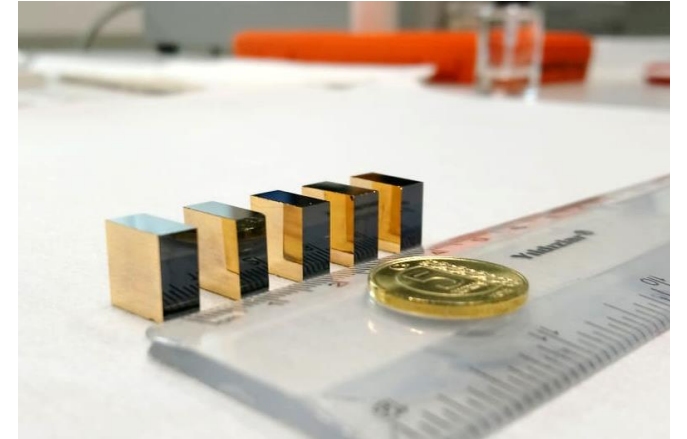
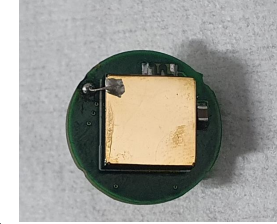
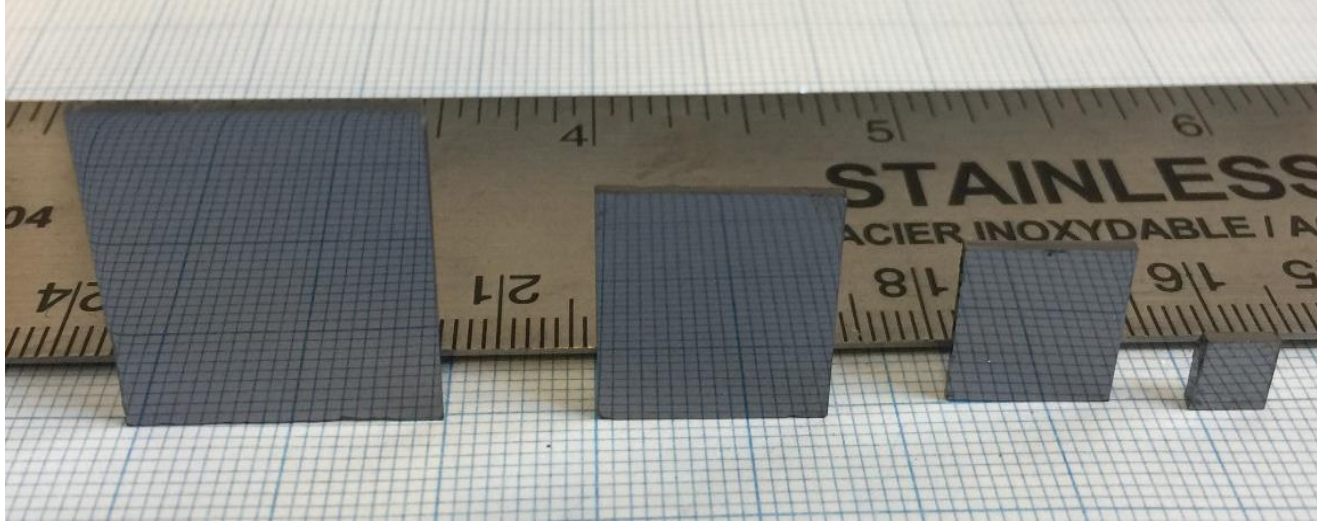


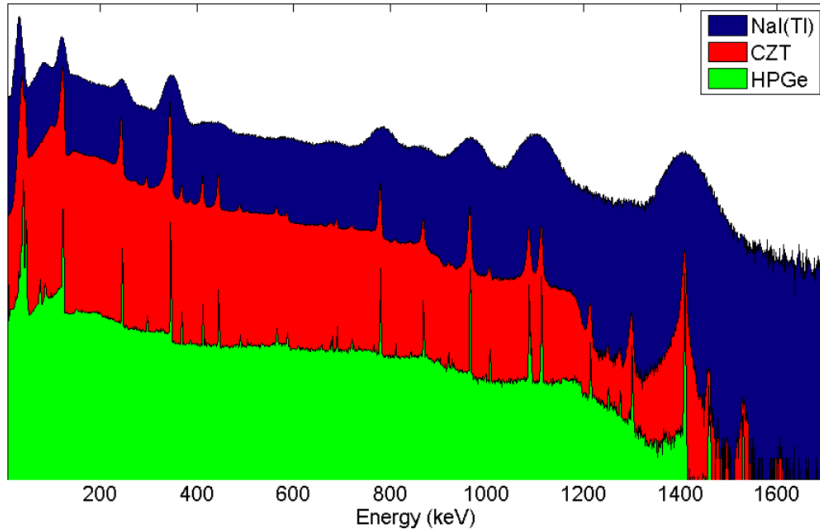
CZT Kristal Büyütme ve Uygulamaları

MEHMET CAN KARAMAN
Okay Tüzel





Detector Comparison
Source: Eu-152



Germanyum, CdZnTe ve NaI (sintilasyon) kristallerinin karşılaştırılması (H. Prettyman, 2021)

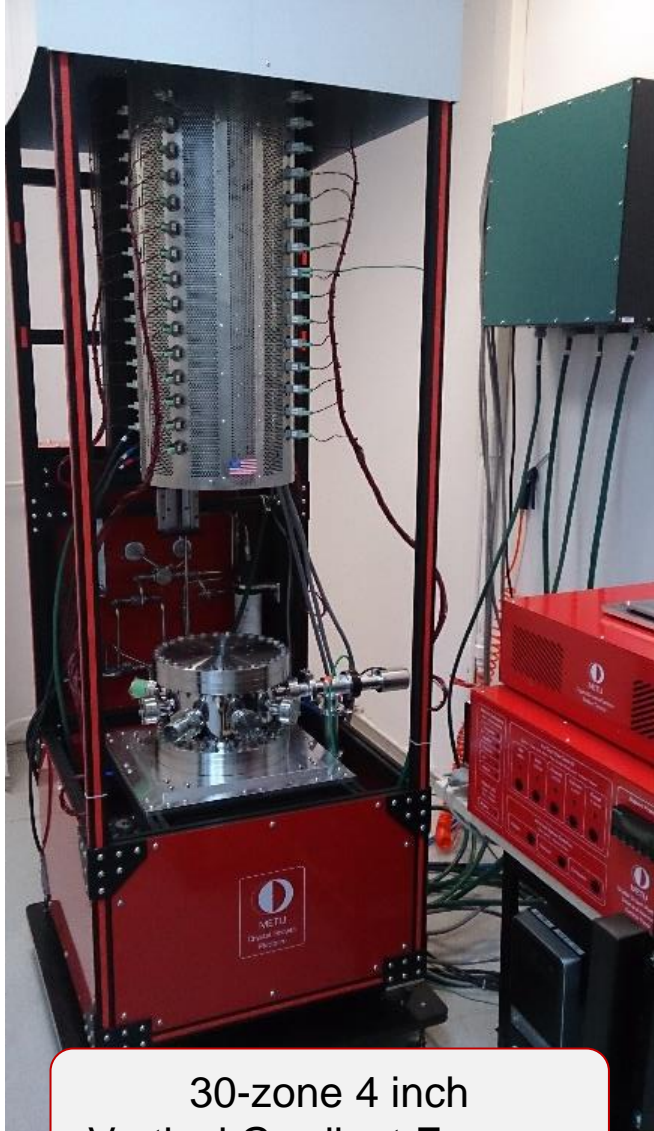
- Yarı iletkenidir.
- Yasak enerji aralığı değiştirilebilir.
- Yumuşak ve kırılmandır.

Avantajları

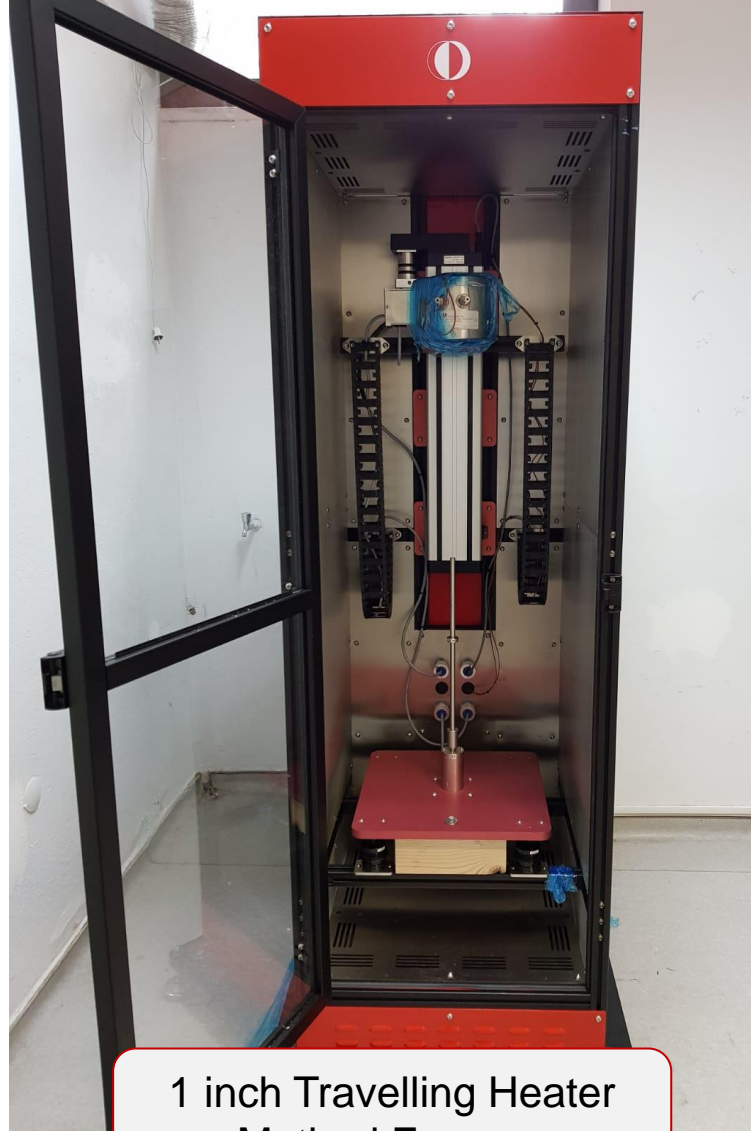
- Düşük gürültü
- Yüksek tayf çözünürlüğü
- Oda sıcaklığında kullanım
- Taşınabilir sistemler üretilmesi

Dezavantajları

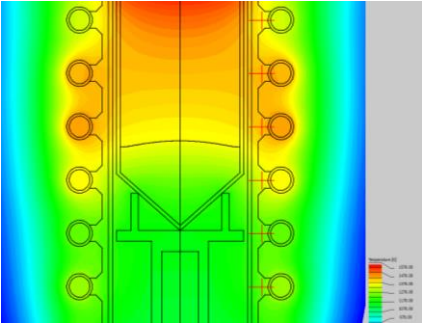
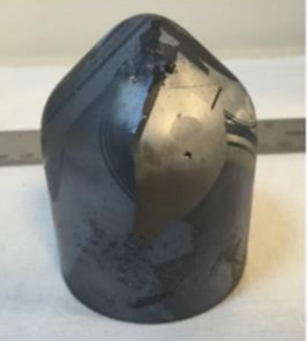
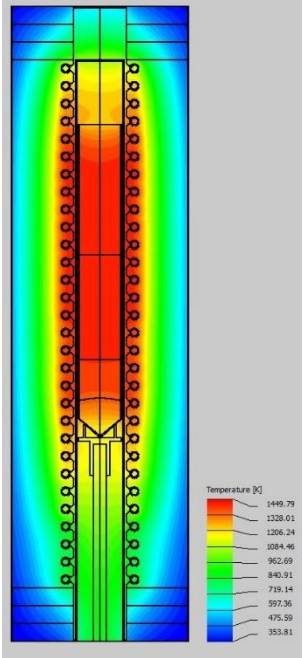
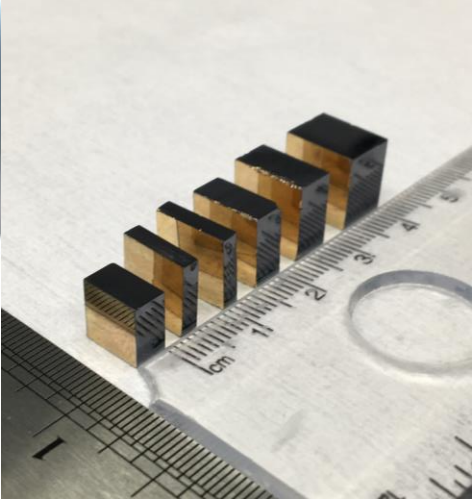
- Kristal büyütmedeki zorluklar
- Yüksek kristal kusuru yoğunluğu
- Elektron ve boşluklar arasındaki hareketlilik farkı

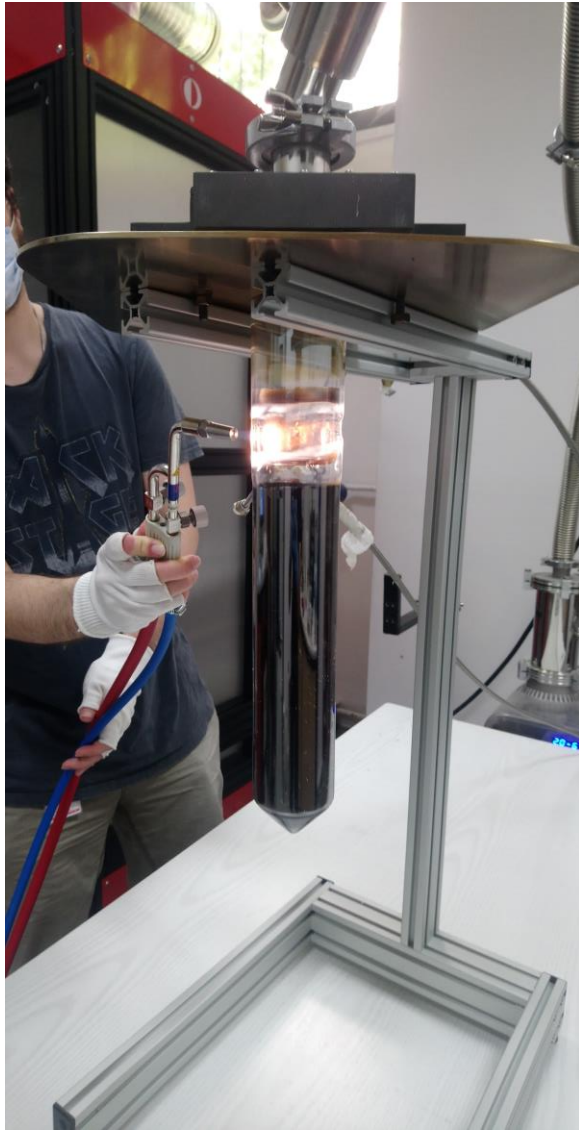
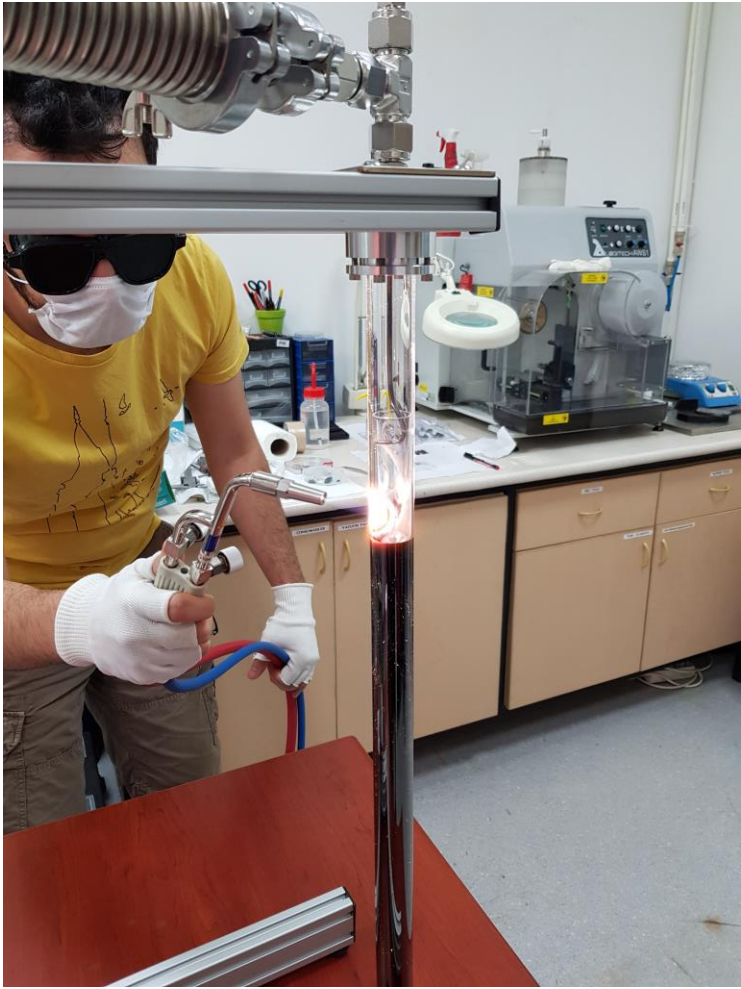


30-zone 4 inch Vertical Gradient Furnace



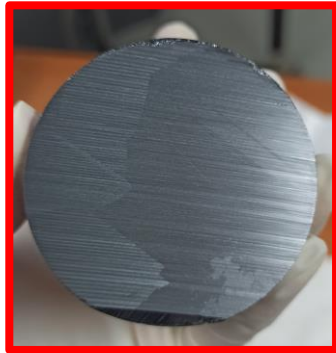
1 inch Travelling Heater Method Furnace







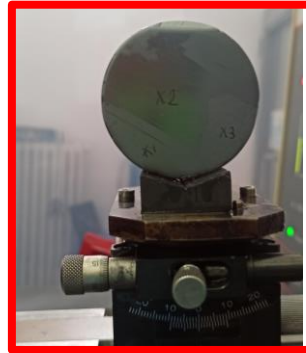
Ingot



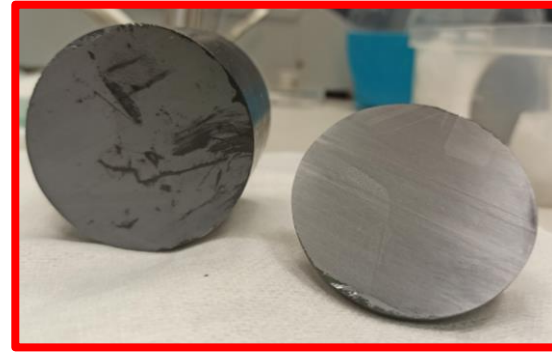
Heel



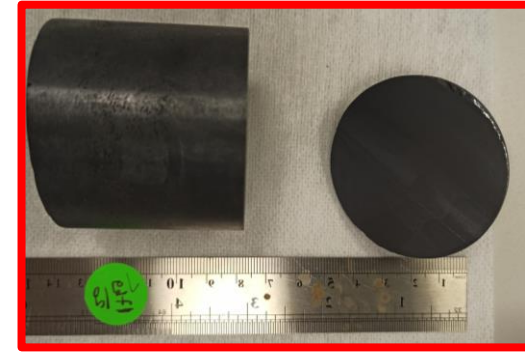
Hand grinded



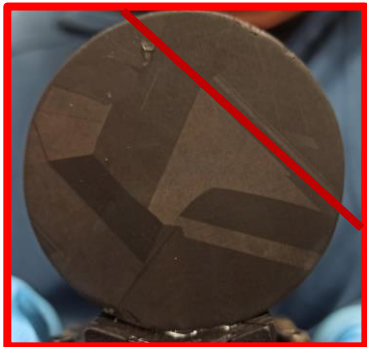
First LAUE



Tip Cut



Grinded + Saucedo



~~R~~
RY1 and RY2
(old saw)



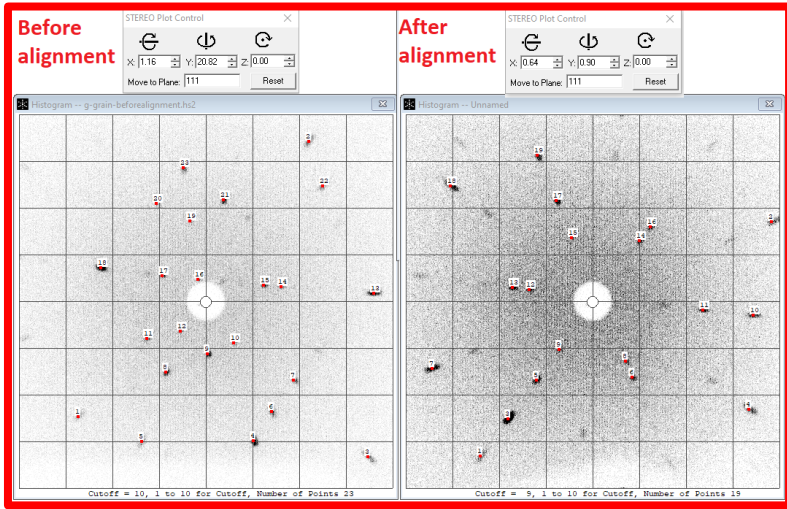
RY2 has Large grain



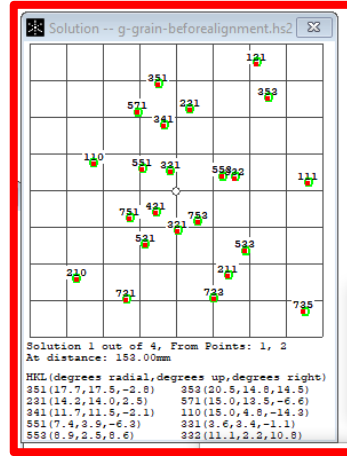
RY0 and RY1
(new saw)



RY1W1-3

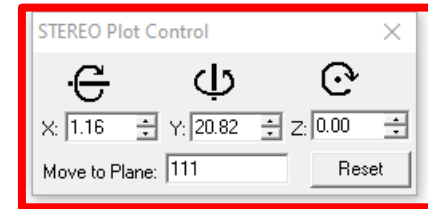


Histogram



Solution suggestions

Stereographic projection



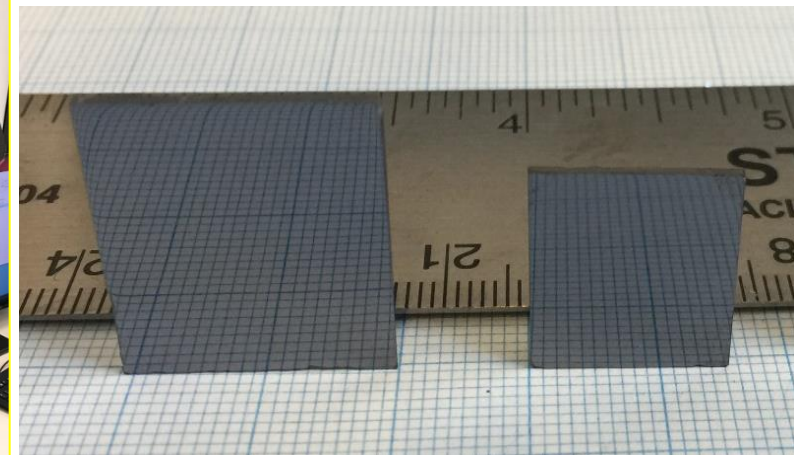
Deviation from <111>



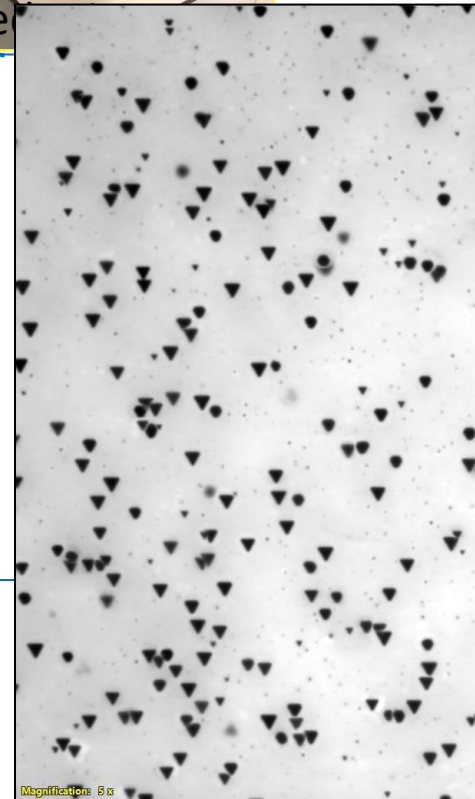
X: 1.16 ° and Y:20.82 ° gave us the <111> orientation. With this alignment we can take our sample to the diamond saw to start the wafer dicing.



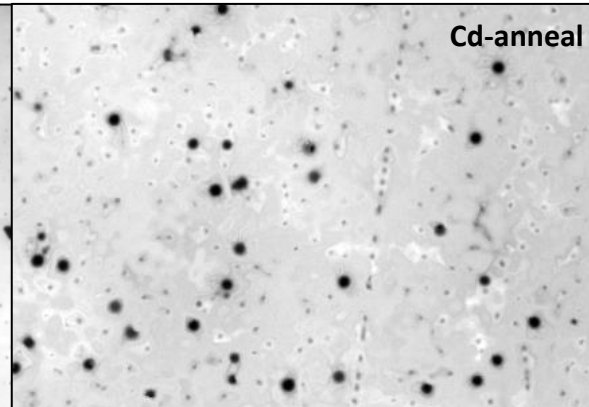
Infrared Doped-3 (5x magnification)



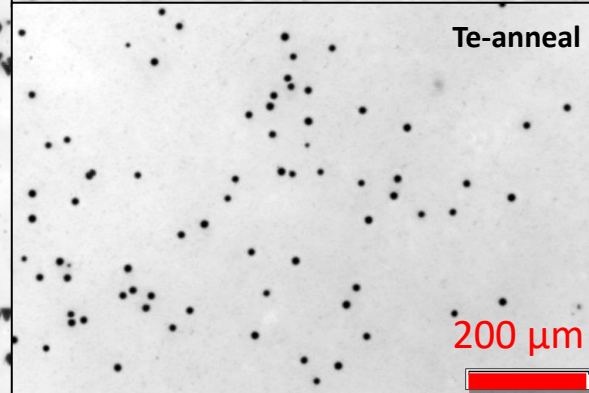
Mechanical Polisher



Magnification: 5x

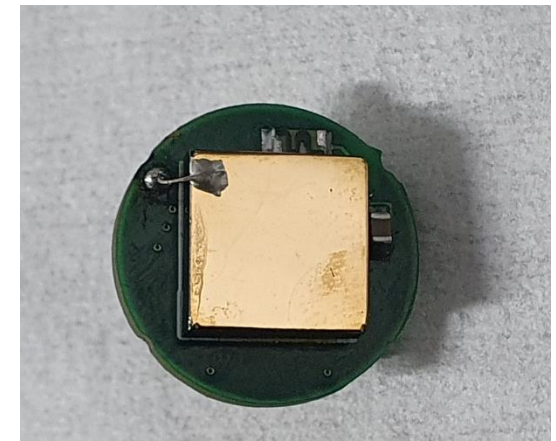
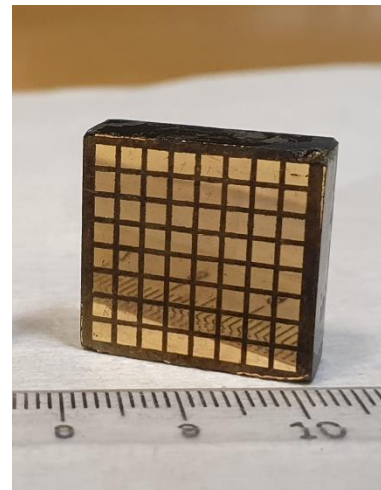
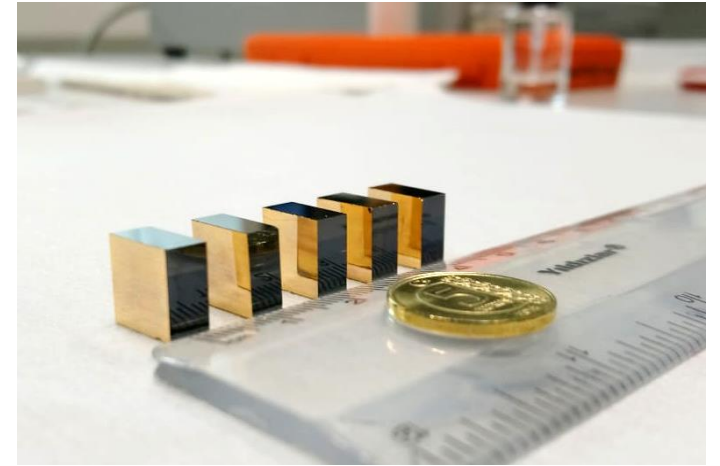
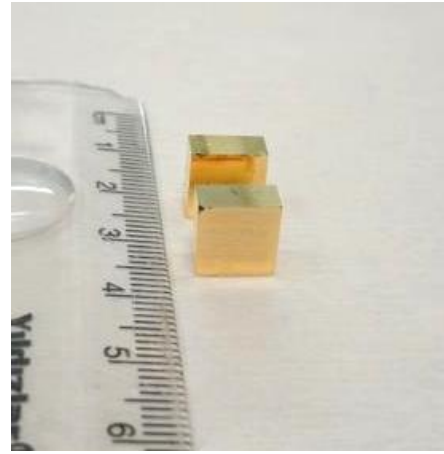
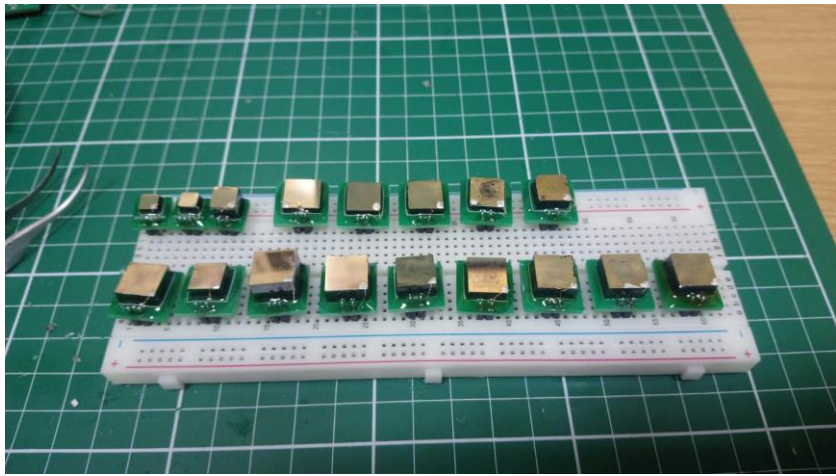


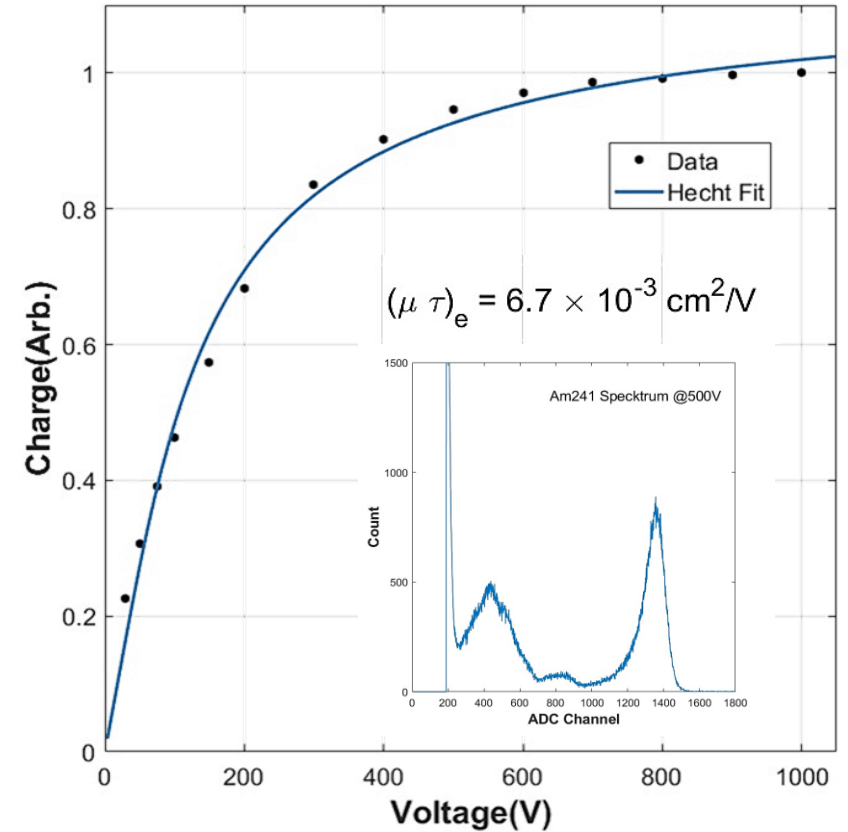
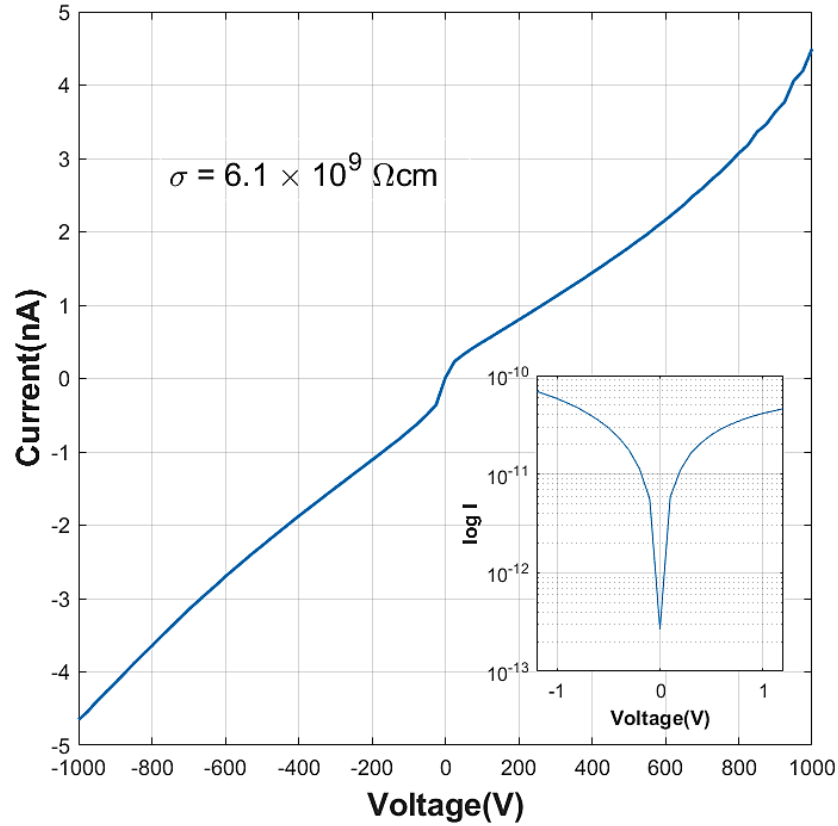
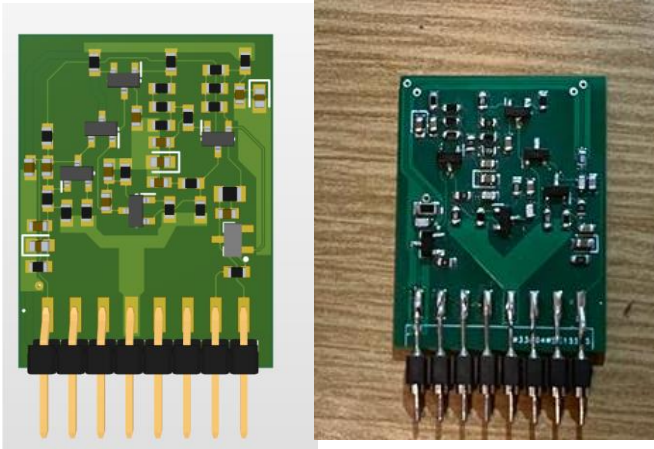
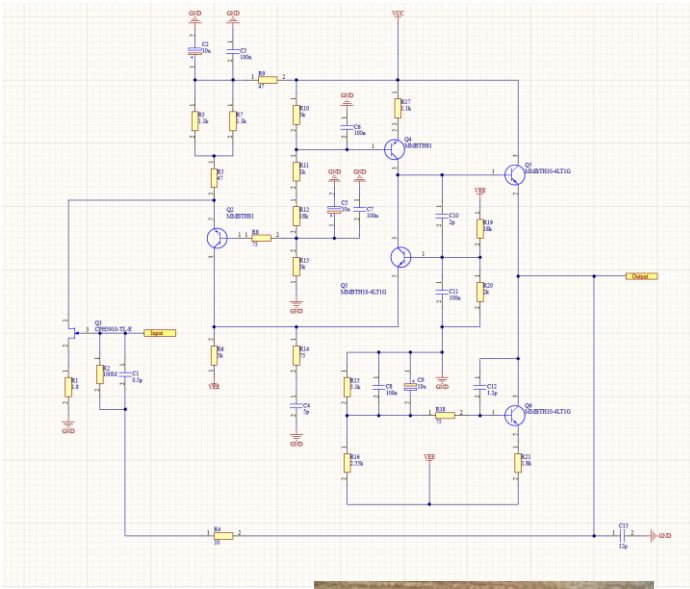
Cd-anneal



Te-anneal

200 μm

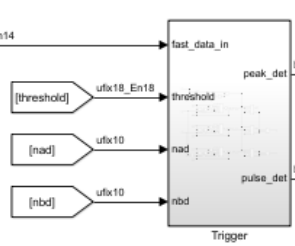
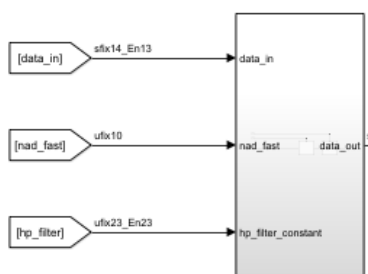
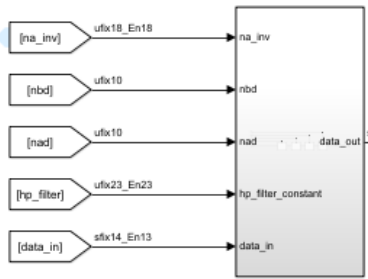




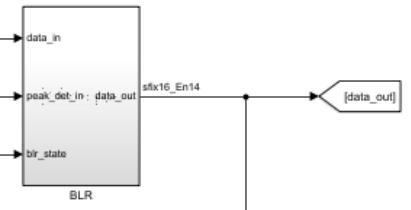
Sample	R(Ω)	$\delta(\Omega\cdot\text{cm})$	Leakage Current @200V	Mobility Lifetime ($\frac{\text{cm}^2}{\text{V}}$)
Commercial-1	9.80×10^9	4.90×10^9	10 nA	7.6×10^{-3}
Commercial-2	1.09×10^9	2.18×10^8	25 nA	5.1×10^{-3}
METU-THM	1.22×10^{10}	6.10×10^9	2 nA	6.7×10^{-3}



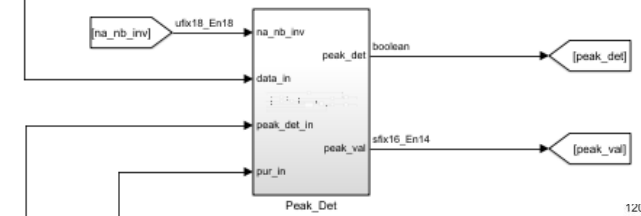
Trapozaid Filtre



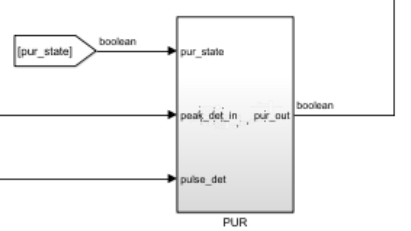
BLR



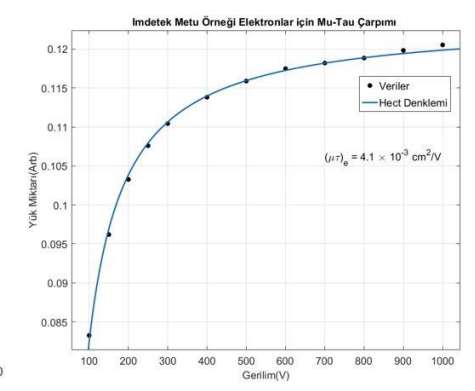
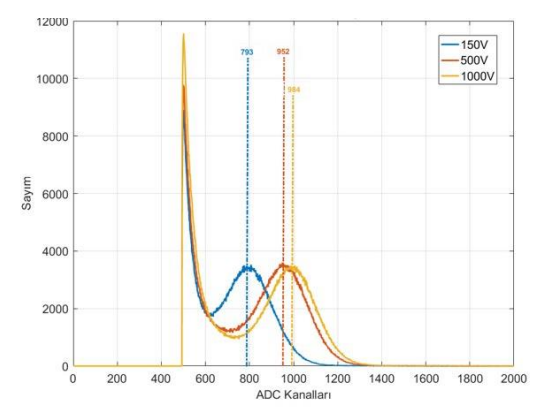
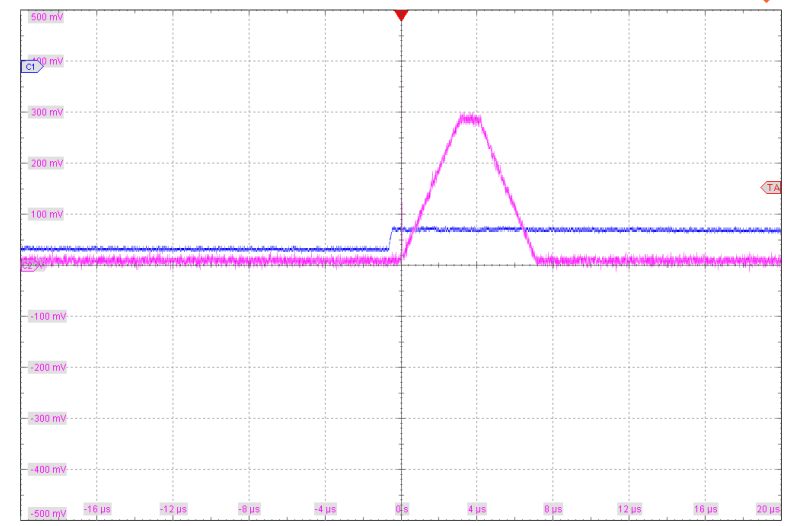
Peak Detect



PUR



2022-08-15 10:29:12



ns laser



CZTS crystal



Broadband Amplifier
DC to 2GHZ

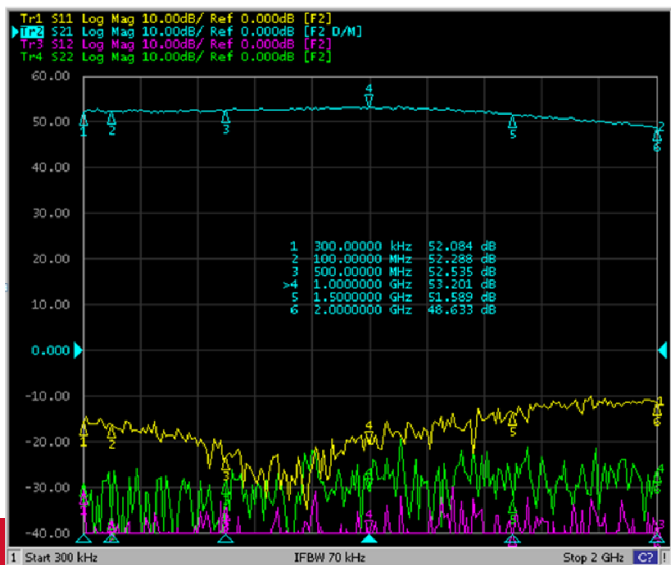
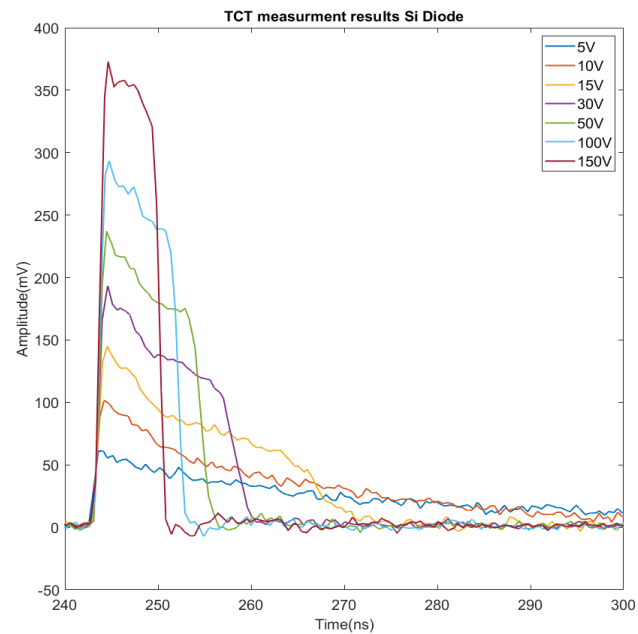
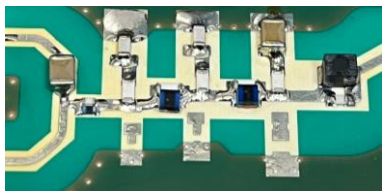


Scope

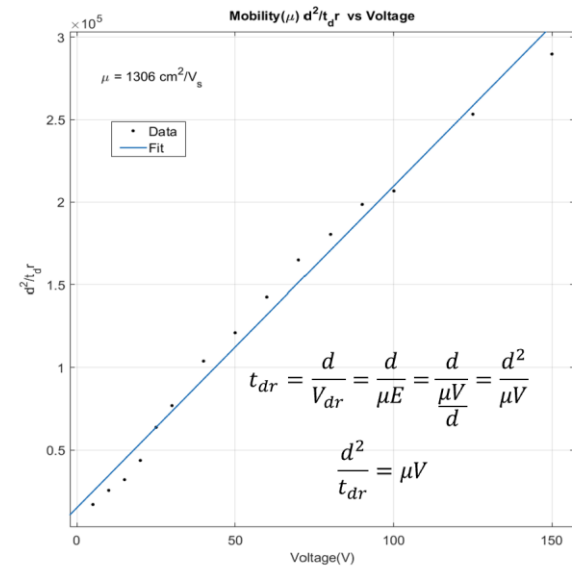
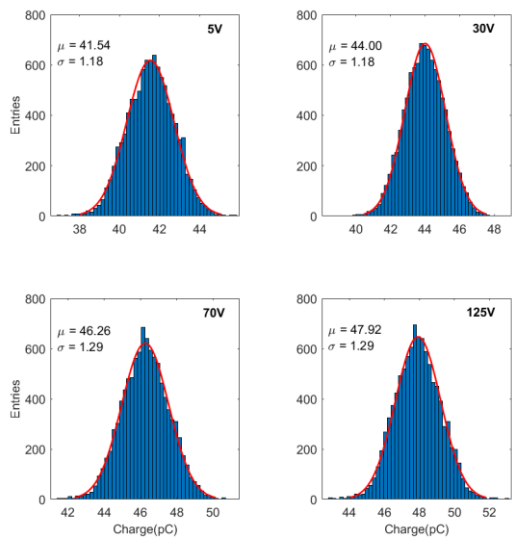


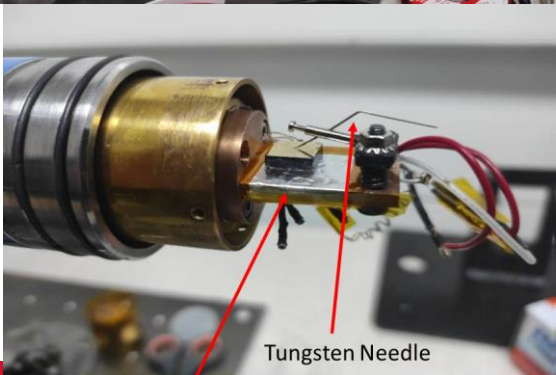
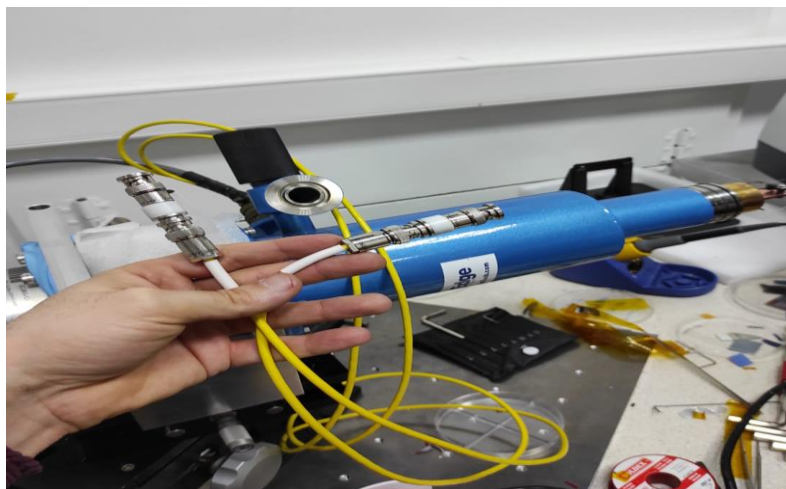
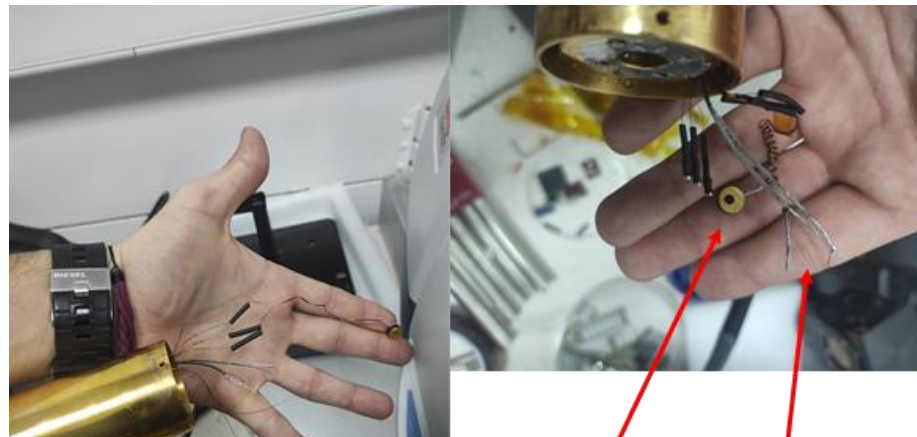
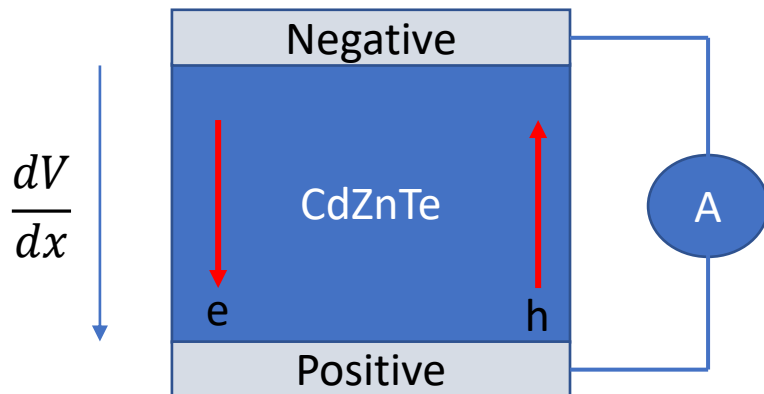
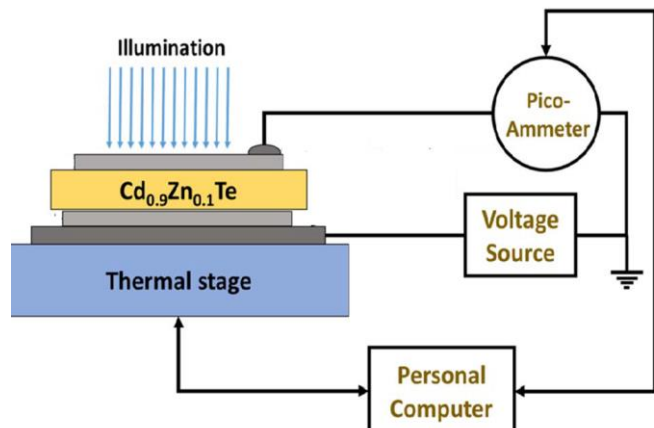
Bias T

Bias Voltage

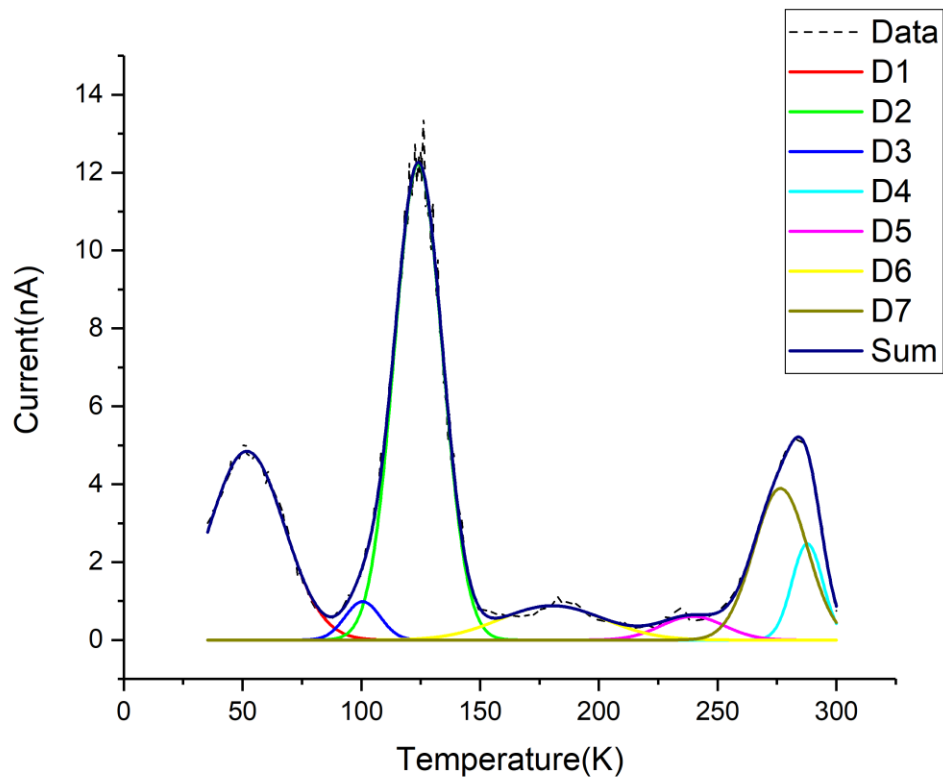


Charge Collection Diffrent Bias Voltages

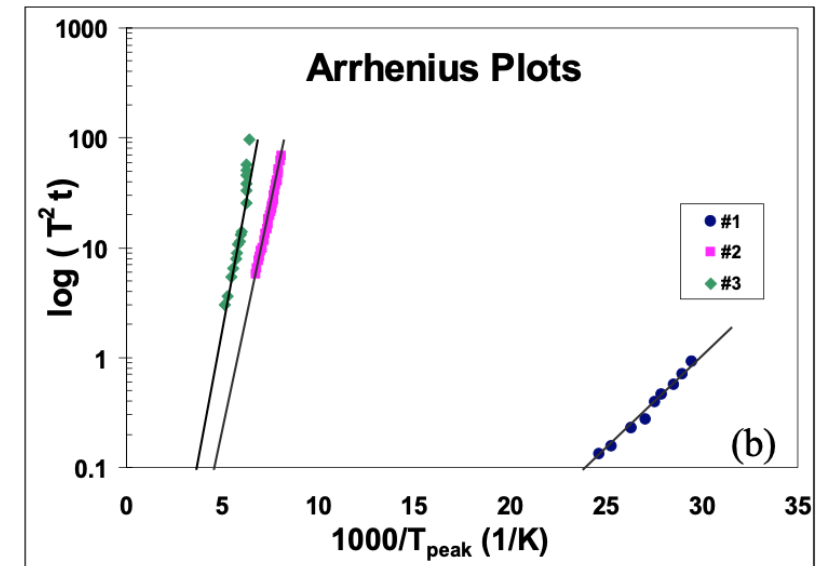
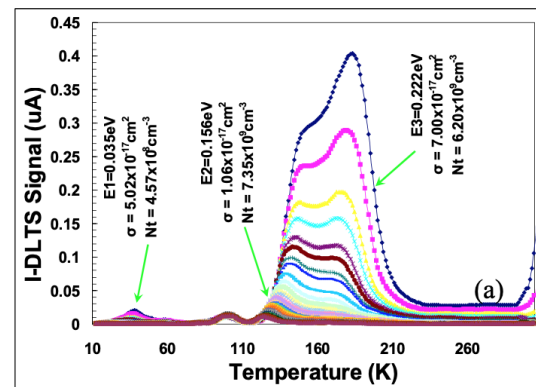
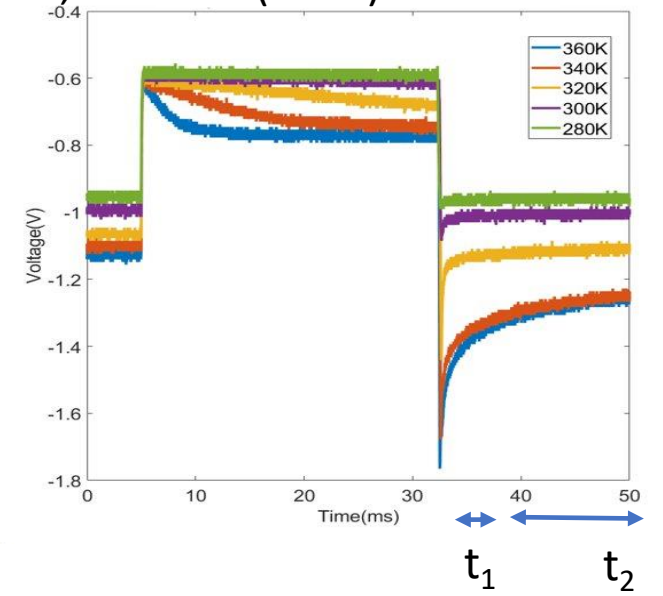
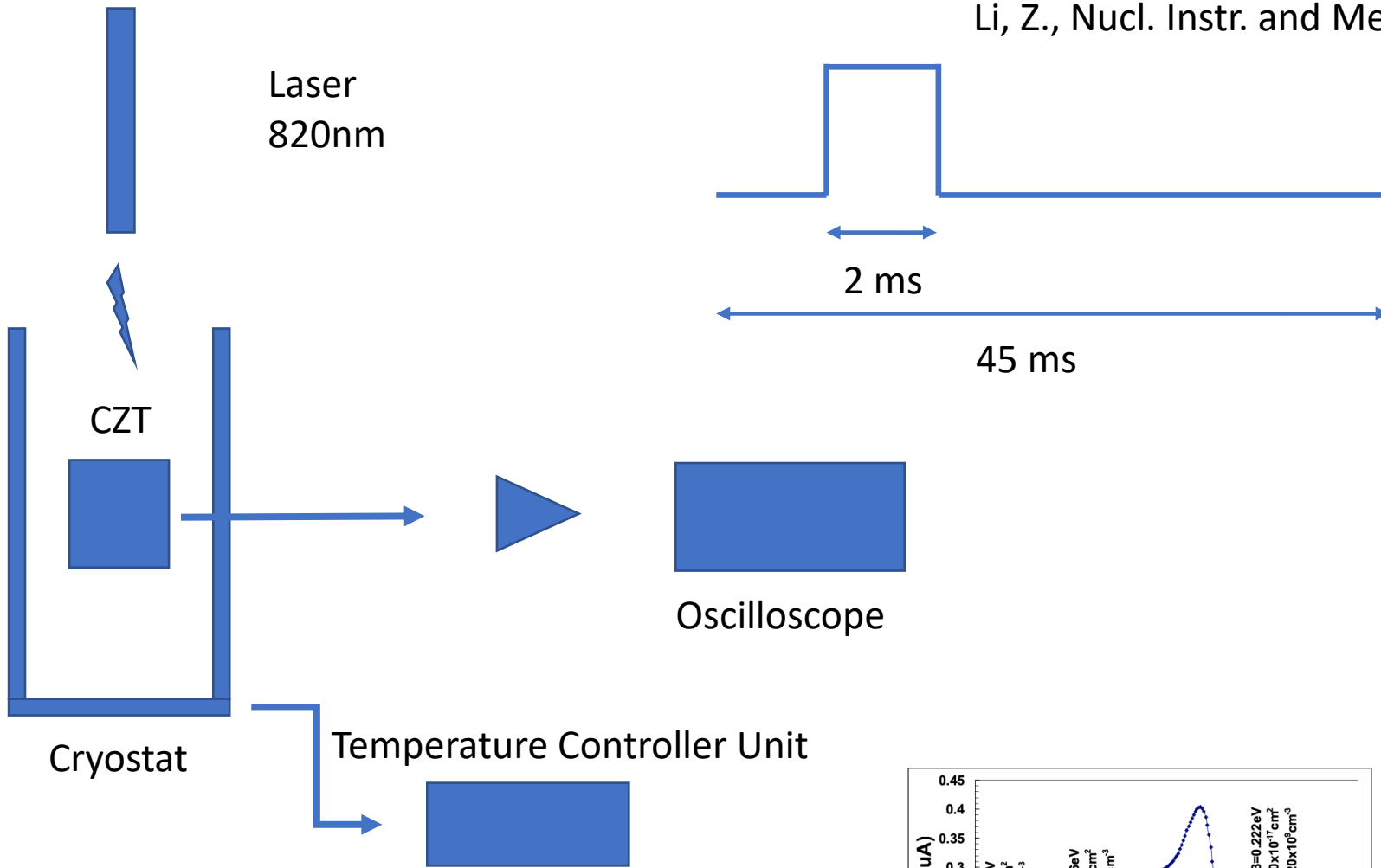


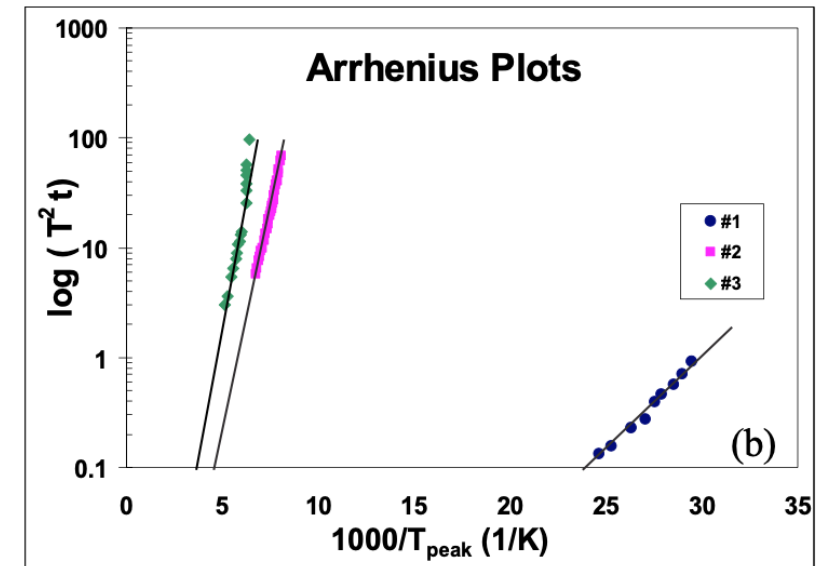
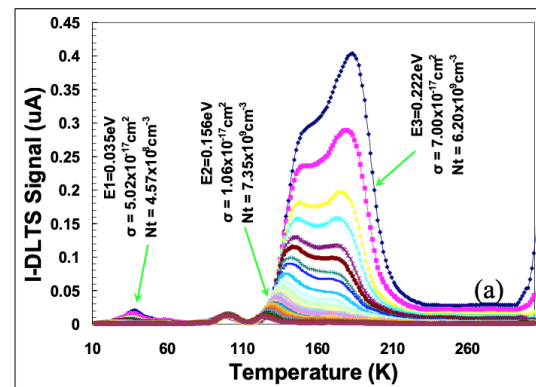
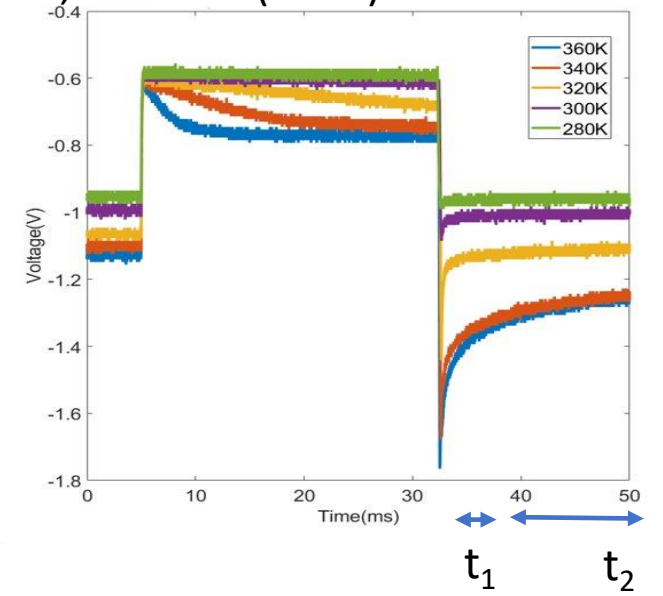
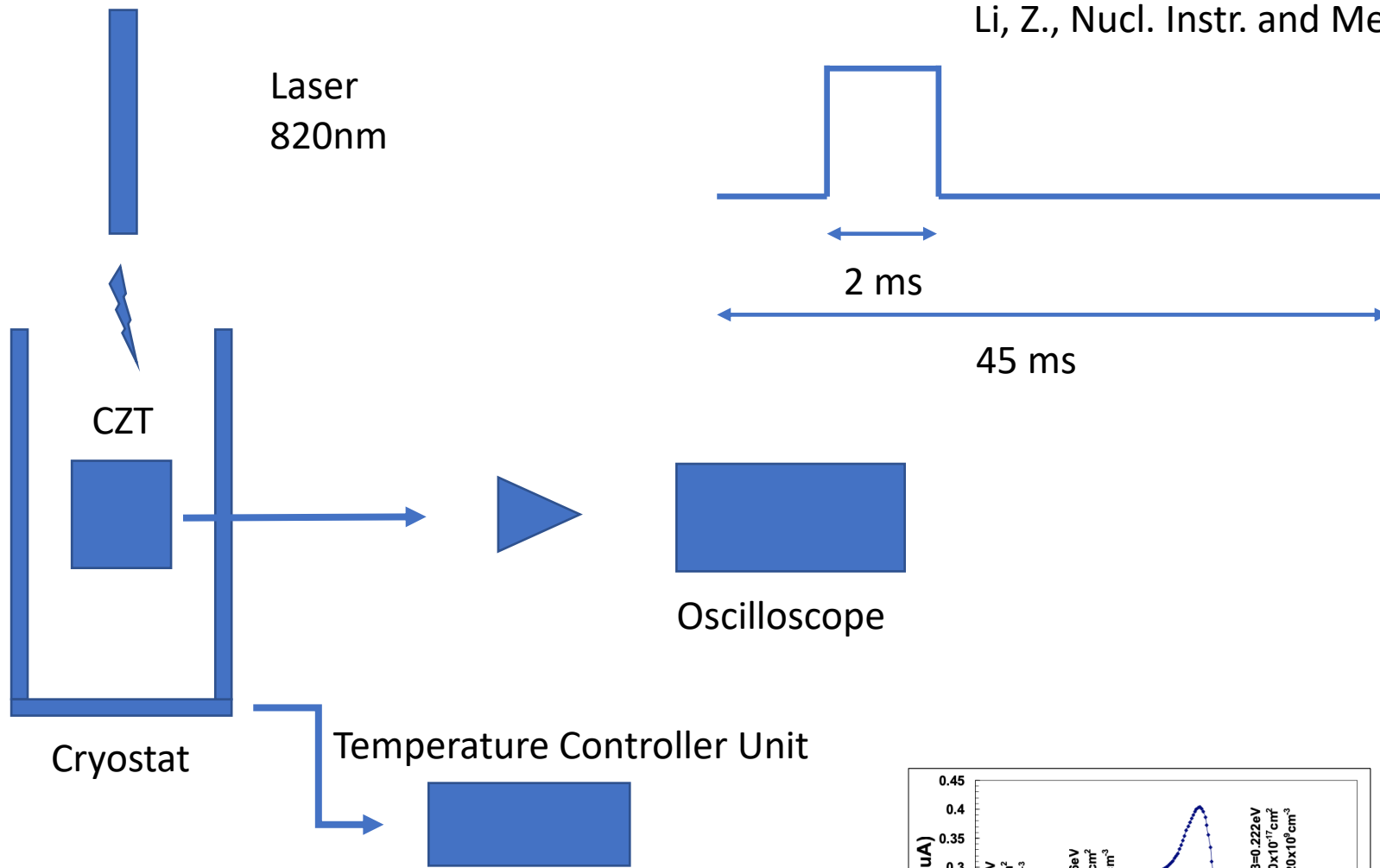


Indium Foil



Deep Level Defects	Peak Temperature(K)	Activat ion Energy (eV)	Origin of Defects
D1	51.9	0.0778	V _{cd} [1]
D2	100.6	0.1738	A center [2]
D3	124.0	0.2232	A center [2]
D4	180.4	0.3481	Zn-related defect [3]
D5	239.6	0.4857	Te _{cd} related defect [4]
D6	276.5	0.5742	Cd vacancy [5]
D7	287.8	0.6016	Te _{cd} ⁻² + V _{cd} ⁻² [6]

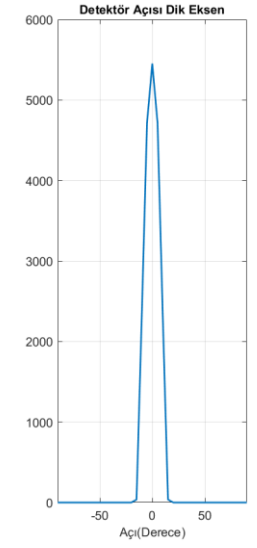
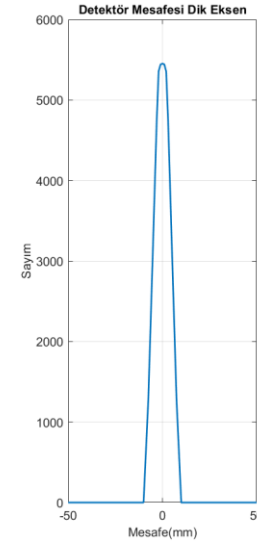
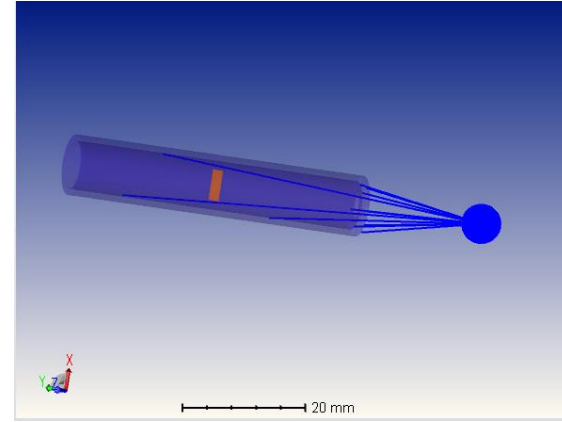
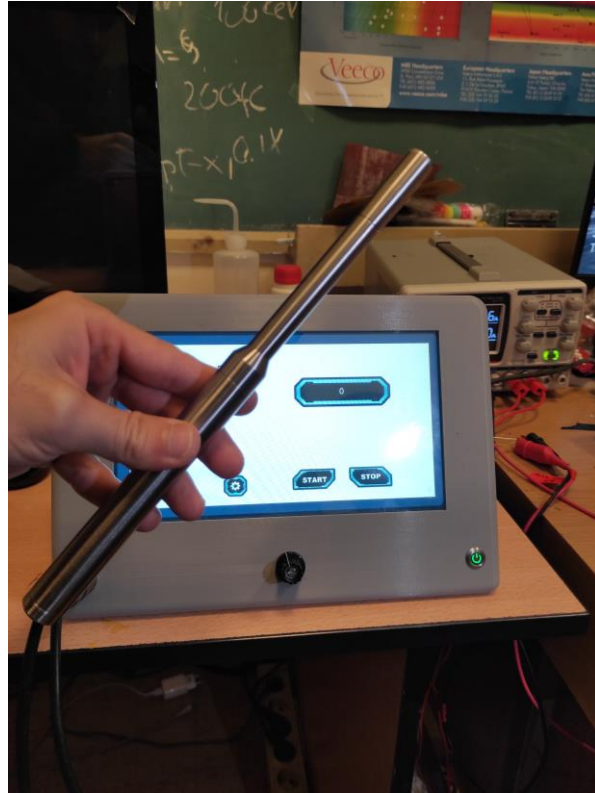






20KeV – 700 KeV

- I-125
- Tc99m
- I-131
- In-111

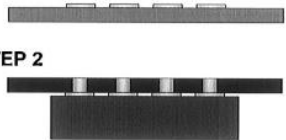




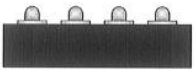
STEP 1



STEP 2



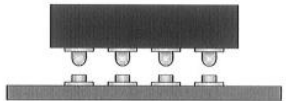
STEP 3



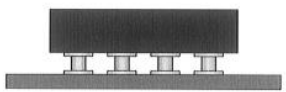
STEP 4



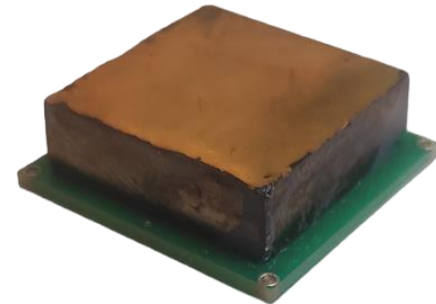
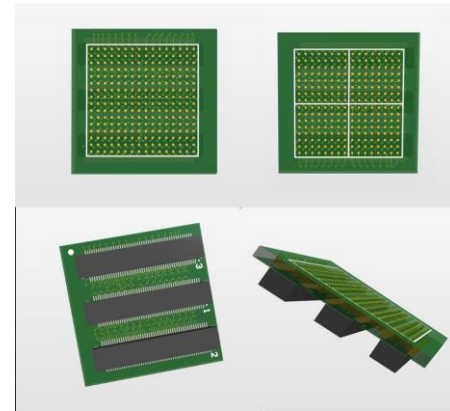
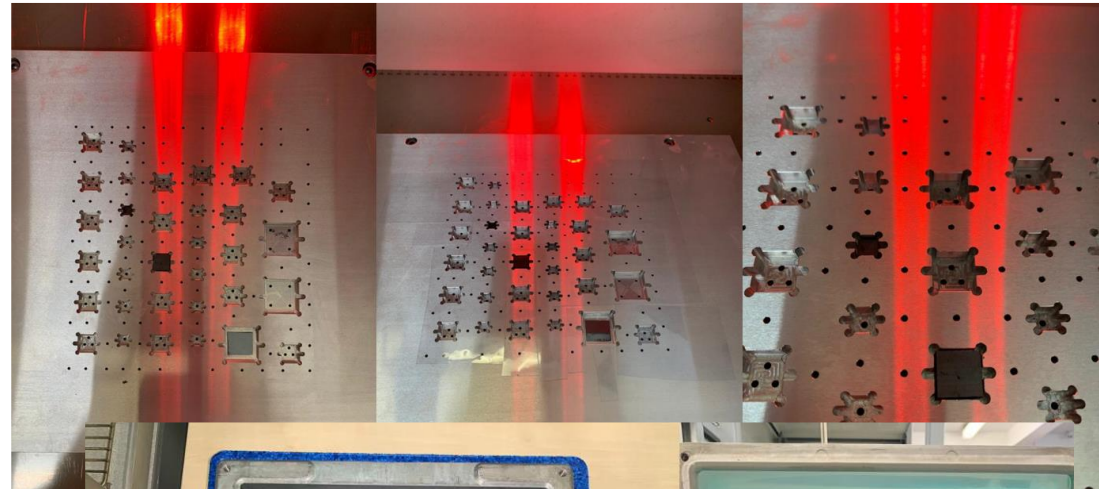
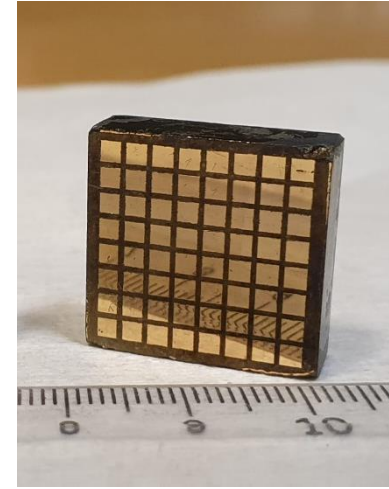
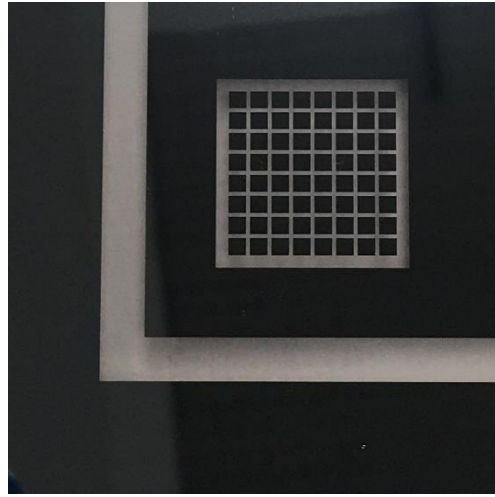
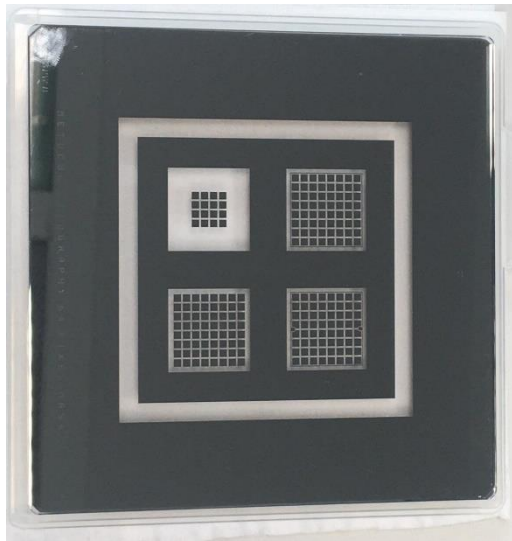
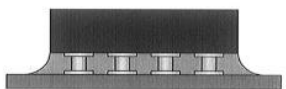
STEP 5

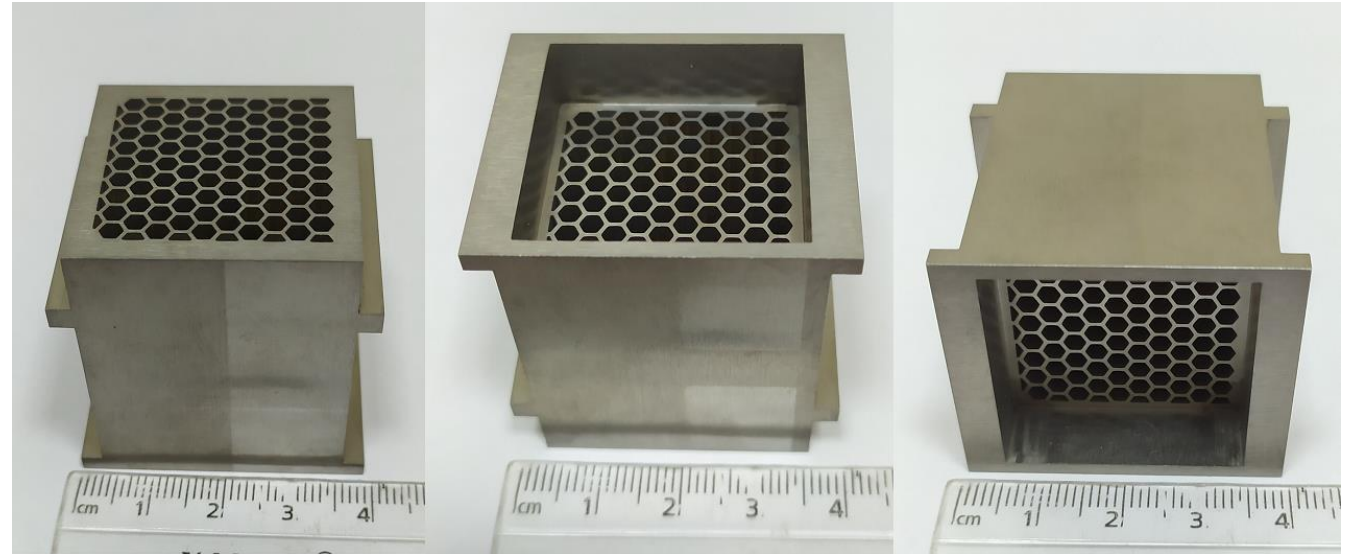
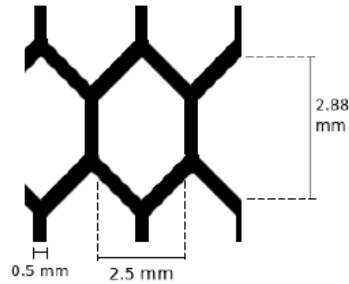
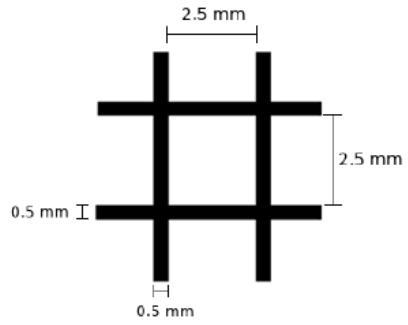
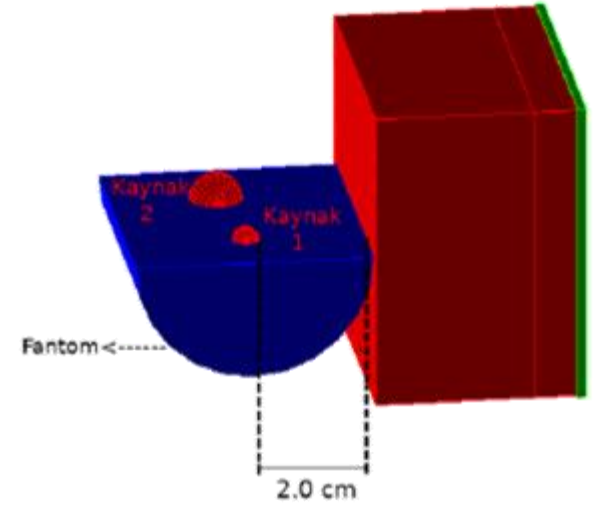
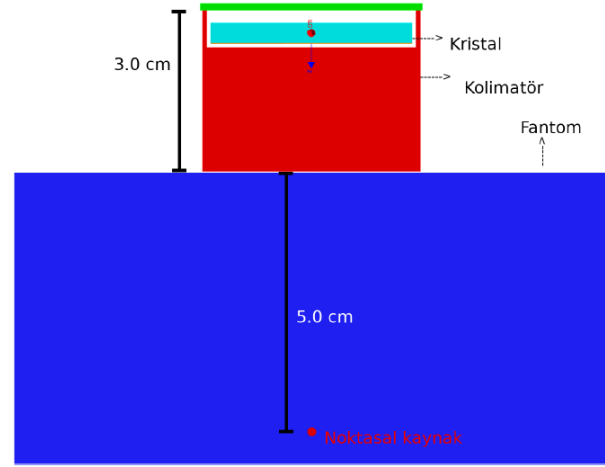
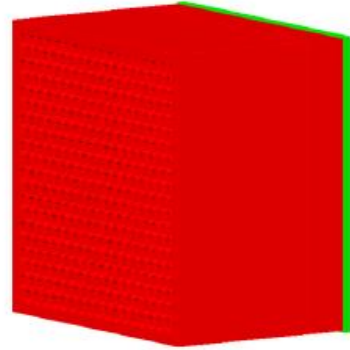
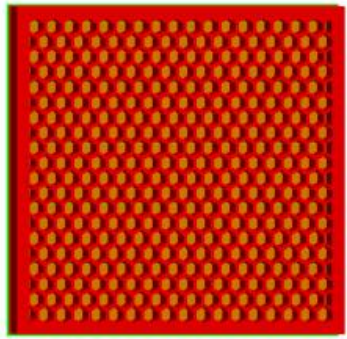


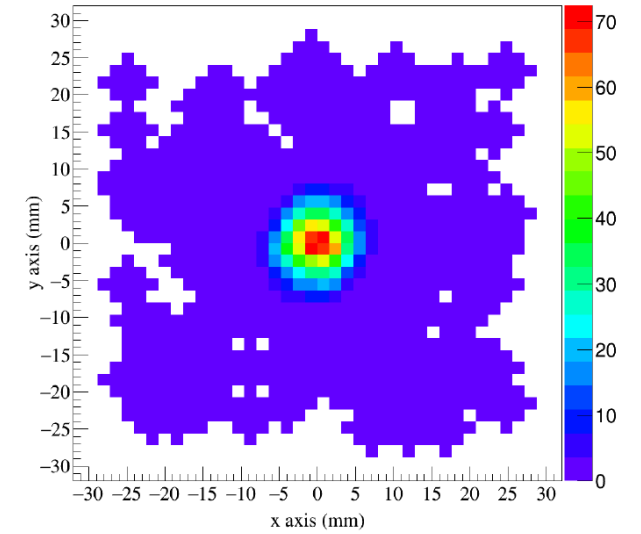
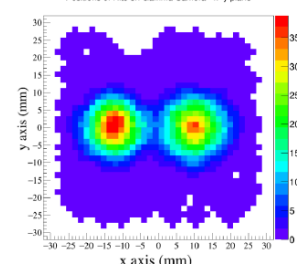
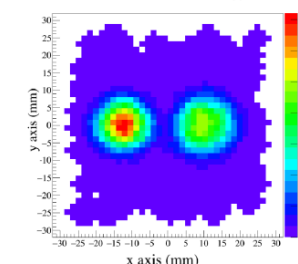
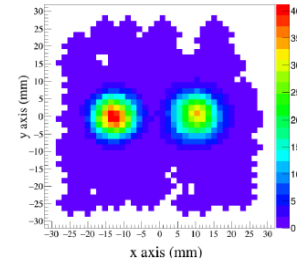
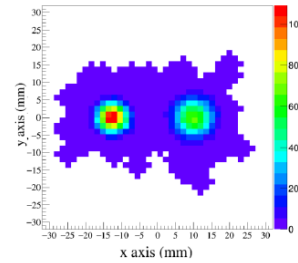
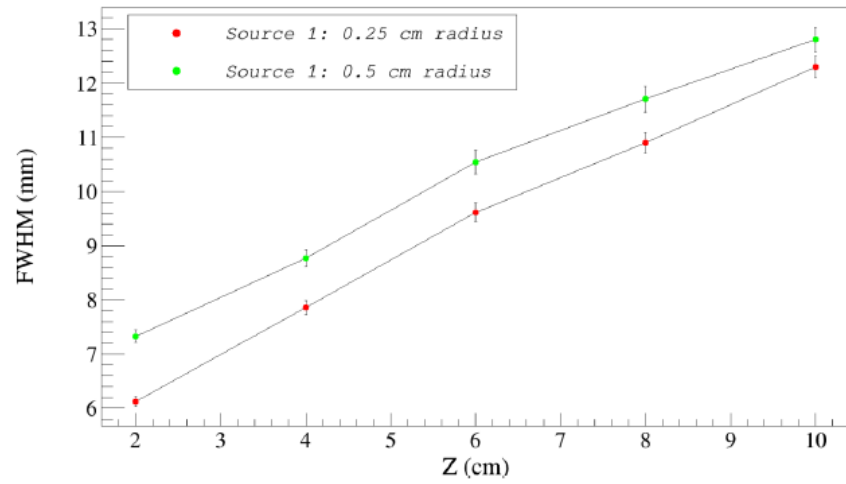
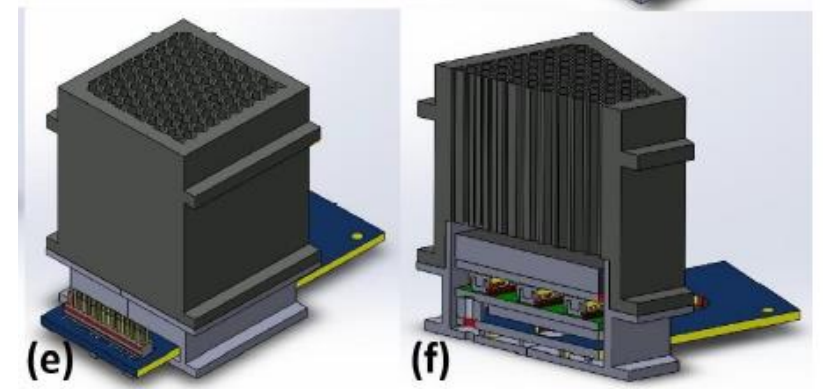
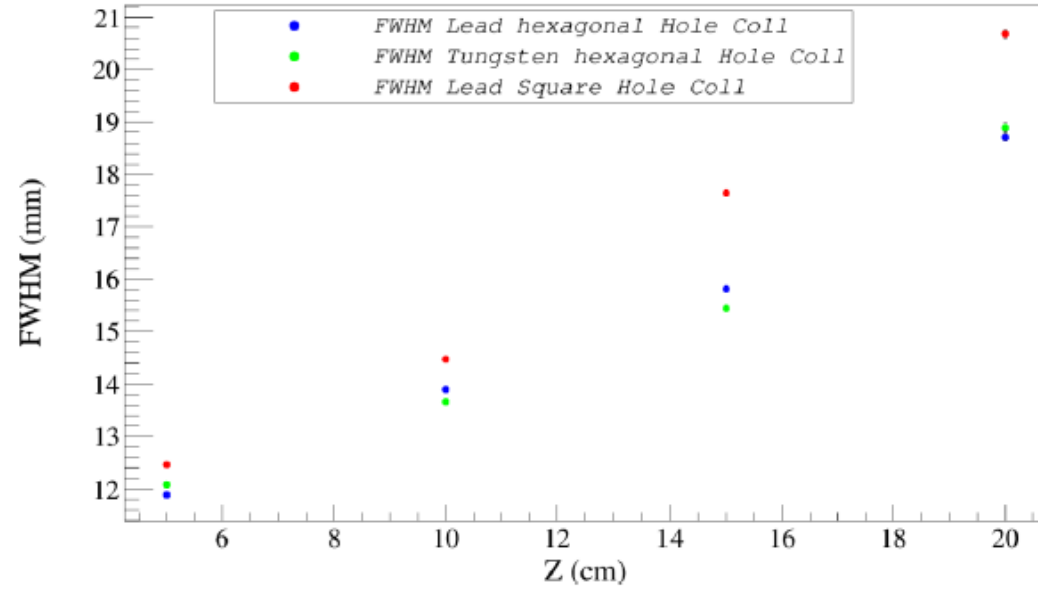
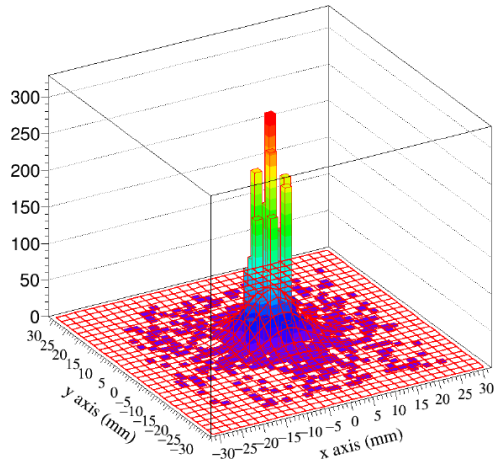
STEP 6

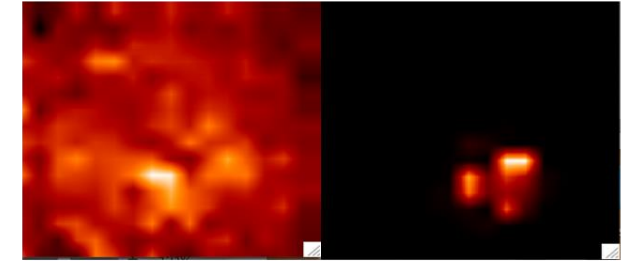
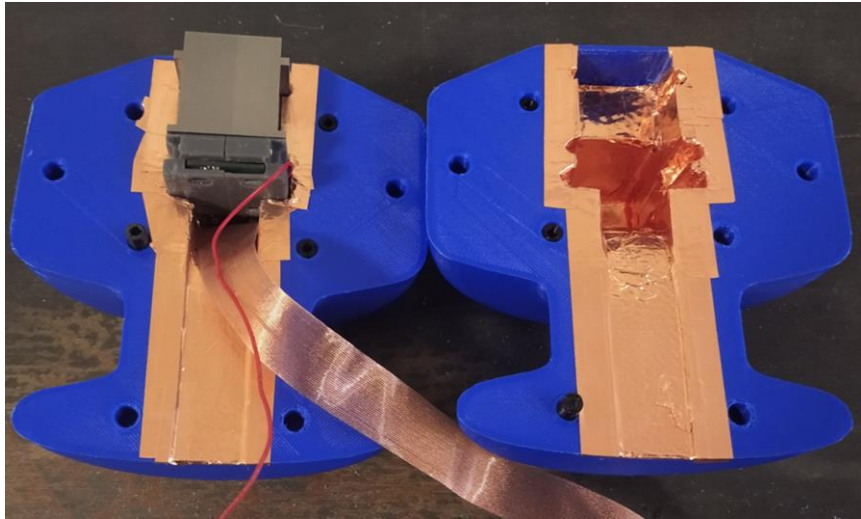
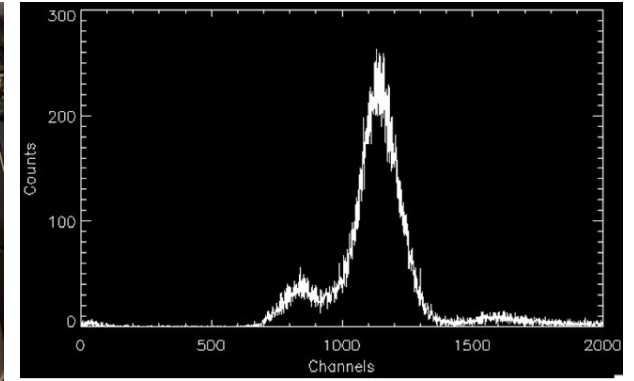
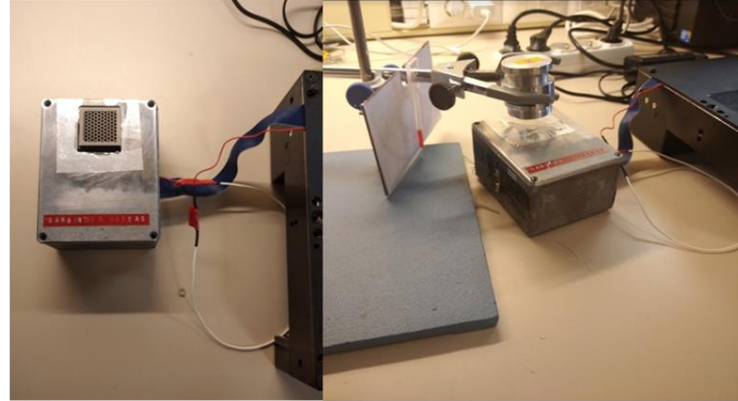
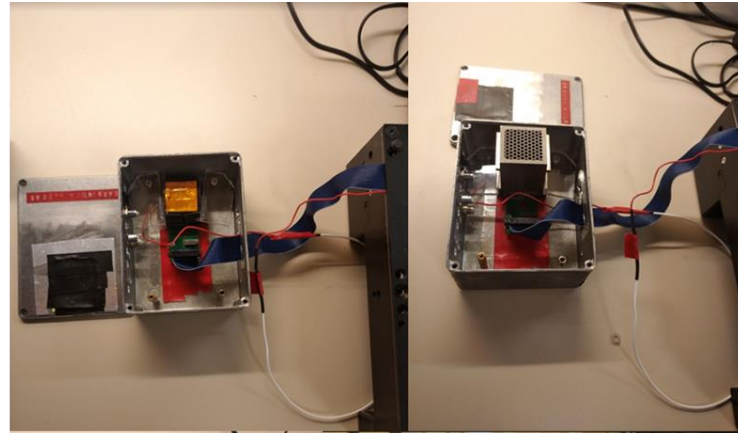
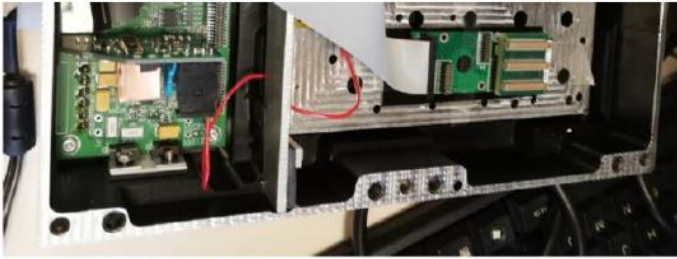
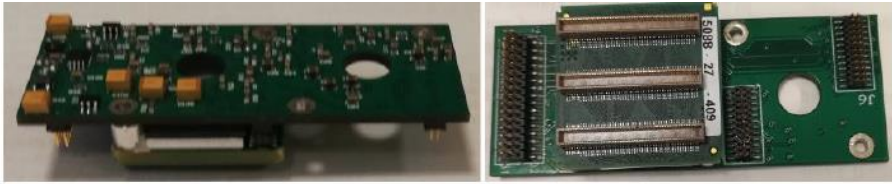


STEP 7

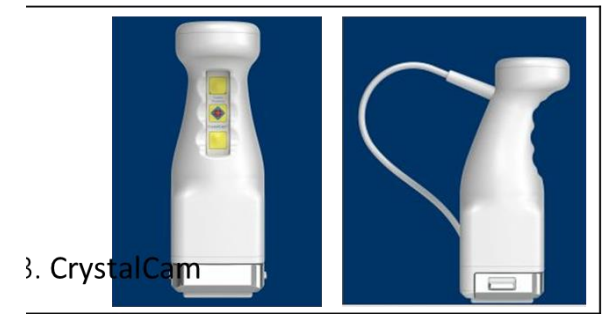








Prototip aşamasında laboratuvar ortamındaki testler

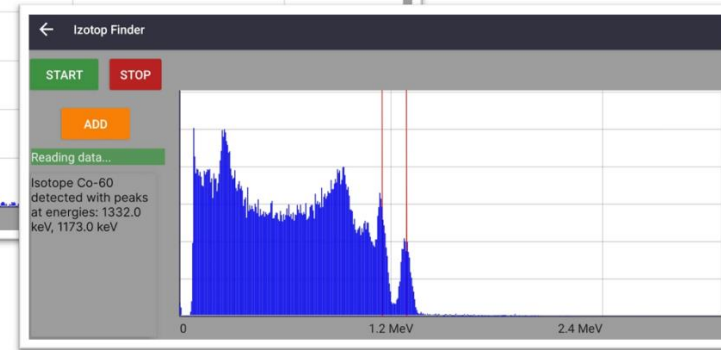
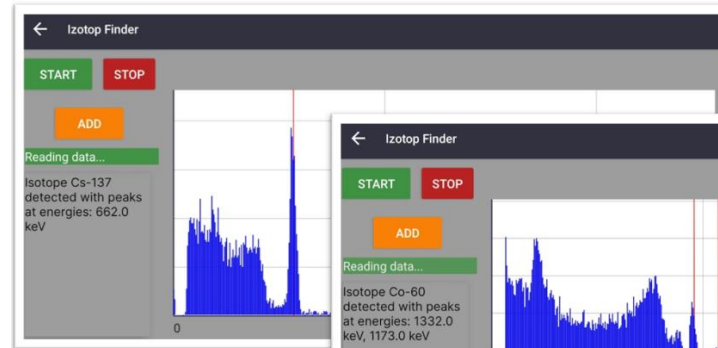




Çok Fonksiyonlu İzotop Tespit ve Nötron Algılama Sistemimiz



- Yüksek çözünürlüklü taşınabilir 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

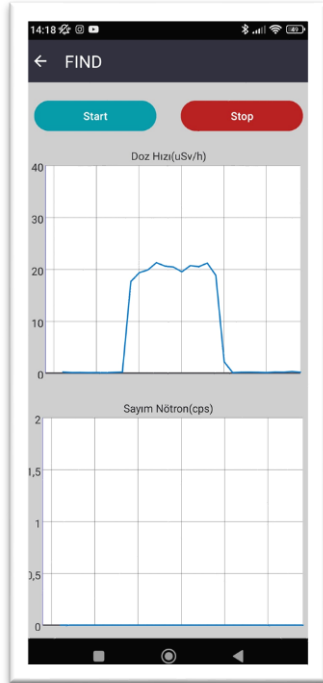
- Sağlık Fiziği
- Nükleer Tesis İzleme
- Nükleer Kaza Müdahalesi
- Gümrük, Polis, itfaiye ve Kurtarma Güçleri Tarafından Güvenlik Taraması
- Alan Araştırmaları
- Askeri
- Sivil Güvenlik



Çok Fonksiyonlu İzotop Tespit ve Nötron Algılama Sistemimiz

İzotop Arama

Arama özelliği, kaynakları bulmayı kolaylaştırır. Dedektör hareket ettirildiğinde, doz oranının arttığını gösteren net görsel grafikler, kullanıcıyı kaynağın konumuna yönlendirir



Doz Ölçümü ve Otomatik İzotop Tanımlama

Spektral veriler, operatörün herhangi bir kalibrasyon faktörünü değiştirmesine gerek kalmadan doğru bir doz değeri vermek için Muontek tarafından geliştirilen bir algoritma ile tüm enerjilerde analiz edilir.

Gama tayfı kaydedilirken, ANSI N42.48 standartlarını karşılamak üzere tasarlanmış, yaygın olarak karşılaşılan 12 radionüklit için tam otomatik radionüklit tanımlaması yapılabilir

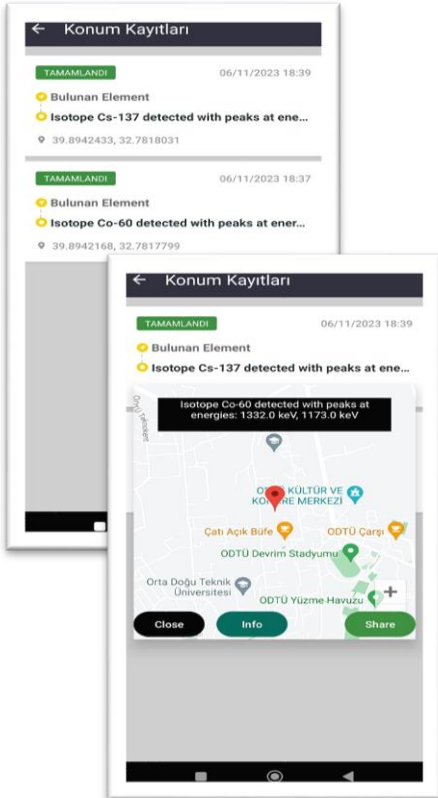




Çok Fonksiyonlu İzotop Tespit ve Nötron Algılama Sistemimiz

Raporlama ve Paylaşma

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



Teknik Özellikler

Algılayıcı: 15x15x30 mm³ 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

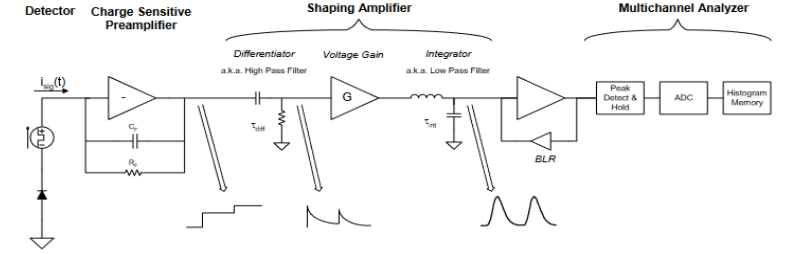
Doz Doğruluğu: < %20 den küçük

Doz Hassasiyeti: 0.15 Bq/g Cs137 için

Analiz Uygulaması: Android NeutronX yazılımı

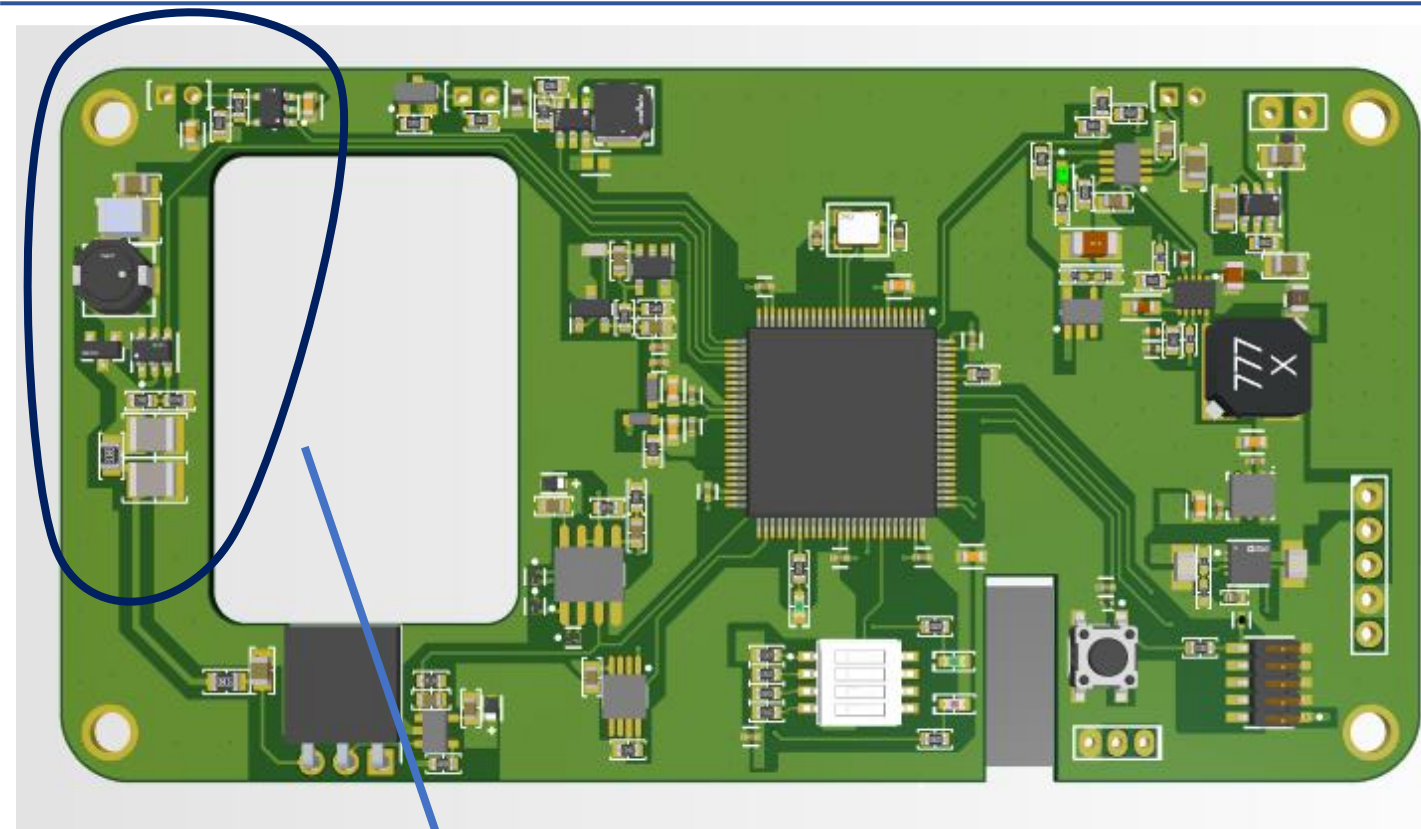
Maximum Boyut: 12.5 x 6.5 x 3.3 cm

Ağırlık: 230 g (pil dahil)

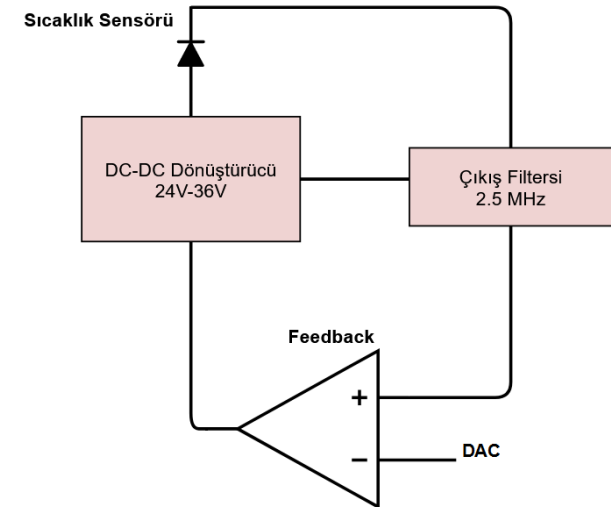
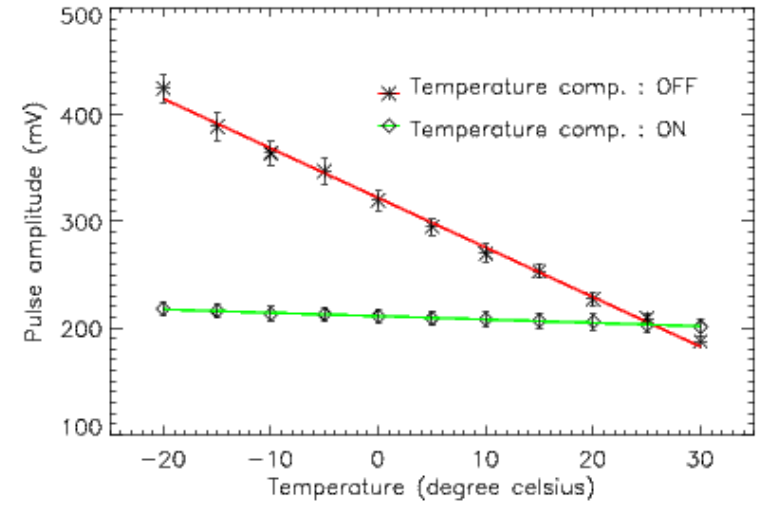




Sistemimiz Geliştirilme Süreci: Kart Entegrasyonu

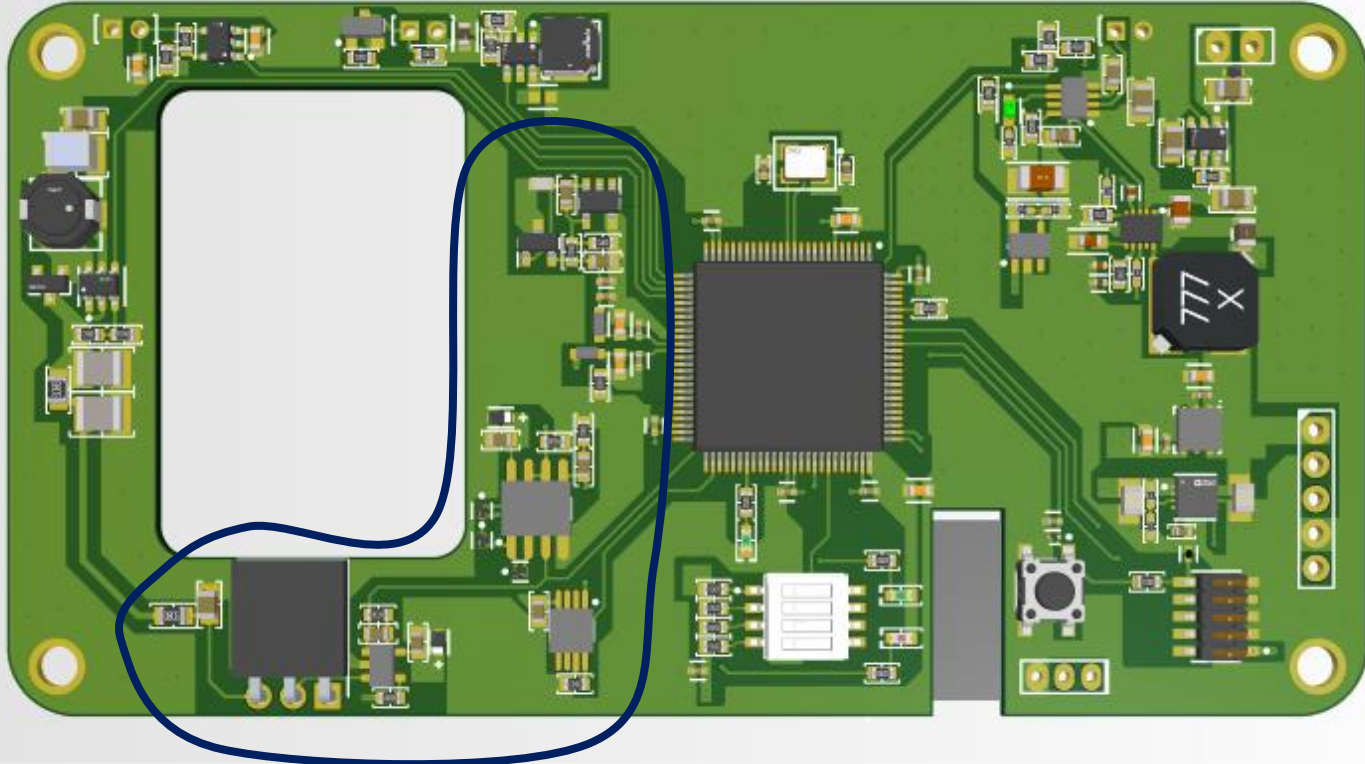


Sıcaklığa Göre Değişen Bias Kontrolü

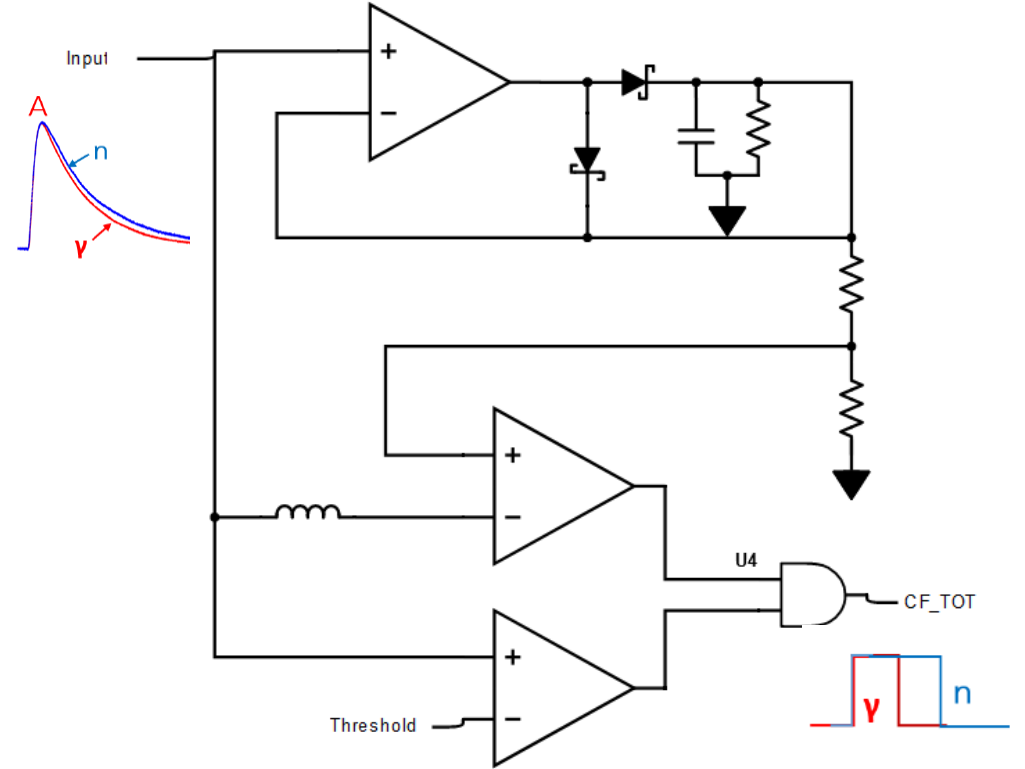




Sistemimiz Geliştirilme Süreci: Kart Entegrasyonu



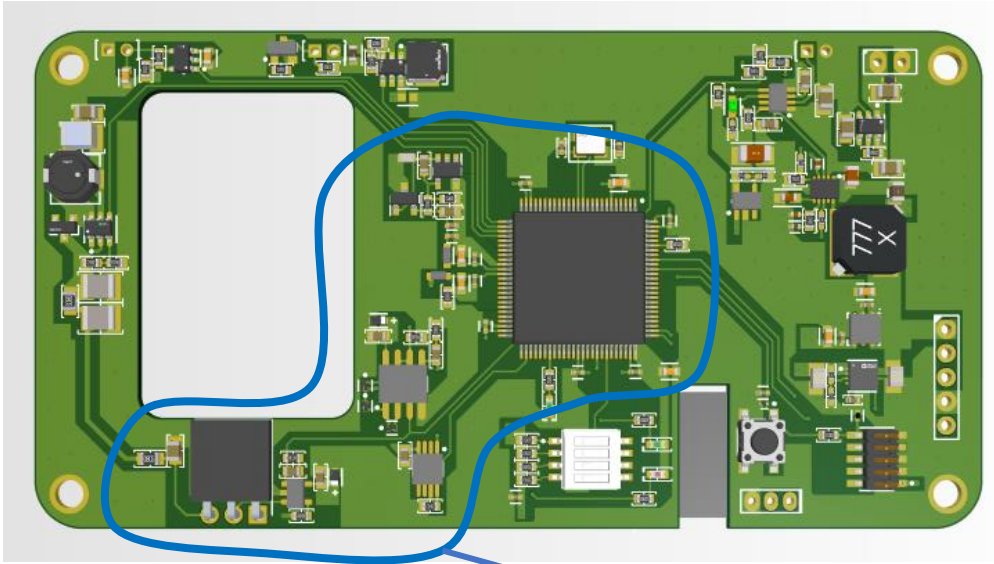
Analog Kısım PSD ve SH



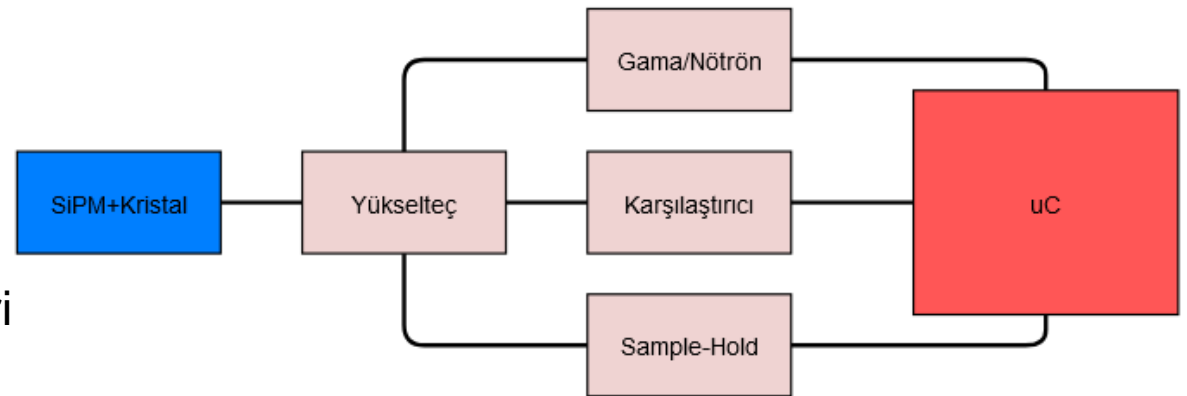
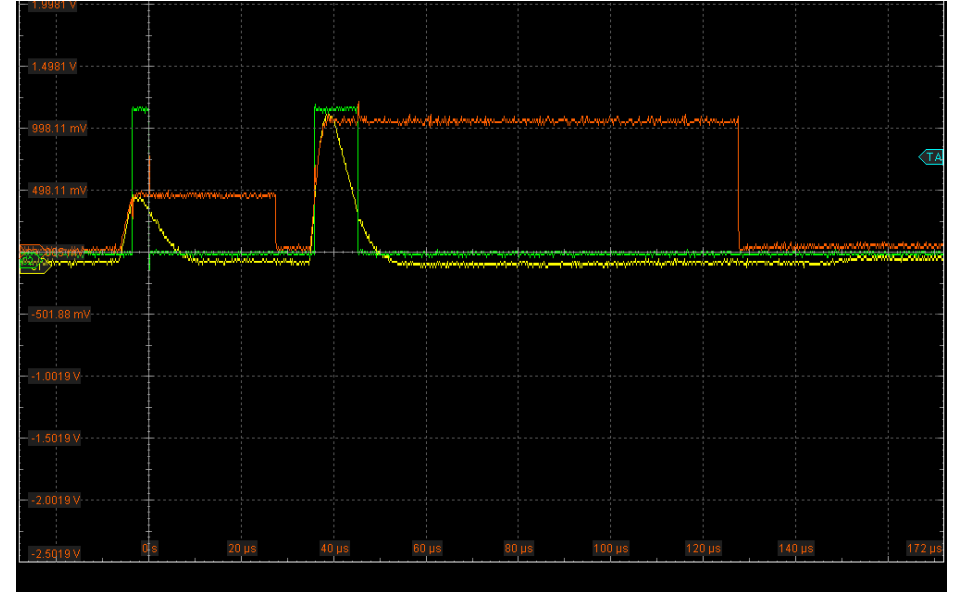
Nötron Gama Ayırıştırılması CF-TOT methoduyla yapılmıştır



Sistemimiz Geliştirilme Süreci: Kart Entegrasyonu

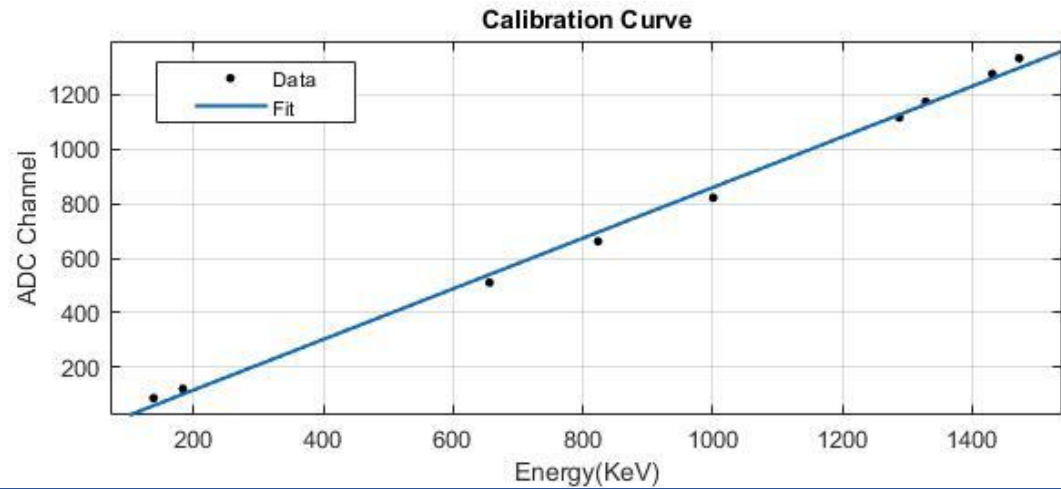
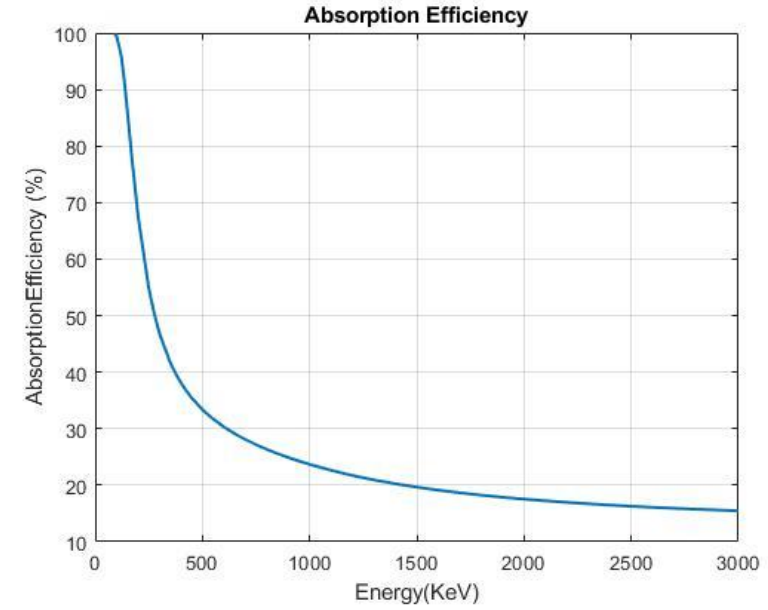
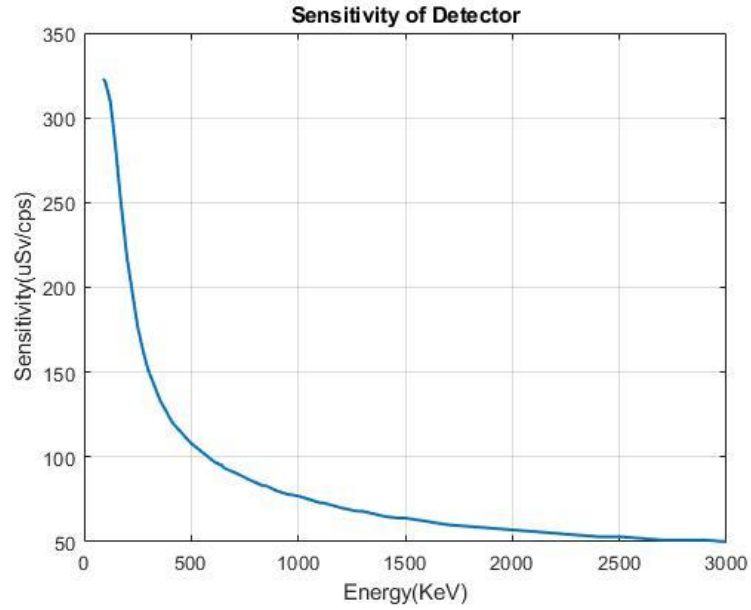


SiPM'den gelen sinyaller yükseltildikten sonra Karşılaştırıcı devrelere ve gama/nötron ayrışımı için CF-TOT devresine aktarılmakta en son aynı Sinyal Sample-Hold devresinde uzatılarak yükseklikleri Tayin edilmektedir





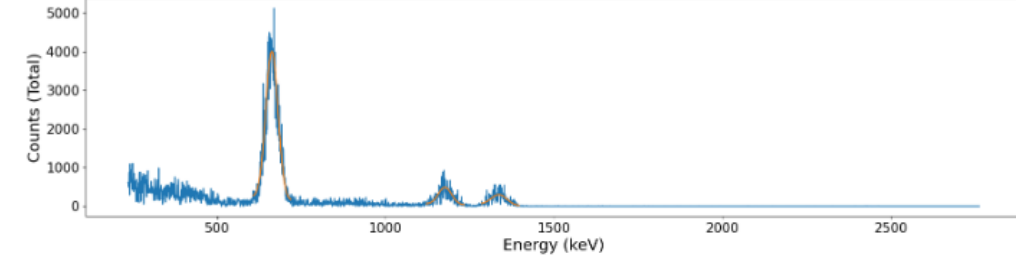
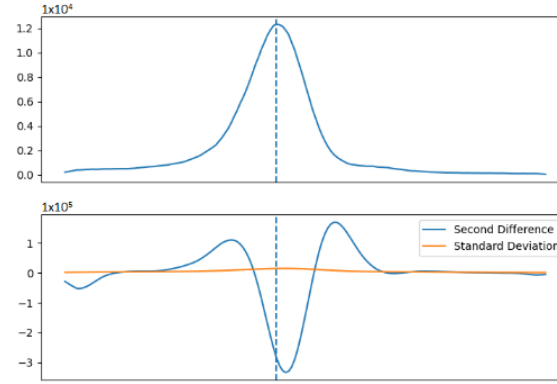
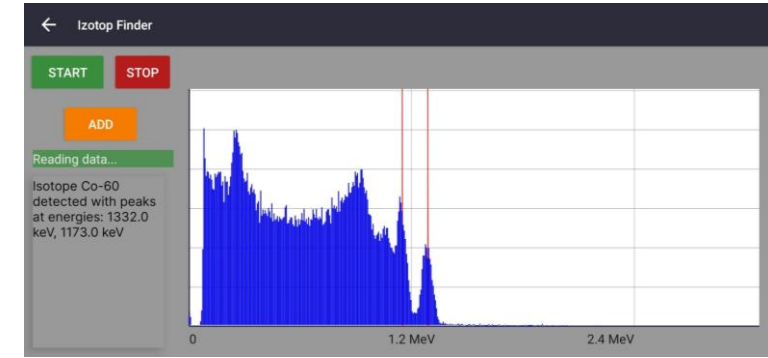
Sistemimiz Geliştirilme Süreci: Simulasyon Doz ve Kalibrasyon



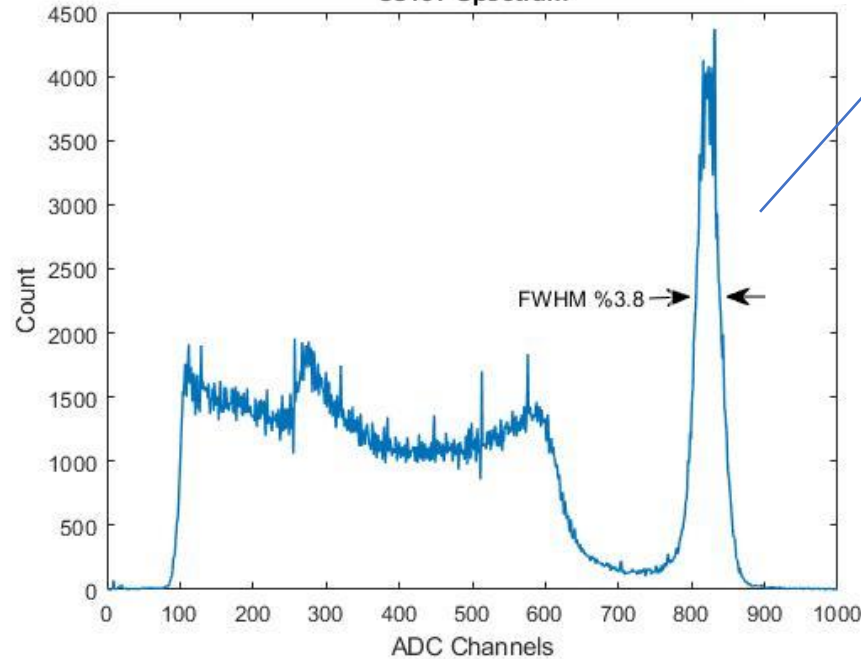
Kalibrasyon datası için farklı kaynaklarla gama tayfı alınıp Enerji değerlerine göre adc kanallarında olan veriler eşleştirildi.



Sistemimiz Geliştirilme Süreci: Tepe Bulma Algoritması



Cs137 Spectrum



Isotope	Energy (keV)	Absolute emission proba	Category	Sub-category
K-40	1460	10.55	Nuclear Power Plant	NORM
Mn-54	835	100	Nuclear Power Plant	IND
Fe-59	1099	56.5	Nuclear Power Plant	OTHER
Co-57	122	85.5	Nuclear Power Plant	IND
Co-58	810	99.4	Nuclear Power Plant	IND
Co-60	1332	100	Nuclear Power Plant	IND

Kütüphanedeki enerji değerleriyle bulunan enerji değerleri yüzde 10 farklılıkla Eşleştirilip bulunan tepe noktasının altında kalan alanda salınım yüzdesi bulunarak Yuzde 10 farkla kütüphanedekiyle eşlesirse izotop bulunmuş sayılıyor.

