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# Promoting HEP research-based Education Through Undergraduate Research Experience for Engineering Students

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# Outline

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- UREP program
- HEP activities
- Students involvements
- outcome

# TAMUQ: Texas A&M University at Qatar

- Established in 2003
- Delivering engineering degree:
  - Chemical
  - Electrical
  - Mechanical
  - Petroleum



# Qatar National Research Fund

A comprehensive list of funding programs: from middle school to university



# UREP program

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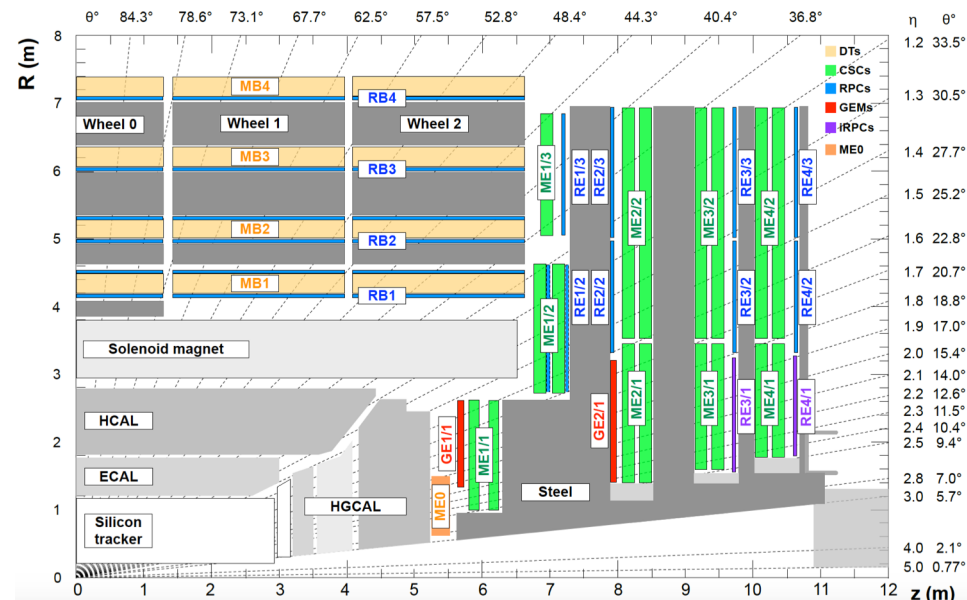
## *Undergraduate Research Experience Program (UREP)*

- 1 year long research program
- Involve up to 3 students in research
- Clear and detailed list of learning outcome
- Weekly meetings
- Periodic reporting to the funding agency  
→ Students receive a stipend based on their progress report

# CMS Muon system upgrade

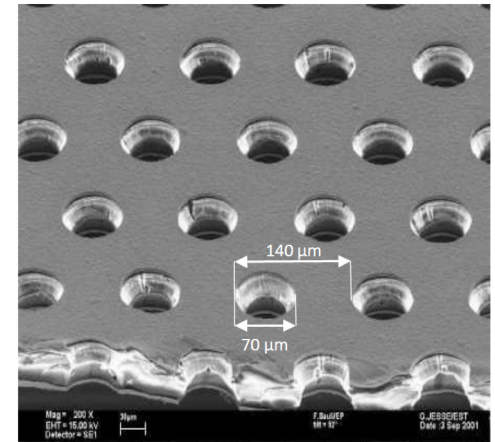
*Our group is involved in the CMS experiment:*

- R&D efforts for the upgrade of the CMS muon system*
- Both simulation and data analysis*
- Addition of detection layers based on Gas Electron Multiplier*

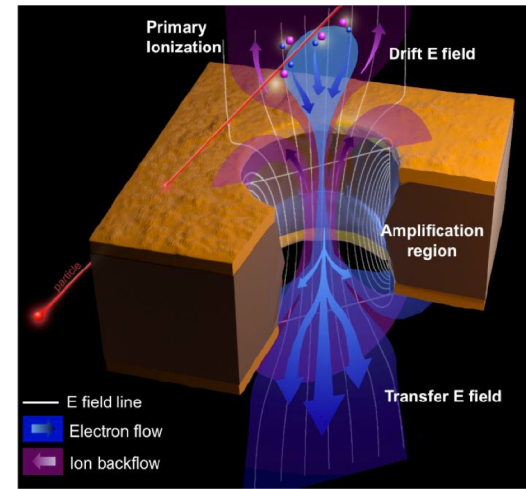


# The Gas Electron Multiplier (GEM)

- 50  $\mu\text{m}$  thick **polymer foil**
- Coated with 5  $\mu\text{m}$  **metal** on each side
- **Regular** (hexagonal) pattern of holes
- Hole diameter 70 $\mu\text{m}$ , interspace 140 $\mu\text{m}$



- Potential difference applied on metal sides
- High **electric field** inside holes
- High **amplification** of electrons entering the holes
- Signal collected with appropriate electronics



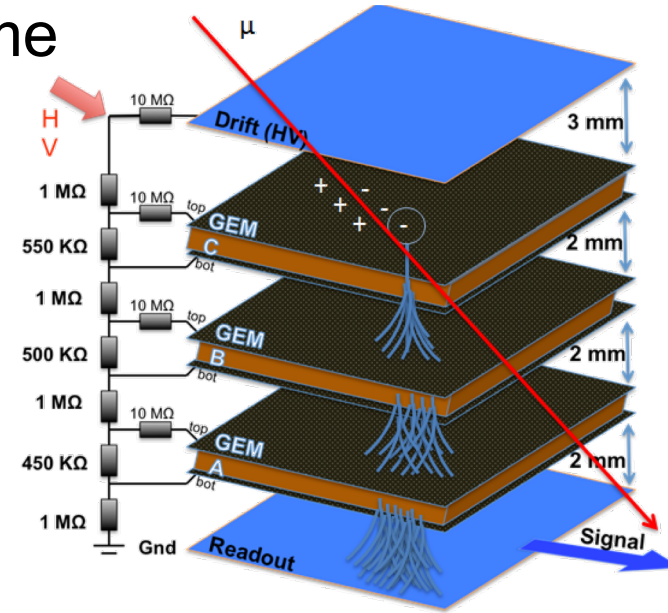
# The triple-GEM detector

- **Three** GEM foils in the same gas volume
- **Multistage amplification**
- Robust detector
- Excellent performances

→ Needed additional R&D

→ A major collaboration-wide effort

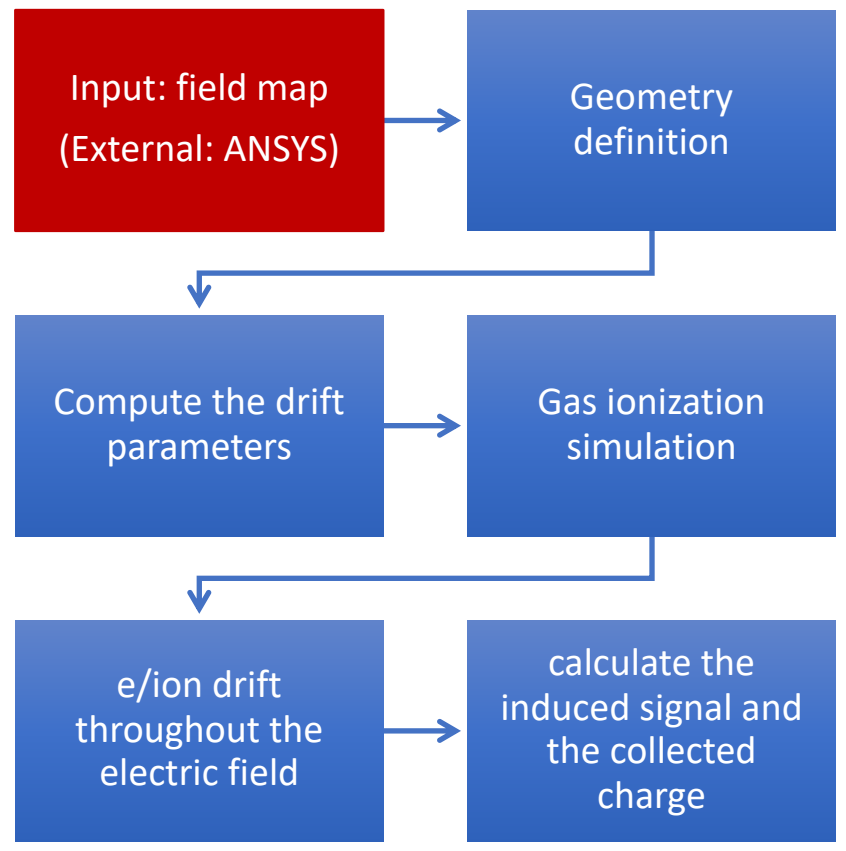
→ **We involve students in simulation work**





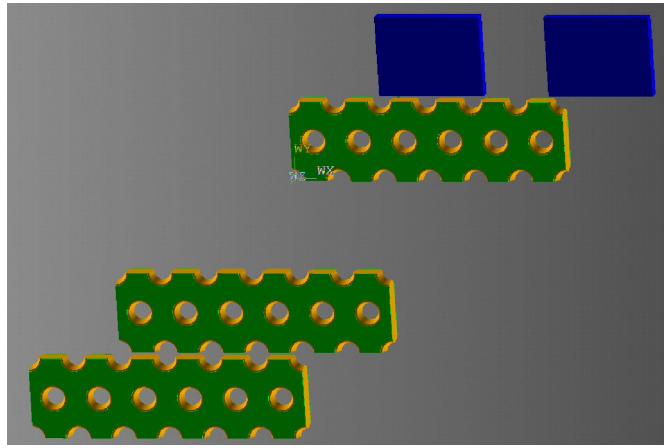
# Simulation workflow (I)

- Generation of electromagnetic field map using FEM software
- Using Garfield++
- Using ROOT for post-analysis

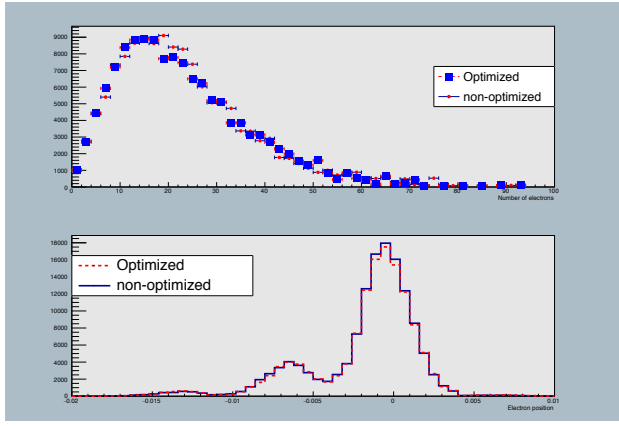
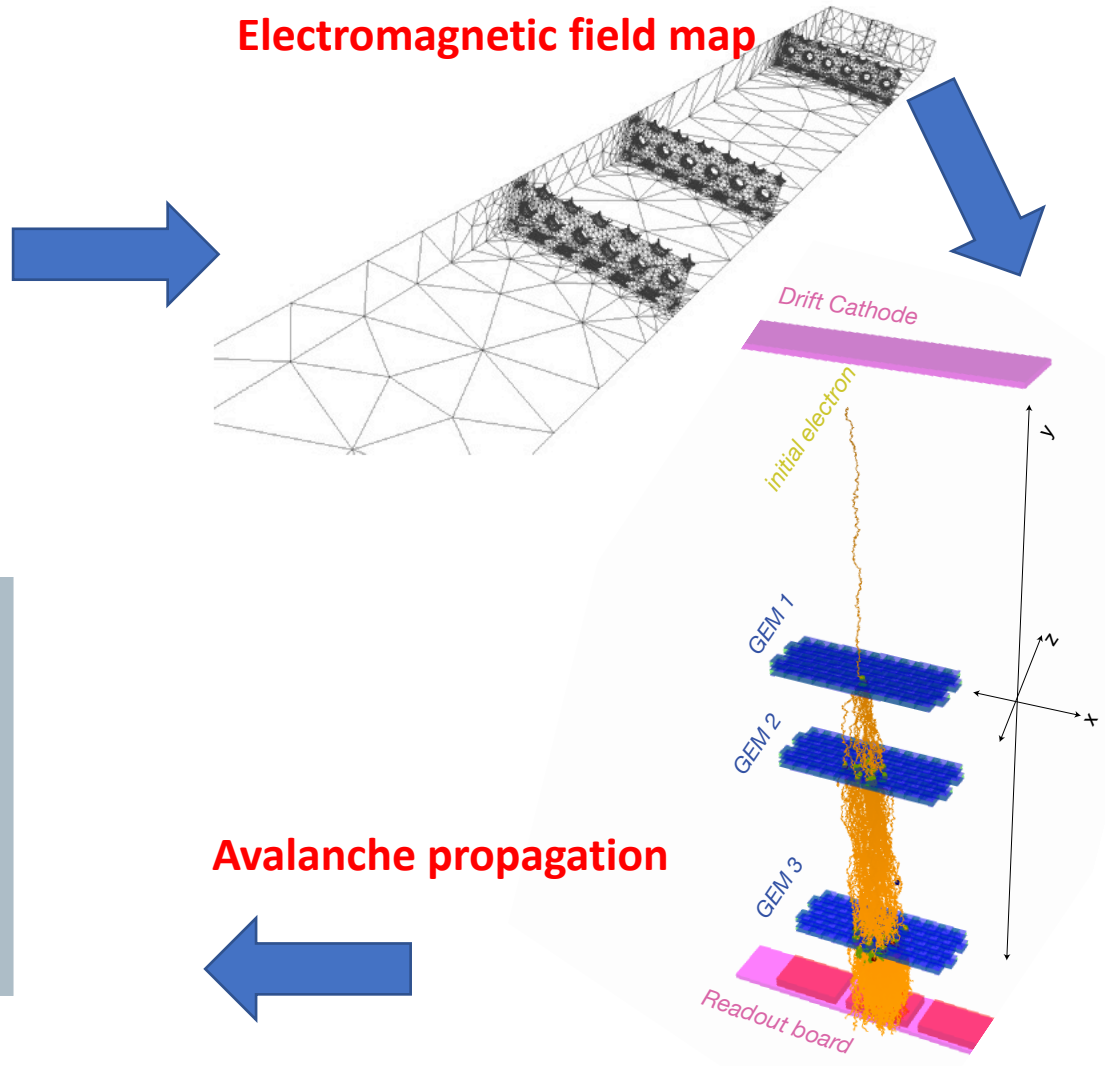


# Simulation workflow (II)

## Geometry definition



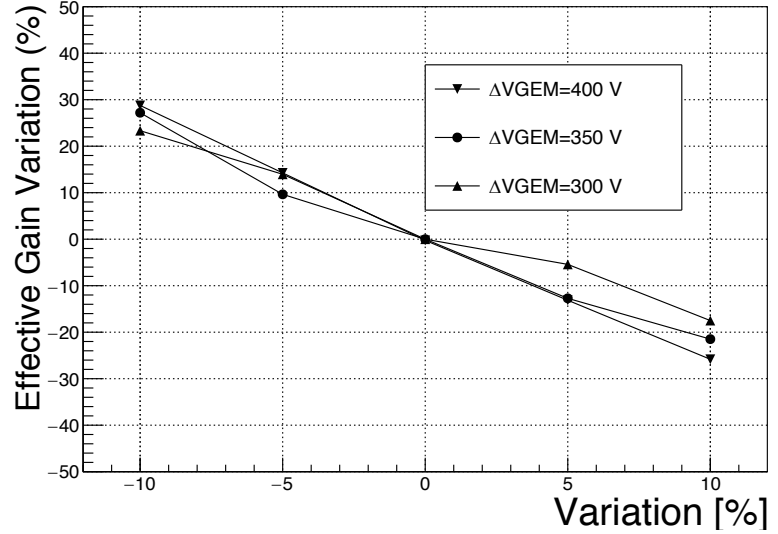
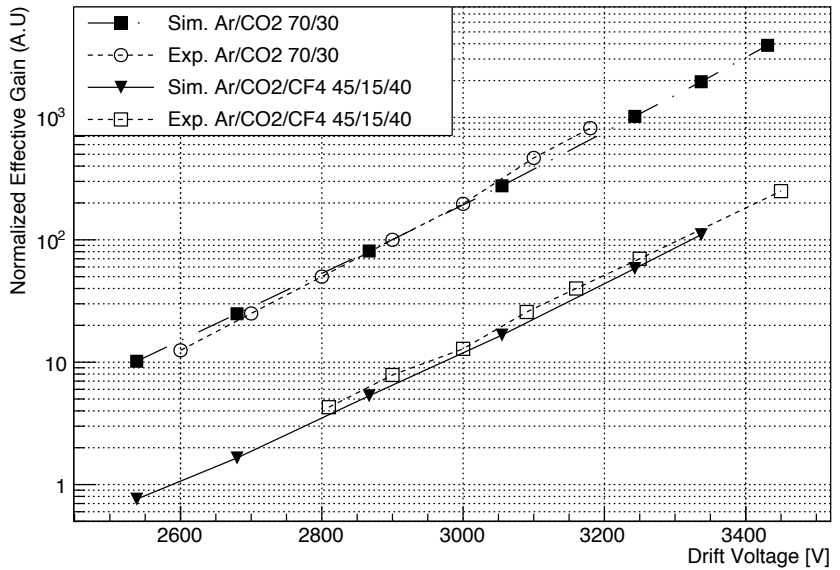
## Electromagnetic field map



## Avalanche propagation

## Output

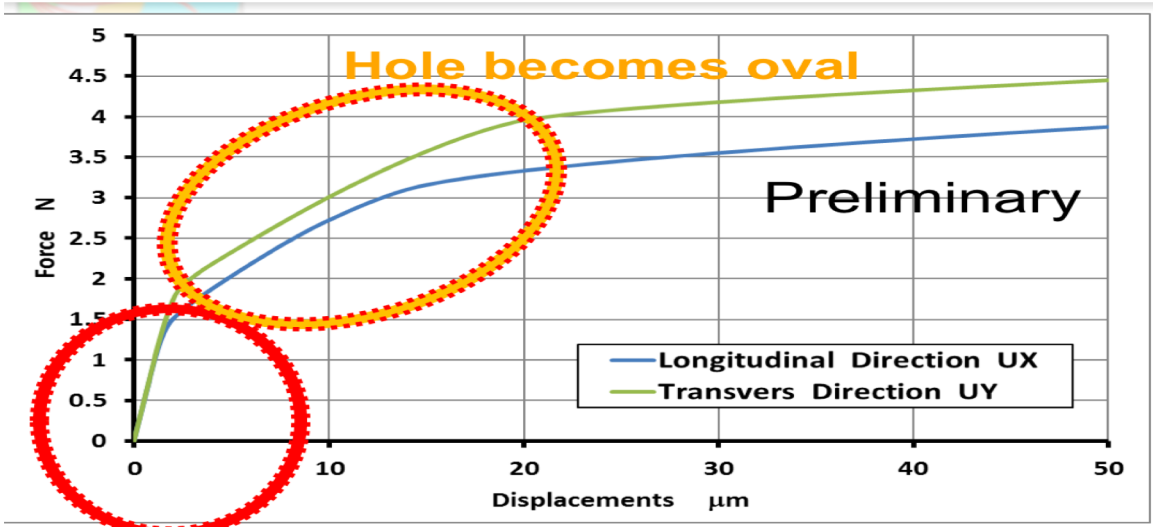
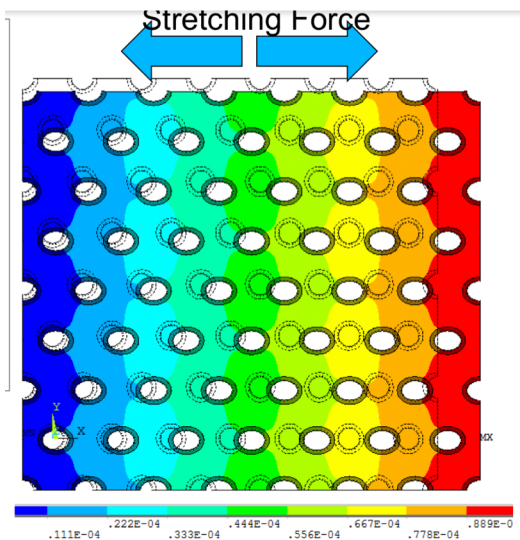
# The triple-GEM detector: gain and uniformity studies



M. Abi Akl, O. Bouhali, Y. Maghrbi, T. Mohamed NIMA 832(2016)

# The triple-GEM detector: Mechanical deformation

- the GEM foil(s) are manually stretched in order to maintain the required gap configuration throughout the detector area.
- This stretching force applied on a GEM foil can introduce local variation in the size or the shape of the perforated holes.



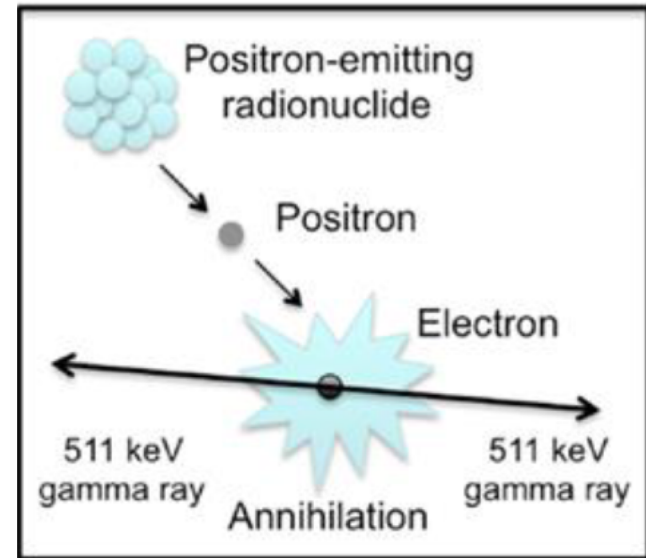
**The hole shape stays circular**

M. Abdalla et al., MPGD 2019

# Medical physics: PET scanners

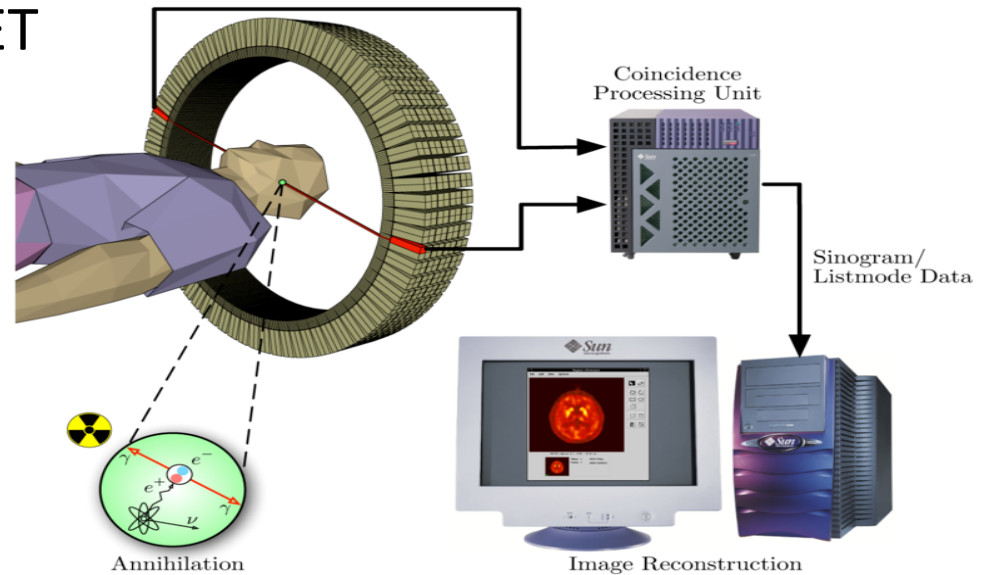
Positron emission tomography:

- based on the physics process of electron-positron annihilation
- Two photons are emitted with 511-keV energy
- Exploited in medical imaging
- PET scanners



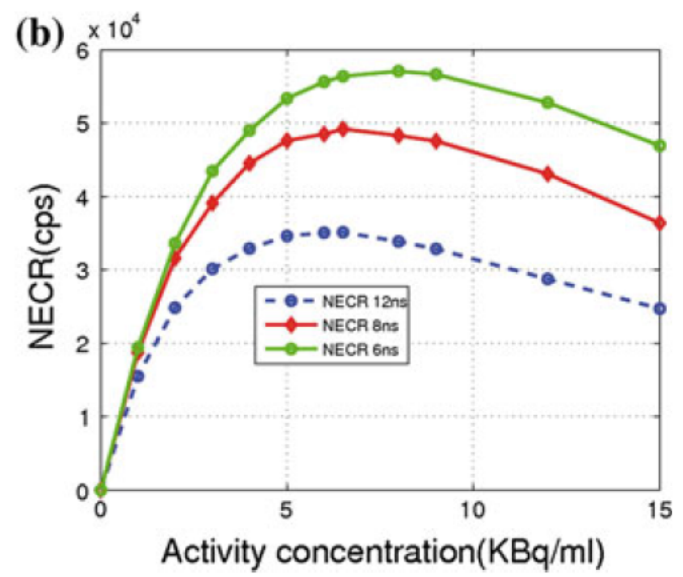
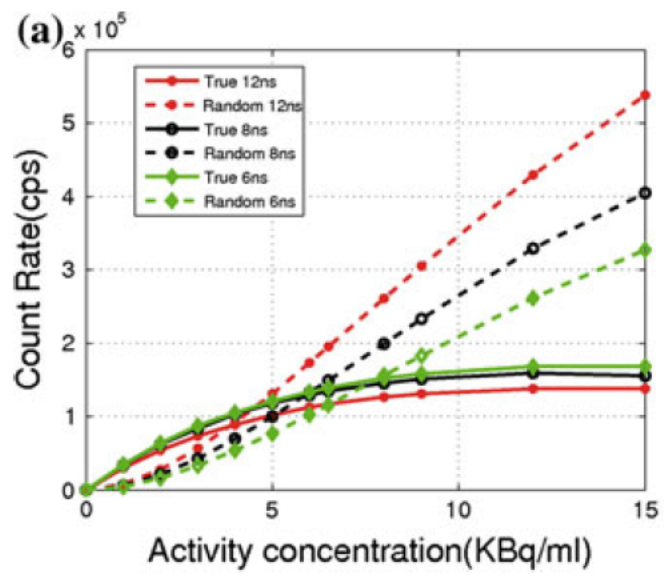
# PET scanners

- Radiotracer is injected in the body
- Radiotracer emits positrons
- Annihilation is detected by detectors in PET



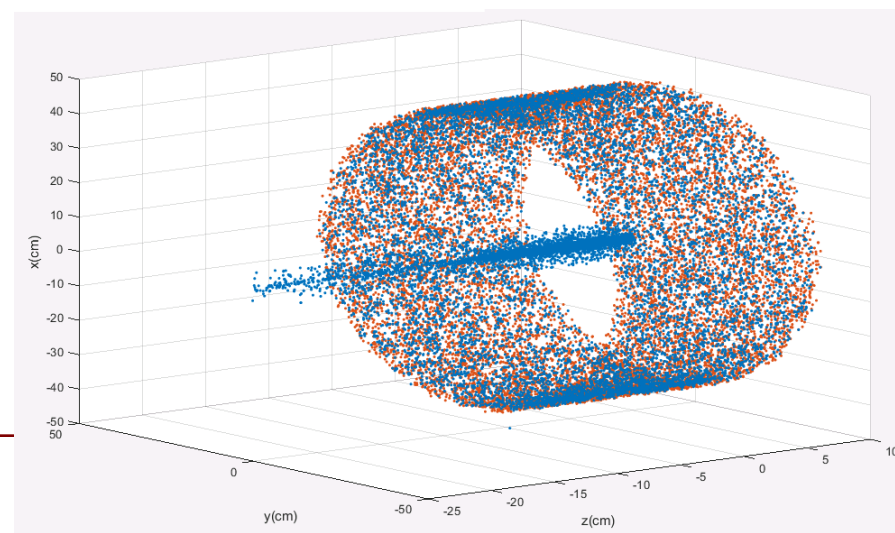
*Use of GATE (GEANT4 based) to model PET scanners*

# Results from student work



## Response of a PET scanner to a Phantom

*R. Saidi et al., Advances in the FLUKA PET tools, International Conference on Monte Carlo Techniques for Medical Applications (MCMA2017).*



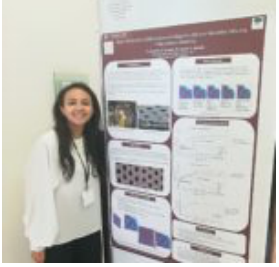
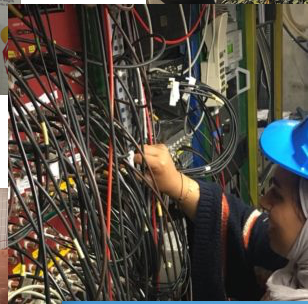
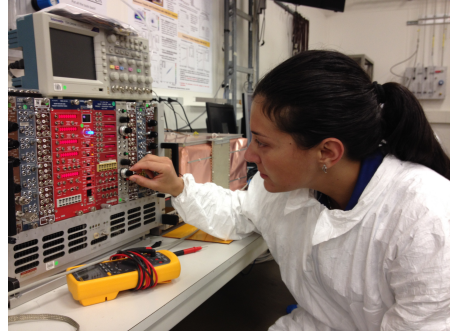
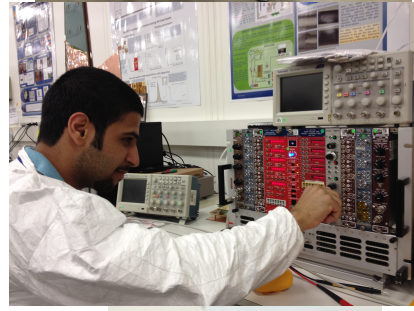
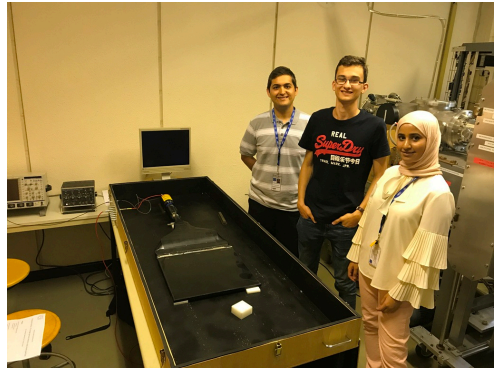
# Simulating in HEP/MP learning process

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Students have to learn:

- C++ and python programming
- Garfield++ , GEANT4 and ROOT
- Conduct an extensive literature review
- How to use a supercomputer for calculation
- Link HEP to their engineering skills (mechanical and electrical)  
→ Publishing and presenting at conferences





# Outcome: capacity building

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In addition to capacity building, students highly benefit from these Programs and get accepted in highly ranked universities.

In the past 3 years, my students involved in UREP got:

- 1 master in biomedical engineering at Stanford
- 3 in physics: University College London, University of Surrey
- 1 in medical physics: Columbia university New York
- 1 in bio-engineering: Texas A&M US

# Summary

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- Involving undergraduate students in research
- It improves their learning outcome
- Is an opportunity to apply what they learned
- Opens the door for their future career
- **Recently this effort gives student a credit in their curriculum**

# Raad-II supercomputer

4200 cores  
1 PB storage



**CRAY STORAGE**

**CRAY RAAD2**

**CRAY**

**OCRI**  
مركز أبحاث المعلومات والبيانات  
Oman Center for Information and Data  
جامعة حمد بن خليفة  
HAMAD BIN KHALIFA UNIVERSITY

**TEES TASC**  
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COMPUTING CENTER  
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