Search for High Mass Resonances decaying to Z(qq)+γ final states and HE Plan B studies at FNAL LPC

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May 24, 2016

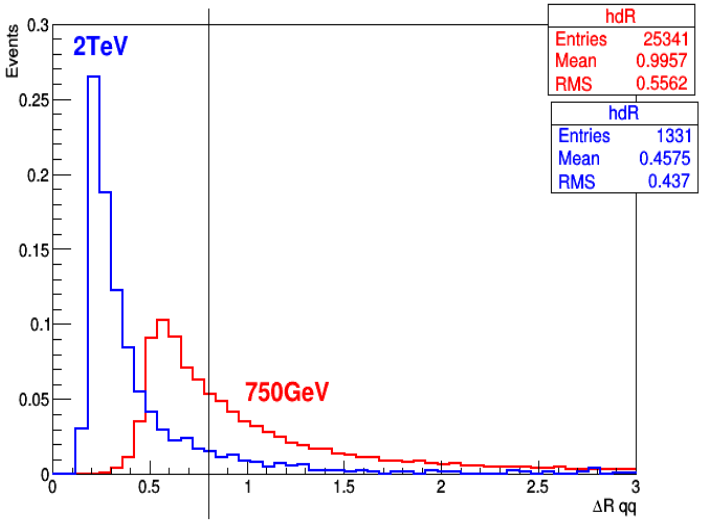
My Work (since Jan, 2016)

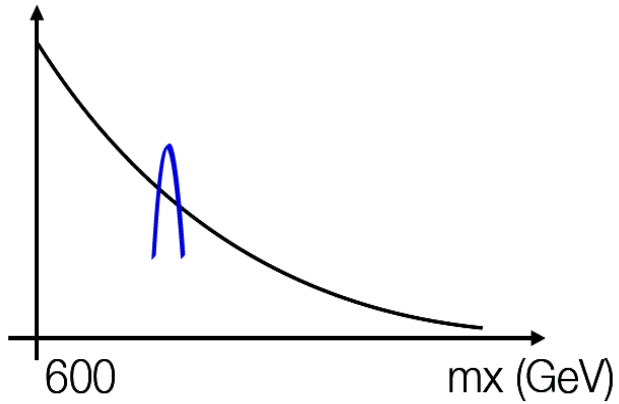
- High Mass Resonance searches, X → Z(qq)+γ
  - EXO-16-020 for 13 TeV
  - EXO-16-025 for 8TeV
  - Collaborators:
    - Yurii Maravin (Kansas State University),
    - Lesya Shchutska (University of Florida, LPC DR 2016),
    - Caterina Vernieri, Lindsey Gray (FNAL),
    - Greg Landsberg, John Hakala (Brown University)
    - Shilpi Jain (LPC visitor, 2015), Chia-Ming Kuo (NCU, Taiwan)
- HE PlanB studies at LPC
  - For Phase2
  - Collaborators:
    - Kevin Pedro, Frank Chlebana, Marek Zielinski, Sunanda Banerjee, Dan Green, Jim Hirschauer (FNAL),
    - Philip Dudero (Texas Tech University),
    - Hongxuan Liu (Baylor University),
    - Markus Klute (MIT)

LPC residents in Red color

X → Z(qq) + γ

- If 750 GeV diphoton excess is a scalar, most likely will decay also to Zγ
- Search for resonant Z(qq)γ production at high masses
  - Use boosted topology and increased branching fraction to improve S/B
- For Mx > 700 GeV, Z boson highly boosted
  - reconstructed from AK8 Jets
- Exploit b-tagging
  - to further discriminate w.r.t background
- Search for a “bump” in M_{Zy} spectrum
- Interpret results in context of scalar signal with two widths: 0.014% and 5.6%



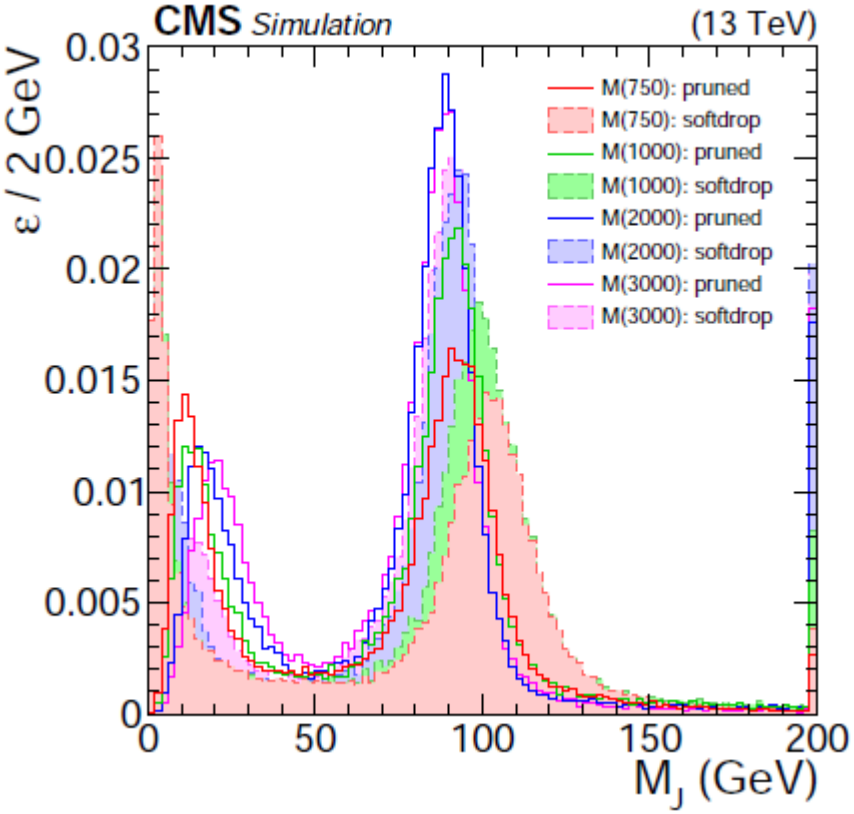


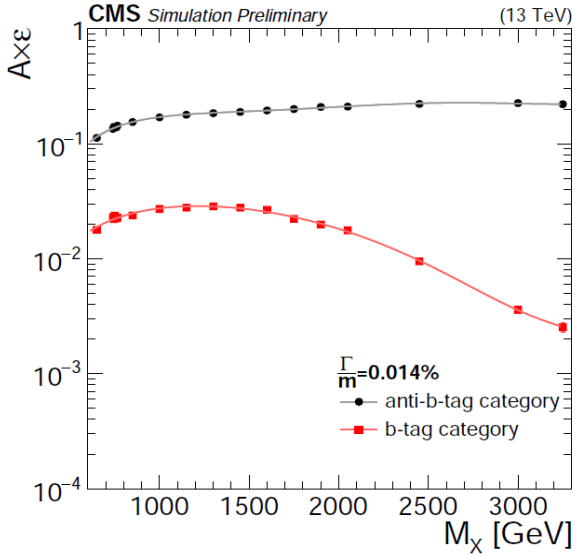
Analysis Strategy

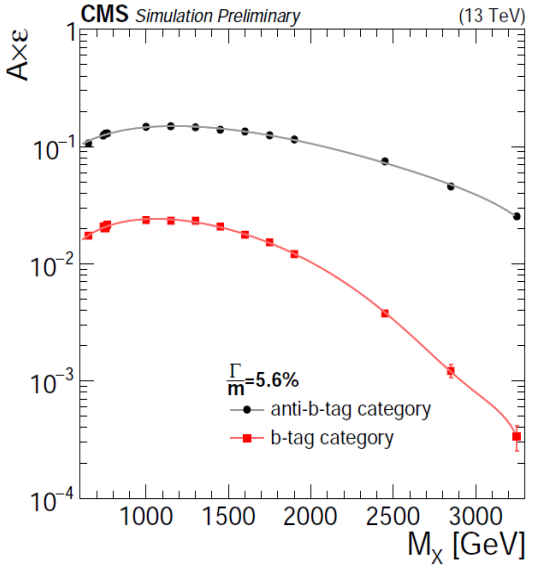
- Select well identified and isolated photons with ECAL barrel region and pT > 170 (180) GeV for Run1 (Run2) data
- Reconstruct Z boson from fat-Jets within a mass window of $75 < M^{J}_{pruned} < 105$ GeV
- From selected events, create Zγ candidates
- To search for "bump", fit $M_{Z\gamma}$ spectrum in data with a parameterized background model
- Define two analysis categories to capture full signal acceptance: B-tagged (low background) and anti-b-tagged (high acceptance)
- Extract exclusion limits for cross-section*BR(Zγ)

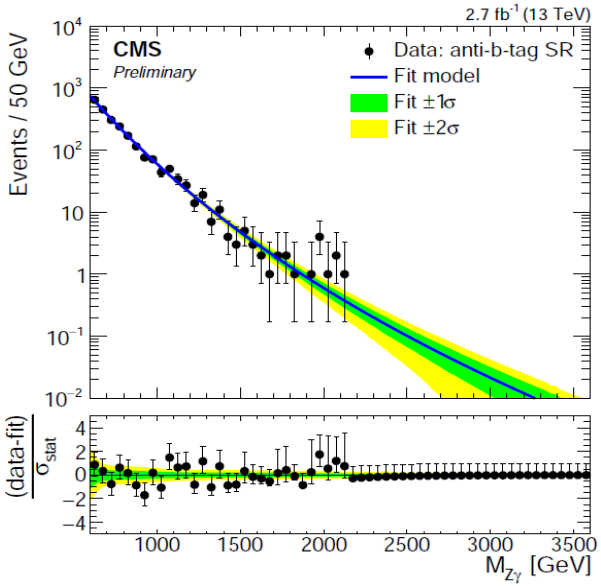
Run-2 (EXO-16-020)

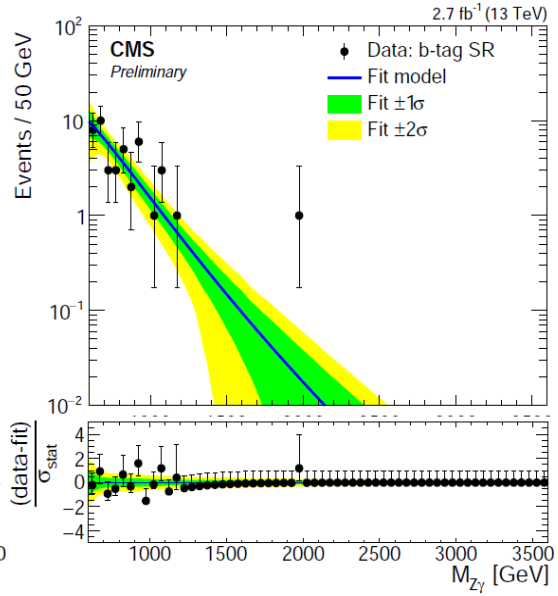
- Analyzed full 2.7 /fb “Single Photon” data collected in 2015 at 13TeV





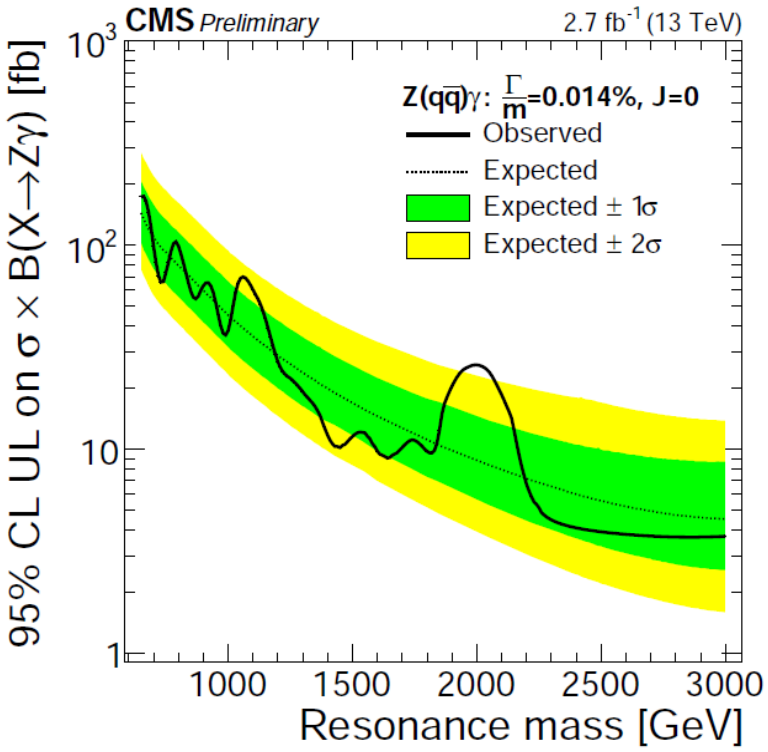


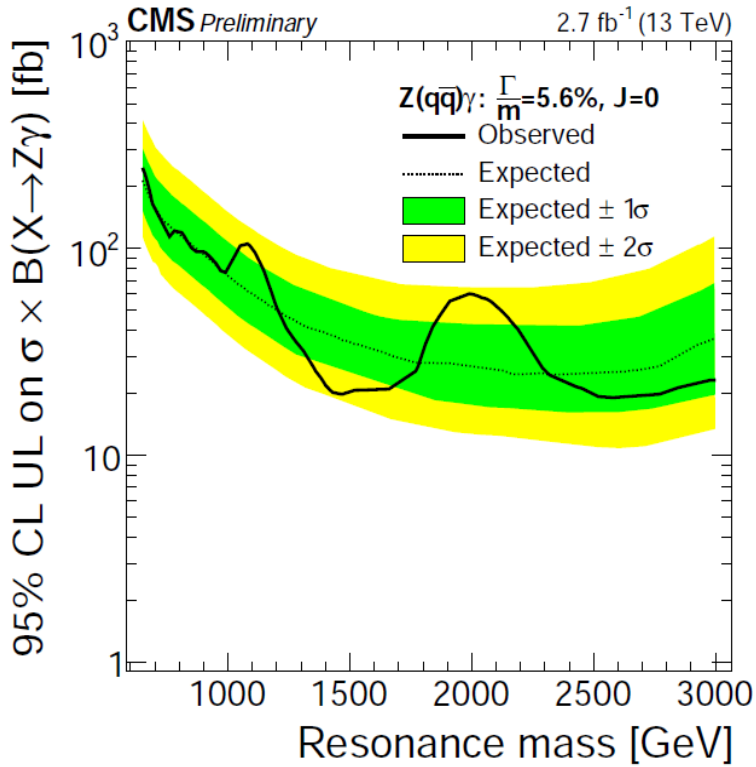




Run-2 (EXO-16-020)

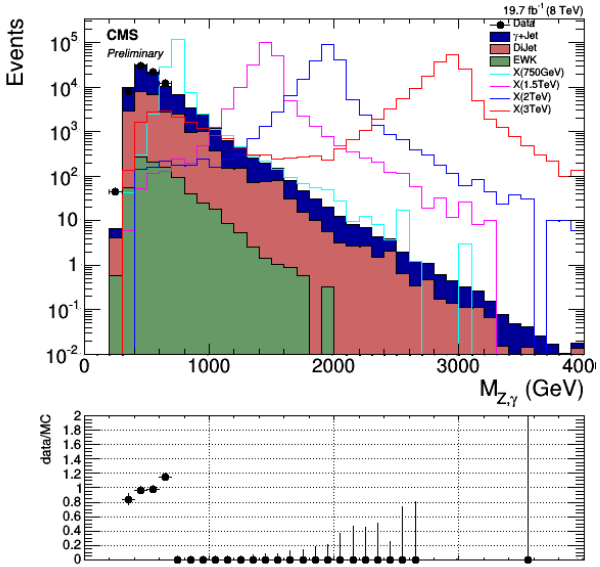
- Recently approved by CMS, but not public yet
- Considered as high priority analysis for 2016 among other di-boson analyses
  - given this 2TeV bump – to be monitored in 2016 !



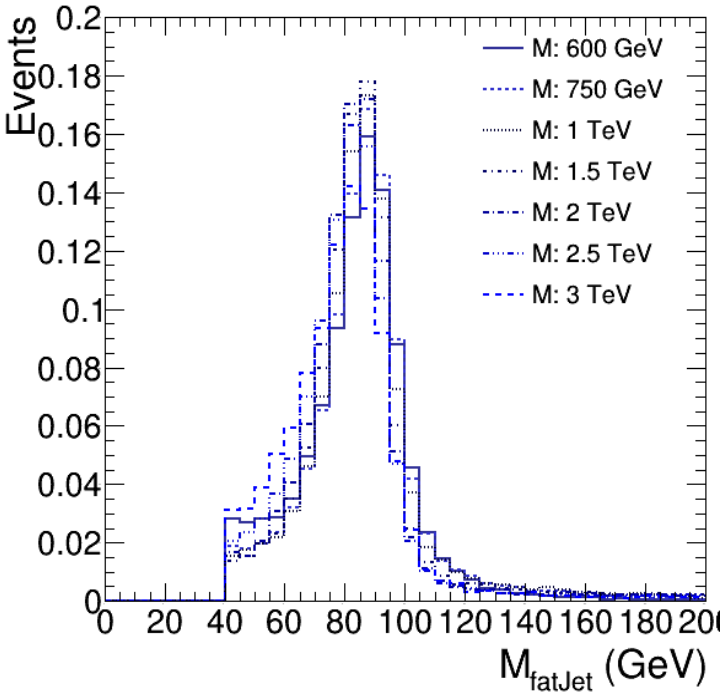


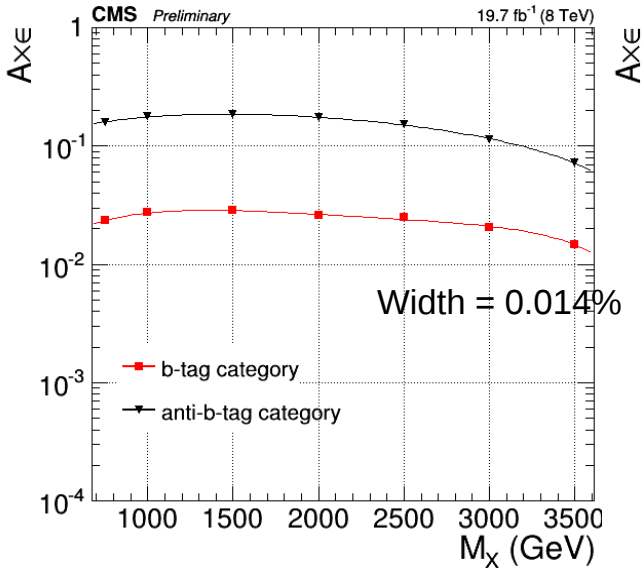
Run-1 (EXO-16-025)

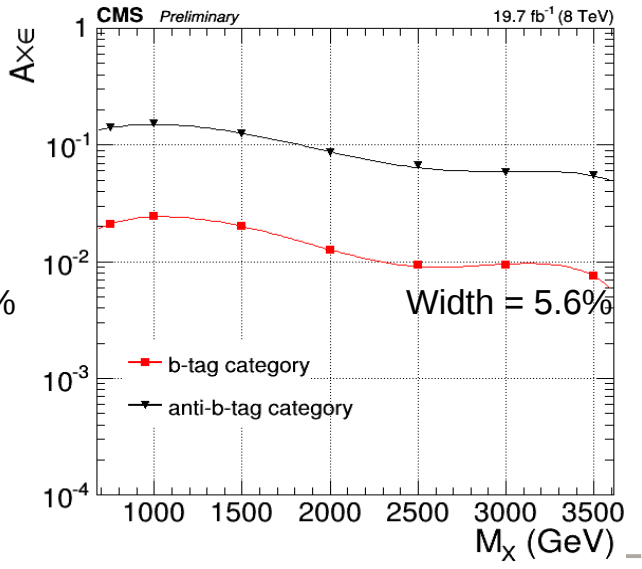
- Given the importance of this channel and no such analysis in Run1, we pursued the same analysis for Run1, used full 19.7 /fb of “Single Photon” data.



Data blinded
(Pre-approved)
Not public yet

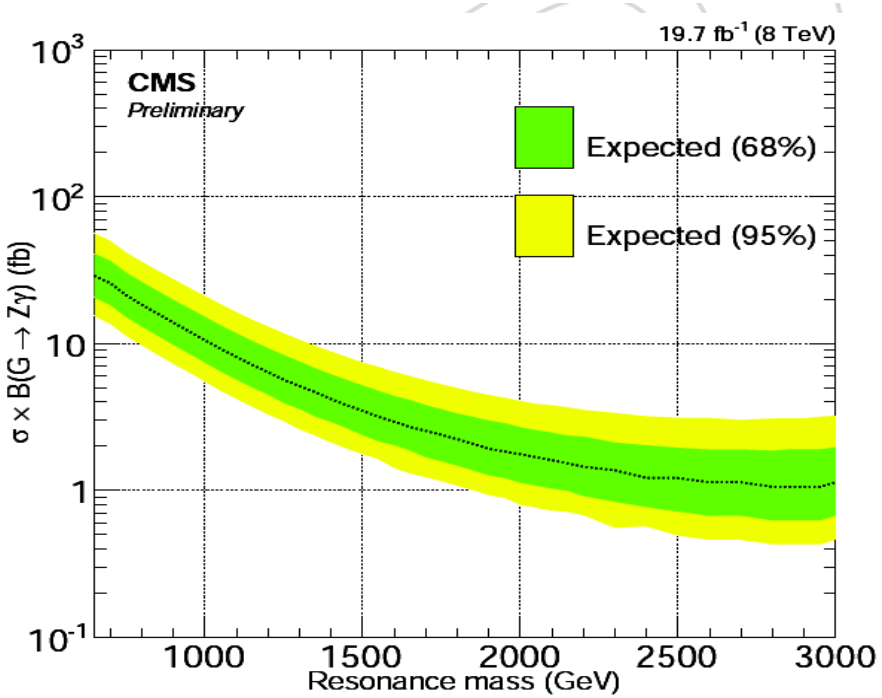




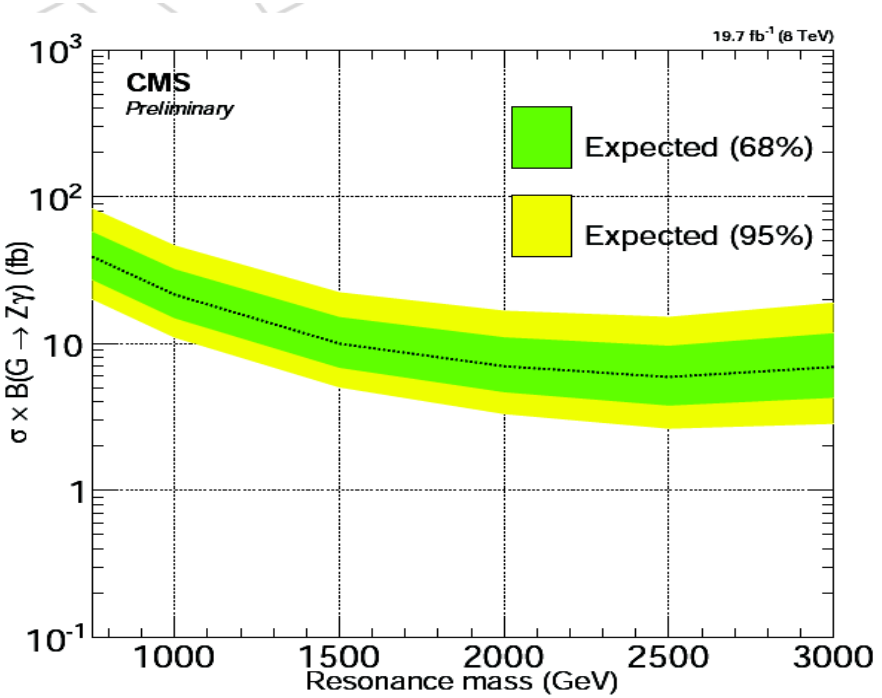


Run-1 (EXO-16-025)

- Data blinded, so no observed limits yet
- Plan is to combine with 13TeV analysis for publication



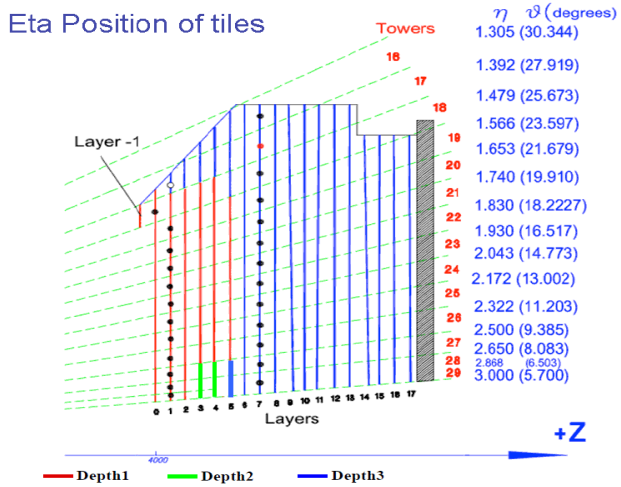
(a) $\frac{\Gamma}{m} = 0.014\%$: combined



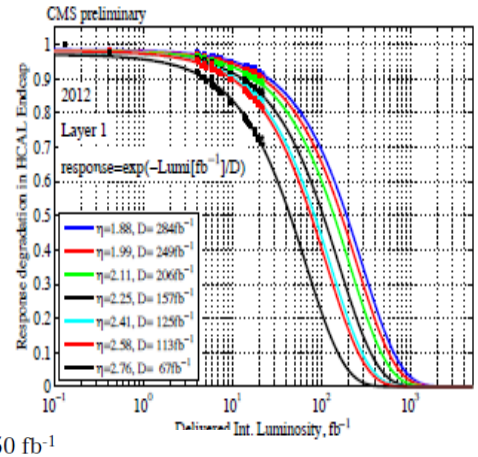
(b) $\frac{\Gamma}{m} = 5.6\%$: combined

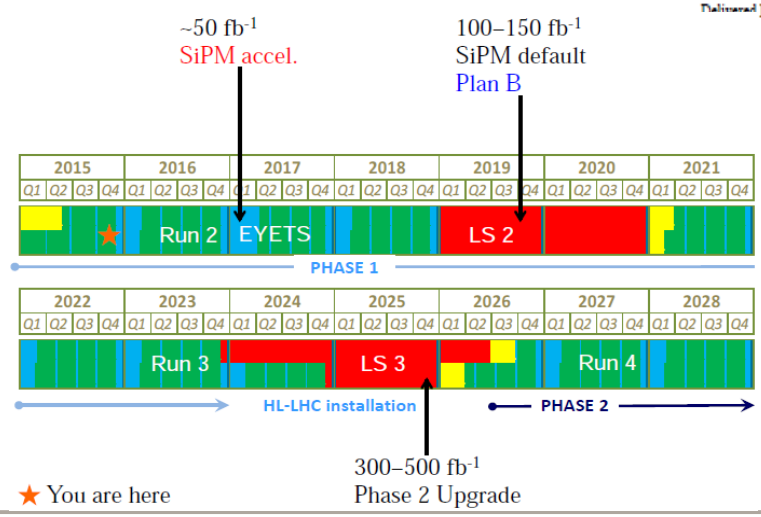
What is HE Plan B?

- Light signal from HE is observed to deteriorate faster than expected due to radiation damage
- To maintain desired physics performance until LS3, replacement of up to 6 layers of HE scintillator megatiles is being considered for LS2 – aka Plan B
- Implementation of Plan B would certainly provide improved performance of the detector after LS2
- Plan B studies examine ramifications of NOT executing the plan (and possibly alternate options).
- It is not about distant future, management decisions are expected by the end of year, so the studies need to be concluded by then.



HE response degradation vs int. lumi





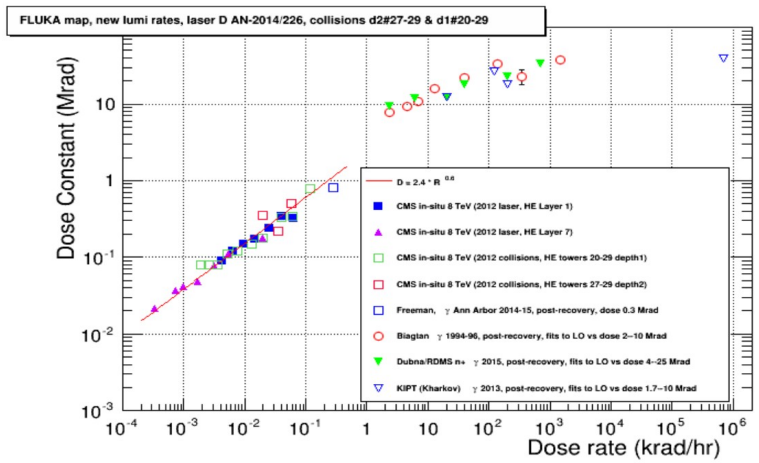
Plan B studies at FNAL LPC

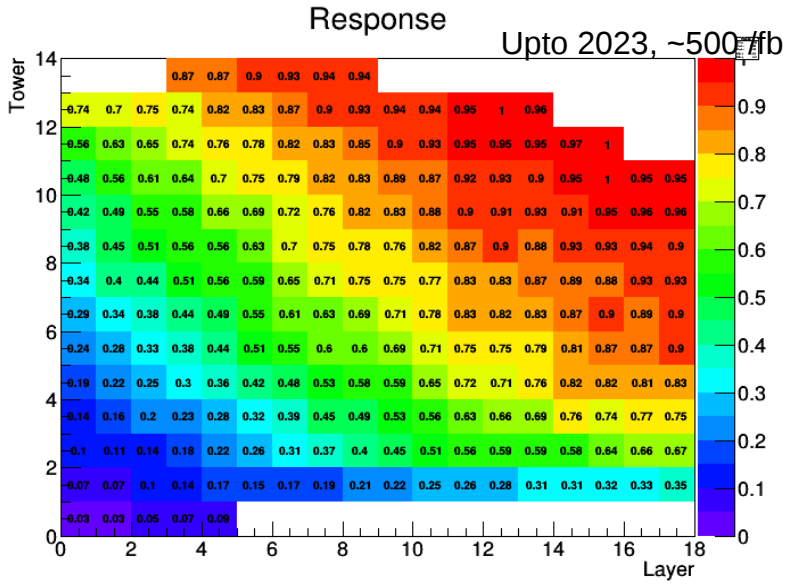
- Goal: help CMS efforts to achieve the best understanding of the expected HE performance by LS3, in the context of scintillator signal deterioration
- We do regular discussions/meetings @ LPC, main topics:
  - Refine the radiation damage model: dose and doserate effects
  - Model HE SiPMs noise, signal, and aging for simulation
  - Re-evaluate impact of HE raddam on physics performance
    - initial studies were based on extrapolating the damage using a lower dose rate which results in over estimating the scintillator darkening.
    - These new studies are based on a more realistic dose rate and results in less damage.
  - Thus we are trying to improve on various past studies.

Updated Dose constant vs Dose Rate

Current fit: $D = 2.4 * R^{0.6}$

- used to recalculate light output predictions, being implemented in simulations

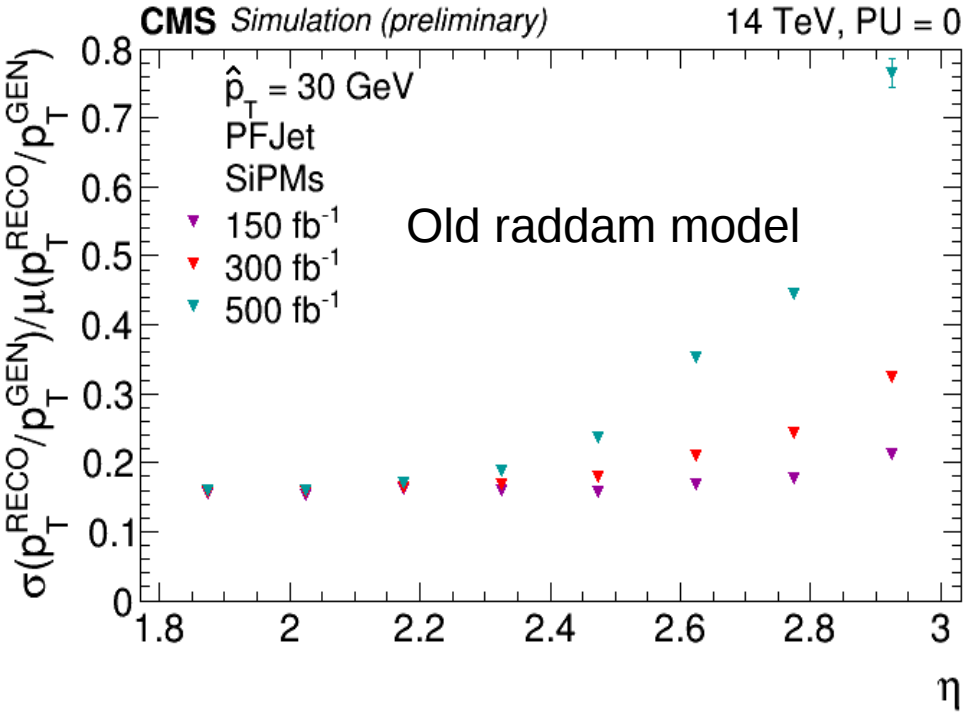


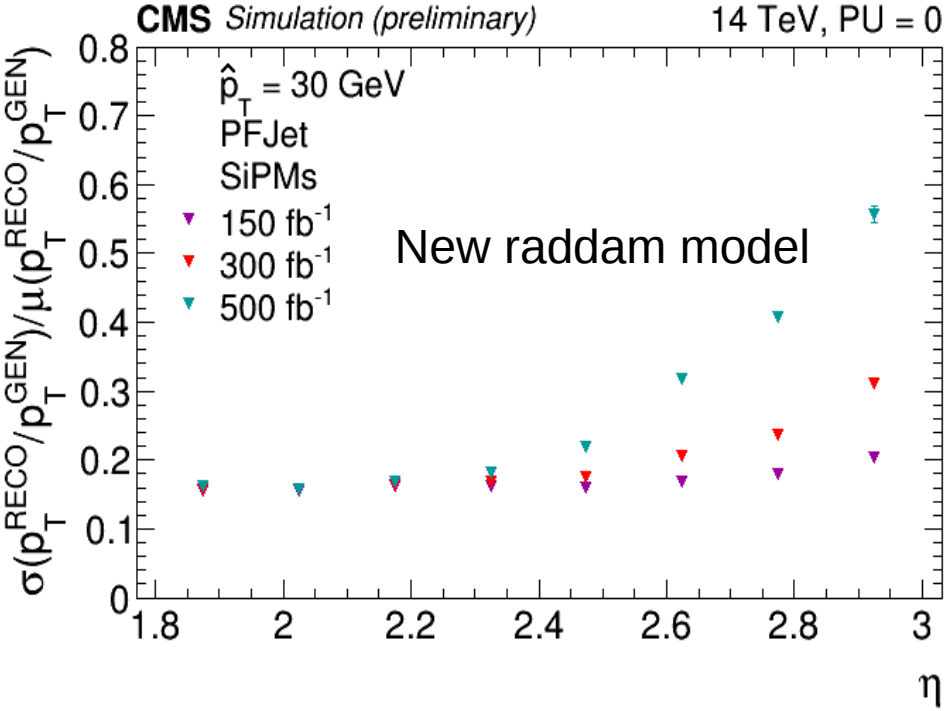


PF Jet Resolution

On-going work

- Stable upto |η| < 2.5, for |η| > 2.5, it degrades.
- new raddam model predicts better jet resolutions than the old
- More corrections in modeling being considered (like SiPM noise, depth segmentation, more accurate radiation maps and so on)





My Additional Activities at LPC

- **HATS @ LPC**
  - Organizer, Oct-2014, Continuing in June-2016
  - on Electrons and Photons with S. Khalil (KSU), R. Kamalieddin (UNL), V. Sharma (LPC visitor), M. Weinberg (FSU), L. Gray (FNAL)
- **CMSDAS**
  - Facilitator, Jan-2015, Jan-2016
  - short exercise on electrons and photons with S. Khalil and S. Toda (KSU), B. Gomber (UW), R. Kamalieddin (UNL)
  - Long exercise on “Dark Matter” with B. Gomber (UW), M. Weinberg (FSU)
- **LPC Physics forum**
  - Speaker, Aug-2014, Excited lepton analysis
  - Speaker, Mar-2016, $X \rightarrow Z(qq)\gamma$
- **Run2 discussion group**
  - Facilitator: leptons and photons
- **Topic of the Week**
  - Committee member

Summary

- LPC is an excellent platform
  - for researchers, scientists and professors from several institutions and creates a rich pool of localized expertise and guidance.
  - Most of the physics object experts are based at LPC, this immensely helped me by allowing interaction/consultations with subject matter experts, mentors and co-workers in real time.
- Thanks to “Distinguished Researcher LPC” fellowship
  - active participation in my physics analysis with other colleagues of FNAL and US-institutes, stationed at LPC
  - and due to my close interaction with LPC based HCAL experts, Plan B studies could be concluded with in deadlines imposed by CMS management !