Progress of CMS China Group

Yajun Mao (Peking univ.)

中国科学院高能物理研究所
Institute of High Energy Physics Chinese Academy of Sciences

PEKING UNIVERSITY
1898

Outline

1. LHC CMS Detector

2. CMS China Group

3. Hardware/Software Contributions

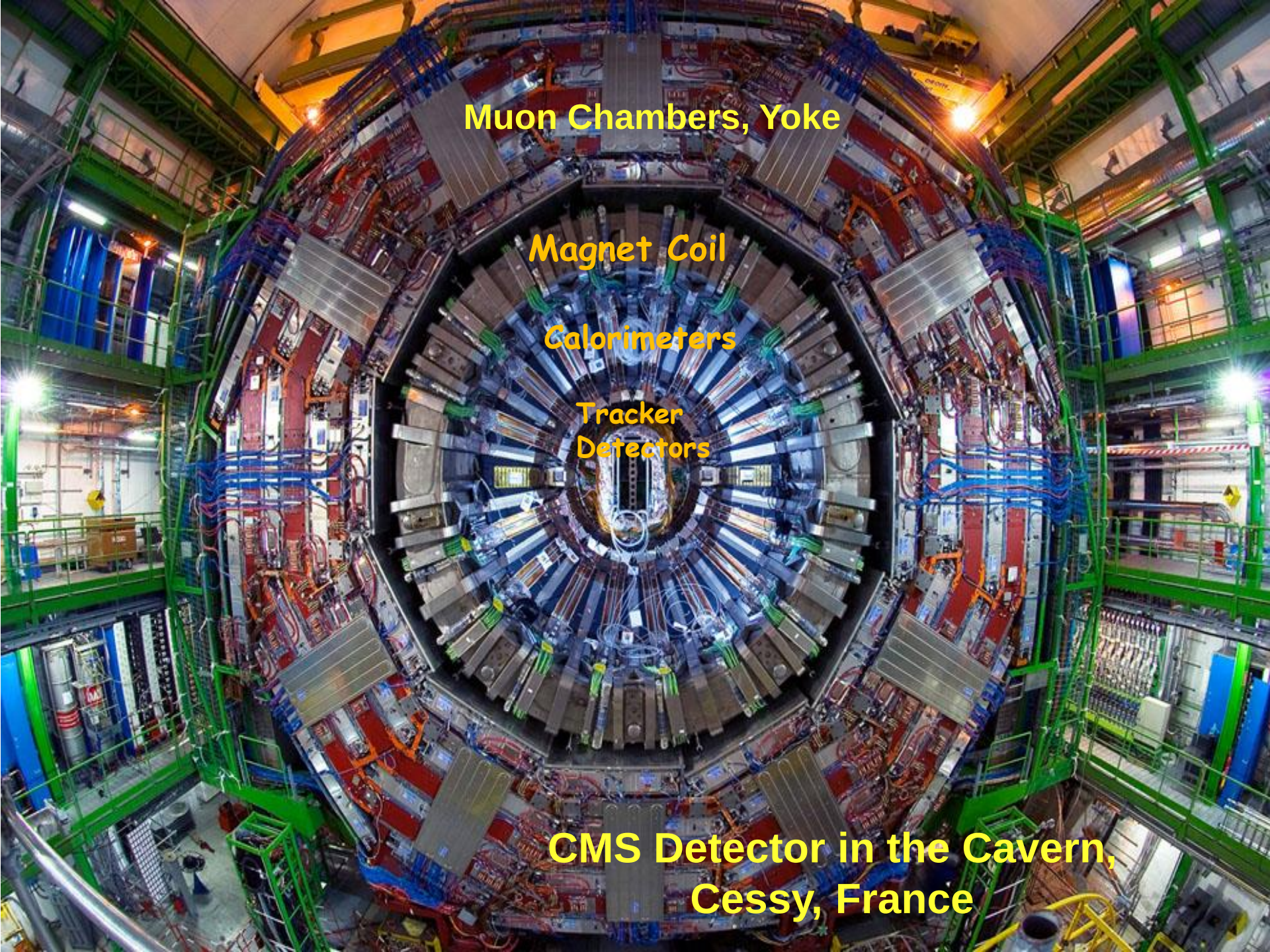
   1/3 CSC (Cathode Strip Chamber), 1/3 endcap RPC (Resistive Plate Chamber)

4. Physics Analysis:

   Higgs, Quarkonium, Top, Electroweak, Forward and Small x QCD, Exotica

5. Ongoing: Physics Analysis , CMS Upgrade: Phase I and II

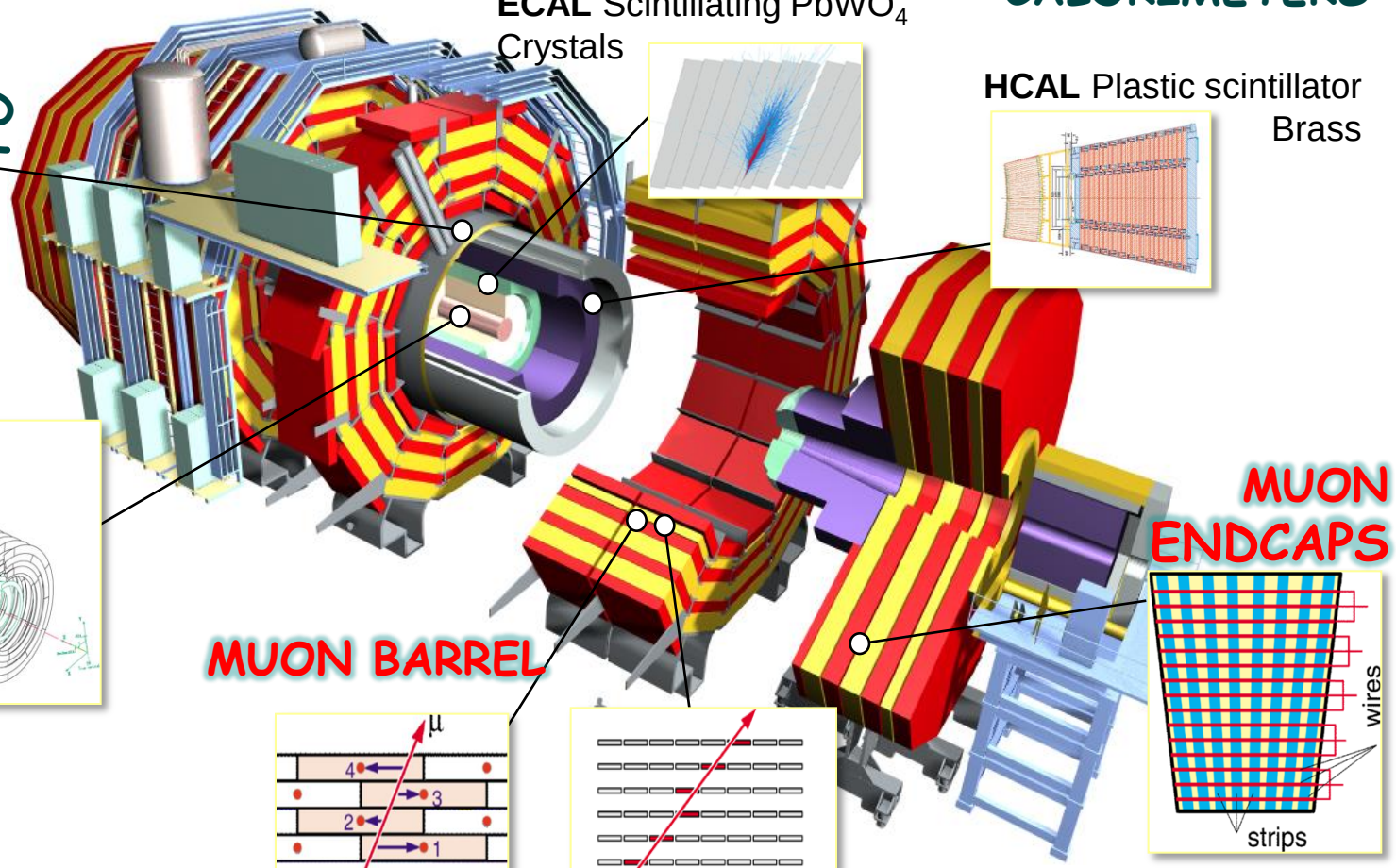

← IHEP & PKU office
B40, CERN,
Meyrin,
Switzerland



CMS Detector in the Cavern, Cessy, France

CMS Detector

weight: 12500 t
overall diameter: 15 m
overall length: 21.6 m



ECAL Scintillating $PbWO_4$ Crystals

CALORIMETERS

HCAL Plastic scintillator Brass

SOLENOID
B = 3.8 T

TRACKER

Pixels
Silicon Strips

MUON BARREL

Drift Tubes (**DT**)

Resistive Plate Chambers (**RPC**)

MUON ENDCAPS

wires

strips

Cathode Strip Chambers (CSC)
Resistive Plate Chambers (RPC)

JINST 3, S08004 (2008)

CMS COLLABORATION RRB CMS-D 98-31

The European Organization for Nuclear Research (CERN)

and

Chinese Academy of Sciences (CAS), Beijing

and

The National Natural Science Foundation of China (NSFC), Beijing

declare that they agree on this Memorandum of Understanding.

For the original version as approved on 27 April 1998 by the CMS Resources Review Board

Done in Geneva, Switzerland on 30 April 1998

For CERN

Lorenzo Foà
Director of Research

For the revisions to the original version
(cf. Annexes 5, 6, 8 A, 9.3 A, 9.3 B, 9.5 B, and page 4 of Annex 10,
as well as Annex 1, page 1 and Annex 4, page 2)

Done in Geneva, Switzerland on 28 April 1999

For CERN

R.J. Cashmore
Director of Research

Done in Geneva, Switzerland
on 28 April 1999

For NSFC

WANG Wai-Yan
Vice-President

Done in Beijing, China
on

For CAS

ZHU Xuan
Secretary-General

29 April 1998 (revised 25 March 1999) Page 9/9 Memorandum of Understanding

Chinese NSFC vice-president WANG Naiyan and CERN research director for collider programs Roger Cashmore sign a new agreement. Peking University president CHEN Jia-er was involved in negotiations

NSFC and CAS signed contract with CERN to join CMS experiments.
Supported well by NSFC, CAS and MOST

1999-2006: Detector Works
2007-: Data Analysis
2013-2014 : Phase I Upgrade

Hardware/Software Contributions

1. 1/3 CSC (IHEP) and 1/3 Endcap RPC (PKU) for muon detecting and triggering;
2. Development of PbWO4 crystal and test its performance (China Group with Shanghai Institute of Ceramics)
3. Fabrication and measurement of high voltage distribution boards and signal coupling boards of drift tubes.
4. 6 supports for the end cap magnets
5. Muon Reconstructing and triggering with Endcap RPC

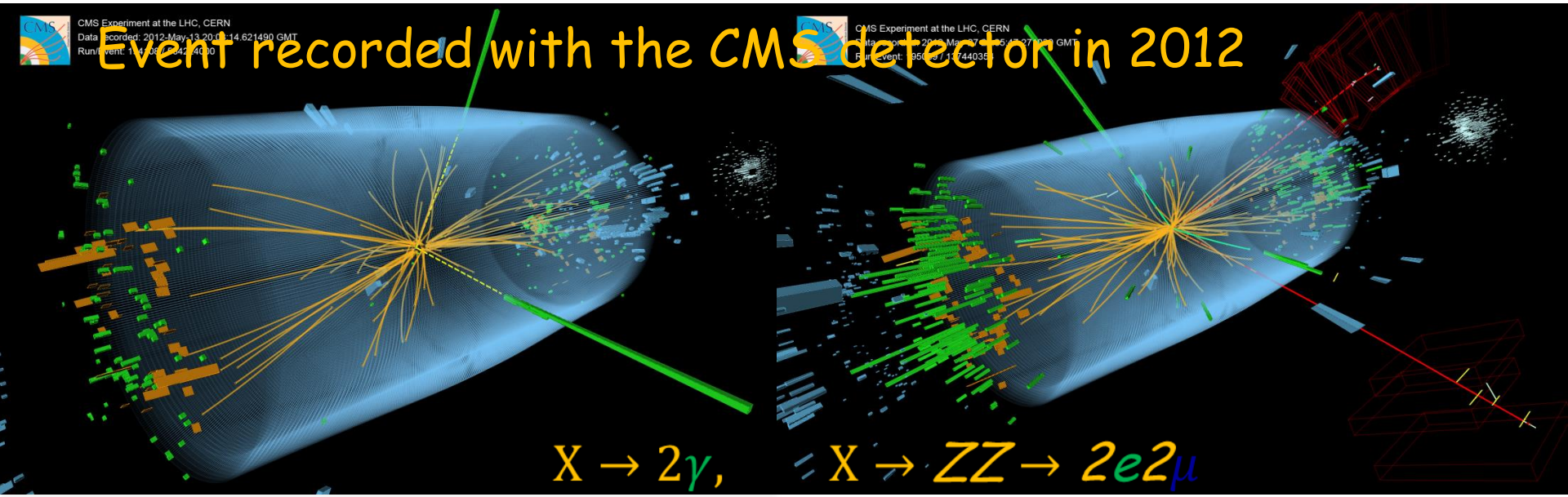
CMS China group has contributed over 36.6M CNY ,

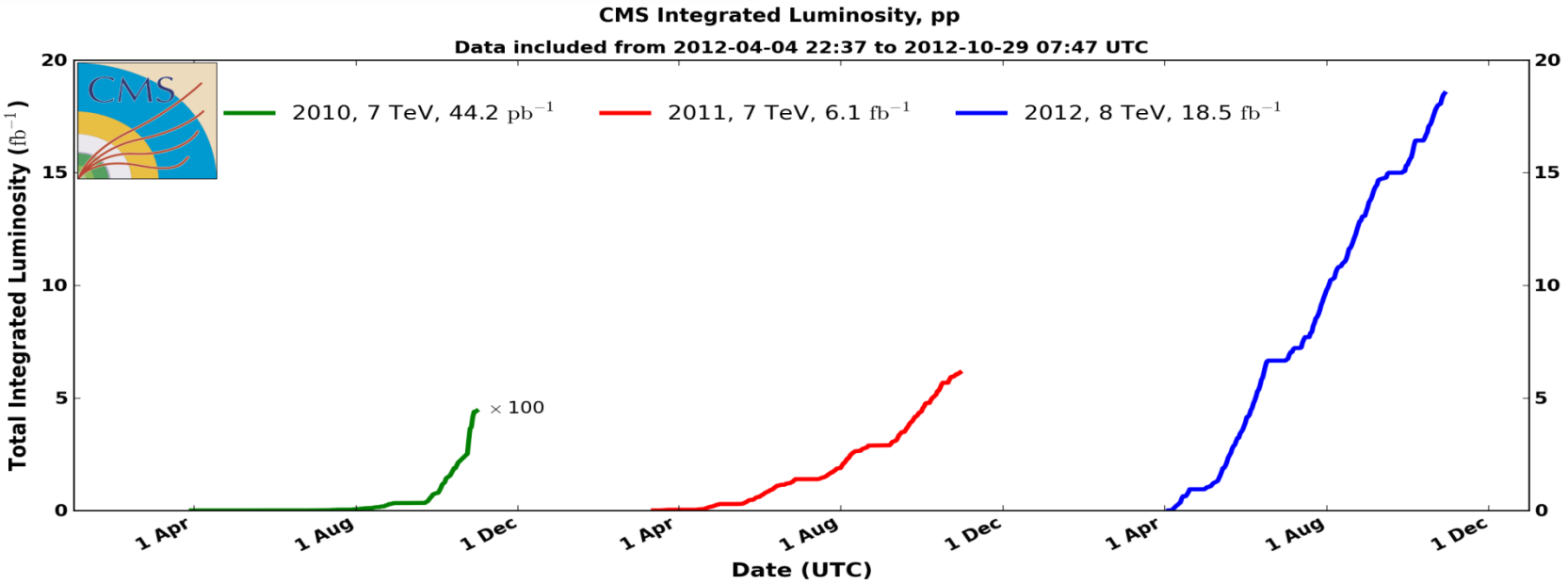
~1% CMS costs

CMS China Group Member

Institute	Prof.	Researcher & Associated Prof.	Postdoc & Ph.D.
IHEP	Hesheng Chen, Guoming Chen, Chunhua Jiang	Zhen Wang, Jianguo Bian, Ming Yang, Xiangwei Meng, Junquan Tao	Ye Chen, Jiawei Fan, Yuqiao Shen, Song Liang, Hong Xiao, Xianyou Wang
Peking Univ.	Yajun Mao, Yong Ban, Sijin Qian	Dayong Wang, Qiang Li	Yifei guo, Wenbo Li, Wei Zou, Linlin Zhang, Shuai Liu, Chayanit Asawatangtrakuldee, Zijun Xu, Mengmeng Wang, Daneng Yang, Zhaoru Zhang
Sum:	**6**	**7**	**16**

CMS Status: Has been running pretty well





Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC

The ATLAS Collaboration

(Submitted on 31 Jul 2012)

A search for the Standard Model Higgs boson in proton-proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb^-1 collected at sqrt(s) = 7 TeV in 2011 and 5.8 fb^-1 at sqrt(s) = 8 TeV in 2012. Individual searches in the channels H->ZZ^(*)->llll, H->gamma gamma and H->WW->e nu mu nu in the 8 TeV data are combined with previously published results of searches for H->ZZ^(*), WW^(*), bbbar and tau^+tau^- in the 7 TeV data and results from improved analyses of the H->ZZ^(*)->llll and H->gamma gamma channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of 126.0 +/- 0.4(stat) +/- 0.4(sys) GeV is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of 1.7x10^-9, is compatible with the production and decay of the Standard Model Higgs boson.

Comments: 24 pages plus author list (39 pages total), 12 figures, 7 tables, submitted to Physics Letters B
Subjects: High Energy Physics - Experiment (hep-ex)
Report number: CERN-PH-EP-2012-218
Cite as: arXiv:1207.7214v1 [hep-ex]

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC

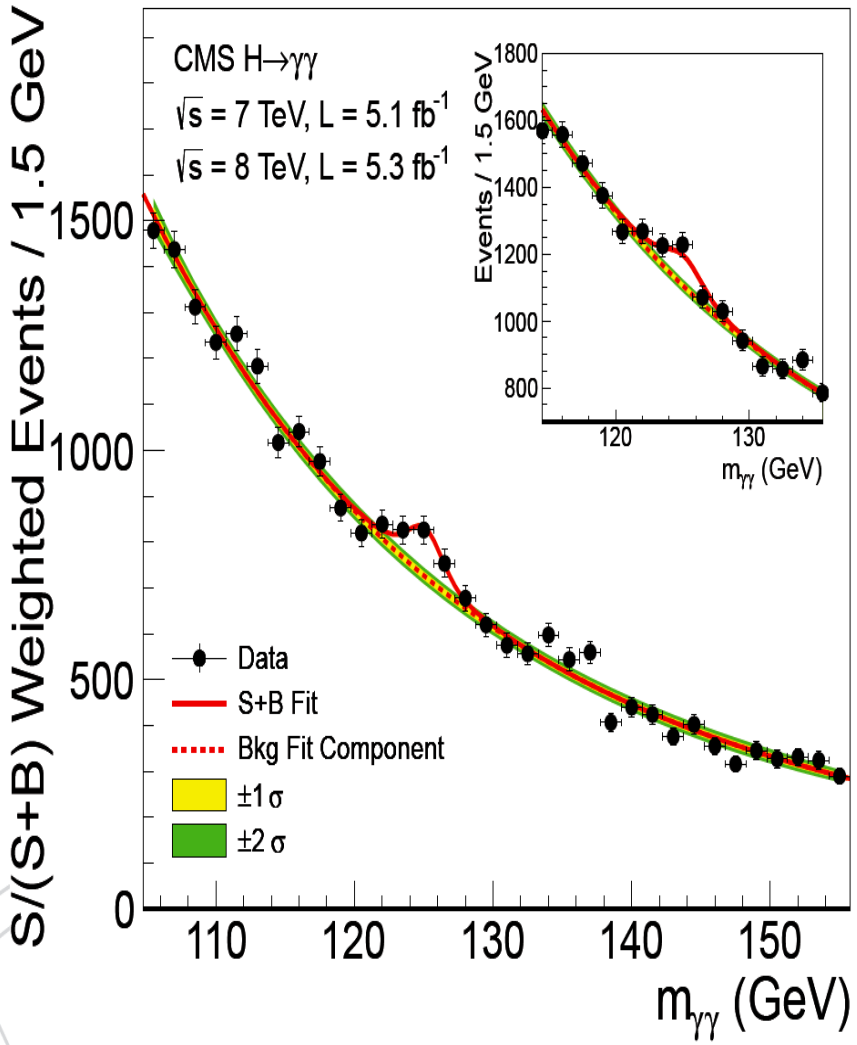
The CMS Collaboration

(Submitted on 31 Jul 2012)

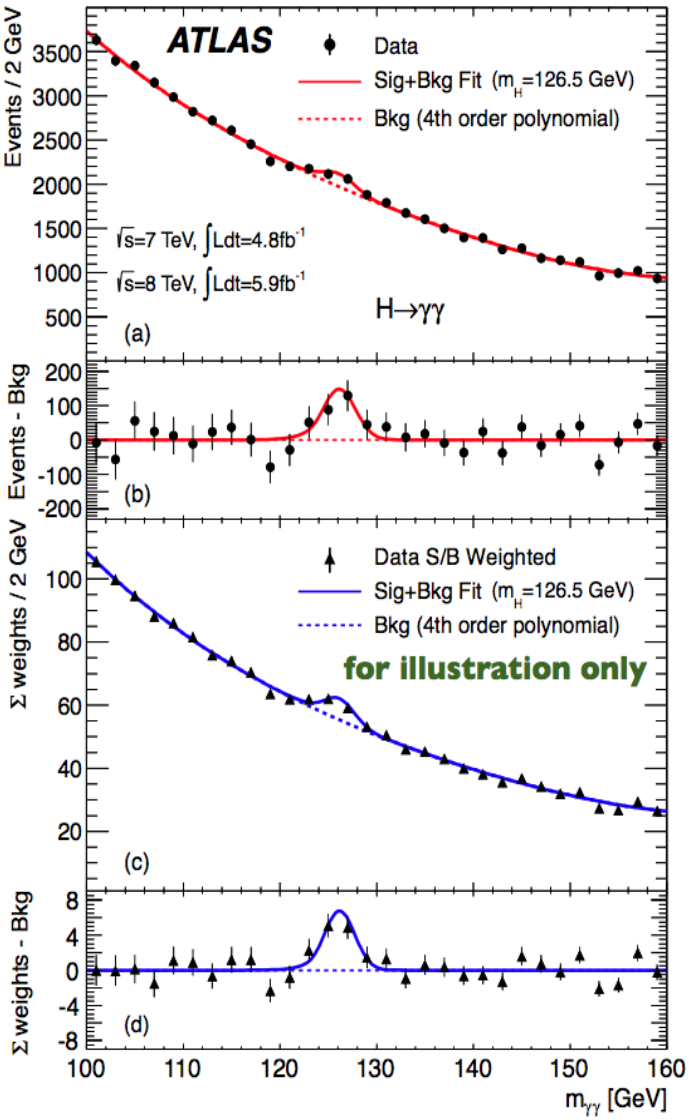
Results are presented from searches for the standard model Higgs boson in proton-proton collisions at sqrt(s)=7 and 8 TeV in the CMS experiment at the LHC, using data samples corresponding to integrated luminosities of up to 5.1 inverse femtobarns at 7 TeV and 5.3 inverse femtobarns at 8 TeV. The search is performed in five decay modes: gamma gamma, ZZ, WW, tau tau, and b b-bar. An excess of events is observed above the expected background, a local significance of 5.0 standard deviations, at a mass near 125 GeV, signalling the production of a new particle. The expected significance for a standard model Higgs boson of that mass is 5.8 standard deviations. The excess is most significant in the two decay modes with the best mass resolution, gamma gamma and ZZ; a fit to these signals gives a mass of 125.3 +/- 0.4 (stat.) +/- 0.5 (syst.) GeV. The decay to two photons indicates that the new particle is a boson with spin different from one.

Comments: Submitted to Phys. Lett. B
Subjects: High Energy Physics - Experiment (hep-ex)
Report number: CMS-HIG-12-028; CERN-PH-EP-2012-220
Cite as: arXiv:1207.7235v1 [hep-ex]

Results on H→γγ

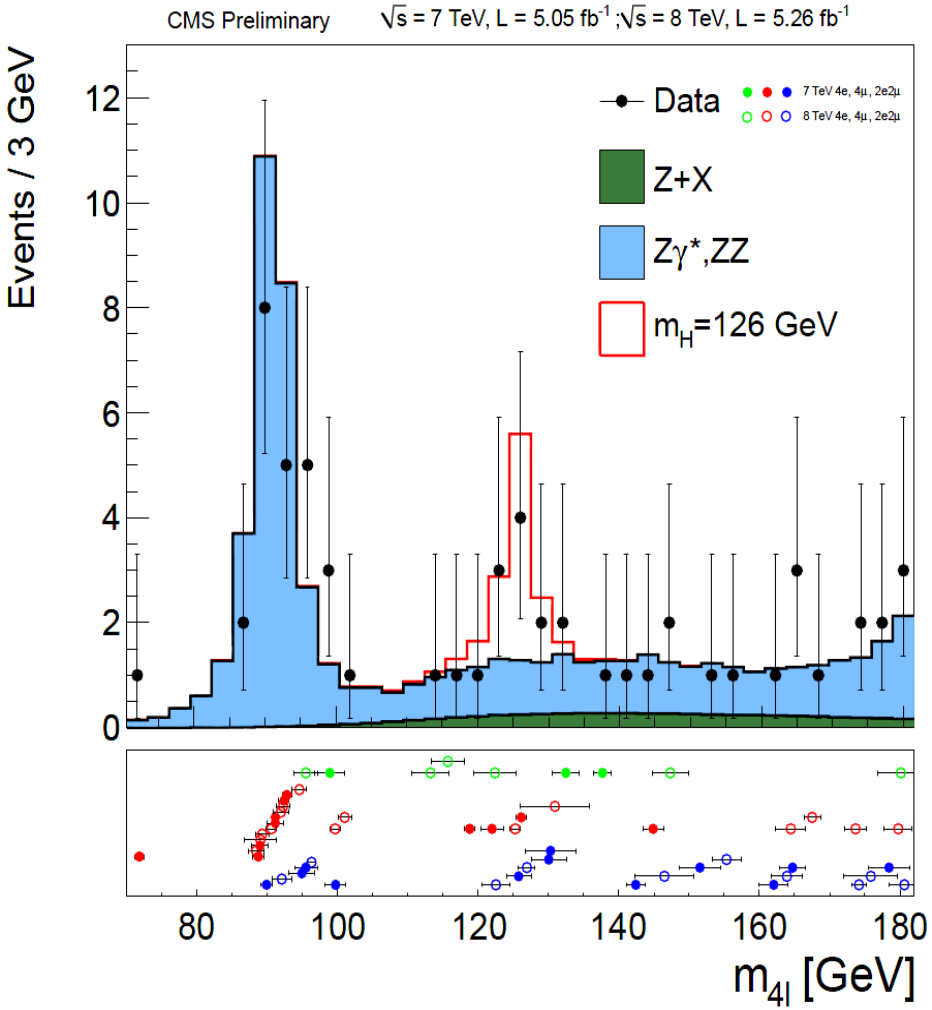


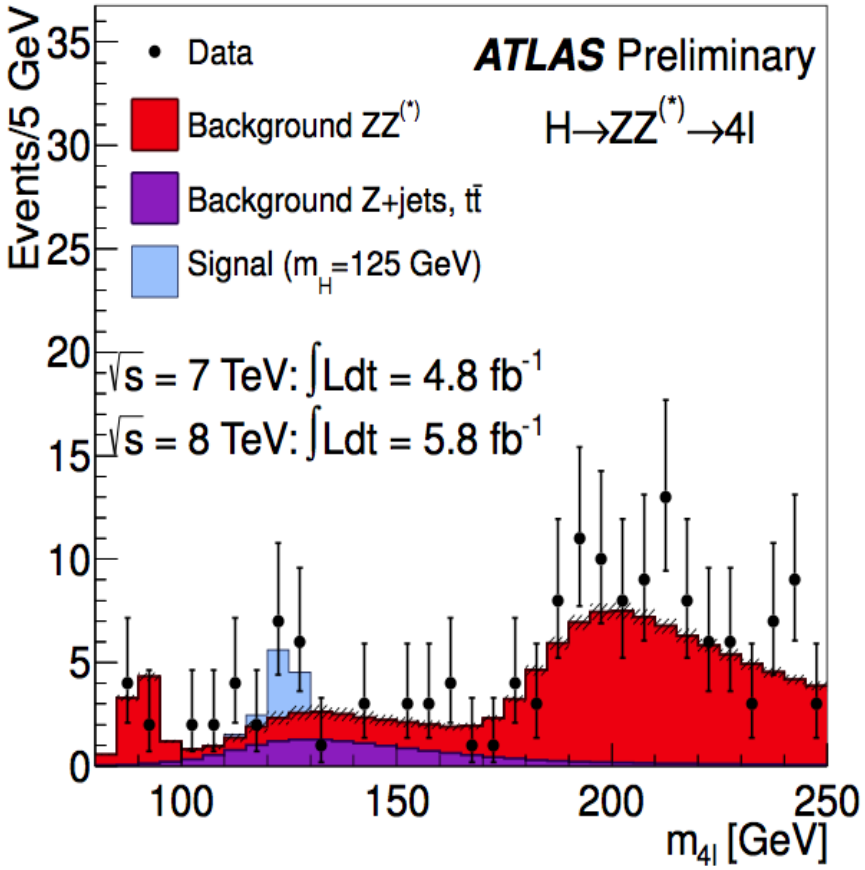
4.1 sigma



4.5sigma

Results on H→ZZ→4 leptons

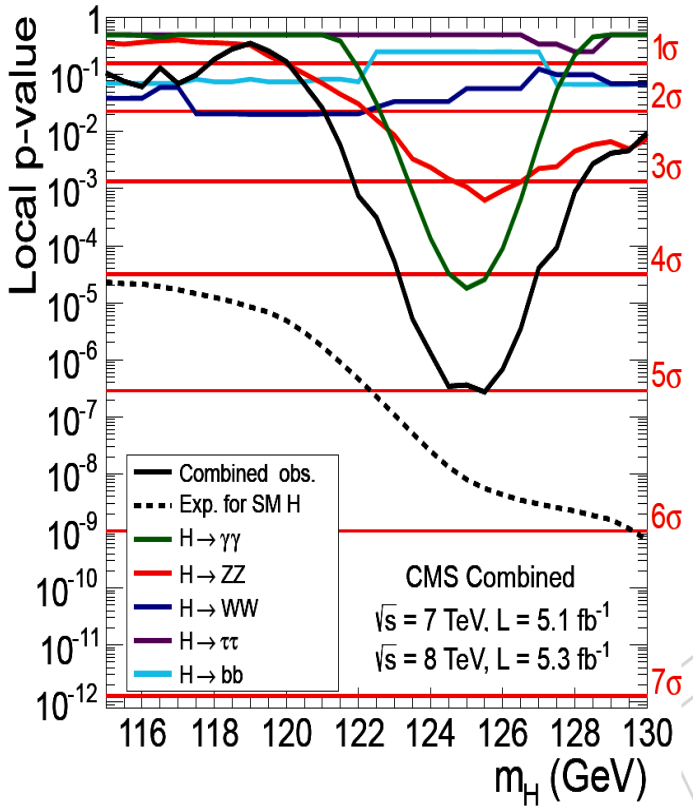


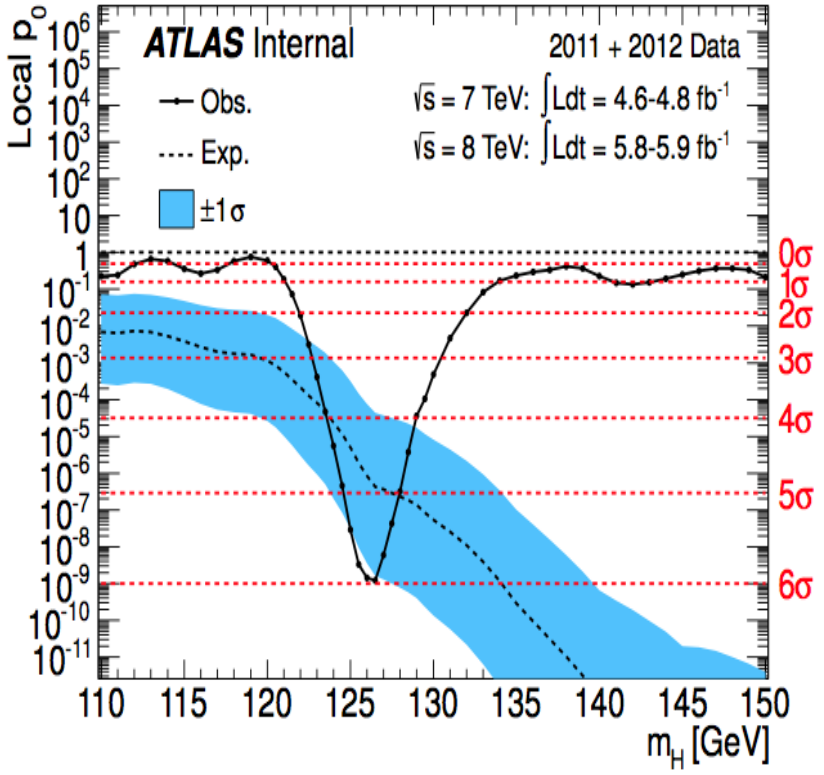


3.2sigma

3.6sigma

Discovery of a new boson.



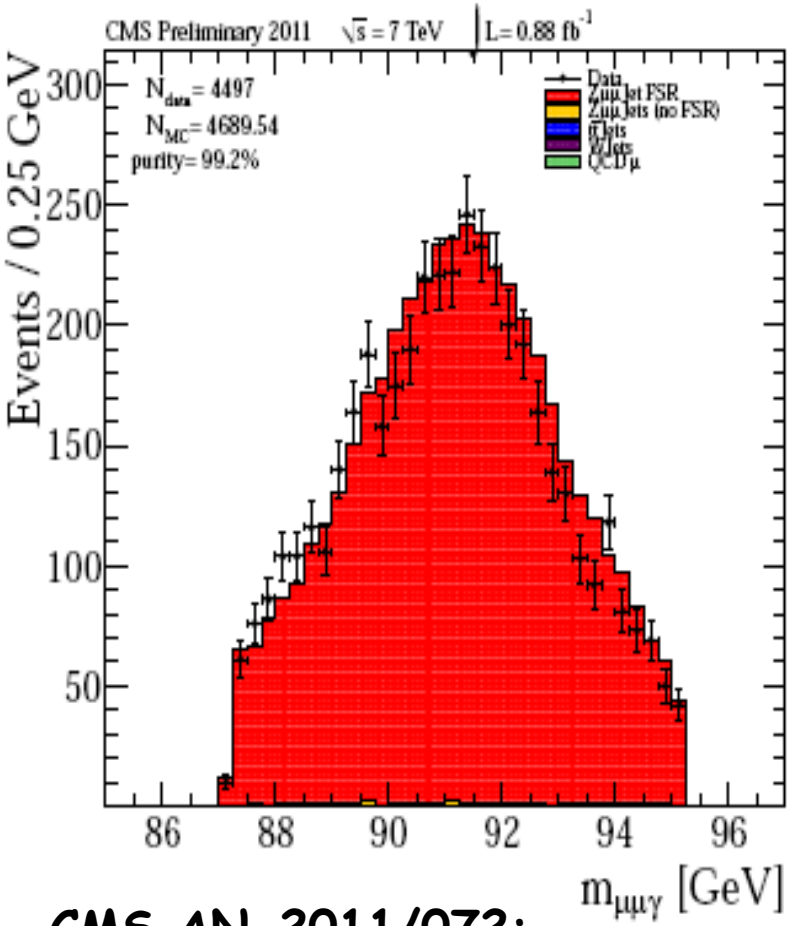


Combined significance 5.0σ for CMS and 5.9σ for ATLAS

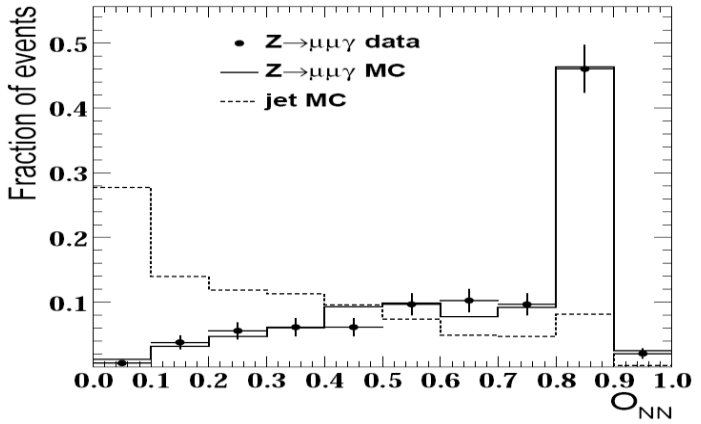
CMS China Group contributions related to Higgs searches

New MVA method to identify Photon and Pion

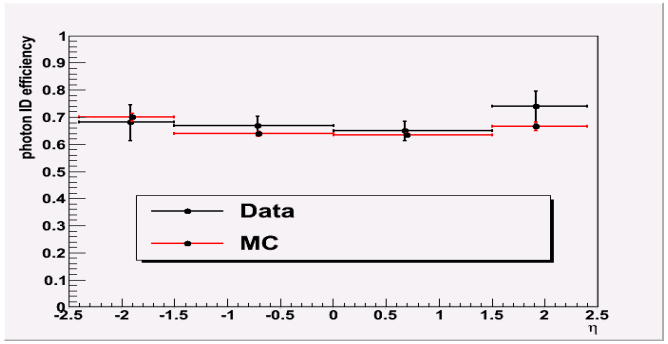
$Z \to \mu\mu\gamma$ Control Sample



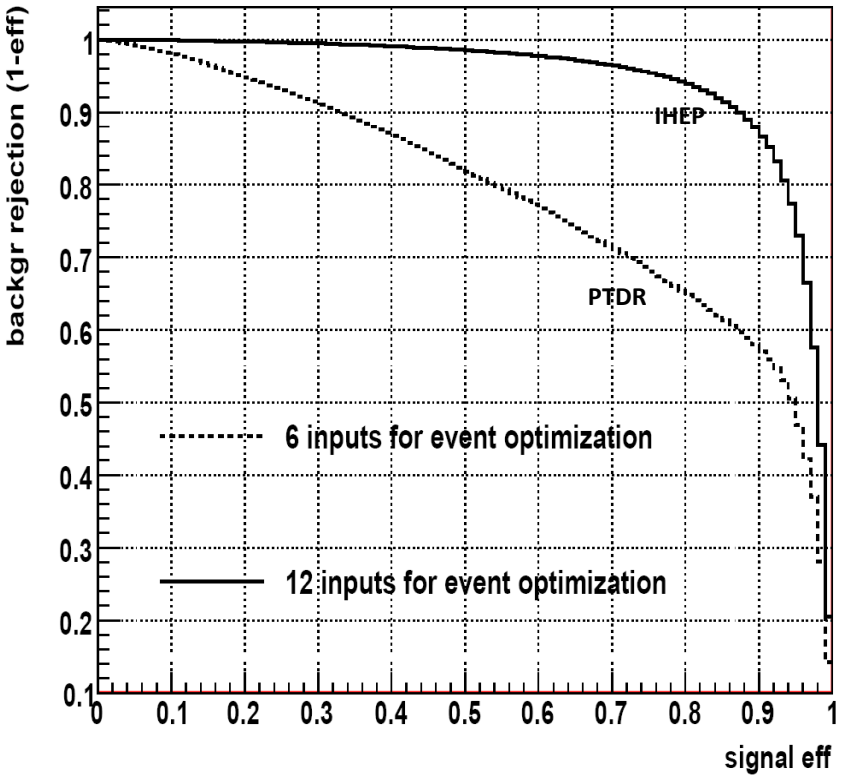
Neural Network Output for Data/MC



Photon ID Eff: Data vs. MC



CMS AN-2011/072:
Neural Network Methods for Photon Identification, prompt photon and diphoton purity determination and γ/π0 discrimination for the H→ γγ search



IHEP method to identify Photon from Pion has better performance and has been accepted by CMS in data analysis

CERTIFICATE

September 10th 2012

Dear Sir or Madam,

This is to certify that Dr. Junquan Tao is one of the authors of the search for the standard model Higgs boson decaying into two photons with the CMS experiment at the LHC. He mainly contributed to the photon identification with the Multivariate analysis (MVA) techniques, the interference correction study of $gg \rightarrow H \rightarrow \gamma\gamma / gg \rightarrow \gamma\gamma$, the rescaling of shower topology variables for the photon reconstruction. He is still working with the CMS Higgs to 2Gamma group.

Yours sincerely,

Marco Pieri

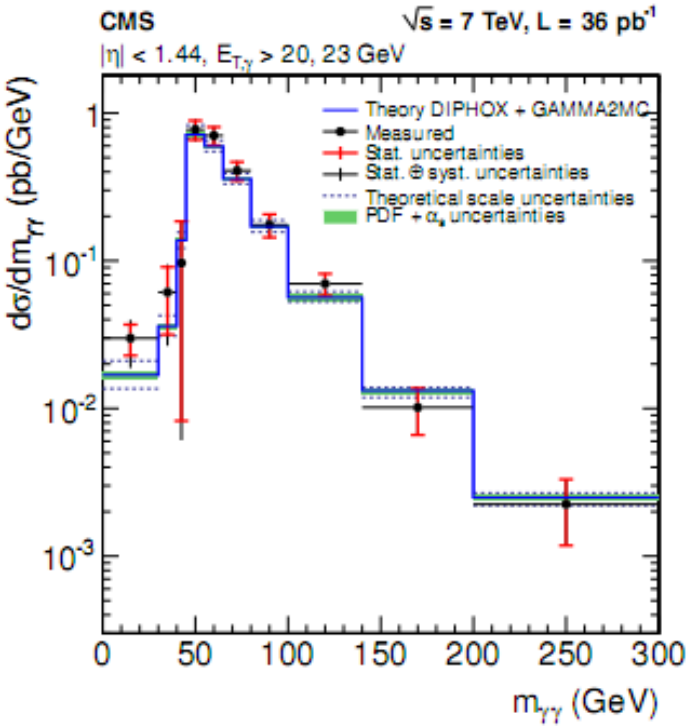
Co-convenor of the CMS Higgs to 2Gamma Analysis Group

Large Hadron Collider

European Organization for Nuclear Research

pp→γγ+X xsec Measurement

Irreducible Bkg to H →γγ, Important SM measurement



JHEP01(2012)133
Collaborated with French Colleagues. contributed significantly (see rightside)

CERTIFICATE

February 1st 2012

Dear Sir or Madam,

This is to certify that Dr. Junquan Tao is one of the authors of "Measurement of the Production Cross Section for Pairs of Isolated Photons in pp collisions at √s= 7 TeV" (Journal of High Energy Physics, Volume 2012, Number 1 (2012), 133, DOI: 10.1007/JHEP01(2012)133), based on the CERN-PH-EP-2011-171 formed from the CMS physics analysis summary CMS-QCD-10-035. He contributed significantly to the diphoton cross section measurement of 7TeV data collected by the CMS detector at the LHC, contributing to the choosing and binning of the observables, the prompt diphoton yields determination, the efficiency of photon reconstruction and identification, and the unfolding of the data analysis. He also worked in the running of theoretical software packages and the discussion on the theoretical predictions, which were used for the comparisons with the data analysis results.

Yours sincerely,

Susan Gascon-Shotkin

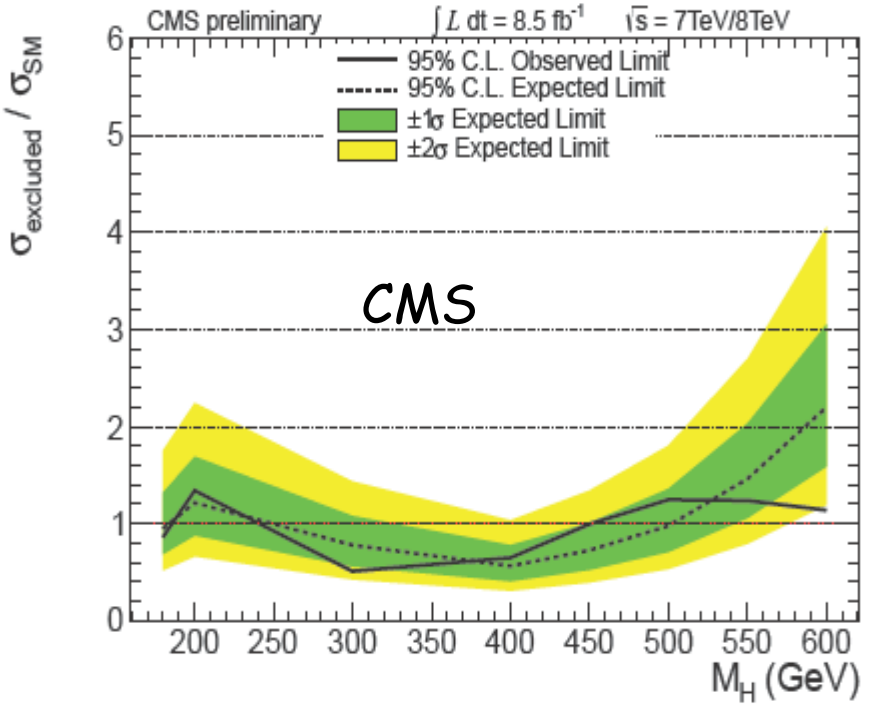
Co-convenor of the CMS QCD Photons Group

Large Hadron Collider

European Organization for Nuclear Research

H → WW →lvjj：intermediate and high mass region

- Although suffered from large QCD bkgs, can benefit from larger br ratio and reconstructable Higgs spectrum
- Crucial for heavier SM or non-SM Higgs searches
- Approved analyses with 2011 and 2012 data, excluding now SM Higgs in [240-450]GeV.



CMS PAS HIG-12-003,021,046

CMS AN-2008/052,066

CMS AN-2011/111

CMS AN-2012/139,193

PKU participated from early MC studies, and contributed in signal MC simulations and test, WJs bkg estimation, electron eff , VBF analysis and Heavy Higgs interference.

We proposed how to deal with Heavy higgs Interference effects

Heavy Higgs meeting

Friday, October 12, 2012 from **12:00** to **14:00** (Europe/Zurich)
at **CERN**

Friday, October 12, 2012

12:00 - 12:20 Introduction: status and proposed strategy for HCP *20'*
Speaker: Sara Bolognesi (Johns Hopkins University (US))
Material: **Slides**

12:20 - 12:40 First studies of rewieghting for interference in WW *20'*
Speaker: Qiang Li (Peking University (CN))
Material: **Slides**

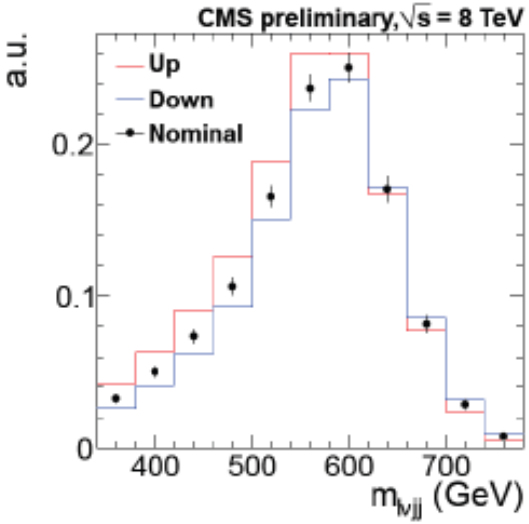
approved and being used in many CMS Heavy Higgs searches

See also HWW talk at HCP 2012 on next page:

H→WW→lνjj Systematics

- Dominant systematics are background normalization, shape
- Signal systematics include effect of gg → WW interference
  - which changes the shape and enhances the cross section
  - Effect starts around 400 GeV and increases with M_H
- We estimate the effect using K-factors from H→ZZ and reweight signal events by a ratio R2 = 1 + intf/LO
  - Signal shape uncertainty also determined by this procedure

Method Proposed by PKU

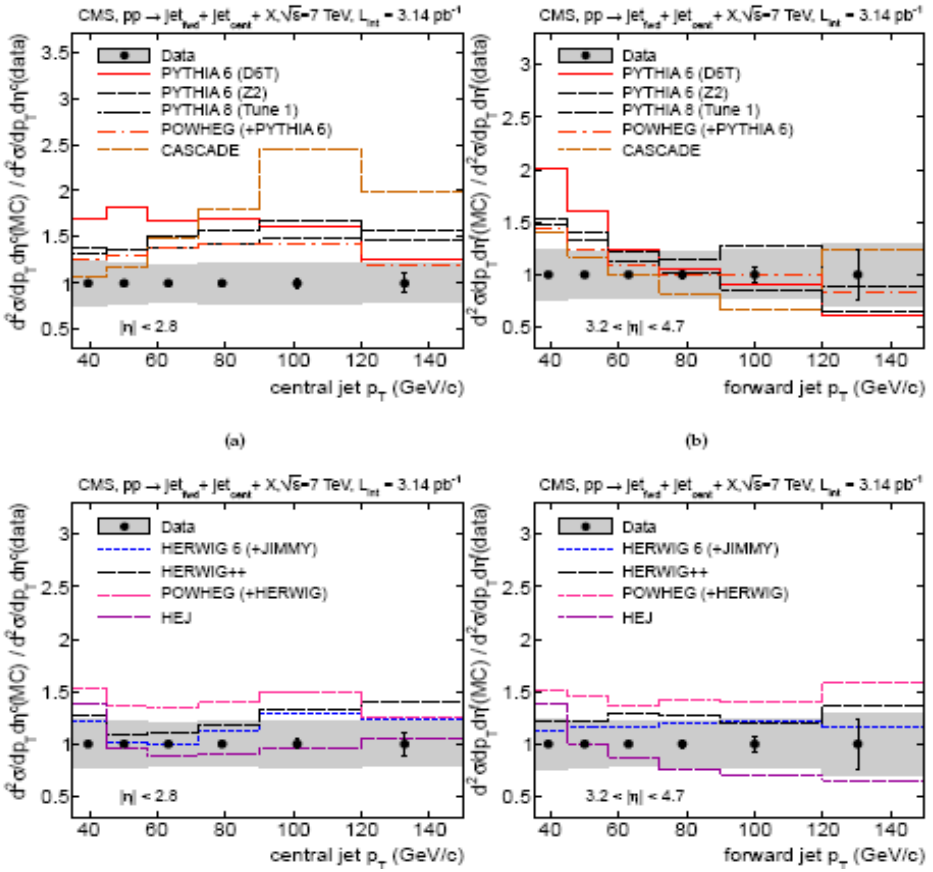


Source of uncertainty	Magnitude
Background $m_{\ell\nu jj}$ shape	See Fig. 4
Background normalization	0-2%
Higgs boson cross-section	13-15%
Theory acceptances (PDF)	1-2%
Scale uncertainties from jet binning	4-28%
Luminosity	4.4%
Lepton selection eff.	1-2%
Lepton trigger eff.	1%
Jet energy scale, resolution, and $\not{E}_T$	<1%
Likelihood selection	10%
Signal shape (interference)	See Fig. 6

Central && Forward Jets Measurement : Inputs for VBF Higgs

- Measure for the first time the Xsec. of one central jet (|η|<2.8)production associated with one forward jet (3.2 < | η |< 4.7), with 3.14pb-1 data at 7TeV LHC.

- Can give useful inputs on tagged jets in VBF Higgs studies



Bo Zhu (朱博), Peking Univ.,

PAS organizer, speaker of

pre-approval and approval talks

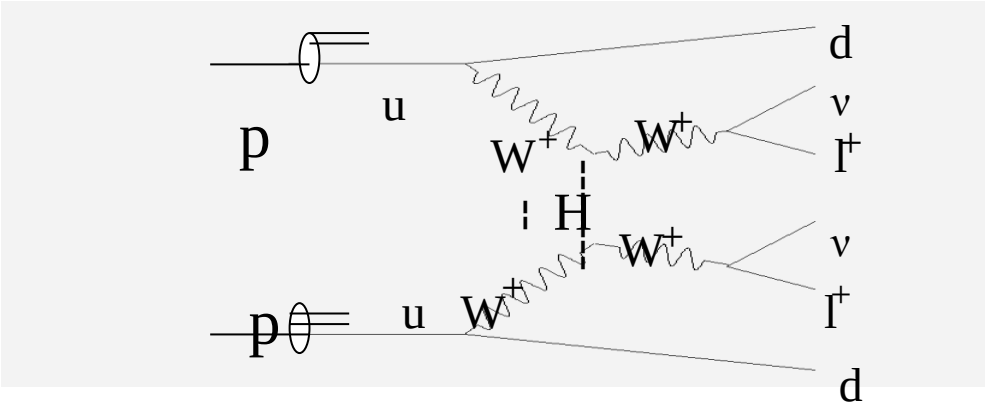
JHEP06(2012)036

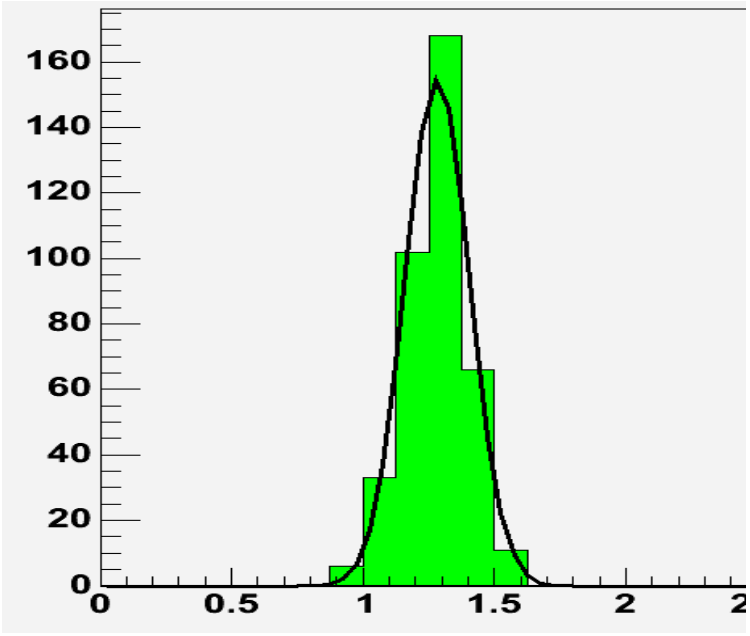
CMS Paper-FWD-11-002,
CMS PAS-FWD-10-006,
CMS AN-11-036

Sensitivity to measure the anomalous gauge couplings of the Higgs boson via W^+W^+ scattering at the CERN LHC

Inspired by Prof. Kuang (邝宇平院士)

Phys. Rev. D78, 073010(2008)





- **MC Study on Anomalous HWW coupling**
- **With 300fb^{-1} of data at 14TeV LHC, sensitive up to**

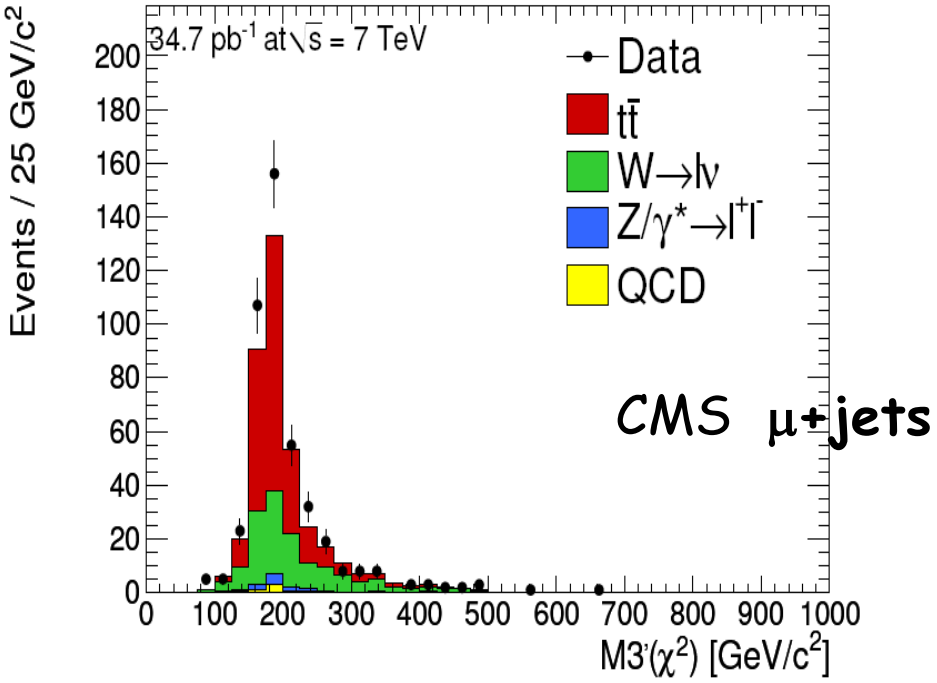
$-0.010 < G_{HWW} < 0.009$

With 300 fb-1, can measure Anomalous coupling parameter with an accuracy up to 10%

Will go on with Exp. analysis

CMS China Group contributions on non-Higgs physics analyses

Top quark pair production Xsec.



l+jets，ll+jets， l=e，μ

IHEP：μ+jets
2 CMS Notes

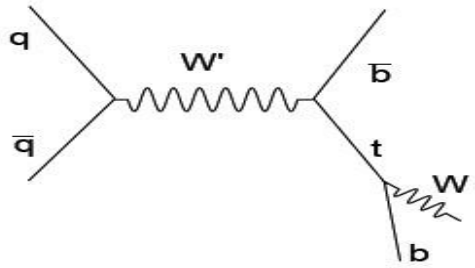
CMS AN-2010/173 Selection of tt Candidates in the Muon+Jets Channel

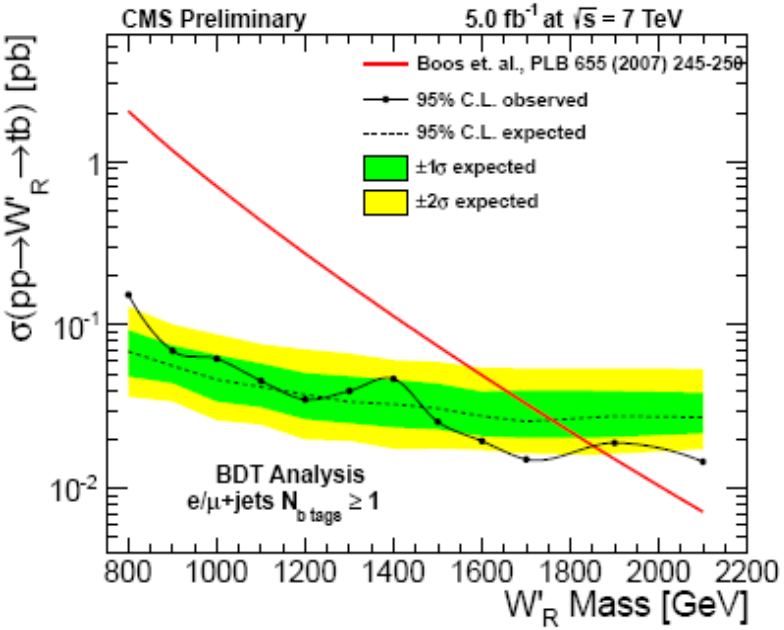
CMS PAS TOP-10-002 Measurement of the $t\bar{t}$ Pair Production Cross Section At $\sqrt{s}$ = 7 TeV using the Kinematic Properties of Lepton + Jets Events

First Measurement of Cross Section for Top-Quark Pair Production in Proton Proton Collisions at $sqrt{s}$ = 7 TeV, Phys. Lett. B, 695: 424-443, 2011.

W′→tb Search

- W' and Z' predicted by many extension-SM models with enlarged gauge symmetries.
- Tevatron set a mass limit on Right Handed W' as 890GeV [PRL 100 (2008) 031804].
- We looked into semileptonic: 2 jets+MET+lepton





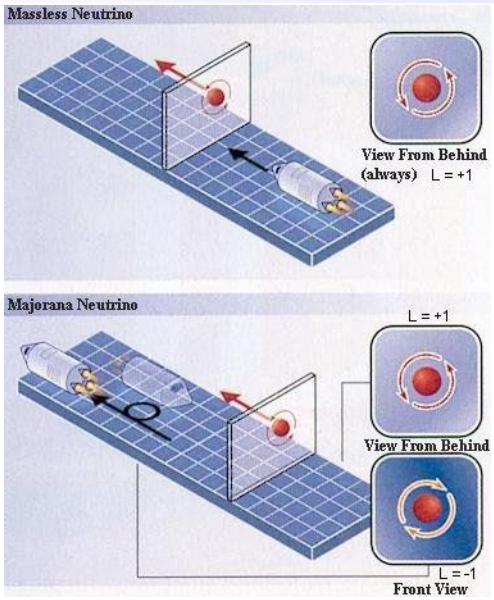
1. With the 5 fb^{-1} of 2011，we pushed the limit up to 1.8TeV.
2. Zou Wei (邹伟) from PKU is one of the main contributers, In collaboration with Brown Univ. and FNAL：

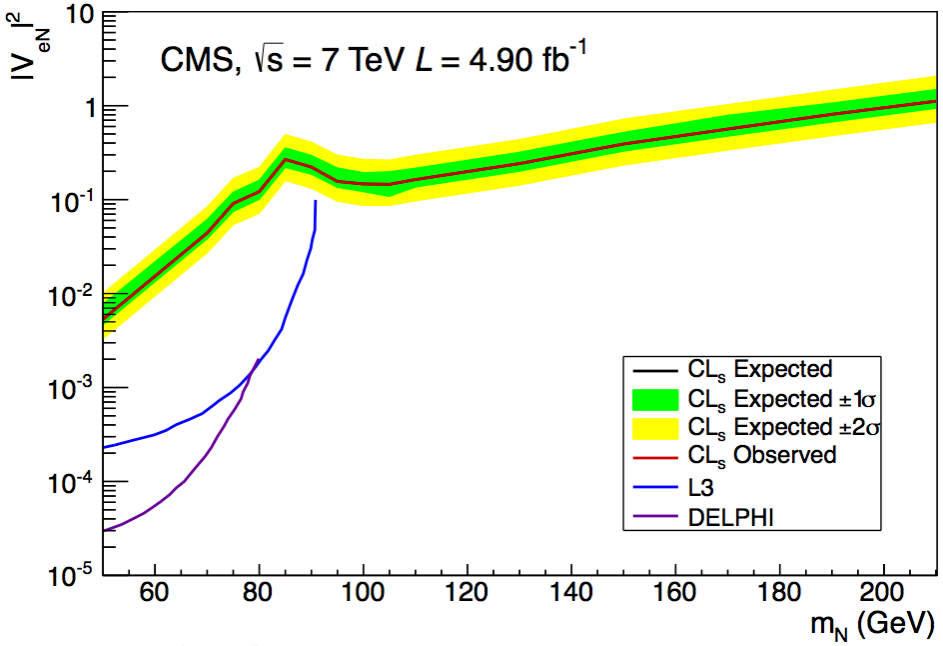
CMS AN-2011-170 , AN-2012-046

CMS PAS-EXO-11-046，EXO-12-001

arXiv: 1208.0956 Submitted to PLB

Search for heavy Majorana neutrinos in same sign lepton events

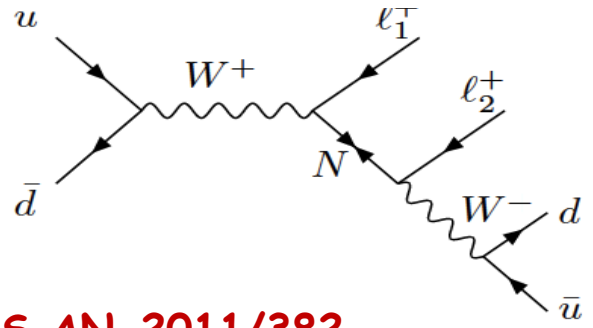




- Dirac vs Majorana Neutrino:

- With ~5 fb^{-1} from 2011 LHC 7TeV collisions,

Extended significantly previous excluded limits from LEP



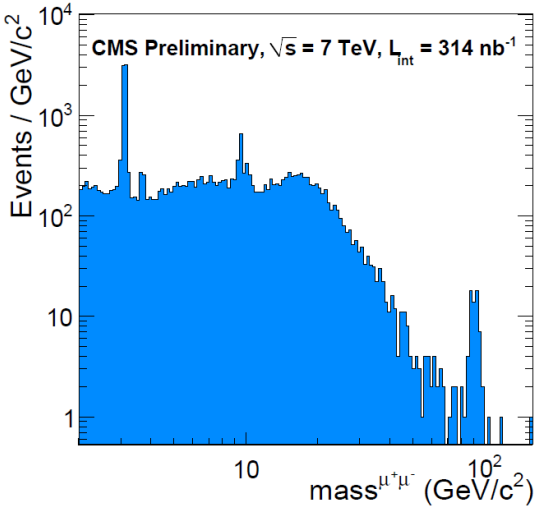
- Yifei Guo (郭逸飞) from PKU worked with FNAL and UCR, in charged of the electron channel analysis

CMS AN-2011/382
CMS PAS EXO-11-076
arXiv: 1207.6079
Phys.Lett. B717 (2012) 109-128

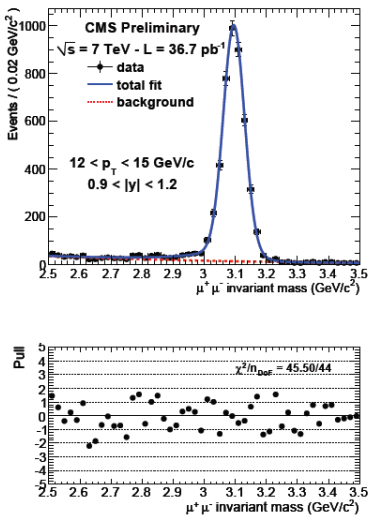
- No significant excess in the data over predicted background observed
- Set limit to $|V_{eN}|$ and $|V_{\mu N}|$
- In Majorana mass < 90 GeV region, we did not go beyond old results; while for > 90 GeV region, it is the first experiment limit.

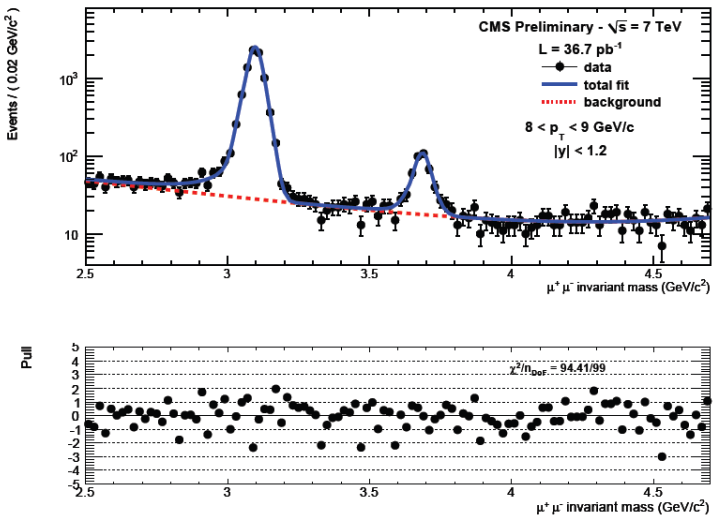
Measuring J/ψ and ψ(2S) production Xsec.

- **Crystal Ball function for signal, Exponential function for background;**



CMS dimuon mass spectrum (standard cuts)





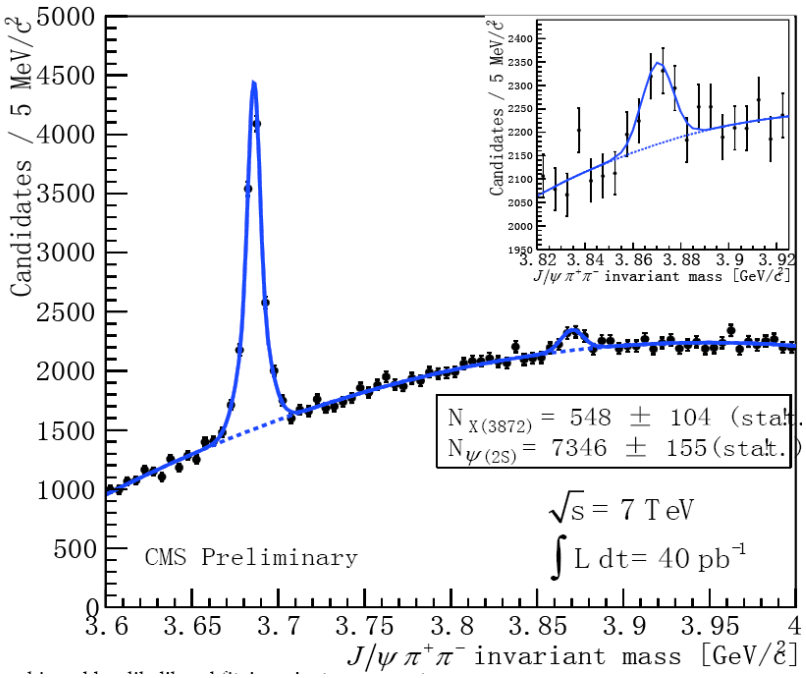
J/ψ and ψ(2S) mass spectrum

with standard cuts, in $12 < p_T^{J/\psi} < 15 GeV/c$ *and* $0.9 < |y^{J/\psi}| < 1.2$ *(middle),* $8.0 < p_T^{J/\psi} < 9.0 GeV/c$ *and* $|y^{J/\psi}| < 1.2$ *(right).*

CMS AN-2010/138,
CMS PAS BPH-10-002, 10-014,
EPJC 71,1575,2011,
Phys.Rev.D83:112004,2011

Shuang Guo (郭爽) from PKU,
Presentation at HQL2010, Paris

Measuring X(3872) ,ψ(2S) → J/ψπ⁺π⁻



Examine the property of X (3872) by studying it xsec. ratio over ψ (2s)

•Dr. JianGuo Bian, Dr. Jian Wang, and Xianyou Wang from IHEP, played important roles, in collaborations with Italian colleagues

• Dr. Jian Wang gave a presentation at Hadron2011, Munich.

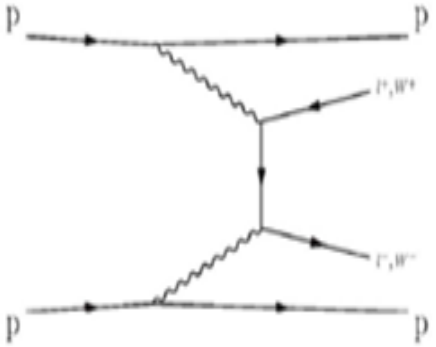
• Xianyou Wang made a poster Presentation at PLHC2011, Perugia

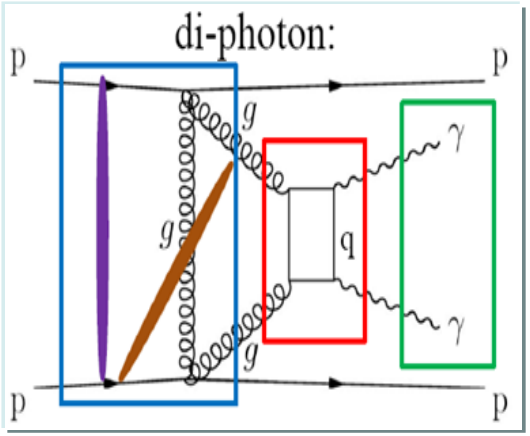
X（3872）与ψ(2S)的产生截面之比为：0.087±0.017（stat）±0.009 (syst).

CMS AN -2011/346, DPS -2011/005

CMS PAS BPH-10-018 Measurement of the production cross section ratio of X(3872) and ψ(2S) in decays to J/ψπ+π− in pp collision at sqrt(s)=7TeV

Exclusive di-photon and di-electron Measurement





- **Protons remain intact**
- **Di-electron or photon produced in central region**
- **Crucial to test forward and small x QCD**

Number of events remaining after each selection:

exclusive diphoton analysis		exclusive dielectron analysis	
selection criterion	events remaining	selection criterion	events remaining
Trigger	3 023 496	Trigger	3 023 496
Photon reconstruction	1 683 526	Electron reconstruction	132 271
Photon identification	40 692	Electron identification	2 648
Cosmic ray rejection	32 775	Cosmic ray rejection	2 023
Exclusivity requirement	0	Exclusivity requirement	17

Wenbo Li (李文博) from PKU played the leading role

Made a presentation at DIS2012, Bonn

CMS PAS-FWD-11-004
arXiv:1209.1666,
Submitted to JHEP

Publications: papers with important contributions

1. **Measurement of the charge ratio of atmospheric muons with the CMS detector，** Phys. Lett. B 692, 83-104 (2010) 陈明水： 电荷误判率随动量的变化
2. **Measurement of the B+ Production Cross Section in pp collisions at sqrt(s) = 7 TeV,** Phys. Rev. Lett. 106, 112001 (2011) 我方 **cross check**
3. **Prompt and non-prompt J/psi production in pp collisions at sqrt(s) = 7 TeV，** *Eur. Phys. J. C*71, 1575 (2011) 孟祥伟：B强子Pt 分布反卷积， 杨宗长，郭爽：触发研究、接受度与效率修正等。
4. CMS Collaboration, Measurement of the Inclusive Upsilon production cross section in pp collisions at sqrt(s) = 7 TeV, Phys. Rev. D 83, 112004 (2011) 郭爽: MC模拟分析与实验数据拟合等
5. First Measurement of the Cross Section for Top-Quark Pair Production in P-P Collisions at $sqrt{s}$ = 7 TeV, Phys. Lett. B, 695: 424 (2011). 王健:
6. Search for the standard model Higgs boson decaying into two photons in pp collisions at sqrt(s)=7 TeV. PLB 710 (2012) 403 高能所
7. **Combined results of searches for the standard model Higgs boson in pp collisions at sqrt(s) = 7 TeV.** Phys.Lett. B710 (2012) 26-48 高能所，北大
8. **J/psi and psi(2S) production in pp collisions at sqrt(s) = 7 TeV.** JHEP 1202 (2012) 011 高能所，北大
9. **Measurement of the production cross section for pairs of isolated photons in pp collisions at sqrt{s} = 7 TeV.** JHEP01(2012)133 高能所
10. **Measurement of the inclusive production cross sections for forward jets and for dijet events with one forward and one central jet in pp collision at sqrt(s)=7 TeV** JHEP 1206 (2012) 036 北大
11. **Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC.** Phys. Lett. B. 716 (2012) 30-61 高能所 北大
12. Search for heavy Majorana neutrinos in mu+mu+[mu-mu-] and e+e+[e-e-] events in pp collisions at sqrt(s) = 7 TeV, arXiv:1207.6079, **Phys.Lett. B717 (2012) 109,**北大

- **4 Preprints**

1. Search for a W' boson decaying to a bottom quark and a top quark in pp collisions at sqrt(s) = 7 TeV, arXiv:1208:0956, submitted to PLB 北大
2. Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, arXiv:1207.7235, accepted by PLB 高能所，北大
3. Measurement of the Upsilon(1S, 2S, 3S) polarizations in pp collisions at sqrt(s) = 7 TeV, accepted by PRL, CMS PAS BPH-11-023 北大
4. A new boson at a mass of 125 GeV observed with the CMS Experiment at the Large Hadron Collider. sent to Science. 高能所 北大

- **6 MC Papers**

1. Sensitivity to measure the anomalous gauge couplings of the Higgs boson via W+W+ scattering at the CERN LHC, Z. Zhang, et al., PRD78, 073010 (2008)

2. Discovery Potential of New Boson W1± in the Minimal Higgsless Model at LHC， Bian Jian-Guo et. al., Nucl.Phys.B, 819(201) 2009

3. Prospects for a new boson W1± in the minimal Higgsless model at the LHC, Ming-Shui Chen, et. al, J. Phys. G: Nucl. Part. Phys. 36 (2009) 075004

4. Same sign WW scattering process as a probe of Higgs boson in pp collision at sqrt(s) =10 TeV, Bo Zhu et al., Eur. Phys. J. C (2011) 71: 1514, arXiv:1010.5848

5. Probing New Physics via pp-> W+W- -> lvjj at the CERN LHC, Shuai Liu et al., Phys.Rev. D86 (2012) 074010.

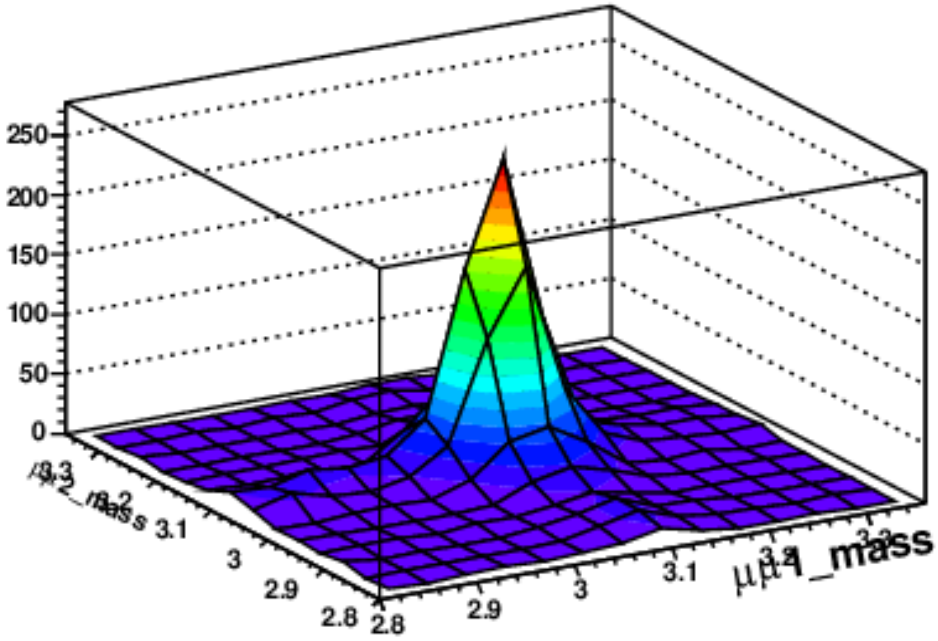
6. Probing W+W-gamma Production and Anomalous Quartic Gauge Boson Couplings at the CERN LHC, Daneng Yang et al., arXiv:1211.1641

- **International reports: 19**

Ongoing: Physics Analysis

pp→ J/ψJ/ψ+X
(Suggested by Prof. Congfeng Qiao)

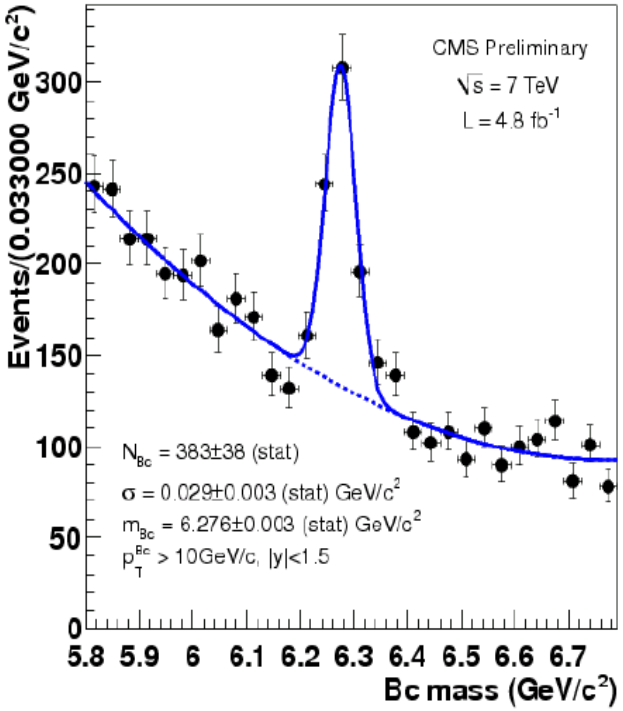
Test Color Singlet Model and Color Octet Predicti

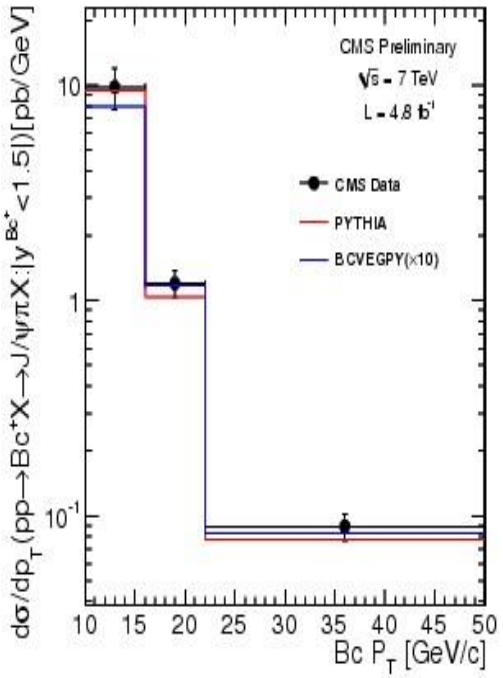


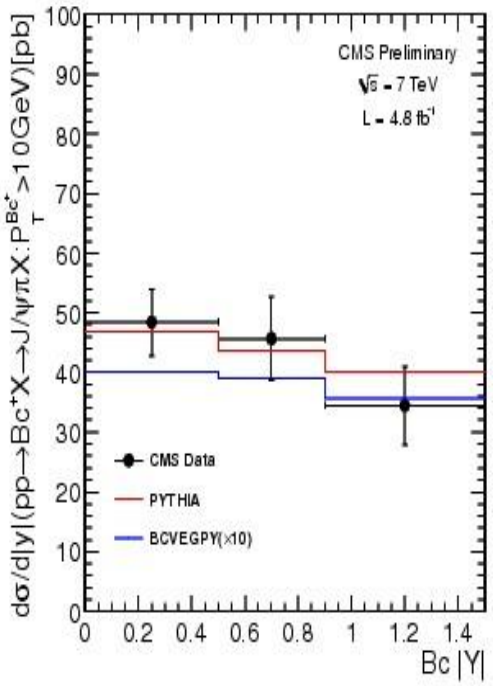
Dr. JianGuo Bian (卞建国) from IHEP is now leading this project.
Designed 3μ HLT trigger, and proposed 4D fit for the time

Bc→J/ψπ Suggested by Prof. Chao-Hsi Chang(张肇西院士)

- Bc Meson can be produced copiously at the LHC, can be used to test QCD

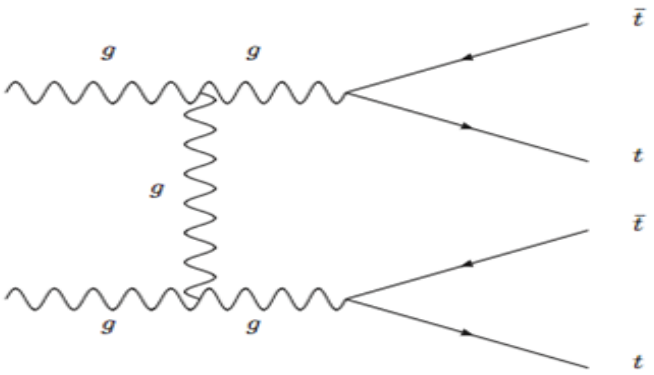




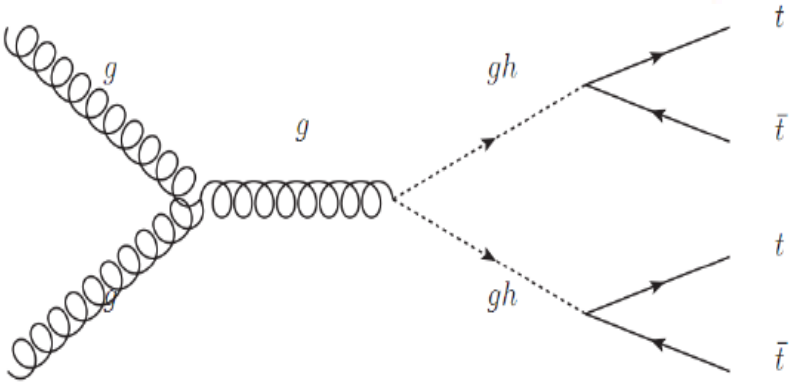


Measuring the differential cross section of Bc productions, led by IHEP group, including Xianyou Wang, Song Liang, Dr. Zhen Wang

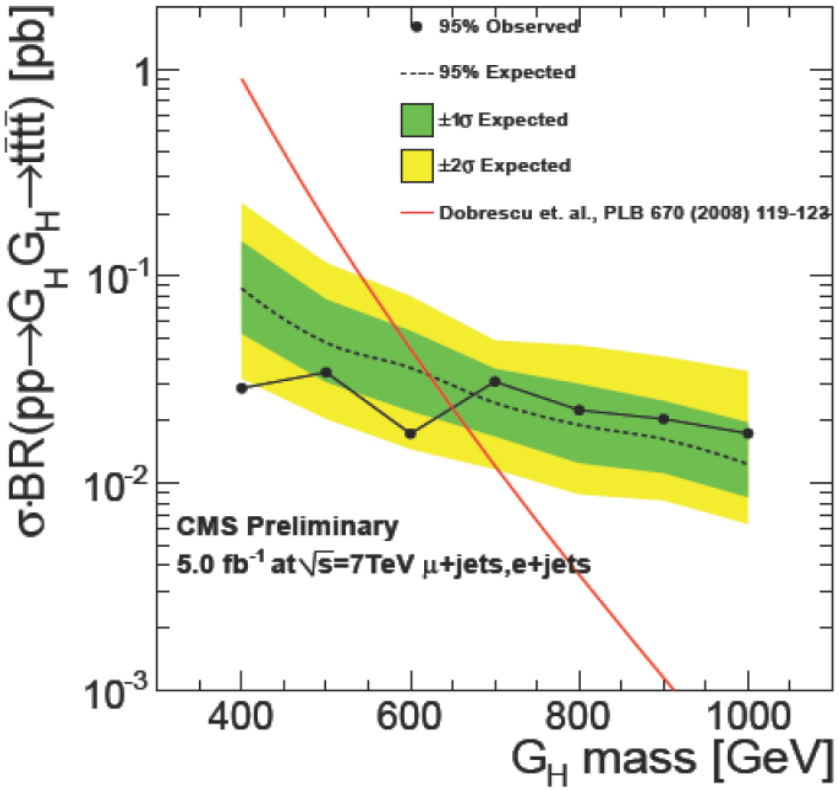
4-top productions: SM test and New physics search



SM 4-top



New Physics contributions



- With 5fb^{-1} data of 2011年, we set the upper limit on xsec as 9fb
- Constaining New Physics model parameters

pre-approved,
Wei Zou (邹伟) from PKU made the presentation
CMS AN-2012-077
CMS PAS-TOP-12-005

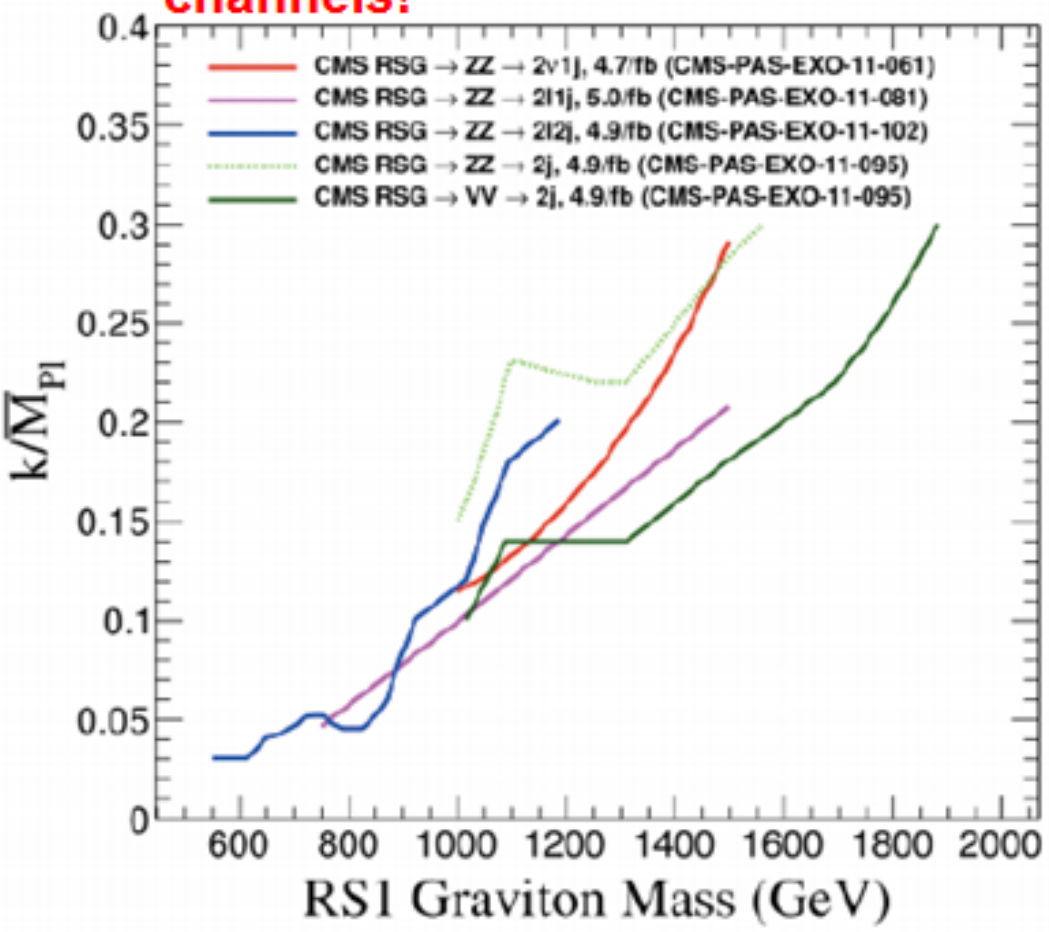
VV resonance:
VBF
Jet Substructure

EXODIBOSON

- New group established in Jul 2012
  - Established at July 23rd 2012
  - Members of the team
  - A.Bonato, A.Hinzmann, M.Pierini, F.Santanastasio(CERN)
  - M.Mozer(Wisconsin)
  - C.Bernardes, J.CuperXno, F.Dias, T.Thiago(SPRACE)
  - Y.Xin(JHU)
  - Y.Mao, Q.Li, S.Liu, Z.Xu, C.Asawatangtrakuldee, D.Yang(PKU)
  - N.Tran (FNAL)

- Integration of analyses with X → VV signatures
  - Z (lept lept) + V (hadronic)
  - W (lept nu) + V (hadronic)
    - Lept := electron and muon
  - Open to other possibilities

WW->lv+j missed Last Year!! This year we will combine all channels!



Ongoing & future: CMS Upgrade

Long Shutdown 1: 2013.3-2014

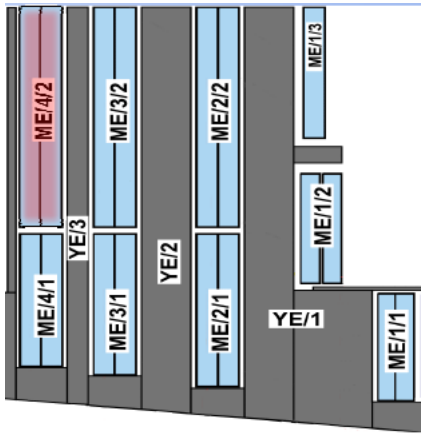
Upgrade Phase I

Restart: late 2013 or in 2014

Long Shutdown 2: ~end year 2017

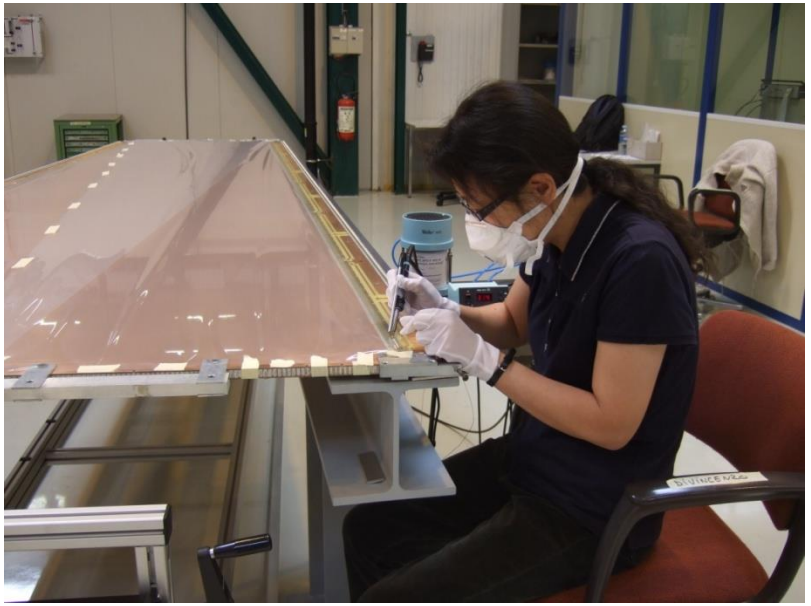
Upgrade Phase II

CMS Endcap Muon ME4/2 Construction/Installation

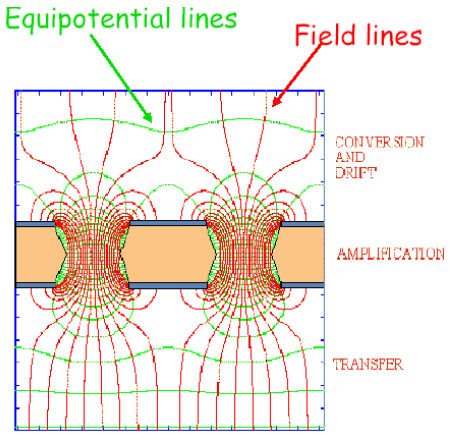


在CERN建立清洁间，由中国高能所,俄罗斯,和美国三国派工程师技术员前来参加批量组装，宇宙线测试，电子学部件安装等工作。样机已经在费米实验室启动，已经于2011年在CERN启动全面组装工作。

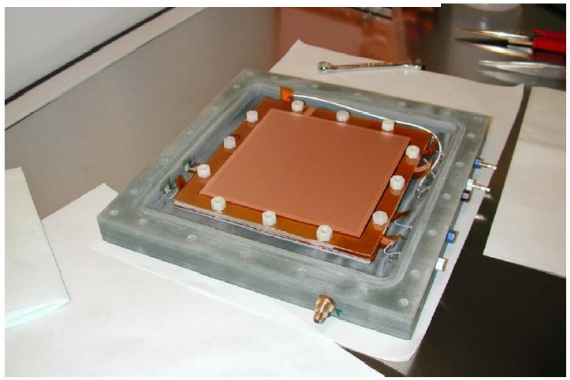
按照比例，中国应派人员每年2人,共三年完成。研制和组装技术没有难点，高能所有着成熟的经验。目前参加这一部分工作，是我们的责任同时也有益于年轻学生的硬件训练和培养。



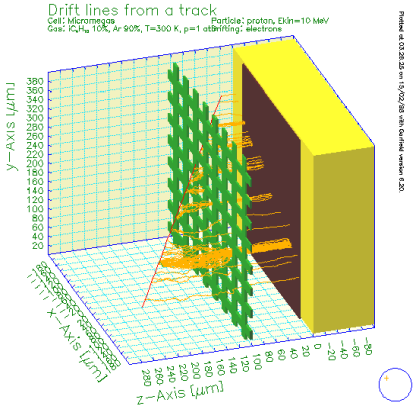
End cap RPC upgrade : R&D on MPGD



MPGD Project



- 端盖内圈缪子探测器靠近束流管区域，辐射极强，计划用MPGDs(Micro-Patten Gas Detectors)探测器作内圈μ触发系统的研制



- 北大组2010年起加入该计划
  1）束流测试以研究MPGD效率
  2）开发软件将MPGD并入CMSSW、提供数字化与触发模块
  3）利用开发的软件模块，优化MPGD设计、提出MPGD原型方案

Thanks to Qiang Li and Guoming Chen for the help on preparing this talk and to all CMS chinese colleagues for their hardwork for CMS.