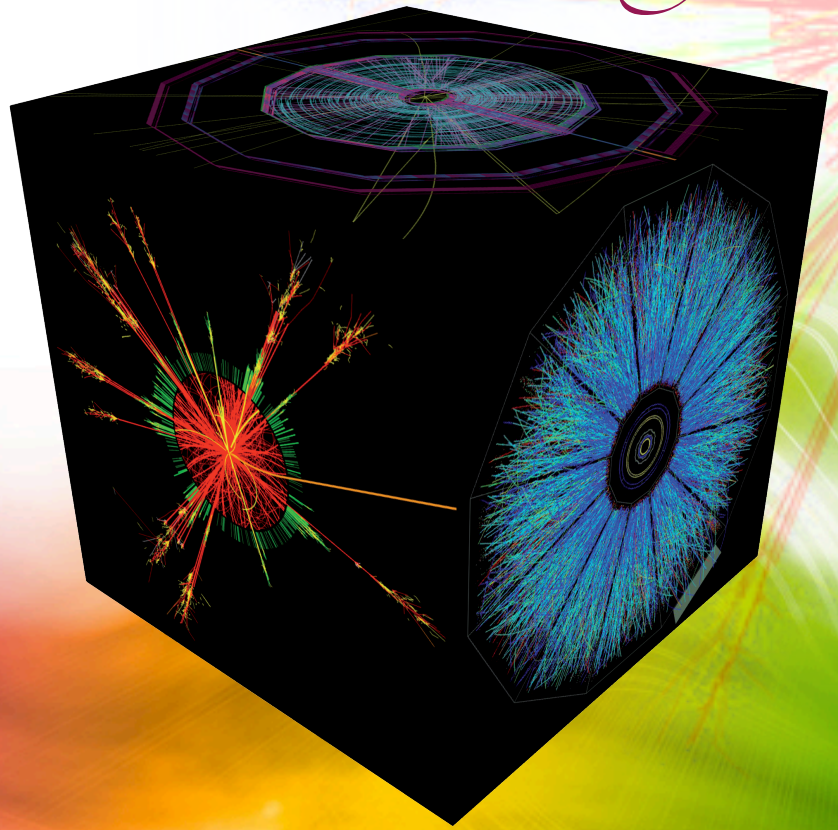
Search for Fundamental Particles and Underlying Physics at Large Hadron Collider



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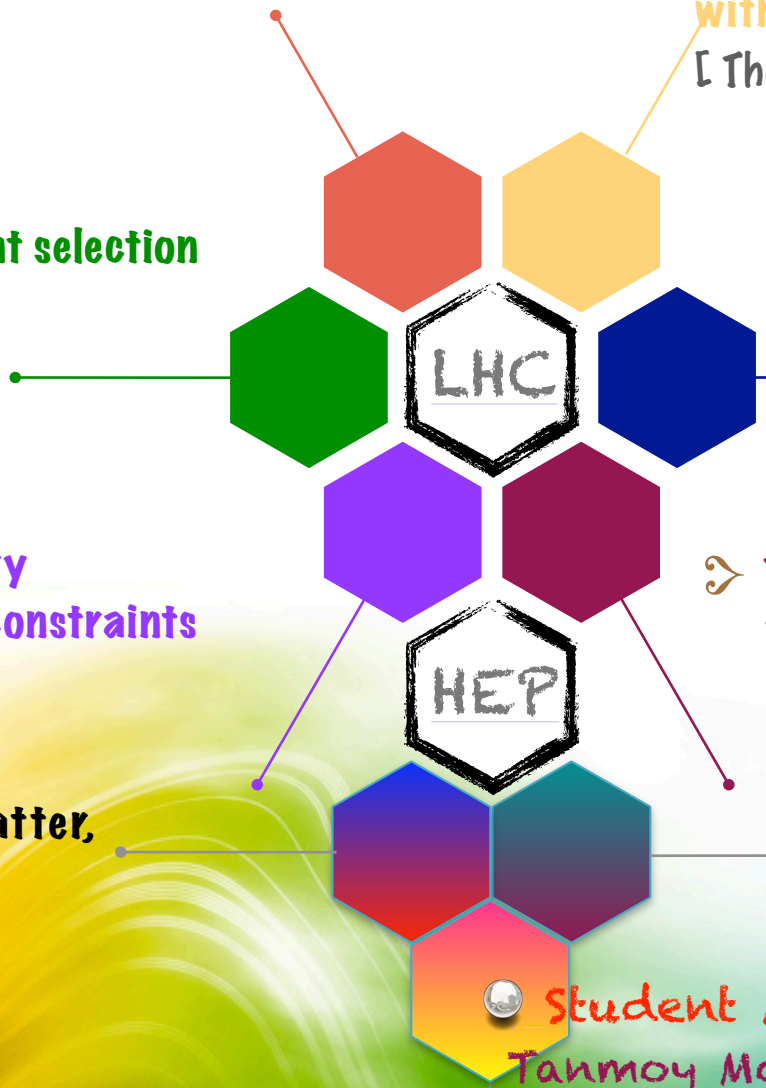
Scientific works during PRL — In few classes

New Physics search at Large Hadron Collider

- **Stability and boundedness with scalar potential**
  [Thesis work [1]]
- **Mass measurement & Event reconstruction with semi-invisible events**
  [Thesis work [2]]
- **Kinematic variables for event selection**
  [Ongoing]
- **TeV scale seesaw mechanism & neutrino signatures at collider**
  [Thesis work [8]]
- **Compressed SUperSYmmetry with Higgs & Dark Matter constraints**
  [Thesis work [9]]
- **Testing space-time non-commutativity**
  [Thesis work [3]]
- **Models on Dark Matter, neutrino mass, Leptogenesis**
  [Thesis work [6] : Ongoing]
- **Jet substructure & boosted objects**
  [Thesis work [4] : Ongoing]
- **Machine learning & Big data analysis**
  [Thesis work [5] : Ongoing]



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Mass measurement & Event reconstruction of semi-invisible events with exotics at the LHC

- ✺ 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

- ◉ Phys. Rev. D93 (2016) 015021
- ◉ Phys. Lett. B757 (2016) 211
- ◉ JHEP 1503 (2015) 142

Kinematic variables for event selection at LHC Higgs property from semi-invisible decay

- ☑ 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

- ◉ J. Phys. G (2019) 10500
- ◉ JHEP 1804 (2018) 024
- ◉ Phys. Rev. D96 (2017) 9. 095011

TeV scale seesaw mechanism & signatures at LHC

- 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

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

Stability & boundedness of scalar potential

- 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. D89 (2014) 095008
- Phys. Rev. D92 (2015) 096005

Testing non-commutativity at the LHC

- 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.

- JHEP 06 (2019) 108
- Phys. Rev. D93 (2016) 116003
- Int.J.Mod.Phys. A30 (2015) 1550159

Compressed SUSY with 125 GeV Higgs

- ❖ 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

- e-Print: (2020) 2007.00351
- JHEP 1601 (2016) 051
- JHEP 1601 (2016) 051

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

- e-Print: (2020) 2007.00351
- *J.Phys.G* 47 (2020) 7, 075002
- Phys.Rev.D 100 (2019) 5, 055040
- JHEP 1802 (2018) 083

Physics at Next to Leading Order

- NLO calculations are extremely important in precision prediction while several LHC measurements tests for new physics.
- Detailed analysis in production of heavy neutrino production at different HEP collider.

- *JHEP* 06 (2016) 019
- *Phys.Lett.B* 647 (2007) 460-465

Dark Matter, neutrinos mass & Cosmology

- Model building and computation of properties
- Constraints and Phenomenological study

Such effect can be tested at the LHC

- ☑ Utilising well understood theoretical and experimental constraints
- ☑ Singlet-doublet dark matter scenario, explaining light neutrino mass in seesaw mechanism,

- e-Print: (2020) 2007.15608
- *Phys.Rev.D 102 (2020) 015024*

Machine learning - Big data - AI

- ❖ Emerging area of research based on deep learning
- ☑ Huge improvement over traditional search

- Invisible Higgs search at VBF - One of the very important channel probing BSM through Higgs
- Shown - impressive capability to improve the bound on invisible branching ratio by a factor of three
- Analysed with CNN and different High-level and low-level variables

- e-Print: (2020) 2008.05434