Institut für Kernphysik

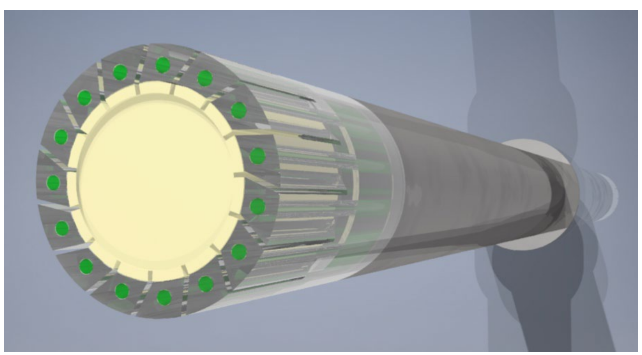
Status and plans for experiments with polarised target at MAMI

1.-Experimental setup: γ- beam and detector - Tagger + Crystal Ball@MAMI

Frozen Spin Target

2.-Active Target developments 2015-2020

3.- New Developements 2021 Maik Biroth

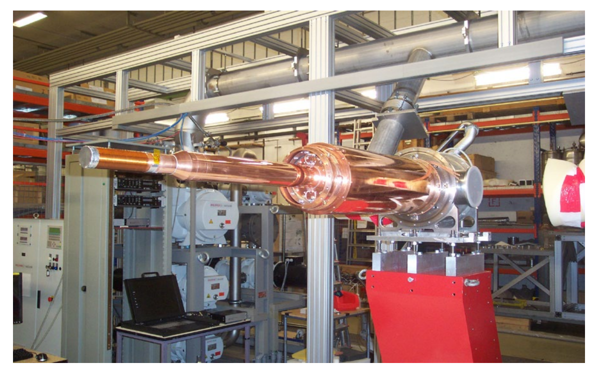


EU Meeting

Bonn, Online

June 24th , 2021

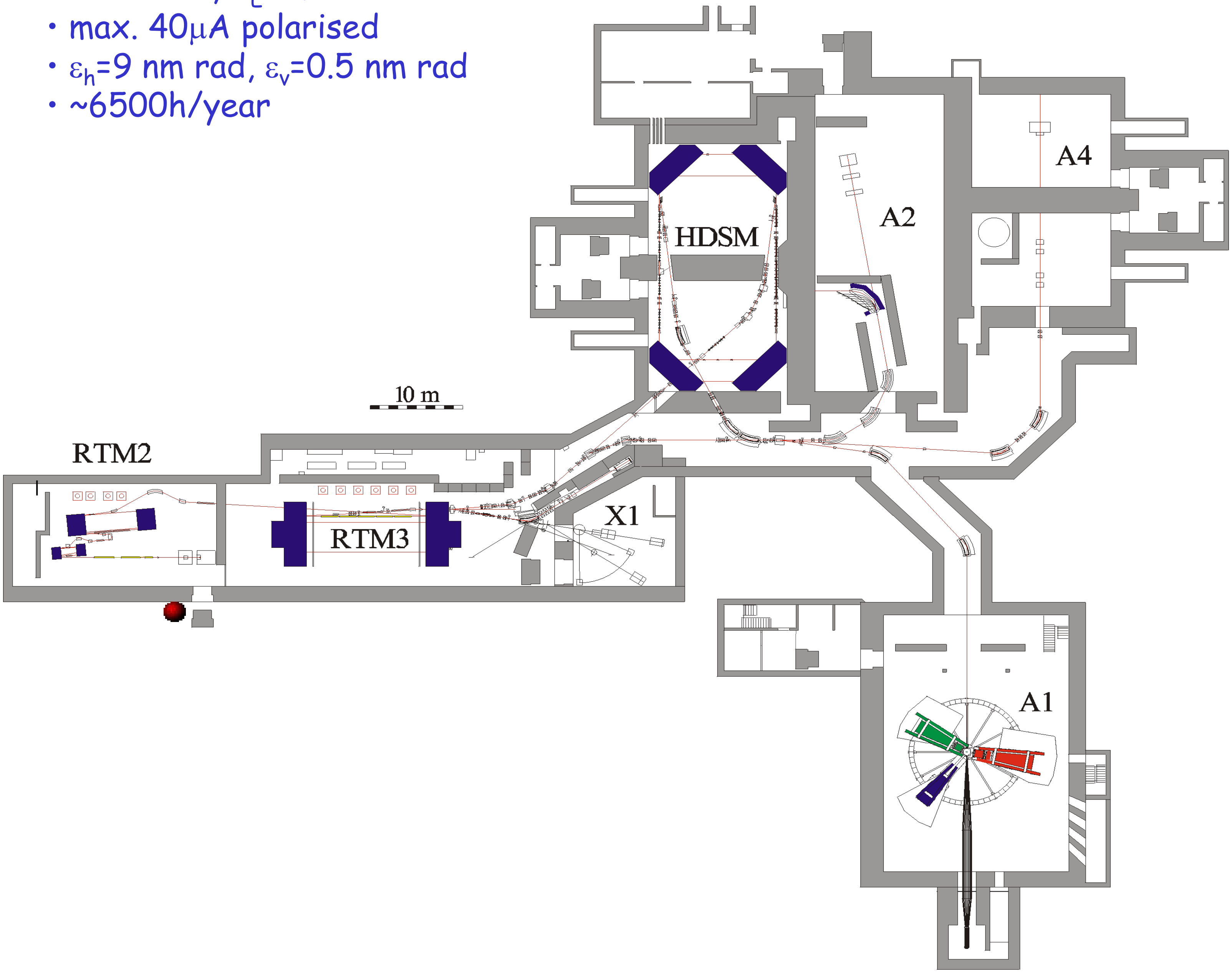
Andreas Thomas



The Mainz Microtron MAMI

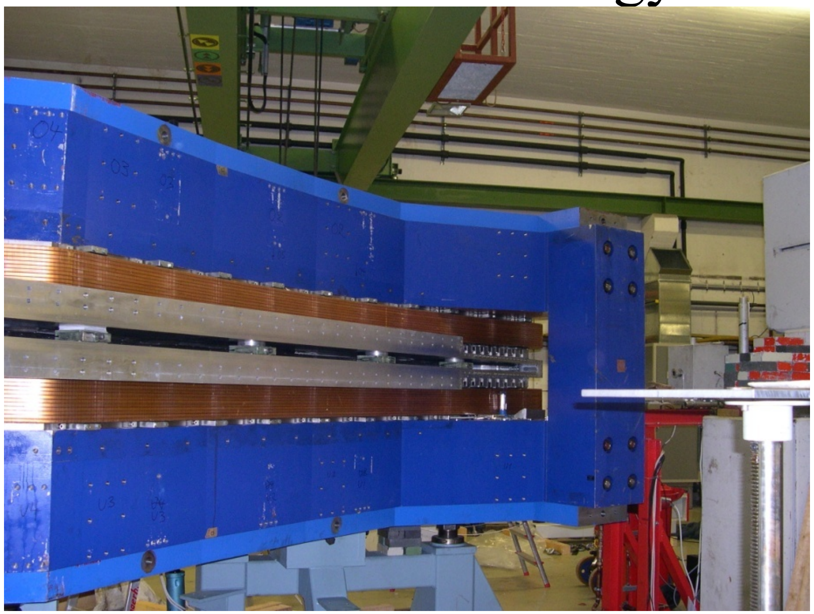
Parameter

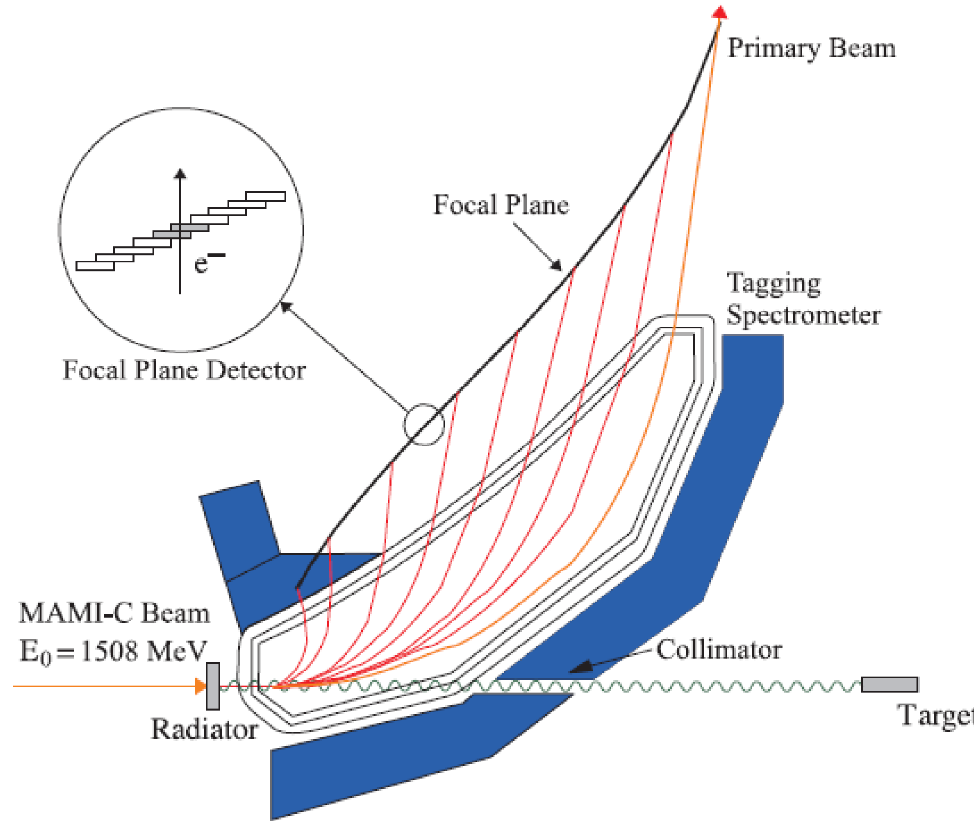
- 1604MeV, σ_E=0.100MeV
- max. 40μA polarised
- ε_h=9 nm rad, ε_v=0.5 nm rad
- ~6500h/year



A2 Tagging system (Glasgow, Mainz)

1. Production and energy measurement of the Bremsstrahlung photons.





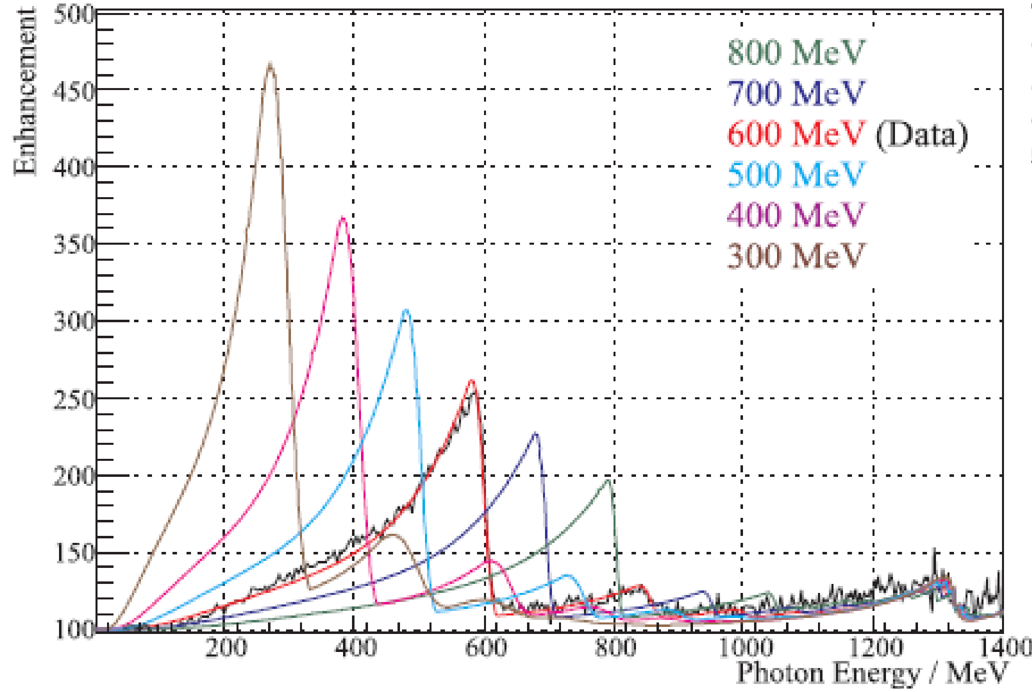
Glasgow Tagging Spectrometer
EPJ A 37, 129 (2008)

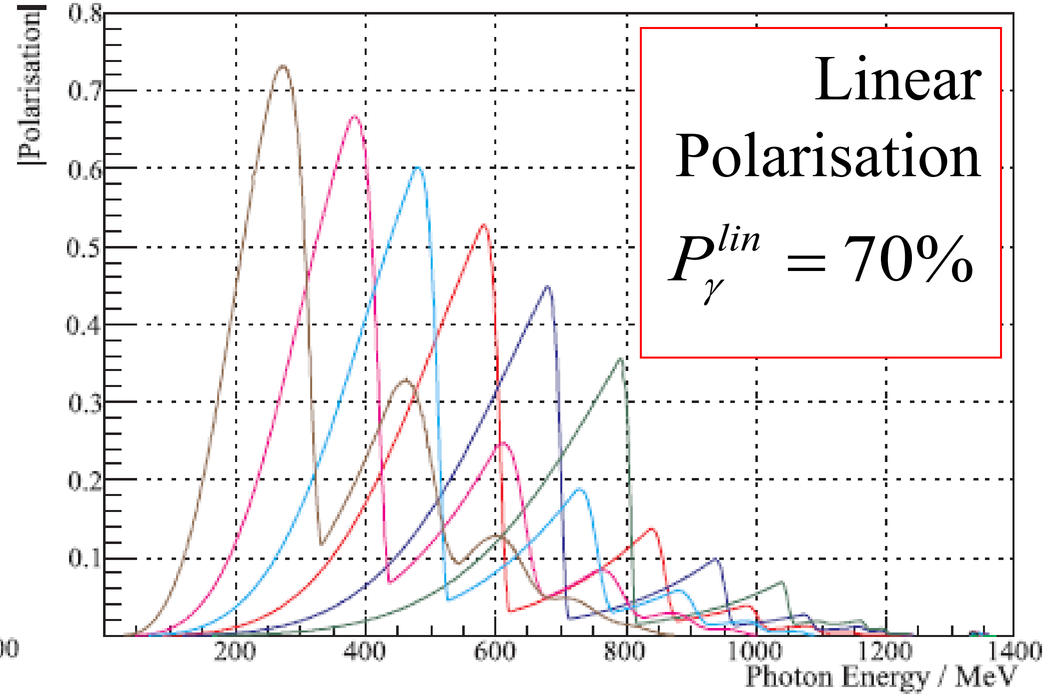
2. Determination of the degree of polarization of the electron beam (Moeller Polarimeter). Circularly pol. photons.

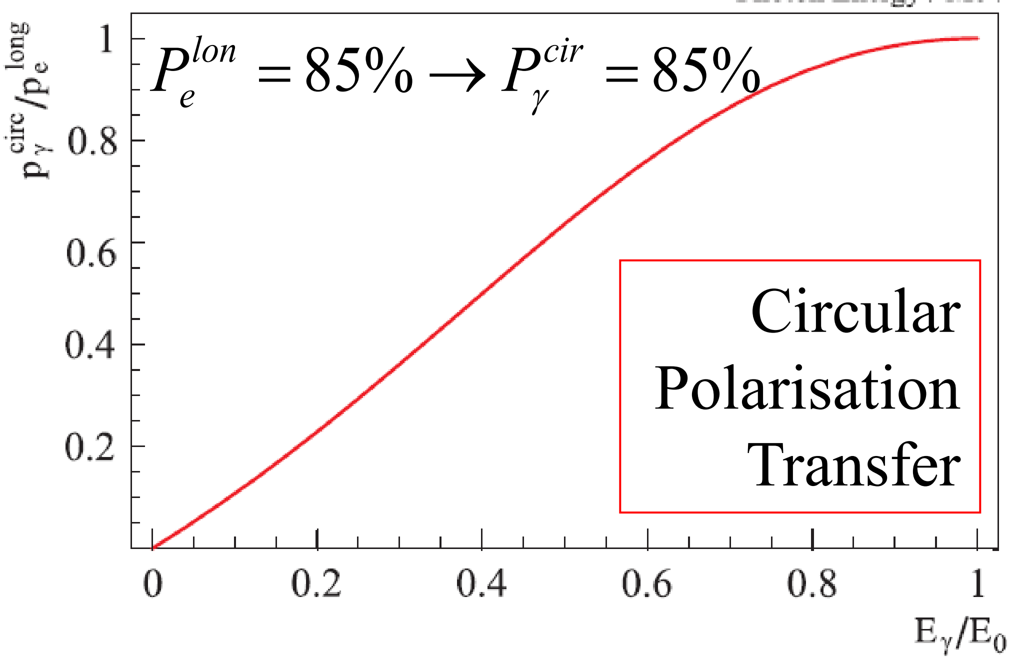
$$A = \frac{N^+ - N^-}{N^+ + N^-} = a\vec{p}_t\vec{p}_b\cos(z)$$

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

Polarised Photons @ MAMI C







E_γ = 75 ... 1480 MeV

ΔE_γ = 4 MeV

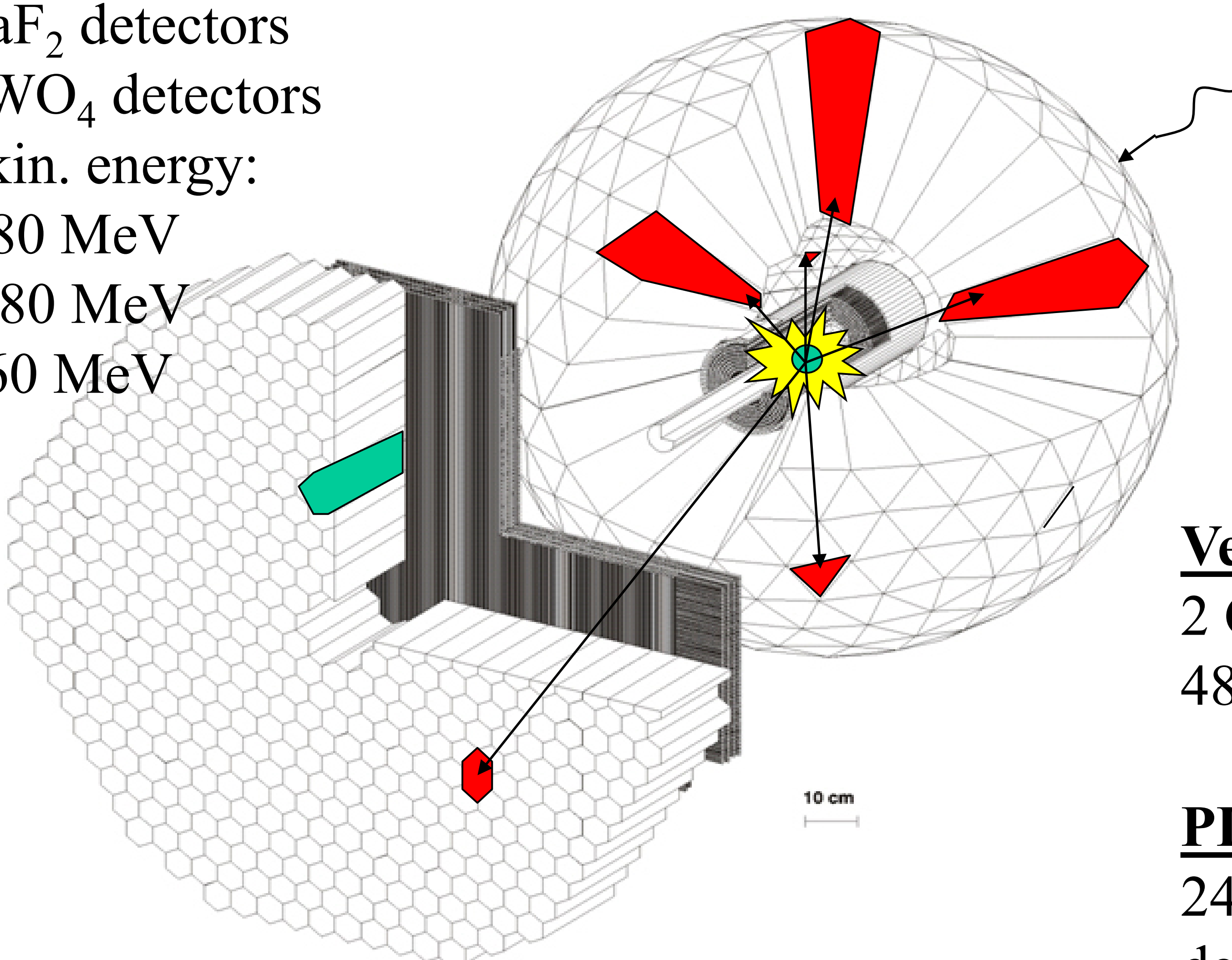
N_γ = $2 \cdot 10^5$ s^{-1} MeV^{-1}

High Polarisation
High Photon Flux

4π photon Spectrometer @ MAMI

TAPS:

366 BaF_2 detectors
72 $PbWO_4$ 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:

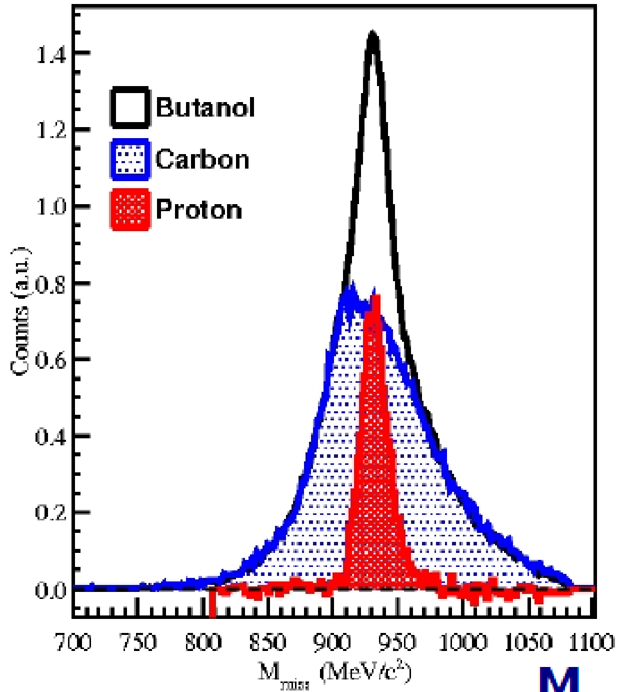
2 Cylindr. MWPCs
480 wires, 320stripes

PID detector:

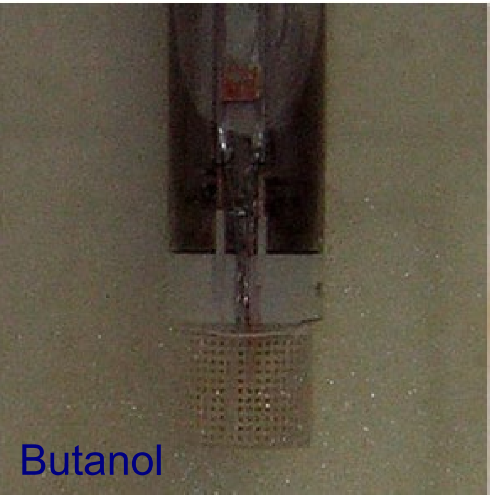
24 thin plastic detectors

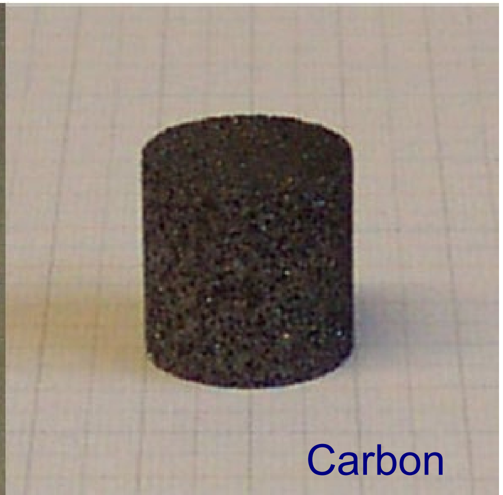
Additional challenges for the analysis of experiments with Frozen Spin Target → Dilution Factor.

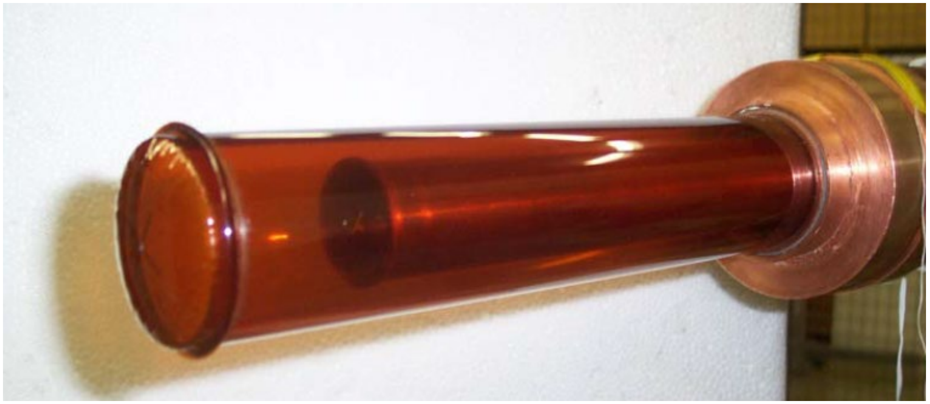
Missing Mass



$M_{miss.}$

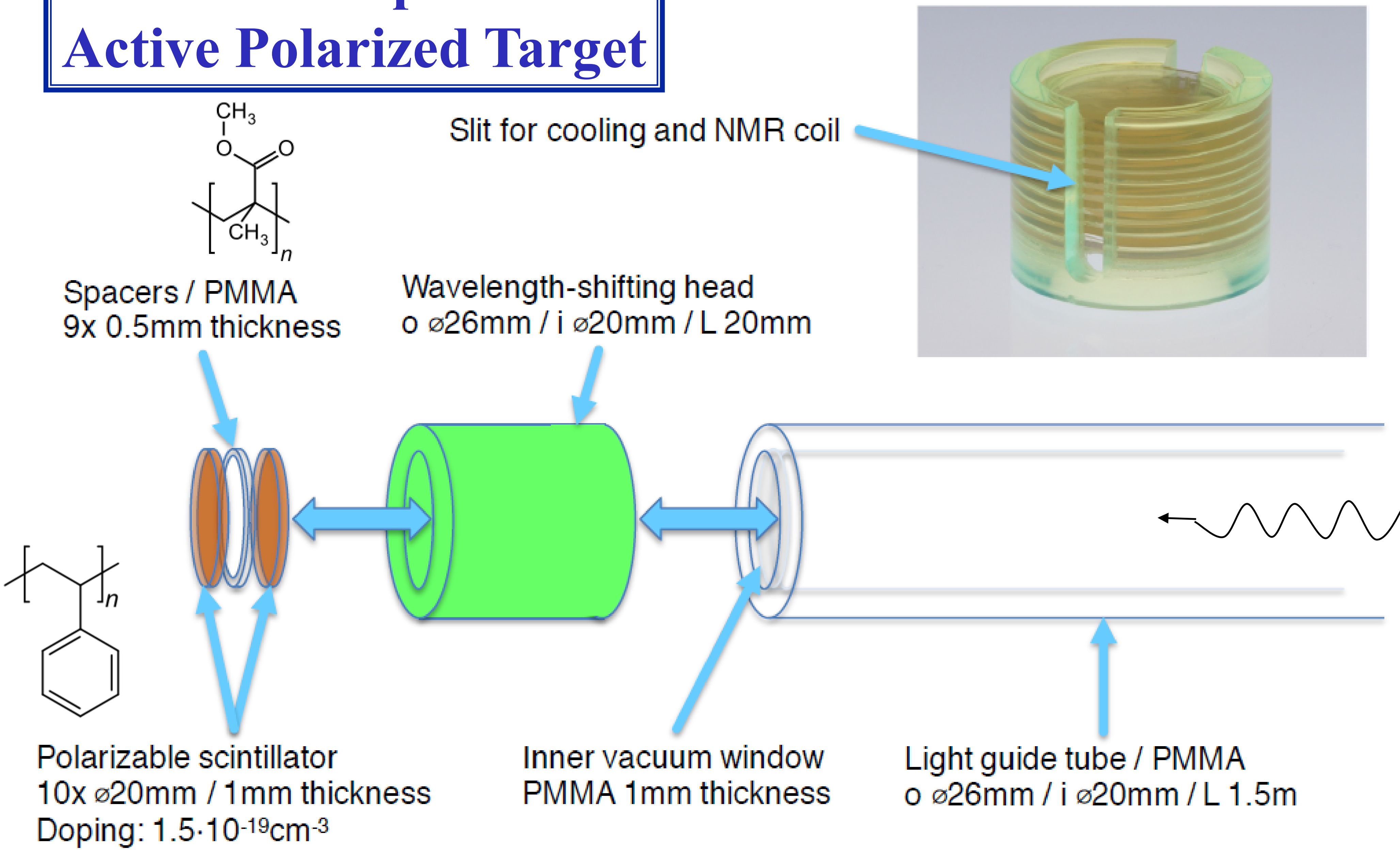




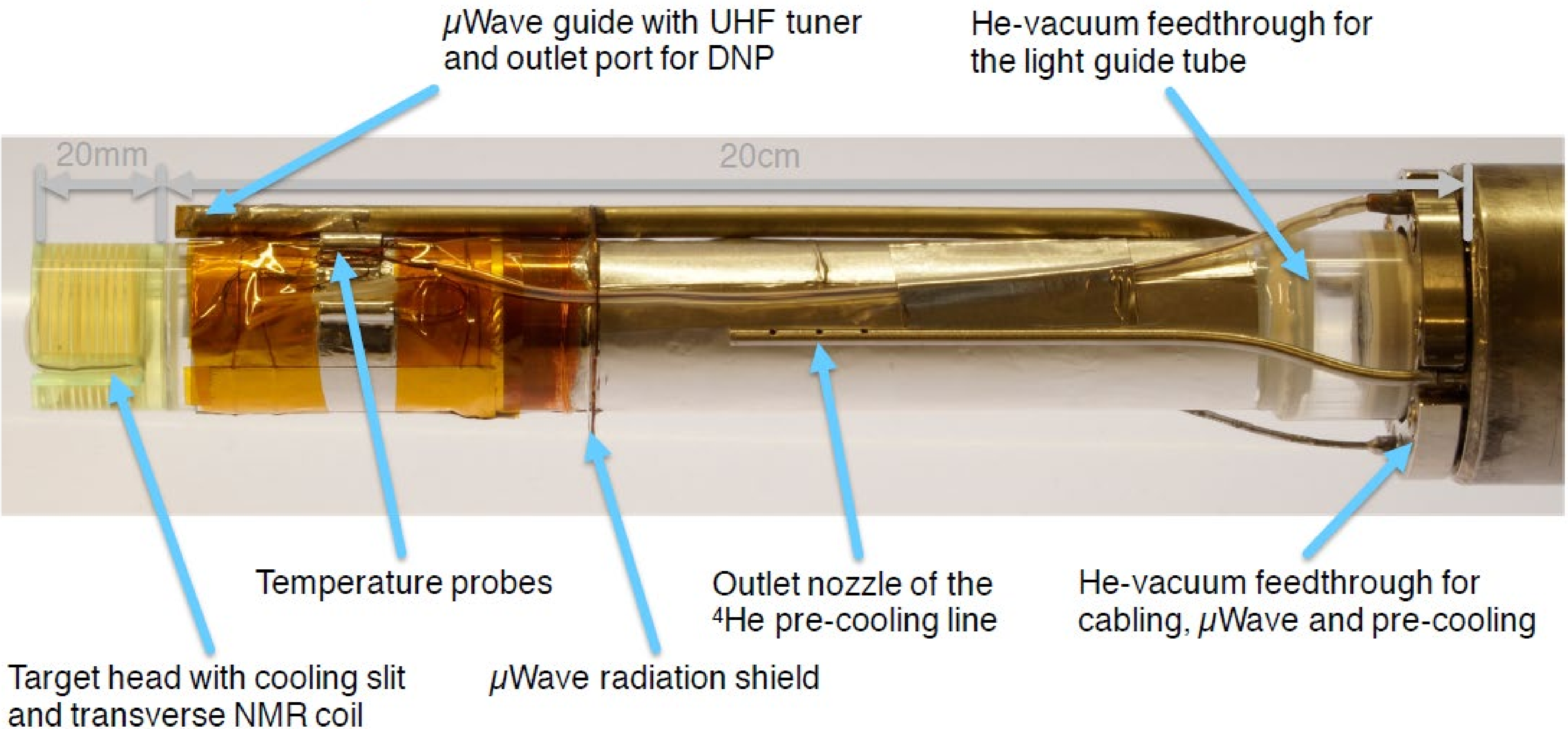


Hydrogen

New Developement: Active Polarized Target



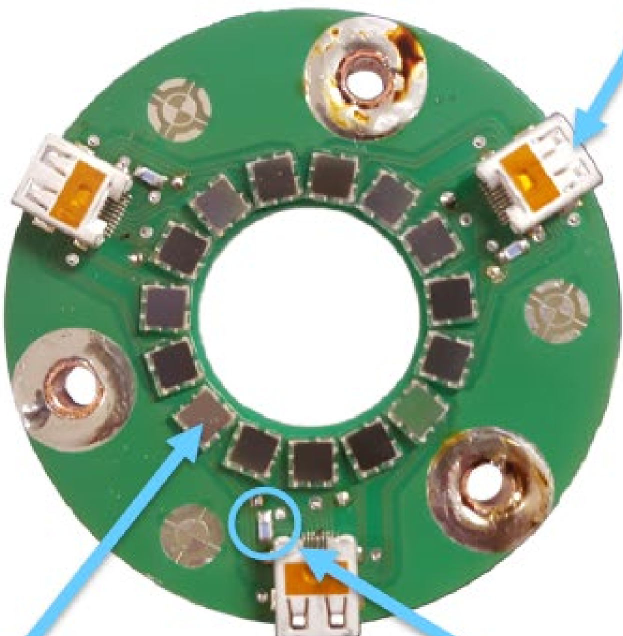
Active Polarized Target

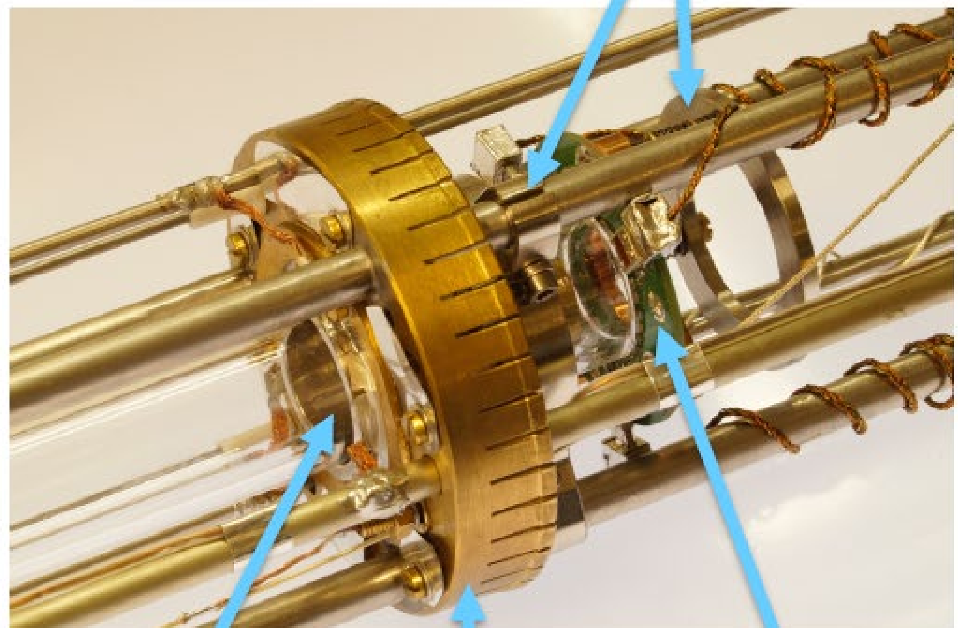


T=45mKelvin after 5 days by $^3He/^4He$ mixture ← ←Vacuum in beampipe

Detector Electronics at 150Kelvin

[M.Biroth et al., IEEE Transaction on Nuclear Science, Vol. 64, Issue 6, June 2017]



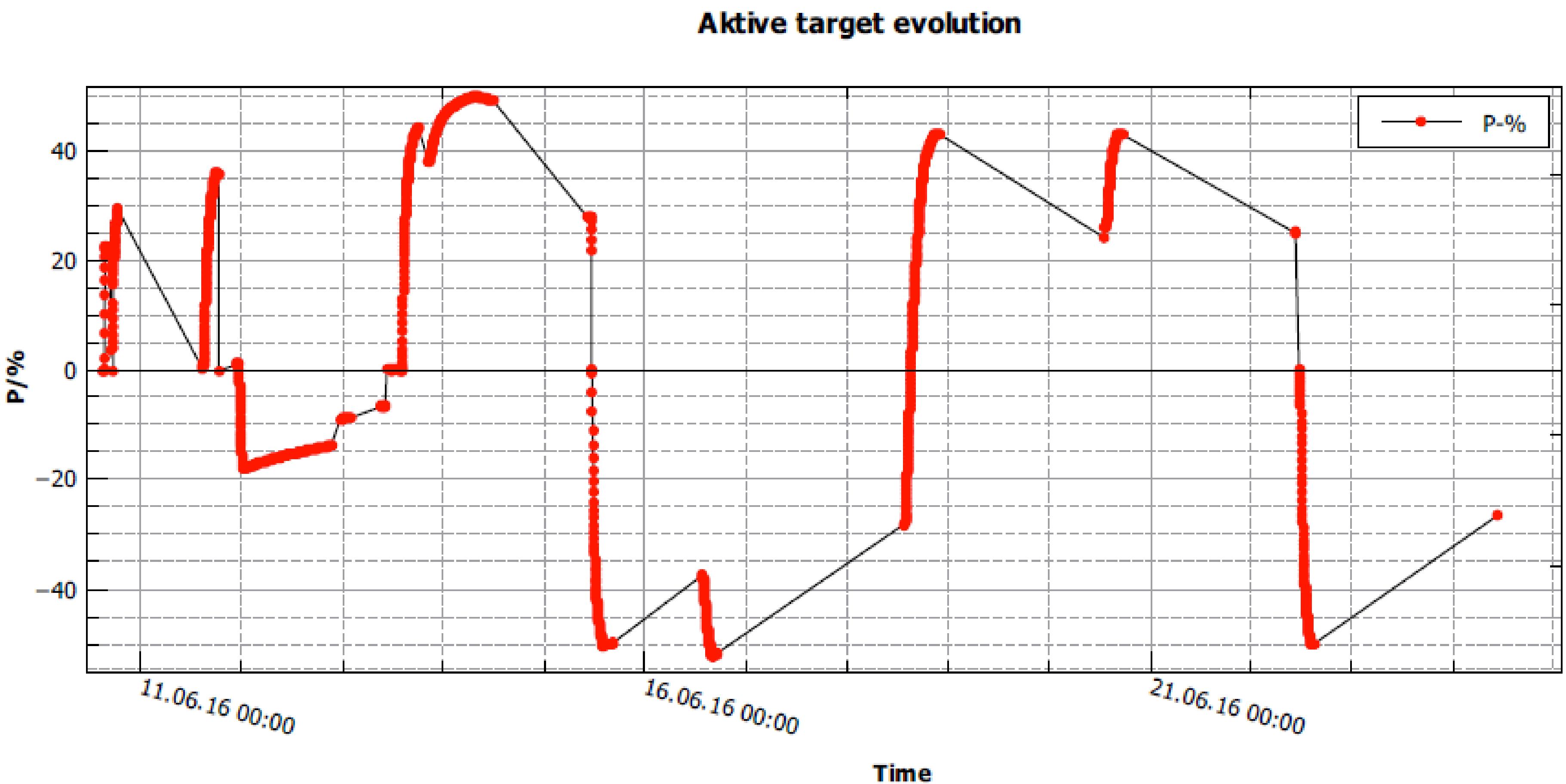


SiPMs gain depends strongly from the temperature ~1% K-1. Therefore it is necessary to control the 25V bias voltage to ~10mV and to have a stable temperature. [PhD M.Biroth, Mainz]

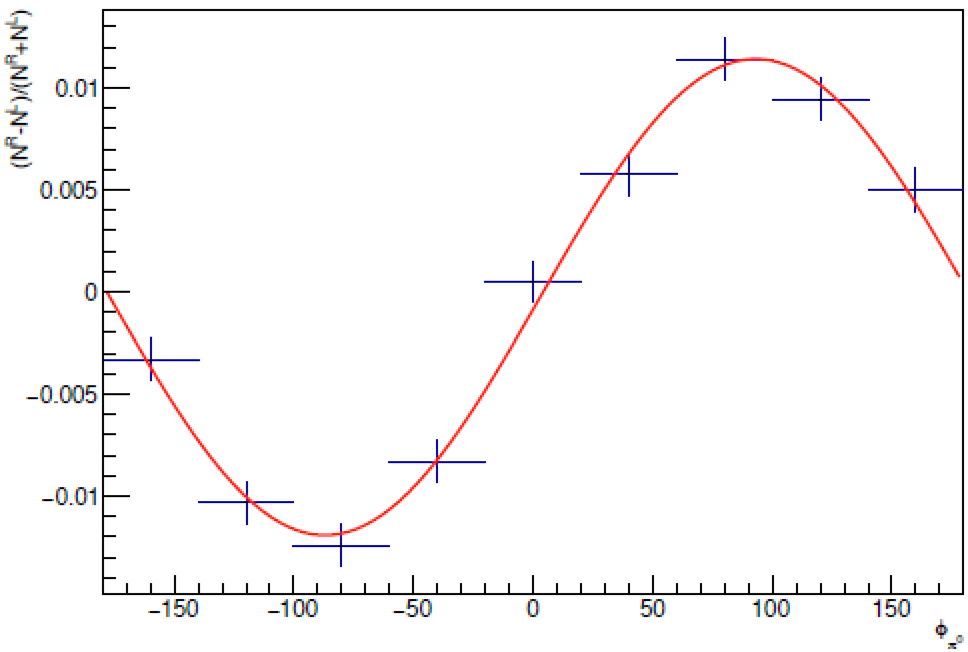
Run June 2016

Holding coil 437.5mT, temperature 45mK

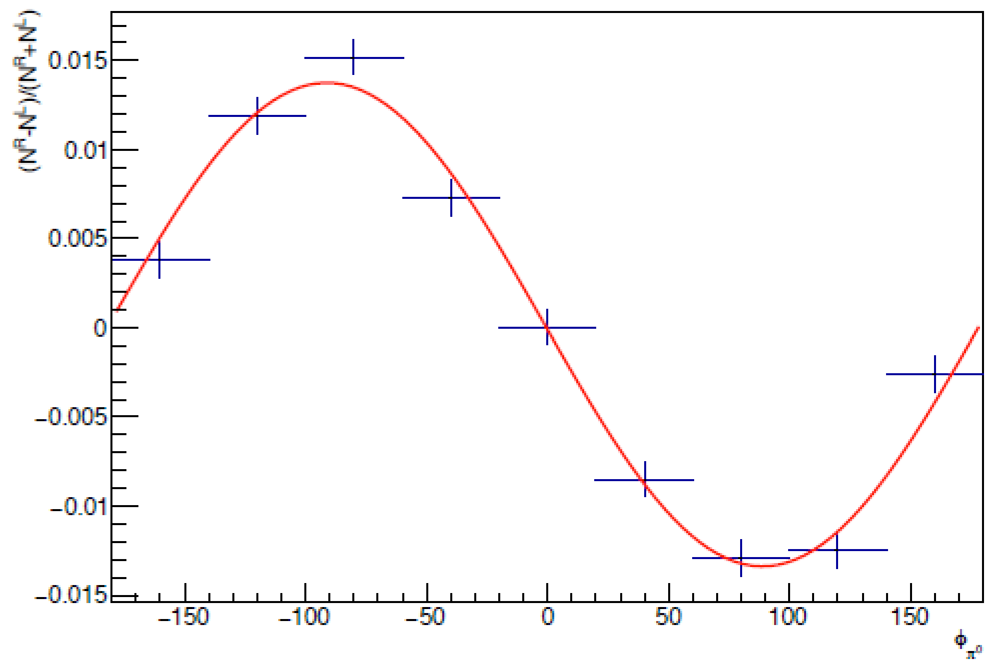
Spin setting	Max. Polarization	Max. Relaxation Time
Positive	(46±1)%	78.3h
Negative	(49±1)%	74.1h



First count rate asymmetries from June 2016
ϕ distribution for π^0 production



Target +



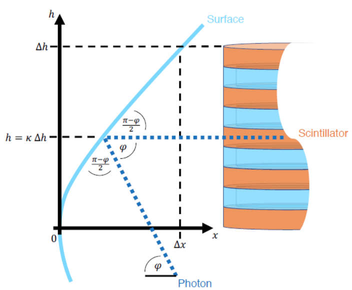
Target -

JRA10:CryPTA:Task 3

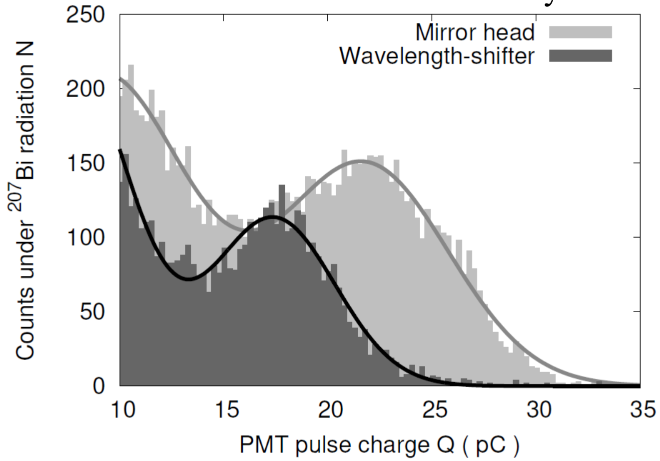
3.1 Design studies for polarized, scintillating target material

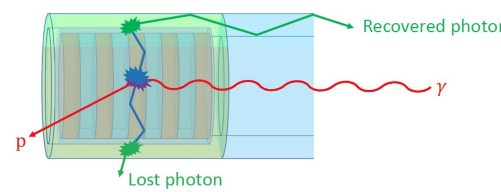
Detailed analysis, calculations and comparison of concepts for target heads for better light collection

eg. mirror head target ⟷ vs. ⟷ wave length shifter concept



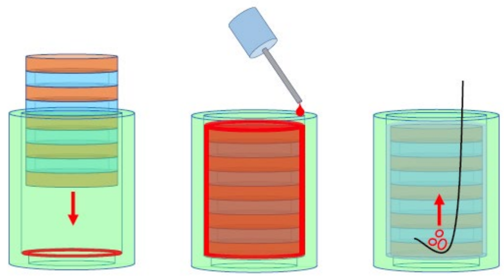
The mirror head shows a superior light collection efficiency.
Problem: Mechanical stability.



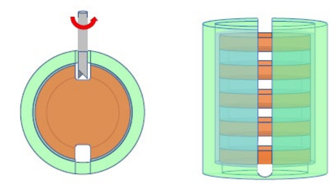


JRA10:CryPTA:Task 3

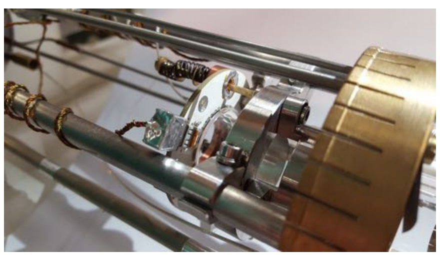
3.2 Prototypes of a scintillating target stack with electronic readout

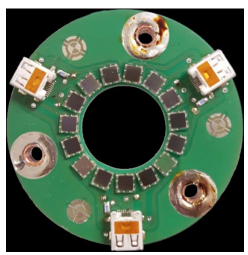


The production process of the
active polarized target stacks has been optimized.

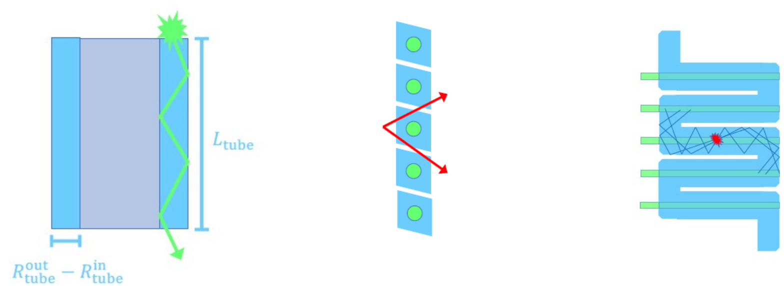


The machining procedure for post production
for NMR and cryogenic cooling slits was further developed.





The coupling of the electronic readout to the light guide
components is well under control and documented.

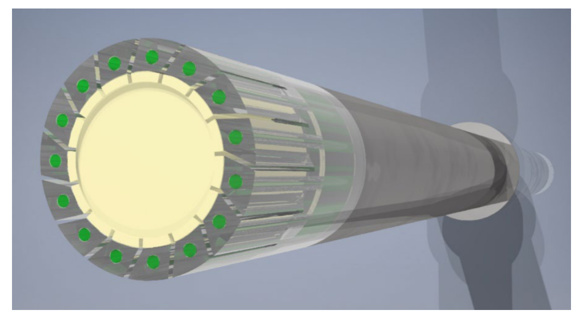


Conclusion and Outlook

- The active polarised proton target was in operation in our 4π detector system in 2016.

- The detailed analysis in the framework of Maik Biroth gave a lot of new ideas for a better construction.

- R&D for polarised active szintillator target for threshold production and Compton is continued. Analysis of first data proofs light output.
  New active target insert with better light transport system, fibers,
  Scintillating target container with Butanol.



- Maik Biroth is working on the EU project from 04/2021 -09/2021 to produce an improved active target insert in Mainz.

- Dilution cryostat back in Mainz in 2022. Integration of new insert planned.

Thank You!

M. Biroth, P. Achenbach, E. Downie, and A. Thomas, “Silicon photomultiplier properties at cryogenic temperatures,” Nucl. Instrum. Methods Phys. Res. A, vol. 787, pp. 68–71, Jul. 2015.

P. Achenbach, M. Biroth, E. Downie, and A. Thomas, “On the operation of silicon photomultipliers at temperatures of 1–4 kelvin,” Nucl. Instrum. Methods Phys. Res. A, vol. 824, pp. 74–75, Jul. 2016.

M. Biroth, P. Achenbach, E. Downie, and A. Thomas, “A low-noise and fast pre-amplifier and readout system for SiPMs,” Nucl. Instrum. Methods Phys. Res. A, vol. 787, pp. 185–188, Jul. 2015.