Hellenic Society for the Study of High Energy Physics (HeSSHEP) Activities

Aristotelis Kyriakis
On behalf of HeSSHEP

MISSION

The Hellenic Society for the Study of High Energy Physics (HeSSHEP) was founded in 1975. The majority of the Greek scientists (both in Greece and abroad) working in this field are members of the Society. Its main objectives are to promote the scientific work of the Greek scientists and to inform the general public and the Greek state on matters concerning the subject of HEP.

In this general talk an overview of the activities of HeSSHEP will be presented in both Experiment and Theory:

Experiment

- LHC EXPERIMETS (ALICE, ATLAS CMS)
- LHC DETECTOR upgrade
- KM3NeT
- MoMEDAL
- ASTRONEU
- R&D

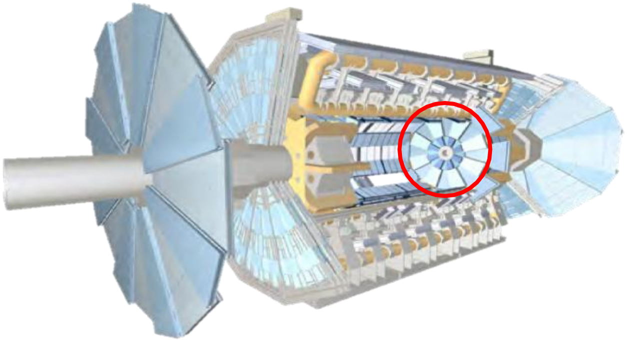
Theory

- LHC Phenomenology
- Beyond Standard Model Theories (SUSY, Strings, Extra Dimentions
- Cosmology

ATLAS experiment @ CERN

AUTH, NTUA, NKUA, Aegean, UWA,
NCSR “Demokritos”

The ATLAS Small Wheel Upgrade



Pseudorapidity coverage: $1.3 < |\eta| < 2.7$

- The Small Wheel is the region with highest background rates in the present ATLAS Muon Spectrometer
- Present system: Cathode Strip Chambers (CSCs), Monitored Drift Tubes (MDTs) and TGCs

- Expected rates at HL-LHC: up to 15 kHz/cm^2 → present detectors performance severely affected
  - Spatial resolution is deteriorated
  - Efficiency decreases
  - Trigger bandwidth limit exceeded due to fake triggers

  Replace with novel high-rate capable detectors (New Small Wheel)

The Greek Contribution to the NSW

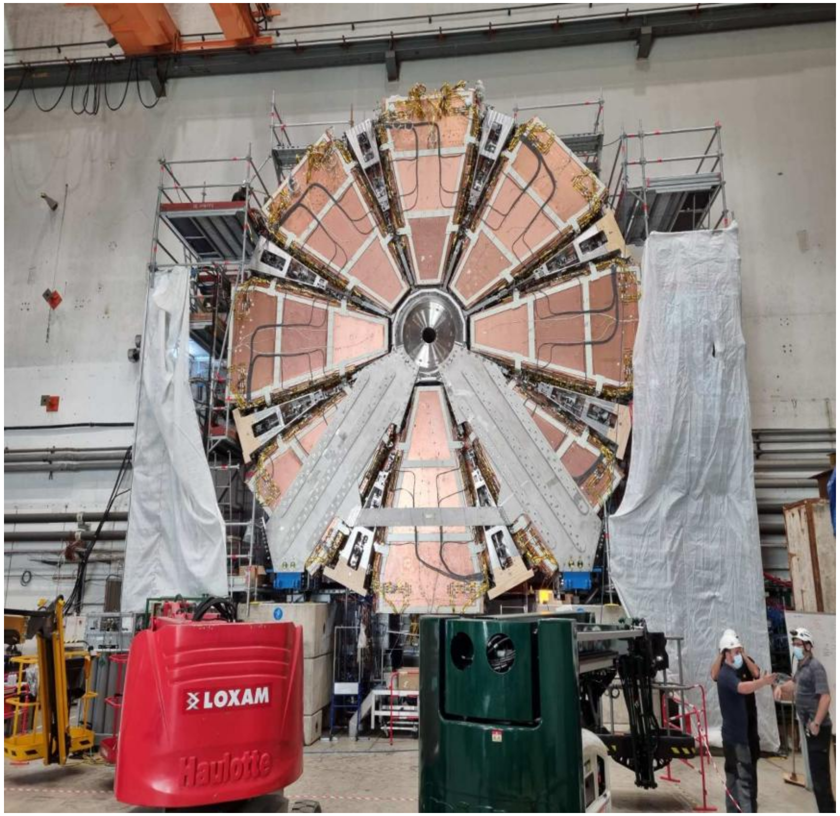
Development of ***Large-Size Micromegas Detector*** for the Upgrade of the ATLAS Muon System, MAMMA project (2007- 2013).
Test beam activities with Micromegas prototypes and Large size (~2 m^2) (2010-)

MM Chamber Construction

AUTH (LM2)

Detector Integration

AUTH, NTUA, NKUA, Aegean, UWA, NSCR "Demokritos"



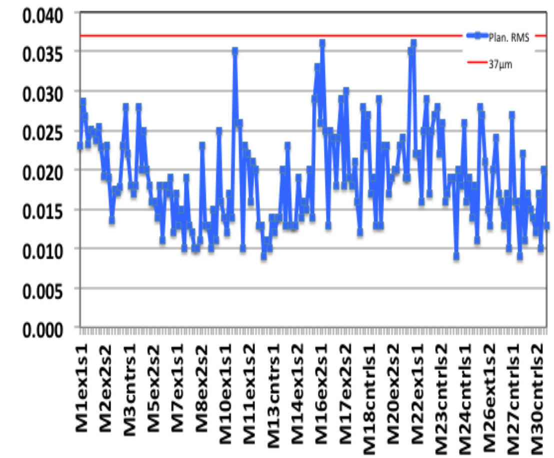
Electronics

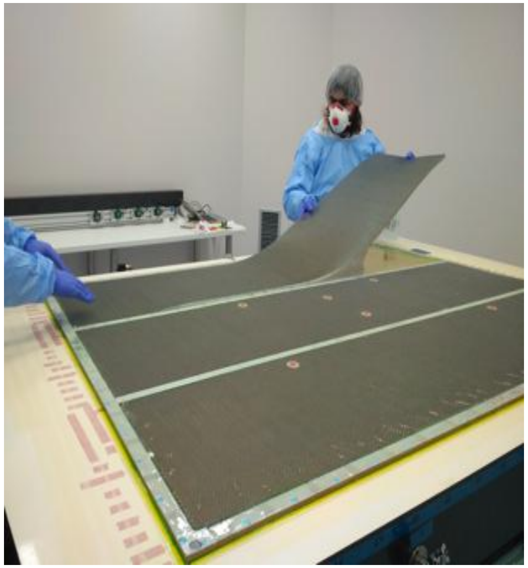
NTUA, NKUA, Aegean, UWA, NSCR "DEMOKRITOS"

LM2 drift panels construction @ Thessaloniki

- The production and test of **96+9 Drift panels** equipped with mesh sent to Dubna for the chamber assembly (quadruplet)
- New Laboratory for detector construction established (360 m^2)
- New Clean Room (145 m^2, *Grade D*)
- **Production started July 2017 – ended January 2020**

Panel Planarity (<37µm)





Double wedge Assembly and integration at BB5 (CERN)

- 2 integration tables Large DWs
  - 5 rotation stations in use
  - All SFs are finished
  - All but 2 DWs of side C are left for mechanical assembly
  - **All but 3 DWs of side C are left for service completion**
  - 3 rotation stations in use for elx integration and validation
  - 6 SS and 1 LS of side C have been validated
  - **End of integration of all side C sectors by August 2021**

NTUA, AUTH, Aegean, UWA,

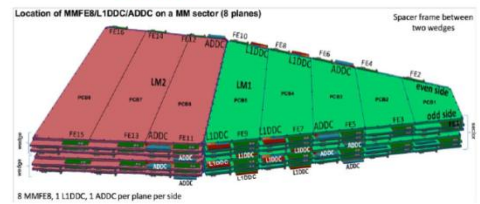
Integration: Electronic boards

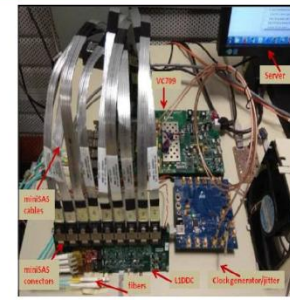
Each Micromegas double-wedge
Has 65536 read out channels
Combines 4 different types of elx boards

- 128 MMFE8 -- MicroMegas Front-End
- 16 L1DDC -- Level-1 Data Driver Card
- 16 ADDC -- Address in Real Time Data Driver Card
- 16 LVDB -- Low Voltage Distribution Board

All the cards are fully tested on the bench before installation on the detector

ADDCs and L1DDCs (for both MM and sTGCs) were validated in 2019 by NTUA, NCUA, Univ. of WA and NCSR "Demokritos" teams

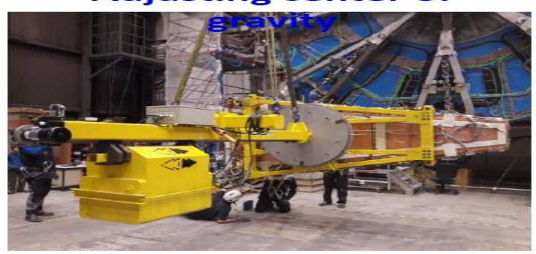




1st Sector Installation 12/2019

Grabbing of the sector

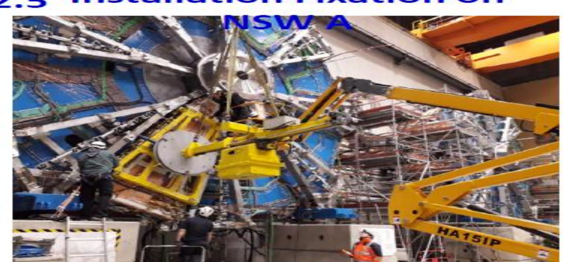
Adjusting center of gravity



Moving towards the wheel

Set orientation to 22.5 deg

Installation Fixation on NSW A



Ready for survey

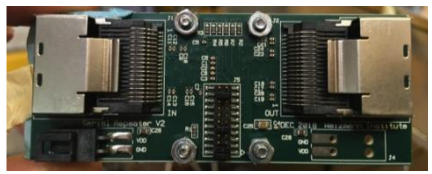
Detector Integration

AUTH, NTUA, NKUA, Aegean, UWA, NSCP "Demokritos"

sTGC Repeaters Boards

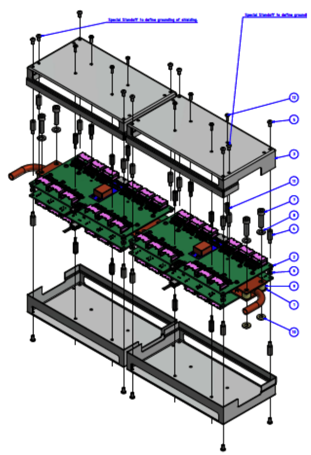
Full responsibility of Demokritos
Design, construction, commissioning and Integration (2018 – 2021)

Repeaters reinstate attenuated signal for the Trigger data transmission at 4.8 Gbps
Serial Repeaters: **full production of 880 boards and Shielding boxes build in Greece (PRISMA SA, Rentron)**

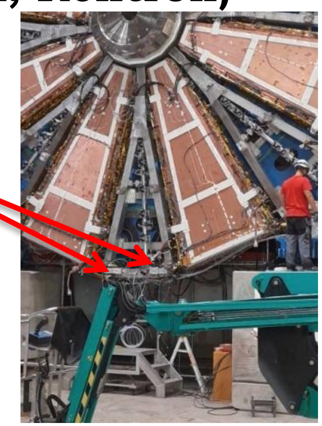


LVDS Repeaters: **full production of 140 boards and Shielding boxes build in Greece (PRISMA SA, Rentron)**

Test setup designed and developed at NCSR "Demokritos"

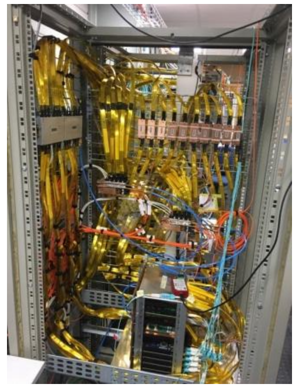






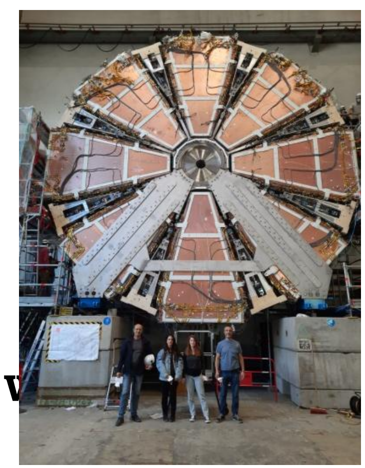
sTGC Trigger Commissioning

Build by Demokritos group the sTGC Trigger Slice system:
One wedge full system for remote development



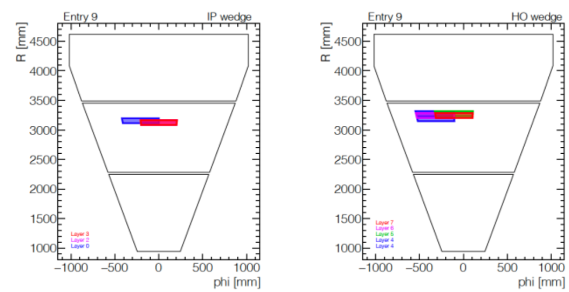
Used extensively during lockdown and for Trigger Commissioning

- **sTGC Trigger Commissioning.** Full responsibility of the Trigger Commissioning of all sectors in B191 and in the ATLAS Cavern for sTGCs



Connectivity tests
Functionality tests
Cosmics Data

Recommissioning at ATLAS



Development of Trigger packages

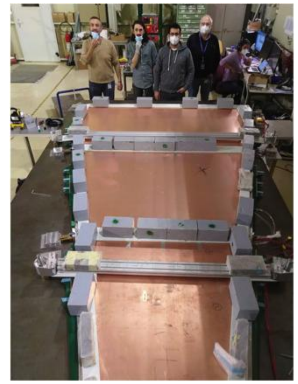
Cosmic muon in sTGC on V

- Fake Sector Logic FPGA design
- ALTI LHC Clock/signals driving package

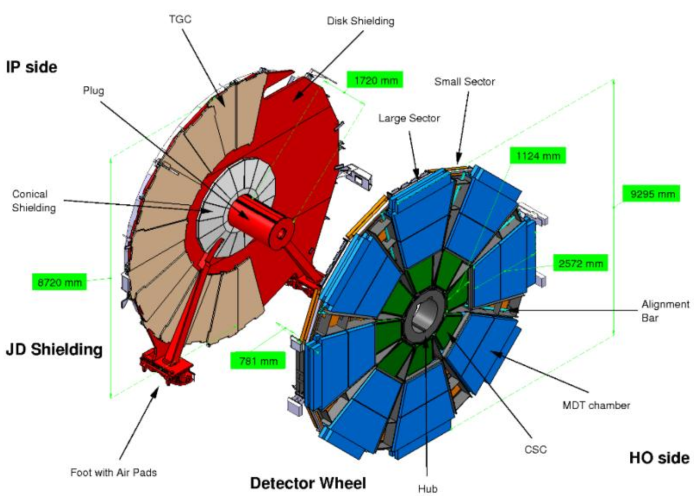
Integration of the sTGCs/Software

Demokritos Contributions (C) and responsibilities (R)

-sTGC Assembly in the Clean room (C)
-Faraday cages (C)
-Cooling system (R)
-Mechanical parts design/build (R)
-Design and build Cooling system for the L1DDC boards (R)



NSW Alignment in Reconstruction



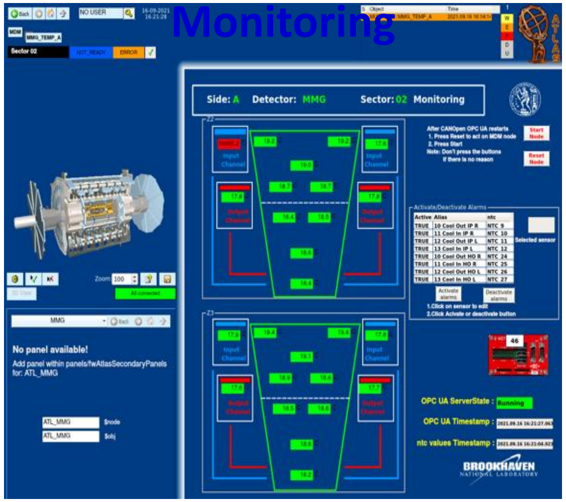
Realistic detector description

- as-built parameters
- Alignment of Stations
- Deformations

Implemented and merged into the official ATLAS s/w.

Development of NSW Detector Control Syste

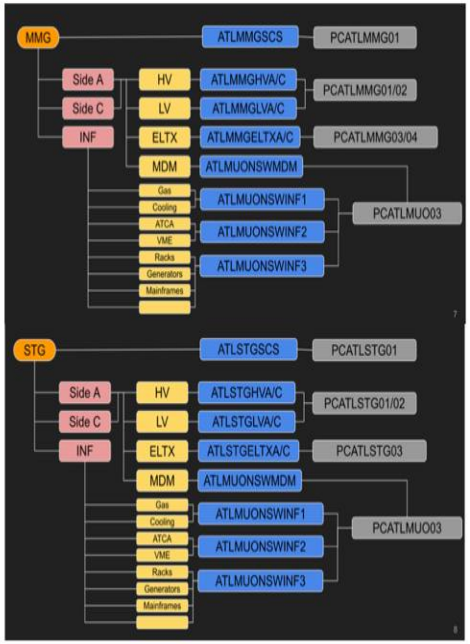
Temperature Monitoring



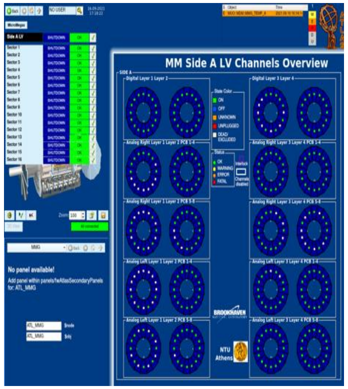
- ATLAS NSW DCS
  - Hardware testing and debugging
  - Connectivity and Overall system validation
  - Coordination by NTUA
- Various WinCCOA projects
  Software Development includes:
  - Power Supply system
  - Electronics Monitoring
  - Temperature and magnetic field monitoring

Electronics Monitoring

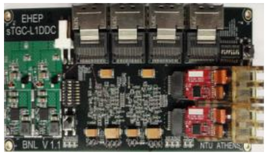
NSW DCS structure



Low Voltage Control



Electronics board Design for Micromegas & sTGC NSW upgrade



Rim-L1DDC prototype-I

Rim-L1DDC prototype-II

L1DDC prototype-I

GPVMM

BBAA

sTGC-L1DDC prototype-III

LVDB prototype-1

sTGC-L1DDC prototype-IV

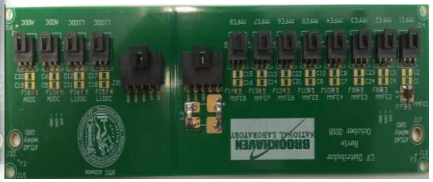
Twinax cable tester

Fanout board V2

Gas tightness station

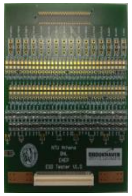
USB-I2C board

LVDB prototype-2



sTGC-L1DDC pre-prod

ESD tester



miniSAS FMC

miniSAS to SMA

MM-L1DDC prototype-II

mu2e prototype-I

MM-L1DDC prototype-III

mu2e prototype-II

MDT 436

MDT 446

MMFE1

MMFE1 WB

MM-L1DDC pre-productio

BBALA

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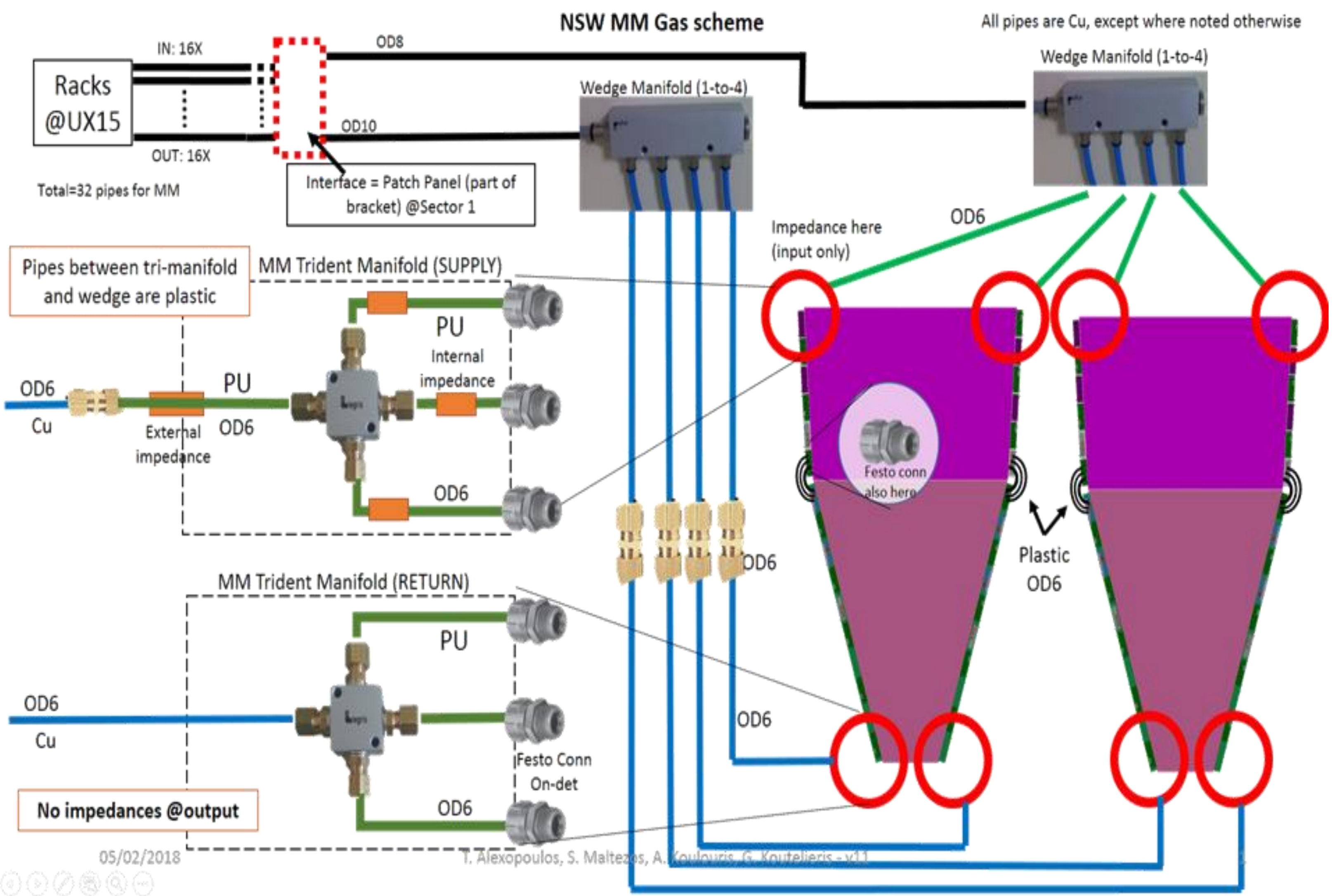
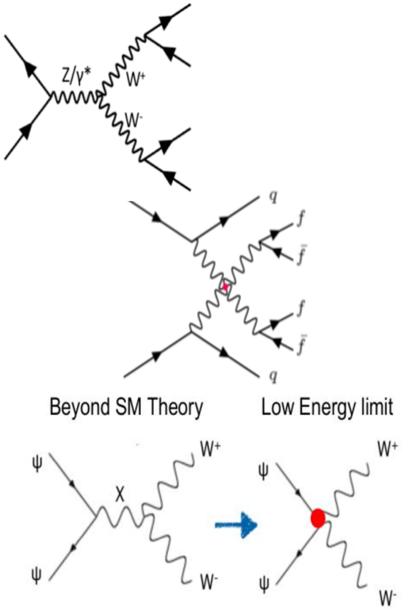
Design of Micromegas NSW Gas System



Physics from ATLAS-Greece. Indicative topics

- Production of 2 Vector Bosons (= W or Z)

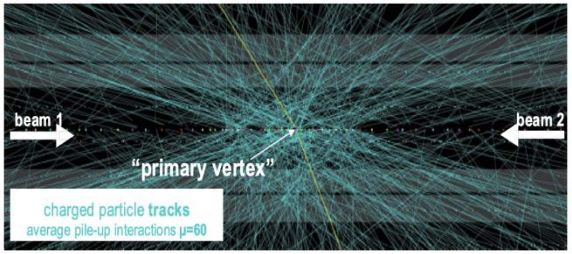


  - Production of WZ → 3 leptons(l) + neutrino(ν), ZZ → 4l or 2l+2ν
    - Inclusive production & limits on anomalous Triple Gauge Couplings
    - Produced with 2 forward jets: Vector Boson Scattering and probing of Quartic Gauge Couplings.
    - Interpretation in the Effective Field Theory (EFT) framework
    - Search for New Resonances decaying to WZ , ZZ

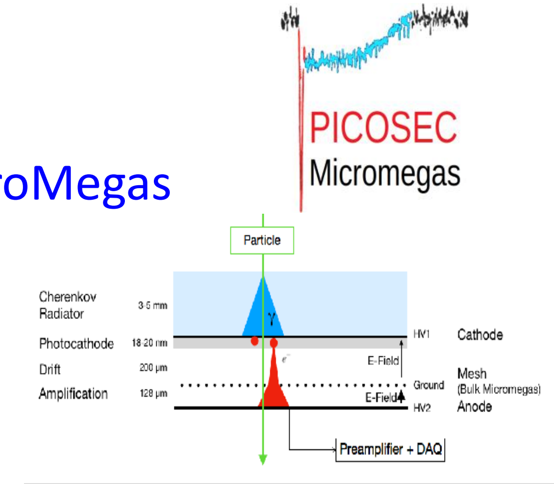
- Higgs production and couplings in H → ZZ channel
  - on-shell & off-shell Higgs production
- Search for new bosons (heavy Z' , W', light Z') and SUSY
- B-physics: J/ψ production, B fragmentation fractions, $B_s \to \mu^+ \mu^-$
- All results available at: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicResults

Other hardware activities

- ATLAS Trigger and offline software : tracking in inner detector and in muon system
  - CPU time to reconstruct all tracks in an event increases dramatically with additional ("pileup") pp vertices.
    - Software and dedicated electronics with FPGAs to do pattern recognition and track -fitting
      - Fast TracKer (FTK) : phase I upgrade
      - Hardware Track Trigger (HTT) : phase II
      - Muon reconstruction software



- R&D on Precise timing devices: PICOSEC MicroMegas
  - Testbeams, analysis, resolution (<25 ps)
  - Physics modelling of the devices



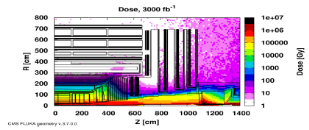
CMS experiment @ CERN

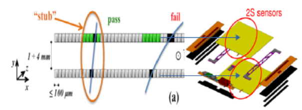
NTUA, NKUA, UOI, NCSR
“Demokritos”

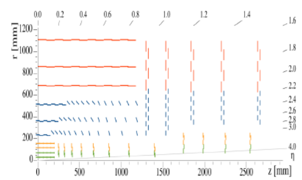
Process quality control (PQC) of silicon sensors for the Phase-2 upgrade of the CMS Tracker

Phase-2 upgrade of CMS Tracker

- Due to high number of pile-up events and radiation levels a major upgrade of the CMS experiment is needed. Three of the most important requirements for the CMS Tracker upgrade are :
  - Radiation Tolerance. ⇒ Flip from p-on-n to n-on-p sensors, Oxygen-rich substrates
  - High Pile up ⇒ Increase granularity.
    - Increased number of sensors
    - Increased segmentation to each sensor.
  - Improve CMS trigger system ⇒ Contribution of CMS Tracker at Level-1 Trigger.
    - Discrimination of low p_T events at module level at bunch crossing rate.
    - Reduce data volume.
    - Keeping the most interesting events for physics studies.
- Outer Tracker:
  - 2S modules Two very closely spaced strip sensors
  - PS modules Two very closely spaced sensors. One with macro-pixels (PS-p) and one with strips (PS-s)
- Inner Tracker:
  - Pixel modules Pixel very thin detectors with two pixel geometries ($50x50$ μm),($100x25$ μm)

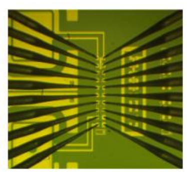


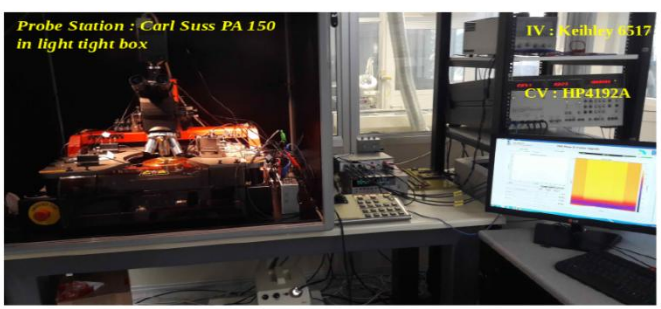




Experimental setup

- Electrical characterization setup consisting of:
  - Probe Station: Karl Suss PA 150
  - CV: HP4092A
  - IV: Keithley 6517A
  - IV: Keithley 2410A
  - The whole setup is controlled with a LabView program
  - A probe card and switching matrix is used for automatization of the measurments on the flute structures





Outer Tracker sensors

Outer Tracker will encompass 200 m^2
Consisting of 24000 sensors
Two different modules with three different sensors

- 2S sensors
  - 6″ wafers
  - n-on-p sensors
  - Float-zone technique
  - Active thickness 290 um
  - AC coupled with Poly-silicon biasing
- PS-s sensors
  - 6″ wafers
  - n-on-p sensors
  - Float-zone technique
  - Active thickness 290 um
  - AC coupled with Poly-silicon biasing
- PS-p sensors
  - 6″ wafers
  - n-on-p sensors
  - Float-zone technique
  - Active thickness 290 um
  - DC coupled
  - Biased with punch-through structures

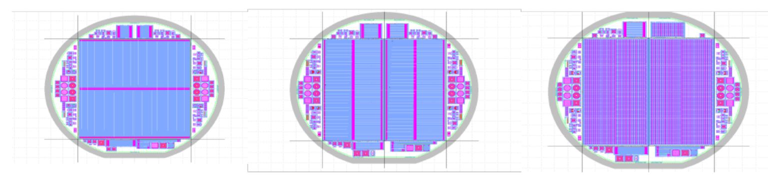
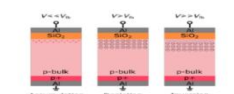
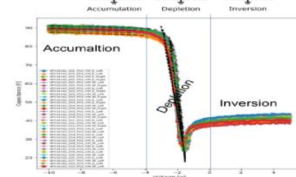


Figure: *Design of the 2S, PS-s and PS-p wafers* [1]

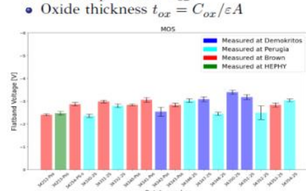
Example of measurements: MOS capacitors

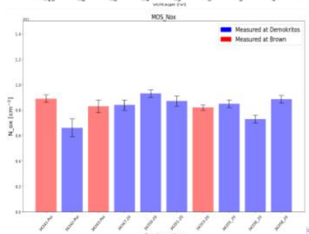
- MOS capacitor is the most useful device in the study of semiconductor surfaces and interfaces.



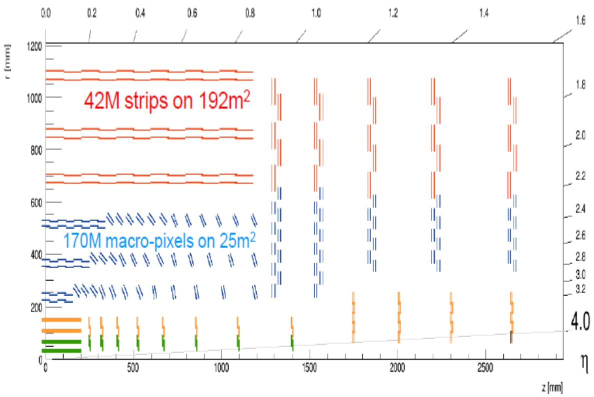


- Parameters measured with this device:
  - Flatband voltage $V_{fb} = \phi_{Al} - \phi_{Si}$
    - Ideal case: $V_{fb} = 0$
    - Non ideal: $V_{fb} \propto N_{ox}$
  - Fixed oxide charge concentration N_{ox}
  - Oxide capacitance C_{ox}
  - Oxide thickness $t_{ox} = C_{ox}/\varepsilon A$





MOS irradiation studies for Phase II CMS Tracker Upgrade and TCAD model



2 types of Outer Tracker:

- 2S (Strip-Strip sensor modules)
- PS (macro-Pixel Strip sensor modules)

2 types of Inner Tracker modules

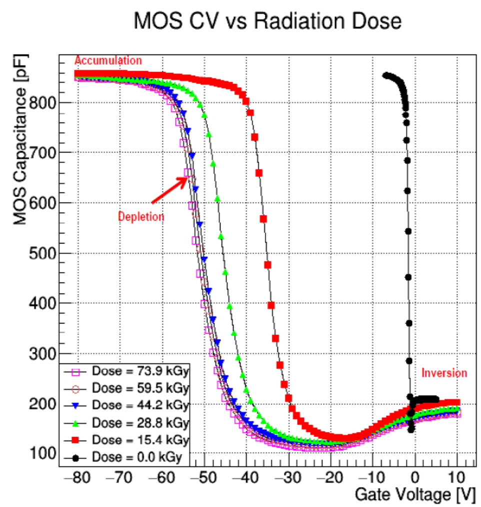
- 2×2 Pixel Chip modules
- 2×1 Pixel Chip modules

Expected Total Dose for various CMS Phase II Tracker Sets

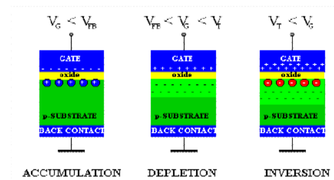
Set	Dose kGy
Low outer	38
Nom. outer	77.5
Max outer	155
Low inner	300
Nom. inner	900
Max inner	1500

1Gy = 100rad

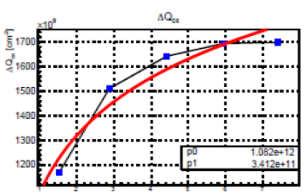
Float zone oxygenated silicon n-in-p MOS test structures: Thinned 240 μm produced by Hamamatsu



- Clear evidence of positive charge induced in the SiO_2 of the MOS structures after exposure to gamma photons: e/h produced by irradiation but since electrons have higher mobility they shift towards surface
- Shift of the flatband voltage (V_{fb}) i.e. the voltage where the MOS behavior changes from accumulation to depletion, to higher negative values since $V_{fb} = \varphi_{Al} - \varphi_{Si}$ and more and more electrons accumulated in Al



Type	Energy (eV)	Band width (eV)	σ_e (cm^2)	σ_h (cm^2)
Donor	$E_V < E_T < E_V + 0.54$	0.54	1.0×10^{-15}	1.0×10^{-16}
Acceptor	$E_C - 0.58 < E_T < E_c$	0.58	1.0×10^{-16}	1.0×10^{-15}

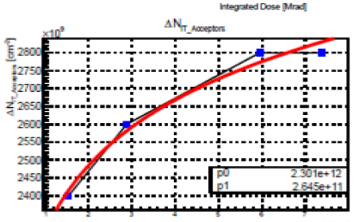


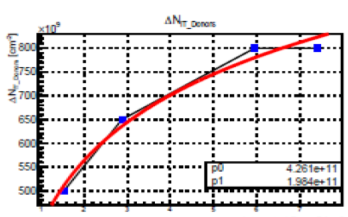
$$\Delta Q_{ox}(x) = 1.08 \cdot 10^{12} + 3.41 \cdot 10^{11} ln(x) \quad [cm^{-2}]$$

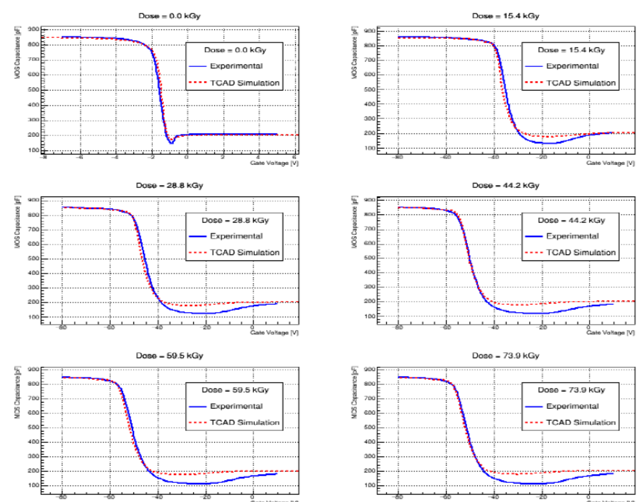
$$\Delta N_{IT_{acc}}(x) = 2.30 \cdot 10^{12} + 2.65 \cdot 10^{11} ln(x) \quad [cm^{-2}]$$

$$\Delta N_{IT_{don}}(x) = 4.26 \cdot 10^{11} + 1.98 \cdot 10^{11} ln(x) \quad [cm^{-2}]$$

x is the dose in Mrad







- The proposed modifications work reasonably well for ^{60}Co γ-ray doses up to 74kGy = 7.4Mrad

DAQ development for the Phase-II Tracker of the CMS experiment

Developed by RD53 Collaboration: 19 Institutes (CMS + ATLAS)
RD53A ROC Chip 65 nm CMOS successful demonstrator – used to develop Sensors, Modules and System

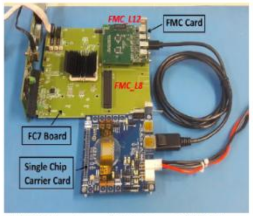
- 20×12 mm² (~½ of final size)
- 3-in-1 different Front-End architectures – accurate review process CMS (& Atlas) made their choice for the final chip *using dedicated DAQ system "µDTC"*

CMS final chip: CROC (submission Mar '21)

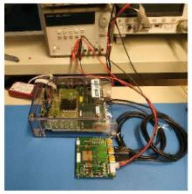
CMS Choice   ATLAS Choice

Phase-1		HL-LHC	
Rate 400 MHz/cm²	x 8	Rate 3.2 GHz/cm²	×60 Bandwidth
L1 rate 100 kHz	x 7.5	L1 rate 750 kHz	
Latency 3.2 µs	x 4	Latency 12.8 µs	×32 Buffers
Radiation ~100 Mrad	x 10	Radiation ~1.2 Grad	

- **Challenging Specifications**
  - Very high bandwidth required to support high data rate from really large number of pixels
- **Multiple Design flavors to support**
  - Different operation modes (Crate or Desktop mode)
  - Several Front-End (FE) object configurations (x16 Single-Chips, x10 Double Modules, x5 Quad Modules)
  - Different link types for communication with FE objects (electrical or optical through lpGBT + VTRx)
  - Different FE objects (RD53A and RD53B so far)



INPP DIL setup with SCC and RD53A on electrical link (Desktop-mode)



INPP DIL setup with SCC and RD53B on electrical link (Desktop-mode)

- The readout and control of the future front-end modules of the CMS Tracker, will be performed by the DAQ, Trigger and Control (DTC) System.
- The µDTC project was established to perform these tasks in the prototyping and production phases.
- Common framework for Outer Tracker (OT) and Inner Tracker (IT) based on FC7 board and IPBus* - this presentation focuses mostly on Inner Tracker implementation (IT-µDTC).

Software Suite
OT: INFL
IT: Milano + Demokritos (*A.Papadopoulos*)

+

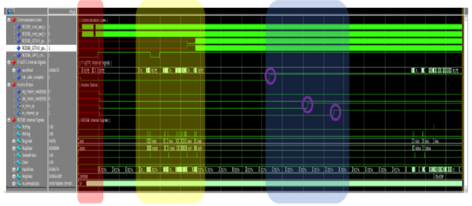
Firmware Suite
OT: DESY
IT: Demokritos (*I.Kazas*)

+

Hardware

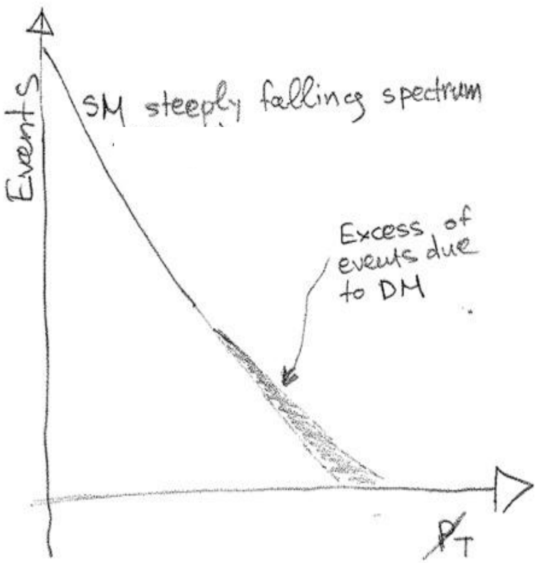
FC7 Board,

- **Preparing DAQ to provide support for the next version of RD53 ASIC (CROC)**
  - ATLAS flavor of the chip (RD53B) is already fabricated → very similar to CMS flavor
  - First tests with RD53B already successful
- **IT-µDTC will be used for wafer tests of the CROC**
  - Everything has to be ready and fully debugged *before* the chip arrives
  - Developed common simulation framework and testbench in Questa to test the **whole** readout chain (software + firmware + RTL of the ASIC)



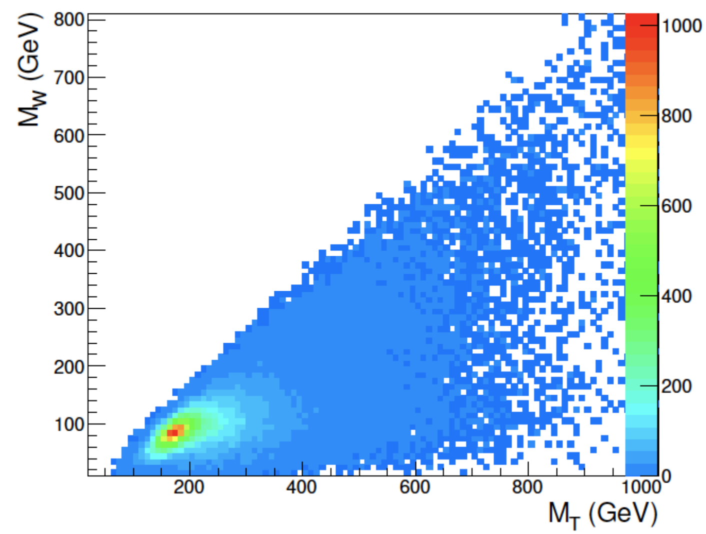
Initialize CDR circuits
Initialize uplink & downlink
Communication Established
- DDR3 Calibration done
- Aurora Lane/Channel up

Discovery with missing energy difficult to be established (tail of a rapidly falling distribution).



Even if established what can we say about the model?

Instead perform bump hunting by reconstructing events with 2 invisible particles



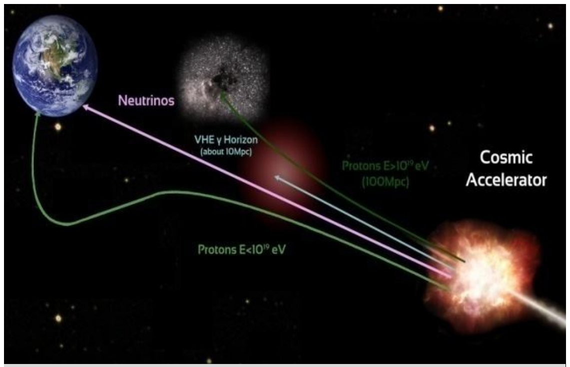
G. Anagnostou, JHEP07 (2021) 112

KM3NeT

NCSR “Demokritos”

KM3NeT: Science Objectives

ARCA:
Exploring the High Energy Universe



ν: unique messengers

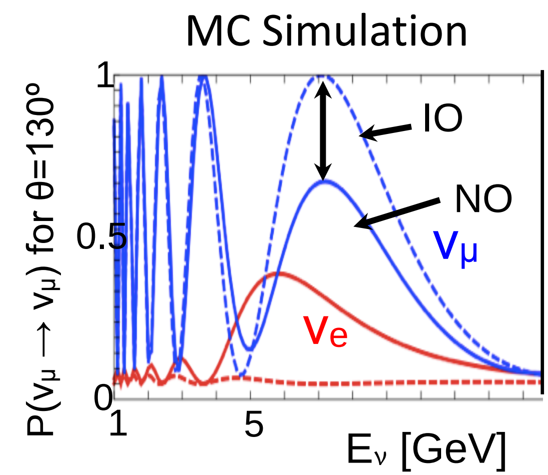
ARCA: Astroparticle Research in the Abyss

- observe high energy (>TeV energy regime) neutrinos from astrophysical sources
- measure the diffuse flux of astrophysical neutrinos

ORCA: Oscillation Research in the Abyss

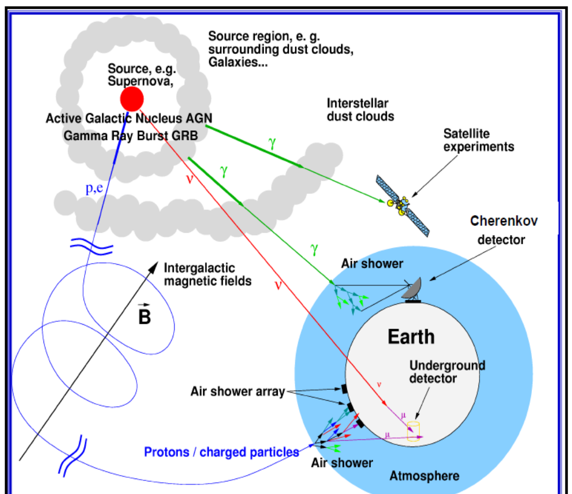
- study atmospheric neutrino (~ few GeV energy regime) oscillations – oscillation pattern distorted by Earth matter effects

ORCA:
determine the neutrino mass ordering



Four messengers for the high energy phenomena in the Universe:

- ❑ Photons
- ❑ Cosmic rays
- ❑ Neutrinos
- ❑ Gravitational waves



Multi-messenger astronomy

- **see deeper into astrophysical sources**
- **understand the production mechanism of γ-rays**
- **Learn what is the origin of cosmic rays**

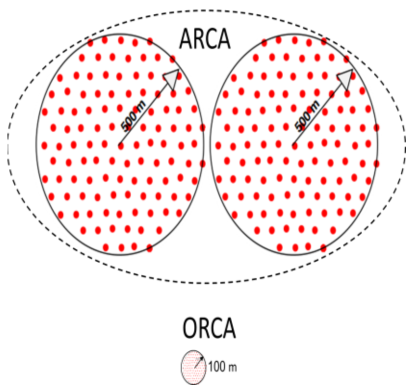
KM3NeT: Technology

ARCA: Astroparticle Research with Cosmics in the Abyss

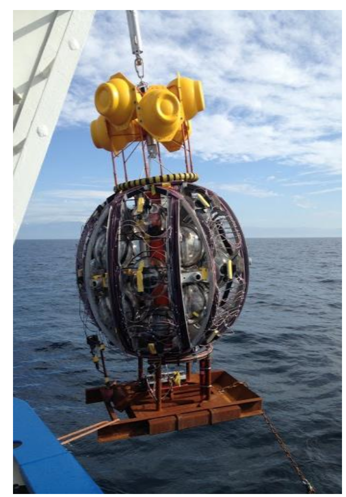
- ✓ KM3NeT-It site; 3500 m; Capo Passero, Italy.
- ✓ Astrophysical Neutrinos (TeV-PeV Energies).
- ✓ 2 blocks of 115 DUs each: Sparsely instrumented.

ORCA: Oscillations Research with Cosmics in the Abyss

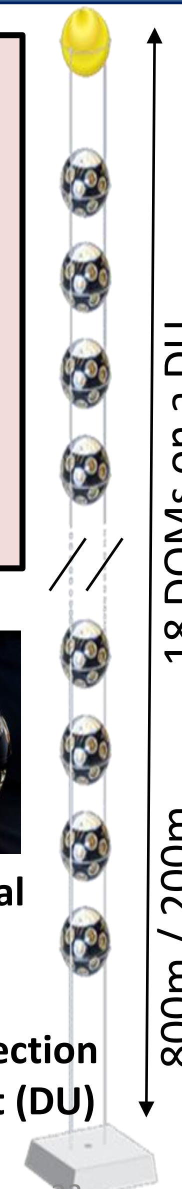
- ✓ KM3NeT-Fr site; 2475 m; Toulon, France.
- ✓ Atmospheric neutrinos (GeV Energies).
- ✓ 1 block of 115 DUs : More densely instrumented.



Launcher of DOMs



Digital Optical Module (DOM)

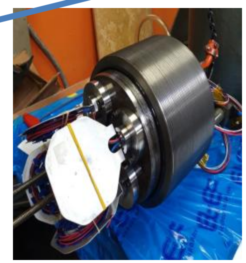


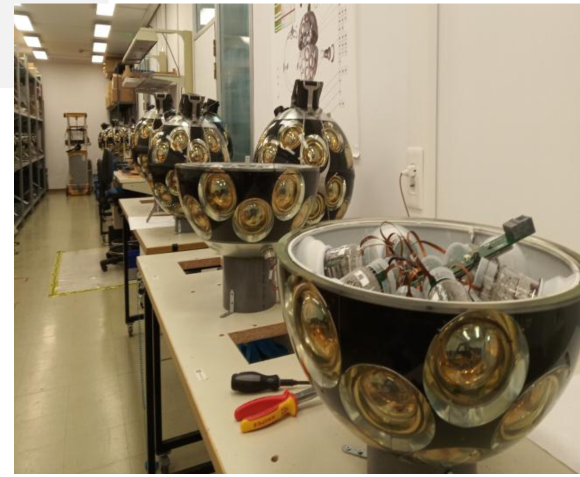
Detection Unit (DU)

INPP @ KM3NeT: Technical Activities, t spheric neutrino candidates from ARCA & ORCA

INPP@KM3NeT: C. Markou, E. Tzamariudaki, E. Drakopoulou, C. Bagatelas, V. Tsagli, A. Vougioukas, A. Sinopoulou, D. Stavropoulos, V. Tsourapis , G. Zarpapis

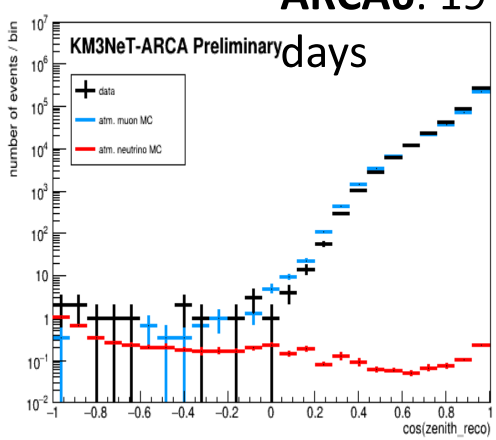
- **Construction**
  - DOM integration
  - Calibration of electronics and sensors
  - High pressure testing of deep sea components - single point failure items

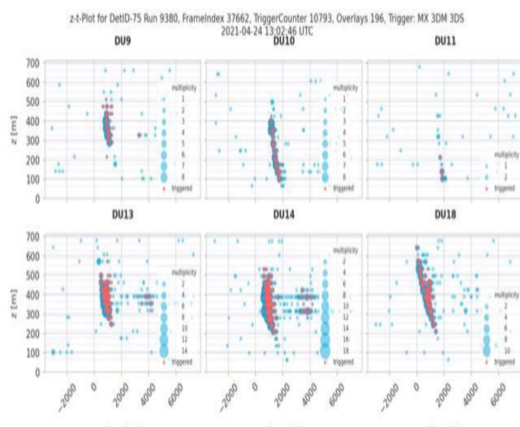


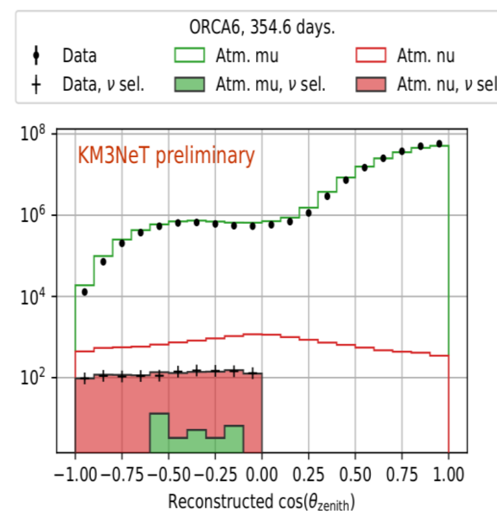


- **Atmospheric neutrinos from the ARCA and ORCA data**

ARCA6: 19 days

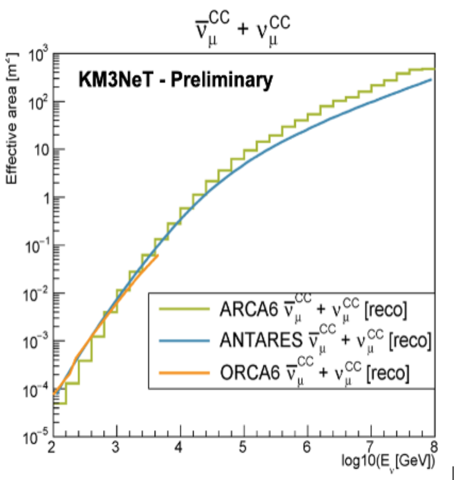






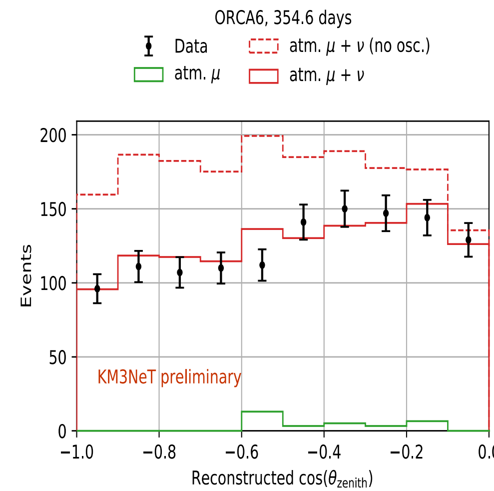
KM3NeT: Status & short term planning

12 KM3NeT Detection Units now



ARCA6 effective area larger than ANTARES!
By the end of 2021 ARCA & ORCA will have doubled the number of DUs

ORCA6 neutrino oscillations



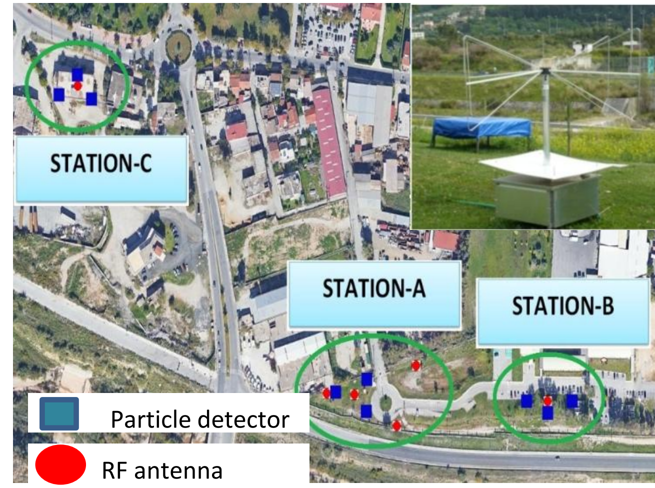
- **ARCA**
  - Sea campaign currently ongoing: Deployment of 5 DUs.
  - Spring 2022: integrate and deploy 12 more DUs, 1 Junction Box, 1 Calibration Base.
- **ORCA**
  - Fall 2021: deployment of 7 additional DUs + 1 Calibration Unit.
  - Spring 2022: integrate and deploy 7 more DUs.

ASTRONEU

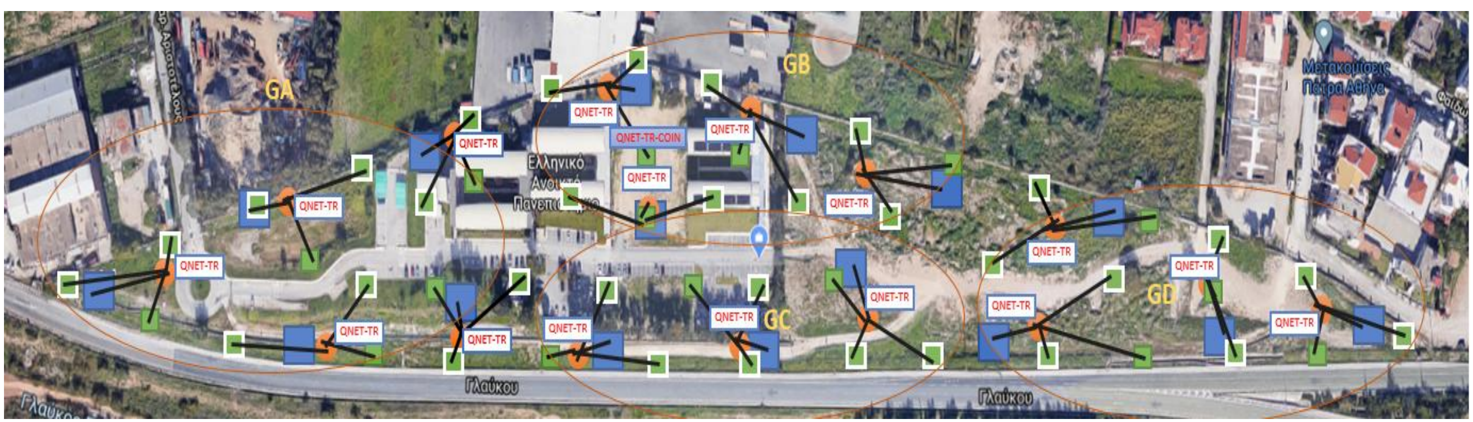
Aegean University, HOU

ASTRONEU

Astroneu is a hybrid Extensive Air Shower detection array, which is deployed at the Hellenic Open University (HOU) campus on the outskirts of Patras in western Greece. The array was designed, constructed and operated by the Physics Laboratory of HOU.
Astroneu offers the means of conducting R&D in the field of radio detection of high energy Cosmic Rays. In addition, it provides the framework for the development of novel Detector Instrumentation, as well as for Educational activities and Outreach. In the initial phase of operation (2014-2020) the array consisted of 9 scintillator detector modules and 6 RF antennas arranged in 3 autonomous detection stations.



Currently, a new array is under construction comprising 16 particle detector stations and 32 RF antennas. The particle detectors as well as the RF antennas of this system are designed and constructed by the Physics Laboratory of HOU. The new DAQ system is based on VME and NIM modules providing full waveform recording from both particle detectors and RF antennas. The array is expected to be in operation by the end of 2022.

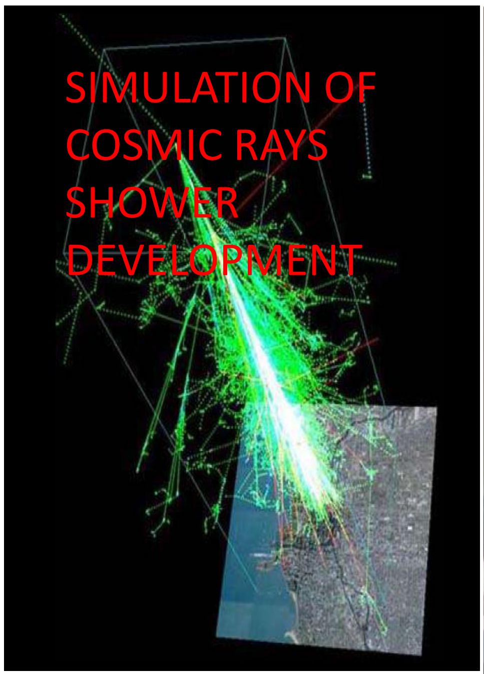


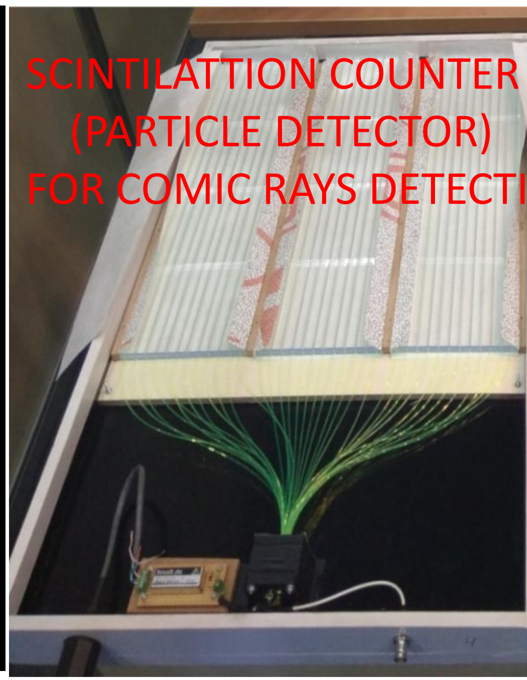
AEGEAN UNIVERSITY
SCHOOL OF ENGINEERIG
DEPARTMENT OF FINANCIAL AND MANAGEMENT ENGINEERING

APPLIED PHYSICS RESEARCH LABORATORY

ASTROPARTICLE PHYSICS

COSMIC RAYS RADIO FREQUENCY DETECTION (ASTRONEU)





Up to now ...

- Confirmation of Cosmic Rays RF detection in environment with strong electromagnetic noise and with small scale hybrid arrays.
- Reconstruction of the shower axis direction using the timing info from the RF antennas.
- The RF pulse from single antenna combined with MS simulations might give access to the cosmic ray arrival direction.
- Reconstructing core, energy, X_{max} and primary mass is feasible with 4 RF antennas and simulations.

Future Plans

- Search for low frequency pulses (1-10MHz) from showers.
- Efforts to build a new low cost RF antenna.
- Expand the Astroneu array with more particle detectors and RF antennas.

Cosmic Rays Radio Frequency Detection (ASTRONEU)

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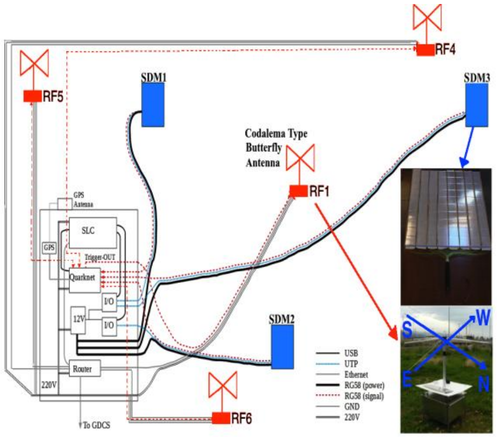
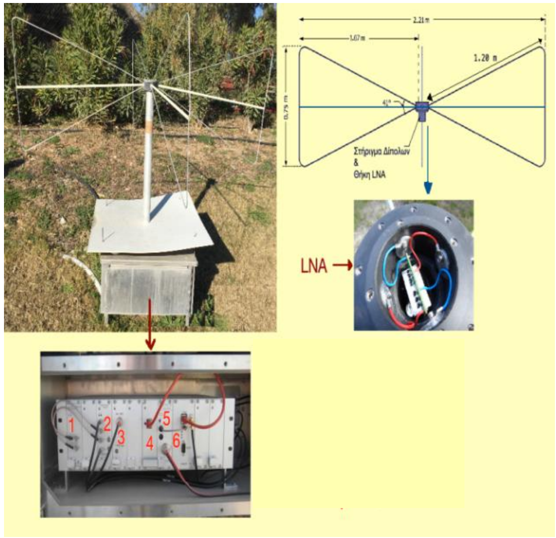
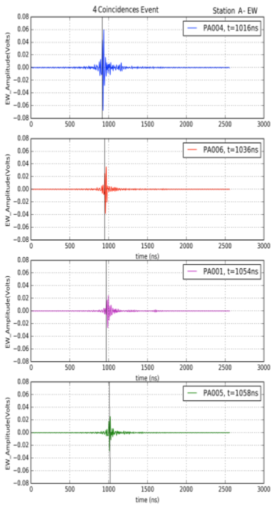
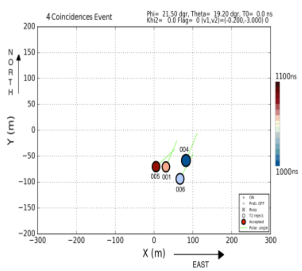


Cosmic Rays detection with the help of the hybrid station-A of the ASTRONEU telescope, consisting of 3 particle detectors (scintillation counters – SDM) and 4 RF antennas

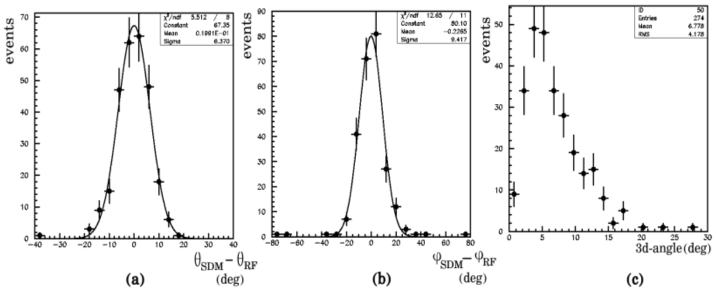


RF antenna

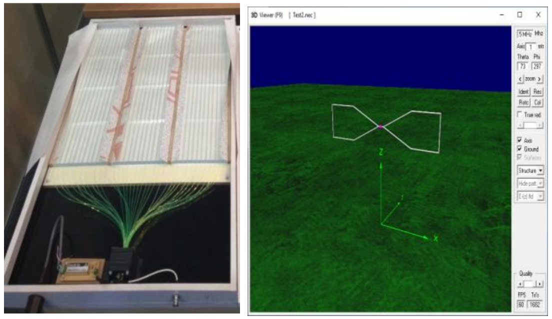




Reconstruction of the cosmic shower axis direction using the arrival time of the pulses in the 4 RF antennas



Reconstruction of the cosmic shower axis direction using event spectra data in accordance with those of the developed SDM response model.



Design of the new RF antennas used in the new autonomous detection station of the Astroneu telescope (3SDM-nRF)

MoEDAL

King’s College London (KCL),
IFIC – CSIC / University of
Valencia

MoEDAL – Monopole & Exotics Detector At LHC

LHC's first dedicated *search* experiment
(approved 2010)

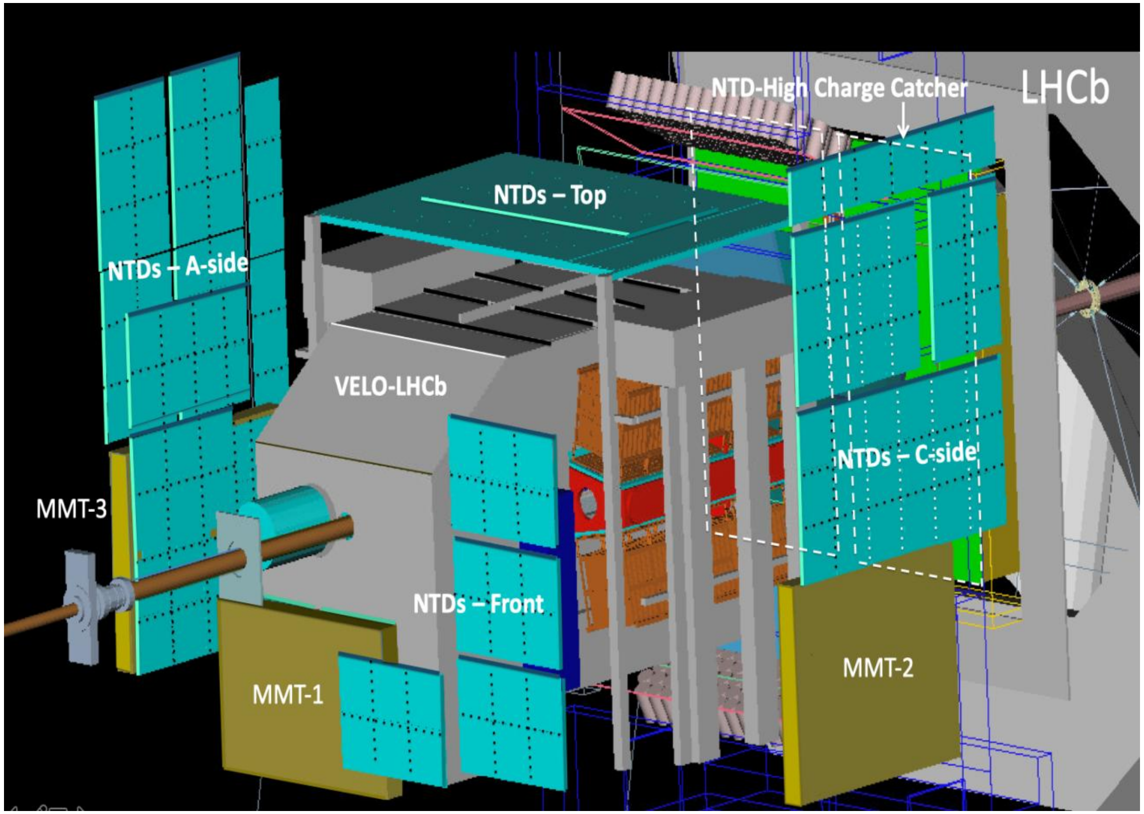
- King's College London (KCL), University of London, UK
  - N. E. Mavromatos* : **MoEDAL Physics Coordinator** & KCL Team Leader
- IFIC – CSIC / University of Valencia, Spain
  - V. A. Mitsou: **Chair of the MoEDAL Collaboration Board**, **MoEDAL Analysis Coordinator** & IFIC Team Leader

Optimised for anomalously ionising (meta)stable particles

- **Highly ionising particles** – magnetic & electric charges
  - magnetic monopoles
  - SUSY sleptons & R-hadrons
  - doubly charged Higgs
  - ν mass models
  - KK extra dimensions
  - D matter
  - black-hole remnants
- **Very low ionisation ➜ MAPP**
  - *fractional* electric charges
  - displaced vertices from *neutral* particles

MoEDAL

Baseline MoEDAL detector



DETECTOR SYSTEMS

① Low-threshold NTD (**LT-NTD**) array
  - z/β > ~5-10

② Very High Charge Catcher NTD (**HCC-NTD**) array
  - z/β > ~50

③ **TimePix** radiation background monitor

④ Monopole Trapping detector (**MMT**) – aluminum bars

MoEDAL physics program
Int. J. Mod. Phys. A29 (2014) 1430050

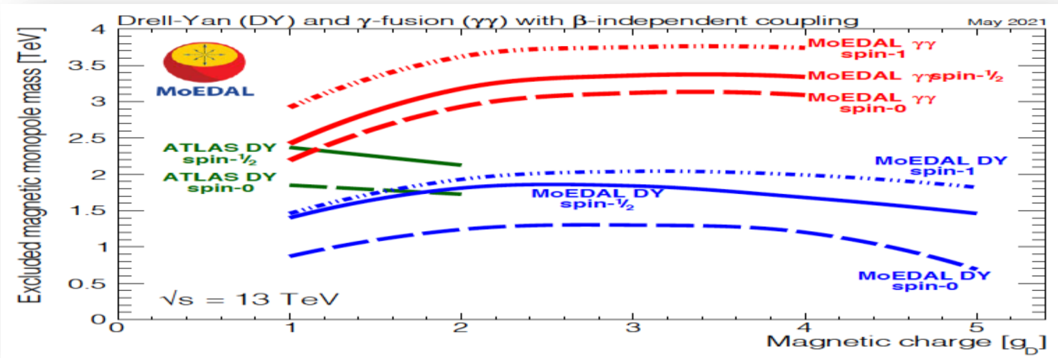
- Mostly **passive detectors**; no trigger; no readout
- Permanent physical record of new physics
- No SM physics backgrounds

MoEDAL RESULTS

1) Magnetic monopole limits

MoEDAL has set the world-best collider limits for **|g| > 2 g_D**

2) Monopole results: Drell-Yan & γγ-fusion



Extended reach by combining Drell-Yan and γ-fusion production processes

3) First search for Dyons in colliders

- Dyons possess both electric and magnetic charge
- Mass limits **750-1910 GeV** were set for dyons with
  - up to 5 Dirac magnetic charges (**5g_D**)
  - electric charge **1e – 200e**

4)Monopole search via Schwinger mechanism

- First limits based on non-perturbative monopole production cross section
- First direct search sensitive to monopoles that are not point-like

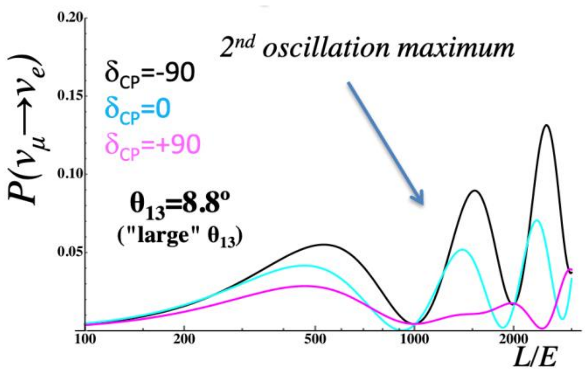
ESSnuSB

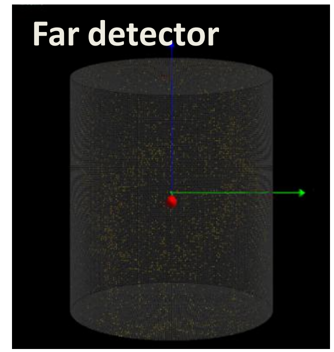
NCSR “DEMOKRITOS”

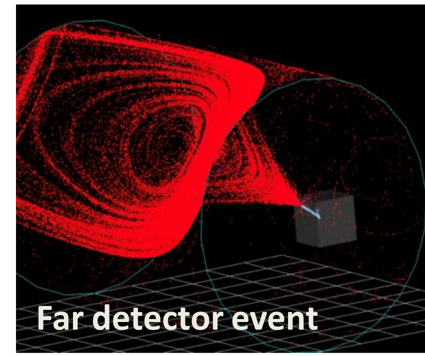
ESS ν Super Beam (ESSnuSB) project

Funded by the Horizon 2020 Framework Programme of the European Union

A Conceptual Design Study for a second generation neutrino experiment to precisely measure the CP violation at the 2nd Oscillation Neutrino maximum with a High Intensity neutrino beam at ESS and a Near and Far detector complex. 15 Institutes from 11 countries are participating in the ESSνSB project.

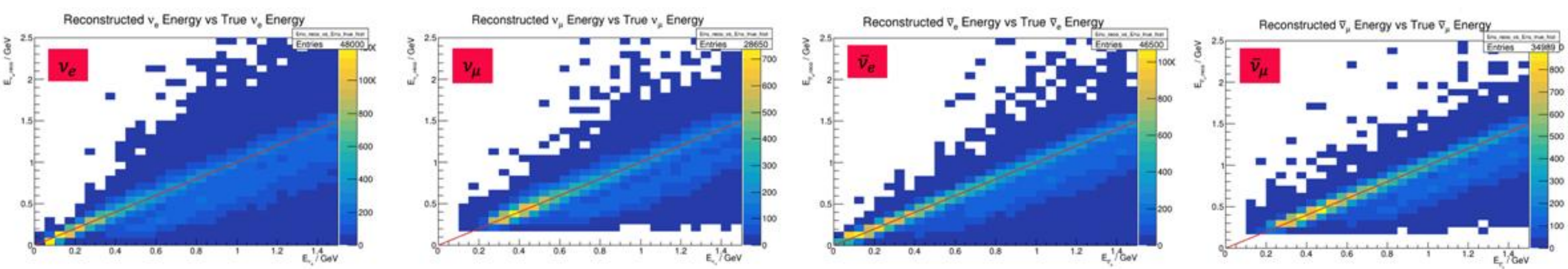






The NCSR "Demokritos" group works mainly on the design of the Far Cherenkov detector, which consists of two upright cylinders of 78m x 78m dimensions each, of a total of ~540 ktons water mass and a 30% 20" phototube coverage.

Migration matrices: Reconstructed vs True Neutrino (or Antineutrino) Energy



The goal is to measure the neutrino-antinuetrino oscillation asymmetry:

$$\mathcal{A} = \frac{P_{\nu_\mu \to \nu_e} - P_{\bar{\nu}_\mu \to \bar{\nu}_e}}{P_{\nu_\mu \to \nu_e} + P_{\bar{\nu}_\mu \to \bar{\nu}_e}}$$

More information at: http://essnusb.eu/
Also search YouTube for ESSnuSB videos.

Theory Activities

UoA, UoI, AUTH, NCSR “DEMOKRITOS”

Basic activities

❖Standard Model (SM) Physics and higher order quantum corrections calculations related to LHC experiments.

❖Beyond Standard Model (BSM) physics stydies based on Supesymmetry and Supergravity. String theories stydies.

❖Study of the Ads / CFT correspondence between gravity and gauge theories. Analysis of the effects

❖of this correspondence on problems with black holes and the information paradox.

❖Study of BSM cosmological effects on Dark Matter, Dark Energy and various models of cosmic inflation.

❖Phenomenology for accelerator experiments based on new Physics beyond SM.

Thank you