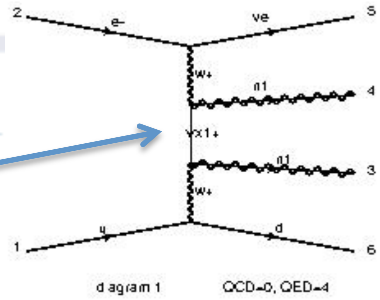
Search for SUSY DM & Sleptons at future ep colliders

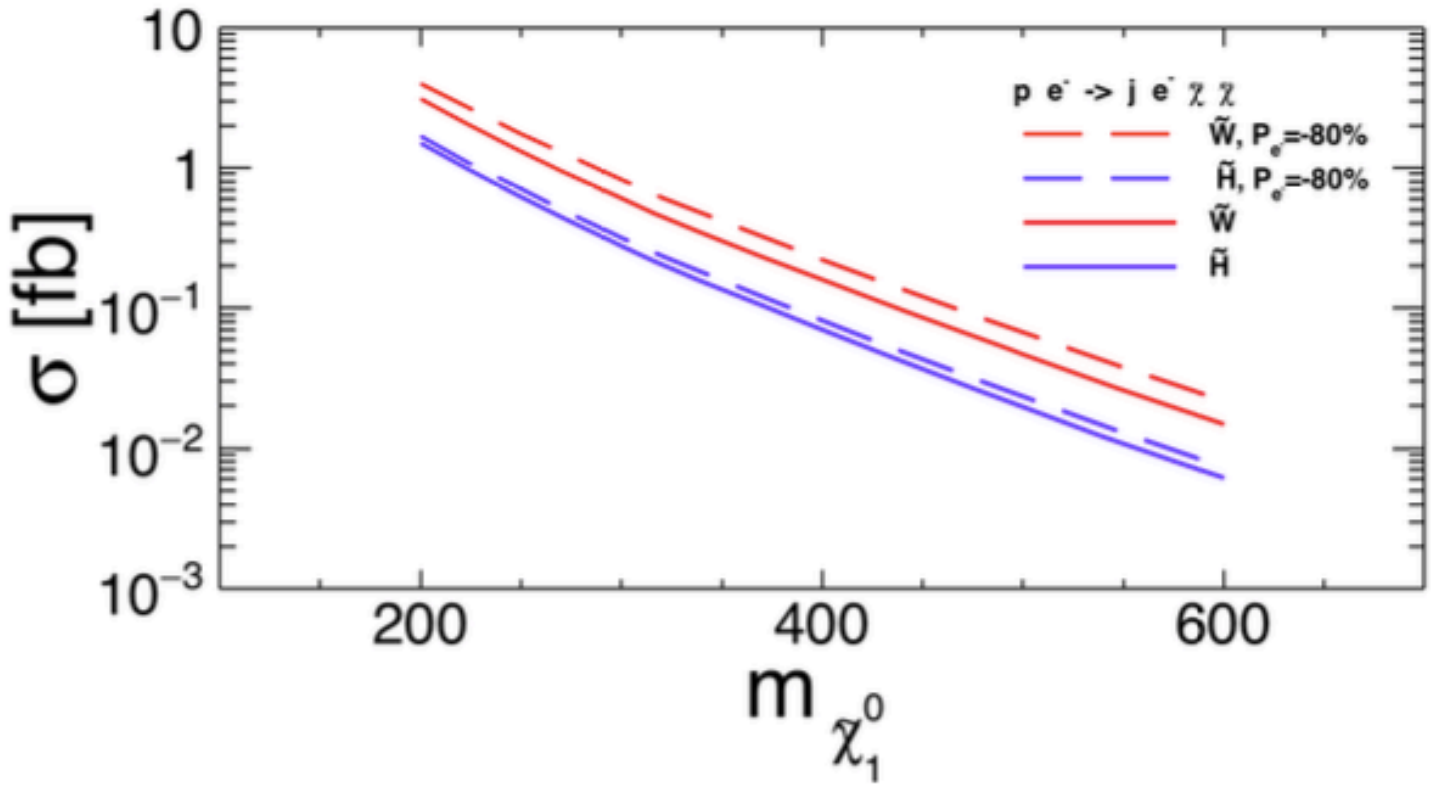
August 11, 2017

EWK RPC-SUSY production

- Question: can anything be done at the FCC-eh ?
- Production of monojet-like signatures → not feasible
- Production of the kind e+j+MET → possible
- Polarization -0.8 lead to a 30% increase in x-sections, which are anyway small:



Kechen Wang



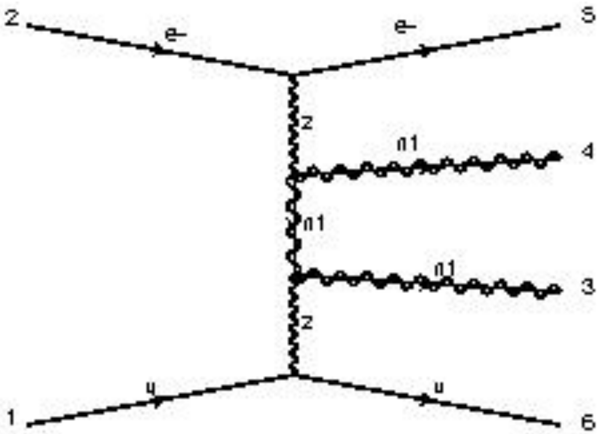
Signal Event Generating

Collider:
FCC-eh (Ep = 50 TeV, Ee = 60 GeV).

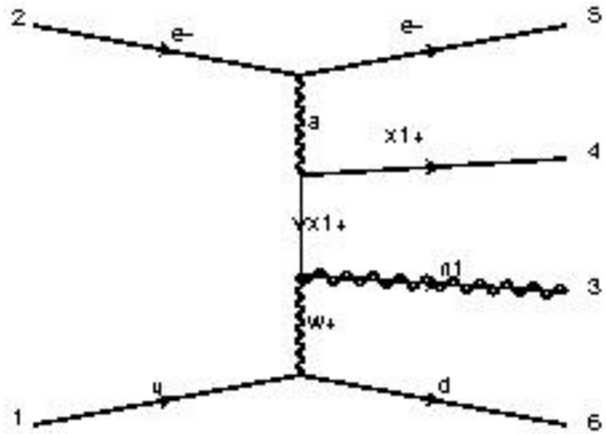
Benchmark point:
pure Wino DM: M2 ~ 200 GeV; M1, μ >> M2;
m(neutrino1) ~ m(chargino1) ~ 200 GeV.

MadGraph generating:
“import model mssm-full
define dm = n1 n2 x1+ x1-
generate p e- > dm dm e- j / go ul cl t1 ur cr t2 dl sl b1 dr sr b2 ul~ cl~ t1~ ur~ cr~ t2~ dl~ sl~ b1~ dr~ sr~ b2~ h2 h3 h+ h- sve svm svt el- mul- ta1- er- mur- ta2- sve~ svm~ svt~ el+ mul+ ta1+ er+ mur+ ta2+ n3 n4 x2+ x2- QCD=0 QED=4 ”

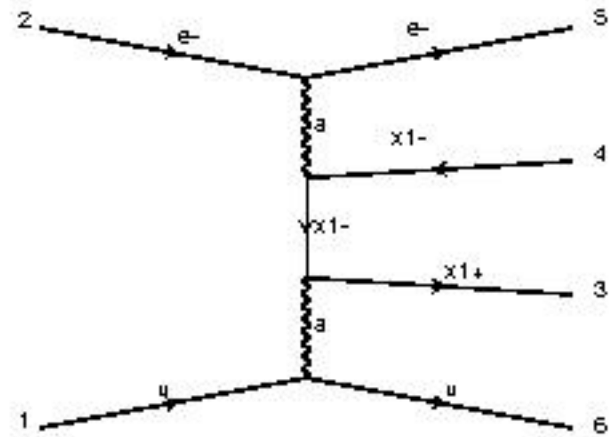
Signal Event Generating



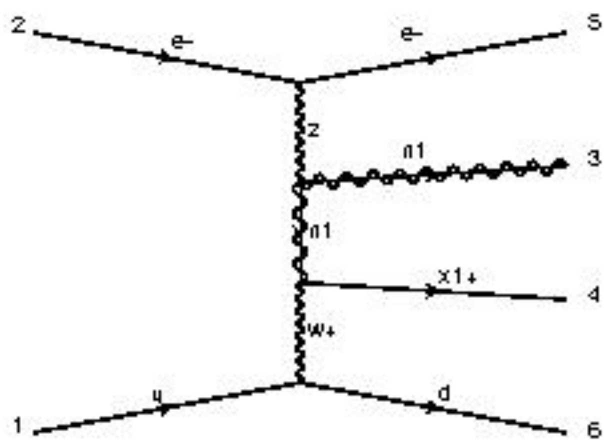
d agram 1 QCD=0, QED=4



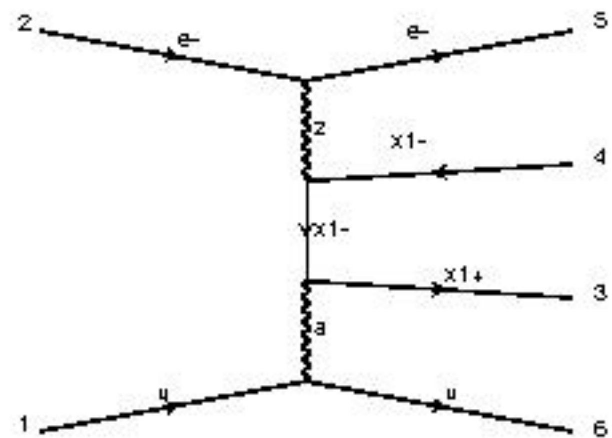
d agram 1 QCD=0, QED=4



d agram 1 QCD=0, QED=4



d agram 3 QCD=0, QED=4



d agram 3 QCD=0, QED=4

Background Event Generating

Collider:
FCC-eh (Ep = 50 TeV, Ee = 60 GeV).

MadGraph generating:
“import model sm-full
define dm = ve vm vt ve~ vm~ vt~
generate p e- > j e- dm dm ”

→ Similar to Higgs->invisible
→ Including "W j v", "Z j e",
"e- j v v (via ZZ/WZ/WA fusion)”
→ Missing “W j e-”, single top

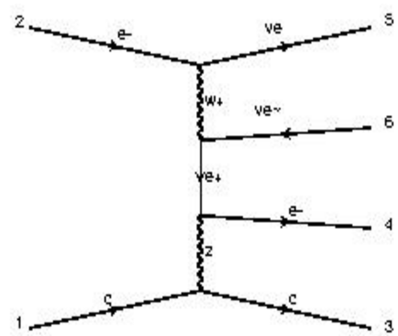


diagram 7 QCD=0, QED=4

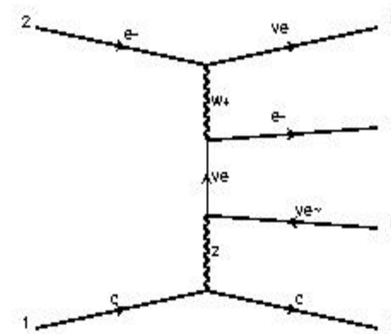


diagram 8 QCD=0, QED=4

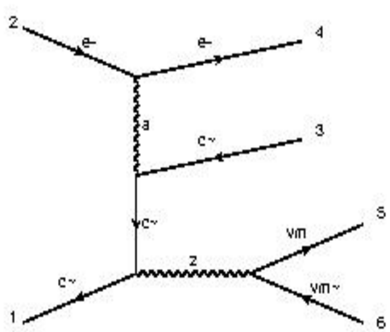


diagram 11 QCD=0, QED=4

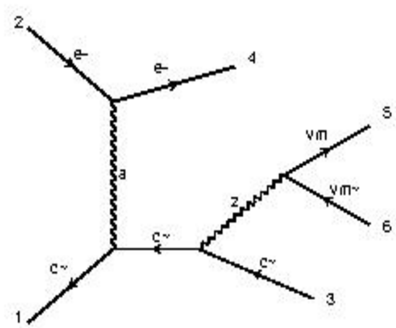


diagram 12 QCD=0, QED=4

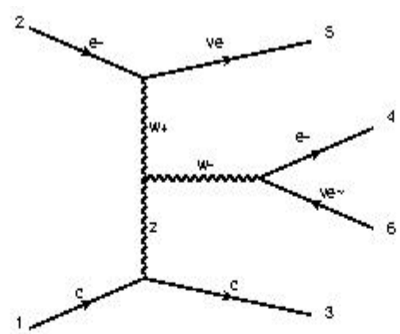


diagram 11 QCD=0, QED=4

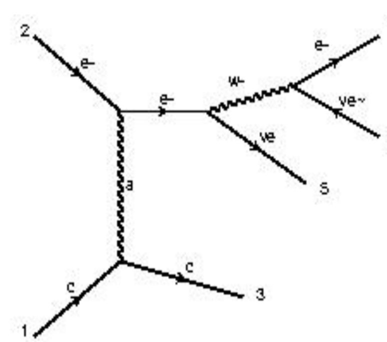


diagram 12 QCD=0, QED=4

Cut Flow Table

Wino = 200 GeV						
unpolarized beam	tight run_card_1			loose run_card		
Cuts		Signal			Background	
	# of events	Cut efficiency	cross section [fb]	# of events	Cut efficiency	cross section [fb]
initial	50000		2.290	21058		1492
N(e) >= 1	50000	100%	2.290	21058	100%	1492
N(e-) >= 1	50000	100%	2.290	21058	100%	1492
N(j) >= 1	50000	100%	2.290	21058	100%	1492
p_T(e-) > 5 GeV	37903	76%	1.736	14374	68%	1018.426
eta(e-) > -5.0	37903	100%	1.736	14374	100%	1018.426
eta(e-) < 1.0	27464	72%	1.258	5625	39%	398.542
p_T(j) > 50 GeV	16987	62%	0.778	2087	37%	147.868
eta(j) > 3.0	14043	83%	0.643	984	47%	69.718
MET > 100 GeV	9903	71%	0.454	352	36%	24.940
M_T(met,j) > 150 GeV	9599	97%	0.440	336	95%	23.806
dPhi(met,j) > 3.0	5230	54%	0.240	123	37%	8.715
dPhi(e-,j) < 2.0	3592	69%	0.165	72	59%	5.101
dEta(e-,j) > 5.0	2072	58%	0.095	11	15%	0.779
m(e + j) > 350 GeV	2071	100%	0.095	11	100%	0.779
M_T(met,e + j) > 500 GeV	2067	100%	0.095	11	100%	0.779
Significance with 1000 fb^-1			3.2			
Significance with 600 fb^-1			2.5			

Total cut efficiency:

Signal: 4.1%; Background: 0.05%

Cut Flow Table

Wino = 200 GeV

polarized beam

+40%

Cuts	tight run_card_1 Signal # of events	Cut efficiency	cross section [fb]	tight run_card_1 Background # of events	Cut efficiency	cross section [fb]
initial	50000		3.197	60000		1905
N(e) >= 1	50000	100%	3.197	60000	100%	1905
N(e-) >= 1	50000	100%	3.197	60000	100%	1905
N(j) >= 1	50000	100%	3.197	60000	100%	1905
p_T(e-) > 5 GeV	41198	82%	2.634	53780	90%	1707.515
eta(e-) > -4.2	41198	100%	2.634	53780	100%	1707.515
eta(e-) < 1.2	30011	73%	1.919	21728	40%	689.864
p_T(j) > 60 GeV	17292	58%	1.106	7776	36%	246.888
eta(j) > 3.0	14353	83%	0.918	3797	49%	120.555
MET > 100 GeV	11007	77%	0.704	1522	40%	48.324
M_T(met,j) > 160 GeV	10625	97%	0.679	1446	95%	45.911
dPhi(met,j) > 3.0	4858	46%	0.311	515	36%	16.351
dPhi(e-,j) < 2.0	3313	68%	0.212	314	61%	9.970
dEta(e-,j) > 3.6	2785	84%	0.178	154	49%	4.890
m(e + j) > 350 GeV	2682	96%	0.171	128	83%	4.064
M_T(met,e + j) > 500 GeV	2676	100%	0.171	127	99%	4.032

Significance with 1000 fb^-1 2.6

Significance with 600 fb^-1 2.0

Total cut efficiency:

Signal: 5.4%; Background: 0.21%

(4.1%); (0.05%)

Future Work on DM & Sleptons
Using the Kinematical Observables

1. Kechen will finish the study using the kinematical observables.

(1) The benchmark point for "heavy slepton scenario" will be:
Bino ~ m_{neutralino1} = 200 GeV;
Wino ~ m_{chargino1} = m_{neutralino2} = 205 GeV;
slepton is decoupled and heavy.

The SM background for "heavy slepton scenario" will be:
(a) two-neutrino process:
define dm = ve vm vt ve~ vm~ vt~
generate p e- > j e- dm dm

(b) one-neutrino process:
generate p e- > j e- l vl

Will do the "MadGraph + PYTHIA + Delphes" simulation and try to finish the analysis at detector-level using the BDT method.

Future Work on DM & Sleptons Using the Kinematical Observables

(2) After that, I will do the "light slepton scenario":
Bino ~ m_{neutralino1} = 200 GeV;
Wino ~ m_{chargino1} = m_{neutralino2} = 205 GeV;
The right-handed m_{selectron_R} = 220 GeV (or a little bit heavier to make the electron from selectron decay harder).

In this scenario, the dark matter production can be enhance by the slepton production.

The SM background for this scenario will be the same as "heavy slepton scenario", because the final state will be the same.

Future Work on DM & Sleptons Using the Kinematical Observables

2. Sho will finish the disappearing track study.

(1) We agree that we will use the detector design "FCCeh_Option0" for disappearing track study.

(2) The scenarios will be 5 different scenarios listed in Sho's previous note:

(a) Pure-wino LSP
(b) Pure-wino LSP co-produced with left-handed selectron
(c) Pure-higgsino LSP
(d) Slepton LLCP scenarios (without Bino co-production)
(e) Slepton LLCP scenarios with Bino co-production

We expect the "(a) pure-wino LSP" scenario will have some limits, while "(c) Pure-higgsino LSP" scenario may have worse limits due to the small production.