



# COMPASS

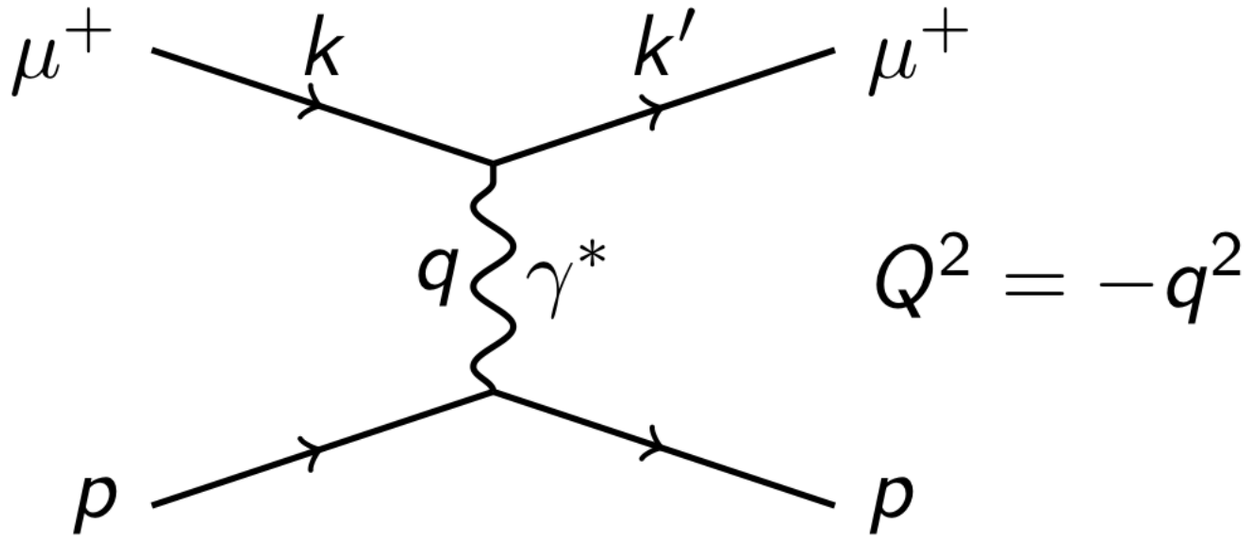
## Technical Board Meeting

## 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 $10^{0}$ GeV$^2$/c$^2$
  - extract Radius from its shape
- muon scattering angle between 100 μrad and 10 mrad
- proton recoil energy between 100 keV and 500 MeV

➡ challenge: identify elastic reactions

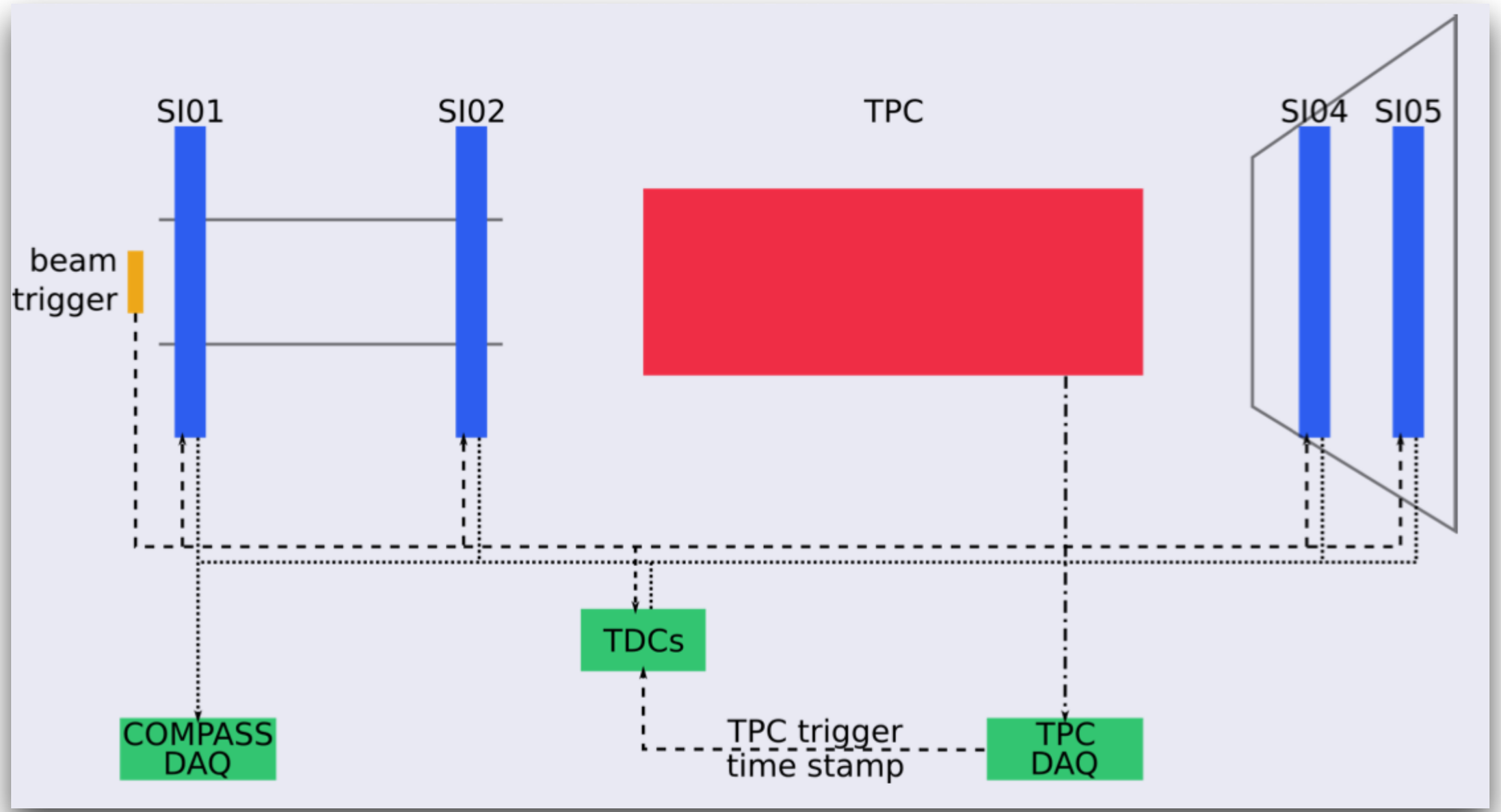
# Test Beam Goals

- 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

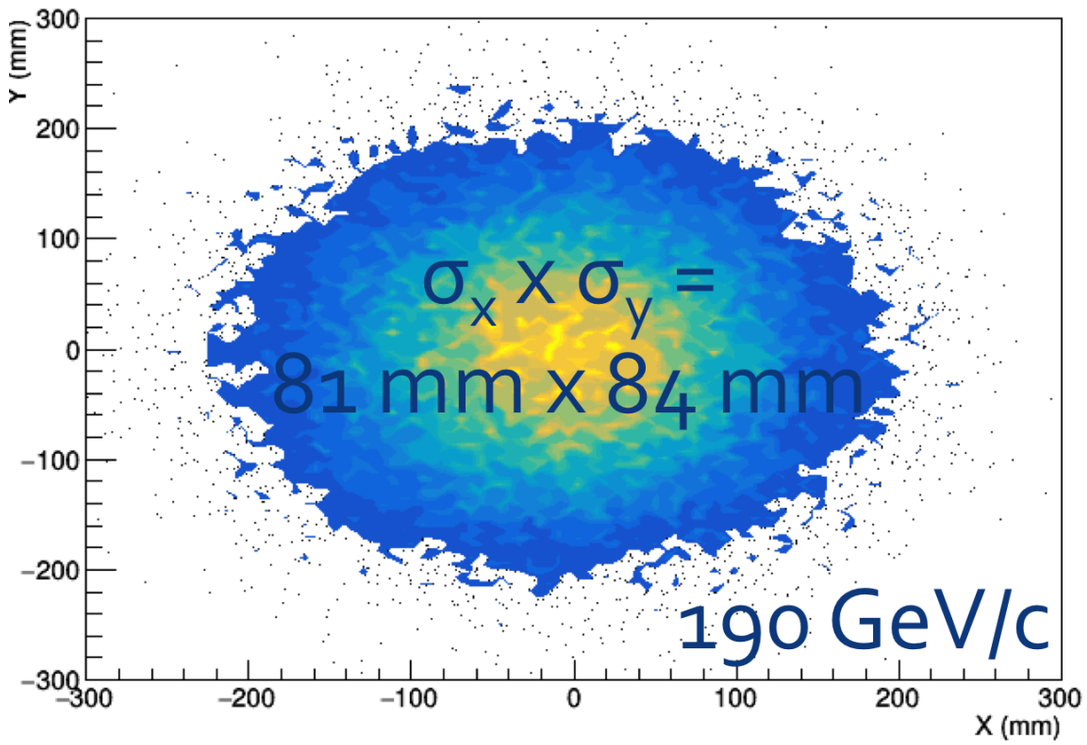
- collect experience for the future measurement

# Test Beam Setup

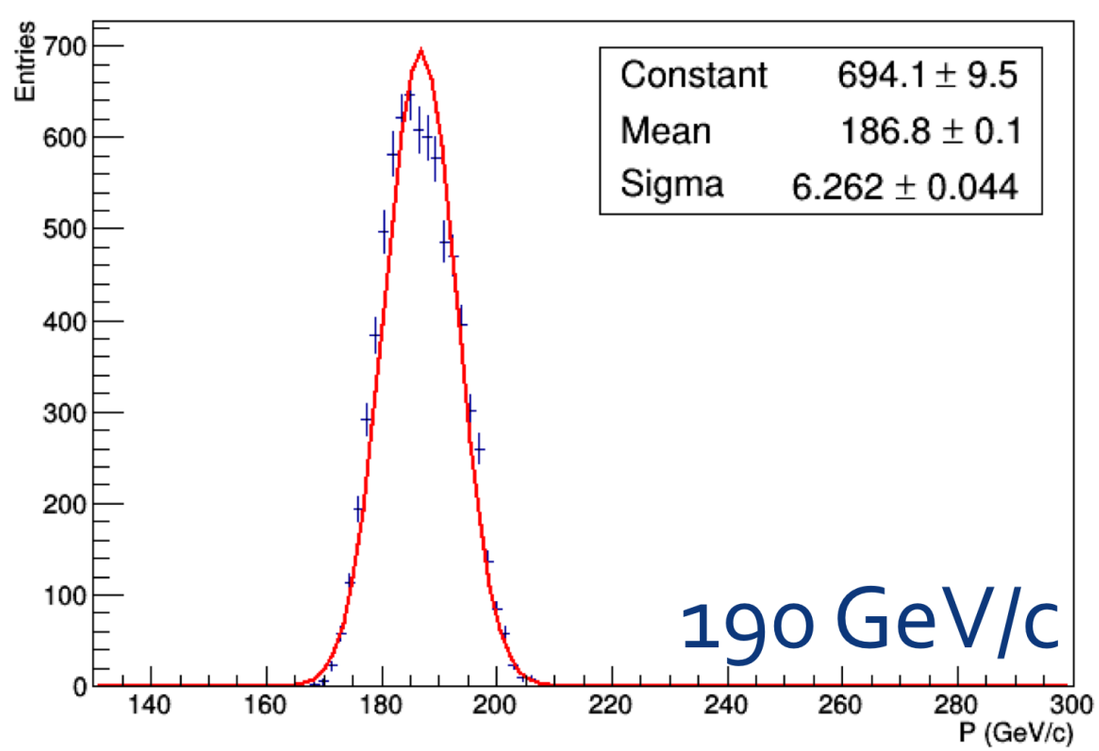


# Test Beam Properties

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




muon beam distribution

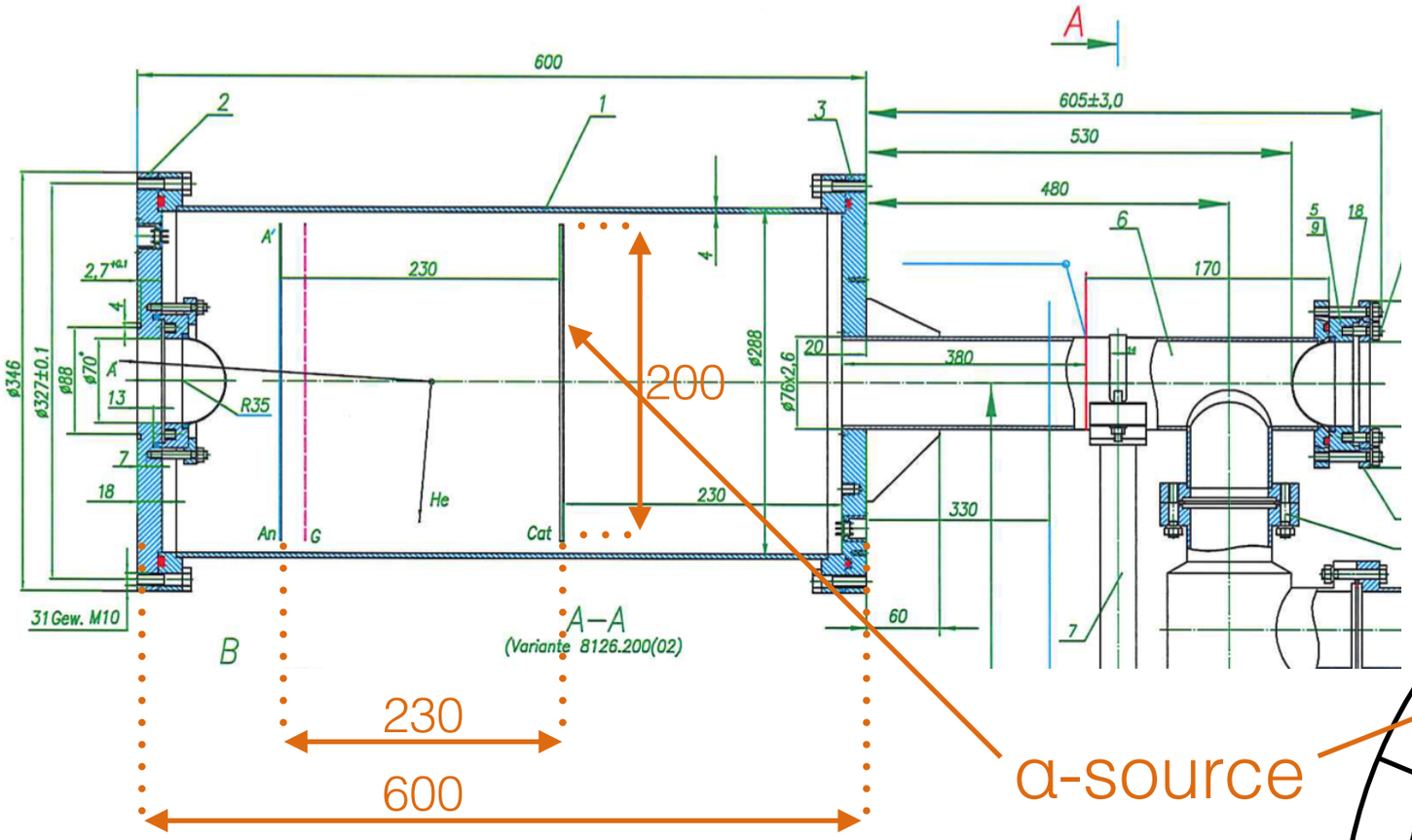



muon beam momentum

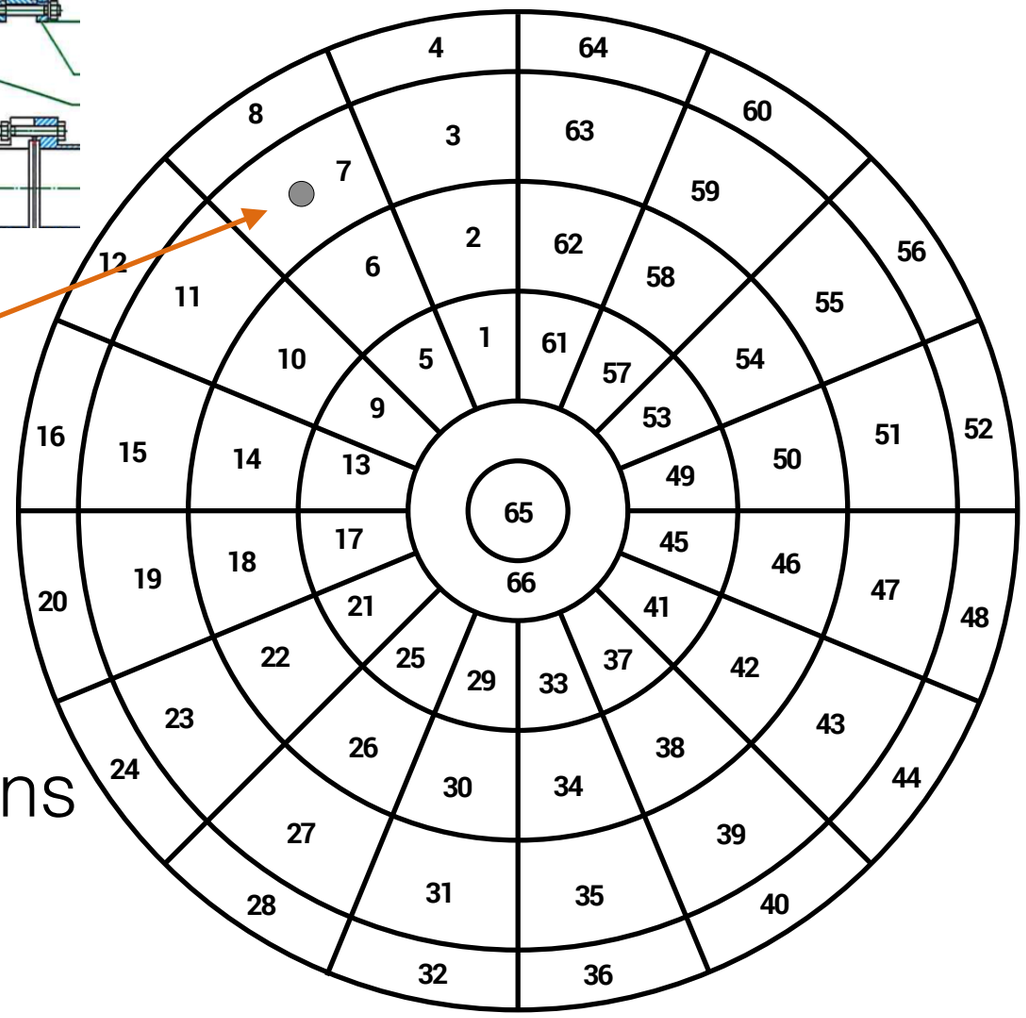
- beam distribution at 190 GeV/c: $\sigma_x$ *x* $\sigma_y$ = *81* mm *x 84* mm
- beam momentum at 190 GeV/c: *p = 186.8* GeV/c with $\sigma$ = *6.2* GeV/c

# Test Beam Setup

# Test Beam TPC Readout

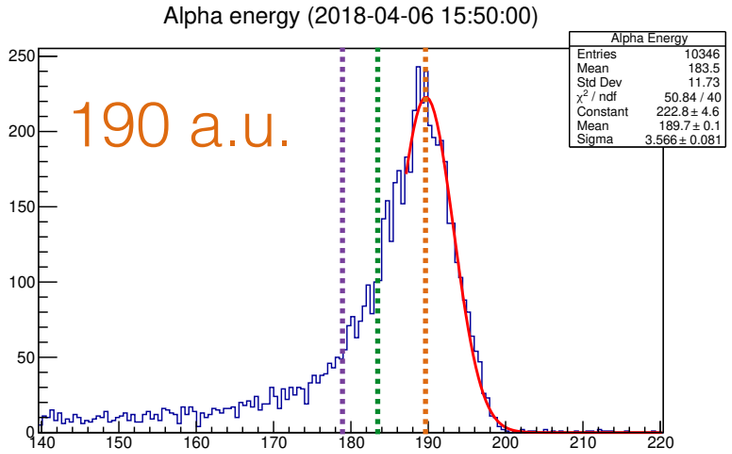


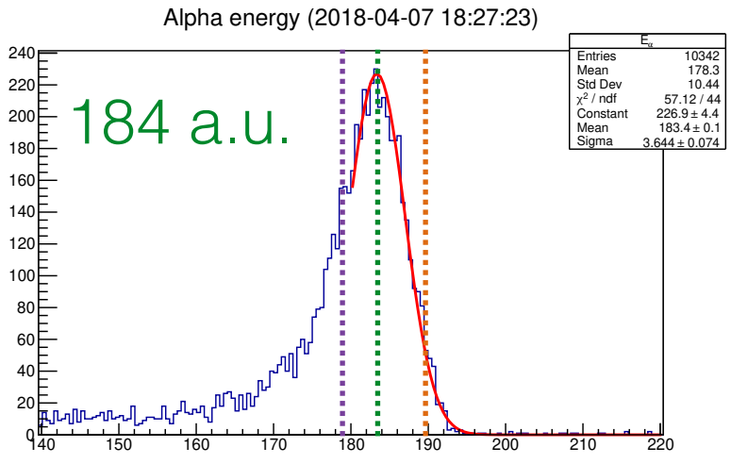

readout plane

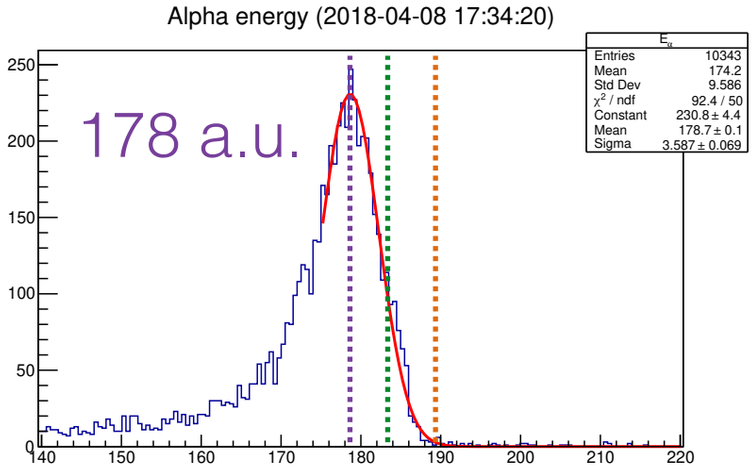



- segmented pad readout with 66 sections
- α-source for calibration

# Test Beam TPC Readout



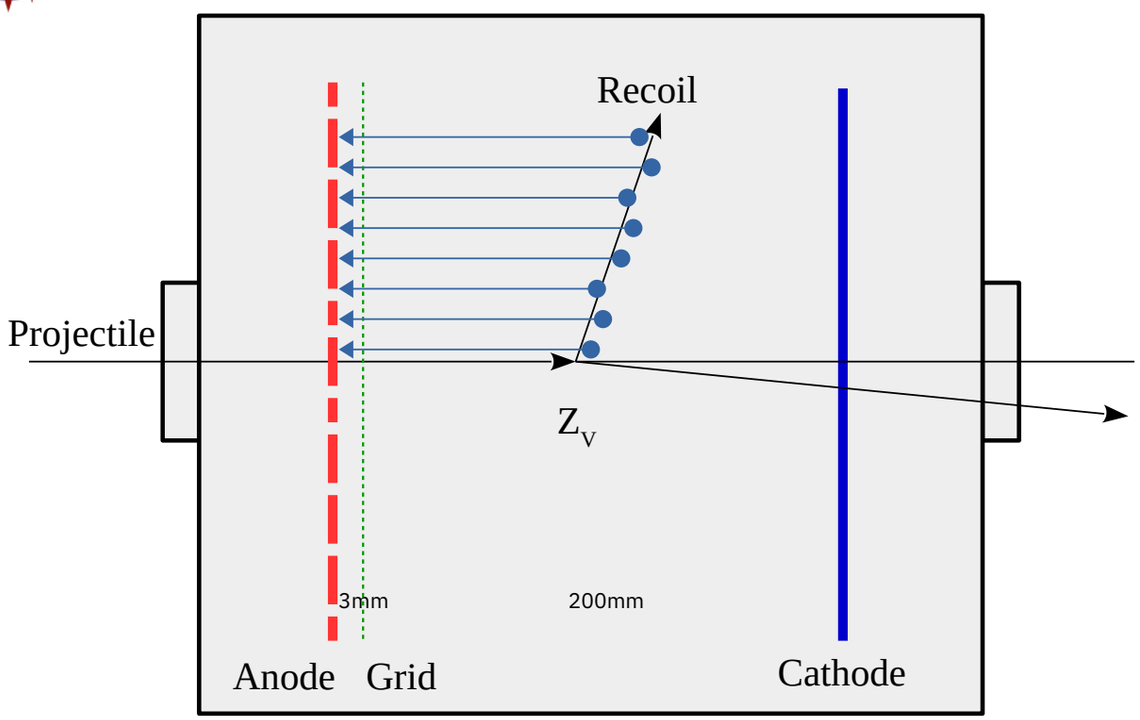



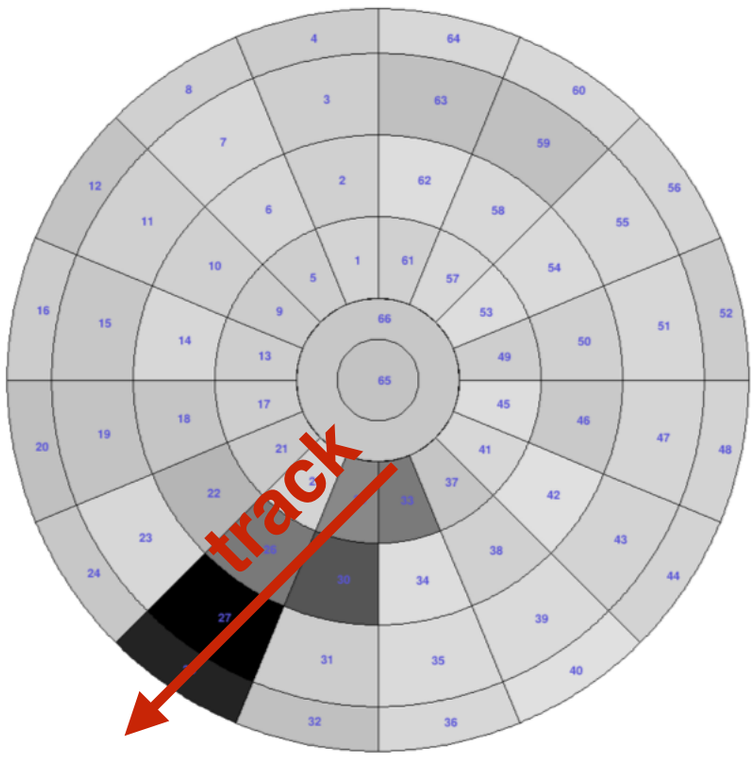




- shift of α-line due to impurities (out-gassing)
- change by 3.2% per day

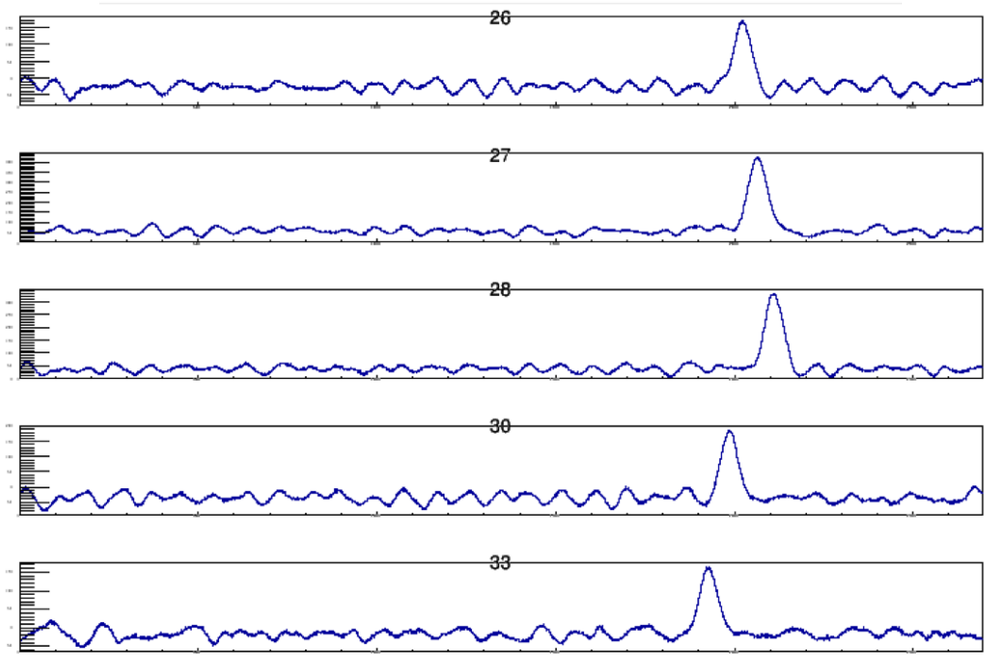
➡ refilling of TPC once per week

# Test Beam TPC Readout



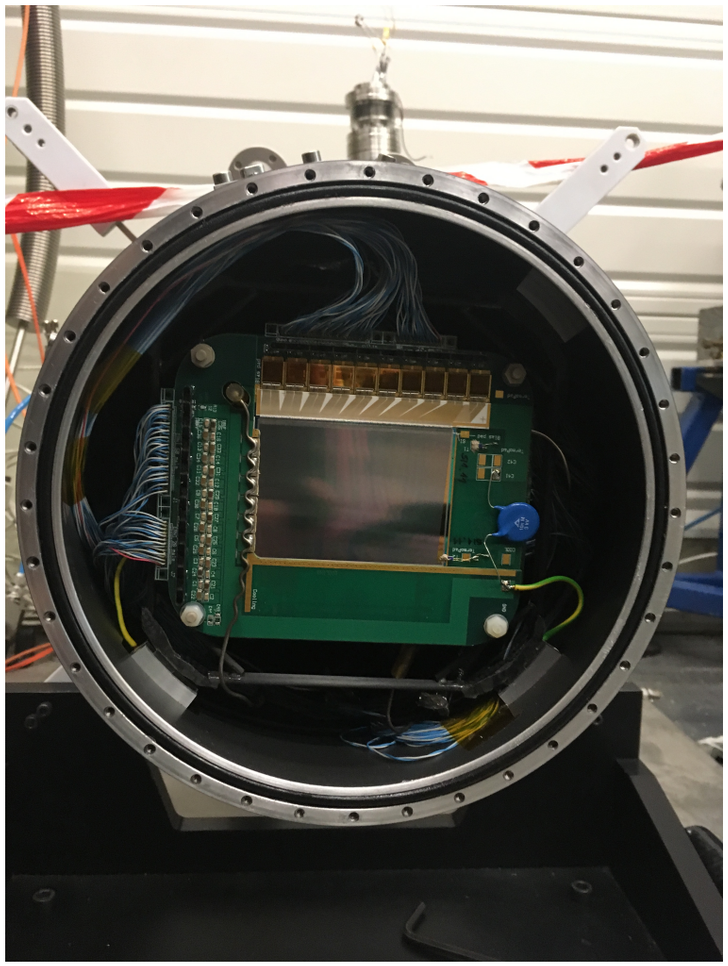




- recoil generates ionization
- different pads: amplitude and time

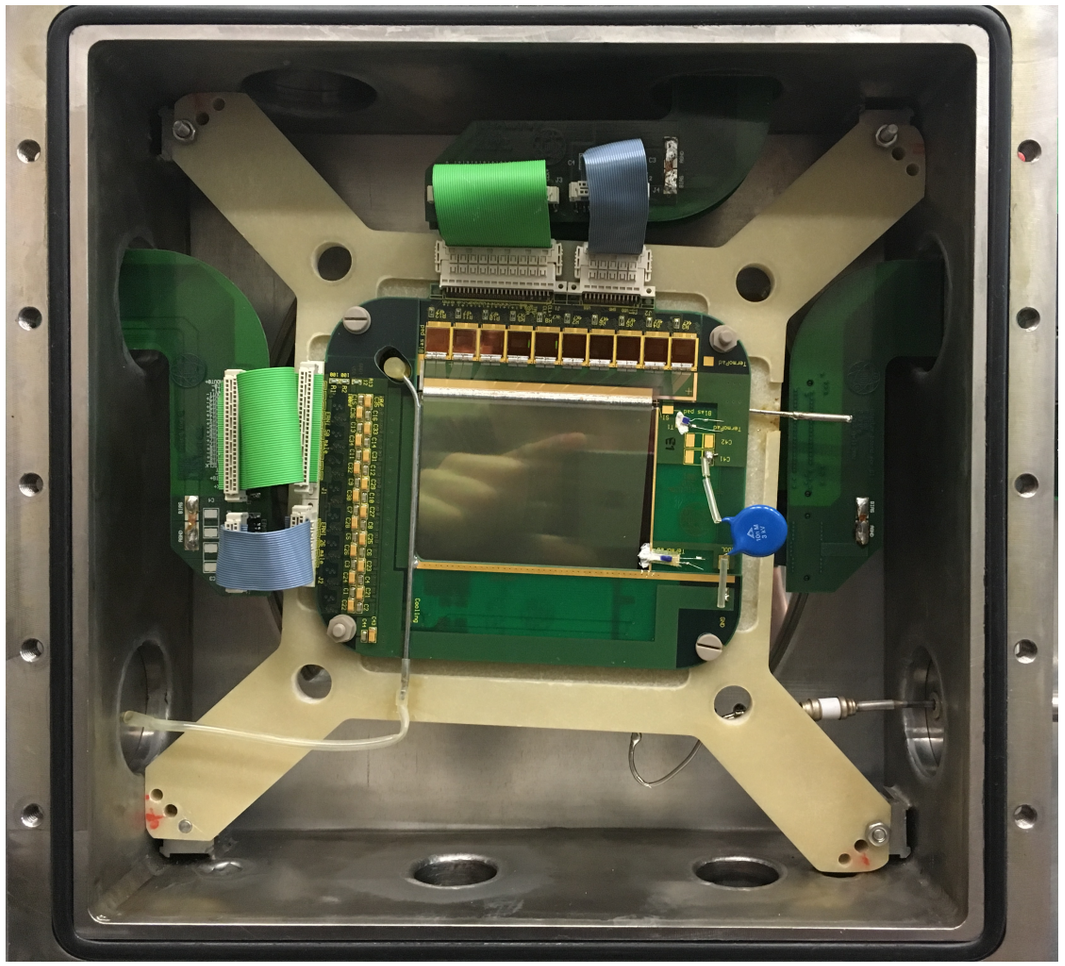


# Test Beam Silicons

## 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 $LN_2$ - APVs cooled with nitrogen gas stream

# Test Beam Trigger

- 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

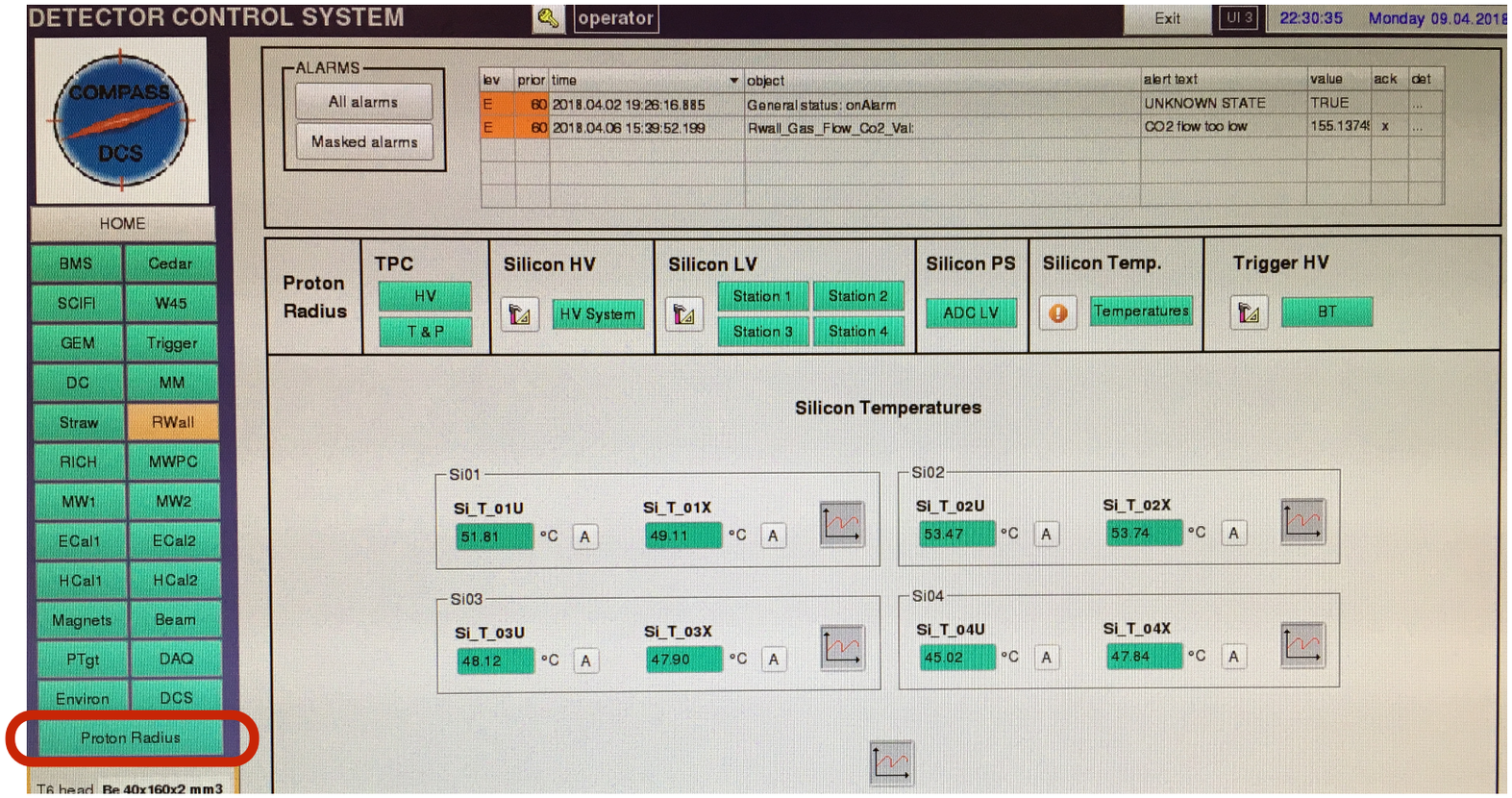
- own DAQ for TPC
- COMPASS DAQ (stand-alone) for Silicons

➡ <u>challenge</u>: combine both DAQs and triggers

- two data sets (TPC and Silicon) for events

➡ <u>challenge</u>: combine events via time stamp and reconstruction

# Test Beam DCS




- 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

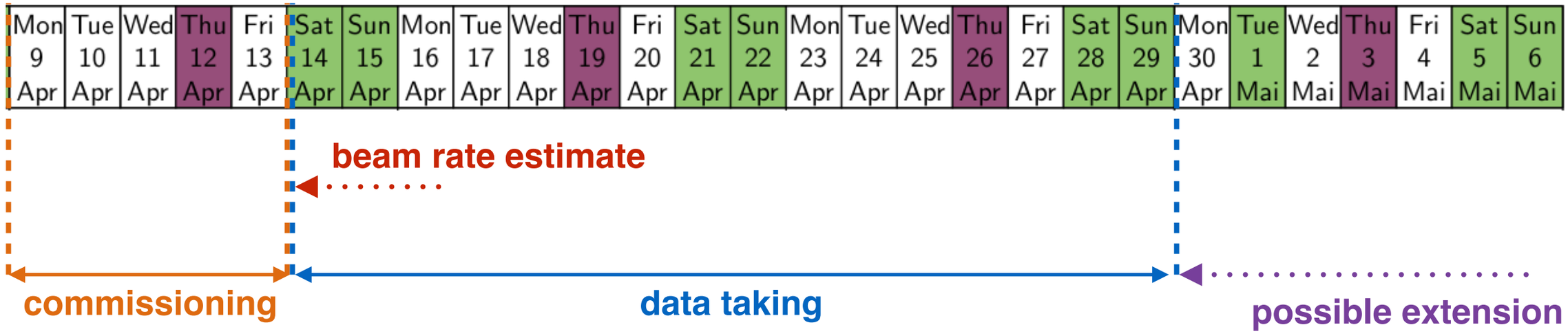
- Silicons: high voltage scan
- Trigger calibration
- Silicons: latency settings
- TPC DAQ settings for beam

- TPC beam test with high intensity

➡ depending on result - lower intensities

➡ event matching of Silicons and TPC

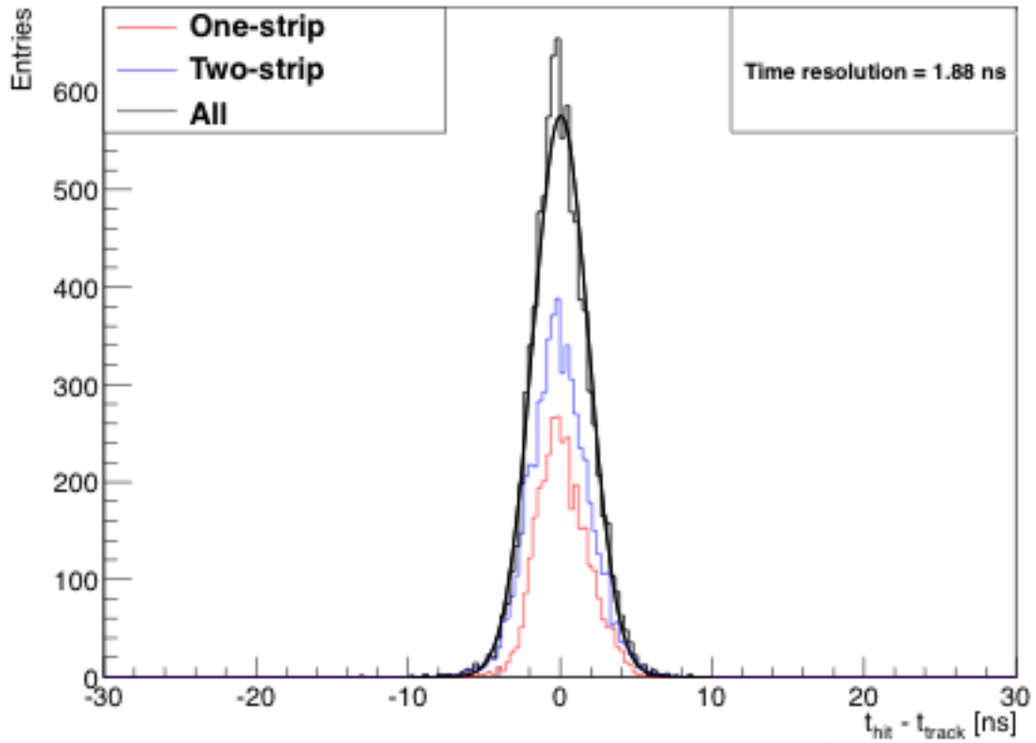
# Test Beam Schedule



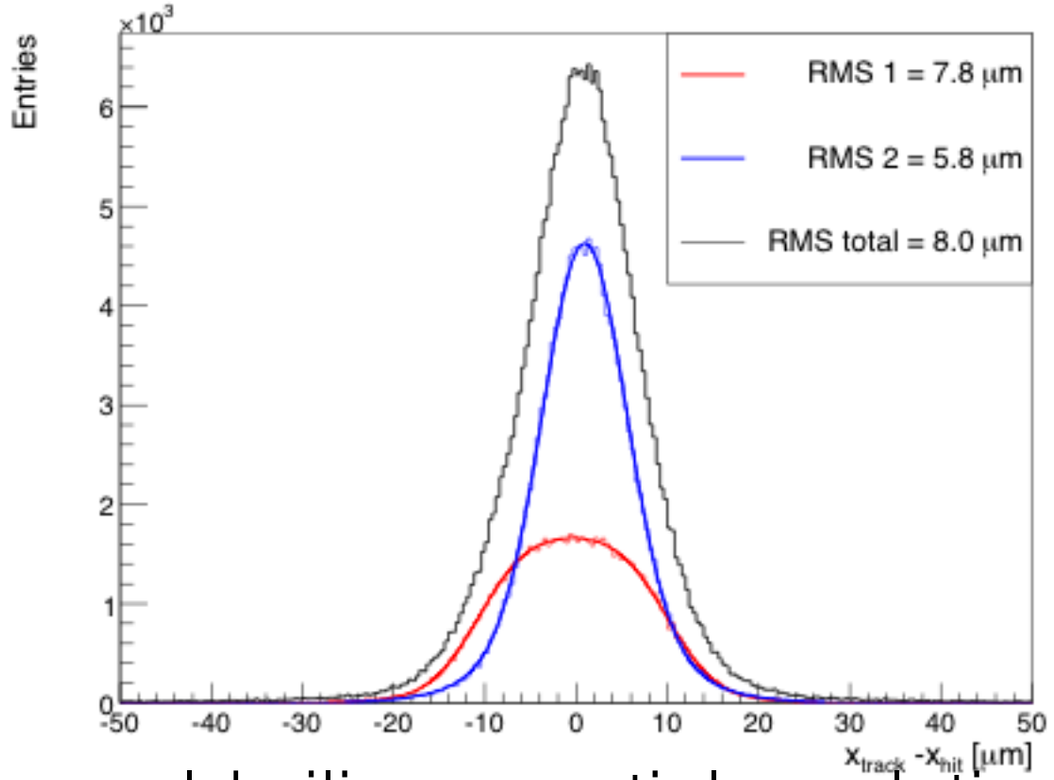

- commissioning phase: finish all calibrations and issues
- estimate best beam rate for data taking
- data taking during night and „non-used“ beam for COMPASS
- possible extension of data taking after end of April

Thank you for your attention!

# Test Beam Silicon Performance



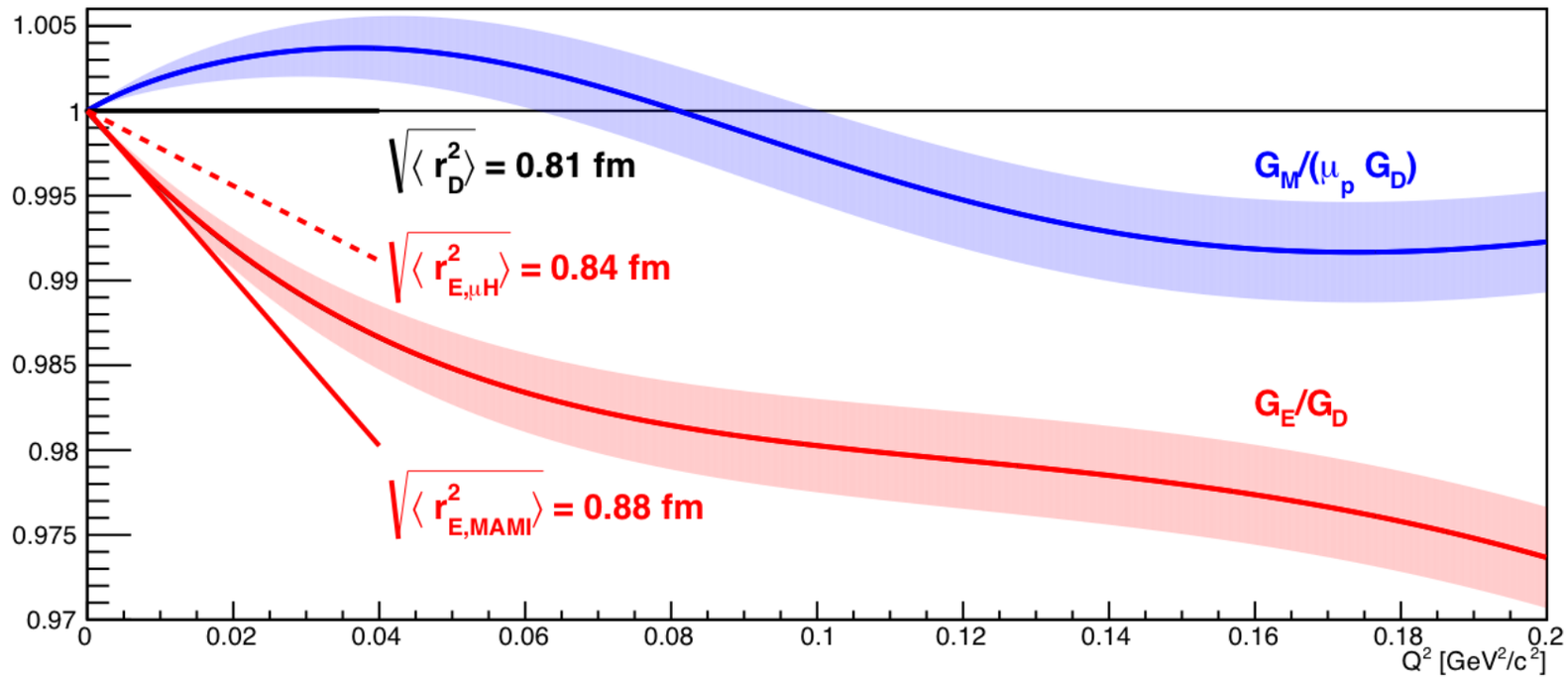

cold silicon time resolution




cold silicon spatial resolution

- expected time resolution: ~*3* ns
- expected spatial resolution: ~10 μm

# Proton Radius Measurement




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

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

mean squared charge-radius

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