

**TENMAK**

**TURKISH ENERGY, NUCLEAR AND  
MINERAL RESEARCH AGENCY**

Nuclear Energy Research Institute Status and Plans  
UPHUK VIII, V. Erkan Özcan, 5 September 2022

- Accelerators
- Research Reactors
- Climate Change
- CERN
- SESAME

**Big Science Run/Fund**



**Technical Support Organisation**

- Develop Strategy
- Carry out
- Fund
- Facilitate

**R&D**

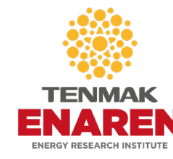
- NPPs
- Medicine
- Radiological

**Radioactive Waste Management**



**Radiological Metrology**

- Multiple ministries
- Nuclear Regulatory Agency
- Various research organisations
- Security, forensics, customs
- Cultural heritage
- Import, export
- .....
- Top of the metrology pyramid regarding radiological metrology
- Calibration and testing services



Over 800 personnel, about 60% of which is at NÜKEN.

## Research Campuses

### ❖ *Ankara Sarayköy Campus*



Will be TENMAK's main research campus.  
Accelerator, irradiation and detector technologies.

### *İstanbul Çekmece Campus*

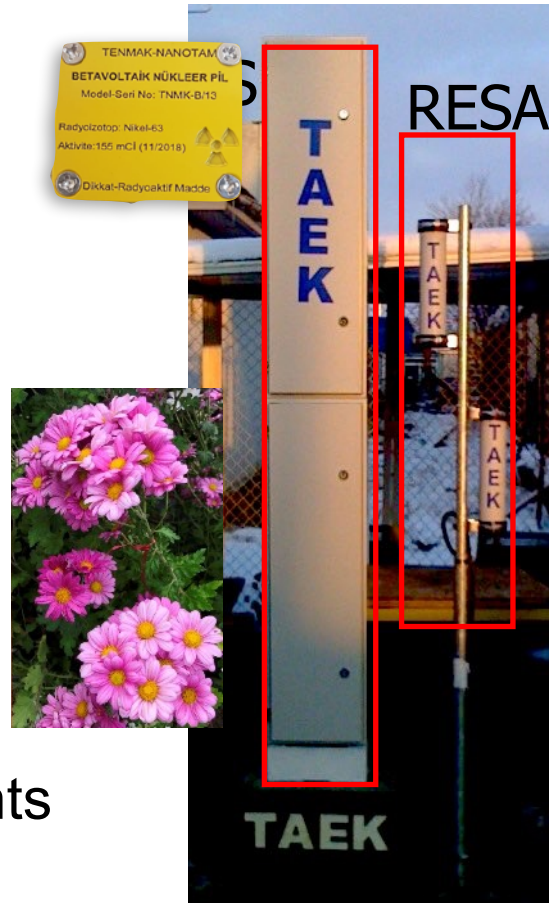


First campus established in 1958.  
Nuclear reactor, fuel, waste and related technologies.

BOREN, TEMEN and the  
administrative campus are  
located closer to Ankara  
city center.

## Example NÜKEN R&D Projects

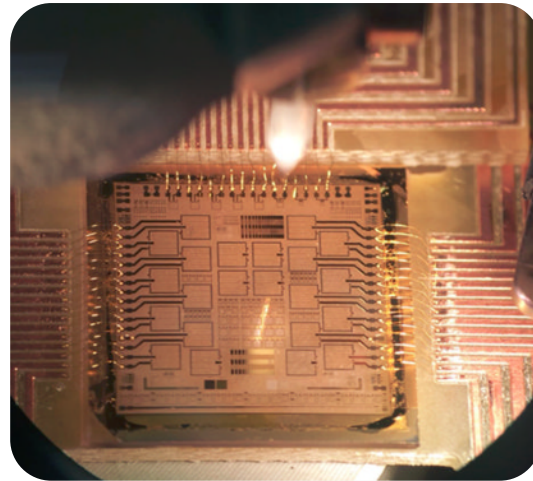
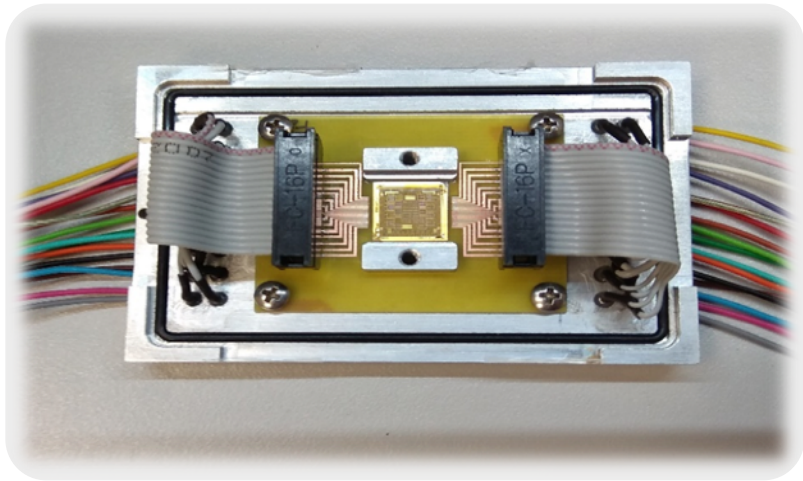
- ❖ Beta-voltaic battery
- ❖ B-10 enrichment through chemical process
- ❖ Deuterium fusion reactor
- ❖ Radiation early warning system (RESA)
- ❖ Radiation monitoring system (checkpoints and border gates)
- ❖ Mutation breeding in plants (crops and ornamental)



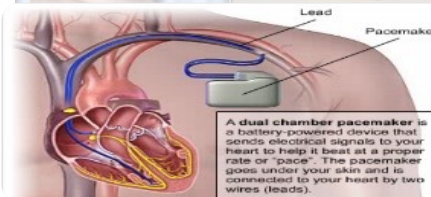
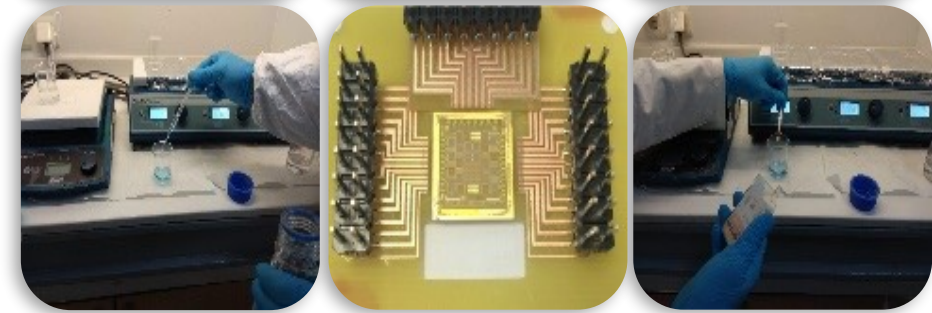
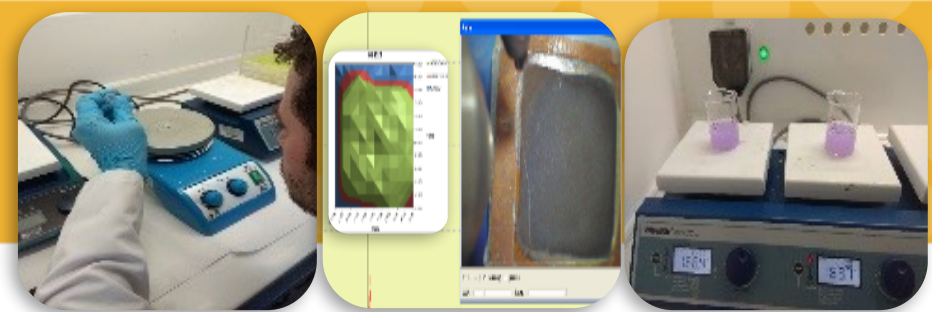
## A Selection of NÜKEN Services

- ❖ Radiation metrology, test and calibration
- ❖ Dosimeter services
- ❖ Biological dose determination
- ❖ Production and maintenance of radiation detection systems
- ❖ Co60 irradiation of spices, medical equipment, etc.
- ❖ Identification of radioactive matter,
- ❖ Emergency preparedness, CBRN calls
- ❖ In collaboration with NRC: Auditing of radiation therapy and imaging devices

# Beta-voltaic Battery



- Designed for stable running lifetime >20-25 years.
- 2018: First prototype with Ni-63.
- 2022: 5 times better performance, Ni-63 and tritium.



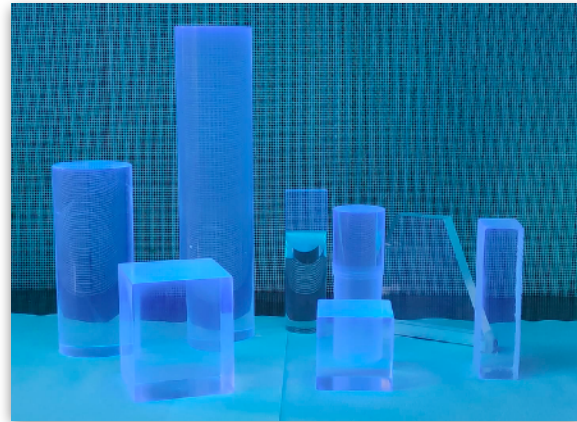
Scintillator Formula	Doping	Density (g/cm <sup>3</sup> )	#Photons per MeV	Decay Time (ns)	Emission Peak (nm)	Resolution (%)
SrI <sub>2</sub> :Eu	Eu <sup>2+</sup>	4.5	104,000	1.10	432	2.62
LaBr <sub>3</sub> :Ce	Ce <sup>3+</sup>	5.1	78,000	26	-	2
CeBr <sub>3</sub>	Ce <sup>3+</sup>	5.2	68,000	17	371	3.2
GdI <sub>3</sub> :Ce	Ce <sup>3+</sup>	5.2	44,000	45	560	4.7
Lu <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> :Pr	Pr <sup>3+</sup>	6.7	19,000	20	310	4.6
Nal:Tl	Tl <sup>+</sup>	3.6	45,000	60	415	7.1
<b>GYGAG</b>	<b>Ce<sup>3+</sup></b>	<b>6.9</b>	<b>71,000</b>	<b>20</b>	<b>550</b>	<b>3.8</b>
<b>LaYO</b>	-	<b>5.7</b>	<b>20,000</b>	<b>20</b>	<b>445</b>	<b>4.9</b>



- New gamma dose rate meter developed using our scintillators
  - Dead time < 20 µs
  - Linear response with Cs-137 source in the range : 2.5 mSv/hr – 381 mSv/hr

# Plastic Scintillators - Bulk

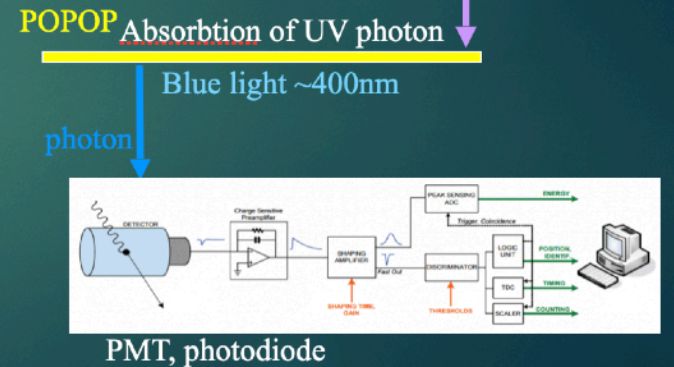
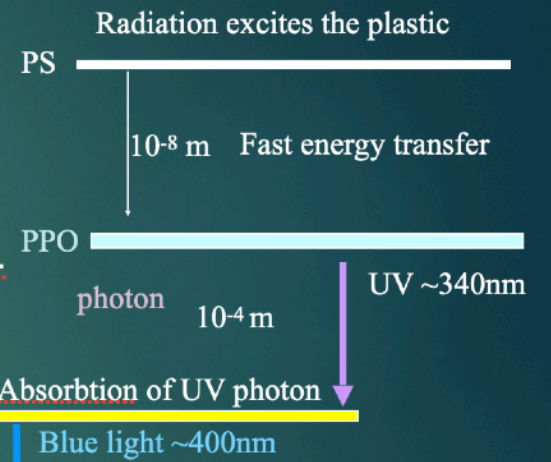
- PS production experience going back more than a decade
- Quality tests at CERN



- Recently started **producing large blocks**, to be integrated into the radiation tracking system at the border gates

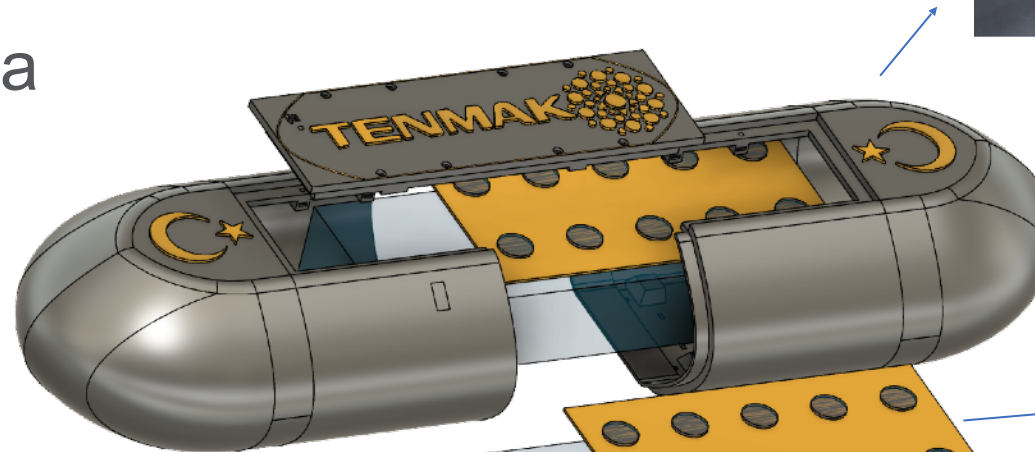
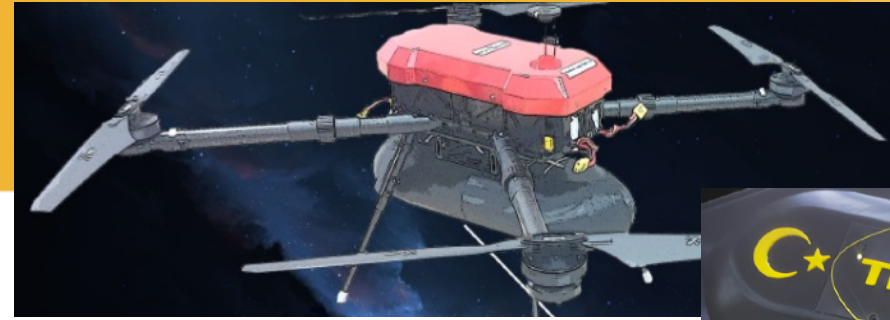


- Styrene (monomer or polymer)
- PPO (2,5 diphenyloxazole)
- POPOP (1,4-Bis(5-phenyl-2-oxazolyl) benzene)

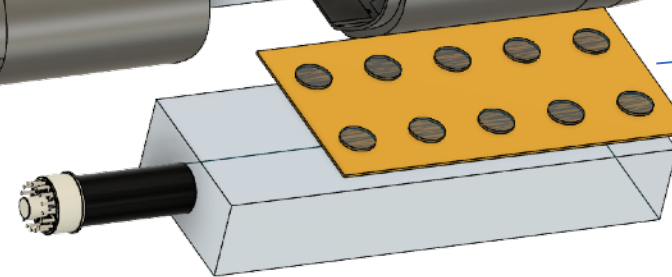
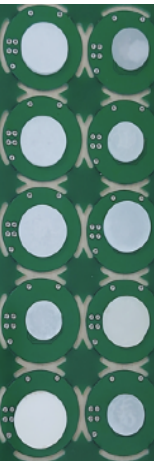


# Radioactivity Detection System on a UAV

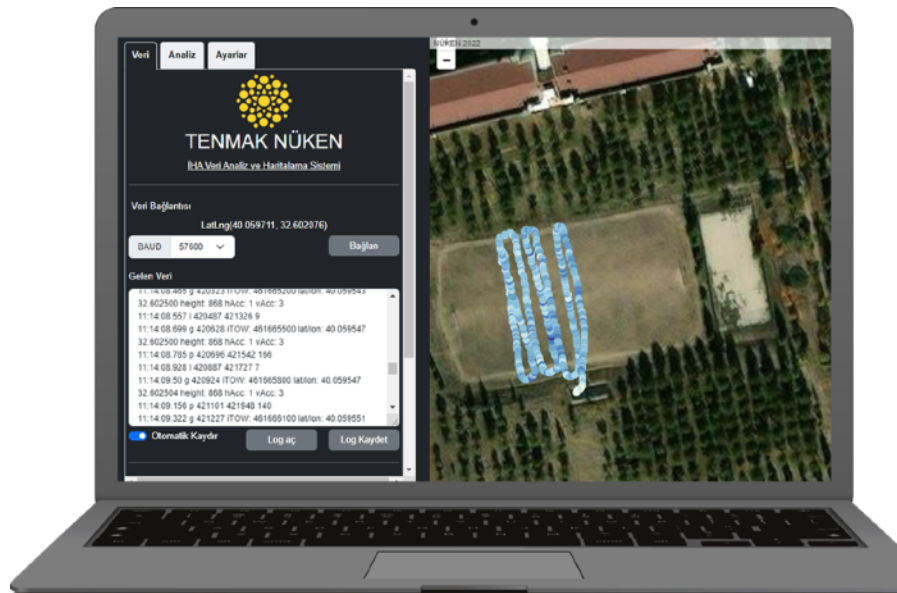
- Detect  $1\mu\text{g}$  of Cs137 from a distance of  $\sim 2.5\text{m}$ .



NUKEN  
produced  
ceramic  
scintillators



NUKEN  
produced  
plastic  
scintillator





# GM Tube Production System

- Ongoing project to construct a system to mix gases and fill them into glass tubes with appropriate cathode and anode.
  - Aim to produce GM tubes to fully supply the GM-based radiation detectors (dose and rate meters) that have been produced by the institute for decades.



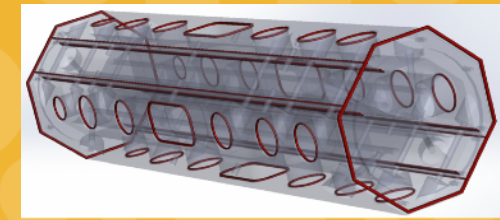
# Electron Accelerator Facility



- ICT, 350-500 keV, 1-20 mA electrostatic electron accelerator
- Aiming to bring electron beam treatment technology to use in Turkish industry.
- Flue gas, waste water and solid/liquid irradiation systems implemented in NUKEN.



Upcoming workshop in collaboration with IAEA. October 17-21, 2022.

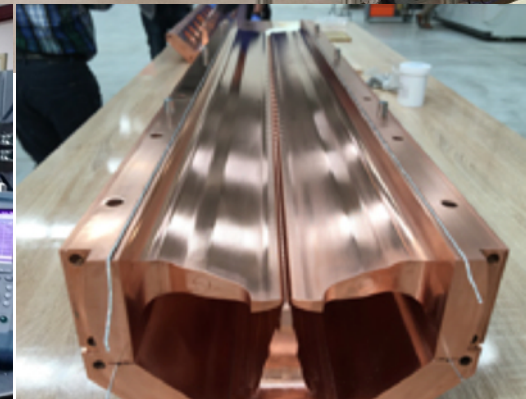
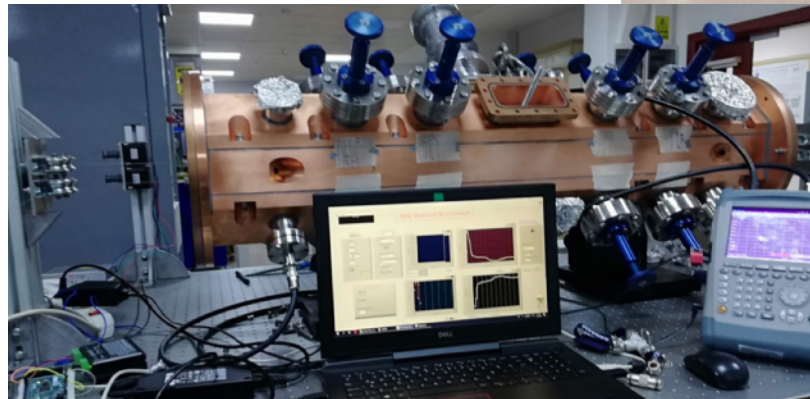


# NÜKEN RFQ

- SANAEM Project Prometheus.
  - Turkey's first RFQ; including its RF PSU, transmission line, circulator, beam diagnostic system, cavities, beam-pull system
  - Commissioned with Indium o-rings, plasma cleaning
  - 20 keV to 1.3 MeV, 352.21 MHz, 1.2 m

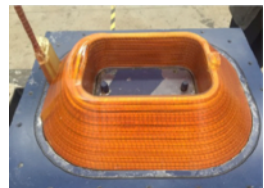
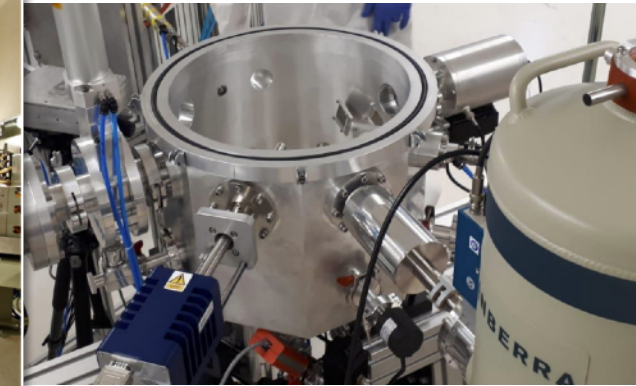
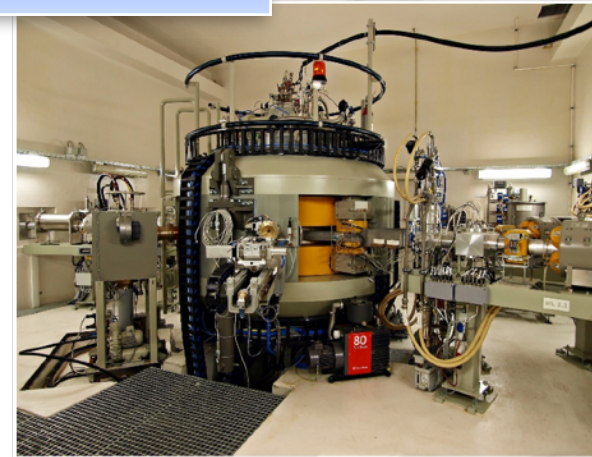
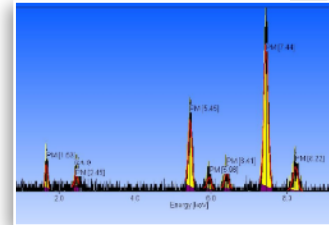


Aim to upgrade the machine for use with PIXE, RBS!



# Proton Accelerator Facility

- 15-30 MeV, 1.2mA proton cyclotron from IBA:
  - 3 beam lines for radioisotope production, gas/liquid/solid targets
    - FDG,  $^{123}\text{I}$ -NaI and  $^{201}\text{Tl}$ -TlCl
    - **In-house generator and production setup for  $^{68}\text{Ga}$**  (ongoing project)
  - 1 R&D beam line split with 5-port magnet:
    - defocusing for space applications: 20x15 cm<sup>2</sup> test area, wide selectable flux menu ( $10^5$ - $10^{10}$ p/cm<sup>2</sup>/s). Some quad magnets produced in Turkey & tested at CERN
    - in-house beam degrader from 15 MeV down to ~2MeV - pA current for PIXE, PIGE, RBS, PESA (ongoing project)

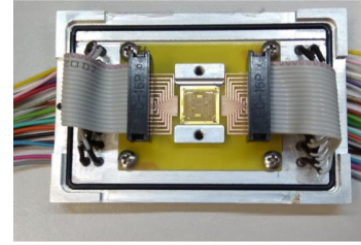


R&D irradiation room: Irradiation service in vacuum or in air. **Being redesigned into an autonomous room.**

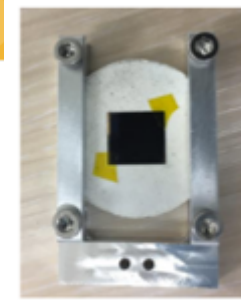
The beam can also be directed towards METU defocussing beamline.



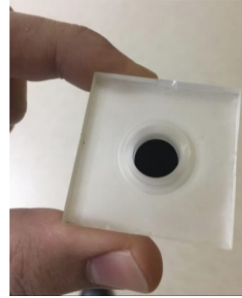
Arpa



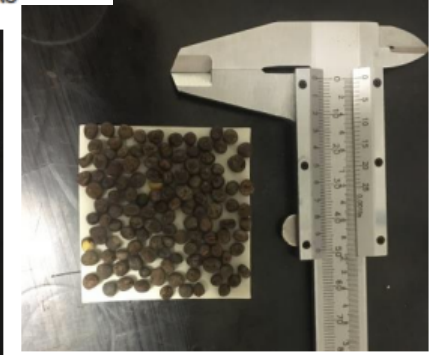
Nükleer Pil (GaAs)



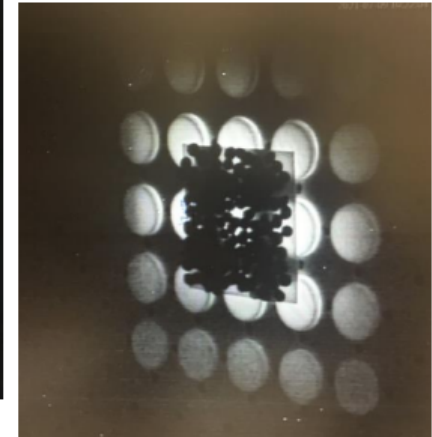
GaAs



Karbon nano-tüp

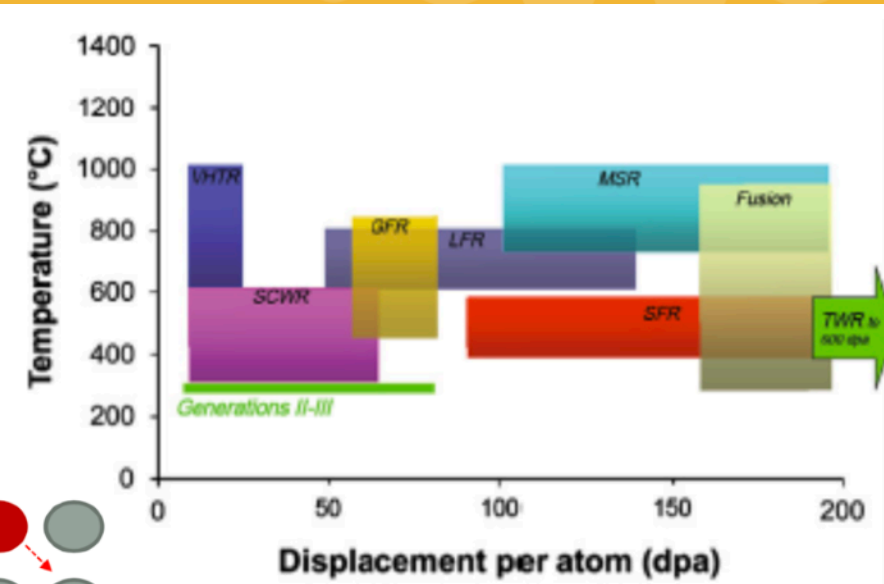
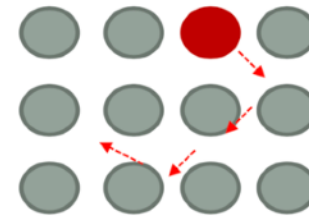


Bakliyat türleri

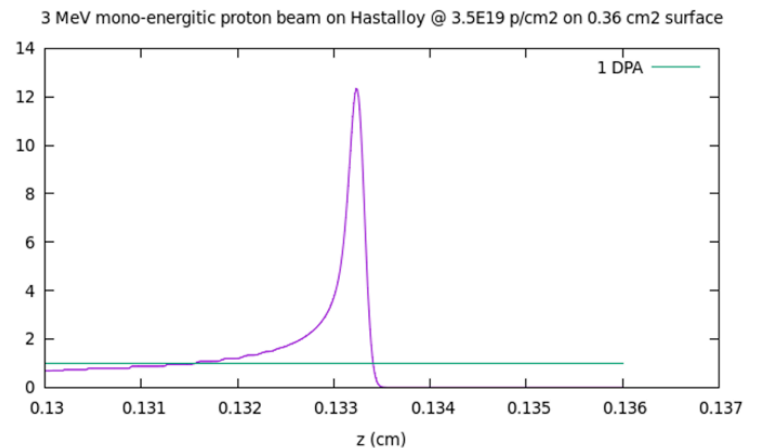
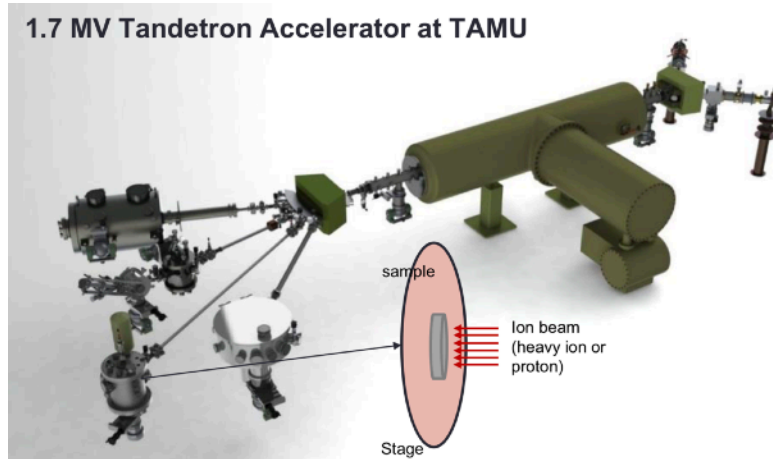


# Simulating Neutron Damage

- Investigation of the proton beam radiation effects on the micro structural properties of oxide dispersion nickel/iron-based alloys manufactured by additive methods for future reactor applications
- In collaboration with Dr. Eda Aydoğan from METU Dept. of Met. and Mat. Eng.
- Neutron damage can be simulated with protons.
  - Decrease proton beam energy down to couple MeV.
  - Produce and test new materials



Dpa (displacements per atom) is the number of times that an atom is displaced from its original lattice position



## Conclusion

- TENMAK has been taking concrete steps toward restructuring itself as an agile agency that actively listens to academics, forges collaborations with universities and industry, aims to be a reliable supporter of big science.
- We welcome opportunities for all sorts of collaboration.
  - In particular, we are looking for any applications of our 30 MeV beam and its upgrades.



# TENMAK

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