SuperB
attività a Milano

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INFN - Sezione di Milano

Consiglio di Sezione
Milano,5 luglio 2012

Outline

- SuperB physics potential
- Status of the project
- Activity in Milano

Physics results in 2012 and SuperB

- New Higgs results from the LHC experiments are very exciting and stimulating for all our community.
  - Congratulation for this important achievement!
- However:
  - SUSY and "Exotics" searches did not find a significant signal at LHC
  - Standard Model reigns supreme at the LHC so far (happy to be wrong!)
- Standard Model in tension with BaBar and LHCb/CDF results:
  - $B \to D^{(*)} \tau \upsilon / B \to D^{(*)} l \upsilon$ is 3.4σ away from SM predictions (BaBar)
  - Evidence for direct CP violation in the D^0 decays at 3.5σ (LHCb/CDF)
- SuperB potential:
  - With no clear hint of new physics in direct searches, flavor physics continues to be a critical search focus.
  - If new physics will be discovered at the LHC, flavor physics will be able to provide complementary informations: new physics couplings, phases, discriminate among different models.
- Competition: LHCb, Belle II

As example: testing SM with $B \to D^{(*)}\tau\nu / B \to D^{(*)}l\nu$

- We test the SM measuring the ratios

$$R(D) = \frac{Br(\bar{B} \to D\tau\nu)}{Br(\bar{B} \to D\ell\nu)} \qquad R(D^*) = \frac{Br(\bar{B} \to D^*\tau\nu)}{Br(\bar{B} \to D^*\ell\nu)}$$

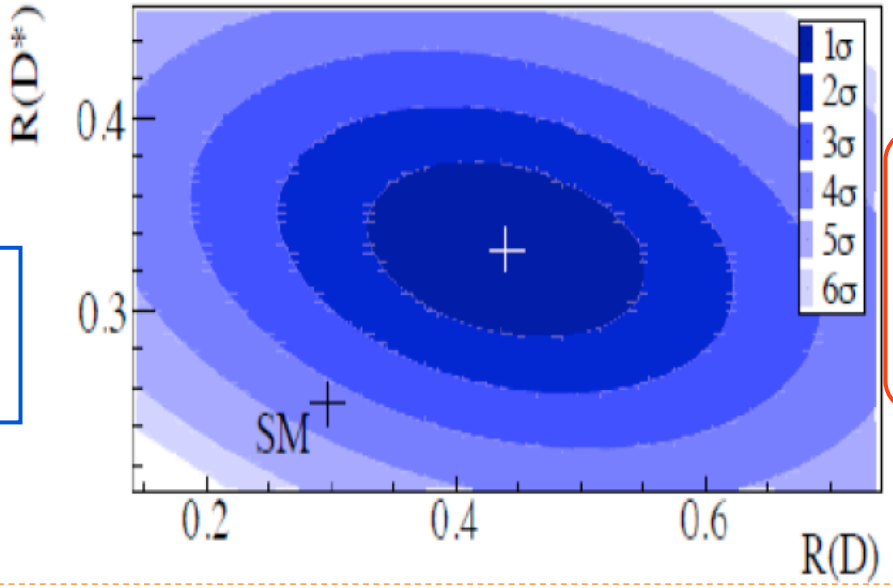
Sensitive to New Physics contributions.
For example to a charged Higgs.

- Violation of lepton universality?

Z. Phys, C46, 93 (1990)
PRD 82, 0340276 (2010)
PhD 85, 094025 (2012)
and recent updates

	R(D)	R(D*)
BABAR	0.440 ± 0.071	0.332 ± 0.029
SM	0.297 ± 0.017	0.252 ± 0.003
Difference	2.0 σ	2.7 σ

BaBar preliminary
arXiv:1205.5442 submitted to PRL



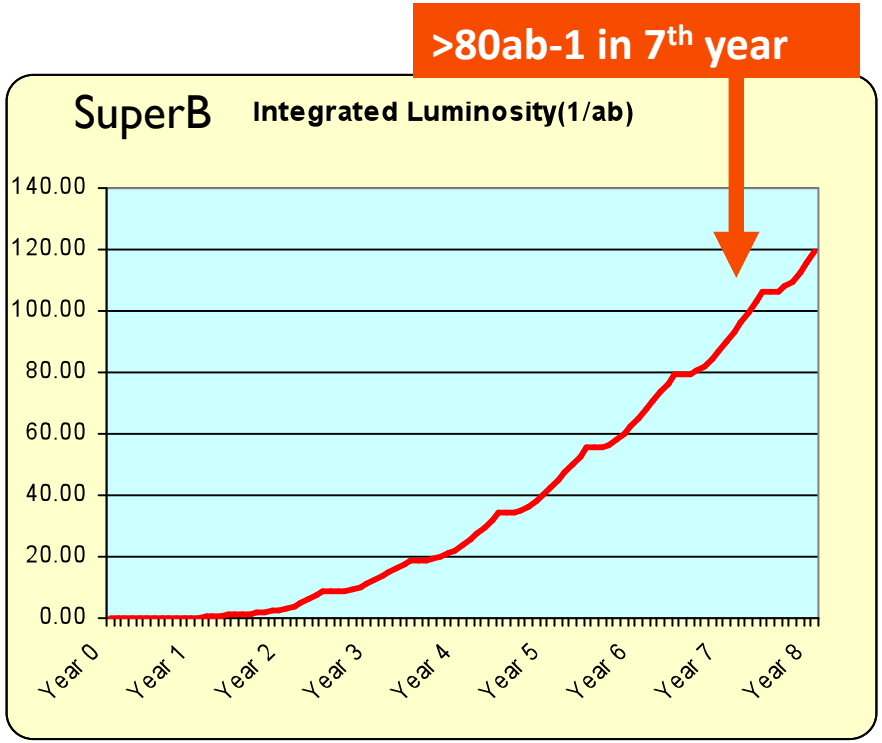
Combinination yields
χ^2 / n.d.o.f. = 14.6/2
(probability: 6.9×10^{-4})
3.4σ away from SM

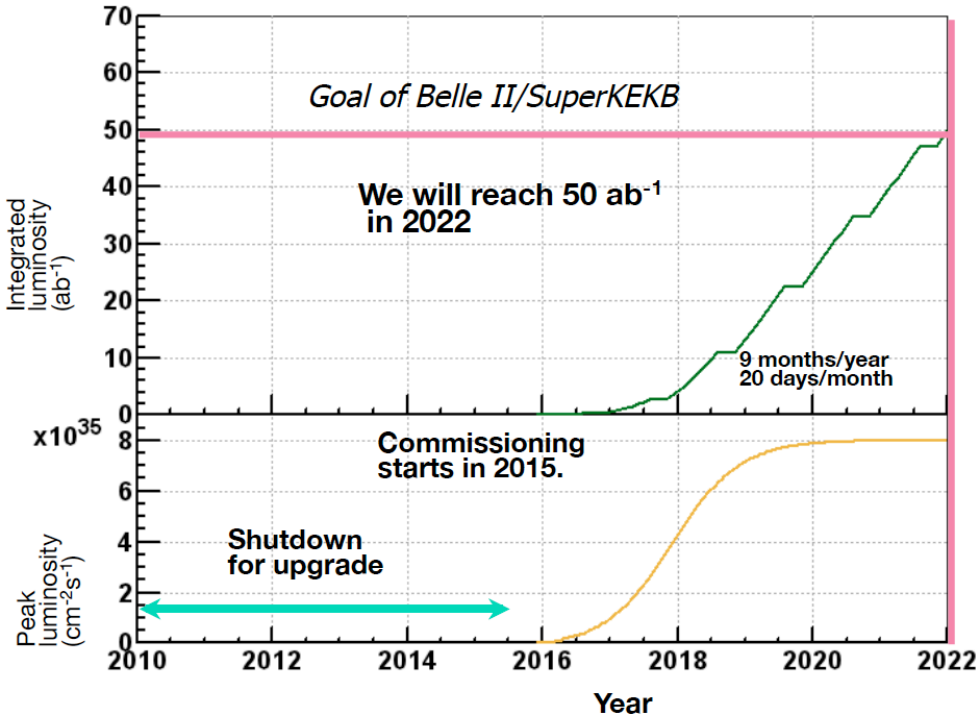
Only next generation of
B factories will be able
to improve this measurement

SuperB project documents

- Conceptual Design Report (2007):
  - CDR [arXiv:0709.0451]
- Progress reports (2010):
  - Physics
    - Physics Progress Report [arXiv:1008.1541]
  - Accelerator
    - Accelerator Progress Report [arXiv:1009.6178]
  - Detector
    - Detector Progress Report [arXiv:1007.4241]

SuperB and SuperKEKB luminosity plan





- SuperB design peak luminosity 10^{36} $cm^{-2}s^{-1}$
  - Additional features:
    - one polarized beam 80%
    - possibility to run at low energies: i.e. charm threshold
- SuperKEKB design peak luminosity $8 \cdot 10^{35}$ $cm^{-2}s^{-1}$

Project Status

- SuperB inserted in April 2010 among the Italian National Research Program (PNR) Flagship Projects
- In december 2010 first funding of 19M€ as first part of a pluriennal funding plan and 22M€ in 2011
- In april 2011 approval of the PNR, including 250M€ for SuperB
- May 2011, site decision: Univ. Tor Vergata campus, Rome
- Oct 2011, Cabibbo Laboratory (Consorzio INFN - Univ. Tor Vergata) for the management and governance of the project (CERN like). Evolution to ERIC is the final goal.
- Jun 2012, Started recruitment for the construction: mainly Accelerator Physicists and Engineers (18 positions)
- July 2012, Costing WBS of the project almost completed (97%):
  - Total value (accelerator + infrastructure) 800 M€
  - Total cost (no personnel cost, no VAT if ERIC) 500 M€
  - Asked to the government in 2010: 500 M€
  - Approved so far: 250 M€.
  - Negotiation with the government for the additional 250 M€

Funding and Management

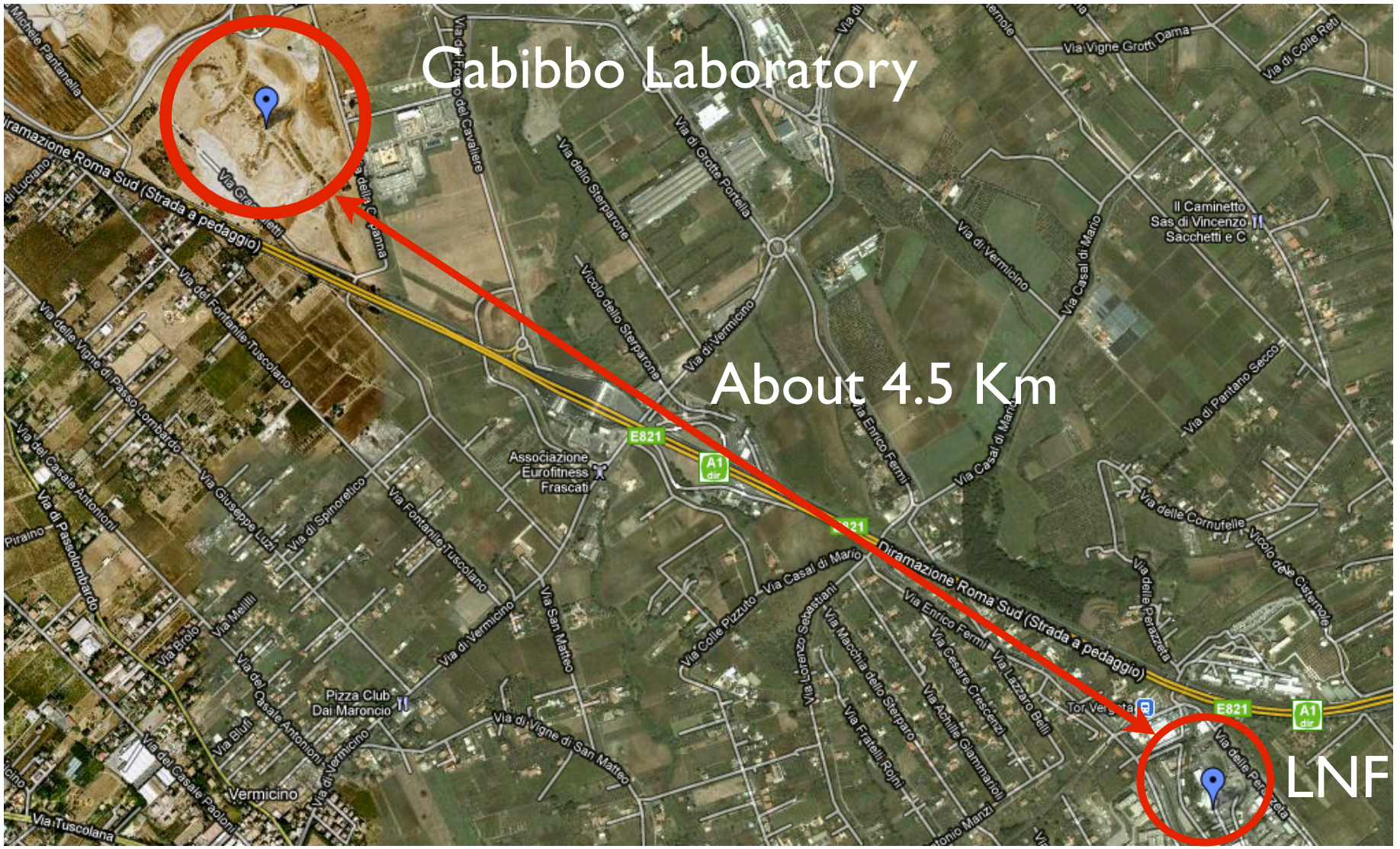
- MoUs for the TDR with France, UK, Russia, SLAC and CERN
- Expect that
  - For the accelerator and infrastructure most funding will be Italian
  - For the detector only half of the needed funding will come from Italy (about 25M€)
- The project will be managed through a European Research Infrastructure Consortium (ERIC)

From Cabibbo Lab director general (Petronzio)

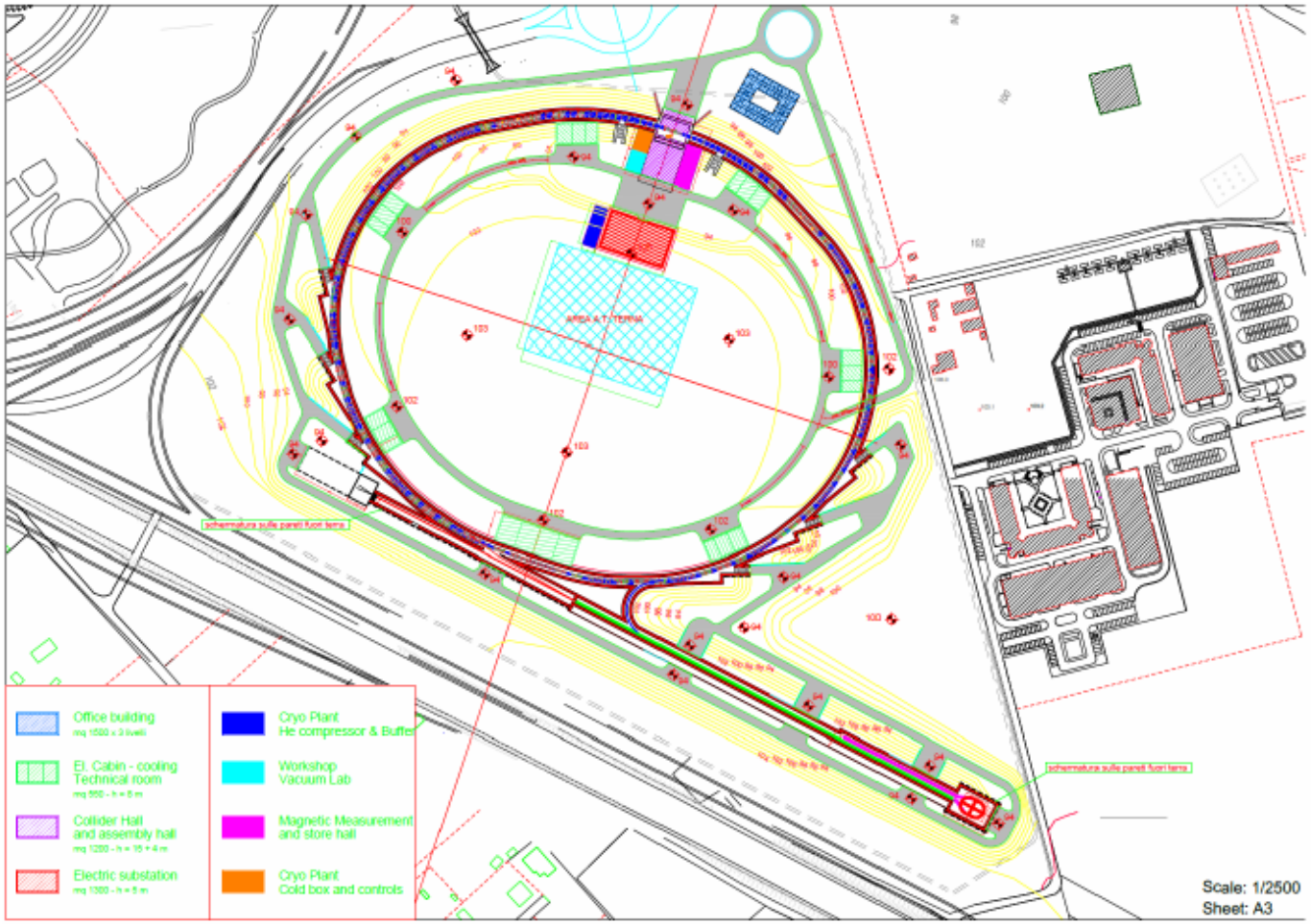
Il profilo del Cabibbo Lab

- Un laboratorio di acceleratori
  - Particelle elementari (SuperB)
  - Life e nanoscience (X-FEL) compatibile con il Linac di SuperB
  - Test facility per I futuri acceleratori (FTF, Frascati Test Facility)
- Suscettibile di ulteriori sviluppi
  - Una sorgente di fotoni per fisica nucleare
  - Una irradiation facility per caratterizzare materiali (ESA) e per studi di radiation hardness

The SuperB Factory will be built at the University of Rome "Tor Vergata"



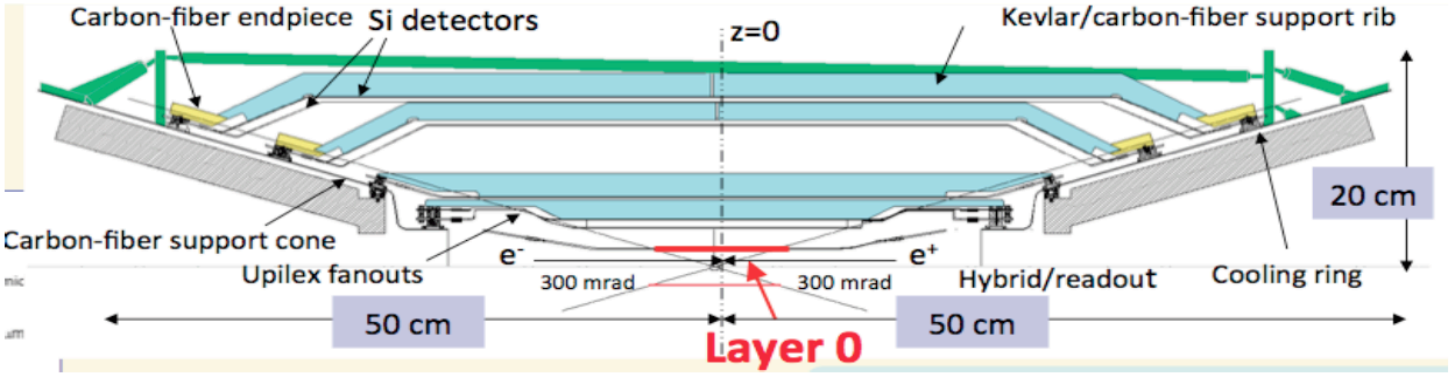
Site layout


Office building
El. Cabin - cooling Technical room
Collider Hall and assembly hall
Electric substation
Cryo Plant He compressor & Buffer
Workshop Vacuum Lab
Magnetic Measurement and store hall
Cryo Plant Cold box and controls
Scale: 1/2500
Sheet: A3

Attività SuperB Milano 2012

- Completato lo studio delle performance del rivelatore di vertice SVT in presenza di background
- Testbeam per SVT al CERN (Novembre 2012)
  - ricostruzione e analisi dati
- Elettronica analogica di Front-End per i layer esterni
- Elettronica periferica per SVT

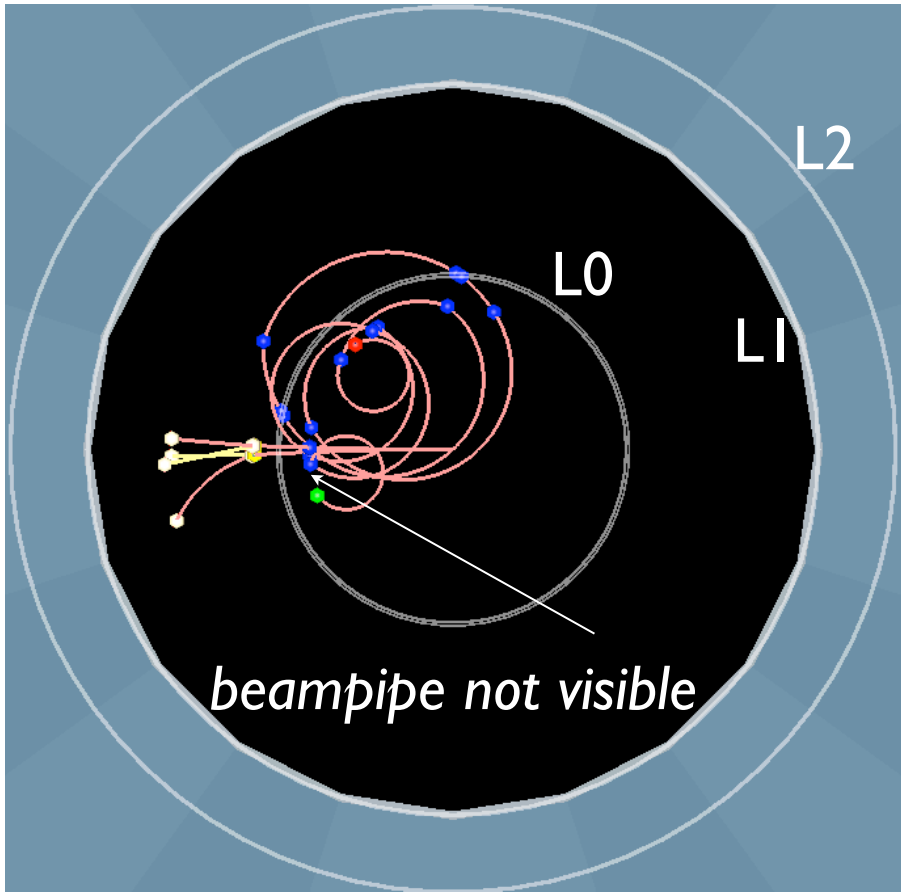
The SuperB SVT



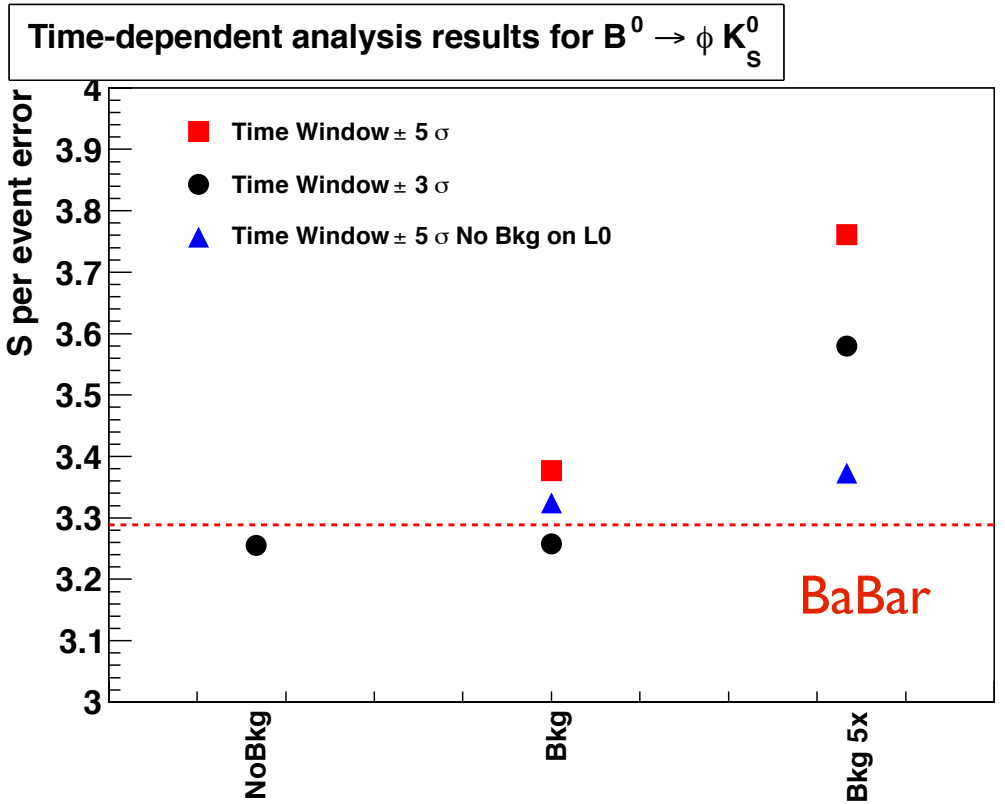
- The components:
  - Sensors
  - Fanout
  - Front-End Electronics
  - Readout chain
  - Mechanics and cooling
- Milano activities:
  - SVT performance studies
  - Layer0 fanout
  - External layers analog FEE
  - HDI, tail, transition card, power distrib.
  - Transition card support and cooling

SVT performances in presence of background

- $e^+e^- \rightarrow e^+e^-e^+e^-$ is the dominant background source in Layer0.
- Total Bkg Hit rate ~ 20 MHz/cm^2

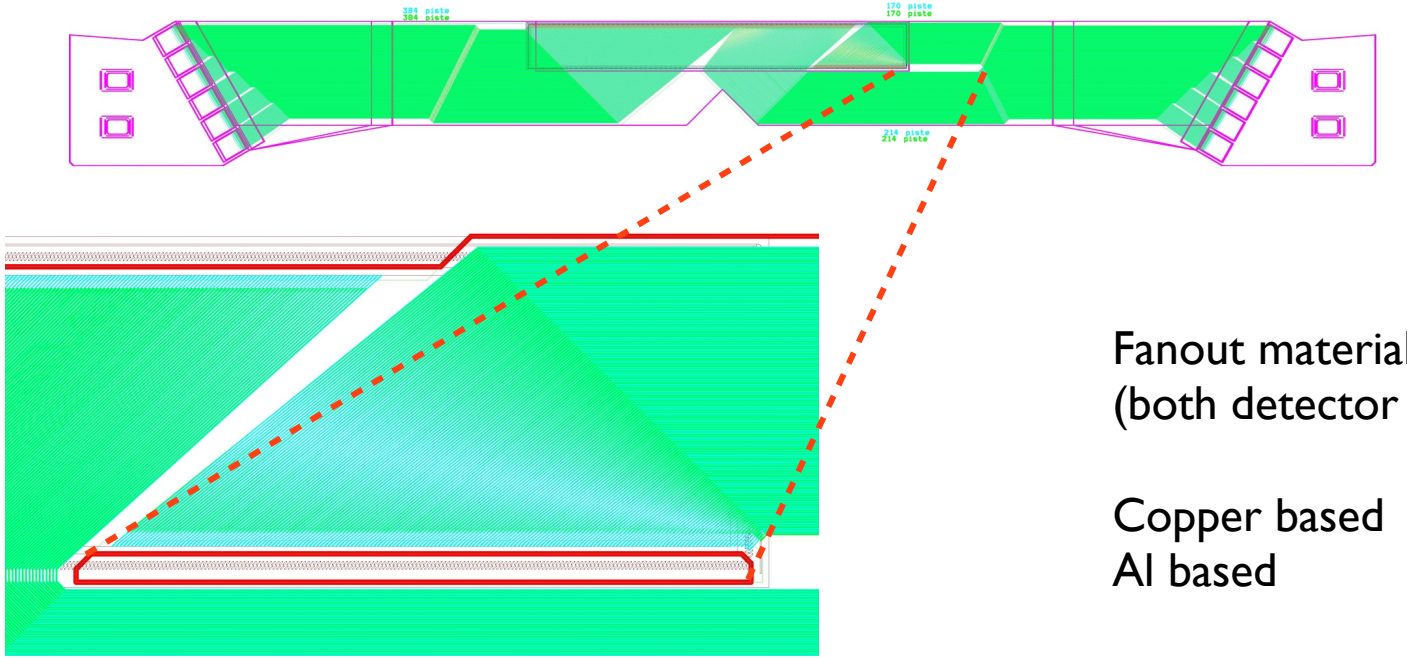


- Physics performance with different bkg levels and Layer0 occupancies (different cuts on the time of arrival of the hits)



Fanout Layer0

- Two layer solution with effective pitch of 38 microns
  - traces are staggered plane to plane with trace pitch of 68 microns
  - Aluminum and copper based solution under production at CERN
  - complex geometry due to mechanical constraints



Fanout material for Layer0
(both detector sides)

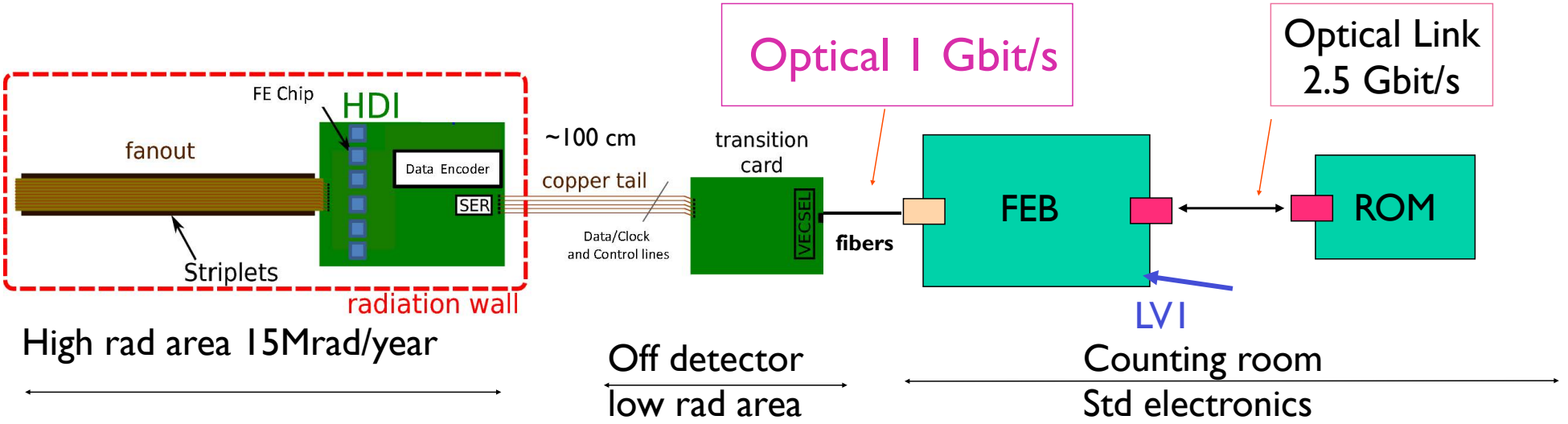
Copper based 0.1 % X_0
Al based 0.06 % X_0

Elettronica per SVT

From Mauro Citterio's talk at SuperB meeting

DAQ chain independent on the chosen FE options

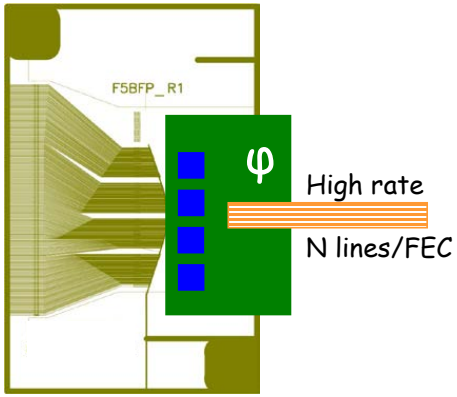
HDI +Transition card+FEB+ROM



INFN Milano, responsabile della progettazione e realizzazione di:

- Fanout
- FE chip per layer esterni, parte analogica
- HDI and transition card
- Data Encoder IC (progettazione e realizzazione)
- Rad-hard serializer (selezione fra componenti esistenti)
- Copper tail
- Power distribution

HDI and output bus

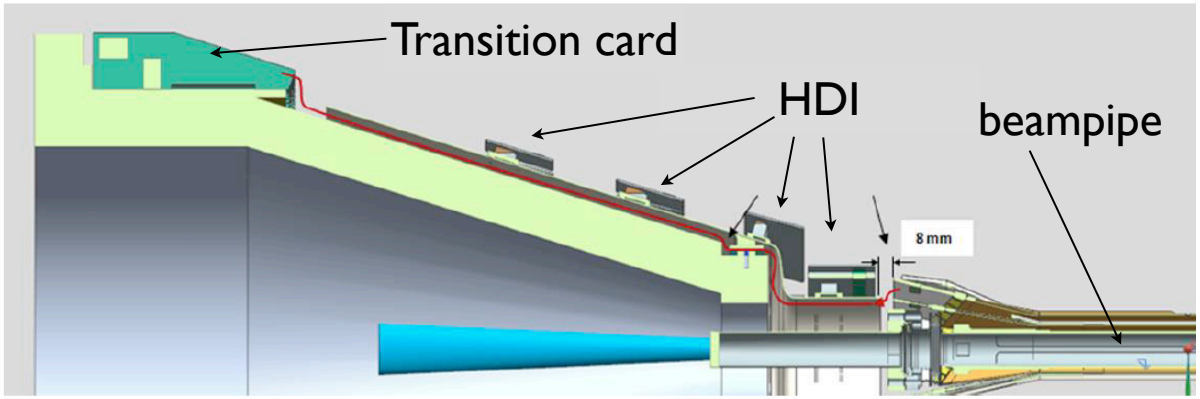


Minimal number of elements on HDI
(ideally only FE chips and possibly a serializer)

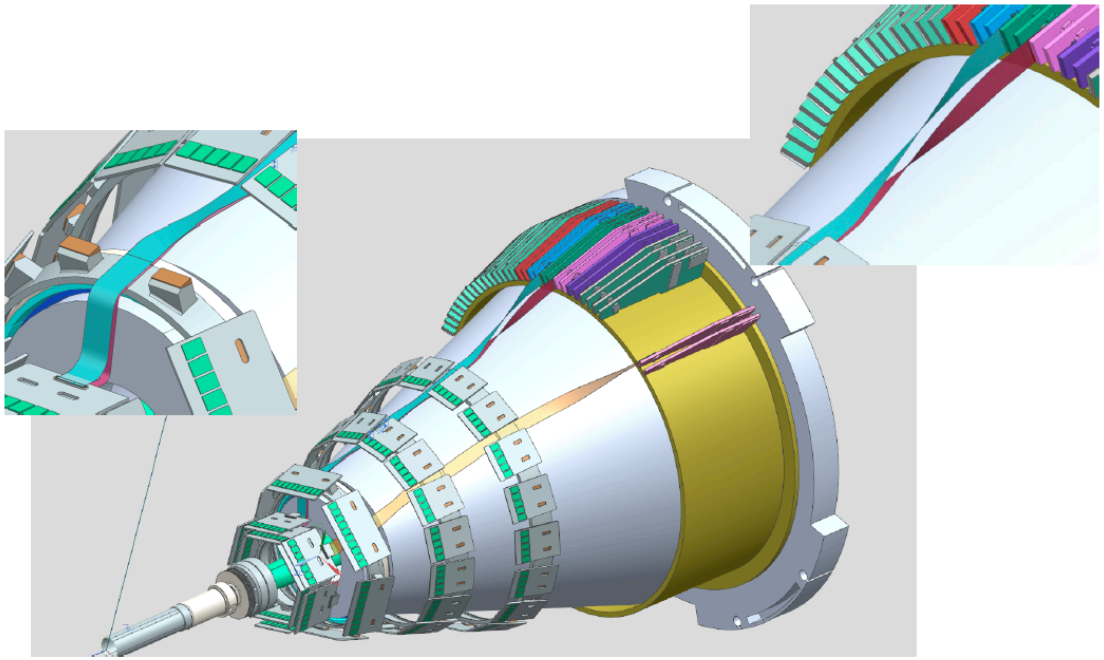
6 shared input lines:
Reset, Clock, FastClock,
Timestamp, Trigger, RegIn
1 shared output line:
RegOut
N lines x M chips in output
Ground and powering on the bus
Signal lines in standard LVDS
(CMOS to/from LVDS required on HDI if not provided on FE)

- HDI elements should be:
- Rad-hard characteristics dependent on chips
  - Requirement: > 5 Mrad/year
- Power dissipation: < 1 W/chip (guess-estimate, past values)
- *Option for a serializer on HDI*

SVT mechanics



- Drawings of the region close to the IP



Transition card support and cooling

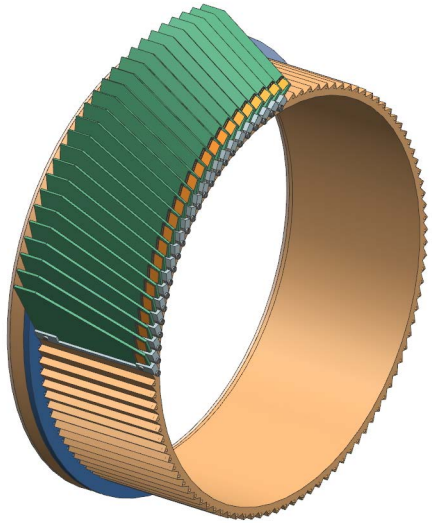
Istituto Nazionale di Fisica Nucleare Sezione di Milano

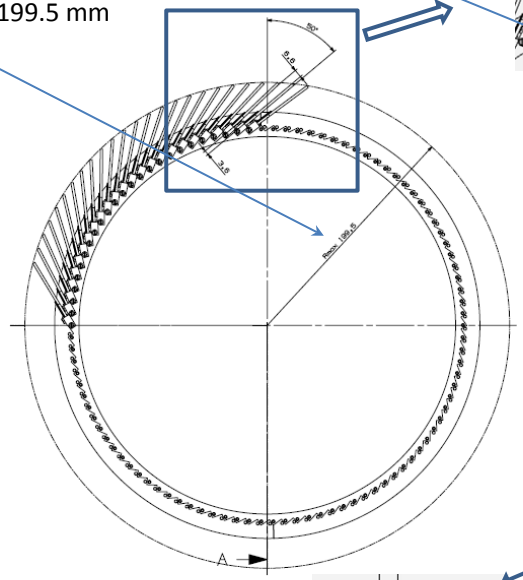
16 March 2012

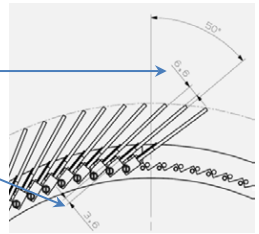
Transition cards – Turbine layout

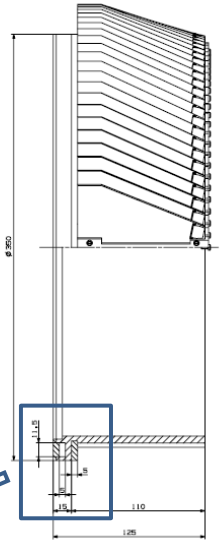
Max gap: 6.6 mm
Min gap : 3.6 mm

Max envelope radius : 199.5 mm

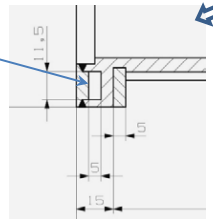








cooling space in back flange



M. MONTI S. COELLI

21 March 2012 Mauro Citterio - SVT Parallel - Frascati 17

FEE design for Layer4 and Layer5

Activity carried out up to June 2012

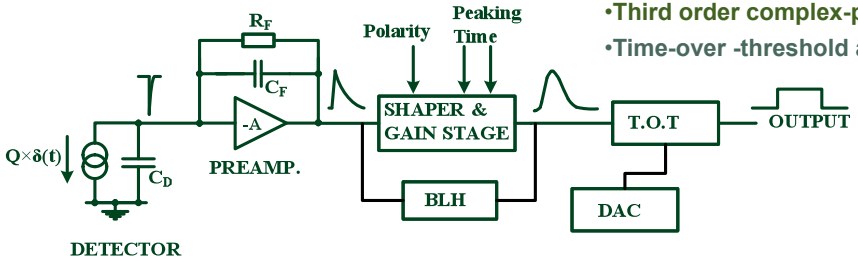
- **Design of the readout architecture (preamplifier, shaper, TOT)**
- **Noise simulations**
- **Studies of the Efficiency of SVT outer layers**

Activity foreseen in second half of 2012

- **Design and layout of a first prototype of FE analog channel**
- **Submission of design in the IBM run of November 2012**

Readout architecture and simulation studies

Readout architecture

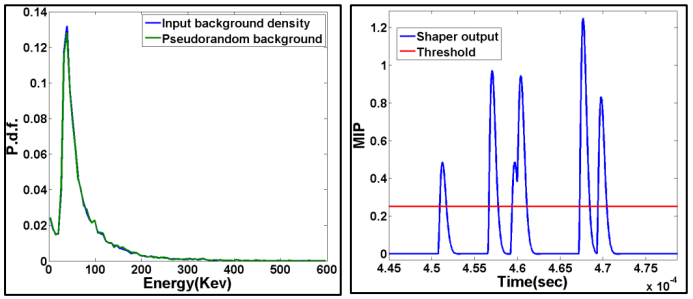


- Charge preamplifier with continuous reset
- Third order complex-pole shaping
- Time-over -threshold amplitude measurement

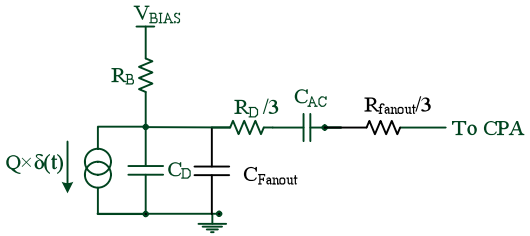
Digital control:

- 4 selectable peaking time (1000, 750, 500, 375 ns)
- 2 polarity (n-strip, p-strip)
- 2 gain setting (nominal gain, +30%)

Efficiency simulation using TOT



Noise Estimation



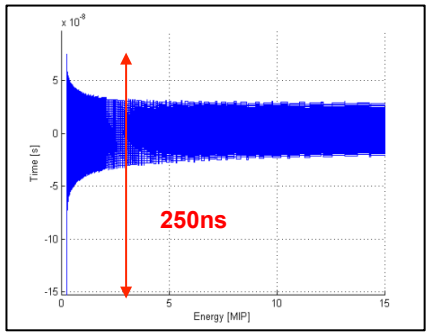
Long-Strip detector model including:

- Strip resistance and Cap.
- Fan-out parasitic
- Radiation damage

Better performance achieved with shorter peaking time after radiations damage.

S/N still low with 5x safety on BKG. (Improve cooling!)

Expected Timing Resolution



Residual error of time-stamp and time-walk correction

Time error due to:

1. Time stamp clock (33 MHz)
2. Time walk, corrected with TOT amplitude
3. Effect of TOT error (TOT clock)

Attività SuperB Milano 2013

Partecipanti nel 2013

2013	FTE
Assegno Ric. INFN	100%
V. Liberali PA	40%
N. Neri RIC INFN	80%
F. Palombo PA	80%
FTE Ricercatori	3.0

C. Fiorini PO (PoliMi)	40%
M. Citterio DirTEC	40%
S. Coelli TEC	30%
Bayan Nasri (Dott. PoliMi)	100%
A. Stabile Ass. Ric.	30%
FTE Tecnologi	2.4

Responsabilita'/Attivita'

- N. Neri — Charm Physics Co-Convener; SVT Fast Simulation
- M. Citterio — SVT elettronica periferica
- C. Fiorini — FEE analogico layer esterni SVT
- S. Coelli — SVT supporto transition card + cooling system

- 5.4 FTE in 2012
- 5.4 FTE in 2013

Richiesta per Servizi di Sezione
- Laboratorio Elettronica 20 m.u.

Servizio Progettazione e Officina meccanica
- Ufficio Tecnico 4 m.u.
- Officina Meccanica 4 m.u.

- Studi di sensibilita' per canali benchmark
  - Fisica del charm e del B, misure di violazione di CP time-dependent
- Sviluppo del software di simulazione di SVT
  - Fast Simulation
- Testbeam: ricostruzione e analisi dati
- Contributo al progetto e costruzione di SVT:
  - Elettronica periferica
  - FEE per il readout dei layer esterni, Layer4, Layer5
  - Sistema di cooling di SVT per FEE, supporto per elettronica periferica

Progetto SuperB

impegni Servizio Progettazione e Officina Meccanica

- meccanica per il supporto per HDI e transition card con sistema di cooling
- produzione e test prototipi

Più avanti:

- definizione delle procedure di assemblaggio dei moduli dei vari layer
- design dei vari jigs per assemblaggio dei moduli di alcuni layer, procedure di montaggio.
- possibile partecipazione all'integrazione del rivelatore con la beampipe

Richieste finanziarie 2013

- MI (22 K€):
  - Relative ad attivita' SVT
    - 9 K€ per contatti con collaboratori e ditte esterne
  - Partecipazione a meeting di collaborazione
    - 13 K€
- ME (18 K€):
  - Relative ad attivita' SVT
    - 10 K€ per contatti CERN
  - Partecipazione a meeting di collaborazione
    - 8 K€

Richieste finanziarie 2013

- Consumi (136 K€)
  - Relative attivita' SVT
- 127 K€ (HDI, encoder, fanout+tail per L0, transition card, Al pixel bus, prototipi per cooling e supporto meccanico per transition card)
  - Metabolismo
- 9 K€

- Totale richieste 176 K€

Backup slides

Physics program in a nutshell

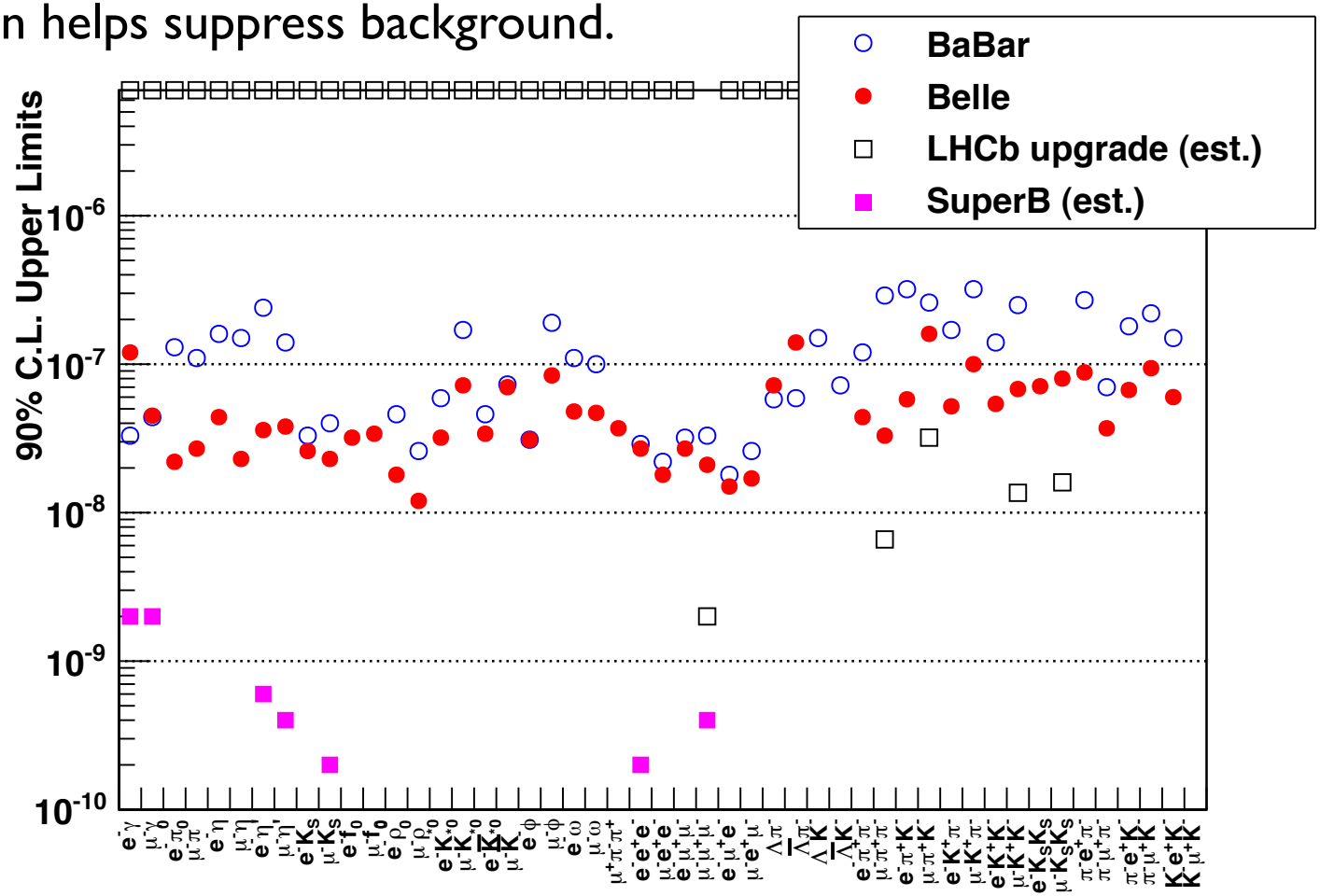
- Versatile flavor physics experiment
  - Probe new physics observables in wide range of decays.
    - Pattern of deviation from Standard Model can be used to identify structure of new physics.
    - Clean experimental environment means clean signals in many modes.
    - Polarized e^- beam benefit for precision electroweak measurements and for τ LFV searches.
  - Best capability for precision CKM constraints of any existing/ proposed experiment.
    - Measure angles and sides of the Unitarity triangle
    - Measure other CKM matrix elements at charm threshold and using τ data.

τ Lepton Flavor 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.
- e^- beam polarization helps suppress background.

Two orders of magnitude improvement at SuperB over current limits.

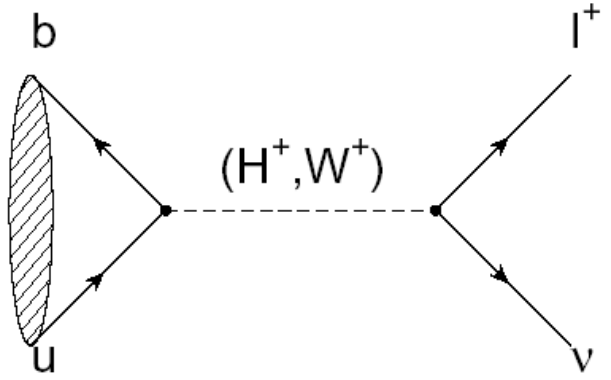
Hadron machines are not competitive with e^+e^- machines for these measurements.

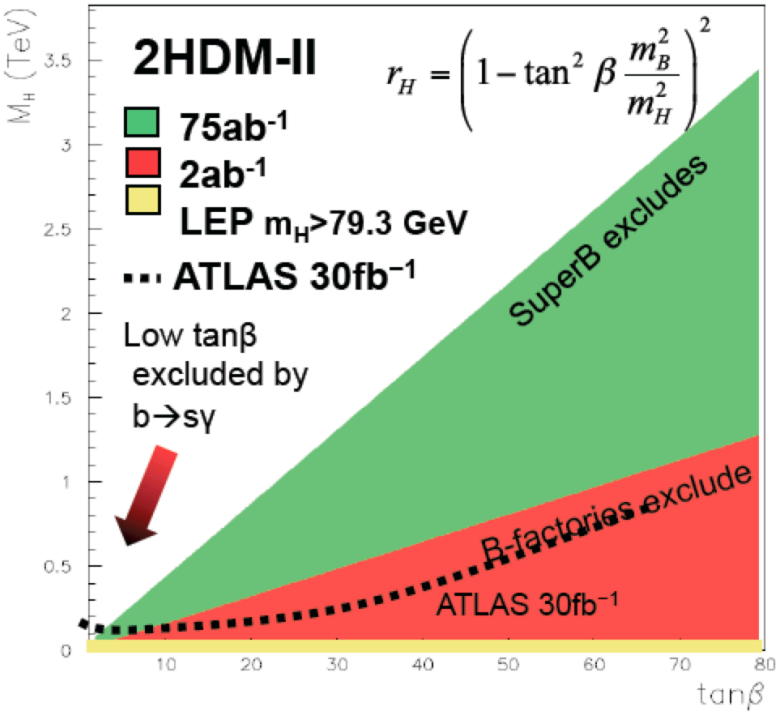


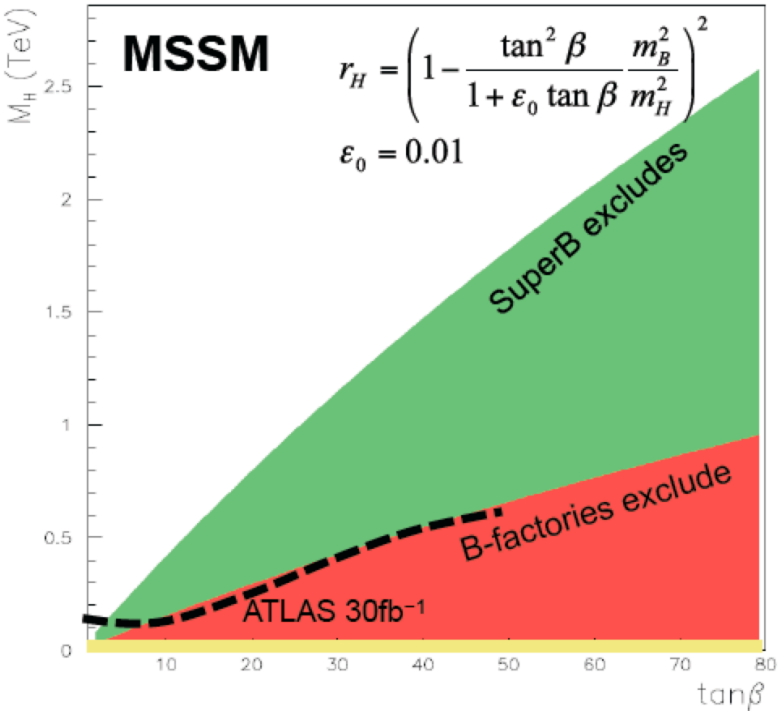
$B_{u,d}$ physics: Rare Decays

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

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







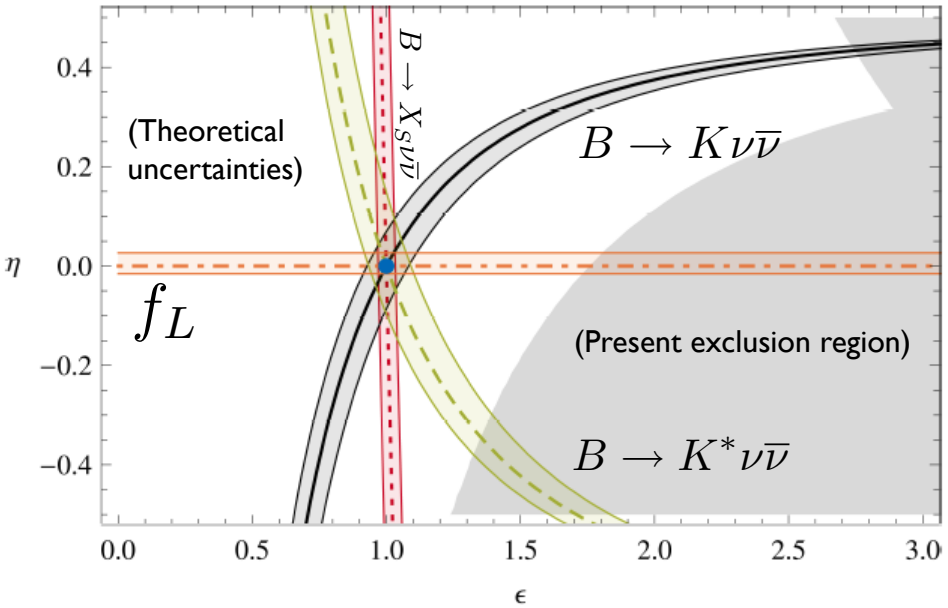
$B_{u,d}$ physics: Rare Decays

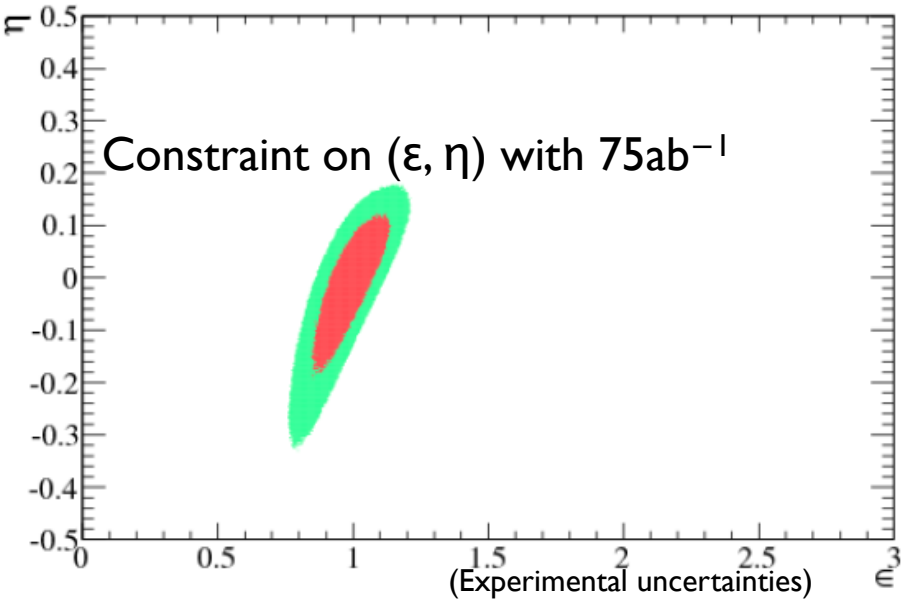
- Example: $B \to K^{(*)}\nu\bar{\nu}$
  - Need 75ab^{-1} to observe this mode.
  - With more than 75ab^{-1} we could measure polarization.

$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{\rm SM}|}\,, \qquad \eta = \frac{-{\rm Re}\,(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2}$$

Sensitive to models with Z penguins and RH currents.

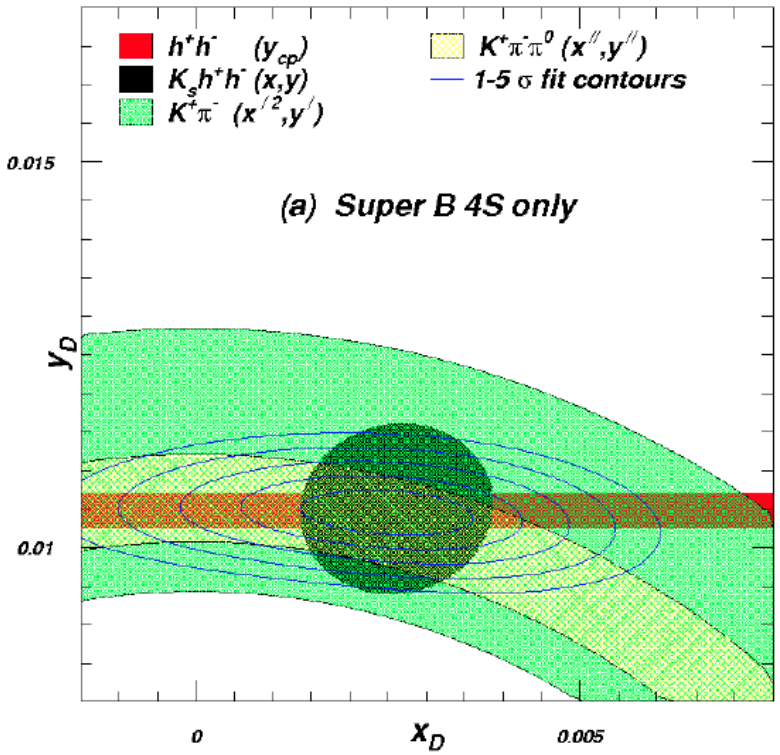
e.g. see Altmannshofer, Buras, & Straub *JHEP04(2009)022*

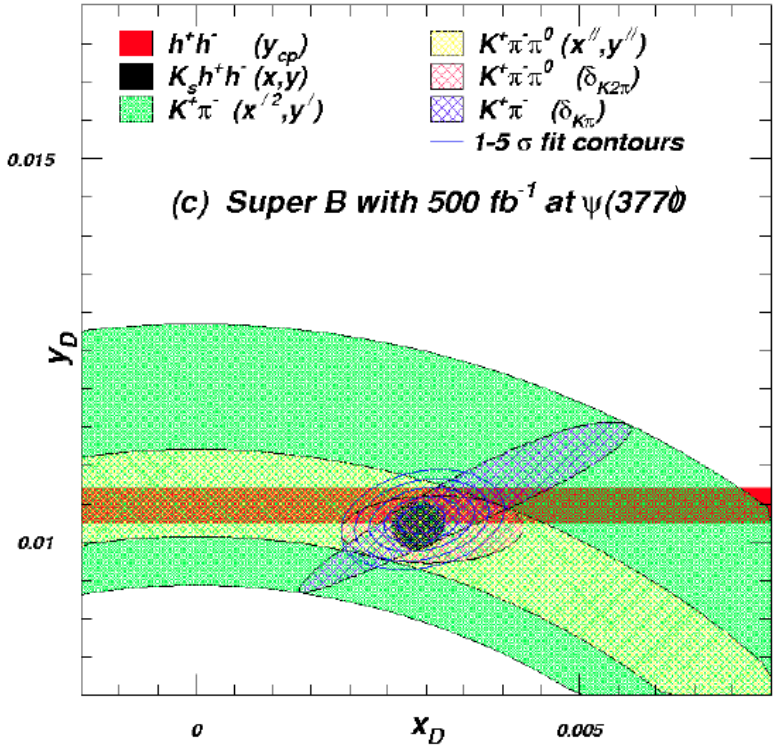




Charm

- Collect data at threshold and at the Υ(4S).
  - Benefit charm mixing and CPV measurements.

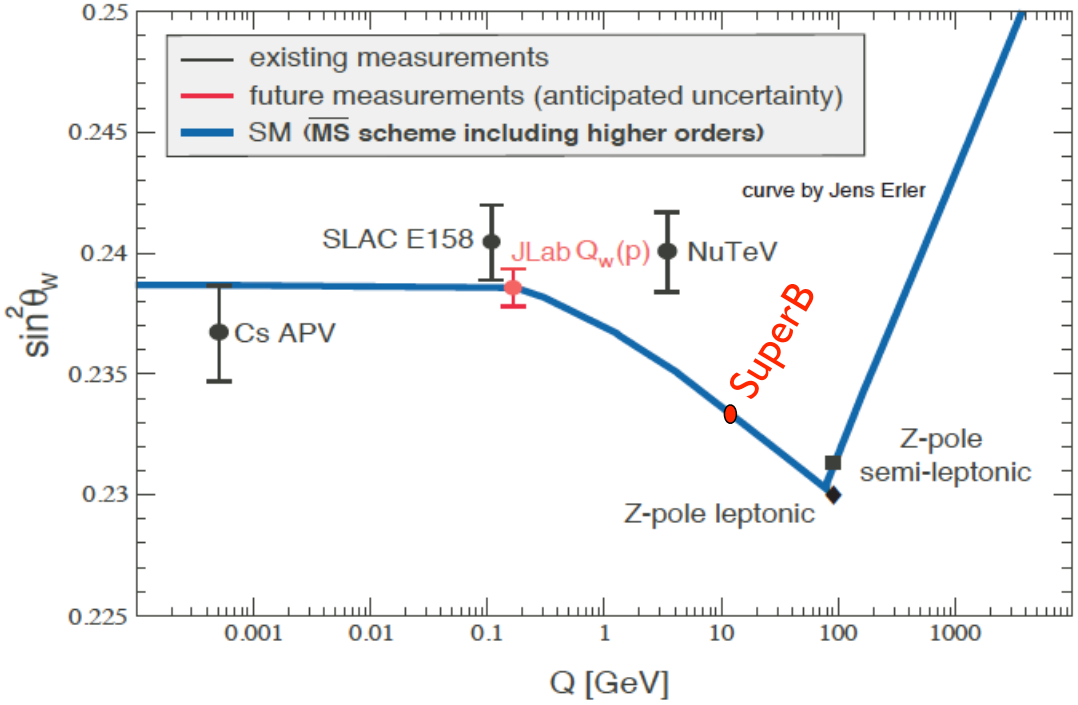




  - Also useful for measuring the Unitarity Triangle angle γ (strong phase in D→Kππ Dalitz plot).

Precision Electroweak

- $\sin^2\theta_W$ can be measured with polarized e^- beam
  - differential cross-section in $e^+e^- \to f^+f^-$ events
  - $\sqrt{s} = \Upsilon(4S)$ is theoretically clean, c.f. b-fragmentation at Z pole



$$A_{LR} = \frac{\sigma(P)-\sigma(-P)}{\sigma(P)+\sigma(-P)} = \frac{16}{\sqrt{2}} \left(\frac{G_F q^2}{4\pi\alpha}\right) \left(\frac{g_A^e\, g_V^b}{Q_b}\right) P$$

(P= e^- beam polarization)

- Measurable for all $B^0\,\bar{B}^0$ and $B^+\,B^-$ final states, both resonant and continuum.
- **All** QCD corrections included in the **single** form factor that cancels in the asymmetry.
- Very clean measurement, no **large** theoretical corrections (in progress...)

$\Rightarrow$ Excellent opportunity to measure g_V & $\sin^2\theta_W$ at SuperB with polarized beams!!

Perform the measurement also at the Ψ(3770) peak, with polarized beams.

Plot adapted from QWeak proposal (JLAB E02-020)

Interplay

- Combine measurements to elucidate structure of new physics.

	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)										
✓	$B \to K^{(*)+}\nu\bar{\nu}$			★	★★★			★	★	★	★	★
✓	S in $B \to K^0_S\pi^0\gamma$					★★★						
✓	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	★★									★★★	

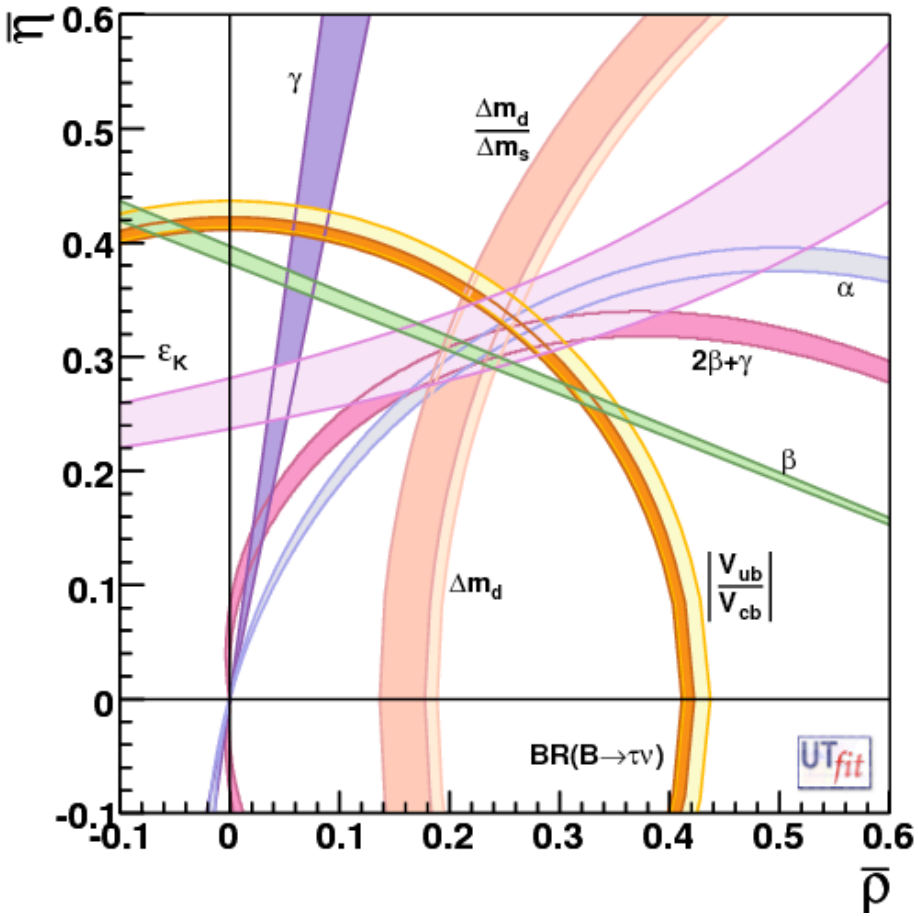
✓= SuperB can measure this

★★★ signals large effects, ★★ visible but small effects and ★ implies that the given model does not predict sizable effects in that observable.

Precision CKM constraints

- Unitarity Triangle Angles
  - $\sigma(\alpha) = 1-2°$
  - $\sigma(\beta) = 0.1°$
  - $\sigma(\gamma) = 1-2°$
- CKM Matrix Elements
  - $|V_{ub}|$
    - Inclusive $\sigma = 2\%$
    - Exclusive $\sigma = 3\%$
  - $|V_{cb}|$
    - Inclusive $\sigma = 1\%$
    - Exclusive $\sigma = 1\%$
  - $|V_{us}|$
    - Can be measured precisely using τ decays
  - $|V_{cd}|$ and $|V_{cs}|$
    - can be measured at/near charm threshold.

The "dream" scenario with 75ab^{-1}

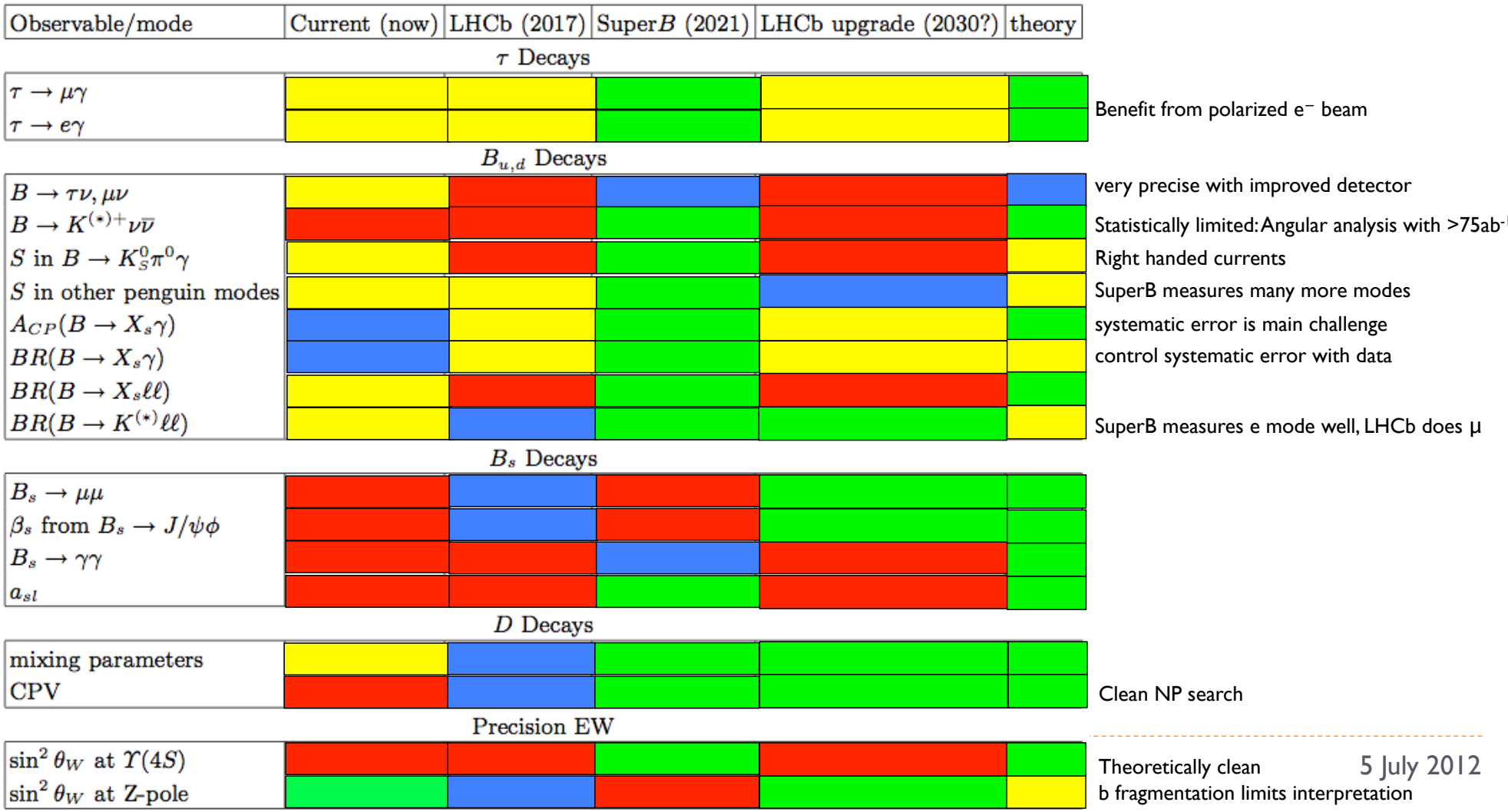


- SuperB Measures the sides and angles of the Unitarity Triangle

Golden Measurements: General

Experiment: No Result | Moderate Precision | Precise | Very Precise

Theory: Moderately clean | Clean Need lattice | Clean



Future milestones

- July 2012, Internal costing document (WBS)
- September/October 2012, Technical Design Report
- November 2012, Review MIUR (Cabibbo Lab Financial Committee)
- December 2012, Review MAC (Machine Advisory Committee)
- Spring/Summer 2013, Review CTS INFN