BEACH2012: Summary

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64 talks, huge number of new results:
Impossible to put everything in summary !
This is necessarily a partial and
personal view….

"A Unified and Unbiased Attack on New Physics"

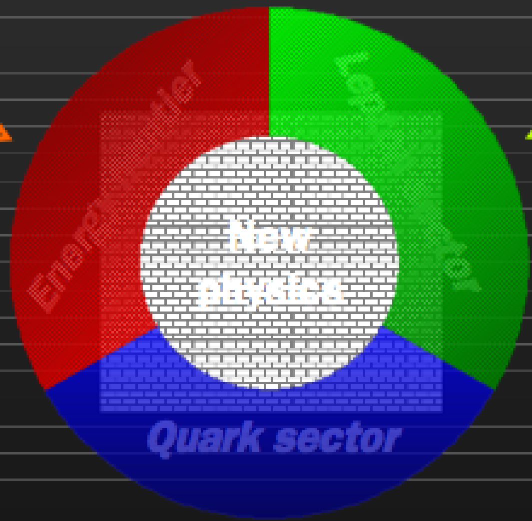
T. Browder, FNAL Seminar, 2006

LHC, ILC

mass spectrum
interactions

ν experiments,
$g_\mu - 2$, $\mu \to e\gamma$, EDM, …

ν mass and mixing
CPV and LFV



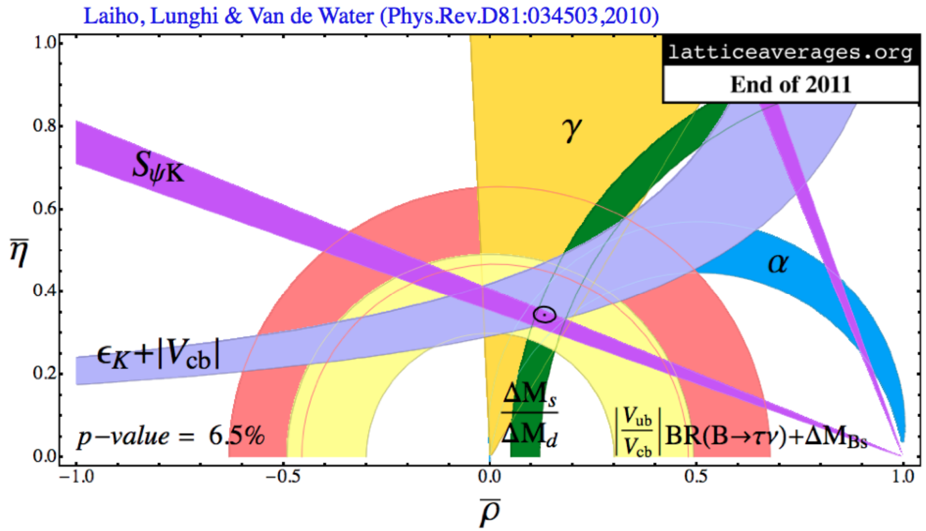
τ LFV
τ CPV

flavour mixing
CPV phases

Super-*B* factory, LHCb, *K* experiments…

Talk centered on search for “new things”

We had also a long list of excellent other results on cross sections, QCD and ChiPT tests, form factors, spectroscopy et. etc.
that I won’t have time to mention
However these measurements are essential ingredients for new physics searches



Error bands are (still) dominated by theory errors, in particular due to hadronic matrix elements.

Also we had a very good overview of future facilities but I will only have time to mention a few

A new Resonance (consistent with Higgs boson)

Summary

ATLAS

Significant resonant excesses found in searches for **H→γγ and H→ZZ*→4l**

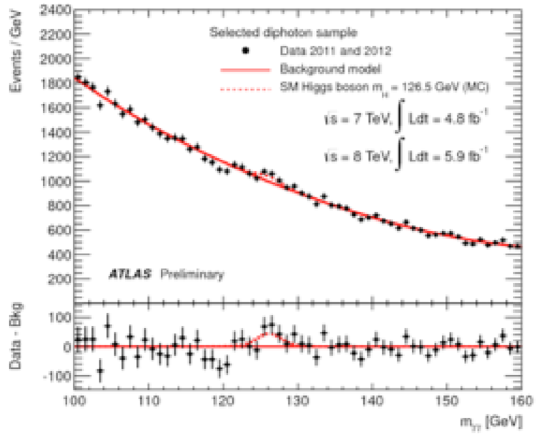
- **Combined 5σ local significance**
- **Individual local significances of 4.5σ and 3.5σ, respectively**
- **Consistent in mass (~126.5 GeV), across subchannels, across time**
- **Compatible with the SM Higgs boson**

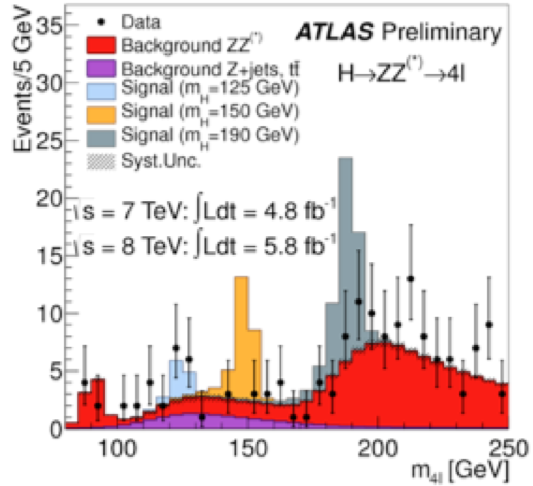
New evidence found in the search for **H→WW**

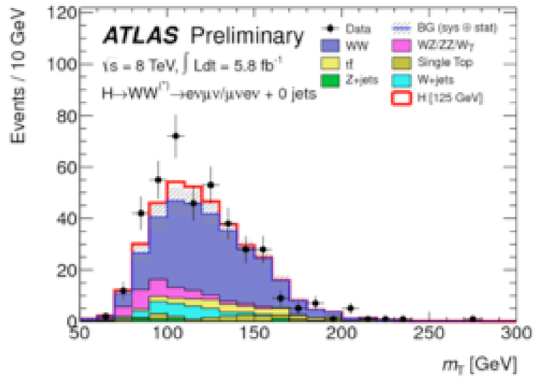
- **Local significance of 2.8σ at m_H = 125 GeV**
- **Consistent across two subchannels**
- **Compatible results from separate 7 TeV and 8 TeV analyses, consistent with the SM Higgs boson**

ATLAS now excludes the Higgs across a wide range of possible masses

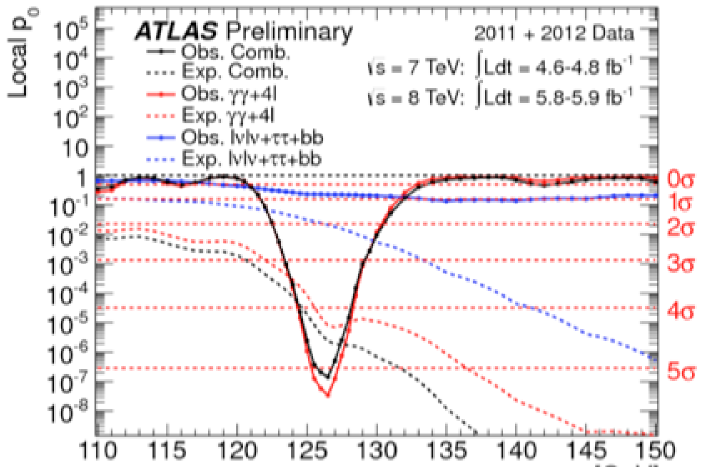
- **SM Higgs excluded for m_H from 110–122.6 GeV and from 129.7–558 GeV at 95% CL**
- **Pushing sensitivity well below the SM expectation for many m_H**

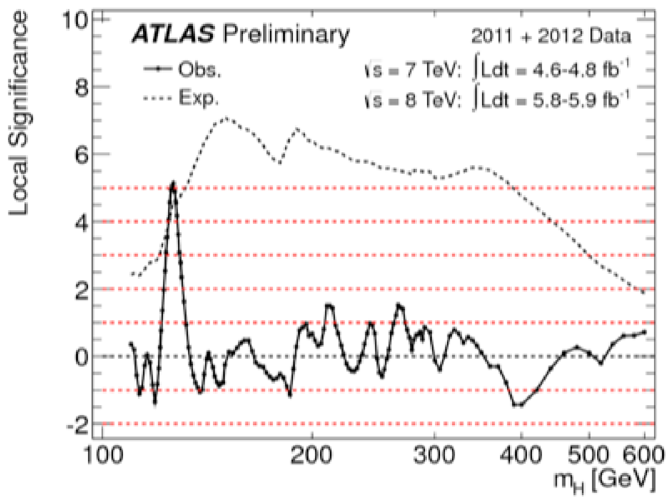






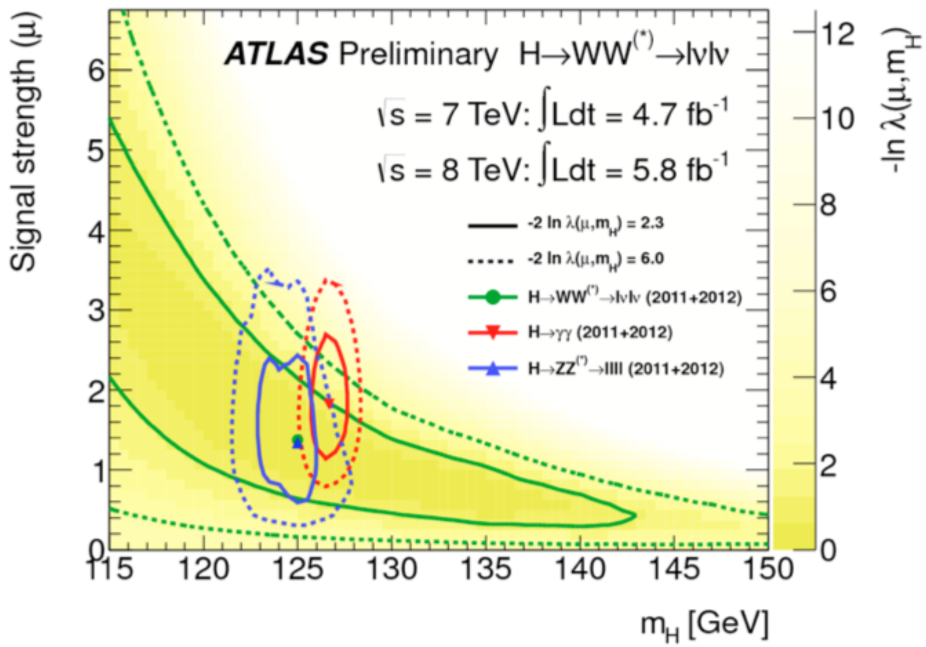
Combination of $H\to\gamma\gamma$ and $H\to ZZ^*\to 4l$



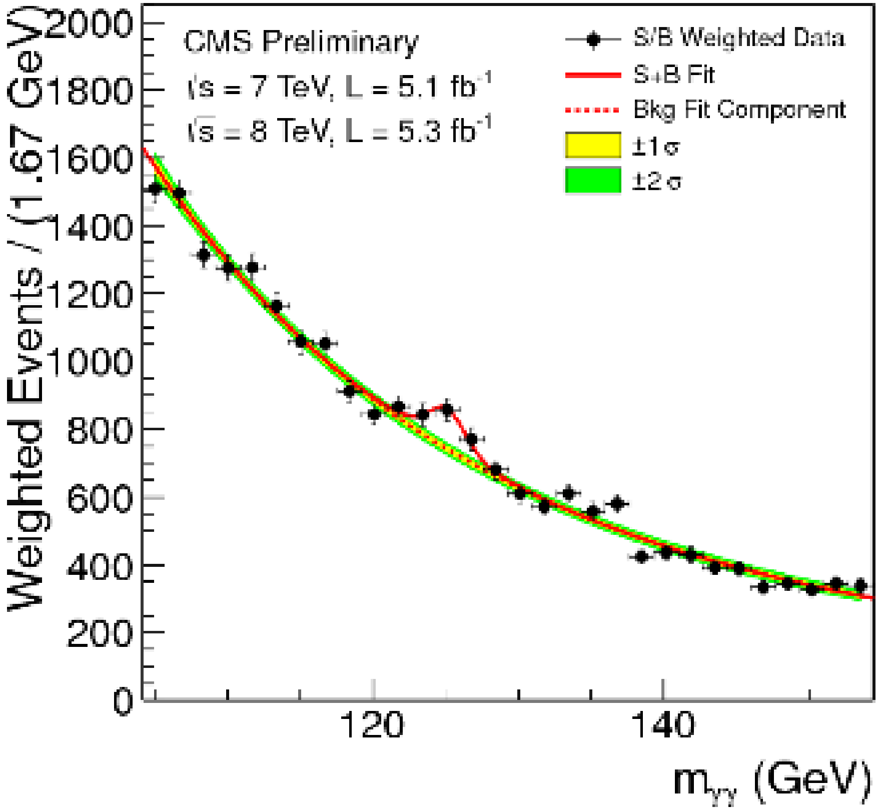


Maximum excess observed at m_H = 126.5 GeV with local significance of 5.0σ

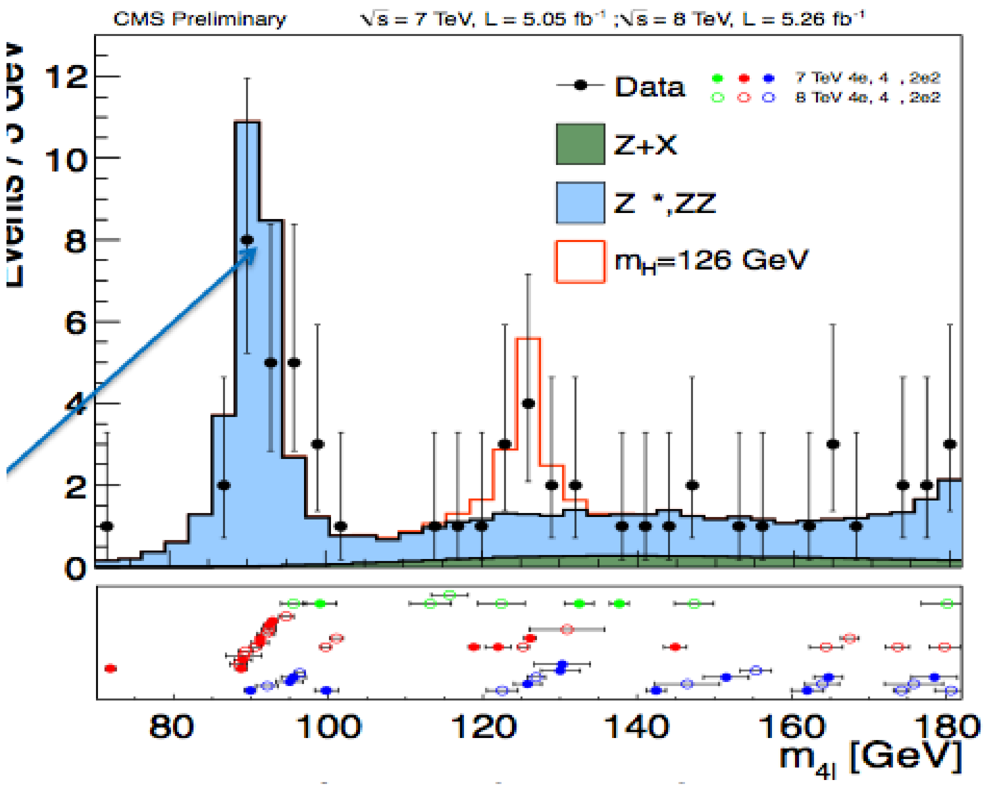
- *Expectation for m_H = 126.5 GeV SM Higgs: 4.6σ*
- *Global significance: 4.1–4.3 σ for LEE over 110–600 or 110–150 GeV*
- *Consistent across multiple channels, time*



CMS

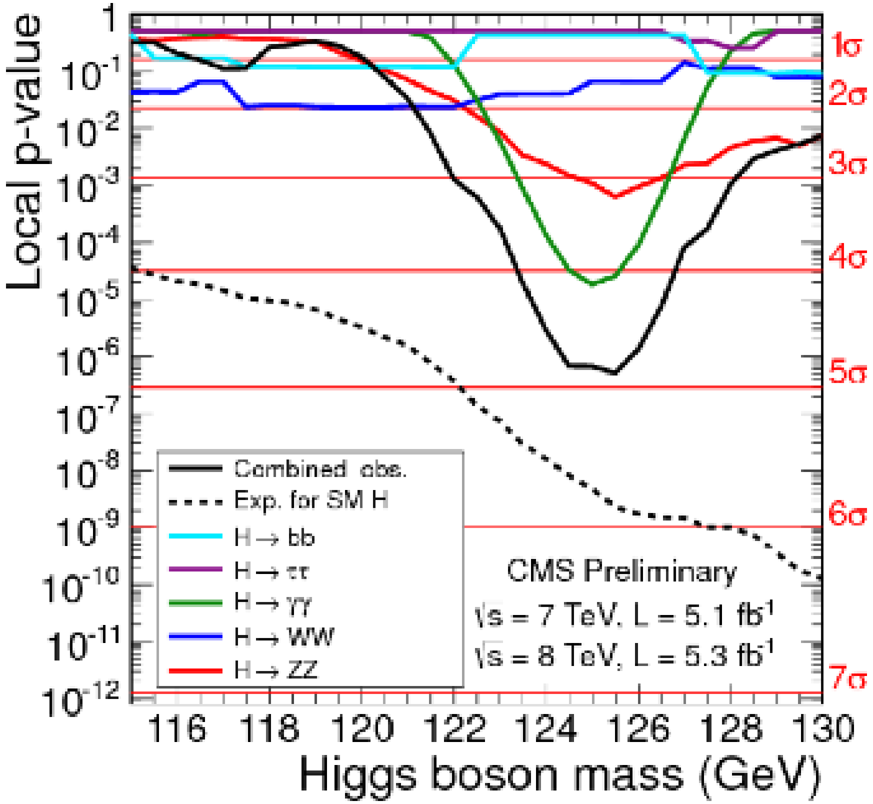


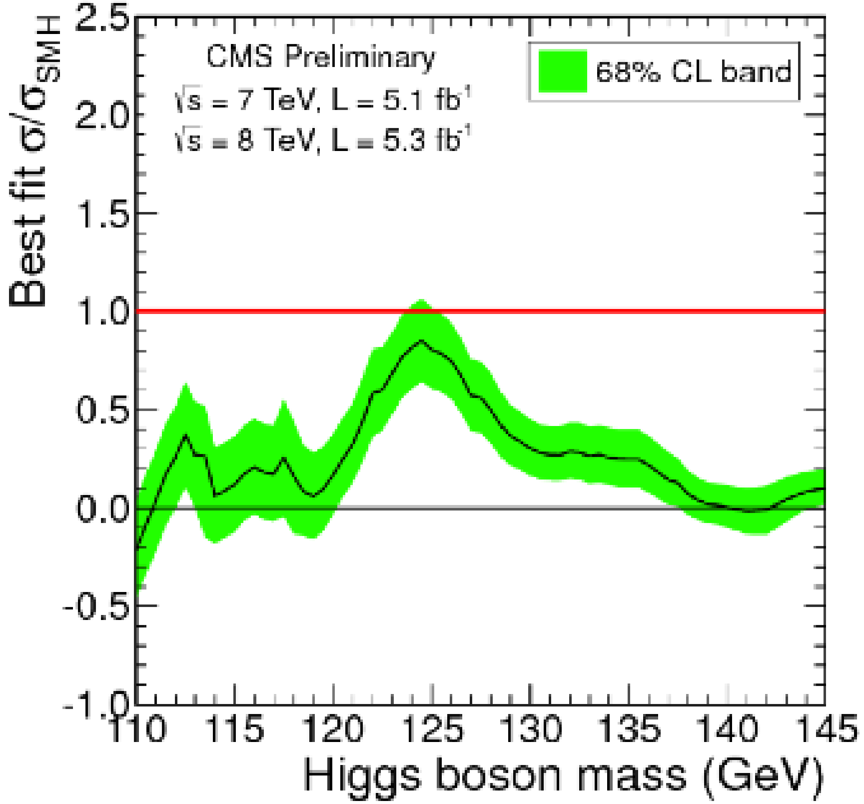
CMS Preliminary
√s = 7 TeV, L = 5.1 fb⁻¹
√s = 8 TeV, L = 5.3 fb⁻¹
S/B Weighted Data
S+B Fit
Bkg Fit Component
±1 σ
±2 σ
Weighted Events / (1.67 GeV)
m γγ (GeV)



CMS Preliminary
√s = 7 TeV, L = 5.05 fb⁻¹ ; √s = 8 TeV, L = 5.26 fb⁻¹
Data
Z+X
m H=126 GeV
m 4l [GeV]

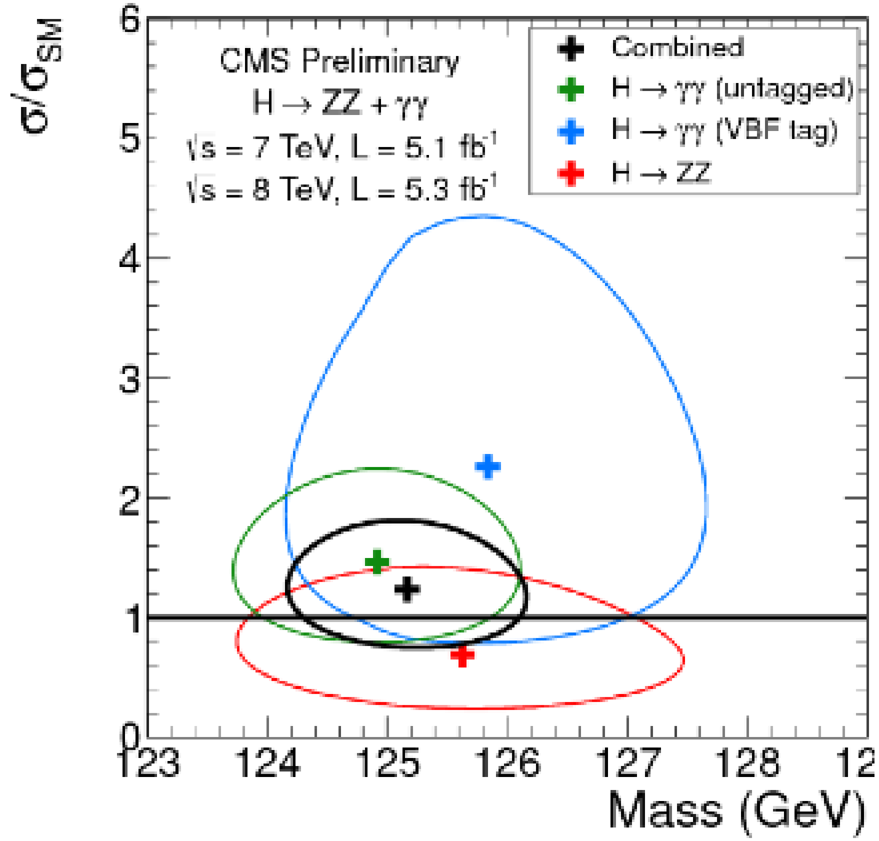
Combined results: all channels



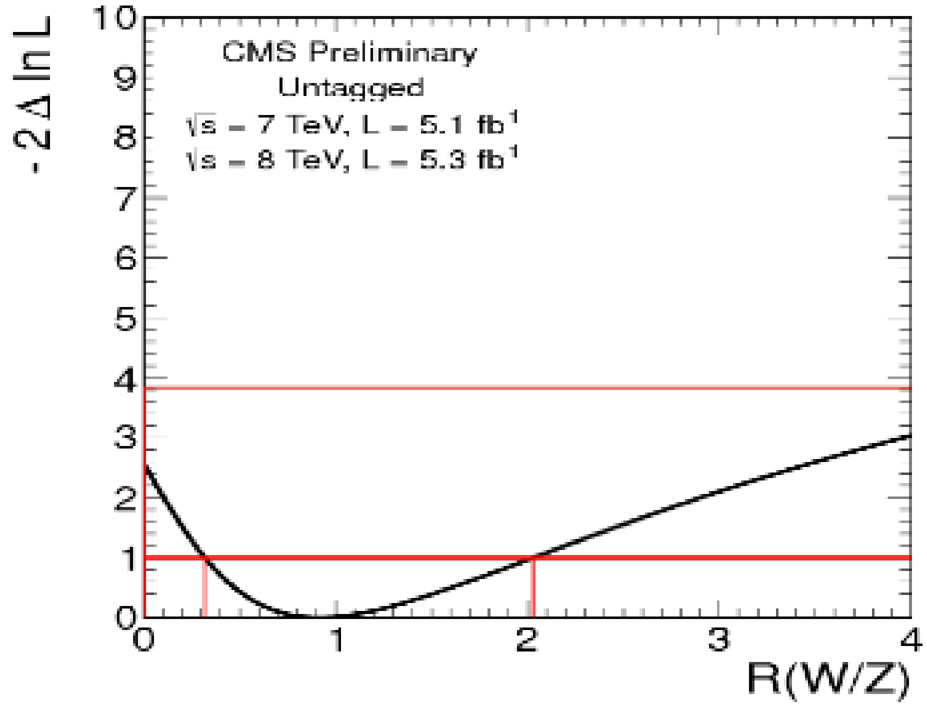


Local significance 4.9 σ, SMH expected 5.9σ

The best fit signal strength at mass 125 GeV: (0.80 ± 0.22) × σ_{SMH}



Results are compatible within the uncertainties



Signal strength ratio of WW and ZZ modes in VBF:
driven by the ratio of the Higgs couplings to WW and ZZ

Compatable with SM $R_{W/Z} = 0.9^{+1.1}_{-0.6}$

Tevatron

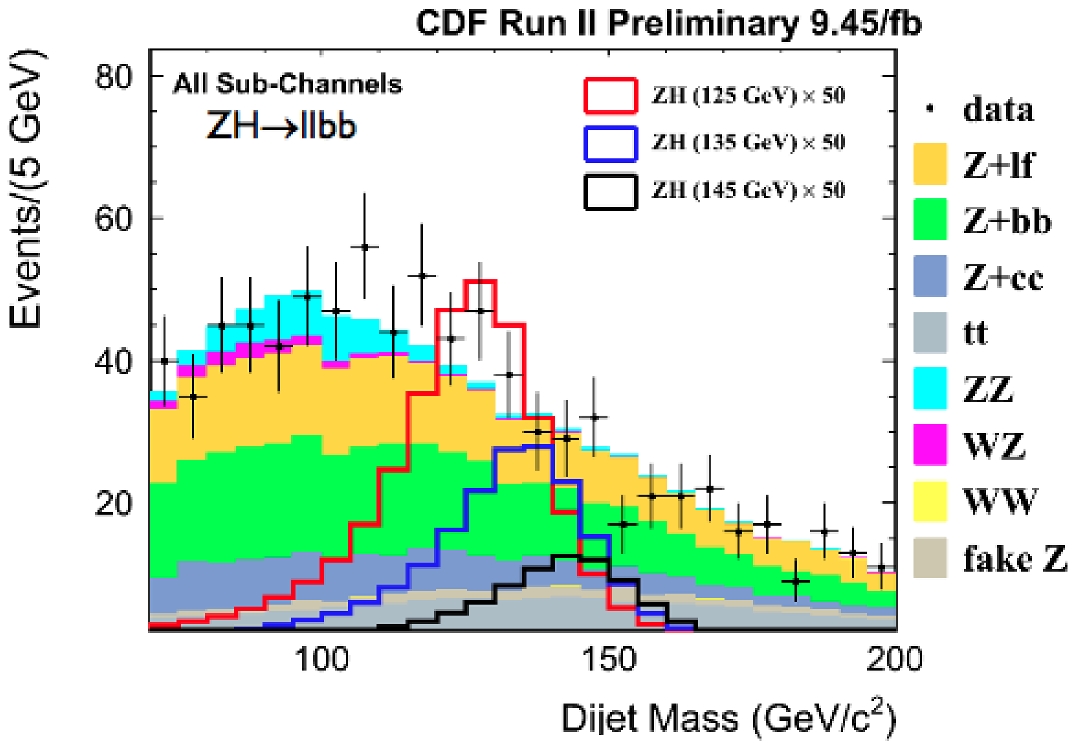
Individual channel sensitivity

Four channels contribute almost equally in the interesting region!

- qq→ZH→llbb
- qq→WH→lνbb
- qq→ZH→ννbb
- gg→H→WW→lνlν

Remaining channels have a combined weight of ~10%

- gg→H→ZZ→llll
- gg→H→γγ
- . . . and others

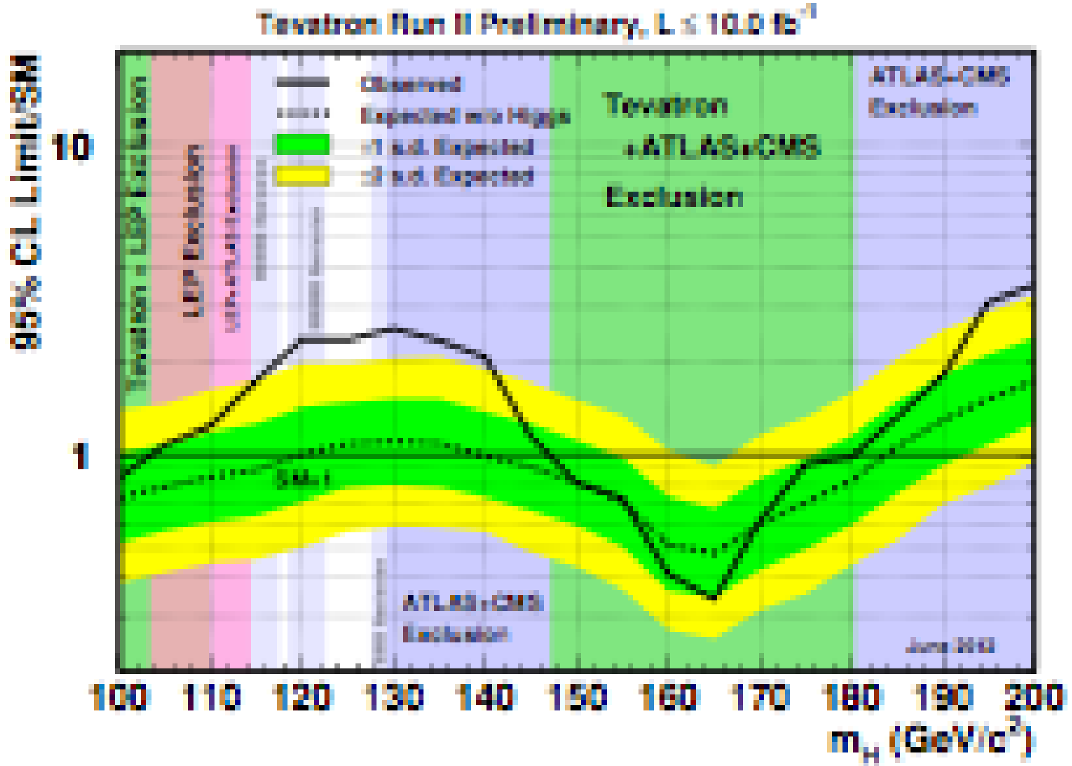


At m_H=125 GeV/c²		
	CDF	CMS
H→γγ	~10*SM	0.5-1*SM
H→WW	~3.5*SM	~1*SM
H→bb	~1.8*SM	~1.4*SM

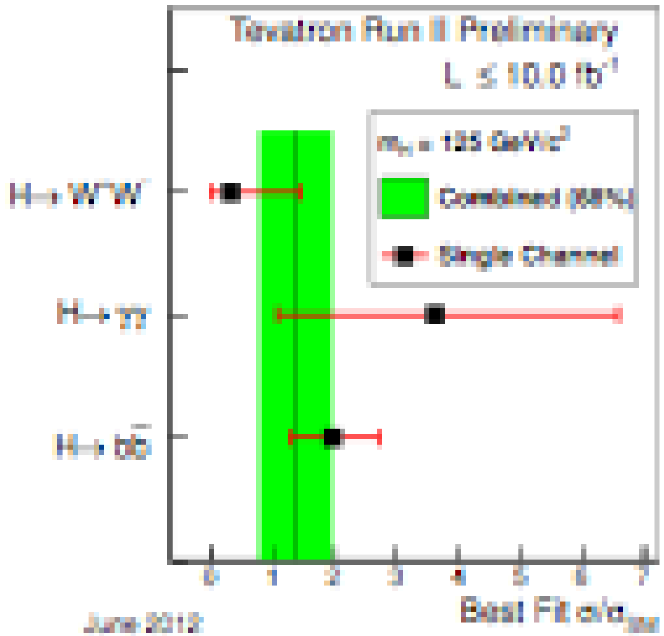
Broad mass

Summary Plot

D0



Tevatron data does not exclude a SM Higgs with mass near 125 GeV (expected 95% CL limit = 1.08 σ_{SM} for B-hypothesis)



Data is consistent with expected decay modes of 125 GeV SM Higgs including decay to $b\bar{b}$.

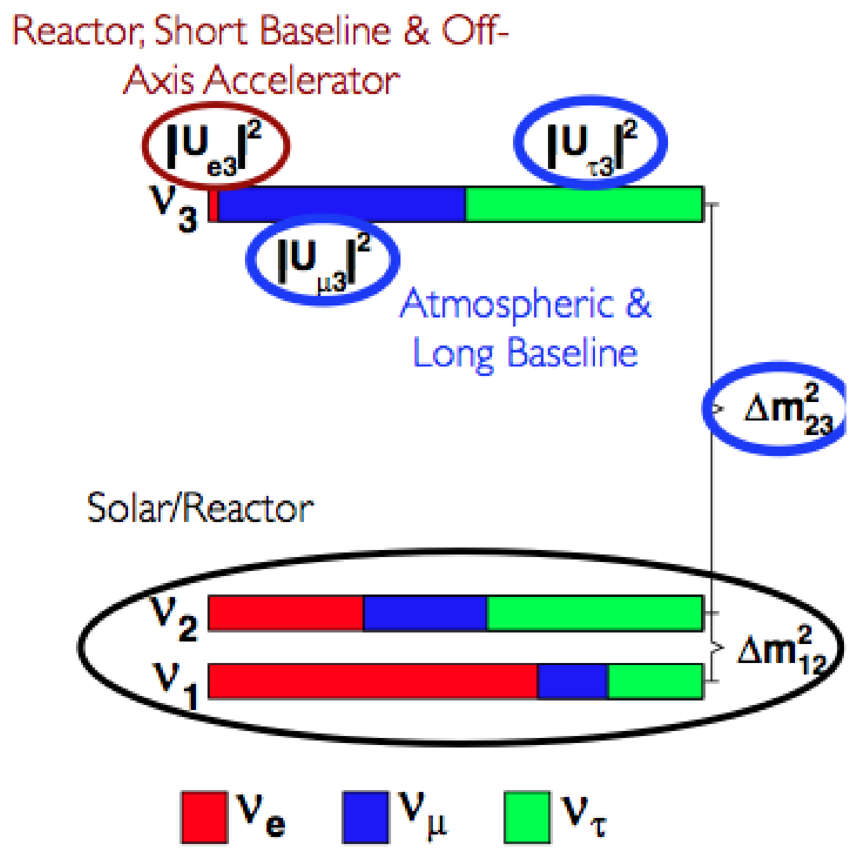
Overall background-only p-value = 0.4%.

Neutrinos….

Neutrino Oscillations

- Measuring the PMNS matrix

Experiment type	Oscillation Channel
Solar, Reactor	$(\nu_e \rightarrow \nu_\mu)$
Reactor, Short Baseline, Off-Axis	$(\nu_e \rightarrow \nu_e)$ $(\nu_\mu \rightarrow \nu_e)$
Atmospheric & Long Baseline	$(\nu_\mu \rightarrow \nu_\mu)$ $(\nu_\mu \rightarrow \nu_\tau)$



$$|U_{PMNS}| \sim \begin{pmatrix} 0.8 & 0.5 & 0.2 \\ 0.4 & 0.6 & 0.7 \\ 0.4 & 0.6 & 0.7 \end{pmatrix}$$

$$|V_{CKM}| \sim \begin{pmatrix} 1 & 0.2 & 0.004 \\ 0.2 & 1 & 0.04 \\ 0.008 & 0.04 & 1 \end{pmatrix}$$

$$\begin{pmatrix} |\nu_e\rangle \\ |\nu_\mu\rangle \\ |\nu_\tau\rangle \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} |\nu_1\rangle \\ |\nu_2\rangle \\ |\nu_3\rangle \end{pmatrix}$$

Neutrino Oscillation (3-flavor)

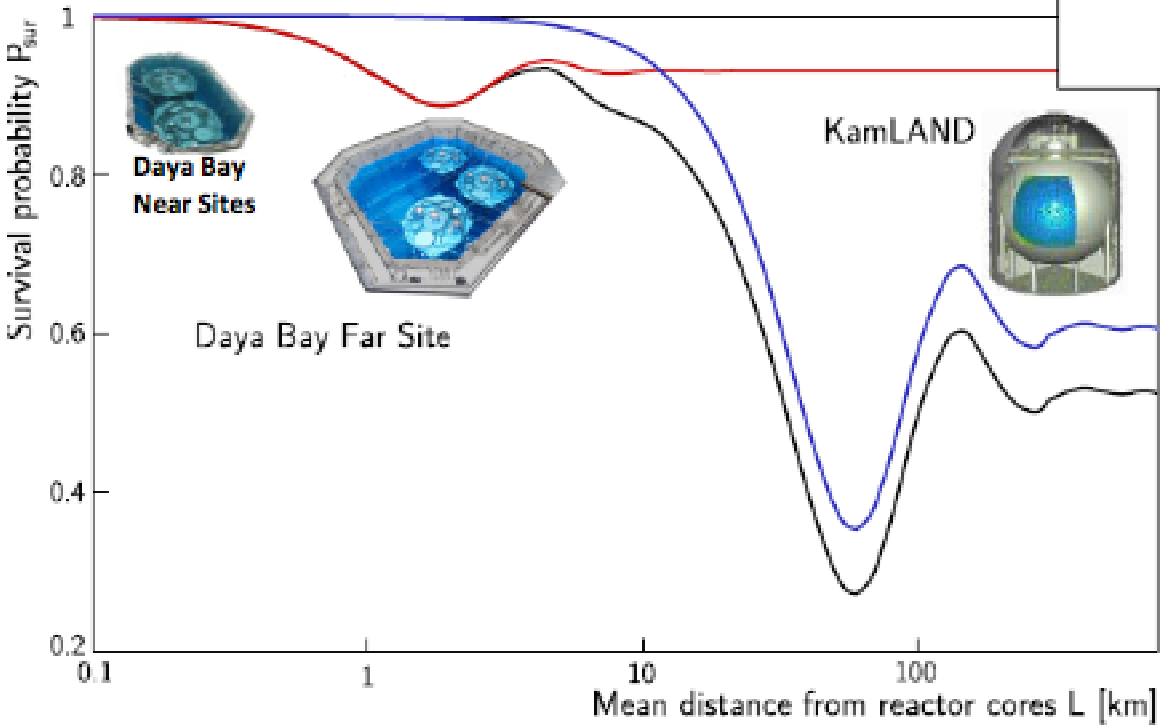
$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} 1 & & \\ & c_{23} & s_{23} \\ & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & & s_{13}e^{-i\delta} \\ & 1 & \\ -s_{13}e^{i\delta} & & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & \\ -s_{12} & c_{12} & \\ & & 1 \end{pmatrix} \begin{pmatrix} e^{i\alpha_1/2}\nu_1 \\ e^{i\alpha_2/2}\nu_2 \\ \nu_3 \end{pmatrix}$$

$c_{ij} = \cos(\theta_{ij})$;
$s_{ij} = \sin(\theta_{ij})$;

U_{MNSP} Matrix
Maki, Nakagawa, Sakata, Pontecorvo

$$P_{sur} \approx 1 - \sin^2 2\theta_{13} \sin^2\left(\Delta m^2_{32} \frac{L}{4E}\right) - \sin^2 2\theta_{12} \cos^4 2\theta_{13} \sin^2\left(\Delta m^2_{21} \frac{L}{4E}\right)$$

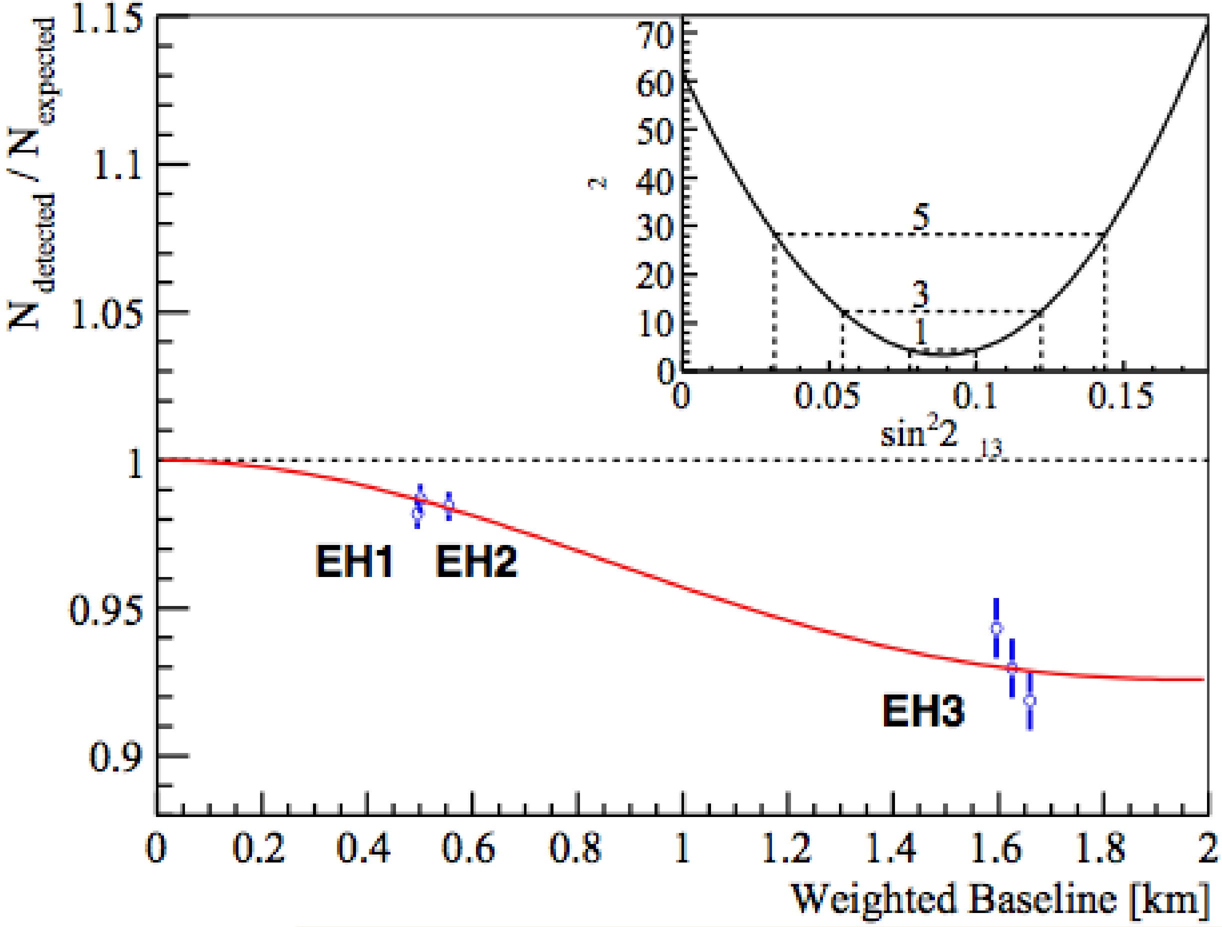
$$\Delta m^2_{32} \approx \Delta m^2_{31} \approx \Delta m^2_{atm}$$



Why measure θ_{13}?
- Least-known mixing angle
- Access to ν hierarchy
- Access to CP-violating phase δ

Rate Analysis

Estimate θ_{13} using measured rates in each detector.



Uses standard χ^2 approach.

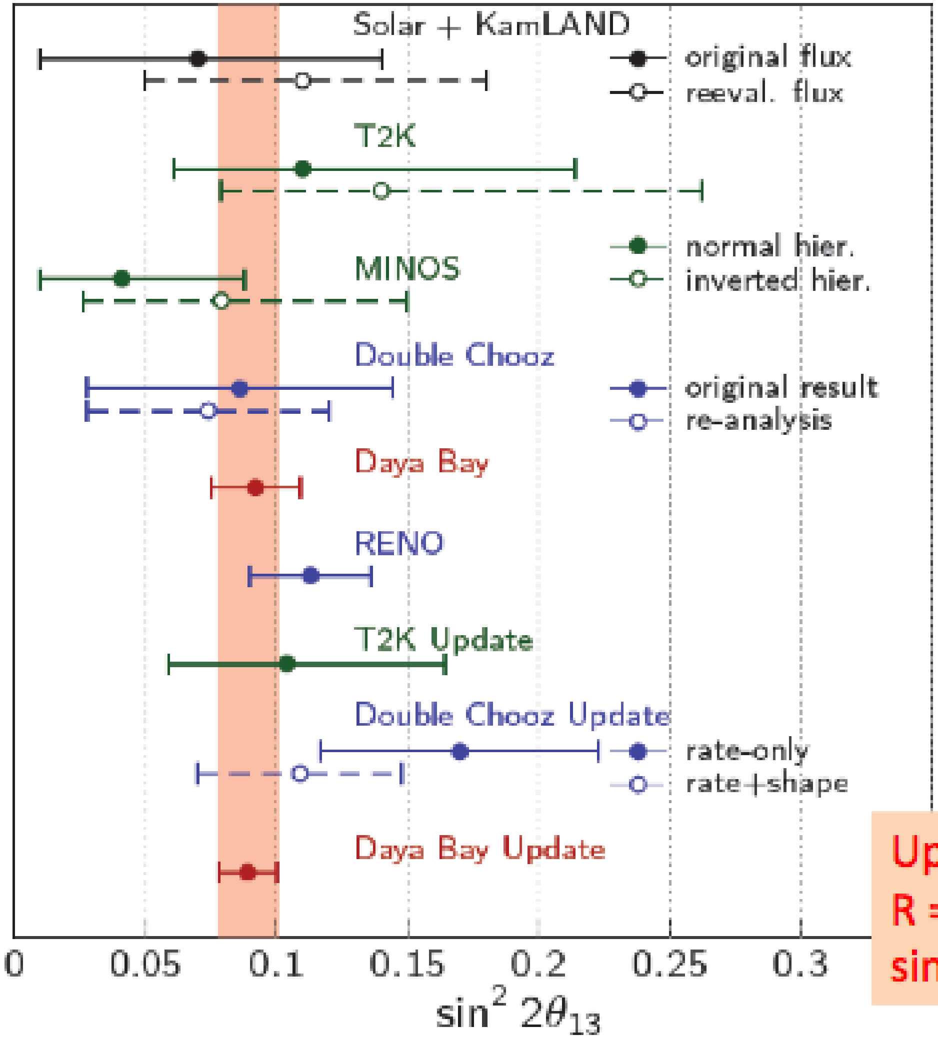
Far vs. near relative measurement.
[Absolute rate is not constrained.]

Consistent results obtained by independent analyses, different reactor flux models.

Most precise measurement of $\sin^2 2\theta_{13}$ to date.

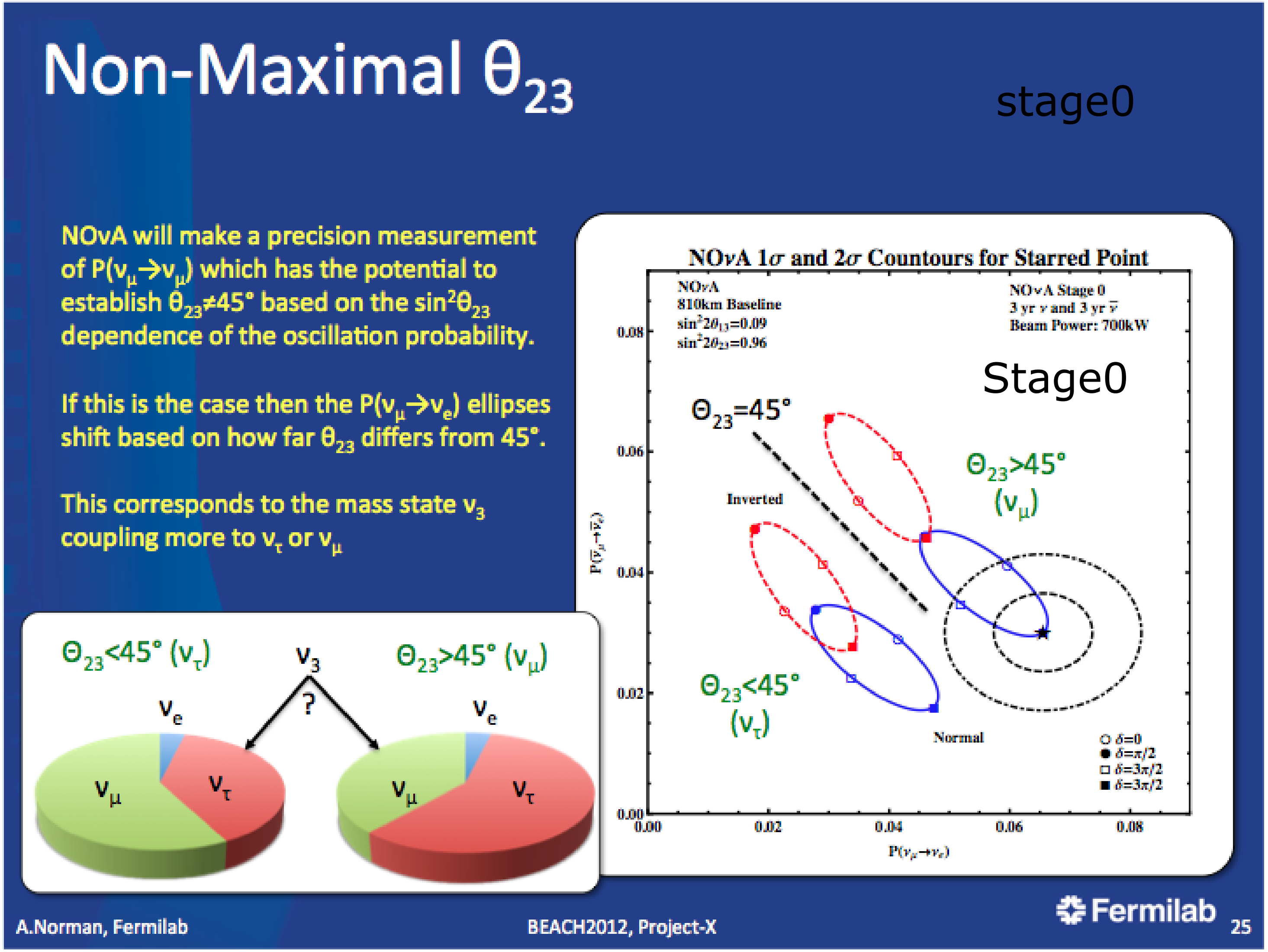
$\sin^2 2\theta_{13} = 0.089 \pm 0.010$ (stat) ± 0.005 (syst)

Comparison of θ_{13} Measurements



PRL:
R = 0.940 ± 0.011 (stat) ± 0.004 (sys)
$\sin^2 2\theta_{13}$ = 0.092 ± 0.016 (stat) ± 0.005 (sys)

Updated result:
R = 0.944 ± 0.007 (stat) ± 0.003 (syst)
$\sin^2 2\theta_{13}$ = 0.089 ± 0.010 (stat) ± 0.005 (syst)



Also IceCube, DeepCore, PINGU
And MIPP

Symmetries (CP,T)

KLOE

$K_S \rightarrow \pi^0\pi^0\pi^0$: search for a CP violating decay

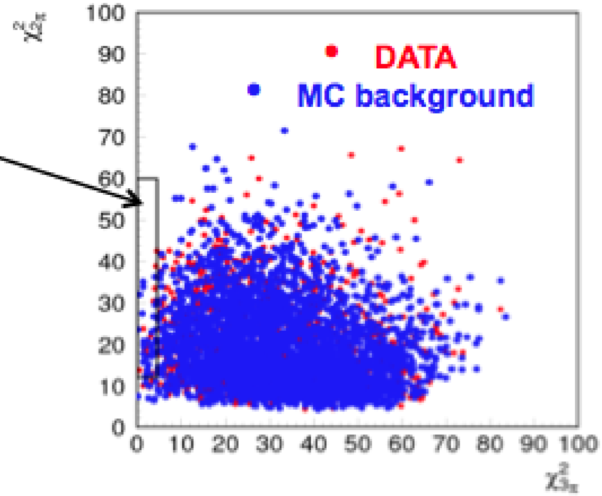
- The analysis has been updated
  - improving clustering procedure to reduce split clusters
  - hardening the $\beta^*(K_L)$ cut for tagging the Ks decays
  - processing the entire data set (~8×10^7 tagged K_SK_L pairs)

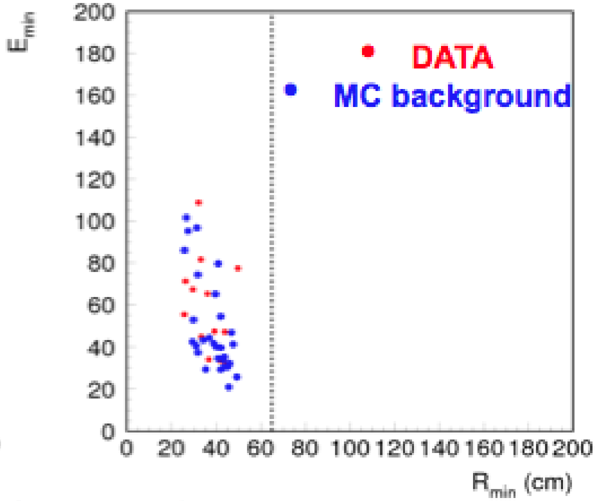
- N_{obs} =0 evts. in data
- N_{exp}=0 evts. in MC
- 0.12 evts expected in SM

- signal box
- $R_{min} > 65$ cm
- $\varepsilon_{3\pi} = 0.23(1)$

- $N_{3\pi^0} \leq 2.33/\varepsilon_{3\pi^0}$ at 90% C.L.

- Normalized to $N_{2\pi^0}/\varepsilon_{2\pi^0}=(1.14130\pm0.00011)\times10^8$





KLOE internal refereeing completed
formal approval by KLOE collaboration ongoing
KLOE paper in preparation

$BR(K_S\rightarrow3\pi^0) < 2.7 \times 10^{-8}$ @ 90% CL

New KLOE result

$|\eta_{000}| < 0.009$ @ 90% CL

This result points to the feasibility of the first observation at KLOE-2

Standard Model prediction:
$BR(K_S \rightarrow 3\pi^0) = 1.9 \cdot 10^{-9}$

Conclusions

- DAΦNE commissioning in progress
- KLOE detector is fully operational
- KLOE-2 upgrades are being completed
- At KLOE-2 an improvement of about one order of magnitude in the precision of several CP/CPT symmetry tests is expected.
- KLOE-2 physics program described in EPJC 68 (2010) 619-681

- In the meanwhile the analysis of the full KLOE data set is being completed:
- New upper limit for $BR(K_S \to 3\pi^0)$. At KLOE-2 this analysis will benefit of the presence of low θ calorimeters QCALT- CCALT. With $O(10fb^{-1})$ it might be possible to have a first observation of the decay
- A new method has been implemented to perform the CPT and Lorentz symmetry test. The analysis of the full KLOE data set analysis is almost completed.
  At KLOE-2 it will benefit of the new inner tracker detector improving Δt resolution, and of the new interaction region scheme with a doubled ϕ momentum (increasing the sensitivity to Δa_0).

$B \to 3K$ CP *V*

- Indication of direct CP violation in $B^+ \to \phi K^+$ at 2.8σ.
  - $A_{CP} = (12.8 \pm 4.4 \pm 1.3)\%$
  - SM: $(0 - 4.7)\%$

$A_{CP}(\phi K^+)$ larger than SM expectation:

$A_{CP} = (1.6^{+3.1}_{-1.4})\%$ (QCDF) Beneke, Neubert, Nucl Phys B675, 333

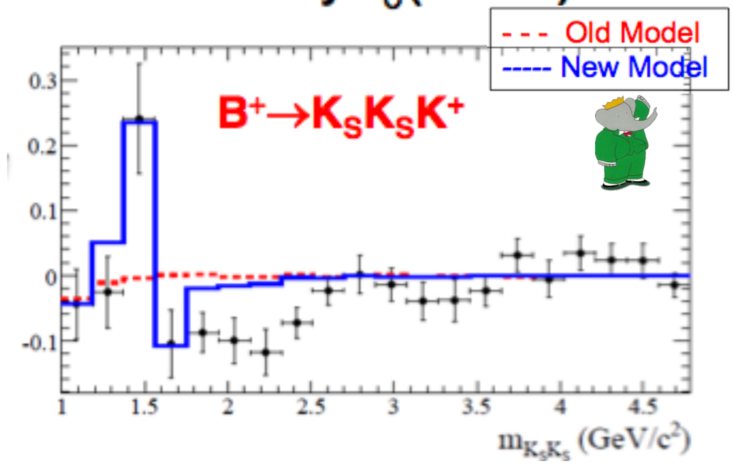
$A_{CP} = (1^{+0}_{-1})\%$ (PQCD) Li, Mishima, PRD 74, 094020

- World's most precise measurement of $\beta_{eff}(\phi K_S)$:
  - $\beta_{eff} = (21 \pm 6 \pm 2)$ degrees

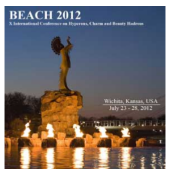
Good agreement with SM

Charmonium:
$\beta = 21.4 \pm 0.8$ deg

- $f_X(1500)$ not a single resonance – well described by $f_0(1500)$ + $f_2'(1525)$ + $f_0(1710)$

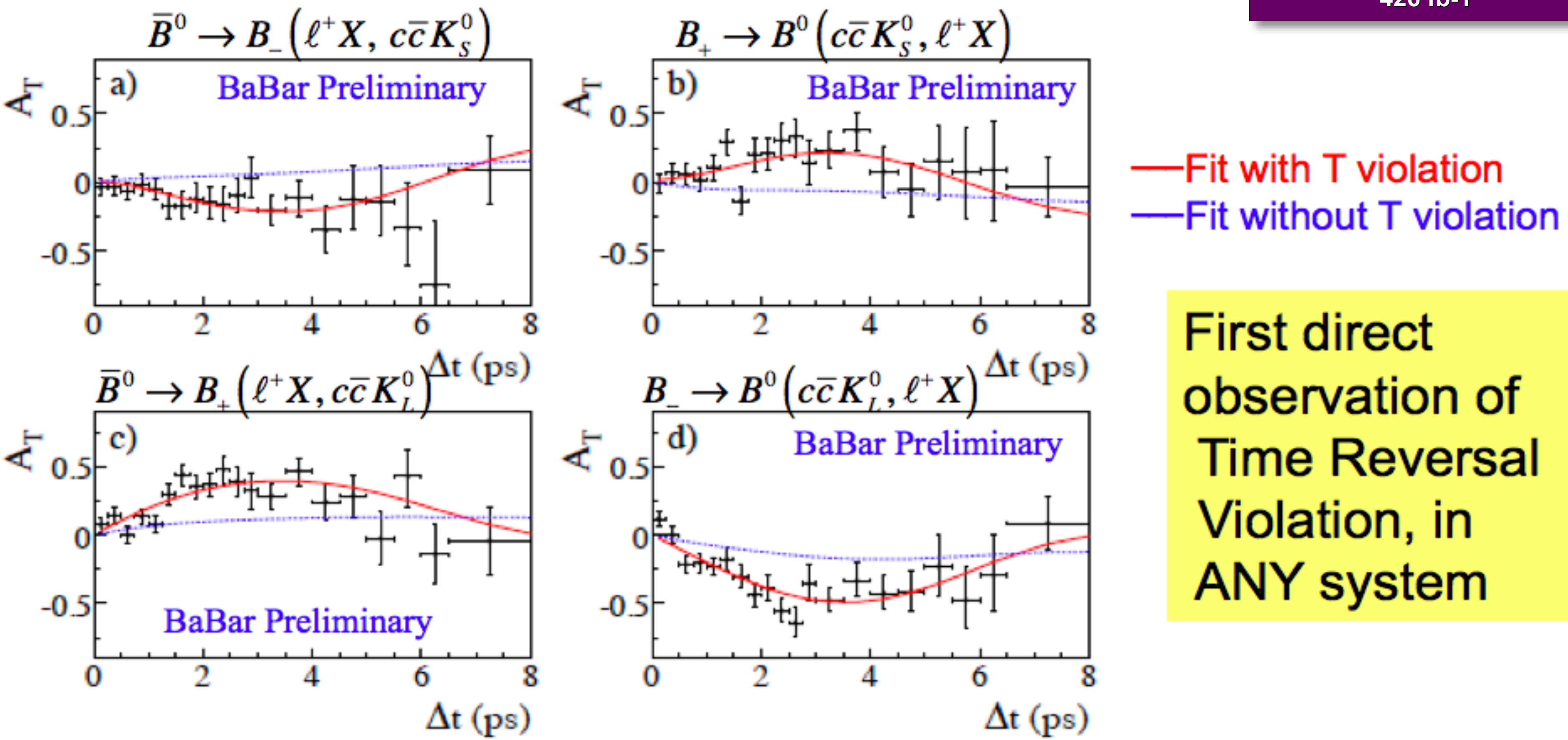


arXiv:1201.5897, PRD 85:112010 (2012) 426 fb^{-1}



$B^0 \rightarrow J/\psi K^0$

To be submitted to PRL,
426 fb-1



First direct observation of Time Reversal Violation, in ANY system

$\Delta S_T^+ = -1.37 \pm 0.14 \pm 0.06$
$\Delta S_T^- = 1.17 \pm 0.18 \pm 0.11$

T violation, independent of CP, CPT
14σ significance

Result consistent with CPV, assuming CPT

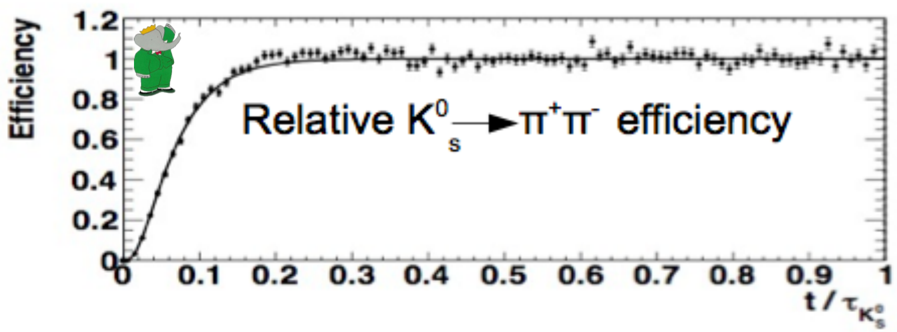
$\tau^- \to K^0\pi^-\nu$ CP *V*

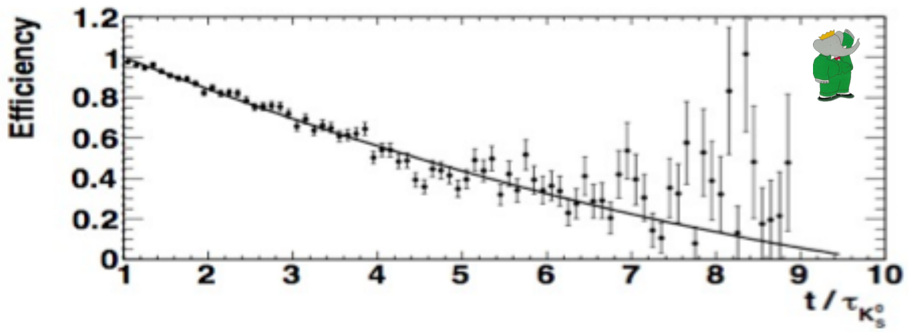
arXiv:1109.1527,
PRD-RC 85:031102 (2012)
476 fb-1

- After correction and taking into account the residual $\tau \to K^0_s$ BKG charge asymmetries:

A_Q=(-0.45±0.24±0.11)% FIRST MEASUREMENT

- Systematics from detector & selection bias, BKG subtraction and $K^0/\overline{K^0}$ nuclear interaction





- K^0_s - K^0_L interference affects the predicted A_Q=(0.33±0.01)%
  - Correction to be applied in terms of the $K^0_s \to \pi^+\pi^-$ decay time dependence of the selection efficiency (Grossman, Nir, arXiv:1110.3790):

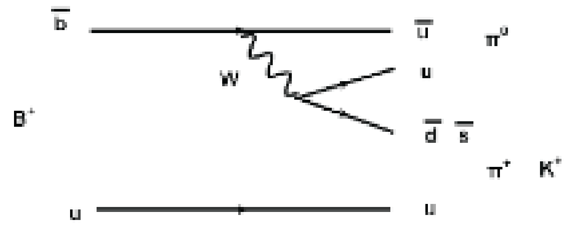
- $A_Q^{COR}=A_Q$*(1.08±0.01)=(0.36±0.01)%

Measurement is 3.1 standard deviations from the SM predictions

Introduction

$B \rightarrow hh$

- The branching fraction between theoretical calculations and exprimental measurements have large uncertainties.
- The $\mathcal{A}_{CP}$ measurements will help observe SM quantities.
- Improved experimental uncertainties can help our understanding of the standard model and help indentify New Physics.



$$\Delta\mathcal{A}_{K\pi} = \mathcal{A}_{CP}(K\pi^0) - \mathcal{A}_{CP}(K\pi)$$

~0 in Standard Model

- As $B^+ \rightarrow K^+\pi^0$ and $B^0 \rightarrow K^+\pi^-$ have very similar leading order feynman diagrams, we would expect them to have similar $\mathcal{A}_{CP}$.
- A difference could indicate the enhancement of the color suppressed tree diagram.
- However, the previous Belle result found the sign and magnitude of these asymmetries to be different.
- The difference in these could indicate New Physics, such as a difference between direct CP in neutral and charged B decays.

Current Results

(Belle preliminary)

$$\Delta\mathcal{A}_{K\pi} = \mathcal{A}_{CP}(K\pi^0) - \mathcal{A}_{CP}(K\pi)$$

Previous Belle Result :

$\Delta\mathcal{A}_{K\pi} = +0.164 \pm 0.037\ 4.4\sigma$

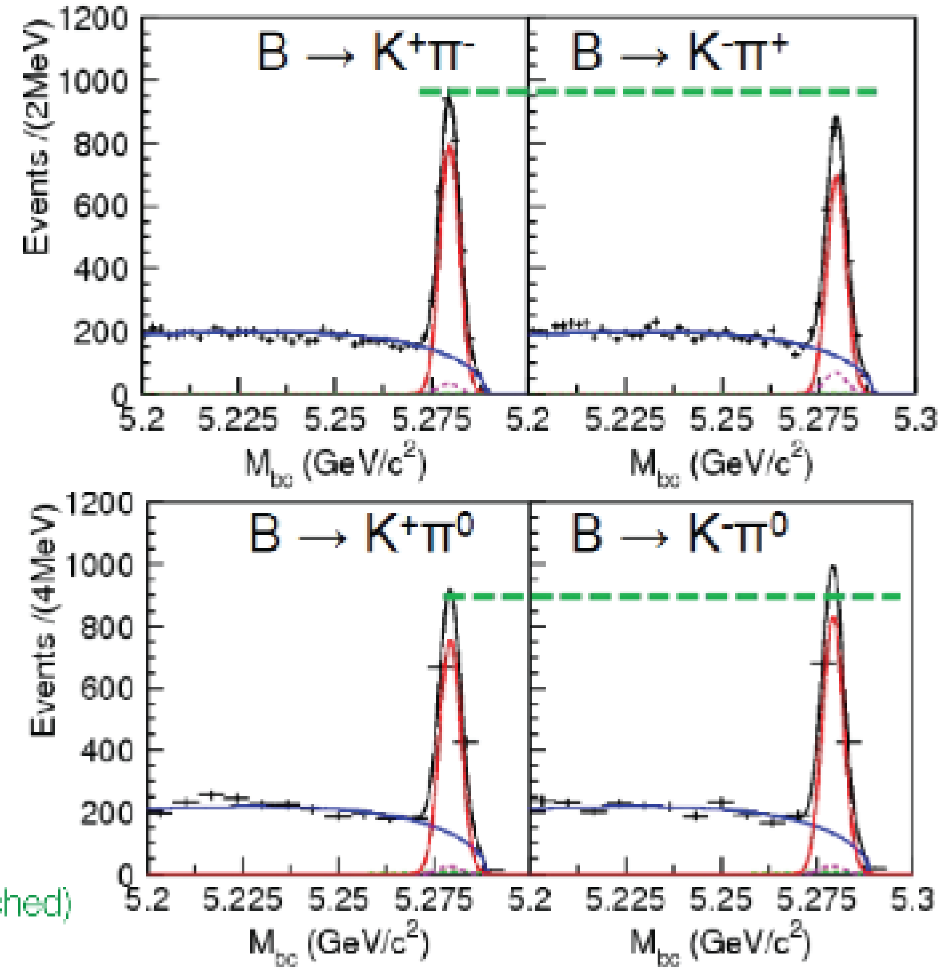
($535 \times 10^6\ B\bar{B}$ pairs)

New Result :

$\Delta\mathcal{A}_{K\pi} = +0.112 \pm 0.027\ 4\sigma$

($772 \times 10^6\ B\bar{B}$ pairs)

HFAG : 0.124±0.022



Background from charmless B decays (hatched)

Background from mis-identification (dashed)

CP violating phase ϕ_s in $B_s^0 \to J/\psi\,\varphi$

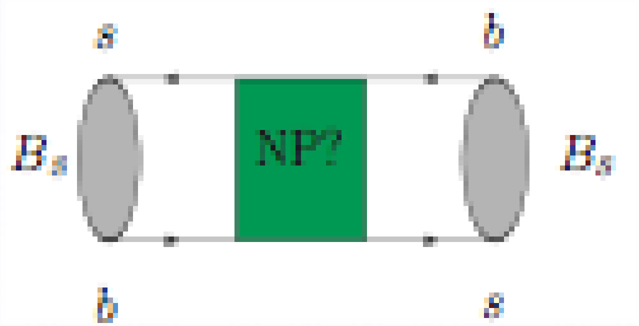
- The final state $J/\psi\,\varphi$ is accessible to both B_s^0 and $\overline{B}_s^0$: Interference between decays with and without mixing
- Interference measured through weak phase ϕ_s
- $\phi_s = \phi_M - 2\phi_{c\bar{c}s}$

Mixing phase

- $\phi_M^{SM} = \arg\left(V_{tb}V_{ts}^*\right)^2 = -2\,\beta_s$

Decay phase

- $\phi_{c\bar{c}s}^{SM} = \arg(V_{cb}V_{cs}^*) \approx 0$ + small penguin contribution



- Standard Model (SM) prediction is small: $\phi_s^{SM} = -2\,\beta_s \approx -0.04$

(arXiv: 1102.4274)

- NP models: $\phi_s \to \phi_s^{SM} + \Delta\phi^{NP}$

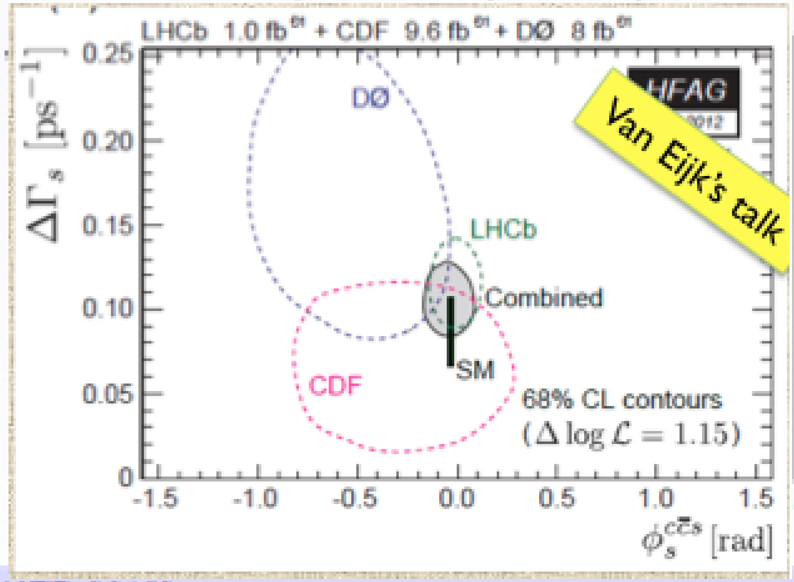
ϕ_s combinations

LHCb simultaneous fit of $B_s^0 \to J/\psi\,\varphi$ and $B_s^0 \to J/\psi\,\pi^+\pi^-$ (preliminary)

$\phi_s = -0.002 \pm 0.083\,(\text{stat.}) \pm 0.027\,(\text{syst.})$ LHCb-CONF-2012-002

Global ϕ_s combination (HFAG)

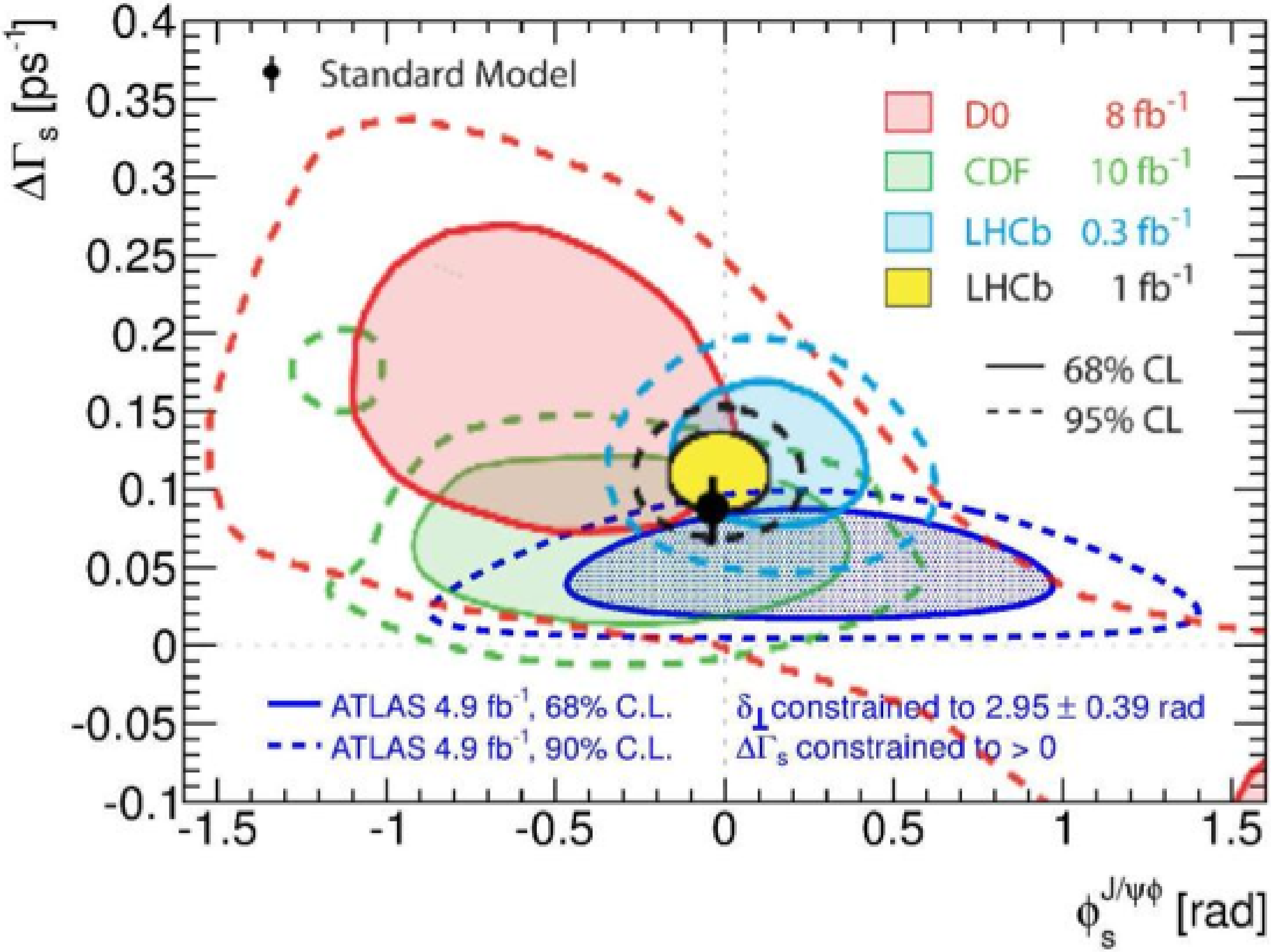
$\phi_s = -0.044^{+0.090}_{-0.085}$, $\Delta\Gamma_s = 0.105 \pm 0.015\,\text{ps}^{-1}$ arXiv: 1207.1158



ATLAS results (ICHEP 2012)

- $\phi_s = 0.22 \pm 0.41\,(\text{stat.}) \pm 0.10\,(\text{syst.})$
- $\Delta\Gamma_s = 0.053 \pm 0.021\,(\text{stat.}) \pm 0.008\,(\text{syst.})\,\text{ps}^{-1}$

Comparison

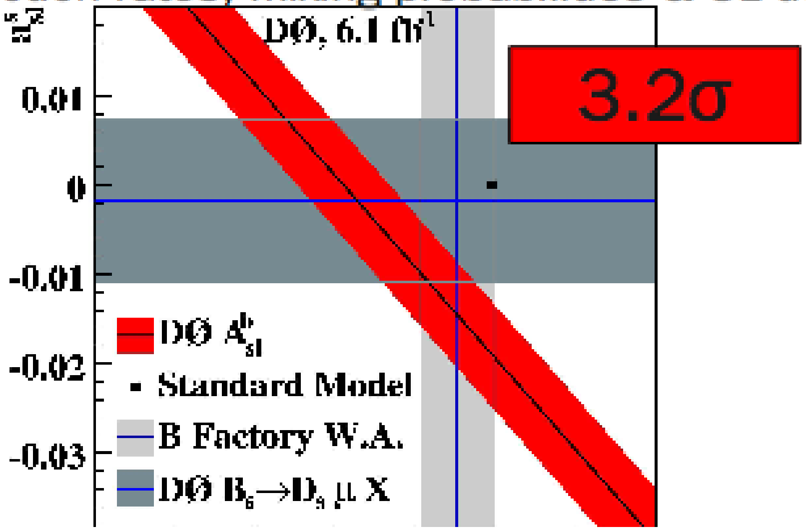


Standard Model
D0 8 fb-1
CDF 10 fb-1
LHCb 0.3 fb-1
LHCb 1 fb-1
68% CL
95% CL
ATLAS 4.9 fb-1, 68% C.L.
ATLAS 4.9 fb-1, 90% C.L.
δ⊥ constrained to 2.95 ± 0.39 rad
ΔΓs constrained to > 0
ΔΓs [ps-1]
φs J/ψφ [rad]
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-1.5
-1
-0.5
0
0.5
1
1.5

Like-sign dimuon asymmetry

- Semileptonic decays are flavour-specific
- B mesons are produced in $B\overline{B}$ pairs
- Like-sign leptons arise if one of $B\overline{B}$ pair mixes before decaying
- If no CP violation in mixing N(++) = N(−−)
- Inclusive measurement ↔ contributions from both B_d^0 and B_s^0
  - relative contributions from production rates, mixing probabilities & SL decay rates

D0 experiment
arXiv:1005.2757 & arXiv:1007.0395



Final Results

Combine two a^d_{sl} measurements, with correlations accounted for:

$$a^d_{\rm sl} \;=\; [0.93 \pm 0.45\ ({\rm stat.}) \pm 0.14\ ({\rm syst.})]\%$$

- Consistent with SM at 2σ level
- More precise than existing WA from B-factories: (−0.05 ± 0.56)%
- Paper in preparation

Corresponding time-integrated measurement of a^s_{sl}:

$$a^s_{\rm sl} = [-1.08 \pm 0.72\,({\rm stat}) \pm 0.17\,({\rm syst})]\,\%$$

- Supersedes previous worlds-best measurement (D0, 2009)
- Consistent with results of dimuon asymmetry…
- Submitted to Phys. Rev. Letters (arXiv:1207.1769 [hep-ex])

Combination

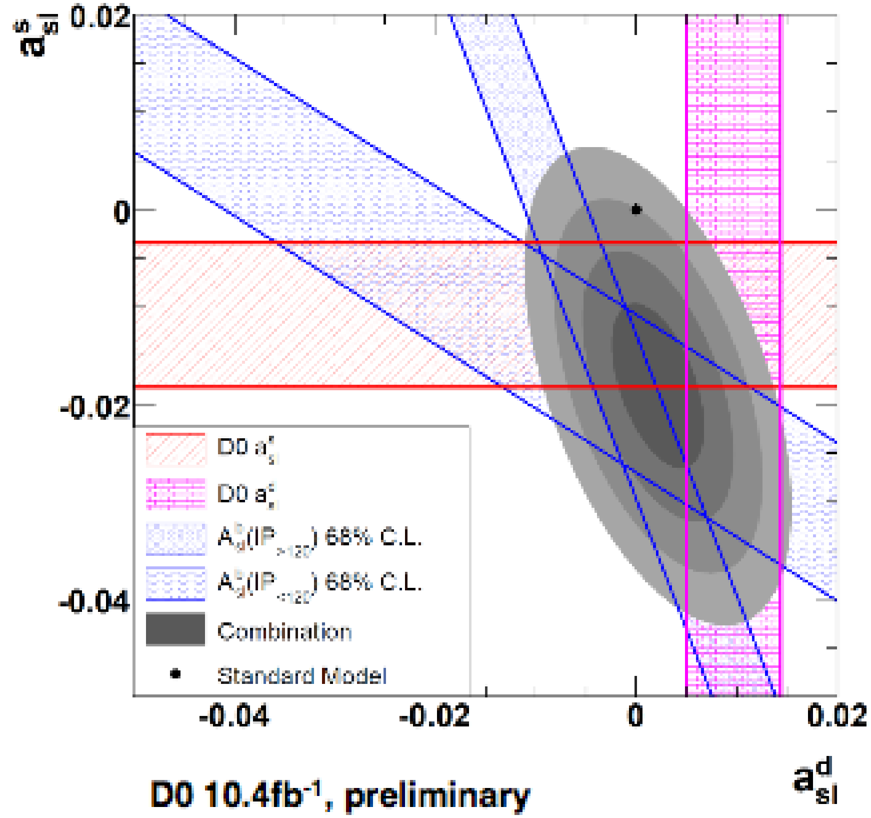
Combine D0 results from dimuon asymmetry (2011), a^d_{sl} and a^s_{sl}:

$$a^d_{\rm sl}(\text{comb.}) = (0.22 \pm 0.30)\%,$$
$$a^s_{\rm sl}(\text{comb.}) = (-1.81 \pm 0.56)\%.$$

Correlation coefficient: −0.50

χ^2/dof = **4.7/2**

p-value of SM: **0.29% (3.0σ)**



B^0 meson: consistent with SM (zero)

B_s^0 meson: **>3σ evidence** for anomalous CPV

CP violation in mixing: a_{sl}^s measurement (preliminary)

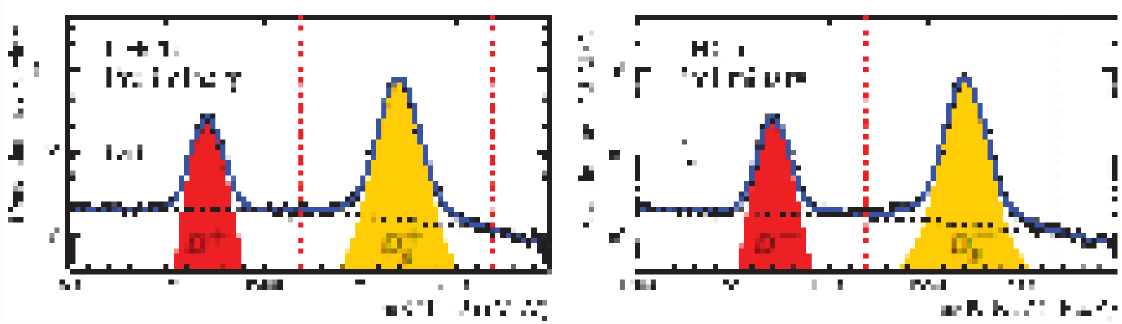
B_s^0 mixing:

$$\phi_{M/\Gamma} = \arg\left(-\frac{M_{12}}{\Gamma_{12}}\right)$$

Observable:

$$a_{sl}^s = \frac{\Gamma(\overline{B}_s^0(t) \to f) - \Gamma(B_s^0(t) \to \overline{f})}{\Gamma(\overline{B}_s^0(t) \to f) + \Gamma(B_s^0(t) \to \overline{f})} = \frac{\Delta\Gamma_s}{\Delta m_s} \tan\phi_{M/\Gamma}$$

- SM prediction: $a_{sl}^s = (1.9 \pm 0.3) \times 10^{-5}$ *(arXiv: 1205.1444)*
- Use as final state $D_s^{\pm} X \mu^{\mp} \overset{(-)}{\nu}, D_s^{\pm} \to \varphi\pi^{\pm}$



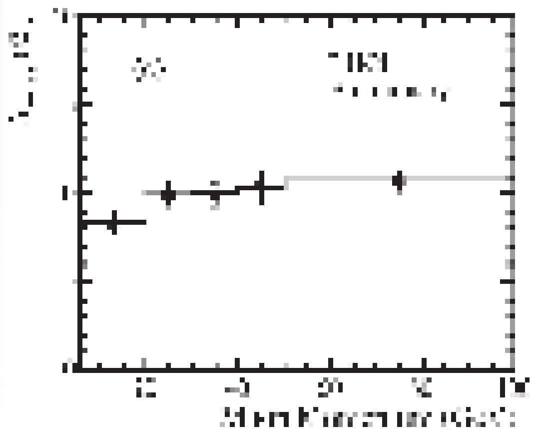
LHCb-CONF-2012-022

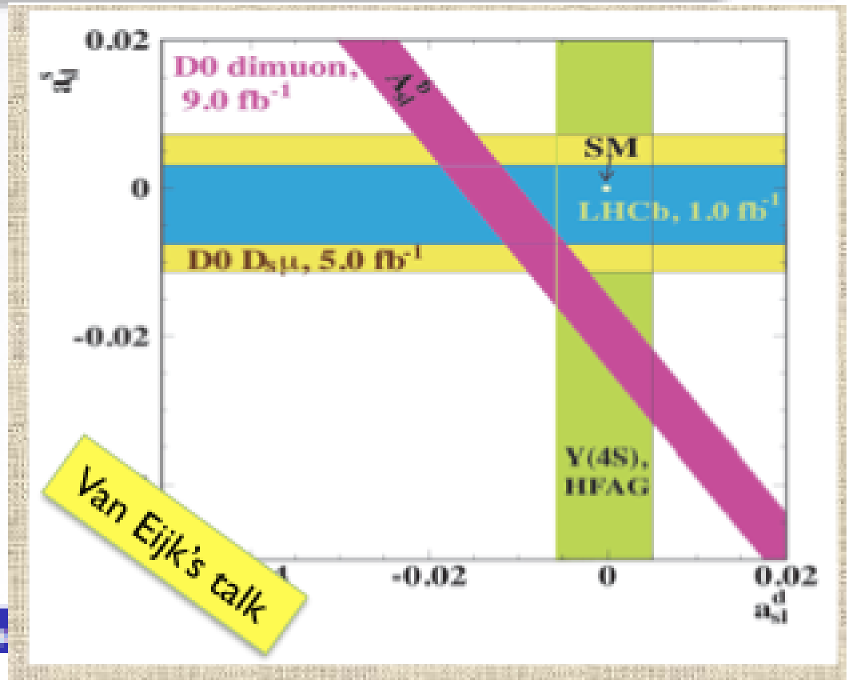
CP violation in mixing: a_{sl}^s measurement (preliminary)

$$A_{meas} = \frac{\Gamma[D_s\mu^+] - \Gamma[D_s\mu^-]}{\Gamma[D_s\mu^+] + \Gamma[D_s\mu^-]} = \frac{a_{sl}^s}{2} - \left(a_p - \frac{a_{sl}^s}{2}\right) \frac{\int_{t=0}^{\infty} e^{-\Gamma_s t} \cos(\Delta m_s t)\, \epsilon(t)\, dt}{\int_{t=0}^{\infty} e^{-\Gamma_s t} \cosh\frac{\Delta\Gamma_s t}{2}\, \epsilon(t)\, dt}$$

- Time-integrated measurement:
  - Effect of small production asymmetry eliminated due to large Δm_s
- Detection asymmetries estimated from calibration samples
- Residual detector asymmetries averaged out using magnet-up and magnet-down data (roughly equal-sized datasets)

$a_{sl}^s = (-0.24 \pm 0.54 \pm 0.33)\%$





$B_{d,s} \to K\pi$

$$A_{CP}(B^0 \to K\pi) = \frac{\Gamma(\bar{B}^0 \to K^-\pi^+) - \Gamma(B^0 \to K^+\pi^-)}{\Gamma(\bar{B}^0 \to K^-\pi^+) + \Gamma(B^0 \to K^+\pi^-)}$$

$$A_{CP}(B_s^0 \to \pi K) = \frac{\Gamma(\bar{B}_s^0 \to \pi^- K^+) - \Gamma(B_s^0 \to \pi^+ K^-)}{\Gamma(\bar{B}_s^0 \to \pi^- K^+) + \Gamma(B_s^0 \to \pi^+ K^-)}$$

- CP asymmetry is well established in $B^0 \to K\pi$
- Consider CP violation in B_s system: 14 times lower decay rate, 4 time lower production rate, stronger rejection of combinatorial background required

	$A_{CP}(B^0 \to K\pi)$	$A_{CP}(B_s^0 \to \pi K)$
BaBar[1]	$-0.107 \pm 0.018^{+0.07}_{-0.004}$	
Belle[2]	$-0.094 \pm 0.018 \pm 0.008$	
CLEO[3]	$-0.04 \pm 0.016 \pm 0.02$	
CDF[4]	$-0.086 \pm 0.023 \pm 0.009$	$0.39 \pm 0.15 \pm 0.08$
PDG	-0.097 ± 0.012	0.39 ± 0.17

[1] Phys.Rev.Lett 99 (2007) 021603

[2] Nature 452 (2008) 332

[3] Phys.Rev.Lett 85 (2000) 525

[4] Phys.Rev.Lett 106 (2011) 181802

Results

$$A_{CP}(B^0 \to K\pi) = -0.088 \pm 0.011(stat) \pm 0.008(syst)$$

- Good agreement with World Average
- Most precise measurement
- First observation $(> 6\sigma)$ of CP violation at a hadron collider

$$A_{CP}(B_s^0 \to \pi K) = 0.27 \pm 0.08(stat) \pm 0.02(syst)$$

- First evidence $[3.3\sigma]$ of CP violation in B_s decay
- Agreement with the only measurement available (CDF, Phys.Rev.Lett 106 (2011) 181802)

Results

$R^{K\pi}_{K/\pi}$	=	$0.0774 \pm 0.0012 \pm 0.0018$
$R^{KK}_{K/\pi}$	=	$0.0773 \pm 0.0030 \pm 0.0018$
$R^{\pi\pi}_{K/\pi}$	=	$0.0803 \pm 0.0056 \pm 0.0017$
$A^{K\pi}_{\pi}$	=	$-0.0001 \pm 0.0036 \pm 0.0095$
$A^{K\pi}_{K}$	=	$0.0044 \pm 0.0144 \pm 0.0174$
A^{KK}_{K}	=	$0.1480 \pm 0.0369 \pm 0.0097$
$A^{\pi\pi}_{K}$	=	$0.1351 \pm 0.0661 \pm 0.0096$
A^{KK}_{π}	=	$-0.0194 \pm 0.0091 \pm 0.0116$
$A^{\pi\pi}_{\pi}$	=	$-0.0009 \pm 0.0165 \pm 0.0094$
R^{-}_{K}	=	$0.0073 \pm 0.0023 \pm 0.0004$
R^{+}_{K}	=	$0.0233 \pm 0.0034 \pm 0.0007$
R^{-}_{π}	=	$0.00410 \pm 0.00038 \pm 0.00005$
R^{+}_{π}	=	$0.00352 \pm 0.00033 \pm 0.00007$

Total significance of 5.8σ: direct CP violation in $B^+ \to DK^+$ is observed

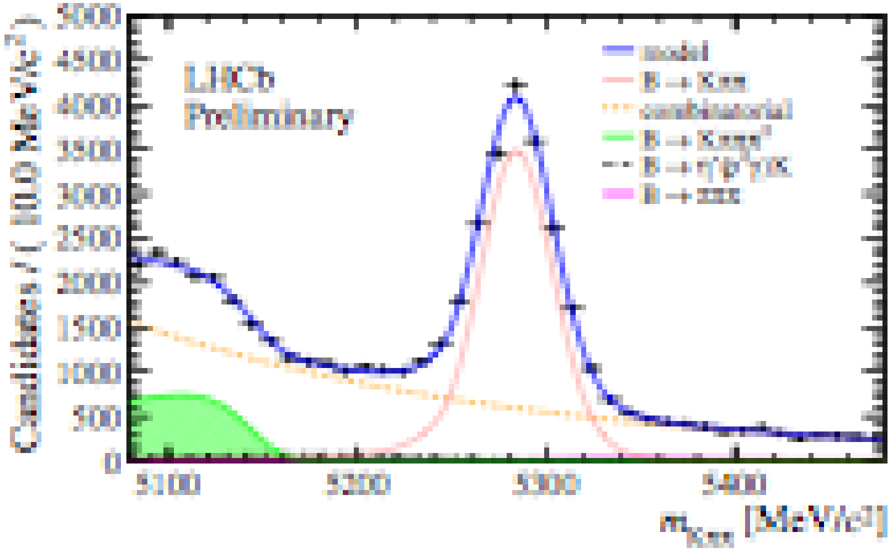
GLW observables

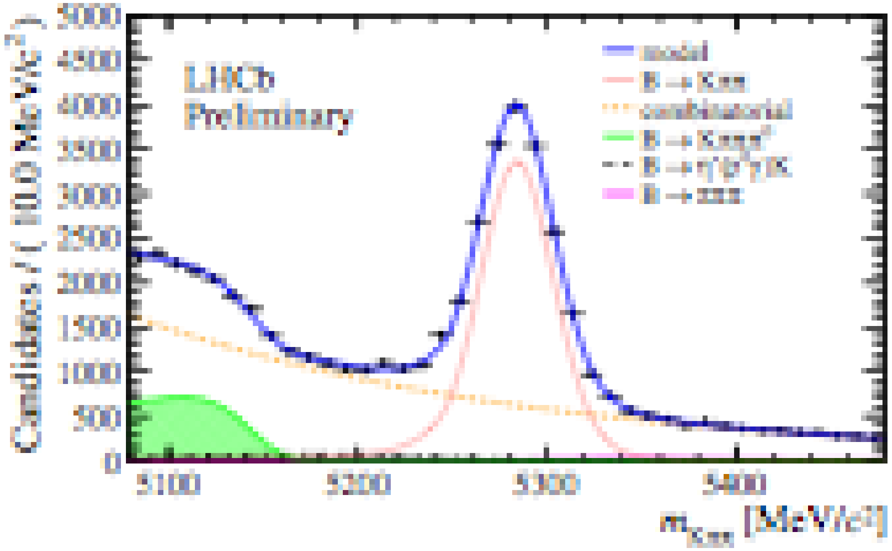
- $R_{CP+} =< R^{KK}_{K/\pi}, R^{\pi\pi}_{K/\pi} > / R^{K\pi}_{K/\pi} =$ $1.007 \pm 0038 \pm 0.012$
- $A_{CP+} =< A^{KK}_{K}, A^{\pi\pi}_{K} >= 0.145 \pm 0.032 \pm 0.010$
- Both KK and $\pi\pi$ modes show positive asymmetries
- The combined asymmetry significance is 4.5σ

ADS observables

- $R_{ADS(K)} = 0.0152 \pm 0.0020 \pm 0.0004$
- $A_{ADS(K)} = -0.520 \pm 0.150 \pm 0.021$
- $R_{ADS(\pi)} = 0.00410 \pm 0.00025 \pm 0.00005$
- $A_{ADS(\pi)} = 0.143 \pm 0.062 \pm 0.011$
- $B \to D_{ADS}K$ observed with 10σ and evidence (4σ) of negative asymmetry
- $B \to D_{ADS}\pi$ shows hint of positive asymmetry (2.4σ)

CP asymmetry in $B^+ \to K^+\pi^+\pi^-$





$N(B^-) = 18168 \pm 170$

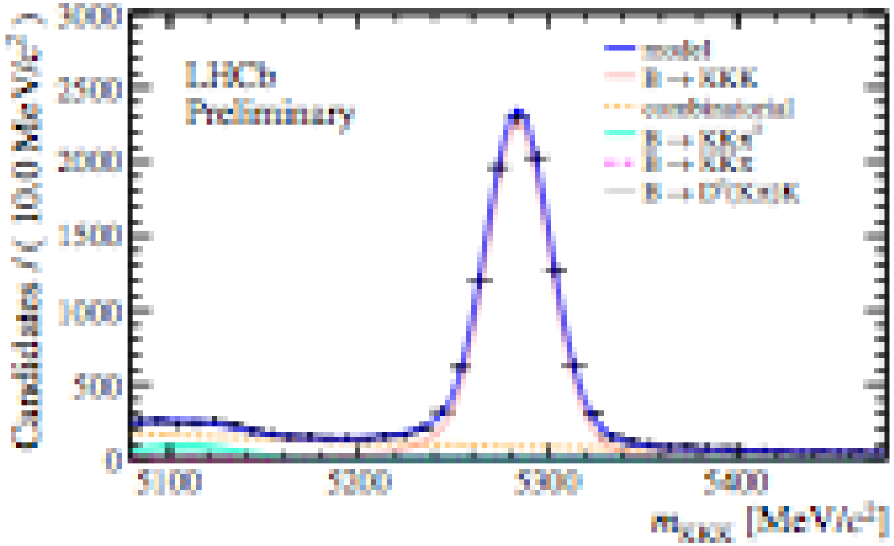
$N(B^+) = 17540 \pm 169$

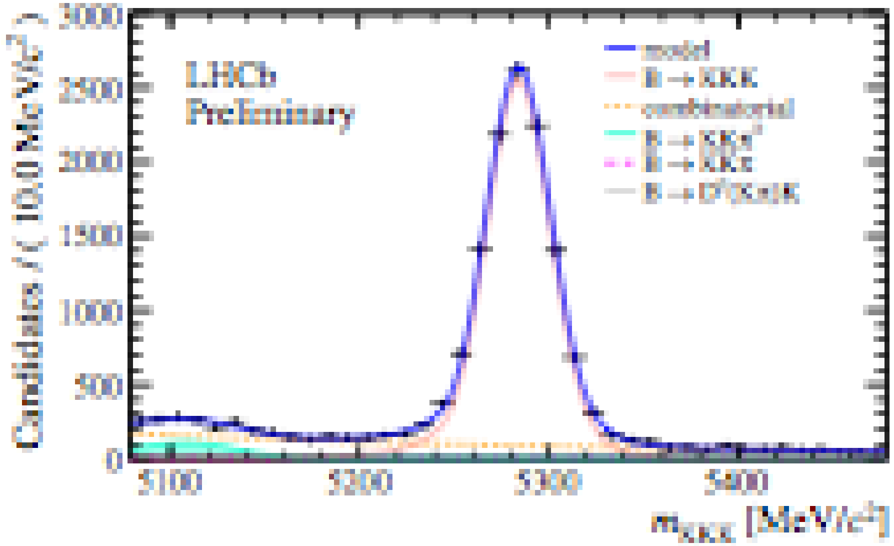
Preliminary

$$A_{CP}(K\pi\pi) = A_{CP}^{RAW}(K\pi\pi) - A_{CP}^{RAW}(J/\psi K) + A_{CP}(J/\psi K) =$$
$$= +0.034 \pm 0.009(stat) \pm 0.004(syst) \pm 0.007(J/\psi K)$$

Significance of 1.8σ

CP asymmetry in $B^+ \to K^+K^+K^-$





$N(B^-) = 11606 \pm 117$

$N(B^+) = 10289 \pm 110$

Preliminary

$$A_{CP}(KKK) = A_{CP}^{RAW}(KKK) - A_{CP}^{RAW}(J/\psi K) + A_{CP}(J/\psi K) =$$
$$= -0.046 \pm 0.009(stat) \pm 0.005(syst) \pm 0.007(J/\psi K)$$

First evidence of inclusive CP asymmetry in charmless three-body B^+ decays (Significance of 3.7σ)

$D^0 \to KK$ and $D^0 \to \pi\pi$ CP asymmetries

- Predicted to be small in the SM
  - early predictions were less than 10^{-4}
  - but predictions for charm are difficult.
- Real difficulty is to cancel detector induced asymmetries.
- The *KK* and $\pi\pi$ asymmetries are of opposite sign in SM
  - the difference is particularly sensitive
  - and most detector asymmetries cancel in the difference
- Use $D^{*+} \to D^0 \pi^+$ and c.c. to tag D^0 production flavor.

http://www-cdf.fnal.gov/physics/new/bottom/120216.blessed-CPVcharm10fb/

http://www-cdf.fnal.gov/physics/new/bottom/100916.blessed-Dpipi6.0/

Individual Mode Asymmetries

$$A_{CP}(\pi^+\pi^-) = [0.22 \pm 0.24(\text{stat}) \pm 0.11(\text{sys})]\,\%$$

$$A_{CP}(K^+K^-) = [-0.24 \pm 0.22(\text{stat}) \pm 0.09(\text{sys})]\,\%$$

World's best measurements.

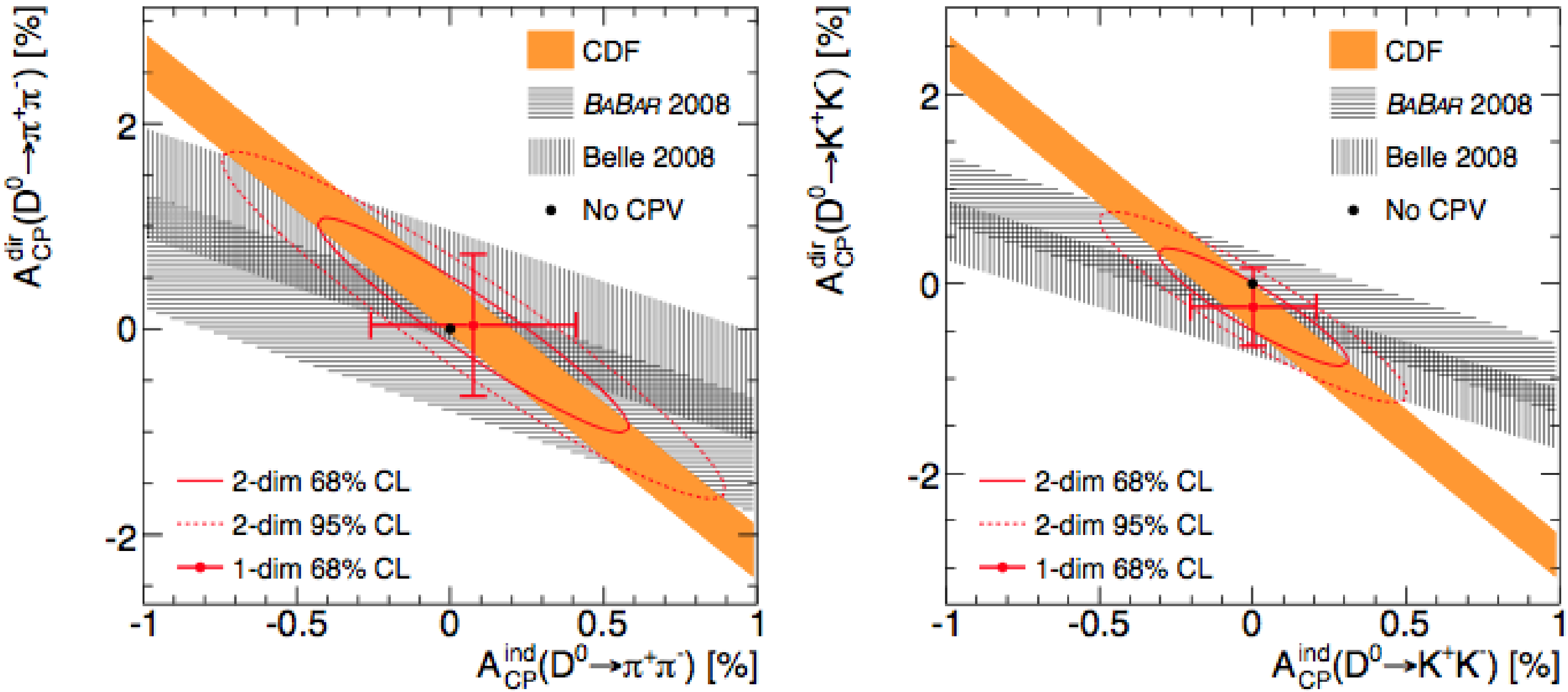
Measured CP asymmetry is a combination of direct and indirect CP asymmetries.

$$A_{CP} = A_{CP}^{\text{dir}} + \int_0^\infty A_{CP}(t)D(t)dt \approx A_{CP}^{\text{dir}} + \frac{\langle t \rangle}{\tau} A_{CP}^{\text{ind}}$$

Line in the direct-indirect asymmetry plane.

Charm Asymmetries:

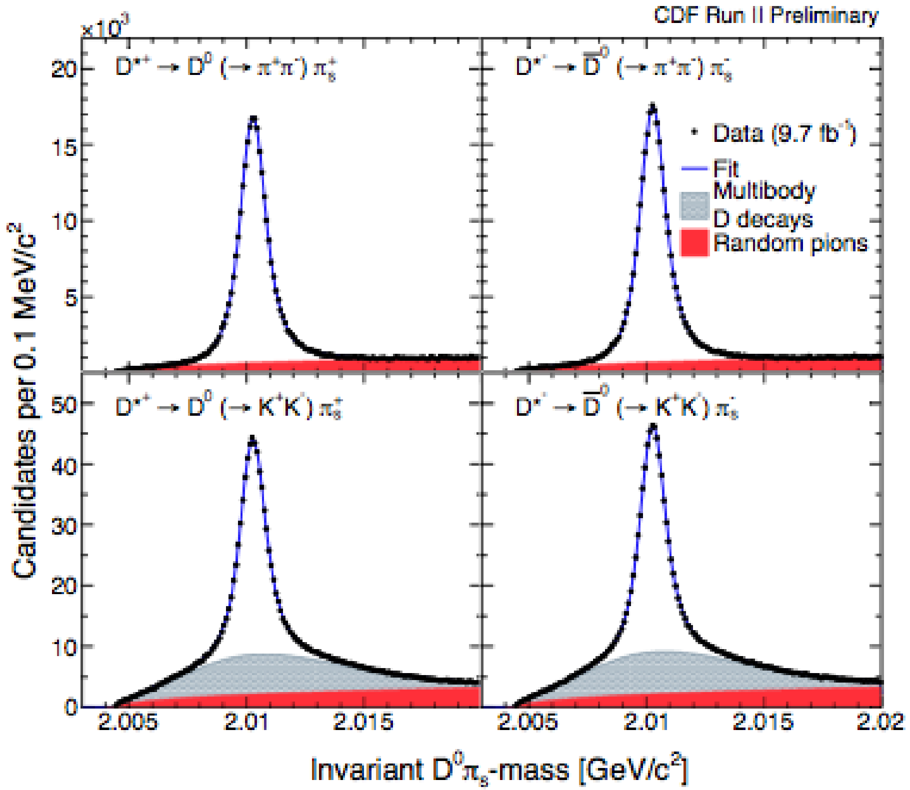
- 2010 – 2011: CDF measures ACP in $D^0 \rightarrow \pi\pi$ and $D^0 \rightarrow KK$ separately PRD 85, 012009 (2012)



CDF: Charm Detector Facility?

CDF ΔA_{CP} Measurement:

- For ΔA_{CP} measurement, selection can be loosened, and full data set used → more than doubling the statistics.
- Cross check with data binned in different η, ϕ regions.

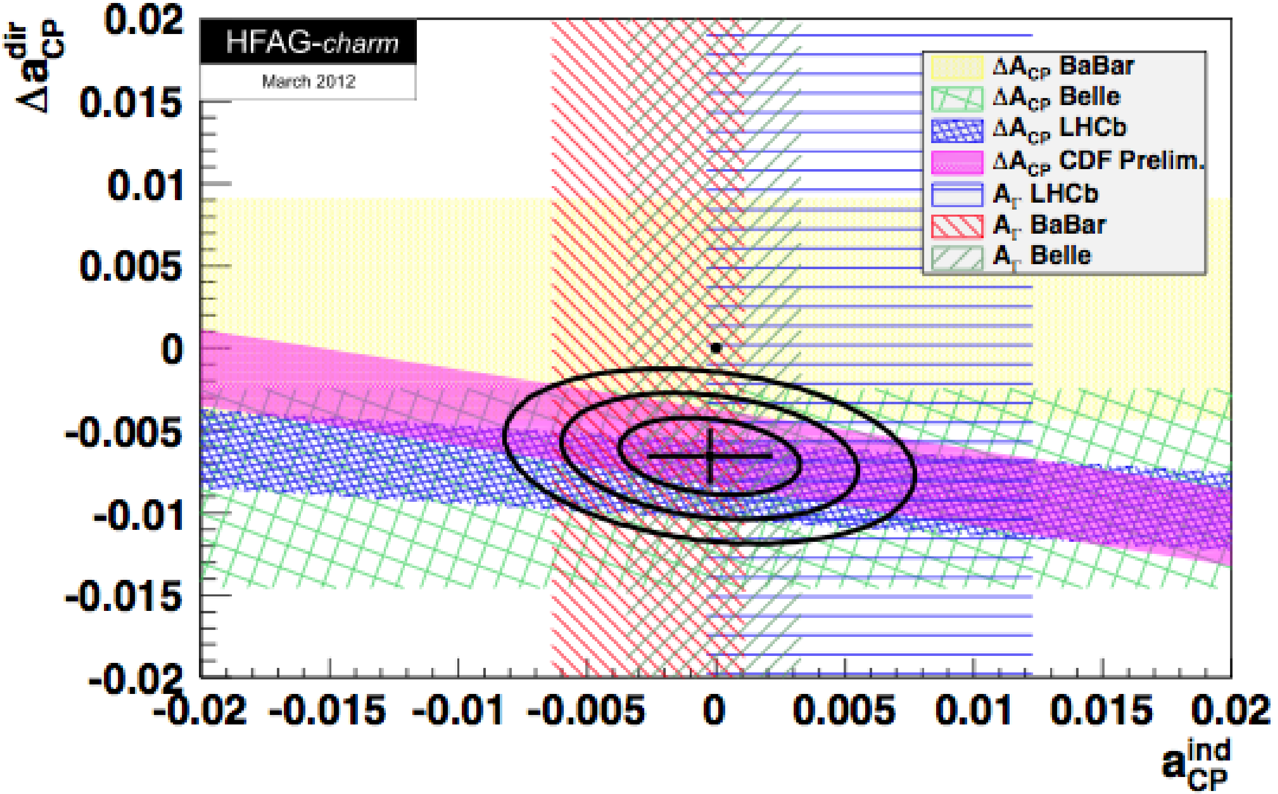


$$\Delta A_{CP} = (-0.62 \pm 0.21 \pm 0.10)\%$$

arXiv:1207.2158

HFAG Combination of All ΔA_{CP} Results

$$A_{CP}^{\text{ind}} = (-0.03 \pm 0.23)\%$$
$$A_{CP}^{\text{dir}} = (-0.66 \pm 0.15)\%$$



Rare, or forbidden processes

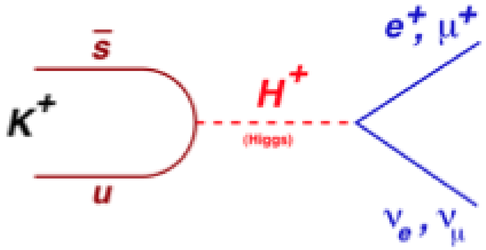
R_K beyond the SM: SUSY

SUSY (MSSM framework) produces sizeable effects to R_K(SM)

➔ R-parity is the source of Lepton Universality violating effects

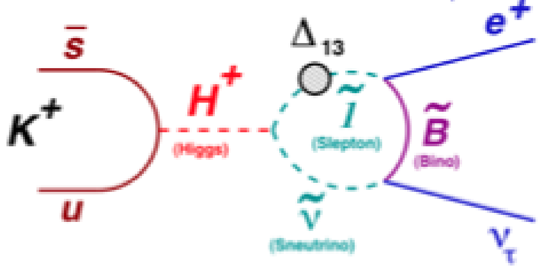
➔ 2 Higgs Doublets Model (A. Masiero, P. Paradisi, R. Petronzio, PRD74 (2006) 011701, JHEP 0811 (2008) 042)

2HDM – tree level: K_{l2} proceeds via exchange of sizeable charged Higgs $H^{\pm}$ instead of $W^{\pm}$



2HDM – one-loop level: $H^{\pm}$ mediated LFV terms with emission of ν_τ are the dominant contribution to ΔR_K

$$R_K^{LFV} \approx R_K^{SM}\left[1+\left(\frac{m_K^4}{m_{H^\pm}^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right)|\Delta_{13}|^2 \tan^6\beta\right]$$



Δ_{13} ➔ mixing parameter of superpartners of right-handed leptons
➔ LFV term connected to Helicity suppression in K_{e2}
$\tan\beta$ ➔ ratio of the two Higgs vacuum expectation values

At large $\tan\beta$ values with a massive $H^{\pm}$, LFV contributions dominate and produce sizable O(1%) effects to R_K

(Ex.: $\Delta_{31}=5\times10^{-4}$, $\tan\beta=40$ and $M_H=500$ GeV/c^2 → $R_K^{LFV} = R_K^{SM}$ (1+0.013))

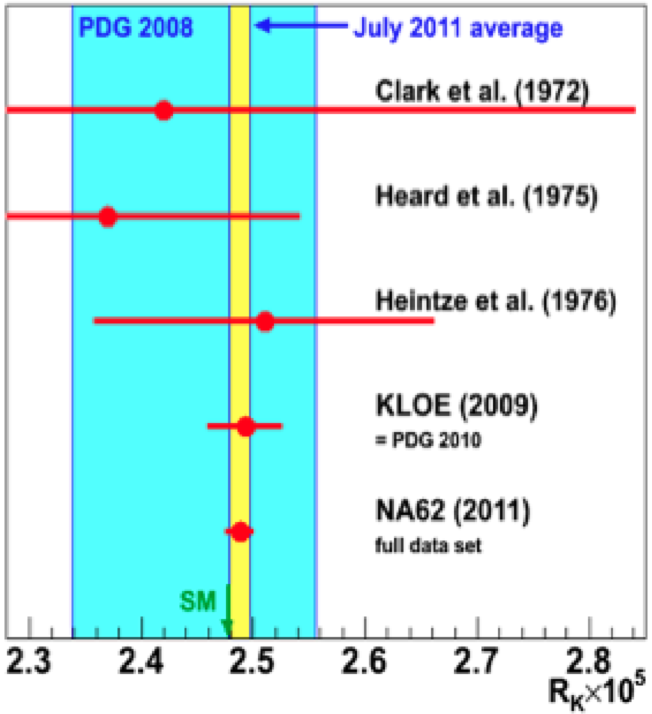
R_K World Average

PDG'08 (1970s measurements): $R_K=(2.45\pm0.11)\times10^{-5}$ $(\delta R_K/R_K=4.5\%)$

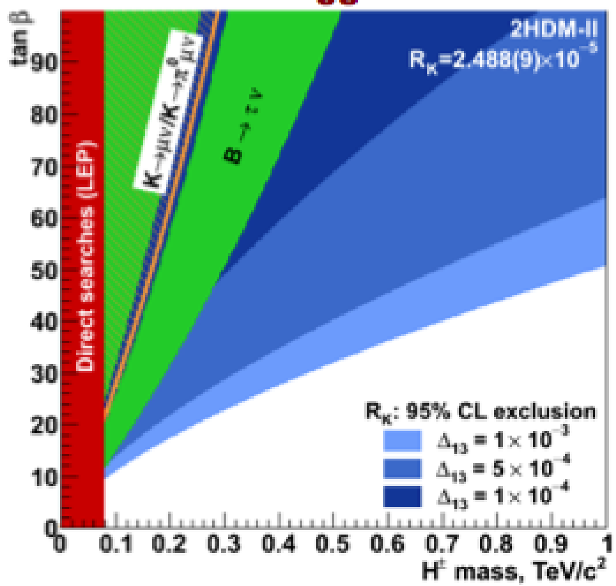
KLOE (LNF), 2009: $R_K=(2.493\pm0.031)\times10^{-5}$, 13.8K K_{e2} 15% bkgd $(\delta R_K/R_K=1.3\%)$

NA62 (CERN), 2011: $R_K=(2.487 \pm 0.013)\times10^{-5}$, ≈60K K_{e2} ≈9% bkgd $(\delta R_K/R_K=0.7\%)$

July 2011 World Average: $R_K=(2.488\pm0.009)\times10^{-5}$ $(\delta R_K/R_K=0.4\%)$

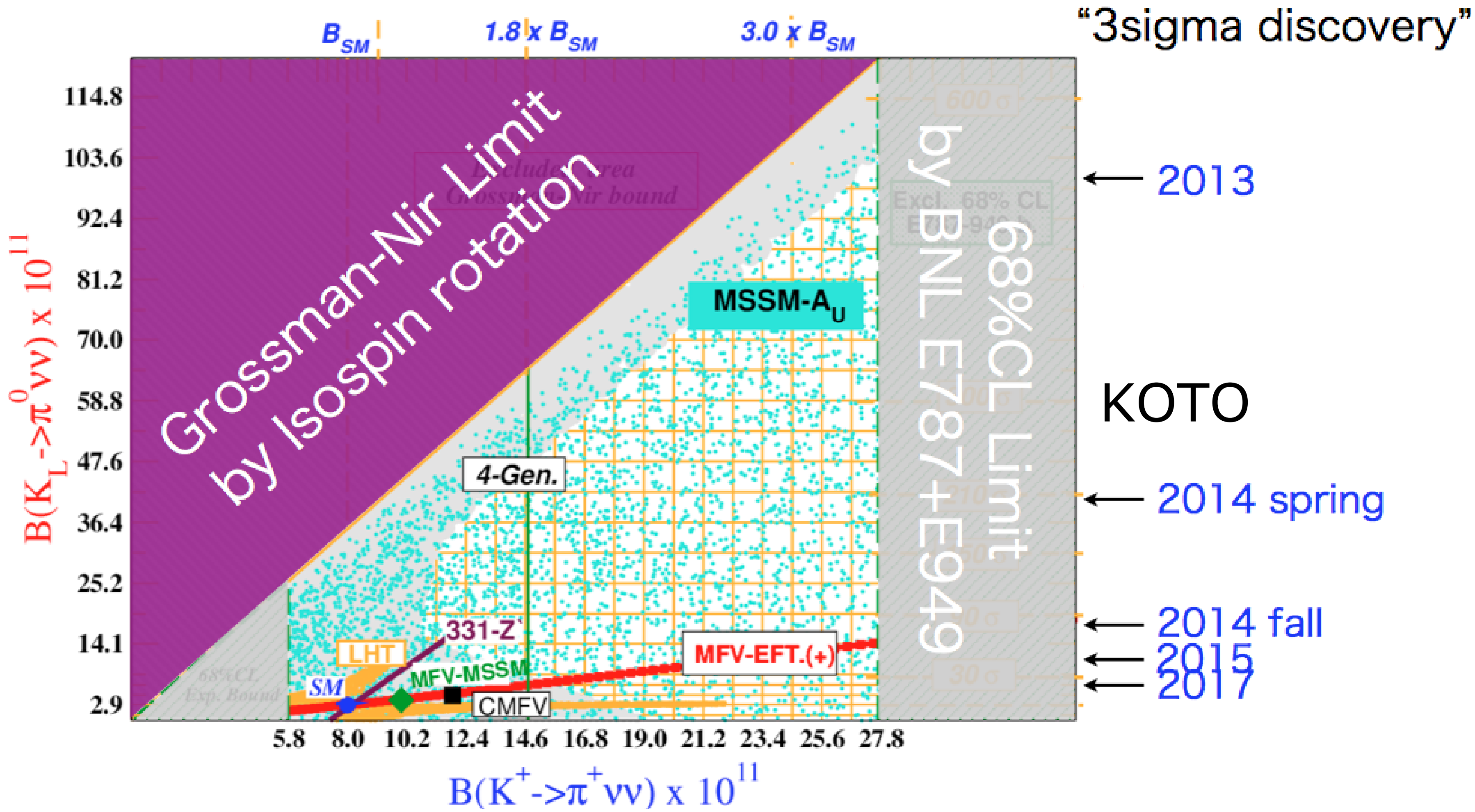


Constraints to 2 Higgs Doublets Model



➔ for non-tiny values of the LFV slepton mixing Δ_{13}, the sensitivity to $H^{\pm}$ in R_K is better than in $B\to\tau\nu$

Prospect
Kaons rare decays



NA62: 10% measurement by 2015-2016

ORKA: 5% measurement in 5 years (in ~10 years from now)

Sensitivity to New Physics

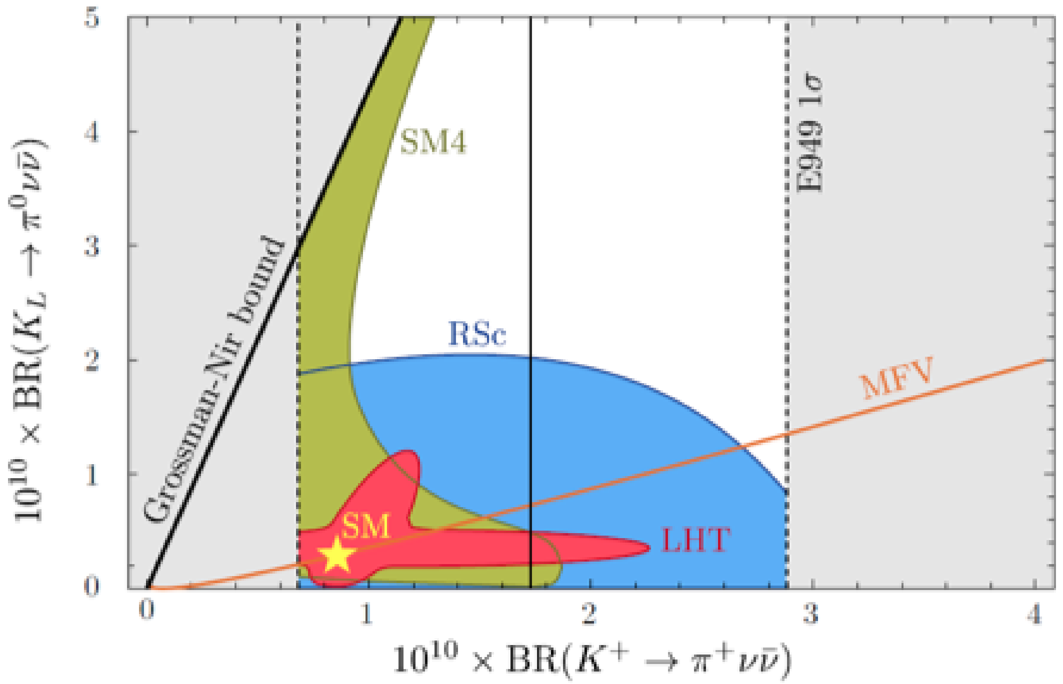


Figure 1: Correlation between the branching ratios of $K_L \to \pi^0 \nu\bar{\nu}$ and $K^+ \to \pi^+ \nu\bar{\nu}$ in MFV and three concrete NP models. The gray area is ruled out experimentally or model-independently by the GN bound. The SM point is marked by a star.

D.M. Straub, CKM 2010 Workshop, arXiv:1012.3893[hep-ph]

Project-X Enabled Physics

Kaon Physics:

Stage2

Rich and varied experimental opportunities

- $K^+ \to \pi^+ \nu \bar{\nu}$ — >1000 events, Precision rate and form factor.
- $K_L \to \pi^0 \nu \bar{\nu}$ — >1000 events, enabled by high flux & precision TOF.
- $K^+ \to \pi^0 \mu^+ \nu$ — Measurement of T-violating muon polarization.
- $K^+ \to (\pi, \mu)^+ \nu_x$ — Search for anomalous heavy neutrinos.
- $K^0 \to \pi^0 e^+ e^-$ — <10% measurement of CP violating amplitude.
- $K^0 \to \pi^0 \mu^+ \mu^-$ — <10% measurement of CP violating amplitude.
- $K^0 \to X$ — Precision study of a pure K^0 interferometer:
- Reaching out to the Plank scale ($\Delta m_K / m_K \sim 1/m_P$)
- $K_L \to \mu^\pm e^\pm$ — Next generation Lepton Flavor Violation experiments
- $K^0, K^+ \to \mathrm{LFV}$

...and more

Day-1 Experiment: ORKA

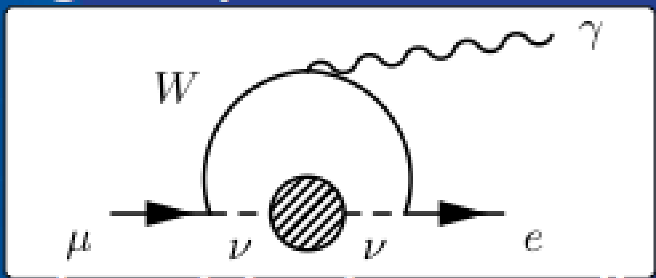
Lepton Mixing in the Standard Model

- We have three generations of leptons:

$$\begin{pmatrix} e \\ \nu_e \end{pmatrix} \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix} \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}$$

No SM couplings between generation!

- In the standard model Lagrangian there is no coupling to mixing between generations
- But we have explicitly observed *neutrino oscillations*
- *Thus charged lepton flavor is **not** conserved.*
- Charged leptons must mix through neutrino loops



$$Br(\mu \to e\gamma) = \frac{3\alpha}{32\pi} \left| \sum_\ell V^\star_{\mu\ell} V_{e\ell} \frac{m^2_{\nu_\ell}}{M^2_W} \right|^2$$

$$\leq 10^{-54}$$

- But the mixing is so small, it's effectively forbidden

General CLFV Lagrangian

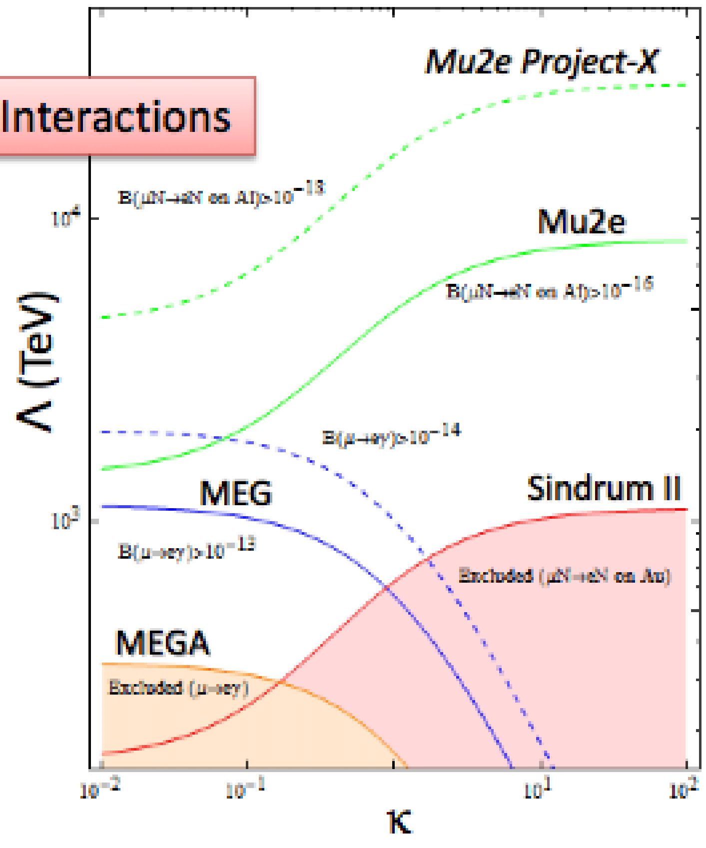
- Recharacterize these all these interactions together in a model independent framework:

Loops

Contact Interactions

$$\mathcal{L}_{CFV} = \frac{m_\mu}{(\kappa+1)\Lambda^2}\bar{\mu}_R\sigma_{\mu\nu}e_L F^{\mu\nu} + \frac{\kappa}{(1+\kappa)\Lambda^2}\bar{\mu}_L\gamma_\mu e_L\left(\bar{u}_L\gamma^\mu u_L + \bar{d}_L\gamma^\mu d_L\right)$$

  - Splits CLFV sensitivity into
    - Loop terms
    - Contact terms
  - Shows dipole, vector and scalar interactions
  - Allows us to parameterize the effective mass scale ¤ in terms of the dominant interactions
  - The balance in effective reach shifts between favoring 1N!eN and 1!e° measurements .
  - For contact term dominated interaction (large κ) the sensitivity in Λ, reaches upwards of 10^4 TeV for the coherent conversion process

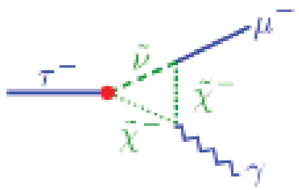


τ physics

$\sigma(e^+e^- \to \tau^+\tau^-)_{\sqrt{s}=M(Y(4S))} \sim \sigma(e^+e^- \to Y(4S) \to B\bar{B})$ ➔ SuperB is a tau factory

- Lepton flavor violation

ν mixing leads to $BF \sim 10^{-54}$
→ Enhancement to observable levels possible with new physics

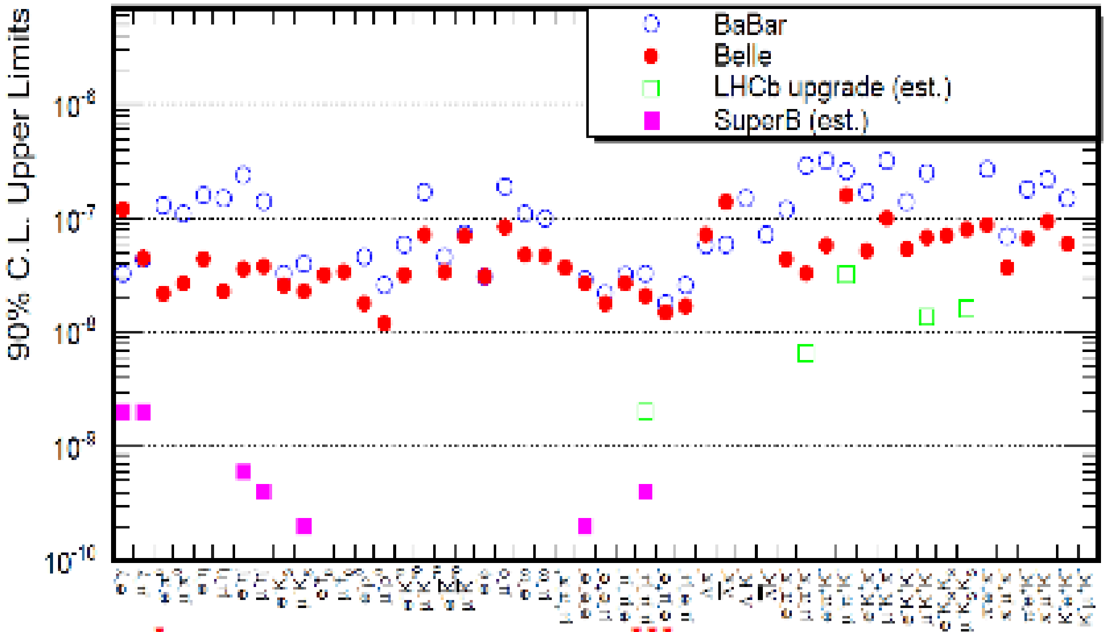


- CP violation
- precision $|V_{us}|$ measurement
- τ g-2
- τ EDM

Up to two orders of magnitude improvement at SuperB over current limits

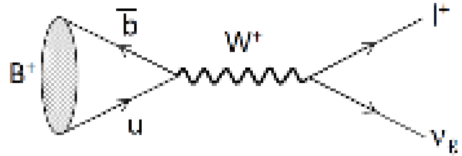
Hadron machines are in general not competitive

e^- beam polarization helps suppress background or discriminate among NP models

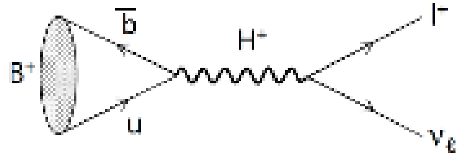


$B \to \tau\nu$: motivation

- $B(B \to l\nu) = \frac{G_F{}^2 m_B}{8\pi} m_l{}^2 \left(1 - \frac{m_l{}^2}{m_B{}^2}\right)^2 f_B{}^2 |V_{ub}|^2 \tau_B$



- Leptonic B decays to test SM predictions.
  - Very clean theoretically.
  - Uncertainties from f_B and $|V_{ub}|$. Lattice QCD talk
  - $B \to \mu\nu$ and $B \to e\nu$ out of reach at current B factories.
- Probe of physics beyond the SM.
  - Decay can be mediated by a charged Higgs.
- $B(B \to l\nu)_{2HDM} = B(B \to l\nu)_{SM} \left(1 - \tan^2\beta \frac{m_B{}^2}{m_H{}^2}\right)^2$



$B \rightarrow \tau\nu$: result discussion

- New BABAR result:
  - $B(B \rightarrow \tau\nu) = \left(1.83\ {}^{+0.53}_{-0.49} \pm 0.24\right).10^{-4}$ — 468 M $B\bar{B}$
- Comparison with other measurements:

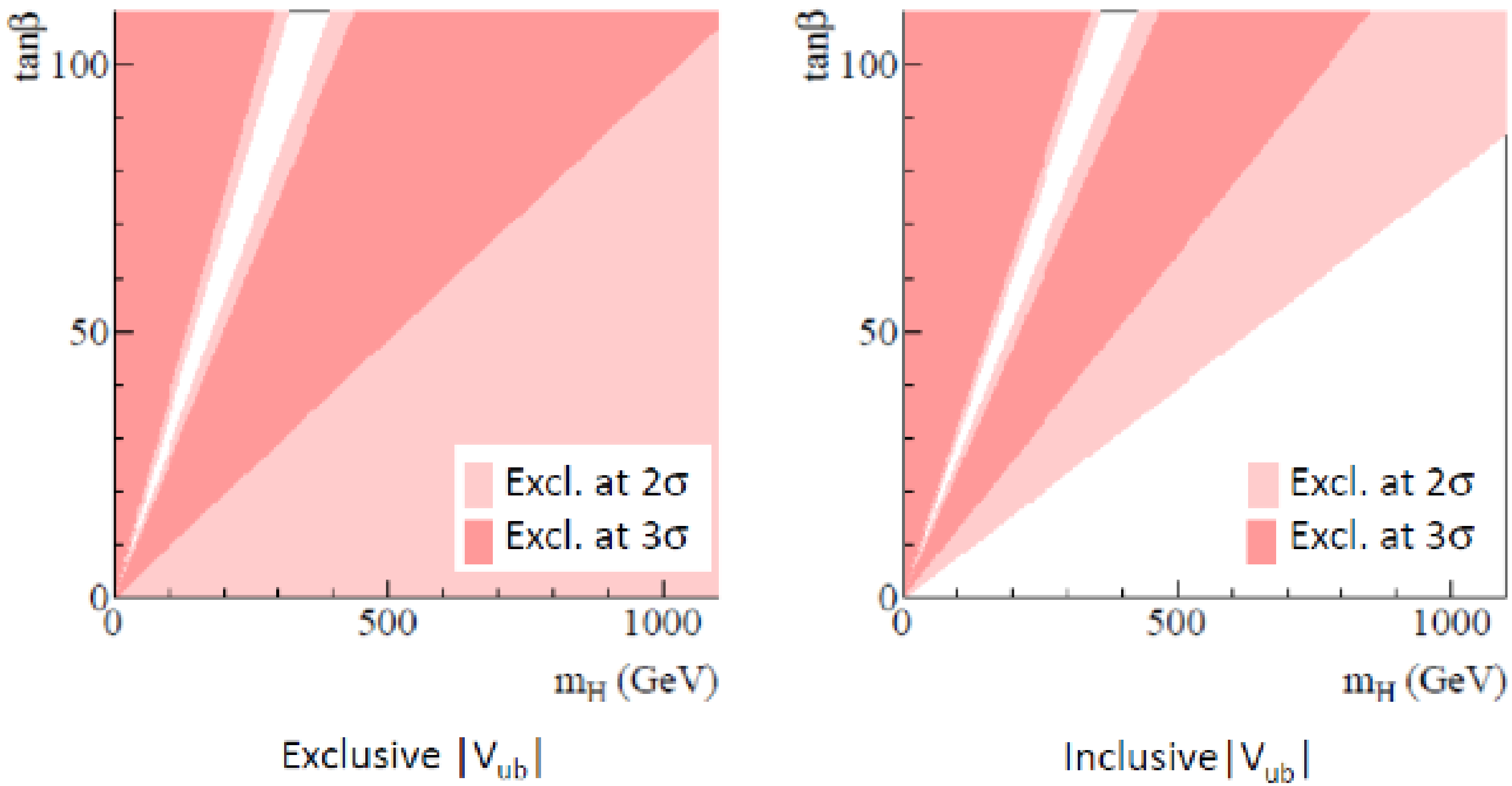
Experiment	Tag	Branching Fraction ($\times 10^{-4}$)	
BABAR	hadronic [8]	$1.8^{+0.9}_{-0.8} \pm 0.4 \pm 0.2$	383 M $B\bar{B}$
BABAR	semileptonic [9]	$1.7 \pm 0.8 \pm 0.2$	459 M $B\bar{B}$
Belle	hadronic [10]	$1.79^{+0.56}_{-0.49}{}^{+0.46}_{-0.51}$	449 M $B\bar{B}$
Belle	semileptonic [11]	$1.54^{+0.38}_{-0.37}{}^{+0.29}_{-0.31}$	657 M $B\bar{B}$

  - BELLE (ICHEP 2012): $B(B \rightarrow \tau\nu) = \left(0.72\ {}^{+0.27}_{-0.25} \pm 0.11\right).10^{-4}$ — 722 M $B\bar{B}$

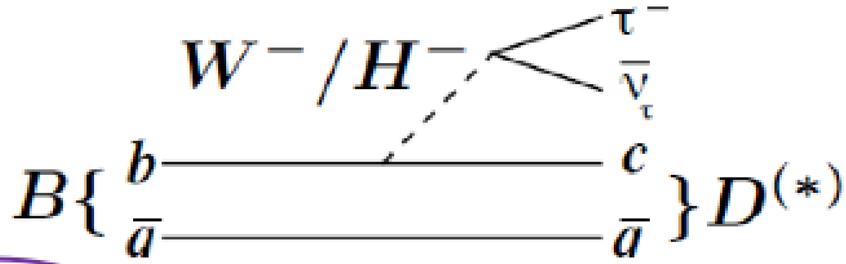
- Comparison with SM prediction (using $f_B = (189 \pm 4)$ MeV): HPQCD arXiv:1202.4914
  - 2.4 σ with $B_{SM}(B \rightarrow \tau\nu) = (0.62\ \pm 0.12).10^{-4}$ ($|V_{ub}|$ exclusive PoS(EPS-HEP2011)155).
  - 1.6 σ with $B_{SM}(B \rightarrow \tau\nu) = (1.18\ \pm 0.16).10^{-4}$ ($|V_{ub}|$ inclusive arXiv:1112.0702).

$B \to \tau \nu$: constraints in 2HDM (II)

- Most of the parameter space excluded at 95% CL with exclusive $|V_{ub}|$.
- 95% CL exclusion up to 1 TeV at very high $\tan\beta > 70$ with inclusive $|V_{ub}|$.



B → D$^{(*)}$ τ ν : motivation



- Semileptonic decays with a τ.

$$\frac{d\Gamma_\tau}{dq^2} = \frac{G_F^2 |V_{cb}|^2 |p_{D^{(*)}}| q^2}{96\pi^3 m_B^2} \left(1 - \frac{m_\ell^2}{q^2}\right)^2 \left[(|H_+|^2 + |H_-|^2 + |H_0|^2) \left(1 + \frac{m_\ell^2}{2q^2}\right) + \frac{3m_\ell^2}{2q^2} |H_s|^2 \right]$$

only for B → D* τ ν

H$^-$ enters here

- Test the SM by measuring the ratios:
  $R(D) = \frac{B(\bar{B}\to D\tau\nu)}{B(\bar{B}\to Dl\nu)}$ and $R(D^*) = \frac{B(\bar{B}\to D^*\tau\nu)}{B(\bar{B}\to D^*l\nu)}$.
  - Several theoretical and experimental uncertainties cancel in the ratio.

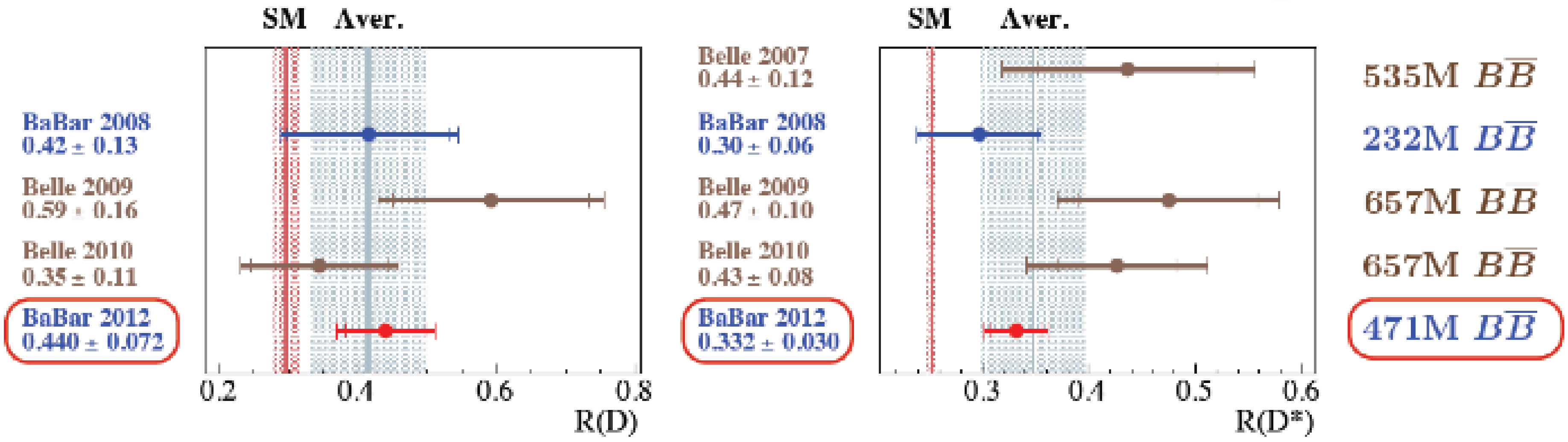
- Sensitive to additional amplitudes.
  - Charged Higgs (entering through the scalar amplitude).

$B \to D^{(*)} \tau \nu$: results and comparison to previous measurements

Decay	N_{sig}	N_{norm}	$R(D^{(*)})$	$\mathcal{B}(B \to D^{(*)}\tau\nu)$ (%)	$\Sigma_{tot}(\sigma)$
$D\tau^-\overline{\nu}_\tau$	489 ± 63	2981 ± 65	$0.440 \pm 0.058 \pm 0.042$	$1.02 \pm 0.13 \pm 0.11$	6.8
$D^*\tau^-\overline{\nu}_\tau$	888 ± 63	11953 ± 122	$0.332 \pm 0.024 \pm 0.018$	$1.76 \pm 0.13 \pm 0.12$	13.2

- **First 5σ observation of B→Dτν**
- **Agreement** with **previous measurements**

Average does not include this analysis

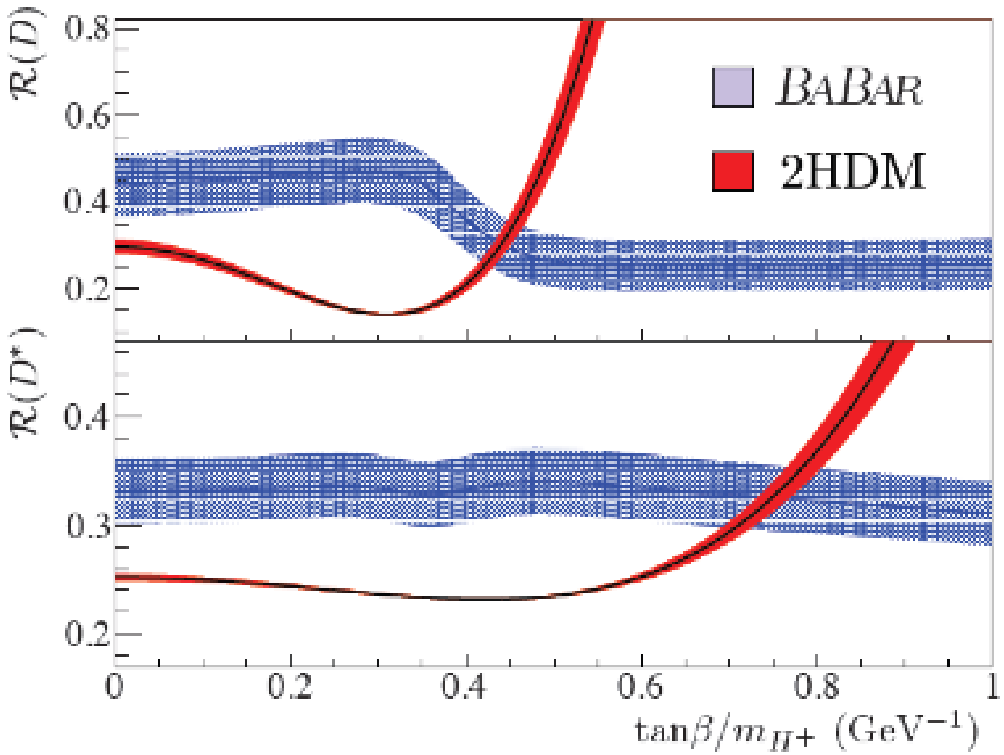


$B \to D^{(*)} \tau \nu$: 2HDM

R(D) and R(D*) are Not independent

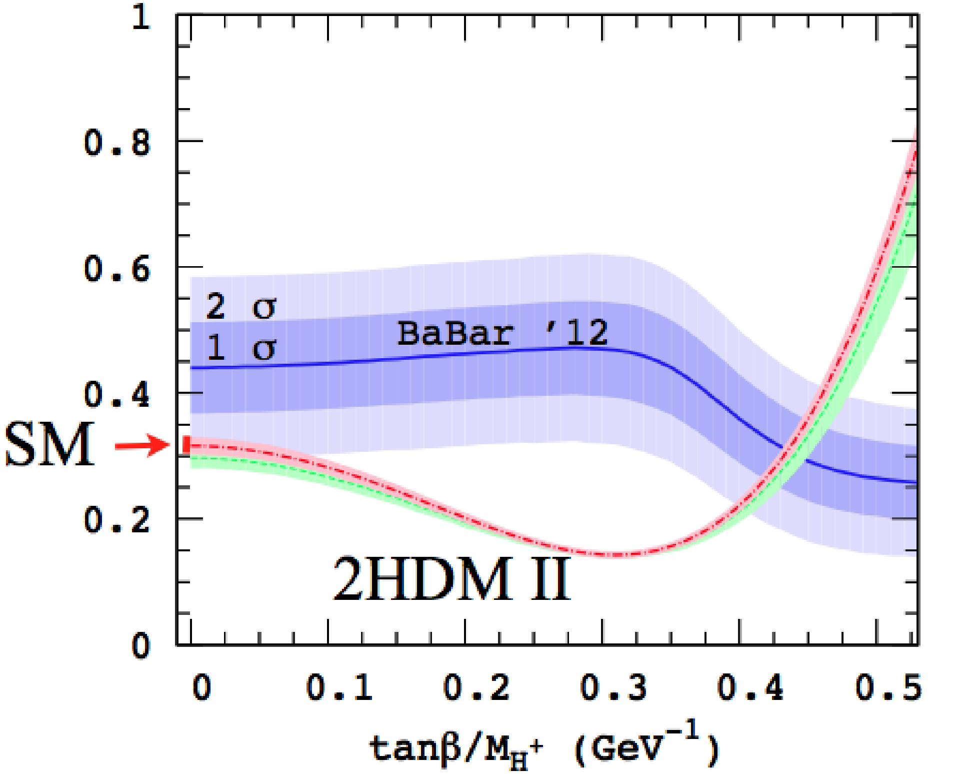
- A charged Higgs of spin 0 will affect H_s and modify $R(D^{(*)})$.
- Data match 2DHM type II at
  - $\tan\beta/m_H = 0.44 \pm 0.02$ for R(D)
  - $\tan\beta/m_H = 0.75 \pm 0.04$ for R(D*)
- Combination excludes 2HDM type II with a probability greater than 99.8% provided $m_H > 10$ GeV.

$$H_s^{2HDM} \approx H_s^{SM} \times \left(1 - \frac{\tan^2\beta}{m_{H^+}^2} \frac{q^2}{1 \mp m_c/m_b}\right)$$



Form factor ratio $R(D) = \mathrm{Br}(B \to D\tau\nu)/\mathrm{Br}(B \to D\ell\nu)$

FNAL/MILC (arXiv:1206.4992, PRL)



2HDM II with FNAL/MILC form factors (band includes sys. error)

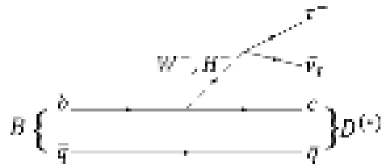
FNAL/MILC form factors: from partial data set used in arXiv:1202.6346

2 HDM II with form factors using quenched LQCD, HQS, kinematic constraints, ...

- similar estimate for $R(D)_{SM}$ by Becirevic, Kosnik, Tayduganov (arXiv: 1206.4977)
- $R(D^*)$: need four form factors, larger discrepancy with SM

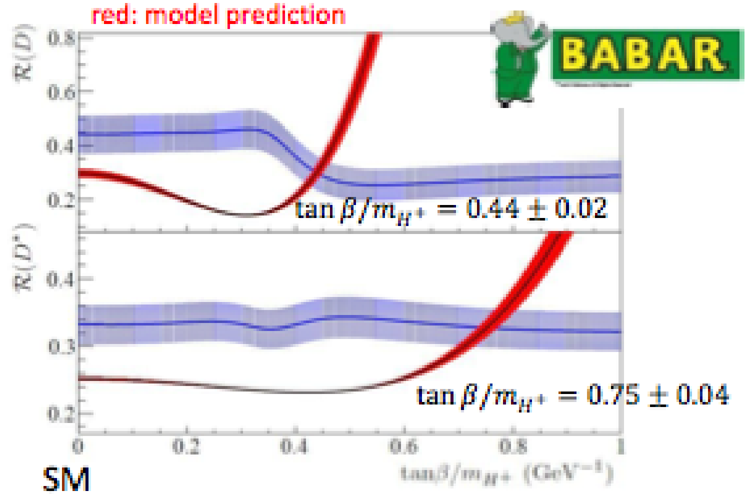
$B \to D^{(*)}\tau\nu$ and $B \to \tau\nu$

BaBar measurement of
$\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau$, 0.43 ab^{-1}



see G. Vasseur tomorrow

arXiv:1205.5442 sub. to PRL
blue: measured R vs model parameter
red: model prediction



SM

SM calc.

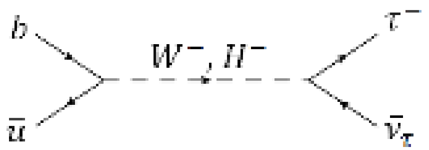
$$R(D) = \frac{BF(\bar{B} \to D\tau^-\bar{\nu}_\tau)}{BF(\bar{B} \to Dl^-\bar{\nu}_l)} = 0.440 \pm 0.072 \qquad 0.297 \pm 0.017$$

$$R(D^*) = \frac{BF(\bar{B} \to D^*\tau^-\bar{\nu}_\tau)}{BF(\bar{B} \to D^*l^-\bar{\nu}_l)} = 0.332 \pm 0.029 \qquad 0.252 \pm 0.003$$

$R(D) + R(D^*)$ inconsistent with SM (3.4σ) and exclude the type II 2 Higgs doublet model with 99.8% CL

More data needed. Cannot be measured at hadron colliders (neutrinos in final state)

$B^- \to \tau^-\bar{\nu}_\tau$



$$BF_{2HDM-II} = BF_{SM} \times (1 - \tan\beta^2 m_B^2/m_H^2)^2$$

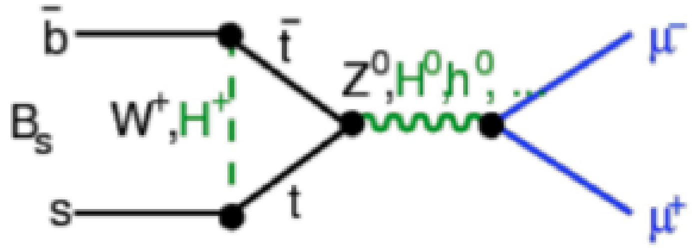
decay mode	expected BF_{SM}	2012 $\sigma(BF)/BF_{SM}$	SuperB 75ab^{-1} $\sigma(BF)/BF_{SM}$
$B^- \to \tau^-\bar{\nu}_\tau$	$\sim 10^{-4}$	20%	4%
$B^- \to \mu^-\bar{\nu}_\mu$	$\sim 5 \times 10^{-7}$	---	5%
$\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau$	$\sim 10^{-2}$	10%	2%

Motivation to search for $B_s \to \mu^+\mu^-$

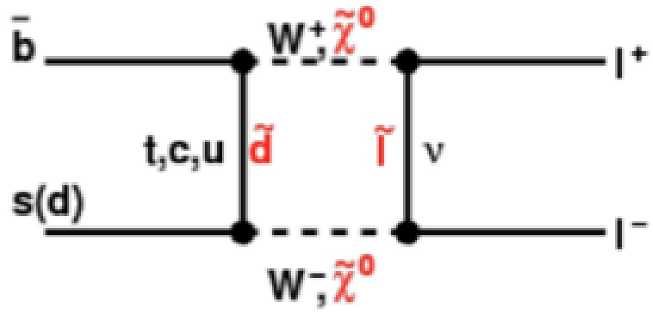
- Standard model prediction

$$\mathcal{B}(B_s \to \mu^+\mu^-) = (3.2 \pm 0.2) \times 10^{-9}$$

Buras et al., PLB 694, 402 (2011)

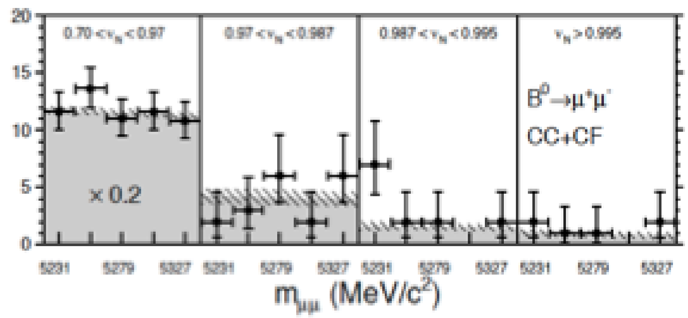


- New Physics models
  - Virtual SM particles in loops could be replaced by heavy NP particles and thus significantly enhance the branching ratio



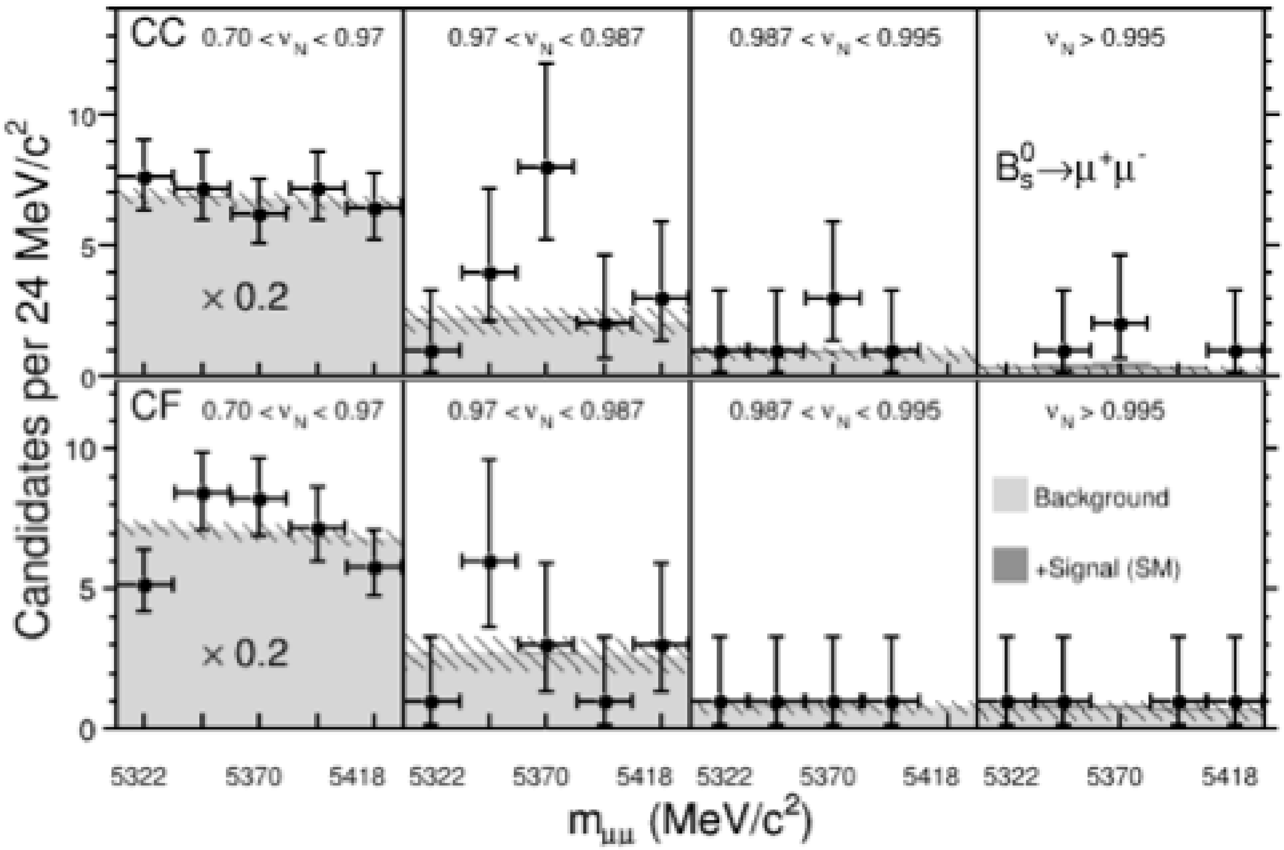
- Search for New Physics
  - Due to its small and precisely calculated branching ratio $B_s \to \mu^+\mu^-$ is a very sensitive mode for NP at very high masses
  - Search is complementary to direct searches at the energy frontier
- Best published limit on $BR(B_s \to \mu^+\mu^-)$ at the end of 2011 from CDF

$$\mathcal{B}(B_s \to \mu^+\mu^-) < 4.0 \times 10^{-8} \text{ @ 95\% CL}$$



CDF, PRL 107, 191801 (2011)

$B_s \rightarrow \mu^+\mu^-$ Signal Window



CC Central cei

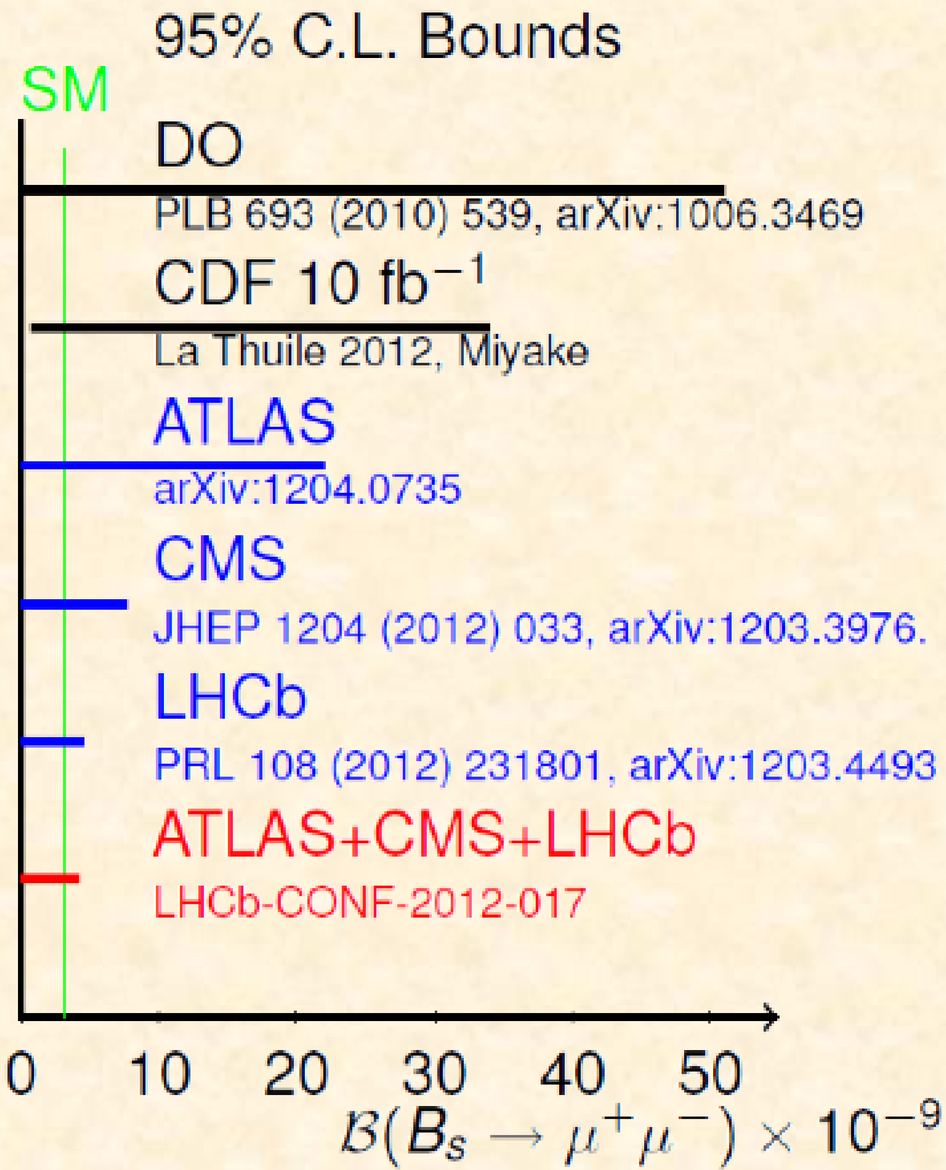
p-value = 0.94%
(bkgd only)
p-value = 7.1%
(bkgd + SM sig.)

CF Central forw

CI

Excess remains but is not reinforced with additional data.

background-only fit returns p-value greater than 2σ



LHCb-CONF-2012-017

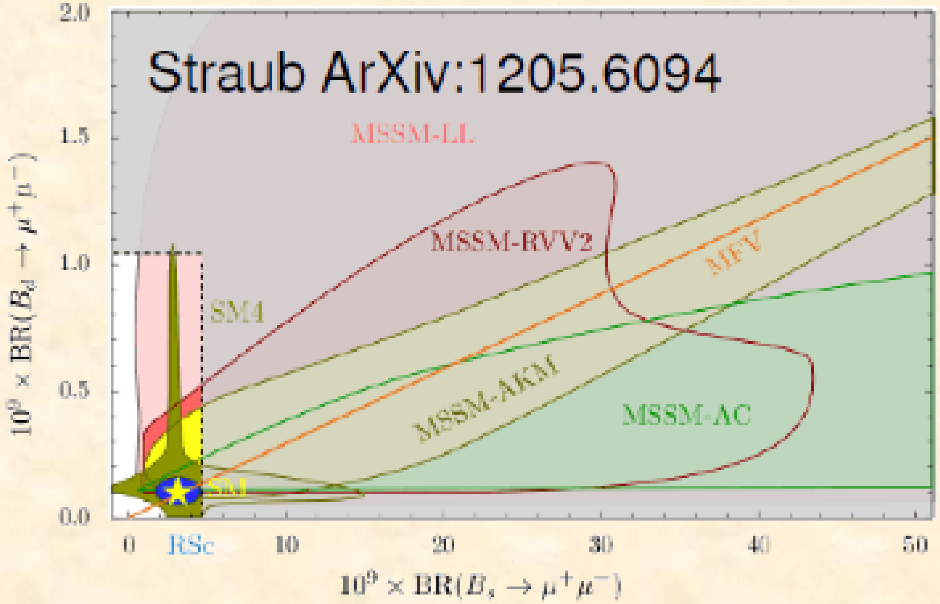
Upper Limits (95%C.L.):

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 4.2 \times 10^{-9}$$

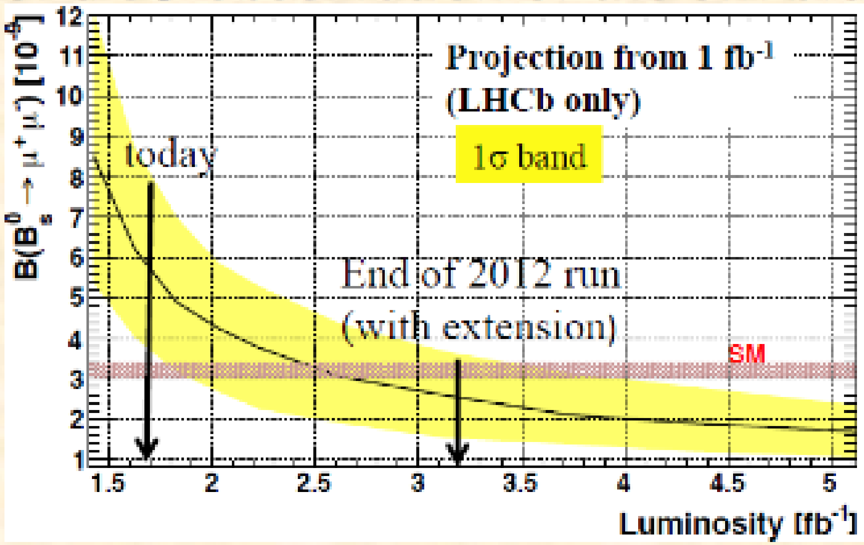
$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 8.1 \times 10^{-10}$$

Preliminary limit combination

Limits on super-symmetric models



Prospects for a 3σ observation of the SM branching ratio:

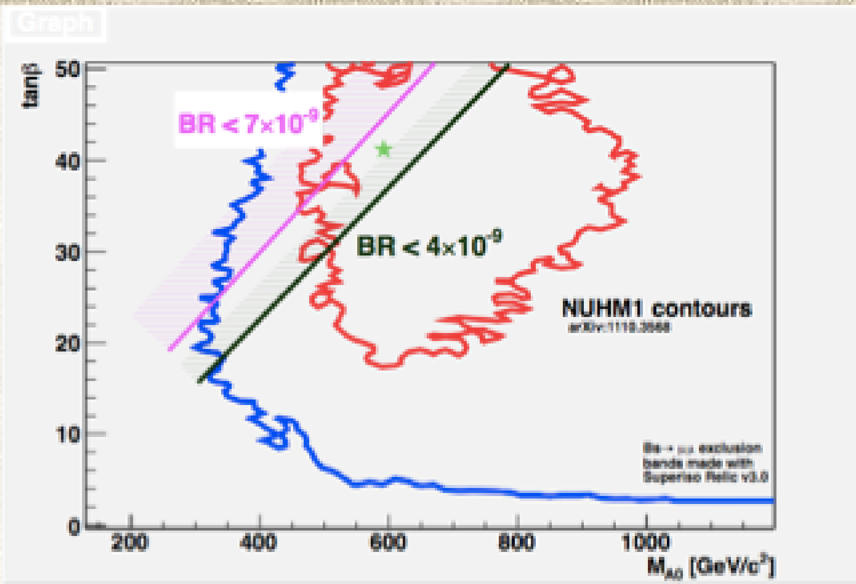


Implications of LHCb results on New Physics (I)

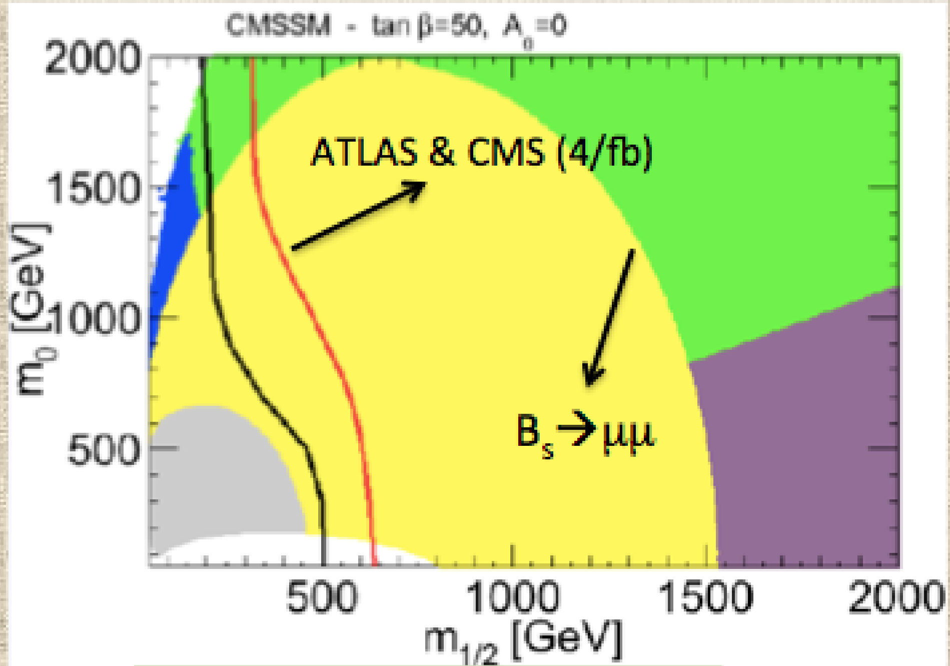
→ Hints of SM deviations of previous measurements have not been confirmed. However, more precise measurements are mandatory

- BR($B_s \to \mu\mu$) sets strong bounds on mass scales in SUSY (at least in high *tan β* models), complementary to direct searches in ATLAS and CMS
- LHCb results enter the SUSY and CKM fits, starting to impose severe bounds on several models and flavor variables

These implications will increase with the full data sample 2011-2012 (> 3/fb)



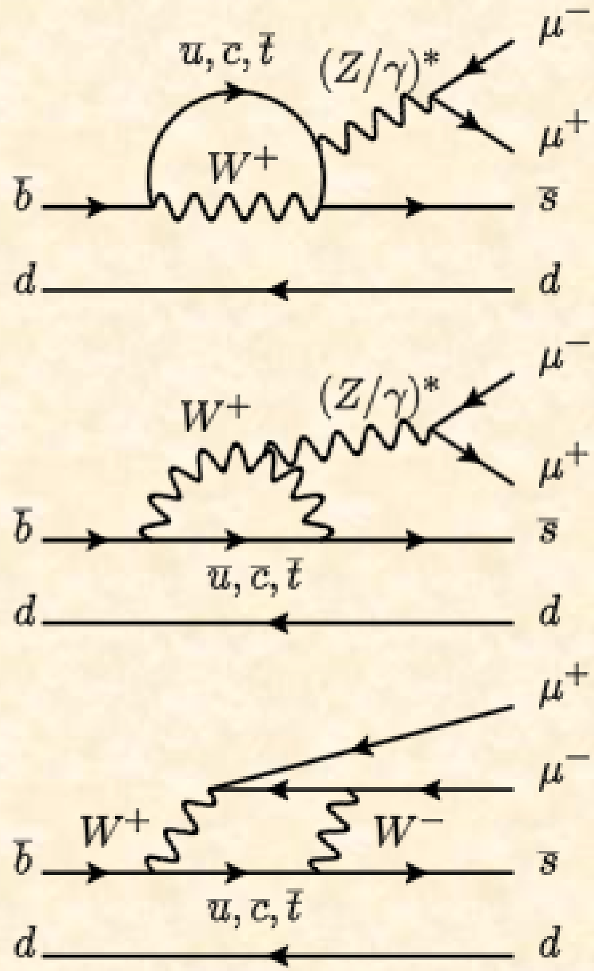
arXiv 1201.5359



N. Mazhoudi, Moriond QCD2012

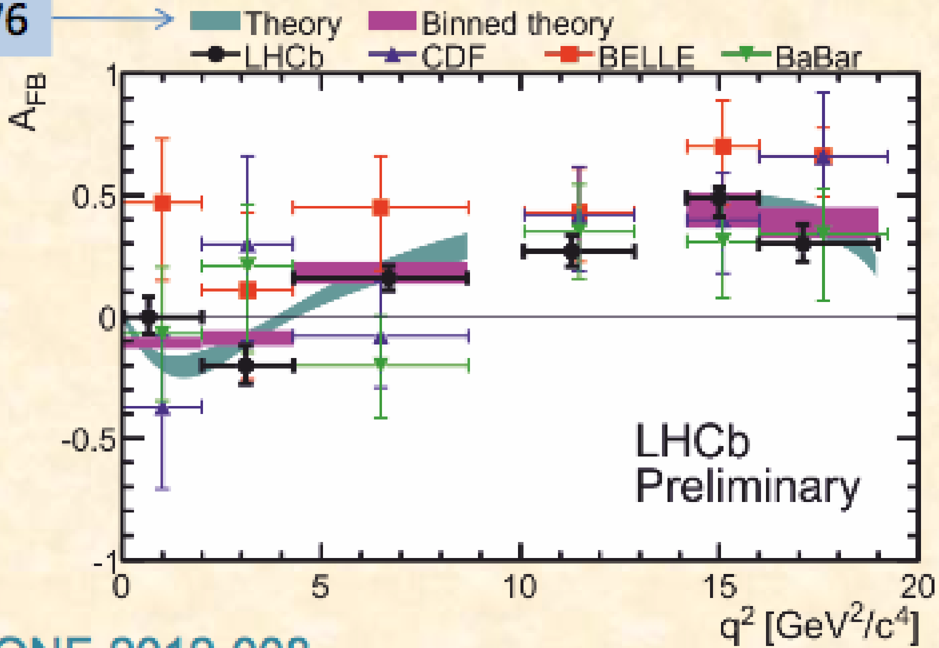
$B^0 \to K^{*0}\mu^+\mu^-$

Standard model decays have FCNC through electroweak loops.
Lots of angles to measure, most are sensitive to new physics in the loops



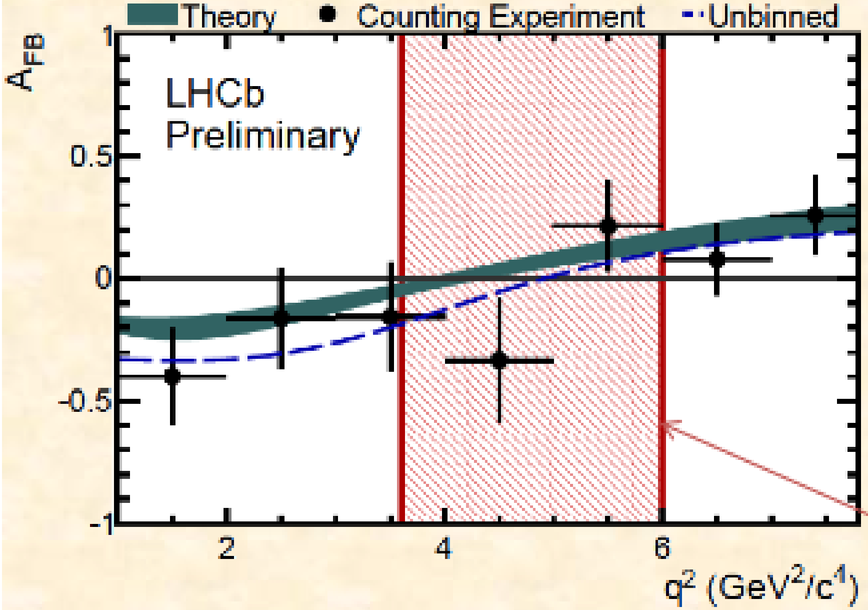
A good SM prediction for the zero point of A_{FB} for the muon system is at 4.0–4.3 GeV^2/c^4

arXiv:1105.0376



CERN-LHCb-CONF-2012-008

$B^0 \rightarrow K^{*0}\mu^+\mu^-$



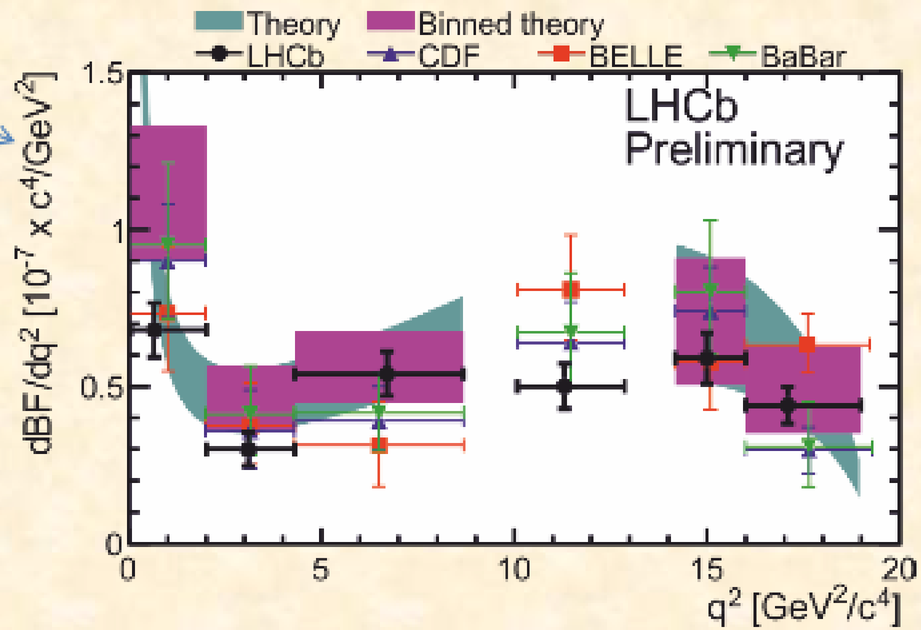
LHCb preliminary measurement is

$$q_0^2 = (4.9^{+1.1}_{-1.3})\ \mathrm{GeV}^2/\mathrm{c}^4$$

the first measurement of the crossing point

68% CL for unbinned crossing point
Error bars on points are statistical only

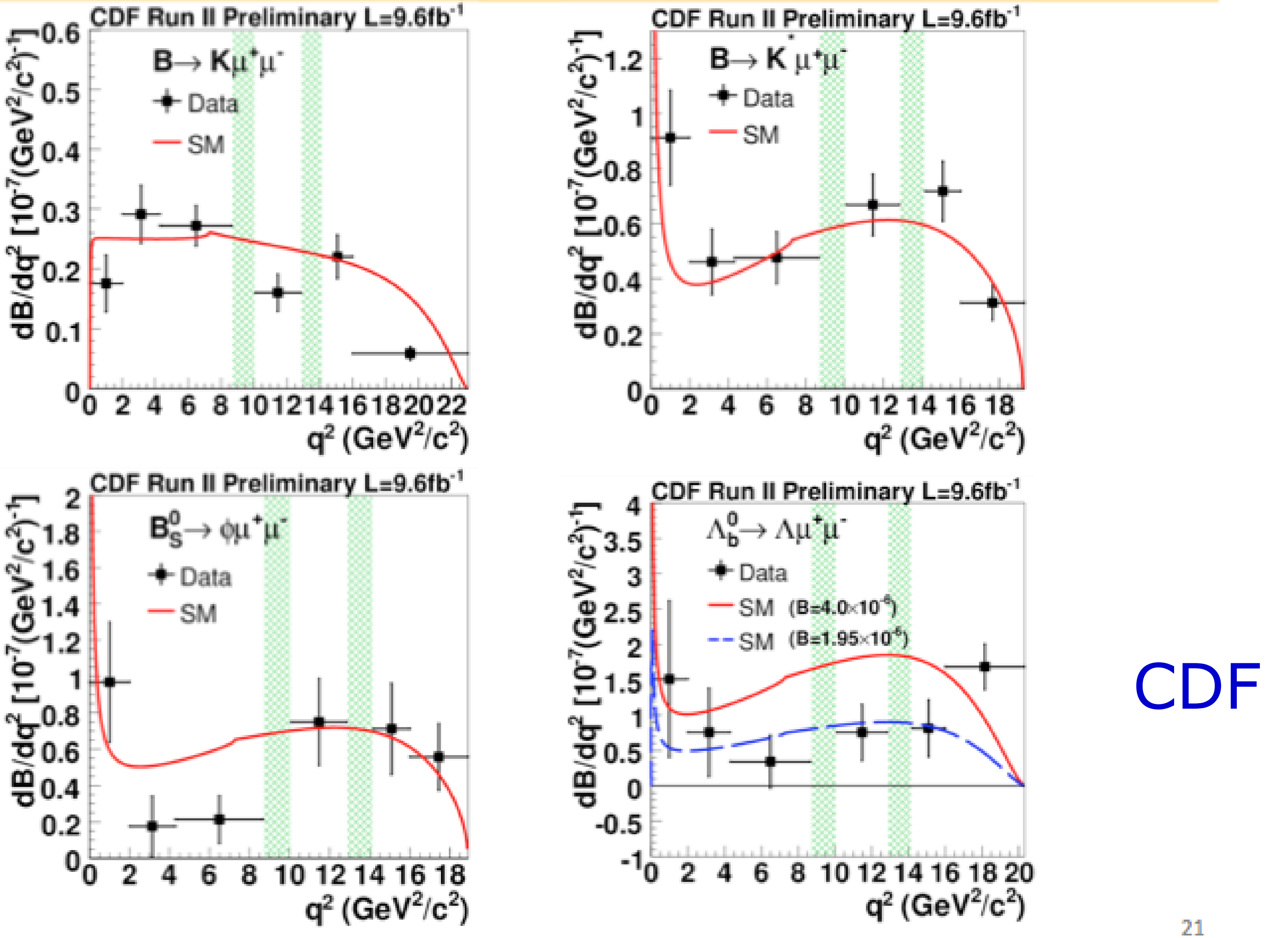
Also look at the differential branching fraction normalised to $B^0 \rightarrow K^{*0}J/\psi$



Another 3 parameters are also fitted
F_L, S_3 and S_9
Where theoretical predictions exist they are compatible with the SM

CERN-LHCb-CONF-2012-008

Differential Branching Ratios



CDF

Angular fit results

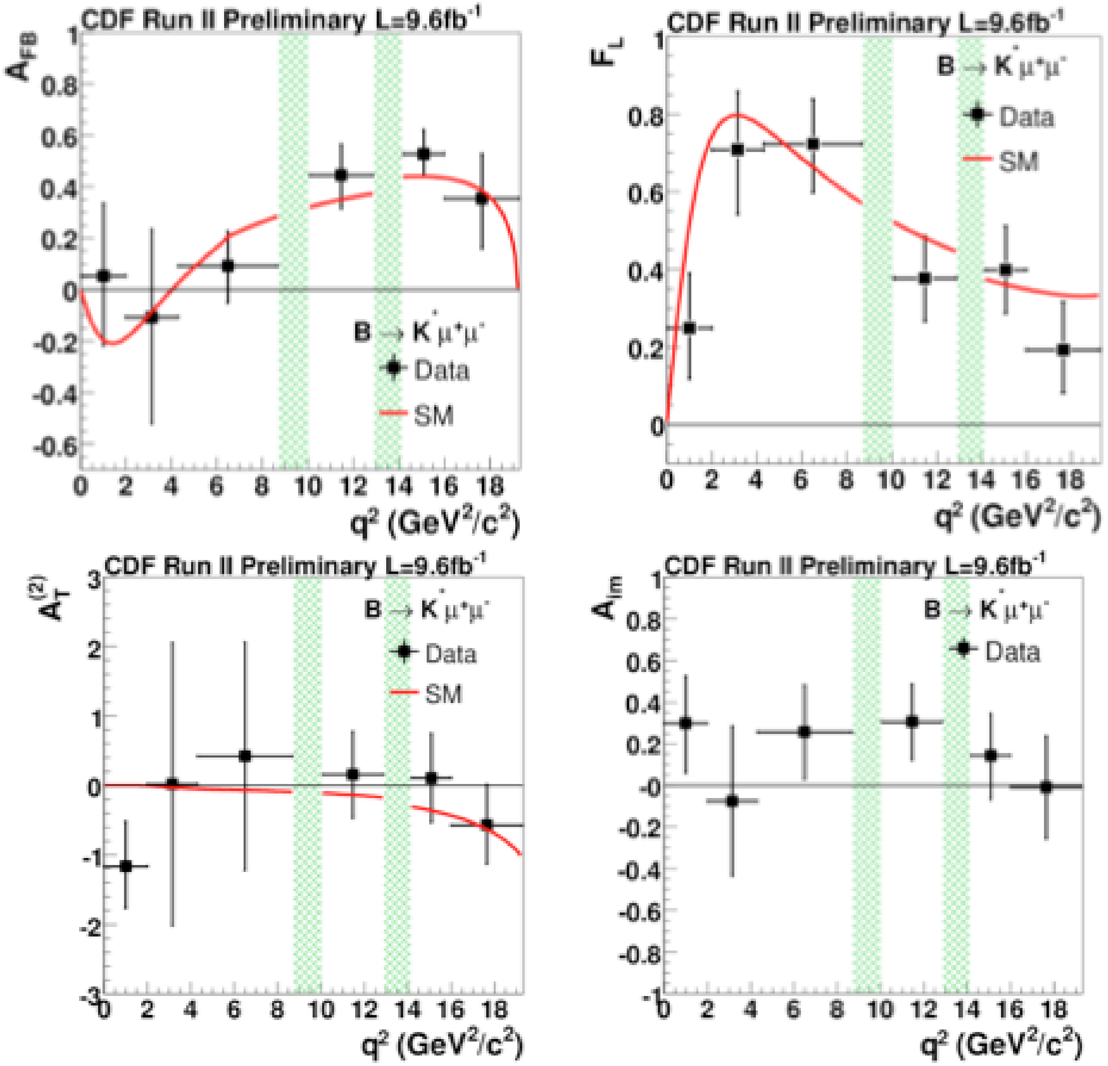
Simultaneous fit with K^{*0} and K^{*+}

A_{FB}

F_L

$A_T^{(2)}$

A_{im}

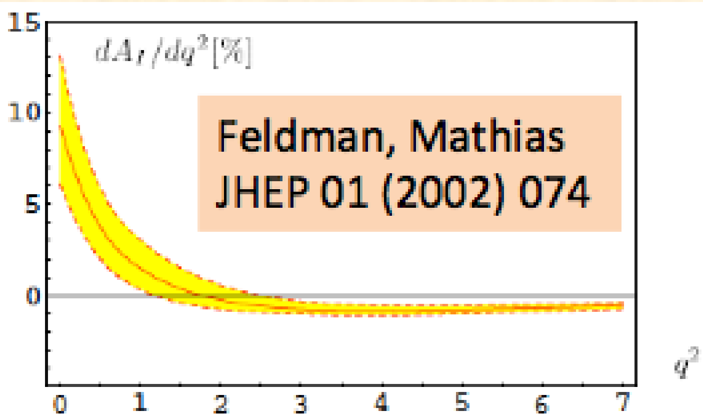


CDF Public Note 10894

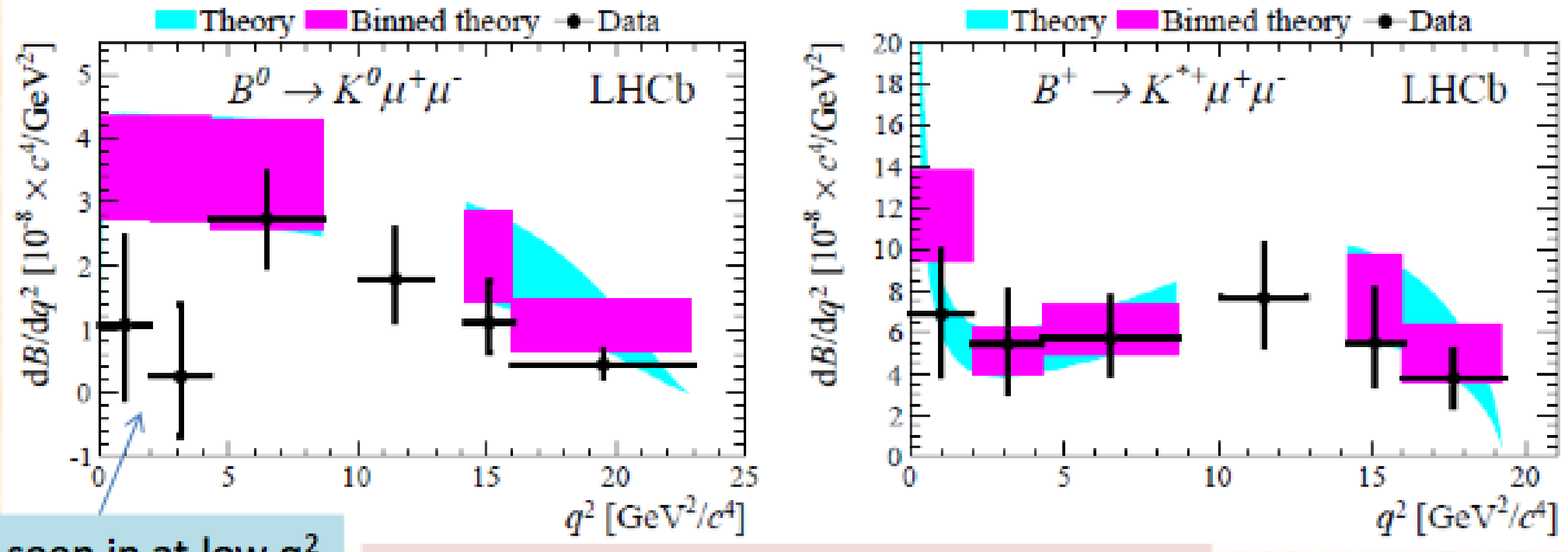
Isospin asymmetry in $B \rightarrow K^{(*)}\mu^+\mu^-$

$$A_I = \frac{\mathcal{B}(B^0 \rightarrow K^{(*)0}\mu^+\mu^-) - \left(\frac{\tau_0}{\tau_+}\right)\mathcal{B}(B^\pm \rightarrow K^{(*)\pm}\mu^+\mu^-)}{\mathcal{B}(B^0 \rightarrow K^{(*)0}\mu^+\mu^-) + \left(\frac{\tau_0}{\tau_+}\right)\mathcal{B}(B^\pm \rightarrow K^{(*)\pm}\mu^+\mu^-)}$$

- A_I is the isospin asymmetry in the $B \rightarrow K^{(*)}\mu^+\mu^-$ system
- τ_0/τ_+ is the ratio of B^0 to B^+ lifetimes
- Expected to be O(1%) in the SM

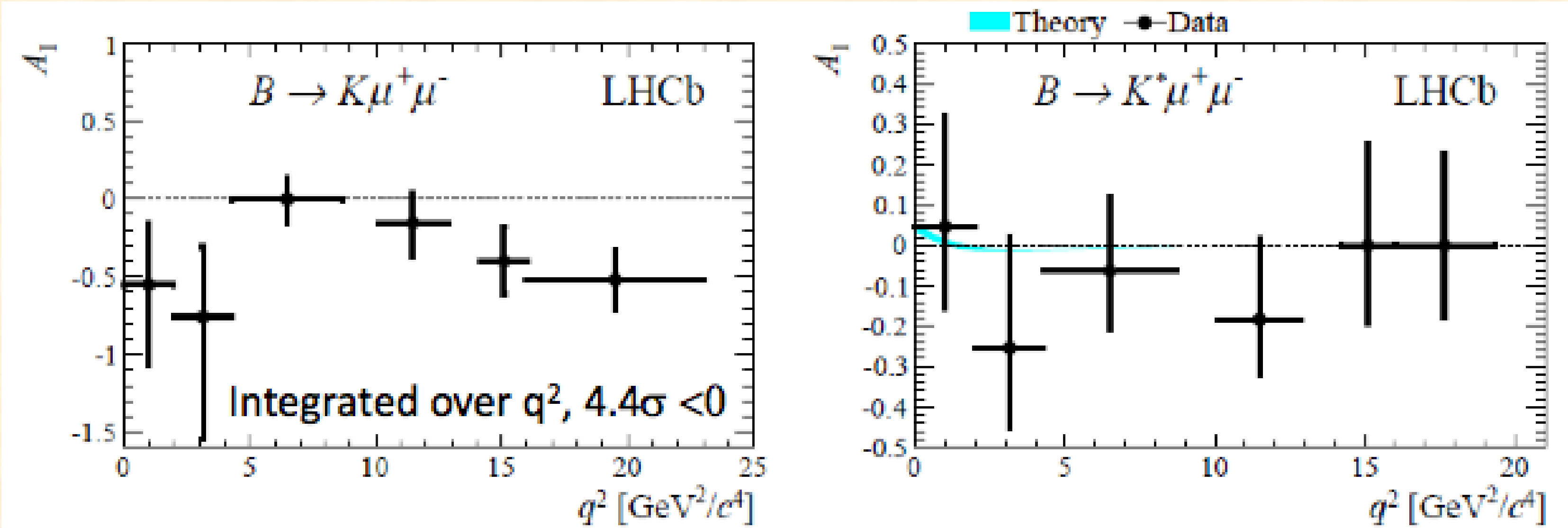


- For $B \rightarrow K^*\mu^+\mu^-$ the prediction is for positive at low q^2, dropping to small and negative as q^2 rises



Deficit seen in at low q^2

Differential Branching ratio measurements



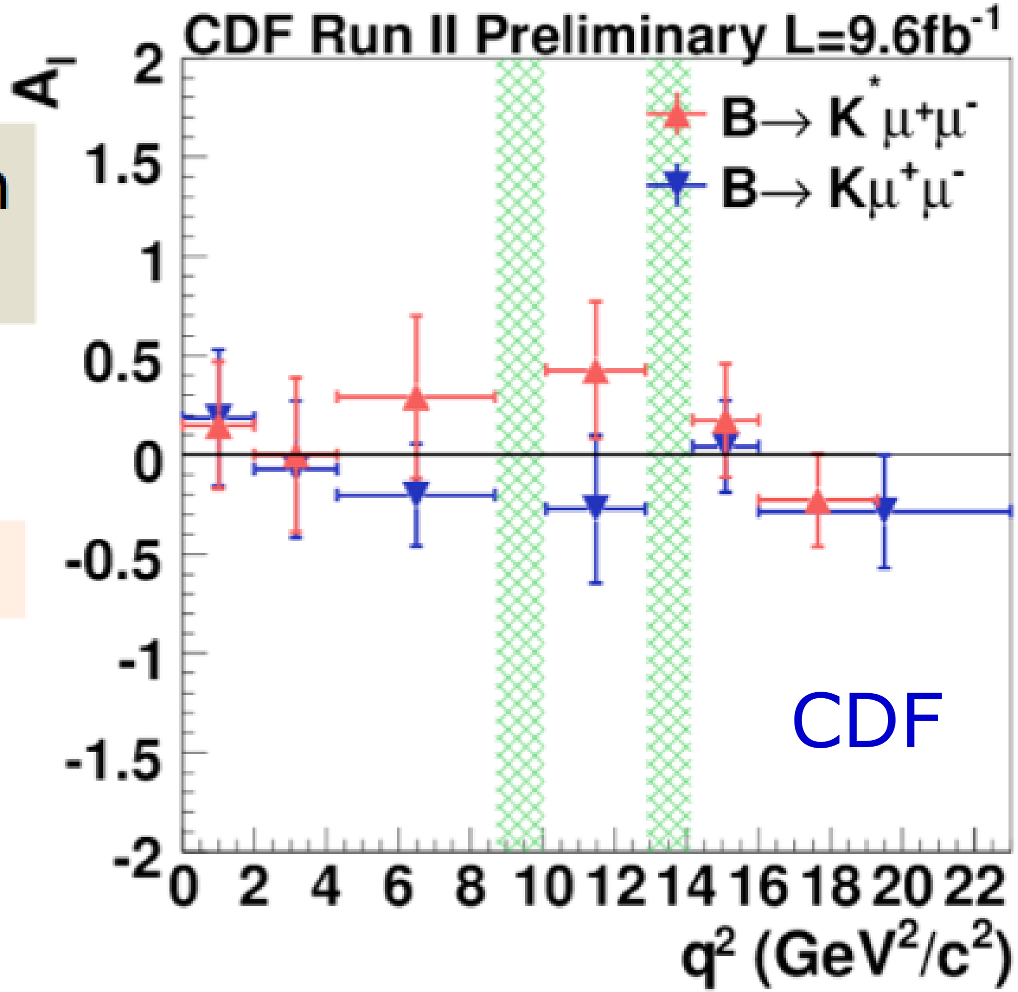
Integrated over q^2, 4.4σ <0

Isospin Asymmetry

LHCB-PAPER-2012-011, submitted to JHEP

Isospin Asymmetry

Difference between $K^{(*)+}$ and $K^{(*)0}$ rates



LHCb sees a 4σ effect.

“Deviations” from SM (shown at BEACH2012) are:

$A_{CP}(B^+ \to \phi K^+) = (12.8 \pm 4.4 \pm 1.3)\%$ BABAR
SM = (0 - 4.7)%

$A_Q(\tau^- \to K^0 \pi^- \nu) = (-0.45 \pm 0.24 \pm 0.11)\%$ BABAR
SM = (0.36 ± 0.01) %

$\Delta A_{CP} = A_{CP}(K^+\pi^0) - A_{CP}(K^+\pi^-) = 0.124 \pm 0.022$ HFAG (BABAR, Belle, CDF, LHCb, CLEO)
SM = 0.019 +0.058 - 0.048

$\Delta A^{CP}_{dir}(D \to hh) = (-0.678 \pm 0.147)$ HFAG (LHCb, CDF, Belle)
SM = ?

$Br(B \to \tau\nu) = (1.83^{+0.53}_{-0.49} \pm 0.24) 10^{-4}$ BABAR (but not Belle)
SM = $(0.62 \pm 0.12)\ 10^{-4}$ - $(1.18 \pm 0.16)\ 10^{-4}$

$R(D) = Br(B \to D\tau\nu)/Br(B \to Dl\nu) = (0.440 \pm 0.072)$ BABAR
SM = 0.297 ± 0.017
$R(D^*) = Br(B \to D\tau\nu)/Br(B \to Dl\nu) = (0.332 \pm 0.030)$ BABAR
SM* = 0.252 ± 0.003

Together Exclude 2DHM

$B^0 \to K^0 \mu^+ \mu^-$ deficit in isospin asymm. at low q^2 LHCb (but not CDF)
O(1%) in SM

I’m afraid this talk will NEVER be a replacement for
not attending the Conference ….
which has been very good and full of very good talks
and results !