

# The Shape of ' $\mu$ '

## The Magneto-Muon Dependance

presented by Team '*Cryptic Ontics*'





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Cover Picture: Artistic view of a cosmic rays shower. *Credit: ASPERA/  
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# The "Who"

Although part of our team name happens to describe itself, we, the *Cryptic Ontics*, wish to do the opposite of what it suggests: We wish to uncover the beautiful conundrums that the cosmos presents towards us. We are a group of endlessly curious 11th and 12th graders from R. N. Podar School, Mumbai, and we are very proud of this trait-we consider it to be a defining aspect of our persona. It is an excess of this, along with our shared interest for physics, that brought us together and drove us all to apply for the BL4S competition.

All the natural sciences stand on two legs: Empiricism and introspection; theory and experiment. We began our journey with the former three years back with CERN itself: We were part of a video tour regarding the LHC presented by CERN (with Mr. Markus Joos). We believe the time has come for us to now have a go with the latter. The BL4S is in every way the ideal way for us to take the first step towards the experimental sciences. It provides the ideal platform for us to step onto and peep over to see what wonders the world of particle physics holds.

# The "What"

Our idea is inspired from a flavor of Gauge system's theory first formulated by Hermann Weyl. The idea of Weyl concerns with the very aspect of measurement which is quite central to physics. Measurement is the comparison of two different attributes, say two different lengths and Weyl suggests that when two such lengths have to be compared, the result may depend on the route pursued in passing from one place to the other. This may perhaps be due to the effect of gravitational and various other fields that are present along.

The general features of these field theories is that though these fundamental fields themselves can't be measured, we can measure the associated attributes and infer something about the fields in general. Since we can't directly work with gravity at CERN, we try to study an alternative scenario to study the interaction of muons with the magnetic field and thereby draw various conclusions. Muons race onto the Earth's surface every second and do interact with earth's magnetic field. Unlike gravitational field, we can re-create the magnetic field (of course, many scales less) within the CERN Experimental area. Thereby and study the following:

**Statement: Can we create a Muon barricade using Magnetic field?**

By studying the interaction between Muons and Magnetic field we can reverse-engineer and learn about the anomalies in Earth's Magnetic field as a function of variance of muon detection rate.

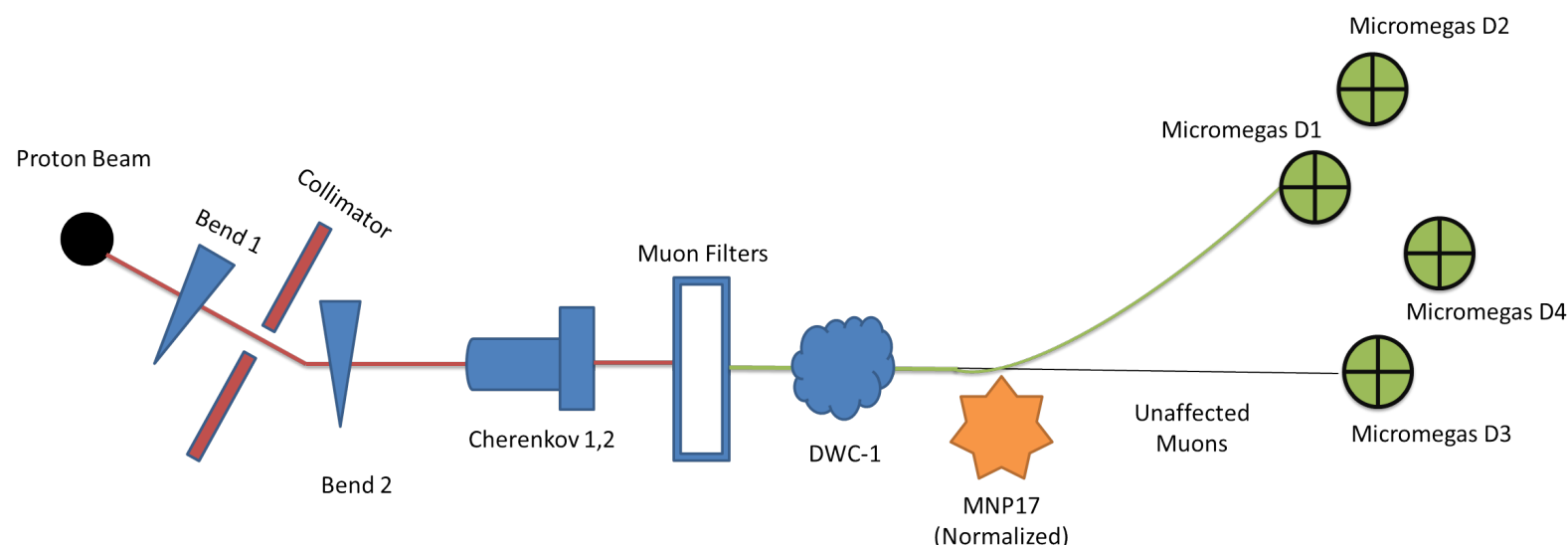
# The "How"

- Muons obtained from the decay of Pions (and Kaons) from PS (T9 Beamline) are sent thereby through Muon filters to obtain a selected-beam of Muons and thereafter passed through a Delay Wire Chamber DWC (10x10 cms) – in the experimental area – to further nail down the momentum and the angular distribution.
- Muons then pass through a magnetic field of the order  $\approx 0.96$  T.
- A set of 1-D Micromegas (or D(X/Y) – 40x40cms) are arranged (as showed in the figure below) at varied angles ' $\theta$ ' to detect the deflection of muons.

For a basic unit of electric charge ' $e$ ', the Lorentz Force is expressed by  $F = eE + e[v \times B]$ , ' $E$ ', ' $B$ ' being the electric and magnetic field vectors and ' $v$ ' the velocity of the particle. So the angle of deflection in a magnetic field given the arc length of a dipole magnet ' $l$ ' and the radius of the trajectory (local) ' $\chi$ ' is

$$\theta = \frac{l}{\chi}$$

- We then plot the graph and compare various muon detection rates (with and without magnetic field) to infer a heuristic.
- Repeat the experiment with magnetic field direction reversed.



# Some Predictions

We want to tabulate the following after we obtain the data

Micromegas	Detection Rate (per minute)	Total time (elapsed)
D1		
D2		
...		

With the increase of the magnetic field strength we predict that the Micromegas detectors placed along the higher angles alone will detect muons and thereby study if one can completely deflect muons by a magnetic field. The detection rate dependence on the magnetic field will also give us an insight into some general properties of muons.

# The “What-After”

We have made forays into the scientific community previously, such as the video tour with CERN. We have also attended numerous talks and workshops along similar lines and are currently the editors of a [TED-Ed newsletter](#)<sup>1</sup> with the aim of spreading exposure among students towards such foundational questions, and one of us has submitted an essay to [FOXi](#) this year as an attempt to win their periodic essay contest.

By selecting us, CERN would not only be enabling us to take advantage of this once-in-a-lifetime opportunity by allowing us to perform an experiment alongside such an illustrious and Brobdingnagian scientific institute with interests that correspond so closely to ours (which include disseminating science and uncovering the physical foundations of our world), and would be giving a great boost to our ambitious endeavors, CERN would also be giving us some of the invaluable knowledge and experience that we are all craving for regarding particle physics and experimental physics which we will forever treasure and try to spread around! Succeeding the BL4S competition, we intend on applying to as many scientific endeavors as a group of 17-year-olds can in order to take the next step towards our ultimate goal of going into the field of physics and scientific research- but, most importantly, to satiate our curiosity.

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<sup>1</sup> Covering four topics – Analytic Philosophy, Cognitive Science, Relativity and Quantum mechanics.

# Acknowledgements

We are immensely grateful to Mr. Markus Joos for encouraging us for the past two years and for patiently answering our emails and for motivating us over and over. We are also quite thankful to Dr. Lau Gatignon for helping us with a lot of practicalities and we hereby acknowledge his immense expertise in the area of particle physics. We also thank Mrs. Avnita Bir and Mr. Shyam Wuppuluri for their ever present support.