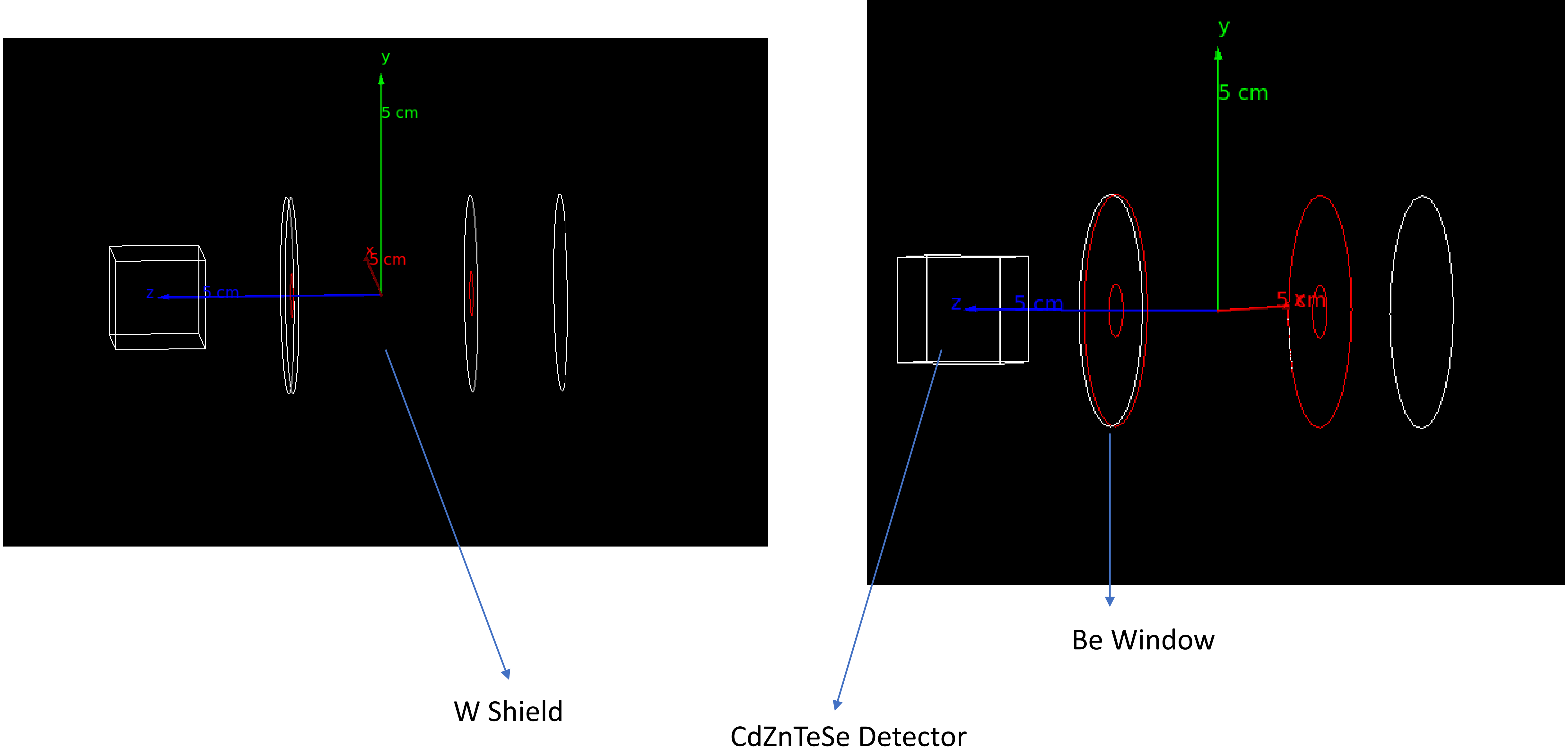
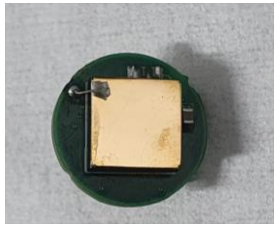
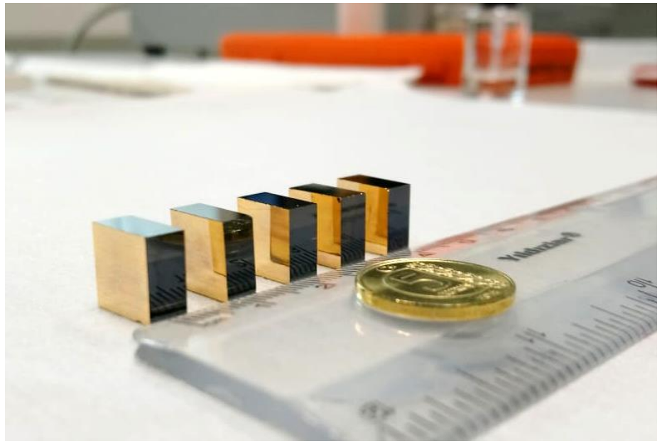
Geant4 Example: Energy Deposition

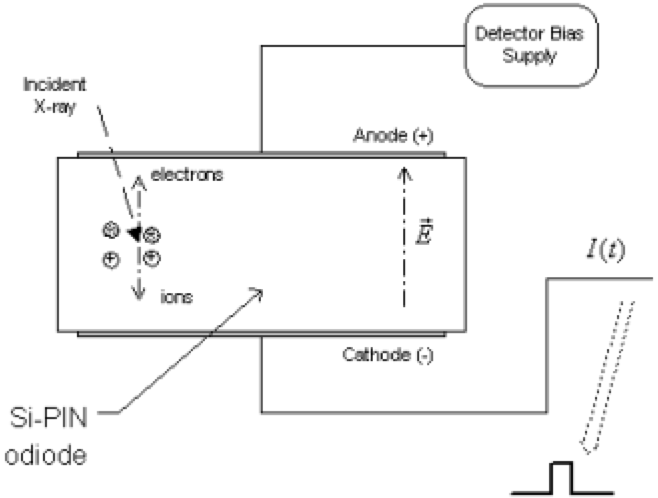
MEHMET CAN KARAMAN


y
5 cm
x
5 cm
z
5 cm
W Shield
CdZnTeSe Detector
Be Window

```cpp
elCd = new G4Element("Cadmium", "Cd", 48., 112.411*g/mole);
elZn = new G4Element("Zinc", "Zn", 30., 65.38*g/mole);
elTe = new G4Element("Tellurium", "Te", 52., 127.60*g/mole);
elSe = new G4Element("Selenium", "Se", 34., 78.971*g/mole);

double density = 5.8*g/cm3; // Assume or adjust based on literature/experimental data
CdZnTeSe = new G4Material("CdZnTeSe", density, 4); // 4 components

CdZnTeSe->AddElement(elm: elCd, nAtoms: 90);  // Proportion of Cd
CdZnTeSe->AddElement(elm: elZn, nAtoms: 10);  // Proportion of Zn
CdZnTeSe->AddElement(elm: elTe, nAtoms: 98); // Proportion of Te
CdZnTeSe->AddElement(elm: elSe, nAtoms: 2); // Proportion of Se*/
```

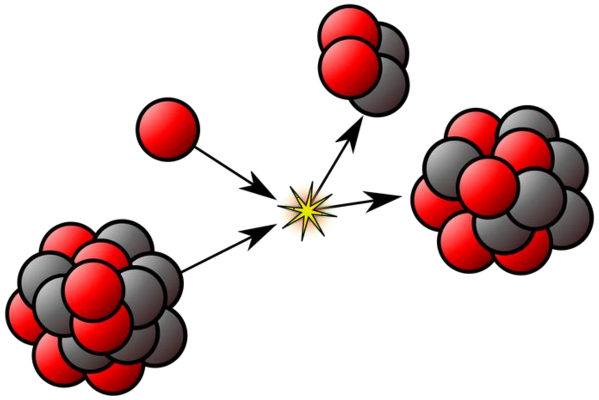






Less energy to create a pair → bigger signal, less intrinsic fluctuation
Higher density and atomic number for better stopping

```cpp
void MyPrimaryGenerator::GeneratePrimaries(G4Event *anEvent){

    G4ParticleDefinition *particle = fParticleGun->GetParticleDefinition();

    if(particle == G4Geantino::Geantino()){
        G4int Z = 55;
        G4int A = 137;
        G4double charge = 0*eplus;
        G4double energy = 0*keV;
        G4ParticleDefinition *ion = G4IonTable::GetIonTable()->GetIon(Z,A,E: energy);
        fParticleGun->SetParticleDefinition(aParticleDefinition: ion);
        fParticleGun->SetParticleCharge(aCharge: charge);
    }
    fParticleGun->GeneratePrimaryVertex(evt: anEvent);
}
```

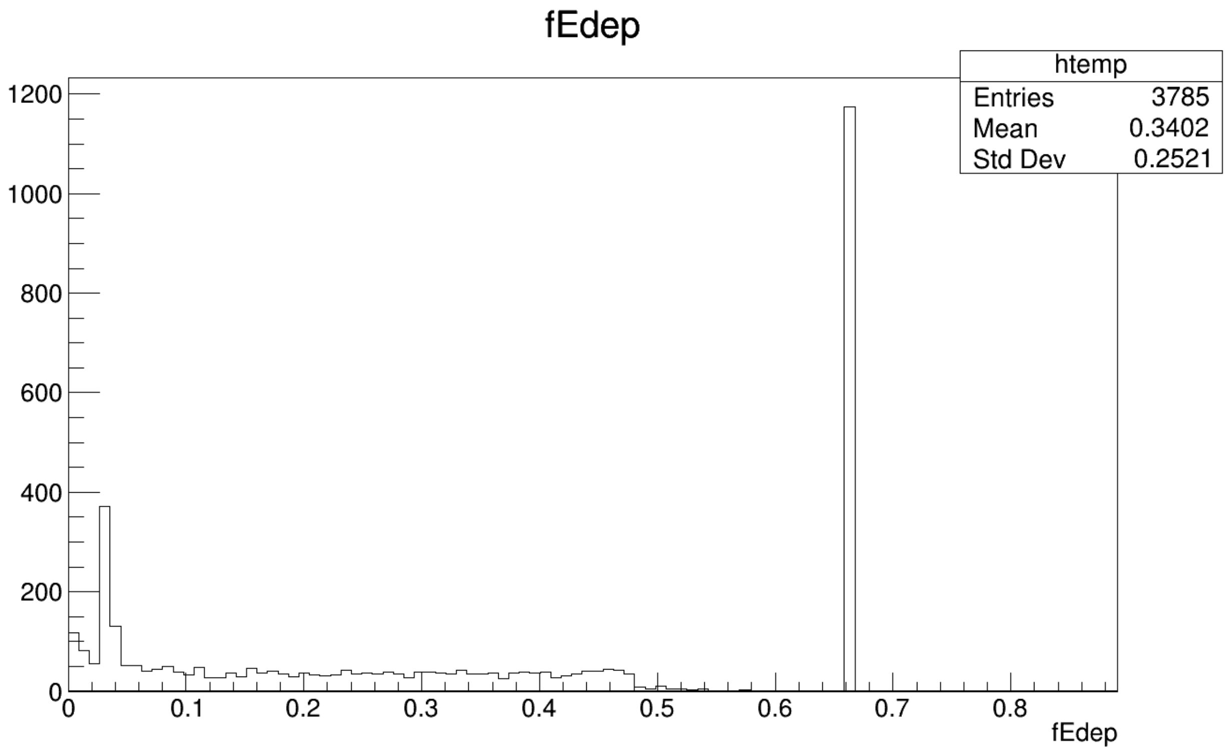


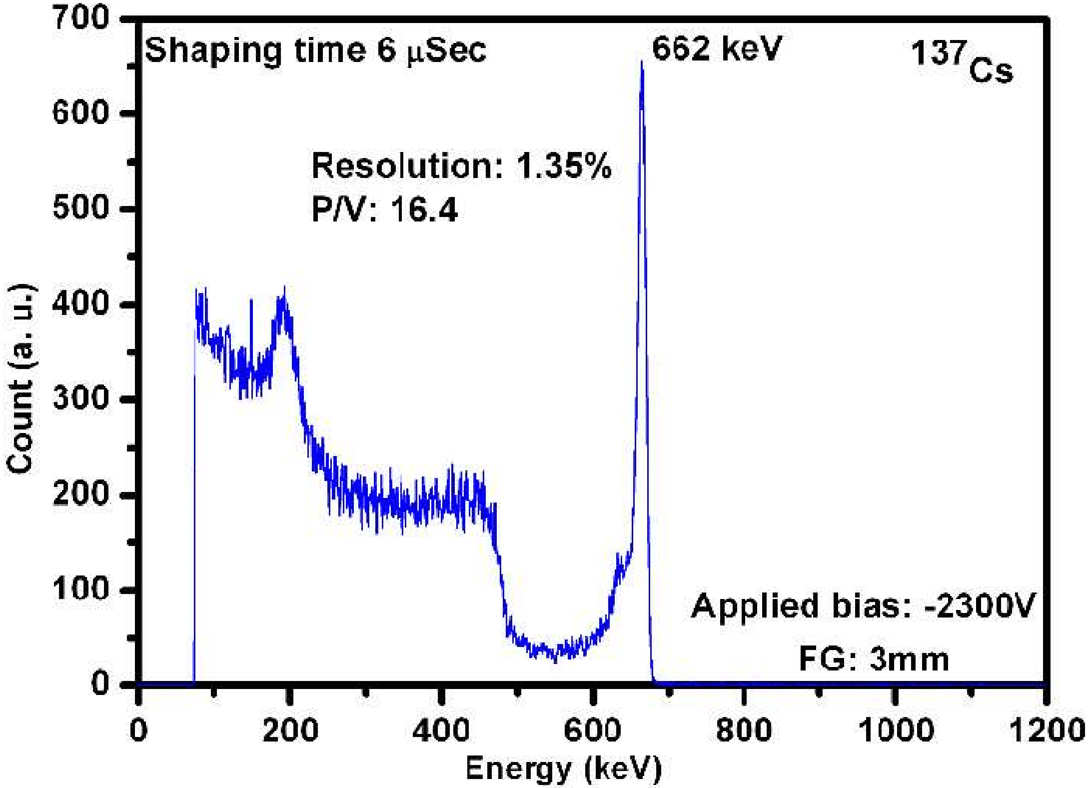
```cpp
void MySteppingAction::UserSteppingAction(const G4Step *step){

    const MyDetectorConstruction* detectorConstruction = static_cast<const MyDetectorConstruction*>(G4RunManager::GetRunManager()->GetUserDetectorConstruction());

    G4LogicalVolume* logicTube = detectorConstruction->GetLogicTube();
    G4LogicalVolume* logicEndcap = detectorConstruction->GetLogicEndcap();
    G4LogicalVolume* logicBeCylinder = detectorConstruction->GetLogicBeCylinder();

    G4LogicalVolume* volume = step->GetPreStepPoint()->GetTouchableHandle()->GetVolume()->GetLogicalVolume();

    if (volume == logicTube || volume == logicEndcap) {
        step->GetTrack()->SetTrackStatus(aTrackStatus: fStopAndKill);
    }

    G4LogicalVolume *fScoringVolume = detectorConstruction->GetScoringVolume();

    if(volume != fScoringVolume)
        return;

    G4double edep = step->GetTotalEnergyDeposit();
    fEventAction->AddEdep(edep);
}
```

Stepping.cc

```cpp
void MyEventAction::EndOfEventAction(const G4Event*){
    //G4cout<<"Energy Dep" << fEdep << G4endl;
    auto * G4GenericAnalysisManager * man = G4AnalysisManager::Instance();
    if (fEdep<=0.0*MeV)
        return;
   // G4cout<<"Energy Dep" << fEdep << G4endl;
    man->FillNtupleDColumn(ntupleId: 1,columnId: 0,value: fEdep);
    man->AddNtupleRow(ntupleId: 1);


}
```

Event.cc

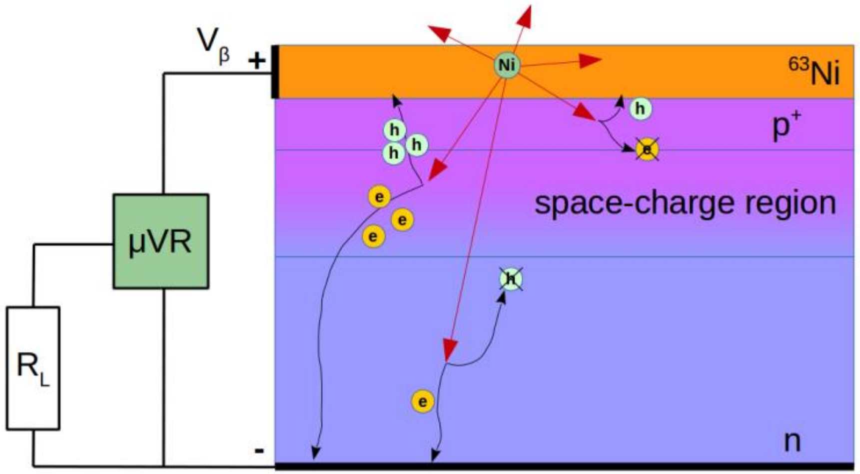

fEdep
htemp
Entries 3785
Mean 0.3402
Std Dev 0.2521
1200
1000
800
600
400
200
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
fEdep


Shaping time 6 μSec
662 keV
137Cs
Resolution: 1.35%
P/V: 16.4
Applied bias: -2300V
FG: 3mm
Count (a. u.)
Energy (keV)
700
600
500
400
300
200
100
0
200
400
600
800
1000
1200

$$E_{dep} := 6\cdot\text{keV} \qquad \frac{E_{dep}}{\varepsilon_{pair}} = 1.7\times10^{3}\,q_e \qquad \frac{E_{dep}}{\varepsilon_{pair}} = 2.7\times10^{-16}\,C$$

$$v_e := \mu_e\cdot\frac{200V}{0.5\cdot mm} = 6\times10^{4}\,\frac{m}{s} \qquad T_e := \frac{0.5\cdot mm}{v_e} = 8.3\times10^{-9}\,s \qquad I_e := \frac{E_{dep}}{\varepsilon_{pair}\cdot T_e} = 3.2\times10^{-8}\,A$$

$$v_h := \mu_h\cdot\frac{200V}{0.5\cdot mm} = 1.8\times10^{4}\,\frac{m}{s} \qquad T_h := \frac{0.5\cdot mm}{v_h} = 2.8\times10^{-8}\,s \qquad I_h := \frac{E_{dep}}{\varepsilon_{pair}\cdot T_h} = 9.6\times10^{-9}\,A$$



Çok Fonksiyonlu İzotop Tespit ve Nötron Algılama Sistemimiz

- Yüksek çözünürülüklü taşınılabilir radyasyon algılama sistemidir. Gama/Nötron yayan radyoizotopları tespit etmek, ölçmek, tanımlamak ve analiz etmek için kullanılabilir.
- Gamma-Neutronx algoritmaları, spektral doz, radionüklit tanımlama ve aktivite nicelendirmesi sağlar.
- CLLBC algılayıcısı, net ve kesin yorumlar için yüksek çözünürlüklü gama ışını tayfları üretir ve geliştirilen İleri düzeyde darbe şekli ayrıştırma yeteneğiyle nötron/gamma ayrımı yapabilir.
-

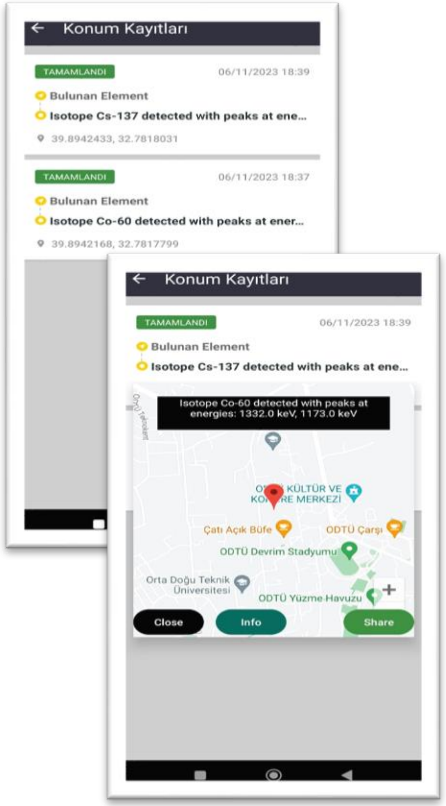
Uygulama Alanları

- Sağlık Fiziği
- Nükleer Tesis İzleme
- Nükleer Kaza Müdahalesi
- Gümrük, Polis, itfaiye ve Kurtarma Güçleri Tarafından Güvenlik Taraması
- Alan Araştırmaları
- Askeri
- Sivil Güvenlik

Çok Fonksiyonlu İzotop Tespit ve Nötron Algılama Sistemimiz

Raporlama ve Paylaşma

Gama tayfı analiz edildikten sonra detaylı rapor android uygulamasında tutularak farklı yollarla paylaşılabilir.



Teknik Özellikler

Algılayıcı: 15x15x30 mm^3 CLLBC kristali

Yüksek Enerji Çözünürlüğü: %3.5-4.0 FWHM @662 KeV

Uyarı: Sesli, Titreşimli

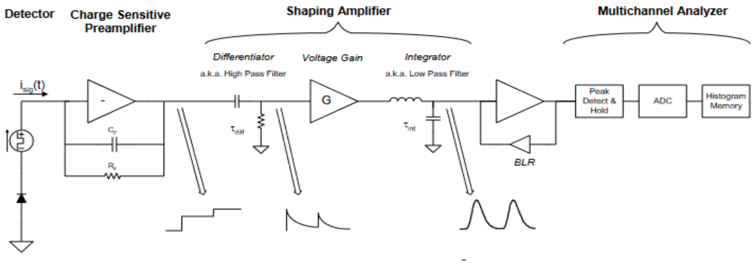
Doz Hızı Gösterimi: uSv/hr

Bağlantı: Bluetooth

Enerji Aralığı: 50KeV – 3MeV

Maksimum Sayım: Saniyede 20000

ADC Kanal Sayısı: 4096



Pil: 9V Duracell Alkalin ya da Varta Ultra Lithium ile 10 saat kullanım ömrü

Kütüphane: 42 izotop

Gama/Nötrön Ayrımı: CF-TOT methodu

Tayf Kayması: ±5 ADC Kanalı 12 saatlik ölçüm süresinde

Doz Doğruluğu: < **%**20 den küçük

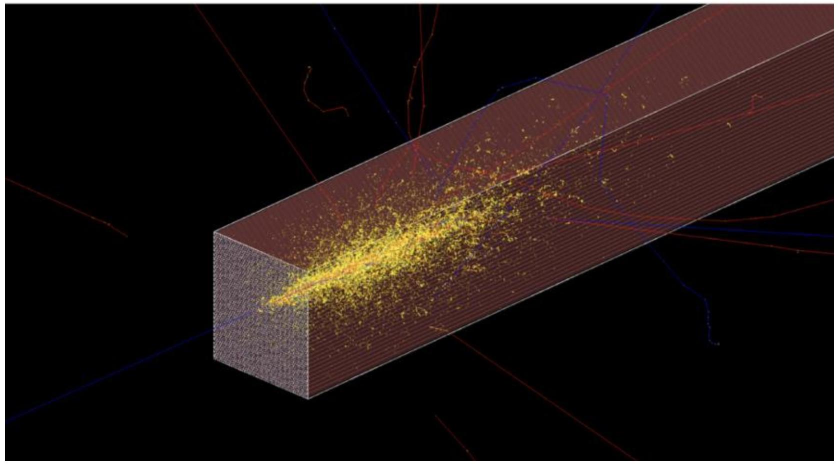
Doz Hassasiyeti: 0.15 Bq/g Cs137 için

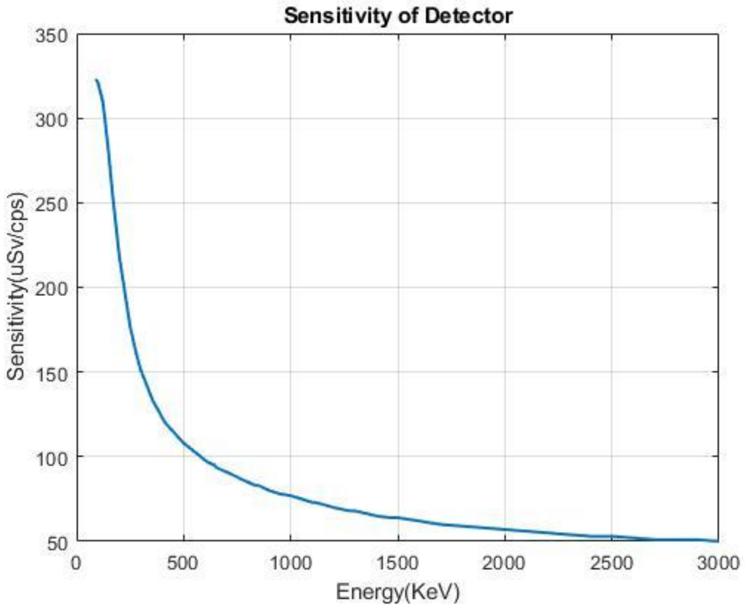
Analiz Uygulaması: Android NeutronX yazılımı

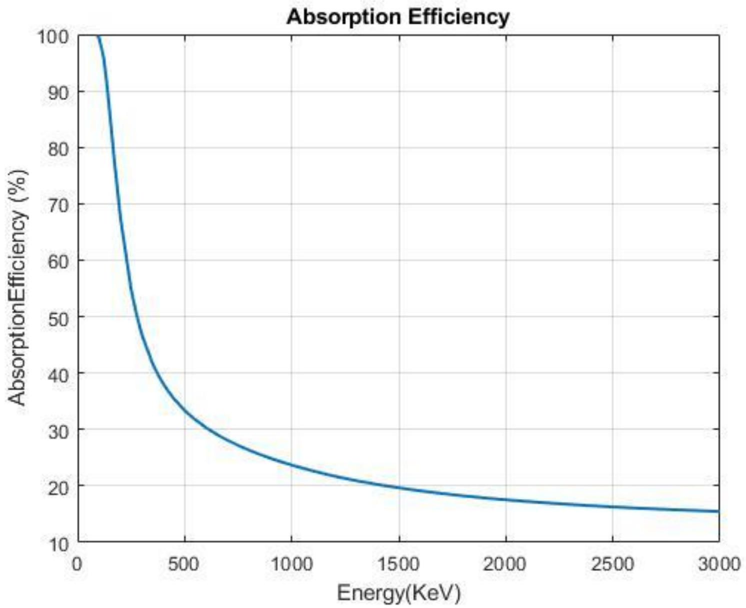
Maximum Boyut: 12.5 x 6.5 x 3.3 cm

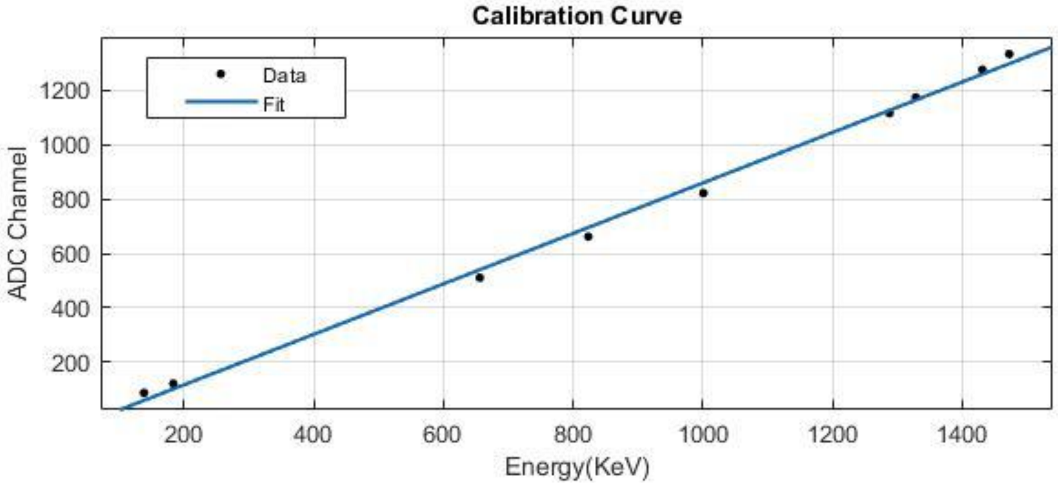
Ağirlık: 230 g (pil dahil)

HOMEWORK



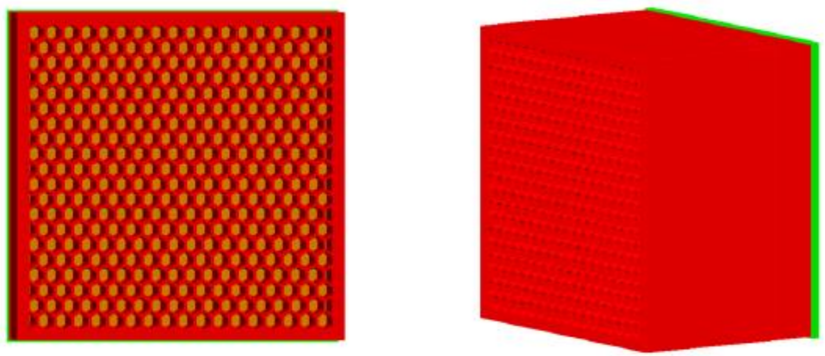


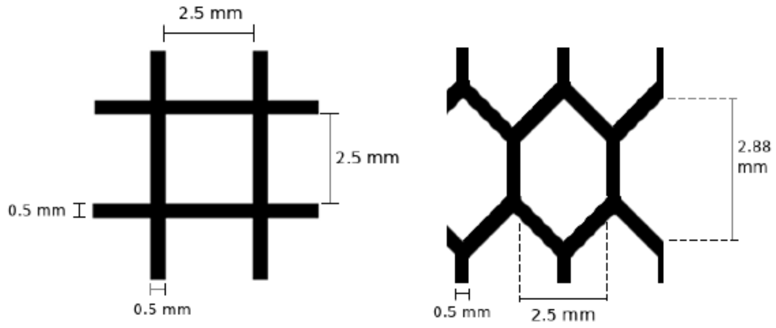




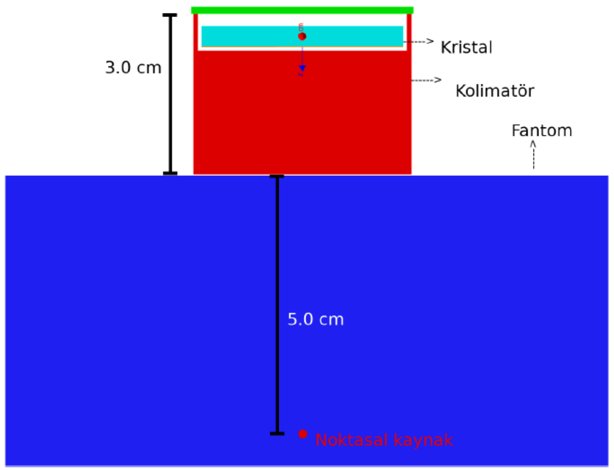
Cs2LiYCl6:Ce

Algılayıcı: 15x15x30 mm^3 CLYC kristali

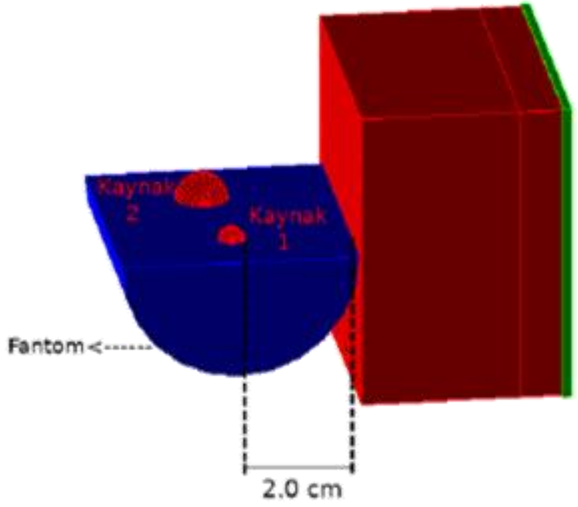




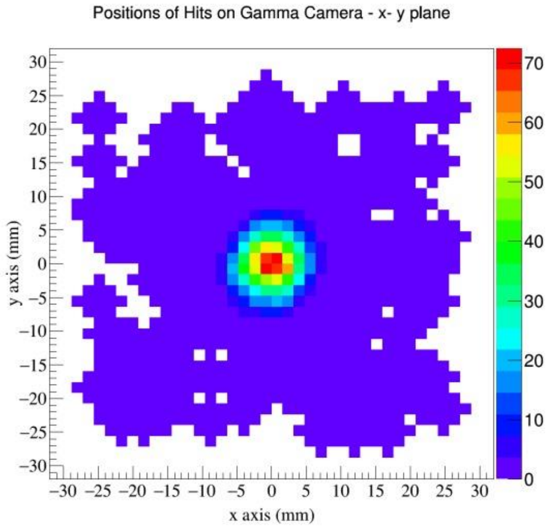
2.5 mm
2.5 mm
0.5 mm
0.5 mm
2.88
mm
0.5 mm
2.5 mm



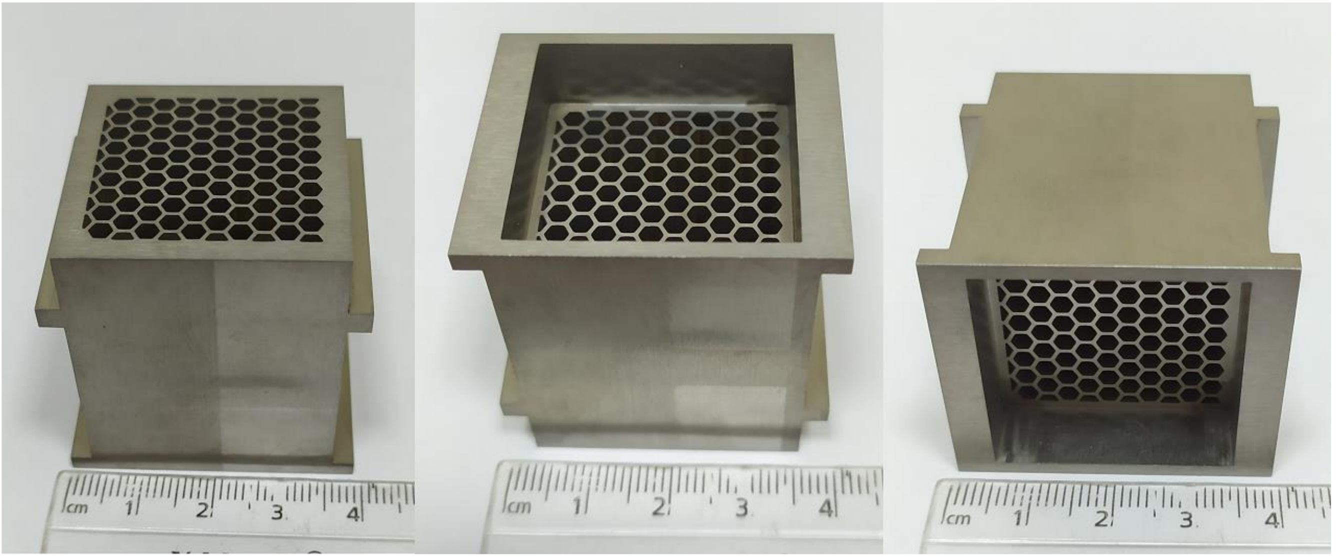
3.0 cm
Kristal
Kolimatör
Fantom
5.0 cm
Noktasal kaynak

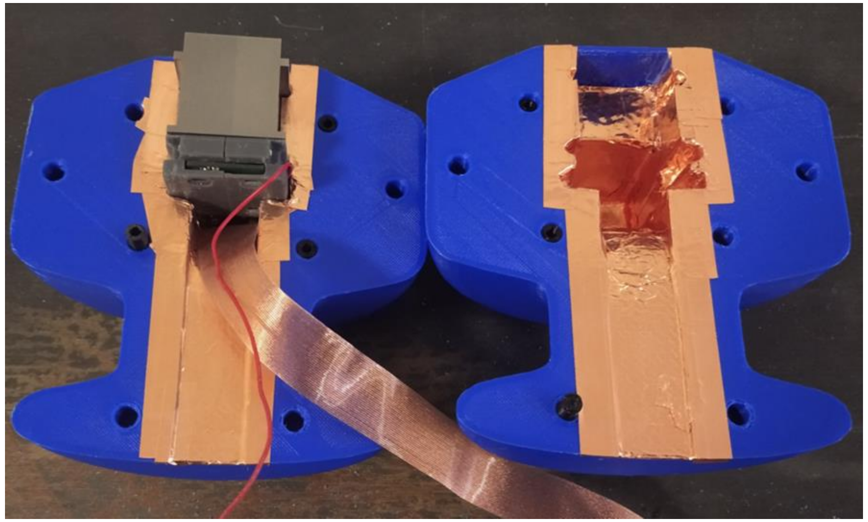


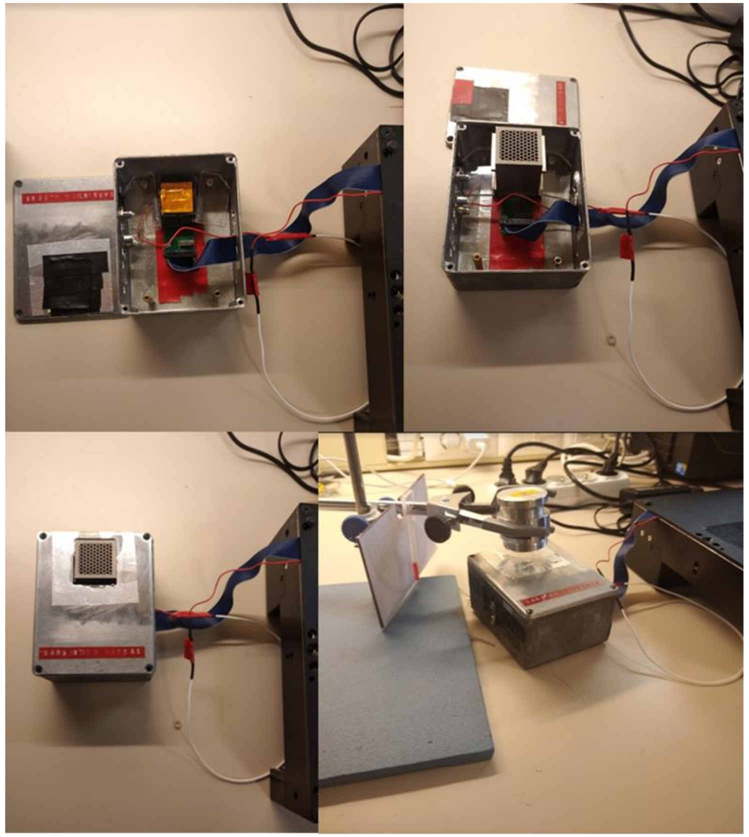
Kaynak
2
Kaynak
1
Fantom
2.0 cm



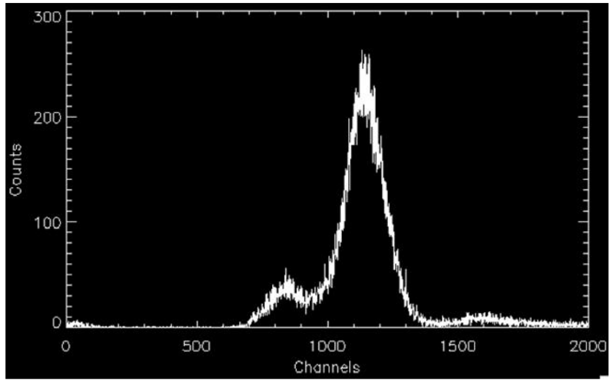
Positions of Hits on Gamma Camera - x- y plane
y axis (mm)
x axis (mm)

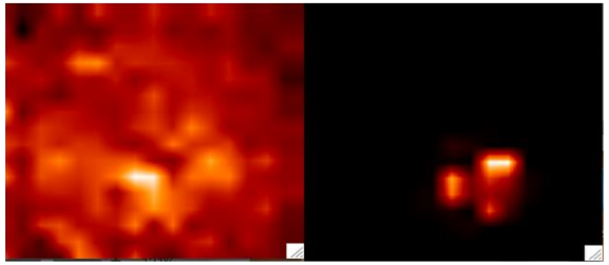


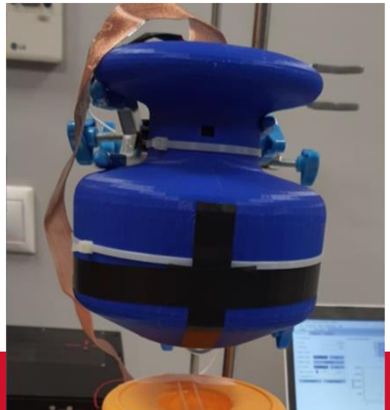




Prototip aşamasında laboratuvar ortamındaki testler







3. CrystalCam