Detector Activities in Turkey

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RECFA Visit to Turkey, Boğaziçi University, 6 October 2017

HEP-EX in Turkey - Bright Side

- "Experimental" particle physics community is quite diverse.
  - Experimental HEP in Turkey dates back to 1960s. Now includes over 100 users of CERN from Turkish institutions.
  - Perhaps a comparable number of nuclear physicists and users of nuclear physics detectors.
  - Spread over a large geography, from Istanbul to Kars.
  - Most groups maintain international networks: their old research groups, their graduate advisors, old group members currently living abroad, etc.
  - Their research interests are diverse: experiments @ CERN, FNAL, IHEP, KEK, Turkish Accelerator Center, ...

Europe - Where do we contribute?

- A short non-exhaustive list of what parts of which "European" detectors Turkish teams contribute to.
  - KTO Karatay Uni, Konya & Yıldız Technical Uni, İstanbul: ALICE SPD & TPC
  - Adıyaman Uni, Adıyaman; Çukurova Uni, Adana; METU, Ankara; Boğaziçi Uni and İstanbul Technical Uni, İstanbul; Çağ Uni, Mersin; Gaziosmanpaşa Uni, Tokat: CMS HCAL & HF
  - Bahçeşehir, Bilgi and Boğaziçi Universities, İstanbul; Gaziantep Uni, Gaziantep: ATLAS TRT, RPC & TDAQ
  - METU, Ankara: OPERA emulsion image microscopy
  - Bilgi, Bogazici Universities, İstanbul: CAST KWISP
- Experience with Si and gas tracking detectors, calorimeters, TDAQ, emulsion.
  - International collaborations have significantly effected local choices.

Dark Side

- While the overall experimental HEP community is not small, most of the research expertise in Turkey has been:
  - Close to phenomenology, or
  - Some form of design, simulation or data analysis study, or
    - Involves detectors that are located at centres abroad (like CERN, FNAL, etc).
- The reason for this choice of research topics is historical and is related not only to the interests of the scientists, but also to the funding structure in Turkey.
  - Unfortunately, this situation had previously limited our expertise mostly to calibration and software kind of work.

Disclaimer

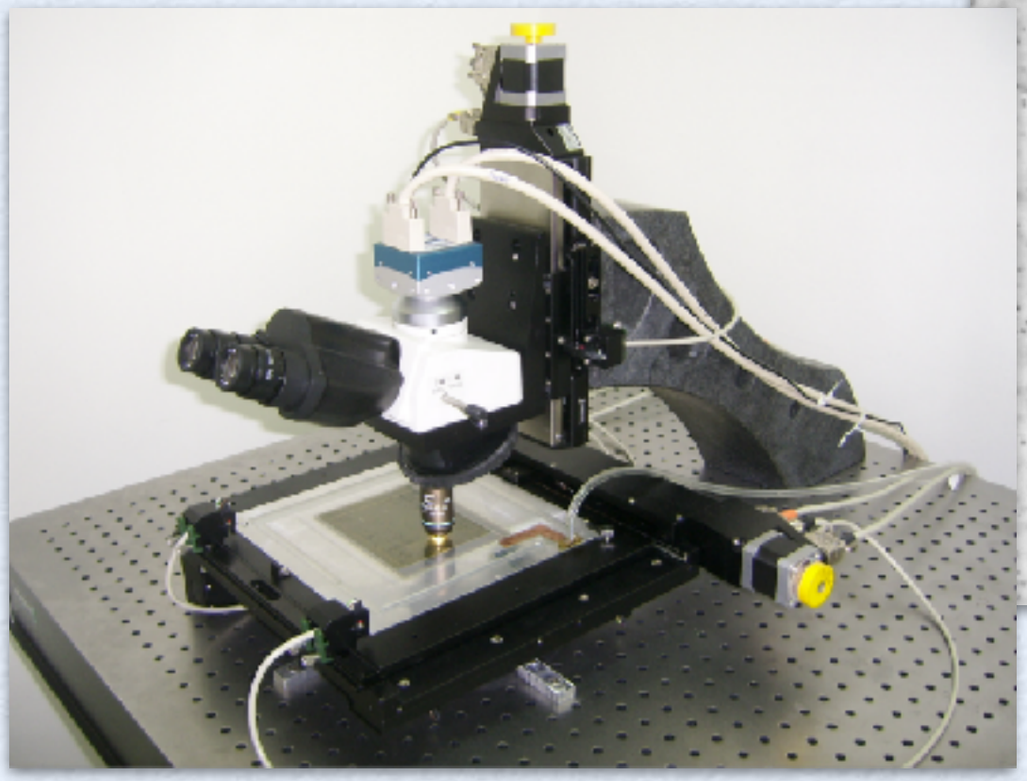
- There is a small but growing community of people dirtying their hands in building their own detectors.
  - These groups are not in regular contact with each other; and they have their own small laboratories.
  - It is not our intention to cover the work of all the small groups: not practical.
    - Instead we try to cover the larger groups, or umbrella teams. This is more meaningful as it also reflects how small groups congregate to work together.
    - This does NOT mean that the small groups are necessarily on the same financial support. They quite often have their own independent project finances, in addition to common funds.
  - This talk tries to give emphasis on work performed at local laboratories; and we cover not just detector physics, but also some work that relates to accelerators, if they are being carried by a detector group.

Ege University

- An example of a typical small group; 2 faculty members and 2 PhD students at the nuclear physics lab.
- Activities include:
  - Mounting Detector Crystals to Photomultiplier Tubes and their Performance Tests
  - Energy Resolution Enhancement
  - Time Resolution Enhancement
  - Time/Energy Coincidence Measurements
  - FLUKA Monte Carlo Calculations
  - Radiation Detection by MPPC (Multi-Pixel Photon Counter, SiPM- Si photomultiplier)
  - LabVIEW Studies (Radiation Detection and Measurement Investigations via LabVIEW)
  - Studies on Nuclear Electronics to improve Medical Imaging Performance

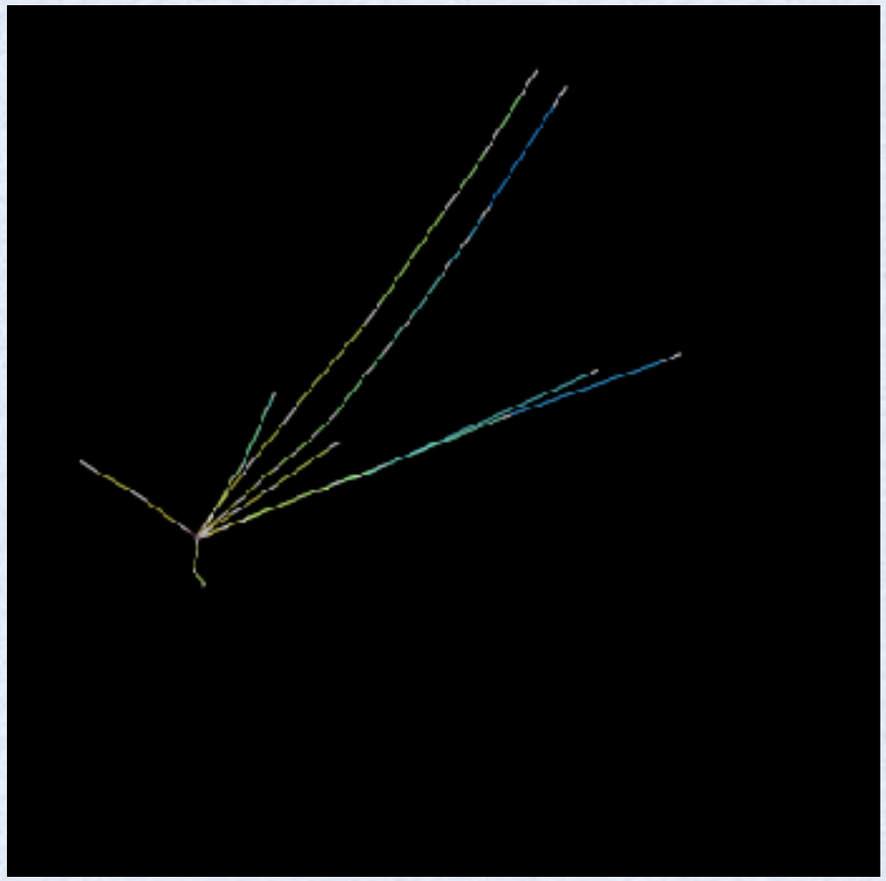
METU Emulsion Microscope

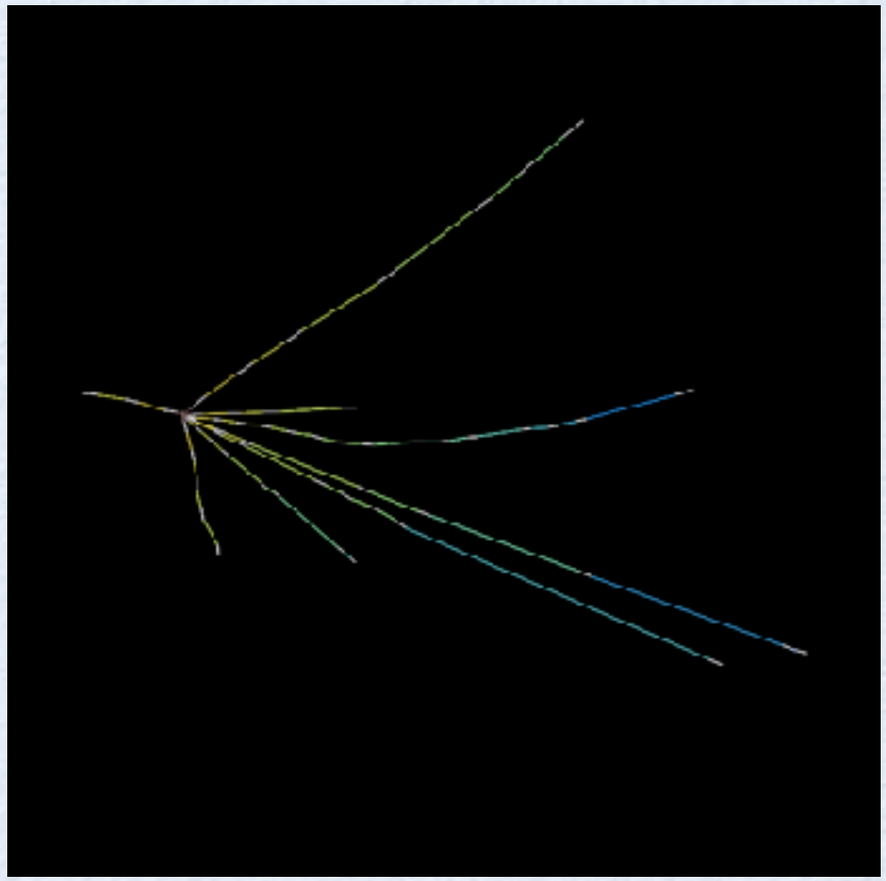
- Middle East Technical University is the oldest hep-ex group in Turkey
  - 5 hep-ex faculty members on various experiments, including AMS, Belle2, CMS, OPERA.



- European-style automated scanning system for studying OPERA emulsion targets.
- nano-step motors (VEXTRA 5-phase) and optical encoders; provide 205 mm travel range in X-Y and 50 mm in Z with a resolution of 0.1 μm

Opera Neutrino Events @ METU





- Neutrino interactions detected by our scanning system at METU.
- Supported by TUBITAK (grant 108T324).

M. Guler, O. Altinok, Performance of automatic scanning microscope for nuclear emulsion experiments. ICCMSE2015, AIP Conf.Proc. 1702, 190015(2015).

METU Defocusing BeamLine

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

Volume 730, 1 December 2013, Pages 232-234

Proposal for an irradiation facility at the TAEK SANAEM Proton Accelerator Facility

B. Demirköz [a] ⁂, A. Gencer [a], D. Kiziloren [a], R. Apsimon [b]

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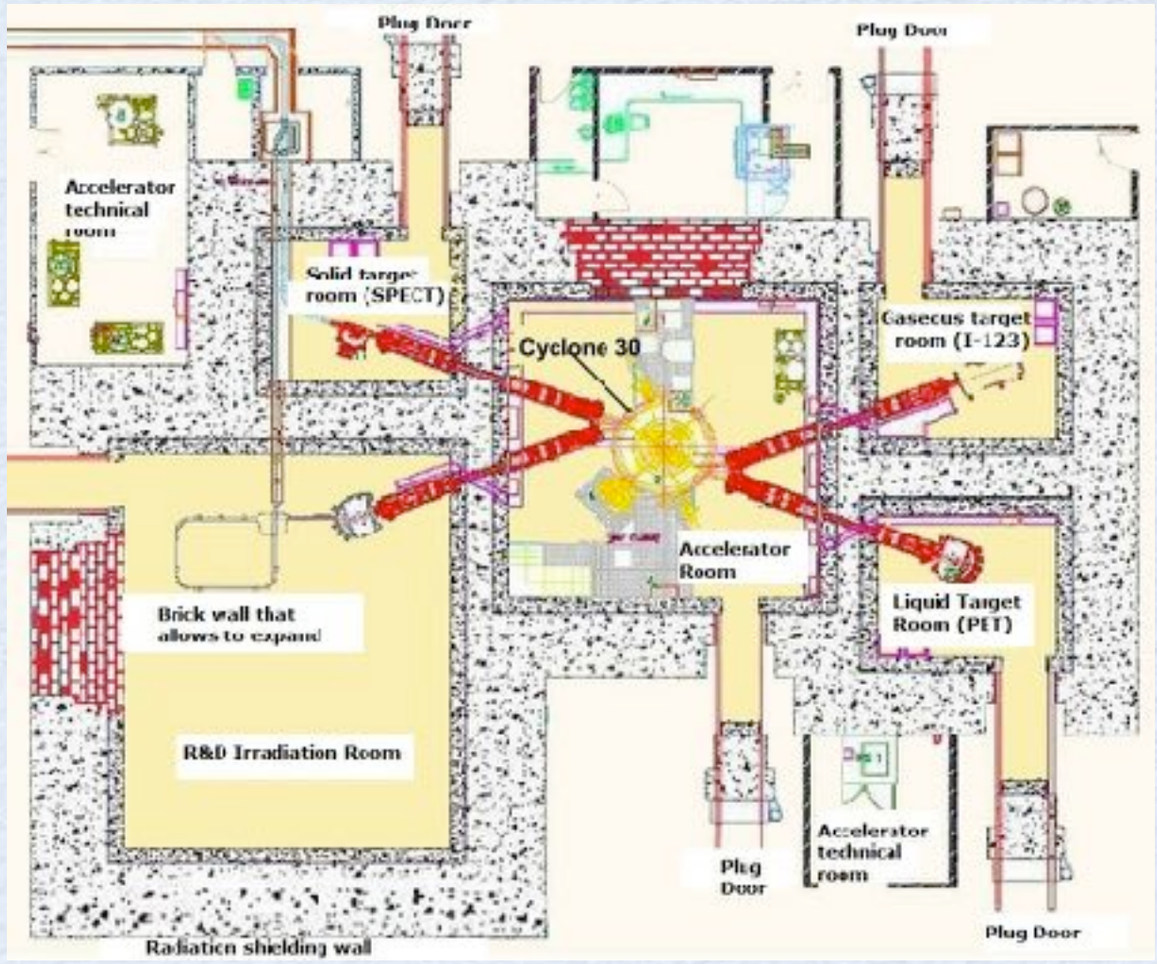
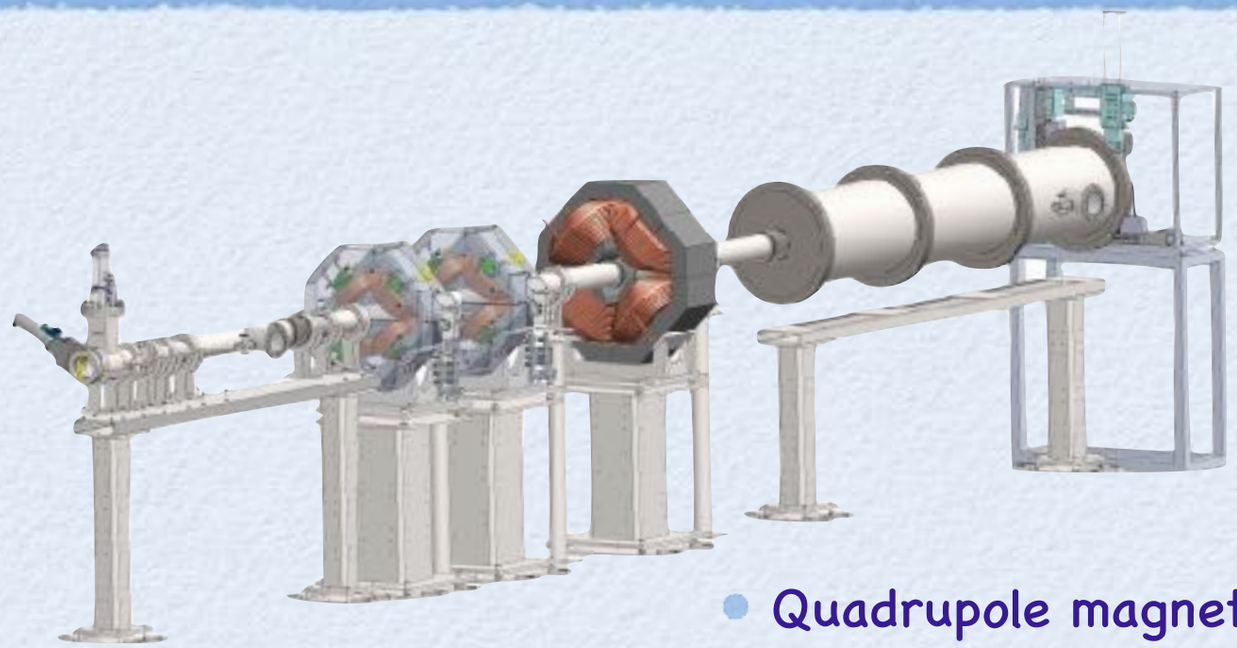
Abstract

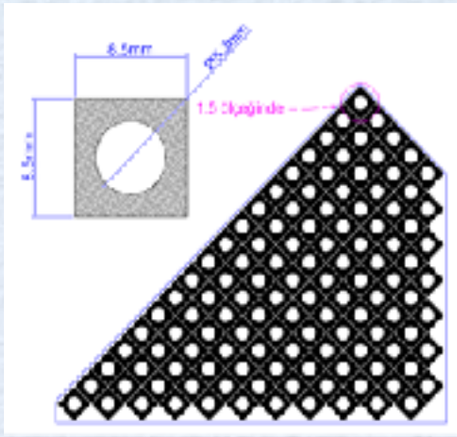
Turkish Atomic Energy Authority's (TAEK's) Proton Accelerator Facility in Ankara, Turkey, has been inaugurated in May 2012 and is under the process of being certified for commercial radio-isotope production. Three of the four arms of the 30 MeV cyclotron are being used for radio-isotope production, while the fourth is foreseen for research and development of novel ideas and methods. The cyclotron can vary the beam current between 12 μA and 1.2 mA, sufficient for irradiation tests for semiconductor materials, detectors and devices. We propose to build an irradiation facility in the R&D room of this complex, open for use to the international detector development community.

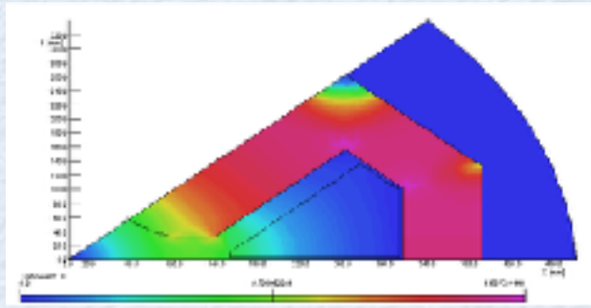


- Ongoing work for an irradiation facility to be built on a beamline at the TAEK 30MeV proton cyclotron in Ankara.
  - Beam diameter at R&D room: 1cm; current range 0.1μA - 1.2mA
  - Enlarge beam, reduce flux, beam diagnostics, irradiation tests for space & nuclear applications

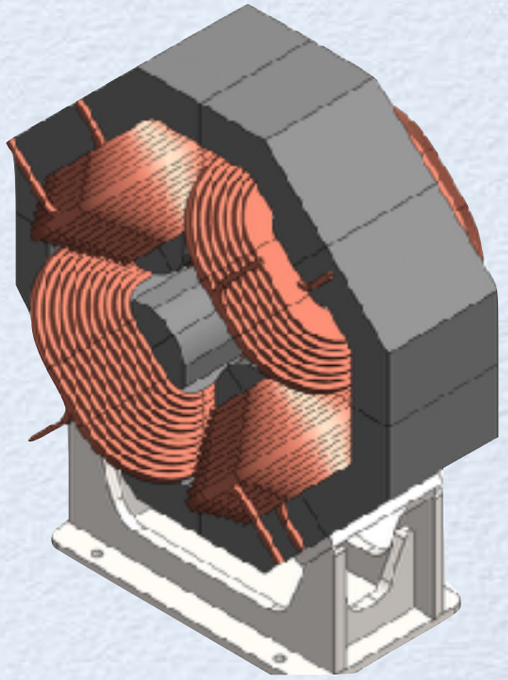
METU DBL



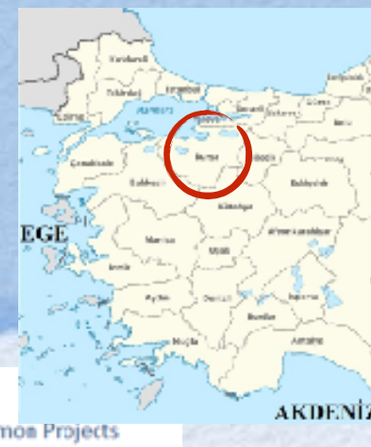




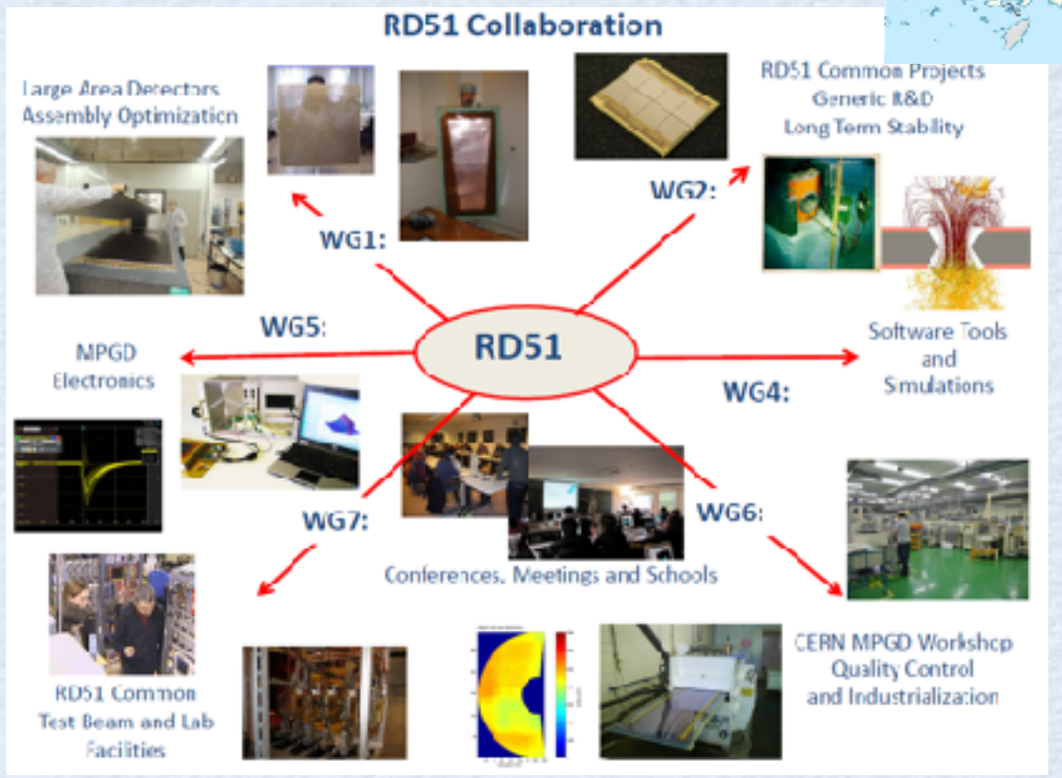
- Quadrupole magnets produced in Turkey
- Preliminary tests scheduled for Oct'17.
- 'Single Event Effect Test' - August'18.

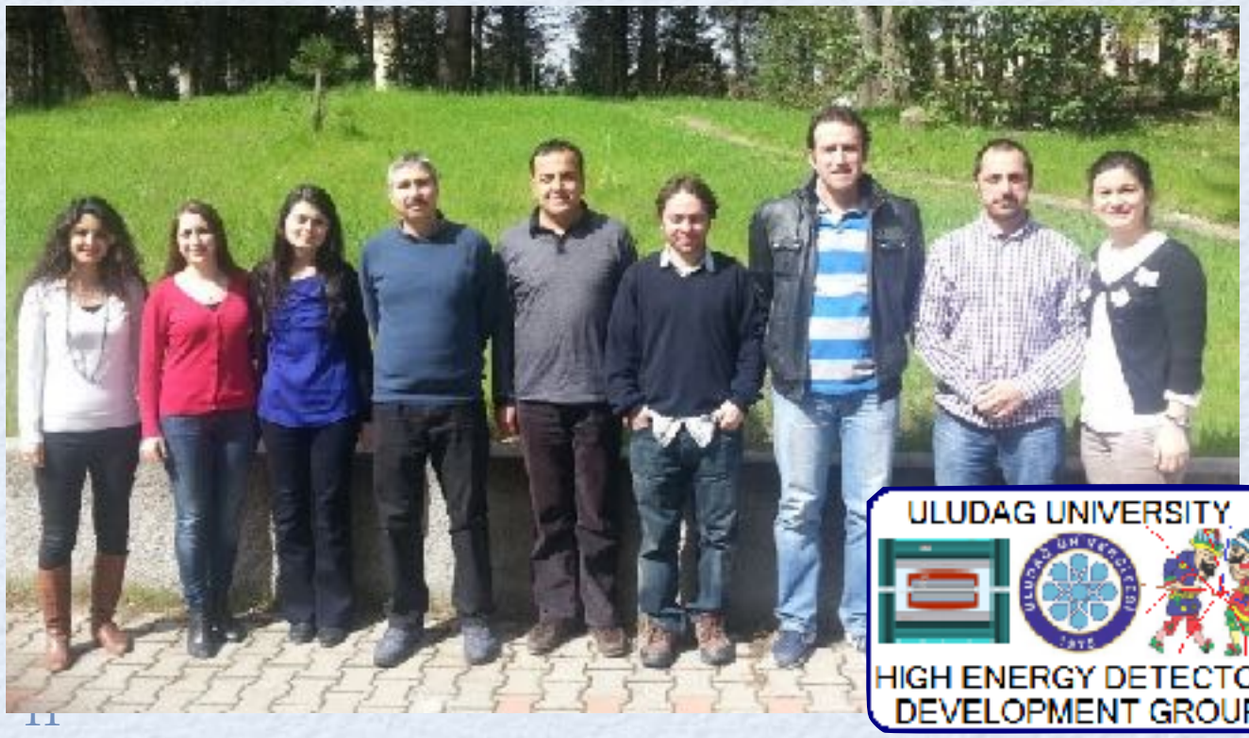


Uludağ University



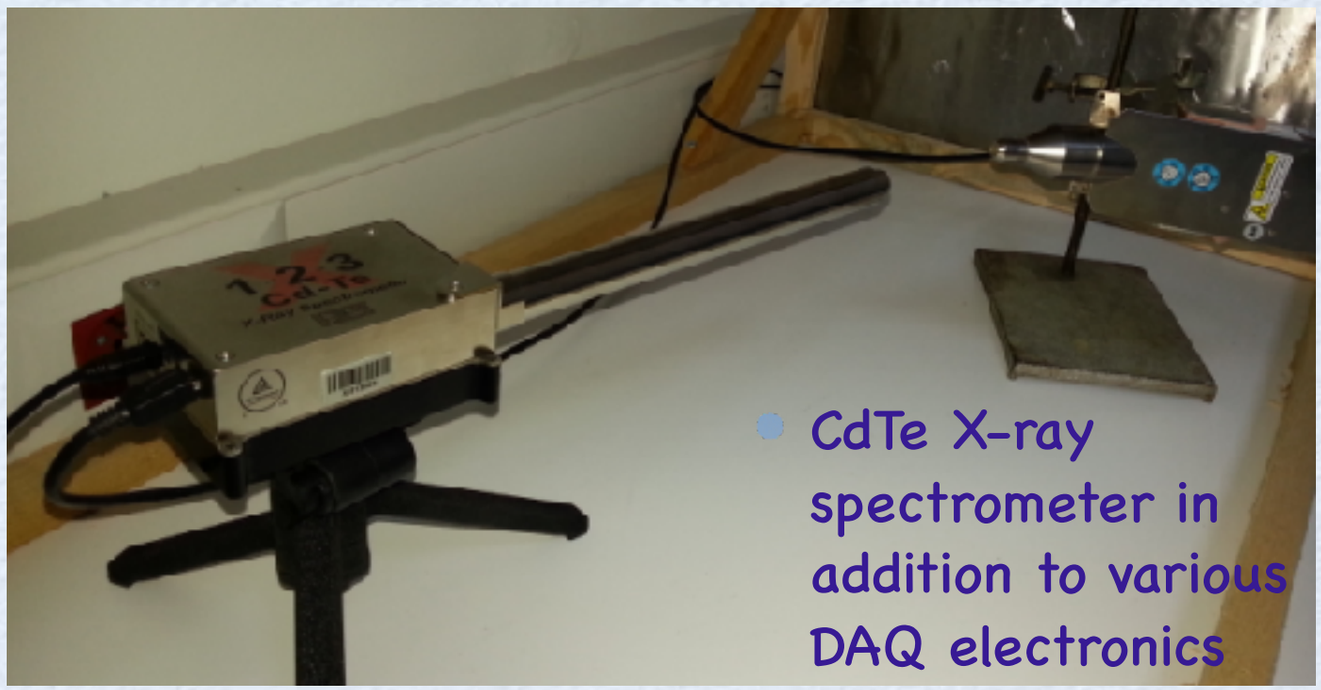
- A team of ~10 faculty members, including two visiting faculty (S. Biagi & R. Veenhof) from CERN.
- The team from Uludağ University is a member of CERN's RD51 collaboration.
  - Development of Micro-Pattern Gas Detectors technologies
  - Total of 450 people from 80 institutes
  - Uludağ team on WGs 2 and 4.
- Extensive experience with FLUKA.
- Also contributing to the systematic studies on the ageing of MPGDs, and the development of a standard for MPGDs.



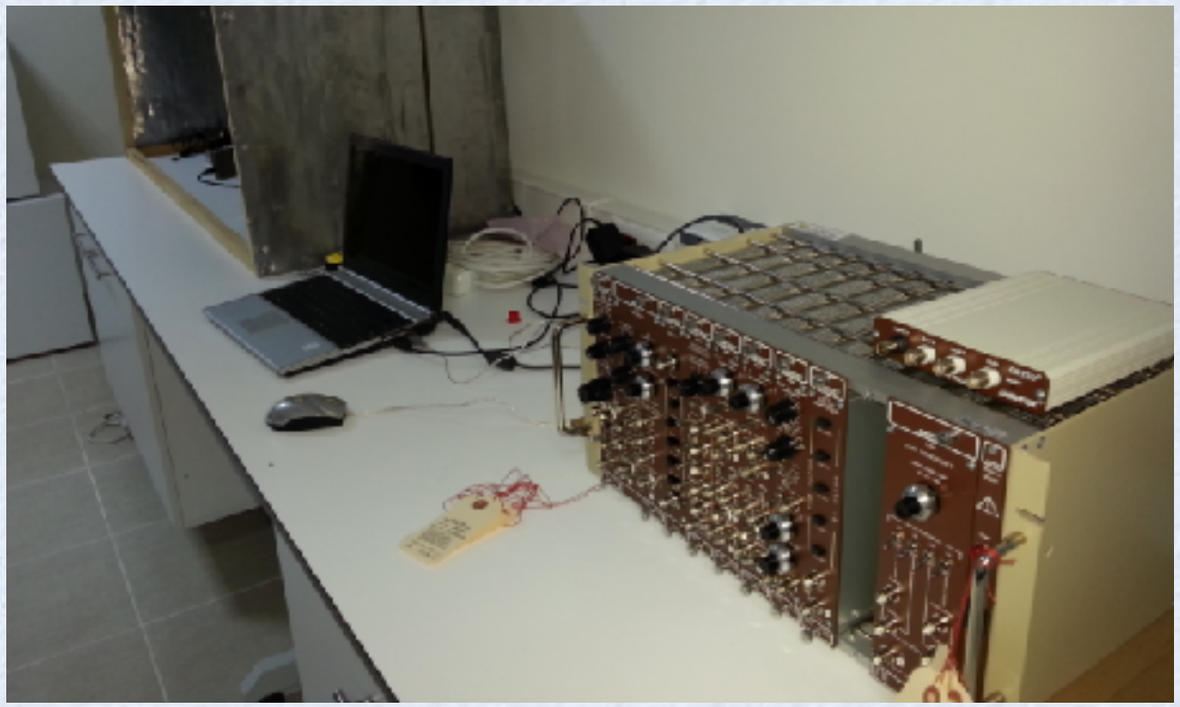


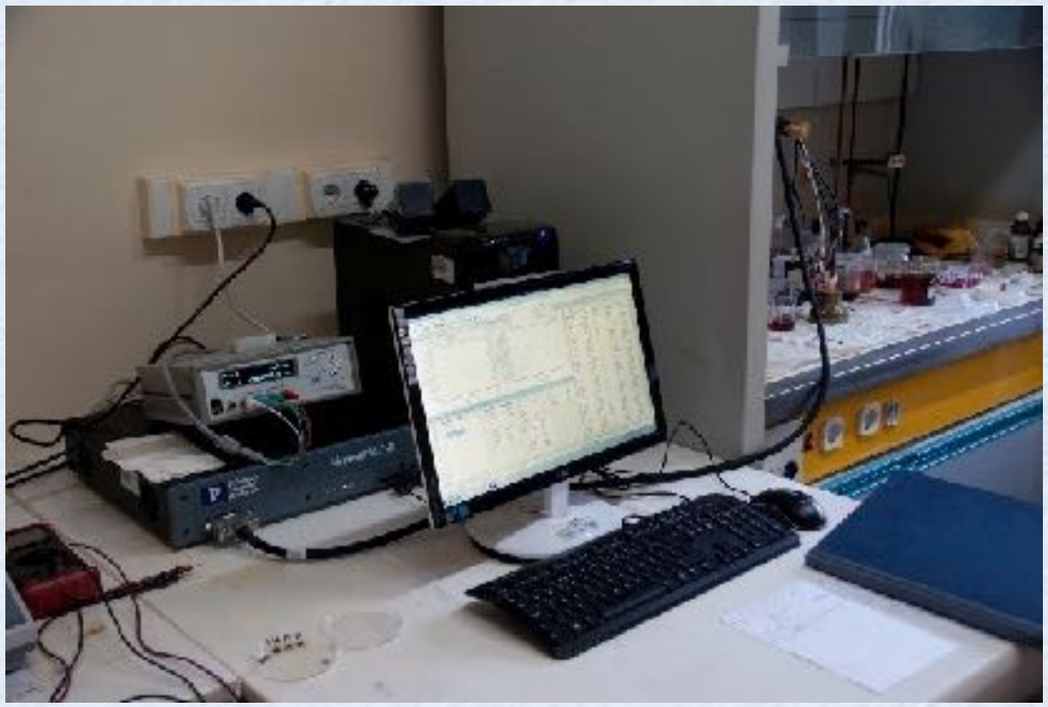
ULUDAG UNIVERSITY
HIGH ENERGY DETECTOR DEVELOPMENT GROUP

Uludağ University Nuclear Instrumentation Lab

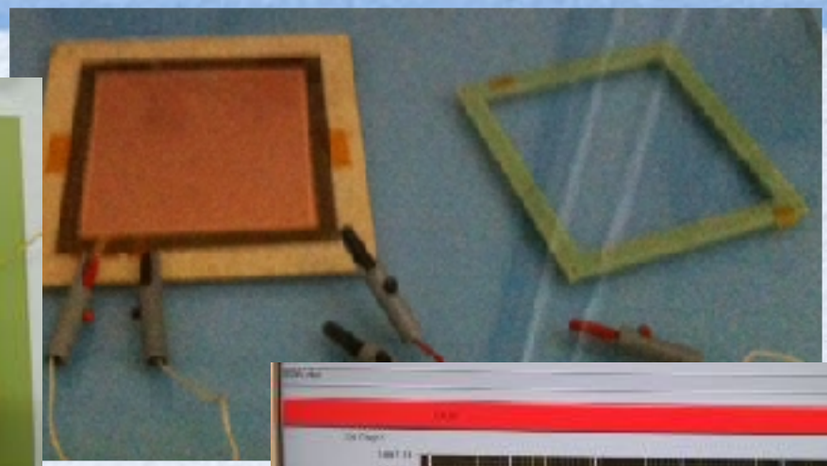


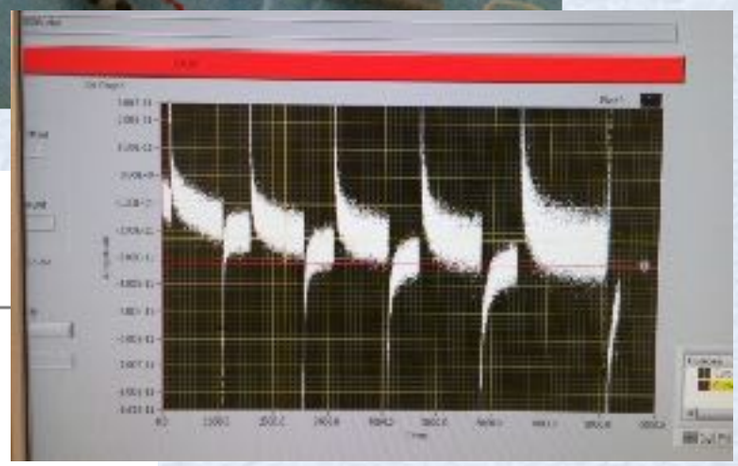
- CdTe X-ray spectrometer in addition to various DAQ electronics

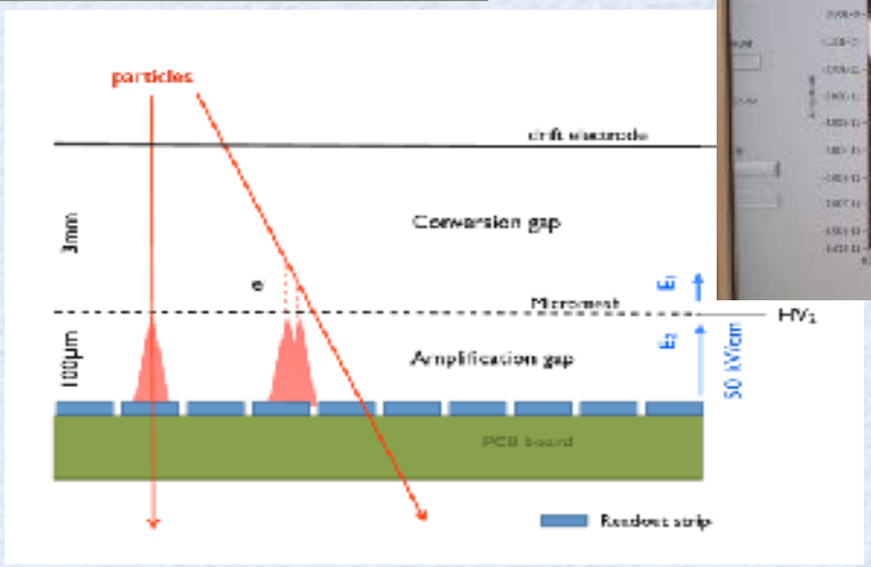


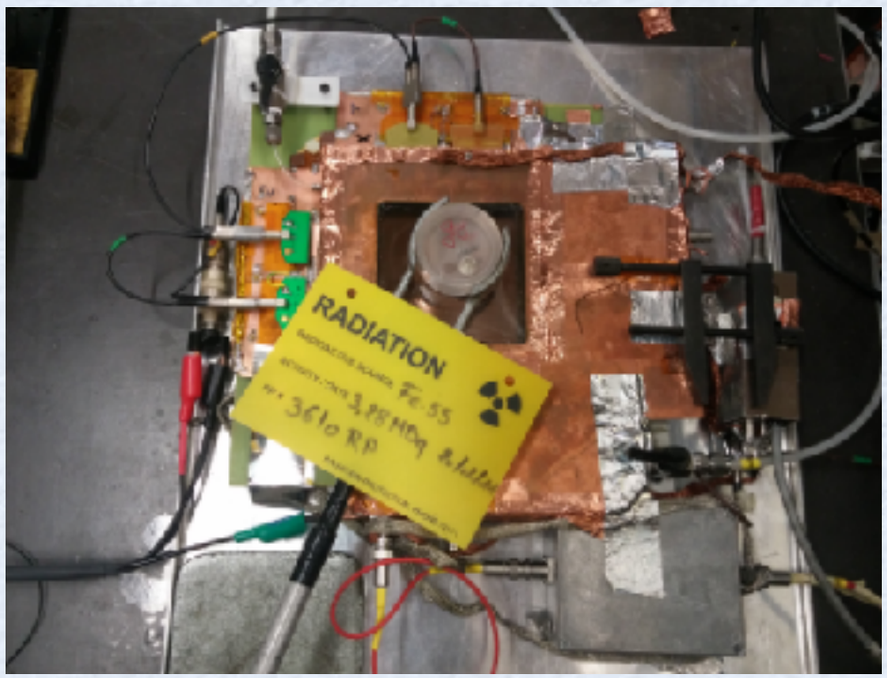


GEM Characterization



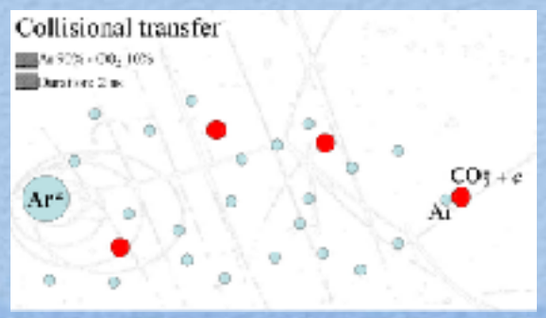


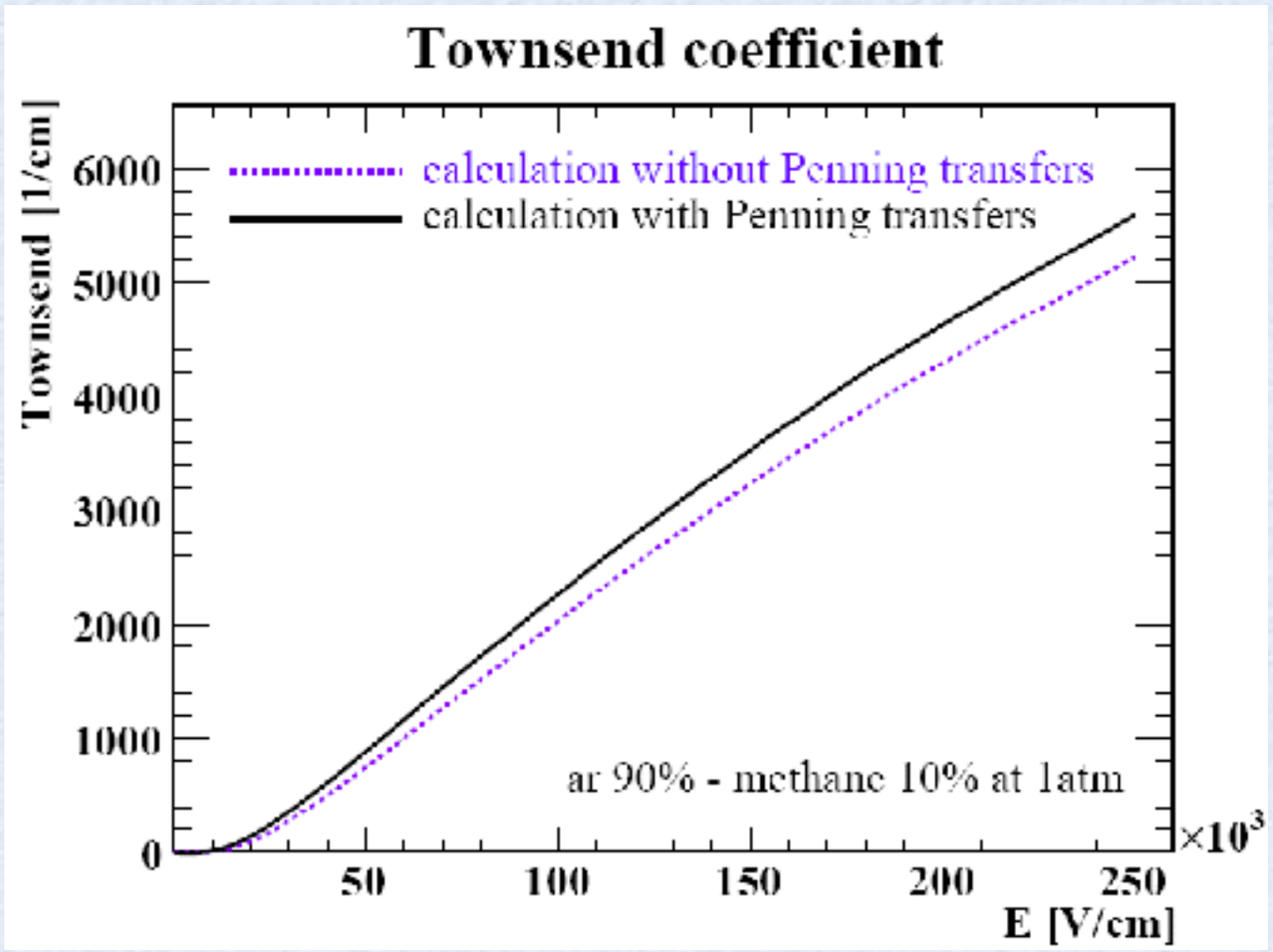


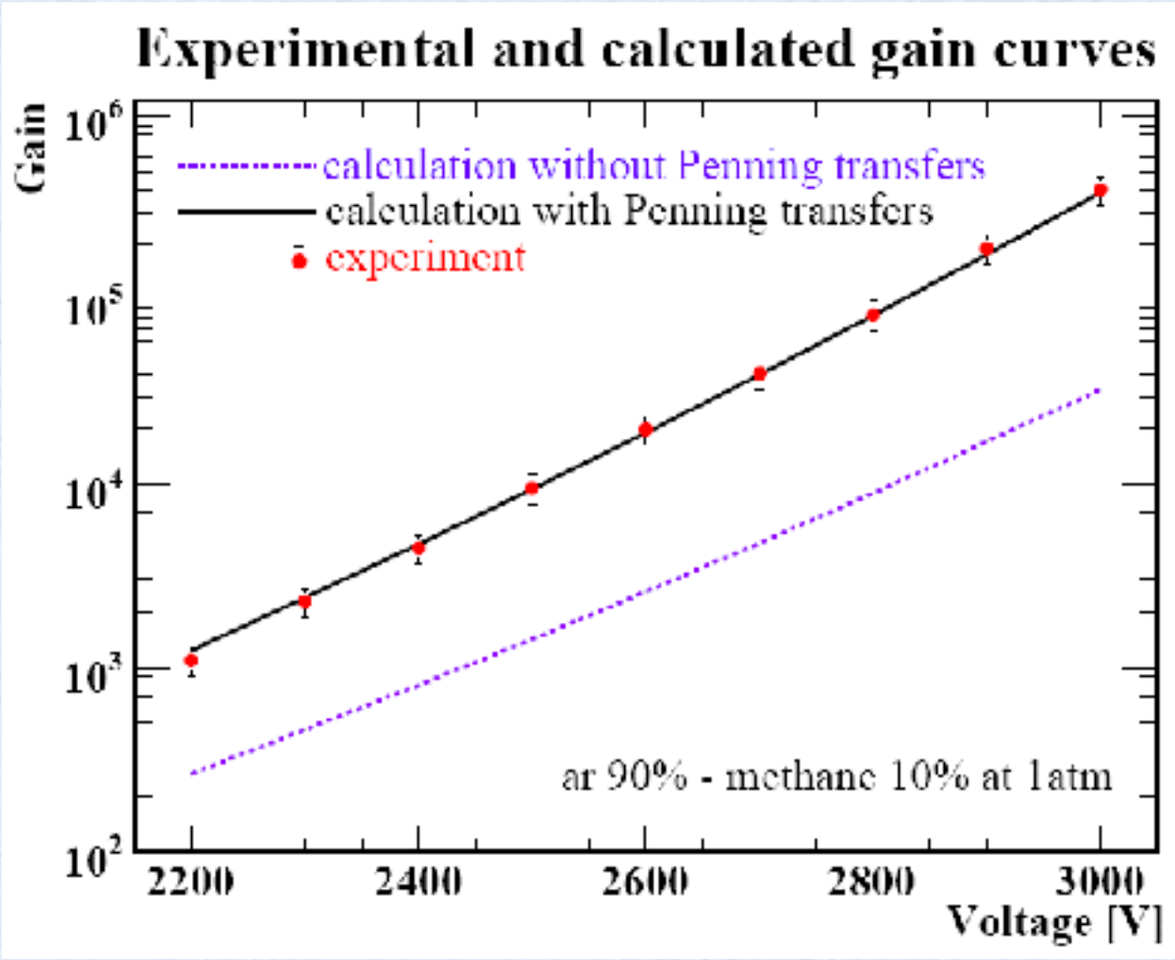


- Characterization & gain calibration of triple GEM detectors
- Work on identifying the reasons for 2-fold discrepancy in gain between simulations and experimental results
- Work on reducing readout noise

Work On Simulations
Penning Effect







There may be many non-ionising interactions in avalanche formations. In such interactions some fraction of the energy is spent on the creation of short or long lived (metastable) excited states. Excited gas atoms or molecules can transfer their excess energy to ionise the other ones in the mixture by making collisions with them. Such an energy transfer is known as Penning effect and often occurs in the gas mixtures when the metastable excitation energy level of one gas component is energetically higher compared to the ionisation energy of the other gas component. These kinds of mixtures are also known as Penning gas mixtures which consist of a noble gas and an admixture at lower concentrations.

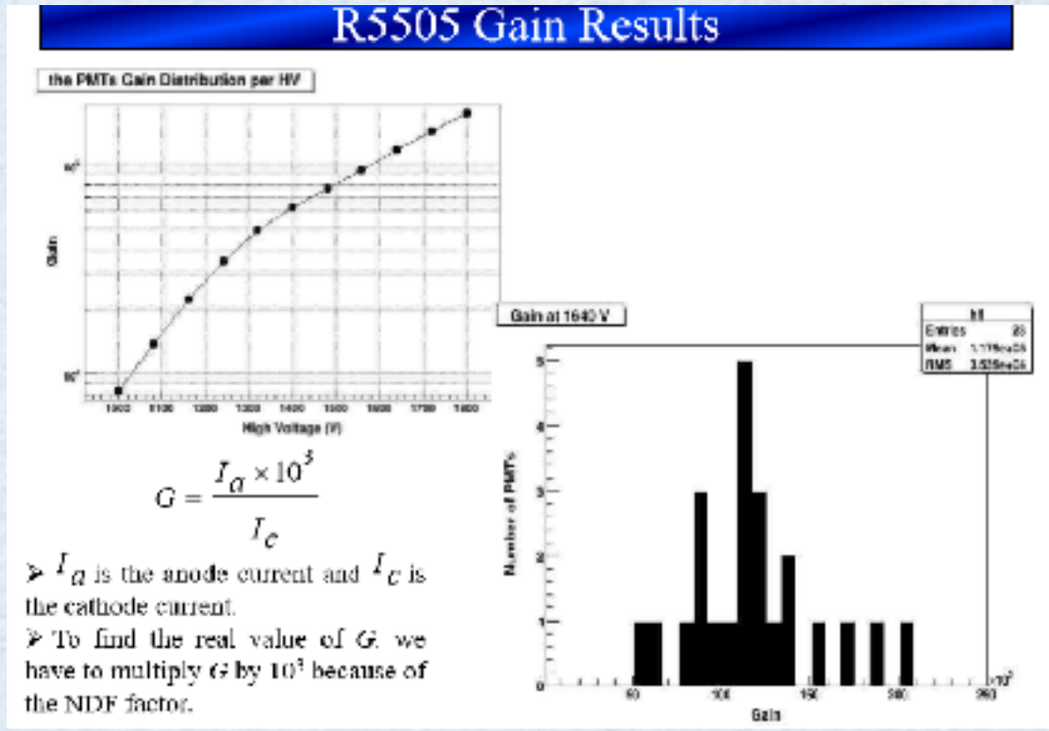
Çukurova Team

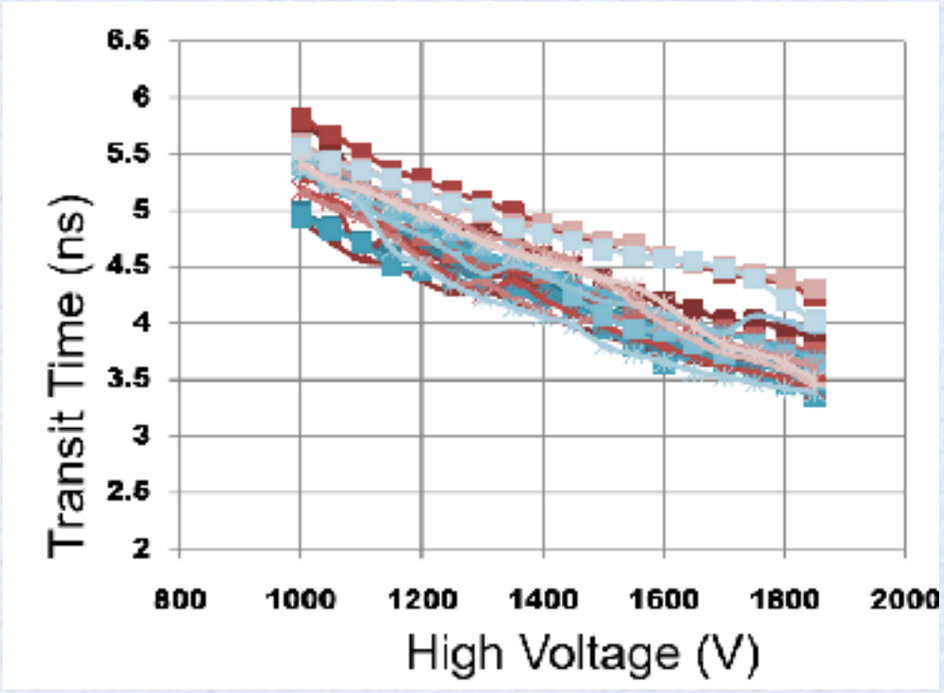
- Another of the oldest hep-ex teams in Turkey
  - Member of CMS since 1996
  - Contributes heavily to CMS HF calorimeter
- Active research team Çukurova team which includes ~10 faculty members from 4 institutions, and a number of graduate students.
  - A good network with a healthy ratio of junior and senior people

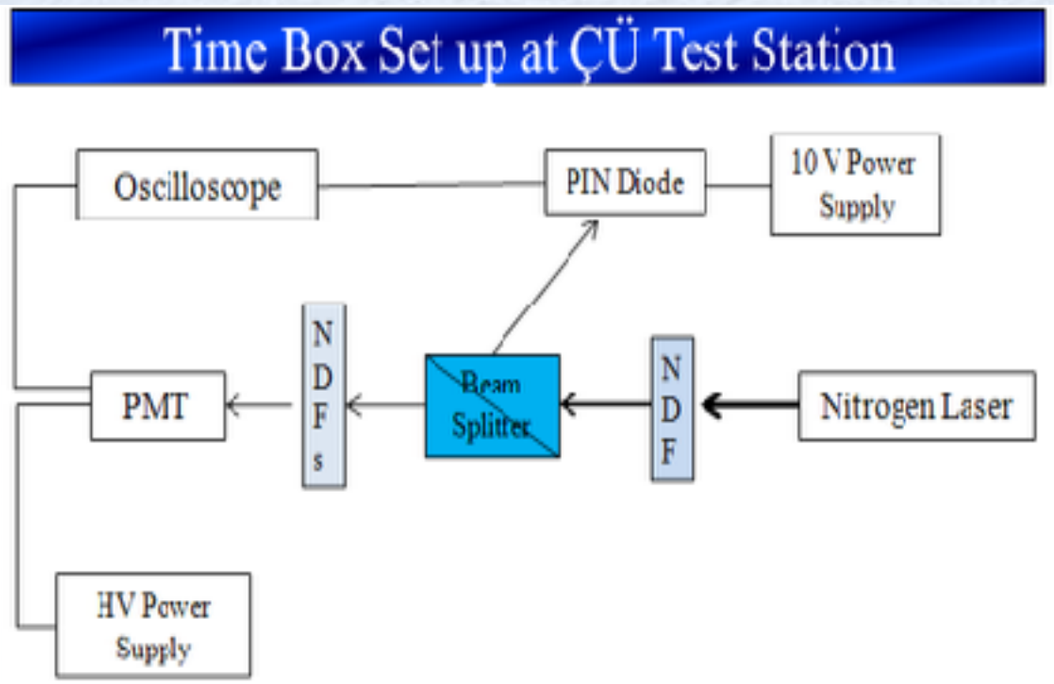
Çukurova University

- Two CMS centers, allowing contribution to DQ analysis
- Adana lab: Setup to test quality of photomultipliers that have been used in CMS calorimeters.

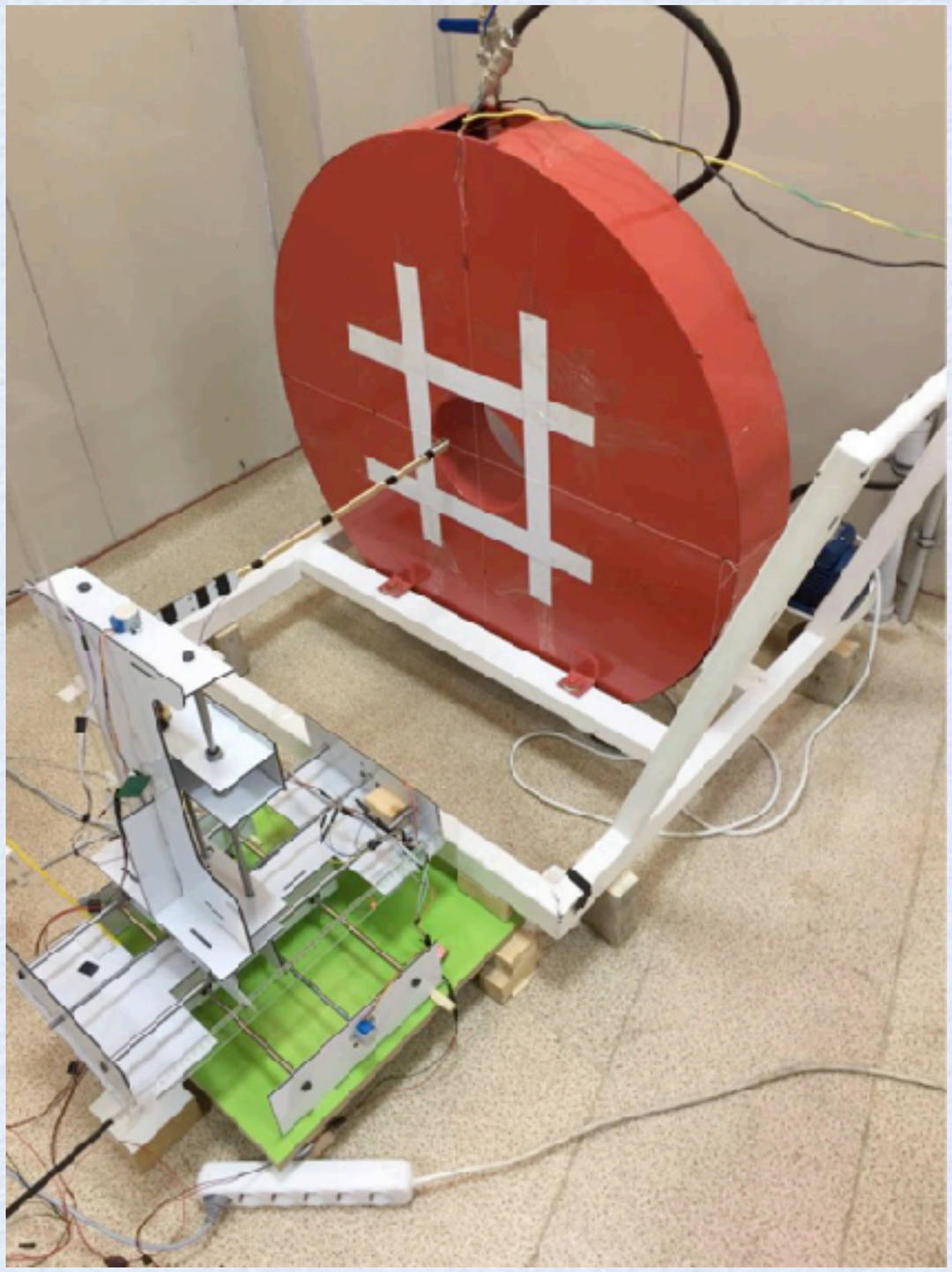
CMS PMT Tests

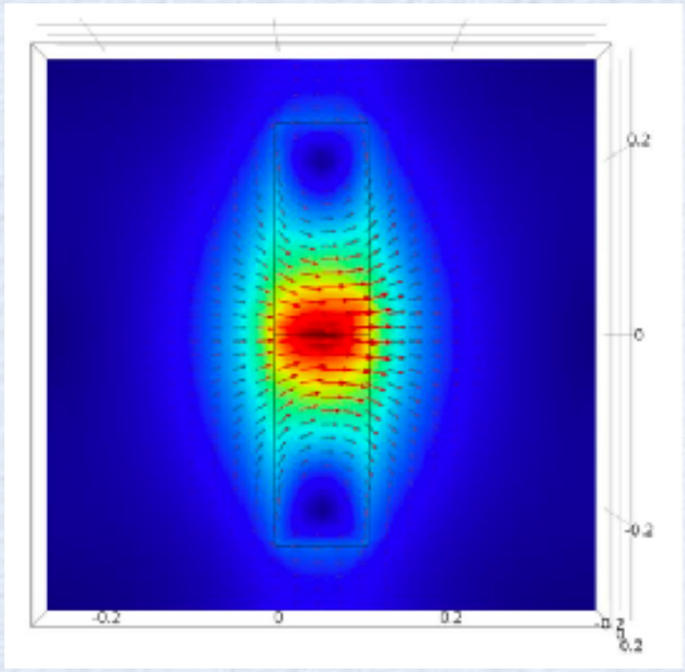






Adiyaman University





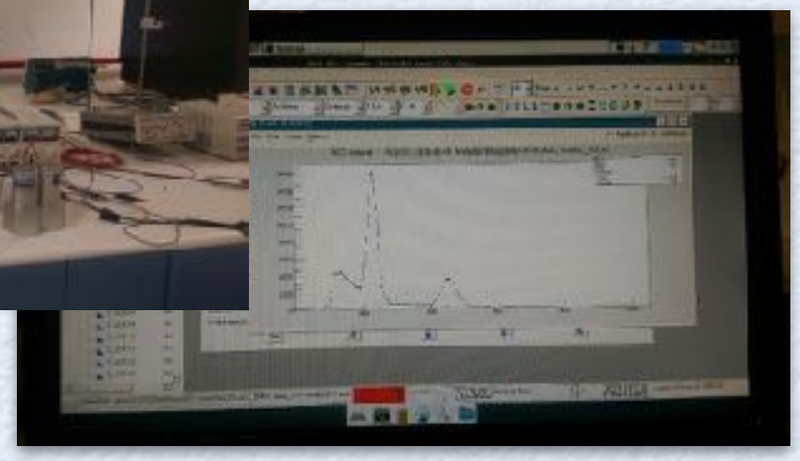
- Design, simulation and construction of a solenoid magnet and its field mapper, to be used at beamline projects.

MSGSU - YTU Team

- 7 faculty members from 6 institutions.
  - Bilgi Uni, Mimar Sinan GSU, Yıldız Technical Uni, Sebahattin Zaim Uni @ İstanbul + Ege Uni, Izmir + Nigde Uni
- Contributing to a number of experiments abroad:
  - NEDA (Neutron Detector Array): for experiments at SPIRAL2/GANIL, SPES/LNL, NUSTAR/FAIR
  - EXOGAM2: Digital instrumentation of the EXOGAM detector
  - DEGAS: Involvement in the Active Gamma Shield, a.k.a. the back catcher, for the DEGAS (DESPEC Germanium Array Spectrometer) detector prototyping, building, and its tests.

MSGSU - YTU Facilities

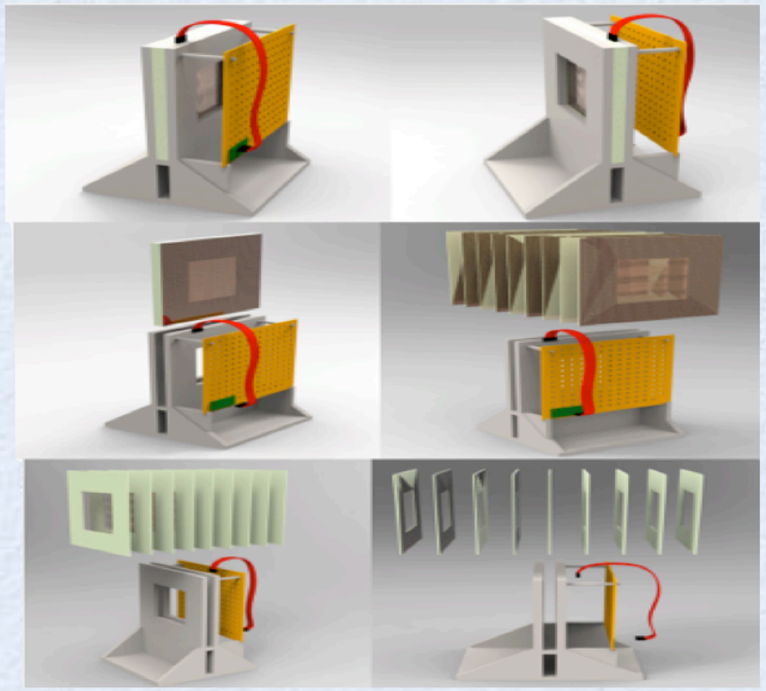
- Two labs, one at each institute
  - GSI-DAQ setup (VME Based Multi Branch System).
- Using Euroball BGO (Bi Ge oxide) for Degas Backcatcher prototype test
- Testing BGOs with SIPM for Degas Back-catcher detector, Petiroc2A for Degas, Numexo2 for NEDA

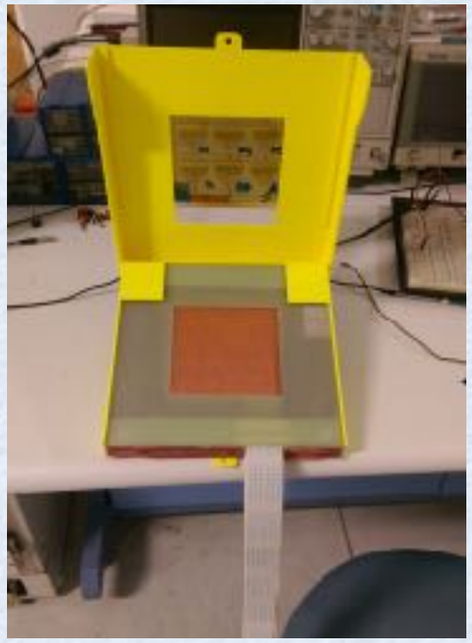


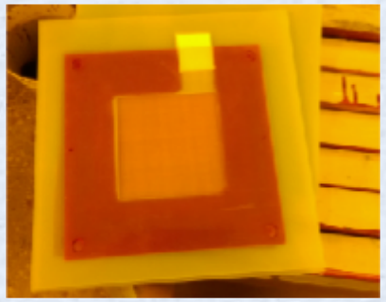
SEE Calorimeter

- Calorimeter Based on Secondary Electron Emission
  - Developed with funding from TÜBİTAK (grant 113F337) - March 2014 - March 2017.
  - radiation hard, fast and compact to be used in nuclear and high energy physics experiments
  - implemented semi-empirical model of SEE process in to the Geant4

Design and Production

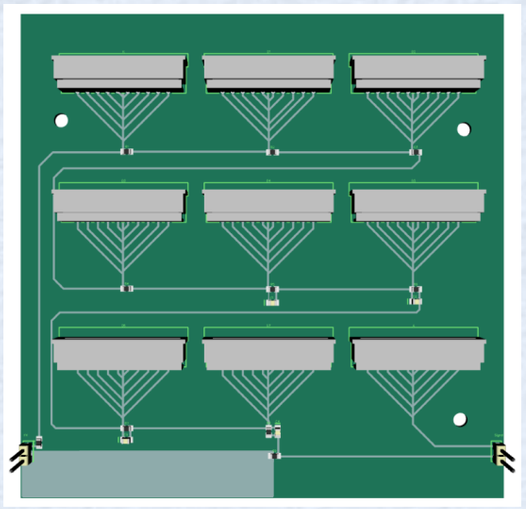


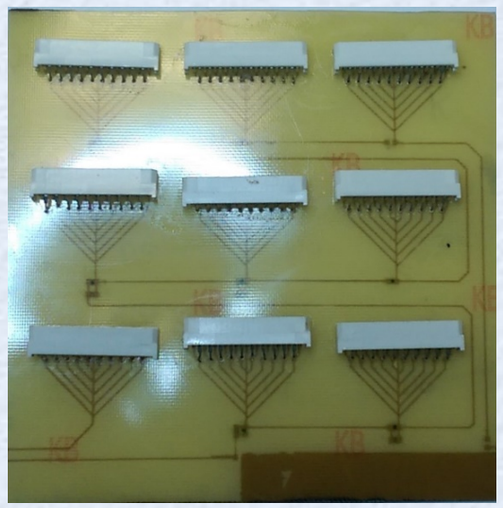




SEE Readout Electronics

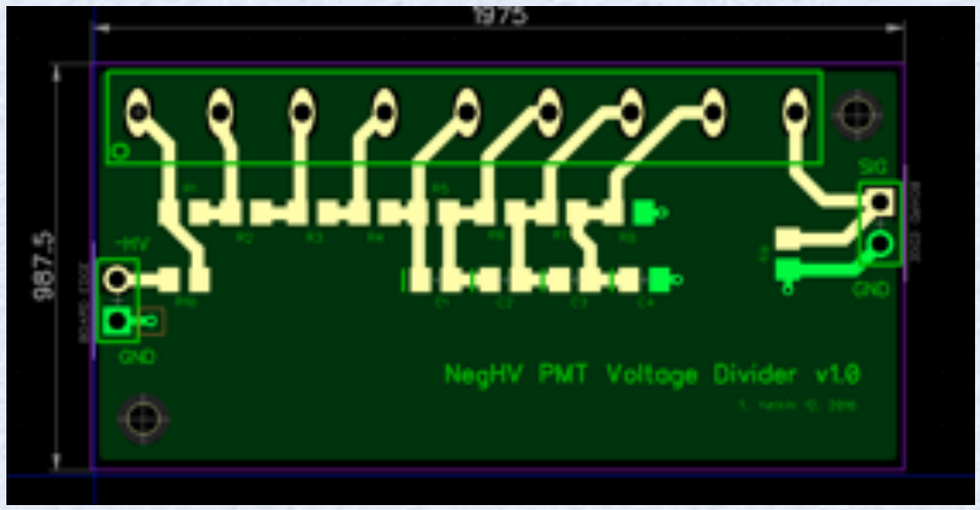
Voltage Divider used in the prototype





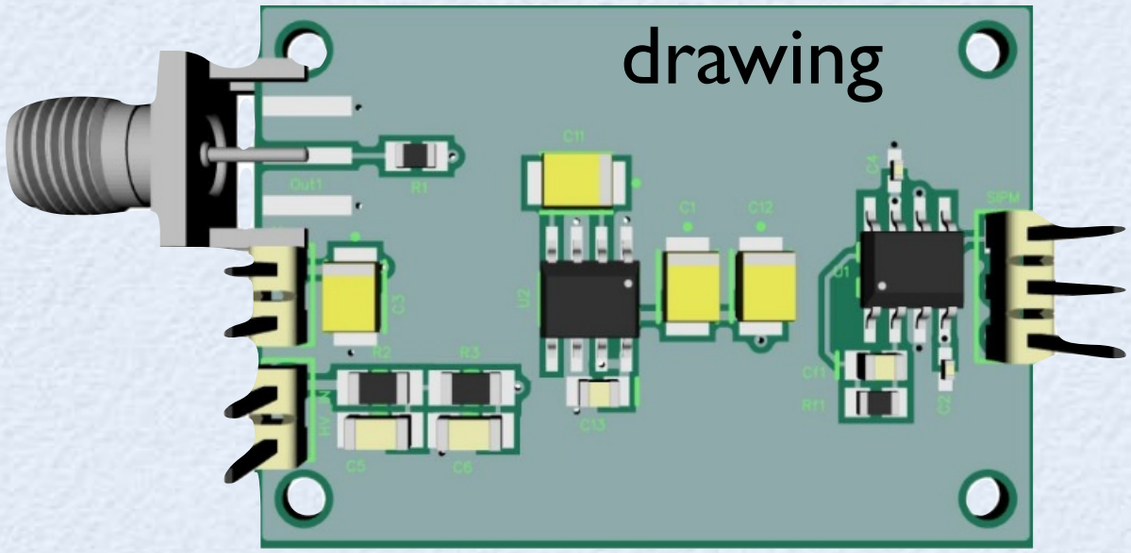
cables connecting
SEE layers to HV divider

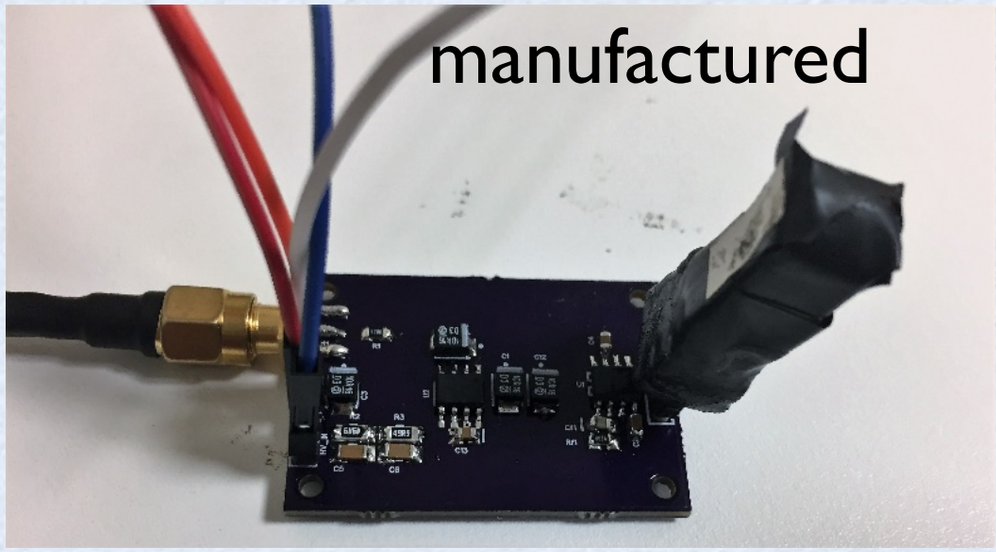
Voltage Divider: a smaller version



Other Electronics Designs

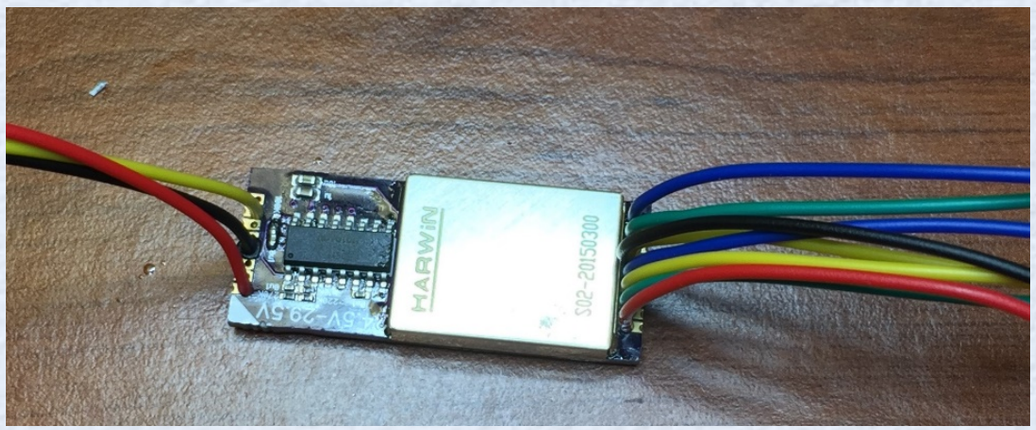
Bias Filter & Signal Preamplifier





Signal splitter

24.5-29.5 Bias Voltage Generator



Boğaziçi Team

- Composed of ~8 faculty members from 4 institutions.
  - Bahçeşehir, Bilgi, Boğaziçi @ İstanbul + Gaziantep
  - Two labs housed at two campuses of Boğaziçi University, İstanbul.
  - Also collaborating with partners from other universities in Ankara, Istanbul, Izmir, Kutahya, Tokat + UCI/CERN.
- On ATLAS since the time of the original technical proposal.
  - Contributing to TDAQ (mainly software) and Transition Radiation Tracker (TRT).
- Boğaziçi also has a CMS team, with ~3 faculty members from 3 institutions.

Engin Arik Lab

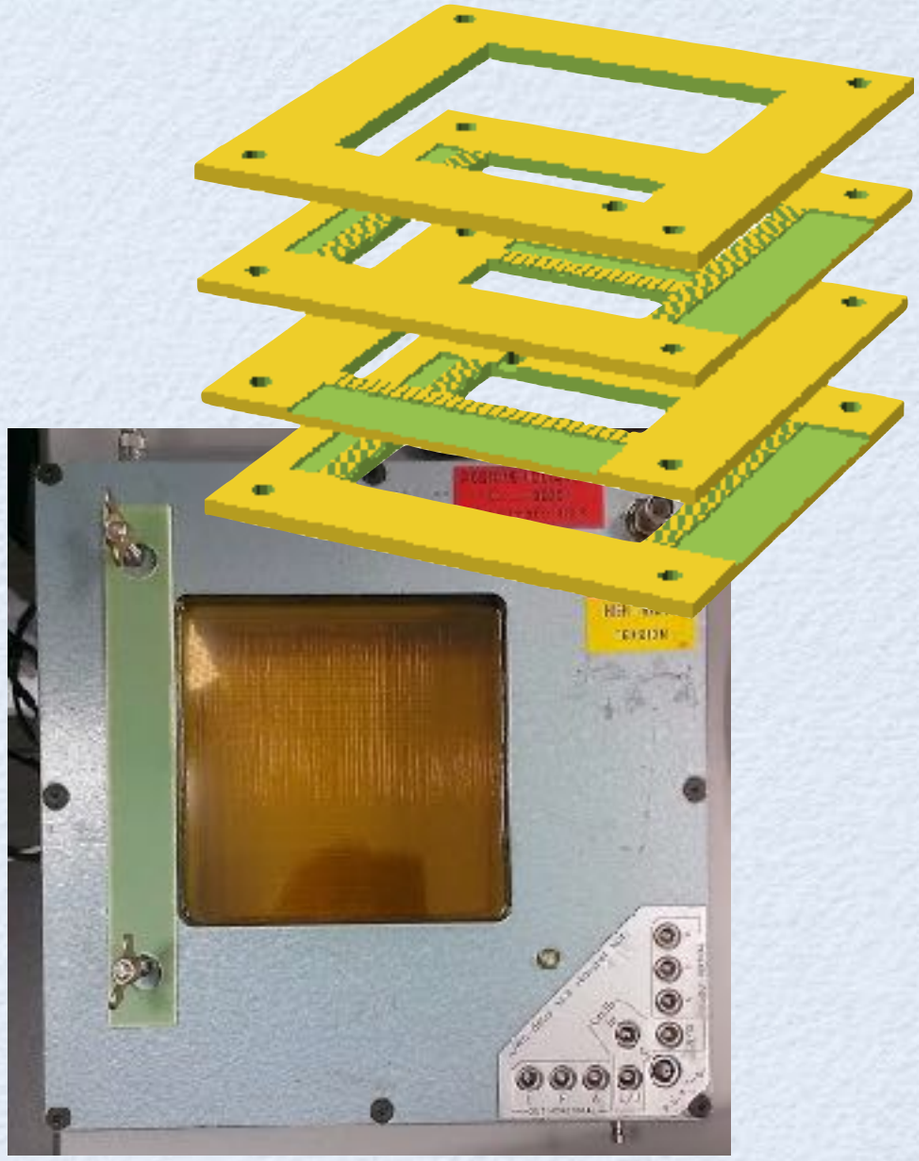
- Computer, detector and DAQ lab
  - Currently shelters ATLAS & CMS data analysis teams and the cosmic ray prototype detector
- Active since 1990s
  - Turkey's first PET detector prototype
  - Home of ATLAS DAQ-1
- Based @ Boğaziçi main site

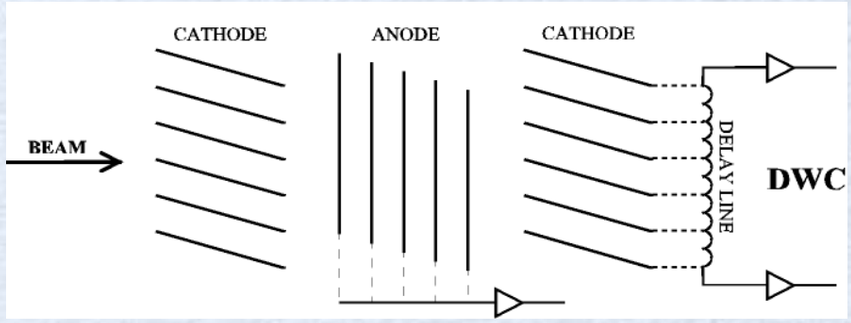
KAHVE LAB

- New lab at the Kandilli campus
  - Over 150m^2 area for detector and accelerator research, in addition to office spaces.
  - Another 150m^2 area to become available in Q1 2019.

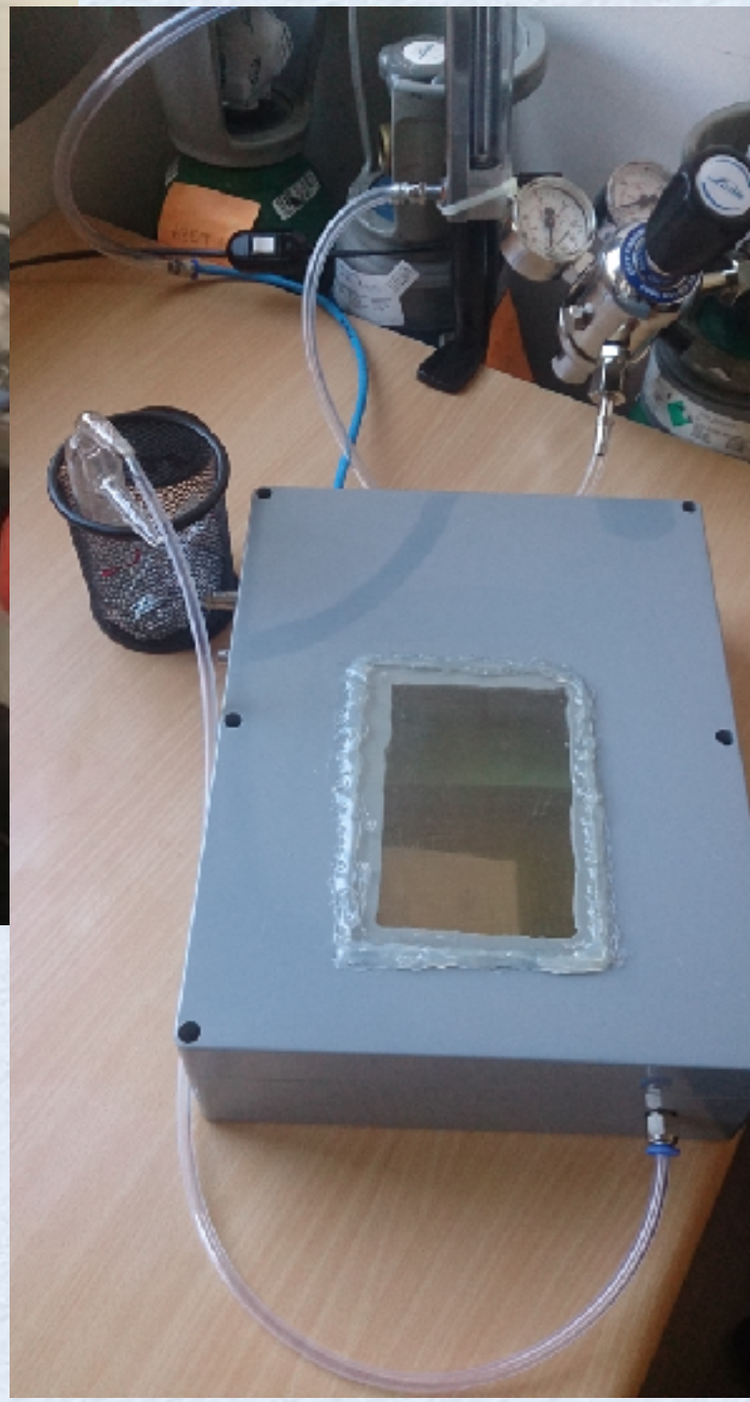
Boğaziçi Projects

- Delay wire chamber (DWC).
  - Design, production, calibration all from scratch.
  - Gold coated tungsten wires; electronics for signal readout and amplification (4-layer PCB, analog delay, fast opamps); DAQ electronics; better than 200μ position resolution in x & y.
  - Project supported by TUBITAK (grant 114F467); May 2015-2017.
- ATLAS TRT monitoring, DQ and calibration.
  - Work on a small TRT prototype for local tests.
- Prototype cosmic ray detector that can become part of an array to measure UHE cosmic rays.
  - Reconstruction code able to independently repeat Auger analysis with couple degree zenith angle resolution.
- Beam diagnostics for RFQ proton beam in Ankara.
- RF Circulator + transmission line @ 800 MHz.





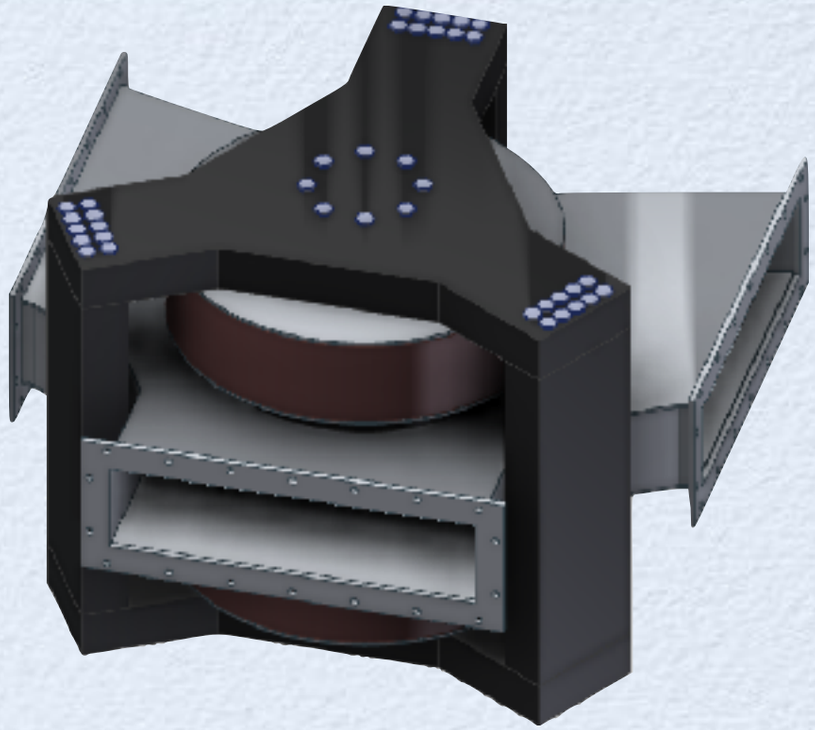
Delay Wire Chamber



- Example stages from our test production.
- Successful tests of chamber at CERN.
- To be used for emittance measurements at the TAEK 30MeV proton beamline.

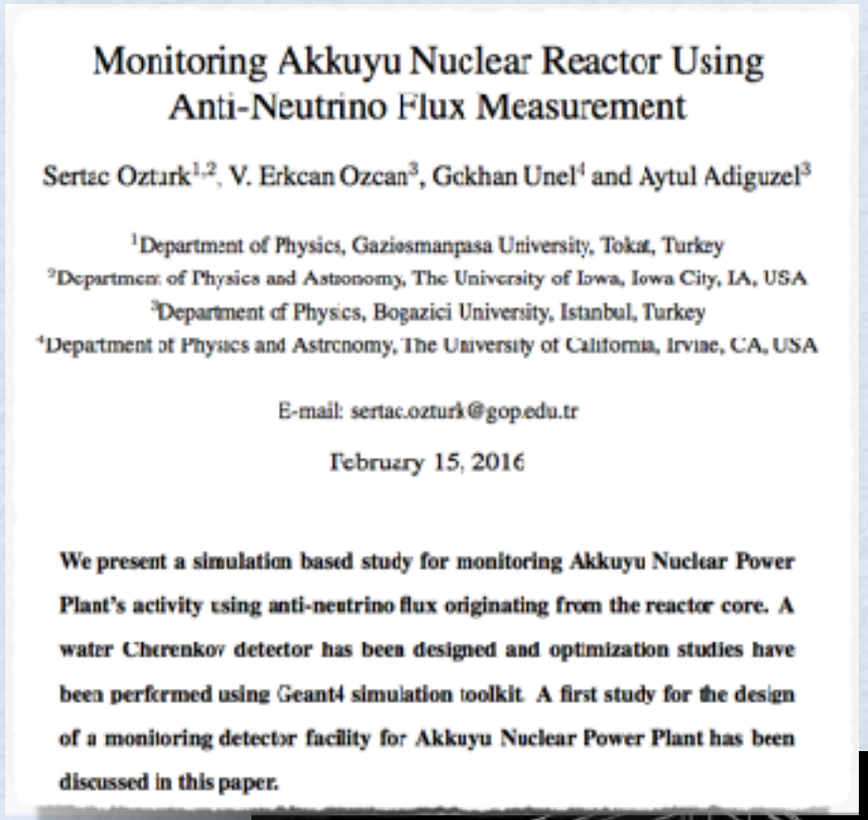
RF Circulator

- RF transmission line and circulator.
  - 50-100 kW, UHF band.
  - Applications both in accelerator physics and in defense industry.
  - Required technologies; know-how: metal processing, ferrite materials, electromagnets, high-power RF sources, cooling.
  - Ongoing TUBITAK project (grant 116E221), in collaboration with İYTE, İzmir and TOBB ETU Uni, Ankara.



representative photo

Projects in the Pipeline



Monitoring Akkuyu Nuclear Reactor Using Anti-Neutrino Flux Measurement

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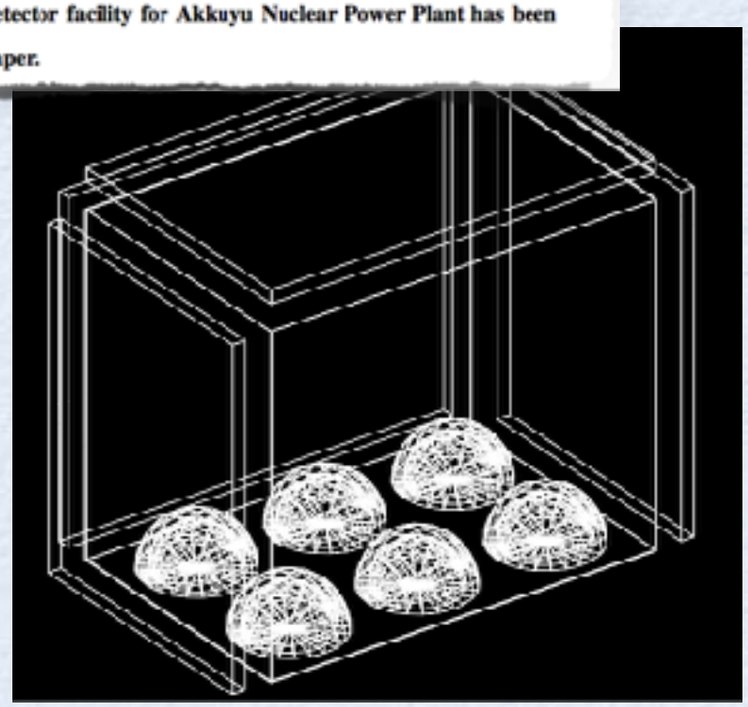
February 15, 2016

We present a simulation based study for monitoring Akkuyu Nuclear Power Plant's activity using anti-neutrino flux originating from the reactor core. A water Cherenkov detector has been designed and optimization studies have been performed using Geant4 simulation toolkit. A first study for the design of a monitoring detector facility for Akkuyu Nuclear Power Plant has been discussed in this paper.

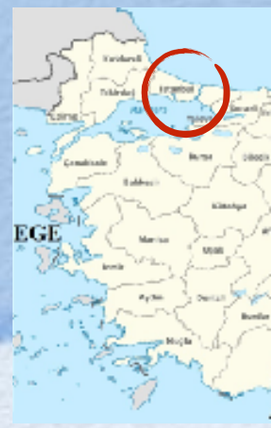


- Expressed intent to contribute to the Phase2 upgrade of ATLAS muon system.
  - ATLAS intends to increase the coverage of the muon trigger (from 75% to over 90%) with new thin RPC modules.
  - We plan to form a larger gaseous detector program, which will include building RPCs locally.
    - Got positive response from TAEK to our letter of funding request, but…
- TUBITAK project proposal to collaborate with Gaziosmanpaşa University, Tokat.
  - We propose to build a ~1ton Gd-doped water Cherenkov detector to monitor the nuclear power plants that are to come online by 2018-19.
- TUBITAK project proposal to collaborate with Dumlupınar University, Tokat.
  - We propose to build a ~1ton Gd-doped water Cherenkov detector to monitor the nuclear power plants that are to come online by 2018-19.

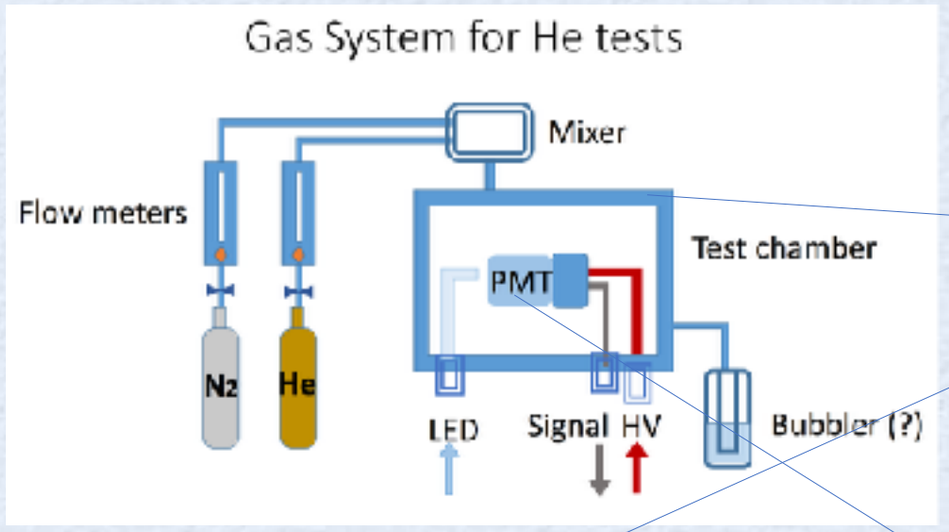
Gaziantep University

- Small spark chamber with self-developed custom trigger and readout electronics built with COTS; self-built HV supply.

Istanbul University



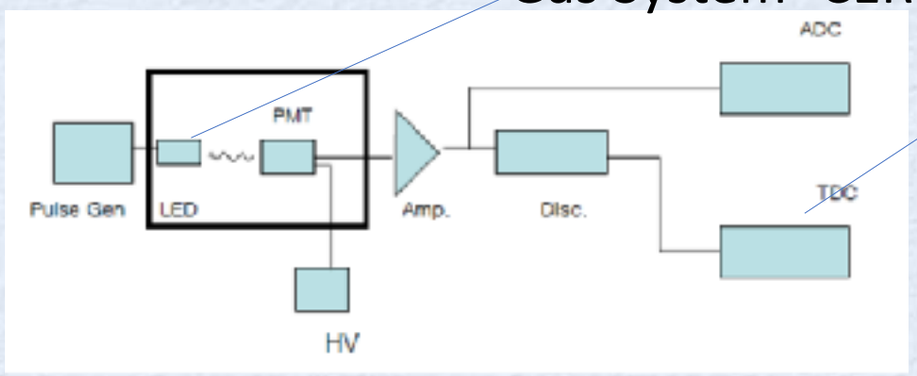
- ~10 exp. nuclear & HEP faculty. Various projects.



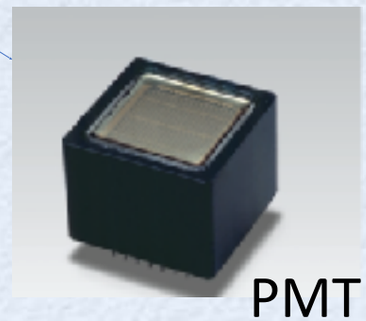
Gas System -CERN

Gas Tight Box -IU

NIM Modules-IU



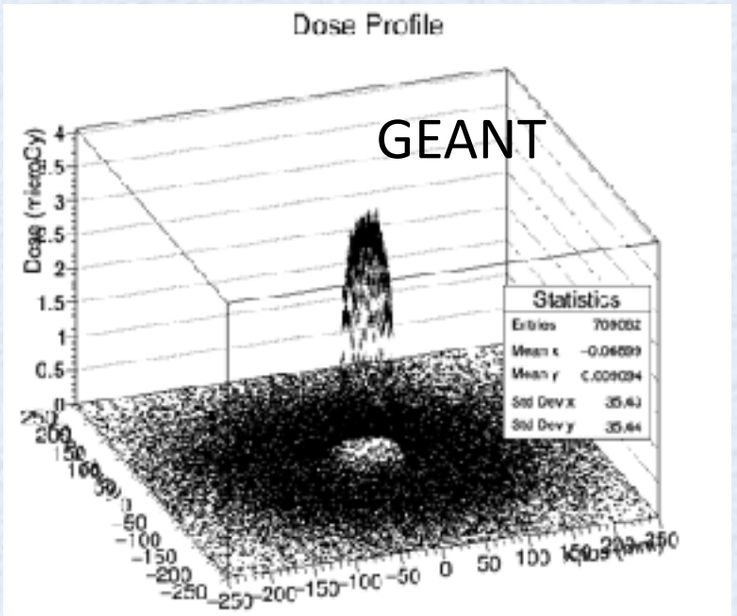
Readout Scheme- IU

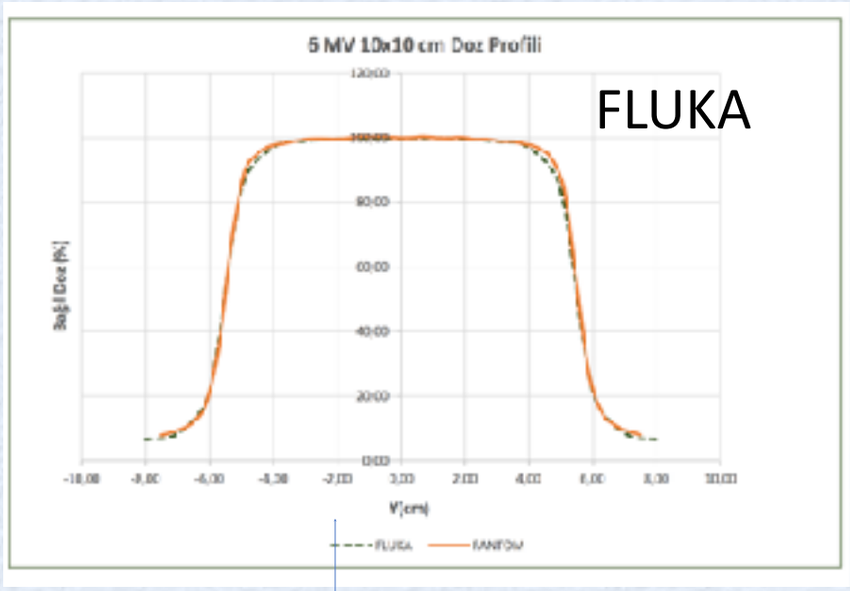


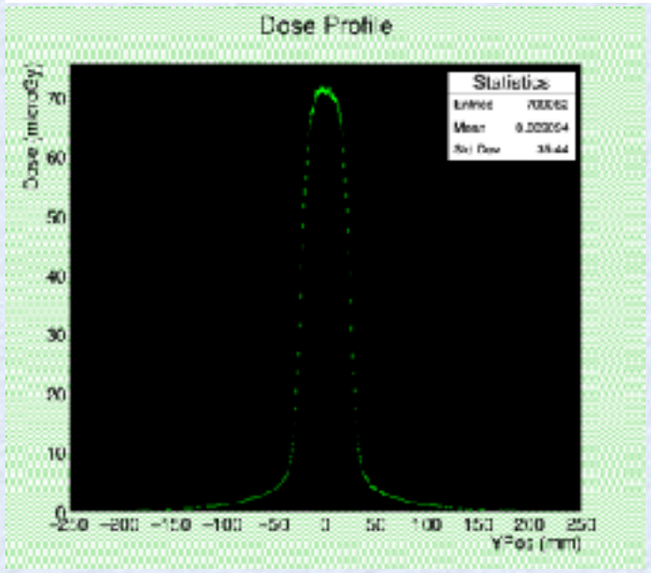
PMT - IU
Hamamatsu
7600U-400

- After Pulse - He Contamination Test for HF PMT.

Dose Profile Simulation for Medical Linacs



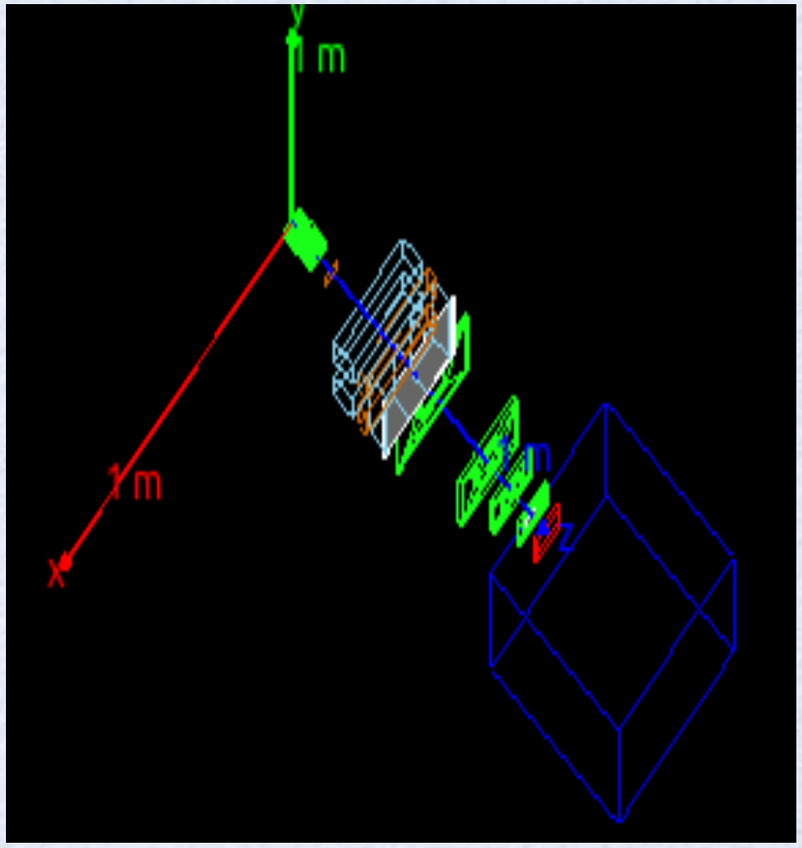




DOSE PROFILES

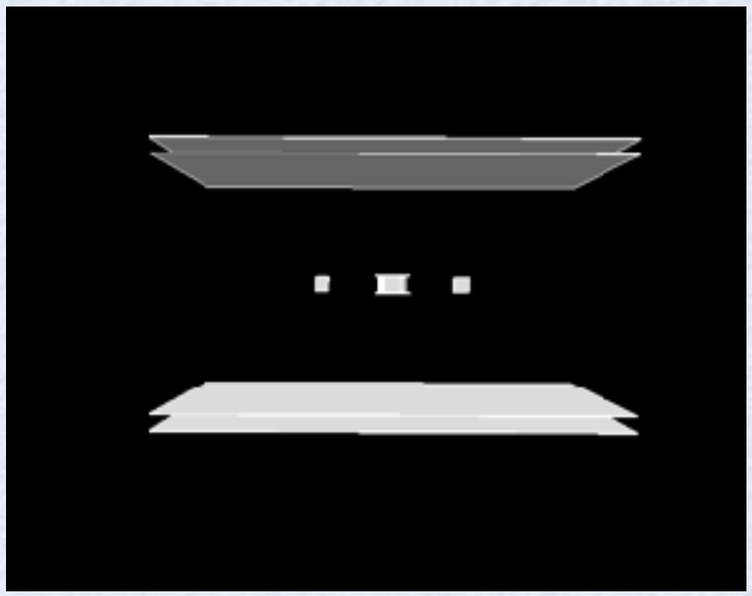
Medical linac:
Phantom
size: **500 cm**
SSD **: 100 cm**

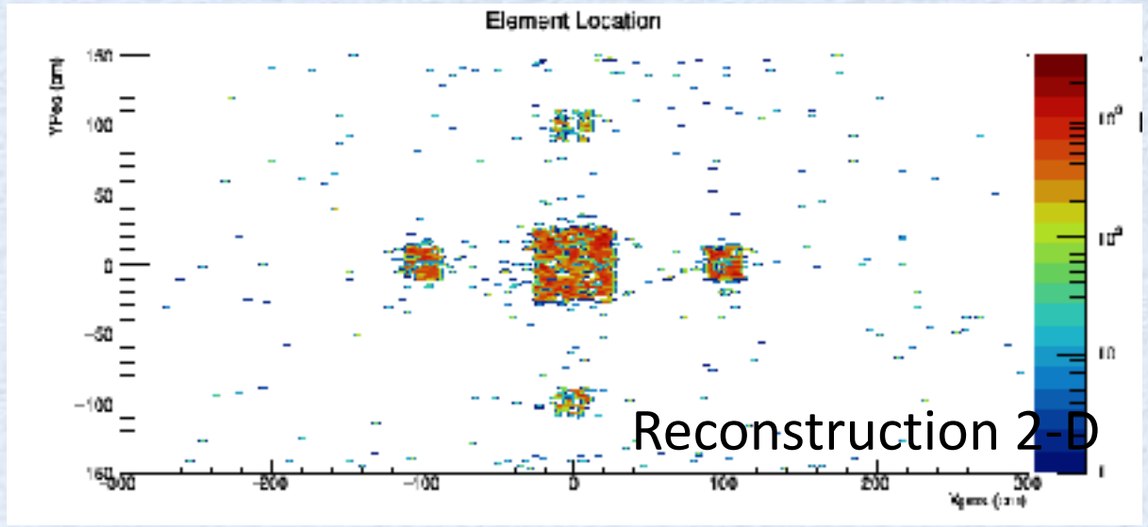
Geometry of Medical LINAC



Suat Özkorucuklu, Mahmutjian Lipit, Gökce Aydoğdu

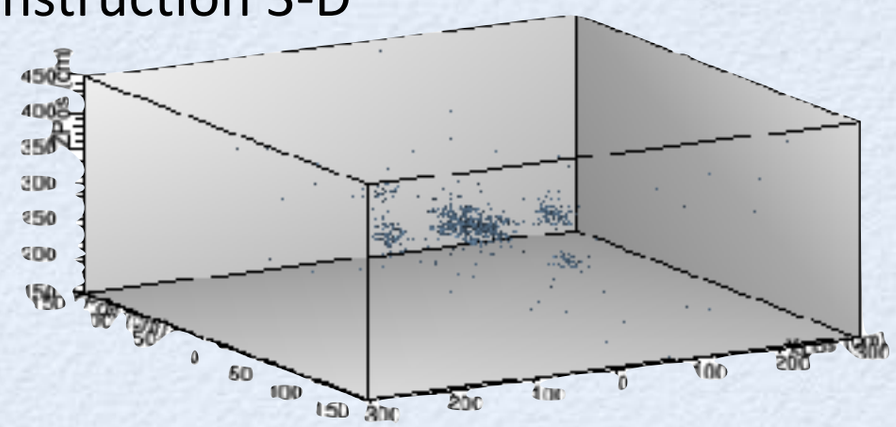
Muon Tomography - IRADETS

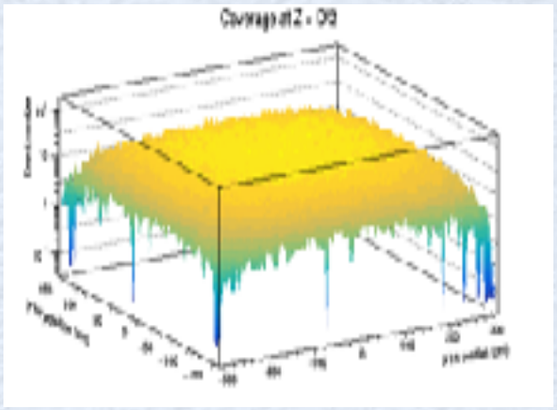




3D position

Reconstruction 3-D





Detector Covarage

Detector:

ScintillatorSizeX = **6 m**
ScintillatorSizeY = **3 m**
ScintillatorPlaneThickness = **10 mm**
Detector Planes Separation = **10 cm**
Top and Bouttom Detectors Separation = **3.5 m**

- IRADETS: Industry – academia collaboration

Suat Özkorucuklu, Mahmutjian Lipit, Behçet Alpat

Overall

- A national workshop held in June 2016 with special focus only on detectors & accelerators being developed locally.
- Some of the discussion topics included:
  - Cosmic muon tomography
  - Medical imaging for proton therapy
  - RF supply, circulator & transmission line for Turkey's first RFQ + its measurement box
  - Design and production of radiation-hard CPUs
  - Gaseous detectors, including RPCs and wire chambers
  - Cherenkov detectors for monitoring nuclear reactor activity
  - Plastic scintillator production; testing scintillating fibers and PMTs
  - Applications of ultrafast burst lasers (including their use for photoinjectors)
  - Home-grown simulation and DAQ software

Conclusion

- Large hep-ex community in Turkey
  - Internationally well connected, many having spent significant amount of time at CERN or other labs.
  - Modest local detector effort in proportion to our population/size of economy.
    - However, a growing level of interest and improving (but "instable") funding.
      - Highly motivated fresh people, willing to dirty their hands even when in situations with limited resources.
- People from various institutions on a diverse geography are able to form teams.
  - The fracturing of the groups due to historical reasons.
  - Each team was mostly isolated from the others, but improving level of collaboration.
    - Young talented people but issue with absence of proper postdoc support.

BACKUPS

Motivation

- The secondary electron emission (SEE) process is used in many applications: e.g. vacuum electronic devices, particle detectors, and scanning electron microscopy.

- In 1990 Derevshchikov et al. [1] proposed to use SEE process in suitably instrumented chambers with radiation hard emitters as active layers in calorimeter.

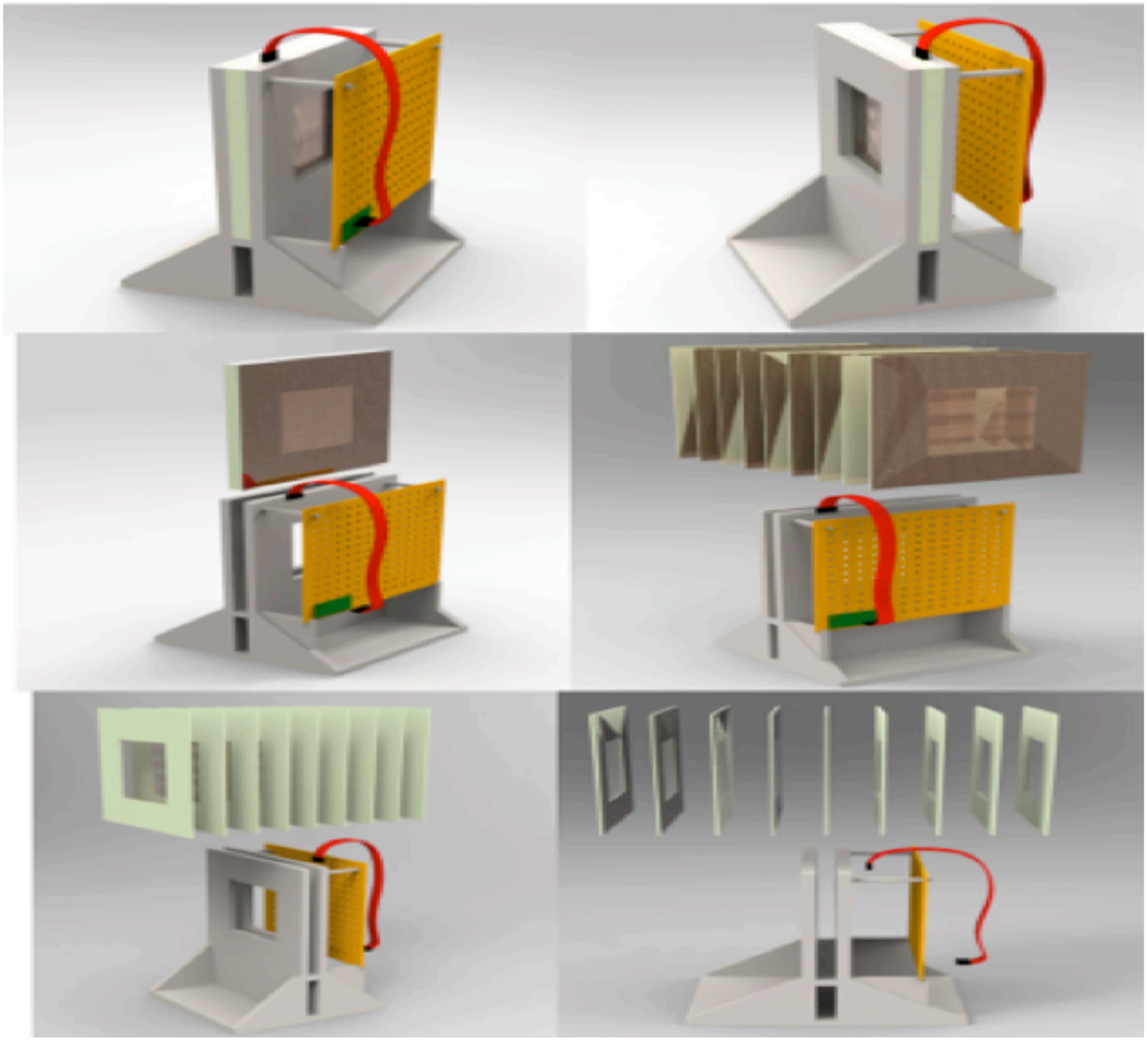
  - Since then, several other studies were performed to built such a calorimeter [2-6]

- **<u>Our design:</u>** If the outcome from the real beam provides successful results, our design will be the first SEE calorimeter which is designed by using emissive layers, instead of cathode blind PMT or multichannel PMT as used in the literature.

TUBITAK 1001

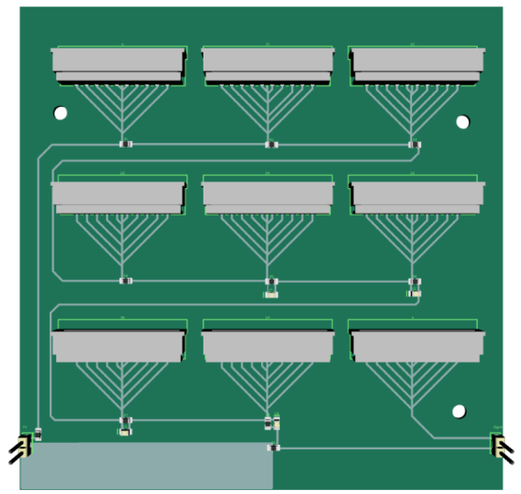
- **Part1:** Implementing a semi-empirical model of SEE process in to the Geant4
  - To compare the performance of our design with traditional scintillation sampling calorimeter.
  - Published in JINST (JINST 12 P07014 (2017))
- **Part2:** Building and testing the SEE calorimeter module
  - Module was successfully built
  - Electonics of the setup were also designed, and produced by us.
- **Next Items:**
  - Testing the electronics in vacuum environment
  - Pedestal measurements with a radioactive source
  - Testing the prototype with beam and compare the performance with Geant4 simulations

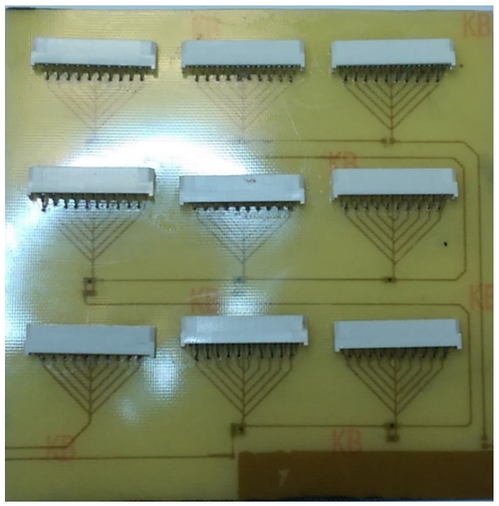
SEE Calorimeter: Prototype Design



Designed SEE Readout Electronics

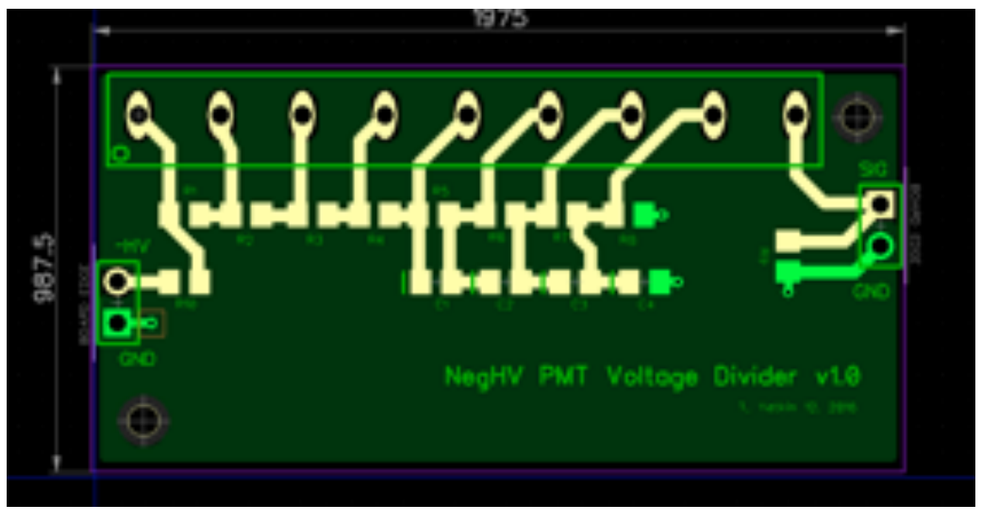
Voltage Divider used in the prototype





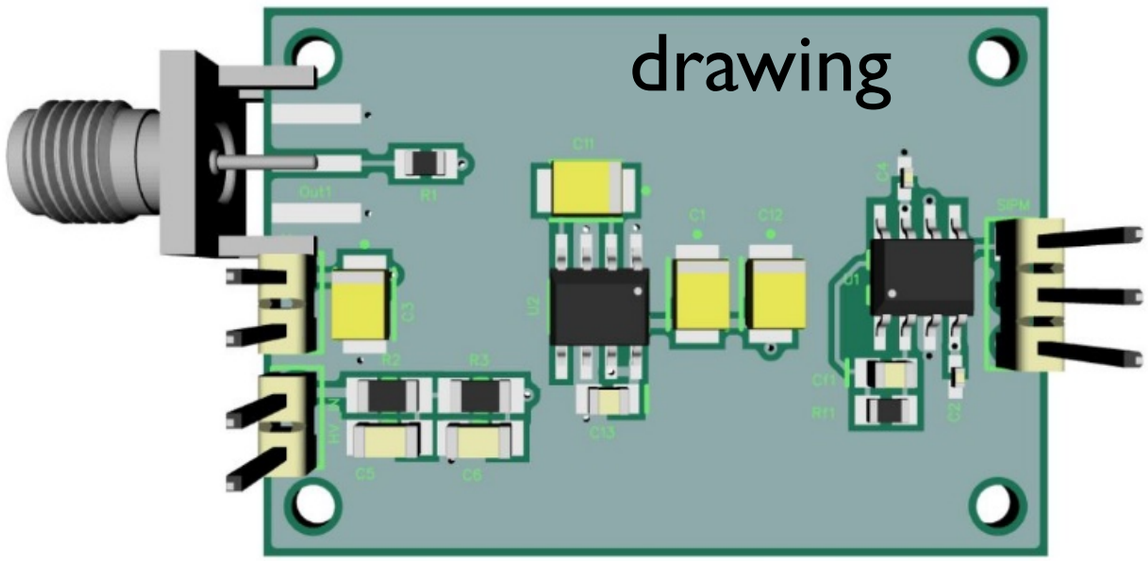
cables connecting
SEE layers to HV divider

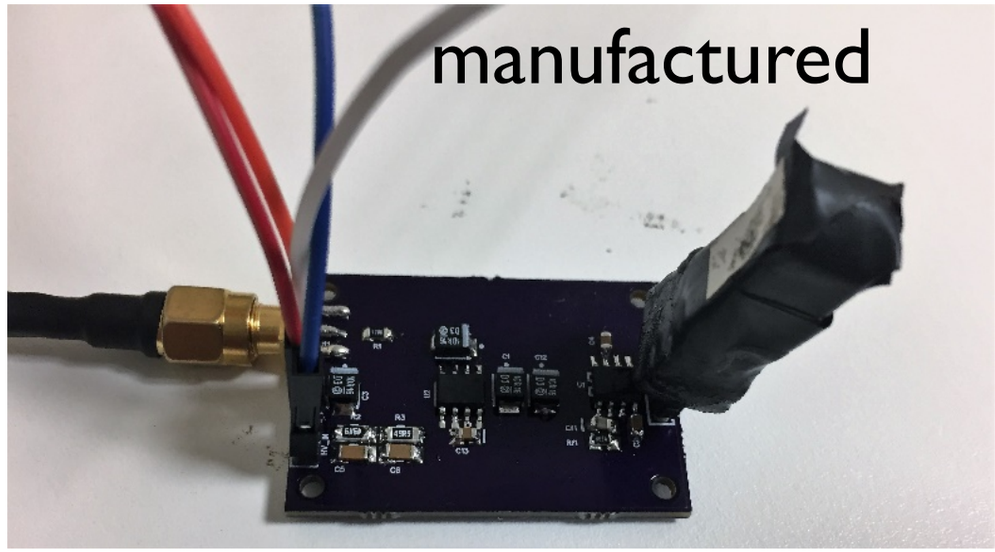
Voltage Divider: a smaller version



Other Electronics Designs by Our Group

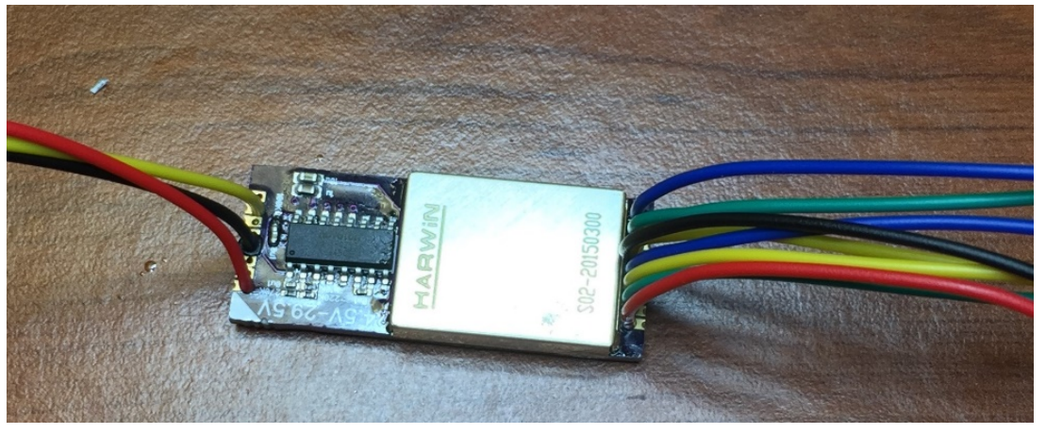
Bias Filter & Signal Preamplifier



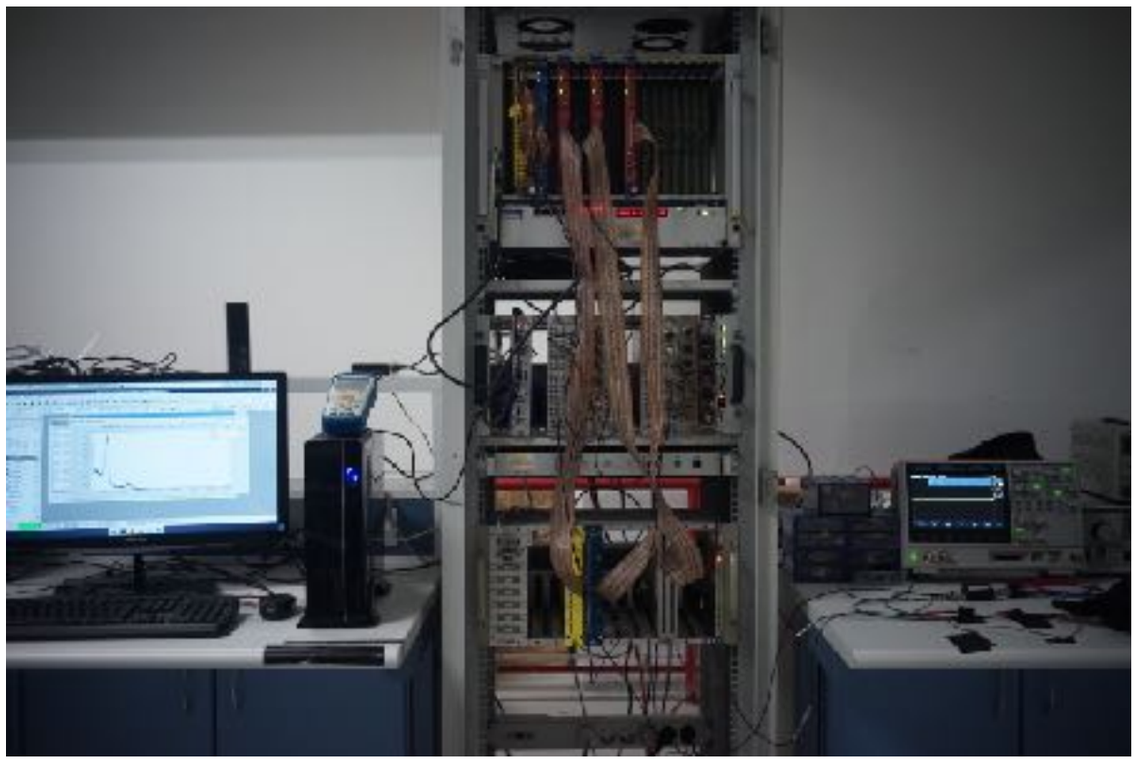


Signal splitter

24.5-29.5 Bias Voltage Generator



Nuclear & Particle Physics Labs



Nuclear & Particle Physics Labs

- We have two labs located at YTU and MGSU Physics departments
- What we do:
  - Photodetector tests (linearity, dark current, gain, etc.)
  - Energy spectrum & detector timing measurements
  - Readout electronic design & PCB production (manufacturing domestically or internationally)
  - Mechanical design & prototyping (in collaboration width industrial partners)

U.Ü. Ekibinin çalışmaları

JINST

PUBLISHED BY IOP PUBLISHING FOR SISSA

RECEIVED: November 18, 2009
REVISED: March 12, 2010
ACCEPTED: March 14, 2010
PUBLISHED: May 4, 2010

Penning transfer in argon-based gas mixtures

2010

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BALKAN PHYSICS LETTERS
©Bogazici University Press
BPL, 20, 201018, pp. 158 - 161

22 February 2012

UPDATE OF IONISATION CROSS SECTIONS FOR XENON

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Drift Velocity Effect on Argon Based Gas Detector Performances

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Abstract. Drift velocities of electrons in gaseous is important for the gas-filled detectors performances. In this work, drift velocities of electrons have been investigated for argon based gas mixtures are widely used in gaseous detectors. Magboltz program has been used to calculate drift velocities in various gas mixtures with different mixing ratios. The results are analyzed for the detector performance.

Nuclear Instruments and Methods in Physics Research A 718 (2013) 432–433

Contents lists available at SciVerse ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Secondary avalanches in gas mixtures

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ARTICLE INFO

Available online 30 August 2012

Keywords:
Excited states
Gas gain
Photon feedback

ABSTRACT

Avalanche development in gas-based detectors relies not only on direct ionisation but also on excitation of noble gas atoms. Some quencher molecules can be ionised when they collide with excited atoms, a process on which we reported earlier [1]. Alternatively, excited atoms can decay by photon emission. If these photons are inefficiently absorbed by the quencher yet capable of ionising, then they may escape from the avalanche region and start secondary avalanches. This process, called photon feedback, leads to an over-exponential increase of the gas gain which limits the working range. In this paper, we derive photon feedback parameters from published gain measurements for several gas mixtures and fit these parameters in a model which describes their dependence on the quencher concentration and the pressure.

- Rolling grant?
- R&D percentage?
- Beraber basvuruluyor mu?