SuperB: Physics

Overview of the physics programme

- The LHC is homing in on the SM Higgs, hope to find it this year: then there is a planned shutdown for the machine.
- No sign of physics beyond the SM (yet):
  - Naturalness arguments motivated theorists to expect NP at Λ_{NP}~1TeV.
  - But no data pointing to an energy scale accessible to the LHC.
    - Can combine observables measured at SuperB to place model dependent upper bounds on Λ_{NP} if nothing found by the time we start taking data.
    - Otherwise constrain model parameters BSM.
  - The interplay between NP and observables can help to unlock the potential of the global HEP programme.

Λ_{NP}: the energy scale

- e.g. MSSM with generic squark mass matrices.

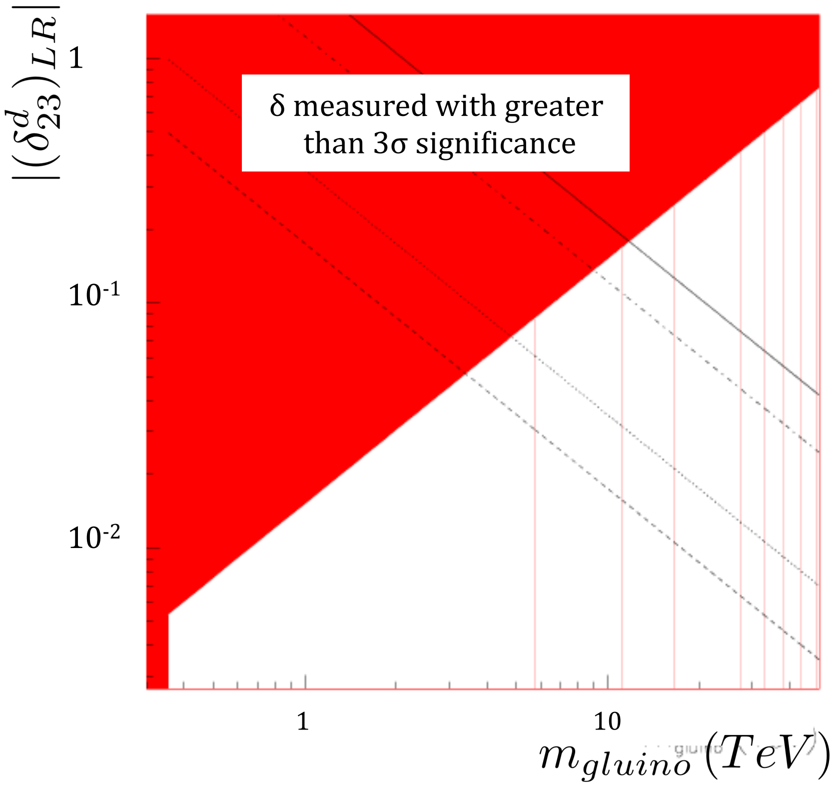
- Use Mass insertion approximation with $m_{\tilde{q}} \sim m_{\tilde{g}}$ to constrain couplings:

$$(\delta^q_{ij})_{AB} = \frac{(\Delta_{ij})^q_{AB}}{m^2_{\tilde{q}}}$$

- Can constrain the δ^d_{ij}'s using

$$\mathcal{B}(B \to X_s \gamma)$$
$$\mathcal{B}(B \to X_s \ell^+ \ell^-)$$
$$\mathcal{A}_{CP}(B \to X_s \gamma)$$

Existing LHC constraints on the gluino mass, mean couplings are non-zero, so we can provide an upper bound on Λ_{NP}.



e.g. see Hall et al., Nucl. Phys. B **267** 415-432 (1986)
Ciuchini et al., hep-ph/0212397

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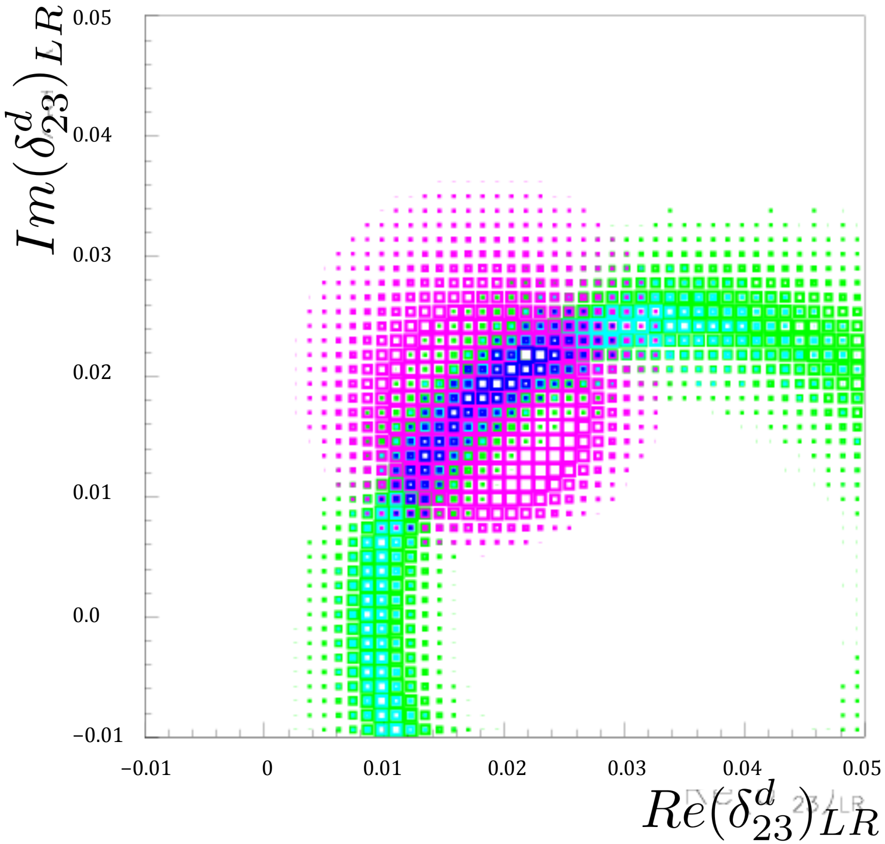
- Can constrain the δ^d_{ij}'s using
  - $\mathcal{B}(B \to X_s \gamma)$ (green)
  - $\mathcal{B}(B \to X_s \ell^+ \ell^-)$ (cyan)
  - $\mathcal{A}_{CP}(B \to X_s \gamma)$ (magenta)

& Constrain parameters BSM once the LHC fixes the scale



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Overview of the physics programme

- Our understanding of the matrix of observables vs. models is improving

Observable/mode	charged Higgs high tan β	MFV NP low tan β	non-MFV NP 2-3 sector	NP in Z penguins	Right-handed currents	LHT	SUSY					
							AC	RVV2	AKM	δLL	FBMSSM	GUT-CMM
$\tau \to \mu\gamma$							★★★	★★★	★	★★★	★★★	★★★
$\tau \to \ell\ell\ell$						★★★						?
$B \to \tau\nu, \mu\nu$	★★★(CKM)											
$B \to K^{(*)+}\nu\bar{\nu}$			★	★★★			★	★	★	★	★	?
S in $B \to K_S^0\pi^0\gamma$			★★		★★★							
S in other penguin modes			★★★(CKM)		★★★		★★★	★★	★	★★★	★★★	?
$A_{CP}(B \to X_s\gamma)$			★★★		★★		★	★	★	★★★	★★★	?
$BR(B \to X_s\gamma)$		★	★★		★							★★
$BR(B \to X_s\ell\ell)$			★★	★	★							?
$B \to K^{(*)}\ell\ell$ (FB Asym)							★	★	★	★★★	★★★	?
a_{sl}^s			★★★			★★★						★★★
Charm mixing							★★★	★	★	★	★	
CPV in Charm	★★									★★★		

- But there is still a lot of work to do to expand this to cover the whole physics programme: particularly in terms of B_s and charm physics.
- Once the Higgs mass is known, $\sin^2\theta_W$ becomes a NP sensitive parameter.

Overview of the physics programme

- Our understanding of the matrix of observables vs. models is improving

Observable/mode	charged Higgs high tan β	MFV NP low tan β	non-MFV NP 2-3 sector	NP in Z	Right-handed	LHT	SUSY	UT-CMM
$\tau \to \mu\gamma$								★★★
$\tau \to \ell\ell\ell$								?
$B \to \tau\nu, \mu\nu$	★★★(CKM)							
$B \to$								?
S in B								
S in o								?
$A_{CP}($								?
$BR(B$								★★
$BR(B \to X_s\ell\ell)$			★★					?
$B \to K^{(*)}\ell\ell$ (FB Asym)								?
a_{sl}^s			★★★					★★★
Charm mixing								
CPV in Charm	★★							

$\tau \longrightarrow \mu\gamma$

$\tau \longrightarrow \ell\ell\ell$

Golden modes to distinguish LHT vs. SUSY, what about other modes & models?

What about CPV in τ decay?

& then there is the τ g-2 (see Oberhof on Thursday)

etc.

- But there is still a lot of work to do to expand this to cover the whole physics programme: particularly in terms of B_s and charm physics.
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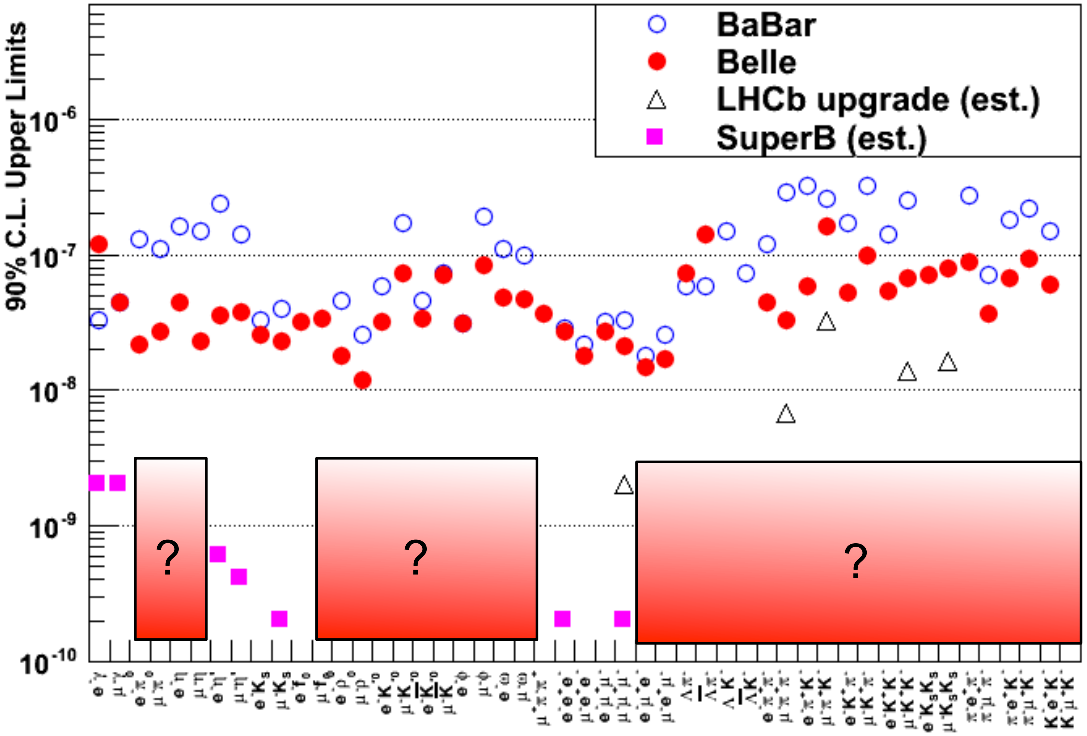
Overview of LFV

- SuperB will be able to challenge NP using charged LFV



- We have studied a few modes in detail & this work must continue.
- Manpower needed for
  $$\tau \to \mu\gamma$$
- Should update our work to cover the remaining channels to give a comprehensive estimate of the reach in this area.

Marcin recently started working on
$$\tau^{\pm} \to \mu^{\pm}\mu^{-}\mu^{+}$$
& we look forward to seeing results from him soon.

Overview of the physics programme

- Our understanding of the matrix of observables vs. models is improving

Observable/mo	...	-CMM
$\tau \to \mu\gamma$		★★
$\tau \to \ell\ell\ell$		?
$B \to \tau\nu, \mu\nu$		
$B \to K^{(*)+}\nu\overline{\nu}$		?
S in $B \to K^0_S\pi^0$		
S in other peng		?
$A_{CP}(B \to X_s\gamma$		?
$BR(B \to X_s\gamma)$		★
$BR(B \to X_s\ell\ell)$		?
$B \to K^{(*)}\ell\ell$ (F		?
a^s_{sl}		★★
Charm mixing		
CPV in Charm		

$B \to \tau\nu, \mu\nu$
$B \to K^{(*)+}\nu\overline{\nu}$
S in $B \to K^0_S\pi^0\gamma$
S in other penguin modes
$A_{CP}(B \to X_s\gamma)$
$BR(B \to X_s\gamma)$
$BR(B \to X_s\ell\ell)$
$B \to K^{(*)}\ell\ell$ (FB Asym)

Golden rare decay & time-dependent modes.

Most are well understood from the B factory era. SuperB will perform precision measurements of these.

Some new ideas are still to be explored: B_d time-dependent using data from Y(5S) – See Drutskoy on Thursday.

- But there is still a lot of work to do to expand this to cover the whole physics programme: particularly in terms of B_s and charm physics.
- Once the Higgs mass is known, $\sin^2\theta_W$ becomes a NP sensitive parameter.

Overview of the physics programme

- Our understanding of the matrix of observables vs. models is improving

Observable/mode	charged Higgs high tan β	MFV NP low tan β	non-MFV NP 2-3 sector	NP in …	Right-handed …	LHT	SUSY …	…CMM
$\tau \to \mu\gamma$								★★
$\tau \to \ell\ell\ell$								?
$B \to \tau\nu, \mu\nu$	★★★(CKM)							
$B \to K^{(*)+}\nu\bar{\nu}$			★					?
S in …								
S in …								?
A_{CP} …								?
$BR(B \to X_s\gamma)$		★	★★					★
$BR(B \to X_s\ell\ell)$			★★					?
$B \to K^{(*)}\ell\ell$ (FB Asym)								?
a^s_{sl}			★★★					★★
Charm mixing								
CPV in Charm	★★							

a^s_{sl}

e^+e^- only NP sensitive rare decays exist.

e.g. $B_s \to \gamma\gamma$

These need to be studied and added incorporated into our programme.

Anyone interested in such opportunities should contact Alexey Drutskoy.

- But there is still a lot of work to do to expand this to cover the whole physics programme: particularly in terms of B_s and charm physics.
- Once the Higgs mass is known, $\sin^2\theta_W$ becomes a NP sensitive parameter.

Overview of the physics programme

- Our understanding of
  improving

Observable/mode	charged Higgs high tan β	MFV NP low tan β		FBMSSM	GUT-CMM
$\tau \to \mu\gamma$				★★★	★★★
$\tau \to \ell\ell\ell$					?
B					
B				★	?
S					
S				★★★	?
A				★★★	?
$BR(B \to X_s\gamma)$		★			★★
$BR(B \to X_s\ell\ell)$					?
$B \to K^{(*)}\ell\ell$ (FB Asym)				★★★	?
a_{sl}^s					★★★
Charm mixing				★	
CPV in Charm	★★				

Charm mixing

CPV in Charm

Traditional mixing and CPV observable sensitivities are understood from BaBar /Belle.

Lots of activity toward developing an understanding about time-dependent CPV sensitivity at the $\Upsilon(4S)$ and $\psi(3770)$.

What about LHCb's ΔA measurement? To disentangle penguin pollution from possible signs of NP one needs to measure a variety of final states: *some only accessible at an e^+e^- machine*.

A_{CP} in D to $\pi^+\pi^0$ is an e^+e^- game only.

... and our charm rare decay programme could benefit from some work. e.g. the not so-rare $D \to \gamma\gamma$ as a starting point.

- But there is still a lot … whole
  physics programme: … ysics.
- Once the Higgs mass … ive
  parameter.

Opportunities (I)

- A few of our young post-docs have moved on, so there are a number of important studies that would benefit from additional manpower.

- In particular if you are interested in joining in the effort for
  - polarisation/τ physics: contact Mike Roney & Alberto Lusiani
  - B_s physics: contact Alexey Drutskoy

  about important channels to study.

Some other ideas for areas of study can be found in the previous slides.

Opportunities (II)

- Some of you may have students who need to analyse data for their thesis. You might consider having them work on SuperB and analyse BaBar data for their thesis:
  - Contact Abi Soffer (abi@slac.stanford.edu)
  - https://bbr-wiki.slac.stanford.edu/bbr_wiki/index.php/Physics/Analyze_This!

- Partial list of *partially complete* analyses:
  - $B \to D_{sJ} D$
  - Search for non-Abelian dark gauge boson
  - Polarisation of $B \to \psi(2S) K^*$
  - Study of $e^+e^- \to \psi K^+ K^-$
  - Study of $e^+e^- \to J/\psi \to \gamma\phi\phi$ via ISR
  - Search for dark photon in $\pi^0 \to e^+e^-\gamma$

  These are in varying stages of completeness most having ntuple ready.

Documentation

- As part of the tools effort Matteo is building a team of people to oversee tools we use.
- We now have permission from BaBar to migrate

BAD 53 Choice of Kinematic Variables in B Meson Reconstruction---Take 3
BAD 102 Vertexing
BADs 246, 332, 497, 1471 Related to backgrounds and trickle injection impacting upon data quality
BAD 318 Recommended Statistical Procedures for BaBar
BAD 509 sPlots
BAD 522 EvtGen documentation
BAD 831 Describes the standard ISR NTUPLEs used in BaBar for events where the ISR photon is reconstructed
BAD 1312 Related to the luminosity measurement
BAD 1500 PID
BAD 1675 A Likelihood-based Charm Flavor Tag
BAD 1850 Related to the luminosity measurement
BAD 2069 Hadronic and Gamma-Pair Event Selection for Upsilon(3S) Counting
BAD 2126 Summary of Upsilon(2S) Counting
BAD 2186 Offline measurement of recorded BaBar luminosity in R24
BAD 2082 Studies towards an improved tagging algorithm: Tag

to alfresco. Expect this to happen over the coming week.

This Week

- Joint Sessions with computing:
  - Computing+physics+tools: Tuesday 17:00
  - Computing+Physics: Thursday 15:00

- Other Parallel Sessions
  - Thursday 08:30, 11:00
    - Will include a discussion on planning for the Elba Collaboration meeting.

- All physics related sessions in Aula Seminari

Elba Physics in brief

- As with last year: review all aspects of the physics programme in general.

- Specific focus on:
  - B_s physics
  - Charm physics
  - polarisation

  to expand our understanding in these areas.