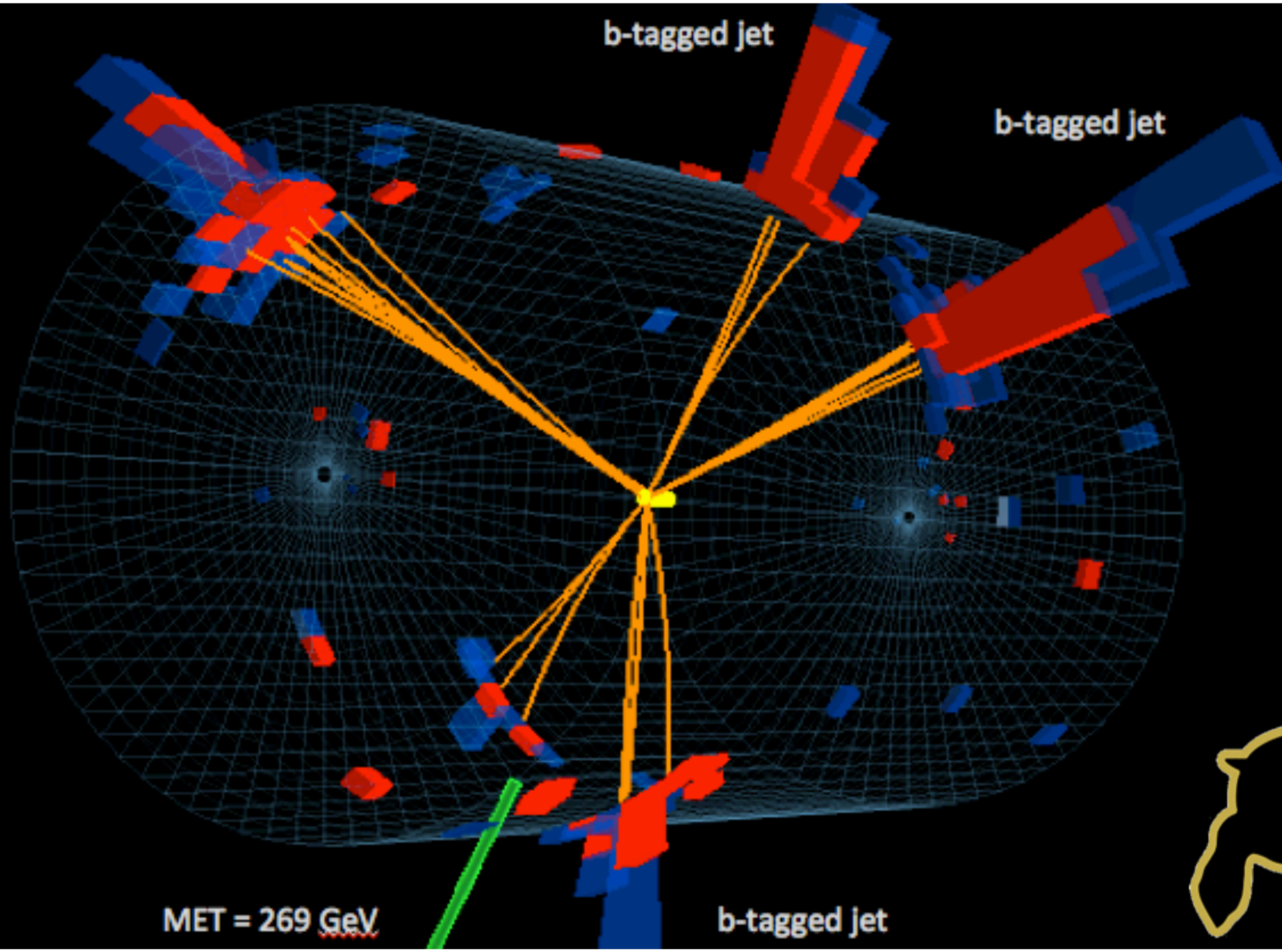
SUSY Sensitivity Studies at 14 TeV from CMS



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APS-DPF, Santa Cruz

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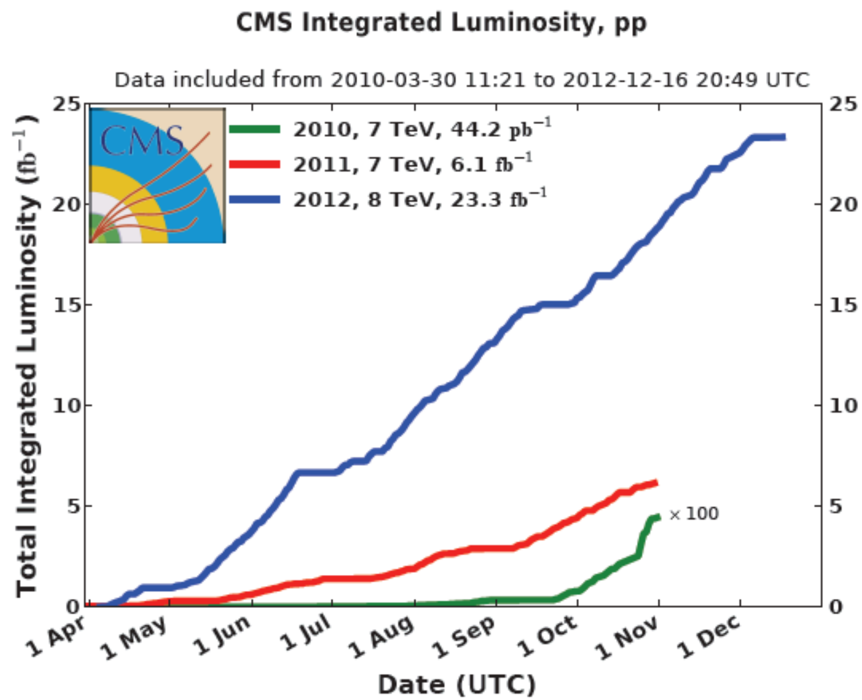
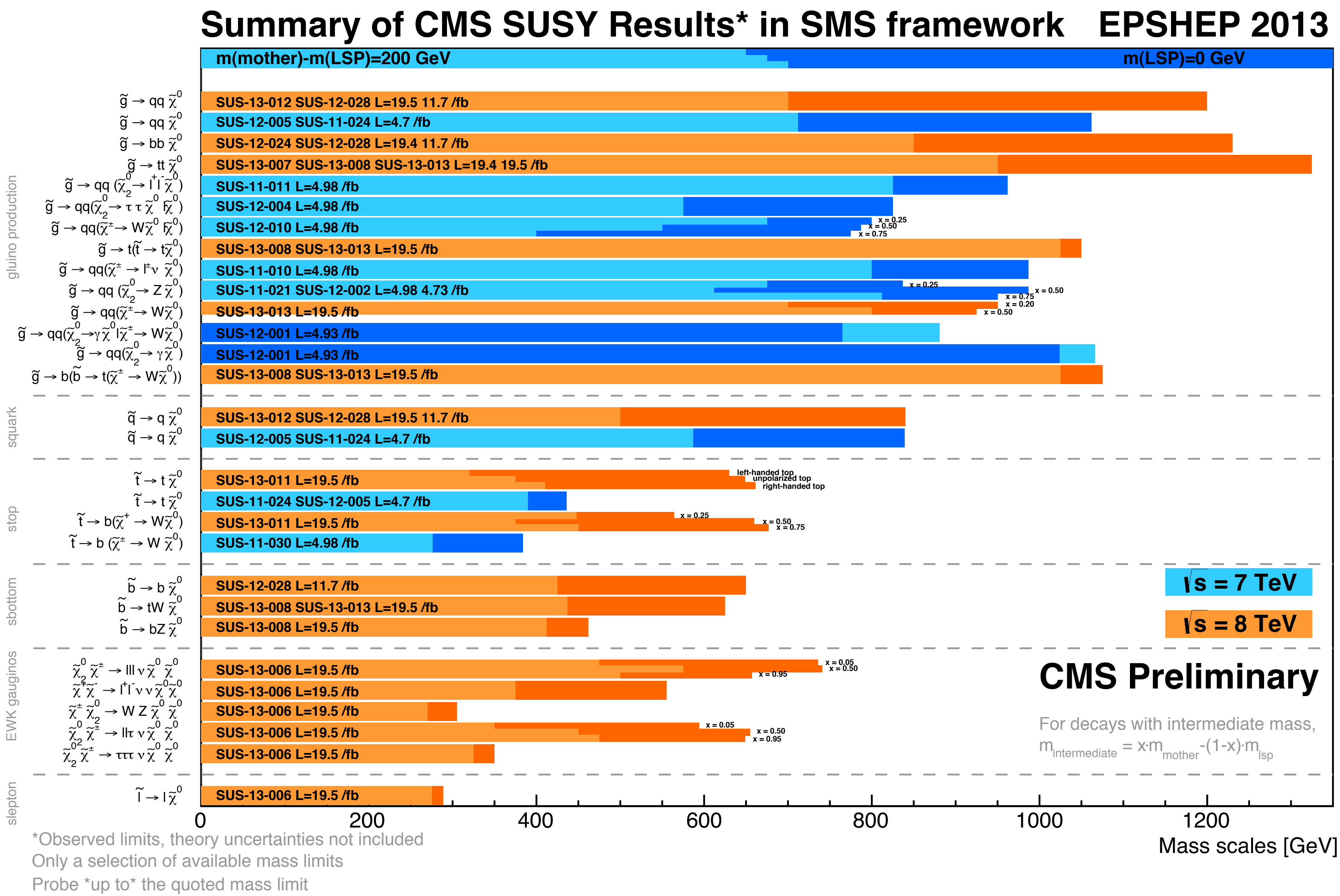
LHC run 1

- LHC run 1 is over
  - Currently in long shutdown 1 (LS1)
  - Will return to operation in 2015
- Very successful run
  - 25 fb^{-1} collected at $\sqrt{s} = 7$ and 8 TeV
  - Higgs boson discovered
  - Many, many new physics searches significantly restrict available phase space
  - No NP discoveries yet…
- This talk will show sensitivity studies for several key supersymmetry searches with the next LHC runs

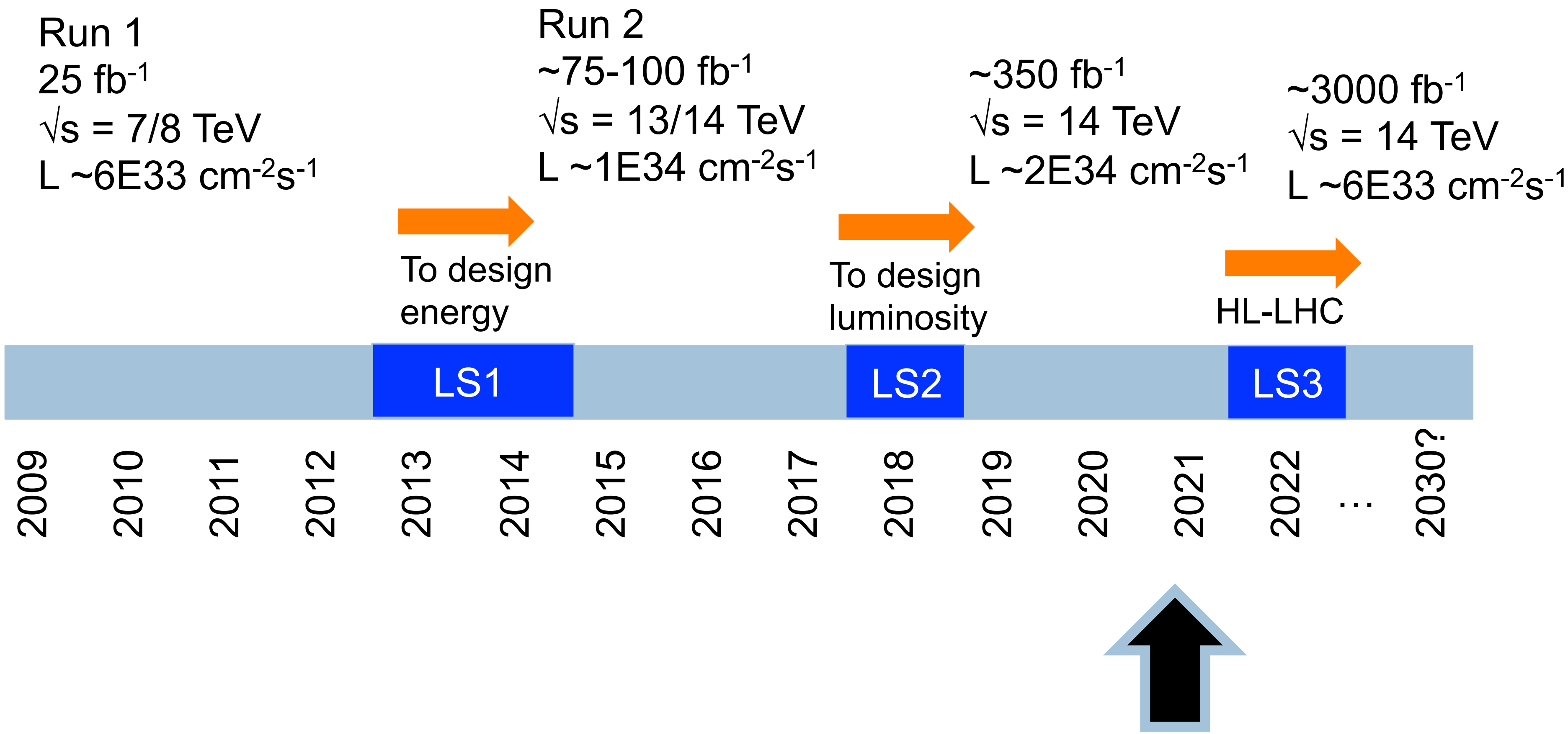


Results from whitepaper submitted by CMS to Snowmass: arXiv:1307.7135

State of the art for SUSY searches



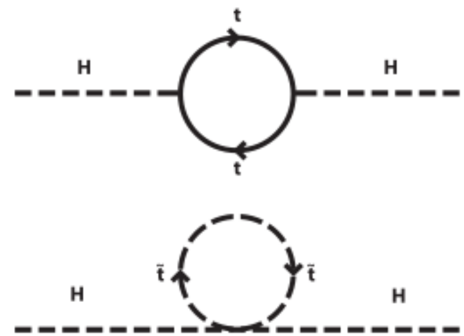
LHC timeline

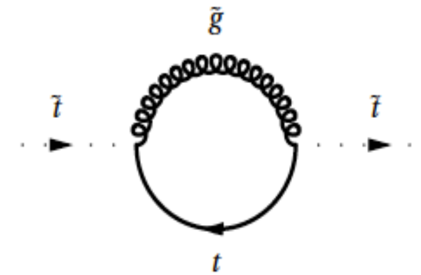


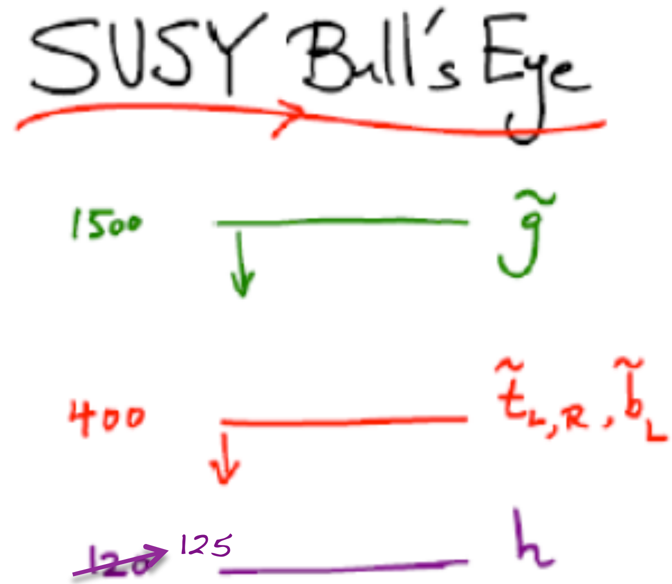
This talk shows projections out to 300 fb^{-1} at $\sqrt{s}$ = 14 TeV

Questions on the horizon for SUSY

- Naturalness
  - Observation of Higgs boson ensures hierarchy problem
    - Something must protect the Higgs mass from quadratic divergences
  - Natural SUSY (minimal fine tuning) is a prime candidate
    - Stop shouldn't be too much heavier than the top
    - Sbottom around stop by SU(2)
    - Gluino enters at 2nd order and also shouldn't be too heavy
- LHC run 1 sensitivity is right at the edge of this crucial region
  - The next runs will give the needed reach!



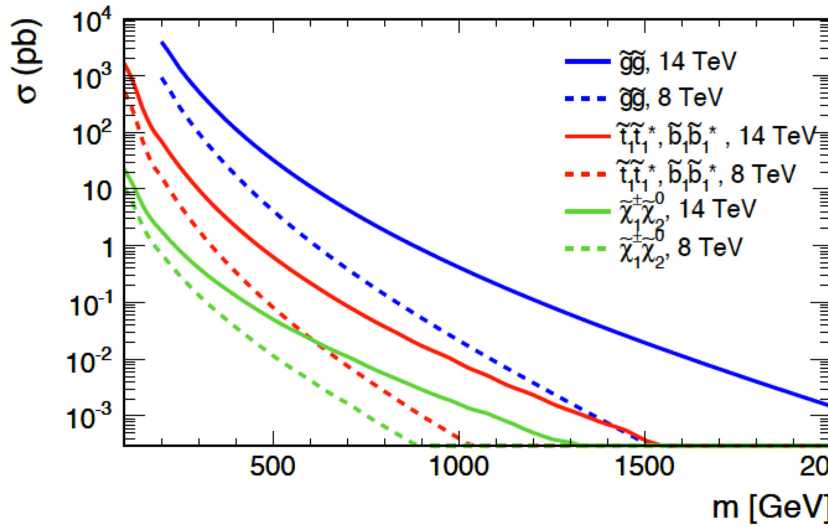




N. Arkani-Hamed
https://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=157244

Projection assumptions

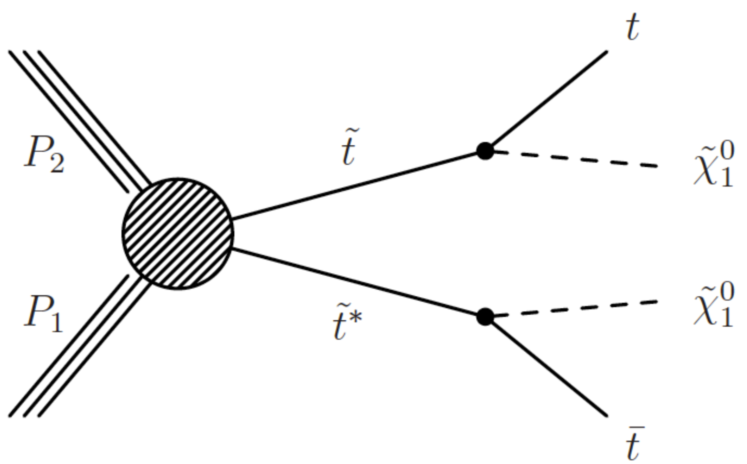
- Assume planned upgrades will mitigate the increased radiation damage and complications from higher luminosity and pileup
- Analyses for 14 TeV are extrapolated from 8 TeV searches
  - Reoptimizing the searches for higher energy would improve them
  - Signal and background cross sections scaled to 14 TeV predictions



SUSY production cross sections
Going from $\sqrt{s}$ = 8→14 TeV

Direct stop production

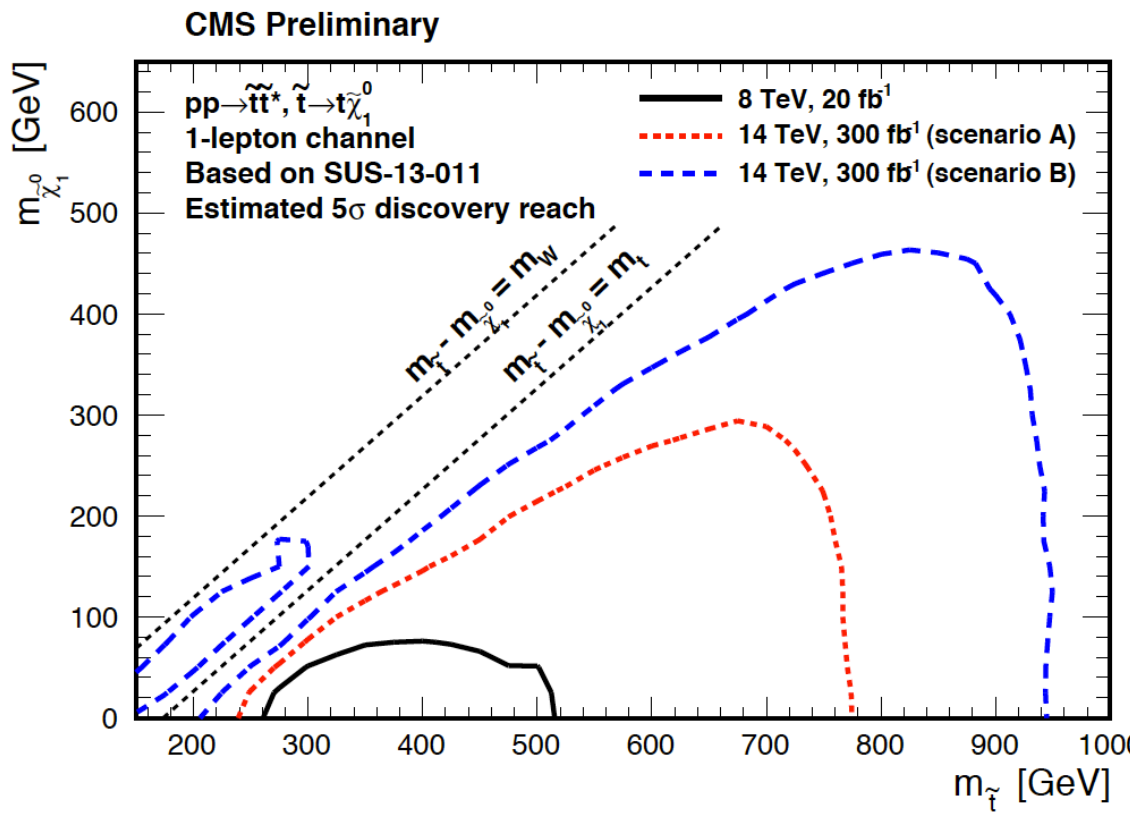
- Simplified model stop→top,LSP used to benchmark direct stop production
- CMS single lepton search used for projection
  - SUS-13-011
- Signal and background yields are scaled from 20 fb^{-1} at 8 TeV to 300 fb^{-1} at 14 TeV
  - Signal cross section increases by factors of ~4-20 for 200-1000 GeV stop mass
  - Main background tt cross section increases by factor of ~4



$$R_{\mathrm{sig(bkg)}} = \frac{300\ \mathrm{fb}^{-1}}{20\ \mathrm{fb}^{-1}} \times \frac{\sigma_{\mathrm{sig(bkg)}}(14\ \mathrm{TeV})}{\sigma_{\mathrm{sig(bkg)}}(8\ \mathrm{TeV})}$$

Direct stop production

- Uncertainty on background estimation considered in two scenarios
  - Scenario A
    - Scaled R_{bkg}
    - Assumes same fractional uncertainty as 8 TeV analysis
  - Scenario B
    - Scaled by $\sqrt{R_{bkg}}$
    - Assumes improvement with luminosity
    - Maintain minimum of 10% uncertainty

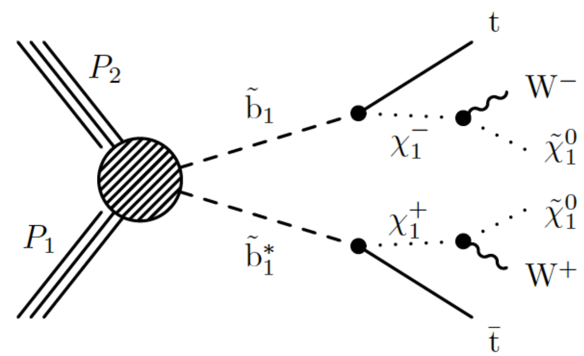


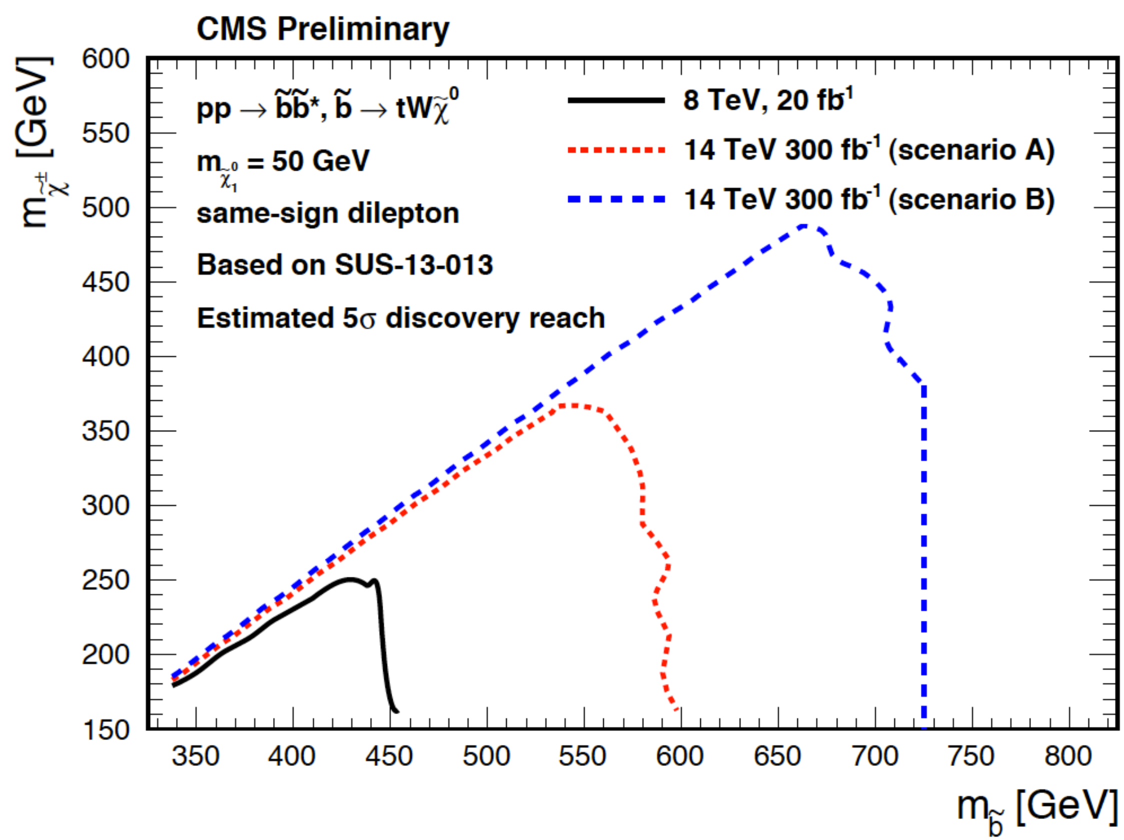
With optimistic scenario, 5σ discovery reach extends to 950 GeV stops

Direct sbottom production

- Same-sign dilepton search used to project direct sbottom reach
- Signal cross section (300-700 GeV) larger by 5-12x
- Background cross section larger by ~3-4x
- Backgrounds dominated by systematics
  - Assume no improvement for scenario A
  - Assume 20-40% improvement for scenario B
- 5 σ discovery reach up to 700 GeV

8 TeV search described in detail earlier today by Ryan Kelley

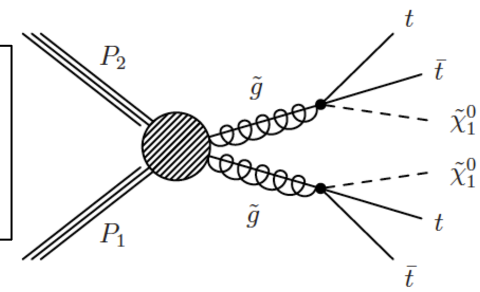


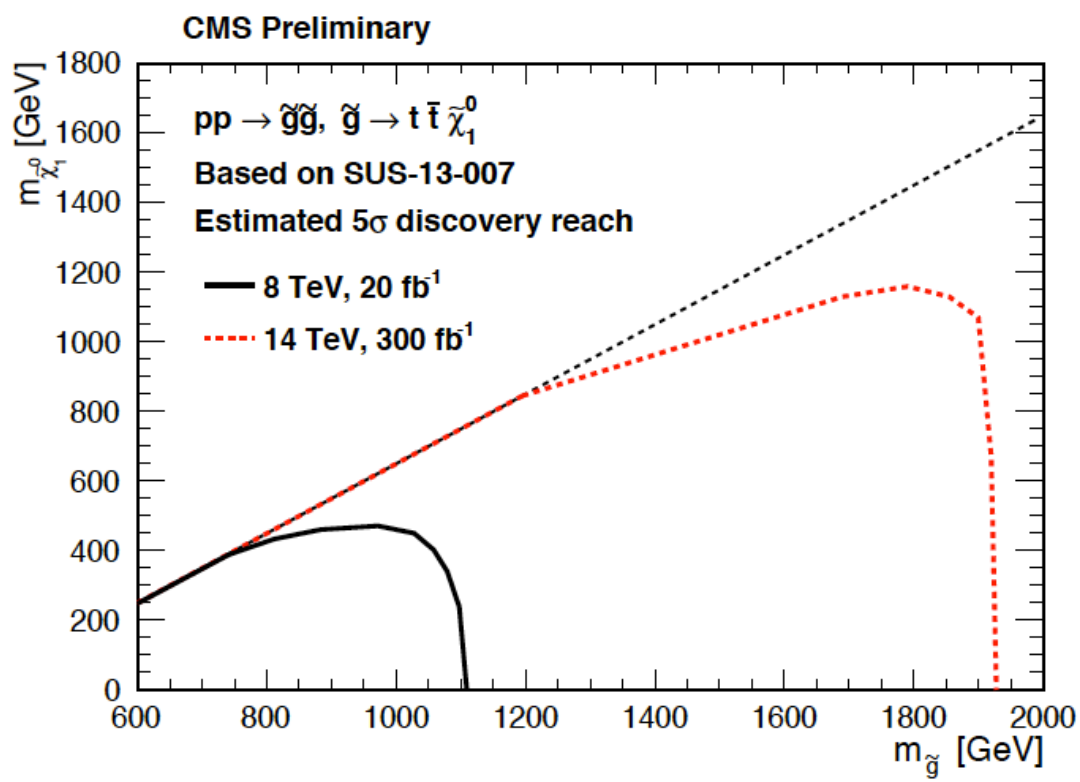


gluino-mediated stop production

- Single lepton search used for projection
- Signals and backgrounds scaled from 8 TeV search to 300 fb^{-1} at 14 TeV
- Background uncertainty dominated by control sample statistics, which scale as $1/\sqrt{R_{bkg}}$
  - Treatment of systematics has minimal impact, so only scenario A is shown
- 5σ discovery reach extends to nearly 2 TeV gluinos

8 TeV search described in detail in previous talk by Tom Danielson

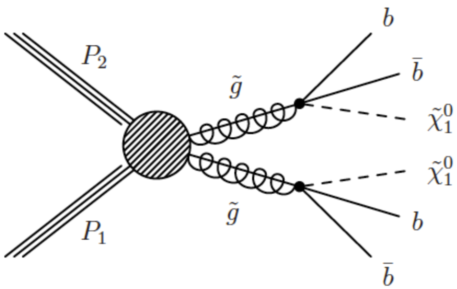


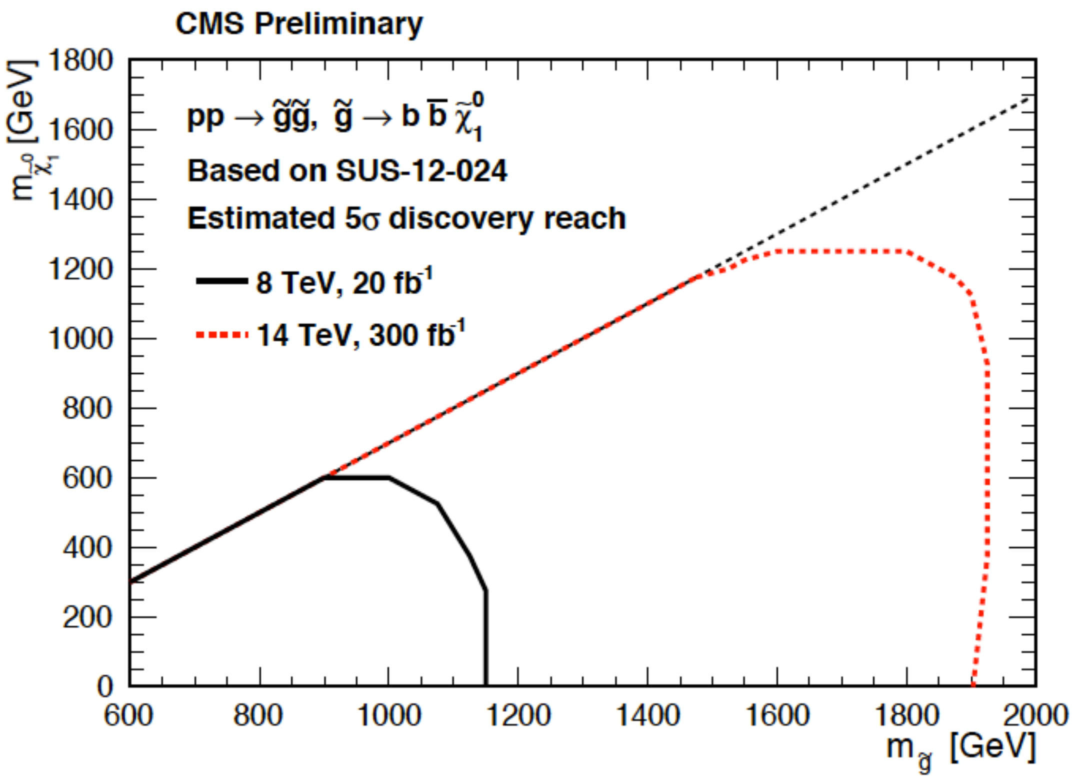


gluino-mediated sbottom production

- Hadronic b-jets + MET search used for gluino-mediated sbottom projection
- Scenario A shown for background uncertainties
  - Background uncertainties statistics limited
- 5σ discovery reach extends to nearly 2 TeV gluinos
- Tightest signal region has >100 background events with simple extrapolation from 8 TeV analysis
  - Optimized analysis would provide even better sensitivity

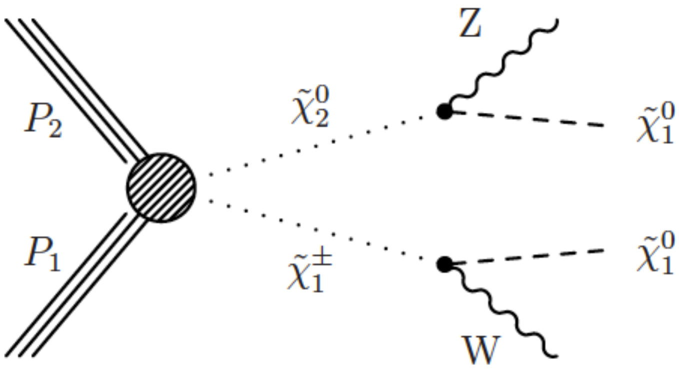
8 TeV search described in detail in previous talk by Tom Danielson

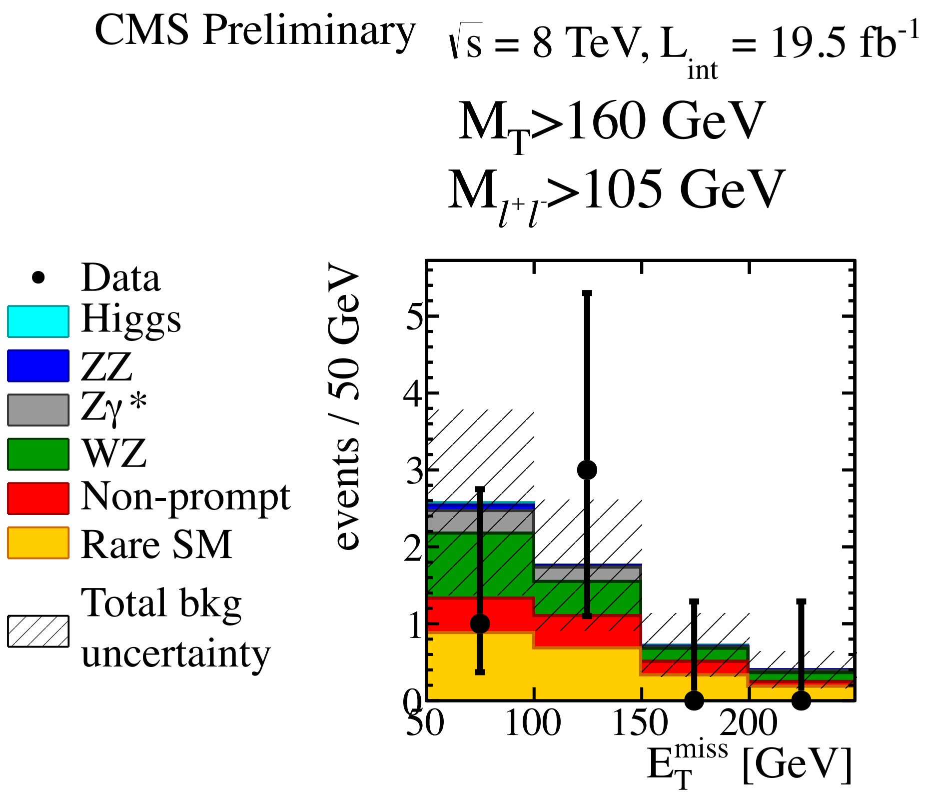




Direct electroweak-ino production

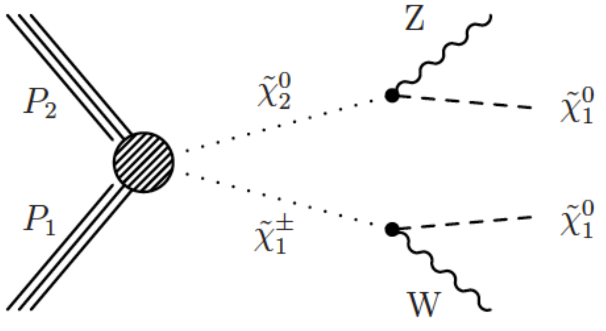
- Direct electroweak production benefits greatly from increased cross section at 14 TeV
  - Minimal sensitivity at 8 TeV
- Multi-lepton search used for extrapolations
  - ≥3 leptons + MET
  - Sensitive to neutralino-chargino production decaying to W+Z+MET final state

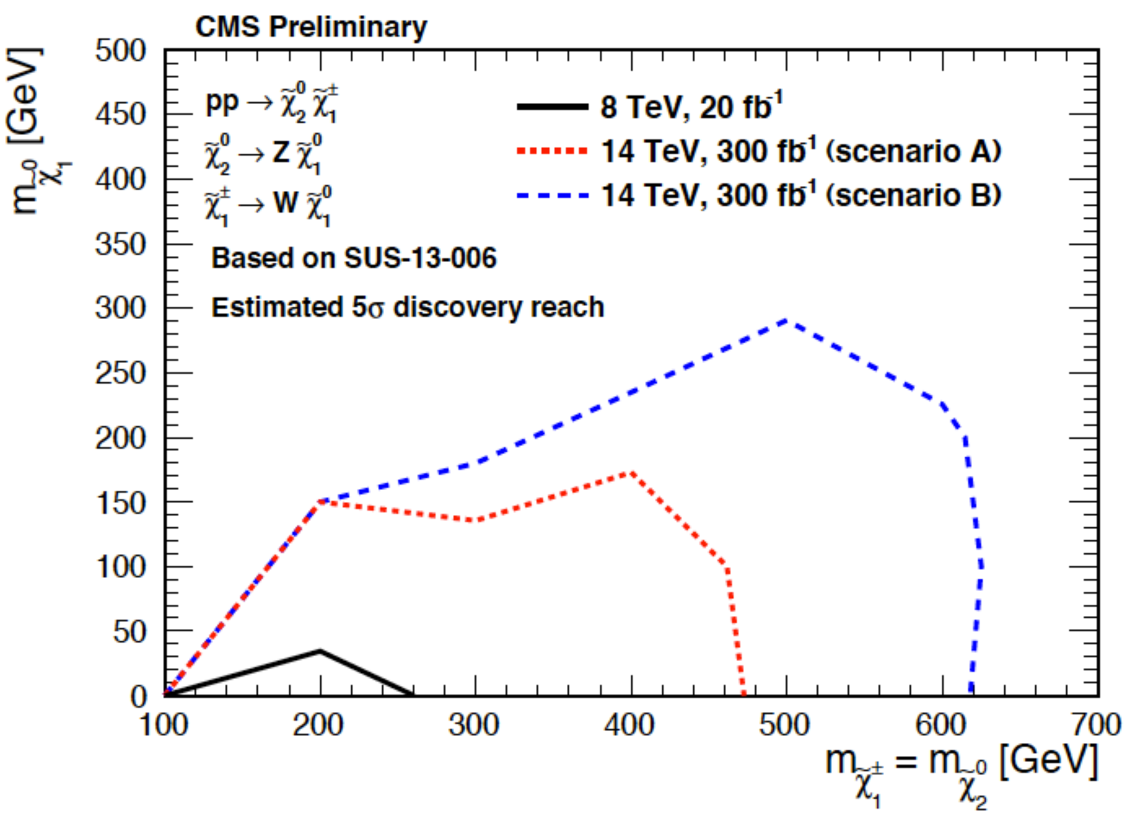




Direct electroweak-ino production

- Signal and background counts scaled by luminosity and production cross section
- Scenario A and B both considered for background uncertainty
- Potential 5σ discovery reach out to 600 GeV charginos



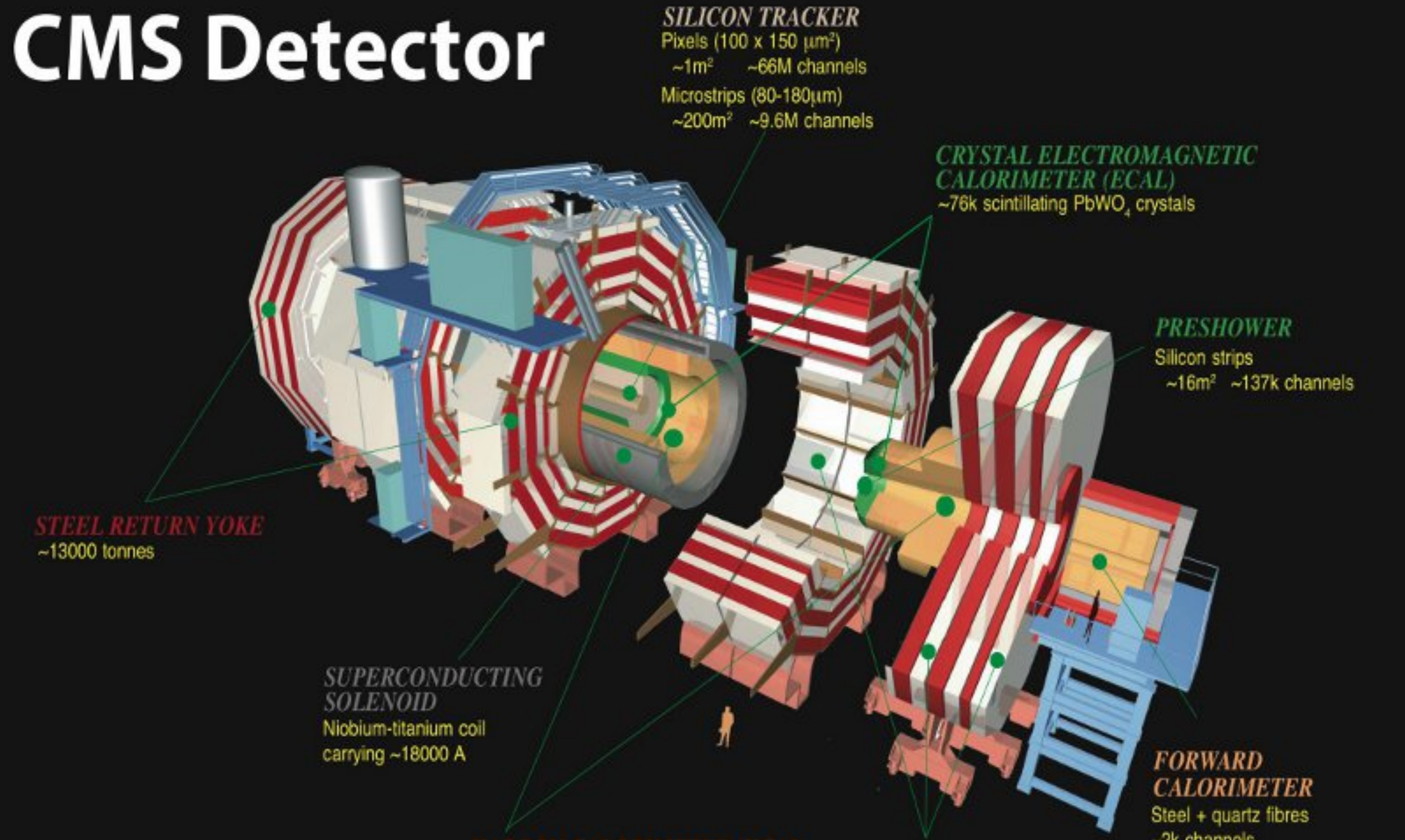


Conclusions

- LHC run 1 saw a very successful program
  - Higgs discovery
  - Stringent limits on large variety of new physics scenarios
- Future LHC runs should be even more exciting
  - Greatly extended reach for the full range of the SUSY search program with 300 fb^{-1} at $\sqrt{s} = 14$ TeV
  - Probe natural SUSY as solution to hierarchy problem

Extra slides

CMS Detector



Total weight	: 14000 tonnes
Overall diameter	: 15.0 m
Overall length	: 28.7 m
Magnetic field	: 3.8 T