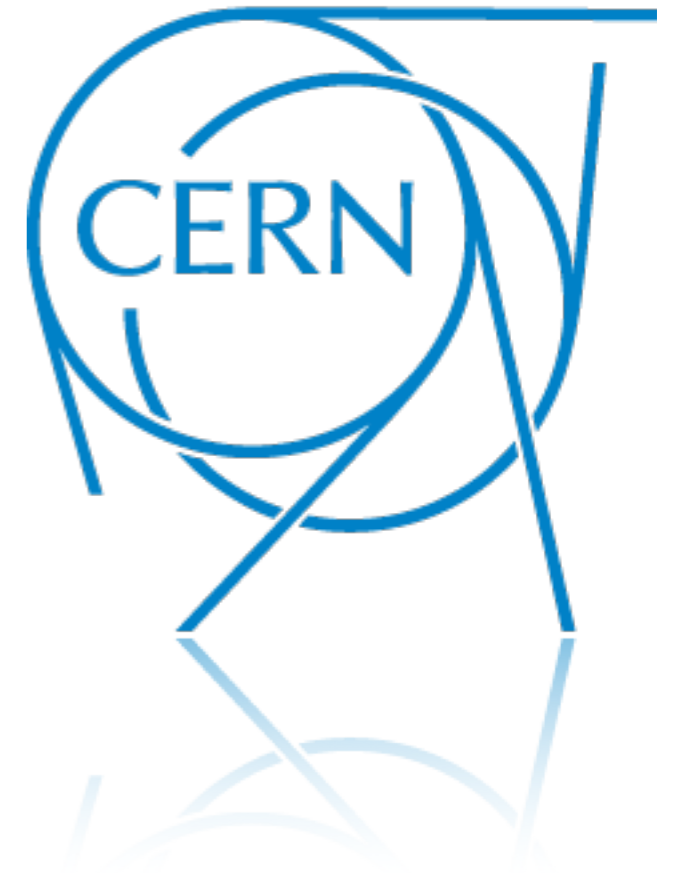




COMPASS



Technical Board Meeting

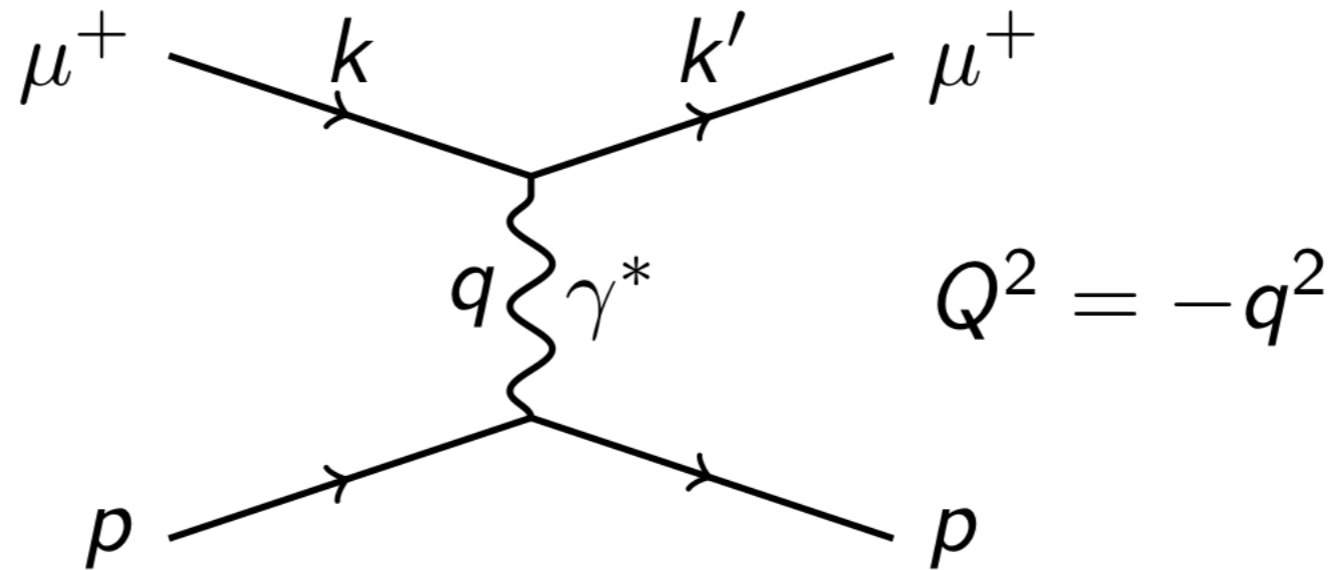
Proton Radius Measurement  
Test Beam 2018

Tuesday, 10. April 2018

Christian Dreisbach



# Proton Radius Measurement



- elastic scattering of muons off a proton target
  - measure  $Q^2$  spectrum over wide range:  $10^{-4}$  to  $10^0$   $\text{GeV}^2/c^2$ 
    - extract Radius from its shape
  - muon scattering angle between  $100 \mu\text{rad}$  and  $10 \text{mrad}$
  - proton recoil energy between  $100 \text{keV}$  and  $500 \text{MeV}$
- ➔ challenge: identify elastic reactions



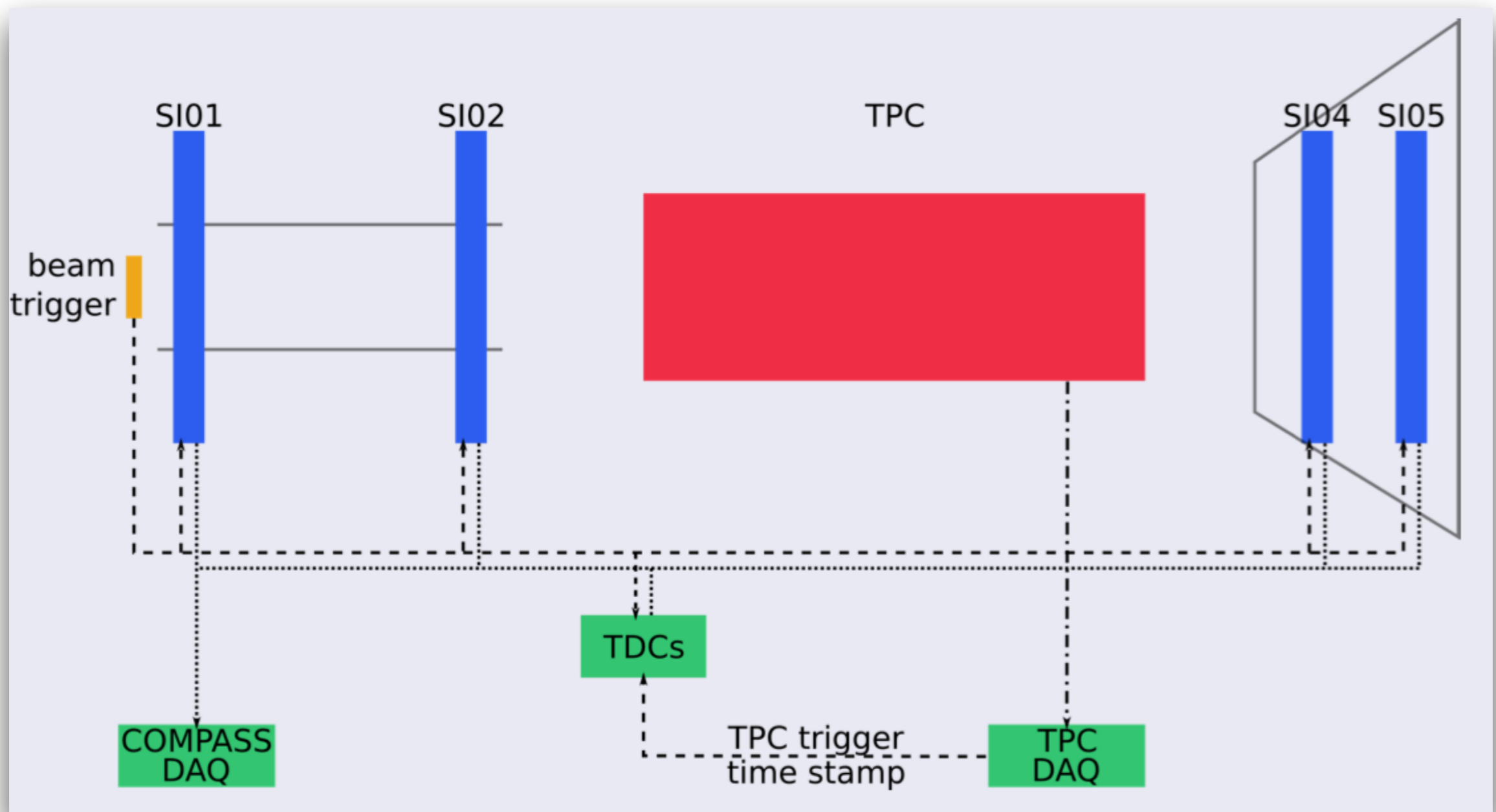
# Test Beam Goals



- performance of TPC as active target in muon beam
  - beam rate studies - background and readout
  - possibility to identify candidates for recoil protons
- correlate events in silicon detectors with TPC events
  - possibility of using time stamps and tracking
- collect experience for the future measurement



# Test Beam Setup

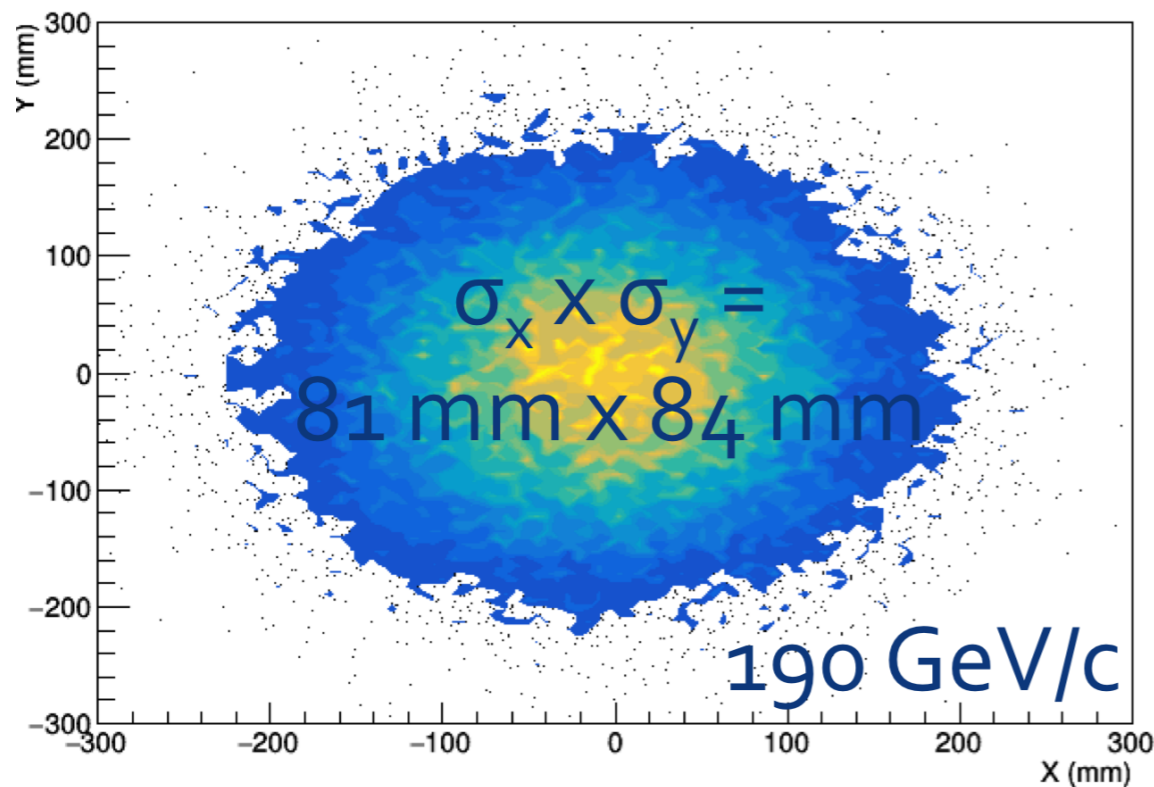




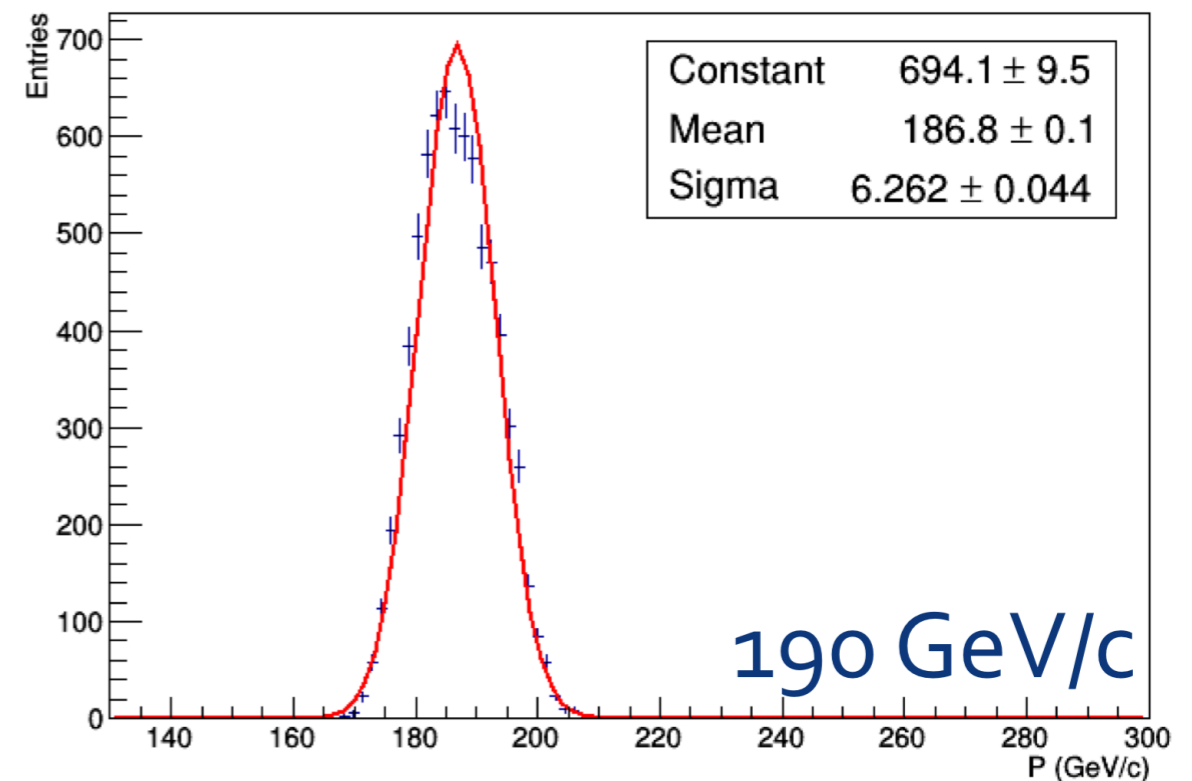
# Test Beam Properties



Simulations of beam at the test experiment position (J. Bernhard)



muon beam distribution



muon beam momentum

- beam distribution at 190 GeV/c:  $\sigma_x \times \sigma_y = 81 \text{ mm} \times 84 \text{ mm}$
- beam momentum at 190 GeV/c:  $p = 186.8 \text{ GeV/c}$  with  $\sigma = 6.2 \text{ GeV/c}$

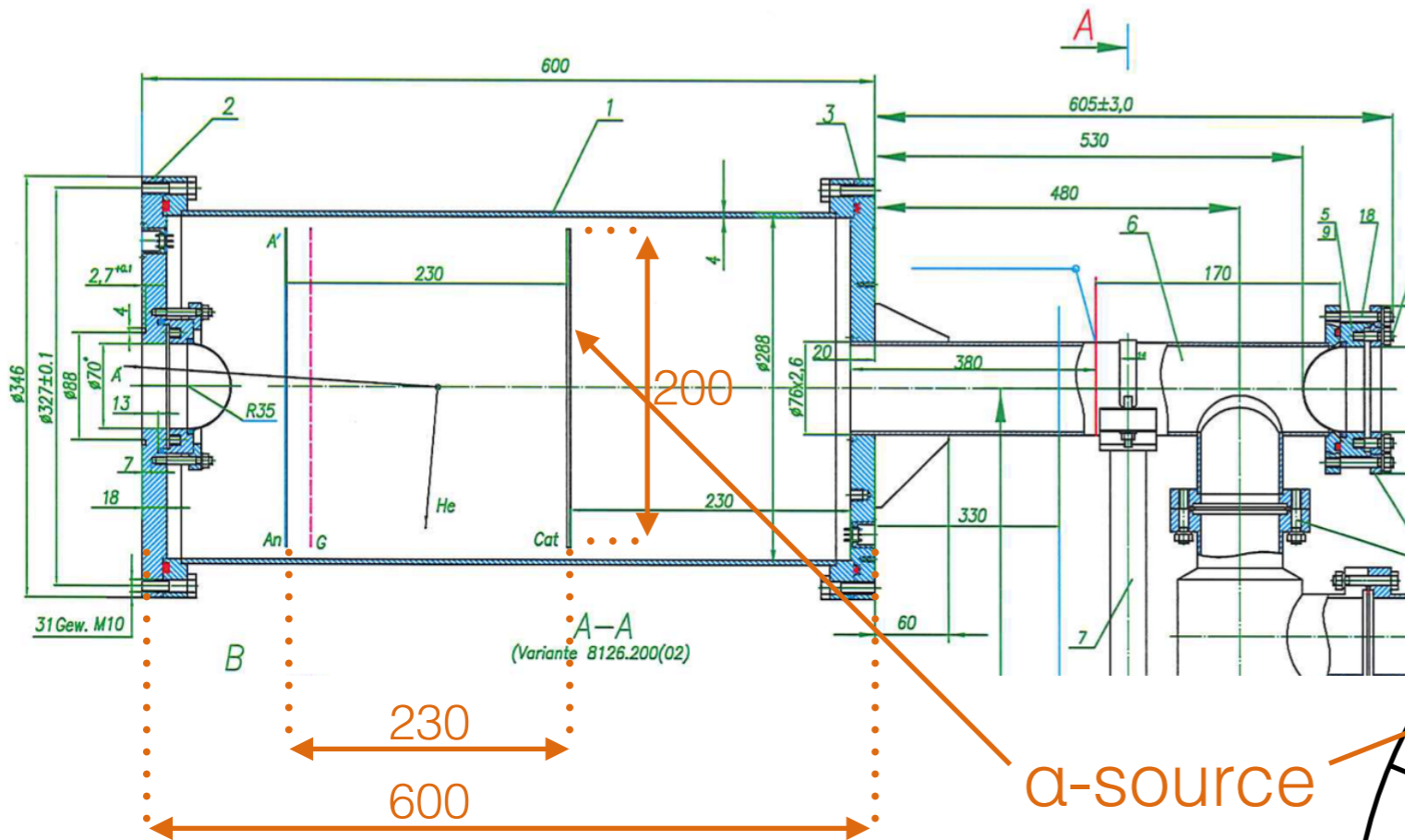


# Test Beam Setup

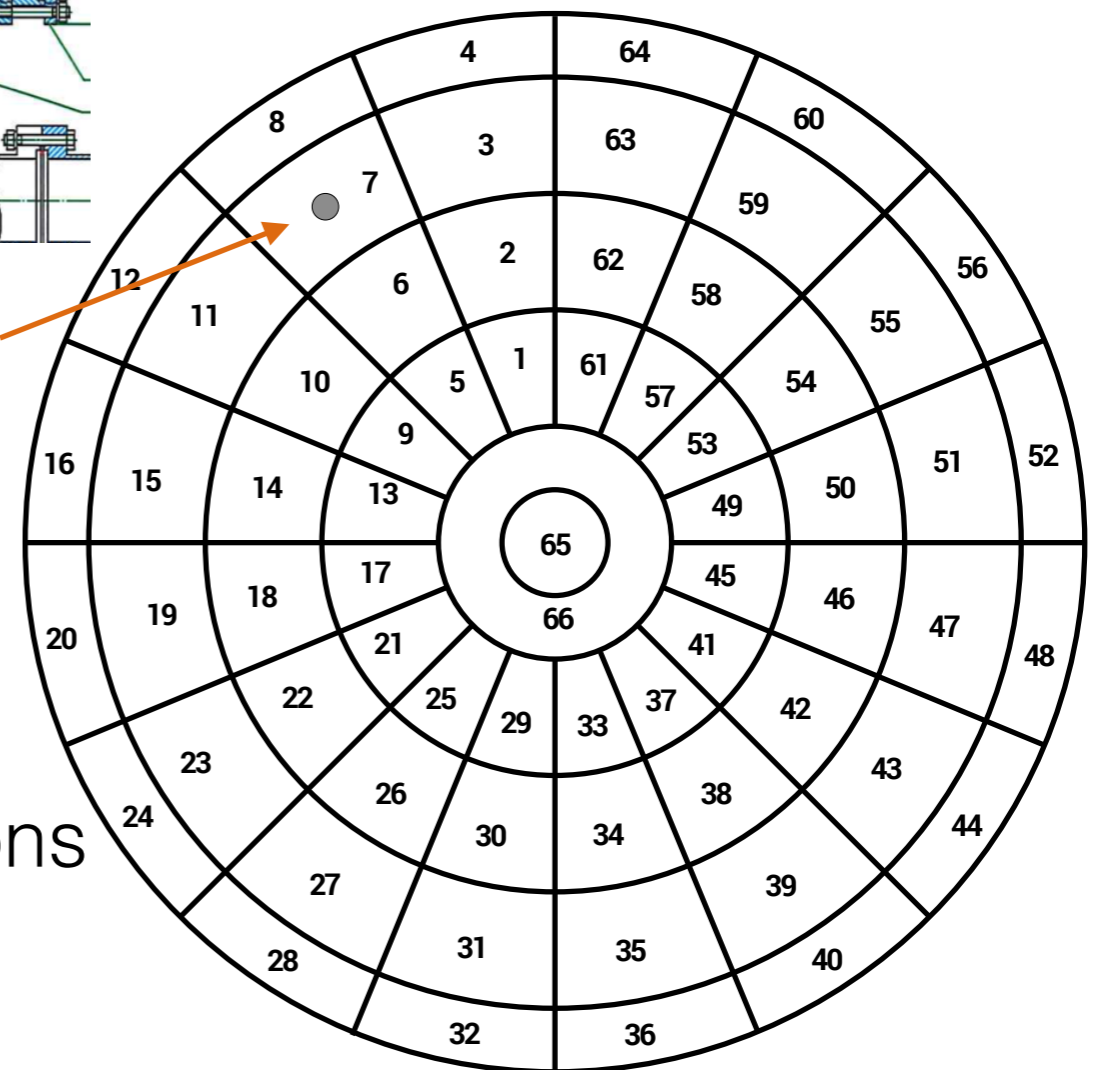




# Test Beam TPC Readout



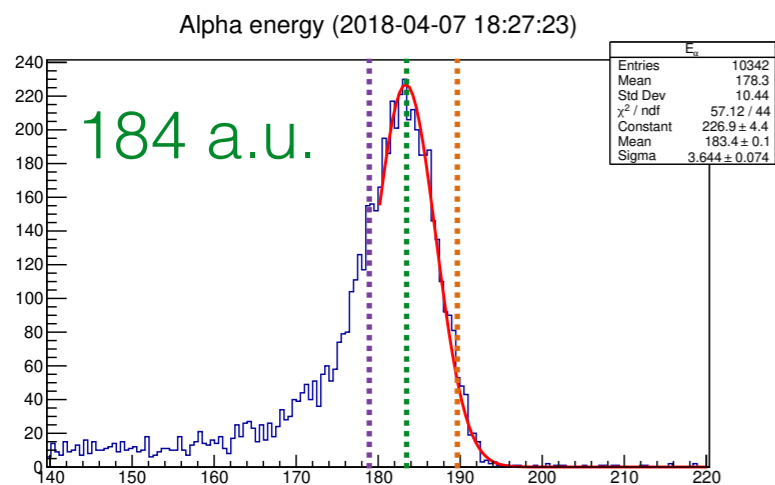
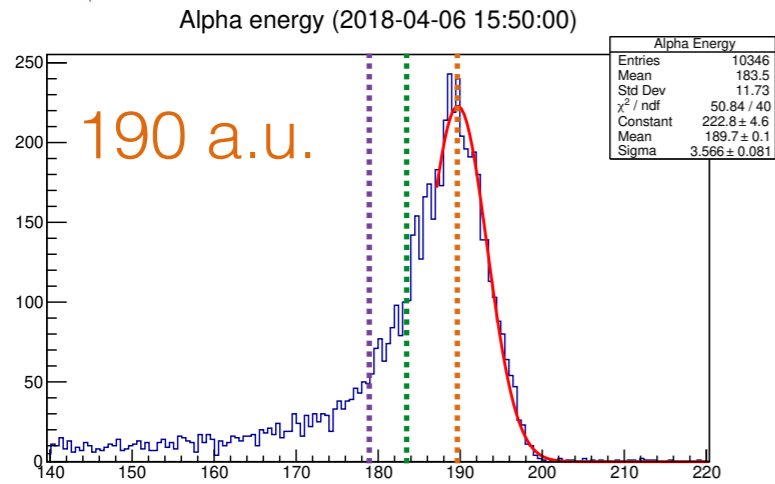
readout plane



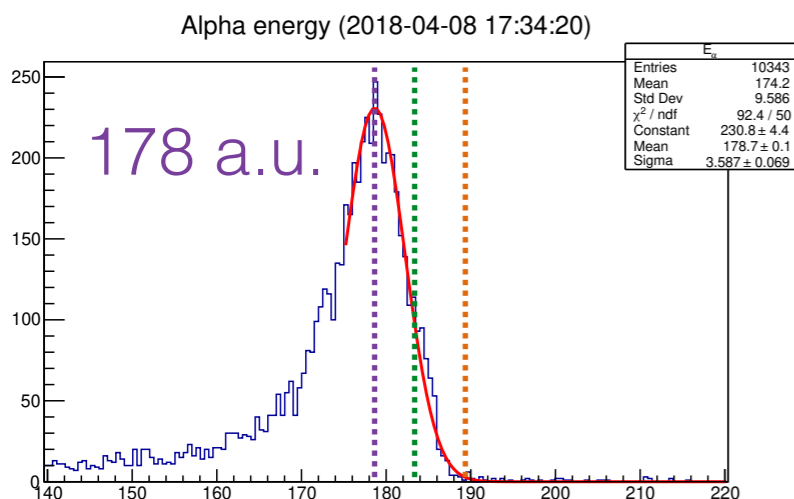
- segmented pad readout with 66 sections
- $\alpha$ -source for calibration



# Test Beam TPC Readout



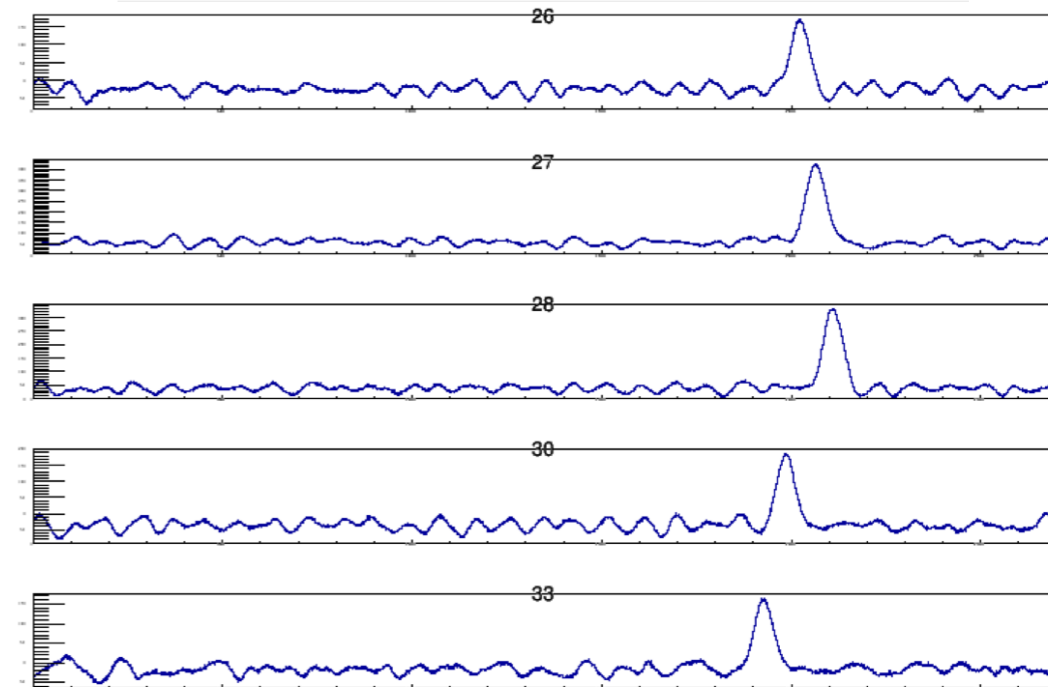
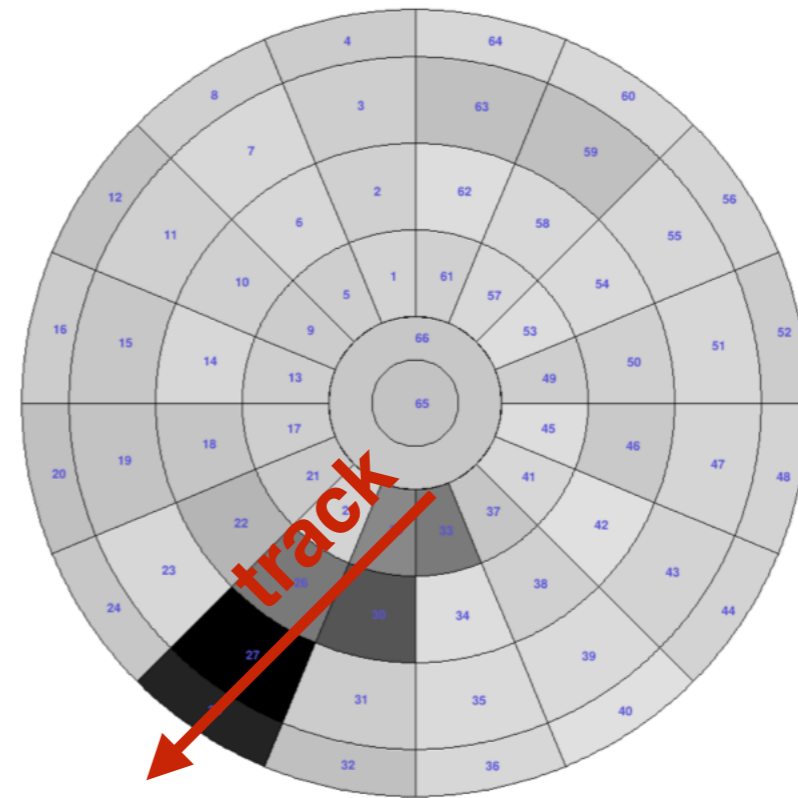
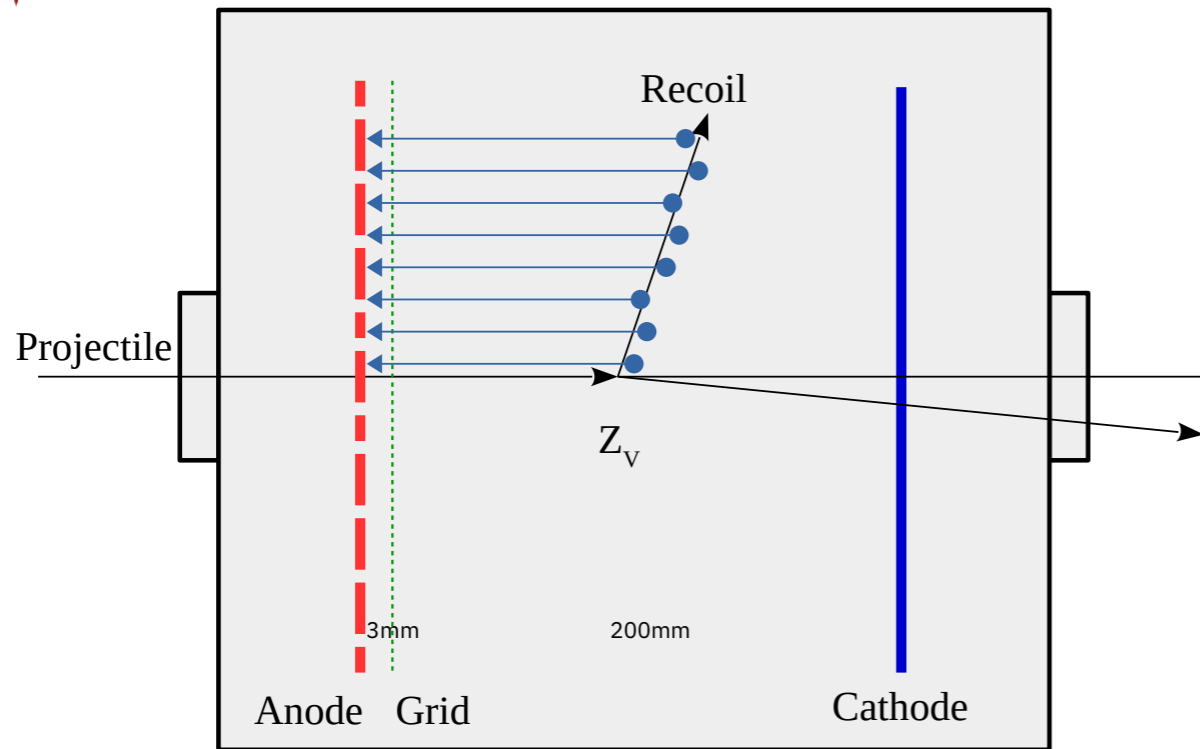
- shift of  $\alpha$ -line due to impurities (out-gassing)
  - change by 3.2% per day
- ➔ refilling of TPC once per week





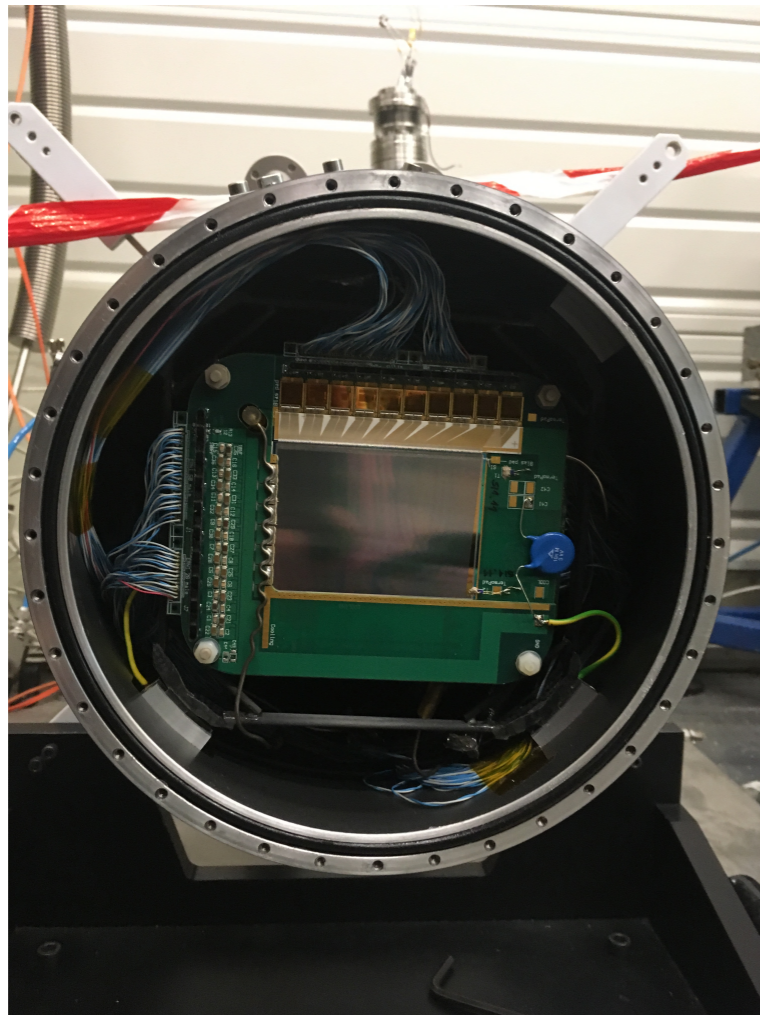


# Test Beam TPC Readout

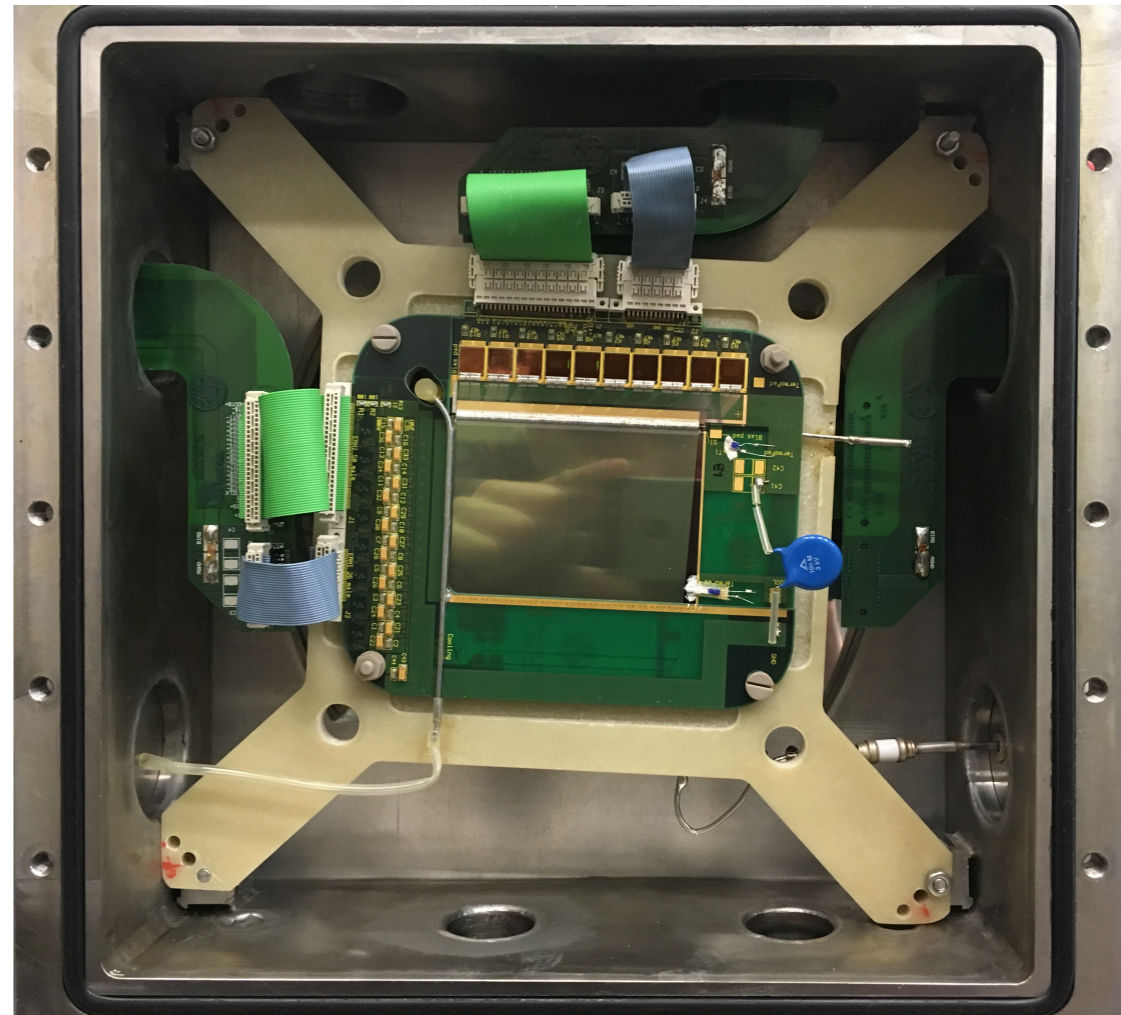


- recoil generates ionization
- different pads: amplitude and time

Conical Cryostat



Warm Stations



- four silicon stations with four planes (U,V,X,Y) in each station
- wafer size of 7 cm x 5 cm
- strip readout with 1024 channels (U,X) and 1280 channels (V,Y)
- no cooling with LN<sub>2</sub> - APVs cooled with nitrogen gas stream



- active area: 7 cm x 5 cm (Silicon)
- three trigger elements:
  - one segmented trigger elements (movable)
  - two normal scintillator elements (fixed)
- ➔ estimate for beam rate



# Test Beam DAQ



- own DAQ for TPC
  - COMPASS DAQ (stand-alone) for Silicons
  - ➔ challenge: combine both DAQs and triggers
- 
- two data sets (TPC and Silicon) for events
  - ➔ challenge: combine events via time stamp and reconstruction



# Test Beam DCS



The screenshot displays the COMPASS DCS interface. At the top, it shows the title 'DETECTOR CONTROL SYSTEM' and the user 'operator'. The interface is divided into several sections:

- ALARMS:** A table showing active alarms. The first alarm is 'General status: onAlarm' with a value of 'TRUE'. The second alarm is 'Rwall\_Gas\_Flow\_Co2\_Val: CO2 flow too low' with a value of '155.1374'.
- Navigation Menu:** A vertical list of system components including BMS, SCIFI, GEM, DC, Straw, RICH, MW1, ECal1, HCal1, Magnets, PTgt, Environ, Cedar, W45, Trigger, MM, RWall, MWPC, MW2, ECal2, HCal2, Beam, DAQ, DCS, and Proton Radius (highlighted with a red circle).
- Control Panels:** Panels for Proton Radius, TPC (HV, T & P), Silicon HV (HV System), Silicon LV (Station 1-4), Silicon PS (ADC LV), Silicon Temp. (Temperatures), and Trigger HV (BT).
- Silicon Temperatures:** A detailed view showing four temperature measurement points (Si01-Si04) with their respective U and X channel values in °C and 'A' status.

lev	prior	time	object	alert text	value	ack	det
E	60	2018.04.02 19:26:16.885	General status: onAlarm	UNKNOWN STATE	TRUE		...
E	60	2018.04.06 15:39:52.199	Rwall_Gas_Flow_Co2_Val:	CO2 flow too low	155.1374	x	...

Si	Channel	Value (°C)	Status
Si01	Si_T_01U	51.81	A
	Si_T_01X	49.11	A
Si02	Si_T_02U	53.47	A
	Si_T_02X	53.74	A
Si03	Si_T_03U	48.12	A
	Si_T_03X	47.90	A
Si04	Si_T_04U	45.02	A
	Si_T_04X	47.84	A

- Trigger, TPC and Silicons are controlled via COMPASS DCS



# Test Beam Summary



- installation of test beam platform ✓
  - installation of silicon detectors ✓
  - transportation and installation of the TPC ✓
  - setting up the DAQ system ✓
  - setting up the DCS system ✓
  - installation of trigger system ✓
- ➔ physical installation of the test setup finished



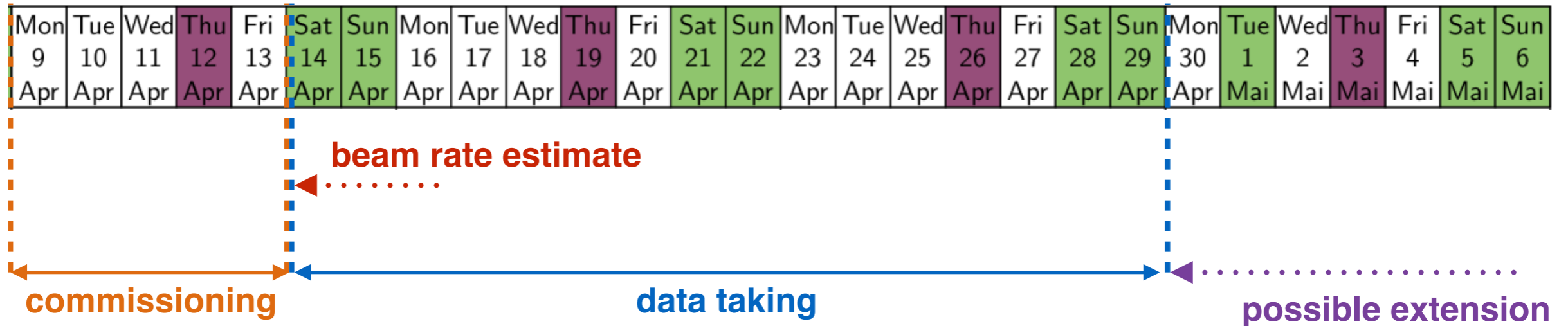
# Test Beam Outlook



- Silicons: high voltage scan
- Trigger calibration
- Silicons: latency settings
- TPC DAQ settings for beam
  
- TPC beam test with high intensity
  - ➔ depending on result - lower intensities
  - ➔ event matching of Silicons and TPC



# Test Beam Schedule



- commissioning phase: finish all calibrations and issues
- estimate best beam rate for data taking
- data taking during night and „non-used“ beam for COMPASS
- possible extension of data taking after end of April

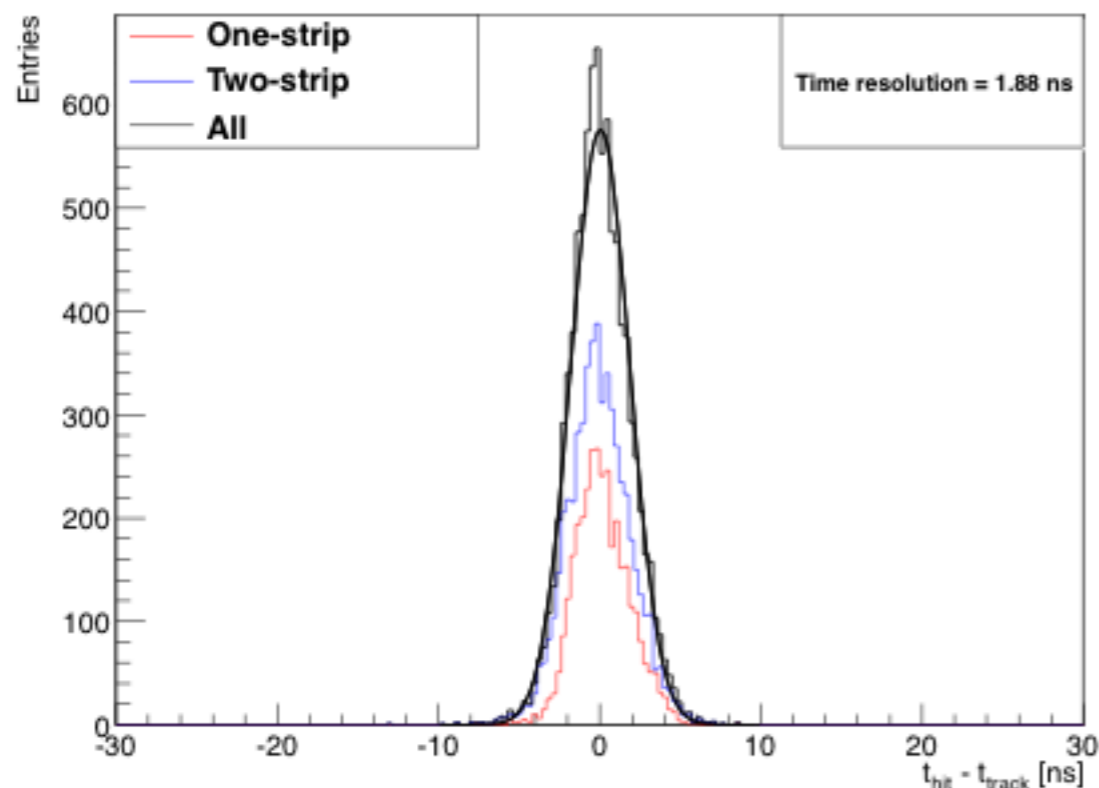




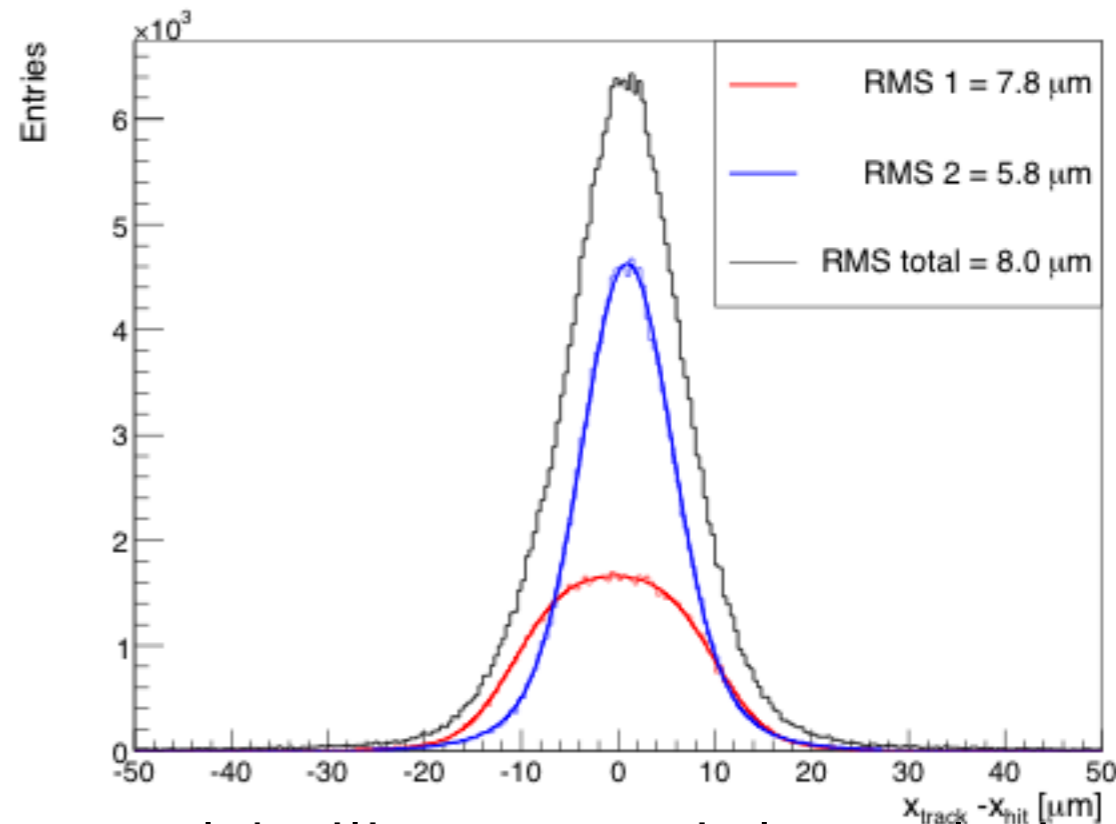
Thank you for your attention!



# Test Beam Silicon Performance



cold silicon time resolution

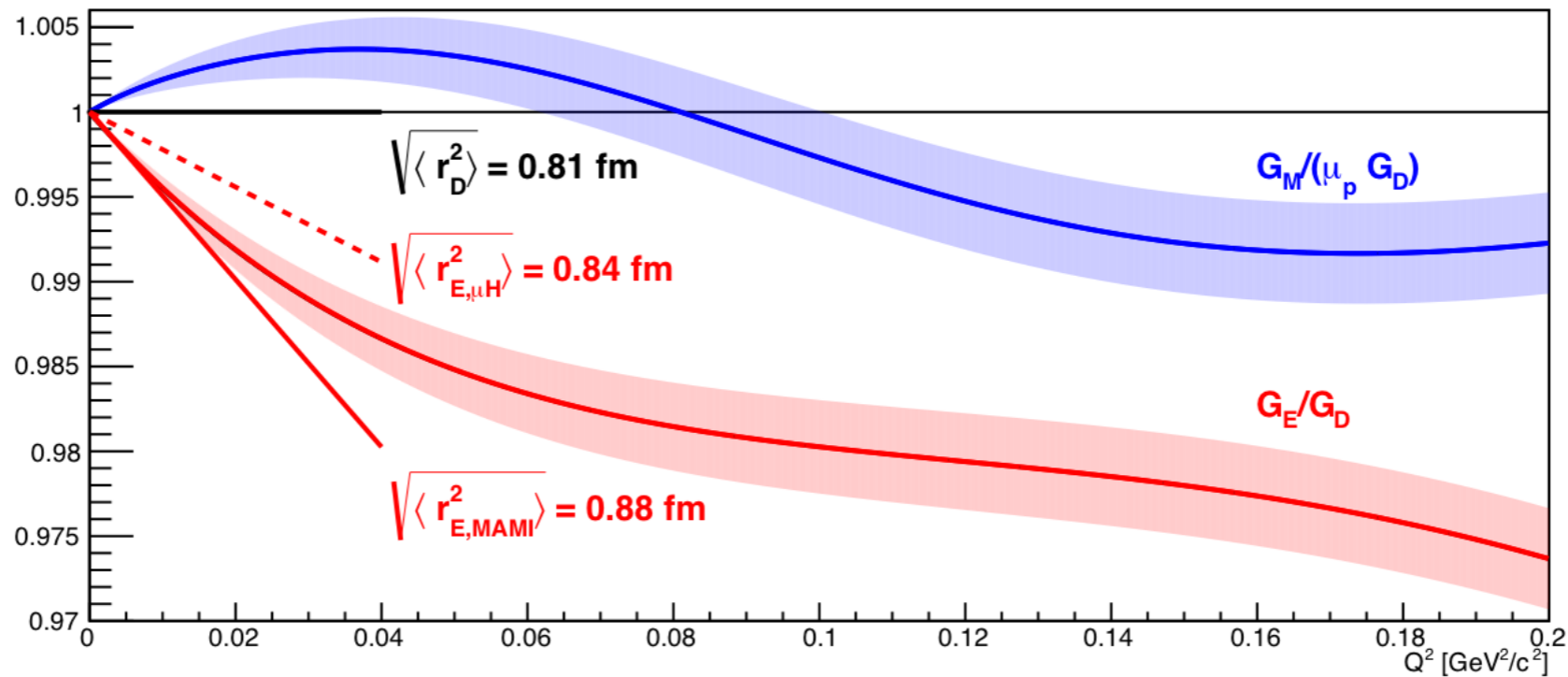


cold silicon spatial resolution

- expected time resolution:  $\sim 3$  ns
- expected spatial resolution:  $\sim 10$   $\mu\text{m}$



# Proton Radius Measurement



$$\frac{d\sigma}{dQ^2} = \frac{\pi\alpha^2}{Q^4 m_p^2 \vec{p}_\mu^2} \left[ \left( G_E^2 + \tau G_M^2 \right) \frac{4E_\mu^2 m_p^2 - Q^2 (s - m_\mu^2)}{1 + \tau} - G_M^2 \frac{2m_\mu^2 Q^2 - Q^4}{2} \right]$$

$$\text{with } \tau = Q^2 / (4m_p^2)$$

mean squared charge-radius

$$\langle r_E^2 \rangle = -6\hbar^2 \left. \frac{dG_E(Q^2)}{dQ^2} \right|_{Q^2 \rightarrow 0}$$