The TRIC Experiment:

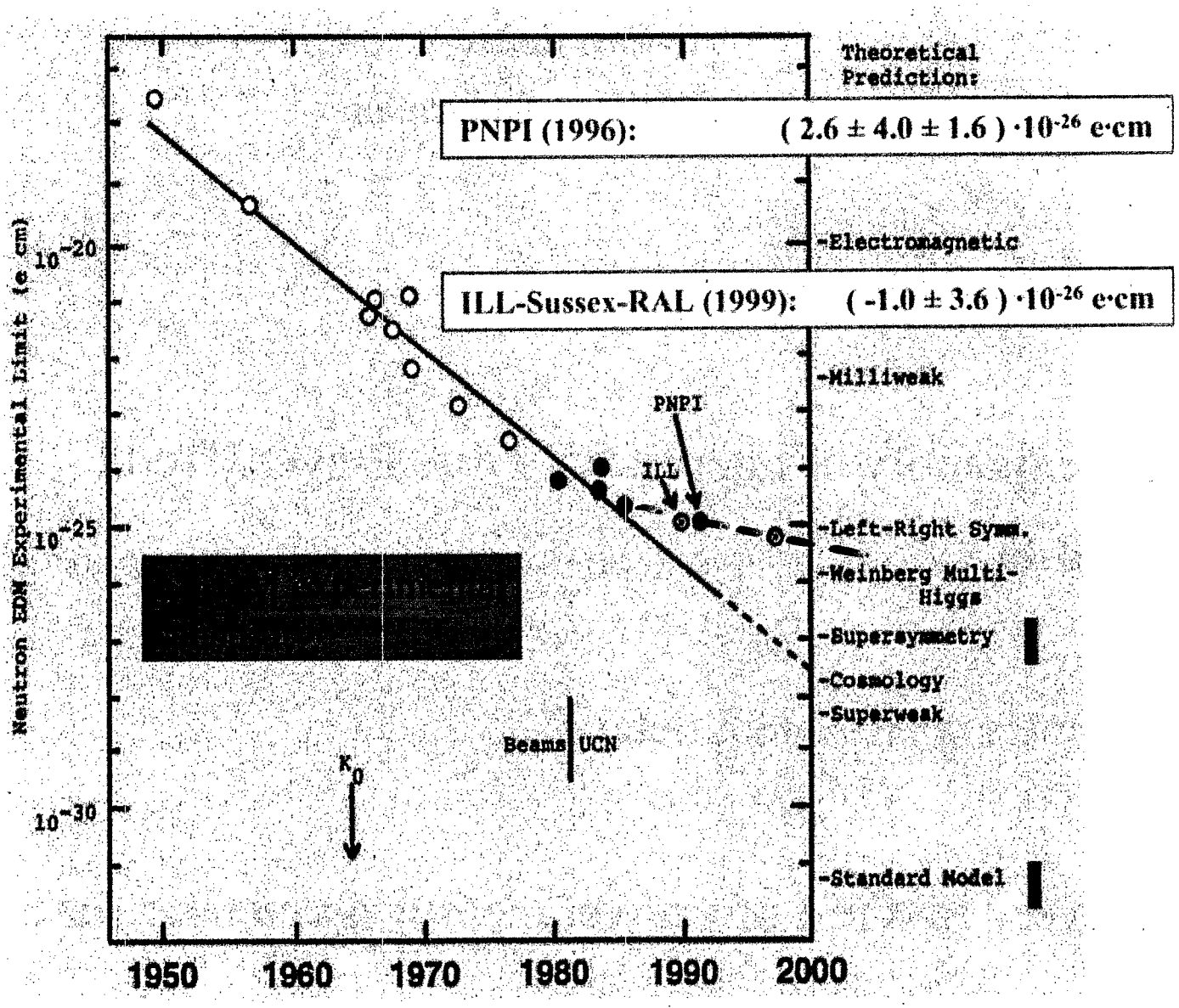
A P-even Time-Reversal Invariance Test at COSY

D. Eversheim

for the TRIC Collaboration

- Introduction
- The quantity of interest for a true P-even/T-odd null-test
- Some experimental details
- A very first test of a novel measuring method for total cross-sections
- Summary

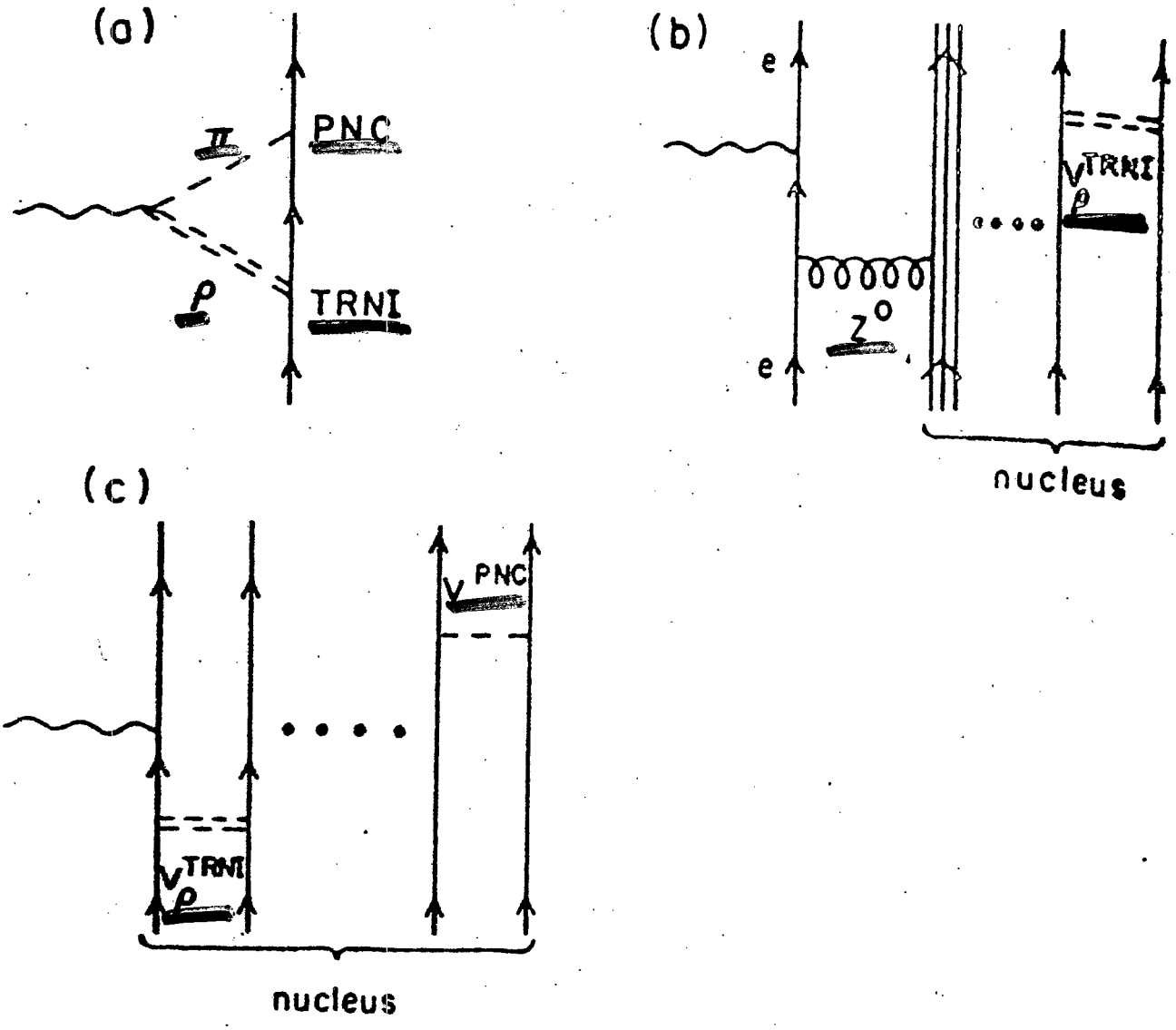
EDM Measurements



$$V \propto V_0 + V_{CPT} + V_{CTP} + V_{PTC}$$ ← EDM

$$= V_{CPT} + V_{CPT} + V_{CTP} + V_{PTC}$$

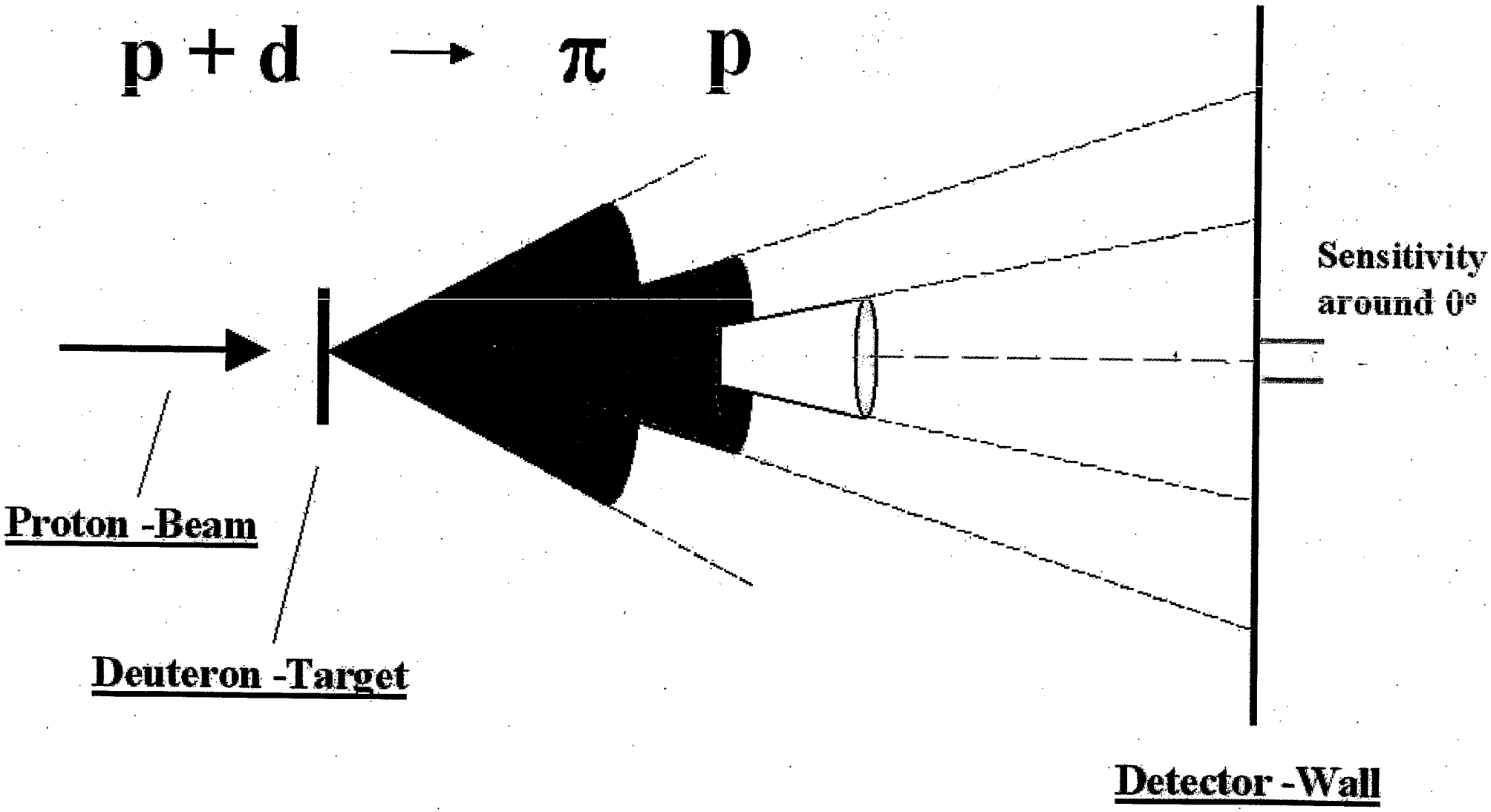
TRIC



Schematic representations of (a) the π-ρ loop contribution to the nucleon EDM, (b) the atomic EDM generated by Z exchange between the electrons and nucleons in combination with a polarizing TRNI ρ potential in the nucleus, and (c) the nuclear EDM generated by the simultaneous polarization of the nucleus by TRNI ρ and PNC π potentials.

External Fixed Target

Scattering-Cones and Detector-Sensitivity



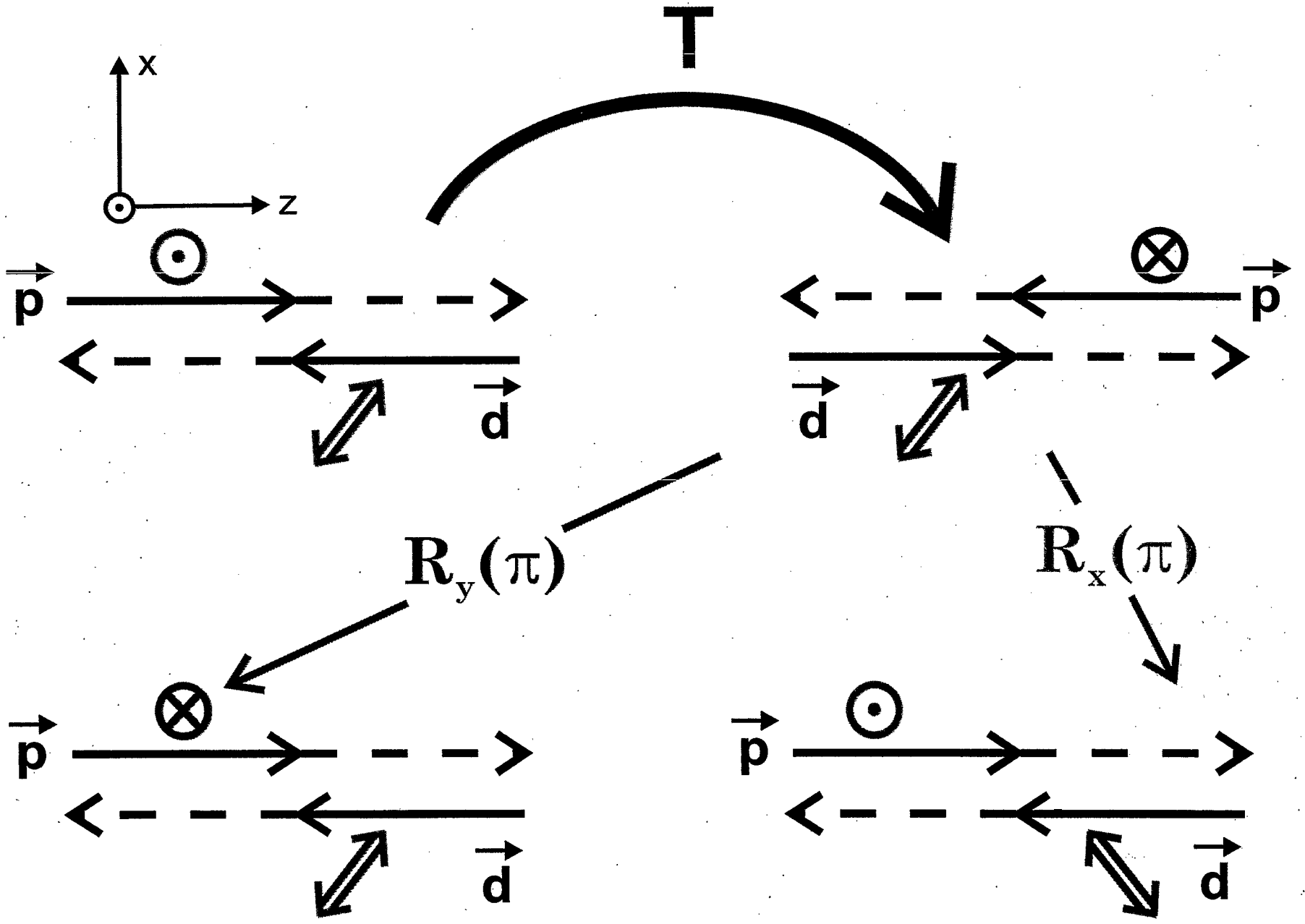
Quantity	T	P	
r	r	$-r$	
p	$-p$	$-p$	
σ (spin)	$-\sigma$	σ	
E (el. field)	E	$-E$	
B (magn. field)	$-B$	B	
$\sigma \cdot E$	$-\sigma \cdot E$	$-\sigma \cdot E$	~~T~~
$\sigma \cdot B$	$\sigma \cdot B$	$\sigma \cdot B$	
$\sigma \cdot p$	$\sigma \cdot p$	$-\sigma \cdot p$	~~P~~
$\sigma \cdot (p_1 \times p_2)$	$-\sigma \cdot (p_1 \times p_2)$	$\sigma \cdot (p_1 \times p_2)$	~~T~~
$p \cdot (\sigma_1 \times \sigma_2)$	$-p \cdot (\sigma_1 \times \sigma_2)$	$-p \cdot (\sigma_1 \times \sigma_2)$	~~T~~
$p \cdot (\sigma_1 \times \sigma_2)(p \cdot \sigma_2)$			~~T~~

Example:

$p_z \cdot (\sigma_{x1} \times \sigma_{y2})(p_z \cdot \sigma_{z2}) \longrightarrow A_{x,yz}$

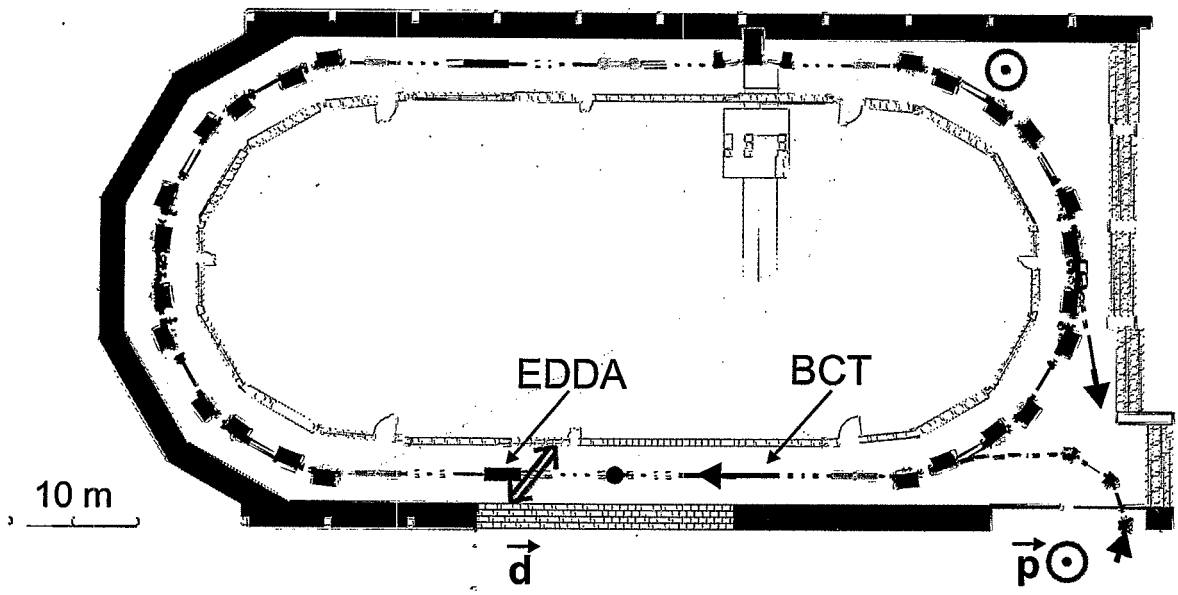
$p_z \cdot (\sigma_{y1} \times \sigma_{x2})(p_z \cdot \sigma_{z2}) \longrightarrow A_{y,xz}$

The Principle of the Time Reversal Invariance test at COSY (TRIC)



The Experimental Setup

COoler-SYnchrotron COSY at Juelich



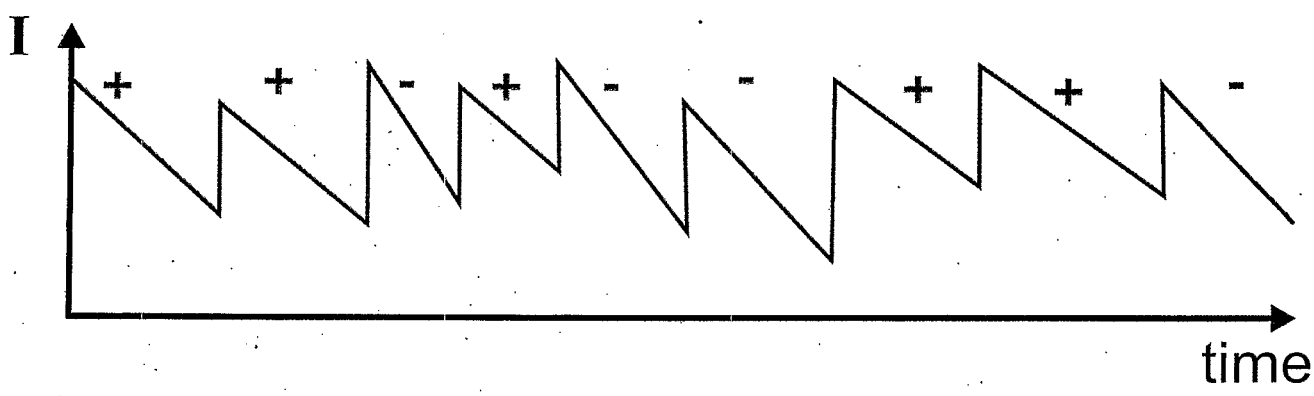
BCT - Beam Current Transformer
EDDA - Cylindrical Polarimeter with **Tensor** Polarized Atomic **Deuteron** Beam Target

The total pol. correlation $\mathbf{A_{y,\,xz}}$ is measured via the forward scatt. amplitude $\mathcal{F}(0)$

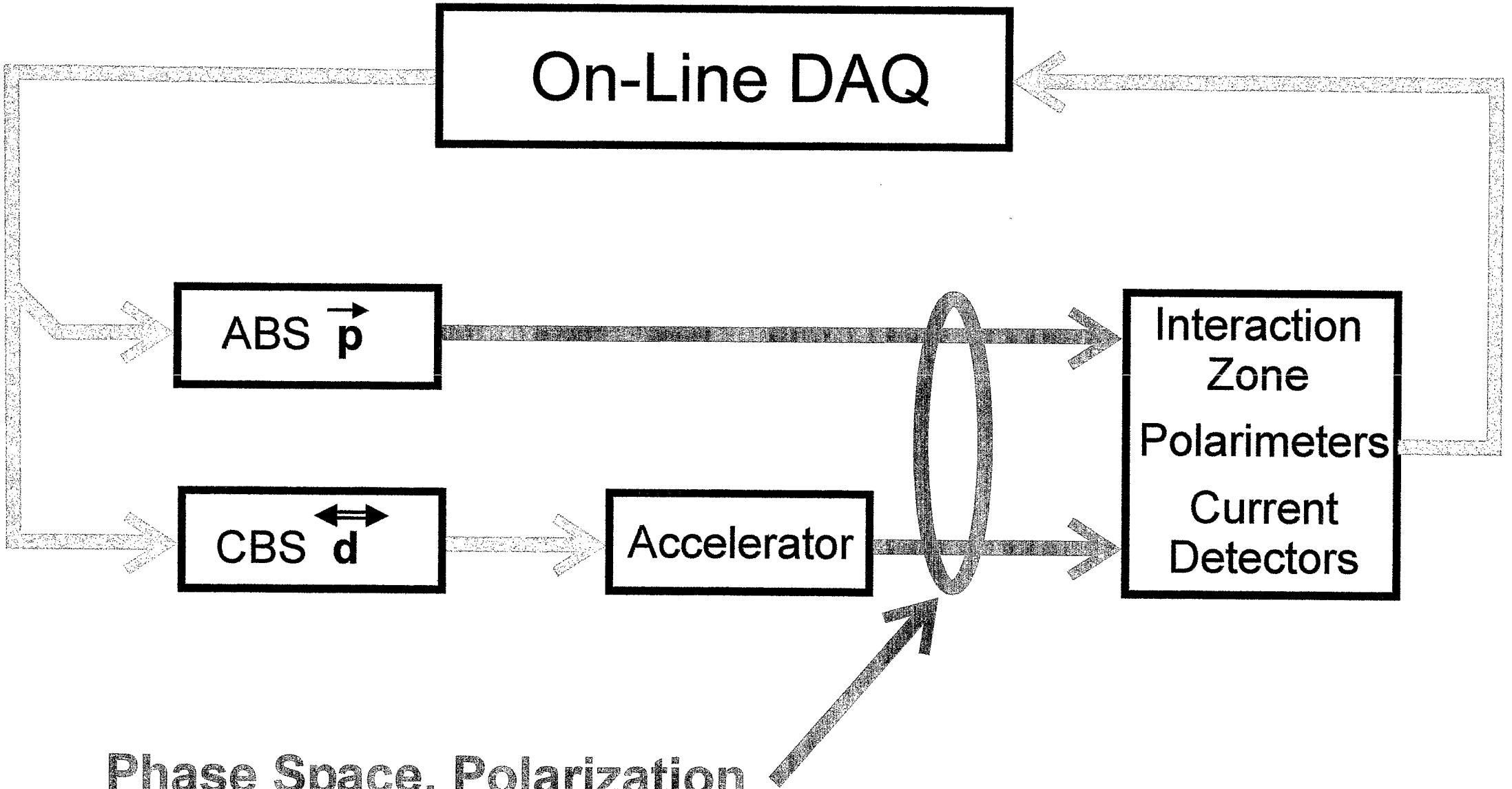
$$\sigma_{tot} = \frac{4\pi}{k}\, Im F(0) \quad \rightsquigarrow \quad \frac{4\pi}{k}\, Im\, tr\,(\rho\, \mathcal{F}(0))$$

$F(0)$ - Forward scatt. amplitude for unpolarized particles
ρ - Density matrix
$\mathcal{F}(0)$ - Forward scatt. amplitude (matrix) for polarized particles

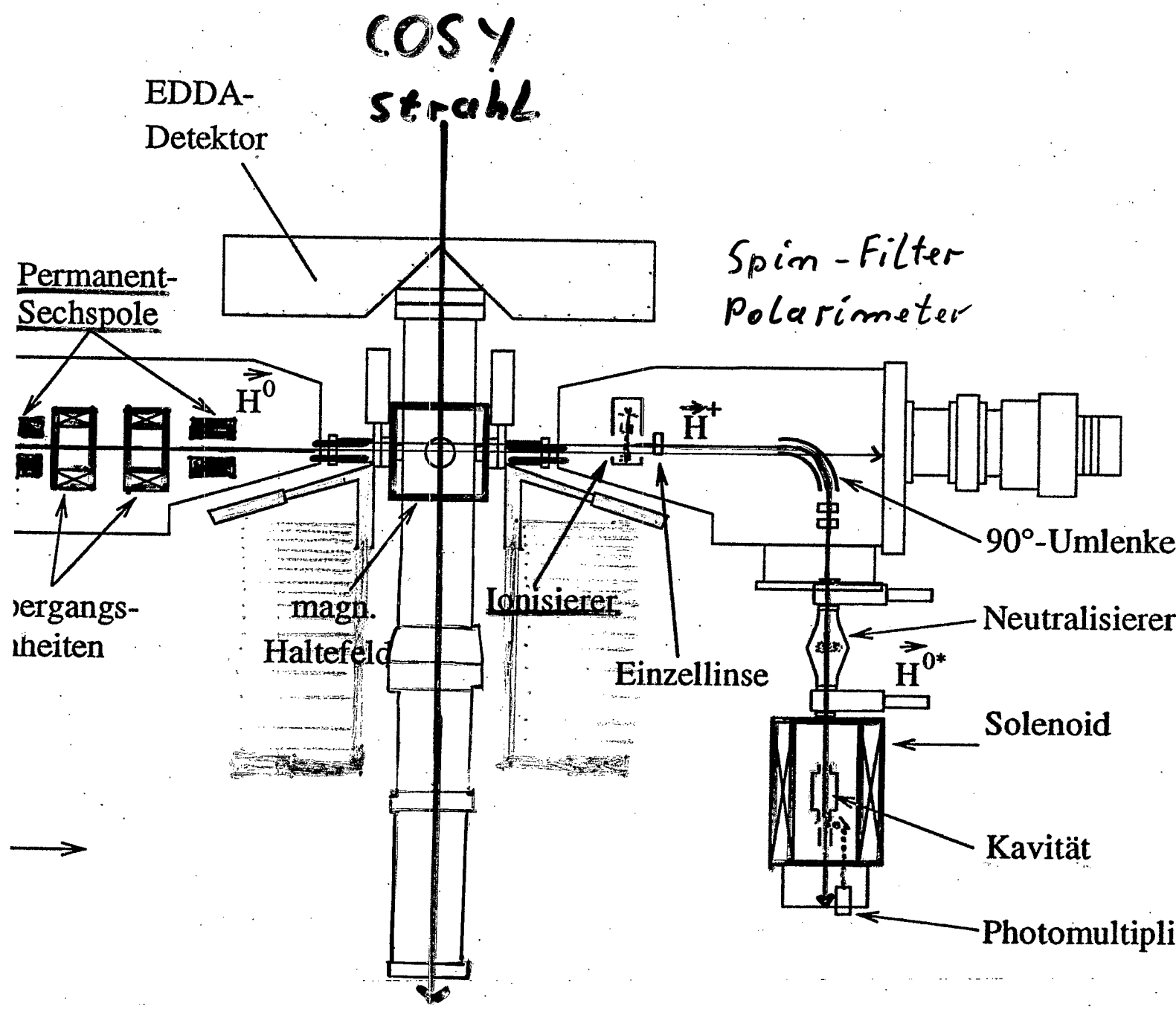
$\mathbf{A_{y,\,xz}}$ is proportional to the relative difference of the current slopes of the circulating proton beam with respect to the chosen polarization configuration (+/-) of the proton beam and deuteron target.



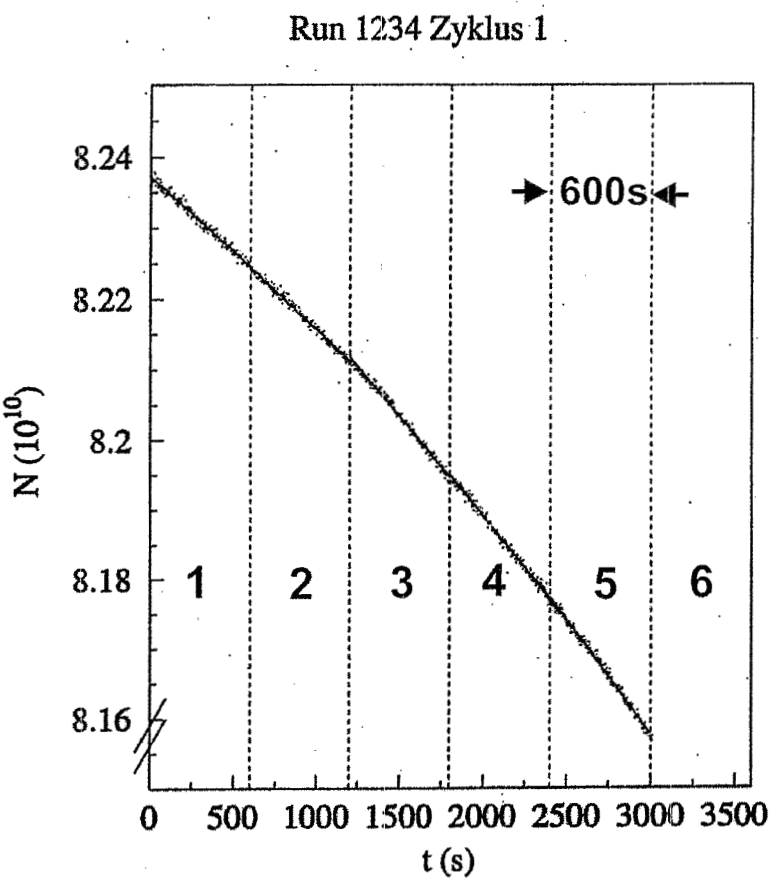
Error Path


On-Line DAQ
ABS $\vec{p}$
CBS $\overleftrightarrow{d}$
Accelerator
Interaction Zone
Polarimeters
Current Detectors
Phase Space, Polarization

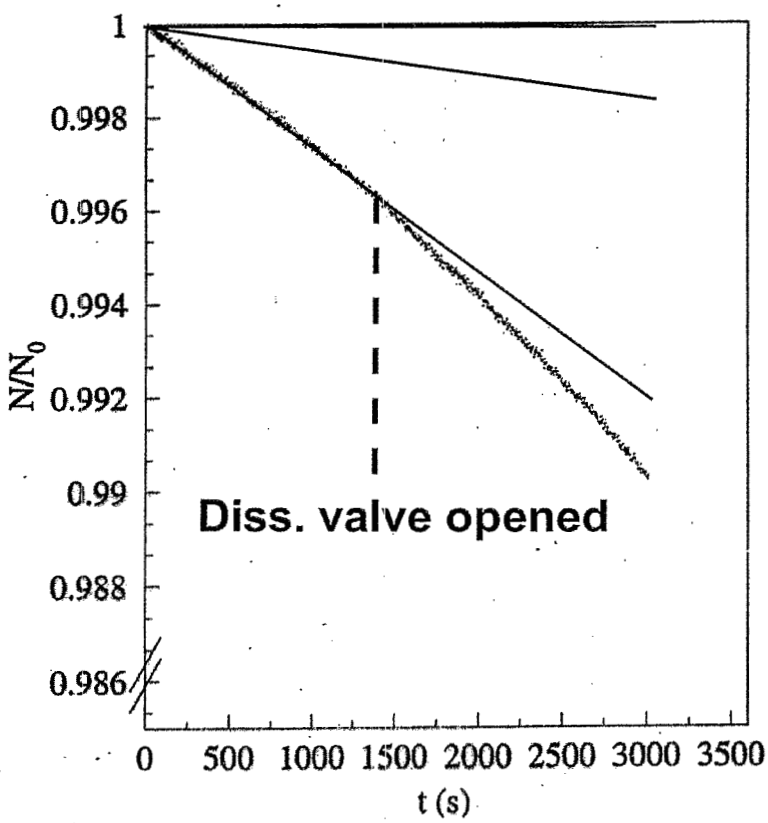
uhLtargit für den internen COSY Strahl.



Mean Residual Pressure Measurement in the COSY Ring



Measurement Interval

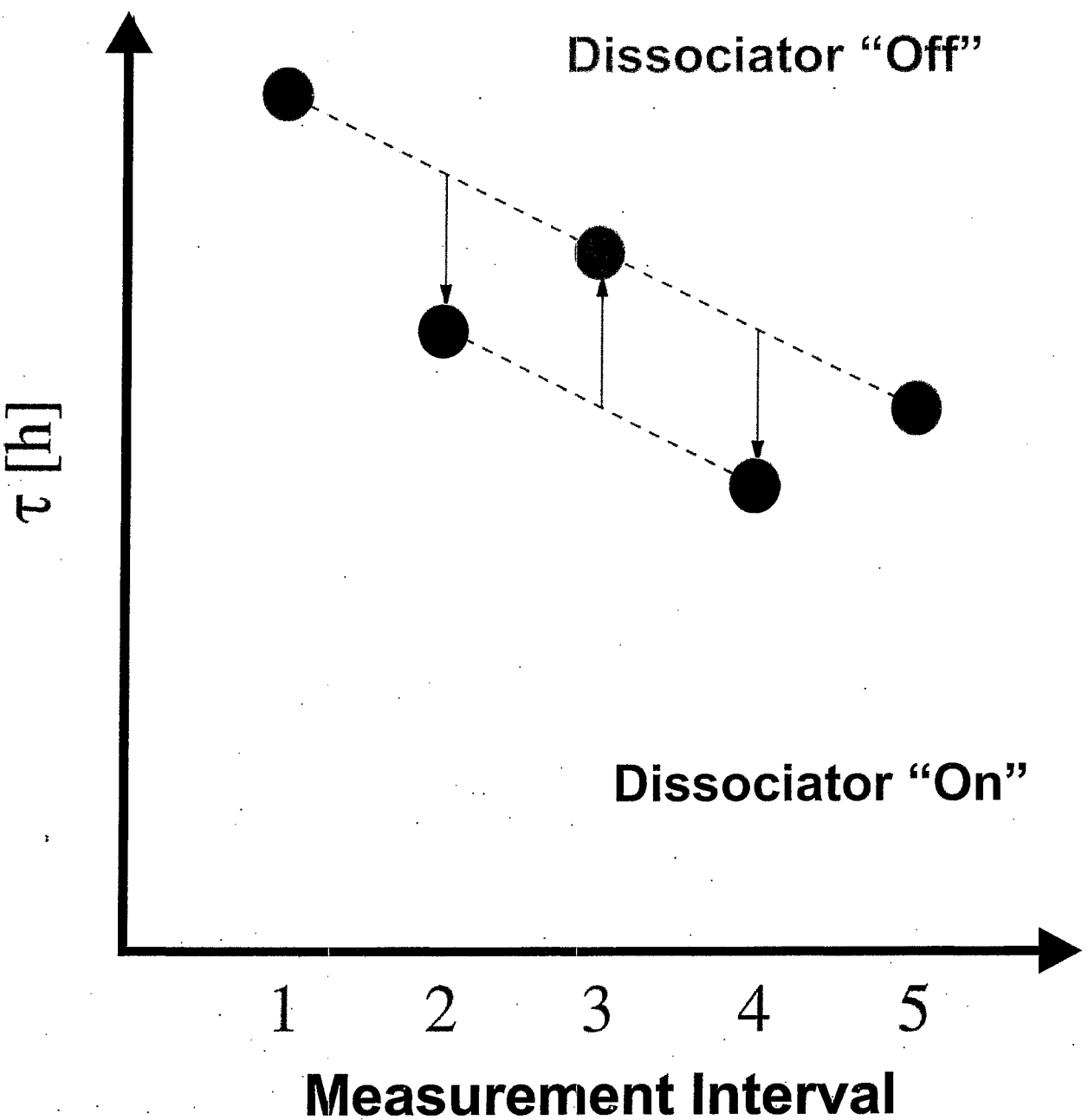


$1 \cdot 10^{-9}$mbar

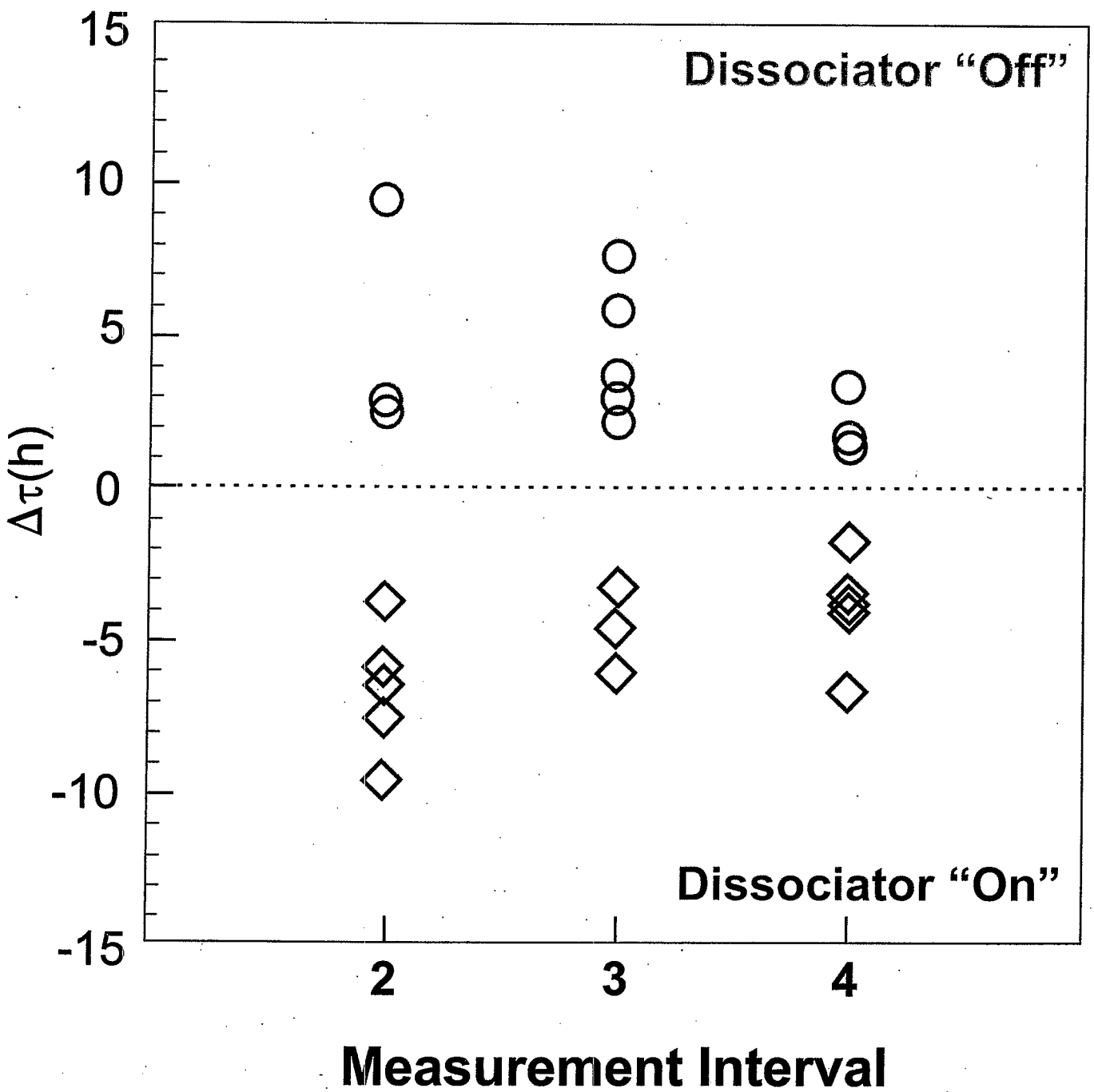
$1 \cdot 10^{-8}$mbar

$5 \cdot 10^{-8}$mbar

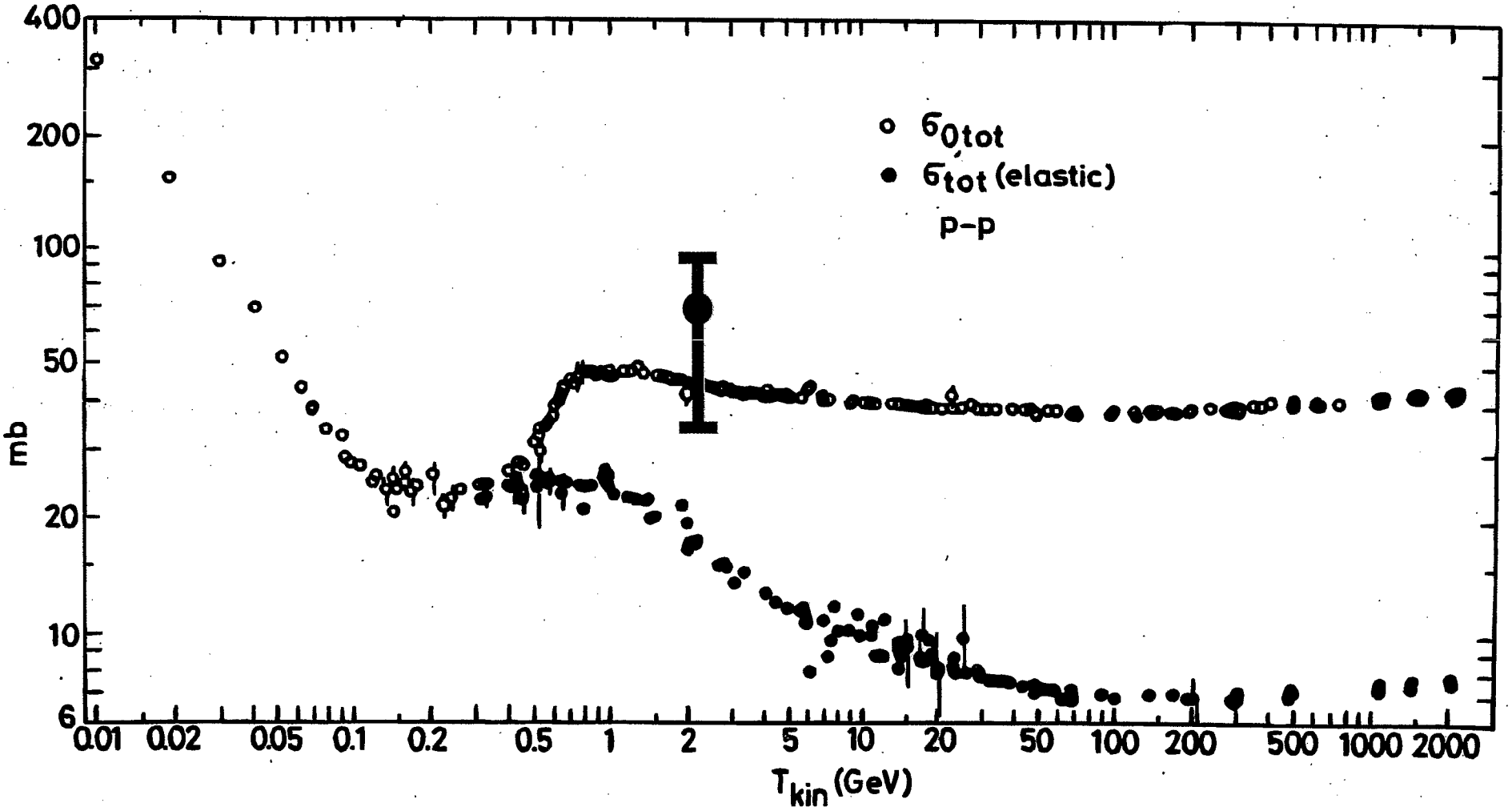
Determining Differences in Lifetime



Differences in the Lifetime of the Circulating COSY Beam



Result for the Total p-p Cross Section



Summary

- Polarization observables are especially suitable for precision experiments.

- More time-reversal violating processes are expected and are urgently needed.

- The total cross-section asymmetry $A_{y,xz}$ probes P-even, T-odd effects in an null-experiment.

- For the measurement of time-reversal invariance in $\vec{p}$-$\vec{d}$ scattering COSY serves as accelerator, forward spectrometer, and detector.

- The novel measurement technique allows already to determine the mean residual vacuum pressure in the COSY ring and the total cross-section in p-p scattering.