## Who am I?

### Mauro Belgiovine

- Computer Science Degree (University of Bologna)
- Assignee of Studentship at INFN (Bologna)

Interests: Programming, Open Source, Electric Guitars, Music Production

# What I'm doing at INFN?

#### GPGPU/Heterogeneous computing:

- Programming with C/C++ and both CUDA and OpenCL frameworks (floatMatrix)
- Modified version of clMAGMA 1.0 library (multi-GPU support, dynamic environment/devices initialization, cross-device code portability)

Just started working with people from LHCb and ATLAS for integrating
 GPUs in such experiments

PCle readout and event-building

36. × 3.2 = 115.2 Gb/s

GBT optical links

PCle Gen3 provides 8 Gb/s per lane
×16 lanes → 128 Gb/s

FEWORE Building Switch

PCle40 readout board to be plugged to the event builder server motherboard through x16 PCle-3 edge connectors.

~ 36 GBT driven optical links

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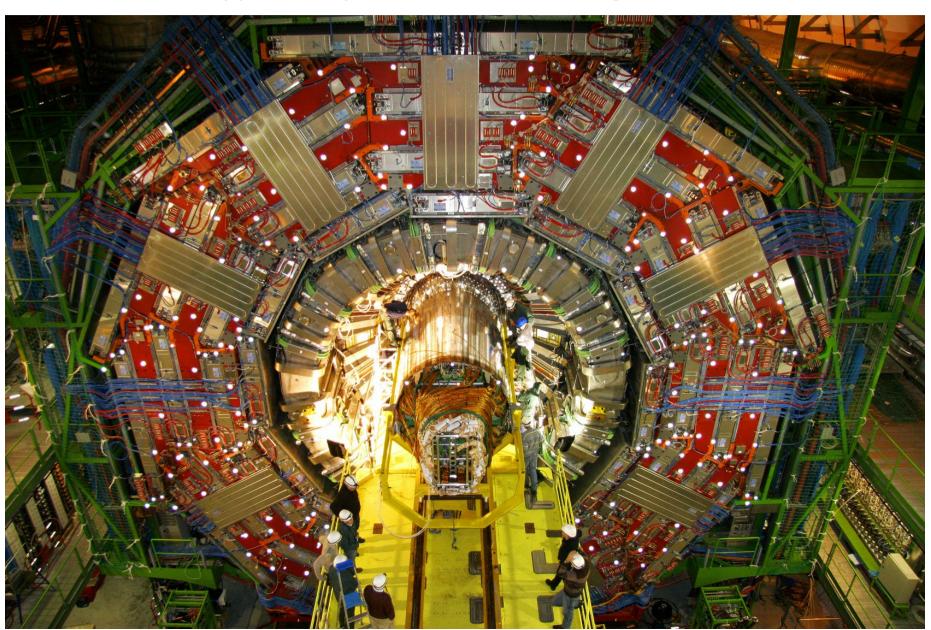
~ 36 GBT driven optical links

# Why I'm here?

I'm interested in (more) efficient programming, large scale / distributed applications, heterogeneous computing and learning better techniques and knowledge in programming with CUDA / OpenCL.

# Giuseppe @ CMS

Giuseppe Codispoti, Università di Bologna and INFN

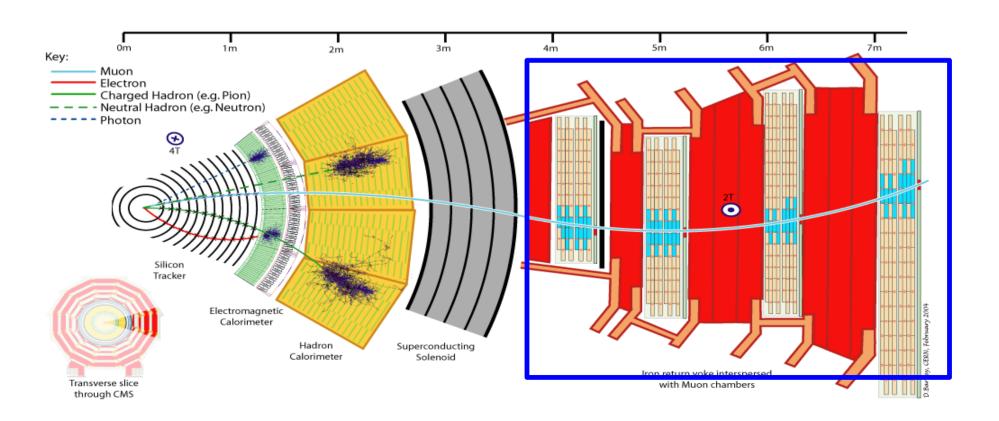


## My Story

- High energy physics in LHC experiments: CMS
  - Physics analysis:
    - Higgs haunting (H->ZZ->llqq)
    - W helicity in top quark semi-leptonic decay
    - Top quark mass in all hadronic channel
  - Computing:
    - Tools for analysis and Monte Carlo job submission to Grid and local batch systems
      - user oriented job submission and tracking for analysis
      - automatic job submission and tracking for MC production
  - Detector and trigger:
    - Control software for Drift Tubes sub-detector readout and trigger
    - Data Quality Monitoring
    - Studies for the upcoming upgrade

# Study new algorithms for Drift Tubes trigger track finding

- Deeply study existing implementation of the Level-1 muon trigger
- Combine info with other sub-detectors for more efficient trigger
  - Right now each muon sub-detector has its own trigger chain and "best" muons are selected are the last trigger step



## Slow control for DT hardware (upgrade oriented)

- Implement, maintain, improve current software architecture
  - Make expert tools communicate with official framework(s)
- Implement slow control for new hardware

RU/BU DAQ A sketch of the existing DAQ FED VME CHIE software infrastructure, still with a few missing FM pieces... Logger Trig DB Client DCS CCB Server

# Simone Coscetti

- \* INFN Pisa
- \* Ph.D. School of Information Engineering Univeristà di Pisa
- Master's degree in Physics Univeristà di Pisa
  - W to tau nu decay in CMS
- Current Activities:
  - ALEPH Computing Environment and Analysis preservation (DPHEP);
  - User support at T2\_IT\_PISA (CMS Collaboration).

# ALEPH analysis preservation

- Data collected still has physics potential with new theoretical model emerging.
- \* This is an attempt to revive and preserve the ALEPH Computing Environment:
  - not only the preservation of the data files
  - \* but of the full environment a physicist would need to perform brand new analysis.
- \* The whole analysis chain has been reproduced:
  - ready for interactive usage;
  - software components can be modified;
  - interactive and batch processing are possible.

# Future Activity

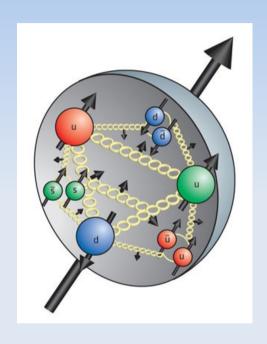
- Lattice QCD with staggered fermions on GPUs using NVIDIA's CUDA platform
  - \* this is the main reason why I am attending this school

## ESC13



# J. Osvaldo Gonzalez H. INFN Torino

## Interests



Hadron Tomography.

### More specifically...

- Generalized Parton Distributions (GPDs).
- Transverse Momentum-Dependent Distributions (TMDs).
   (Current Work)

## Research

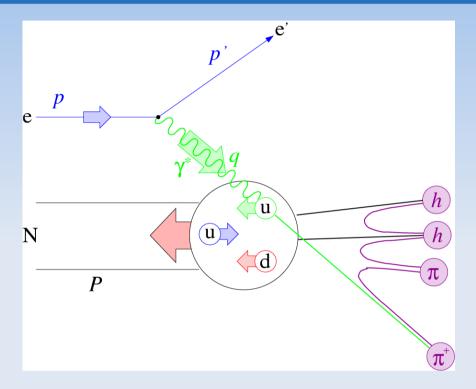


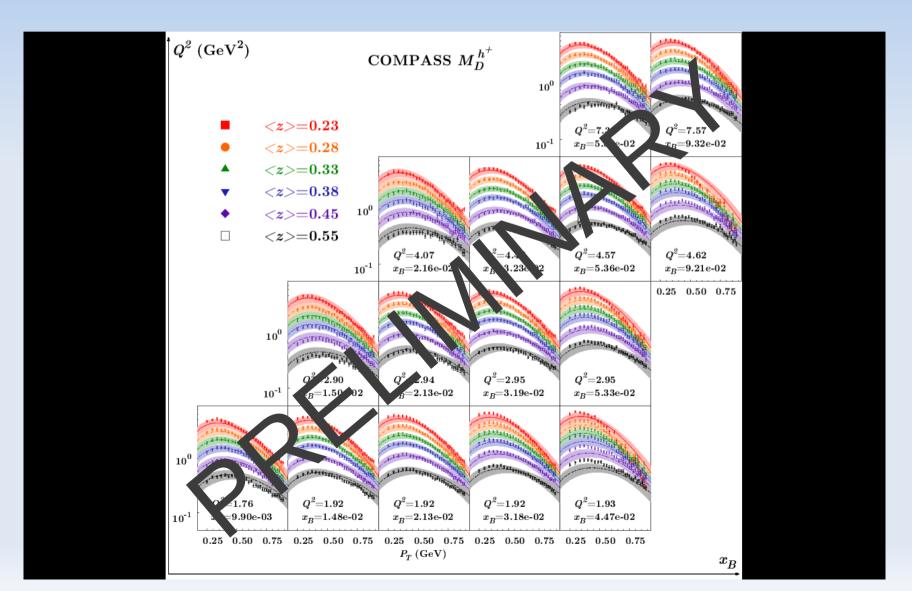
Image taken from: Burkardt, M. et al. Rept.Prog.Phys. 73 (2010) 016201

- Extraction of TMDs from Semi-Inclusive Deep Inelastic Scattering.
- •New multidimensional data from HERMES and COMPASS.
- Theoretical developments.

An update on previously extracted TMDs is essential.

## Research

Our group: M. Anselmino, M. Boglione, S. Melis, J.O. Gonzalez H. (Torino) In Collaboration with: A. Prokudin (JLab)







#### European School of Computation 2013

Hasib Ahmed

University of Oklahoma, USA

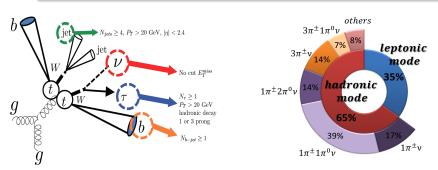
November 22, 2013



#### Analysis



#### Measurement of cross section $t\bar{t} \to \tau_{had} + jets$



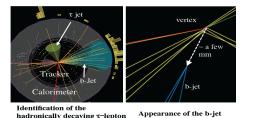
- Topology consists of 10% of  $t\bar{t}$  events
- Cut based analysis
- Multivariate analysis

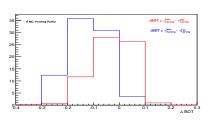


#### Analysis

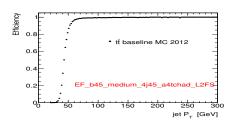
### A A

#### Hadronic $\tau$ identification





#### b-jet trigger Scale Factors



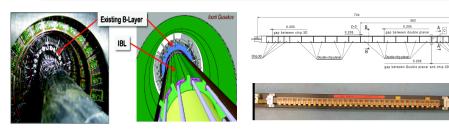
- $\bullet$  Trigger is not efficient till 60 GeV
- Jet trigger scale factor
- b-tagging scale factor



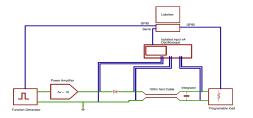
#### Hardware



#### Insertable B layer: 4th layer of Pixel detector



#### Pulsed Powering scheme in particle detectors: Run 3



- Conventionally DC powering scheme
- Merging new technology with the old one is a big powering challenge

### **LUCIA MORGANTI**

**CNAF** - National center for R&D into the field of IT applied to HE experiments

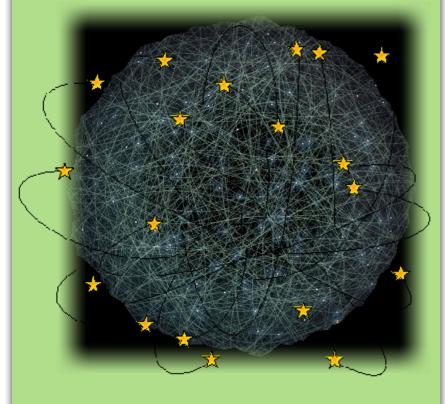


#### ME

Background: PhD in Astrophysics @



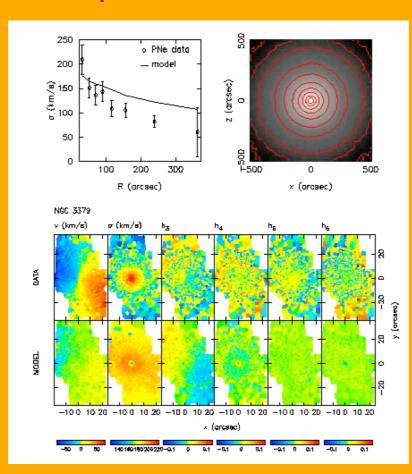




**Dynamics of elliptical galaxies:** orbits of stars, dark matter haloes

#### **COMPUTING**

Made-to-measure dynamical models of galaxies with the parallel code **NMAGIC** 



Modelling a variety of observational data by training a system of particles

Morganti L. & Gerhard, O. 2012 Morganti et al 2013

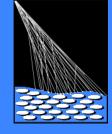
#### **EXPERIMENT SUPPORT**

for astroparticle experiments

@ CNAF





















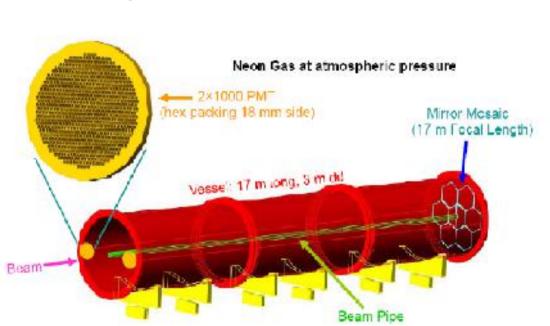


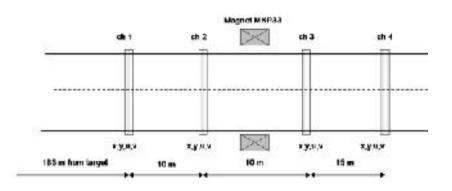
problems with distributed
 computing, storage, data transfer
 setting up the computing
 environment

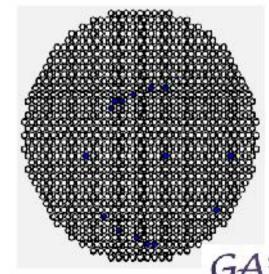
## Parallel Trigger algorithm for particle tracking

### NA62 experiment at CERN SPS

- GPU for level L1 trigger:
  - Magnetic spectrometer composed by 4 straw chambers (1792 straw each chambers)
- GPU for level L0 trigger:
  - RICH ring recostruction







## Tracker pattern recognition

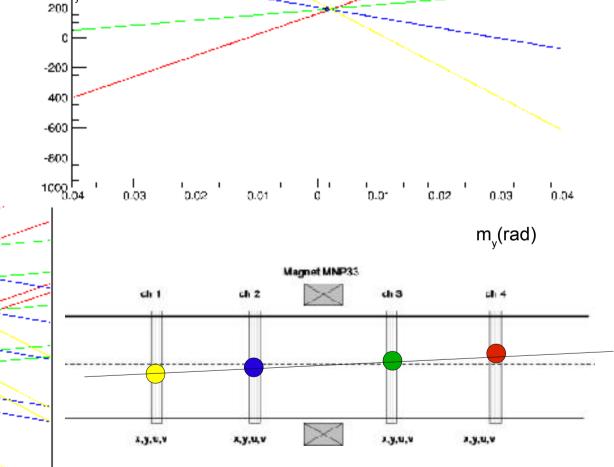
800

600

400

(mm)

- Two-dimesional Hought trasform
  - Points (y,z) -> sheaf of straight lines (m<sub>v</sub>,q<sub>v</sub>)
  - Track is the intersection of the straight lines

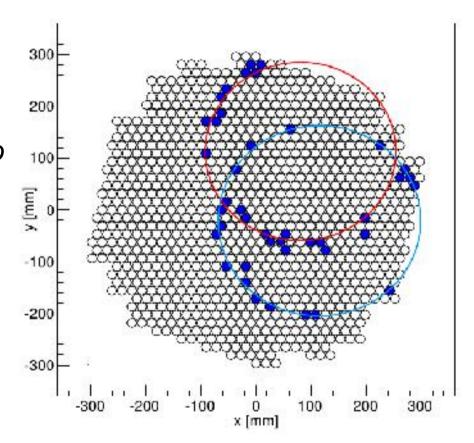


Jacopo Pinzino

## **RICH Trigger Algorithm**

 Ptolemy's theorema fot pattern recognition ⇒ For a cyclic quadrilateral, the product of the measures of its diagonals is equal to the sum of the products of the measures of the pairs of the opposite sides

mathematical fit



Esecution time: ~ 1µs per event in packet of 256 events

# Michele Pozzato ESC - 2013

Bertinoro 2013/10/22

#### **OPERA** experiment

long baseline neutrino experiment located at LNGS.

- → put in operation of the computing infrastructure needed to analyze the OPERA data.
  - → Microsoft Active Directory domain;
  - → Computing cluster based on a continuous access to an Oracle DB.
- → development of the OPERA MC official software (ROOT environment).

### **NESSiE** experiment

Proposal for a short baseline neutrino experiment @ CERN

- → Development of a tracking system based on scintillator bars
  - → DAQ development with VME (test purpose)

## Kamakura Alexandre Telnov Corporation

### **Background in HEP**

- BSc (1995) and PhD (2003) in Experimental High Energy Physics
- BaBar experiment: full-time in 1995-2009
  - First big science experiment to adopt C++ (decision in early 1994)
- Roles in BaBar:
  - ~50% data analysis
    - ~25% develop "user analysis code" in C++, PAW and ROOT
    - ~25% data analysis proper: analysis, review, publication
      - Most important: Observation of *CP* violation in  $B^0 \to K^+\pi^-$ ,  $B^0 \to \pi^+\pi^-$
  - ~50% collaboration service
    - ~20% design, construction, commissioning
    - ~5% operation, review of other people's work
    - ~25% computing, including leading roles in
      - Solaris farm infrastructure: diskless client (1998)
      - Develop  $K_S \to \pi^+\pi^-$  reconstruction efficiency calibration framework (2003)
      - Muon subsystem software redesign to accommodate new hardware (2004-05)
      - Develop track-level dE/dx calibration framework (2006-2007)
      - Particle ID selectors based on boosted decision trees (2007-08)
      - Valgrind (memcheck/cachegrind/callgrind) BaBar Sim+Reco (2007)
- In other words, ~40% of time doing C++ (or ROOT) code development.



# Kamakura Corporation Alexandre Telnov

### Since 2009: Kamakura Risk Manager

- Software for enterprise-wide financial risk management
  - Banks
  - Insurance companies
  - Retirement funds
  - Government agencies
- Development started in 1990, in C++ from the very beginning (!)
- First release in 1993
- Code constantly updated and expanded to follow state-of-the-art in Risk Management — and state-of-the-art in computer science:
  - Native C++, solid modularity and OO design, fully multithreaded

#### Typical questions of Risk Management:

- Value at Risk: given a portfolio of bonds, stocks, options, etc., how much money are we risking at x% C.L. at time t?
- Risk Attribution: how much of that risk is due to each individual instrument in my portfolio?

## Kamakura Corporation Alexandre Telnov

### Performance challenges

- Monte Carlo simulation, typically O(1000) O(100,000) scenarios
- O(10-100) risk factors drive valuation (e.g., oil price, exchange rates)
- Number of instruments: can easily be O(1,000,000)
- Simulation often needs to be redone overnight, each night
- Scenario simulation is "embarrassingly parallel" but scenario sorting and risk attribution is a serial process that needs to be done at the end.

#### Therefore:

- Hundreds of CPU cores often needed to meet time requirements
  - A dedicated farm or a shared farm?
  - Fair-share batch queue system or dynamic allocation of resources?
- Datasets are often in the O(1 TB) range  $\rightarrow$  DB disk I/O challenge

#### Potential R&D areas:

- MPI (and variations) to achieve dynamic allocation of computing resources
- GPU for faster valuation (hard because control flow is exceedingly complex)

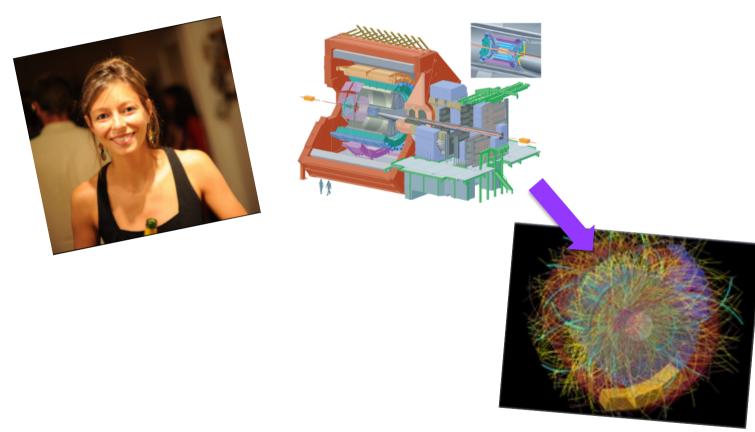
## Matteo Tenti (Me)

- ✓ Specialistica (Master) degree at Bologna University (2008)
  - ' Thesis on: validation of OPERA event reconstruction procedure using OPERA nuclear emulsion exposed to NuMI neutrino flux
- ✓ Ph.D. at Bologna University (2012)
  - r Thesis on:  $ν_e$  identification optimization and  $ν_μ → ν_e$  oscillation search in OPERA experiment
- ✓ Now Research Fellow at CNAF (from 2012)
  - Support for grid user/experiment
  - · Development of a CNAF farm accounting system

Myself and ALICE



Myself and ALICE



- Myself and ALICE
- Calibration
  - Run1: 2009-2013 data taking
    - Calibrations done quasi-online and offline
    - Rates O(100 Hz) in PbPb → Sustainable to use an offline approach
    - Interdependencies between detectors solved through calibration chain of two steps



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    - Improving performance of algorithms
      - Faster, less memory-consuming
      - GPU, HLT...



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  - Run3: 2019-2021 data taking, the upgrade and the O<sup>2</sup> project
    - New challenges: Rates O(50 kHz), Processing, Storing...

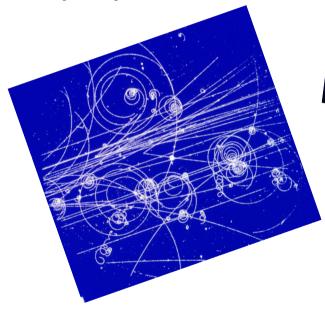


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    - New challenges: Rates O(50 kHz), Processing, Storing...
    - Online calibration and reconstruction able to deal with distortions of O(20 cm), with a required precision of O(100 μm)
      - Even faster and better algorithms
      - Parallelization...



## Chiara Zampolli – introduction II

- Analysis
  - Multiplicity distributions
  - $-\Lambda_c \rightarrow K_s^0 p$





## Chiara Zampolli – introduction II

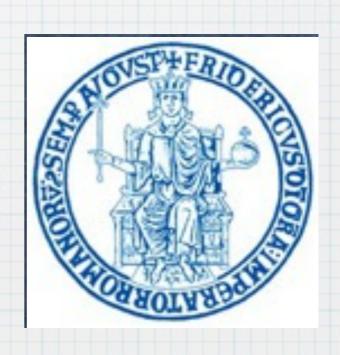
- Interest in this school
  - For optimization of calibration algorithms:
    - Memory management
    - Efficient and high performance programming
  - For developing new calibration procedures, aimed at ALICE Upgrade:
    - Knowledge of the state-of-art computing
    - GPU programming
    - Parallelization



# ESC 2013 - Bertinoro

Giovanni Zurzolo - A very fast "lightning"...



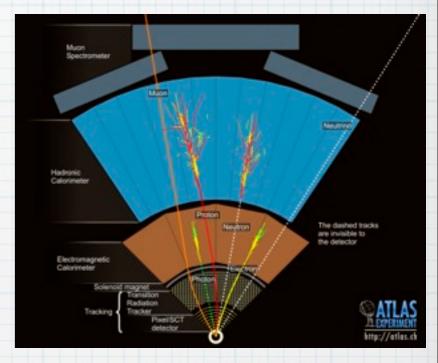


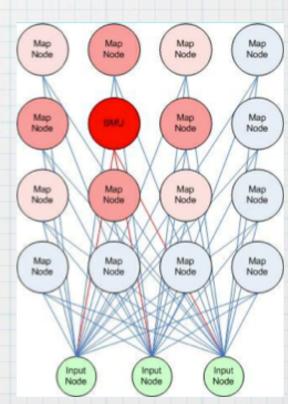
# Who I am and what I do

- \* I'm a Ph.D. student in Fundamental and Applied Physics at "Federico II" University of Naples
- \* I graduated at "La Sapienza" University of Rome with a thesis on the Higgs searches in the "WH->WWW->llqq+MET" channel in the ATLAS experiment

## And now...

- \* I still work in the ATLAS experiment at LHC:
  - o in the analysis of the H->ZZ\*->llqq decay channel using 2012 data
  - o to develop a new tool for the discrimination between quark and gluon jets using an unsupervised learning algorithm called SOM, "Self-Organizing Map"





# What I would like to learn

- \* For the core Higgs analysis and for q-g tagging tool:
  - now to write a really efficient code
  - hot to reach the best performances in terms of time and memory costs
- \* For the ongoing shutdown and upgrade of LHC:
  - used in the next "generation" of (SW and HW) components of the ATLAS experiment

# Thank you!

