

# Physics Summary & Outlook

John Walsh  
INFN, Pisa

SuperB Collaboration Meeting  
LNF, December 2011

## Outline

1. Physics meeting
2. fastsim production planning
3. TDR planning
4. Physics tools
5. Physics studies
6. Future physics meetings

# SuperB Physics Meeting

- 2-day meeting held Dec 11-12, i.e. just before this CM
- Very good turnout: ~20 “guests” ( 16 theorists + 4 experimentalists) and about 15-20 SuperB folks
- Special topic:  $B \rightarrow X_s \gamma$  several talks covering theoretical and experimental issues  $\Rightarrow$  lively discussion
- Many other topics covered as well:  $B_s$  physics, charm, NP from the pheno side, etc.

M. Ciuchini

- We would like to continue this format, if it proves feasible
- See Marco Ciuchini’s detailed summary from Tuesday

## Conclusion

We think that the workshop was successful:

- Short and focused
- Lively
- With the right number of people
- Thanks to everybody (particularly the secretariat for assistance on Sunday!)

# Upcoming fastsim studies/MC production

- **Goal** – perform physics studies with fastsim, with reasonable generic samples and BG conditions in 2012 → moving towards Physics Book
- **Physics Book** – next big milestone: time scale of Physics Book is end of 2013 – we want to have the most and best possible knowledge of SuperB physics at that point
- Use the next 12-18 months:
  - develop tools necessary for the best fastsim studies we can do
  - get experience with fastsim, production, analysis
  - get new people involved in performing detailed studies with fastsim

# Upcoming fastsim studies/MC production

- Compiling a list of analyses that will participate in upcoming fastsim production

Name	Channel(s)	Hadronic tags	SL tags	Notes	WG
Elisa Manoni	$K^{(*)}n\nu$	yes			Rare
Steve Robertson	$B \rightarrow Xs l+l-$	yes			Rare
Wenfeng Wang	$B \rightarrow Xs \gamma$	?	?		Rare
Alejandro Perez			yes	support for SL tags	Rare
Marcello Rotondo, Valentina Santoro	$B \rightarrow \mu \nu, e \nu$	yes			Rare
Guglielmo De Nardo	$B \rightarrow \tau \nu$	yes			Rare
Alberto Cervelli	$\tau \rightarrow \mu \gamma$				tau
Marcin Chrzasczcz	$B \rightarrow K \phi \phi$				CPV & mixing

**Goal: have analysis ntuples available for Summer 2012**

# Planning TDR contribution

- Plan a single chapter of 20-30 pages that can be used in both the Detector TDR and the Accelerator TDR
- Material is essentially in hand in the form of the Physics White Paper and the SuperB Impact paper
  - mostly an editing job
- Section that specifically addresses physics motivations of accelerator choices

# Planning TDR contribution



## TDR: Detector

- Emphasis on the detector TDR is best motivated in terms of topic. Suggestion is:
- ~5 p. ▪ Rare decay searches for NP Walsh
- ~5 p. ▪ CPV and mixing studies Bevan
- ~4 p. ▪ Forbidden decays: e.g.  $\tau$  LFV Lusiani
- Other physics e.g. A. N. Other
- ~1 p. ▪  $\tau$  EDM
- ~1 p. ▪ g-2 related measurements
- ~1 p. ▪  $\sin^2\theta_W$
- ~4 p. ▪ Spectroscopy
- ~5 p. ▪ Interplay discussion – brief review of this. Marco (tbc)
  - We have the white paper and impact document to refer to.
- ~1-2 p. ▪ Review in context of accelerator.

LNF April 2011

Aim for 20-30 pages

A. Bevan



## TDR: Detector

- Emphasise a thematic approach to help illustrate the different aspects of the programme by run type:

- 4S running:  $75\text{ab}^{-1}$
- 5S running:  $1\text{ab}^{-1}$
- High energy scan: ~1 week
  - precision  $m_b$  as input to GUTs
- Lower Y resonance running.

- $\psi(3770)$  running

- Polarisation

• Need to understand a reasonable upper limit on the beam energy.

• For now assuming that 11.2 GeV is the target that will be able to give us a high energy scan early in the programme.

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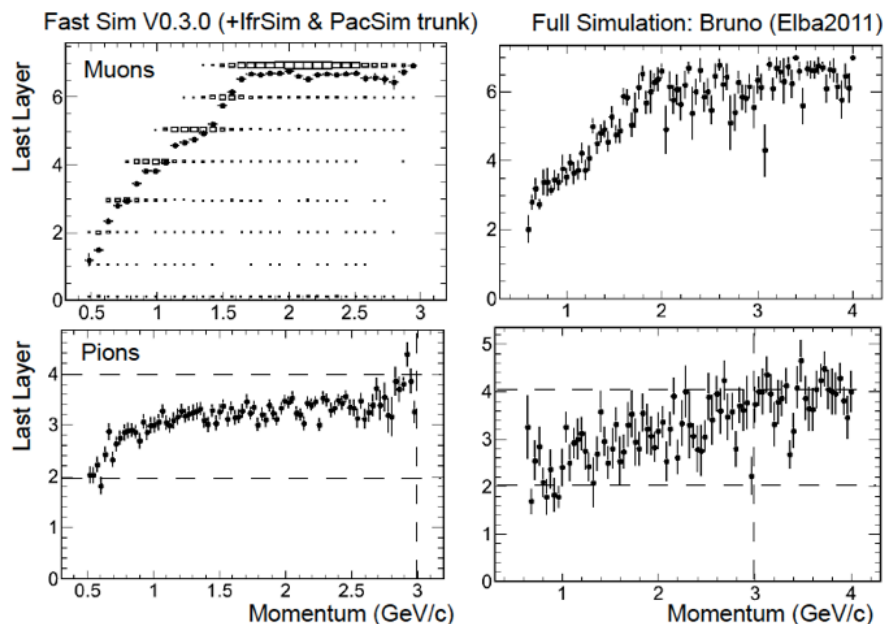
Aim for 20-30 pages

# Physics Tools: Matteo Rama

- Joint Physics/computing parallel session on Physics Tools
- Focus on preparations for upcoming fastsim production

M. Rotondo - IFR fastsim development

## Distribution of the Last Layer (profiles)



SuperB Collaboration Meeting

M. Rotondo

Thursday, 15 December 2011

11:00

[75] **Overview**

by Matteo RAMA (LNF)

(Aula Seminari: 11:30 - 11:40)

slides

[174] **FastSim - BaBar FullSim comparison with HAD Breco**

by Elisa MANONI (PG)

(Aula Seminari: 11:40 - 11:55)

slides

[71] **fDIRC development status and plan**

by Dr. NICOLAS ARNAUD (LAL ORSAY CNRS-IN2P3)

(Aula Seminari: 11:55 - 12:10)

slides

12:00

[72] **EMC development status and plans**

by Dr. Chih-hsiang CHENG (Caltech)

(Aula Seminari: 12:10 - 12:25)

slides

[73] **IFR development status and plans**

by Marcello ROTONDO (PD)

(Aula Seminari: 12:25 - 12:40)

slides

[74] **FastSim tools for charm threshold running**

by Mr. Gianluca INGUGLIA (Queen Mary University of London)

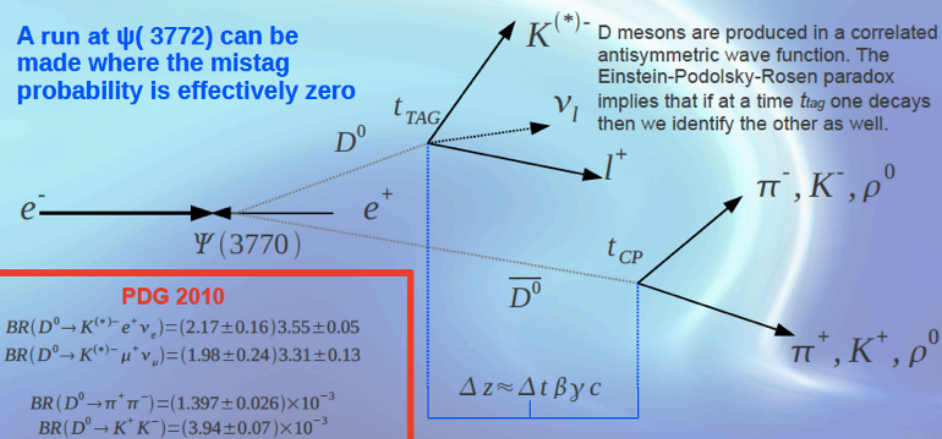
(Aula Seminari: 12:40 - 12:55)

slides

G. Inguglia - charm tagging tool

## Correlated mesons and flavor tagging

A run at  $\psi(3772)$  can be made where the mistag probability is effectively zero






At time  $t_{TAG}$  the decays  $D \rightarrow K^{(*)\pm} l^{\mp} \nu_l$  account for 11% of all  $D$  decays and unambiguously assigns the flavour:  $D^0$  is associated to a  $l^+$ ,  $\bar{D}^0$  is associated to a  $l^-$

One may consider  $D^0 \rightarrow K^+ X$  ( $X$ =anything) to flavor-tag a  $D^0$  meson with a mistag probability  $\sim 3\%$  and a total BR  $\sim 54\%$

8-2

# Physics studies

- Beyond the Physics Workshop, several additional physics studies were presented in Phys || sessions this week

[64] <b>Plans for <math>B \rightarrow K(*) \nu \nu</math></b>	 <a href="#">slides</a>
by Elisa MANONI (PG) (Aula Seminari: 15:00 - 15:20)	
[85] <b><math>B \rightarrow K \phi \phi</math> at SuperB</b>	 <a href="#">slides</a>
by Mr. Marcin CHRZASZCZ (Institute of nuclear physics) (Aula Seminari: 15:20 - 15:35)	
[86] <b>Status of tau studies</b>	 <a href="#">slides</a>
by Mr. Alberto CERVELLI (PI) (Aula Seminari: 15:35 - 16:00)	
[50] <b>BaBar Low-Multiplicity Triggers for New Physics</b>	 <a href="#">slides</a>
by Prof. Yury KOLOMENSKY (UC Berkeley/LBNL) (Aula Seminari: 17:00 - 17:30)	
[61] <b>Charm mixing at threshold</b>	 <a href="#">slides</a>
by Dr. Nicola NERI (MI) (Aula Seminari: 09:00 - 09:25)	
[199] <b>Electroweak Physics at SuperB: Update</b>	 <a href="#">slides</a>
by Prof. Michael RONEY (University of Victoria) (Aula Seminari: 09:25 - 09:55)	

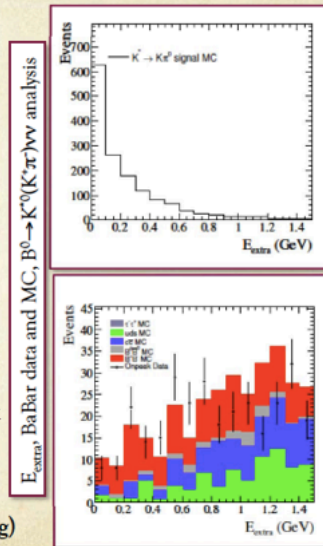


# Plans for $B \rightarrow K^* \nu \bar{\nu}$ — Elisa Manoni (Perugia)

## $B_{\text{sig}}$ reconstruction and selection

- Search for the signal signature in the rest of the events
  - veto on extra-tracks
  - cut on event-shape and kinematic variables
  - most discriminant variables
    - $P_{\text{miss}} = E_{\text{beam}} - E(\text{reco neutrals and tracks})$
    - $E_{\text{extra}} = \text{Extra neutral energy in Electromagnetic Cal (EMC) not associated to } B_{\text{sig}} / B_{\text{reco}}$
- Signal yield extraction
  - Cut-and-count analysis
  - Fit to  $E_{\text{extra}}$
  - combine discriminant variables in a Neural Network and fit output distribution
- Systematics
  - largely dominated by MC statistics (i.e. PDF modeling)

elisa manoni - infn pg

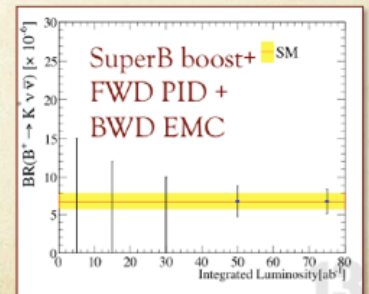
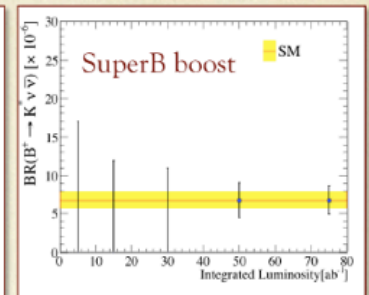
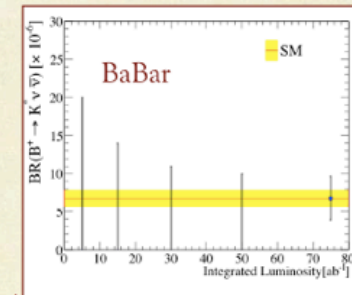


## $B \rightarrow K^* \nu \bar{\nu}$ : SuperB expected sensitivity


- assume SM branching fraction
- $3\sigma$  significance @
  - BaBar :  $75 \text{ ab}^{-1}$
  - SuperB-boost :  $50 \text{ ab}^{-1}$
  - SuperB+boost+ PID +EMC :  $42 \text{ ab}^{-1}$

with  $\sim 30\%$  precision on  $\mathcal{B}$


- $75 \text{ ab}^{-1}$  SuperB boost + PID + EMC precision :  $\sim 25\%$



# B → Kφφ at SuperB – Marcin Chrzaszcz (Krakow)



## Why this channel?



You can measure CP and T violation in one go =)

$$B^\pm \rightarrow K^\pm \phi\phi \qquad B^\pm \rightarrow \eta_c K^\pm \quad \eta_c \rightarrow \phi\phi$$


$b \rightarrow s\bar{s}s$  penguin                       $b \rightarrow c\bar{c}s$  transition

Both channels look similar in the detector: 5 charged kaons.

Direct measurements of CP violation:

$$A_{cp} = \frac{N(B^-) - N(B^+)}{N(B^-) + N(B^+)} \qquad \arg \left( \frac{V_{tb}V_{ts}^*}{V_{cb}V_{cs}^*} \right) \approx 0$$

2011-12-14                      M.Chrzaszcz



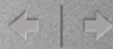
## Background

Other possible candidates for background are:

$$\begin{aligned} B^\pm &\rightarrow \phi K^\pm K^- K^+ \\ B^\pm &\rightarrow K^\pm K^- K^+ K^- K^+ \\ B^\pm &\rightarrow f_0 K \phi \\ B^\pm &\rightarrow f_0 K^\pm K^- K^+ \end{aligned}$$

# Tau studies – Alberto Cervelli (Pisa)

## g-2 with taus



## Motivation

Very high precision SM prediction: tested on  $e, \mu$  but not on  $\tau$ .

Anomaly in  $a_\mu$  w.r.t  $a_e$  has been observed. Many NP models predict larger anomalies which scale with lepton mass.  $a_\tau$  could be a good probe for NP

Experiments on  $\tau$  harder than with lighter leptons: short lifetime: the magnetic properties should be inferred from cross section measurements  
B-factories (and super flavor factories) provide huge statistics in clean environment  
Box diagram contributions negligible at  $\sqrt{s}=10.58$  GeV  
It has been suggested that looking at spin spin correlation between  $\tau$ s in hadronic decays could provide more observables

EXPERIMENT ↓	Cross Section	Normal Asymmetry
	$\text{Re}\{F_2\}$	$\text{Im}\{F_2\}$
Babar+Belle $2ab^{-1}$	$4.6 \times 10^{-6}$	$2.1 \times 10^{-5}$
Super B/Flavor Factory (1 yr. running) $15ab^{-1}$	$1.7 \times 10^{-6}$	$7.8 \times 10^{-6}$
Super B/Flavor Factory (5 yrs. running) $15ab^{-1}$	$7.5 \times 10^{-7}$	$3.5 \times 10^{-6}$

Stat only

Most precise measurement  
 $-0.053 < a_\tau < 0.013$



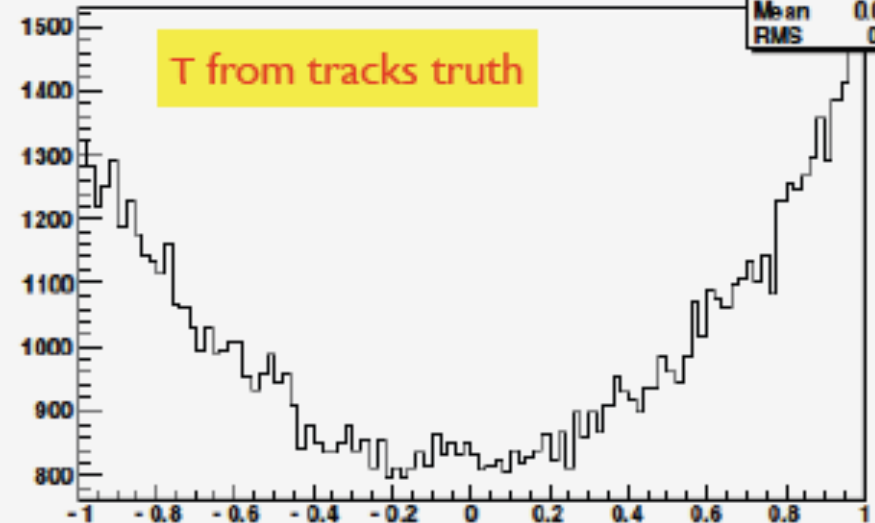
Alberto Cervelli  
Universita' di Pisa

SuperB  
Collab Meeting  
Wednesday, December 14, 2011

$$\cos \theta_{\pm} = \frac{2E_{\tau\pm}E_{h\pm} - m_{\tau}^2 - m_{h\pm}^2}{|p_{\tau\pm}||p_{h\pm}|}$$

$$\begin{aligned} |\vec{p}_{\tau-}||\vec{p}_{h-}| \cos \theta_- &= \vec{p}_{\tau-} \cdot \vec{p}_{h-} \\ |\vec{p}_{\tau-}||\vec{p}_{h+}| \cos \theta_+ &= -\vec{p}_{\tau-} \cdot \vec{p}_{h+} \end{aligned}$$

## Tau- Theta CM Reco



RecoThetaTau	
Entries	122582
Mean	0.01895
RMS	0.6107

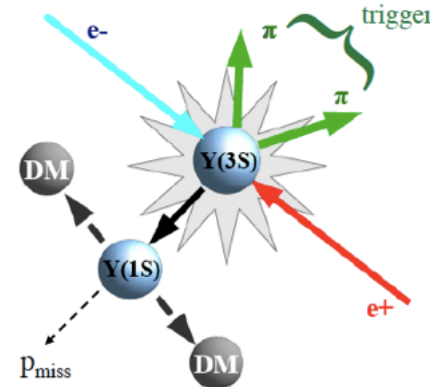
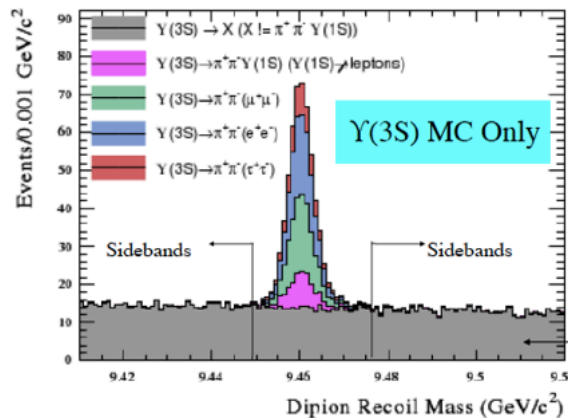


# Low-multiplicity triggers and NP – Yury Kolomensky (UC Berkeley)

12

## More Light Dark Matter: $\Upsilon(1S) \rightarrow \text{invisible}$

Leverage the charged dipion transition to the  $\Upsilon(1S)$  (4.48%) to suppress background



$$m_{recoil}^2 = s + m_{\pi\pi}^2 - 2 E_{\pi\pi} \sqrt{s}$$

Additional non-peaking backgrounds from  $e^+e^- \rightarrow \gamma^* \gamma^* \rightarrow e^+e^- \pi^+ \pi^-$  not included

- Physics of low-mass Higgs and Dark Forces
- Review of Babar triggers to capture this physics
- Outlook for SuperB

## Low-Multiplicity Triggers

### • Three event topologies deployed @ BABAR

#### □ Single-photon (trigger+filter)

- ☞ 1 high-energy cluster + “nothing else”

#### □ Single-photon+2 tracks (BGFilter)

- ☞ Mainly for dark photon searches
- ☞ Requires a radiative bhabha veto (cut on two-track mass  $m < 5$  GeV if one of the tracks is an electron)

#### □ Low-mass dipion (trigger+filter)

- ☞ Two low-momentum pions, consistent with transition  $\Upsilon(nS) \rightarrow \pi\pi\Upsilon(mS)$

12/14/2011

YGK: Low-Multiplicity Triggers

# Charm mixing at threshold – Nicola Neri (Milano)

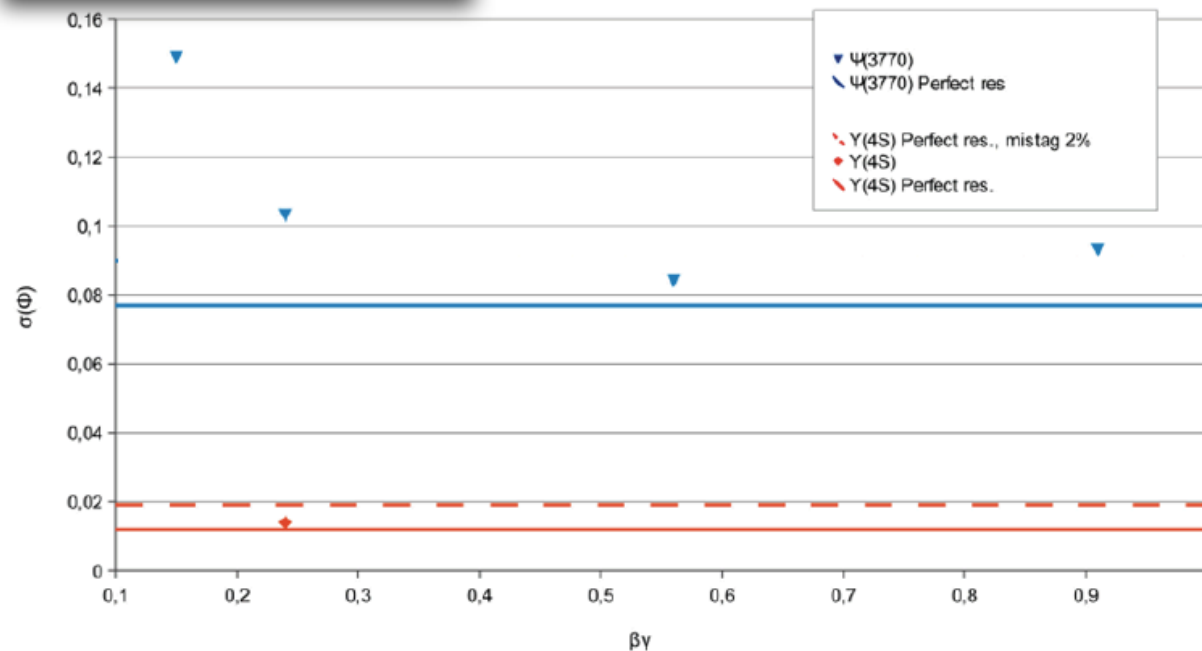
## Goal

- Estimate and compare the experimental sensitivity on charm mixing and CP violating parameters at SuperB:
  - $Y(4S)$
  - $\Psi(3770)$  as a function of CM boost and detector configuration
- First step: study the 2-body decays
  - preliminary results presented today
- Second step: include the 3-body decays

## Sensitivity studies: expected num. of events

Selected decays	$\Upsilon(4S)$ 75 ab <sup>-1</sup>	LB $\Psi(3770)$	IB $\Psi(3770)$	HB $\Psi(3770)$
		$\Psi(3770)$ 0.5 ab <sup>-1</sup> , $\beta\gamma = 0.238$	$\Psi(3770)$ 0.5 ab <sup>-1</sup> , $\beta\gamma = 0.56$	$\Psi(3770)$ 0.5 ab <sup>-1</sup> , $\beta\gamma = 0.91$
$l^\pm X^\mp, CP+$	19600000	569395	525890	418331
$l^\pm X^\mp, CP-$	30900000	685053	612430	491599
$l^\pm X^\mp, K^\pm\pi^\mp$	222900000 (790000)	4181494 (13798)	3862011 (12744)	3072118 (10137)
$l^\pm X^\mp, K_S^0\pi^+\pi^-$	86600000	828850	689557	498370
$l^\pm X^\mp, l^\mp X^\pm$	85300000 (50)	1067615 (51)	986045 (47)	784370 (38)
$K^\mp\pi^\pm, K^\pm\pi^\mp$	N/A (N/A)	1067615 (51)	986045 (47)	784370 (38)
$CP+, K^\mp\pi^\pm$	N/A	309608	285953	227467
$CP-, K^\mp\pi^\pm$	N/A	291814	260879	209408
$CP+, CP-$	N/A	92526	82717	66397
$CP+, K_S^0\pi^+\pi^-$	N/A	113691	91553	66770
$CP-, K_S^0\pi^+\pi^-$	N/A	115525	93030	67847
$K_S^0\pi^+\pi^-, K_S^0\pi^+\pi^-$	N/A	290342	217578	142875

$\sigma(\varphi=\arg(q/p))$  vs  $\beta\gamma$



# Status of EW physics – Mike Roney (UVic)

$$e^+e^- \rightarrow \mu^+\mu^- \text{ @ } \sqrt{s}=10.58\text{GeV}$$

Diagrams	Cross Section (nb)	$A_{\text{FB}}$	$A_{\text{LR}}$ (Pol = 100%)
$ Z+\gamma ^2$	1.01	0.0028	-0.00051

$$\sigma_{\text{ALR}} = 6 \times 10^{-6} \rightarrow \sigma_{(\sin 2\theta_{\text{eff}})} = 0.0002$$

$$\text{cf SLC } A_{\text{LR}} \sigma_{(\sin 2\theta_{\text{eff}})} = 0.00026$$

relative stat. error of 1% (pol=80%)  
require  $< \sim 0.5\%$  systematic error on  
beam polarisation

SM input

$$g_V^{f \neq b} / g_V^\mu = (T_3^f - 2Q_f \sin^2 \theta_W) / (-0.5 + 2 \sin^2 \theta_W)$$

## Relative vector couplings

take ratios of  $\mu, \tau, c, b$   $A_{\text{LR}}$  so that of the electron  
cancels polarisation systematic errors and the  
electron axial-vector coupling: stat. error dominated

	SM (Mh=125GeV)	LEP	SuperB error
$g_V^\mu / g_V^\tau$	1	0.997 +/- 0.068	$\sim 2\%$ from tau stats
$g_V^c / g_V^{\text{lepton}}$	5.223 +/-	-4.991 +/- 0.074	$\sim 1\%$ muon stats +/- 0.05
$g_V^b / g_V^{\text{lepton}}$	9.357 +/-	8.58 +/- 0.16	$\sim 1\%$ from mu stats +/- 0.08

# Planning: future meetings

- We aim to continue with 2-day Physics Meetings that take place in conjunction (before or after) SuperB Collab. Mtg.
- Plan to have two such meetings in 2012, the tentative plan is attach them to the CM in
  - Elba, end of May, 2012
  - Frascati, December 2012
- For the Elba meeting, there are additional constraints
  - only 1 day
  - limited number of hotel rooms
- Also expect plenty of activity during CMs

still need to think  
about this

# New Physics Convener

- Dave Brown has made many contributions to SuperB, including serving as Physics Convener, but he has moved on to other things
- Jim Olsen of Princeton University has agreed to become the 4th Physics Convener of SuperB, joining Adrian, Marco and myself
- He will work closely with the Phenomenology Working Group

**Many thanks to Dave and Welcome to Jim**



# Conclusion

- There is good participation in physics activities, both within SuperB and in the theory community
- TDR plan in place
- We are planning a centralized fastsim MC production for Spring 2012
- Physics Tools group is very active, many opportunities to contribute → contact Matteo
- More generally, to participate in Physics activities, contact Adrian, Marco, Jim or myself
- Thanks