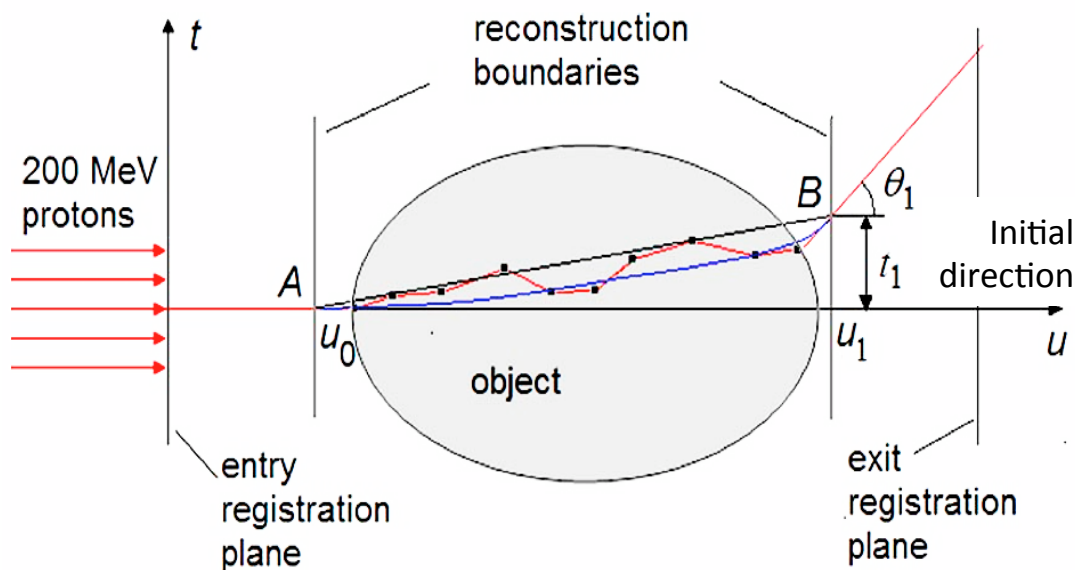


Why do we need proton radiography/CT?

- ✦ Proton radiography/CT imaging has a big potential to minimize the uncertainties of proton stopping powers (PSP) from 3-5% or bigger (currently used in clinics) down to 1%. This is necessary to make an accurate proton treatment plan for the patient and spare surrounding healthy tissues
- ✦ Proton radiography/CT delivers PSP directly, thus model independent

The idea/Concept → Physics-Statistics-Computing (PSC)



[1] T. Li et al., *Med Phys* **33** (3) 699-706

Algorithms used for reconstruction:

- Filtered Back Projection (FBP) assumes a **proton traversing materials in straight lines**
- Most Likely Path (MLP) predicts FWHM of Multiple Coulomb Scattering (MCS) distribution for **homogeneous materials** using Gaussian approximation
- FBP along MLP (**homogeneous phantom**) considers curved most likely path of each proton
- Backprojection-then-filtering approach (BPF), a reverse approach of FBP with **cubic spline**, has an advantage in omitting binning requirement in FBP (non-linear paths of protons, **phantom with various densities**)

Ultimately

↓ PSC

Physics (MCS)

Statistics (straggling, statistical models)

Computing (parallel computing CPU/GPU)

- ◆ Multiple Coulomb Scattering (MCS) of a proton in various tissues (different densities) of the patient needs to be considered (main cause of image blurring)
- ◆ Development of algorithm, in which a proton path is followed in various tissues
- ◆ Development of an application specific reconstruction algorithm with an optimized mathematical model
- ◆ The computation time of the proton radiography/CT image should not exceed a few seconds to deliver an accurate PSP map of the patient (clinically acceptable)
- ◆ Reconstruction algorithm should work in combination with a fast and compact proton radiography/CT imaging system to be clinically applicable

} Proton does not travel in a straight line

} Tuning for a proton radiography/CT application

} Fast

} Compatible with the experimental system

Potential Impact

A more accurate proton stopping power map reconstruction will provide a fast feedback to proton treatment planning software (TPS) to re-plan the treatment when required (i.e. anatomical changes during the course of treatment) to fully benefit from proton therapy