Search for Fundamental Particles and Underlying Physics at Large Hadron Collider

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New Physics search at Large Hadron Collider

- **Stability and boundedness with scalar potential**
  - Thesis work [1] - Done

- **Kinematic variables for event selection**
  - Ongoing

- **Compressed SUperSYmmetry with Higgs & Dark Matter constraints**

- **HEP code development**
  - Ongoing

- **Machine learning & Big data analysis**
  - Ongoing & Future direction

- **Mass measurement & Event reconstruction with semi-invisible events**
  - Thesis work [2] - Done

- **TeV scale seesaw mechanism & neutrino signatures**
  - Ongoing

- **Testing space-time non-commutativity**
  - Thesis work [3] - Done

- **Jet substructure & boosted objects**

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Mass measurements are complicated once dark matter particles involved.
- Dark matter particles are invisible at the detector.
- We construct optimal variable using all available informations.
- Constrains unstable particle mass

- Reconstruct dark matter particle mass at LHC.
- Reconstruct the event with invisible momenta

Usefulness of different kinematic variables sensitive to the compressed mass region
Propose a search strategy considering phenomenological clean search channel
Exploring CP phase in T-lepton Yukawa coupling in Higgs decays at the LHC
Opening up challenging compressed top squark region
Exact mechanism for the generation of small neutrino mass is yet unknown.

TeV-scale seesaw models -
Smallness of neutrinos mass is attributed to:
- small lepton number violating coupling. (Minimal Linear Seesaw)
- an unconstrained matrix R originated from Casas-Ibarra parametrization. (Quasi Degnerate neutrinos)

Fully reconstructible from present neutrino oscillation data
Can be probed at the LHC

Discovery potential at LHC.

- Next-to-Leading Order QCD corrections to the heavy neutrino production

Stability of the vacuum from scalar potential

- Recently discovered Higgs has a submissive impact on stability of the new physics models

- New mathematical prescription for computing the vacuum stability criteria developed

- Also studied Implications of unitarity and charge breaking minima in ugh left-right symmetric model

- Phys. Rev. D91 (2015) 075007
- Phys. Rev. D91 (2015) 095007
- JHEP 1606 (2016) 019

- Phys. Rev. D89 (2014) 095008
Field theories on the non-commutative spacetime introduce a fundamental length scale in the model. Such effect is tested at the LHC.

- Utilising well understood Drell-Yan process
- Some exotic vertices contribute in tree level.
- Some of the characteristic signatures, such as oscillatory azimuthal distributions, are an outcome of the momentum-dependent effective couplings.

Compressed spectrum was proposed as an explanation for the elusiveness of low-energy supersymmetry. Significantly hindered the search with a weaker bound.

- Consistent with the observed Higgs mass
- Consistent with the dark matter constraints
- Full spectrum is compressed

Multi-jet + MET and mono-jet + MET final states are studied and compared.
Jet substructure & boosted objects at LHC

- Recently developing ideas on utilising additional information in highly boosted events
- Substructure brings capability in event selection
- New tool to control backgrounds at the LHC.

- High energy collider
- Higher resolution at detector calorimeter
- Fast jet algorithm

HEP code development

- Available codes are typically developed by HEP community and diverse
- Several gaps are identified where progress can be made.

Machine learning - Big data - AI

- Emerging area of research based on deep learning
  - Can be extremely handy at the HEP study too
    - Classification
    - Regression

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