

Acronyms

This is a list of alphabetically sorted acronyms used throughout this work.

CR	<i>Cosmic Ray</i>	11
DAQ	<i>Data Acquisition</i>	5
FD	<i>Fluorescence Detector</i>	5
SD	<i>Surface Detector</i>	13
PAO	<i>Pierre Auger Observatory</i>	5
UHECR	<i>Ultra High Energy Cosmic Ray</i>	5
WCD	<i>Water Cherenkov Detector</i>	5

Contents

Main Content

1	Introduction	3
2	The Pierre Auger Observatory	5
2.1	Science Goal and Open Questions	5
2.1.1	Mass Composition	6
2.1.2	Muon Deficit	6
2.1.3	AugerPrime	6
2.2	The Fluorescence Detector	6
2.3	The Surface Detector.	6
2.4	Central Data Acquisition System	7
2.5	<u>Offline</u> and Event Reconstruction	7
3	Example shit	9
3.1	Section.	10
3.1.1	Subsection	10
3.2	References and labels	10
3.2.1	Labels	10
3.2.2	Referencing labels.	10
3.2.3	Citations	11
3.3	Acronyms	11
3.4	Units	11
3.5	Figures.	12
3.6	Tables	15
3.7	Mathematical and decay equations	15
3.8	Reminders.	15
3.9	Miscellaneous	16
A	Hallo	17

Supplementary Information

Todo list

remove todos	1
add pdf hyperref keywords	1
more recent spectrum? proper citation to whom?	15

Figure: 16

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add pdf hyperref keywords



Chapter 1: Introduction

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.



Chapter 2: The Pierre Auger Observatory

2.1 Science Goal and Open Questions	5
2.1.1 Mass Composition	6
2.1.2 Muon Deficit	6
2.1.3 AugerPrime	6
2.2 The Fluorescence Detector	6
2.3 The Surface Detector	6
2.4 Central Data Acquisition System	7
2.5 <u>Offline</u> and Event Reconstruction	7

The *Pierre Auger Observatory* (PAO) is the (by area) largest scientific experiment in the world. It consists of an array of 1660 *Water Cherenkov Detectors* (WCDs), which form the *Surface Detector* (SD), and 27 fluorescence telescopes, that make up the *Fluorescence Detector* (FD).

With a region spanning roughly 3000 km² in the Argentinian pampa at a median elevation of 1400 m, it offers a unique possibility to observe *Ultra High Energy Cosmic Rays* (UHECRs) at the tail-end of the *Cosmic Ray* (CR) energy spectrum.

We begin this chapter in Section 2.1 by stating the design intentions and formulating open questions that the PAO aims to answer. Design details for FD and SD are given in Section 2.2 and Section 2.3 respectively. Following a discussion on the *Data Acquisition* (DAQ) process and event detection in Section 2.4, we finish by detailing the event reconstruction and higher level analysis in Section 2.5.

2.1 Science Goal and Open Questions

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2.1.1 Mass Composition

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2.1.2 Muon Deficit

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2.1.3 AugerPrime

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

2.2 The Fluorescence Detector

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2.3 The Surface Detector

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

2.4 Central Data Acquisition System

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

2.5 Offline and Event Reconstruction

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Chapter 3: Example shit

3.1 Section	10
3.1.1 Subsection	10
Subsubsection	10
3.2 References and labels	10
3.2.1 Labels	10
3.2.2 Referencing labels	10
3.2.3 Citations	11
3.3 Acronyms	11
3.4 Units	11
3.5 Figures	12
3.6 Tables	15
3.7 Mathematical and decay equations	15
3.8 Reminders	15
3.9 Miscellaneous	16

```
\chapter{Chapter: Types of section distinctions}
\blindtext
\section{Section}
\blindtext
\subsection{Subsection}
\blindtext
\subsubsection{Subsubsection}
\blindtext
```

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all

letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

3.1 Section

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

3.1.1 Subsection

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Subsubsection

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

3.2 References and labels

3.2.1 Labels

Make sure to label sections to refer back to throughout your work. Make it an intuitive name.

```
\label{sec:cosmicrays}
\label{subsec:crs_eas}
```

3.2.2 Referencing labels

Use `cref` instead of `ref`; it smartly labels if it’s a section, chapter, figure, table, etc. Fig. 3.1.

```
\cref{fig:crs_eas_heitler1}
\cref{subsec:fd}
```


- 10^{20} eV
- 12 km^2 for multiple units
- 90 % for precentages
- $\approx 5 \times 10^{19}$ eV
- 37 g cm^{-2} for grammage
- 30 GeV if GeV is not recognized, specify by metric prefix
- 3×10^{15} eV
- 30 % to 60 % a way to consistently format ranges
- $\text{km}^2 \text{ sr yr}$

```
\SI{e20}{\eV}
\SI{12}{\square\km}
\SI{90}{\percent}
$\approx \SI{5e19}{\eV}$
\SI{37}{\grammage}
\SI{30}{\giga\eV}
\SI{3e15}{\eV} 3{\times}10^{19}
\SIrange{30}{60}{\percent}
$\si{\square\km \steradian \year}$
```

3.5 Figures

In a PhD thesis you should always use only [t] (top) figure placement. Also note that due to the `\graphicspath{{figures/}}` command in the preamble, the file paths are relative to the `./figures` directory which can thus be dropped from the line. If you also omit the filename extension (e.g. `.pdf` or `.jpg`) your source file will be compilable with both, `latex` and `pdflatex`.

```
\begin{figure}[h]
  \centering
  \includegraphics[width=0.8\textwidth]{intro/heitler}
  \caption{Illustration of an \ac{EAS}' particle components.}
  \label{fig:crs_eas_heitler1}
\end{figure}
```

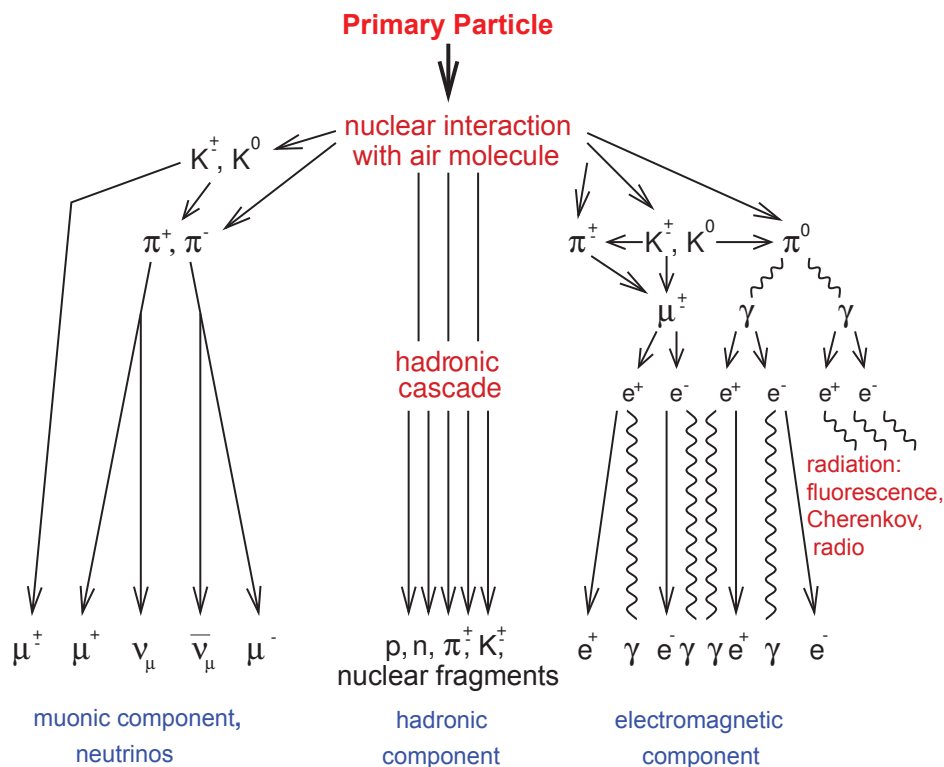


Figure 3.1: Illustration of an EAS! (EAS!)’ particle components.

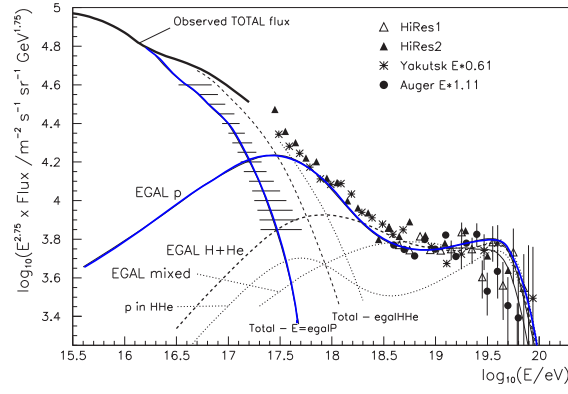
Use subref to reference elements within a figure for your text or captions.

```
\begin{figure}[t]
  \centering
  \subfloat[]{\includegraphics[width=0.48\textwidth]{intro/Berezinsky2}}
  \label{plot:crs_ankle_berezinsky}
  \hspace{0.2cm}
  \subfloat[]{\includegraphics[width=0.48\textwidth]{intro/Hillas2}}
  \label{plot:crs_ankle_hillas}
}
\caption[]{\Visualization of the \subref{plot:crs_ankle_berezinsky} pair
  ↪ production dip \cite{berezinskycr} and \subref{plot:
  ↪ crs_ankle_hillas} mixed composition \cite{hillascr} scenarios that
  ↪ describe the ankle feature.}
\label{fig:crs_ankle}
\end{figure}
```

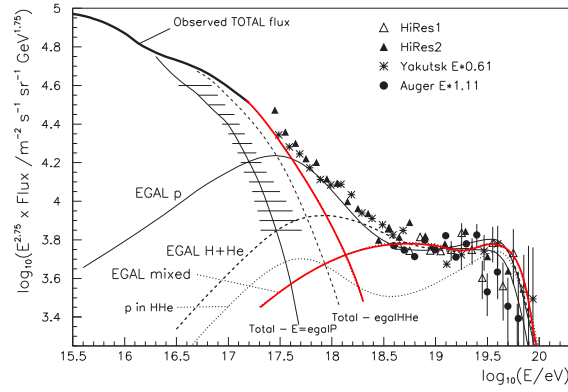
If you need a footnote in a figure, you have to use `footnotemark`

```
\begin{figure}[t]
\centering
\subfloat[]{\includegraphics[height=5cm]{intro/auger_dipole}}
\label{plot:pao_dipole}}
\end{figure}
```

¹As discussed further in the reconstruction Chapter, quality cuts are performed on reconstructed data from the *Surface Detector* (SD). One of these cuts is known as the 6T5-trigger; it requires that the detector with the highest signal has all of its 6 closest neighbors working at the time of the event. Similarly, a 5T5 only requires 5 of the closest neighbors to be working.



(a)



(b)

Figure 3.2: Visualization of the (a) pair production dip [?] and (b) mixed composition [?] scenarios that describe the ankle feature.

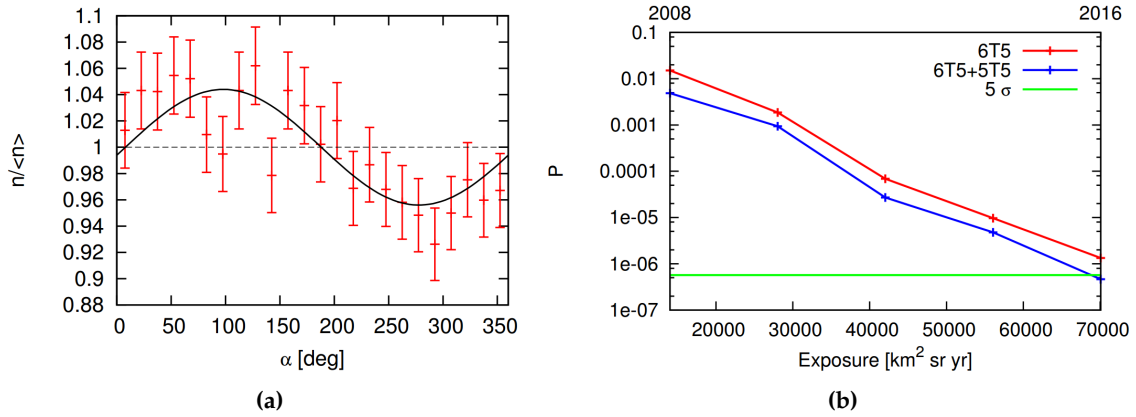


Figure 3.3: (a) (b) Probability for the amplitude of the dipole to arise from an isotropic distribution as a function of the integrated exposure of the Pierre Auger Observatory. Various data sets with different tank triggers are shown ¹[?].

```
\subfloat[]{\includegraphics[height=5cm]{intro/auger_dipole_sig}
\label{plot:pao_dipole_sig}}
\caption[]{\subref{plot:pao_dipole} \subref{plot:pao_dipole_sig}}
  ↳ Probability for the amplitude of the dipole to arise from an
  ↳ isotropic distribution as a function of the integrated exposure of
```



```

    ↪ the Pierre Auger Observatory. Various data sets with different tank
    ↪ triggers are shown \footnotemark \cite{Mollerach2016_1}.
}
\label{fig:pao_dipole}
\end{figure}
\footnotetext{As discussed further in the reconstruction Chapter, quality
    ↪ cuts are performed on reconstructed data from the \ac{SD}. One of
    ↪ these cuts is known as the 6T5-trigger; it requires that the detector
    ↪ with the highest signal has all of its 6 closest neighbors working
    ↪ at the time of the event. Similarly, a 5T5 only requires 5 of the
    ↪ closest neighbors to be working.}

```

3.6 Tables

Table 3.1: Dipole components and direction in equatorial components [?].

E/EeV	d_{\perp}	d_z	d	α	δ
4-8	-0.024 ± 0.010	0.006 ± 0.006	0.025 ± 0.009	$-75^{\circ} \pm 15^{\circ}$	$82^{\circ} \pm 57^{\circ}$
> 8	-0.026 ± 0.015	0.060 ± 0.010	0.065 ± 0.011	$-24^{\circ} \pm 12^{\circ}$	$100^{\circ} \pm 10^{\circ}$

3.7 Mathematical and decay equations

For decay equations, use align

$$\begin{aligned} \gamma_{\text{CMB}} + p &\rightarrow \Delta^+ \rightarrow p + \pi^0, \\ \gamma_{\text{CMB}} + p &\rightarrow \Delta^+ \rightarrow n + \pi^+. \end{aligned}$$

```

\begin{align*}
\gamma_{\mathrm{CMB}} + p &\rightarrow \Delta^+ \rightarrow p + \pi^0 \ , \\
    ↪ , \\
\gamma_{\mathrm{CMB}} + p &\rightarrow \Delta^+ \rightarrow n + \pi^+ \ , \ . \\
\end{align*}

```

For writing 5.5σ , use

```
\sig{5.5}
```

3.8 Reminders

Use to dos so that you don't have to dig through latex code. [inline] makes it so it takes up the line and isn't hanging off the page

- To add a todo inline like this

more recent spectrum? proper citation to whom?

```
\todo[inline]{more recent spectrum? proper citation to whom?}
```

- To generate this for missing figures:



```
\missingfigure{}
```

- To generate a list of all your todos and their page numbers, use

```
\listoftodos
```

3.9 Miscellaneous

- 4.6×10^{-7}

```
$4.6{\times}10^{-7}$
```

- For degrees 148.4°

```
\ang{148.4} or 148.4^\circ
```

- For formatting numbers otherwise in text, -2.0

```
\num{-2.0} or $-2.0$
```

- Superscripts for text like 20th

```
20\textsuperscript{th}
```

- For marking out text — ~~Due to the clean room environment~~, use:

```
\deleted{Due to the clean room environment}
```

This may be useful for editing your thesis later.



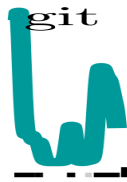
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Chapter A: Hallo

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