Measuring masses of new particles in central exclusive processes at the LHC

Kazuki Sakurai
(DESY, Theory Group)

in collaboration with:

L.A. Harland-Lang (Cambridge U.), C.H. Kom (Liverpool U.)

W.J. Stirling (Cambridge U.)

Based on:
arXiv:1110.4320 [hep-ph]

2012/1/9 LHC Physics Discussions (DESY)

Plan

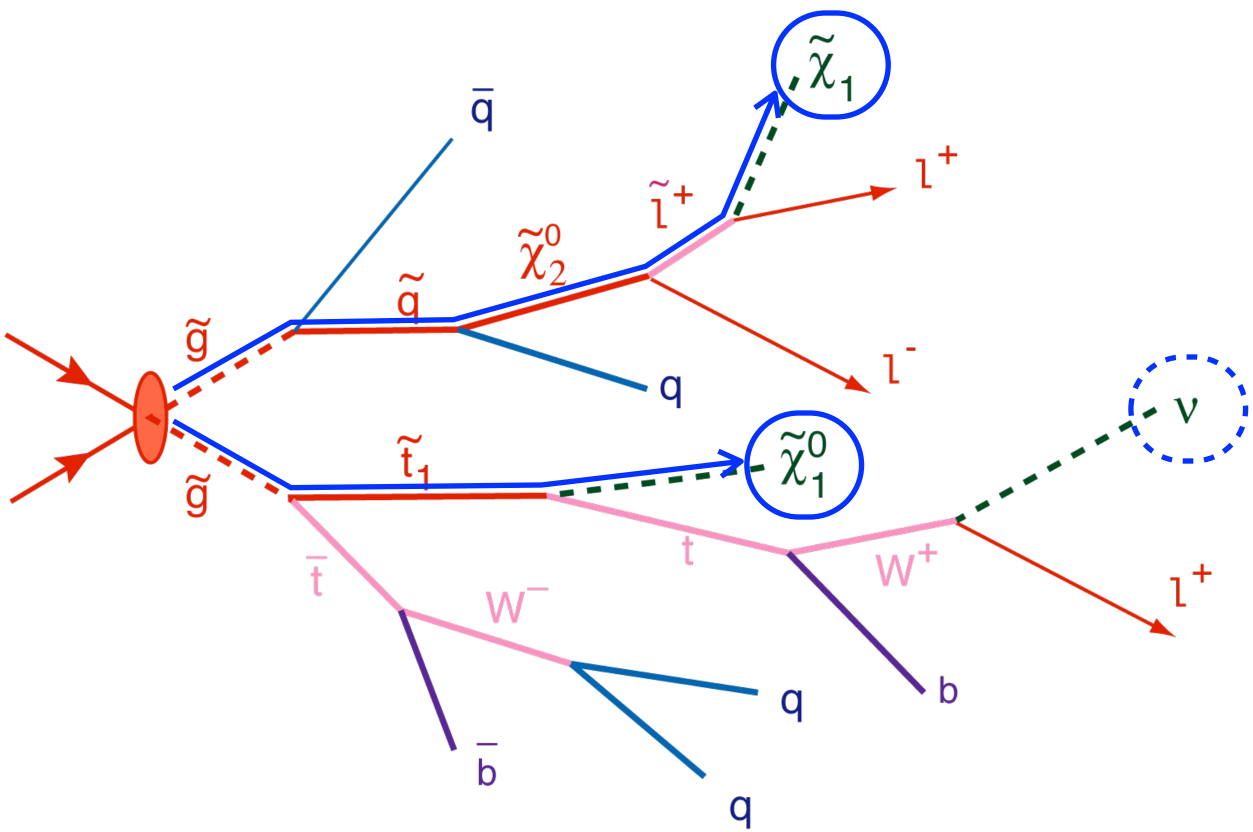
- Introduction
- Edge method and mT2
- A new method in central exclusive processes
- Summary

Introduction

Measuring the masses of new particles may be a bit tricky at the LHC.

Stability of the DM ← Symmetry (e.g. R-parity in SUSY) →

- Pair production
- At least two missing (DM) particles in the final state.



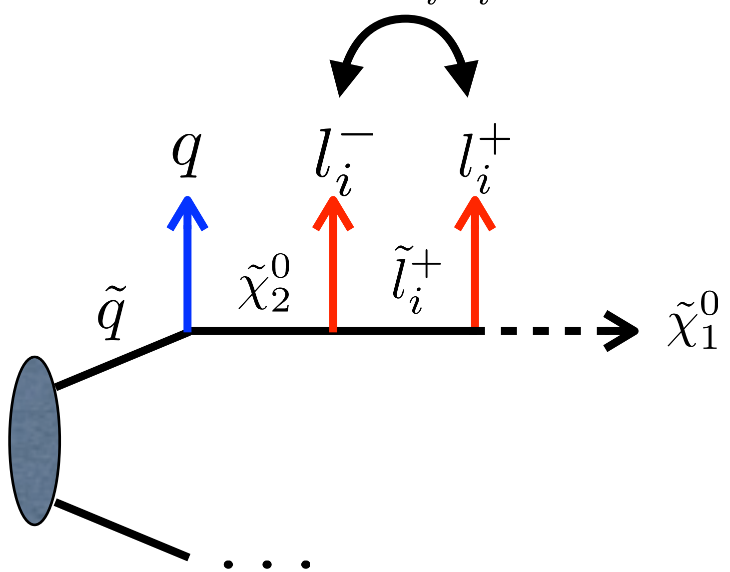
Simple mass reconstruction (e.g. like Z→μμ) is not possible.

$$M_{NP}^2 = (p_1 + p_2 + \cdots + \cancel{p}_{DM})^2$$

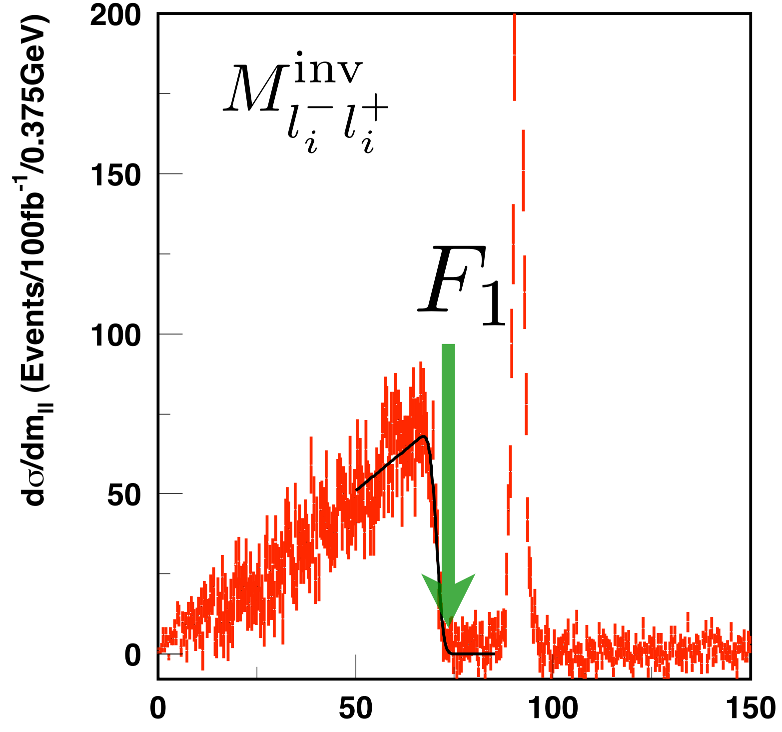
↑ can't be measured

Edge method

$$M^{\rm inv}_{l_i^- l_i^+}|_{\max} = F_1(m_{\tilde\chi_1^0}, m_{\tilde l}, m_{\tilde\chi_2^0})$$



B.C.Allanach, C.G.Lester, M.A.Parker, B.R.Webber ’00

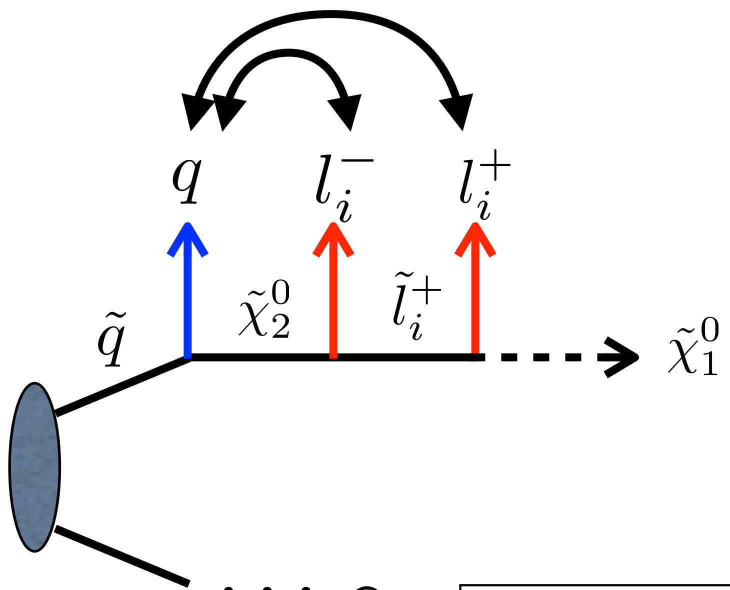


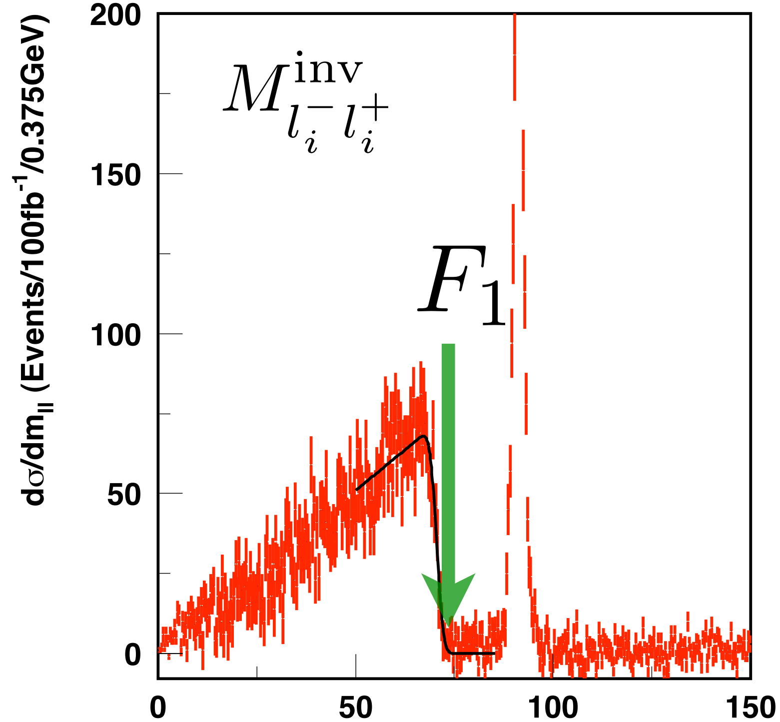
Edge method

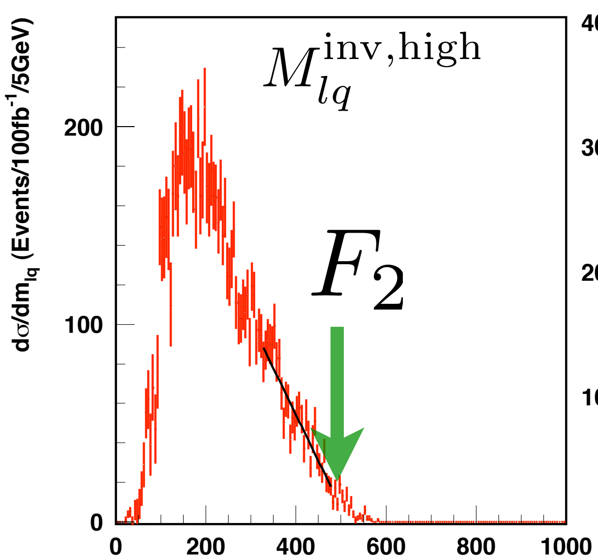
B.C.Allanach, C.G.Lester,
M.A.Parker, B.R.Webber '00

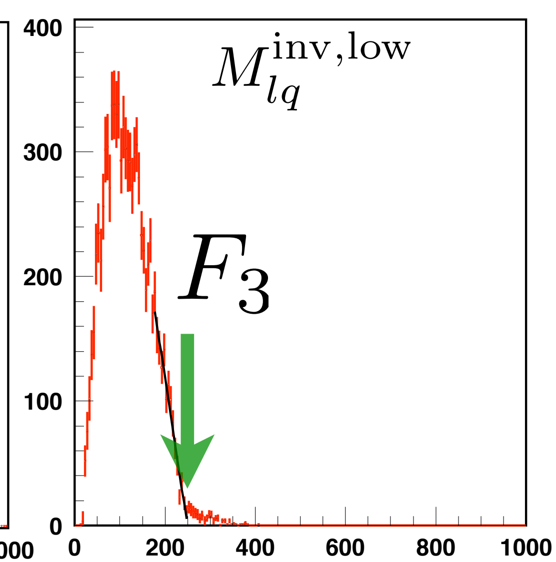
$$M_{lq}^{\rm inv,high}|_{\rm max} = F_2(m_{\tilde{\chi}_1^0}, m_{\tilde{l}}, m_{\tilde{\chi}_2^0}, m_{\tilde{q}})$$

$$M_{lq}^{\rm inv,low}|_{\rm max} = F_3(m_{\tilde{\chi}_1^0}, m_{\tilde{l}}, m_{\tilde{\chi}_2^0}, m_{\tilde{q}})$$





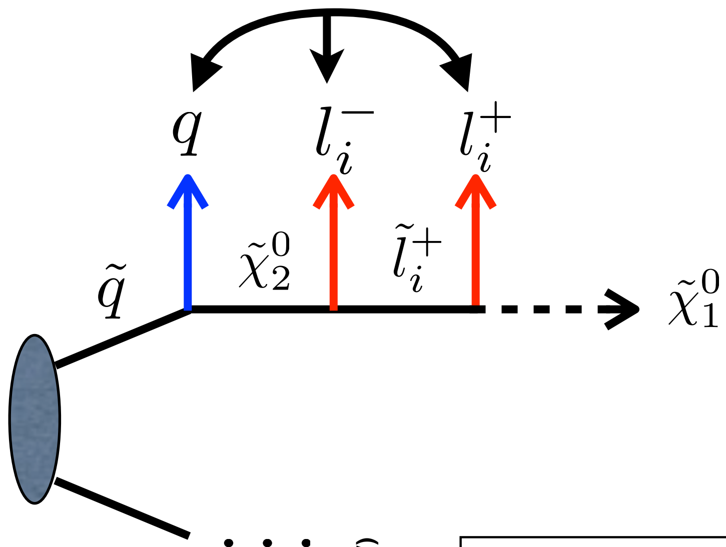


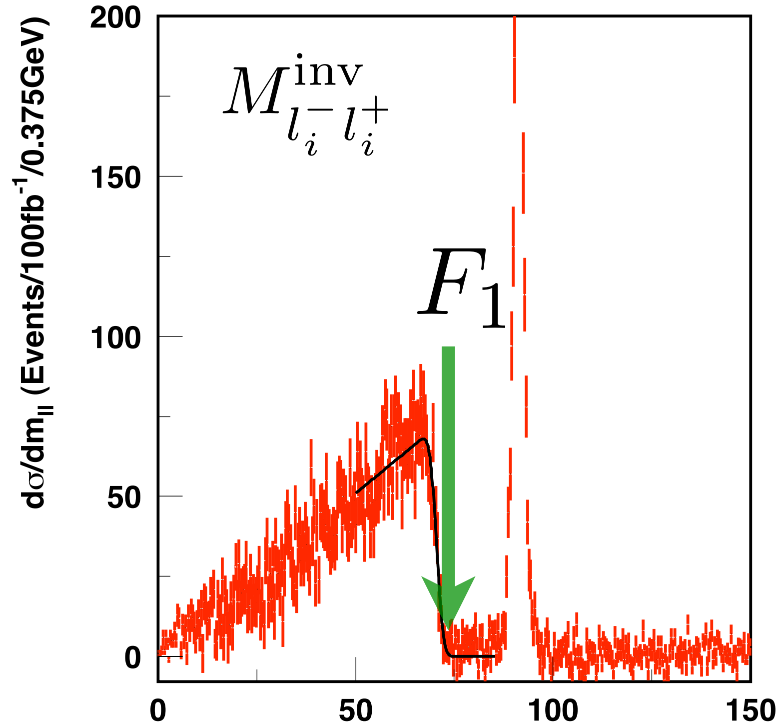


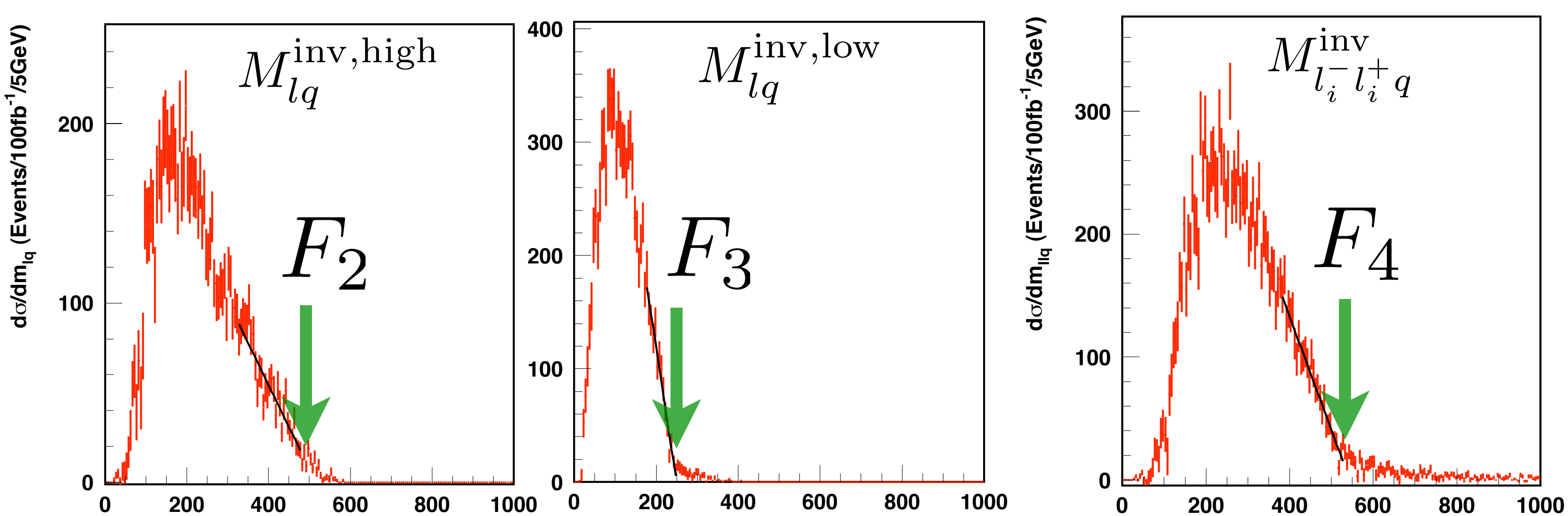
Edge method

B.C.Allanach, C.G.Lester,
M.A.Parker, B.R.Webber '00

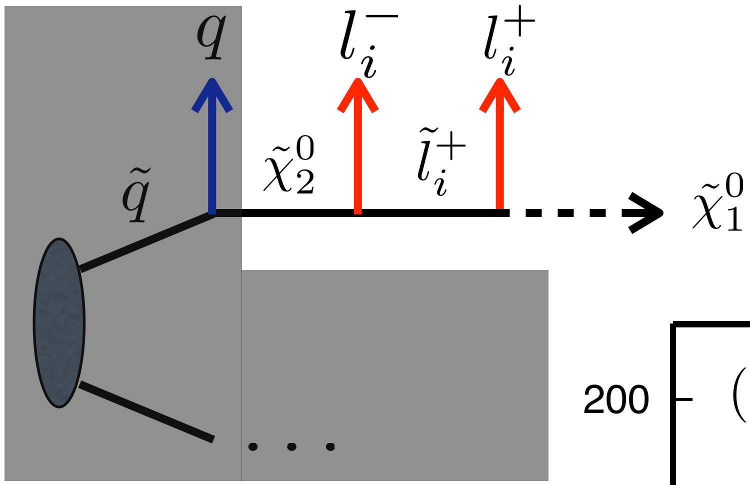
$$M^{\rm inv}_{llq}\big|_{\rm max} = F_4(m_{\tilde{\chi}^0_1}, m_{\tilde{l}}, m_{\tilde{\chi}^0_2}, m_{\tilde{q}})$$

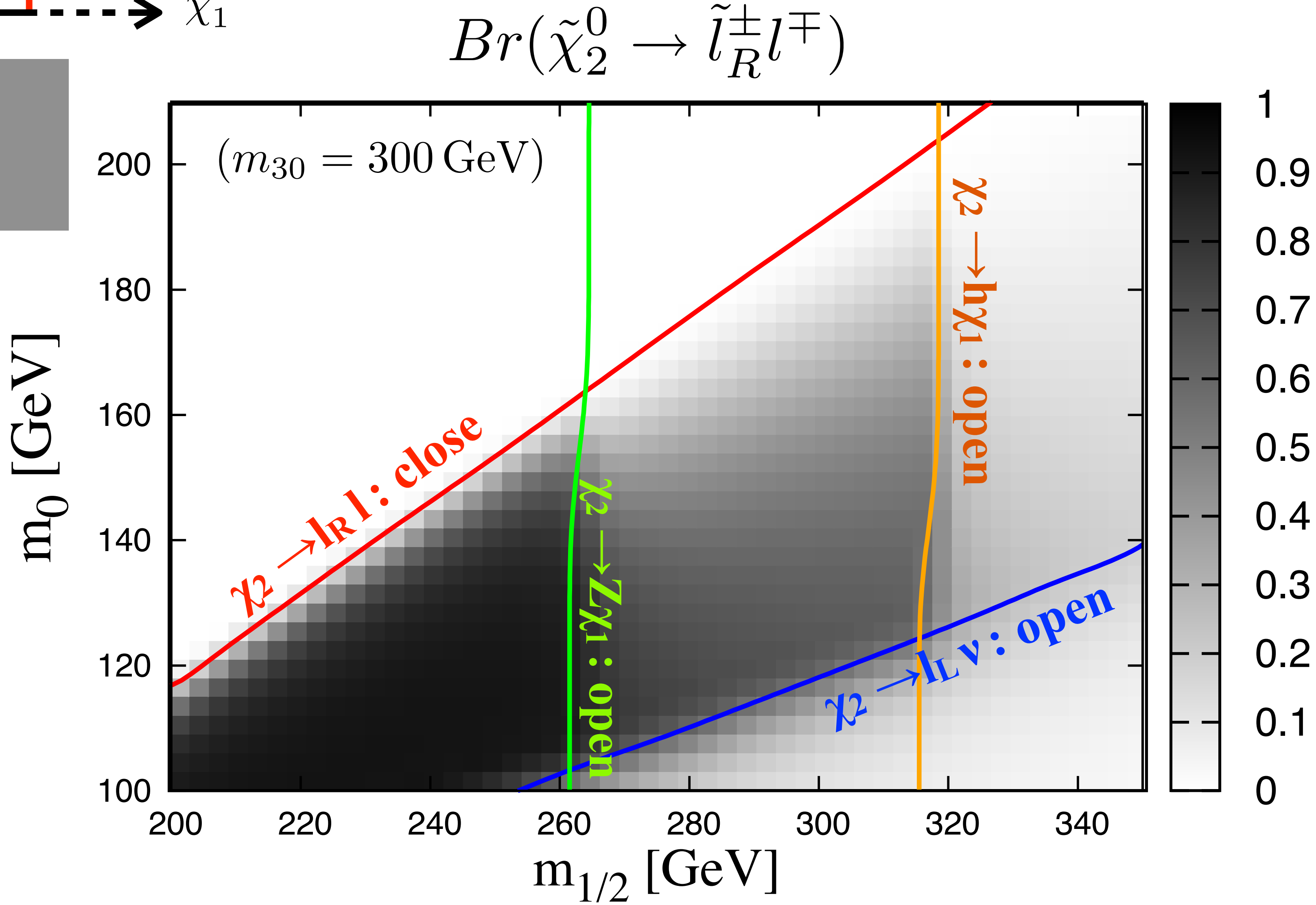




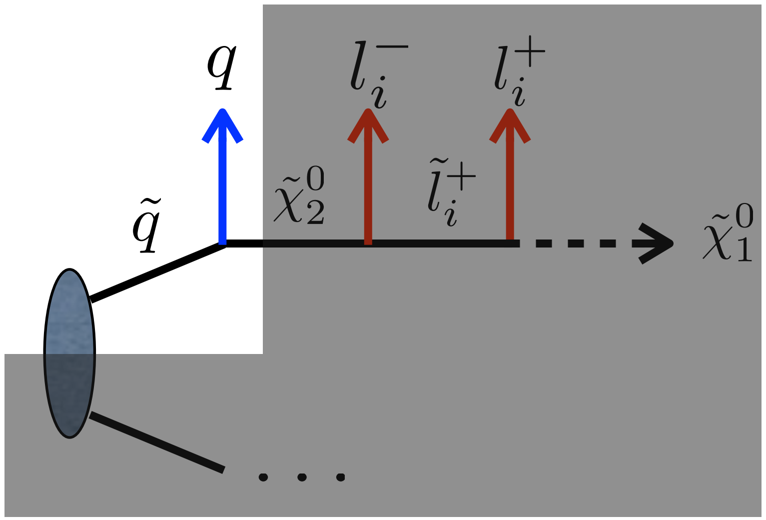


• The edge method may not be promising . . .

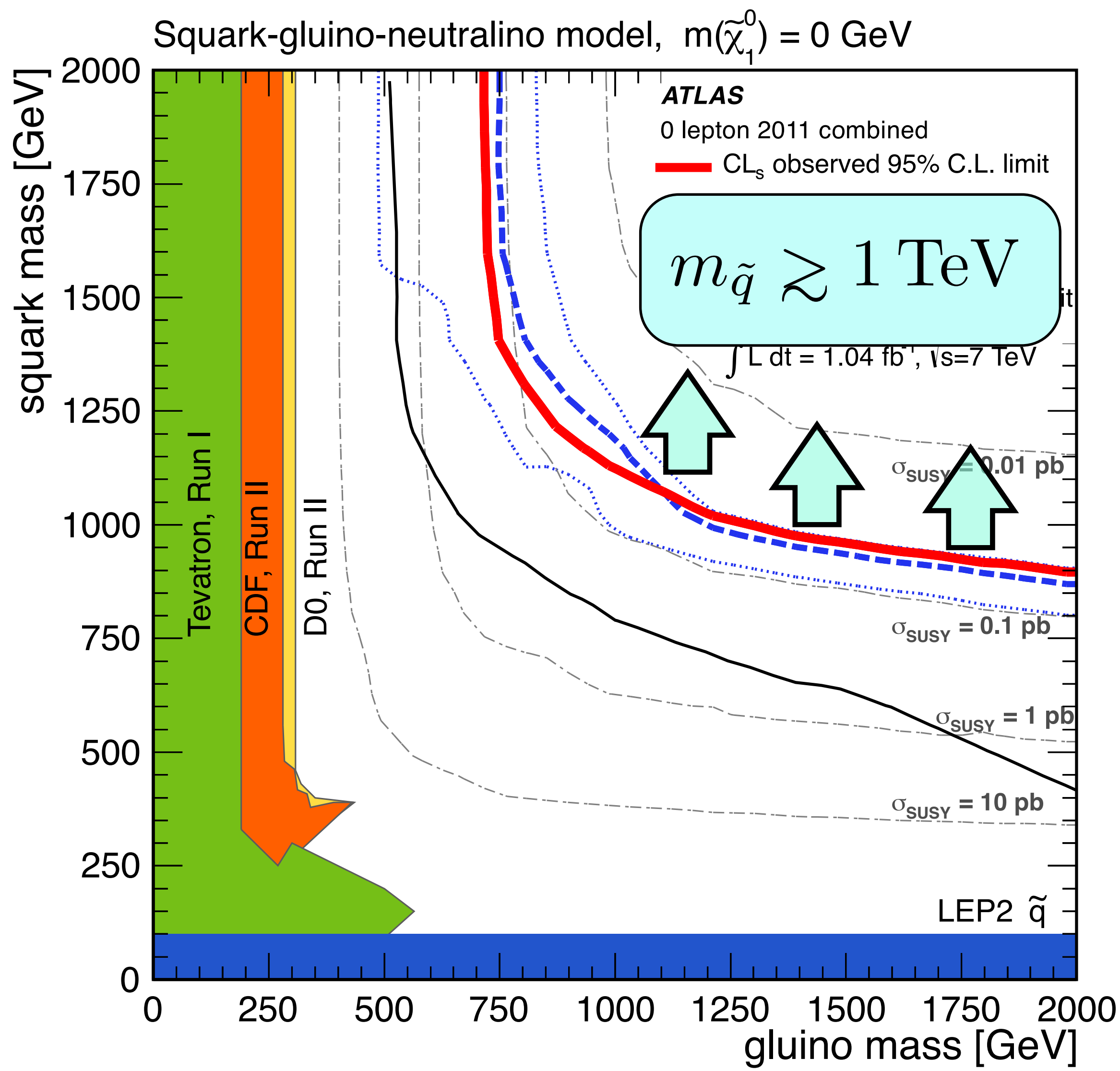




• The edge method may not be promising . . .

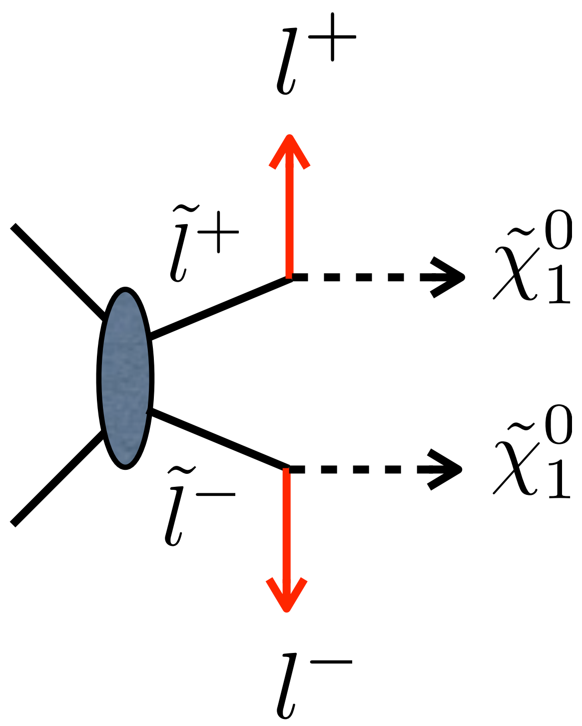


Large statistics may not be available.



Slepton pair production

- Unlike squarks, the constraint on the slepton mass is weak: $m_{\tilde{l}} \gtrsim 100\,\mathrm{GeV}$
- Observed anomaly in the muon (g-2): ➜ *light slepton is preferred!*



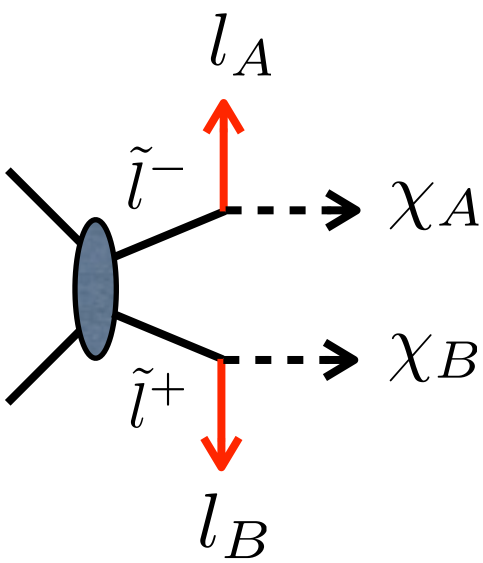
How to extract the masses of the slepton and the neutralino from this event ?

A.Barr, B.Gripaios, C.Lester 0711.4008

W-S.Cho, K.Choi, Y-G.Kim, C-B.Park 0709.0288

H-C.Cheng, Z.Han 0810.5178

mT2 method



Let us assume the $\chi_{A(B)}$ has the mass $m^\star_\chi$ and the momentum $p^\star_{\chi_{A(B)}}$. Then, we have two conditions:

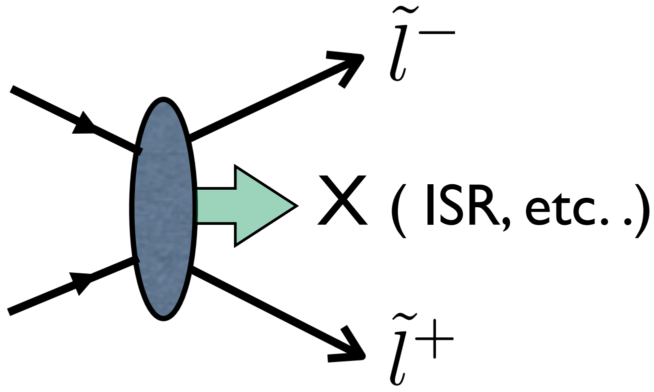
$$\mathbf{p}^{\star T}_{\chi_A} + \mathbf{p}^{\star T}_{\chi_B} \overset{(1)}{=} \mathbf{p}^{\mathrm{obs.}T}_{\mathrm{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 \overset{(2)}{=} (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

$$M_{T2}(m^\star_\chi) \equiv \min_{\substack{\text{all possible } (p^\star_{\chi_A}, p^\star_{\chi_B}) \\ \text{subject to (1) and (2)}}} \left[\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B})\right]$$

The M_{T2} provides the upper bound on the M_{slep} under the assumption on the m_χ of m^*_χ .

mT2 kink method

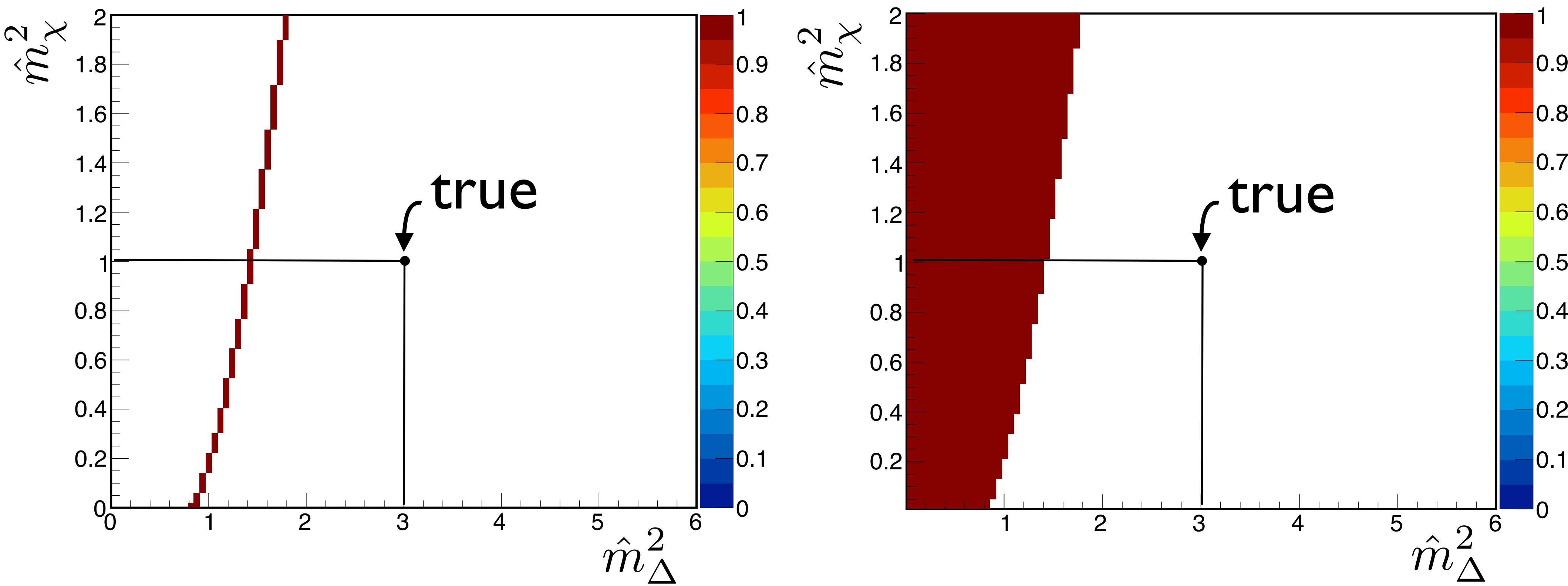


$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

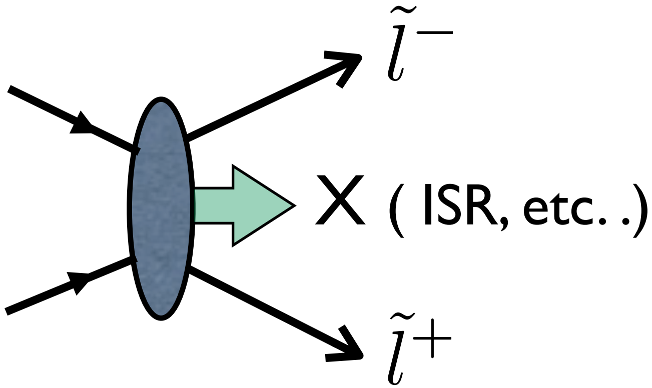
$$\hat{m}_\chi^2 \equiv (m_\chi^{\star})^2/(m_{\tilde{\chi}}^{\rm true})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

—— 1 event with $|\mathbf{X}_T| = 0$ ——



mT2 kink method

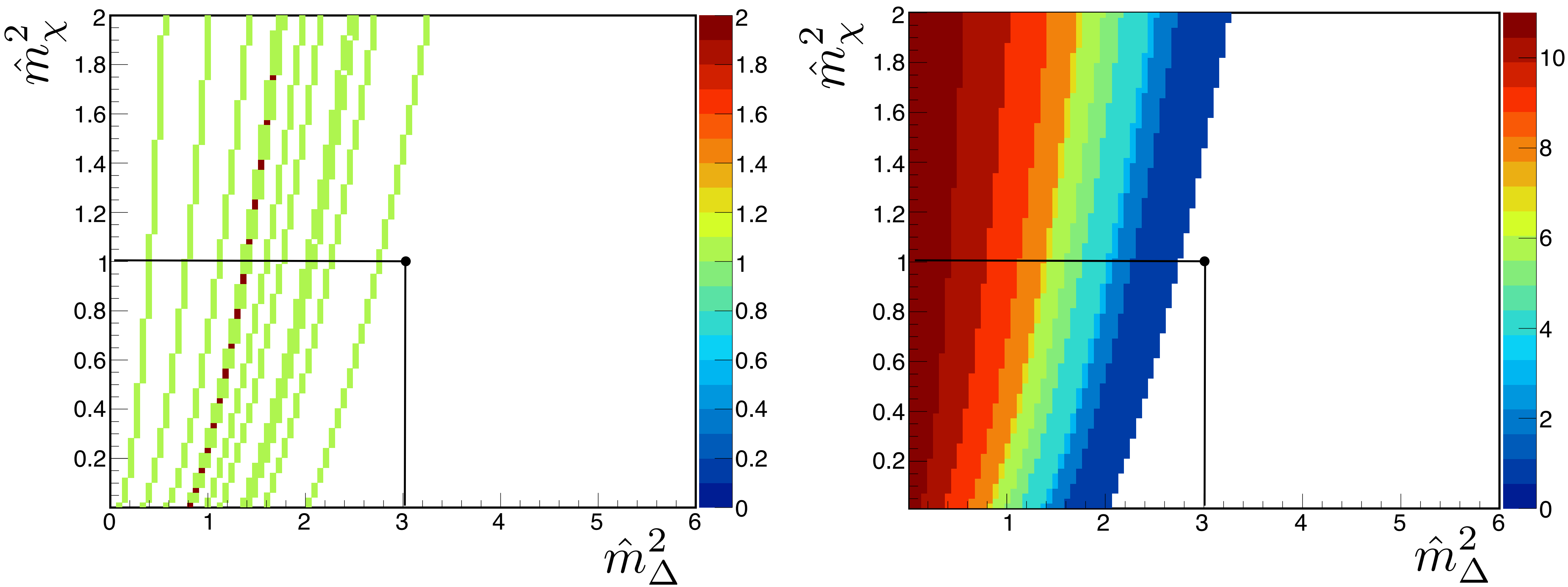


$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

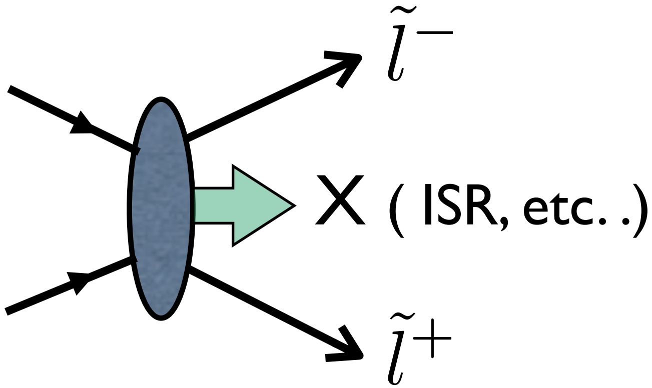
$$\hat{m}_\chi^2 \equiv (m_\chi^{\star})^2/(m_{\tilde{\chi}}^{\rm true})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

10 event with $|\mathbf{X}_T| = 0$



mT2 kink method

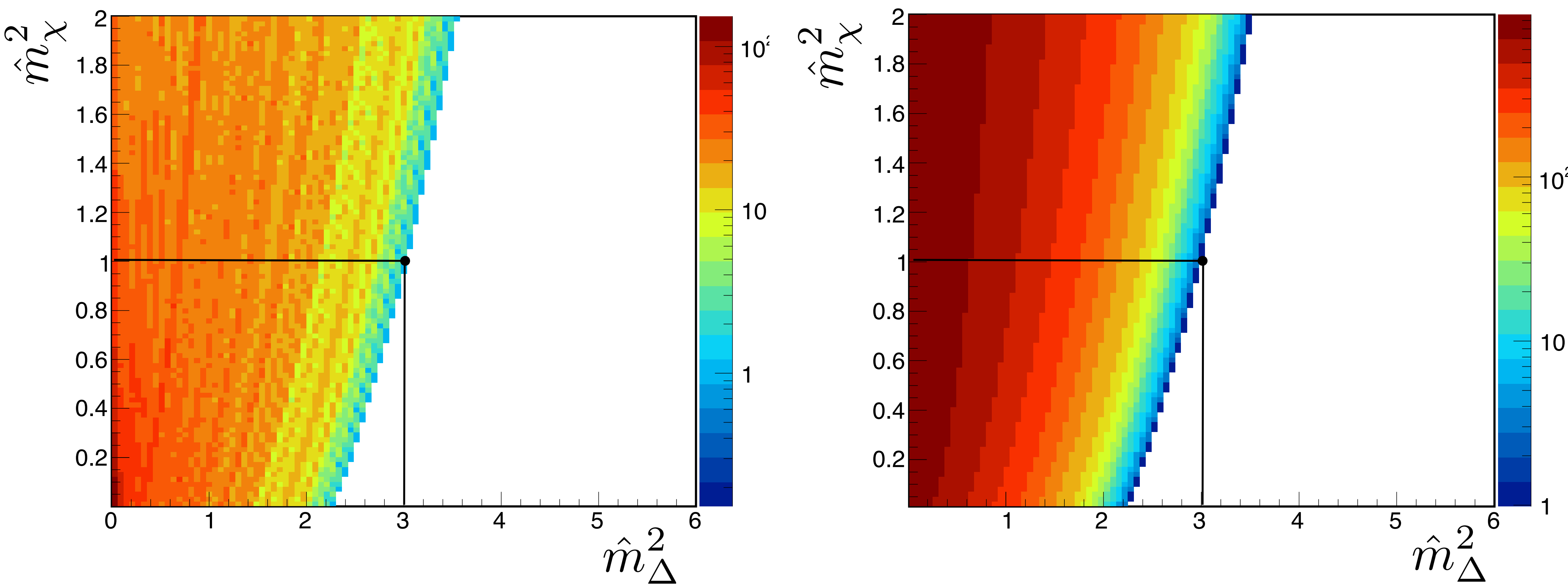


$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

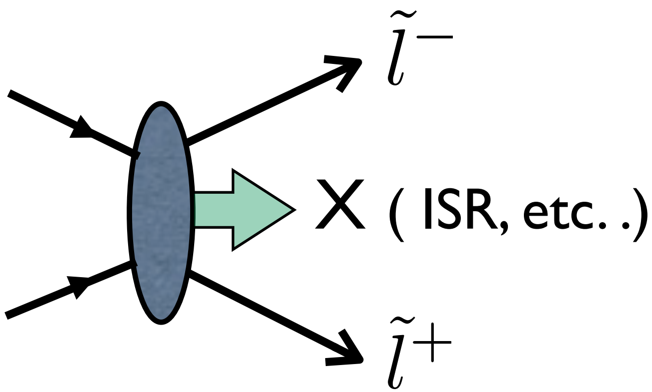
$$\hat{m}_\chi^2 \equiv (m_\chi^{\star})^2/(m_{\tilde{\chi}}^{\rm true})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

—— 1000 event with $|\mathbf{X}_T| = 0$ ——



mT2 kink method

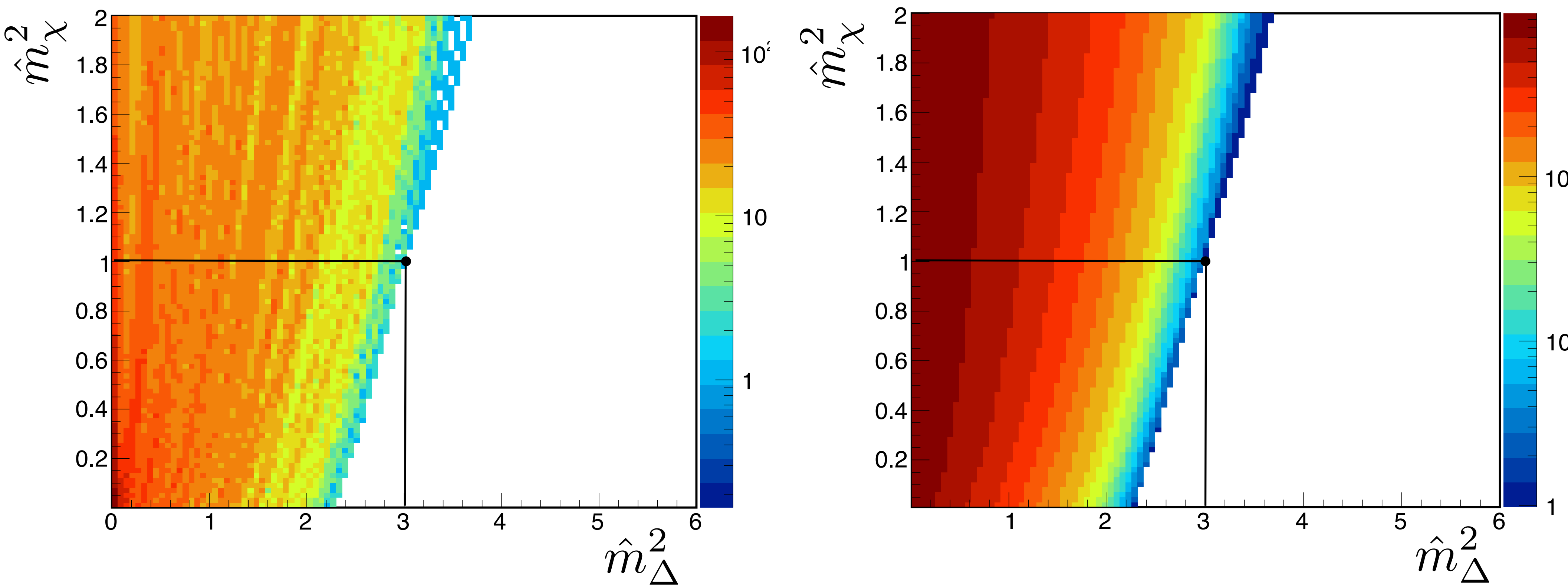


$$\hat{m}^2_\Delta \equiv (m^{\star 2}_{\tilde{l}} - m^{\star 2}_{\chi})/(m^{\rm true}_{\tilde{\chi}})^2$$

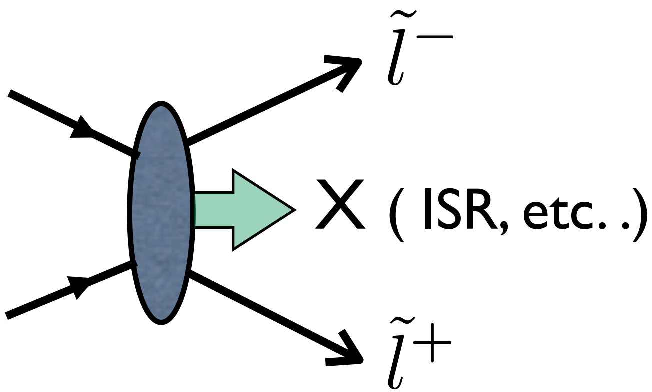
$$\hat{m}^2_\chi \equiv (m^{\star}_{\chi})^2/(m^{\rm true}_{\tilde{\chi}})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

—— 1000 event with $|\mathbf{X}_T| = m^{\rm true}_{\tilde{\chi}}(\mathrm{Random}[0,1])$ ——



mT2 kink method

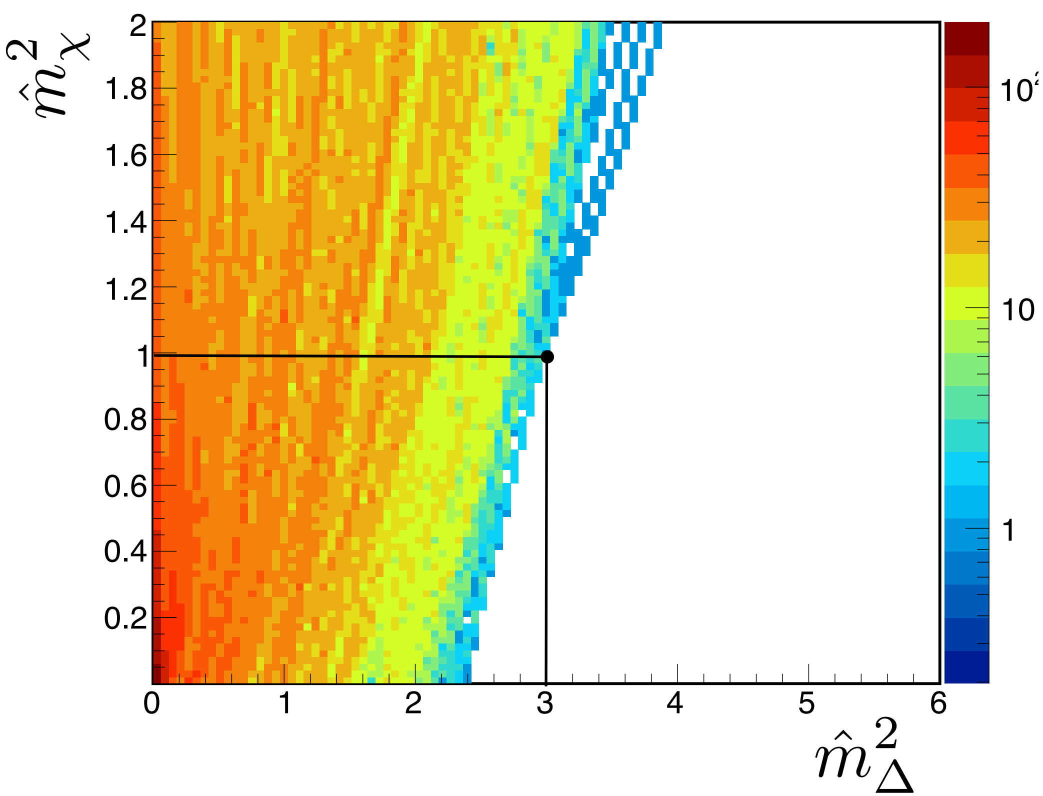


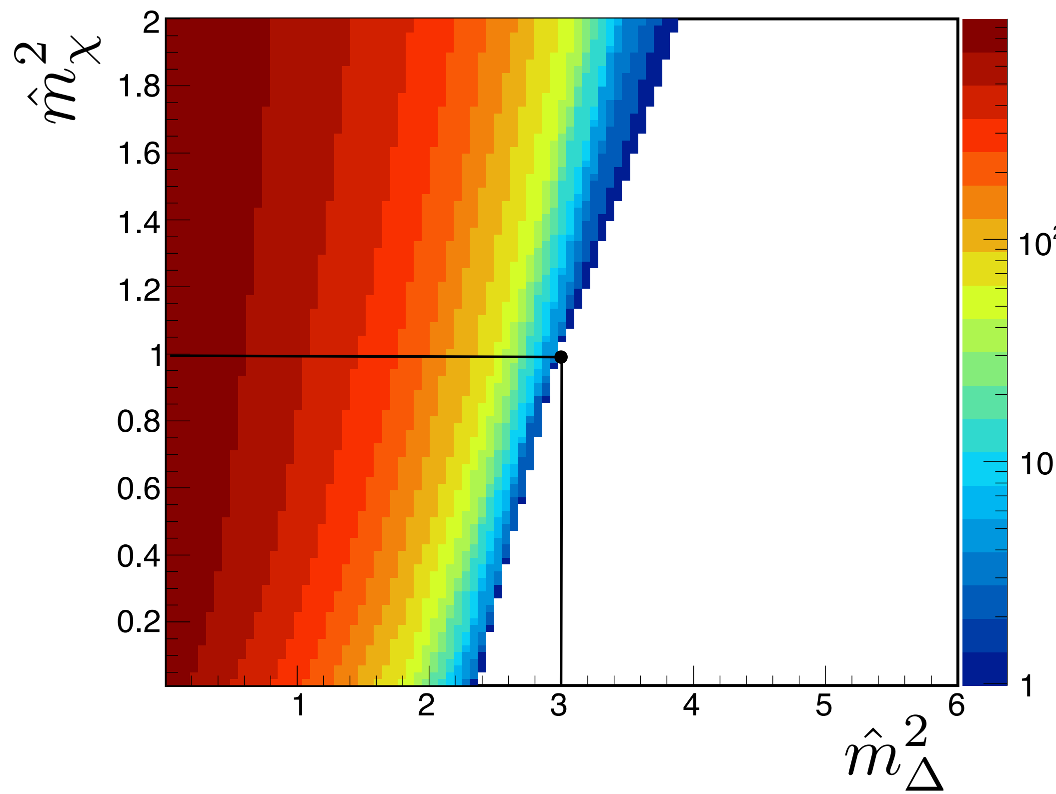
$$\hat m^2_\Delta \equiv (m^{\star 2}_{\tilde l} - m^{\star 2}_{\chi})/(m^{\rm true}_{\tilde\chi})^2$$

$$\hat m^2_\chi \equiv (m^{\star}_{\chi})^2/(m^{\rm true}_{\tilde\chi})^2$$

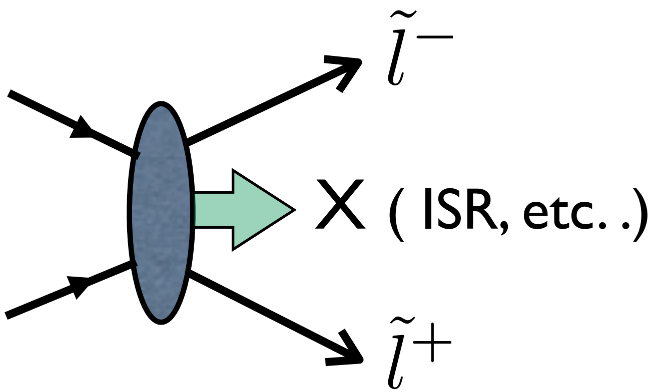
$$(\mathbf{p}_{\tilde l^+} + \mathbf{p}_{\tilde l^+})_T + \mathbf{X}_T = \mathbf{0}$$

1000 event with $|\mathbf{X}_T| = m^{\rm true}_{\tilde\chi}(\mathrm{Random}[0,2])$





mT2 kink method

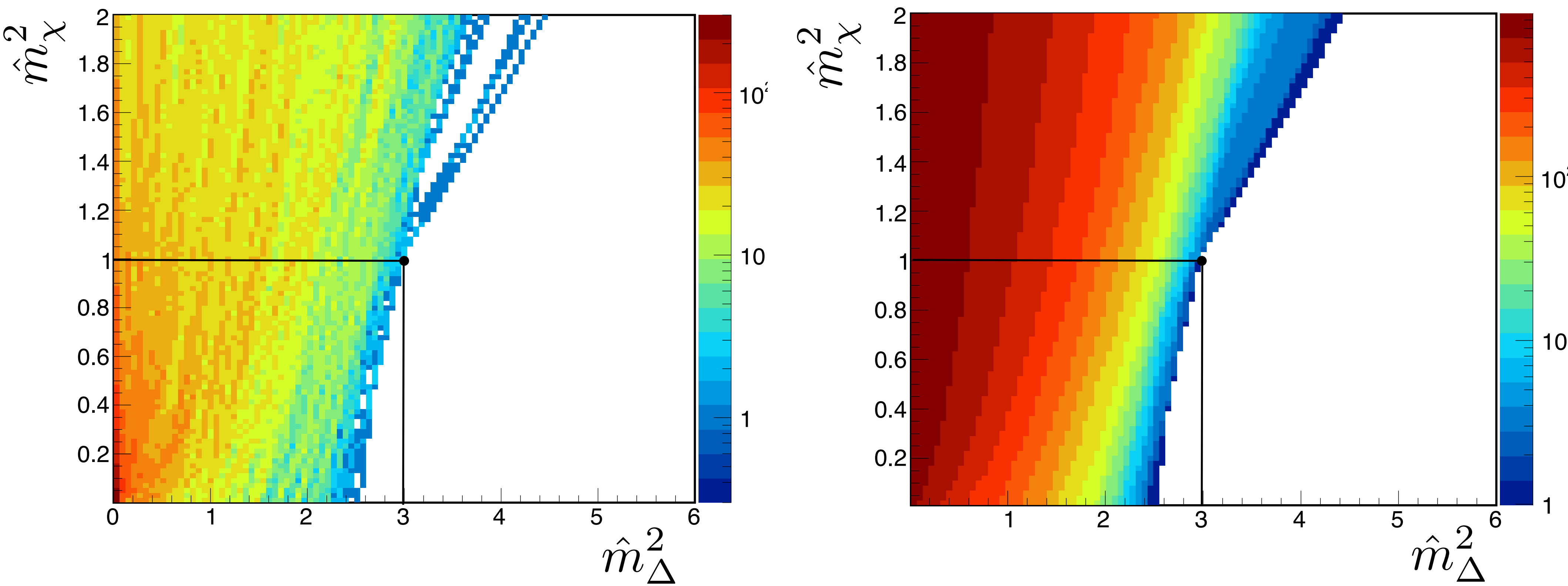


$$\hat{m}^2_\Delta \equiv (m^{\star 2}_{\tilde{l}} - m^{\star 2}_{\chi})/(m^{\rm true}_{\tilde{\chi}})^2$$

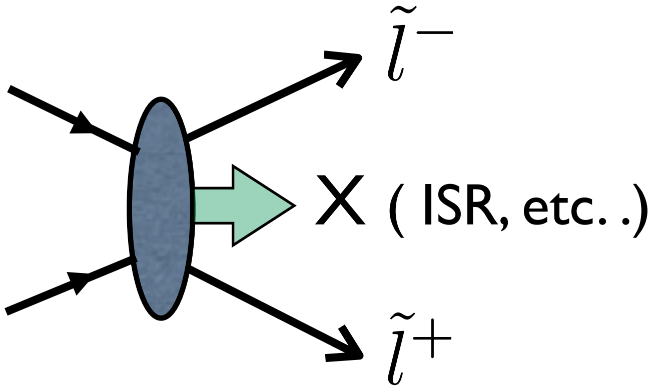
$$\hat{m}^2_\chi \equiv (m^{\star}_{\chi})^2/(m^{\rm true}_{\tilde{\chi}})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

1000 event with $|\mathbf{X}_T| = m^{\rm true}_{\tilde{\chi}}(\mathrm{Random}[0,5])$



mT2 kink method

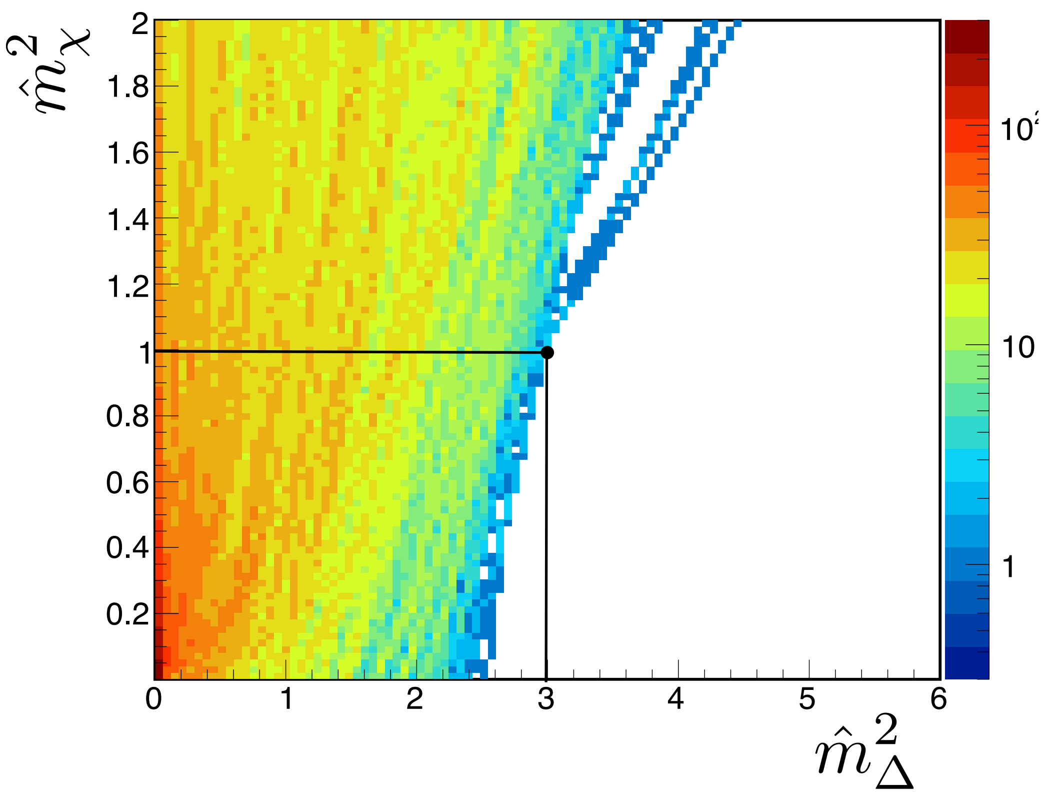


$$\hat{m}^2_\Delta \equiv (m^{\star 2}_{\tilde{l}} - m^{\star 2}_{\chi})/(m^{\rm true}_{\tilde{\chi}})^2$$

$$\hat{m}^2_\chi \equiv (m^{\star}_{\chi})^2/(m^{\rm true}_{\tilde{\chi}})^2$$

$$(\mathbf{p}_{\tilde{l}^+} + \mathbf{p}_{\tilde{l}^+})_T + \mathbf{X}_T = \mathbf{0}$$

— 1000 event with $|\mathbf{X}_T| = m^{\rm true}_{\tilde{\chi}}(\text{Random}[0,5])$ —



- X_T cannot be very large.
(most of the ISR is soft and collinear)
- Small event population at the kink point
- The kink is very fragile against the BG and the momentum mismeasurement.

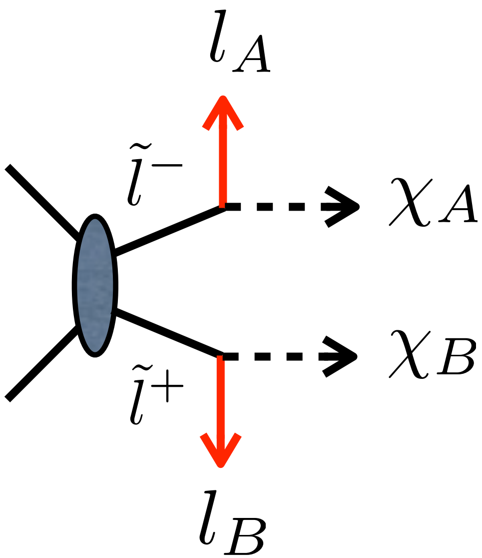
How to improve?

How to improve?

- taking account of more information:

How to improve?

- taking account of more information:



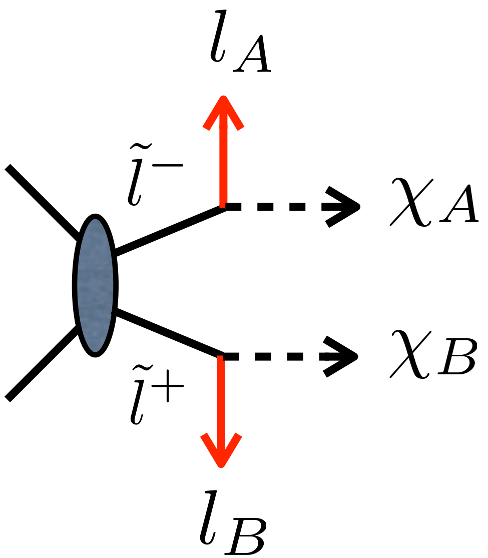
only x and y → all four components

$$\mathbf{p}^{\star T}_{\chi_A} + \mathbf{p}^{\star T}_{\chi_B} = \mathbf{p}^{\mathrm{obs.}T}_{\mathrm{miss}} \longrightarrow p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\mathrm{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 = (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

How to improve?

- taking account of more information:



only x and y $\longrightarrow$ all four components

$$\mathbf{p}^{\star T}_{\chi_A} + \mathbf{p}^{\star T}_{\chi_B} = \mathbf{p}^{\text{obs.}T}_{\text{miss}} \longrightarrow p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\text{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 = (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

- How can we get p^μ_{miss} ?

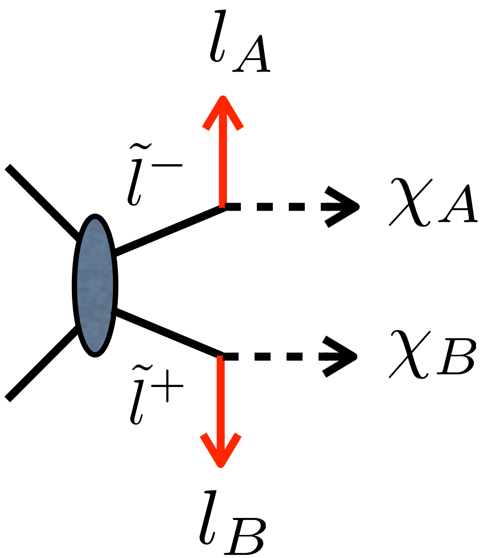
✗ LHC: inelastic scattering

$$p^\mu_{\text{miss}} = p^\mu_{\text{initial}} - p^\mu_{\text{final:visible}}$$

↑ parton momenta are unknown

How to improve?

- taking account of more information:



only x and y $\qquad$ all four components

$$\mathbf{p}^{\star T}_{\chi_A} + \mathbf{p}^{\star T}_{\chi_B} = \mathbf{p}^{\mathrm{obs.}T}_{\mathrm{miss}} \longrightarrow p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\mathrm{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 = (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

- How can we get p^{μ}_{miss} ?

$$p^{\mu}_{\mathrm{miss}} = p^{\mu}_{\mathrm{initial}} - p^{\mu}_{\mathrm{final:visible}}$$

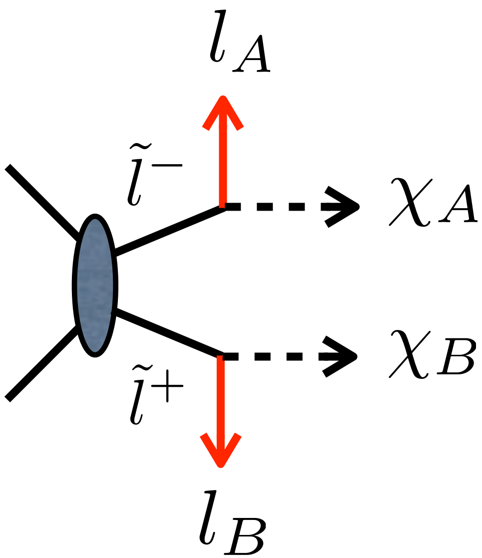
↑ e^+e^- energy is known

✗ LHC: inelastic scattering

✓ ILC

How to improve?

- taking account of more information:



only x and y → all four components

$$\mathbf{p}^{\star T}_{\chi_A} + \mathbf{p}^{\star T}_{\chi_B} = \mathbf{p}^{\mathrm{obs}.T}_{\mathrm{miss}} \longrightarrow p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\mathrm{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 = (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

- How can we get p^{μ}_{miss} ?

$$p^{\mu}_{\mathrm{miss}} = p^{\mu}_{\mathrm{initial}} - p^{\mu}_{\mathrm{final:visible}}$$

✗ LHC: inelastic scattering

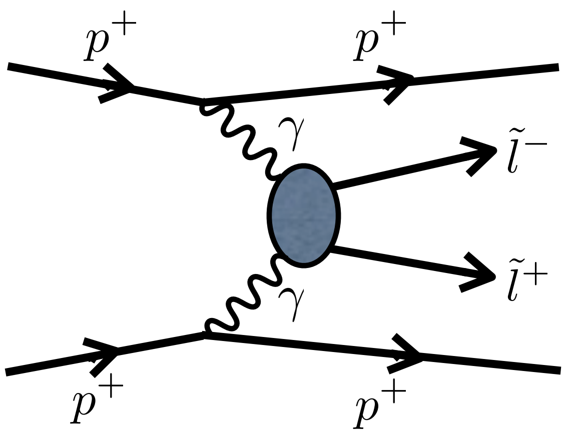
✓ ILC

✓ LHC: *central exclusive processes with forward proton tagging*

Central Exclusive Production (CEP) and forward proton tagging

CEP → forward proton tagging

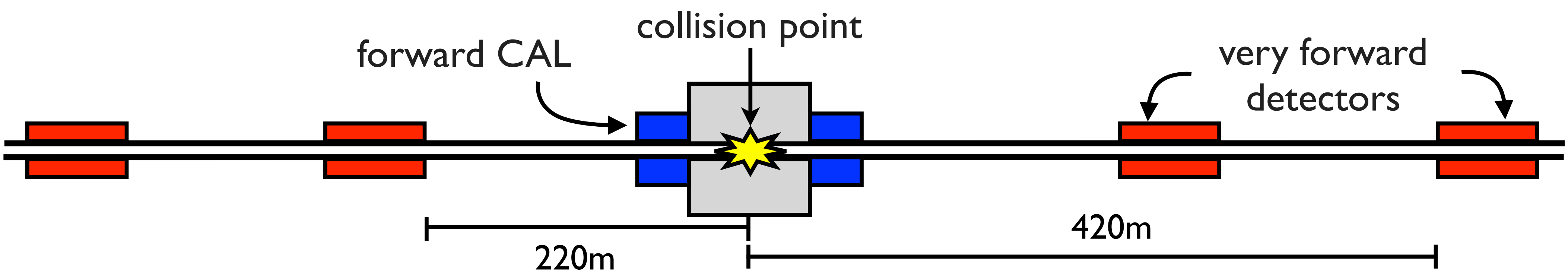
$$p^{\mu}_{\mathrm{miss}} = p^{\mu}_{\mathrm{initial}} - p^{\mu}_{\mathrm{final:visible}}$$



- The proton-proton collisions may create slepton pairs through the two photons, without breaking the protons down.

- Very clean final state: 2 sleptons + 2 protons remained intact, no soft particles in the forward CAL.

- Provided the very forward detectors installed at 220m and 420m away from the collision point (ATLAS forward physics (AFP) project), the energy of the final state protons can be measured with a good accuracy (a few % relative energy resolution).



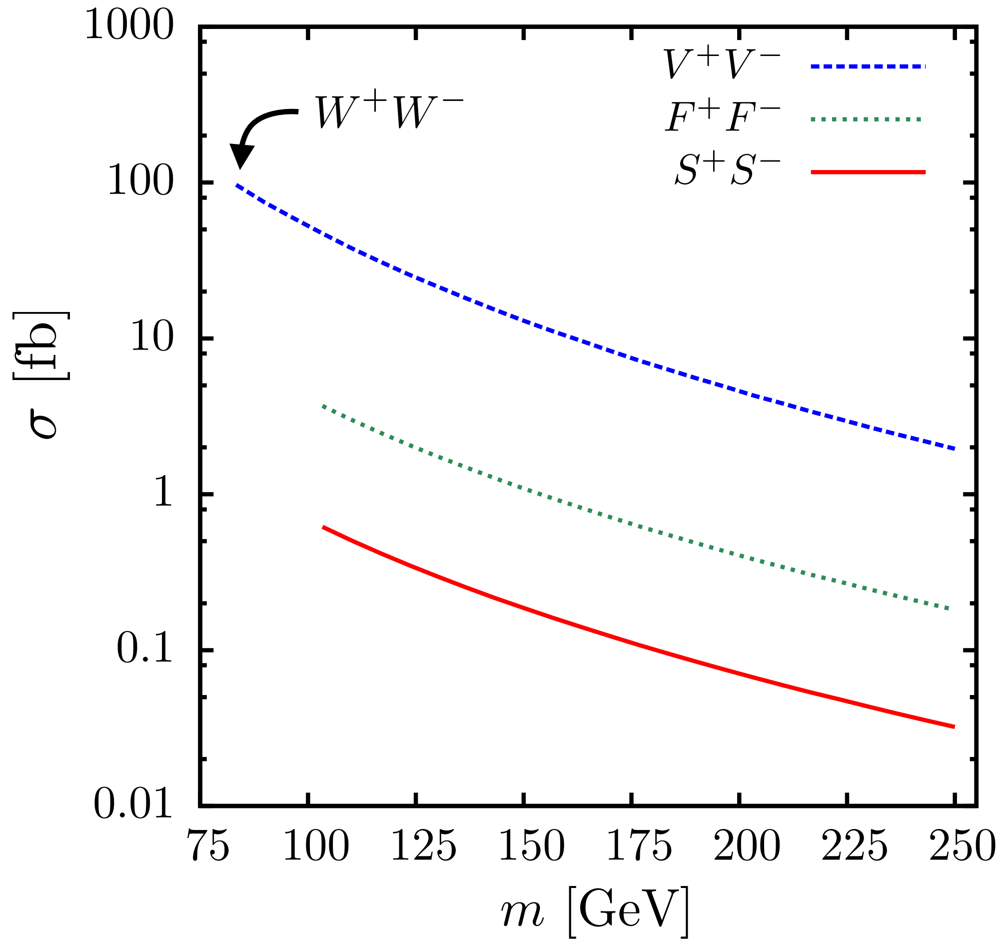
Cross sections

- The cross section can be calculated by using the "equivalent photon approx".

$$\sigma(pp \to pXp) = \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}, Q_1^2, Q_2^2) \prod_{i=1,2} \left[\frac{dN(E_{\gamma_i}, Q_i^2)}{dQ_i^2} dQ_i^2 dE_{\gamma_i}\right] \delta(m_{\gamma\gamma} = \sqrt{(p_{\gamma_1} + p_{\gamma_2})^2}) dm_{\gamma\gamma}$$

$$\sim \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}) \prod_{i=1,2} \left[f(E_{\gamma_i}) dE_{\gamma_i}\right] \delta(m_{\gamma\gamma} = 2\sqrt{E_{\gamma_1} + E_{\gamma_2}}) dm_{\gamma\gamma}$$

$$= \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}) \frac{dL^{\gamma\gamma}}{dm_{\gamma\gamma}} dm_{\gamma\gamma}$$



Cross sections

- The cross section can be calculated by using the "equivalent photon approx".

$$\sigma(pp \to pXp) = \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}, Q_1^2, Q_2^2) \prod_{i=1,2} \left[\frac{dN(E_{\gamma_i}, Q_i^2)}{dQ_i^2} dQ_i^2 dE_{\gamma_i}\right] \delta(m_{\gamma\gamma} = \sqrt{(p_{\gamma_1} + p_{\gamma_2})^2}) dm_{\gamma\gamma}$$

$$\sim \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}) \prod_{i=1,2} \left[f(E_{\gamma_i}) dE_{\gamma_i}\right] \delta(m_{\gamma\gamma} = 2\sqrt{E_{\gamma_1} + E_{\gamma_2}}) dm_{\gamma\gamma}$$

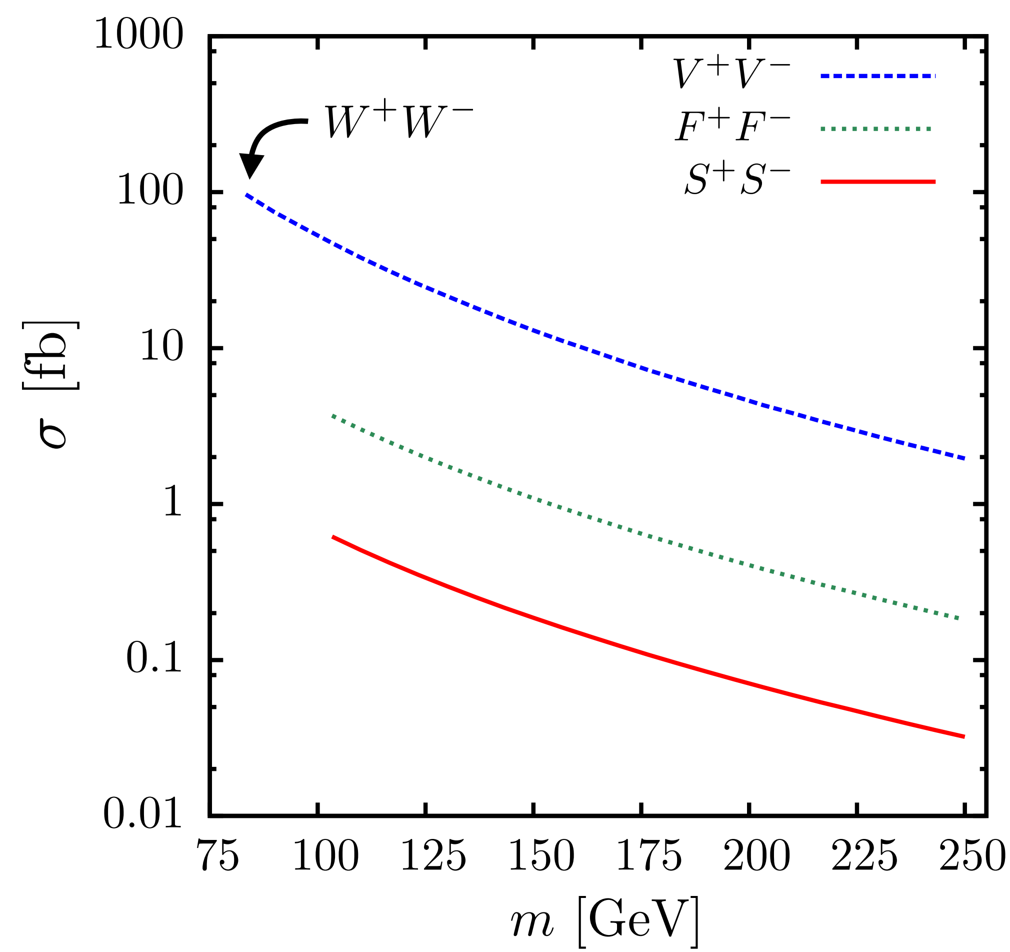
$$= \int d\sigma_{\gamma\gamma\to X}(m_{\gamma\gamma}) \frac{dL^{\gamma\gamma}}{dm_{\gamma\gamma}} dm_{\gamma\gamma}$$

- The VFDs can only measure the final state protons with:

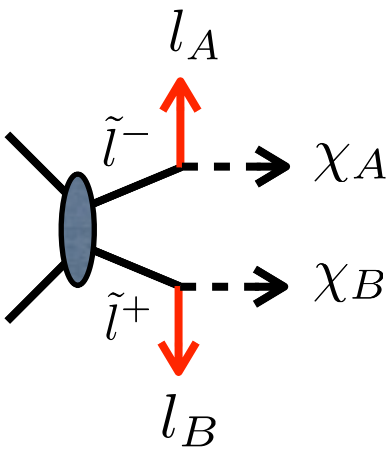
$$0.0015 < \frac{E_p^{\text{ini}} - E_p^{\text{final}}}{E_p^{\text{ini}}} < 0.15$$

- The cross sections after the proton tagging acceptance:

$W^+W^- \to l^+l^-\nu\bar{\nu}$	1.00 fb
$\tilde{l}^+\tilde{l}^-$ $(m_{\tilde{l}} = 150\,\text{GeV})$	0.15 fb



Finding the allowed mass region



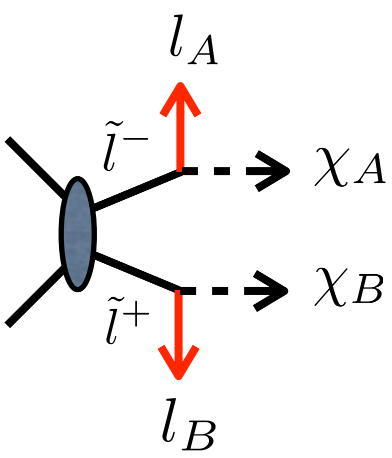
all four components

$$p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\rm miss}$$

$$\widetilde{M}_{\tilde{l}}(m^{\star}_{\chi}, p^{\star}_{\chi_A}, p^{\star}_{\chi_B}) \equiv (p_{l_A} + p^{\star}_{\chi_A}(m^{\star}_{\chi}))^2 = (p_{l_B} + p^{\star}_{\chi_B}(m^{\star}_{\chi}))^2$$

- Given $p^{\mu}_{l_A}$, $p^{\mu}_{l_B}$, $p^{\mu}_{\rm miss}$, which regain in $(\tilde{M}_{\tilde{l}},\, m^{\star}_{\chi})$ plane is consistent with the above conditions?

Finding the allowed mass region



all four components

$$p^{\star\mu}_{\chi_A} + p^{\star\mu}_{\chi_B} = p^{\mu}_{\text{miss}}$$

$$\widetilde{M}_{\tilde{l}}(m^\star_\chi, p^\star_{\chi_A}, p^\star_{\chi_B}) \equiv (p_{l_A} + p^\star_{\chi_A}(m^\star_\chi))^2 = (p_{l_B} + p^\star_{\chi_B}(m^\star_\chi))^2$$

- Given $p^\mu_{l_A}$, $p^\mu_{l_B}$, p^μ_{miss}, which regain in $(\tilde{M}_{\tilde{l}}, m^\star_\chi)$ plane is consistent with the above conditions?

$$\overline{m}^2_\chi \leq c_a(\overline{m}^2_\Delta)^2 + c_b\overline{m}^2_\Delta + c_c \qquad \overline{m}^2_\chi = \frac{m^2_\chi}{p_{l_A}\cdot p_{l_B}} \qquad \overline{m}^2_\Delta = \frac{M^2_{\tilde{l}} - m^2_\chi}{p_{l_A}\cdot p_{l_B}}$$

$$c_a = \frac{1}{4}\frac{(\Lambda_1+\Lambda_2)^2 - 2\Lambda_{\gamma\gamma}}{\Lambda_{\gamma\gamma} - 2\Lambda_1\Lambda_2} \qquad c_b = \frac{1}{2}(\Lambda_1+\Lambda_2-2) \qquad c_c = \frac{1}{4}(\Lambda_{\gamma\gamma} - 2\Lambda_1\Lambda_2)$$

$$\Lambda_1 \equiv \frac{p_{\gamma\gamma}\cdot p_{l_1}}{p_{l_1}\cdot p_{l_2}} \qquad \Lambda_2 \equiv \frac{p_{\gamma\gamma}\cdot p_{l_2}}{p_{l_1}\cdot p_{l_2}} \qquad \Lambda_{\gamma\gamma} \equiv \frac{m^2_{\gamma\gamma}}{p_{l_1}\cdot p_{l_2}} \qquad p_{\gamma\gamma} = p_{l_A} + p_{l_B} + p_{\text{miss}} \qquad m^2_{\gamma\gamma} = p^2_{\gamma\gamma}$$

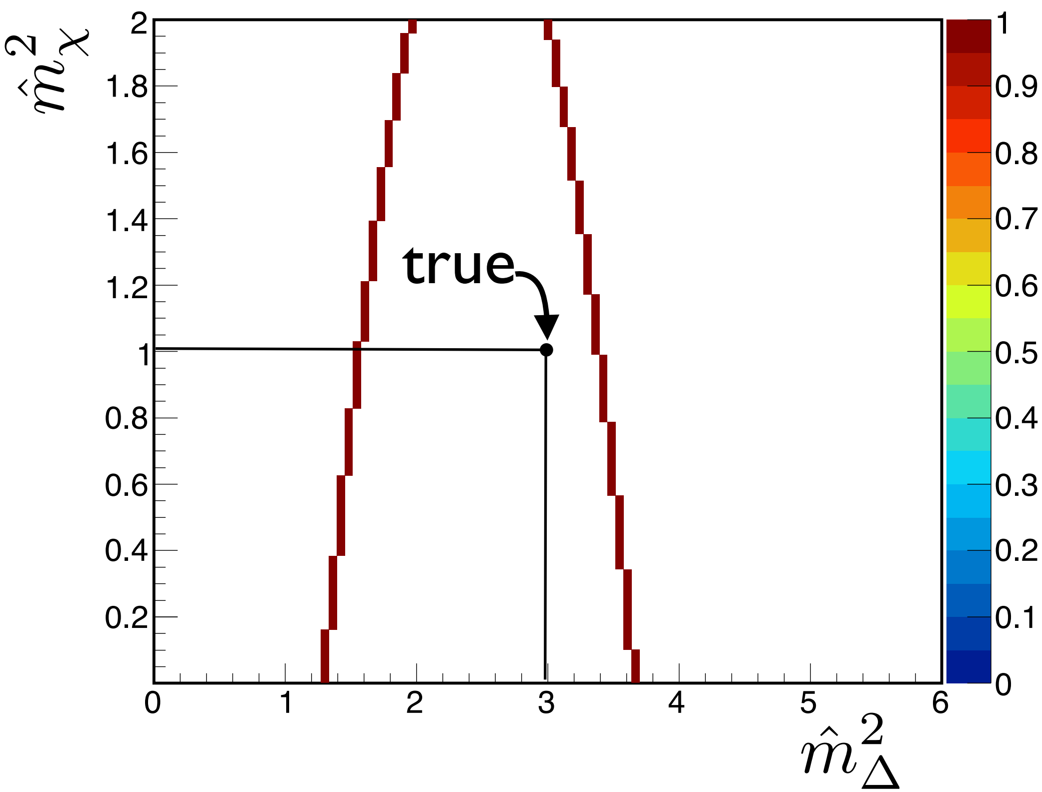
Distributions

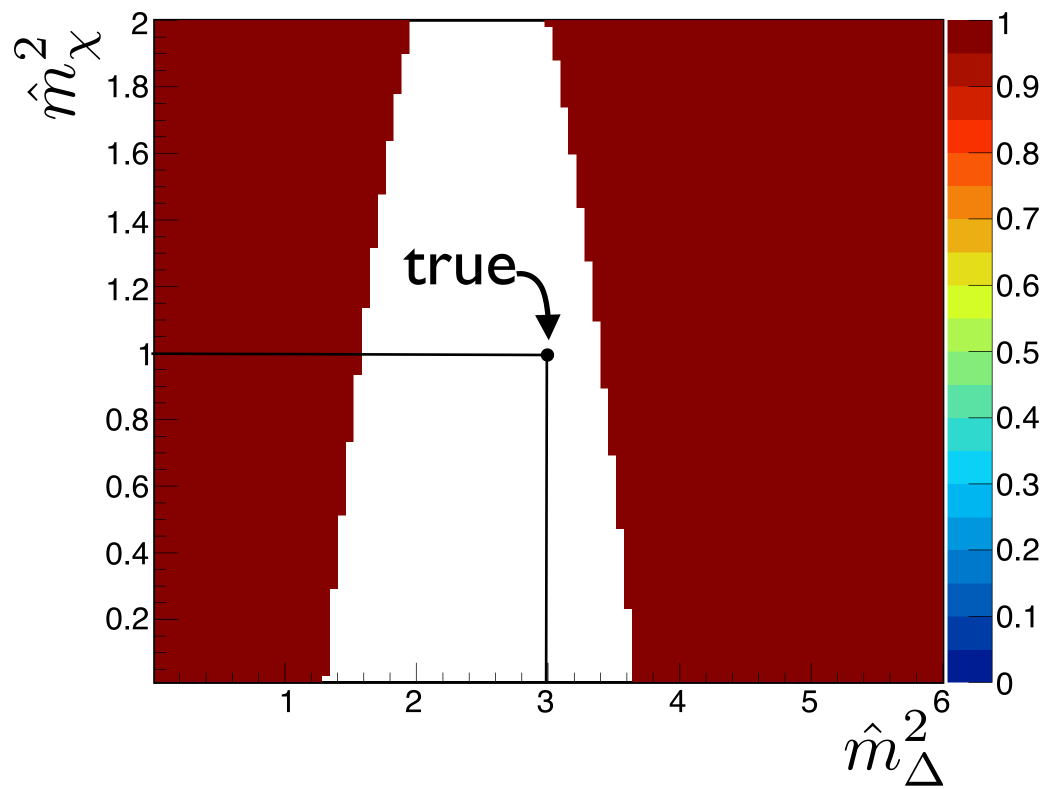
$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\text{true}})^2$$

$$\hat{m}_\chi^2 \equiv (m_\chi^{\star})^2/(m_{\tilde{\chi}}^{\text{true}})^2$$

- Unlike the inelastic case (only m_Δ^{upper}), the both upper and lower bounds on m_Δ are obtained, moreover the upper bound on m_χ is also obtained.

— 1 event with $|\mathbf{p}_{\tilde{l}}^{\text{initial}}| = m_{\tilde{\chi}}^{\text{true}}(\text{Random}[0,2])$ —





Distributions

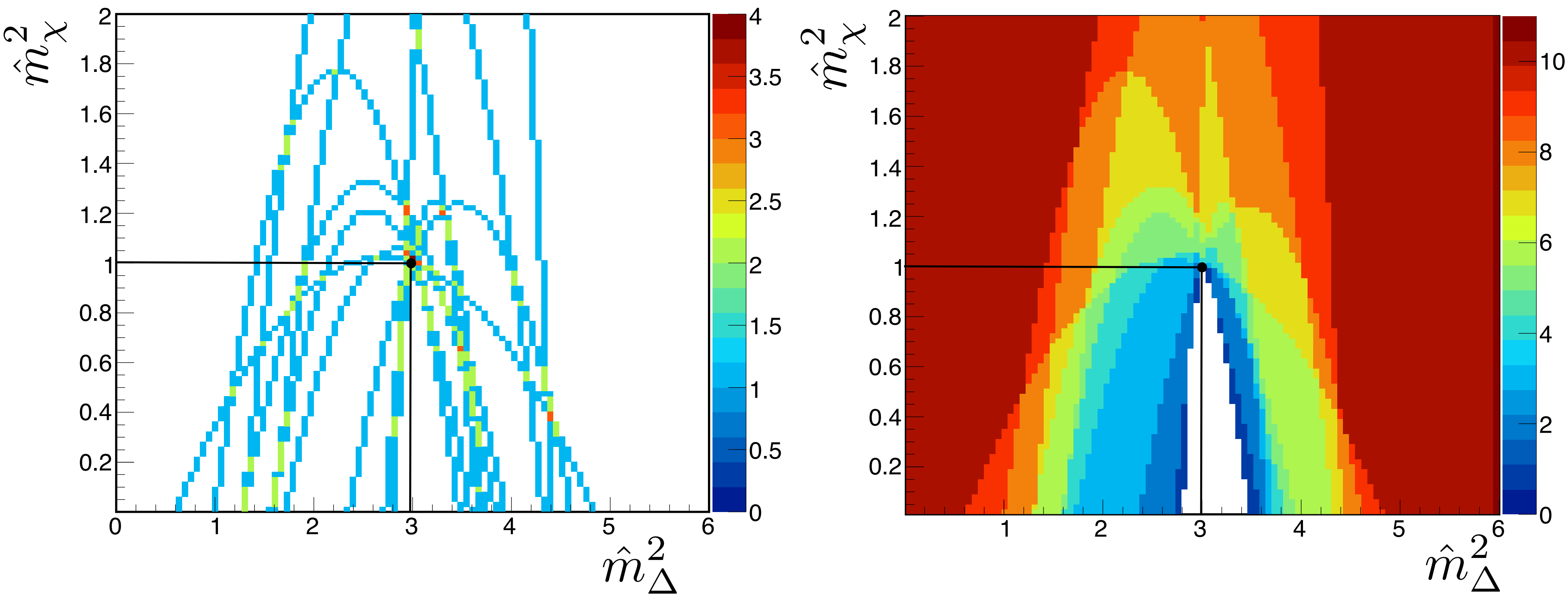
$$\hat{m}_{\Delta}^2 \equiv (m_{\tilde{l}}^{\star 2} - m_{\chi}^{\star 2})/(m_{\tilde{\chi}}^{\mathrm{true}})^2$$

$$\hat{m}_{\chi}^2 \equiv (m_{\chi}^{\star})^2/(m_{\tilde{\chi}}^{\mathrm{true}})^2$$

- Unlike the inelastic case (only $m_{\Delta}^{\mathrm{upper}}$), the both upper and lower bounds on m_{Δ} are obtained, moreover the upper bound on m_{χ} is also obtained.

- The allowed region shrinks rapidly as the number of events increases.

—— 10 event with $|\mathbf{p}_{\tilde{l}}^{\mathrm{initial}}| = m_{\tilde{\chi}}^{\mathrm{true}}(\mathrm{Random}[0, 2])$ ——



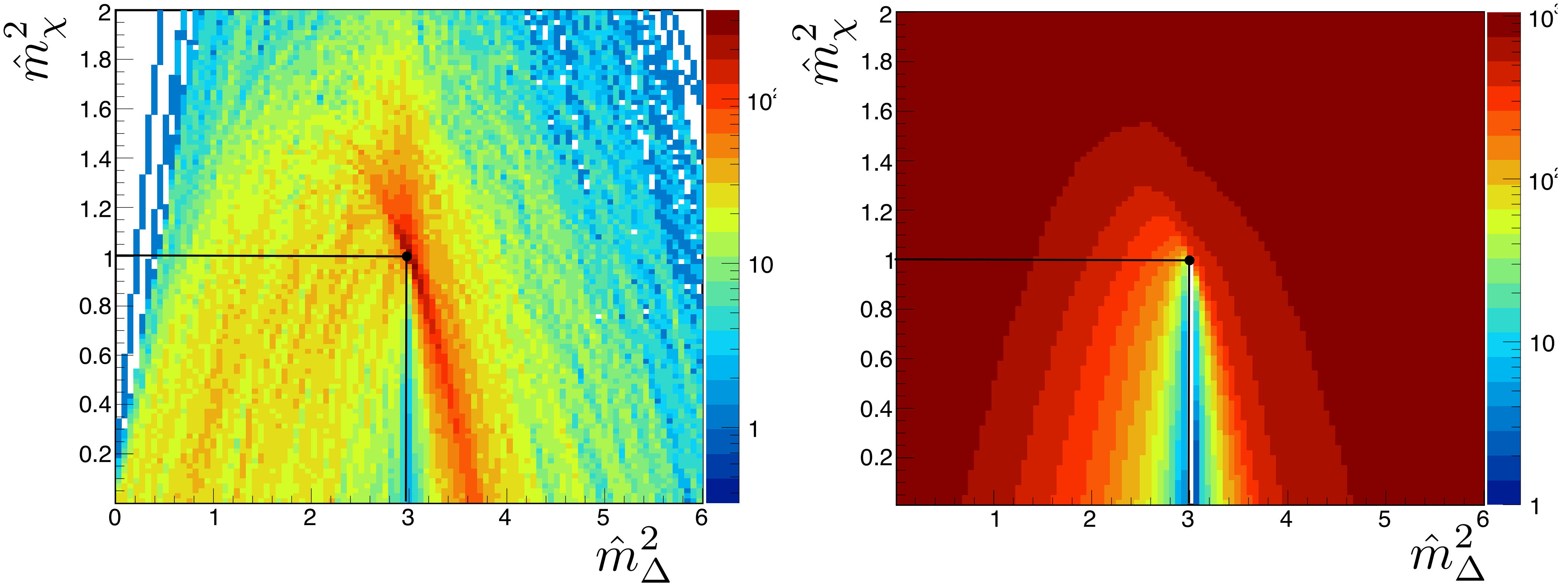
Distributions

$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

$$\hat{m}_\chi^2 \equiv (m_\chi^\star)^2/(m_{\tilde{\chi}}^{\rm true})^2$$

- Unlike the inelastic case (only $m_\Delta^{\rm upper}$), the both upper and lower bounds on m_Δ are obtained, moreover the upper bound on $m\chi$ is also obtained.
- The allowed region shrinks rapidly as the number of events increases.
- The population of the events at the true mass point is large (→ stable against the BG and errors).

1000 event with $|\mathbf{p}_{\tilde{l}}^{\rm initial}| = m_{\tilde{\chi}}^{\rm true}(\mathrm{Random}[0,2])$



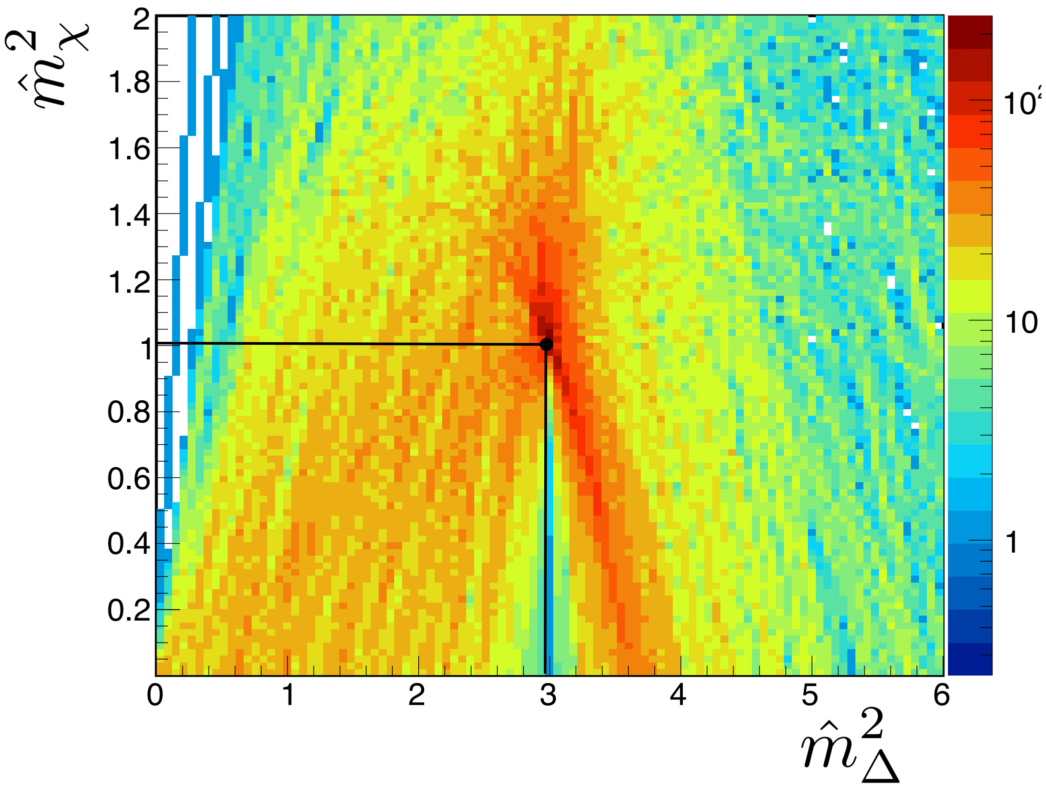
Distributions

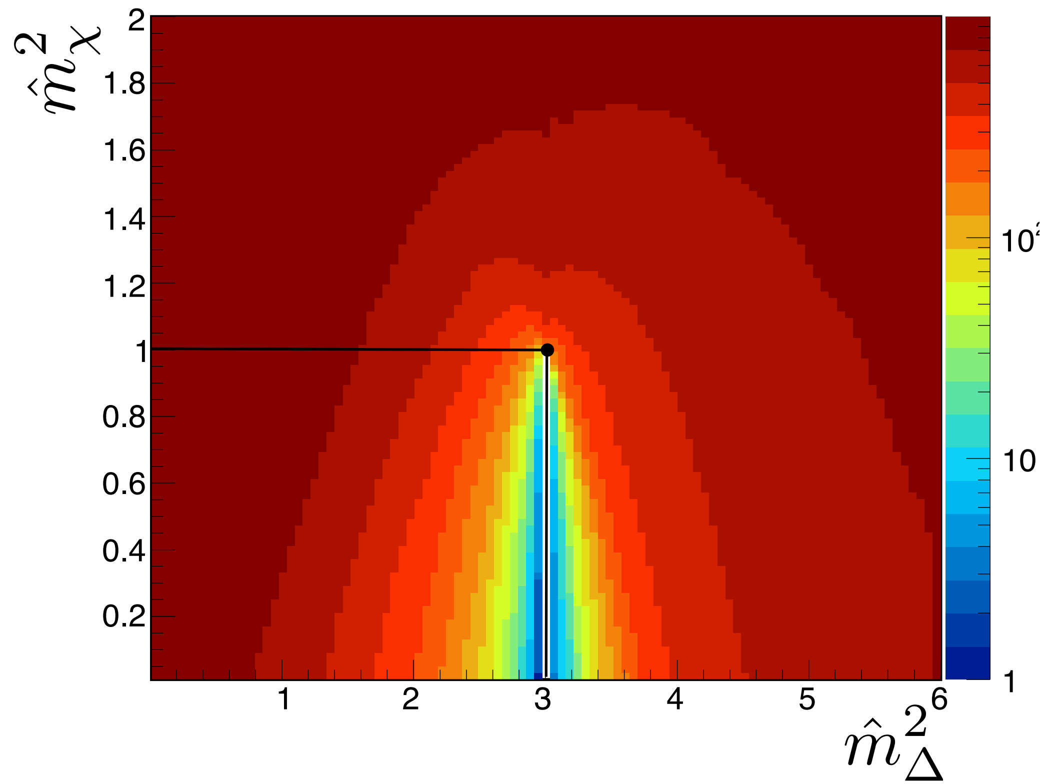
$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

$$\hat{m}_\chi^2 \equiv (m_\chi^\star)^2/(m_{\tilde{\chi}}^{\rm true})^2$$

- Unlike the inelastic case (only $m_\Delta^{\rm upper}$), the both upper and lower bounds on m_Δ are obtained, moreover the upper bound on m_χ is also obtained.
- The allowed region shrinks rapidly as the number of events increases.
- The population of the events at the true mass point is large (→ stable against the BG).
- The distribution depends on the distribution of the $p_{\rm slep}^{\rm ini}$ (or equivalently on the CoM of the γγ).

1000 event with $|\mathbf{p}_{\tilde{l}}^{\rm initial}| = m_{\tilde{\chi}}^{\rm true}({\rm Random}[0,4])$





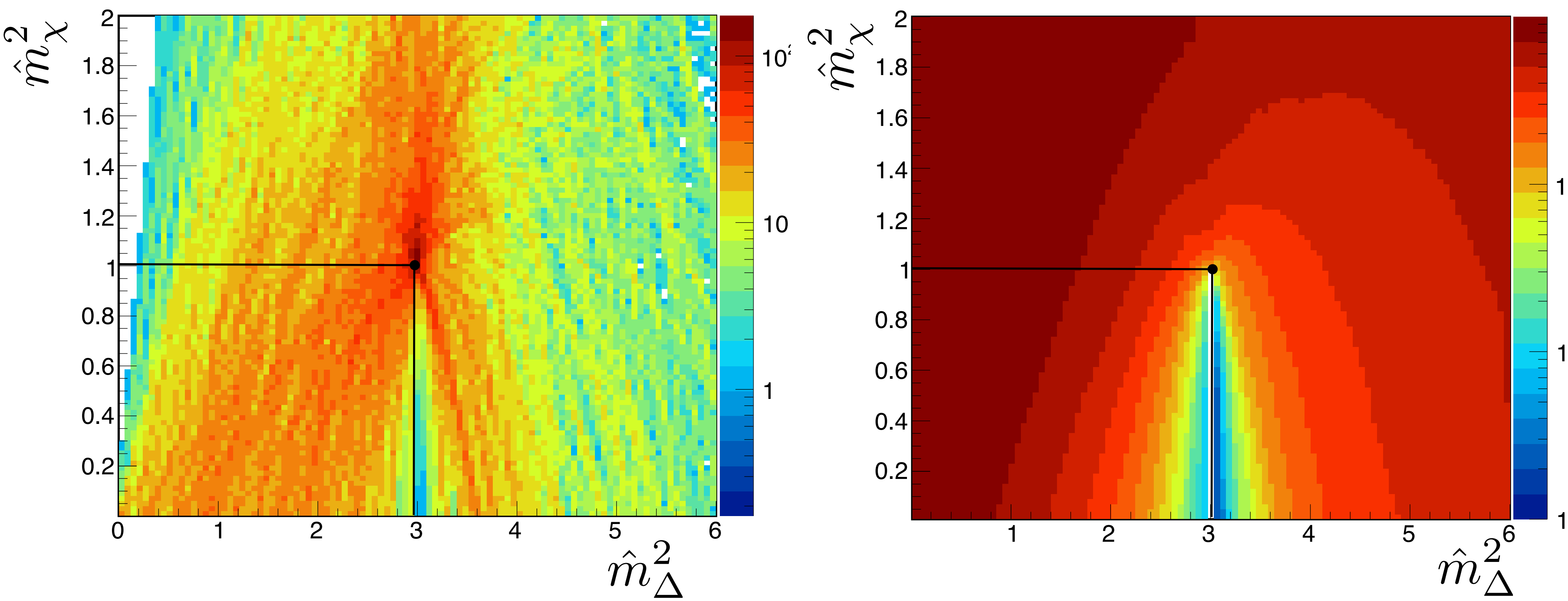
Distributions

$$\hat{m}_\Delta^2 \equiv (m_{\tilde{l}}^{\star 2} - m_\chi^{\star 2})/(m_{\tilde{\chi}}^{\rm true})^2$$

$$\hat{m}_\chi^2 \equiv (m_\chi^{\star})^2/(m_{\tilde{\chi}}^{\rm true})^2$$

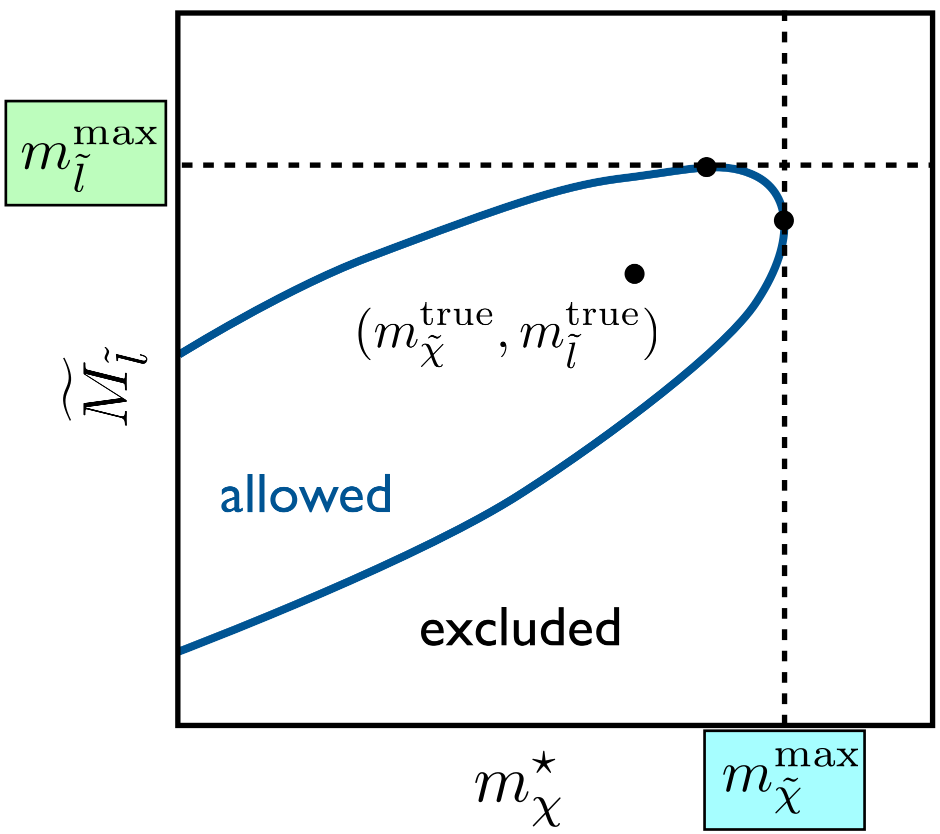
- Unlike the inelastic case (only m_Δ^{upper}), the both upper and lower bounds on m_Δ are obtained, moreover the upper bound on mχ is also obtained.
- The allowed region shrinks rapidly as the number of events increases.
- The population of the events at the true mass point is large (→ stable against the BG).
- The distribution depends on the distribution of the p_{slep}^{ini} (or equivalently on the CoM of the γγ).

—— 1000 event with $|\mathbf{p}_{\tilde{l}}^{\rm initial}| = m_{\tilde{\chi}}^{\rm true}(\mathrm{Random}[0, 10])$ ——



Some variables

• The event-by-event upper bounds on the m_{slep} and the m_χ can be defined, respectively.



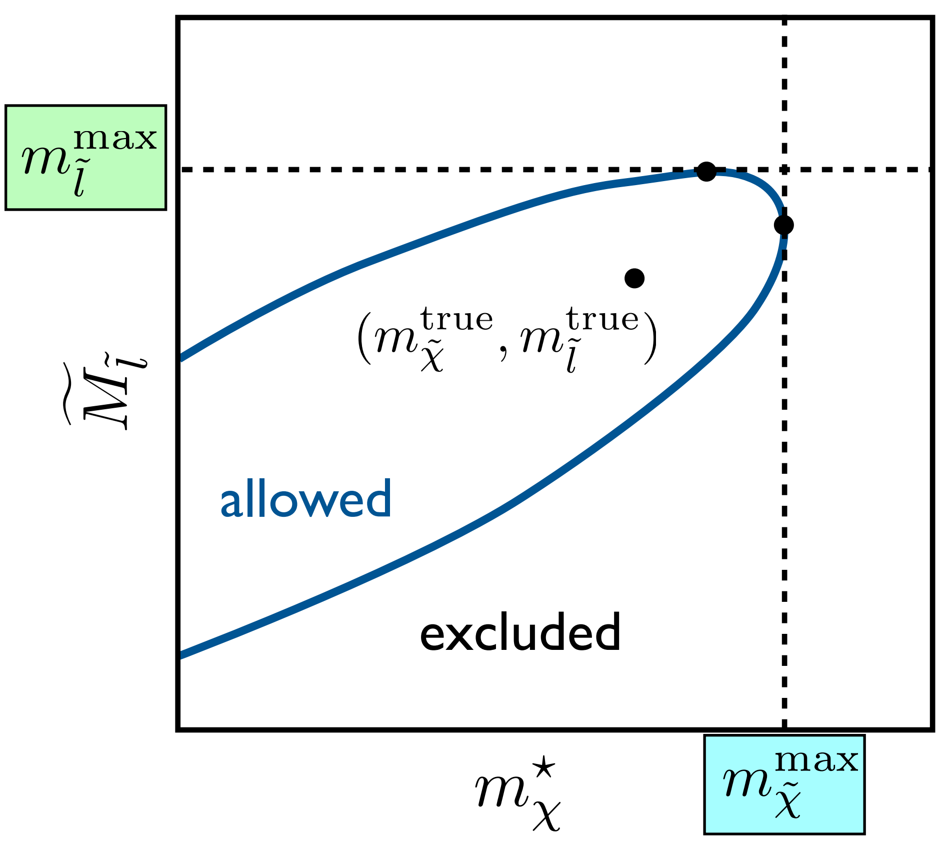
$$(m_{\tilde{l}}^{\max})^2 = (p_{l_1} \cdot p_{l_2}) \times \left(c_c - \frac{(c_b+1)^2}{4c_a} \right)$$

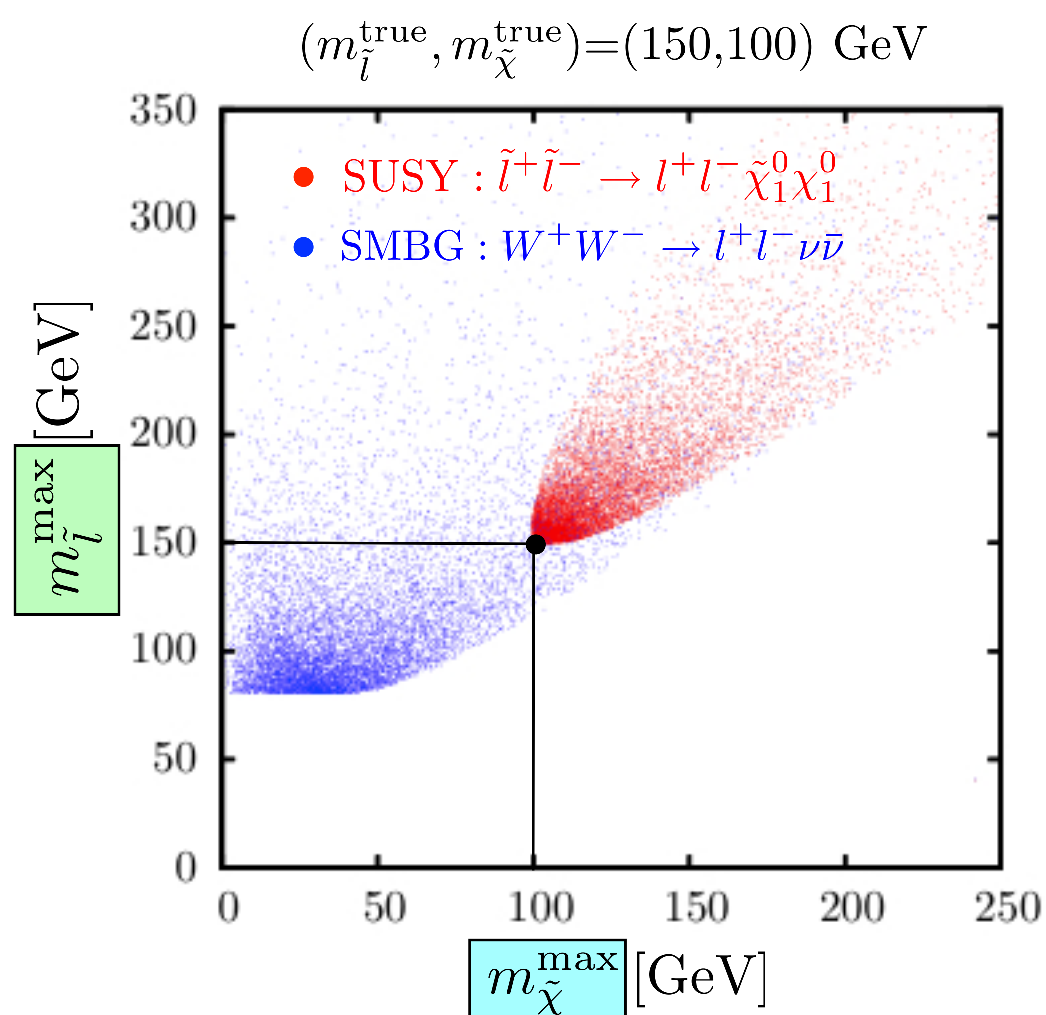
$$(m_{\tilde{\chi}}^{\max})^2 = (p_{l_1} \cdot p_{l_2}) \times \left(c_c - \frac{c_b^2}{4c_a} \right)$$

Some variables

- The event-by-event upper bounds on the m_{slep} and the m_{χ} can be defined, respectively.

- By looking at the m_{slep}^{max} and the m_{χ}^{max} simultanelously, the SMBG can be significantly removed.





Numerical analysis

- The CEP events are generated by the PhoCEP program, which takes into account of the full spin correlation for production and subsequent decays.

- The lepton momentum cut, the detector acceptance and resolutions are taken account. ($|p_T^{lep}|>10$GeV, $|\eta_{lep}|<2.5$, Resolution: 10% for lepton, 4% for the tagged proton)

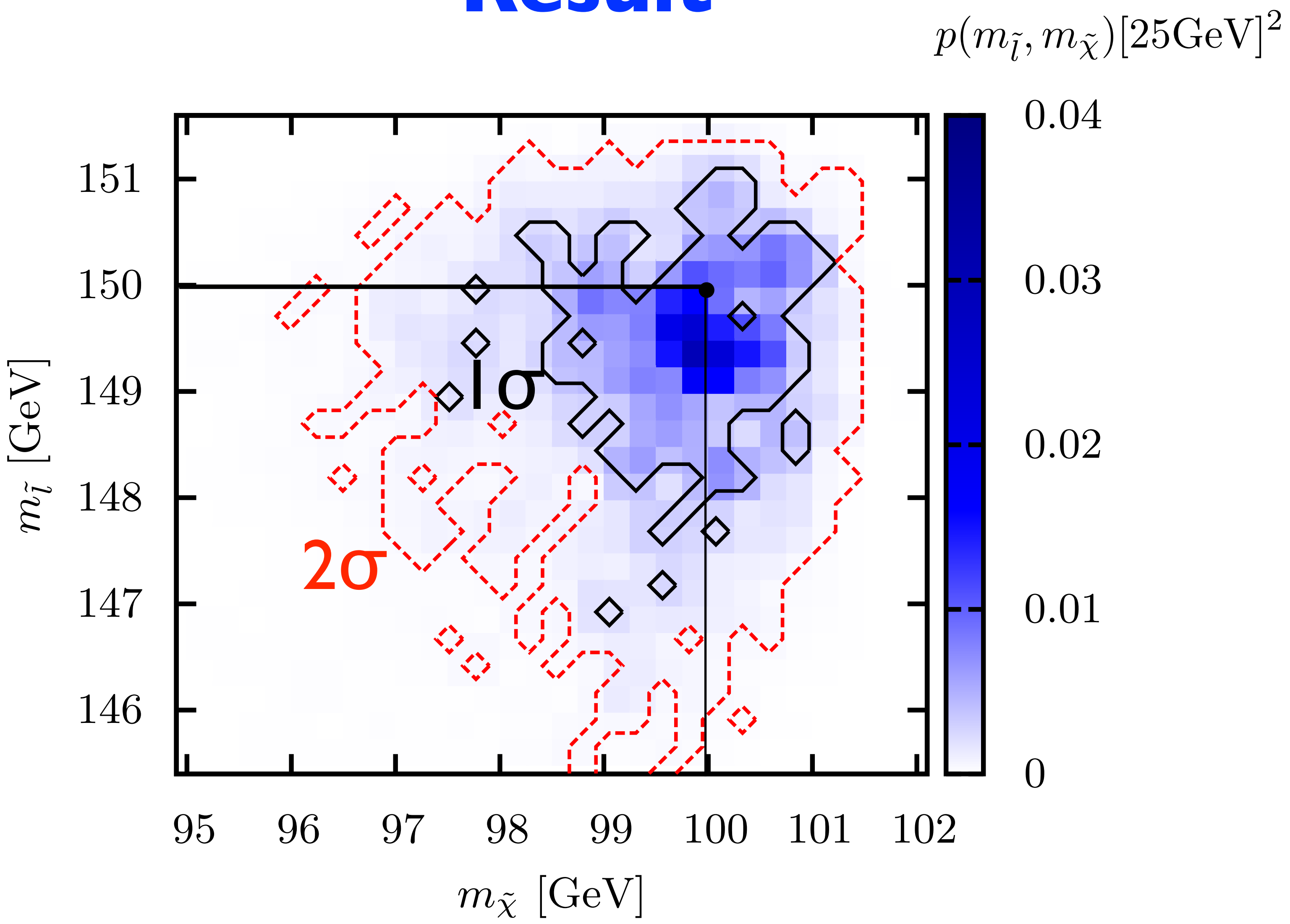
- (m_{slep}, m_X) = (150, 100) GeV, 14TeV LHC with 300 fb^{-1} is assumed.

- The 216 and 38 events are generated for the SMBG and SUSY signal, respectively and used for the pseudo experiment.

- The signal window is defined by m_{slep}^{max}= [130,230] and m_X^{max}= [80,180] reducing the events 216→24 (SMBG) and 38→36 (SUSY), respectively.

- The 2D probability density distributions of the $(m_{slep}^{max}, m_X^{max})$ are estimated by generating 10^6 events for various $(m_{slep}^{true}, m_X^{true})$ assumptions and see which assumption can fit the $(m_{slep}^{max}, m_X^{max})$ distribution observed in the pseudo experiment the best.

Result



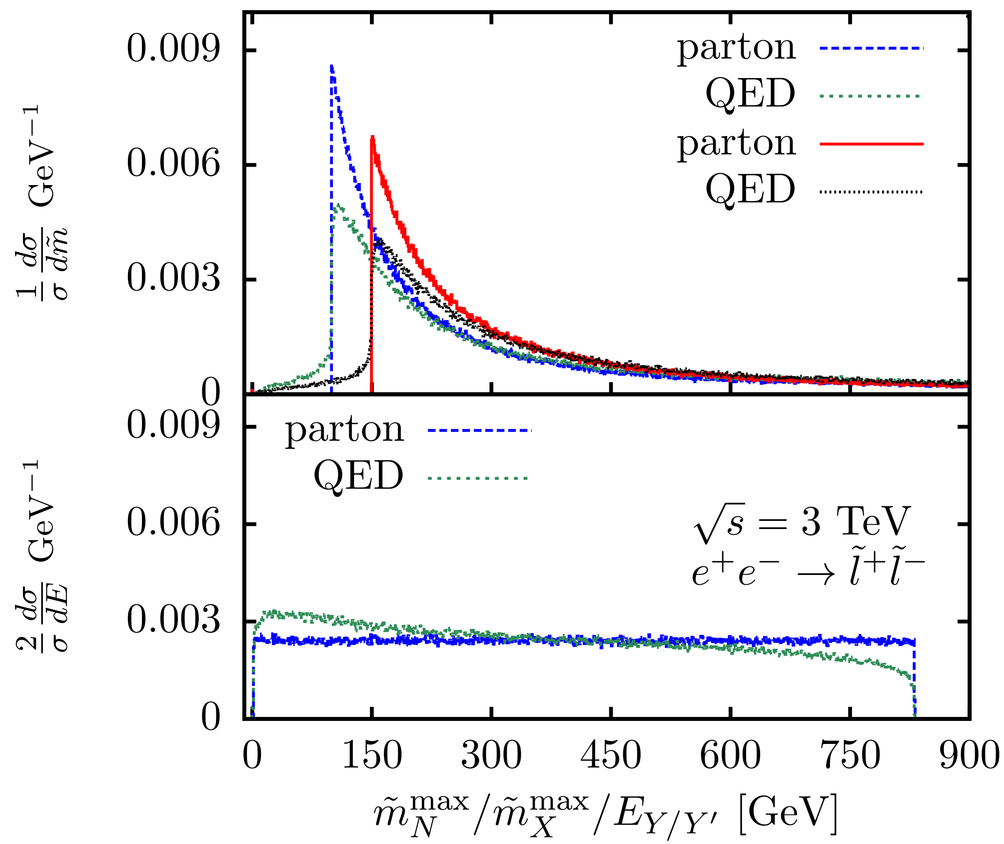
- The expected accuracy of the mass determination is around 1.5 (2.5) GeV for 1(2) σ level for both the slepton and the neutralino.

Summary

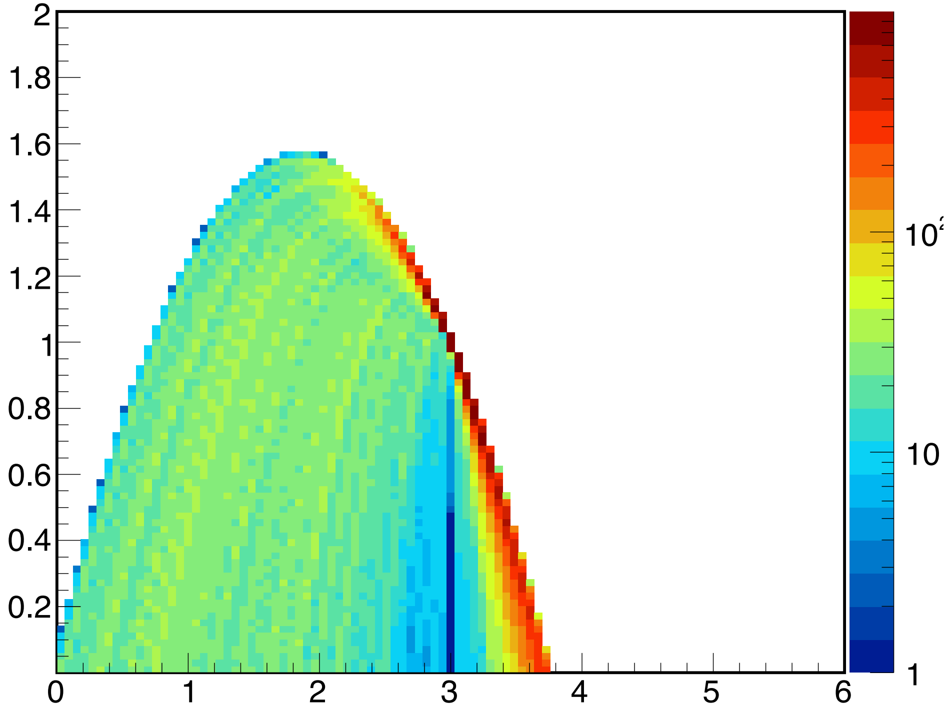
• By looking at the central exclusive slepton pair production with forward proton tagging, all the four components of the sum of the neutralino momenta can be deduced, allowing us to obtain analytically the allowed mass region by all the kinematic constraints.

• Despite the poor statistics of CEP, the new technique for the mass determination is able to determine the masses of both the slepton and the neutralino a few GeV accuracy at 1 or 2 σ level.

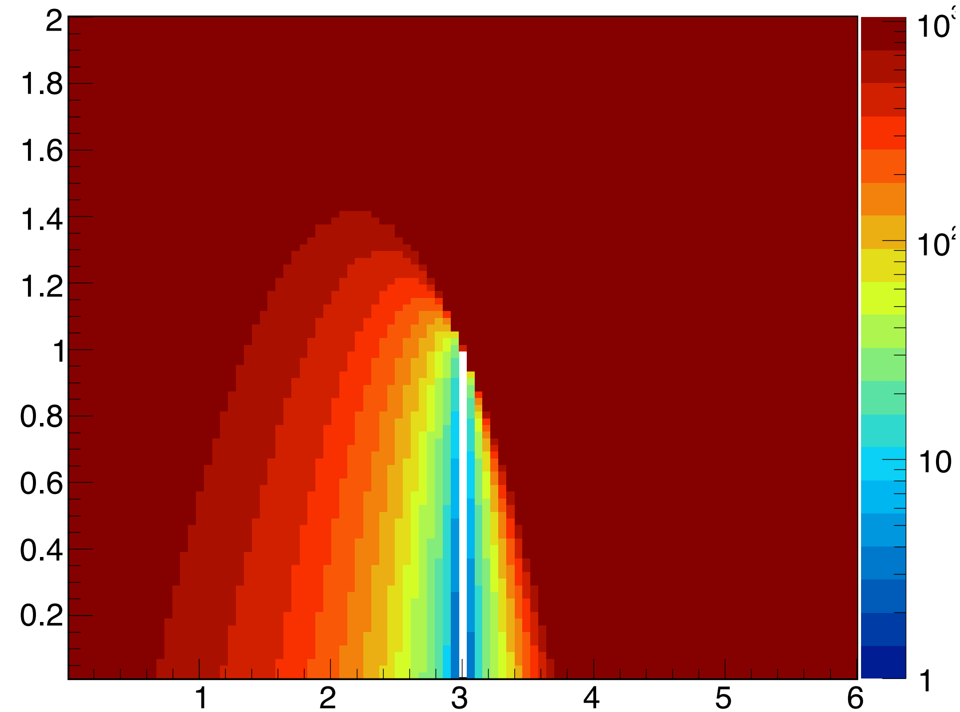
• This method may improve the traditional slepton, neutralino mass measurement at the ILC, because of making full use of the available kinematic constraints.



pback = 0

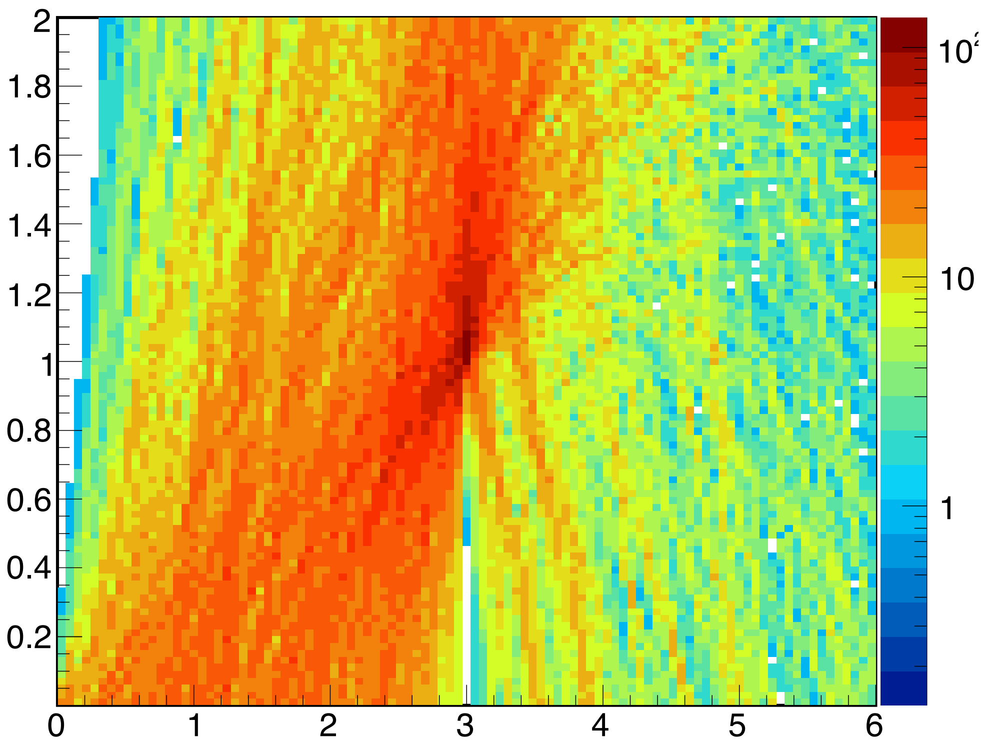


2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
1
10

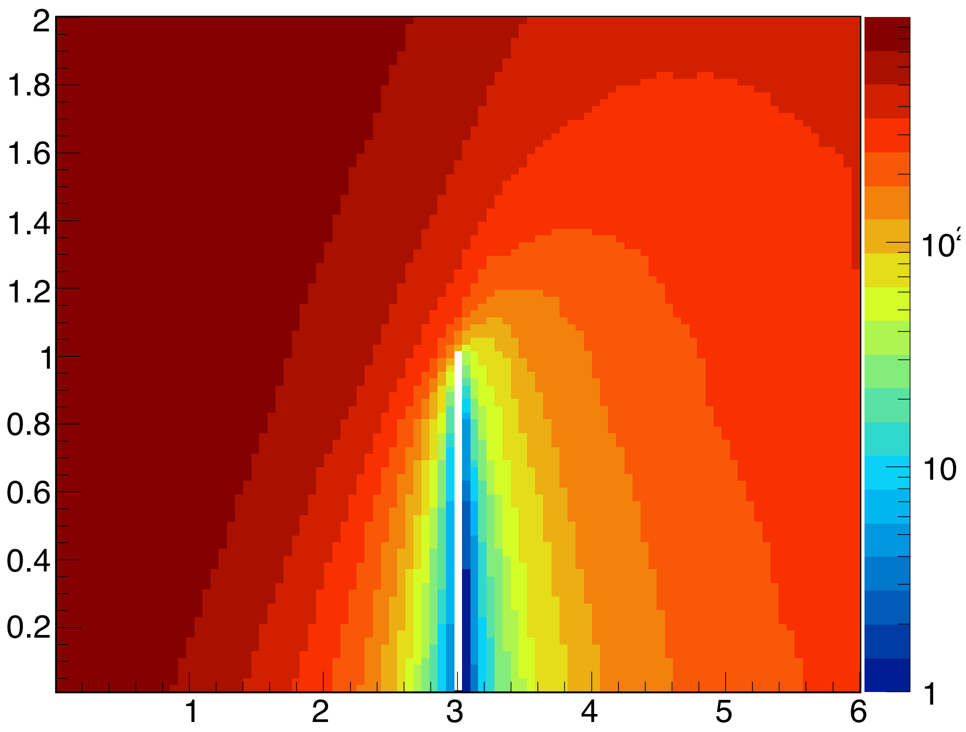


2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
1
2
3
4
5
6
1
10

pback = 10000



2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
10²
10
1



2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
1
2
3
4
5
6
10²
10
1

pback = 100000