Beampipe and Shielding for the ATLAS upgrade

- Beampipe
- Activation
- USA15
- Muon Shielding
- Moderator for the Inner Detector
- LHC magnets in ATLAS
Possible upgrades:
Make beampipe of aluminium
Make beampipe of beryllium
Increase radius

0.8 mm Be at R=29 mm
0.8 mm stainless steel at R=29 mm
1.0 mm SS at R=40 mm
1.0 mm stainless steel at R=40 mm
1.5 mm stainless steel at R=60 mm
13 mm Cu at R=17 mm

The Beampipe

VI
0.8 mm Be at R=29 mm

VA
0.8 mm stainless steel at R=29 mm

VT
0.8 mm SS at R=29 mm
1.0 mm SS at R=40 mm

VJ
1.0 mm stainless steel at R=40 mm
1.5 mm stainless steel at R=60 mm

TAS
13 mm Cu at R=17 mm

Cooling pipes
Rolling beampipe supports
FCAL bore

Fixed Beampipe Support

Fixed Beampipe Support
An aluminium beampipe has been proposed as an upgrade before running at $10^{34}$ cm$^{-2}$s$^{-1}$ in order to reduce the activation. Bellows etc could be a problem.

For long running and cooling times the advantage of an Aluminium beampipe is smaller.

The ratio of the doserate from a steel and an aluminium beampipe with the same thickness.

<table>
<thead>
<tr>
<th>Cooling time</th>
<th>5000d</th>
<th>1000d</th>
<th>100d</th>
<th>30d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 d</td>
<td>9</td>
<td>13</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>5 d</td>
<td>9</td>
<td>15</td>
<td>76</td>
<td>181</td>
</tr>
<tr>
<td>7 d</td>
<td>8</td>
<td>14</td>
<td>68</td>
<td>164</td>
</tr>
<tr>
<td>30 d</td>
<td>4</td>
<td>7</td>
<td>22</td>
<td>39</td>
</tr>
</tbody>
</table>
An aluminium beampipe will also reduce the activation of other parts of the experiment.

Dose rates in $\mu$Sv/h from the disc shield after 100 days of running and 5 days of cooling.

$10^{34}$ cm$^{-2}$s$^{-1}$

The beampipe is made of stainless steel

The beampipe is made of aluminium

(M. Morev)
An aluminium beampipe will give some reduction of the background in the muon spectrometer.

Decrease of background rate when the beampipe is changed to aluminium if

- single counting rate = $0.0005n + 0.0117\gamma + (\mu + p + \pi + 0.25e) / 2$
- penetrating particle rate = $0.00117\gamma + (\mu + p + \pi + 0.25e) / 2$

single counting / penetrating particle: -21% / -19%

-19% / -18%

-19% / -18%

-19% / -13%

-15% / -13%

-16% / -17%

-9% / -6%

-16% / -14%

-16% / -14%

-15% / -13%

Aluminium Beampipe Z=3.5-18.6 m

GCALOR (M. Shupe)
At SLHC we will have to consider going to a beryllium beampipe. The activation of the beampipe will then not be an issue.

Dose rates in $\mu$Sv/h from the VI beampipe.

$10^{34}$ cm$^{-2}$s$^{-1}$

100 days running
5 days cooling

10 years running
5 days cooling

(M. Morev)
A beryllium beampipe is also the only way of significantly reducing the background in the muon spectrometer.

Decrease of background rate when the beampipe is changed to beryllium if

\[
\text{single counting rate} = 0.0005n + 0.0117\gamma + (\mu + p + \pi + 0.25e) / 2
\]

\[
\text{penetrating particle rate} = 0.00117\gamma + (\mu + p + \pi + 0.25e) / 2
\]
A beampipe with larger radius

An increase of the radius will not make a large difference in rate but will make the standard access scenario (when the beampipe is not removed) impossible.

Decrease of background rate when the radius of the beampipe is increased

\[
\text{single counting rate} = 0.0005n + 0.0117\gamma + (\mu + p + \pi + 0.25e) / 2
\]

GCALOR (M. Shupe)
Radiation levels in USA15

The 2 m thick wall between the ATLAS cavern and the USA15 electronics cavern was designed such that USA15 could be designated as a simple controlled area (i.e. unlimited access with film badge).

The present limit for a simple controlled area is 25 $\mu$Sv/h based on maximum does of 50 mSv per year. This is expected to be lowered to a maximum dose of 6 mSv per year.

Prediction for $10^{34}$ is $< 4 \mu$Sv/h

USA15 would not be a simple controlled area at $10^{35}$!

A strengthening of the wall could decrease the rate with a factor 2.
A catastrophic leak of argon

The argon in the calorimeters are going to be activated. In case of a catastrophic leak of argon from one of the endcap calorimeters radioactive argon would be released at the ATLAS site.

A detailed study of the dose levels to the general public from such a leak has been studied with environmental models.

It has been estimated that the nearest neighbour to ATLAS could get a dose of 0.17 mSv for infants and 0.02 mSv for adults at 10^{34} cm^{-2}s^{-1}. Mostly from consuming milk produced around ATLAS. People working in the ATLAS office building would only get 0.002 mSv.

But probably a major part of the isotopes will be trapped inside the calorimeter (see next slide).

Z. Zajacova

Table 1: Limits on the effective dose resulting from an accident as a function of accident probability.

<table>
<thead>
<tr>
<th>Accident Probability</th>
<th>Effective Dose Limit</th>
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<tbody>
<tr>
<td>10^{-1} per year and higher</td>
<td>- together with the dose resulting from facility’s regular operation must not exceed 0.3 mSv</td>
</tr>
<tr>
<td>10^{-1} to 10^{-2} per year</td>
<td>- must not exceed 0.3 mSv, additional to the dose resulting from facility’s regular operation</td>
</tr>
<tr>
<td>10^{-2} to 10^{-4} per year</td>
<td>- must not exceed 1 mSv, additional to the dose resulting from facility’s regular operation</td>
</tr>
<tr>
<td>10^{-4} per year and lower</td>
<td>- is not limited by default, rather it is subject to special procedure. If such an accident could result in a potentially major effect, the Safety Commission, in collaboration with Host State authorities, must specify the necessary preventive measures.</td>
</tr>
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</table>

V. Hedberg - CERN / Lund
A catastrophic leak of argon

Tests have been made at BNL to see how much of the radioactive isotopes will leak out with the argon in case of an accident.

A calorimeter test cell has been built at BNL and exposed to $1.55 \times 10^{15}$ protons at 24 GeV.

50% of the produced Be-7 and Na-24 vented out with the liquid argon when the cell was emptied.

< 1% of the produced Na-24 and S-38 vented out with the gaseous argon when the liquid argon was boiled off.

Conclusions: A release of argon gas from the calorimeter would contain less than 1% of the activity produced in the calorimeters.

A leak of liquid argon into the cavern would contain less than 50% of the produced activity.

Less than 1% of the activity can reach the ATLAS surroundings.

Note on EDMS: ATL-A-TR-003
Improvements of the muon shielding

Modify the JD and SW

Increase the radius of the JD shielding to 150 cm i.e. into the CSC area.

(The present radius of the hub is 54-76 cm).

Modify the JF and BW

Improvements of the muon shielding

Steel ring - 37 tons
R=165-205 cm
Z=13-14 m
Improvements of the muon shielding

Decrease of background rate when the beampipe and shielding is changed if

- single counting rate $= 0.0005n + 0.0117\gamma + (\mu + p + \pi + 0.25e) / 2$
- penetrating particle rate $= 0.00117\gamma + (\mu + p + \pi + 0.25e) / 2$

**single counting / penetrating particle:**
- -55% / -57%
  - (-44% / -44%)
- -60% / -52%
  - (-41% / -44%)

- -63% / -47%
  - (-33% / -29%)
- -63% / -56%
  - (-56% / -47%)
- -63% / -56%
  - (-38% / -9%)

Brass added to disk shield (35 tons)

Steel added to forward shield

Beryllium Beampipe $Z=4.5-16$ m

GCALOR (M. Shupe)
Improvements of the muon shielding

Decrease of background rate when the endcap toroid is changed if

single counting rate = \(0.0005n + 0.0117\gamma + (\mu + p + \pi + 0.25e) / 2\)

penetrating particle rate = \(0.00117\gamma + (\mu + p + \pi + 0.25e) / 2\)

single counting / penetrating particle:

- \(-87\% / -86\%\) (-44\% / -44\%)
- \(-89\% / -91\%\) (-41\% / -44\%)
- \(-70\% / -71\%\) (-33\% / -29\%)
- \(-63\% / -67\%\) (-38\% / -29\%)
- \(-79\% / -86\%\) (-56\% / -47\%)
- \(-78\% / -84\%\) (-67\% / -60\%)

Only the beampipe is changed to Be

- \(-60\% / -64\%\) (-38\% / -9\%)

Beryllium Beampipe \(Z=4.5-16\) m

GCALOR (M. Shupe)
Improvements of the ID shielding

The rate of charged particles in the inner detector will scale with the luminosity.

The neutron radiation is, however, affected by the TRT and the polyethylene shielding.

**FLUKA (I. Dawson)**

Annual 1MeV neutron equivalent fluences assuming $L = 10^{34}$ cm$^{-2}$s$^{-1}$ and 10$^7$ seconds running per year.
Improvements of the ID shielding

The removal of the TRT can be compensated for by a 5 cm thick polyethylene cylinder.

With additional moderators it is possible to decrease the neutron background somewhat but for sure not by a factor of 10. A detailed optimization study of moderators around the inner detector is needed.
Installing LHC magnets in ATLAS

Possible locations of new magnets:

- Hole in front of the FCAL
- Disk shielding plug
- Toroid shielding plug
- Forward Shielding

Diagram showing locations:
- Inner Detector
- LAr Endcap Calorimeter
- Small Wheel
- Endcap Toroid
- Big Wheel Muon Chambers
- EO Muon Chambers
Installing LHC magnets in ATLAS

Replacement of the JM shielding in the alcov in front of the FCAL by a low-mass magnet.

The neutron radiation in the inner detector will increase if the JM is removed.

Increase of neutrons > 100 keV if the JM plug is removed

However, the increase of background due to interactions in the new magnet is unknown.
Installing LHC magnets in ATLAS

Replacement of parts of the toroid shielding by a high mass magnet.

The toroid shielding now consist of 4 cast ductile iron pieces with polyethylene cladding (cost 300 kCHF).
Installing LHC magnets in ATLAS

The toroid shielding is the weakest part of the shielding in ATLAS and a relatively small decrease in thickness will give a significant increase in background.

Fluence of hadrons with E > 20 MeV

GCALOR (M. Shupe)
Installing LHC magnets in ATLAS

One question is if the deposited energy is so large that it will quench the magnets. The quadrupoles that are protected by the TAS collimator can remove 1.6 mW/g without reaching the quench limit.
Future work

A proposal defining a strategy for dealing with background issues at the SLHC has been submitted to the upgrade steering group: “Radiation background benchmarking at the LHC and simulations for an ATLAS upgrade at the SLHC” (edms no. 735306) by Ian Dawson et al.

**SIMULATIONS**
1) New JM design and revised inner tracker fluences.
2) Activation studies.
3) Machine interface studies.
4) GEANT4 predictions and comparisons.

**BENCHMARKING**
1) Radiation monitor installation and analysis of data.
2) Minimum-bias measurements for benchmarking of event generators.

Detectors have already been installed in some TGC sectors in the big wheel.
## Conclusions

<table>
<thead>
<tr>
<th>Category</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beampipe:</td>
<td>A change to a beryllium beampipe will give a significant decrease of the background.</td>
</tr>
<tr>
<td>Activation:</td>
<td>The beryllium beampipe will not be activated. Other parts of the experiment will also be less activated with a Be beampipe. Argon could, however, become a problem.</td>
</tr>
<tr>
<td>USA15:</td>
<td>Access to USA15 will have to be restricted at the SLHC.</td>
</tr>
<tr>
<td>Muon Shielding:</td>
<td>Even with drastic changes to the experiment there will be only a modest decrease of the background.</td>
</tr>
<tr>
<td>Inner Detector:</td>
<td>The loss of the moderator in the TRT can be compensated for by 5 cm of polyethylene. Detailed simulation are needed to determine what additional improvements are possible.</td>
</tr>
<tr>
<td>LHC magnets:</td>
<td>The impact of integrating LHC magnets into ATLAS are not known. A proposal for the magnets are needed in order to be able to start studying the consequences.</td>
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