

# High rate electron beam tests with MuPix sensors at MAMI

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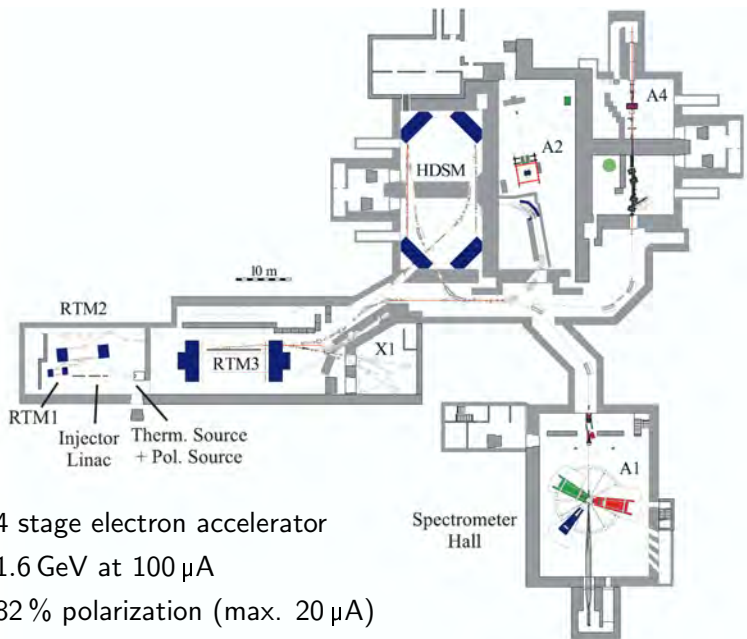


# Outline

- ▶ Mainz Microtron (MAMI) accelerator
- ▶ MAMI testbeam locations
- ▶ MuPix sensor
- ▶ MuPix testbeams at MAMI



# The MAMI accelerator



- ▶ 4 stage electron accelerator
- ▶ 1.6 GeV at  $100 \mu\text{A}$
- ▶ 82 % polarization (max.  $20 \mu\text{A}$ )

## Accelerator stages 1-3 - MAMI-B

- ▶ Linear injector
- ▶ 3 stage racetrack microtrons
- ▶ Energies[MeV]:  
14, 180, 855



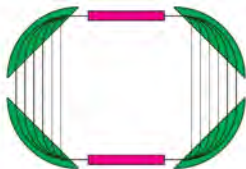
# Accelerator stages 1-3 - MAMI-B

- ▶ Linear injector
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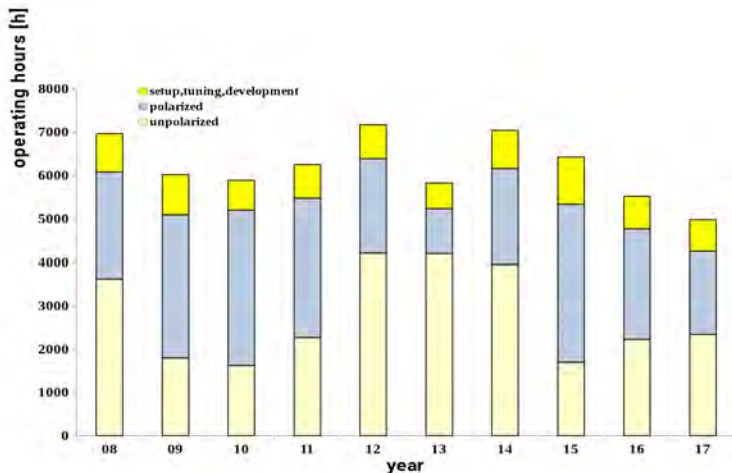


# Accelerator stage 4 - MAMI-C

- ▶ Harmonic double-sided microtron
- ▶ Output energy: 1.6 GeV

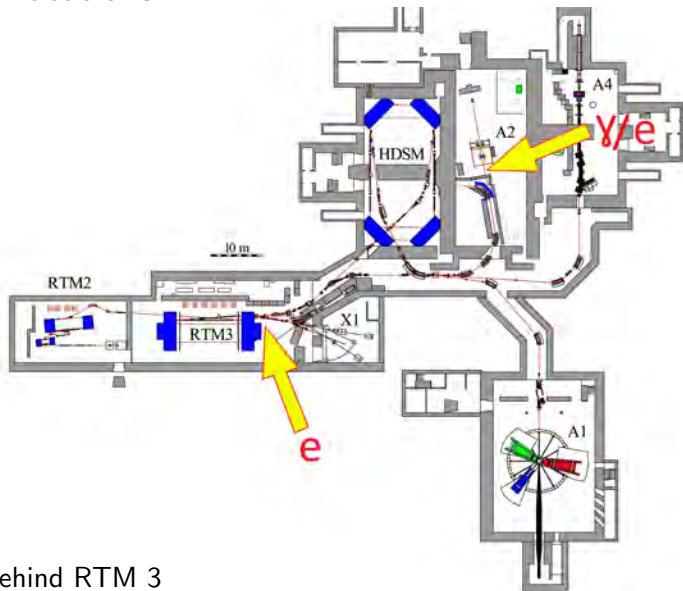


# MAMI operation



- ▶ Up to 70% duty cycle
- ▶ December 2017 missing ( $\approx 150$  h unpolarized)

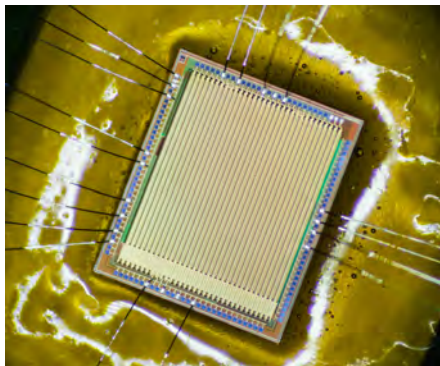
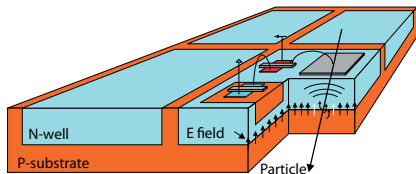
## Testbeam locations



- ▶ X1: behind RTM 3
- ▶ A2 hall: tagger magnet

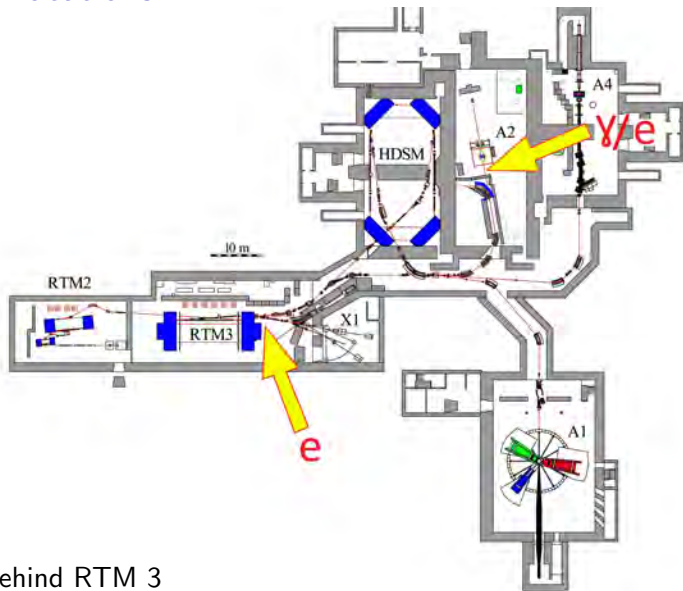


# HV-MAPS - MuPix sensor prototypes



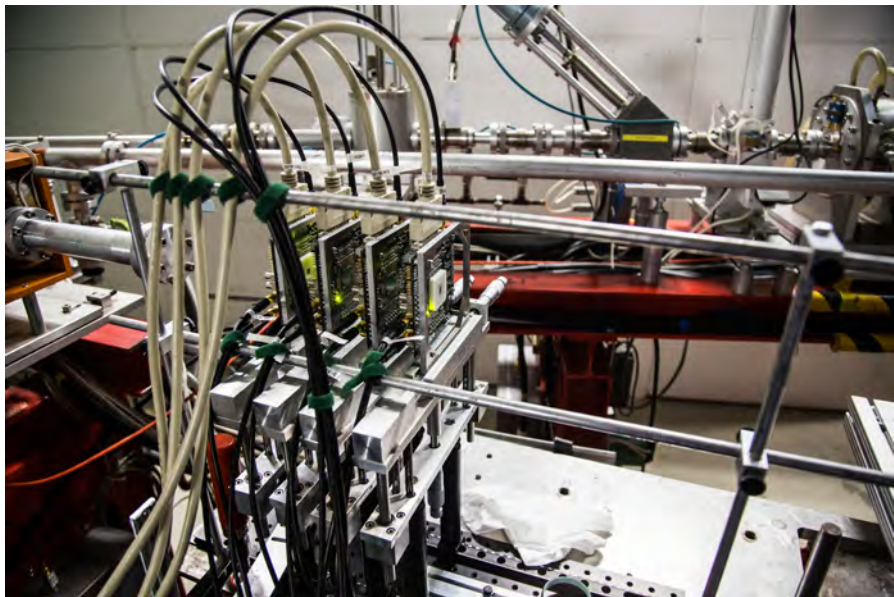
- ▶ 180 nm HV-CMOS technology
- ▶ Reverse biased up to 90 V
- ▶ Readout logic on chip
- ▶ Thinnable down to 50  $\mu\text{m}$
- ▶ MuPix7
- ▶ Pixel size:  $80 \times 103 \mu\text{m}^2$
- ▶ Sensor size:  $3 \times 3 \text{ mm}^2$
- ▶ Used in Mu3e, P2

## Testbeam locations



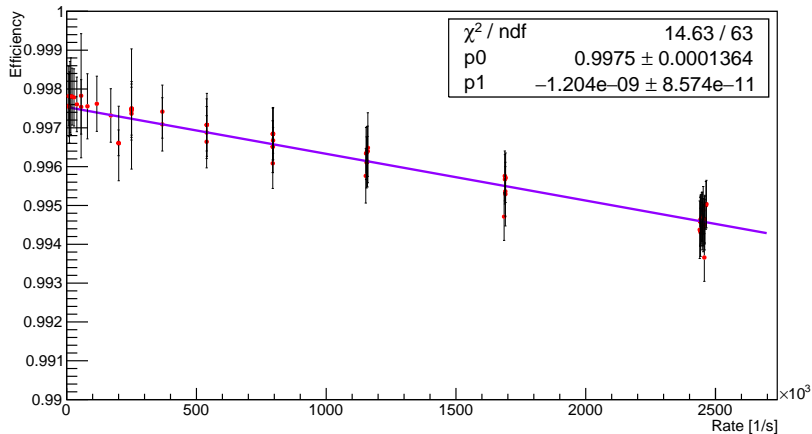
- ▶ X1: behind RTM 3
- ▶ A2 hall: tagger magnet

## X1 - high rate electron testbeam

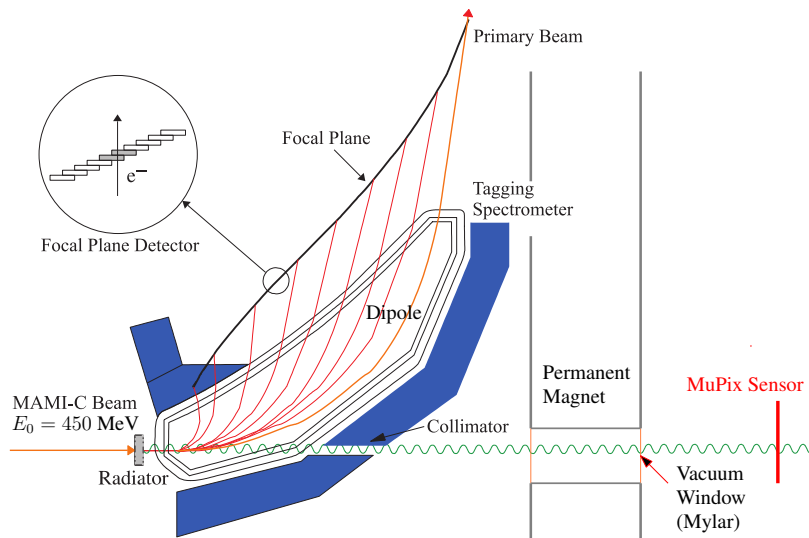


# X1 - high rate electron testbeam

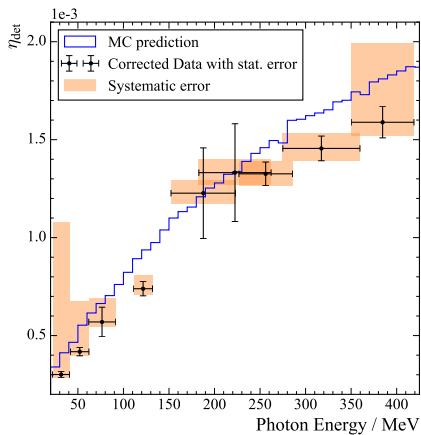
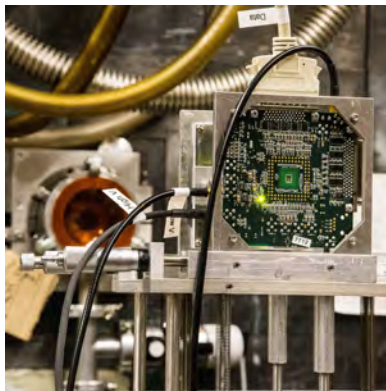
Efficiency vs rate



# A2-Glasgow-Mainz tagger - photon testbeam



# A2-Glasgow-Mainz tagger - photon testbeam

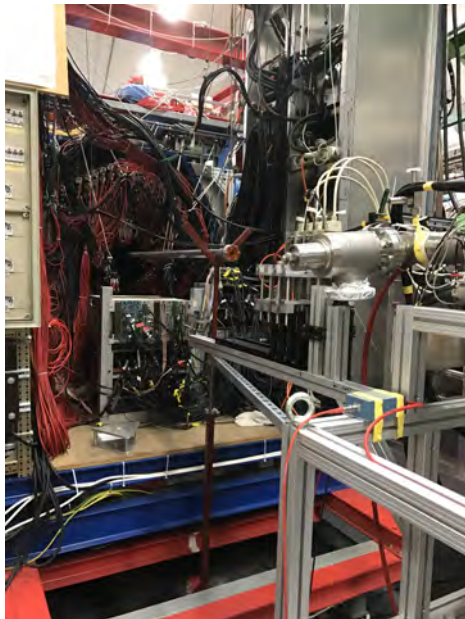


## A2-Glasgow-Mainz tagger - electron testbeam



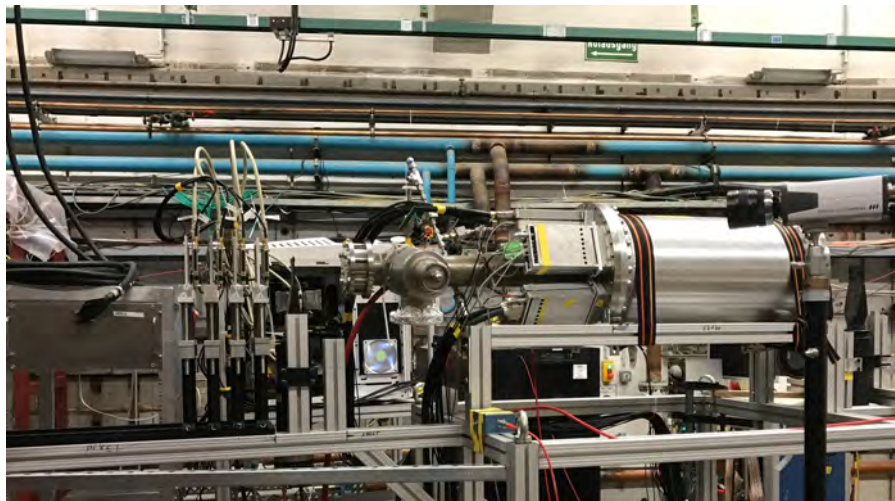
## A2 electron beamline extension - new 2017

- ▶ A2 hall: beamline extended through Crystal Ball
- ▶ No radiator, tagger magnet off
- ▶  $E_{beam} = 700 \text{ MeV}$





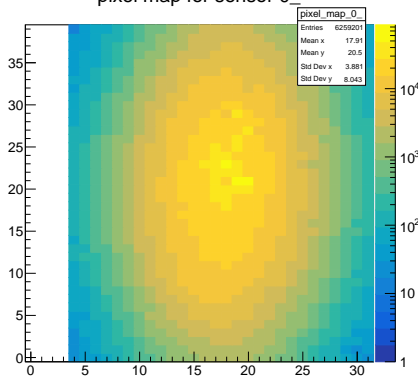
## TPC testbeam - setup in A2 hall



- ▶ MuPix telescope
- ▶ High pressure helium TPC

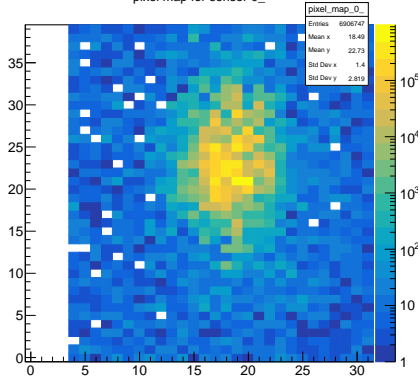
# TPC testbeam - observations

pixel map for sensor 0\_



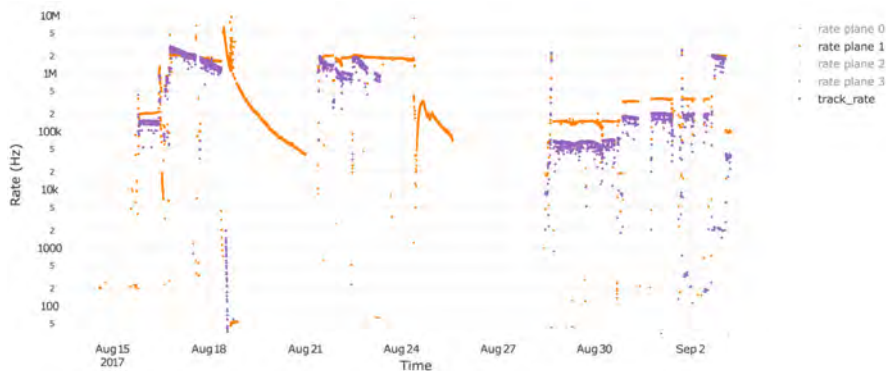
Beamspot

pixel map for sensor 0\_



Background after 2 MHz hit rate

# TPC testbeam - results



- ▶ MuPix telescope operation
- ▶ Beam monitoring
- ▶ Provide reference tracks

## Summary

- ▶ MAMI provides polarized electron beam up to 1.6 GeV
- ▶ Electron & photon testbeams possible
- ▶ MuPix high rate capabilities tested
- ▶ MuPix telescope provides reference tracks up to 2 MHz
- ▶ MuPix8 to be tested in March



# Backup - A1



- ▶ Electron scattering
- ▶ 3 rotatable spectrometers



## Backup - A2



- ▶ Photoproduction by Bremsstrahlung
- ▶ Beam electrons deflected and tagged by spectrometer
- ▶ Meson radiation of target nucleons



## Backup - A4

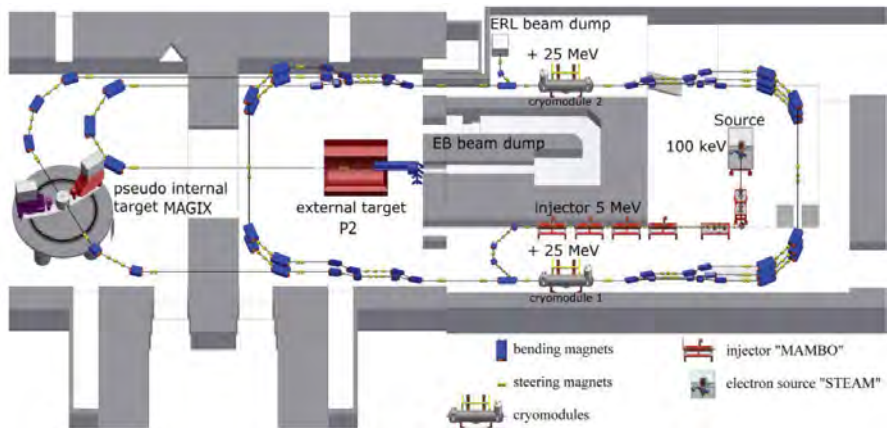


- ▶ Elastic electron scattering
- ▶ Longitudinally polarized electrons
- ▶ Unpolarized  $H_2$  target
- ▶ Measure parity violating asymmetry



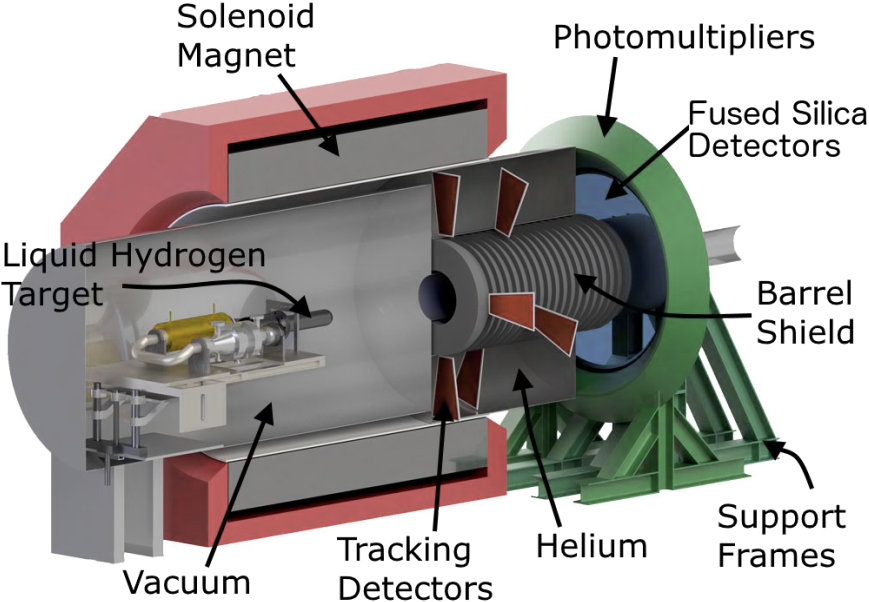
# Backup - MESA

- ▶ Mainz Energy Recovering Superconducting Accelerator (**MESA**)
- ▶ 2 modes, up to 155 MeV, 85 % polarization

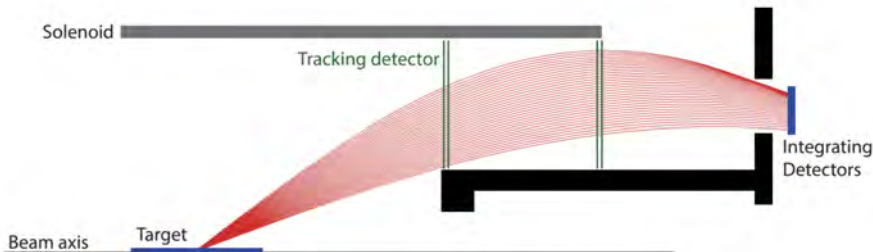




# Backup - P2 experiment

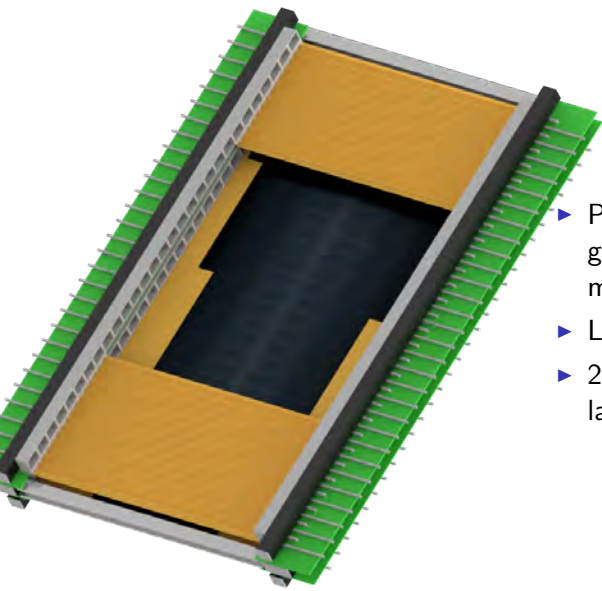


## Backup - P2 spectrometer and tracking system



- ▶ 0.6 T solenoid magnet
- ▶ Inhomogeneous field in tracking system
- ▶ Measure the average  $Q^2$
- ▶ Validate acceptance, alignment
- ▶ Monitor beam and target conditions

## Backup - P2 tracking detector



- ▶ Pixel sensors, electronics, gaseous helium cooling, mechanical support
- ▶ Low material budget
- ▶  $2 \times 4$  modules, double layers, 300 sensors per layer