WIMPs and a 100 TeV Collider

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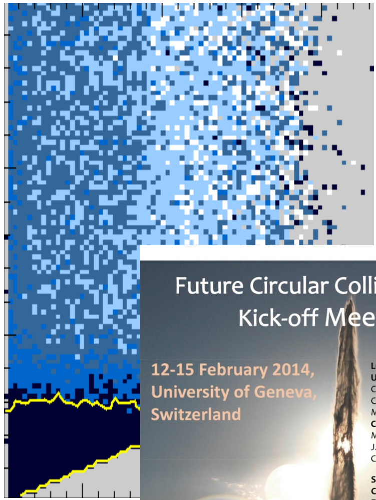
A Arbey, N Mahmoudi

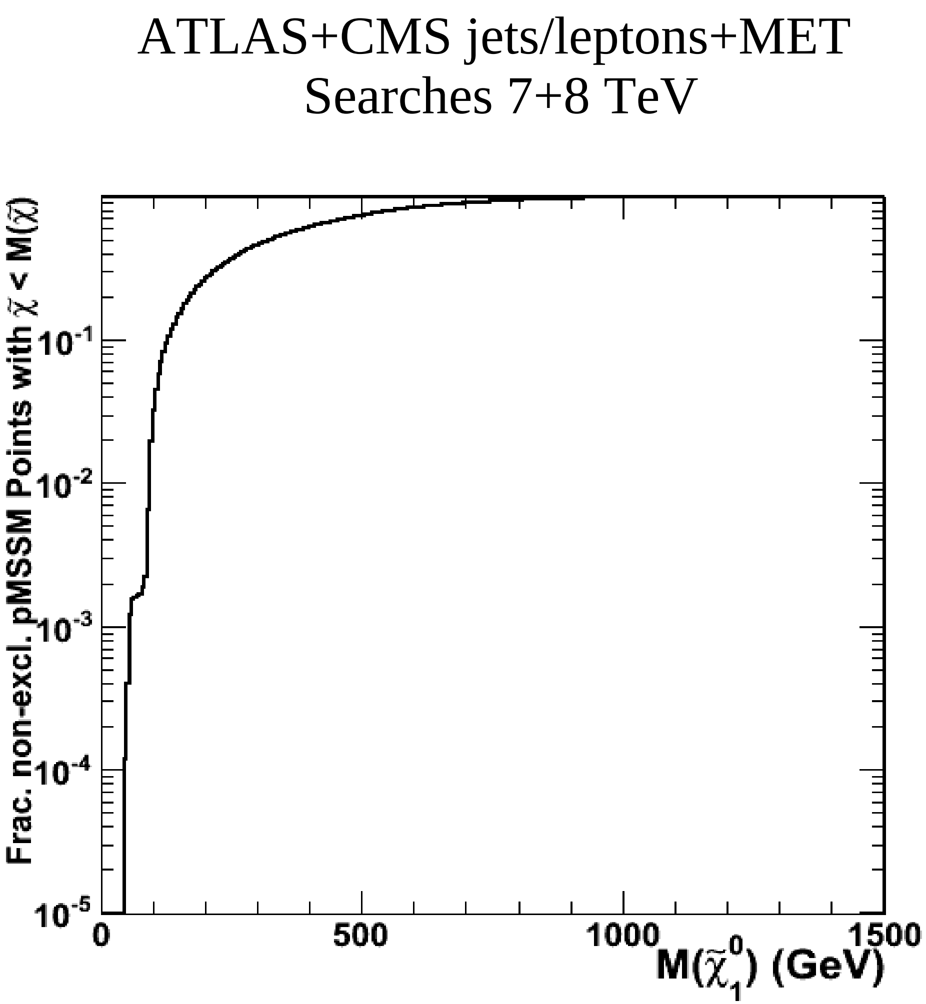


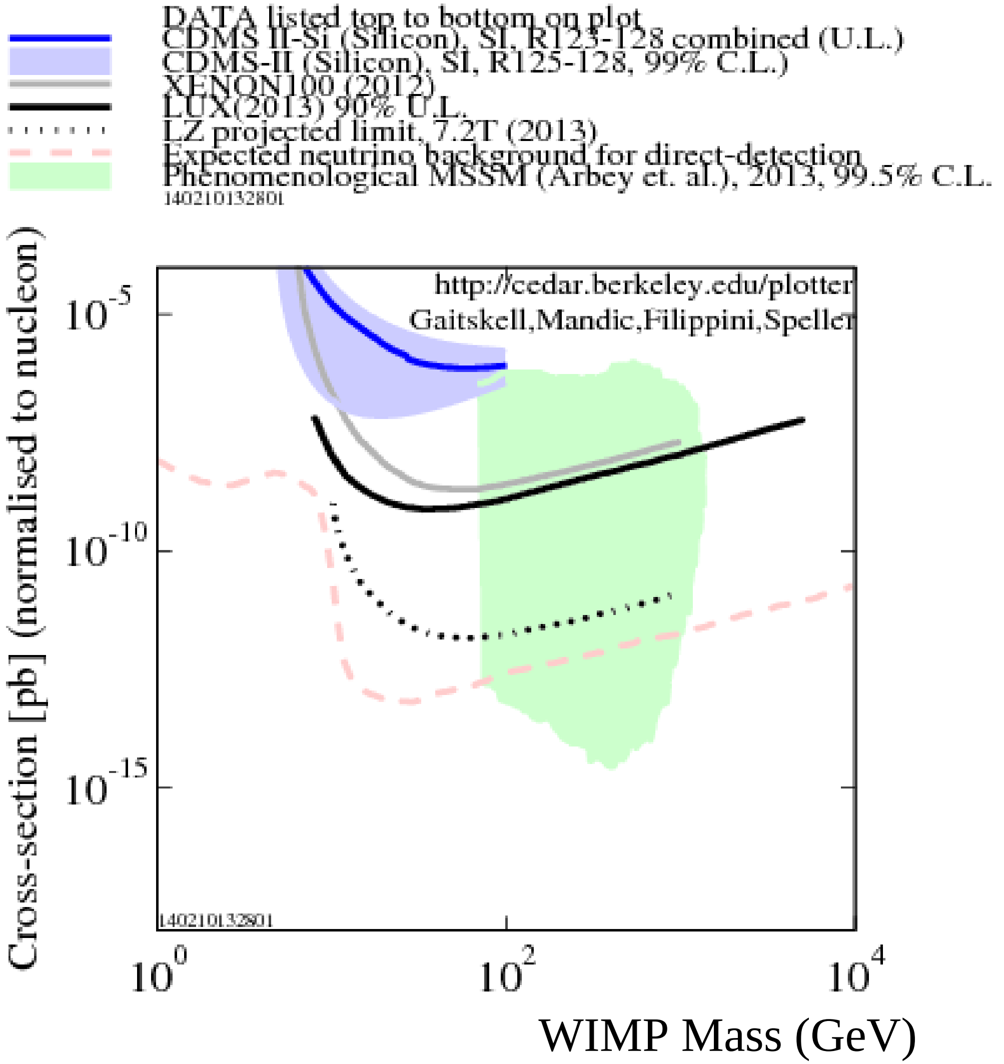
In collaboration with
G Belanger, A Goudelis, A Pukhov
and with contributions by D Kanta

BSM Opportunities at 100 TeV

CERN, 10-11 February 2014

This talk discusses a program of studies of physics opportunites for a 100 TeV collider in direct production of WIMPs, the complentarity with dark matter direct detection expts and its role in the study of their nature;

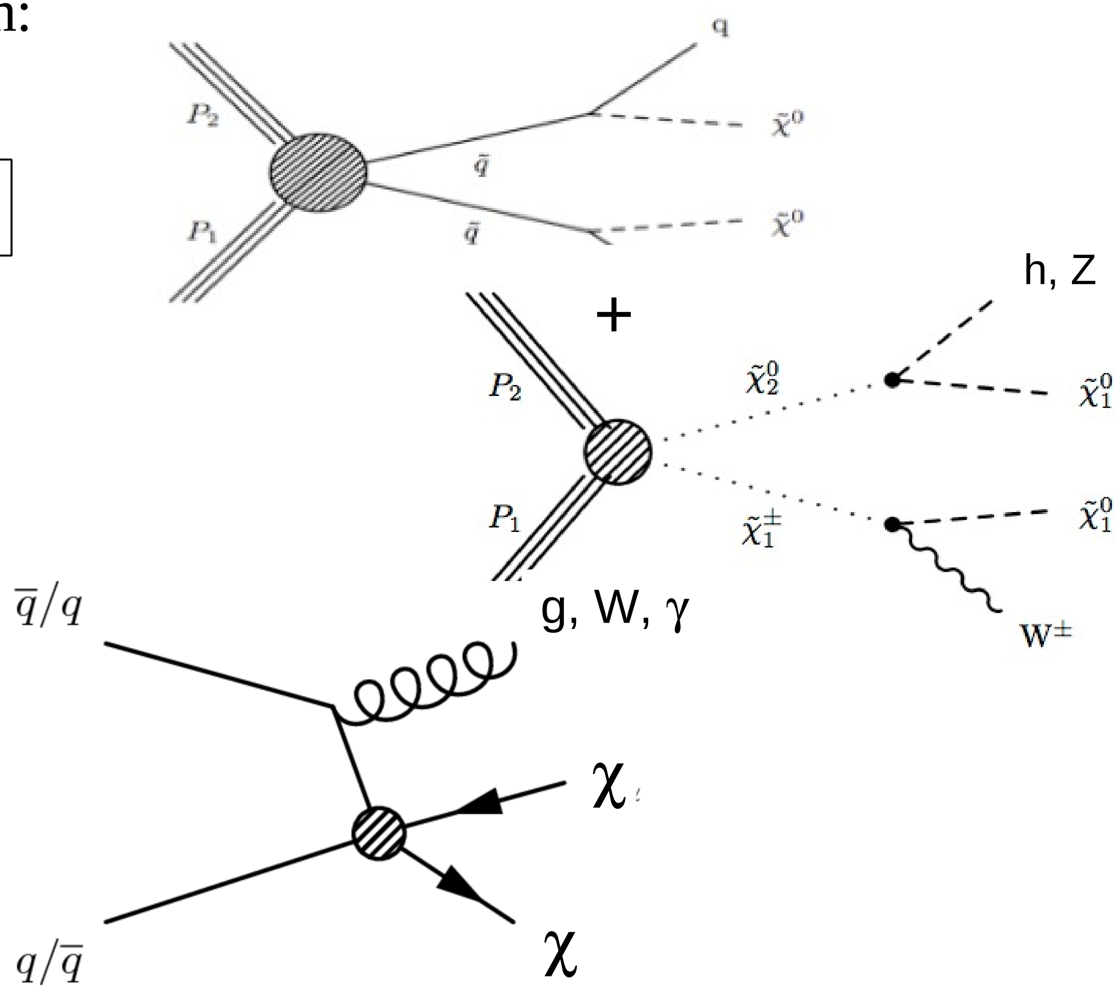




Can a 100 TeV collider say the definitive word on WIMPs at least in some well-defined models/theories (MSMM, …) ? [The answer is not included in this talk]

Combination of constraints from:

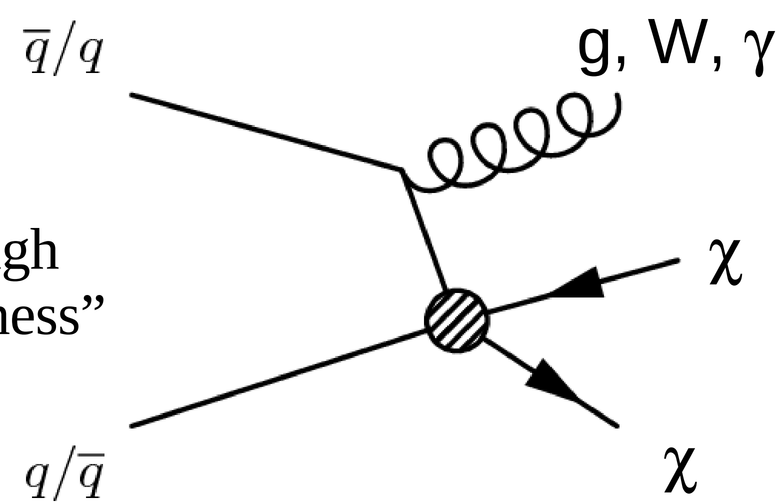
Jets/Leptons + MET Searches



→ Mono-jet/W/Z/g/l Searches

Dark Matter Direct Detection Underground Experiments

Mono-Jet (+ W/Z, γ, l) Signatures from 8 to 100 TeV



pp collider can search for WIMP production through processes with large MET and one parton as “witness” of interaction;

Sensitivity can be estimated using EFT or actual models (SUSY, …);

Results can be interpreted as limits on $\Lambda \equiv M/\sqrt{g_\chi g_q}$ related to limits on

WIMP scattering cross section on nucleons $\sigma_{\mathrm{DD}} \sim g_\chi^2\, g_q^2\, \frac{\mu^2}{M^4}$ to compare

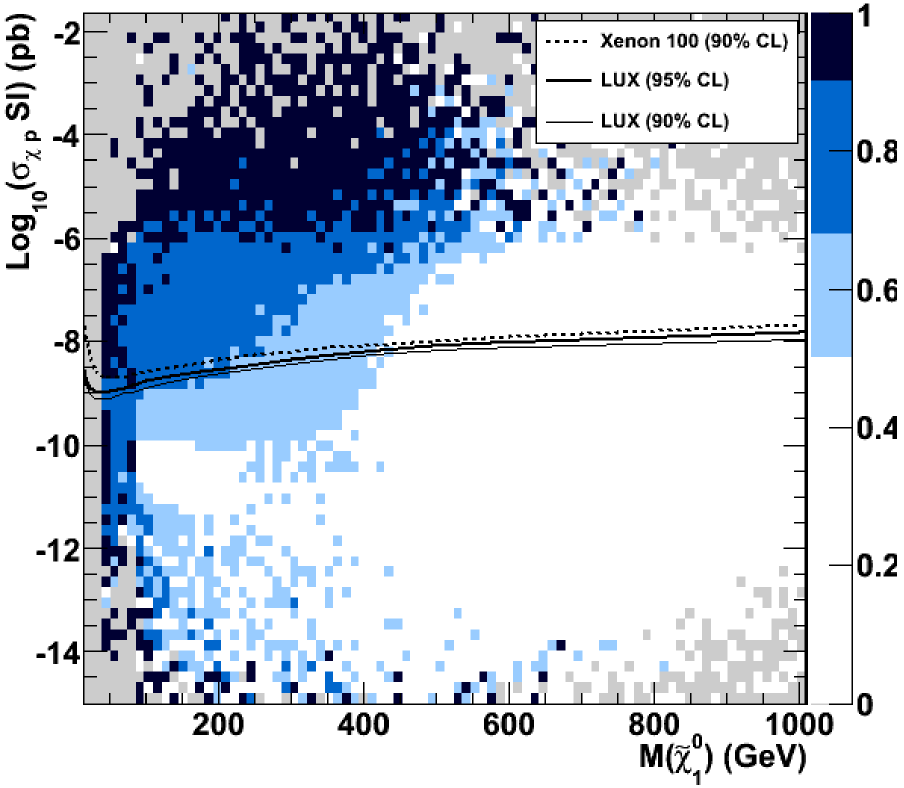
with results of DM direct detection experiments.

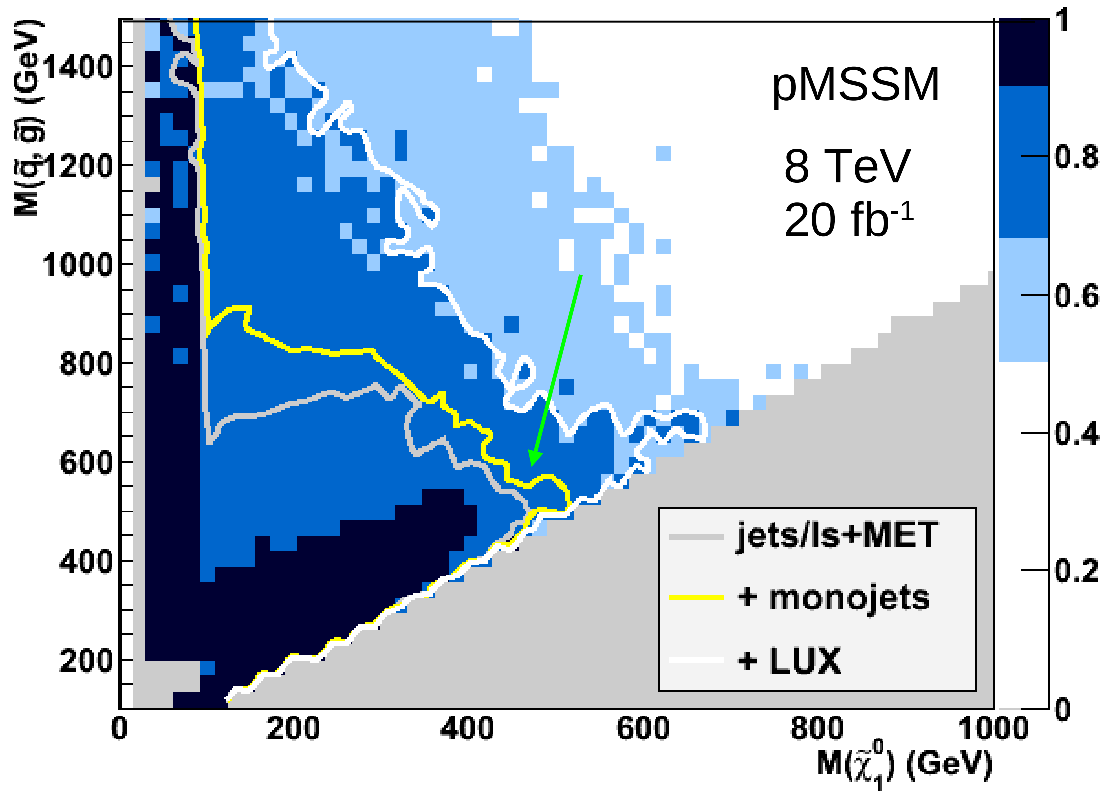
Bai, Fox, Harnik, JHEP 1012 (2010) 048
Goodman et al, PRD 82 (2010) 116010
Goodman et al, PLB 695 (2011) 185
...

Complementarity of Mono-jet and Jets/leptons +MET searches in MSSM

In the case of SUSY χ^0_1 WIMP, results are affected by the availability of multiple propagators and presence of other particles at small mass splitting, still mono-jets add to the LHC sensitivity, notably in the kinematically difficult small ΔM region;

An example at 8 TeV (pMSSM masses limited at 3 TeV):



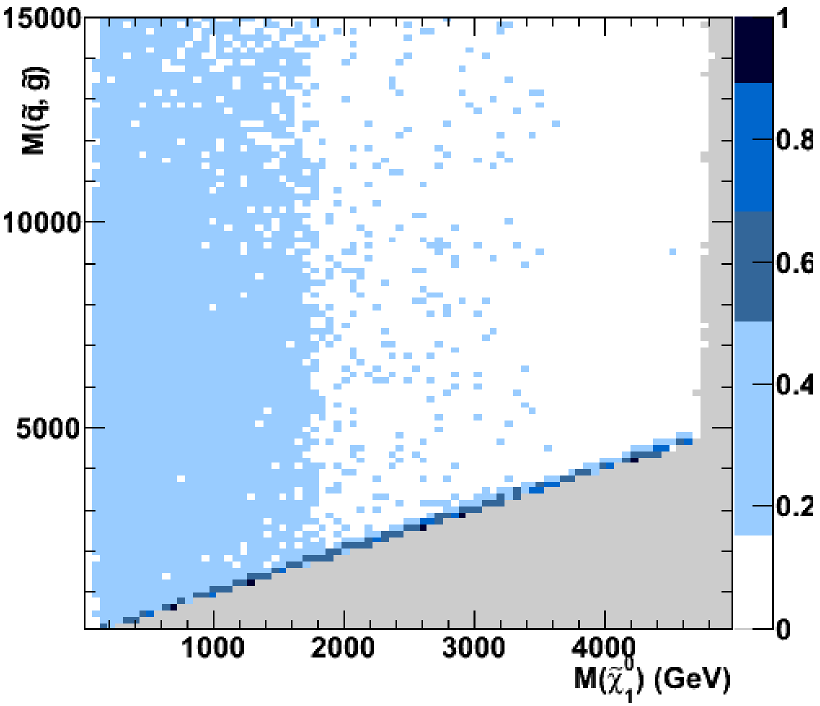


Arbey, MB, Mahmoudi, arXiv:1311.7641

Main regions of interest for mono-jets et al.:

Large mass splitting scenarios where other particles are too heavy to be detected

$M_1 << M_2, M_3, \mu \rightarrow \chi$ WIMP must be bino-like, cross section drops but Ωh^2 is too large



Fraction of pMSSM points compatible with PLANCK $\Omega_\chi h^2$ upper limit (+syst)

Small mass splitting scenarios where kinematics reduces efficiency of jets/leptions+MET searches

$M_1 \sim M_3$ (or $M \sim q$) $<< M_2$, μ Ωh^2 brought down by co-annihilation, mono-jet xsec boosted by production of strongly-interacting sparticles

$M_1 \sim M_2$ or $\mu << M_3$ monoW/Z best suited for detection

First (preliminary) findings in pMSSM

Take analyses as performed at 8 TeV, no cut optimisation, use SM bkg from ATLAS/CMS analyses and scale it up by appropriate factor to describe increase of rate in signal regions (MadGraph): 8 TeV 25 fb^{-1}, 14 TeV 300 and 300 fb^{-1}, 100 TeV 1 ab^{-1}

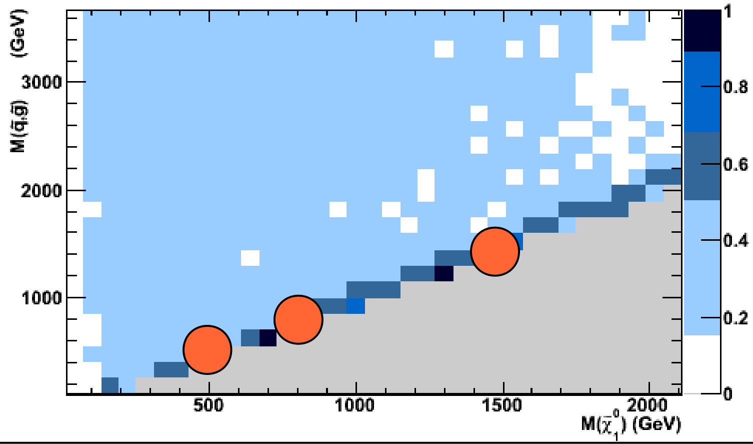
Study S/B in jet pT vs MET plane for points along small mass splitting region at 8, 14 and 100 TeV

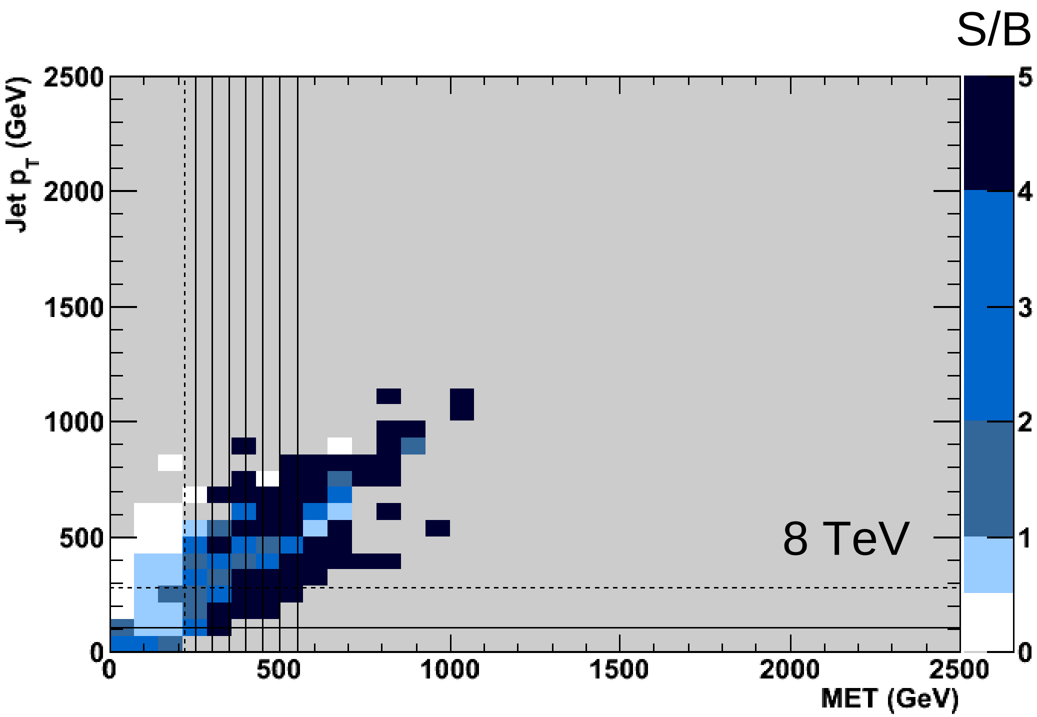
Broad pMSSM scan with sparticle masses up to 25 TeV

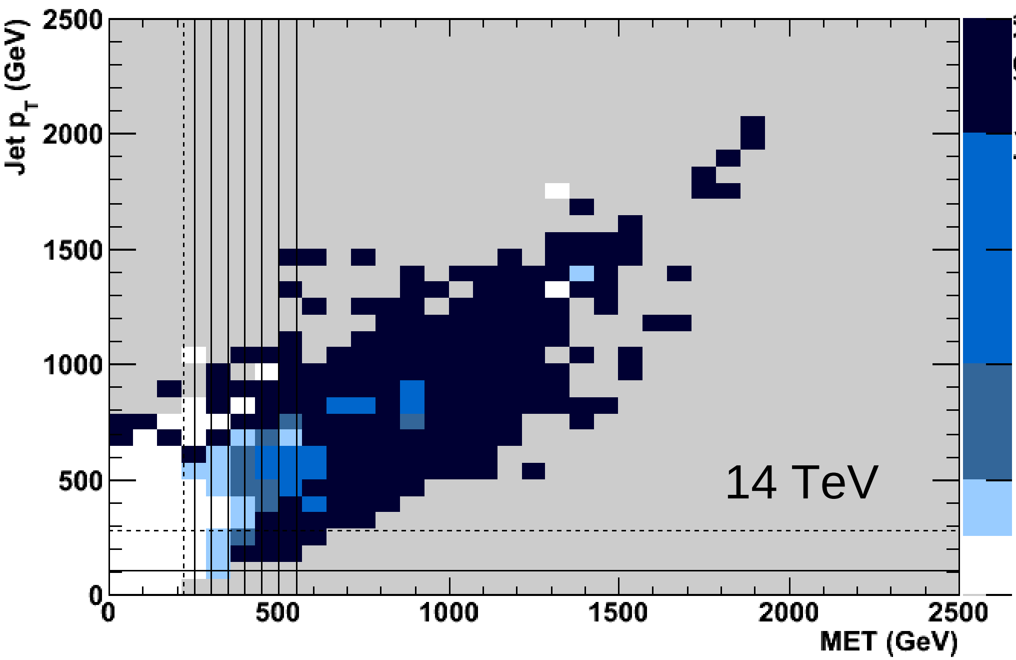
Study M(~q,~g) vs M(χ) and $\sigma(\chi p)$ SI vs M(χ)

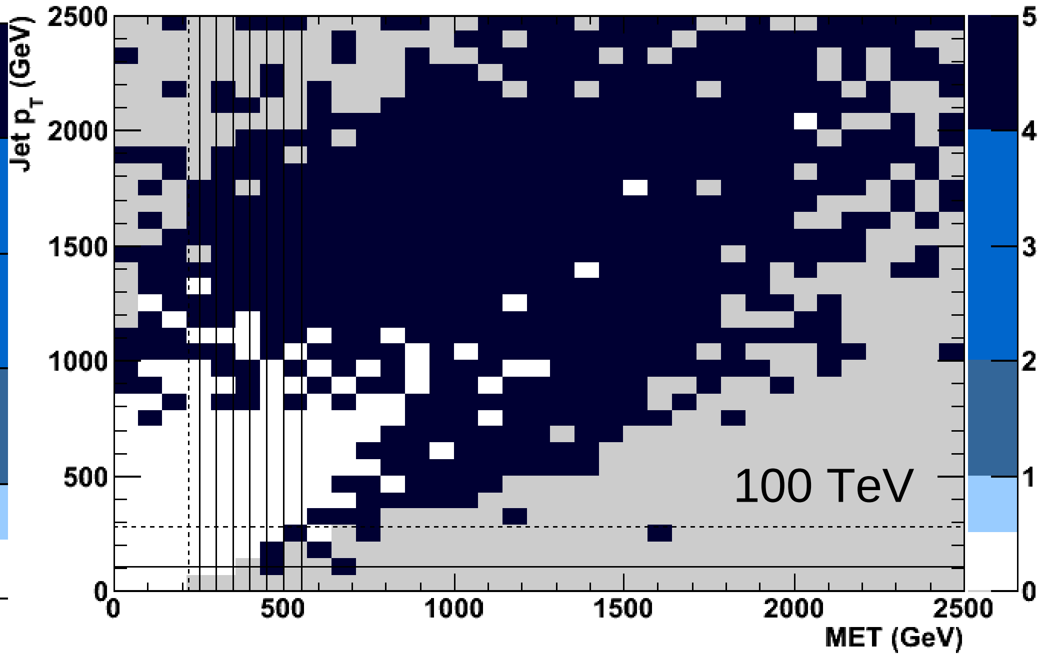
Towards a cut optimisation:

Study S/B in jet pT vs MET plane for points along the small mass splitting region at 8, 14 and 100 TeV



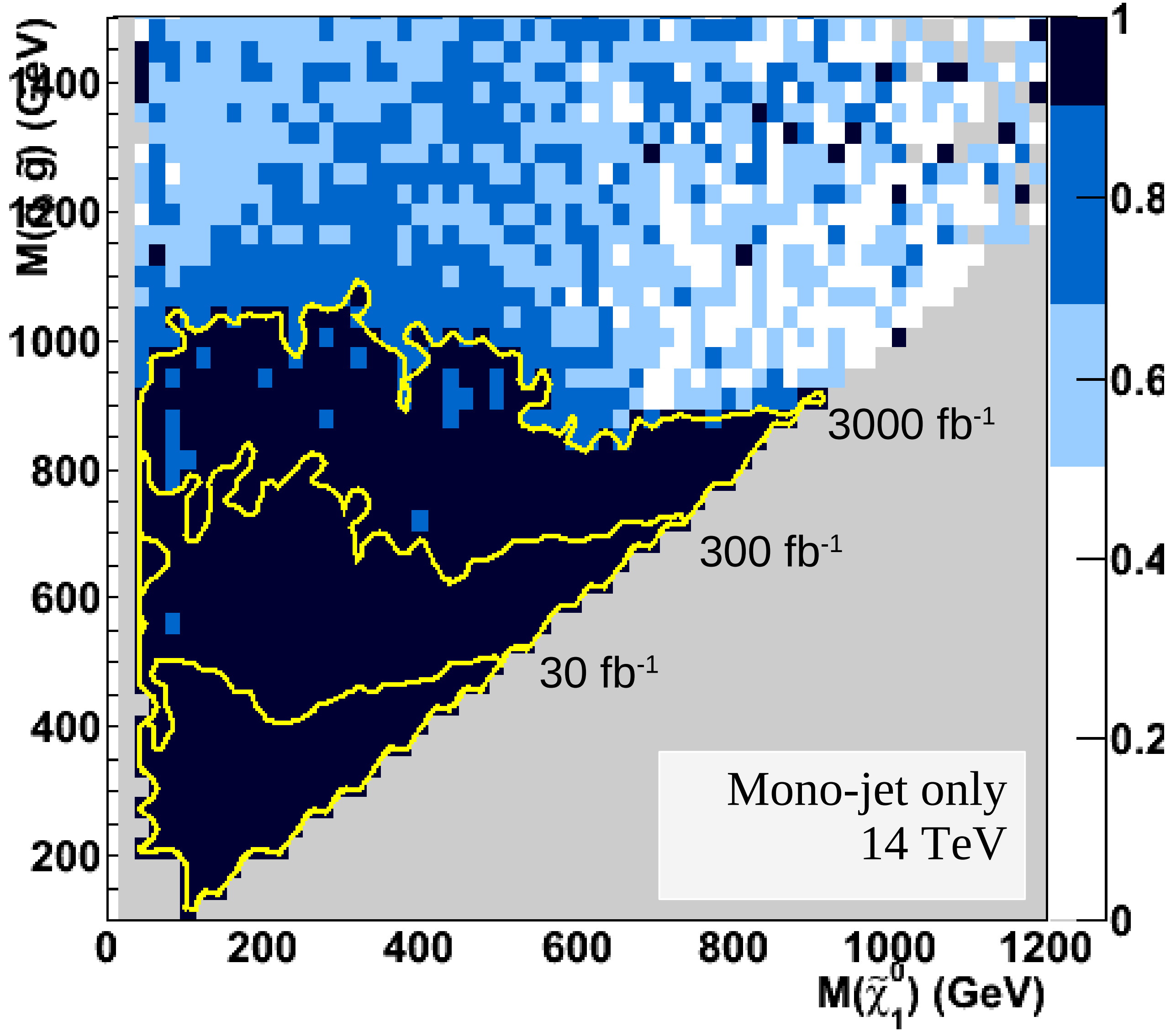




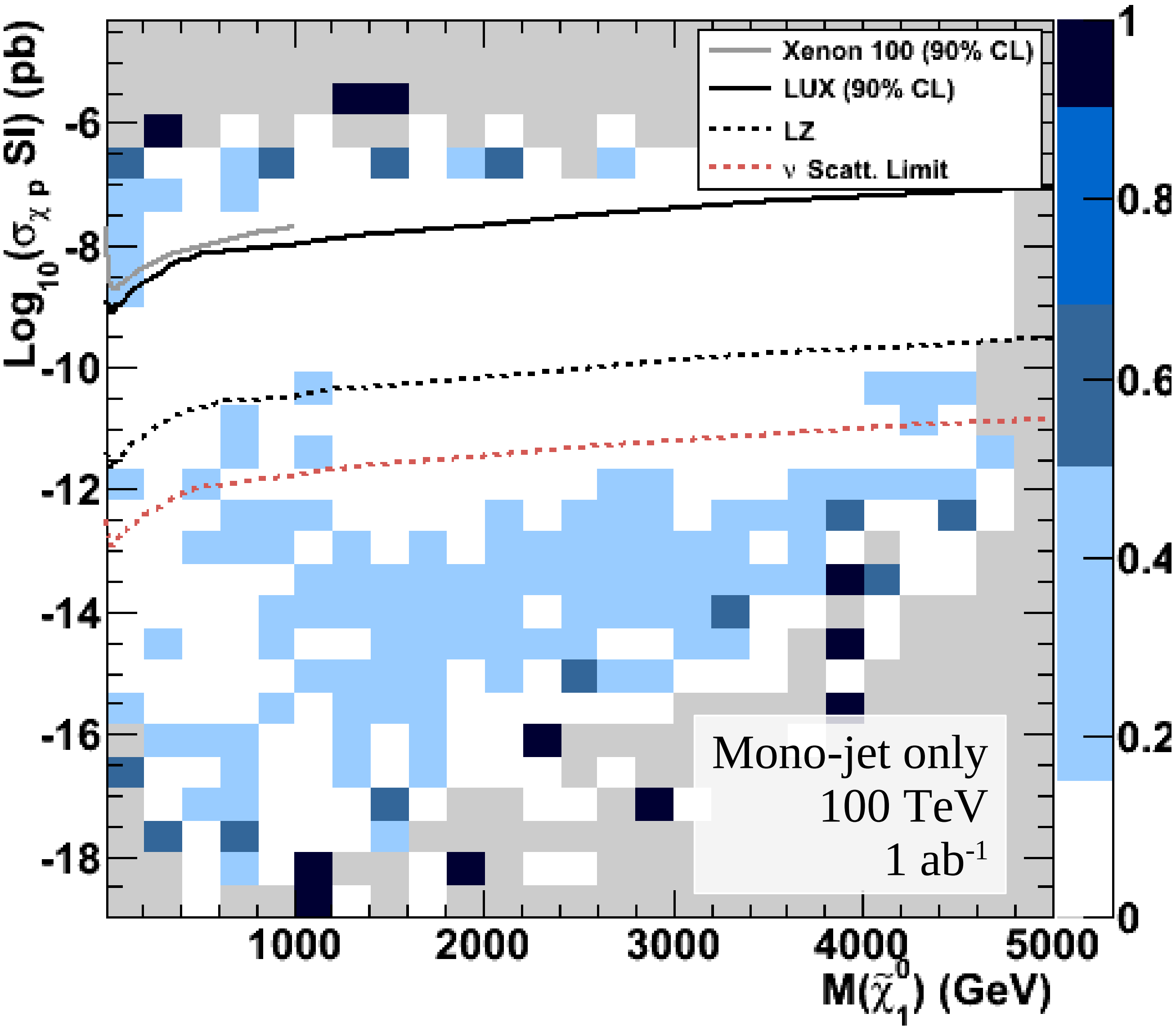


Lightest strongly-interacting SUSY particle mass vs M_{WIMP}

14 TeV

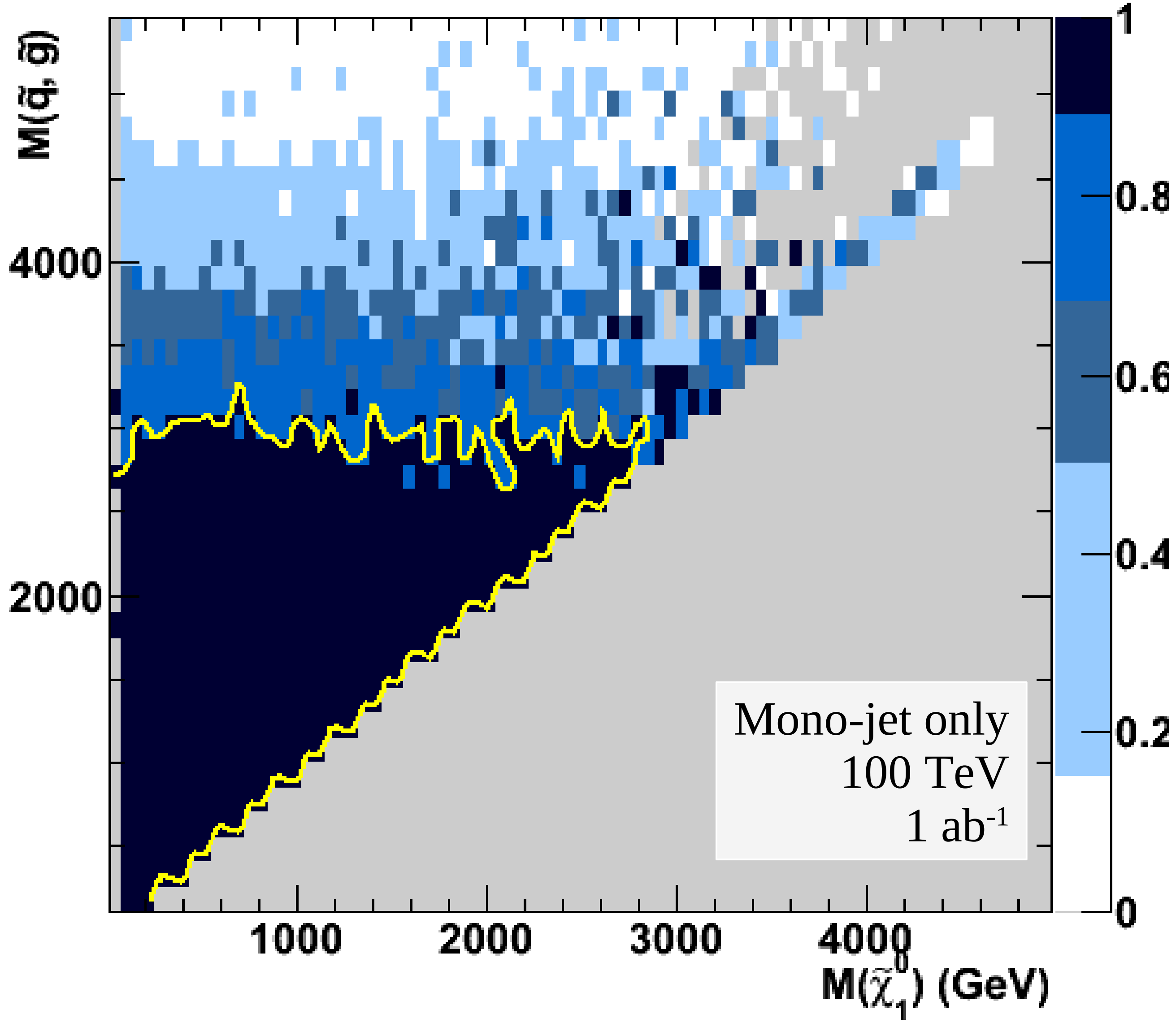


Spin-independent Scattering Cross Section vs M_{WIMP}: 100 TeV

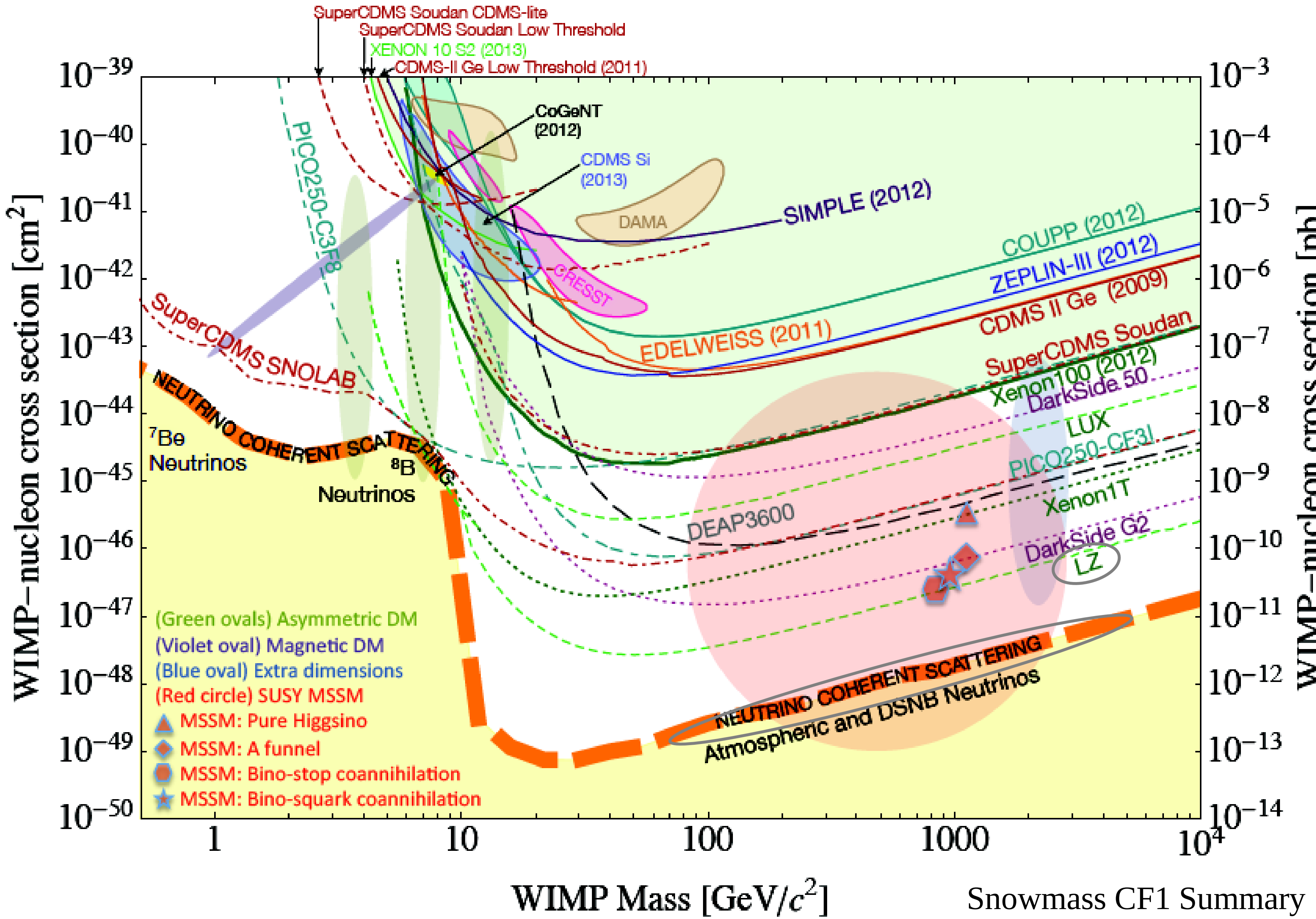


Lightest strongly-interacting SUSY particle mass vs M_{WIMP}

100 TeV

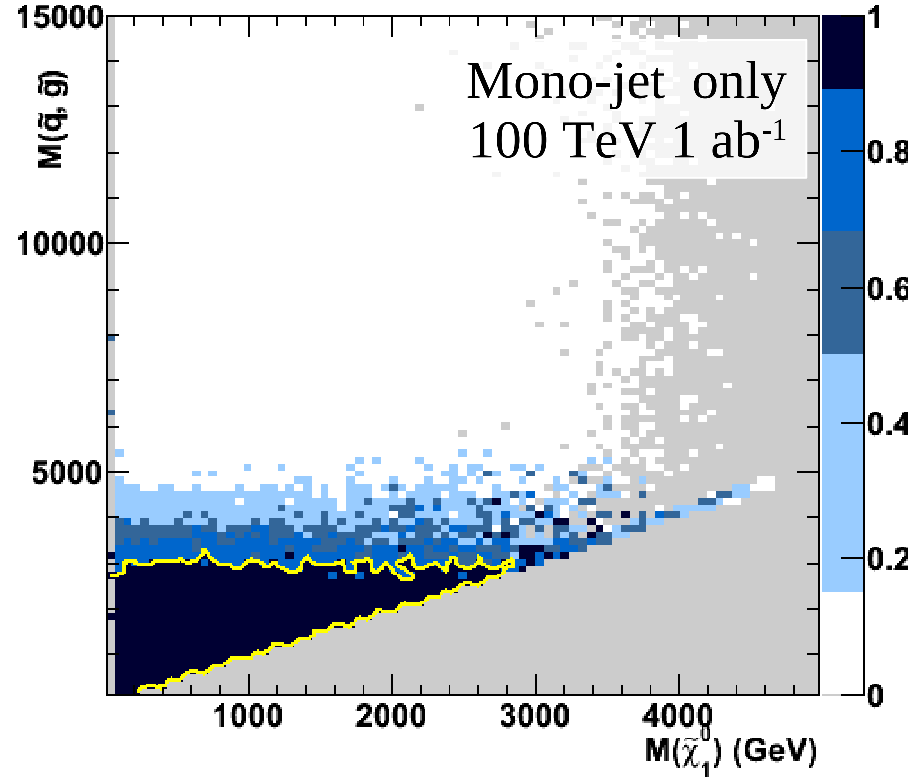


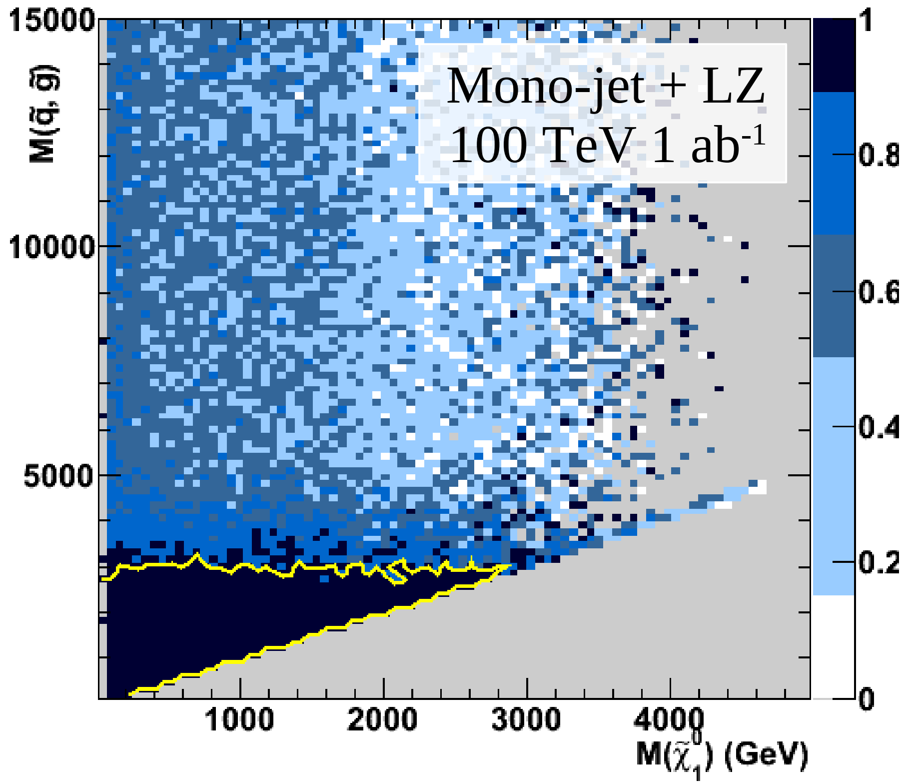
Dark Matter Direct Detection Experiments: Limits and Future Sensitivity

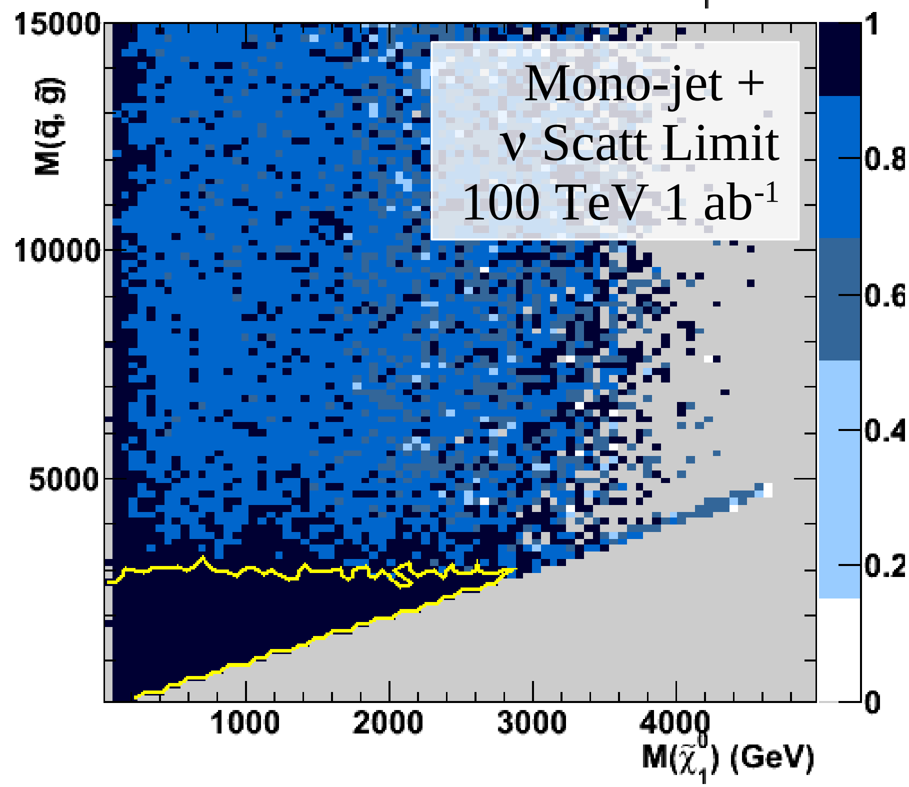


Snowmass CF1 Summary
arXiv:1310.8327

Combining Monojets at 100 TeV with DM Direct Detection Limits







Sensitivity beyond the MSSM

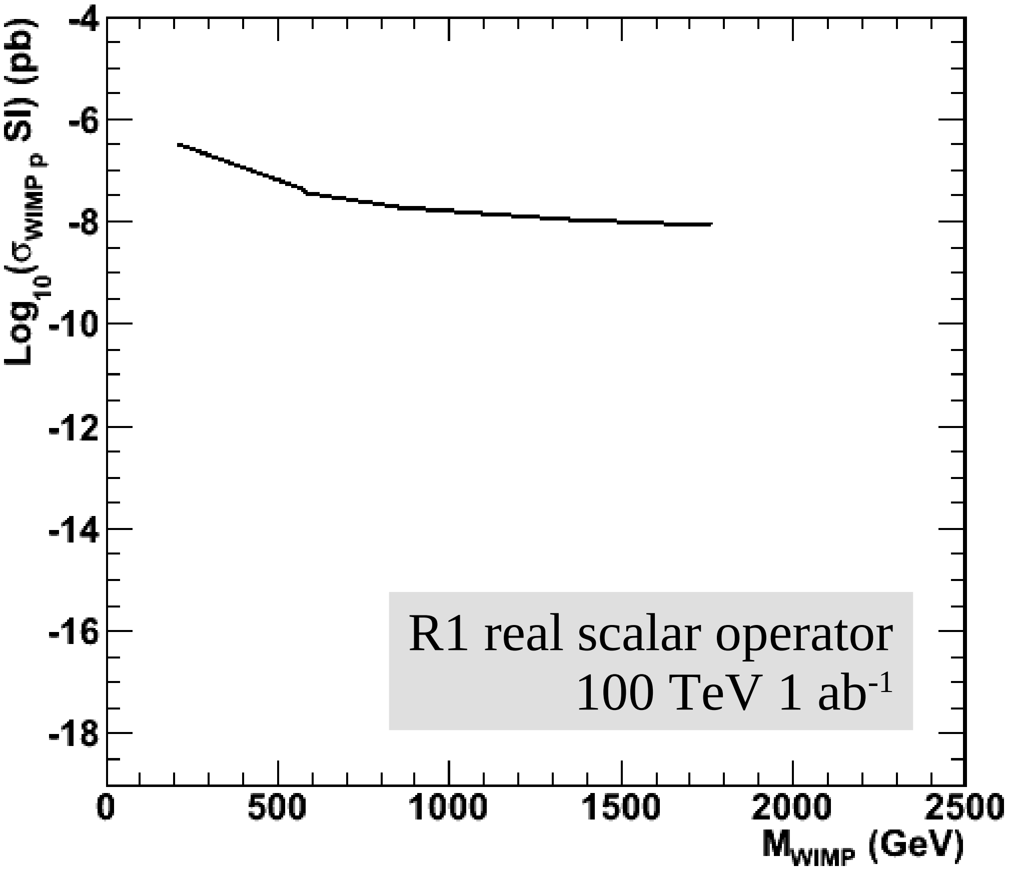
Study reach of 14 and 100 TeV data in effective field theory and contrast with pMSSM results;

Implementation of full list of DM effective operators;

Study effect of monojet, monoW/Z, monophoton and monolepton searches on effective mass cut-off and WIMP scattering cross section;

Interpretation in terms of DM direct and indrect detection and relic density;

Assess limitations of the effective operator method.



What we plan next for this study

Detailed study of mono-jets/W/Z/photon/lepton from 8 to 14 and 100 TeV with optimised selection cuts;

Assess reach of jets+MET for squarks and gluinos and leptons/W/Z/h+MET for charginos and neutralinos in pMSSM at 100 TeV;

Study combinations of the above in terms of reach in LSP mass;

Develop study of effective operators and compare to MSSM case;

Identify requirements in terms of integrated luminosity and detector performance, including pile-up events.