Upstream muon spectrometer

SHiP Collaboration Meeting @ CERN

Daniel Bick

November 23, 2016

Overview

- Status of the OPERA drift-tubes
- Possible redesign of the modules
- Improving the operation
- Getting rid of an external trigger?

Status of the OPERA Drift-Tube Modules

- OPERA has been completey disassembled
- All drift-tube modules are stored in altogether six containers
- Last container filled last week
- Containers stored in Hamburg

Drift-Tubes have arrived in Hamburg

Redesigning the Drift-Tube Modules

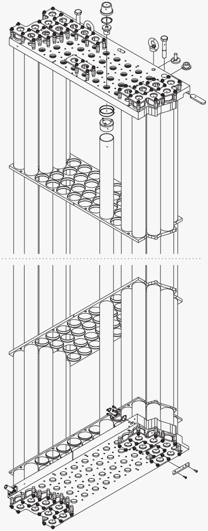
- Modules are currently 8 m long

→ too long for design with shorter muon shield

- Currently thinking about the possibility of shortening the modules
    1. unglue lower endcaps on one side using heat
    2. open wire holders on other side and blow air in the tubes...
    3. ...while cutting the module using a band-saw
    4. reassemble endcap and string new wire
- Has to be tested on a prototype

→ beginning of next year

Redesigned OPERA Drift-Tube Modules



Module Layout

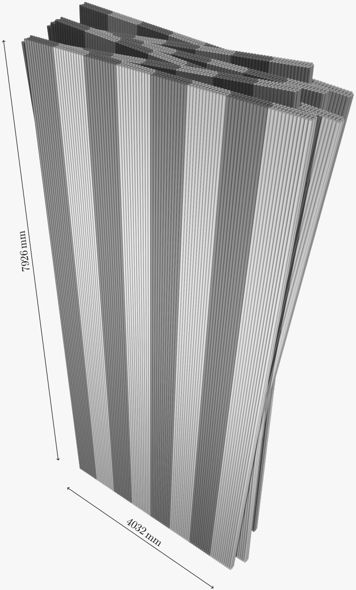
- 48 aluminum tubes staggered in four layers
- Tube diameter: 38 mm, Wall: 0.85 mm thick
- Size: 50.4 cm wide, 19 cm deep, ≈4 m long
- 45 µm gold-plated tungsten sense wire

Stereo planes tiltet by 3.6° in front of magnet

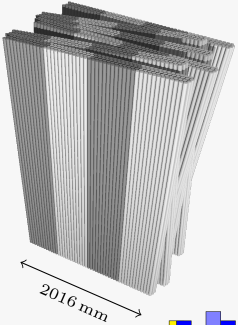
Performance same as in OPERA

- $\Delta p/p = 20\%$
- Spatial resolution: 255 µm

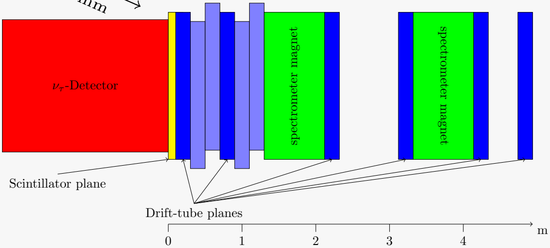
Before:



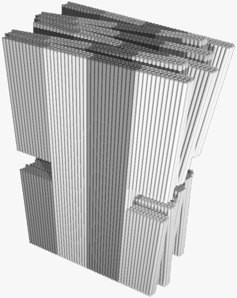
After:



- Height is now variable
- Otherwise spectrometer design unchanged except for the y-dimensions



Possible Optimization for Muon Background

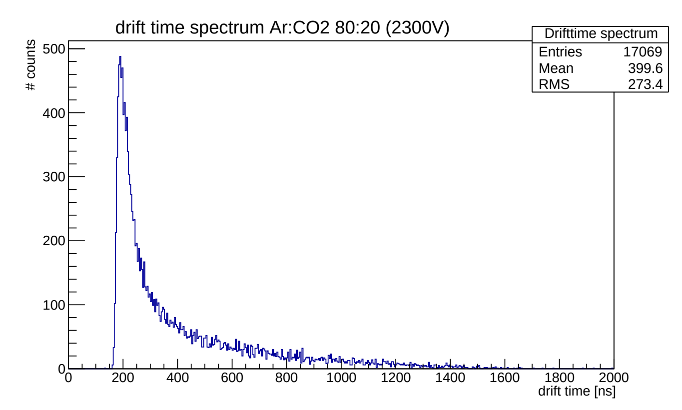


- Region of low muon flux is much more narrow close to the beam axis
- Possibility to leave a gap in the muon spectrometer to avoid
  - backscattering of muons
  - high occupancy in the modules
- Need to check loss of acceptance though

- This should and can be done once the design of the muon shield and neutrino detector is finalized!

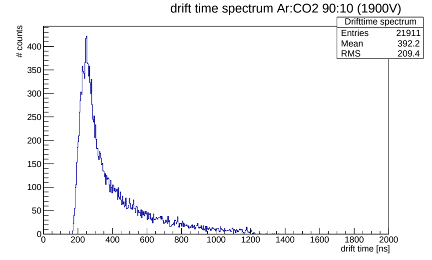
OPERA Driftgas

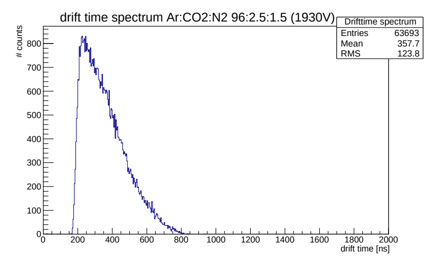
- OPERA used a $\mathrm{Ar}/\mathrm{CO}_2$ 80:20 gas mixture
- Very long drift times $\rightarrow$ not so well suited for SHiP with much higher event rates

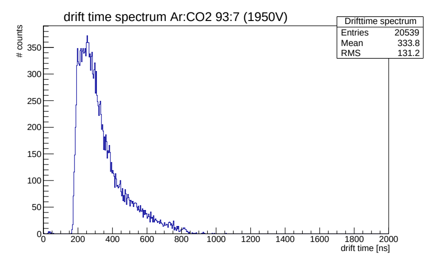


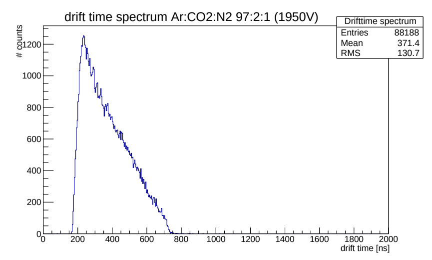
Testing new Driftgases

- Changing ratios of Ar and CO_2, adding N_2

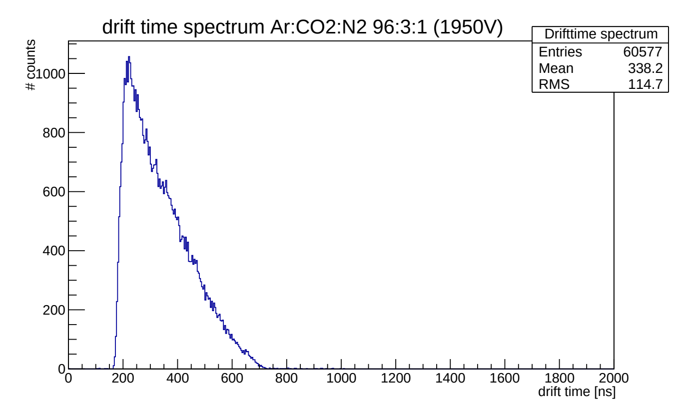






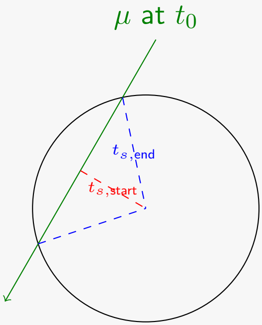


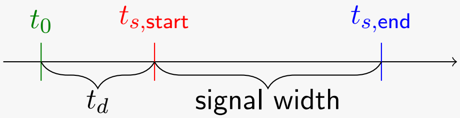
A faster Driftgas



Significant improvements when using less CO_2 and adding N_2

- Best choice (so far): $Ar : CO_2 : N_2$ at a ratio of $96 : 3 : 1$
- Better linearity
- Much faster ($\approx 600\,\mathrm{ns}$ maximum drift-times)



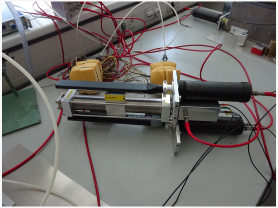


- To get the drift-time t_d you need the time t_0 when the muon passes the detector
- So far an external trigger is needed
- Time $t_{s,\text{end}}$ constant with respect to t_0

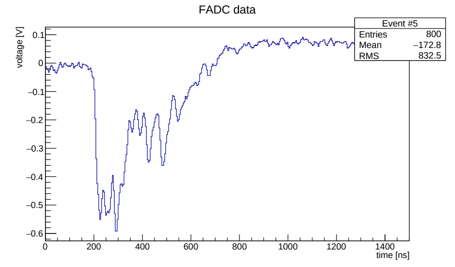
$\rightarrow$ measure the signal width to get t_0 and thus t_d

A look at Events

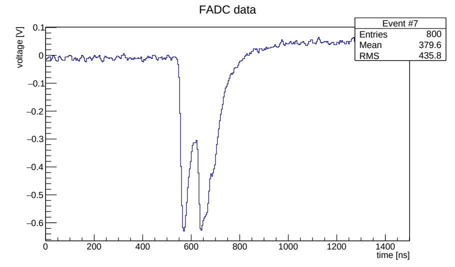
- Use of FADC to analyze pre-amplified signals
- Test-setup with one tube only
- Events triggered by two scintillator planes, $t_0 \approx @180\,\text{ns}$



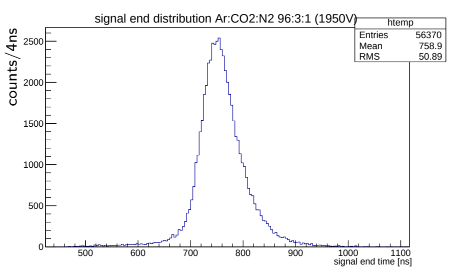
Track close to wire (small t_d):



Track further away from wire (large t_d)



Looking at Signal Ends



- Analysis of FADC data

→ Single hits only

- Triggered by two scintillator planes, so we know true t_0
- Results consistent with drift-time spectrum
- Large time spread

Possible improvements:

- Test different methods to identify signal end
- Use of different threshholds
- Influence of different pre-amp?
- Using multiple hits of a true track will improve results

Conclusions

Summary

- Drift-tube modules are now stored in Hamburg
- Evaluating the options of shortening the modules
- Adapted design could allow for gaps to avoid high muon flux areas
- Search for a better drift-gas is ongoing. Peliminary results look really good
    - However still more checks needed (afterpulses. . .)
- Studies on self-triggering mode in progress

Next Steps

- Use of new drift-gas in test setup for actual tracking to see its performance
- Building a short prototype from existing modules