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## Progress Report

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## Project Aqueous

5

6

Number 6

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School of Physics and Astronomy

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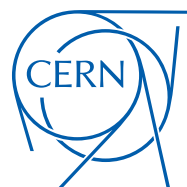
University of Glasgow

9

10

November 2025

11



## Abstract

13 A brief summary of the report.

## Acknowledgements

15 The contributions of Number 2 and Number 1 are acknowledged.

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# 52 Introduction

## 53 0.1 Higgs bosons

54 Higgs bosons are particles that arise through electroweak symmetry breaking. A principal  
55 motivation for the Large Hadron Collider physics programme was the testing of the theory  
56 of electroweak symmetry breaking, through the observation of Higgs bosons. In July of  
57 2012, the existence of the Higgs boson was confirmed by the ATLAS and CMS experiments.  
58 Following this discovery, further studies have been ongoing in order to examine the character  
59 of the particle.



# 60 Chapter 1

## 61 A title for chapter 1

### 62 1.1 Section 1

63 This is content.

#### 64 1.1.1 Time

65 A few time representations follow:

- 66     • 2025-11-26
- 67     • 26 November 2025
- 68     • November 2025
- 69     • 181942
- 70     • 1819
- 71     • 2025-11-26T181942
- 72     • 2025-11-26T1819

### 73 1.1.2 Units and units typesetting

- 74 •  $a^b \text{ m}^2$  – correct unit typesetting (manual siunitx function) (preferred for mathematics
- 75 mode, though note that the function for this is provided by aqueous [see below for
- 76 manual equivalent method not dependent on aqueous])
- 77 •  $10 \text{ kg}$  – correct unit typesetting (siunitx)
- 78 •  $10 \text{ kg}$  – incorrect unit typesetting (mathematics, textnormal)
- 79 •  $10 \text{ kg}$  – incorrect unit typesetting (literally)
- 80 •  $10 \text{ kgms}^{-2}$  – correct unit typesetting (siunitx)
- 81 •  $10^{-28} \text{ m}^2$  – correct unit typesetting, though very manual (siunitx)
- 82 •  $a^b \text{ m}^2$  – correct unit typesetting, though manual (siunitx) (preferred for mathematics
- 83 mode)
- 84 •  $a^b \text{ m}^2$  – dodgy, manual correct unit typesetting (siunitx)
- 85 •  $a^b \text{ m}^2$  (siunitx)
- 86 • The angle is  $14^\circ$ .
- 87 • The temperature is  $14^\circ\text{C}$ . – correct unit typesetting (siunitx)

88 Kerning is the aesthetic adjustment of the horizontal spacing of characters. The kerning of  
 89 the unit symbol for the electron-volt can be improved over the default L<sup>A</sup>T<sub>E</sub>X kerning with  
 90 commands like the following:

```
91 \newcommand{\eV}{\text{e\kern-0.15ex V}\xspace}
92 \newcommand{\MeV}{\text{M\kern-0.15ex eV}\xspace}
93 \newcommand{\GeV}{\text{G\kern-0.15ex eV}\xspace}
94 \newcommand{\TeV}{\text{T\kern-0.1ex eV}\xspace}
```

95 So, TeV becomes TeV.

### 96 1.1.3 Mathematics

97 The following is a referenced equation:

$$E = mc^2 \tag{1.1}$$

98 This is a reference to equation 1.1.

99 This is bold mathematics within non-bold mathematics:  $t\bar{t}\mathbf{H}(b\bar{b})$ .

100 This is bold mathematics:  $t\bar{t}\mathbf{H}(b\bar{b})$ .

#### 101 1.1.4 Lists

102 This is a list:

- 103     • function,
- 104     • Job,
- 105     • JobGroup,
- 106     • ParallelJobProcessor and
- 107     • pool.

108 This is a checklist:

109 ✓ item

110 ✓ item

111     ✓ subitem

112     ✓ subitem

113         ✓ subitem

114 ✓ item

115 ✗ item

### 116 1.1.5 Code

117 This is some code:

```
118           Reco_tf.py --inputBSFile data12.1234.RAW --outputESDFile data12.1234.ESD
```

119 Here is some more code. A single spin- $\frac{1}{2}$  particle is initially “up” along  $z$ , rotated around  
120 the  $x$ -axis by angle  $\theta$ , and we compute the probability that it is still “up” afterwards:

```
121   import numpy as np
122
123   sigma_x = np.array([[0, 1], [1, 0]], dtype=complex)
124   psi0 = np.array([1, 0], dtype=complex)                           # |^z>
125   theta = np.pi / 3                                                # rotation angle
126   U = np.cos(theta/2)*np.eye(2) - 1j*np.sin(theta/2)*sigma_x
127   psi = U @ psi0                                                    # evolved state
128   P_up = np.abs(psi[0])**2                                         # probability of |^z>
129   print(P_up)
```

130 This is a two-level quantum system, where  $U$  is the rotation operator  $e^{-\frac{i\theta\sigma_x}{2}}$ ,  $\psi$  is the  
131 new state after rotation, and  $P_{\text{up}}$  is the Born-rule probability of measuring spin up along  
132  $z$ .

133 **1.1.6 Images**

134 This is a figure set to a defined width:

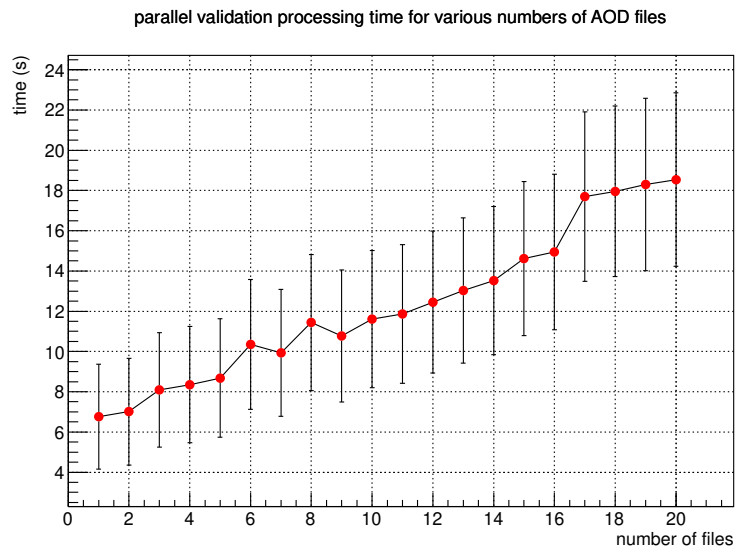


Figure 1.1: Parallel job processor: large efficiency improvement as a result of parallelisation

135 This is a figure set to the text width:

Figure 1.3: Feynman diagram

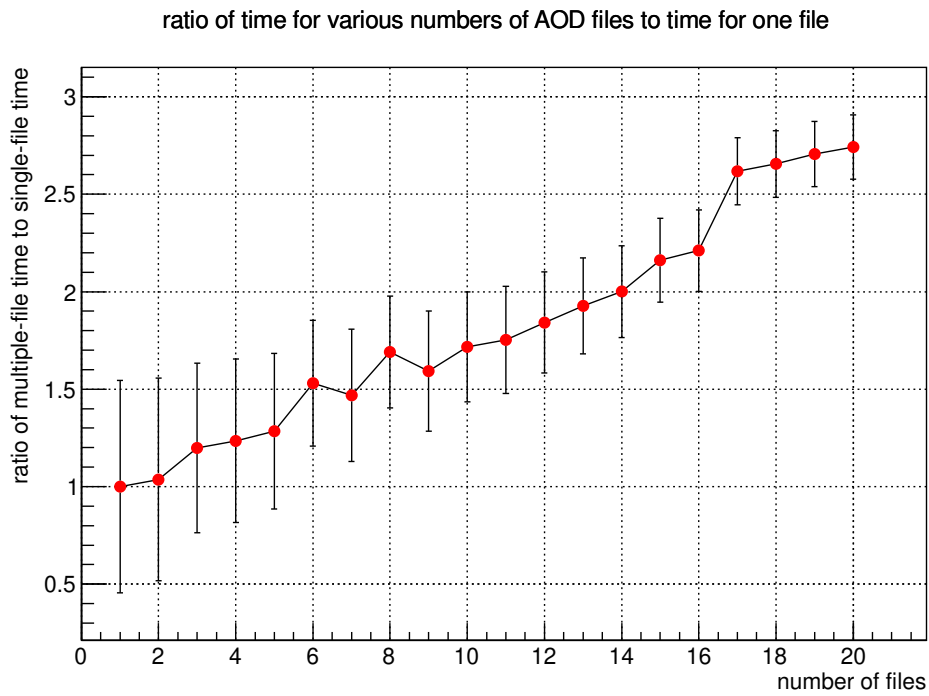


Figure 1.2: parallel job processor

136 Here is a Feynman diagram:

### 137 1.1.7 References

138 This is a reference to figure 1.2. This is a reference [1]. This is another reference [2]. This  
 139 is a URL: <https://github.com/wdbm/aqueous>

### 141 1.1.8 ROOT

142 ROOT [3] is an object oriented data analysis framework aimed at solving data analysis  
143 challenges in high energy physics. While *ROOT* is simply a name, a possible acronym for  
144 the system could be “*Rapid Object-Oriented Technology*” [4]. ROOT was developed in the  
145 context of the NA49 experiment at CERN. NA49 generated data of approximately 10 TB  
146 per run. This rate of data provided a test environment for the development of ROOT, as  
147 the next generation of data analysis. ROOT features *Cling*, a C++ interpreter.<sup>1</sup>

---

<sup>1</sup>This is a footnote.

### 1.1.9 Some paragraphs

149 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut,  
150 placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero,  
151 nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pel-  
152 lentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.  
153 Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla  
154 ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis  
155 in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean  
156 faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor  
157 semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend,  
158 sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

159 Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non  
160 justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor  
161 sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi  
162 ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla.  
163 Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus.  
164 Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus  
165 mauris.

166 Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristi-  
167 que, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus  
168 adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae,  
169 placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan  
170 nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem.  
171 Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim.  
172 Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar  
173 lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

174 Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt  
175 ultrices. Lorem ipsum dolor sit amet, consectetur adipiscing elit. In hac habitasse platea  
176 dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi.  
177 Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac



<sup>178</sup> pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus  
<sup>179</sup> quis tortor vitae risus porta vehicula.

## 1.1.10 tables

input file option	description
--inputHitsFile	input only
--inputBSFile	RAW data (BS = ByteStream), currently input only
--inputRDOFile	
--inputESDFile	
--inputAODFile	

output file option	description
--outputRDOFile valid	if starting from Hits
--outputESDFile valid	if starting from Hits, RDO or BS
--outputAODFile valid	if starting from ESD or anything else upstream
--outputNTUP_XXXFile	can be made from ESD or AOD, BS or RDO

Figure 1.4: Reco.tf.py usage

181 Chapter 2

182 Example of the use of bold  
183 mathematics in chapter titles  
184 while corresponding bold text is  
185 used in contents: the Standard  
186 Model Higgs boson in  $t\bar{t}H$  ( $b\bar{b}$ )

187 2.1 Further example of the use of bold mathematics  
188 in section titles while corresponding normal text is  
189 used in contents: the Standard Model Higgs boson  
190 in  $t\bar{t}H(H \rightarrow b\bar{b})$

## 191 Chapter 3

# 192 A title for future

If we can hit that bullseye, the rest of the dominos will fall like a house of cards. Checkmate!

---

Zapp Brannigan

You hear the bird's gurgling?

---

Pedro Carolino in *English As She is Spoke* (1883), a book which was intended as a Portuguese–English phrase book, but which was written by Carolino using dictionaries as opposed to a comprehension of the English language, hence it is a sort of 19<sup>th</sup> century machine translation.

### 193 3.1 future plans and considerations

194 These are suggestions and plans for the future.

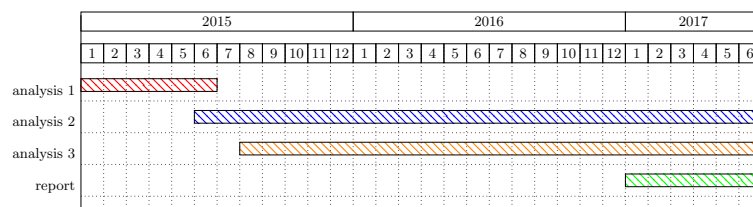


Figure 3.1: Gantt chart of work

# References

- [1] L. Li Tianjun, W. Xia, W. You-kai and Z. Shou-hua, *Distinguishing the Color Octet Axial-Vector-like Particle for Top Quark Asymmetry via Color Flow Method at the LHC* (June 2013), arXiv:1306.3586
- [2] W. S. McCulloch and W. Pitts, *A logical calculus of the ideas immanent in nervous activity*, The Bulletin of Mathematical Biophysics, 5 (4), 115–133 (1943)
- [3] *ROOT: A Data Analysis Framework* (November 2012), URL <http://root.cern.ch>
- [4] R. Brun, *Re: What does ROOT stand for?*, RootTalk (May 1998), URL <http://root.cern.ch/root/roottalk/roottalk98/0718.html>