Search for New Physics using boosted Z bosons at CMS

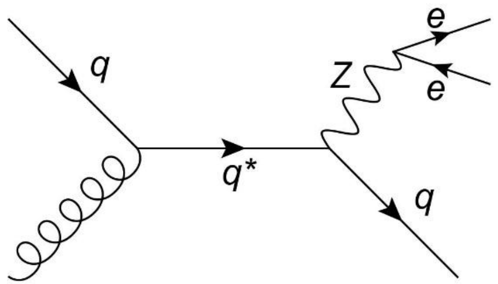
Tom Williams

RAL & University of Bristol

Motivation

- Many theories predict new heavy particles participating in electroweak interactions
  - These particles can decay into Z bosons

- Quark compositeness:
  - Excited quark, *q**

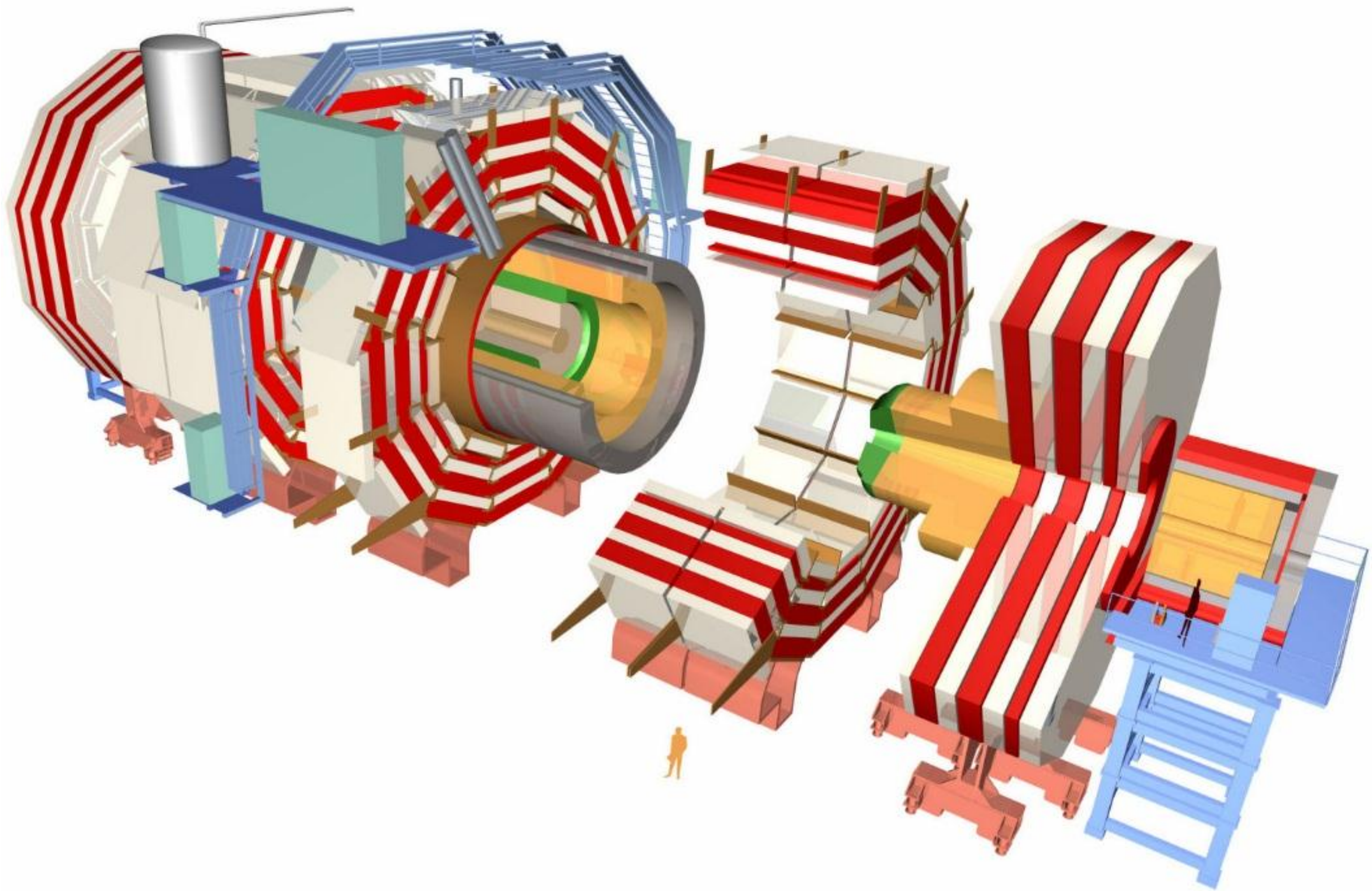


- Randall-Sundrum (RS) models:
  - Kaluza-Klein graviton (G_{KK}) coupled to ZZ

- Also: W' models, technicolor …

- Look for an excess of high-energy Z bosons:
  - Don't specify recoil system => sensitive to all these models
  - And many other models that theorists haven't thought of yet!

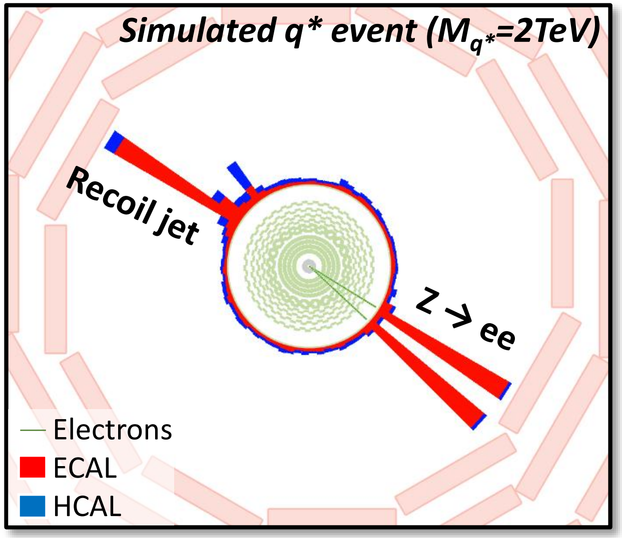
The CMS detector

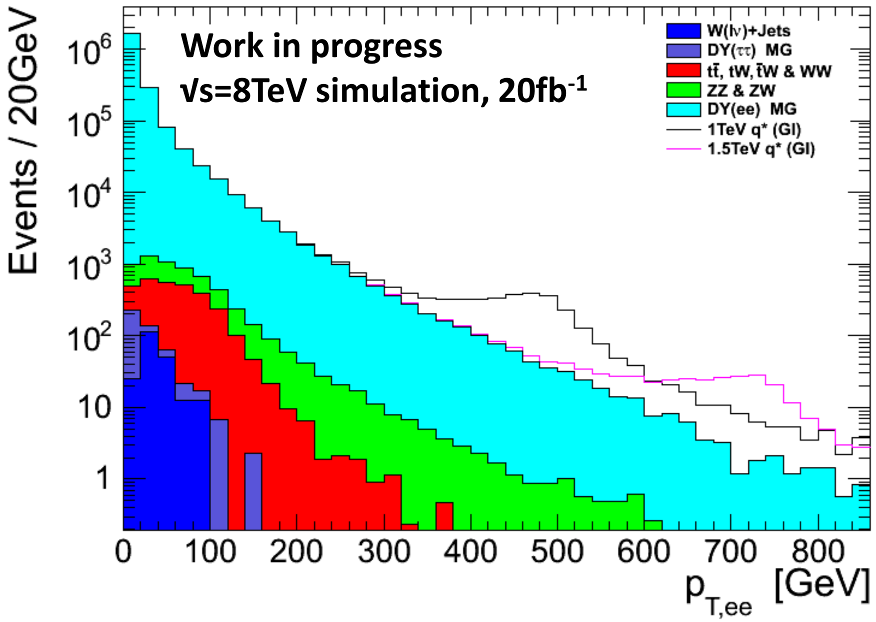


The search

- Looking for the signal …
  - Use *ee* channel: Low backgrounds, good resolution
  - Look for "localised" excess in Z p_T spectrum
  - For excited quark, pp → q* → qZ:

$$p_{T,ee} = \left|\vec{p}_{e1,T} + \vec{p}_{e2,T}\right|$$

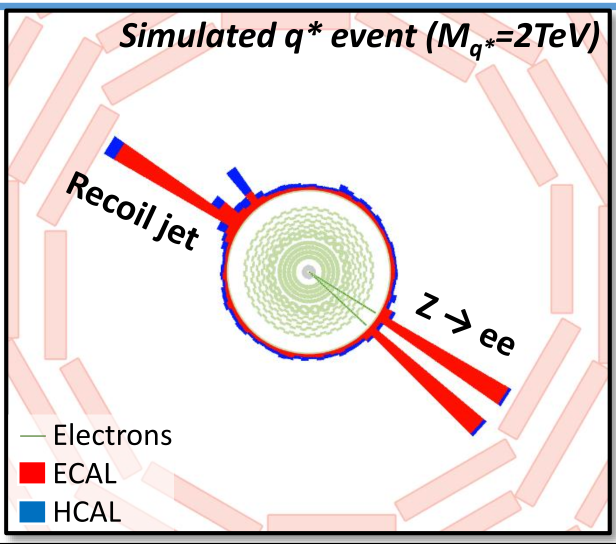


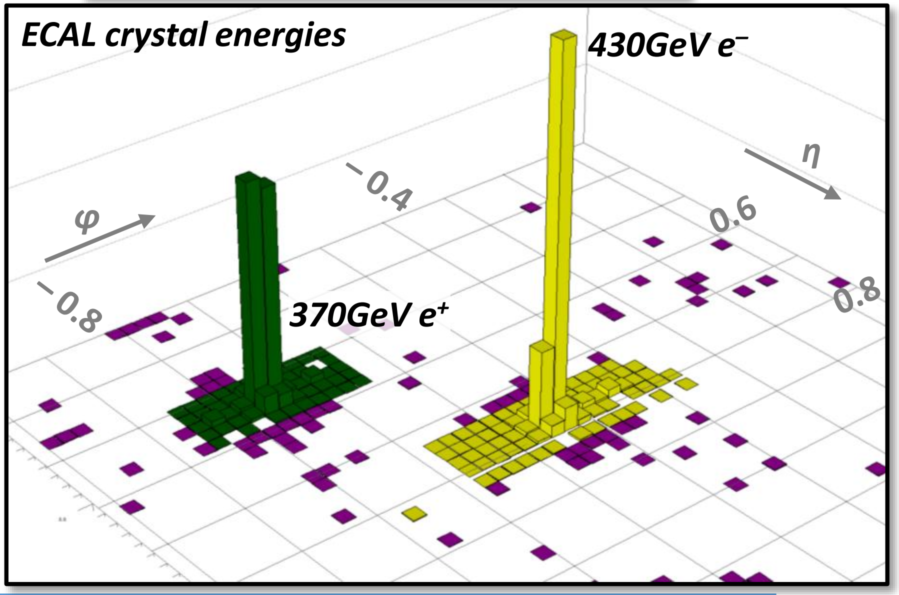


- Event topology:
  - 2 high-energy electrons, recoil system on opposite side
  - Small separation at high Z momentum

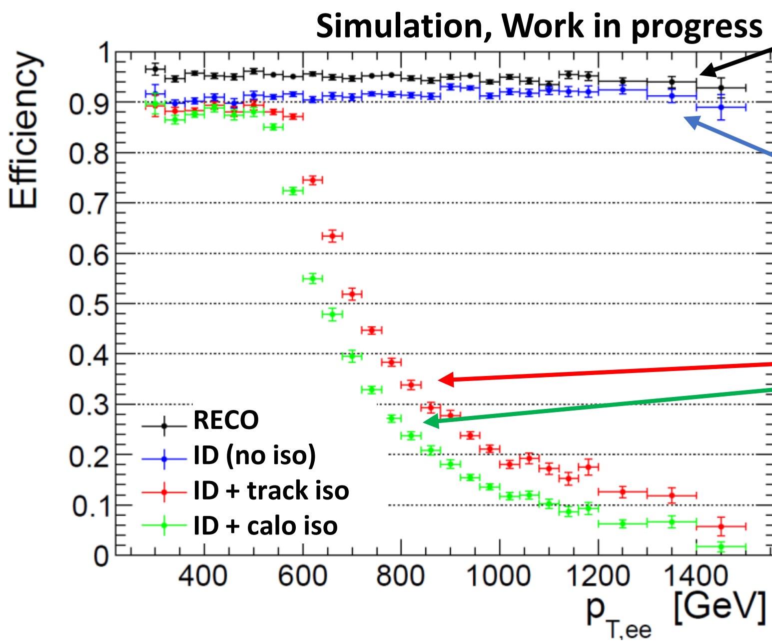
Event selection (1)

- An electron in CMS:
  - Track pointing to EM shower in ECAL
- Electron selection based on:
  - Shape of EM shower
  - Matching of track and shower centre
  - Isolation: Energy/tracks from other particles within ΔR = 0.3 cone
- Standard cuts for high-energy electrons:
  - Not designed for close electron pairs
  - For ΔR < 0.3, need dedicated study:
    - Are electrons still being reconstructed?
    - Are the selection cuts still efficient?





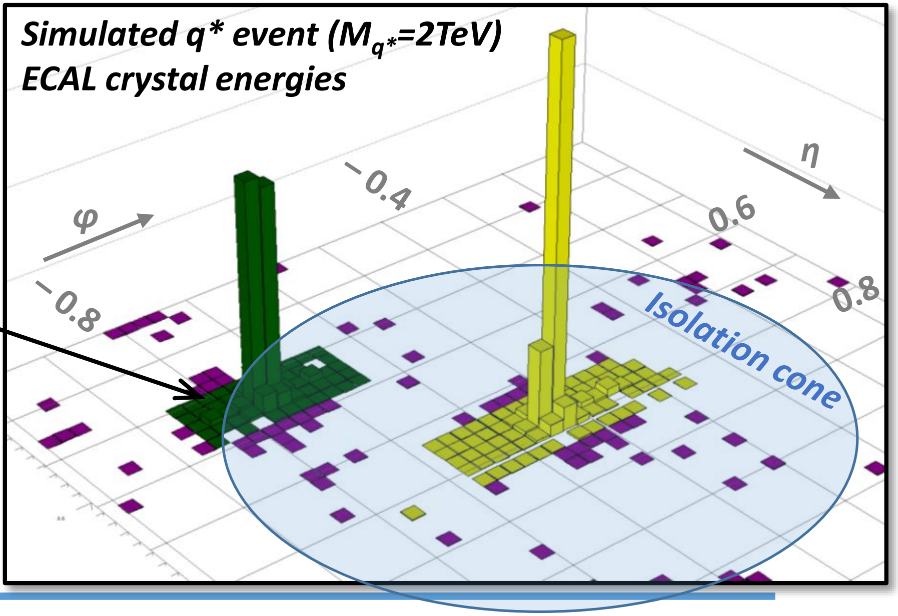
Event selection (2)



Standard reconstruction
Effi. independent of $p_{T,ee}$

Standard electron ID cuts
Effi. independent of $p_{T,ee}$

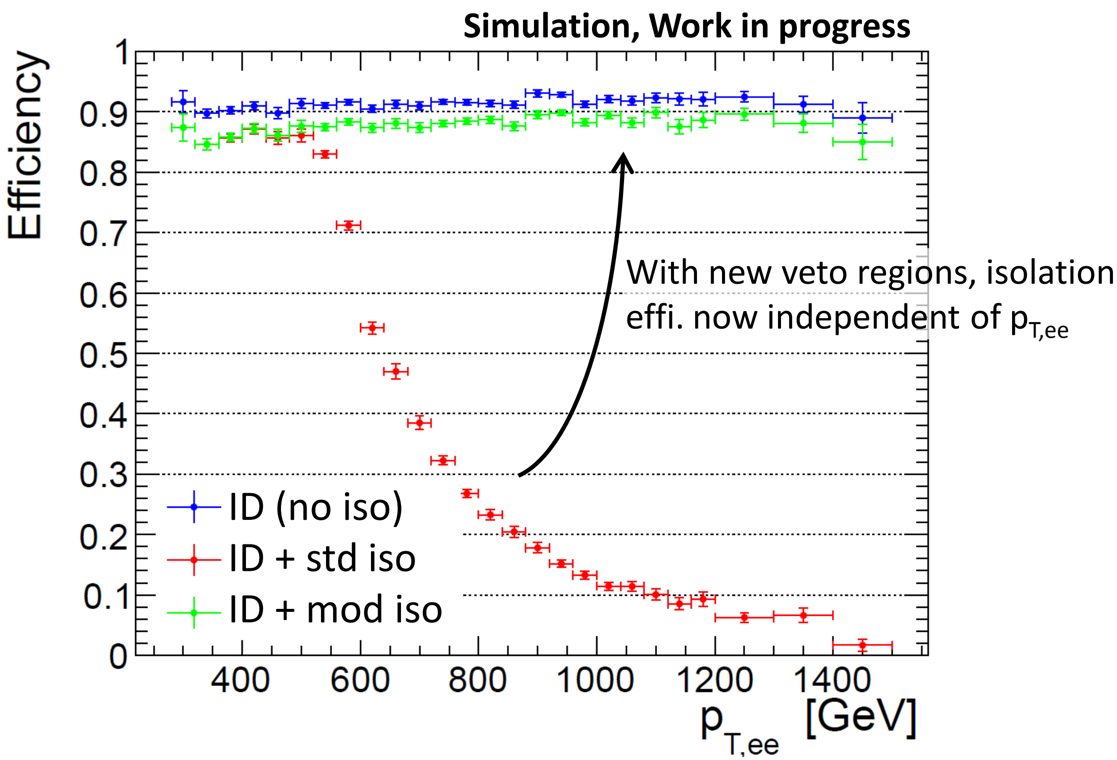
Standard isolation cuts
Effi. drops for M_X > 1.2TeV



- Standard isolation variable includes nearby electron for boosted Z bosons
- Add "veto" regions around other electrons

Event selection (3)

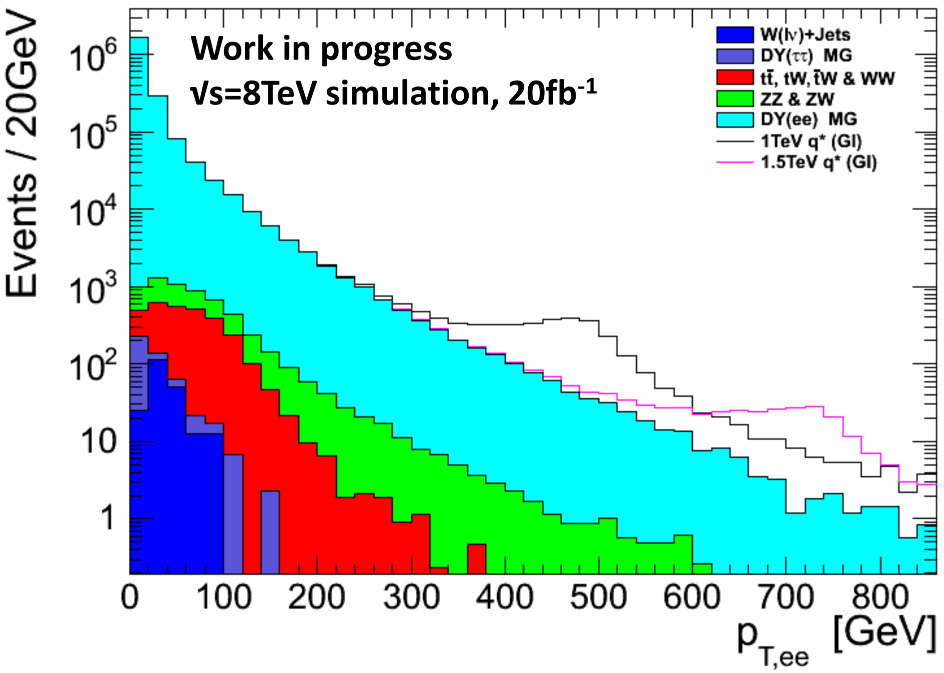
- After optimising veto region around nearby electrons:



- Validated efficiency in simulations match data
    - Measurements agree to within 2.5%

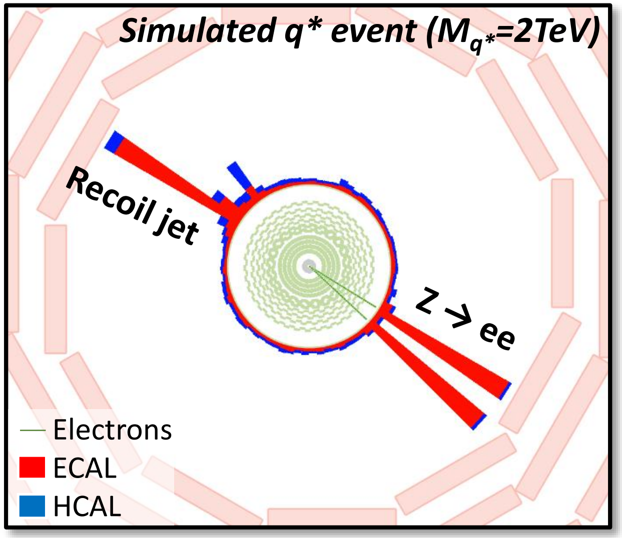
Backgrounds

1. SM processes with Z boson
   - Mostly Z(ee)+jets
   - Compare different generators
2. 2 real electrons
   - ttbar, Z(ττ), WW, etc.
   - Verify simulation with control region
3. QCD & W+jets
   - Jets mis-identified as electrons
   - Data-driven methods



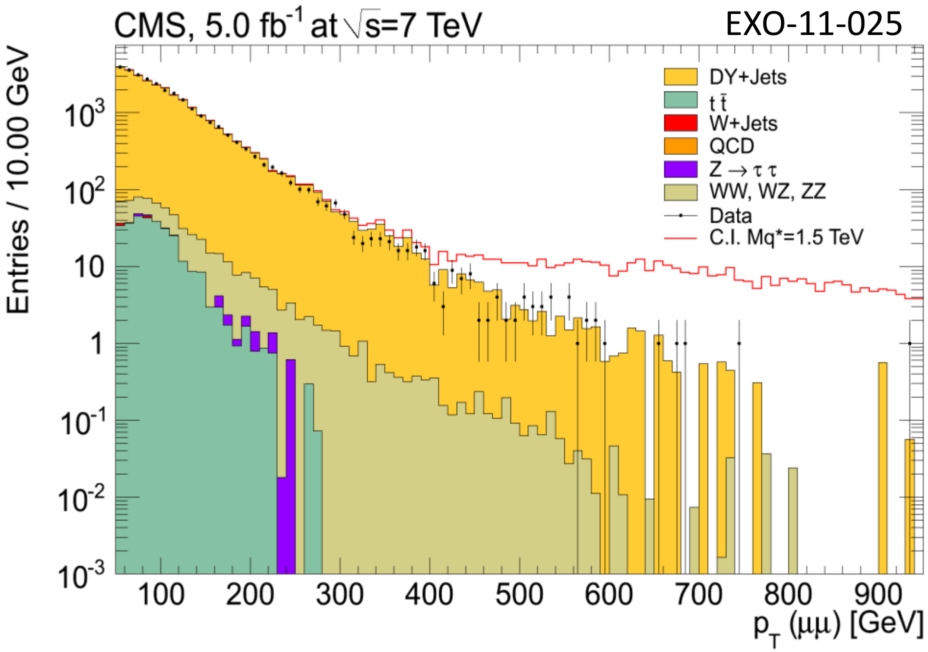
Summary

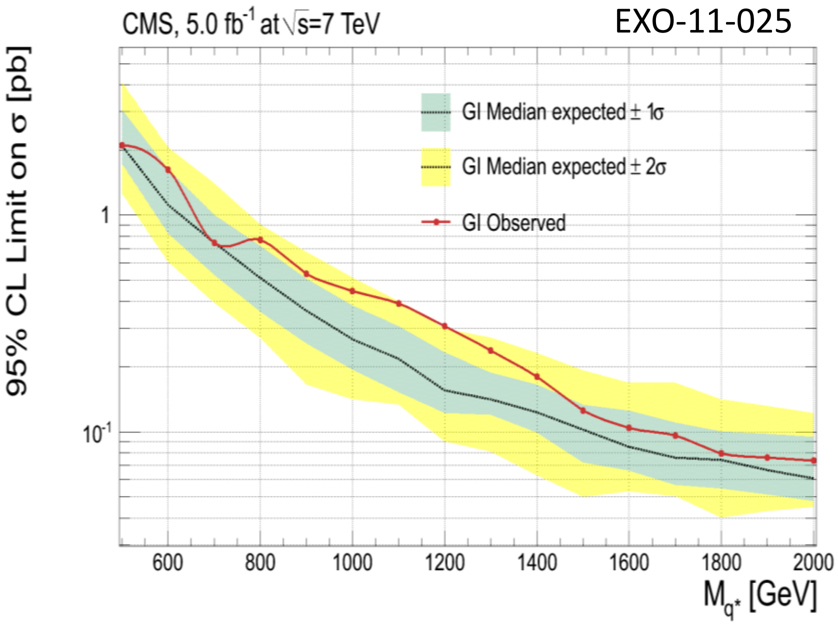
- Search for New Physics using boosted Z bosons at CMS
  - Sensitive to several different BSM theories
  - Dedicated selection for close-electron topology
  - Still work in progress – watch this space …
- Any questions?



BACKUP: Previous searches

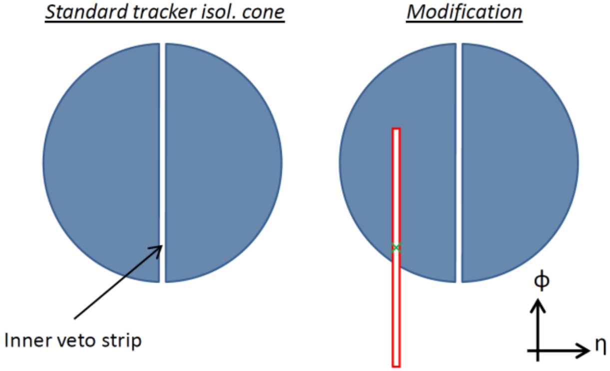
- Previous result from CMS on √s=7TeV dataset (5fb^{-1})
  - Di-muon channel
  - Found no excess; set limits on σ(pp -> q* -> qZ)

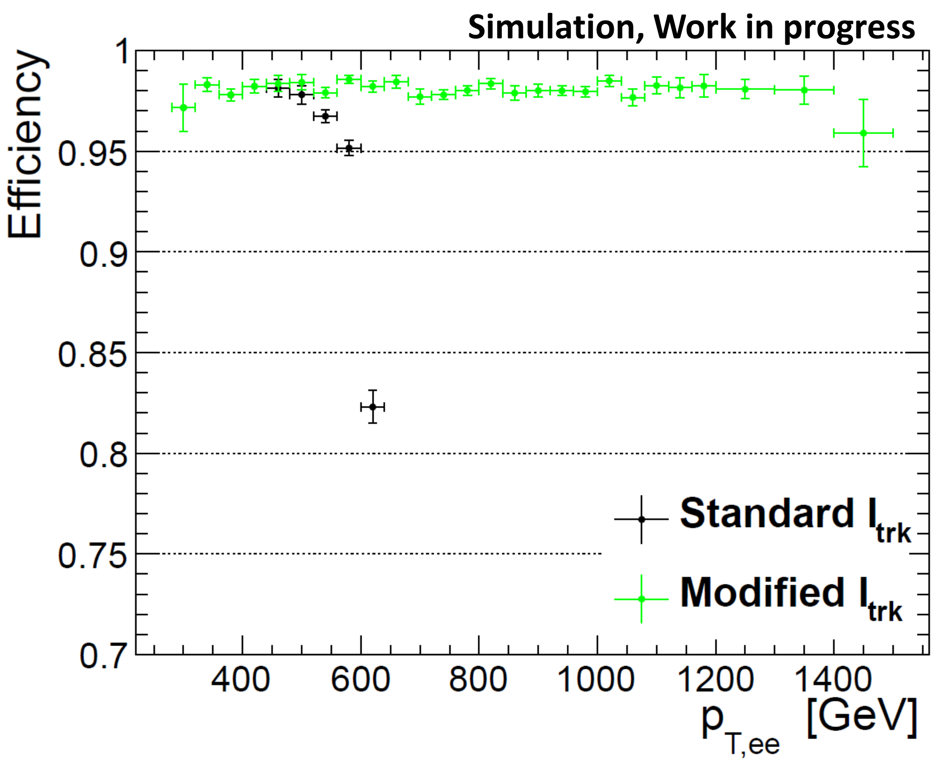




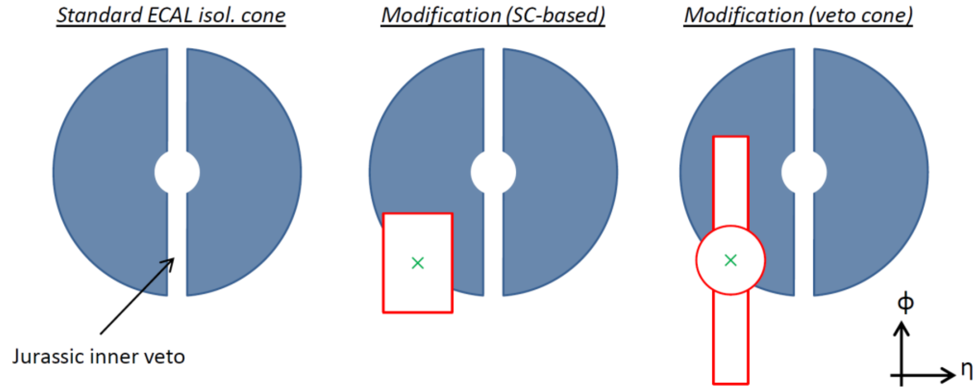
BACKUP: Event selection (1)

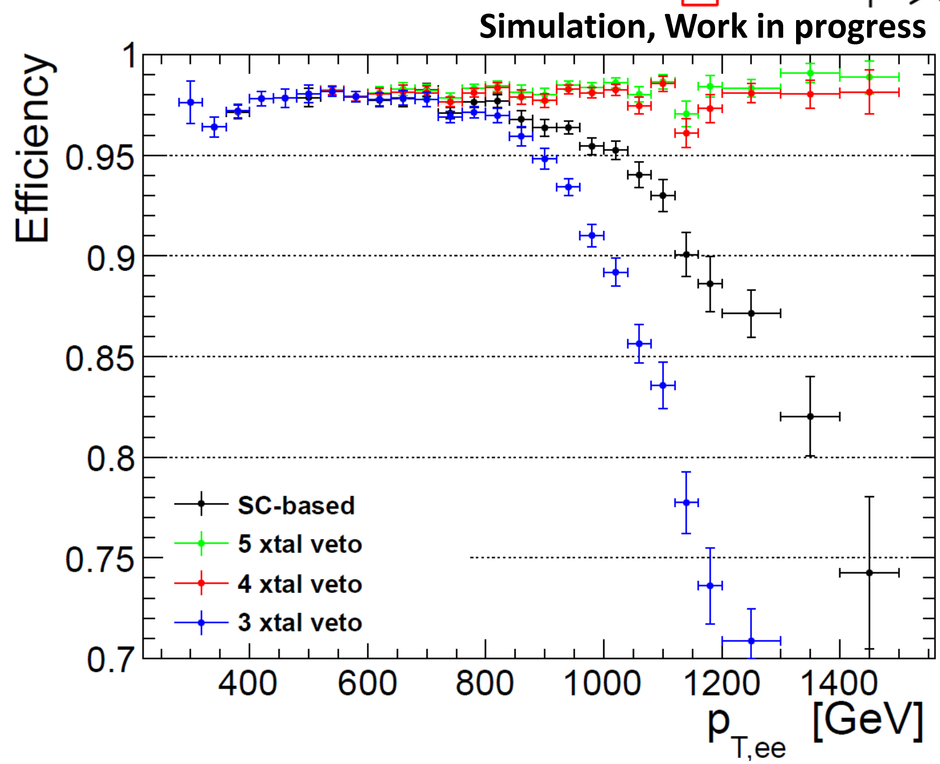
- Track isolation





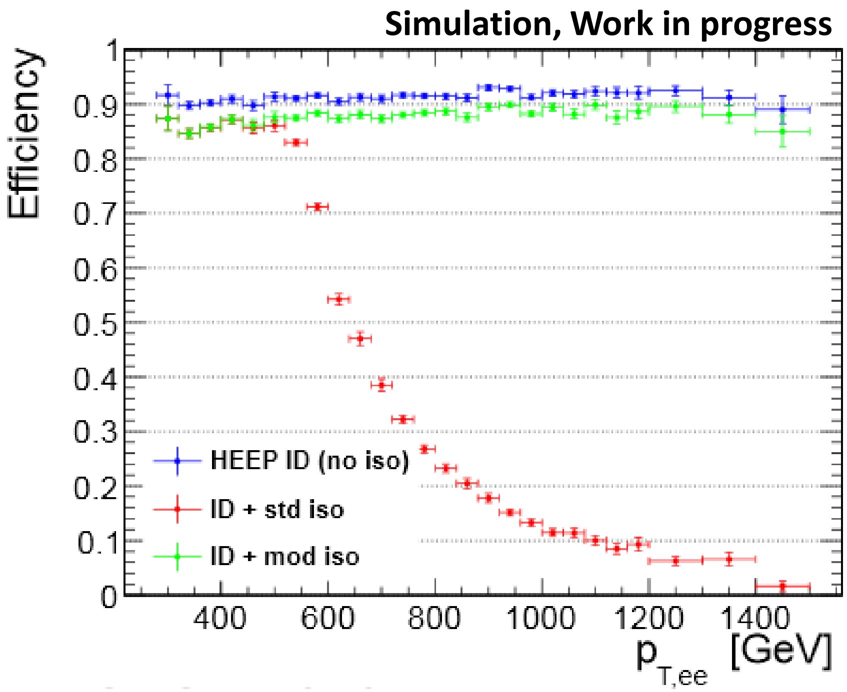
- Calorimeter isolation

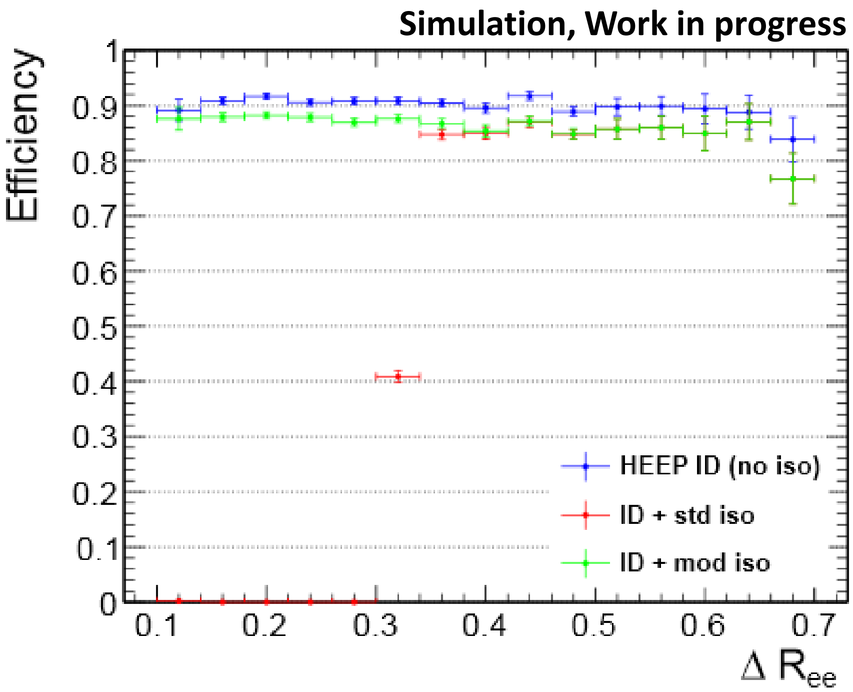




BACKUP: Event selection (2)

- Track + calorimeter isolation combined:





BACKUP: Backgrounds

- Real electron, non-Z backgrounds
  - ttbar, tW, tbarW, WW & DY(ττ)
  - Real ee pair from decay of two Ws or taus
  - B(W -> $e\nu_e$) = B(W -> $\mu\nu_\mu$), as for taus

  => A control region

- Selection: eμ pair in Z mass window