Search for Neutral Higgs of MSSM

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Introduction

- Minimal Supersymmetric Standard Model

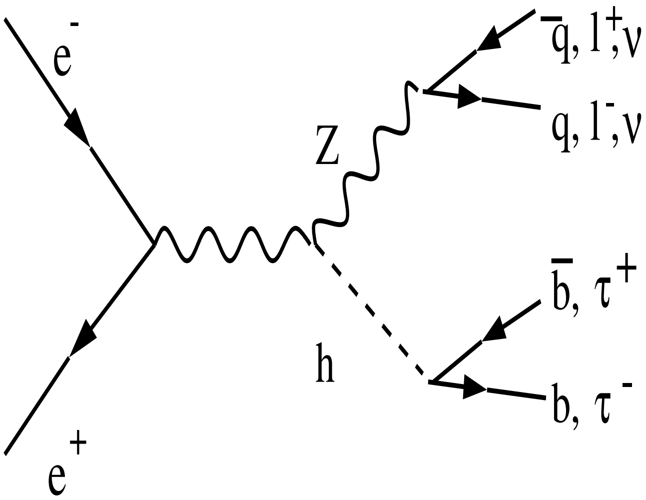
  Two Higgs doublets $\Longrightarrow$ 5 Higgs bosons

  $\rightarrow$ 3 neutral (h & H CP-even, A CP-odd),

  $\rightarrow$ 2 charged Higgs.

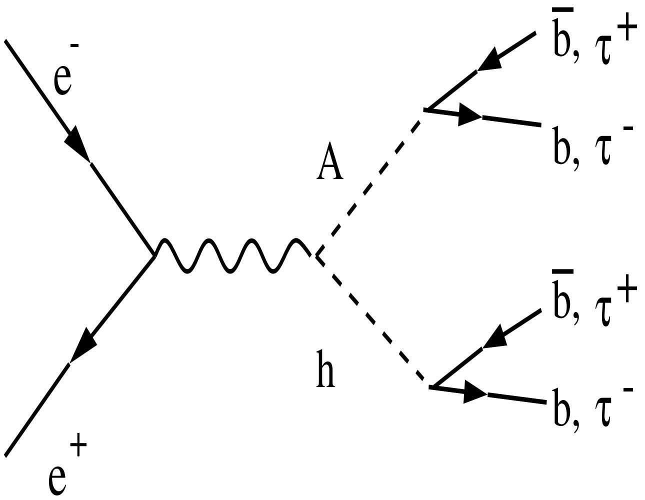
- Two Complementary Processes

Higgsstrahlung



$\propto \sin^2(\beta - \alpha)$

Pair Production



$\propto \cos^2(\beta - \alpha)$

Introduction

- Parameters of the MSSM

  1. Ratio of two Higgs vacuum expectation values: $\tan\beta$
  2. Mass of A boson: m_A
  3. Gaugino mass parameter: M_2(200 GeV)
  4. Universal scalar fermion mass: m_0(1 TeV)
  5. Common squark trilinear coupling: A
  6. Higgs mixing parameter: μ(-200 GeV)

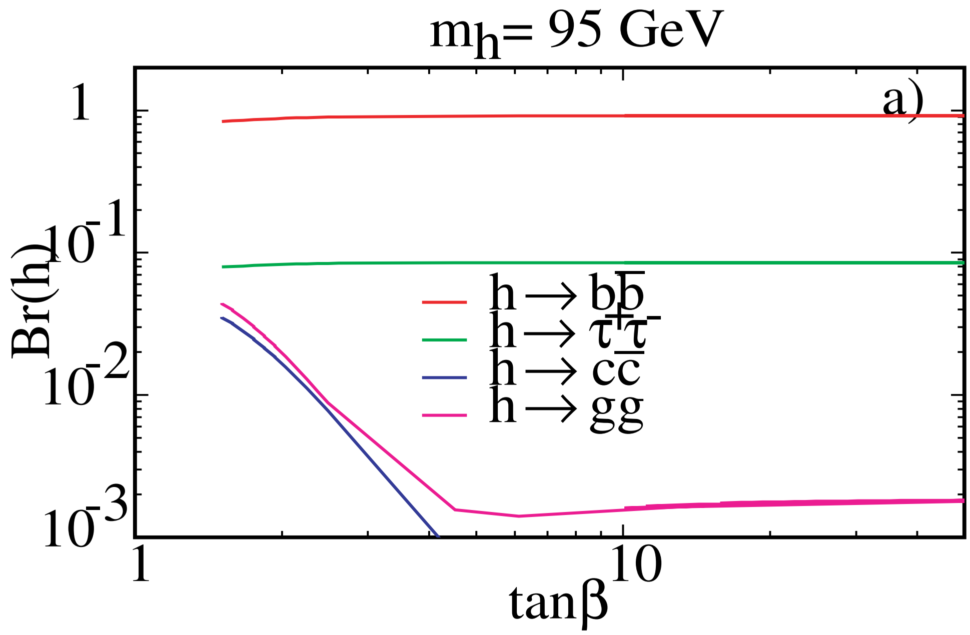
- Two Benchmark Scenarios

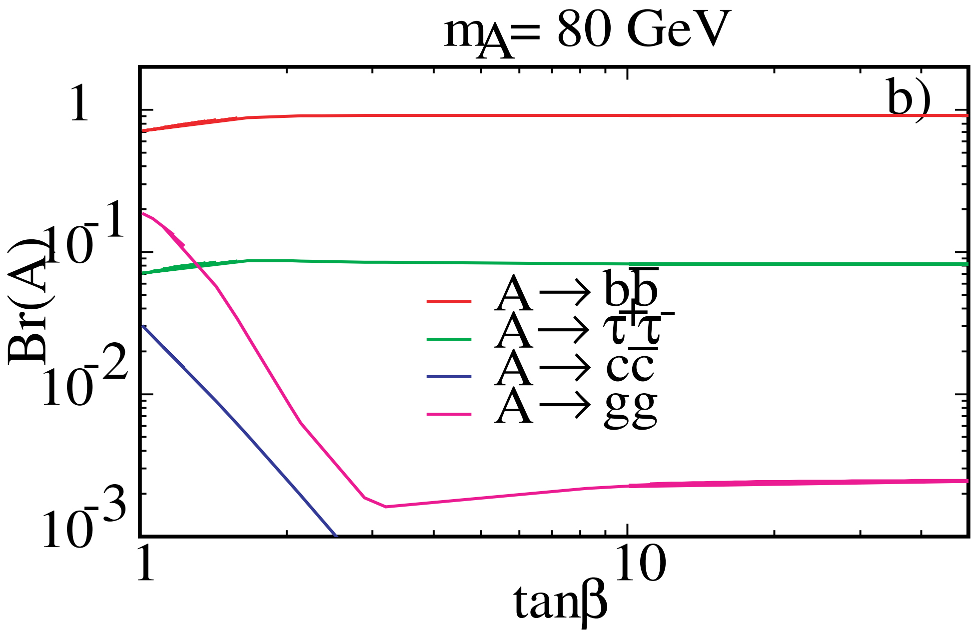
  $\rightarrow$ m_h Maximal
  $X_t = A - \mu\cot\beta = \sqrt{6}$ TeV

  $\rightarrow$ Minimal Mixing: No mixing in stop sector
  $X_t = A - \mu\cot\beta = 0$

- Free Parameters $\Longrightarrow$ m_A and $\tan\beta$

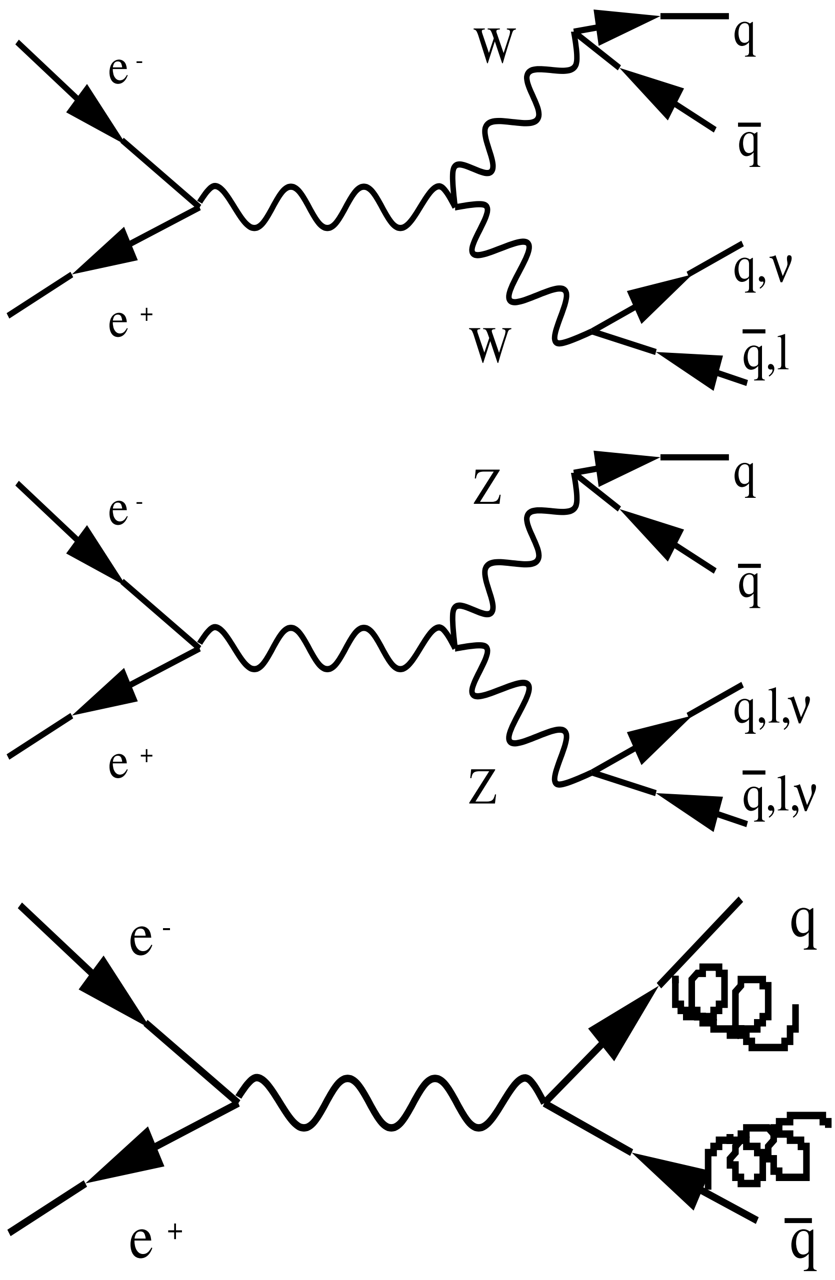
- Higgs decay into $b\bar{b}$ and $\tau^+\tau^-$ is dominant.





$\Longrightarrow$ focused on $hA \rightarrow b\bar{b}b\bar{b}$ and $hA \rightarrow b\bar{b}\tau^+\tau^-$.

Main Backgrounds



- Main backgrounds comes from WW, ZZ, $q\bar{q}$, $e\nu qq$ and Zee.

Analysis Procedure

- 4-jet channel: hA $\longrightarrow b\bar{b}b\bar{b}$

Preselection

$\Downarrow$

Neural Network

$\Downarrow$

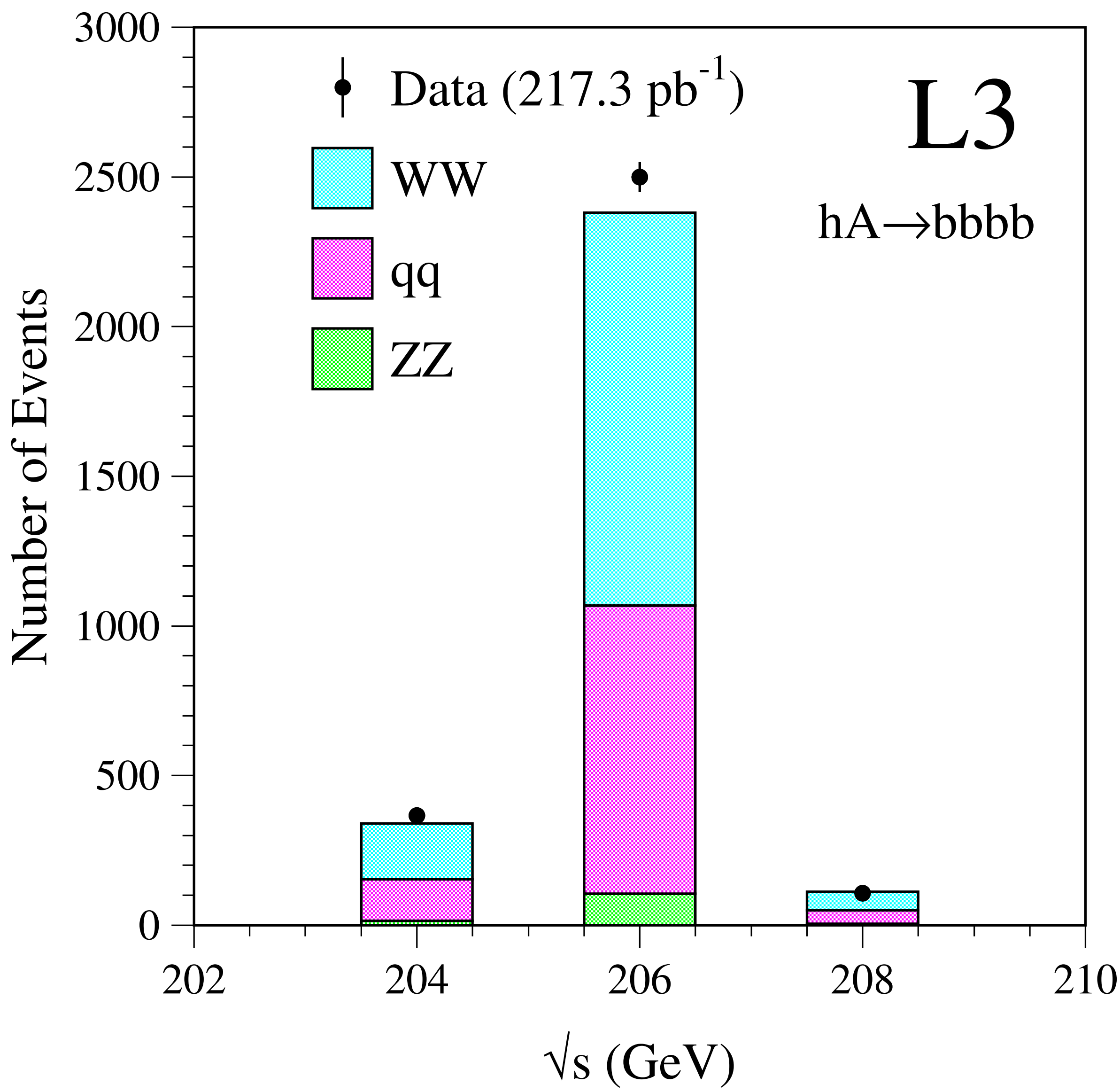
Final Discriminant

Step 1. **Preselection:** To reject low multiplicity backgrounds while keeping high signal efficiencies($\sim 90\%$).

Step 2. **Neural Network:** Discriminant distributions are combined in a neural network.

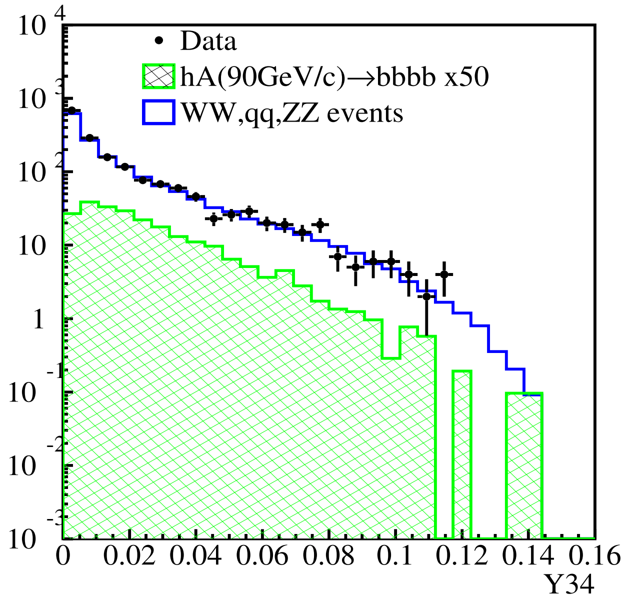
Step 3. **Final Discriminant:** Neural network outputs are used to construct final discriminant variable.

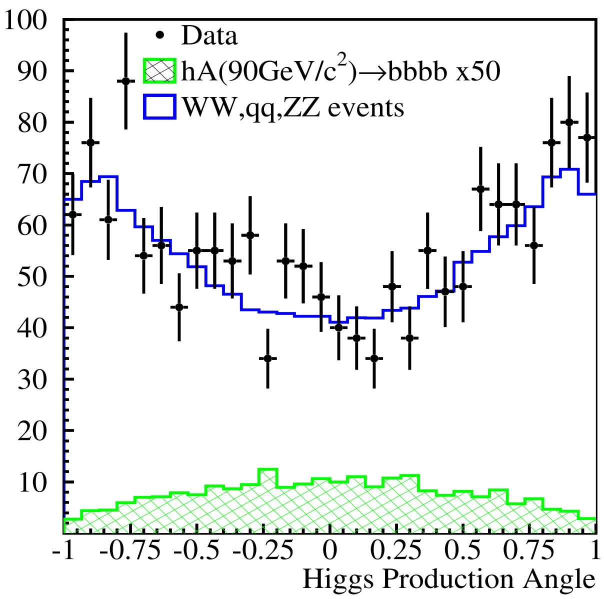
Preselection Results

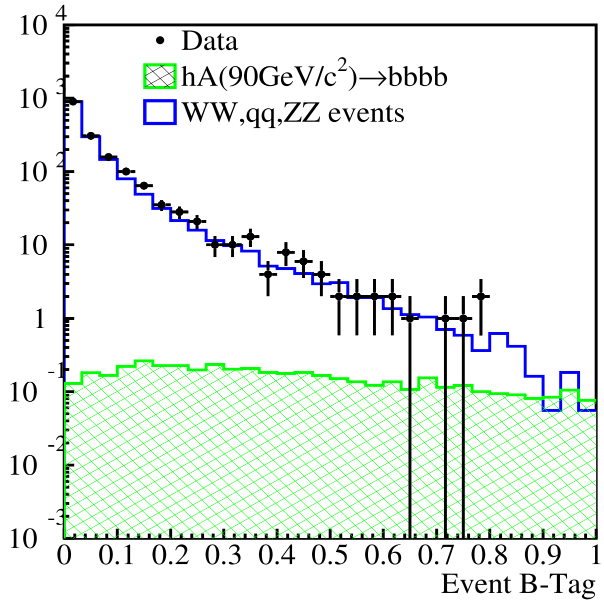


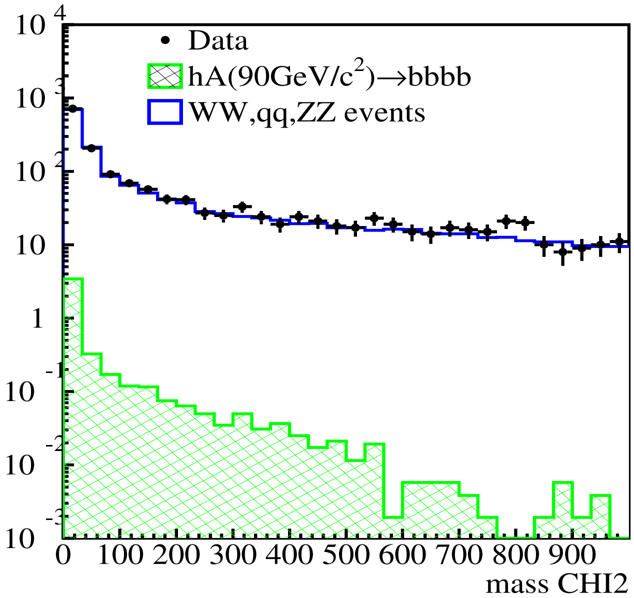
$\Longrightarrow$ Data agree with MC backgrounds at preselection level.

Neural Network Inputs of 4-jet Channel





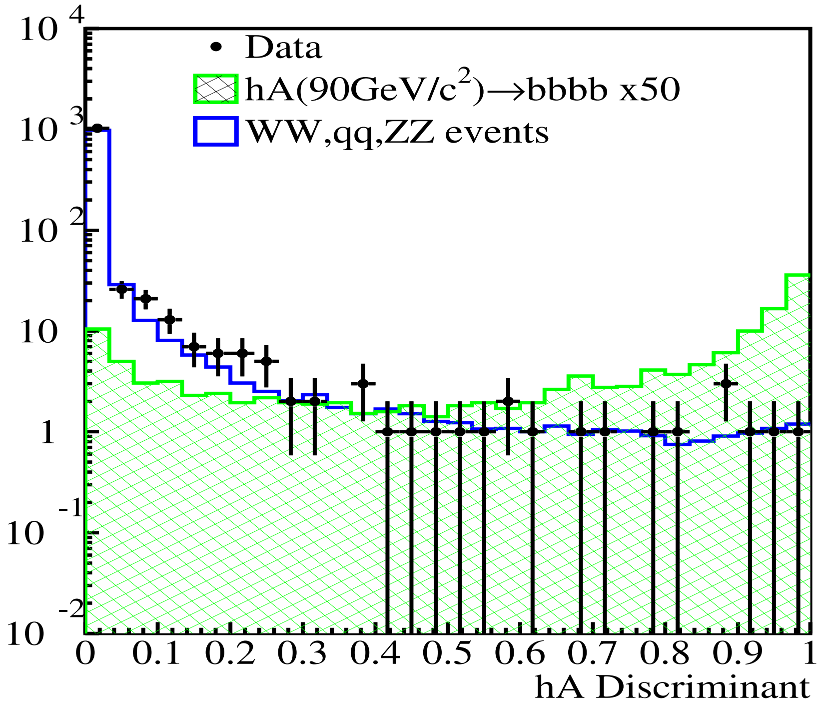


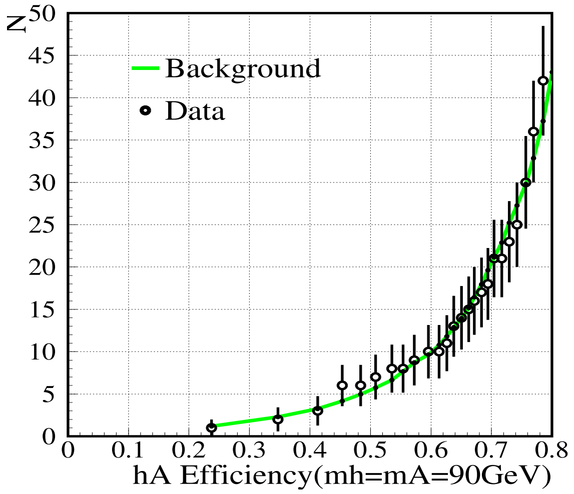


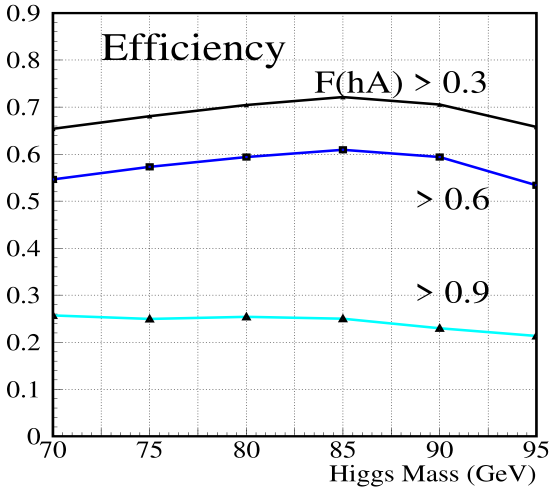
Final Discriminant of 4-jet Channel

- The Final Discriminant is defined as:

$$F_{hA} \equiv Y_{hA} \bullet (1 - Y_{WW}) \bullet (1 - Y_{q\bar{q}})$$



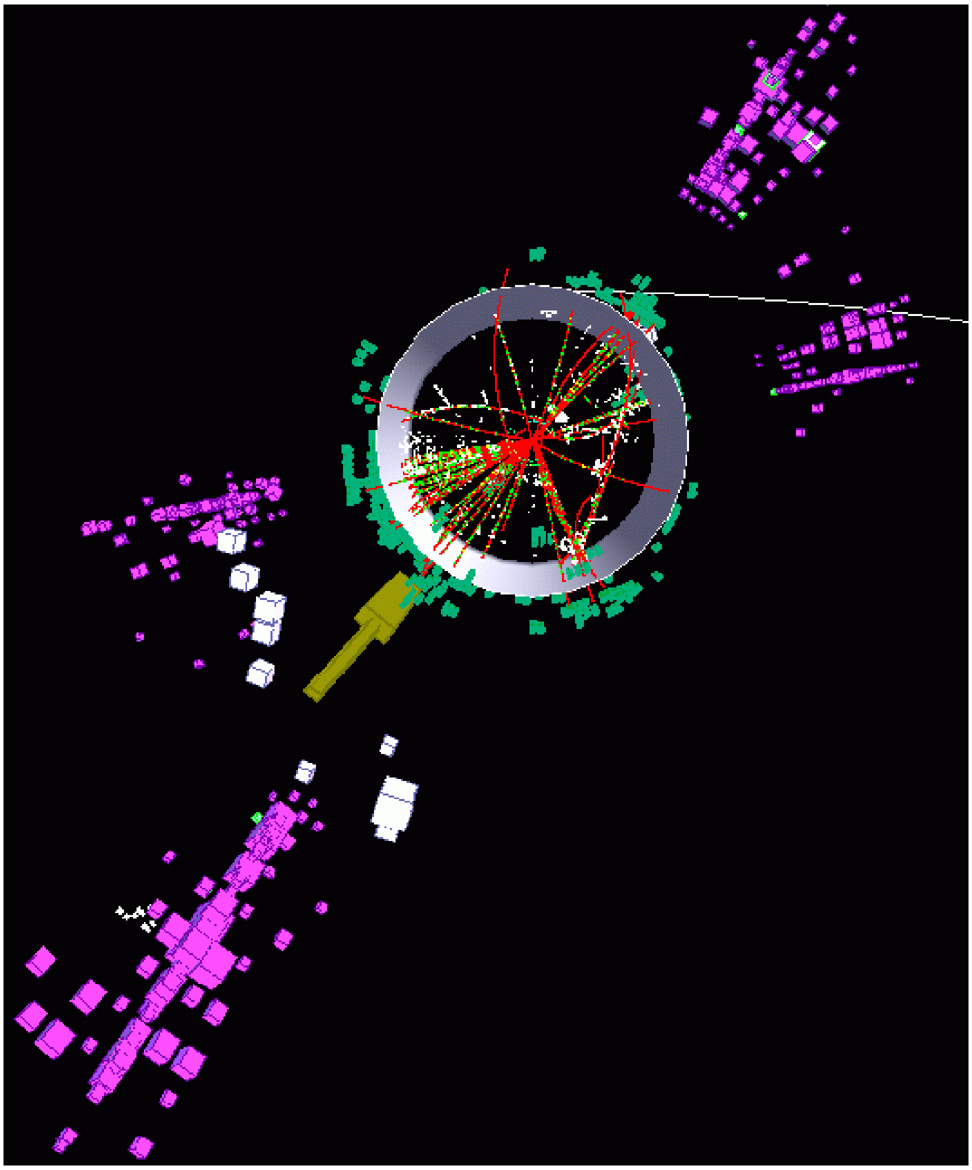




$\Longrightarrow$ Data agree with MC backgrounds.

$\Longrightarrow$ Efficiency is insensitive to Higgs Mass.

Candidate of hA $\rightarrow b\bar{b}b\bar{b}$



- High B-tag = 0.6
- High Discriminant = 0.98
- $m_h + m_A = 178.8$ GeV

Analysis Procedure

- Tau channel: hA $\longrightarrow b\bar{b}\tau^+\tau^-$

Preselection

$\swarrow \qquad \searrow$

Particle based $\qquad$ **Jet based selection**

$\searrow \qquad \swarrow$

Final Discriminant

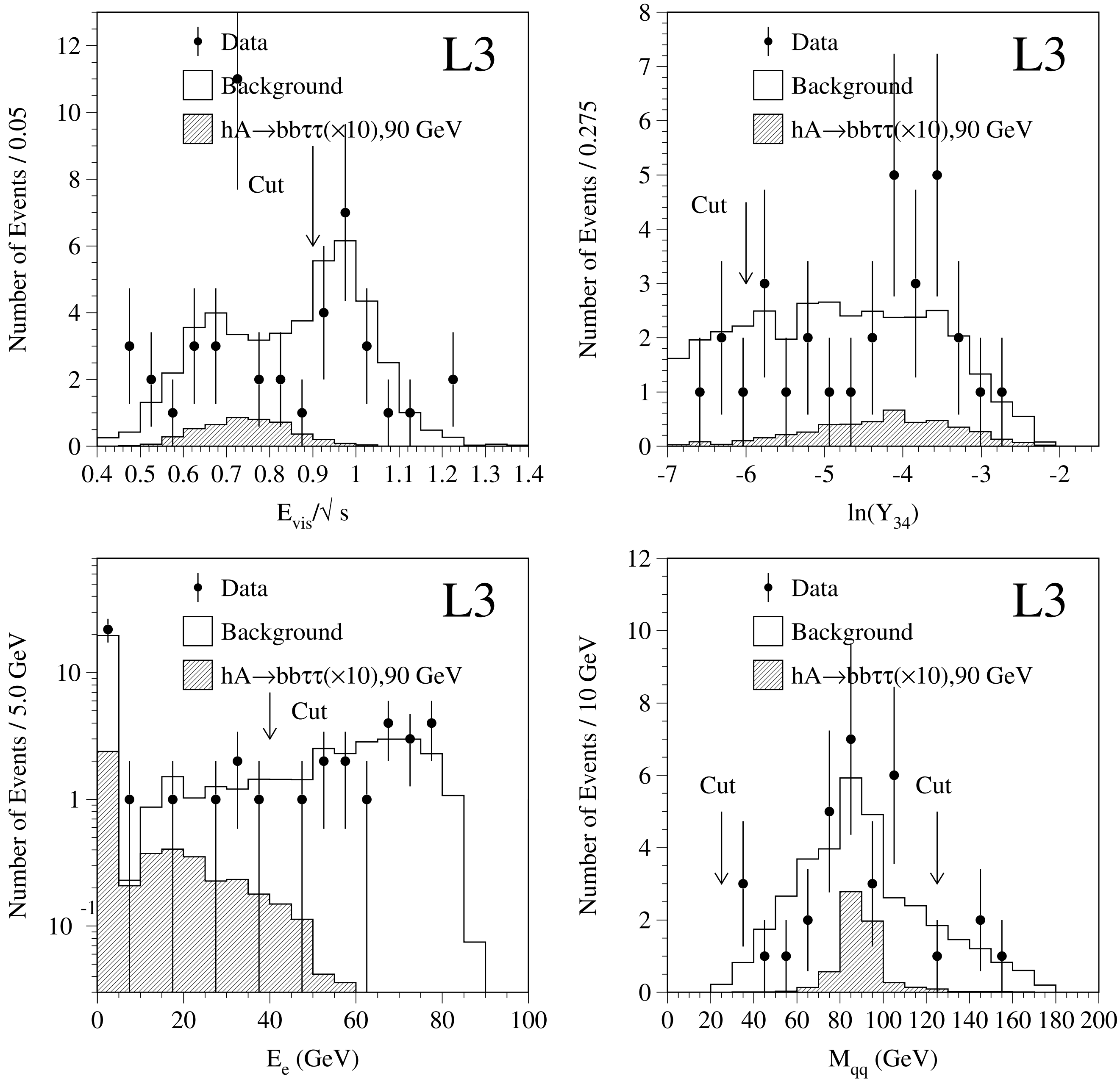
Step 1. **Preselection:** To reject low multiplicity backgrounds while keeping high signal efficiencies($\sim$ 80%).

Step 2. **Final Selection:** Two inclusive selections are performed. One based on tau identification(Particle based selection) and the other relying on event kinematics(Jet based selection).

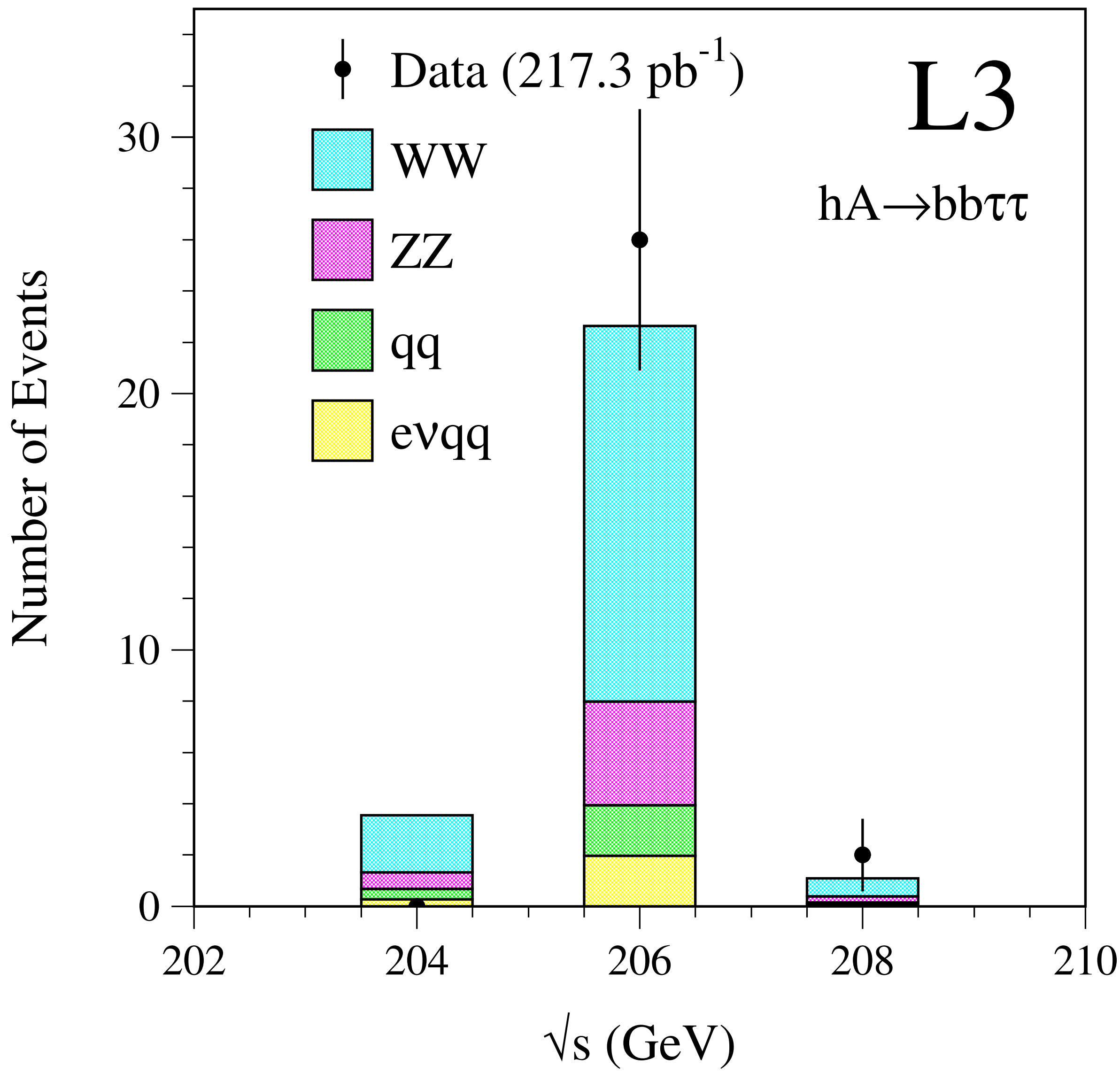
Step 3. **Final Discriminant:** B-tag of jets, di-jet masses are used to construct final discriminant.

Selection Cuts

- N-1 plots of Tau channel



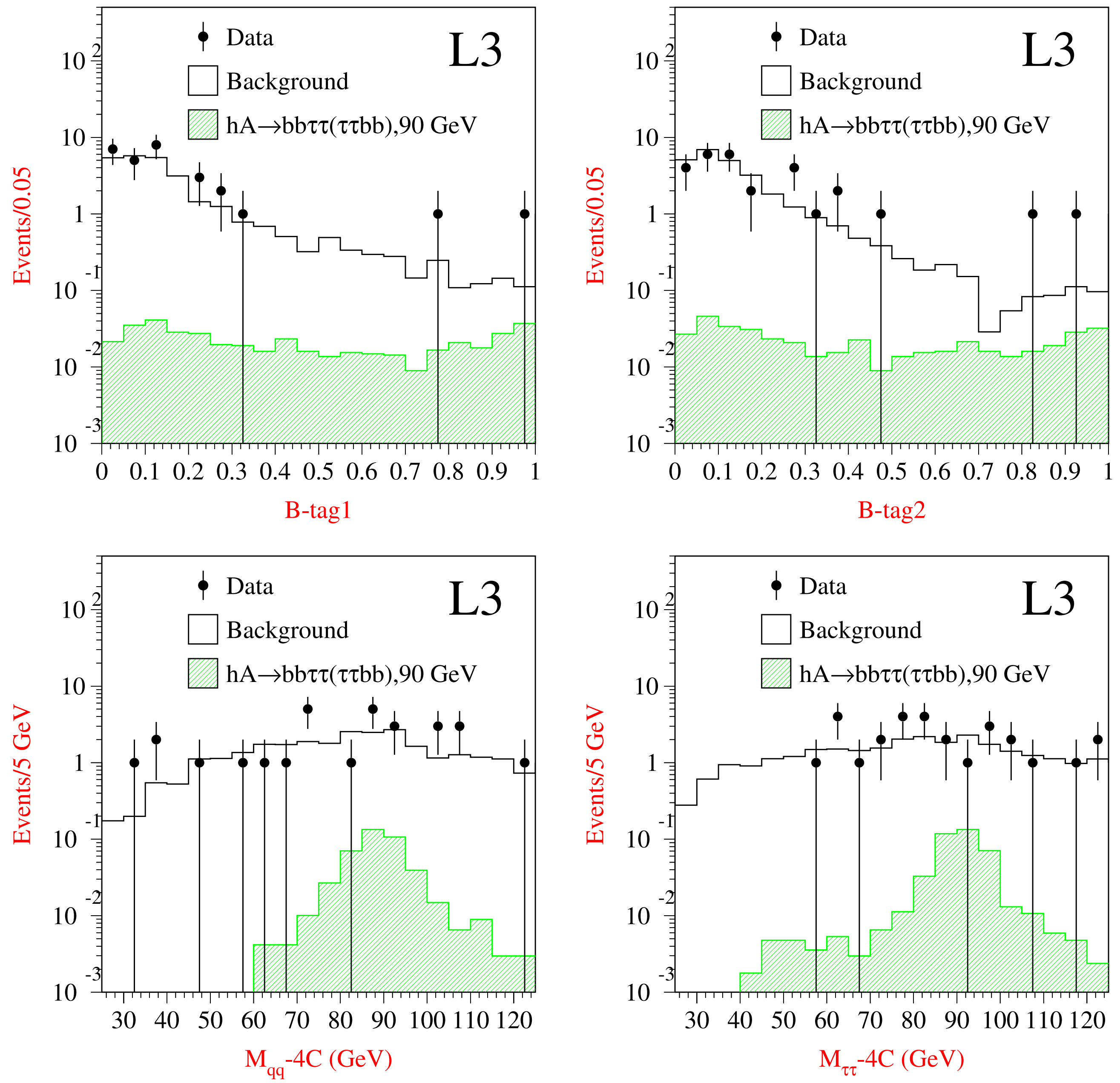
Selection Results



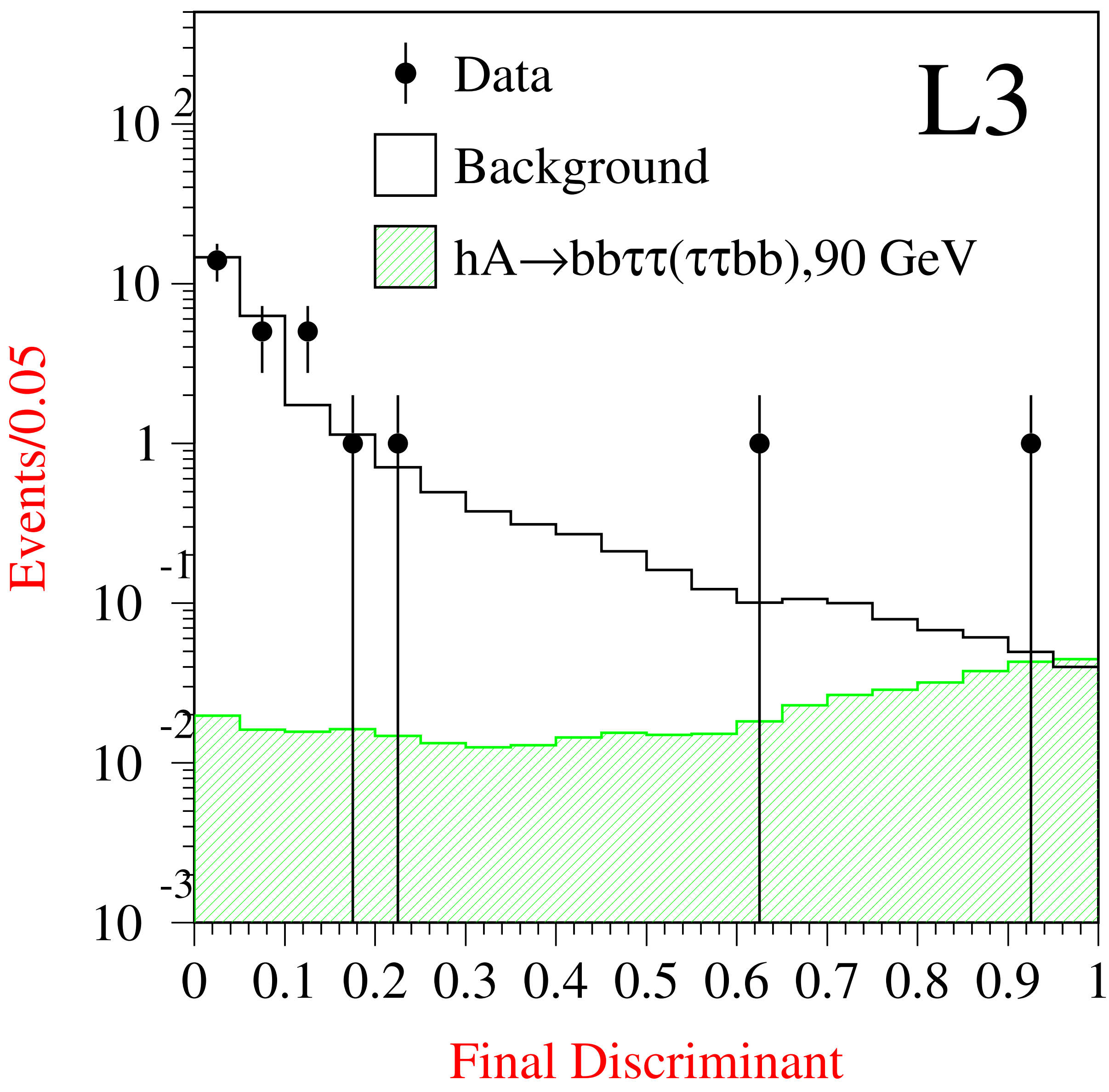
⟹ Data agree with MC backgrounds.

Discriminant Variables of Tau Channel

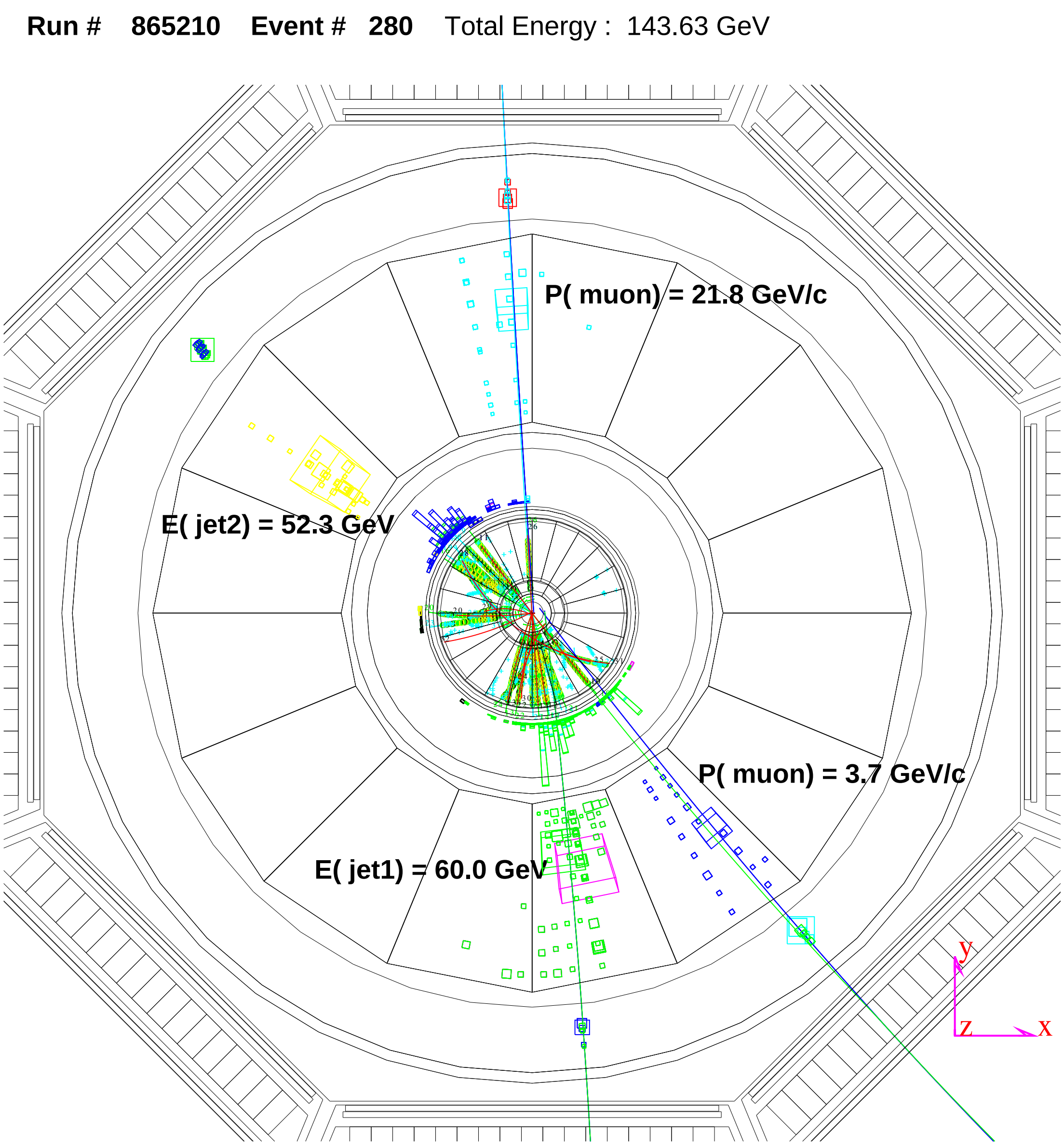
- Distributions used to construct final discriminant.
- Based on binned likelihood technique.



Final Discriminant of Tau Channel



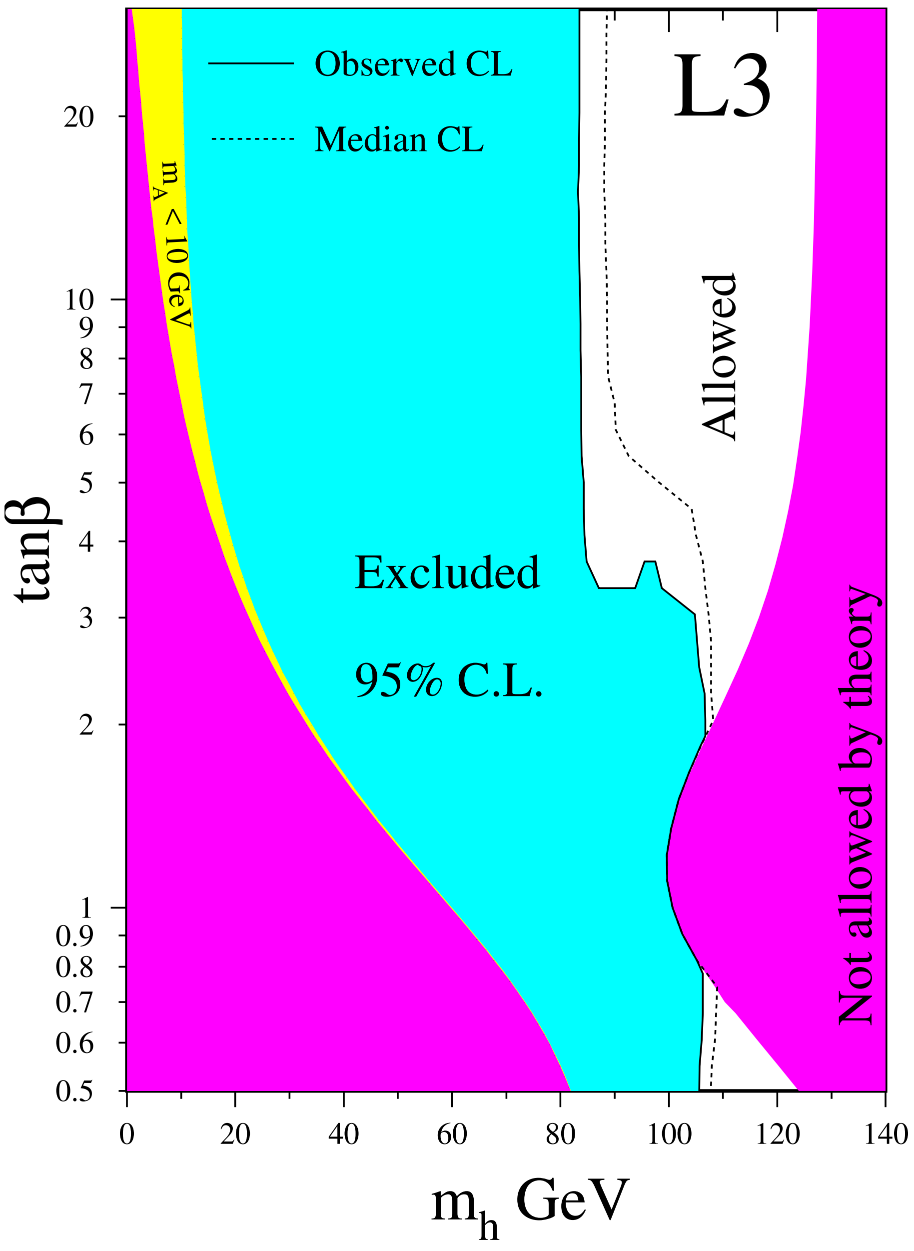
Candidate of hA $\rightarrow b\bar{b}\tau^+\tau^-$



- $B_{tag1} = 0.965$, $B_{tag2} = 0.359$, $M_{jj} = 90.68$ GeV, $M_{\tau\tau} = 98.28$ GeV.

$$\Longrightarrow e^+e^- \rightarrow hA,\ h \rightarrow b\bar{b},$$
$$A \rightarrow \tau^+\tau^-(\tau^\pm \rightarrow \mu^\pm\nu\bar{\nu})$$

Combined Result



- m_h Maximal Scenario

$\Longrightarrow m_h$: obs / med = 83.7 / 88.1 GeV

$\Longrightarrow m_A$: obs / med = 83.9 / 88.3 GeV

Conclusion

• 4-jet channel and Tau channel of hA are studied using Y2K data.

• Data agree with SM backgrounds.

$\Longrightarrow$ No significant evidence of MSSM neutral Higgs are observed.

$\Longrightarrow$ Lower Higgs mass limits with 95% C.L. are obtained:

$$\boxed{m_h > 83.7 \textbf{ GeV, } m_A > 83.9 \textbf{ GeV}}$$