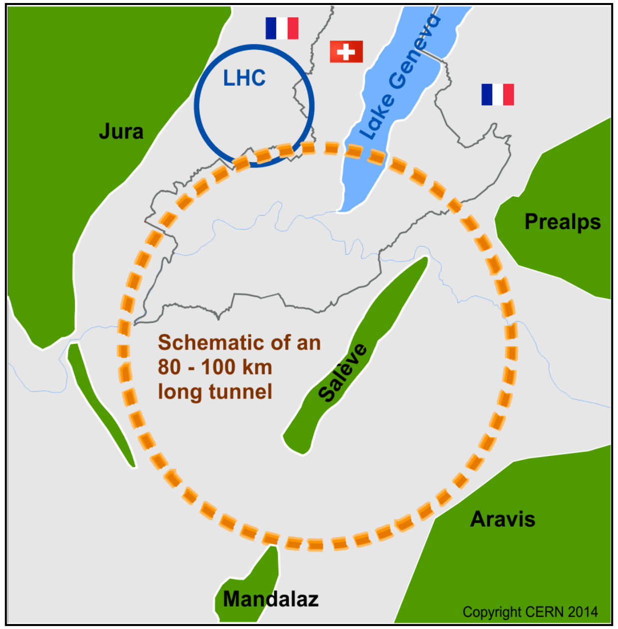
FCC-hh BSM

FCC-hh BSM group: workplan discussion

Michelangelo Mangano, Filip Moortgat (CERN)



FCC-hh

OBVIOUS FUTURE

BIG MACHINES,
BIG PHYSICS IDEAS

LIFEBLOOD OF
FUNDAMENTAL PHYSICS

(N. Arkani-Hamed)

"The bigger the better … in everything" (F. Mercury)

FCC-hh

<u>pp at 100 TeV opens three windows:</u>

➥ Access to new particles in the few→30 TeV mass range, beyond LHC reach

➥ Immense rates for phenomena in the sub-TeV mass range ⇒

increased precision w.r.t. LHC

➥ Access to very rare processes in the sub-TeV mass range ⇒

search for stealth phenomena, invisible at the LHC

M. Mangano, FCC kickoff

FCC-hh

FCC-hh: starting to make the physics case …

FHC.1.2 Exploration of BSM phenomena

FHC.1.2.1 discovery reach for various scenarios (SUSY, new gauge interactions, new quark and leptons, compositeness, etc.)

FHC.1.2.2 Theoretical implications of discovery/non-discovery of various BSM scenarios, e.g. address questions such as:

- FHC.1.2.2.1 what remains of Supersymmetry if nothing is seen at the scales accessible at 100 TeV?
- FHC.1.2.2.2 which new opportunities open up at 100 TeV for the detection and study of dark matter?
- FHC.1.2.2.3 which new BSM frameworks, which are totally outside of the HL-LHC reach, become accessible/worth-discussing at 100 TeV ?

A lot of opportunities to contribute!!!!

FCC-hh BSM

→ Start to think about physics benchmarks along the following lines:

1) scenarios where the LHC could discover new physics, but could not really measure its properties

2) scenarios where the LHC cannot discover new physics, even if it's at low mass, because it's stealthy (e.g. compressed spectra)

3) scenarios that are out of reach for the LHC

Please give special attention to
physics benchmarks that could influence the detector design

Today

Today's meeting:

- present ideas for material that could be included in the FCC physics report
- format: 5' presentation + 10' possible discussion time

Future :

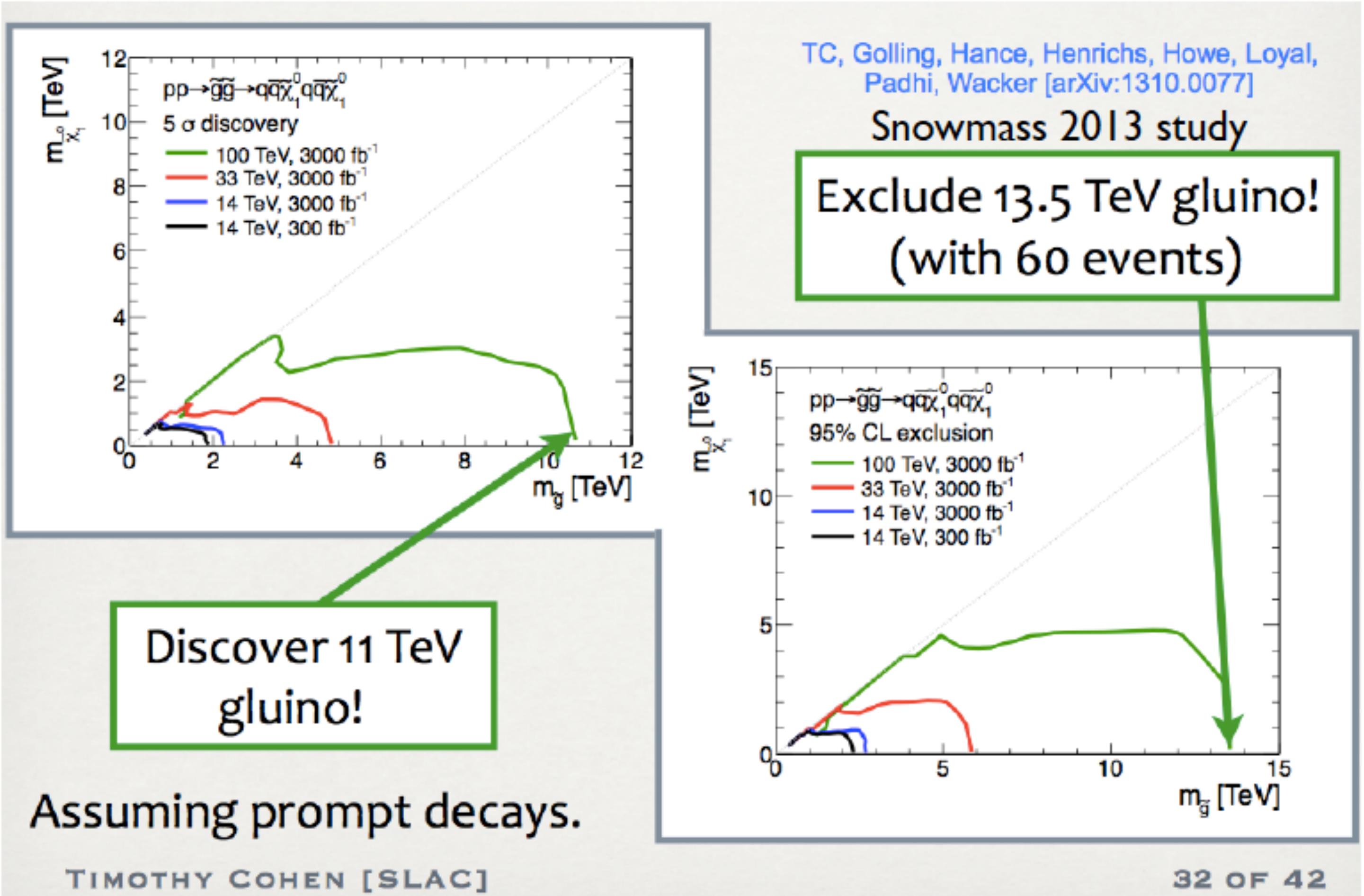
Follow-up meetings and discussions + workshop in Feb/March 2015

Twiki (will be updated after meeting):

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/BSM

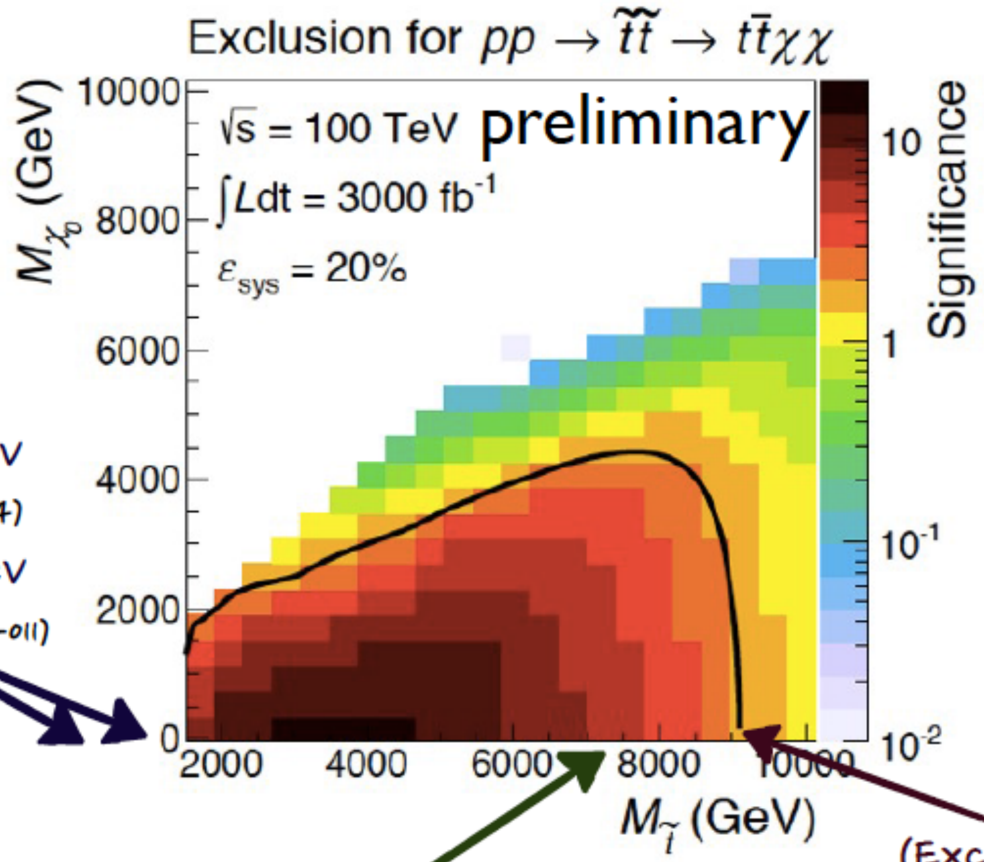
backup

SUSY @ 100 TeV



T. Cohen, FCC Kickoff preparatory workshop

stops



LHC8: 650 GeV

(ATL CONF-2013-024)

LHC14: 1.4 TeV

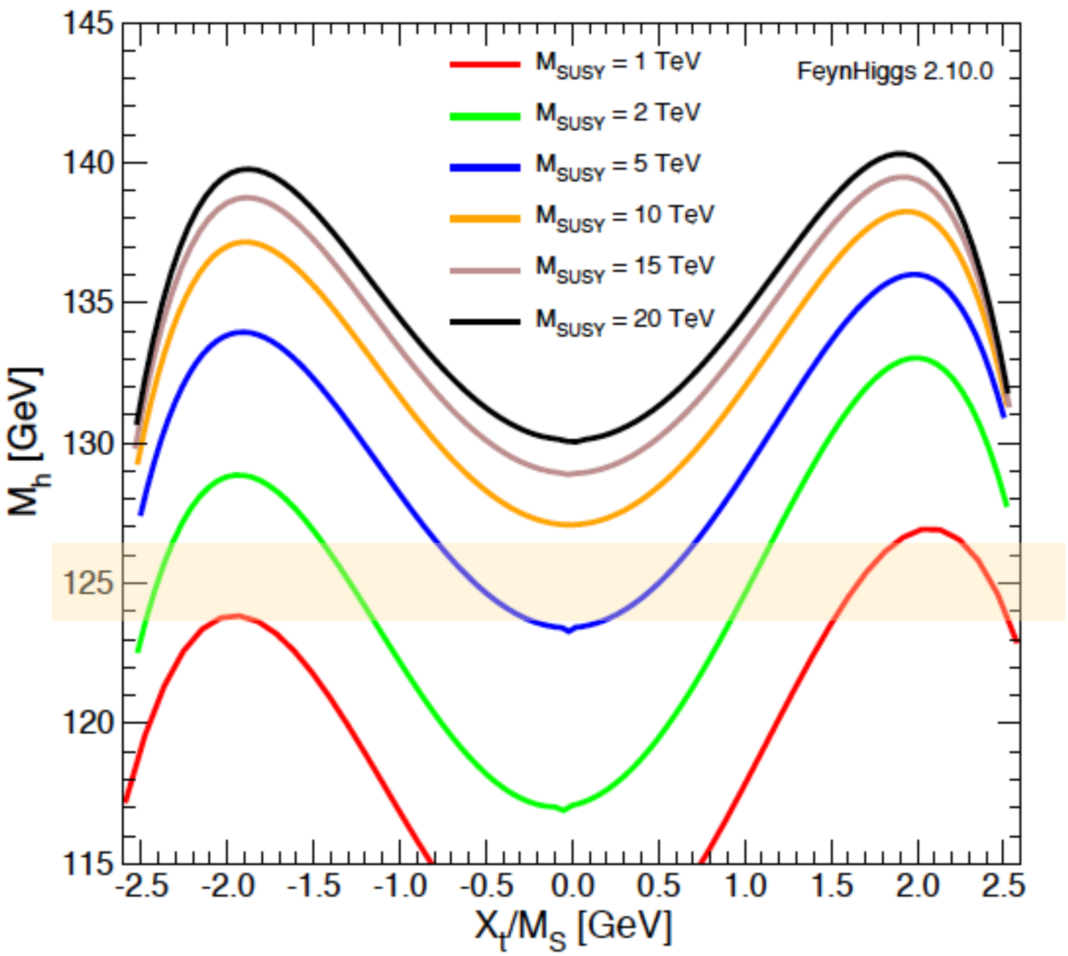
(ATL-PHYS-PUB-2013-011)

(Exclude ~9 TeV Stop)

(~ 100 events)

Discover ~7 TeV Stop!

A hint from the Higgs?



→ M_{SUSY} = 1 – 9 TeV ??

→ that's possibly outside of the LHC reach but within the FCC-hh reach!!

S. Heinemeyer, ICHEP2014

Final word on naturalness?

* Tuning probe $\propto E_{CM}^2$
* Higgs + nothing else @ 100 TeV

$\Longrightarrow \sim 10^{-4}$ tuning!

* Never seen this level of tuning in particle physics.
* Qualitatively new, mortal blow to naturalness

Even more surprising things could be found:

——— ~10 TeV scale

——— $H_2 \sim 1$ TeV

——— $H_1 \sim 125$ GeV

* Tuning $\sim (10^{-4}) \times (10^{-2}) \sim 10^{-6}$!
* Kills "anthropic" explanations

N. Arkani-Hamed, FCC Kickoff

Dark Matter

Unitarity Bound

- If dark matter is a thermal relic whose abundance is determined by its annihilation cross section, there is an upper bound on its mass.
- The bound is derived from partial wave unitarity, assuming purely inelastic (annihilation) scattering. It can be expressed:

Griest, Kamionkowski PRL64, 615 (1990)

$$\sigma_{\rm in} v \leq \frac{4\pi}{m_\chi^2 v_{\rm rel}}$$

- For an s-wave annihilator and the canonical thermal cross section, this bound implies that the WIMP mass is less than about ~100 TeV.

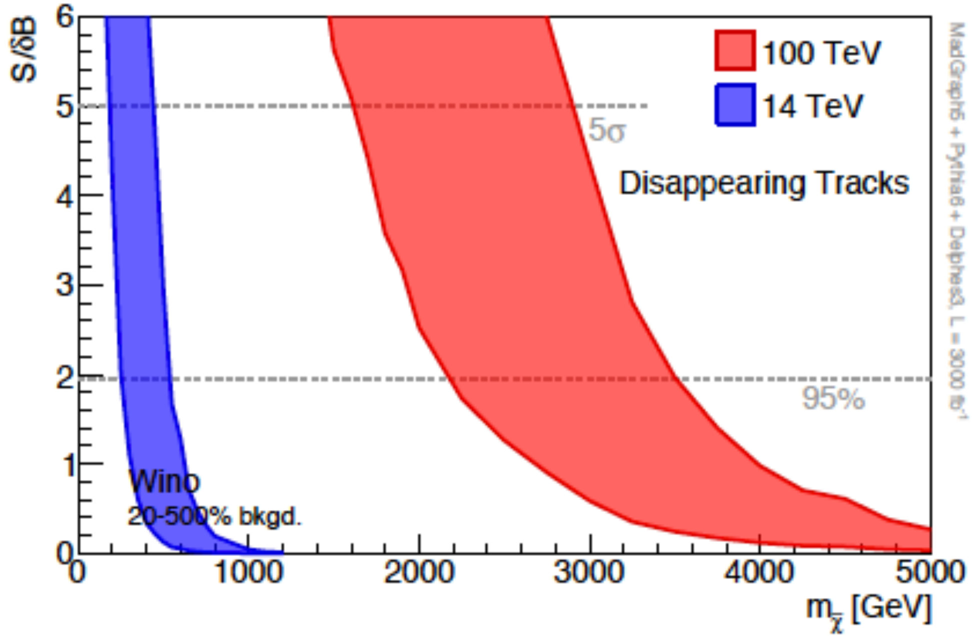
T. Tait, SLAC 100 TeV workshop

Dark Matter

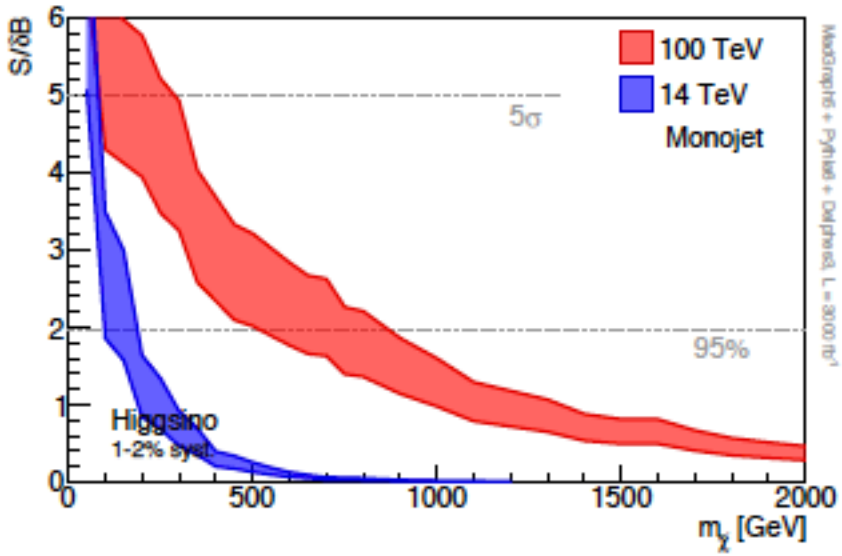
DM overclosure upper limits:
$M_{WIMP} < 1.8\,\mathrm{TeV}\,(g^2/0.3) \Rightarrow$

wino: m≲3 TeV

higgsino: m≲1.1 TeV



Wino LSP



Higgsino LSP

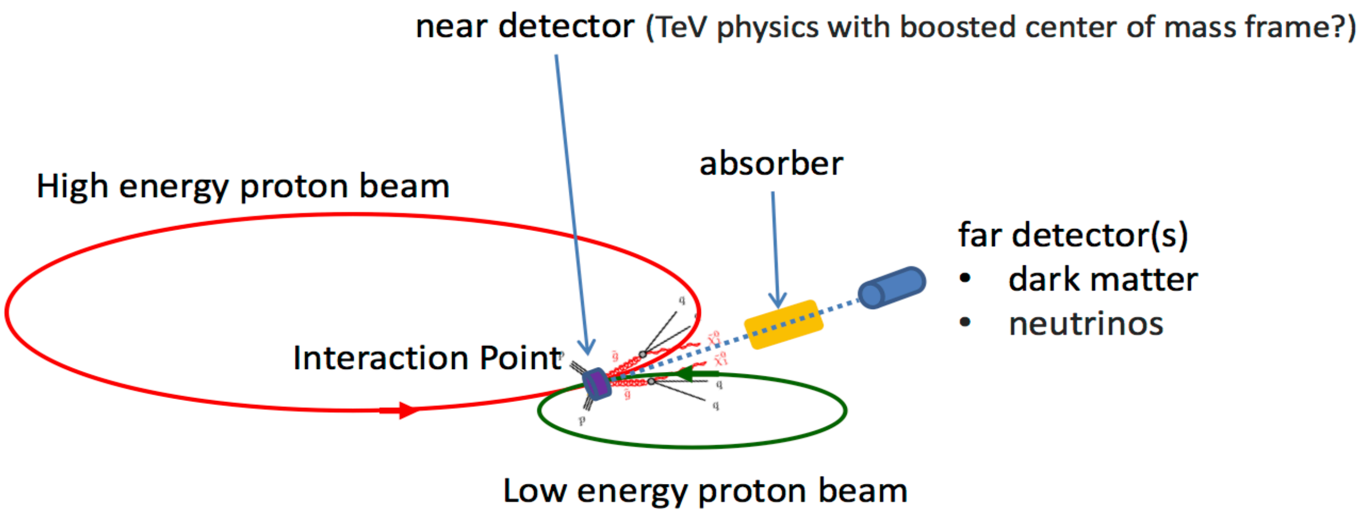
→ Wino case pretty much covered!

L-T. Wang, FCC Kickoff preparatory workshop

Dark Matter beam?

D. Cote, FCC Kickoff

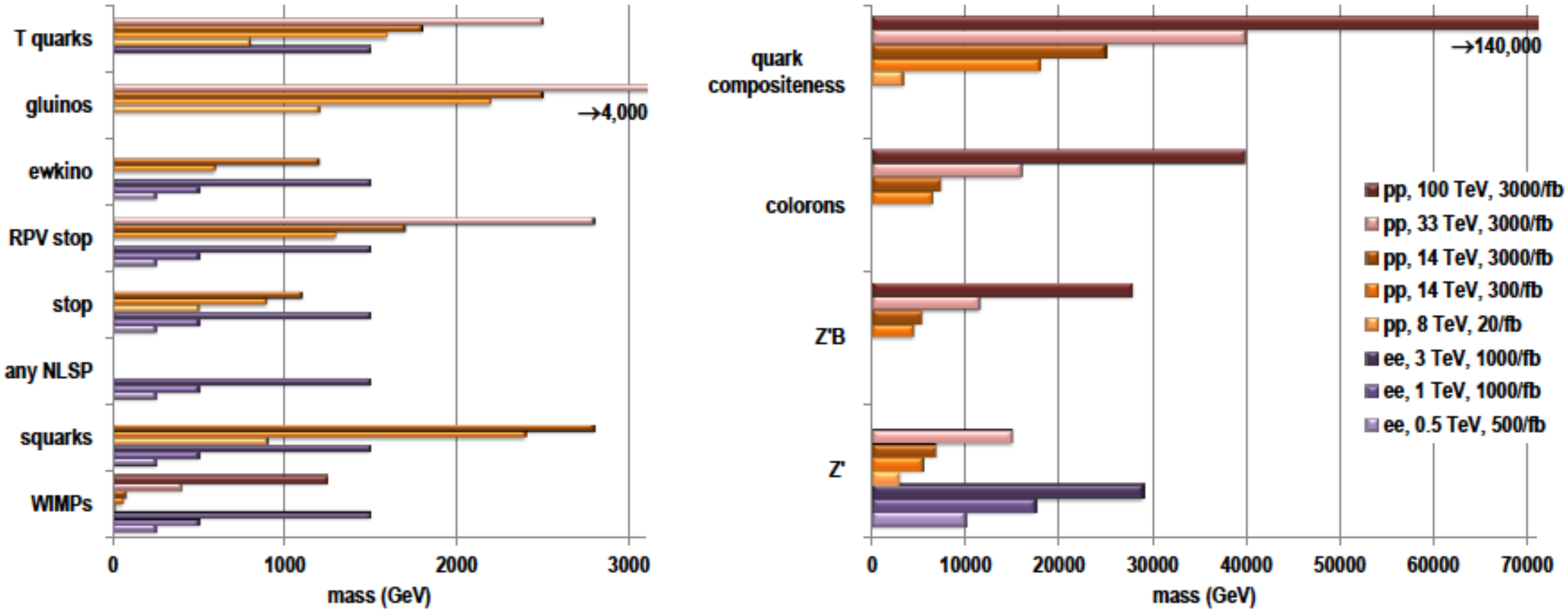
DM Beam from Asymmetric Collider



	E_{high} $[TeV]$	E_{low} $[TeV]$	E_{cm} $[TeV]$	
FHC→Fixed Target	50	0.001	0.3	← insufficient E_{cm}
FHC↔LHC	50	7.000	37.4	promising!
FHC↔Super-SPS	50	3.000	24.5	

Future Collider Reach

Future colliders comparison



Energy Frontier Snowmass study (1311.0299)