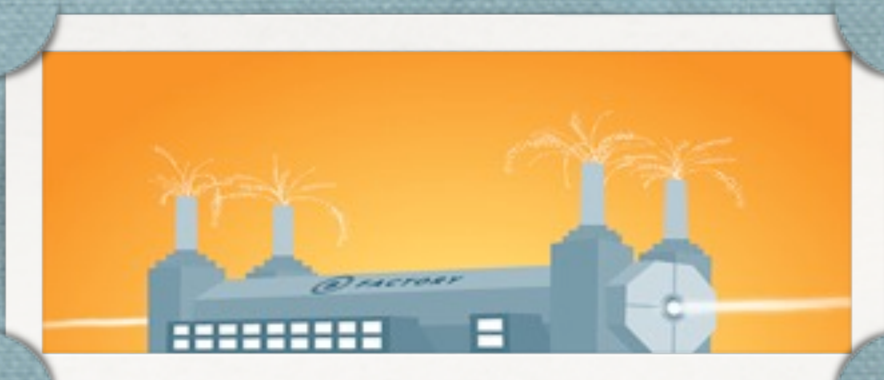


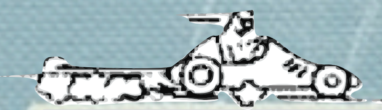
Super*B*

Eugenio Paoloni (INFN & Università di Pisa)

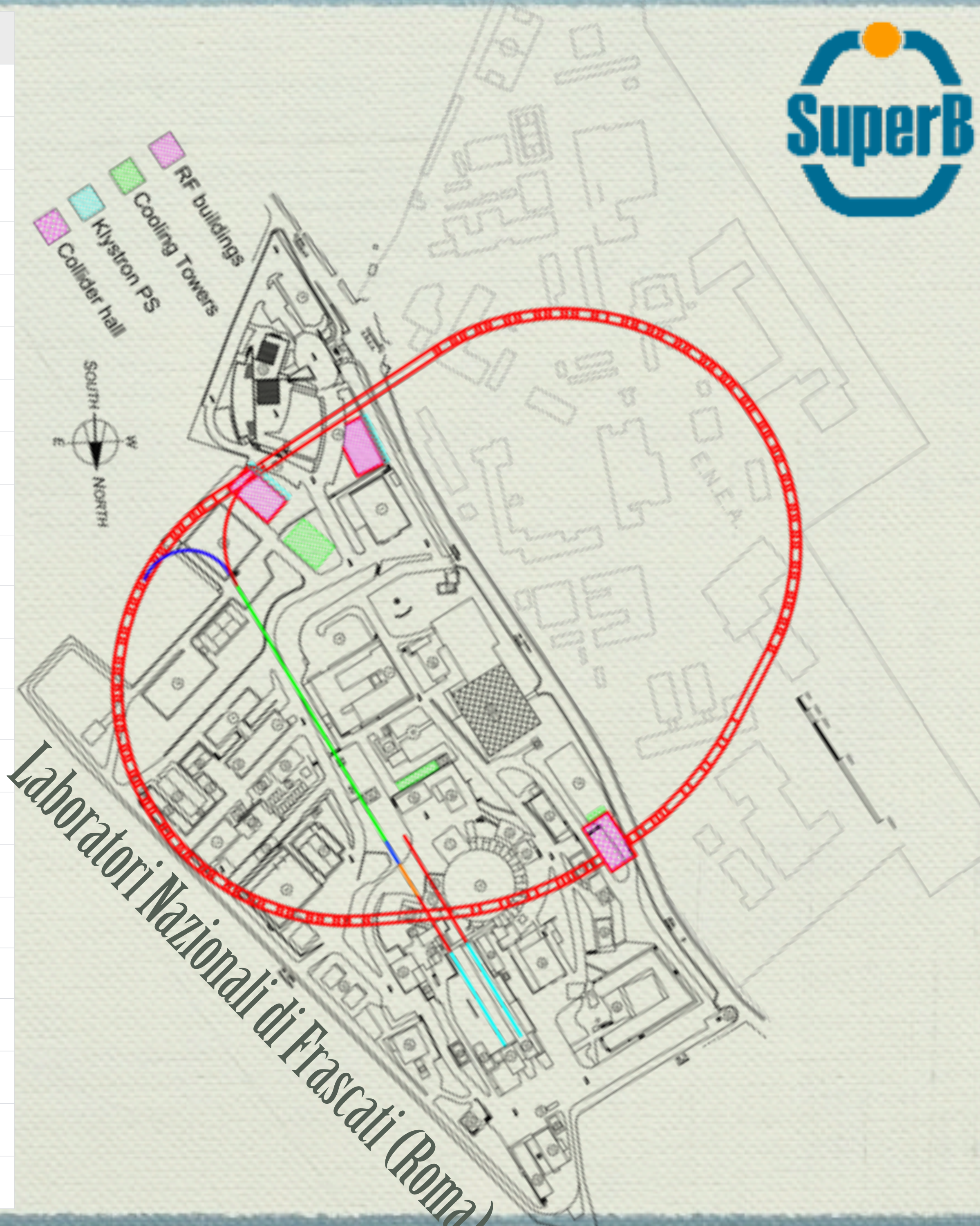
The Super*B* team: Machine, Theory, Detector, Data Analysis

SuperB: a II generation e⁺e⁻ B factory

$$\mathcal{L} \equiv f_{coll} \frac{N^+ N^-}{2\pi \Sigma_x \Sigma_y} = 10^{36}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1} = 1\,\mathrm{kHz/nb}$$



	Units	HER	LER
Release		LNF 22-Jul-09	
Circumference	***m***	***1315***	
Frequency turn	Hz	2.28E+05	
# bunch		1011	
Frequency collision	Hz	2.31E+08	
Full crossing angle	Rad	0.060	
Energy	GeV	6.7	4.18
Energy ratio		1.60	
βx	cm	2	3.2
βy	***cm***	***0.032***	***0.02***
coupling		0.0025	0.0025
εx	nm	1.6	2.56
εy	pm	0.004	0.0064
Bunch length	cm	0.5	0.5
Current	A	2.12	2.12
# particles		5.74E+10	5.74E+10
σx	micron	5.66	9.05
σy	***micron***	***0.036***	***0.036***
Piwinsky angle		26.52	16.58
Horizontal tune shift	%	0.17	0.45
Vertical tune shift	%	11.70	11.70
Luminosity	***Hz/cm^2***	***1.02E+36***	



The data samples

e^+e^-	$\rightarrow$	σ
$b\bar{b}$		1.05 nb
$c\bar{c}$		1.30 nb
$s\bar{s}$		0.35 nb
$u\bar{u}$		1.39 nb
$d\bar{d}$		0.35 nb

- B Physics @ Υ(4S) :
  ~1 kHz x 1.5 10^7 s / year = 15 10^9 Υ(4S)/year
- Dedicated runs @ Υ(5S) for B_s Physics (possibles)
- D Physics:
  - ccbar continuum @ 10.58 GeV (1kHz)
  - Short (2 months) dedicated run @ ψ(3770) (Cleo-C sample x 500 + boost)
- tau Physics:
  - Polarization of the e^- beam for tau CP studies

How can Super*B* pin down the 4th family parameters?

- Scenario:
  - There is an SM fermionic 4th family: 4x4 CKM matrix, heavy 4th neutrino
- The Players:
  - Super*B* (5 years of data taking starting around 2015) + Super KEKB
  - BaBar + Belle (datasets fully exploited)
  - CDF + D0 (collecting data till at least 2011...)
  - CMS,Atlas, LHCb (collecting data from now on)

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\sin(2\beta)$ $(J/\psi\, K^0)$	0.018	0.005 (†)
$\cos(2\beta)$ $(J/\psi\, K^{*0})$	0.30	0.05
$\sin(2\beta)$ (Dh^0)	0.10	0.02
$\cos(2\beta)$ (Dh^0)	0.20	0.04
$S(J/\psi\, \pi^0)$	0.10	0.02
$S(D^+D^-)$	0.20	0.03
$S(\phi K^0)$	0.13	0.02 (∗)
$S(\eta' K^0)$	0.05	0.01 (∗)
$S(K_S^0 K_S^0 K_S^0)$	0.15	0.02 (∗)
$S(K_S^0 \pi^0)$	0.15	0.02 (∗)
$S(\omega K_S^0)$	0.17	0.03 (∗)
$S(f_0 K_S^0)$	0.12	0.02 (∗)
γ $(B \to DK,\, D \to CP$ eigenstates)	$\sim 15^\circ$	2.5°
γ $(B \to DK,\, D \to$ suppressed states)	$\sim 12^\circ$	2.0°
γ $(B \to DK,\, D \to$ multibody states)	$\sim 9^\circ$	1.5°
γ $(B \to DK$, combined)	$\sim 6^\circ$	1–2°
α $(B \to \pi\pi)$	$\sim 16^\circ$	3°
α $(B \to \rho\rho)$	$\sim 7^\circ$	1–2° (∗)
α $(B \to \rho\pi)$	$\sim 12^\circ$	2°
α (combined)	$\sim 6^\circ$	1–2° (∗)
$2\beta + \gamma$ $(D^{(*)\pm}\pi^\mp,\, D^\pm K_S^0 \pi^\mp)$	20°	5°

CP violating measurements: SM framework to be recast in SM4

[0709.0451] SuperB: A High-Luminosity Asymmetric e+ e- Super Flavor Factory. Conceptual Design Report

Observable	B Factories ($2\ \mathrm{ab}^{-1}$)	Super$B$ ($75\ \mathrm{ab}^{-1}$)
$\lvert V_{cb}\rvert$ (exclusive)	4% (∗)	1.0% (∗)
$\lvert V_{cb}\rvert$ (inclusive)	1% (∗)	0.5% (∗)
$\lvert V_{ub}\rvert$ (exclusive)	8% (∗)	3.0% (∗)
$\lvert V_{ub}\rvert$ (inclusive)	8% (∗)	2.0% (∗)
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%
$\mathcal{B}(B \to \rho\gamma)$	15%	3% (†)
$\mathcal{B}(B \to \omega\gamma)$	30%	5%
$A_{CP}(B \to K^*\gamma)$	0.007 (†)	0.004 († ∗)
$A_{CP}(B \to \rho\gamma)$	~ 0.20	0.05
$A_{CP}(b \to s\gamma)$	0.012 (†)	0.004 (†)
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.006 (†)
$S(K_S^0\pi^0\gamma)$	0.15	0.02 (∗)
$S(\rho^0\gamma)$	possible	0.10
$A_{CP}(B \to K^*\ell\ell)$	7%	1%
$A^{FB}(B \to K^*\ell\ell)s_0$	25%	9%
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\bar{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

[0709.0451] SuperB:
A High-Luminosity Asymmetric e+ e-
Super Flavor Factory.
Conceptual Design Report

Unitary triangle in 2020 assuming a *lot* of work on the experimental & theoretical side

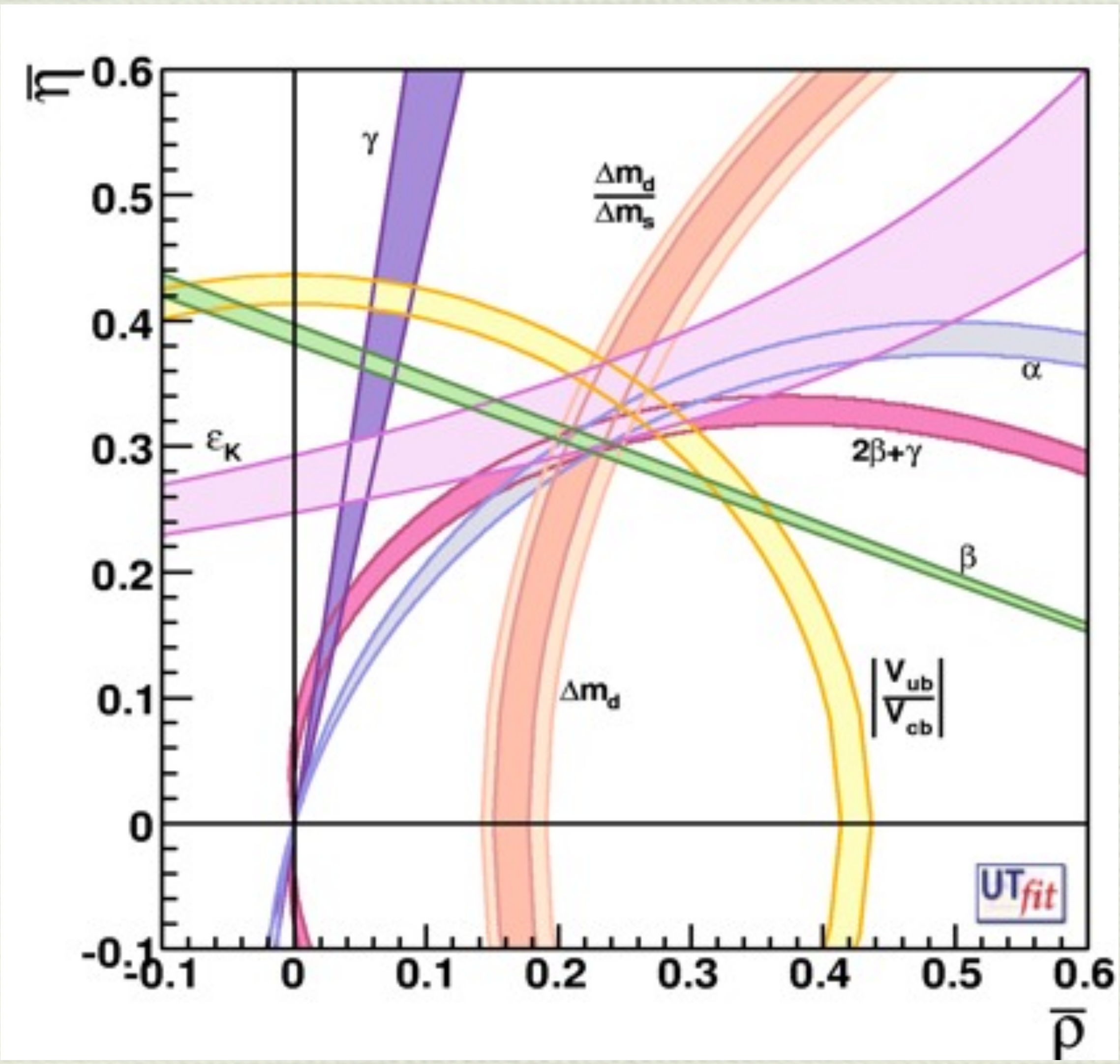
"It is tough to make predictions, especially about the future"

The Dream

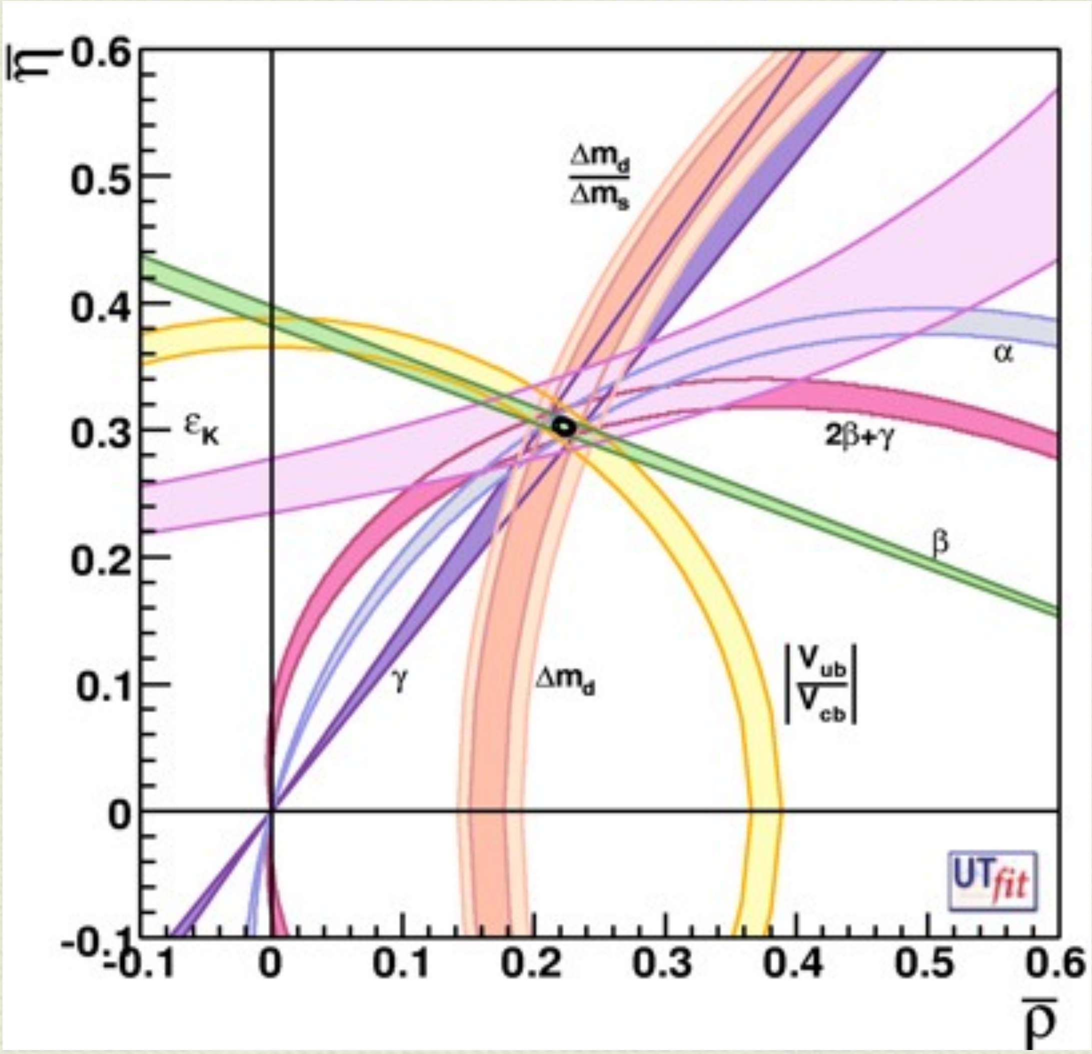
The Nightmare

Unitary triangle in 2020 assuming a *lot* of work on the experimental & theoretical side

"It is tough to make predictions, especially about the future"

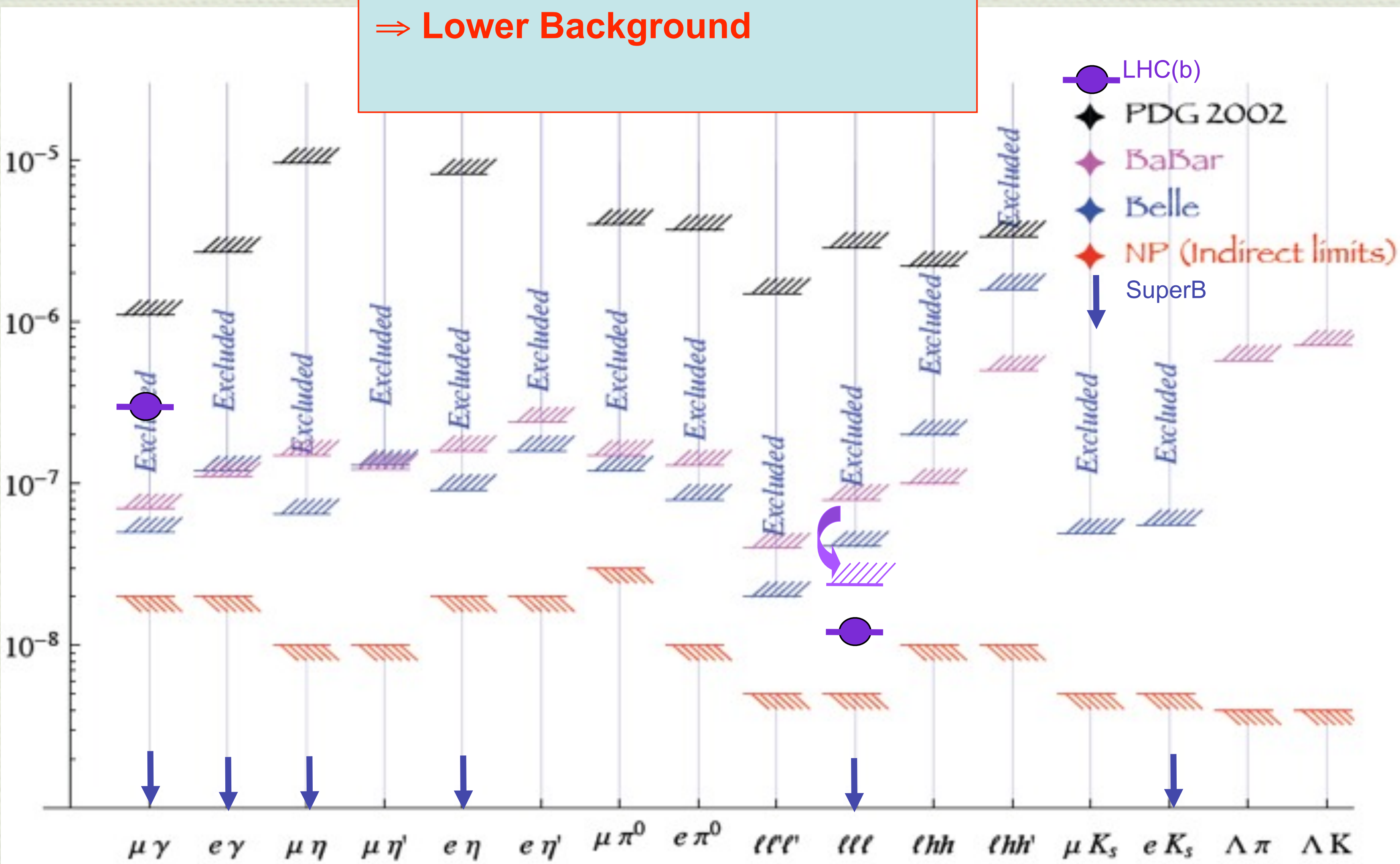


The Dream



The Nightmare

Tau Physics: LFV



SuperB Sensitivity ($75ab^{-1}$)

Process	Sensitivity
$\mathcal{B}(\tau \to \mu\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\mu\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_s)$	2×10^{-10}

Charm Physics

Running at charm threshold
(SuperB specific)

Strong dynamics and CKM measurements @threshold(4GeV)

D decay form factor and decay constant @ 1%
Dalitz structure useful for γ measurement

ξ~1%,
exclusive V_{ub} ~ few %
syst. error on γ from Dalitz Model <1^{o}

Rare decays FCNC down to 10^{-8}

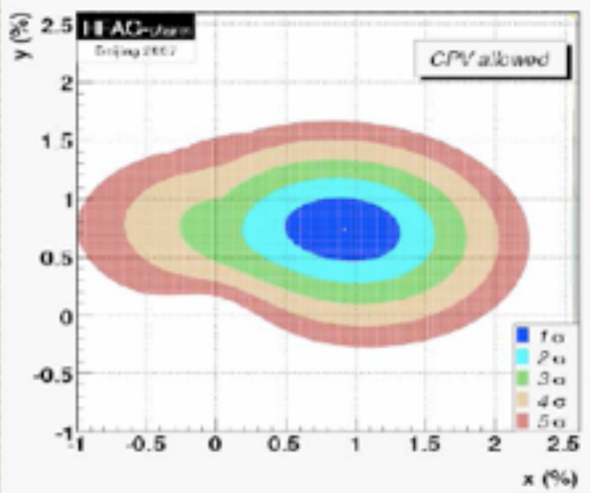
@threshold(4GeV)

Channel	Sensitivity
$D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$	1×10^{-8}
$D^0 \to \pi^0 e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K_S^0 e^+e^-$, $D^0 \to K_S^0\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+ e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K_S^0 e^\pm\mu^\mp$	3×10^{-8}
$D^+ \to \pi^- e^+e^+$, $D^+ \to K^- e^+e^+$	1×10^{-8}
$D^+ \to \pi^-\mu^+\mu^+$, $D^+ \to K^-\mu^+\mu^+$	1×10^{-8}
$D^+ \to \pi^- e^\pm\mu^\mp$, $D^+ \to K^- e^\pm\mu^\mp$	1×10^{-8}

D mixing

Better studied using the high statistics collected at Υ(4S)

10



Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	$2\text{–}3 \times 10^{-3}$	7×10^{-4}
	x'^2_D	$1\text{–}2 \times 10^{-4}$	3×10^{-5}
$D^0 \to K_S^0\pi^+\pi^-$	y_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1\text{–}2 \times 10^{-3}$	3×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}

CP Violation in mixing could now addressed

Charm Physics

Running at charm threshold
(SuperB specific)

Using the charm produced at Υ(4S) +

Charm physics at threshold 0.3 ab^{-1}

Consider that running 2 month at threshold
we will collect 500 times the stat. of CLEO-C

Strong dynamics and CKM measurements

@threshold(4GeV)

D decay form factor and decay constant @ 1%
Dalitz structure useful for γ measurement

ξ~1%,
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Rare decays FCNC down to 10^{-8}

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$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_s e^+e^-$, $D^0 \to K^0_s\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+ e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
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$D^+ \to \pi^- e^\pm\mu^\mp$, $D^+ \to K^- e^\pm\mu^\mp$	1×10^{-8}

D mixing

Better studied using
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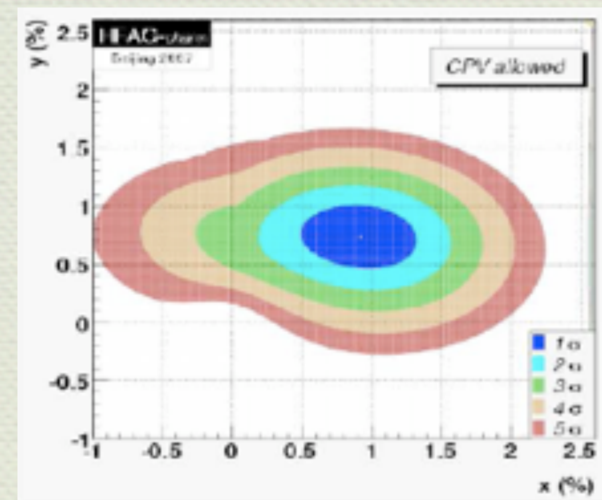

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	x'^2_D	$1\text{–}2 \times 10^{-4}$	3×10^{-5}
$D^0 \to K^0_S\pi^+\pi^-$	y_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1\text{–}2 \times 10^{-3}$	3×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}

CP Violation in mixing could now addressed

Conclusions and Questions

- The 4^{th} family have many way to play in Super*B*
  - *CP violation*
  - *FCNC in B and D mesons and in tau*
  - *If it shows up early in hadron machines, then* ***much*** *of fun measuring all the consequences*
- Are there golden modes?
- What campaign of measurements are useful to measure the 2 extra phases? What is the needed precision?