Karlsruhe Institute of Technology

FUTURE CIRCULAR COLLIDER

ETP FCC MEETING

Sofia Giappichini, 25.04.2024

Karlsruhe Institute of Technology

FUTURE CIRCULAR COLLIDER

CEPC CONFERENCE

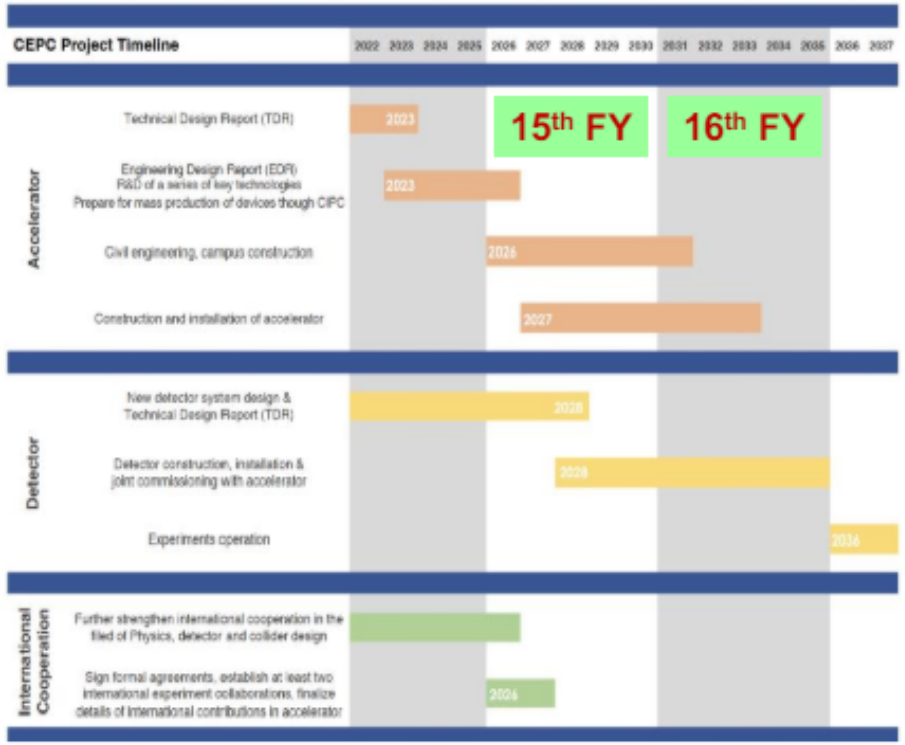
CEPC TIMELINE

CEPC Planning and Schedule

2012.9	2015.3	2018.11	2023.12	2025.6	2027	15th five year plan (2026-2030)
proposed	Pre-CDR	CDR	Acc. TDR	Det. TDR	EDR	Start of construction

CEPC EDR Phase: 2024-2027

- **CEPC Accelerator EDR** starts with 35 WGs in 2024, to be completed in **2027**
- **CEPC Reference Detector TDR** will be released by June, **2025**
- **CEPC proposal** will be submitted to Chinese government for approval in **2025**
- **Upon approval**, establish at least two international experiment collaborations
- **CEPC construction starts** during the 15th five year plan (2026-2030, e.g. **2027**)
- **CEPC construction complete** around **2035**, at the end of the 16th five year plan



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CEPC Marseille

CEPC PLANS

CEPC Operation Plan

Mode	$E_{c.m.}$ (GeV)	Years	SR Power (MW)	Lumi. per IP ($10^{34}cm^{-2}s^{-1}$)	Integrated Lumi. per year (ab^{-1}, 2 IPs)	Total Integrated Lumi (ab^{-1}, 2 IPs)	Total Events
H*	240	10	50	8.3	2.2	21.6	4.3×10^6
			30	5	1.3	13	2.6×10^6
Z	91	2	50	192**	50	100	4.1×10^{12}
			30	115**	30	60	2.5×10^{12}
W	160	1	50	26.7	6.9	6.9	2.1×10^8
			30	16	4.2	4.2	1.3×10^8
$t\bar{t}$	360	5	50	0.8	0.2	1.0	0.6×10^6
			30	0.5	0.13	0.65	0.4×10^6

* Higgs is the top priority, the CEPC will commence its operation with a focus on Higgs.

** Detector solenoid field is 2 Tesla during Z operation, 3 Tesla for all other energies.

*** Calculated using 3,600 hours per year for data collection (~250 days with 60% efficiency).

100 km tunnel to optimize $t\bar{t}$ stage (no geographical constraint)

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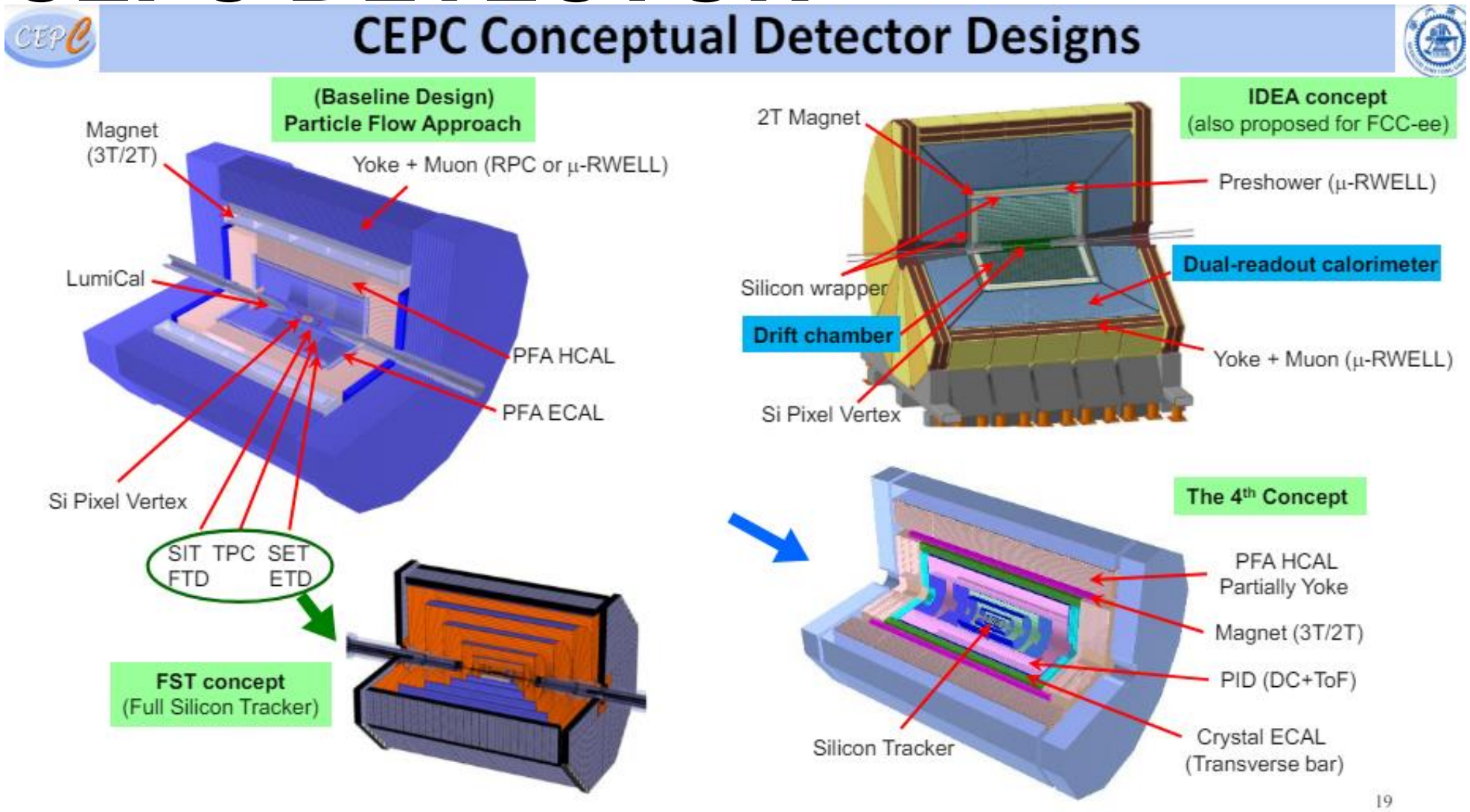
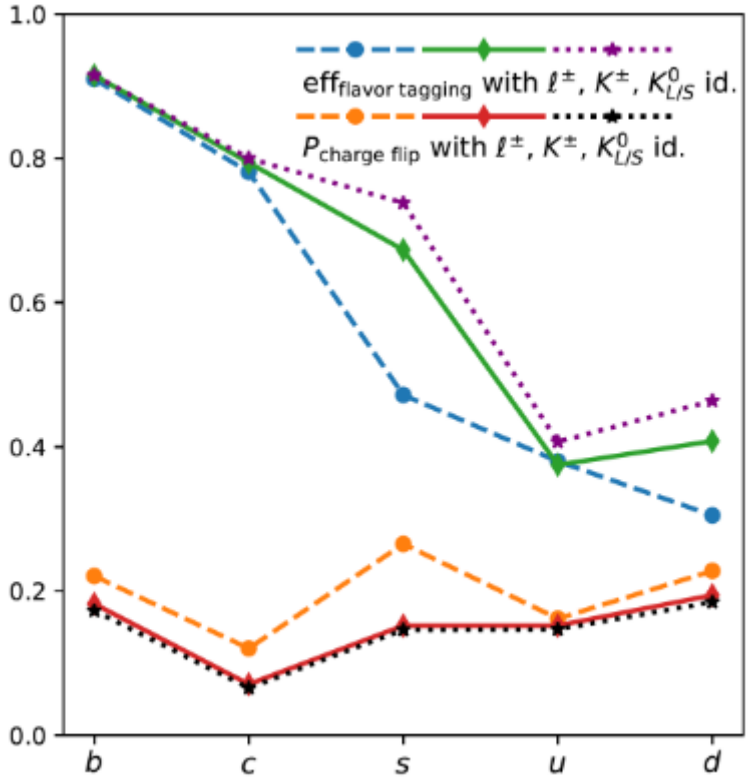
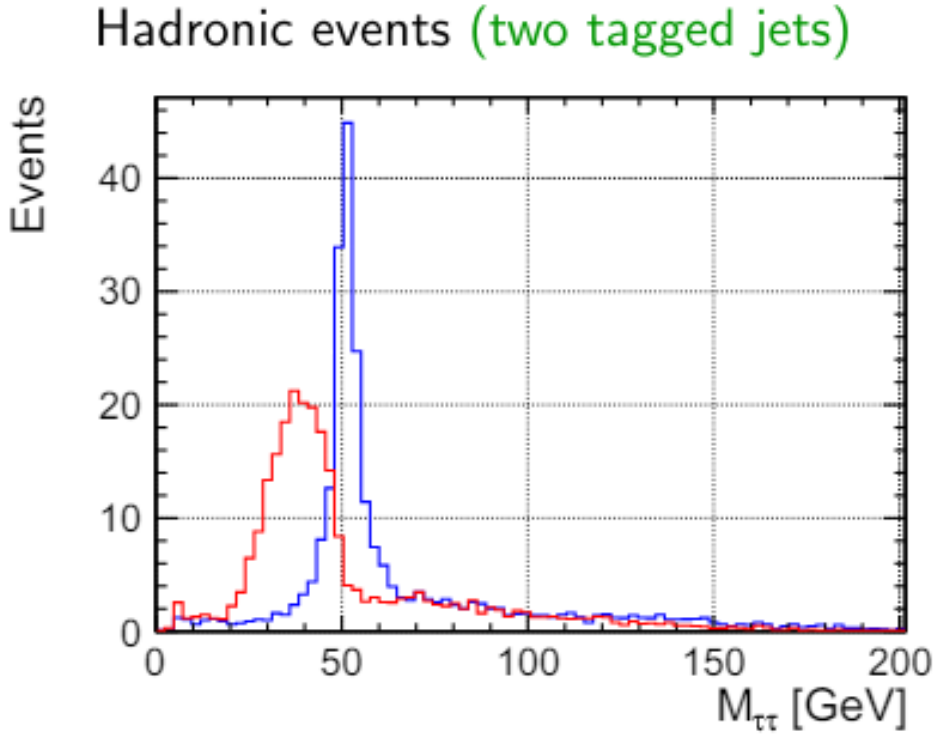
CEPC DETECTOR



CEPC PHYSICS



red is raw, blue corrected for $M_S = 50\ GeV$ for $S \to \tau\tau$



- Quark tagging (u, d, c, s, b and g) -> Jet origin ID based on ML, CEPC
- Tau reconstruction -> coplanarity, 70% efficiency on $\tau_h\tau_h, \tau_h\tau_l, \tau_l\tau_l$, ILC

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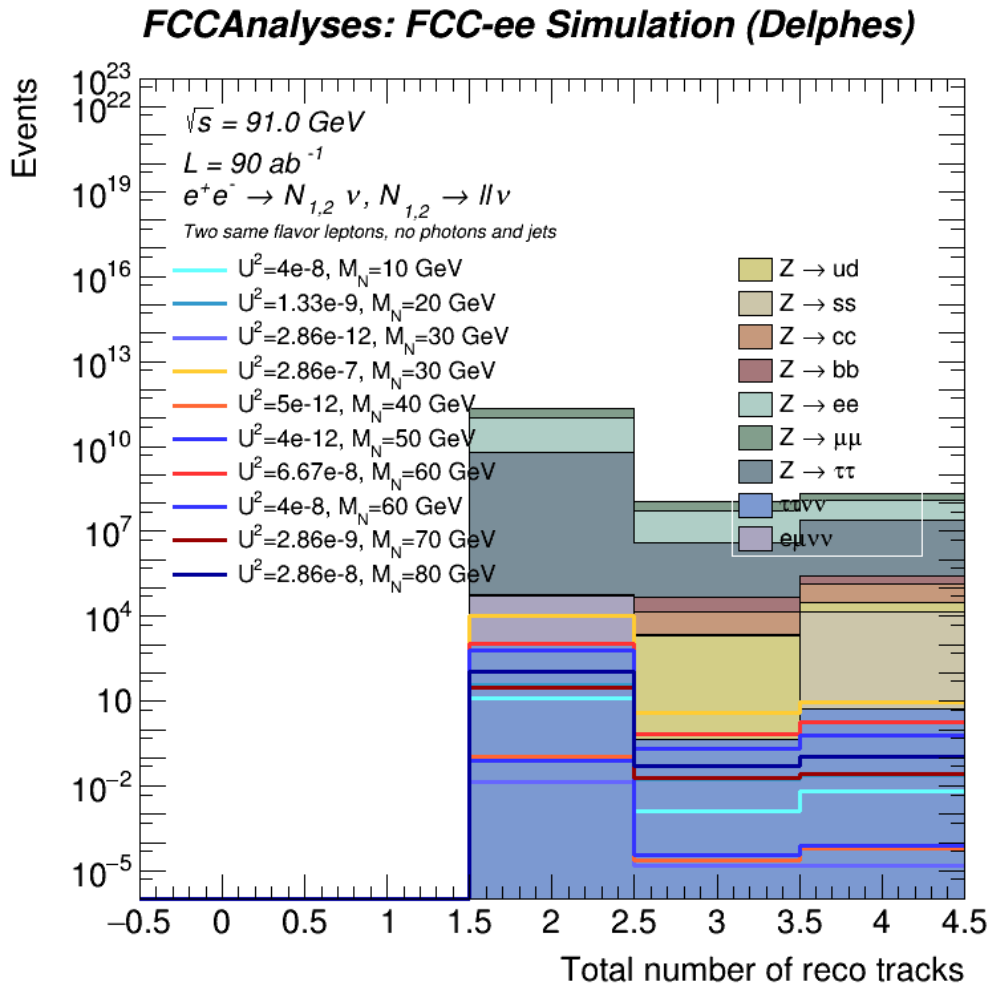
FUTURE CIRCULAR COLLIDER

UPDATE ON HNLs

CUT ON TRACKS

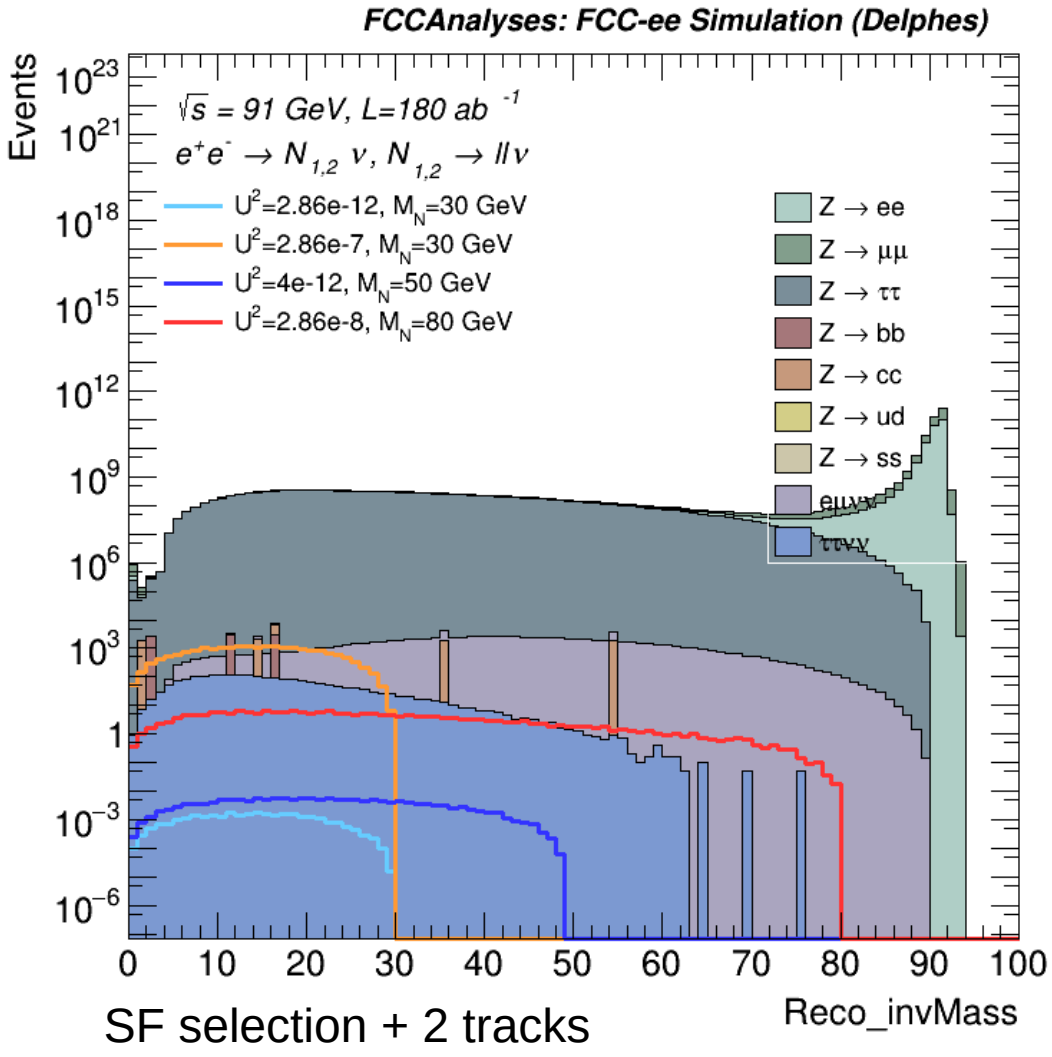
- Selecting excatly two reconstructed tracks (besides two leptons, no photons, no jets) eliminates almost all hadronic backgrounds
- Signal is not too much reduced
- We need fewer additional cuts to get even higher significance



ADDITIONAL CUTS

1. Invariant mass: $M(\ell, \ell') < 80\ GeV$ -> no signal events after that
2. Missing momentum: $p_{T,miss} > 11.5\ GeV$ for SF and $p_{T,miss} > 7\ GeV$ for DF
3. Lepton momentum: $p < 40\ GeV$ only for SF
4. Angle between the leptons: $cos\theta > (-0.8)$

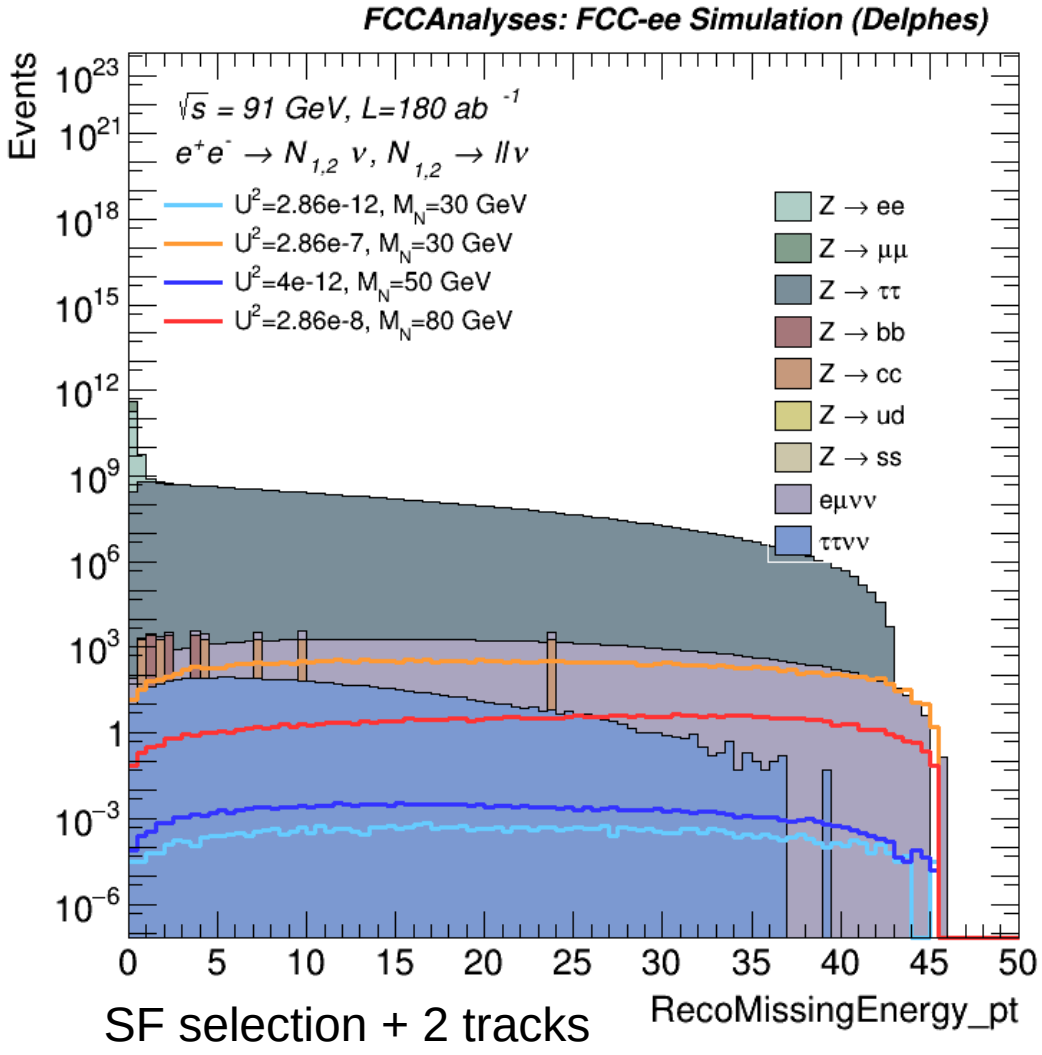
chosen by optimizing $\frac{s}{\sqrt{s+b}}$ and based on previous ones



ADDITIONAL CUTS

1. Invariant mass: $M(\ell, \ell') < 80\ GeV$
2. Missing momentum: $p_{T,miss} > 11.5\ GeV$ for SF and $p_{T,miss} > 7\ GeV$ for DF -> excludes Z$\mu\mu$
3. Lepton momentum: $p < 40\ GeV$ only for SF
4. Angle between the leptons: $cos\theta > (-0.8)$

chosen by optimizing $\frac{s}{\sqrt{s+b}}$ and based on previous ones



ADDITIONAL CUTS

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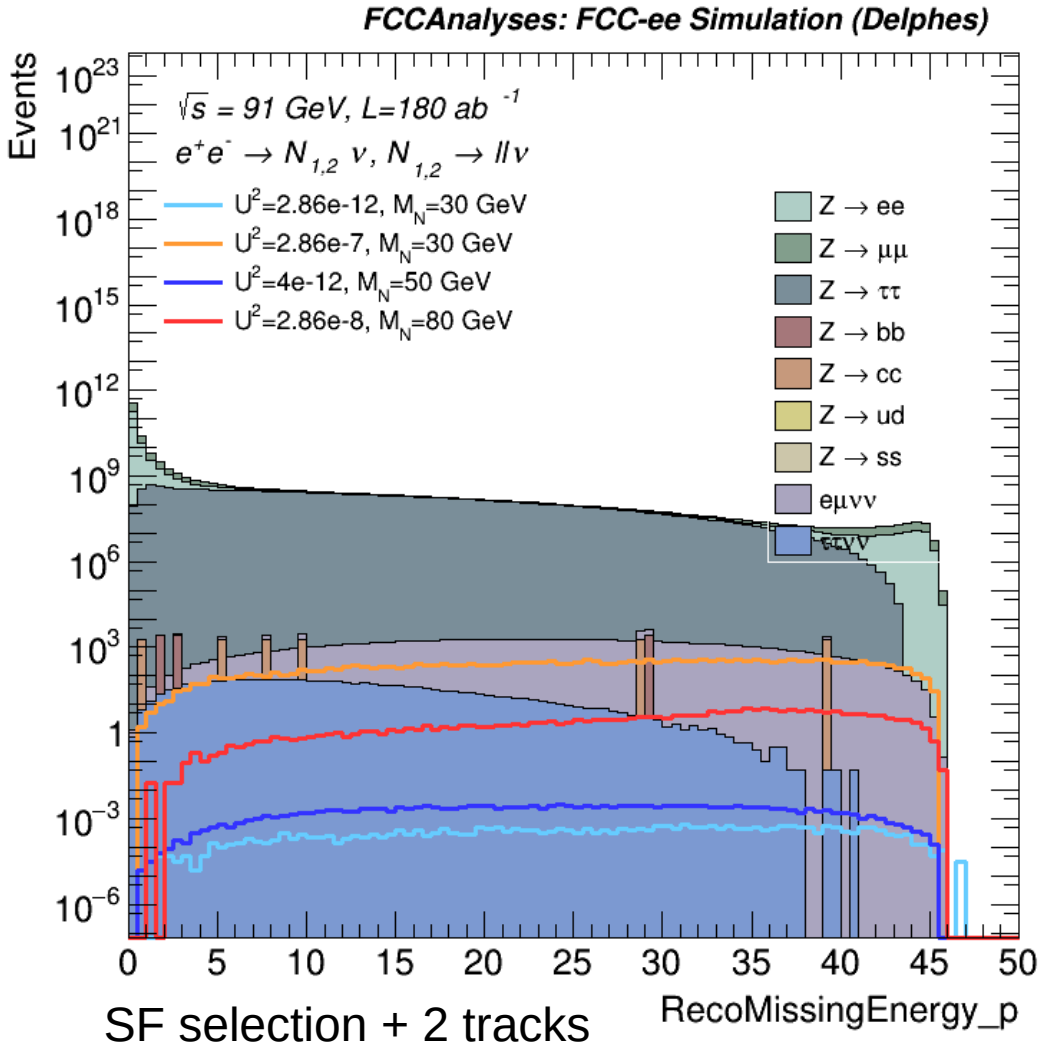
2. Missing momentum: $\mathrm{p}_{T,miss} > 11.5\ GeV$ for SF and $\mathrm{p}_{T,miss} > 7\ GeV$ for DF
3. Lepton momentum: $p < 40\ GeV$ only for SF -> reduced Zee
4. Angle between the leptons: $cos\theta > (-0.8)$

chosen by optimizing $\frac{S}{\sqrt{S+b}}$ and based on previous ones



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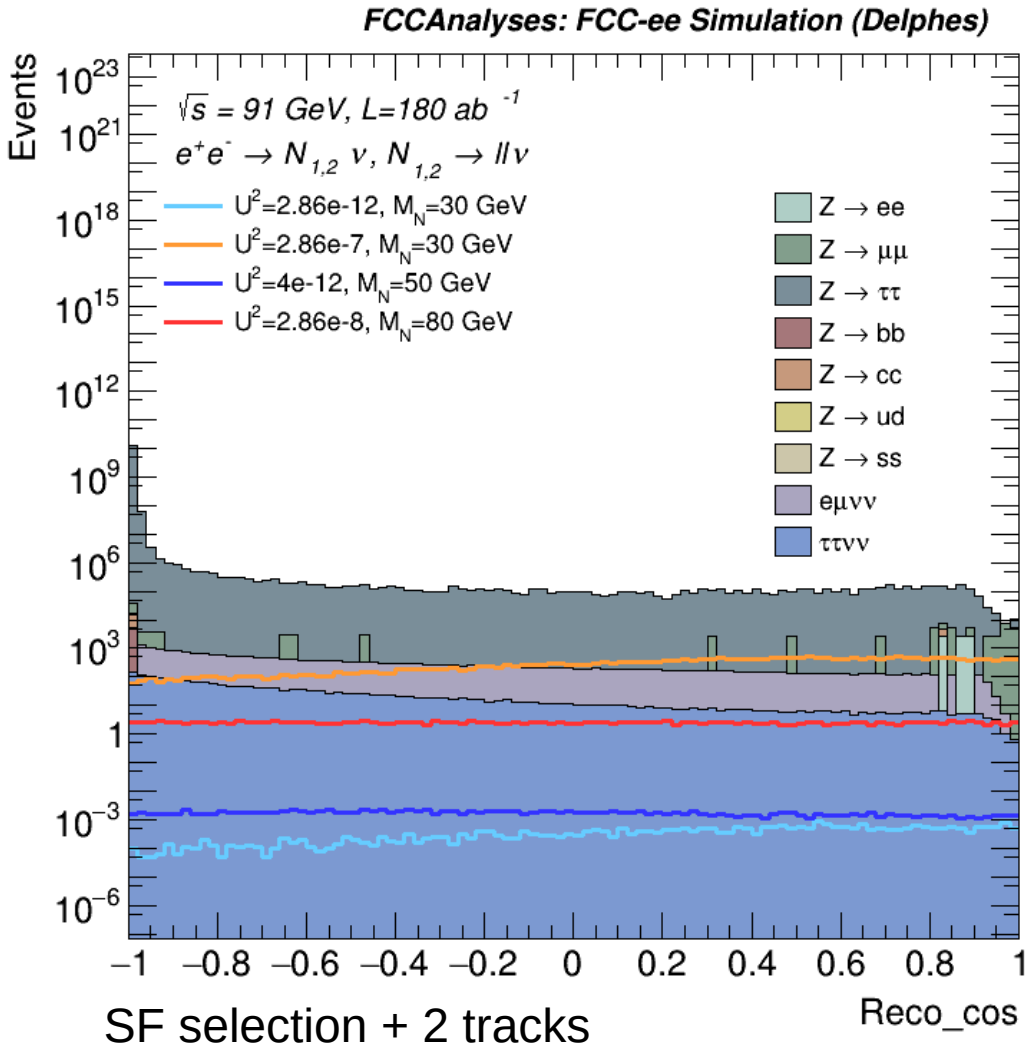
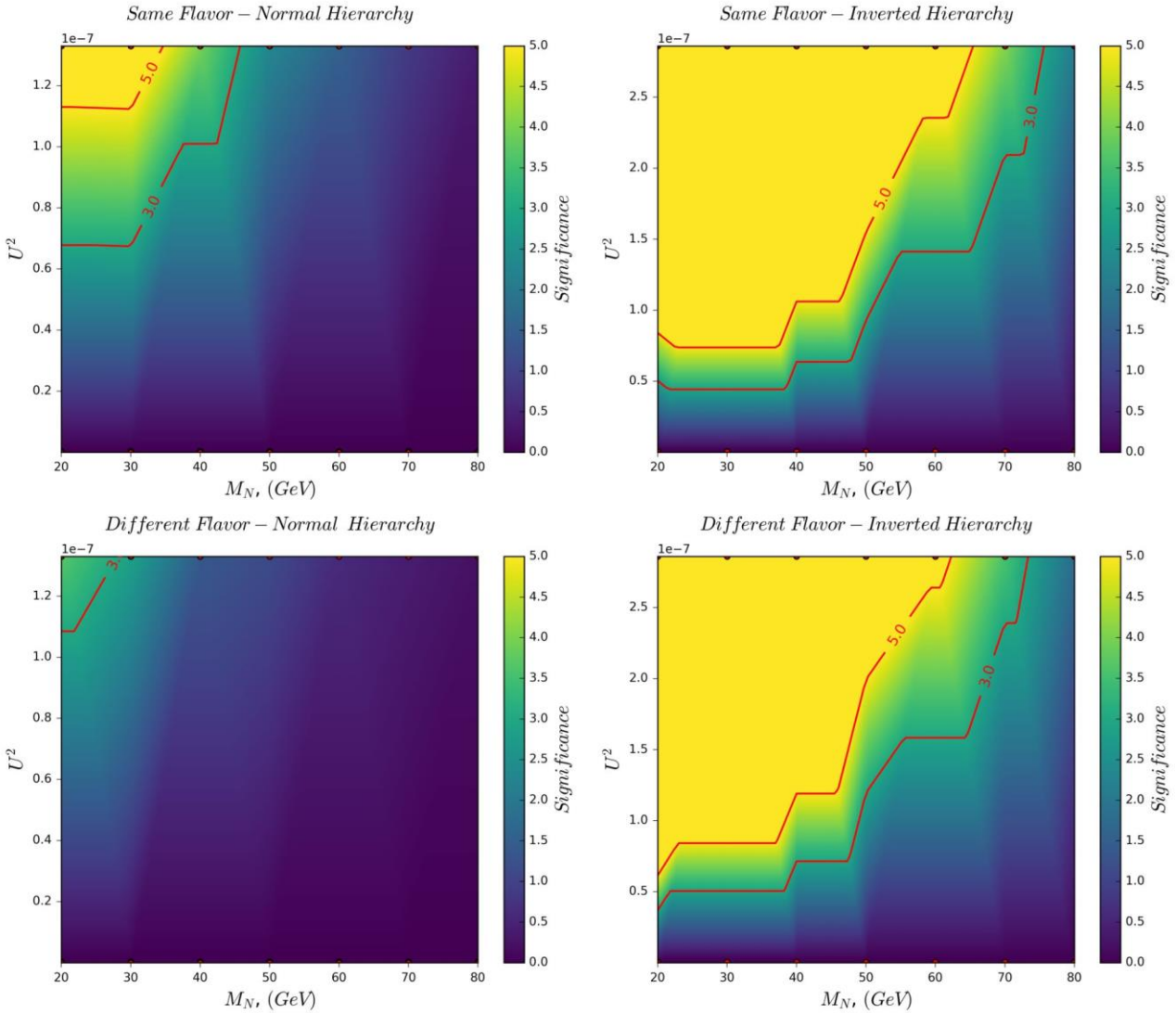
chosen by optimizing $\frac{s}{\sqrt{s+b}}$ and based on previous ones

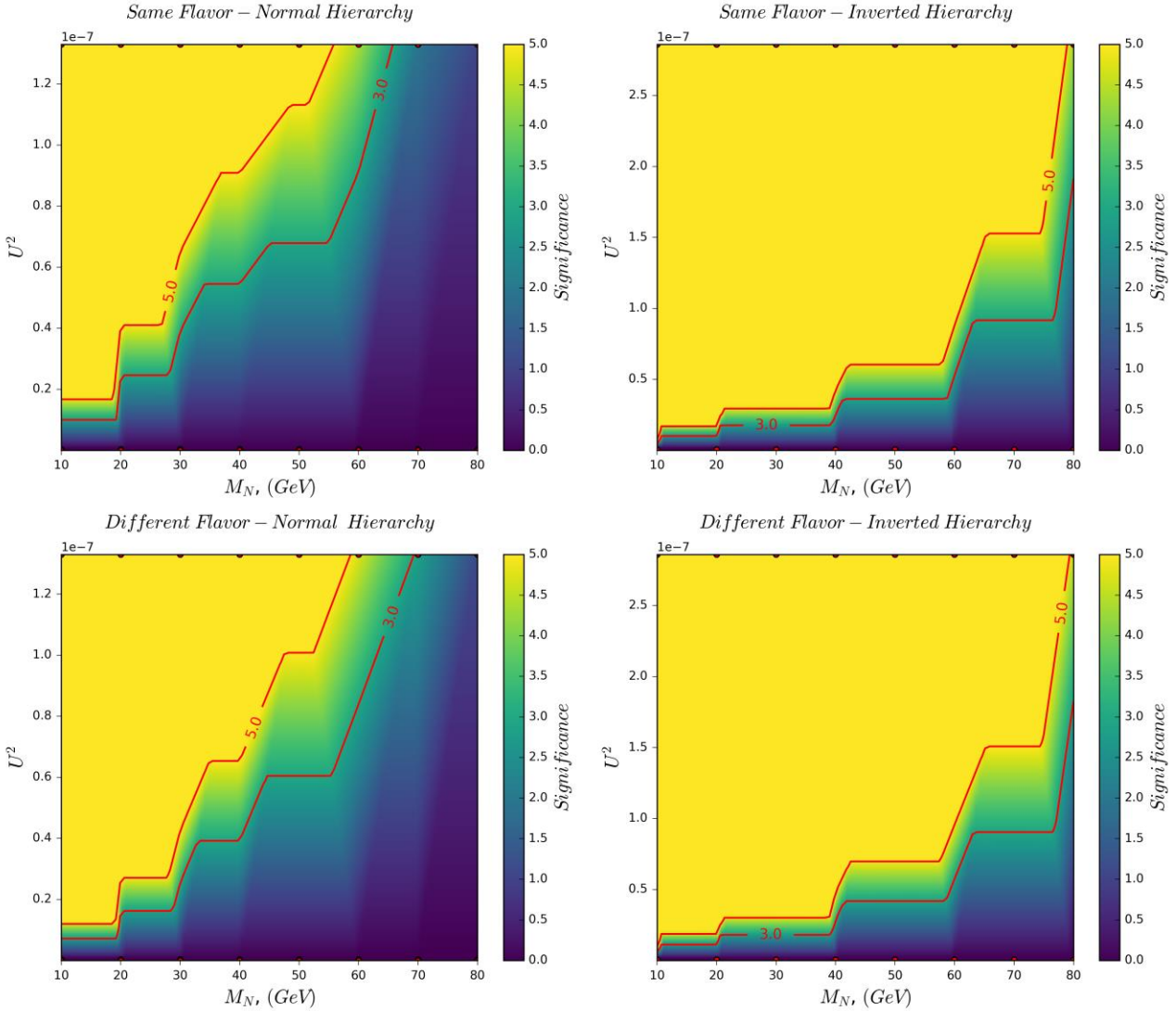


SIGNIFICANCE

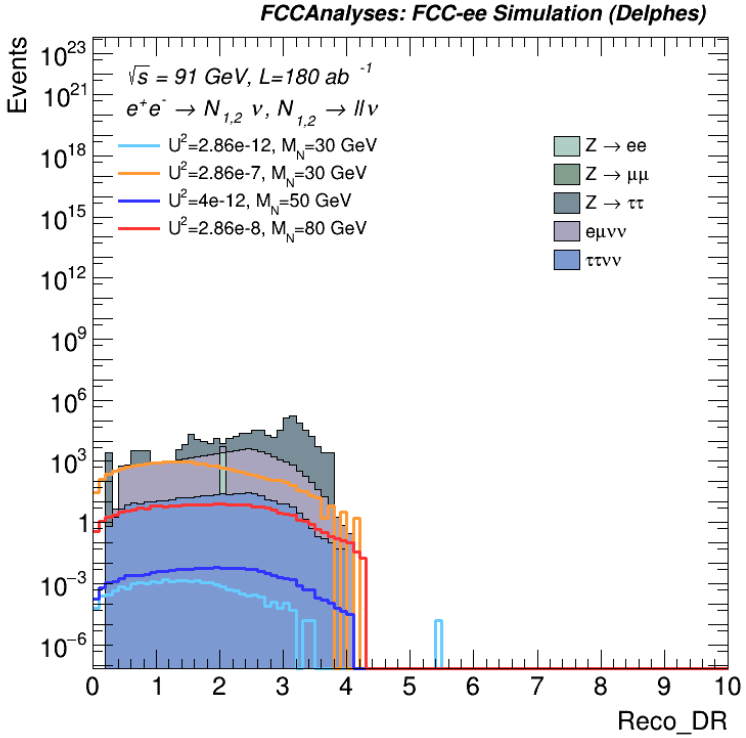


- SF:
  1. Invariant mass: $15 < M(\ell, \ell') < 80\ GeV$
  2. Missing energy: $ME > 10\ GeV$
  3. Lepton momentum: $p < 42\ GeV$
  4. Cosine of the angle between the leptons: $cos\theta > (-0.8)$
  5. Missing theta: $0.2 < \mathrm{ME}_\theta < 3$
- DF:
  1. Invariant mass: $15 < M(\ell, \ell') < 80\ GeV$
  2. Missing energy: $10 < ME < 43\ GeV$
  3. Lepton momentum: $p < 39\ GeV$
  4. Cosine of the angle between the leptons: $cos\theta > (-0.8)$

SIGNIFICANCE



- Cuts on tracks -> significance is improved
- Sensitivity to 10 GeV (and lower) HNLs
- ΔR is better than $cos\theta$ in this case



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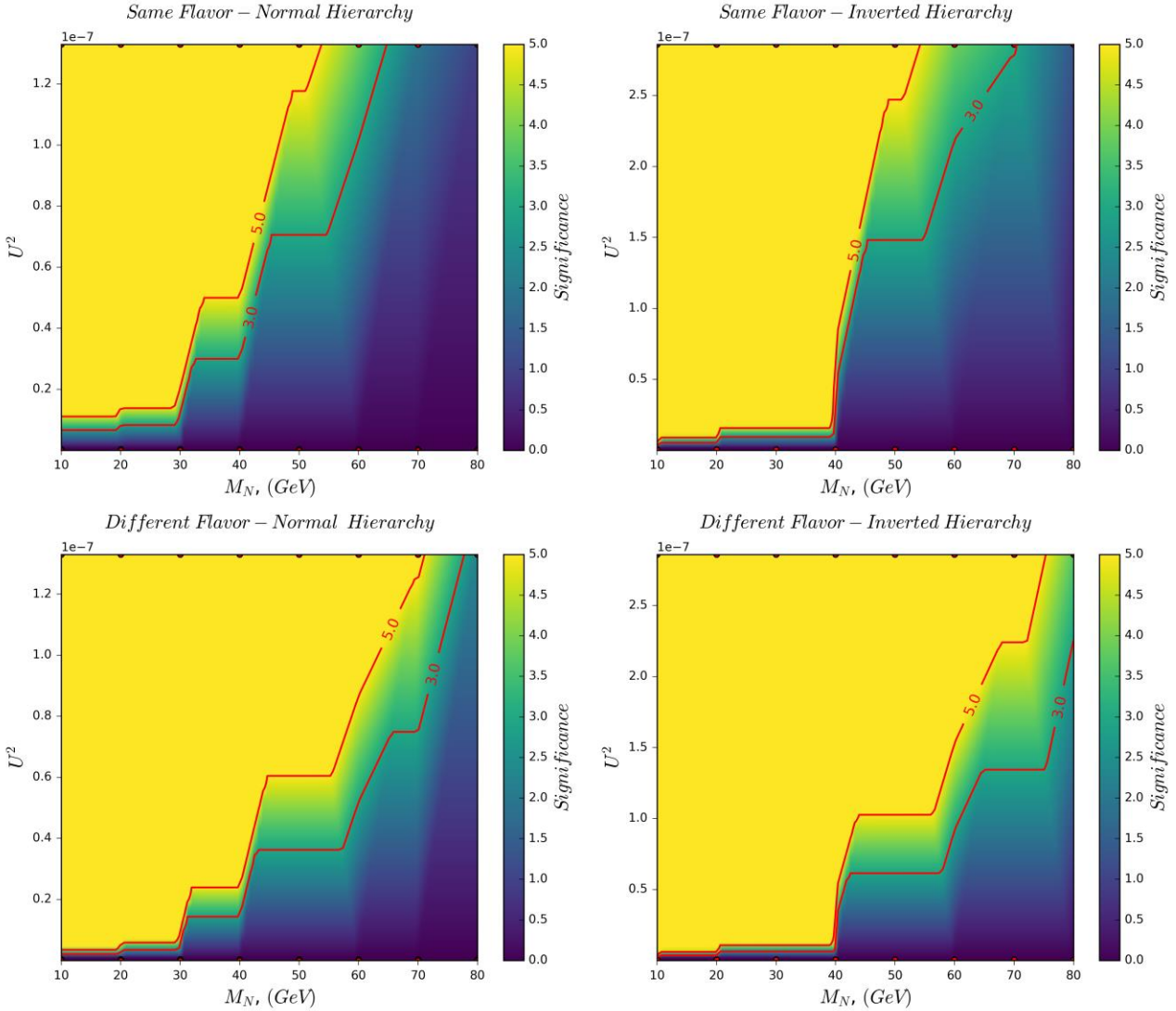
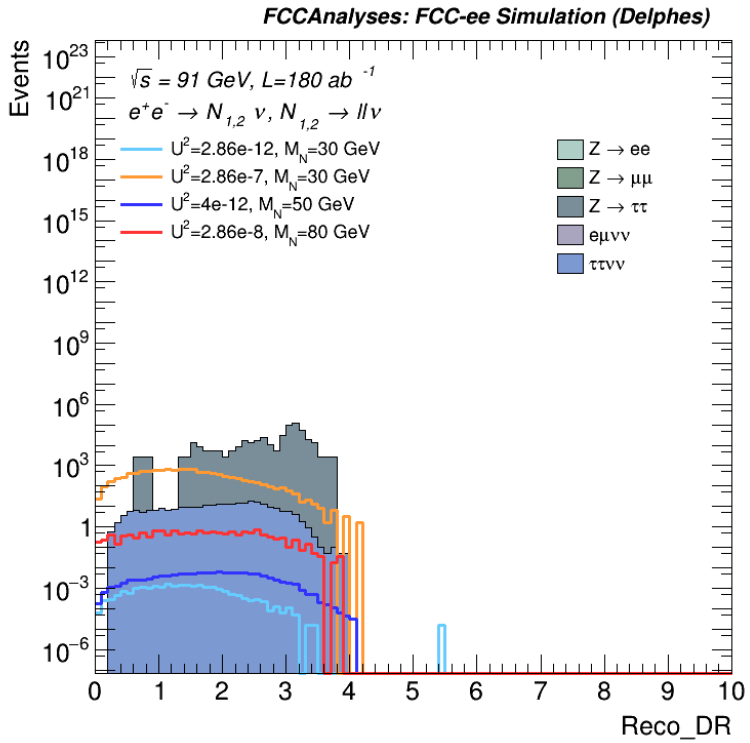
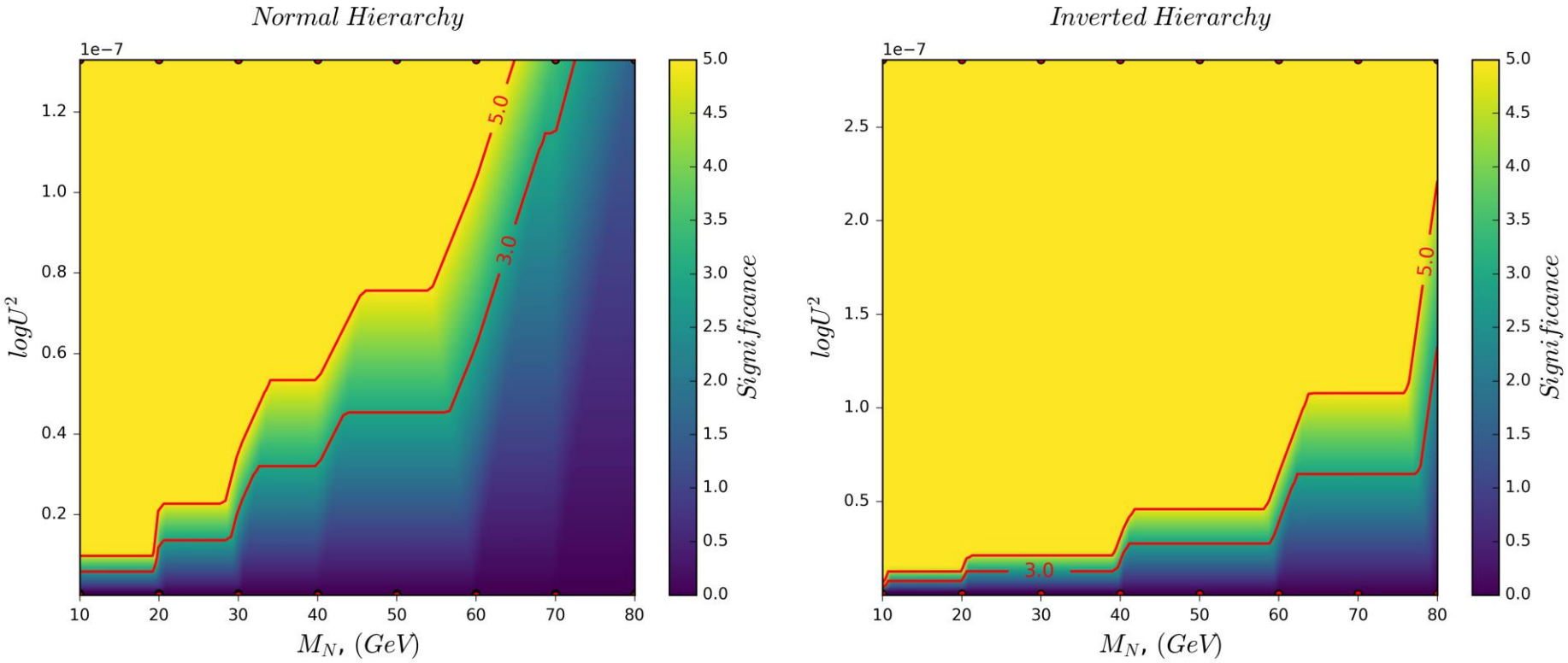


- Decay length: L_xy>0.04 (excludes $e\mu\nu\nu$ and Zee)
- Improves normal hierarchy (red), inverted is worse (blue)

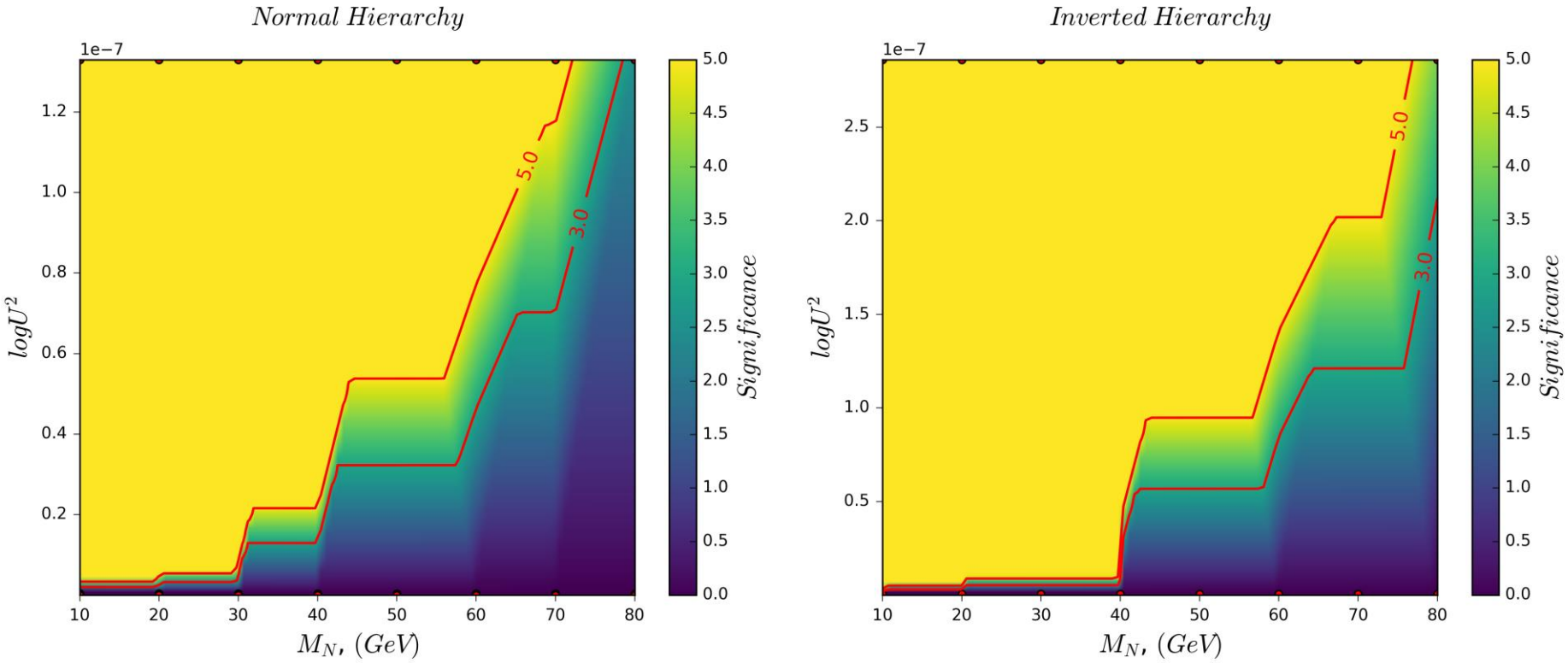


SIGNIFICANCE



- Combined same and different flavor events
- Two tracks and cuts

SIGNIFICANCE

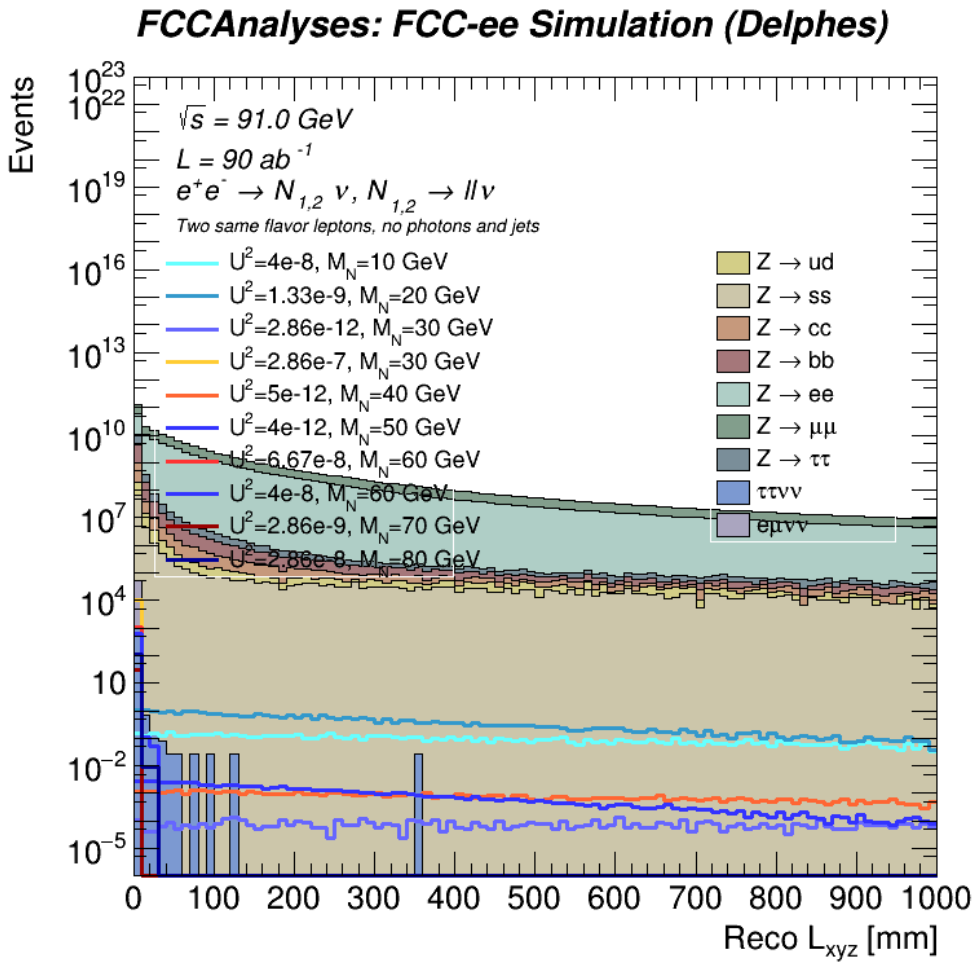


- Combined same and different flavor events
- Two tracks and cuts including L_{xy}

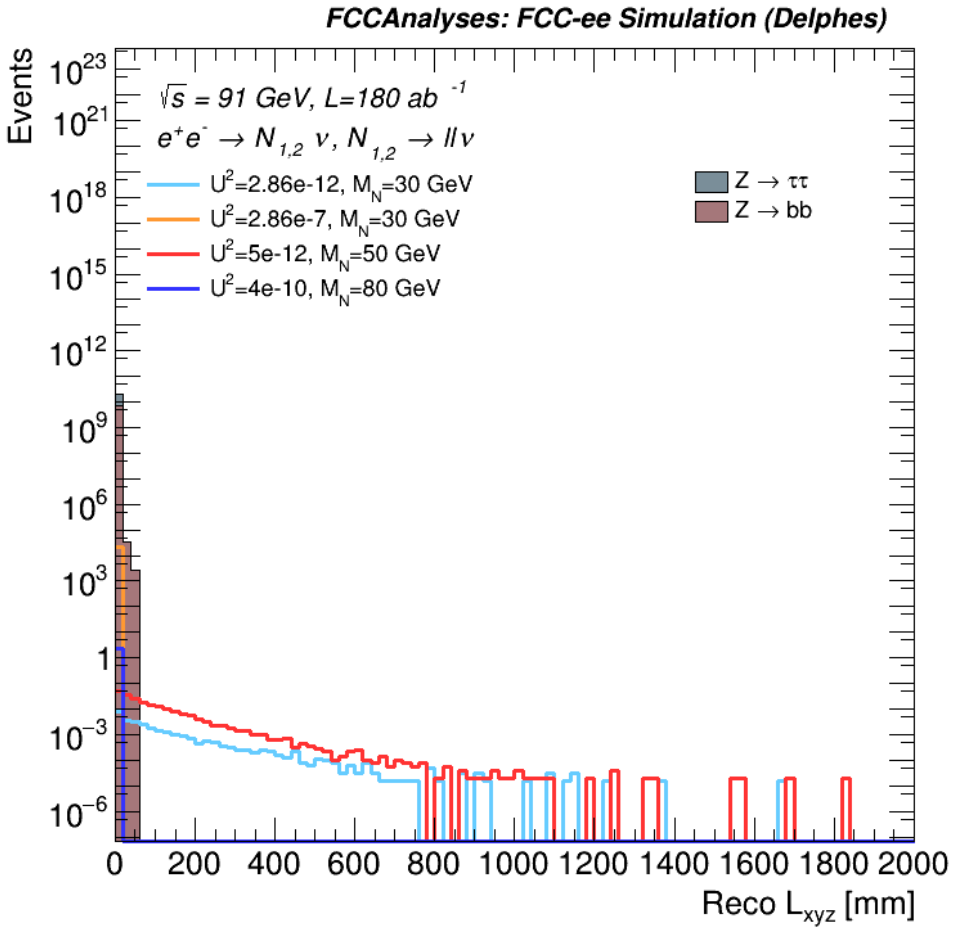
RECO DV

- Got number of primary and secondary tracks
  - Most of the signals have one PT and one ST
  - Reco decay lenght is always at least $1\ mm$ even for prompt signals
- Using beam spot constraint on dv fitting reduces considerably the backgrounds' decay length and a bit the signals'

DECAY LENGHT

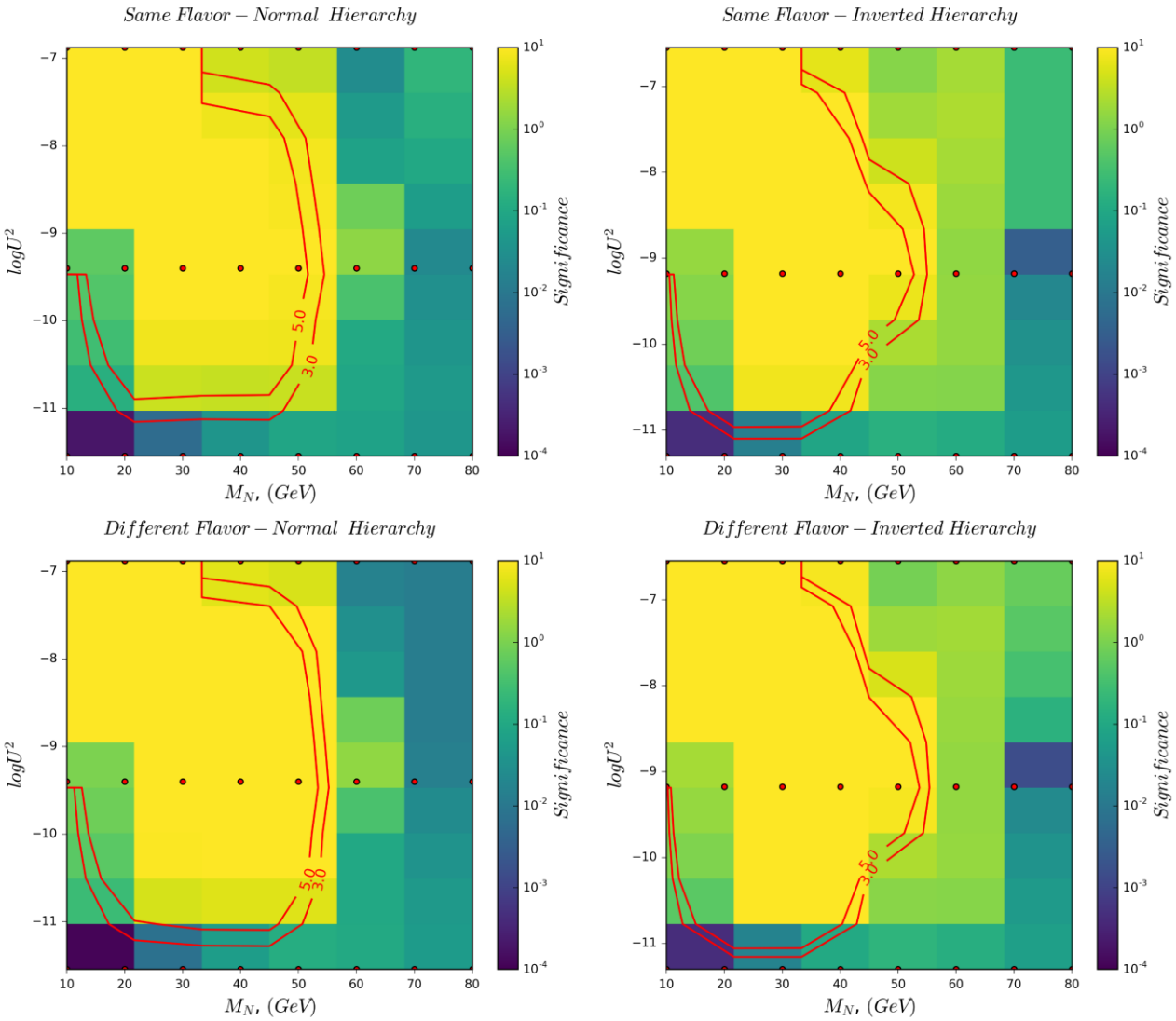


100% background samples,
Vertexfitter on lepton tracks for DV (2)

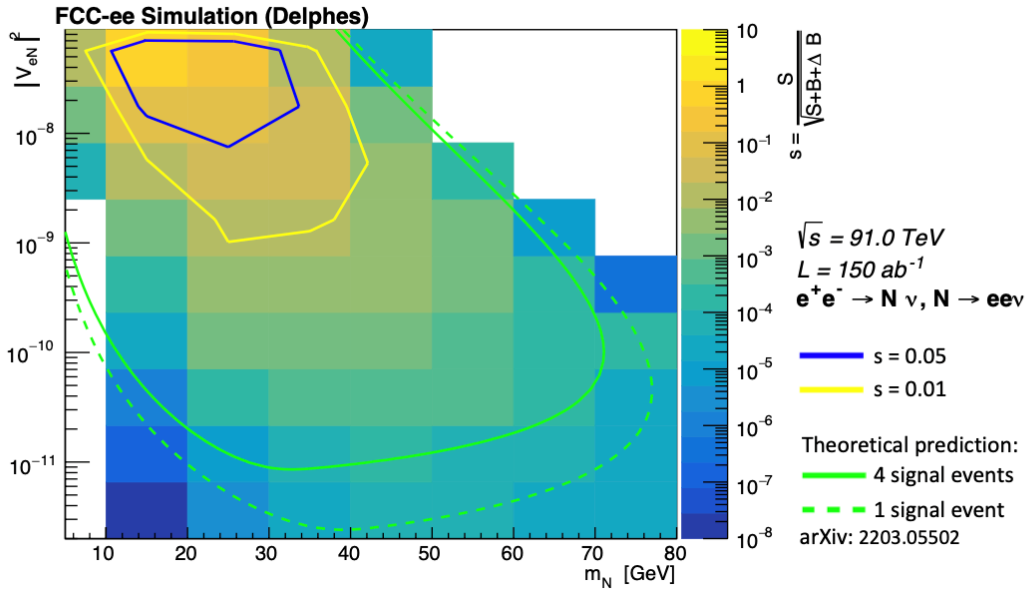


100% background samples, vertexfitter on lepton tracks for DV (2 + beam spot)

NUMBER OF EVENTS



- Two tracks selection with full cuts, vertex fitting without bsc
- Additional cut on $L_{xyz} \sim 3\ mm$ to have no backgrounds



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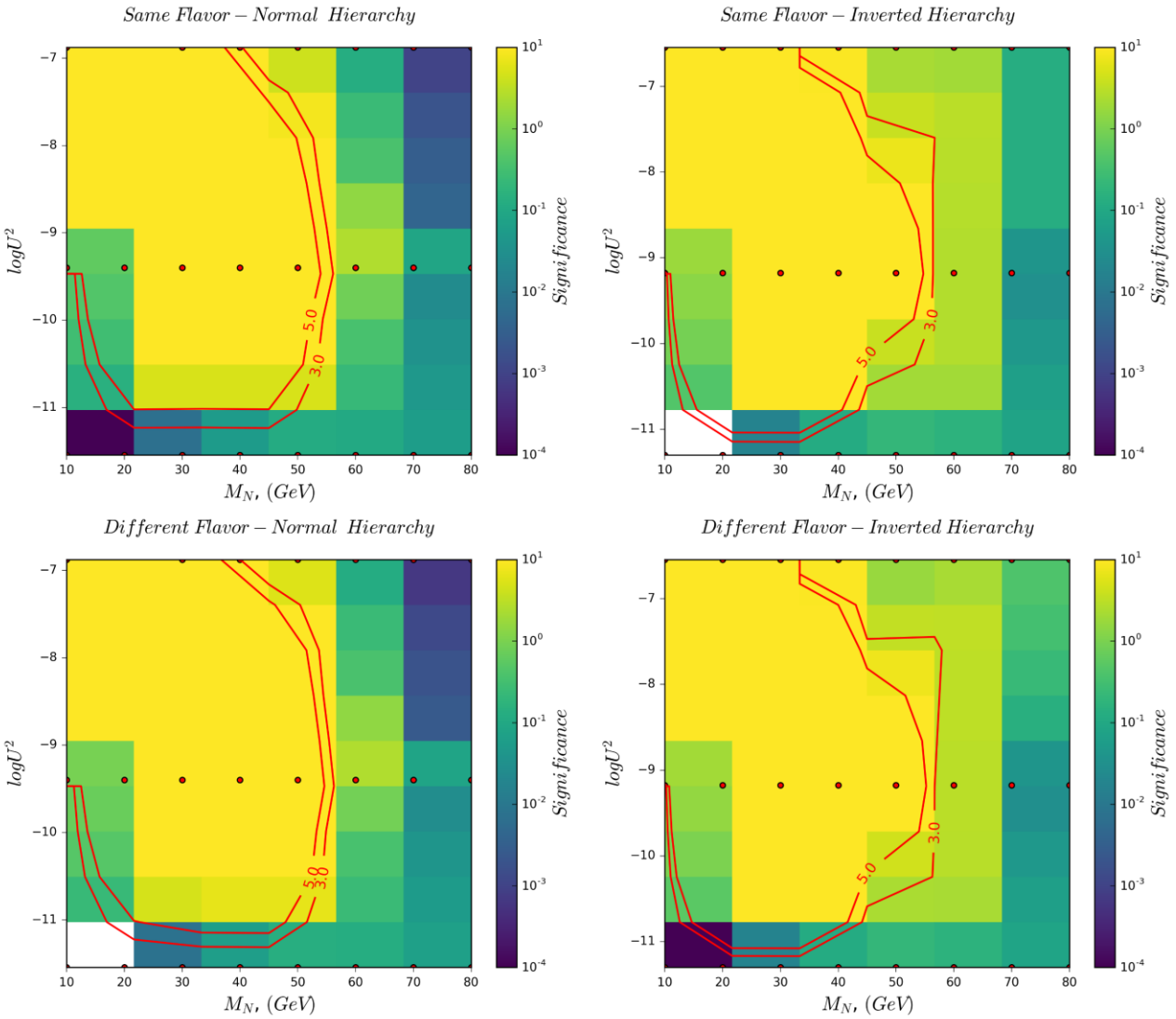

- Two tracks selection, vertex fitting with bsc
- $L_{xyz} > 1.7\ mm$ (Zττ) excludes all backgrounds
- Similar results with less cuts

- Two tracks selection, vertex fitting with bsc
- $L_{xyz} > 1.7\ mm$ (Zττ) excludes all backgrounds
- Similar results with less cuts

FUTURE PLANS

- Add at least one set of intermediate signal samples in the high significance region to have better resolution
- Undertsand how to assign a signifiance value for background-free events, including some statistical uncertainty on the assumption