

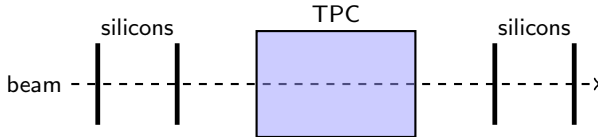
# Proton Radius at COMPASS - Test Measurement 2018

## Status Report

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COMPASS Technical Board Meeting  
5<sup>th</sup> June, 2018



## Principle of the measurement

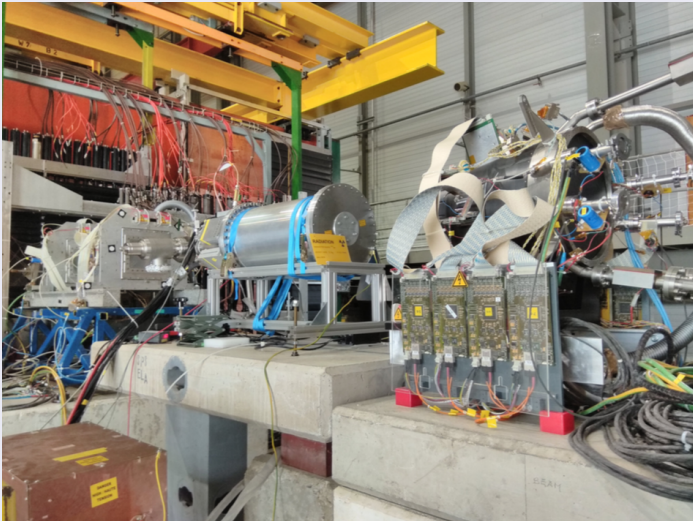
- hydrogen TPC acting as active target
  - measurement of energy of recoil proton
  - between 0.5 and 100 MeV
  - required energy resolution:  $\Delta \approx 60 \text{ keV}$
- silicon telescopes up- and downstream of target
  - measurement of muon scattering angles
  - $300 \mu\text{rad}$  at  $Q^2 \approx 10^{-3} (\text{GeV}/c)^2$
  - required angular resolution  $\sigma \lesssim 100 \mu\text{rad}$

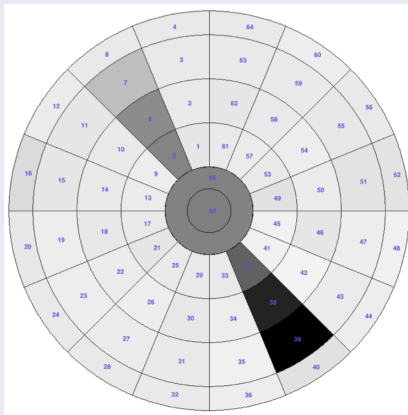
## Combination of TPC and silicon detectors

- in simulation: required resolution achieved down to small  $Q^2$

## Combination of TPC and silicon detectors

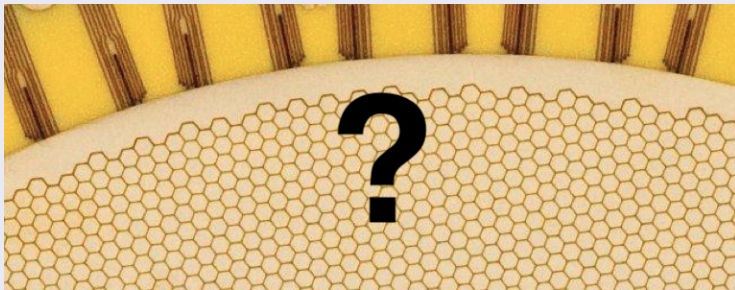
- in simulation: required resolution achieved down to small  $Q^2$
- test beam this year





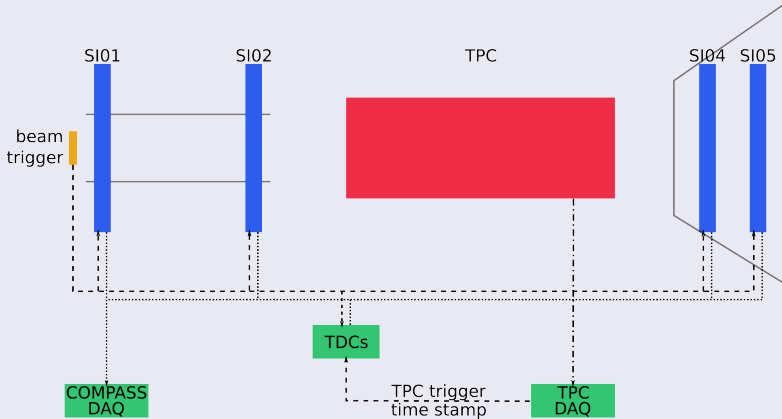
- calibration with  $\alpha$ -source ( $^{241}\text{Am}$ )
- performance of TPC in muon beam

## Test beam set-up



- calibration with  $\alpha$ -source ( $^{241}\text{Am}$ )
- performance of TPC in muon beam
- investigate need or benefit of a higher granularity of the readout plane

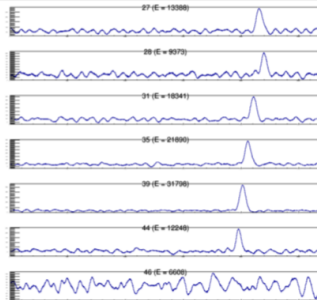
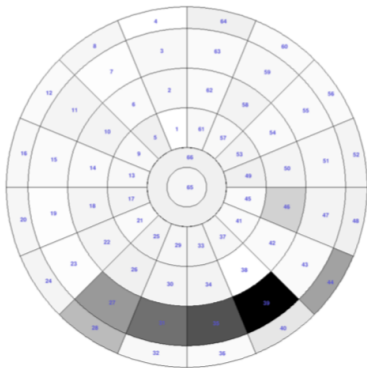
## Test beam set-up



- calibration with  $\alpha$ -source ( $^{241}\text{Am}$ )
- performance of TPC in muon beam
- investigate need or benefit of a higher granularity of the readout plane
- correlate events in silicon detectors with events in TPC

## Performance of TPC

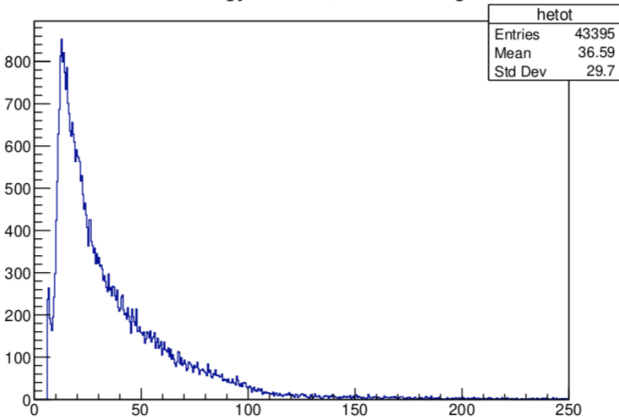
Anode Map | All traces



- recoil protons with muon beam observed

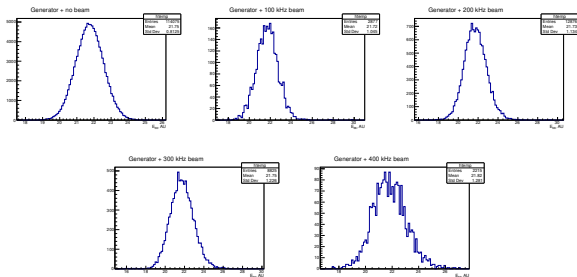


## Total energy on A65, A66 and ring 1



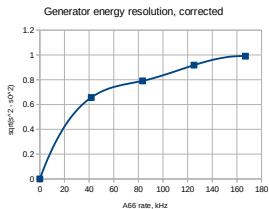
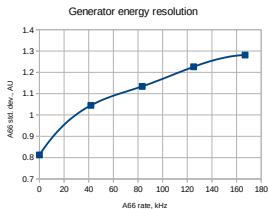
- recoil protons with muon beam observed
- energy spectrum of recoil protons shows expected features

## Generator + beam (A66)



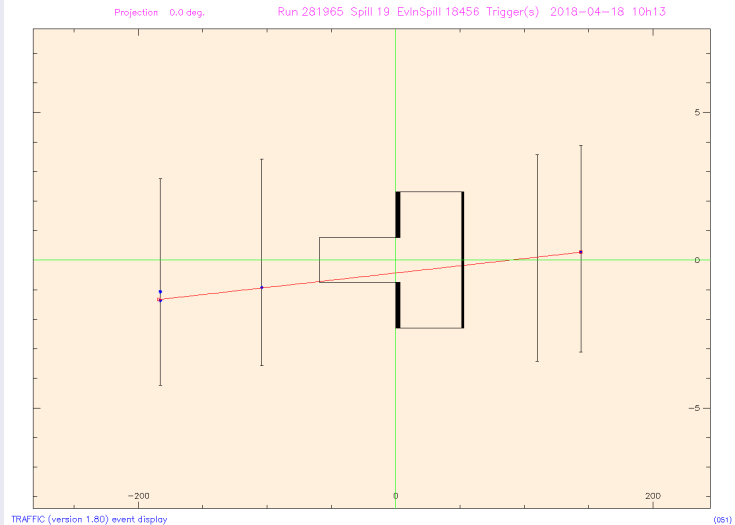
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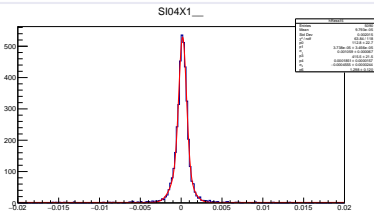
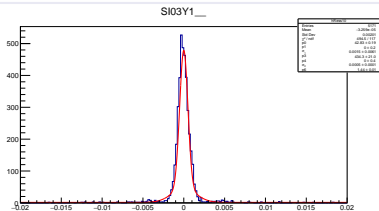
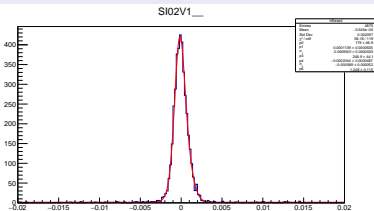
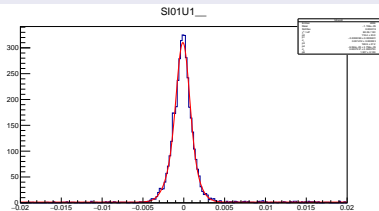
- recoil protons with muon beam observed
- energy spectrum of recoil protons shows expected features
- required energy resolution achievable in our environments

# Reconstruction of the data of the silicon telescope



- reconstruction of straight tracks

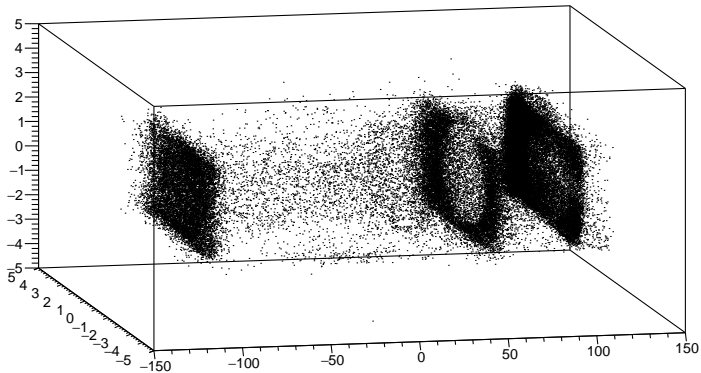
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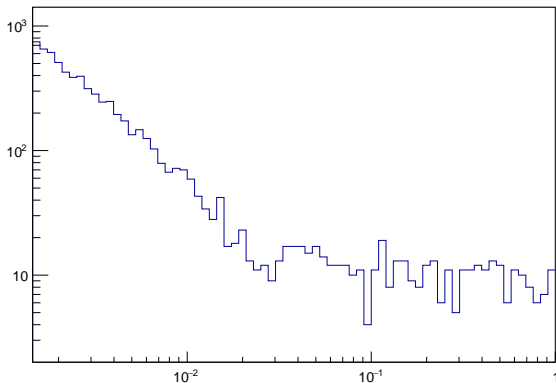
- reconstruction of straight tracks

## Reconstruction of silicon telescopes

vertexY:vertexX:vertexZ {theta > 0.002}



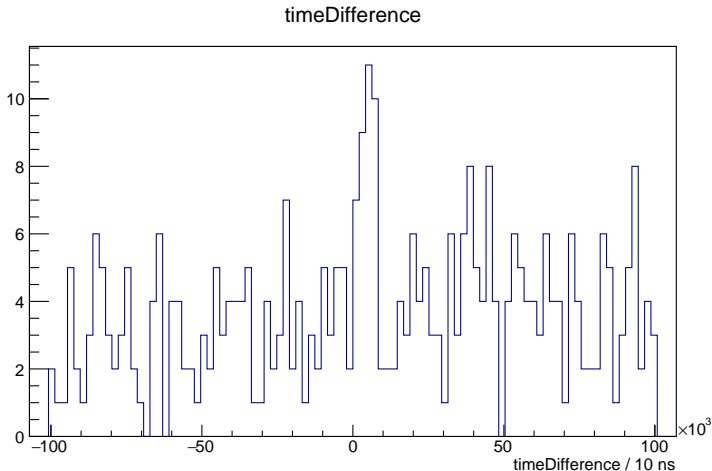
- vertices found at right positions
  - reliable alignment  $\Rightarrow$  details of TPC clearly visible



- vertices found at right positions
  - reliable alignment  $\Rightarrow$  details of TPC clearly visible
- basic  $Q^2$  spectrum visible

## Combination of TPC and silicon data

- first  $\sim 10\%$  of data processed
- measured  $Q_{Si}^2 \geq 10^{-3} \text{ GeV}^2 (\theta \geq 300 \mu\text{rad})$
- vertex located in TPC volume



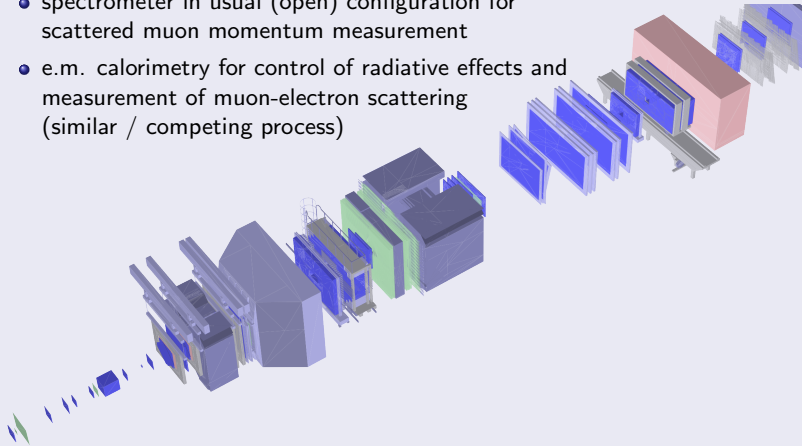


## Preliminary conclusions from the 2018 test

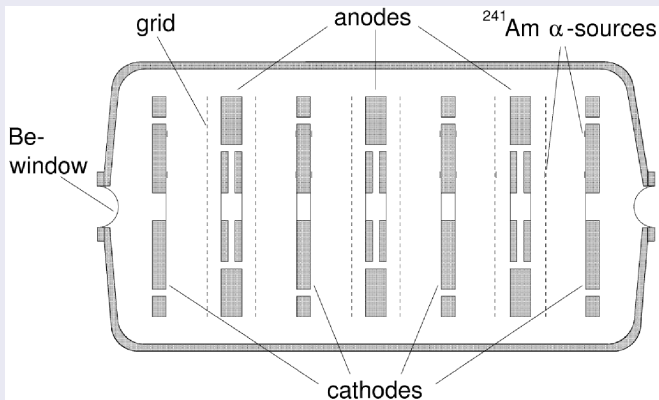
- good performance of (test) TPC in “broad” muon beam
- good performance of (test) silicon telescopes
- evidence for correlation of proton and muon signals
  - ⇒ to be studied in full detail

## Setup for the COMPASS measurement

- TPC and silicon telescopes in the nominal COMPASS target region
- trigger: two scenarios under investigation
  - SciFi with high segmentation for a “kink trigger”
  - high-rate triggerless readout  
(requires new readout scheme for the silicon detectors)
- spectrometer in usual (open) configuration for scattered muon momentum measurement
- e.m. calorimetry for control of radiative effects and measurement of muon-electron scattering  
(similar / competing process)

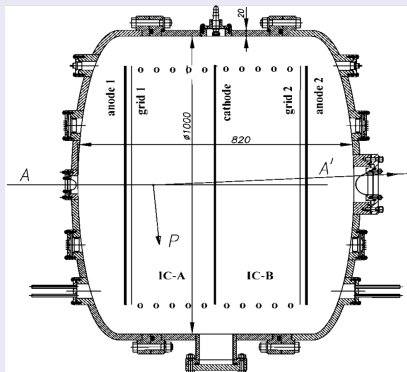


## Possible realization for TPC



- 400 mm anodes, 100 mm drift
- IKAR TPC available, but needs a lot of modifications to increase performance (feedthroughs, flanges, segmentations, etc.)

## Possible realization for TPC



- 820 mm length, 1000 mm diameter and 240 mm drift gaps
- pressure up to 25 bar  
⇒ needs to be built

## Organizational

- several options for the TPC, existing ones or construction of a new one
- decision and agreements must be taken now without further delay for realizing the measurement in 2022

## On the achievable precision

- for  $Q^2 > 0.001$  (sensitive to proton radius) the measurement is dominated by the statistical precision of the one-year beam time
- for  $Q^2 < 0.001$  (control region) the systematic effects will dominate (efficiencies, MS, RC,...)
- full evaluation (adaption of the MC simulation) still to be done, depends on the final setup configuration
- high-precision scattering c.s. measurements reach best 0.5 - 1%; reaching the  $10^{-3}$  level is a new challenge

## Outlook and future plans

- thorough analysis of the recorded data
  - time, spatial and energy matching of events
  - extract (dummy) value for proton radius from data
  - studies of i.e. different pressure and beam conditions
- construction of SciFi “kink trigger” elements ongoing
  - possible beam test with SI telescope in September