

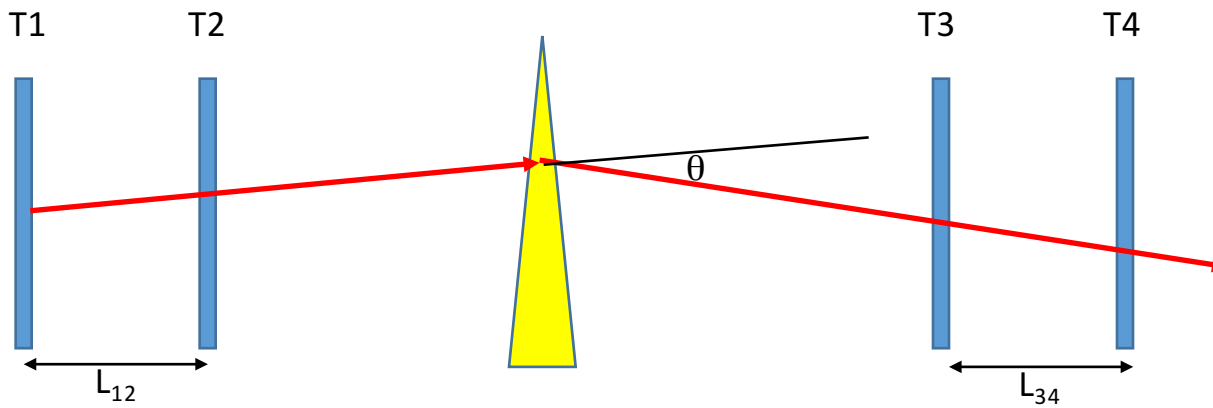
# Beam Spectrometer Resolution

“Back-of-the-envelope calculation”

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- Quick analytical calculation to estimate the expected momentum resolution of the spectrometer for various scenarios for ProtoDUNE-SP
- A good starting point for Nikos to run full GEANT4 simulation to refine the setup
- Using a pair of trackers both upstream and downstream of the dipole magnet → measure the difference of two vectors
- Ignoring space constraints and other effects (e.g. multiple scattering, misalignment, etc.) at the moment



$\sigma_x$  (mm)= point resolution of T1-4 trackers

$\theta \approx 0.118 \text{ rad}$  (nominal bend angle for H4 beamline)

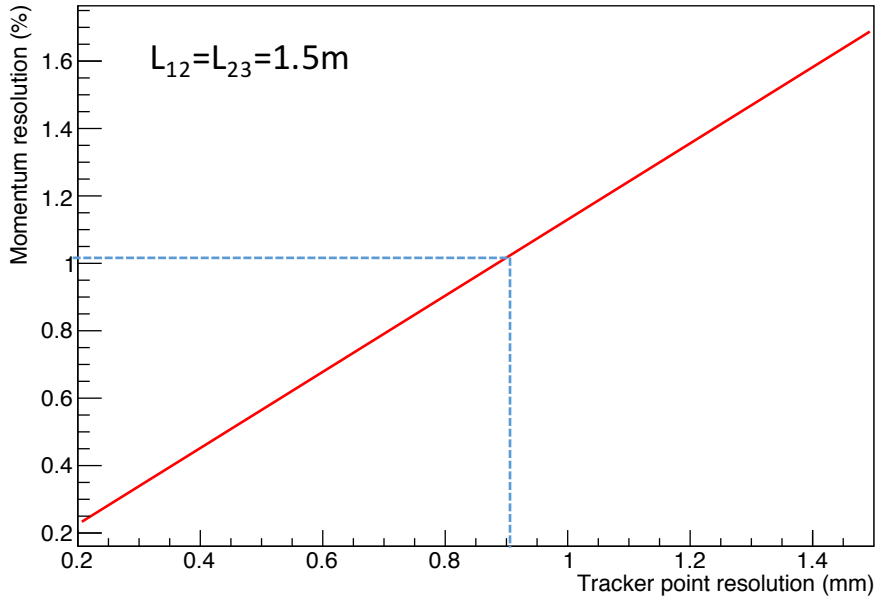
$\Delta\theta_{12}$  (rad)=angular uncertainty of T1 to T2 vector

$\Delta\theta_{34}$  (rad)=angular uncertainty of T3 to T4 vector

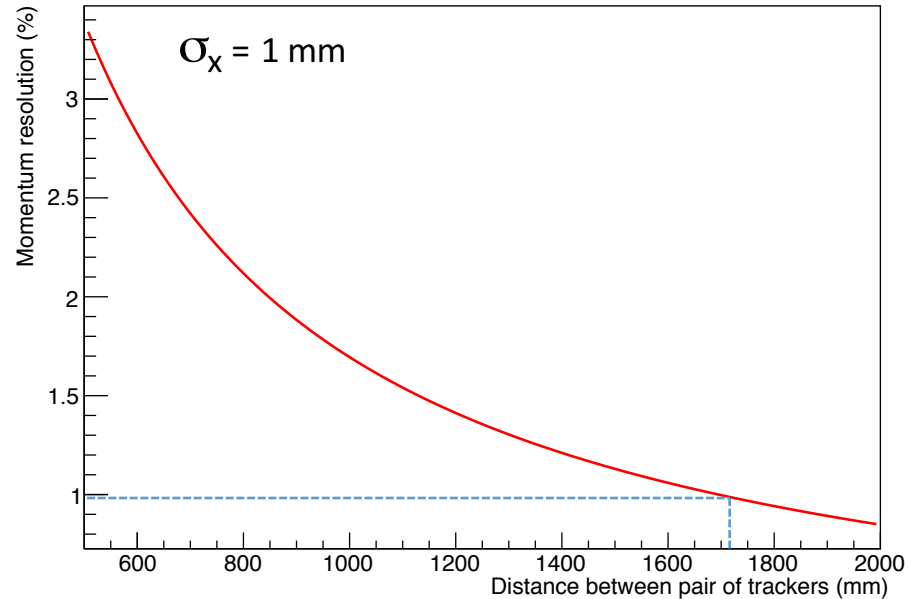
$$\Delta\theta = \sqrt{\Delta\theta_{12}^2 + \Delta\theta_{23}^2} = \sqrt{2 \left(\frac{\sigma_x}{L_{12}}\right)^2 + 2 \left(\frac{\sigma_x}{L_{34}}\right)^2}$$

$$\frac{\Delta P}{P} = \frac{\Delta\theta}{\theta} \approx \frac{\sqrt{2 \left(\frac{\sigma_x}{L_{12}}\right)^2 + 2 \left(\frac{\sigma_x}{L_{34}}\right)^2}}{0.118 \text{ rad}}$$

## Dependence on the Point Resolution of Tracker



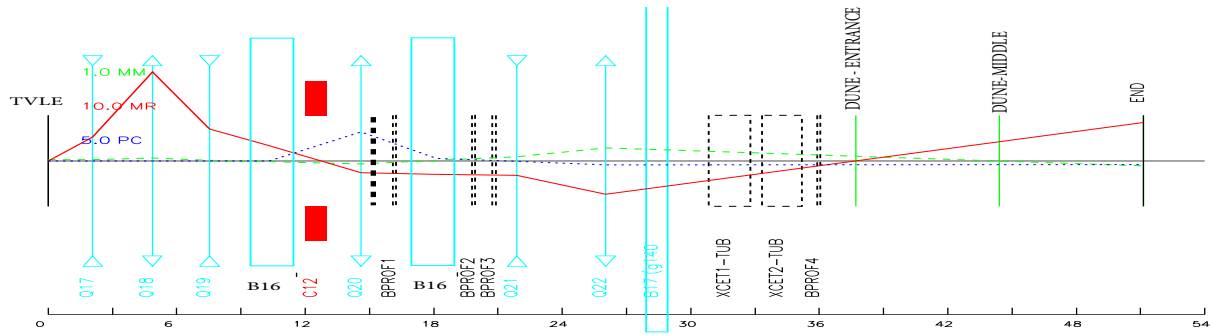
## Dependence on the Distance Between Pair of Tracker



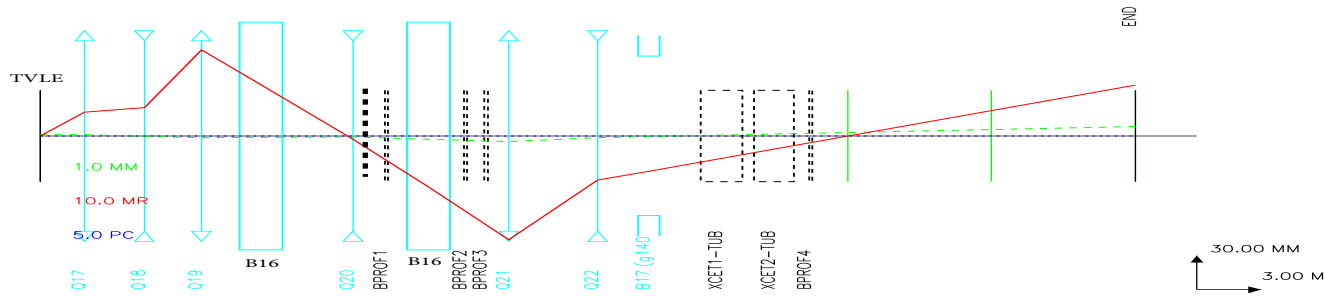
Momentum resolution (to first order):

- scales linearly with the point resolution of the tracker
- Inversely proportional to the distance between the trackers
- largely independent of the distance of the trackers from the dipole magnet

Nikos should cross-check the results with full GEANT4 simulation



H4 beam to Single Phase ProtoDune  
27/05/2016



### Optimizing the placement for the trackers:

- For four trackers system, maximize the distance between trackers,  $L_{12}$  and  $L_{34}$ .
- If  $L_{12}$  and  $L_{34}$  can be at least 1.7m, then tracker position resolution on the order of 1mm seems adequate to achieve  $\Delta P/P$  on the order of 1% (ignoring other systematic effects at the moment)