ATLAS

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1 Introduction

The activity of the ATLAS LNF group is focused on five items: Higgs four leptons analysis (R. Di Nardo is the group convener), Paricle Flow, PF, and Missing Transverse Energy reconstruction, MET, (M. Testa is the group con- vener), computing activity includin the PRIN tasks on Proof on Demand, Fast TracK (FTK) upgrade phase 1 activity, new Small Wheel for the upgrade of the muon system (G. Maccarrone is the INFN coordinator).

2 Particle Flow Reconstruction and PileUp suppression

The increase of luminosity expected for RunII, to up to 80 mean interaction per bunch crossing, will induce serious degradation of the jets and $\not{E}_T$ resolutions and increase in fake rate contamination from Pileup jets.
Standard ATLAS reconstruction exploits several techniques to mitigate Pileup effects in the jets and in the $\not{E}_T$ reconstruction. These techniques are aimed to improve resolution and reduce the fake rate of jet and $\not{E}_T$. One well established approach is calorimeter based and uses the "Jet Area" method [1], which basically evaluates the average energy Pileup contribution under the area of the jet and subtract it. This approach has the intrinsic limitation to not be able to capture local Pileup fluctuations, limiting therefore the resolution improvements and the rejection of Pileup jets. Other local approaches based on tracks have been develop to reduce Pileup jets rate. They exploit the possibility of extrapolating the tracks to the interaction vertex and therefore to identify a signal jet coming from the hard scatter vertex from the Pileup Jets coming from other Pileup vertices [2]. Even if those techniques are track-based, the constituents of the jets are calorimeter clusters. Therefore, no improvement in the resolution of jets is expected and signal jets will still suffer resolution degradation from Pileup contamination.
To face the future unprecedented Pileup conditions a Particle-Flow reconstruction has been revisited and developed within the collaboration. This kind of reconstruction can maximally mitigate Pileup effects by exploiting the correlations among the inner detector and the calorimeter. Through the association between tracks and calorimeter deposits and the track pointing to the interactions vertices, calorimeter energy deposits coming from Pileup interactions can be removed in the jets and $\not{E}_T$ reconstruction. Large improvements in resolutions and fake rate reduction can be therefore achieved.
Figure 1 (top) shows the fractional p_T resolution of calorimeter based standard jets and Particle-Flow jets, with no pile-up and conditions similar to 2012 running. The bottom of figure 1 shows the resolution on the η direction versus the truth p_T of the jet. The algorithm has been integrated into the ATLAS software framework for Run 2 and is now available for use in physics analyses.

3 Large Eta Studies for Phase-II upgrade

After the "Phase-I" upgrade in 2018, the LHC will undergo a "Phase-II" upgrade in 2023, to deliver the instantaneous luminosity o $5 \times 10^{34} cm^{-2} s^{-1}$, a factor 10 beyond its design value, corresponding to unprecedented PileUp conditions with an a average of 140 interactions per crossing. The ATLAS detector will undergoes upgrades to maintain its capabilities. In particular the Inner Detector (ID) will be substituted by a new, all-silicon Inner Tracker (ITk), whose default layout extends maximally to $|\eta|$ =2.7. Currently important studies are on going to evaluate the benefits of extending in η the ITk, considering either longer pixel barrel layers and/or additional pixel disks or rings [3]. There is tremendous potential for improved performance for jets and $\not{E}_T$ in the very forward region. Tracking information can be used by

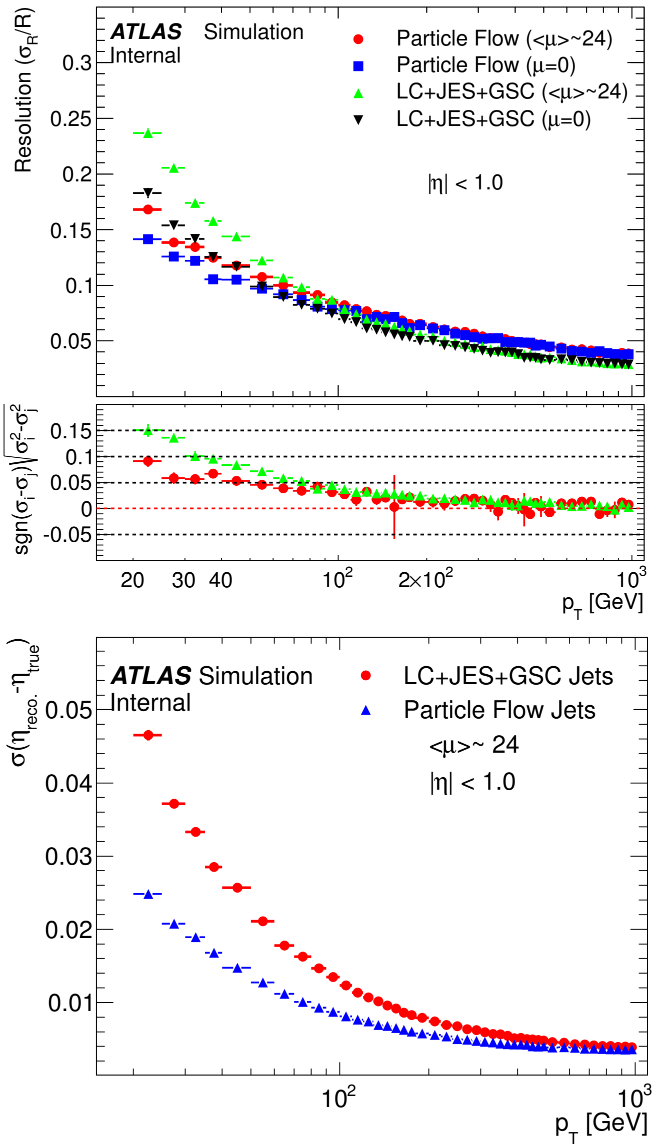

Figure 1: Top: The resolutions of calorimeter and particle flow jets determined as a function of pT in Monte Carlo dijet simulation, compared with no pile-up and conditions similar to 2012 running. The quadratic difference in the resolution with and without pile-up is shown in the lower panel. Bottom: the angular resolution measured in Monte Carlo by fitting Gaussian functions to the difference between the truth and reconstructed quantities.

tagging pile-up jets in the forward region as has been done in the central region for Run I. Forward pile-up rejection induces an improvement in $\not{E}_T$ as well. The variable used to study the forward pile-up jet tagging is $R_{pT} = \frac{\Sigma_k p_T^{trk_k}(PV_0)}{p_T^{jet}}$ which computes the scalar sum of the p_T of the charged tracks associated with a particular jet, which are also associated with the primary vertex (PV0), and normalizes this to the p_T of the relevant jet. Small values of R_{pT} correspond to jets with very small charged fraction associated with the primary vertex, and hence very likely to be pileup jet. The efficiency of the R_{pT} cut for hard-scatter jets versus the efficiency for pile-up jets is shown in Figure 2, left, where each curve represents a scan over the observable R_{pT} for jets in a range of $|\eta|$. The three η ranges in this plot correspond to the possibilities to use a tracker with increasing η-coverage in the three upgrade scenarios, referred as Reference, Middle and Low. More details are given in [4]. For jets with $3.2 < |\eta| < 3.8$ a rejection of pileup jets by roughly a factor of 100 is achievable with an inefficiency for the signal jets from the primary vertex of only about 10%. The $\not{E}_T$ resolution derived from fully simulated $t\bar{t}$ events with average $\mu = 200$ as a function of ΣE_T is shown in Figure 2, right. The relative improvement in resolution grows with ΣE_T, until the Middle scenario is 40% worse than the Reference scenario, and the Low scenario is 70% worse for the most energetic events in the sample.

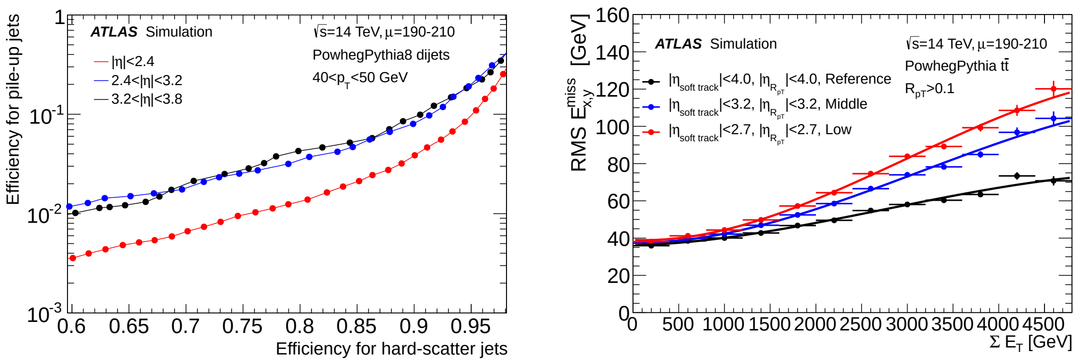

Figure 2: Left: The efficiency for pile-up jets as a function of the efficiency for hard-scatter jets with $40 < p_{\mathrm{T}} < 50$ GeV using a track-matching algorithm for $\mu = 200$. The algorithm can be applied in $|\eta| < 2.4$ the Low scenario, $|\eta| < 3.2$ in the Middle scenario and $|\eta| < 3.8$ in the Reference scenario. Right: The resolutions of the x and y components of $\not{E}_T$in the three scoping scenarios for samples of $t\bar{t}$ events with $\mu = 200$. The resolutions are shown as a function of the scalar sum of total energy in the event, with MC statistical uncertainties.

4 Higgs Physics at LHC

In the 2012 data taking ATLAS collected proton-proton collisions at 8 TeV center of mass energy corresponding to an integrated luminosity of about 20 fb^{-1}. On 4 July, 2012, the LHC experiments reported the evidence of an Higgs boson-like particle with a mass of about of 125 GeV and great interest has been posed on the measurements of its properties to assure whether it is the Standard Model (SM) Higgs boson or not. In this context, the measurement of the Higgs properties remains one of the main goals of the LHC-RunII physics program since hints of New Physics (NP) effects can be hidden in the Higgs sector. Deviations from the SM expectations could indicate exotic properties of the Higgs or presence of exotic particles in association with Higgs.

What emerges from RunI measurements shows that deviations from the SM expectations in the Higgs sector are small: the Higgs quantum numbers are measured to be $J^P = 0^+$ (alternative hypotheses are excluded with a 97.8% C.L.), its signal strength ($\mu = Ev_{obs}/Ev_{SM}$) and coupling

measurements to vector bosons and fermions are found to be consistent with the SM with an accuracy of the order of 10%.
Our group contributed significantly to this discovery with fundamental contributions to the analysis and to the measurement of the Higgs boson properties in the $H \to ZZ^* \to 4\ell$ decay channel.

4.1 Off-shell Higgs boson couplings measurement using $H \to ZZ^* \to 4\ell$ events at High Luminosity LHC

Several studies have shown that the high-mass off-peak regions in the $H \to ZZ^*$ and $H \to WW^*$ channels above the 2_{m_V} threshold ($V = W, Z$) have sensitivity to off-shell Higgs production and interference effects, therefore, this feature can be exploited to characterize the Higgs boson off-shell signal strength and its associated couplings. A study on the off-shell Higgs boson signal strength in the $ZZ^* \to 4\ell$ final state at the High Luminosity LHC (HL-LHC) has been carried out.
The off-shell signal strength in the high-mass region selected by the analysis ($200 < m_{4l} < 1000$ GeV) at an energy scale $\hat{s}$, $\mu_{off-shell}(\hat{s})$, can be expressed as:

$$\mu_{off-shell}(\hat{s}) \equiv \frac{\sigma^{gg\to H^*\to VV}_{off-shell}(\hat{s})}{\sigma^{gg\to H^*\to VV}_{off-shell,SM}(\hat{s})} = k^2_{g,off-shell}(\hat{s}) \cdot k^2_{V,off-shell}(\hat{s})$$

where $k^2_{g,off-shell}(\hat{s})$ and $k^2_{V,off-shell}(\hat{s})$ are the off-shell coupling scale factors associated with the $gg \to H^*$ production and the $H^* \to VV$ decay.
The off-shell signal strength and coupling scale factors are assumed in the following to be independent of $\hat{s}$ in the high-mass region selected by the analysis. The off-shell Higgs boson signal cannot be treated independently from the $gg \to VV$ background, as sizeable negative interference effects appear.
The Higgs boson mass is set to $m_H = 125.5$ GeV and the QCD factorization and renormalisation scales are fixed at m_{ZZ}.
In order to extract the upper limit on the off-shell signal strength for the HL-LHC scenario, the matrix element (ME) based kinematic discriminant is used. The distributions of the ME-based kinematic discriminant at s=8 TeV for gg-initiated samples, namely signal (S), background (B) and SBI including detector simulation are scaled to 14 TeV as a function of the four-lepton invariant mass.
The systematic uncertainties on this model are:

- the signal LO-to-NNLO k-factor for the $pp \to H^* \to ZZ$ and $gg \to H^* \to ZZ$ processes ($\sim 30\%$)
- the background-to-signal k-factor ratio ($R^B_{H^*}(m_{ZZ}) \sim 10 - 30\%$), but the theory predictions on the gg-initiated processes will improve on the timescale of the HL-LHC.
- normalization systematic uncertainty to the $qq \to ZZ$ process, due to QCD and PDF scale uncertainties ($\sim 10\%$)

The fit is then performed using the samples scaled to the center-of-mass energy of 14 TeV for the two integrated luminosity scenarios ($300 fb^{-1}(L1)$ and $3000 fb_{-1}(L2)$).
Figure 3 shows the likelihood curves with and without systematic uncertainties (normalization only and normalization+shape) in the scenarios L1 and L2 respectively. The double-minimum

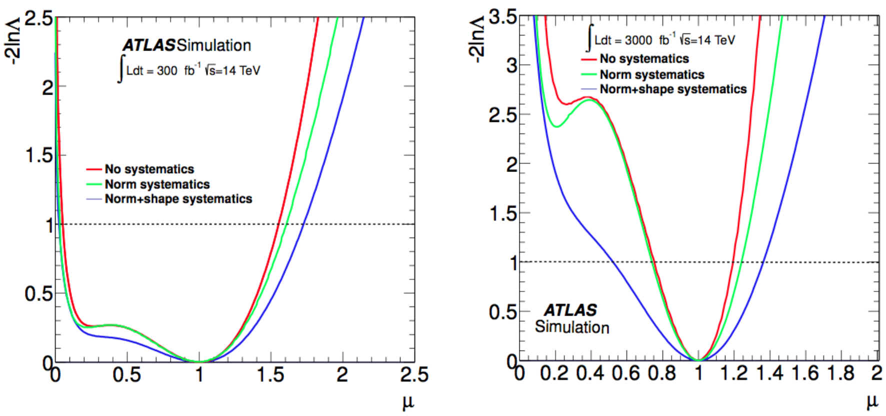

Figure 3: Likelihood scans on $\mu_{off-shell}$ with and without systematic uncertainties for the configuration L1 and L2. The error on μ is computed at the 1σ level and the uncertainty on $R^{B}_{H*}(mZZ)$ is set to 10%.

structure observed for $\mu_{off-shell} < 1$ is related to the quadratic dependency of the observed yields on the off-shell signal strength. The SM minimum gets more and more resolved as the statistics grows so that the likelihood function is quite parabolic close to its minimum for $3000 fb^{?1}$. It should be noted that the distributions of the ME discriminant are able to constrain the three components S, B and SBI at very high luminosity and the SM minimum is preferred with respect to the second one at a level better than one standard deviation. The systematic uncertainties on the ME shape, in this scenario, play a very important role. It will be therefore very important to obtain improvements on the theory side not only on the values of the k-factors for S, B and SBI but also on the ME distributions.
The fitted values of $\mu_{off-shell}$ with the 1σ uncertainties, for the two luminosities assuming a systematic uncertainty on R^{B}_{H*} of 10% , are:

$$\mu^{(L1)}_{off-shell} = 1.00^{+0.72}_{-0.96}(stat + syst) \quad \mu^{(L2)}_{off-shell} = 1.00^{+0.36}_{-0.49}(stat + syst)$$

Another way of parametrizing the Higgs boson off-shell couplings is to use the k formalisms defining: $\mu_{off-shell} = k^2_{off-shell}$. In this way the measured yields are sensitive to the relative sign of the off-shell couplings with respect to the Standard Model (SM) background process. where k is the product of the couplings of the Higgs boson to the initial and final states. This parametrization is particularly suitable for the description of beyond SM scenarios because it is sensitive to possible non-SM positive interference resulting in negative values of k.

$$k^{(L1)}_{off-shell} = 1.00^{+0.32}_{-0.84}(stat + syst) \quad k^{(L2)}_{off-shell} = 1.00^{+0.19}_{-0.29}(stat + syst)$$

Furthermore, the ratio of the off-shell and on-shell Higgs boson couplings can be used to measure the total width under several assumptions briefly summarized in the following. The cross-section for on-shell Higgs production allows a measurement of the signal strength:

$$\mu_{on-shell} = \frac{\sigma^{gg\to H\to ZZ}_{on-shell}}{\sigma^{gg\to H\to ZZ}_{on-shell,SM}} = \frac{k^2_{g,on-shell} \cdot k^2_{Z,on-shell}}{\Gamma_H/\Gamma_H^{SM}}$$

which depends on the total width Γ_H.

Assuming identical on-shell and off-shell Higgs couplings, the ratio of $\mu_{off-shell}$ to $\mu_{on-shell}$ provides a measurement of the total width of the Higgs boson. This assumption is particularly relevant to the running of the effective coupling $k_g(\hat{s})$ for the loop-induced $gg \rightarrow H$ production process, as it is sensitive to new physics that enters at higher mass scales and could be probed in the high-mass m_{ZZ} signal region of this analysis. It is also assumed that any new physics which modifies the off-shell signal strength $\mu_{off-shell}$ and the off-shell couplings k_i, off-shell does not modify the predictions for the backgrounds. Further, neither are there sizeable kinematic modifications to the off-shell signal nor new, sizeable signals in the search region of this analysis unrelated to an enhanced off-shell signal strength. Assuming that the on-shell couplings will be measured at high luminosity with much higher precision, the projection on the off-shell Higgs boson coupling can be translated into a projected determination of the Higgs boson total width at $3000 fb^{-1}$ (10% systematic uncertainty on $R^{B}_{H^{*}}$):

$$\Gamma_H^{(L2)} = 4.2^{+1.5}_{-2.1} MeV(stat + sys)$$

The measurement of $\mu_{off-shell}$ is carried out in the same way as in the standard analysis, explicitly by employing a likelihood fit using ME-based templates that have been scaled in order to account for different luminosity and energy conditions. A simple treatment of the theoretical uncertainties, considering both normalization and shape variations, is also introduced in the model.

The best fitted value returned by the likelihood fit on $\mu_{off-shell}$ at $3000 fb^{-1}$ allows to determine the parameter of interest in the fit with an accuracy of approximately 50% at the 1σ level. Assuming that the on-shell couplings will be measured with much higher precision, this projection can be translated into a projected determination of the Higgs boson total width of $\Gamma(L2) = 4.2^{+1.5}_{-2.1}$ MeV when the systematic uncertainty on $R^{B}_{H^{*}}$ is set to 10%.

4.2 EFT approach for the Higgs physics at LHC

The main idea that lies behind the work is to present a sensitivity study based on the EFT parametrization proposed by G. Isidori, A. Greljo, D. Marzocca and M. González- Alonso [5]. The approach that will be shown is a general EFT approach, and it reflects the importance of investigating the kinematics of the events and the total rate at the same time. To do so, the decay amplitude $H \rightarrow 2e2\mu$, defined as a function of 5 pseudo-observables, has been used to extract the parameter values via a binned Likelihood fit.

The pseudo-observables, defined from the on-shell decay amplitude, allow for a systematic inclusion of higher order QED and QCD corrections, including the best up-to-date SM predictions in absence of NP effects and can be computed in any EFT approach to the Higgs physics.

In order to extract the contact terms values it is necessary to study the differential decay distributions in q_1^2 and q_2^2.

This work will focus only on the Higgs boson decay to pairs of muons and electrons, which is a particularly clean process with non-trivial kinematics; the double differential rate is a quadratic polynomial function in $k = (k_{ZZ}, \epsilon_{ZeL}, \epsilon_{Z\mu L}, \epsilon_{ZeR}, \epsilon_{Z\mu R})^T$, therefore, the decay amplitude can be written as a function of the parameters as follows:

$$d\Gamma_{H\rightarrow 2e2\mu/dm_{12}dm_{34}} = \Sigma_{j\geq i} X_{ij} k_i k_j$$

where m_{12} and m_{34} are the invariant masses of the $2e$ and 2μ respectively.

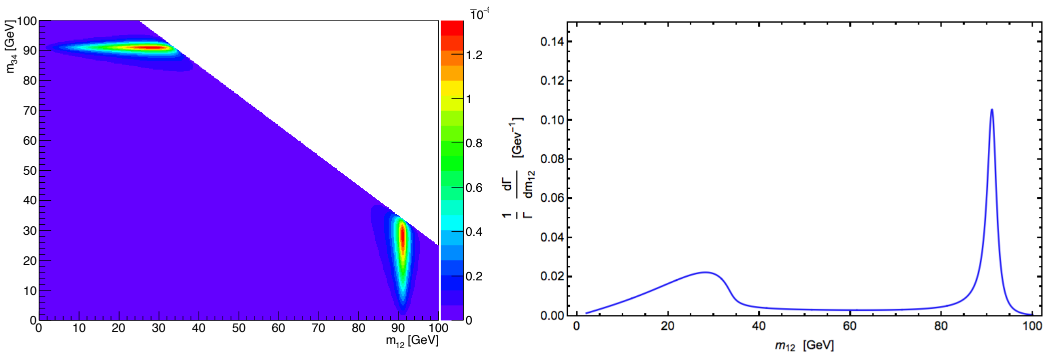

Figure 4: (left) Two dimensional function generated with parameters set to SM values: (k_{ZZ}, ϵ_{ZeL}, $\epsilon_{Z\mu L}$, ϵ_{ZeR}, $\epsilon_{Z\mu R}$) = (1,0,0,0,0). (right) The projection along m_{12} is shown, integrating over m_{34}.

Figure 4 shows the $2D$ function generated at SM values and the projection along m_{12} integrating over m_{34}.
The assumptions that lie behind the parametrization in use, can be summarized as follows:

- the Higgs boson, whose mass is 125 GeV is a spin-0 particle
- there are no new particles with mass below 125 GeV able to distort the decay amplitude of the Higgs in SM particles.
- it is not necessary to assume that the Higgs boson is part of an $SU(2)_L$ doublet, neither make assumptions as Lepton Flavor Universality (LFU) nor CP invariance.

At this stage, the extraction of the events can be done from the double differential rate and an Asimov dataset has been used for our purpose, normalized to the statistics recorded by both ATLAS and CMS in the LHC RunI. The total amount of events recorded by the two experiments is ~ 15 events in the $2e2\mu$ channel in the mass window $[120-130]$ GeV [6] [7].
A binned Likelihood then has been built and a scan over the parameter of interest has been performed; studies were carried out following several configurations and will be given for the statistics available in the LHC RunI (ATLAS + CMS); projections for $100 fb^{-1}$ at 13 TeV for the RunII of LHC will be given accordingly.
Different combinations of the parameters have been chosen to be studied since they were showing interesting features in investigating possible deviations from the SM values of the pseudo-observables. In order to do so, among the 5, some of them have been fixed to their SM values, fitting the others.
Results shows that the sensitivity on the contact term that we have with the statistics available from RunI is not sufficient to exclude some EFTs, but $100 fb^{-1}$ at 13 TeV would be enough to start discriminating between EFTs due to the typical values of the contact terms which goes around 0.2.

5 Tier2

5.1 Activity during 2015

During the year 2015 the Frascati Tier2 successfully and continuously performed all the typical activities of an ATLAS Tier2: Monte Carlo production and users and physics groups analysis and

the efficiency of the site was always maintained above 90%.
During the year, the Tier2 farm has grown to 17 kHEPSPEC of computing power and about 1.4 PB raw of disk space; moreover, in addition to the LHC VOs, new virtual organizations (VO) are supported: Belle, CTA and KM3Net.
Among the most significant activities that involved the Tier2 staff we can mention the participation in the INFN computing PRIN STOA-LHC, with the test activity of the analysis tool PROOF on Demand (PoD) [9)]. This activity started in 2012 in collaboration with CERN developers and the other ATLAS Italian Tier2s, and continued until 2015 in order to test PoD with the new ATLAS Prodsys2 workload management system and the new PROOF features of dynamic workers addition: the addition of new enabled workers to an already started PROOF-based analysis [8)].
About the participation of the Tier2 staff in the ATLAS computing activities, we should mention the role of the VO manager assumed by the Tier-2 responsible. This activity is of primary importance for the experiment, in fact, it is recognized as in kind contribution of the Italian group.
Finally, for what concern the Grid middleware, during 2015 the accounting system for the CPU usage, based on the Home Location Register (HLR), was migrated to APEL (Accounting Processor for Event Logs). APEL is a CPU usage accounting tool designed and deployed for the WLCG/EGEE Grids. It interprets logs of Grid gatekeeper and batch system logs to produce CPU job accounting records to publish into a centralized repository at a Grid Operations Centre (GOC).

5.2 Collaboration for CTA computing

The CTA project will involve INFN and INAF in the coming years. It is considered strategic, for both institutions, to develop, in synergy, the aspects of the project related to calculation. To integrate different skills and experiences in developing scientific software for data analysis and simulations, the approach is the gradual evolution of the commitment in the project through a modular development that addresses, in succession, the need for calculation for:

- CTA Prototype Small Size Dual Mirror Telescope (SST-2M);
- Mini Array of Small Size Dual Mirror Telescope in the context of CTA;
- CTA Data Center.

The goal for the CTA data centre is to get to an Italian solution that combines experiences in the management of large computing infrastructures (INFN) and implementation of softwares for data analysis and management of archives and astronomy databases (INAF).
The choice for the Laboratories of Frascati depends on the proximity to the INAF structure that develops and coordinates the software, the archive and the database.
Thereforeforee, during 2015 the Tier2 was opened to the CTA VO activities; moreover, a collaboration was started between the Tier2 staff, the Institut National de physique nuclaire et de physique des particules (IN2P3), the INAF-OAR CTA/Astri group and the INFN Turin CTA/Astri group to the aim of configuring an activity of development and testing for the ASTRI-Miniarray project, identified as the first seed of the whole CTA range mini array simulation software.
In the light of the experience gained in this first phase, we will proceed, then, to integrate the archive and analysis system mini array of SST-2M, that will be installed at the site on the south of the observatory CTA. The software and the archive are developed by INAF - Astronomical Observatory of Rome, Monte Porzio Catone - and its integration into the computing system of the Tier2 at LNF is expected.

5.3 Collaboration for RMLab

The RMLab project aims to create a shared computing area between INFN-LNF, INFN-Roma Tor Vergata and INFN-Roma Tre taking advantage from a dedicated network with low latency and an architectural and collaborative approach as distributed and automated as possible.
Among the various use cases of this datacentre are the applications of high energy physics (such as the computing activities of ATLAS) and the pre-production of the archive Cherenkov Telescope Array (CTA), and ASTRI-Miniarray project in particular.
The RMLab network infrastructure was created by GARR as a Virtual Private Network (VPN), Layer 3 protocol based on Multi Protocol Label Switching (MPLS) connectivity, currently at 1Gbps, will then be increased to 10Gbps. The resources (computing, networking and storage) will be managed with Cloud Paradigm and OpenStack technology, with redundant services in high availability.

6 FTK

The trigger is a fundamental part of any experiment at hadron colliders. It is needed to select online the interesting low cross-section physics from the huge QCD background. Experience at high luminosity hadron collider experiments shows that controlling trigger rates at high instantaneous luminosity can be extremely challenging. As the luminosity increases, physics goals change in response to new discoveries, and detector ageing. It is thus essential that the trigger system be flexible and robust, and redundant and significant operating margin. Providing high quality track reconstruction over the full ATLAS Inner Detector by the start of processing in the level-2 computer farm can be an important element in achieving these goals. With the goal to improve and make more robust the ATLAS trigger, during summer 2007 the group joined the Fast-Track (FTK) proposal for A hardware track finder for the ATLAS trigger. This is a proposal to build a hardware track finder as an upgrade to the ATLAS trigger. It will provide global reconstruction of tracks above 1 GeV/c in the silicon detectors, with high quality helix parameters, by the beginning of level-2 trigger processing. FTK can be particularly important for the selection of 3rd-generation fermions (b and τ). These have enormous background from QCD jets, which can be quickly rejected in level-2 if reconstructed tracks are available early. This RD proposal was completed with the submission of the FTK Technical Proposal that was finally approved by the ATLAS collaboration meeting in June 2011 [10].

Under the FTK context we contributed in the development and test of the Associative Memory (AM) chips for track detection and the FTK Input Mezzanines (IMs) boards for hit information clustering.

6.1 FTK Input Mezzanines

The FTK IMs boards receive data to be processed from the detectors Read Out Drivers (RODs) over 380 S-Link for a total input rate of $760Gbps$. Each board receives data over four optical links at $2Gbps$, performs an early reduction of the data to optimize the subsequent FTK processing and transmits forward the clustered data by a $200MHz\ DDR$ signalling over 16 LVDS pairs [11], [12].

Due to the high occupancy of the IBL ATLAS pixel layer, the previous version of the FTK IM board based on Xilinx Spartan6 FPGA could not process all the data coming from the detector. We have developed this board together with FTK Japanese group of Waseda University. As responsible of this board the FTK collaboration ask us to develop a new version of the FTK IM based on a Xilinx Artix7 FPGA. This is a more recent and powerfull FPGA.

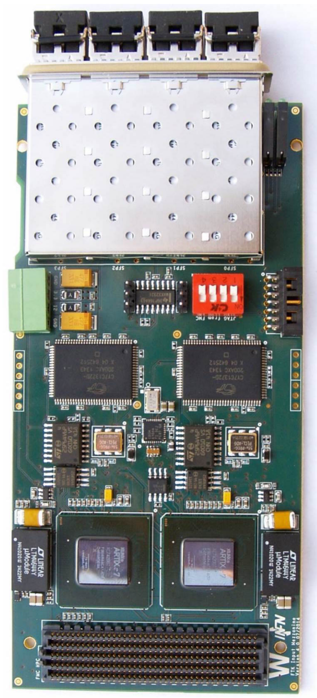

Figure 5: Artix7-IM

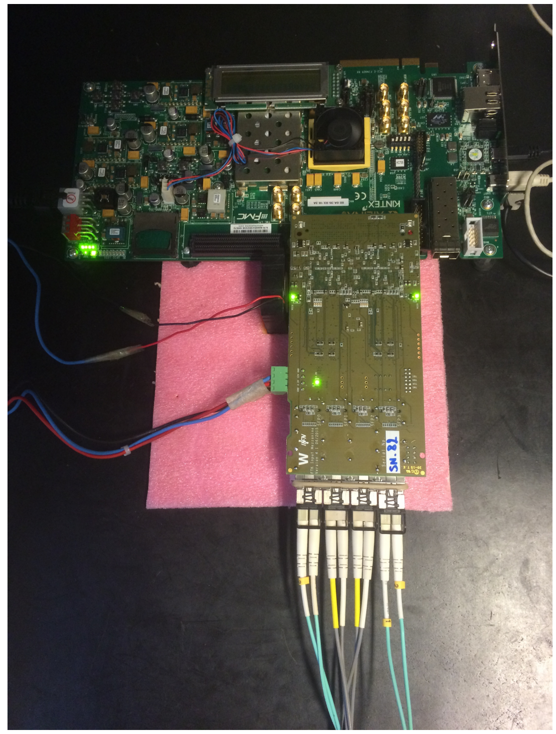

Figure 6: Artix7-IM Test Setup

The new board have been designed in 2014 5. During 2015 the first prototype has been fully tested. Subsequently the requested 80 boards have been produced, tested and delivered to CERN.

The test procedure has been developed in FRASCATI by using the Xilinx evaluation board KC705. The test environment 6 is designed to test all the interfaces at double the rate of the working specification. During the test we reached a Bit Error Rate (BER) less than $1e-12$ in the whole production and a BER less than $1e-15$ in the first prototype and on samples in the production. In the same year we ported the firmware for the previous device to the new device by redesigning all the interfaces and by modifying the previous S-Link implementation to allow the communication with the new IBL RODs.

6.2 FTK AMCHIP06 test

In 2015 was started the associative memory chip final version AMchip06 pre-production. LNF is involved in the test of this chip with these items:

- design and production of the test board;
- organizing and following the mass production test with external company.

In the following paragraph the listed items will be described.

The test board for the Amchip06 is designed to be compatible with the standard FMC connectors hosted on Xilinx evaluation board. This because the firmware that controls the tests is implemented in Xilinx Virtex6 FPGA. The specification used to design the board was the following:

- FMC HPC connector

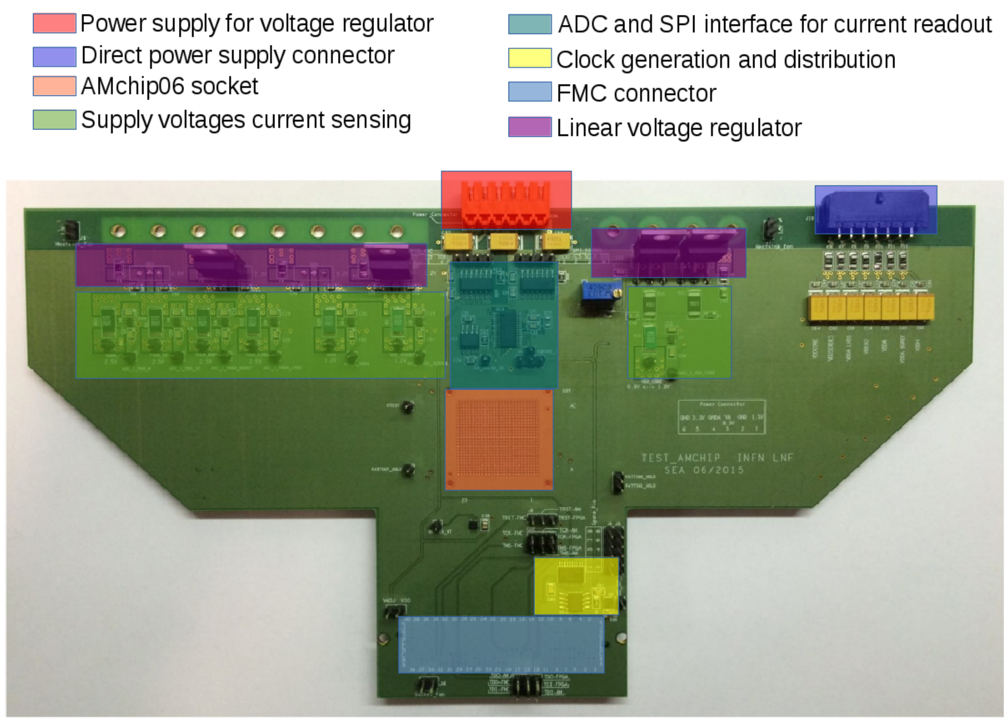

Figure 7: Artix7-IM

- On Board 100MHz clock
- FMC alternative clock distribution
- 12 differencial high speed (2.5 GHz) lines
- On board power supply current and voltage monitor
- On board linear voltage regulator with VDDcore adjstment
- Possibility to connect external power supply and bypass on board voltage regulator

The board designed with all features highlighted are shown in the picture 7

We have produced, tested and distributed to the various test site six boards.

LNF FTK group is in charge to follow the tender for the test of the AMchip06 production. The company choose for test the chip is Microtest. We have visited the company and agree with them about the test procedure and the installation of the test stand in their laboratories in 2016.

Internal documents and public presentations:

- ATLAS Collaboration, "ATLAS Phase-II Upgrade Scoping Document", public document: CERN-LHCC-2015-020 ; LHCC-G-166

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- G.Mancini, “Differential cross section measurements of the Higgs boson in the $H \to ZZ^* \to 4\ell$ and $H \to \gamma\gamma$ decay channels”, IL NUOVO CIMENTO Vol. 38 C, 2015 (DOI 10.1393/ncc/i2015-15050-1, Colloquia: IFAE 2014, 21st July 2015.
- R.Di Nardo, “Off-shell Higgs boson couplings measurement using $H \to ZZ^* \to 4\ell$, events at High Luminosity LHC”, ATL-PHYS-PUB-2015-024.

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