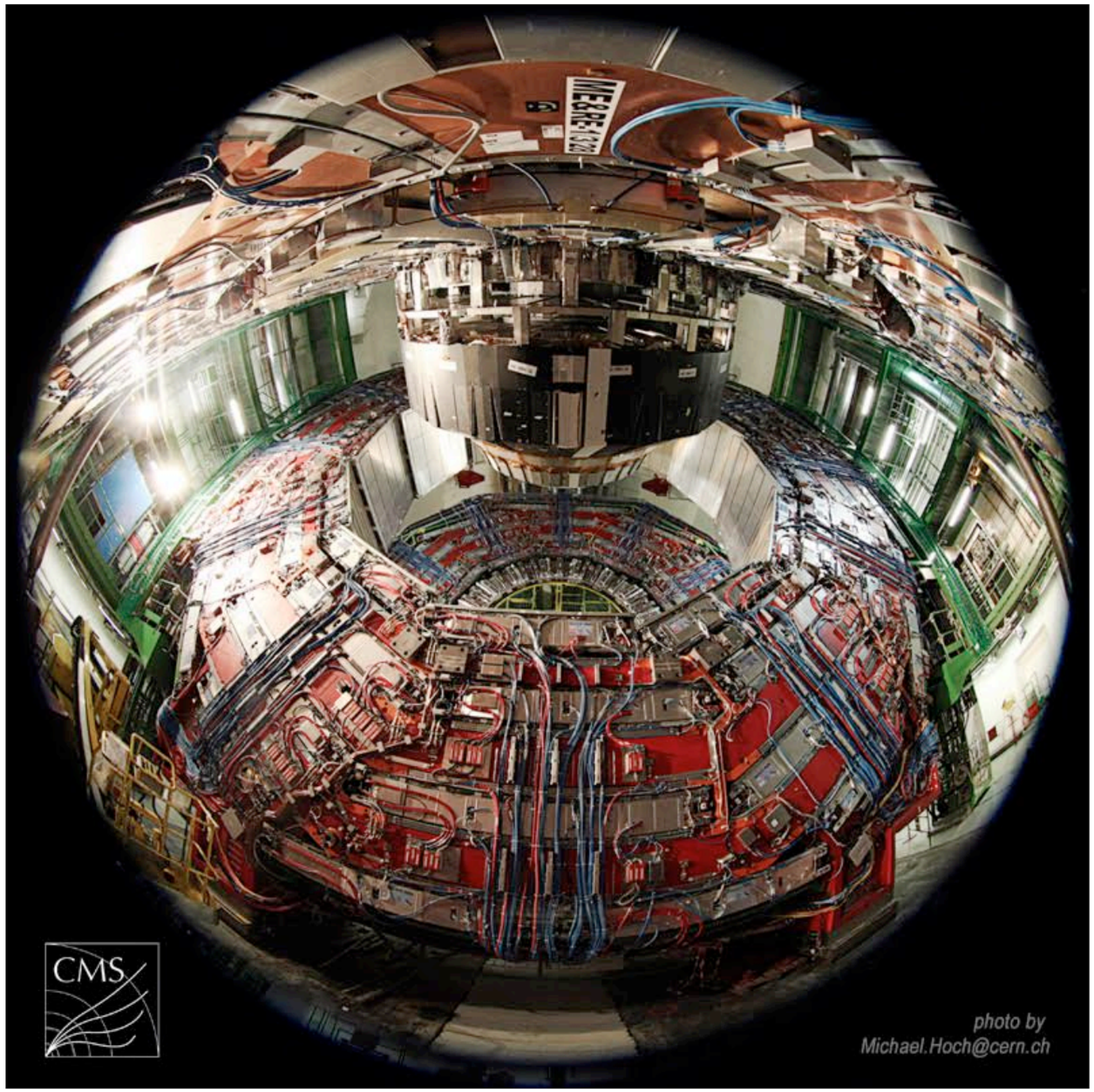

Search for New Light Higgs Bosons in Boosted Tau Final States at CMS

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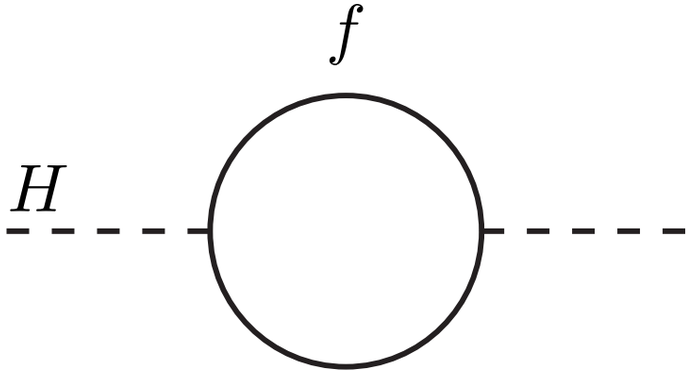
Motivations

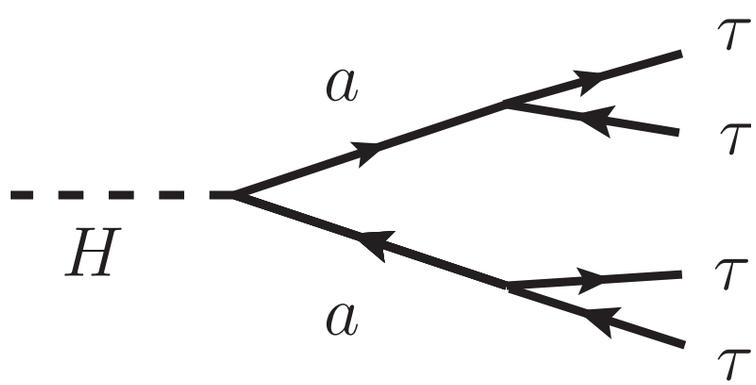
- Higgs discovery: important validation of SM
- Hierarchy problem: no explanation why $m_H \ll$ Planck scale
- MSSM: simplest SUSY extension of SM, addresses hierarchy problem, but μ-term needs fine-tuning
- NMSSM: extension of MSSM by an extra singlet superfield, solves μ-problem
- Recent Tevatron/LHC results allow up to ~**30% BR** for H(125) to unseen decay modes



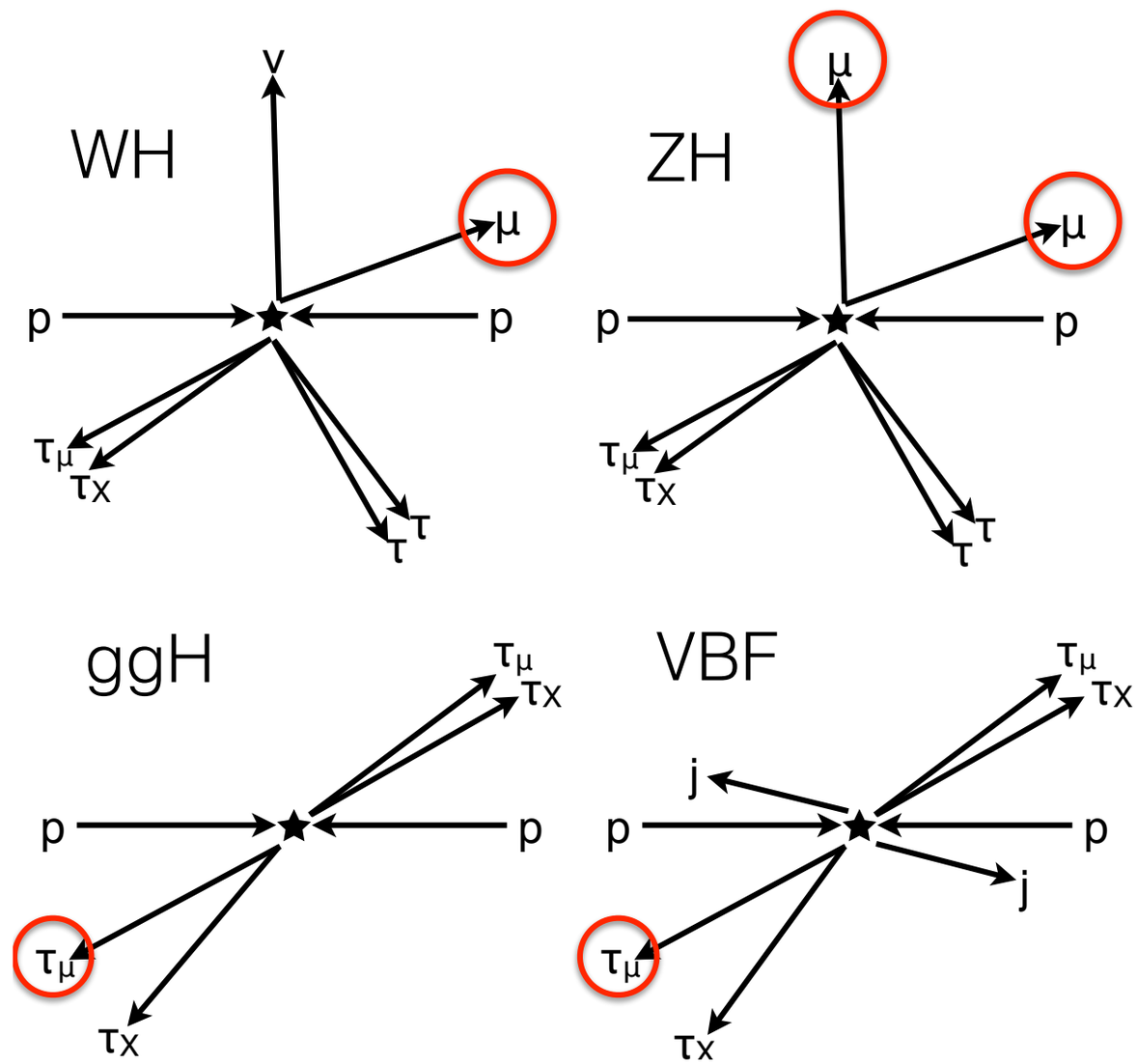
$$\Delta m_H^2 = -\frac{|\lambda_f|^2}{8\pi^2}\Lambda_{\rm UV}^2 + \ldots.$$

NMSSM Higgs sector
$H^{\pm}$
h_1, h_2, h_3
a_1, a_2

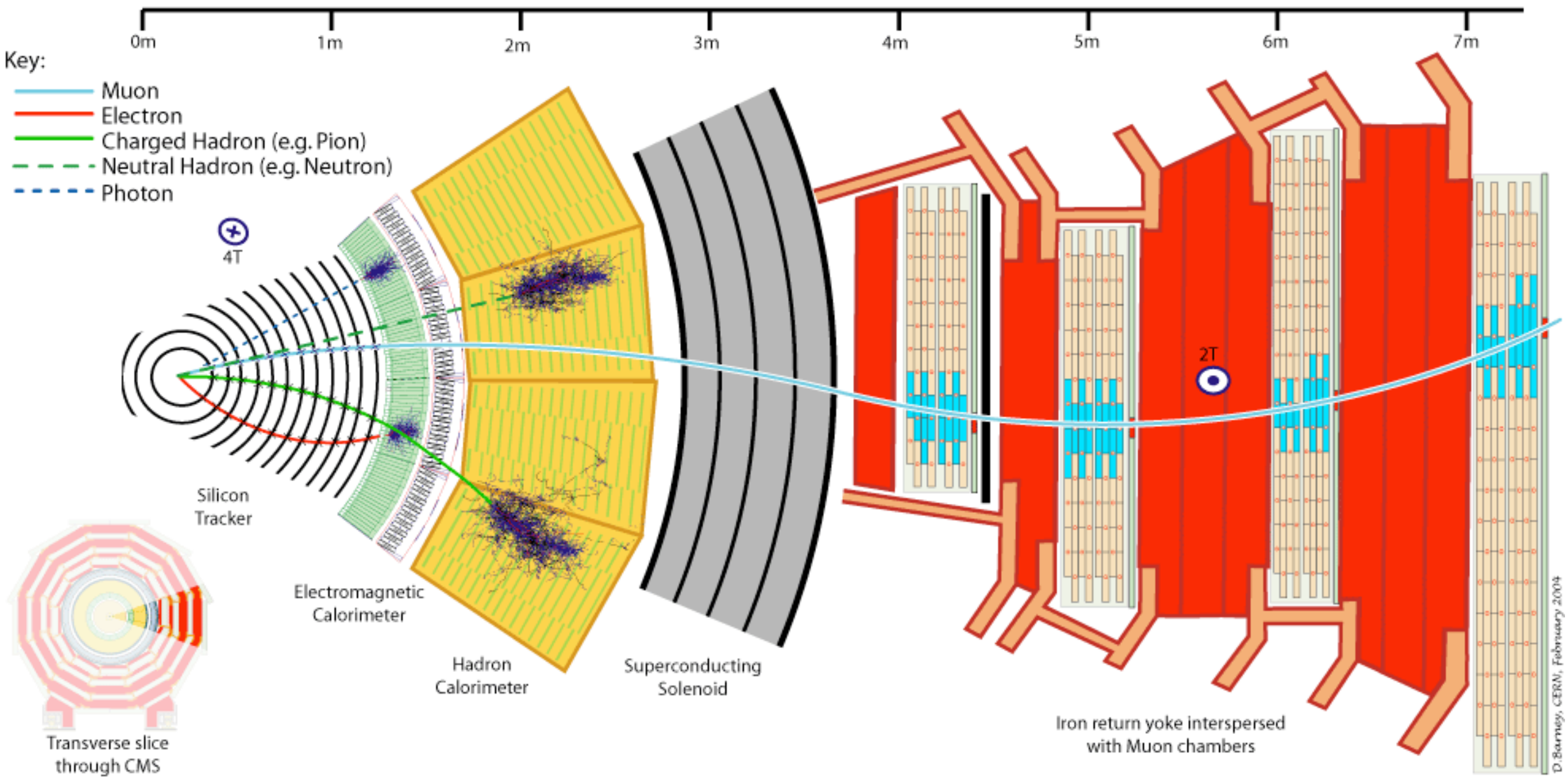
Signature



- Search for H decays to light pseudoscalars, motivated by some 2HDM's such as NMSSM
- Benchmark model: NMSSM $H \rightarrow aa \rightarrow 4\tau$
  - m_H = 125 GeV (h_2 in NMSSM)
  - m_a = 5-15 GeV (a_1 in NMSSM)
- 4 production modes: ggH, VBF, WH, and ZH



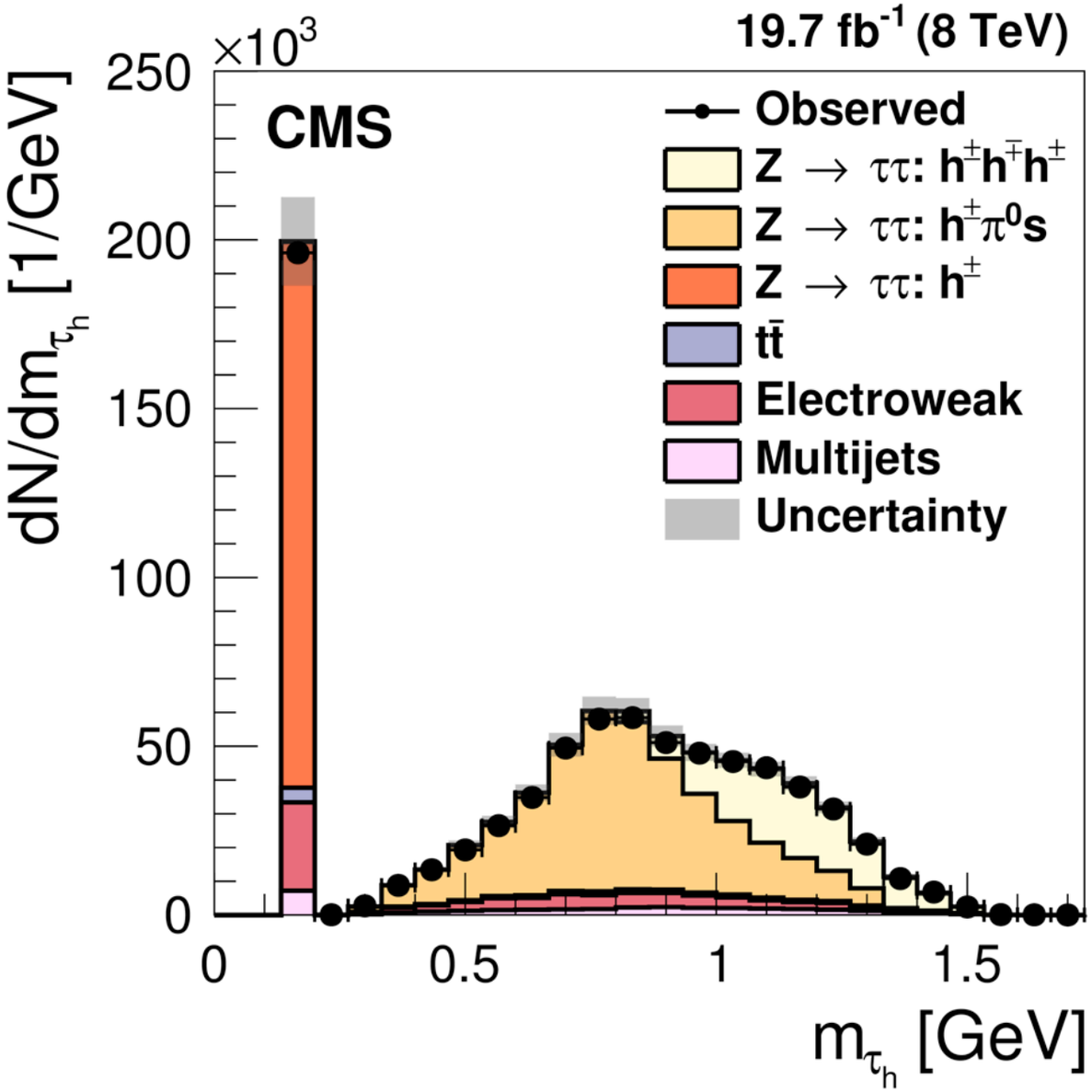
CMS Experiment



Why look for hadronically decaying taus?

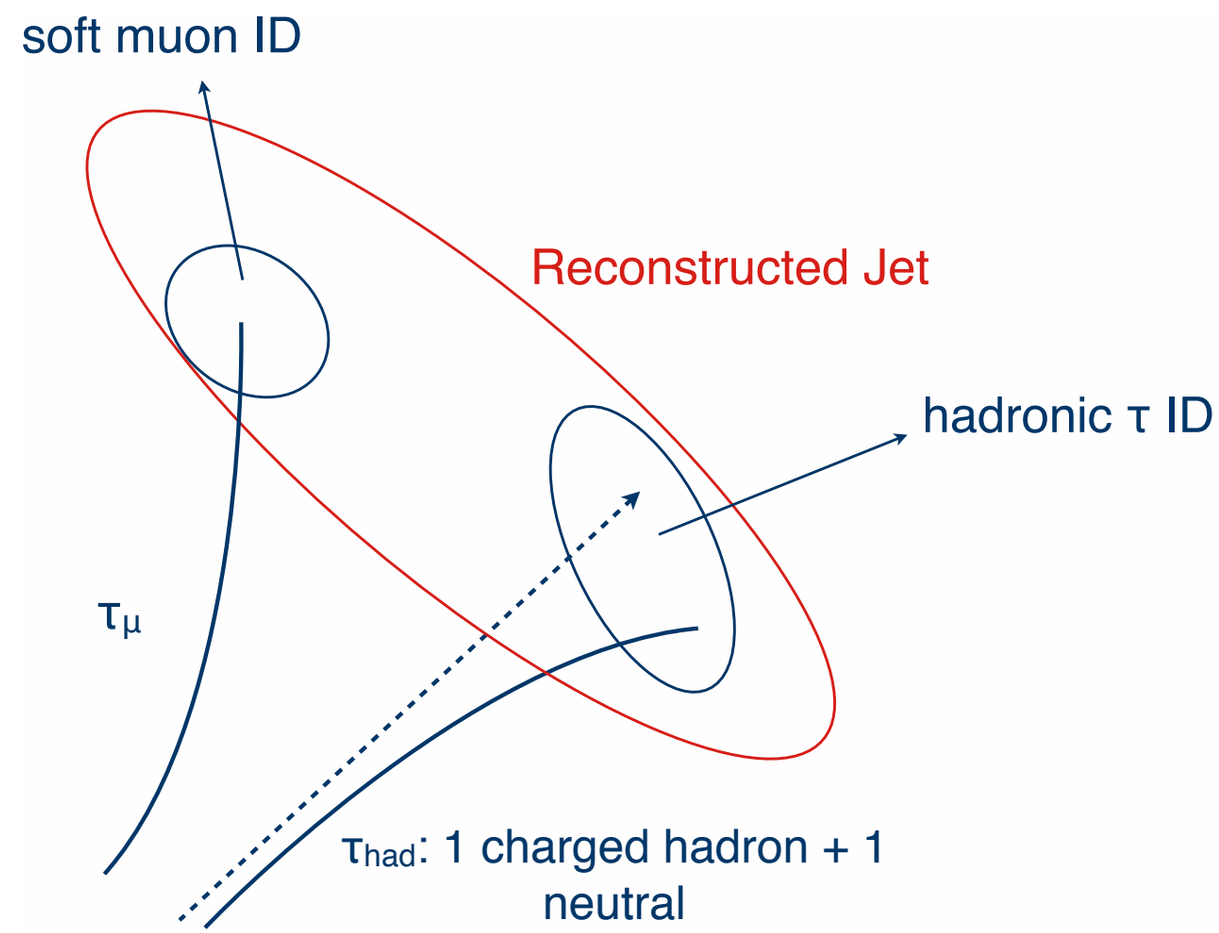
- This analysis focuses on $a \rightarrow \tau_\mu \tau_h$
- Br($\tau \rightarrow$hadrons) ~ 65%, compared to Br($\tau \rightarrow \mu$) and Br($\tau \rightarrow e$) ~ 17% each
- Excellent τ_h reconstruction and ID performance at CMS (standard algorithm "hadrons-plus-strips", HPS)

CMS-TAU-14-001

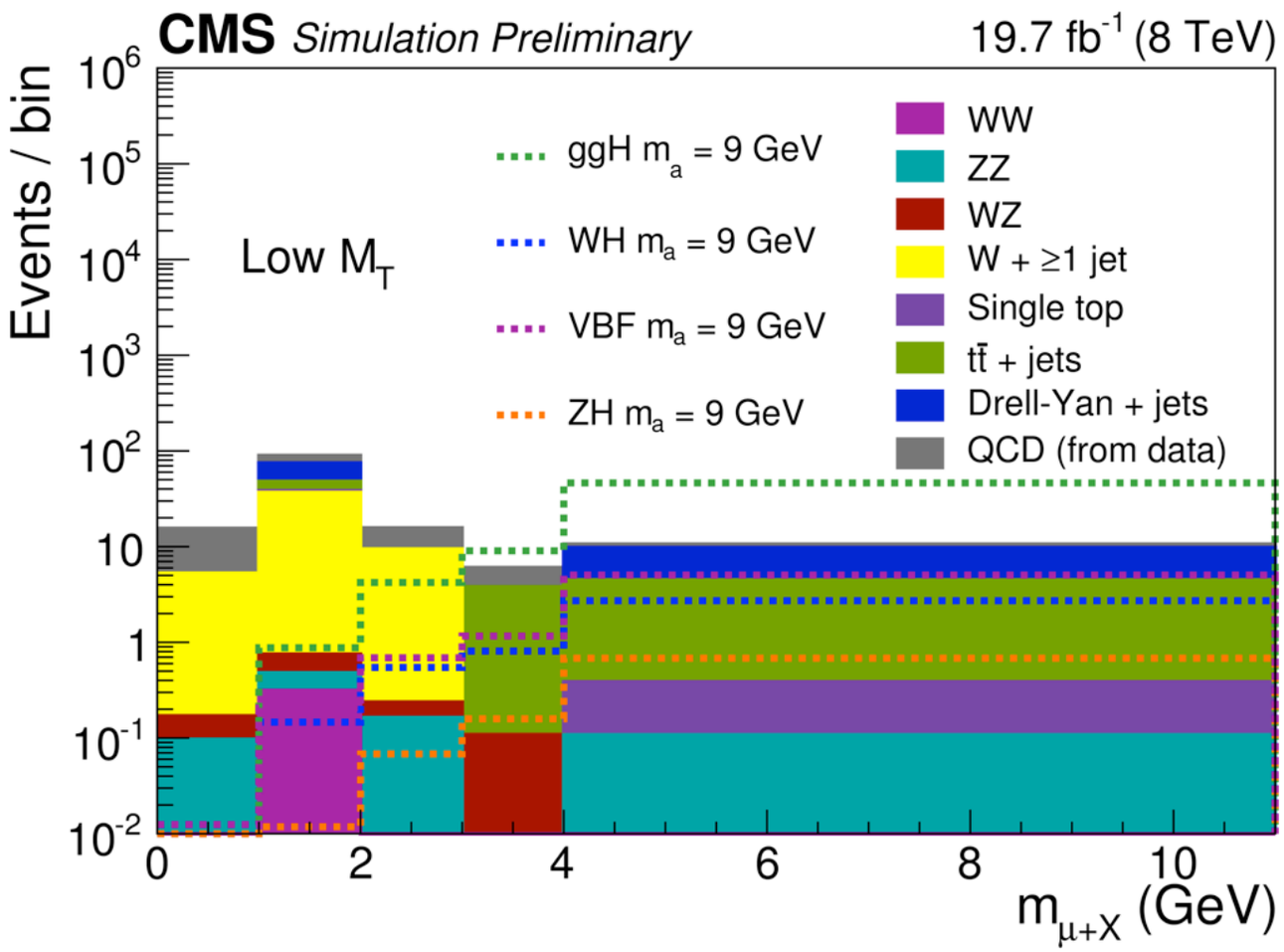


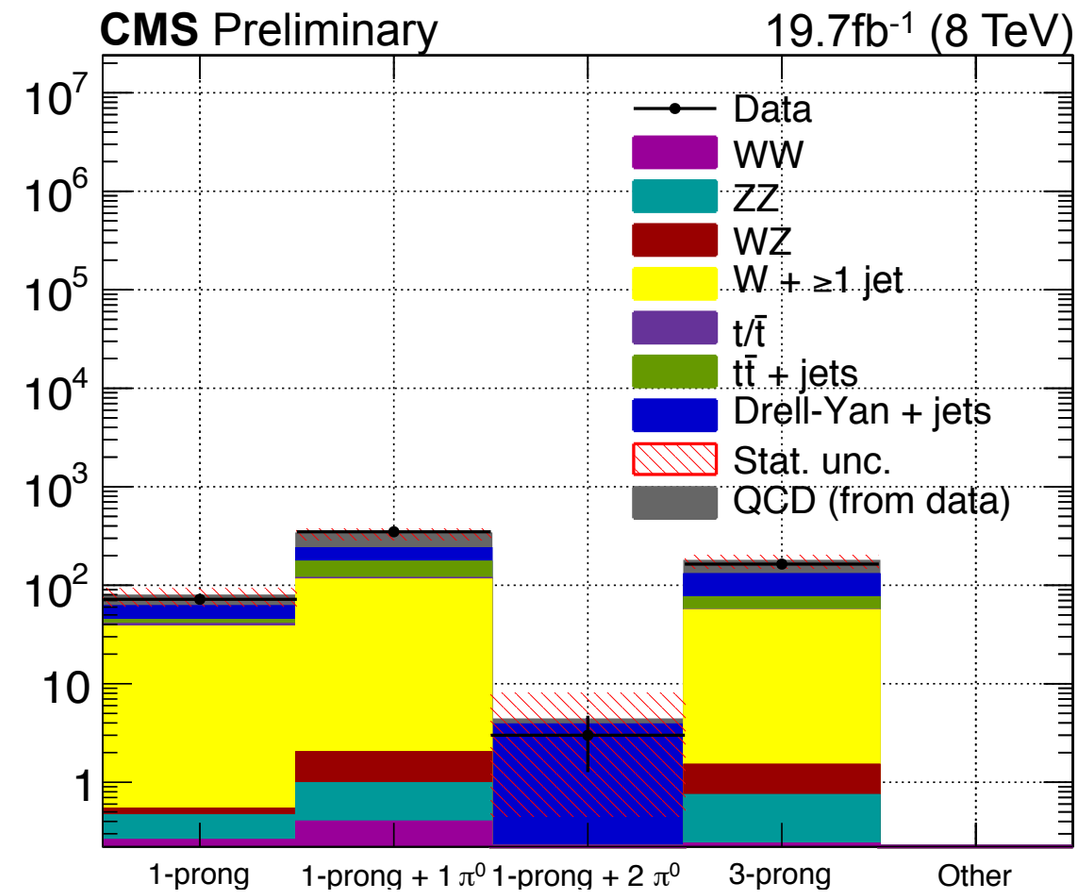
Boosted $\tau_\mu\tau_h$ ID

- $m_H \gg m_a \Rightarrow$ boosted a decays to collimated τ pair
- Standard HPS algorithm for τ reconstruction fails due to overlapping τ decay products
- Boosted $\tau_\mu\tau_X$ ID:
  - remove soft μ from particle candidates of jet used to seed HPS τ
  - significant recovery of τ ID efficiency (e.g, from ~20% before muon removal to ~60% after muon removal)
- At least one $\tau_\mu\tau_X$ object required per event



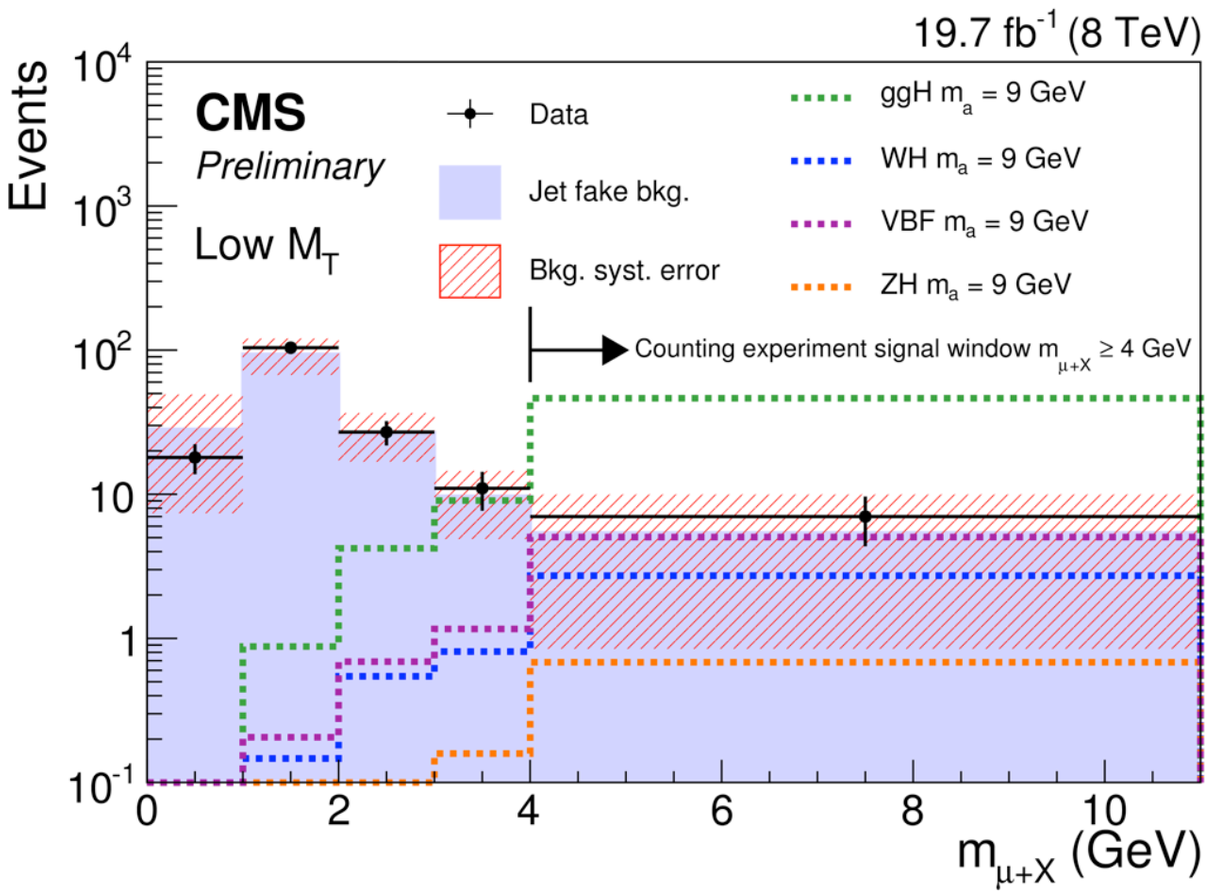
Analysis strategy

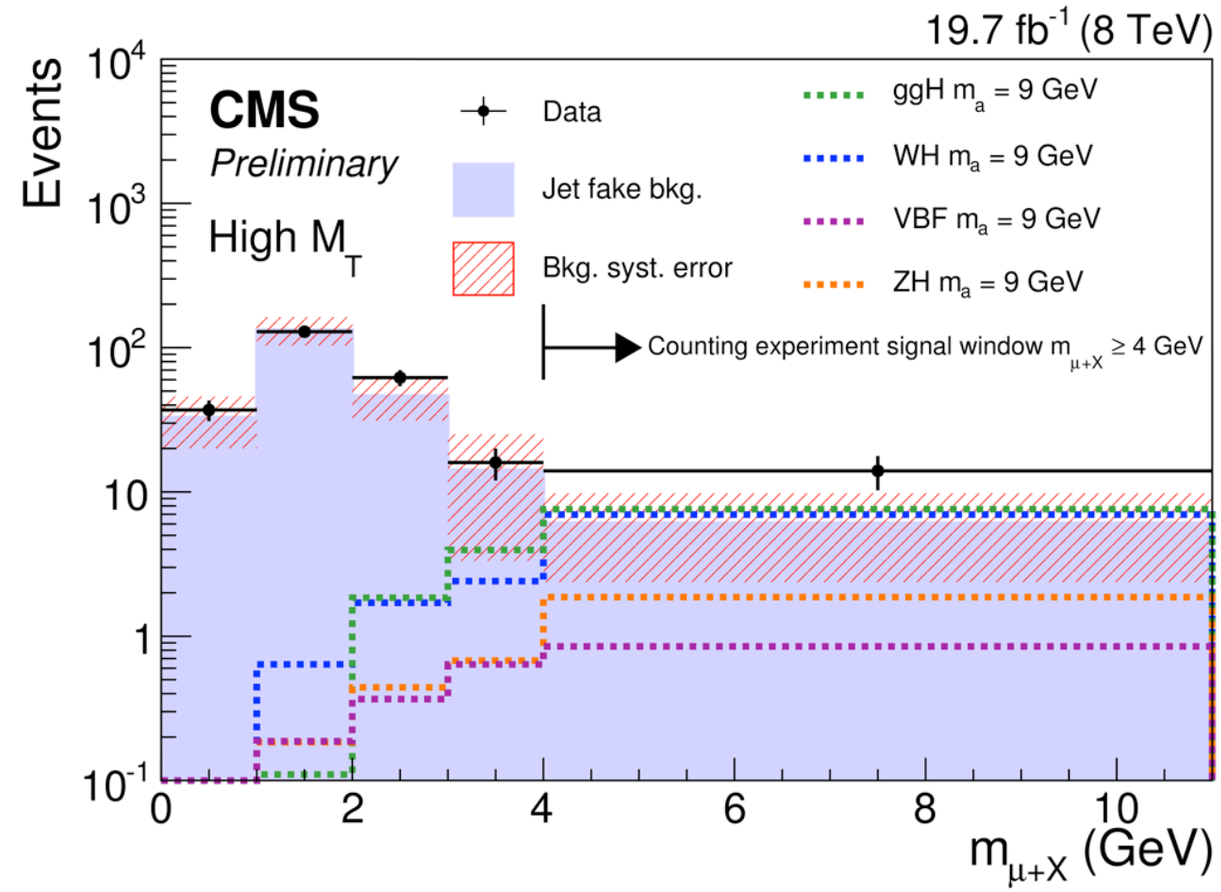




- $m_{\mu+X}$: signal-to-background discrimination after full selection (left plot)
- Data control region: events passing all selection cuts EXCEPT τ_h isolation
  - used to model predicted background $m_{\mu+X}$ shape in search region
  - good data/MC agreement (example: right plot, tau decay modes)

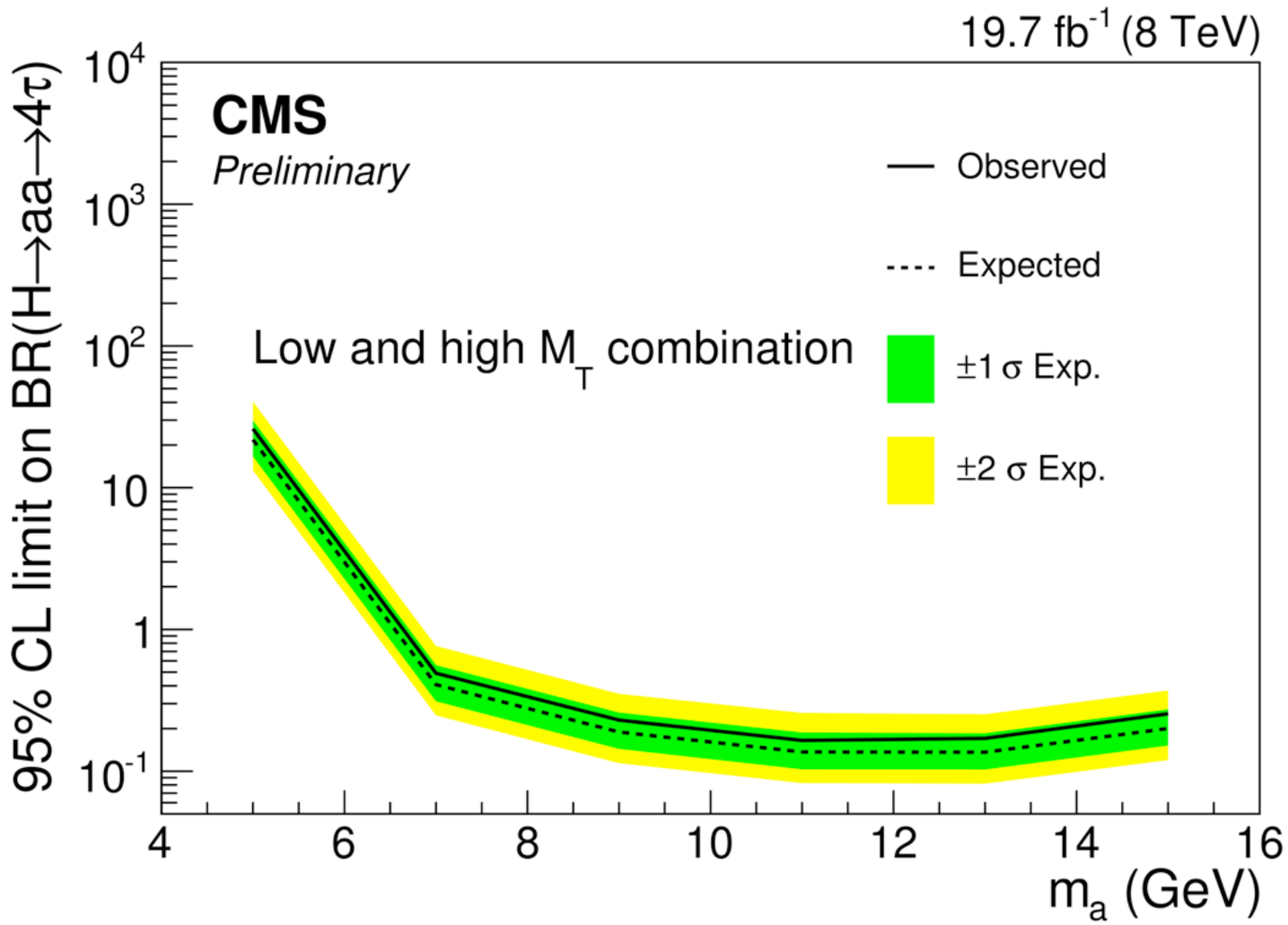
Results





- Perform counting experiment in $m_{\mu+X} > 4$ GeV, look for excess above expected SM background
- No significant excess observed above expected background
- Use results to set upper limits on $Br(H \rightarrow aa) \cdot Br^2(a \rightarrow \tau\tau)$

Limits

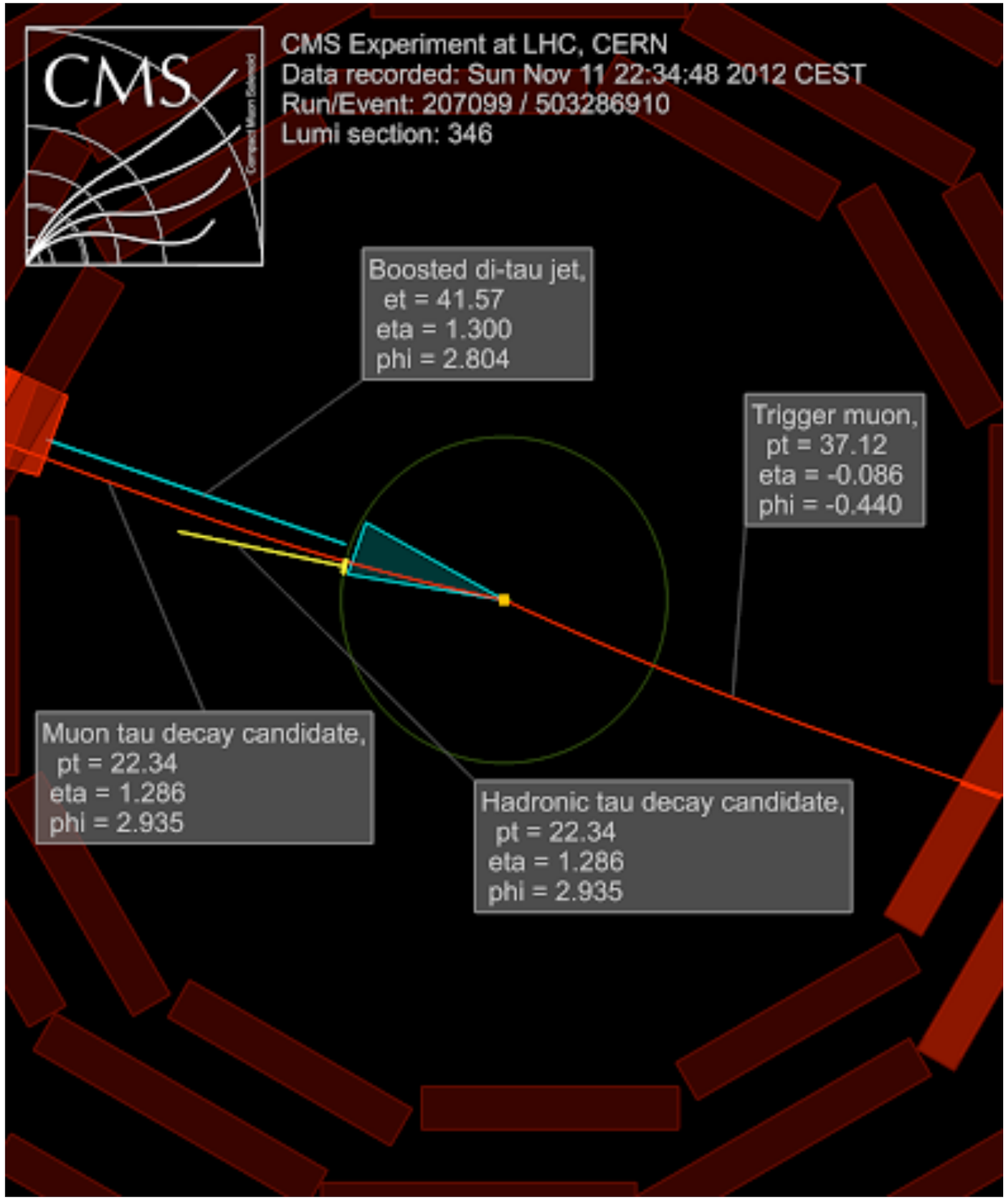


m_a (GeV)	Expected limit	Observed limit
5	no limit	no limit
7	40.8%	49.1%
9	18.9%	23.0%
11	13.7%	16.5%
13	13.6%	17.1%
15	20.0%	25.4%

- At m_a = 11,13 GeV, strongest limits on $Br(H\rightarrow aa)\cdot Br^2(a\rightarrow\tau\tau)$
- Model-independent limits ⇒ can be interpreted in context of different benchmarks

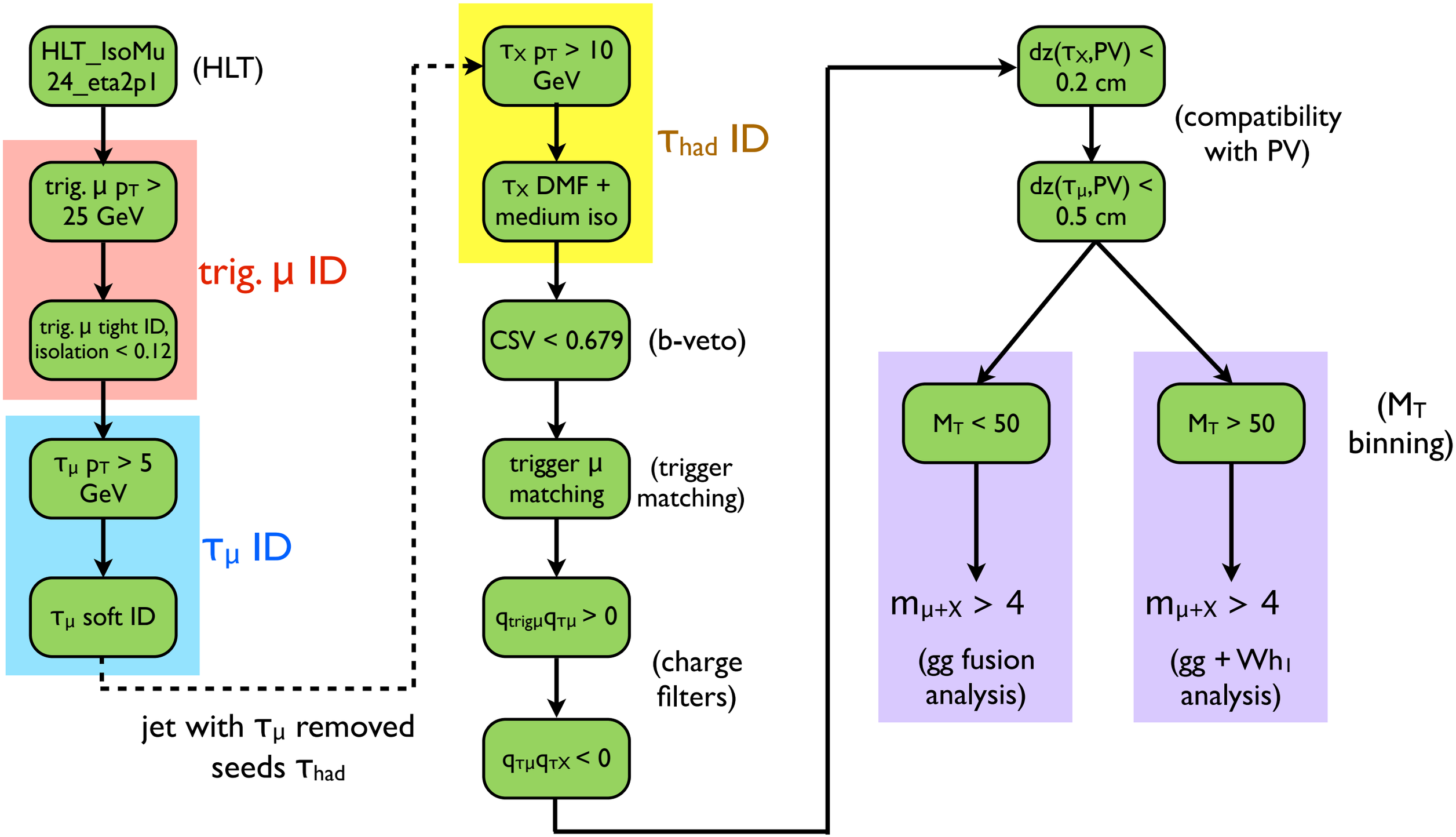
Conclusions

- Search for Higgs decays to light pseudoscalars
  - First public limits on a four-τ signature of this kind
  - New method for boosted $\tau_\mu\tau_h$ ID
- Run II
  - Higher energies, new possibilities for BSM physics searches
  - Exploring other methods for identifying boosted tau topologies (e.g., tau jet substructure)



Backup

Selection sequence



Signal-to-background prediction, high M_T