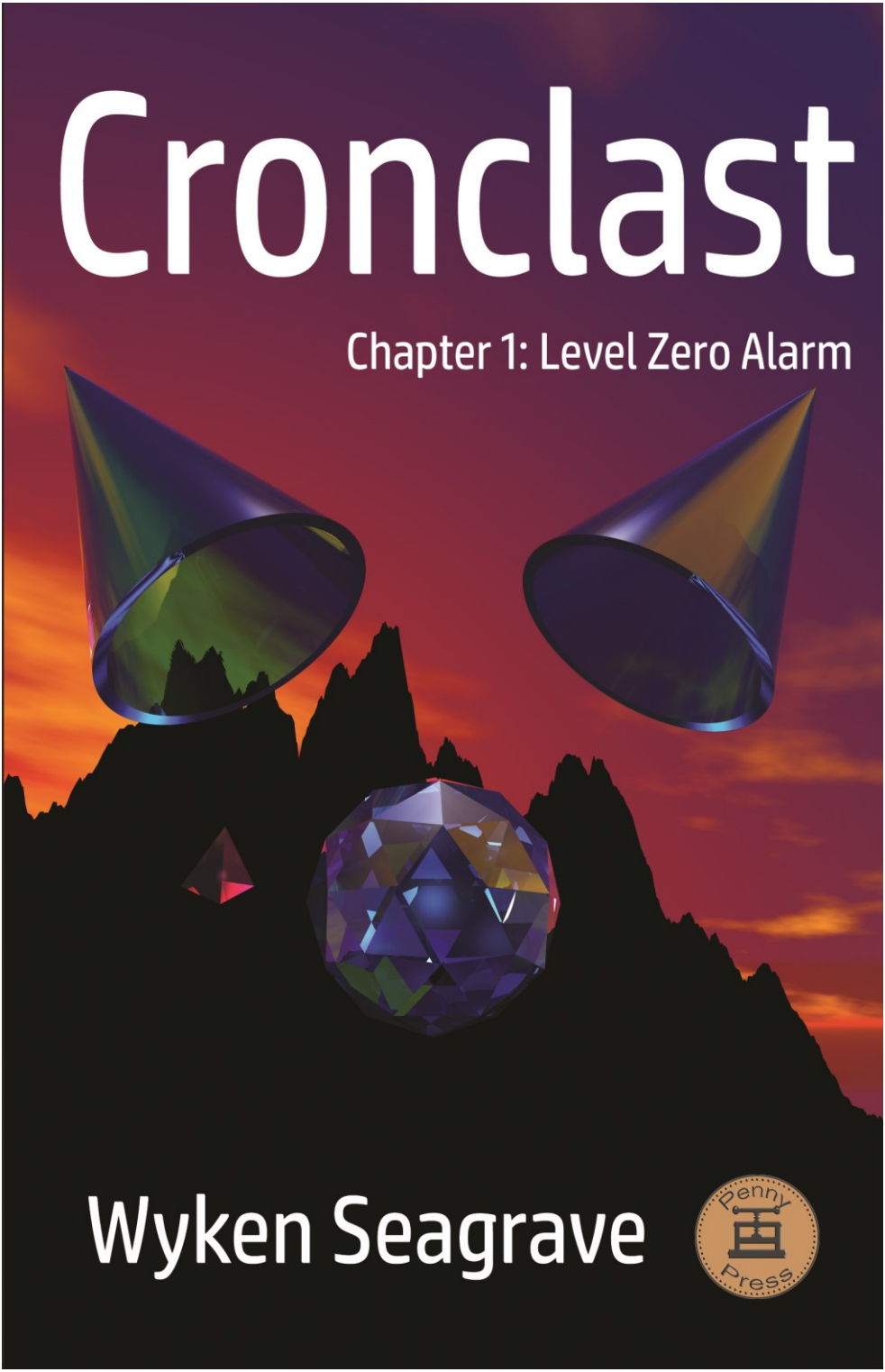
Cronclast

Chapter 1: Level Zero Alarm



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1 Level Zero Alarm

'Level Zero Alarm'

Looking back on it afterwards, Declan thought that was the moment when his life, and the lives of all the scientists here in CERN, and indeed the lives of everyone here on Earth had changed. But it took him a long time to realise that, in reality, it was the fate of the whole universe that had actually changed with those three words.

Declan O'Donoghue had been working here in the ATLAS Control Room all night, helping his team to restart the huge complex ATLAS detector after the long shutdown that had just ended.

During those long months, thousands of scientists and engineers had worked hard to upgrade the dozens of systems in this, the world's largest scientific experiment. The engineers of the Large Hadron Collider had done a huge amount of work to increase the energy of the two beams of protons spinning millions of times around the long circular LHC tunnel that stretched from here in Switzerland over to the distant Jura Mountains in France, getting faster and faster with each circuit until they reached almost the speed of light.

The protons in these two beams now had more energy than any particles ever created by man and were smashing into each other inside the complex ATLAS detector the size of a cathedral a hundred metres beneath his feet. As they collided their energy was converted into matter. New particles were being created, particles which had not existed since a tiny fraction of a second after the Big Bang, and they went

shooting out, decaying into other particles as they passed through the subsystems of ATLAS.

Almost all of these subsystems had also been upgraded. As each of them had been restarted during the night, many small but significant errors had arisen that he had been called upon to help solve. But finally he and the scientists had overcome them all and now they were observing collisions with more energy than men had ever before created. Everyone in the ATLAS team was hoping for new physics to emerge over the next few months and years. That was why this start-up had attracted so much attention, both from scientists and from the world's media.

Finally a few minutes ago ATLAS had successfully started collecting these data and it was time for him to go home and get some sleep. He had headed for the door. The dozens of visiting scientists crowded into the long, narrow room had congratulated him, even the two-times Nobel Prize winning Russian physicist Vladimir Shishkin who normally looked down on engineers like Declan with some disdain. A dozen television cameras followed him as he headed for the door.

It was just as he turned the door handle that the computer-generated voice had boomed down from the overhead speakers.

'Level Zero Alarm'

Declan paused, hand on door-handle, and waited for the second part of the message. All the scientists in the room stopped talking and looked at each other quizzically.

'What does that mean?' one of the journalists asked him.

'It's a fault, a minor fault. Wait.'

Level zero alarms indicated faults of the lowest priority, but he couldn't go home yet, not before he found out what sort of

error it was. In his fatigued state it felt as if fate were calling him, stopping him leaving. There was a moment of total silence in the room, then the computerized voice said

'Data Storage System Overflow'

A buzz of excitement flew around the room as some of the scientists realised the possible implications. Declan's heart too began to pound. The journalist began to ask him what it meant but Declan shook his head and told him to go and talk to Evangelos Theodorakis, his replacement as shift-leader. He was too tired to explain, and too preoccupied with what this might really mean.

He had met and resolved thousands of ATLAS's faults during the fifteen years he had worked here in CERN, but he had never heard of this one before. Data Storage System Overflow. It meant that the data storage sub-system was being swamped by too many data. And there was one very obvious and intensely exciting but ludicrously unlikely explanation for that and he dismissed it out of hand.

Although completely exhausted, his mind automatically clicked back into problem-solving mode and he tried to identify any other possible causes of the error. Clearly it was not a problem with the proton beams. If they had stopped, there would have been no data to collect, but this error indicated that there were too many data for the storage system to capture them all. No, the protons in the beams must still be smashing together inside ATLAS, a billion of them every second.

Could they have already found some new physics? Could ATLAS really be creating completely new and unknown particles so early in the run? They had only started taking data about an hour ago! No, the idea of making new particles

in such vast numbers that they swamped the data storage system was so preposterous that he dismissed it and began to search for other more plausible explanations.

The most obvious cause was a fault with one of the subsystems. During the night there had been a series of problems with the calorimeter, one of the three major data-gathering components of ATLAS, each with half a dozen complex sub-systems. He thought they had finally fixed them all, but maybe…

His weary eyes moved to Evan who was typing rapidly into one of the eight computer screens arranged in two tiers above his desk. Declan had no doubt that he had never met this error before either and was searching for the correct procedure in the DCS Operations Layer of the ATLAS TWiki.

Evan was almost as experienced as himself. He'd soon sort out this problem. But still Declan hesitated. He was intensely curious. Could this possibly be what he was afraid to even think about? And if it was, did he really want to go home and miss all the excitement if they really had created some new particle? Like a marathon runner getting his second wind, his mind began to clear.

Declan finally let go of the door-handle. I'll just go and check how Evan's coping, he told himself and walked back down the room, pushing his way through the anxious scientists, all of them as puzzled and excited as Declan.

'We're getting a lot of events,' Evan said. 'The Sub-Farm Output file servers are swamped.'

'How many events are we getting out of the TDAQ?'

It was the job of the elaborate system of hardware and software filters known as the Trigger and Data Acquisition System to filter out most of the data coming out of ATLAS,

keeping only those one in every million records that might be the result of some new physical interaction that deserved further study.

'We're getting over two thousand events per second.'

'Two thousand…' A sweat broke out on Declan's back. 'That's ten times more than the system was designed to handle!' Somewhere deep inside him a voice was screaming 'It's a new particle!' but once more he dismissed the idea. 'They can't be real events,' he said. 'This has to be a fault. What kind are they supposed to be?'

Evan clicked on a menu and a histogram on one of his screens changed into a single bar. 'They're all missing energy events!'

'I don't think so,' Declan said dismissively. Everyone knew that missing transverse energy provided a distinct and important signature for new physics at the LHC, but such events were few and far between. There was no way they could have found some new physics which could possibly create so many data so quickly. 'There's probably still something wrong with the calorimeter. Or maybe a hardware fault in the level 1 trigger system.'

A hardware fault with the front-end electronics buried in one of the ATLAS sub-systems was his worst nightmare. It would require another complete shutdown to allow them to dismantle the system and replace the faulty component. Desperate to find a less serious explanation, he began mentally tracing through the route the data took from the level 1 triggers out to the data storage system. The more he thought about it the more he found, including one that would be relatively easy to fix. 'It could even be a bug in the ROD crate processors software.'

Evan's eyebrows rose and he nodded as he considered the implications. 'That would be easy to fix!' The Read Out Drivers took the filtered data from the level 1 triggers and passed them on to the level 2 filters. 'Somebody will need to go down into USA15 and use the ROD crate workstation to check the functionality of the crate processors.' USA15 was one of the underground caverns one hundred meters below their feet. While the LHC beams were running, nobody was allowed to enter the main ATLAS cavern because of the high level of radiation emerging from the detector, but they could still visit the adjacent caverns without risk of exposure. 'It's a two-man job, Declan. Can you come and help or are you too tired?'

Declan wiped his sweating palms on his trouser legs. 'Yeah, I'd be glad to help. I'm not even tired any more.' This was a lie, but if the unthinkable had happened and these really were new particles then he would kill himself if he went home and slept through the discovery. Exhausted or not, he had no choice but to try to find out if this was a fault or real data. It shouldn't take too long and if necessary he could grab a nap on a floor somewhere. He'd done it before.

'I'll stop beam intersection,' Evan said. 'No point in collecting more spurious data.'

'No, just a minute! If it's a fault we'll need to follow the data through the TDAQ in order to trace the error. And we'll need to check whether it's a fault in the region of interest builders or perhaps in one of the readout subsystems. If we lose the signal we won't be able to monitor their activity. And if…' The little silent scream in his head finally found its voice. 'Just suppose these events were real. That would mean ATLAS has found a new type of particle. So if we turned it off…'

‘Then we’d miss collecting any of these incredible new data. Okay, Declan, I’ll leave her running.’