Expressive Experiments : Art and Particle Physics

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Abstract

In this paper I present recent examples of my art practice which transverses the disciplines of media art and particle physics. As I will discuss, my work engages with both conceptual and material aspects of experimental particle physics, and is in itself an experimental practice. Through the analysis of the works and processes involved in the development of artworks produced at CERN, I will discuss aspects of art / science collaboration.

Epistemic things

The experimental scientist Ian Hacking states that 'Quantum observation necessitates affecting the object [of investigation, and that] we gain an understanding not by looking but by manipulating'. [1] On the subatomic scale, as photons of light have momentum and energy comparable to that of the particles they are being used to study, 'the measurement *necessarily* disturbs the object', [2] and, under certain conditions, actually creates them. I have been peripherally involved with such quantum physics experiments, where the interrelations between the quantum and the macroscopic worlds are quite dynamic, namely through at the CERN Large Hadron Collider (See fig 1.), through the 'art@CMS' collaboration.

The Large Hadron Collider or LHC probes the fundamental nature of the material universe, through the focusing of trillions of electron volts of energy on unimaginably small subatomic particles that are accelerated to almost the speed of light around the twenty seven kilometre accelerator ring. When the particles collide with each other, immense energies are released for an instant of time, which are captured by gargantuan instruments such as the Compact Muon Solenoid detector, or CMS, the most complex detector ever built. This was one of the devices that proved the existence of the Higgs Boson, also known as the "God Particle". This apparatus, weighs in at weighing in at 15,000 tonnes and detecting up to 10 million 'frames' of collision data per second in 3D. This device which took over 10,000 people to design and build, is the most complex scientific detector in the world, and is beyond any single person's knowledge capability. It can be described as an "epistemic object" or "epistemic thing".

Fig 1. *LHC accelerator tunnel*, 2014, Chris Henschke, photograph. Image courtesy of the author.

Unlike objects that have definite forms and uses, epistemic things are, according to a term coined by scientist Hans Rheinberger, 'objects of knowledge [which] appear to have the capacity to unfold indefinitely. [As they] are always in the process of being materially defined, they continually acquire new properties and change the ones they have… [and] can never be fully attained.' [3]

The sociologist Karin Knorr Cetina describes epistemic things, or objects of knowledge, as having a crucial aspect of a 'lack in completeness of being'; although they have material manifestations, they must also be conceived of as 'unfolding structures of absences: as things that continually "explode" and "mutate" into something else.' [4] Such expressive terms indeed describe the high energy collisions occurring in the LHC, where subatomic matter literally explodes into energy, which creates other forms of matter. In a subtle yet direct reference to the LHC, using the appropriate yet obscure technical term 'liquid argon calorimeter' to describe the gigantic detectors at CERN, she states:

> Epistemic objects frequently exist simultaneously in a variety of forms. They have multiple instantiations, which range from figurative, mathematical, and other representations to material realizations. Take the case of a detector in a high-energy physics

> experiment. ‘It’ continually circulates through a collaborating community of physicists in the form of partial simulations and calculations, technical design drawings, artistic renderings, photographs, test materials, prototypes, transparencies, written and verbal reports, and more. These instantiations are always partial in the sense of not fully comprising ‘the detector’. [5]

Expanding on the nature of such epistemic things and their relations to the researchers that develop them, Rheinberger states the following:

> Epistemic things are … things that let something be desired. They stand for a particular relation to the world: a relation of epistemicity. This relation is exploratory, driven by the desire of finding, not of knowing. Experimenters are specialists in arranging situations in which finding becomes possible. Scientific finding neither obeys the logic of chance nor that of necessity. It obeys a logic of its own, composed of elements of both, and in so doing, undoes the stochastic rigor of the one and the deterministic rigor of the other. It is a game of eventuation, an engagement with the material world that, on the one hand, requires intimacy with the matter at hand, and, on the other, disentanglement, the capacity of rendering strange—of estrangement. I am convinced that the poet’s and the artist’s activities share the basic feature of this epistemic condition. [6]

The Apparatus

Nature of the Apparatus is an audio-visual artwork, five minutes in duration, I produced during my “art@CMS” collaboration at CERN in 2015. As Rheinberger states, the work seeks to convey experiential, epistemic aspects of the LHC in a way that is both entangled and yet estranged. It is derived from ultra-high definition video I shot with collaborating CMS physicist Dr. Michael Hoch at various locations across CERN, including areas that are usually inaccessible. The locations ranged from old near-abandoned experimental zones, such as a hundred deep metre UA1 shaft, which the CERN scientists refer to as “The Black Hole”, to contemporary experiments, such as CMS, also situated 100 metres underground. However, the material that was captured on my video is largely of inert devices - it is not possible for anyone to be on location when the LHC is active, as the radiation levels emanating from the particle collisions would be fatal (although it is not just buried under the ground for this reason, hairdryers and passing trains affect the detector’s sensitivities). Thus I experimented with the footage in order to express the implicit energetic aspects of the devices in the footage, in a way that creatively manifested the nature of such experiments.

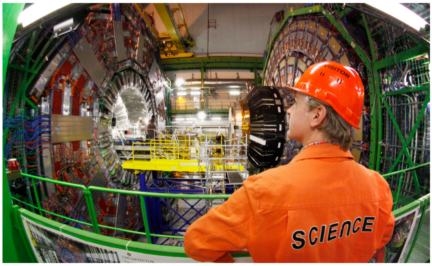

Fig 2. *Observing the CMS detector*, 2015, Chris Henschke, photograph. Image courtesy of the author.

I manipulated the video footage in a way that uses the “sound” of the accelerator beam energy to affect the spatiotemporal flow of the video. This sound is a transverse electromagnetic vibration of the energy beam in the SPS accelerator, analogous to the way a violin string vibrates. In a unique experiment, collaborating accelerator physicist Ralph Steinhagen energetically ‘plucked’ the beam, by adding pulses of radio-frequency energy into the accelerator, and recorded the electromagnetic vibrations it made. The fundamental frequency of this transverse wave is about 4000 Hz, within the audible range of human perception, so, with a simple translation of data, the sound of the LHC can be heard, in the same way that an audio signal can be heard when it is attached to a speaker. This energy vibration is used to affect the video by algorithmically mapping (video) time into (screen) space. The source video footage is experimentally manipulated by a custom algorithm in a way that, like streak cameras used in physics experiments, maps slices of the footage across the space of the screen, with the resultant effect that the greater the energy intensity is, the larger the temporal splicing (see Fig. 3). The work is an experiment, as it had to be rendered our outputted to see how the algorithm used the sound to affect the images. The result spatiotemporally compressed and extended the source footage within the space of the output screen. The modulated output audio-visually folds the machine and attendant scientists into a dynamic topology of matter and energy, in a way that could be described as “phenomena”, a term used in particle physics experiments.

Fig 3. *Nature of the Apparatus*, 2015, Chris Henschke, still from digital video, 6 mins. Image courtesy of the author.

Founding quantum physicist Niels Bohr developed the term “phenomena” to explain the relationship between apparatuses and objects of investigation in particle physics. For Bohr, the interaction between object and apparatus ‘forms an inseparable part of the phenomenon’. [7] As Bohr stated, ‘whatever the “true” nature of the electron, the behaviour it exhibits is conditioned by the kinds of experiments we choose to perform’. For example, an experiment designed to look for particles will produce particulate phenomena, whereas a wave experiment will produce wavelike effects. The issue with trying to observe subatomic phenomena that are utterly invisible on the human or macroscopic scale is that such experiments have to produce ‘effects substantial enough to be observed and recorded in the laboratory, perhaps in the form of an exposed photographic plate, or in the deflection of a pointer in a voltmeter, or the observation of a track in a cloud chamber’. [8] Bohr states that we are ‘constrained by our inability to construct experimental apparatus in anything other than classical dimensions, [thus] we are denied an insight into the ‘true’ quantum world. What we get instead is the quantum world as reflected in the mirrors of our classical apparatus’. [9] Unlike the classical or macroscopic world, where we can ask definite questions about what things *are*, in the quantum realm, one should ask:

> Does the electron (or any other object) *behave* like a particle or like a wave? That question is answerable, but only if one specifies the experimental arrangement by means of which ‘one looks’ at the electron. That is what Bohr meant when he said; ‘An independent reality in the ordinary [that is, classical] physical sense can … neither be ascribed to the phenomena nor to the agencies of observation’. [10]

As philosopher physicist Karen Barad states, ‘apparatuses are not passive observing instruments, on the contrary, they are productive (and part of) phenomena.’ [11] Barad points out that Bohr never defined ‘what precisely constitutes the limits of the apparatus’. [12] Is it the detector, the computer terminal, the display screen (see Fig. 4), the scientist viewing it, or even the organizations responsible for funding the project?

Fig 4. *Niels Bohr Commemorative Screen, CERN*, 2016, Chris Henschke, photograph. Image courtesy of the author.

Barad argues that when we deal with the boundary between the quantum and classical or macroscopic worlds, the nature of the apparatus becomes an entanglement of matter and meaning. ‘it is not merely the case that human concepts are embedded in apparatuses, but rather that apparatuses *are* material / discursive practices… *Hence, apparatuses are boundary making practices*.’ [13] But also, as Barad states ‘boundaries do not sit still’. The universe and us are not separate, we are in a continual dance of inter-definition. As scientist philosopher Michael Polanyi puts it, ‘The knower does not stand apart from the universe, but participates personally within it’. [14]

The media assemblage of the various materials in *The Nature of the Apparatus* can be seen as a manifestation of ‘phenomena’, or a kind of epistemic object, or even as a ‘readymade’, in the sense of the term coined by the French mathematician Poincare, the ‘grandfather of relativity’. [15] Poincare used the term ‘tout fait objects [readymades] to describe ‘the epiphanies resulting from a barrage of pre-established ideas’. [16] According to Poincaré’s formulation of the nature of human creativity, following an intensive but more or less random input of study, ideas appear to sort themselves out in what he calls the unconscious mind. There follows "tout fait," the illuminating flash of insight.

Expressive Events

According to the new materialist perspective of philosopher Manuel DeLanda, light and sound are forms of illumination and expression applicable not only to us. DeLanda states:

> ‘The characteristics [of wavelength components and vibration frequency] allow both light and sound to produce distinctive effects on animal and human brains, effects that may be used for expressive purposes… by human artists. But possession of a nervous system is not necessary to make expressive use of colour or sound. Even humble atoms can interact with light… in a way that literally expresses their identity’. [17]

From a flash of inspiration brought on by the expressive forms created in the CMS detector, I developed *Edge of the Observable* a 12 minute audio-visual artwork (see Fig. 5). The artwork uses visual data from CMS collision events, in a way that amplifies the dynamic and expressive qualities produced, specifically using one of the billions of collisions that occur daily in the CMS detector: event 416497095 of event run 46944. This event in itself has no particular scientific value, but I found it to have unique and compelling formal qualities. The data taken from the collision event is the source material for the artwork; however it is manifested through an experimental installation I developed. Taking the basic setup of a physics experiment, the event is emitted as light from an energy source; it is then modulated through an optical device; and is then captured and recorded by a detection device. Against the popular (mis)conception of experiments being precisely repeatable, I could only get this unique combination to manifest once, suddenly appearing as as in my detector (also known as a camera viewfinder!). And such uniqueness also occurs in every collision in the LHC – every event is different, each collision producing, in frozen picosecond instants, delicate unique forms, through the particle jets and magnetically guided curve trajectories captured by the detector.

The artwork plays with the concept of the "Golden Event", a term used in particle physics to describe a perfectly captured image of an expression of a rare or important collision event. However, such visual knowledge, manifested through the bubble chamber experiments of the early and mid 20th Century, was largely superseded by the types of numeric and statistical analysis used in modern physics. Physicist Peter Galison describes the tension between these "image and logic traditions":

> Images [captured in bubble chambers] are presented, and defended, as mimetic – they purport to preserve the forms of things as they occur in the world. … Against this mimetic tradition…[is].. the "logic tradition" which has used electronic counters coupled in electronic logic circuits… to make statistical arguments for the existence of a particle or effect. The clash of image and logic traditions [is the clash of the] golden event versus statistical demonstration, the objectivity of passive registration versus the persuasiveness of experimental control, vision versus numbers, and photography versus electronics. [18]

Heralding a kind of renaissance in scientific imaging, experiments such as CMS combine image and logic based analysis, in a 'shift from the pure to the hybrid' experiment and from 'the modern to the postmodern laboratory', where such devices are 'high-tech bricolages' of both bubble chamber and electronic logic devices. [19] These these hybrid detectors contain the 'historical epistemology' of experimental particle physics, where golden events are 'produced by electronics, fished by a computational net out of the ocean of microphysical debris'. [20] But this technologically hybridized gaze can still only penetrate so far – in the heart of each particle collision event recorded at CMS and other contemporary detectors is a small spherical void, known as the vertex of kinetic undetectability, a threshold somewhat like the event horizon of a black hole, which even the most advanced detectors still cannot reach past. This is literally the edge of the observable, and what occurs within this region has to be inferred from the secondary particles produced.

Edge of the Observable incorporates such concepts, and plays with the methods, and results of experimental physics, but is in itself neither science or scientific illustration, rather it critiques the role and nature of images produced in such experiments. The work is a kind of concrete abstraction, existing somewhere between the mimetic (representing an actual specific event) and abstract (expressing formal qualities manifested overall),

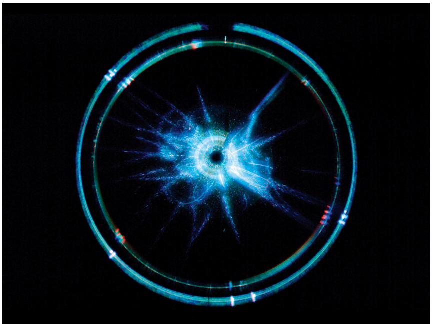

Fig 5. *Edge of the Observable*, 2014, Chris Henschke, still from digital video, 12 mins. Image courtesy of the artist.

akin to the aforementioned struggles which occurred during the development of such detectors. Through my experimental amplification of the visual qualities manifested in the original collision events, the output challenges the physicists' ownership of the forms created in the detectors, seeking to express the dynamics in a way that transcends the realm of the specialist.

During the development of the artwork, I developed a philosophical understanding of the nature of the Higgs Boson, based on my readings of the philosophies of Niels Bohr and Karen Barad, and discussions with the physicists I was collaborating with. When I presented the work at a science talk at the Karlsruhe Institute of Technology, I told the attending physicists (to the bemusement of some) that 'the Higgs Boson does not exist… in this room, cup, and other such normal objects – it only exists in the apparatus that manifests it, i.e. the LHC.' Through my discussion of Bohr's theories of complementarity and phenomena, most of the scientists (some begrudgingly) agreed with me. I have also presented it at other physics events, including the International Conference on High Energy Physics, in Valencia, Spain, (July 1–7, 2014). At the conference, the work was presented in the style of a science information stand, with faux-scientific posters and brochures, under a banner emblazoned with the phrase "Colliding Events: Turn Every Phenomenon into a Golden Event". Displaying the work as a mock science installation opened the way to discussions with scientists attending the conference. Some thought it was some kind of scientific display, and probably would not have been interested had it been explicitly presented as an artwork. I also showed the work at the University of Southampton John Hansard Gallery, as part of the 'Small Infinite' exhibition (August 5–October 20, 2014), which featured cosmology-inspired artworks by late British artist John Latham. Exhibiting the work in such a context provided a resonance between my piece and the other artworks, and yet the relief and familiarity of being in an artspace was offset by the lack of the challenging environment.

Conclusion

Undertaking such an inter-disciplinary practice has its difficulties, none the least being an artist in a realm full of physicists. In such a domain one must resist becoming the awe-struck handmaiden of science, especially when gazing up at the behemoth detectors of CERN, and falling into the trap of artist as scientific 'dabbler or dilettante.' [22] However, artists that work in-situ at such scientific facilities need to know and understand the science involved in order to meaningfully engage with it. Didacticism is sometimes a necessary gateway one must get through, in order to gain a deeper level of connection, which allows critically meaningful dialogue with the collaborating scientists. The fact that it is impossible to understand it all, doesn't imply that you have to be a dilettante or merely engage superficially, that is where collaboration comes in.

Such collaboration is itself a unique and experimental process. This can only develop through actual practical engagement and interaction, which must be nurtured by both parties. Through shared experiences, idiosyncratic heuristics evolve, and a kind of creole or lingo is established. It is through these personal participatory experiences and communications that a form of mutual understanding forms, which, although limited, gets both parties to think about their disciplines in different ways to the everyday. I am dubious about the likelihood that somehow such collaboration will lead to new scientific discoveries, nor should it aim to.

To paraphrase Bohr, from such collaborations, what we get … is the *scientific* world as reflected in the mirrors of our *artistic* apparatus, in a way that turns the scientific apparatus into a tool for art. However, the art is about the apparatus itself, which creates a deeper level of engagement. Through such engagement with scientific concepts and materials, the artist also informs the scientists about contemporary art. In a sense this does lead to new discoveries, in the way scientific concepts, processes and technologies can be used by artists. Developing such applications as a way to engage with the science itself can lead to a more critical relationship. In such collaborations, we can, indeed we must, critically engage with science in its own territory. The physicists I work with agree with this method of critiquing science through creative engagement and exploration (and of course they would, otherwise they wouldn't be working with me).

In conclusion, such collaborative projects have the potential to set the 'pre-conditions for the creation of new intellectual possibilities [which do] more than replicate an image of the knowledge reproduced onto a new subject', [23] akin to setting up an experiment, where the inputs are known but the outcomes are unknown. In the words of the biologist and philosopher Francisco Varela, these collaborations are 'interdisciplinary adventure[s]' where 'the practitioner is taking on a new vocabulary and lingo, other modes of thinking, other sets of procedure...to take bits and pieces from here and there to construct a new assemblage, another kind of aggregation - a collaging from which different, unscripted knowledge effects are squeezed out.' [24]

In my collaboration with CMS physicists Wolfgang Adam and Michael Hoch, the processes described above are fundamental to the construction of a kind of assemblage of science and art, in terms of methods and outcomes. The artworks I have described above form part of such an assemblage, which is still being developed in an exploratory and open-ended manner. To paraphrase Varela and Hacking, through my interdisciplinary adventures at CERN, I collaged together conceptual and experimental bits and pieces, 'not [just] by looking, but by manipulating', manifested in the processes developed and artworks produced. Linking the idea of art as knowledge effect with my collaboration as an experiment that expressively manifests conceptual and material aspects of high energy physics, the body of work produced can itself be seen as an interdisciplinary epistemic thing.

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