The ATLAS/LHC Demokritos group research activities

Theodoros Geralis
NCSR Demokritos
6/6/2024

OUTLINE

- **The ATLAS New Small Wheel Muon Upgrade**
  - **sTGC Trigger/Detector**
  - **NSW Software development**
  - **Physics Analysis: Z mass**

- **Instrumentation Laboratory DAMA**
  - **Resistive Micromegas R&D**
  - **Picosec Micromegas**
  - **Real x-y microbulk micromegas**
  - **Micromegas and use of graphene**

FTE Students meeting
6 June 2023, NCSR "DEMOKRITOS", Athens, Greece

The ATLAS Group – 2023

NCSR Demokritos **full member** of **ATLAS** since Oct. 2017

Researchers

Georgios Fanourakis (Emeritus)	: gfan@inp.demokritos.gr
Theodoros Geralis (Team representative)	: geral@inp.demokritos.gr
Georgios Stavropoulos	: stavrop@inp.demokritos.gr
Andreas Psallidas	: Andreas.Psallidas@cern.ch

Doctoral Students

Olga Zormpa

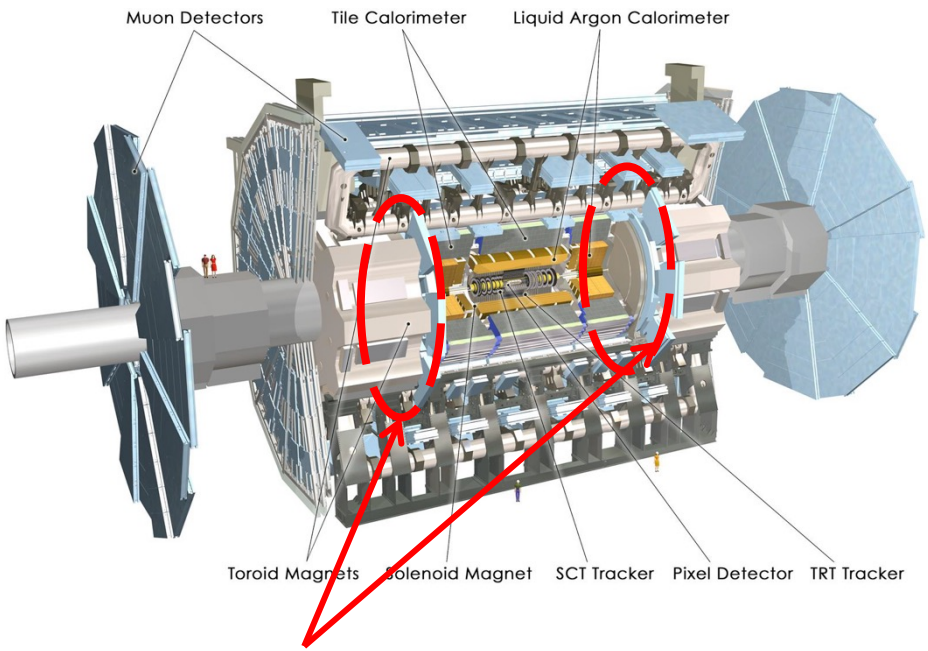
Master Thesis

Elena Kanellaki

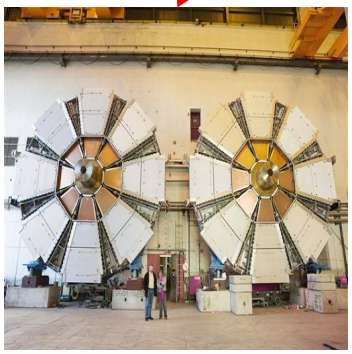
Technician (Electronics)

Yannis Kiskiras

The ATLAS Experiment - Upgrade



Small Wheels

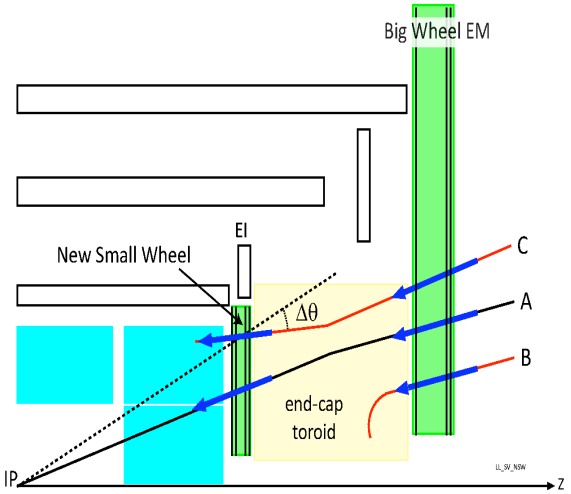


- ATLAS - General purpose detector
- Muon Small wheels:
  Between the End-cap Calorimeter and End-cap Toroid
- 10 m in diameter
- Consist of:
  - Cathode Strip Chambers (CSC)
  - Thin Gap Chambers (TGC)
  - Monitor Drift Tube (MDT)
- Coverage: $1.3 < |\eta| < 2.7$

NEW SMALL WHEELS

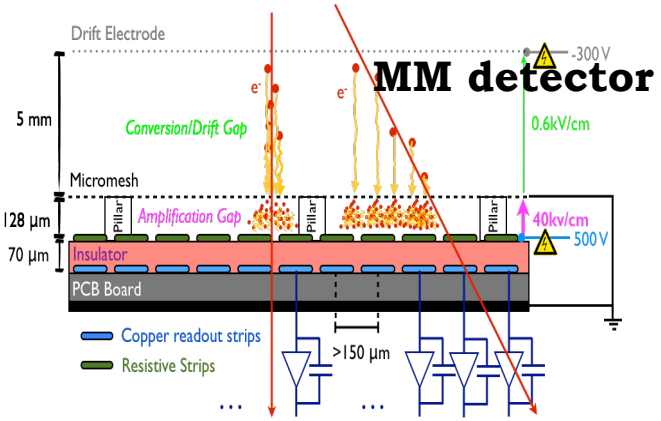
Mechanical structure

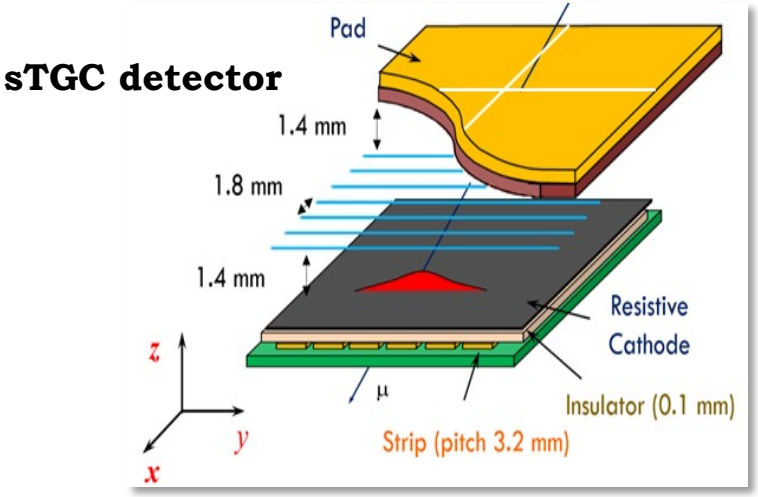
Operation principle MMs and sTGC (NSW Technologies)



New Small Wheels (NSW)

- Work at high background rates (n,γ) 20kHz/cm^2
- Will provide online high angle resolution (σ_θ~1mrad)
- Spatial resolution at 100 μm
- Significant reduction of fake triggers





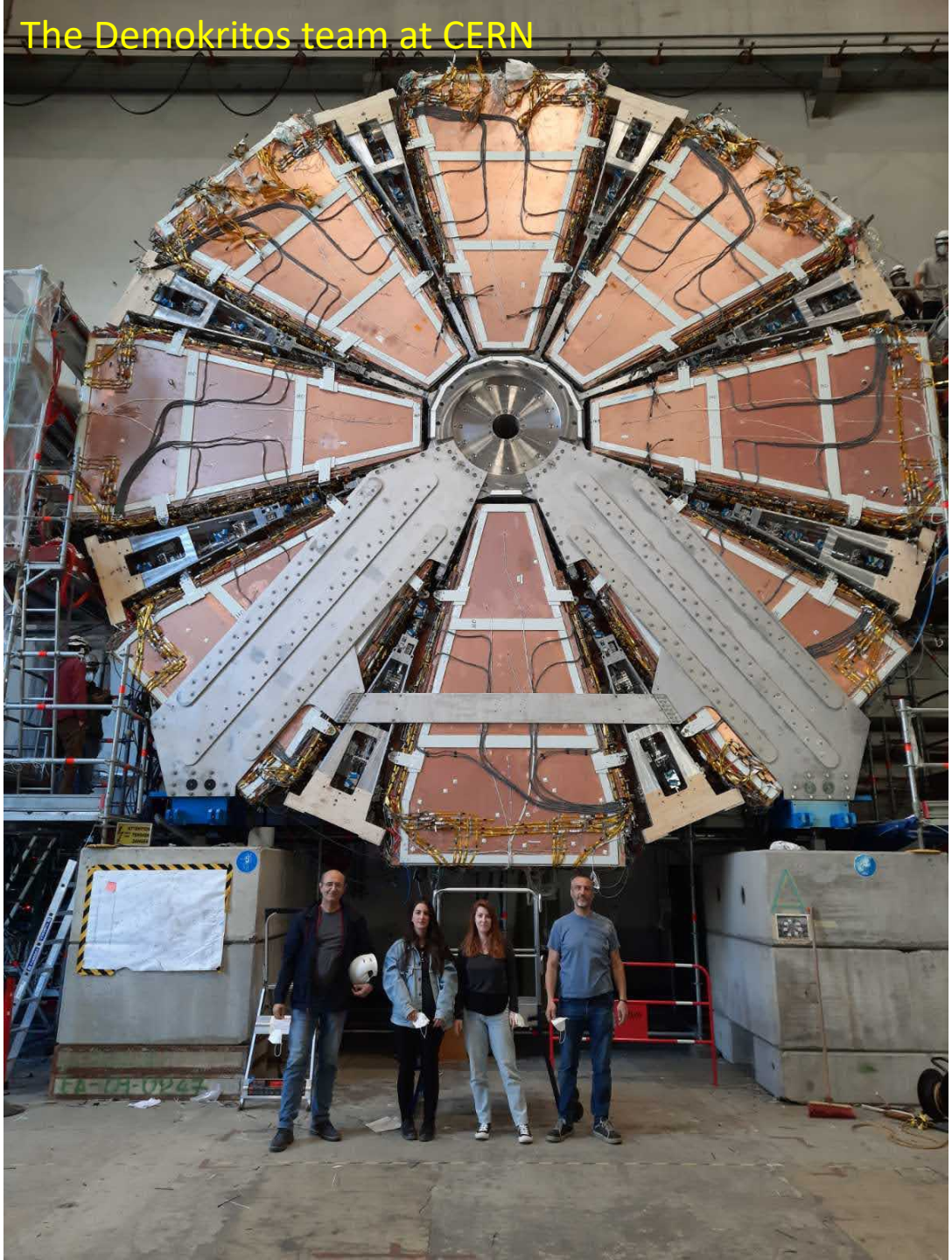
Micromegas – 2.1 Million Channels

MM strips for tracking, first hit for trigger
- -Strip pitch: 450 μm
- -Precision: ~ 100 μm/layer
- -Data rates: Up to 8 Gbps/plane

sTGC – 330 k Channels

- sTGC wires/strips for tracking, strips/pads for trigger
  - Precision: ~ 100 μm/layer
  - Data rates: up to 1.77 Gbps/plane

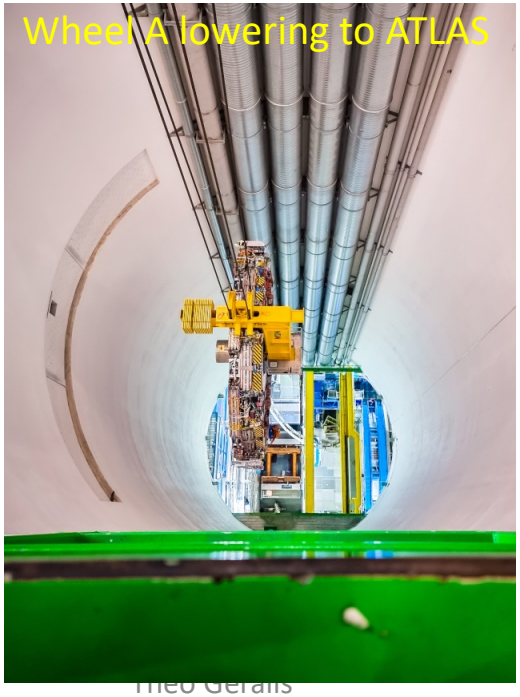
The Demokritos team at CERN




Wheel A trasported to P1/ATLAS

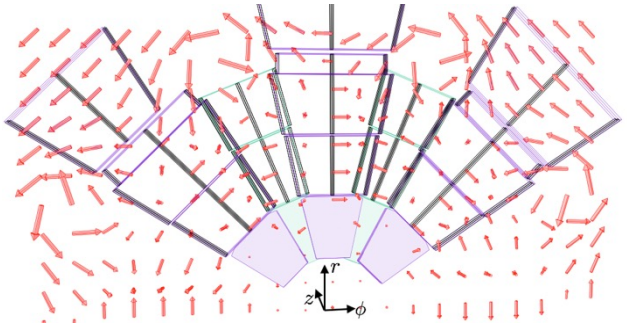

Wheel A on the crane to lower to ATLAS


Wheel A lowering to ATLAS


Wheel A lowering to ATLAS


November 2021
Wheel A and C
Installed in ATLAS

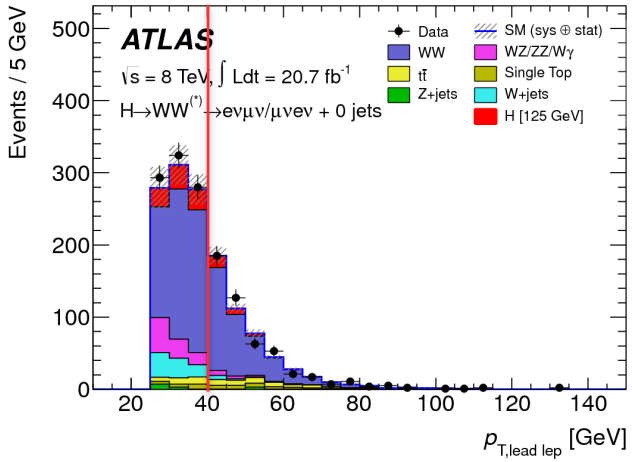
NSW: Impact on Physics

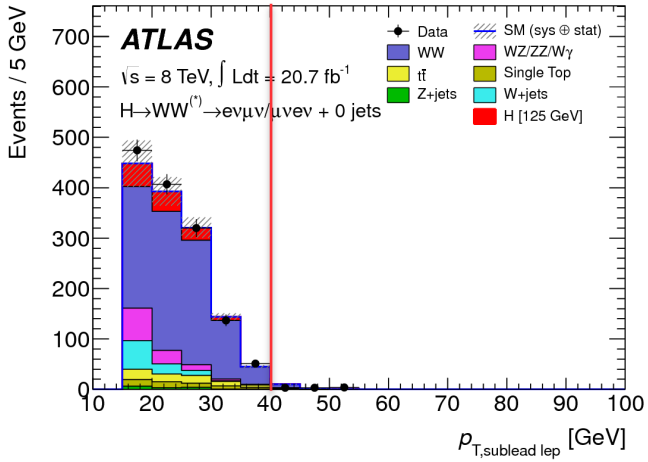


- Toroid Magnetic field requires dense tracking ➔ NSW
- Possibility for proper reconstruction to the IP and resolve pile-up events (up to 150 in HL-LHC)
- Reconstruction of μ P_T~10 GeV
- Keep efficiency and acceptance very high > 90% at HL

- Trigger rates without NSW:
  P_T > 40 GeV ➔ single μ- Trigger rate 60kHz
- Trigger rates with NSW:
  P_T > 20 GeV ➔ single μ- Trigger rate 20kHz
- Can keep lower P_T (>10GeV) subleading μ

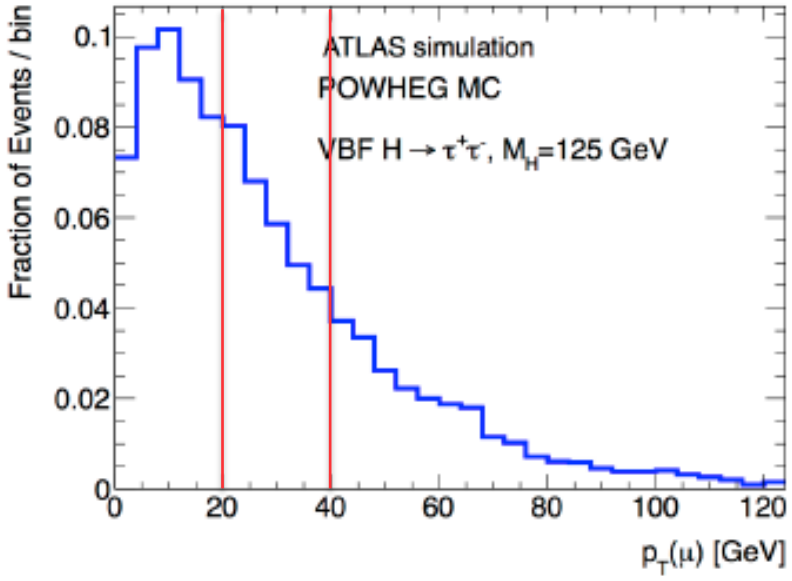
Example: H→WW*→lνlν





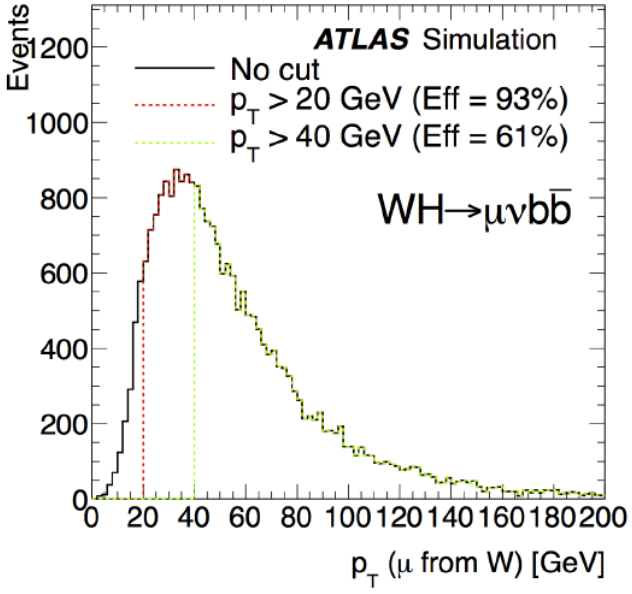
A P_T cut at 40 GeV would suppress most of the signal

Higgs production by VBF: Lower cross section but distinct signature



Higgs coupling to Vector Bosons Via Higgs-strahlung: pp→ WH

Trigger on leptons from W decays



High P_T (>100 GeV) μ require high precision and high efficiency tracking

NSW: 16 layers, high efficiency in high occupancy

Allow physics channels with high mass Z', W', Higgs boson A decaying to muons

ATLAS

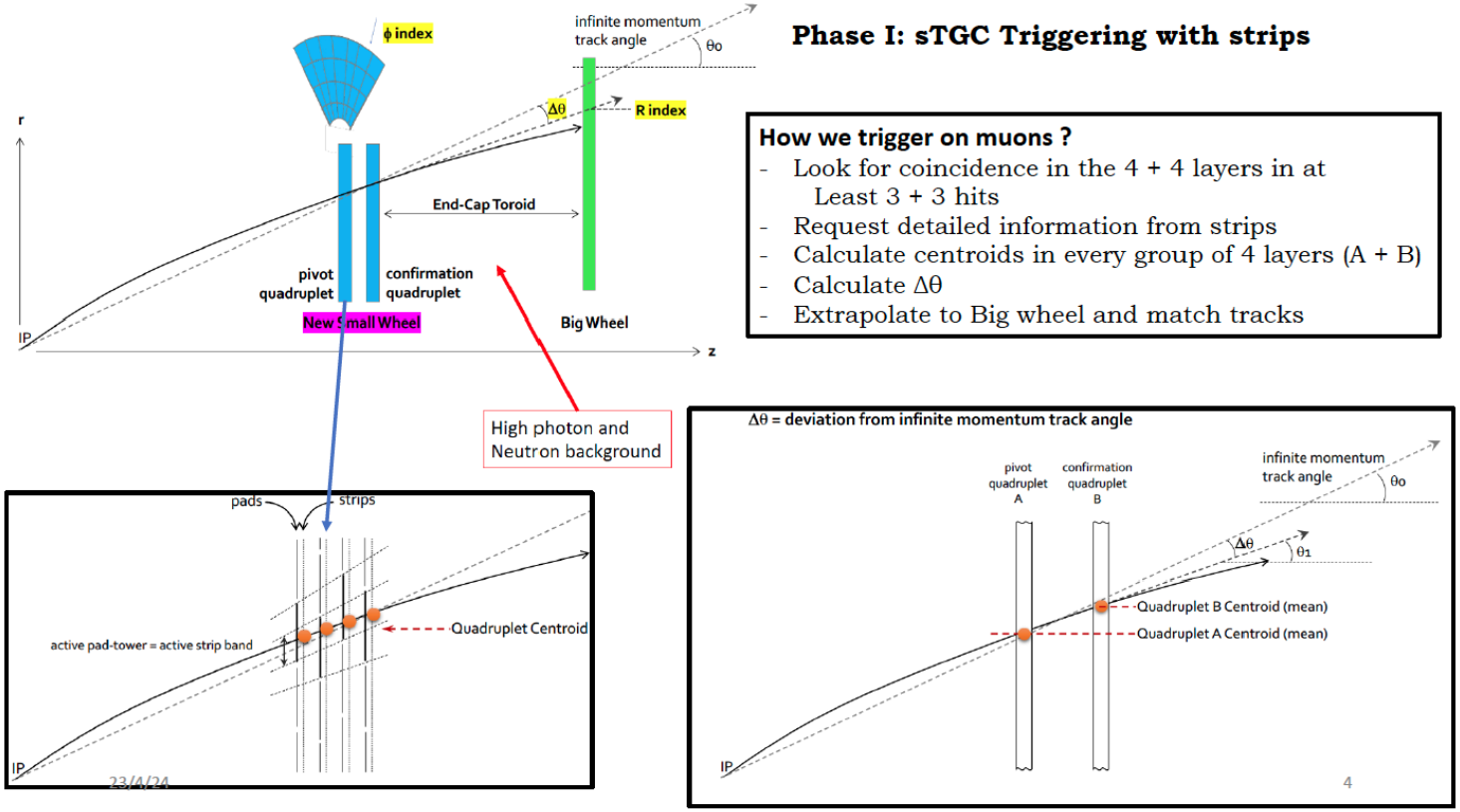
Η ομάδα του ΙΠΣΦ/ΕΚΕΦΕ Δημόκριτος έχει αναλάβει σημαντικές υπευθυνότητες στο πείραμα ΑΤΛΑΣ INPP:

Muon System software coordination, NSW Trigger, Physics Analysis

Προσφέρεται ένα θέμα για εκπόνηση Διπλωματικής Μάστερ:

«Φυσική με το νέο ανιχνευτή μιονίων New Small Wheel – Ανάπτυξη αλγόριθμου για την βέλτιστη επιλογή μιονίων με το σύστημα του σκανδαλισμού»

Προαπαιτούμενα: Καλή γνώση C++



DAMA instrumentation RD

DAMA INFRASTRUCTURE

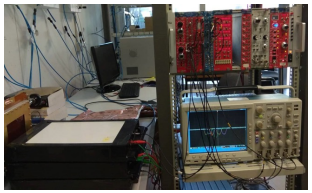
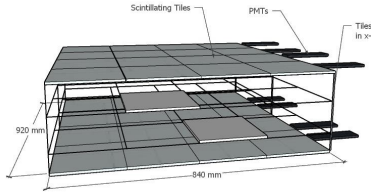



- **THREE FULLY EQUIPPED TEST BENCHES FOR STUDYING MPGDs**
  - **Electronics Rack, Gas distribution, Workstation, Osciloscope**

- **NEW GAS MIXER and distribution of premixed gases (K. Damanakis)**
  - **Mixing 3 gases**
  - **Operate at pressure range 100 mbar – 2 bar**

- **ELECTRONICS AND DAQ SYSTEMS**
  - **VME Data Acquisition (Controller, CRAMS, sequencer, ADC, Gate gen.**
  - **SRS - Scalable Readout System (APV FE, 2000 channels readout)**
  - **FEMINOS readout for TPC mode**
  - **Electronics: Racks (1 VME and 4 NIM crates), NIM units (Multifunction NIM modules, Amplifiers, Discrim., HV PS, LV PS, Pulse generators, NIM/TTL/NIM conv, etc), MCAs (2), Preamps**

- **DESIGN PACKAGES**
- **COSMIC STAND (Olga Zormpa, George Stavropoulos)**
  - **Scintillator based cosmic veto for triggering on muons**
  - **Used for studies of the Micromegas**

- **CLEAN ROOM (12 m² – two rooms Class 10,000 and Class 100,000)**
  - **Microscope**

Examples of Students works

Micromegas R&D

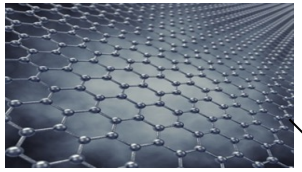
Microfabrication

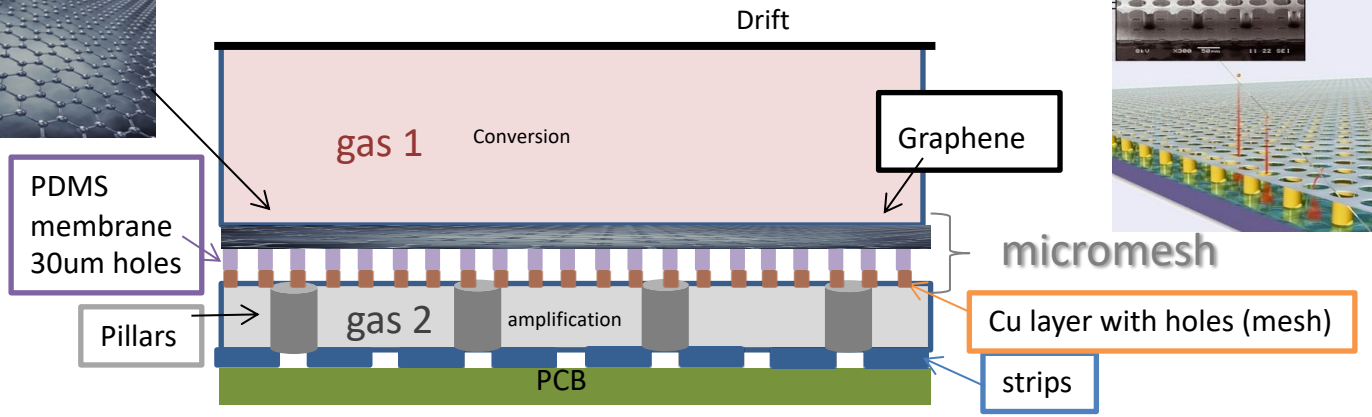
Graphene

Micromegas Detector microfabrication

Aim: Build Micromegas Using microfabrication Techniques and Graphene (Proof of principle at this stage)

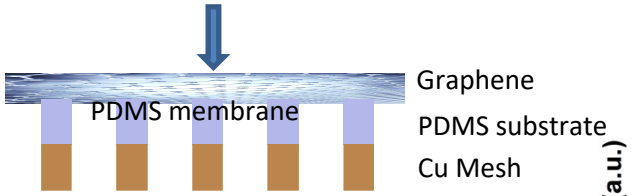
Collaboration (INPP, INN, ITE Patras):
T. Geralis, A. Tserepi,
A. Dimoulas, I. Parthenios



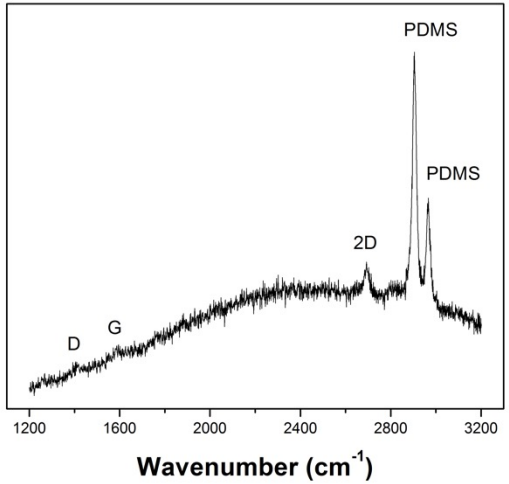


This is our ambition

1) Two-gas phase detector separated by a Graphene layer
2) Exploit differences in gas properties to improve performance
3) Should have high electron transparency (test to be performed)
4) It may be used to eliminate ion backflow



We have placed a graphene surface of 1 x 1 cm² on to of the PDMS substrate



ATLAS Local Trigger Interface (ALTI)

ALTI : Double VME board **Upgrade** to the current timing, trigger and control (TTC) system

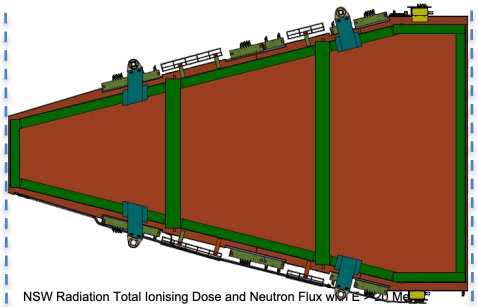
Primary function: Interfaces the Level-1 **Central Trigger Processor** and the **TTC network** to the front-end electronics of each of the ATLAS sub-detector

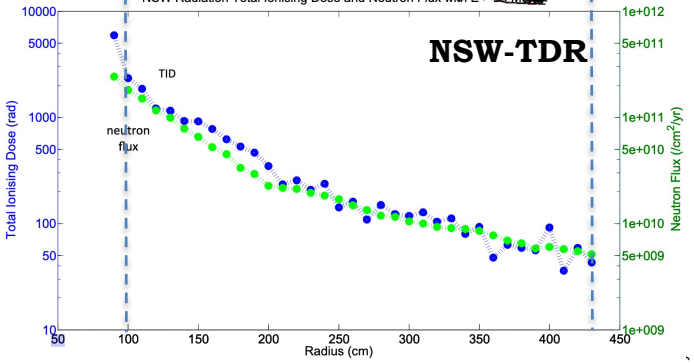
```
#----------------------
#                    M
#                    u
#                    l
#                    t
#                    i
#                    p
#                    l
#   CCC              i
#  BRRR    T BBBB TTT  c
#O UEEE    T GGGG TTTL i
#R SQQQ    Y OOOO RRR1 t
#B Y210    P 3210 321A y
#----------------------
 1 0000 0x00 0000 0000 40  # orbit signal
 0 0000 0x00 0000 0000 11
 0 0000 0x00 0000 0000 1   # BCR signal
 0 0000 0x00 0000 0000 99
 0 0000 0x00 0100 0000 1   # test pulse signal
 0 0000 0x00 0000 0000 69
 0 0000 0x00 0000 0001 1   # L1A signal
 0 0000 0x00 0000 0000 3342 # LHC orbit of 3564 BC -> 11.245 kHz
 1 0000 0x00 0000 0000 40
 0 0000 0x00 0000 0000 11
```

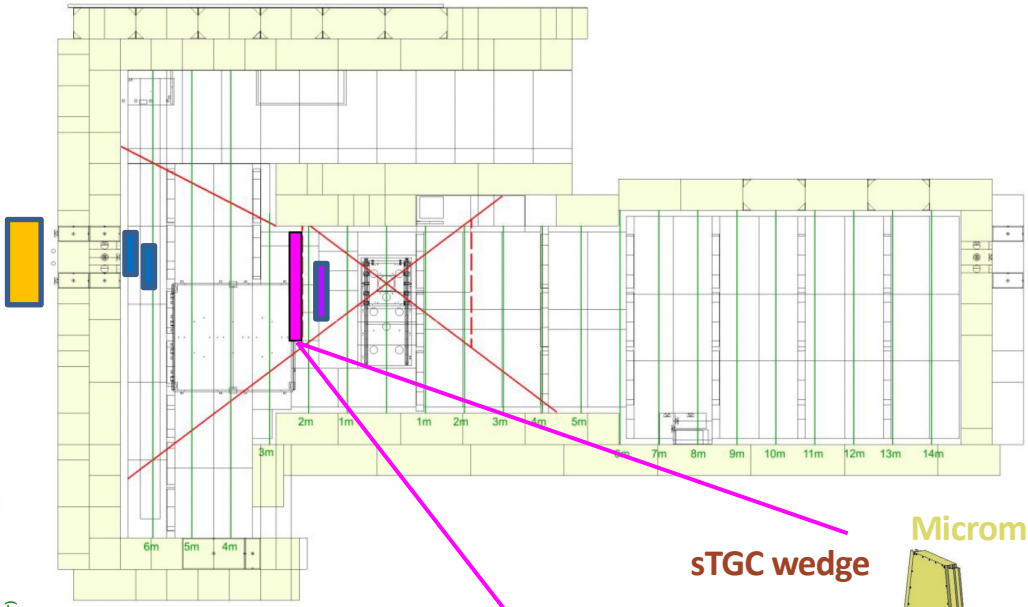
Currently provides an artificially generated pulse pattern with the **TTC information** and the **Bunch Crossing clock** at 40 MHz for data synchronization.

Irradiation tests at GIF: Gamma Irradiation Facility

- **Irradiation with γ (^{137}Cs 662 keV) at LHC expected fluxes**
- **Aim: 1) measure μ efficiencies under irradiation**
  2) Measure fake rates

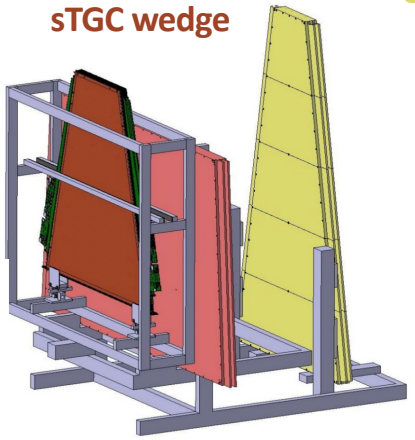


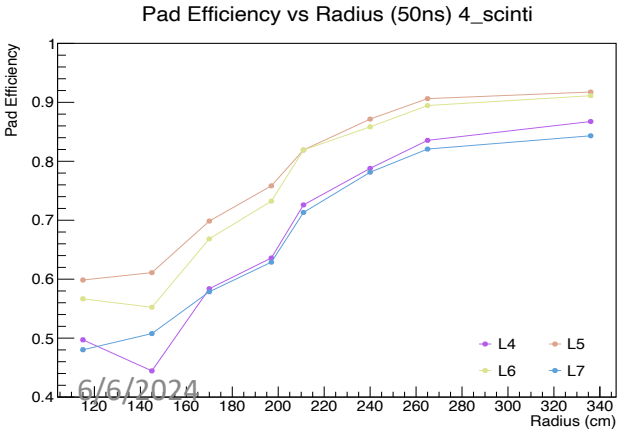


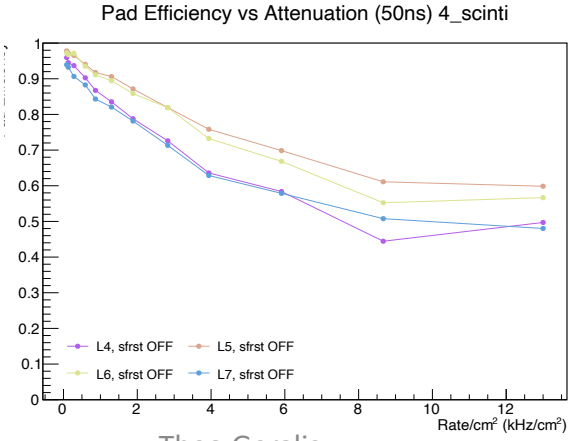


Micromegas

sTGC wedge







Gas Mixer System in ELEA

Designed by T. Geralis, developed by Kostas Damanakis, Athanasia Papaioannou.

Goals

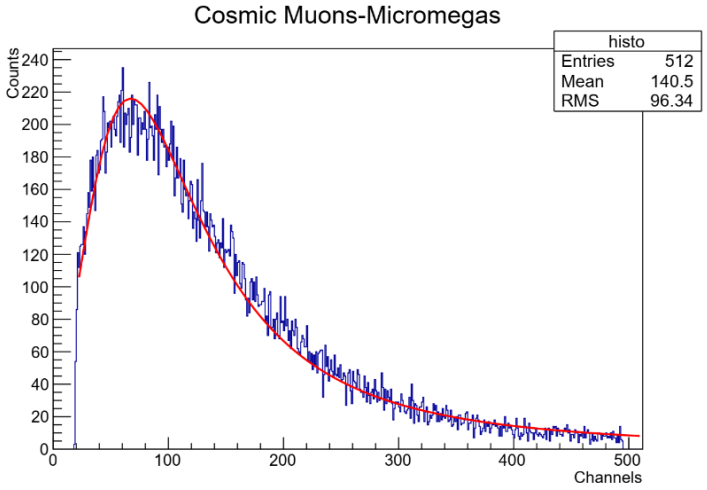
- Mixing three different gases and filling the Micromegas Detector with the gas mixture
- Choosing to mix the gases with the mixing system in order to minimize the imperfections that could possibly exist in industrially developed gases
- Study and improve the efficiency of the MMs under different gas mixtures

Cosmic Stand

Eva Eleftheriou, Stathis Logothetis (Practice students), Olga Zormpa (Masters student)

Goal: Design, set up and installation of a cosmic stand. **Purpose:** Reconstruction of muon tracks. Test and calibration of detectors (mainly MicroMeGaS)

Cosmic Stand + Micromegas Detector



FCN=667.556 FROM MIGRAD STATUS=CONVERGED 111 CALLS 112 TOTAL					
EDM=2.58823e-007 STRATEGY= 1 ERROR MATRIX UNCERTAINTY 2.0 per cent					
NO.	NAME	VALUE	ERROR	STEP SIZE	DERIVATIVE
1	Constant	1195.360000	9.686580	-0.275756	0.000120
2	MPV	74.530200	0.488637	0.005695	-0.000465
3	Sigma	32.518700	0.257339	0.000014	0.280630

Callibration with Fe-55: Channel 351 → 5.9 keV

Landau MPV: **channel 75 → E_{mu}=1.26 keV**

$\{\chi^2 = \frac{FCN}{ndf} = \frac{667.556}{509} = 1.3/df\}$

2.44 keV/cm→ **$E_{mu,th}$=1.22 keV**

15/11/2019 8

Monitoring of DAMA lab environmental variables

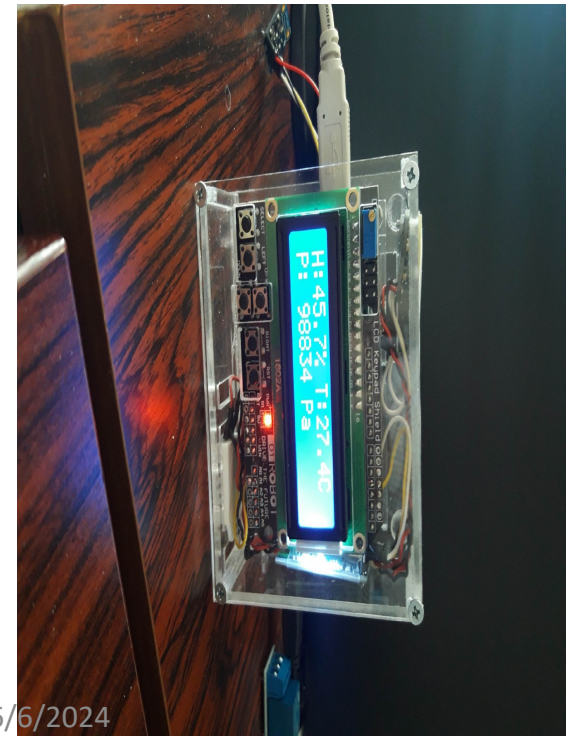
<u>Practice Students</u>: Alexopoulos I., Giannakopoulos D., Remoundou Th.

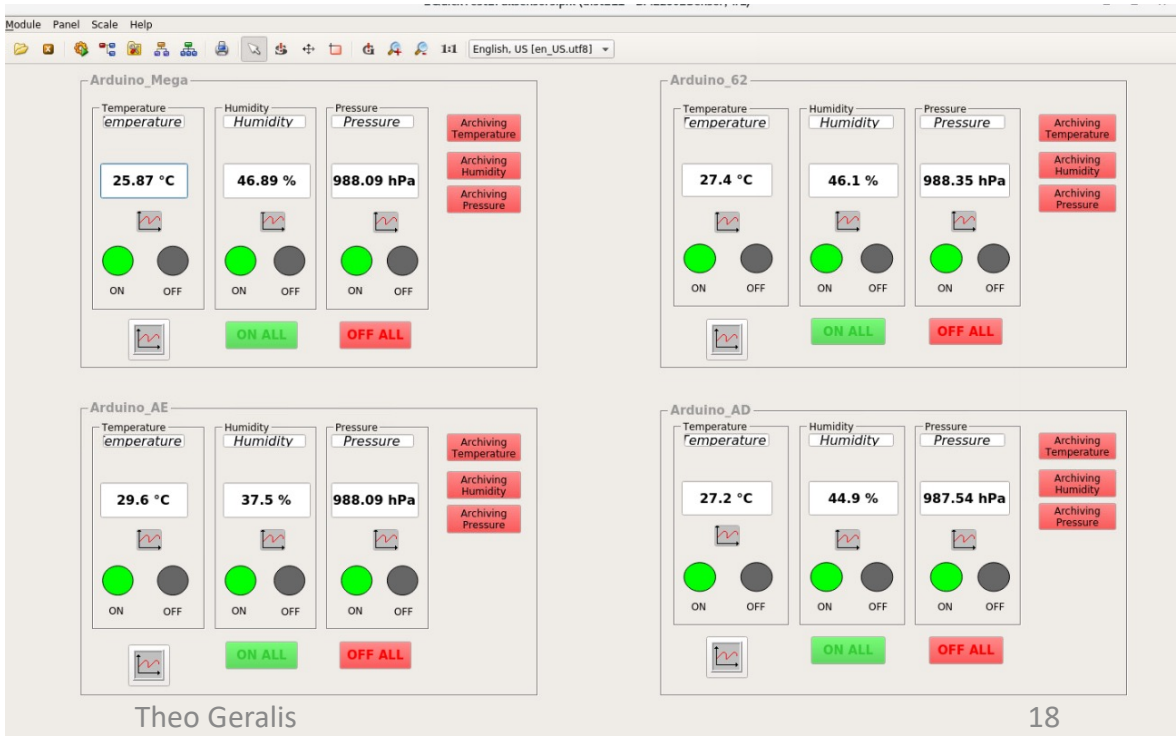
<u>Masters Student</u>: Kannelos N. <u>Technician</u>: Kiskiras I.

4 Arduino-based modules designed and constructed.

PC communication via Bluetooth (3 modules) and USB (1 module)

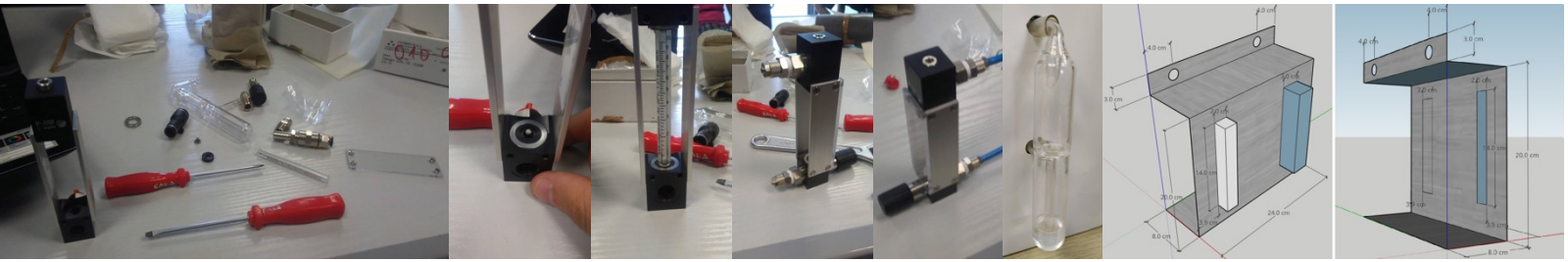
Commercial sw (WinCC) used for monitoring.

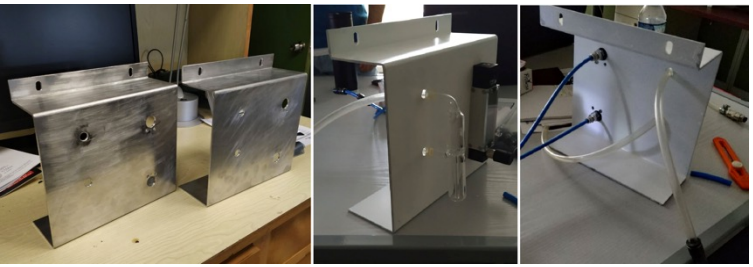


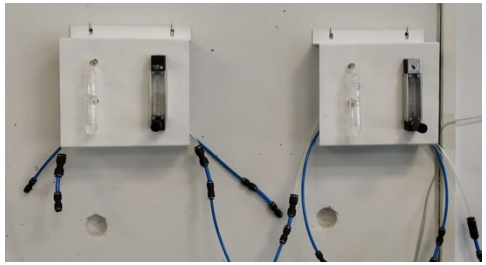


Work by the Practical students: Stamatis Tzanos, Vasilis Blanas

Build 2 Gas Flow Controllers

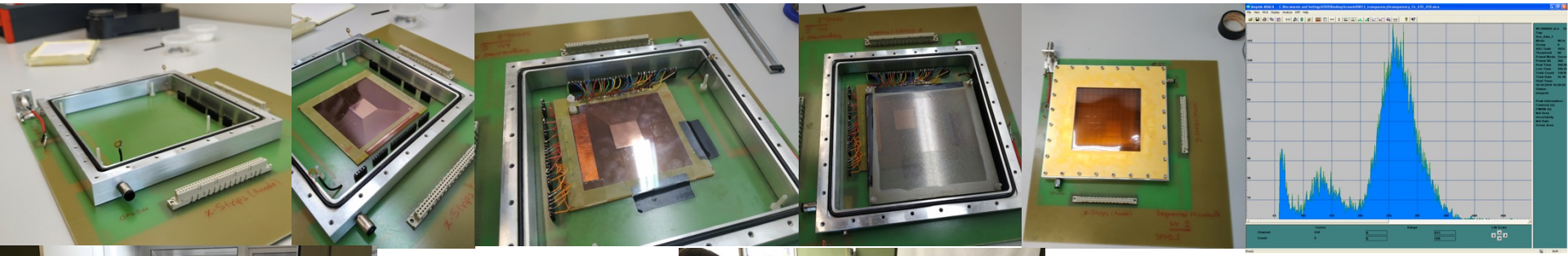






Excellent work
Done from A-Z

Work on the “Real x-y Segmented Microbulk”: First real x-y with 700 μm strip pitch



Working in the Clean Room

Preparing the Cloud Chamber For Researcher’s Night