European Research Council

ERC Starting Grant – Stage 1
Research proposal

Strategies for the Commissioning of the Muon Spectrometer of the ATLAS experiment with LHC data

ATLASMUCOMMTRIGPHYS

Principal Investigator: Stefania Spagnolo
Hosting Institution: Istituto Nazionale di Fisica Nucleare
Project duration in months: 48

The ATLAS experiment at the LHC proton-proton collider has a wide potential for discovery of new physics and for precise measurements of known processes. Since final states with muons are of great interest a high resolution Muon Spectrometer has been designed and is under installation these days.
The achievement of the design performance of the muon trigger and reconstruction system depends not only on the spatial resolution of carefully calibrated detectors, but also on the constant monitoring of run time dependent conditions: chamber relative alignment and distortions, inner tracker to the muon spectrometer overall alignment. Furthermore, the ATLAS Muon Trigger has to cope with high background from meson decays in flight, at low transverse momentum, and high rate of uncorrelated background hits at high luminosity. As a consequence, the muon High Level Trigger algorithms deserve a long term optimization and tuning with physics data, depending on the run conditions.
Therefore, we propose to address the following items:
deploy software tools for detector description that can provide a run-time correction of realistic effects for the use of offline and online muon identification algorithms; introduce realism in the simulation of the Muon Spectrometer as much as the comparison with data will require; add flexibility to the implementation of the HLT muon selection, in order to ensure efficiency and robustness; study how critically the muon HLT depends upon detector misalignments and other run-time conditions; define strategies for an overall calibration of the Muon Spectrometer using well known physics processes; determine from data the absolute muon momentum scale (essential for improving the precision on the measurement of the W boson mass with the ATLAS data).
Alongside these activities, we propose to take part to the early physics search program of ATLAS, with particular involvement in the search for SUSY processes with muonic signatures.

A. Principal Investigator (PI)

i. Curriculum Vitae and Scientific Activity

Curriculum Studiorum

July 1988 Maturità Classica (high school diploma) at Liceo Ginnasio "Virgilio", Lecce; score 60/60.

October 1988 Unrolled at Università degli Studi di Lecce (now Università del Salento), Facoltà di Scienze, Corso di Laurea in Fisica. The plan of studies is oriented to Particle Physics;

Dic. 1993 Degree in Physics with scores 110/110 e lode.

Mach-June 1994 School for post-graduate students "Corso di Perfezionamento in Fisica", at Dipartimento di Fisica Nucleare e Teorica, Università di Pavia.

February 1995 S. Spagnolo passed the competition for a fellowship to attend the three year Course of "Dottorato in Fisica (X Ciclo)",at Università degli Studi di Lecce.

In the **a.a. 1997-1998** S. Spagnolo obtained a fellowship in the program SOCRATES-ERASMUS for student and lecturer mobility between the Universities of Lecce and Montpellier 2.

Jan. 1998 Defense of the PhD Thesis in front of the internal committee in the Physics Department of Università di Lecce.

10 June 1998 Title of "Doctor in Physics" after the defense of the PhD Thesis with the National committee at Università di Roma "La Sapienza".

Other post-graduate schools: Sep. 1994 "VII Seminario Nazionale di Fisica Nucleare e Subnucleare" di Otranto; **July 1995** ICFA'95 School of "Instrumentation in Elementary Particle Physics", Ljubliana; **April 1996** "LNF Spring School in Nuclear and Subnuclear Physics and IV EURODAFNE Collaboration Meeting", Frascati; **September 1996** "1996 European School of High-Energy Physics", Carry-le-Rouet, CERN-JINR; **August 1997** "International school of Subnuclear Physics, 35th Course :HIGHLIGHTS: 50 YEARS LATER", Erice.

Degree Thesis

"La camera a drift di KLOE: definizione dei parametri e misure di ionizzazione primaria in miscele di elio", A.A. 1992-1993; Advisors: Prof. Pio Pistilli and Dr. Francesco Grancagnolo.

PhD Thesis

"La camera a drift di KLOE e prospettive e obiettivi di una nuova misura del contributo adronico al *g*-2 del muone a DAΦNE". Advisors: Dr. Francesco Grancagnolo, Prof. Claudio Verzegnassi.

Fellowships and Contracts

From **1992 to 1998** S.Spagnolo has been associated to INFN LECCE, taking part to the KLOE experiments at the DAΦNE collider in Frascati.

February-March '98 she was offered a three year RA position at the University of Siegen (Germany) to work on the ALEPH experiment. At the same time, she was offered a two year post-doctoral fellowship in the framework of the EURODAΦNE Collaboration (TMR Project ERB4061PL970448, to be spent in DESY-Zeuthen/University of Karlsruhe) for the investigation of the DAΦNE potential in the measurement of the hadron cross section at low energies. Finally, she was selected for a three years Research Associate position at CCRLC (Rutherford Laboratory, Oxfordshire, UK) to work in the OPAL experiment and she accepted this offer.

30 March '98 S. Spagnolo was employed by CCLRC. She spent the last two year of her contract at CERN, taking part to the OPAL data taking and to the data analysis. In the process

of personnel review at CCLRC in the **year 2000**, she was promoted from band 5 to band 4 for the achievements reached during the previous year.
Oct. 2000 S.Spagnolo won the competition for a fixed term position at the University of Lecce as "Researcher in Nuclear and Sub-Nuclear Physics".
April 2001 S. Spagnolo was employed at the Faculty of Science, University of Lecce (now Università del Salento), where she still works. Her research activity, in these years, has been carried out, under the founding of INFN LECCE, where she has a contract for "Incarico di ricerca", mainly in the ATLAS experiment at LHC (CERN), with a short involvement in the MEG experiment at PSI, Zurich, in the years 2003-2005. Since a few months, she participates to a new research and development project, CLUCOU, aiming at the implementation of the cluster counting technique, in custom electronics, for an improved performance, in terms of spatial and dE/dx resolution, of classical drift chambers in the next generation of experiments at e+e- colliders.

Research activity
As undergraduate and PhD student, S.Spagnolo worked in the KLOE experiment at the Φ factory DAΦNE of LNF Rome, designed to study CP violation in the neutral kaon system. She worked at the design of drift chamber: optimised the parameters, provided the drilling maps for the carbon fibre end-plates of the chamber, developed an original 3d pattern recognition algorithm for the stereo geometry of the drift chamber, measured the performance of the detector on a full scale prototype and studied the calibration procedures on MC and test beam data. This work is reported in the degree and PhD theses, in the Addendum to the KLOE Technical Proposal "The KLOE Central Drift Chamber", LNF-95/014 (IR) Mar. 1995, in G.Cataldi, et al., NIM A 388 (1997) 127-134, in A.Andryakov *et al.*, NIM A 404 (1998) 248, in several contributions to conferences presented by S.Spagnolo for the KLOE Tracking Group and in various collaboration notes. Moreover, she studied the gain in π/K separation achievable in KLOE with the cluster counting technique using simulated and test beam data (Degree Thesis and G.Cataldi, F.Grancagnolo and S.Spagnolo, NIM A A386 (1997) 458-469). Finally, she performed a feasibility study of the measurement of the hadron cross section at KLOE with the use of ISR events where the effective centre of mass energy fall below the mass of the Φ meson. The outcomes, in terms of improvements on the theory prediction for the muon g-2 are reported in the PhD thesis and in S. Spagnolo, "The Hadronic Contribution to the Muon *g*-2 from hadron production in initial state radiation events at the *e+e-* collider DAΦNE", EPJ C6 (1999) 637-645.
S. Spagnolo has carried out phenomenological studies of the effects, in low energy observables, of new physics parameterised with SU(2)×U(1) gauge invariant effective lagrangians. These studies, firstly motivated by the impact of the measurement of σ_{had} at KLOE on the muon g-2 predictions, are reported in F.M.Renard, S.Spagnolo and C.Verzegnassi, PL. B 409 (1997) 398; M.Beccaria et al., PL B448(1999) 129; M.Beccaria et al., PL B475 (2000) 157-167.
In the OPAL experiment at LEP, she took part, during the last three years of running, to the activity of standard maintenance, monitoring and calibration of the end-cap electromagnetic calorimeter. She shared, as online expert, the responsibility for the operation of the sub-detector, performed the migration on UNIX platform of the online monitoring and calibration software and reviewed the DAQ software to ensure its Y2K compliance.
S.Spagnolo has been responsible for the production of Monte Carlo samples of fermion pairs with the precision generator KKMC, that she first imported in the OPAL software, widely used by the collaboration for all precision measurements at LEP2. She has been working in the "LEP2 SM working group" and her primary fields of interest have been anomalous gauge couplings and fermion pair production. In particular, she performed a search for neutral gauge boson couplings in $Z\gamma$ production with the OPAL data collected at 189 GeV. The results are reported in G. Abbiendi et al., EPJ.C.17 (2000) 553. As a result of the involvement

in different activities in the SM and Gauge Couplings working group, S.Spagnolo presented, on behalf of the OPAL Collaboration, the status of the quartic gauge boson couplings search at LEP in the XXXth International Conference on High Energy Physics, 2000, Osaka, Japan.
In the MEG experiment, by supervising a PhD student, S. Spagnolo has been working to the reconstruction of the positron tracks emerging from the decay at rest of a muon, with the aim of providing full efficiency for the $\mu \to e\gamma$ decay and a high rejection for the background processes. The pile-up of physics background processes was simulated and a fast pattern recognition algorithm, providing the required performance, was implemented and tested.
The ATLAS experiment is, since April 2001 the framework of the main research activity of S.Spagnolo. She has been involved in the construction and test on site (Lecce INFN Laboratory) of the RPC detectors providing the muon trigger in the central pseudo-rapidity region, in ageing test of these detectors at the GIF, CERN in the years 2002-2004 and in performance studies of the RPC at beam-test on the H8 beam line in 2003 and 2004. S.Spagnolo is strongly involved in the development of muon specific software in the fields of Detector Description and muon trigger for the Event Filter. In addition, she takes part to the development of tools for data decoding and preparation (for the RPC detectors) and tracking in the muon spectrometer. She contributed to the Data Challenge 2 of ATLAS and is now involved in the Computing System Commissioning, both for a detailed study of the muon EF to be summarised in a forthcoming ATLAS note, and for the upgrade of the detector description software for the Muon Spectrometer leading to the ability of handling condition data. She's finally involved in feasibility studies of SUSY searches in the ATLAS data. Her most relevant ATLAS publications are: M. Bianco et al., "The Lecce cosmic ray testing facility or the ATLAS RPC", NIM A565:450-456,2006; T. Lagouri et al.,"A Muon Identification and Combined Reconstruction Procedure for the ATLAS Detector at the LHC at CERN", IEEE TNS51:3030-3033,2004; M. Biglietti et al., "Study of second lightest neutralino spin measurement with ATLAS detector at LHC", ATL-PHYS-PUB-2007-004; S.Armstrong et al. "Implementation and performance of the third level muon trigger of the ATLAS experiment at LHC", IEEE TNS, 53 (2006) 500-505; S.Spagnolo et al, "The Description of the Atlas Detector", Proceedings of CHEP'04, Interlaken, 27Sep.-1Oct. 2004.

ii. Self Evaluation
In my activity in High Energy Physics research, I believe to have demonstrated: *flexibility*, having been able to work, with a reasonable impact, from detector development to physics analysis; *commitment*, since I've vigorously pursued the goal of each project I've been working to; *independence of scientific judgment*, since I've been able to move beyond the scope of the work strictly planned by the project leader or supervisor; *adaptability to the working environment*, having moved enthusiastically from one group/experiment/country to another, for the seek of scientific interest and improved self-education; *intellectual honesty*, having been available to spend considerable time and efforts on activities of general interest and limited personal satisfaction. I judge I might be able to lead a team with a common project, since, I believe, I can focus on the most relevant aspects of a problem, plan consequently a work strategy and undertake friendly and open relationships with colleagues.

iii. Funding ID
I'm currently employed, with a fixed term contract, by Università del Salento, Faculty of Sciences, where I work in the Physics Department. I am the supervisor of a post-doc whose contract ends in December 2007 and is founded jointly by the Physics Department and INFN LECCE. My research activity is financially supported by INFN LECCE with a generic budget allocated for limited mobility (attendance to collaboration meetings and conferences). These resources will sum up to the more consistent budget achievable within this grant scheme, as requested by the leadership of an independent project.
I do not benefit of any ERC issued grant or any other founding scheme.

B. Research Project

i. State-of-the-art and objectives

The Large Hadron Collider at CERN is the world largest proton-proton accelerator ever constructed. Final installations and testing of accelerator components are carried out these days and the first beam collisions will be provided to the experiments during next year. LHC allows to explore fundamental processes and elementary constituents of matter at the highest energy scale ever reached (14 TeV in the p-p centre of mass); moreover the high beam intensity and the beam time structure will lead to unprecedented instant luminosity of the accelerator, which will produce 23 superimposed interactions per beam crossing at the rate of 40 MHz in each experiment. Hence, ATLAS at LHC is a powerful facility which will provide a wide scientific output for the next 10 years in the field of processes at the TeV scale.
High energy muons are key signatures for many interesting Standard Model and new physics processes. At low transverse momentum and low luminosity, muons can be used to tag b-jets for high statistics studies of B physics, potentially improving the results achieved in B-factories. For these reasons, the ATLAS Muon System has been designed as a high resolution spectrometer with a air core toroidal magnetic field with bending power in the range 2-8 Tm, depending on the region, which provides a low transverse momentum cut on muons entering the system, tracking acceptance up to $|\eta| <2.7$ and trigger capability up to $|\eta| <2.4$. The muon detectors, MDT and CSC (the latter only in a limited region at high pseudorapidity) for precision tracking, and RPC and TGC for trigger and tracking in the non bending plane, are arranged in three layers, sampling the muon track at the entrance, exit and in the middle of the toroidal magnetic field. The ultimate transverse momentum resolution for muons, arising from the combined reconstruction using the Inner Detector and the Muon Spectrometer, is of a few percent from 6GeV/c up to several hundred of GeV/c, where it start increasing up to the value of 10% at p_T=1 TeV/c. Tracks from muons of transverse momentum of 1 TeV/c will exhibit a sagitta of about 500μm, which must be measured with precision of 50μm in order to meet the required p_T resolution. Therefore, the achievement of the design performance of the muon reconstruction system depends not only on the spatial resolution of the detectors (80μm per single measurement in MDTs) and on a careful calibration of the detector response (t0, space-time relations) but also on the constant monitoring of run time dependent conditions affecting the whole system: **chamber relative alignment and distortions**, inner tracker to muon spectrometer alignment. As a matter of fact, the residual uncertainty on chamber alignment is one of the dominant sources of the p_T resolution above 200GeV/c. A complex alignment system , based on CCD images of coded masks, monitors the in-plane deformations of each MDT chamber and its relative position in the axial and projective directions with respect to chambers in the same $\eta\varphi$ tower. The system has been tested on beam test data, collected at the H8 beam line in 2004, where it showed the capability to correct for mis-alignments up to less than 20μm. Moreover, the MDT chambers have a light mechanical structure (aluminium tubes arranged three or four staggered layers) which is subject to sizable deformations as a consequence of mechanical stresses or thermal gradients. These deformations can also be monitored by the optical alignment system, which is, therefore, supposed to provide, several times during a single run, a direct determination of alignment and deformation constants essential for a full exploitation of the Muon Spectrometer potential. Eventually, a cross determination of the alignment constants with data will be needed for testing purposes and also in order to address the alignment of chambers not equipped with the optical sensors.
The ability to describe and implement in the software for **Detector Description** alignment and chamber deformations is functional to the achievement of the design performance of the muon system. More generally, the **simulation of the ATLAS Muon Spectrometer** deserves quite some attention due to the complexity of the system and to the peculiar background

situation. The muon chambers are embedded in a diffuse background of thermal neutrons, photons of energy in the range 10-1000keV, π, K and protons of momentum of about 100 MeV/c, producing a rate of up to 1 kHz/cm^2 in the forward region.

In addition, the determination of the **absolute scale of the ATLAS muon spectrometer** will also depend on the magnetic field knowledge. The toroidal field will be initially sampled in 5000 points by Hall probes with 0.1% resolution. Refinements of the field map can be obtained via the physics monitor of the di-muon Z resonance ($3\cdot10^4$ events/day at low luminosity) with a simultaneous fit of the magnetic field and of the energy loss in the material in front of the spectrometer. Any bias in the absolute momentum scale of the system will reflect in systematic uncertainties for measurements requiring a precise momentum determination. In this respect, the most demanding physics goal in the scientific program of ATLAS is the improved measurement of the mass of the W boson from the study of the edge of the lepton spectrum, taking advantage of the high statistics but requiring a very accurate control of the momentum scale.

The **muon Trigger** is a key component of the ATLAS experiment. Its hardware implementation at level-1, uses the fast signals from RPC and TGC to identify a Region of Interest (RoI, to be processed by the level-2 trigger) and provides the central trigger processor with the number of muon candidates for six p_T programmable thresholds. It is based on a majority logic in coincidence windows both in φ and η. The window size defines the p_T threshold with a 25% resolution. Two different logics are applied for the low and the high p_T thresholds. In the barrel, the low p_T trigger requires hits in at least 3 out of the 4 measurement planes in each view from the two RPC chambers in the middle layer. The high p_T trigger requires, in addition, the coincidence with at least 1 of the 2 planes in both views of the RPC outer station. The same logic is applied in the end-cap region. The fully programmable logic of the level-1 muon trigger allows to setup more robust or relaxed coincidence requirements to cope with very high background conditions or detector inefficiencies. The level-2 muon trigger is a software process (running within a latency of 10ms) which has access to the MDT hits in the detectors selected by the level-1 RoI, where it performs a fast track reconstruction thus improving, via look-up tables, the p_T resolution (5%) and reducing to a negligible level the rate of spurious triggers generated by the cavern background. The level-3 (or Event-Filter) muon trigger is based on the full offline muon reconstruction software (which can be safely run in the total latency of 1s) and is intended to provide a good sharpness of the p_T threshold by taking advantage of a resolution as close as possible to the one achievable in offline reconstruction. Old estimates of the level-1 trigger rate based on non final layout of the muon spectrometer, indicate a throughput of 25 kHz at low luminosity for a p_T threshold of 6GeV/c from physics events and a similar rate of fakes induced by cavern background (if a safety factor of 5 is assumed on the background normalization). These estimates and those for the rates expected at Level-2 and Event-Filter are going to been revised with the most recent implementation of the Level-1 emulation and with the latest versions of the HLT muon software in the framework of the Computing System Commissioning of ATLAS using dedicated simulations.

The trigger decision arises from a sequence of HLT (Level-2 and Event-Filter) steps, some performing the reconstruction of physical quantities associated to trigger elements, some others testing hypotheses on the previously defined trigger elements (consistency with threshold, isolation, topological constraints, etc). Any item in the trigger menu can produce a trigger if the sequence configured for its identification are satisfied at each step. The final aim of the Muon trigger is to provide full efficiency for muons in two typical regimes: 6 GeV/c threshold at low luminosity and 20 GeV/c threshold at high luminosity. This goal has to met within the constrains of a total rate well below the limiting value of 200 Hz (dictated by the full DAQ output capability) and the latencies per level discussed above. In this respect, the most critical items to keep under control are: the high rate of low p_T muons induced from decays in flight of light mesons (pions and kaons) at low luminosity and the high rate of uncorrelated background hits from cavern background at high luminosity. As a consequence, the muon High Level Trigger algorithms deserve a long term optimization and tuning with physics data, depending on the run conditions.

ii. Methodology

Within the scope of the present project, I propose to address the following items that, I think, are particularly relevant for the full commissioning of ATLAS Muon Spectrometer required for a successful achievement of the goals in scientific program of the experiment:

1. *deploy software tools for detector description that can provide a run-time correction of realistic effects for the use of offline and online muon identification algorithms; introduce realism in the simulation of the Muon Spectrometer as much as the comparison with data will require*.

   The current software for Detector Description, implemented for the Muon Spectrometer mainly by myself, has the potential for providing reconstruction clients with a transparent and realistic representation of the muon chambers (and inert material in the spectrometer). Alignment constant for full muon stations are already handled successfully in simulations and the prototype implementation was tested on real data in simple test beam setup of 2004. Nevertheless, the ability to handle alignment constant at run time has to be demonstrated (first exercise will come on simulation within the Condition Data Challenge, planned for fall 2007); corrections to the nominal chamber geometry, using measurements for tomography based surveys, have to be described; the implementation of deformation has to be completed, scrutinised in terms of coherence with conventions from the hardware optical alignment system and tested in reconstruction of simulated and real data; many inert materials in the spectrometer are not yet described, therefore a detailed simulation requires improvement of the detector description and tuning of the material description, also in comparison with first data.
2. *define strategies for an overall calibration of the Muon Spectrometer using well known physics processes; determine from data the absolute muon momentum scale.*

   While a well established program for MDT calibration (t0 and space-time relation) exists along with very clear commitment of several working group, the item of overall calibration with data is sparsely addressed in the collaboration. Basic plans were studied and reported in the Detector Performance and Physics Technical Design Report, published in 2000, which were based on superseded software tools. Several sub-projects can be identified: calibration of the optical alignment system with straight tracks (to be collected in dedicated runs with the toroids off); alignment with tracks of chambers not equipped with the optical alignment sensors with respect to chambers optically aligned; Relative alignment with tracks of the Inner Detector to the Muon Spectrometer; Monitor of the reconstructed Z mass peak in di-muon events, in order to tune the absolute momentum scale, affected by the accuracy on the knowledge of the magnetic field map and of the average energy loss in the material in front of the muon spectrometer. I think that my general understanding of the systematic effects relevant to the muon system performance can allow me to contribute with a specific sub-project to this areas to be defined according to the involvement of other ATLAS collaborators in the subject.
3. *add flexibility to the implementation of the HLT muon selection, in order to ensure efficiency and robustness; study how critically the muon HLT depends upon detector misalignments and other run-time conditions.*

   As discussed above, the muon trigger has to cope with very different physics backgrounds depending on the run conditions (luminosity, thresholds, trigger menus). However, while the Level-1 configurability is hardware constrained, the HLT muon selection can be fully programmed and configured to match the physics needs and the system requirements. Having been working to the muon Event-Filter selection algorithms and to the implementation of the muon sequence, I propose to pursue the program of studying the muon trigger performance on real data and optimize the selection (in terms of configuration parameters, sequence definition, threshold tuning, algorithm refinements) with the forthcoming ATLAS data. A first step in the process will involve the online implementation of the full muon trigger slice (the sequence of HLT algorithms) for triggering cosmic rays in the early stage of the Muon Spectrometer Commissioning; Afterwards the study of first collision data will require a major detailed commissioning of the muon trigger system which will later on evolve depending on the specific run conditions. At high luminosity the impact of the cavern background on the muon trigger rate and overall selectivity will require particular care as a consequence of the large uncertainties on the flux of soft neutral and charged particles diffusing in the whole spectrometer and on the very limited simulation capability for the processes leading to such background.

4. *take part to the early physics search program of ATLAS, with particular involvement in the search for SUSY processes with muonic signatures.*
   The understanding of the main systematic uncertainties affecting the muon reconstruction and trigger, gained in the work program outlined in 1-3, can be a strong help in facing any physics studies involving final states with muons. Therefore, I plan to organize the efforts of the working group members on a physics analysis task, possibly in the field of search for SUSY signal in the early ATLAS data. In most of the MSUGRA parameter space, super-symmetry manifests itself with an excess of leptonic final states. A deep control of the Standard Model background, including instrumental effects, is strictly necessary to the establishment of any signal or any constraint on this ot other kinds of new physics phenomena.

iii. Resources

The project proposed here consists of activities for software development, systematic studies of detector, data and algorithms and physics analysis. It, therefore, requires the establishment of a working group of people fully dedicated to the project and provided with significant capability of moving from INFN LECCE to CERN, in the experiment site, or wherever a specific middle-term objective of the project requires. It is estimated that three researchers, two post-doc with short-medium research experience and one with medium-high experience, would need to collaborate with the principal investigator. While sharing the same overall research goal and contributing all together to the undertaken physics analyses, the team members might individually concentrate their efforts mostly into one specific service item: one researcher will be particularly involved with HLT issues, one with Detector Description and Simulation, the other with calibration procedures with data. The estimated personnel cost accounts for the salary of the three team members. It is worth considering that team and the PI's activity will be performed half of the time in INFN LECCE and half abroad (mainly at CERN). On the other hand, mobility is the only source of the estimated direct costs of the project. The group activity will involve massive data processing, which will be performed using the grid facilities available to the ATLAS virtual organization. In particular, dedicated tasks requiring intensive CPU and large storage capability, might be negotiated with Italian or foreign Tier2 facilities. The final analyses of reconstructed, or otherwise processed, data will be performed with personal computing facilities or small size computing farms, dedicated to ATLAS activities, that INFN LECCE will provide access to. Only the personal computing facilities of the team members and principal investigator are considered as indirect additional costs of the project.

C. Research Environment

i. Transition to independence

Although my position at Università del Salento allows me to define my scientific activity in a independent manner, the organization of the activities in the national founding agency INFN and the history of my group and of its involvement in ATLAS didn't really allow me to effectively follow a personal research project in the collaboration. I judge this grant scheme an excellent opportunity for becoming fully responsible of a scientific project while remaining committed to the general scientific interest of my hosting organization.

ii. Hosting institution

INFN is a well established scientific organization with a wide range of activities in the area of fundamental scientific knowledge and advanced technology. Its long history does not need to be discussed here. The Sezione INFN of Lecce has been established in 1990 and it has progressively grown in terms of scientific associates or employees and scientific activities. It has provided a periphery Physics Department with the vitality of world class international scientific projects. In the area of high energy physics at particle accelerators INFN LECCE has taken part to E771 at FERMILAB (beauty production at fixed target), KLOE at DAΦNE (CP violation in the kaon system), ATLAS at LHC, MEG at PSI (search for the lepton flavour violating decay $\mu \to e\gamma$). In addition, many experiments for cosmic ray studies and astro-particle physics have been and are curried out (MACRO, ARGO, NOE, AUGER). The INFN High Energy Laboratory in Lecce has hosted the construction and test of several detectors (the KLOE drift chamber full scale prototype, the ATLAS RPC) in addition to experimental facilities dedicated to specific studies. The INFN Electronics Laboratory of Lecce has been developing custom electronics for MEG, ARGO, AUGER, CLUCOU. A very active mechanics design laboratory is also hosted in INFN LECCE; it has been strongly involved in the challenging ATLAS RPC mechanics design, after the successful project of the KLOE drift Chamber and the construction of its prototype. Finally, a computing service, managed by INFN LECCE, is providing support for any computing facilities requested by INFN activities, alongside with infrastructure and support for the Department computing needs. Highly professional personnel is in charge of network maintenance, general software management and support for grid infrastructures.

iii. Budget

The project outlined here involves activities for software development, systematic studies of detector, data and algorithms and physics analysis. It, therefore, requires the establishment of a working group of people dedicated to the project and provided with resources allowing a considerable mobility, for easy interaction with other members of the ATLAS collaboration involved in complementary studies. It is estimated that three researchers, 2 post-doc with short-medium research experience and one with medium-high experience, would need to collaborate with the PI. For them a salary of 45000 or 72000 euro per year is requested, depending on the past research experience (no personnel cost is requested for the PI, freely performing the proposed activity after its permanent position at Università del Salento). 120000 euro per year are requested for the mobility (mainly to CERN) of the group members (PI and three collaborators). It is assumed that the computing facilities of the INFN Tier2 (and eventually Tier1) will be available for the work of the group. Additional 20000 euro are requested for personal computing resources: laptops, desktops, mass storage.

iv. Additional participants

Although the planned work will necessarily be performed in strong collaboration with many groups and individuals in the ATLAS collaboration, no specific additional participants to the project are foreseen.