Paper No:1 *CLOUD CHAMBER: A PERFORMANCE INVOLVING REAL TIME TWO-WAY INTERACTION BETWEEN SUBATOMIC RADIOACTIVE PARTICLES AND VIOLINIST*

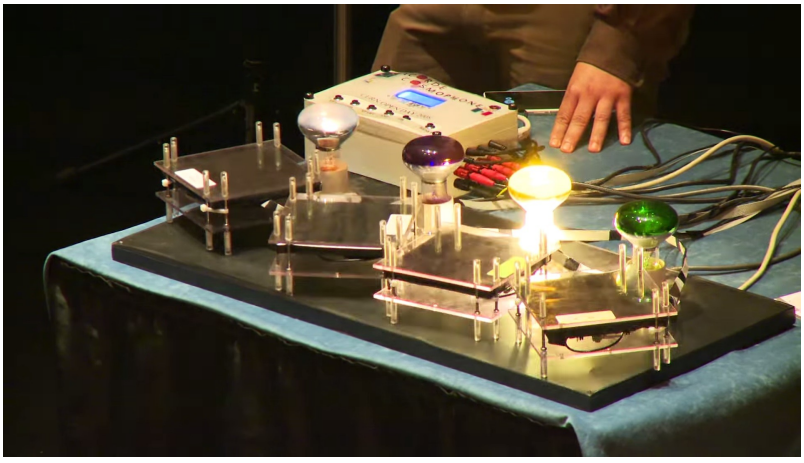
Points:

1) the invisible quantum world becomes visible as a violinist and subatomic particle tracks duet together for an audience. An instrument has been developed which can be "played" live by radioactive atomic particle

Article No:1 *CERN Scientists Make Music Using Particle Physics And 'Cosmic Piano'*

Points:

1) Cosmic Piano uses particle data to produce live music.
2) part of A Large Ion Collider Experiment (ALICE) project, transforms **particles into musical notes.**
3) The instrument has a detector pad that transforms passing particles into musical notes. The charged particles are produced with the interaction of cosmic rays and molecules in the Earth's atmosphere. The piano also has a plastic scintillator that transforms particles into optical signals that are converted into bleeping notes and synchronized flashes of light.
4) The Cosmic Piano has some features like producing light and sound only when n (n= 2, 3,...8) modules are hit at the same time (coincidence events, technically named "cosmic showers") or generate a "random musical noise" when any of the eight detectors is impacted by a charged particle
5) Resources: http://alicematters.web.cern.ch/?q=ALICEcosmicpiano , I'm not able to access this, if someone can, pls share with me the article.



6) **About The Structure**: *The instrument has been described as something that looks a bit like a fancy staircase. It also sounded like the robot R2-D2 from Star Wars. On its own, the piano may produce an odd sound but when it is played*

along with a pro jazz musician, the sound it produced was described as something more avant garde.

7) **About the Functioning/ Mechanism behind it:** *"sonification": the process by which raw data is transmuted into sound*
As reported by Gizmodo, the piano makes use of charged particles, created when cosmic rays interact with molecules in the Earth's atmosphere. A plastic scintillator within the piano then turns the particles into optical signals, which are then converted into "R2 D2"-like bleeping notes and synchronized (and jazzy) flashes of light

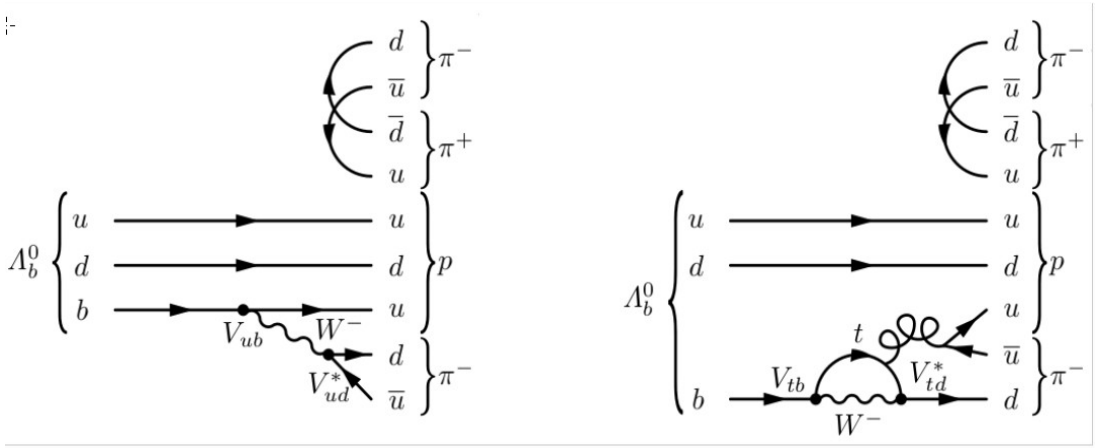
8) Scientists at CERN performed a composition that was written based on data from major experiments conducted with the Large Hadron Collider. It is known as the **LHC Chamber Music Project.**
Scientists performed a piece for strings, keys and woodwind, based on data collected by the Large Hadron Collider.
Pls anyone watch this and take notes, Request to Chinmay.
https://www.youtube.com/watch?v=gPmQcviT-R4

9) **SIMILAR PROJECTS** : Nasa launched an online streaming broadcast called CRaTER, which stands for Cosmic Ray Telescope for the Effects of Radiation. It allows people to listen to data from the Lunar Reconnaissance Orbiter that are constantly transformed into audio soundscapes. Also, an interesting resource is here https://prediccs.sr.unh.edu//craterweb/craterliveradio.html which can help us to combine Sanvi's idea in our project.

10) Some More studies-
- ~~A study of R2-D2 robot structure, mechanism of functioning~~
- Gizimodo's Article https://gizmodo.com/cerns-cosmic-piano-makes-music-out-of-raw-particle-da-1729203007
- Add the points of Y-Tube Video and other linked under this Article no-1, here in this section only

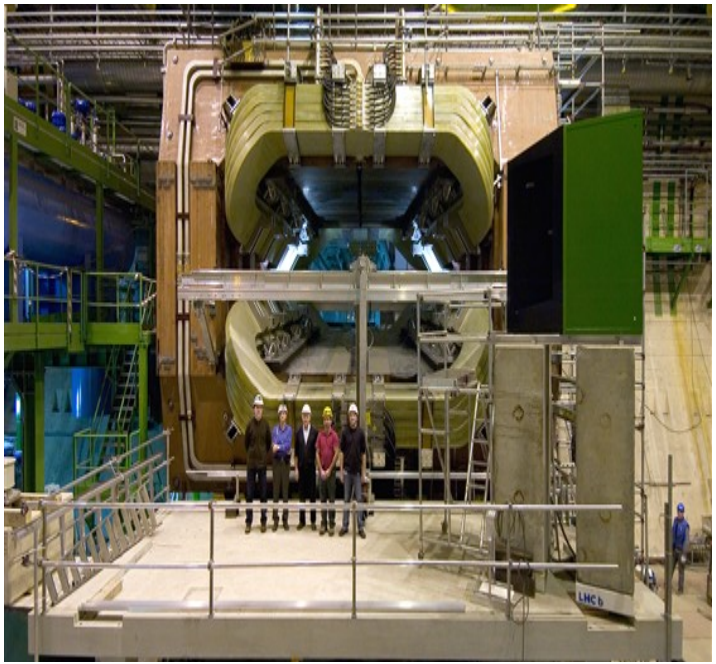
Article No:2 *Sound of the Underground: making music from particle physics*

The answer lies in an asymmetry between matter and its counterpart – antimatter. If the universe was perfectly symmetric, both kinds of matter would cancel out. However, we are here, hence there must be a difference. This difference is called as CP violation-a mismatch between how particles and antiparticles behave



Feynman diagrams describing what happens when particles collide. We'll interpret these results as music.

- This asymmetry in a very specific set of particle decays, where a heavier $Lambda\ b\ baryon$– decays into 4 other particles. The particle decays are produced by accelerating protons to almost the speed of light in the LHC and are detected by the LHCb detector, which is designed with the CP violation analyses as one of its main purposes.



Some points(approaches) to keep in mind-

- The sequence of all pitches is pre-decided and strictly

followed throughout the piece.

- The type of material: in the free section the music is written in a way **where synchronous actions can be performed by ensuring eye contact between player pairs** (an interpretation of interaction).
- The role of the scientist as both an observer and interferer: the piece begins unconducted, with the conductor only indicating the start of bars. It then moves on to strict, timed and conducted material – there is both *a visual (conducting begins) and audio change (different kind of music, more movement)*.
- Two asymmetrical movements: long and short, signifying the miniscule process itself and its implications (the titles of the movements are Zoom In and Zoom out) in reverse (small size – large movement and vice versa)

YOUTUBE LINK: https://youtu.be/l0L2yhnGBbg

https://www.mub.eps.manchester.ac.uk/physics/2020/12/18/physics-music/