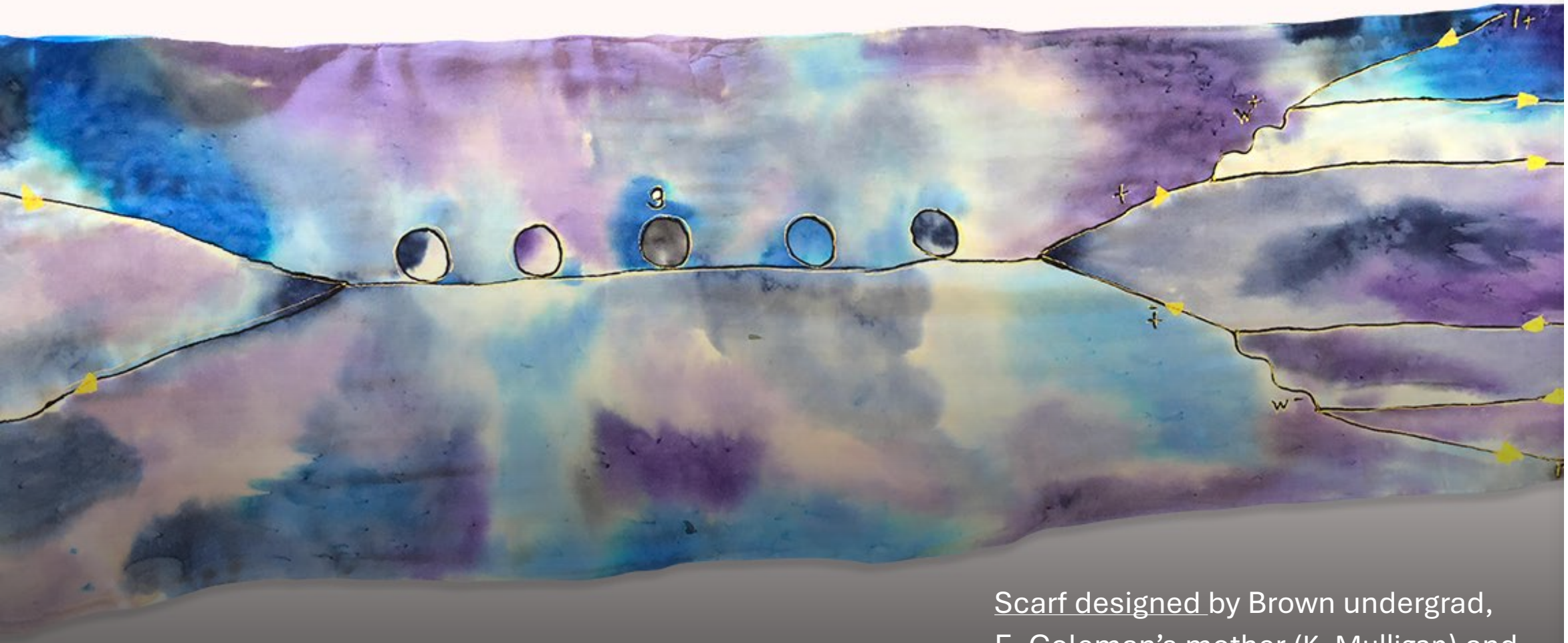
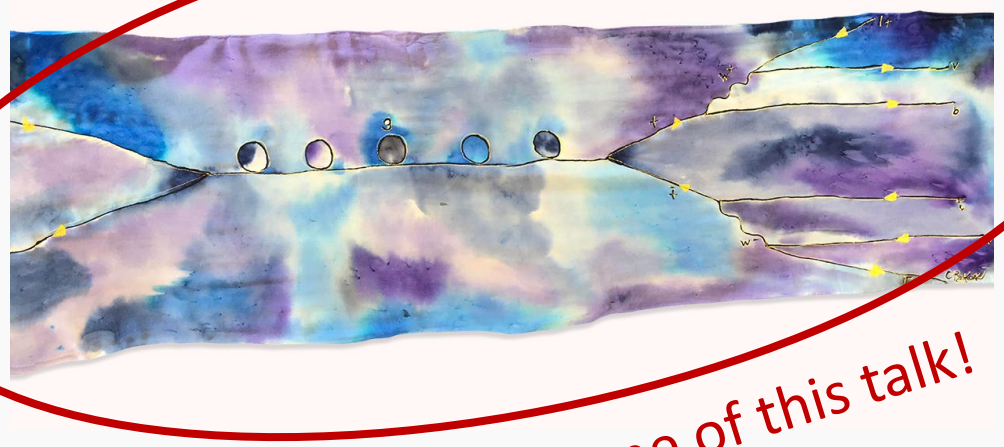
CMS Physics



Scarf designed by Brown undergrad, E. Coleman's mother (K. Mulligan) and created by silk artist, C. Baker



Underlying theme of this talk!

Meenakshi's CMS legacy is HUGE!

Impossible to do justice to it in a single talk

119 notes in the CMS internal notes system!

CMS
Compact Muon Solenoid

authors=Narain
target=
2023.03.02 AD at 21:48:26
» Tools » Notes » View

1 to 20 from 119 items found matching the criteria one of the author – "Narain"

Many thanks to Patrizia Azzi, Kevin Black, Daniel Bloch, Xavier Coubez, Robin Erbacher, Julie Hogan, Boaz Klima, Kenneth Lane, Alex Schmidt, Pedro Silva and Ulrich Heintz for providing me comments, anecdotes, pictures, slides…

From the Tevatron to the LHC…

PHYSICAL REVIEW LETTERS

Highlights Recent Accepted Collections Authors Referees Search Press About

Editors' Suggestion

Evidence for Production of Single Top Quarks and First Direct Measurement of $|V_{tb}|$

V. M. Abazov *et al.* (DØ Collaboration)
Phys. Rev. Lett. **98**, 181802 – Published 1 May 2007

”We have discovered the top quark in pairs. Now we can see it produced singly in a rare mode by the weak force, which means we can understand its properties better.”

“Today's discovery is tomorrow’s background”

From the Tevatron to the LHC…

Interview by **NEIL DEGRASSE TYSON on PBS NOVA SCIENCENOW (2007)**

“We may find things which nobody has ever thought of, or told us before.

We basically do not understand why some particles got mass and others didn't. What happened? What gave mass?

The best case, in my mind: we do not find the Higgs particle, and we find a whole new set of new particles.”

Searches for new particles…

NEW PHYSICS AT THE LHC: A LES HOUCHES REPORT

Physics at TeV Colliders 2007 – New Physics Working Group

G. Brooijmans[1], *A. Delgado*[2], *B.A. Dobrescu*[3], *C. Grojean*[4,5], *M. Narain*[6], *J. Alwall*[7], *G. Azuelos*[8,9], *K. Black*[10], *E. Boos*[11], *T. Bose*[6], *V. Bunichev*[11], *R.S. Chivukula*[12], *R. Contino*[4], *A. Djouadi*[13], *L. Dudko*[14], *J. Ferland*[8], *Y. Gershtein*[15], *M. Gigg*[16], *S. Gonzalez de la Hoz*[17], *M. Herquet*[18], *J. Hirn*[19], *G. Landsberg*[6], *K. Lane*[20,21], *E. Maina*[22], *L. March*[17], *A. Martin*[19], *X. Miao*[23], *G. Moreau*[13], *M.M. Nojiri*[24], *A. Pukhov*[25], *P. Ribeiro*[26], *P. Richardson*[4,14], *E. Ros*[17], *R. Rosenfeld*[27], *J. Santiago*[3,28], *V. Sanz*[20], *H.J. Schreiber*[29], *G. Servant*[4,5], *A. Sherstnev*[14,30], *E.H. Simmons*[12], *R.K. Singh*[13,21], *P. Skands*[3,4], *S. Su*[23], *T.M.P. Tait*[31,32], *M. Takeuchi*[33], *M. Vos*[17], *D.G.E. Walker*[34,35].

convenor of *Non SUSY New Physics* working group

[1] Physics Department, Columbia University, New York, NY 10027, USA
[2] Dpt. of Physics, University of Notre Dame, Notre Dame, IN 46556, USA
[3] Fermilab, PO Box 500, Batavia, IL 60510, USA
[4] Physics Department, Theory Unit, CERN, CH-1211 Geneva 23, Switzerland
[5] IPhT, CEA-Saclay, Orme des Merisiers, F-91191 Gif-sur-Yvette Cedex, France
[6] Department of Physics, Brown University, Providence, RI 02912 , USA

Les Houches 2007:

2-week long workshop **brought together theorists and experimentalists** working on the physics of upcoming **TeV colliders**

Throughout her career, Meenakshi was always able to very successfully engage with theorists and was always keen on exploring new models/theories

Searches for new particles...

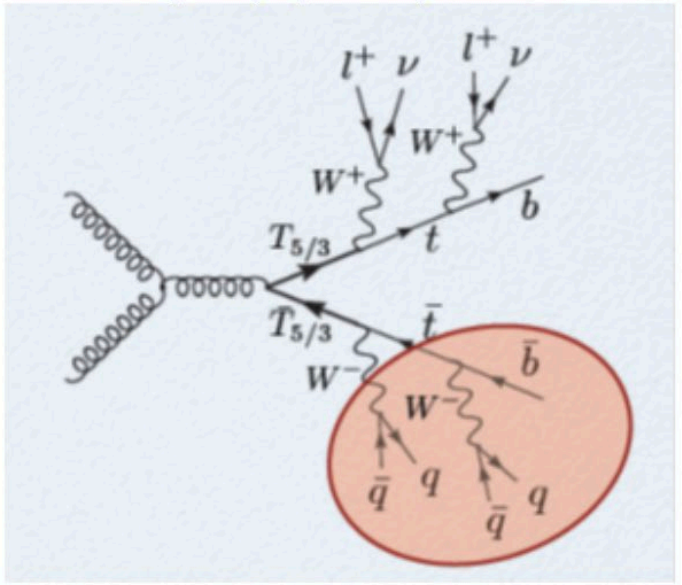
- Sensitivity study done using CMS fast simulation samples
- Critical issue: how to deal with the **ttbar** background
- Followed up soon after with a full simulation study incorporating
  - latest and greatest object identification strategies and corrections
  - development of background estimation methods for difficult instrumental backgrounds

(Bose, Narain)

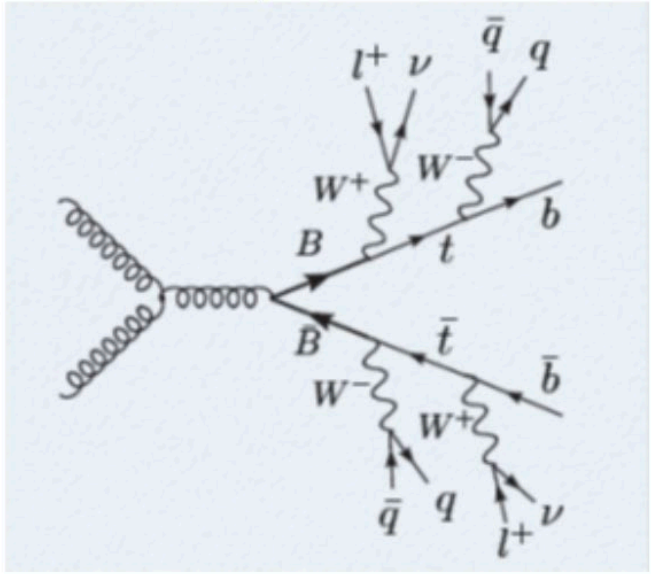
Exotic top partners

Some BSM theories predict the existence of:

heavy top quark partner



heavy bottom



- **Model suggested by Contino and Servant** : arXiv:0801.1679 (2008)

"Discovering the top partners at the LHC using same-sign dilepton final states"

Perform a sensitivity study using CMS fast simulation samples:

EXO-08-008

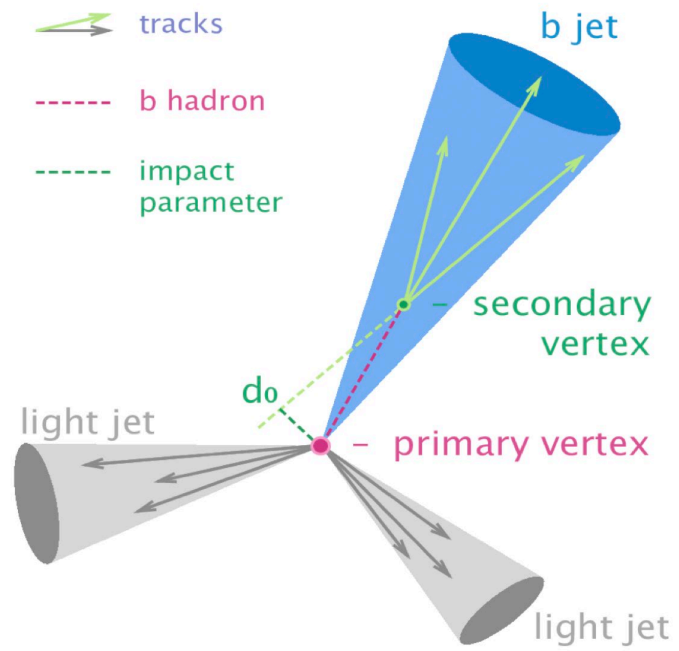
Meenakshi and her beloved* b-tagging

* Quoted by Meenakshi at a b-tag workshop

Jets from b quark decay and fragmentation occur in many physics process: top t->bW, Higgs H->bb, … and many new physics scenarios

methods to identify b jets were developed at LEP and Tevatron, relying on track impact parameters and secondary vertex from b decay; multi variate methods (MVA) combining information were emerging

But techniques had also to be developed to measure the b-tag (and c-tag and light-tag) efficiencies from the real data, in order to minimize the use of Monte Carlo simulation.



Meenakshi made a huge difference to this effort!

”Meenakshi worked her magic here and very soon there was a framework in place to measure data/MC scale factors!”

“Meenakshi was an esteemed contributor, a leader and an inspiration in this area”

Meenakshi had extensive experience on b quark jet identification from D0. Already in 2007, she played a critical role in how to use b-tagging and how to measure its tag and mistag efficiencies from data **in the harsh collider environment** expected at the LHC

b Tag and Vertexing Workshop (FNAL)

9 Jul 2007, 09:00 → 12 Jul 2007, 18:00 Europe/Zurich

Sunrise WH11NE (Fermilab)

Cecilia Gerber (University of Illinois at Chicago), Ian Tomalin (RAL), Meenakshi Narain (Brown University), Thomas Speer (UNIVERSITY OF ZURICH, SWITZERLAND)

Description General review of b tagging and vertexing, but with particular emphasis on how to measure performance with real data.
(password=btag)
vrvs backup: IP 88123456
(phone +1-510-883-7860)

Chair:
Monday: Cecilia
Tuesday: Thomas
Wednesday: Ian
Thursday: Meenakshi

Meenakshi's ability to organize groups of people and make them deliver on important projects was unique!
She always led by example!

Unfamiliar newcomers learned about esoteric concepts such as taggability and tagging rate functions…

Conclusions

- We should try to investigate:
  - Use of track-jets for b-tagging
  - "taggable jets" – should discuss defining such jets, and measuring the b-tagging efficiency wrt to those jets
    - This defines a unified way of comparing different algorithms
    - Eliminates the dependence on run conditions which may effect the tracking efficiencies or calorimeter efficiencies

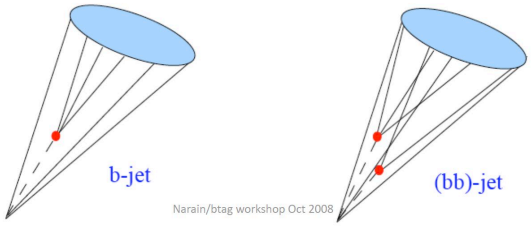
Need to Understand:
- Do we really need data vs MC scale factors?

Or
- just use parameterized tag rate functions derived from data to weight the MC.

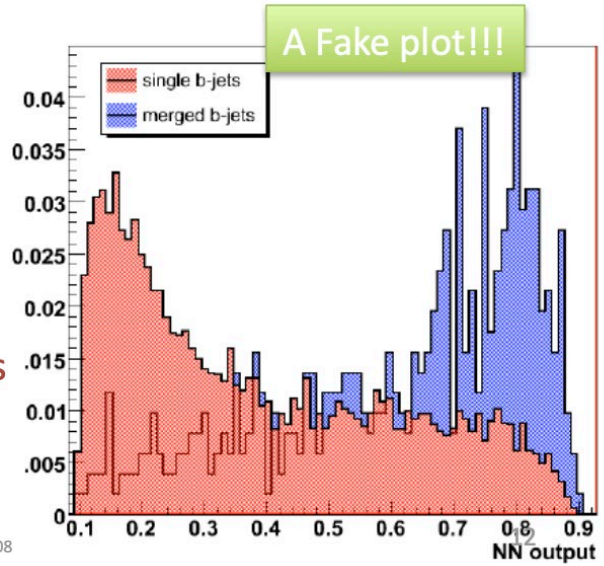
Slide from Meenakshi's talk

One of Meenakshi's greatest strengths was to **rapidly adapt to new and unforeseen situations**, as here in Oct. 2008 after the LHC incident, where she paved the way for b-tagging to be fully in place at the LHC restart:

She was also starting to consider tagging high energetic (boosted) jets with 2 b quarks



Meenakshi's forward-thinking mindset in action!



Hope to see something like this in a month or so…

Hmm…

- When I agreed to give this talk, I thought we would have seen some first collisions and will be commissioning our detectors.
- Then talking about what we can do to prepare and look ahead for 100pb^{-1} or more data makes sense.
- Now, this talk sort of seems out of place, but I have tried to take the view that we should prepare ourselves for the next steps ahead of time, make sure we have the ideas, tools and the techniques in place.

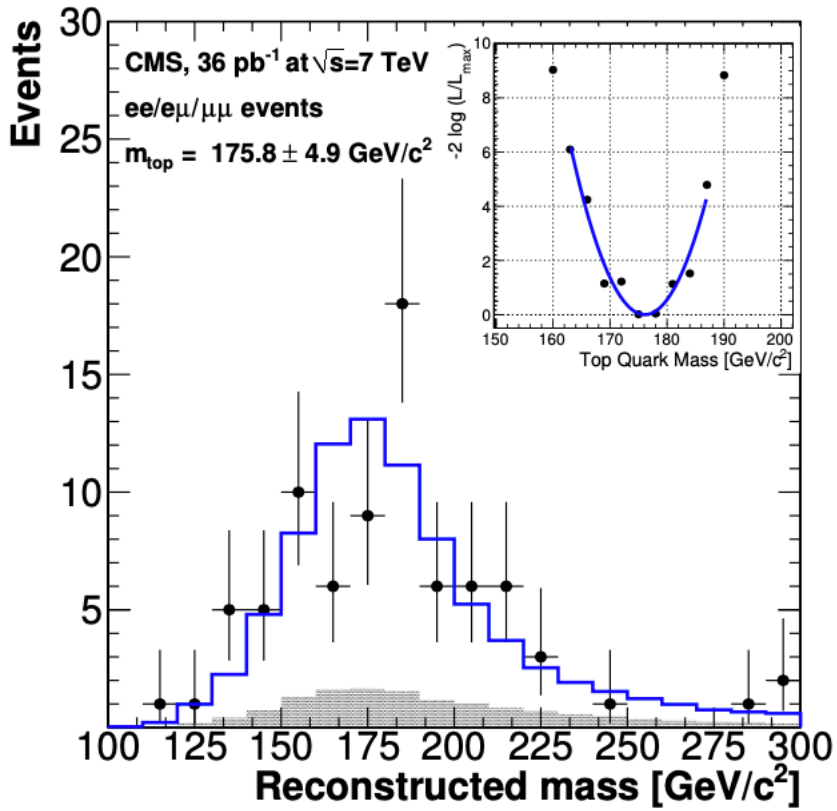
10/30/08 Narain/btag workshop Oct 2008 2

Meenakshi's talk at b tag Workshop, CERN, Oct. 2008

Top mass at the LHC!

The Ulrich + Meenakshi team and the first top mass measurement with LHC data

- Measured using only 36 pb^{-1} of data and competitive with other measurements at that time
- "*It's the first not made at the Tevatron! Different energy, mostly uncorrelated with Tevatron. It validates detector performance. We should take advantage of the opportunity to claim the first outside Tevatron!*" (cit. Ulrich and Meenakshi)
- Several students advised by Meenakshi & Ulrich continued to improve further the precision in the dilepton channel throughout Run 1 using the AMWT technique : <2 yr after the first result the precision decreased by a factor of 4!!!



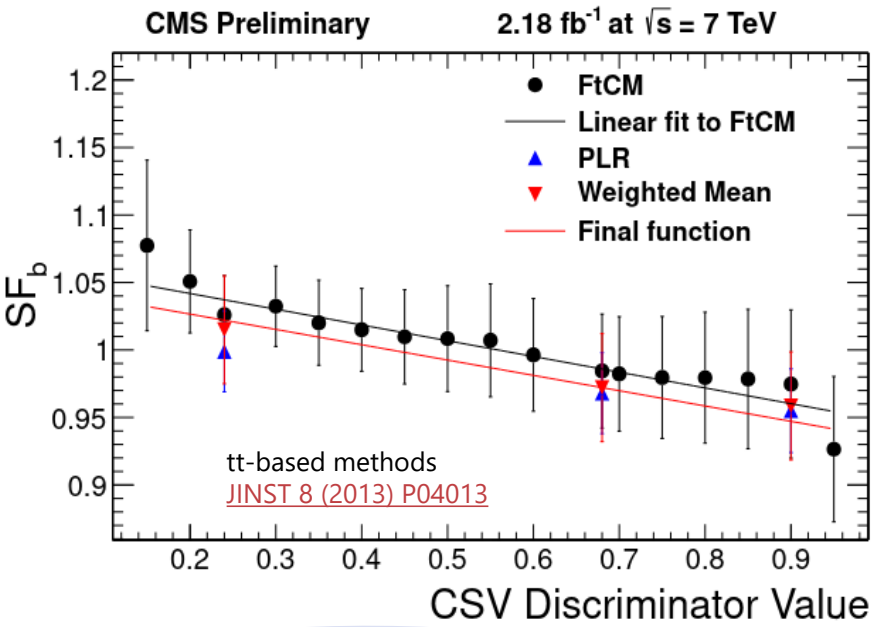
"Meenakshi's enthusiasm, energy and commitment were crucial for starting a successful CMS top mass program!"

- Meenakshi's crucial contributions to b-tagging continued throughout Run 1 and Run 2.

- She was appointed BTag and Vertexing (BTV) co-convener in 2011-2012 and led by example, an enthusiastic and creative group of about 30-40 people

- As convencer, she constantly stimulated open discussion of the main challenges and prompted for new avenues to improve precision and reliability of methods- e.g. "*we have now enough top data to measure as function of the discriminator, p_T, η*"

- Simultaneouly set smart goals for the group: results were crucial for top, H→bb, searches



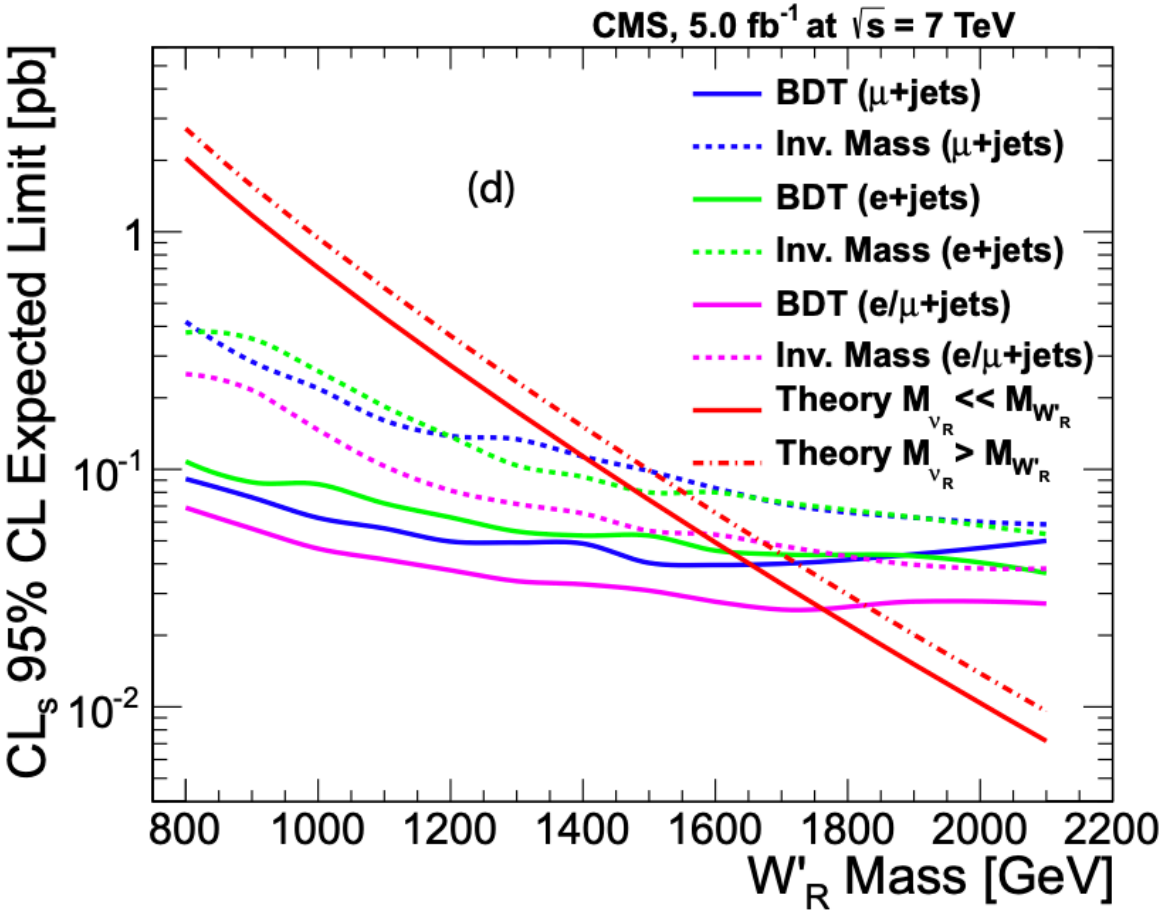
"Meenakshi truly reached out to young people - she would ask our opinion and give value to it even though she was much more experienced than us. And she would reach out to "catch up" every single time she came to CERN. She took us on board as scientific peers and persons. That kind of respect is irreplaceable."

Meenakshi really enjoyed the friendly and lively atmosphere of the BTV group in CMS and actively (animatedly!) engaged in many meetings and workshops over the years (through Run 1, Run 2, the pixel Phase 1 upgrade and HL-LHC studies)

b tag Workshop, VUB Brussels, Apr. 2018

Top as a tool for discovery – Run 1

Building on our D0 search: W'→ tb

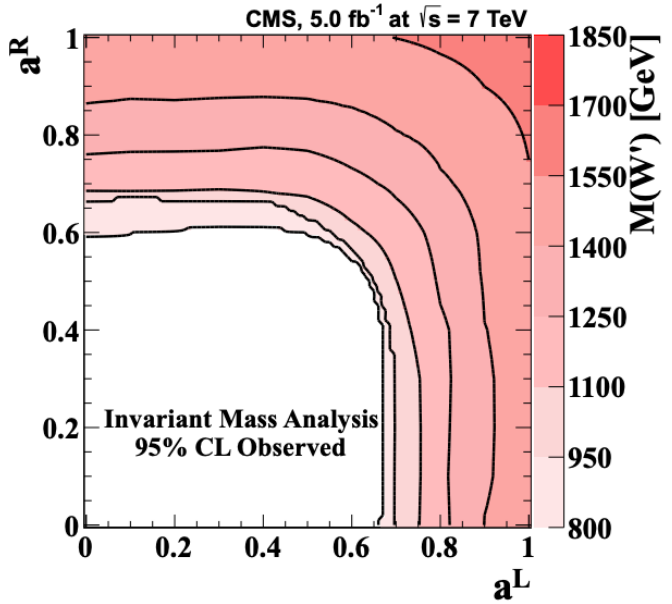


Phys. Lett. B 718 (2013) 1229

Large gains due to use of boosted decision trees

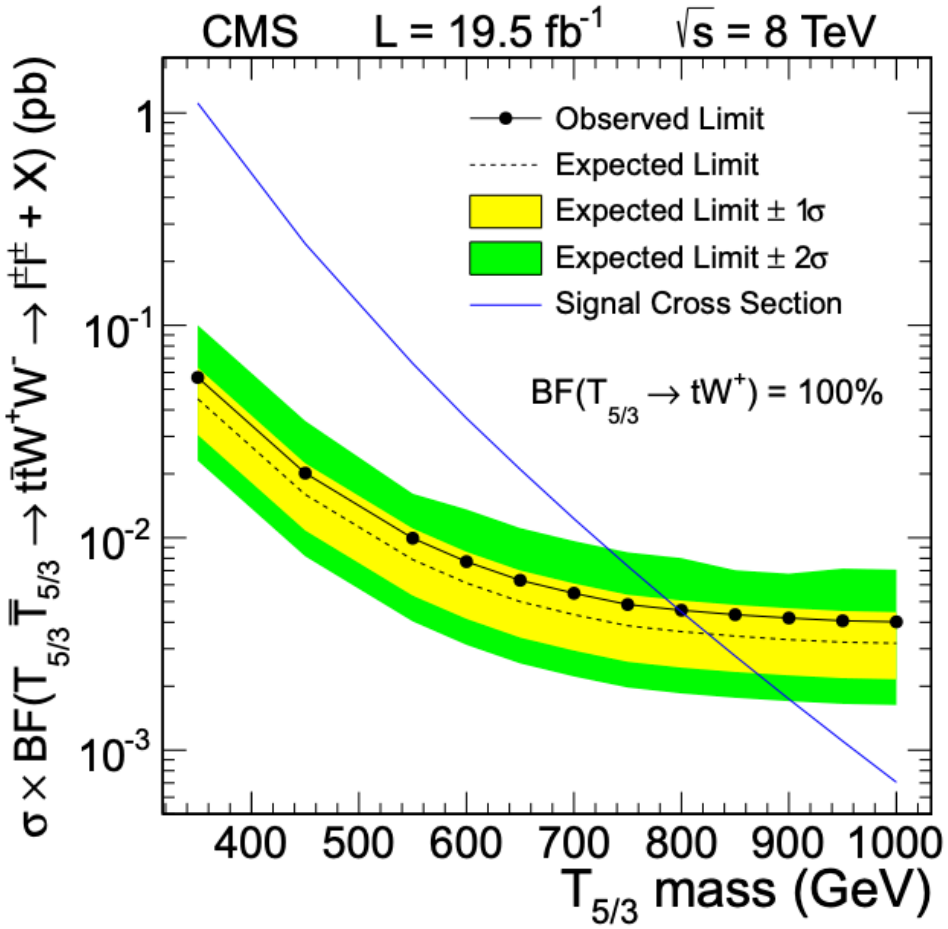
Looked at arbitrary combination of left and right-handed couplings

A first for the LHC!



Top as a tool for discovery – Run 1

- The B2G (Beyond 2 Generations) physics analysis group was created in 2012 and Meenakshi jumped right in with several analyses



Search for T(5/3) production:

A first for the LHC!

Same-sign dilepton final state

Data-driven background estimation methods for estimating backgrounds

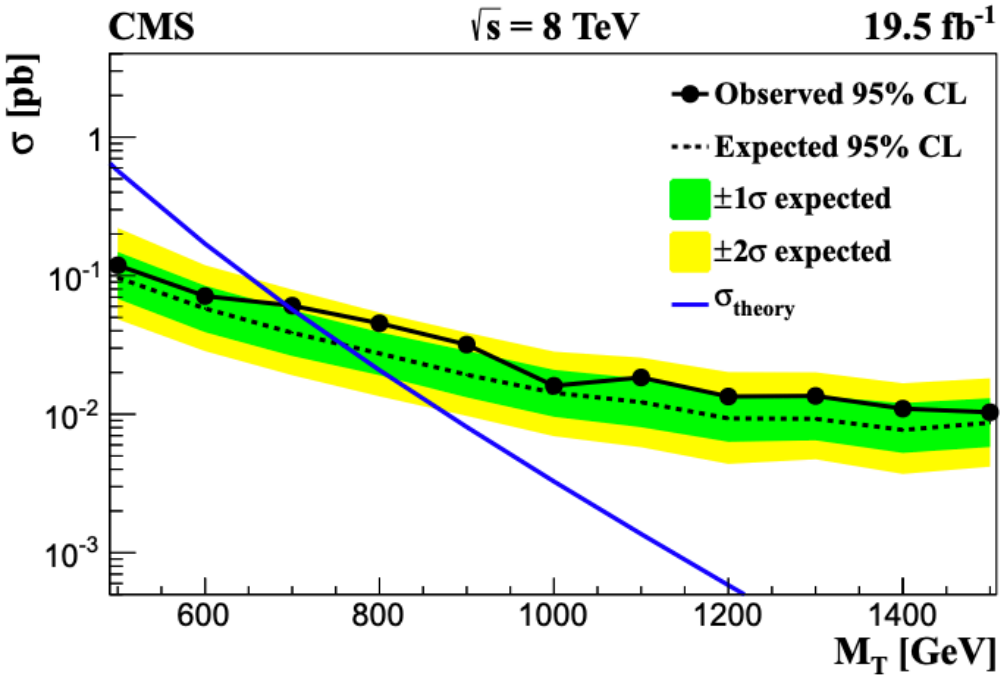
Use of jet substructure techniques for boosted tops/W

Phys. Rev. Lett. 112 (2014) 171801

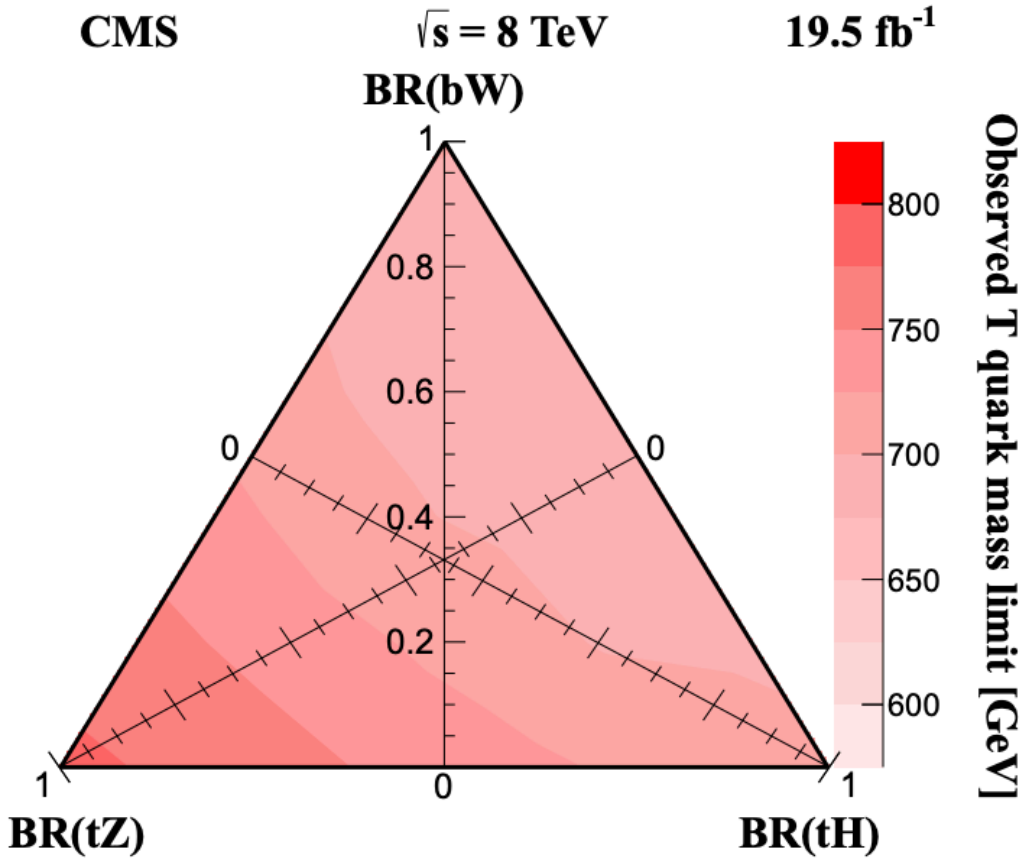
Top as a tool for discovery – Run 1

- Inclusive search for a vector-like top quark T w/ charge 2/3
- First search to consider all three decays: bW, tZ, and tH
- The first VLQ “triangle” plots!

Phys. Lett. B 729 (2014) 149



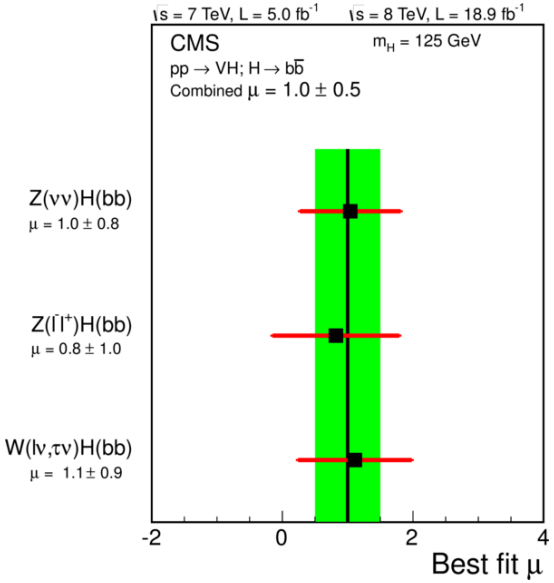
nominal branching fractions:
into bW, tH, tZ of 50%, 25%, 25%

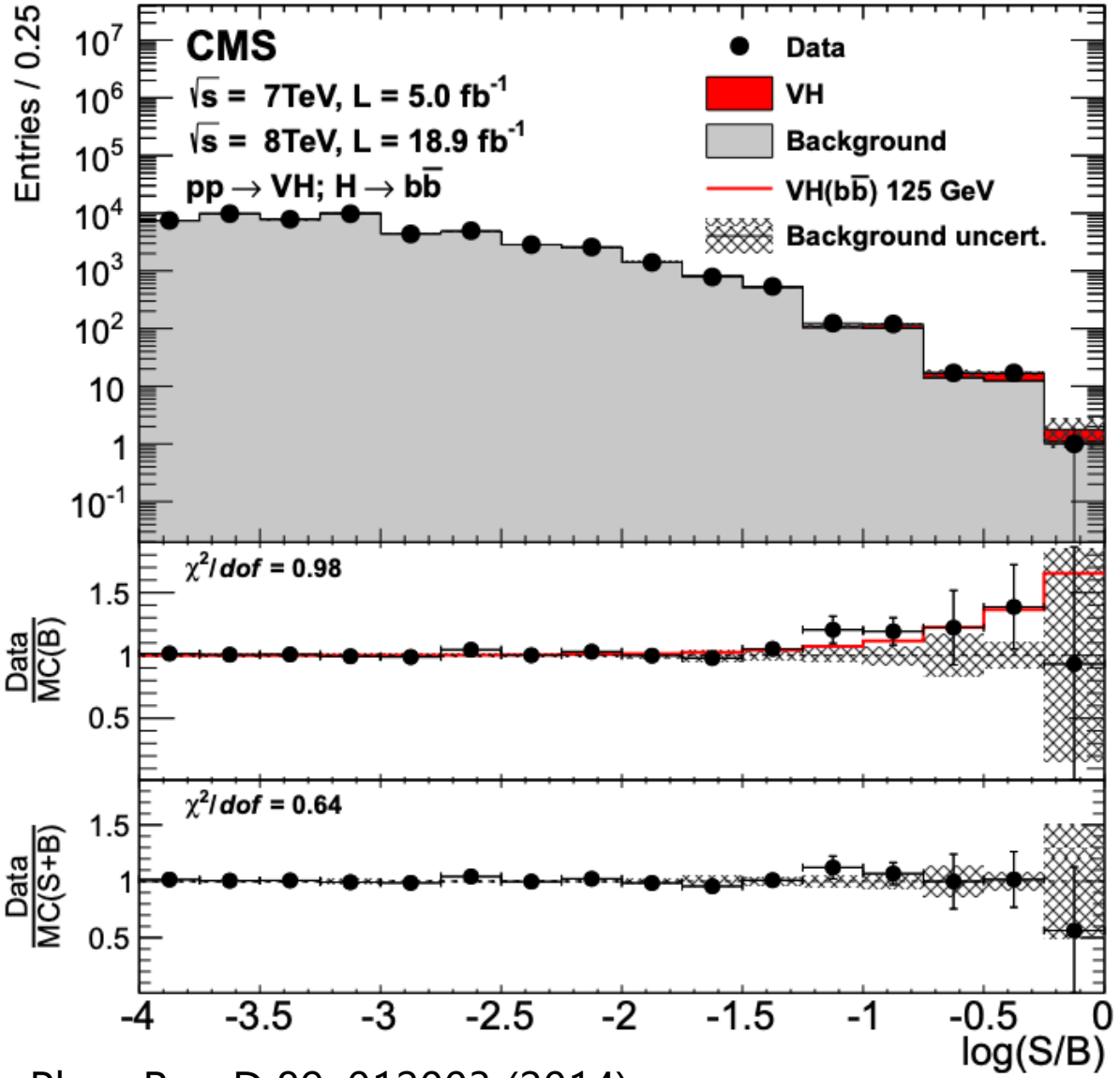


Hunting for the Higgs – Run 1

- Search for SM Higgs boson in the W(τν)H(bb) final state
  - Took advantage of Meenakshi's extensive b-tagging experience. BDTs
- Combination with other VH channels

  → first indication of H->bb (2.1 σ)

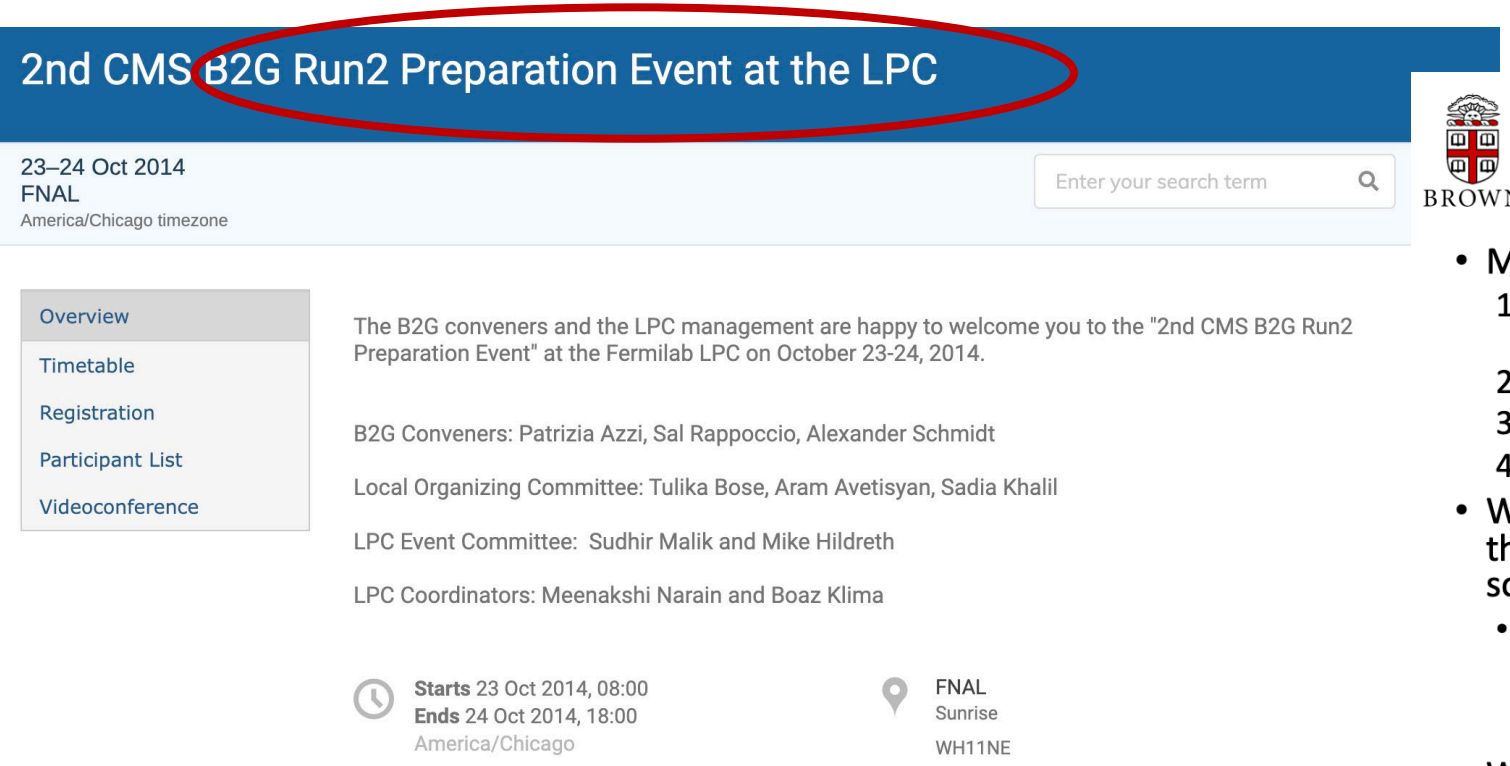




Phys. Rev. D 89, 012003 (2014)

Top as a tool for discovery – Run 2

Meenakshi played an important role in preparations of search analyses for Run 2



Meenakshi's talk on "VLQ Analysis for 2015 with a Focus on "Discovery"

BROWN

Combining Efforts for Run2

- Most of the effort in
  1. understanding global Data/MC comparisons at the preselected sample stage
  2. background control region determination and evaluation
  3. fake rate for backgrounds
  4. lepton efficiency and trigger efficiency determination
- While #4 is mostly shared, much of efforts devoted to #1 through #3 are separate and to first order does not need to be so.
  - of course there are multiple ways of determining the eff and backgrounds, and it would be good to have this develop synergistically by final state signature (and lead to understand systematics etc)
- With focus on final state signature based analyses, a lot of basics common issues can be shared and thus "expediting" the publications

Meenakshi & B2G in pictures

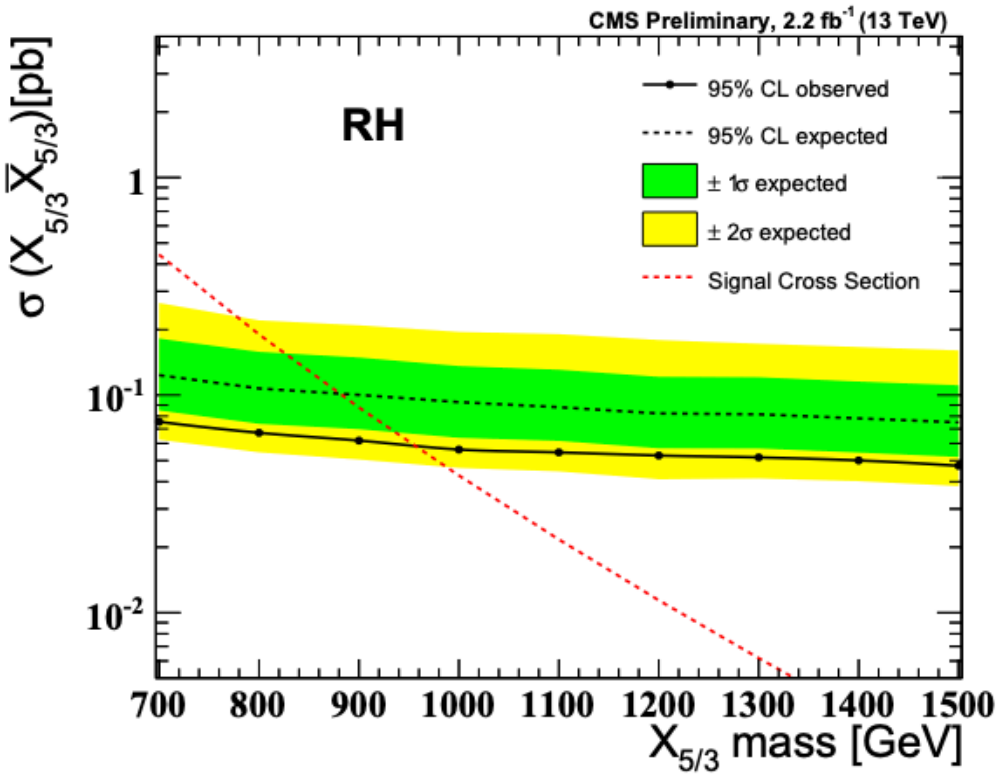
Dancing to Diwali music

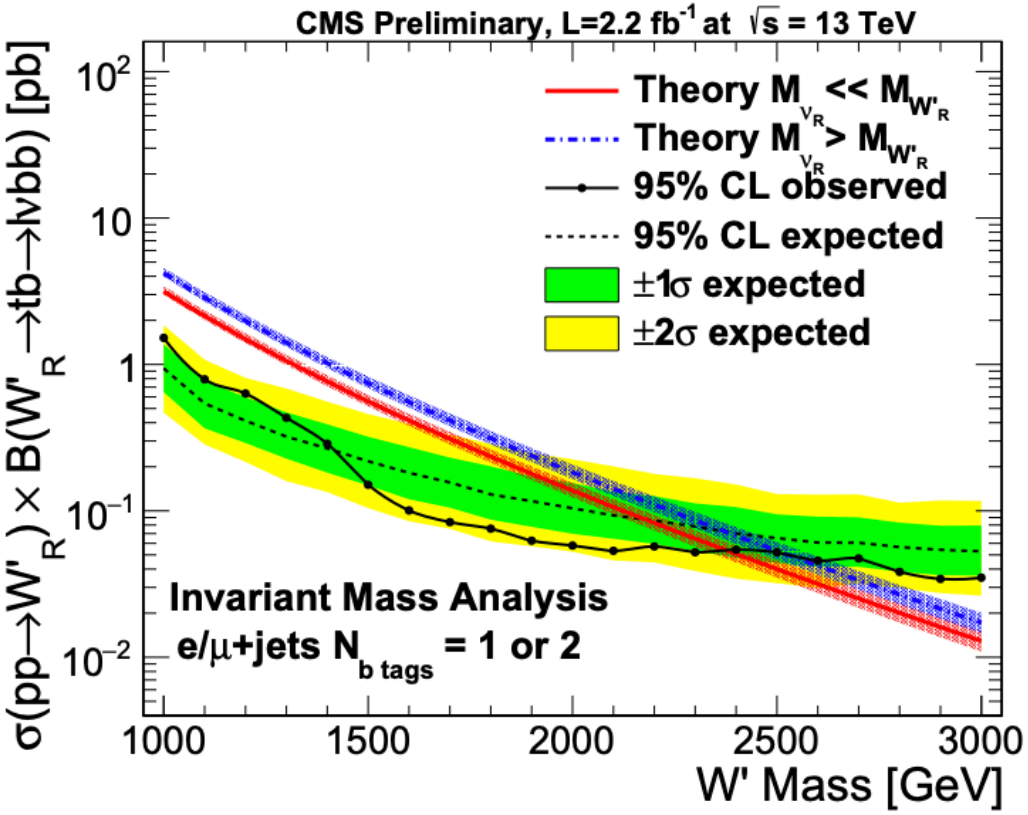
B2G dinners!

Cheering Germany during soccer

The first B2G Run 2 analyses (Dec 2015)

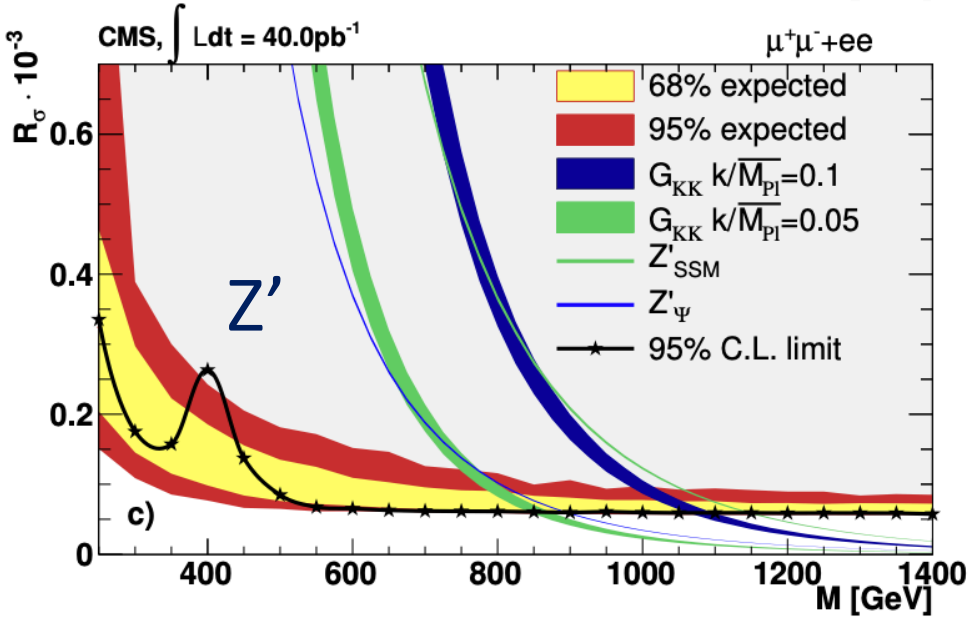
Within a few months of Run 2 data-taking at 13 TeV, the first search results shown at the end-of-year CERN jamboree

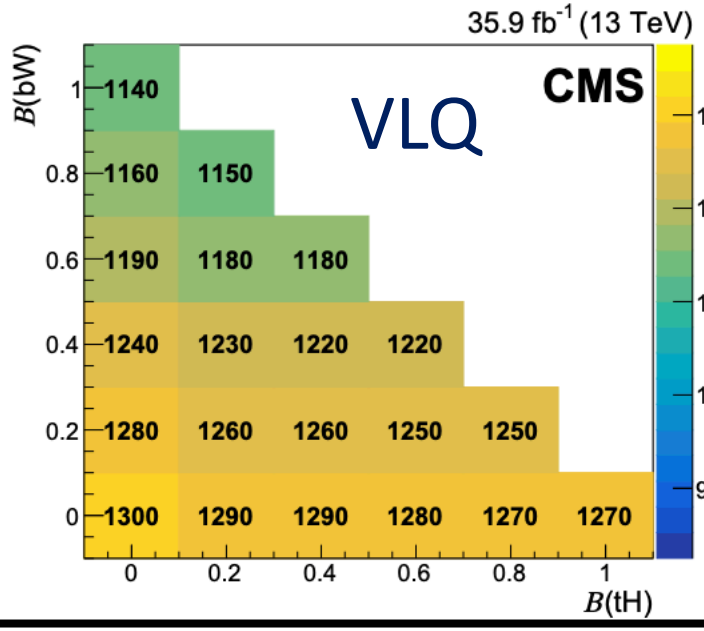


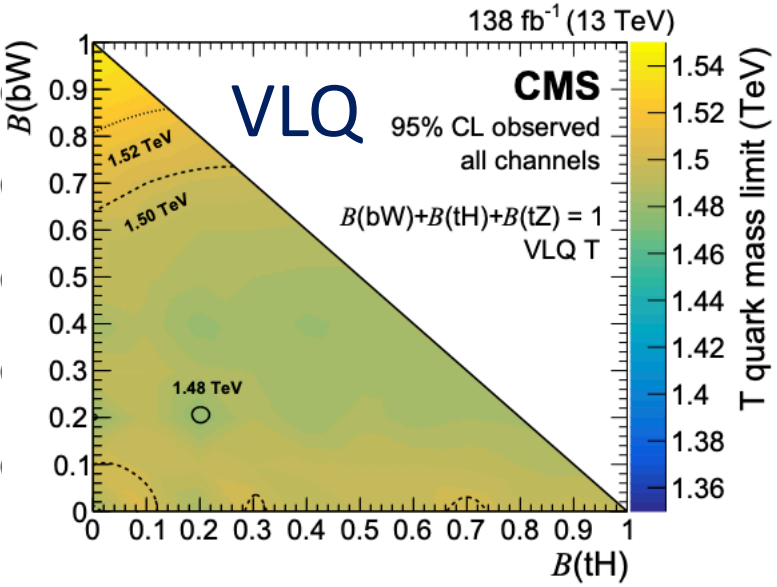


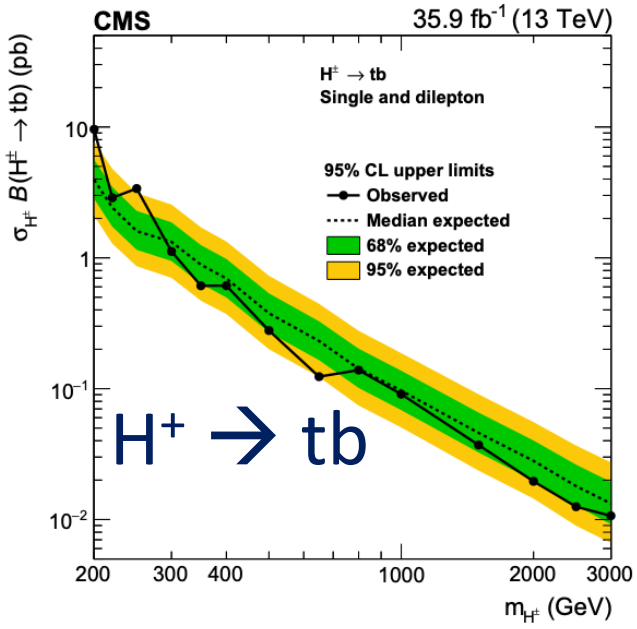
Many follow-on searches that took advantage of Meenakshi's expertise in several areas: top, b-tagging, MVA methods, strong connections with theory community….

And many more…



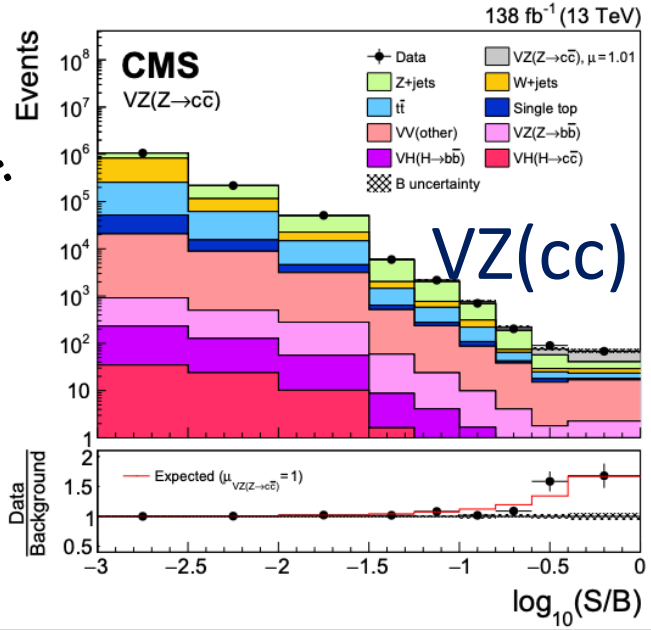


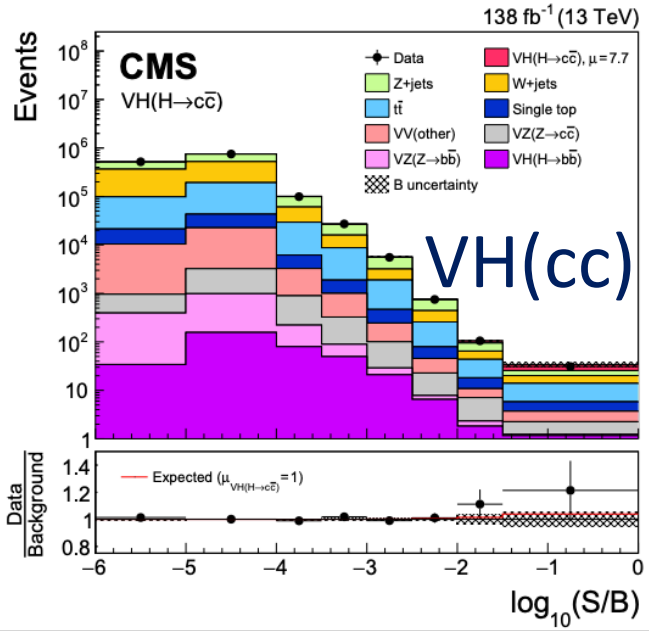




VZ/VH (cc)
"Resolved" jet topology:
Brown + Aachen

arXiv:2205.05550

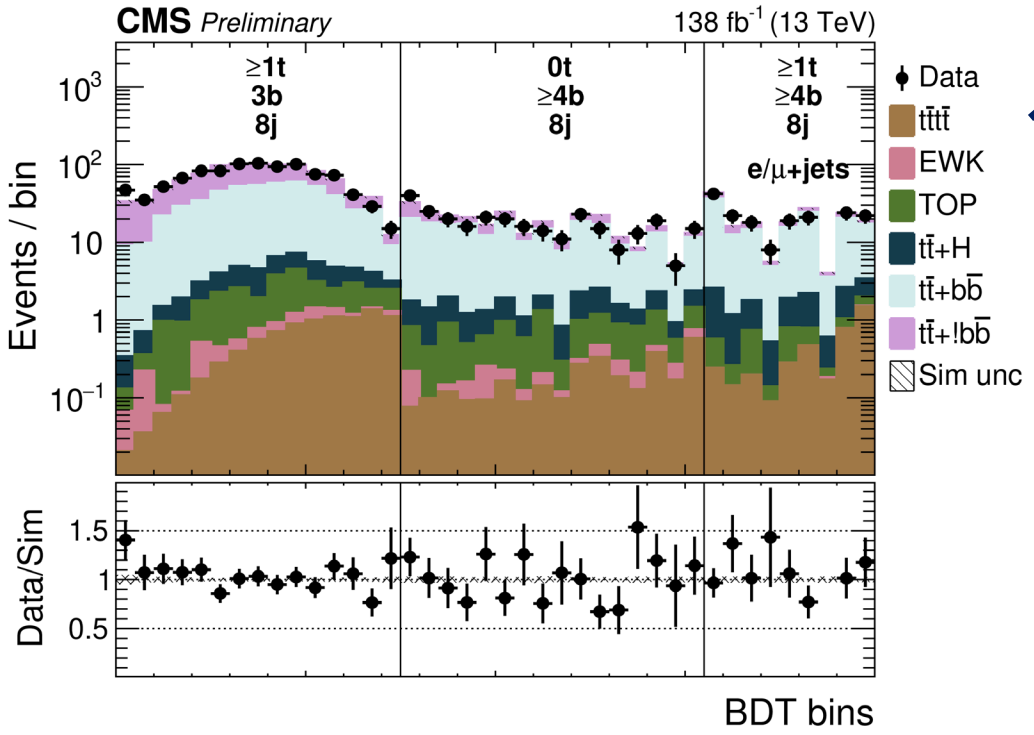


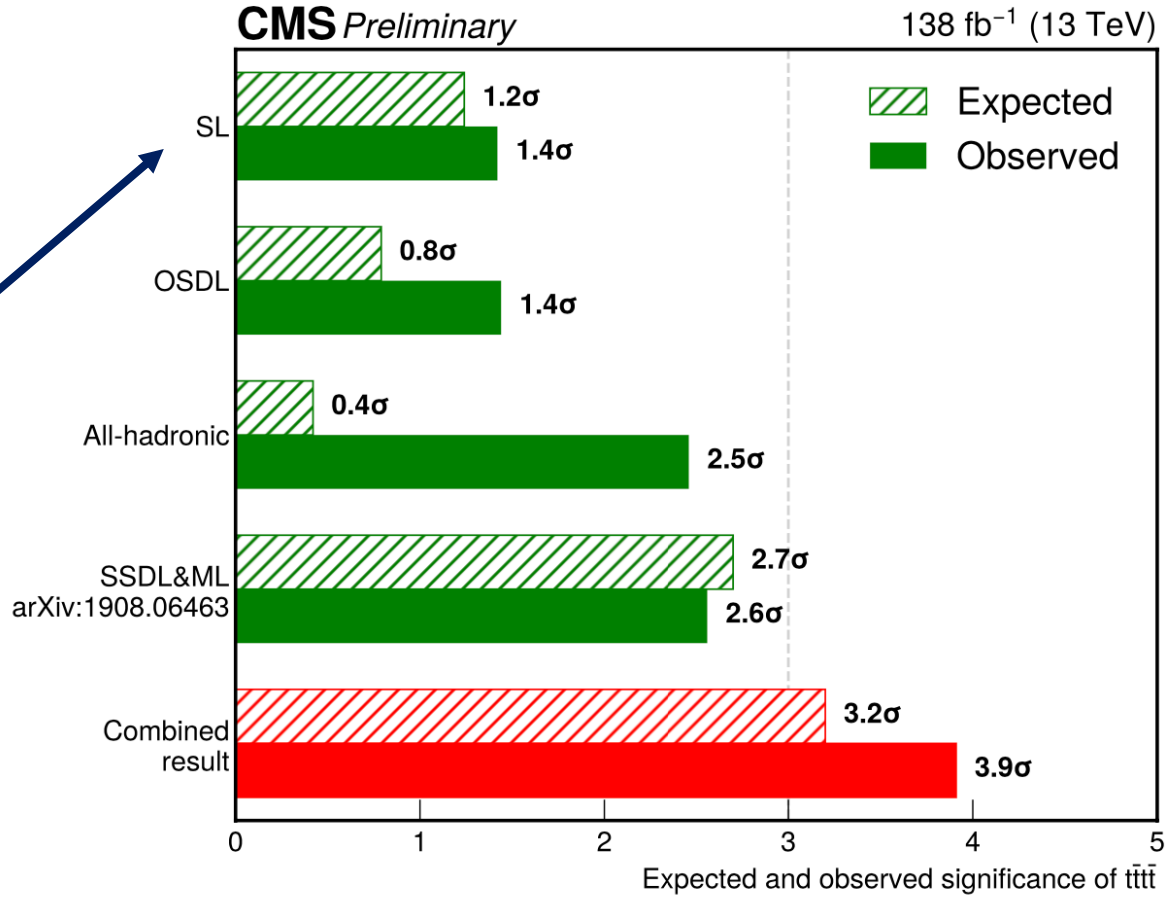


Evidence for four top quark production

Fast-forward to 2022

- Taking advantage of improved methods of b-tagging, top identification, BDTs, full Run 2 luminosity, upgraded detectors…





TOP-21-005

The top legacy...

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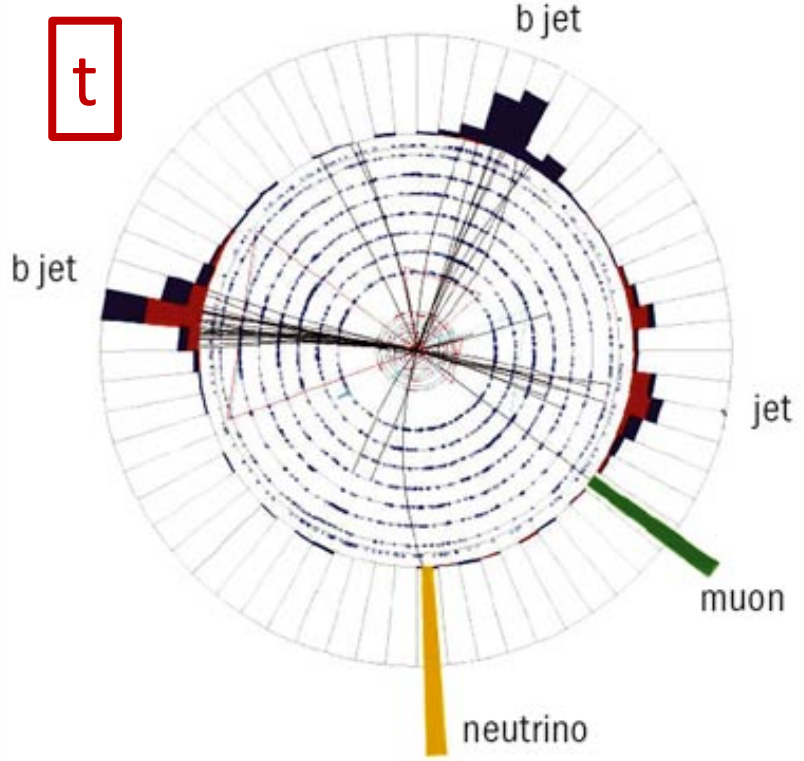

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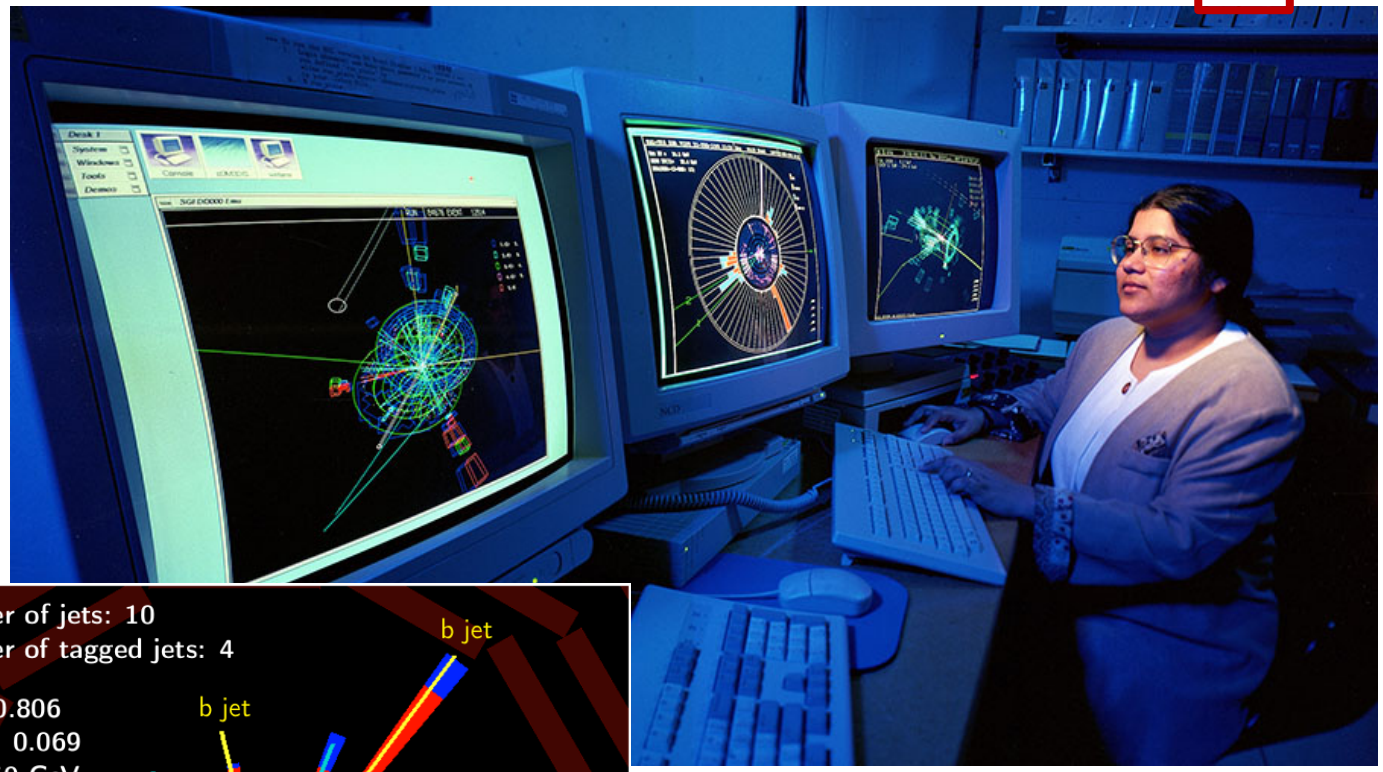
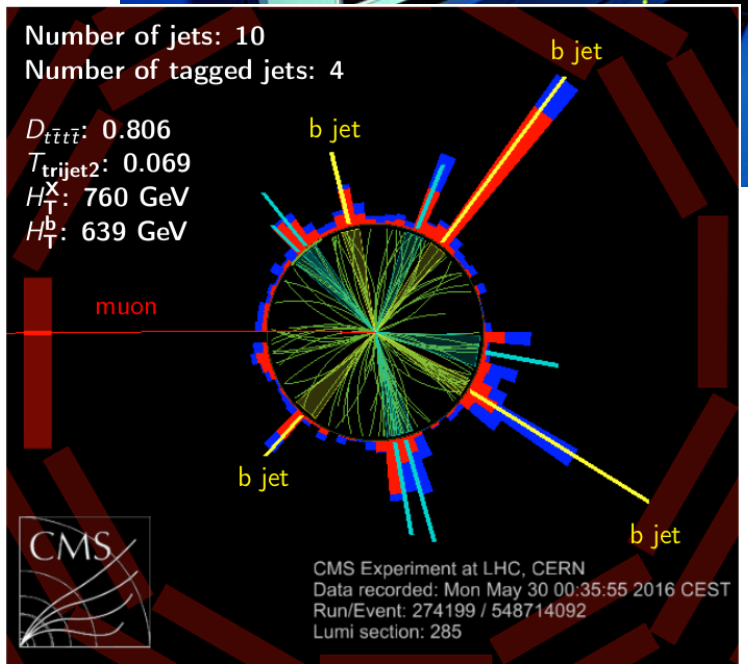




tttt

What about ttt production ?

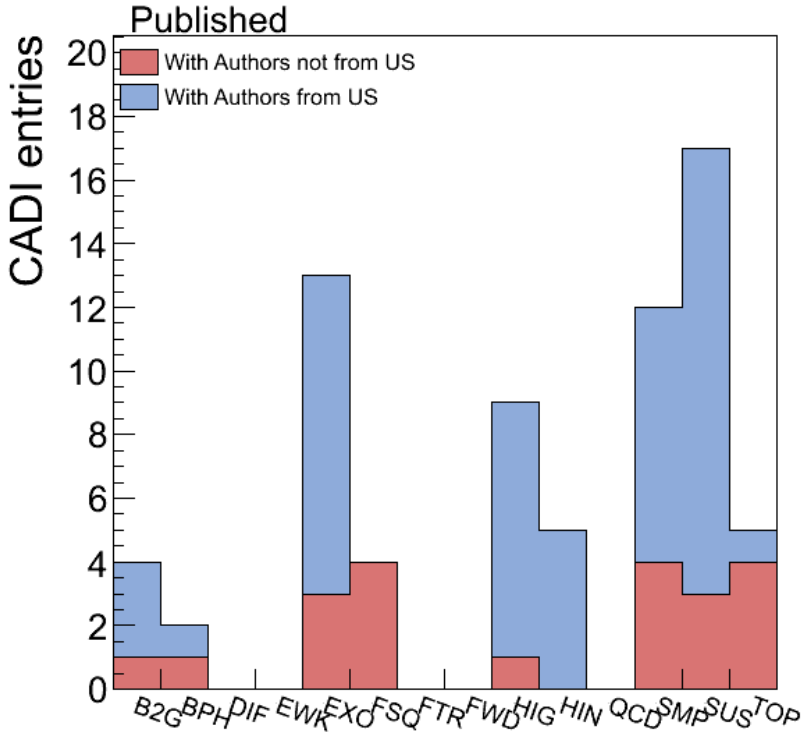
Meenakshi's student currently working on this analysis, in review

Enabling Physics - LPC

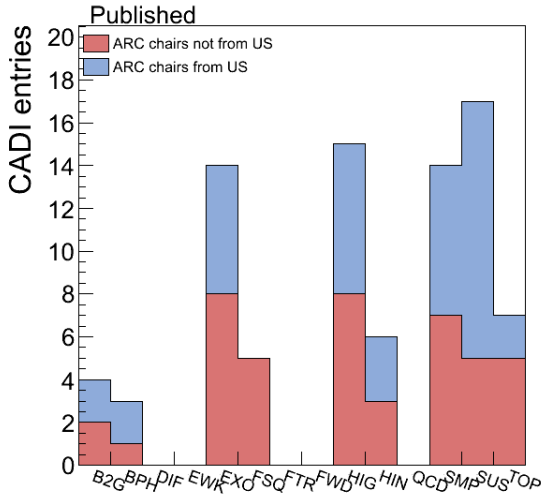
- Meenakshi served as the LHC Physics Center (LPC) co-coordinator for two terms (2013-2017)
  - Included the critical period before and at the start of Run 2

Meenakshi was the **driving force** behind changing the CMSDAS exercises from the good-old Run1 software to the emerging (and in many cases not yet fully debugged) Run2 software back at **CMSDAS2015 ("Preparations for Run2")**.

"It was a heroic effort, which would not have been done if not for Meenakshi's persistence and dedication"



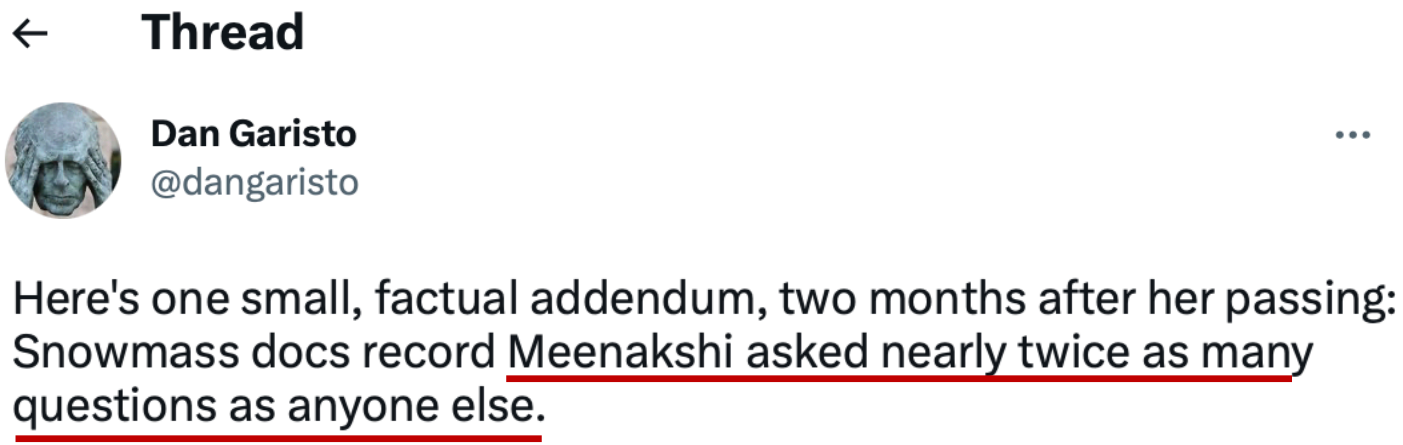
Meenakshi's plots (2014) were key in demonstrating US leadership in physics (very useful for reviews!)



Enabling Physics - ARCs

- Meenakshi served on innumerable Analysis Review Committees (ARC) and **chaired 17 of them!**
- The chair bears the brunt of the work while shepherding analyses through the exhaustive CMS review/publication process
- Meenakshi had an excellent eye for catching problems and very few would go un-noticed!
- At the same time, while being thorough, she was pragmatic and efficient

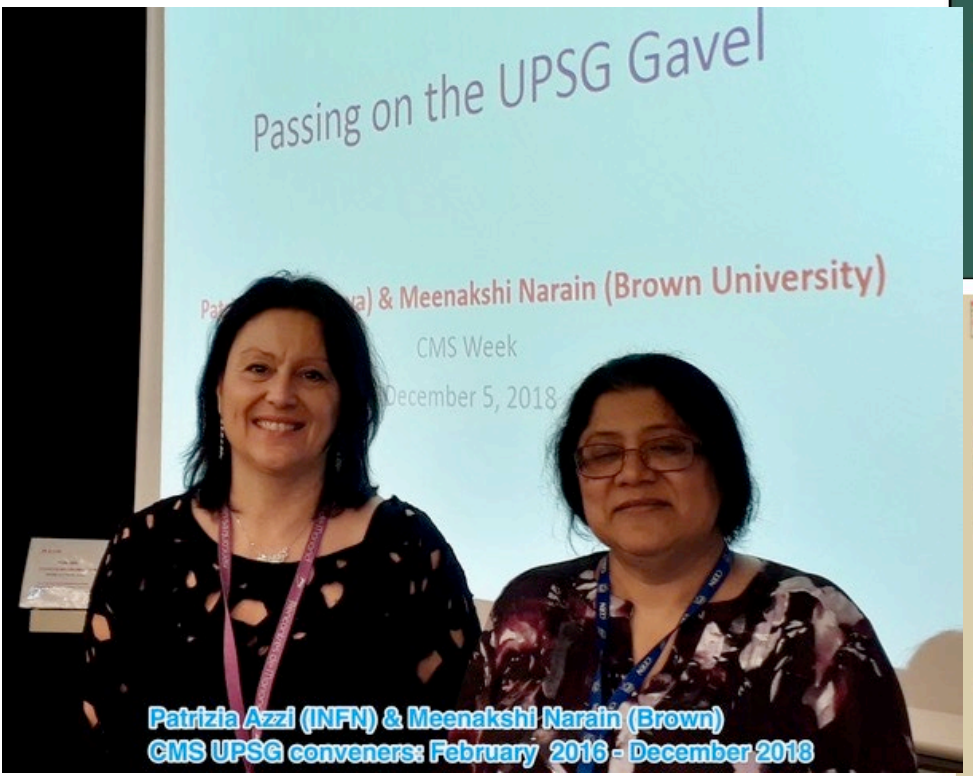
"Learned a lot from her - always be rigorous when claiming something"
Putting forward a result with a claim we can measure something to x% is different from validating a method"

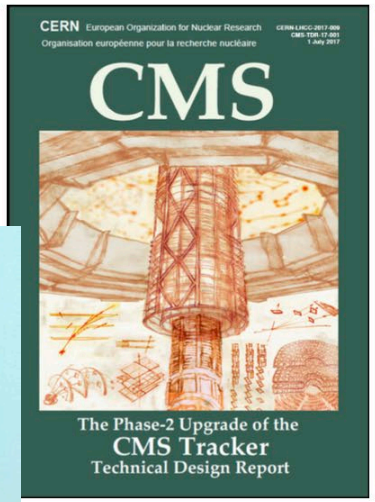


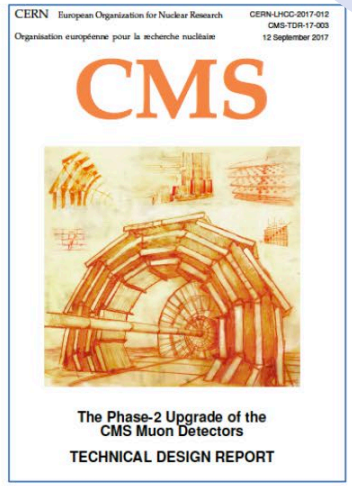
UPgrade Studies Group (UPSG)

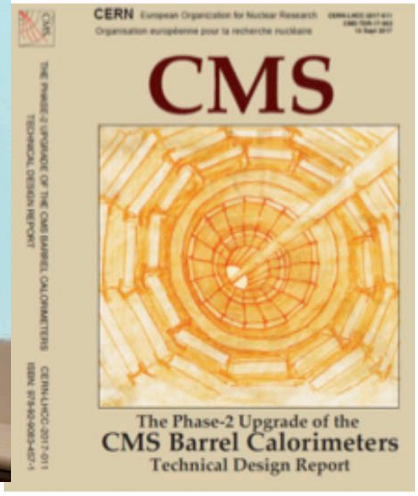
"It was good to have someone that was really a co-convener, a collaborator that knew how to work in a team, together. I am extremely proud of what we accomplished. It would not have been possible without her energy of course. "

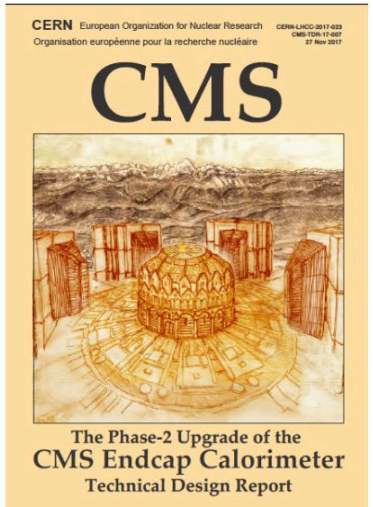
Under Meenakshi's leadership, there were **4 TDRs and 41 analyses** documented in the CERN "Yellow Reports"











CMS

Technical Proposal: CERN-LHCC-2015-010
https://cds.cern.ch/record/2020886
Scope Document CERN-LHCC-2015-019
https://cds.cern.ch/record/2055167
Tracker TDR
https://cds.cern.ch/record/2272264
Barrel Calorimeter TDR
https://cds.cern.ch/record/2283187
Muon TDR
http://cds.cern.ch/record/2283189
Endcap Calorimeter TDR
https://cds.cern.ch/record/2293646
L1 Trigger Interim document
https://cds.cern.ch/record/2283192

PHYSICS STUDIES
http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/FTR/index.html

Meenakshi Narain:

A **brilliant scientist**, a **beloved mentor** and an **inspiring leader** who made the world a better, more equitable and inclusive place.

Her legacy will live on via the generations of physicists she inspired over the years.

A few personal comments...

Heard the forecast?
A baby is predicted, but first there will be a Shower!

You are invited to join us for lunch
as we honor and bless

Tulika and Kevin

during the Shaadh ceremony

Sunday, August 29, 2010
12:30 pm

Given by:
Family and Friends

RSVP by August 22nd

(narain@hep.brown.edu)