**Measurement of $t\bar{t}H$ (bb, leptonic) with Multivariate Analysis Techniques at CMS**

**Marcel Rieger on behalf of the CMS Collaboration**

**II. Physics Institute A**

---

**Analysis Challenges**

1. **$t\bar{t}H$ is very rare** compared to $t\bar{t}$ (main background): $\sigma_{t\bar{t}H} = 0.5071 \text{ pb}$ vs. $\sigma_{t\bar{t}} = 831.76 \text{ pb}$ ($\sqrt{s} = 13 \text{ TeV}, m_{H} = 125 \text{ GeV}$)

2. **Irreducible backgrounds**: (e.g.) $t\bar{t}b\bar{b}$ has same final state and event topology

3. **Uncertain background modeling**: $\Delta \sigma_{t\bar{t}b\bar{b}} \sim 50\%$ → $\Delta \sigma_{t\bar{t}b\bar{t}} = 7 \times \sigma_{t\bar{t}H}$

→ Challenging analyses require sophisticated methods

---

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter

---

**Results**

$t\bar{t}H$ (bb) analysis with MVA techniques has significant impact on $t\bar{t}H$ observation

**Discriminants**

Discriminants selected by highest expected significance

**Analysis Flow**

**Events**

- Single lepton
- Dilepton

**Categorization**

- Combinations of all channels yielded an excess of events above the expected background in agreement with SM predictions

**Measurement**

- $L = 3.59 \text{ fb}$

---

**Motivation**

**Analysis Strategy**

**Results**

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter

---

**Motivation**

**Analysis Strategy**

**Results**

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter

---

**Motivation**

**Analysis Strategy**

**Results**

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter

---

**Motivation**

**Analysis Strategy**

**Results**

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter

---

**Motivation**

**Analysis Strategy**

**Results**

**Event Categorization with Deep Neural Networks**

Precision of categorization scheme using jets & b-tags degrades with high b-tag multiplicity

→ Use DNNs to categorize using jets & most probable process

- Multi-class approach generates enriched categories for signal and each background
- Backgrounds constrained separately in fitting procedure
- Improves extraction of signal strength parameter