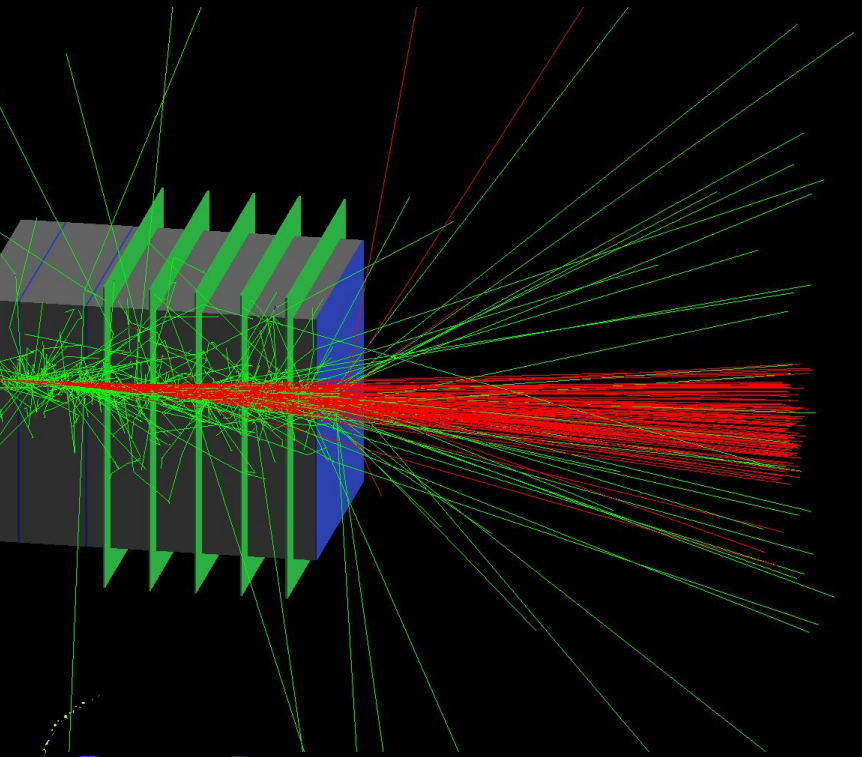


GEANT4 Modelling of a Si-W Sampling Calorimeter

NİSA BETÜL YILDIRIM

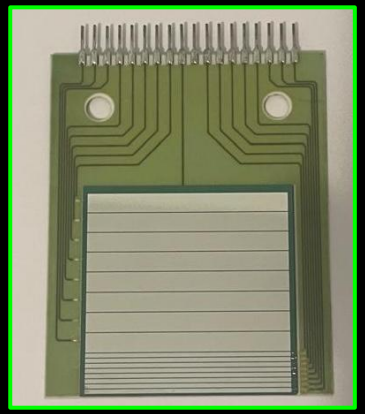
PART I — Physical Motivation & Detector Layout

Silicon Strip & Full-Area Detectors



FAD

50 x 50 mm² detector



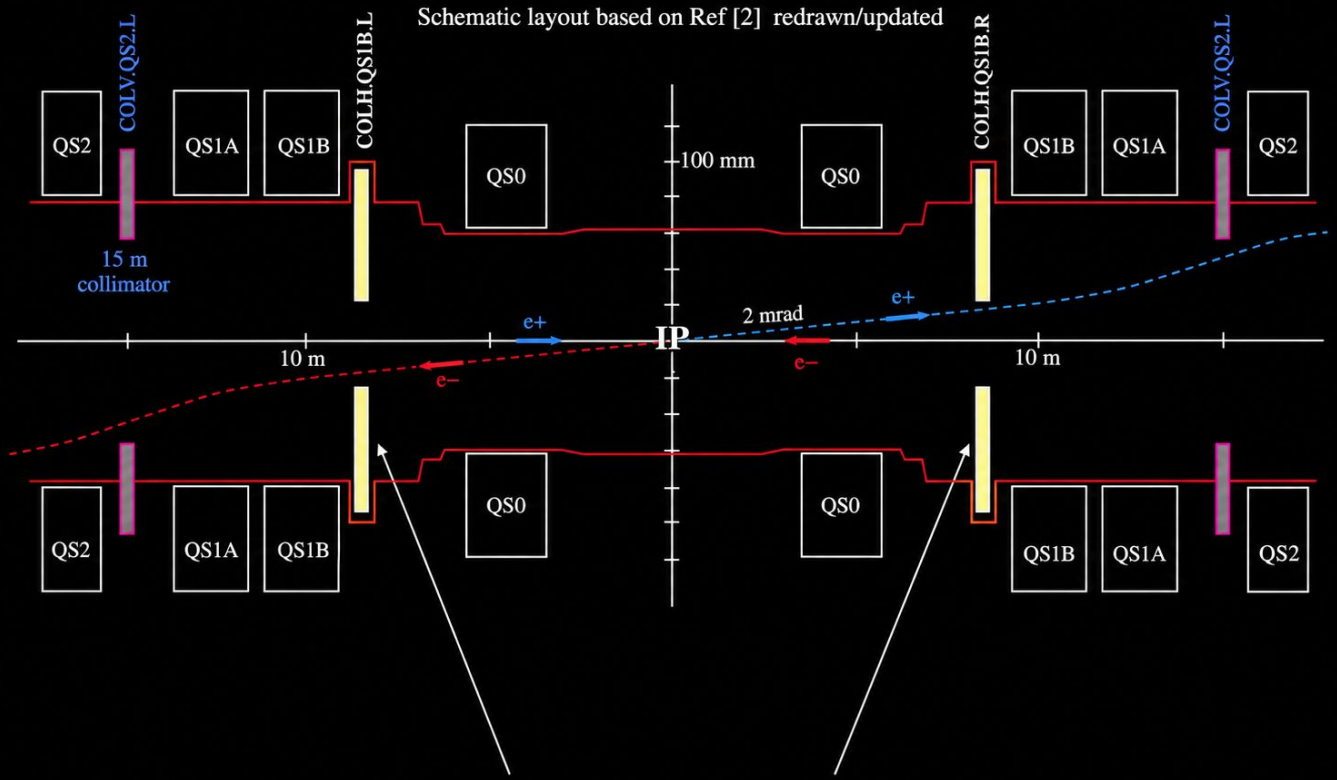
SSD

40 x 40 mm² detector
16 vertical strips:
8 strips x 1 mm
8 strips x 4 mm
Silicon thickness:
300 µm silicon





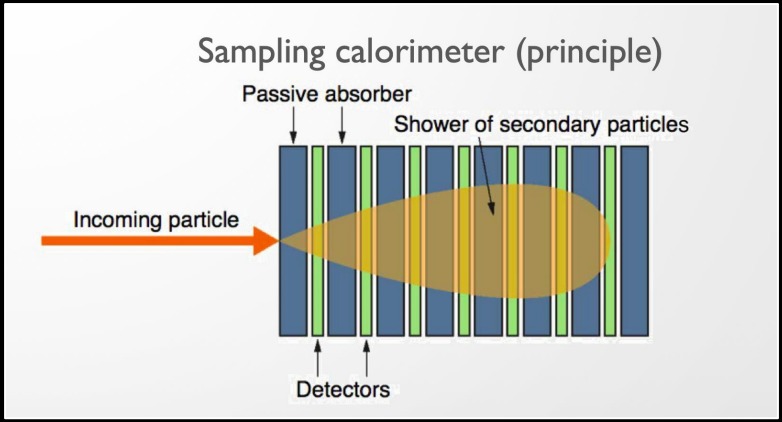
LEP Machine Low Angle Bhabha Monitor, Layout



Instrumented horizontal 8.5 m collimator

SAMPLING CALORIMETER

A sampling calorimeter consists of alternating layers of passive absorbers and active detectors

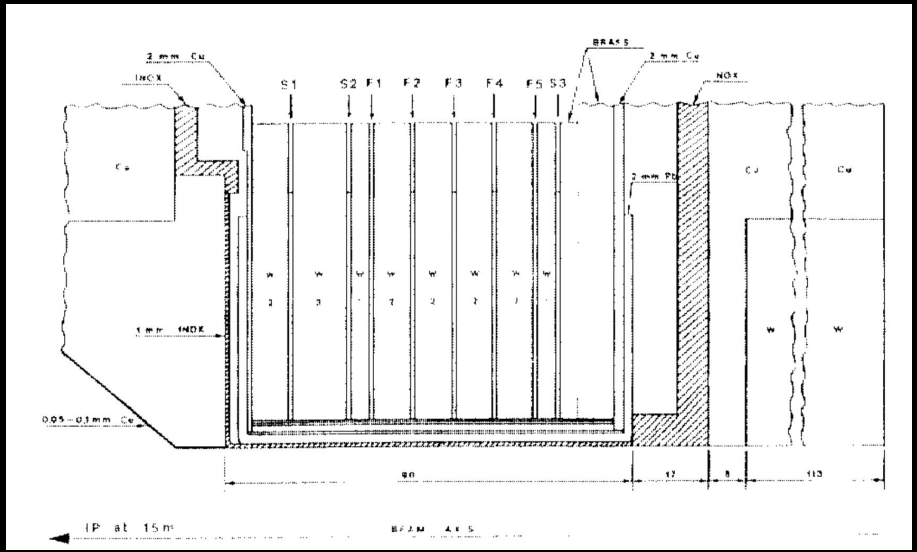


Typical active detectors:

- Plastic or crystal scintillators
- Silicon detectors
- liquid noble gas ionization chambers
- Gas detectors

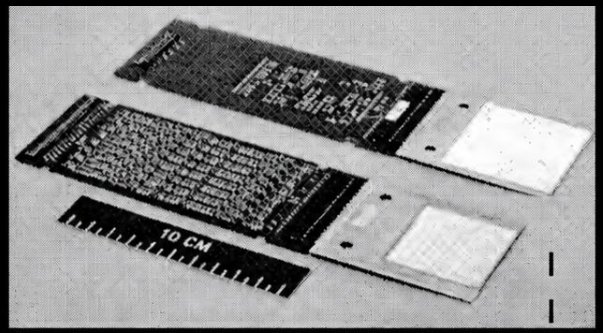
Typical absorbers are materials with high density,

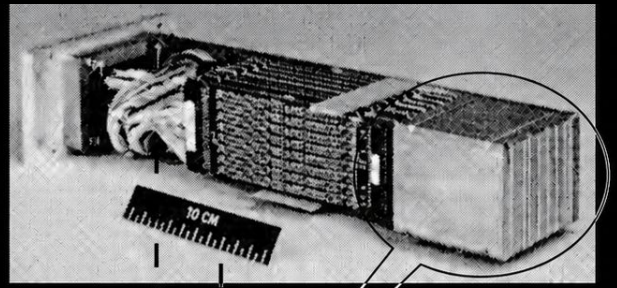
- e.g.: Fe, Pb, U

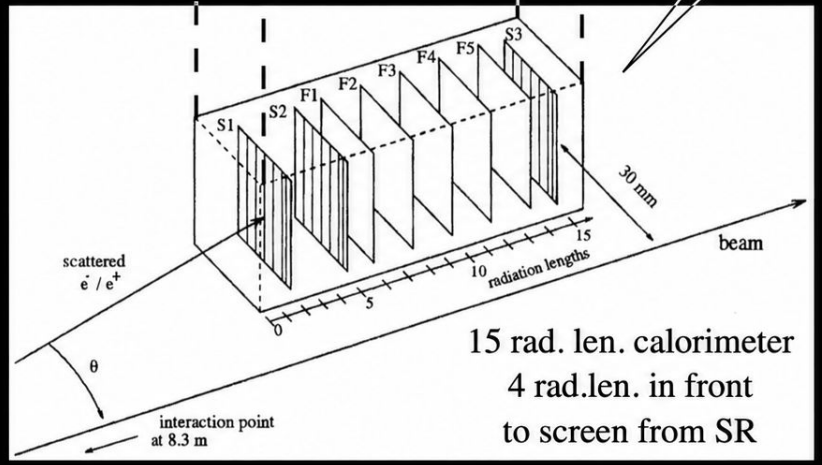


Cross-sectional view of the Si-W calorimeter (LEP Bhabha Monitor)

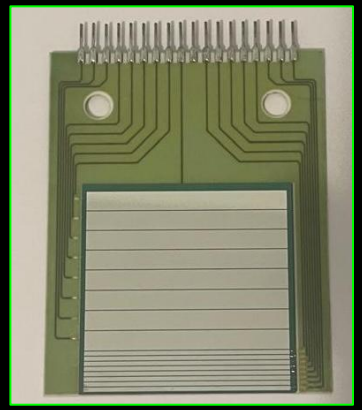
Si–W Calorimeter and Silicon Detector Layout







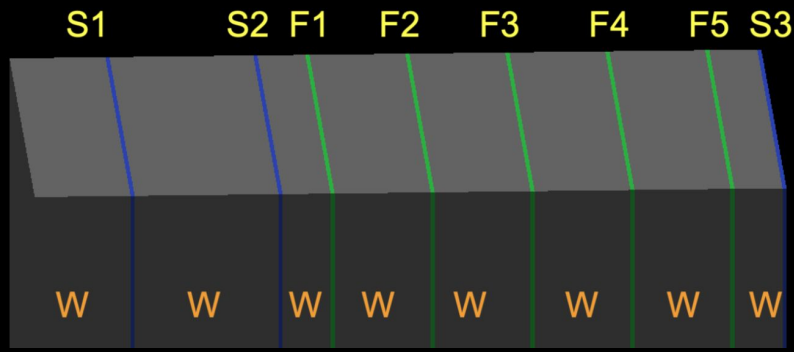




PART II — Geant4 Modelling & Physics Results



Geant4 Detector Model



$S1=2X_0$

$S2=5X_0$

$F1=6X_0$

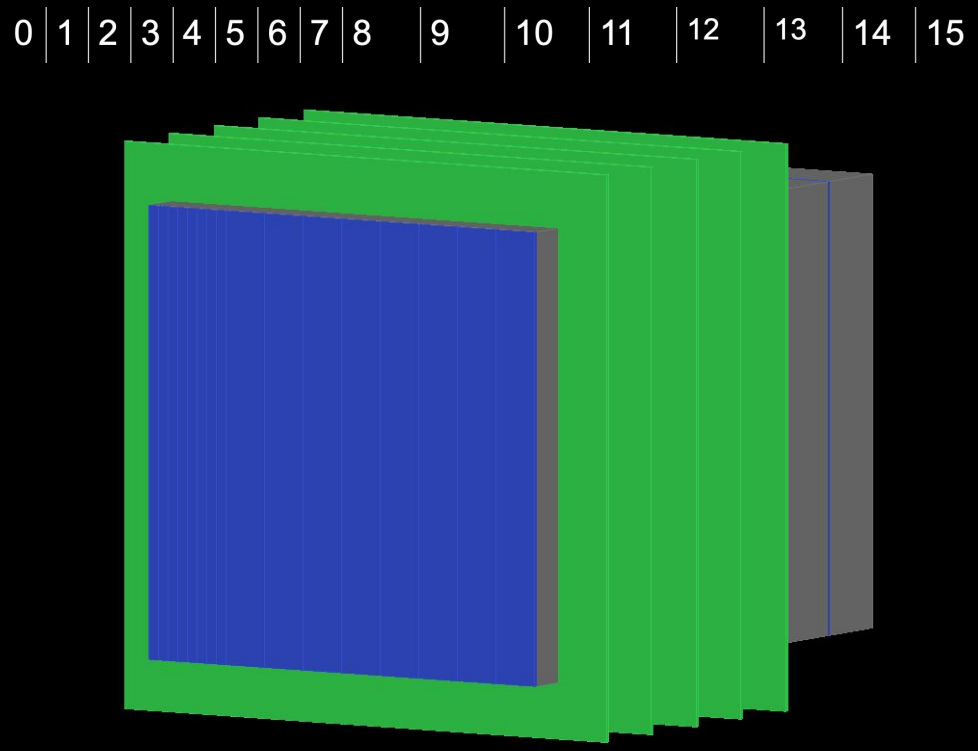
$F2=8X_0$

$F3=10X_0$

$F4=12X_0$

$F5=14X_0$

$S3=15X_0$

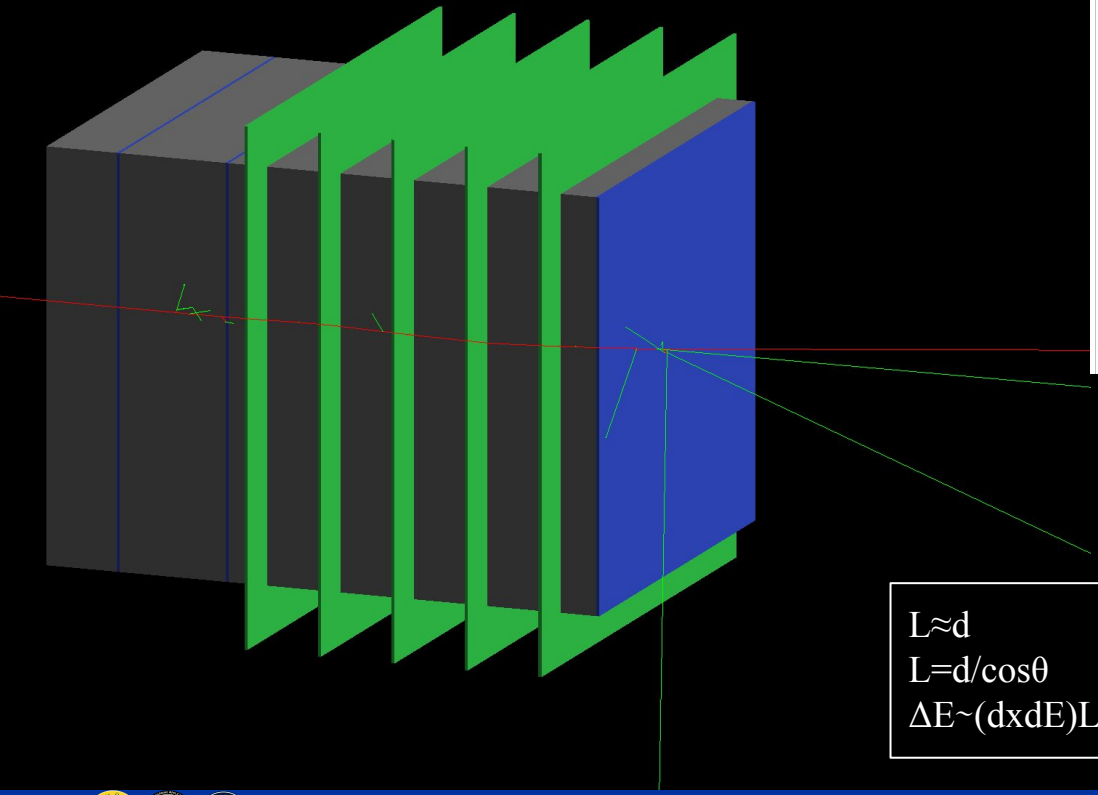


Simulation Architecture

LEPSimulation/

- CMakeLists.txt
- Main (.cc)
- src/
  - DetectorConstruction.cc
  - PhysicsList.cc
  - ActionInitialization.cc
  - EventAction.cc
  - RunAction.cc
  - SteppingAction.cc
  - TrackerSD.cc
  - FullAreaSD.cc
  - Analysis.cc
- include/
  - DetectorConstruction.hh
  - PhysicsList.hh
  - ActionInitialization.hh
  - EventAction.hh
  - RunAction.hh
  - SteppingAction.hh
  - TrackerSD.hh
  - FullAreaSD.hh
  - Analysis.hh

Single-Event Simulation : 1 GeV μ^-



```
G4WT3 > ========== EVENT 0 SUMMARY ==========
G4WT3 > First W entry energy     : 1000 MeV
G4WT3 > Last W exit energy       : 853.641 MeV
G4WT3 > Primary energy decrease  : 146.359 MeV
G4WT3 > Tungsten energy loss     : 145.086 MeV
G4WT3 > Tungsten total Edep      : 98.7347 MeV
G4WT3 > Tungsten path length     : 52.6266 mm
G4WT3 > muIoni steps             : 17
G4WT3 > CoulombScat steps        : 1
G4WT3 > Transportation steps     : 8
G4WT3 > Secondary particles      : 17
G4WT3 > Secondary e-             : 17
G4WT3 > Secondary gamma          : 0
G4WT3 > Secondary e+             : 0
G4WT3 > Secondary other          : 0
G4WT3 > Secondary e- kinetic E   : 46.351 MeV
```

```
========== STRIP SILICON ==========
G4WT3 > S1 total Edep : 69.2843 keV
G4WT3 > S2 total Edep : 287.095 keV
G4WT3 > S3 total Edep : 78.3437 keV
G4WT3 > ================================
```

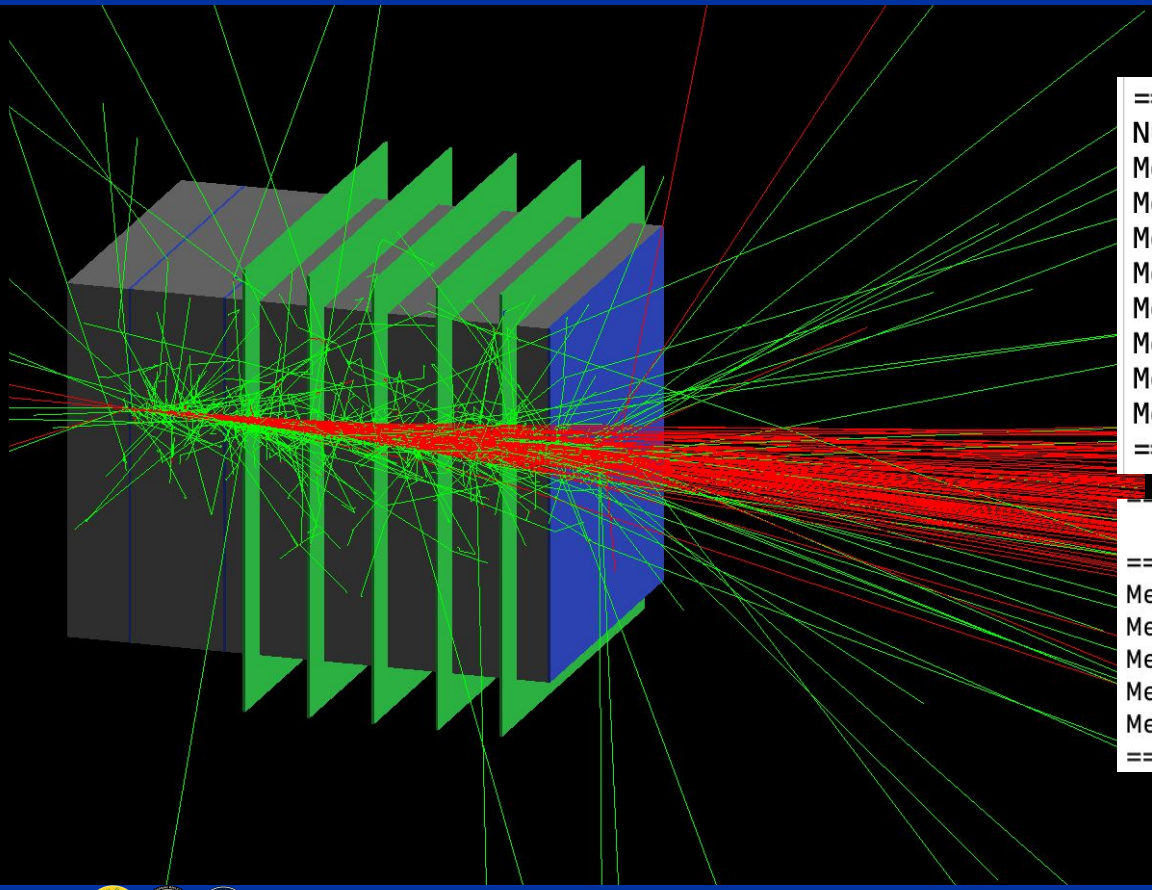
$L \approx d$

$L = d/\cos\theta$

$\Delta E \sim (dxdE)L$

```
========== FULL AREA SILICON ==========
G4WT3 > F1 Edep : 185.506 keV
G4WT3 > F2 Edep : 156.524 keV
G4WT3 > F3 Edep : 113.424 keV
G4WT3 > F4 Edep : 295.147 keV
G4WT3 > F5 Edep : 161.923 keV
```

100-Event Simulation: 1 GeV μ^-



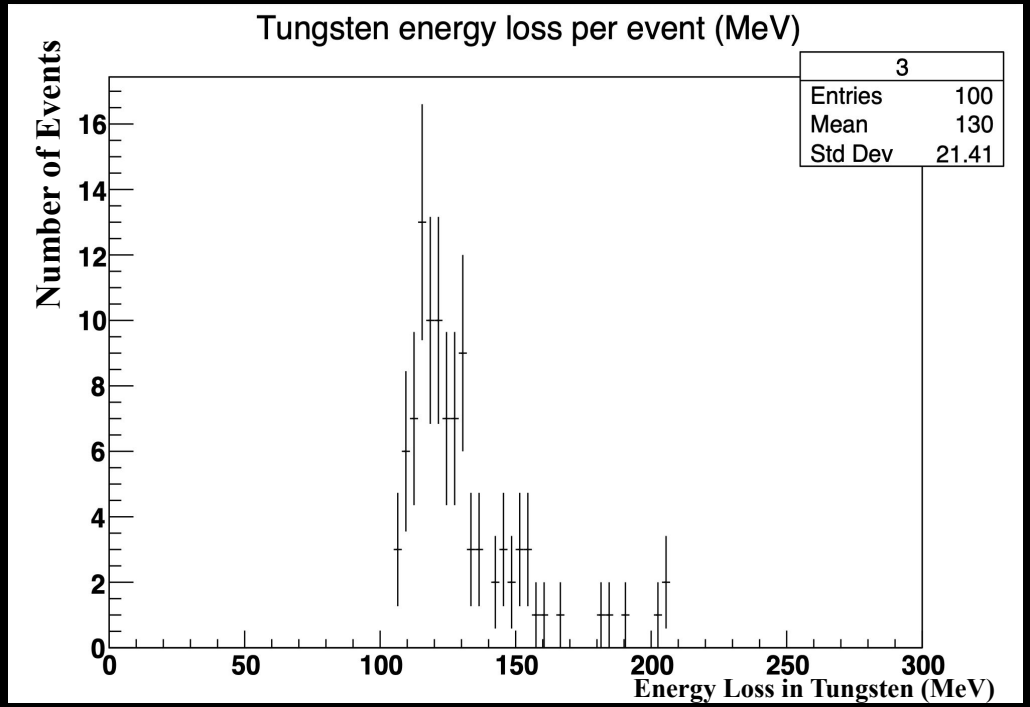
```
========== RUN SILICON SUMMARY ==========
Number of events : 100
Mean S1 Edep : 127.652 keV
Mean S2 Edep : 123.311 keV
Mean S3 Edep : 124.716 keV
Mean F1 Edep : 117.162 keV
Mean F2 Edep : 128.344 keV
Mean F3 Edep : 116.254 keV
Mean F4 Edep : 108.937 keV
Mean F5 Edep : 111.408 keV
=========================================
```

```
==========================================

========== RUN TUNGSTEN SUMMARY ==========
Mean W energy loss : 130.039 MeV
Mean W Edep : 99.2789 MeV
Mean W path length : 52.653 mm
Mean secondary e- count : 17.73
Mean secondary e- kinetic E : 30.0085 MeV
==========================================
```

Event-by-Event Analysis with ROOT

Tungsten energy-loss distribution for 1 GeV primary μ−:



$$N_{\text{events}} = 100$$

$$\langle \Delta E_W \rangle = 130.04 \text{ MeV}$$

$$\sigma_{\Delta E_W} = 21.41 \text{ MeV}$$

Results and Next Steps

Results

- Si–W detector geometry successfully implemented in Geant4
- Energy deposition obtained for all Si layers (S1–S3, F1–F5)
- Primary μ− transport through tungsten was analyzed
- Mean W energy loss: 130.04 MeV
- Mean W energy deposition: 99.28 MeV
- Mean secondary e− production: 17.73/event
- Event-by-event W energy-loss distribution obtained with ROOT
  σ=21.41MeV

Next Steps

- Increase event statistics
- Analyze Si energy-deposition distributions
- Study secondary-electron energy and multiplicity distributions
- Correlate W energy loss with Si detector response
- Compare simulation results with experimental measurements
- Refine the detector model using the real detector configuration

Thank you…