Hadronic Working Group: Reference Analyses
Plans, draft, discussion

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Analysis Strategy in a Nutshell

- Systematically cover all important basic signature searches:
  - Reference Analyses

- Control and measure the primary backgrounds directly from the data:
  - Data Driven Bkg. Methods: redundancy and complementarity are crucial.

- Develop robust, simple, and convincing analysis strategies for first searches:
  - Robustness comes before sophistication and Flexibility is more important than (model) optimization

- Understand the basics physics objects: MET, jets, leptons, photons (including trigger):
  - SUSY Physics Commissioning
Reference Analyses

Reference analyses are deliverables from the SUSY group

- They are both *common and critical*
- We want to treat them as such
  - Complete and thorough coverage
  - Fully explored and cross-checked

This is a team effort

- There are a lot of *issues* and a lot of *approaches*; also a lot that *has been* and *is being* done
- This work (done, being done, to be done) needs to be put together
- The following is a first step to “feed” the *discussion*
- We want to *document* it with contributions from all experts

Reference analyses are not the only analyses

- Other ideas are very welcome
- But we (as CMS) have to make sure that *at least* these (reference) analyses are fully covered

Frederic Ronga, March 26th
We don’t know what to expect. Hence, we must be as generic as possible! → Categorize basic signatures in bins of the fundamental objects

"#Jets vs. #Leptons vs. #Photons" Search Matrix

<table>
<thead>
<tr>
<th># of Jets + # Photons</th>
<th>0l</th>
<th>1l</th>
<th>2l (SS)</th>
<th>2l (OS)</th>
<th>&gt;=3l</th>
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<td>&gt;=4</td>
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3rd Dimension:
“MET-like variable” > X GeV (e.g. 200 GeV for MET).
or a scan in this variable

Signature Management:
Hadronic working group:
- Hadronic topology including photons (GMSB)

Leptonic working group:
- Leptonic topologies

Needs also overall coordination between the working groups!
RA1: Exclusive n-jet analysis (e.g. di-jet)

- $Z \rightarrow \text{invs}$ and QCD are important backgrounds, the relative importance depends on $n$
- QCD suppression using kinematic variables like $\alpha_T$

RA2: Inclusive 3+X jet analysis (overlaps with RA1)

- All backgrounds (QCD, $Z \rightarrow \text{invs}$, $tt\bar{t}$) are important
- QCD is dominated by jet mismeasurements causing MET less depending on badly modeled additional radiations

RA3: Di-photon analysis (GMSB)

- QCD jets faking photons is dominated background
- Electron-photon mis-identification
- Electro-weak processes $W\gamma$, $Z\gamma$
List of issues and questions

- Signature – defines the analysis
- Trigger and skims
- Event cleaning
- Jet, MET pre-selection (loose) and selection
- Any additional selection (kinematic, \(\tau\), b, lepton veto, ...)
- Cross cleaning
- Background list and determination methods
- Control sample
- Critical commissioning issues
- Others? ... → Your input!

→ Example: 3+X jet inclusive analysis
This is the most sensitive analysis, where a lot of effort has already been put into!

- **Signature**: $\geq 3$ jets, 0 leptons, MET control regions, e.g.:
  - low MET (QCD factorization method)
  - $<3$ jets (QCD jet-smear-method)
  - $\gamma, W, Z\rightarrow \mu\mu$ (Z→invisible)

- **Trigger**
  - explicit list of triggers, backup trigger, for control samples
  - signal efficiency, background reduction, noise sensitivity
  - development and study of new MHT trigger

- **Skims**
  - small sample but loose selection
  - must include all signal and background control regions

►► Studies needed ← SUSY Commissioning Group
• **Object selection**: (e.g. PTDR cuts on uncalib. jets)
  
  \[ \text{jet1: } p_T > 180 \text{ GeV, jet2: } p_T > 110 \text{ GeV, jet3: } p_T > 30 \text{ GeV,} \]
  \[ \text{MET > 200 GeV, } (M_T - \text{jet1 } p_T) > 500 \text{ GeV,} \ldots \]

  - MET, MHT, HT? Calo, particle flow, track-corrected?
  - lepton veto

• **Cross cleaning**
  - jets, electrons, photons, muons, taus
  - lepton veto

• **Event Cleaning**
  - cosmics, beam halo, detector noise, punch-through
  - event charge and EM fractions, primary vertex, timing studies
  - pile-up, instantaneous luminosity dep. on MET, lepton veto?
• **QCD background determination:**
  → Smearing method: 1. derive smear-function (γ-jet, Z-jet, di-jet)
     2. Apply to data-events with ~no MET
     3. Comparison with control sample
  → Factorization method: Calculating the amount of QCD in
     signal region from control regions, consider correlation uncert.
  → Compare methods

**Z→invisible background determination**
  → using γ-jets, replace γ: Studied background, and systematics
  → Z/W→ muon(s): Uncertainties due to statistics, lepton eff., ...
  → Compare methods

• **ttbar background determination**
  → template from data, estimate lepton mis-identification
     efficiencies from data, concentrate on tau mis-ID

• **Putting the analysis together**
  → combining the methods in one framework

►► More work and new people needed!
Conclusion

**This is a proposal, open for input and discussion**

- There has already a lot been done, there is still a lot to do
- Need to cover all issues for each signature, and put all efforts together
- Please give us feedback:
  - **Hadronic** analyses: Alex & Christian
  - **Leptonic** analyses: David & Frederic

**Next steps / milestones:**

- Summary at the next general SUSY meeting, April 7
- Document with all contributions (internal note, TWiki)
- Reference analyses workshop during Physics Days, May 11-15