Search for monopoles

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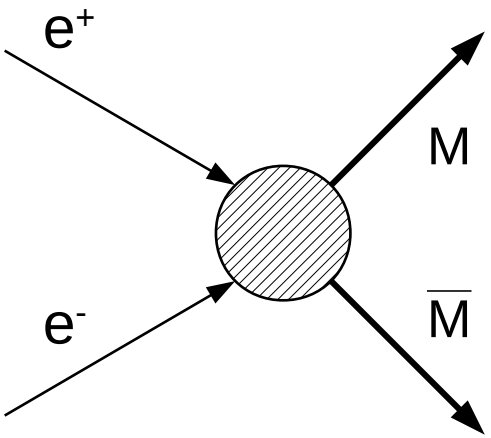
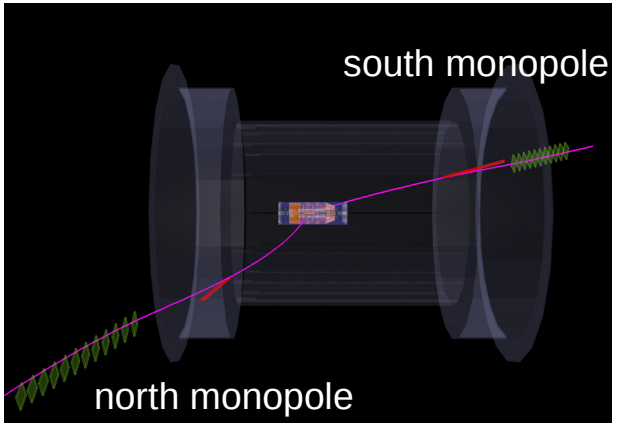
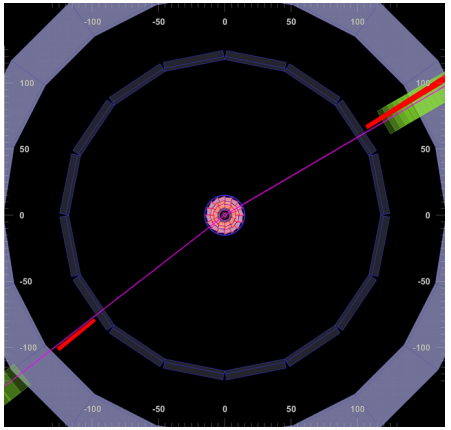
Monopoles: Introduction

- Monopole - a stable particle carrying magnetic charge
  (dyons have both magnetic and electric charges)
- Proposed by Dirac in 1931 as a way to quantize electric charge
  - $e_0 g_0 / \hbar c = n/2$
  - Minimal magnetic charge $g_D = 68.5e$
- Lower charges are not ruled out (e.g composite particles)
  arXiv:1707.05295
- It is possible to search for such particles with Belle II
- https://confluence.desy.de/x/kLfiB



$$\frac{d\sigma_{M\overline{M}}}{d\Omega} = \frac{\alpha\alpha_m(\hbar c)^2\beta^3}{4s}(1+cos^2\Theta)$$



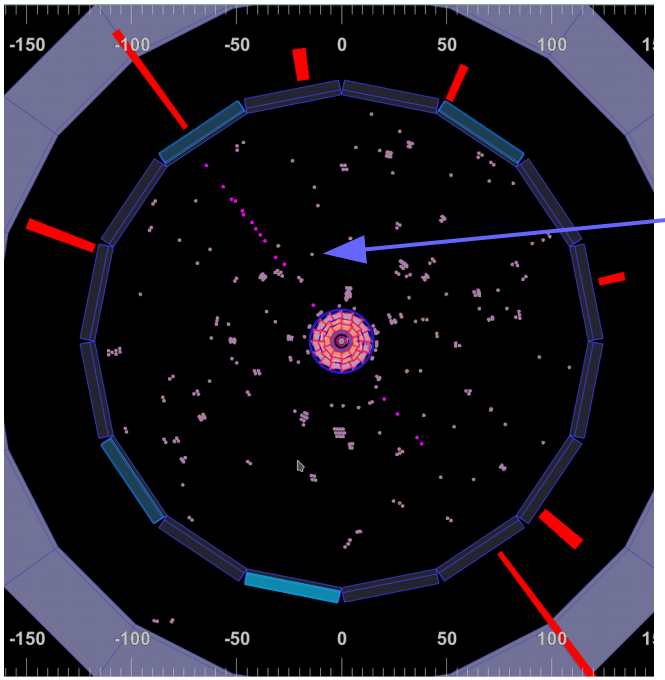


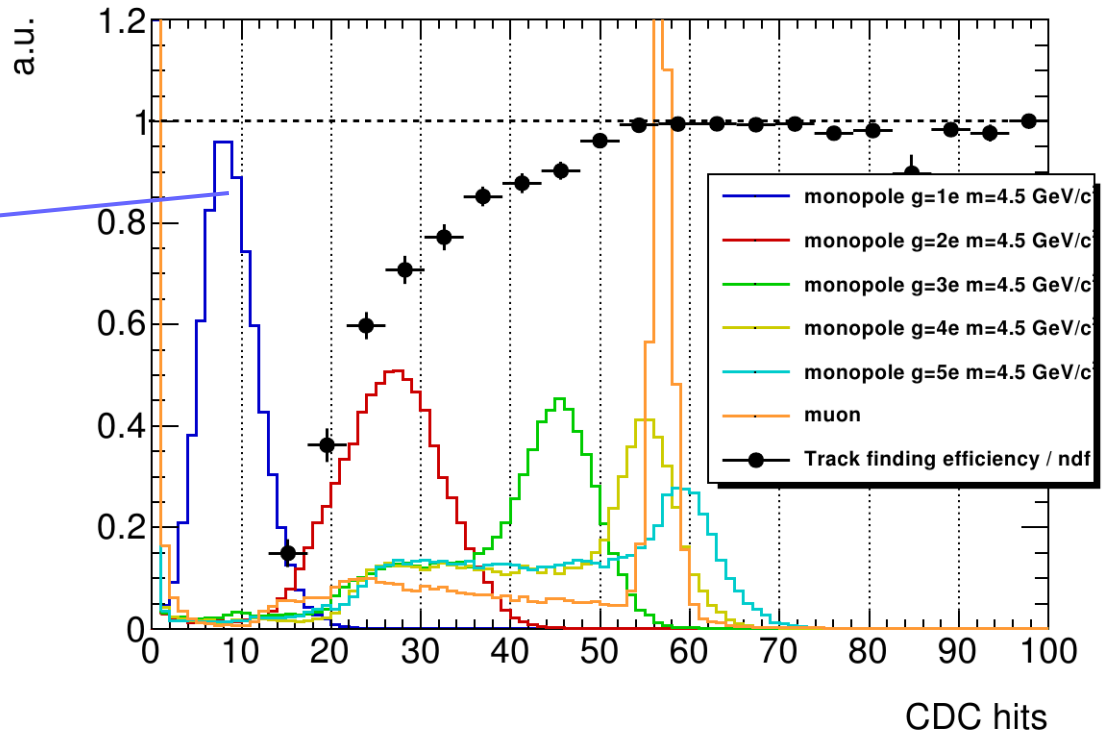
Monopole parameters:

- Mass $\boldsymbol{m}$
- Magnetic charge $\boldsymbol{g}$
- Electric charge $\boldsymbol{q}$

Monopole tracking challenge

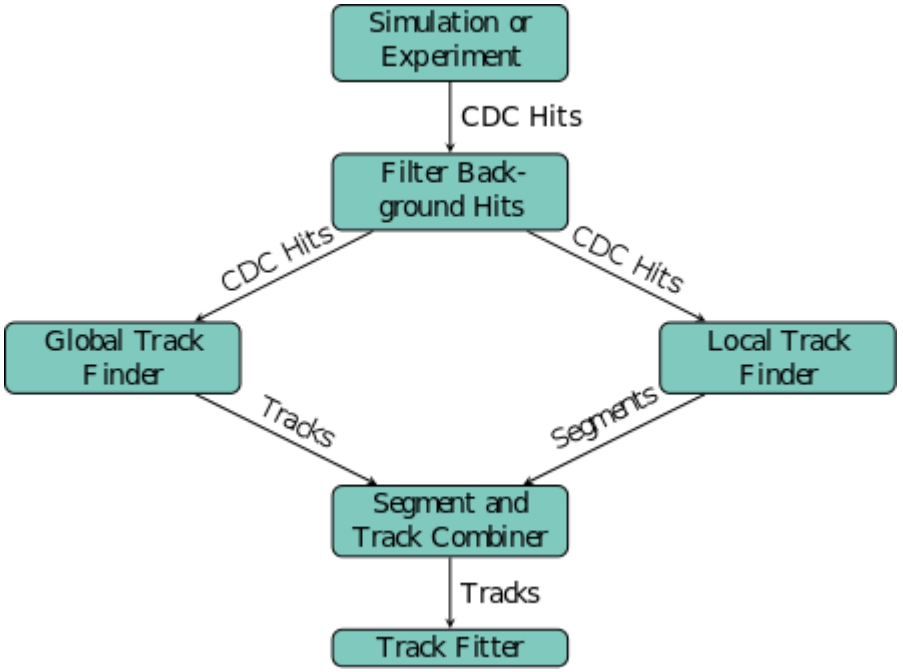
- Because of $1/\beta^2$ absence in dE/dx for magnetic charges, monopoles leave fainter signal than electrically charged particles
- Monopoles require dedicated tracking algorithm with three cases
  - Low ionisation (hits) monopoles
  - Generic monopoles
  - Generic dyons
- Tracks have one degree of freedom more than usual helix tracks

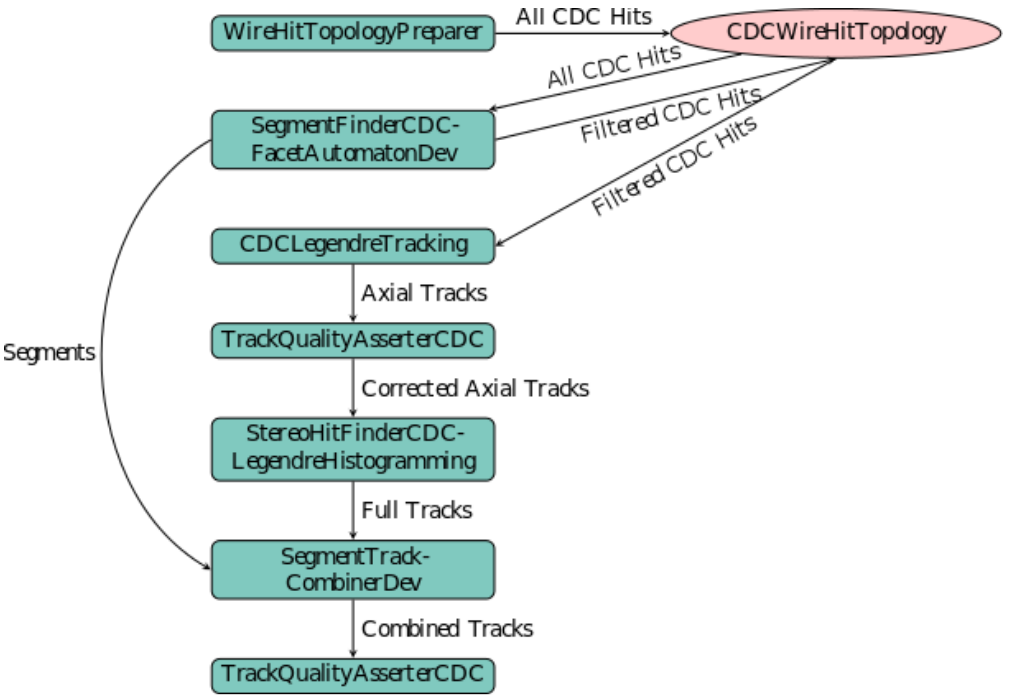




Tracking in CDC

General tracking flow:

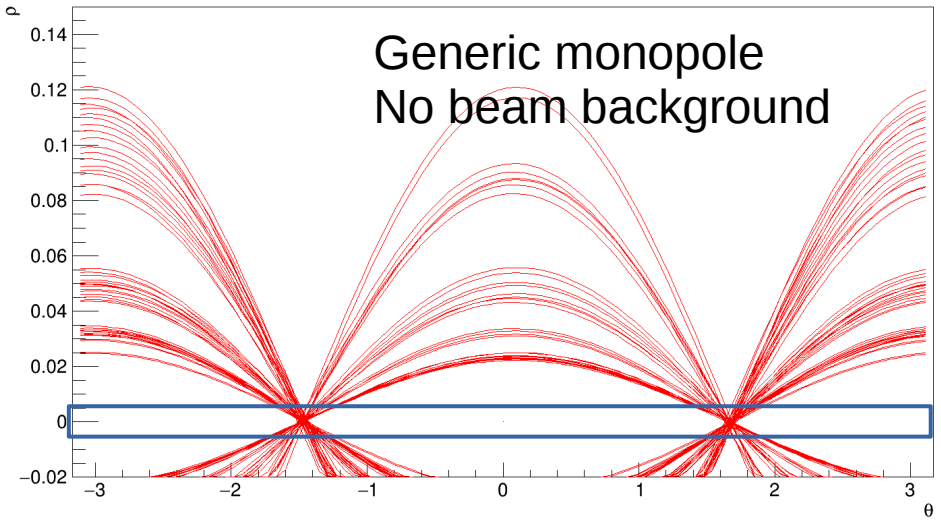


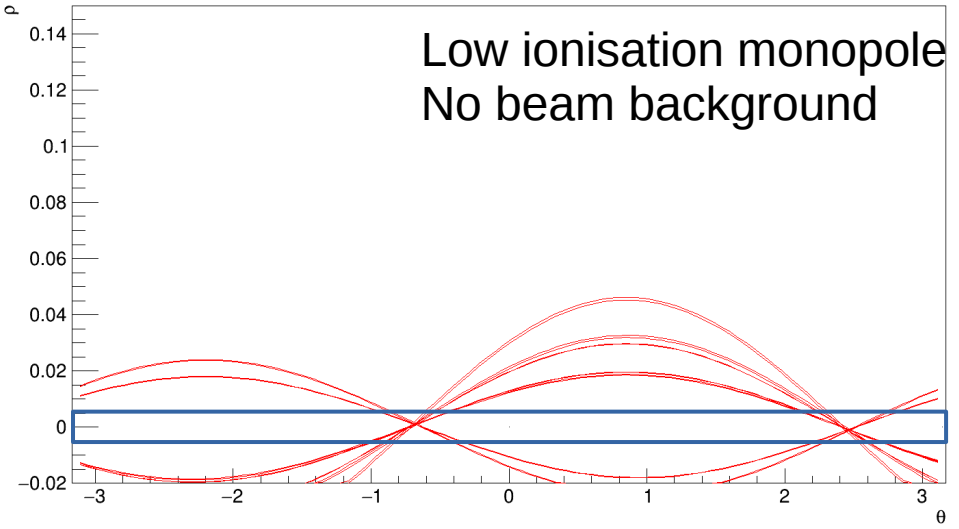


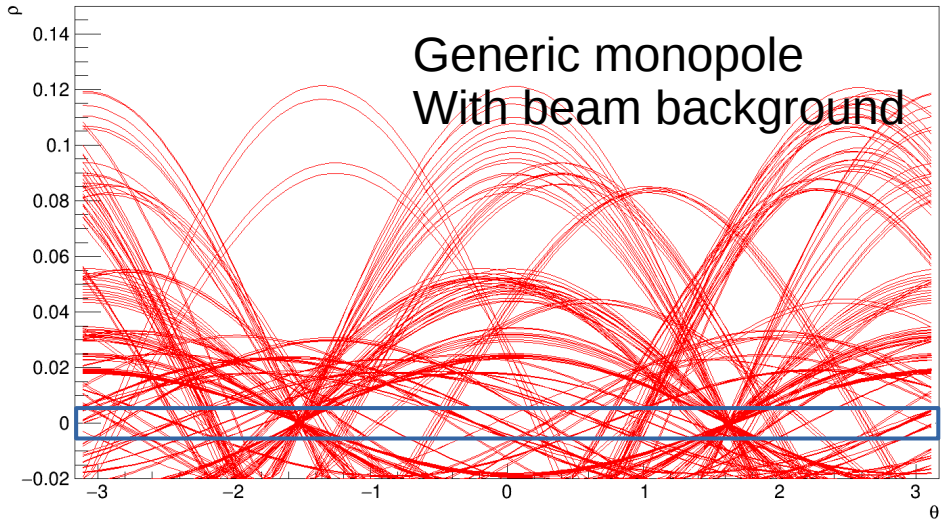
- Local track finder:
  - Hits → Clusters → Segments in superlayers
- Global track finder
  - Hits in all axial layers → 2D tracks
- Combine everything together in best possible way

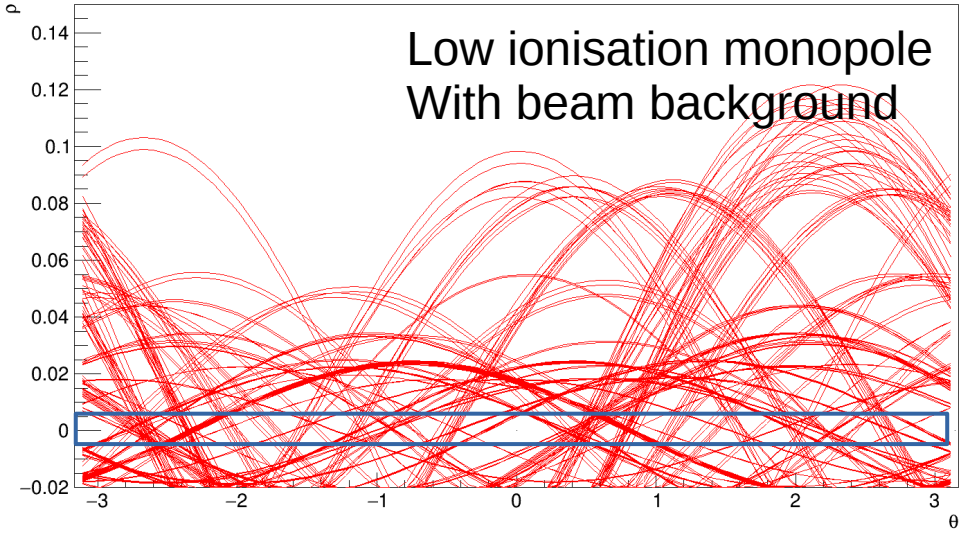
Monopole 2D track finding

Conformal Legendre transforms
ρ is track curvature, θ is track polar angle







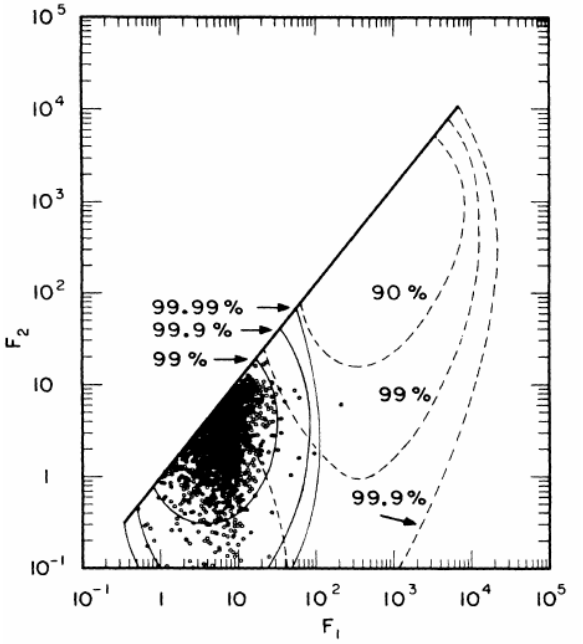


Monopole signal extraction

- 2D track candidates search: efficiency(nCDCHits, fit precision)
  - Increase efficiency at the cost of fake candidates amount
- Expect low curvature
- Utilize ECL hit information to filter some fake candidates
- Try assigning stereo hits and perform two types of track fit
  - $z=a_0+a_1 s$
  - $z=a_0+a_1 s+a_2 s^2$
- Use Chi squared discriminator to separate signal

$$F = \frac{\chi^2_L - \chi^2_Q}{\chi^2_L/(N-3)}$$

Discriminator performance on a track pair @CLEO



Summary

- Search for monopole pairs is possible in phase II data (WG9)
- Simulation is implemented in basf2
- Tracking efforts are ongoing
- The most interesting case of g = 1e monopoles require special attention and more modifications than other cases

- Feature freeze for release-02-00-00 on 1st May