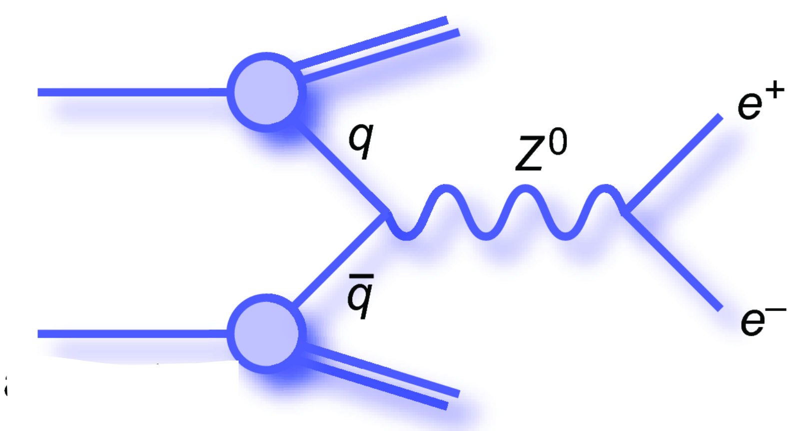
Brief Summary of the $\gamma^*/Z\rightarrow ee$ Cross-Section Measurement at Start-Up



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Intro & News

- The $\gamma^*/Z \rightarrow ee$ cross-section measurement may be one of the first analyses to come out of CMS: It is a "standard candle" analysis, critical to validating the understanding of our detector and a prerequisite for many more exotic analyses.

- The analysis for the cross-section measurement of W/Z in the electron channels at start-up went for approval in June … and was approved!

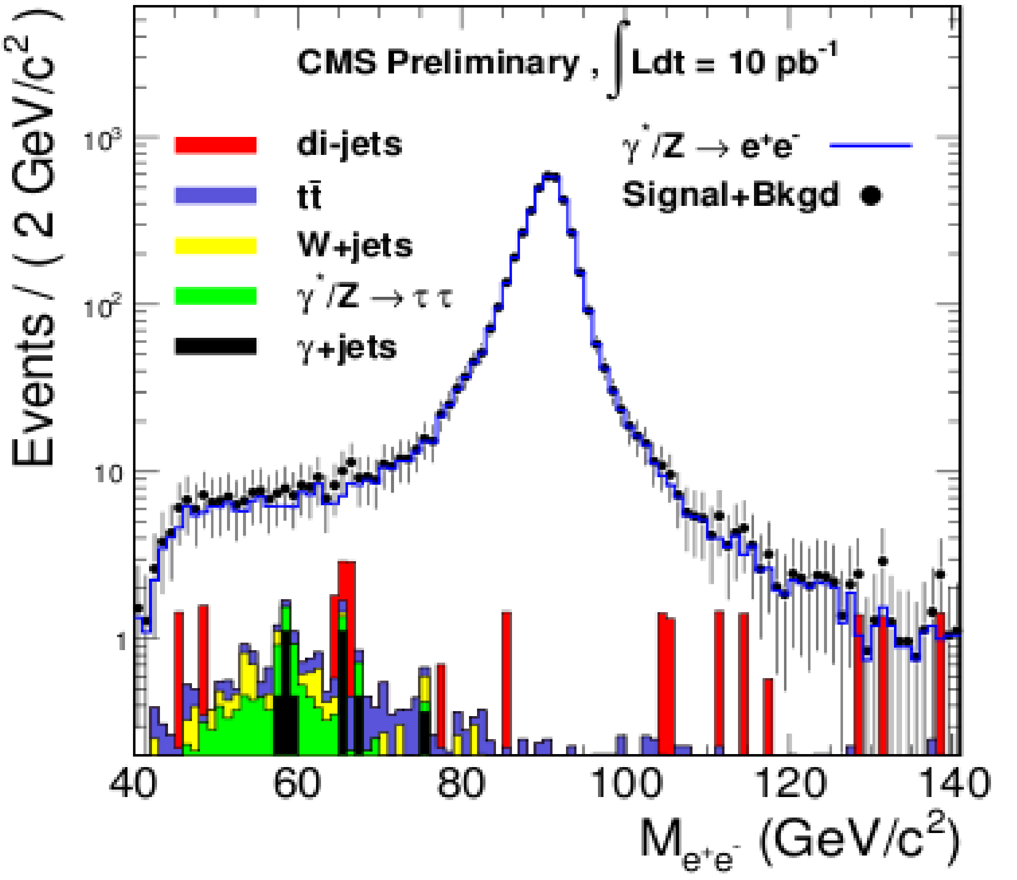
- Both a PAS and an AN were approved:
  - PAS: EWK 09/004
  - AN: 2009/098
- The work is thorough, and the emphasis has been put squarely on robust, data-driven methods in order to optimize readiness for start-up
- Very well positioned for early data
- Author List: N. Adam, D. Bandurin, J. Berryhill, G. Daskalakis, V. Halyo, K. Mishra, N. Rompotis, C. Seez, S. Tourneur, D. Wardrope, J. Werner

The analysis assumes 10 pb^{-1} and $\sqrt{s}$ = 10 TeV

Main Topics

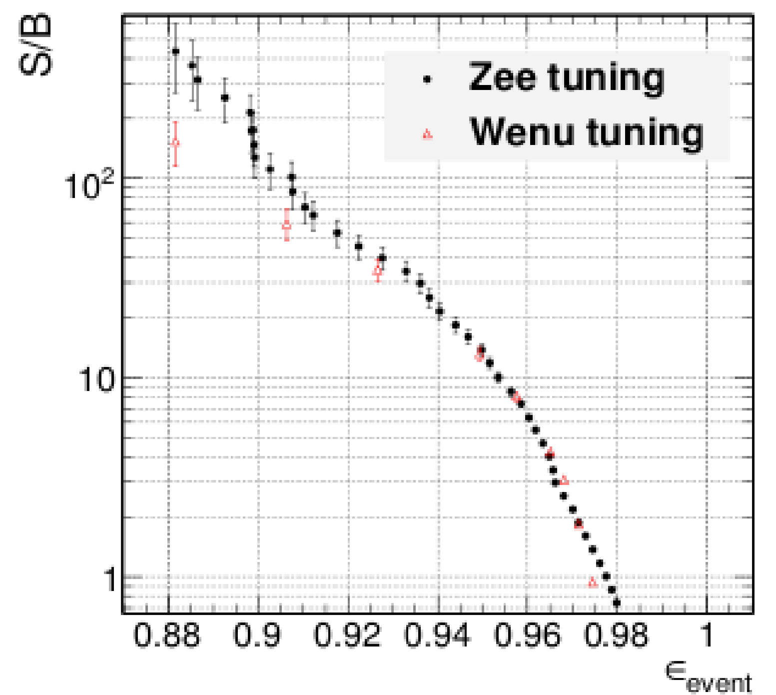
- **Selection**
- **Systematics**
- **Efficiencies**
- **Backgrounds**

from the PAS:



Selection

- Objective: Negligible background after a loose electron ID and isolation cuts
- Use simple cut based selection incorporating robust POG recommended variables: $\sigma_{i\eta i\eta}$, $\Delta\eta_{in}$, $\Delta\varphi_{in}$, TrackIso, EcalIso, HcalIso
- These should be the variables that are the best modeled in the simulation at start-up
- Robust iterative optimization procedure maximizes background rejection for a given signal efficiency
- Online use the simple SingleElectron trigger



Selection (Cont.)

- 2 GSF electron candidates in fiducial region ($|\eta| < 2.5$, but $1.4442 < |\eta| < 1.56$ exluded) with SC $E_T > 20$ GeV, at least one of which matches the SingleElectron trigger candidate object
- Both electron candidates pass ID and iso cuts
- $70 < M_{ee} < 110$ GeV

	EB	EE
Trk Iso	7.2	5.1
Ecal Iso	5.7	5.0
Hcal Iso	8.1	3.4
$\sigma_{i\eta i\eta}$	0.01	0.028
$\Delta\varphi$	not applied	not applied
$\Delta\eta$	0.0071	0.0066

Systematics

- At 10 pb^{-1} the *selected* candidate yield will be ~4K events, so even already at this low integrated lumi the uncertainty is dominated by the systematics
  - Total statistical uncertainty: ~2%
- The systematics will be dominated by the luminosity measurement, which is expected to have an uncertainty at start-up of ~10%
- The only other substantial systematic uncertainty is expected to come from the (geometric and kinematic) acceptance – as calculated from Monte Carlo simulation – at the level of ~2.5%
- Other contributions to the systematic uncertainty will arise from the background and efficiency measurements, which are expected to be at the level of $\lesssim$ 0.5% and $\lesssim$ 1%, respectively

Total Uncertainty $\simeq 2\% \,|_{stat} \pm 2.7\% \,|_{non\ lumi\ syst} \pm 10\% \,|_{lumi}$

Efficiencies

- Use a "Tag & Probe" method
- Successfully used at both Tevatron Experiments
- Basic idea is to determine the efficiency of whatever cut using an unbiased, high-purity electron sample from Z→ee decays. Then for each event we have a
  - Tag Electron: passes tight selection criteria
  - Probe Electron: passes loose selection criteria that is dependent on the cut under study

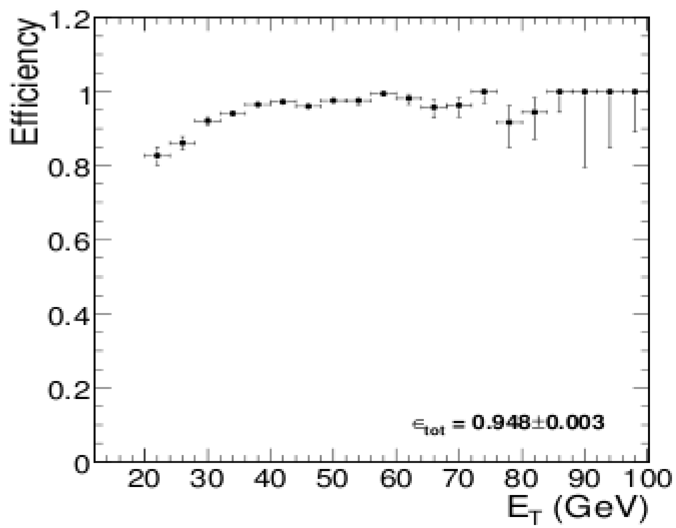
$$\varepsilon_{offline} = \varepsilon_{\mathrm{clustering}} \times \varepsilon_{\mathrm{tracking}} \times \varepsilon_{\mathrm{gsfele}} \times \varepsilon_{\mathrm{isolation}} \times \sum_i (f^i_{\mathrm{classification}} \varepsilon^{\mathrm{i}}_{\mathrm{eid}})$$

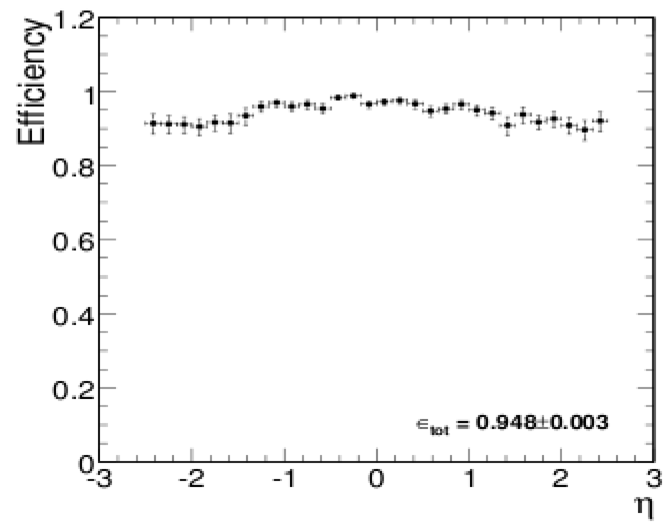
Tag & Probe Efficiency Example

- **Tag and Probe criteria for calculating the isolation efficiency:**

TAG	PROBE
A PixelMatchGsfElectron which: - is capable of passing the single electron HLT - is in fiducial ($\|\eta\| <1.444$ and $1.560< \|\eta\| <2.5$) - SuperCluster E_T >15 GeV - is isolated (track isolation)	A PixelMatchGsfElectron which: - is in fiducial ($\|\eta\| <1.444$ and $1.560< \|\eta\| <2.5$) - SuperCluster E_T >20 GeV

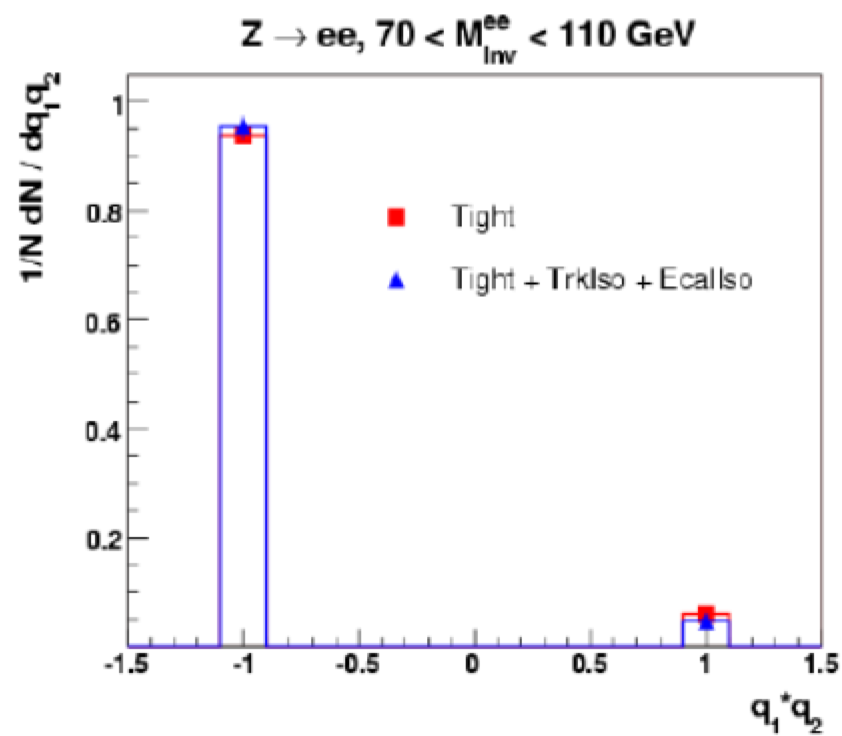
- **Iso eff Vs E_T (left) and η (right):**





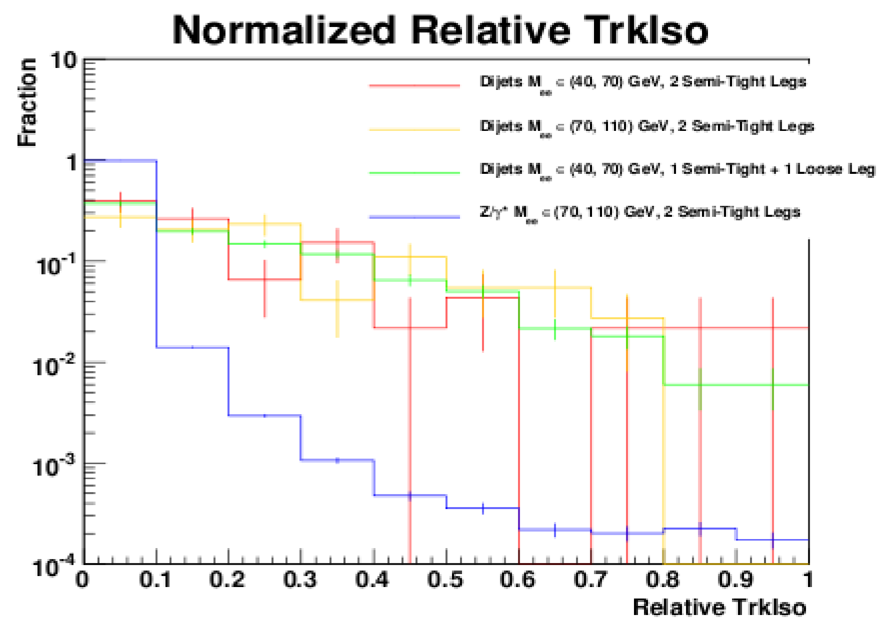
Backgrounds

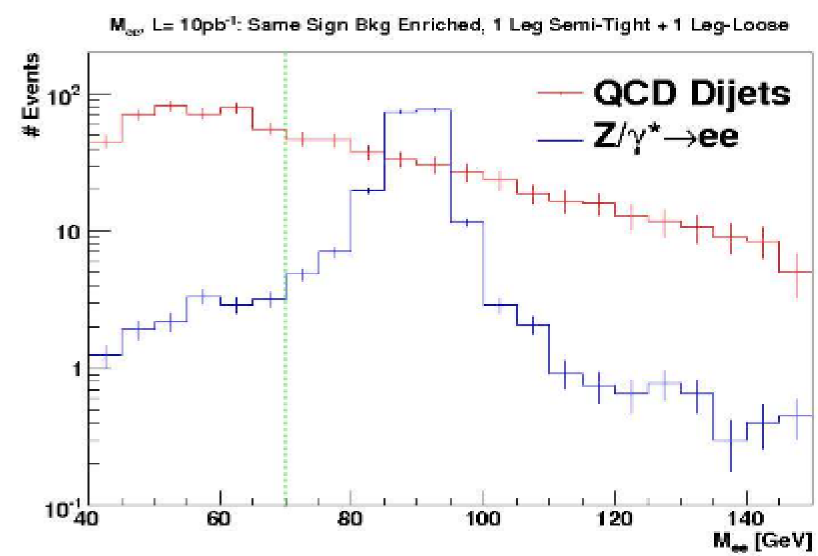
- Objective: Development of multiple robust, data-driven methods
- Largest bkgs: ttbar and QCD dijets – Still only ~1/1000 parts each in Monte Carlo land
- Same/Opposite Sign Method: Can leverage the fact that $q_1 \times q_2 = -1$ for signal to estimate the background
  - Use very tight cuts to get a high-purity sample from which to measure the q_{misid}
  - We then have $N_{sig} = (N_{OS} - N_{SS})/(1 - 2q_{misid})^2$
  - Robust and precise
  - Expected uncertainty: ~0.7-1.0 %



Backgrounds (Cont.)

- Template fitting method: Estimate the bkg under the Z peak by using the shape of a “good” discriminating variable for signal electrons
  - Possible good variables: TrackIso, calo isos, $\sigma_{i\eta i\eta}$
  - Use a tight selection under the peak to get the signal template
  - Get the bkg shape from a side band with the additional requirement that $q_1 \times q_2 = +1$
  - Determine the bkg contribution from the templates using a fractional fitter
  - Robust
  - Expected uncertainty: ~2.5-3%



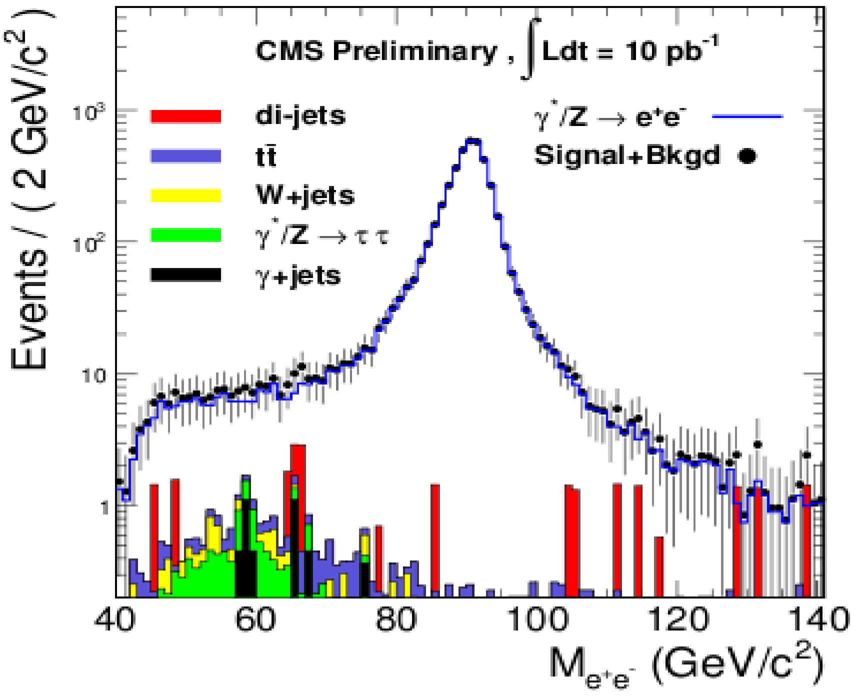


Conclusions

- CMS is well prepared to perform a $\gamma^*/Z \rightarrow ee$ cross-section measurement in the early days of LHC operations
- The analysis is thorough: All major components of the measurement have been sufficiently addressed, and are well documented in notes
- The result of the full Monte Carlo exercise is $\sigma_{\gamma^*/Z} \times BR(\gamma^*/Z \rightarrow ee) = 1300 \pm 20\ pb^{-1}$

  … from Monte Carlo truth we have

  $\sigma_{\gamma^*/Z} \times BR(\gamma^*/Z \rightarrow ee) = 1296\ pb^{-1}$



- A lot of the work done right here at the LPC
- Can invert the measurement to normalize the absolute lumi for other analyses