BSM group summary

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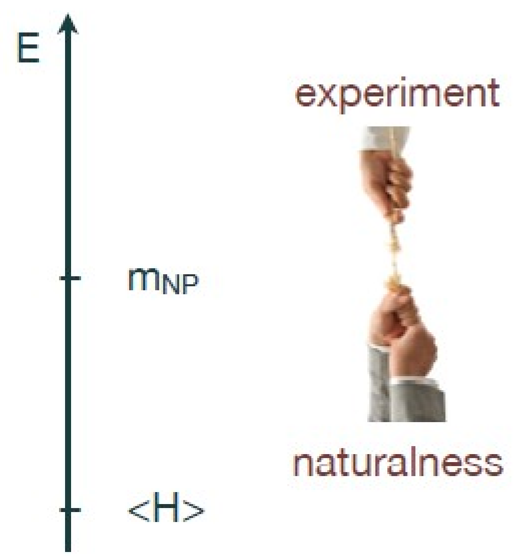
Conveners: G. P., S. Rahatlou, A. Romanino, A. Wulzer

Introduction

- General goal, as stated in document prepared for what next:
  - Which directions should be taken by Fundamental Physics in absence of discoveries at the LHC and with DM direct detection experiments by 2017
- Main guidelines emerging from discussions in group:
  - Searching for new physics justifed by the naturalness argument is and remains a priority
  - The naturalness argument does not provide an absolute scale for New Physics discoveri nor on the scale of new phenomena
- Try to develop a program of work which allows us to say something about the next steps to be taken on the basis of these arguments
- Benchmark on several future facilites: HL-LHC, 33 TeV LHC, 100 TEV pp collider, ILC, TLEP

Naturalness



From the talk of A. Romanino yesterday

The mass of the higgs is drawn to new physics scale by radiative corrections

keep the bounds as they are
make them palatable

weakly interacting way	strongly interacting way
Low scale nMSSM	Composite Higgs

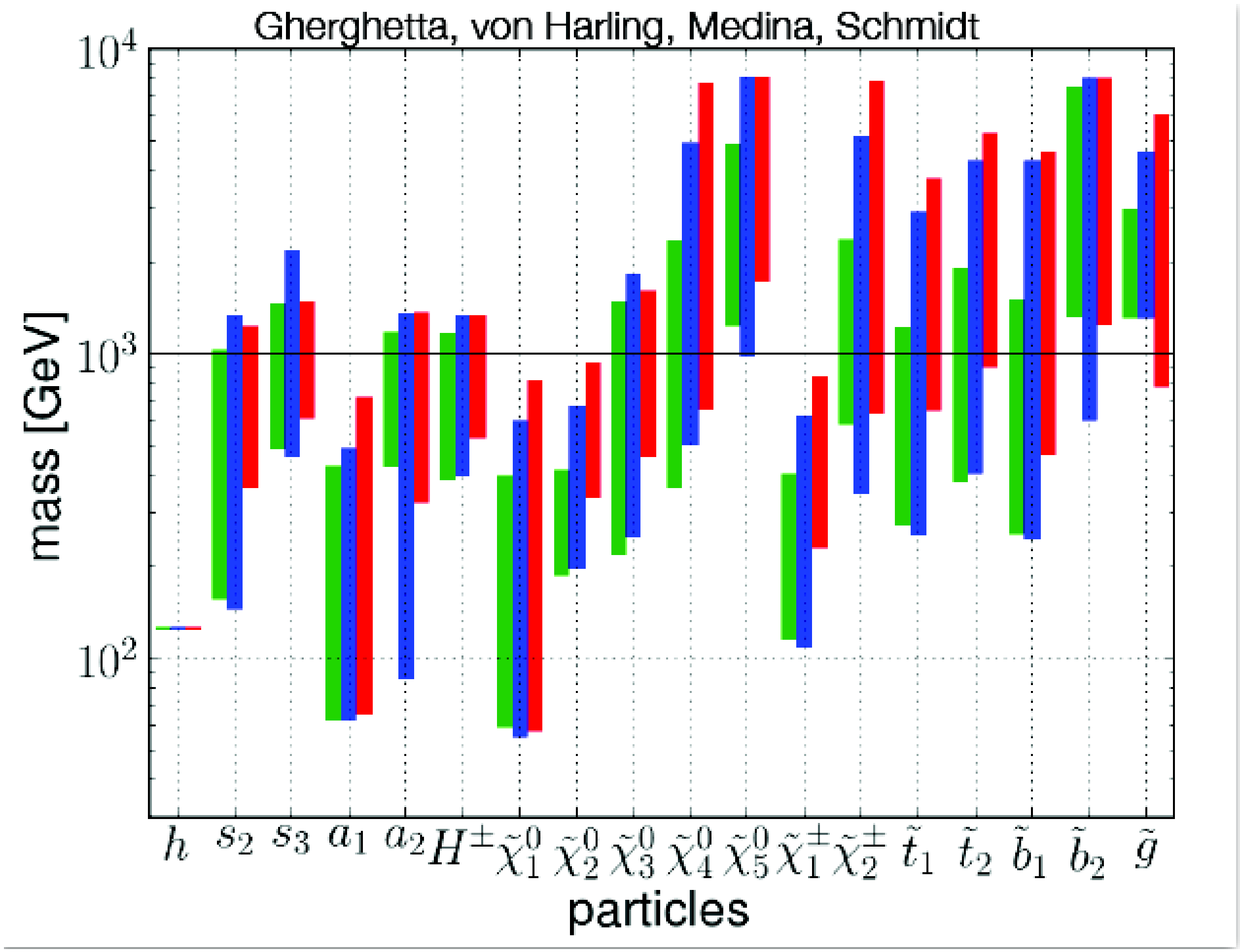
Merit factor is Δ, required cancellation
Among terms which are larger than
m^2_h by a factor Δ

$$\Delta \geq \left(\frac{m_{NP}}{450\,\mathrm{GeV}}\right)^2$$

Statement of the problem

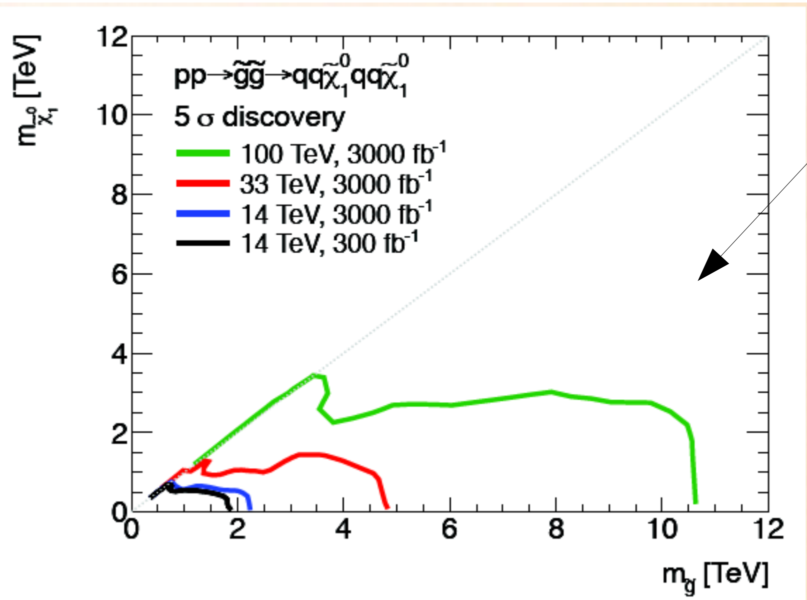
- Question is, given the range of sparticle masses giving a reasonable level of tuning to the theory, what are the facilities which will allow us to explore completely this range
- 'Soft' requirement, as the 'reasonable' in the previous point is not well defined
- However, help in figuring out to what level we will saturate naturalness already at the level of Run II
- Relevant formulae shown yesterday in talks by A. Romanino and T. Lari, I will show main results, and draw tentative conclusions out of them

Theoretical input



Range of masses giving a tuning of 5%, 1-5%, >1% (green, blue, red) in A nMSSM model assuming Λ=20TeV

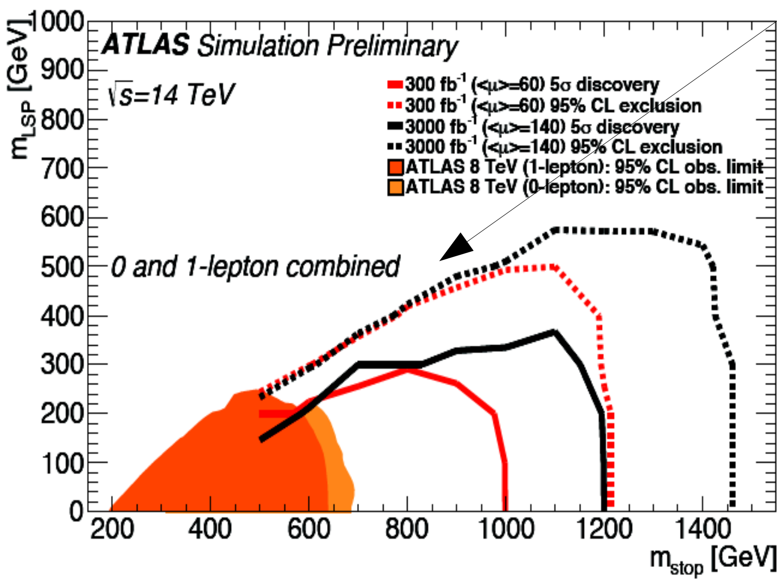
Experimental input

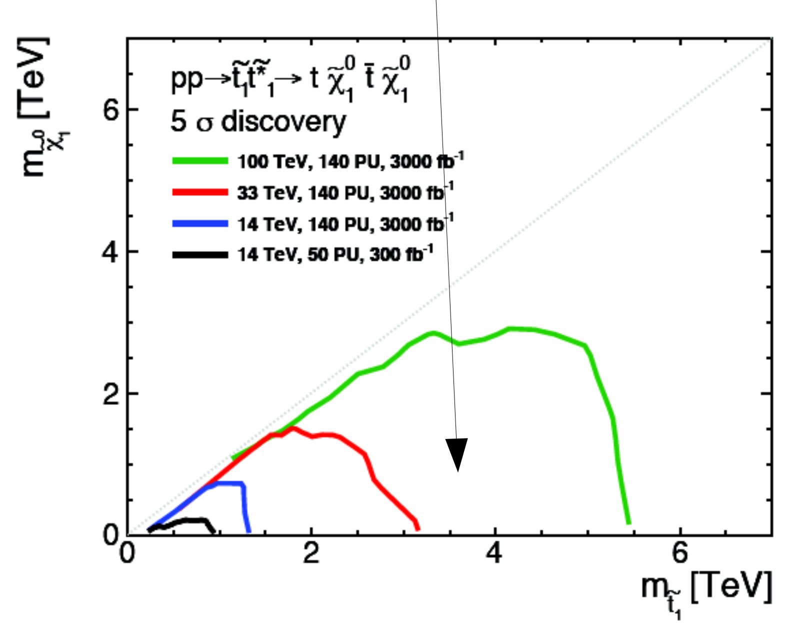


Gluino: at 100 TeV reach mass of 10 TeV:
1.5% tuning of theory

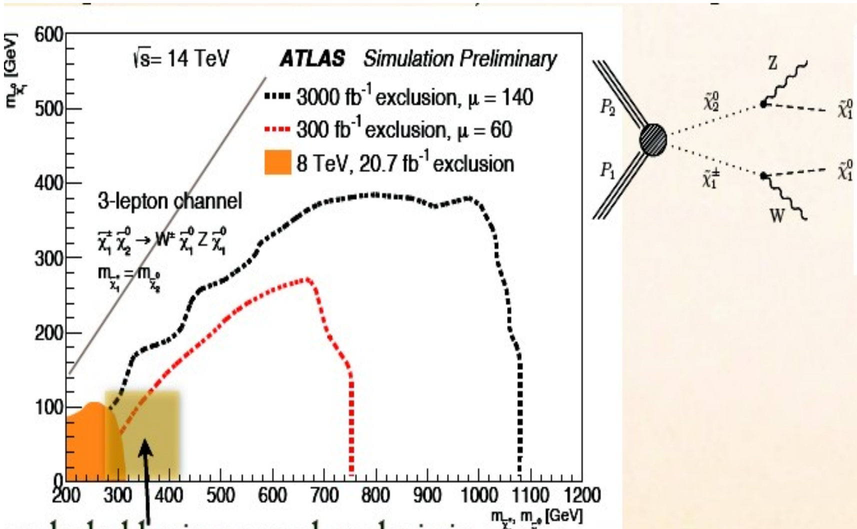
Stop: gain ~20% from HL-LHC
At 33 TeV reach mass of 3 TeV:
1% tuning of theory

Available projections do not address
Case of stop degenerate with neutralino:
Set up dedicated simulation program

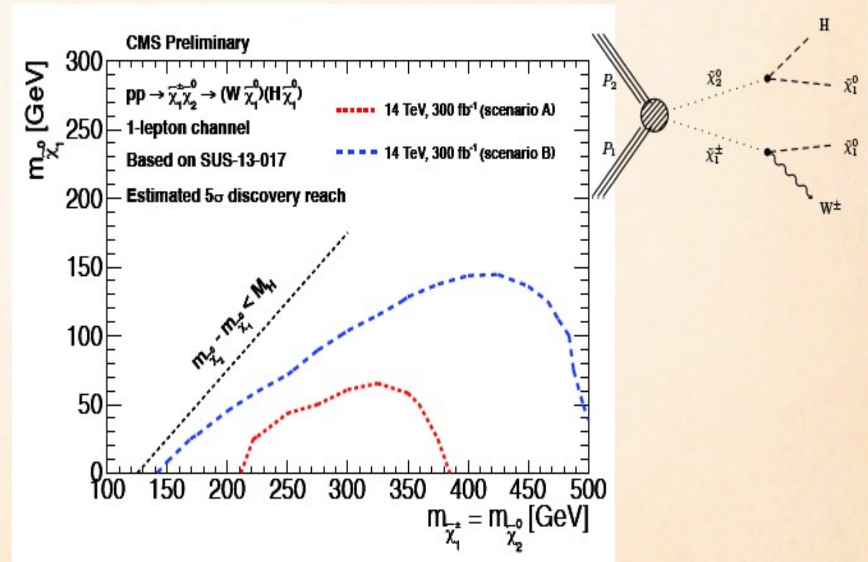


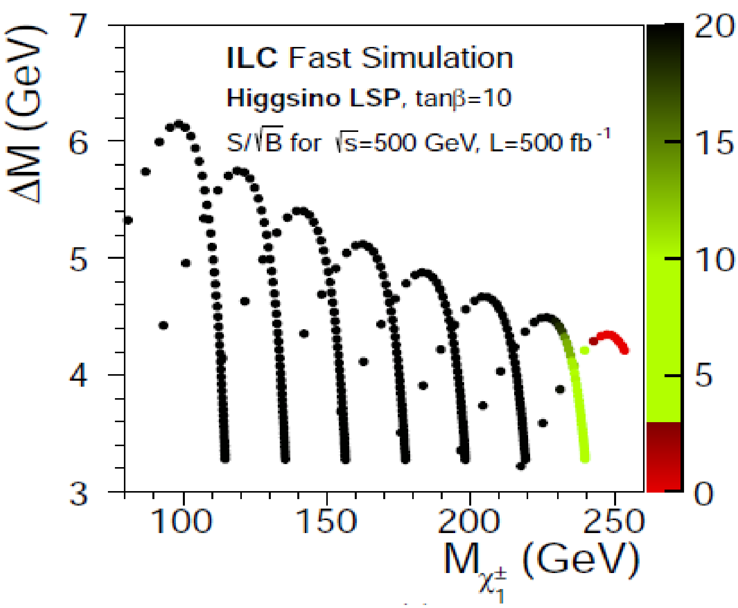


Experimental input (2)



excluded by improved analysis in paper
w.r.t. the preliminary results





Chargino-neutralino production:
Goes beyond naturalness range already
At HL-LHC for large chargino-LSP mass gap

Ongoing studies suggest possible coverage
Up to 100-200 GeV for degenerate higgsino, work
In progress

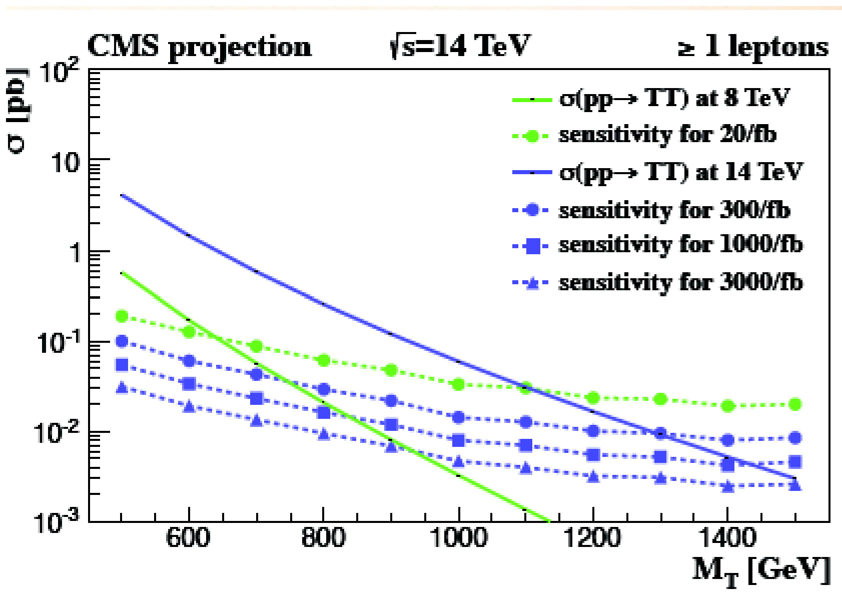
500 GeV ILC study shows almost saturation of
Kinematic limit for very small mass gap

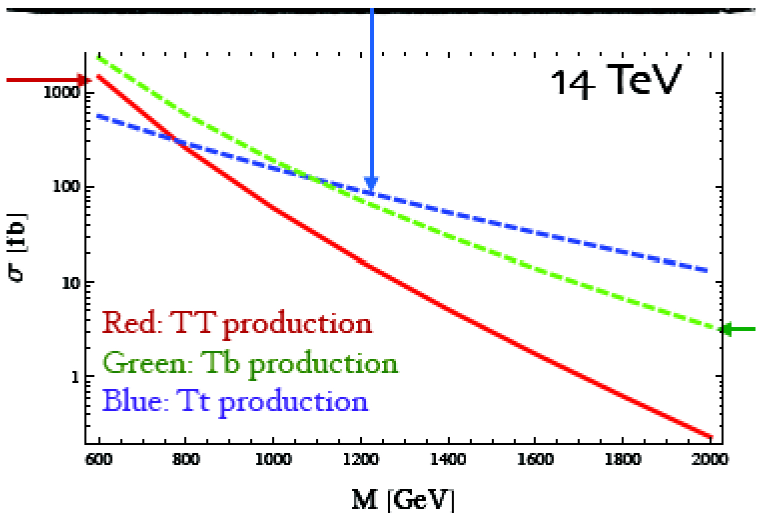
Tentative conclusions on SUSY

- For a moderate SUSY Messenger scale (10-20 TeV)
  - Need to get to maximum possible machine energy (100 TeV) in order to reach percent levels of fine-tuning for all relevant channels
  - For stop highly degenerate with neutralino and for direct ewkino production no extrapolations to high energy machines available.

    From high luminosity studies, clear that HL-LHC will play an important role in this sector
  - A 1 TeV ILC might be necessary to cover direct higgsino production in highly degenerate cases for masses up to 500 GeV

Composite Higgs



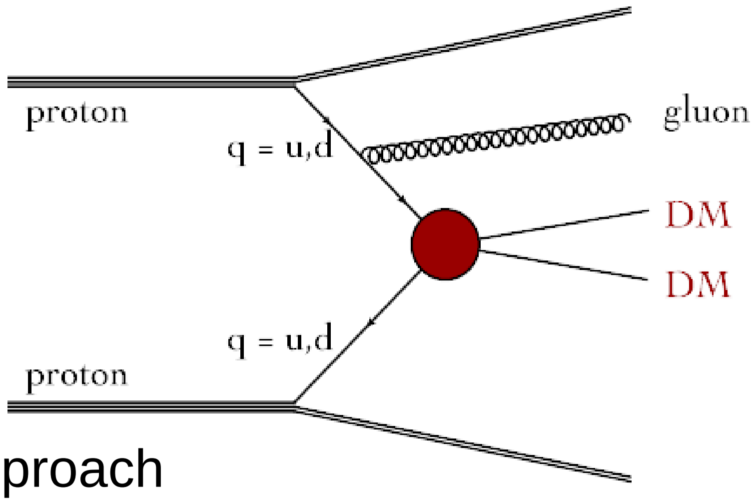


- Consider partner T of top quark: fine tuning of ~5% reached for ~2.4 TeV mass
- From Snowmass studies on pair production need 33 TeV machine in order to reach this level
- From old (2004) ATLAS study, it might be possible to reach this level already at LHC run II if search for single T is performed
- Simulation work in progress to verify this statement

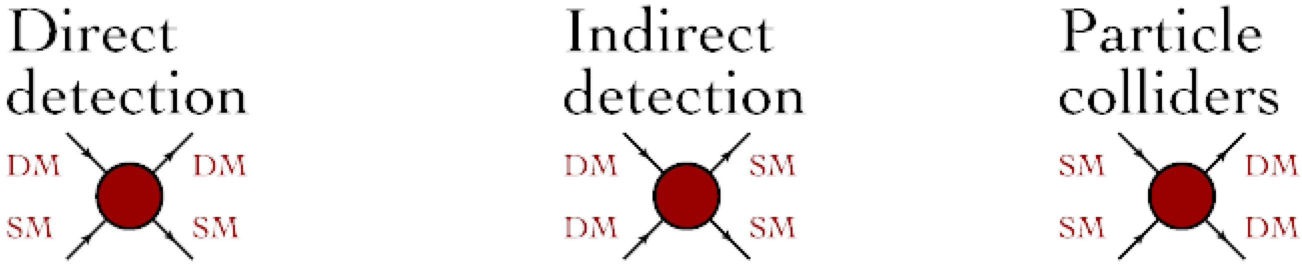
Dark Matter connection

- Direct production of Dark Matter at Colliders possible in two modes:
  - Direct production of DM
  - Presence of DM in cascade decays of new physics

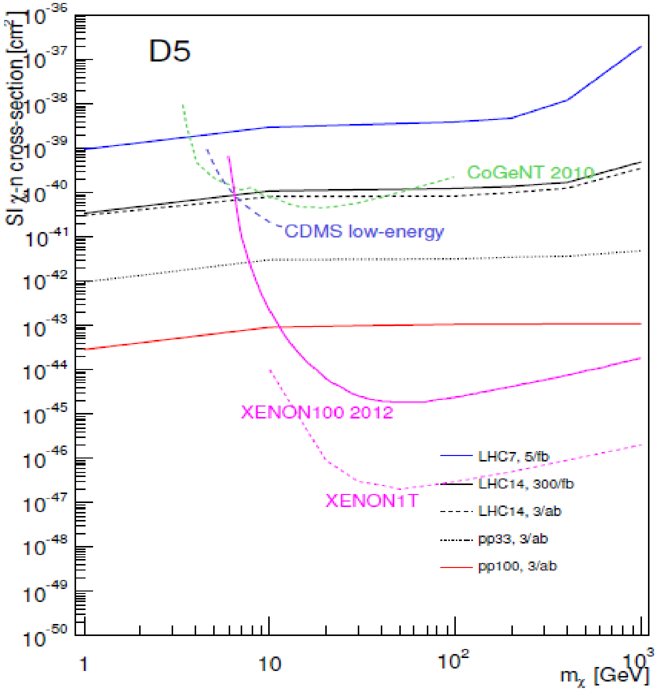
Direct production searched for
In events with additional particles
Radiated from the initial state

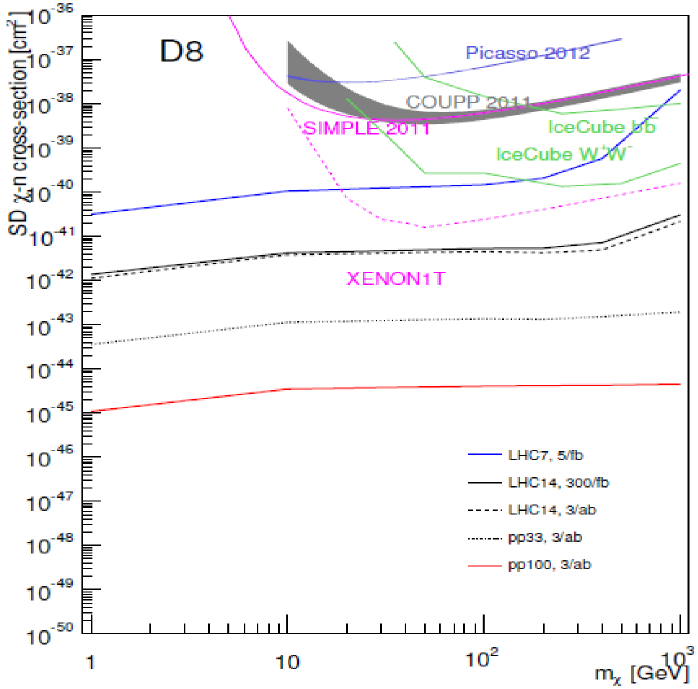


Can be interpreted in terms of direct
and indirect detection by crossing diagrams
and using an Effective Field Theory (EFT) approach



Results and projections of mono-X searches





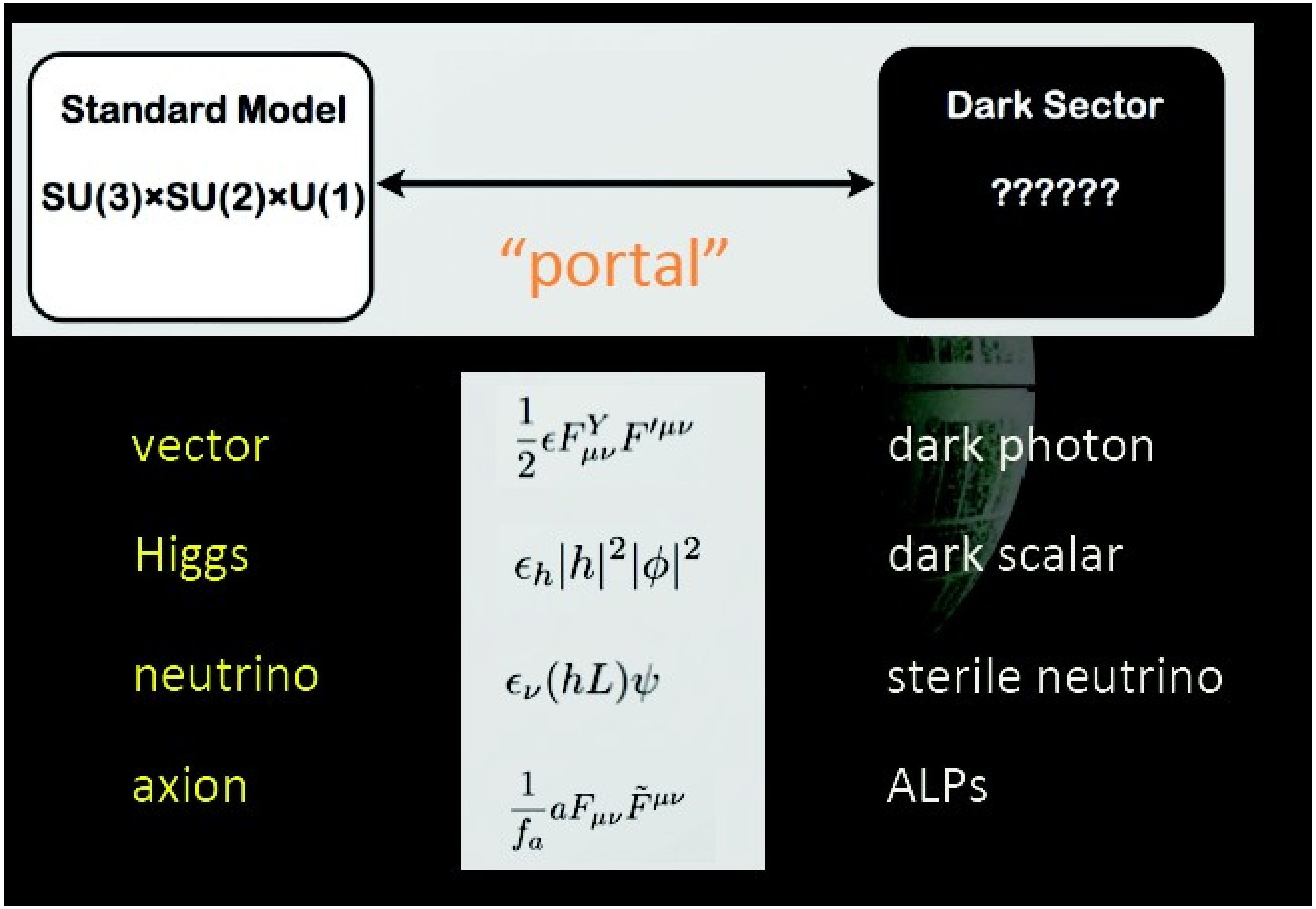
- For spin-independent cross-section LHC unique in 1-10 GeV mass range
- For spin dependent LHC competitive on whole range

For spin-independent interactions need to go to 33 TeV machine to cover the region where hints of signal observed in direct searches

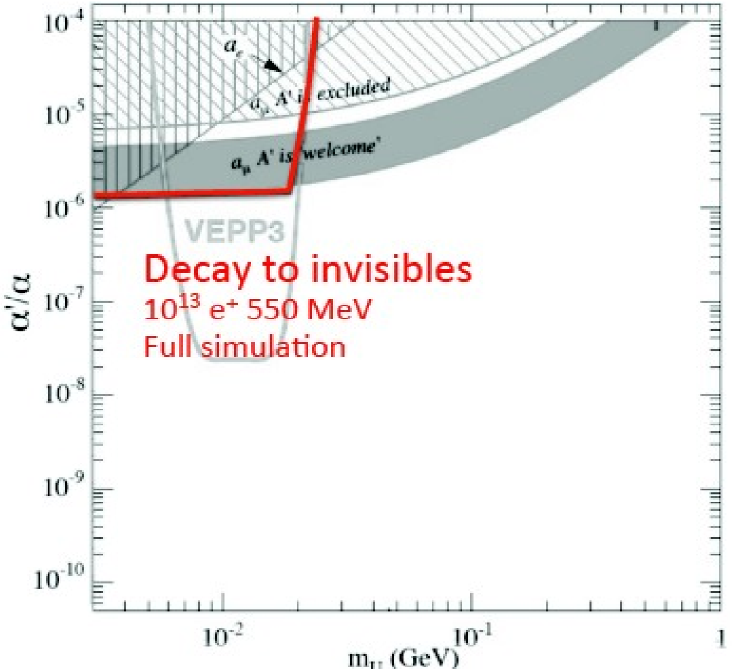
Need to develop simplified model interpretation which goes beyond of limitations of EFT approach and can become a standard for comparison with dedicated experiments. Liaise with DM group for this

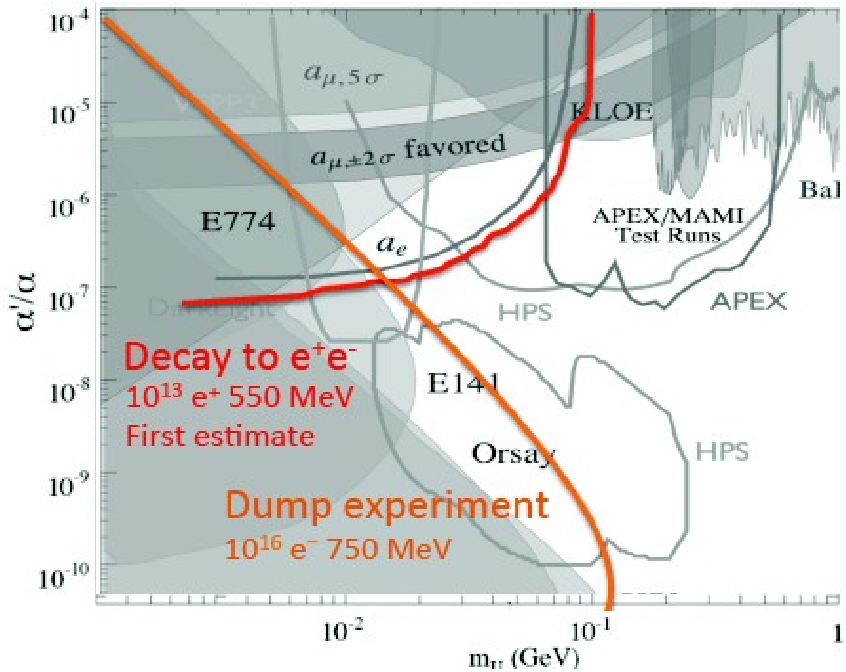
Secluded sector

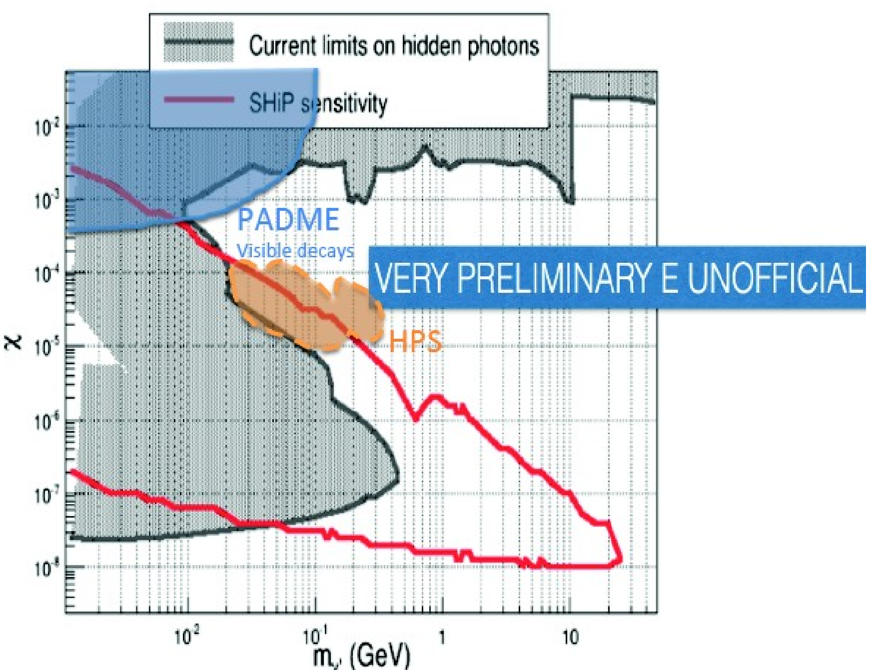
Problem: connect Dark Matter to SM particles while being compatible
With measurements: low elastic X-s on nuclei, low productionX-s at the LHC



Large effort on dark photon appearing in simple model with additional U(1) symmery





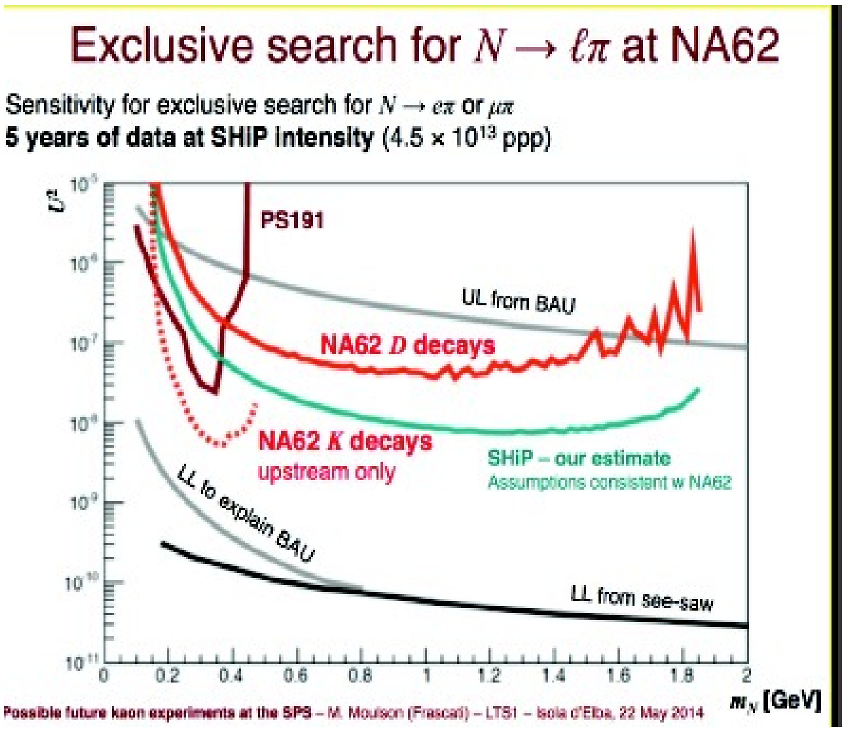


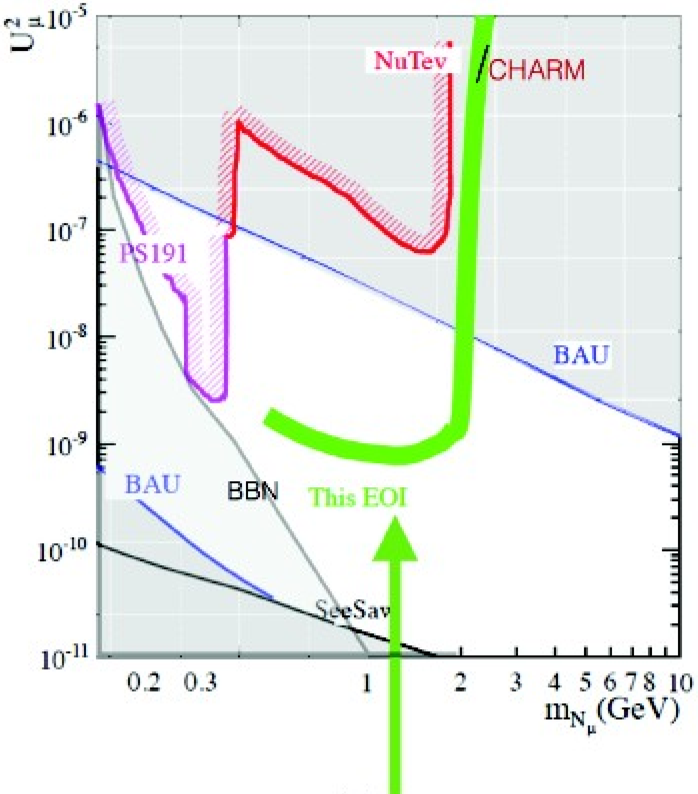
Excluded areas and expected sensitivity
In parameter space of dark photon mass
And its couplings

Several fixed target experimental proposals covering complementary areas of interesting and relevant parameter space.
Often small and simple experiments providing alternate windows on new physics

Sterile neutrino

Search in decays of mesons in experiment with large decay length





N—>uπ

SHIP experiment

Conclusions

- The criterion of naturalness, even after LHC Run 1 is valid criterion for search of new physics
- From the study of benchmark models compatible with LHC constraints emerges the utility of going to higher energy proton colliders, a clear role for HL-LHC, and a limited area of opportunity for a 1 TeV ILC
- Direct production of dark matter particles at collider competitive with direct and indirect searches. It would benefit from higher energy colliders.
- Rebirth of fixed target activity looking for light, typically long lived signals for new physics which may be of difficult access at the high energy colliders