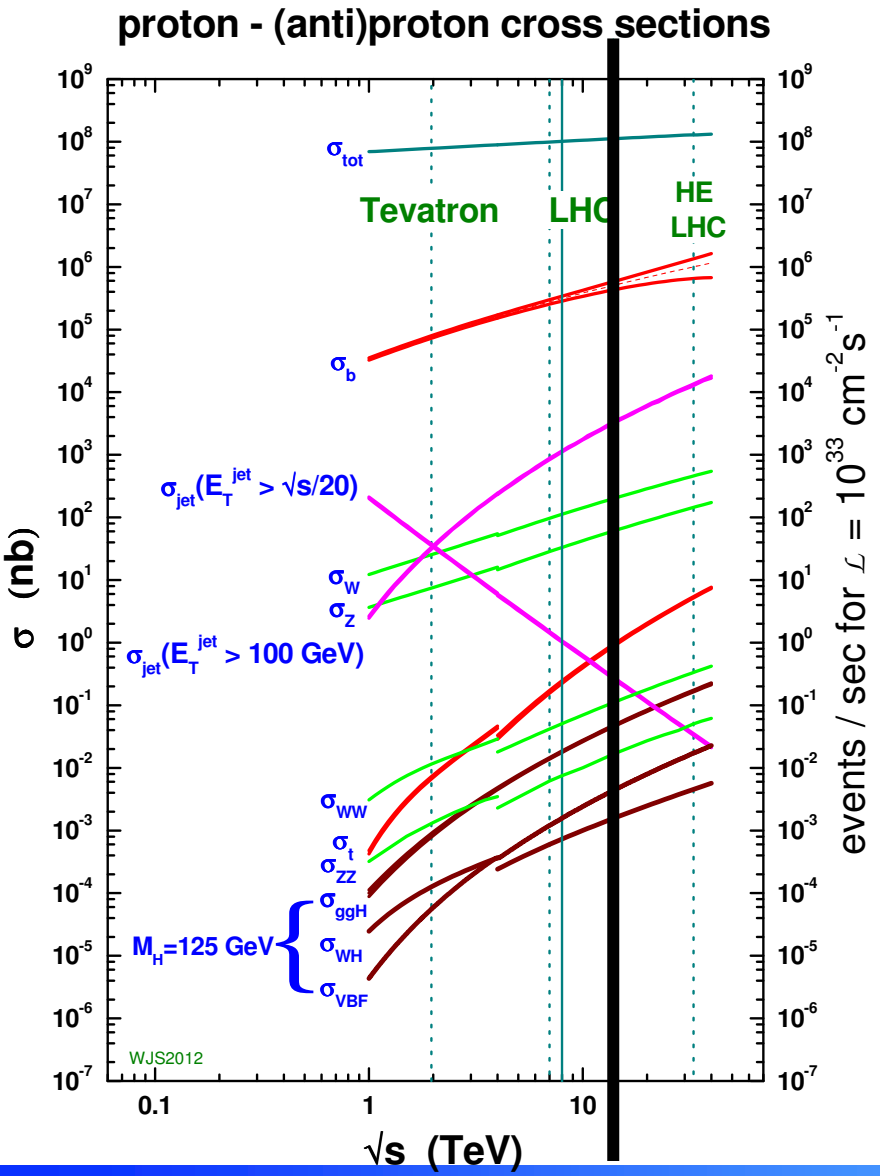
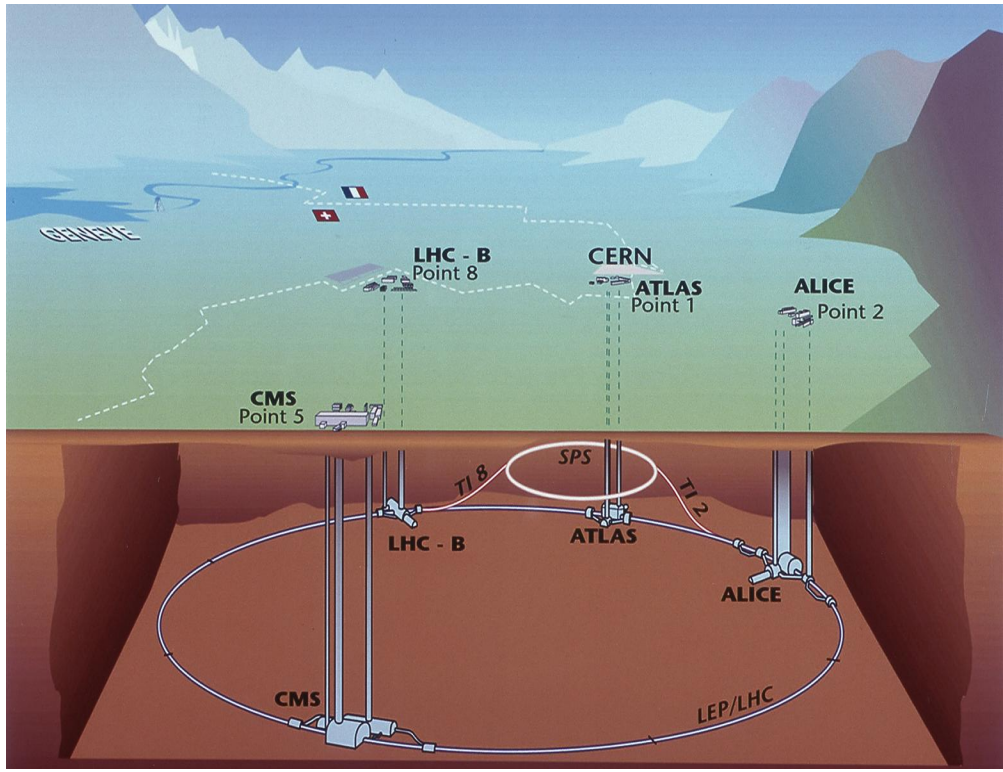
（Highlight）physics at CMS

Huaqiao Zhang (IHEP, Beijing)

(18-21,Aug,2018@Tianjing, China)

LHC: a discovery machine of energy frontier





Large Hadron Collider (LHC):

A machine that has highest Ecm that mankind ever made

Located at CERN, 27km tunnel, 14 TeV E_{cm}

CMS detector

最重的探测器

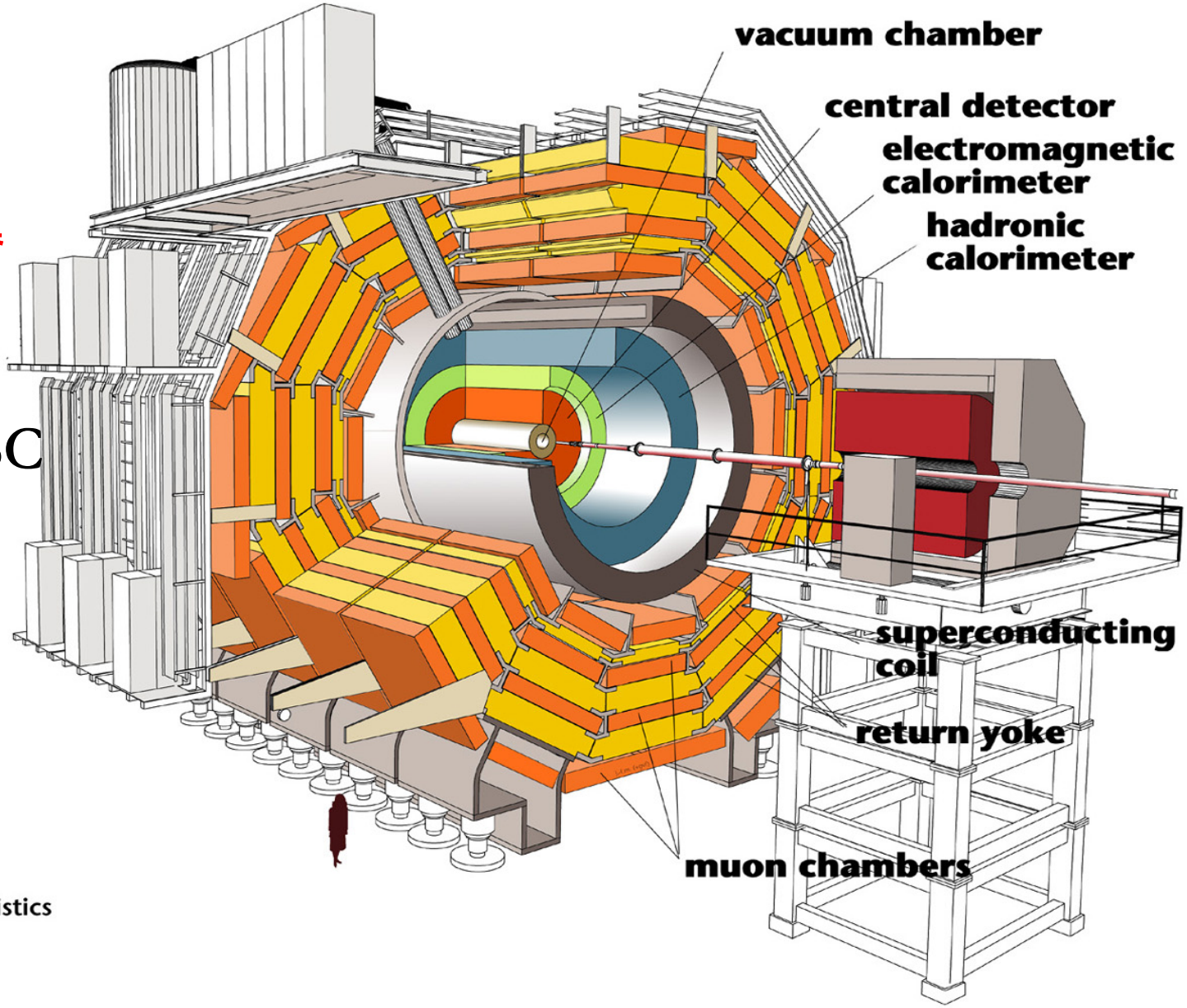
中国

RPC/CSC

Trigger

GEM

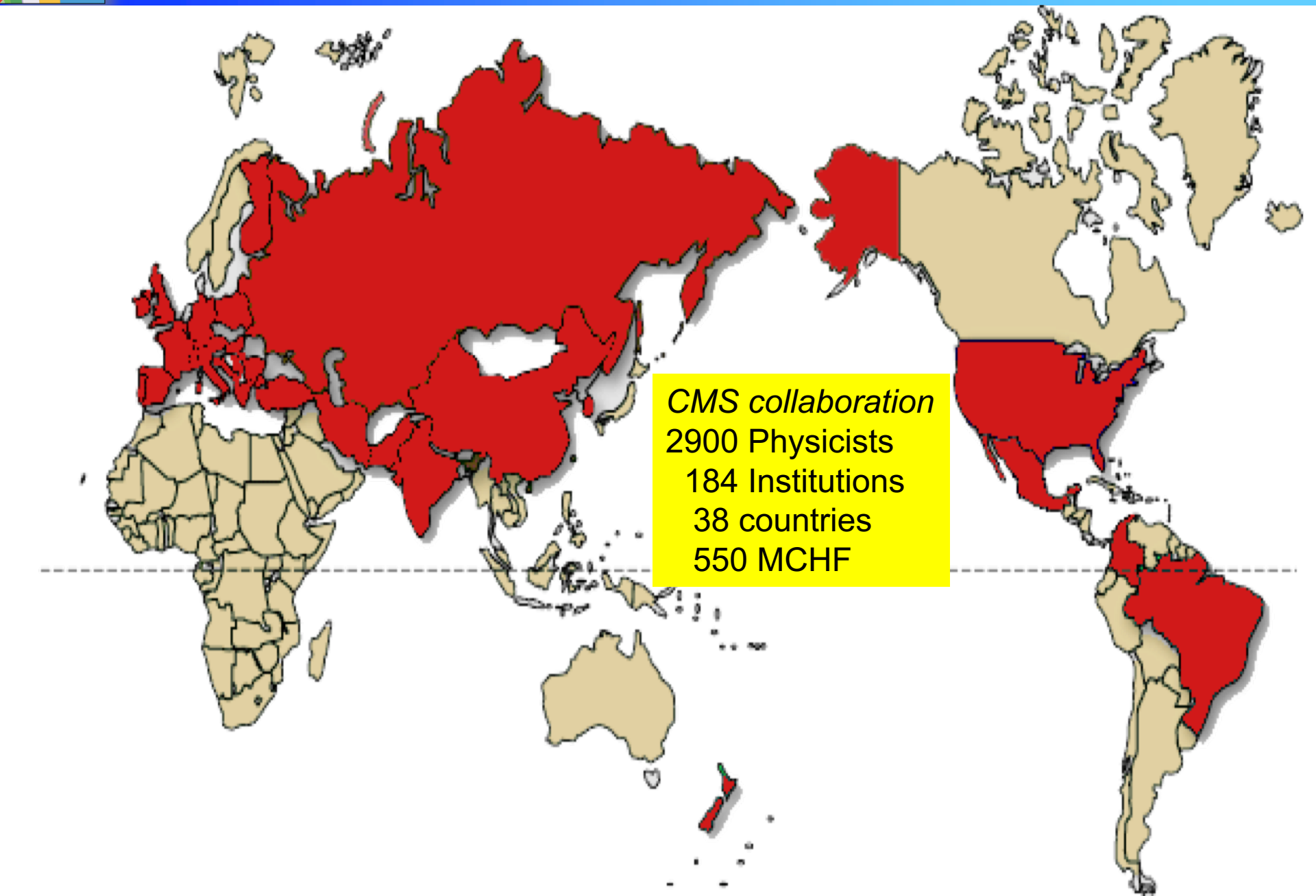
HGCal



Detector characteristics

Width: 22m
Diameter: 15m
Weight: 14'500t

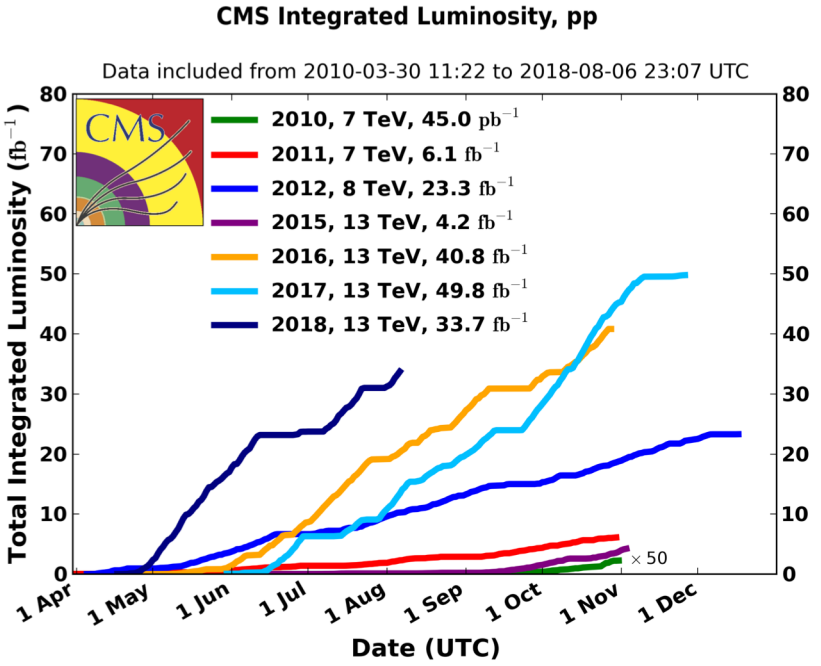
CMS collaboration

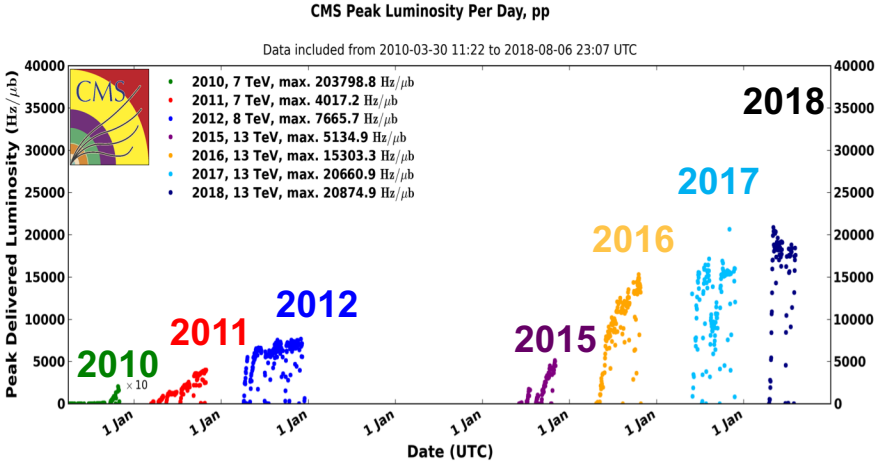


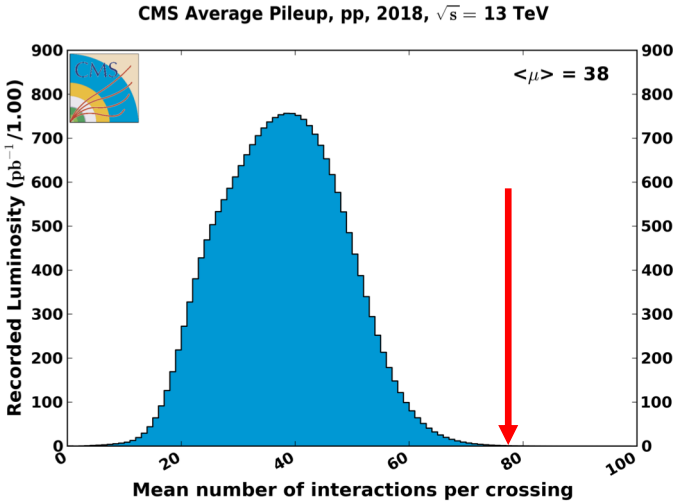
Data taking status

- Data taken from 2010-2018
  - 7TeV → 8 TeV → 13 TeV
- Integrated Luminosity

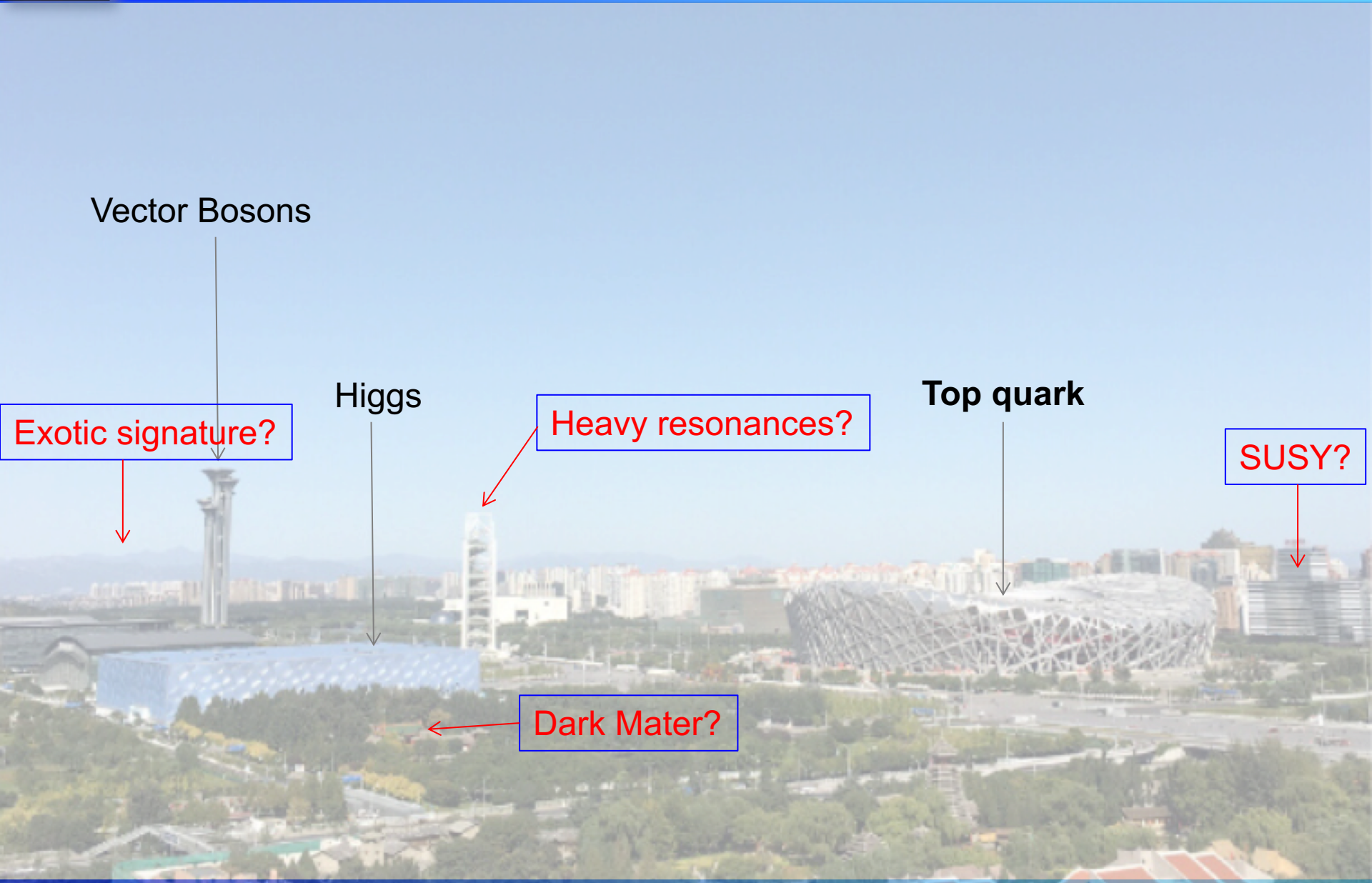
7TeV: ~6.2 fb^{-1}
8TeV: ~23 fb^{-1}
13TeV: ~124 fb^{-1}

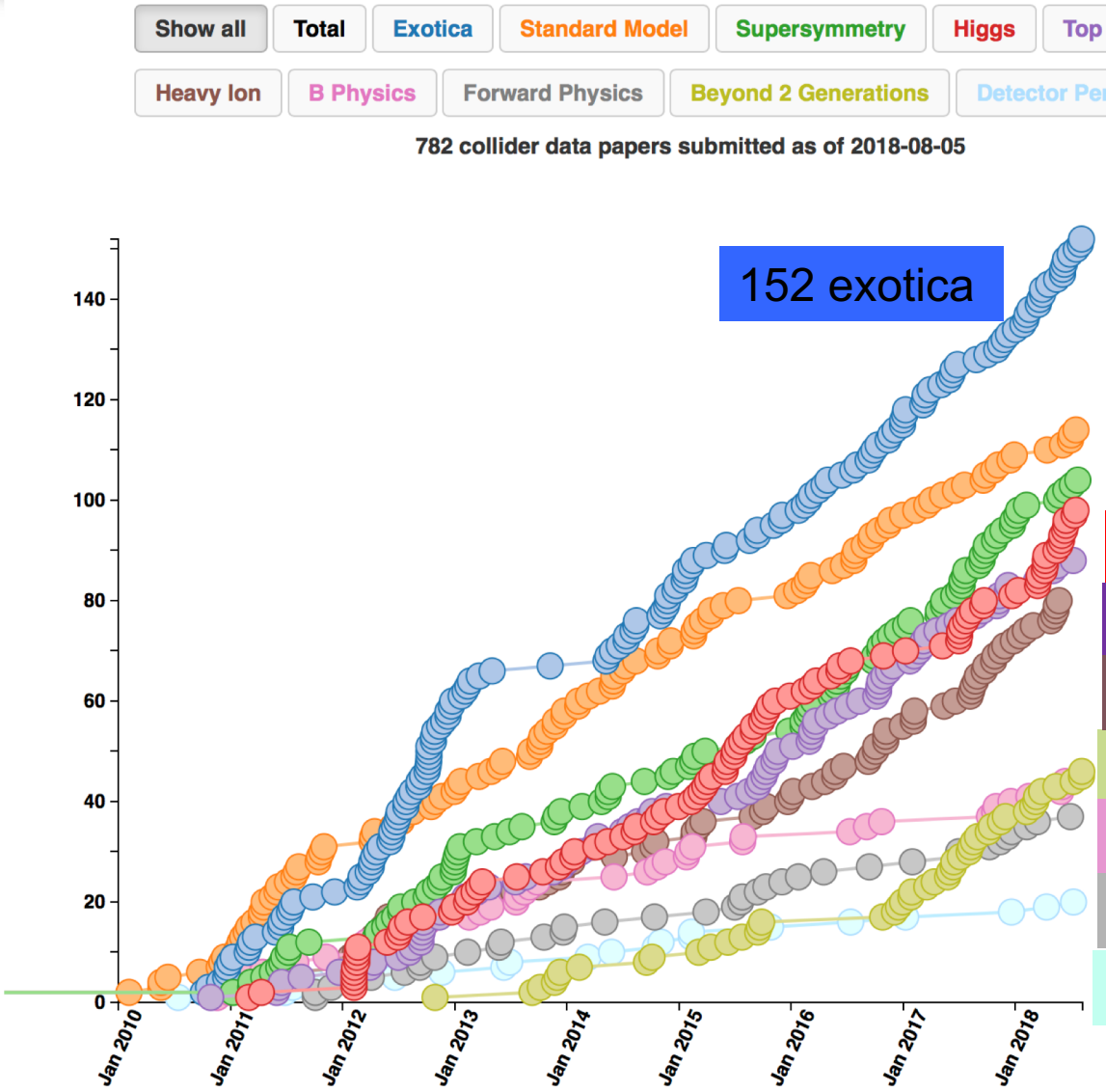






Content of this presentation





152 exotica

114SM

104 SUSY

98 Higgs

88 Top

80 HI

46 B2G

44 Bphysics

37 Forward physics

20 performance

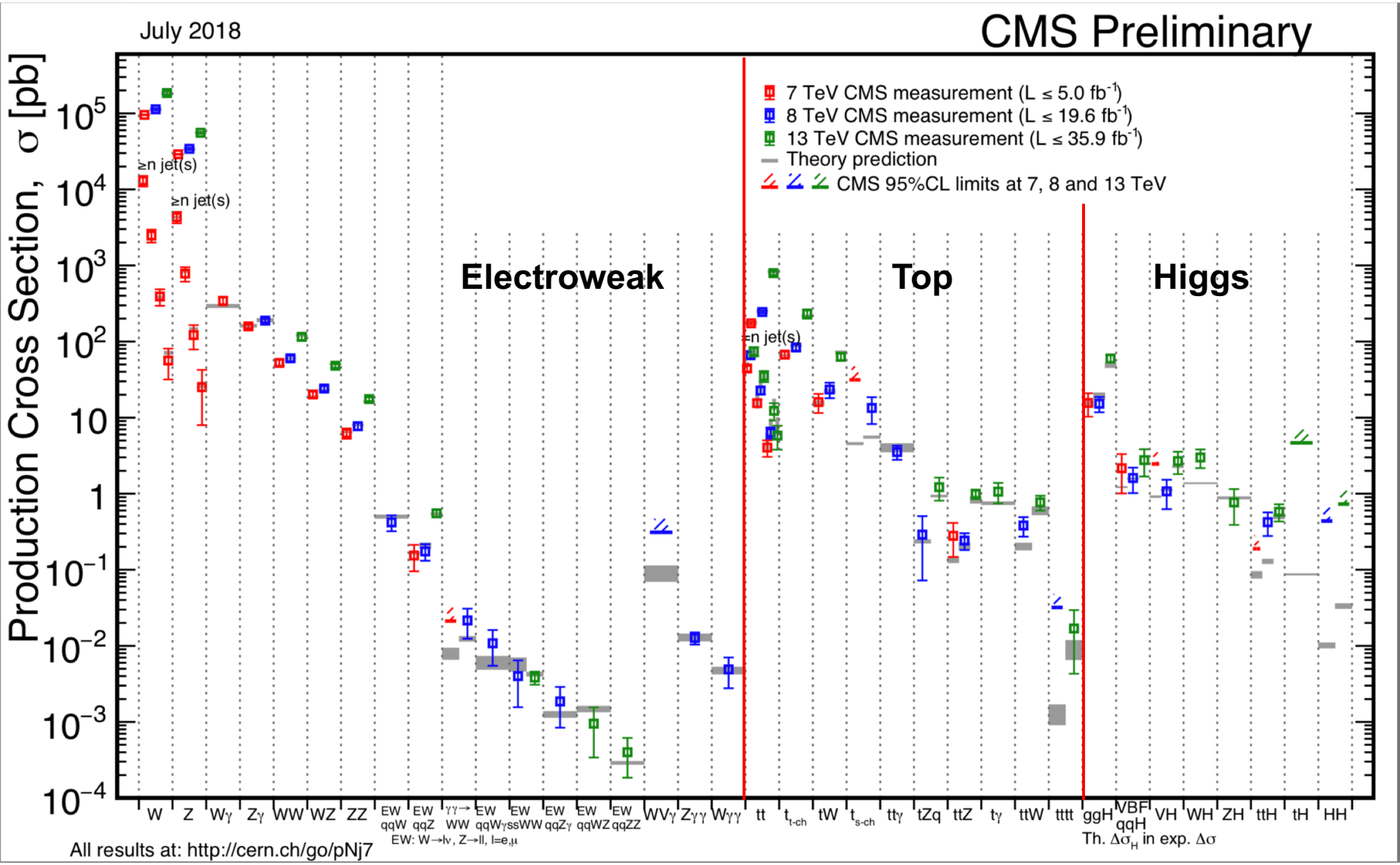
As 7th Aug 2018

there are 782 papers from CMS, similar from ATLAS

More public conference notes with period updates

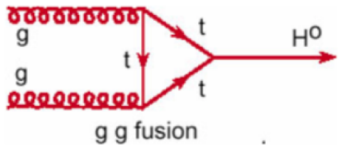
Can only cover very small portion of the total efforts at LHC

Overview of cross section measurement

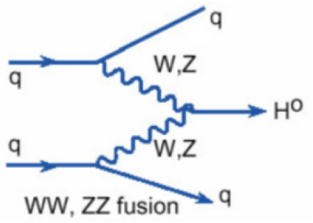


Higgs production at LHC

	ggF	VBF	WH	ZH	bbH	ttH	tHq	tHW
8 TeV	19.5	1.60	0.70	0.42	0.20	0.13	0.019	0.0012
13 TeV	44.1	3.78	1.37	0.88	0.49	0.51	0.074	0.0029
ratio	2.3	2.4	2.0	2.1	2.5	3.9	3.9	2.4

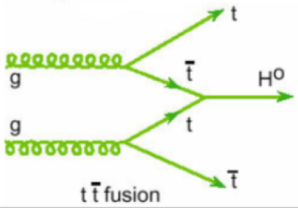


g g fusion

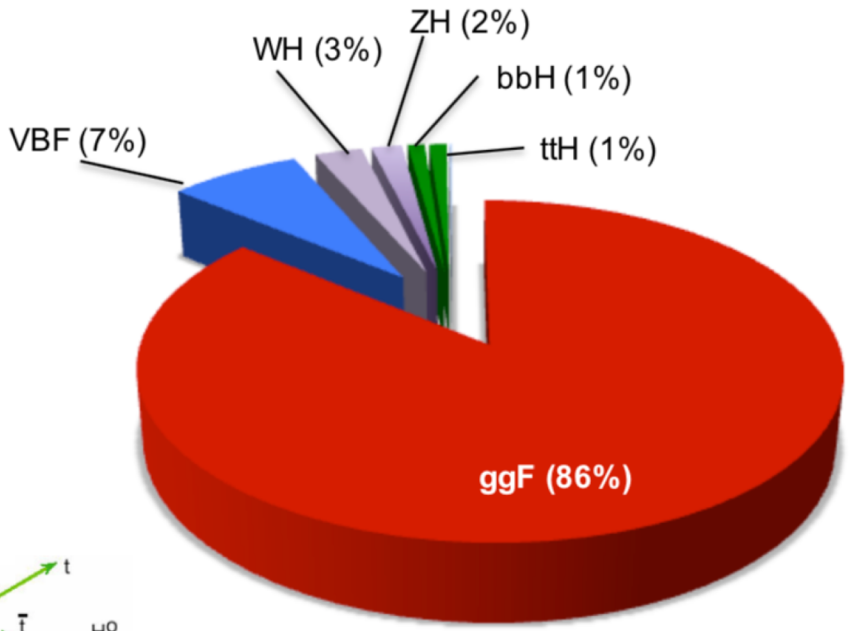


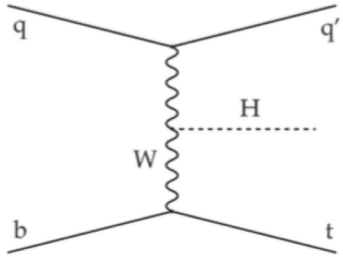
WW, ZZ fusion

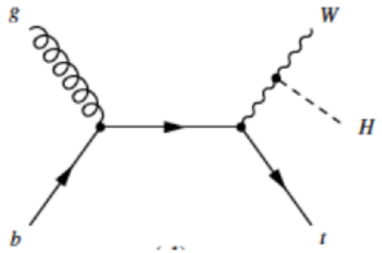
W, Z bremsstrahlung



t t̄ fusion

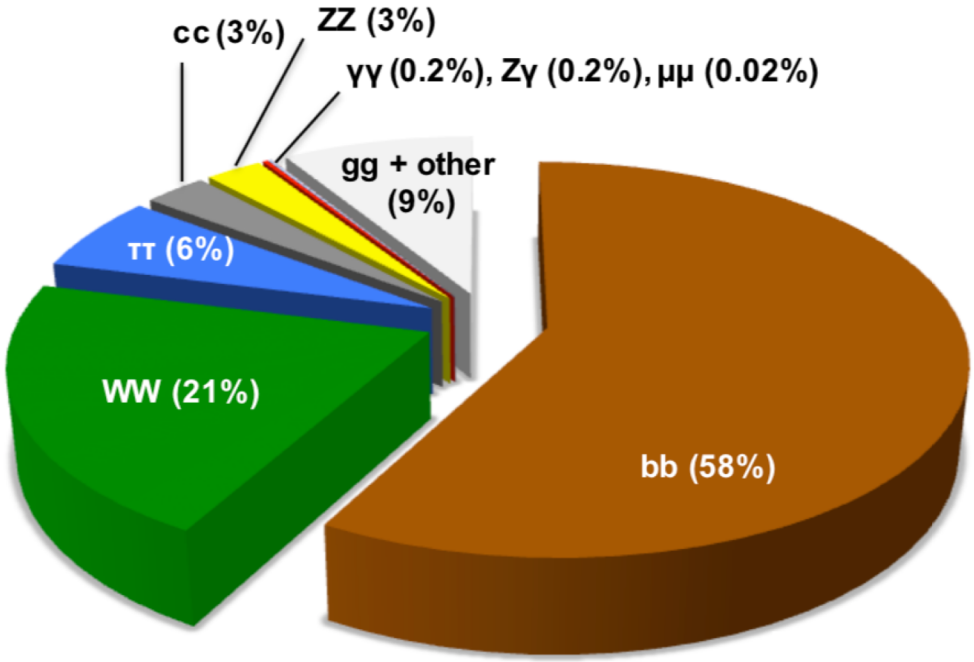


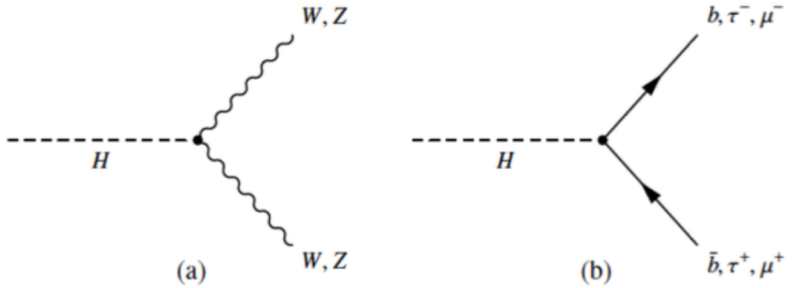


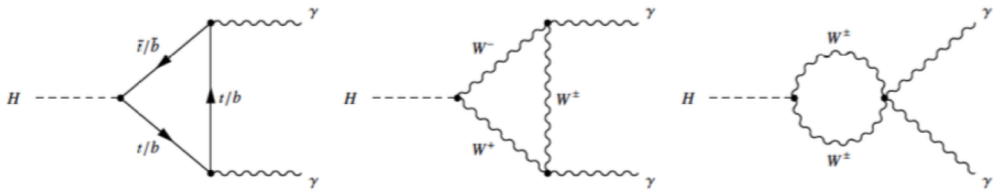


Higgs Decays

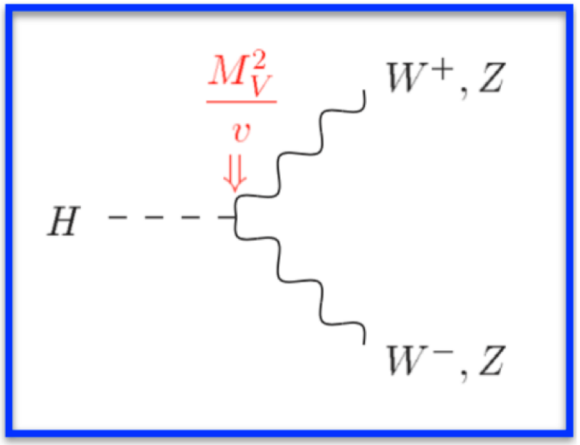
	bb	WW	ττ	cc	ZZ	γγ	Zγ	μμ	gg + …
all	58%	21%	6.3%	2.9%	2.6%	0.23%	0.15%	0.022%	9%
leptonic		0.76%			0.012%		0.09%		

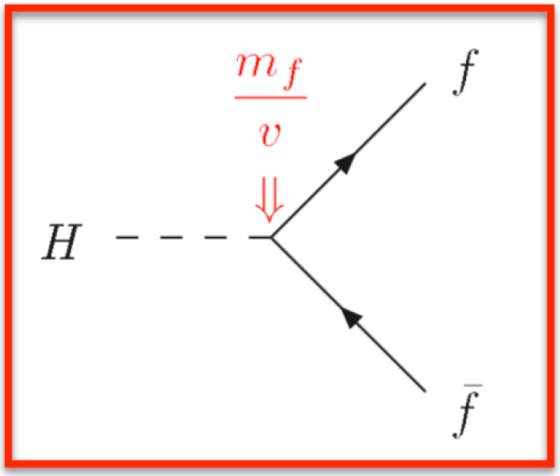


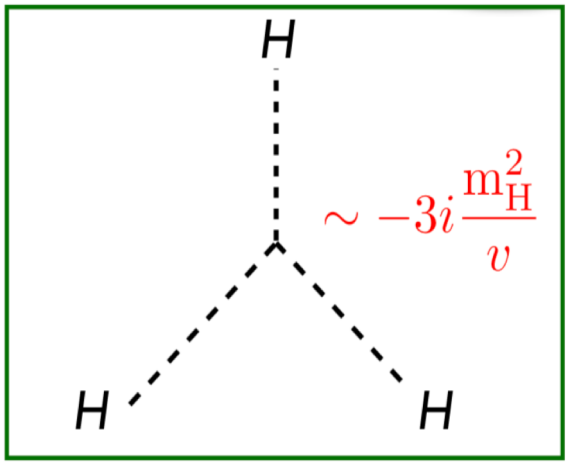


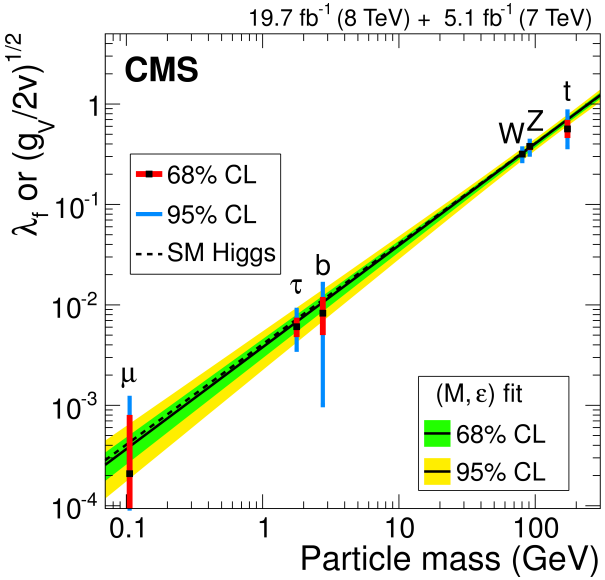


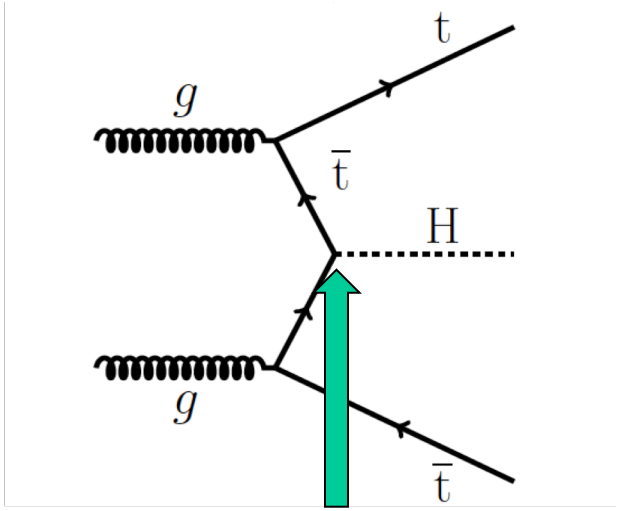
Higgs couplings











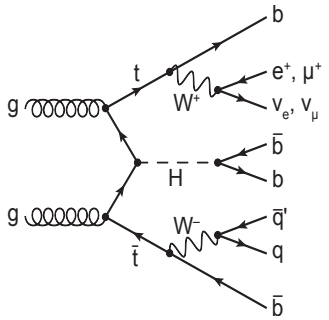
direct detection

ttH: probably the only channel that can **direct** probe Higgs Yukawa coupling at LHC

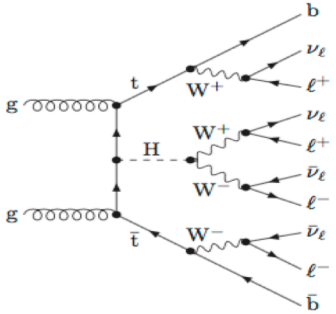
How to hunt ttH

- Search in H→multilepton,bb,$\gamma\gamma$/ZZ
- MVA analysis, multiple(21) signal and control regions

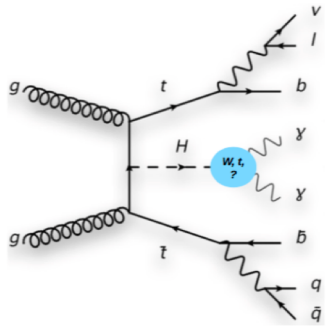
Higher cross-section ⟵ ⟶ Higher purity



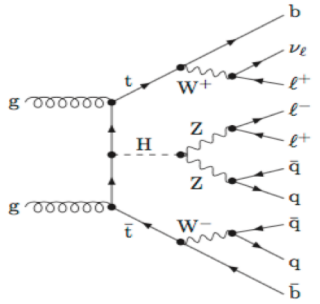
arXiv:1804.03682



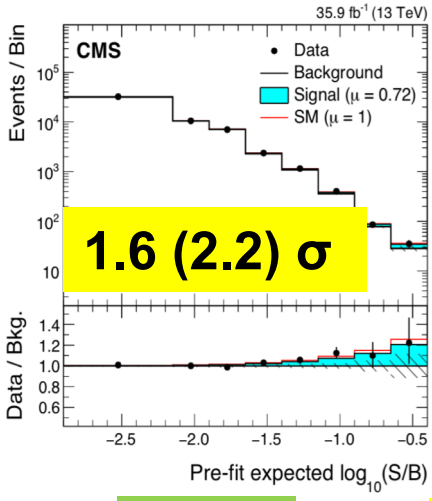
arXiv:1803.05485



arXiv:1804.02716

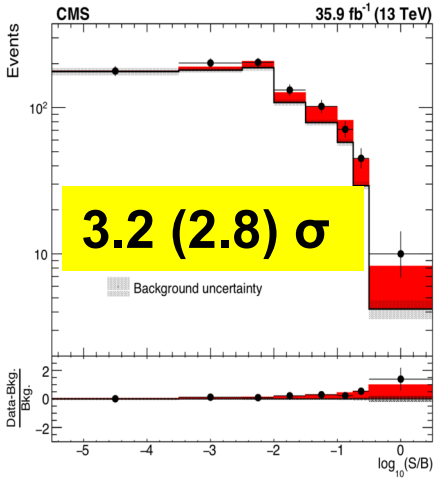


JHEP11(2017)047



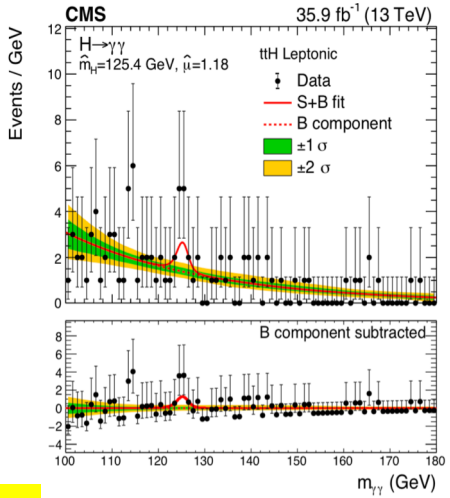
1.6 (2.2) σ

IHEP

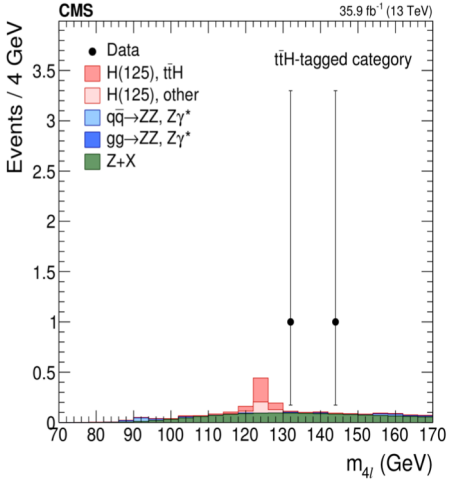


3.2 (2.8) σ

IHEP pre-approval/PKU



IHEP

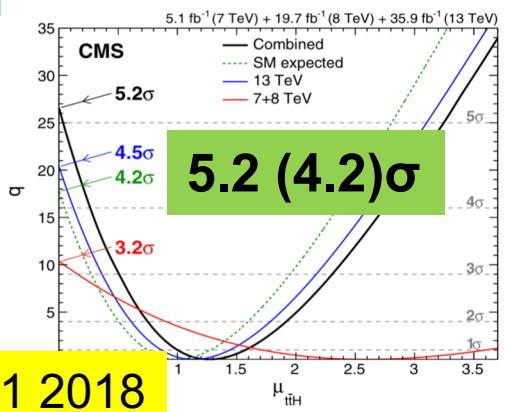


IHEP

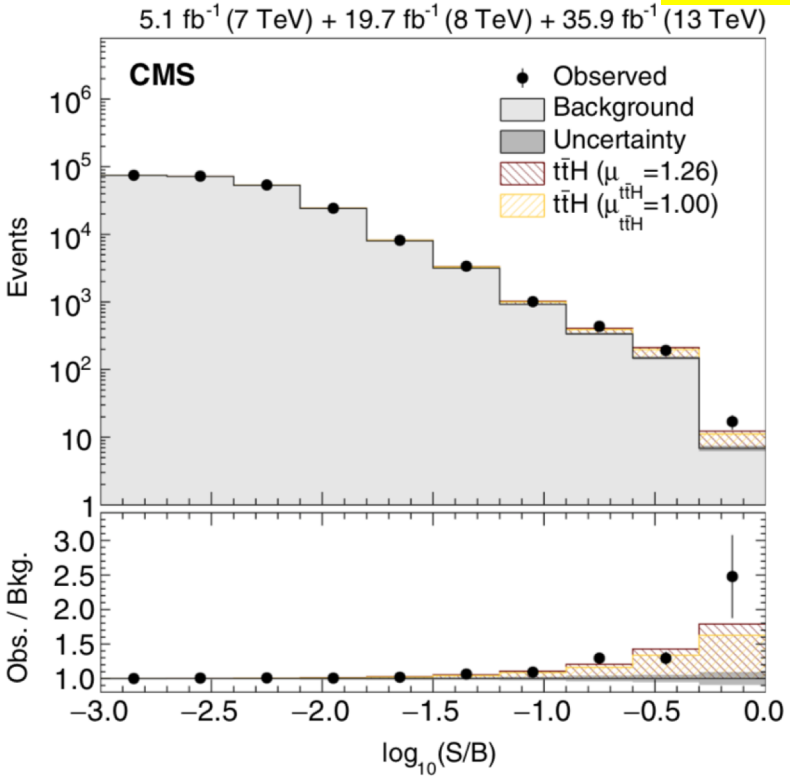
Observation of ttH

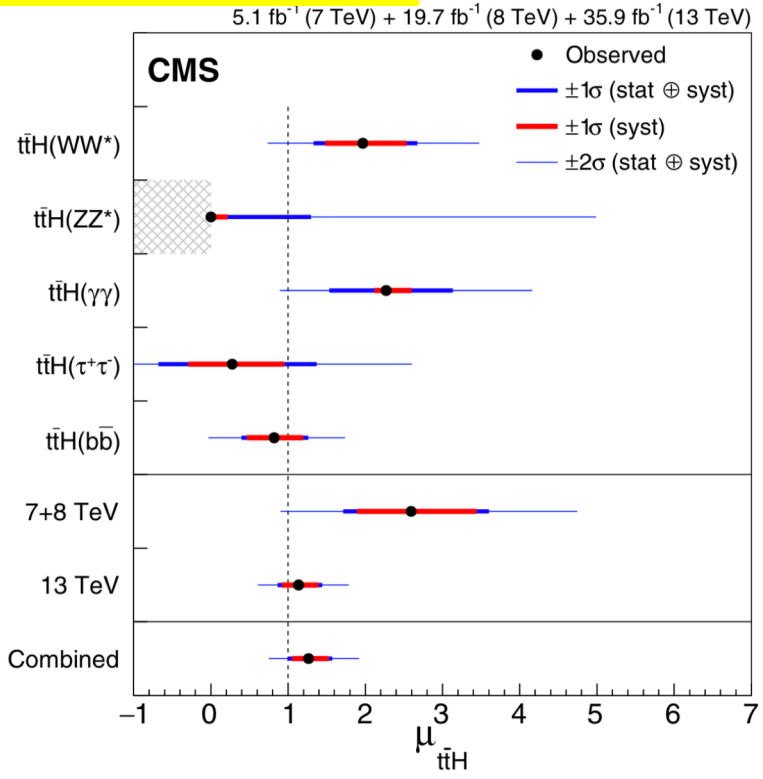
- Combination of ttH,H→WW/ ττ /bb/γγ/ZZ
  - 7TeV + 8TeV + 13 TeV(35.9 fb^{-1}, data taken up to 2016)
- Simultaneous ML fit to all decay modes/Ecm

$$\mu_{t\bar{t}H} = 1.26^{+0.31}_{-0.26}$$



Phys. Rev. Lett. 120, 231801 2018





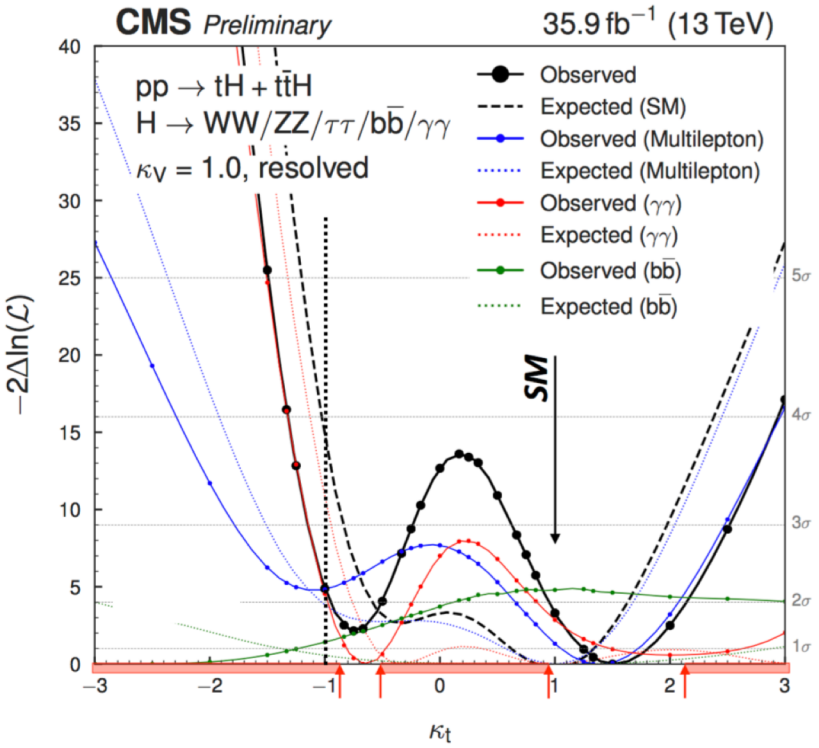
First observation, ATLAS confirmed with more data

tHq searches

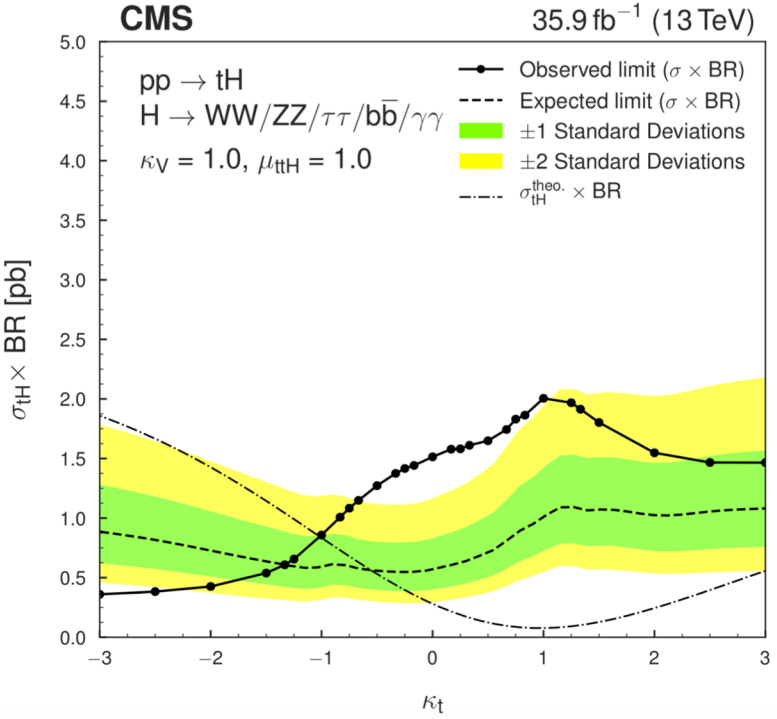
- Sensitive to Yt/gHVV
- Search in H→multi-lepton/bb/$\gamma\gamma$
- Data favors SM phase at 1.5(4)σ
- tHq+ttH about 2 σ within SM pred.

CMS PAS HIG-18-009, about to submit to PRD

$$\sigma_{tH} \propto \left| \propto \kappa_t \equiv y_t / y_t^{SM} + \propto \kappa_V \equiv g_{HVV} / g_{HVV}^{SM} \right|^2$$



Destructive interference in SM

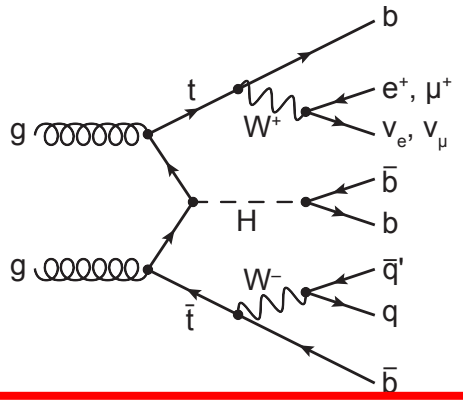


Observation of Higgs decay to bottom quarks

- Higgs Largest decay mode

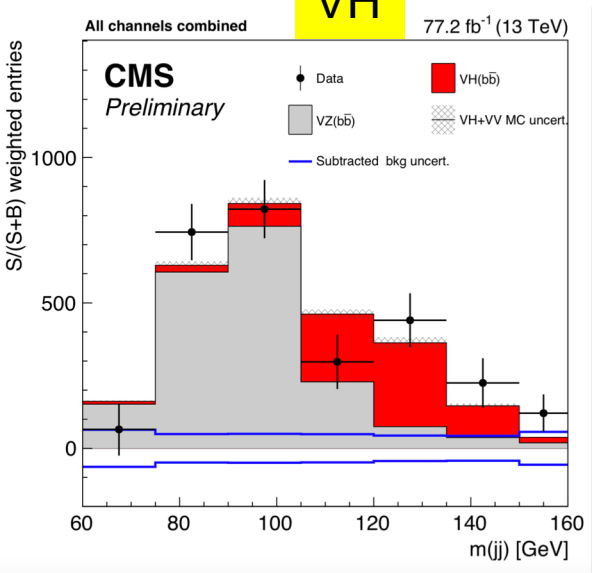
CMS PAS HIG-18-016; to be submitted to PRL

- Search with 4 productions modes
  - VH,H→bb; with 0/1/2 leptons
  - ttH+tH,H→bb; PRL 120, 231801 2018 (IHEP)
  - VBF H, H→bb; PRD 92, 032008 (2015)
  - ggF H, H→bb bosted; PRL 120,071802,2018

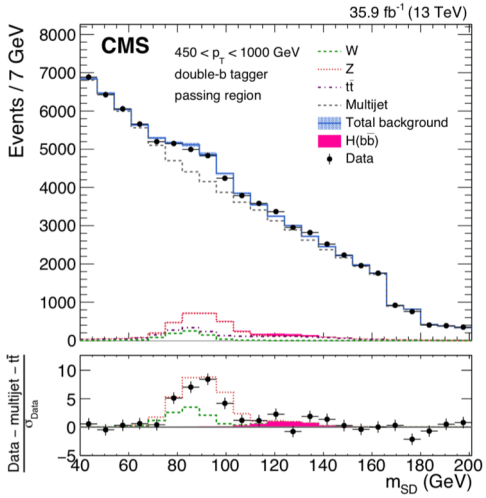


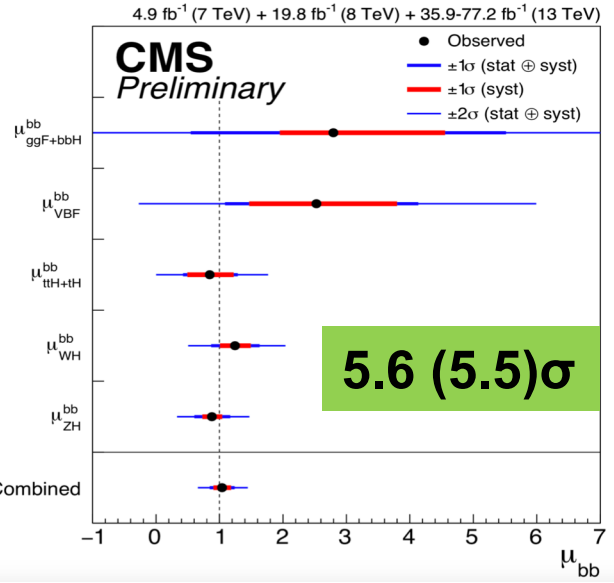
$$\mu = 1.04 \pm 0.20$$

VH



ggH, boosted





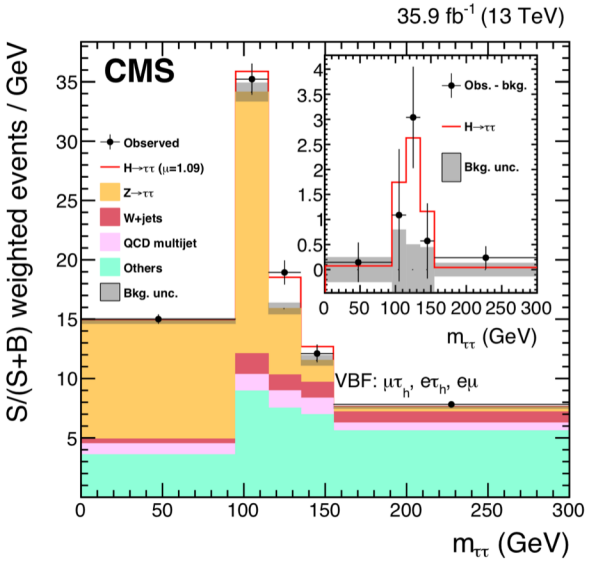
Observation of H→ττ

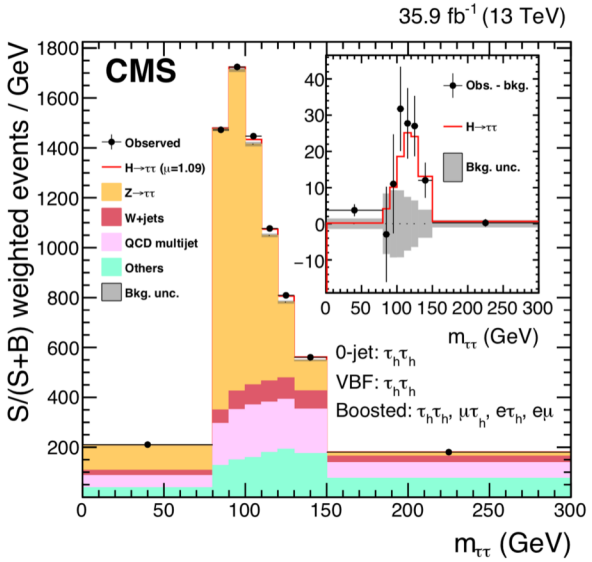
PLB 779 (2018) 283

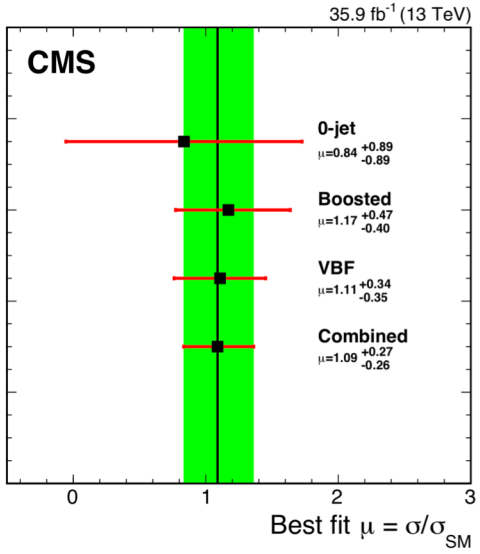
- Strong (relatively to other leptons) coupling to Higgs
- Large background dominated by Z→ ττ
- Search H→ ττ in the production mode of ggH,VBF,VH
  - ttH,H→ ττ comes recently and not yet in the combination
  - Categorized into: 0-jet, VBF, boosted

5.9σ 7/8/13 TeV

$$\mu = 1.09^{+0.27}_{-0.26}$$



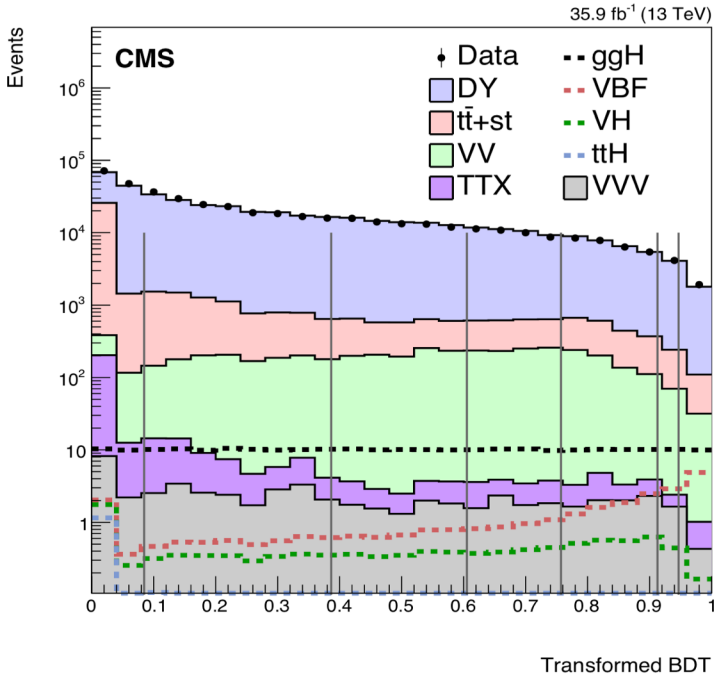


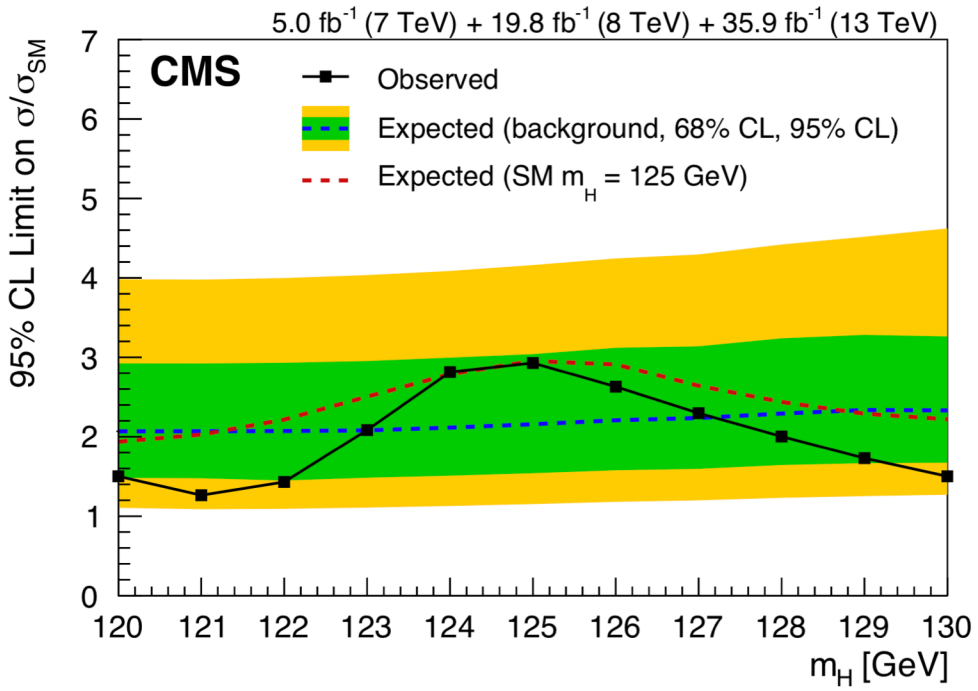


Search for H→$\mu\mu$

- Higgs couples to 2nd generation?
- Very small decay BR (0.02%)
- Overwhelming by DY background (cat. And BDT used)
- Getting close for access assume SM
  - <2.92(2.16) SM @ 95% CL

arXiv:1807.06325; submitted to PRL

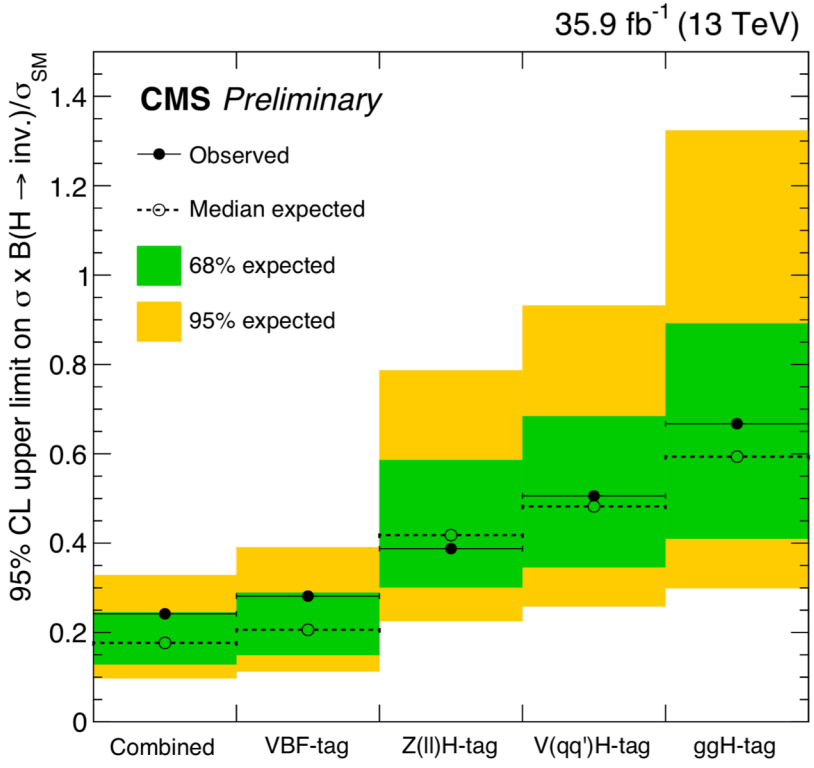




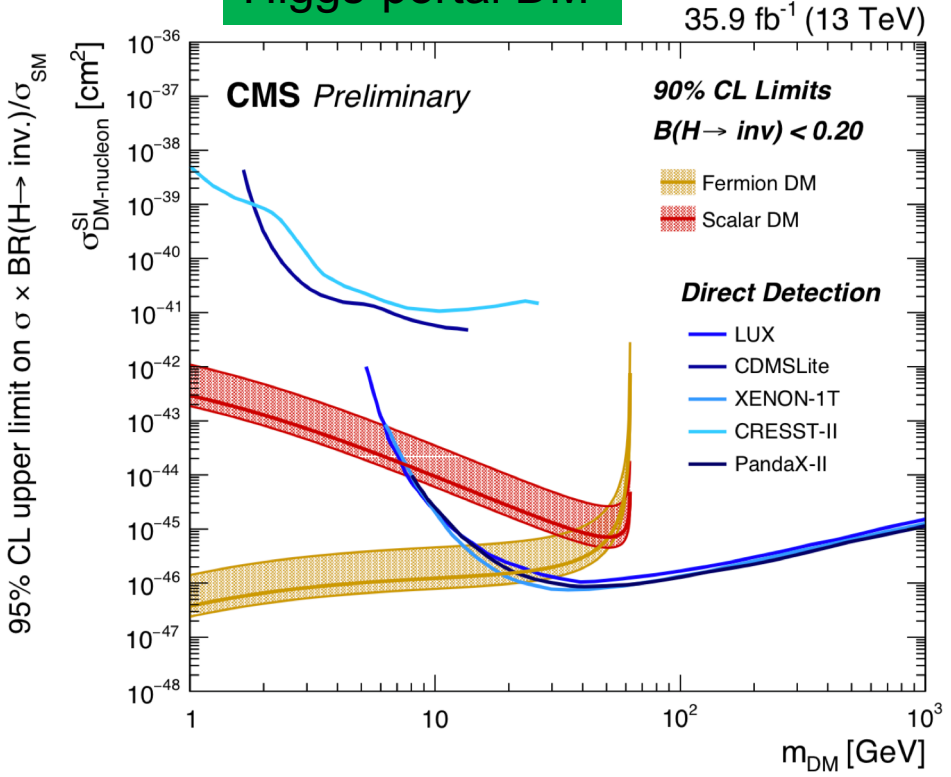
Search for H→inv.

- SM pred. H→inv. Br: <0.1%
- Enhanced from BSM, ex: DM
- <0.24 (0.18) @ 95%

HIG PAS 2017-023 ,
to be submitted to PLB



Higgs-portal DM



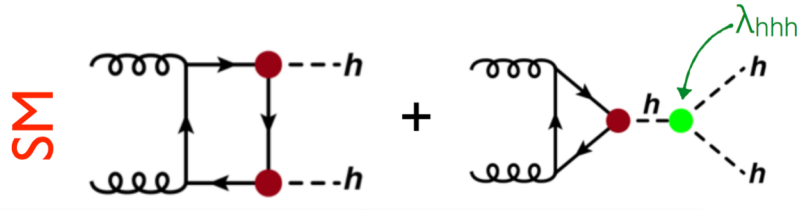
Search for double Higgs

- Production w/w.o. Higgs self coupling
  - Probe Higgs self coupling
- Searched with multiple final states

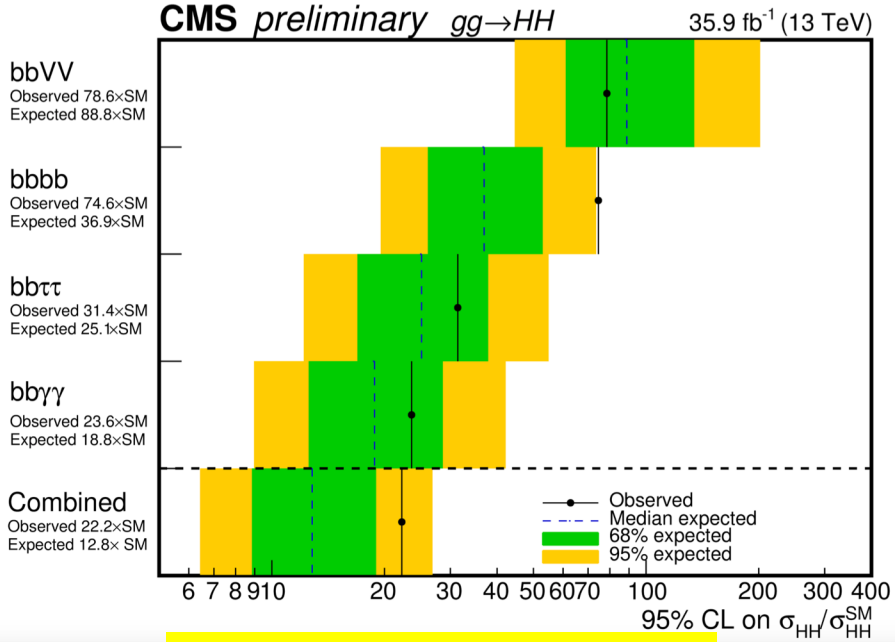
HIG PAS 2017-030

bbbb	bbWW	bbττ	bbγγ
34%	25%	7%	0.26%

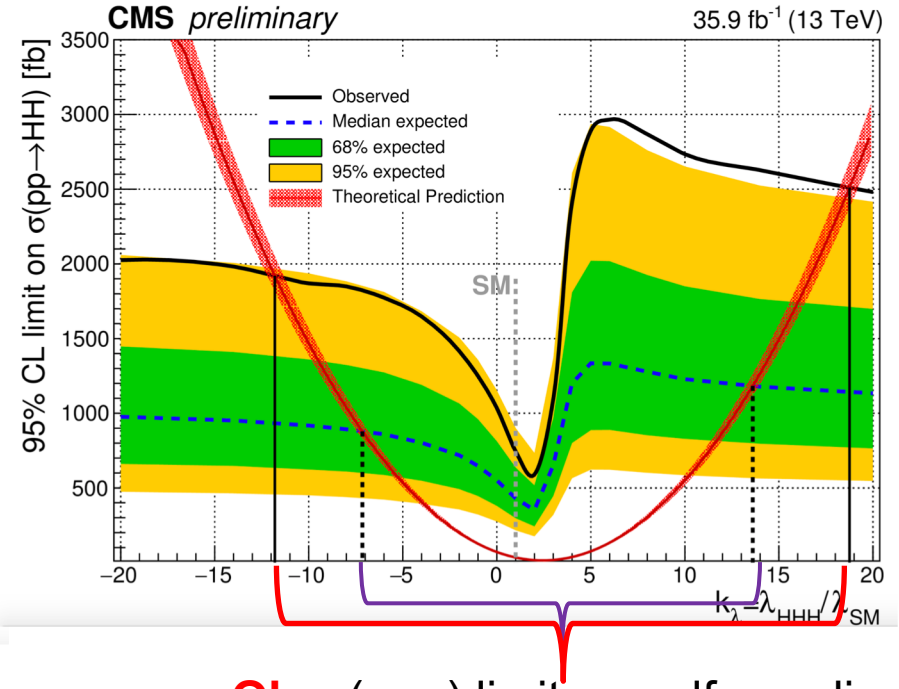
purity



Need HL-LHC



Limit: <22(13) SM pred.

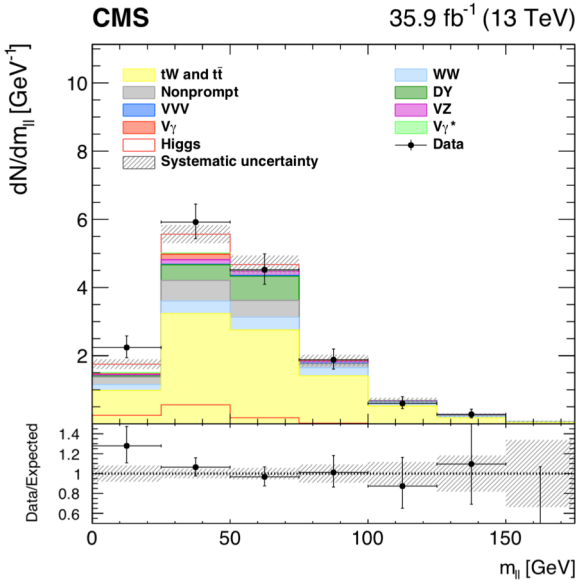


Obv. (**exp**) limit on self coupling

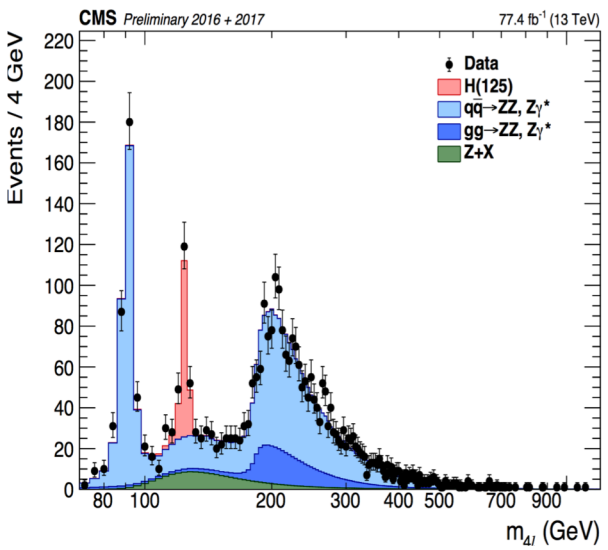
Re-establish H→WW/ZZ/$\gamma\gamma$

- Observed decay channel at beginning of Higgs discovery(2012)
  - WW: 21.5%: large BR, missing final states information
  - ZZ: 2.6%: Clean and narrow peak, low/flat background
  - $\gamma\gamma$: 0.2%, narrow peak over smooth falling background

arXiv:1806.05246

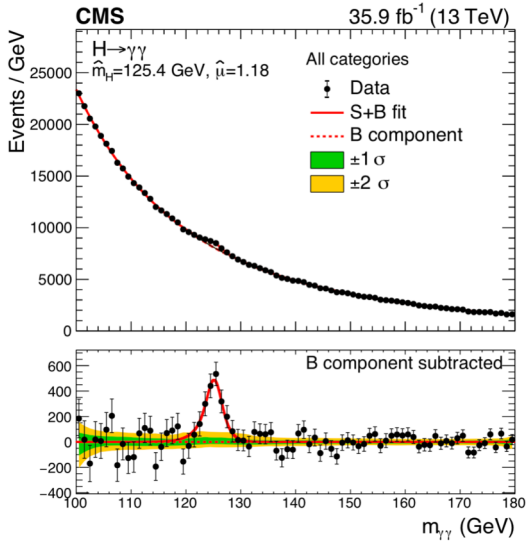


CMS PAS HIG-18-001



IHEP

arXiv:1804.05246

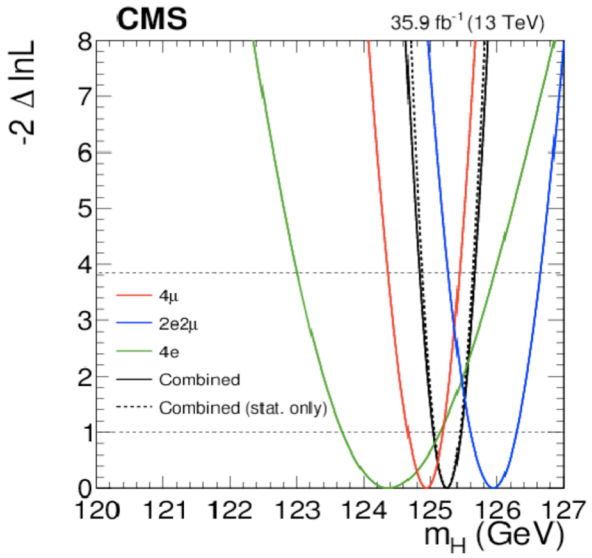


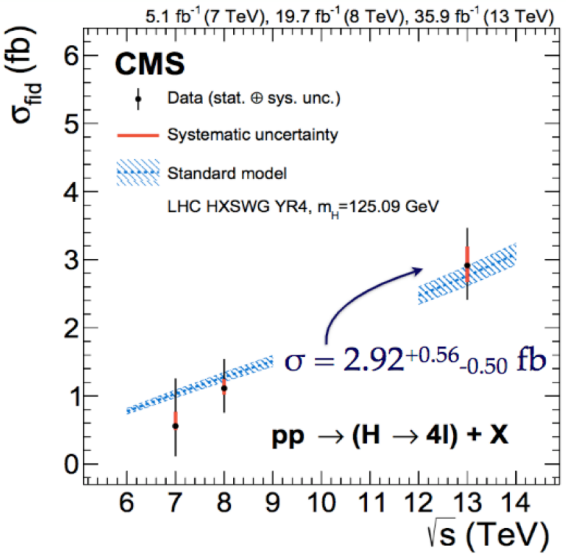
IHEP

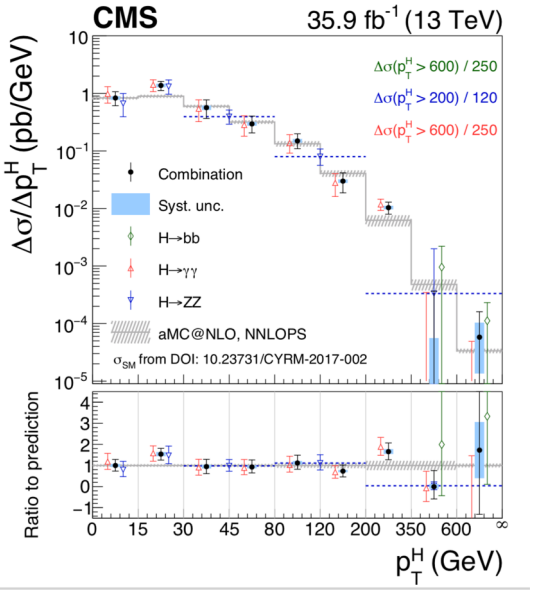
Higgs mass/width/fiducial-differential cross section

- Measurement performed with high precision channels
  - ZZ/ $\gamma\gamma$/WW
- Mass: Run2 ZZ: 125.26 +- 0.21 GeV (statistical dominate)
- Width: SM: 4MeV; direct measurement: < 1.1 GeV; onshell/offshell ratio: <14.4 MeV

PAS HIG-18-028

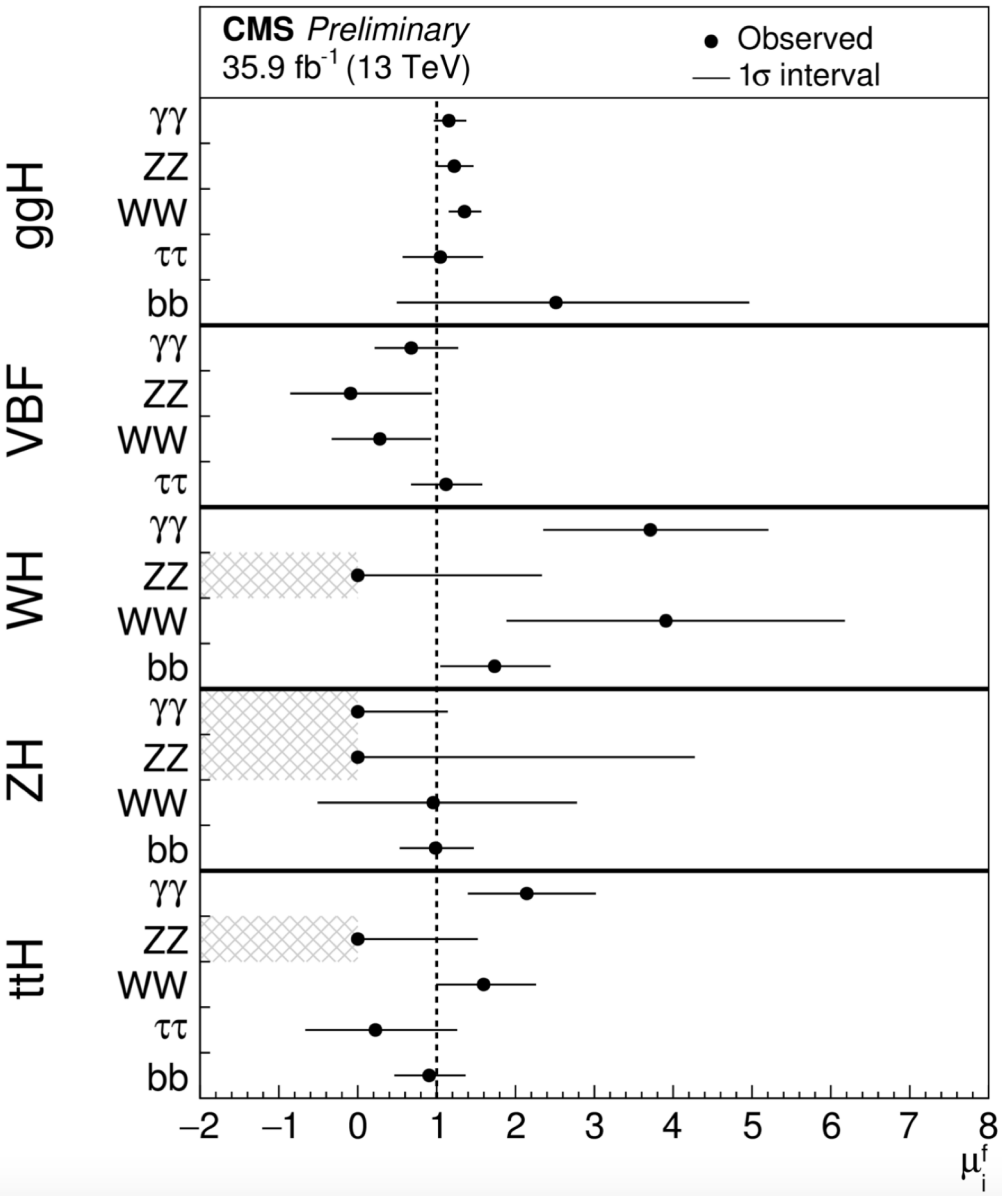


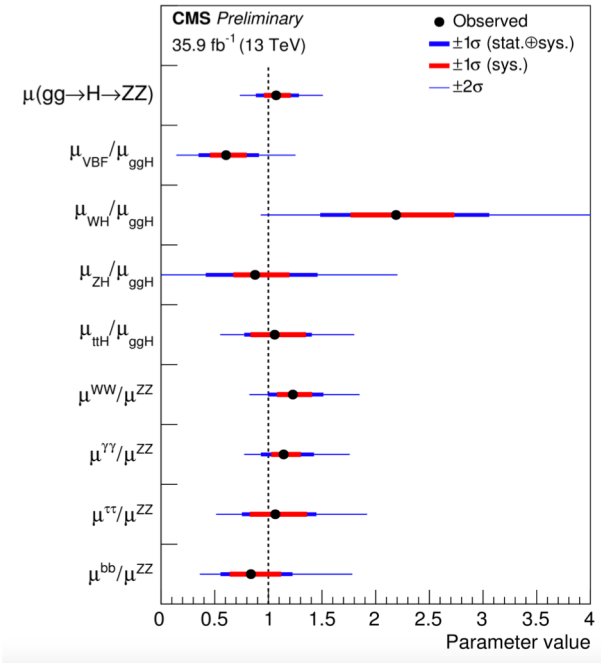


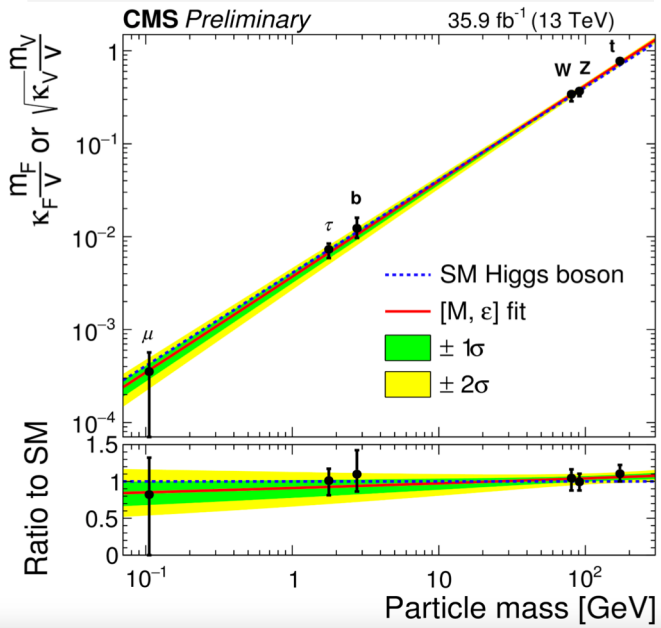


Summary of Higgs production and decays (13 TeV)

CMS PAS HIG-17-031





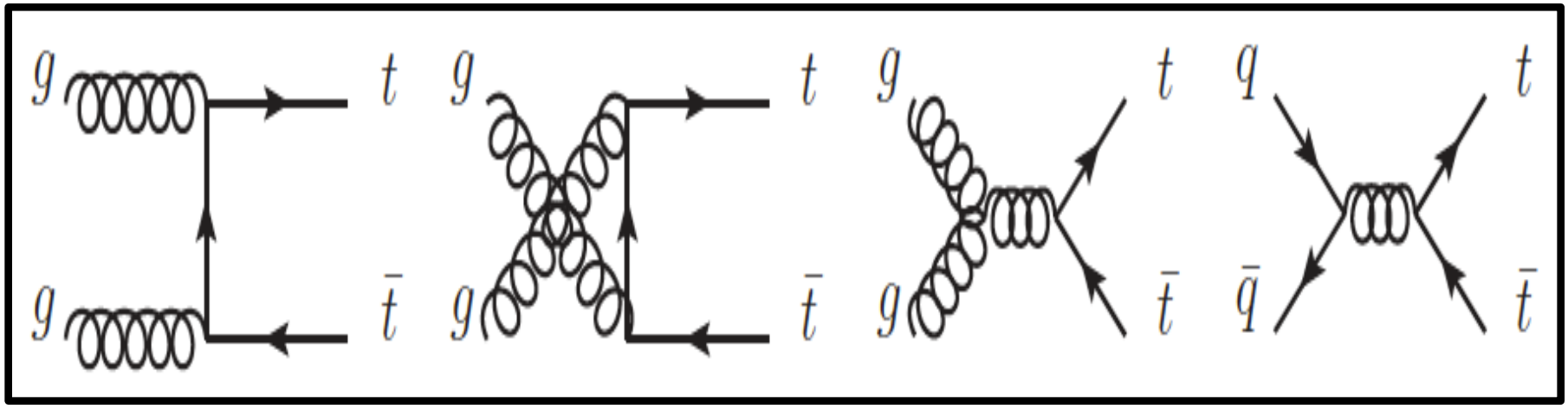


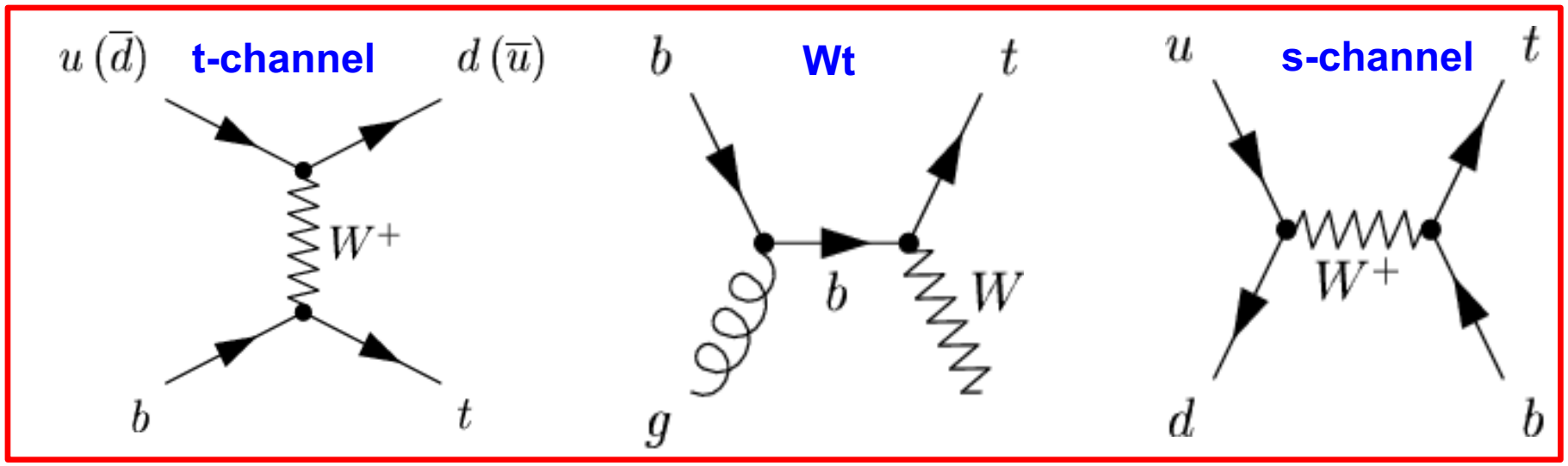
LHC, a top quark factory

- ~$3*10^8$ top events generated at LHC

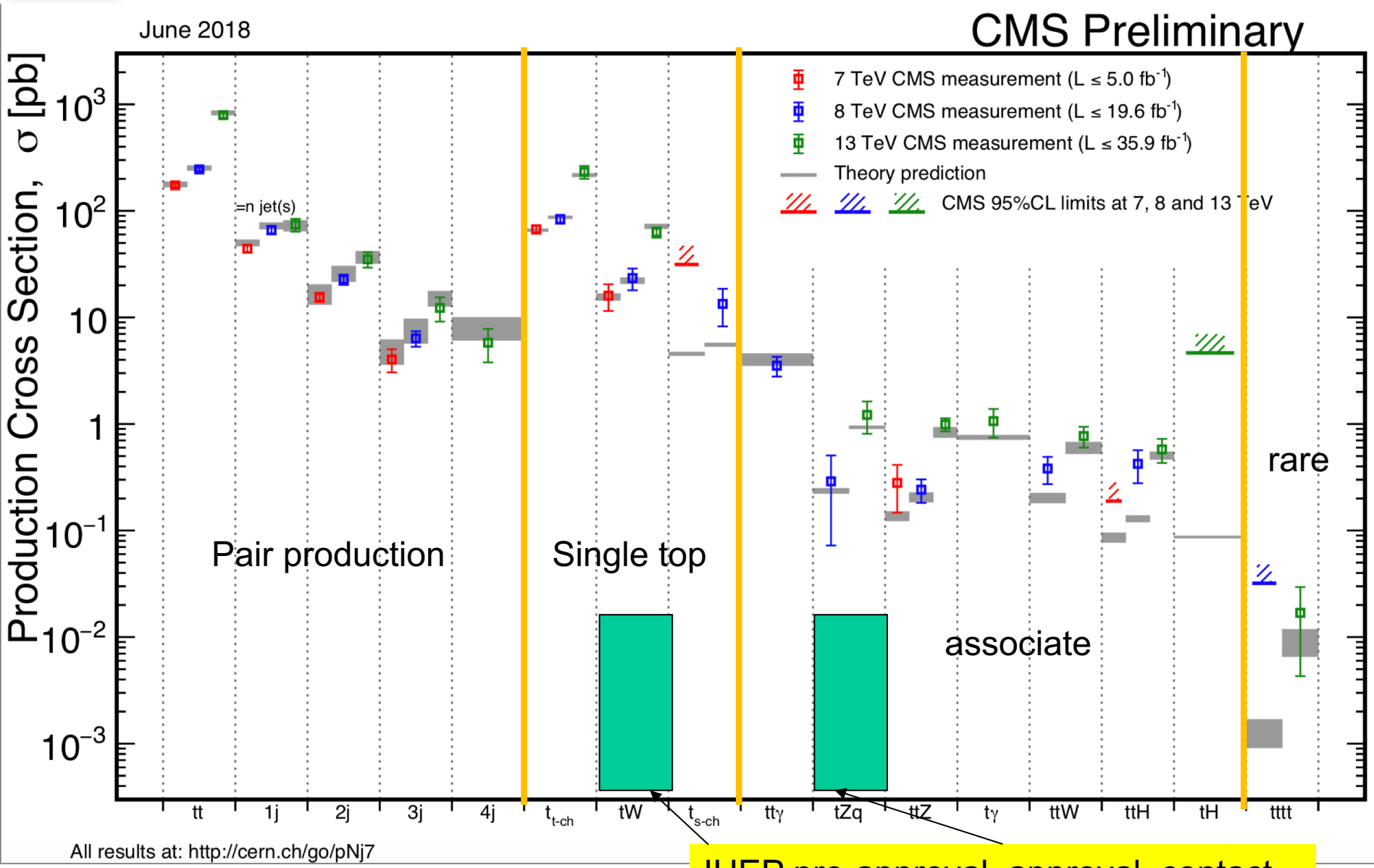
Overview of top physics

- Mass: heaviest (known) elemental particle
- Decay before hadronization



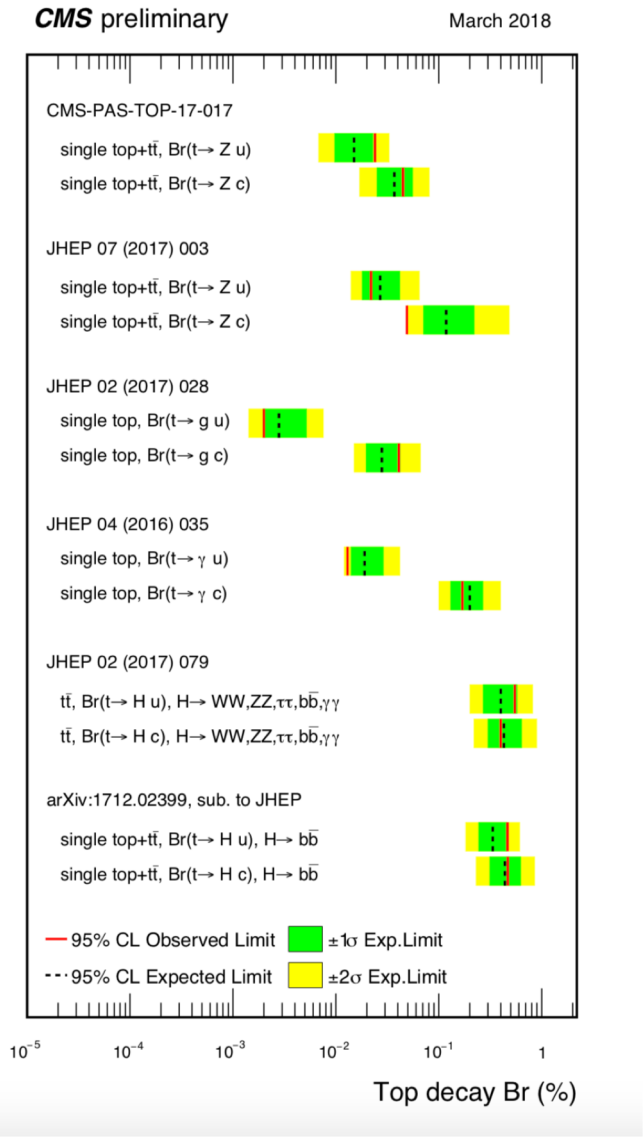


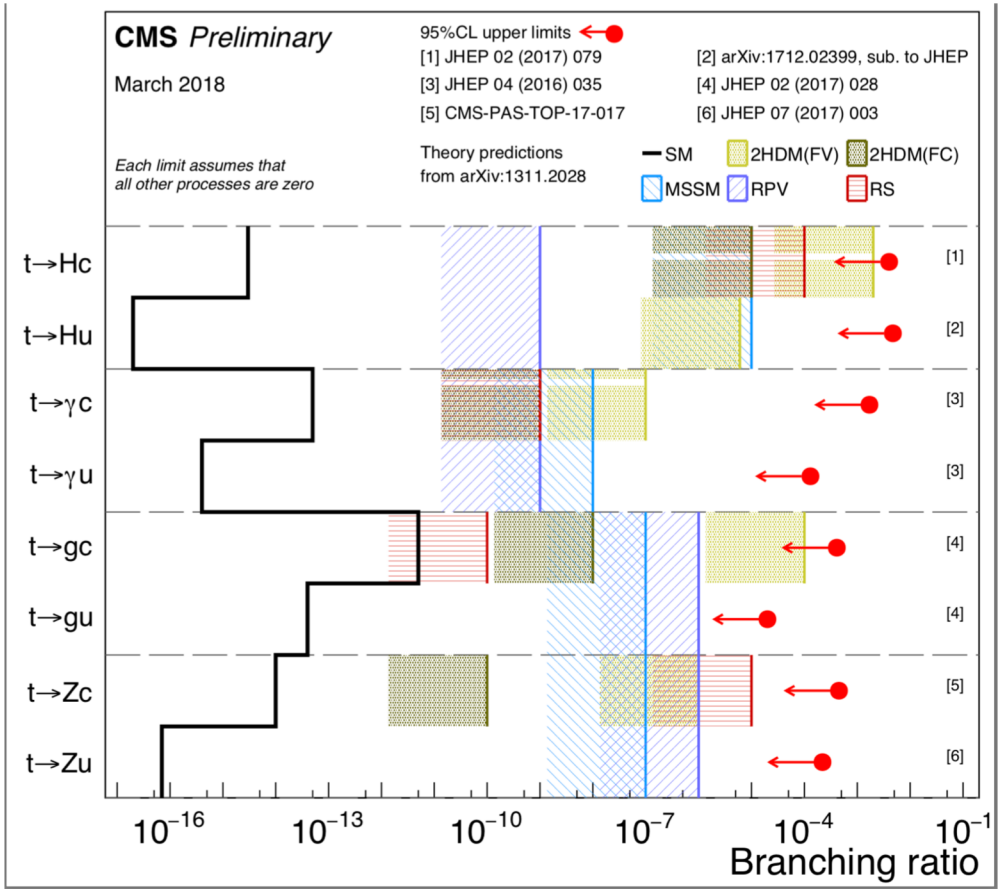
Top production cross section measurement



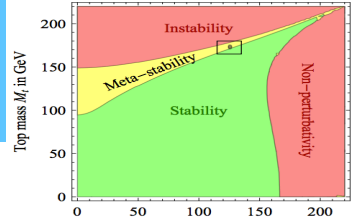
IHEP pre-approval, approval, contact

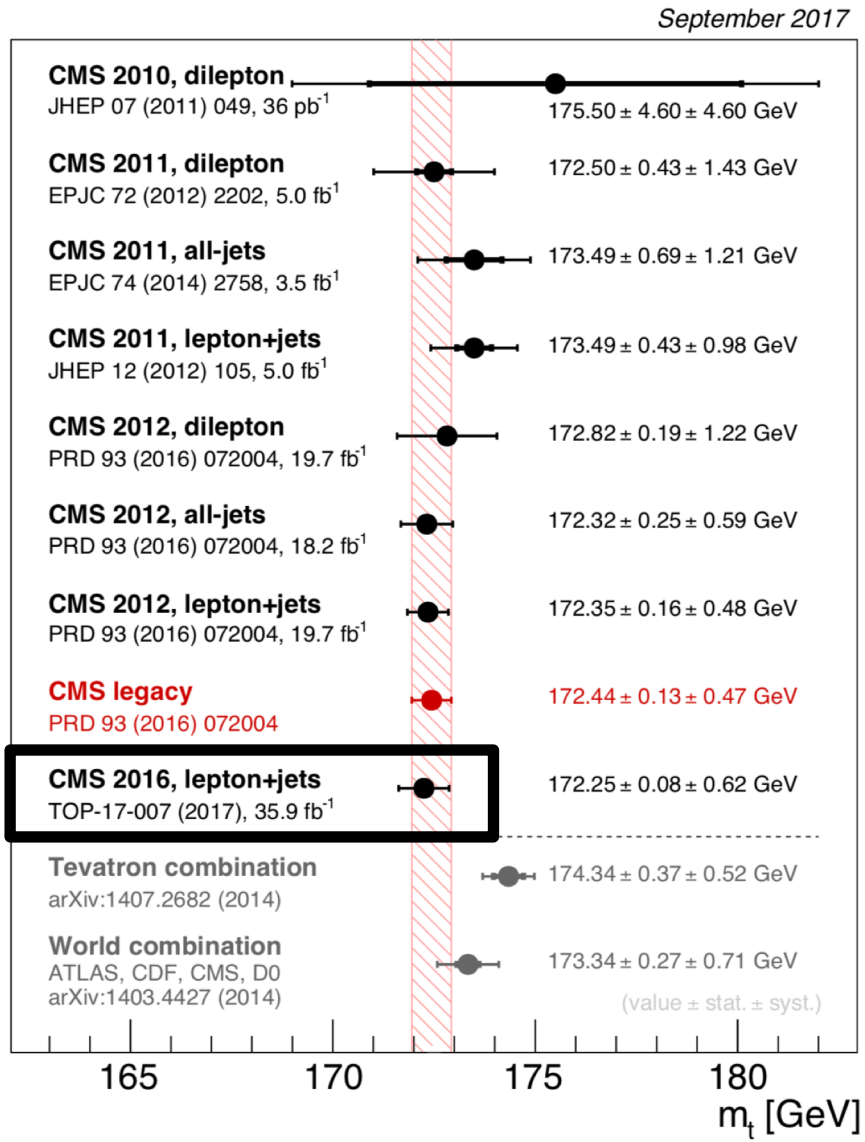
Top rare decay

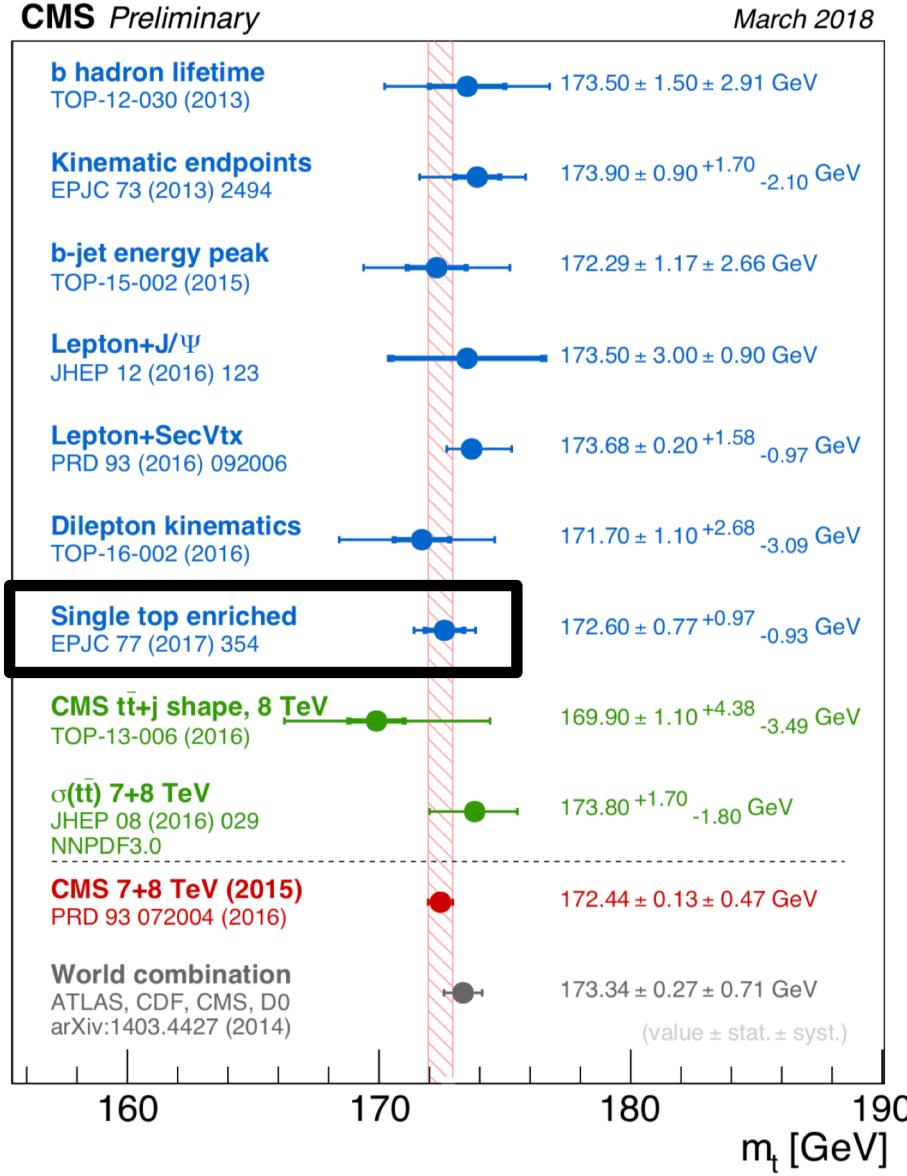




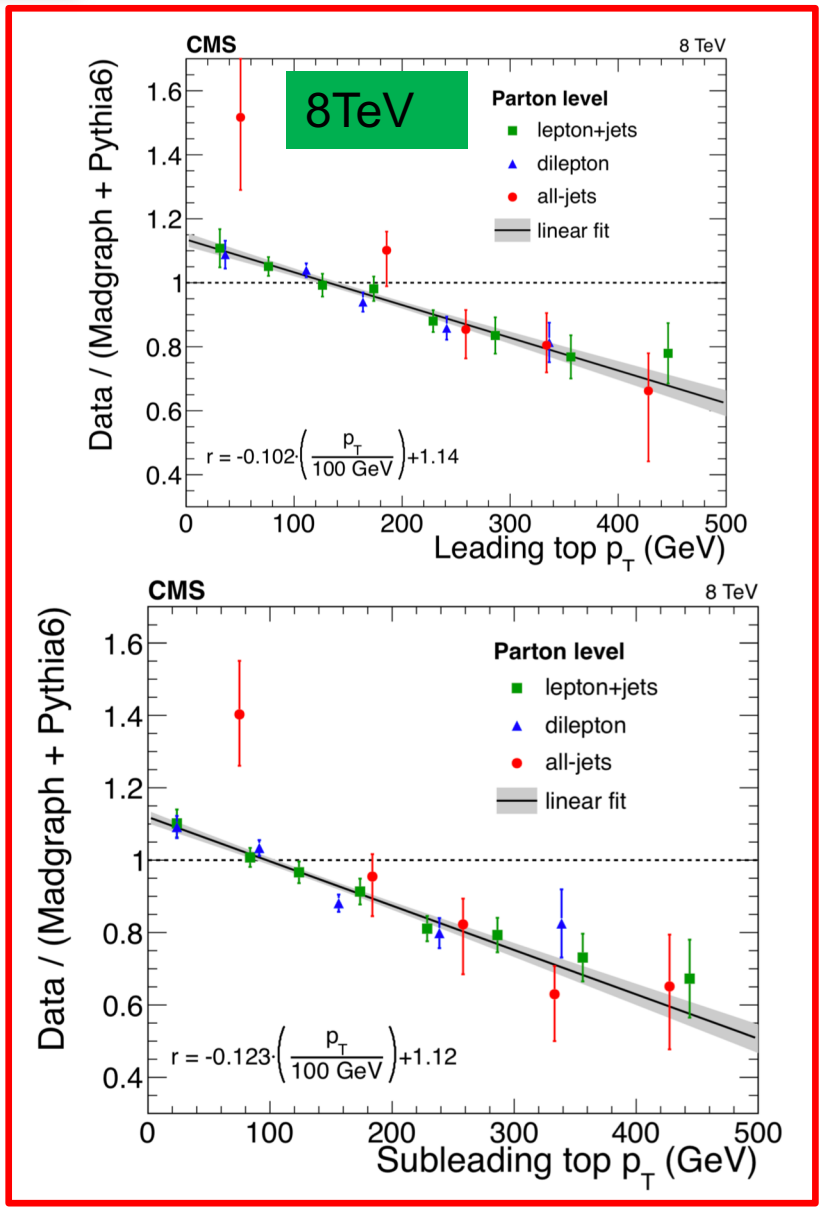
Top mass

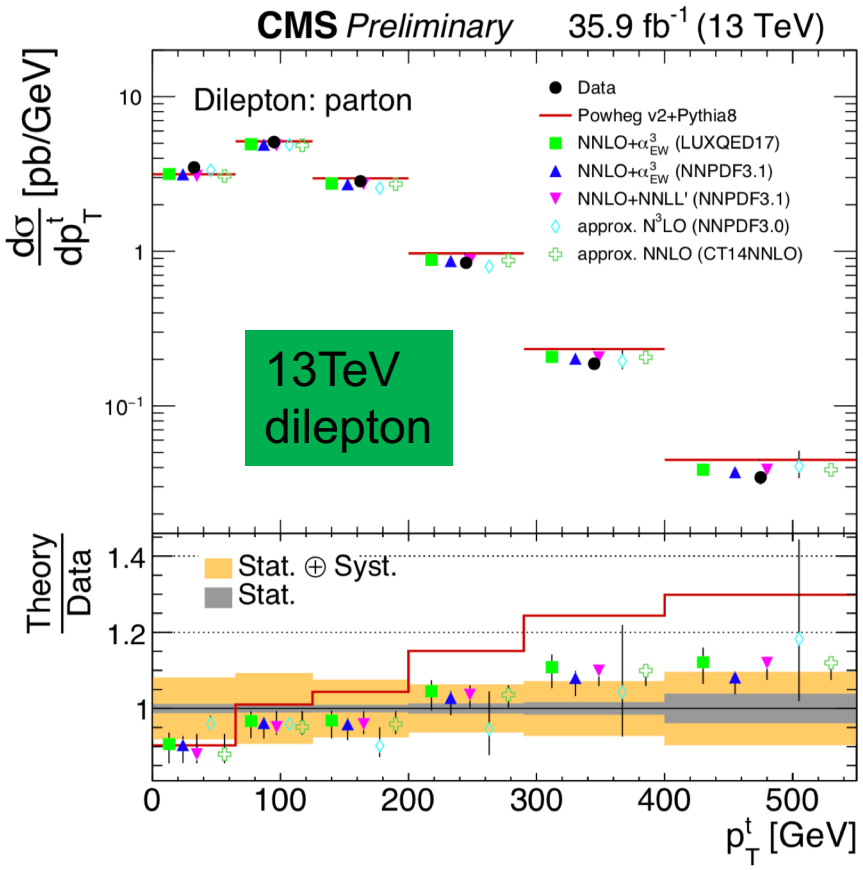

Instability
Meta−stability
Stability
Non−perturbativity
Top mass M_t in GeV
200
150
100
50
0
0
50
100
150
200


September 2017
CMS 2010, dilepton
JHEP 07 (2011) 049, 36 pb^{-1}
175.50 ± 4.60 ± 4.60 GeV
CMS 2011, dilepton
EPJC 72 (2012) 2202, 5.0 fb^{-1}
172.50 ± 0.43 ± 1.43 GeV
CMS 2011, all-jets
EPJC 74 (2014) 2758, 3.5 fb^{-1}
173.49 ± 0.69 ± 1.21 GeV
CMS 2011, lepton+jets
JHEP 12 (2012) 105, 5.0 fb^{-1}
173.49 ± 0.43 ± 0.98 GeV
CMS 2012, dilepton
PRD 93 (2016) 072004, 19.7 fb^{-1}
172.82 ± 0.19 ± 1.22 GeV
CMS 2012, all-jets
PRD 93 (2016) 072004, 18.2 fb^{-1}
172.32 ± 0.25 ± 0.59 GeV
CMS 2012, lepton+jets
PRD 93 (2016) 072004, 19.7 fb^{-1}
172.35 ± 0.16 ± 0.48 GeV
CMS legacy
PRD 93 (2016) 072004
172.44 ± 0.13 ± 0.47 GeV
CMS 2016, lepton+jets
TOP-17-007 (2017), 35.9 fb^{-1}
172.25 ± 0.08 ± 0.62 GeV
Tevatron combination
arXiv:1407.2682 (2014)
174.34 ± 0.37 ± 0.52 GeV
World combination
ATLAS, CDF, CMS, D0
arXiv:1403.4427 (2014)
173.34 ± 0.27 ± 0.71 GeV
(value ± stat. ± syst.)
165
170
175
180
m_t [GeV]


CMS Preliminary
March 2018
b hadron lifetime
TOP-12-030 (2013)
173.50 ± 1.50 ± 2.91 GeV
Kinematic endpoints
EPJC 73 (2013) 2494
173.90 ± 0.90 $^{+1.70}_{-2.10}$ GeV
b-jet energy peak
TOP-15-002 (2015)
172.29 ± 1.17 ± 2.66 GeV
Lepton+J/Ψ
JHEP 12 (2016) 123
173.50 ± 3.00 ± 0.90 GeV
Lepton+SecVtx
PRD 93 (2016) 092006
173.68 ± 0.20 $^{+1.58}_{-0.97}$ GeV
Dilepton kinematics
TOP-16-002 (2016)
171.70 ± 1.10 $^{+2.68}_{-3.09}$ GeV
Single top enriched
EPJC 77 (2017) 354
172.60 ± 0.77 $^{+0.97}_{-0.93}$ GeV
CMS tt̄+j shape, 8 TeV
TOP-13-006 (2016)
169.90 ± 1.10 $^{+4.38}_{-3.49}$ GeV
σ(tt̄) 7+8 TeV
JHEP 08 (2016) 029
NNPDF3.0
173.80 $^{+1.70}_{-1.80}$ GeV
CMS 7+8 TeV (2015)
PRD 93 072004 (2016)
172.44 ± 0.13 ± 0.47 GeV
World combination
ATLAS, CDF, CMS, D0
arXiv:1403.4427 (2014)
173.34 ± 0.27 ± 0.71 GeV
(value ± stat. ± syst.)
160
170
180
190
m_t [GeV]

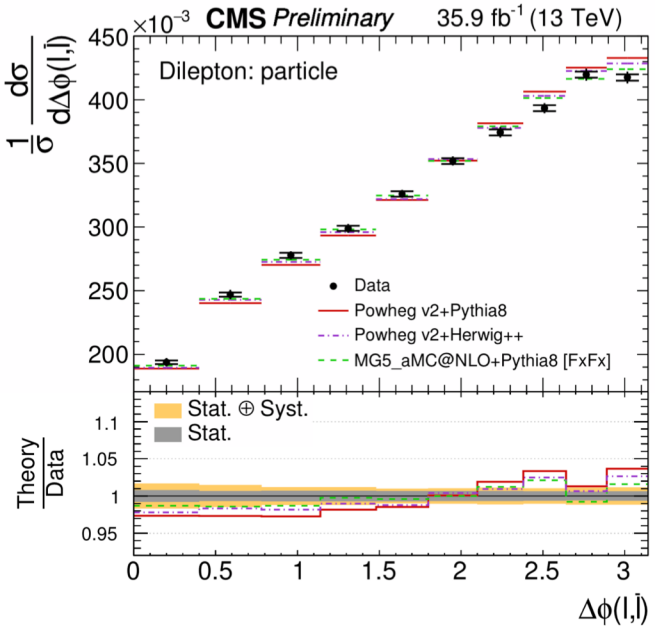
Top pt

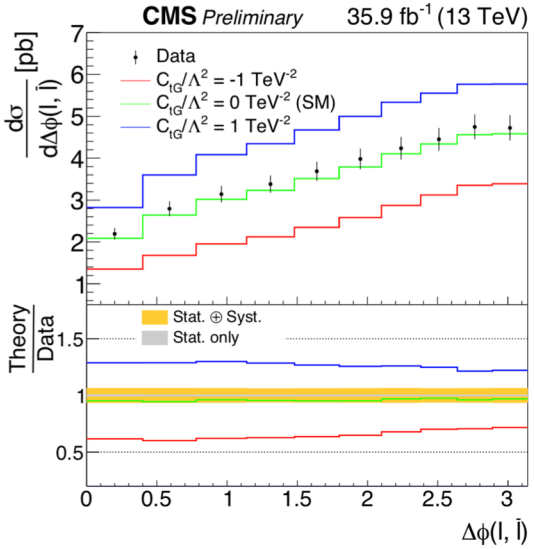


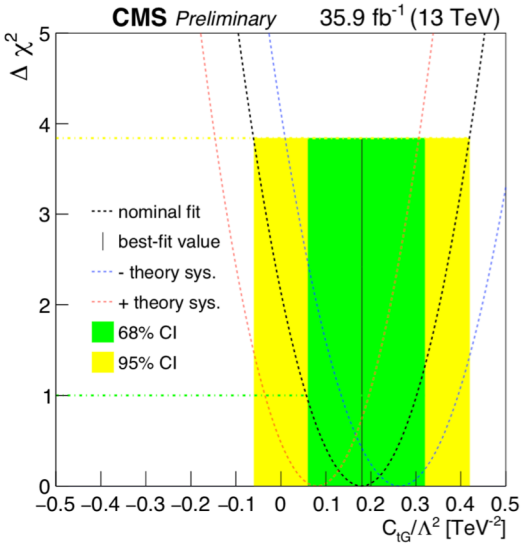


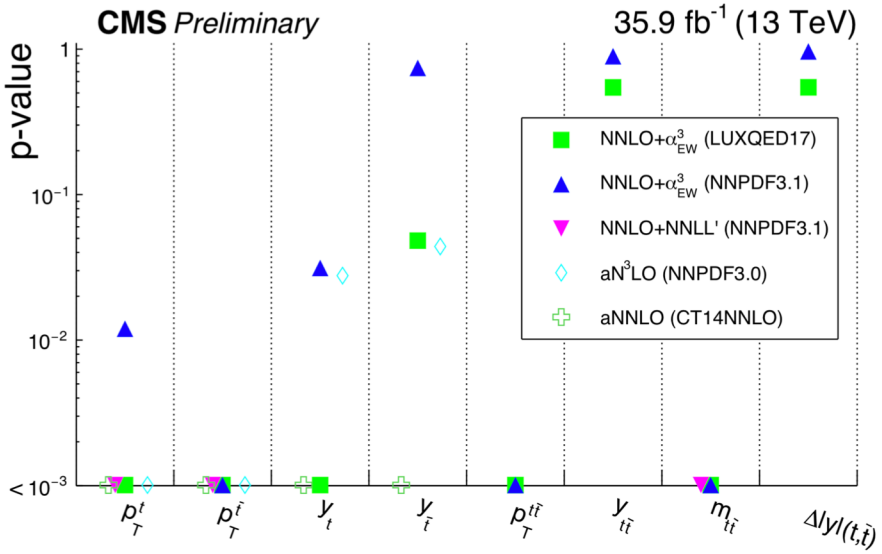
PAS TOP-2017-014 ,
to be submitted to JHEP

Differential cross section (dilepton)



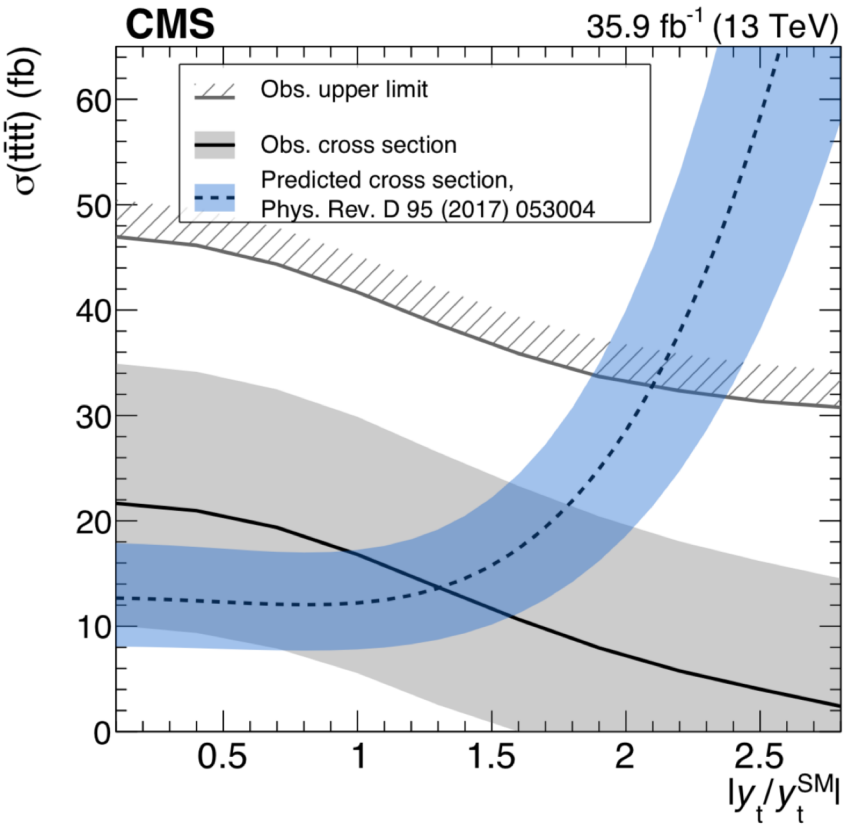


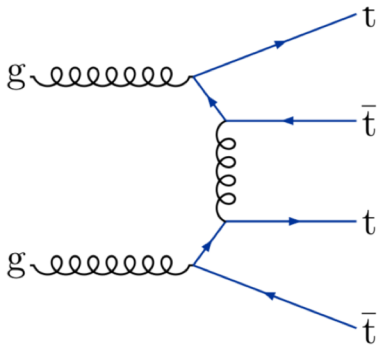


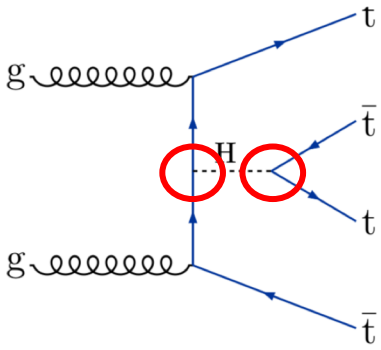


PAS TOP-2017-014 ,
to be submitted to JHEP

4 tops





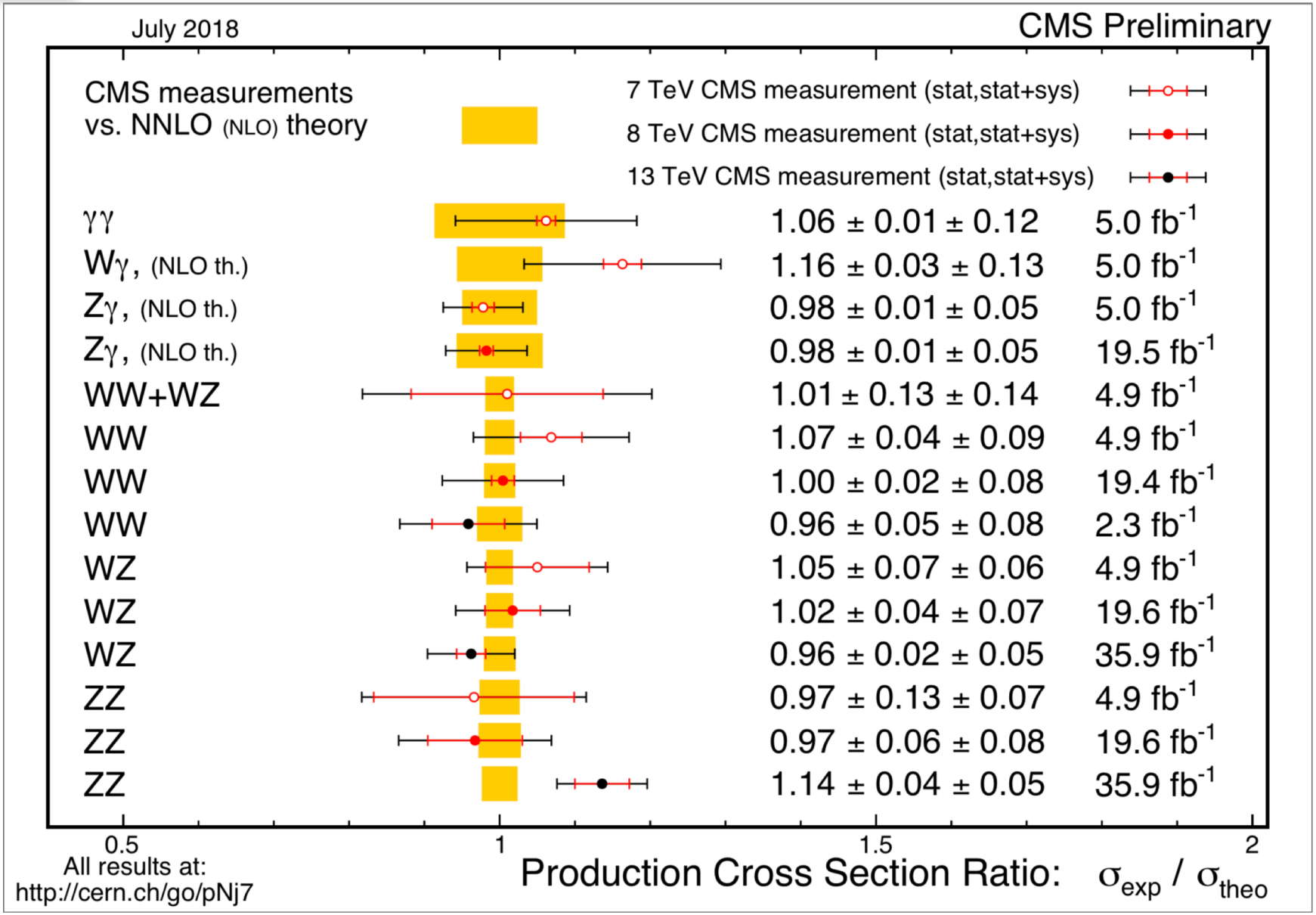


- ~1/10^5 of ttbar events
- Sensitive to new physics (e.g. High mass scales), and top quark Yukawa coupling
- Need more data to explore

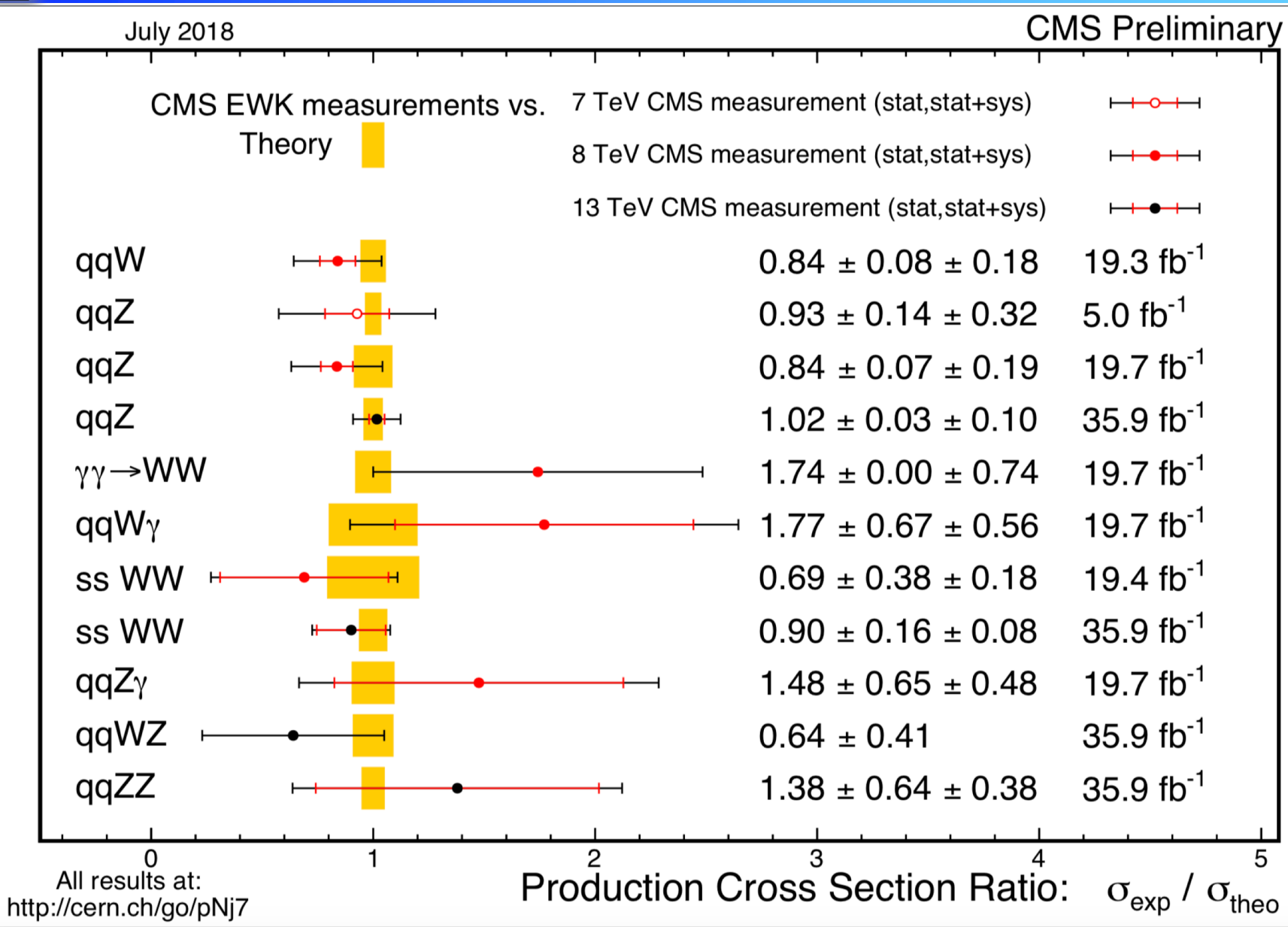
$$\left|y_t / y_t^{SM}\right| < 2.1$$

1.6 (1.0) σ

Diboson production measurements



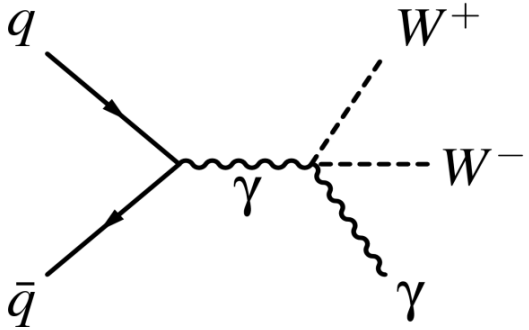
Electroweak process



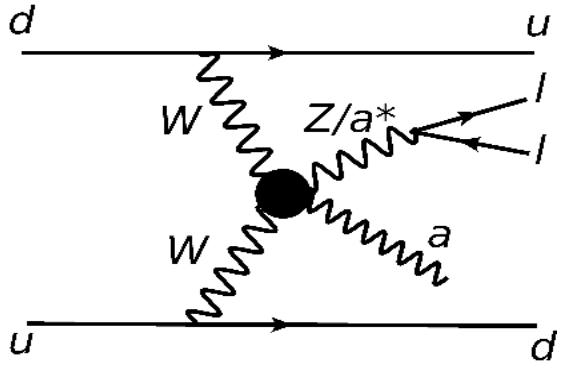
标准模型多玻色子物理

高能对撞机一般为电子或质子对撞。此前研究多集中于单、双玻色子产生。多玻色子产生过程异常复杂，只有在LHC上才可以观测！北大组提出在LHC上观测多玻色子末态，并完成了一系列的原创性的研究：

WVγ	PRD90 (2014) 032008	终审报告
VBF W+2Jets	JHEP 11 (2016) 147	分析负责人
VBS Wγ+2Jets	JHEP 06 (2017) 106	分析负责人
VBS Zγ+2Jets	PLB 770 (2017) 380	分析负责人
WV	PLB 772 (2017) 21	文章编辑人

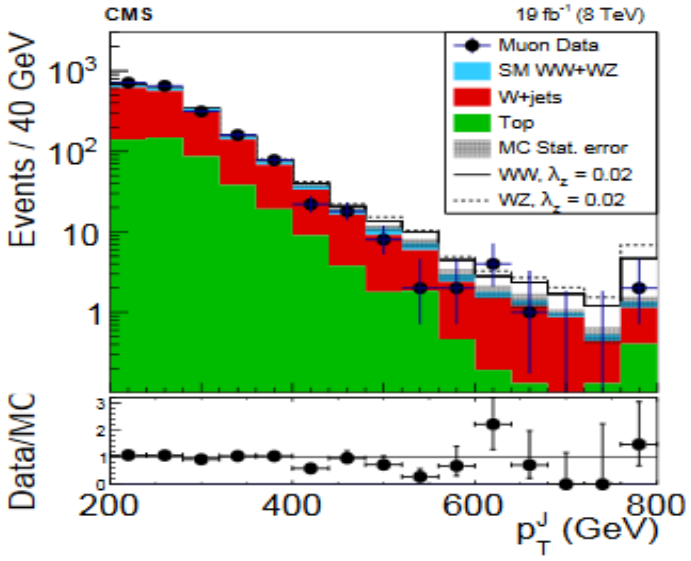


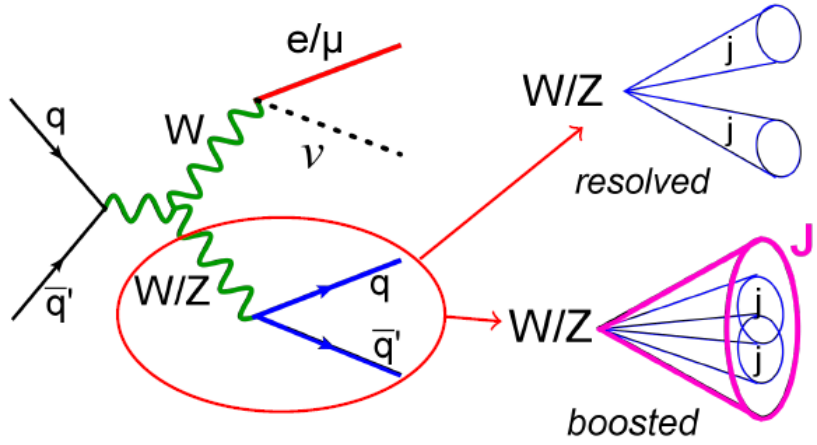
率先提出并完成LHC 第一个三规范玻色子过程的测量。给予物理终审报告。



PKU率先提出并完成LHC 含光子的VBS W/Z+γ过程 首次以3 σ水平观测到了Zγ散射迹象。

WV半轻道探测反常耦合

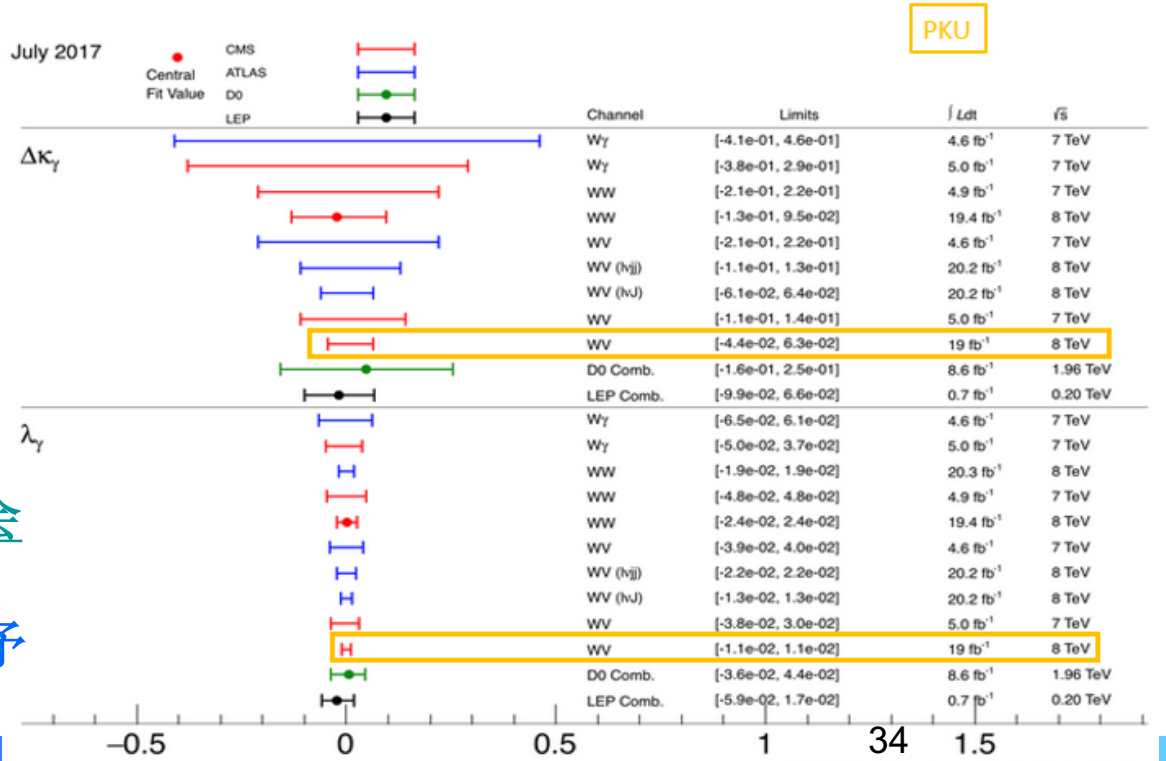




世界最强aTGC限制

Phys. Lett. B 772 (2017) 21

PKU



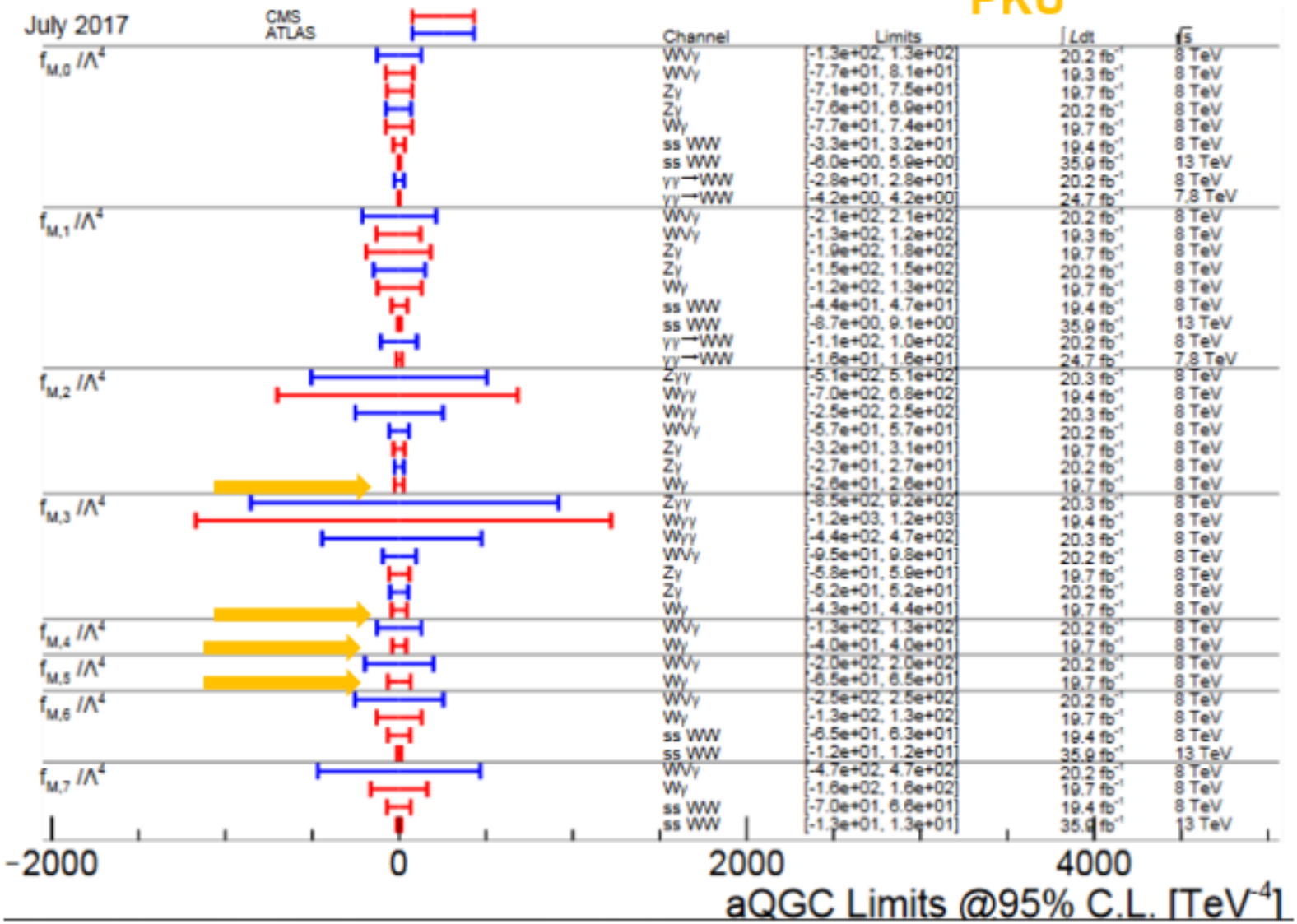
1. 首次将FatJet技术应用到SM diboson及反常耦合测量上

2.李强在Lepton-Photon2017会议上，对包括这个分析在内的CMS多玻色子物理分析结果给予了报告。

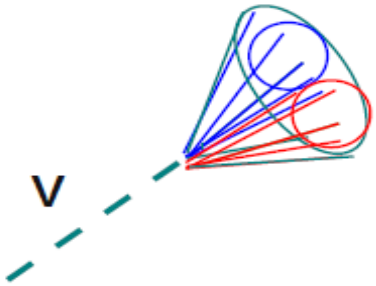
aQGC限制

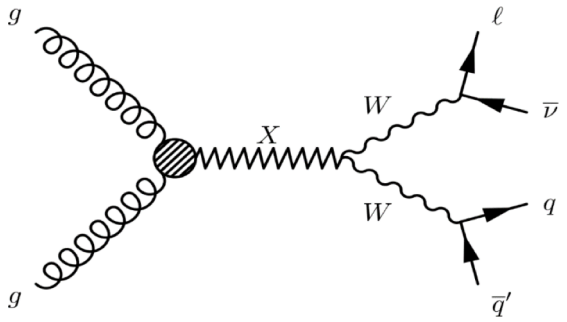
Phys.Lett. B770 (2017) 380; JHEP 06 (2017) 106

PKU



胖W喷注标记及应用



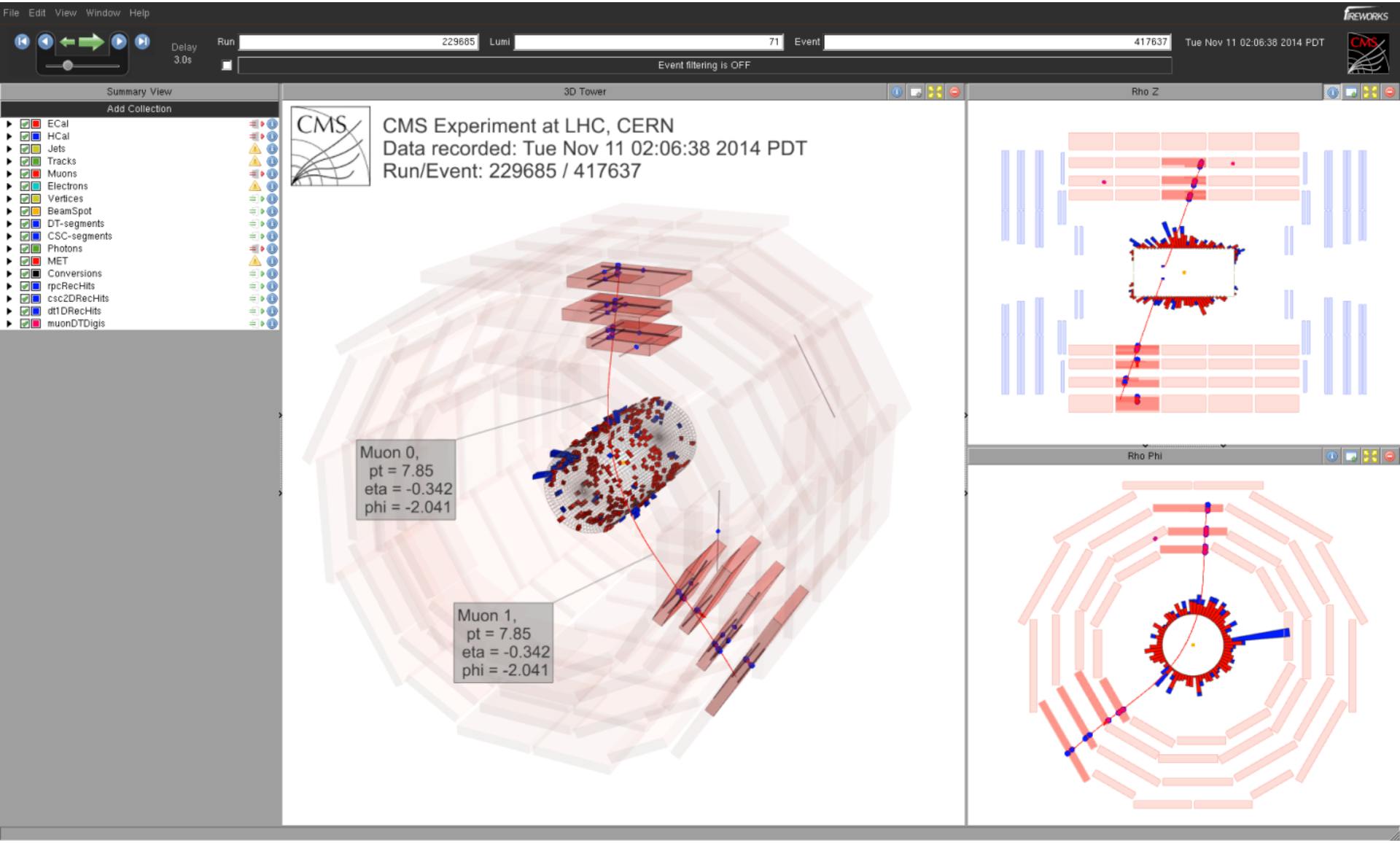


大Lorentz Boost的胖W喷注标记技术，
被合作组广泛使用。

首次寻找WW共振态，
首次将W-标记技术用到引力子寻找。

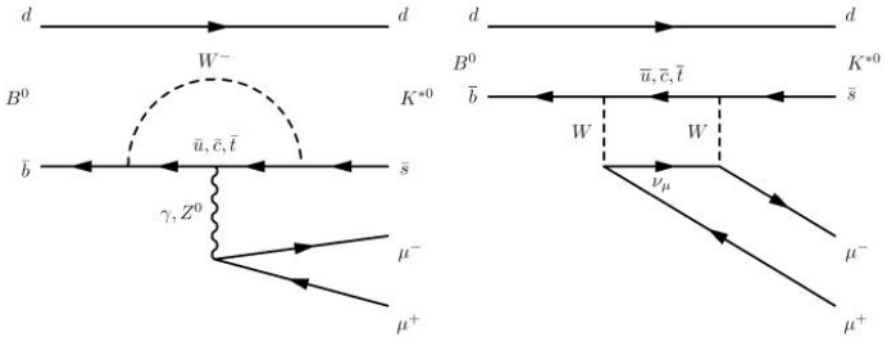
WW	JHEP08(2014)174	预审报告
W-tagging	JHEP 12(2014)017	文章编辑人
WH	EPJC76 (2016) 237	分析负责人
2015 WV	PLB774 (2017) 533	终审报告
2015 VV	JHEP 03 (2017) 162	预审报告
2016 WV	JHEP 05 (2018) 088	分析负责人

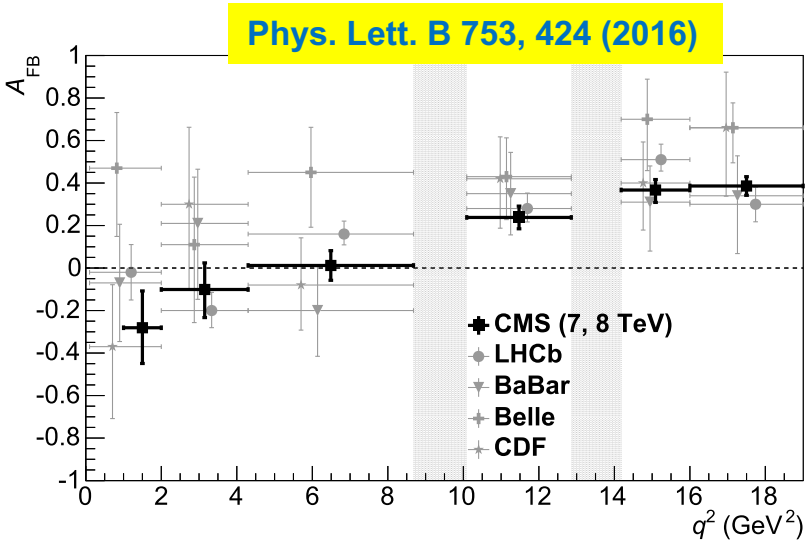
B physics


File Edit View Window Help
Delay 3.0s
Run 229685
Lumi 71
Event 417637
Tue Nov 11 02:06:38 2014 PDT
Event filtering is OFF
Summary View
Add Collection
ECal
HCal
Jets
Tracks
Muons
Electrons
Vertices
BeamSpot
DT-segments
CSC-segments
Photons
MET
Conversions
rpcRecHits
csc2DRecHits
dt1DRecHits
muonDTDigis
3D Tower
CMS Experiment at LHC, CERN
Data recorded: Tue Nov 11 02:06:38 2014 PDT
Run/Event: 229685 / 417637
Muon 0,
pt = 7.85
eta = -0.342
phi = -2.041
Muon 1,
pt = 7.85
eta = -0.342
phi = -2.041
Rho Z
Rho Phi

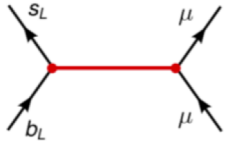
对B → K(*)μ⁺ μ⁻的测量和角度分析

味道改变中性流过程，对新物理极敏感

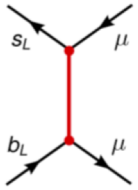




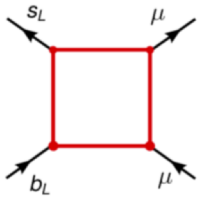
“B 介子反常”=> 多种新物理模型



- Z′
- $SU(2)_L$ singlet or triplet



- Leptoquark
- Spin 0 or 1



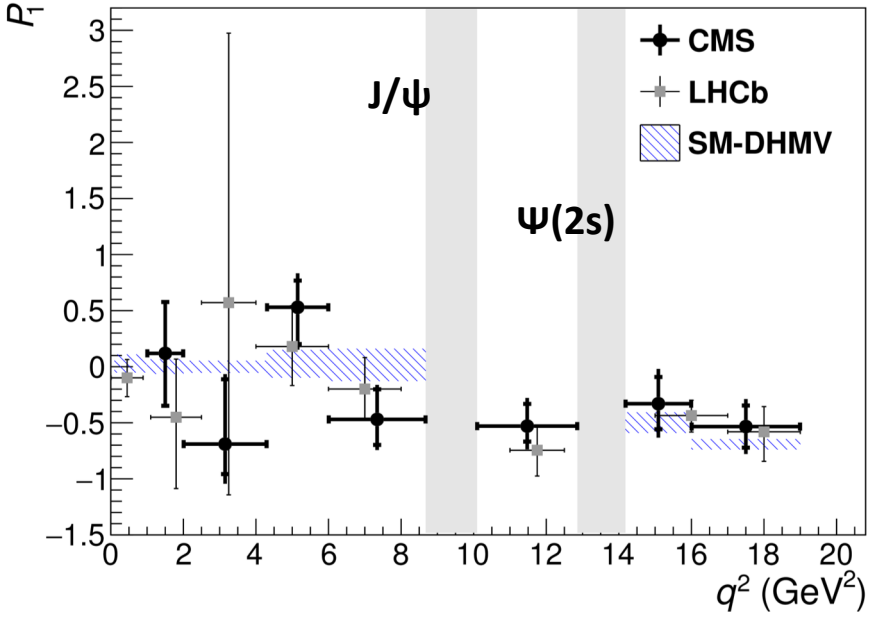
- New scalars/vectors, also leptoquarks possible

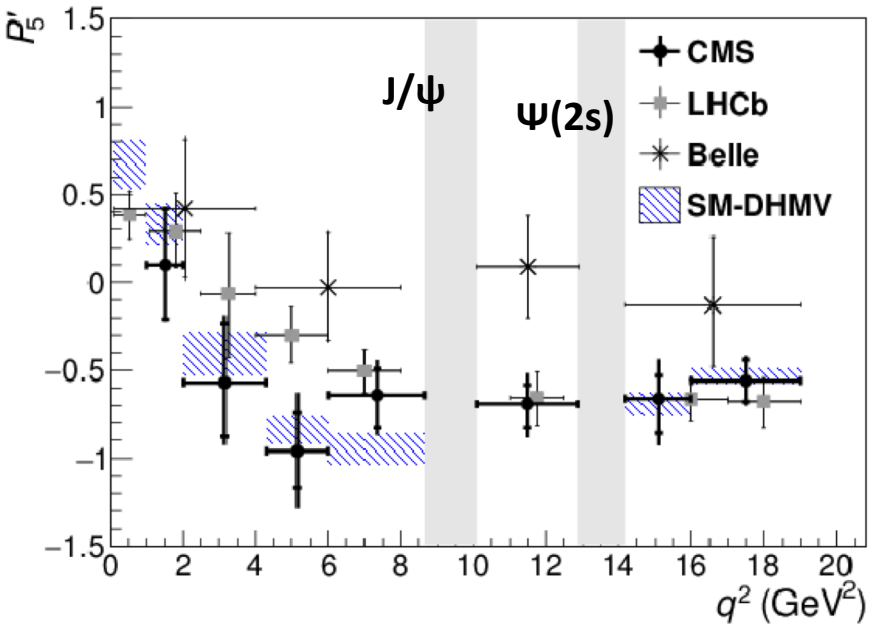
北大组做了一系列工作，并代表CMS在一系列重要国际会议上报告:

ICHEP2016 （口头报告）
LHCP2017 (1口头报告，1墙报)
BEAUTY2018 （口头报告）
BEACH2018 （口头报告）
ICHEP2018 （口头报告）

$B^0 \to K^{*0} \mu^+\mu^-$: P_1 and P_5' results

CMS-BPH-15-008





- CMS结果与标准模型以及其他实验符合，未发现偏离迹象.

LHCb: *JHEP 02 (2016) 104*
Belle: *Phys. Rev. Lett. 118, 111801 (2017)*
SM-DHMV: *JHEP 01 (2013) 048, JHEP 05 (2013) 137*

arxiv: 1710.02846
Phys. Lett. B 781 (2018) 571

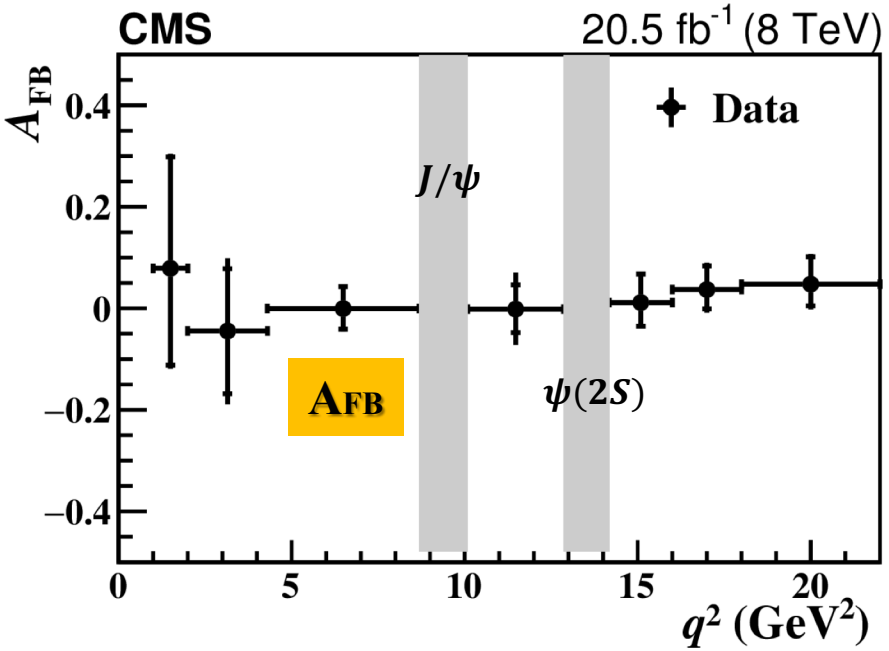
CMS结果与标准模型一致，在误差范围内与LHCb符合。被选为Moriond2017 CMS 唯一的joker报告，多次在国际会议报告

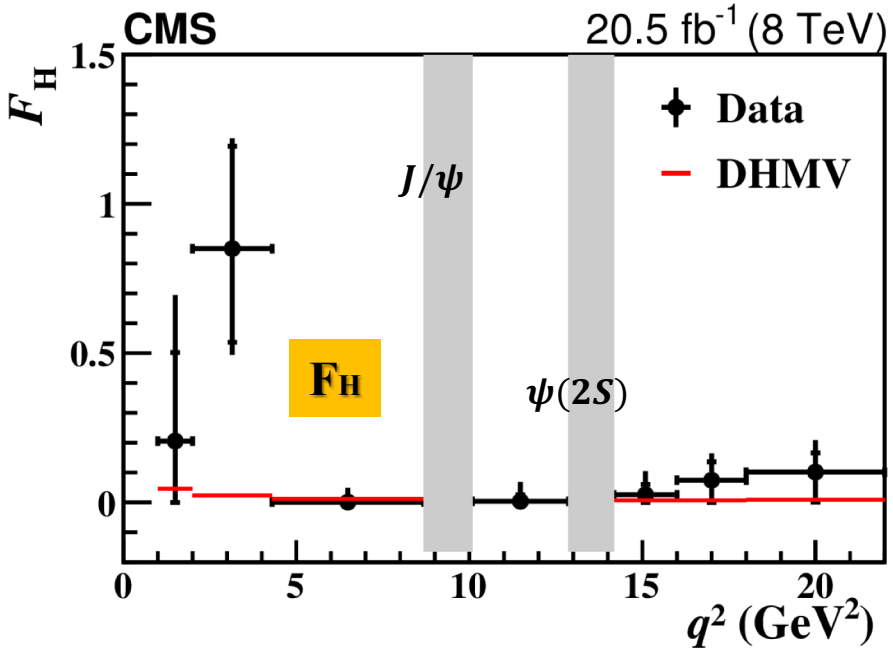
该分析由北大组与Milano, Padova合作完成
参与人：李林蔚/王大勇

北大pre-approval报告

$B^+ \to K^+\mu^+\mu^-$ A_{FB} and F_H results

CMS-BPH-15-001





arxiv: 1806.00636, submitted to Phys. Rev. D

The measured A_{FB} and F_H show good agreement with the SM predictions within the uncertainty.

No clear indication of new physics beyond the SM could be drawn from present results.

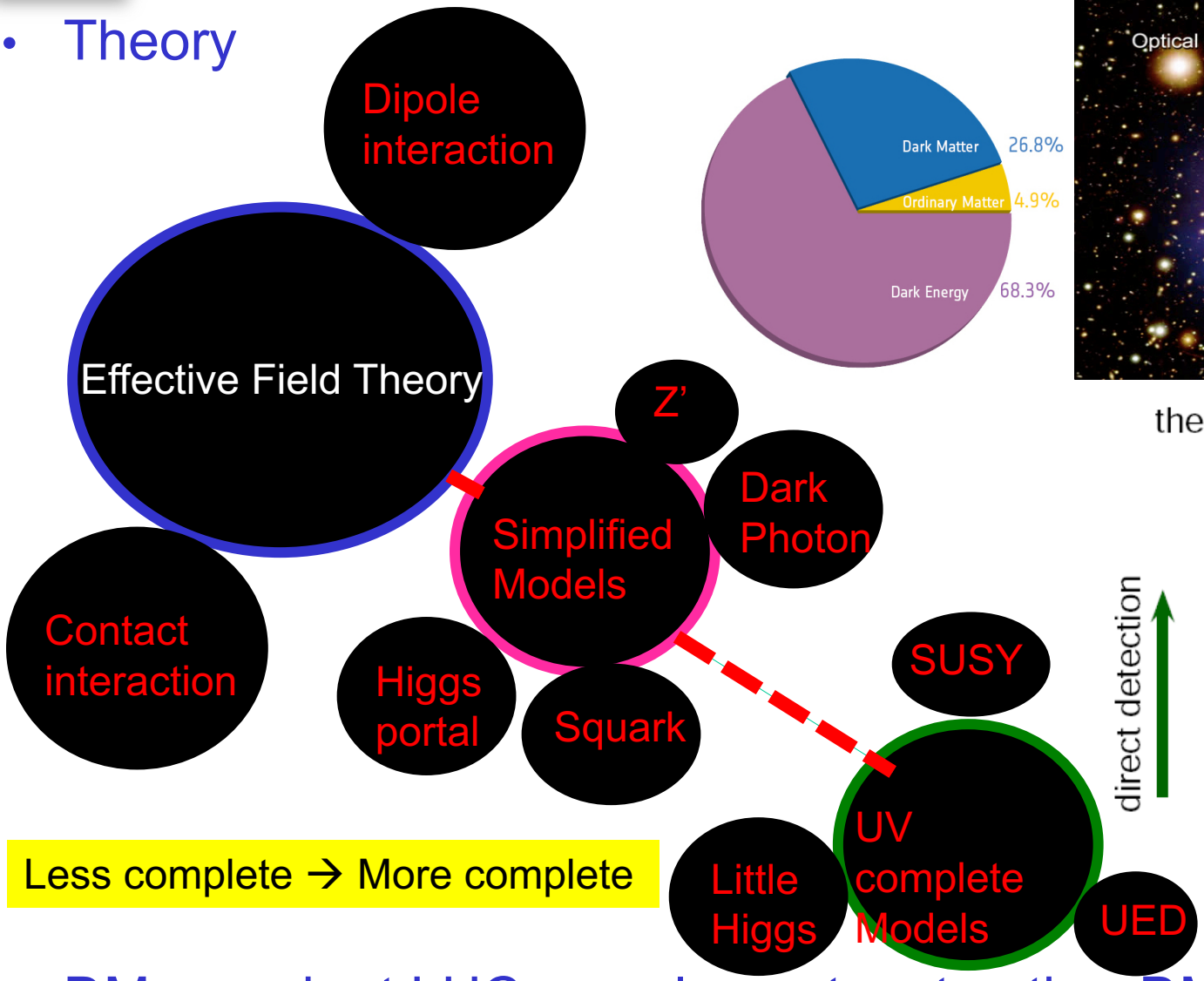
CMS结果与标准模型一致。在Moriond2018会议首次公开，多次在国际会议报告

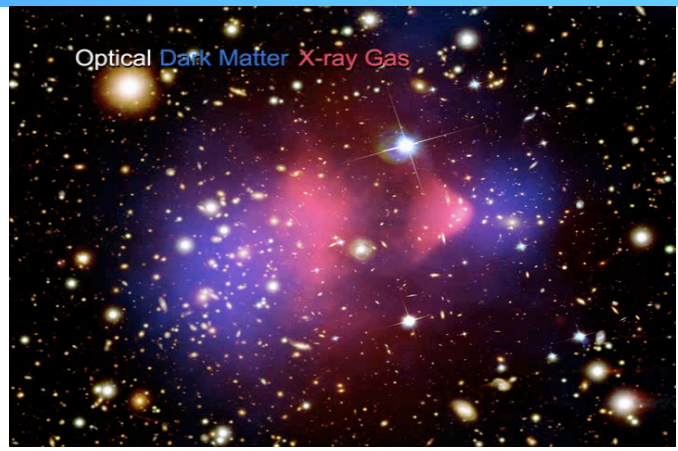
该分析由北大组提出并完成，担任联络人
参与人：陈耿/王大勇

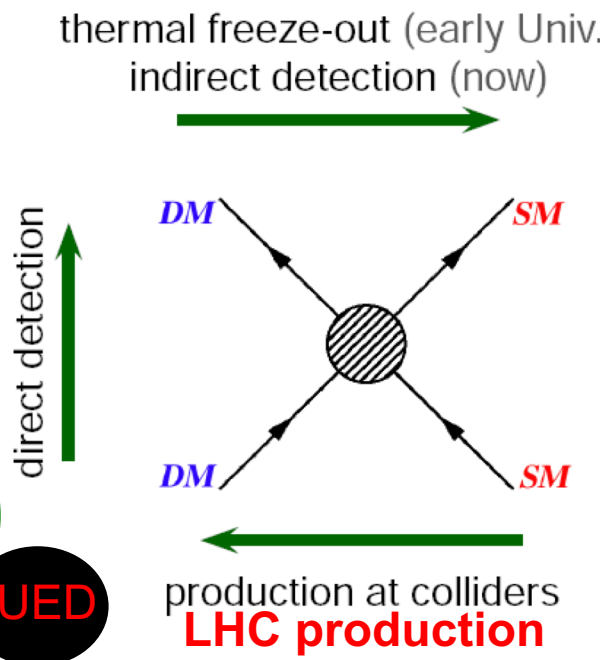
北大pre-approval，approval报告

Dark mater searches

- Theory





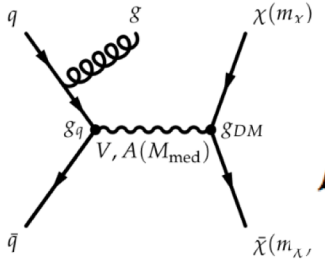


- DM search at LHC complementary to other DM searches

Dark mater bench mark model at LHC

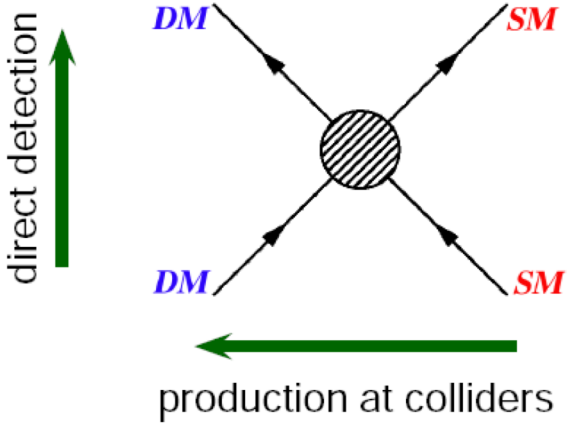
arXiv:1507.00966

- Keep the mediator information
- Simplified model with parameters of
  - $M_{mediator}$, $M\chi$, g_q, g_χ

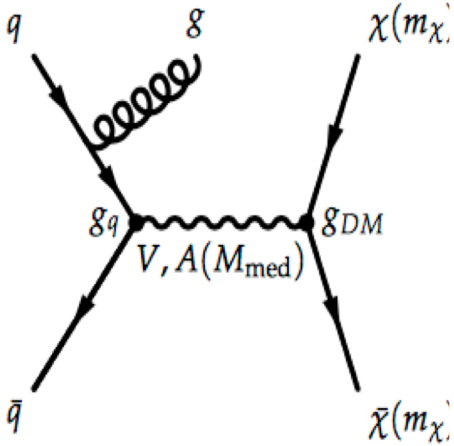


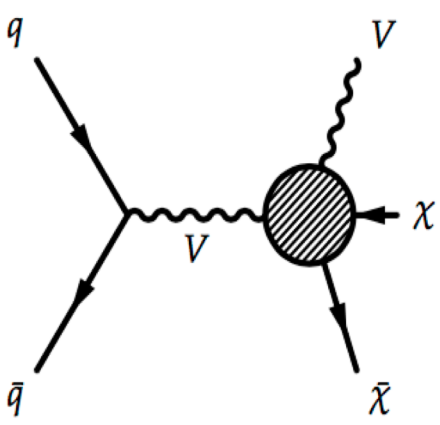
$$\mathcal{L}_{vector} = g_q \sum_{q=u,d,s,c,b,t} Z'_\mu \bar{q}\gamma^\mu q + g_\chi Z'_\mu \bar{\chi}\gamma^\mu \chi$$

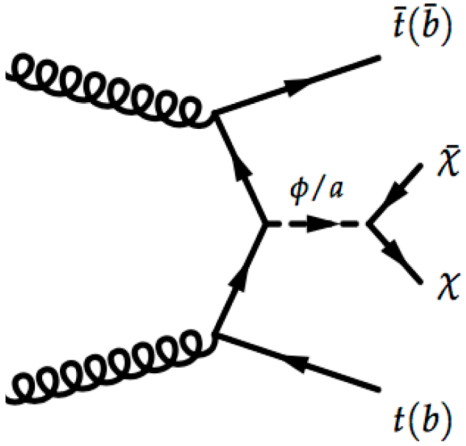
$$\mathcal{L}_{axial-vector} = g_q \sum_{q=u,d,s,c,b,t} Z'_\mu \bar{q}\gamma^\mu\gamma^5 q + g_\chi Z'_\mu \bar{\chi}\gamma^\mu\gamma^5 \chi$$

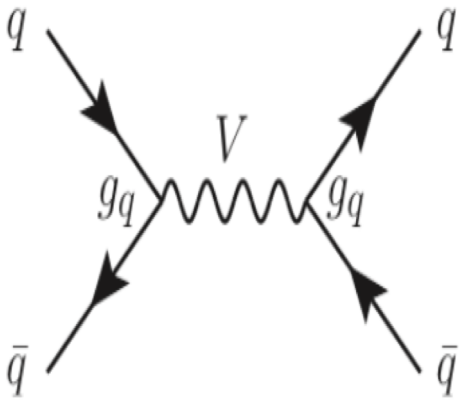


- Searches with MET + X or mediator

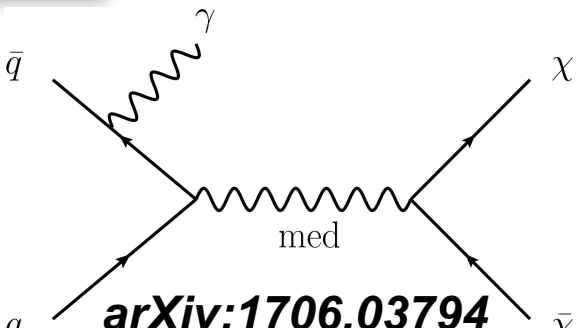




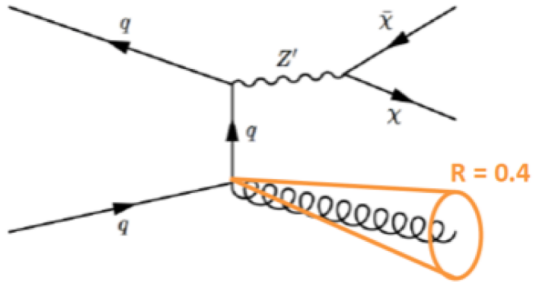




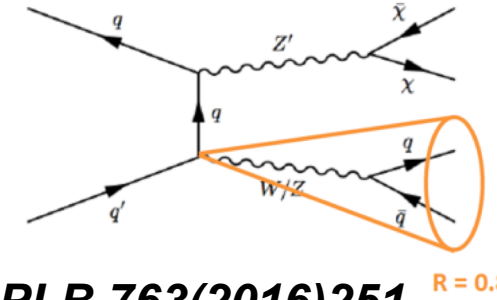
Mono-γ/jet + MET, Searches



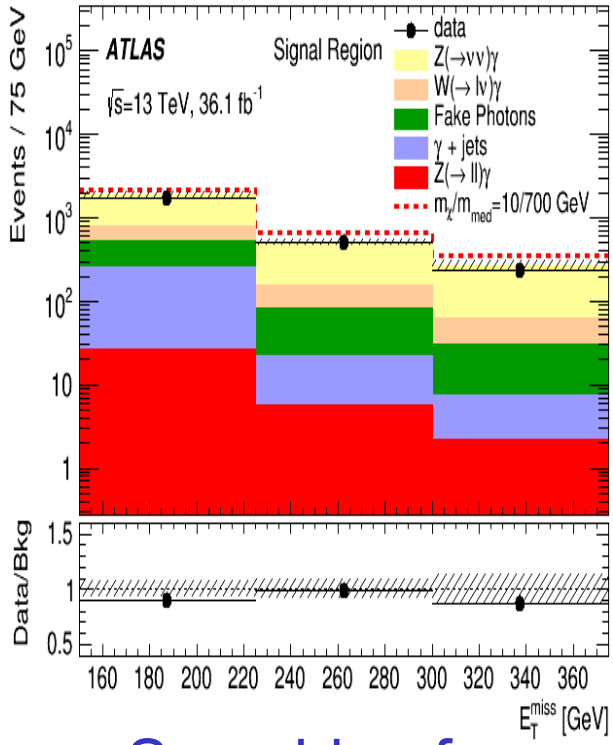
arXiv:1706.03794
Eur. Phys. J. C 77 (2017) 393

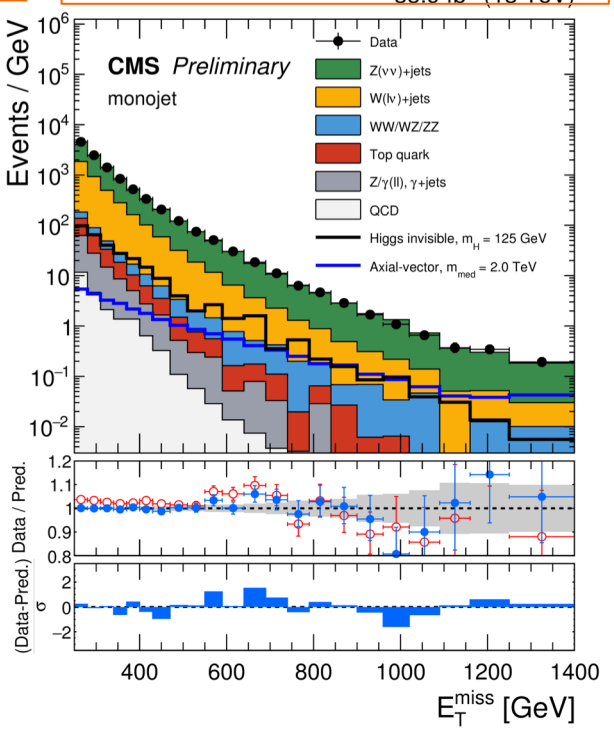


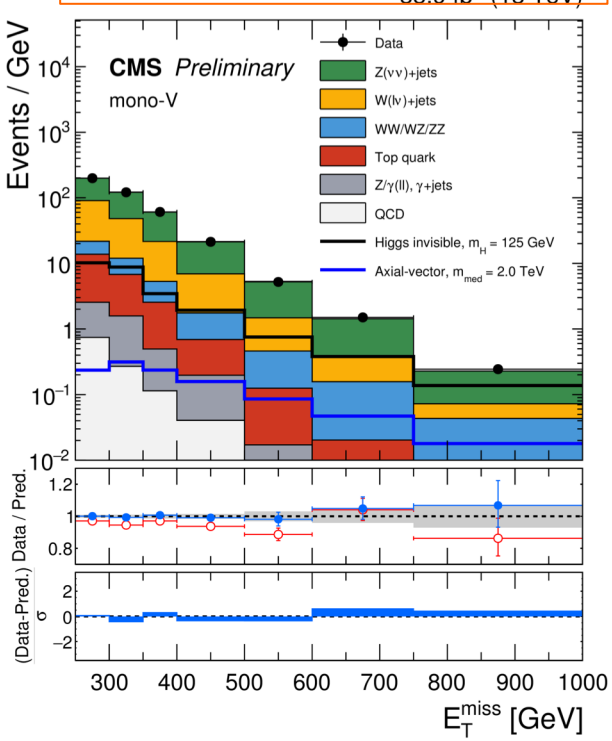
ATLAS-CONF-2017-060
CMS-PAS-EXO-16-048



PLB 763(2016)251
CMS-PAS-EXO-16-048





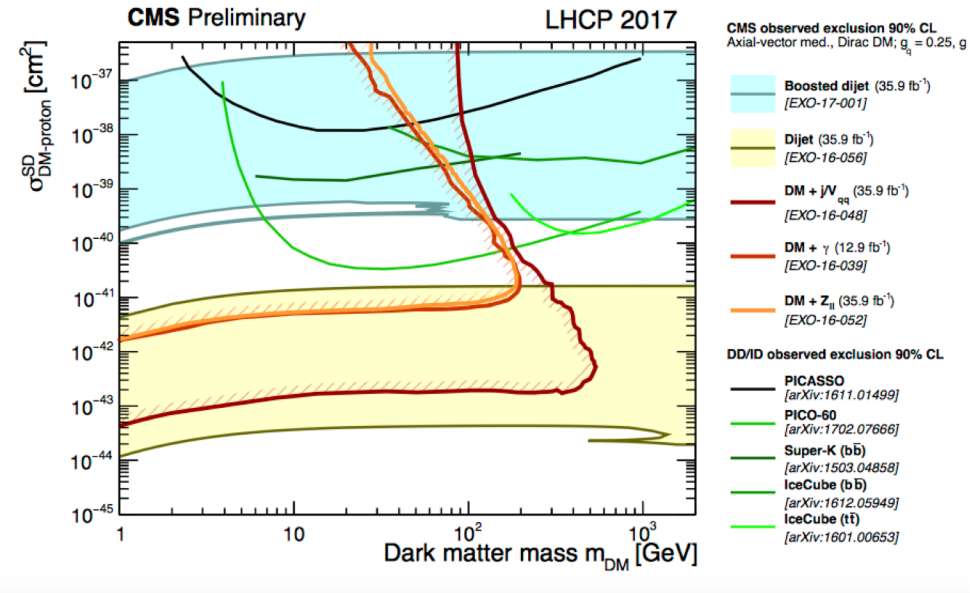


- Searching for excess on MET after mono-objet selection

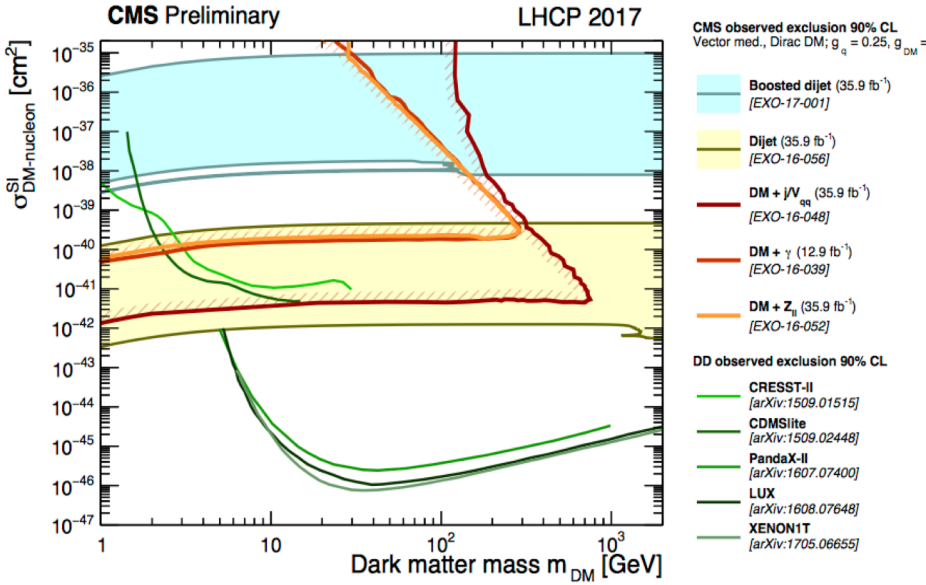
Summary of dark matter searches at CMS

- No sign of DM (yet)

Spin dependent



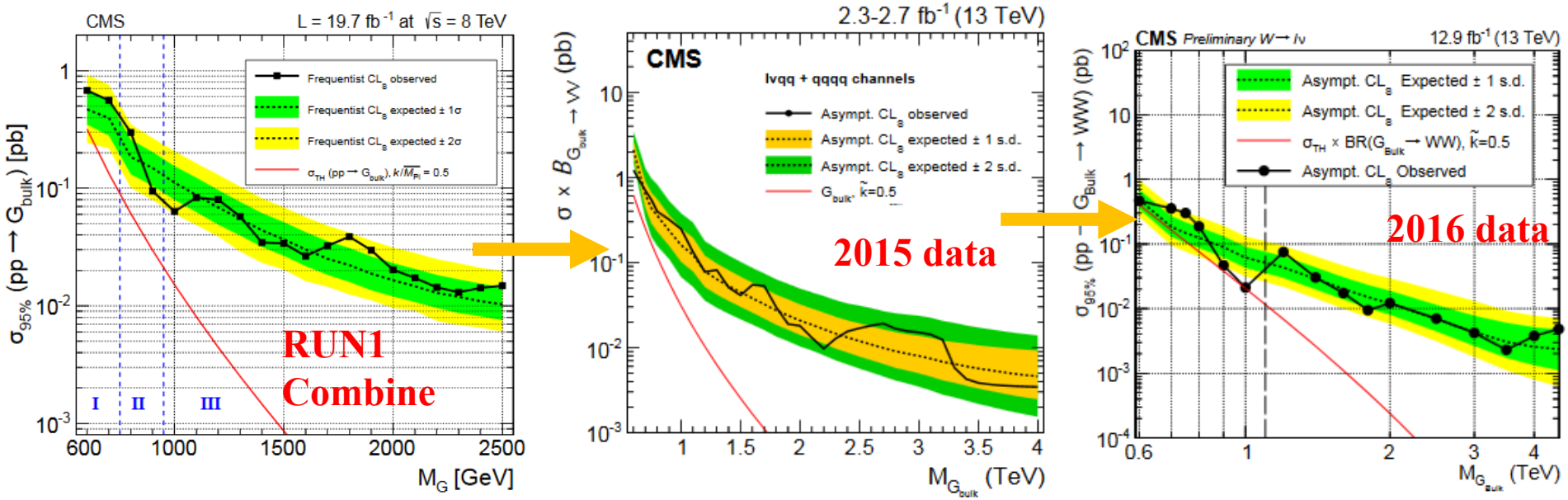
Spin independent



双玻色子共振态的寻找

自2012年以来持续推进主导完成了WV双玻色子共振态的寻找：

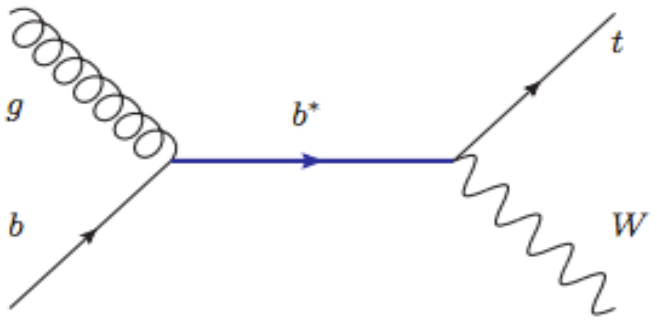
将引力子质量探寻范围扩展到4.5TeV，对模型的限制也大大增强，
如2TeV引力子产生截面上限与Run1相比严格了4-5倍。



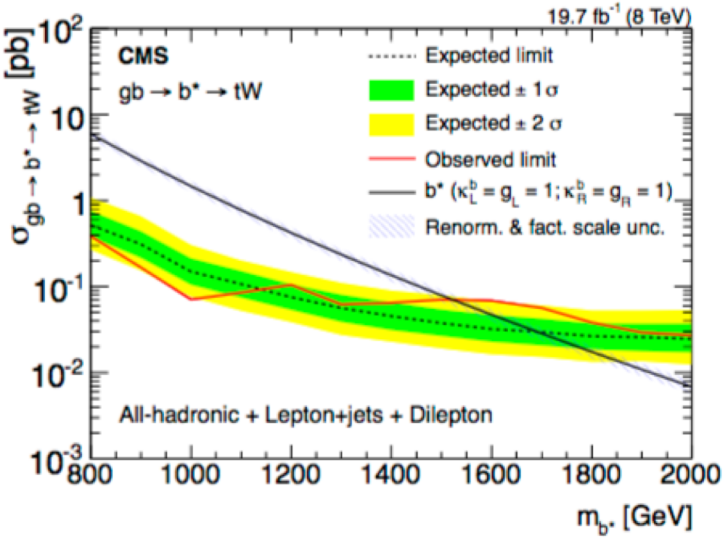
JHEP08(2014)174　　PLB774 (2017) 533　　JHEP 05 (2018) 088

Excited bottom quark (JHEP 01 (2016) 166)

- 寻找**第三代**夸克激发态：gb→b*→tW
- 物质无限可分:激发态=>夸克内部结构？
- **CMS首次寻找单b*产生的分析（B2G-14-005)**
- **高能所贡献**
  - Contact person: IHEP 张华桥
  - Approval talk by IHEP 张华桥
  - 多个分析末态
    - Lepton+jets(AN2014/103): IHEP
    - Dilepton(AN2013/415): NTU, IHEP, UVB
    - Full hadronic(AN2014/049): JHU
    - Combination(AN2014/202): IHEP, JHU, NTU, UVB
- 排除了质量小于1.5TeV的区域:
  - 外推到2维的新物理耦合常数平面
  - 目前最好的limit



JHEP 01 (2016) 166



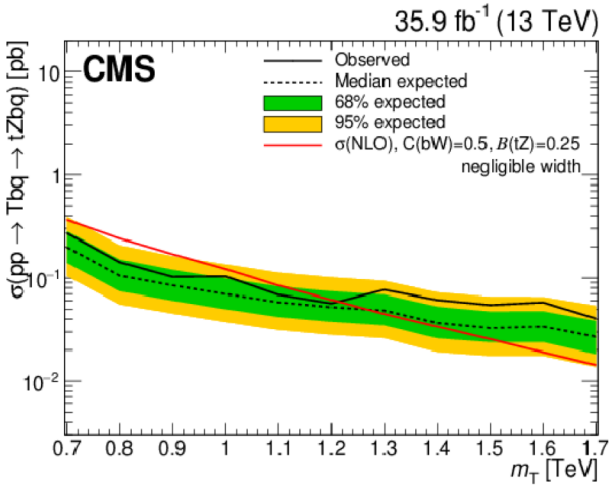
高能所approval报告，contact，组织

寻找类矢量夸克 T’->tZ

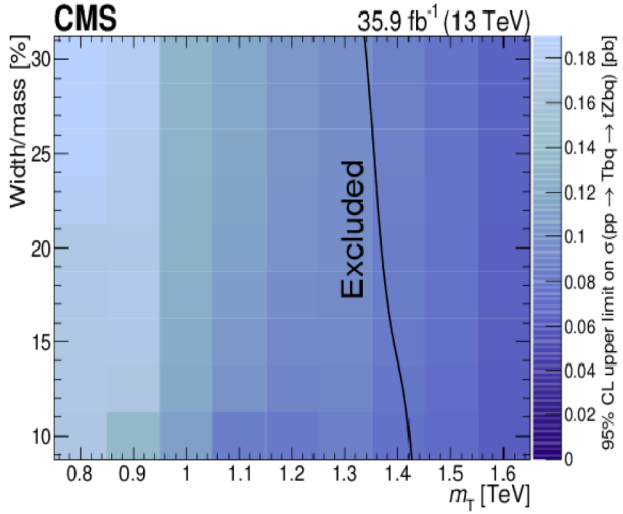
在双轻子以及喷注末态中寻找单个产生的类矢量顶夸克

- ✓ 很多新物理模型，如复合希格斯模型等，同时预言了类矢量夸克的存在。
- ✓ 基于2016年13TeV数据独立完整的完成；
- ✓ 分析联系人：Aniello Spiezia
- ✓ PAS和分析note的editors：Aniello Spiezia，Hongbo Liao；
- ✓ Pre-approval和Approval报告：Aniello Spiezia；

CMS-PAS-B2G-17-007



PLB 781(2018)574



- ✓ 对单个类矢量顶夸克产生的最强限制；
- ✓ 首次对不同共振态宽度进行设限；
- ✓ 对 Z′ 到Tt产生的最强限制.

Physics updates

高能所独立完成，pre-approval，approval报告，contact

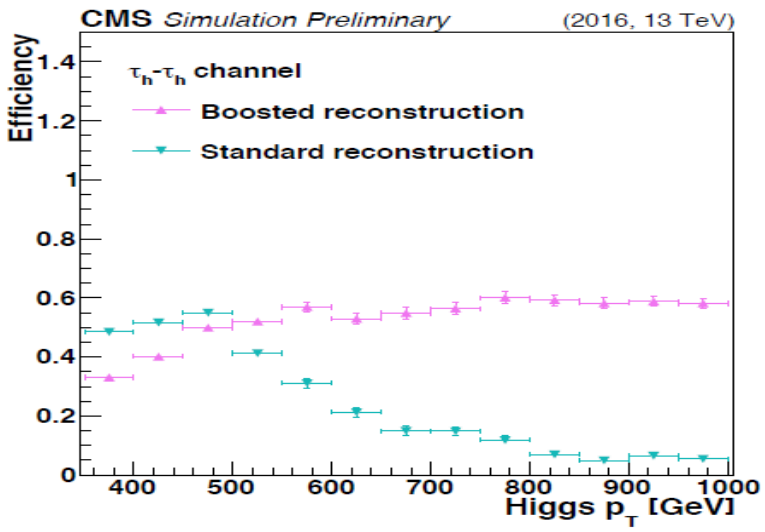
大质量新共振态粒子的寻找

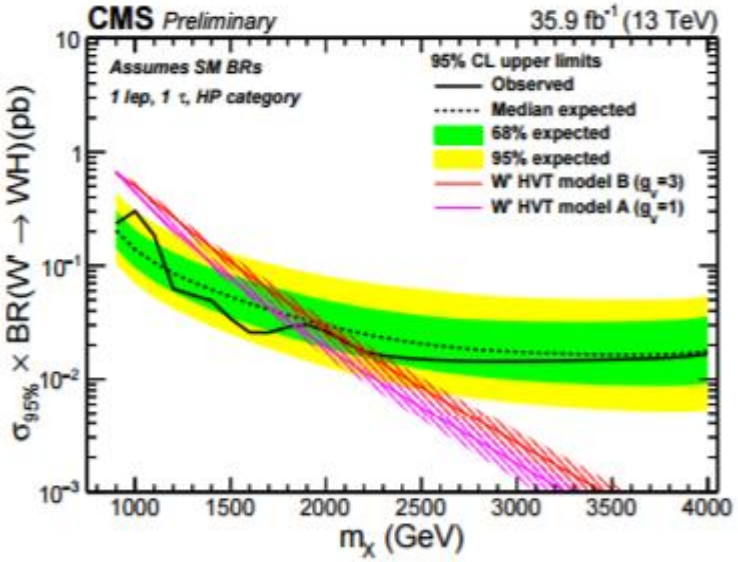
•许多超出标准模型理论预测了质量超过1TeV，并且衰变到高横动量希格斯粒子的大质量共振态粒子的存在，这是直接寻找新物理的一个重要途径；

•高横动量希格斯粒子衰变出来的俩个陶轻子很近，从而带来陶轻子重建的困难；

•高能所团队发展了新型算法重建具有子结构的来源于希格斯衰变的陶子对(博士后Aniello Spiezia主导完成)，并应用到大质量新共振态粒子衰变到WH,ZH以及HH的分析当中；

CMS-PAS-B2G-17-006

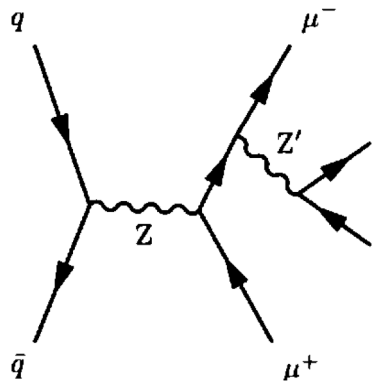


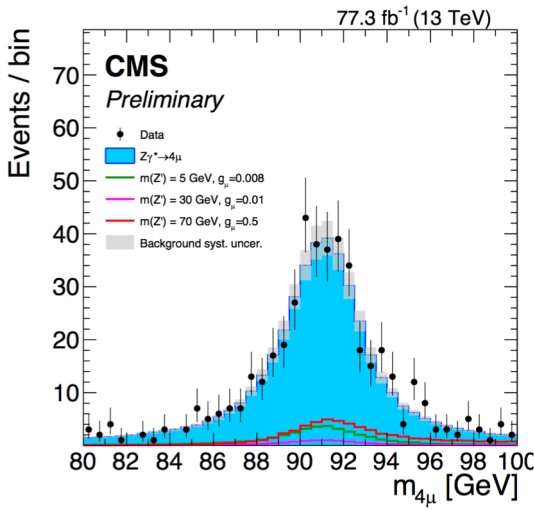


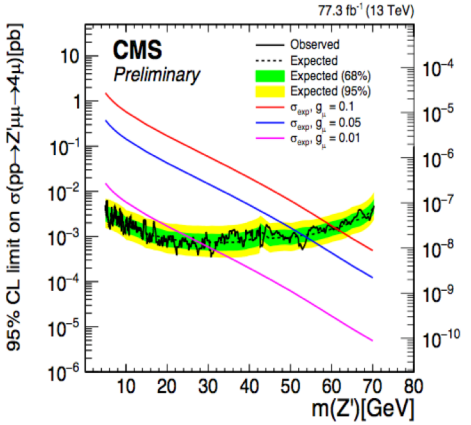
Search for an L_μ-L_τ gauge boson

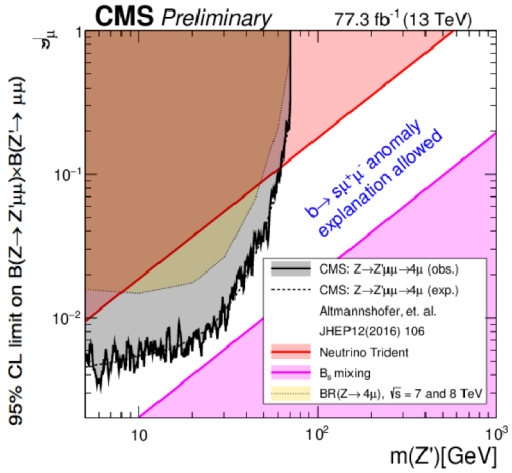
CMS-PAS-EXO-18-008

- Search for a narrow light Z' decaying in $\mu^+\mu^-$ using $Z \to 4\mu$ events
- These L_μ-L_τ symmetries could explain possible LF universality violations in B-meson decays, muon g-2 anomaly, and current negative observations in direct dark matter detections
- CMS uses the 77.3/fb 2016+2017 dataset
- Observations are consistent with the SM predictions





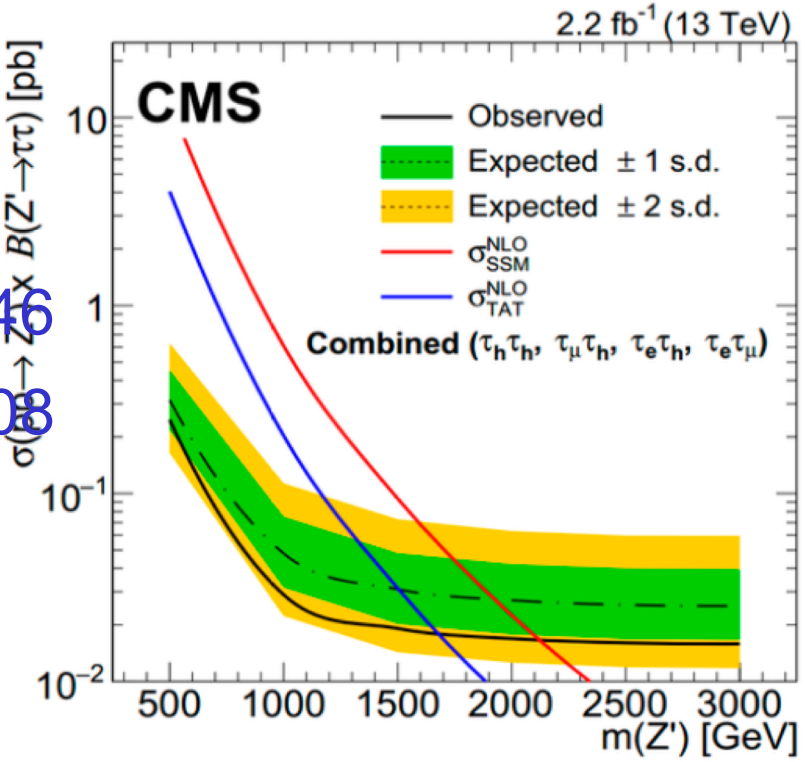




高能所approval报告，contact

高质量双tau共振态的寻找

- 双轻子共振态是LHC上寻找的热点
- 有模型预言重共振态倾向衰变到双tau共振态

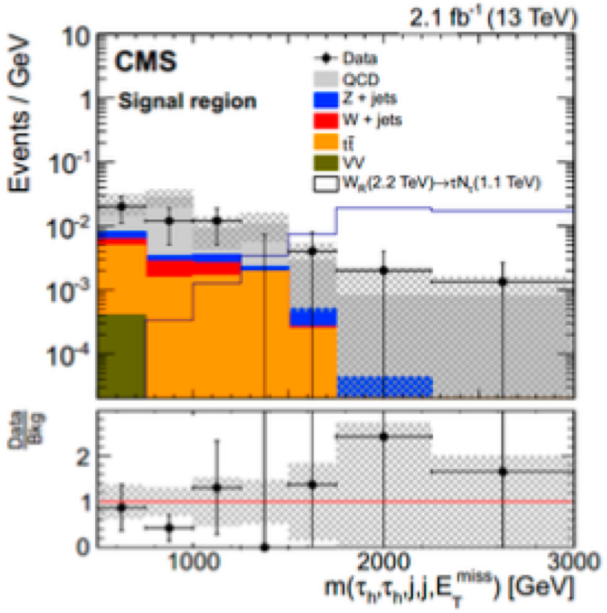


- RUN1 PAS：CMS-PAS-EXO-12-046
- RUN2 PAS：CMS-PAS-EXO-16-008
- 文章：JHEP 02（2017）048

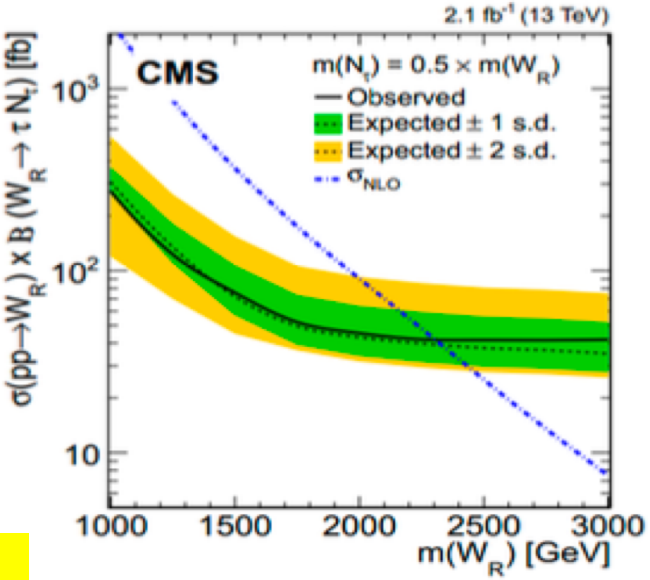
- 高能所贡献
  - RUN1 PAS的负责人，approval报告
  - 参与Run2分析协调，各步骤的策略制定

重中微子寻找

- Run2: Tau末态分析中
  - 目前没有找到重中微子信号
  - 排除2.3TeV以下的质量区间
  - PAS：CMS-PAS-EXO-16-016
  - 文章：JHEP 03（2017）077



- Run2: ee（mumu ）末态中
  - 排除4.3(4.5)TeV以下的质量区间
  - 最灵敏的重中微子下限
  - PAS：EXO-16-026
  - 文章：提交到PLB

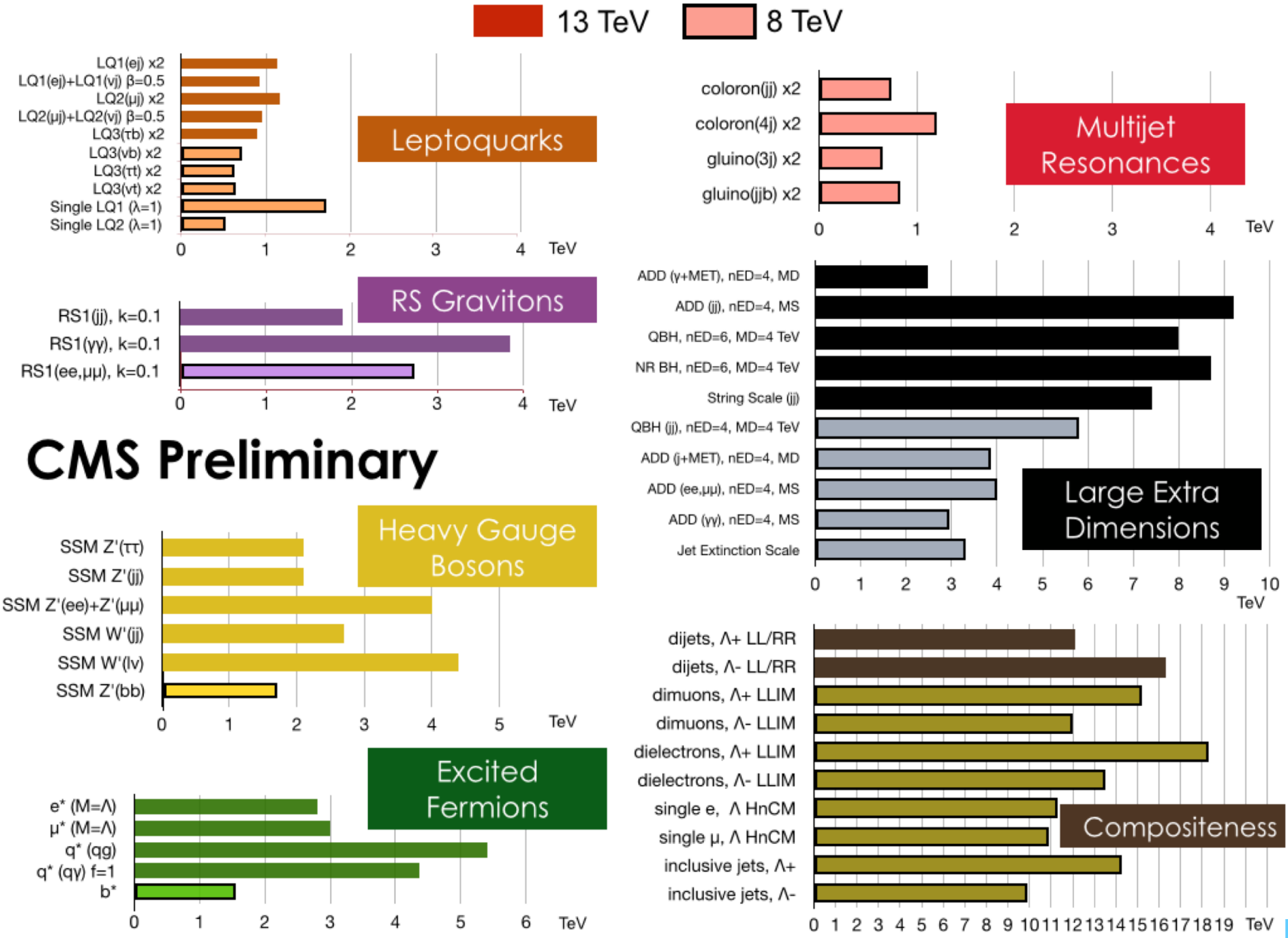


- 高能所主导贡献
  - FR：ee/mumu 末态分析负责人
  - FR：ee/mumu末态approval报告（2016.8）
  - 参与制定tautau 末态分析策略，步骤

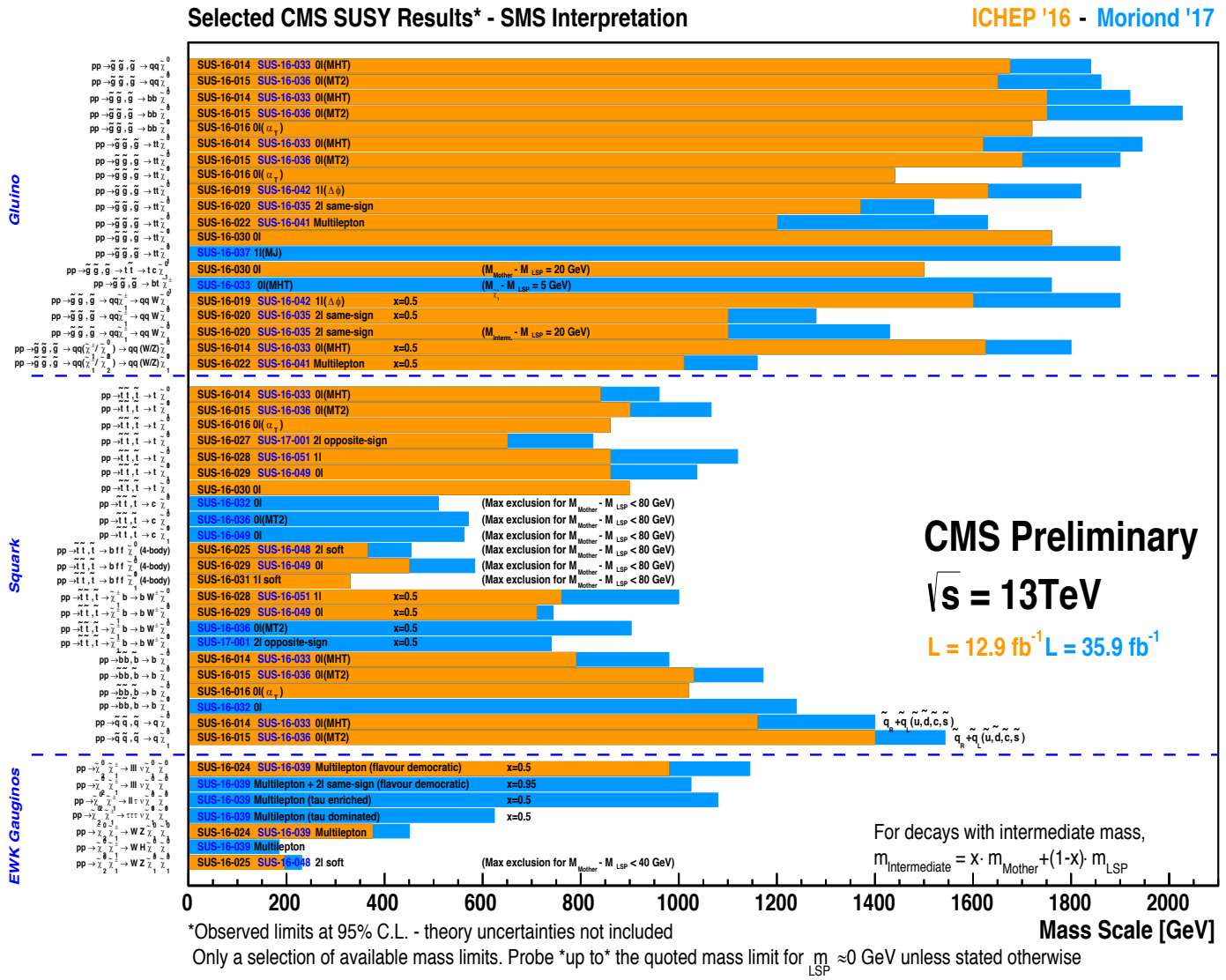
Physics updates

高能所approval报告，contact

Summary of BSM searches



Summary of SUSY searches



中国CMS组(主导)参与的物理分析

- Higgs physics :
  - ttH: IHEP 张华桥/廖红波
  - H→ZZ: IHEP 陈明水（浙大 肖蒙？）
  - H→$\gamma\gamma$: IHEP 陶军全
- Di-boson : PKU 李强
- B物理: PKU 王大勇
- 单顶夸克(IHEP):tZq, tW:张华桥
- 新物理寻找(All Chinese CMS，高能所，北大，北航…):
  - Diboson, VLQ, b*, Heavy majorana neutrinos, L_μ-L_τ gauge boson, low mass di-photon resonance, Z'→ee/mm/tautau …

Summary

- Observation of Higgs coupling to 3rd generation quarks
  - Top (direct production), bottom, tau (decay)
  - All Higgs Main production and decay modes observed
  - Search for Higgs rare process updated

3 Observations in one year

- Precision tests of SM through top/diboson processes
  - Next focus?

- Extensive search for new physics
  - No concrete sign of new physics yet

- More data coming extend to new era
  - ~150 fb^{-1} data on tape vs 3000 fb^{-1} in coming years

Chines CMS colleagues play leading role in many analysis