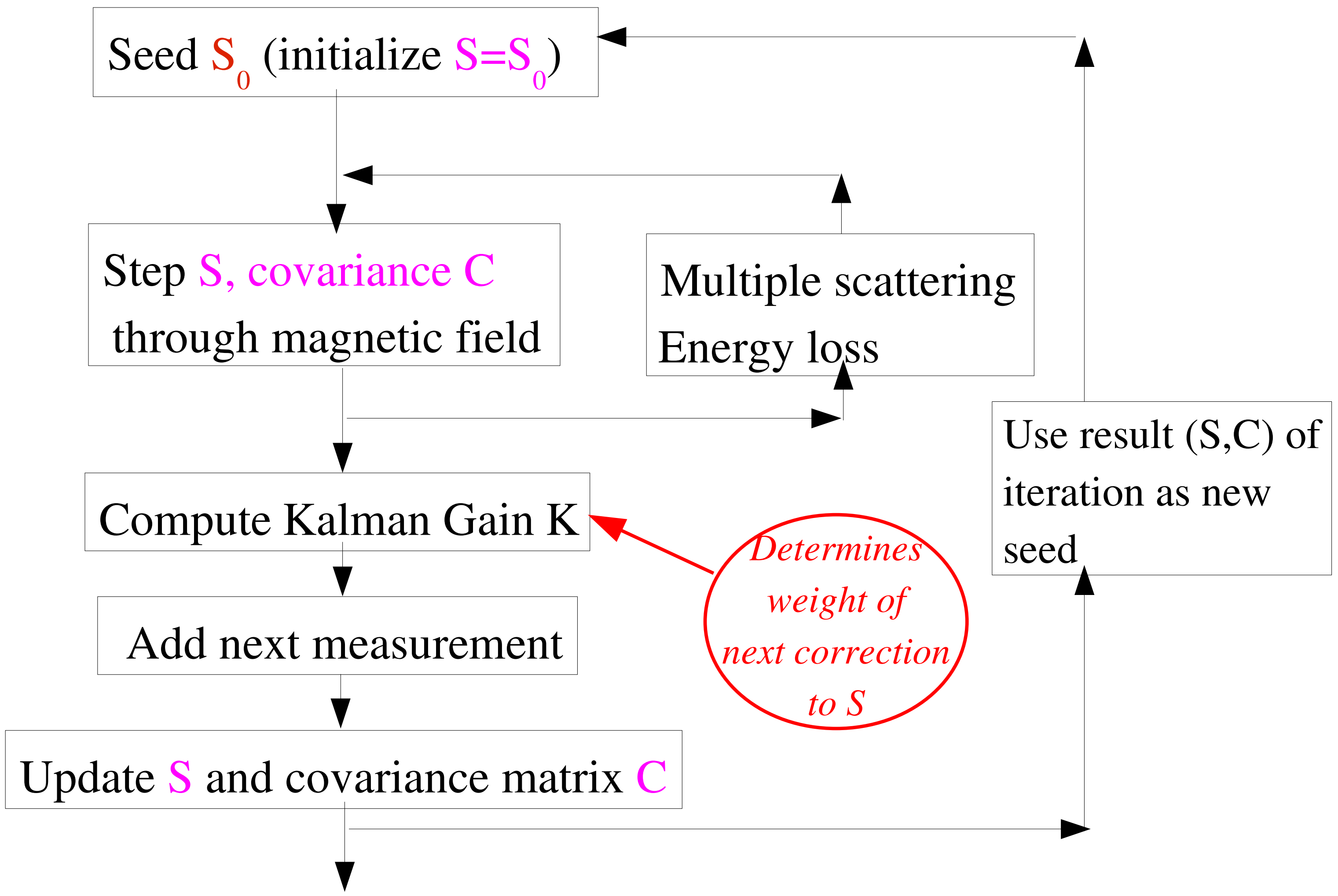
Kalman Filter Update

- Track described by 5-parameter state vector at each point along its path
- State vector propagated step-by-step toward target
  - Multiple scattering and energy loss taken care of at each step
  - Does not require inversions of large matrices (at most 2x2 for FDC hits)
  - Jacobian matrix elements computed analytically
- State vector treated as a perturbation to an initial guess
  - Generate reference trajectory by swimming with initial parameters from the target
- Perform filter in three passes
  - Can iterate up to 10 times per pass, checking for χ^2 convergence
  - Regenerate reference trajectory based on results of previous pass

Algorithm

Start with seeds coming from CDC and FDC track finding code (helical fits)

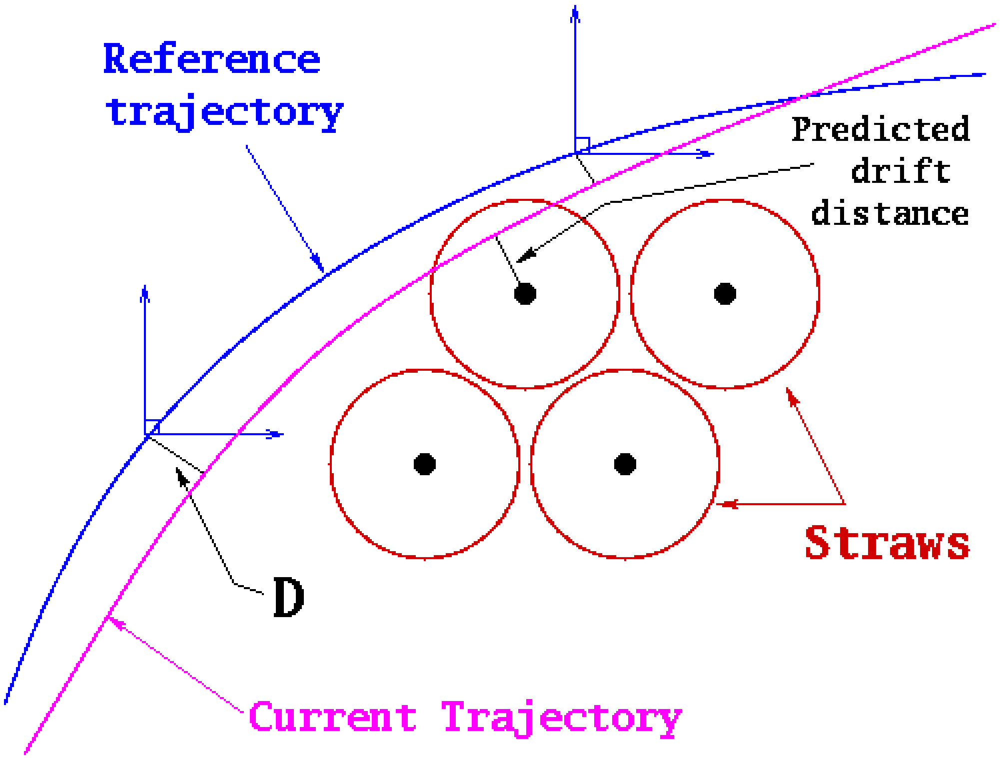


Forward Tracking

- State vector $\{x, y, t_x=dp_x/dp_z, t_y=dp_y/dp_z, q/p\}$
  - "Fitted" state vector considered as small perturbation relative to a seed
    - Seed determined from list of track candidates using helical model
- First step: create reference trajectory from seed, swimming from "vertex" to most downstream FDC hit
  - Take into account multiple scattering and energy loss when stepping through the field – *only do this for the reference trajectory...*
- Measurements added one by one, starting with most downstream hit
  - Apply Lorentz corrections at this stage
  - Iterate up to 10 times – generally only 2 or 3 iterations needed for convergence
  - CDC hits included without changing state vector

Central Tracking

- Start out by swimming a reference trajectory as for forward tracking



- Use central parameters:

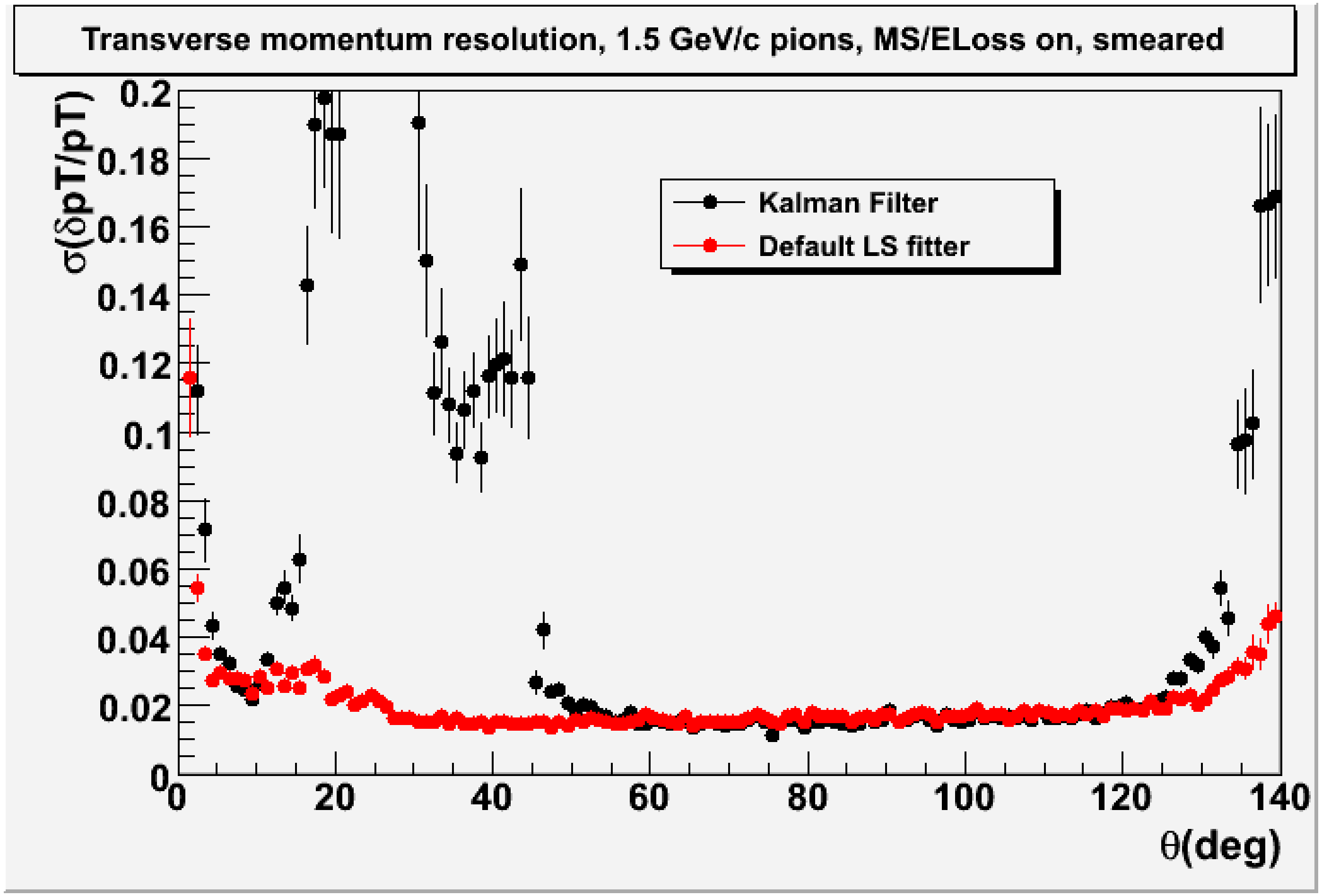
  $$\{q/p_T, \phi, \tan\lambda, D, z\}$$

  - D=distance of closest approach to the reference trajectory at a given time along the particle's path
    - Origin of coordinate system for D moves from point to point along reference trajectory

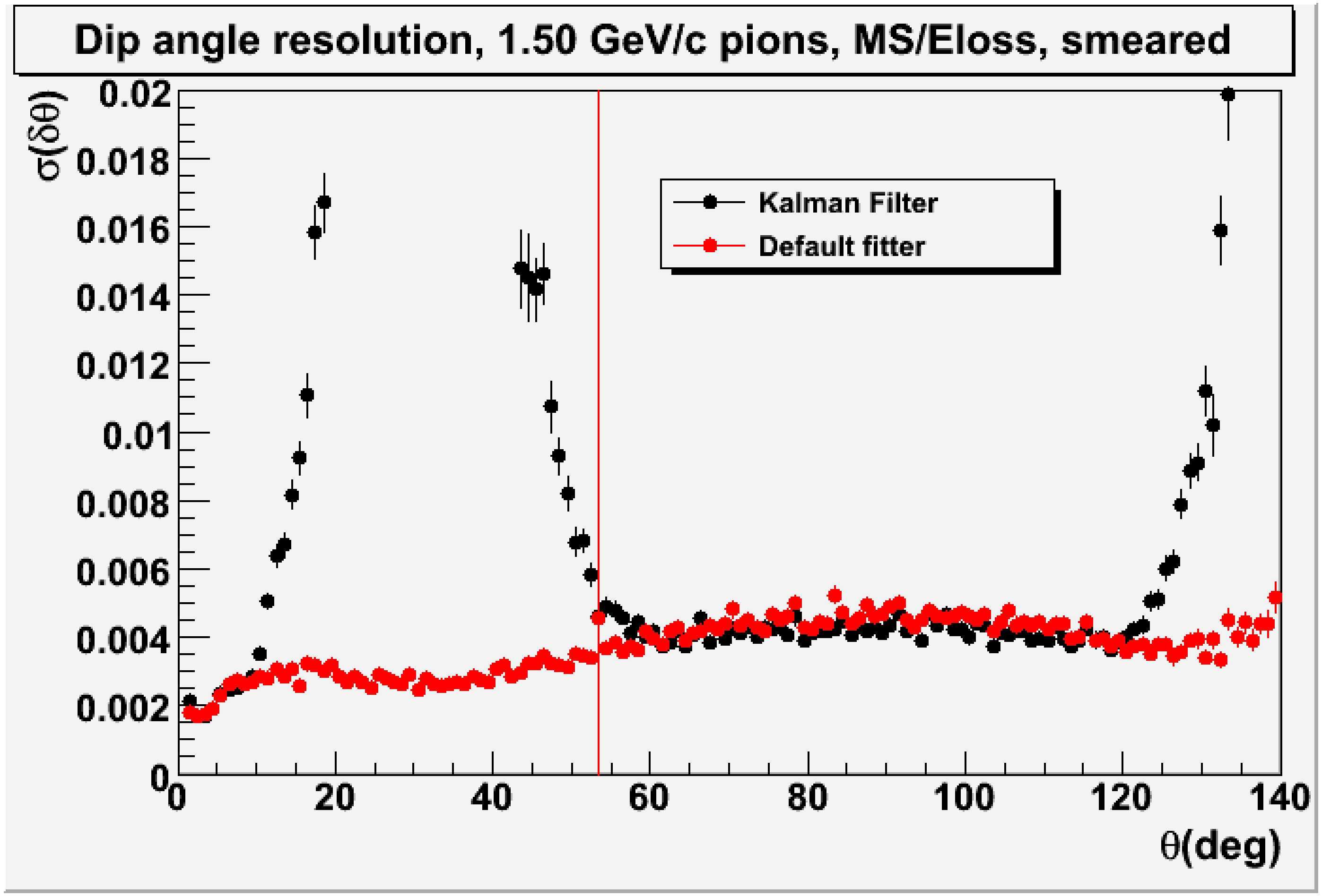
- Initial guess for covariance matrix (off-diagonal elements=0)

  $(\Delta p_T/p_T) = 10\%$, σ_D=1 mm, σ_z = 3 mm, σ_ϕ=10 mrad, σ_λ=10 mrad

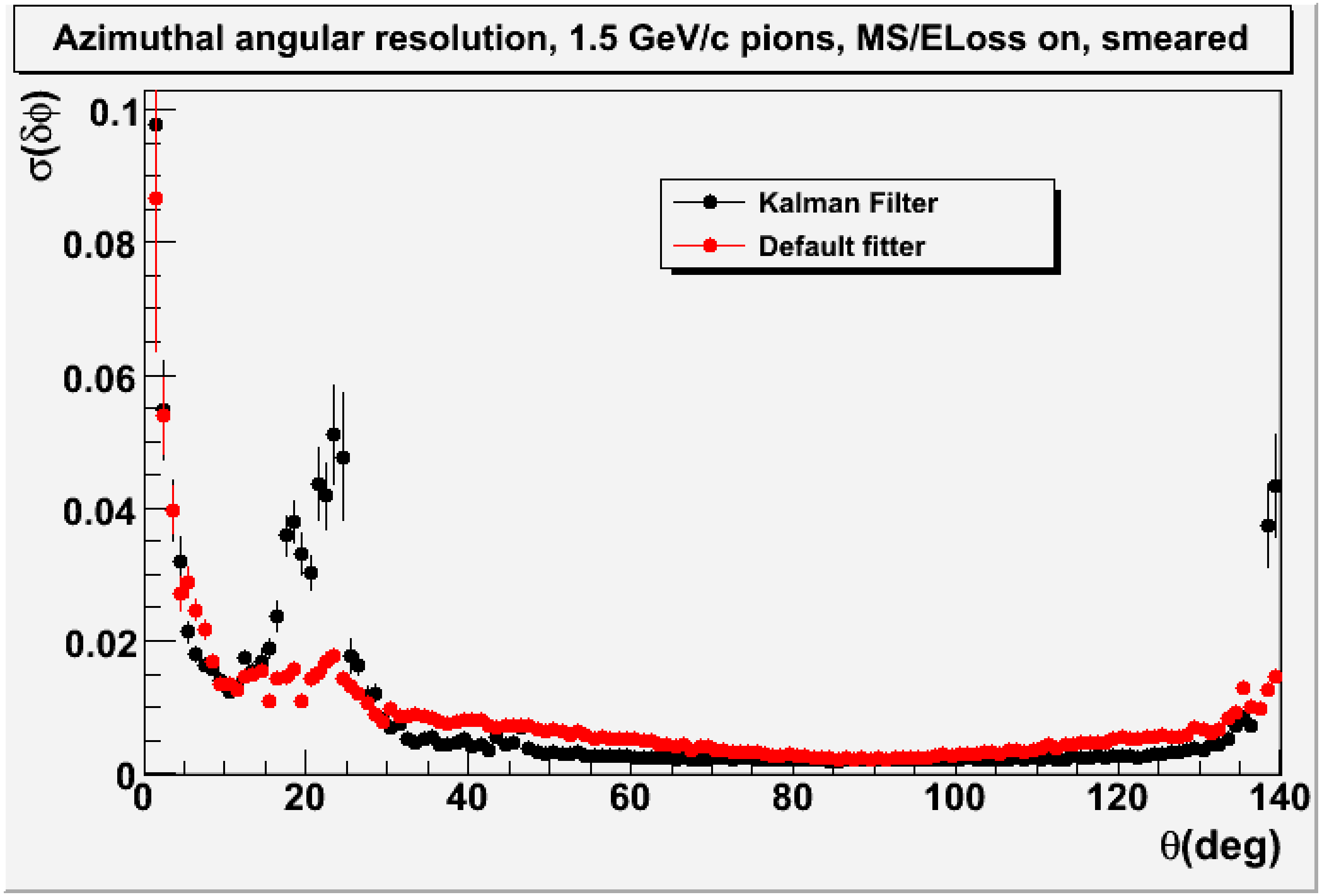
Transverse Momentum Resolution



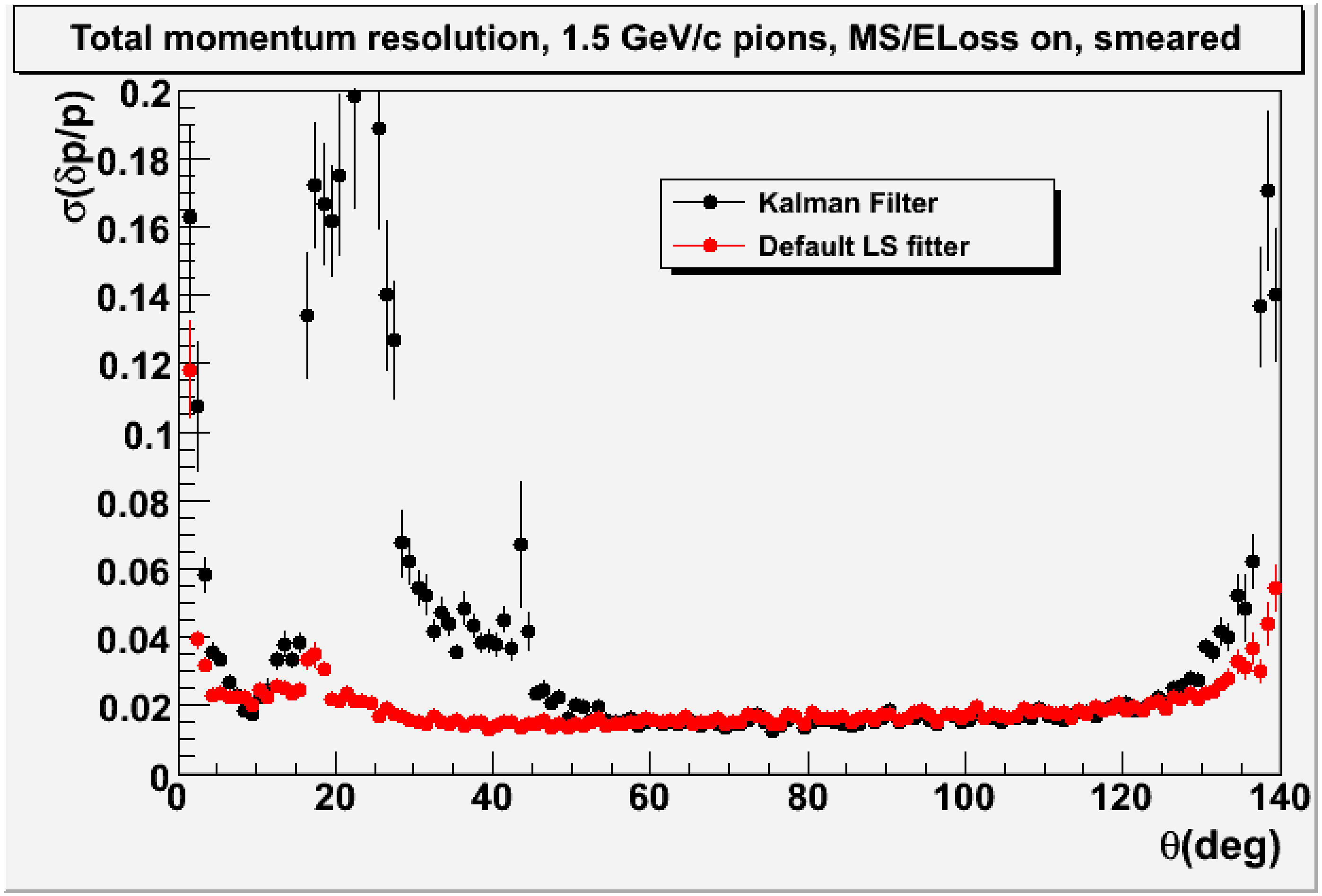
Dip Angle resolution



Azimuthal angle resolution



Momentum magnitude resolution

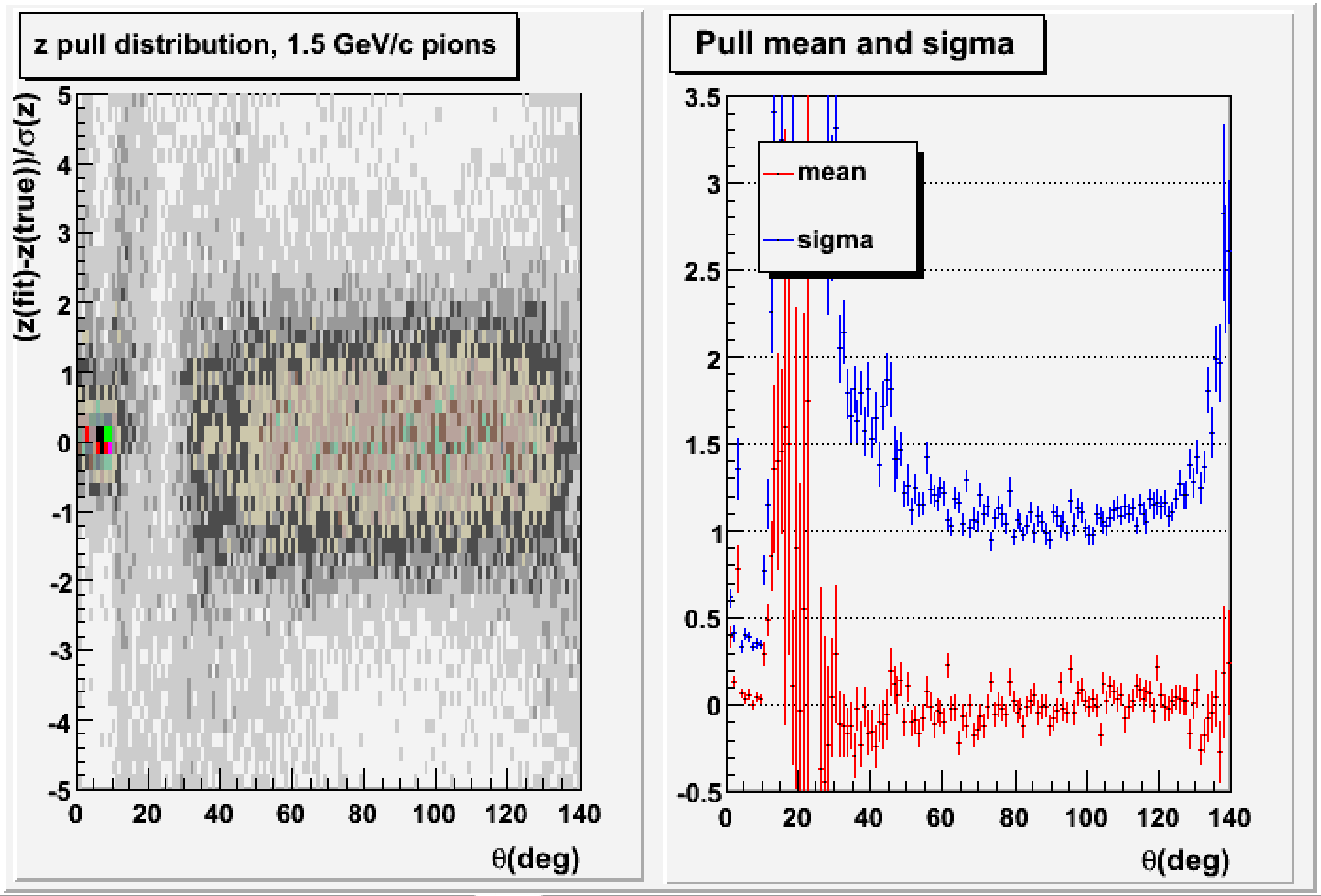


Pull Distributions

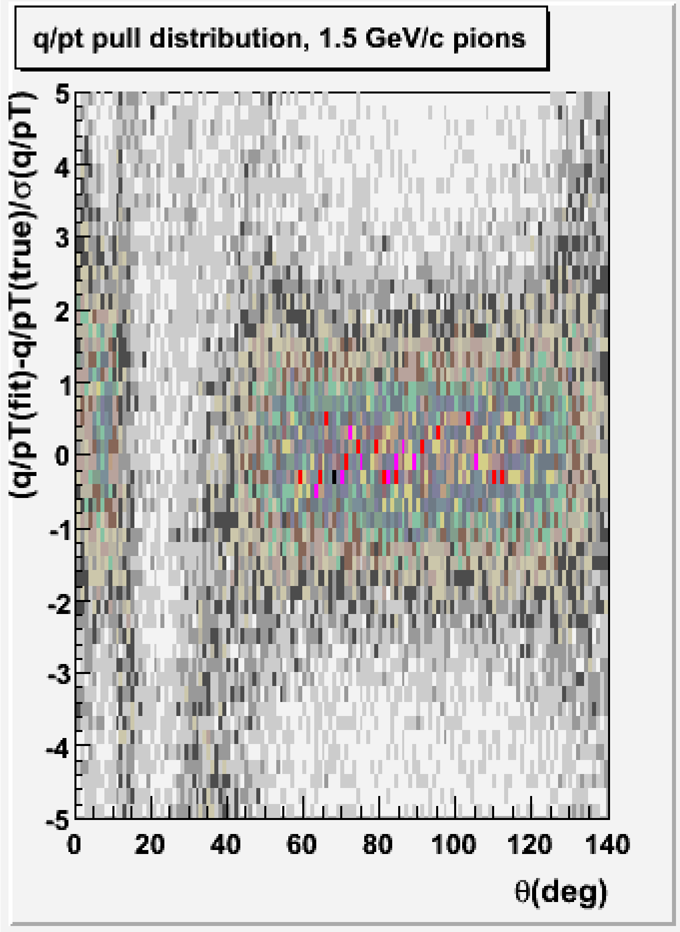
- Check for biases, check that errors are correct

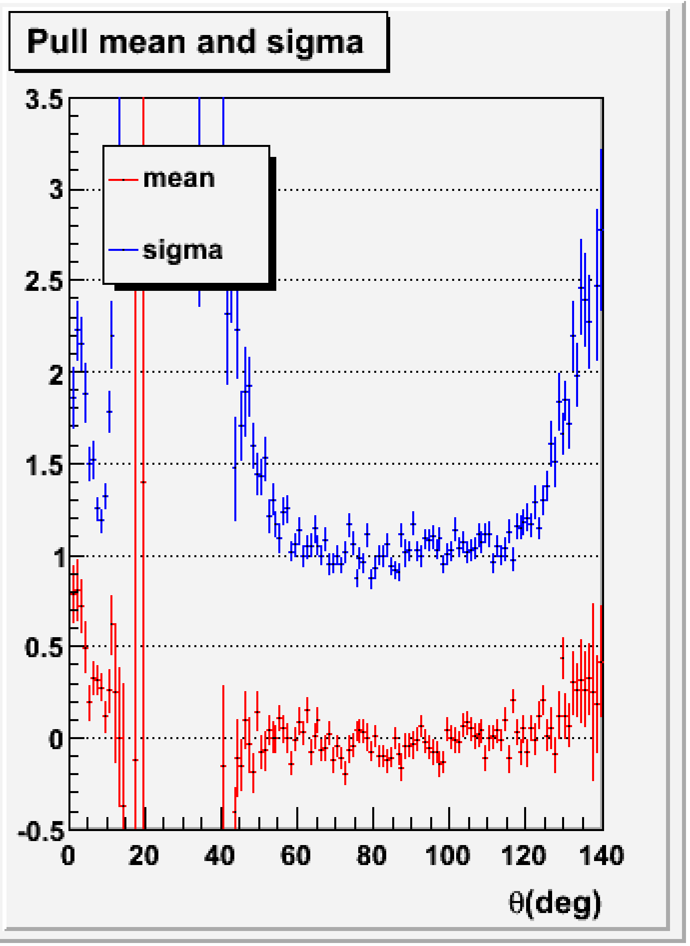
$$Pull(z) = \frac{z - z_{true}}{\sqrt{\sigma^2(z)}}$$

- Mean should be 0
- Standard deviation should be 1

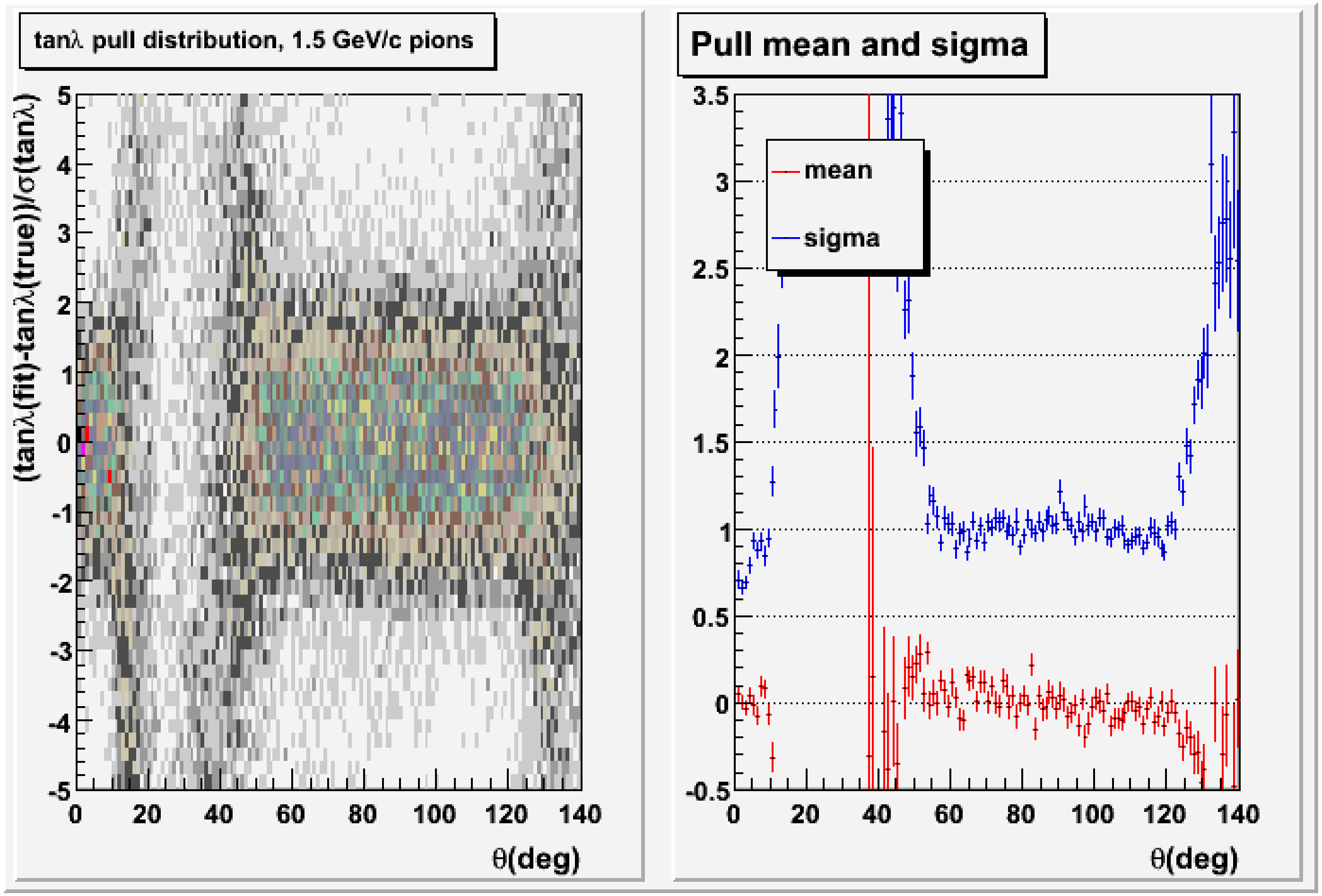


Pull Distribution for q/p_T

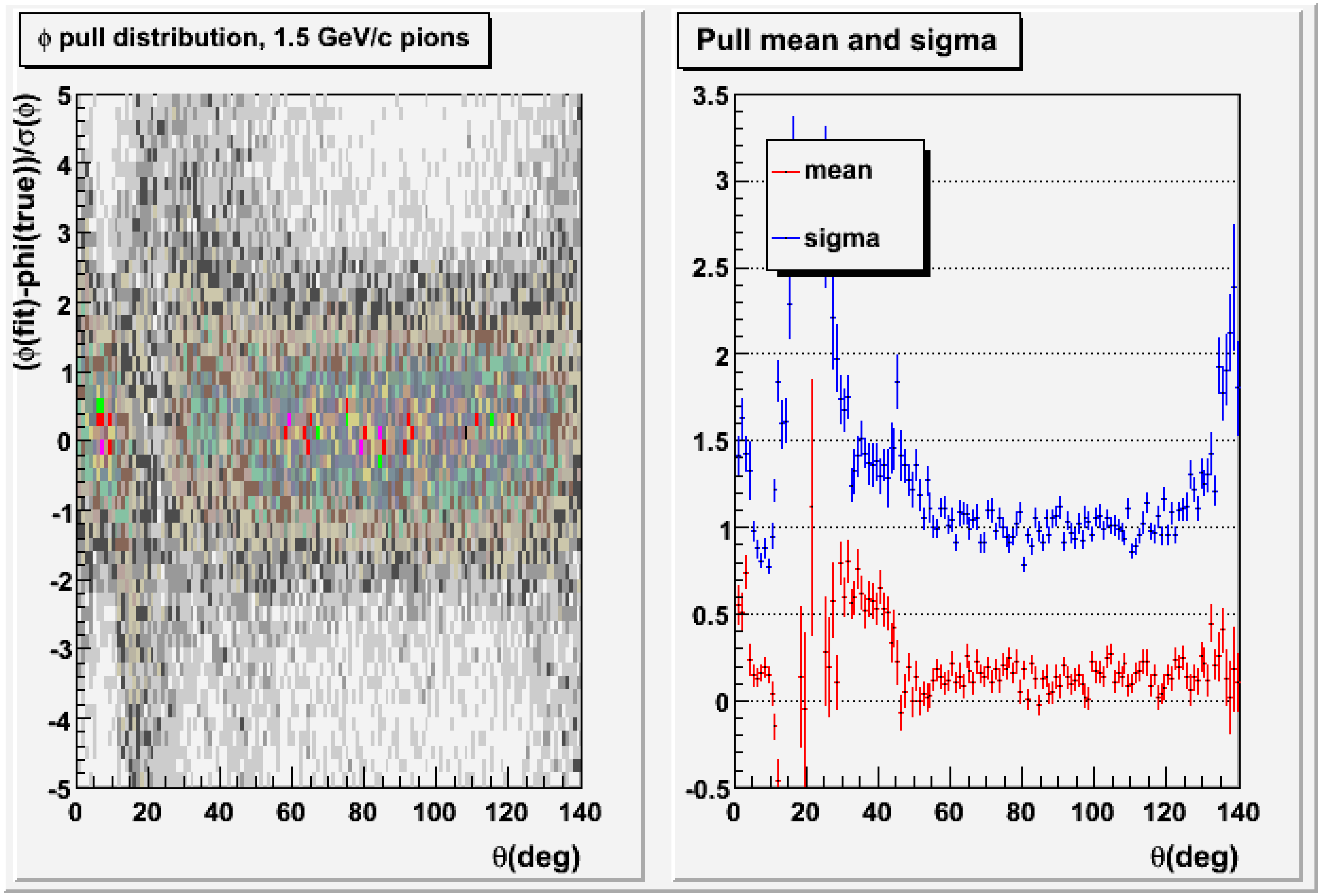




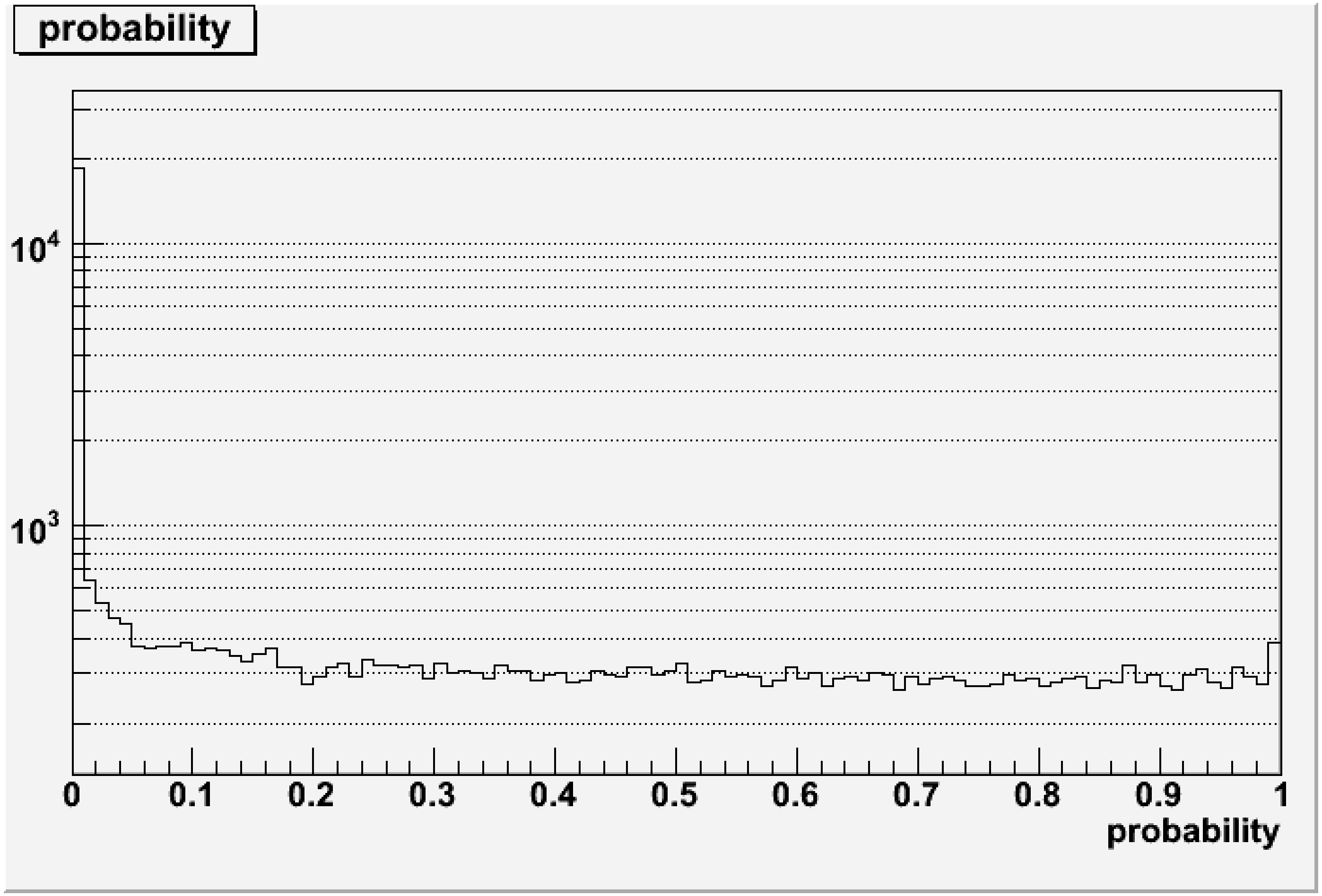
Pull Distribution for tanλ



Pull Distribution for ϕ



Probability distribution



Summary/Outlook

- Kalman filter now working well for $60° < \theta < 120°$
  - Pull distributions have mean ~ 0, σ ~ 1
  - Probability distribution is flat
- Code is failing for $\theta > 120°$ and $10° < \theta < 60°$
  - Still investigating source of discrepancy between Kalman filter and least squares fitter
  - Suspect issues with dealing with material (multiple scattering)
    - Do we need to include variations in position as well as angles?