IL NUOVO CIMENTO Vol. ?, N. ? ?

Supersymmetry searches with ATLAS detector at LHC

U. De Sanctis(1) *on behalf of the ATLAS Collaboration*

(1) *Università di Milano - Dipartimento di Fisica and Istituto Nazionale di Fisica Nucleare - Sezione di Milano, Via Celoria 16, I-20133 Milan, Italy*

Summary. — In this paper a brief overview of the principal strategies for Supersymmetry searches with ATLAS detector at LHC is presented. The aim is to evaluate the ATLAS discovery potential within mSUGRA parameter space of Supersymmetry, both in inclusive and exclusive channels, and to estimate the achievable precision in SUSY parameters in relation to the integrated luminosity available at LHC.

11.30.Pb; 12.60.Jv; 14.80.Ly; 04.65.+e.

1. – Introduction

One of the main purposes of LHC is the search for physics beyond the Standard Model (SM). In this framework, Supersymmetry (SUSY) plays an important role, because it's one of the most popular and credited candidates to extend the SM [1]. It introduces a new symmetry that predicts the existence of super-partners for all ordinary SM particles. These super-partners have the peculiarity to follow a different statistic with respect to their SM partners. This means that for each SM boson, SUSY introduces a fermionic super-partner and vice versa. Therefore, following this symmetry, one can classify all SUSY particles foreseen by the theory dividing them into: scalar fermions (called sleptons and squarks) and gauginos (called Winos, Binos, Zinos, photinos and gluinos). Higgs sector is composed by two doublets of fermions (in order to avoid triangular anomalies) that give origine to five physical scalar bosons, and four fermionic partners called Higgsinos (two neutral and two charged).

While the gluino is a mass eigenstate, Higgsinos and the other gauginos mix giving four charged mass eigenstates called Charginos and four neutral mass eigenstates called Neutralinos. In the R-parity (1) conserving models, the lightest neutralino is the LSP (Lightest Supersymmetric Particle) that provides a suitable candidate for Dark Matter

---

(1) R-parity is a quantum number defined by the relation $R = (-1)^{3(B-L)+2S}$ where B is the barionic number, L is the leptonic number and S is the spin. For SM particles it has the value +1, while for SUSY particles has the value -1.

because it's stable, neutral and weakly interacting.
Nevertheless, SUSY has not been discovered yet, and this means that this symmetry must be broken (electron and s-electron have different mass). Hence, one needs to add in the lagrangian some terms breaking Supersymmetry in order to remove mass degeneracies between particles and their super-partners.
The final number of free parameters needed for MSSM (Minimal Supersymmetric Standard Model) is then 105, including mass terms, couplings, mixing angles and CP-violation phases. Because of this large number of free parameters, a more constrained framework called mSUGRA is often used at LHC in order to develop analysis strategies. In this framework, characterised by gravity mediated SUSY-breaking [2], there are only five independent parameters: the common gaugino mass $m_{1/2}$, the common scalar mass m_0, the common trilinear gauge coupling A_0 at some high unification scale, the ratio of the vacuum expectation values of the two Higgs doublets $tan\beta$ and the sign of the Higgsino mixing parameter μ. The top mass can be treited like a sixth independent parameter because it strongly affects the value of physical quantities.
All the analysis in this paper are performed in mSUGRA framework with the addition of the R-parity conservation.
If SUSY exists at the electroweak scale, as requested to solve hierarchy problem, it could hardly escape detection at LHC. The center-of-mass energy of 14 TeV available in proton-proton collisions at LHC, extends the search for SUSY particles up to masses of 2.5 to 3 TeV/c^2 [3].
SUSY particles will be produced in pairs and coloured states (scalar quarks and gluinos) are expected to dominate the production cross section; their decay chains into LSP, which escapes detection, produce an excess of events with multijets, missing energy and isolated leptons final states compared to the SM expectations.
In order to perform detailed studies of SUSY discovery potential for the ATLAS detector, specific sets of values of the mSUGRA space parameters have been chosen (benchmark points) [3]. These were selected taking into account the constraints arising from experimental data (in particular LEP experiments for direct limits on Higgs and SUSY particles and B-factory experiments for precision measurements of physical quantities influenced by SUSY contributions), from theoretical reasons (request of electroweak symmetry breaking mechanism) and from cosmological data (compatibility of abundance of cold Dark Matter in the Universe with relic density of lightest neutralinos). [4]
In many regions of the mSUGRA space parameters, this relic density is too large; therefore a mechanism of neutralinos annihilation is needed to put the relic density compatible with cosmological data. This happens in four relatively narrow regions of mSUGRA space:

- *Co-annihilation region:* Low m_0 region where the $\chi\tau$ annihilation process forces neutralinos density to be small;
- *Focus-Point region:* High m_0 and low $m_{1/2}$ region where the $\chi\chi$ annihilation allows relic neutralinos density;
- *Bulk region:* Low m_0 and low $m_{1/2}$ region, where the SUSY masses are very light;
- *Funnel region:* where the $\chi\chi \rightarrow Z^* \rightarrow H$ resonance yields relic density small.

After a brief description of the ATLAS detector in section 2, in section 3 an overview of the ATLAS performances for inclusive SUSY searches and discovery potential are reported, while in section 4 ATLAS performances for some significant exclusive channels are investigated.

2. – The ATLAS detector

The ATLAS detector is one of the two general purpose detectors constructed for the Large Hadron Collider at CERN in Geneva, that will start data taking at the end of 2007. The detector is designed to be sensitive to the full range of high p_T physics processes occuring in 14 TeV proton-proton collisions, with an emphasis on efficient tracking identification of charged particles, and accurate, large acceptance calorimetric measurement of shower p_T and E_T^{MISS}. The detector consists of the following main components:

- An inner detector for charged particle tracking and identification. Tracking close to the beam-pipe is provided by high granularity, radiation-hard Si microstrip and pixel detectors while at larger radii straw tubes sensitive to transition radiation signals provide both tracking and electron identification. Tracking extends to $|\eta| \approx 2.5$ with full coverage in ϕ(2).

- An electromagnetic sampling calorimeter (ECAL) providing electron and photon identification and measurement. The ECAL consists of lead absorber plates immersed in an active liquid argon (LAr) matrix read-out with a maximum granularity of 0.003 in η and 0.025 in ϕ. Electromagnetic calorimetry extends to $|\eta| \approx 3.2$.

- A hadronic sampling calorimeter (HCAL) providing jet p_T and E_T^{MISS} measurements over the range $|\eta| < 5$ with full coverage in ϕ. In the barrel region ($|\eta| < 1.7$) the HCAL consists of iron absorber plates instrumented with plastic scintillating tiles, while in the endcaps ($1.5 < |\eta| < 3.2$) LAr modules with Cu absorber are used. In the forward region ($3.1 < |\eta| < 4.9$) an active LAr matrix is again used, but with a tungsten absorber.

- A magnet system facilitating track p_T measuremets in the inner detector and muons system consisting of a central 2 Tesla solenoid and three superconducting air-cored toroids spanning the muon spectrometer.

Further details regarding the ATLAS detector and associates trigger and data acquisition systems can be found in [3].

3. – Inclusive SUSY search and discovery potential in ATLAS

3˙1. *Introduction.* – Inclusive searches essentially consist in a check for any significant deviation from SM predictions in channels characterized by a particular signature. If SUSY exists at the scale of about 1 TeV this kind of searches needs a relatively small integrated luminosity, but are strongly dependent on a very good knowledge of SM processes at that energy scale (never explored until now) and on an understanding of detector's performances. Hence, the goal of this kind of searches is to find a statistically significant deviation from SM predictions in some characteristic kinematical variable and to do an approximate estimation of the SUSY mass scale. More difficult in this case will

---

(2) $\eta = -ln(tan(\theta/2))$, ϕ is the angle in the orthogonal plane with respect to the beam axis.

be the possibility to strong constraints model's parameters.
All the ATLAS detector components will contribute to the detection of SUSY events: calorimeters for energy resolutions and hermeticities (measurements of jets by the ECAL and HCAL can lead to significantly increased rates of high-E_T^{MISS} backgrounds QCD events); tracking systems for b-jets tagging (especially Pixel sub-detector) and high p_T leptons reconstruction; muon chambers for a precise reconstruction of muon momenta.
In the R-parity conserving framework of mSUGRA model, LHC phenomenology is consisting in high multiplicity events of high p_T SM particles and two invisible LSPs (lightest neutralinos). Probably this framework is only a simplified approximation to the rich SUSY phenomenology but is nearly completely determined at hadron-collider by only two parameters (m_0 and $m_{1/2}$) which determine masses and production cross-sections of the strongly interacting sparticles (gluinos and squarks).
Inclusive searches for SUSY therefore concentrate on channels containing jets, n leptons and E_T^{MISS}, with the required number of leptons being varied depending on the desired signal-to-background ratio and hence sensitivity to systematic uncertainties in background rate.
The signal events from mSUGRA models in different points of $m_0 - m_{1/2}$ plane and principal background sources coming from $t\bar{t}$, W+n jets, Z+n jets and QCD events ($q\bar{q}$ production, except $t\bar{t}$) are generated, while parametrized detector simulation is carried out using ATLFAST [5].

3˙2. *Selection and optimization of Cuts.* – Cuts on the following variables are found to be the best to separate signal from background:

1. E_T^{MISS} : Missing E_T of event;
2. $p_{T(1)}$: p_T of hardest jet;
3. $p_{T(2)}$: p_T of second hardest jet;
4. $\Sigma_i |p_{T(i)}|$: Scalar sum of p_T of jets in event;
5. $M_{EFF} = E_T^{MISS} + \Sigma_i |p_{T(i)}|$: Effective mass;
6. N_j : Number of jets in event;
7. $p_{T(lep)}$: p_T of isolated leptons (if any);

These cuts are then optimized to find the maximum significance.

3˙3. *Results.* – A first kind of analysis that can be developped consists on choosing one of these kinematical variables for a specific channel jets+E_T^{MISS}+ n leptons (with $n = 0, 1, 2, 3$), on optimizing cuts for some of the others variables and on plotting it for signal SUSY events and for SM background events. A different behaviour of the shape of the distributions can show an eventual significant excess of events that SM does not foresee.
At this point it is useful define 'ATLAS' significance variable S_f. The definition is $S_f = S/\sqrt{B}$ for $S \geq 10$, where S and B are respectively the number of signal and background events. The 'ATLAS variable', that quantifies signal significance in standard deviation units in the gaussian statistical regime, is related to the probability that an observed excess of events S above the expected mean number of background events B is caused by an up-fluctuation of the background rather than the presence of a true signal.

The left plot of Fig.1 is obtained performing an inclusive analysis scanning the $m_0 - m_{1/2}$ plane [6] for different channels, using the 'ATLAS' significance variable S_f corresponding to a 5σ excess above background ($S_f = 5$) for 10 fb^{-1} of integrated luminosity.

The regions in this $\text{m}_0 - \text{m}_{1/2}$ plane below the various curves can be covered by ATLAS with an integrated luminosity of 10 fb^{-1} (corresponding to one year at starting luminosity of $2 \cdot 10^{33} \text{cm}^{-2}\text{s}^{-1}$). The E^T_{MISS} channel (with no lepton requirement) is found to give the gratest discovery potential, covering $\tilde{q}$ and $\tilde{g}$ masses up to 2 TeV. The next greatest discovery potential is provided by the lepton veto channel ('$0l$'), which performs better than the $n > 0$ lepton channel. However the channels with at least one isolated lepton are less sensible with respect to the systematics coming from QCD background that are difficult to estimate. This implies that these channels could be more competitive with the early data.

Extrapolating these results at lower values in integrated luminosity, already with 0.1 fb^{-1} (one week of running) it should be possible explore a wide region of the mSUGRA parameter space, up to about 1.5 TeV for gluinos and squarks mass values, as shown in the right plot of Fig.1.

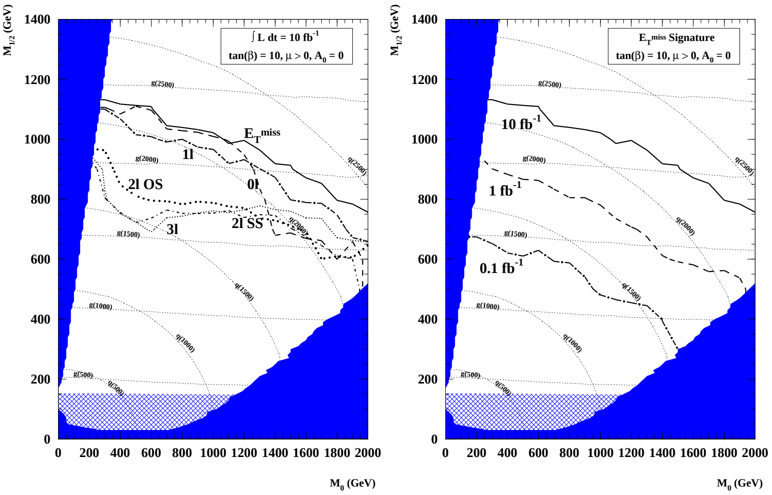

Figure 1. – Left Plot: 5σ discovery potential ('ATLAS variable') in the $m_0 - m_{1/2}$ plane for mSUGRA models with $tan\beta = 10$, $\mu > 0$ and $A_0 = 0$ assuming 10 fb^{-1} integrated luminosity. Bold curves correspond to: E^T_{MISS} channel (full curve), $0l$ channel (dashed curve), $1l$ channel (dash-dotted curve), $2l$ OS channel (i.e. Opposite Sign) (dotted curve), $2l$ SS (i.e. Same Sign) channel (dash-dash-dotted curve) and $3l$ channel (small dots). Light curves correspond to squark and gluino iso-masses contours (masses in GeV). The full dark regions are excluded because ISAJET (SUSY events generator) failed to converge, while the hatched dark regions are excluded by current experimental bounds from LEP [7], Tevatron [8] [9] and elsewhere. Right plot: 5σ discovery potential ('ATLAS variable') of the E^T_{MISS} channel in the $m_0 - m_{1/2}$ plane for mSUGRA models with $tan\beta = 10$, $\mu > 0$ and $A_0 = 0$ assuming 0.1 fb^{-1}, 1 fb^{-1} and 10 fb^{-1} integrated luminosity. Curves and shaded regions are the same of the left plot.

4. – Exclusive SUSY searches

4·1. *Introduction.* – Exclusive SUSY searches consist in reconstruction of specific decay channels in order to estimate physical parameters characterising the decay itself. At LHC this kind of searches aims at reconstructing kinematic endpoints (edges and thresholds) in invariant mass distributions of various subsets of particles (usually leptons and quarks and their combinations), because in R-parity conserving framework all SUSY particles decay to an invisible LSP (χ_1^0) and then there are no mass peaks.

It is clear that this analysis needs more statistic than inclusive one's because of precision needed to extract parameters from kinematical distributions, but it's the only one that is able to give strong constraints on mass spectrum and SUSY parameters.

A reconstruction of di-leptonic edge and a complete reconstruction of an entire decay chain based on it will be proposed in next section like a paradigm for this type of analysis.

4·2. *Di-leptonic edge reconstruction.* – This channel is the authentic 'golden channel' for exclusive studies. Despite its relatively small cross section, the signature of two isolated leptons in the final state provides a natural trigger, and the energy resolution is high.

Feynmann diagrams that contribute at this channel are shown in figure 2. The resulting distribution in phase-space is given in [10], but it's strongly dependent on mSUGRA space parameter region. For example, in Point SPS1A [11] lying in the 'Bulk region', where $m_{\chi_2^0}$ = 176.82 GeV, $m_{\tilde{l}_R}$ = 142.97 GeV and $m_{\chi_1^0}$ = 96.05 GeV, both diagrams contribute at the distribution on phase-space, while in 'FocusPoint region', where neutralinos masses are comparable but $m_{\tilde{l}_R}$ is in the multi-TeV region, only the diagram with Z-exchange gives a significant contribution. In this last case, moreover, for example for the FocusPoint benchmark point discussed in [13], there is also a contribution from direct decay $\chi_3^0 \rightarrow \chi_1^0 l^+ l^-$ (with almost the same branching ratio than χ_2^0 channel) that significantly modifies the di-leptonic invariant mass distribution.

More details on the analysis' strategies are avalaible for SPS1A point in [12] and for FocusPoint region in [13]. Here a final summary of the cuts choosen to isolate the decay channel:

For SPS1A point:

- At least 4 jets, the hardest three satisfying:
  $p_{T,1} > 150$ GeV, $p_{T,2} > 100$ GeV, $p_{T,3} > 50$ GeV;
- $M_{EFF} \equiv E^T_{MISS} + p_{T,1} + p_{T,2} + p_{T,3} + p_{T,4} > 600$ GeV;
- $E^T_{MISS} >$ max (100 GeV, $0.2 M_{EFF}$);
- Two isolated Opposite Sign Same Flavour (OSSF) leptons (not τ) with $p_T(l1) > 20$ GeV and $p_T(l2) > 10$ GeV.

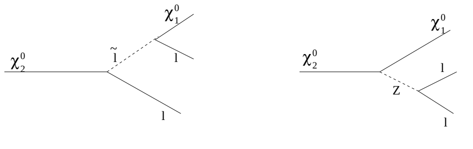

Figure 2. – Feynman diagrams of the neutralino leptonic decay.

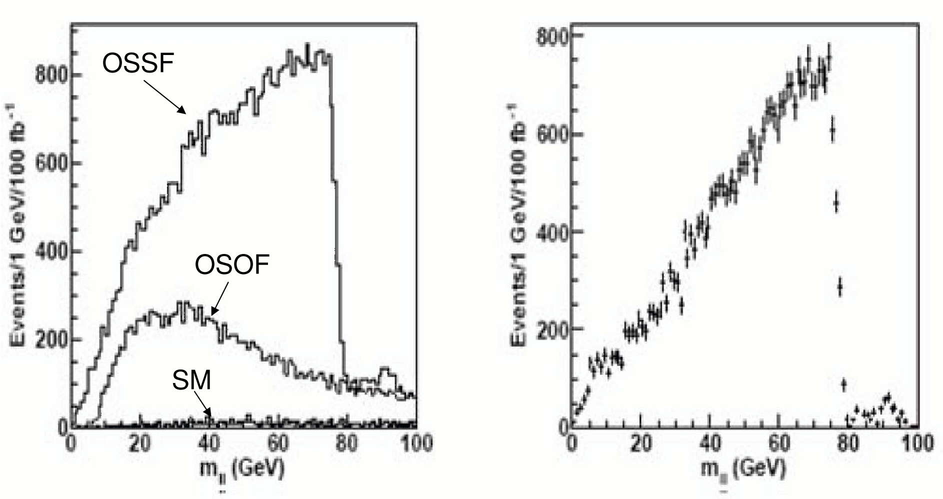

Figure 3. – Effect of subtracting background leptons, for an integrated luminosity of 100 fb^{-1}. In the left plot: the curves represent OSSF leptons, OSOF leptons and the SM contribution. In the right plot, the flavour subtraction OSSF-OSOF have been plotted: the triangular shape of the theoretical expectation is reproduced.

while for FocusPoint region:

- At least one jet with $p_T > 80$ GeV, at least four jets with $p_T > 60$ GeV, at least six jets with $p_T > 40$ GeV;
- $M_{EFF} \equiv E^T_{MISS} + \Sigma_i p_{T,i} > 1200$ GeV;
- $E^T_{MISS} > 80$ GeV, $E^T_{MISS}/M_{EFF} > 0.06$;
- Two isolated Opposite Sign Same Flavour (OSSF) leptons (not τ) with $p_T > 10$ GeV and $|\eta| > 2.5$.

These cuts have the aim to eliminate the only Standard Model process to have all the features of our signal event: $t\bar{t}$ production where both W's decay leptonically. However, because of pile-up and detector effects, other SM processes may also mimic the signatures above. For both analyses W+jets, Z+jets, ZZ/WW/WZ and QCD backgrounds samples are considered.

The basic signature of our decay chain are two OSSF leptons; but two such leptons can also be produced by other processes. If the two leptons are independent of each other, one would expect equal amounts of OSSF leptons and OSOF leptons (i.e combinations $e^+\mu^-$, $e^-\mu^+$). Their distributions should also be identical, and this allows us to remove the background contribution for OSSF by subtracting the OSOF events.

In Fig. 3 the invariant mass of the two leptons for SPS1A point is plotted; the same for FocusPoint region have been done in Fig. 4. In both case it's evident that SM background is clearly negligible. The real background consists of other SUSY processes, but these are effectively removed by the OSOF subtraction.

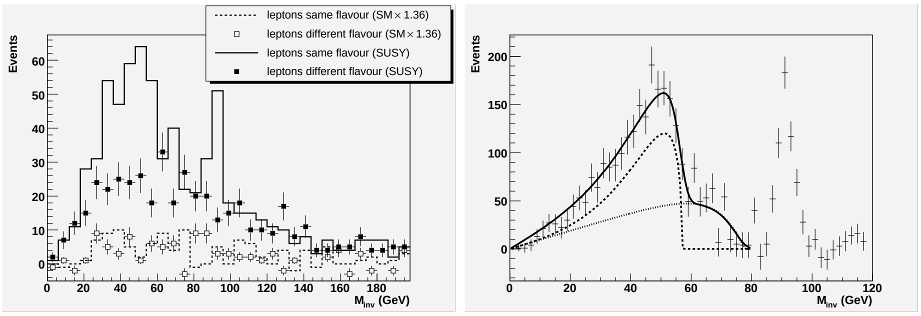

Figure 4. – In the left plot, full and dashed lines are the distributions of the OSSF di-lepton invariant mass respectively for SUSY events and SM background. The full markers (SUSY) and empty markers (SM) are the distribution of OSOF leptons. The number of events corresponds to an integrated luminosity of 30 fb^{-1}. In the right plot, flavour subtracted distribution of invariant mass of leptons pairs (*i.e.* OSSF-OSOF leptons), for an integrated luminosity of 300 fb^{-1}. The fit function (gaussian smearing of theoretical distribution [13]) is superimposed as a full line, while the contributions from χ^0_2 and χ^0_3 decays are shown separately as a dashed and dotted line respectively.

From these invariant mass distributions one can obtain constraints between involved masses following these relations:

$$(1) \qquad \begin{array}{ll} SPS1A: & (m^2_{ll})^{edge} = \frac{(m^2_{\chi^0_2}-m^2_{\tilde{l}_R})(m^2_{\tilde{l}_R}-m^2_{\chi^0_1})}{m^2_{\tilde{l}_R}} \\ FocusPoint: & (m_{ll})^{edge} = m_{\chi^0_{2,3}} - m_{\chi^0_1} \end{array}$$

Mass differences have been evaluated obtaining results showed in Table I. With 100 fb^{-1} (corresponding to one year at luminosity of $10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$) for SPS1A, a precision better than 0.1% should be possible. For the FocusPoint region, whose signal has a cross section smaller than SPS1A point, with an integrated luminosity of 300 fb^{-1}, a precision of 0.1% should be possible for the first edge. For the second edge, instead, the precision avalaible is about 2%.

This approach can also be used to estimate edges or thresholds coming from the complete decay chain. For SPS1A point, because right-handed squarks decay directly to the LSP,

Table I. – *Endpoints values found from fitting the edges in Fig. 3 and Fig. 4. The largest cross section for SPS1A point with respect to FocusPoint allows a better precision in edge measurements with lower integrated luminosity.*

Point	Int.lumin.	EDGE	Nominal value	Fit value	Stat. Error
SPS1A	100 fb^{-1}	$m(ll)^{edge}$	77.077 GeV	77.024 GeV	0.05 GeV
FocusPoint	300 fb^{-1}	$m(\chi^0_2) - m(\chi^0_1)$	57.02 GeV	57.2 GeV	0.4 GeV
	300 fb^{-1}	$m(\chi^0_3) - m(\chi^0_1)$	76.41 GeV	78.1 GeV	1.4 GeV

due to the bino-like nature of χ_1^0, left-handed squarks decay to χ_2^0 giving the decay chain:

$$\tilde{q}_L \to q\chi_2^0 \to q l_2^{\pm} \tilde{l}_R^{\mp} \to q l_2^{\pm} l_1^{\mp} \chi_1^0 \tag{2}$$

where $\tilde{q}_L$ is a quark of the first two generations; a similar decay involving sbottom quark is also possible. Plotting invariant masses of combinations of one jet with one or both leptons, and using eq.3 and eq.4 (more details in [14]), is possible to estimate edges in the qll or ql combinations, as shown in Fig.5, fitting the endpoints of the distributions.

$$(m_{qll}^2)^{edge} = \frac{(m_{\tilde{q}_L}^2 - m_{\chi_2^0}^2)(m_{\chi_2^0}^2 - m_{\chi_1^0}^2)}{m_{\chi_2^0}^2} \tag{3}$$

$$(m_{ql}^2)^{edge}_{max} = \frac{(m_{\tilde{q}_L}^2 - m_{\chi_2^0}^2)(m_{\tilde{l}_R}^2 - m_{\chi_1^0}^2)}{m_{\tilde{l}_R}^2} \tag{4}$$

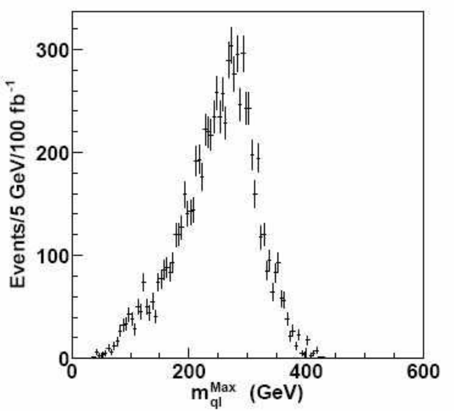

Figure 5. – Invariant mass distributions with kinematical endpoints, for an integrated luminosity of 100 fb^{-1}. In the left plot for qll combination, in the right plot for the maximum of ql combination.

The precisions in this measurements is worst than in di-leptonic edge, but 100 fb^{-1} are enough to evaluate the edges with a precision of order of 1%.

5. – Conclusions

If Supersymmetry exists at the electroweak scale, the initial discovery depends on how quickly we can understand the systematics coming from the detector and the background knowledge. Studies in both inclusive and exclusive search channels have been presented, in the framework of mSUGRA model with R-parity conservation.

Inclusive searches will be sensitive to models with squark and gluino masses ≤ 2 TeV for 10 fb^{-1} of integrated luminosity independent of the value of $\tan\beta$. The greatest discovery potential is obtained with the inclusive jets+E^T_{MISS} channel incorporating no lepton requirements, followed by the zero lepton, one lepton and multi-lepton channels, even if the channels with at least one isolated lepton could be more competitive with early data, because their smaller dependence on QCD background systematics.
For exclusive searches, the cleanest signature is the opposite sign same flavour invariant mass distribution of leptons pairs (electrons and muons). From its endpoints, one can extract precise constraints on differences in masses between s-particles involved in the decay chain, with a statistical precision of 0.1% or better, with an integrated luminosity of 100 fb^{-1} or more, depending on regions of mSUGRA space parameters.

* * *

This work has been performed within the ATLAS Collaboration, making use of the detector fast simulation and tools which are the result of collaboration-wide great efforts. I wish to thank the community of the ATLAS SUSY World Group, who has strongly contributed to the work presented here. My sincere thanks to T.Lari, C.Troncon (INFN Milano) and my PhD tutor F.Ragusa (University of Milano) for their helpful suggestions and comments on the preparation of this document and for stimulating and encouraging me in my daily work.

REFERENCES

[1] Y.GOL'FAND AND E.LIKTHMAN: *JETP Lett.* **13** (1971) 323;
D.VOLKOV AND V.AKULOV: *Phys. Lett.* **B46** (1973) 109;
J.WESS AND B.ZUMINO: *Nucl. Phys.* **B70** (1974) and **B78** (1975) 1.
[2] H.P.NILES: *Phys Rev.* **110** (1984) 1;
A.H.CHAMSEDDINE, R.ARNOWITT AND P.NATH: *Phys. Rev. Lett.* **49**, 970 (1982).
[3] THE ATLAS COLLABORATION: *'ATLAS Detector and Physics Performance Technical Design Report'*, CERN/LHCC 99-14 (1999).

[4] J.R.ELLIS: *et al.*, *Phys. Lett.* **B565** (2003) 176;
H.BAER AND C.BALASZ: *J. Cosmol. Astr. Phys.* **0305** (2003) 006.
[5] E.ROCHTER-WAS, D.FROIDEVAUX AND L.POGGIOLI: *ATLAS NOTE* **ATL-PHYS-98-131**.
[6] D.R.TOVEY: *Eur. Phys. J.* **C4**, N4 (2002).
[7] LEPSUSYWG, ALEPH, DELPHI, L3 AND OPAL EXPERIMENTS: *note LEPSUSYWG/01-03.*
[8] F.ABE *et al.*: *Phys. Rev. Lett.* **76** (1996) 2006.
[9] B.ABBOTT *et al.*: *Phys. Rev. Lett.* **83** (1999) 4937 24.
[10] M.M.NOJIRI AND Y.YAMADA: *Phys. Rev.* **D60** (1999) 015006.
[11] B.C.ALLANACH: *et al.*: *Proc. of the APS/DPF/DPB Summer Study on the Future of particle Physics (Snowmass 2001)* edited by N.GRAF, *Eur. Phys. J.* **C 25** (2002) 113 [eConf **C010630** (2001) P125] [hep-ph/0202233].
[12] B.K.GJELSTEN, E.LYTKEN, D.J.MILLER, P.OSLAND AND G.POLESELLO: **ATL-PHYS-2004-007**.
[13] U.DE SANCTIS, T.LARI, S.MONTESANO, C.TRONCON: **ATL-PHYS-2006-023**.
[14] B.C.ALLANACH, C.G.LESTER, M.A.PARKER AND B.R.WEBBER: *JHEP* **0009** (2000) 004 [hep-ph/0007009].