# 北大高能实验组介绍

冒亚军,钱思进,班勇, 王思广, 王大勇,李强

2014年5月19日

# 主要内容

- 北大高能组简要回顾
- 北大BES组进展
- 北大CMS组进展
- 其他研究进展
- 总结

# 北大高能实验组全家


2010年3月12日


NTU visit to PKU group, Jan 4-5, 2013

# BES北大组主要工作进展

## 轻强子谱学研究

- 通过J/ψ->ωηππ衰变道观察到X(1870) 发表于PRL
- J/ψ → γπ⁰π⁰以及γηη过程的分波分析 发表于PRD
- Measurements of EM Dalitz decays of J/psi 发表于PRD

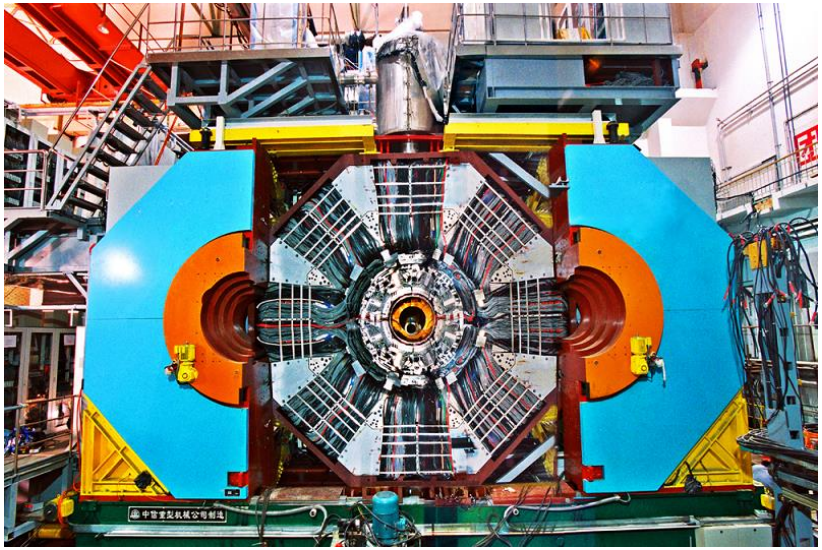
## 粲偶素物理研究与精确测量

- ψ(2S)→ γP(P = η, η′ , π⁰)的测量 发表于PRL
- $\chi_{cJ}$ → VV衰变模式的研究 发表于PRL
- 粲偶素到赝标介子对衰变的测量 draft完成

## 其他研究进展

- BESIII量子纠缠研究 初步分析中
- 探测器性能研究与软件开发 为BESIII官方使用

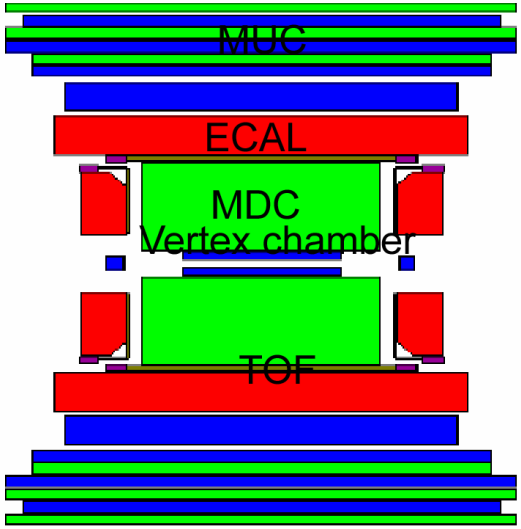
# BEPC对撞机和BES-III实验



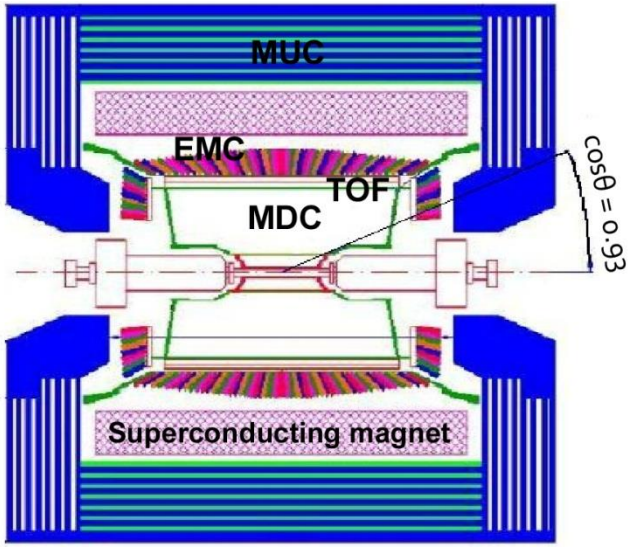
- BEPC-BES3是目前国际上唯一运行在τ-charm能区的对撞机实验。
- BES3合作组包括30个国内研究单位，12个欧洲研究单位，5个美国研究单位和4个其它亚洲国家研究单位
- BES3积累了国际上最多统计量的J/ψ和ψ(2S)数据，可进行粒子物理的精确测量
- 2012年进一步获取了 10亿 J/ψ 数据

# 从BESII到BESIII

**BES II @ BEPC**




**BES III @ BEPC II**




| | BESII | BESIII |
|---|---|---|
| MDC | $\sigma(p)/p = 1.78\,\% \cdot \sqrt{1+p^2}$<br>$dE/dx_{reso} = 8\,\%$ | $\sigma(p_t)/p_t = 0.32\,\% \cdot p_t$<br>$dE/dx_{reso} < 6\,\%$ |
| TOF | 180 ps (for bhabha) | 90 ps (for bhabha) |
| EMC | $\sigma(E)/E = 22\% \cdot \sqrt{E}$ | $\sigma(E)/E = 2.3\,\% \cdot \sqrt{E}$ |
| MUC | 3 layers for barrel | 9 layers for barrel, 8 for endcap |

# BESIII数据获取现状

2008年4月30日：BESIII移至对撞点

2008年7月19日：第一次正负电子对撞

2008年11月： ~ 14M ψ(2S)事件 BESII数据

2009年4月19日： ~ 110M ψ(2S)事件 （×4CLEOc）

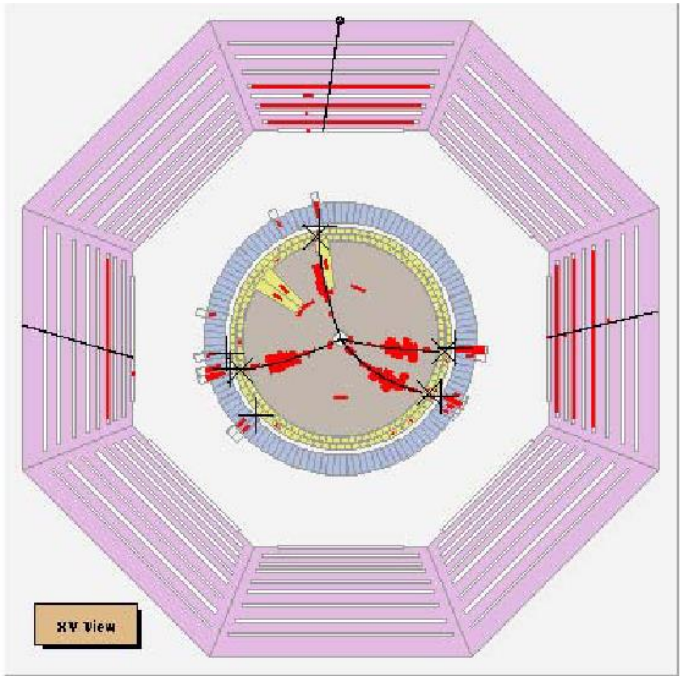
2009年5月30日：42pb-1的连续区数据

2009年7月28日：~ 220M J/ψ数据 （×4 BESII）

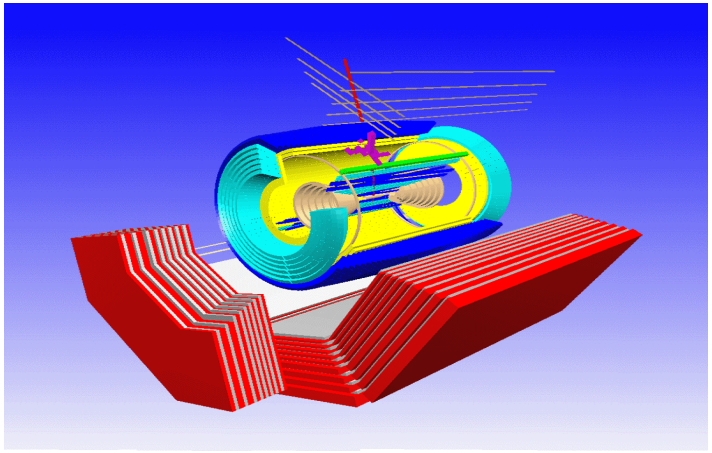
*2011年： ~ 2.9fb$^{-1}$的ψ(3770)数据 和~ 500-600pb$^{-1}$的ψ(4040)数据*

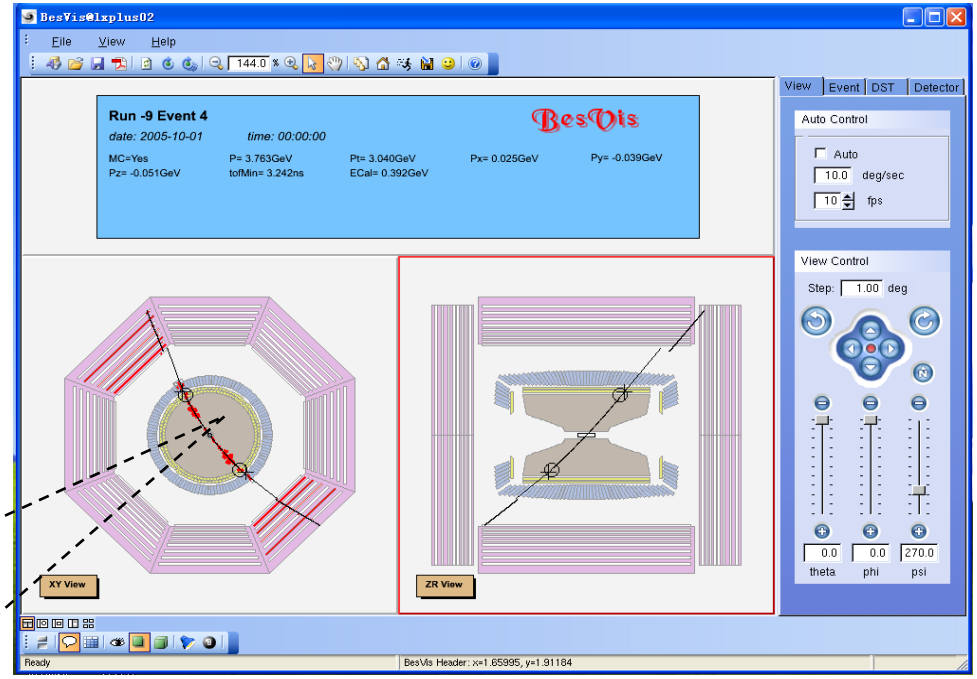
*2012-2013年：1B J/ψ数据，0.5B ψ'数据， 2fb-1 XYZ 数据*

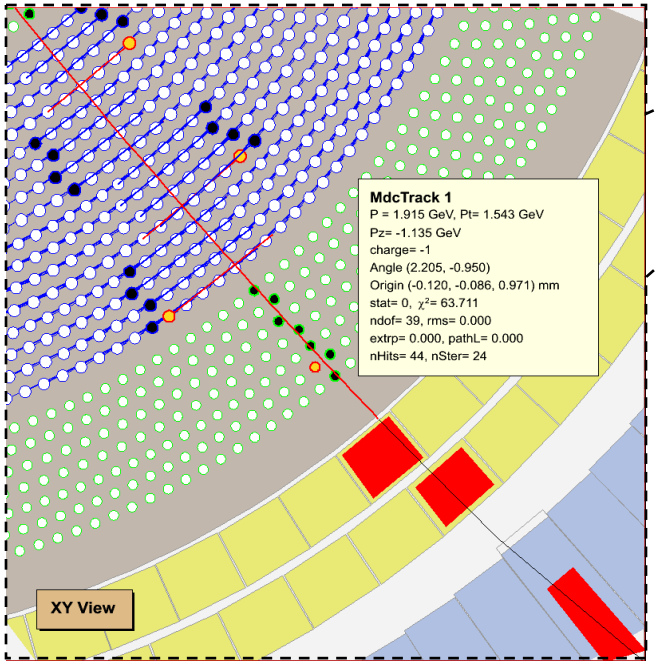
*2014年： R值扫描， 高质量粲偶素 ...*




# BES软件工作






北京大学是BESIII离线分总体的主要负责单位之一，独立承担的软件开发包括了缪子子系统的模拟、重建、粒子鉴别、 GDML用于BESIII探测系统模拟、BESIII探测器及事例显示软件（如图所示）等。发表NIMA文章1篇，CPC文章4篇。

# 探测器研究与软件开发

**探测器性能与数据质量研究**：

- 低动量$\pi^0$在EMC的重建效率的data/MC对比；
- 带电的π/K的重建效率以及粒子鉴别效率的；data/MC对比

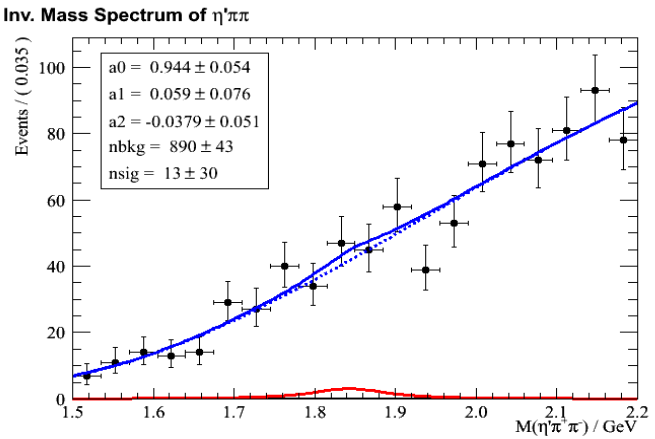
**分析工具开发**：

- 分bin分波分析程序的可靠性验证，包括大量样本的Pull检验以及显著性检验；
- 参与开发的基于GPU的并行分波拟合程序的开发，相比BESII的分波拟合程序速度提高了两个量级；
- 参与开发了基于BESIII软件框架的自动物理分析软件BesDChain；

**本项工作是BESIII合作组官方需要，作为各单位的应尽服务**

# 观察到X(1870)

**BESII 通过J/ψ→γπ⁺π⁻η′发现X(1835)，并在BESIII得到确认**

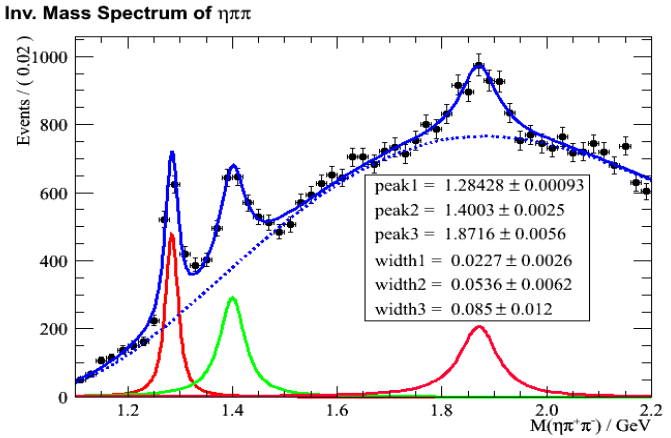



$J/\psi \rightarrow \omega\eta'\pi\pi$

- The physics motivation is to search for X(1835) observed in $J/\psi \rightarrow \gamma\eta'\pi\pi$
- No clear evidence of X(1835) is seen, the upper limit is estimated to be:

$Br(J/\psi \rightarrow \omega X) \times Br(X \rightarrow \eta'\pi\pi)$:

$< 5.1 \times 10^{-5}$ @ 90% C.L.



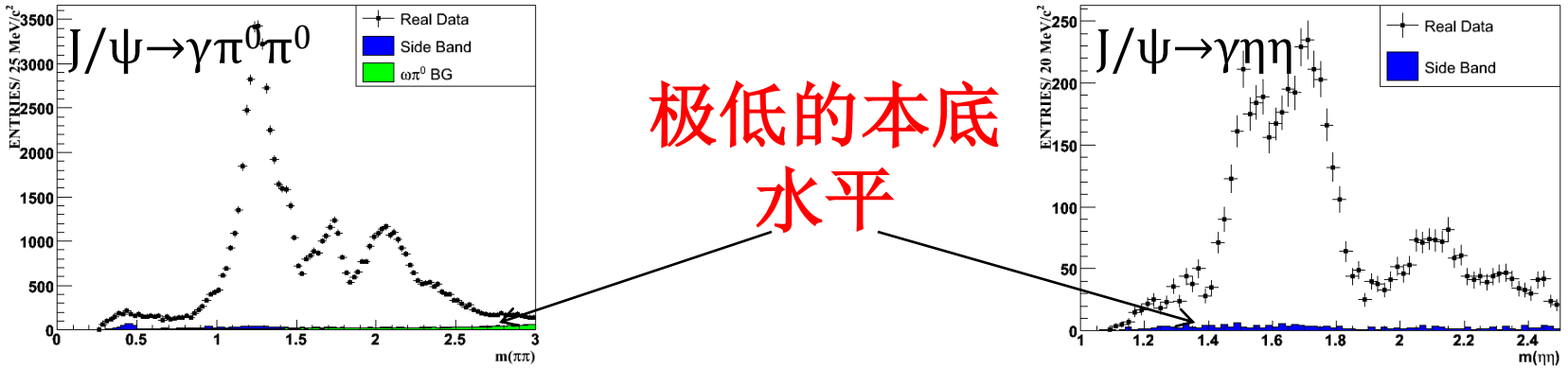

$J/\psi \rightarrow \omega\eta\pi\pi$

- A resonance with mass of 1.87 GeV and width of 85 MeV is observed.
- Simple fit shows:
  - $M = 1.8716 \pm 0.056$ GeV
  - $\Gamma = 85 \pm 12$ MeV
  - Significance: $7.9\sigma$

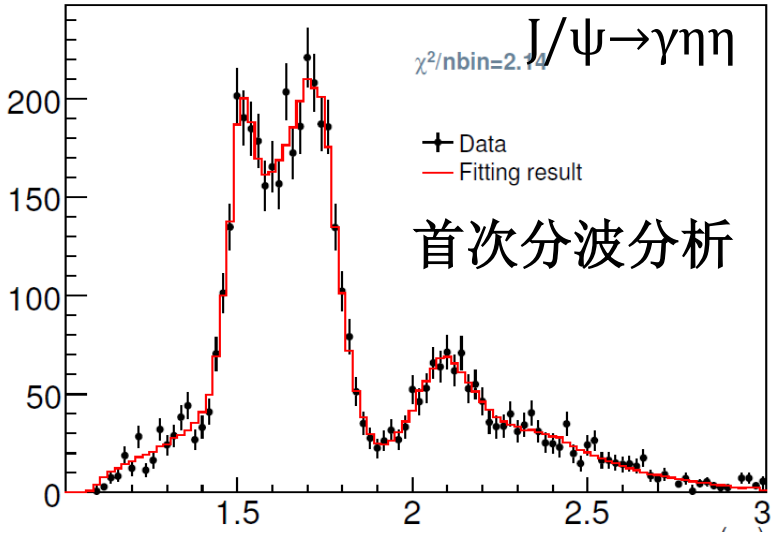
**刘坤完成，发表*Phys. Rev. Lett. 107, 182001 (2011)***

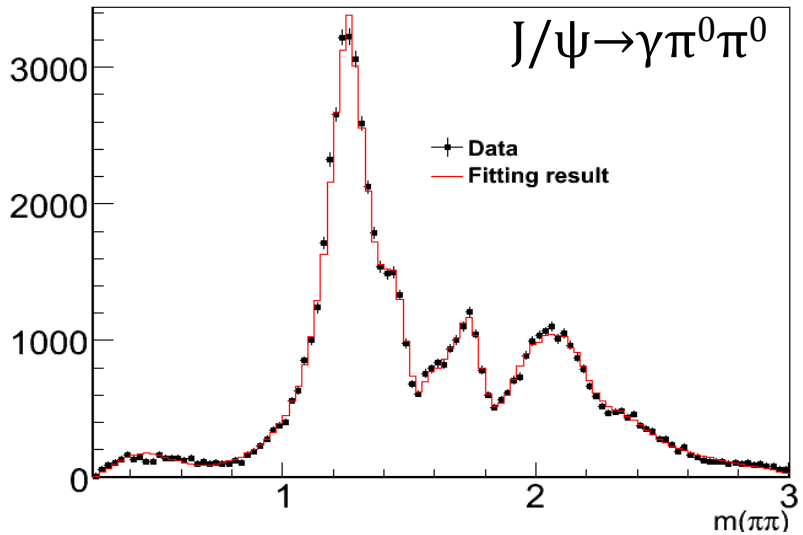
# $J/\psi\to\gamma\pi^0\pi^0$以及$\gamma\eta\eta$过程的分波分析：动机

- $J/\psi\to\gamma\eta\eta$ 仅在1982年由Crystal Ball合作组在极低的统计下进行过研究.
- 综合研究$J/\psi$辐射衰变到两个赝标介子($\eta$，$\pi$)，可以了解中间态，尤其是标量胶球候选粒子的组份等信息，对确认胶球的存在具有重要意义。
- 同时，两个反应道之间的结果的对比可以提供有效的物理信息和交叉验证
- 纯中性道(末态完全是光子)在BESIII上具有独特的优势



# $J/\psi\to\gamma\pi^0\pi^0$以及$\gamma\eta\eta$过程的分波分析：结果



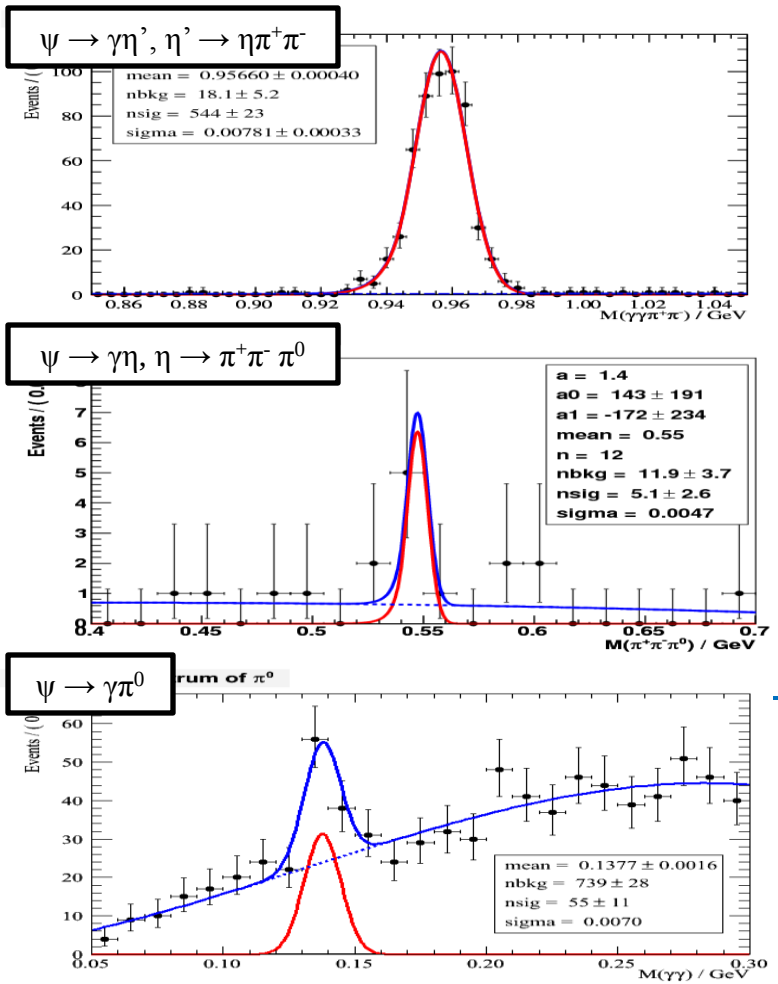



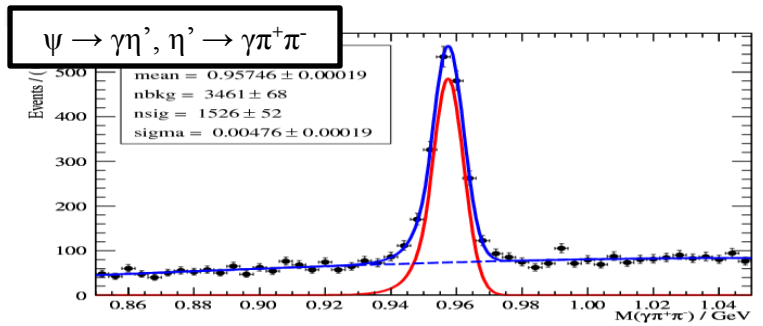

| Resonances | Mass(GeV) | Width(GeV) | $Br(J/\psi\to\gamma X\to\gamma\eta\eta)$ |
|---|---|---|---|
| $f_0(1500)$ | $1.468^{+0.014+0.014}_{-0.015-0.073}$ | $0.136^{+0.041+0.022}_{-0.026-0.090}$ | $1.61^{+0.29+0.28}_{-0.32-1.15}\times10^{-5}$ |
| $f_0(1710)$ | $1.759^{+0.006+0.010}_{-0.006-0.024}$ | $0.172^{+0.010+0.024}_{-0.010-0.011}$ | $2.35^{+0.07+0.59}_{-0.07-0.25}\times10^{-4}$ |
| $f_0(2100)$ | $2.081^{+0.013+0.013}_{-0.013-0.011}$ | $0.273^{+0.027+0.072}_{-0.024-0.036}$ | $9.99^{+0.57+6.32}_{-0.52-3.27}\times10^{-5}$ |
| $f_2(1525)$ | $1.513^{+0.005+0.005}_{-0.005-0.010}$ | $0.075^{+0.012+0.014}_{-0.010-0.009}$ | $3.41^{+0.43+1.14}_{-0.50-0.55}\times10^{-5}$ |
| $f_2(1810)$ | $1.822^{+0.029+0.035}_{-0.024-0.039}$ | $0.229^{+0.031+0.112}_{-0.039-0.157}$ | $5.38^{+0.60+3.79}_{-0.67-1.64}\times10^{-5}$ |
| $f_2(2340)$ | $2.362^{+0.031+0.139}_{-0.030-0.072}$ | $0.334^{+0.062+0.158}_{-0.054-0.095}$ | $5.58^{+0.61+0.77}_{-0.65-2.28}\times10^{-5}$ |

**$f_0(1500)$, $f_0(1710)$是标量胶球的最有力候选者，$f_2(2340)$可以是张量胶球的候选。**

**徐光明为主分析人员，** arXiv：1301.0053 已发表 PRD

# 赝标介子八重态-单态混合




- Primary motivation is to measure pseudo scalar octet-singlet mixing
- CLEO-c reported large discrepancy of results from J/ψ and ψ decay.
- The isospin violating decay $\psi \to \gamma\pi^0$ is used to test Vector Dominate Model.

$$Br(\psi(2S)\to\gamma\eta') = (1.16\pm0.03\pm0.04)\times10^{-4}$$

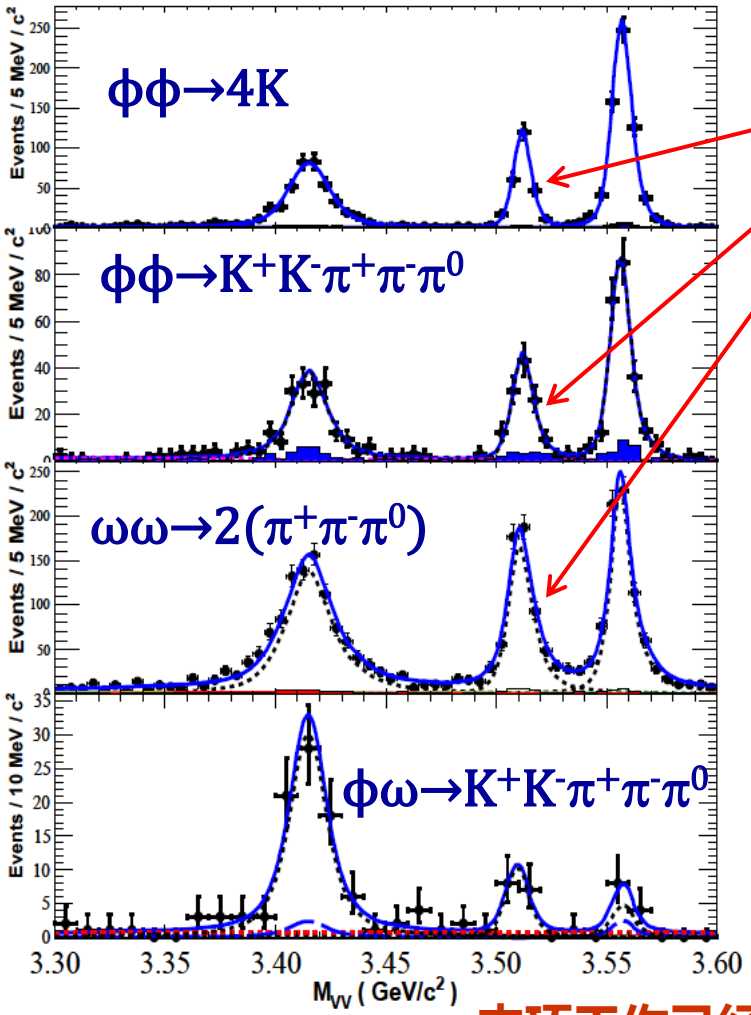
$$Br(\psi(2S)\to\gamma\eta) = (1.3\pm0.6\pm0.7)\times10^{-6}$$

$$Br(\psi(2S)\to\gamma\pi^0) = (1.9\pm0.4\pm0.3)\times10^{-6}$$

$$R_2 = Br(\psi(2S)\to\gamma\eta')/Br(\psi(2S)\to\gamma\eta) < 1.7\%\ @\ 90\%\ C.L.$$

刘坤与南大张磊合作完成，发表于PRL 105, 261801 (2010)

# $\chi_{cJ} \rightarrow VV$衰变模式的研究




非常清楚的$\chi_{c1}$信号！

$\chi_{cJ}$衰变是对QCD的重要检验，在BESIII之前受限与统计量很难实现

- 只有$\chi_{c0}$与$\chi_{c2}$到VV末态的衰变在之前的实验中被观测到；
- $\chi_{c1} \rightarrow VV$在pQCD中由于螺旋度守恒被强烈压低；
- $\chi_{cJ} \rightarrow \omega\phi$是一个双重OZI压低的过程，在之前从未被观测到；

本项工作已经发表于*Phys. Rev. Lett.107, 092001 (2011)*

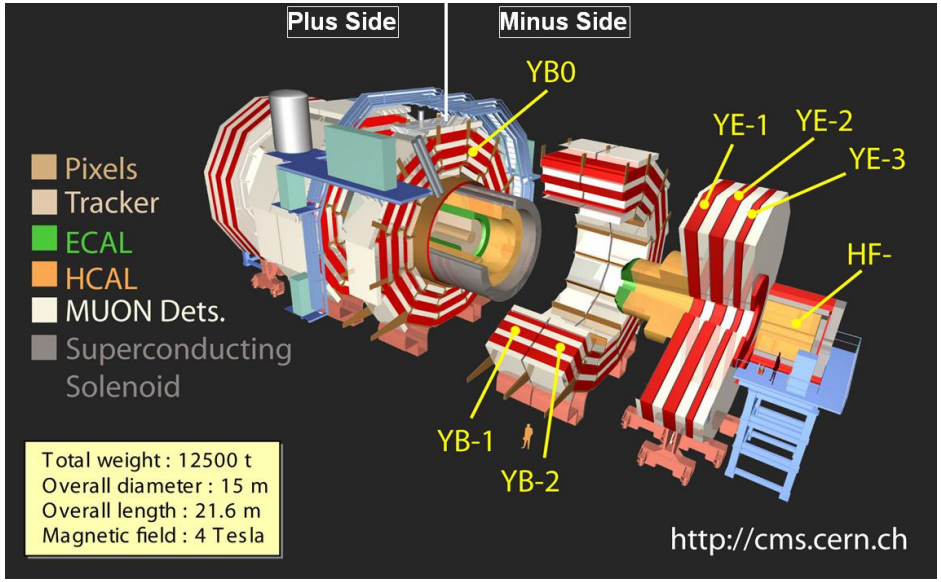
# BESIII其他课题/论文

- $J/\psi \rightarrow \gamma K_S K_S \pi^0/\eta$ 过程的分波分析 准备Memo
- $J/\psi \rightarrow \gamma \eta_c$ ($\eta_c \rightarrow$)用于纠缠态研究 数据分析中
  PRD86 (2012) 056003, NIM A679(2012)14
- 粲偶素到赝标介子对衰变的测量， J/psi(psi)->Ks Ks 内部评审中
- $J/\psi \rightarrow \gamma \eta \eta \eta$ 数据分析中
- 通过中性DD*和D*D*末态研究Zc(3900)和Zc(4025)
- $J/\psi \rightarrow \gamma K_S K_S$ 过程的分波分析 数据分析中
- Analytical determination of optimal luminosity for tau mass scan, Chin. Phys. C (2013) Vol. 37 (2)
- Data taking strategy for the phase study in $\psi'$ →K + K − . Int.J.Mod.Phys. A27 (2012) 1250150
- 利用 $J/\psi \rightarrow \Lambda\bar{\Lambda}\eta$ 过程检验Y(2175)的理论模型
- 其他课题

# 北大CMS组主要进展

- 硬件贡献
- 软件工作
- 物理分析

# CMS合作组





The Compact Muon Solenoid Experiment
CMS Bulletin
CERN, CH-1211 GENEVA 23, Switzerland
Bulletins are available on CMS internal information server: http://cmsdoc.cern.ch/cms.html
Number 06-01
13 March 2006

Moving Forward !

YE+1 yoke equipped with CSC/RPC packages (inner ring) and RE1/3 RPC's (outer ring).

The ME1/3 CSC's now cover the RPC outer ring and hence complete the first Muon station on YE+1.

- 高22米，直径15米，总重14500吨；总投资三亿美圆，
- 中国政府共投资1200万人民币，占总投资约1%；
- 08年统计，38个国家，183个机构，3600人参与；
- 96年北大进入CMS，负责部分阻抗板RPC的建造
- 04年北大开始物理模拟分析

2009年11月6-7日，CMS“看到”splash 事件
2009年12月14日，CMS首次观察到2.4TeV对撞（新的世界纪录），随后获取到15k对撞事例
2011年，7TeV 对撞、2012年，8TeV对撞
2012年7月4日，宣布发现Higgs玻色子！

# CMS μ探测系统升级：端部第4层RPC探测器

运到CERN的蜂窝板支撑盒和信号读出条

CERN的RPC探测器组装测试大厅

- 我们负责研制生产的具体结构部件为200套蜂窝板支撑盒，电子学屏蔽盒，信号读出条及绝缘和屏蔽膜组成的法拉第盒。
- 尽管第四层探测器与已安装的前三层探测器有同样的结构，我们还是和国外同行及国内有关厂家一起，对结构的技术细节进行了详细研究，并对部件的设计、生产工艺流程等方面提出了可能的改进方案。
- 我们参加在CERN进行的组装测试，以及最后的安装调试工作。

LHC speeds towards collisions

***AFP*, 23 November**: Atom-smasher aims for maximum power in 2010

*LHC and CMS. If you see any other reso*
*you think would be of interest to other C*
*readers, please send them to:*
*cmstimes@cern.ch*

## People

### The Peking University (China) in CMS

Representatives of PKU CMS at CERN

The Peking University (PKU) group has been a member of the CMS collaboration since 1996. Currently consisting of 3 professors, 3 engineers and technicians and about 10 PhD students, the group has been heavily involved in both hardware and physics analysis. As part of the RPC project, the group shares the work on the R&D, assembly and testing, installation and commissioning of the RPC detector for the CMS Muon Trigger System.

The RPC performance has been studied with cosmic ray data and the RPC seed reconstruction has also been developed by the group. In the CMS physics programme, the group's interests include the study of the production mechanism and polarization of heavy flavor quarkonium J/ψ and Upsilon in the high-pT region, a feasibility study on the search for a SM Higgs Bosons in a close collaboration with the Fermi Lab and INFN, as well as Top Physics, forward Physics and b Physics.

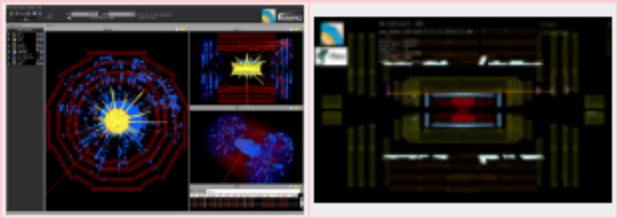
## LHC Re-start / First LHC Collisions

The LHC re-started in earnest on a foggy Friday 20th November 2009.

The first step was to pass beam 1 (the clockwise one) around the full ring, proceeding systematically sector-by-sector.

At 19:19 the beam reached CMS producing "splash" events of muons from the beam striking the collimators. These were seen by the calorimeters and muon detectors; the tracker was switched off. By 22:10 the LHC operators had "captured" beam 1 with the Radio Frequency (RF) system and circulated it for several minutes - the beam was under control! They then switched to [illegible] and succeeded in making a circulating beam by 23:55 followed by RF capture. This capturing was scheduled to take about eight hours per beam but in fact (for beam 2) took only 10 minutes, a real testament to how well understood this incredible machine is.

The successful re-start of the LHC was declared in a CERN press release (see "The LHC is back"). Splash events and then beam halo events (essentially muons accompanying the circulating proton beams) were seen by the event display programs by the teams at P5 and the CMS Centres at CERN (Meyrin) and Fermilab.



First displays from LHC running on Friday: left - a

A packed CMS Control Room at point 5 [illegible] weekend excit[illegible]

CMS Spokesperson Jim Virdee signs a champagne to commemorate the first coll in CMS, whilst Tiziano Camporesi (CMS Commissioning Coordinator) proudly sho 900 GeV collision event candida

This decision paid-off on Monday when, end of a long difficult day, the LHC circu

# 北大组软件贡献

- **CMS端部RPC效率研究**

  提供了效率分析软件，解决了端部RPC效率低下的问题，并在模拟程序再现真实效率，其中包括避免CSC高噪声单元等。

- **添加RPC子探测提供μ子重建的Seed**

  1）seed算法研究

  2）修改理想偏转至考虑多重散射效应

  3） 对不同的$P_t$的μ子，选取不同算法提供seed 等

- **MPGD的软件开发与研究**

  为CMS升级项目MPGD开发相应的模拟与重建软件。

- **强子量能器噪声监测软件**

PAG

- **重味夸克素**

J/psi, psi', ϒ Xsec/polarization measurement

- **Higgs**

H→ WW → lnjj PAS HIG-12-046
H→ WW → lnj PAS HIG-13-008
VBF H-> Invisible PAS HIG-13-013

- **SM**

Semileptonic WV EPJC73 (2013) 2283
Semileptonic WVGamma PAS-SMP-13-009
Central && Forward Jets JHEP06(2012)036
Exclusive di-photon and di-electron JHEP 11 (2012) 080

- **奇特新物理**

W'→tb Phys. Lett. B 718 (2013) 1229
heavy Majorana neutrinos Phys.Lett. B717 (2012) 109
Exo-WW resonance PAS EXO-12-021
4-top TOP-12-005

POG

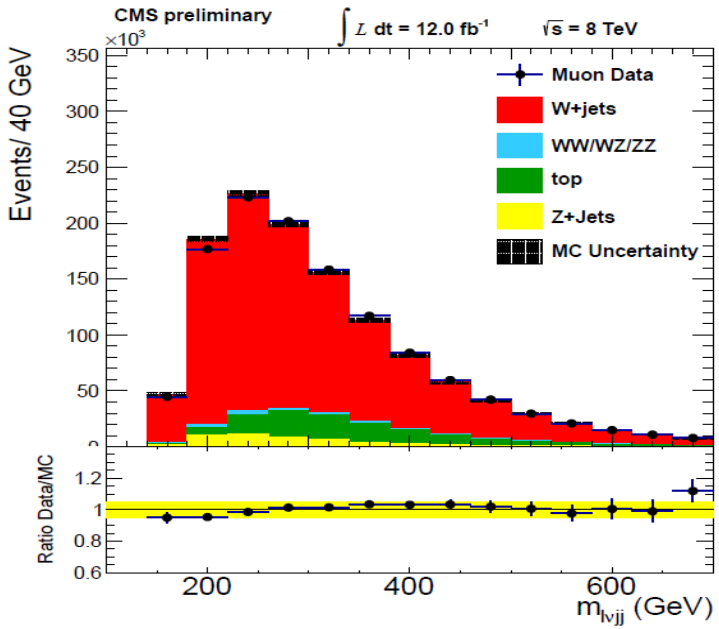
- **MET Performance**

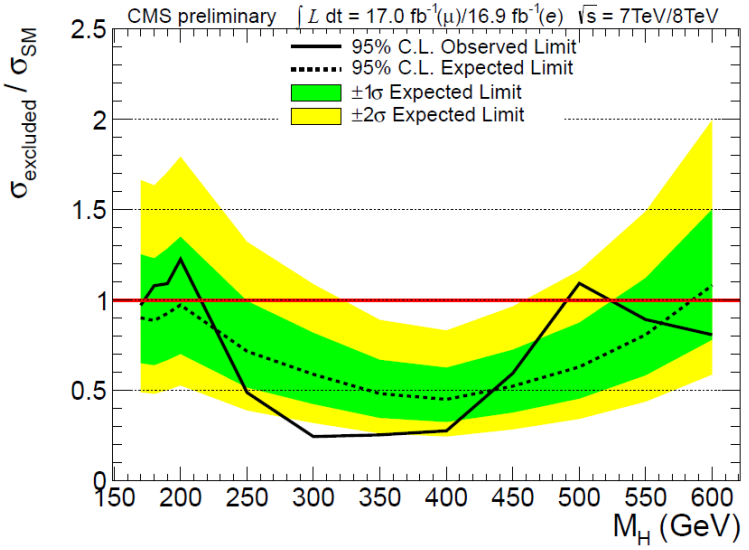
PAS JME-12-002/003

- **W-tagging**

PAS JME-12-006

# H → WW →lv+jj




**CMS北大组从早期MC研究就已加入该分析，在信号MC样本产生验证，QCD Wjets本底估计，轻子效率，VBF道分析，重Higgs干涉效应方面做出了重要贡献。**

- 尽管QCD本底W+jets巨大，却具有大衰变分支比及可重建H质量的优势，是寻找SM或非SM Higgs的重要的探寻道。

- 利用2011年LHC 7TeV对撞的5 $fb^{-1}$ 和2012年LHC 8TeV对撞的12 $fb^{-1}$数据，排除了[215-490]及[525-600]GeV区域的SM Higgs。


**(1) CMS PAS HIG-12-046 (HCP 2012)**
**(2) CMS PAS HIG-12-021 (ICHEP 2012)**
**(3) CMS PAS HIG-12-003 (Moriond 2012)**
**(4) CMS PAS HIG-12-034**
**(5) Eur. Phys. J. C 73 (2013) 2469**

# H → WW →lv+1j:Boosted Jet technique

- 对重Higgs (>600GeV)，W衰变的2个partons倾向于聚合为一个肥喷注。
- 本分析利用了Jet Substructure 技术来压低QCD本底。是W-tagging技术在CMS最早的应用之一。

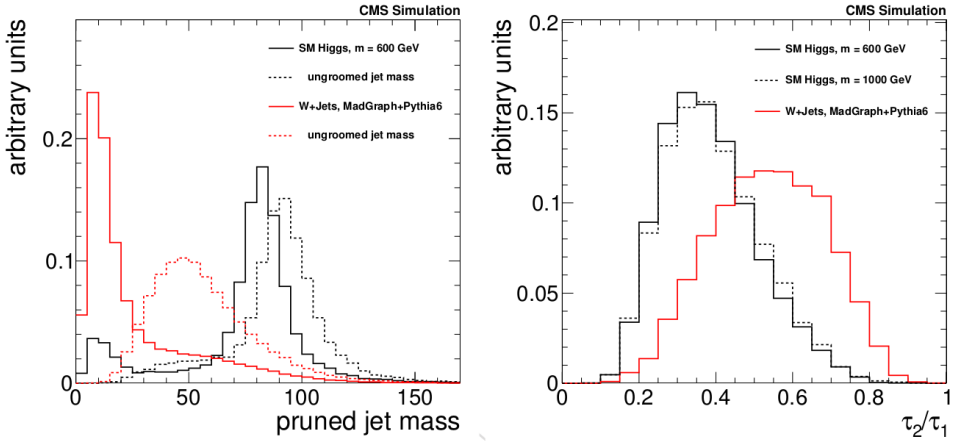
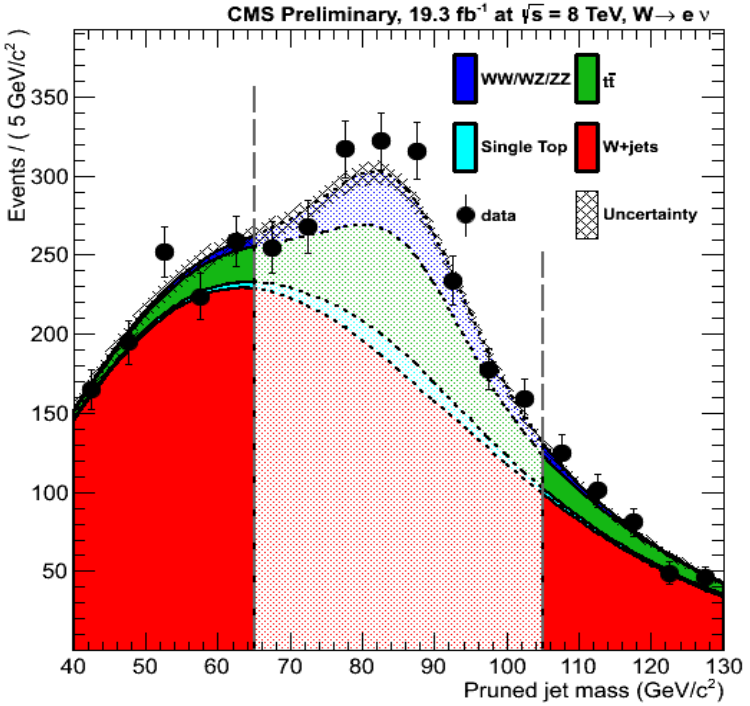



Figure 2: Signal and background distributions from simulation of pruned jet mass (left) and $\tau_2$ $\tau_1$ (right) after analysis level cuts described in Section. 5. On the left plot, we also show the ungroomed jet mass as dotted lines to show the effect of pruning.



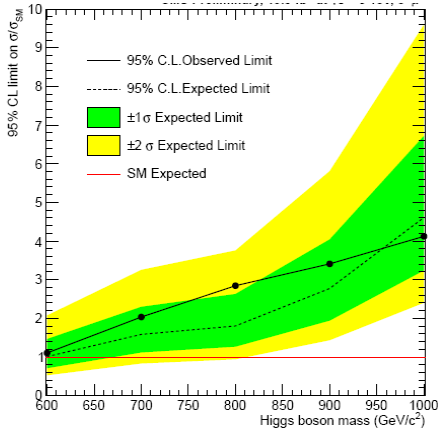




Figure 6: The 95% CL limit on $\sigma/\sigma_{SM}$ for a Higgs boson decaying to WW → $l\nu q\bar{q}'$.

- 最重要的本底W+Jets和TTbar通过Data-Driven技术得到。

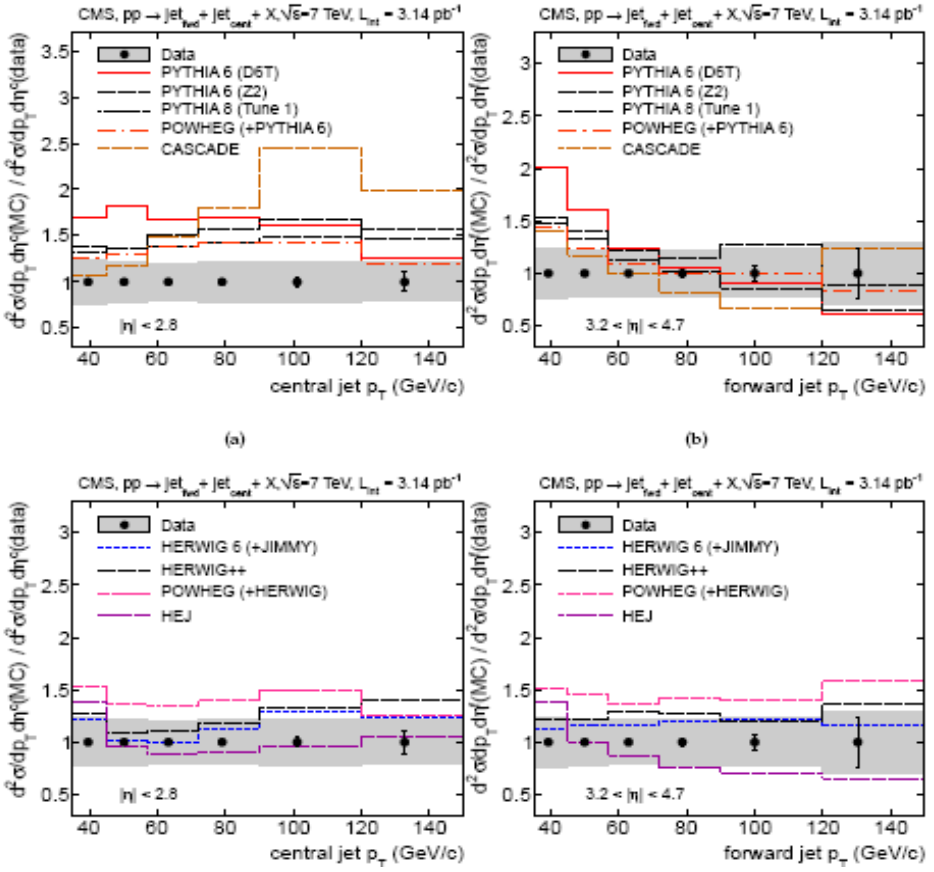
1. CMS PAS HIG-13-008
2. CMS AN AN-12-381

Zijun Xu (徐子骏) presented the Approval talk on May/10/2013

# 中心区-前向区喷注关联测量

- 利用LHC 7TeV对撞的3.14 $pb^{-1}$ 数据，首次测量了在|η|<2.8 及 3.2 < | η |< 4.7区域中心及前向Jet关联产生的截面

- 这个工作可以给未来的VBF Higgs及VV散射工作提供重要的信息

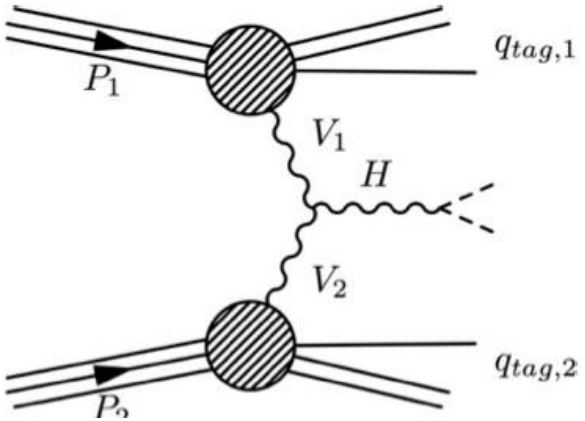



**CMS Paper-FWD-11-002,**
**CMS PAS-FWD-10-006,**
**CMS AN-11-036**

**Bo Zhu (朱博) presented the Approval talk for jet-jet measurement**

**JHEP06(2012)036**

# VBF Higgs→不可见物质研究




- 许多BSM模型预言了Higgs的不可见衰变：
  LSPs in SUSY, Graviscalars in ADD model

- 利用VBF道测量Higgs不可见衰变的分支比，在95%置信度上给出 BF(H→ Invisible) < 64%

- 主要本底全部采用data-driven方法估计得到
  - Z+jets irreducible background
  - W+jets where lepton is unidentified
  - QCD multijets background


University of BRISTOL Imperial College London tifr CMS

Pre-Approval : HIG-13-013
Search for invisible Higgs decays in the VBF channel

R. Aggleton[3], C. Asawatangtrakuldee[1], J. Brooke[3], O. Buchmueller[4], D. Colling[4], P. Dunne[4], S. Kumar[2], Q. Li[1], A-M. Magnan[4], K. Mazumdar[2], A. Nikitenko[4], J. Pela[4] and P. Srimanobhas[5]

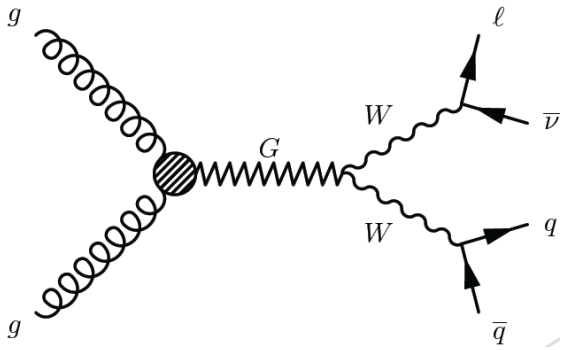
[1] Peking University, China
[2] Tata Institute of Fundamental Research, India
[3] University of Bristol, UK
[4] Imperial College of Science, Technology and Medicine, UK
[5] Chulalongkorn University, Thailand

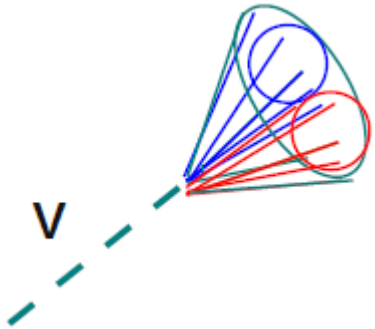
4th July 2013
Happy Birthday, Higgs boson!

**Pre-approved on 4th July 2013 by Chayanit Asawatangtrakuldee（马妙钟）**

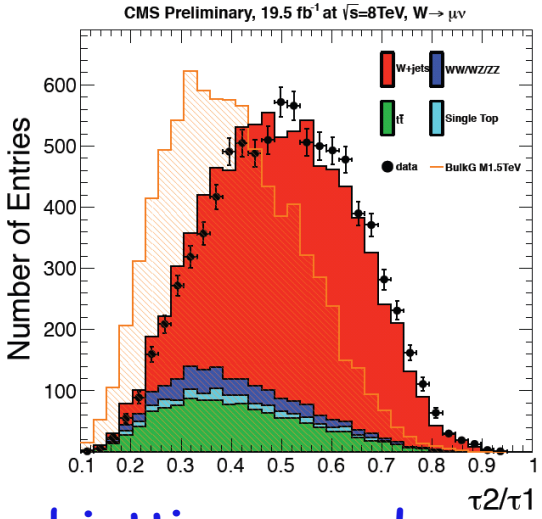
arXiv:1404.1344

# 通过WW末态寻找新粒子




Two jets from W merged to one




Nsubjettiness used as Discriminating Observables to identify W-jet

- 寻找WW半轻道共振态， 对于下一步双玻色子散射研究极为重要
  - → 验证WW高能散射下的幺正行为
  - → 利用Jet Substructure技术

EXO-12-021, pre-Approved on July/17, 2013 by Shuai Liu (刘帅),

arXiv:1405.3447

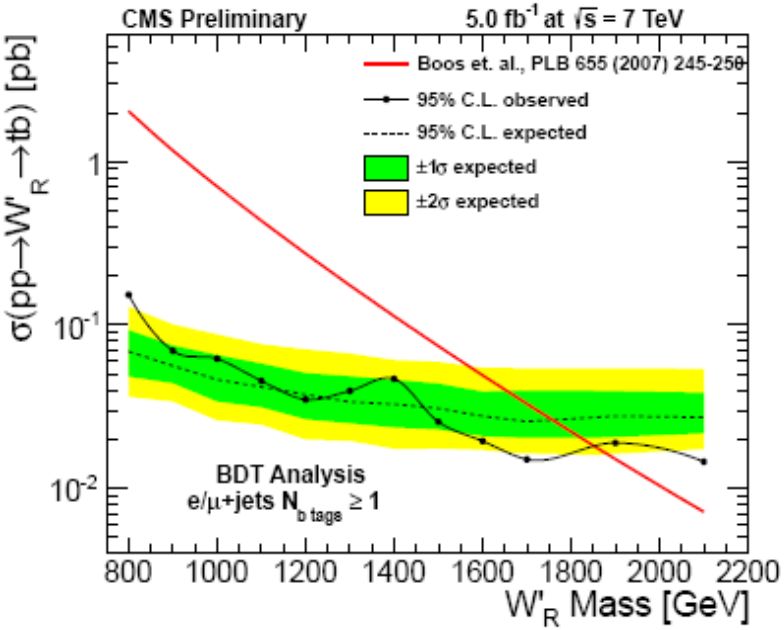
Zijun Xu from PKU presented at Boston Jet Workshop, 2014;
Shuai Liu presented at PASCOS 2013, Taipei;
Qiang Li presented at CMS Week 2013, Taipei

# 寻找 W’ → tb

- W’在很多新物理中存在，如果右手耦合大，那么衰变到夸克的比率会很高。Tevatron 研究W′→tb，给出890GeV的下限[PRL 100 (2008) 031804]。

- 我们考虑的衰变道为： W’->top + b -> W + b + b -> u/e + v + b + b

信号类型为：至少 2 jets+MET+Muon /Electron，并且至少有一个b tag jet.



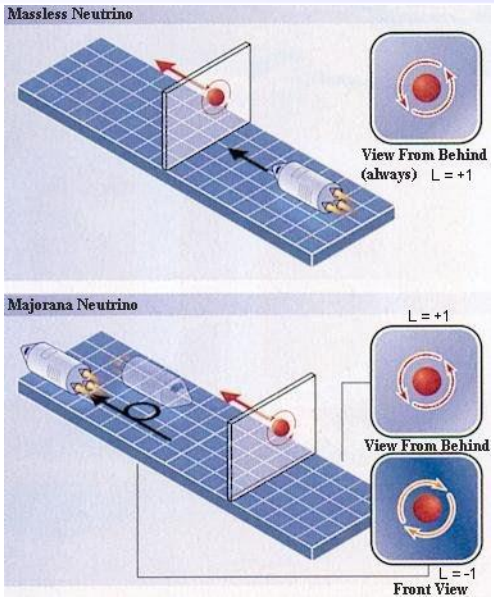

1. 利用5 fb$^{-1}$ 的数据，我们将Tevatron的下限提高到了1.8TeV.
2. Wei Zou (邹伟)与费米实验室合作， 2012年3月28日通过approval

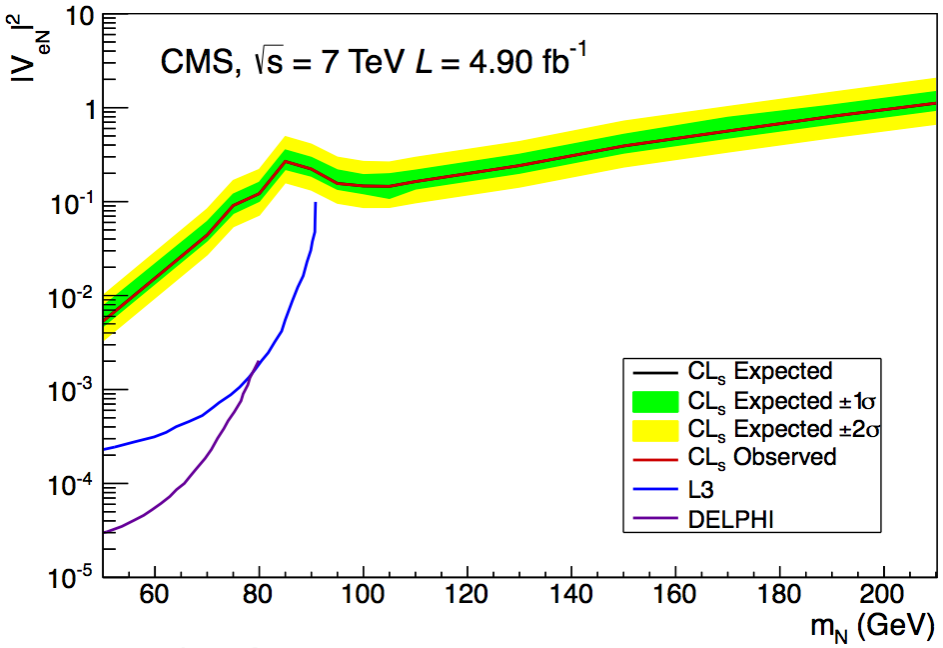
CMS AN-2011-170 , AN-2012-046

CMS PAS-EXO-11-046, EXO-12-001

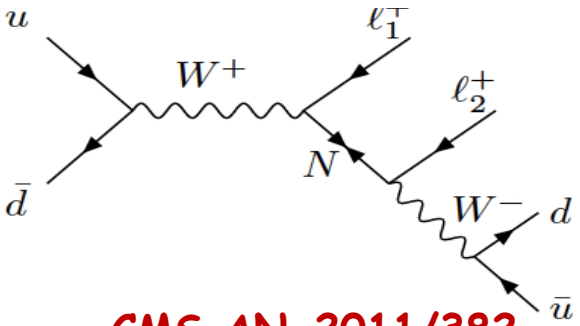
Phys. Lett. B 718 (2013) 1229

# 寻找Marjorana中微子




- Dirac vs Majorana:
  - 无质量 vs 有质量（速度低于光速）
  - 区分正反中微子 vs 反粒子是其自身（轻子数不守恒）




- 利用2011年LHC 7TeV对撞的~5 fb$^{-1}$数据，大大拓展了LEP对Marjorana中微子质量及混合耦合参数的限制结果
- Yifei Guo(郭逸飞)与费米实验室及UCR合作，负责电子道分析。

CMS AN-2011/382

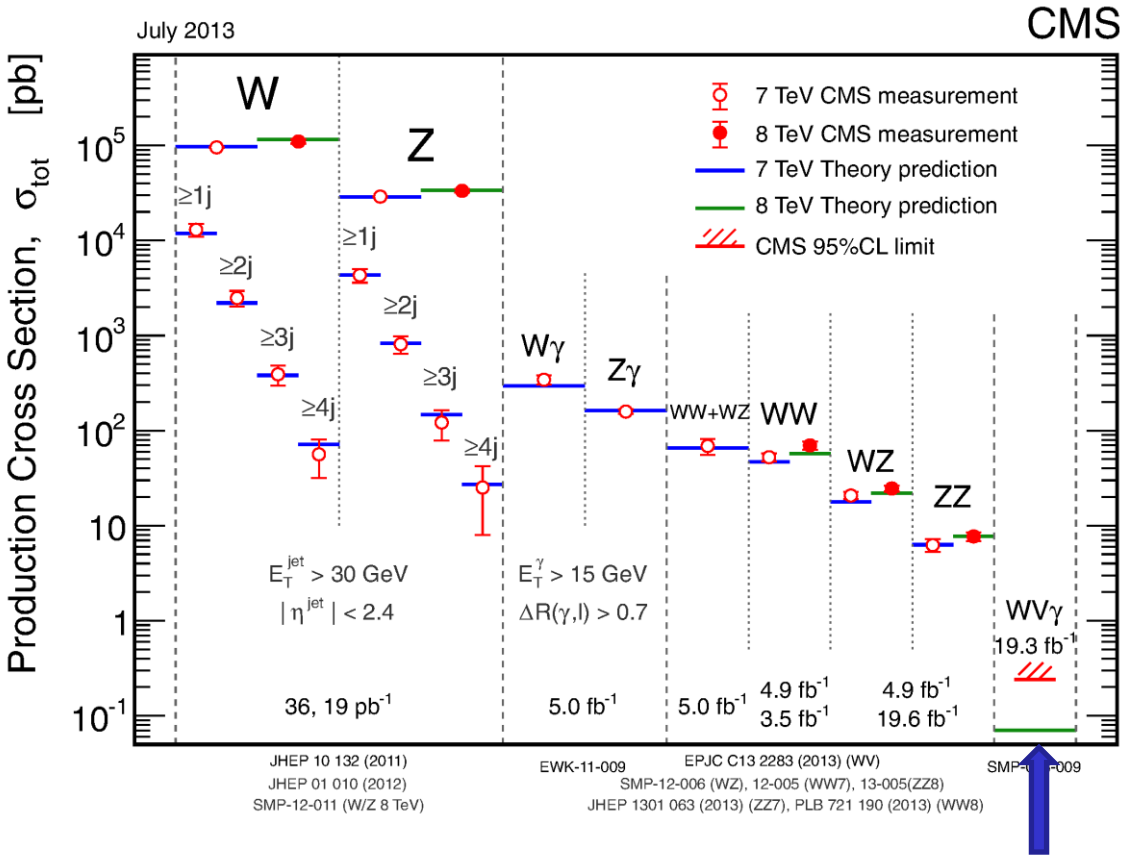
CMS PAS EXO-11-076

arXiv: 1207.6079

Phys.Lett. B717 (2012) 109-128

# 反常4规范玻色子耦合

- 三规范玻色子测量可以提供对SM规范对称性的更进一步的验证
- 可以限制反常四规范玻色子耦合

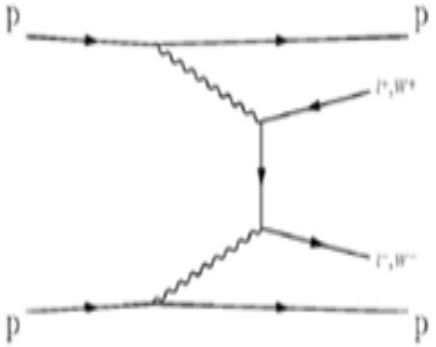


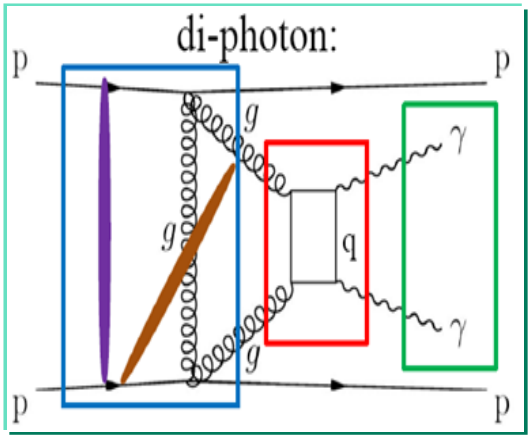

arXiv:1404.4619
CMS PAS SMP-13-009
Submitted to PRD

我们完成世界首次3规范玻色子产物截面测量

**Daneng Yang presented as Poster at PASCOS 2013, Taipei;**
**Qiang Li presented at WIN2013, Natal, Brazil**

# 单举/半单举双光子和双电子测量




- **Proton不被破坏。中心区域产生双电子或双光子**
- **验证前向及小X区域QCD预言**

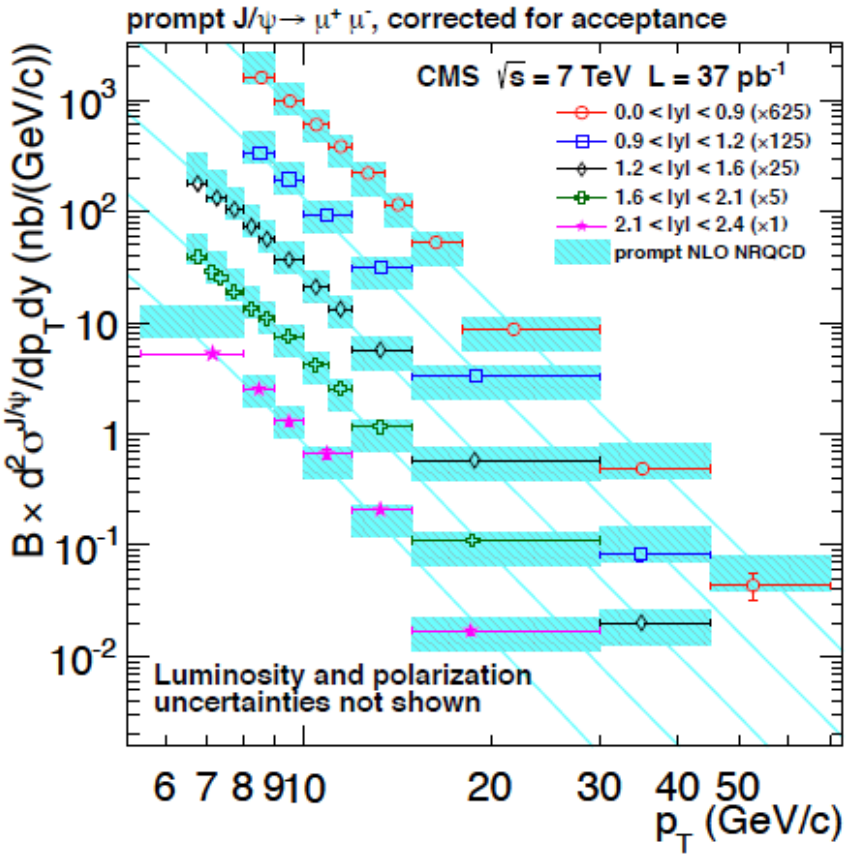
Number of events remaining after each selection:

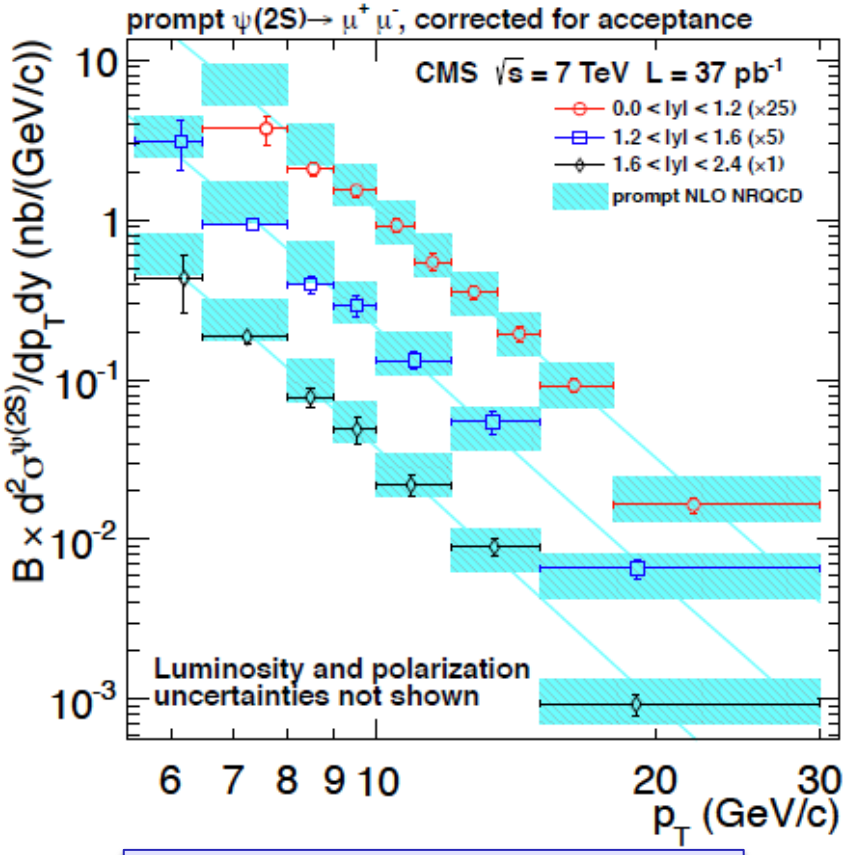
| exclusive diphoton analysis | | exclusive dielectron analysis | |
|---|---|---|---|
| selection criterion | events remaining | selection criterion | events remaining |
| Trigger | 3 023 496 | Trigger | 3 023 496 |
| Photon reconstruction | 1 683 526 | Electron reconstruction | 132 271 |
| Photon identification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

**李文博 做pre-approval和approval报告，**
**代表CMS在DIS2012报告**

**CMS PAS-FWD-11-004**
**JHEP 11 (2012) 080**

# J/ψ and ψ' 截面测量



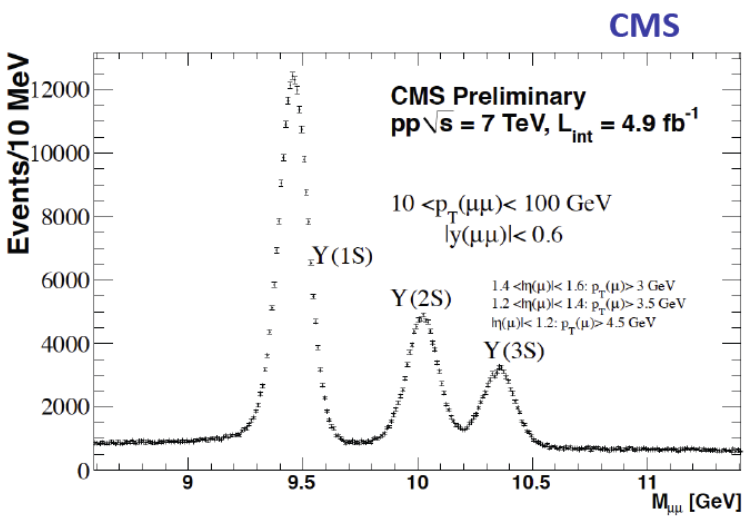

**CMS, JHEP 02 (2012) 011**

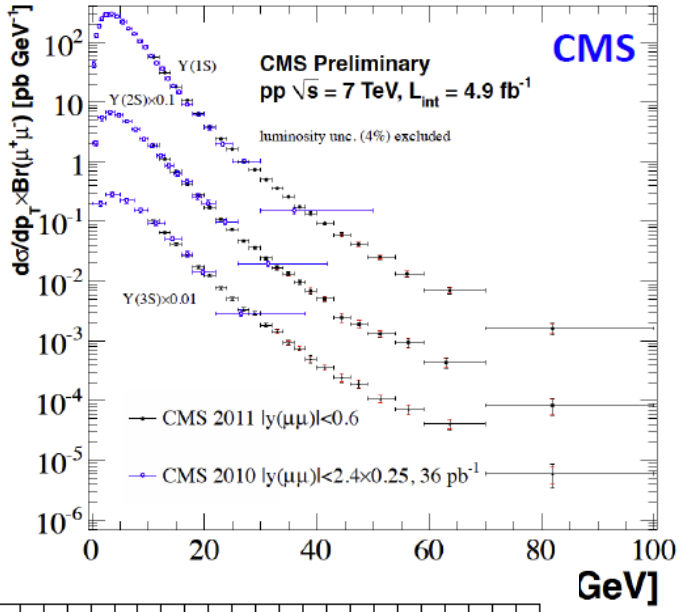
- Excellent agreement with NLO NRQCD predictions

  赵光达等理论家重点研究方向

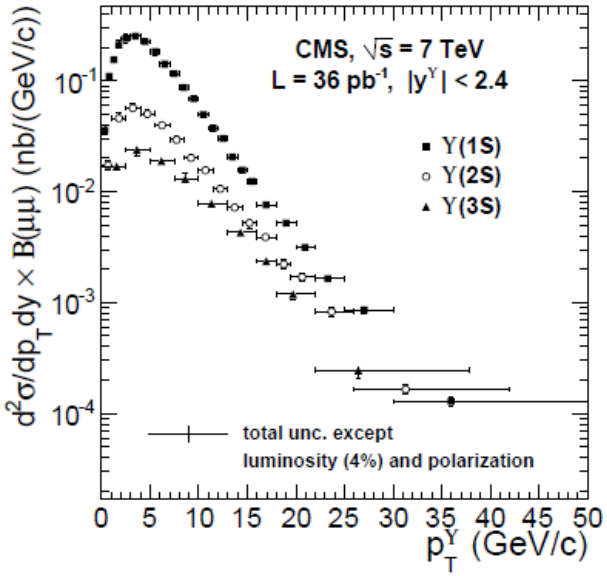
# Υ(nS) 截面测量

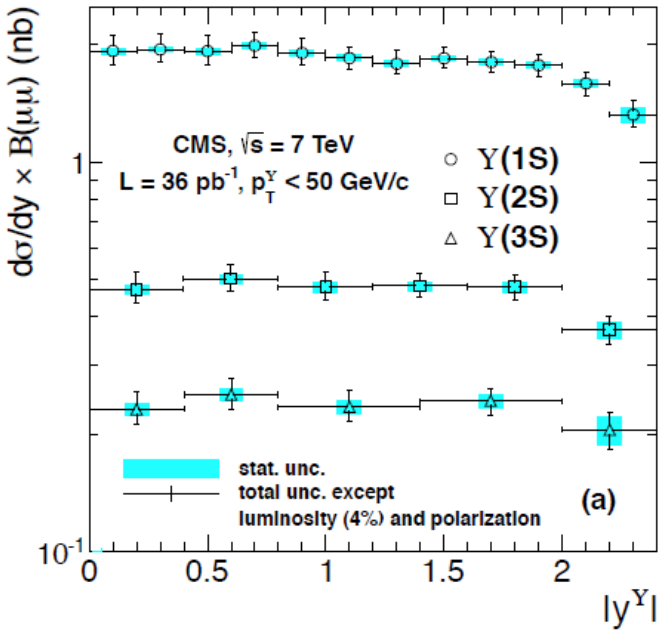
CMS-BPH-12-006




- Acceptance from measured Υ(nS) polarization
- Cross sections measured up to very large pT (pT >> m )
- **Stringent QCD test**



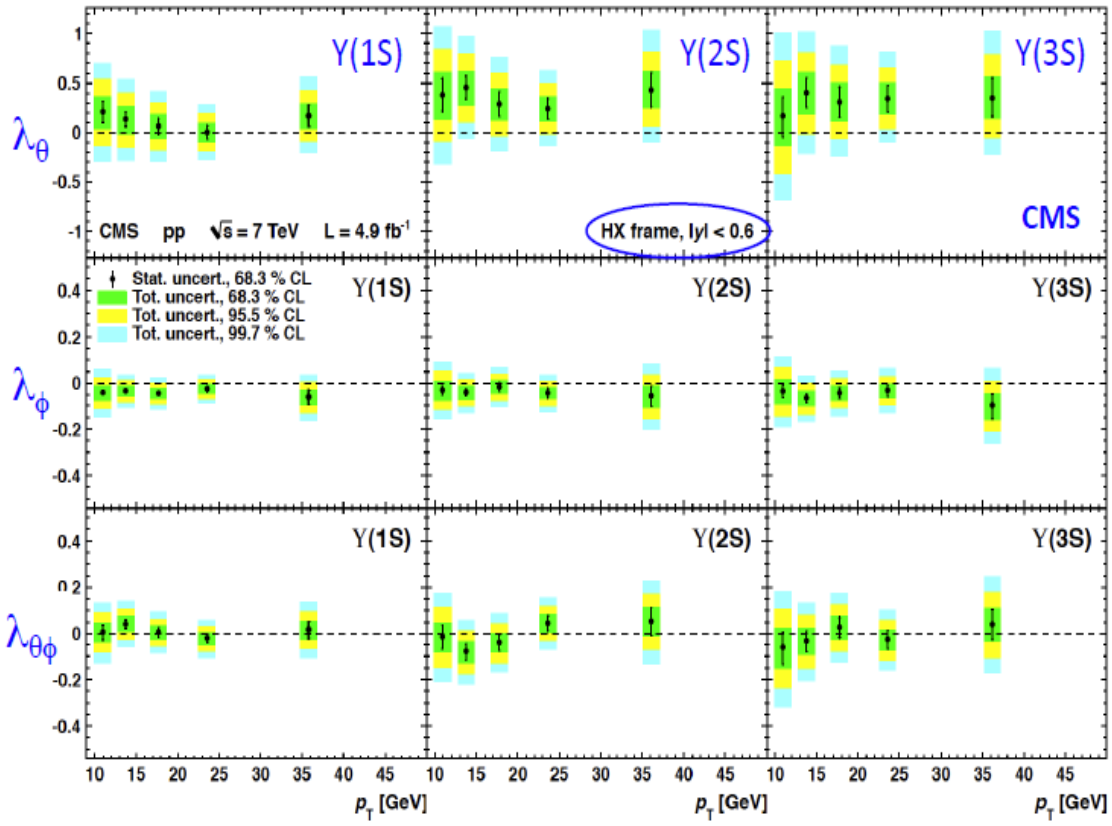

**2010 data:**
**Phys. Lett. B 727 (2013) 101**

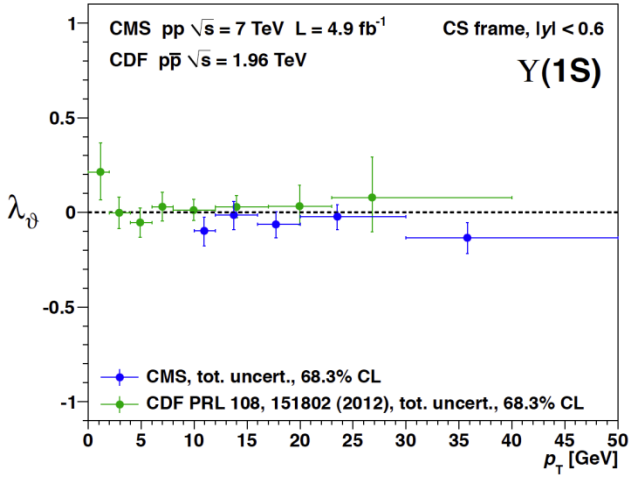
- Υ(nS) corss section is flat until |y| ~ 2

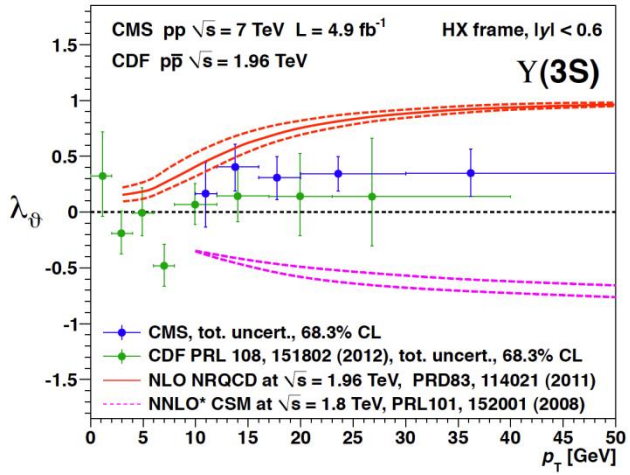
# Upsilon 极化测量

- CMS measured the Y(nS) polarizations vs. pT in two |y| bins and three polarization frames: helicity (HX), Collins-Soper (CS) and perpendicular helicity (PX)

**CMS, PRL 110 (2013) 081802**



# CMS物理分析下一步的计划

PAG

- **Jet Substructure**

WH / tH resonances

- **VH Higgs anomalous coupling**
- **VBF SUSY Search**
- **VVV**

WWW (l+MET+4j, 2l+MET+2j)
ZVGamma (2l+2j+Gamma)

- **EWK/VBF single/di-boson**

EWK V/VV+2J

POG

- **JETMET Trigger**

online JEC

- **CA8 JEC**

Subjet JEC

- **PV/Tracking for Phase II**
- **MC Tuning**

PY8 validation/Tuning

# 2012年来代表CMS合作组报告

1. 23-Jan-14, Search for heavy VV resonances in the semi-leptonic final state, Boston Jet Physics Workshop, Zijun Xu.
2. 21-Nov-13, Search for non--SM Higgs bosons with CMS, PASCOS 2013 , Chayanit Asawatangtrakuldee
3. 21-Nov-13, Searches for RS Gravitons at the CMS Experiment, PASCOS 2013, Shuai Liu
4. 16-Sep-13, Multiboson production and searches for anomalous gauge couplings at CMS, WIN 2013, Qiang Li
5. 21-Aug-13, Quarkonium production and polarization in CMS, Charm 2013, Linlin Zhang
6. 22-Apr-13, Quarkonium polarization in pp collisions at 7 TeV with the CMS experiment, Quarkonium 2013, Linlin Zhang
7. 22-Apr-13, Performance of Jet/MET in CMS, CHEF2013, Chayanit Asawatangtrakuldee
8. 11-Jan-13, Search for heavy gauge bosons (W'/Z') in CMS LHEP2013 Wei Zou
9. 11-Jan-13, Latest results and future research plan of CMS LHEP2013 Dayong Wang
10. "CMS results on central exclusive production", Wenbo Li, Diffraction 2012, Lanzarote, Spain, 10-15 September, 2012.
11. Exclusive processes at CMS (poster with 10 minutes presentation)", Wenbo Li, WE-Heraeus-Summerschool, Heidelberg, Germany, 5-9 September, 2011.
12. "Exclusive processes in pp collisions in CMS", Wenbo Li, DIS 2012, Bonn, Germany, 26-30 March, 2012.
13. "Recent CMS Results on exclusive production", Wenbo Li, LowX 2012, Paphos, Cyprus, 27-30 June, 2012.

**共13人次**

# CMS Pre-Approval 或Approval Talk

1. Bo Zhu for central-forward jet group, pre-approval talk, Feb 4th 2011,FWD-PAG.
2. Bo Zhu for central-forward jet group, Approval talk, Apirl 8th 2011, Physics Approvals meeting.
3. Wenbo Li, Preapproval FWD-11-004: Exclusive diphoton and dielectron production , 20 Dec, 2011
4. Wenbo Li, Approval of exclusive di-eletrons and di-photons analysis, 07, Feb, 2012.
5. Wei Zou, Pre-approval TOP-12-005, 24, May, 2012.
6. Zijun Xu, HIG-13-008 Approval Presentation - Search for High-Mass Higgs Boson in the WW(lvjj) Channel, 10, May, 2013
7. Chayanit Asawatangtrakuldee, HIG-13-013 Preapproval - VBF H with H-> invisible, 4, July, 2013
8. Daneng Yang, SMP-13-009 Approval Presentation - WVgamma search in W gamma dijet channel and aQGCs at 8 TeV, 15, July, 2013
9. Shuai Liu, EXO-12-021 (X-->W-->lvJ): Pre-approval talk, 17, July, 2013
10. Wei Zou, Pre-approval of SMP-13-012: ewk W+2j production, 18, Oct, 2013

# Other Projects

- Belle and Belle II
- Daya Bay II
- Hermes/Phenix/Jlab
- R&D of new detector  (CEPC)

# 小结

- BESIII与CMS相继于近年开始投入运行，我们取得大量的实验数据
- 在BES上我们开展了
  1）非常规强子态研究（胶球、混杂态、多夸克态）
  2）量子纠缠研究
  3）其他有特别兴趣的课题
- 在CMS上我们开展了
  1）NRQCD研究（大横动量区重味夸克素截面与极化）
  2）Higgs物理研究（qqH以及H至暗物质衰变）
  3）单举双光子与电子对研究
  4）寻找超出标准模型的新粒子…
- 我们将继续加强理论实验结合、国际国内合作并举

→ *我们已迎来丰收季节，有望真的能有所斩获！*


谢谢！