Atlas Drift Tube ageing test

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• Goal of Drift Tube ageing test
• Setup
• Ageing as function of total charge [mC/cm]?
• Influence on the choice of gas for ATLAS
• Conclusion
Goal of Drift Tube ageing tests

Drift Tubes for the precision chambers of the Atlas Muon Spectrometer

**Single Tubes**
- Number: 380,000
- Length: up to 6m

**Rates:**
- high $\gamma$ and n Background
- Counts up to **300Hz/cm** over **10 years** of operation

**DT Operating Point**
- Gas gain: $2 \times 10^4$
- High resolution: **80μm**

**Goal:**
- Lifetime $> 0.6$ C/cm
  (with security factor 5)

**Gas Mixtures**
- **Ar-CO$_2$ 93-7**, "Baseline Gas"
- **Ar-CH$_4$-N$_2$-CO$_2$ 94-3-2-1**, "R&D Gas"
Parameters influencing ageing

• Parameters to optimize ageing performance of detector

• Parameters of ageing tests
  (needed for extrapolation, I will focus my talk on this point)
Optimization of Ageing-Performance

• Cathode/Anode coating
• Cathode/Anode cleanliness
• Gas mixture
• Gas additives
• Gas flow
• Gas purity

red = tested in Freiburg

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How to make an ageing test?

An ageing test should be made in a **short time** on **laboratory scale** and be reliable!

Possibilities to accelerate ageing tests:
increased **gas gain** and **irradiation rate**

- Irradiation length
- High-Voltage
- Irradiation Rate
- Primary Ionisation

Can we conclude anything from the collected total charge [mC/cm]?
**Experimental discrepancies**

using $\text{Ar-CH}_4\text{-N}_2\text{-CO}_2$

<table>
<thead>
<tr>
<th>Setup</th>
<th>Freiburg 1998</th>
<th>CERN X5-GIF 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>No ageing up to 3000 mC/cm</strong></td>
<td><strong>All (48) tubes inefficient after 80 mC/cm</strong></td>
</tr>
<tr>
<td>Tube cleanliness</td>
<td>higher</td>
<td>lower</td>
</tr>
<tr>
<td>HV</td>
<td>3350 Volt</td>
<td>3400 Volt</td>
</tr>
<tr>
<td>Irradiation zone</td>
<td>2.5 cm</td>
<td>340 cm</td>
</tr>
<tr>
<td>Irradiation rate</td>
<td>0.5 – 13kHz/cm</td>
<td>1.8 kHz/cm</td>
</tr>
<tr>
<td>Gas flow/ Volume exchange time</td>
<td>2 – 240 hours</td>
<td>2.5 hours</td>
</tr>
<tr>
<td>Gas system</td>
<td>all parallel</td>
<td>each 3 serial</td>
</tr>
<tr>
<td>Photon energy</td>
<td>14, 18 and 60 keV</td>
<td>660 keV</td>
</tr>
</tbody>
</table>

Cathode cleanliness and gas flow alone could not explain the different results.

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• 1995 Start of ageing tests
• Active zone (irradiation zone) 1.5 to 8 cm
• Total length of the tube: 30 cm
• 4 different irradiation rates (4 distances)
• 5 Setups \( \rightarrow \) 80 individual tubes
4 ways to measure the drift tube efficiency

1.) **Current** (every 30min)

2.) **Count Rate** (every 30min)

3.) **Mean Pulse Height** (every 3days)

4.) **Ageing** (4 times in a MDT-operation time)

\[
\text{ageing} := \frac{\text{ADC (irradiated zone)}}{\text{ADC (Not Irradiated zone)}}
\]

Independent of electronics, gas mixture, high voltage

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Example of an inefficient Tube

**Tube is defined to be inefficient if:**
- Mean Pulse Height < 70%
- Ageing-Ratio < 70%

**Typical:**
- Onset of Malter-Effect after death
- Drop of Count Rate
Ageing dependence on High Voltage

Lifetime = Total Charge/Length up to 70%-Level of pulse height

Equal Colors = identical parameters except Voltage

Strong HV-Dependence of Lifetime
Ageing dependence on irradiation rate

Lifetime = Total Charge/Length up to 70%-Level of pulse height
Equal Colors = identical parameters except irradiation rate

Strong rate-dependence of Lifetime
Ageing dependence on irradiation zone

Lifetime = Total Charge/Length up to 70%-Level of pulse height
Equal Colors = identical parameters except irradiation zone

Strong length of irradiation zone dependence of Lifetime
Dependences of lifetime in Ar-CH$_4$-N$_2$-CO$_2$

Strong dependence of the lifetime on HV, irradiation rate and irradiation zone.

Extrapolation to Atlas-Operating Point (600cm, 300Hz/cm, 3130V) not possible.

“safe ageing test”: full length, higher rate & HV \[ \Rightarrow X5 \]

Is this behaviour independent from gas-mixture?
Interpretation of the ageing dependences

Irradiation in gas mixtures with hydro-carbons can produce ageing

Polymerisation on the wire reduces the gas gain (experimental result)

Does ageing depend on chemical concentration?
(That is up to now an unchecked idea)

**Chemical concentration** increases:

• with higher HV
• with higher irradiation rate
• in serial gas systems with position in the series

• along direction of gas flow
• with longer irradiation zone
Dependence of lifetime in Ar-CO$_2$ 93-7

Ar-CO$_2$ (93-7) :
- Number: 21 Tubes
- HV: 3400V, 3500V (HV$_{ATLAS}$=3080 Volt)
- Irradiation Zone: 2,5 – 8 cm

⇒ 100% efficient after 1,3 C/cm (avr.)
⇒ one tube 4,8 C/cm

Ar-CO$_2$ (90-10) :
- Number: 47 Tubes
- HV: 3400V, 3440V
- Irradiation Zone: 3,4 m

⇒ 100% efficient after 0,6 C/cm

(no sign of ageing)
However

Drift tubes in a safe gas like Ar-CO$_2$ can age if there are small quantities of impurities in the tube.

We have seen ageing in Ar-CO$_2$, when the tube is sealed with Araldit (Contact surface $<<$ 1mm$^2$) (Araldit AW106, HV 953).
Conclusion

- Ageing has a strong dependence on HV, irradiation rate and length of irradiation zone.

- To make an useful ageing test, you have to study the dependence on these parameters.
  A safe test in Ar-CH$_4$-N$_2$-CO$_2$: full length, higher rate and higher HV.

- A safe gas for the Atlas Muon Drift tubes is Ar-CO$_2$ 93-7.