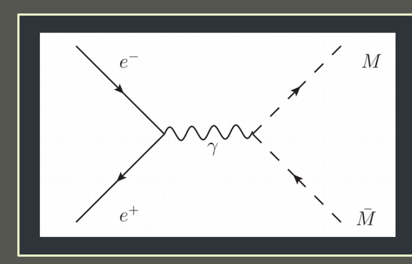
Clusters in electromagnetic calorimeter

Straight tracks in transverse plane

South monopole

What and why:

A magnetic monopole is a stable particle carrying magnetic charge, it is suggested by the symmetry of Maxwell's equations and appears in e.g. Grand Unification Theories. Originally it was proposed by Dirac in 1931 as a way to quantize electric charge: $e_0 g_0 = n\hbar c/2$, thus giving minimal Dirac charge $g_D = 68.5e$.



Modern experiments focus on high ionization of a Dirac charge, while lower charge monopoles predicted by other theories are easy to be missed without a dedicated tracking and trigger setup.

Most recent searches:

- High magnetic charge
  2017 MoEDAL 68.5e < g
  2016 ATLAS 34e < g < 137e
- Low magnetic charge
  1988 TASSO 10e < g < 70e
  1987 CLEO 2e < g < 10e

Monopole parameters:

- Mass m
- Magnetic charge g
- Electric charge q

Challenge:

Monopole tracks in a magnetic field are non-helical - as the magnetic charge gets accelerated in the B field, the tracks are curved along magnetic field lines and are straight in the transverse plane.

Moving magnetic particles interact with electrons in atoms as an electric charge βg, thus the average ionization loses characteristic $1/\beta^2$ dependence and monopoles produce less hits in the tracking device.

A dedicated tracking algorithm is required to reconstruct these unconventional tracks.

Production:

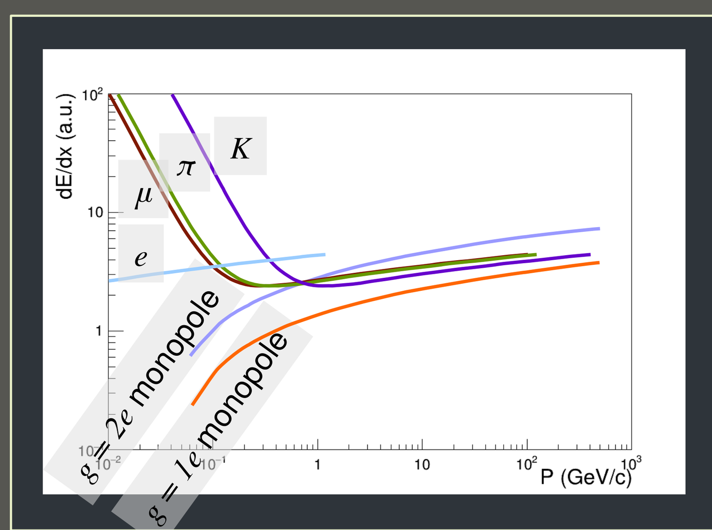
$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2\beta^3}{4s}\left(1+\cos^2\Theta\right)$$

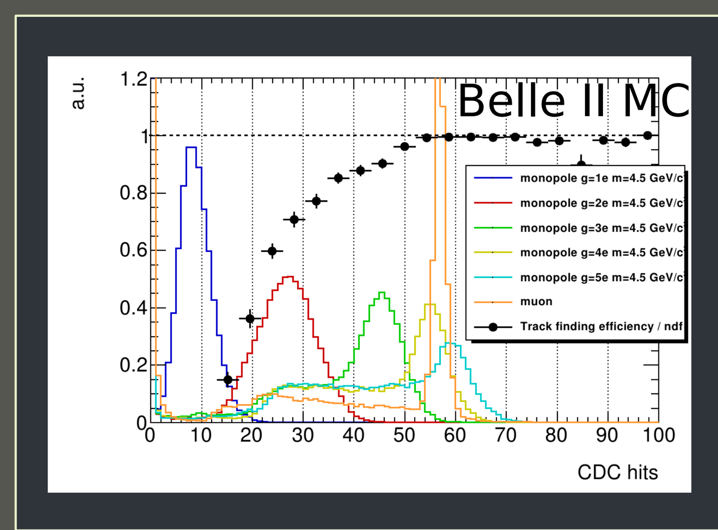
β^3 suppression relative to $\mu\bar{\mu}$

Ionization:

$$-\frac{dE}{dx} = \frac{4\pi N_A Z g^2 \alpha^2 (\hbar c)^2}{A m_e c^2}\left[\ln\left(\frac{2\gamma^2 m_e \beta^2 c^2}{I}\right) - \frac{1}{2}\right]$$

instead of $A m_e \beta^2 c^2$ in electric Bethe-Bloch





10.58 GeV e^+e^- collision

Search for Magnetic Monopoles

with the Belle II experiment

Dmitrii Neverov, Nagoya University
neverov@hepl.phys.nagoya-u.ac.jp
Nagoya University
Kobayashi-Maskawa Institute for the Origin of Particles and the Universe
Belle II

Furhter reading:

Monopole searches overview	arXiv:1412.8677
Proposal to search in Belle II	arXiv:1707.05295
Low charge monopoles theory	arXiv:1807.09606
High charge monopoles ionisation	Rev.Mod.Phys. 52, 121
Belle II detector physics program	arXiv:1808.10567
Perfect monopole candidate #1	Phys.Rev.Lett. 48, 1378
Perfect monopole candidate #2	Nature 321, 402-406

Tracks bend along magnetic field

1.5 T

North monopole

Tracking approach:

Axial track finder
(r,φ info)

Finds all hits in axial wires compatible with a line from the interaction point to a calorimeter cluster.

Alternative search is done with a Legendre transform for the case of particles with both magnetic and electric charge.

→

Stereo track finder
(z info)

Reconstructs hits in stereo wires based on found axial tracks and selects those compatible with a

$$z(s) = z_0 + \frac{p_z}{p_T}s + \frac{gBm}{2p_T^2}s^2$$

Extra term for magnetic charge

using a Hough algorithm.

→

Genfit 2.0
(track fit)

Fits accepted hits in order to obtain track parameters like fit quality and gm product.

→

Offline analysis

Separate monopole candidates that are better fit by a helix, look for peaks above background in what is left.

progress bar

Simulation results: