INFN SuperB Status

M.A.Giorgi
INFN & Università di Pisa

88th Plenary ECFA Meeting

CERN *November 25, 2010*

Outline

Progress Reports before TDR have been published.

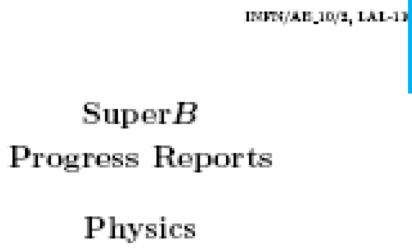
- Machine parameters fixed.
- Better understanding of Physics with Polarization.
- Detector requirements for full exploitation of the collider potential.
- Site requirements and evaluation process

Process:

- Completion together with partners of MOU 's for the project.
- Definition of partnership with IIT and its contribution to the construction
- ERIC SuperB preparation of the Statute.

Toward the start

In Preparation of TDR


INFN/AE_10/5, LAL-1

SuperB
Progress Reports

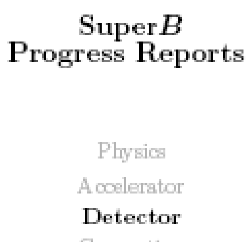
Physics

arXiv:1008.1541v1


SuperB
Progress Reports

The Collider

arXiv:1007.4241v1


SuperB
Progress Reports

Physics
Accelerator
Detector

arXiv:1009.6178v1

Since September 2010 the three SuperB Progress Reports have been published.

Important step forward to the completion of the TDR in time, in 2011.

Machine parameters are fixed including the tunnel length , a Physics update after the 2008 Valencia document, the Detector is almost frozen.

Toward fixing the site requirements.

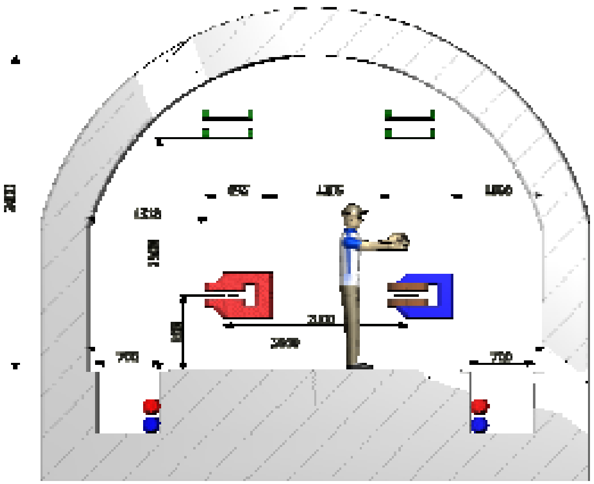
- An ad hoc committee has been set up to prepare the requirements for the site choice , preliminary to the infrastructure design and collect the information needed to proceed toward the executive phase
- Requirements and design will be reviewed by an International Review Committee

Site Requirements Evaluation For SuperB And Synchrotron Light Facility Project

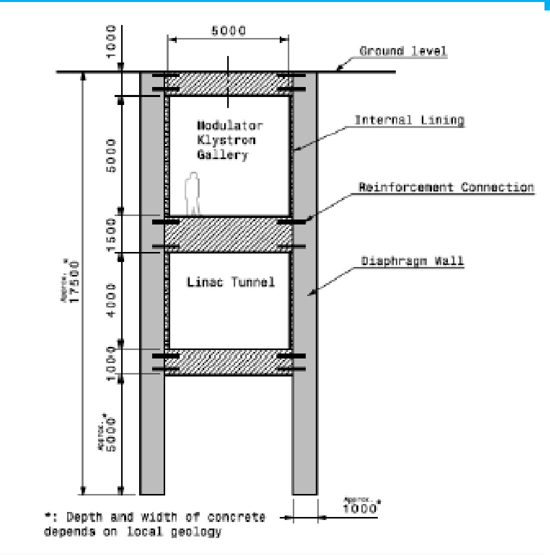
E. Di Fabrizio[1], M. Esposito[2], P. Popolizio[3], P. Raimondi[4], J. Seeman[5], S. Tomassini[4]

November 16th 2010

Studies for Tunnel

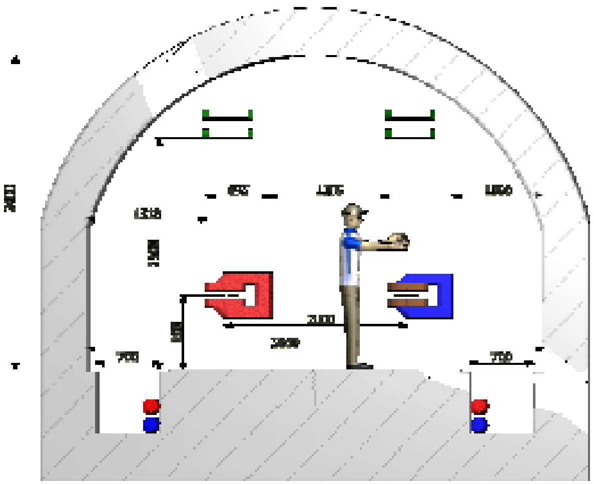


Ring X-section

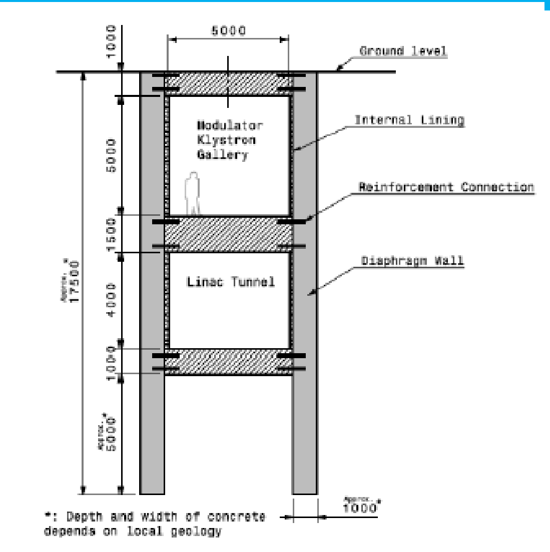


Linac X-section

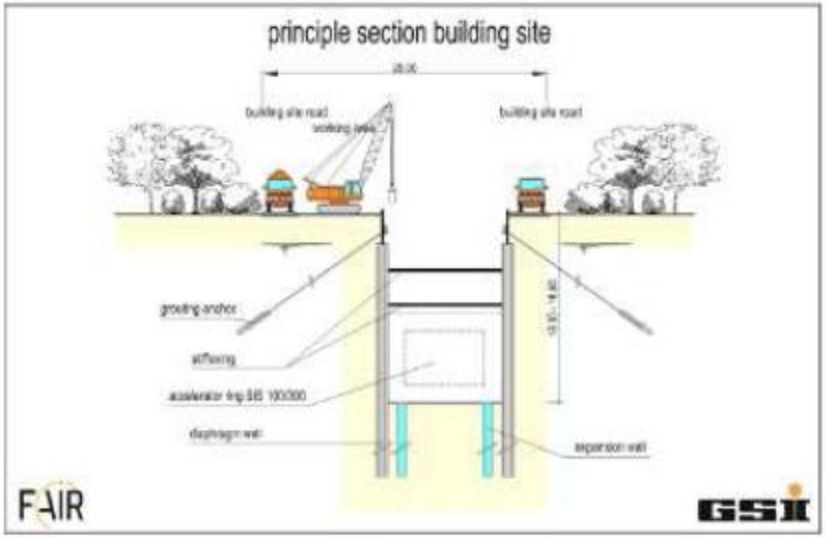
Studies for Tunnel



Ring X-section



Linac X-section

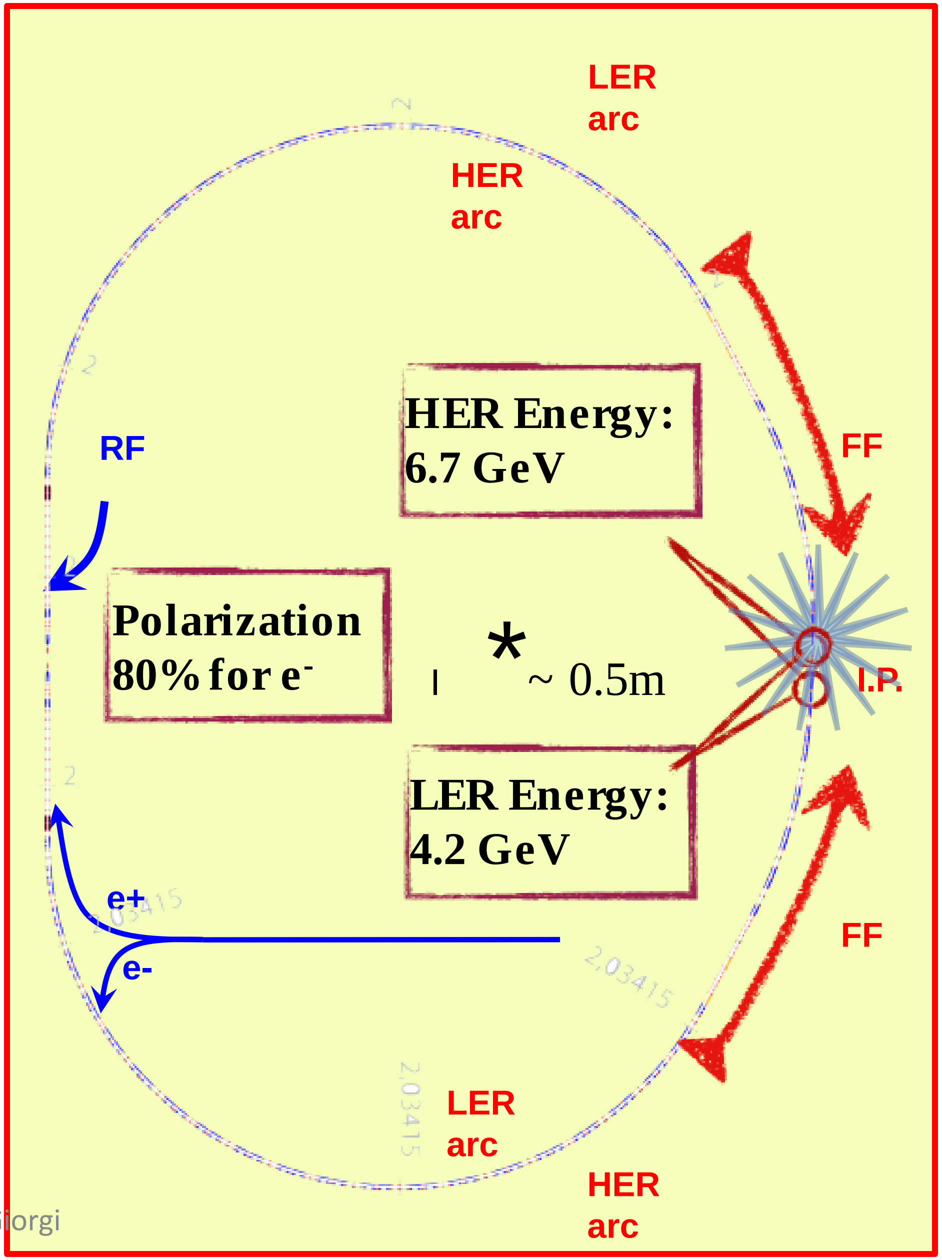


Example of Cut&Cover Technique

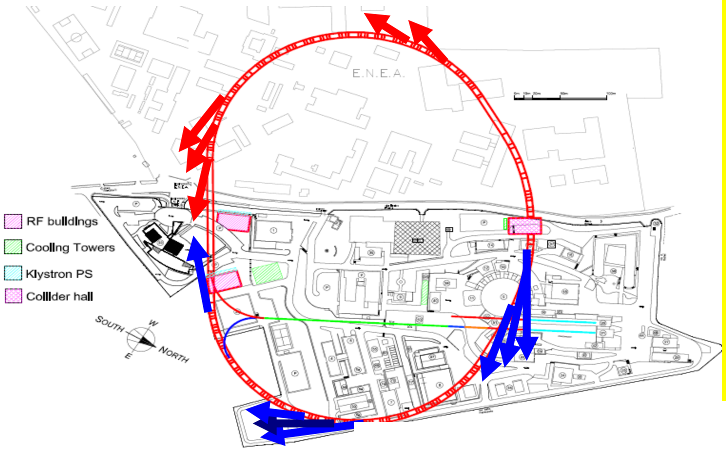
Collider Parameters

		Base Line		Low Emittance		High Current		Tau-charm	
Parameter	Units	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	$cm^{-2} s^{-1}$	1.00E+36		1.00E+36		1.00E+36		1.00E+35	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18	2.58	1.61
Circumference	m	1258.4		1258.4		1258.4		1258.4	
X-Angle (full)	mrad	66		66		66		66	
β_x @ IP	cm	2.6	3.2	2.6	3.2	5.06	6.22	6.76	8.32
β_y @ IP	cm	0.0253	0.0205	0.0179	0.0145	0.0292	0.0237	0.0658	0.0533
Coupling (full current)	%	0.25	0.25	0.25	0.25	0.5	0.5	0.25	0.25
Emittance x (with IBS)	nm	2.00	2.46	1.00	1.23	2.00	2.46	5.20	6.4
Emittance y	pm	5	6.15	2.5	3.075	10	12.3	13	16
Bunch length (full current)	mm	5	5	5	5	4.4	4.4	5	5
Beam current	mA	1892	2447	1460	1888	3094	4000	1365	1766
Buckets distance	#	2		2		1		1	
Ion gap	%	2		2		2		2	
RF frequency	MHz	476.		476.		476.		476.	
Revolution frequency	MHz	0.238		0.238		0.238		0.238	
Harmonic number	#	1998		1998		1998		1998	
Number of bunches	#	978		978		1956		1956	
N. Particle/bunch (10^{10})	#	5.08	6.56	3.92	5.06	4.15	5.36	1.83	2.37
σ_x effective	μm	165.22	165.30	165.22	165.30	145.60	145.78	166.12	166.67
σ_y @ IP	μm	0.036	0.036	0.021	0.021	0.054	0.0254	0.092	0.092
Piwinski angle	rad	22.88	18.60	32.36	26.30	14.43	11.74	8.80	7.15
Σ_x effective	μm	233.35		233.35		205.34		233.35	
Σ_y	μm	0.050		0.030		0.076		0.131	
Hourglass reduction factor		0.950		0.950		0.950		0.950	
Tune shift x		0.0021	0.0033	0.0017	0.0025	0.0044	0.0067	0.0052	0.0080
Tune shift y		0.097	0.097	0.0891	0.0892	0.0684	0.0687	0.0909	0.0910
Longitudinal damping time	msec	13.4	20.3	13.4	20.3	13.4	20.3	26.8	40.6
Energy Loss/turn	MeV	2.11	0.865	2.11	0.865	2.11	0.865	0.4	0.17
Momentum compaction (10^{-4})		4.36	4.05	4.36	4.05	4.36	4.05	4.36	4.05
Energy spread (10^{-4}) (full current)	dE/E	6.43	7.34	6.43	7.34	6.43	7.34	6.43	7.34
CM energy spread (10^{-4})	dE/E	5.0		5.0		5.0		5.0	
Total lifetime	min	4.23	4.48	3.05	3	7.08	7.73	11.4	6.8
Total RF Wall Plug Power	MW	16.38		12.37		28.83		2.81	

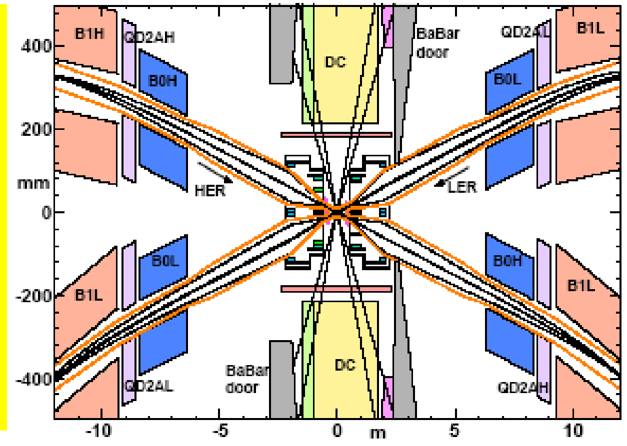
SuperB Collider Progress Report



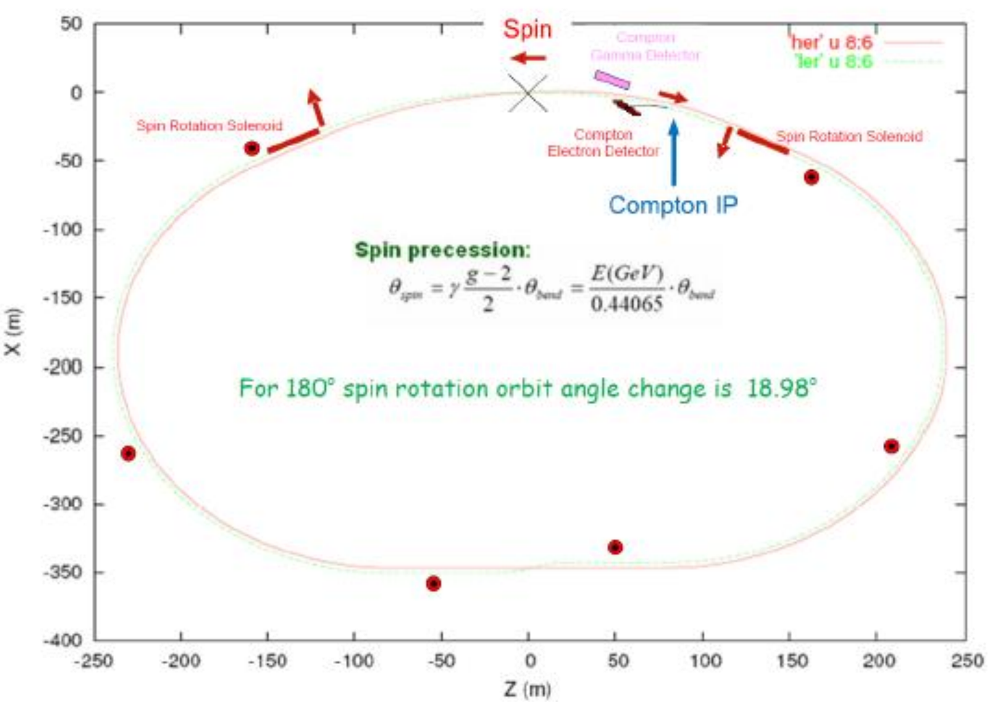
In a" Possible" Location with and interaction region . Photon Lines are included . (Synergy with IIT)



Interaction Region designed and used in the current background studies for detector

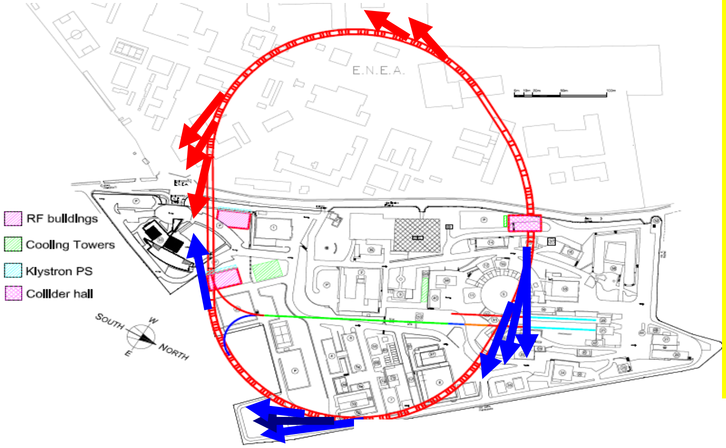


Interaction Region

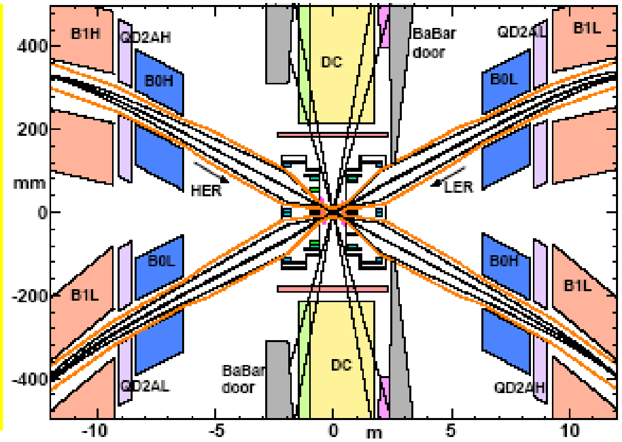


Spin Rotator location for Beam Polarization

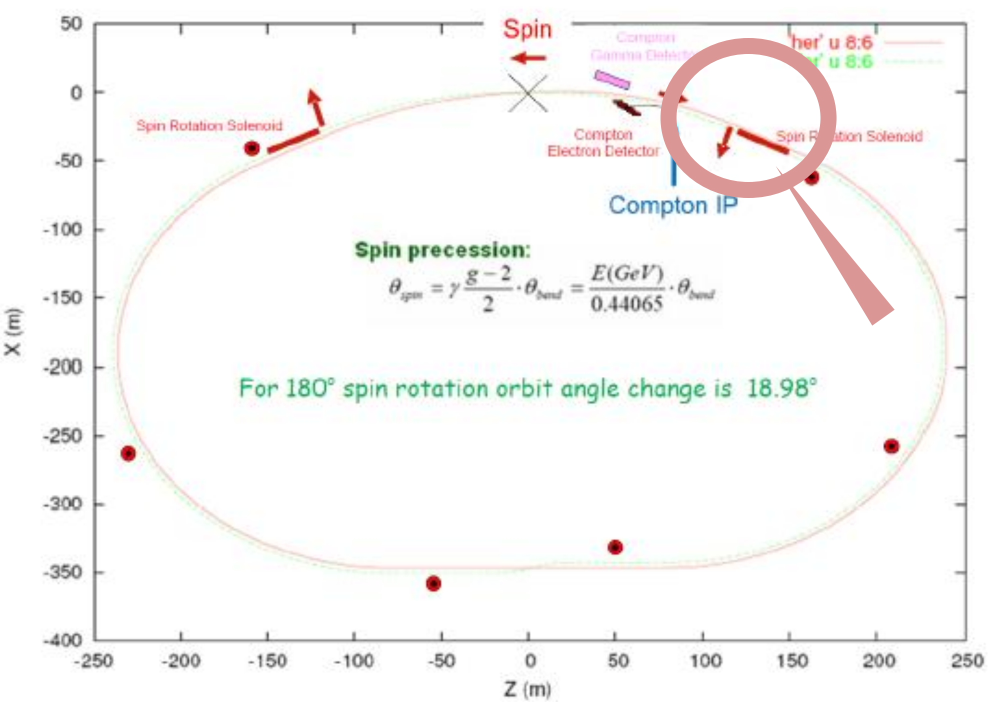
In a" Possible" Location with and interaction region . Photon Lines are included . (Synergy with IIT)



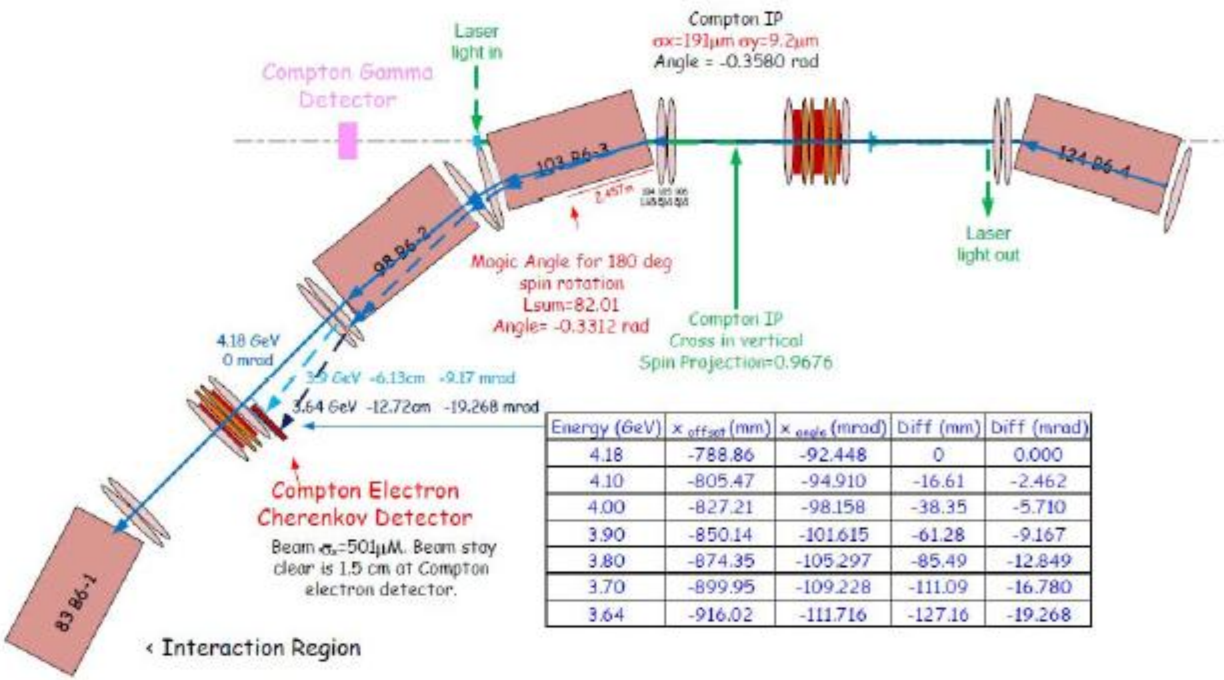
Interaction Region designed and used in the current background studies for detector



Interaction Region



Spin Rotator location for Beam Polarization



Energy (GeV)	x_{offset} (mm)	x_{angle} (mrad)	Diff (mm)	Diff (mrad)
4.18	-788.86	-92.448	0	0.000
4.10	-805.47	-94.910	-16.61	-2.462
4.00	-827.21	-98.158	-38.35	-5.710
3.90	-850.14	-101.615	-61.28	-9.167
3.80	-874.35	-105.297	-85.49	-12.849
3.70	-899.95	-109.228	-111.09	-16.780
3.64	-916.02	-111.716	-127.16	-19.268

Figure 16.9: Layout of the Compton polarimeter.

SuperB is designed with 80% longitudinal polarization for e^-.

Polarization allows:

- Precision Measurement in ElectroWeak sector
- EDM and g-2 in τ .
- BKG reduction for LFV in τ .

- Polarized beams provide measurements of $\sin^2\theta_W(\text{eff})$ with comparable precision to SLD but at much lower energies.
- Polarization allows for NC Z-bb coupling measurement with better precision and different systematic w.r.t. LEP measurement of A_{FB}^{b} .

Differential Cross sections in $e^+e^- \rightarrow f^+f^-$

Diagrams	σ (nb)	A_{FB}	A_{LR} (Pol = 100%)
$\|Z+©\|^2$	1.01	0.0028	-0.00051
$\|Z\|^2+\|©\|^2$ No interference	1.01	0.0088	-0.00002

Asymmetries at Z-pole for measured σ

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$
$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} \frac{1}{\langle|\mathcal{P}_e|\rangle}$$
$$A_{LRFB} = \frac{(\sigma_F - \sigma_B)_L - (\sigma_F - \sigma_B)_R}{(\sigma_F + \sigma_B)_L + (\sigma_F + \sigma_B)_R} \frac{1}{\langle|\mathcal{P}_e|\rangle} .$$

Interference term is $\sim g_A^e g_V^f$

at LEP: 15M hadronic Z decays, unpolarized
at SLC: 0.5M hadronic Z decays, polarized e^-
at SuperB: Z-term ~30M, polarized e^-

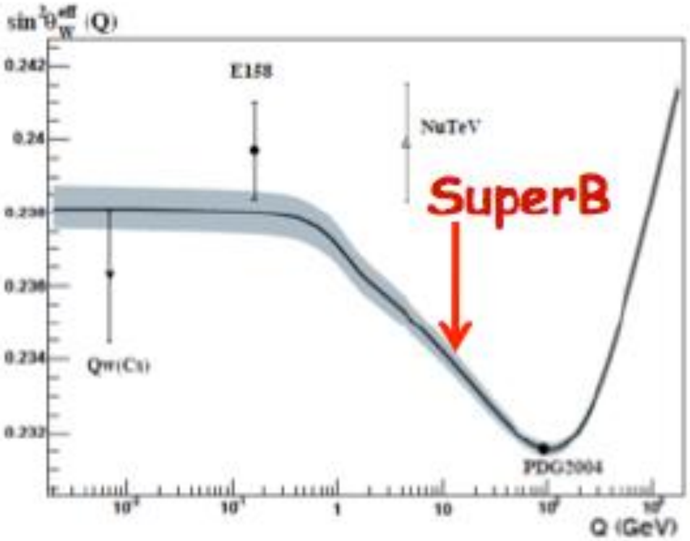
Expected stat. error: $\sigma(A_{LR}) = 4.6 \times 10^{-6}$
relative stat. error 1.1% (80% polarization).
Systematics <0.5% on polarization needed

$$A_{LR} \propto g_V^f \propto (T_3^f - 2Q_f \sin^2\theta_{eff}^f)$$

→ $\sigma(\sin^2\theta_{eff}) = 1.8 \times 10^{-4}$
cfr SLC $\sigma(\sin^2\theta_{eff}) = 2.6 \times 10^{-4}$

Electroweak measurement @ SuperB POLARIZATION NEEDED

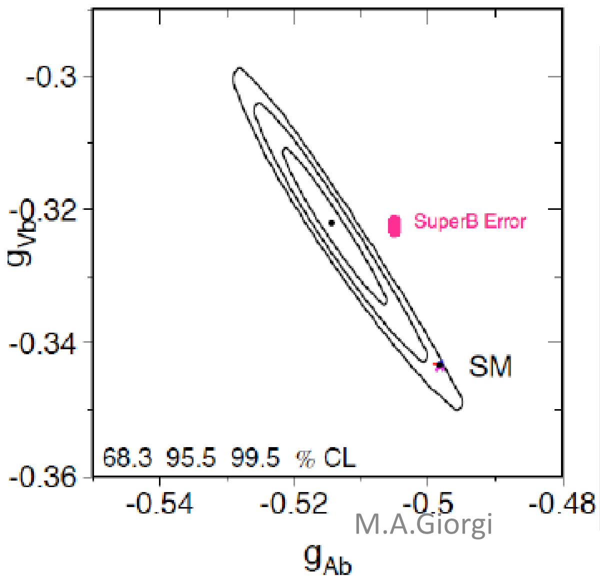
M.Roney et al.



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

- 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!!



0.5% polarization syst.
0.3% stat. error
→ 0.0021

The L-R luminosity asymmetry has to be very well controlled.Possibly done using monitoring using Bhabhas
Polarization should be measured better than .05%
luminosity dependent polarization affects systematic uncertainties

Is this measurement also possible with Charm?

1. @ Υ(4S) . But hadronization correction.
2. Operate at a ccbar vector resonance above open charm threshold Ψ(3770), use the same analysis method as for b.

Polarization at low energies with high luminosity is needed

Is this measurement also possible with Charm?

1. @ Y(4S) . But hadronization correction.
2. Operate at a ccbar vector resonance above open charm threshold $\Psi(3770)$, use the same analysis method as for b.

Polarization at low energies with high luminosity is needed

That is included in the SuperB design

g-2 Reach (Valencia Report 2008)

Δa_μ is not in good agreement with SM

Measuring differential cross section of tau production would lead to measurement of the real part of tau form factor.

$$\frac{d\sigma}{d\cos(\theta)} = a\cdot\cos(\theta)^2 + b$$

$$a \propto \beta^2 |F_1|^2$$

$$b \propto (2-\beta^2)\cdot|F_1|^2 + 4\mathrm{Re}[F_2]$$

SPS	1a	1b	2	3	4	5
$\Delta a_\mu \times 10^{-9}$	3.1	3.2	1.6	1.4	4.8	1.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4	0.3

We began considering 1-3 prong whose experimental selection is cleaner

Need to tag the sample:

Lepton tag: higher purity & higher diluition (at least 3 neutrinos)

Hadronic tag: lower purity & lower diluition (2 neutrinos)

Systematics come mainly from tracking

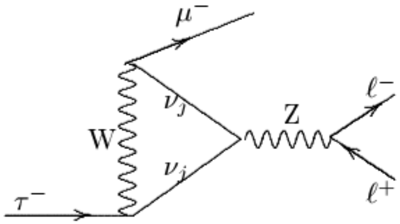
Should be able to measure the real part $(0.75\text{-}1.7)\times10^{-6}$

EXPERIMENT ⇓	Cross Section	Normal Asymmetry
	$Re\{F_2\}$	$Im\{F_2\}$
Babar+Belle $2ab^{-1}$	4.6×10^{-6}	2.1×10^{-5}
Super B/Flavor Factory (1 yr. running) $15ab^{-1}$	1.7×10^{-6}	7.8×10^{-6}
Super B/Flavor Factory (5 yrs. running) $75ab^{-1}$	7.5×10^{-7}	3.5×10^{-6}

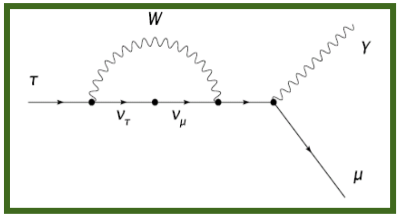
Beyond SM:LFV in τ decays

SM allows LFV: observed in neutral sector.

In charged sector may happen via loops with small expected BR (e.g. $BR_{SM}(\tau\to\mu\gamma) < 10^{-54}$).



Even less in τ→ 3l

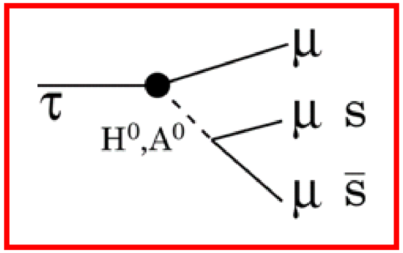


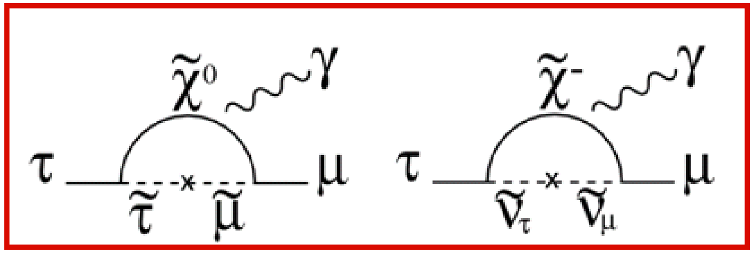
If detected, LFV would imply New Physics with present (and near future) luminosities.

Many New Physics models predict τ LFV BR up to [$O(10^{-8})$].

If detected in more than one channel it provides

Useful information on NP flavor structure, by looking at LFV BF Ratios. [arxiv:hep-ph0610344v3]





Some NP predictions

		$\tau\to\mu\gamma$	$\tau\to lll$
SM + ν mixing	Lee, Shrock, PRD 16 (1977) 1444 Cheng, Li, PRD 45 (1980) 1908	10^{-54} – 10^{-40}	10^{-40}
SUSY Higgs	Dedes, Ellis, Raidal, PLB 549 (2002) 159 Brignole, Rossi, PLB 566 (2003) 517	10^{-10}	10^{-7}
SM + heavy Maj ν_R	Cvetic, Dib, Kim, Kim , PRD66 (2002) 034008	10^{-9}	10^{-10}
Non-universal Z'	Yue, Zhang, Liu, PLB 547 (2002) 252	10^{-9}	10^{-8}
SUSY SO(10)	Masiero, Vempati, Vives, NPB 649 (2003) 189 Fukuyama, Kikuchi, Okada, PRD 68 (2003) 033012	10^{-8}	10^{-10}
mSUGRA + Seesaw	Ellis, Gomez, Leontaris, Lola, Nanopoulos, EPJ C14 (2002) 319 Ellis, Hisano, Raidal, Shimizu, PRD 66 (2002) 115013	10^{-7}	10^{-9}

$\tau \to \mu\gamma$:Bkg extrapolation (using BaBar analysis)

BaBar expects 5.1 events in the 2σ signal region

1.7 from lepton tags
1.4 from 3 hadron tags
2.0 from $\pi+\rho$ tags

96% comes from real τ decays (86% from $\mu\nu\nu\gamma$)

Background from taus is considered irreducible

Bkg extrapolated to SuperB gives
300 events in the signal box.
It can be reduced thanks to:
Improved resolutions
Improved EMC coverage
~250 events expected

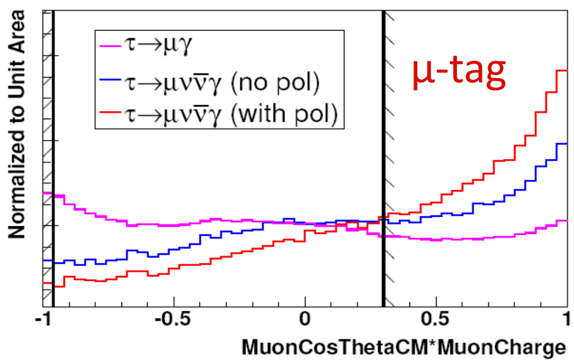
Need to reduce backgrounds to an acceptable level to scale better than $\sqrt{L}$

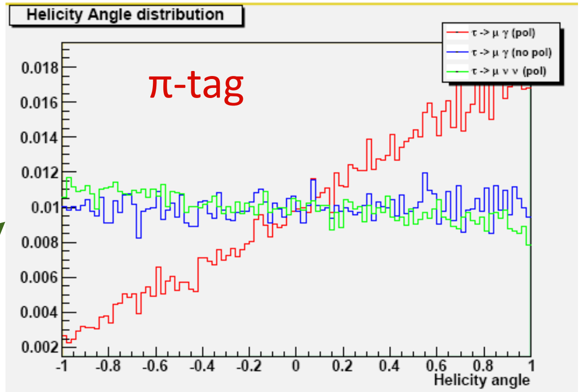
τ→μγ with Polarization

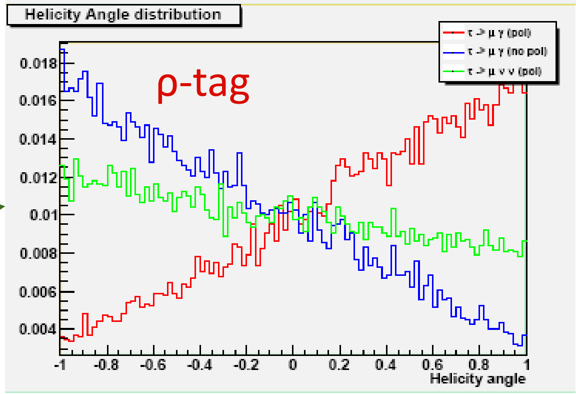
Using Polarization a more viable option is exploit hadron tags: only one ν in the event ⇒ fixed helicity

Signal helicity angle was studied for signal (both Polarized and Unpolarized) and backgrounds.

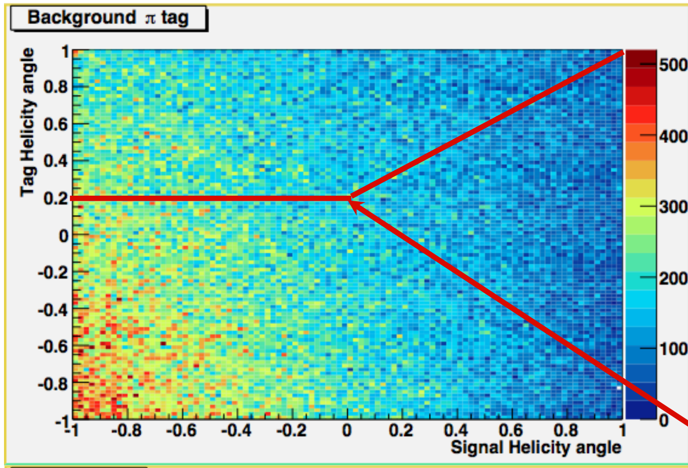
$$\theta_h = \tau_{\text{charge}}^{\text{tag}} \cdot \theta_{h-tag}$$

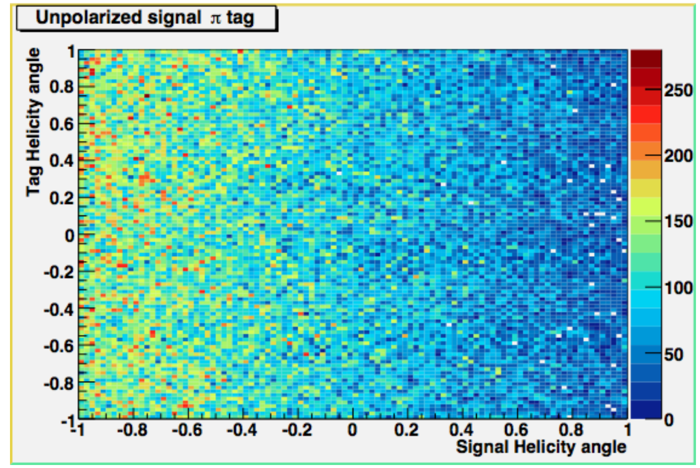


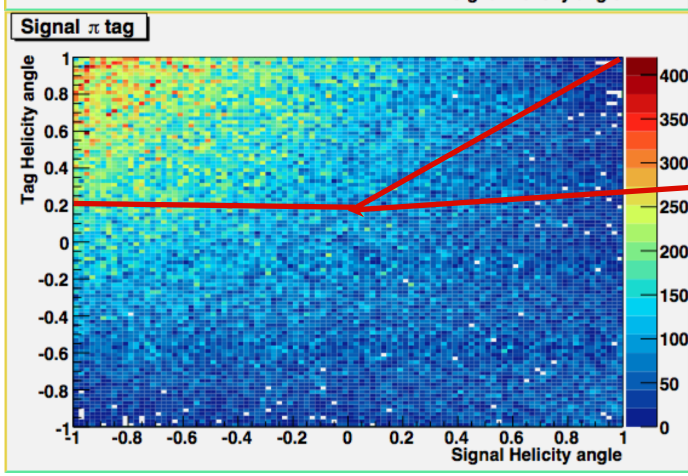




A simple analysis







Trapezoidal Cuts
eff. on signal:
41.6%π 49.4%ρ
bkg retained
11.5%π 9.8%ρ

Polarization Effects

BaBar Expected UL $8x10^{-8}$
scaling with √L (factor 12)
BaBar scaled Expected UL $6.4x10^{-9}$

Using Polarization background drops to O(15) events: UL scaling better than √L

Using a bayesian approach we may estimate an UL given the expected bkg

UL $3.9x10^{-9}$ using only ρ tag

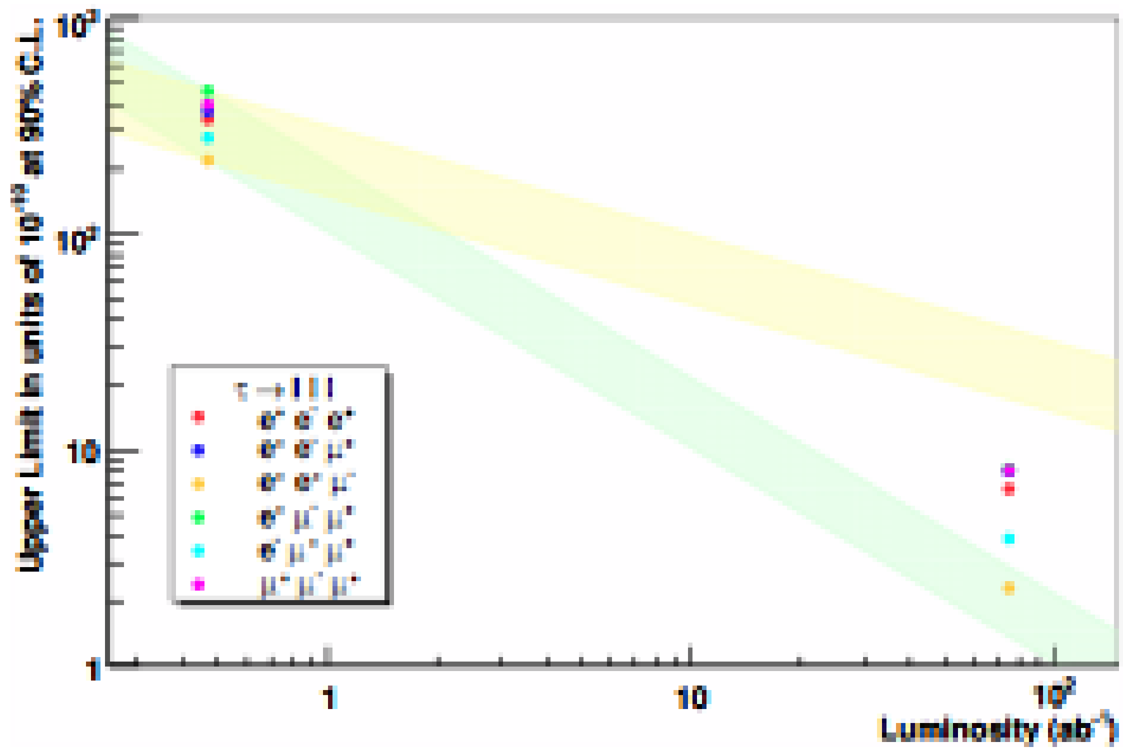
Using polarization we obtain an improvement equivalent to a 2.6 increase in integrated Luminosity
albeit using only 25% BF

Further improvement adding all tags, but with some dilution.

$\tau \to 3l$: expectations

$\tau \to lll$ suffers from smaller backgrounds than $\tau \to \mu\gamma$ channel, and is dominated mostly by continuum and QED bkg

Extrapolating from BaBar expect UL is expected to scale almost linear with integrated luminosity reaching unprecedented sensitivities of almost 10^{-10}



Interest of running @ threshold

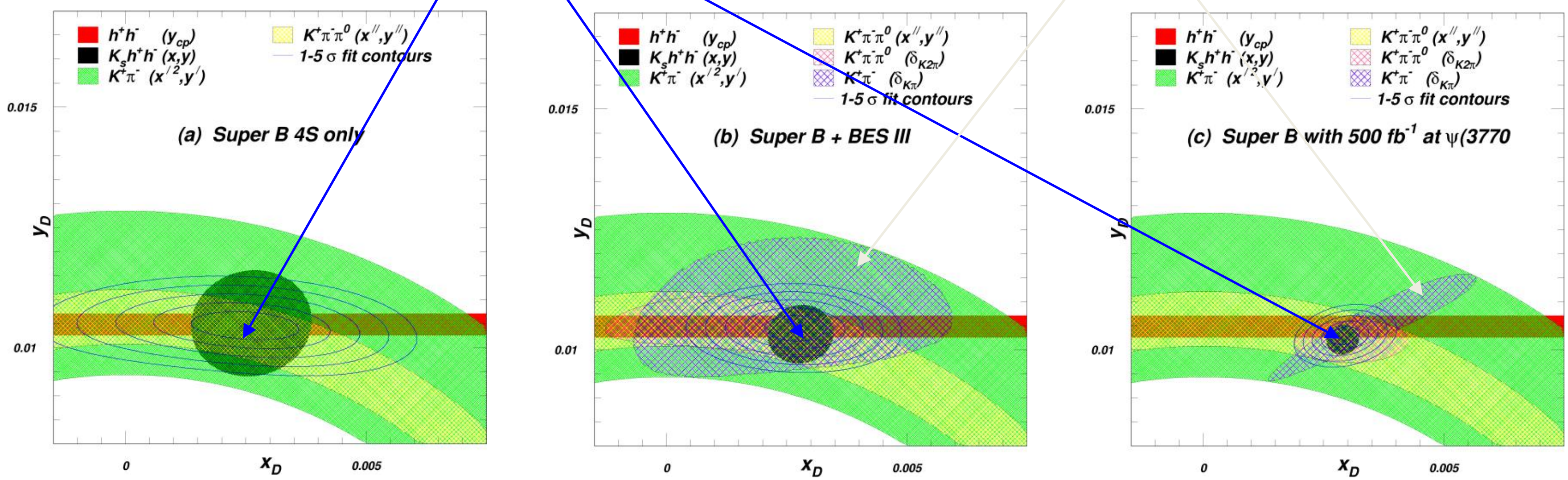
B. Meadow et al.

500 fb-1 at $\psi(3770)$

Decays of $\psi(3770) \rightarrow D^0D^0$ produce coherent $(C=-1)$ pairs of D^0's. Quantum correlations in their subsequent decays allow measurements of strong phases

- Required for improved measurement of CKM γ
- Also required for D^0 mixing studies

- Dalitz plot model uncertainty shrinks
- Information on overall strong phase is added



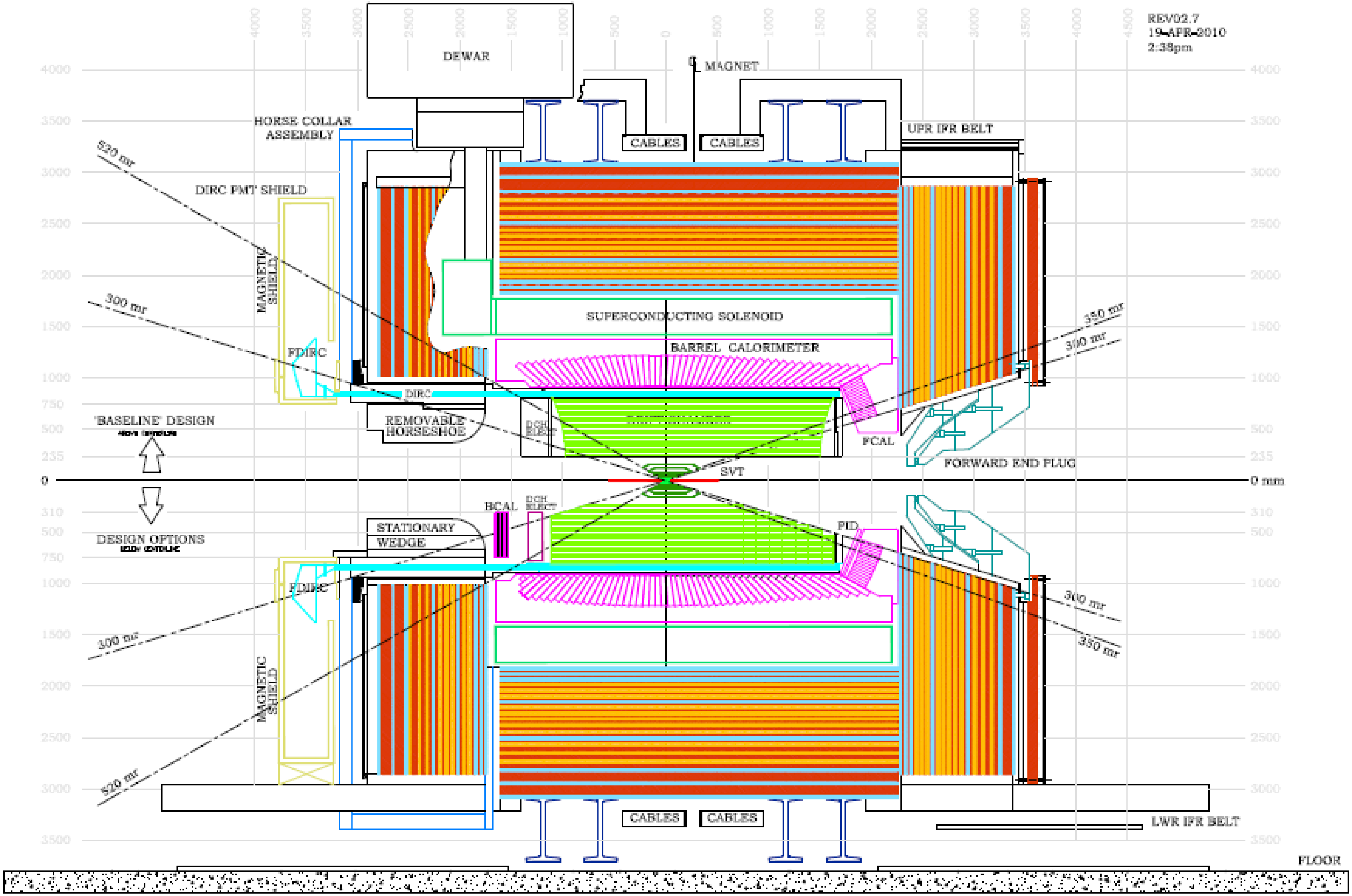
Fit	$x \times 10^3$	$y \times 10^3$	$\delta^o_{K\pi-}$	$\delta^o_{K\pi-\pi^0}$
(b)	$xxx^{+0.72}_{-0.75}$	$xxx \pm 0.19$	$xxx^{+3.7}_{-3.4}$	$xxx^{+4.6}_{-4.5}$
Stat.	(0.18)	(0.11)	(1.3)	(2.9)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^o_{K\pi-}$	$\delta^o_{K\pi-\pi^0}$
(c)	$xxx \pm 0.42$	$xxx \pm 0.17$	$xxx \pm 2.2$	$xxx^{+3.3}_{-3.4}$
Stat.	(0.18)	(0.11)	(1.3)	(2.7)

Fit	$x \times 10^3$	$y \times 10^3$	$\delta^o_{K\pi-}$	$\delta^o_{K\pi-\pi^0}$
(d)	$xxx \pm 0.20$	$xxx \pm 0.12$	$xxx \pm 1.0$	$xxx \pm 1.1$
Stat.	(0.17)	(0.10)	(0.9)	(1.1)

Uncertainty in x_D improves more than that of y_D

SuperB Detector (with options)



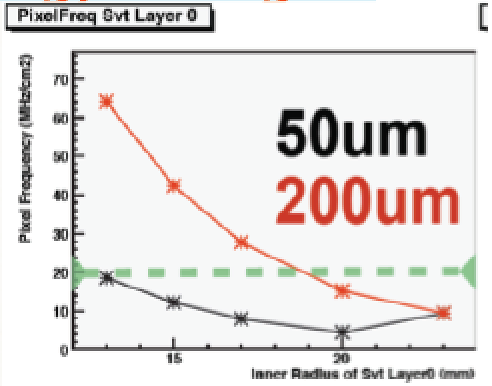
Understanding background

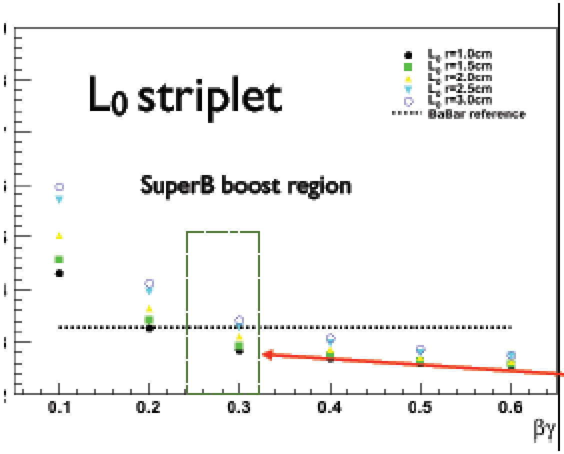
Layer0 radius & technology vs bkg.

E.Paoloni et al

Update on background:

- Hit rate vs Layer0 radius from pairs production depends strongly on sensor thickness:
  - on thick sensor larger cluster width for low momentum tracks with large crossing angle
- Large difference for thin pixels (50 um) and striplets (200 um)
- Hybrid pixel with 200 um sensor will be like striplets, unless thinner sensor can be used





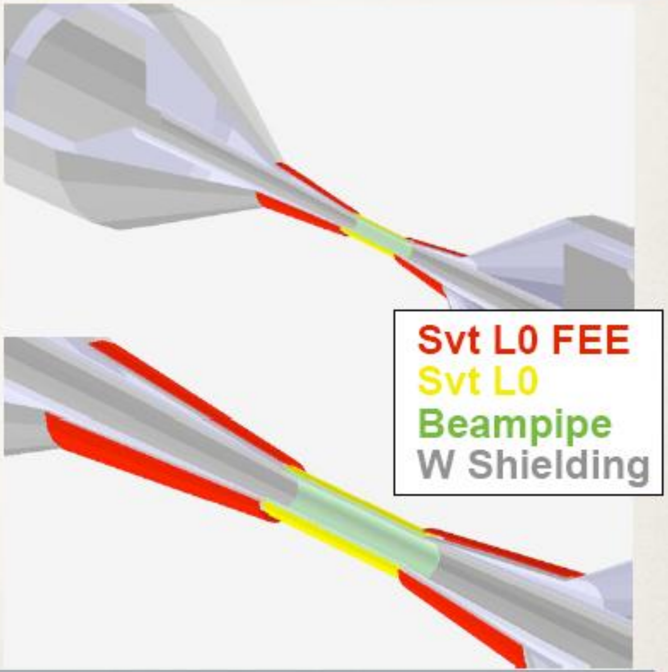
Sustainable background hit rate (radius) depends on technology: striplets vs pixel area and readout chip.

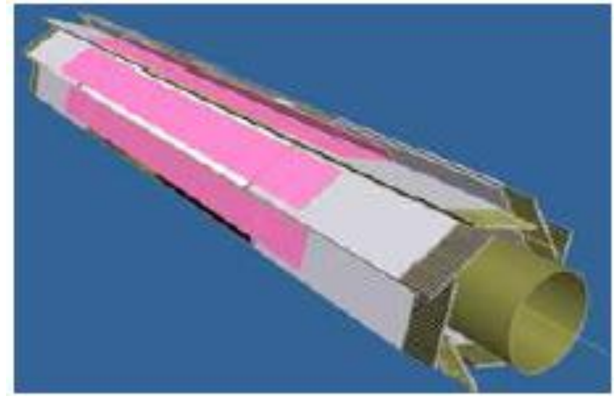
- Development of thin pixel chip readout architecture continue: data push and triggered with target 100MHz/cm2 (safety x5 included) with timestamp 100 ns. → R~1.3cm
  - Still to demonstrate: scaling to large matrix, rad hardness for MAPS.
- Assumed 100MHz/cm2 hard limit for striplets (~ 10% occupancy in 100 ns, area~10^{-2} cm^{-2}) → R~2 cm
  - performance similar to BaBar and thin pixel at lower radius. No margin left!

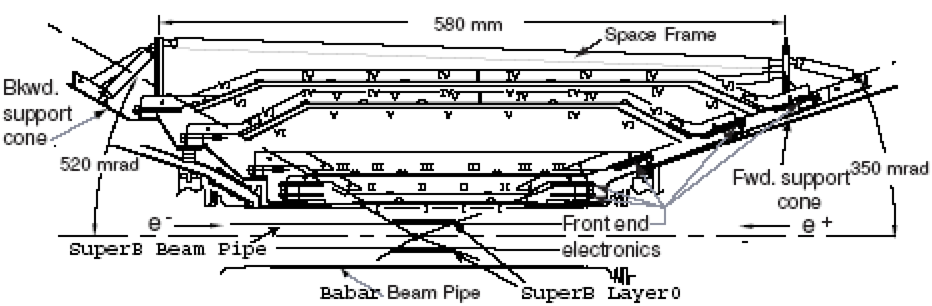
Understanding background

L0 electronics position

- Additional 2 volumes
  - Cones around IR tungsten shielding close to L0
  - 1mm of Si at 2mm from shields (radiation probes)
- Sensitive volumes: additional BrnRootHits list dumped by RooEvt object





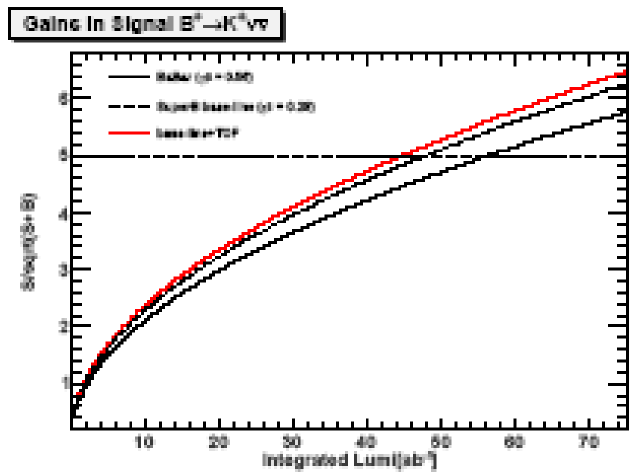


For the time being the striplet solution is still the baseline for layer L0.
Pixels are under study and the R@D continues in various labs : Italian labs and Rutherford.

Forward PID option

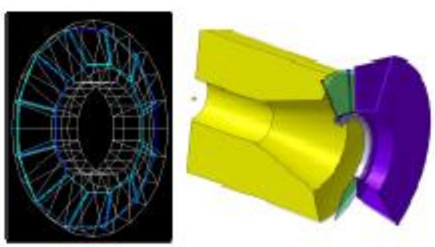
Decision about forward PID has not been taken yet. It is one of the issues in the agenda of the coming General SuperB Collaboration Meeting (Caltech December 14-18).

One benchmark is $B \rightarrow K^{(*)} \nu \bar{\nu}$.

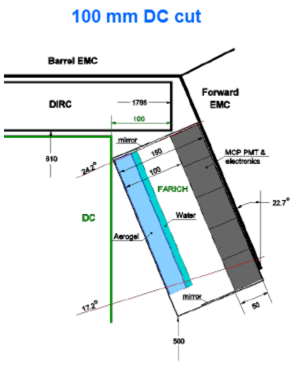


If decision would be YES to Forward PID then there are two options:

TOF



and FARICH.



FARICH has:

- Good K/p separation in 0.6 to 6.0 GeV
- Improves Momentum resolution By > 10%

But about 28% x0 in front of calorimeter

Many channel

Forward & Backward Calorimeter

The SuperB calorimeter will reuse the Babar barrel of CsI crystals. In the forward endcap CsI will be replced with YLSO crystals, while for the backward the solution is lead+scintillating fibers 2.8 mm Pb alternated with scintillator for different layers there are different

patterns :

- Right handed logarithmic spiral
- Left-handed logarithmic spiral
- Radial wedge

The readout fibers are embedded in grooves cut in scintillator.

As Photo-Detector a pixel device will be used Either MPPC or SiPM.

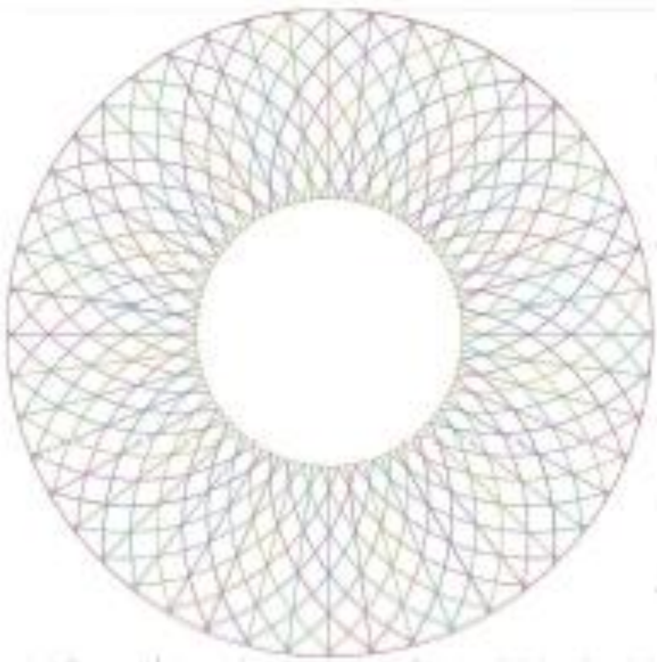


Figure 27: The backward EMC, showing the scintillator strip geometry for pattern recognition.

While we are expecting the official start

- Signals from italian government continue to be positive.
- Meanwhile as a serious partner IIT is offering co-funding the SuperB construction at the level of 100M€.
- Prepare to submit to EU set up of SuperB ERIC. A draft of governance is ready and circulated to SuperB Project Board

Cover Page of the Governance Draft

SuperB ERIC Statute

12 October 2010-Draft

DRAFT

Statute of the European Research Infrastructure Consortium SuperB

(SuperB "N. Cabibbo" ERIC)

My last slide in July at the 87th ECFA meeting

START

- A formal commitment with INFN for the project with the declaration of some available budget in the current year is expected
- This commitment will set the start of the project

Thanks for your attention