Status of the polarization facilities at Mainz

1.- Introduction

2.- Polarized beams at the MAMI Accelerator

3.- Polarized Targets

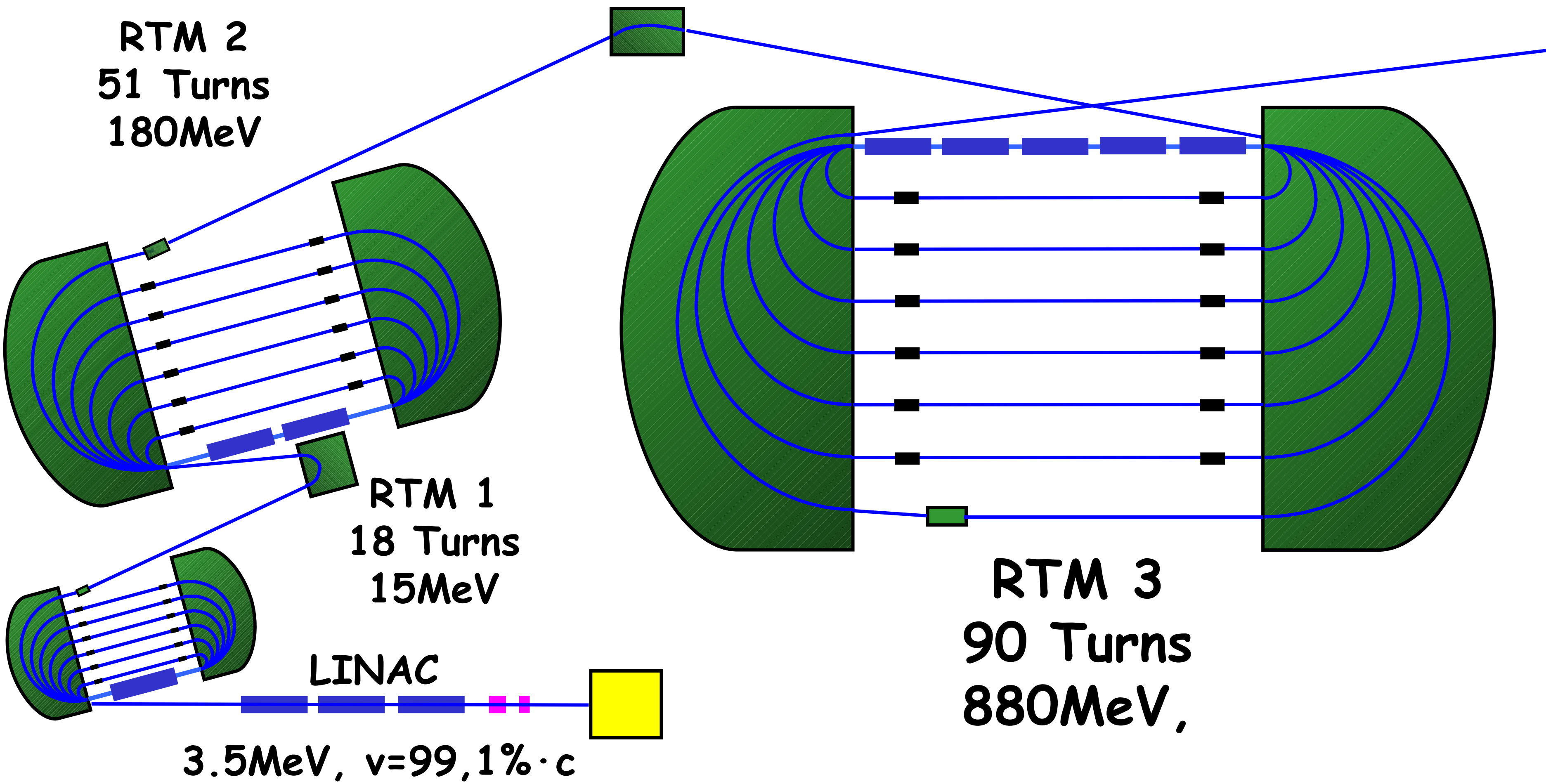
4.- Recoil polarimeter at the Crystal Ball/TAPS detector

5.- Conclusions and Outlook

International Symposium on polarized targets and its applications
29. Feb. -1. March 2008
Yamagata, Japan

Andreas Thomas
A2- and CBall@MAMI- Collaborations

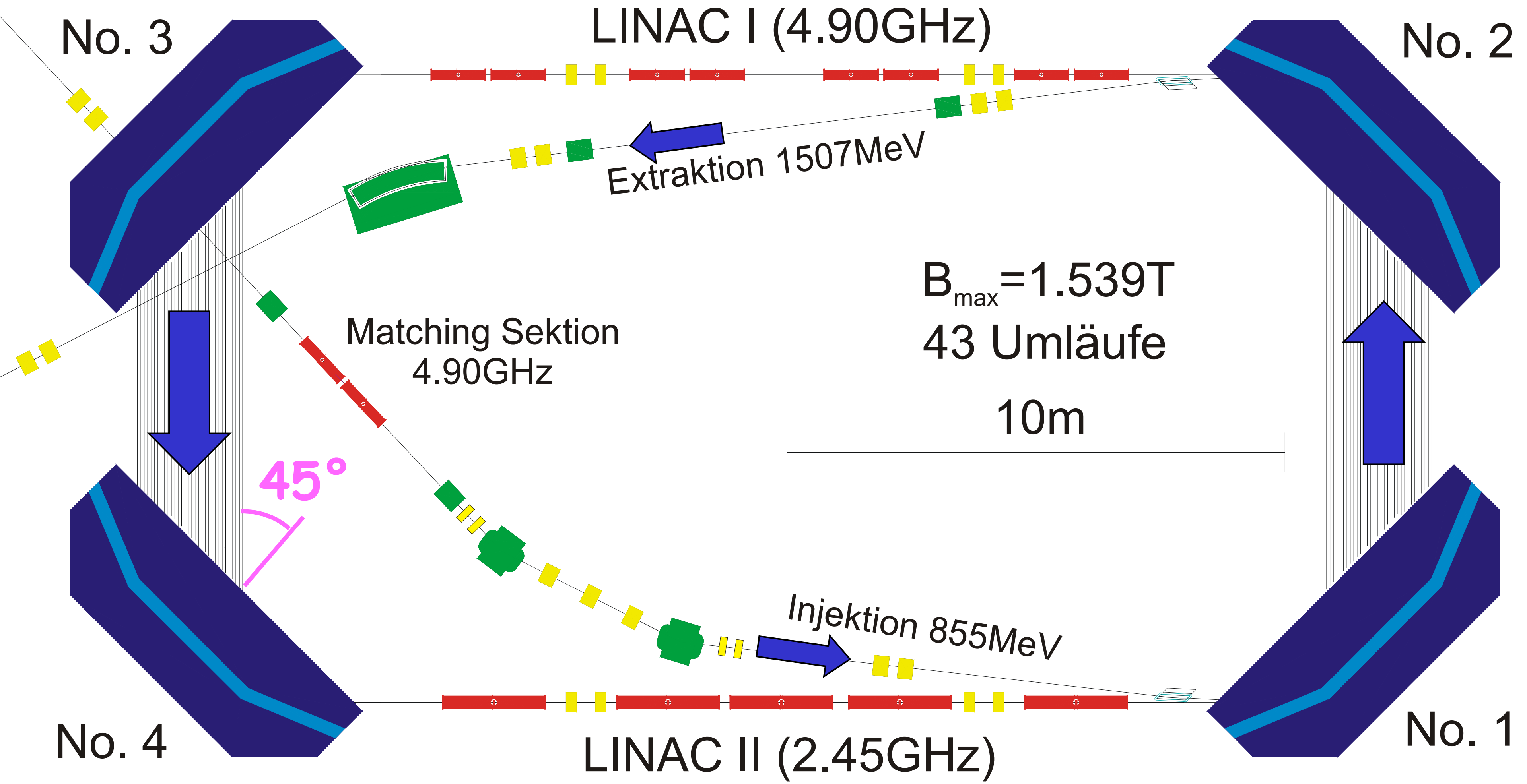
MAMI B Microtron-Cascade for electron acceleration



MAMI A, 1979 + 1983

MAMI B, 1990

Harmonic Double Sided Microtron (HDSM)

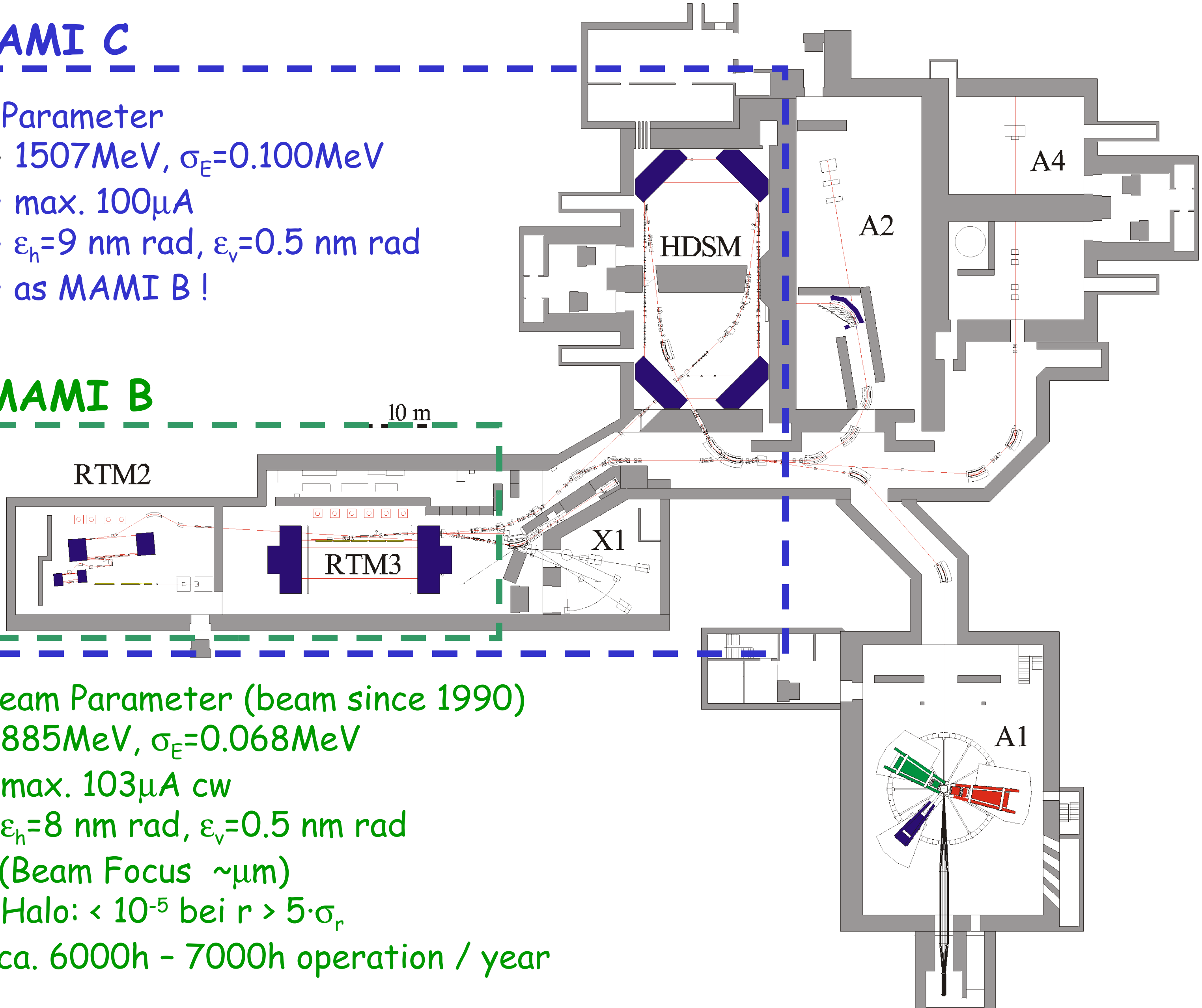


MAMI C

Parameter

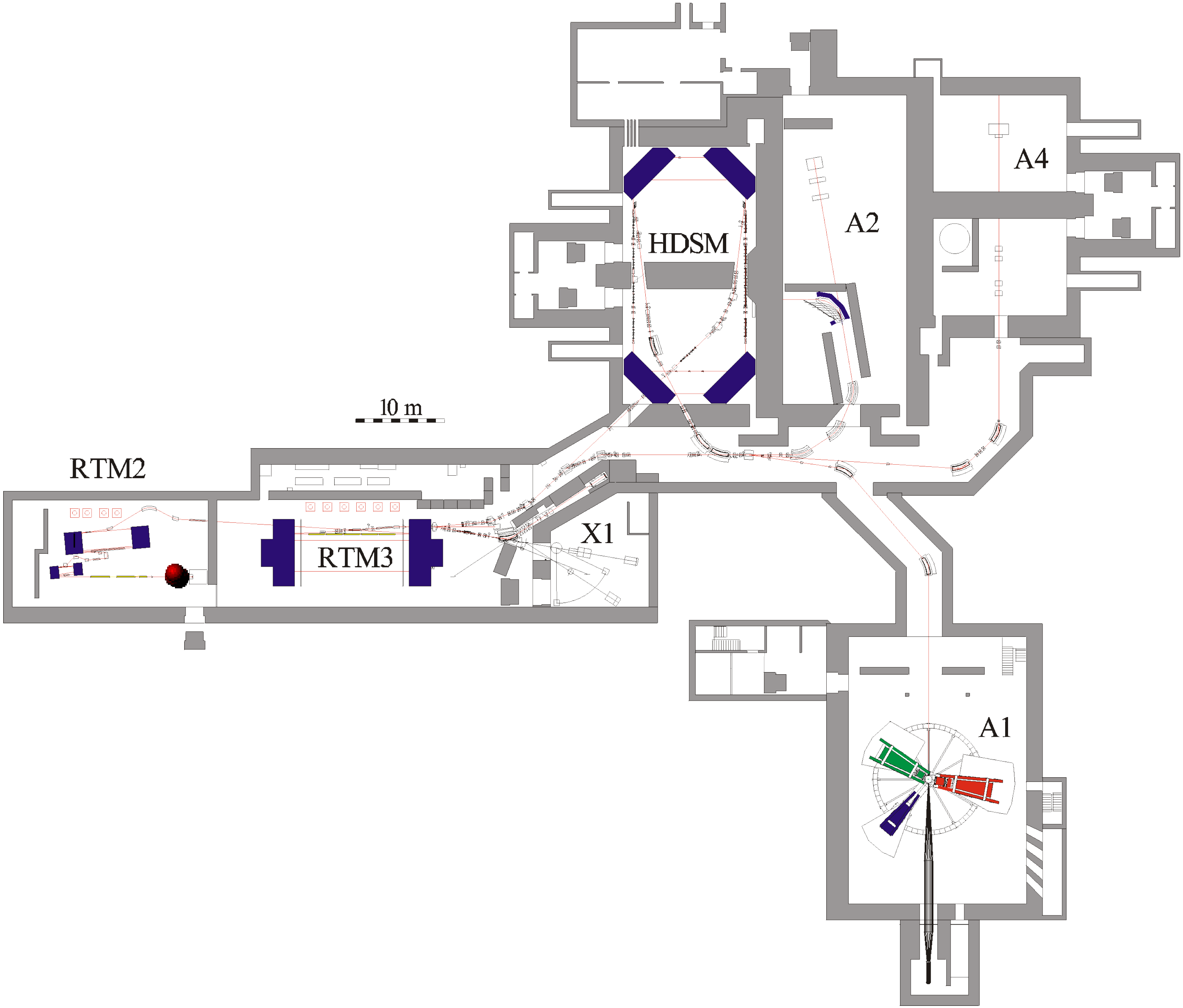
- 1507MeV, σ_E=0.100MeV
- max. 100µA
- ε_h=9 nm rad, ε_v=0.5 nm rad
- as MAMI B !

MAMI B



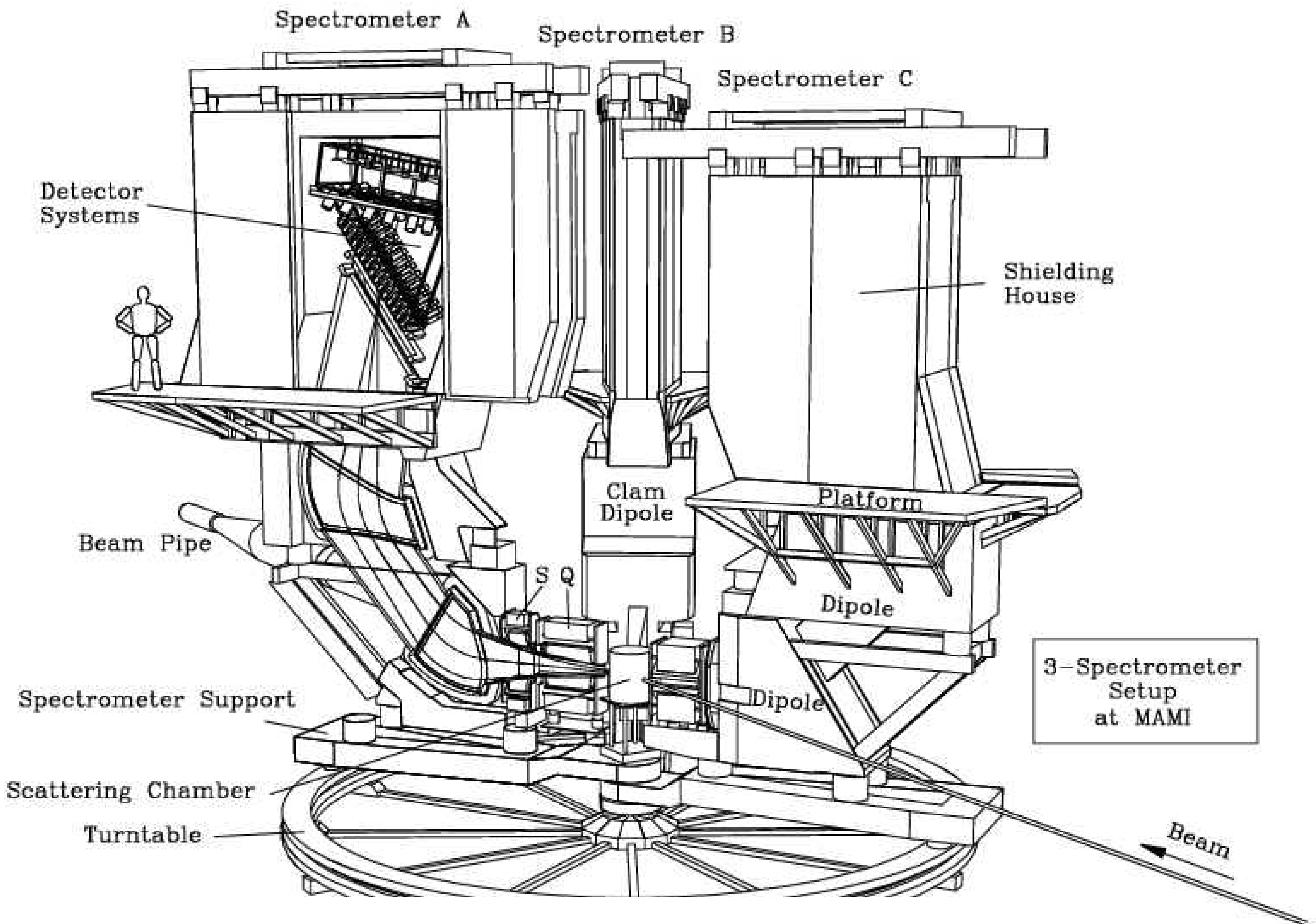
Beam Parameter (beam since 1990)

- 885MeV, σ_E=0.068MeV
- max. 103µA cw
- ε_h=8 nm rad, ε_v=0.5 nm rad (Beam Focus ~µm)
- Halo: < 10^{-5} bei r > $5 \cdot \sigma_r$
- ca. 6000h – 7000h operation / year



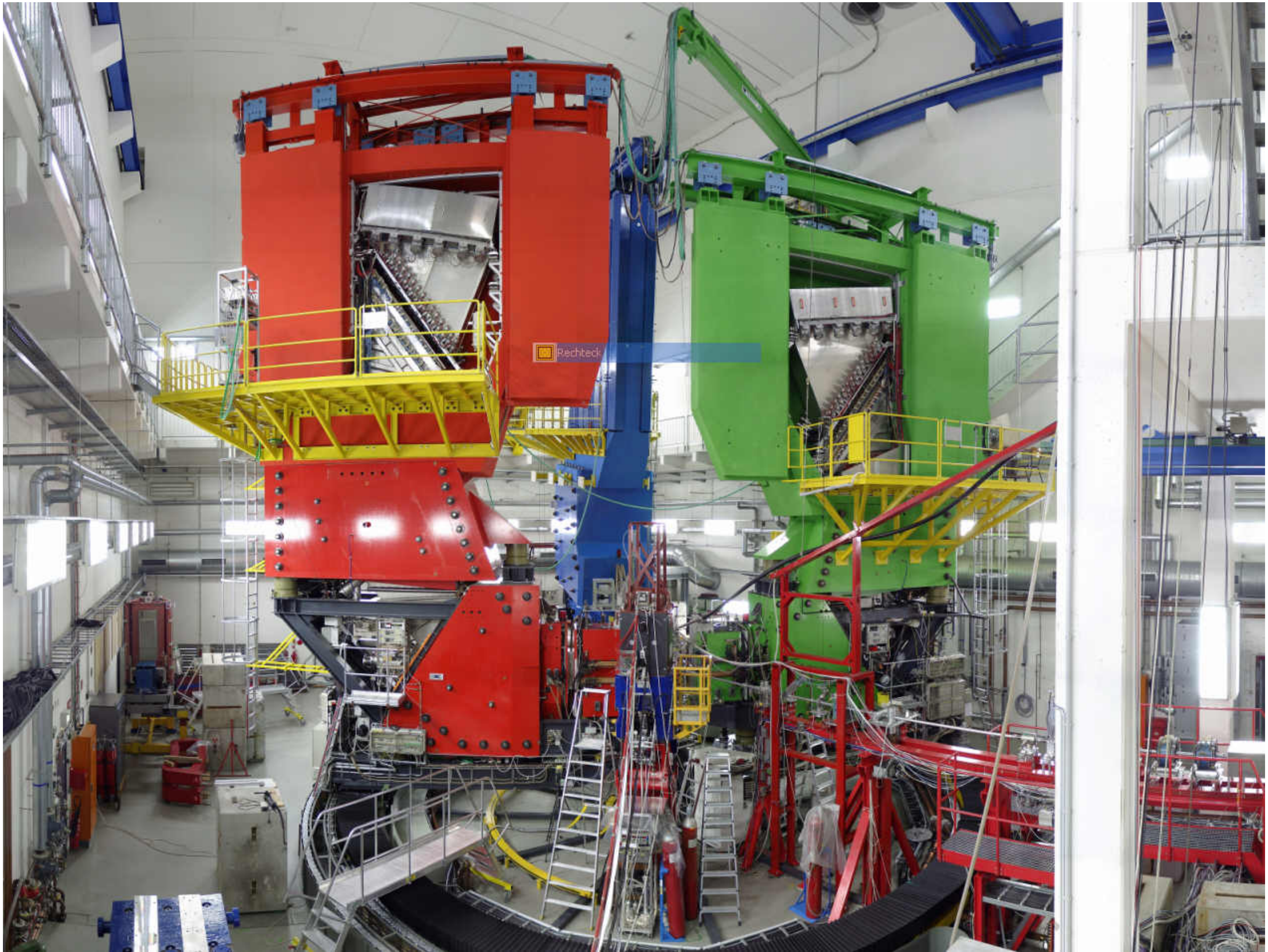
HDSM
A2
A4
10 m
RTM2
RTM3
X1
A1

Electroproduction Experiments

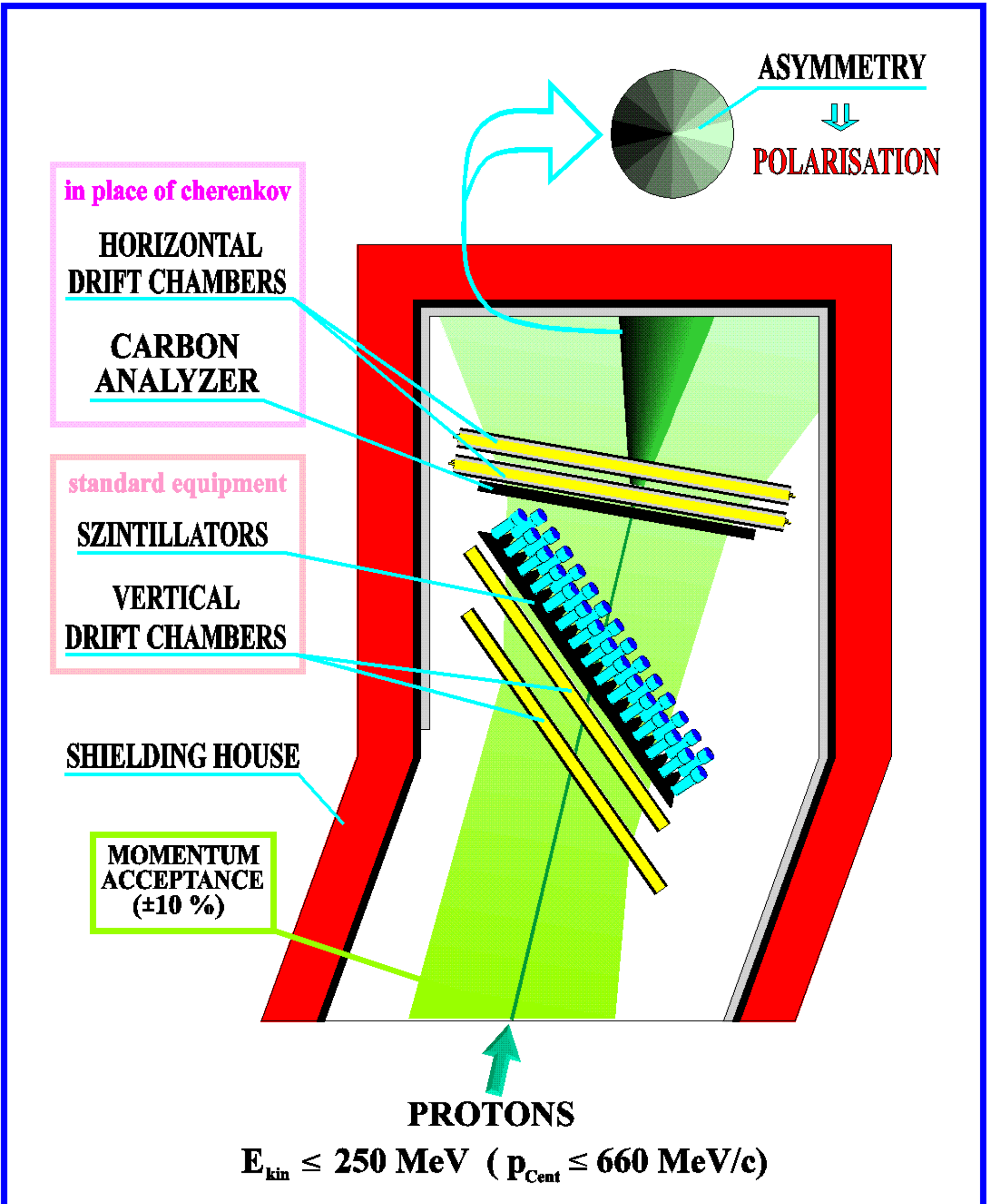


Three-Spectrometer-Setup A1: Electron scattering

Three-Spectrometer-Setup A1: Electron scattering



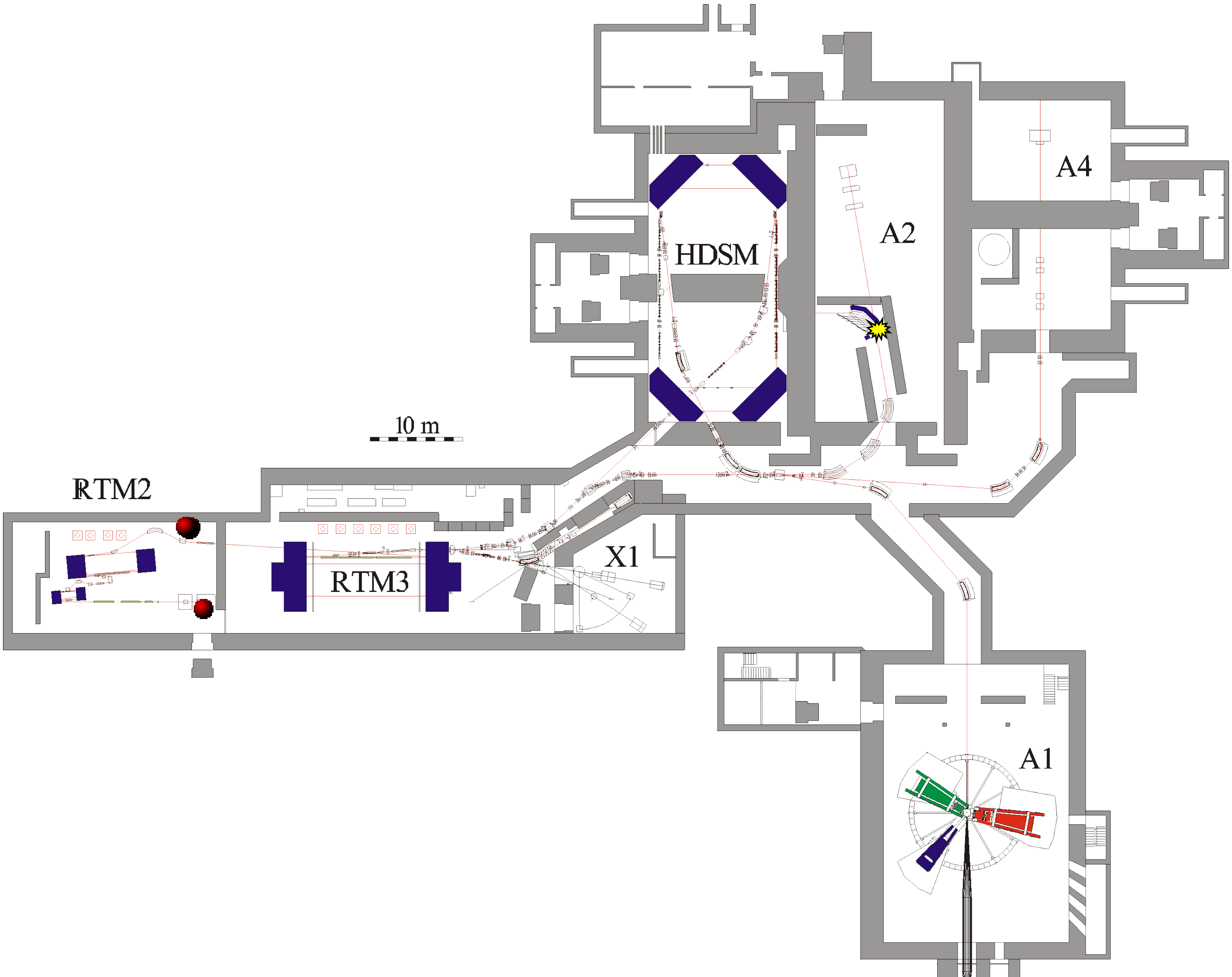
Recoil Polarimeter



Typical reaction:

$p(\vec{e},e'\vec{p})\eta$

Measurement of the degree of
proton recoil polarisation
and
electron polarisation
(via Moeller polarimeter: ~85%)



A4
A2
HDSM
10 m
RTM2
RTM3
X1
A1

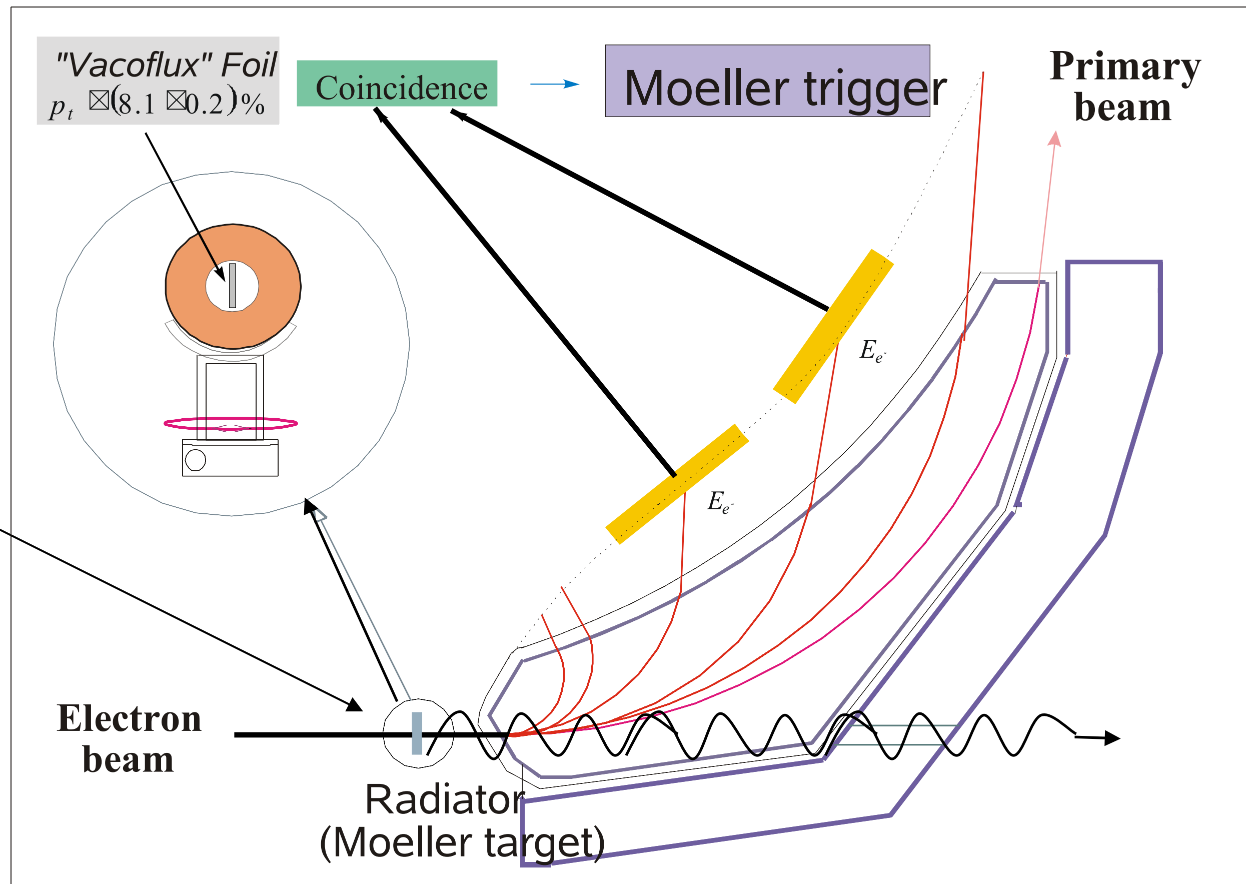
A2 Tagging system (Glasgow,Mainz)

1. Production und energy measurement of the Bremsstrahlungs photons

2. Determination of the degree of polarization of the electron beam (Moeller Polarimeter); Circularly pol. photons

$$A = \frac{N^+ - N^-}{N^+ + N^-} = a\vec{p}_t\vec{p}_b\cos(z)$$

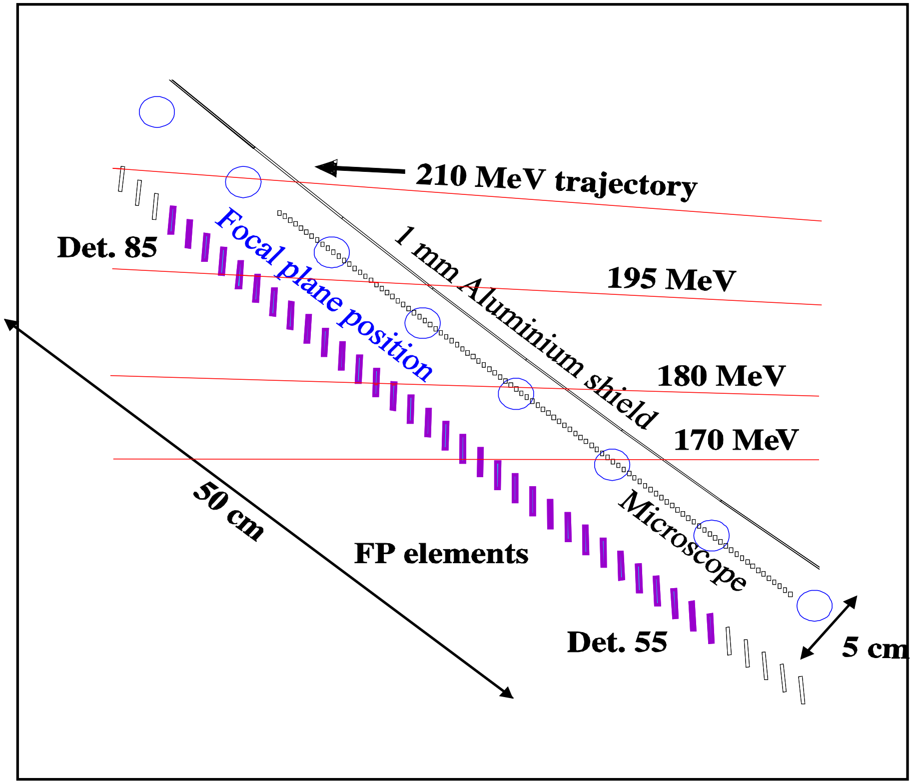
3. Coherent production of linearly polarized photons on a diamond radiator



Tagger Detectors and Tagger Microscope

Energy resolution of our standard tagger ladder (352 plastics) **4 MeV per Channel**.

- **96 Plastic Scintillator** Fibers (3x2 mm).
- 1/3 Overlap of the fibers with its neighbor. Overlap region defines the Mikcroscope chanal ***μch*** **(191 channels)**.
- Energy resolution: **0.3 MeV per microscope channel (*μch*)**.
- Microscope Tagger is positioned in the electron energy range of the reaction threshold, eg. Beam energy E_0=883 MeV corresponds to a p**hoton energy range from 674 MeV to 730 MeV** (*η-threshold* ~707 MeV).

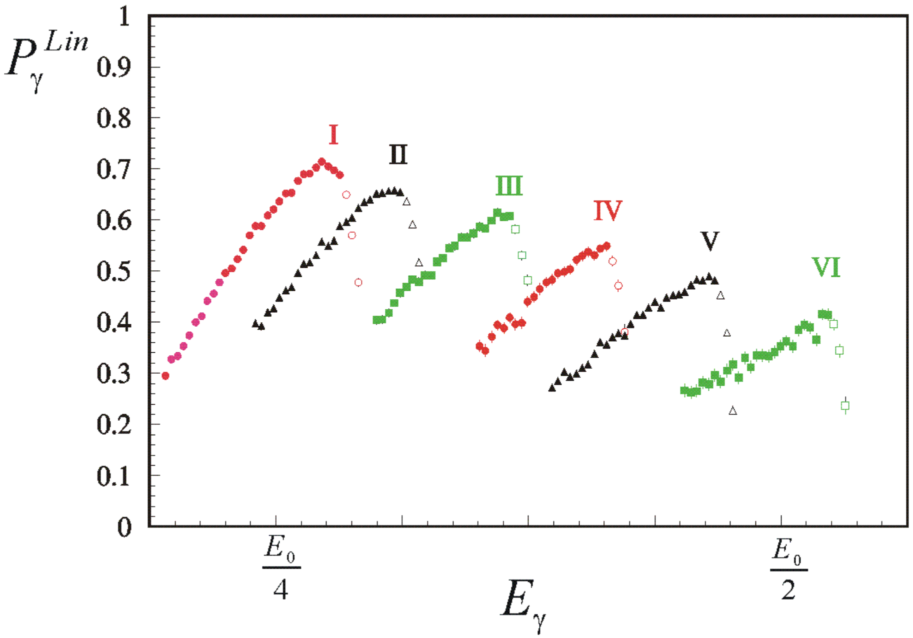


Polarised Photons @ MAMI C

$E_\gamma = 75 \ldots 1425$ MeV $\qquad \Delta E_\gamma = 0.1 - 4$ MeV

$N_\gamma = 2 \cdot 10^5\ s^{-1}\ MeV^{-1}$

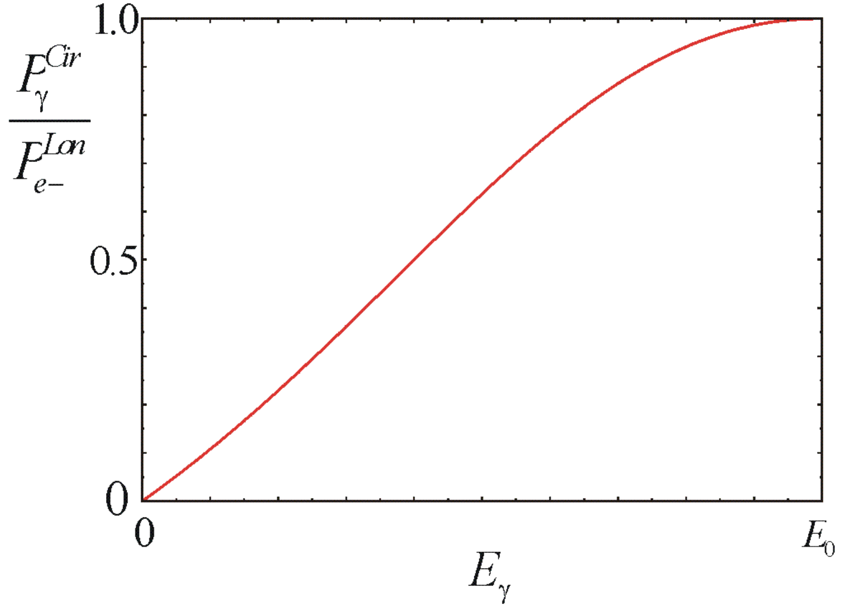
linearly polarized photons



$P_\gamma^{Lin} = 70\%$

- high photon flux !

circularly polarized photons



$P_{e-}^{Lon} = 80\% \rightarrow P_\gamma^{Cir} = 80\%$

- high polarization !

Picture of a Proton (Skale fm).

FERMIONS
matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	−1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	−1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	−1

Quarks spin = 1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	−1/3
c charm	1.3	2/3
s strange	0.1	−1/3
t top	175	2/3
b bottom	4.3	−1/3

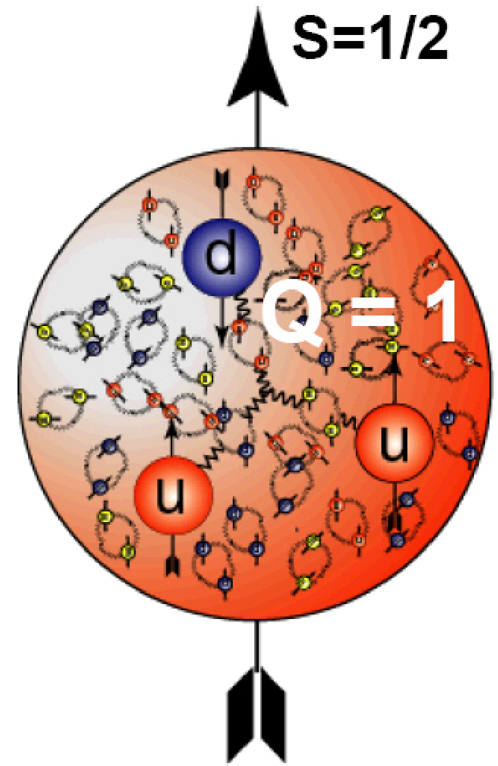
BOSONS
force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W$^-$	80.4	−1
W$^+$	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

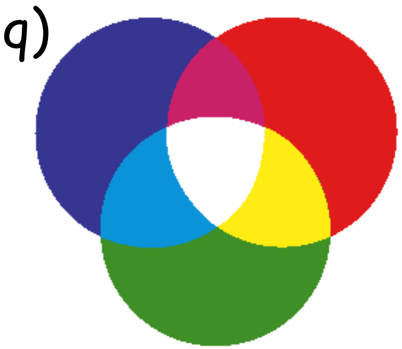
Name	Mass GeV/c^2	Electric charge
g gluon	0	0



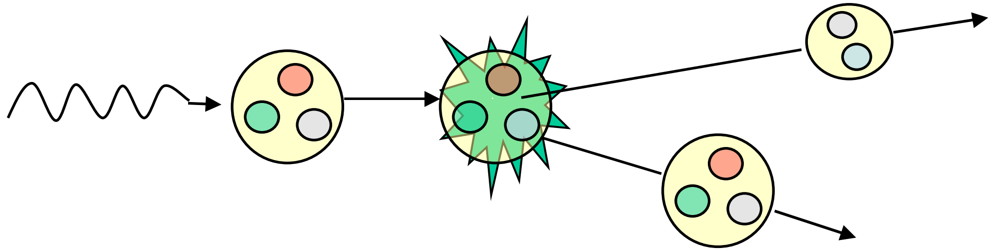
Colourless objects:

Baryons (qqq)

Mesons (qq)

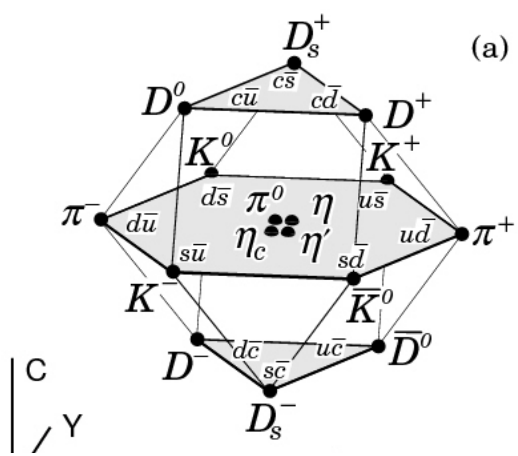


Resonance spectrum of nucleons is excited and Mesons are produced.



MAMI Energy Range ($E_{elektron}$ < 1507MeV)

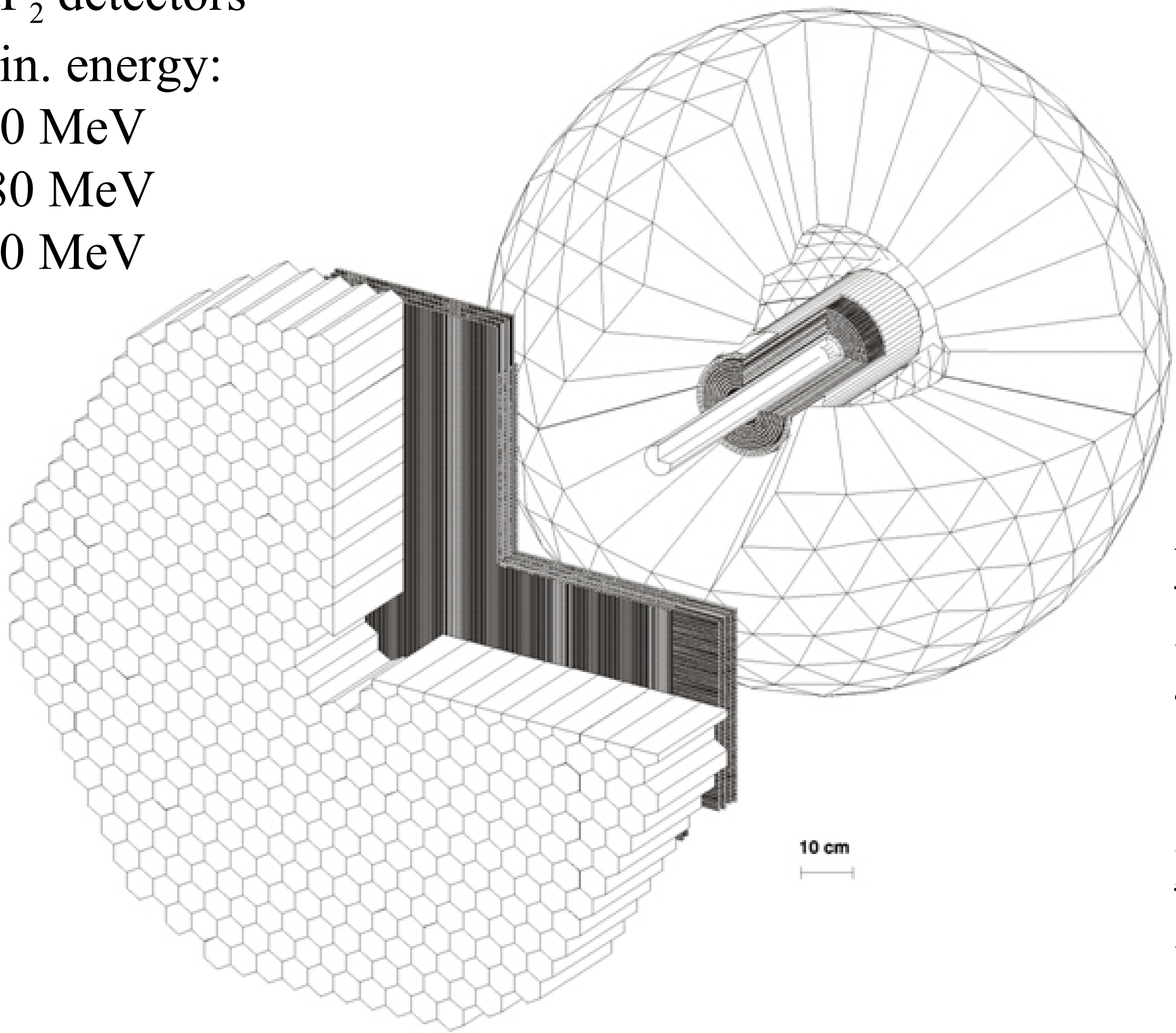
π -, η– and η‘-Mesons are produced.



4π photon Spectrometer @ MAMI

TAPS:
510 BaF_2 detectors
Max. kin. energy:
π^{+-} : 180 MeV
K^{+-} : 280 MeV
P : 360 MeV

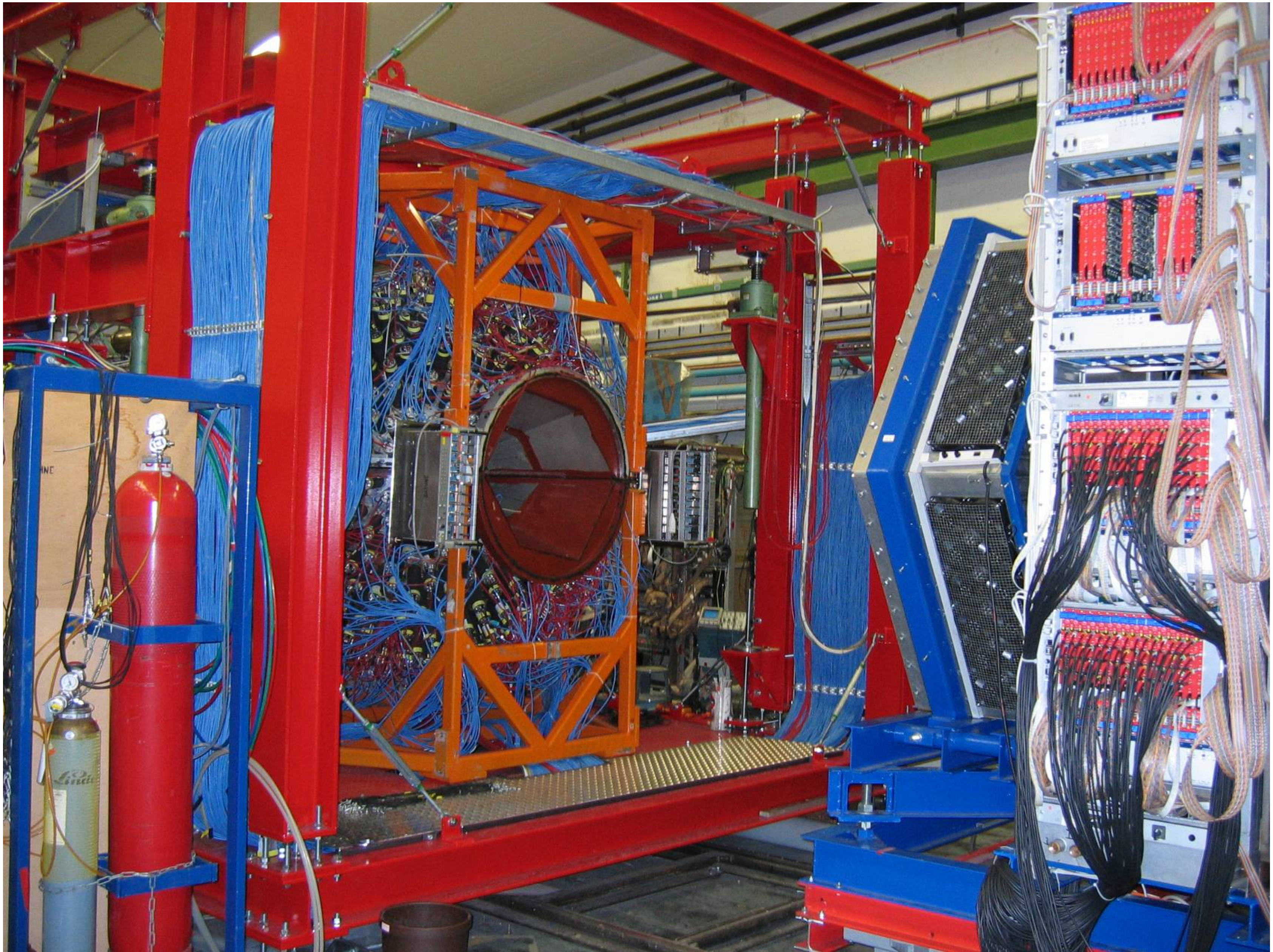
Crystal Ball:
672 NaJ detectors
Max. kin. energy:
μ^{+-} : 233MeV
π^{+-} : 240 MeV
K^{+-} : 341 MeV
P : 425 MeV



Vertex detector:
2 Cylindr. MWPCs
480 wires, 320stripes

PID detector:
24 thin plastic detectors

Crystal Ball / TAPS



First round (3600h) with CB@MAMI B (882MeV) in 2004 and 2005 (only beam polarized)

- Data set with high statistics for pion and double pion production.
- Helicity Asymmetry in double pion production.

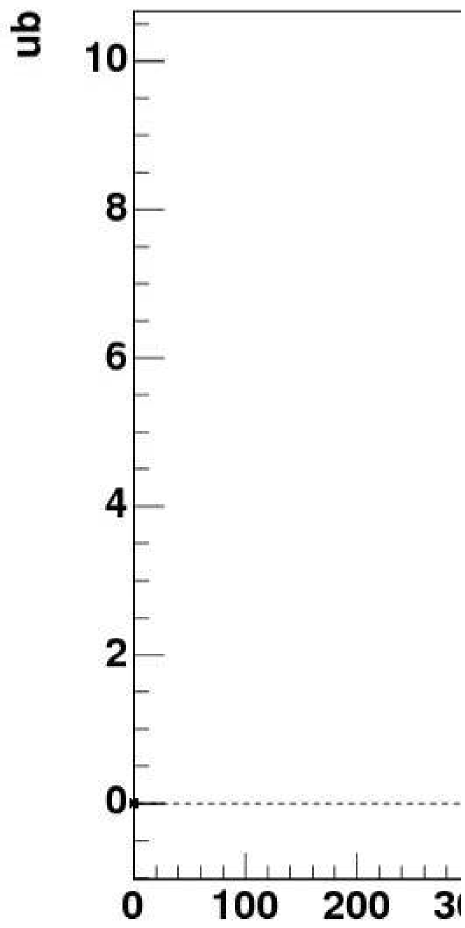
- Precision measurement to determine the η-mass.
- $30*10^6$ η produced for the investigation of rare η-decays (C, CP-Violation) and the η - Dalitz-decay $\eta \rightarrow e^+e^-\gamma$.
- Dalitz Plot Parameter in the $\eta \rightarrow \pi^0\pi^0\pi^0$ decay. Sensitiv to the quark-mass-differenz m_u-m_d.
- Investigation of η-mesic nuclei (^{7}Li-, ^{3}He-target).

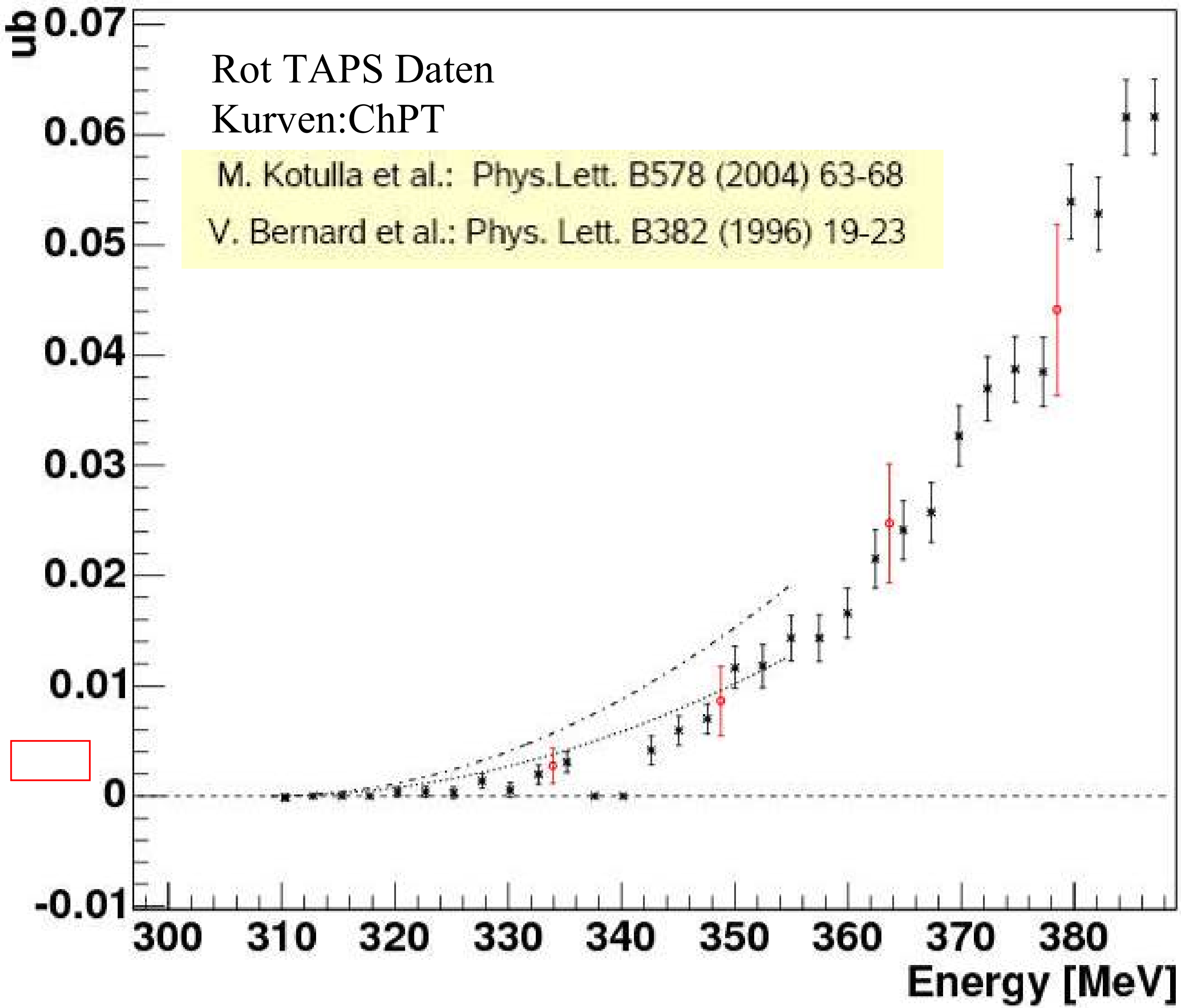
- Magnetic Moment of the Δ-Resonance.
- Data set on nuclei (modified ππ Interaction in nuclear matter).
- Coherent π0 production on nuclei.

Data set with high statistics for π and ππ production

[F.Zehr, S.Schumann]

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

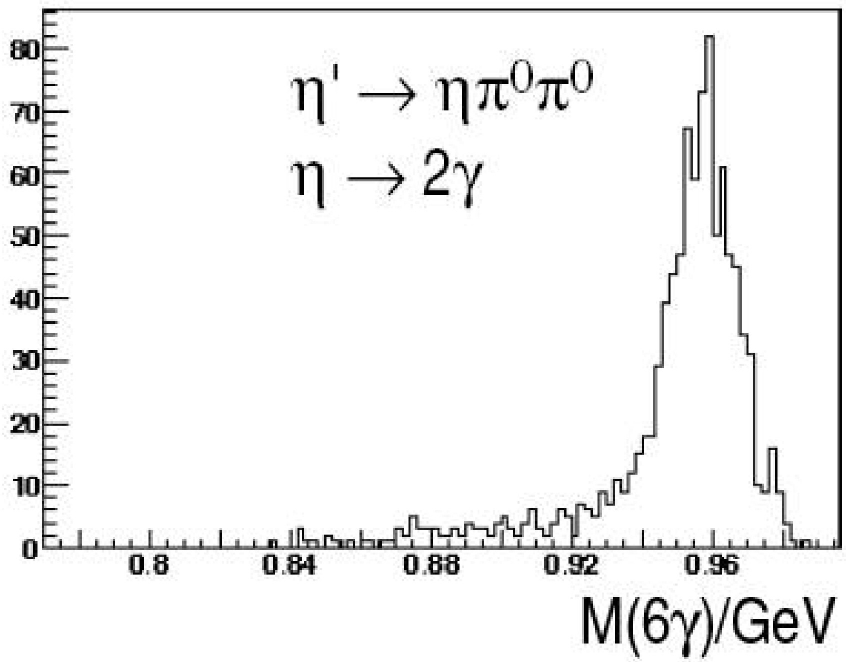


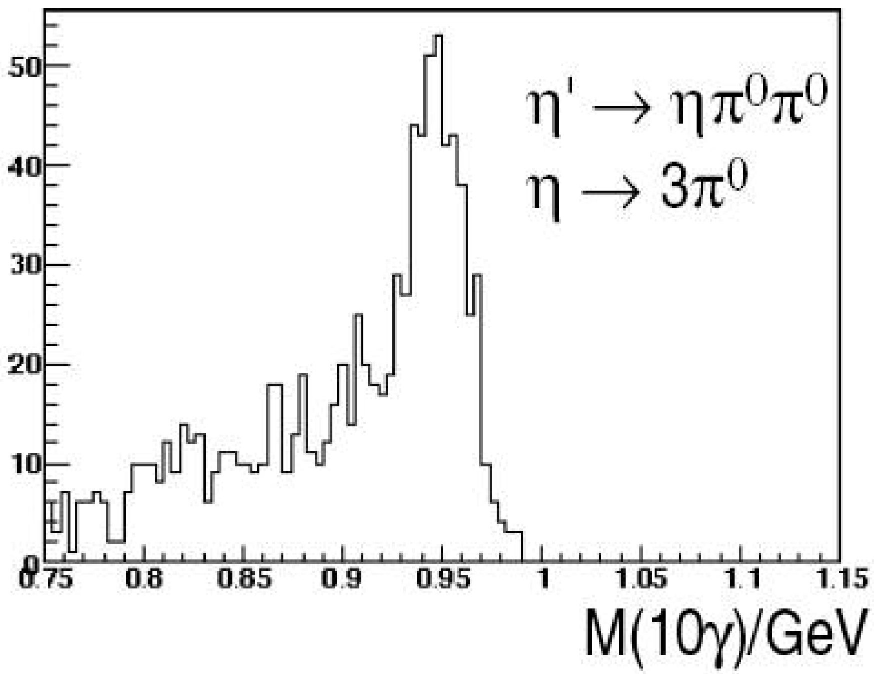


Now running: first experiment @ MAMI C with CB and TAPS detectors

(600 hours of beamtime approved)

- First reconstructed $\eta' \to \eta\pi^0\pi^0$ decays





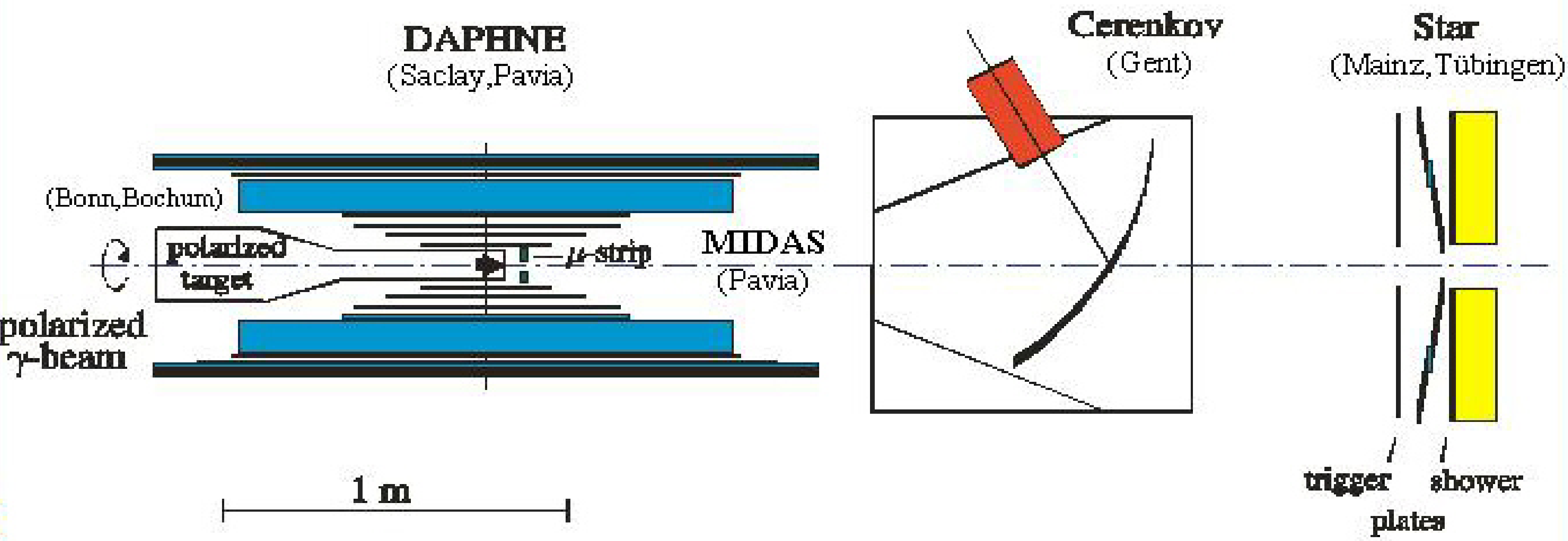
- Expected number reconstructed decays:

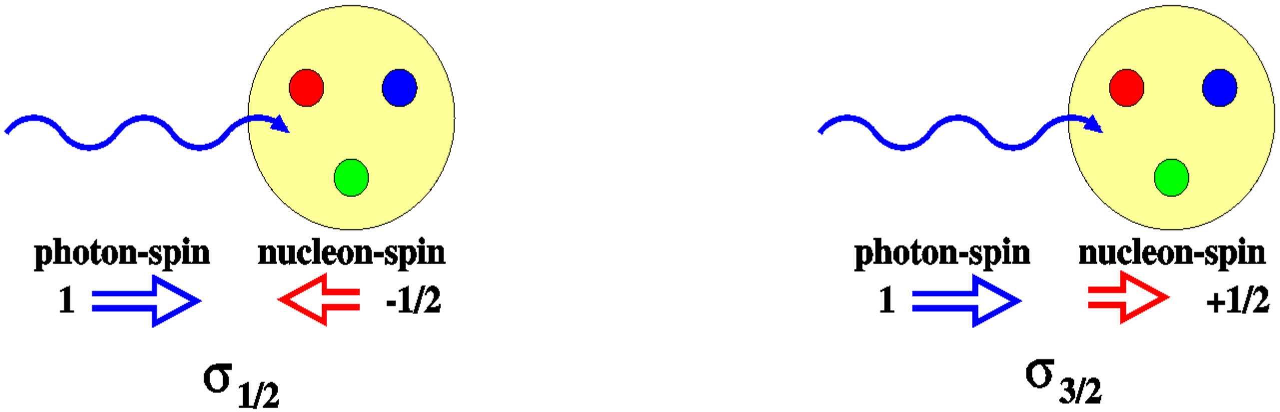
$\eta' \to \eta\pi^0\pi^0$ ~100/h (BR=21%)

$\eta' \to 3\pi^0$ ~1/h (BR=0.16%)

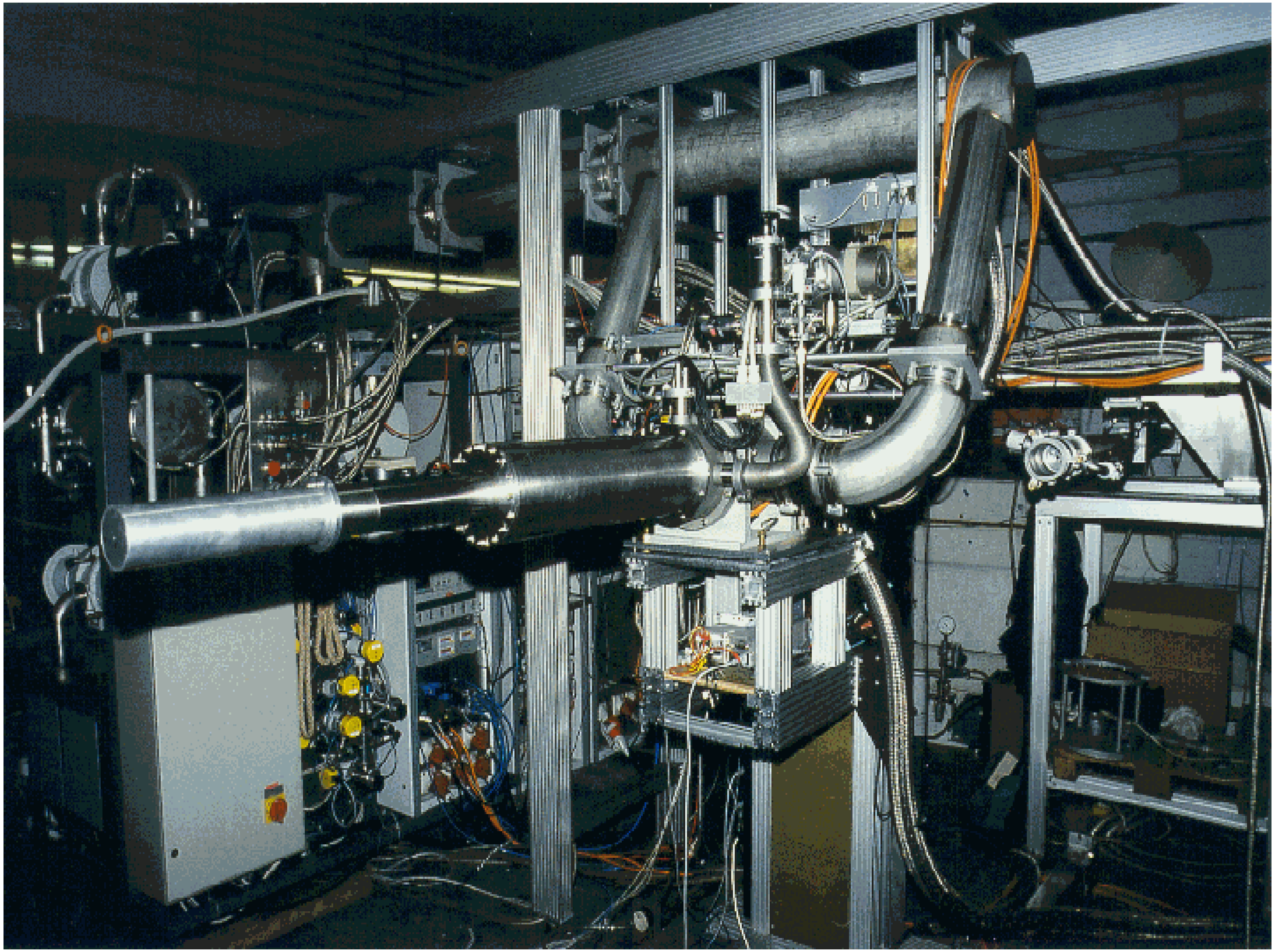
Polarized Target:

GDH experiment @ MAMI B with DAPHNE detector (1998 – 2003)





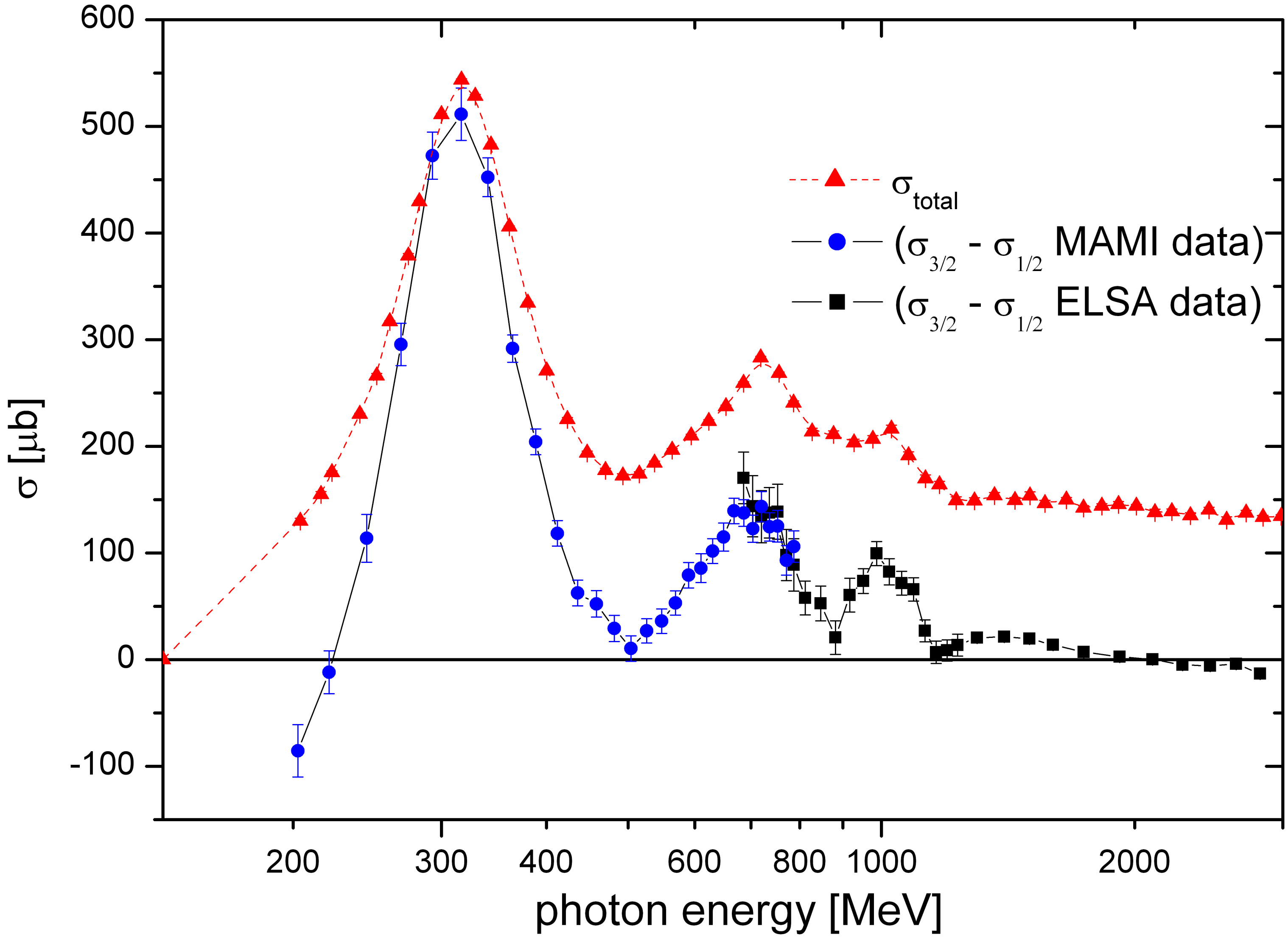
Target collaboration from Bochum, Bonn, Nagoya, Mainz



Bonn Frozen Spin Target at A2 / MAMI [C.Bradtke et al., NIM **A436**, 430 (1999)]

World record in Deuteron polarisation in a frozen spin experiment due to new doping material with small ESR from **Bochum in 2003**. [W.Meyer et al.]

GDH Sumrule

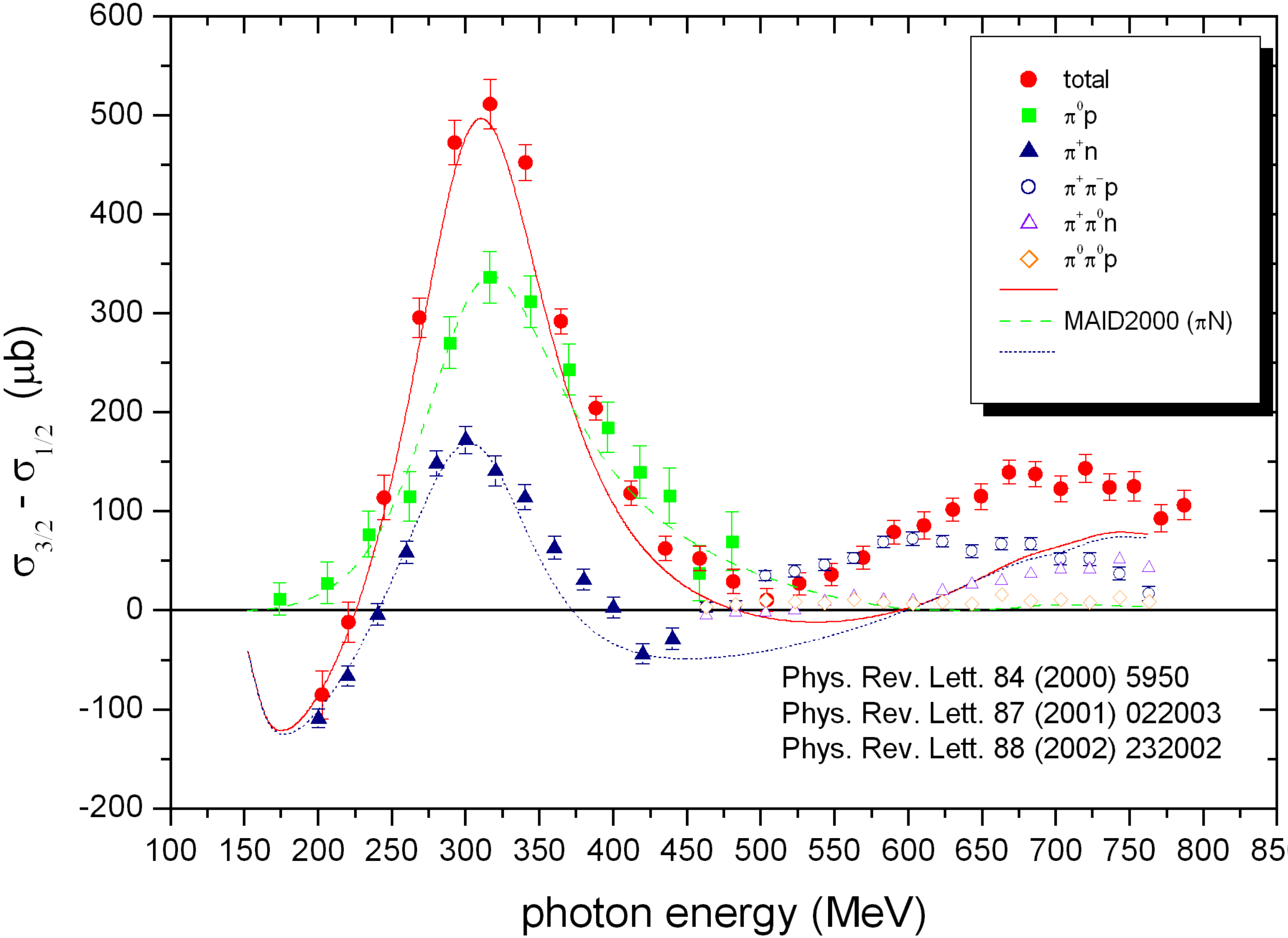


600
500
400
300
200
100
0
-100
σ [μb]
200
300
400
600
800
1000
2000
photon energy [MeV]
σ_total
(σ_3/2 - σ_1/2 MAMI data)
(σ_3/2 - σ_1/2 ELSA data)

Partial reaction channels

➡ Input for PWA to extract resonance parameters

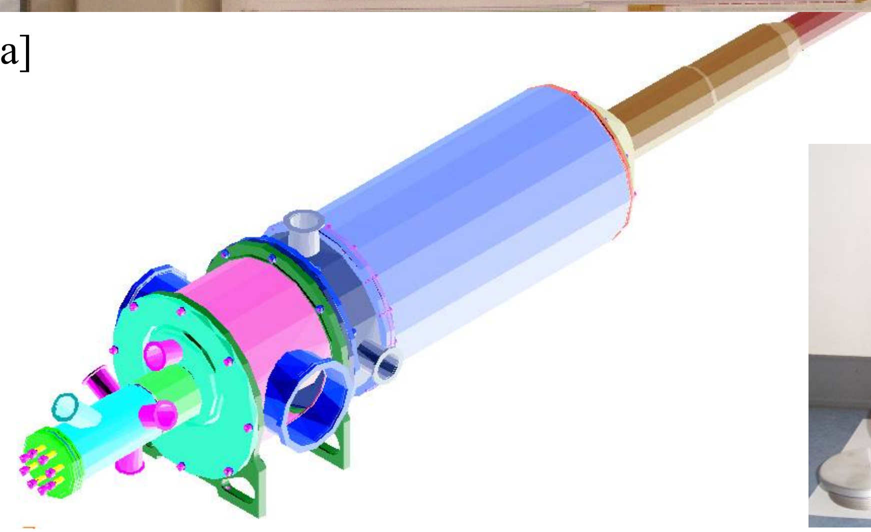
Measurements in 1998 at MAMI with DAPHNE and Bonn PT

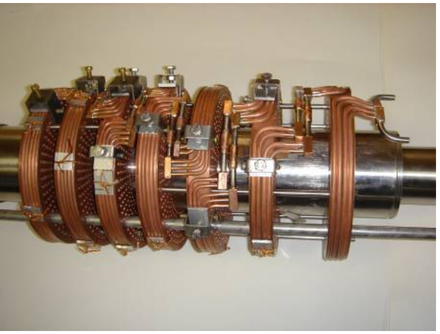


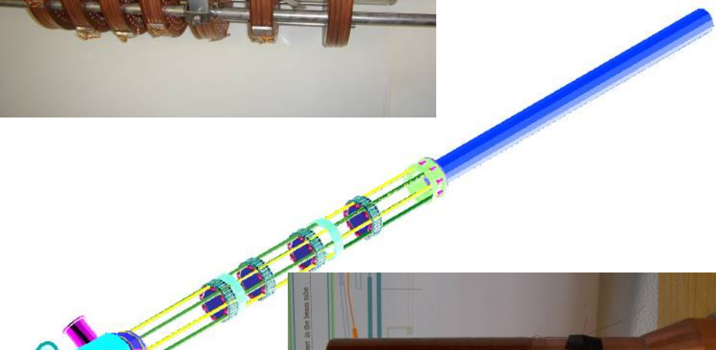
Frozen Spin Target for Crystal Ball @ MAMI

^{3}He/^{4}Helium Dilution cryostat [JINR Dubna]
with ^{4}Helium-evaporator as precooler:

T<30mK; Pp=90%; Pd=70%.

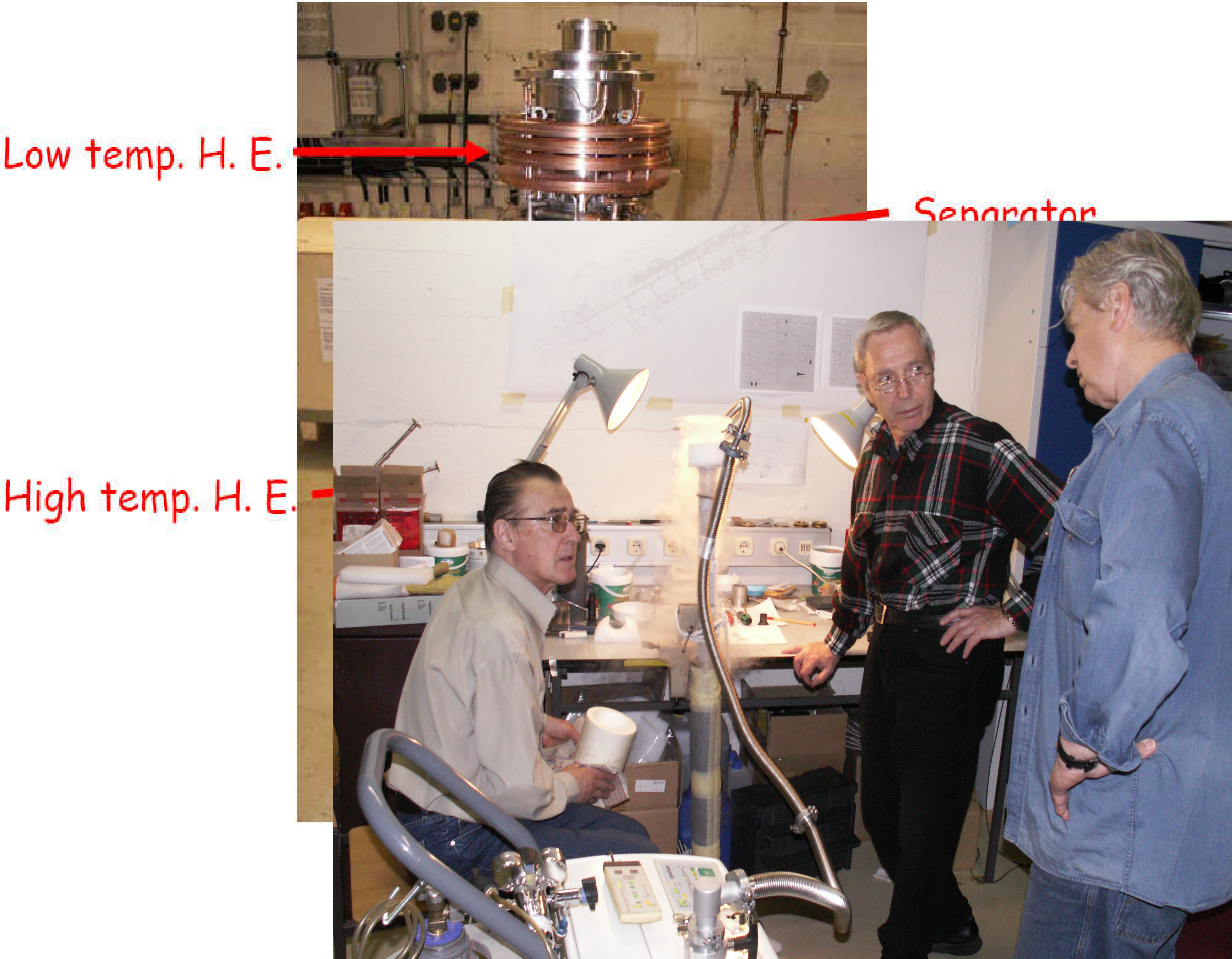


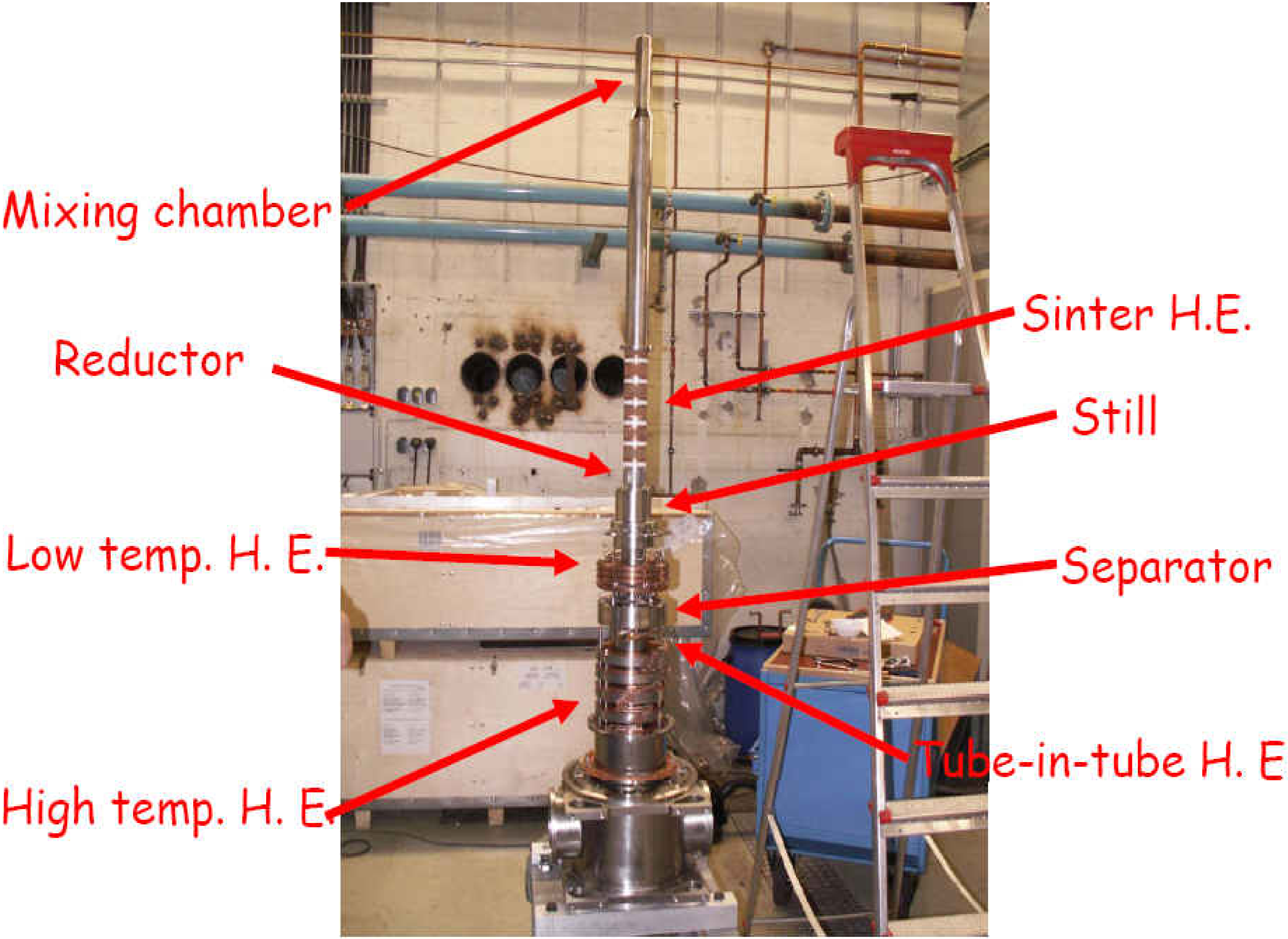




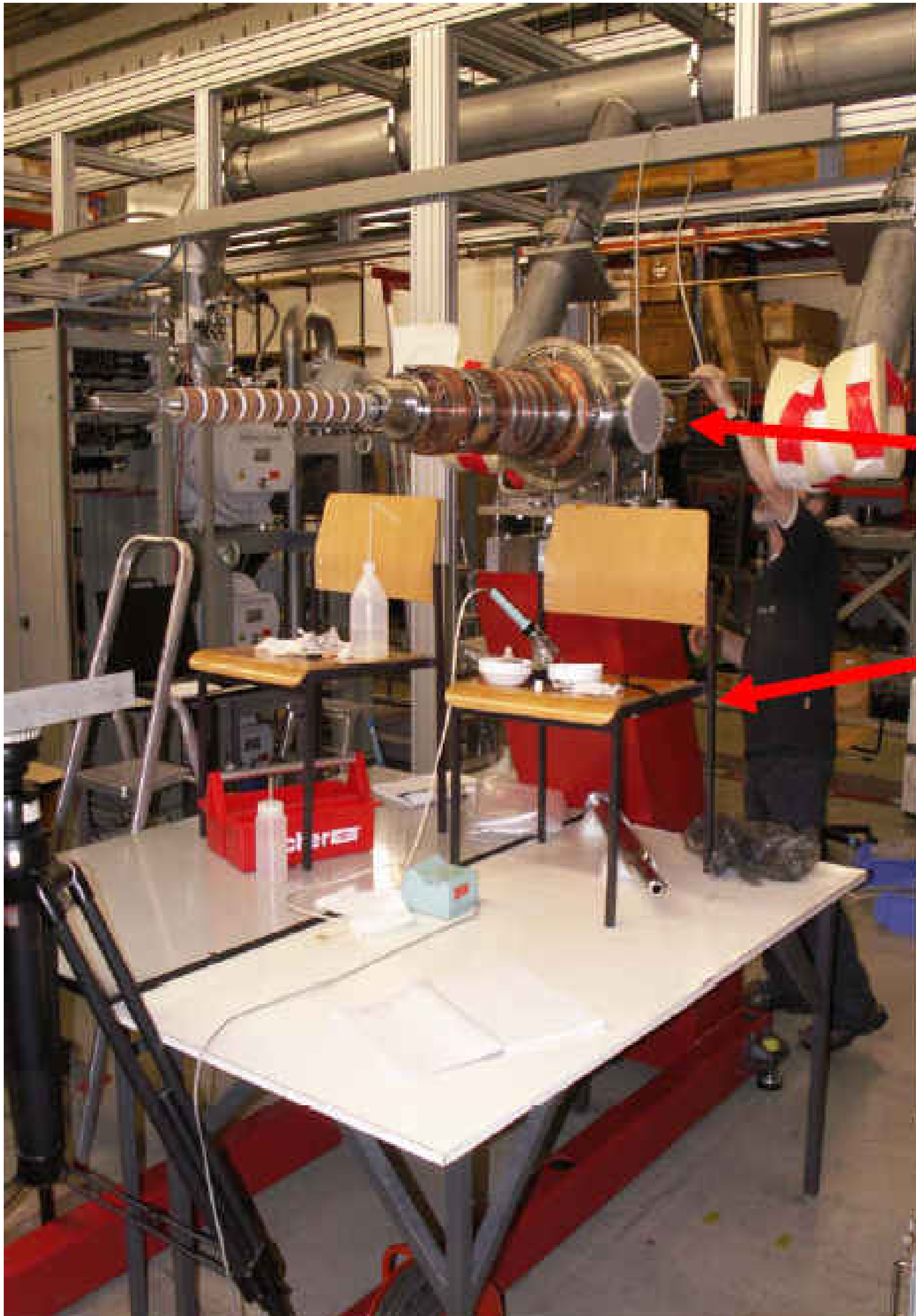
Transport from Dubna to Mainz

2.Mai.2007


Low temp. H. E.
Separator
High temp. H. E.

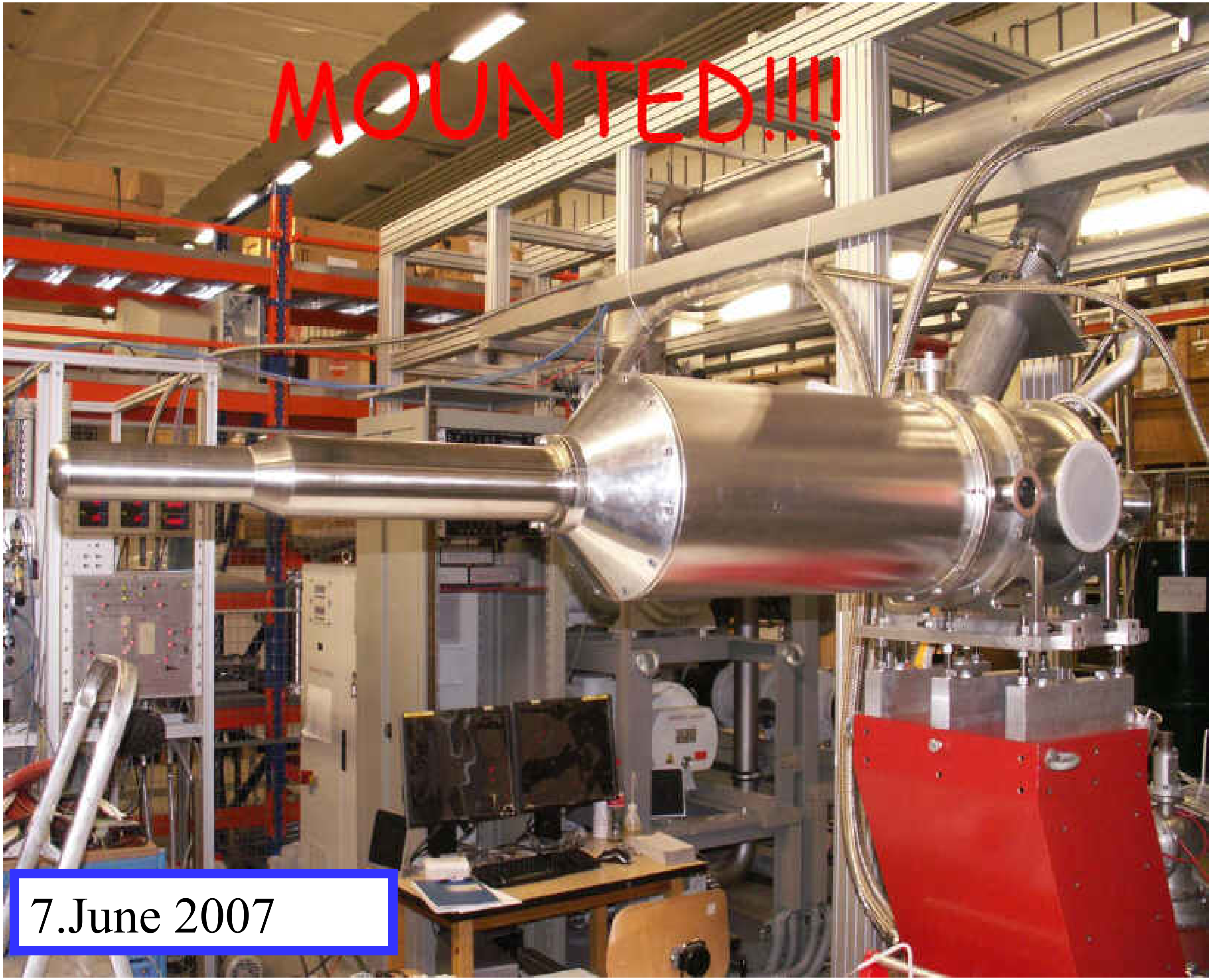


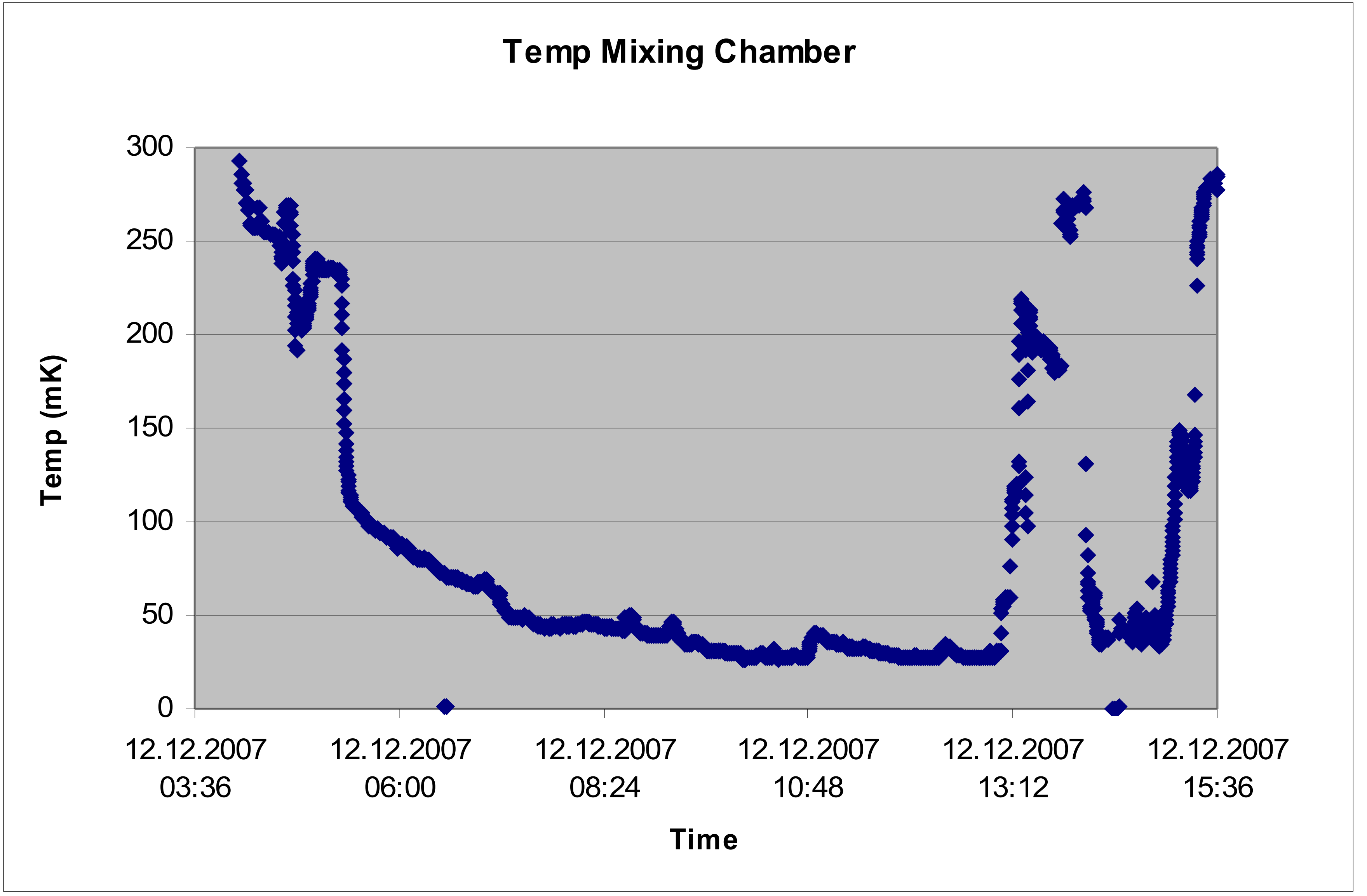
Mixing chamber
Sinter H.E.
Reductor
Still
Low temp. H. E.
Separator
Tube-in-tube H. E.
High temp. H. E.



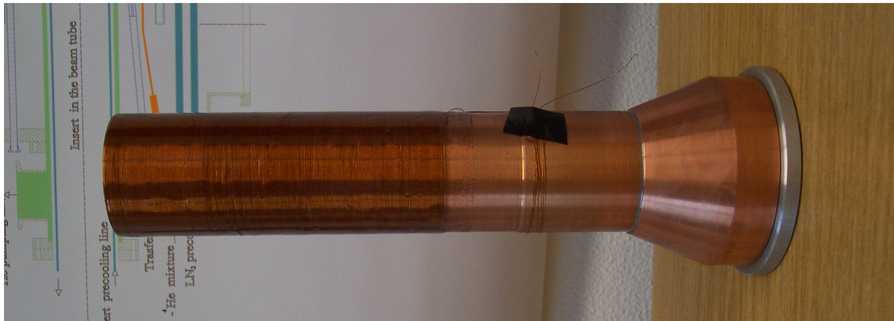
Cryostat
+
Support


Holding coil
fischer


MOUNTED!!!!
7.June 2007


Temp Mixing Chamber
Temp (mK)
300
250
200
150
100
50
0
12.12.2007 03:36
12.12.2007 06:00
12.12.2007 08:24
12.12.2007 10:48
12.12.2007 13:12
12.12.2007 15:36
Time

25mKelvin at 12.December2007

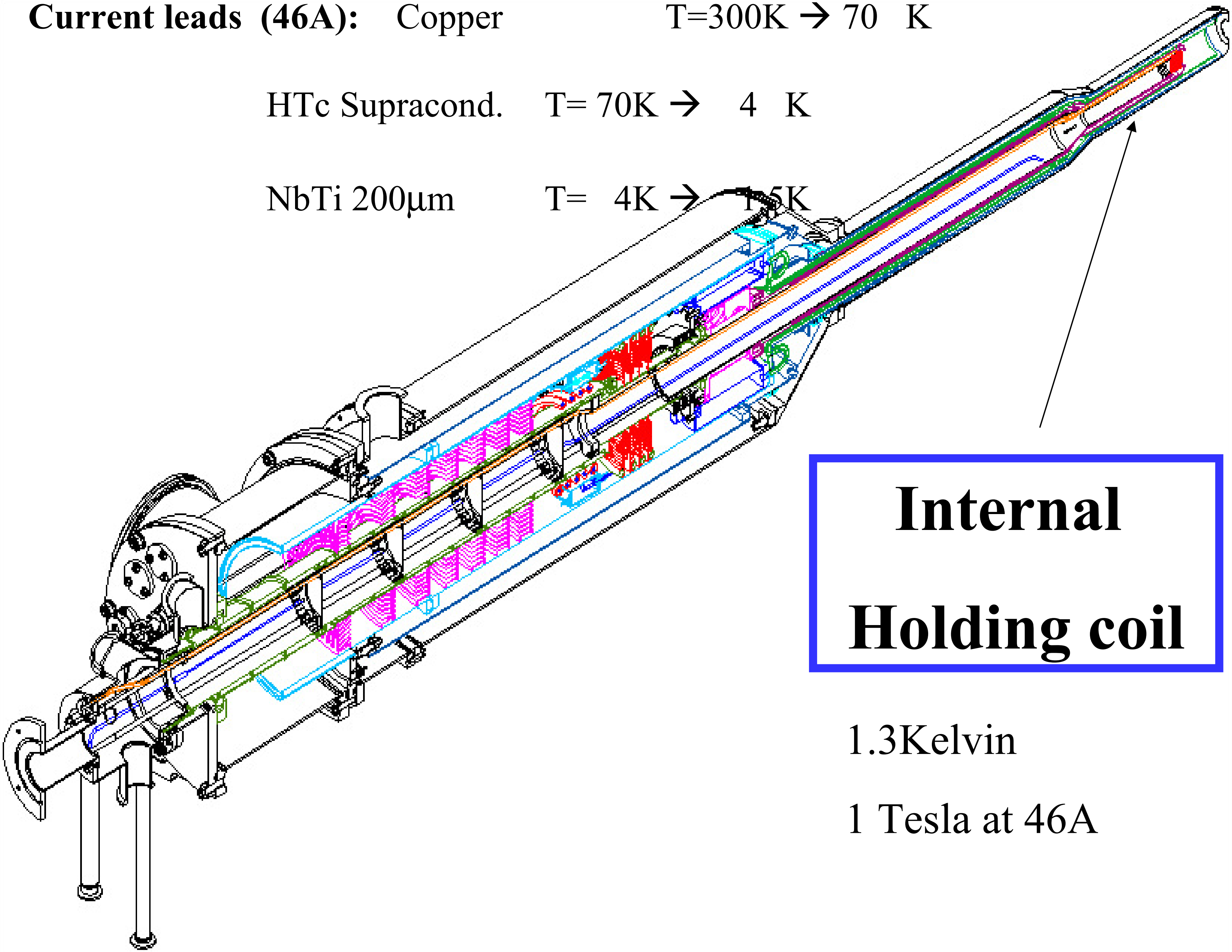


Coil production in the Mechanics workshop

Current leads (46A): Copper T=300K → 70 K

HTc Supracond. T= 70K → 4 K

NbTi 200µm T= 4K → 1.5K



Internal Holding coil

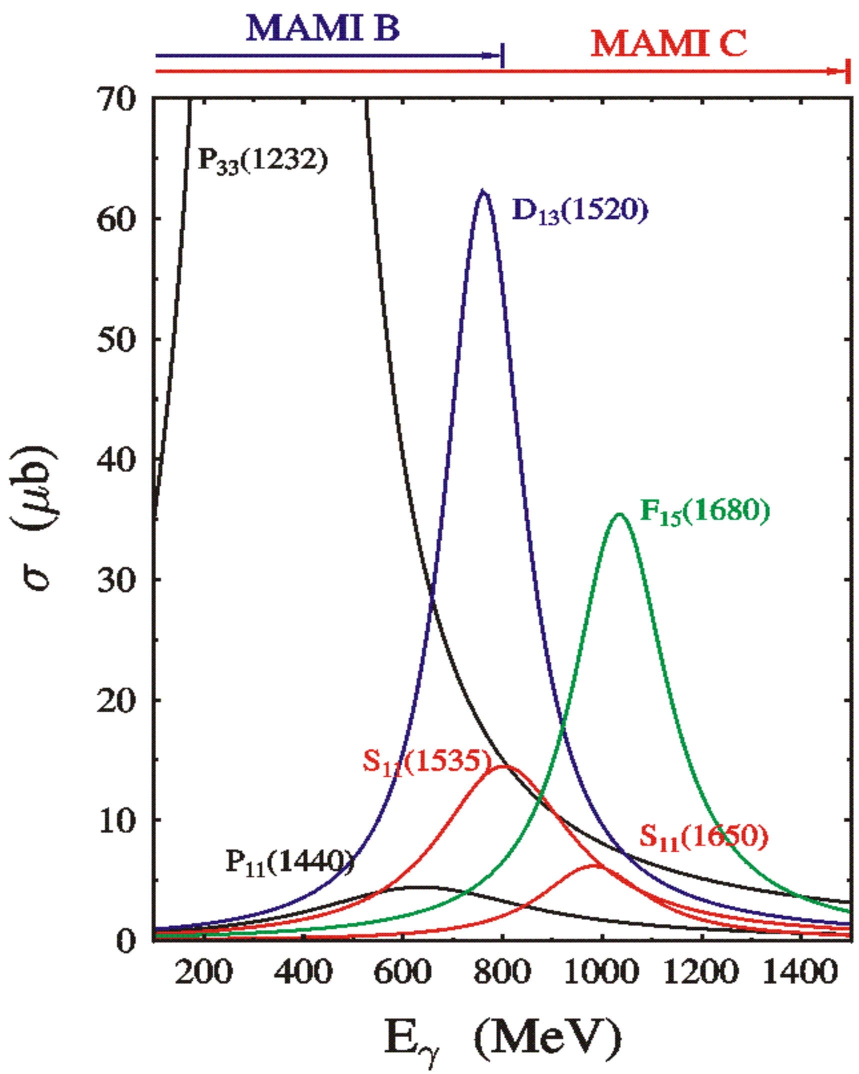
1.3Kelvin

1 Tesla at 46A

Future project: Excitation Spectrum of the nucleon

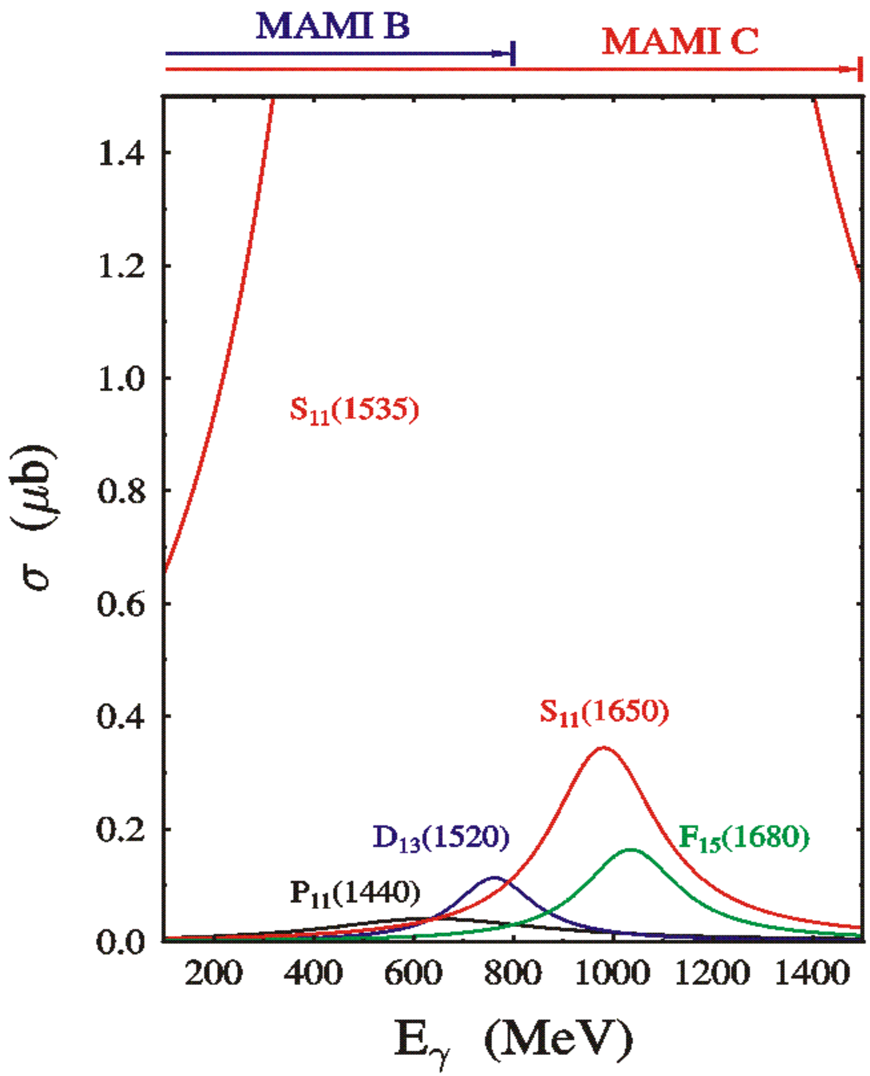
Pion Production

$\gamma + N \rightarrow N^* \rightarrow N + \pi$



Eta Production

$\gamma + N \rightarrow N^* \rightarrow N + \eta$



➡ polarisation observables essential

Observables in pseudoscalar meson prod.

(Barker, Donnachie & Storrow Nucl Phys B95 (1975))

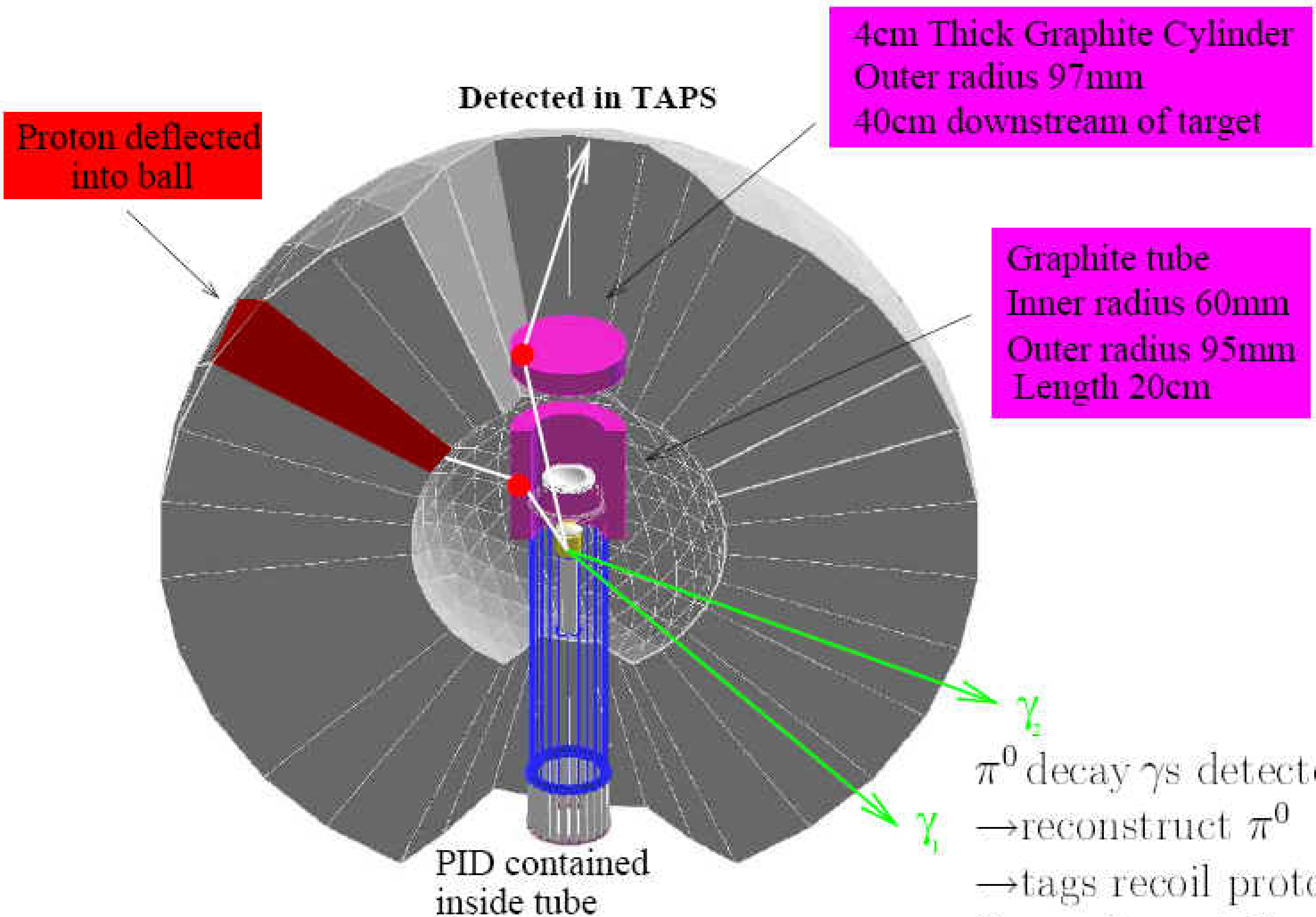
$$
\begin{aligned}
\rho_f \frac{d\sigma}{d\Omega} = \frac{1}{2}\left(\frac{d\sigma}{d\Omega}\right)_{unpol} \{ 1 - & P_\gamma^{lin} \Sigma \cos 2\phi + P_x (P_\gamma^{circ} F + P_\gamma^{lin} H \sin 2\phi) \\
& + P_y (T - P_\gamma^{lin} P \cos 2\phi) + P_z (P_\gamma^{circ} E + P_\gamma^{lin} G \sin 2\phi) \\
& + \sigma'_x [P_\gamma^{circ} C_x + P_\gamma^{lin} O_x \sin 2\phi + P_x (T_x - P_\gamma^{lin} L_z \cos 2\phi) \\
& + P_y (P_\gamma^{lin} C_z \sin 2\phi - P_\gamma^{circ} O_z) + P_z (L_x + P_\gamma^{lin} T_z \cos 2\phi] \\
& + \sigma'_y [P + P_\gamma^{lin} T \cos 2\phi + P_x (P_\gamma^{circ} G - P_\gamma^{lin} E \sin 2\phi) \\
& + P_y (\Sigma - P_\gamma^{lin} \cos 2\phi) + P_z (P_\gamma^{lin} F \sin 2\phi + P_\gamma^{circ} H)] \\
& + \sigma'_z [P_\gamma^{circ} C_z + P_\gamma^{lin} O_z \sin 2\phi + P_x (T_z + P_\gamma^{lin} L_x \cos 2\phi) \\
& + P_y (- P_\gamma^{lin} C_x \sin 2\phi - P_\gamma^{circ} O_z) + P_z (L_z + P_\gamma^{lin} T_x \cos 2\phi)] \}
\end{aligned}
$$

8 Observables needed for complete determination of this reaction

(worldwide combined efford: SPRING8, JLAB, GRAAL, ELSA, MAMI....)

Recoil polarimeter: Asymmetry of the produced protons

Next Beamtime



π^0 decay γs detected as normal

$\rightarrow$reconstruct π^0

$\rightarrow$tags recoil proton.

$p_{rec} = \gamma_{beam} + p_{target} - \pi^0$

Conclusion and Outlook

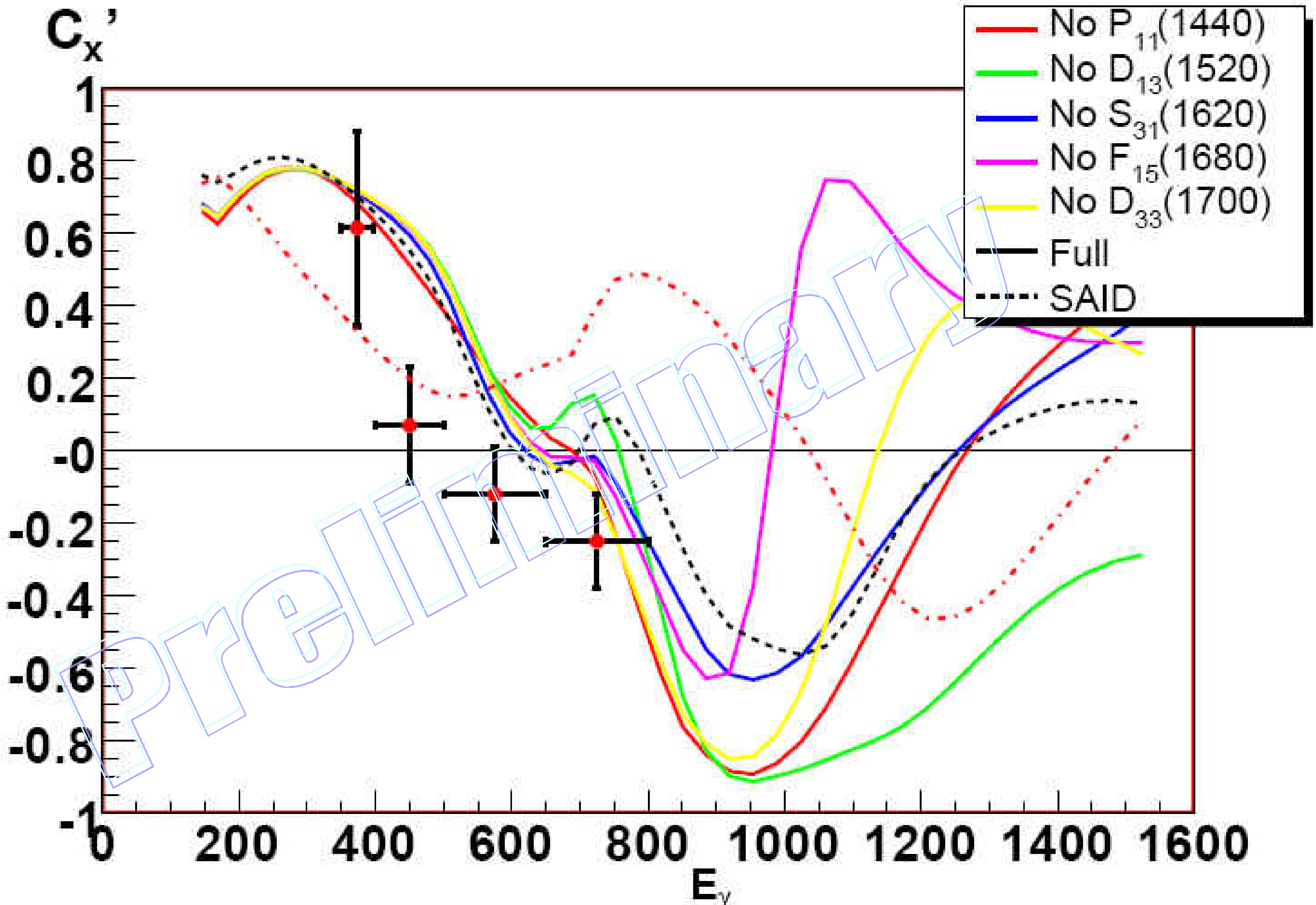
- MAMI C is delivering polarised beam with 1508 MeV and high Intensity for the experiments since 2007.

- Data from ‚Crystal Ball' detector in combination with TAPS and further detectors at MAMI B (882MeV) in the years 2004/5 are under analysis. First Publications planned for this year (Unpolarized and Beam polarized) :
  Measurement η-mass, rare η-decays, Dalitz Plot Parameter α, MDM

- Experiments with ‚Crystal Ball@MAMI C' (1507MeV) started. First measurement is dedicated to η' production with unpol. H_2 target.

- Future projects:
  In A2 we will do double polarised experiments with polarised beam, polarised target and recoil-polarimeter.
  A new NMR system for the PT is beiing constructed in collaboration with Bochum and Zagreb.

Recoil Polarimeter [D. Watts, D. Glazier]



Measurement of the Target Asymmetry of η and π^0 Photoproduction on the Proton

A. Bock,*,† G. Anton,* W. Beulertz,* Chr. Bradtke, H. Dutz, R. Gehring,‡ S. Goertz,‡ K. Helbing,* J. Hey,*
W. Meyer,‡ M. Plückthun, G. Reicherz,‡ and L. Sözüer*
Physikalisches Institut der Universität Bonn, Nußallee 12, D-53115 Bonn, Germany

M. Breuer, J. P. Didelez, and P. Hoffmann-Rothe
IN2P3, Institut de Physique Nucleaire, 91406 Orsay, France
(Received 4 August 1997)

!!!Transversely

Pol. Target

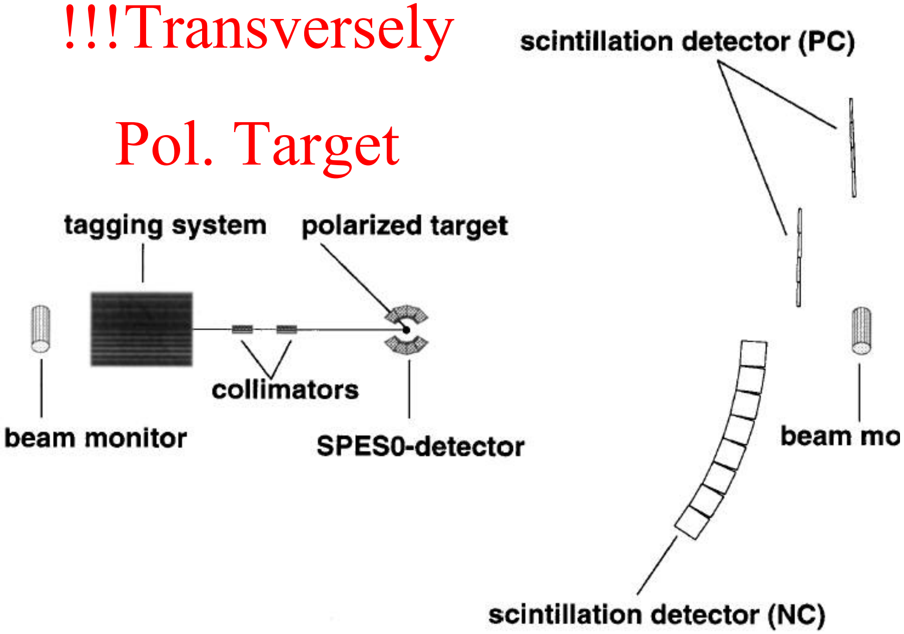
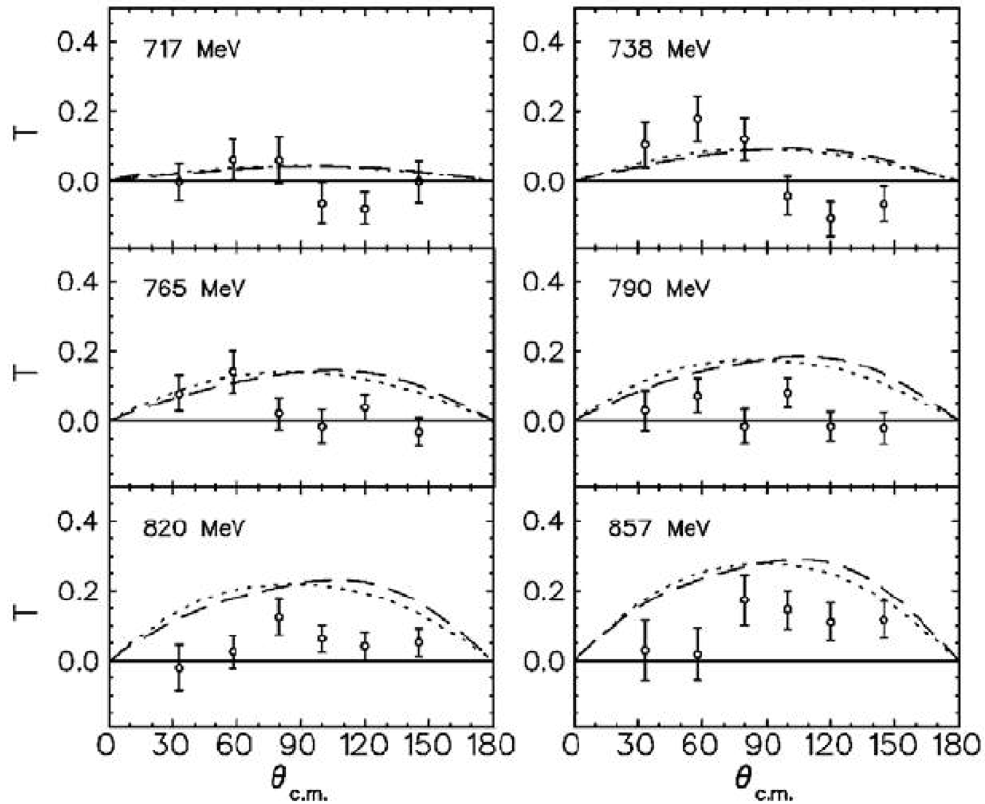
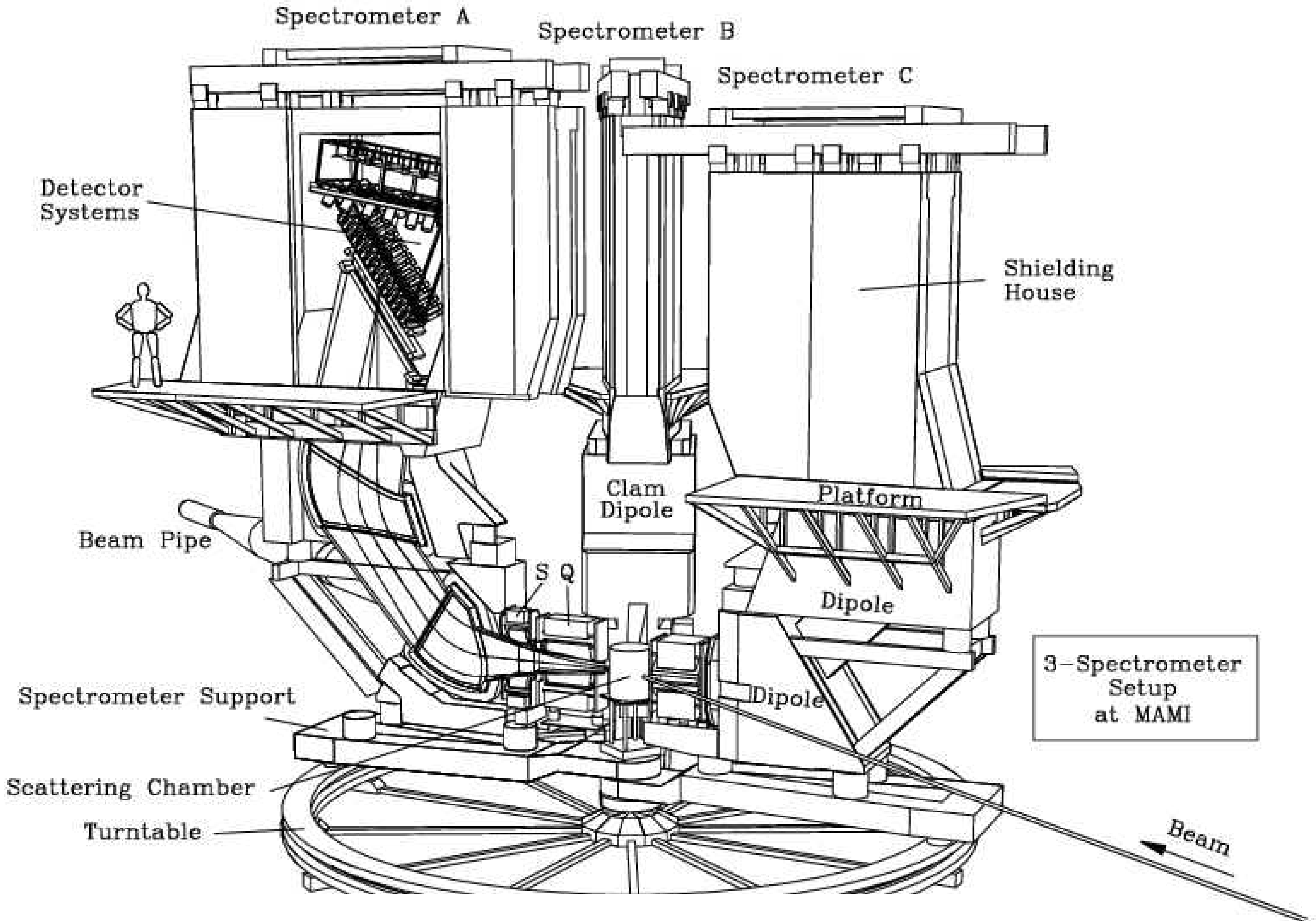


FIG. 1. Top view of the experimental setup.



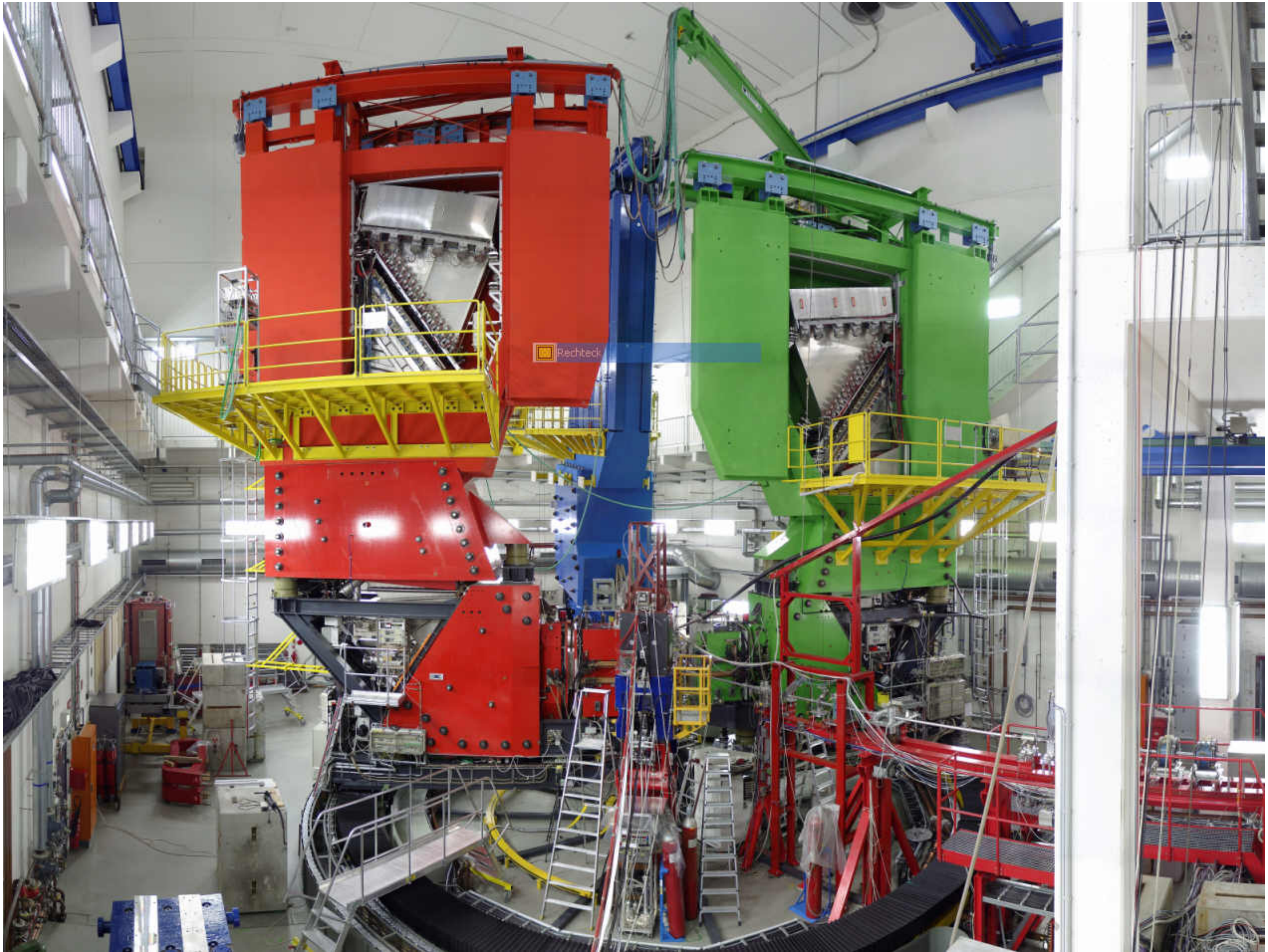
„Isobar“ models, e.g. EtaMaid (Breit-Wigner resonances + background) **failed !!**

Electroproduction of the η-Mesons at low Q^2



Three-Spectrometer-Setup A1: Electron scattering

Three-Spectrometer-Setup A1: Electron scattering

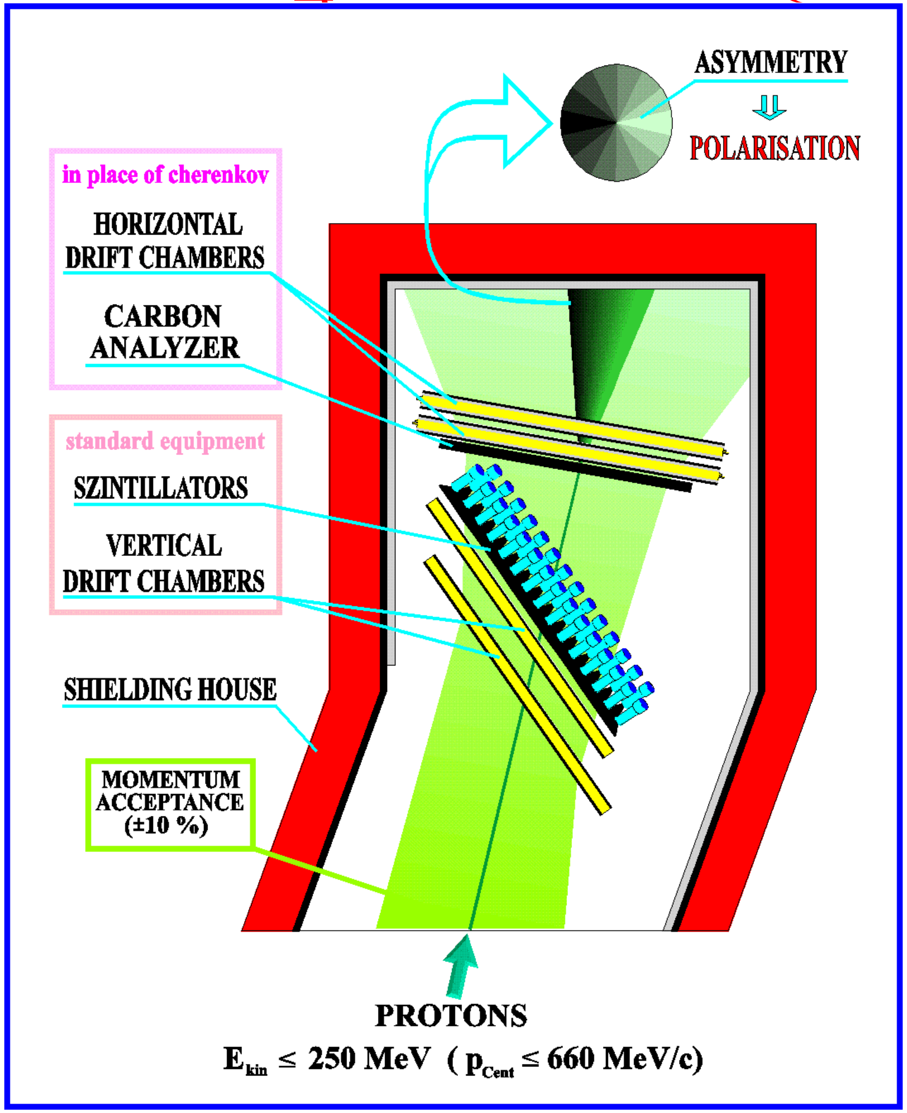


Electroproduction of the η-Mesons at low Q^2

$p(\vec{e},e'\vec{p})\eta$

Data taking 170h

I=10μA



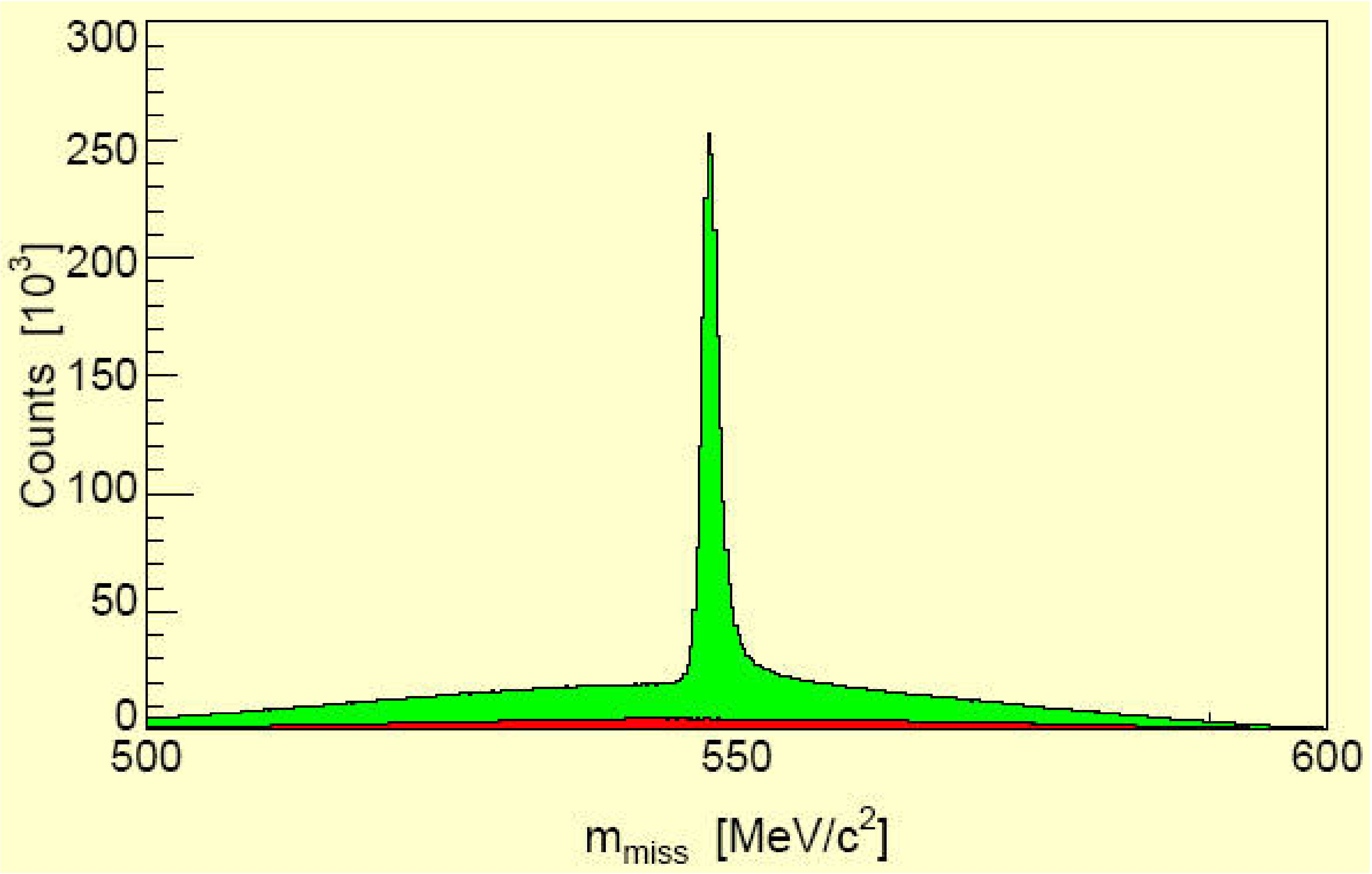
Kinematic:

$$\begin{aligned} E_0 &= 1508\,\text{MeV} \\ \theta_A &= 26.2^\circ \\ p_A &= 660.0\,\text{MeV}/c \\ \theta_B &= 18.0^\circ \\ p_B &= 678.3\,\text{MeV}/c \end{aligned}$$

$$\begin{aligned} q^2 &= -0.1\text{GeV}^2/c^2 \\ \epsilon &= 0.68 \\ W &= 1510\,\text{MeV} - 1540\,\text{MeV} \\ \theta_{CM} &= 120^\circ \\ \phi_{CM} &= 0^\circ \end{aligned}$$

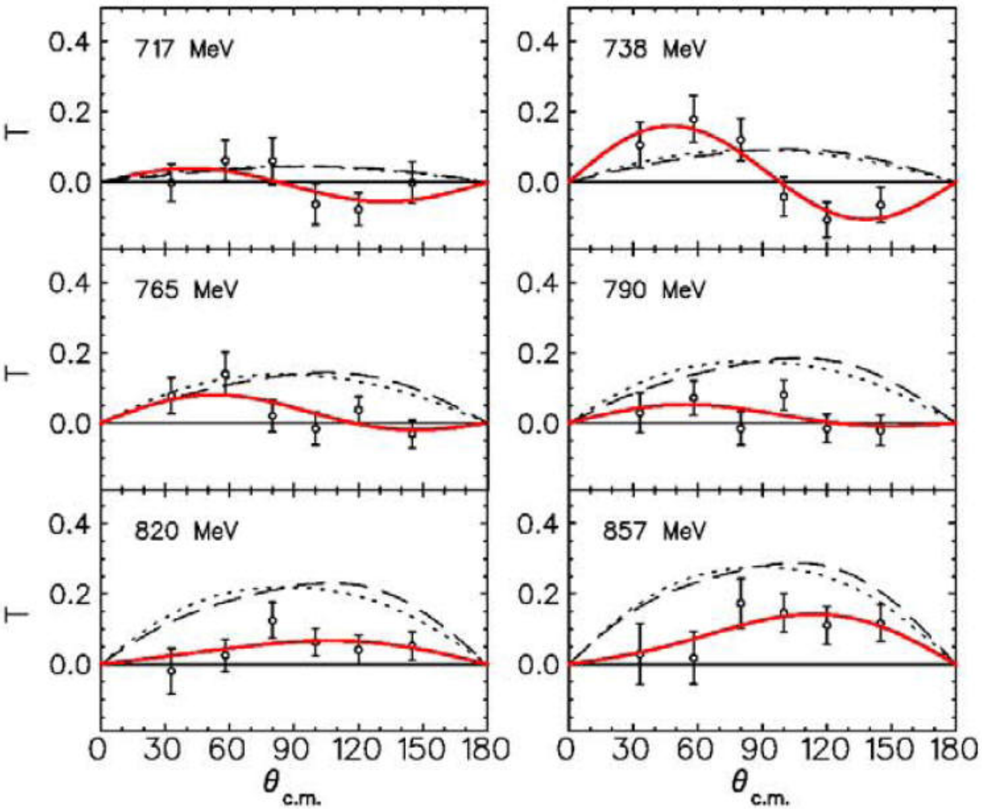
Measurement of the degree of proton recoil and electron polarisation (via Moeller polarimeter: 79%)

Reconstruction of the η-meson in the,missing mass‘- Spectrum



1.9 * 10^6 η-Mesons
Background ~ 10%
Random background ~2.5%

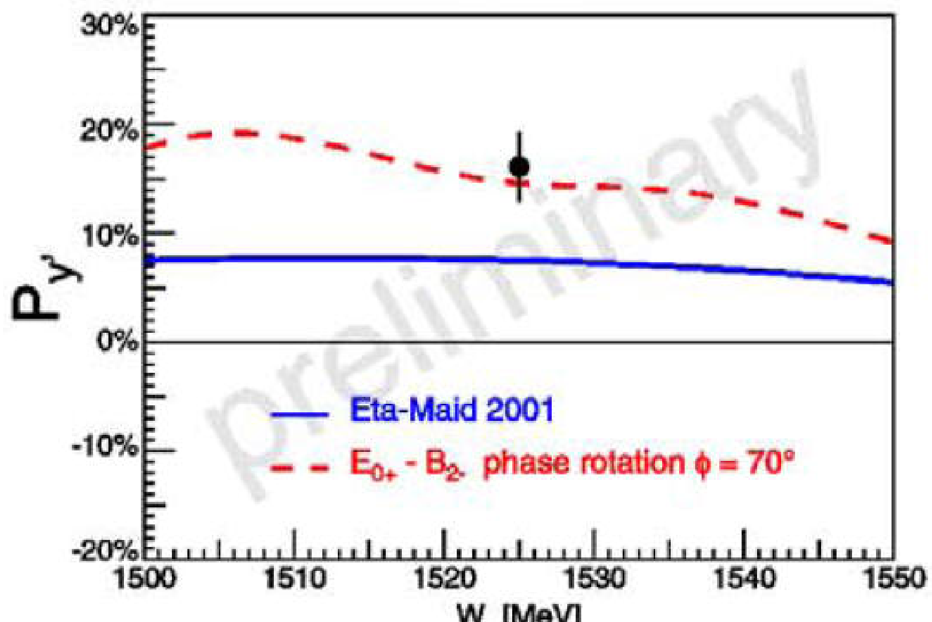
Goal of the measurement:
Cross-section + Recoil polarisation



16 polarization observables
in photoproduction of pseudoscalar mesons π,η,η', K

Photon		Target			Recoil			Target – Recoil			
	–	–	–	–	x'	y'	z'	x'	x'	z'	z'
	–	x	y	z	–	–	–	x	z	x	z
unpolarized	σ	0	T	0	0	P	0	$T_{x'}$	$-L_{x'}$	$T_{z'}$	$L_{z'}$
linear polariz.	$-\Sigma$	H	$(-P)$	$-G$	$O_{x'}$	$(-T)$	$O_{z'}$	$(-L_{z'})$	$(T_{z'})$	$(-L_{x'})$	$(-T_{x'})$
circular polariz.	0	F	0	$-E$	$-C_{x'}$	0	$-C_{z'}$	0	0	0	0

Red curves: Multipole analysis based on S11 dominance and data from dσ/dΩ, S and T
(strong phase change between E_{0+} and $E_{2-} + M_{2-}$)
L.Tiator *et al.*, Phys. Rev. C60 035210 (1999)



Recoil polarization and beam-recoil double polarization measurement of η electroproduction on the proton in the region of the S11(1535) resonance
H. Merkel *et al.*, arXiv:0705.3550v1 , submitted to Phys. Rev. Lett.

KaoS Spectrometer

short live-time of the kaons ($c\tau_K$=3.71 m)

short orbit Spectrometer in forward direction

- Very compact magnetic spectrometer suitable especially for the detection of kaons.
- Detectors for triggering, particle identification and momentum determination by ray-tracing.
- Plastic scintillator hodoscopes, Cherenkov detectors and wire chambers.

The GDH collaboration

J.Ahrens[9], S.Altieri[15,16], J.R.M.Annand[6], G.Anton[3], H.-J.Arends[9], K.Aulenbacher[9], R.Beck[9], C.Bradtke[1], A.Braghieri[15], N.Degrande[4], N.d'Hose[5], H.Dutz[2], S.Goertz[1], P.Grabmayr[17], K.Hansen[8], J.Harmsen[1], S.Hasegawa[13], T.Hasegawa[11], E.Heid[9], K.Helbing[3], H.Holvoet[4], L.VanHoorebeke[4], N.Horikawa[14], T.Iwata[13], P.Jennewein[9], T.Kageya[14], B.Kiel[2], F.Klein[2], R.Kondratiev[12], K.Kossert[7], J.Krimmer[17], M.Lang[9], B.Lannoy[4], R.Leukel[9], V.Lisin[12], T.Matsuda[11], J.C.McGeorge[6], A.Meier[1], D.Menze[2], W.Meyer[1], T.Michel[3], J.Naumann[3], A.Panzeri[15,16], P.Pedroni[15], T.Pinelli[15,16], I.Preobrajenski[9,12], E.Radtke[1], E.Reichert[10], G.Reicherz[1], Ch.Rohlof[2], G.Rosner[6], D.Ryckbosch[4], F.Sadiq[6], M.Sauer[17], B.Schoch[2], M.Schumacher[7], B.Seitz[7], T.Speckner[3], M.Steigerwald[9], N.Takabayashi[13], G.Tamas[9], A.Thomas[9], R.van de Vyver[4], A.Wakai[14], W.Weihofen[7], F.Wissmann[7], F.Zapadtka[7], G.Zeitler[3]

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[15,16] INFN Sezione di Pavia and Dept. of Nucl. Physics of the University, Pavia, Italy
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J.W. Price, **California State University, Dominguez Hills, Carson, CA, USA**

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H. Staudenmaier, **Universität Karlsruhe, Karlsruhe, Germany**

D.M. Manley, K.Bantawa **Kent State University, Kent, USA**

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D. Sober, **Catholic University, Washington DC**

M. Vanderhaeghen, **College of Williams and Mary, Williamsburg, USA**

Run	2004/2005 →	700 Stunden Tests 3600 Stunden Datennahme	12 PhD

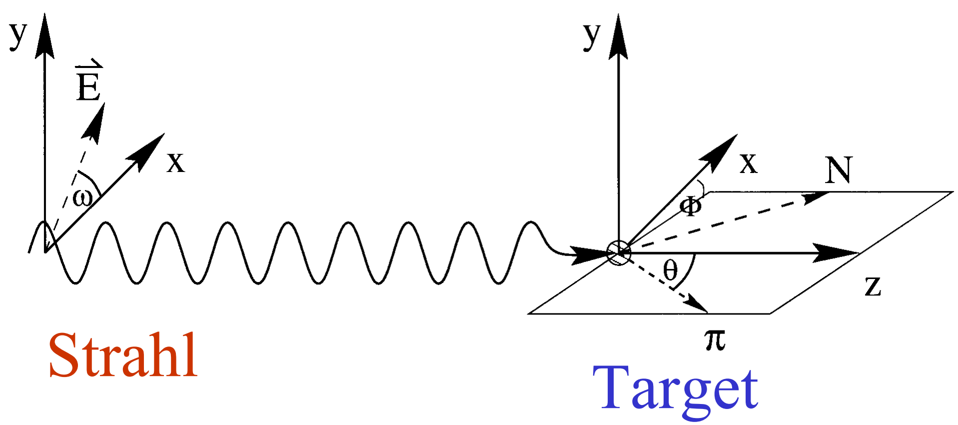
Photoproduction of pseudoscalar π, η, η‘, K with polarised beam and target

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{unpol} \Big[1 - P_\gamma^{lin}\Sigma(\theta)\cos(2\phi)$$

$$+ P_x\left[-P_\gamma^{lin}H(\theta)\sin(2\phi) + P_\gamma^{circ}F(\theta)\right]$$

$$+ P_y\left[-T(\theta) + P_\gamma^{lin}P(\theta)\cos(2\phi)\right]$$

$$+ P_z\left[-P_\gamma^{lin}G(\theta)\sin(2\phi) + P_\gamma^{circ}E(\theta)\right]\Big]$$

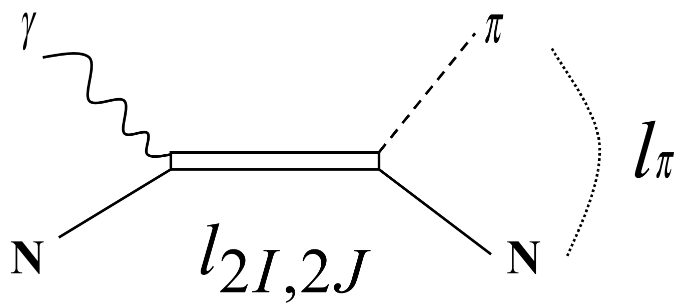


Beam / Target	[illegible] unpol	$P_{[illegible]}^{lin}$	$P_{[illegible]}^{lin}$	$P_{[illegible]}^{circ}$
Target		[illegible] 0, [illegible] 2 [illegible]	[illegible] 4 , [illegible] 4 [illegible]	
P_{unpol}	[illegible] d [illegible] / d [illegible]	[illegible] (θ)	-	-
P_x	-	-	$H(\theta)$	$F(\theta)$
P_y	$T(\theta)$	$P(\theta)$	-	-
P_z	-	-	$G(\theta)$	$E(\theta)$

Pion Photoproduction with Polarized Beam and Polarized Target

$$L = l_{\gamma N} + 1$$

EL, ML



$E_{l\pm}, M_{l\pm}$

Multipole components of the electromagnetic radiation

Angular momentum and parity conservation

$$J^P(\gamma N) = J^P(R) = J^P(\pi N)$$

Angular momentum

$$L \pm \frac{1}{2} = J = l_\pi \pm \frac{1}{2}$$

Parity

EL : $(-1)^L = (-1)^{l_\pi + 1} \Rightarrow |L - l_\pi| = 1$

ML : $(-1)^{L+1} = (-1)^{l_\pi + 1} \Rightarrow L = l_\pi$

Multipole amplitudes:

$$E_{l+}, E_{l-}, M_{l+}, M_{l-}$$

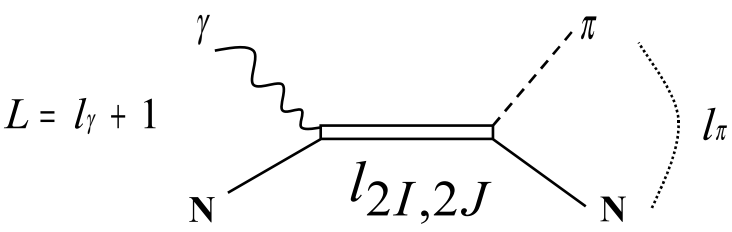
$J = l + \frac{1}{2}$ (→ E_{l+})

$J = l - \frac{1}{2}$ (→ M_{l-})

Connection between ▪1/2 and ▪3/2 and Multipoles and Resonances

π-prod. –> Δ(1232) –>E2/M1 ->Deformation

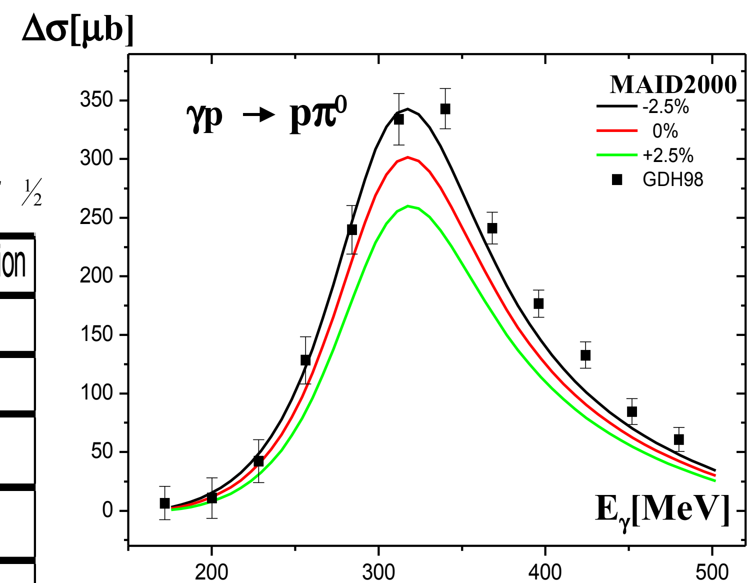
[Phys. Rev. Lett. 84, 5950 (2000)]

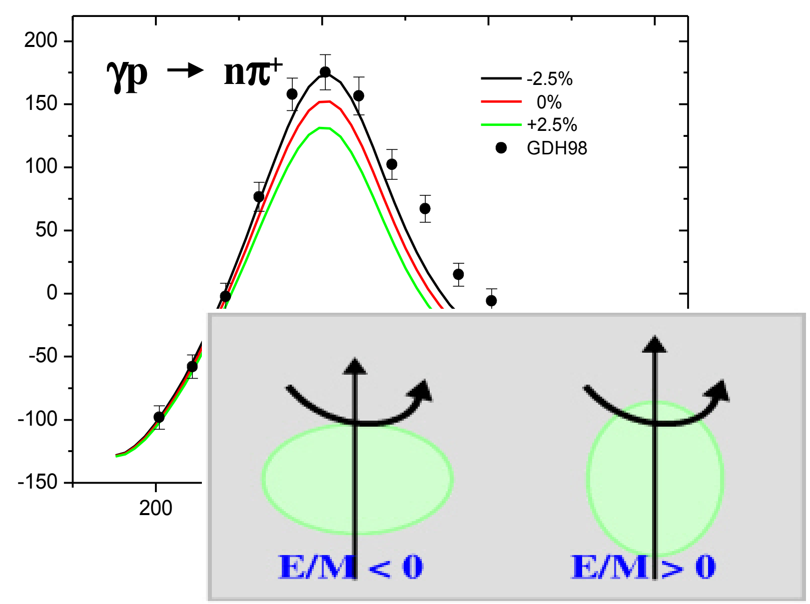


$$\Delta\sigma = \sigma_{3/2} - \sigma_{1/2}$$

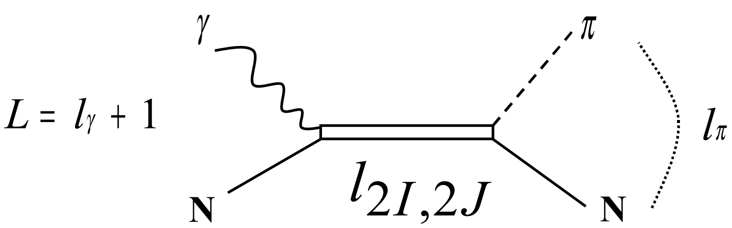
Photon L	Photon Multipole	Total J	P	Pion l_π	Multipole Amplitude	Resonance	Contribution to Δσ
1	E1	1/2	-	0	E_{0+}	S_{11}	-
		3/2	-	2	E_{2-}	D_{13}	+
	M1	1/2	+	1	M_{1-}	P_{11}	-
		3/2	+	1	M_{1+}	P_{33}	+
2	E2	3/2	+	1	E_{1+}	P_{33}	-
		5/2	+	3	E_{3-}	F_{15}	+
	M2	3/2	-	2	M_{2-}	D_{13}	-
		5/2	-	2	M_{2+}	D_{15}	+

$$\Delta\sigma = 8\pi \frac{q}{k}\left\{ -|E_{0+}|^2 - 3|E_{1+}|^2 - 6\mathrm{Re}\{E_{1+}^* M_{1+}\} + |M_{1+}|^2 - |M_{1-}|^2 + |E_{2-}|^2 + 6\mathrm{Re}\{E_{2-}^* M_{2-}\} \pm \ldots\ldots \right\}$$





Connection between ▪½ and ▪3/2 and Multipoles and Resonances



$\Delta\sigma = \sigma_{3/2} - \sigma_{1/2}$

Photon	Photon	Total		Pion	Multipole	Resonance	Contribution
L	Multipole	J	P	l_π	Amplitude		to Δσ
1	E1	1/2	-	0	E_{0+}	S_{11}	-
		3/2	-	2	E_{2-}	D_{13}	+
	M1	1/2	+	1	M_{1-}	P_{11}	-
		3/2	+	1	M_{1+}	P_{33}	+
2	E2	3/2	+	1	E_{1+}	P_{33}	-
		5/2	+	3	E_{3-}	F_{15}	+
	M2	3/2	-	2	M_{2-}	D_{13}	-
		5/2	-	2	M_{2+}	D_{15}	+

$$\Delta\sigma = 8\pi \frac{q}{k}\left\{ \begin{array}{l} -\left|E_{0+}\right|^2 - 3\left|E_{1+}\right|^2 - 6\,\mathrm{Re}\{E_{1+}^{*} M_{1+}\} + \left|M_{1+}\right|^2 \\ -\left|M_{1-}\right|^2 + \left|E_{2-}\right|^2 + 6\,\mathrm{Re}\{E_{2-}^{*} M_{2-}\} \pm \ldots\ldots\ldots \end{array} \right\}$$

2nd Resonance region –> D_{13}(1520)

–>Resonance Parameters 20% changed

[Phys. Rev. Lett. 88 (2002) 232002]

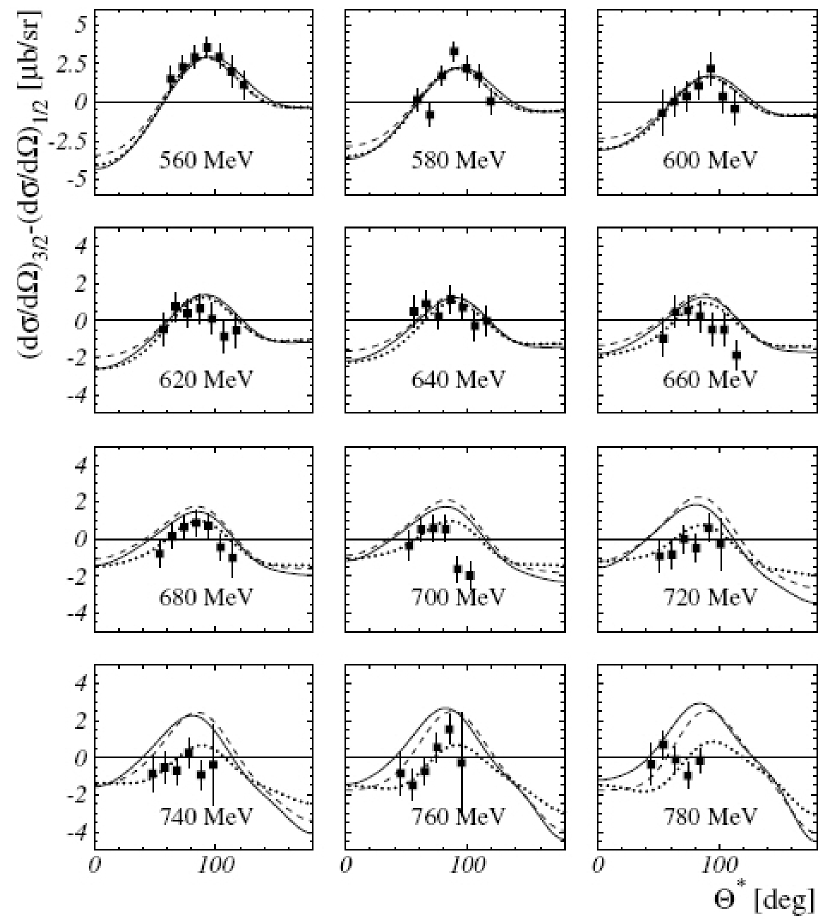
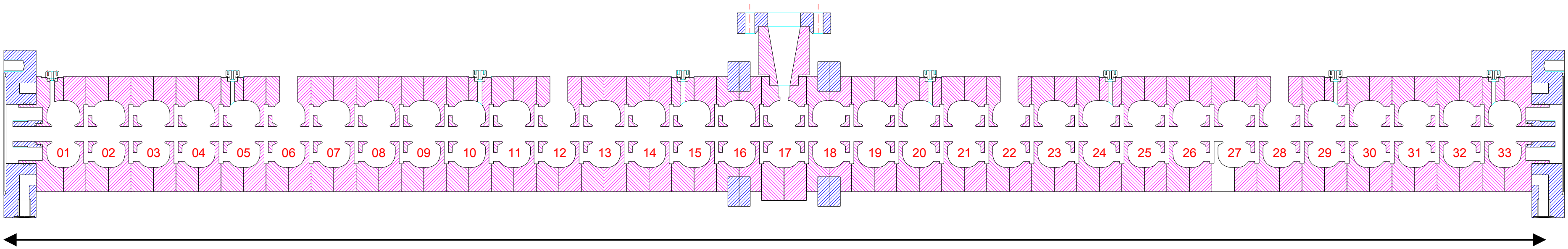


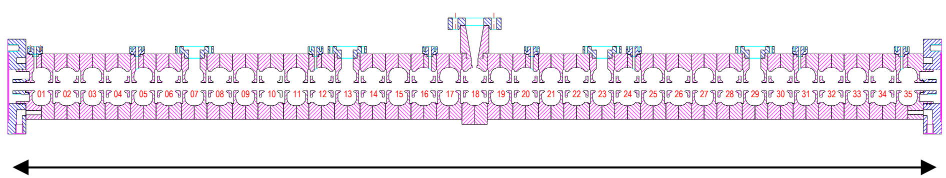
FIG. 3. The measured helicity dependent differential cross section Δ_{31} for $\vec{\gamma}\vec{p} \to p\pi^0$ (solid squares). The errors shown are statistical only. Curves as in Fig. 2.

2,45GHz MAMI Section

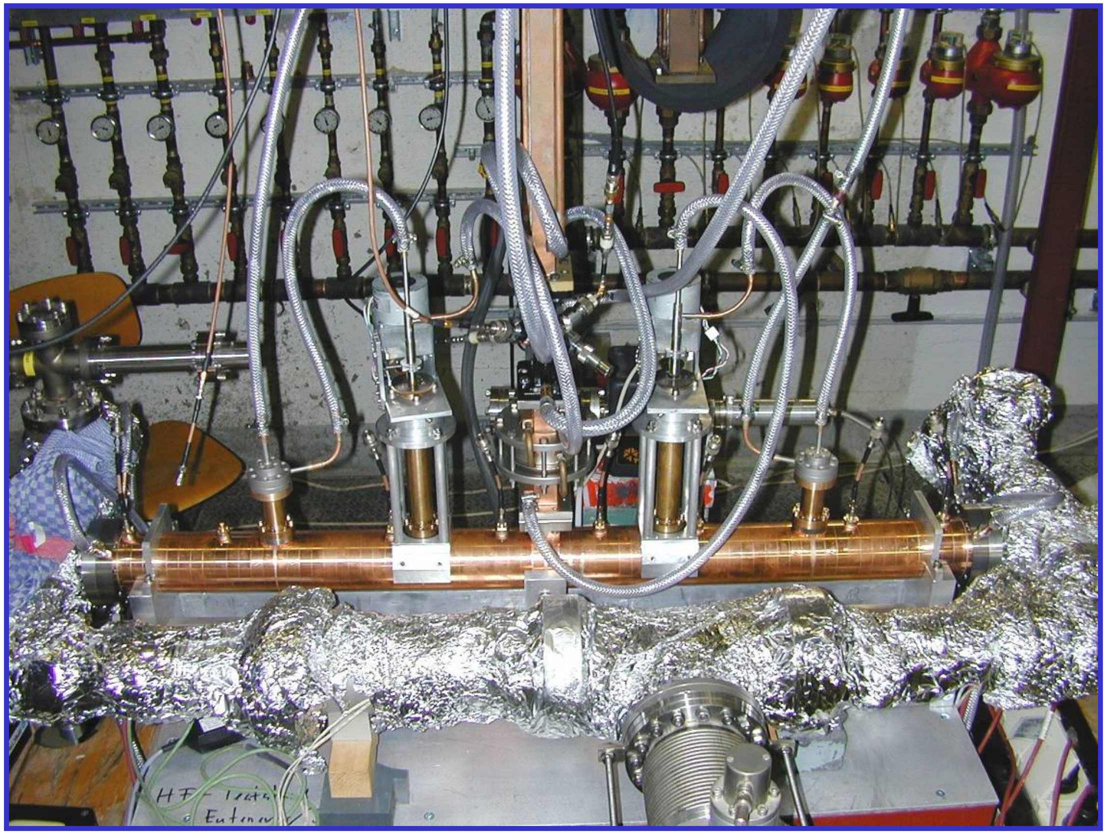


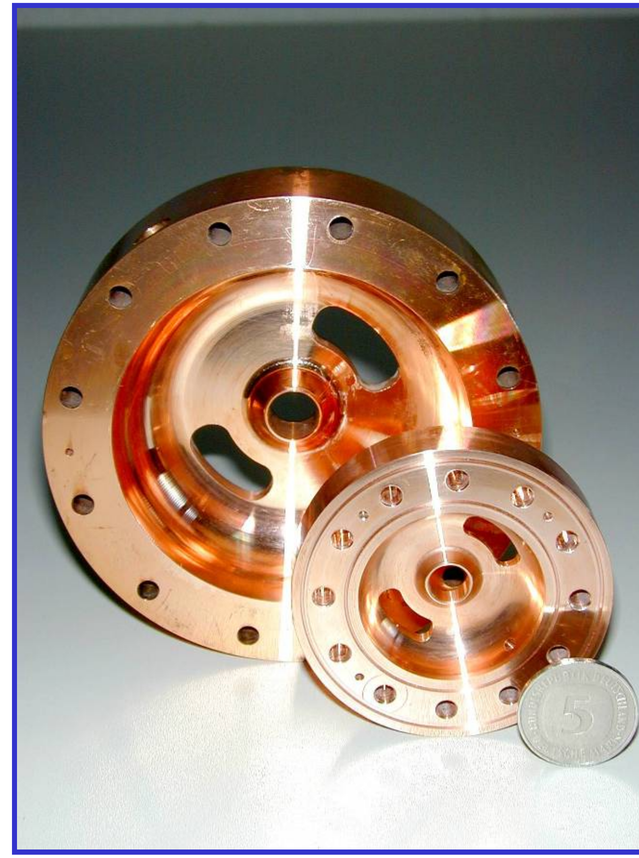
l=2,07m

Worldwide first 4,90GHz Linac Section. Prototype developed, constructed and tested at IKPH,



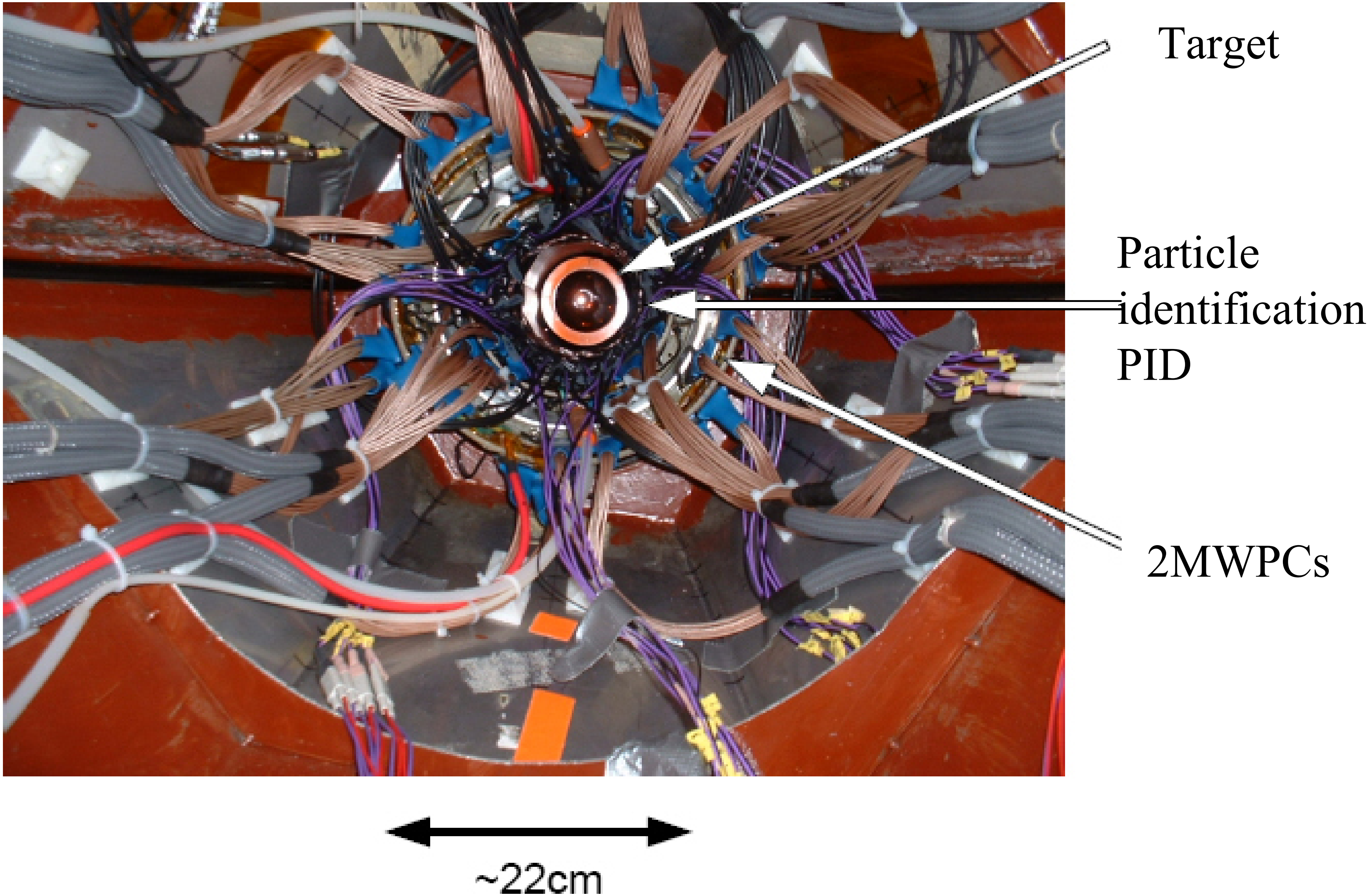
l=1,12m



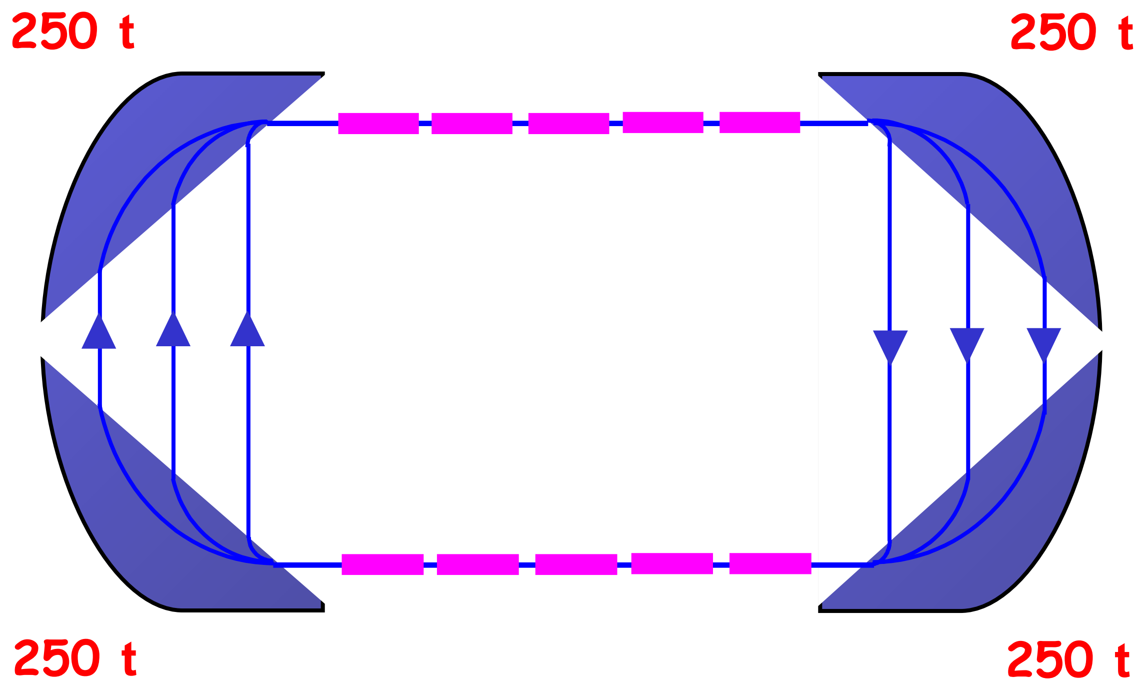


Polished Cupper Surface (~ 0,0005mm) !
Geometry better 0,005mm !

15m Linear Sections with 9mm aperture !
(43 turns, overall 2000m pathlength in HDSM)

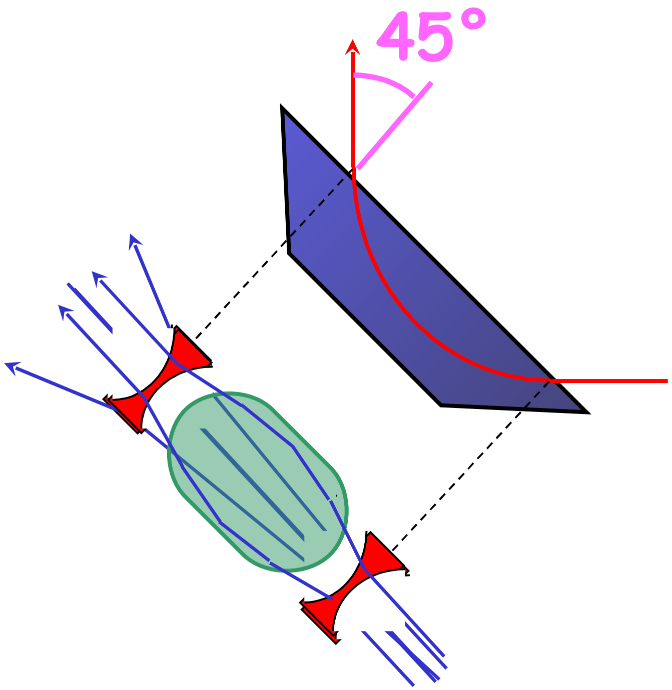

Target
Particle
identification
PID
2MWPCs
~22cm

Double Sided Microtron
(K.H. Kaiser et al.)

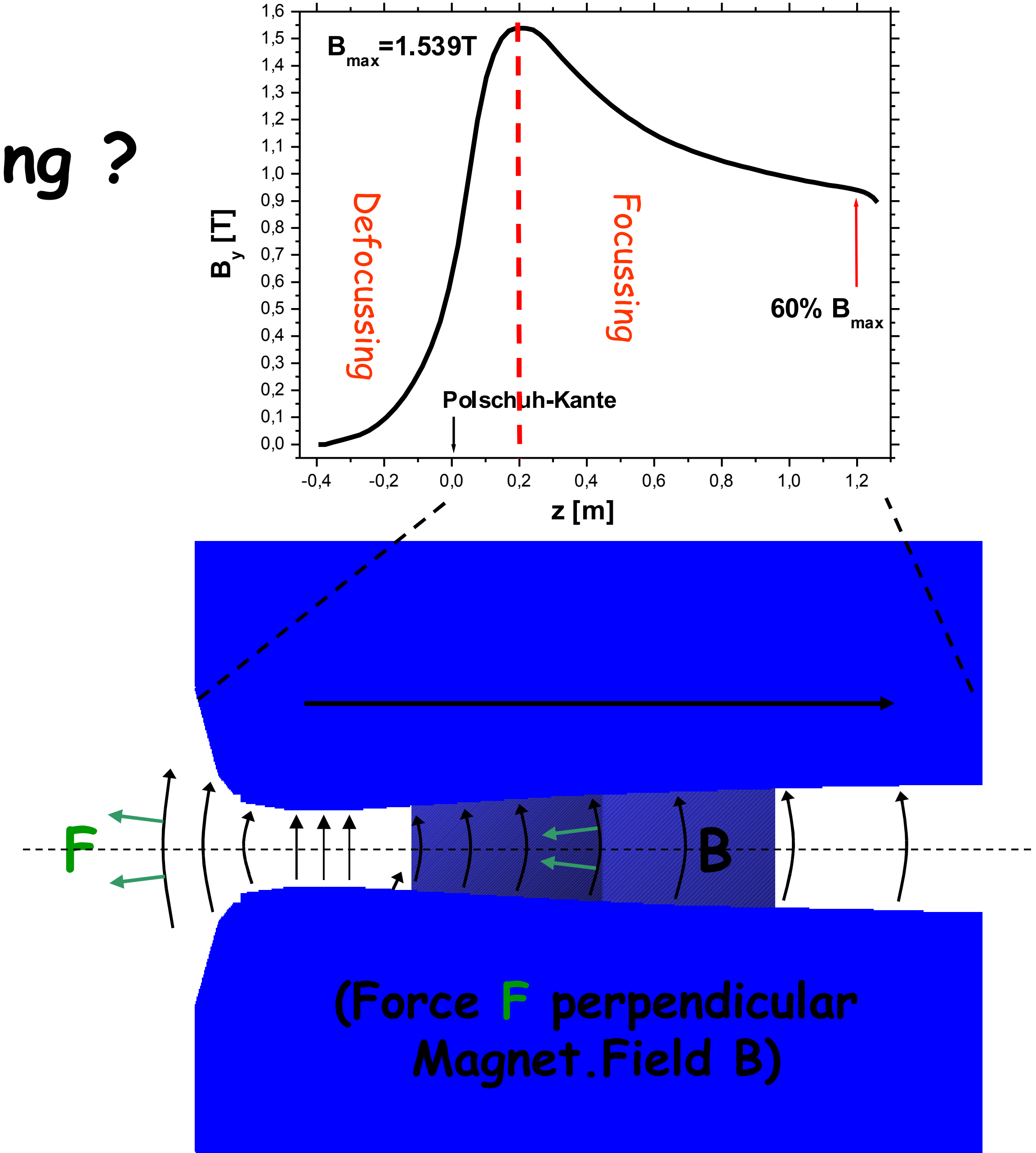


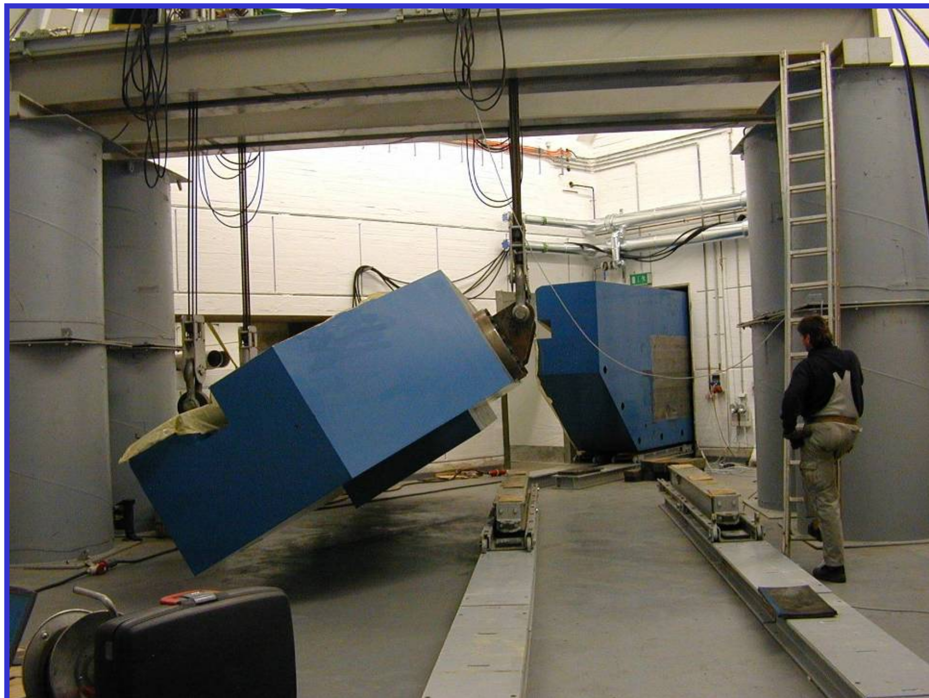
43 Turns, 855MeV → 1,5GeV

Compensation of 45°-Edge-Defocussing ?

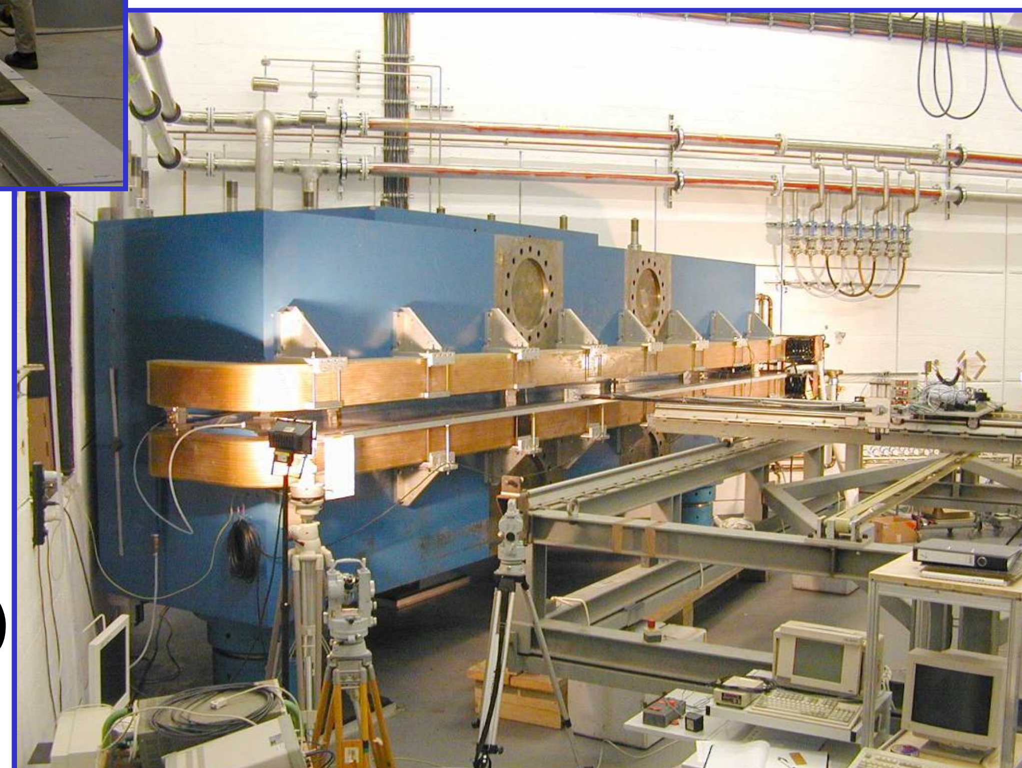


Dipole with Fieldgradient

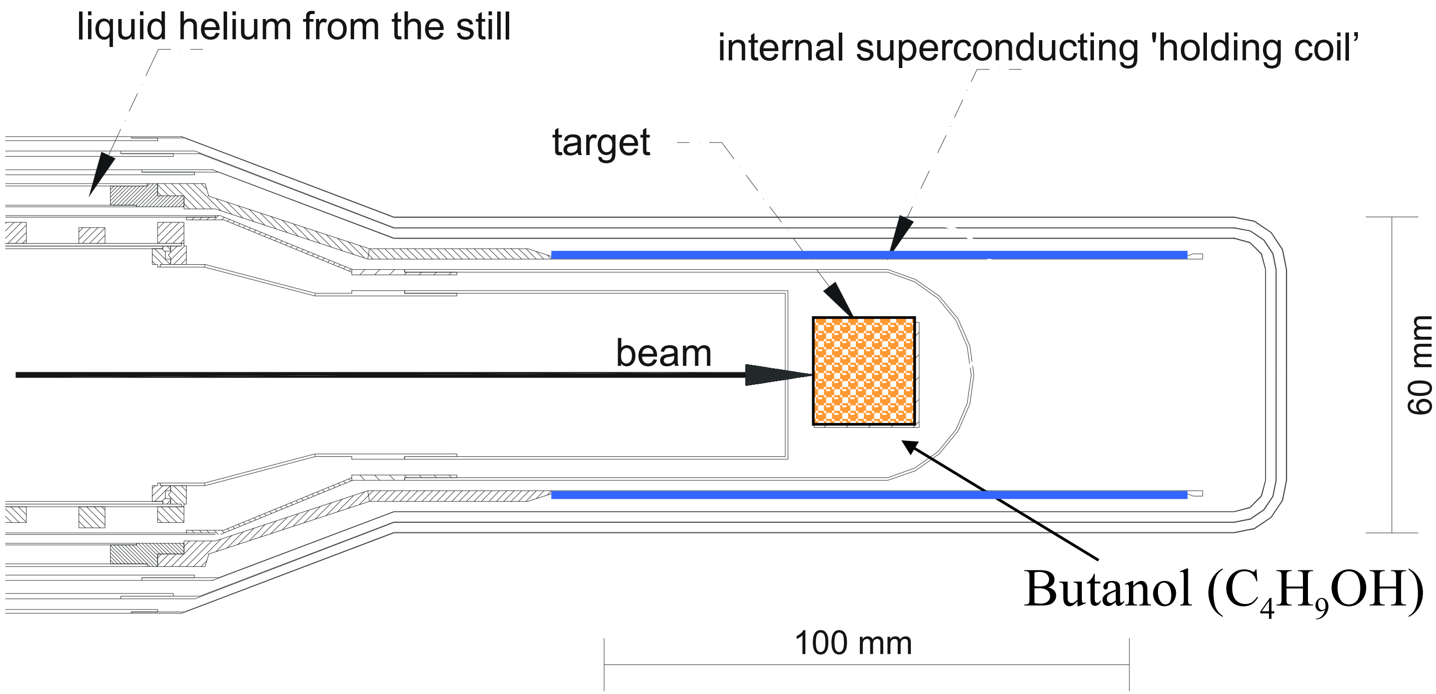


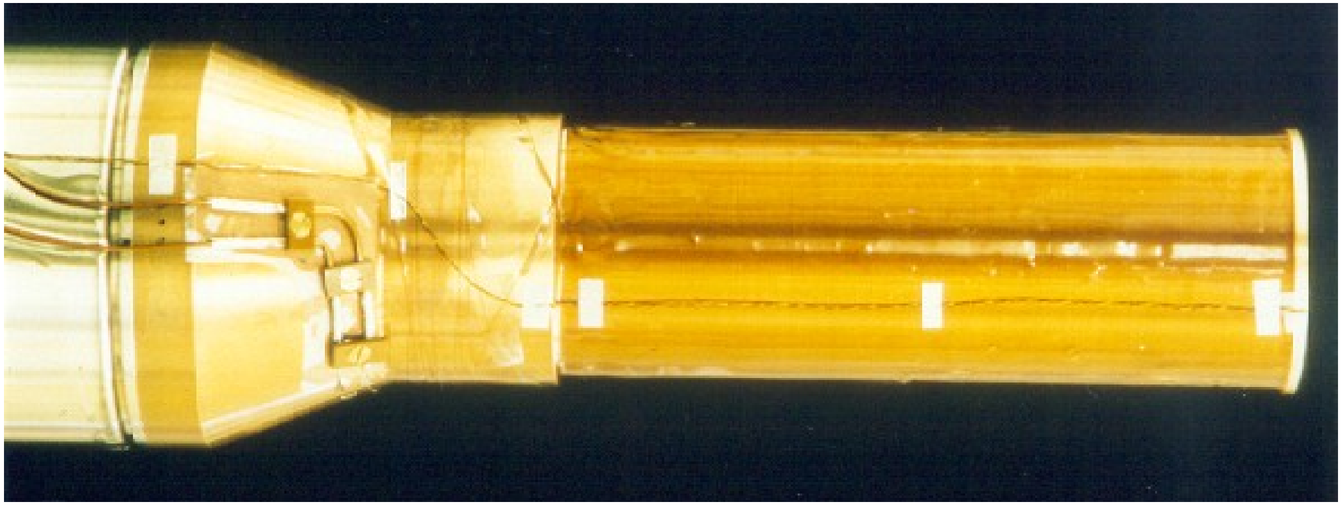


250t, 1.539T
90° Dipole Magnet



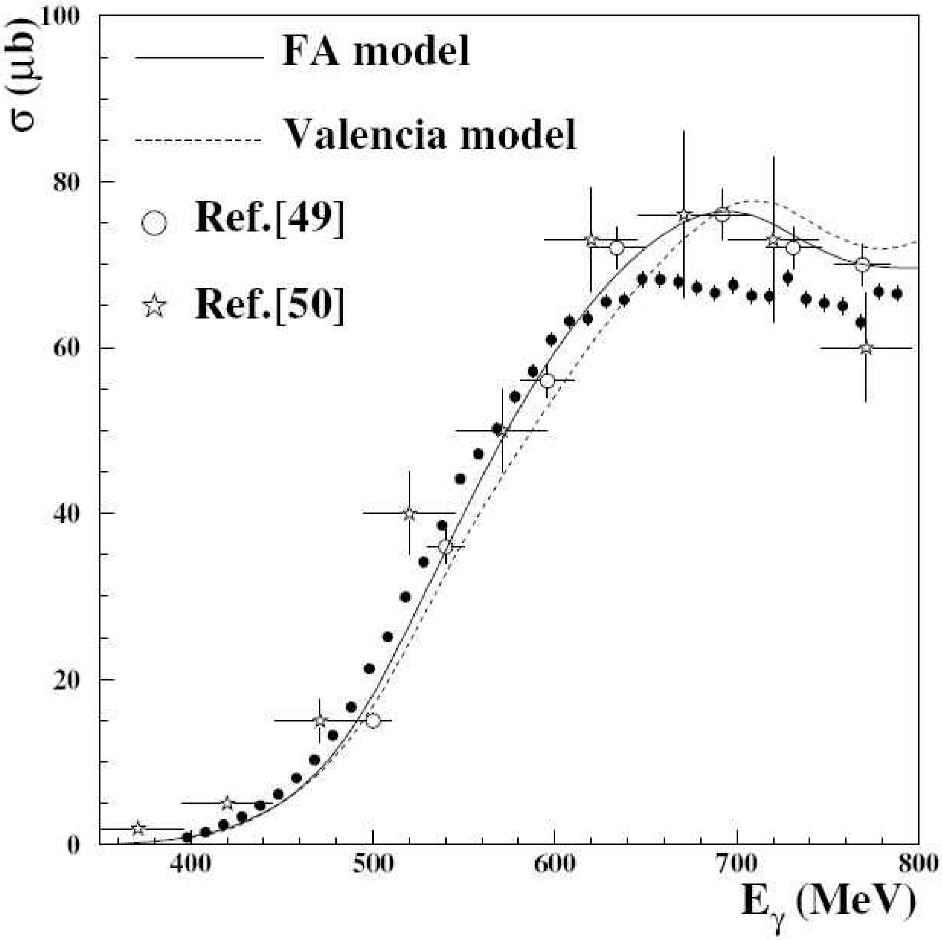
Designed at IKPH
Produced 2002 in close
Collaboration with
Industrial company (France)

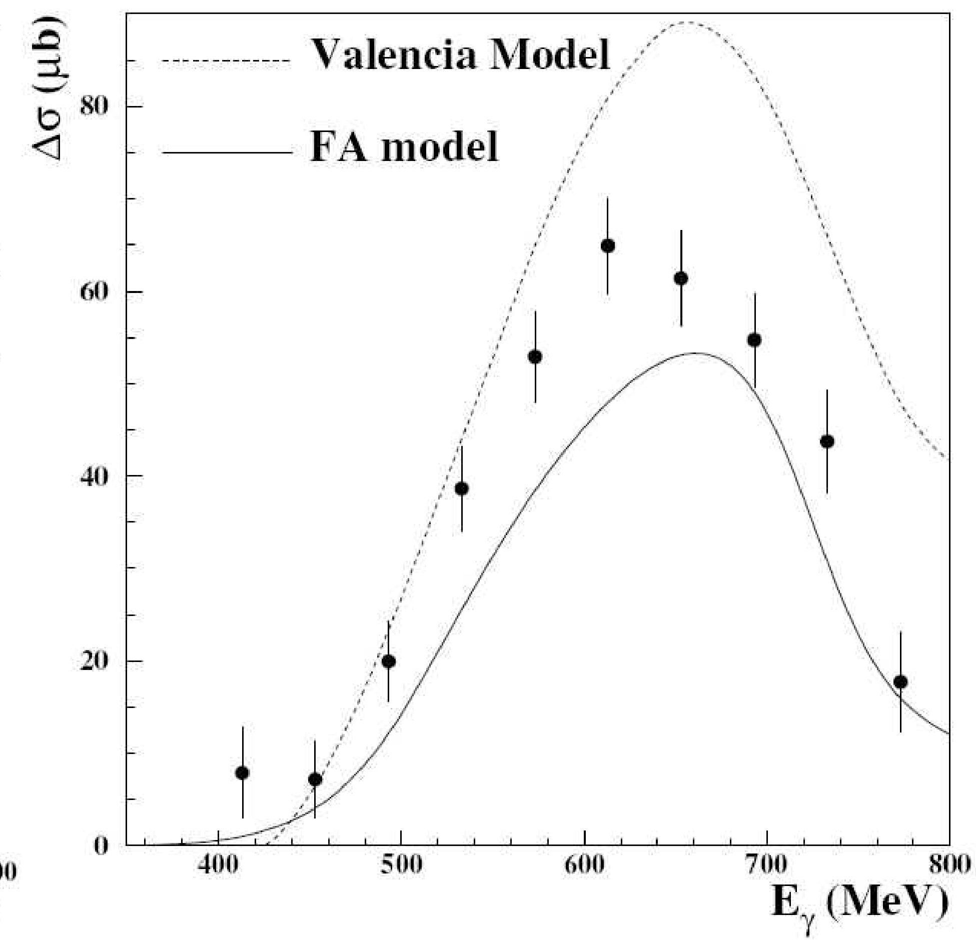

liquid helium from the still
internal superconducting 'holding coil'
target
beam
60 mm
Butanol (C_4H_9OH)
100 mm



New: First measurement of the helicity dependence for the $\gamma p \rightarrow p\pi^+\pi^-$ reaction

J.Ahrens et al., submitted to EPJ A



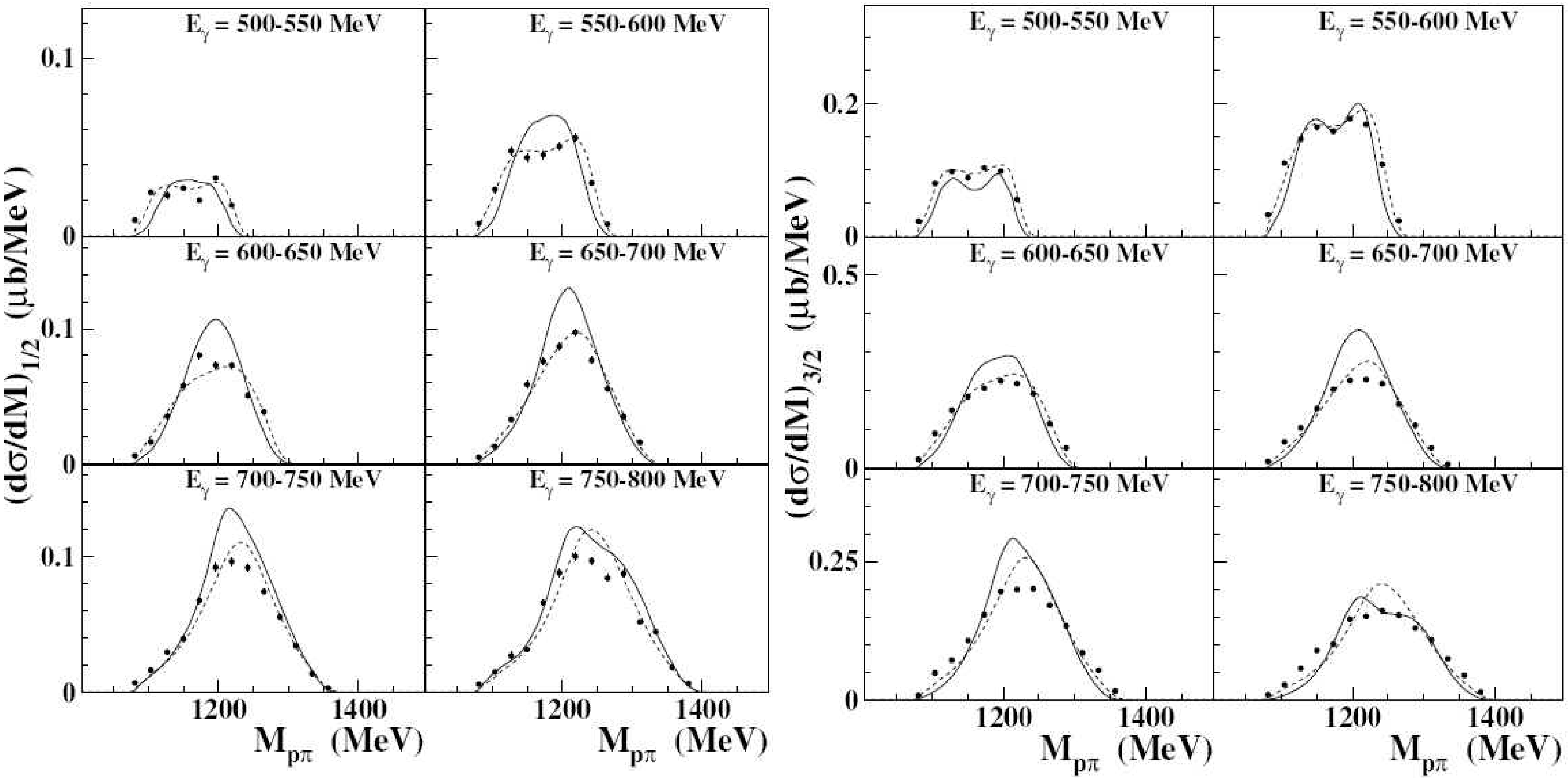


FA [A. Fix and H. Arenhövel, Eur. Phys. J. A 25 (2005) 115.]

Effective Lagrangian approach including four-star resonances with masses up to 1700 MeV.

Valencia model [J. Nacher and E. Oset, Nucl. Phys. A 697 (2002) 372.]

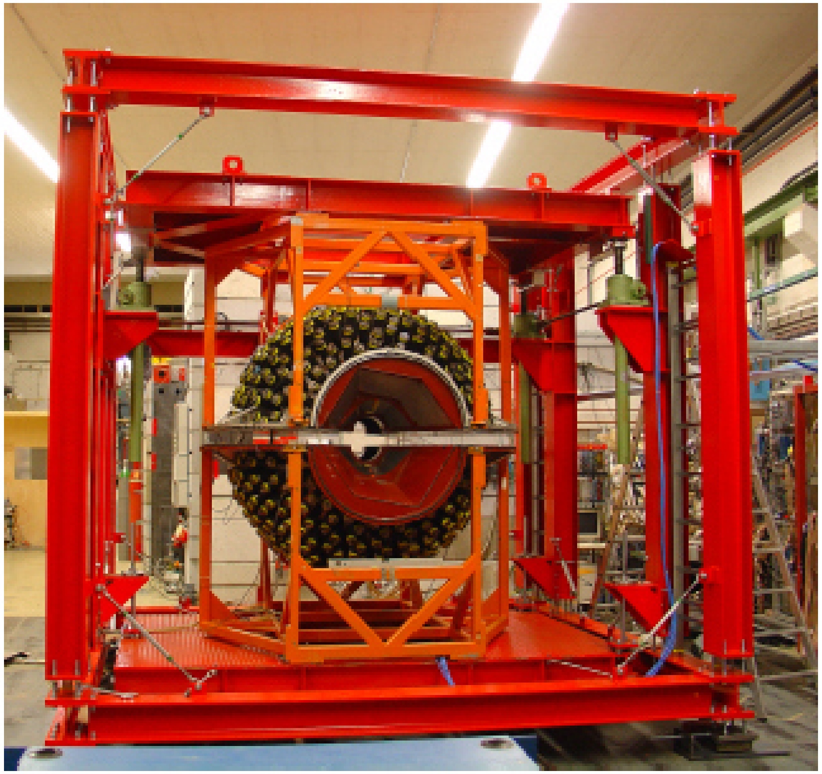
Kinematical overdetermination in DAPHNE acceptance →
Experimental helicity dependent invariant mass distributions for the pπ system



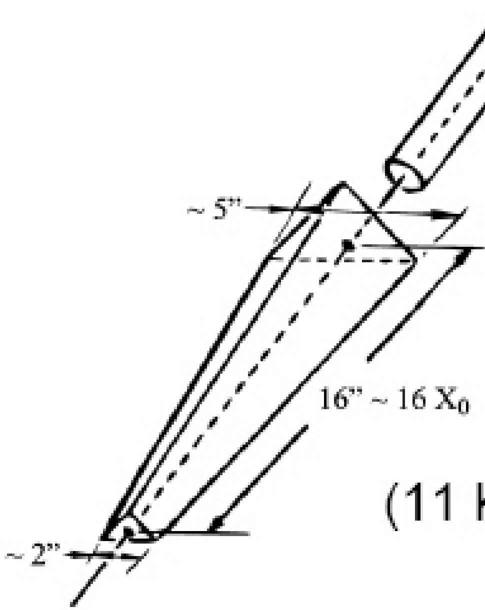
Full curves: [A. Fix and H. Arenhövel, Eur. Phys. J. A 25 (2005) 115.]
Dashed: simple DPPS model - uniform Δπ phase space distribution

➡ Further theoretical and experimental studies needed to check prod. mechanism.

Crystal Ball Detector: UCLA



672 NaI(Tl) Kristalle
35cm (~16 Strahlungslängen)



(11 Kristallformen)

Energieauflösung:

$$\frac{\sigma_E}{E} = \frac{2.7/100}{\sqrt[4]{E(GeV)}}$$

Winkelauflösung:

$$\sigma_\theta = 2° - 3°$$

$$\sigma_\phi = 2°/\sin\theta$$