rightarrow \Delta$

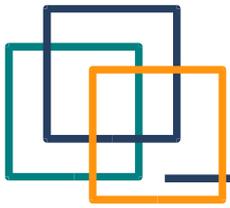
▶ reaction mechanisms ?

☪ one-gluon exchange

☪ instanton-induced forces

☪ Goldstone-boson exchange

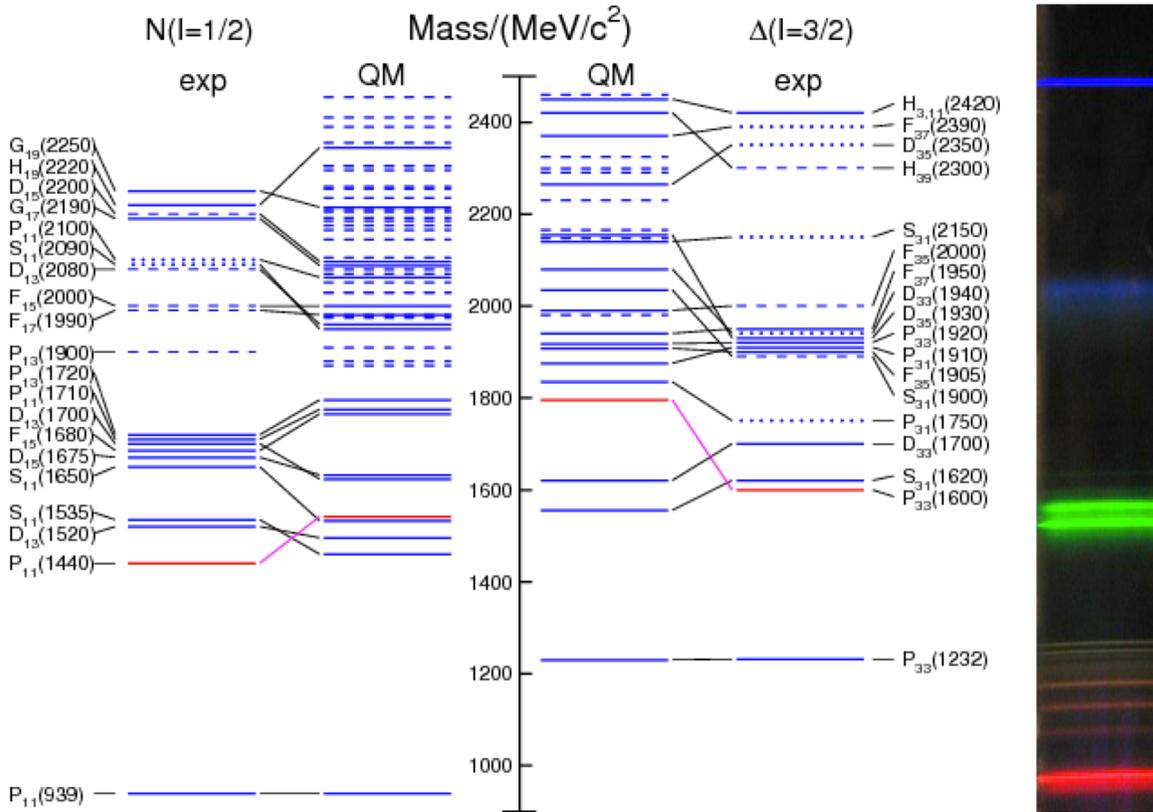




Comparison

known excited states in constituent quark model

(Capstick & Roberts)



ordering of low lying states ?
missing resonances ?

degrees of freedom ?

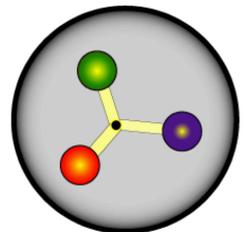
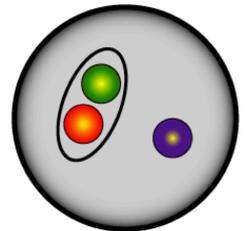
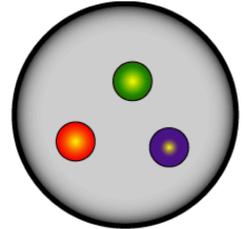
▶ **3 constituent quarks**

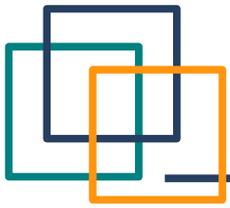
▶ **quark-diquark**

▶ **quark flux-tube**

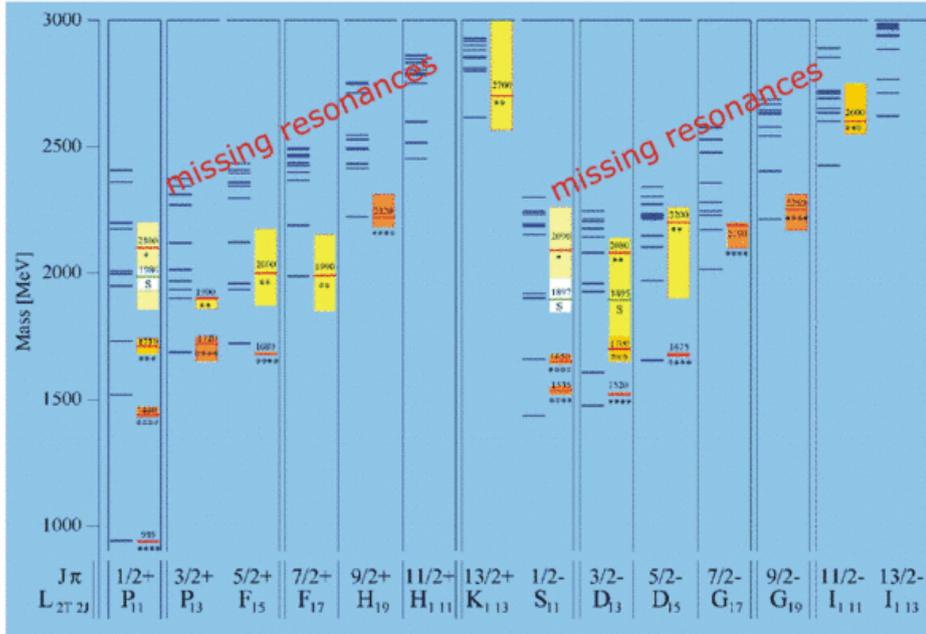
▶ **coupled channel**

dynamics

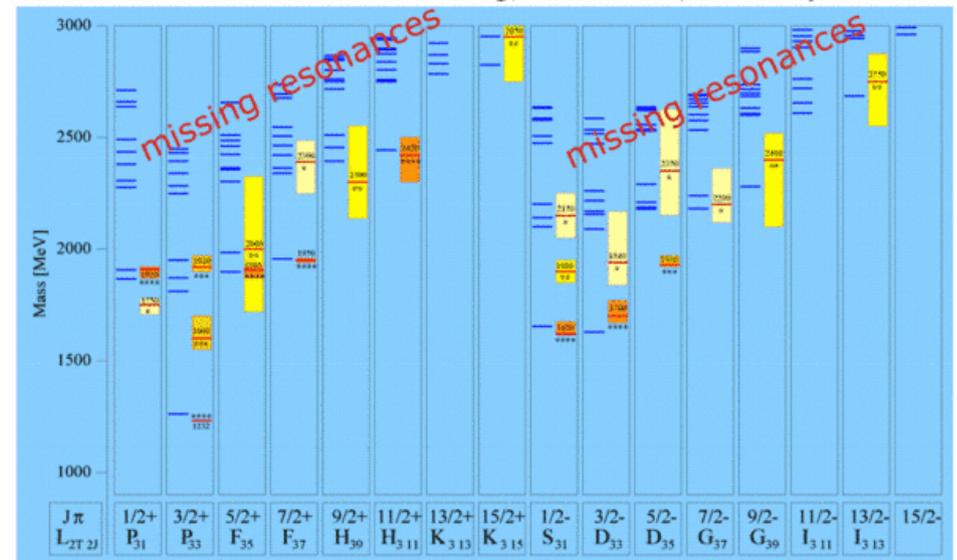
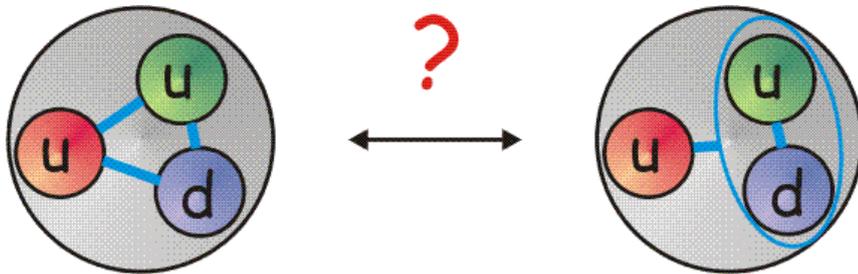


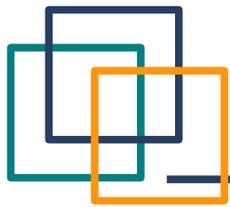


Comparison

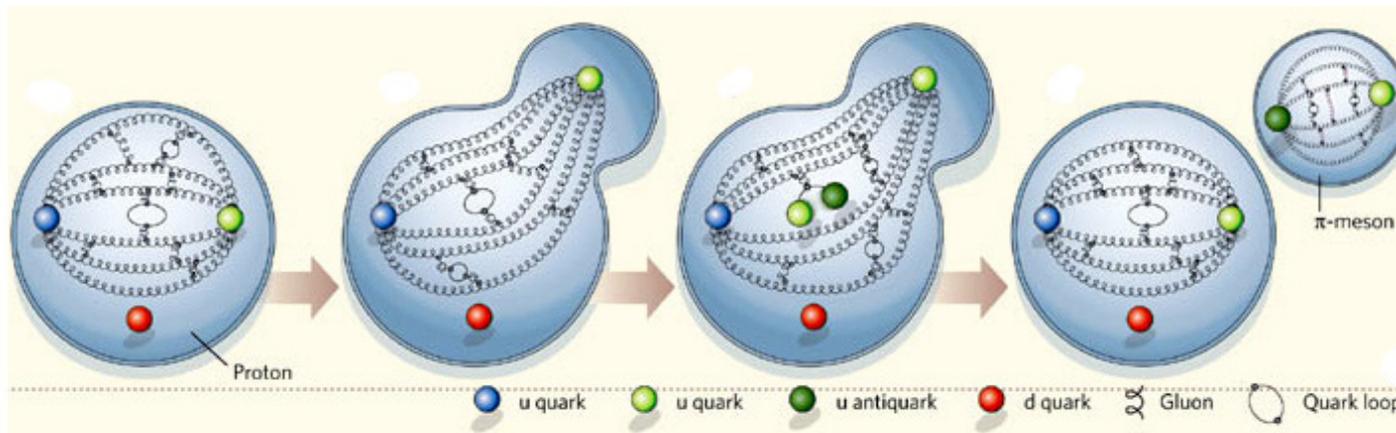


Resonances as calculated in the **Bonn model** in comparison to experimental results.

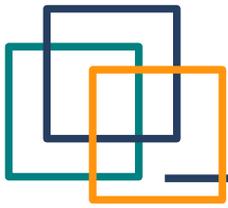




Innovation in nature

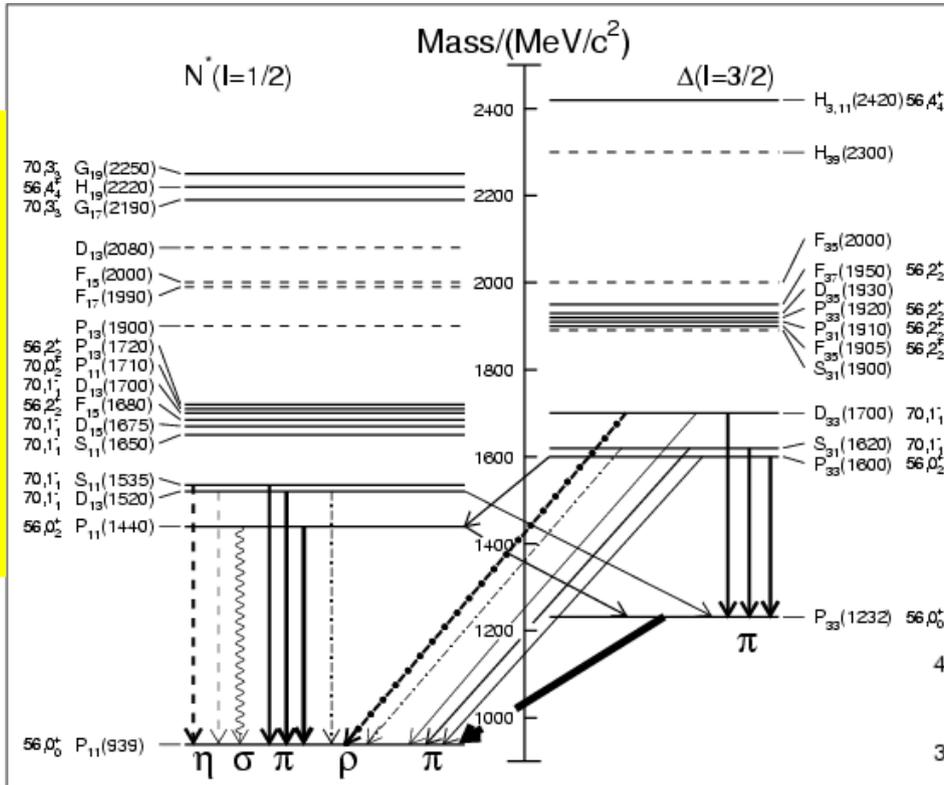


...needs time.



Nature and properties of known resonances

excited states of the nucleon



Since: $\pi^0 - I^G(J^{PC}) 1^-(0^+)$

$\eta - I^G(J^{PC}) 0^-(0^+)$

η iso-spin filter

$N^*/\Delta^* \rightarrow \Delta p$

$N^* \rightarrow N^* \eta/p$

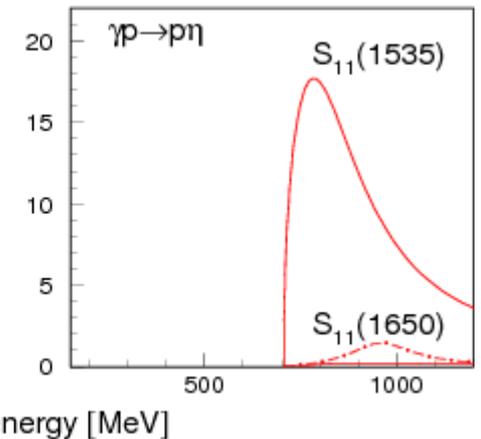
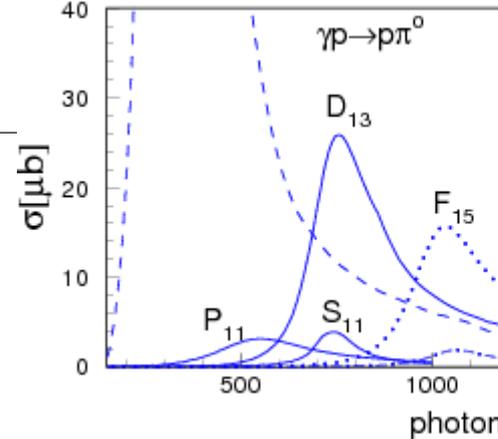
$N^*/\Delta^* \rightarrow N^* p$

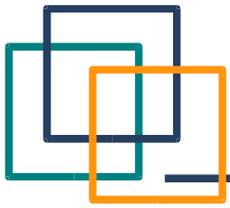
$D^* \rightarrow D \eta$

nuclear spin / iso-spin filter

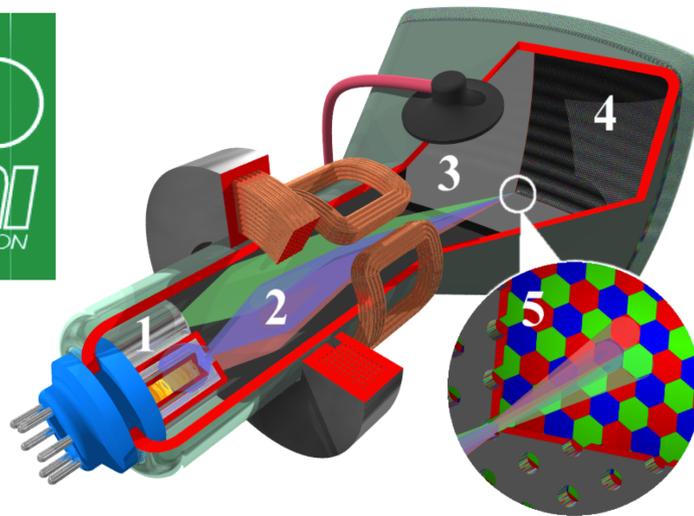
$\gamma d \rightarrow \pi^0 \pi^0 d$ only N^* allowed

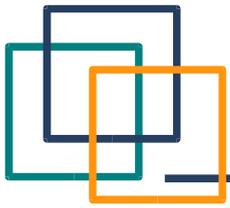
$\gamma^3 \text{He} \rightarrow \pi^0 \pi^0 {}^3 \text{He}$ N^* and D^* allowed



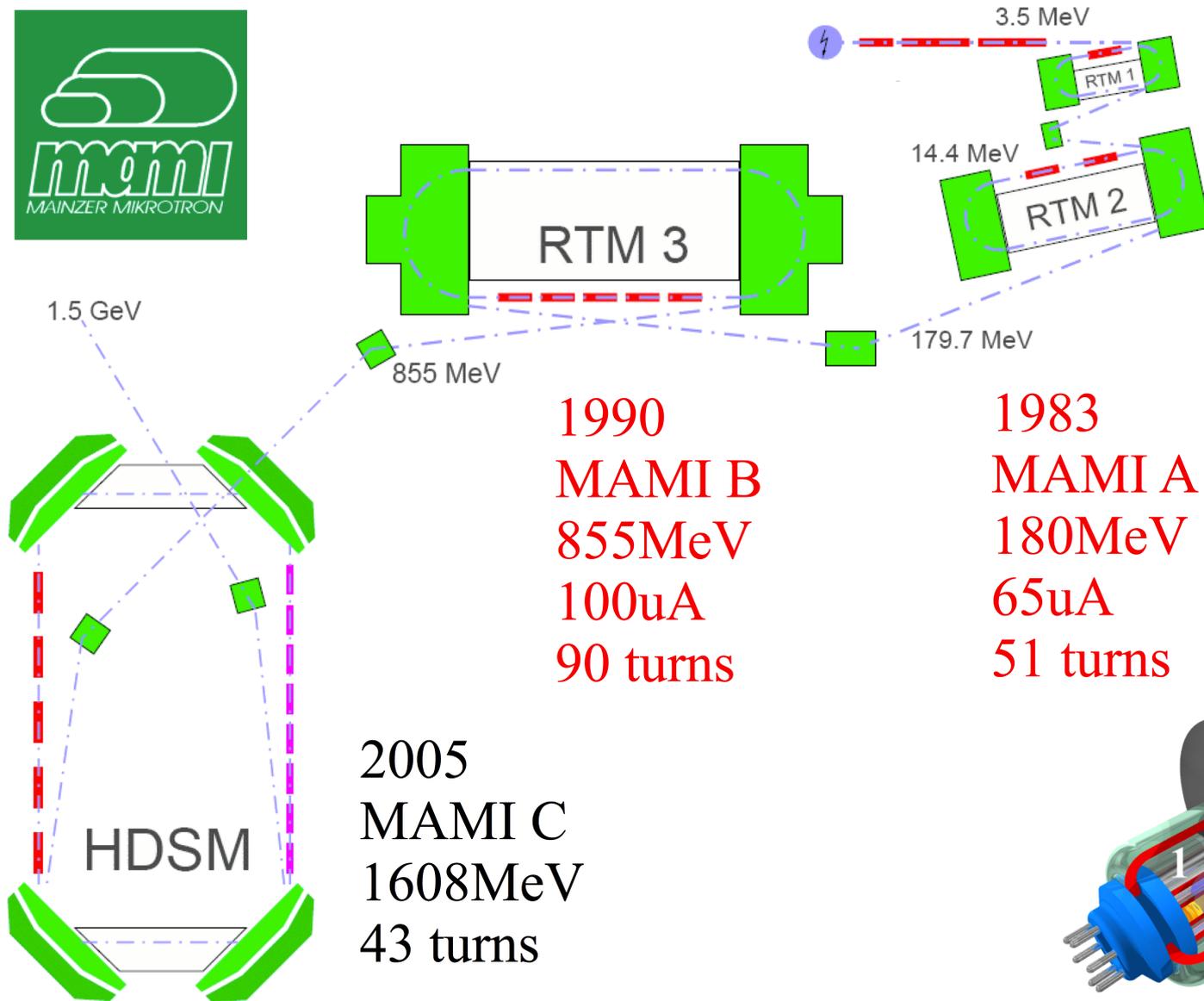


Accelerators





Accelerators

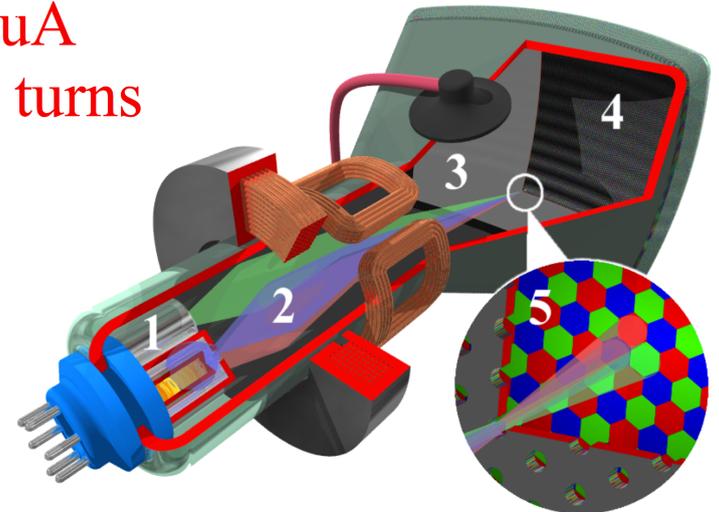


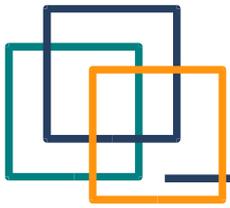
1979
RTM 1
14MeV
85uA
18 turns

1990
MAMI B
855MeV
100uA
90 turns

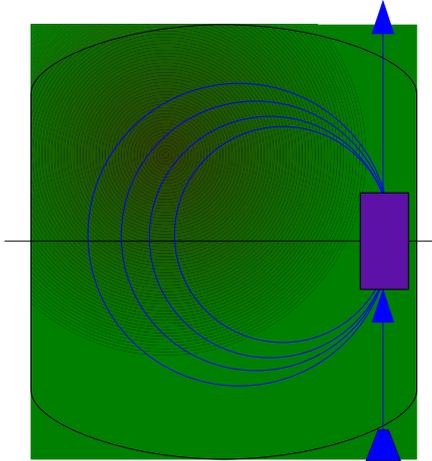
1983
MAMI A
180MeV
65uA
51 turns

2005
MAMI C
1608MeV
43 turns

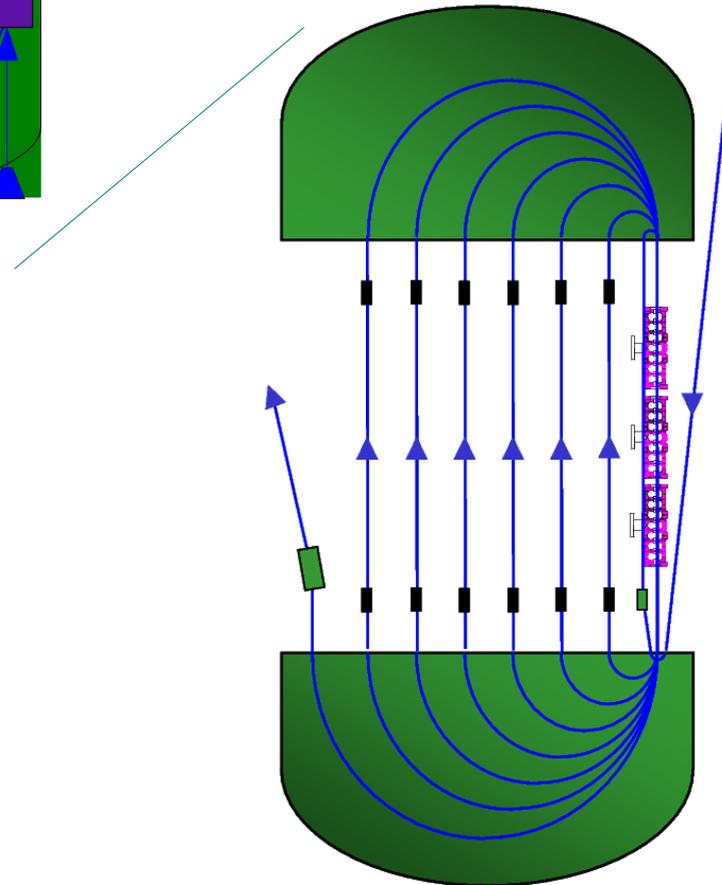
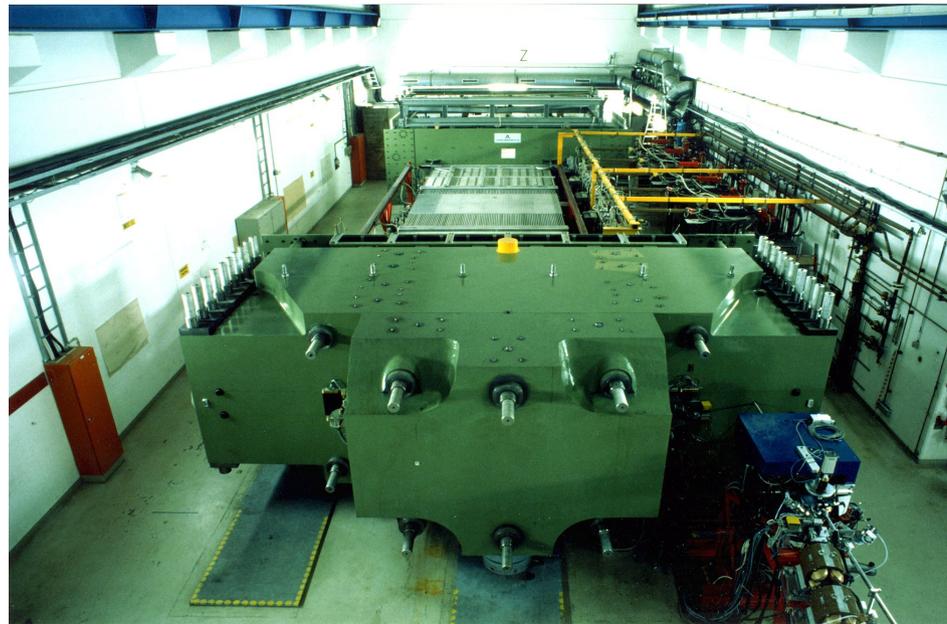


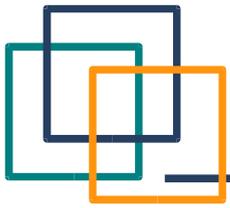


Accelerators



$$E = E_{inj} + N \cdot \Delta E$$



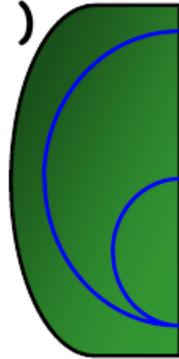
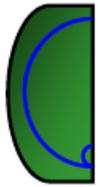


Accelerators

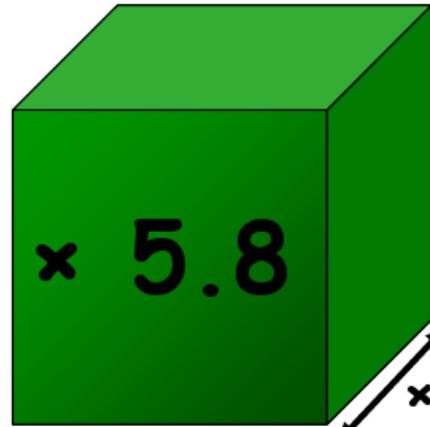
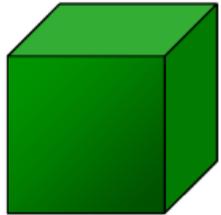
$E=855\text{MeV}$

$E=1500\text{MeV}$

($B = 1.28\text{ T} = \text{const.}$)



$\times 1.8$



$\times 1.8$

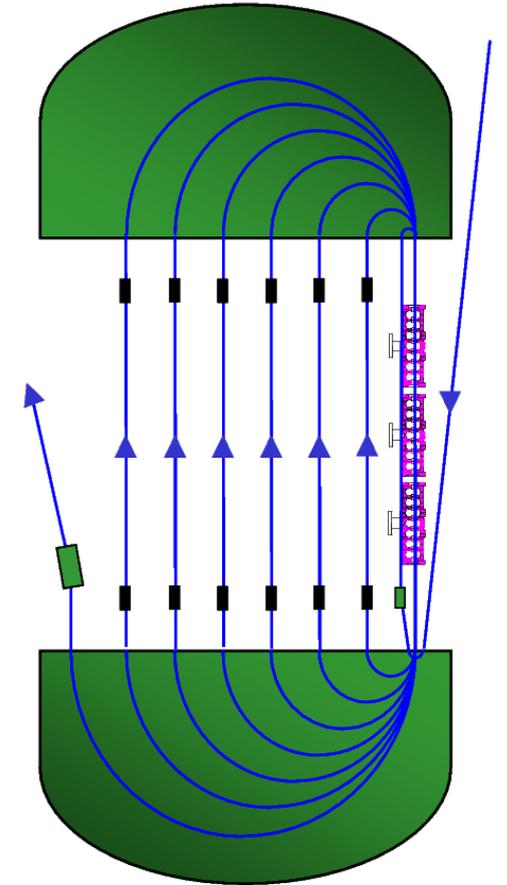
$\times 5.8$

$\times 1.8$

$\times 1.8$

~~2000t~~

450t



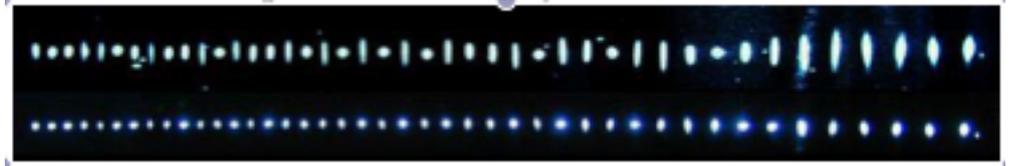
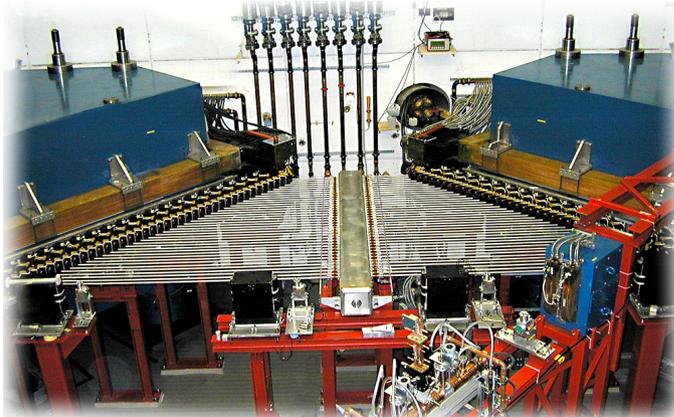
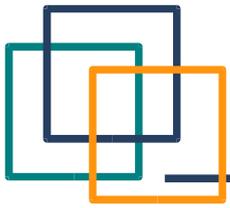
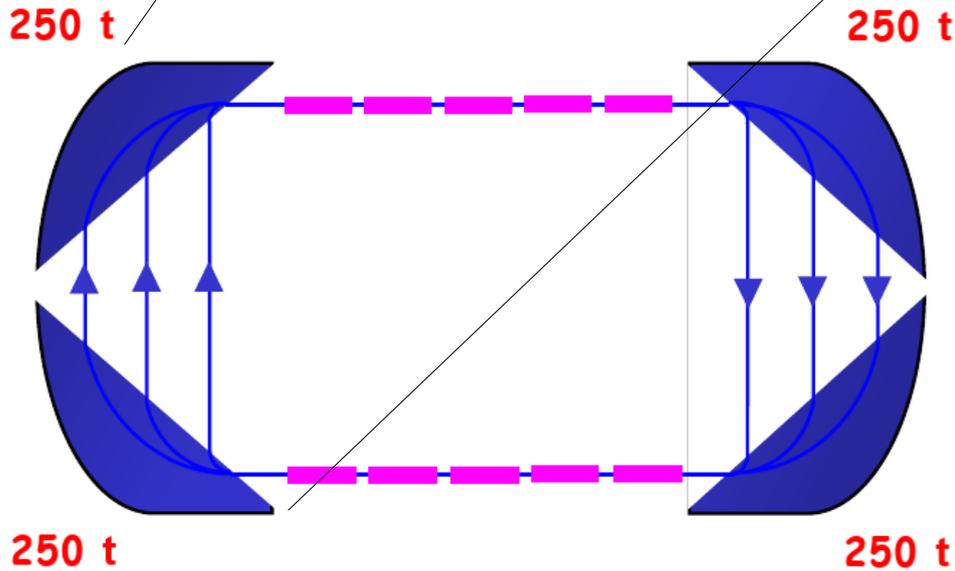
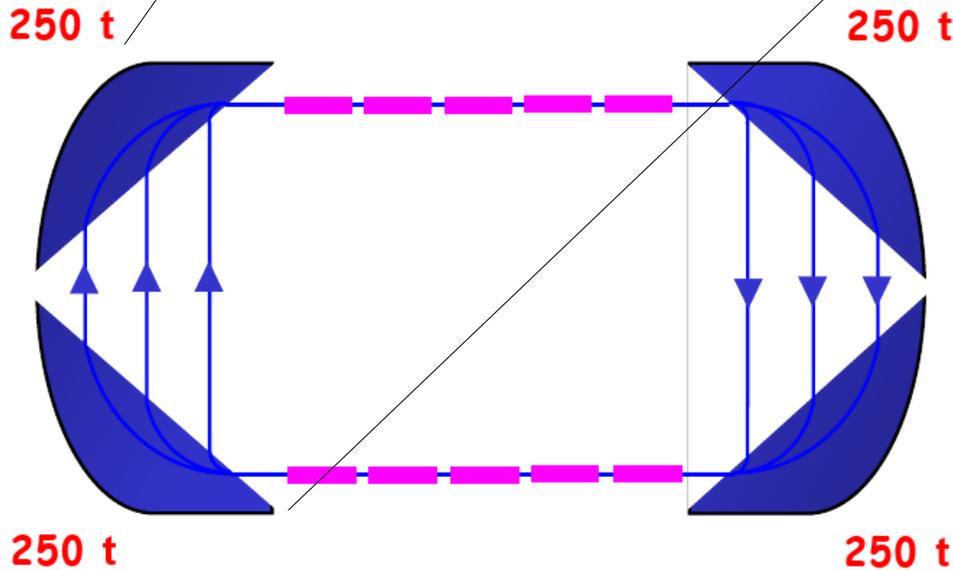
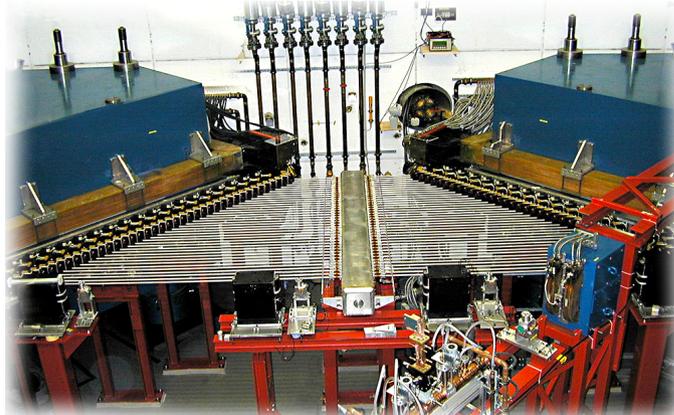
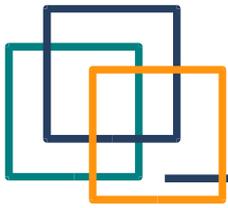


Fig. 4: Synchrotron radiation fan with 43 beam spots from dipole 2. Upper row: before matching / Lower row: after optimisation of matching

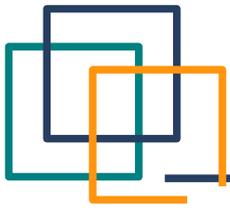


43 turns, 855MeV → 1,5GeV

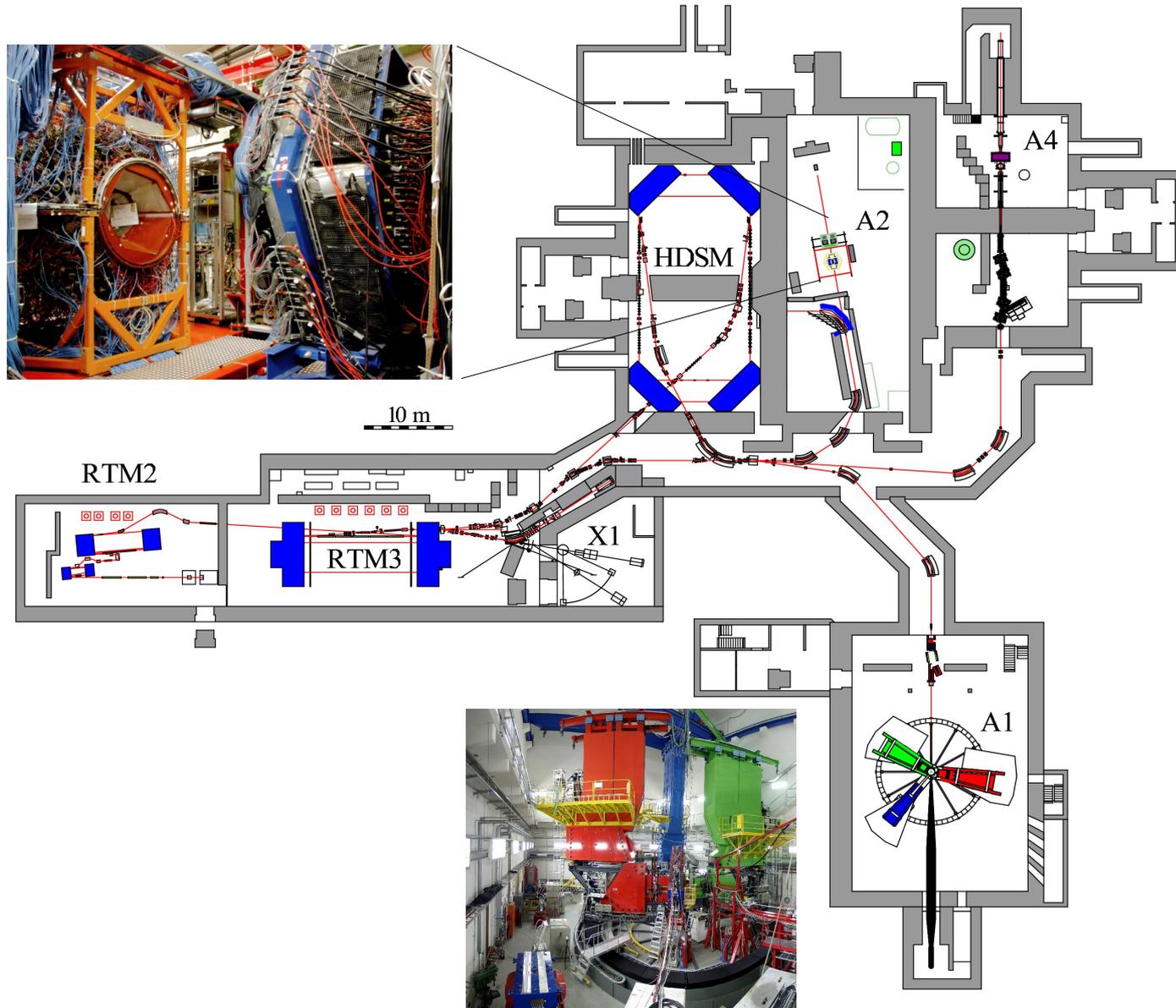


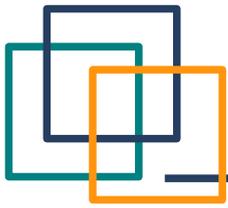
		RTM 3	HDSM
General			
$E_{inj.}$	MeV	180.2	855.3
$E_{extr.}$	MeV	855.3	1508.4
turns	#	90	43
power consumption	kW	650	1400
RF system			Linac 1 Linac 2
linac amplitude	MV	7.80	9.05 9.30
energy gain / turn	MeV	7.50	16.7 – 14.0
frequency	GHz	2.4495	4.8990 2.4495
sections/klystrons	#	5/5	8/4 ^(*) 5/5
electrical linac length	m	5×1.77	8×1.07 5×2.02
shunt-impedance	MΩ/m	72	80 72
dissipated power	kW/m	10.8	14.0 11.8
beam load@100μA	kW	67.5	37.0 28.4
Magnet system			
min. / max. field	T	1.2842	0.939 – 1.539
min. / max. gap	mm	100	85 – 140
min. / max. radius	m	0.47 – 2.22	2.23 – 4.60
weight	t	2×450	4×250
Beam parameters			
Energy width	keV	13	110 ^(**)
hor. emittance	nm rad	8	9 ^(**)
vert. emittance	nm rad	0.5	0.4 ^(**)

43 turns, 855MeV → 1,5GeV



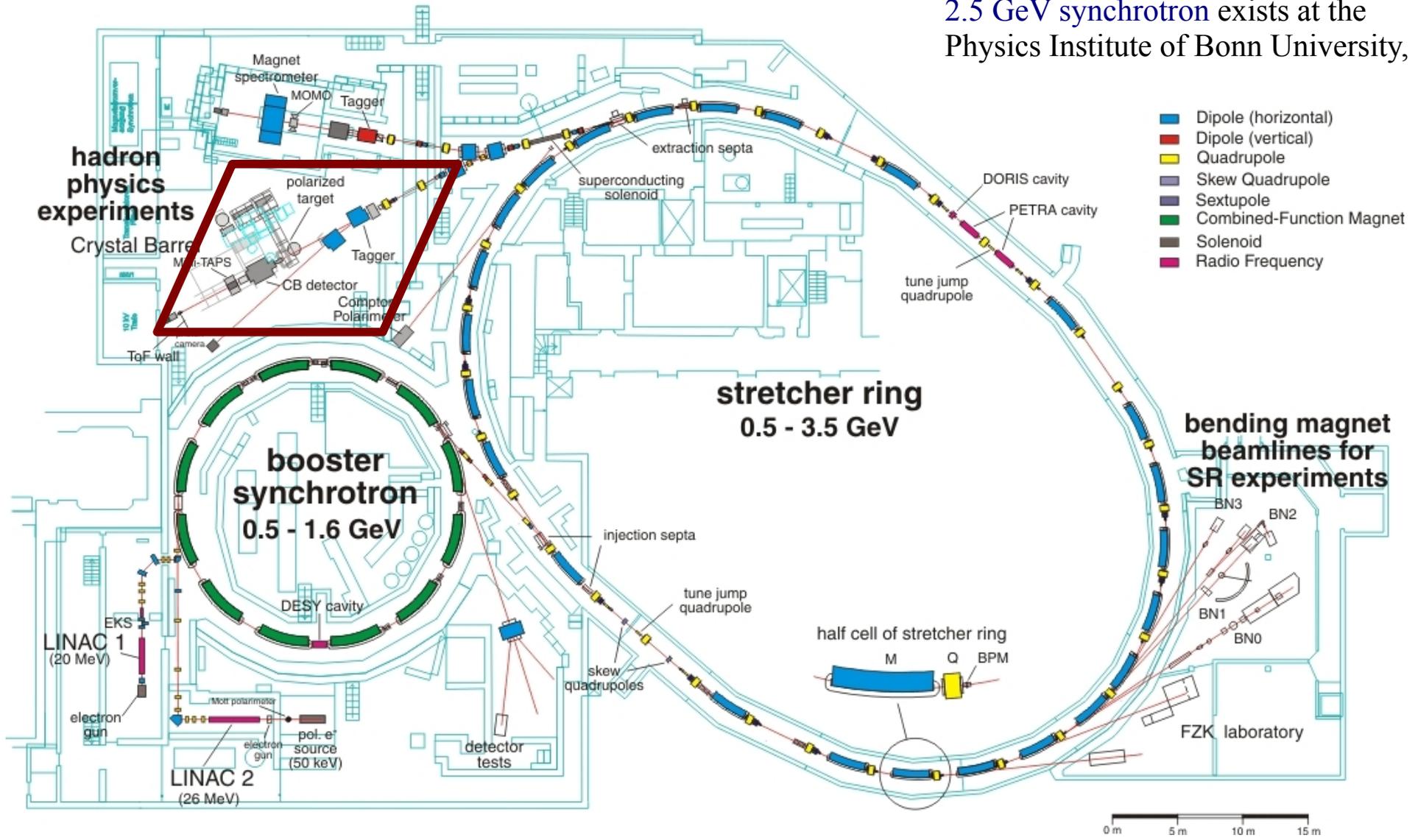
Detectors

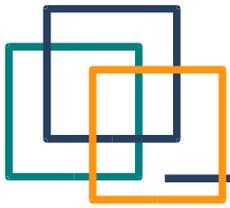




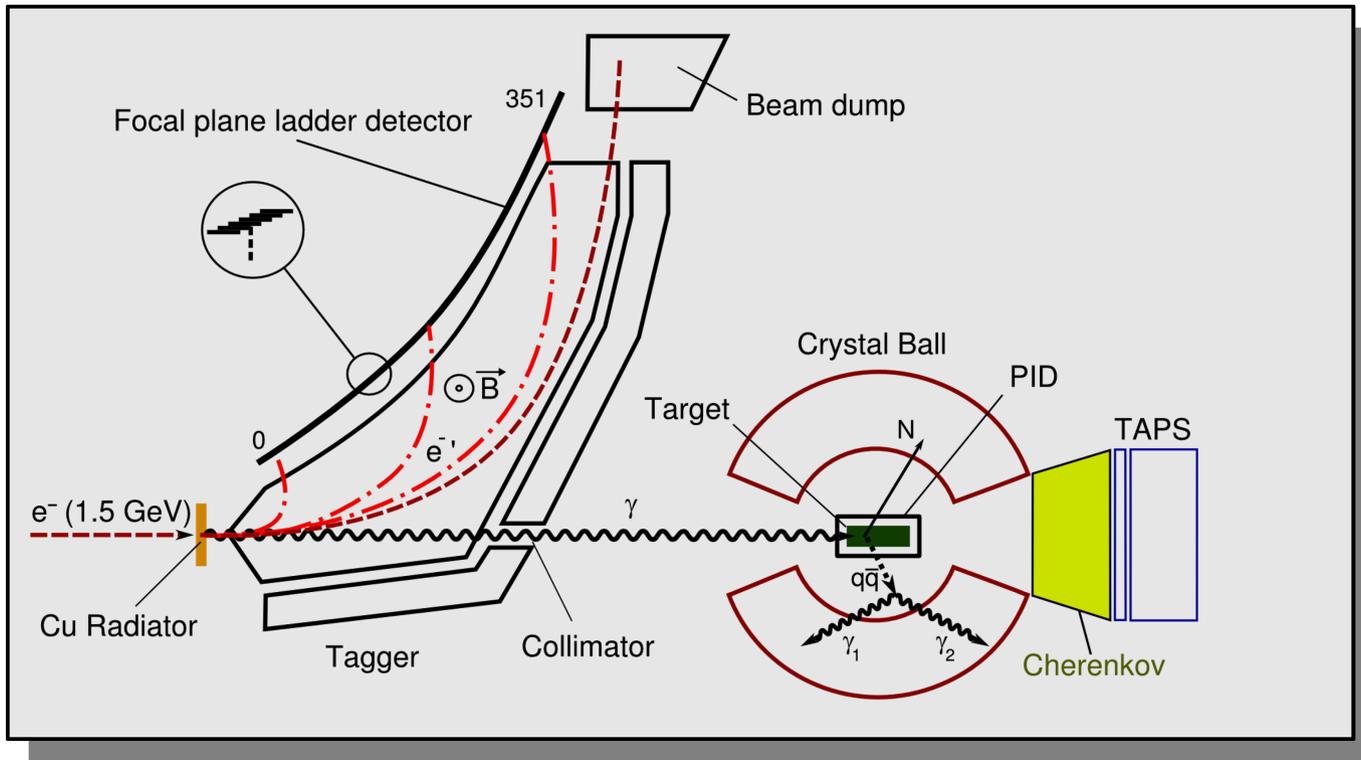
Electron Stretcher Accelerator (ELSA)

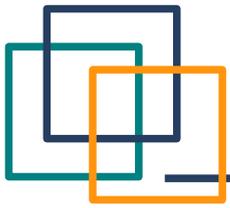
Since 1967 a pulsed 2.5 GeV synchrotron exists at the Physics Institute of Bonn University,





Detectors

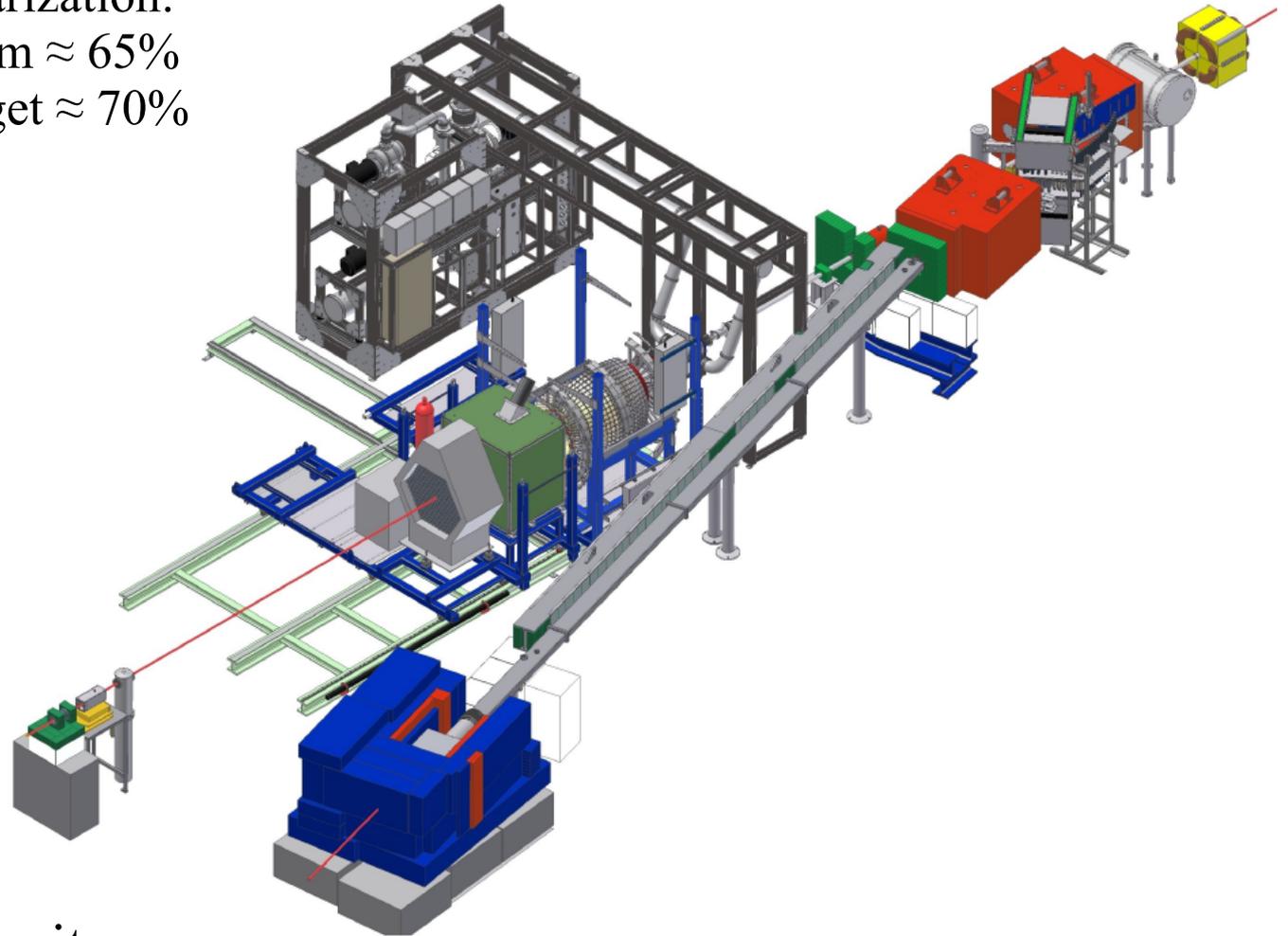


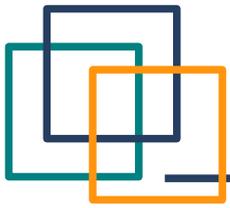


Crystal Barrel - TAPS

Electron beam
3.5GeV
Polarization:
Beam $\approx 65\%$
Target $\approx 70\%$

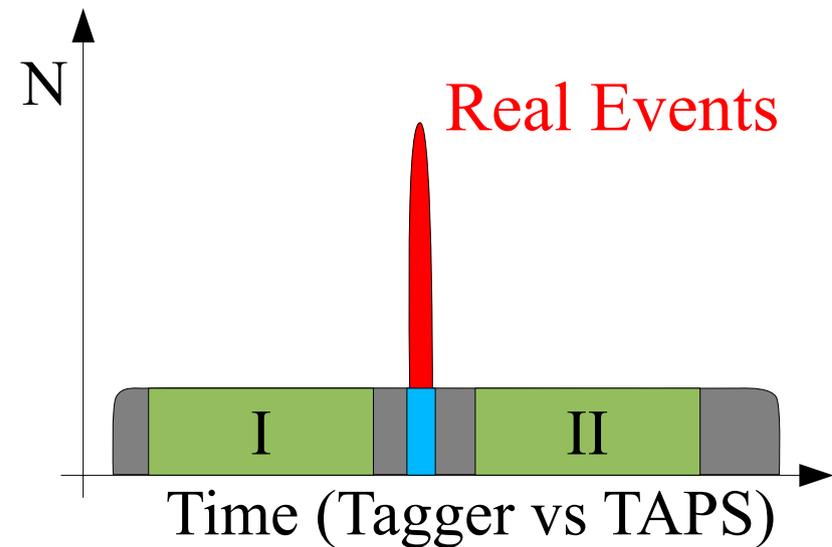
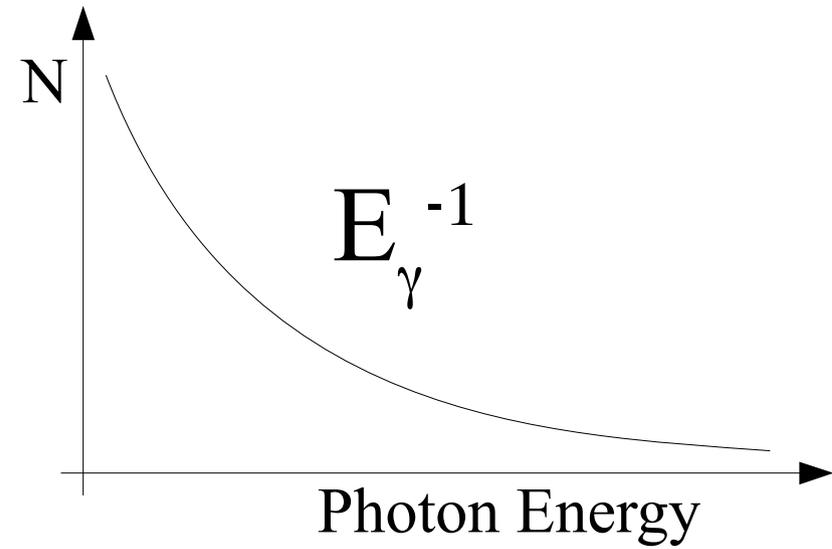
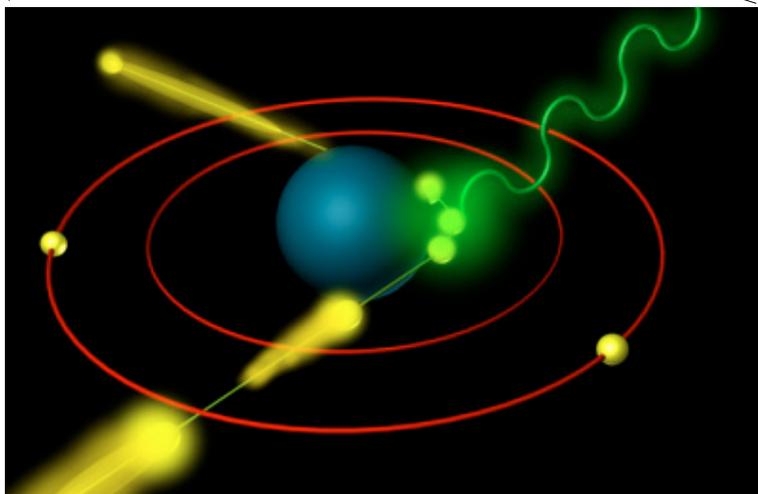
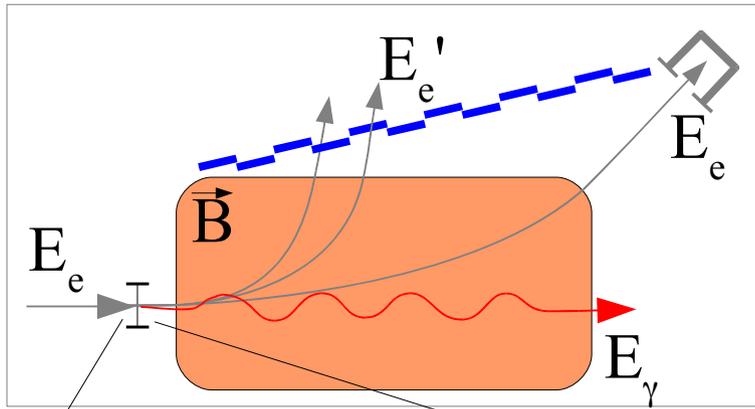
- Tagging System
- Polarized Target
- Crystal Barrel
- Forward Plug
- Mini TAPS
- Gas Cherenkov
- Beamdump
- Gamma Intensity Monitor

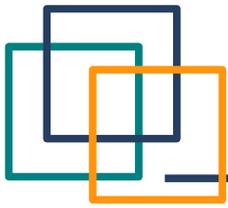




Tagger system

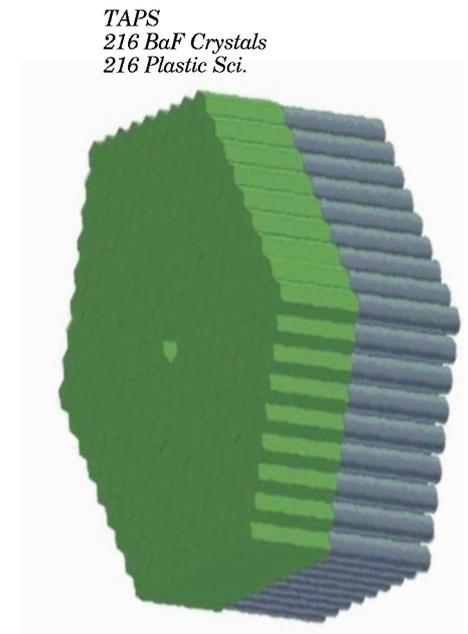
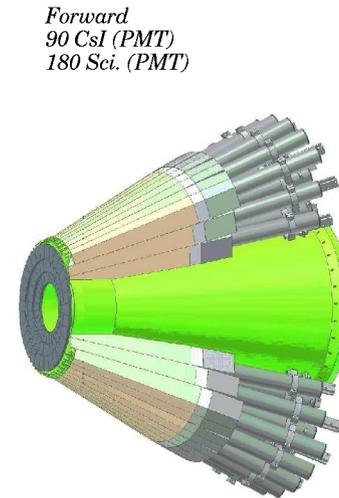
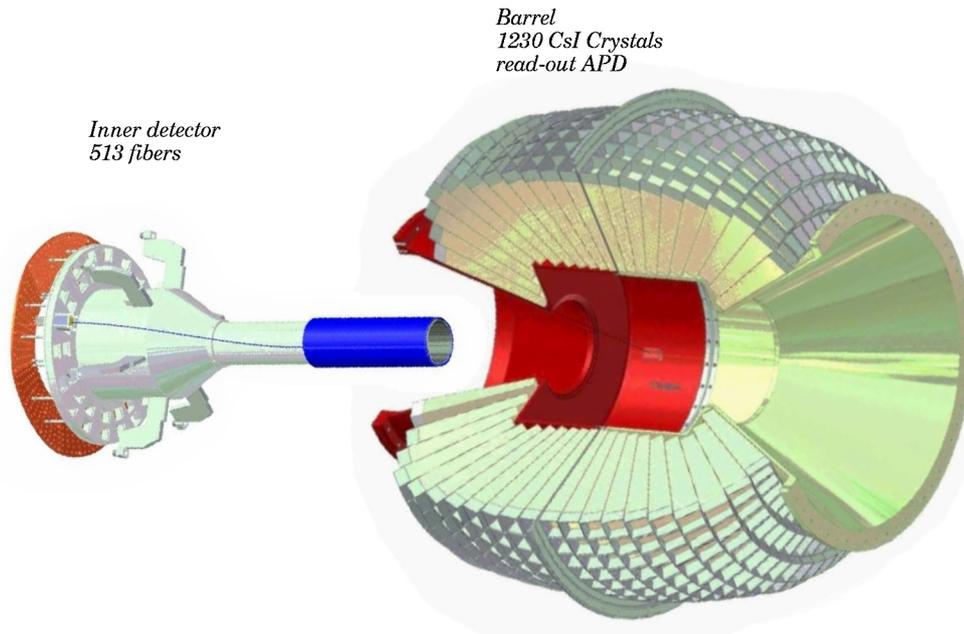
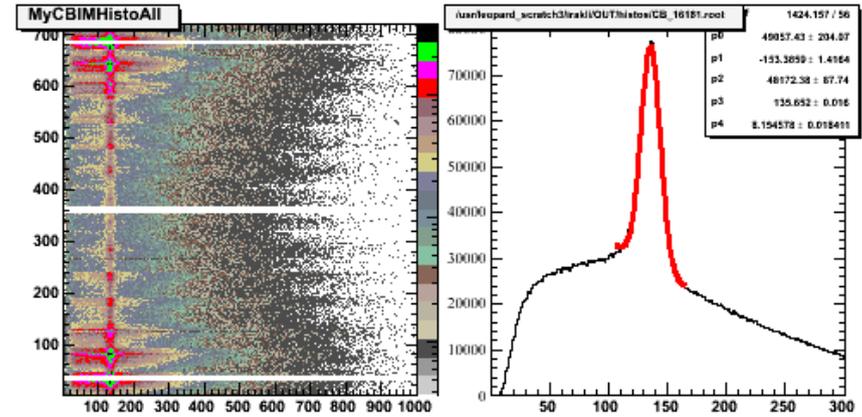
$$E_{\gamma} = E_e - E_e'$$





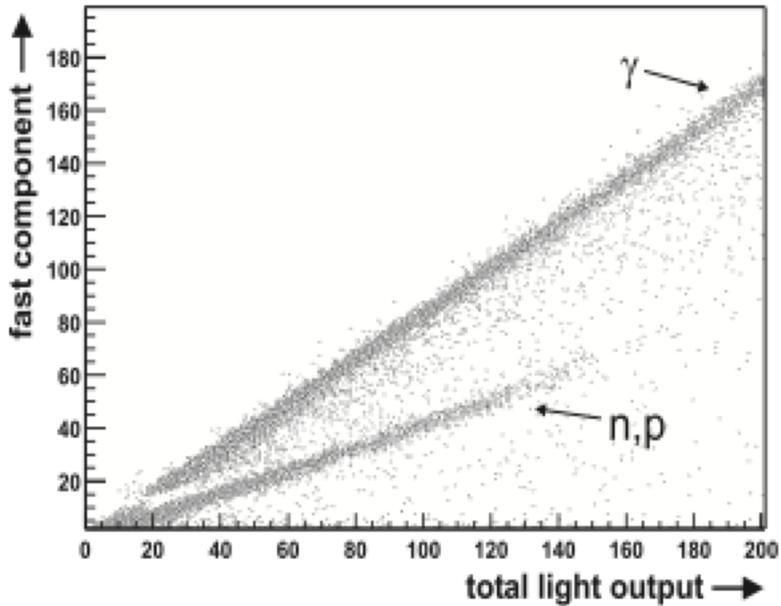
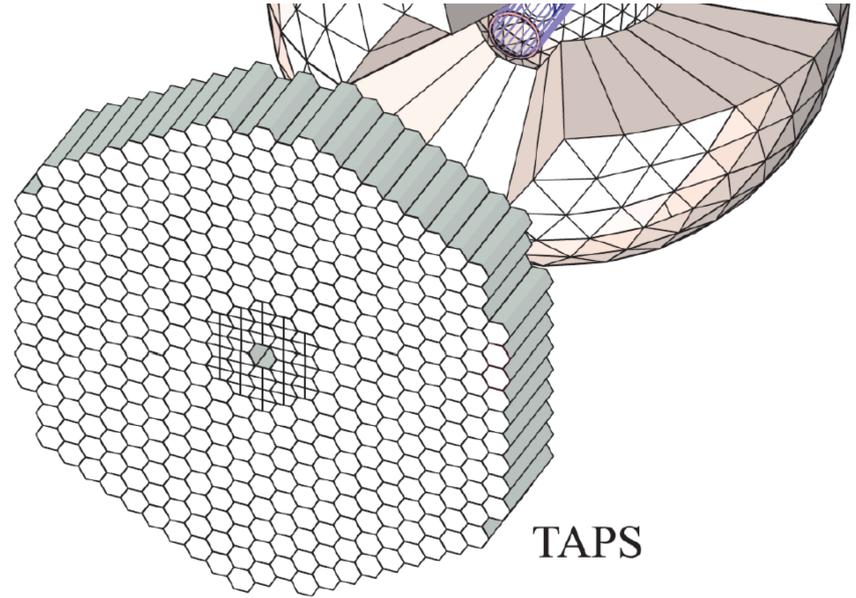
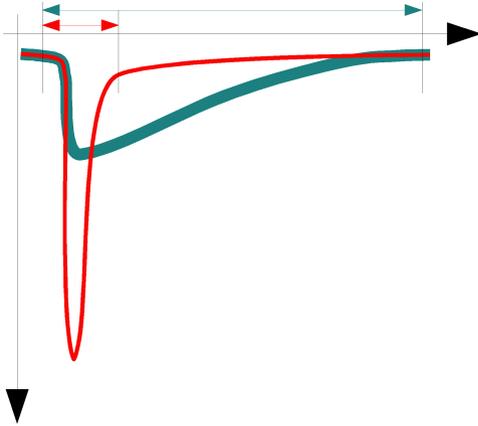
Crystal Ball (NaI)

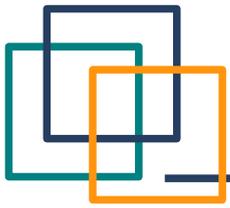
Crystal Barrel (CsI)
TAPS (BaF)



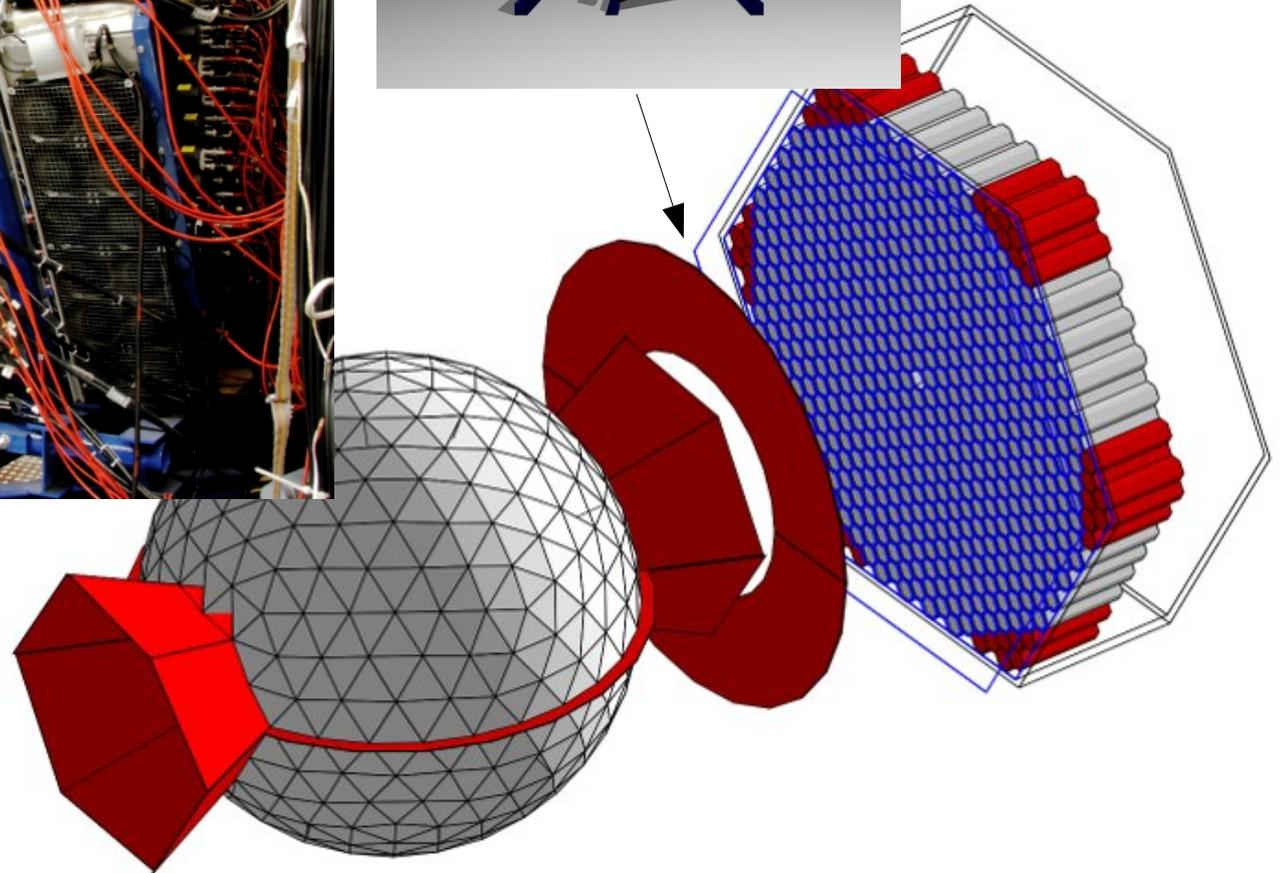
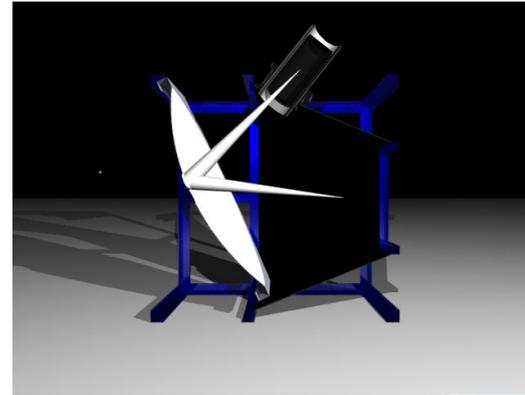
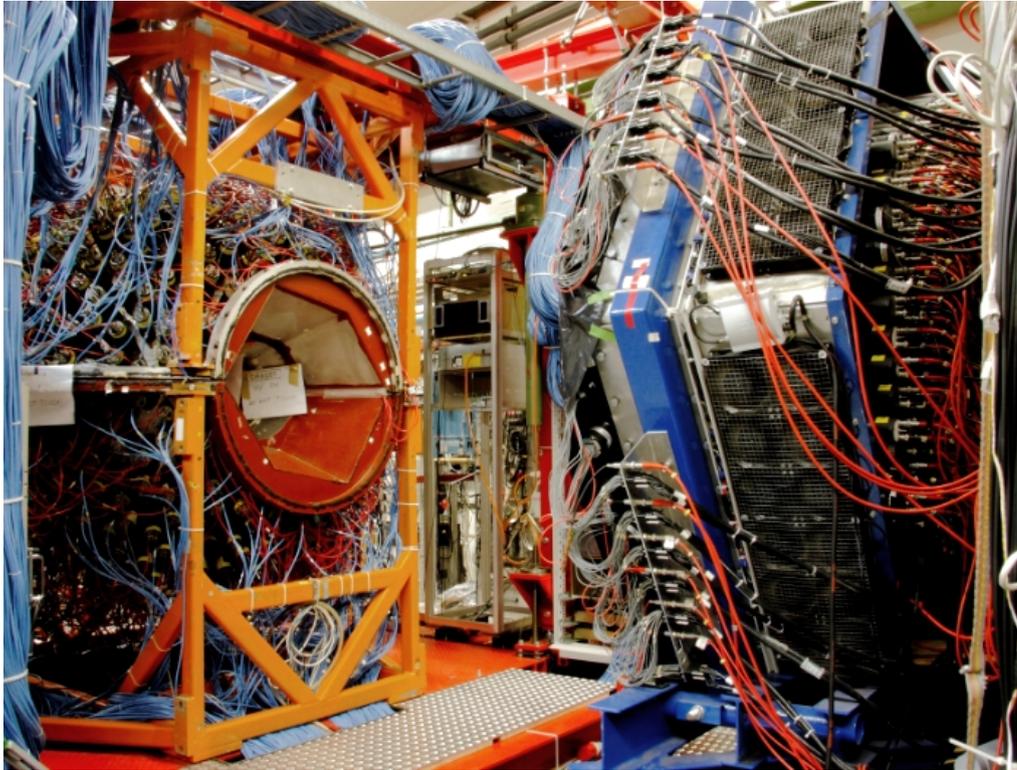


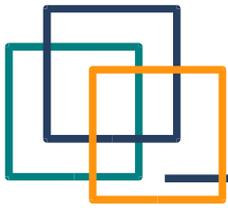
Two Arms Photon Spectrometer - TAPS





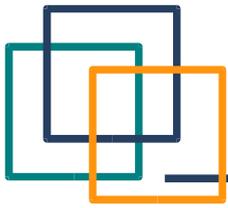
Chereknov Veto





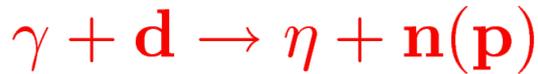
Group of Prof. B. Krusche
University of Basel

- Neutron Anomaly (Bonn and Mainz)
I.Jaeglé, D.Werthmueller and L.Witthauer
- Helicity Asymmetry (Mainz)
F.Zehr
- Coherent Eta production off light nuclei
F.Pheron and Y.Maghrbi
- Coherent π^0 η photoproduction off Carbon

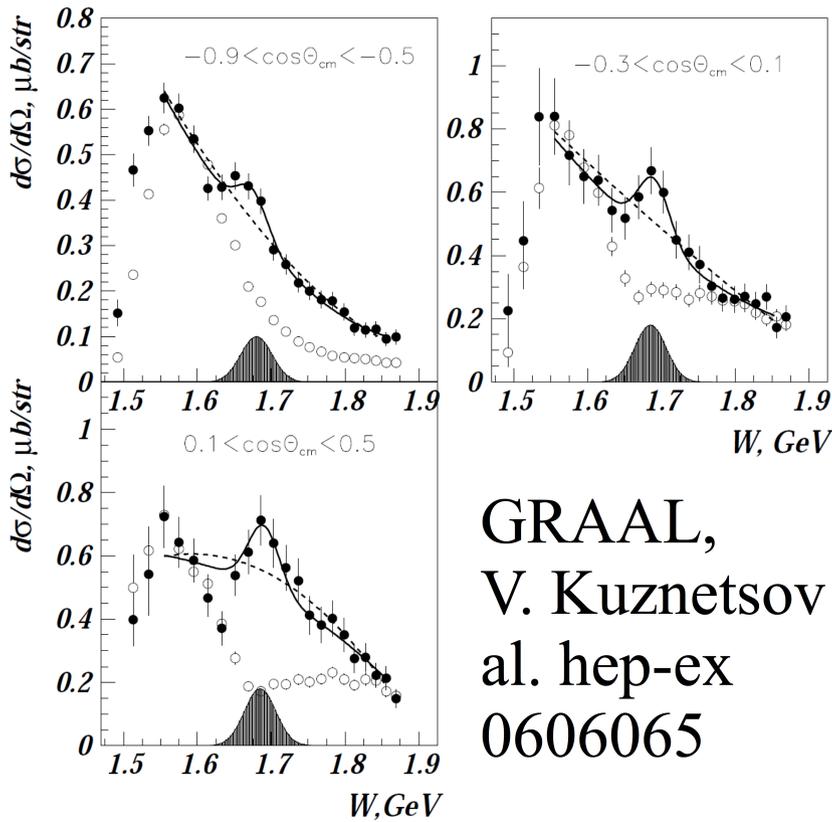


Neutron Anomaly

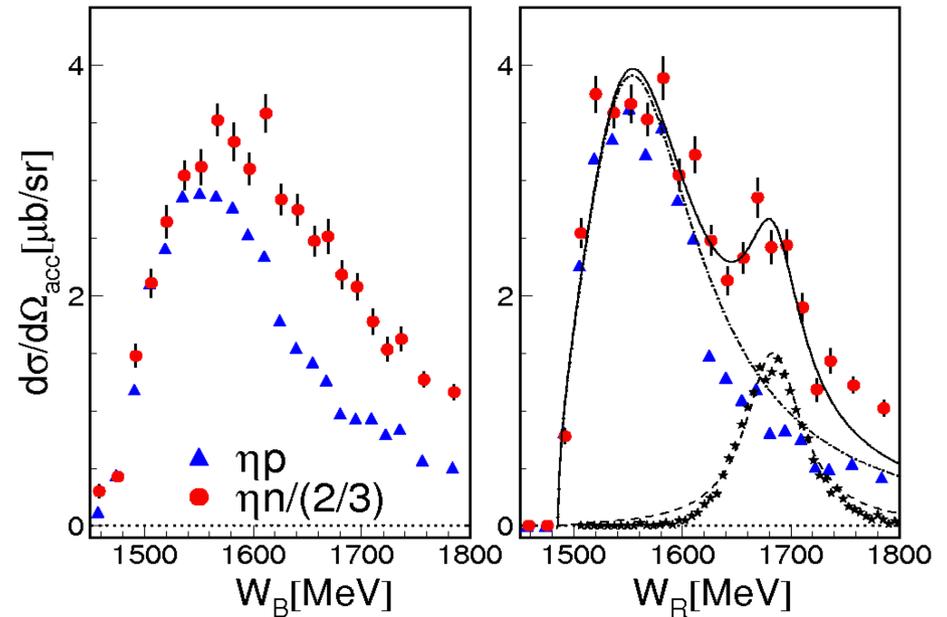
- CBELSA/TAPS collaboration,
- GRAAL collaboration,
- LNS-Sendai: **narrow structure** in the cross section:



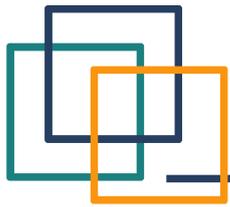
$W = 1683 \text{ MeV}$
 $\Gamma < 60 \pm 20 \text{ MeV}$



GRAAL,
 V. Kuznetsov et
 al. hep-ex
 0606065

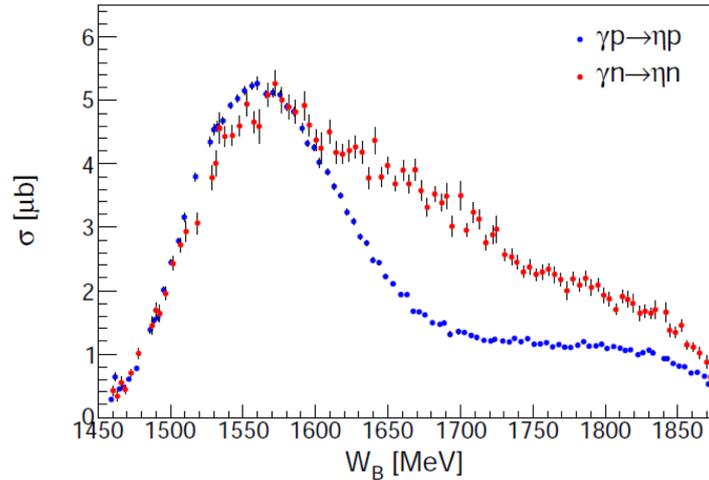


ELSA, I. Jaeglé et al.,
 Phys. Rev. Lett. 100 (2008) 252002

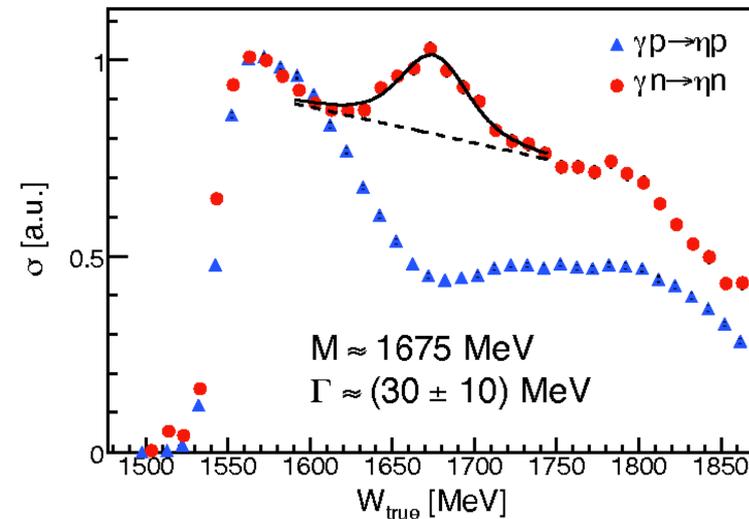
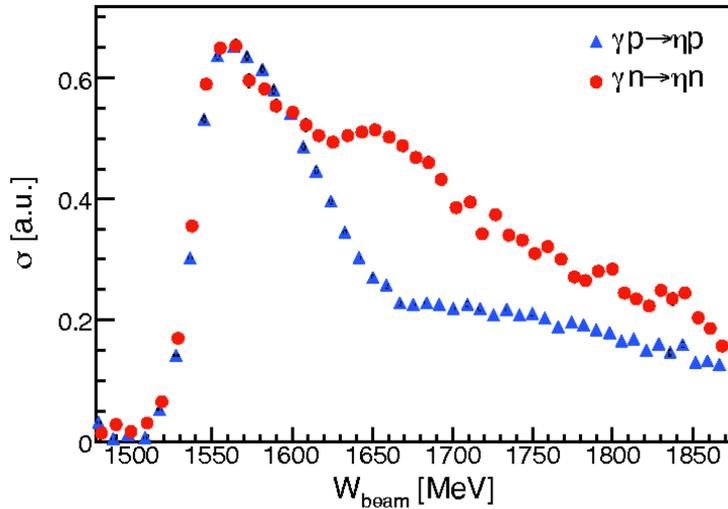
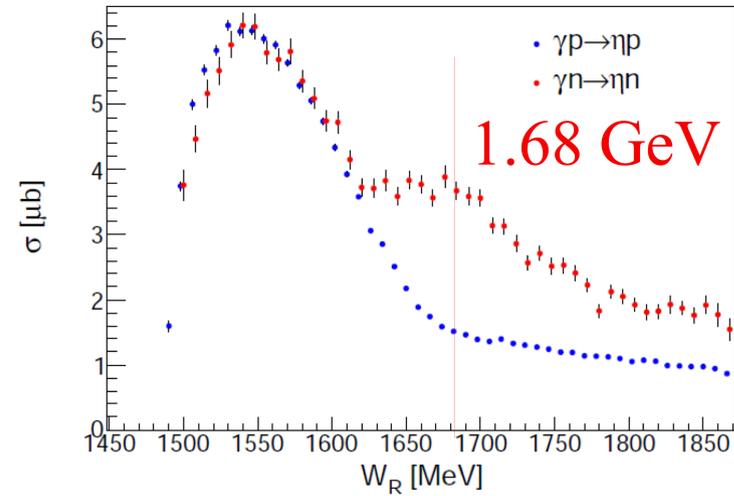


Defolding Fermi Motion

$$W_B^2 = (\mathbf{P}_\gamma + \mathbf{P}_{N,i})^2 = 2E_\gamma m_N + m_N^2$$

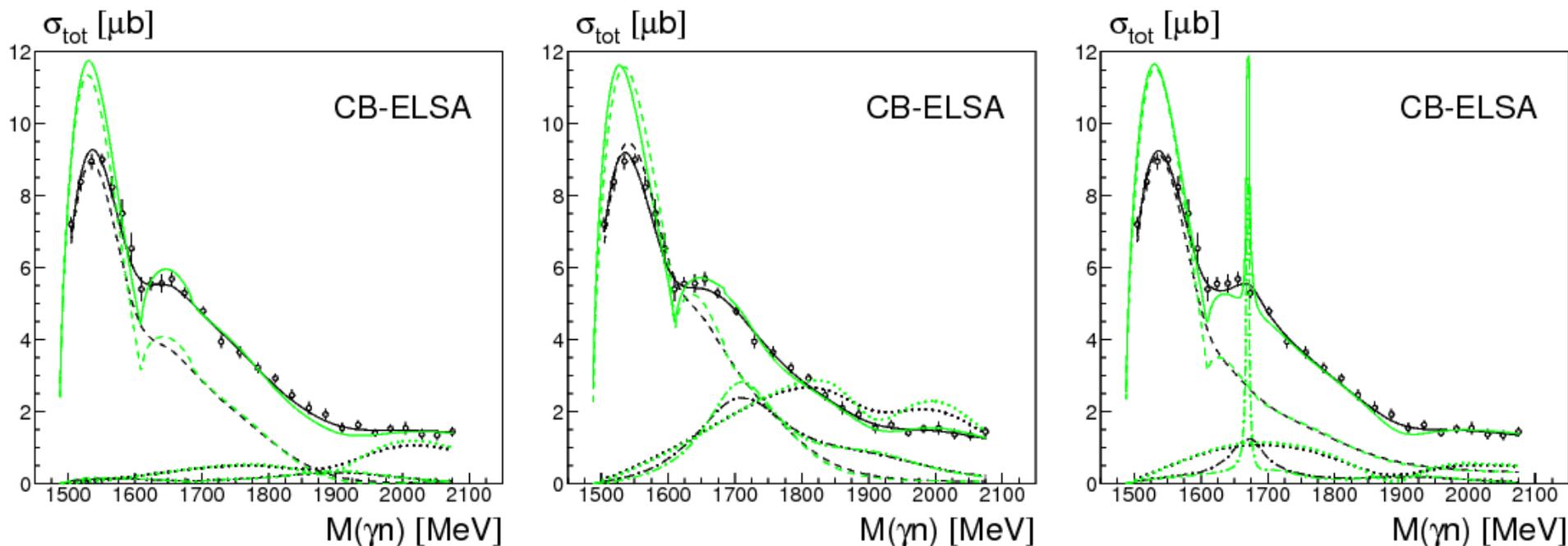


$$W_R^2 = (\mathbf{P}_\eta + \mathbf{P}_{N,f})^2$$



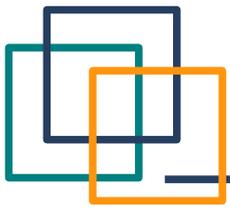
HE
L. Witthauer

LD₂
(D. Werthmüller)



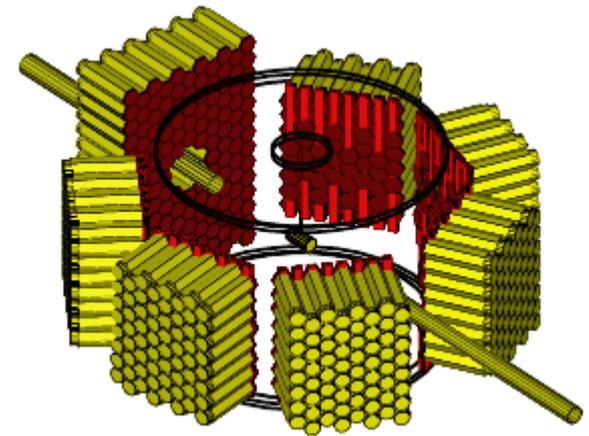
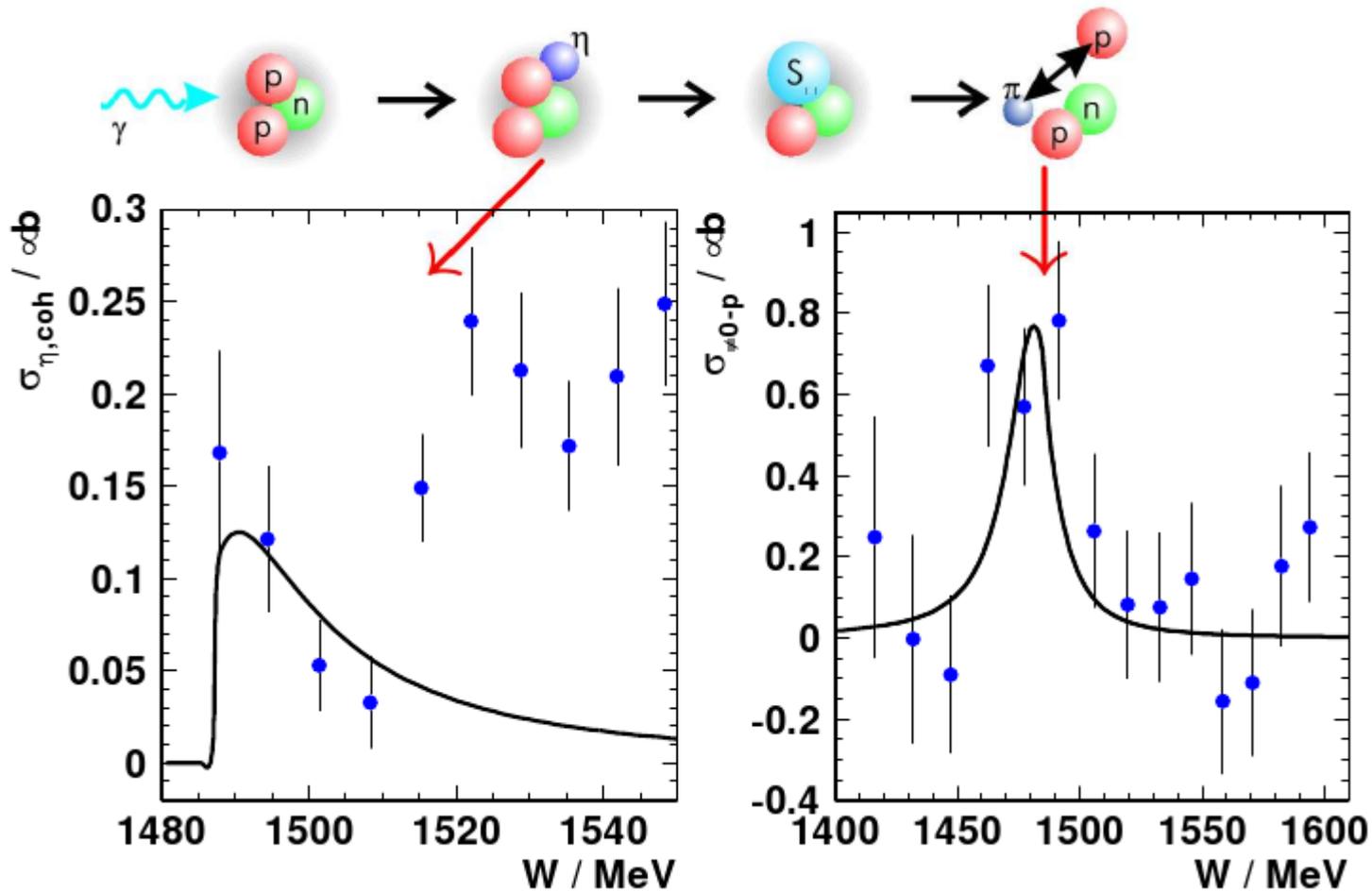
Different scenarios to reproduce 'bump' structure:

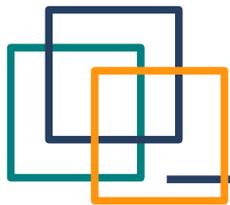
- left: Interference in S11-sector: adjusting phases etc.
- middle: Introduction of conventional (broad) P11 resonance
- right: Introduction of very narrow P11 resonance



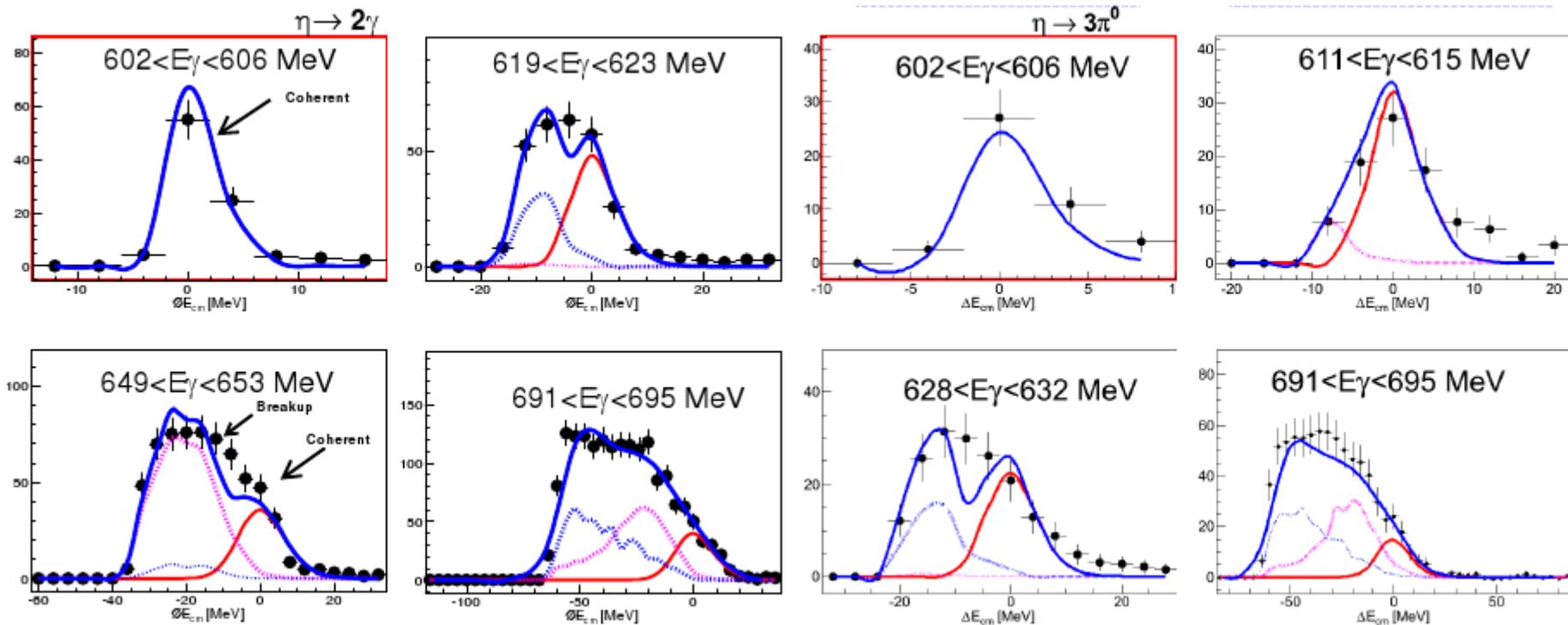
η – mesic ^3He

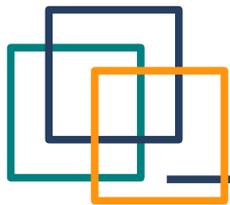
PhD Work of Francis Pheroncvcv



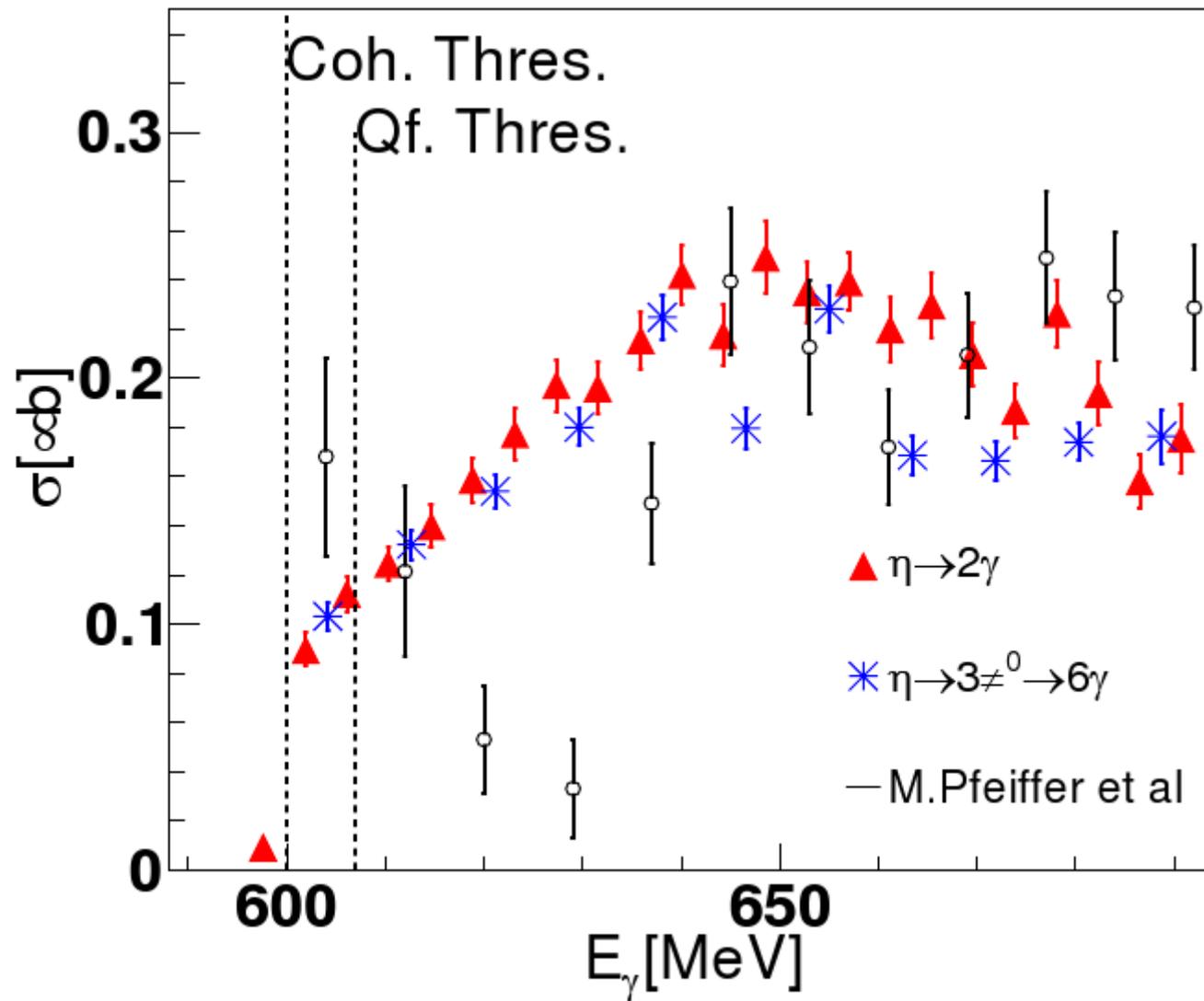


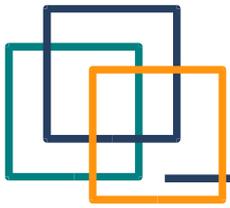
η – mesic ${}^3\text{He}$



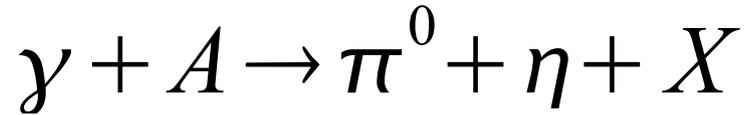


η – mesic ${}^3\text{He}$



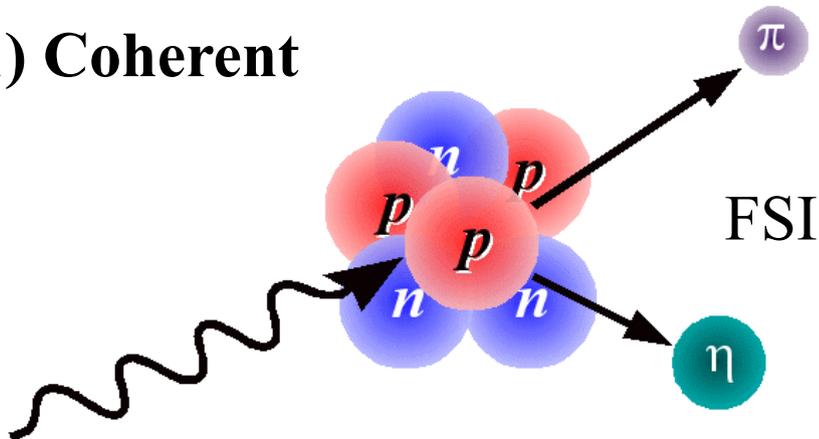


Coherent production

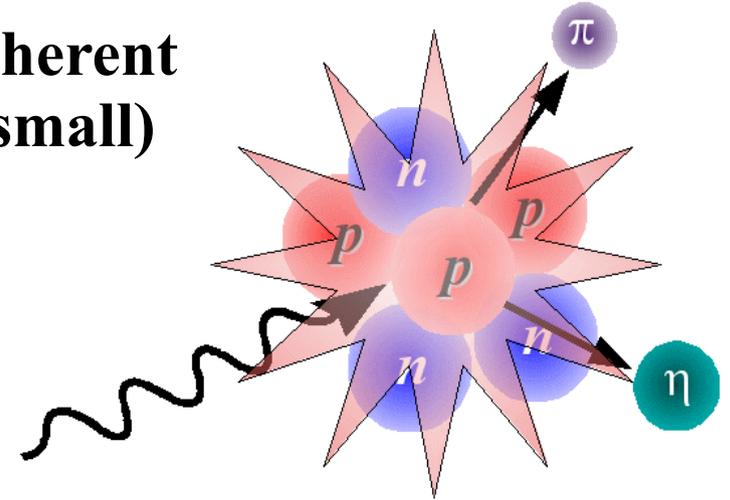


Mechanisms for
Coherent $\pi^0\eta$ production

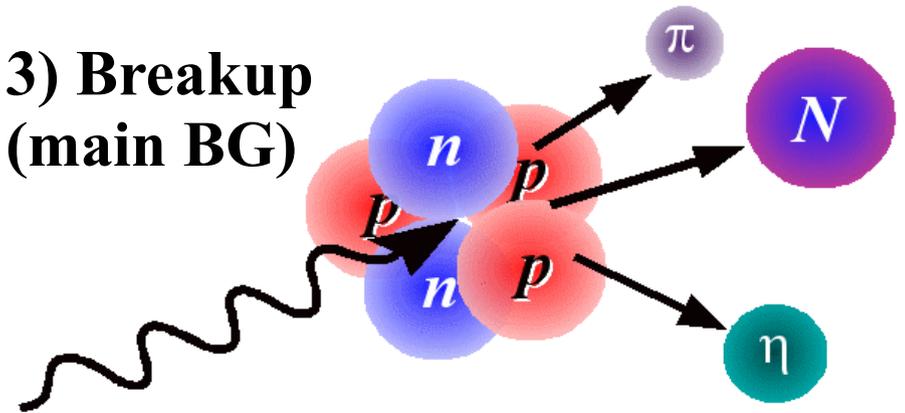
1) Coherent

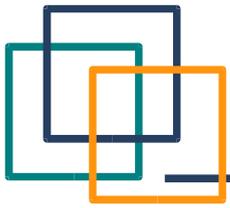


2) Incoherent
(XS is small)

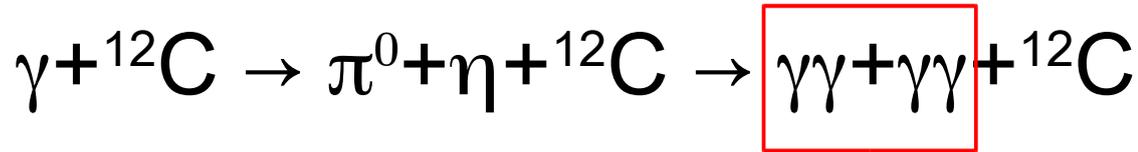


3) Breakup
(main BG)

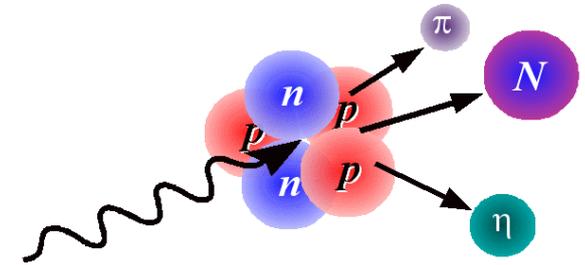
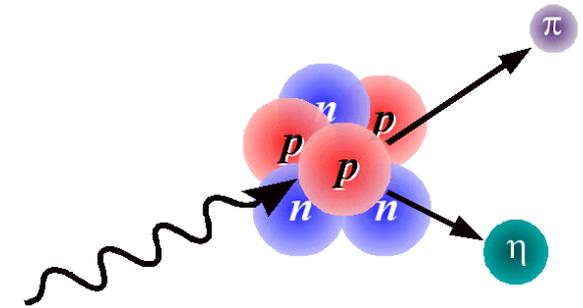




Simulations

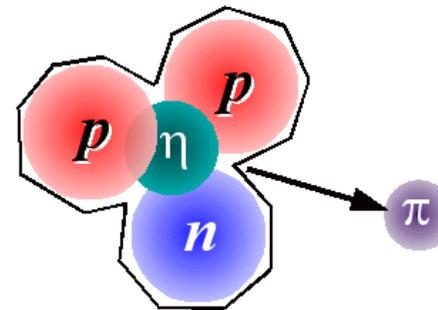
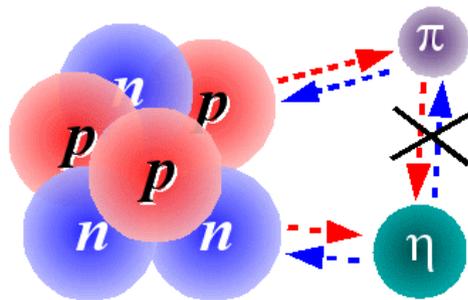
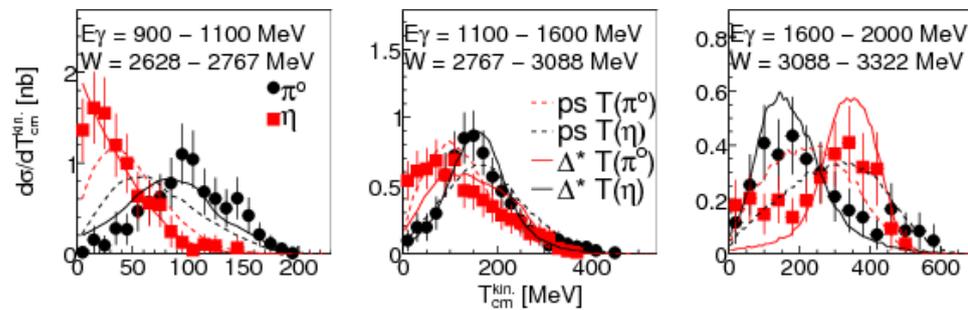


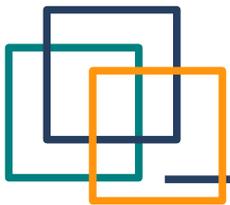
- $\gamma + {}^{12}\text{C} \rightarrow \Delta + \eta \rightarrow \pi^0 + \eta + {}^{12}\text{C}$
- $\gamma + {}^{12}\text{C} \rightarrow \Delta + \eta \rightarrow \pi^0 + \eta + {}^{11}\text{C} + n$
- $\gamma + {}^{12}\text{C} \rightarrow \Delta + \eta \rightarrow \pi^0 + \eta + {}^{11}\text{B} + p$





• $\gamma + d \rightarrow \Delta + \eta \rightarrow \pi^0 + \eta + d$

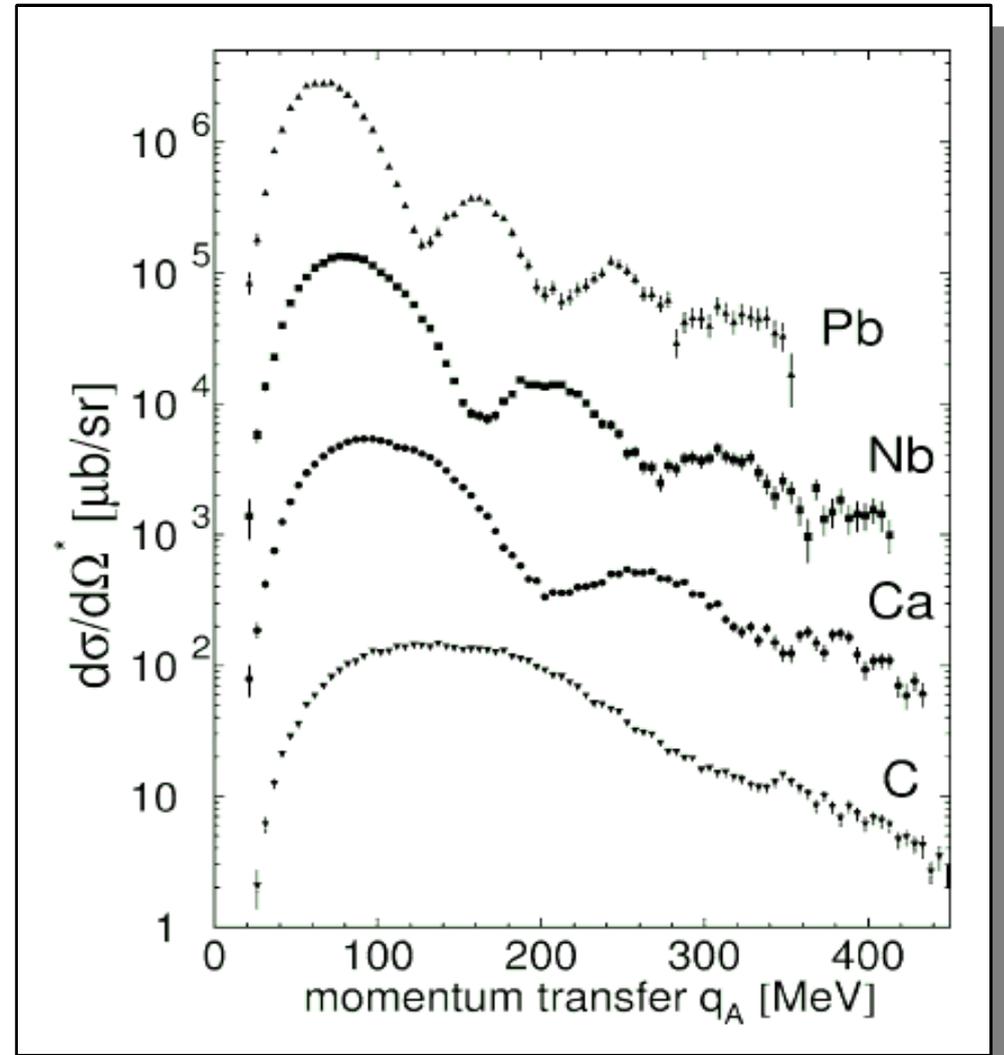
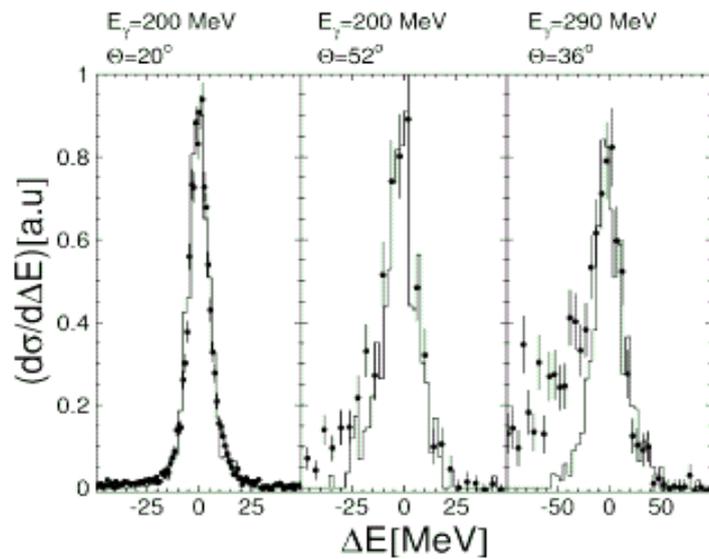


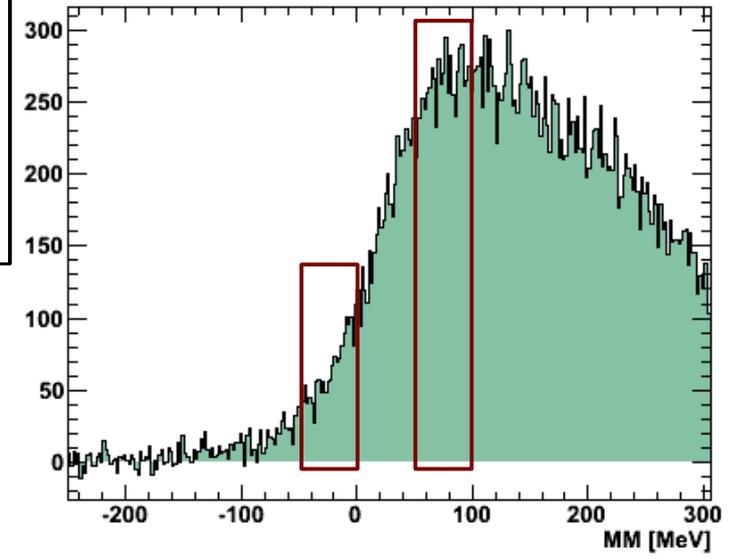
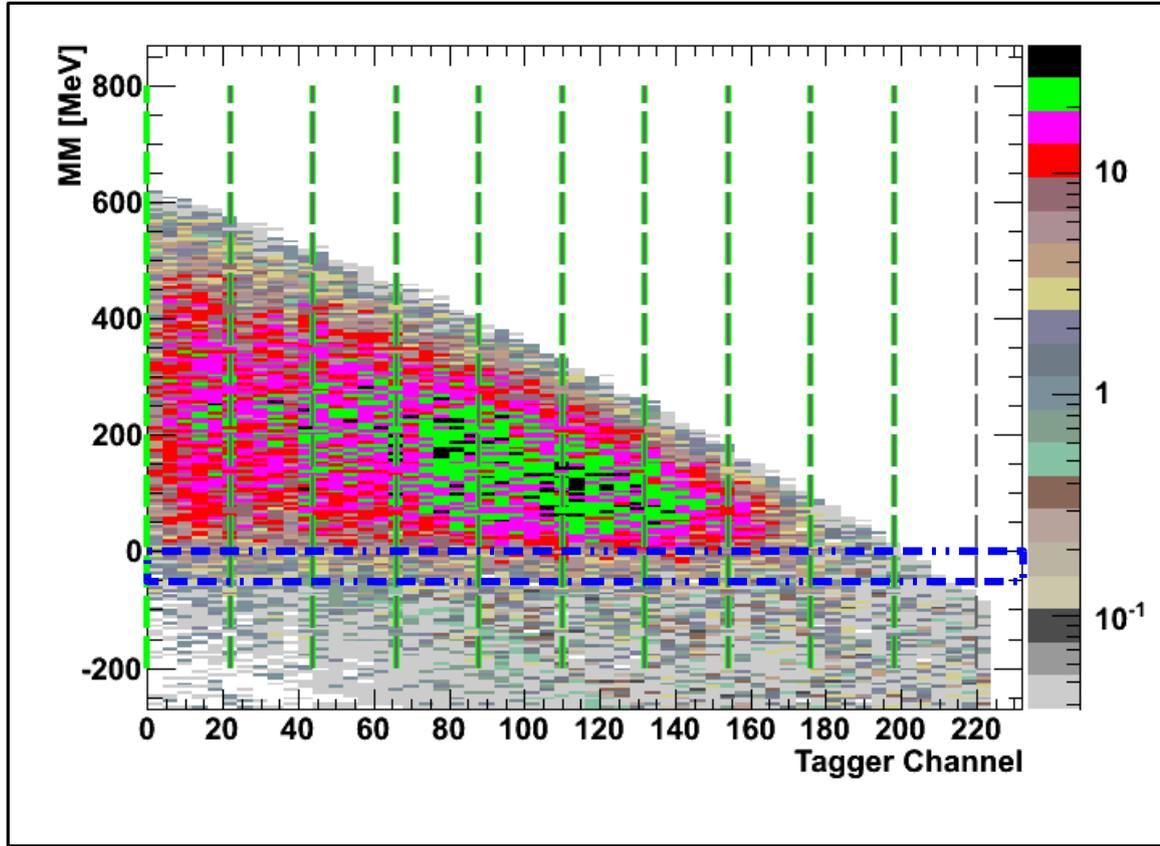
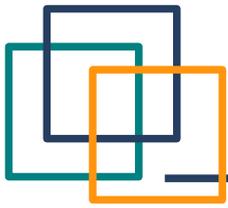


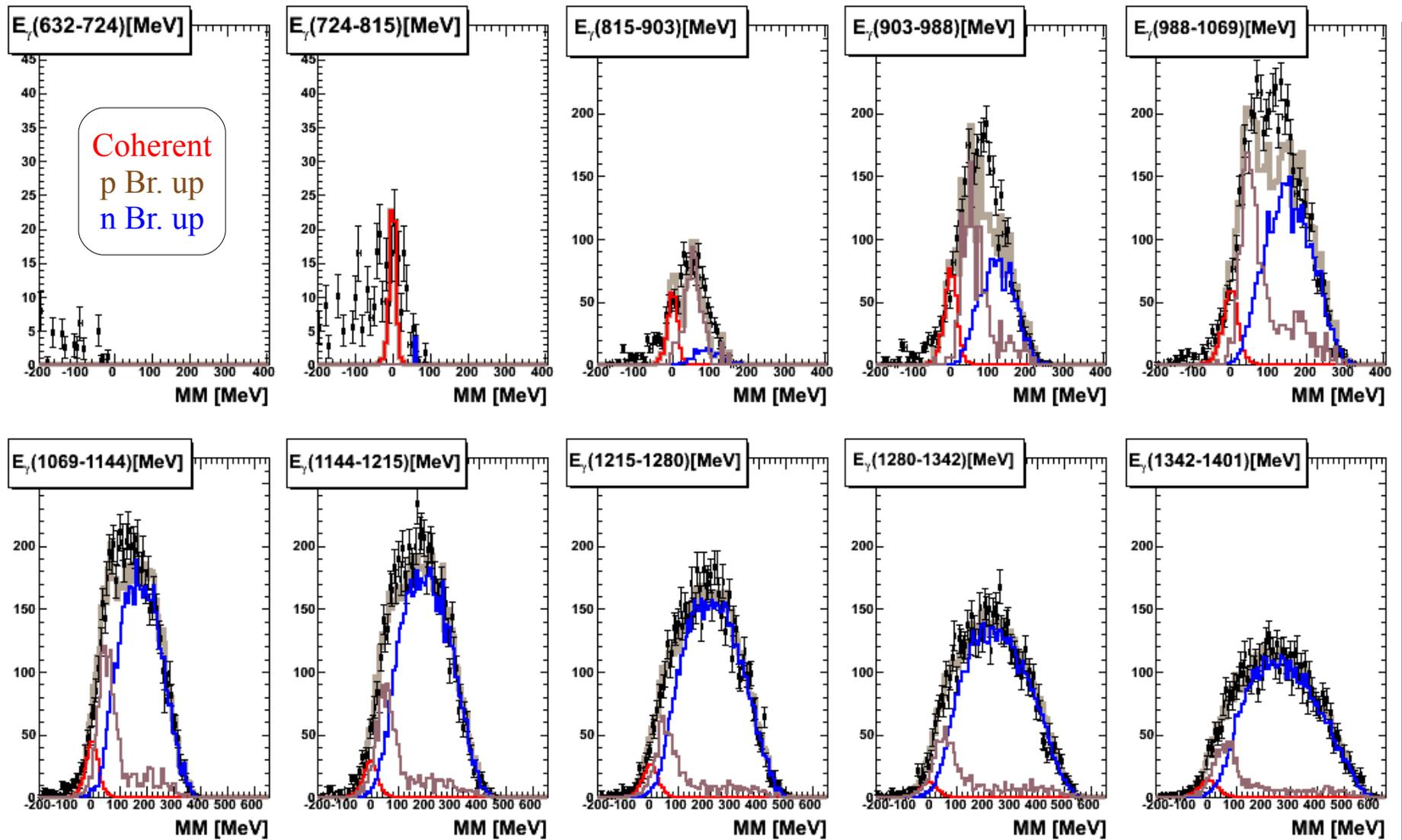
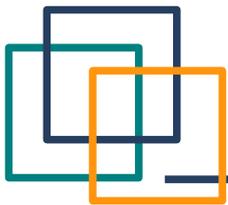
Physics Letters B 526 (2002)

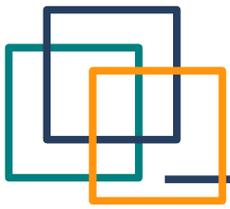
Coherent π^0 -photoproduction from atomic nuclei

B. Krusche, et al.

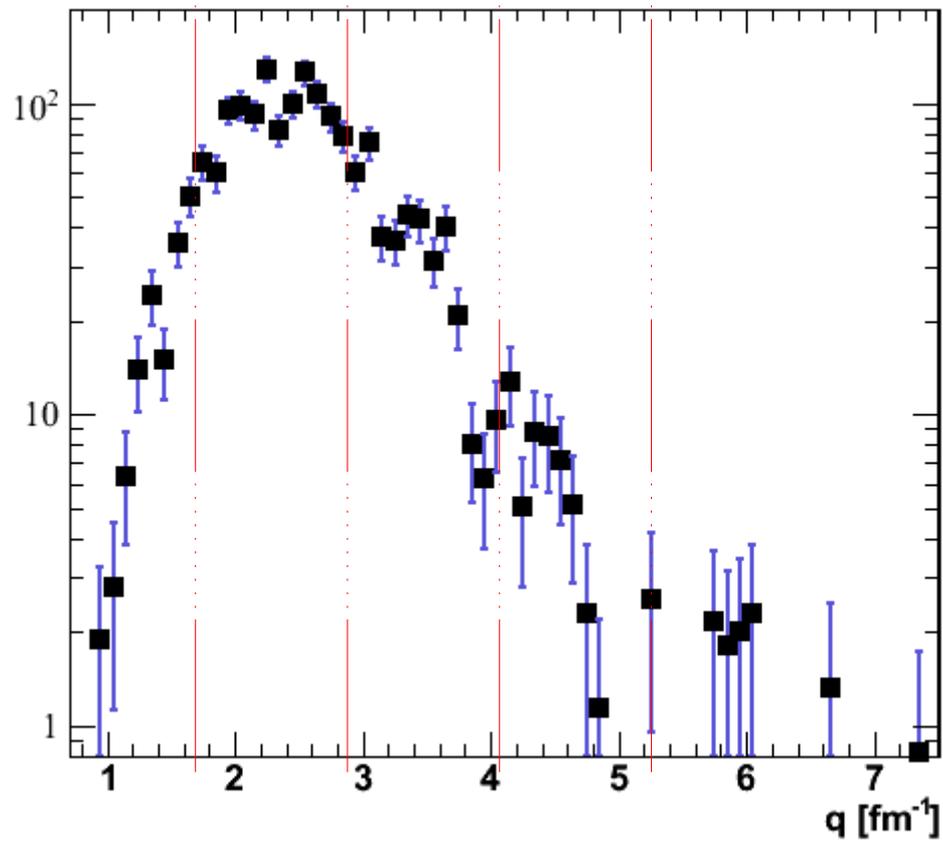


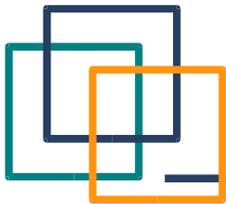






Defractive min. 1) 1.66 fm 2) 2.85 fm 3) 4.03 fm 4) 5.2 fm

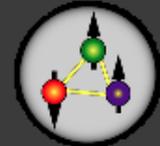




4.5.2010



Experimental Nuclear and Particle Physics Krusche Group



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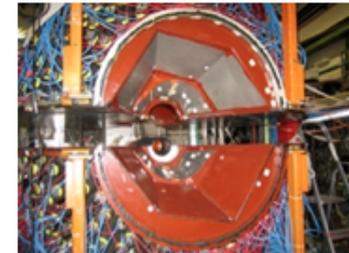
contact

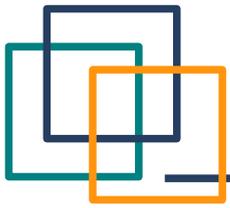
links

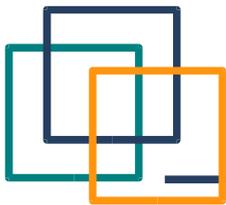
Welcome to the website of the Krusche Group at the Department of Physics, University of Basel!

The main research topic of our group is the structure of hadrons (nucleons and mesons) which reflects the properties of the strong interaction. This interaction - one of the four fundamental forces of nature - is responsible for binding together protons and neutrons to form atomic nuclei. But it also dictates the internal structure of protons and neutrons, which - like all hadrons - are composed of elementary particles called quarks. Unlike any other composite system, most of the mass of hadrons is not related to the mass of its building blocks - the quarks - but generated by their interaction. As an example, the sum of the masses of the three quarks forming a proton, contributes only about 0.6% - 1.8% to the total proton mass. More than 98% of the mass of ordinary matter arise from dynamical effects of the strong interaction.

At present, most of our experiments are done in the framework of international collaborations ([Crystal Ball at MAMI](#), [Crystal Barrel at ELSA](#) , [TAPS](#)) at the electron accelerators [MAMI](#) and [ELSA](#) . Our group is furthermore involved in the [PANDA-project](#) at GSI, where from the second half of this decade an Anti-Proton beam will be available for hadron structure experiments.







16 Polarization Observables in Meson Photoproduction

Photon		Target	Recoil	Target-Recoil
		$x \quad y \quad z$	$x' \quad y' \quad z'$	$x' \quad x' \quad z' \quad z'$ $x \quad z \quad x \quad z$
unpolarized	σ	$0 \quad T \quad 0$	$0 \quad P \quad 0$	$T_{x'} \quad -L_{x'} \quad T_{z'} \quad L_{z'}$
linearly polarized	$-\Sigma$	$H \quad (-F) \quad -G$	$O_{x'} \quad (-I) \quad O_{z'}$	$(-L_{z'}) \quad (I_{z'}) \quad (-L_{x'}) \quad (-I_{x'})$
circularly polarized	0	$F \quad 0 \quad -E$	$-C_{x'} \quad 0 \quad -C_{z'}$	$0 \quad 0 \quad 0 \quad 0$

good experimental results only for :

σ, Σ, T, E

Observable G
sensitive to $P_{11}(1440)$

$\bar{\gamma} \bar{p} \rightarrow p \pi^0$

Kaon threshold production

$\bar{\gamma} p \rightarrow K^0 \bar{\Sigma}^+ \quad \bar{\Sigma}^+ \rightarrow p \pi^0$ self analyzing

Observable E
sensitive to GDH sum rule

