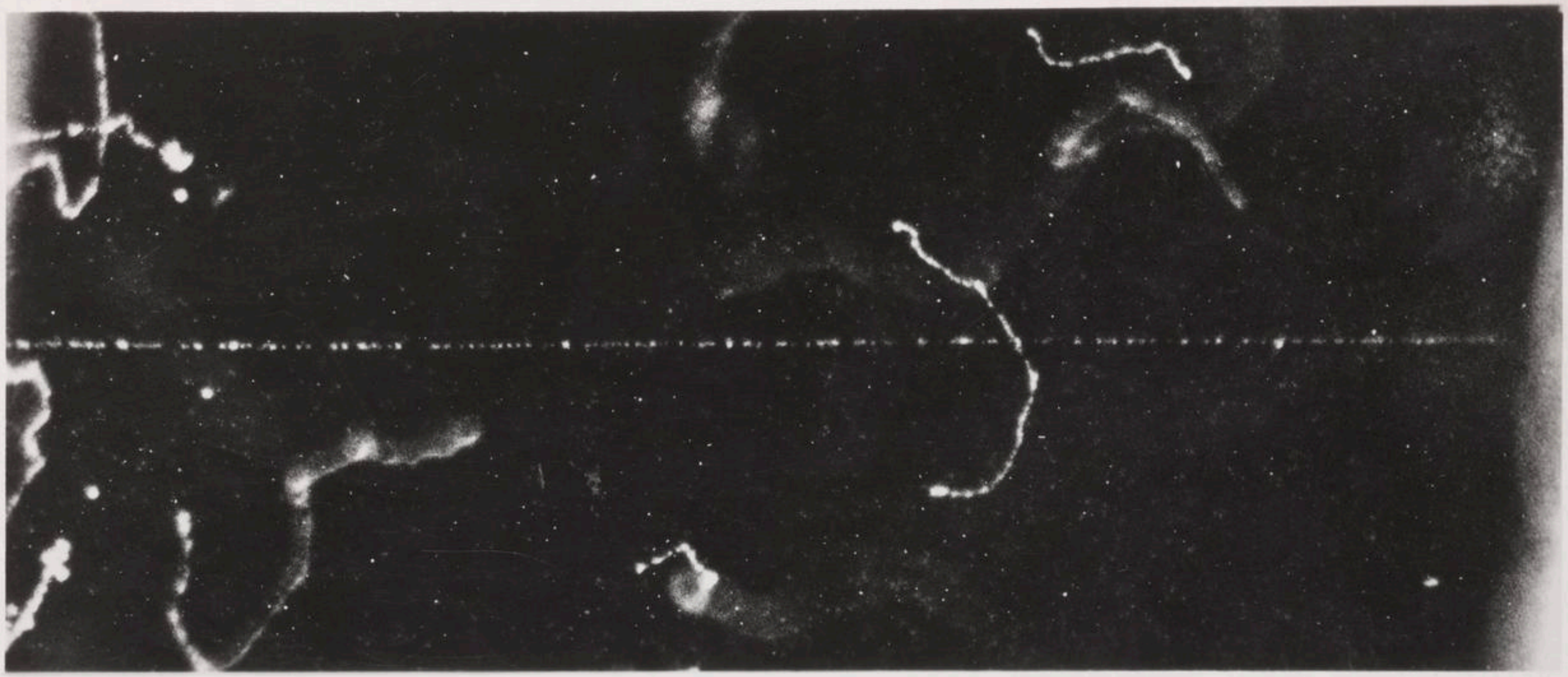


Science Museum Group. Two black and white photographic print of electron tracks in the Wilson cloud chamber (1948-67).

USING THE EVENT ACTION

LESSON 6

RANGE OF ELECTRONS

- Simulate electrons with different energies propagating in different materials
- Estimate the CSDA range and the projected range
  - CSDA = continuous-slowing-down approximation
  - Rate of energy loss at every point along the track is assumed to be equal to the total stopping power
  - Obtained by integrating the reciprocal of the total stopping power with respect to energy
- Compare CSDA range with NIST values
- Use E = 10 keV, 100 keV and 1 MeV
- In air (ϱ=1.205 mg/cm3) and soft tissue (ϱ=1.05 g/cm3)

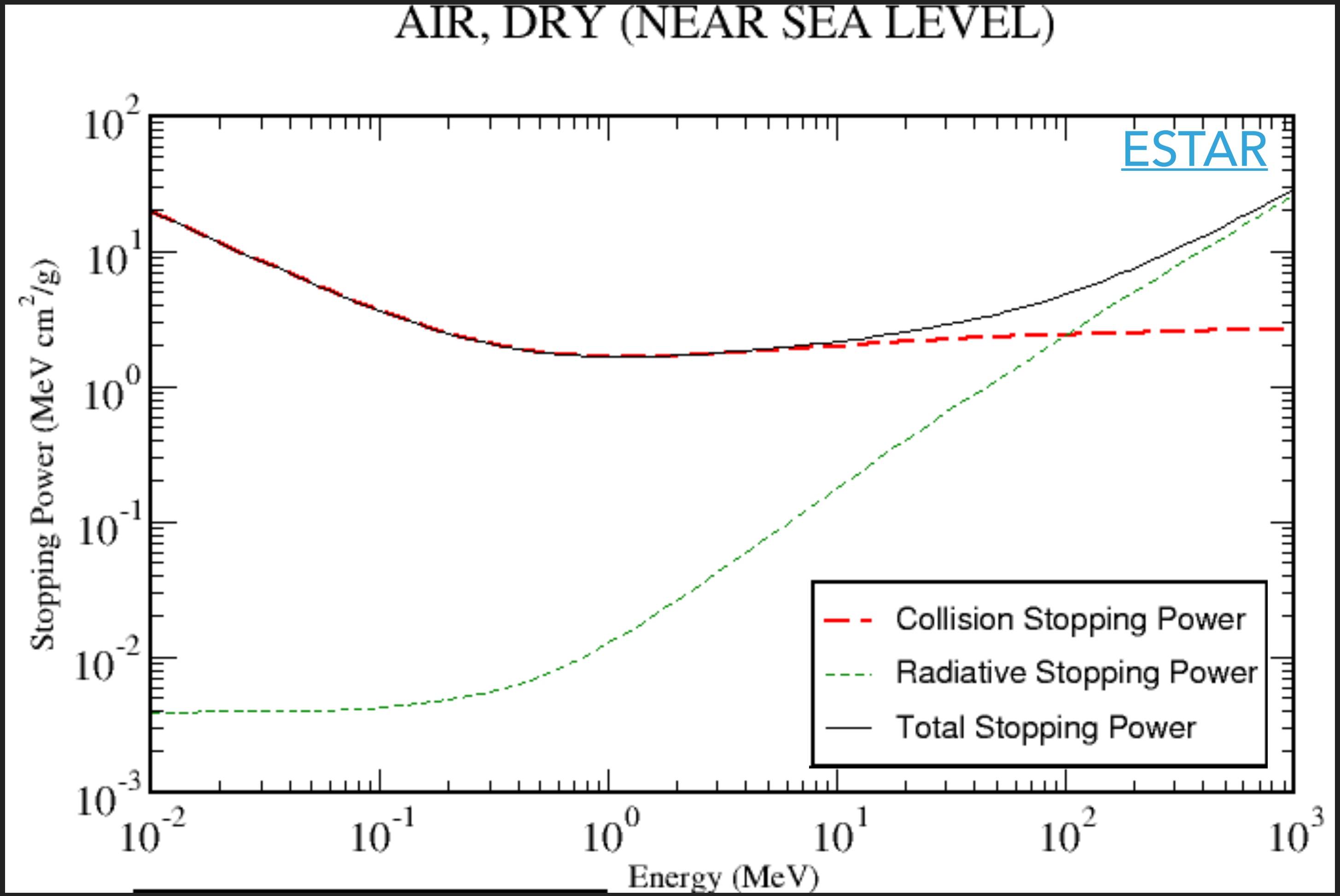
RANGE OF ELECTRONS

- Get the eRange.zip simulation skeleton from lip.pt/~alex/G4Classes/Examples
- We will use NIST materials in GEANT4
  - much easier to define
  - standard materials that can be compared by everyone
  - makes sense given that we're comparing with NIST ranges
- G4_Air and G4_MUSCLE_SKELETAL_ICRP
  - Check full list of materials here: http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/ForApplicationDeveloper/html/Appendix/materialNames.html
  - You can compare these with NIST materials here: http://physics.nist.gov/cgi-bin/Star/compos.pl

RANGE OF ELECTRONS

- Check (and modify if needed) the mandatory classes
  - Detector construction, PrimaryGenerator
- Compile and run the simulation in interactive mode
  - Use ***/tracking/verbose 1*** followed by ***/run/beamOn 1*** to get details on what is going on
  - You can get the CSDA range from the total track length
  - **Note that there are usually secondary electrons**
- Modify the SteppingAction to write out the CSDA range
  - What is the best way to identify the primary electrons?

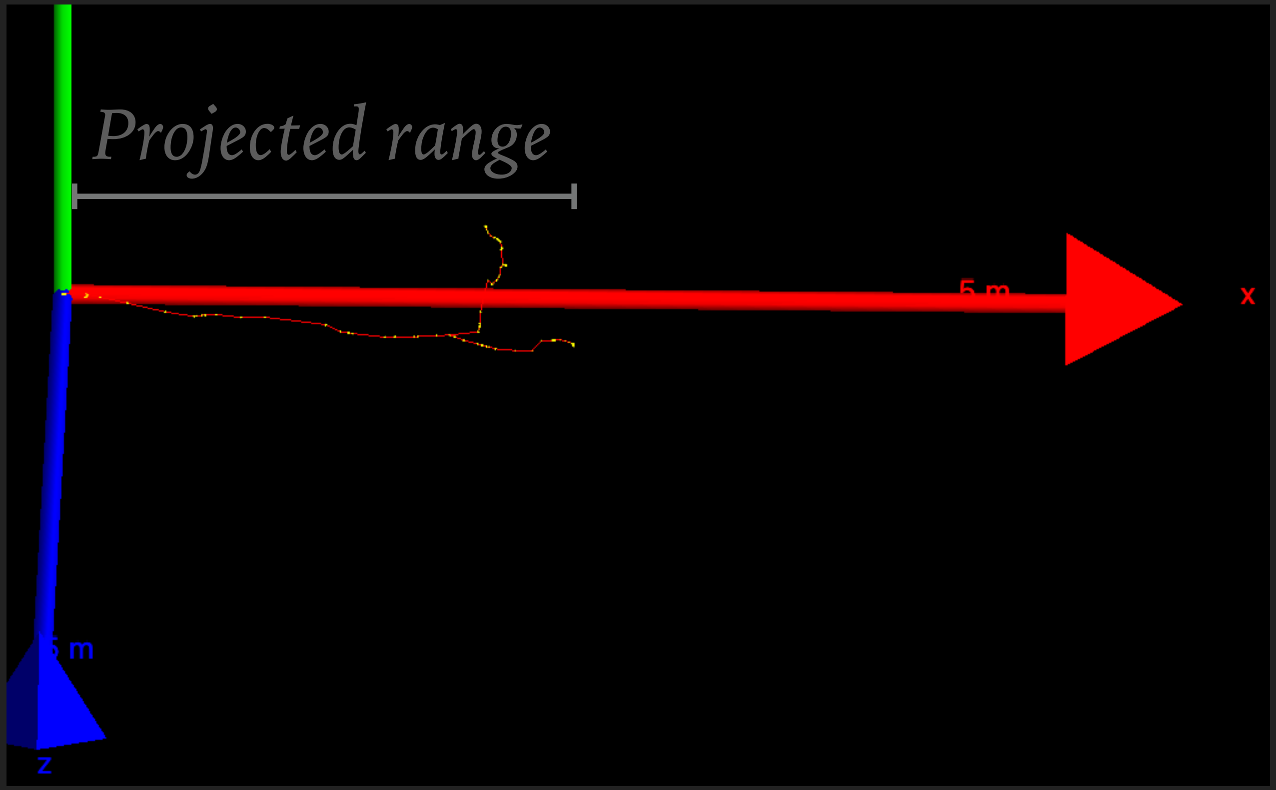
RANGE OF ELECTRONS



Energy (MeV)	Range in air [cm] (ϱ=1.205 mg/cm³)		Range in muscle tissue [cm] (ϱ=1.04 g/cm³)	
	R_{CSDA} (cm)	R_{proj} (cm)	R_{CSDA} (cm)	R_{proj} (cm)
0,01	0,24		2.4×10^{-4}	
0,1	13,5		1.4×10^{-2}	
1	408		0,42	

PROJECTED RANGE

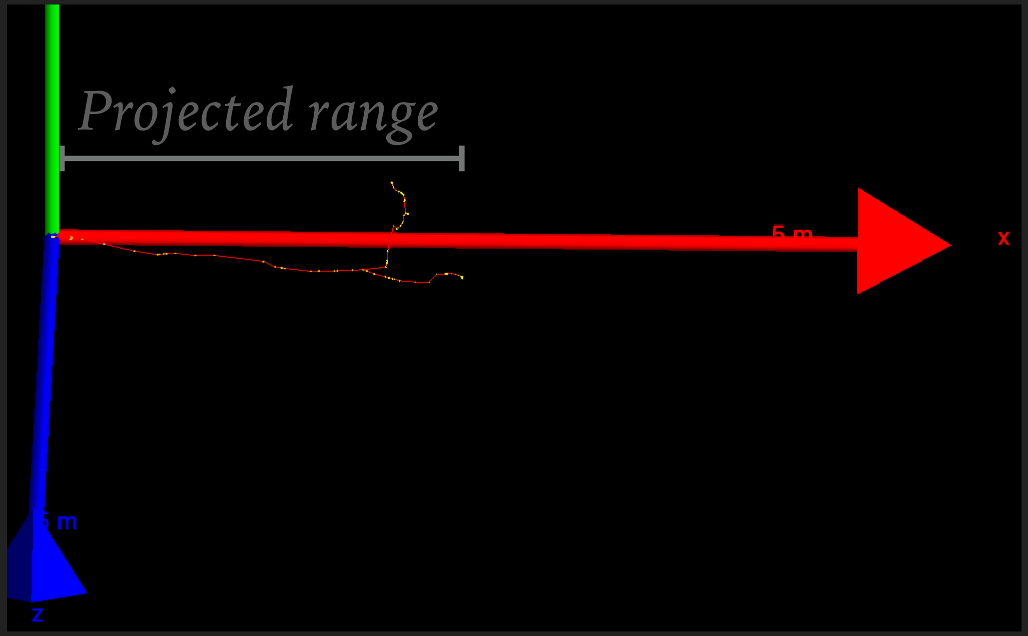
- Let us define"projected range" as the maximum depth an electron reaches along its initial direction

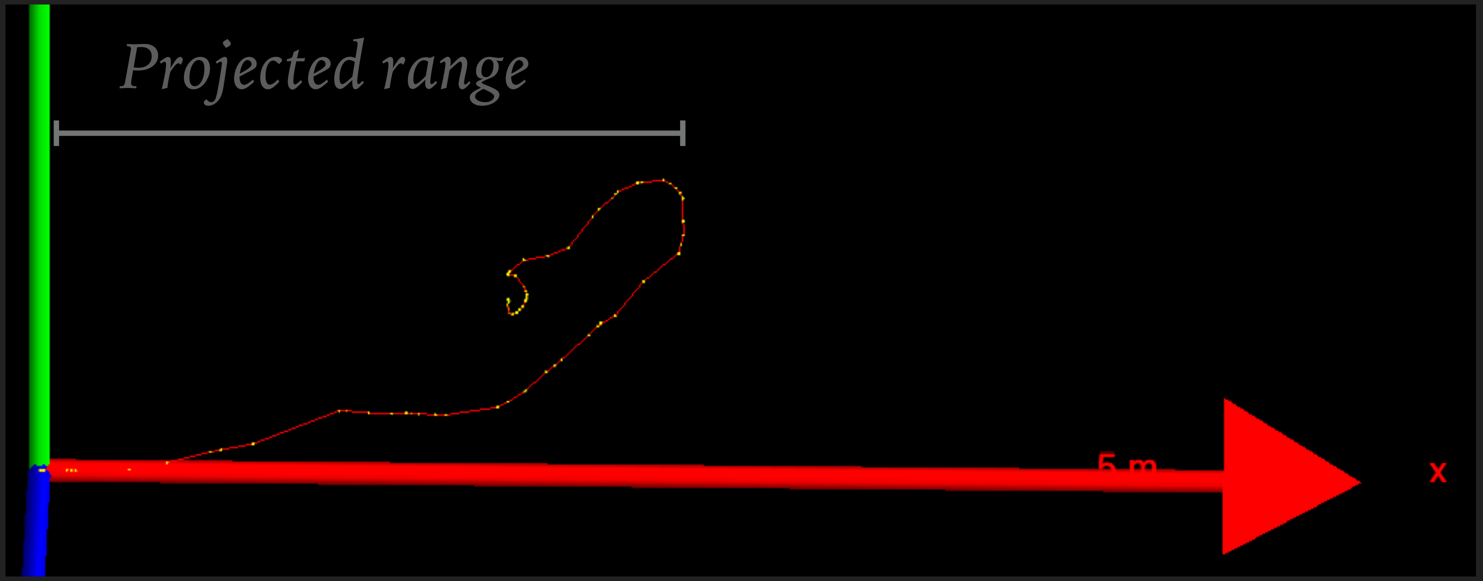


- For the CSDA range we just used the total length of the track
- How can we get the projected range?

PROJECTED RANGE

- Sometimes (many times) the point with maximum projected range will not coincide with the end point





- How do we handle these cases?
- In the SteppingAction class we don’t have access to the history of the track, only to it’s current status

EVENT ACTION

- This cannot be done using the SteppingAction class
  - Inside this class we do not have access to the history of the track, only the current “local” step
- This is where the **EventAction** class is helpful
  - It provides 2 methods: one is called at the start of each event and the other at the end
  - We can use them to initialise variables (at the beginning) and write them to file (at the end), and these variables live (and are accessible) throughout the entire event
  - We can have a variable to store the maximum projected range, and update it at each step in the SteppingAction
- Edit SteppingAction and EventAction as needed to store the CSDA and projected ranges for each event
- Make histograms of both these quantities and compare them. You can also make a 2D plot to compare them directly