ATLAS Monitored Drift Tube Chambers for Super - LHC
Background rates
[Hz/cm^2]

LHC design luminosity
10^{34}/cm^2s

Safety factor 5

S-LHC: 10*luminosity

MDT: 500 Hz/cm^2, 1.5 kHz/cm, 300 kHz/tube (L=2m, D=3cm)

Baranov et al.: ATL-GEN-2005-001, Geneva 2005
• Barrel Region:
  • Studies of faster and linear drift gases

• High Rate Endcap Region:
  • 15 mm drift tube detectors

• Sensitivity and resolution under 11 MeV neutron background
Ar:CO2 = 93:7

3 bar, 20 °C

ns without background

measurement CERN (X5) 2004

990 Hz / cm²

no irradiation

degradation due to space-charge fluctuations
assumptions: 2 dim, $\mu = \text{const.}$

$$\frac{dr}{dt} = \mu \cdot E(r) \rightarrow dt = \frac{dr}{\mu \cdot E(r)}$$

charge density:

$$\rho(r) = \frac{N_c G Q}{2\pi \mu r E(r)}$$

Gauss theorem:

$$2\pi r E(r) = \frac{\gamma}{\varepsilon_0} + \frac{1}{\varepsilon_0} \int_a^r 2\pi R \rho(R) dR$$

differentiating

$$E(r)^2 + r E(r) \frac{dE(r)}{dr} = \frac{N_c G Q}{2\pi \mu \varepsilon_0}$$
Change of Electric Field

\[ E(r) = \sqrt{c1 \frac{k}{r}} \sqrt{1 + \frac{r^2}{k^2}} \]

\[ c1 = \frac{NcGQ}{2\pi \mu \epsilon_0} \]

\[ \int_a^b E(r) \, dr = V \]
Why is another drift gas reasonable?

faster  => less occupancy
linear  => better position resolution under high rate conditions

| AR  | CO2 | N2 |
|-----|-----|----|
| 100-X | X | 0 |
| 98-X  | 2 | X |
| 97-X  | 3 | X |

**simulation**

- Ar:CO2 = 93:7
- Ar:CO2:N2 = 93:5:2
- Ar:CO2:N2 = 94:4:2
- Ar:CO2:N2 = 96:3:1
  97:2:1
Cosmic Ray Facility (Munich)

- muon trigger 1 ns resolution
- 2 ref chambers for $\mu$-track determination
- test chamber with different gas mixtures
- drift gases with up to 4 components mixable

\[ D=3\text{cm}, \quad U = 3080 \text{ V}, \quad p=3000 \text{ mbar} \]
Position Resolution Using $\mu$-Tracks

- Gauss fit describes distribution
- tails due to fast $\delta$-electrons
Single Tube Resolution

- resolution of alternative gases similar to standard gas in agreement with simulations
- simulations show almost no resolution deterioration at high $\gamma$-rates
- to be proven this spring with measurements @CERN GIF

![Graph showing resolutions measurement no background]
15 mm Ø Tubes
as Potential Replacement
for CSC Chambers and
High Rate EI MDT Chambers

Poster: “Precision Drift-Tube Detectors for High Radiation Rates at Super-LHC”
B. Bittner #86 board F-2
Change of Electric Field

\[ E(r) = \sqrt{c_1 \frac{k}{r} \sqrt{1 + \frac{r^2}{k^2}}} \quad c_1 = \frac{N_c G Q}{2 \pi \mu \varepsilon_0} \quad \int_a^b E(r) \, dr = V \]
Setup @ GIF
Expectations for 15 mm Ø Tubes

Measurement without background

\[ t_{\text{max}}(D = 15\, mm) \approx \frac{1}{4} t_{\text{max}}(D = 30\, mm) \]

half crosssection area \[ \Rightarrow \] expected background sensitivity reduced by almost one order of magnitude
Single Tube Resolution

prelim.

single tube resolutions versus rates

- Garfield 15 mm tubes
- Garfield 30 mm tubes
- GIF 15 mm tubes
- X5 30 mm tubes, 2004
Sensitivity and Resolution under
Fast Neutron Background
Setup @ MLL Tandem (Munich)

11 MeV n flux density: 4-16 kHz/cm^2
\[ \varepsilon = (4.0^{+1.6}_{-0.3}) \cdot 10^{-4} \]
Position Resolution using SI Strip Detectors

\[ f(x) = \frac{a_0}{\sqrt{2\pi w}} e^{-\frac{1}{2} \left( \frac{x-\mu}{w} \right)^2} + \frac{a_0}{\sqrt{2\pi 3w}} e^{-\frac{1}{2} \left( \frac{x-\mu}{3w} \right)^2} \]

\[ w \approx 95\mu m \]
Position Resolution using Triple-sums

\[ S_{\text{meas}} = \frac{1}{2} d_1 - d_2 + \frac{1}{2} d_3 \approx \]

\[ S_{\text{track}} = \frac{1}{\sqrt{a^2 + 1}} \left[ \left( x_2 - \frac{1}{2} \left( x_1 + x_3 \right) \right) + a \left( \frac{1}{2} \left( y_1 + y_3 \right) - y_2 \right) \right] \]

\[ S_{\text{Meas}} - S_{\text{track}} \approx 0 \]
Results for 11 MeV n

- resolution degradation of about 10 $\mu$m
- triple sum method leads to similar result
- $\varepsilon = (4.0^{+1.6}_{-0.3}) \cdot 10^{-4}$
• two alternative fast and linear drift gases:
  \[ \text{Ar:CO2:N2} \quad 96:3:1 \]
  \[ \text{97:2:1} \quad \text{CF4?} \]

• preliminary results for 15 mm drift tubes at high rates:
  resolution without background: 112 \( \mu \text{m} \)
  resolution with background: 120 \( \mu \text{m} \) \( (1400 \text{ Hz/cm}^2) \)

• 11 MeV background neutrons lead to resolution degradation
  of about 10 \( \mu \text{m} \) @ \( \sigma = 90 \mu \text{m} \) \( (4-16 \text{ kHz/cm}^2) \)
  \[ \varepsilon = (4.0^{+1.6}_{-0.3}) \cdot 10^{-4} \]
\[ E(r) = \sqrt{c_1 \frac{k}{r}} \sqrt{1 + \frac{r^2}{k^2}} \quad c_1 = \frac{N_c G Q}{2 \pi \mu \varepsilon_0} \]

\[ \int_{a}^{b} E(r) dr = V \quad \Rightarrow \quad V \sqrt{\frac{2 \pi \mu \varepsilon_0}{N_c G Q}} = k \ln \left( \frac{b \left( k^2 + k \sqrt{k^2 + a^2} \right)}{a \left( k^2 + k \sqrt{k^2 + b^2} \right)} \right) + \sqrt{k^2 + b^2} - \sqrt{k^2 + a^2} \]
Gain Drop

gas gain depends on el. field via line charge => gain drop

\[ G = \left[ \frac{\gamma}{2\pi\mu\varepsilon_0 E_{\text{min}}} \right]^{\frac{\gamma \ln 2}{2\pi\varepsilon_0 \Delta V}} \]

\[ \Delta V = 34.15 \text{ V (average ionisation potential)} \]

\[ E_{\text{min}} = 70.6 \text{ kV/cm (min el. field for avalanche)} \]
CF4 Gas Mixtures

![Graph showing drifttime vs. mixture percentage]