

The P2 tracking detector

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The weak mixing angle

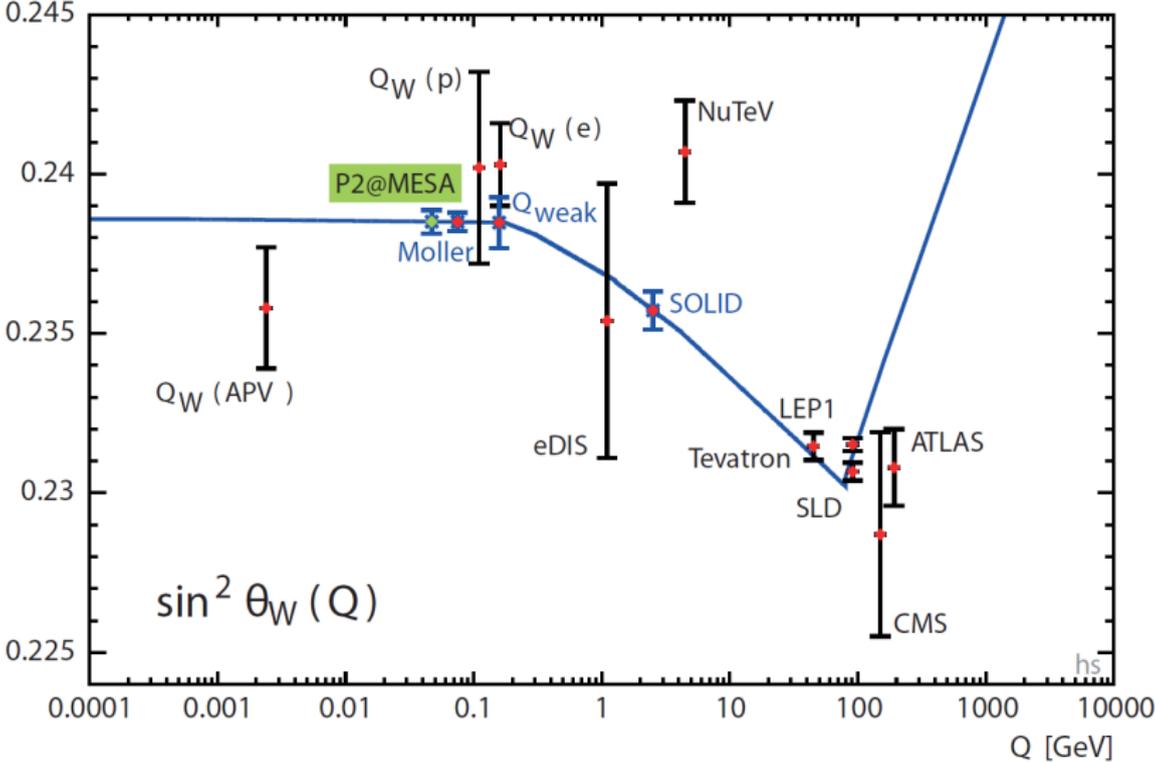
- ▶ fundamental parameter of the standard model
- ▶ mixing between γ and Z^0
- ▶ boson masses and couplings

$$\begin{pmatrix} \gamma \\ Z^0 \end{pmatrix} = \begin{pmatrix} \cos \theta_W & \sin \theta_W \\ -\sin \theta_W & \cos \theta_W \end{pmatrix} \begin{pmatrix} B \\ W_3 \end{pmatrix}$$

$$\cos \theta_W = \frac{m_W}{m_Z}$$

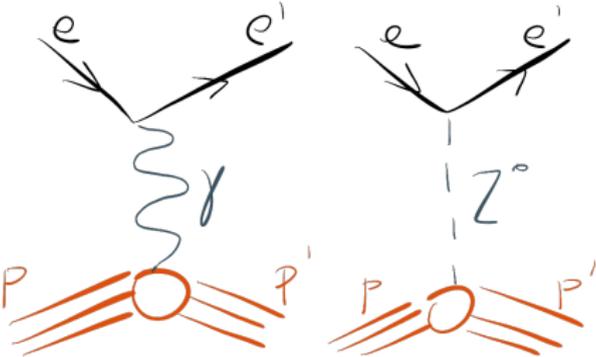
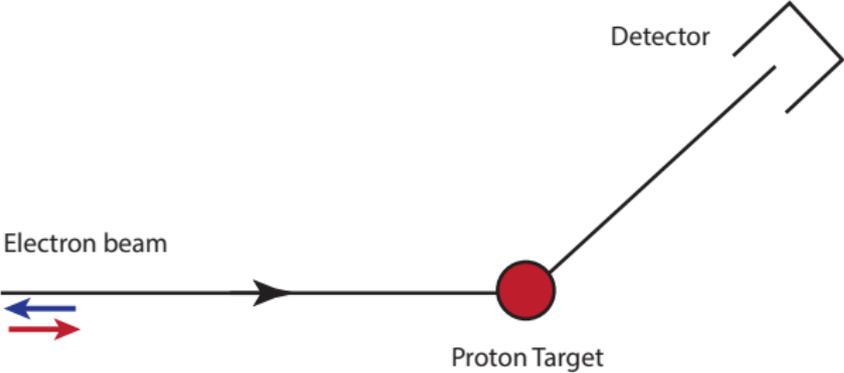
$$\sin \theta_W = \frac{g'}{\sqrt{g^2 + g'^2}}$$

Running of the weak mixing angle



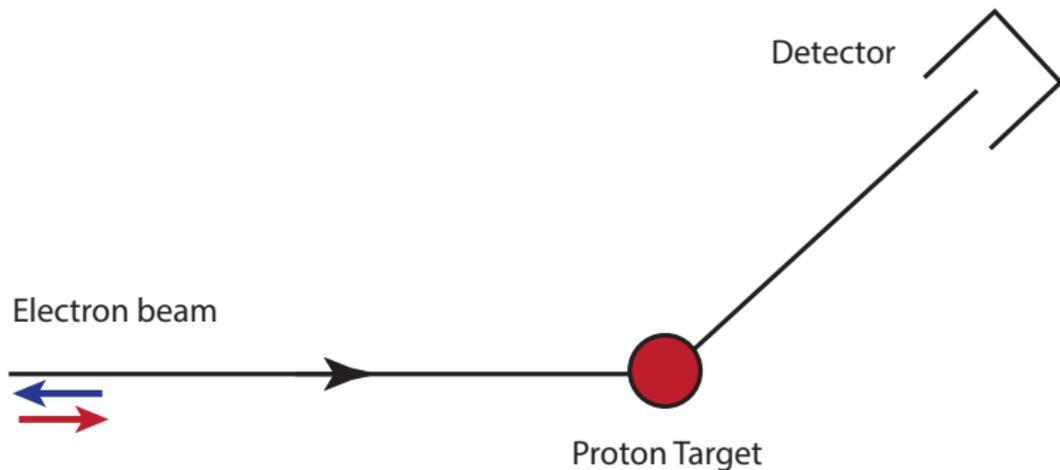
sensitive to new physics e.g.: contact interactions, Z' , dark Z

Measure the weak mixing angle



Measure asymmetry

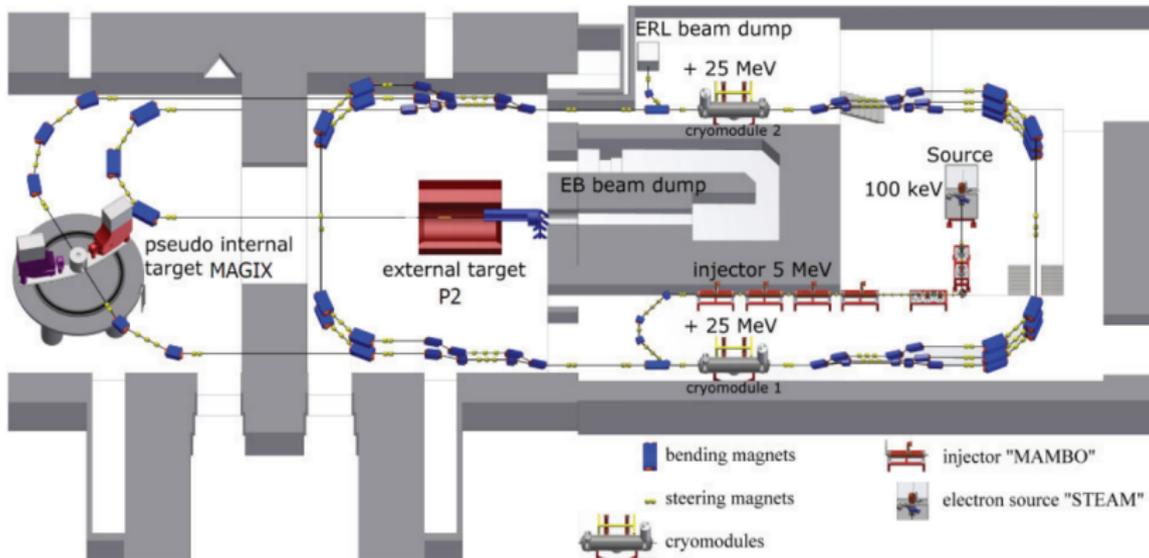
$$A_{PV} = \frac{N_R - N_L}{N_R + N_L} = \frac{G_F Q^2}{4\sqrt{2}\pi\alpha} (1 - 4 \sin^2 \theta_W - F(Q^2))$$



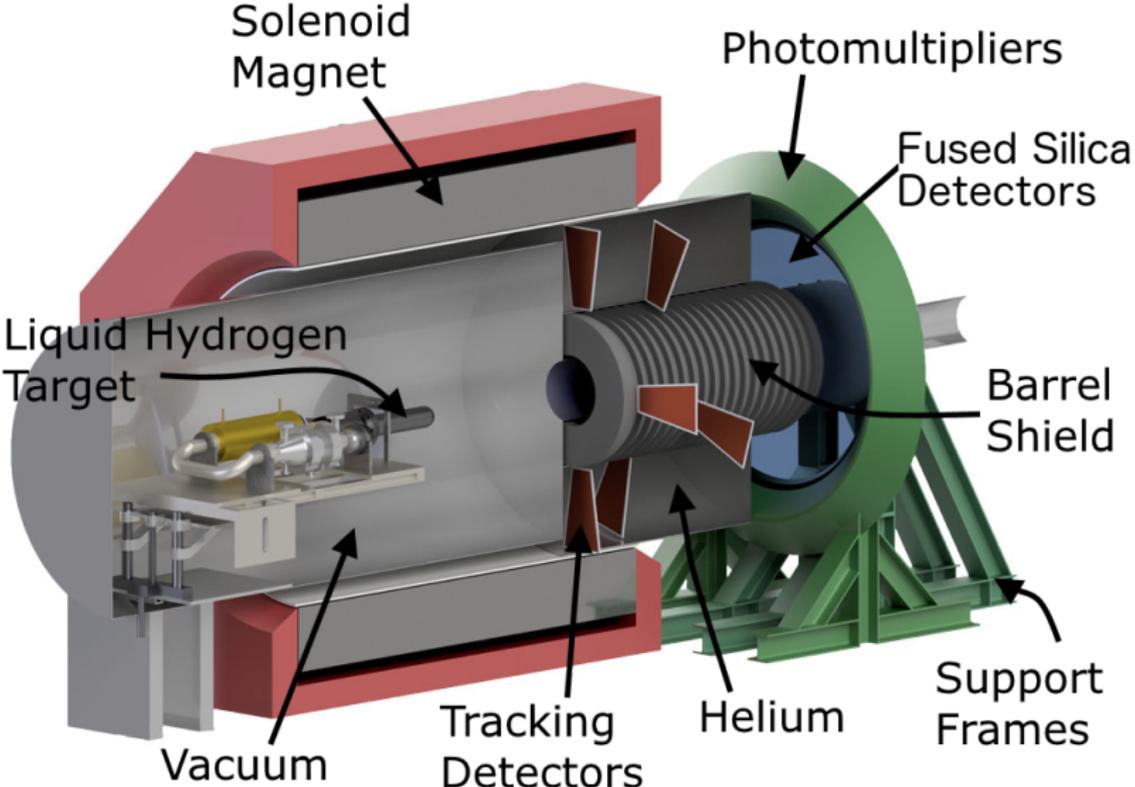
- ▶ measure $\sin^2 \theta_W$ to 0.13% $\Rightarrow 10^{18}$ electrons
- ▶ 100 GHz measuring rate

MESA

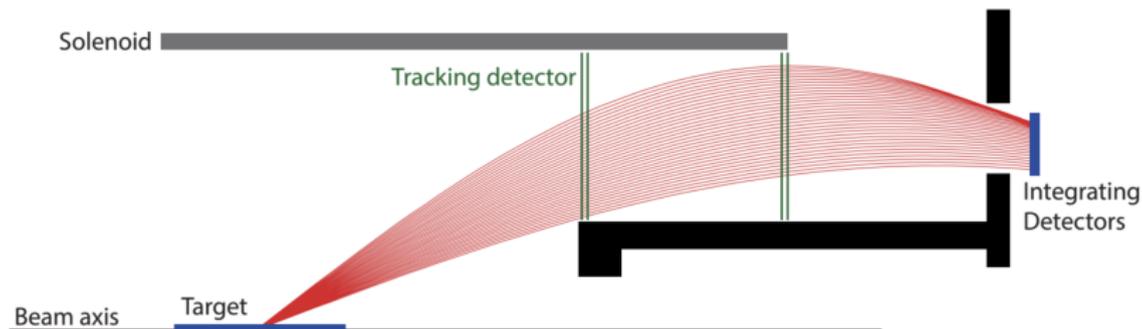
- ▶ Mainz Energy Recovering Superconducting Accelerator (MESA)
- ▶ 2 modes, up to 155 MeV, 85 % polarization



P2 experiment

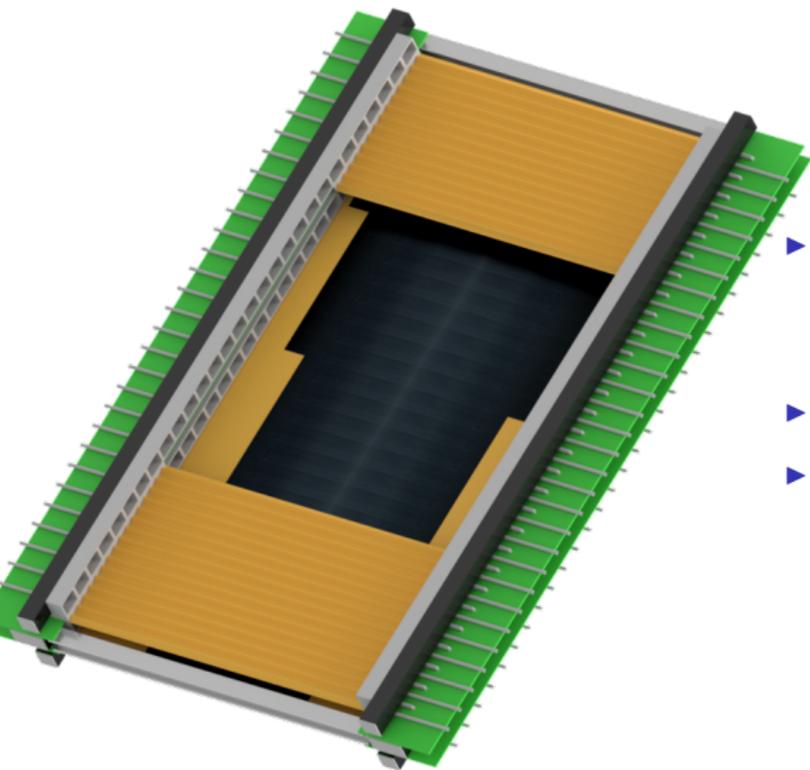


P2 spectrometer and tracking system



- ▶ 0.6 T solenoid magnet
- ▶ inhomogenous field in tracking system
- ▶ measure the average Q^2
- ▶ validate acceptance, alignment
- ▶ monitor beam and target conditions

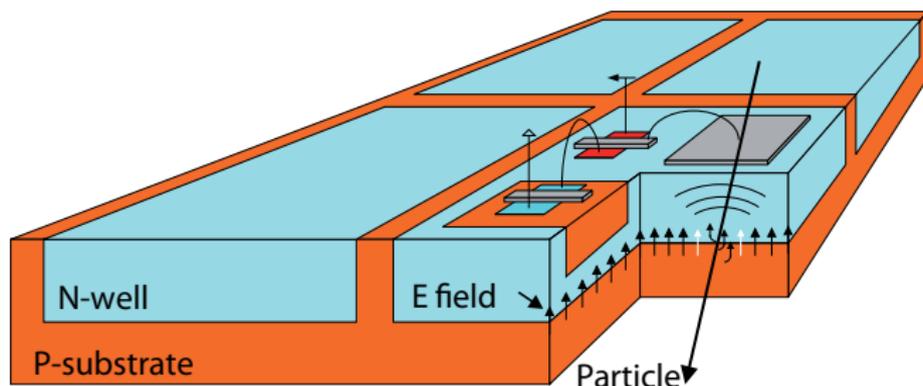
P2 tracking detector



- ▶ pixel sensors, electronics, gaseous helium cooling, mechanical support
- ▶ low material budget
- ▶ 2×4 modules, double layers, 300 sensors per layer

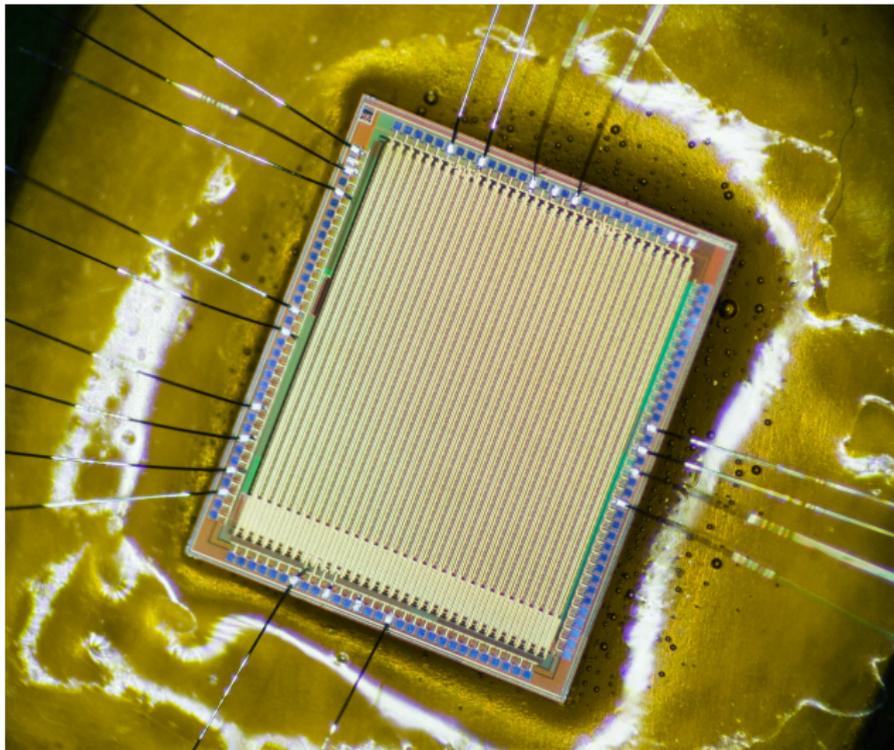
High Voltage Monolithic Active Pixel Sensor - HV-MAPS

- ▶ 180 nm HV-CMOS technology
- ▶ reverse biased up to 90 V
- ▶ readout logic on chip
- ▶ thinable down to 50 μm

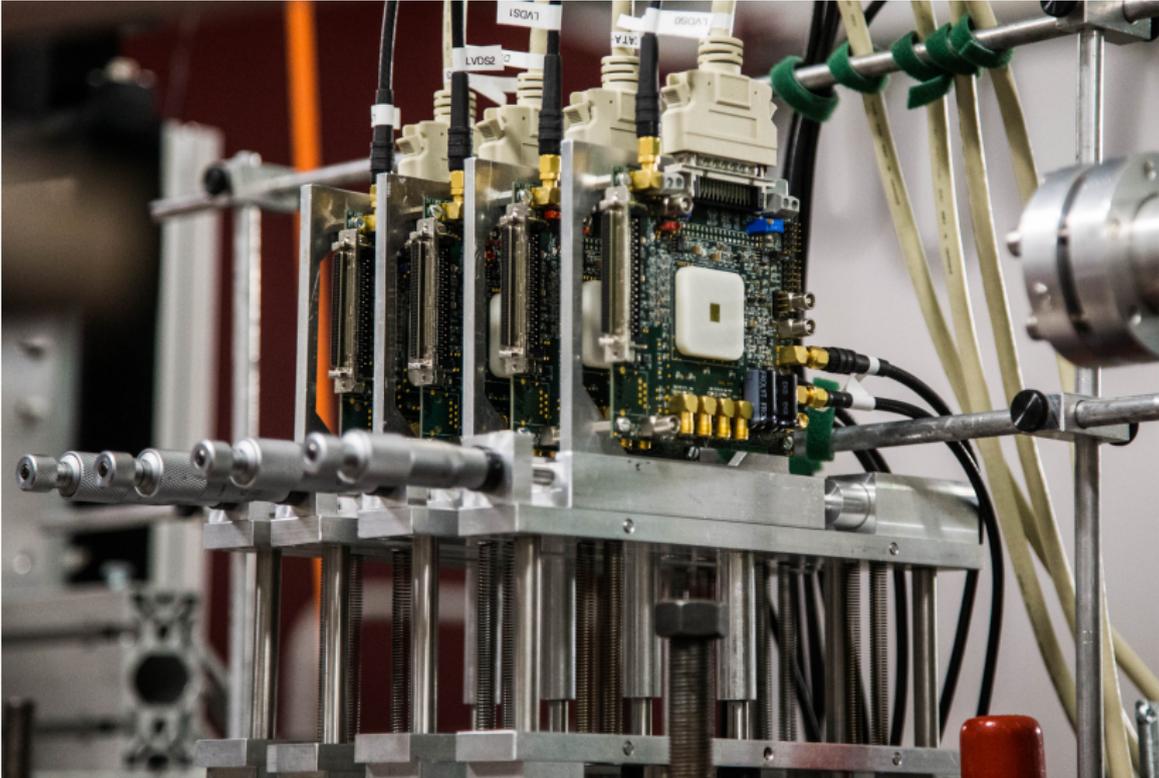


MuPix prototypes

- ▶ Mupix7
- ▶ pixel size:
 $80 \times 103 \mu\text{m}^2$
- ▶ sensor size:
 $3 \times 3 \text{ mm}^2$

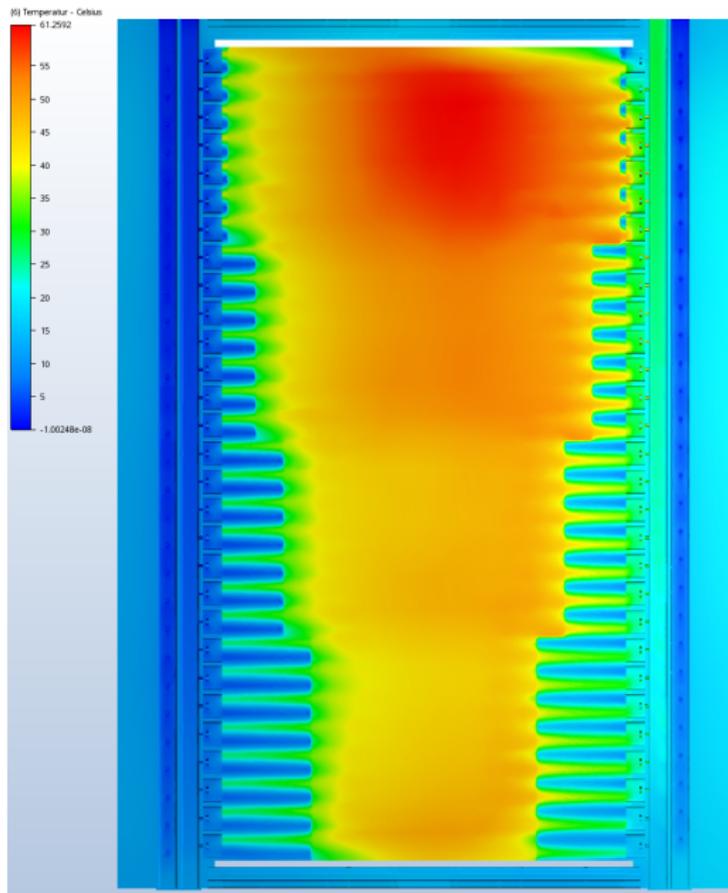


MuPix testbeam

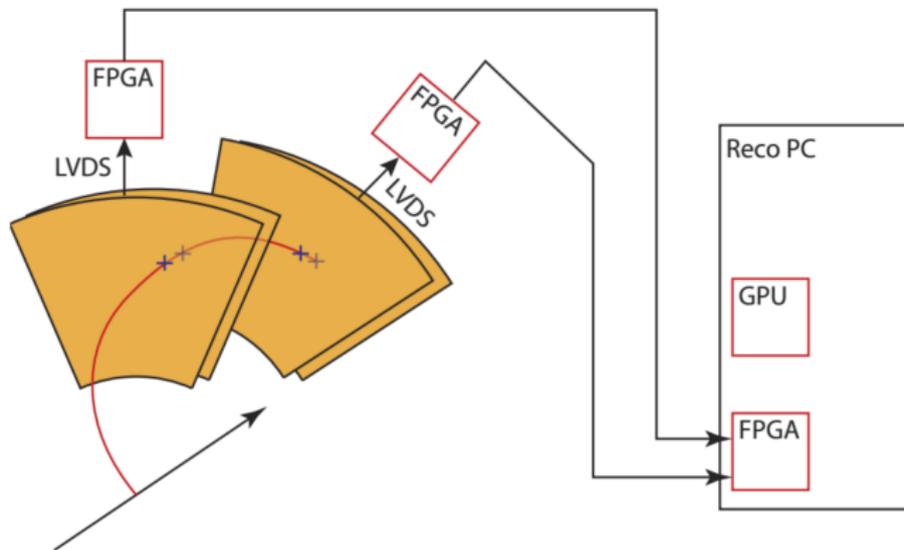


Cooling the P2 tracking detector

- ▶ 300 mW cm^{-2} heat production
- ▶ 42 L s^{-1} helium flow @ 0°C
- ▶ max. 62°C

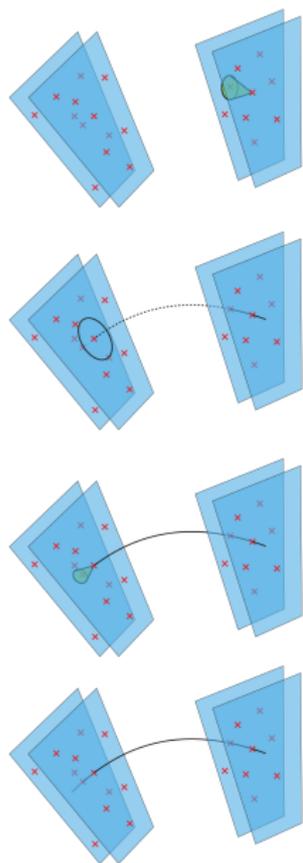


P2 tracking detector readout

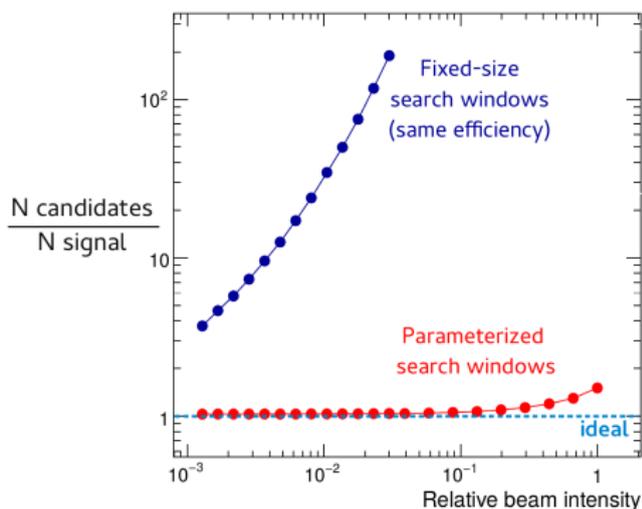


- ▶ triggerless, digital readout
- ▶ Sensor → Front-End FPGA → Reconstruction PC
- ▶ gated mode to reduce data rate

P2 online track reconstruction

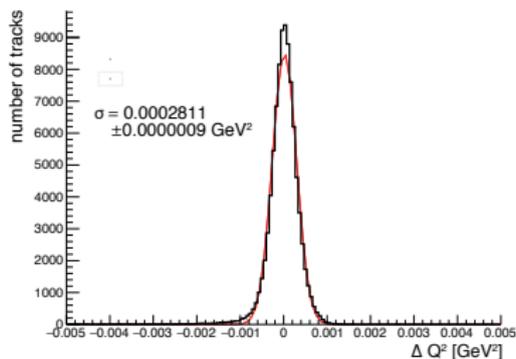
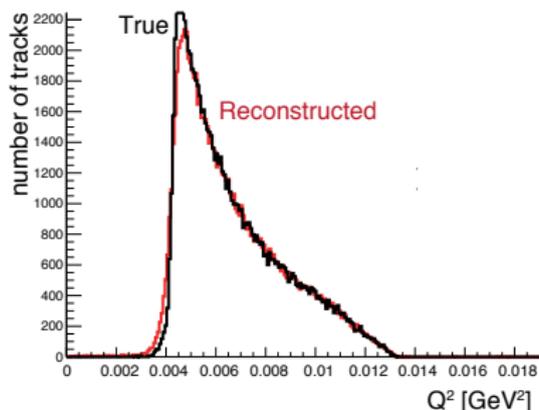


- ▶ polynomial functions to propagate tracks
- ▶ simulation for parameter estimation
- ▶ faster than conventional track following
- ▶ reduced combinatorics compared to fixed search windows



Simulated performance of track reconstruction

- ▶ GEANT4 detector simulation
- ▶ broken line fit in inhomogeneous magnetic field
- ▶ using GENFIT package



Summary

- ▶ P2 is going to measure the weak mixing angle
- ▶ tracking detector to measure average Q^2
- ▶ ongoing development and testing of components e.g. pixel sensors, mechanics, cooling, readout and simulation

