

# **Prospects For Charged Higgs Discovery At Colliders (CHARGED 2010)**

Monday, 27 September 2010 - Thursday, 30 September 2010

Uppsala

## **Book of Abstracts**



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## Evolution of Universe to a modern state if Dark Matter is given by additional Higgs doublet (inert model)

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We discuss thermal evolution of Universe after inflation in the frame of Inert doublet model in the case when modern state of Universe with dark matter is described by inert doublet model.

### Summary:

There is an opportunity that Dark Matter is given by additional as compare SM, Higgs doublet (inert model). This Higgs doublet interacts with standard Higgs doublet and don't interact to fermions. During cooling down of Universe parameters of this interaction vary. It can results in change of phase states of Universe. In particular, very probable variant is that after EWSB transition the Universe comes to the state without candidates for Dark Matter and only later on it comes to the modern state with Dark Matter either via 1-st order phase transition or via chain of two 2-nd order phase transitions.

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## Charged Higgs production and decay for Signature of Inert Higgs Doublet Model.

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We propose method for using of production of charged Higgs pair in  $e^+e^-$  collisions (at LC) for discovery of Dark Matter (DM) particles and measuring of their mass if they appear as scalar of Inert doublet model. In many cases this approach is also useful for another mechanisms of DM.

### Summary:

There is an opportunity that Dark Matter is given by additional as compare SM, Higgs doublet (inert model). This Higgs doublet interacts with standard Higgs doublet and don't interact to fermions. This additional Higgs doublet is realized as 3 scalars, neutral scalar D and pseudoscalar  $D_A$  and charged scalar  $D^\pm$ , with conservation of  $D$ -parity. In this model D realizes Dark Matter (DM) while  $D^\pm$  and  $D_A$  are more heavy. Typically  $M_D < 80$  GeV. The best machine for checking on this model is  $e^+e^-$  Linear Collider. The dominant decay of  $D^\pm$  is decay to  $DW^\pm$  with  $W$  either on mass shell (if mass of  $D^\pm$  is high enough) or beyond. The main discovery channel is  $e^+e^- \rightarrow D^+D^- \rightarrow W^+W^-DD$ . The cross section of this process is about 5% from that of entire hadron production. We suggest to observe  $W$  bosons in two jet modes and to measure their effective mass  $M_{jj}$ . The signature of this process is observation of these two  $W$ 's with large missed transverse energy. The SM processes with such production

has much lower cross section (additional factors  $\alpha$  for each additional neutrino). The details of momentum distribution of produced  $W$  allow to determine masses  $D^\pm$  and  $D$  with reasonable accuracy. The measuring of cross sections  $e^+e^- \rightarrow D^+D^-h$  and  $e^+e^- \rightarrow D^+D^-hh$ ,  $e^+e^- \rightarrow D^+D^-DD$  allows to determine all couplings of model.

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## ttbar backgrounds in charged Higgs searches

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Top quark pair production is the main background for searches in most charged Higgs boson channels. The characteristics of this background are shown, as well as the contribution of the different ttbar decay modes: they can be separated into “irreducible” ttbar modes with the same final state as the signal, and “reducible” modes which contributes e.g. if an electron is misreconstructed as a tau. I will then present techniques to suppress and estimate the ttbar background contribution to the charged Higgs boson searches.

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## Implications of Yukawa texture in the charged Higgs boson phenomenology within 2HDM-III

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We discuss the implications of assuming a four-zero Yukawa texture for the properties of the charged Higgs boson within the context of the general 2-Higgs Doublet Model of Type III. We begin by presenting a detailed analysis of the charged Higgs boson couplings with heavy quarks and the resulting pattern for its decays, including the decay  $H^+ \rightarrow W^+\gamma$  at 1-loop level. The parameters chosen can still avoid the  $B \rightarrow X_s\gamma$  constraint, the perturbativity and  $\rho_0$  bound. Also, we present the constraints of  $B0 - \bar{B}0$  mixing and of the radiative corrections to the  $Zb\bar{b}$  vertex in the regime small  $\tan\beta$ . The production of charged Higgs bosons is also sensitive to the modifications of its couplings, so that we also evaluate the resulting effects on the top decay  $t \rightarrow bH^+$  as well as on direct  $c\bar{b} \rightarrow H^+ + c.c.$  and indirect  $q\bar{q}, gg \rightarrow \bar{t}bH^+ + c.c.$  production. Significant scope exists at the Large Hadron Collider for several  $H^\pm$  production and decay channels combined to enable one to distinguish between such a model and alternative 2-Higgs doublet scenarios.

**Summary:**

1. Implications of four-zero Yukawa texture for the 2HDM-III.
2. A detailed analysis of the charged Higgs boson coupling with fermions.
3. The resulting pattern for the decays of the charged Higgs boson.



4. The decay  $H^+ \rightarrow W^+\gamma$  at one-loop level.
5. Some electroweaks constraints for mass of the charged Higgs bosons and for parameters of Higgs potential.
6. The top decay  $t \rightarrow bH^+$
7. The direct'  $c\bar{b} \rightarrow H^+ + c.c.$  and indirect'  $q\bar{q}, gg \rightarrow \bar{t}bH^+ + c.c.$  production.
8. We evaluate the events rates at the LHC.

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## Charged-Higgs phenomenology in the Aligned two-Higgs-doublet model

**Author:** Martin Jung<sup>1</sup>

<sup>1</sup> *IFIC*

The alignment in flavour space of the Yukawa matrices of a general two-Higgs-doublet model results in the absence of tree-level flavour-changing neutral currents. In addition to the usual fermion masses and mixings, the aligned Yukawa structure only contains three complex parameters, which are potential new sources of CP violation. For particular values of these three parameters all known specific implementations of the model based on discrete  $Z_2$  symmetries are recovered.

One of the most distinctive features of the two-Higgs-doublet model is the presence of a charged scalar. In this talk, I will discuss its main phenomenological consequences in flavour-changing processes at low energies, ranging from leptonic decays to the recently widely discussed like-sign dimuon charge asymmetry.

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## Status of the CMS experiment

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The review of the latest CMS physics results related to the preparation for the charged Higgs boson discovery at LHC will be given. In particular, the performance of the jet and missing  $E_t$  reconstruction, b-jet tagging, the measurement of the jet-tau fake rate will be presented. The results on the W and Z cross-section measurement and observation of  $t\bar{t}$  events will also be shown.

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## Status of the ATLAS experiment

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The ATLAS Experiment at the CERN Large Hadron Collider was operated with colliding proton beams at 7 TeV center of mass energy since March 2010. It will study a broad range of particle physics at the highest available laboratory energies, from measurements of the standard model to searches for new physics beyond the standard model. At the time of writing ATLAS, with high data taking efficiency, has integrated a luminosity of 330 nb<sup>-1</sup>, which allowed already observation and measurement of standard model processes, like vector boson and top production. Detector status, event reconstruction and particle identification performance in this first period of operation will be presented together with the first physics results.

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## **ATLAS discovery prospects for the charged Higgs in the $H^{\pm} \rightarrow \tau \mu \nu$ final state**

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We present projections for the ATLAS sensitivity to a light charged Higgs boson in channel  $H^{\pm} \rightarrow \tau \mu \nu$ , present in models beyond the Standard Model, with an expected dataset corresponding to an integrated luminosity of 1fb<sup>-1</sup> gathered at the ATLAS detector with the LHC running at 7 TeV. The results are based on re-scaling expectations from detailed analyses at 10 TeV using cross-section ratios.

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## **CMS performance on b reconstruction**

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The identification of jets containing the weak decay of a B-hadron is an essential tool for a wide range of analyses in the context of the Standard Model and beyond. A variety of algorithms exploit the long lifetime and the presence of soft leptons to discriminate these jets from those associated to light quarks. The distributions of the corresponding observables - track impact parameters, secondary vertices and lepton momenta - were measured in pp collisions at  $\sqrt{s} = 7$  TeV and compare well to the predictions of Monte Carlo simulation. First results on efficiencies and mis-identification rates are shown.

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## Missing Et and jets, trigger and reconstruction efficiency in CMS

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The reconstruction of the missing transverse energy and jets, the trigger plans and the reconstruction efficiencies in the CMS detector are discussed. The performance with the 7 TeV proton-proton collision data is presented.

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## Charged Higgses production via vector-boson fusion at NNLO in QCD

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We present the total cross sections at next-to-next-to-leading order (NNLO) in the strong coupling for single and double charged Higgs production via weak boson fusion. Results are obtained via the structure function approach, which builds upon the approximate, though very accurate, factorization of the QCD corrections between the two quark lines. We also provide an estimate for the theoretical uncertainty on the total cross sections at the LHC from higher order corrections and the parton distribution uncertainties.

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## Charged Higgs in CP-conserving 2HDM

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The LHC has started colliding protons. Several extensions of the Standard Model predict a charged scalar particle which according to the LEP bound could be as light as 100 GeV. In this work we compare the four flavour conserving Yukawa versions of a CP-conserving two-Higgs doublet model (2HDM) regarding charged Higgs production and decay. We define a set of benchmarks where an early detection is possible at the 14 TeV LHC. Furthermore, we determine the luminosity required to distinguish between the four Yukawa versions of the CP-conserving 2HDM for a chosen set of benchmarks.

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## **double charged scalars of littlest higgs model in ee colliders**

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Little higgs models, as a result of extended symmetry group of S.M contain heavy scalars in their content of particles. In the littlest Higgs model of little Higgs models there exists a new heavy scalar triplet. The physical states of this triplet contains a double charged scalar, a single charged scalar, as well as a neutral scalar and a neutral pseudoscalar. In little higgs models a majorana type mass term can also be implemented in yukawa lagrangian, resulting lepton flavour violation.

In this work the pair production of double charged scalars in the context of littlest higgs model in ee colliders is studied. Also the final signatures of double charged scalars are investigated depending on lepton flavour violation parameters. Finally it is seen that if there is lepton flavour violation double charged scalars can be observed without any SM background in ee colliders with a collider signal of four leptons, otherwise if there is no lepton flavour violation they can be reconstructed with a background analysis.

**Invited talks on experiment / 15**

## **Status of the LHC machine**

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**Invited talks on experiment / 16**

## **Status of the ATLAS experiment**

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**Invited talks on experiment / 17**

## **Status of the CMS experiment**

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## **Coffee break**

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## **Review of charged Higgs searches at the Tevatron**

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## **Review of indirect charged Higgs searches at B factories**

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## **Interpretation of charged Higgs effects in low energy flavour physics**

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Invited talks on theory and phenomenology / 22

## **Light charged Higgs in NMSSM**

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Invited talks on theory and phenomenology / 23

## **Charged Higgs in Extended Higgs models (non-type II model)**

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Invited talks on theory and phenomenology / 24

## **Higher order corrections to charged Higgs production including EW corrections**

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Invited talks on theory and phenomenology / 25

## **Tools for charged Higgs bosons**

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**discussion on benchmark scenarios / 26**

## **Reports from the Charged Higgs Benchmark working group: general 2HDM**

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**Contributed talks on theory and models / 27**

## **Charged Higgs production at NLO in 4FS vs 5FS**

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## **Contributed talks**

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## **Associated charged Higgs and top production in MC@NLO**

**Corresponding Author:** tilman.plehn@cern.ch

**Contributed talks on phenomenology and tools / 30**

## **HiggsBounds**

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## **Contributed phenomenology talks**

**Contributed talks on charged Higgs analysis tools and backgrounds / 32**

## **Tau trigger and tau reconstruction, efficiency and fake rates in ATLAS**

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Contributed talks on charged Higgs analysis tools and backgrounds / 33

## **b reconstruction, efficiency and fake rates in CMS**

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## **Missing ET and jets, trigger and reconstruction efficiency**

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## **QCD backgrounds in charged Higgs searches**

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## **W + jets backgrounds in charged Higgs searches**

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## **ttbar backgrounds in charged Higgs searches**

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## **Search strategies for charged Higgs in ATLAS**

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## **Search strategies for charged Higgs in CMS**

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## **Systematics in charged Higgs searches in ATLAS**

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## **Systematics in charged Higgs searches in CMS**

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## **ATLAS discovery prospects for the charged Higgs in the $H^{\pm} \rightarrow \tau \mu \nu$ final state**

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Contributed talks on charged Higgs search strategies and systematic / 43

## **ATLAS discovery prospects for a light charged Higgs in the $H^{\pm} \rightarrow c \bar{s}$ channel**

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## **Charge Higgs physics at CLIC/ILC**

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## **Summary and outlook for theory**

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## **Summary and outlook for experiment**



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## **Tau trigger and tau reconstruction, efficiency and fake rates in ATLAS**

**Author:** Yann Coadou<sup>1</sup>

<sup>1</sup> *CPPM Marseille*

Tau leptons will play an important role in the physics program at the LHC. In particular, they provide a useful signature in searches for new phenomena like charged Higgs bosons or Supersymmetry. In addition, they are being used for standard model electroweak measurements and for detector related studies such as the determination of the missing transverse energy scale.

Due to the huge background from QCD processes, efficient tau identification techniques with large fake rejection are essential. Tau objects appear as collimated jets with low track multiplicity and single variable criteria are not enough to efficiently separate them from jets and electrons.

We report on the commissioning steps and performance of the tau trigger, which is designed to efficiently reject low-energy jets while keeping a high efficiency with respect to hadronic tau leptons identified by the offline algorithms.

We present the current status of tau reconstruction and identification at the LHC with the ATLAS detector. Reconstructed tau candidates in dijet backgrounds and  $W \rightarrow \tau \nu$  signal events are studied in data and compared with predictions from Monte Carlo simulation. The performance of the fake tau rejection is estimated in a dijet data sample. We discuss the plans for measuring tau identification efficiency using  $Z \rightarrow \tau \tau$  signal events and the fake rate using photon+jet and  $Z$ +jets background events. Both cut-based and more advanced multivariate techniques which make optimal use of all the information available are presented. These standard model measurements are instrumental in validating tau identification for discovery physics.

**Invited talks on experiment / 48**

## **Welcome by Vicerector Joseph Nordgren**

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## **Charged Higgs production via vector-boson fusion at NNLO in QCD**

**Corresponding Author:** marco.zaro@uclouvain.be

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## **Evolution of Universe to a modern state if Dark Matter is given by additional Higgs doublet (inert model)**

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## **The Inert Doublet Model as the Dark matter**

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## **Charged Higgs production and decay for Signature of Inert Higgs Doublet Model**

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## **Hidden Higgs Doublet model**

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## **Double charged scalars of littlest higgs model in ee colliders**

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## **2HDMC –a two Higgs Doublet Model Calculator**

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## **Flavour constraints and SuperIso**

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## **Constraining the Charged Higgs Mass in the MSSM: A Low-Energy Approach**

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Contributed talks on phenomenology and tools / 58

## **Charged Higgs in CP-conserving 2HDM**

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## **Implications of Yukawa texture in the charged Higgs boson phenomenology within 2HDM-III**

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## **Charged-Higgs phenomenology in the Aligned two-Higgs-doublet model**

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## **Higher-order corrections to $M_{H^+}$ and $\text{stop}_i \rightarrow \text{sbottom}_j H^+$**

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## **Registration**

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## **Report from the Charged Higgs benchmark working group: NMSSM**

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## **Report from the Charged Higgs benchmark working group: Sparticle prod and decay**

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## **Transfer function treatment of leptonic tau decays in the Matrix Element Method**

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