

Pixel Upgrades and Long-lived Searches

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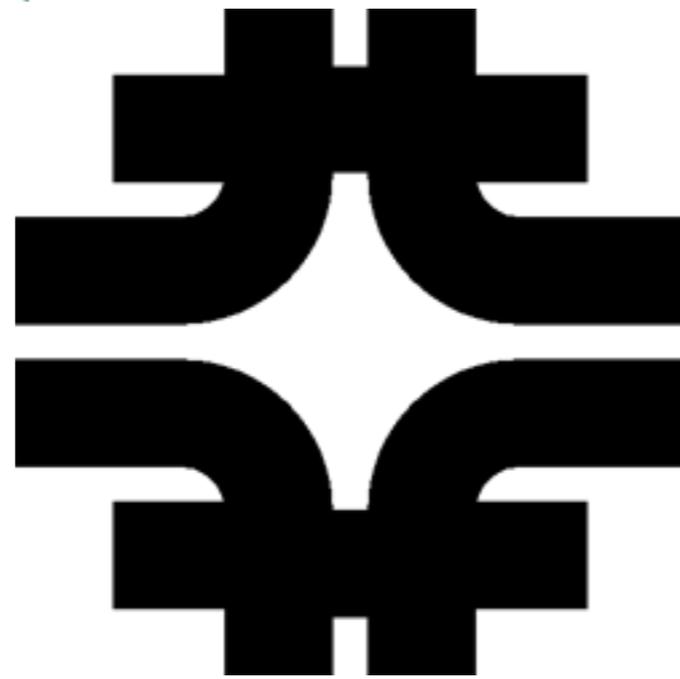
2016 LPC Junior Distinguished Researcher



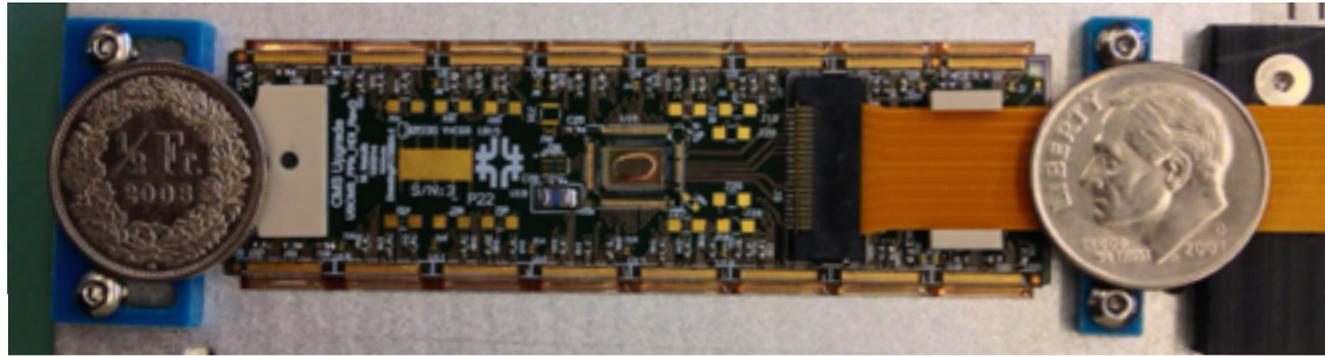
THE OHIO STATE UNIVERSITY



Phase 1 Pixel Upgrade at FNAL



Detector now under construction

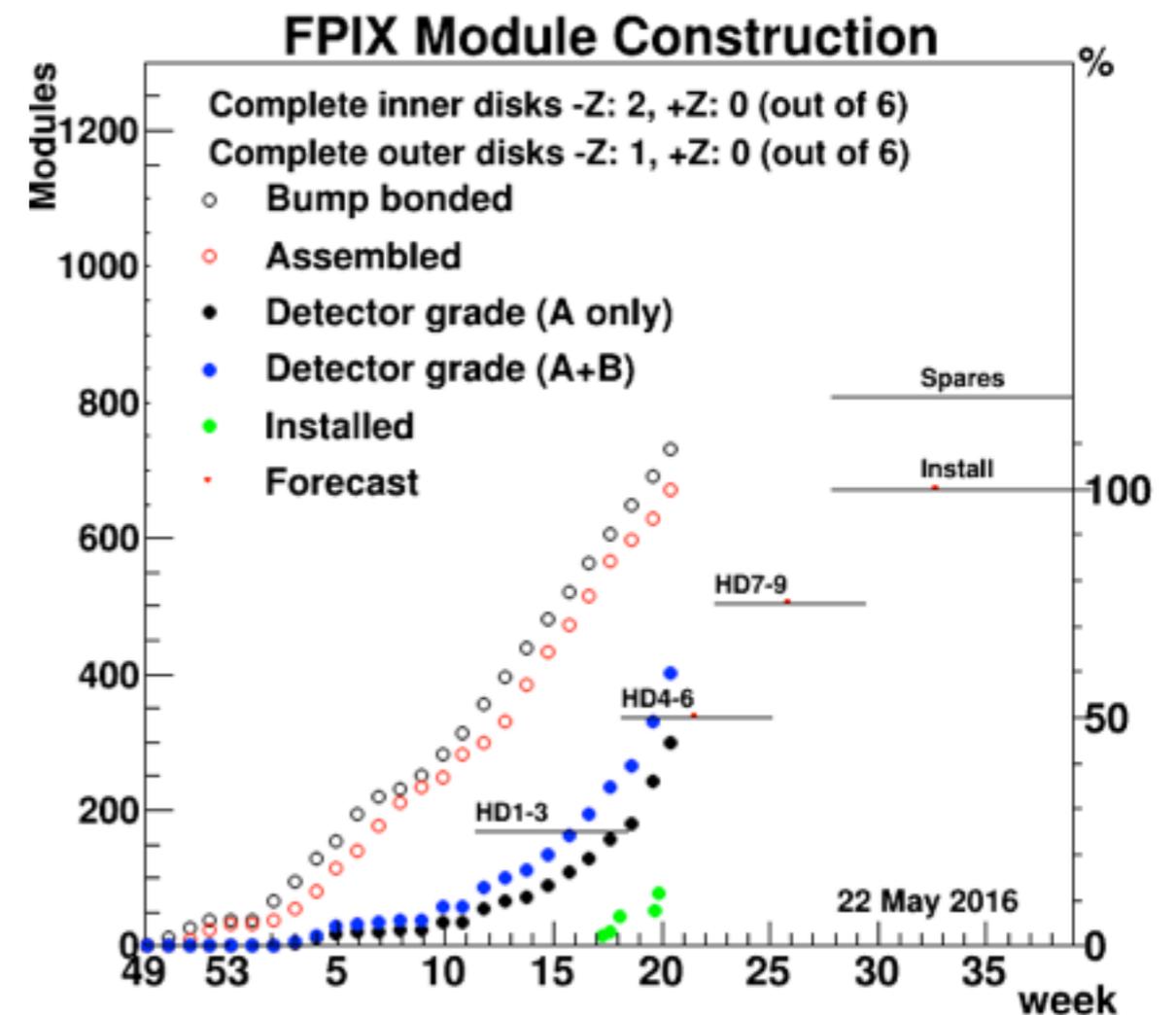
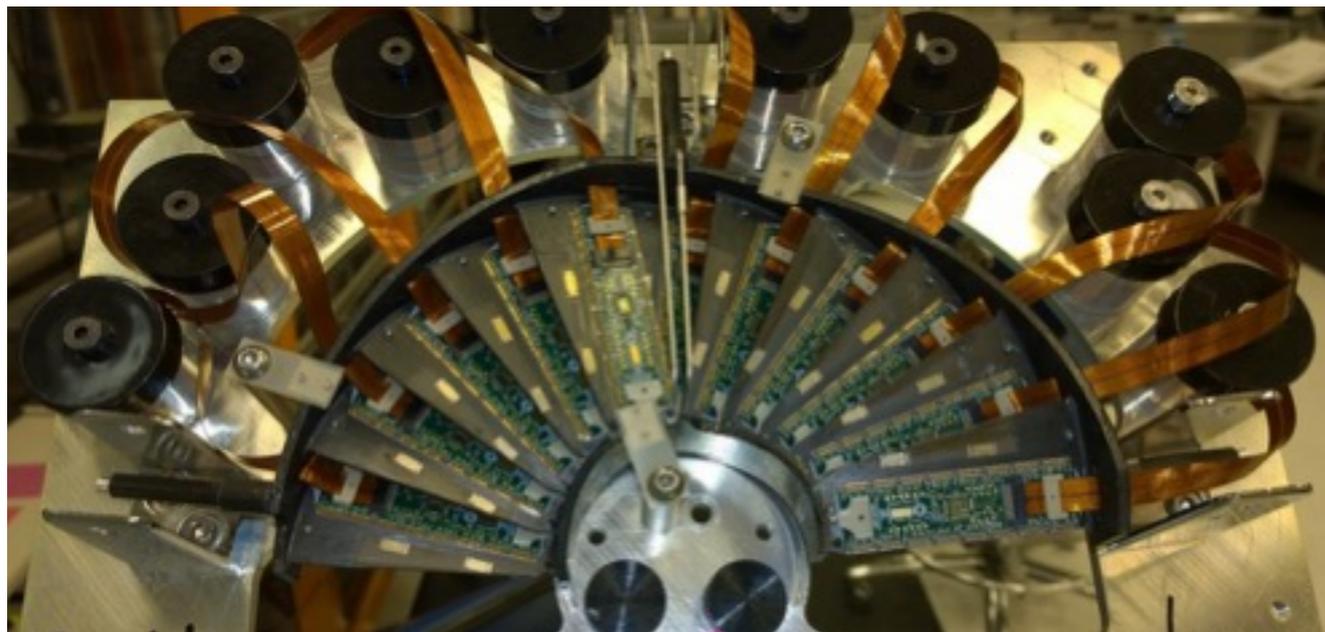


We've started mounting modules on support structures in parallel with module testing

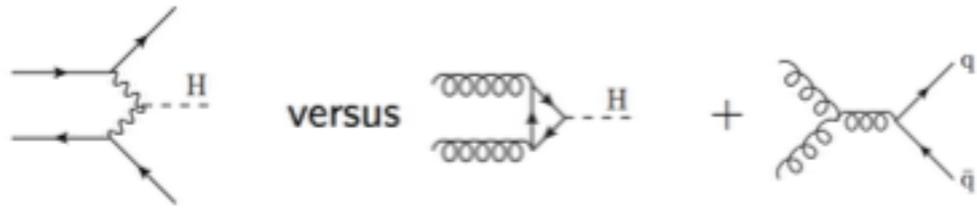
Pictures show first fully instrumented forward pixel half disk!



First half cylinder to be instrumented by the end of the month!

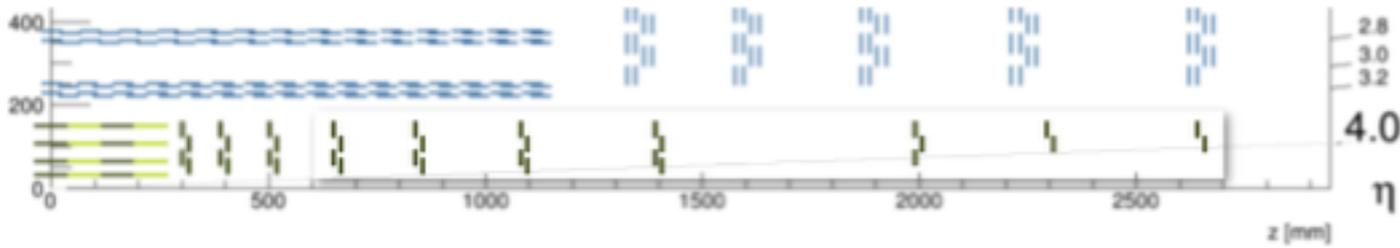


Phase 2 detector simulation



Key part of HL-LHC program requires distinguishing VBF events from gluon fusion plus pileup jets

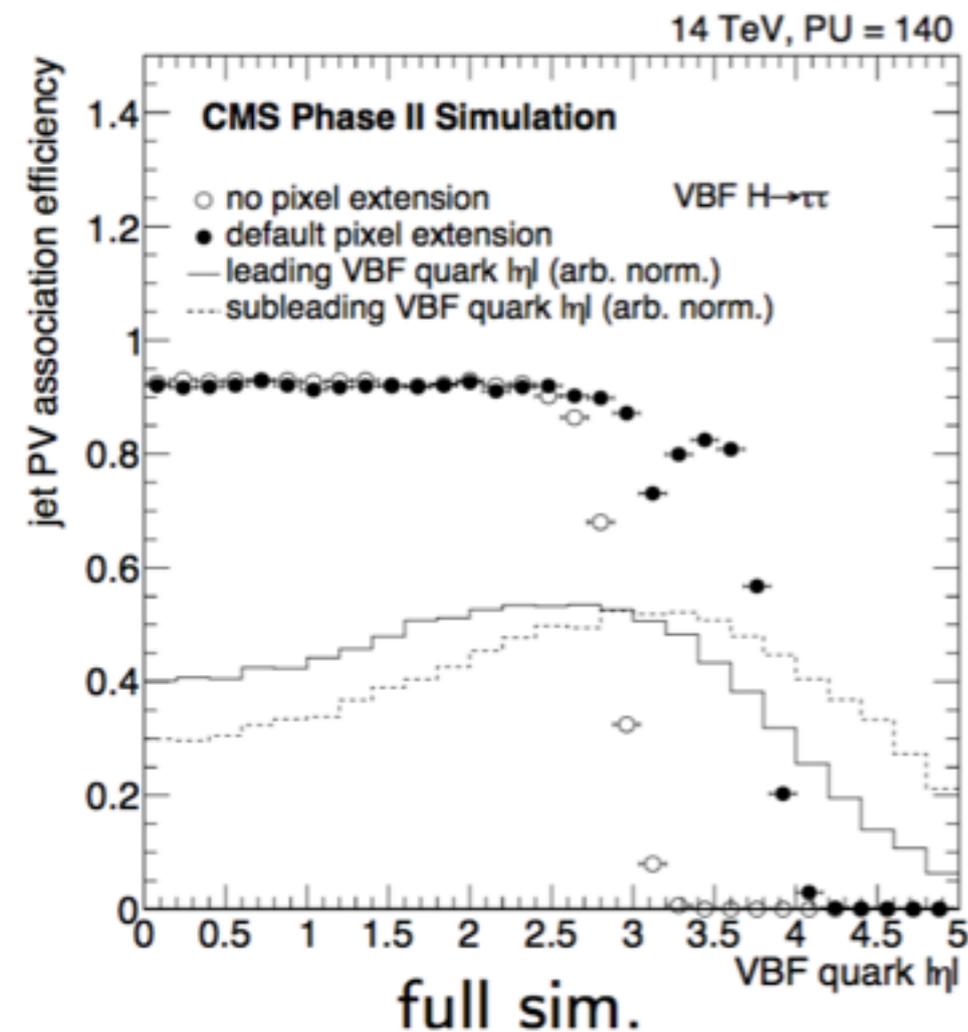
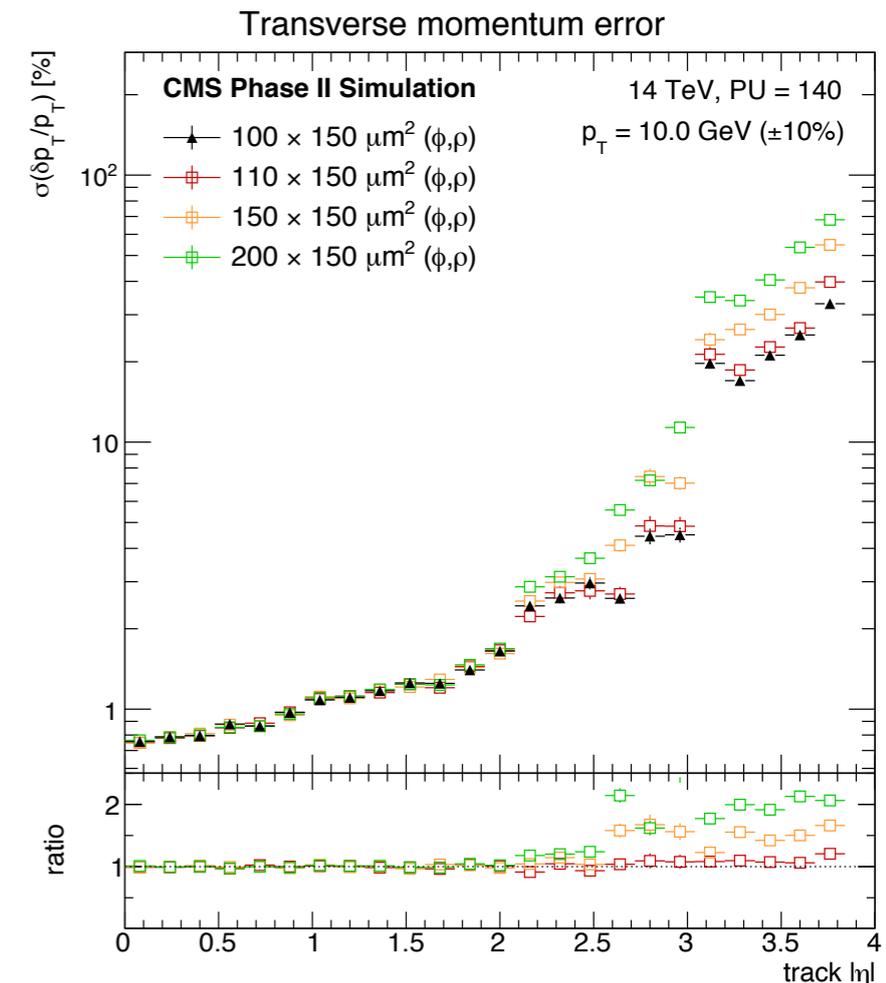
This motivates a forward pixel extension to $\eta=4$ to greatly increase VBF jet tagging region



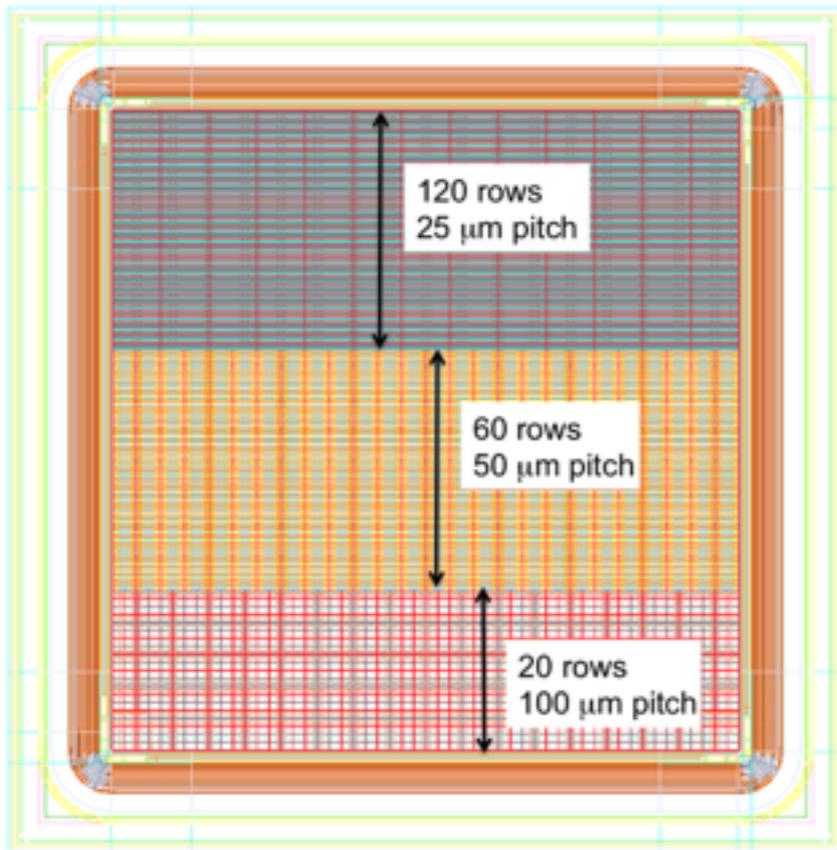
This detector needs to be designed and optimized - ***we're hoping to make the LPC ground zero for this important work***

Currently diffuse team from Buffalo, OSU, Cornell, JHU, others

We've done studies varying the number and position of disks and varying pixel sizes



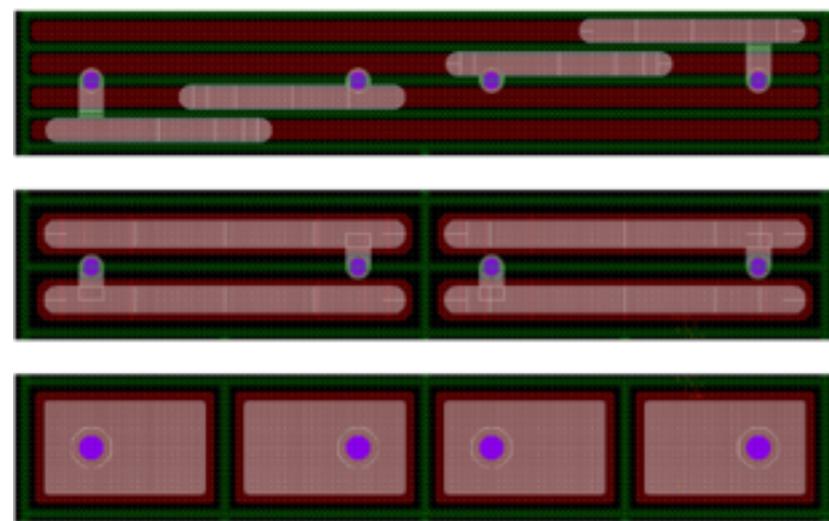
Phase 2 detector R & D



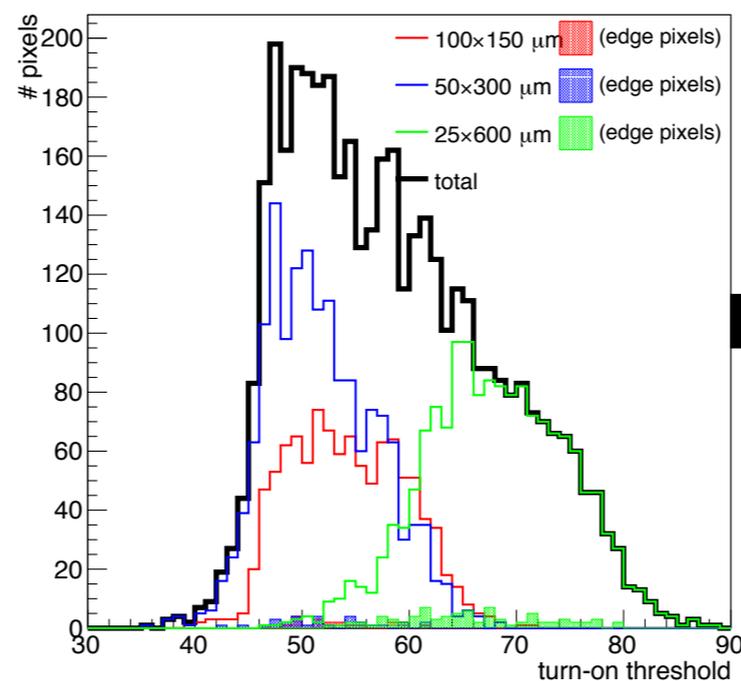
But can we actually build modules with smaller pixels?
Yes, yes we can

Sensors built with 3 regions of different pixel pitches,
bonded to phase 1 readout chip

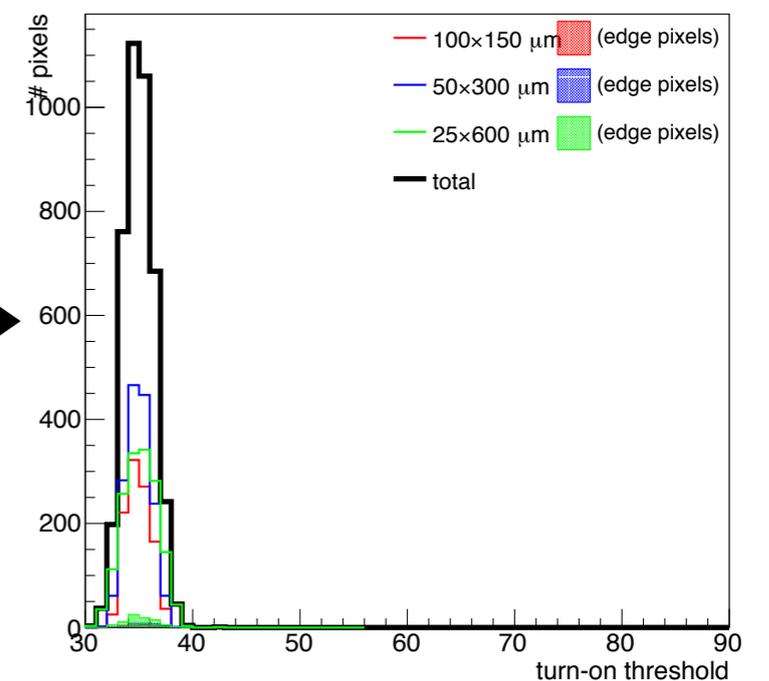
Working with Caterina and other FNAL staff, I was able to
apply my phase 1 experience to help calibrate these
devices: challenging before irradiation, *very* challenging
after irradiation



before calibration

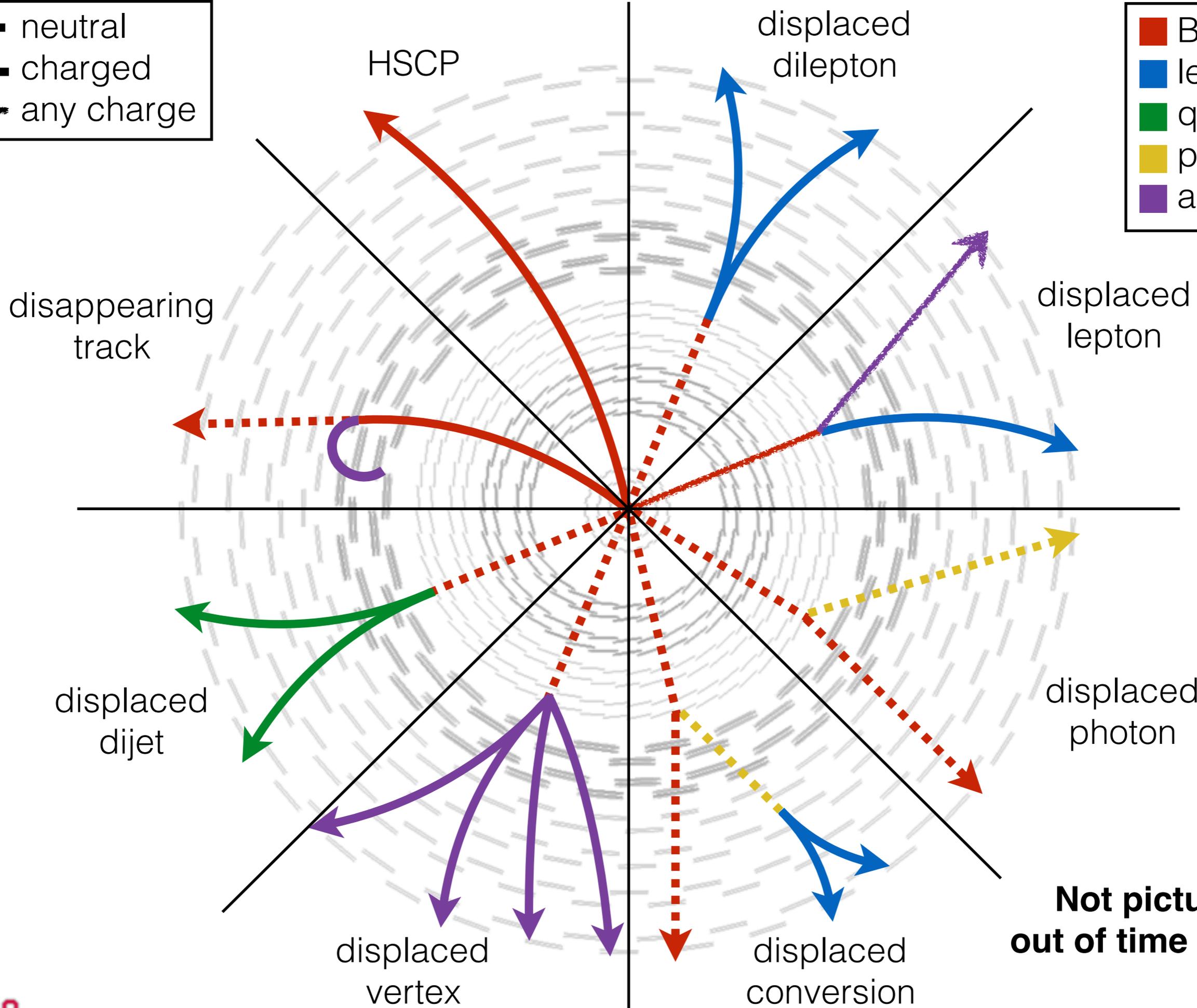


after calibration



■■■■ neutral
 ——— charged
 - - - - any charge

■ BSM
 ■ lepton
 ■ quark
 ■ photon
 ■ anything



CMS has a broad, growing LL program

	Final state targeted	7 TeV	8 TeV
1	displaced SF dilepton pairs	1211.2472	1411.6977
2	displaced μ - μ pairs in muon system		2005761
3	displaced e- μ pairs		1409.4789
4	displaced μ - μ pairs (dark photons)		1506.00424
5	displaced photons using ECAL timing	1212.1838	2063495
6	displaced photons using conversions	1207.0627	2019862
7	displaced vertices		to appear
8	displaced dijets		1411.6530
9	short, highly ionizing disappearing tracks		thesis
10	disappearing tracks		1411.6006
11	kinked tracks		thesis
12	fractionally charged particles	1210.2311	1305.0491
13	heavy stable charged particles (HSCP)	1205.0272	1305.0491
14	stopped particles	1207.0106	1501.05603
15	out of time muons		thesis

As standard methods of finding BSM physics continue to strengthen their constraints, long-lived signatures continue to gain interest as a way of hiding SUSY/DM/etc. in the LHC dataset

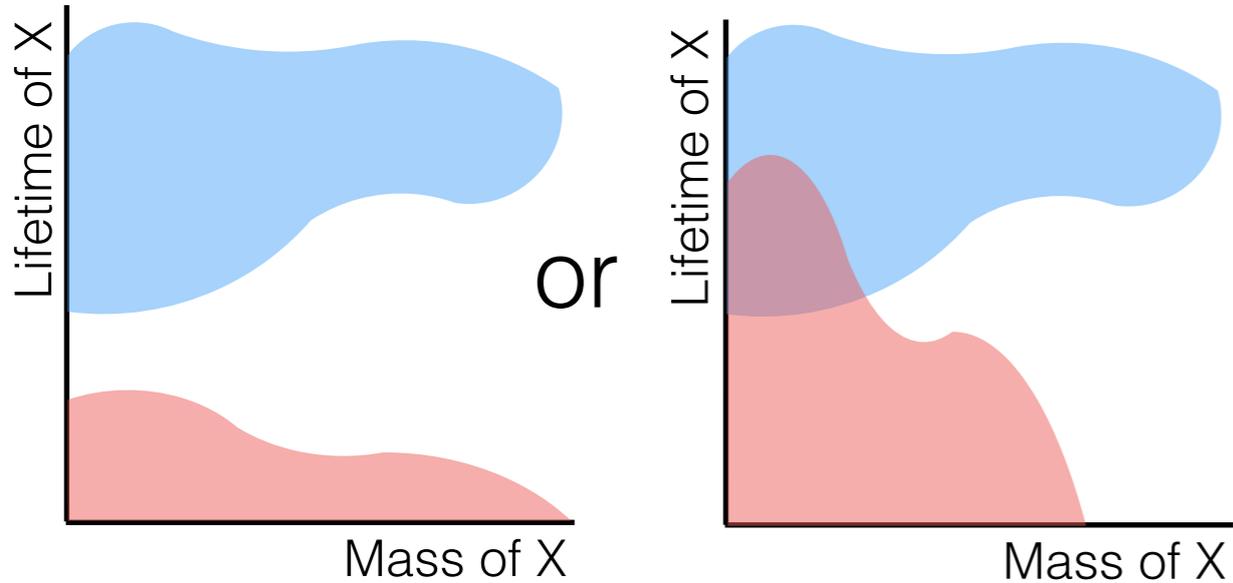
Up to now, long-lived analyses have been very separated from other searches - the LPC has the potential to change that!

13 TeV HSCP: 2114818

- direct searches
- indirect searches

Long-lived and prompt analysts need to work together

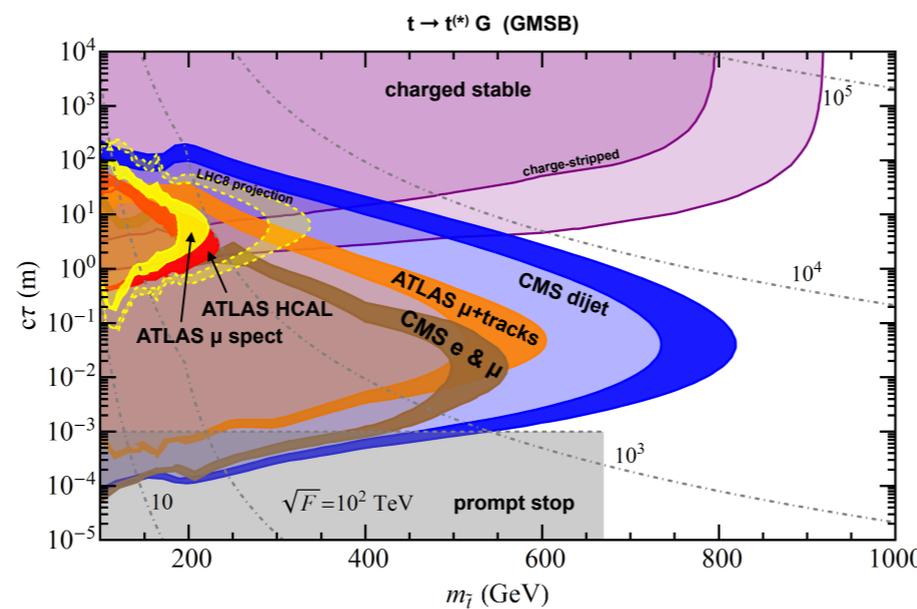
■ prompt search(es)
■ displaced search(es)



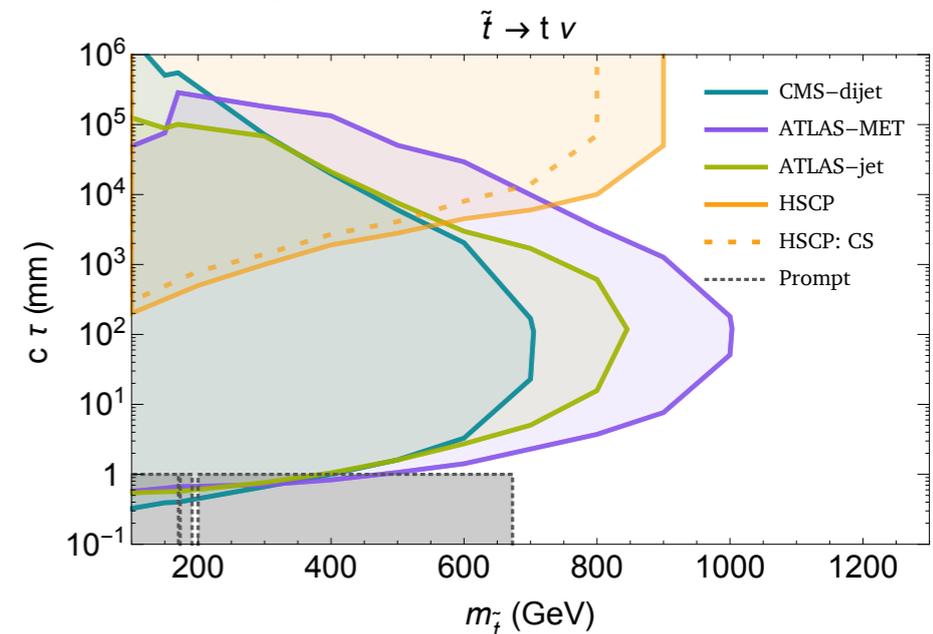
In principle, it's straightforward for "prompt" analysts to run over LL signal samples and produce such limit plots: *communication is the key*

Examples of LHC LL recasting by theorists

Theorists generally have difficulty producing exclusions of long-lived particle scenarios from prompt searches



[1503.05923](https://arxiv.org/abs/1503.05923)



[1505.00784](https://arxiv.org/abs/1505.00784)

There is a lot of potential for collaboration!

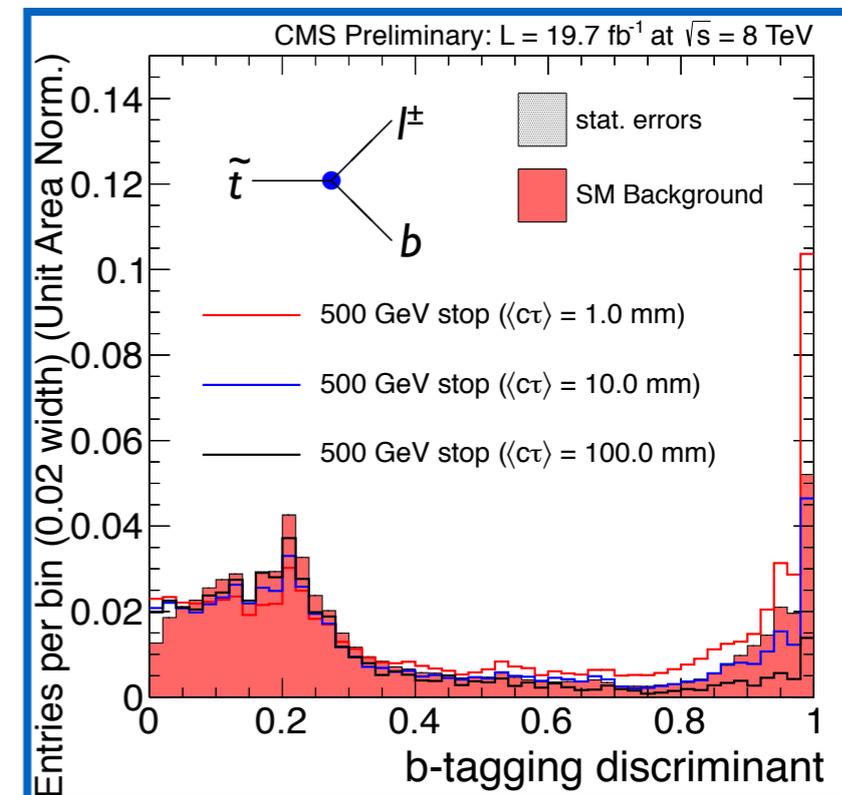
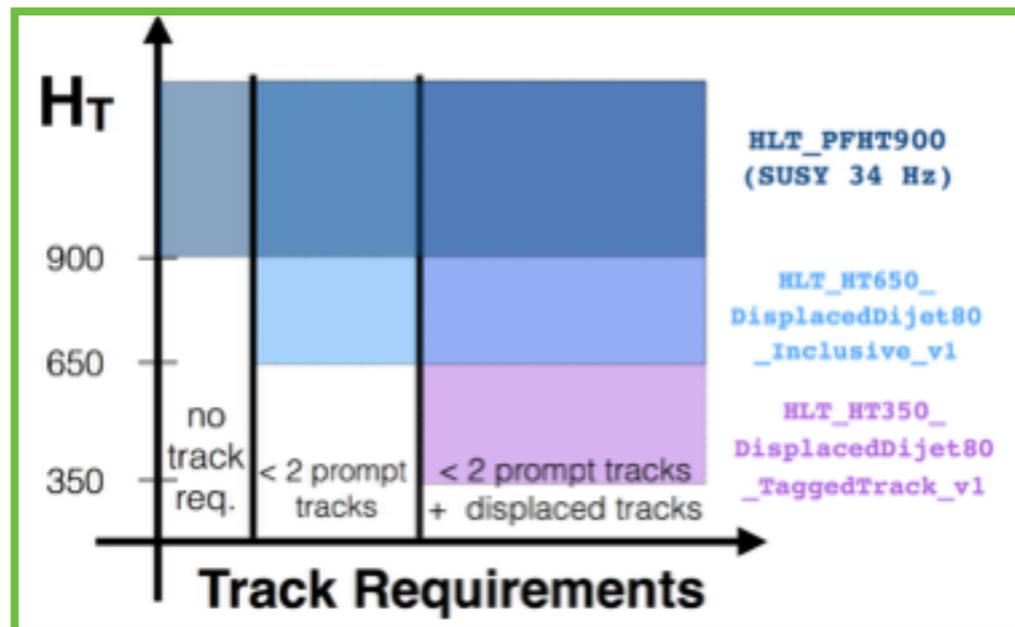
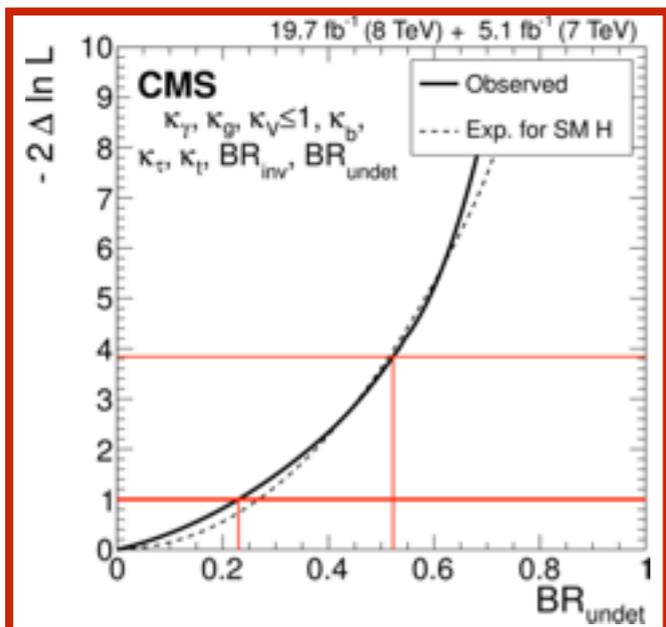
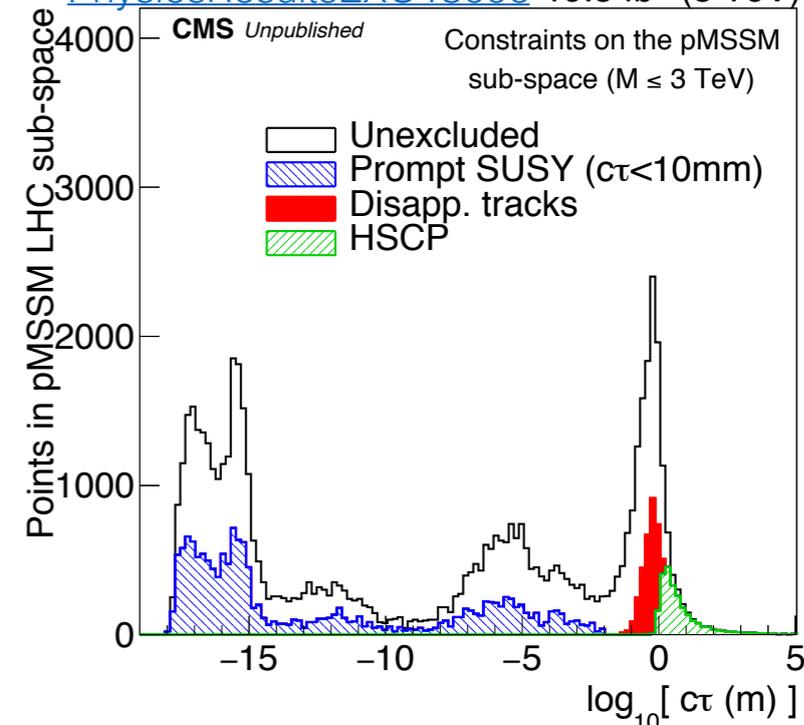
Example 1: Embed disappearing track object in other SUSY searches

- Gain additional handles for triggering and background rejection
- Cover other production modes that include leptons/jets
- Extend coverage to shorter lifetimes
- Interested parties: N. Strobbe (FNAL), B. Schneider (FNAL)

Example 2: Use Higgs as a portal to new physics (c.f. Ben's talk)

- Fraction of undetected Higgs decays could be as high as 50%!
- No hadronic CMS searches for Higgs → long-lived particles
- Previous LL searches have small sensitivity due to requiring hard objects, e.g. H_T at trigger level
- SM $H \rightarrow b\bar{b}$ searches have small sensitivity because of lifetime-sensitive tuning of b-tagging algorithms

PhysicsResultsEXO13006 19.5 fb⁻¹ (8 TeV)



The LPC is a great place to be!

- I've personally found a lot of advantages to residence at the LPC over both CERN and one's home institution
- The LPC is a one stop shop for a variety of analysis and hardware activities, good place to get involved *and* to stay informed on a broad scope of CMS activities
- The LPC provides a broad spectrum of lectures/activities without the over-saturation I had experienced at CERN (i.e. there are so many talks that you end up not going to any)
- The LPC provides a sense of the community that fosters collaboration through casual conversations
 - DR community creates an LPC sub-community of potential collaborators, bringing us together at regular intervals
- The LPC connects postdocs looking for graduate student collaborators with students looking for mentors
- In addition to conference travel, DR-provided travel funds encourage attending workshops, etc. in person - facilitating much more valuable connections

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