

# Higgs, Axions, WIMPs, Other Searches

Ken-ichi Hikasa (Tohoku U.)

# Higgs bosons

---

RPP2012: Last edition with only limits (except addendum in review)

Data cutoff date: mid January 2012

Paid extra efforts to include the newest results up to Apr 2012

# Higgs Bosons

- ‘Mini’review by G. Bernardi, M. Carena, T. Junk  
(36 pages, Updated May 2012 + addendum) → G. Bernardi’s talk
- Data Listings (Overseer: G. Weiglein, Encoder: K. Hikasa)
  - Standard Model  $H^0$  (direct, indirect)
  - MSSM  $H_1^0, A^0$
  - Nonstandard  $H^0, A^0$  (doublet)
  - Charged  $H^\pm$  (doublet)
  - $H^{\pm\pm}$  (triplet/singlet)

# Higgs searches: RPP history

- 1982: First appearance in the data listing, but located in ‘Other stable particle searches’ section

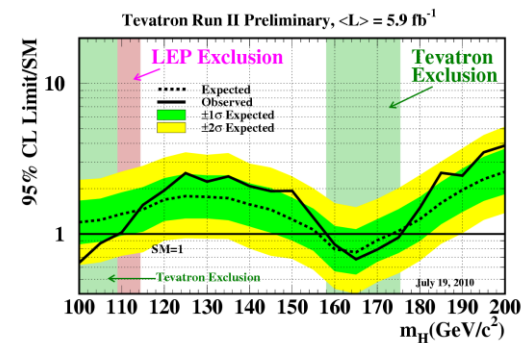
```
-----  
H      HIGGS BOSON MASS LIMIT (GEV)                                1/82*  
H      A      0  0.409  CR MORE          DZHELYADI 81          ETAPRIM-->ETA HIGGS  1/82*  
H  
H      A      DZHELYADIN 81 OBTAINED BR(ETA PRIM-->ETA MU+MU-)<1.5E-5 (CL=.90)  1/82*  
H      A      WHICH EXCLUDES A LIGHT HIGGS BOSON IN MU+MU- CHANNEL.                1/82*  
-----
```

# Higgs searches: RPP history

- 1982: First appearance in the data listing
- 1988: Separate 'Higgs searches' section,  $H^+$ , minireview
- 1990:  $H^0$  entries tripled, first limits from LEP
- 1992: Organized according to the relevant coupling (Z/W, quarkonium, B, K, N, other), MSSM Higgs,  $H^{++}$
- 1998: First LEP2 limits, only Z/W coupling data retained
- 2000: Older (superseded) limits hidden
- 2004-2008: LEP final results, Drop in # of new papers
- 2010: New results from Tevatron, increase of the data
- 2012: 'Discovery' too late for RPP listing

# Prospects (slide from two years ago)

- 34 new papers in 2010 edition (10 in 2008)
- Tevatron is the current main player
  - Each search mode is not capable of giving mass limits (let alone seeing the signal)
  - Combined limits (in PRL, excl. 162-166 GeV) missed the cutoff date by one month (→ will be on in 2011 web update)
- LHC results in 201x edition
  - Hopefully not in the 'searches' category



# New in 2012 Edition

- Standard Higgs
  - Excluded in large mass regions:  $M_H > 115.5$  GeV and none 127-600 GeV (95%CL)
  - Tevatron and LHC: mass/cross section limits in many modes (33 new papers)
- MSSM  $H_1^0, A^0$ 
  - Tevatron and LHC limits (6 papers, mostly  $\tau\tau$  final states)

# New in 2012 Edition (cont'd)

- Nonstandard  $H^0$ 
  - 9 new papers from Tevatron, LEP (still!), B factories
  - Searched modes/scenarios
    - Type II two-doublet models
    - 'Invisible'  $H^0$  (neutralino pairs)
    - Fermiophobic  $H^0 \rightarrow \gamma\gamma$
    - $Y \rightarrow A^0\gamma$
    - $B \rightarrow A^0\rho, A^0K^*$



# New in 2012 Edition (cont'd)

- Charged Higgs
  - 3 new papers
  - Tevatron limit from  $t \rightarrow bH^+$ ,  $H^+ \rightarrow tb$
  - Indirect limit from B physics
- Doubly charged Higgs
  - 2 new papers
  - Tevatron limits in 100-250 GeV range ( $H^{++} \rightarrow l^+ l^+$ , various flavor combinations)

# Higgs Summary & Future

- 50 new papers in 2012 edition (34 in 2010)
- Next edition:
  - Finally real data instead of limits!
  - More and more limits on variants
  - How to treat the 126GeV boson?
    - Discussed at the Collaboration Meeting yesterday

# Possible 2013 Update

## Higgs Bosons (S055) Listings

$H^0$  or  $H^0(126)$  or  $X^0(126000)$  (New Subsection) — Naming should be discussed

The properties of this particle are consistent with being the Higgs boson predicted in the Standard Model.

Spin: 0, 2 or higher (spin 1 is excluded by  $\gamma\gamma$ )

Mass:  $126.\pm$

Decay Modes:

$\gamma\gamma$  seen

$ZZ$  seen

...

$\sigma \cdot B$  relative to  $(\sigma \cdot B)_{\text{SM}}$

...

**STANDARD MODEL  $H^0$  (Higgs Boson) MASS LIMITS**

(Existing and new search results: exclusions – stays for a while)

# Axions and other very light bosons

---

(Axions, invisible axions, Majorons, Goldstone bosons, and others)

Slides prepared by F. Takahashi

# Axions and Other Very Light Bosons

- Encoder: F. Takahashi (Tohoku U)
- Overseer: G. Raffelt (MPI)
- Number of reviewed papers:
  - 18 papers in 2011
    - New entries: 10 papers
    - 3 for light boson, 7 for axions
  - 21 papers in 2012
    - New entries: 10 papers
    - 4 for light boson, 5 for axions, 1 for majorons
- Reorganization planned
  - Limits of the light bosons (e.g. light CP odd Higgs search by BABAR) will be moved from Axions to the Higgs/Heavy Boson Search.

# WIMPs and other particle searches

---

In early times, Higgs searches, ..., extra dimension limits were all in this section.

# WIMPs and Other Particle Searches

- Located at the end of the book
- Contains **everything which cannot be assigned to other sections**
  - Extra Dim limits *used to* be here (2000)
  - WIMPs are still here, but neutralino-specific limits moved to SUSY section (2004)
- ‘Minireview’
  - Just explains the structure of the section

# WIMPs and Other Particle Searches

- Data Listings (Overseer-Encoder: K. Hikasa)
- Subcategories: WIMPs, stable particles in matter, neutral particle production, jet-jet resonances, charged particle production...
- New 2012 entries
  - WIMPs: 19 papers (scattering) + 3 (annihilation)
  - General new physics searches: 5 papers (LHC, Tevatron)
  - Jet-jet resonance: 5 papers (LHC, Tevatron)
  - Highly-ionizing particles: 1 paper (LHC)



## GENERAL NEW PHYSICS SEARCHES

This subsection lists some of the search experiments which look for general signatures characteristic of new physics, independent of the framework of a specific model.

VALUE	DOCUMENT ID	TECN	COMMENT
• • •	We do not use the following data for averages, fits, limits, etc. • • •		
<sup>1</sup>	AAD	11S ATLS	jet + $\cancel{E}_T$
<sup>2</sup>	AALTONEN	11AF CDF	$e^\pm e^\pm$
<sup>3</sup>	CHATRCHYAN	11C CMS	$e^+ e^- + \text{jets} + \cancel{E}_T$
<sup>4</sup>	CHATRCHYAN	11U CMS	jet + $\cancel{E}_T$
<sup>5</sup>	AALTONEN	10AF CDF	$\gamma\gamma + \ell, \cancel{E}_T$
<sup>6</sup>	AALTONEN	09AF CDF	$\ell\gamma b \cancel{E}_T$
<sup>7</sup>	AALTONEN	09G CDF	$\ell\ell\ell \cancel{E}_T$

<sup>1</sup> AAD 11S search for events with one jet and missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 7$  TeV with  $L = 33 \text{ pb}^{-1}$ . The observed events are compatible with Standard Model expectation.

<sup>2</sup> AALTONEN 11AF search for high  $p_T$  like-sign dileptons in  $p\bar{p}$  collisions at  $E_{cm} = 1.96$  TeV with  $L = 6.1 \text{ fb}^{-1}$ . The observed events are compatible with Standard Model expectation.

<sup>3</sup> CHATRCHYAN 11C search for events with an opposite-sign lepton pair, jets, and missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 7$  TeV with  $L = 34 \text{ pb}^{-1}$ . The observed events are compatible with Standard Model expectation.

<sup>4</sup> CHATRCHYAN 11U search for events with one jet and missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 7$  TeV with  $L = 36 \text{ pb}^{-1}$ . The observed events are compatible with Standard Model expectation.

<sup>5</sup> AALTONEN 10AF search for  $\gamma\gamma$  events with  $e, \mu, \tau$ , or missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 1.96$  TeV with  $L = 1.1\text{--}2.0 \text{ fb}^{-1}$ . The observed events are compatible with Standard Model expectation.

<sup>6</sup> AALTONEN 09AF search for  $\ell\gamma b$  events with missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 1.96$  TeV with  $L = 1.9 \text{ fb}^{-1}$ . The observed events are compatible with Standard Model expectation including  $t\bar{t}\gamma$  production.

<sup>7</sup> AALTONEN 09G search for  $\mu\mu\mu$  and  $\mu\mu e$  events with missing  $E_T$  in  $p\bar{p}$  collisions at  $E_{cm} = 1.96$  TeV with  $L = 976 \text{ pb}^{-1}$ . The observed events are compatible with Standard Model expectation.