A Razor Search for Dark Matter at 100 TeV

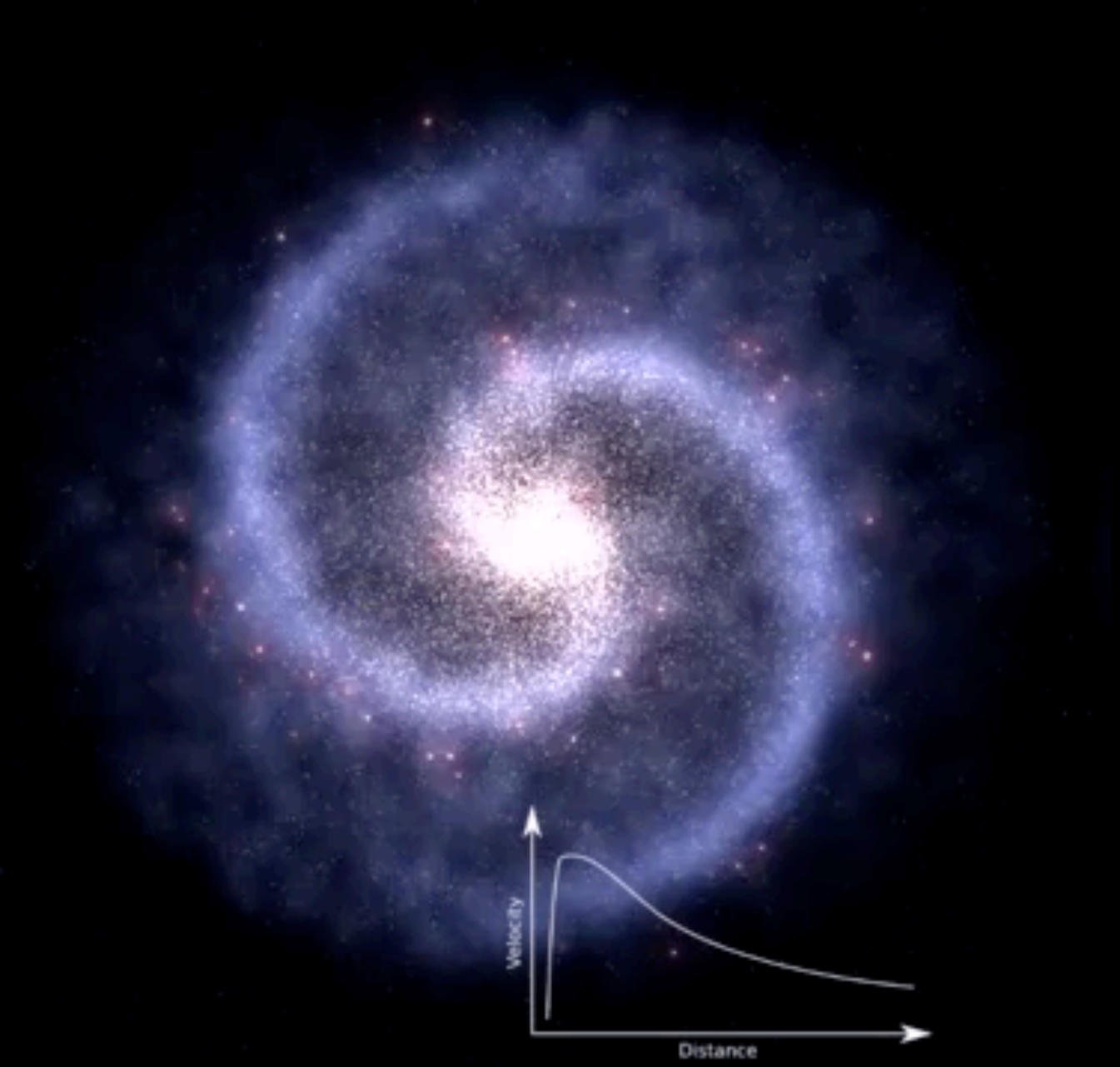
Adarsh Pyarelal

Advisor: Shufang Su

A Razor Search for Dark Matter at 100 TeV

Adarsh Pyarelal

Advisor: Shufang Su

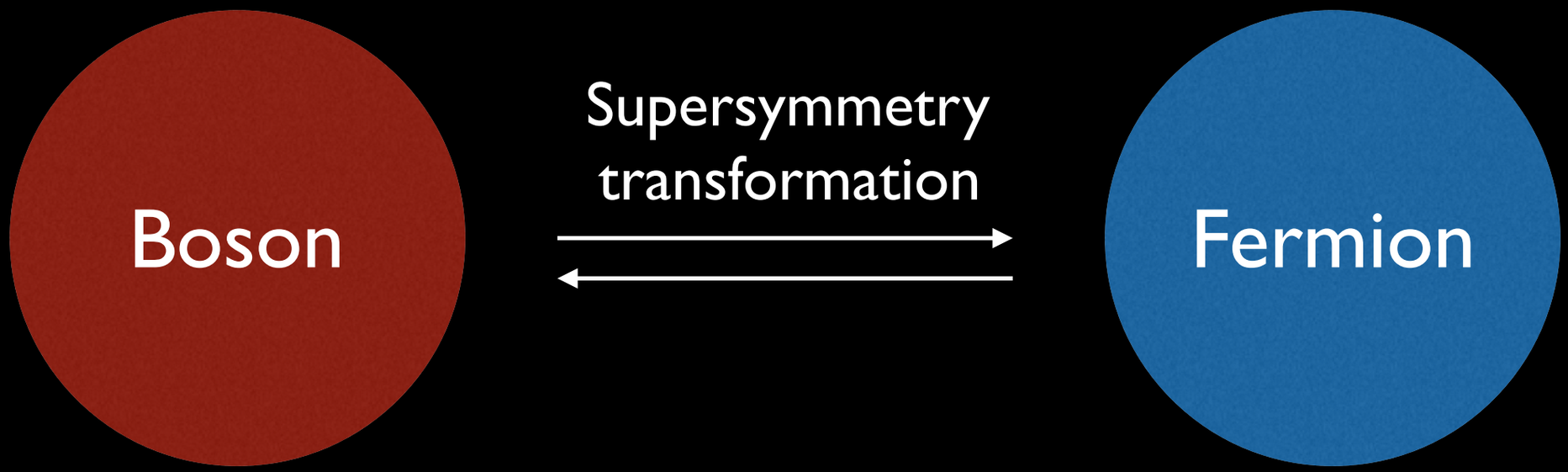

Velocity
Distance

Without dark matter

With dark matter
(edges rotate faster)

By Ingo Berg [CC BY-SA 3.0], via Wikimedia Commons

Dark Matter from Supersymmetry



Dark Matter from Supersymmetry

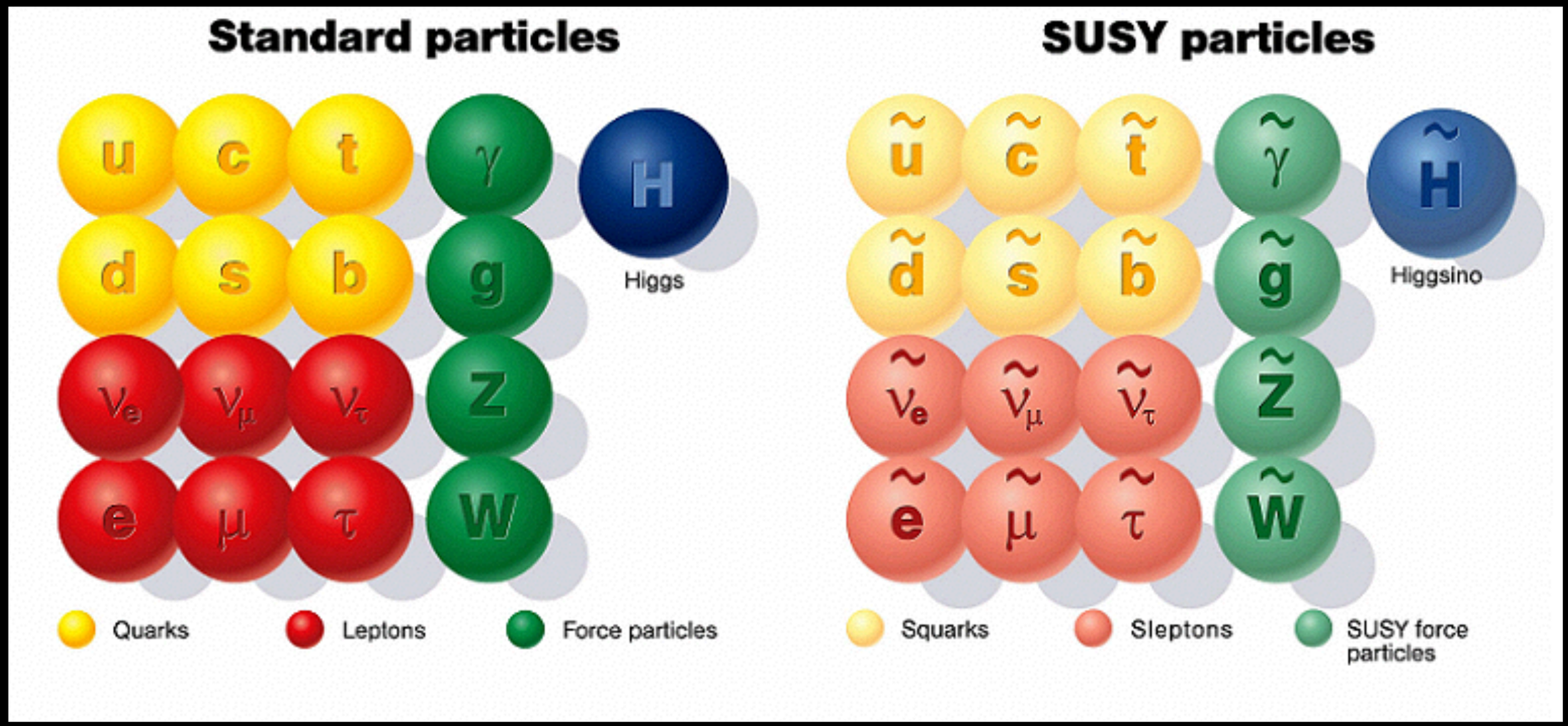


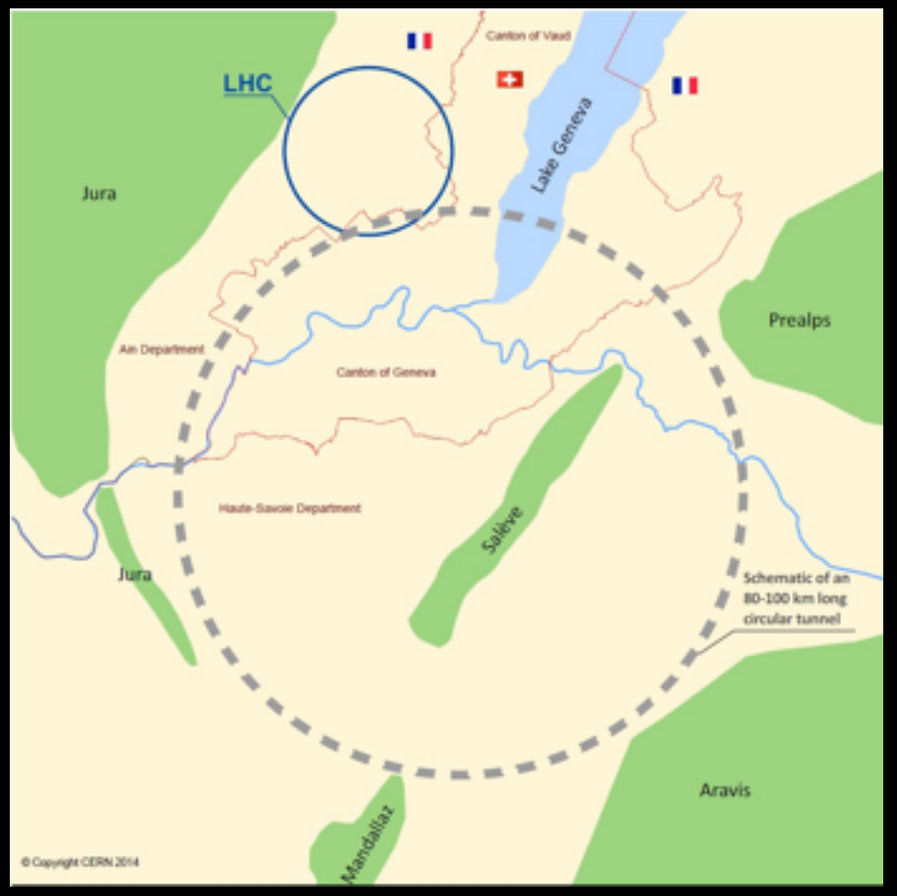
Image credit: DESY at Hamburg

Hunting Dark Matter

- Direct - Earth-based large inert substance detectors
- Indirect - Looking for signs from space
- Collider - Producing dark matter at particle colliders

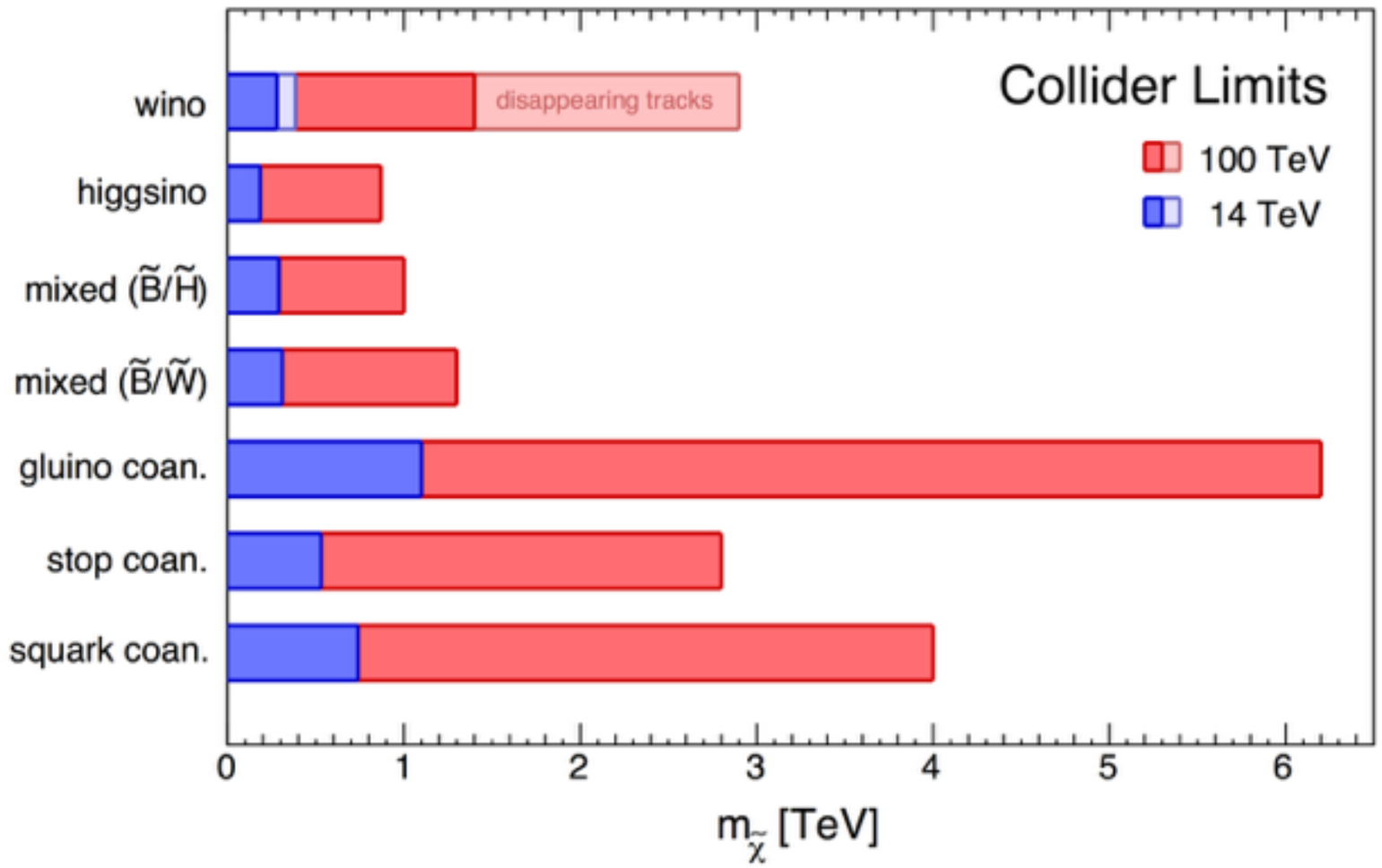
Future Colliders

CEPC-SppC (China)



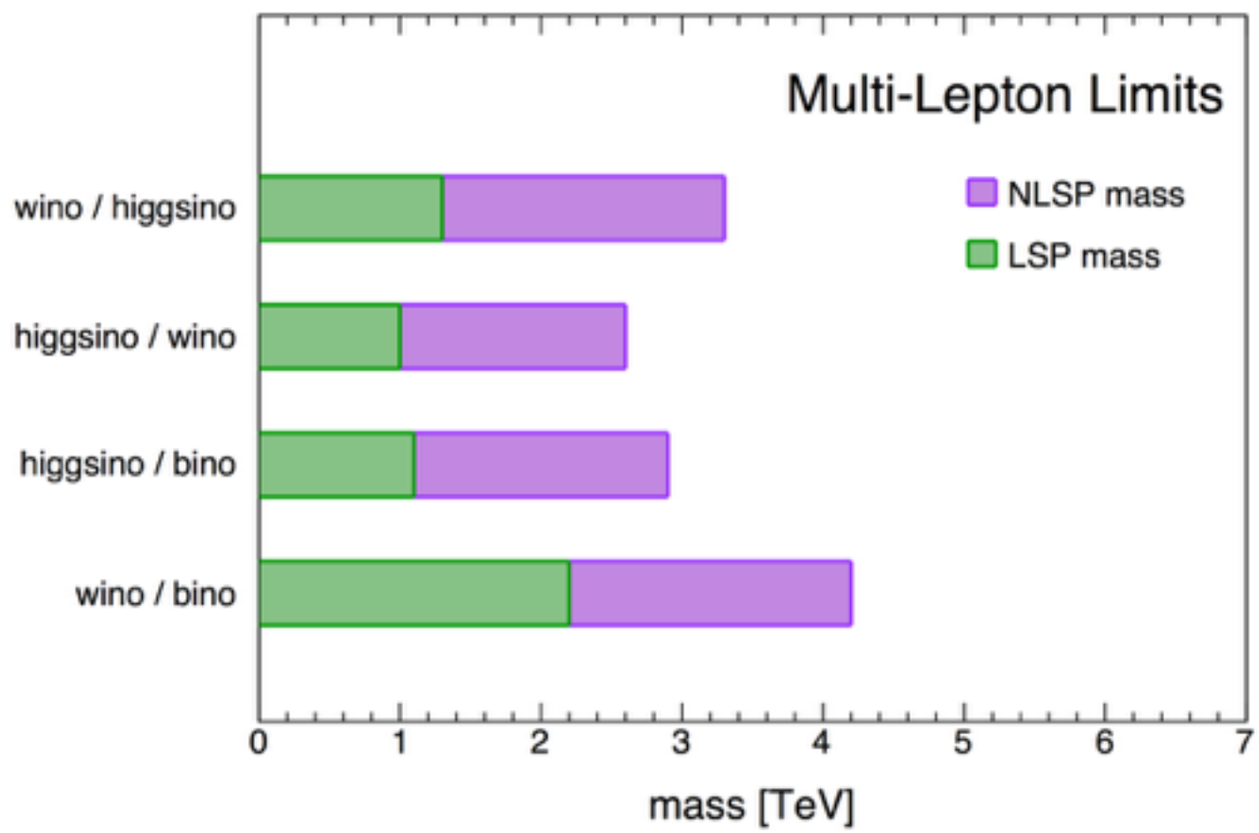
FCC-hh (CERN)

Increased reach at 100 TeV



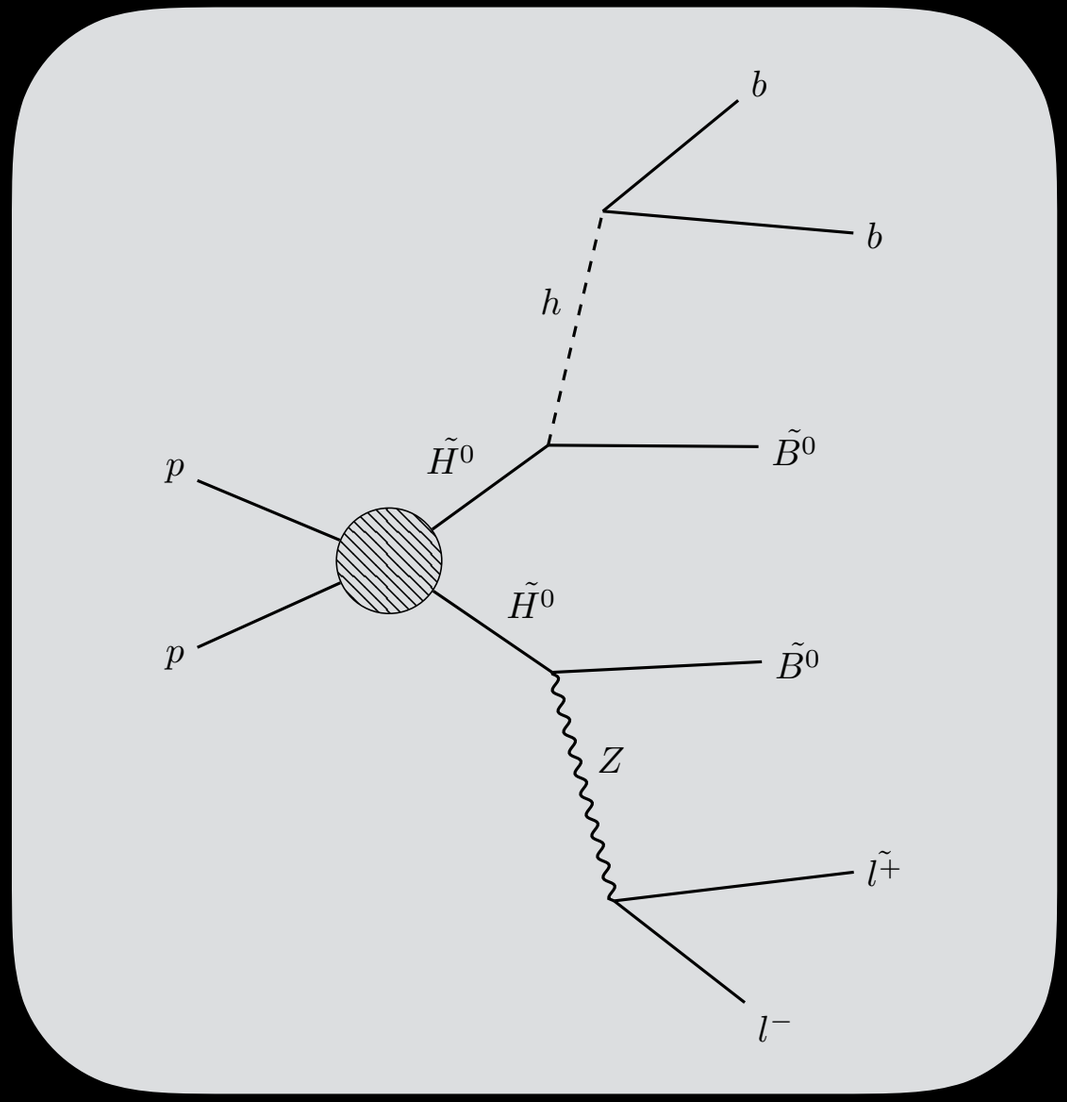
Low, Wang - Neutralino Dark Matter at 14 and 100 TeV (2014)

Increased reach at 100 TeV



Gori et al - Prospects for Electroweakino Discovery at a 100 TeV Hadron Collider (2014)

Signal

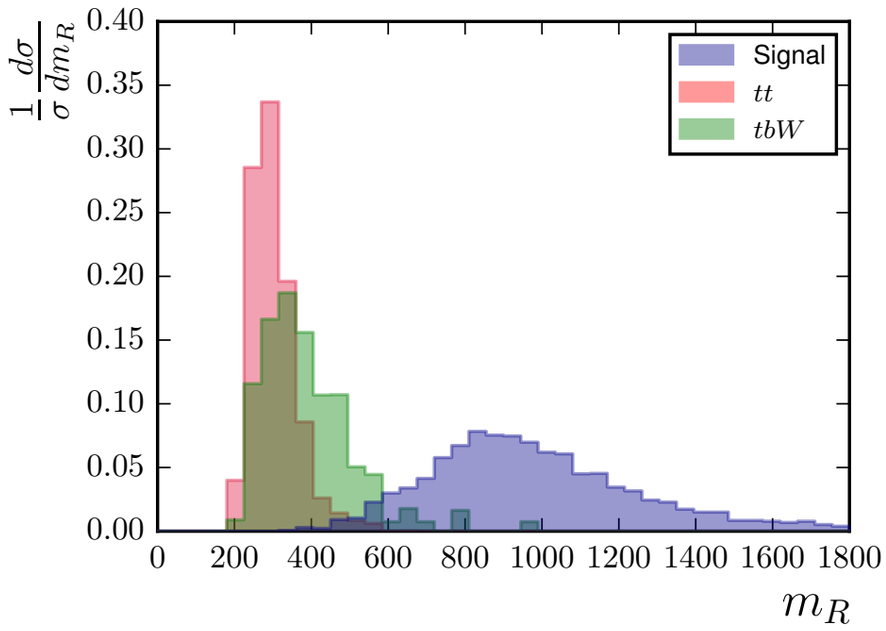


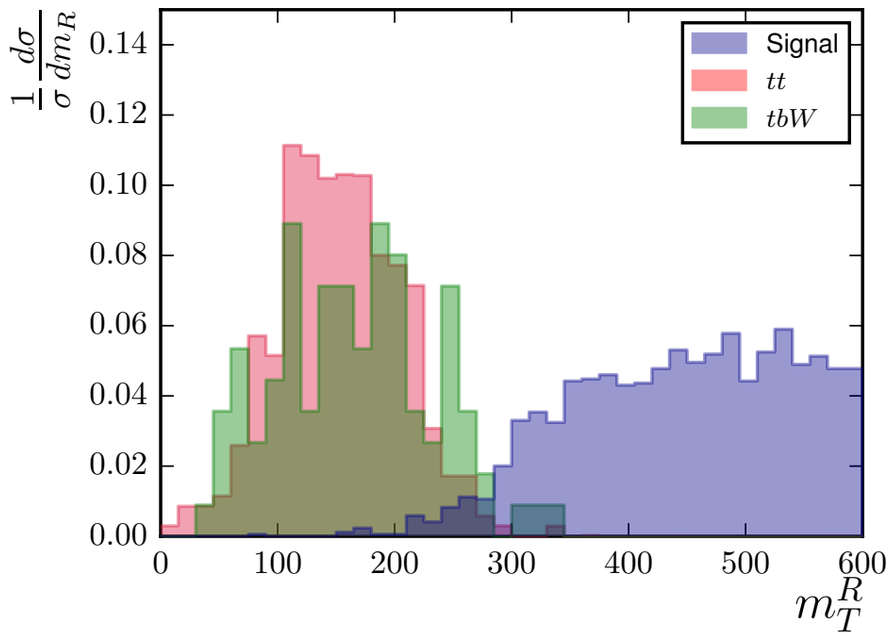
(1 TeV Higgsino, 100 GeV Bino)

Backgrounds

- Top pair production
- tbW with b W not from an on-shell top
- bbWW with no on-shell top quarks

Razor Variable Kinematical Distributions





Cut-flow table

	Cross sections for signal and background (fb)				$S/\sqrt{B}$ (for 3 ab^{-1})
	tt	tbW	bbWW	Signal	
Before cuts	1,105,698	430,086	12940	0.15	0.007
Identification	38452	2300	485	0.012	0.003
Missing energy > 180 GeV	996	459	358	0.011	0.014
Invariant mass cuts	10	2.7	0.038	0.009	0.145
M_R	0.006	0.15	0.038	0.009	1.110
M_T^R	0.004	0.06	0.00	0.009	1.813

Machine Learning

- We want to optimize our analysis using machine learning.
- One option - Boosted Decision Trees

15 Signal
1 Background

yes

no

1 Signal
6 Background

Missing energy > 180 GeV?

16 S
7 Background

no

yes

30 Signal
3 Background

Number of b-jets = 2?

46 Signal
10 Background

Branch node

4 Signal
40 Background

Leaf node

no

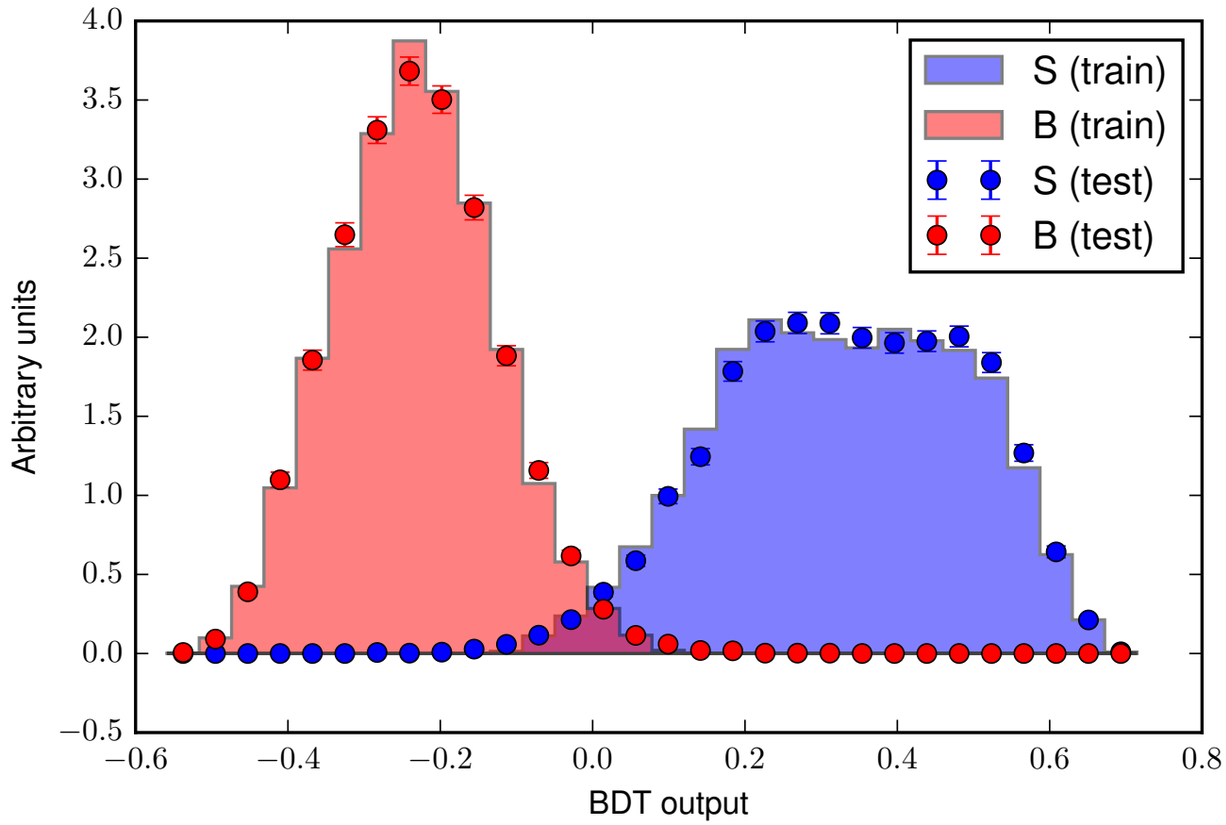
yes

Number of leptons = 2?

Root node

50 Signal
50 Background

Preliminary ML results



Looks promising!

Conclusion

- A future collider would dramatically increase our ability to discover new particles, including dark matter candidates

- Razor kinematic variables and machine learning techniques can help us efficiently isolate signal events from the background.

Backup slides

Detailed cut-flow table

All cross sections in femtobarns

	tt_full xsection	tbW xsection	bbWW xsection	Signal xsection	S/B	S/sqrt(B)
Original	1105697.629	430086.251	12939.944	0.150	9.685e-08	0.007
2 leptons	448781.081	46761.464	8238.581	0.065	1.291e-07	0.005
SF leptons	227386.012	23661.391	4156.951	0.065	2.547e-07	0.007
OS leptons	227378.344	23657.902	4156.869	0.065	2.548e-07	0.007
N(b) = 2	38452.504	2300.250	485.291	0.012	2.955e-07	0.003
MET	996.055	458.864	358.375	0.011	6.044e-06	0.014
m_SFOS	85.807	21.172	0.814	0.010	9.610e-05	0.055
m_bb	10.101	2.695	0.038	0.009	7.396e-04	0.145
m_R	0.006	0.152	0.038	0.009	4.566e-02	1.110
m_T_R	0.004	0.064	0.000	0.009	1.266e-01	1.813