New weakly interacting particles

Scope of the project:

- Hierarchy problem and WIMP DM → new electroweak physics
- Construct and study minimal models:
  - Higgsino and gaugino sectors of natural SUSY / split SUSY, also in extensions of the MSSM
  - generalisation: any sub-TeV massive states with EW quantum numbers
  - minimal dark matter models; dark matter with mediator couplings
- Recast existing experimental limits
- Estimate future reach of colliders and direct detection

People involved:

- Aoife Bharucha (CPT)
- Felix Brümmer (LUPM)
- Michele Frigerio (L2C)
- You, potentially (let us know if you want to join). Some common interests with PESBLADE members, SuSpect development team.
- Future PhD student of F.B. (LUPM), starting October 2015
- Future OCEVU postdoc (LUPM or L2C), starting autumn 2016

Expertise and area of contributions:

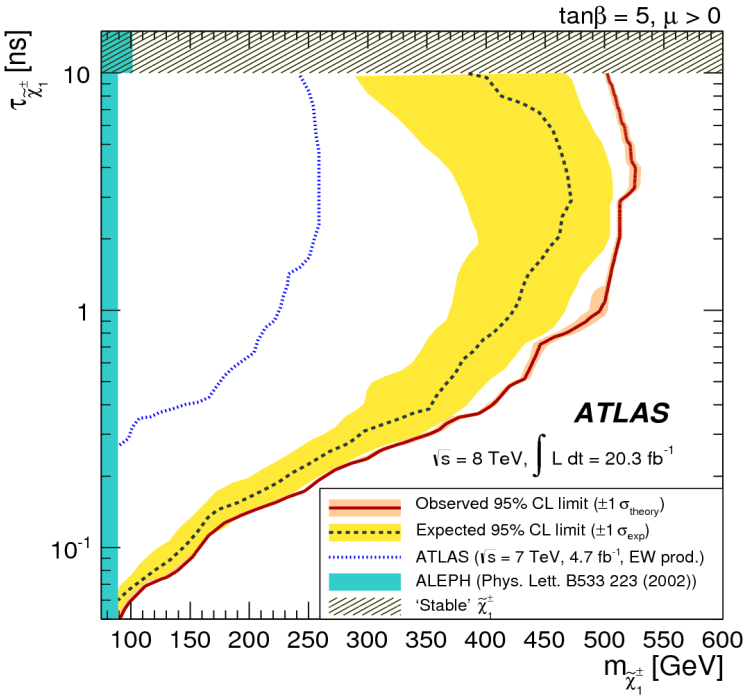
- AB: precision computations for electroweakinos, studies of natural SUSY at colliders and in direct detection
- FB: natural SUSY / light electroweakino model building, collider phenomenology of light higgsinos
- MF: lepton flavour physics, DM models
- Future OCEVU postdoc: Theory/phenomenology profile. Experience with tools for event simulation and analysis essential. If possible also with SUSY spectrum generators (SuSpect...) and recasting tools. Interest in model building welcome.

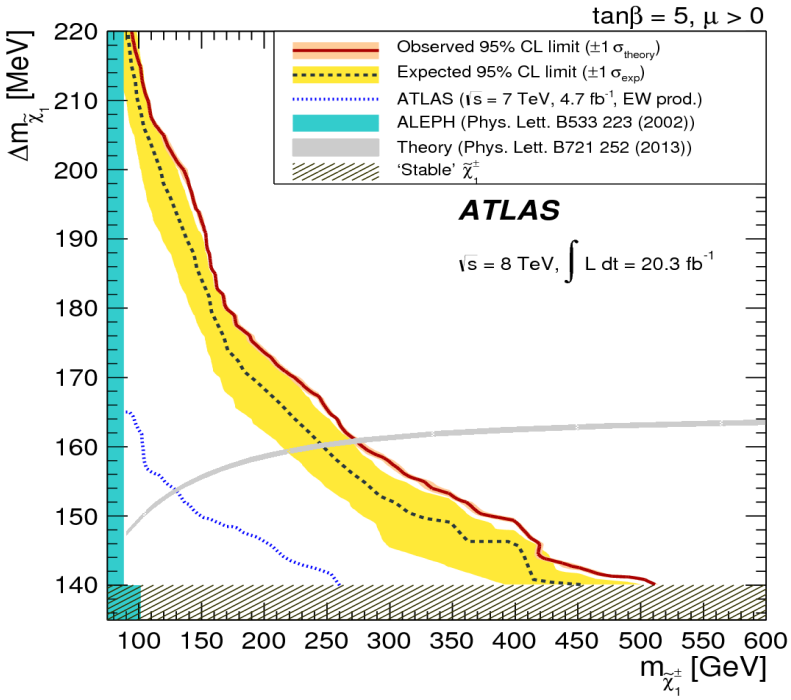
Collaborative aspects:

- Mostly a pheno-heavy theory project between theorists with some complementary expertise (model building / precision calculations) and some common interests (collider pheno, electroweakinos)
- Will help intensify Marseille-Montpellier collaboration
- Experimentalists' contributions welcome, whether or not they want to formally join the project

Example project to start with:

- ATLAS and CMS “disappearing track” searches:
  - EW chargino production, $\chi^{\pm}$ nearly degenerate with χ^0: $\Delta m \approx$ few 100 MeV
  - dominant decay mode: $\chi^{\pm} \rightarrow \chi^0 \pi^{\pm}$ with pion too soft to be detected
  - with ISR jet: signature = MET + jet + disappearing chargino track
  - experiments' interpretation in AMSB: $\chi^{\pm}$ and χ^0 wino-like





- Reinterpret exclusion limits: light higgsino / natural SUSY models
- Generalise to any SU(2) x U(1) multiplet admitting a χ^0
- Study implications for DM and LHC run 2

Another example project:

- “Mediator models” for SM coupled to dark matter sector:

$$\mathscr{L} = \varphi \, \bar{f} \, \Gamma \, f + \varphi \, \bar{\chi} \, \Gamma' \, \chi$$

f = SM fermion; χ = DM; φ = mediator; Γ, Γ' = Dirac structure

- Well studied w.r.t. DM properties. Less well understood w.r.t. collider / flavour physics implications
- Any UV completion needs new states with EW charges! Should be < TeV, otherwise effective couplings to SM too small
- Systematically investigate present and anticipated constraints on effective model and UV completions, complementary to DM experiments:
  - from ATLAS and CMS direct searches
  - from B factories, LHCb

PI Credentials:

- Light Higgsinos as Heralds of Higher-Dimensional Unification; F. Brümmer, W. Buchmüller; JHEP 1107 (2011) 010
- Searching for light higgsinos with b-jets and missing leptons; S. Bobrovskyi, F. Brümmer, W. Buchmüller, J. Hajer; JHEP 1201 (2012) 122
- Consistent on shell renormalisation of electroweakinos in the complex MSSM: LHC and LC predictions; A. Bharucha, A. Fowler, G. Moortgat-Pick, G. Weiglein, JHEP 1305 (2013) 053
- The Fermi scale as a focus point of high-scale gauge mediation; F. Brümmer, W. Buchmüller; JHEP 1205 (2012) 006
- One-loop effects on MSSM parameter determination via chargino production at the LC; A. Bharucha et al.; Eur.Phys.J. C73 (2013) 6, 2446
- Direct Chargino-Neutralino Production at the LHC: Interpreting the Exclusion Limits in the Complex MSSM; A. Bharucha, S. Heinemeyer, F. von der Pahlen; Eur. Phys. J. C73 (2013) 11, 2629
- Tackling light higgsinos at the ILC; M. Berggren, F. Brümmer et al., Eur. Phys. J. C73 (2013) 12, 2660
- Uncovering Natural Supersymmetry via the interplay between the LHC and Direct Dark Matter Detection; D. Barducci, A. Belyaev, A. Bharucha, W. Porod, V. Sanz; 1504.02472