DESY Chain

Introduction to Our Experiment

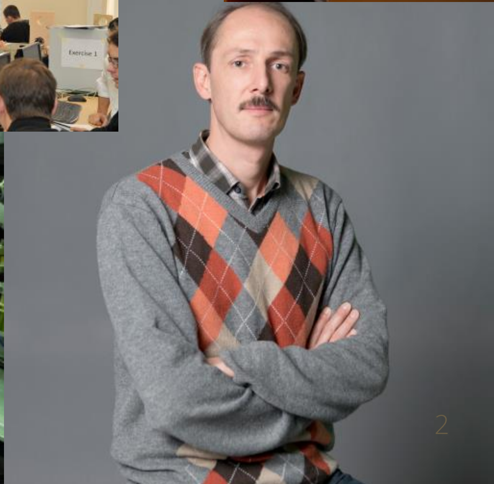
19 October 2019







Special thanks in help with the experiment to Markus and Cristóvão!

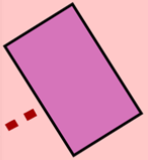
A Brief Introduction

What do we aim to do in our experiment?

Determine energy

Prim
Targe

DESY II
Synchr



Model out how energy deposition is related to luminosity output & possible e^+/e^- differences!

Shoot electron

HC=H
BRM
DWC
Calo=Lead Crystal Calorimeter

Why did we pick it?

Choosing and learning about our experiment

This wasn’t the first idea we thought of…

Determining Nuclear Size

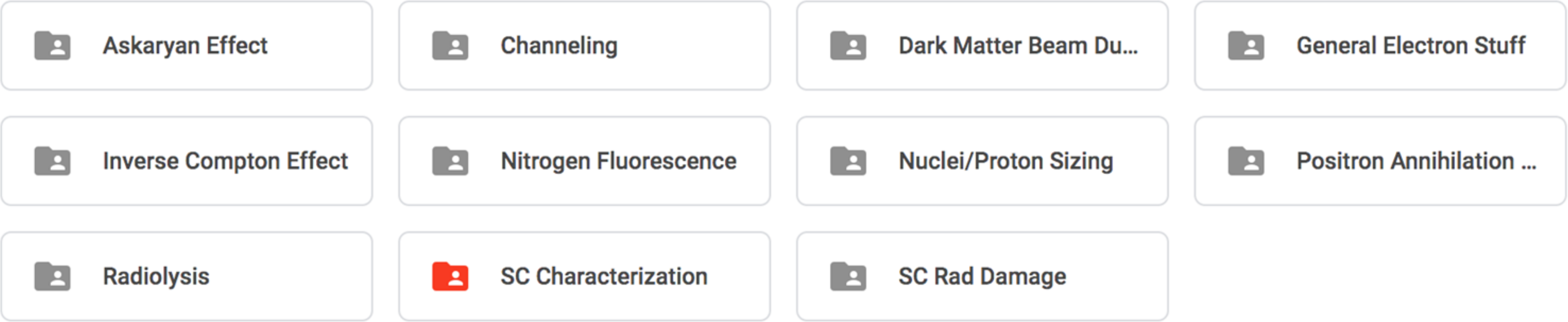
Askaryan Effect

Inverse Compton Scattering

Scintillator Radiation Damage

Channeling Radiation

Nor even just one of several



Askaryan Effect
Channeling
Dark Matter Beam Du...
General Electron Stuff
Inverse Compton Effect
Nitrogen Fluorescence
Nuclei/Proton Sizing
Positron Annihilation ...
Radiolysis
SC Characterization
SC Rad Damage

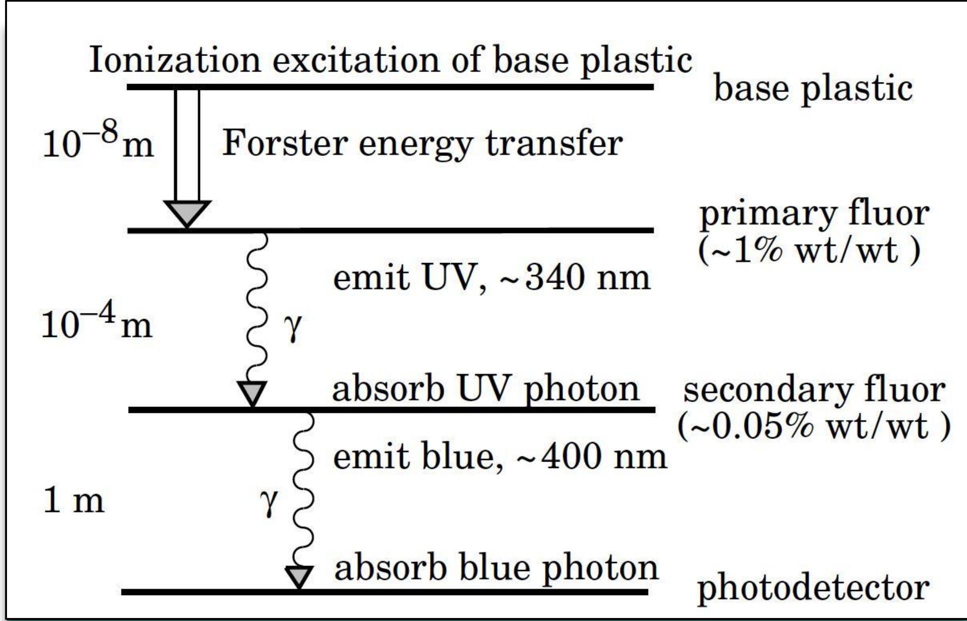
...it was a very exploratory process.

A touch of background (radiation)

Scintillators, mostly, and stuff about them

Scintillators

- Organic scintillator: plastics e.g. PVT and fluors
- Fluoresce when struck by ionizing radiation
- Photon is emitted, with a shifted wavelength (Stokes shift).
    - New wavelength is often more convenient for detection and less likely to self-absorb



Potential Nonlinear Behavior (? energy levels)

Birks' law

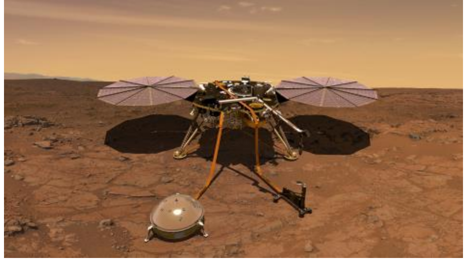
- Does this model work well in our circumstances? (energy levels, scintillator, etc.)?
  - Some models have a second order $(dE/dx)^2$ term
  - Quenching may be insignificant at this energy level
- Is luminescence proportional to energy deposited?
  - Threshold tipping point
- Do positrons annihilate and create significant differences? (calculations suggest low probability)
- Efficiency of scintillator?

At high enou as energy is deposited, it is **quenched** through a variety of processes

A brief interlude

Fun facts about our experimental proposal

Mars Rovers



Insight

Opportunity

II. Why We Want to Go

Last year, our school participated in the BL4S competition for the first time. While our proposal fell short, it was a fascinating experience to gain greater insight into the physics and requirements that go into such accelerator experiments. We were driven by that same curiosity in this year's proposal, and throughout this year's odyssey have had the chance to expand on that through our research. The opportunity BL4S presents us would not only allow us to see such physics actualized — and in experiment! — but also to promote science in our own school: a high-profile showcase of what research and hard work can bring. Our studies have been such an amazing experience, and one we hope to have the chance to share.

Curiosity

Odyssey

Morse Code

-.-. .... . -.-. -.- / - .... . / .--. -- - / --- ..- - .--. ..- - / ..-. .-. --- -- / - ....
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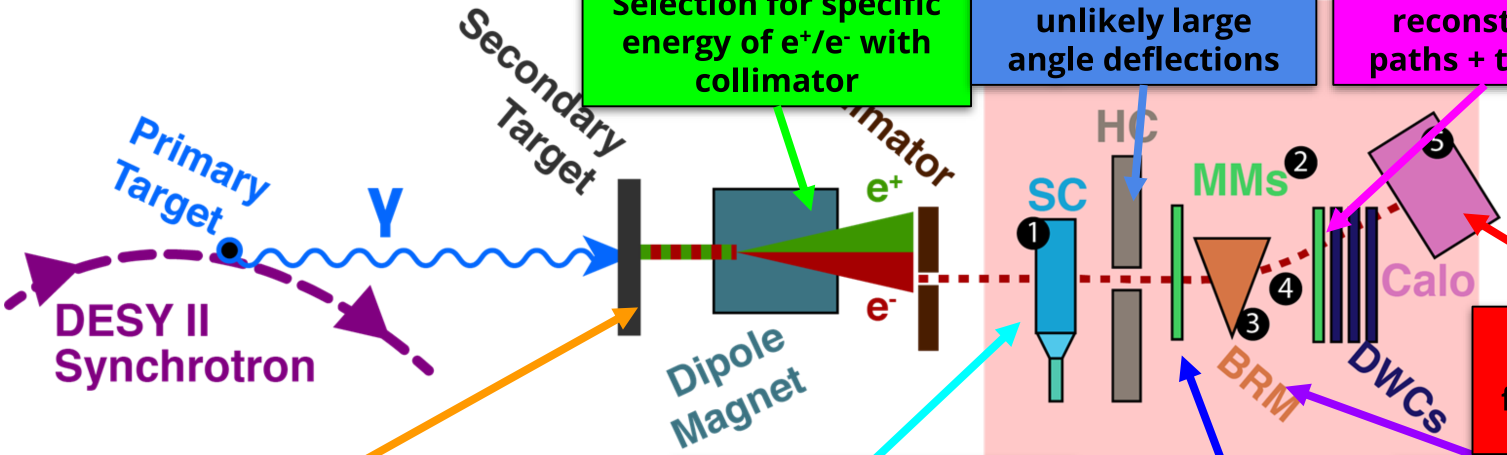
The nitty-gritty

Exploring the important details of the experiment



Selection for specific energy of e^+/e^- with collimator

HC screens for unlikely large angle deflections

MMs/DWCs help reconstruct paths + trigger

Calo provides final energy check

Beam Production (Bremsstrahlung photons → secondary target → pair production)

Particles pass through scintillator of varying lengths

MM#1 & other takes initial impact point of particle

BRM deflects particles

tion

SC=Scintillator
composed of scintillating slab, light guide, and photomultiplier tube
HC=Halo Counter
B=Big Red Magnet (dipole)
MMs=MicroMegas
DWCs=Delay Wire Chambers
Calo=Lead Crystal Calorimeter

Data Collection Methods

Data Collected

- Luminescence as a function of energy deposited, ***L(E)***
- Luminescence as a function of distance traveled (aka scintillator thickness), ***L(x)***
- Energy loss of the particle as a function of distance travelled in the scintillator, ***E(x)***

& What We Can Do With It

Scintillator efficiency is the factor at which energy deposited is transformed into luminescence

Scintillator proportionality is the linearity of ***L(x)***

Birks' law via numerical fitting

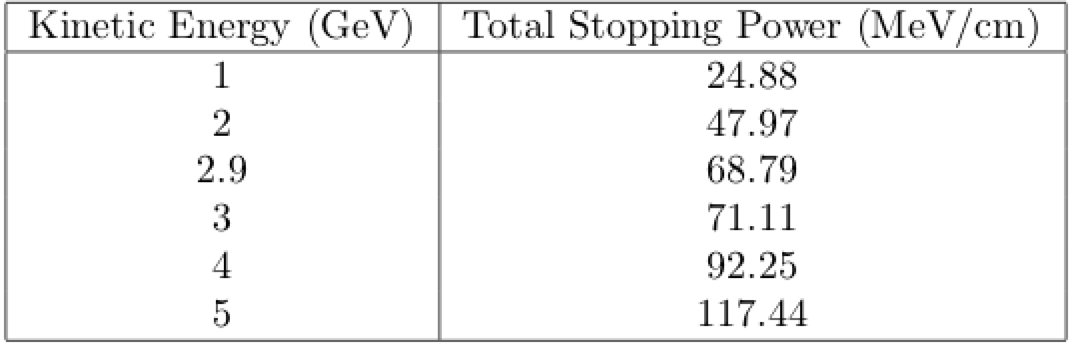
- ***L(x)*** and ***E(x)*** -> ***dL/dx*** and ***dE/dx***
- When ***dE/dx*** is low, we can find the scintillator efficiency alone (L_0)
- Thicker scintillators may start to reach Birks' law

1 : Scintillator Thickness

ESTAR database, based on polyvinyl toluene

How much scintillator material do we need to result in a noticeable ΔE?

- Range of scintillator thicknesses



Kinetic Energy (GeV)	Total Stopping Power (MeV/cm)
1	24.88
2	47.97
2.9	68.79
3	71.11
4	92.25
5	117.44

~0.5 cm for solid energy loss w/ 3 GeV e^-

2: MMs and DWCs

- Both are gaseous detectors

- Different readouts and timescales

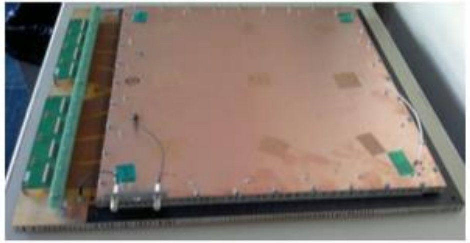


Figure 1: MicroMegas Detector

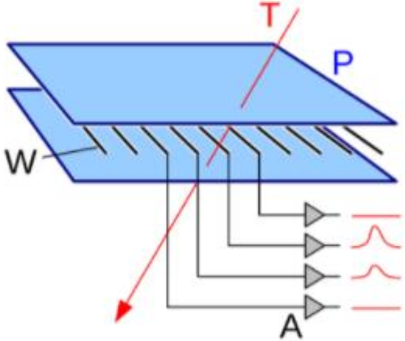


Figure 2: DWC Schematic

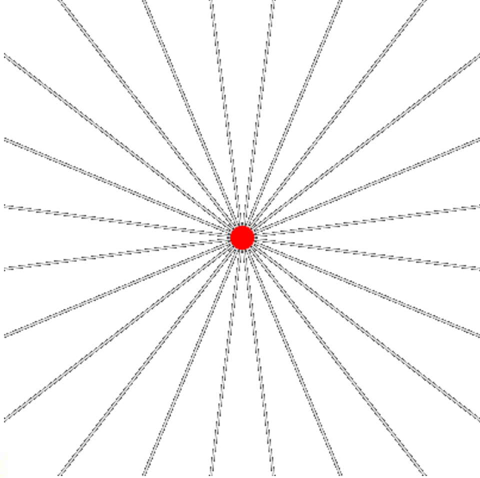
- Reconstructing particle tracks requires multiple tracking chambers

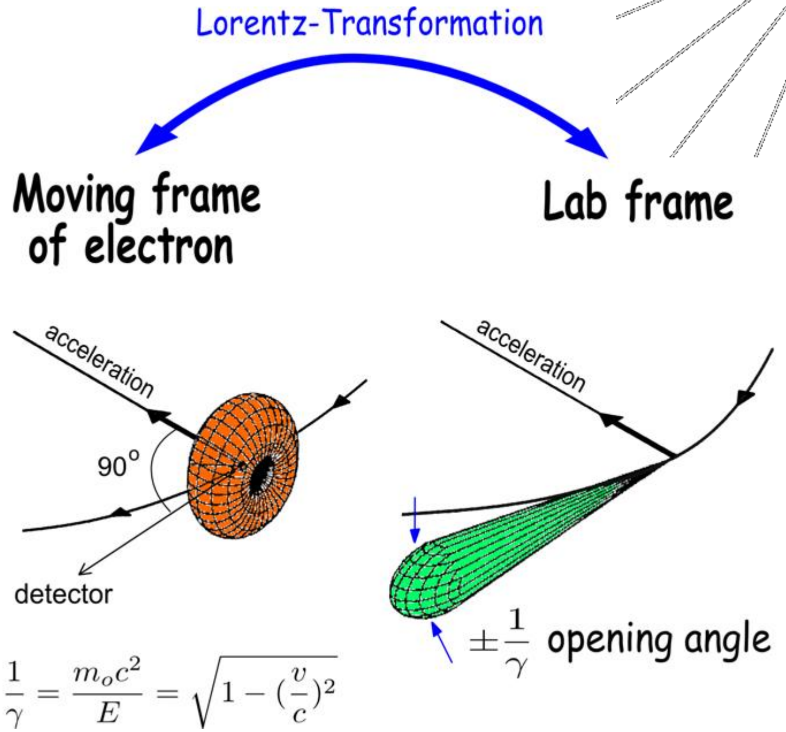
3: Magnets and Bremsstrahlung

Is the Bremsstrahlung radiated by the electron when passing through the BRM significant?

No

$$P = \frac{2Ke^2\gamma^4 c}{3r^2}$$





$$\frac{1}{\gamma} = \frac{m_o c^2}{E} = \sqrt{1-(\frac{v}{c})^2}$$

4: Bending Angle

0.012 GeV is optimistic

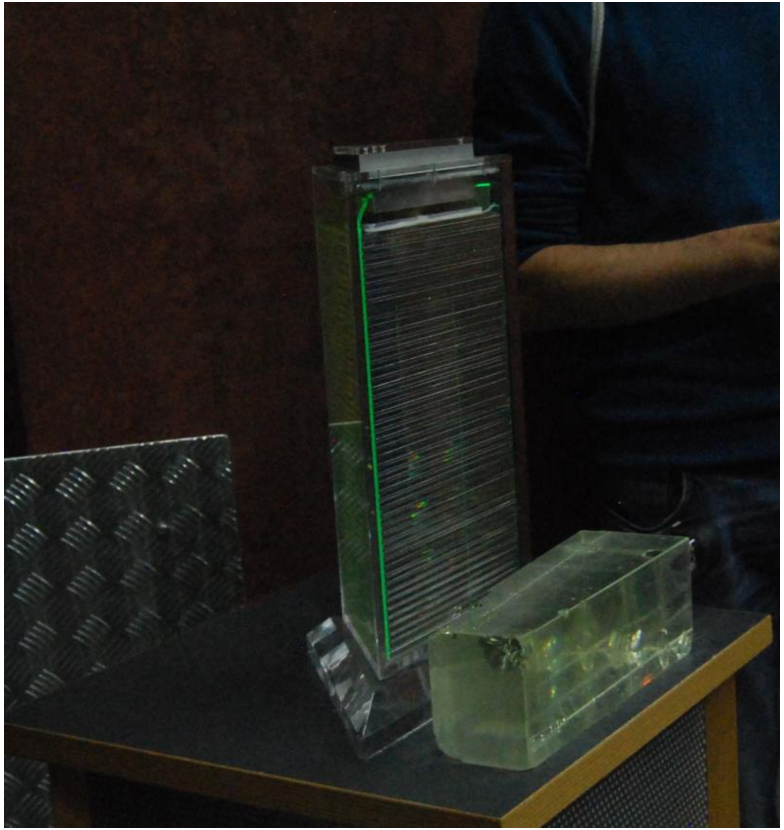
$$\Delta\theta = 0.3\frac{L \cdot B}{p}$$

Size of detectors means placement will be altered as we iterate through energies

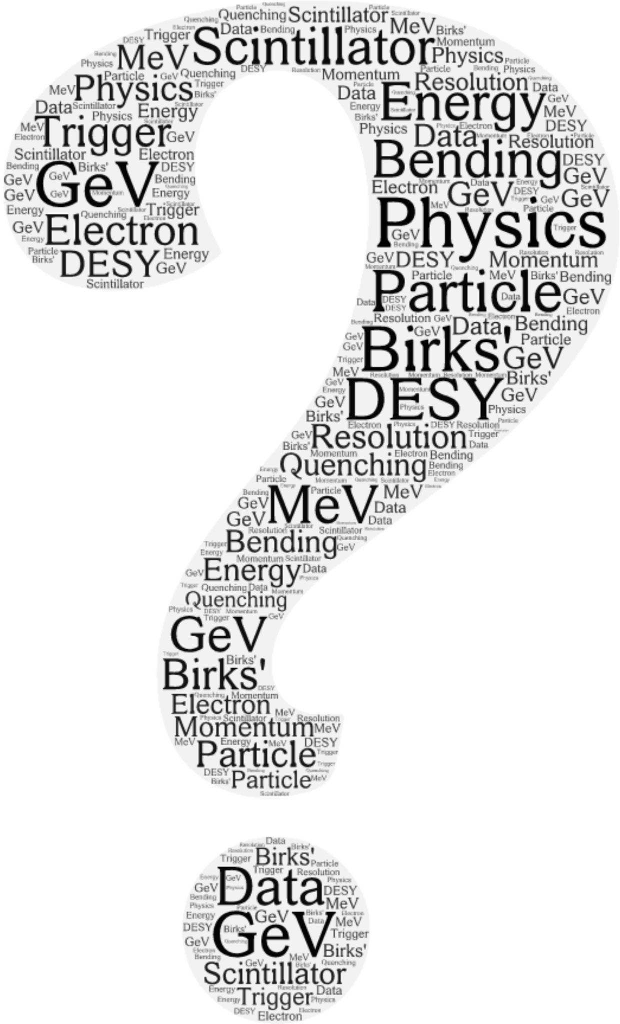
Distance difficulties (resolution v. alignment)

5: The Calorimeter

- The calorimeter will be used to record the final energy of the electrons/positrons.
- Acts as redundancy for energy measurement /calculation
  - In conjunction with BRM



The lead glass scintillator we saw yesterday!



Questions?