Polarized Target for Photon Induced Double Polarization Experiments at ELSA

D1 project Bochum – W. Meyer

Single pion photoproduction

$$A = A(\lambda_\gamma,\ \lambda_1,\ \lambda_2;\ E,\ \theta)$$
$$= H_i\ (E,\ \theta) \quad i = 1..4 \qquad H_i:\ \text{helicity amplitudes}$$

Diff. cross section

Target asymmetry

Beam-Target asymmetry

$$\frac{d\sigma}{d\Omega} \sim |H_1|^2 + |H_2|^2 + |H_3|^2 + |H_4|^2$$
$$T \sim \mathrm{Im}\left(H_1 H_2^* - H_4 H_3^*\right)$$
$$E \sim |H_4|^2 + |H_2|^2 - |H_1|^2 + |H_3|^2$$

$$T = \frac{1}{P_y} \cdot \frac{1}{f}\ \frac{N\uparrow - N\downarrow}{N\uparrow + N\downarrow}$$

P_y : target polarization

f : dilution factor

$N\uparrow,\downarrow$: counting rates

Observables in pseudoscalar meson photoproduction

			Polarization* of		
			γ	Target	Recoil
1.	$d\sigma/d\Omega$	differential cross section			
- Single polarization measurements:					
2.	P	recoil polarization asymmetry			y'
3.	Σ	polarized photon asymmetry	p		
4.	T	polarized target asymmetry		y	
- Double polarization measurements:					
Beam - Target					
5.	E		c	z	
6.	F		c	x	
7.	G		t	z	
8.	H		t	x	
Beam - Recoil					
9.	C_x		c		x'
10.	C_z		c		z'
11.	O_x		t		x'
12.	O_z		t		z'
Target - Recoil					
13.	T_x			x	x'
12.	T_z			x	z'
15.	L_x			z	x'
16.	L_z			z	z'

* quantization axes are defined as follows:

$\hat{z} : \hat{k}$, $\hat{y} : \hat{k} \times \hat{q}$, $\hat{x} = \hat{y} \times \hat{z}$,

$\hat{z}' : \hat{q}$, $\hat{y}' : \hat{k} \times \hat{q}$, $\hat{x}' = \hat{y}' \times \hat{z}'$,

p: photon linearly polarized (0, π/2 w.r.t. scattering plane)

c: photon circularly polarized

t: photon linearly polarized (± π/4 w.r.t. scattering plane)

Asymmetry Measurements with Polarized
Beams & Pure Polarized Targets

$$A = \frac{1}{P_b} \cdot \frac{1}{P_t} \cdot \frac{N\rightleftarrows - N\rightrightarrows}{N\rightleftarrows + N\rightrightarrows}$$

P_b : beam pol.
P_t : target pol.

But: All pol. targets have a fraction of unpol. material

Def.: dilution factor (quality factor) $f = \frac{\text{\# of polarizable nucleons}}{\text{\# of all nucleons in the target}}$

solid targets

$f = 0.1 \quad .... \quad 0.3 \quad .... \quad 0.5 \quad ..... \quad 0.9 \quad = A = \frac{1}{P_b} \cdot \frac{1}{P_t} \cdot \frac{1}{f} \cdot \frac{N\uparrow - N\downarrow}{N\uparrow + N\downarrow}$

^{3}He-Gastargets

internal Gastargets

$$FOM_{target} \sim \frac{1}{\text{running time}} \text{ at a given } \frac{\Delta A}{A}$$

$$\boxed{FOM_{target} = \mathcal{L} \cdot P_b^2 \cdot P_t^2 \cdot f^2}$$

$\mathcal{L}$ = Luminosity

optimize + $\Delta\Omega$

Measurement Time: $t \propto \left(\frac{1}{P_t \cdot f} \right)^2$

Target materials

main qualities

- Polarization (monitored via NMR)
- Dilution Factor (polarizable nuclei)

\+ secondary qualities

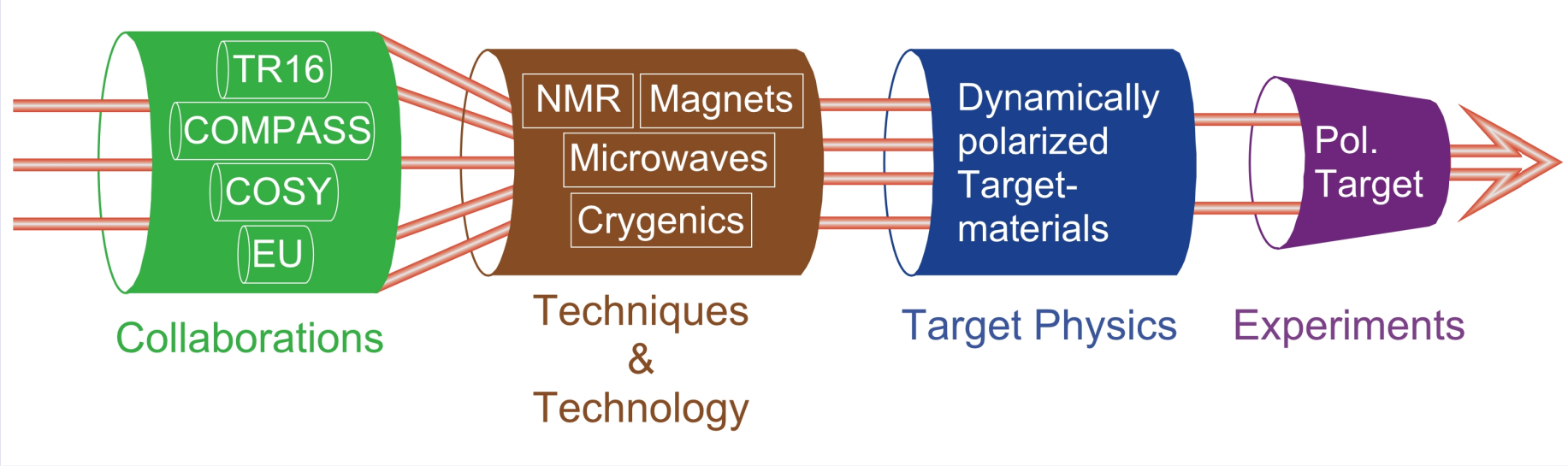
- Slow relaxation
- Beam resistance
- Easy to handle
- Short build up time

needed: **unpaired electrons** as *polarization centers*

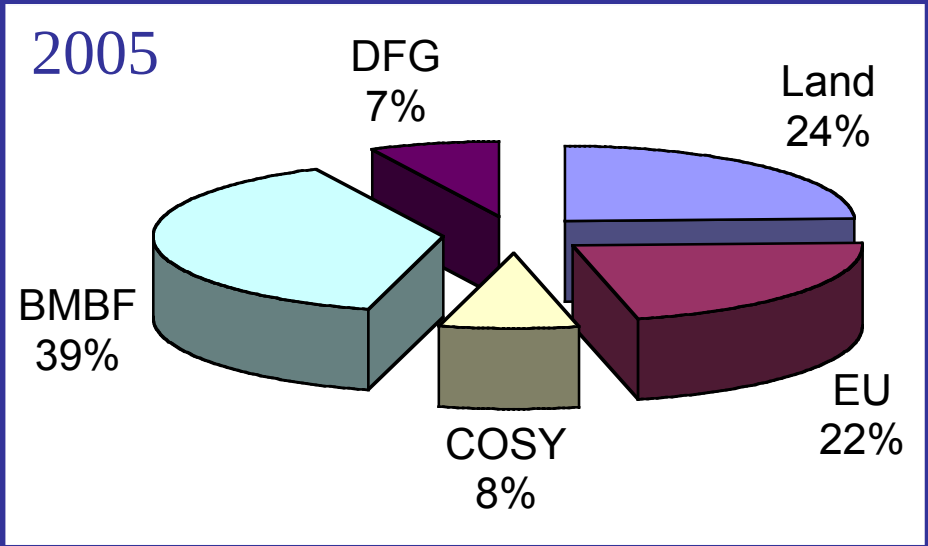
Standard materials: alcohols, ammonia, ^{6}LiD

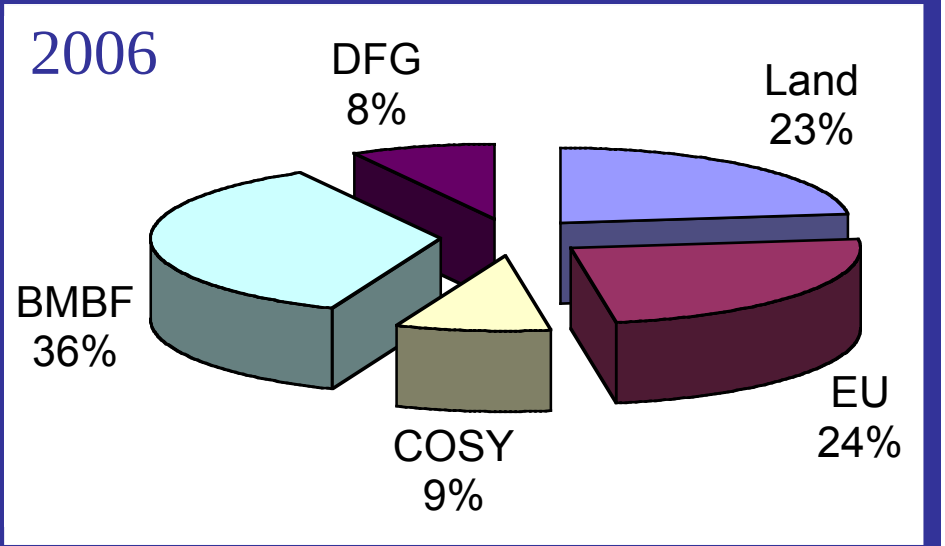
Polarized Target Bochum

N. Doshita, F. Gautheron, F. Greffrath, J. Heckmann, Chr. Heß, K. Horikawa, Y. Kisselev, J. Koivuniemi, W. Meyer, E. Radtke, G. Reicherz, M. Schiemann, Li Wang



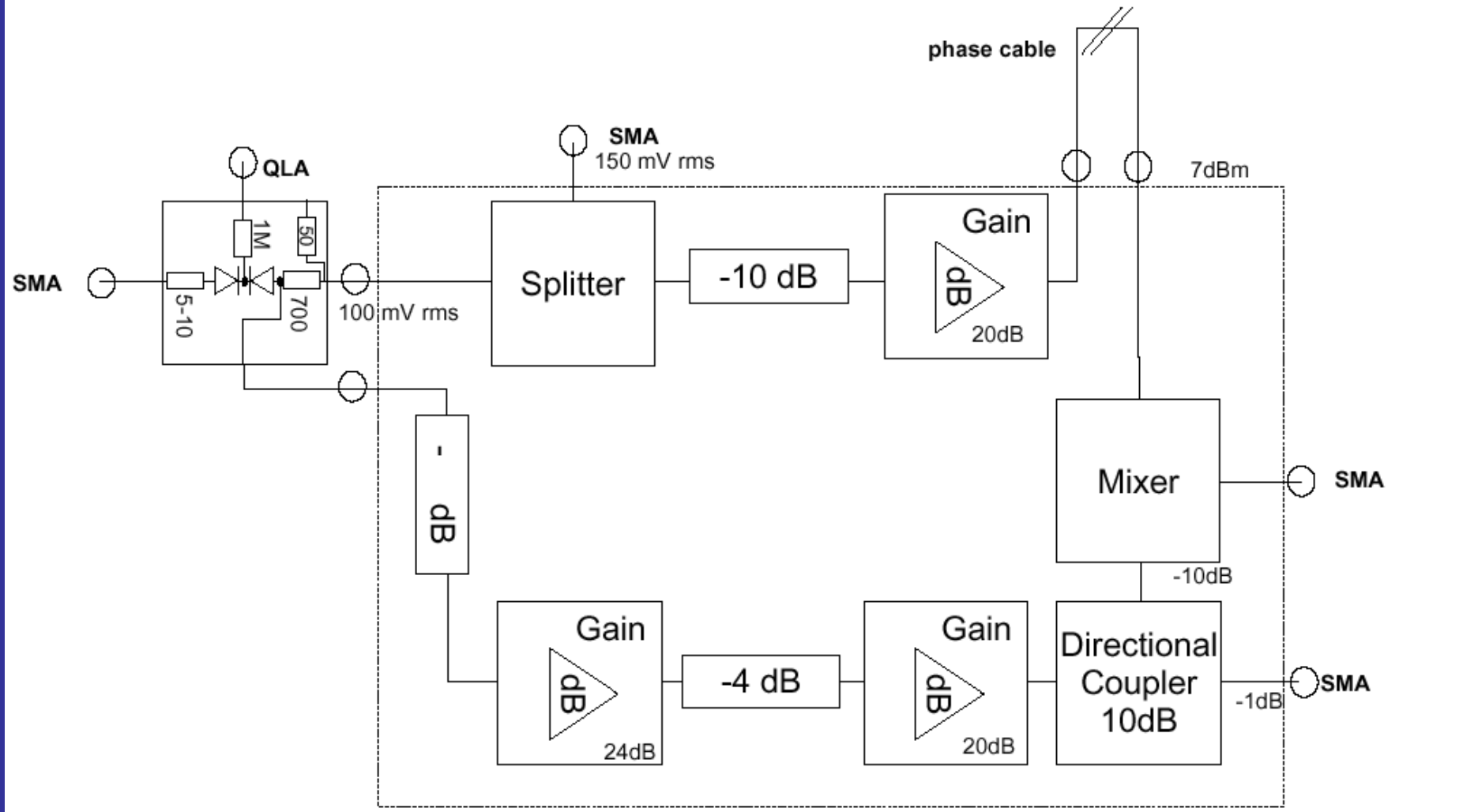
D1-Bochum



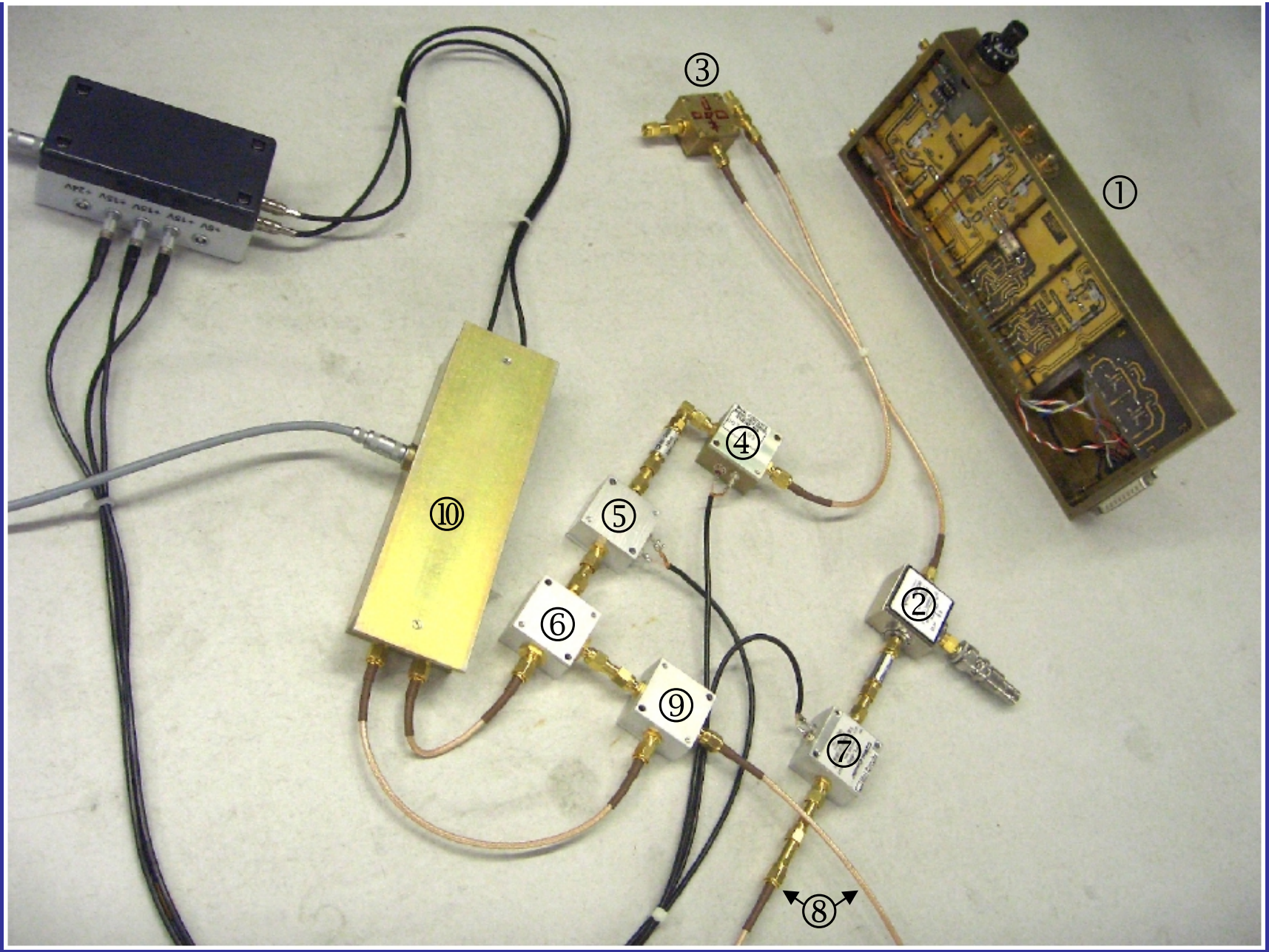


- 1/2 BAT IIa (Radtke, Heckmann – variable periods from 04-06)
- Helium Consumption – Bochum Univ., DFG (main part)
- Small Instruments – Polarized target running in Bochum
- Investments (> 10.000 €) for microwave components
  - ⇒ transverted to urgent needed NMR-components
  - ⇓
  - precise and reliable polarization determination
  - ⇒ BONN–ELSA experiments

New Bochum CW–NMR–Box

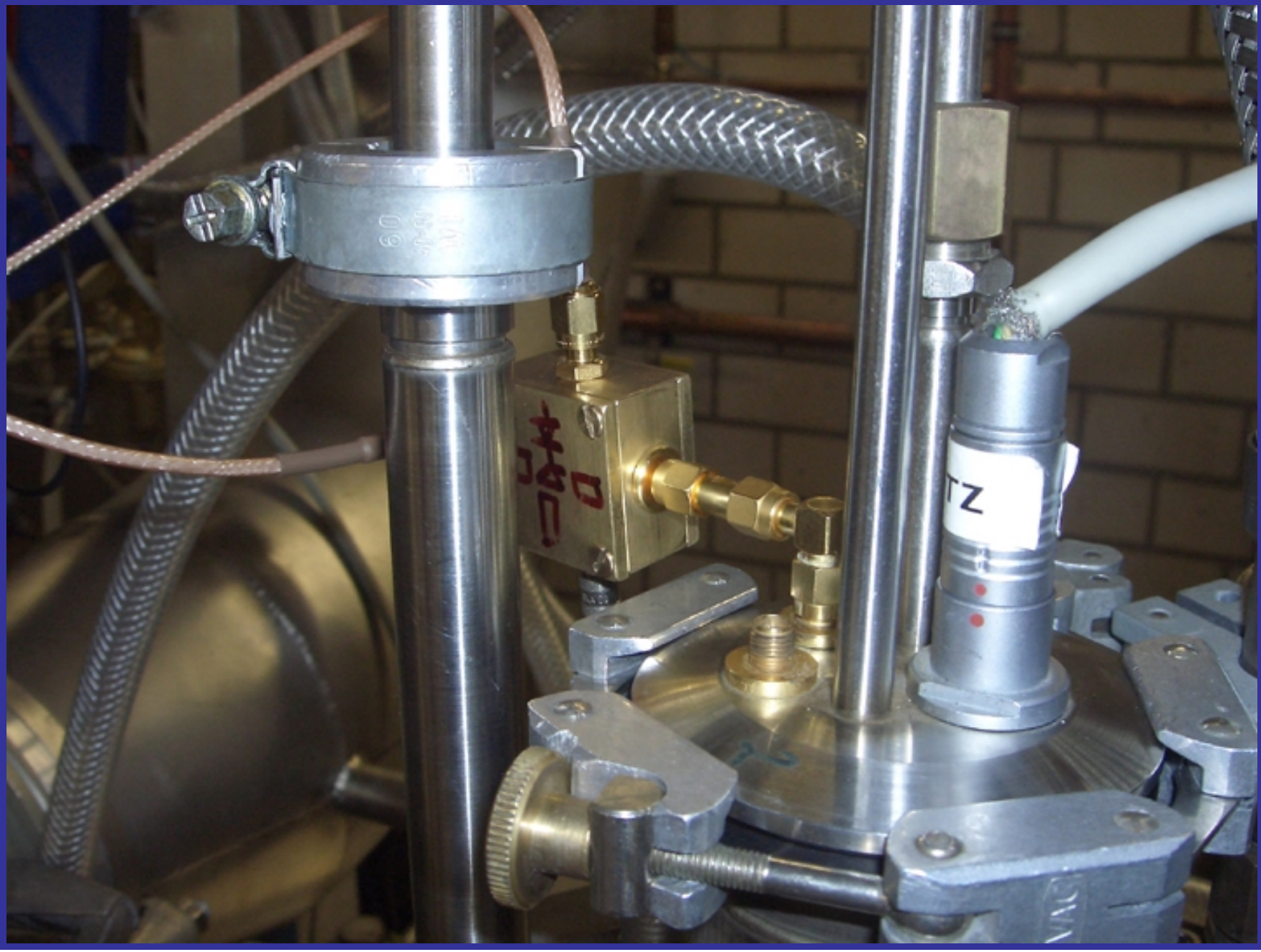


Firma	Ruhr Universität Bochum
Titel	CW-NMR-Box
Autor	Dr. Gerhard Reicherz
Datum	



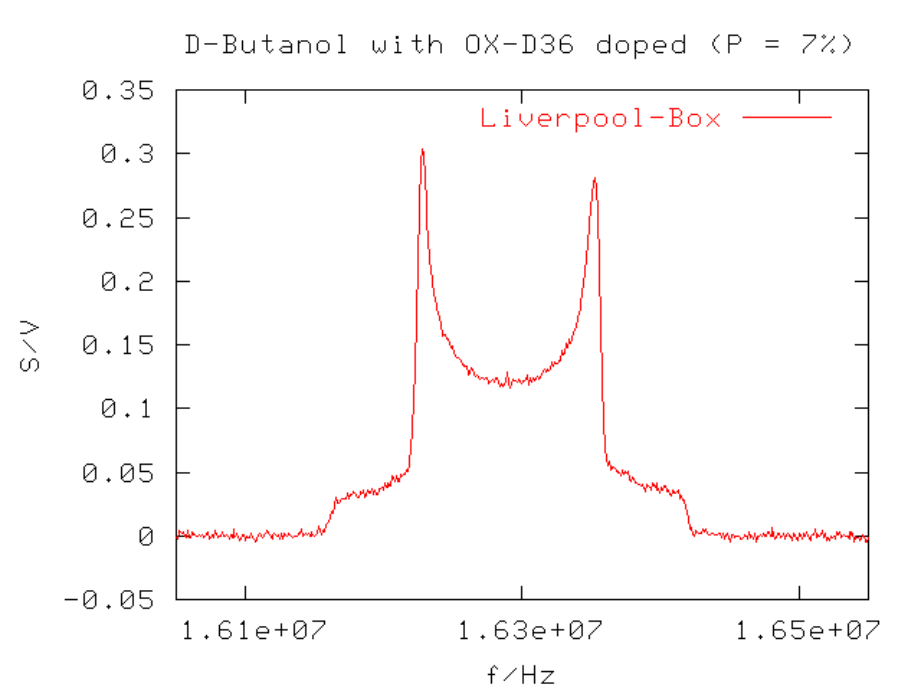
① Liverpool-Box ② rf input (100 rms) ③ tuning box ④ preamplifier ⑤ 2. amplifier
⑥ directional coupler ⑦ decoupling ⑧ phase cable ⑨ ps-detector ⑩ diode & lf amplifier

Cryostat head with NMR–entry

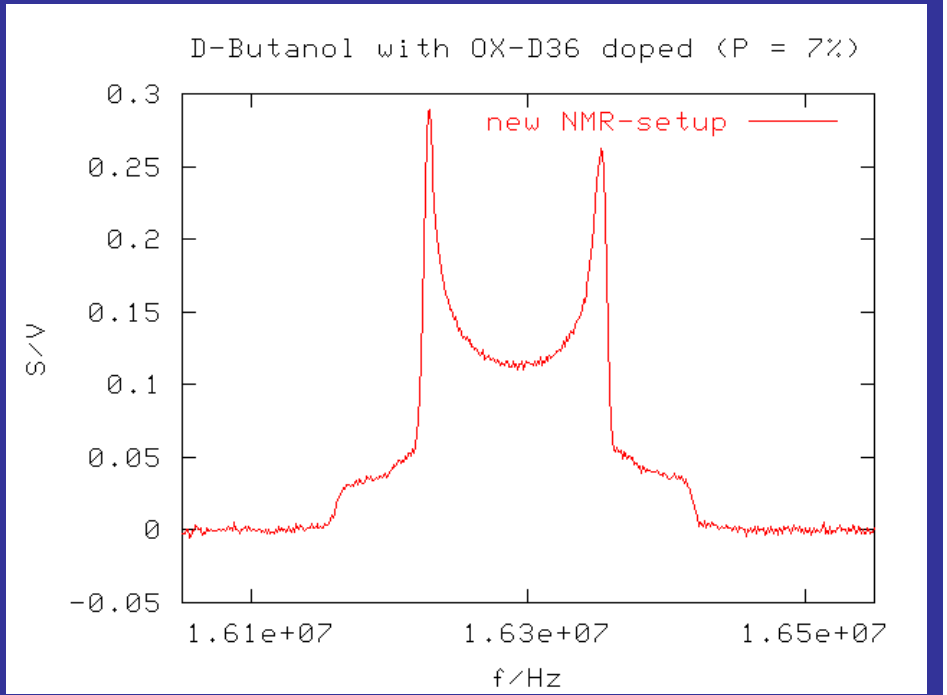


Deuteron Polarization Signals

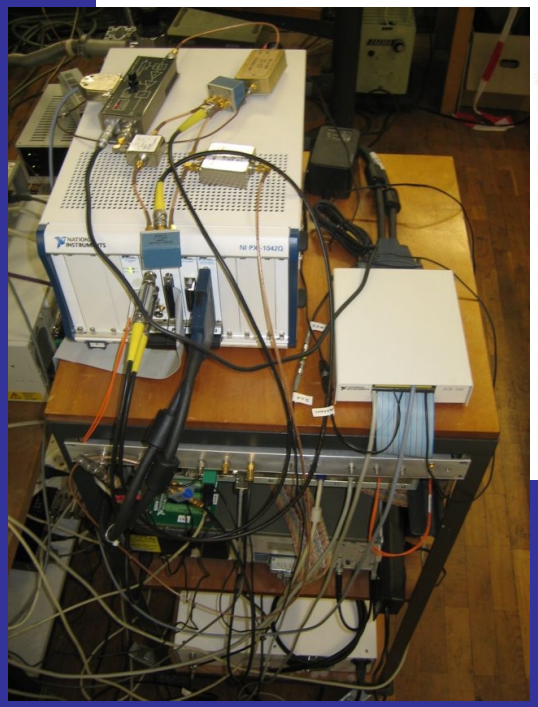
Recent NMR-setup
(Liverpool development)



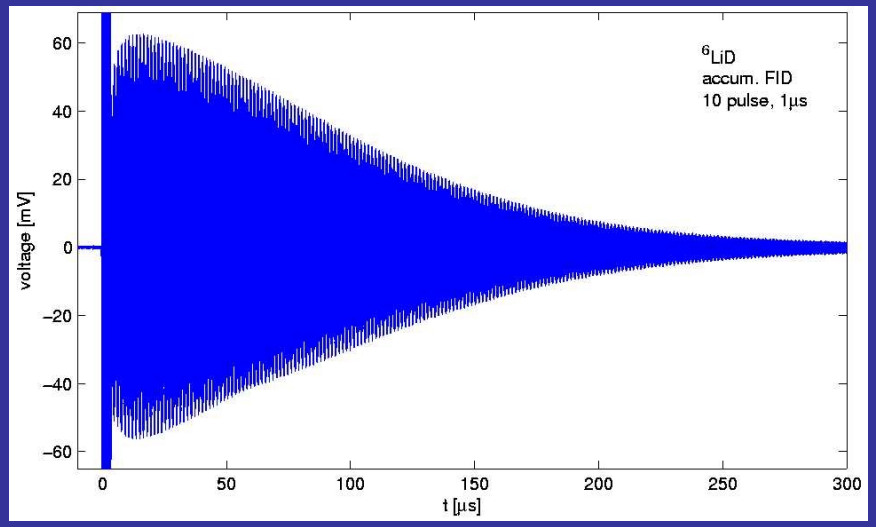
Recent NMR-setup
(Bochum development)

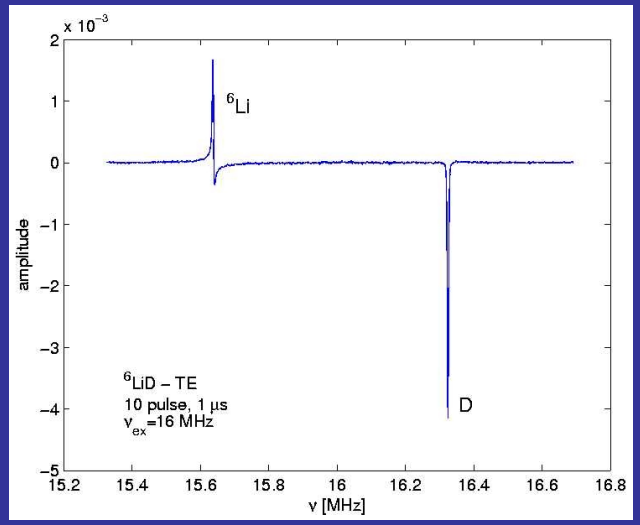


BOCHUM pulsed NMR–system

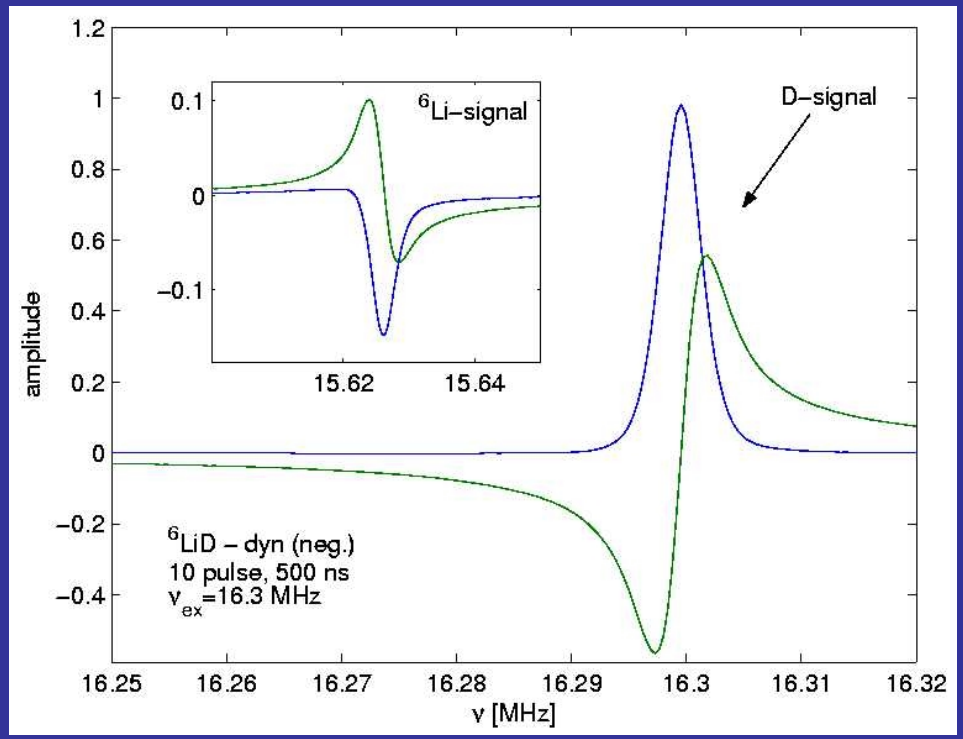


Polarization Signals of 6LiD





T.E. signals
P = 0.05 %



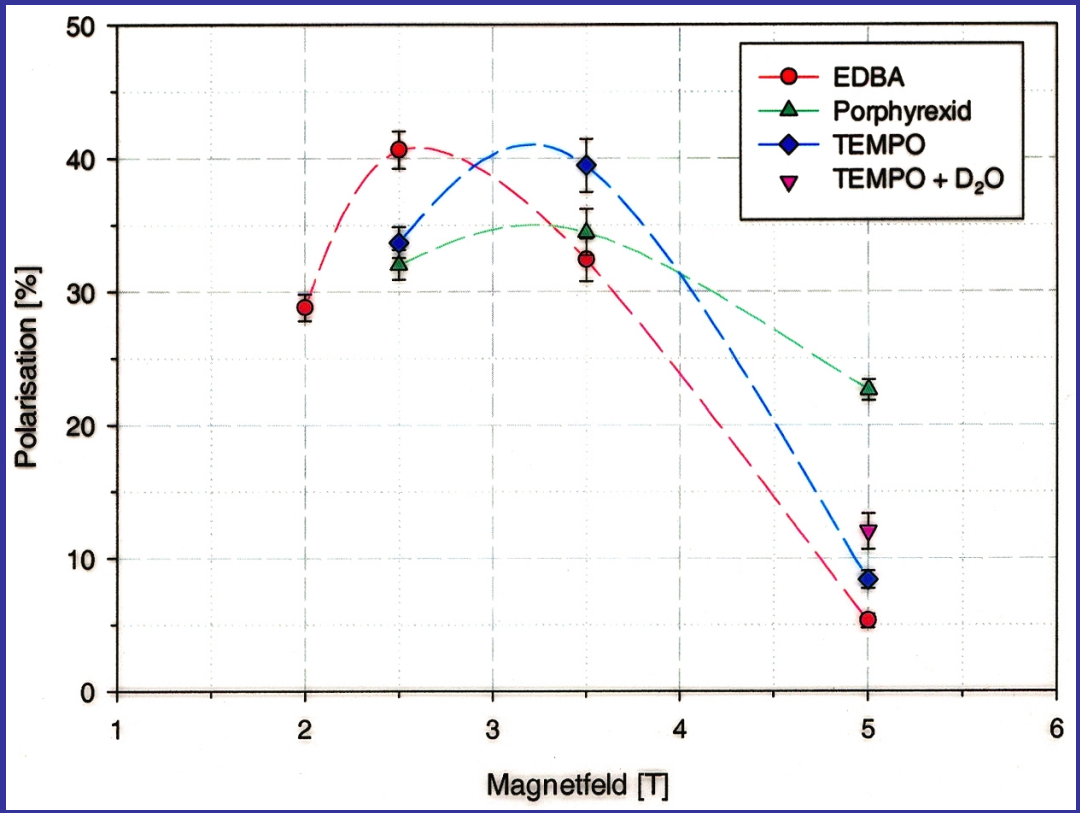
Dynamically pol. signals
P = 5%

Future Research Activity

Study of the polarization behaviour at different magnetic fields, especially < 2T
⇒ Dynamically polarized target with **Internal Polarizing Coil**

Materials: LiH and other proton samples

Example: Chemically doped D-butanol (Bochum 2001)



⇒ new microwave systems for < 2T $\triangleq$ 56 GHz