STATUS OF SuperB

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INFN & Università di Pisa

Plenary ECFA Meeting CERN November 24, 2011

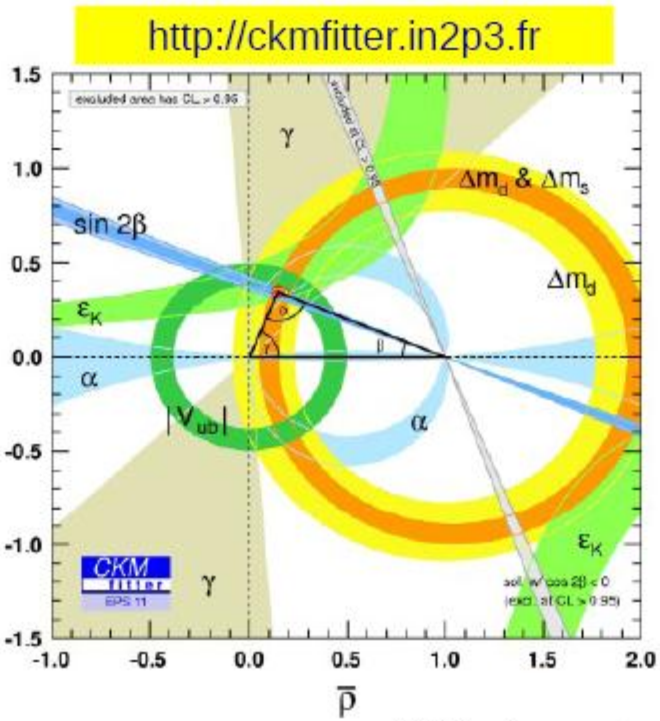
The high intensity path with the SuperB physics program

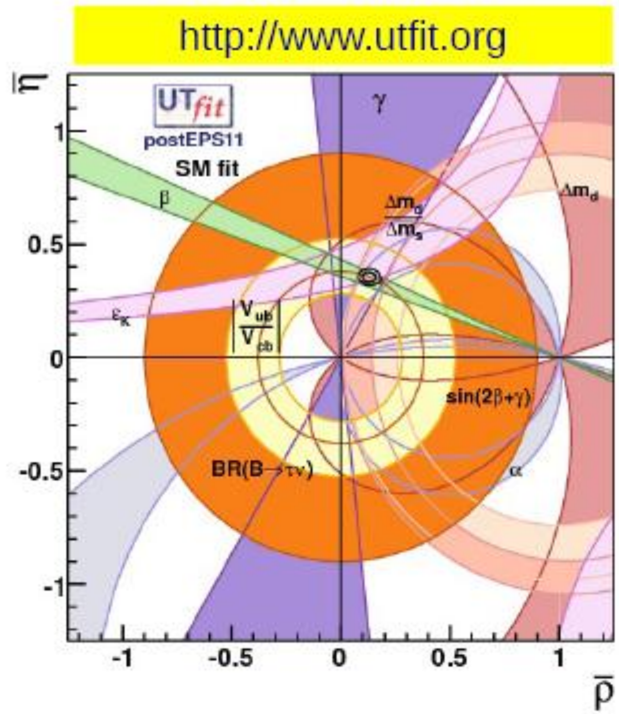
- Versatile flavour experiment
  - Probe new physics observables in wide range of decays.
    - Pattern of deviation from Standard Model can be used to identify structure of new physics.
    - Clean experimental environment means clean signals in many modes.
    - Polarised e^- beam benefit for τ LFV searches.

After Summer 2011

Triumph of CKM from LHCb data

Good agreement no evident discrepancy or “tension” , even with different statistical analysis



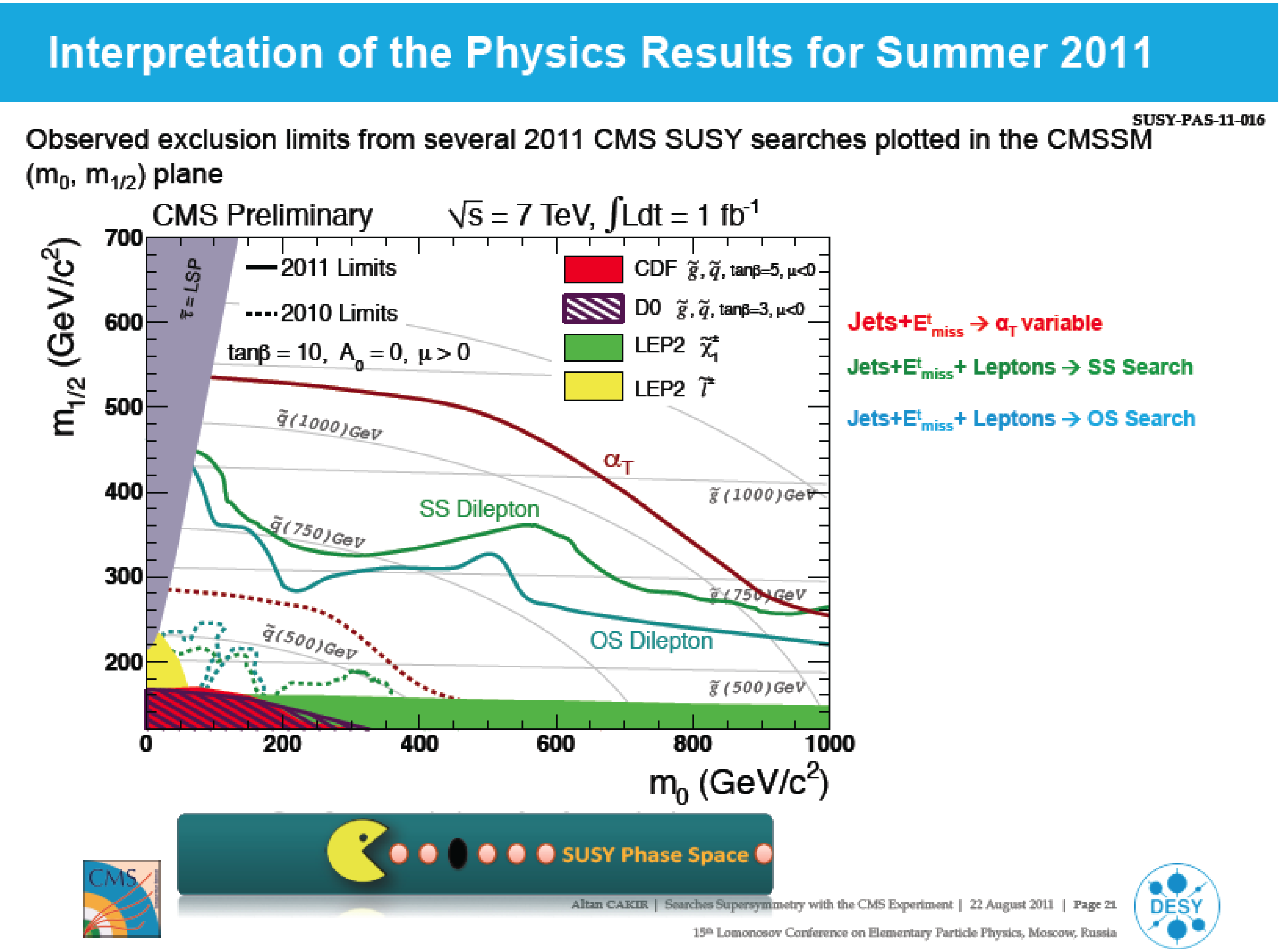


$$\bar{\rho} = 0.144\,^{+0.027}_{-0.018}\ (CKMfitter) = 0.132 \pm 0.020\ (UTfit)$$
$$\bar{\eta} = 0.343 \pm 0.014\ (CKMfitter) = 0.353 \pm 0.014\ (UTfit)$$

T.Gershon @LP11

LHC Results on SUSY (slide from A. Cakir, Lomonosov XV)

Summer 2011



So far no evidence for SUSY.

The SUSY mass scale is now looking likely to be above 1TeV.

This has interesting implications for some of our measurements.

We need to make sure our benchmark processes and assumed scales are still valid.

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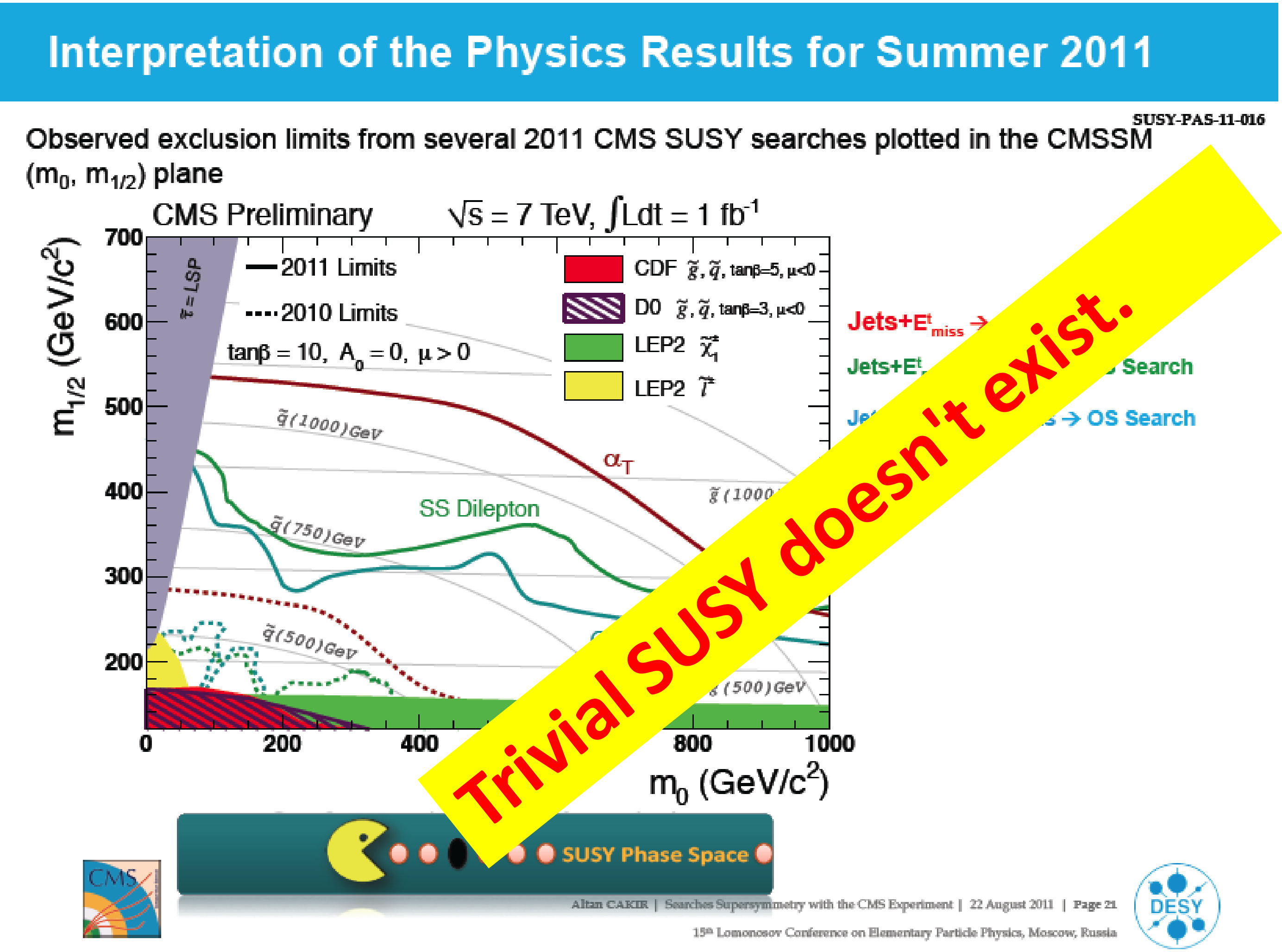

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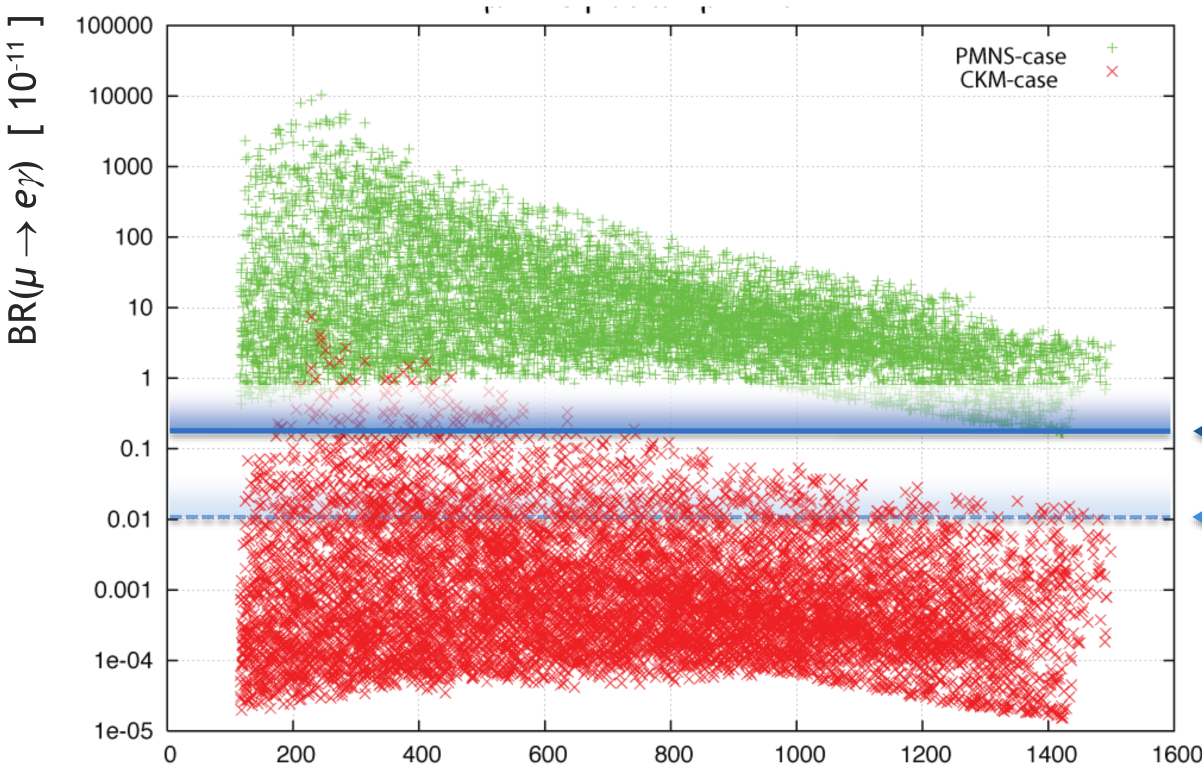
Summer 2011

LFV : MEG results



MEG 2009+2010

MEG 2009-2012

Interpretation in terms of SUSY-GUT SO(10) MSUGRA models:

- CKM case: min. mixing
- PMNS case: max. mixing

90% CL (Feldman-Cousins) upper limit:

$$BR(\mu^+ \to e^+\gamma) < \begin{cases} 2.4 \cdot 10^{-12} & \text{(observed)} \\ 1.6 \cdot 10^{-12} & \text{(expected for no signal)} \end{cases}$$

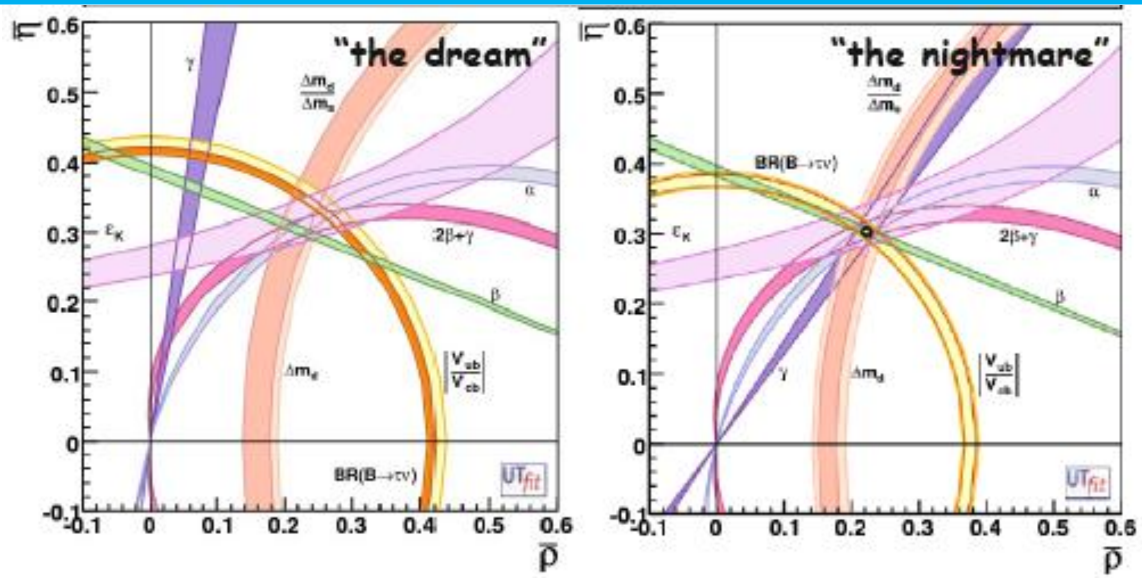
Outline

Question:

After the first results from LHC and 2011 Summer Conferences is there a role for SuperB?

- Accelerator
- Site
- Open issues for Detector.

Precision **CKM** constraints



Unitarity Triangle Angles

$\sigma(\alpha) = 1{-}2°, \sigma(\beta) = 0.1°, \sigma(\gamma) = 1{-}2°$

Cabibbo-Kobayashi-Maskawa Matrix Elements

$|V_{ub}|$: Incl. σ = 2%; Excl. σ = 3%

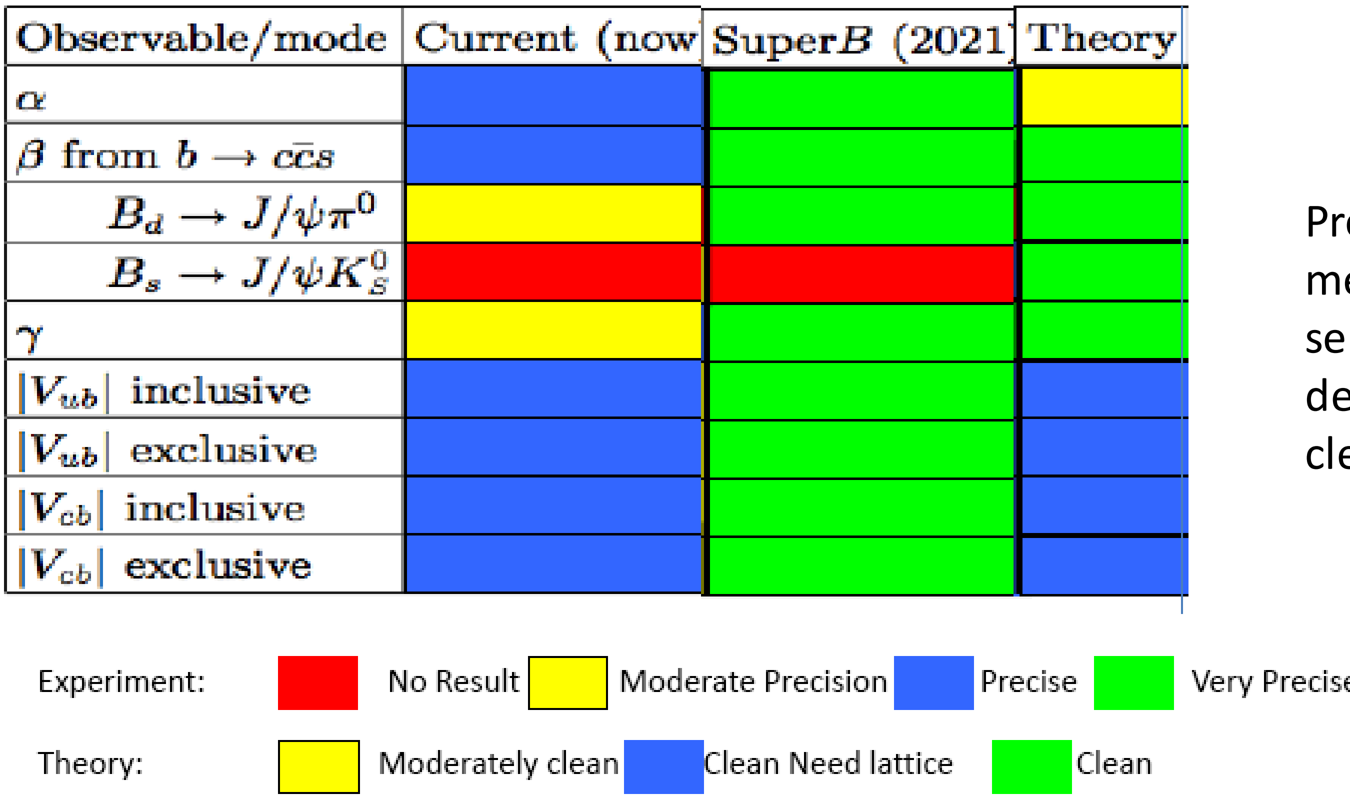
$|V_{cb}|$: σ = 1%

$|V_{us}|$: Can be measured precisely using τ decays

$|V_{cd}|$ and $|V_{cs}|$: can be measured at/near charm threshold.

SuperB Measures the sides and angles of the Unitarity Triangle

Nevertheless: Golden Measurements of CKM

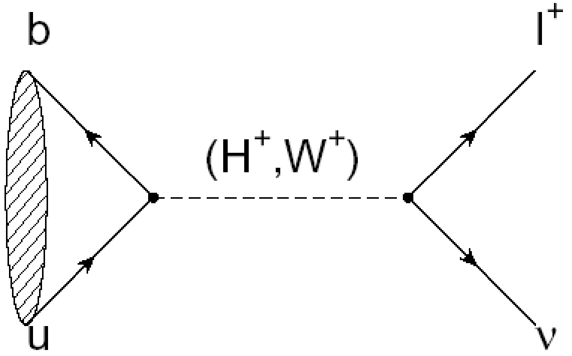


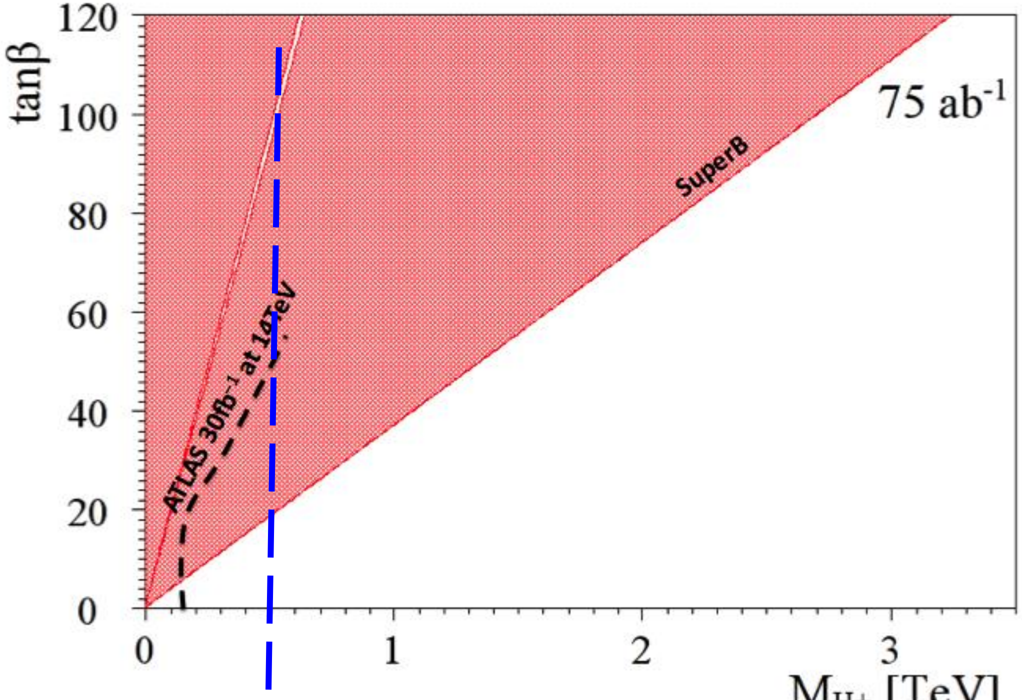
Precision measurements with semileptonic B decays only in e+e- clean environment.

$B_{u,d}$ physics: Rare Decays

- Example: $B^{\pm} \to \ell^{\pm}\nu$
  - Rate modified by presence of H^+

$$r_H = \frac{\mathcal{B}_{SM+NP}}{\mathcal{B}_{SM}}$$





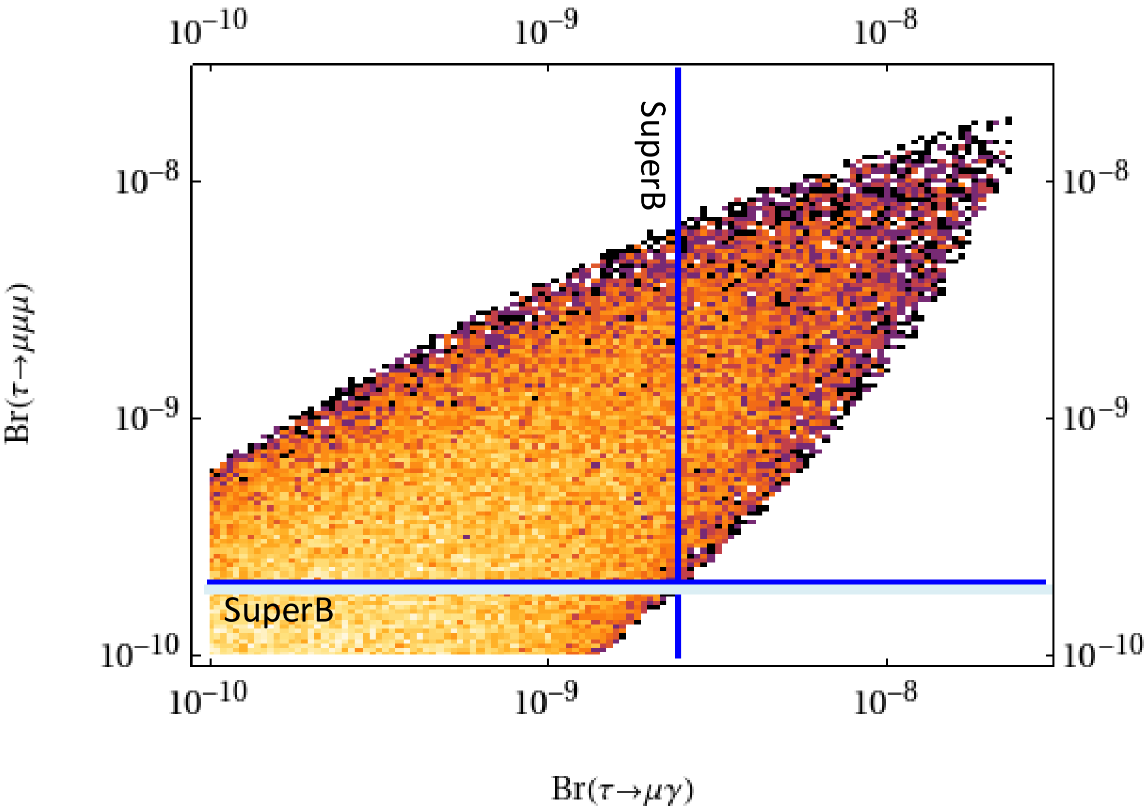
$$r_H = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)$$

Currently the inclusive $b \to s\gamma$ channel excludes $m_{H+} < 295$ GeV/c^2.

The current combined limit places a stronger constraint than direct searches from the LHC for the next few years.

Not only B Physics. The golden LFV $\tau \to \mu\gamma, 3\mu$ modes

- Symmetry breaking scale assumed: 500GeV.



NP scale assumed: 500GeV.

Current experimental limits are at the edges of the model parameter space

SuperB will be able to significantly constrain these models, and either find both channels, or constrain a large part of parameter space.

c/o M. Blanke

M. Blanke et al. arXiv:0906.5454

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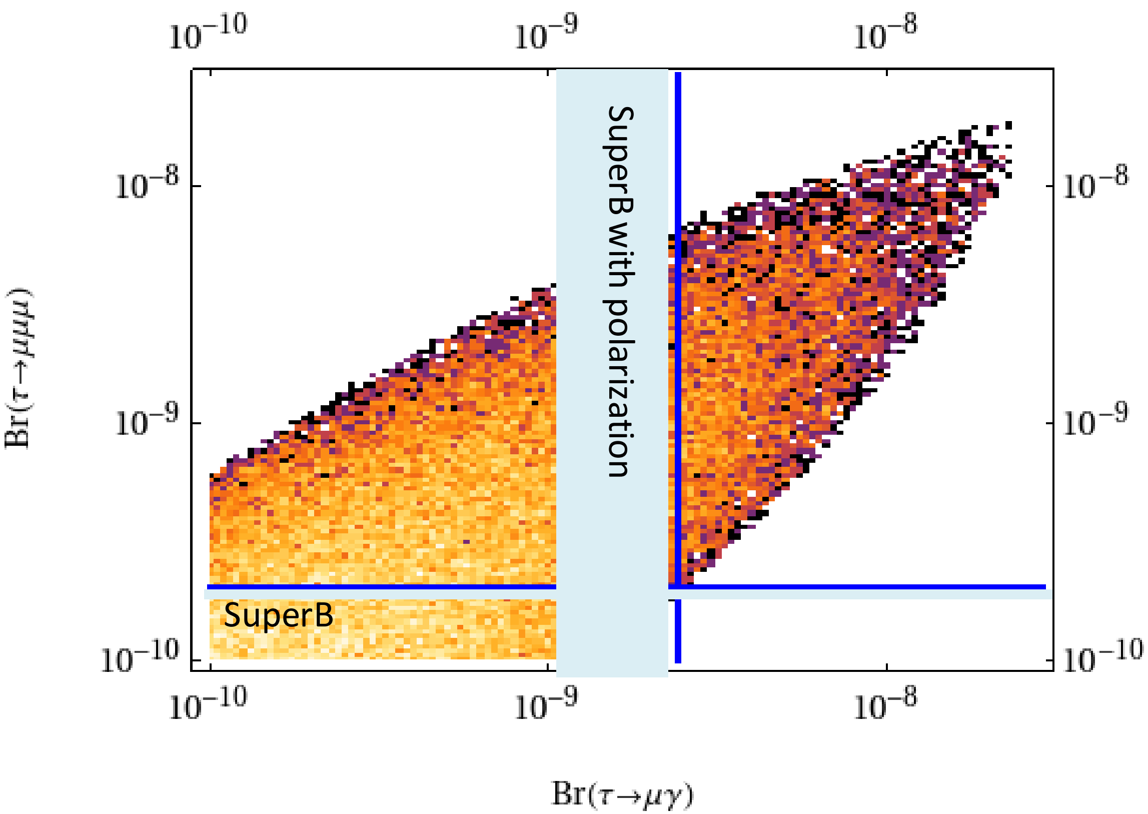

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Charged Lepton Flavour Violation (LFV)

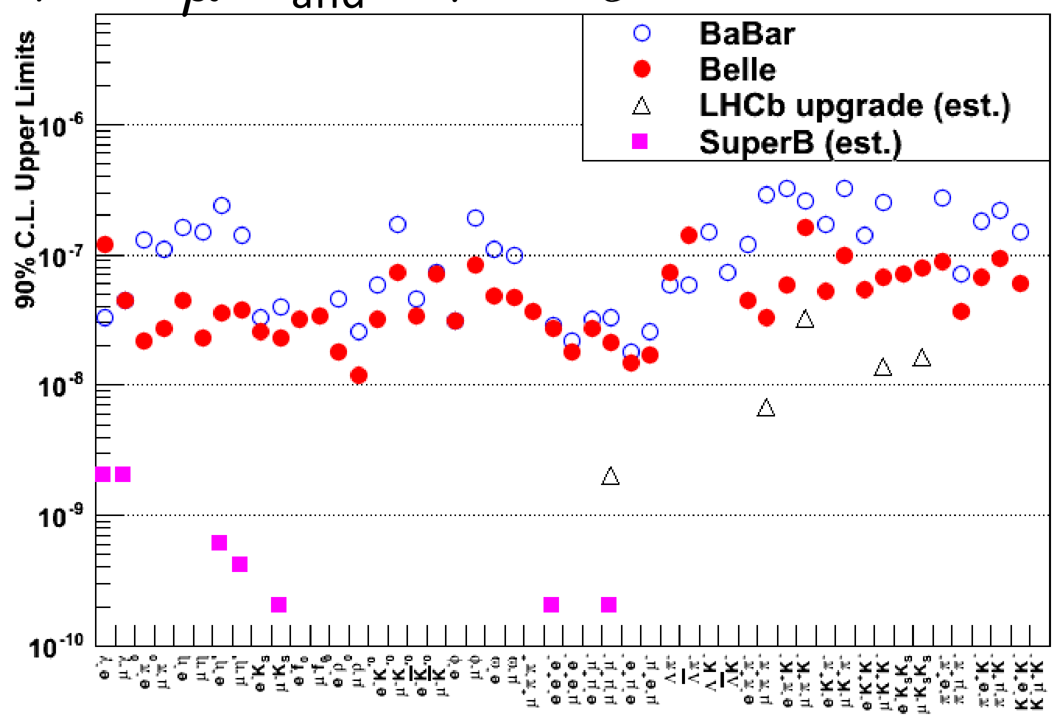
- ν mixing leads to a low level of charged LFV ($B \sim 10^{-54}$).
  - Enhancements to observable levels are possible with new physics scenarios.
  - Searching for transitions from 3rd generation to 2nd and 1st, i.e.

$\tau \longrightarrow \mu$ and $\tau \longrightarrow e$

➢Two orders of magnitude improvement at SuperB over current limits.

➢Hadron machines are not competitive with e^+e^- machines for this.

- N.B. e^- beam polarization helps suppress background.



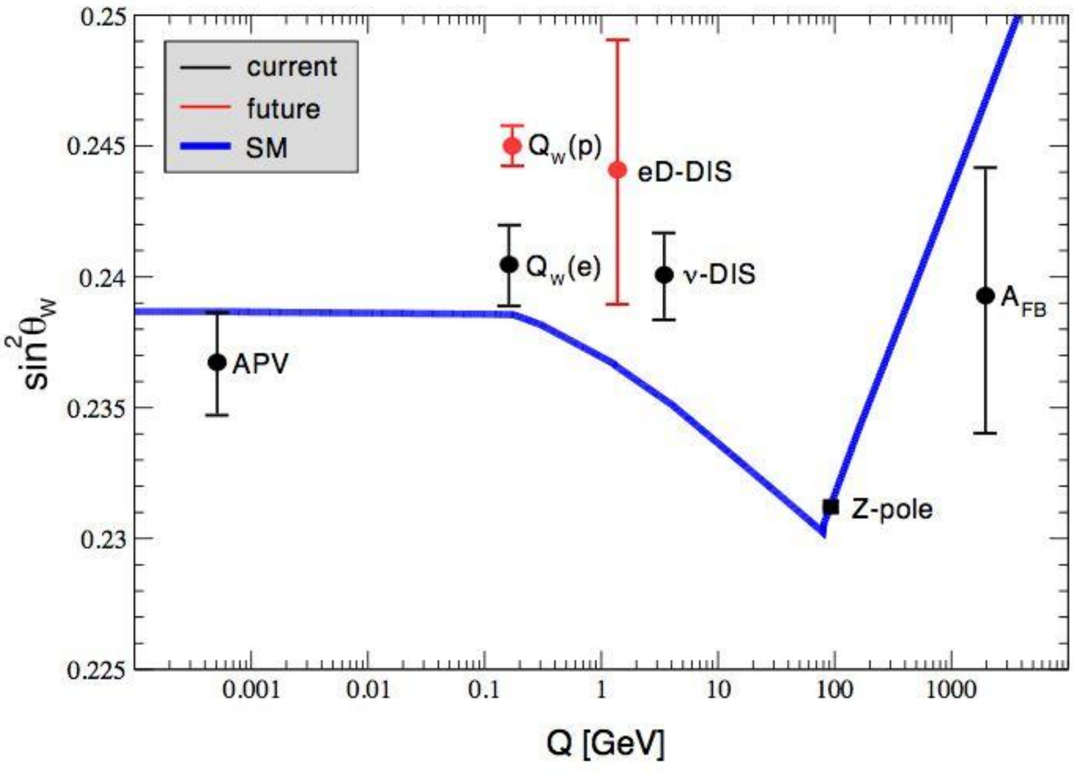
Lepton MFV GUT models — Isidori, 4th SuperB workshop — **complementary with MEG**

$B(\tau\to\mu\gamma):B(\tau\to e\gamma):B(\mu\to e\gamma) \sim \lambda^{-6}:\lambda^{-4}:1 \sim 10^4:500:1$ ← LFV from CKM

$B(\tau\to\mu\gamma):B(\tau\to e\gamma):B(\mu\to e\gamma) \sim [500\text{–}10]:1:1$ ← LFV from PMNS

POLARIZATION: Precision Electroweak

- $\sin^2\theta_W$ can be measured with polarised e^- beam at $\sqrt{s}=\Upsilon(4S)$ is theoretically clean, c.f. b-fragmentation at Z pole



Measure LR asymmetry in

$$e^+e^- \to b\bar{b}$$

$$e^+e^- \to \mu^+\mu^-$$

$$e^+e^- \to \tau^+\tau^-$$

at the $\Upsilon(4S)$ to same precision as LEP/SLC at the Z-pole.

Can also perform crosscheck at $\psi(3770)$ and use $c\bar{c}$ instead of $b\bar{b}$

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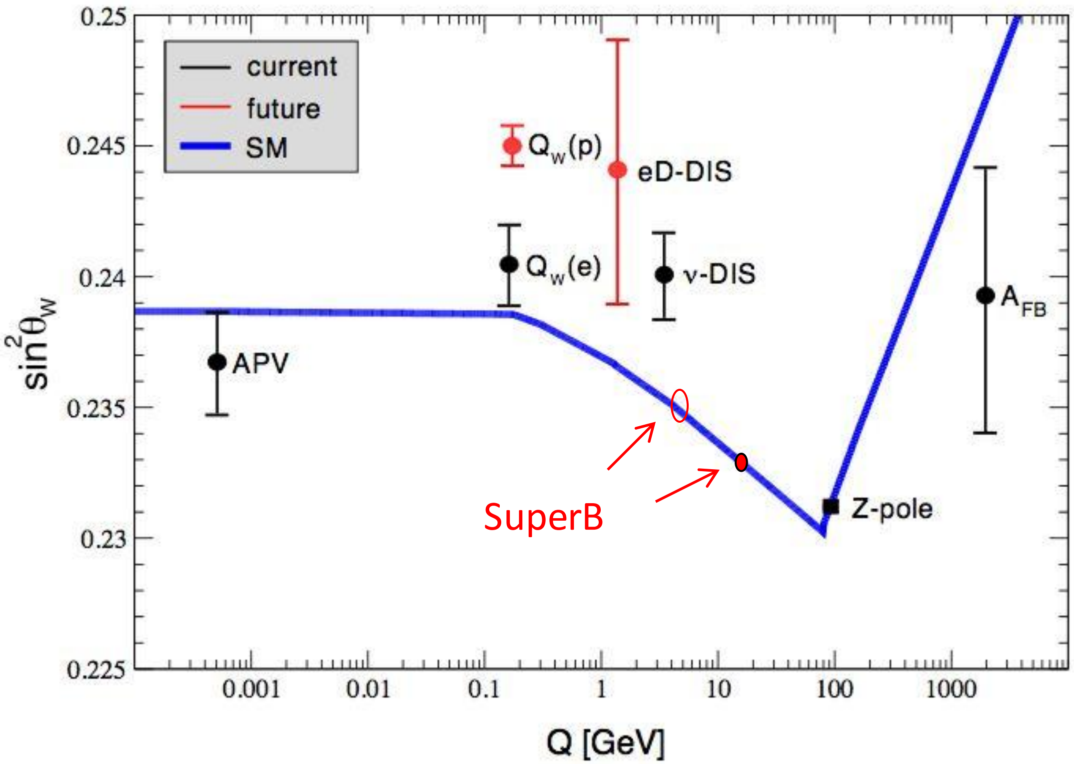

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Charm @ SuperB

- *Run at ϒ(4S):* $\mathcal{L} = 10^{36}\ \ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1};\ \ \int \mathcal{L}\, dt = 75\ \mathrm{ab}^{-1}$ at the $\Upsilon(4S)$

  $\beta\gamma=0.237$

✓ Large improvement in D^0 mixing and CPV: factor 12 improvement in statistical error wrt BaBar (0.5 ab^{-1});

✓ time-dependent measurements will benefit also of an improved (2x) D^0 proper-time resolution. [≈1KHz of $c\,\bar{c}$]

Unique feature of SuperB

- *Run at ψ(3770):* $\mathcal{L} = 10^{35}\ \ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1};\ \ \int \mathcal{L}\, dt =$ 500 fb^{-1} □ 1 ab^{-1} at $\Psi(3770)$

  $\beta\gamma$ from 0.237 to 0.56 (and polarization)

✓ $D\bar{D}$ coherent production with 100x BESIII data and CM boost up to $\beta\gamma=0.56$;

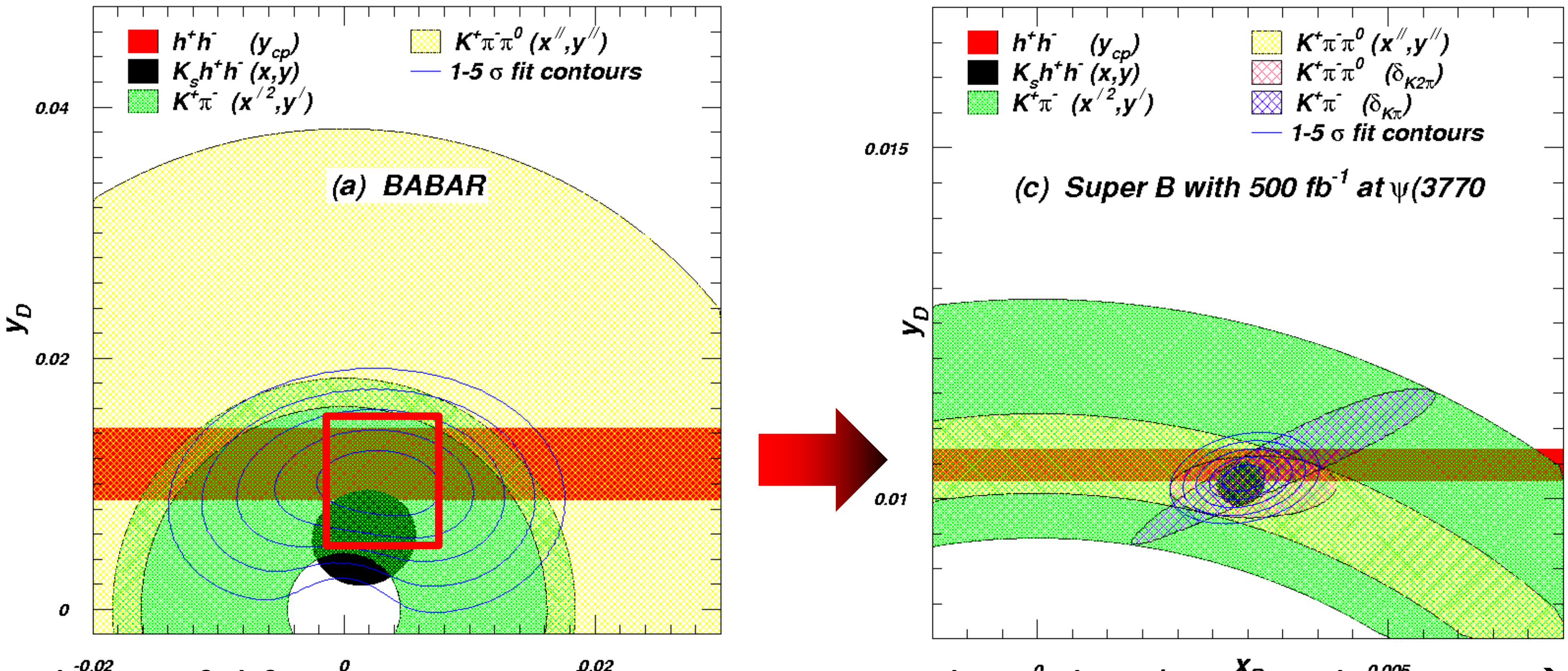
✓ almost zero background environment;

✓ possibility of time-dependent measurements exploiting quantum coherence

✓ **Study CPV with Flavour and CP tagging.**

Charm Mixing & CPV

Collect data also with TDA at threshold and at the Y_{4S}.
Benefit charm mixing and CPV measurements.



Also useful for measuring the Unitarity triangle angle γ (strong phase in D→Kππ Dalitz plot).

Recent very interesting result from LHCb on CPV a **3.5 σ effect**!

Combining with Bfactories results 3.4 σ

Experiment: No Result (red) Moderate Precision (yellow) Precise (blue) Very Precise (green)

Theory: Moderately clean (yellow) Clean Need lattice (blue) Clean (green)

Observable/mode Luminosity	Current $\sim 1\,\mathrm{ab}^{-1}$	SuperB (2022) $75\,\mathrm{ab}^{-1}$	Theory	
$\tau \to \mu\gamma$ $\tau \to e\gamma$	yellow	green	green	Benefit from polarised e⁻ beam
$B \to \tau\nu, \mu\nu$	yellow	blue	blue	very precise with improved detector
$B \to K^{(*)+}\nu\overline{\nu}$	red	green	green	Statistically limited: Ang. analysis with >75ab^{-1}
S in $B \to K_S^0\pi^0\gamma$	yellow	green	yellow	Right handed currents
S (other penguin modes)	yellow	green	yellow	SuperB measures many more modes
A_{CP} $(B \to X_s\gamma)$	blue	green	green	systematic error is main challenge
BR$(B \to X_s\gamma)$	blue	green	yellow	control systematic error with data
BR$(B \to X_s ll)$	yellow	green	green	
BR$(B \to K^{(*)}ll)$	yellow	green	yellow	SuperB measures e mode well, LHCb does μ
$B_s \to \mu\mu$	red	red	green	
β_S from $B_s \to J/\psi\,\phi$	red	red	green	
$B_s \to \gamma\gamma$	red	blue	green	
a_{sl}	red	green	green	
Mixing parameters	yellow	green	green	
CP Violation	red	green	green	Clean NP search
$\sin^2\theta_W$ at $\Upsilon(4S)$	red	green	green	Theoretically clean
$\sin^2\theta_W$ at Z-Pole	green	red	yellow	b fragmentation limits interpretation

Spectroscopy

- Wide range of searches that can be made:
  - SM searches, and understanding the properties particles, e.g. of X, Y, Z (establishing quantum numbers and resolving issues in the field).
  - Searching for light scalar particles (Higgs and Dark Matter candidates).
  - Di-lepton and 4-lepton final states can be used to test:
    - lepton universality (c.f. NA62, many possible measurements in this area).
    - models of Dark Forces (few GeV scalar field in the dark sector).

The BaBar's most cited paper is the discovery of the D_{sJ}.

REQUIREMENTS FROM PHYSICS

Parameter	Requirement	Comment
Luminosity (top-up mode)	10^{36} cm^{-2}s^{-1} @ $\Upsilon(4S)$	Baseline/Flexibility with headroom at 4. 10^{36} cm^{-2}s^{-1}
Integrated luminosity	75 ab^{-1}	Based on a "New Snowmass Year" of 1.5 x 10^7 seconds (PEP-II & KEKB experience-based)
CM energy range	τ threshold to $\Upsilon(5S)$	For Charm special runs (still asymmetric……)
Minimum boost	$\beta\gamma \approx 0.237$ ~(4.18x6.7GeV)	1 cm beam pipe radius. First measured point at 1.5 cm
e^- Polarization Boost up to 0.56 in runs at low energy under evaluation for charm physics	≥80%	Enables τ *CP* and *T* violation studies, measurement of τ *g*-2 and improves sensitivity to lepton flavor-violating decays. Precise measurements of $\sin^2\theta_W$.

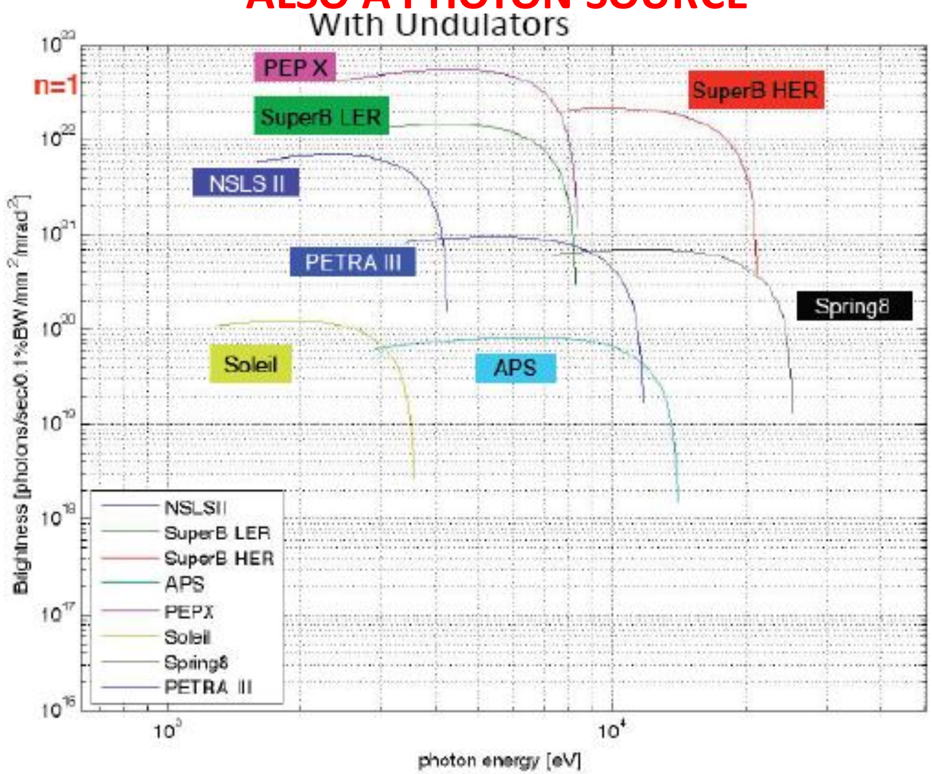
:SuperB can also be a good "light source": work is in progress to design Synchrotron Radiation beamlines (collaboration with Italian Institute of Technology)

Baseline Collider parameters

		Base Line	
Parameter	Units	HER (e+)	LER (e-)
LUMINOSITY (10^{36})	$cm^{-2}\ s^{-1}$	1	
Energy	GeV	6.7	4.18
Circumference	m	1258.4	
X-Angle (full)	mrad	60	
Piwinski angle	rad	20.80	16.91
β_x @ IP	cm	2.6	3.2
β_y @ IP	cm	0.0253	0.0205
Coupling (full current)	%	0.25	0.25
ε_x (without IBS)	nm	1.97	1.82
ε_x (with IBS)	nm	2.00	2.46
ε_y	pm	5	6.15
σ_x @ IP	μm	7.211	8.872
σ_y @ IP	μm	0.036	0.036
Σ_x	μm	11.433	
Σ_y	μm	0.050	
σ_L (0 current)	mm	4.69	4.29
σ_L (full current)	mm	5	5
Beam current	mA	1892	2447
Buckets distance	#	2	
Buckets distance	ns	4.20	
Ion gap	%	2	
RF frequency	MHz	476	
Harmonic number		1998	
Number of bunches		465	
N. Particle/bunch (10^{10})		5.08	6.56
Tune shift x		0.0026	0.0040
Tune shift y		0.1067	0.1069
Long. damping time	msec	13.4	20.3
Energy Loss/turn	MeV	2.11	0.865
σ_E (full current)	$\delta E/E$	6.43E-04	7.34E-04
CM σ_E	$\delta E/E$	5.00E-04	
Total lifetime	min	4.23	4.48
Total RF Power	MW	16.38	

The baseline peak luminosity at Y(4s) is 1.0 10^{36} $cm^{-2}\ s^{-1}$.
It ca be increased by adding RF power up to a factor of 4 .
The runs near charm threshold $\Psi(3770)$ pay a factor O(10) in luminosity. At charm threshold the boost($\beta\gamma$) can be increased up to 0.56 for time dependent measurements , still with a reasonable polarization.

ALSO A PHOTON SOURCE



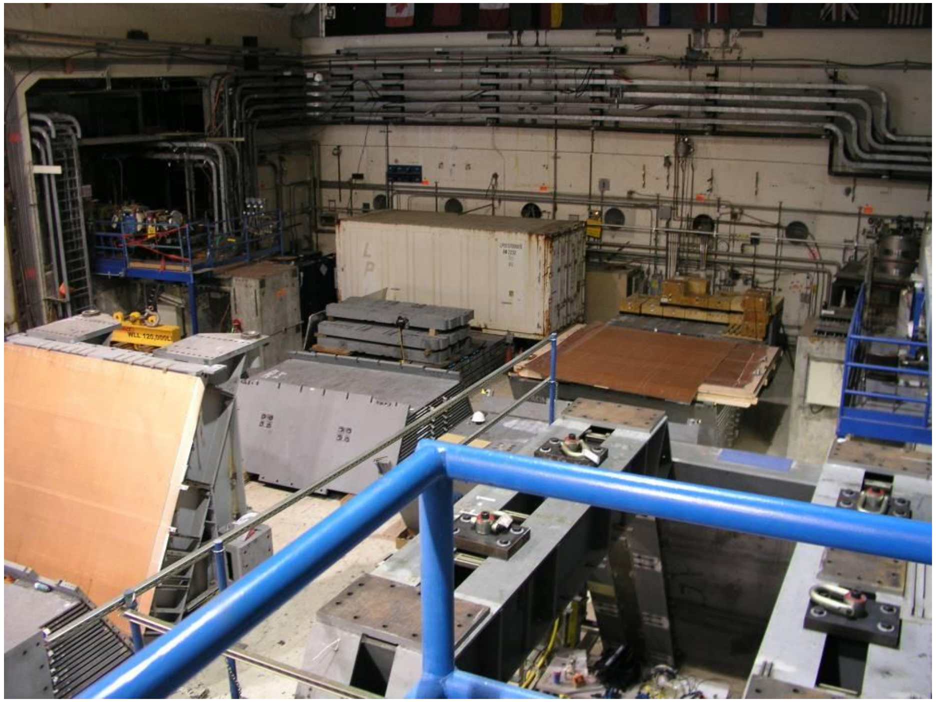
3.5 min beam lifetime → CONTINUOUS INJECTION as in PEPII

BABAR decommissioning

BABAR - March 2009

BABAR decommissioning

Deconstructed Onion Storage



Detec ptions)

Electronics, Trigger, DAQ: all new

IFR: Replace LSST with scintillator + WLS Fibers + SiPM

Solenoid

PID: Focu
Reuse qu
New Ligh

EMC: Opti
Pb / Scinti

SVT: Fiv
strips +

Backgrou
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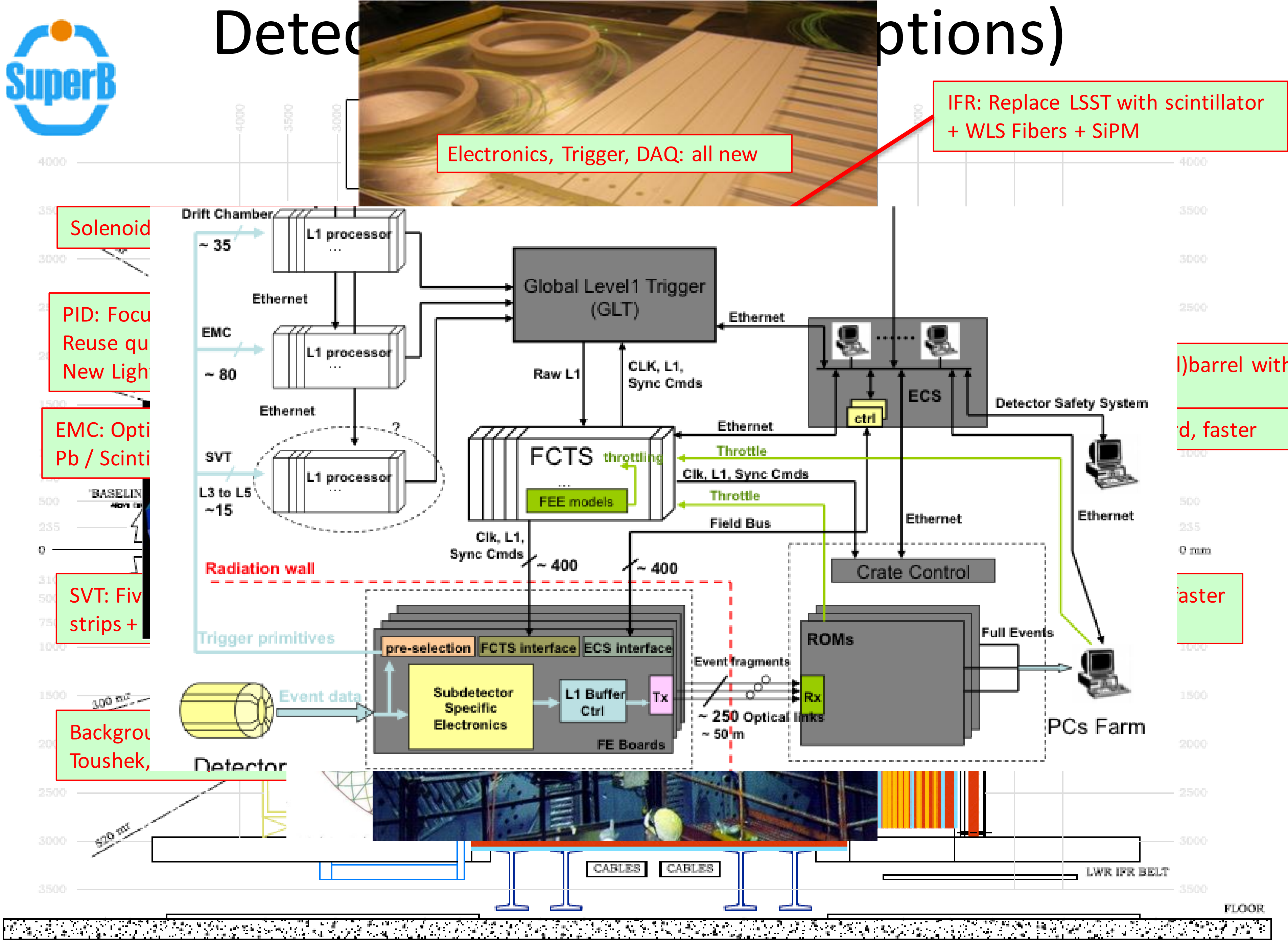
d, faster

faster



System	Institutions
SVT	Bologna, Milano, Pavia, Pisa, Rome3, Torino, Trieste, Trento, LBNL, Queen Mary, RAL, Strasbourg, Bari
DCH	LNF, McGill, Montreal, TRIUMF, UBC, Victoria, Lecce
PID	SLAC, BINP, Cincinnati, Bari, Padova, Maryland, LAL, LPNHE, UC Riverside
EMC	Bergen, Caltech, Perugia, Rome1, Napoli
IFR	Ferrara, Padova, Krakow, Bologna
ETD	SLAC, Caltech, Napoli, Bologna, LAL, Padova, Rome3
Computing	Padova, Ferrara, Torino, Bari, Bologna, Rome2, Pisa, Perugia, LNF, LBNL, Napoli, SLAC
Magnet/ Integration	SLAC, LNF, Pisa, Genova
Backgrounds/MDI	SLAC, Pisa, LNF, LNS, Cagliari, Ohio State
TBD	(Valencia, Barcelona, Annecy, Tel Aviv, Liverpool, Kiev, ITEP, Kansas, Livermore, Louisville, Notre Dame,Ohio State, Princeton, Southern Methodist, South Carolina, Austin, Utah)

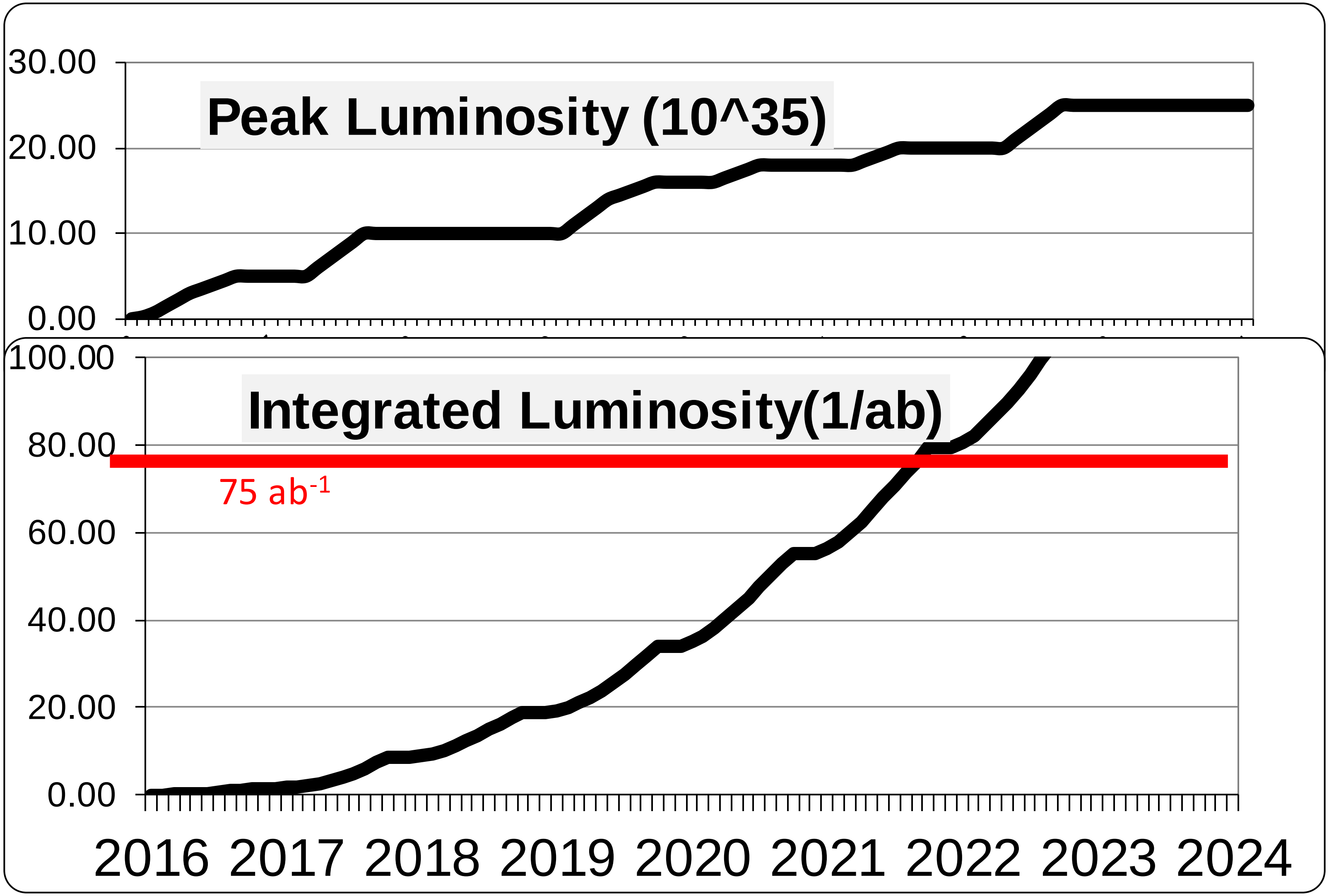
+ Mexico
+ China

September 2011
QMUL

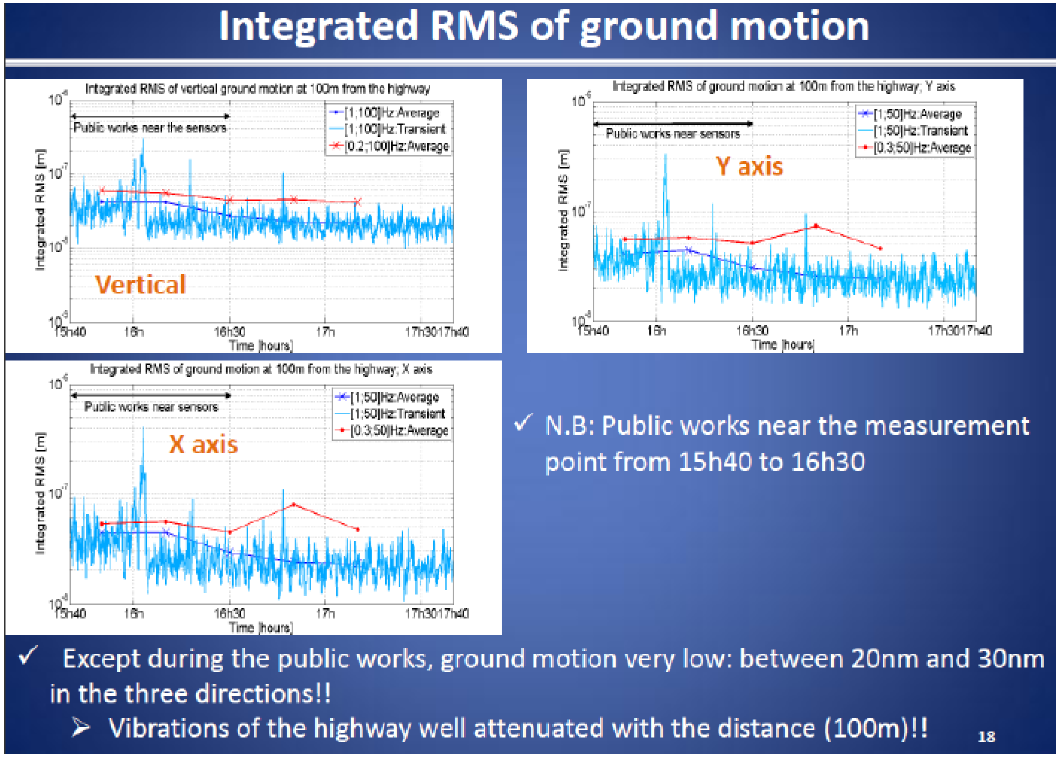
12 Nations
52 Institutions
252 Collaborators

END

SuperB Luminosity model



Ground motion measurements 100 m from highway vs requirements



(B. Bolzon et al)

- Vibration measurements on site (April2011) show «solid» ground in spite of the vicinity of the Rome-Naples Highway 100 m away
- The Highway is at higher level with respect to the site, and the traffic vibrations («cultural noise») are well damped .

	Request (vertical displacement)	Measured (vertical displacement)
IP	300 nm	20-40 nm
Final Focus	300 nm	20-30 nm
Arcs	500 nm	20-30 nm

Documents

- The Discovery Potential of a Super B Factory Slac-R-709
- Physics at Super B Factory: hep-ex/0406071
- SuperB report: hep-ex/0512235
- SuperB Conceptual Design Report arxiv.org/abs/0709.0451
- New Physics at the Super Flavor Factory arxiv.org/abs/0810.1312
- Detector Progress Report: arxiv.org/abs/1007.4241
- Physics Progress Report: arxiv.org/abs/1008.1541
- Accelerator Progress Report: arxiv.org/abs/1009.6178
- The impact of SuperB on Flavour Physics : arxiv.org/abs/1109.5028
- See http://superb.infn.it

Experiment: Red = No Result, Yellow = Moderate Precision, Blue = Precise, Green = Very Precise

Theory: Yellow = Moderately clean, Blue = Clean Need lattice, Green = Clean

Observable/mode	Current (now)	LHCb (2017)	Super$B$ (2021)	LHCb upgrade	theory	
τ Decays						
$\tau \to \mu\gamma$	Yellow	Yellow	Green	Yellow	Green	Benefit from polarised e⁻ beam
$\tau \to e\gamma$	Yellow	Yellow	Green	Yellow	Green	
$B_{u,d}$ Decays						
$B \to \tau\nu, \mu\nu$	Yellow	Red	Blue	Red	Blue	very precise with improved detector
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Precision EW						
$\sin^2\theta_W$ at $\Upsilon(4S)$	Red	Red	Green	Red	Green	Theoretically clean
$\sin^2\theta_W$ at Z-pole	Green	Blue	Red	Green	Yellow	b fragmentation limits interpretation

Future Super B Factories

	SuperB	Super KEKB
Peak Luminosity	$>10^{36}$	0.8×10^{36}
Integrated Luminosity	75 ab^{-1}	50 ab^{-1}
Site	Non Green Field (Tor Vergata)	KEKB Laboratory
Collisions	end 2016	2015
Polarization	80% electron beam	No
Low energy running	10^{35} @ charm threshold	No
Approval status	Approved	Approved

SuperB site @ Tor Vergata, 4.5 Km from LNF