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on behalf of the SuperB collaboration.

VIIIth Rencontres du Vietnam
16-22 December 2012
Quy Nhon

The SuperB project

Outline:

- Project status
- Physics case
- Accelerator
- Detector
- Physics reach

Project status (I)

- 2005: SuperB physics studies initiated:
  - The Discovery Potential of a Super B factory, hep-ph/0503261.
  - SuperB: a linear high-luminosity B Factory, hep-ph/0512235.

- Dec. 2010: SuperB approved as 1st in a list of 14 "flagship" projects within the Italian national research plan, with a financial allocation of 256 M€ in six years.

- May 2011: Tor Vergata (Univerity Roma-II) site choosen.
  SuperB collaboration created. http://superb.infn.it/home

- Oct. 2011: Cabibbo Laboratory consortium created to build the SuperB accelerator.
  International team consisting today of: Italy, US, France, Russia, UK.
  http://www.cabibbolab.it
  Later : evolve towards an ERIC.

- 2012: MOUs with various institutions completed: CERN, Orsay, SLAC, Novosibirsk, ...

Project status (2)

- Nov. 2012: cost review by research ministry.

  ➛ Nov. 29th, 2012: SuperB project as such is too expensive for Italy given the current economical situation.

- INFN news from Nov. 29th, 2012:

" *I risultati della commissione internazionale nominata dal MIUR per il costing review del progetto bandiera SuperB sono stati esaminati ieri dal Ministro della Ricerca che ha voluto discuterne con i vertici dell'INFN e successivamente con quelli del Cabibbolab.*

Il Ministro ha fatto presente che non erano in discussione l'importanza e la qualità del programma, ma che le condizioni economiche del paese e i limiti previsti dal Piano Nazionale per la Ricerca, erano incompatibili con i costi del progetto valutati.

Il Ministro, mostrando grande disponibilità, ha dato la possibilità all'INFN di proporre progetti, sempre nella tipologia dei "progetti bandiera", compatibili con lo stanziamento previsto inizialmente. Le proposte dovranno essere valutate entro pochi mesi. L'INFN sta quindi vagliando le idee in merito.
Tra le possibilità, comunque, verrà esplorata con convinzione l'ipotesi di presentare il progetto per la realizzazione di un laboratorio internazionale finalizzato alla costruzione di una macchina acceleratrice nell'area di Frascati. "

- Next step:

  SuperB is investigating how to answer to this proposition and redefine the project.

  ➛ in the following is presented the SuperB project as it was foreseen until now.

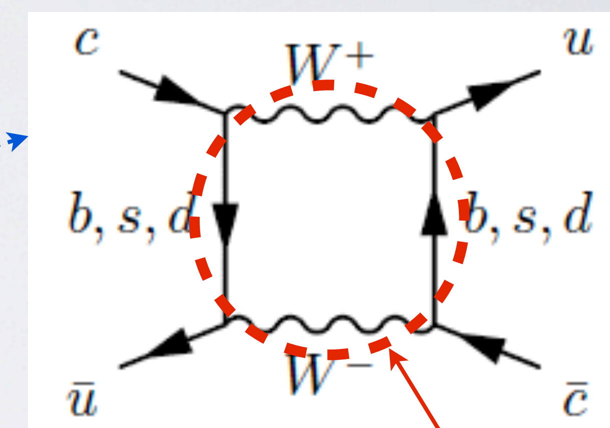
The physics case

- The Higgs-like particle apart, no indications so far of new light particles at LHC:
  Where/what is the Beyond SM physics? Very few experimental indications:
  - lepton flavour is violated,
  - it should exist another source of CP violation,
  - dark matter and dark energy?
  - several puzzling ~3σ smoking guns, mainly in the flavour sector:
    muon g-2, $\sin^2\theta_W$, $B\to\tau\nu$, $B\to D^{(*)}\tau\nu$, di-μ same charge asymmetry, V_{ub}, ...

Finding and decoding NP will not be easy!
➛ a global effort based on different programs:

- The quantum path: intensity frontier.
  Indirect sensitivity to NP needs:
  - high statistics,
  - good experimental precision,
  - good theory understanding.

SuperB

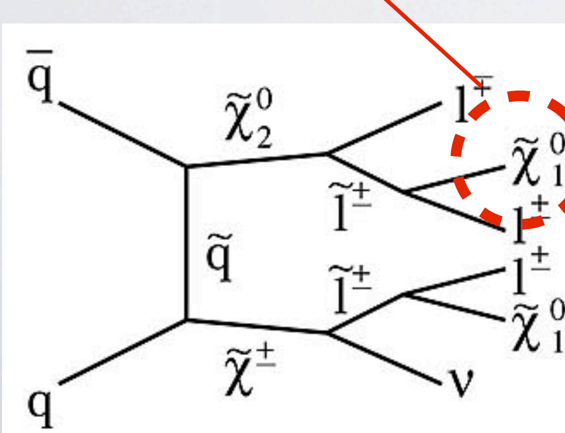


new physics?

- The relativistic path: energy frontier.

LHC

new physics?



➛ complementarity and emulation between different programs:
enhanced sensitivity to New Physics.

The "SuperB" physics program

- Two scenarios when SuperB planned to start taking data (2018):
  - NP is not found at the LHC: look for indirect NP signals, up to larger scales than LHC (10 TeV and more) and exclude regions in parameter space.
  - NP is found at the TeV scale at the LHC: determine the detailed flavour structure of NP couplings.

➛ crucial role of SuperB in all cases, with a program covering:

- CKM matrix elements,
- Rare B and D decays,
- Mixing and CPV in B^0 and D^0,
- B_s^0 physics,
- τ physics,
- Precision electroweak physics,
- Spectroscopy,
- Direct searches.

➛ double prong attack on the quark and lepton sectors

From BaBar to SuperB

- Goal: with same per-event performances as BaBar (spatial resolution, particle-Id), the physics program requires:
  - Integrated luminosity: 75 ab^{-1} in 5 years @ $\Upsilon(4S)$.
  - Instantaneous luminosity: $\geq 10^{36}$ cm^{-2} s^{-1} @ $\Upsilon(4S)$.
  - Longitudinal e^- polarisation: 60-80%.
  - Centre-of-mass energy: flexible from τ threshold to $\Upsilon(5S)$.

    ➛ SuperB is a super τ-B-D factory:

8×10^{10} coherent and boosted $B^0\bar{B}^0$ and as much B^+B^- + 10^{11} $e^+e^- \to c\bar{c}$ and 7×10^{10} $\tau^+\tau^-$
+ several 10^9 coherent and boosted $D^0\bar{D}^0$ and as much D^+D^- + $B^0_s\bar{B}^0_s$.

- Use large parts of the BaBar detector, but:
  - Higher acquisition rate.
  - Increased machine induced backgrounds.
  - Reduced boost: $\beta\gamma = 0.24$ @ $\Upsilon(4S)$ (w.r.t. 0.56 in BaBar)

    ➛ some parts of the SuperB detector need R&D.

➛ the SuperB experiment takes advantage on instrumental and analysis knowledges gained with BaBar.

The SuperB accelerator

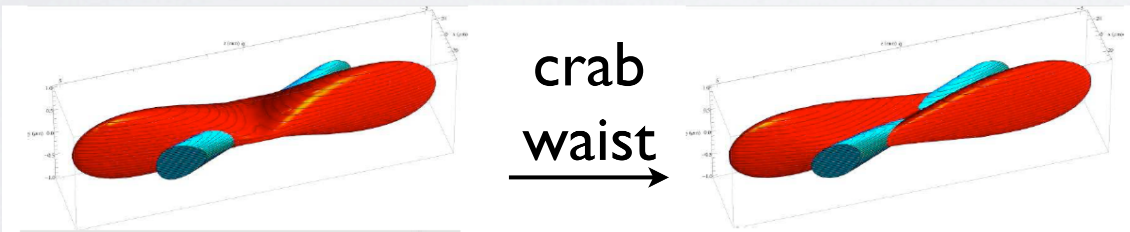
- Asymmetric beams : e^- 4.18 GeV / e^+ 6.7 GeV, in 2 rings of diameter 1258 m.
- Keep low beam currents, similar to PEP-II, to limit the background.
- Minimise building costs: re-use parts of PEP-II.
- SuperB may host a very intense Synchrotron Radiation light source with several beamlines.
- To reach 10^{36} $cm^{-2}s^{-1}$: transverse beam size ~ 30 nm (ultra-low emittance beam from ILC).

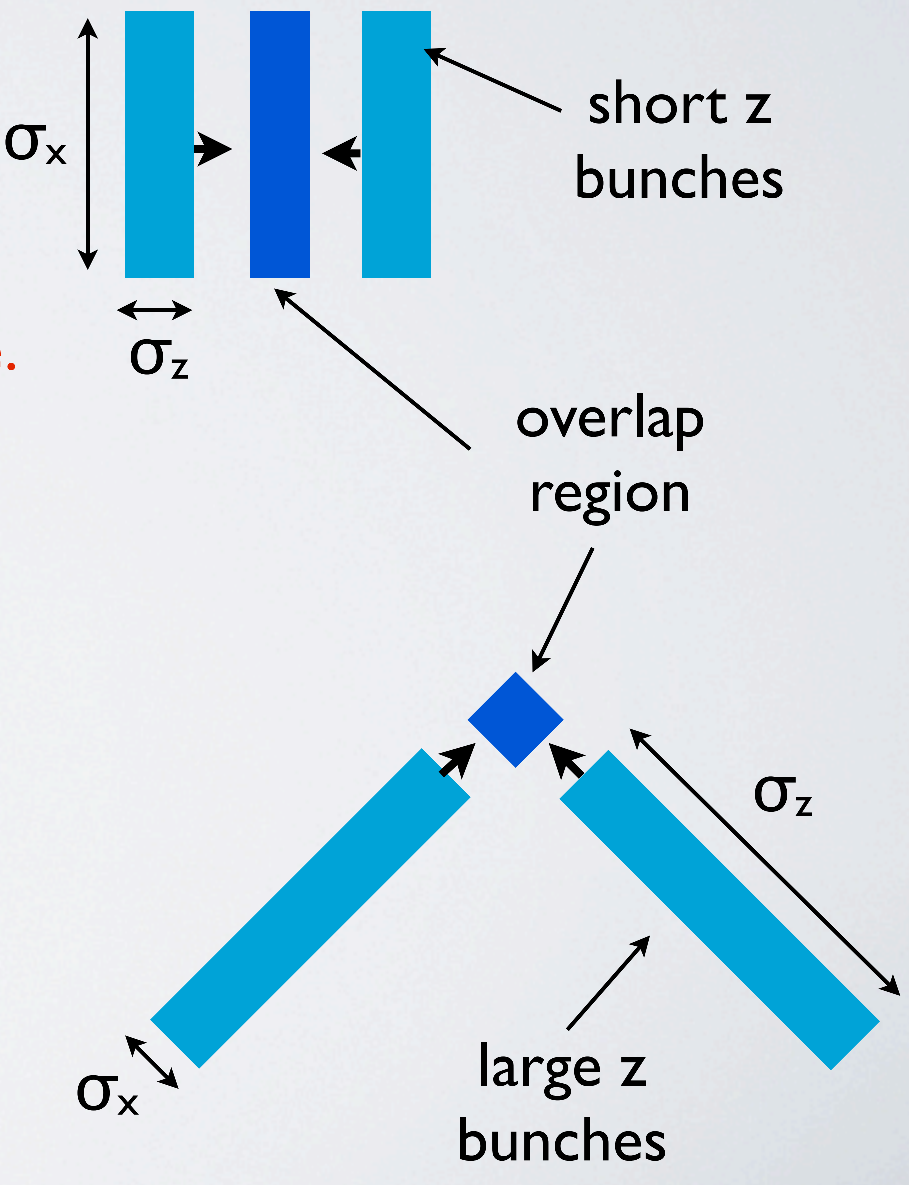
  ➛ need effective σ_z very small: very hard to do.

  ➛ use long bunches (large σ_z) + large Piwinski crossing angle.

  ➛ very large undesirable beam-beam effects.

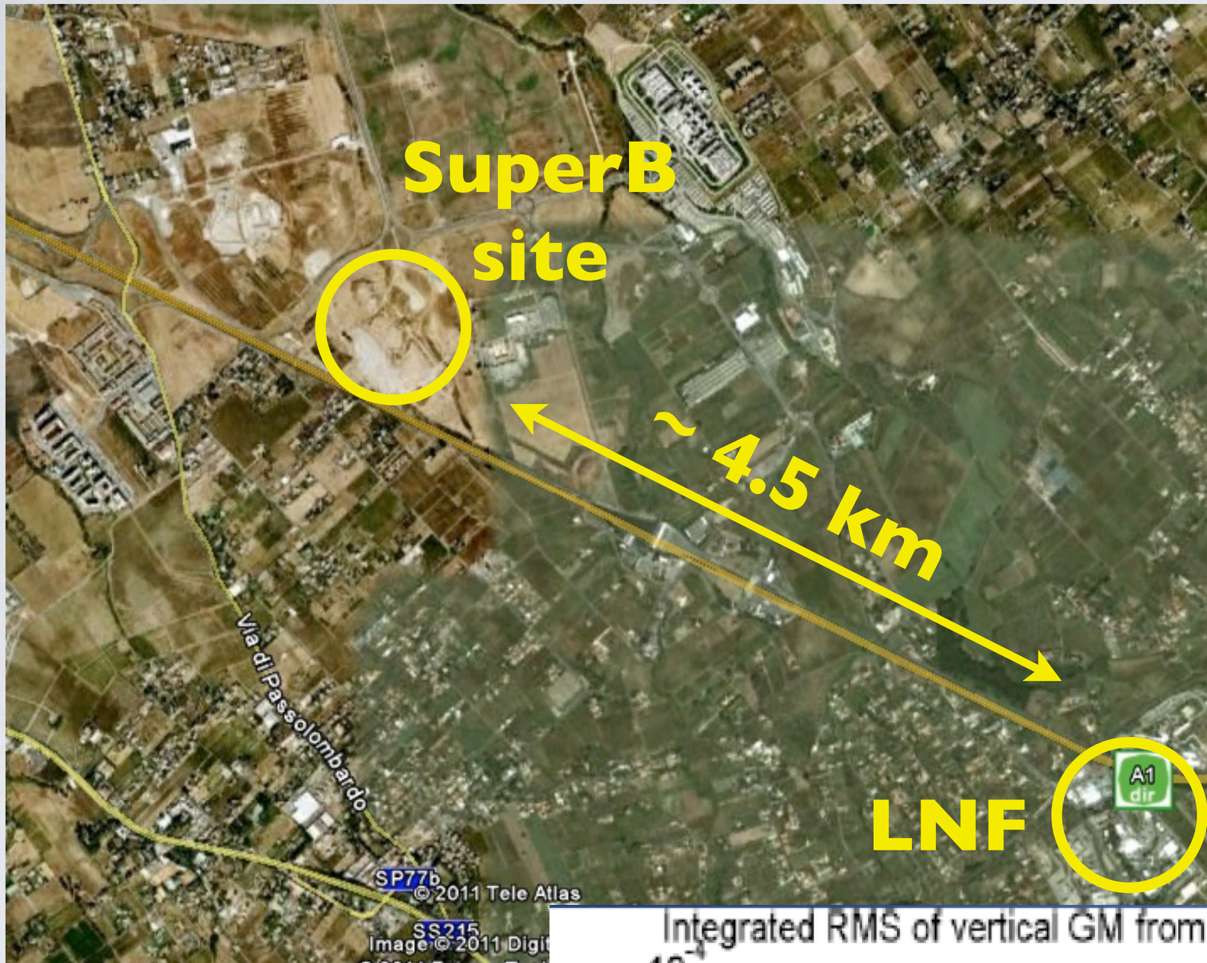
  ➛ pre-distort the beams (crab waist).

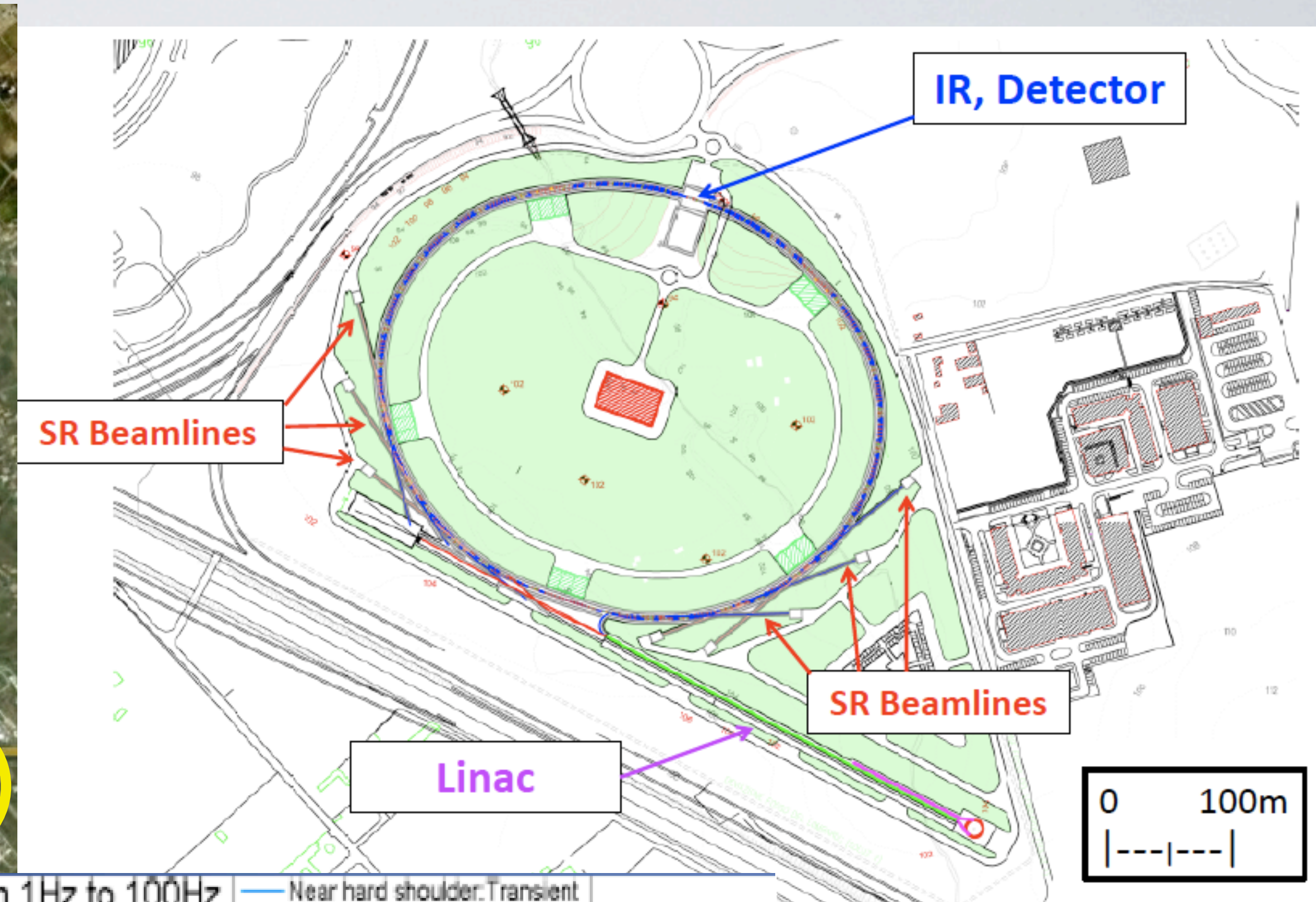


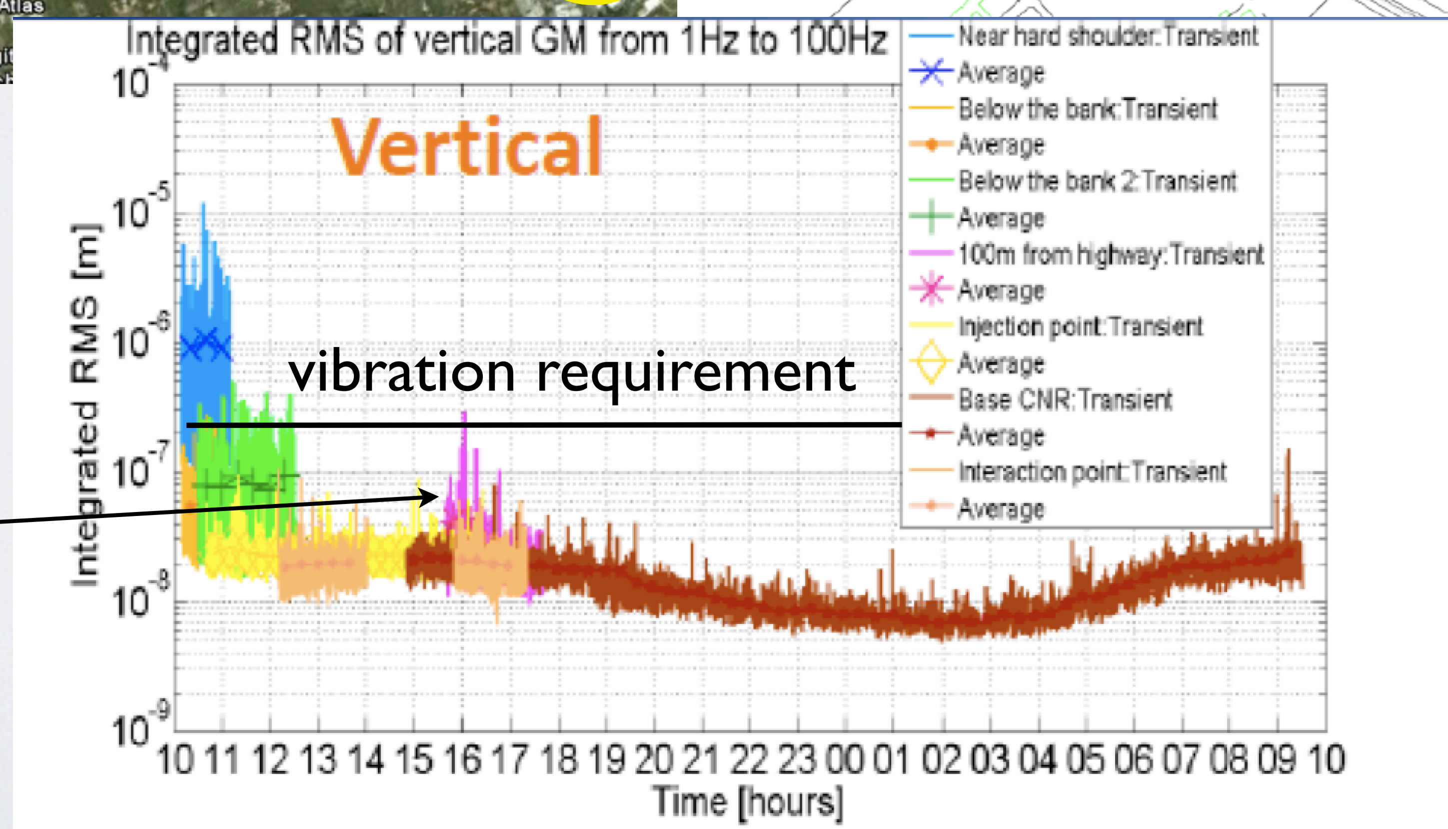


- Collision scheme with large Piwinski angle + crab waist successful tested at DAFNE in 2009: instantaneous luminosity x3.

The SuperB site





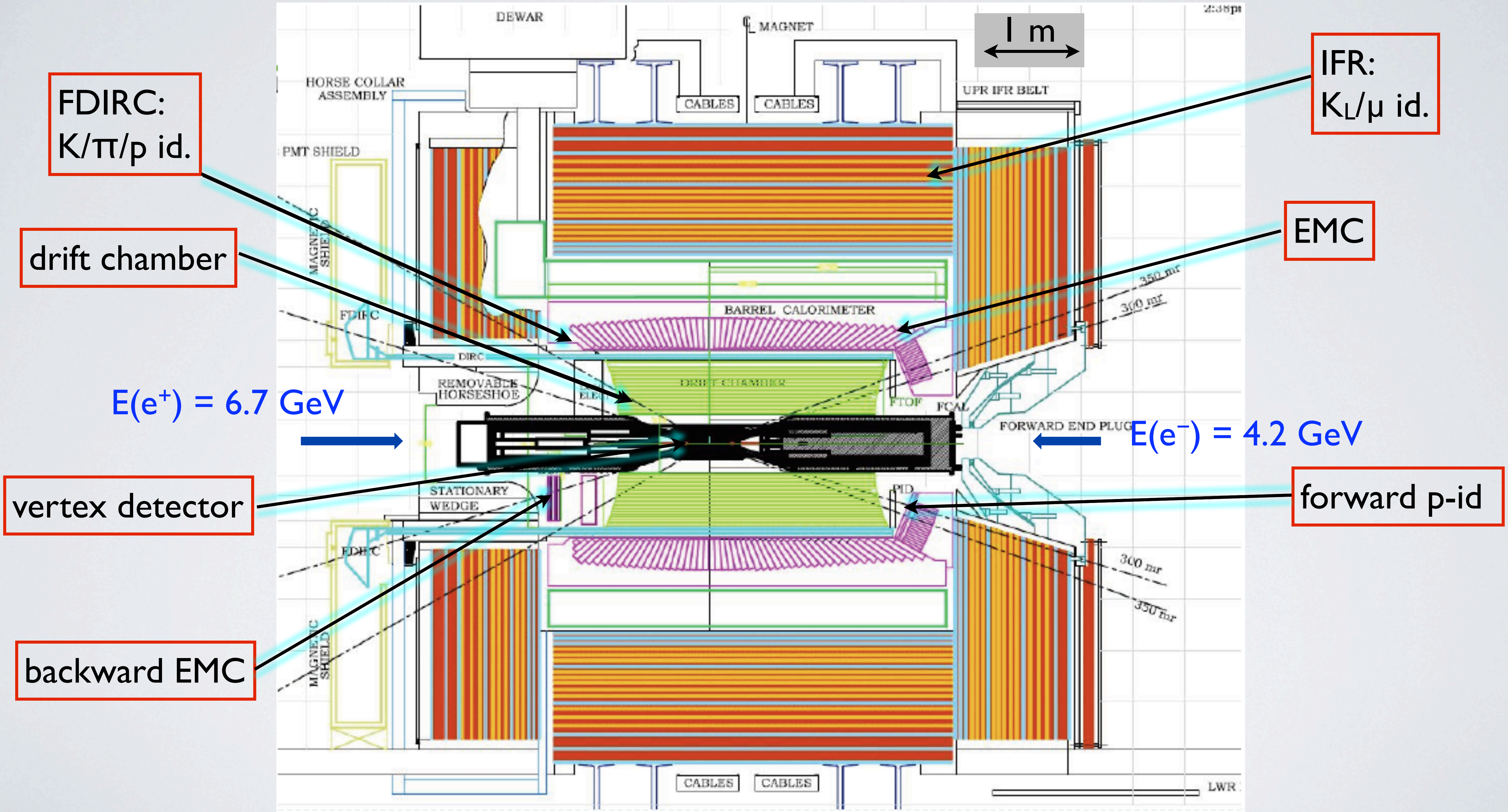


public works near the measurement point!

Site vibrations are extremely small: ~ 30 nm around the ring.

The SuperB detector

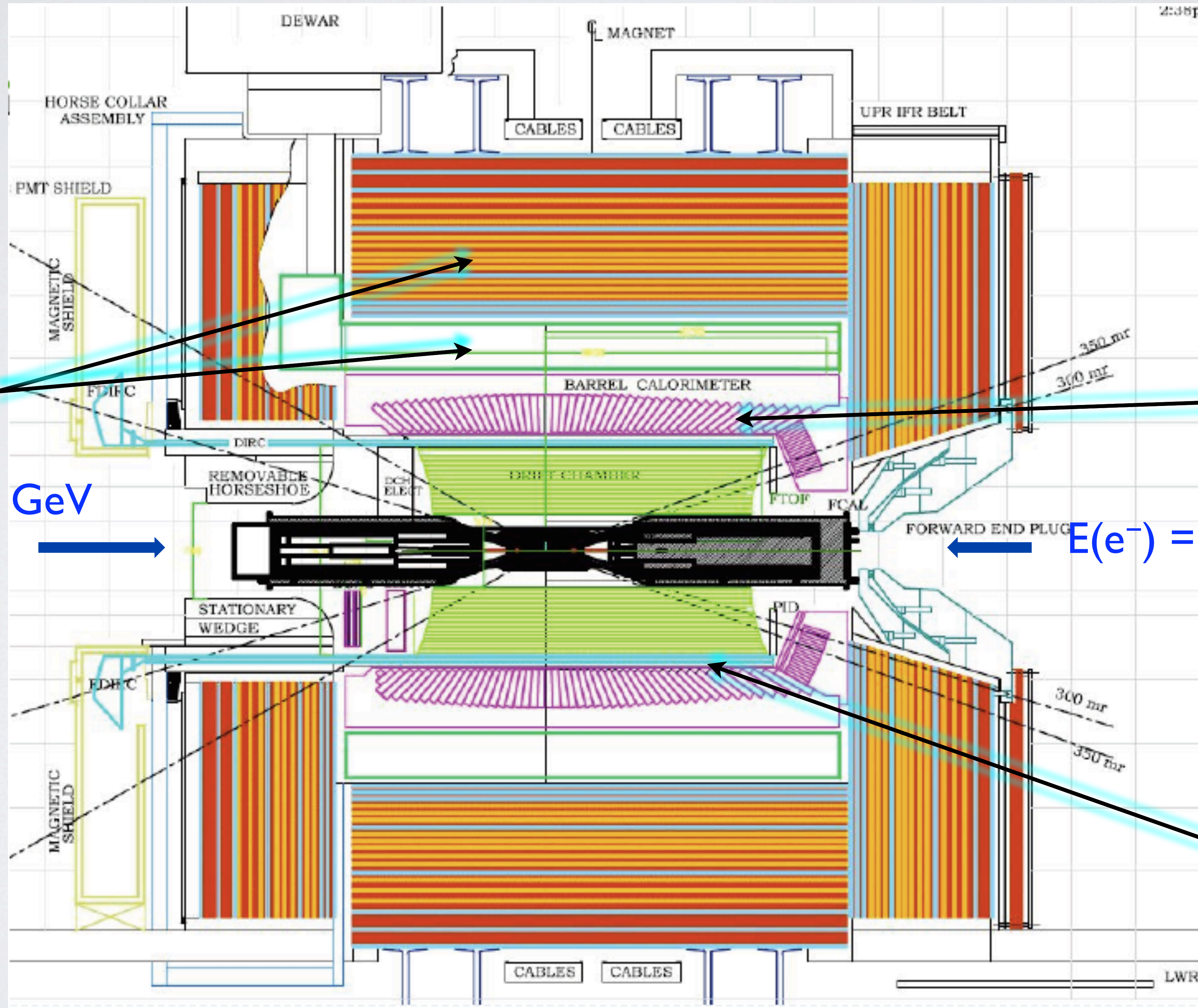
Based on BaBar detector design



The SuperB detector

Parts reused from BaBar detector

solenoid (1.5 T) & Flux return



$E(e^+) = 6.7$ GeV

$E(e^-) = 4.2$ GeV

barrel EMC: CsI(Tl) crystals

Focusing DIRC quartz bars

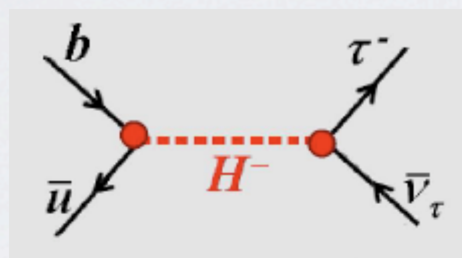
The physics reach

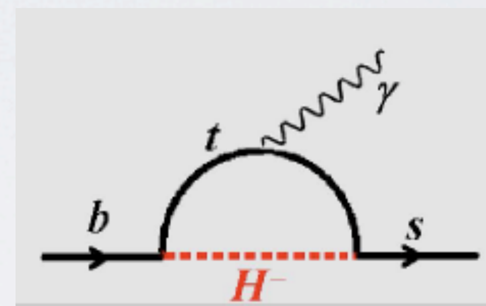
- Predictions = BaBar measurements extrapolations, and simulations = BaBar-like analysis framework:
  - robust predictions,
  - room for improvement: improve tracking algorithm, polarisation, ...
- In general reasonable progresses in theory are assumed.
- Only a very few examples of physics reach are shown here.

Rare decays

- Look for highly suppressed decay modes in the SM
  ➣ any observable rate is an unambiguous sign of NP.

  Some of the SuperB golden channels:
  - $B^+ \to \tau^+\nu$, $B^+ \to \mu^+\nu$, $b \to s\nu\bar{\nu}$, $b \to s\gamma$, $b \to s\ell\ell$
  - $D^0 \to \mu\mu$, $D^0 \to \gamma\gamma$
  - $B_s^0 \to \gamma\gamma$
  - $\tau \to \mu\gamma$, 3ℓ

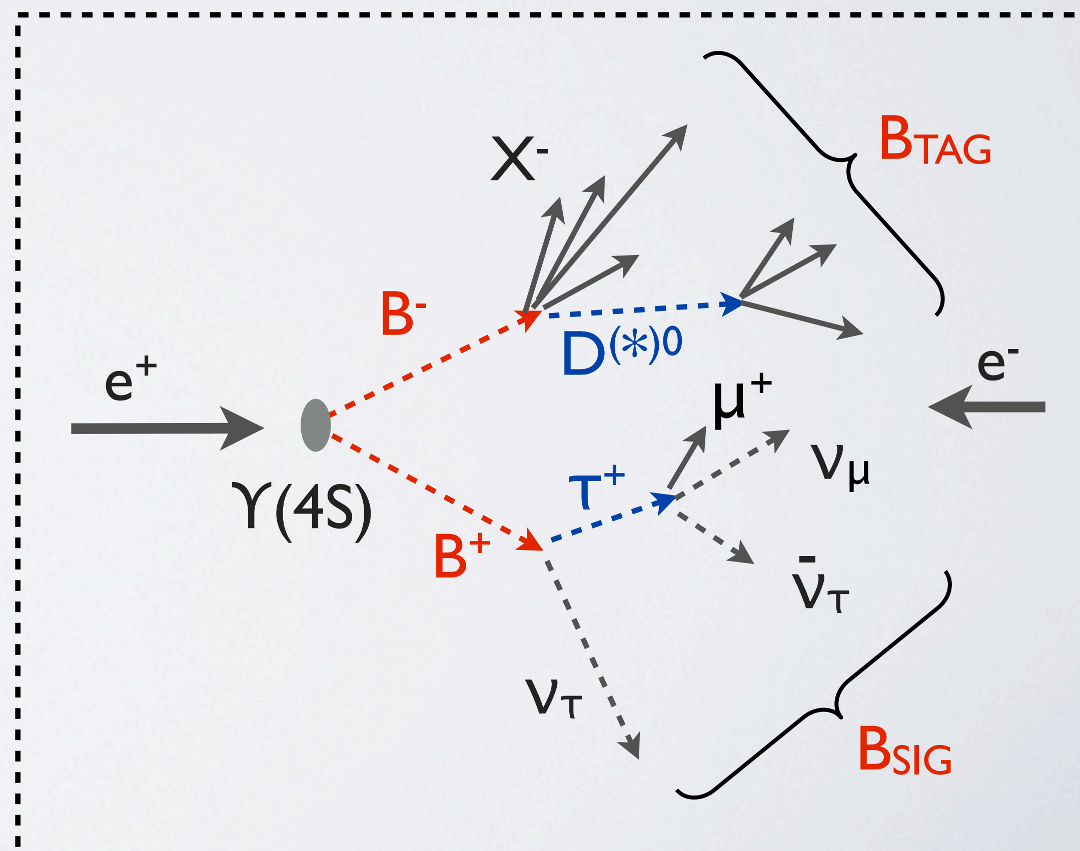




(stolen from...? G.I.?)

- Another way to look for NP at flavour factories: not-so-small decay channels with good SM prediction, e.g. $B \to D^{(*)} \tau^+\nu$.

- SuperB benefits from:
  - A cleaner environment (w.r.t. LHCb): only "signal meson" and "tag meson".
  ➣ good ability to reconstruct inclusive decays and decays with neutrals (ν, γ).
  - Reduced boost (w.r.t. BaBar, Belle, Belle-II) and improved particle identification
  ➣ improved acceptance.



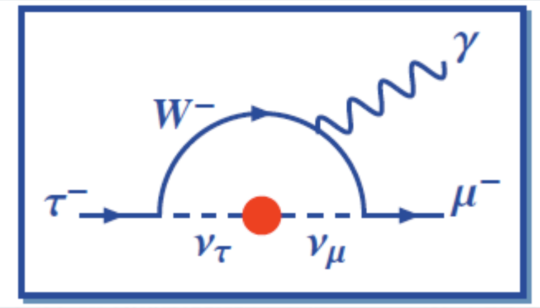
Charged lepton flavour violation

- In the SM with ν oscillations: LFV $\sim(\Delta m_\nu^2/M_W^2)^2$

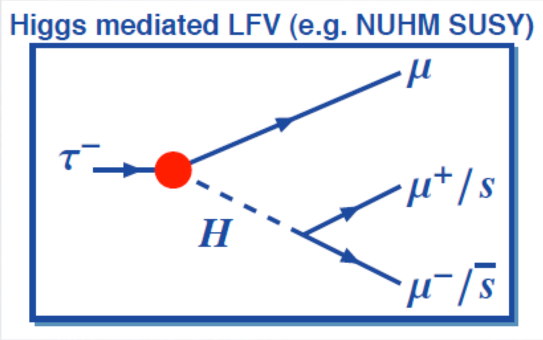
➛ non-observable effects

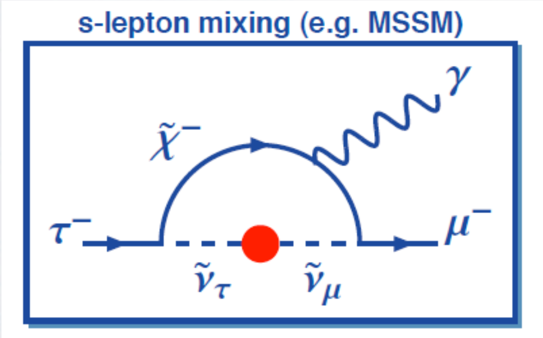
for instance: B.R.($\mu\to e\gamma$) $\sim 10^{-50}$-10^{-54}.

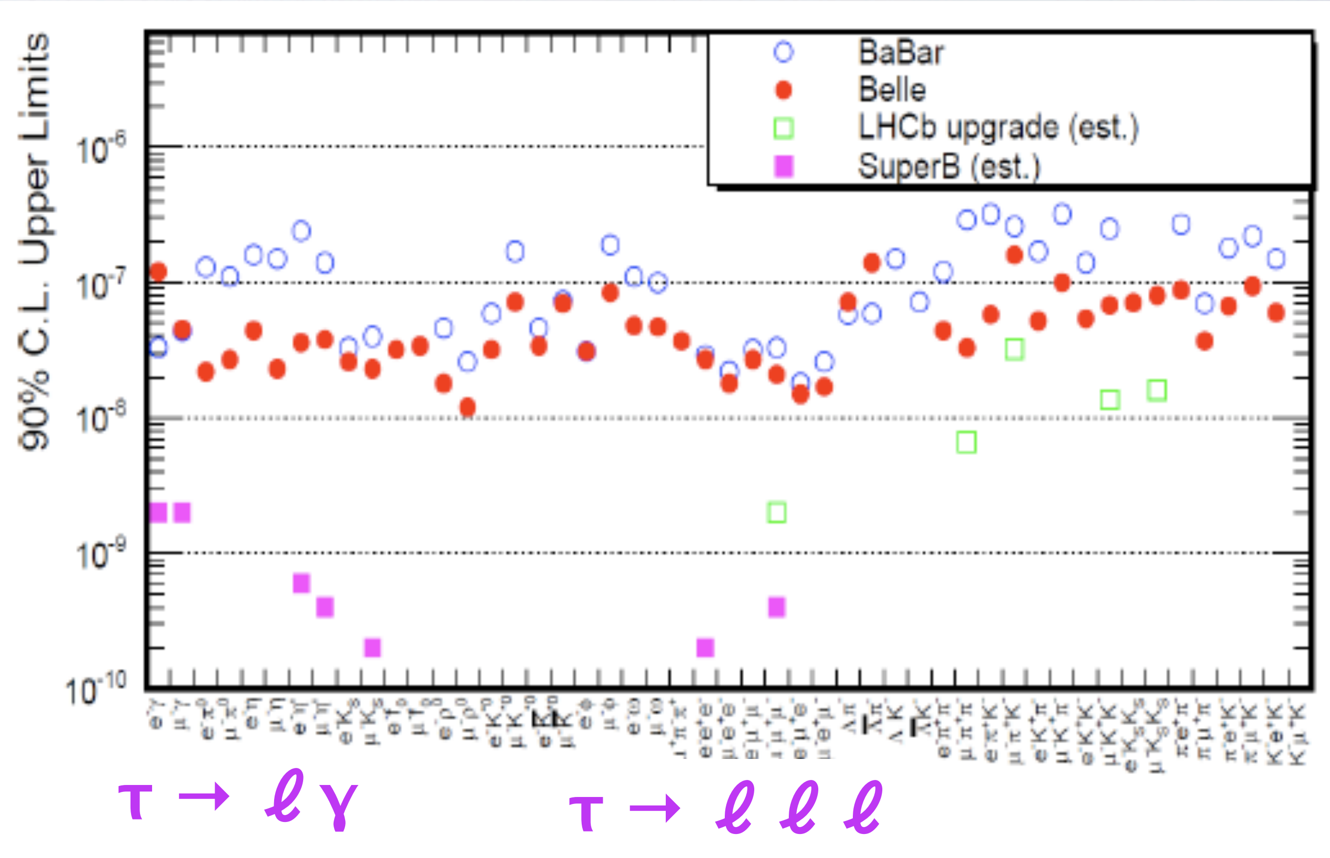
Almost QCD-free SM prediction ➛ unambigous NP signal.



- Many NP scenarios predict enhancements up to observable levels in SuperB.







- Beam polarisation helps suppress background or discriminate among NP models. Sensitivity increased by at least x2, usually better because it is a background-free search.

$\sin^2\theta_W$

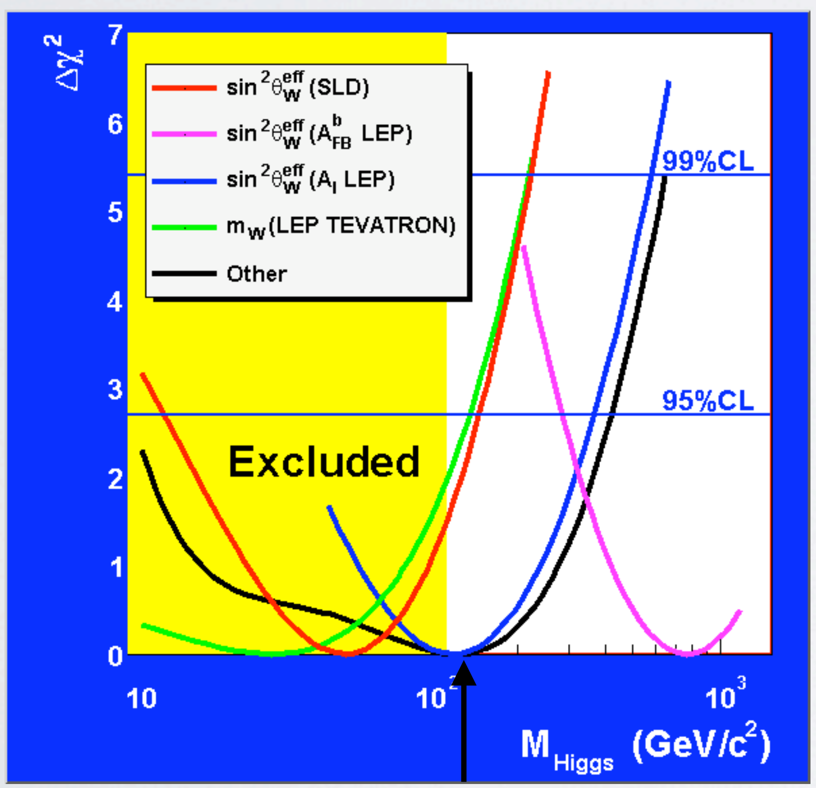
- High luminosity ⊗ clean experimental environment ⊗ polarised beam =
- By measuring A_{LR} in $e^+e^- \longrightarrow e^+e^-, \mu^+\mu^-, \tau^+\tau^-, c\bar{c}$ and $b\bar{b}$ (with Z-γ interference)

$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} \sim g_V^f = T_3^f - 2\,Q_f \sin^2\theta_W$$

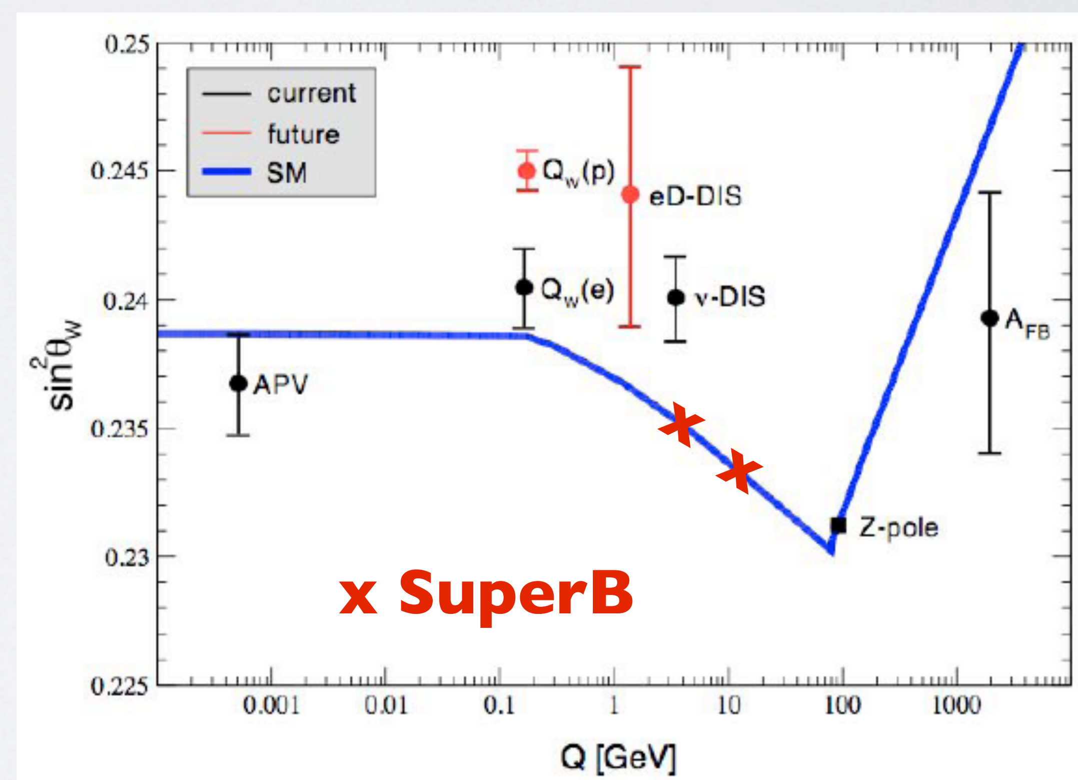
SuperB reaches: $\delta(\sin^2\theta_W) = \pm\, 0.0002$.

To be compared to the SLC accuracy:
$\sin^2\theta_W = 0.23098 \pm 0.00013$

What is the source of the 3.2σ discrepancy on $\sin^2\theta_W$ as measured through A_{LR}(SLD) and A_{FB}(b) at the Z pole?



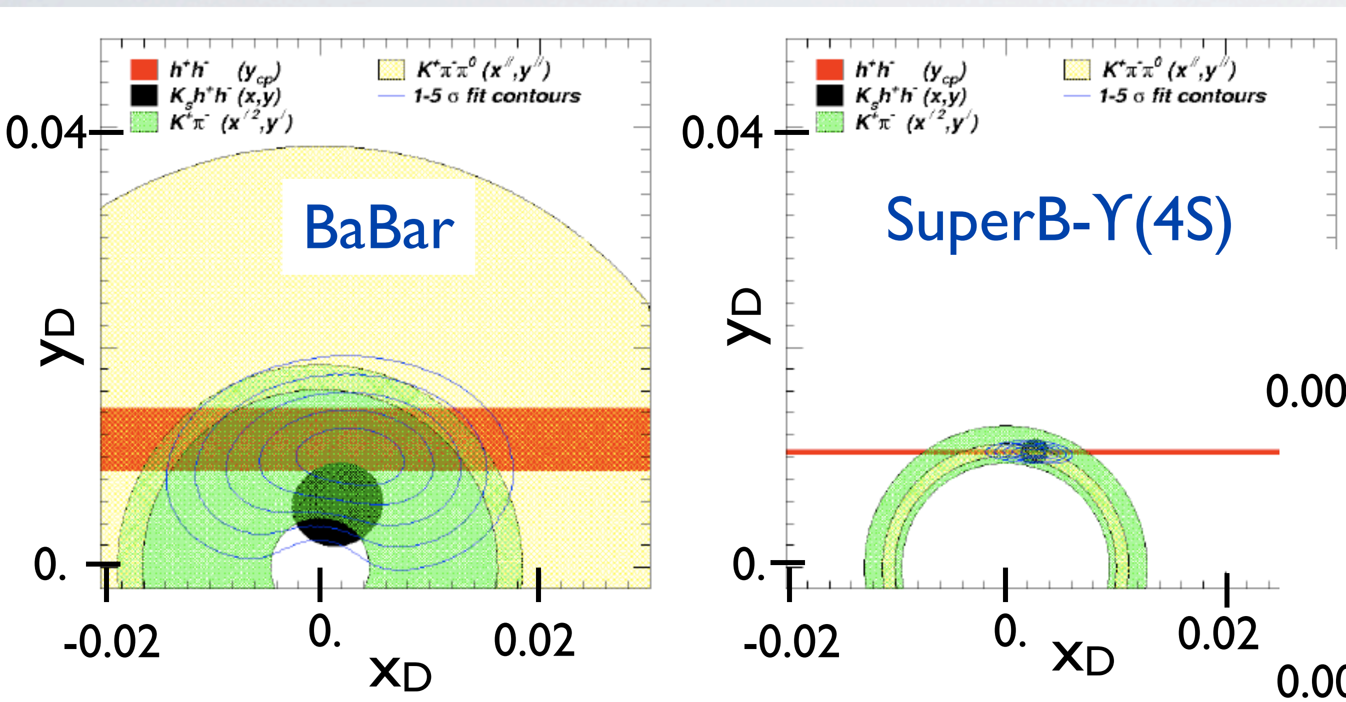
$m_H \sim 125$ GeV



The uncertainty is dominated by the polarisation measurement.

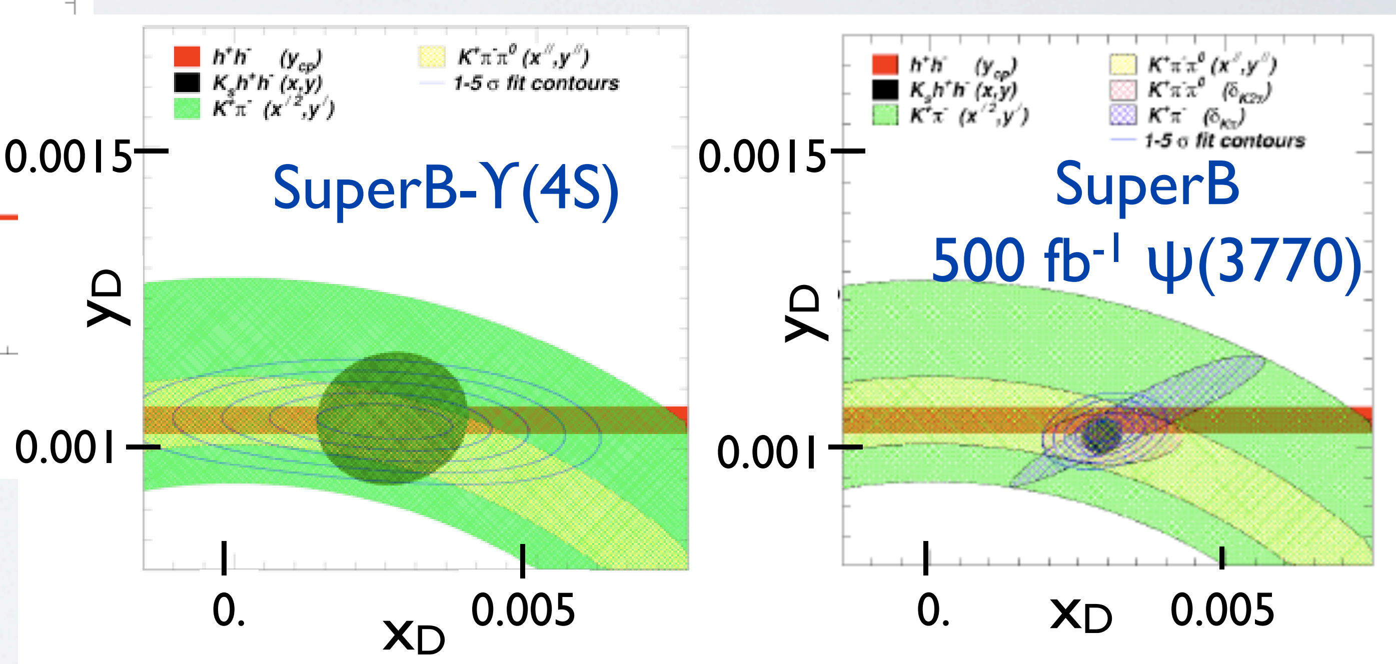
Charm oscillation

- SuperB is a charm-factory! Charm hadrons are produced:
  - at $\Upsilon(4S)$: from $e^+e^- \rightarrow c\bar{c}$ and through B decays ➛ easy to disentangle.
  - at $\psi(3770)$: coherent $D\text{-}\bar{D}$ production ➛ very small background
    + D^0 flavour tagging at production time (semi-leptonic and K).



$D^0\text{-}\bar{D}^0$ mixing parameters:

- $x_D = \Delta m/\Gamma$
- $y_D = \Delta\Gamma/2\Gamma$

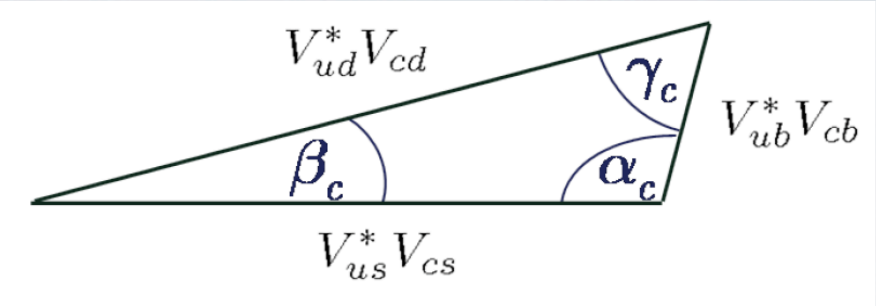


- Run at charm threshold $\psi(3770)$:
  - 500 fb^{-1} at $\psi(3770)$ in < 1 year of SuperB running.
  - Improvements thanks to Dalitz plotz model uncertainty schrinking
    + information on strong phase $\delta_{K\pi}$ added.

CP violation in the charm sector

- Measurement of the *cu* UT:

$$V_{ud}^* V_{cd} + V_{us}^* V_{cs} + V_{ub}^* V_{cb} = 0$$



prediction from CKM fit: $\beta_c = (0.0350 \pm 0.0001)°$

- Important measurements while:
  - New source of CP violation needed ➛ look for additional phases ;
  - Only oscillating system involving down-type quarks in the box diagram ;
  - Recent unexpected direct CPV observation in D^0 decays by LHCb and CDF.

- Example: combined $\Upsilon(4S)$+$\psi(3770)$ sensitivity on β_c using time dependant D^0 and $\bar{D}^0$ decays measurements:

  asymmetry = $f(\lambda_f)$ where: $\arg(\lambda_f) = \Phi_{mix} - 2\beta_c$.

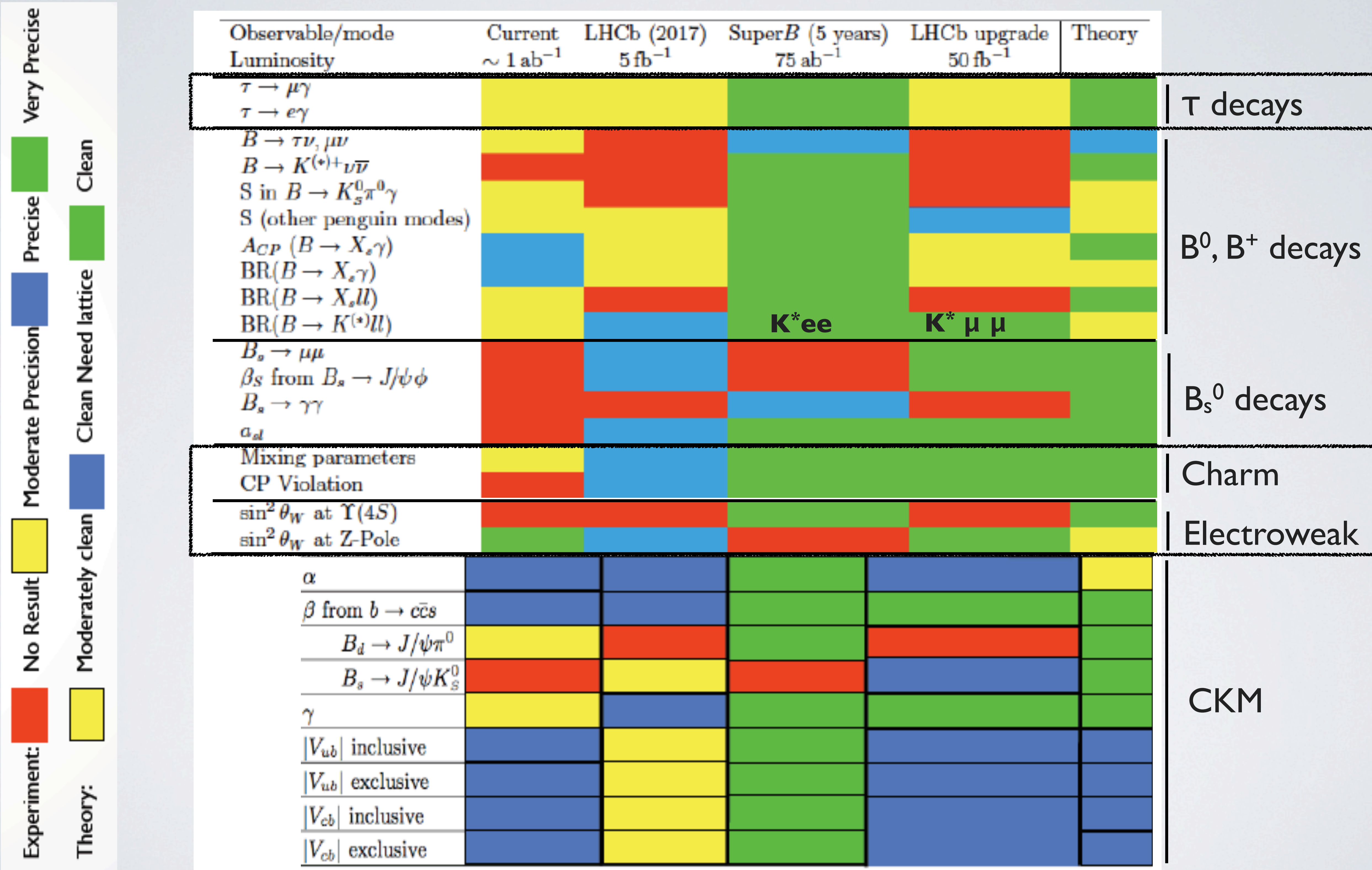
  $\Phi_{\pi\pi}$ ↗ Φ_{KK} ↗

Parameter	Statistical sensitivity	Systematic sensitivity
$\sigma_{\phi_{\pi\pi}}$	1.62^o	0.14^o
$\sigma_{\phi_{KK}}$	1.05^o	0.02^o
$\sigma_{\beta_{c,eff}}$	0.92^o	0.03^o

Phys.Rev. D84 (2011) 114009 and arXiv:1204.2303

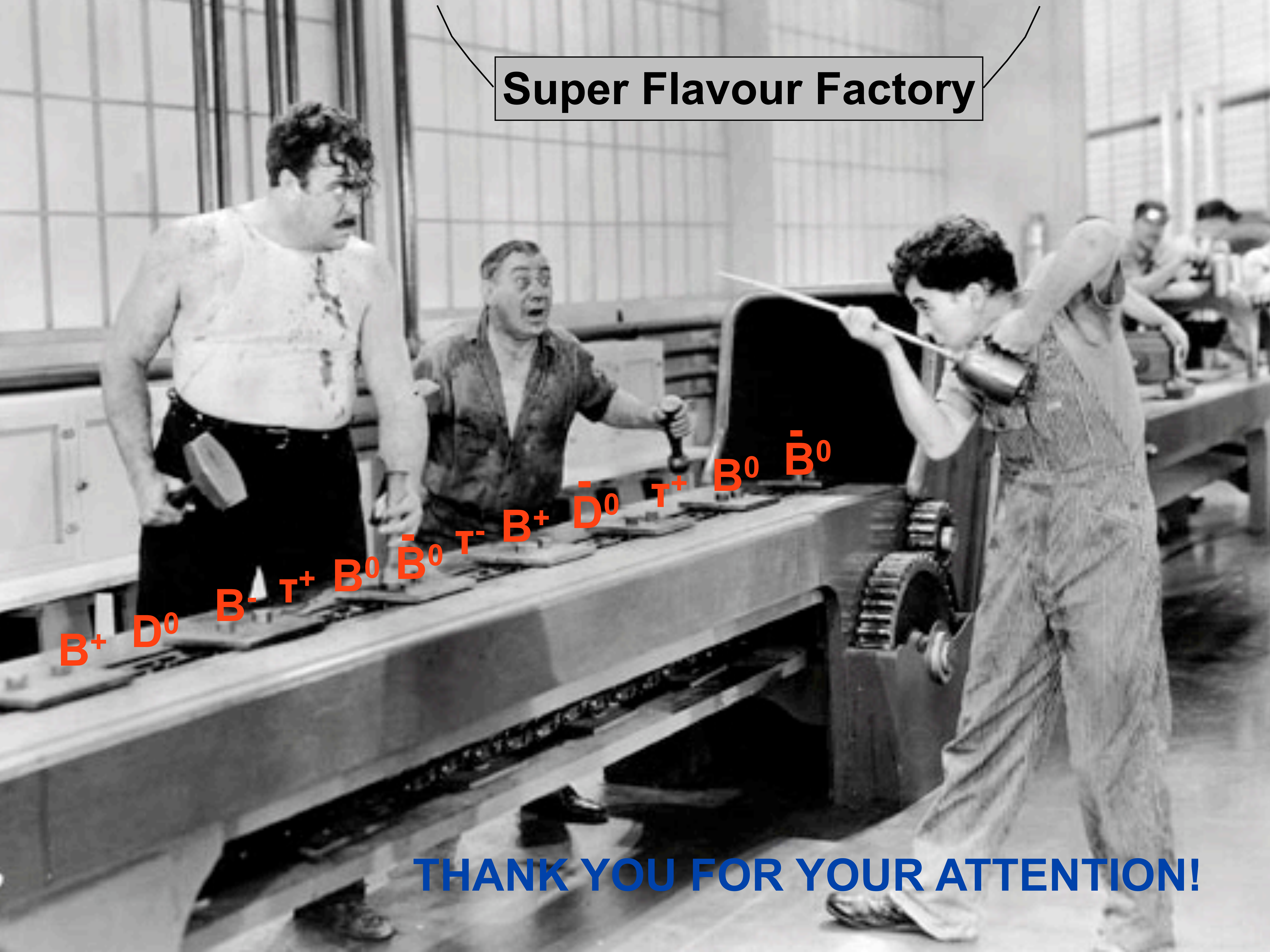
- SuperB vs. LHCb:
  - More statistics at LHCb but more background, lower trigger efficiency, and annoying decay time dependance.
  - Worst decay time resolution in SuperB. Could be improved by a better boost choice at $\psi(3770)$. Studies undertaken to optimise acceptance vs. decay time resolution.

Flavour experiments complementarity



Summary and outlook

- SuperB is an ambitious project based on a very innovative accelerator. Flexible beam energy from charm threshold up to 5S and beam polarisation are unique assets of SuperB.
- Crucial role of SuperB in a "standardissimo" picture: find evidences of NP if no signs at LHC or understand the flavour structure of NP if it is found at LHC.
- Good complementarity also of SuperB with other flavour projects.
- SuperB project was approved and a first financial support was given by the Italy.
- The site was selected and qualified.
- The Nicola-Cabibbo-Laboratory was created to manage the SuperB project.
- SuperB Technical Design Report: currently under review.
- No further allocations are available under the present economic situation. The previously allocated sum is still available for possible new deliverables
  - ➛ SuperB investigates how to propose an alternative project: Tau-Charm Factory.


Super Flavour Factory
B^+ D^0 B^- τ^+ B^0 $\bar{B}^0$ τ^- B^+ $\bar{D}^0$ τ^+ B^0 $\bar{B}^0$
THANK YOU FOR YOUR ATTENTION!

Further documentation

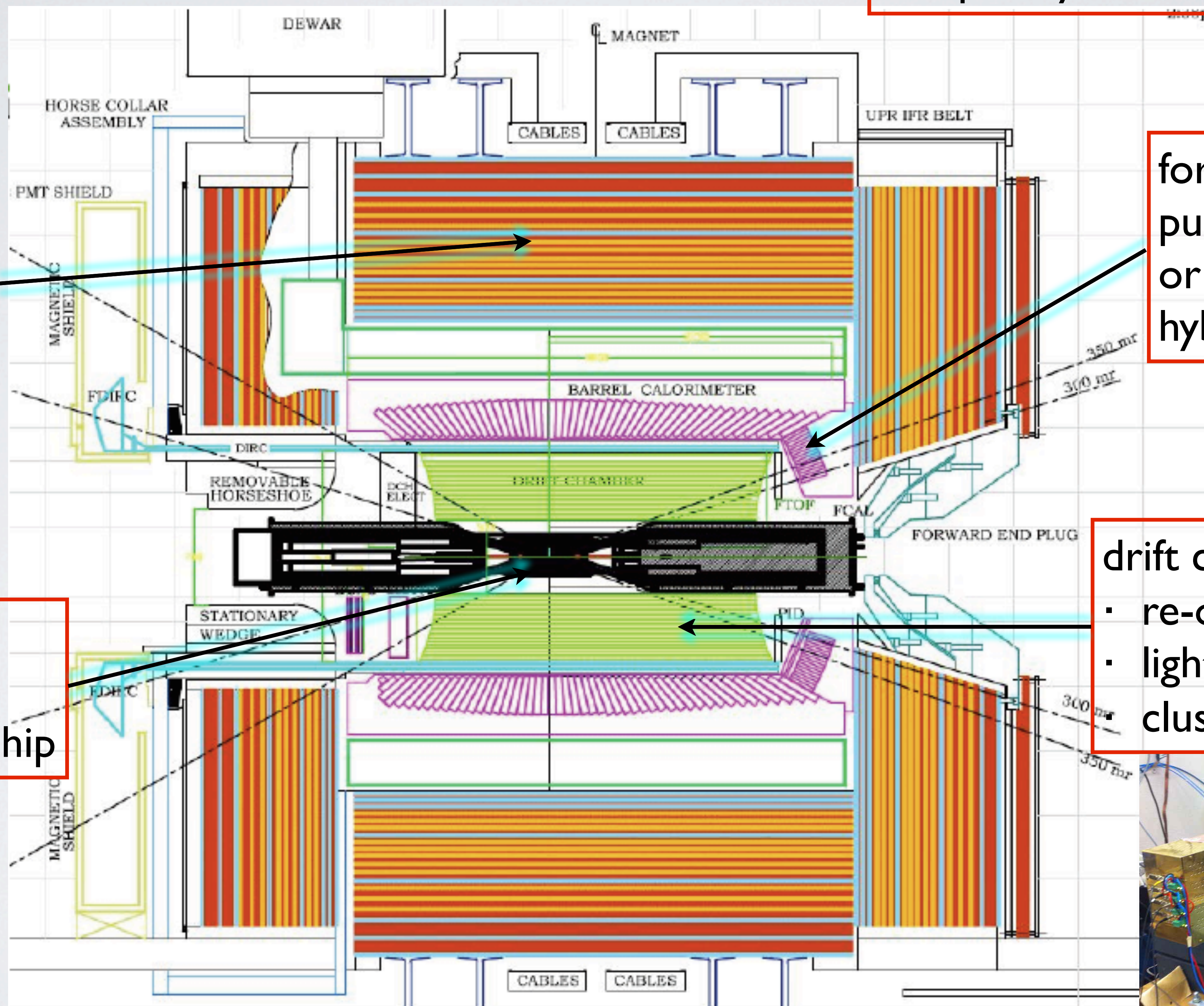
- SuperB Conceptual Design Report: arXiv:0709.0451
- SuperB Progress Report:
  - Physics: arXiv:1008.1541
  - Detector: arXiv:1007.4241
  - Accelerator: arXiv:1009.6178
- The impact of SuperB on flavour physics: arXiv:1109.5028
- European Strategy: SuperB Physics Programme submitted to ESG Cracow Sep 2012.
- SuperB Technical Design Report: currently under review.

The SuperB detector

New R&D's

Electronics - Trigger - DAQ: completely new

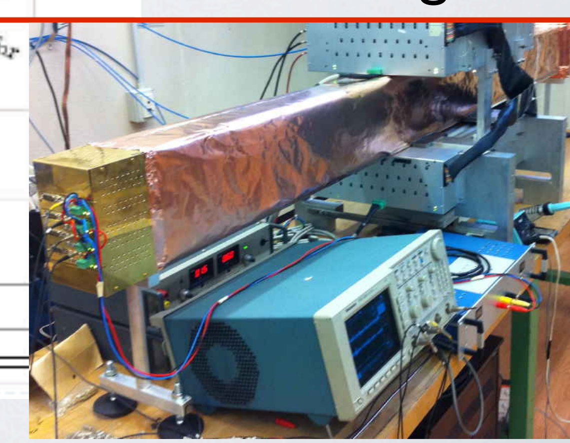
IFR:
- replace LSST with scintillators +WLS fibers + SiPM.
- re-optimise iron distribution.



forward EMC: pure CsI crystals or CsI(Tl)+LYSO hybrid solution

vertex detector:
- add a Layer-0
- new read-out chip

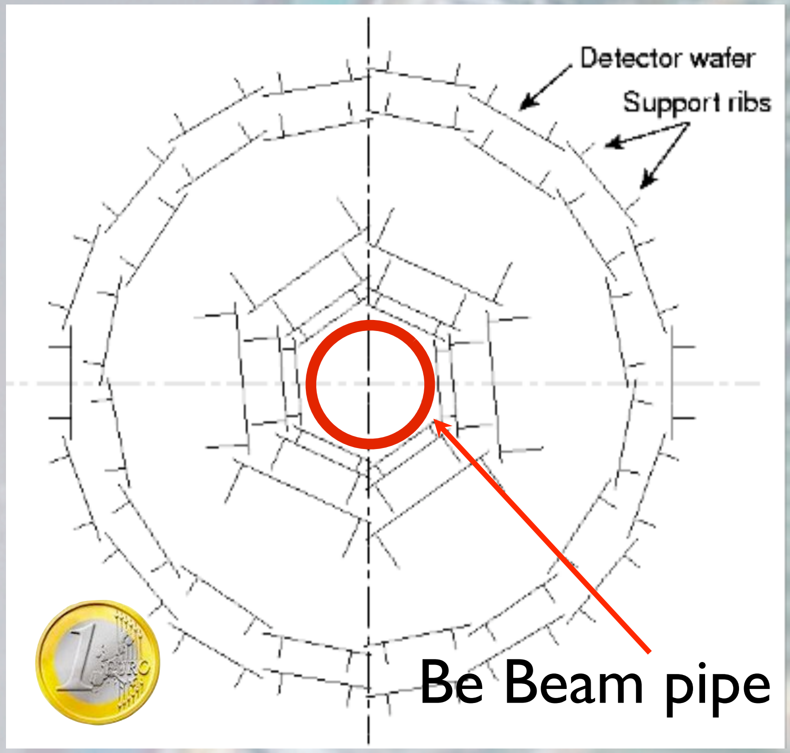
drift chamber:
- re-optimised concept
- lighter and faster
- cluster counting dE/dx

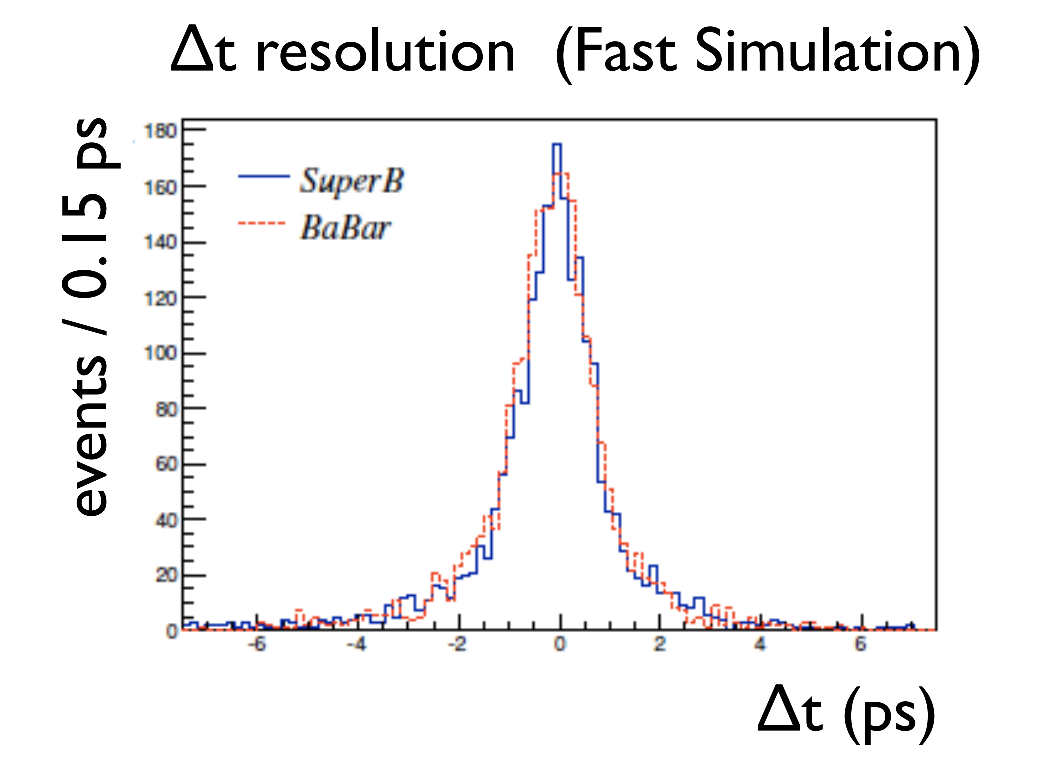


The SuperB vertex detector SVT

- Based on the BaBar vertex detector which performed good.
- Smaller boost at SuperB ➛ smaller Δz and worst σ(Δt).
- Therapy:
  - Additional innermost silicon layer,
  - Reduced beam spot size,
  - Lower beam pipe radius (1 cm)
  - Lower beam pipe material budget (0.52 % X_0).

➛ Preliminary studies show Δt precision comparable to BaBar.





Layer	Radius
0	1.6 cm
1	3.3 cm
2	4.0 cm
3	5.9 cm
4	12.2 cm
5	14.6 cm

Layer 0 → additional layer of double-sided silicon striplets sensors (1.8 cm, 90°)

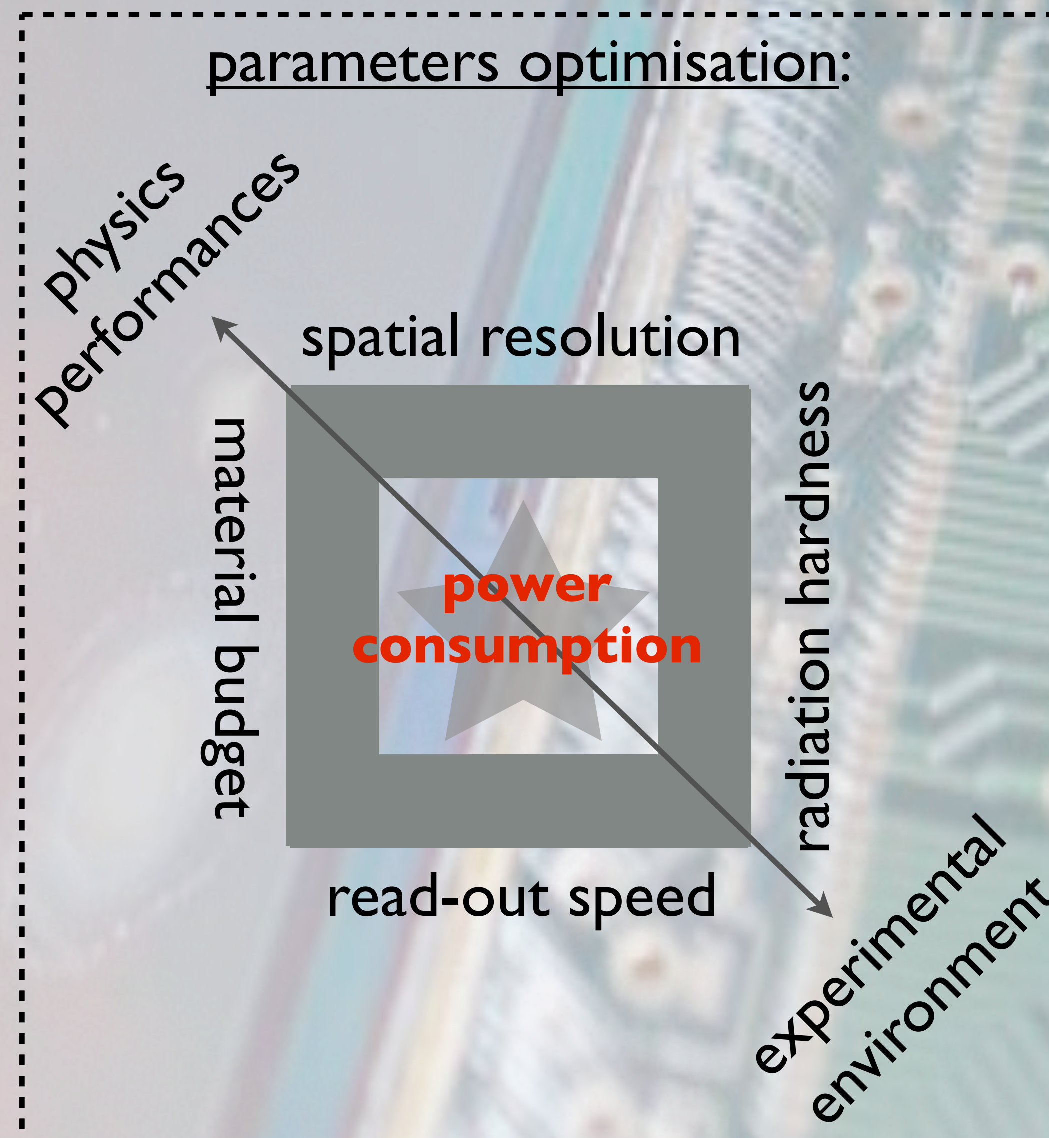
Layers 1–5: BaBar SVT: 5 layers of double-sided silicone strips sensors

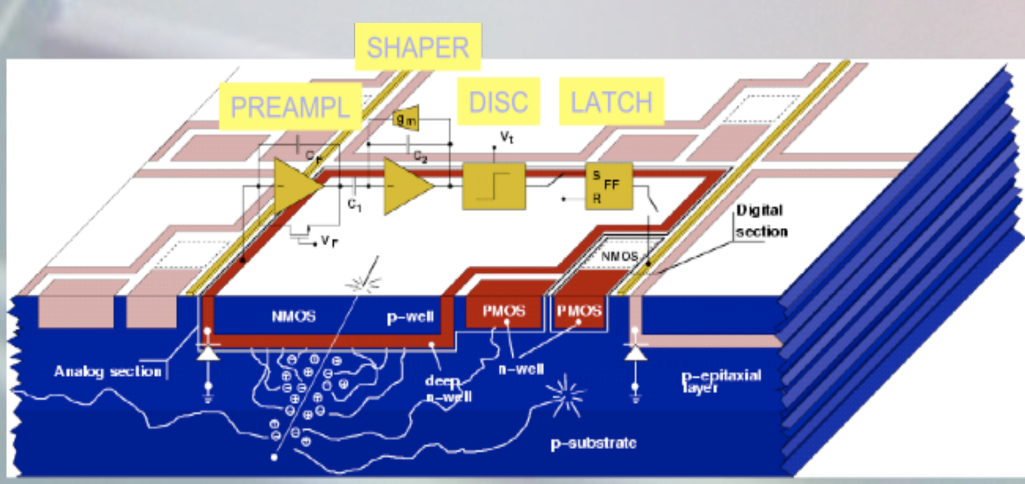
R&D for the SVT layer-0

- Environmental constraints on Layer-0:
  - Yearly ionising radiations: 3 MRad
  - Yearly non ionising radiations: $5 \times 10^{12}\ n_{éq}.cm^{-2}$
  - Hit rate: $20\ MHz.cm^{-2}$
  - Data flow $5\text{-}10\ Gb.s^{-1}$

➛ striplets not robust w.r.t. hit rate.

➛ R&D needed to design a pixellated sensor with:
- material budget per layer < 1 % X_0,
- spatial $R\varphi$ and z resolution < 10 μm,
- time stamp ~ 1 μs.

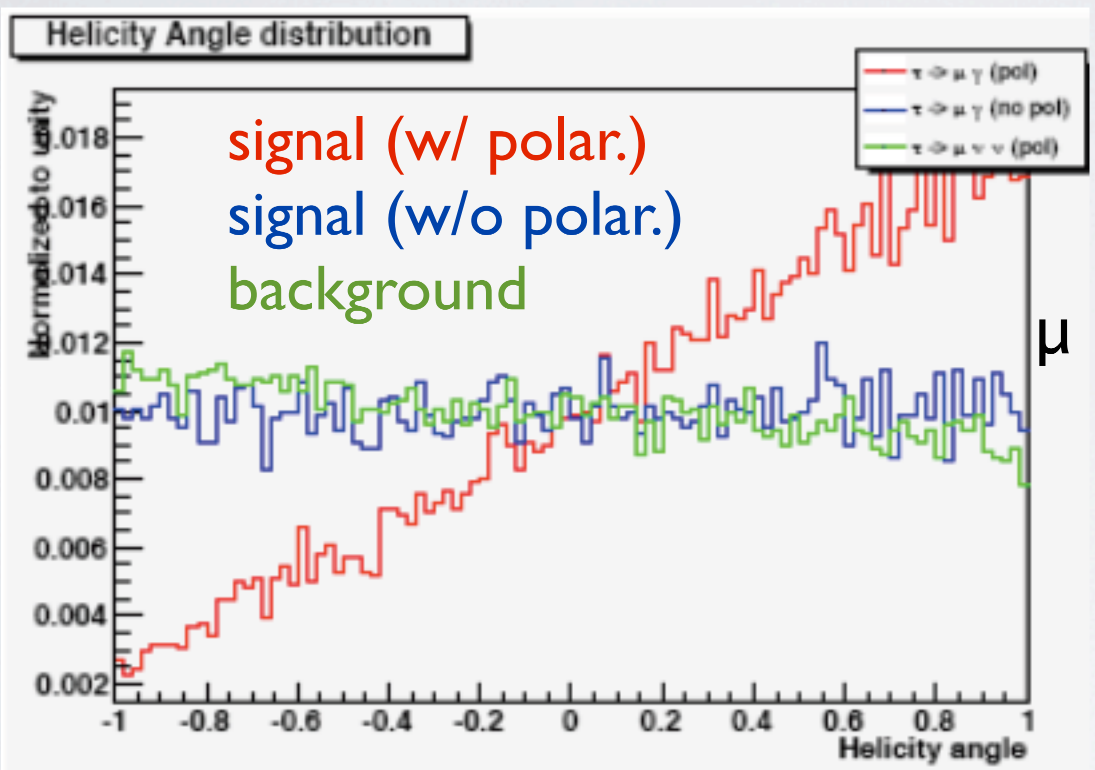


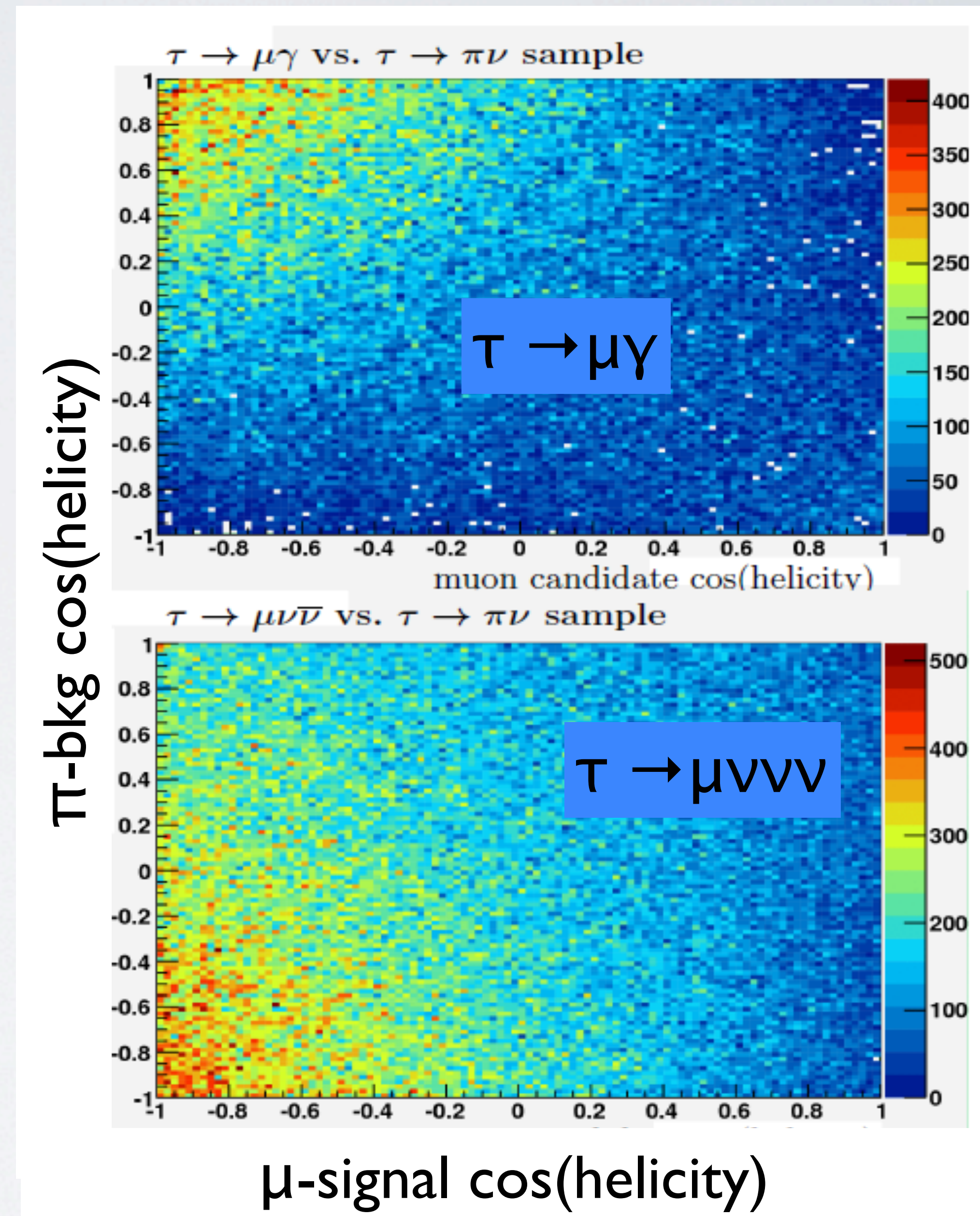


- Several developments on-going with encouraging results on CMOS pixel sensors based on a 0.18 μm technology and high resistivity epitaxial layer.

The benefits of beam polarisation

- Beam polarisation helps suppress background or discriminate among NP models. Sensitivity increased by at least x2.



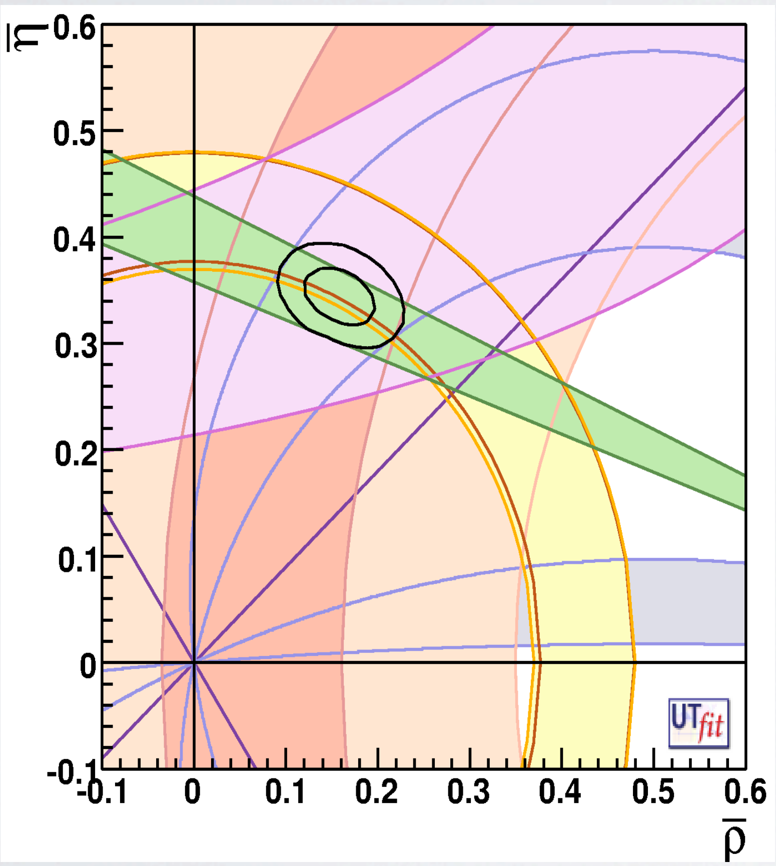


- Polarisation is a unique feature of SuperB. Without polarisation, no sensitivity to:
  - $\sin^2\theta_W$,
  - τ g-2, SuperB sensitivity: $\delta(\Delta a_\tau) \sim 10^{-6}$,
  - τ electric dipole moment.

CKM matrix

- Improve CKM matrix elements precision:
  - Search for NP and new source of CP violation.
  - Major limitation for many NP searches with flavours: cf. $K\rightarrow\pi\nu\bar{\nu}$, $\sin 2\beta$ vs. ε_K UT fits, ...

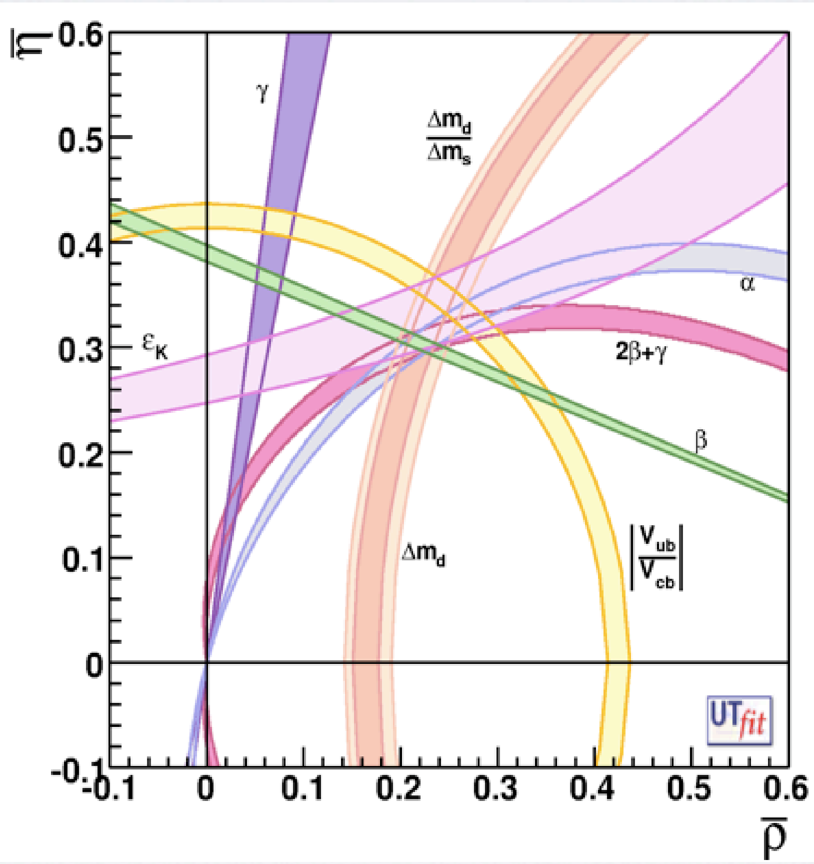
today (1 ab^{-1})



$\rho = 0.0163 \pm 0.028$

$\eta = 0.344 \pm 0.016$

with SuperB (75 ab^{-1})
+ Lattice improvements



$\delta\rho = \pm\, 0.0028$

$\delta\eta = \pm\, 0.0024$

- $\delta(|V_{cb}|)$ = 1 % now
  ➛ 0.5 % with superB,

  $\delta(|V_{ub}|)$ = 8 % now
  ➛ 2 % with superB.

- $\delta(\alpha)$ = 5 % now
  ➛ 1 % with superB,

  $\delta(\beta)$ = 4 % now
  ➛ 0.1 % with superB,

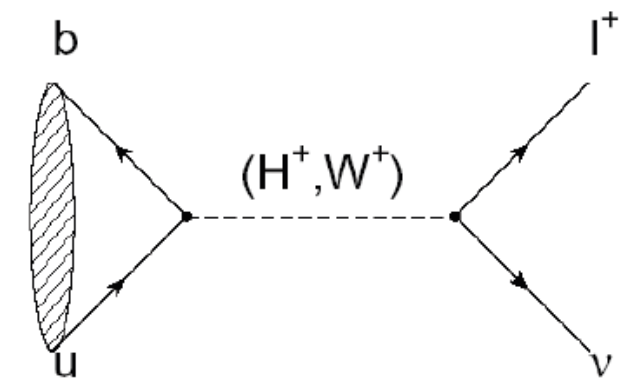
  $\delta(\gamma)$ = 20-25 % now
  ➛ 1 % with superB,

Rare B → τν decay

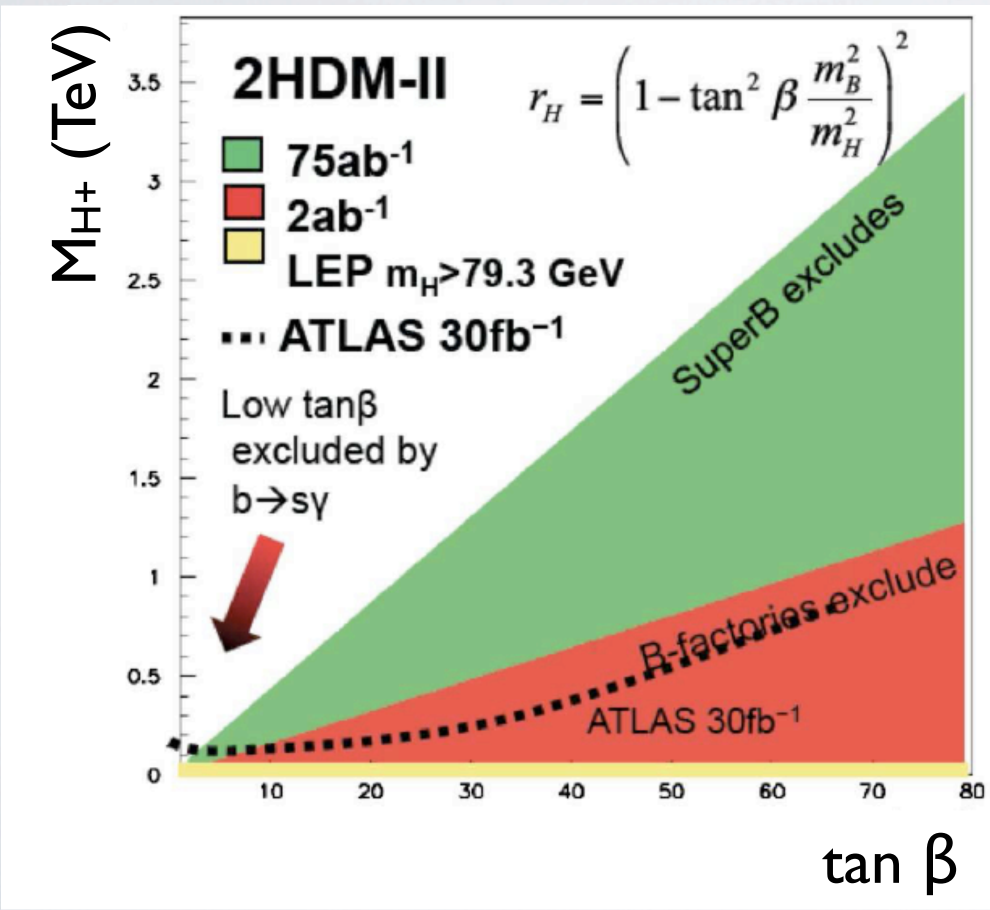
- Current discrepancy between experiment and prediction:

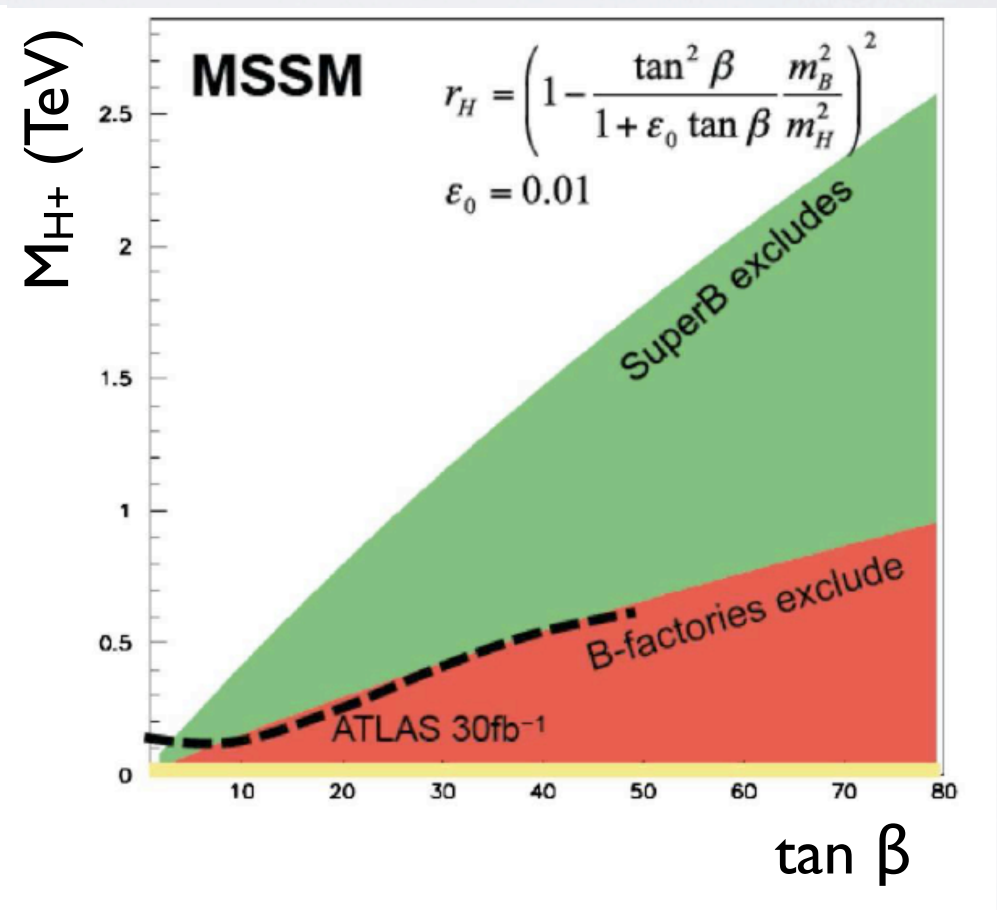
B.R.($B^+ \to \tau^+\nu$) W.A. measurement:	SM prediction through CKM global fit:
$(1.67 \pm 0.30)\times10^{-4}$	$(0.879 \pm 0.084)\times10^{-4}$

but also Belle 2012: $(0.72 \pm 0.29)\times10^{-4}$



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

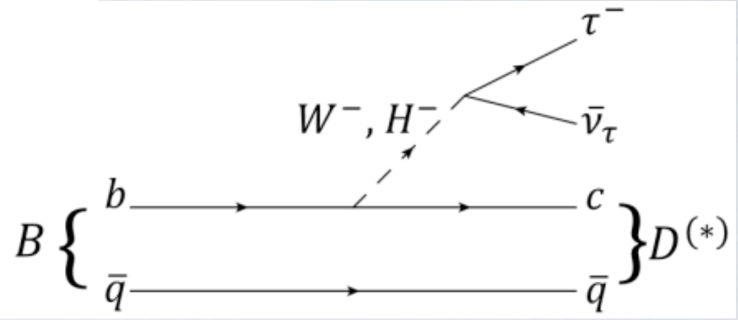


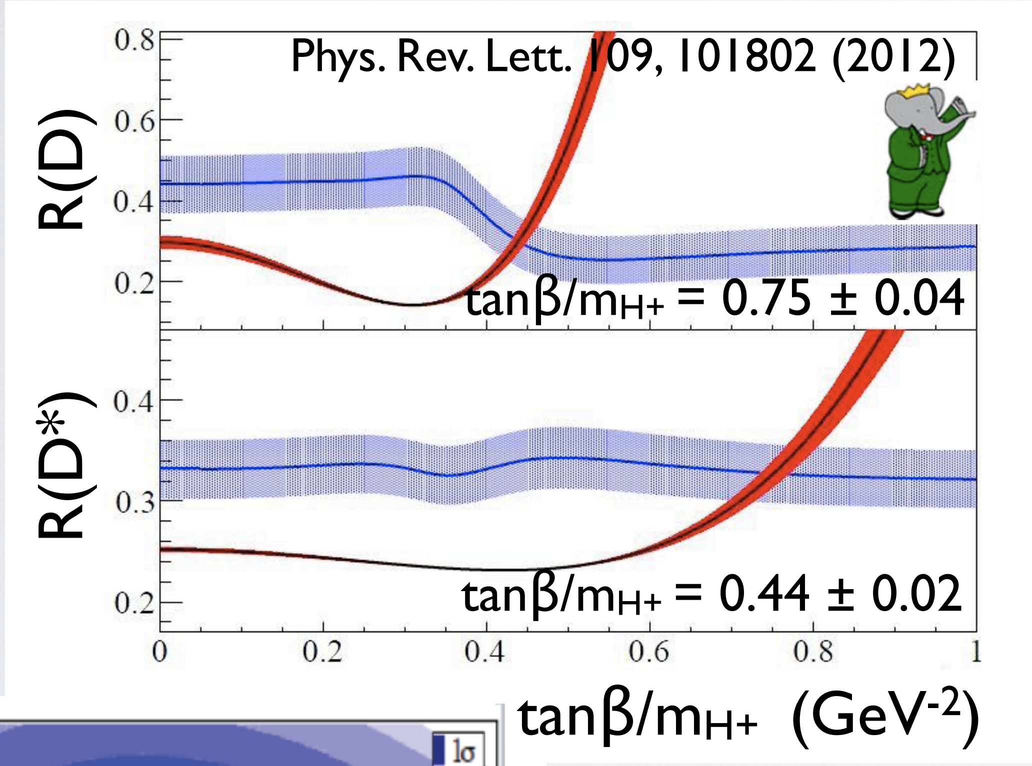


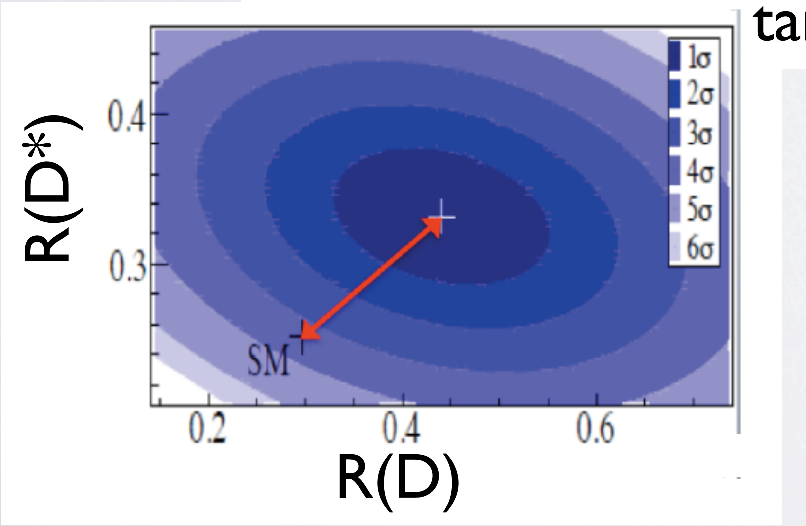
~3% precision possible on B.R. in SM with SuperB (currently 20%). Also $B \to \mu^+\nu$.

B → D(*)τν decay

- Measurement of the ratio: $R(D^{(*)}) = \frac{\mathcal{B}(B \to D^{(*)}\tau\nu_\tau)}{\mathcal{B}(B \to D^{(*)}\ell\nu_\ell)}$
  - ➛ cancellation of several theor. and exp. uncertainties.







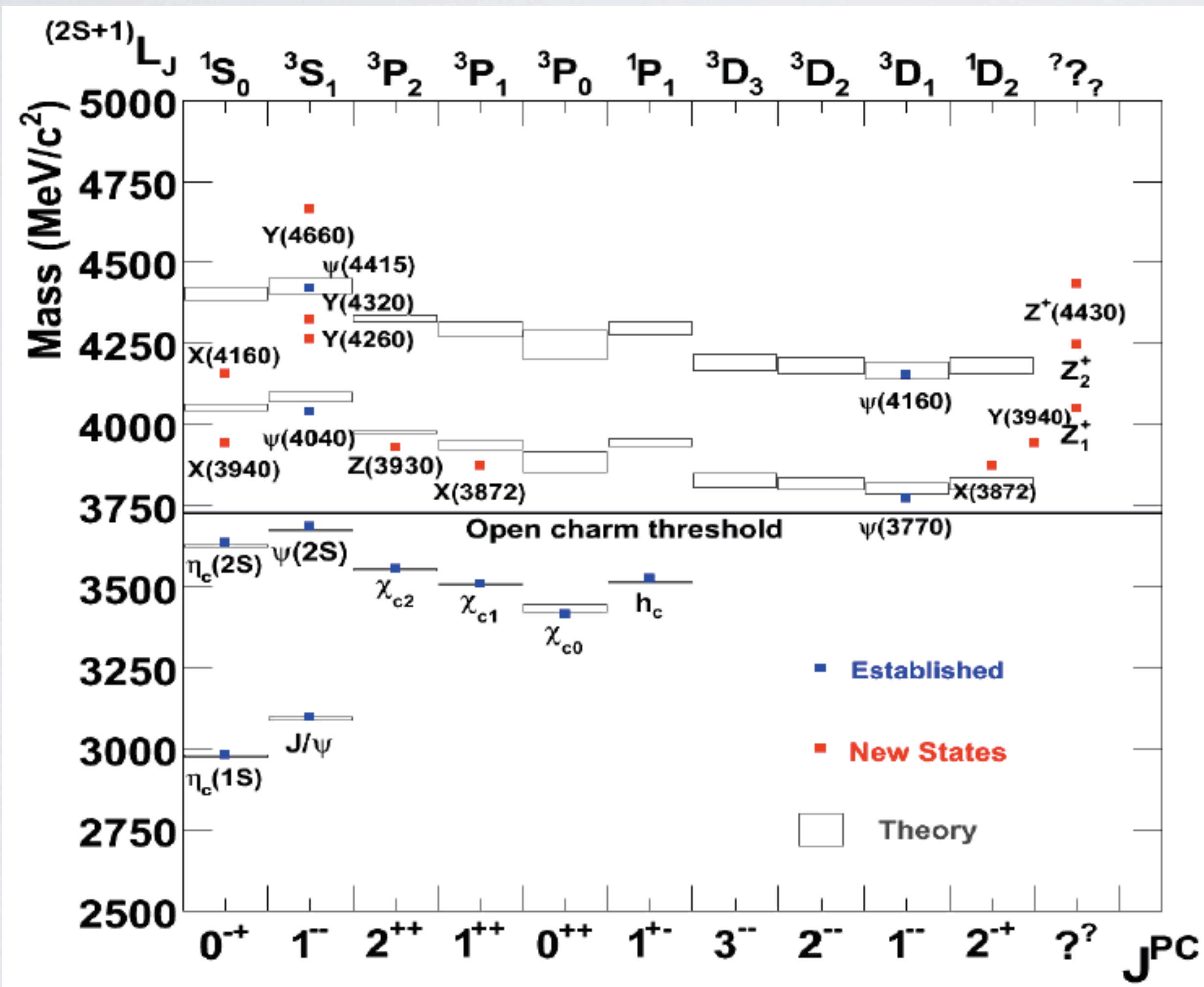
BaBar result:	SM prediction:
R(D) = 0.440 ± 0.072	0.297 ± 0.017
R(D*) = 0.332 ± 0.029	0.252 ± 0.003

➛ 3.4σ inconsistency with SM
and type II 2HDM excluded at 99.8 % C.L.

- To conclude on the presence of NP:
  - Need more data.
  - LHC will not be competitive with Flavour Factories: presence of ν in final state.
  - SuperB reach: 2% precision on B.R. (10% now).

Spectroscopy

- Many new unexpected hadronic states seen at different facilities (Tevatron, B Factories, ...).
  Up to now: difficult to describe theoretically.
  QCD: important for LHC data.



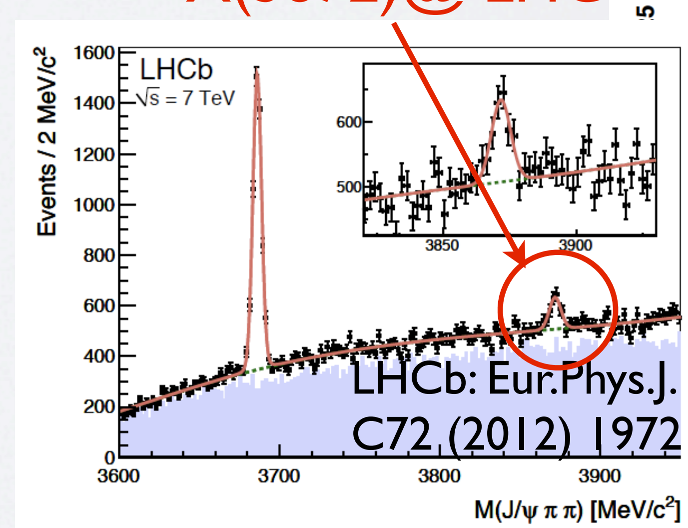
- With SuperB 50 ab^{-1}:
  - Discoveries of new states expected.
  - Much more detailed studies in several decay modes.

Expectations:

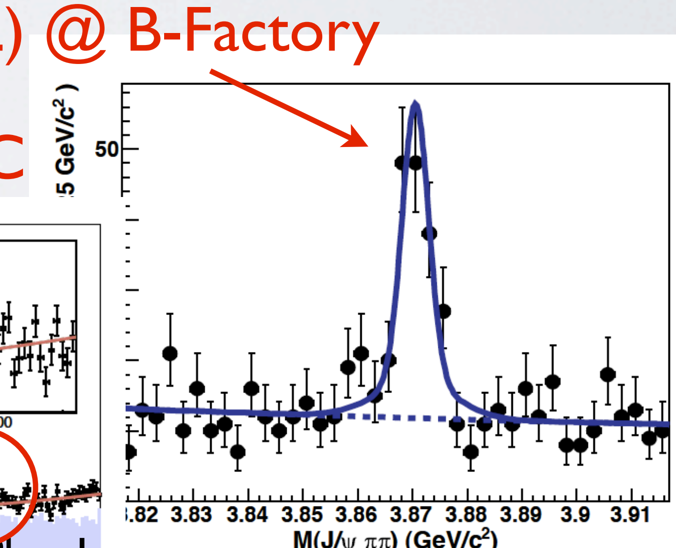
- ~(3000-11000) $B \to X(3872)\,K$
- ~ 30000 $Y(4260) \to J/\psi\,\pi^+\pi^-$
- ~ 3000 $Y(4330) \to \psi(2S)\,\pi^+\pi^-$
- ~ 3000 $Y(4660) \to \psi(2S)\,\pi^+\pi^-$

X(3872) @ B-Factory

X(3872)@ LHC



LHCb: Eur.Phys.J. C72 (2012) 1972



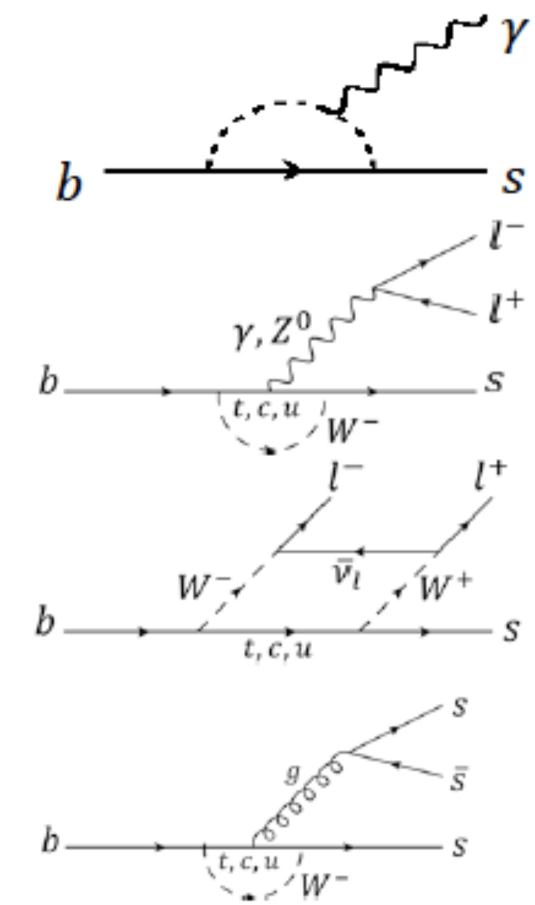
Belle : arXiv:0905.4313

SuperB golden measurements

Observable/mode	Current now	LHCb (2017) 5 fb^{-1}	Super$B$ (2021) 75 ab^{-1}	Belle II (2021) 50 ab^{-1}	LHCb upgrade (10 years of running) 50 fb^{-1}	theory now
			τ Decays			
$\tau \to \mu\gamma$ ($\times 10^{-9}$)	< 44		< 2.4	< 5.0		
$\tau \to e\gamma$ ($\times 10^{-9}$)	< 33		< 3.0	< 3.7 (est.)		
$\tau \to \ell\ell\ell$ ($\times 10^{-10}$)	$< 150 - 270$	< 244 [a]	$< 2.3 - 8.2$	< 10	< 24 [b]	
			$B_{u,d}$ Decays			
BR($B \to \tau\nu$) ($\times 10^{-4}$)	1.64 ± 0.34		0.05	0.04		1.1 ± 0.2
BR($B \to \mu\nu$) ($\times 10^{-6}$)	< 1.0		0.02	0.03		0.47 ± 0.08
BR($B \to K^{*+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 80		1.1	2.0		6.8 ± 1.1
BR($B \to K^{+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 160		0.7	1.6		3.6 ± 0.5
BR($B \to X_s\gamma$) ($\times 10^{-4}$)	3.55 ± 0.26		0.11	0.13	0.23	3.15 ± 0.23
$A_{CP}(B \to X_{(s+d)}\gamma)$	0.060 ± 0.060		0.02	0.02		$\sim 10^{-6}$
$B \to K^*\mu^+\mu^-$ (events)	250[c]	8000	10-15k[d]	7-10k	100,000	-
BR($B \to K^*\mu^+\mu^-$) ($\times 10^{-6}$)	1.15 ± 0.16		0.06	0.07		1.19 ± 0.39
$B \to K^*e^+e^-$ (events)	165	400	10-15k	7-10k	5,000	-
BR($B \to K^*e^+e^-$) ($\times 10^{-6}$)	1.09 ± 0.17		0.05	0.07		1.19 ± 0.39
$A_{FB}(B \to K^*\ell^+\ell^-)$	0.27 ± 0.14[e]	[f]	0.040	0.03		-0.089 ± 0.020
$B \to X_s\ell^+\ell^-$ (events)	280		8,600	7,000		-
BR($B \to X_s\ell^+\ell^-$) ($\times 10^{-6}$)[g]	3.66 ± 0.77[h]		0.08	0.10		1.59 ± 0.11
S in $B \to K^0_S\pi^0\gamma$	-0.15 ± 0.20		0.03	0.03		-0.1 to 0.1
S in $B \to \eta' K^0$	0.59 ± 0.07		0.01	0.02		± 0.015
S in $B \to \phi K^0$	0.56 ± 0.17	0.15	0.02	0.03	0.03	± 0.02
			B^0_s Decays			
BR($B^0_s \to \gamma\gamma$) ($\times 10^{-6}$)	< 8.7		0.3	$0.2 - 0.3$		0.4 - 1.0
A^s_{SL} ($\times 10^{-3}$)	-7.87 ± 1.96 [i]	[j]	4.	5. (est.)		0.02 ± 0.01
			D Decays			
x	$(0.63 \pm 0.20\%$	0.06%	0.02%	0.04%	0.02%	$\sim 10^{-2}$ [k]
y	$(0.75 \pm 0.12)\%$	0.03%	0.01%	0.03%	0.01%	$\sim 10^{-2}$ (see above).
y_{CP}	$(1.11 \pm 0.22)\%$	0.02%	0.03%	0.05%	0.01%	$\sim 10^{-2}$ (see above).
$\lvert q/p \rvert$	$(0.91 \pm 0.17)\%$	8.5%	2.7%	3.0%	3%	$\sim 10^{-3}$ (see above).
$\arg\{q/p\}$ ($^\circ$)	-10.2 ± 9.2	4.4	1.4	1.4	2.0	$\sim 10^{-3}$ (see above).
			Other processes Decays			
$\sin^2\theta_W$ at $\sqrt{s} = 10.58\,\mathrm{GeV}/c^2$			0.0002	[l]		clean

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%

examples of SM FCNC diagrams



Interplay between Measurements and Theory

- More information on the golden matrix can be found in arXiv:1008.1541, arXiv:0909.1333, and arXiv:0810.1312.

SuperB scope	Observable/mode	H^+ high $\tan\beta$	MFV	non-MFV	NP Z penguins	Right-handed currents	LTH	SUSY AC	SUSY RVV2	SUSY AKM	SUSY δLL	SUSY FBMSSM
✓	$\tau \to \mu\gamma$							★★★	★★★	★	★★★	★★★
✓	$\tau \to \ell\ell\ell$						★★★					
✓	$B \to \tau\nu, \mu\nu$	★★★(CKM)										
✓	$B \to K^{(*)+}\nu\overline{\nu}$			★	★★★			★	★	★	★	★
✓	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)							★	★	★	★★★	★★★
✓	$B_s \to \mu\mu$							★★★	★★★	★★★	★★★	★★★
	β_s from $B_s \to J/\psi\phi$							★★★	★★★	★★★	★	★
	a_{sl}						★★★					
✓	Charm mixing							★★★	★	★	★	★
✓	CPV in Charm	★★									★★★	

NP enhancement:
★ Observable effect
★★ Moderately large effect
★★★ Very large effect

- Combine measurements to elucidate NP structure
  → Decoding NP won't be easy

MSSM: flavor violation in quark sector

example: MSSM with generic squark mass matrices

LHCb, SuperB

$$M^2_{\tilde{d}} \approx \begin{pmatrix} m^2_{\tilde{d}_L} & m_d(A_d-\mu\tan\beta) & (\Delta^d_{12})_{LL} & (\Delta^d_{12})_{LR} & (\Delta^d_{13})_{LL} & (\Delta^d_{13})_{LR} \\ & m^2_{\tilde{d}_R} & (\Delta^d_{12})_{RL} & (\Delta^d_{12})_{RR} & (\Delta^d_{13})_{RL} & (\Delta^d_{13})_{RR} \\ & & m^2_{\tilde{s}_L} & m_s(A_s-\mu\tan\beta) & (\Delta^d_{23})_{LL} & (\Delta^d_{23})_{LR} \\ & & & m^2_{\tilde{s}_R} & (\Delta^d_{23})_{RL} & (\Delta^d_{23})_{RR} \\ & & & & m^2_{\tilde{b}_L} & m_b(A_b-\mu\tan\beta) \\ & & & & & m^2_{\tilde{b}_R} \end{pmatrix}$$

LHC, ILC - HE frontier

and similarly for $M^2_{\tilde{u}}$

NP scale: $m_{\tilde{q}}$

Flavor violating and CP violating couplings: $\left(\delta^d_{ij}\right)_{AB} = \left(\Delta^d_{ij}\right)_{AB}/m^2_{\tilde{q}}$

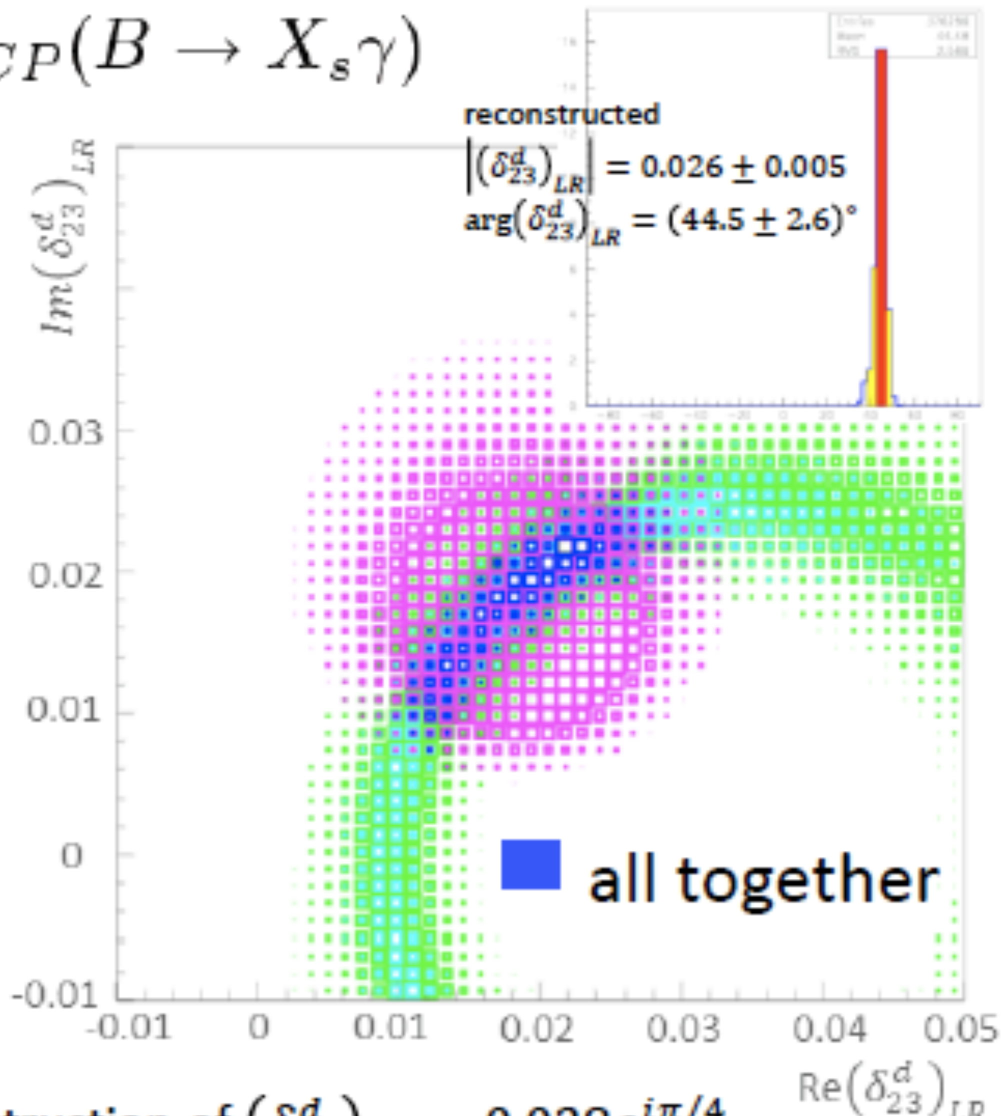
- the energy frontier experiments can probe the diagonal elements
- flavor physics experiments are required to probe off-diagonal terms

Constraints from $b \to s\gamma, b \to s l^+ l^-$

example: SuperB can constrain the $(\delta_{23}^d)_{ij}$ using

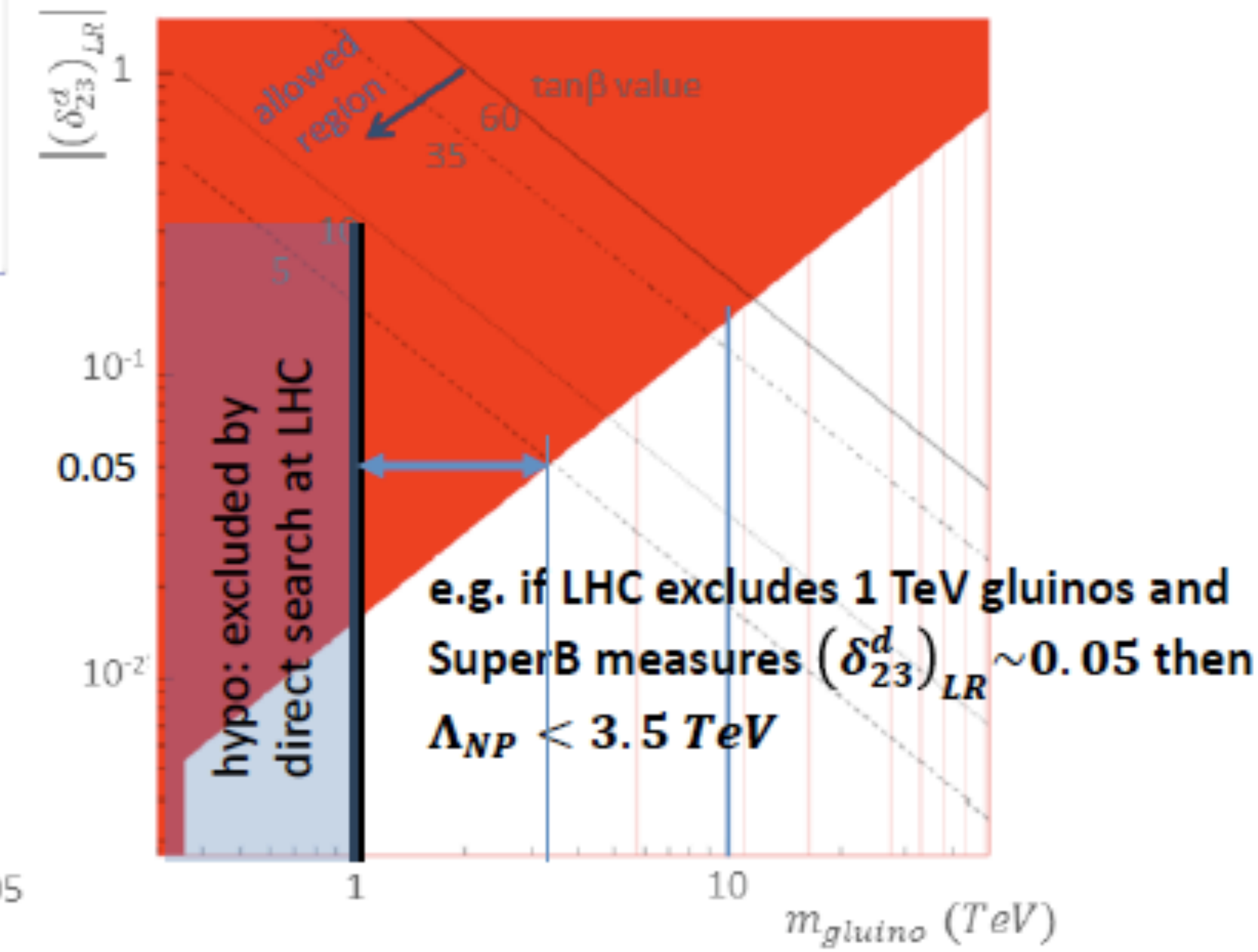
- $\mathcal{B}(B \to X_s\gamma)$
- $\mathcal{B}(B \to X_s\ell^+\ell^-)$ (dataset: 75ab^{-1})
- $\mathcal{A}_{CP}(B \to X_s\gamma)$

L.J. Hall et al, Nucl Phys B 267 (1986)
M. Ciuchini et al, PRD67,075016 (2003)
arXiv:0709.0451



reconstruction of $(\delta_{23}^d)_{LR} = 0.028e^{i\pi/4}$
for $\Lambda_{NP} = m_{\tilde{g}} = m_{\tilde{q}} = 1\ TeV$

red region: $(\delta_{23}^d)_{LR}$ measured with >3σ significance (with 75ab^{-1})



B_s at the Y(5S)

B_s-related measurements are domain of the LHCb (and ATLAS and CMS)

BUT shorts runs at the Y(5S) as done by BELLE and CLEO indicate the potential of e^+e^- machines

Potential highlights from the SuperB:

- B_s decay with neutral particles: $B_s \to J/\psi\eta'$, $B_s \to K_s\pi^0$, $B_s \to D^{(*)} K_s$ ecc..
- Measurement of $B(B_s \to \gamma\gamma)$ which can be enhanced by SUSY
  SM: $BR=(2\text{-}8)\times10^{-7}$, NP(e.g SUSY) 5×10^{-6}
  SuperB precision with 30 ab^{-1} 7% (stat), 5% (syst) (assuming SM BR)
- Measurement of the semileptonic asymmetry of the Bs:

$$A_{SL}^{s} = \frac{\mathrm{B}(B_s \to \overline{B}_s \to D_s^{(*)-} l^+ \nu_l) - \mathrm{B}(\overline{B}_s \to B_s \to D_s^{(*)+} l^- \nu_l)}{(B_s \to \overline{B}_s \to D_s^{(*)-} l^+ \nu_l) + \mathrm{B}(\overline{B}_s \to B_s \to D_s^{(*)+} l^- \nu_l)} = \frac{1 - |q/p|^4}{1 + |q/p|^4}$$

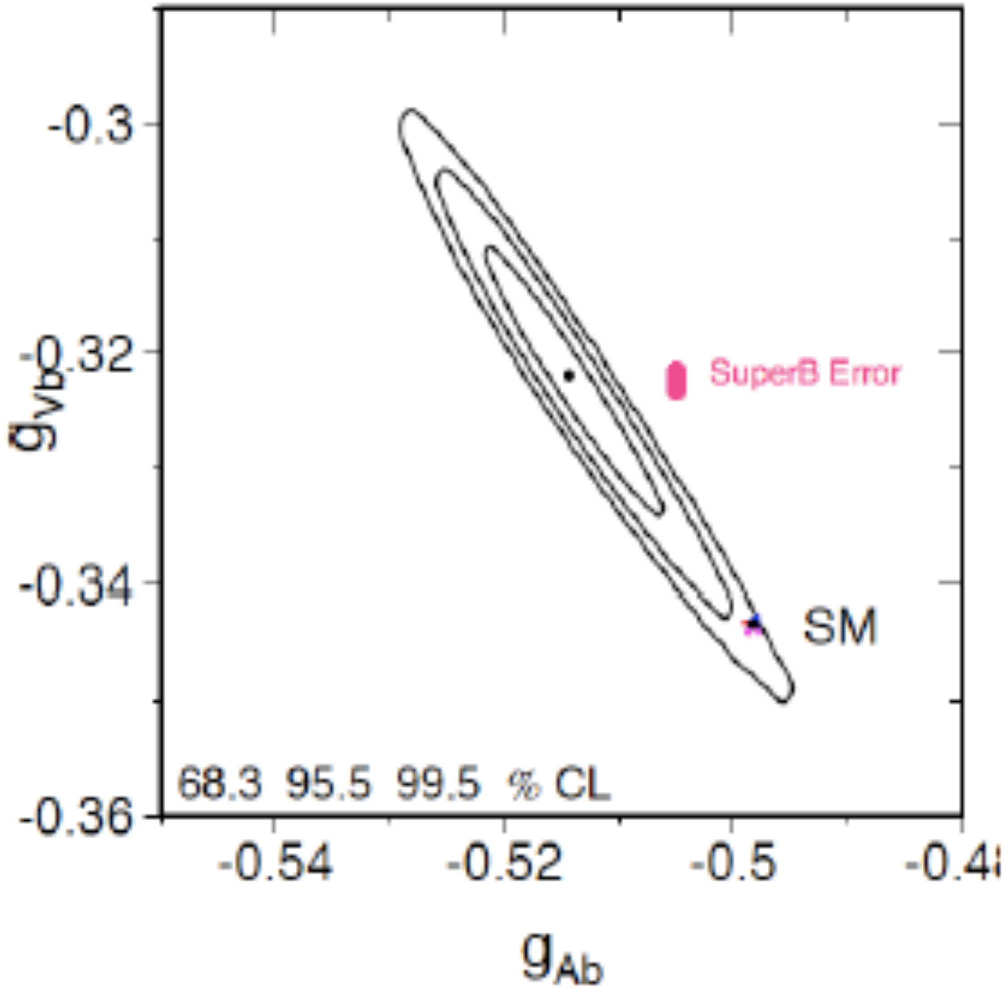
SuperB precision with 30 ab^{-1} ~0.004

from V. Santoro @ X^{th} Quark Confinement and the Hadron Spectrum, Oct. 2012, Münich, Germany.

Observed tension with LEP data at the Z pole:
g_V^b is 2.8σ from SM and g_A^b is 3.1σ from SM with m_H=125 GeV.
SuperB is the only facility able to address this discrepancy.

Measurement of g_V^b

- SM: -0.34372 +0.00049-.00028
- A_{FB}^b: -0.3220±0.0077
- with 0.5% polarization systematic and 0.3% stat error, SuperB can have an error of ±0.0021



τ g-2 Factor

- Long Standing discrepancy for the muon g-2

$$\Delta a_\mu = a_\mu^{exp} - a_\mu^{SM} \approx (3 \pm 1) \times 10^{-9}$$

- Within the MSSM this discrepancy can be naturally accomodate
- A measurement of the τ magnetic moment could be used to confirm or disprove the possibility that the discrepancy is due to NP
- The natural scaling of heavy particle effects on lepton magnetic dipole moments implies

$$\frac{\Delta a_\mu}{\Delta a_\tau} \approx \frac{m_\tau^2}{m_\mu^2}$$

- Interpreting the Δa_μ as signal of NP $\rightarrow \Delta a_\tau \sim 10^{-6}$
- The τ g-2 (and the τ EDM as well) influences both the angular distributions and the polarization of the τ produced in e^+e^- annihilation
- SuperB can measure the g-2 form factor with the resolution of (0.75-2.4×10^{-6})

from V. Santoro @ Xth Quark Confinement and the Hadron Spectrum, Oct. 2012, Münich, Germany.

Funding in the INFN Multi-year Plan

Fully allocated

22M€ allocated

Componenti Super B	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Sviluppo Acceleratore (130 M€) Costruzione infrastrutture, Sviluppo damping rings, Sviluppo transfer lines, Messa in funzione linac, Damping lines transfer lines, Costruzione facility end-user	20	50	60							
Sviluppo Centri Calcolo (43 M€) Sviluppo progettazione costruzione centro di calcolo per analisi dati	5	15	23							
Completamento Acceleratore (126 M€) Installazione componenti negli archi acceleratore, Installazione zona di interazione, Messa in funzione acceleratore				42	42	42				
Utilizzo installazione (80 M€) Costi operazione e manutenzione acceleratore							20	20	20	20
Totale Infrastrutture tecniche (379 M€)	25	65	83	42	42	42	20	20	20	20
Overheads INFN (34.3 M€ equivalente al 9%)	2.3	5.9	7.5	3.8	3.8	3.8	1.8	1.8	1.8	1.8
Cofinanziamento INFN (150 M€)	15	15	15	15	15	15	15	15	15	15
Costo Totale del progetto (563.3 M€)	42.3	85.9	105.5	60.8	60.8	60.8	36.8	36.8	36.8	36.8

256M

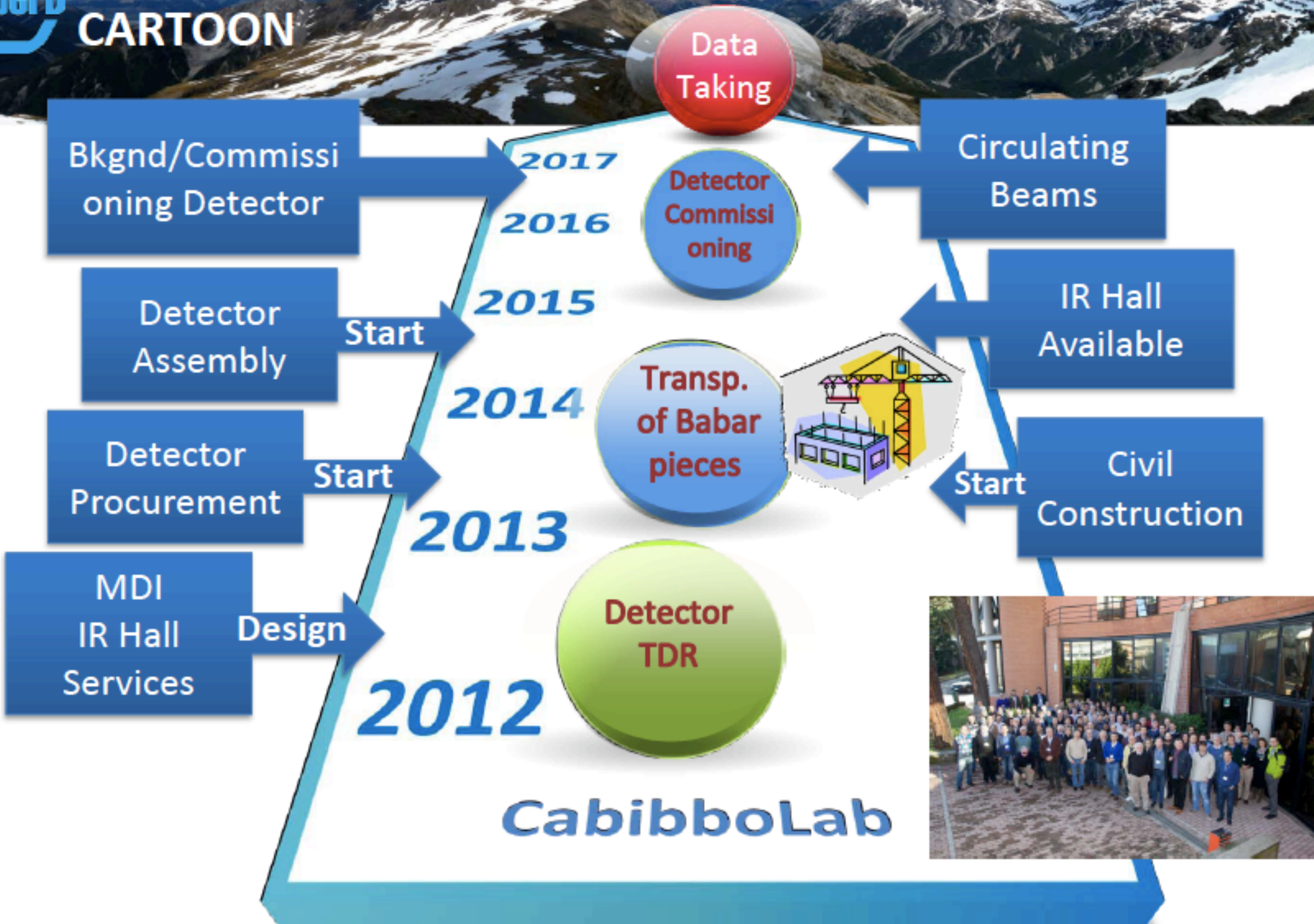
Funding for accelerator and infrastructure

Computing funding from special funds for south development

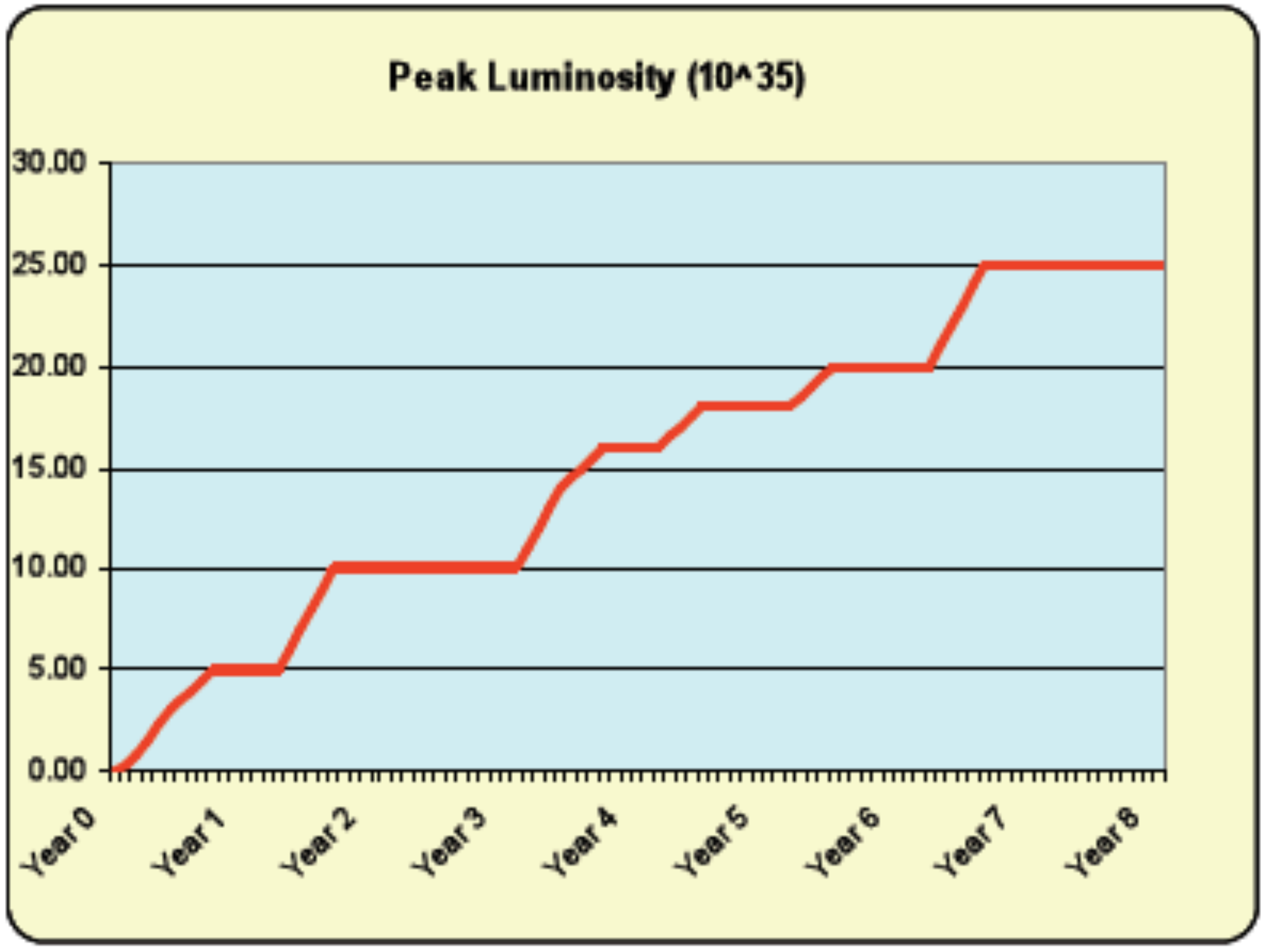
Detector funding inside ordinary funding agency budget.

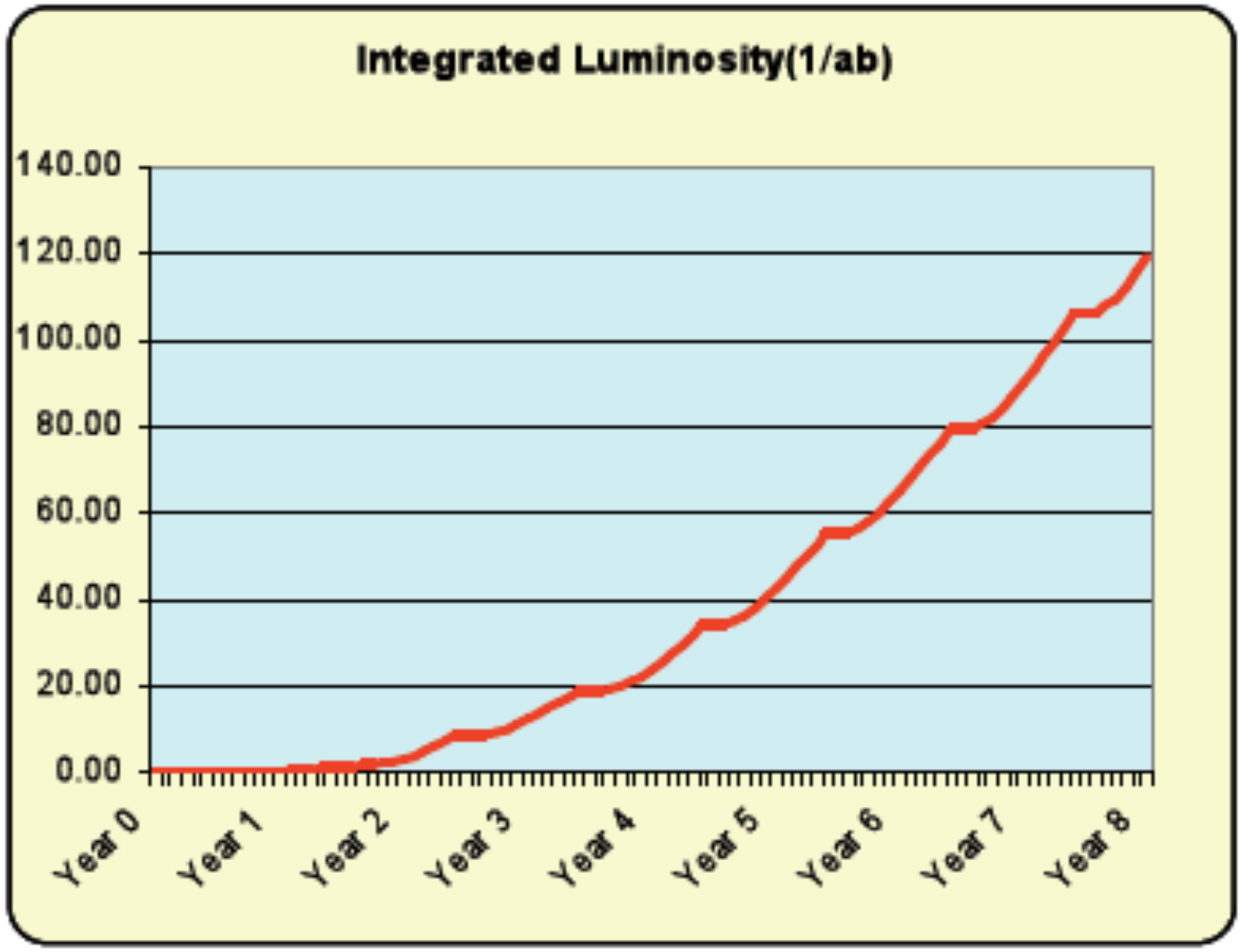
In addition, we re-use parts of PEP-II and Babar, for a value of about 135M€

DETECTOR TIMELINE CARTOON



SuperB expected LUMI





After 7th year integrated Luminosity can grow at rate of ~40 ab^{-1}/year

		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)	δE/E	6.43E-04	7.34E-04
CM σ_E	δE/E	5.00E-04	
Total lifetime	min	4.23	4.48
Total RF Power	MW	16.38	

	PEP-II (SLAC)	SuperB (Italy)	SuperKEKB (KEK)
Luminosity (10^{30} cm^{-2}s^{-1})	12069 (design: 3000)	1.0×10^6	8×10^5
Injection energy (GeV)	2.5–12	e^-/e^+ : 4.2/6.7	e^-/e^+ : 7/4
Transverse emittance ($10^{-9}\pi$ rad-m)	e^-: 48 (H), 1.5 (V) e^+: 24 (H), 1.5 (V)	e^-: 2.5 (H), 0.006 (V) e^+: 2.0 (H), 0.005 (V)	5 (H), 3 (V)
β^*, amplitude function at interaction point (m)	e^-: 0.50 (H), 0.012 (V) e^+: 0.50 (H), 0.012 (V)	e^-: 0.032 (H), 0.00021 (V) e^+: 0.026 (H), 0.00025 (V)	e^-: 0.025 (H), 3×10^{-4} (V) e^+: 0.032 (H), 2.7×10^{-4} (V)
Beam-beam tune shift per crossing (units 10^{-4})	e^-: 703 (H), 498 (V) e^+: 510 (H), 727 (V)	20 (H), 950 (V)	e^-: 12 (H), 807 (V) e^+: 28 (H), 893 (V)
RF frequency (MHz)	476	476	508.887
Particles per bunch (units 10^{10})	e^-/e^+: 5.2/8.0	e^-/e^+: 5.1/6.5	e^-/e^+: 6.53/9.04
Bunches per ring per species	1732	978	2500
Average beam current per species (mA)	e^-/e^+: 1960/3026	e^-/e^+: 1900/2400	e^-/e^+: 2600/3600

$\sigma(e^+e^- \to \tau^+\tau^-)$ around the $\Psi(3770)$ peak

Super charm-tau factory

- $\sigma_{\tau\overline{\tau}}(m_{\tau\overline{\tau}}) \simeq 0.1\,\text{nb}$
- $\sigma_{\tau\overline{\tau}}(\Psi(3770)) = 2.5\,\text{nb}$
- $\sigma_{\tau\overline{\tau}}(4.25\,\text{GeV}) = 3.5\,\text{nb}$ (max)
- $\mathcal{L} \simeq 10^{35}\,\text{cm}^{-2}\text{s}^{-1}$
- integrated $\mathcal{L} = 7.5\,\text{ab}^{-1}$
- **Number of $\tau\overline{\tau} \approx 2.3 \cdot 10^{10}$**

SuperB

- $\sigma_{\tau\overline{\tau}}(\Upsilon(4S)) = 0.92\,\text{nb}$
- $\mathcal{L} \simeq 10^{36}\,\text{cm}^{-2}\text{s}^{-1}$
- integrated $\mathcal{L} = 75\,\text{ab}^{-1}$
- **Number of $\tau\overline{\tau} = 6.9 \cdot 10^{10}$**