# Поляризационные эффекты в фоторождении мезонов


**Третьи Черенковские чтения**

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# 1) Experimental verification of the GDH sum rule

- Proposed in 1966
- Prediction on the absorption of circularly polarized photons by longitudinally polarized hadrons


$$I_{GDH} = \int_{\nu_{thr}}^{\infty} \frac{\sigma_p(E_\gamma) - \sigma_a(E_\gamma)}{\nu} d\nu = 4\pi^2 S \frac{e^2}{M^2} k^2$$

Anomalous magnetic moment

$$\nu_{thr} = \begin{cases} \pi \text{ production threshold (nucleon)} \\ \text{photodisintegration threshold (nuclei)} \end{cases}$$

# 2) Helicity Dependence of Meson Photoproduction

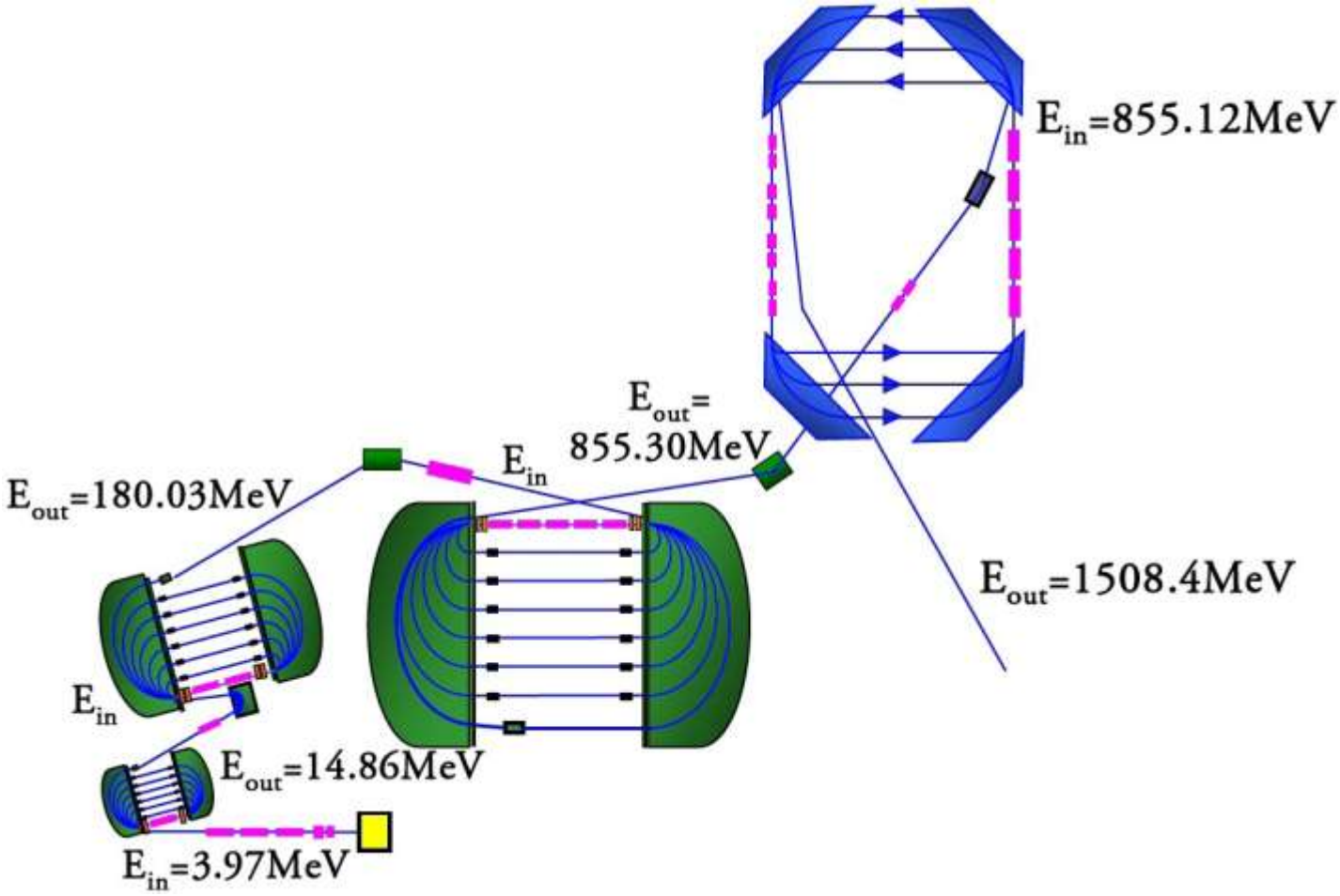
More detailed information on resonance properties and multipole amplitudes

by investigating the helicity structure of partial reaction channels

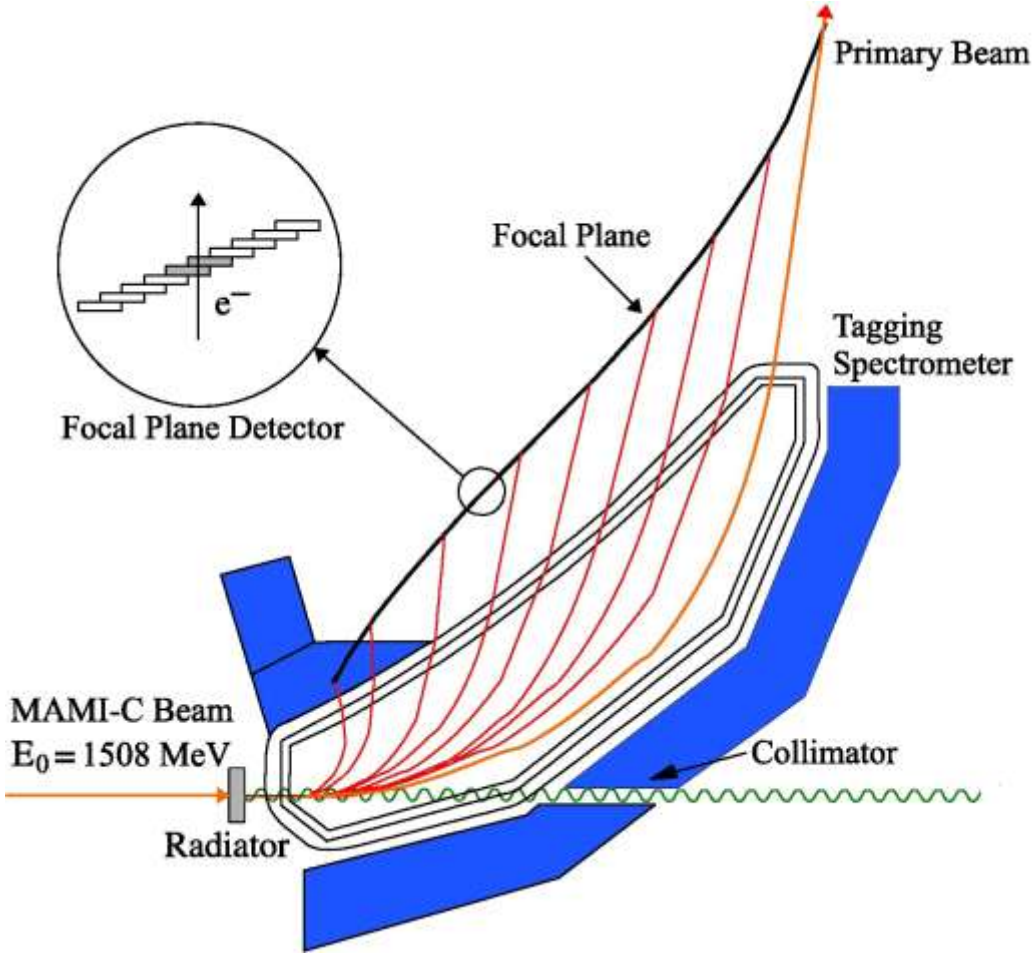
Main goals:

- single $\pi^0$ - production ($D_{13}(1520)$, $F_{15}(1680)$)
- $\eta$- production ($S_{11}(1535)$, $D_{13}(1520)$)
- double $\pi^0$ - production ($D_{13}(1520)$, $P_{11}(1440)$, $P_{11}(1710)$)

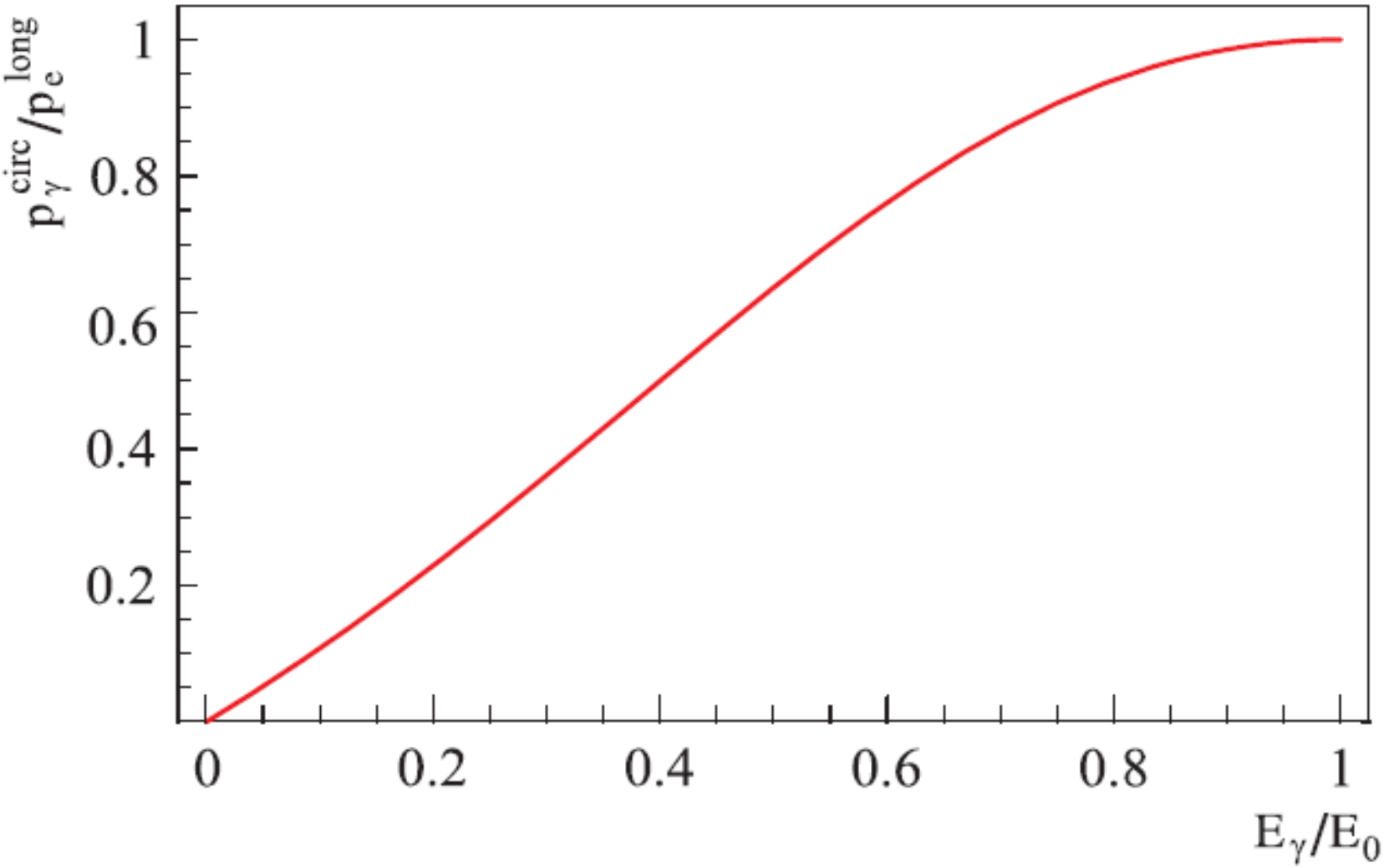
# MAINZ MICROTRON



# Glasgow-Mainz Photon Tagger

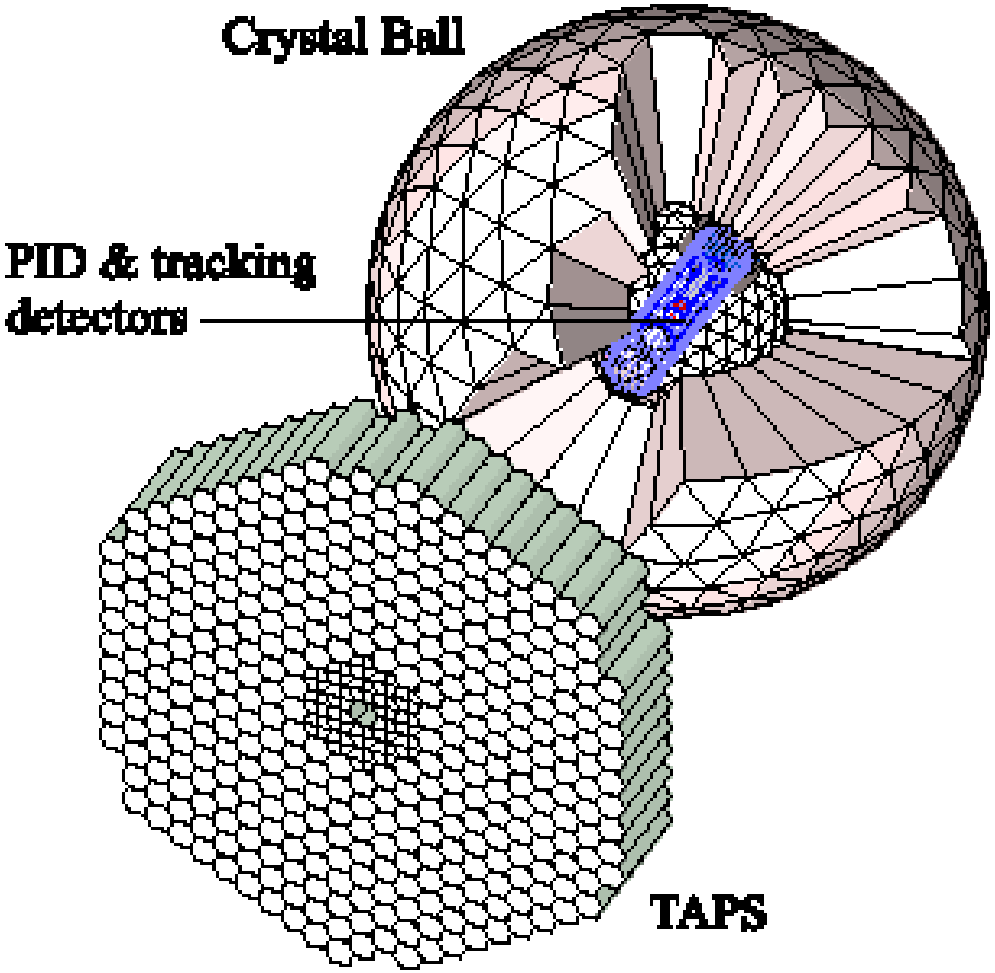


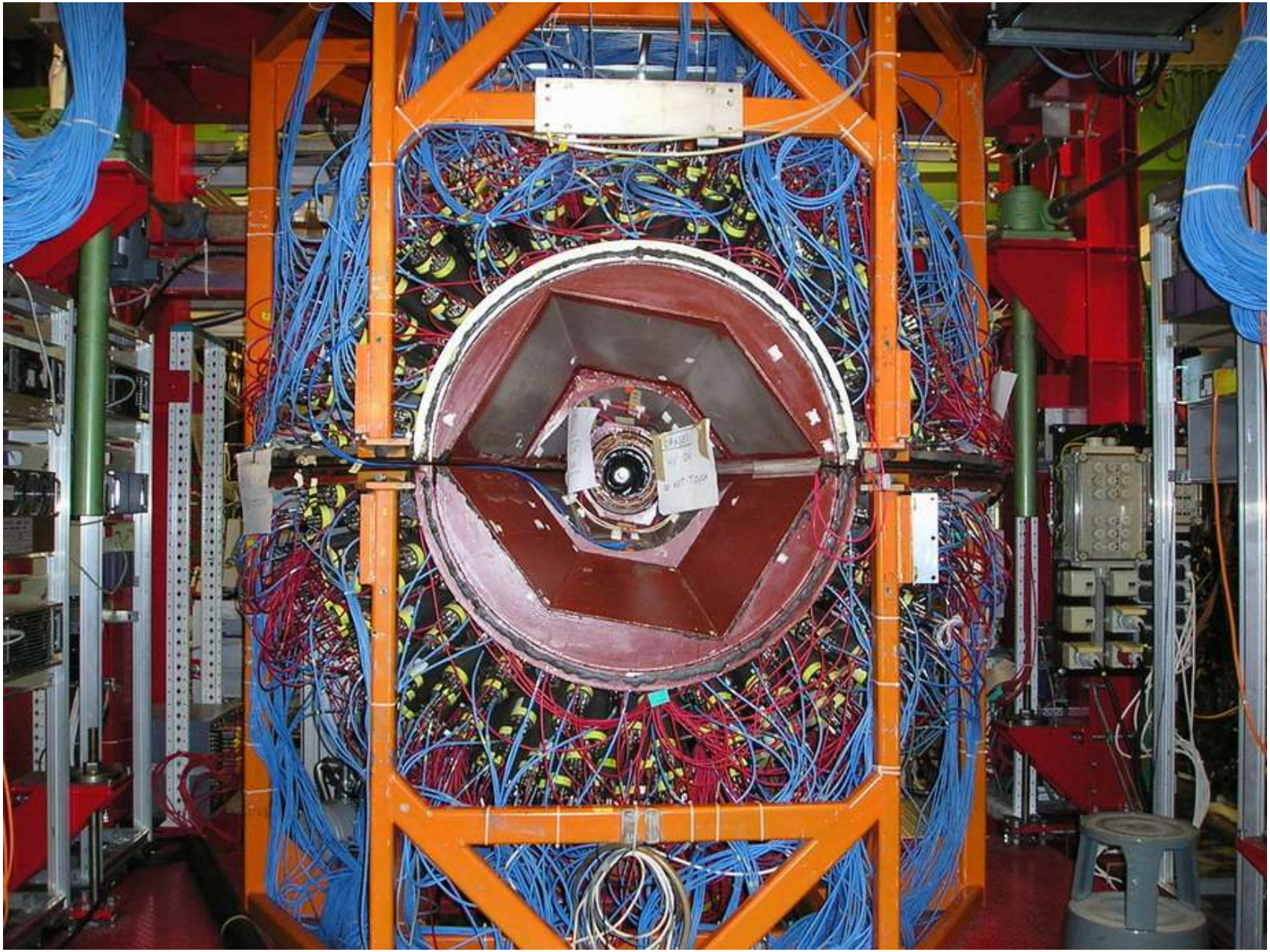
# Polarisation transfer from electron to photon beam as a function of energy transfer. MAMI beam polarisation Pe ≈ 85%.



# A2 DETECTOR SETUP

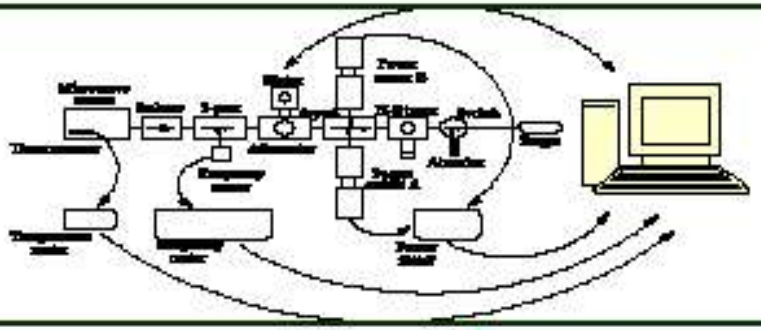
Because of its high-granularity and large acceptance the CB/TAPS setup is a suitable detector system for measurements of reactions with multi-photon final states like in $\pi^0 \rightarrow 2\gamma$, $\eta \rightarrow 2\gamma$ or $\eta \rightarrow 3\pi^0 \rightarrow 6\gamma$



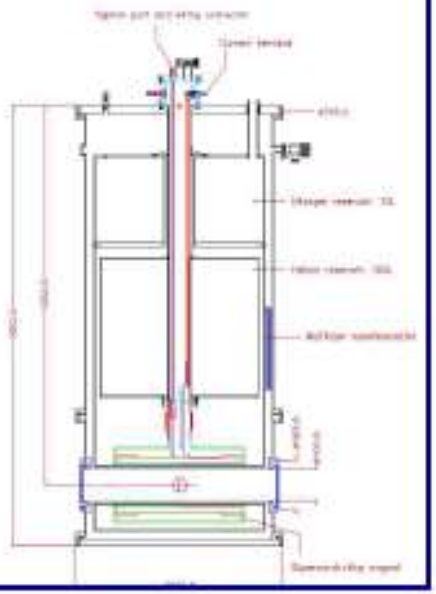


# The Frozen Spin Target

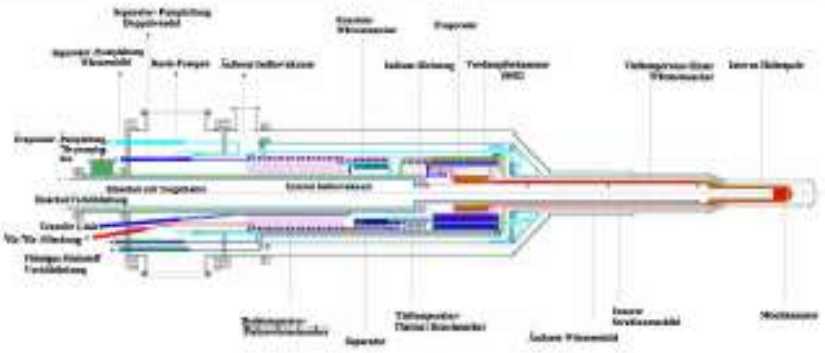
## Microwave System



## Magnet



## Cryostat



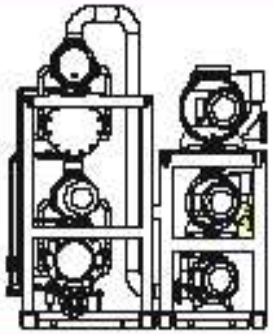
## Target

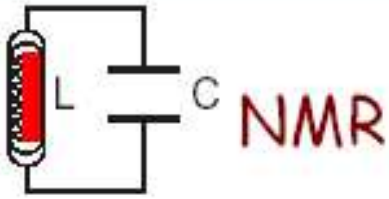
BUTANOL

$C_4H_9OH$

## Control System

## Pumping System

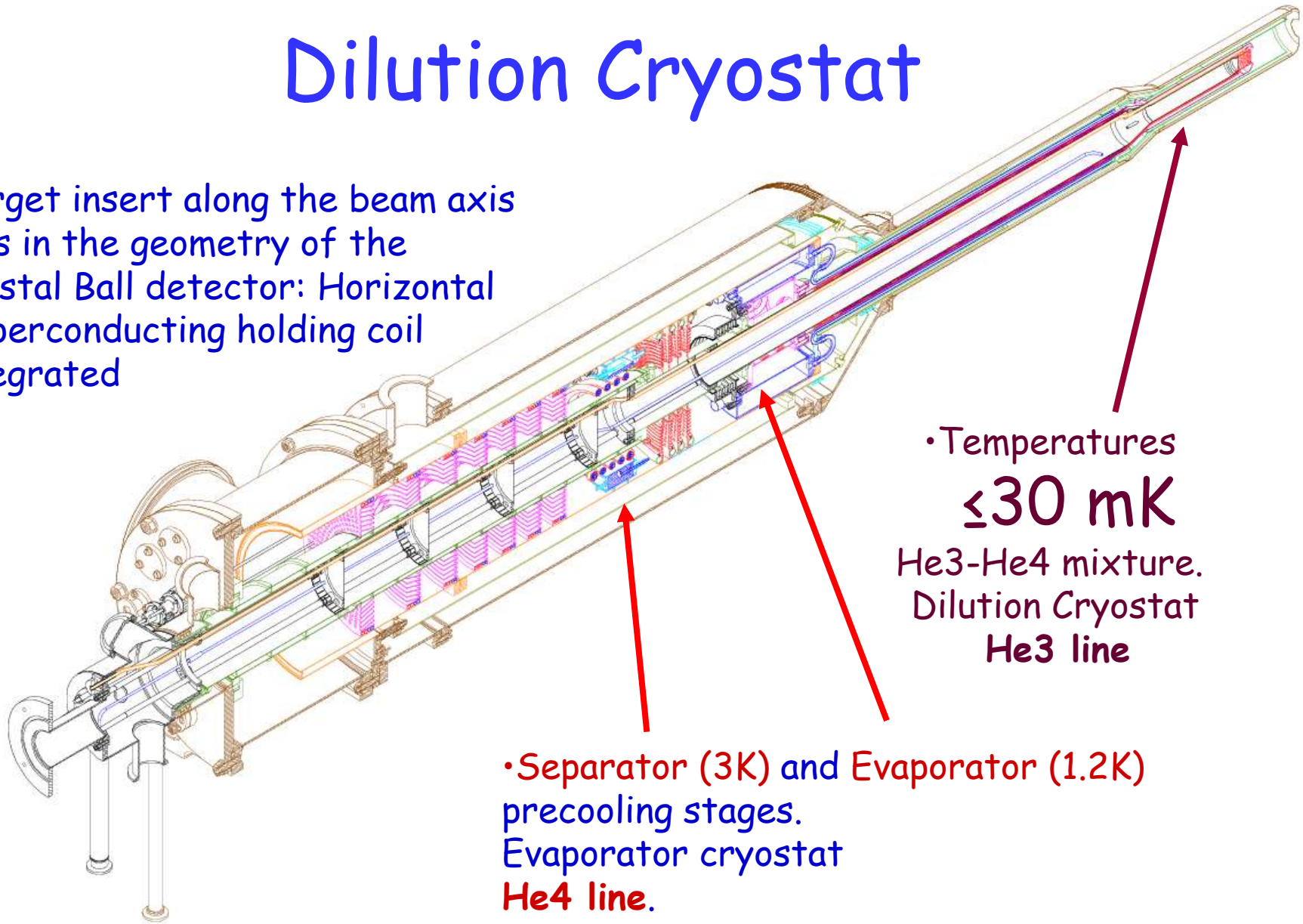





NMR

# Dilution Cryostat

- Target insert along the beam axis
- Fits in the geometry of the Crystal Ball detector: Horizontal
- Superconducting holding coil integrated



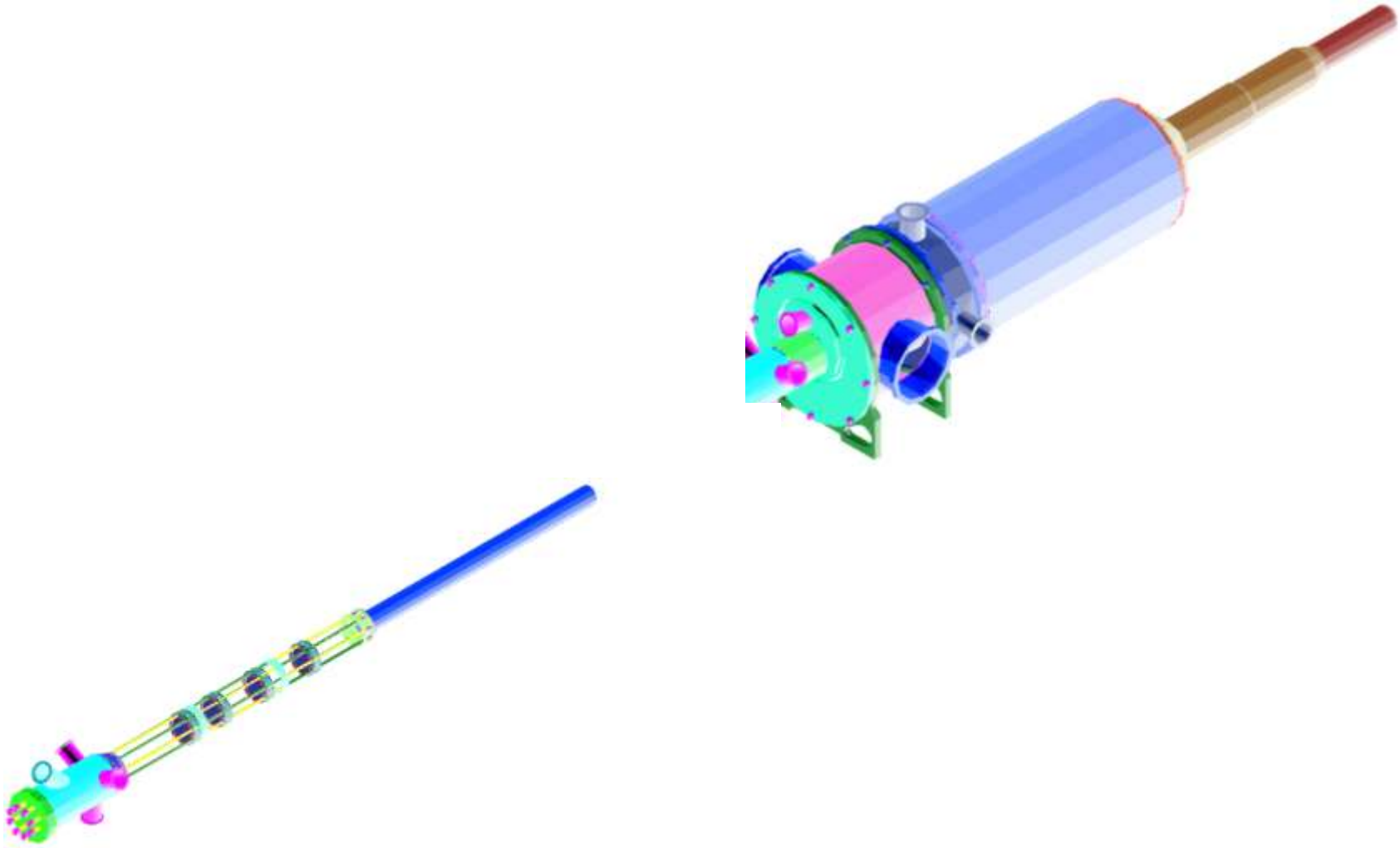
- Temperatures

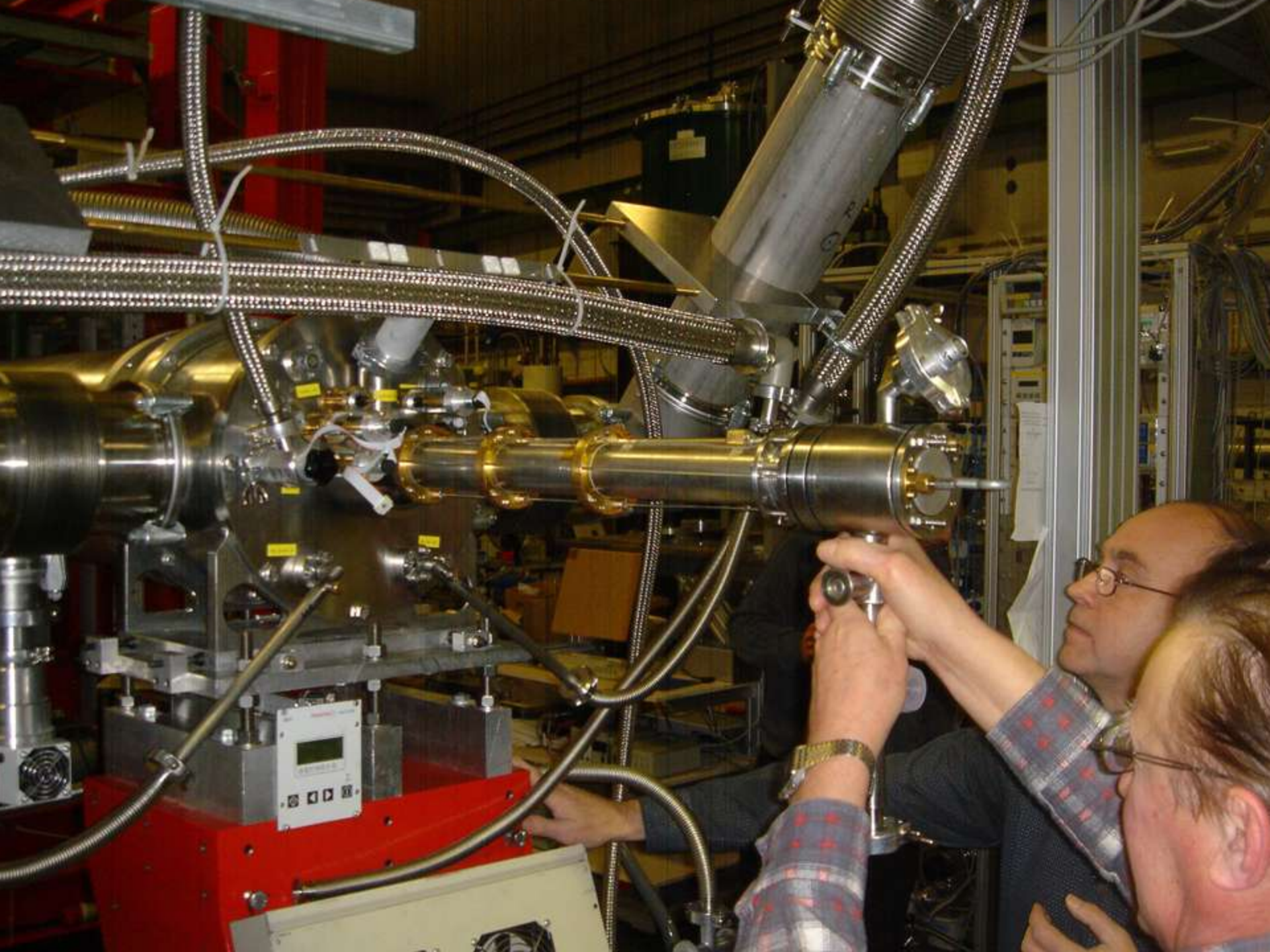
≤30 mK

He3-He4 mixture.
Dilution Cryostat
**He3 line**

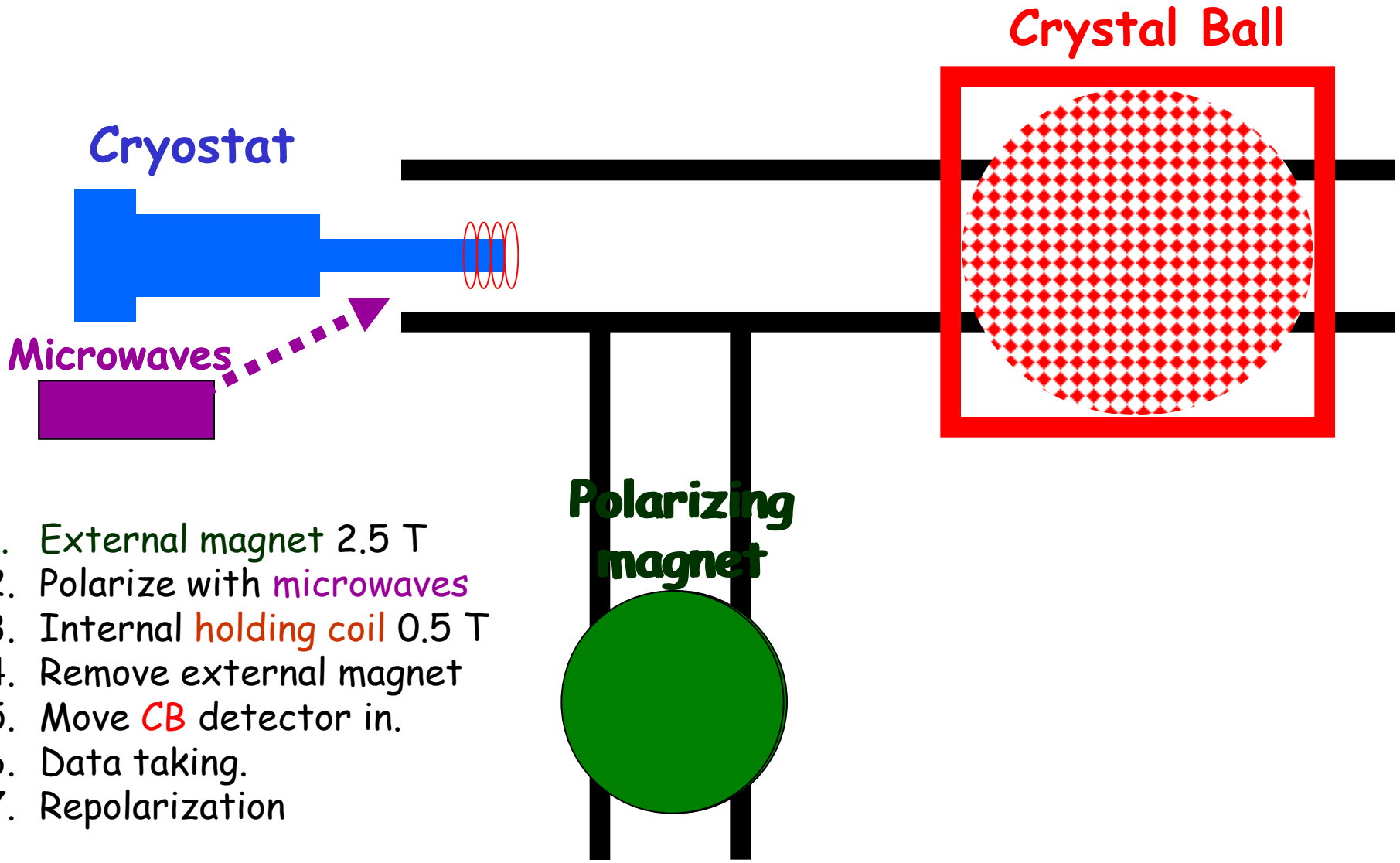
- Separator (3K) and Evaporator (1.2K) precooling stages.
Evaporator cryostat
**He4 line**.

# Loading of the target material into the cryostat



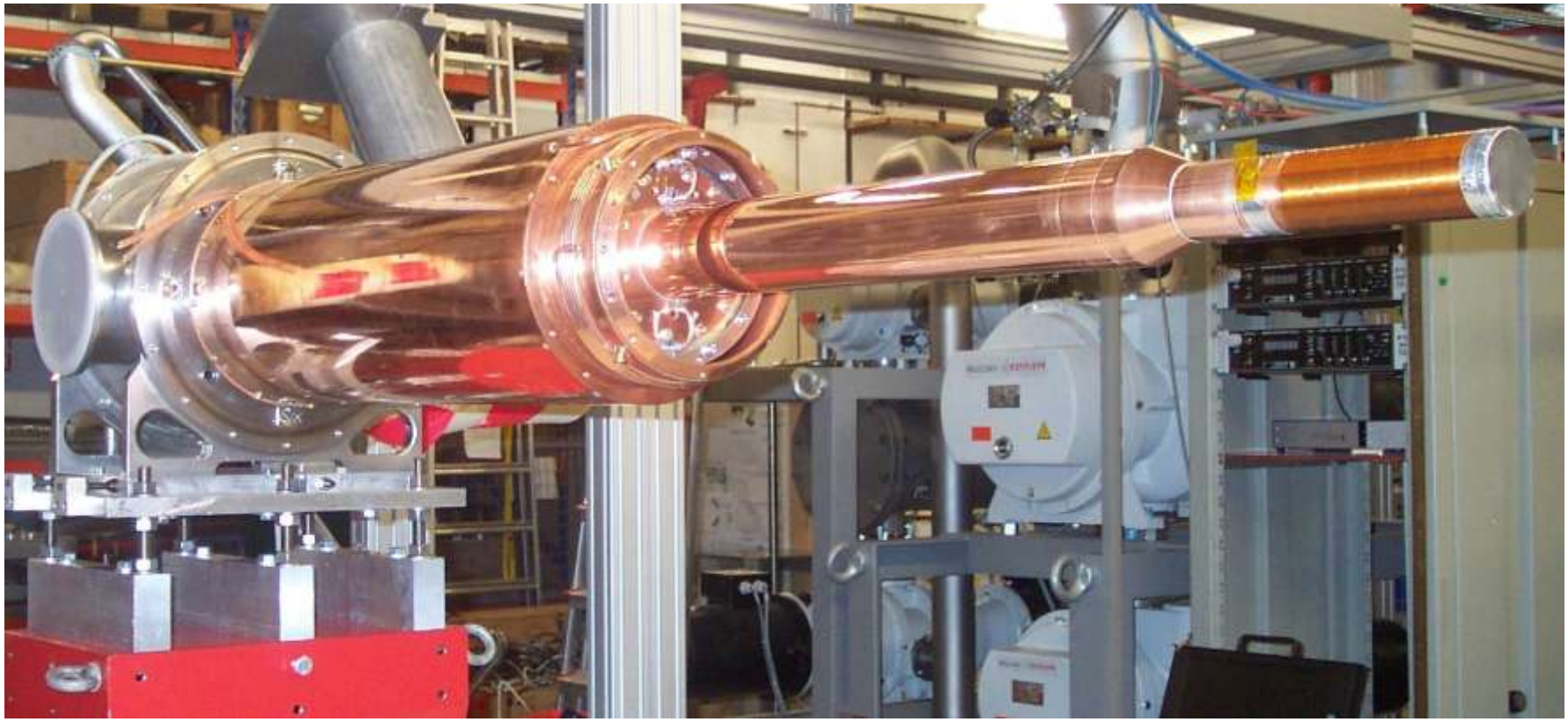


# Polarization procedure

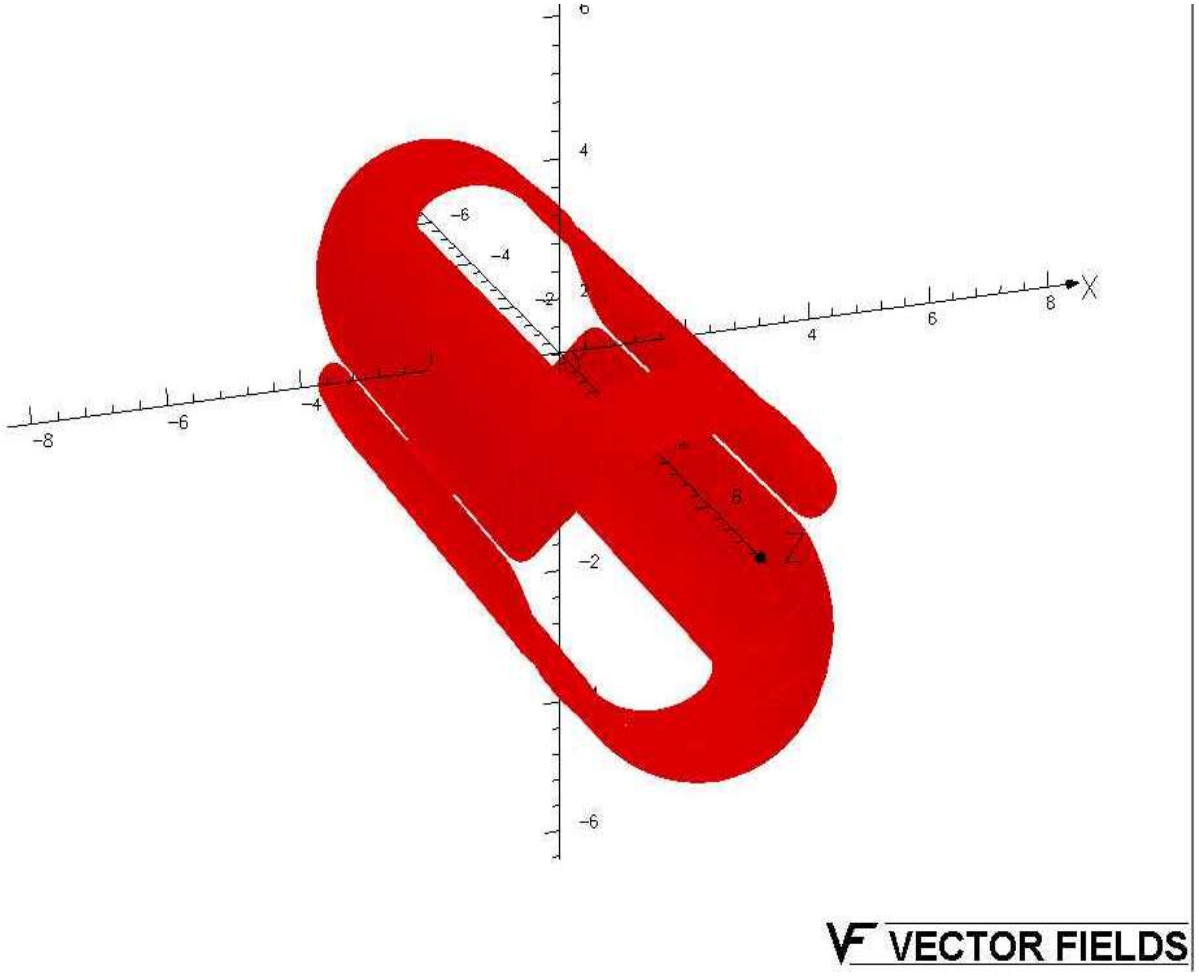



1. External magnet 2.5 T
2. Polarize with microwaves
3. Internal holding coil 0.5 T
4. Remove external magnet
5. Move CB detector in.
6. Data taking.
7. Repolarization

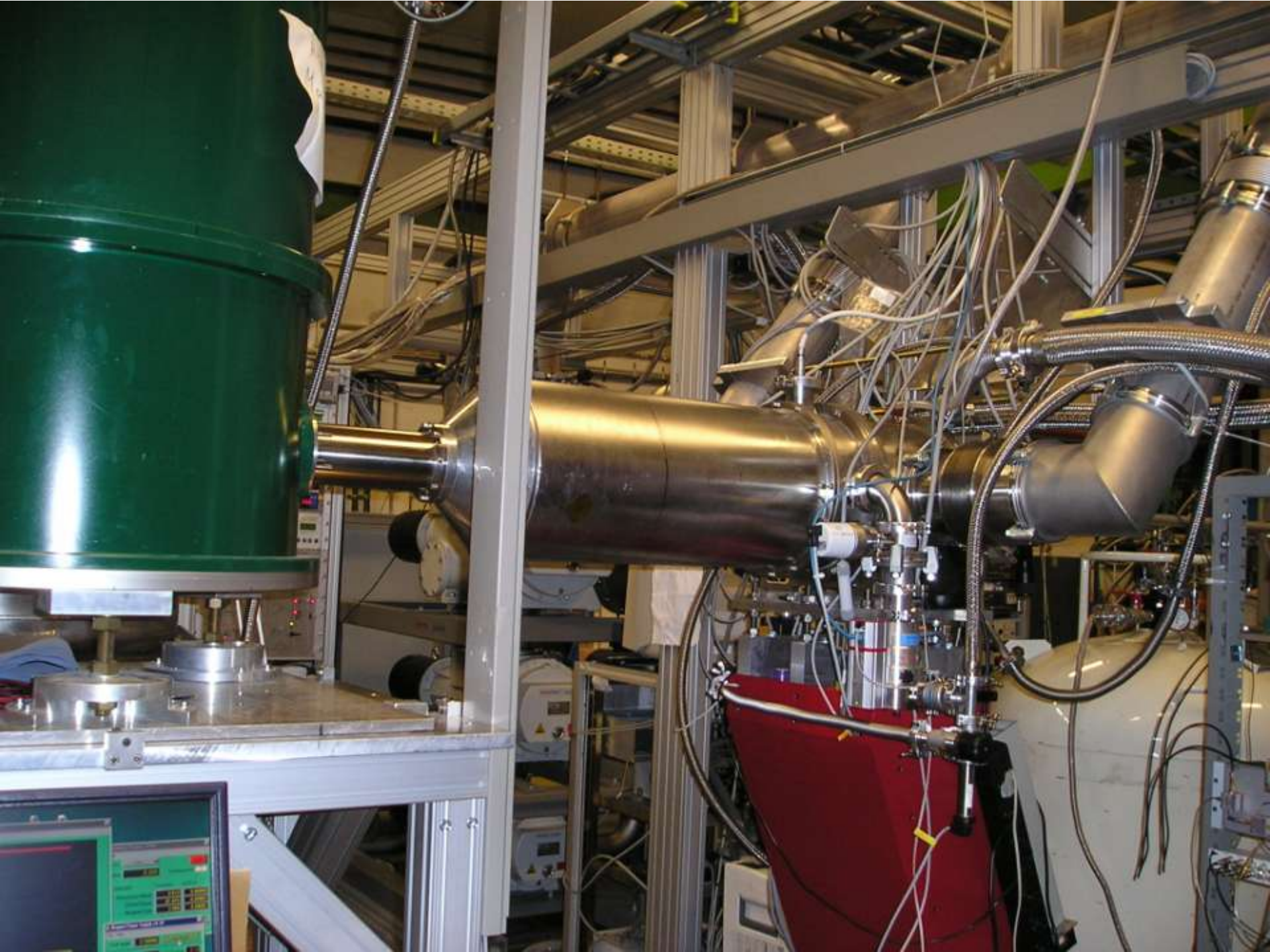
# Internal longitudinal Holding coil

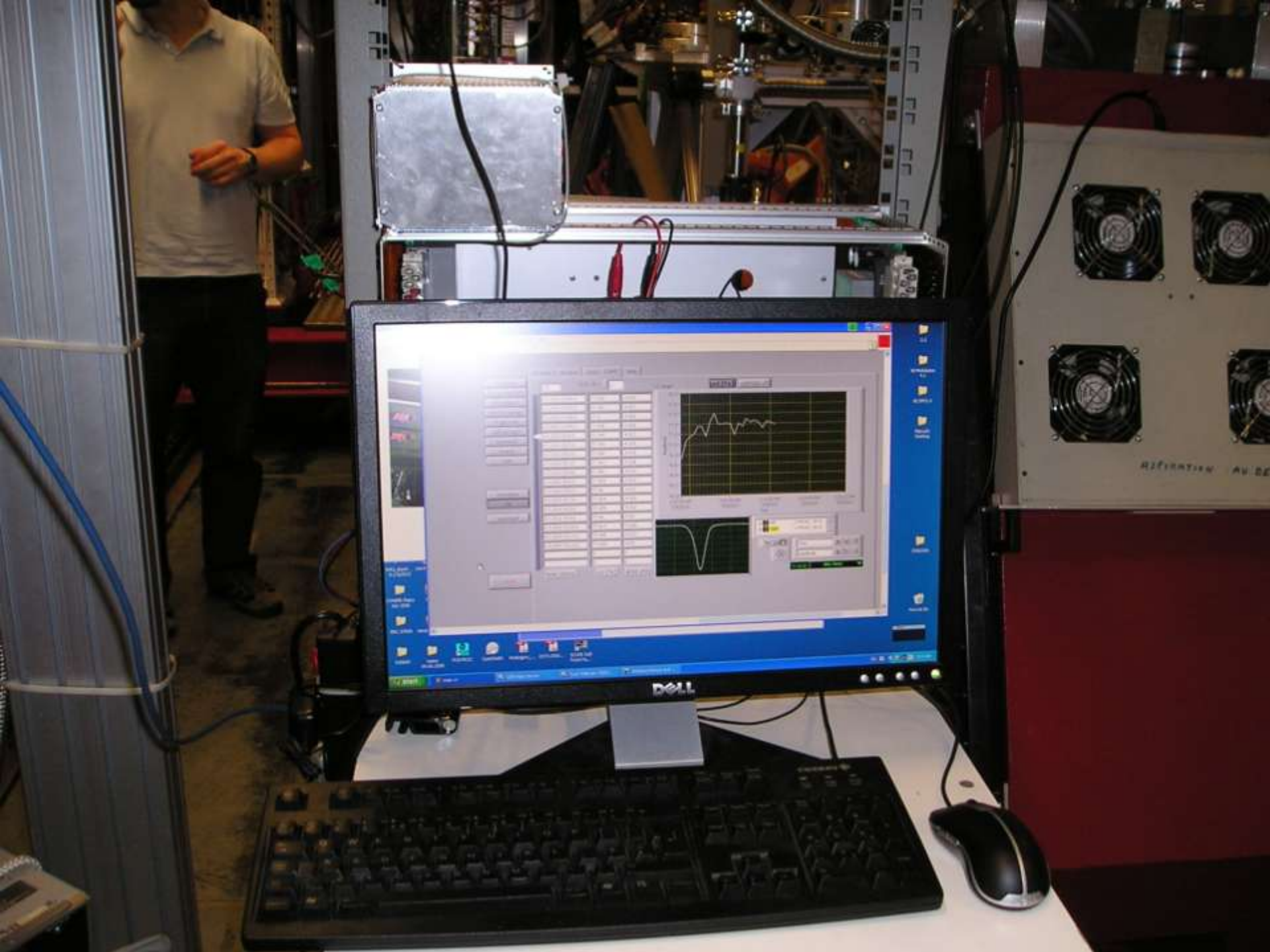


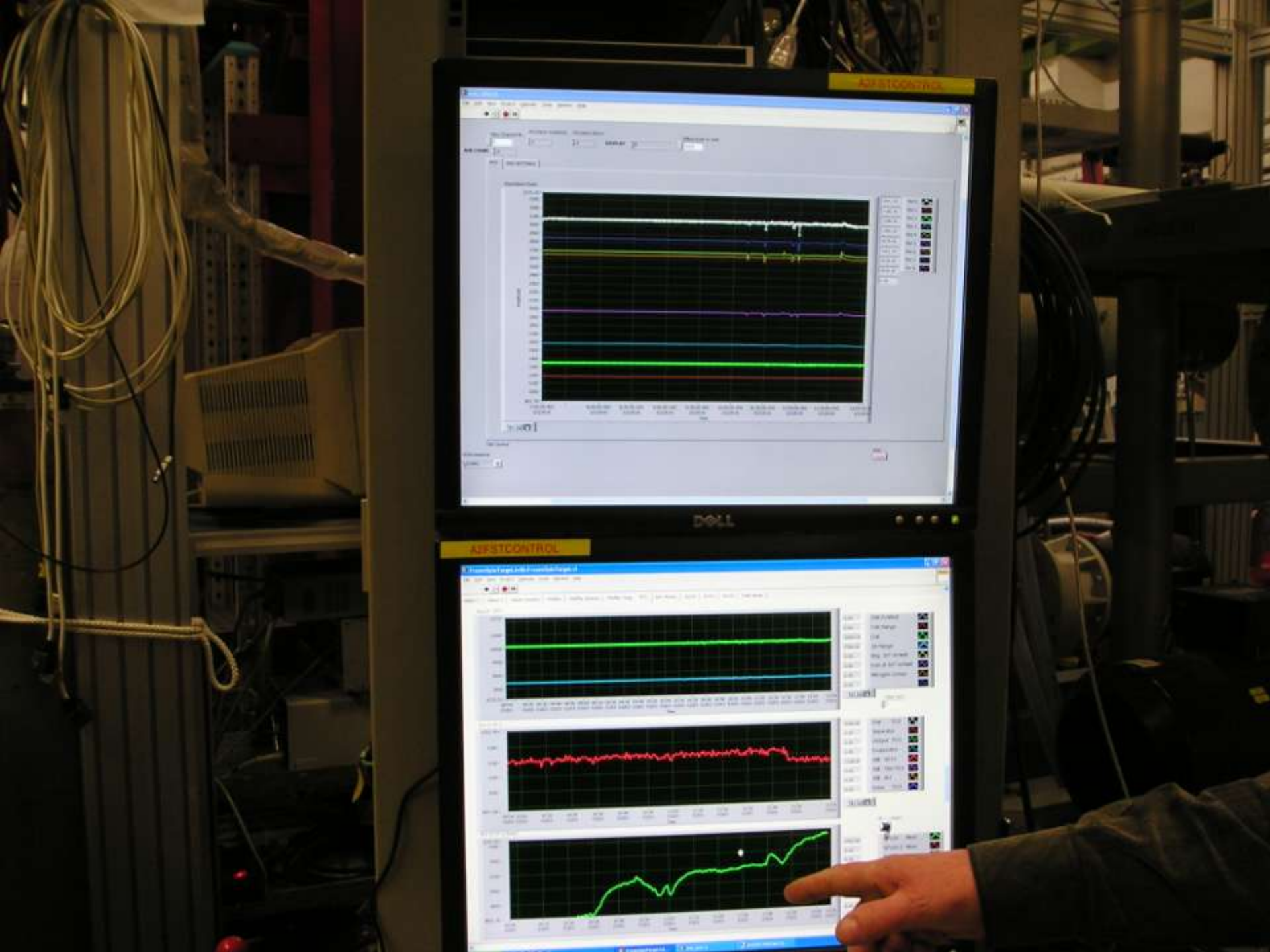
# Internal transverse Holding coil



# Internal transverse Holding coil




DELL


A2FSTCONTROL
DELL
A2FSTCONTROL

# Transverse asymmetries T and F in $\pi^0$ and $\eta$ photoproduction

Physics motivation:

Measurement of the target asymmetry *T* and the double-polarisation observable *F* in order to investigate interference effects between the $S_{11}(1535)$ and the $D_{13}(1520)$ nucleon resonances and to determine the energy-dependent phase shift between *s* and *d* waves, which is not yet taken into account by isobar models (MAID, SAID) for $\eta$ photoproduction.

Equipment:

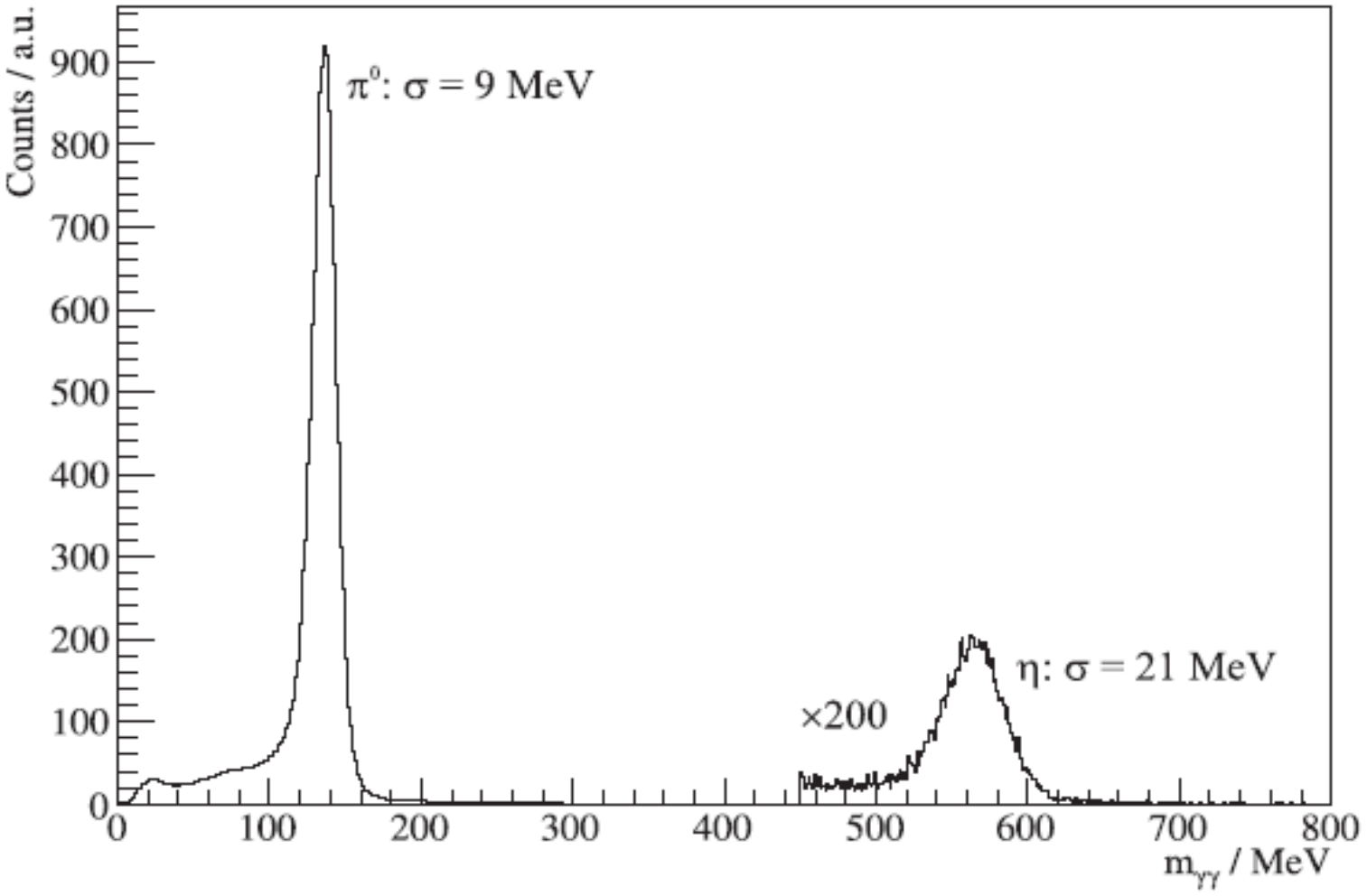
A beam of circularly polarised photons, energy-tagged by the Glasgow-Mainz tagging system, in combination with a transversely polarised 'Frozen Spin' butanol target. The reaction products are detected using the Crystal Ball / TAPS $4\pi$ photon spectrometer; the PID detector and the cylindrical wirechambers perform particle identication and track reconstruction for charged particles.

# The cross section for single meson production in case of a transversely polarised target and a circularly polarised photon beam

$$\left.\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right|_{\mathrm{pol}} = \frac{\mathrm{d}\sigma}{\mathrm{d}\Omega} \cdot \left[1 + p_x^{\mathrm{T}} p_{\mathrm{circ}}^{\gamma} F + p_y^{\mathrm{T}} T\right]$$

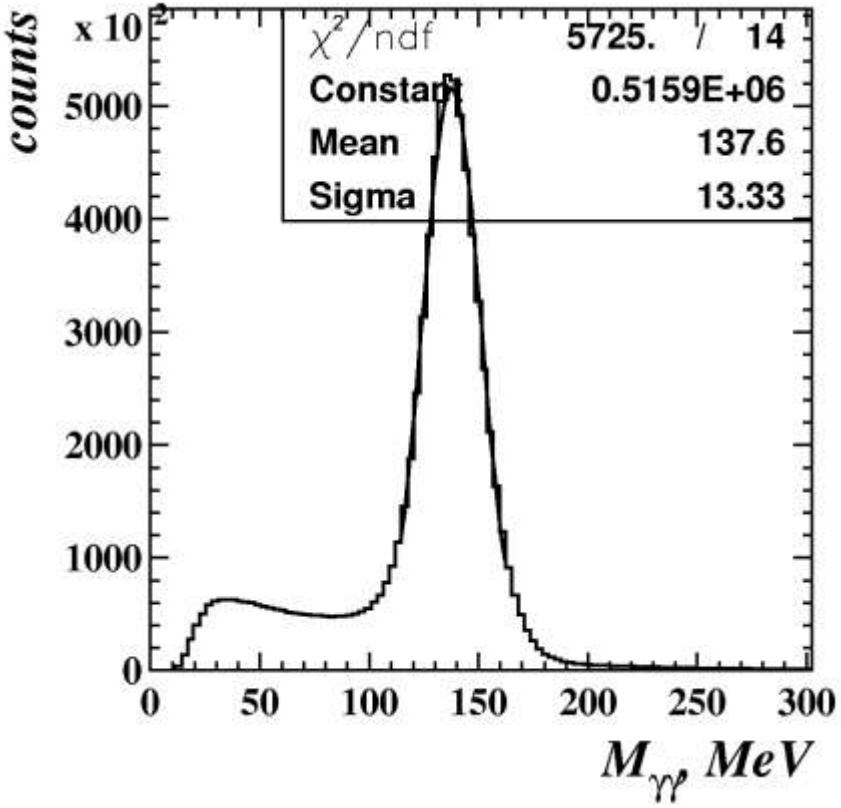
As the target asymmetry *T* is a single polarisation observables, it is accessible with only a polarised target and an unpolarised photon beam. However, using a circularly polarised photon beam does not affect this asymmetry but gives also access to the double-polarisation observable *F*. The target asymmetry *T* can be extracted integrating over both helicity states of the incoming circularly polarised photons, which eliminates any contributions from *F*. In contrast, the double-polarisation observable *F* can be evaluated from the asymmetry for different beam helicity states for a fixed alignment in the azimuthal angle ø of the transverse target polarisation.

# Two photon invariant mass spectrum for the Crystal Ball/TAPS detector setup. Both $\pi^0$ and $\eta$ mesons are seen.



# $\gamma p \rightarrow \pi^o p$ Reaction identification

**Invariant mass cut: 110 – 170 Mev**




from V.L. Kashevarov. 15th Crystal Ball@MAMI Collaboration Meeting, Mainz,8-10 March 2010

# $\gamma p \rightarrow \pi^o p$

# Reaction identification

**Missing mass spectra:**

**160 – 200 MeV**

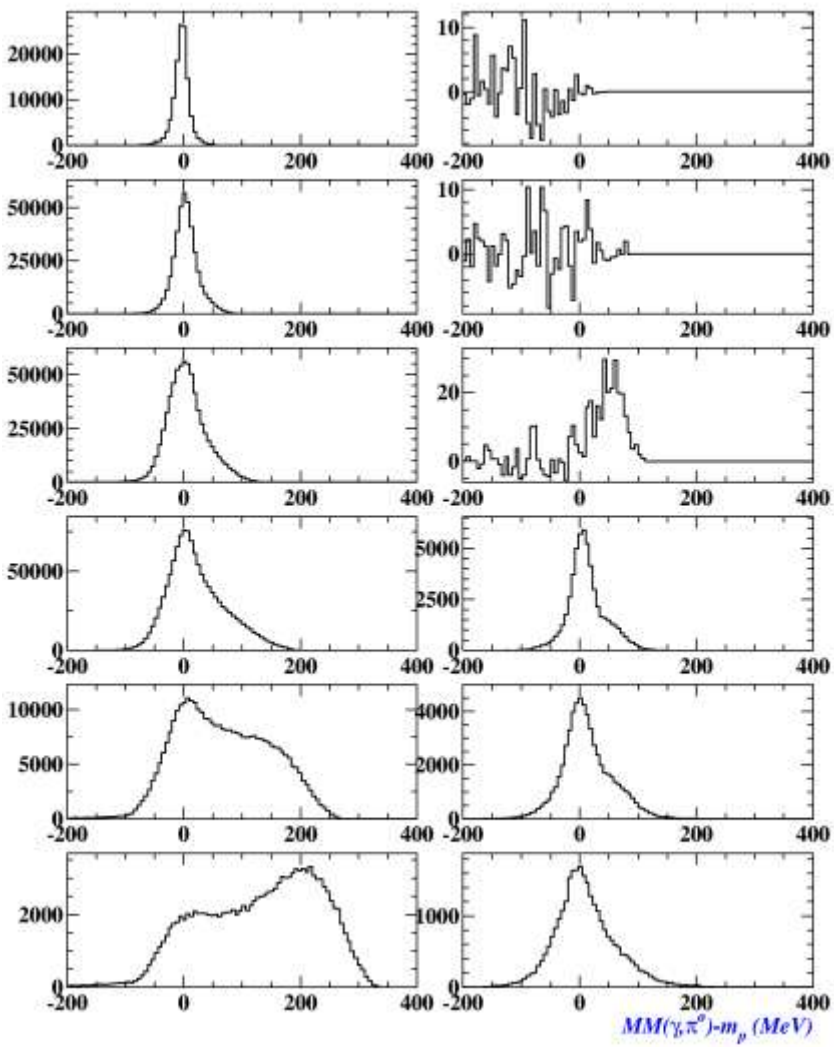
**200 – 250 MeV**

**250 – 300 MeV**

**300 – 400 MeV**

**400 – 500 MeV**

**500 – 600 MeV**

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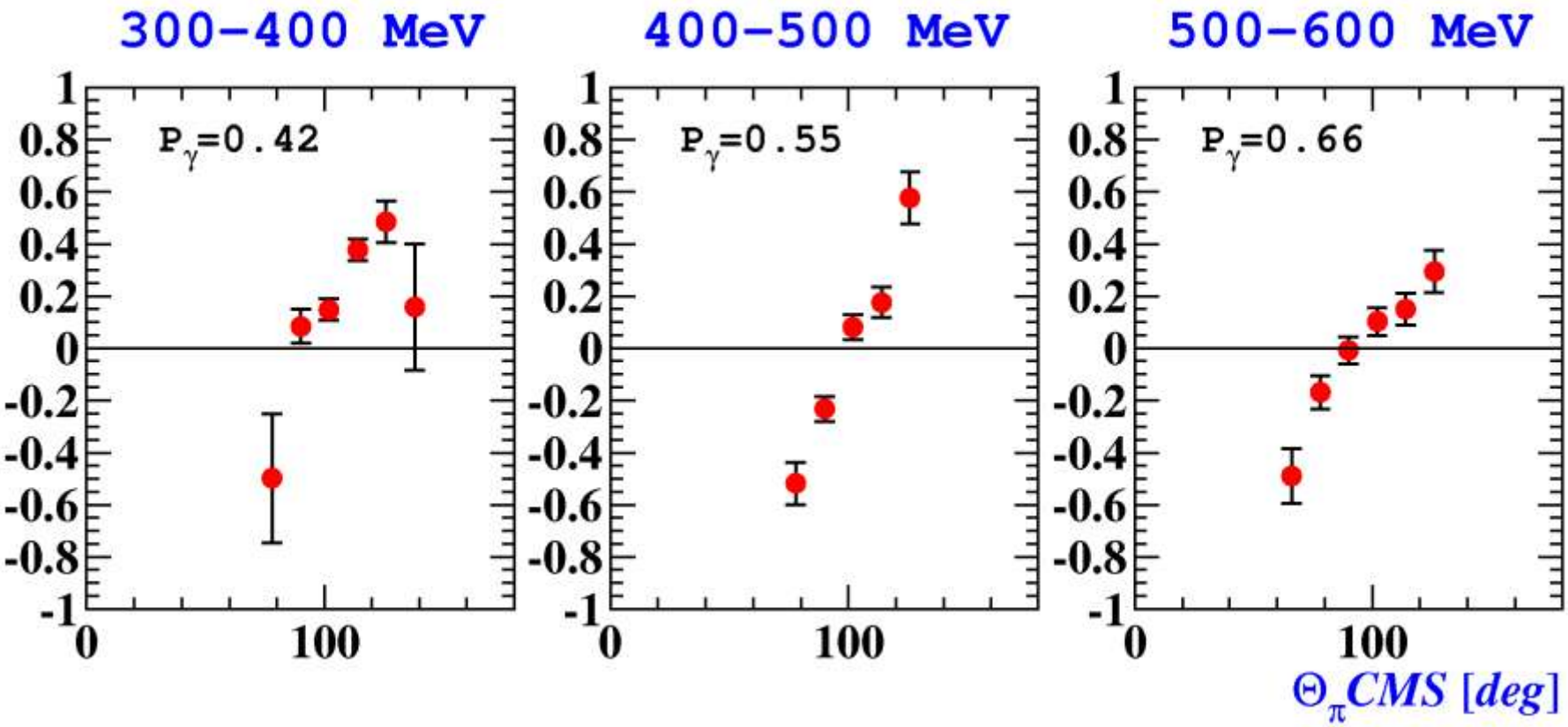
# $\gamma p \rightarrow \pi^o p$

## *Double polarization observable F (preliminary)*

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# ЗАКЛЮЧЕНИЕ

- **MAMI C: циркулярно и линейно поляризованные меченые фотоны с энергией до 1,5 ГэВ**
- **FST: продольно и поперечно поляризованные протоны и дейтроны**
- **Возможны любые комбинации поляризаций пучка и мишени**
- **Детектор Crystal Ball/TAPS: измерения продуктов реакции в 4π геометрии**
- **PAC-2009: из 14 проектов 9 – проекты дважды поляризационных экспериментов**