The Future of Super Flavor Factories

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IFIC *Valencia*

Outline

Present status in Flavor

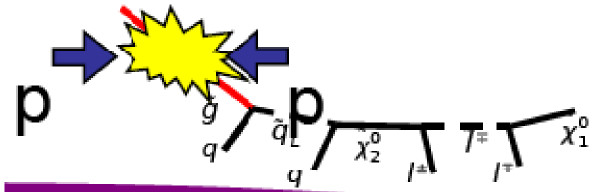
Present and Future Projects in Flavor

….. to New Physics

How move to New Physics

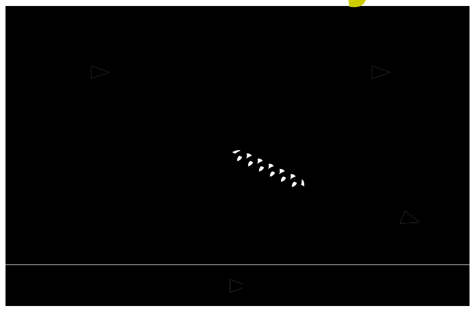
Move to New Physics in two ways:

Relativistic way



LHC (Energy Frontier)

Quantum way

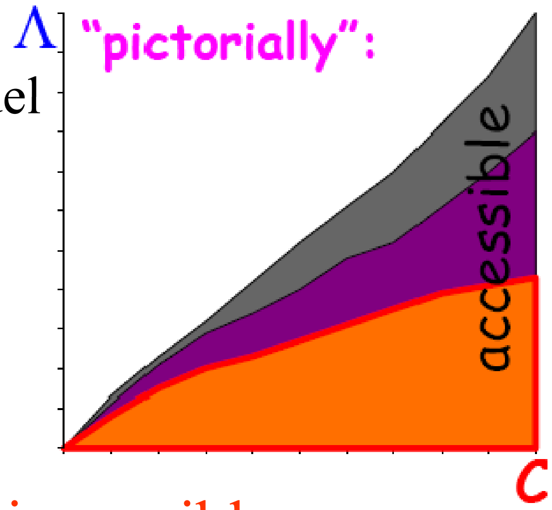


Flavor (High precision measurements)

The two ways are complementary

High Luminosity potential

- Flavour precision measurements sensitive to New Physics (NP)
  - Measure interference effect in known processes
  - Measure decays: rare or forbidden in Standard Model
- NP effects governed by
  - New Physics Scale NP(Λ)
  - Effective coupling C
    - Different Intensities (from interactions)
    - Different Patterns (for instance from simmetries)



With 7-10x1010 pair bb, cc, ττ (75-100 ab^{-1}) it is possible

NP(Λ) found at LHC

- Determine couplings FV e CPV of NP
- Look for heavier states
- Study the flavour structure of NP

NP(Λ) not found at LHC

- Look for indirect signals of NP
- Link them to explaining NP models
- Constrain regions in parameter space with NP(Λ) sensitivity up several tens of TeV.

Some channels as τ LFV clear segnals of NP

Charm beyond b- Is NP accessible from Charm if CPV?

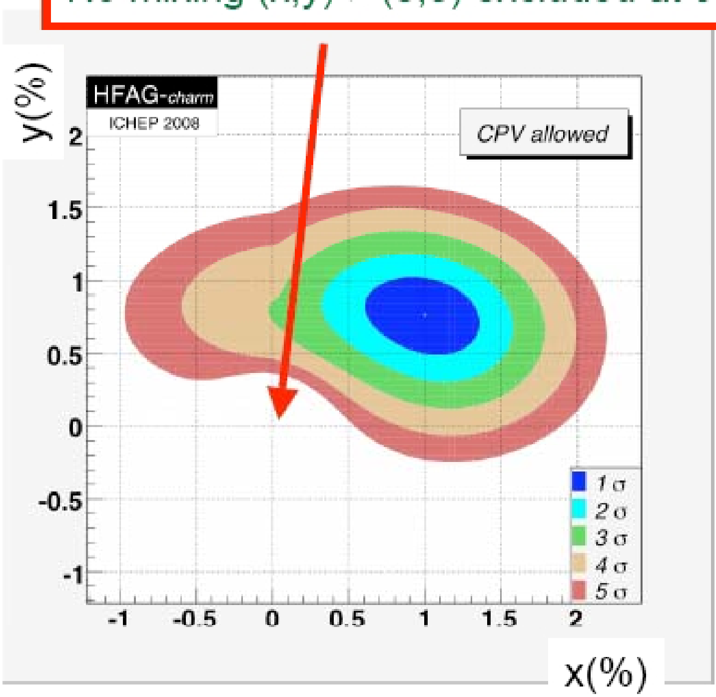
- 2007 BABAR & BELLE:Charm mixing in $D^0 \overline{D^0}$ decay

D^0-$\overline{D}^0$ Mixing:

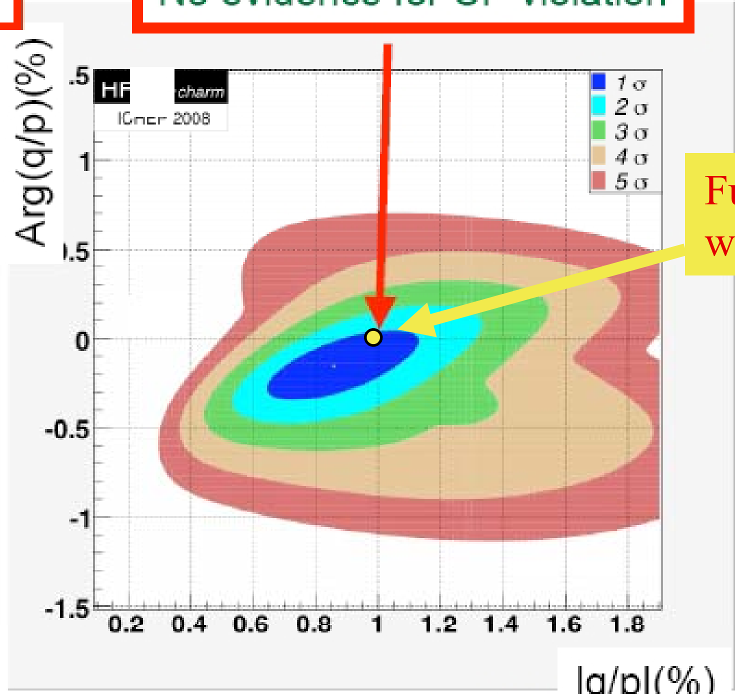
New HFAG Average for ICHEP08

http://www.slac.stanford.edu/xorg/hfag/charm/index.html

No mixing (x,y) ≠ (0,0) excluded at 9.8σ



No evidence for CP violation



Fully compatible with (1,0)

$x = 1.00 \pm^{0.24}_{0.25}$ % 3.4σ

$y = 0.76 \pm^{0.17}_{0.18}$ % 4.1σ

$|q/p| = 0.86 \pm^{0.17}_{0.15}$

$\mathrm{Arg}(q/p) = (8.8 \pm^{7.6}_{7.2})^{o}$

and on b…

From b experiments is coming the confirmation and the triumph of CKM.

Thanks to the measurements of the CP asymmetries and rare b decays, mainly at $e^+ e^-$ Bfactories PEPII and KEKB but also at FNAL Tevatron

(2006 B_s oscillations from CDF and D0

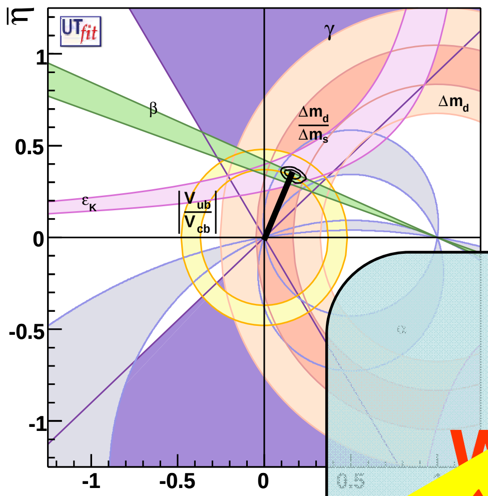
The mixing parameter $x(B_s) = \Delta M(B_s) / \Gamma(B_s) \cong 25$ and no evidence for $\Delta\Gamma(B_s) \neq 0$.

$$CDF: \Delta M(B_s) = (1.17 \pm 0.01) x 10^{-2}\, eV - (17.77 \pm 0.12) ps^{-1}$$
$$D0: \Delta M(B_s) = (1.25 \pm 0.13) x 10^{-2}\, eV - (19 \pm 2)\, ps^{-1}$$

The SM prediction is : $\Delta M(B_s) = (1.20^{+0.43}_{-0.10})\, x\, 10^{-2}\, eV - (18.3^{+6.5}_{-1.5})\, ps^{-1}$

(Some) Results of B-Factories

Unitarity Triangle precision measurements



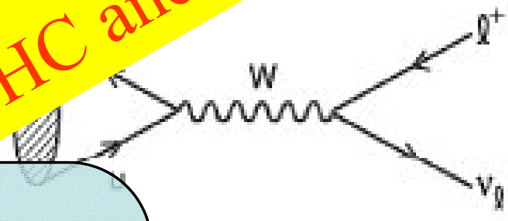
Spectroscopy of new, unexpected states

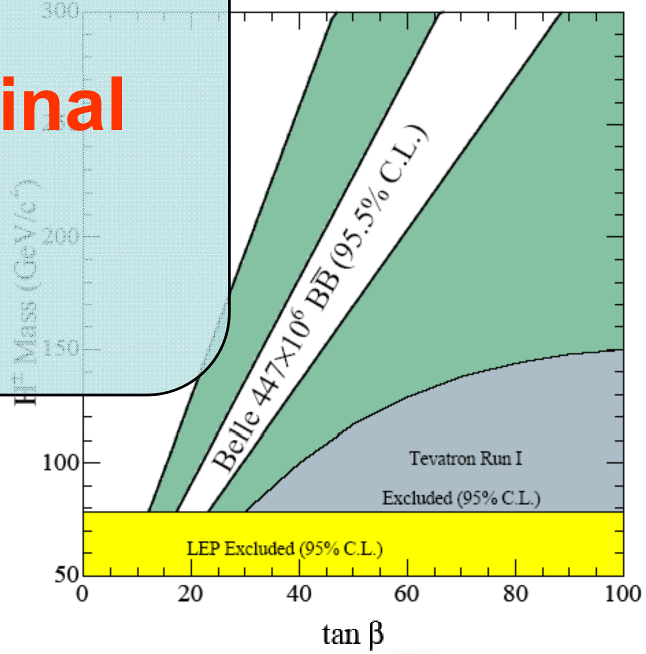
New DK state(s) at 2.86GeV/c²

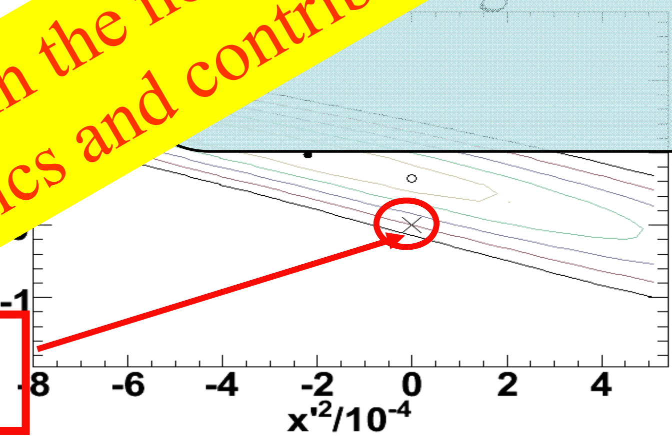
B→

SM

ers







No Mixing

the original goals

What in the next decade will e+ e- factories say about new physics and contribute as complementary to LHC and LHCb ?

To new Physics:Constraints on CKM+ rare lepton decays

Precise measurements of CKM parameters in quark sector, challenging new physics can come from a wide spectrum of future projects (some approved, some close to approval, some….):

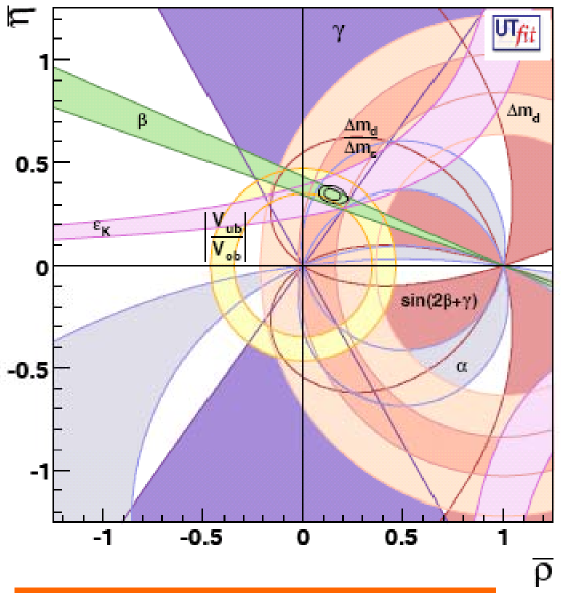
In Kaons there are projects for a next generation of experiments :

$K^{+} \rightarrow \pi^{+}\nu\bar{\nu}$ and $K^{0} \rightarrow \pi^{0}\nu\bar{\nu}$

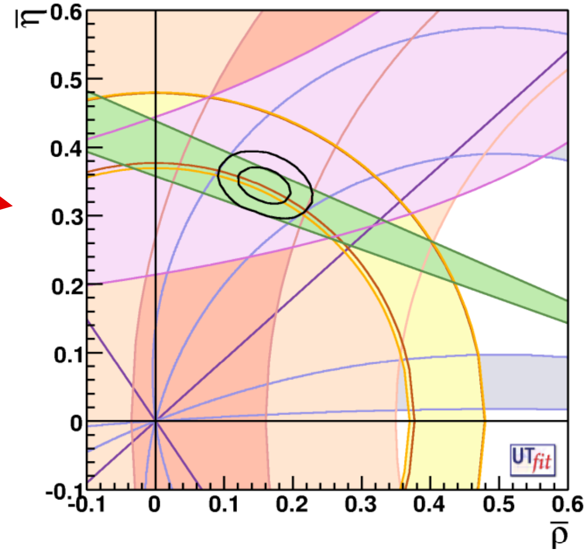
at CERN and at JPARC .

Dedicated experiments on μ-e LVF at PSI (running) , μ →e conversion at JPARC and FNAL in future. In b, c and τ : LHCb at CERN, BES upgrade, KEKB + SuperKEKB, Super c- τ at Novosibirsk and SuperB studying very rare processes in quark and lepton sectors.

Improving CKM precision

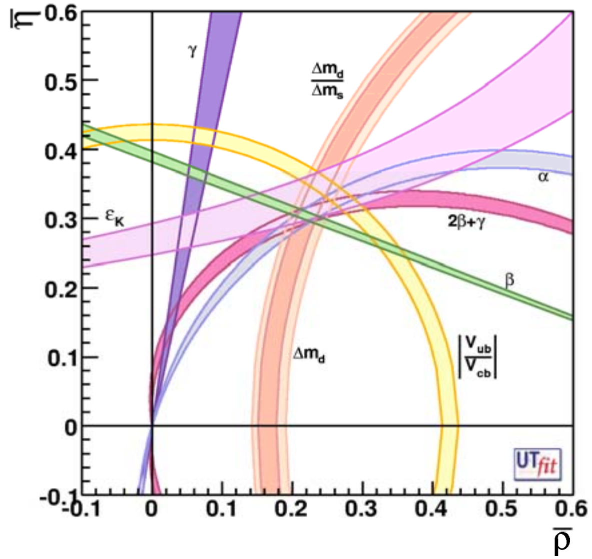


NOW !

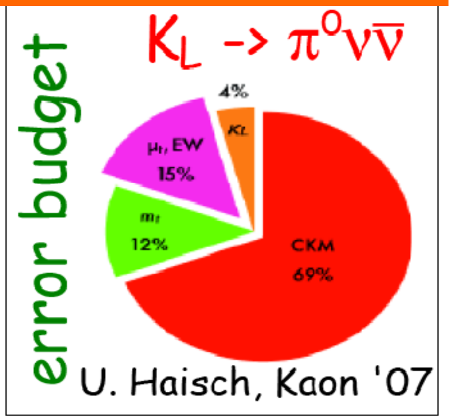


ρ = 0.163 ± 0.028
η = 0.344± 0.016

ρ = ± 0.0028
η = ± 0.0024



Improving CKM is crucial to look for NP

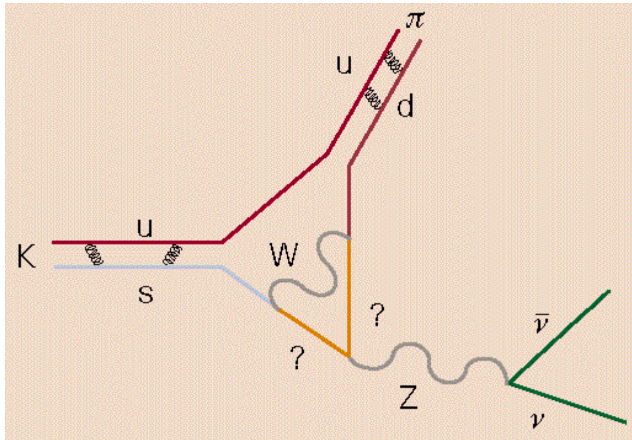


75 ab-1 SuperB and Lattice calculation improvement

Future from Kaons

Short-Distance $K \to \pi \ell \bar{\ell}$ decays

A single hadronic current with well-measured (K-π) matrix element (isospin-related), strong suppression of LD effects and few effective operators: this is **theoretical heaven**



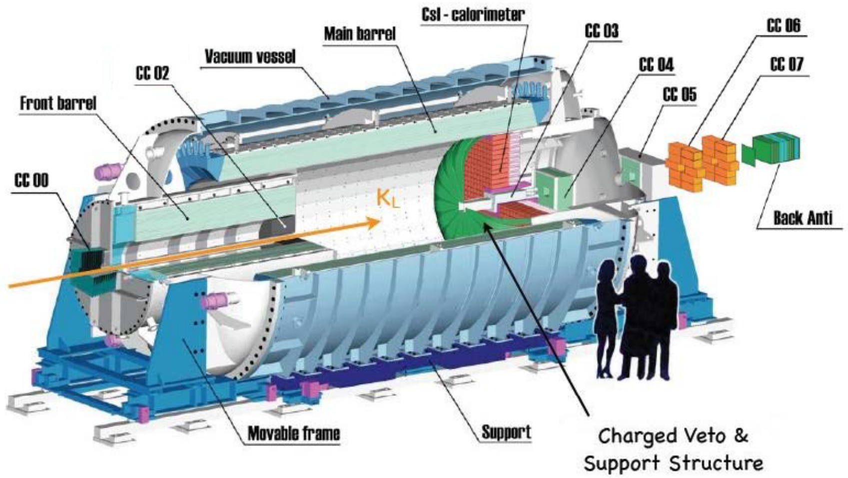
$K_L \to \pi^0 e^+ e^-$	10^{-11} (CPV_{dir} $3 \cdot 10^{-12}$)	$< 2.8 \cdot 10^{-10}$ (FNAL KTeV)	CPC+CPV 3 ev. (2.05 bkg)
$K_L \to \pi^0 \mu^+ \mu^-$	10^{-11} (CPV_{dir} $1 \cdot 10^{-12}$)	$< 3.8 \cdot 10^{-10}$ (FNAL KTeV)	CPC+CPV 2 ev. (0.87 bkg)
$K^+ \to \pi^+ \nu \bar{\nu}$	$8.2 \cdot 10^{-11}$ (at 5% par.)	$1.73^{+1.15}_{-1.05} \cdot 10^{-10}$ (BNL E787+E949)	Dedicated expts. 3+4 evts. (0.5+2.1 bkg)
$K_L \to \pi^0 \nu \bar{\nu}$	$2.8 \cdot 10^{-11}$ (at 2% par.)	$< 6.7 \cdot 10^{-8}$ (KEK E391a)	CPV dir *"Nothing to nothing"*

$K_L \to \pi^0 \nu\bar{\nu}$ "holy grail"

BR(SM) = $(2.5 \pm 0.4)\cdot 10^{-11}$
Non-parametric theoretical uncertainty ~ **1%**

Unmeasurable parent particle.
No kinematic constraints. VETO !!!

Low-energy approach:
K_L TOF for kinematics, large prod. angle, large beam emittance, γ tracking
(KOPIO at BNL, canceled)



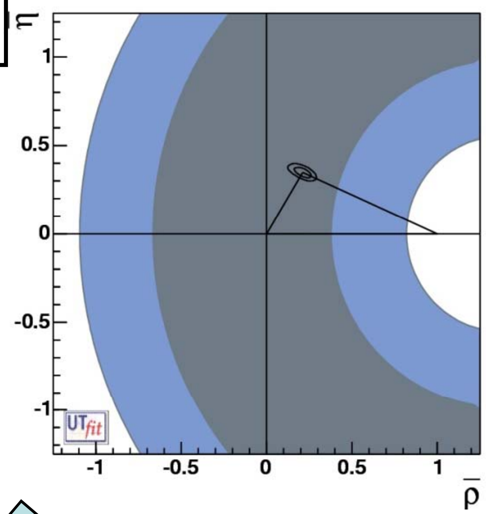
High-energy approach:
excellent vetoing, "pencil" beam for kinematics, high p_T
E391a at KEK now
E17 at J-PARC (3 to 100 events, 2012+)

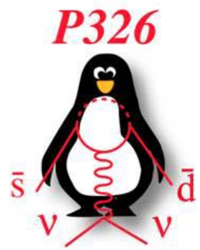
K+ → π+νν science (or) fiction

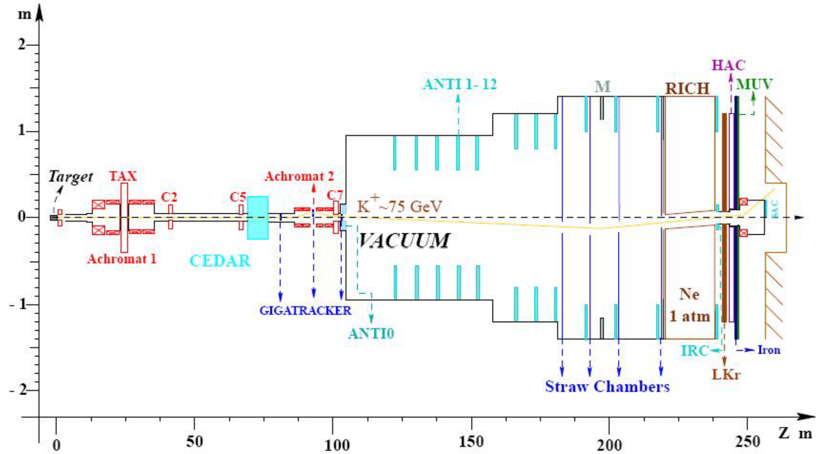
If NA62 approved

("4.4" events)
BR(exp) = 2 x BR(SM)

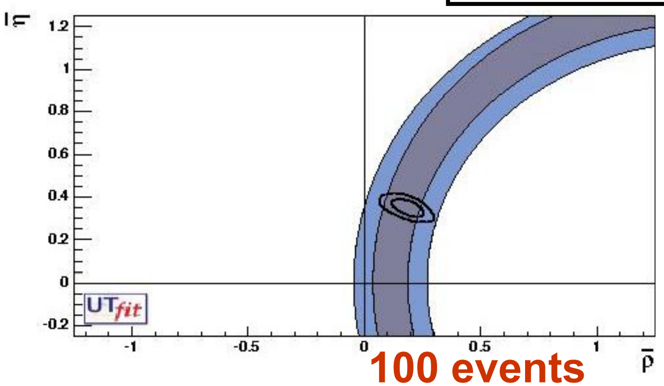
Today



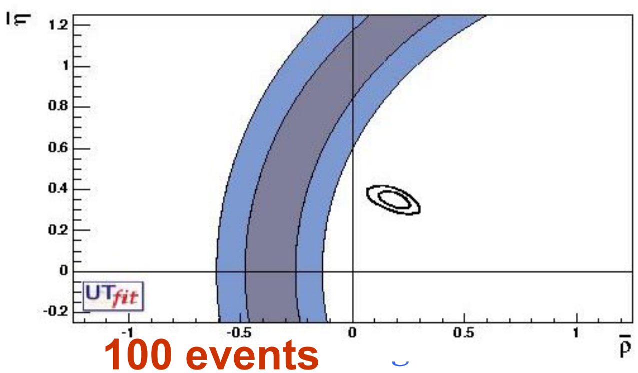




? **Tomorrow (2012?)** **?**



100 events
Mean=SM



100 events
Mean=E787/949

- New approach:
- decay **in flight** 75 GeV/*c* unseparated K^+ beam (K ≈ 6.6%)
- Reuse parts of NA48 and available SPS protons ($3.3 \cdot 10^{12}$ ppp ≈ 1/20)
- Sensitivity not limited by beam flux, much larger acceptance: 14%
- Expect ≈ O(100) events with S/B≈10 in 2 years (2012+)

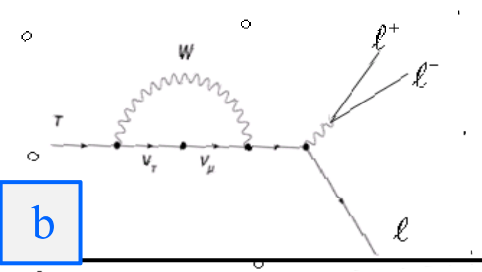
LFV dedicated experiments

LFV in tau and muon decay

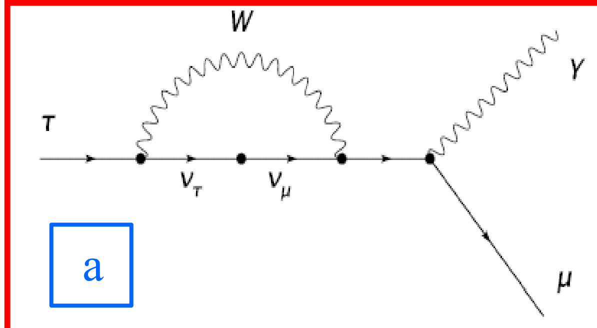
Standard Model allows LFV.In charged leptons it can occur in loops with expected low branching fractions. Es: expected Br ($\tau \rightarrow \mu\gamma$) <O ($10^{-40} \div 10^{-54}$)

Even less in 3 leptons

For this contribution



b

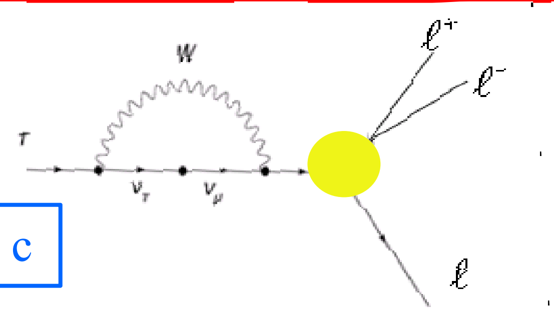


a

But with all contributions c becomes larger than b and c expected same order of a :

$$Br(\tau \rightarrow \mu\gamma) = \frac{3\alpha}{32\pi}\left|\sum_{i=1,2} U^*_{\tau i} U_{\mu i} \frac{\Delta m^2_{li}}{m^2_w}\right|^2 < 10^{-54}$$

$$\Delta m^2_{ij} = m^2_{\nu i} - m^2_{\nu j}$$



c

90% CL limits

Br ($\tau^- \rightarrow e^-\gamma$) < 12×10^{-8}

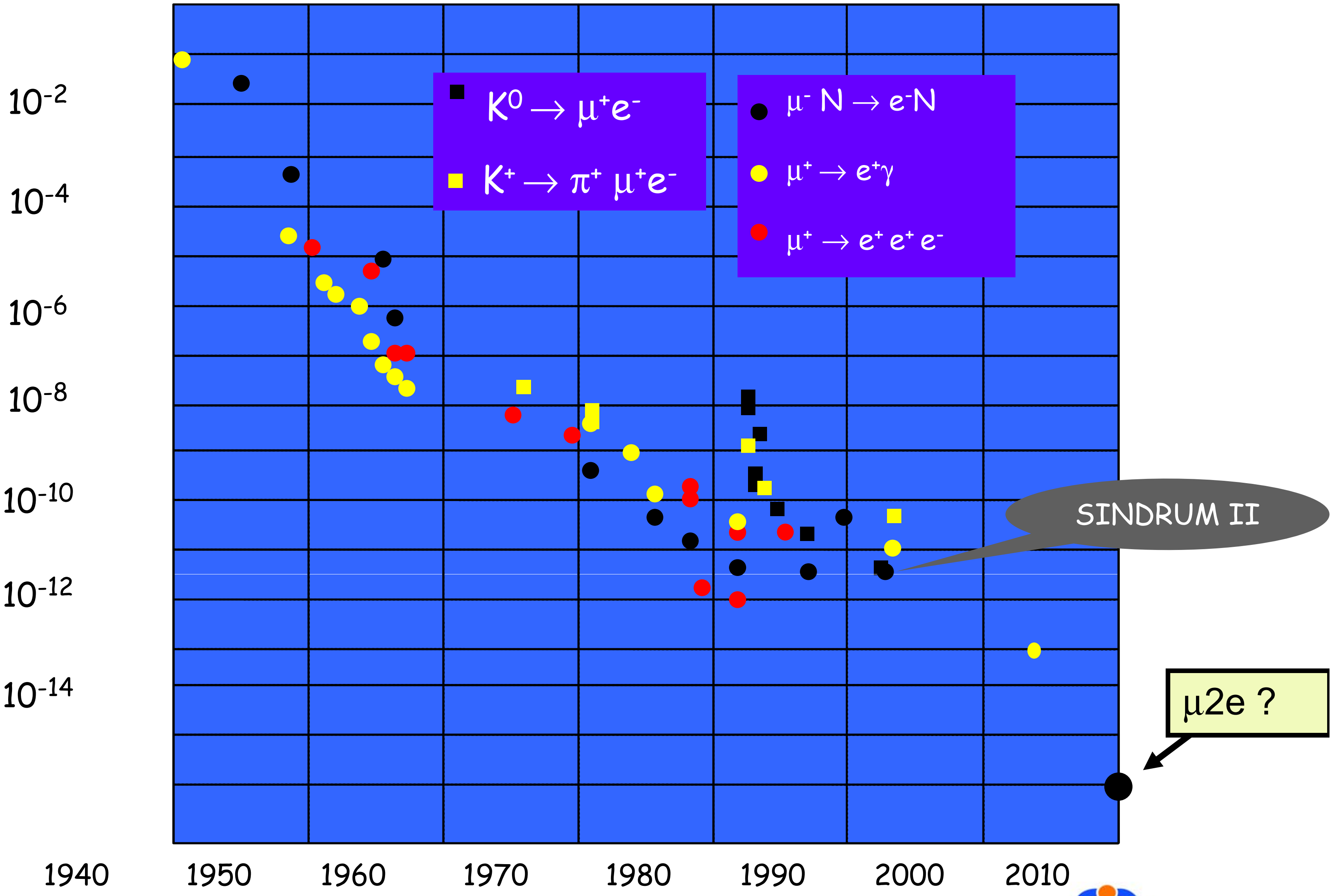
Br ($\tau^- \rightarrow \mu^-\gamma$) < 4.1×10^{-8}

Br ($\tau^- \rightarrow e^-\gamma$) < 11×10^{-8}

Br ($\tau^- \rightarrow \mu^-\gamma$) < 6.7×10^{-8}

Observable lepton decays with FV will allow a clear indication of New Physics.Many New Physis models predict strong enhancement of violating decays of μ and τ. In many models measurable and even quite large τ BR [O(10^{-8})] are expected.

History of Lepton Flavor Violation Searches no tau



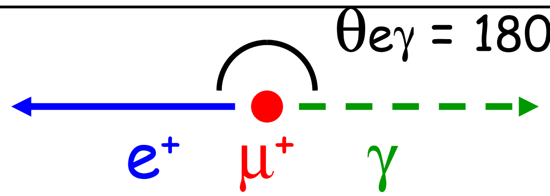
MEG: $\mu \to e\gamma$ search at PSI: sensitive to 10^{-13} BRs

LoI	Proposal		now
Planning	R & D	Assembly	Data Taking

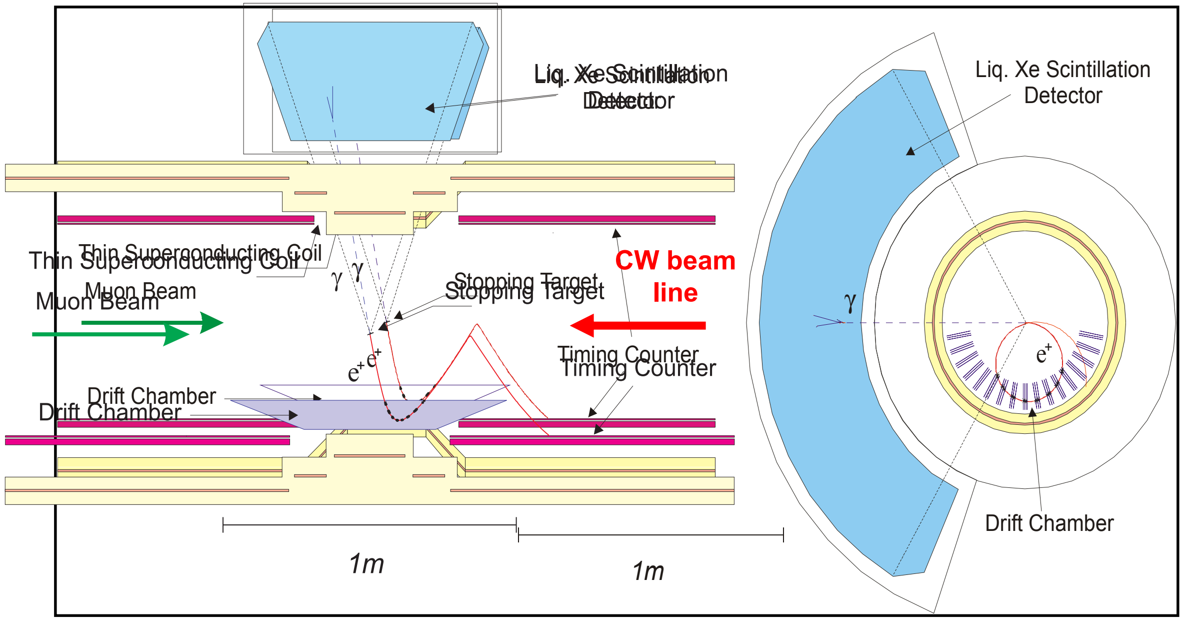
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

SUSY SU(5) predictions	SUSY SO(10) predictions
BR $(\mu \to e\gamma) \approx 10^{-14} \div 10^{-13}$	$BR_{SO(10)} \approx 100\ BR_{SU(5)}$

Easy signal selection with μ^+ at rest



$E_e = E_\gamma = 52.8$ MeV



Detector outline

- Stopped beam of $3\ 10^7\ \mu$ /sec in a 150 μm target

<u>Photon detector</u>

- Liquid Xenon calorimeter for γ detection (scintillation)
  - fast: 4 / 22 / 45 ns
  - high LY: ~ 0.8 * NaI
  - short X_0: 2.77 cm
- 1 MeV Cockroft-Walton for continuous calorimeter calibration

<u>Positron spectrometer</u>

- Solenoid spectrometer & drift chambers for e^+ momentum
- Scintillation counters for e^+ timing

Experimental Approach (Mu2e at FNAL)

If μ^- are stopped in a target A, muonic atom in 1s state are formed ($t \leq 10^{-16}$ s)

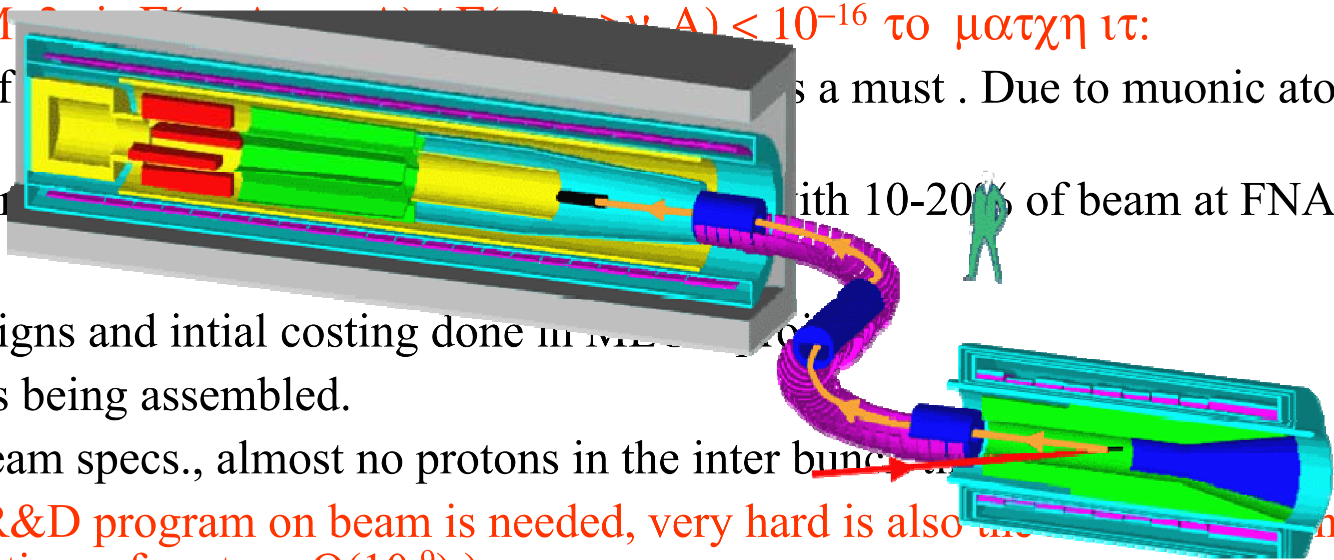
- 3 main reactions: capture, $\mu^- A \rightarrow \nu_\mu A'$, decay, $\mu^- \rightarrow e^- \nu\nu$, conversion, $\mu^- A \rightarrow e^- A'$

In the conversion process : $\mu A \rightarrow eA$:

- Electron are monoenergetic (105 MeV) (it is the main tool to remove background)
- high rates are possible- no coincidence required (needed instead in $\mu \rightarrow e\gamma$)

The goal of M ... $< 10^{-16}$ το ματχη ιτ:

- The use of ... s a must . Due to muonic atom lifetime
- ~4×10^{20} p ... ith 10-20% of beam at FNAL



.Conceptual designs and intial costing done ...

Collaboration is being assembled.

Very hard the beam specs., almost no protons in the inter bun...

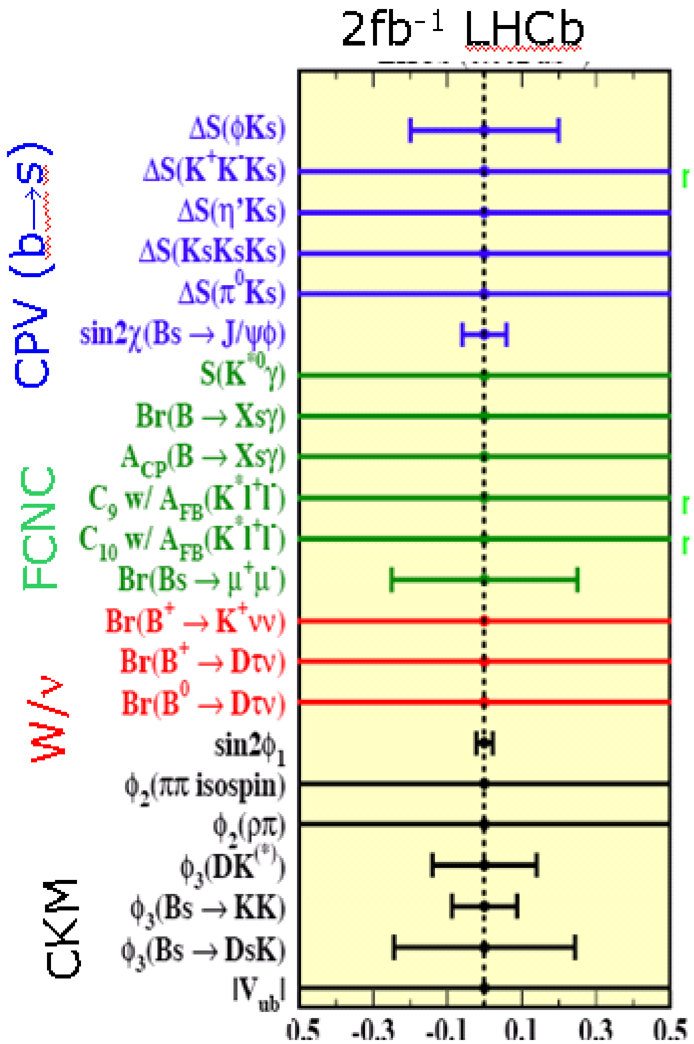
(an aggressive R&D program on beam is needed, very hard is also ... nique for a so low fraction of protons $O(10^{-9})$)

In principle JPARC could allow $R_{me} \sim 10^{-18}$, thanks to the higher muon flux.

Quoting Mu2e documents

Future on B-tau-charm physics and Flavor Factories

From LHCb, expect:



LHC upgrade with 100fb^{-1}

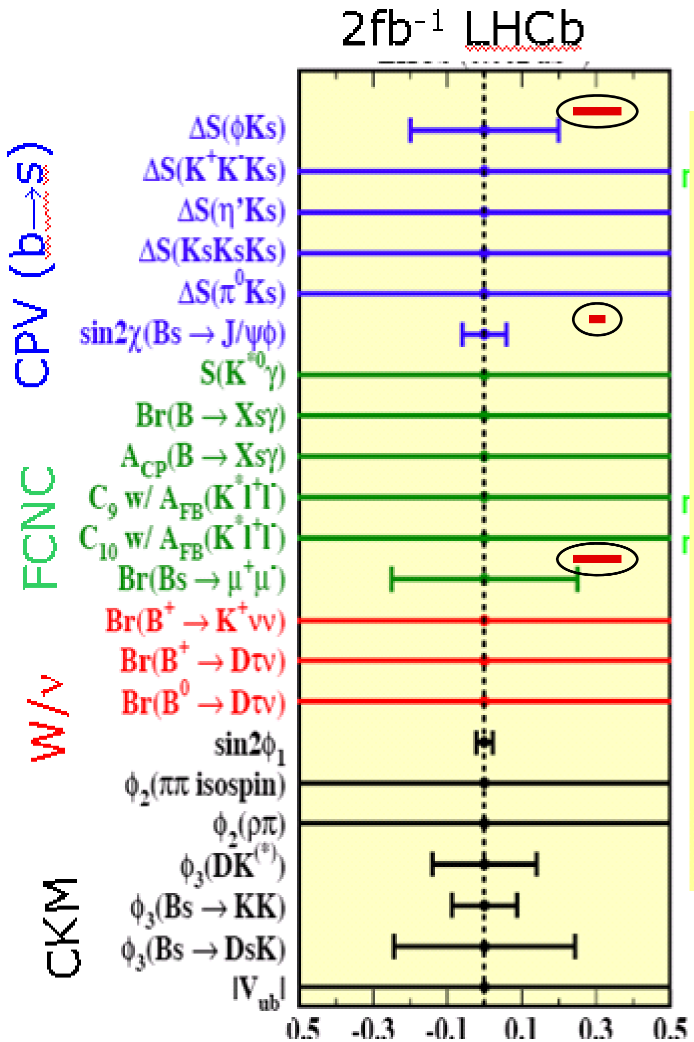
Observable	Sensitivity
$S(B_s \to \phi\phi)$	0.01 – 0.02
$S(B_d \to \phi K_S^0)$	0.025 – 0.035
$\phi_s\ (J/\psi\phi)$	0.003
$\sin(2\beta)\ (J/\psi K_S^0)$	0.003 – 0.010
$\gamma\ (B \to D^{(*)}K^{(*)})$	$< 1^\circ$
$\gamma\ (B_s \to D_s K)$	$1 - 2^\circ$
$\mathcal{B}(B_s \to \mu^+\mu^-)$	$5 - 10\%$
$\mathcal{B}(B_d \to \mu^+\mu^-)$	3σ
$A_T^{(2)}(B \to K^{*0}\mu^+\mu^-)$	0.05 – 0.06
$A_{FB}(B \to K^{*0}\mu^+\mu^-)\ s_0$	0.07 GeV^2
$S(B_s \to \phi\gamma)$	0.016 – 0.025
$A^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	0.030 – 0.050
charm x'^2	2×10^{-5}
mixing y'	2.8×10^{-4}
CP y_{CP}	1.5×10^{-4}

Super flavor factory projects

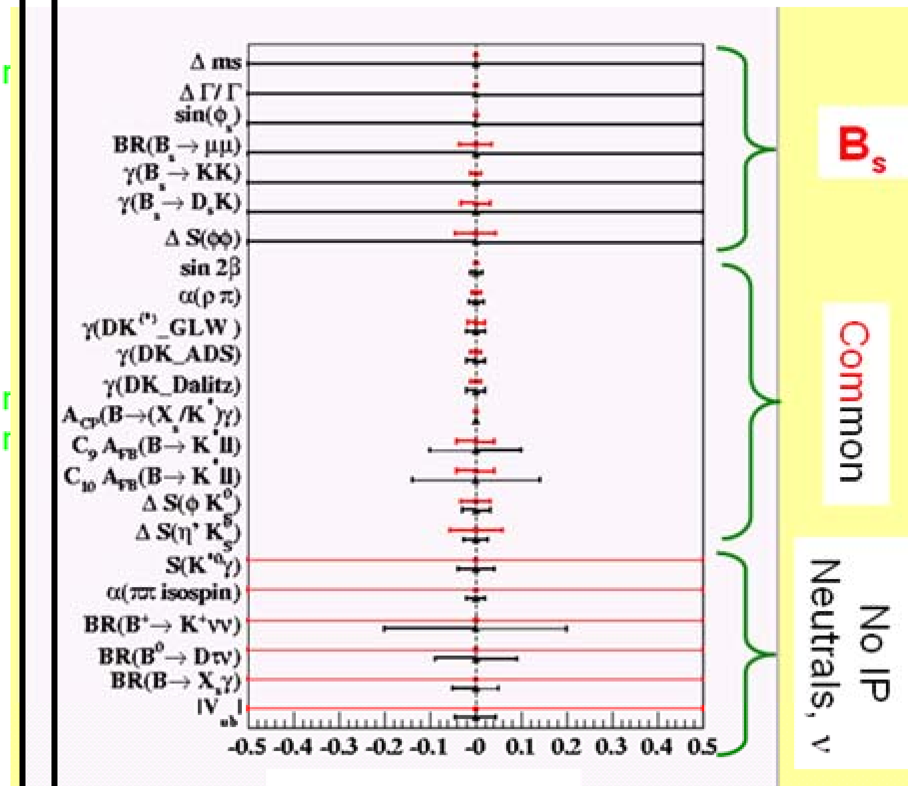
Machine project	Cms Energy (GeV)	Mode	Polarization of e^- beam >80% for τ	Luminosity ($cm^{-2}\ s^{-1}$)
Super c-τ BINP (Russia)	3.0÷4.5	Symmetric	Yes	$1 \div 2\ 10^{35}$
SuperKEKB (Japan)	10.58	Asymmetric	No	$2 \div 8\ 10^{35}$
Super*B*- Roma	10.58 4.0	Asymmetric	Yes	$1 \div 4\ 10^{36}$

Super*B* *is expected to integrate 75 ab^{-1} in 5 years*

From LHCb, expect:



LHC upgrade with $100 fb^{-1}$



Only LHCb?

F.Muheim

SuperLHCb vs. SuperBfactory at $50 ab^{-1}$

B Physics @ Y(4S)

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

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

Charm mixing and CP

Mode	Observable	$\Upsilon(4S)$ (75 ab^{-1})	$\psi(3770)$ (300 fb^{-1})
$D^0 \to K^+\pi^-$	x'^2	3×10^{-5}	
	y'	7×10^{-4}	
$D^0 \to K^+K^-$	y_{CP}	5×10^{-4}	
$D^0 \to K_S^0\pi^+\pi^-$	x	4.9×10^{-4}	
	y	3.5×10^{-4}	
	$\lvert q/p\rvert$	3×10^{-2}	
	ϕ	$2°$	
$\psi(3770) \to D^0\overline{D}^0$	x^2		$(1-2) \times 10^{-5}$
	y		$(1-2) \times 10^{-3}$
	$\cos\delta$		$(0.01-0.02)$

Charm FCNC

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

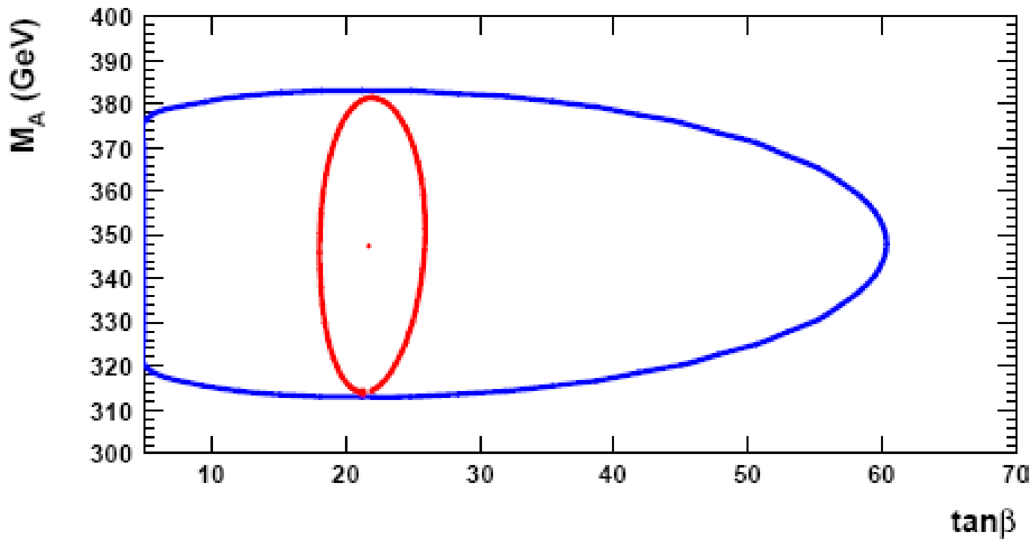
τ Physics

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

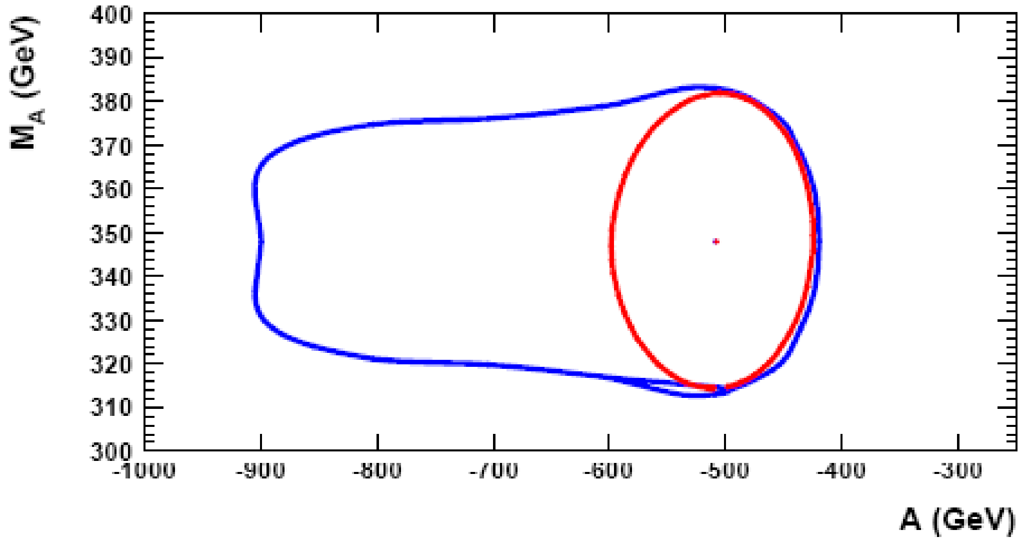
B_s Physics @ Y(5S)

	ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
$A_{\rm SL}^s$	0.006	0.004
$A_{\rm CH}$	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\lvert V_{td}/V_{ts}\rvert$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	10°	3°
β_s from $B_s \to K^0\bar{K}^0$	24°	11°

COMPLEMENTARY: LHC and Flavour with 75 ab^{-1}



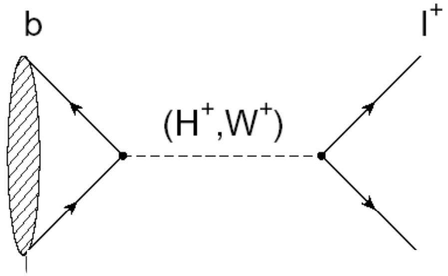
IF LHC DISCOVERS SUPERSYMMETRY



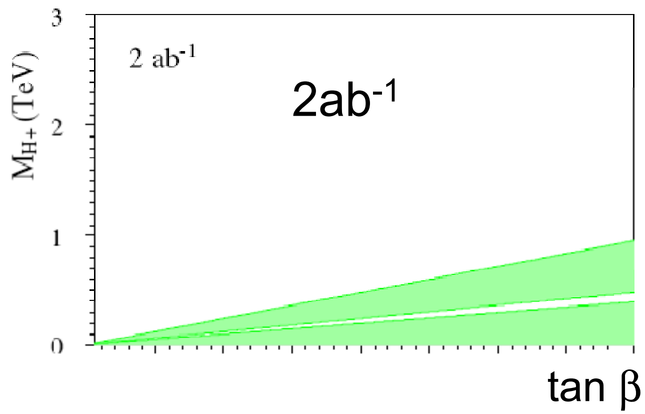
Red are LHC+EW constraints+SuperB

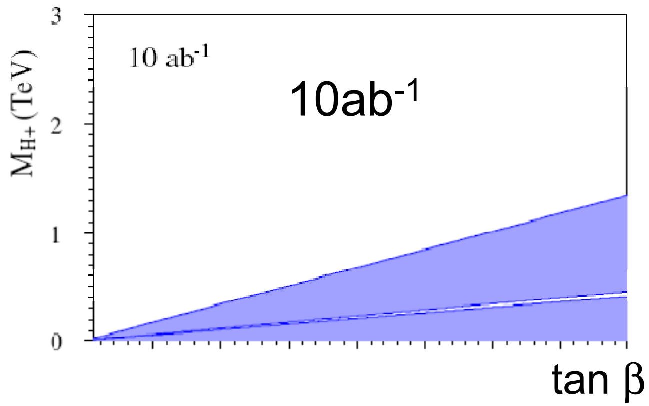
Blue is LHC alone

Higgs-mediated NP in MFV at large tanβ



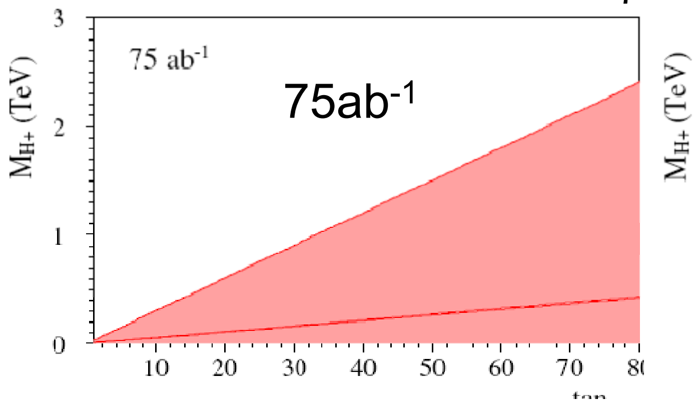
$$BR(B\to\tau\nu)=BR_{SM}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$





2ab^{-1}

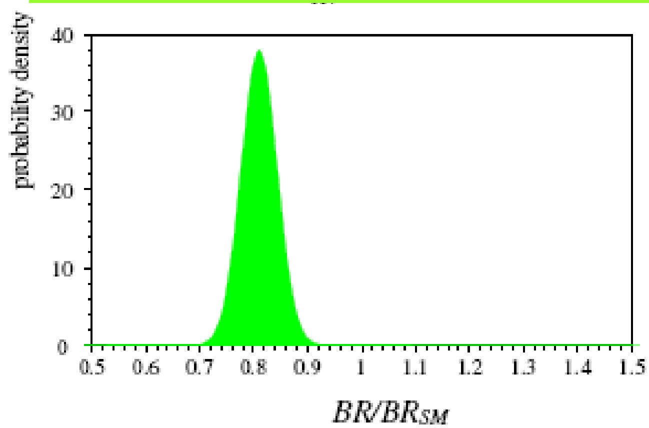
M_H~0.4-0.8 TeV for tanβ~30-60



SuperB -75ab^{-1}

M_H~1.2-2.5 TeV for tanβ~30-60

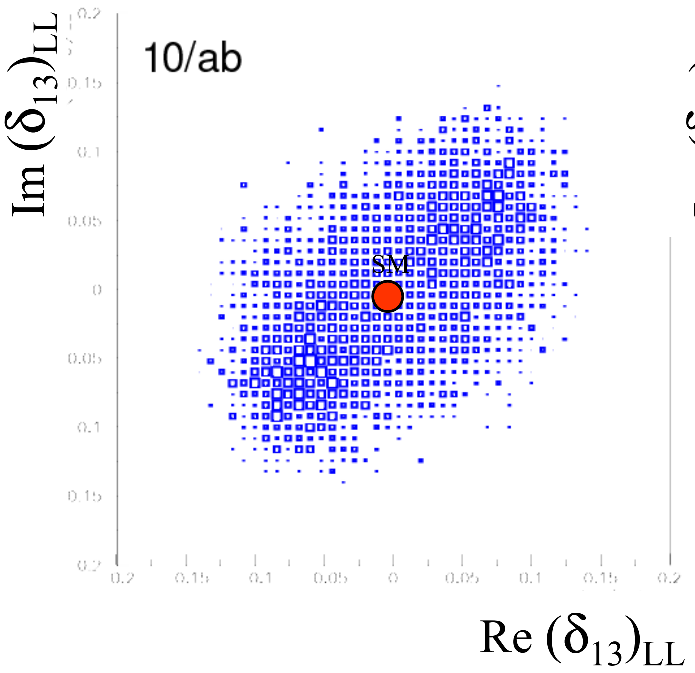
How signal would like with MH=350GeV

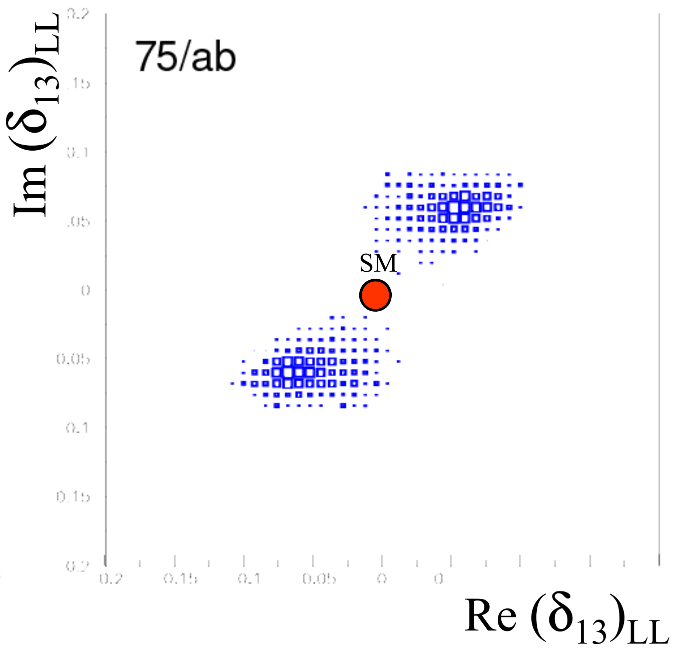


Importance of having very large sample ≥75ab^{-1}

Determination of coupling [in this case : $(\delta_{13})_{LL}$]

with 10 ab^{-1} and 75 ab^{-1}



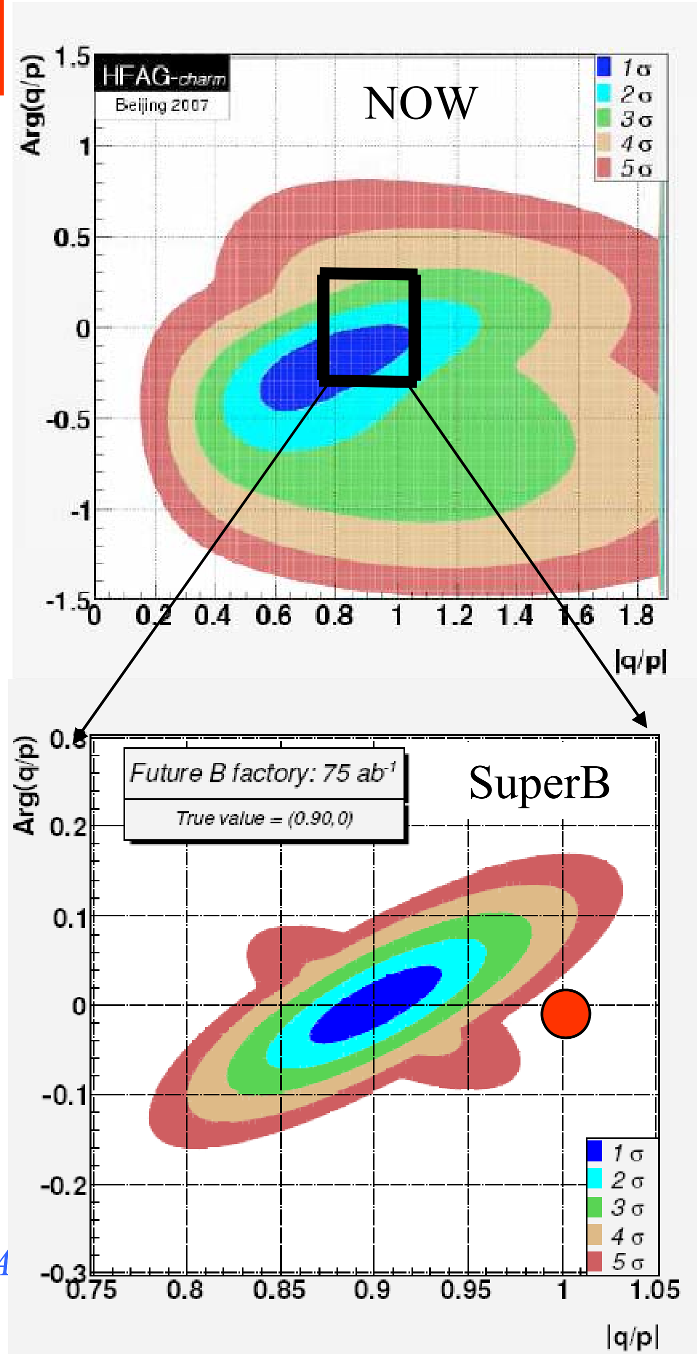


Importance of having very large sample >75ab^{-1}

CP Violation in charm from mixing

Mode	Observable	$\Upsilon(4S)$ ($75\ \mathrm{ab}^{-1}$)	$\psi(3770)$ ($300\ \mathrm{fb}^{-1}$)
$D^0 \to K^+\pi^-$	x'^2	3×10^{-5}	
	y'	7×10^{-4}	
$D^0 \to K^+K^-$	y_{CP}	5×10^{-4}	
$D^0 \to K^0_S\pi^+\pi^-$	x	4.9×10^{-4}	
	y	3.5×10^{-4}	
	$\lvert q/p\rvert$	3×10^{-2}	
	ϕ	2°	
$\psi(3770) \to D^0\overline{D}^0$	x^2		$(1-2) \times 10^{-5}$
	y		$(1-2) \times 10^{-3}$
	$\cos\delta$		$(0.01-0.02)$

Achievable in SuperB but also in 10^{35} Super τ charm

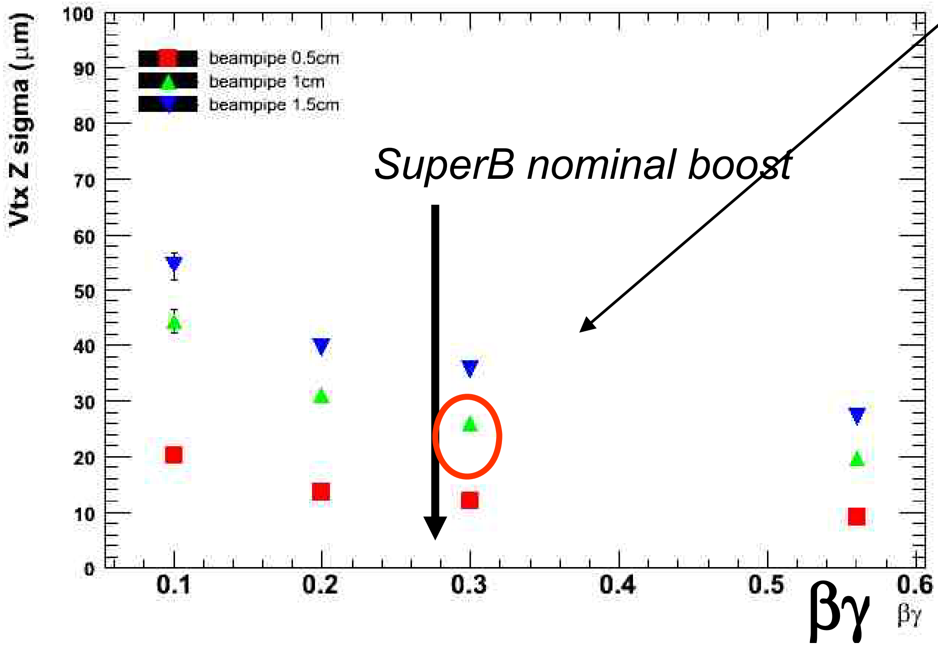


Charm

- Charm events at threshold are very clean: pure DD, no additional fragmentation
- High signal/bkg ratio: optimal for decays with neutrinos.
- Quantum Coherence: new and alternative CP violation measurement wrt to $\Upsilon(4S)$. Unique opportunity to measure D^0-D^0 relative phase.
- Increased statistics is not an advantage running at threshold: cross-section 3x wrt 10GeV but luminosity 10x smaller.
- SuperB lumi at 4 GeV = 10^{35} $cm^{-2}s^{-1}$ produces ~10^9 DD pairs per month of running. (using Cleo-c cross-section measurement [$\sigma(e^+e^- \rightarrow D^0 D^0)$~3.6 nb] +[$\sigma(e^+e^- \rightarrow D^+D^-)$~2.8 nb] ~ 6.4 nb)
- Super tau-charm could well study mixing and CP violation direct/indirect , but not in time dependent analysis as done in in B factories.
- Time-dependent measurements at 4 GeV **only** possible at SuperB to extract weak Phase thanks to the improved time measurement and to the option of running at charm threshold.

Time dependent measurements at DD threshold: only possible at SuperB

- Proper time resolution dominated by decay vertex resolution.
  - Production vertex precisely determined thanks to nm beamspot dimensions



With Super*B* lumi at 4 GeV = 10^{35} cm^{-2}s^{-1} expected $\sim 10^9$ $D\bar{D}$ per month

$\beta\gamma ct = 0.28 \times 120\ \mu m \sim 30\mu m$

Average flight distance similar to vertex resolution $\rightarrow \sigma_t \sim \tau$

is also a τ factory → golden measurement LFV

(Complementarity with $\mu \to e\,\gamma$)

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

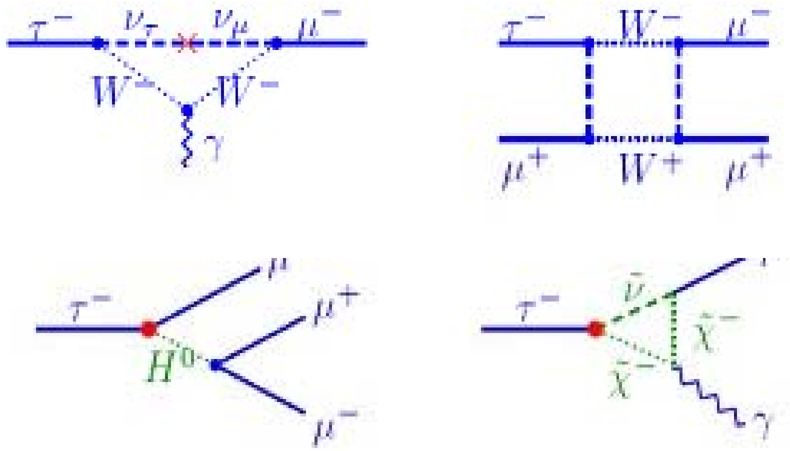
90% CL limits

Br $(\tau^- \to e^-\gamma)$ < 12×10^{-8}

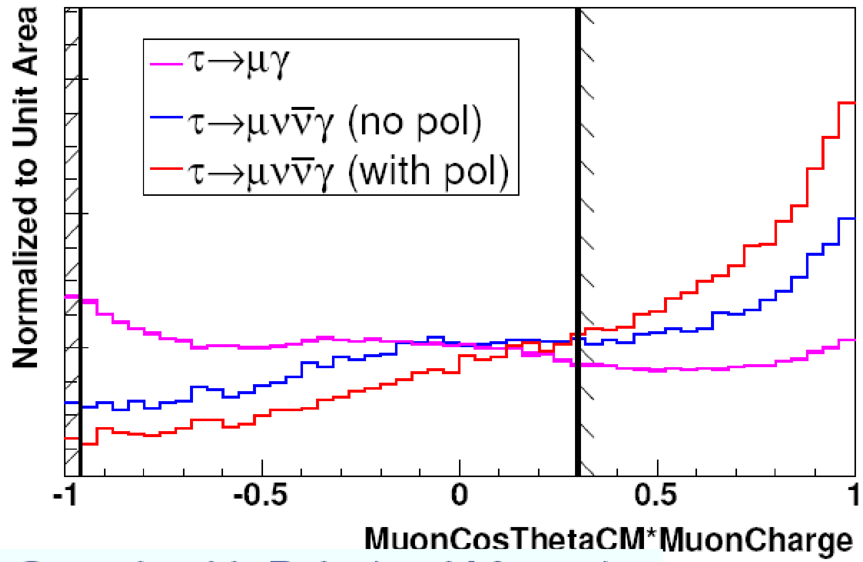
Br $(\tau^- \to \mu^-\gamma)$ < 4.1×10^{-8}

Br $(\tau^- \to e^-\gamma)$ < 11×10^{-8}

Br $(\tau^- \to \mu^-\gamma)$ < 6.7×10^{-8}



Further improvements if polarized beams.



Optimization of BKG rejection is in progress. Pol. Helps also to discriminate models. In some model there is a strong effect on the angular distribution of μ from signal:

(see hep-ph/9604296, Y.Kuno, Y.Okada, $\mu \to e\gamma$ Search with Polarized Muons)

Comparison with Snowmass points on Tau using also Polarization

SuperB with 75 ab-1, evaluation assuming the most conservative scenario about syst. errors

SPS	$M_{1/2}$ (GeV)	M_0 (GeV)	A_0 (GeV)	$\tan\beta$	μ
1 a	250	100	-100	10	>0
1 b	400	200	0	30	>0
2	300	1450	0	10	>0
3	400	90	0	10	>0
4	300	400	0	50	>0
5	300	150	-1000	5	>0

- NP predictions for experimentally constrained SUSY in a number of standard scenarios
  B.C.Allanach *et al.*, hep-ph/0202233

LFV	Snowmass points predictions						SuperB	
	1 a	1 b	2	3	4	5	90% UL	5σ disc
$BF(\tau \to \mu\gamma) \times 10^{-9}$	4.2	7.9	0.18	0.26	97	0.019	**1÷2**	5
$BF(\tau \to 3\mu) \times 10^{-12}$	9.4	18	0.41	0.59	220	0.043	200	880

SuperKEKB worse by a factor 2.5 and 4.5 in $\tau \to \mu\gamma$ and >5 in $\tau \to 3\mu$

Start with the expt. with μ

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

assume Super*B* at 75 fb^{-1}, $\boxed{80\%\ e^-\ \text{beam polarization}}$

extend to all tau decay channels

combine 2 measurement methods for $\mathrm{Re}\{F_2\}$

studies on simulated events show no limiting syst. effects

	Snowmass points predictions						Super*B*
	1 a	1 b	2	3	4	5	exp. resolution
$\Delta a_\mu \times 10^{-9}$	3.1	3.2	1.6	1.4	4.8	1.1	
$\Delta a_\tau \times 10^{-6}$	0.9	0.9	0.5	0.4	1.4	0.3	<1

SuperKEKB, without beam polarization, expected worse by factor ≈ 10, and worse systematics

Make use of all the informations (total x-section,angular distribution, f-b asymmetry.
Measure Re and Im parts

TOOLS (1):Luminosity

For gaussian bunches:

$$\mathcal{L} = f_{\text{coll.}} \times \frac{N_{e+}\, N_{e-}}{4\pi\, \sigma_x\, \sigma_y} \times R_l$$

geometrical Reduction factor

N_e^+ (N_e^-) is the number of positrons (electrons) in a bunch

f_{coll} is the collision frequency

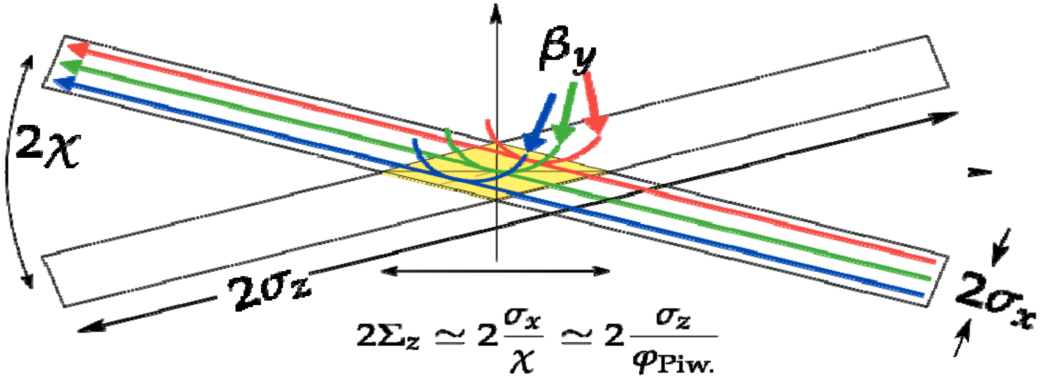
σ_x (σ_y) is the horizontal (vertical) r.m.s. size at the I.P.

R_l is the Luminosity Reduction factor by incomplete overlap: crossing angle and "hour glass" effect.

•TRADITIONAL (brute force): increase the numerator Currents increase: from 1A on 2 A up to 4.1 A on 9.4 A- **Wall Plug Power**, HOM,CSR: hard to surpass 5 10^{35} cm^2s^{-1} **Crab <u>Crossing</u>** to increase $\mathbf{R_l}$ and to optimize beam dynamic

•Super*B*: decrease the denominator (same currents as PEP-II) Bunch sizes: from $\sigma_y = 3\mu m$ down to σ_y = 40 nm Luminosity: 10^{36} cm^2s^{-1} (baseline) . **Crab <u>Waist</u>** and large **Piwinsky** angle to optimize beam dynamic

Crab Waist :The SuperB solution



- Crab waist: modulation of the y-waist position, particles collides a same β_y realized with a sextupole upstream the IP.
- Minimization of nonlinear terms in the beam-beam interaction: reduced emittance growth, suppression of betatron and sincro-betatron coupling
- Maximization of the bunch-bunch overlap: luminosity gain
- Low wall power

SuperB and Super c-τ are based on the crabwaist concept invented in 2006 by P.Raimondi in 2006.

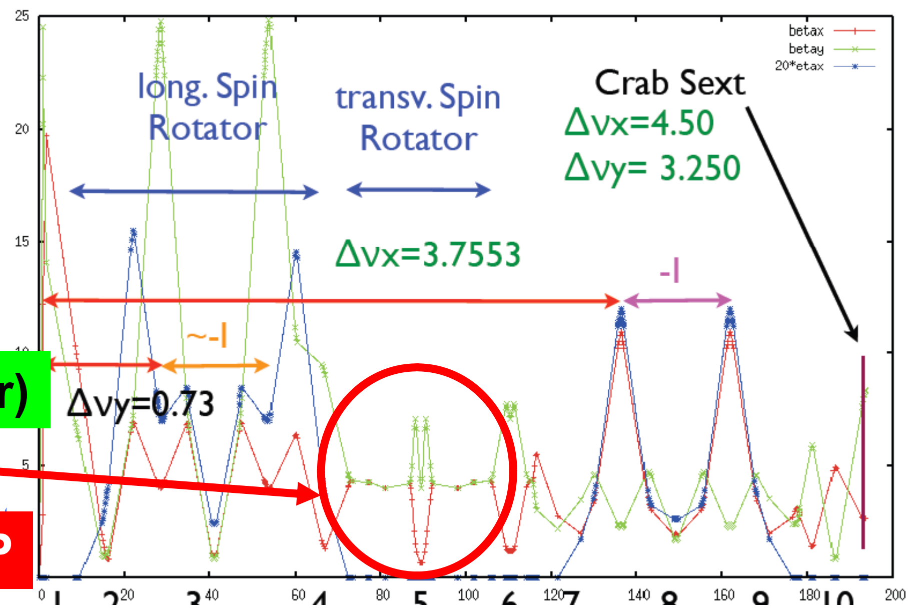
TESTED IIN LNF WITH DAFNE (500 MeV beams)

TOOLS (2):Polarization

- Polarization of one beam is included in *SuperB and also in Super τ–charm*
  - Polarization in LER would be less expensive, in HER easier
  - HER chosen for SuperB
- Longitudinal polarization times and short beam lifetimes indicate a need to inject vertically polarized electrons.
  - The plan is to use a polarized e⁻ source similar to the SLAC SLC source.
- There are several possible IP spin rotators:
  - Solenoids look better at present (vertical bends give unwanted vertical emittance growth)

- Expected longitudinal polarization at IP ~ 87%(inj) x 97%(ring) = 85%(effective)
- Polarization section implementation in lattice is in progress

Half IR with spin rotator (Wienands, Wittmer)



IP

Layout of Novosibirsk Project based on Crab Waist Concept

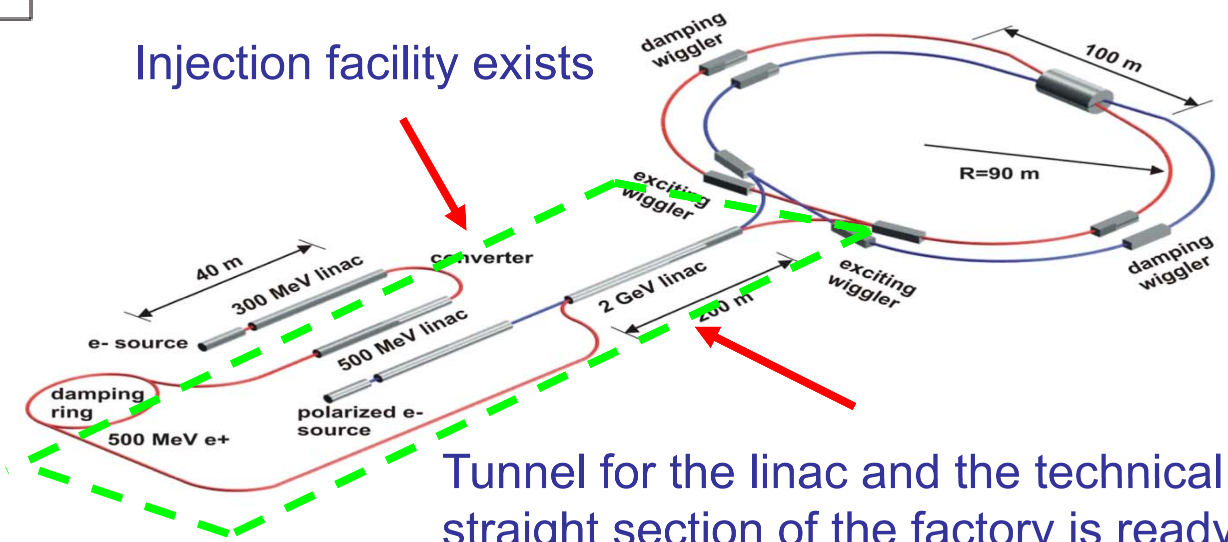
From the talk by Anton Bogomyagkov

Tune shift ξ_y	0.13
Particles per bunch	$7 \cdot 10^{10}$
Luminosity, $\mathrm{cm}^{-2}\mathrm{sec}^{-1}$	$1 \cdot 10^{35}$
Hour glass $\frac{\sigma_x}{\theta\beta_y}$	1.095
Piwinski angle $\varphi = \frac{\sigma_z\theta}{\sigma_x}$	12.021

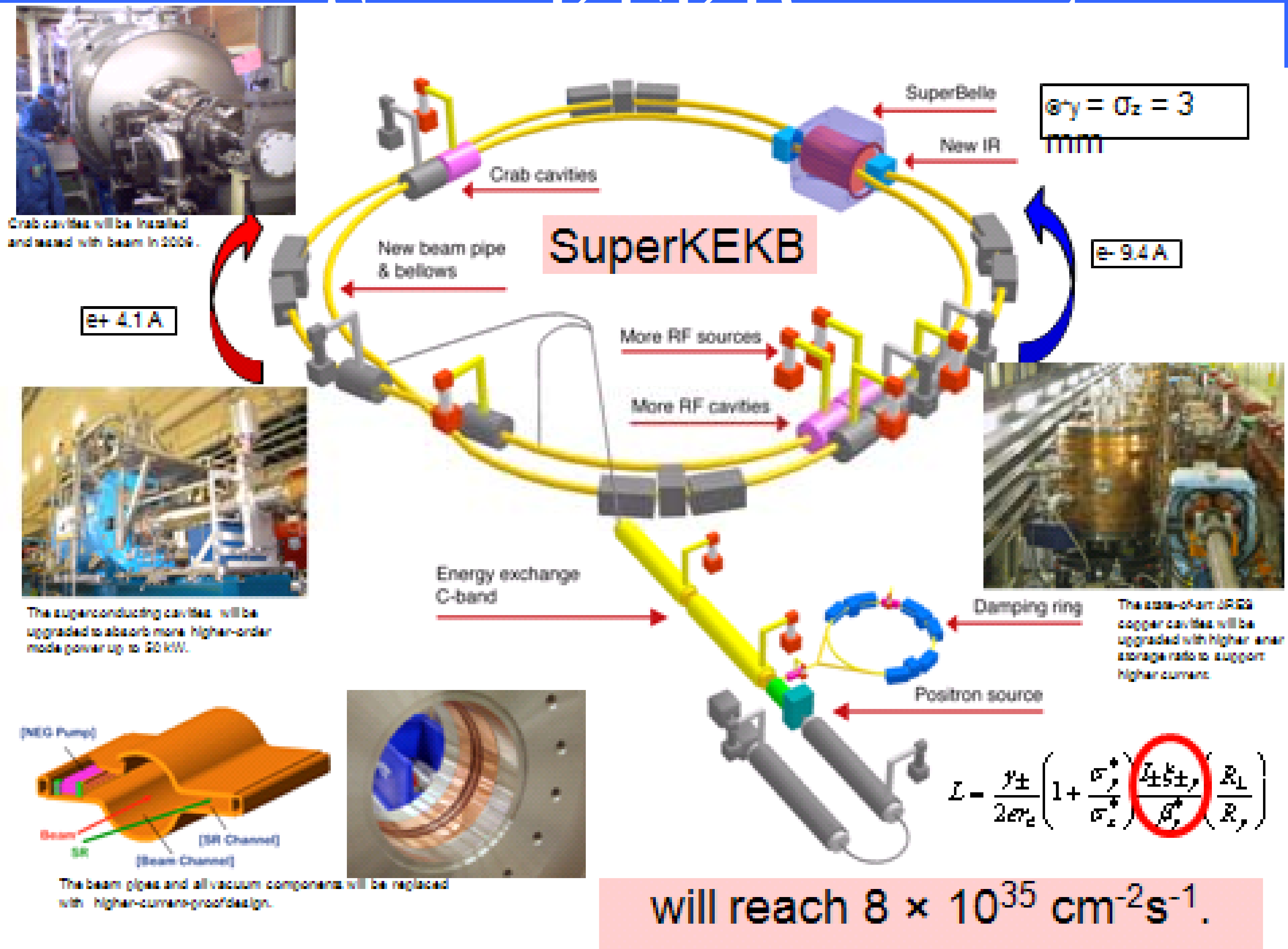
Energy, GeV	2
Beam current, A	1.36
Number of bunches	295
β_x, mm	20
β_y, mm	0.76
ε_x, nm rad	10
Coupling $\varepsilon_y/\varepsilon_x$, %	1
Beam length σ_z, cm	1
Crossing angle, mrad	34

Expected 100x statistics of Cleo and BESII

Injection facility exists

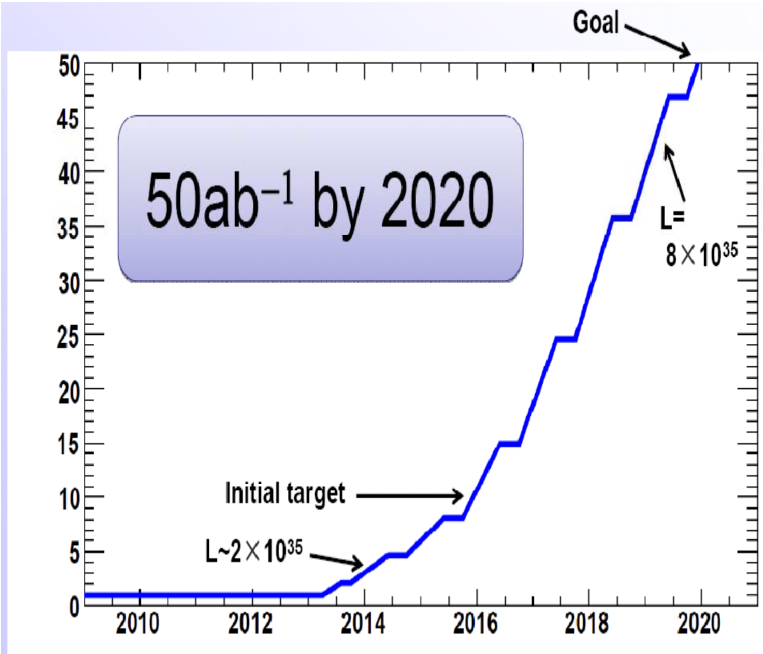


Tunnel for the linac and the technical straight section of the factory is ready



SuperKEKB
$\sigma_y = \sigma_z = 3$ mm
SuperBelle
New IR
Crab cavities
e- 9.4 A
e+ 4.1 A
New beam pipe
& bellows
More RF sources
More RF cavities
Energy exchange
C-band
Damping ring
Positron source
[NEG Pump]
Beam
SR
[SR Channel]
[Beam Channel]
$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\right)\left(\frac{R_L}{R_y}\right)$
will reach 8×10^{35} cm^{-2}s^{-1}.

SuperKEKB



Machine Parameters of SuperKEKB

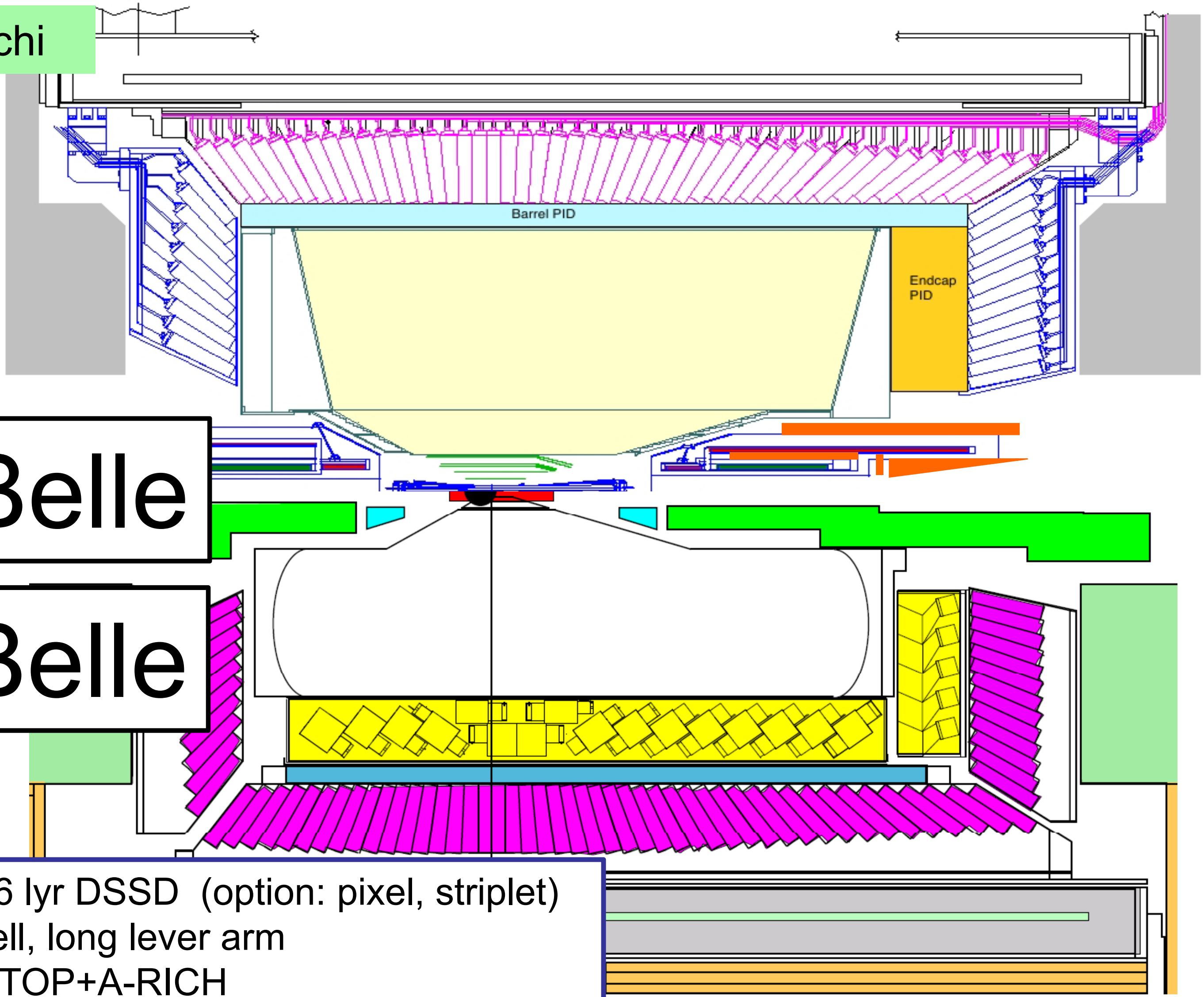
	symbol	LER	HER	unit
Beam Energy	E	3.5	8.0	GeV
Beam current	I	9.4	4.1	A
Circumference	C	3016		m
Number of bunches	n_b	5018		
Number of particles	N/bunch	11.8	5.1	x10^{10}
Emittance	ε_x	9		nm
Emittance ratio	$\varepsilon_y/\varepsilon_x$	0.5		%
Beta (hor.) at IP	β_x^*	200		mm
Beta (ver.) at IP	β_y^*	3		mm
Bunch length	σ_z	3		mm
Crossing angle	θ_x^*	30 to 0		mrad
Beam-Beam (hor.)	ξ_x	0.36		
Beam-Beam (ver.)	ξ_y	0.43		
RF AC plug power	P_{AC}	73		MW
Luminosity	L	8.0		x10^{35} cm^{-2}s^{-1}

A new goal for SuperKEKB

From M.Yamauchi

sBelle: Baseline Design

From M.Yamauchi

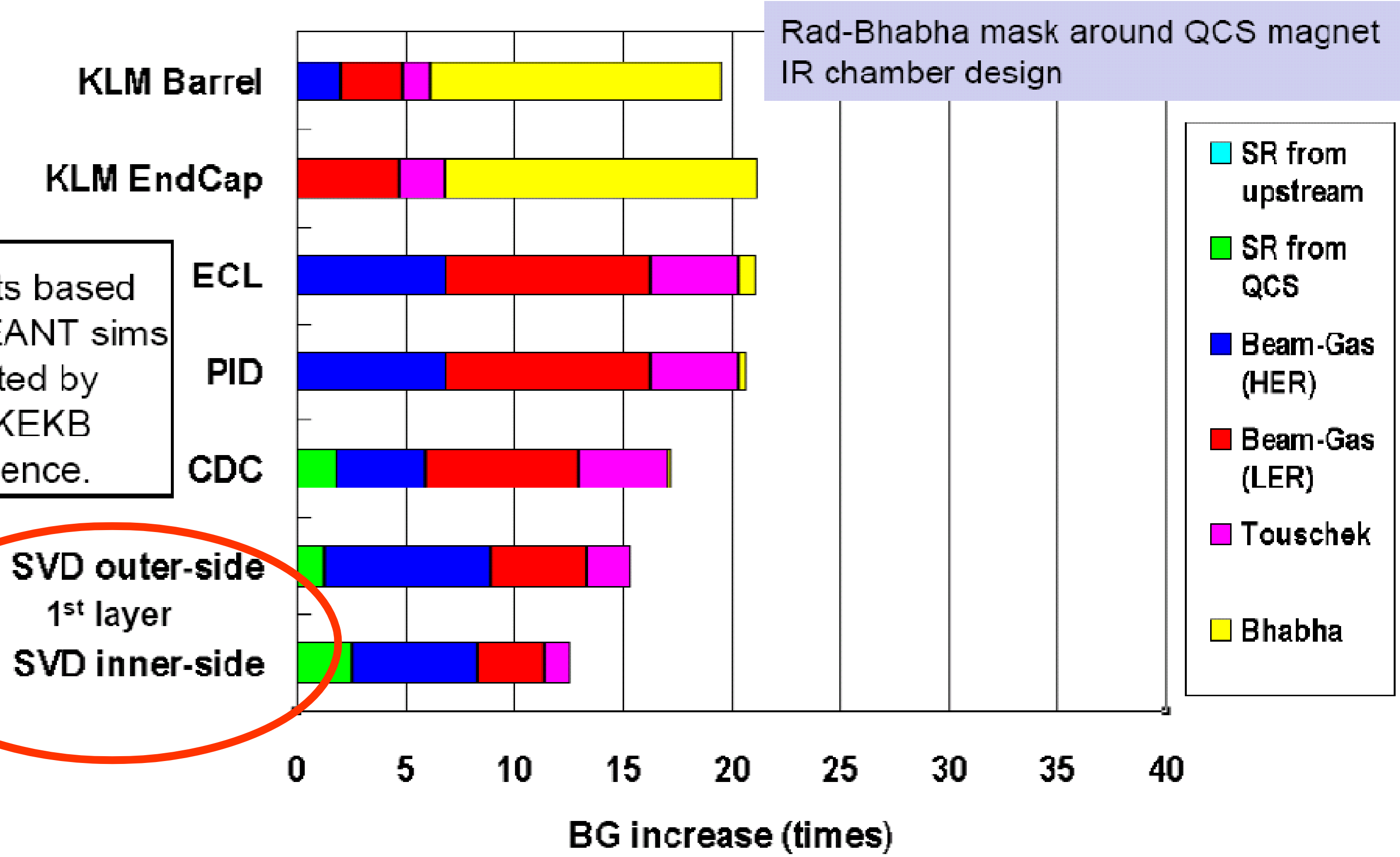


SVD: 4 lyr → 6 lyr DSSD (option: pixel, striplet)
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → **Scintillator +SiPM (end-caps)**

sBelle

Beam Background

From M.Yamauchi



Results based on GEANT sims validated by Belle/KEKB experience.

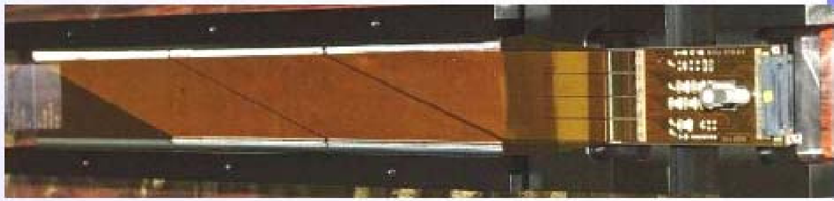
Conservative, robust detector should be handle up to 20 times more background

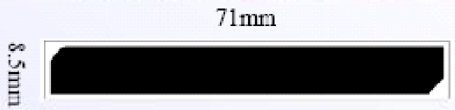
Silicon vertex :sBelle

- Inner layers
  - Pixel detector

    MAPS,**DEPFET**,SOI
  - Or striplet?
- Outer layers

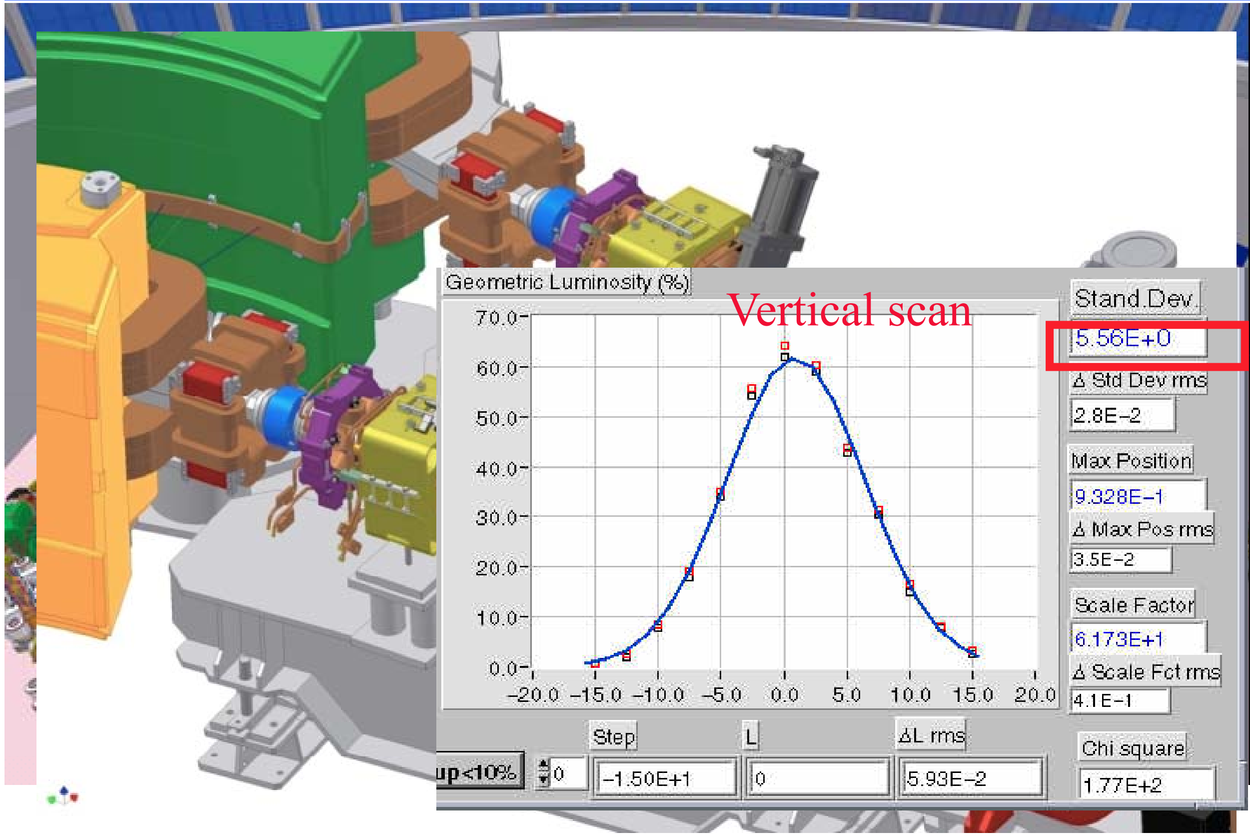
  DSSD +
  - **APV25**
    - t_p = 50ns, pipelined, weak at C_d
  - VA1TA (currently used)
    - t_p = 800ns, hold & readout



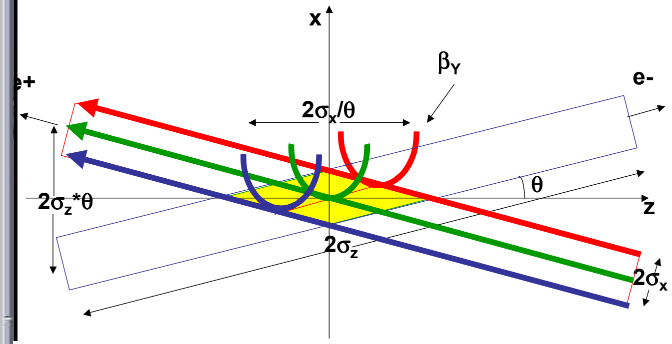


Open questions:
1. Inner radius
2. Outer radius
3. Material budget
4. Readout pitch of outer layers
5. Slant angle

..and Crab Waist in DaΦne upgrade at FRASCATI



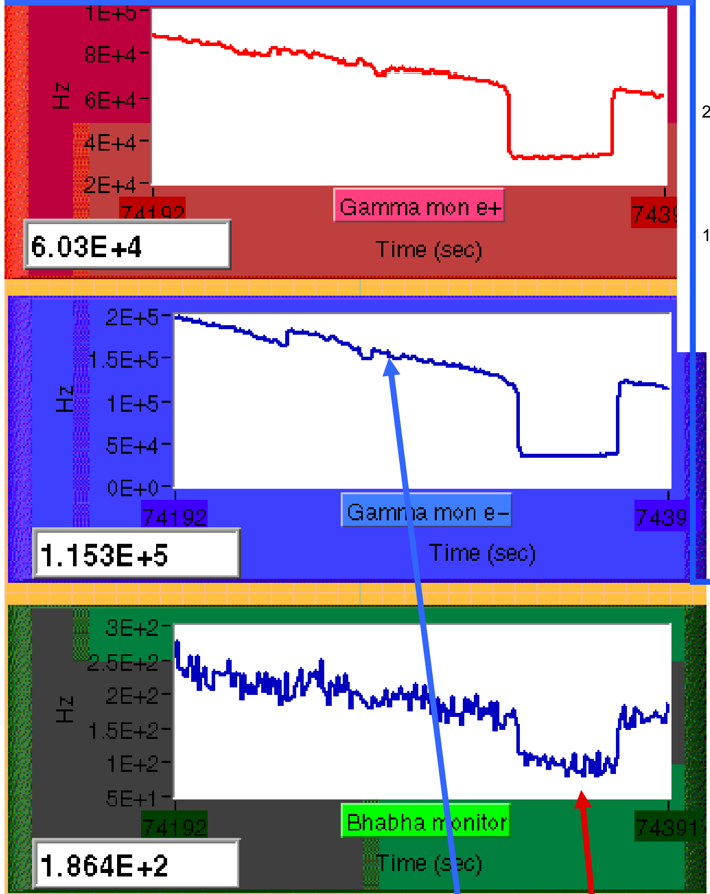
$\sigma_y \approx 3.5\mu m$

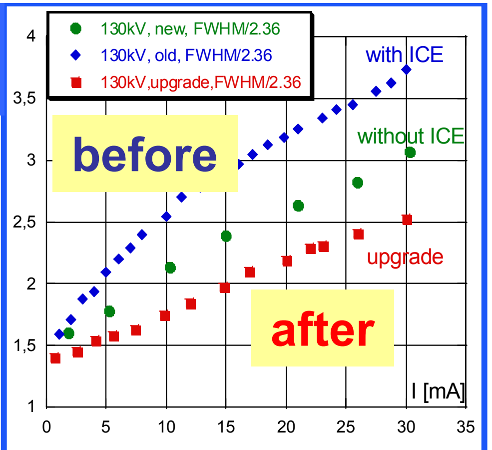


$$\Sigma_y = \sqrt{\sigma_{yp}^2 + \sigma_{ye}^2} \qquad \Sigma_y = \Sigma_y^{meas} * 0.88$$

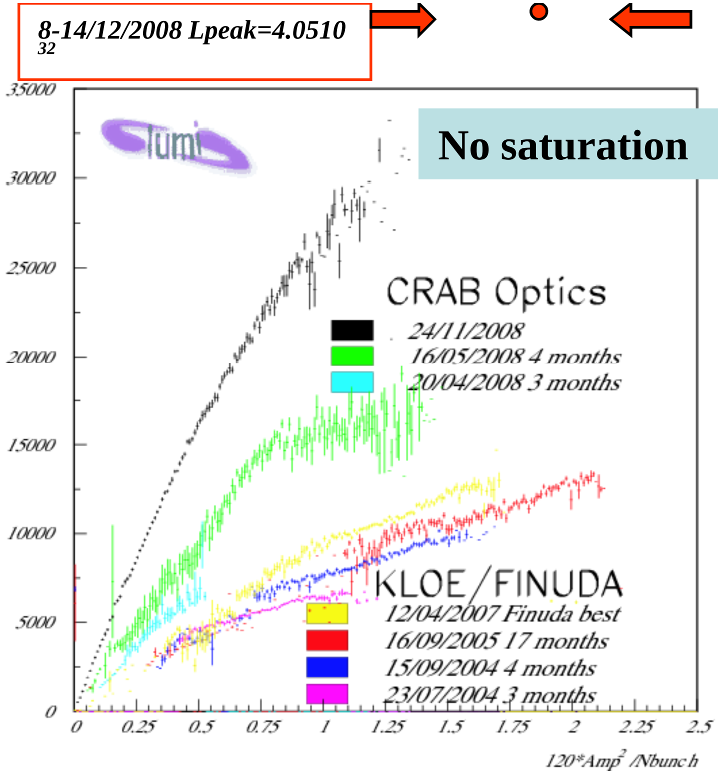
Large Piwinsky angle and "*crab waist*" with a pair of sextupoles/ring $(\Phi = tg(\theta)\sigma_z/\sigma_x)$
Currents comparable to present Factories,lower backgrounds, less HOM and instabilities.

DaΦne test



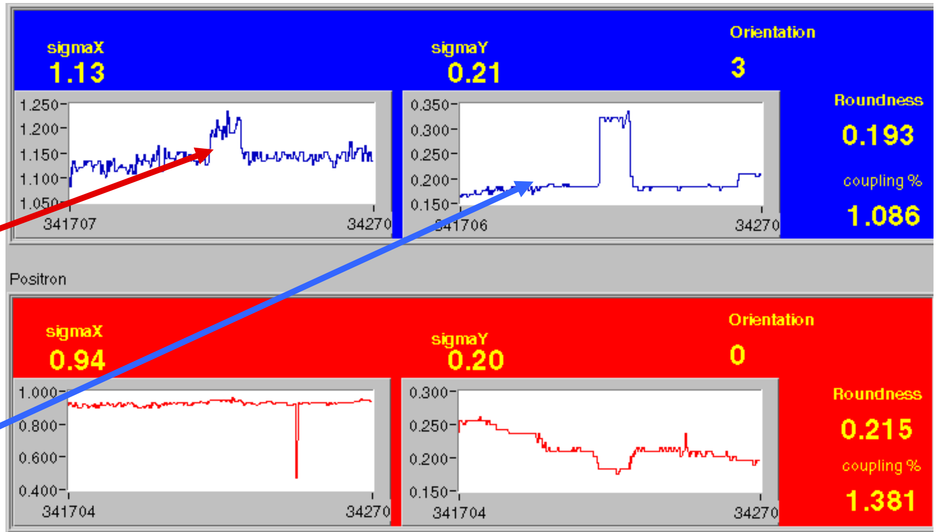


e⁻ bunch lenght vs bunch current as measured before and after upgrade



Crab OFF

Crab ON



Blow-up in beam sizes and decrease Bhabha rates with crab sexts for one ring OFF (other ring ON)

KLOE2 in DaΦne

With "Crab Waist" DaΦne is now currently running at more than 4 10^{32}

and integrating $\geq$ 13 pb^{-1}/day. More than 4 fb-1/ year is now feasible Project.

A plan for the continuation of the KLOE physics program on the upgraded machine,

has been started early in 2006 to improve the detector performance by means of:

- The insertion of an inner tracker
- The modification of the quadrupole calorimeters
- The insertion of crystal calorimeters in the low θ region
- The insertion of a tagging system for $\gamma\gamma$ events

The experiment is expected to re-start its data taking by end 2009. Goal is with

the completion of physics program as:

Check universality in K_{l2} channels

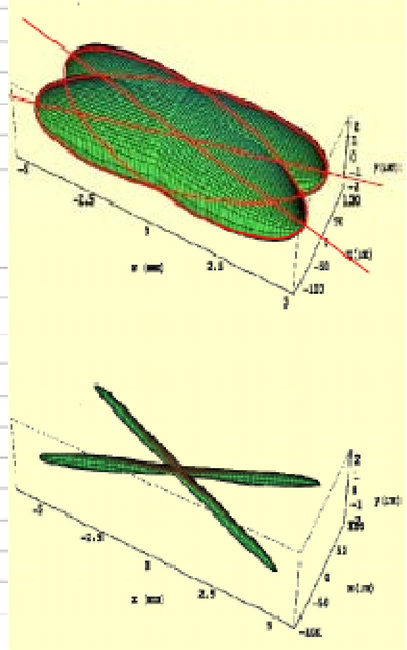
Studying rare decays

Increasing precision on CPT violation parameters

SuperB parameters wrt SuperKEKB

	Nominal		Upgrade		Ultimate		SuperKEKB	
PARAMETER	LER (e+)	HER (e-)	LER (e+)	HER (e-)	LER (e+)	HER (e-)	LER (e+)	HER (e-)
Energy (GeV)	4	7	4	7	4	7	3.5	8
Luminosity x 10^{36}	1.0		2.0		4.0		0.8 (0.4)	
Circumference (m)	1800	1800						
Revolution frequency (MHz)	0.167							
Eff. long. polarization (%)	0	80						
RF frequency (MHz)	476							
Momentum spread ($x10^{-4}$)	7.9	5.6	9.0	8.0				
Momentum compaction ($x10^{-4}$)	3.2	3.8	3.2	3.8				
Rf Voltage (MV)	5	8.3	8	11.8	17.5	27		
Energy loss/turn (MeV)	1.16	1.94	1.78	2.81				
Number of bunches	1251				2502		5000	
Particles per bunch ($x10^{10}$)	5.52				6.78		12	5
Beam current (A)	1.85				3.69		9.4	4.1
Beta y* (mm)	0.22	0.39	0.16	0.27			3	
Beta x* (mm)	35	20					200	
Emit y (pm-rad)	7	4	3.5	2			46	
Emit x (nm-rad)	2.8	1.6	1.4	0.8			9 (24)	
Sigma y* (microns)	0.039	0.039	0.0233	0.0233			0.367	
Sigma x* (microns)	9.9	5.66	7	4			42	
Bunch length (mm)	5		4.3				3	
Full Crossing angle (mrad)	48						30	
Wigglers (#) 20 meters each	0	0	2	2				
Damping time (trans/long)(ms)	40/20	40/20	28/14	28/14				
Luminosity lifetime (min)	6.7		3.35					
Touschek lifetime (min)	20	40	38	20				
Effective beam lifetime (min)	5.0	5.7	3.1	2.9				
Injection rate pps ($x10^{11}$) (100%)	2.6	2.3	5.1	4.6	10	9.1		
Tune shift y (from formula)	0.15		0.20				0.405	
Tune shift x (from formula)	0.0043	0.0025	0.0059	0.0034			0.209	
RF Power (MW)	17		25		58.2		83	

IP beam distributions for KEKB



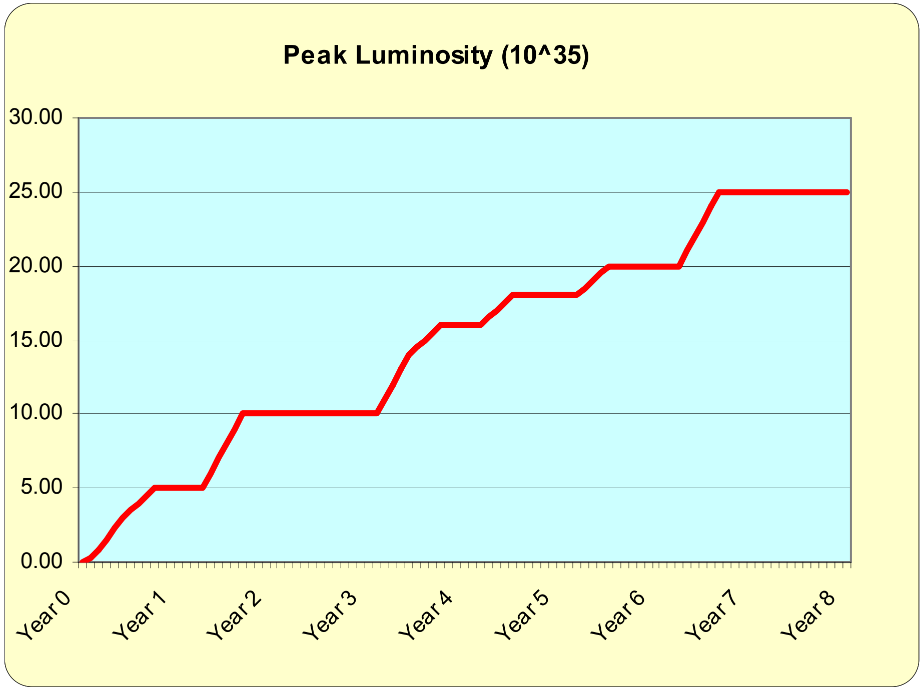
IP beam distributions for SuperB *(without transparency conditions)*

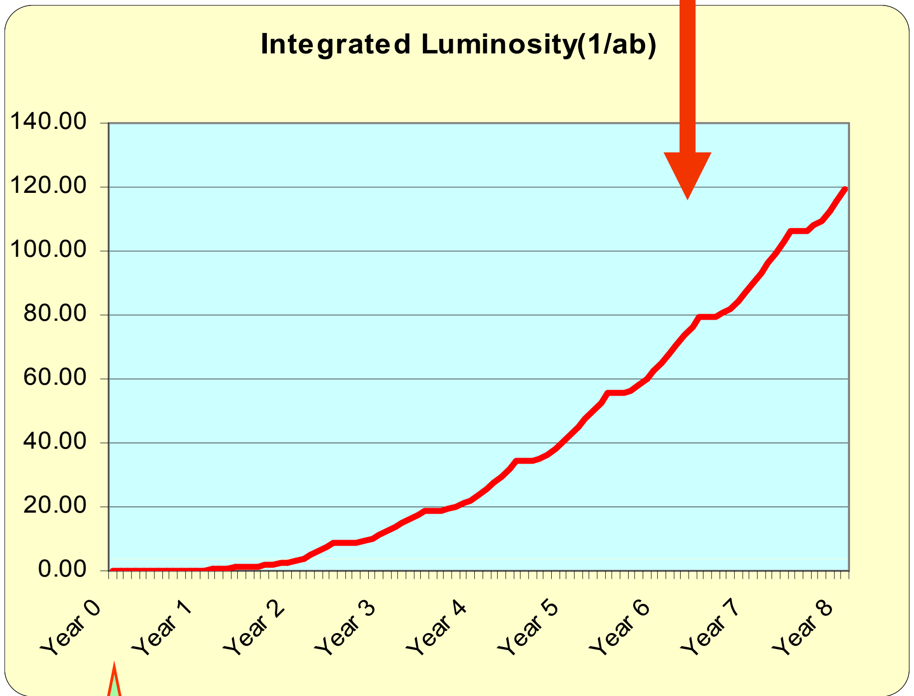
Luminosity doubled by doubling currents and wall power by a factor 2

SuperB expectation

With 7th year integrated Luminosity can grow at rate of ~40 ÷ 60 ab^{-1}/year

>80ab-1 after 6 years

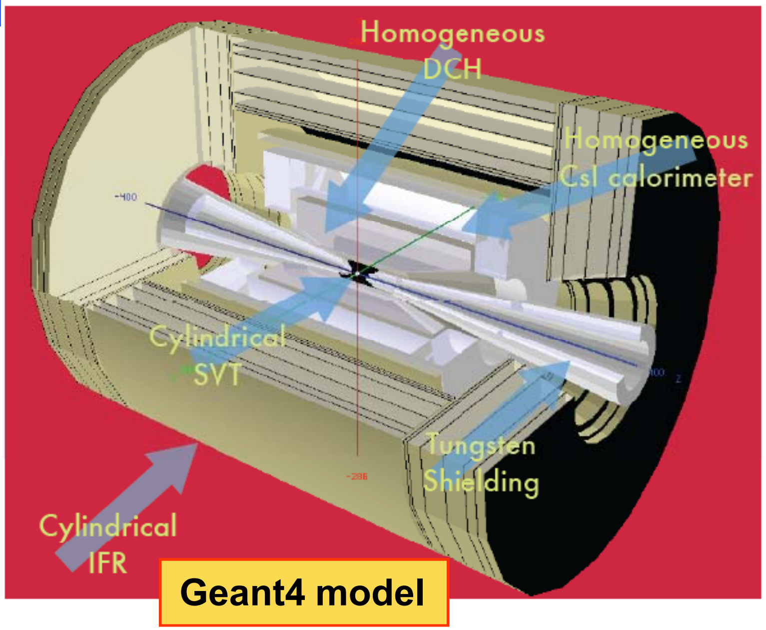


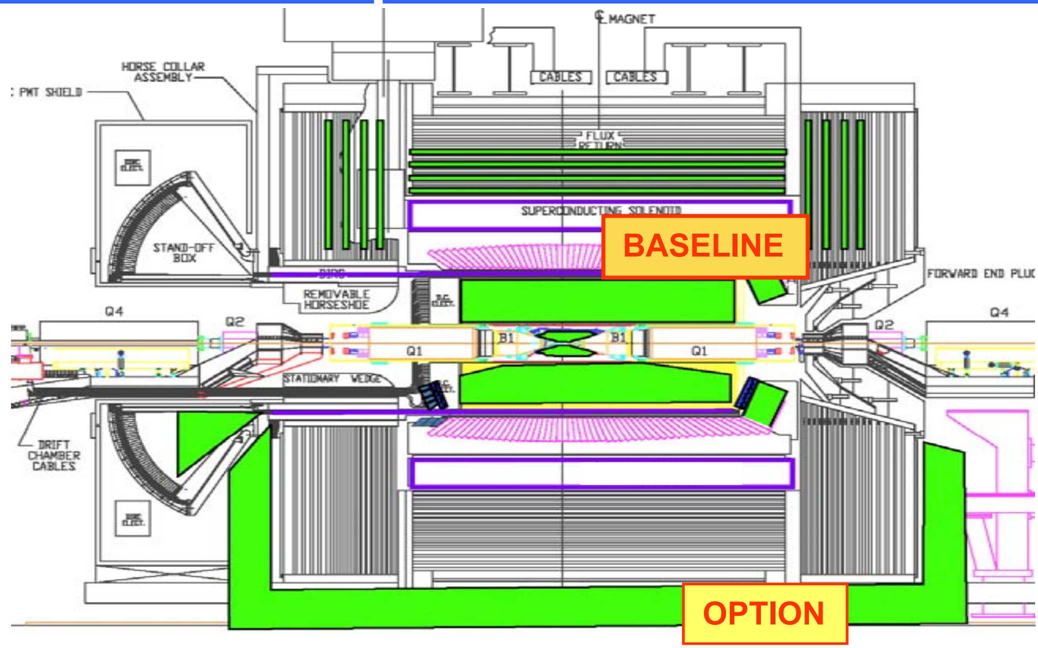


With more money a second interaction can be included in SuperB, without compromising on Luminosity!

2015?

Detector Layout – Reuse parts of Babar





Test beam goals for 2008-2010

Silicon Vertex Tracker
- MAPS pixel devices: resolution, efficiency, readout speed
  - (now under test at CERN !)
- Advanced trigger systems (Associative Memories)

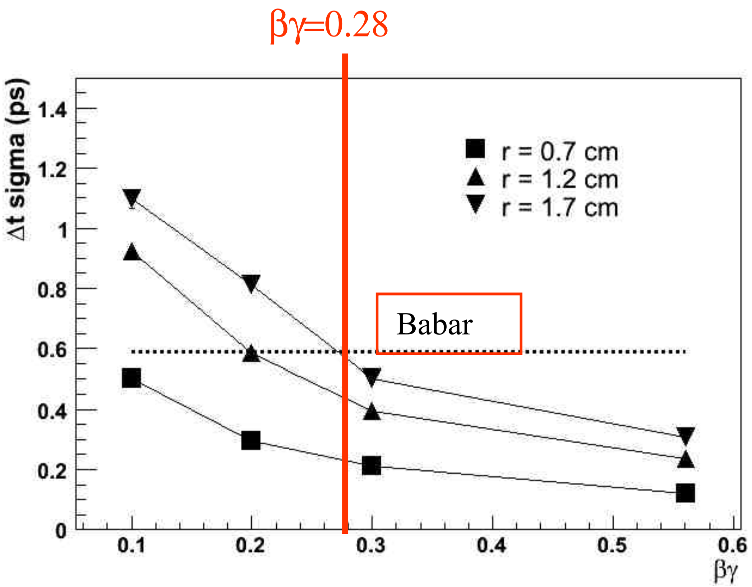
Drift Chamber
- Cell size, shape, and gas mixture

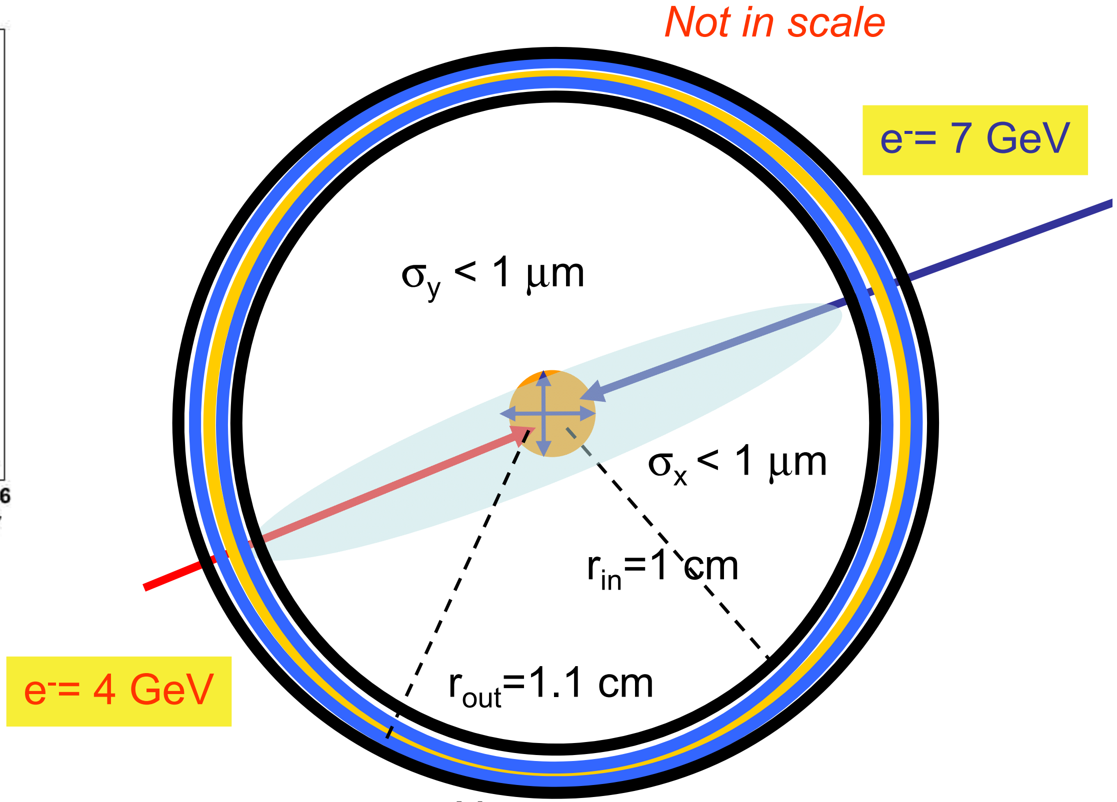
Particle ID system (forward system)
- Radiators (Aerogel, NaF)
- Photon detector (MCP, MAPMTs, SiPM)
- Timing for TOF system

Electromagnetic Calorimeter
- Forw: LYSO Crystals leakage, resolution, mechanical structure
- Back: Lead-scintillator calorimeter resolution

Instrumented Flux Return
- Scintillator, fibers, photon detector, readout electronics

Interaction region SuperB





σ_z = 1 mm

- Be beam-pipe 600 μm thick
- Au foil 4 μm thick
- Water 300 μm thick
- Nickel coating 7 μm thick

X_0

0.170% (Be)

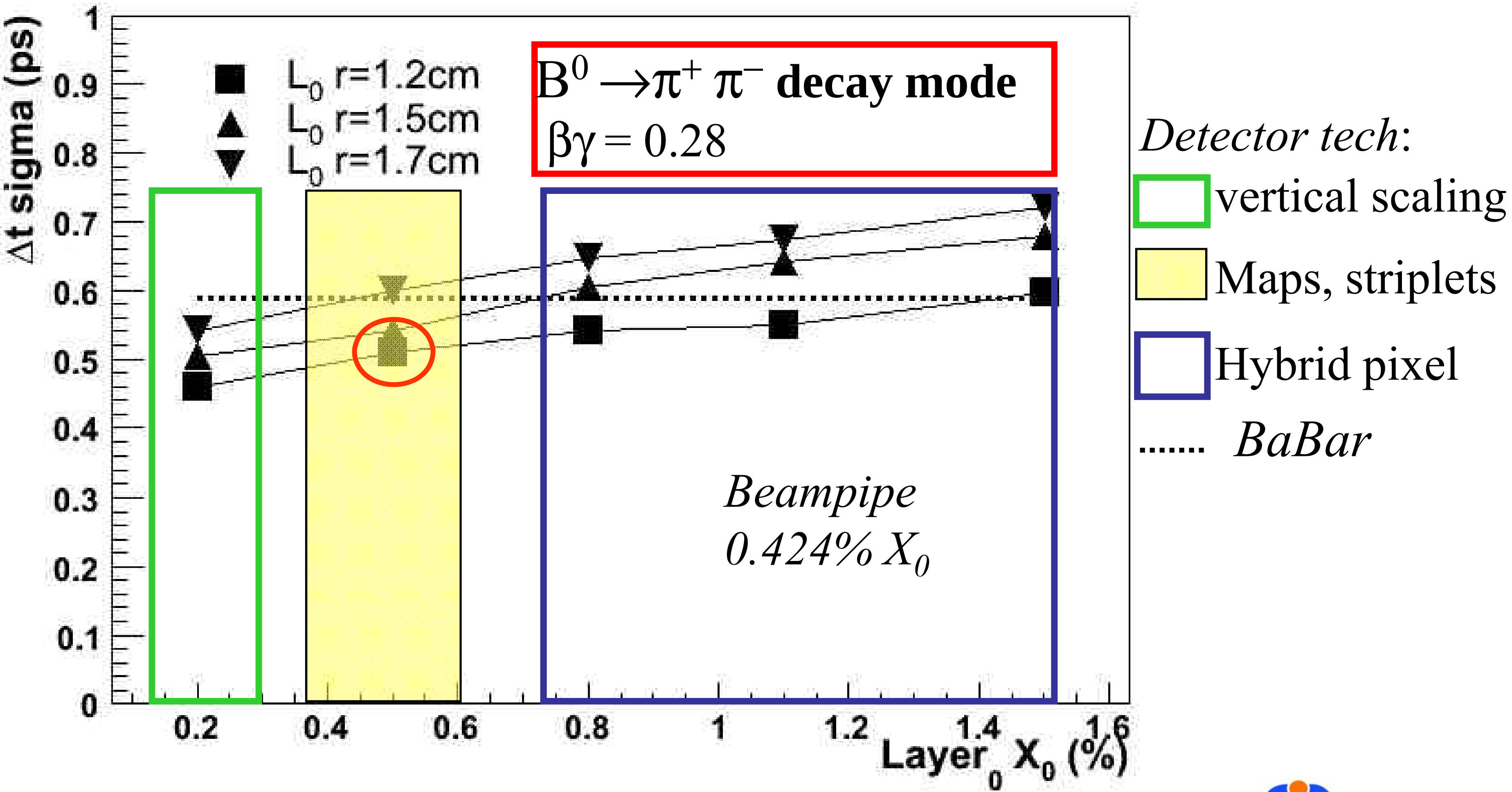
0.121% (Au)

0.083% (H_2O)

0.050% (Ni)

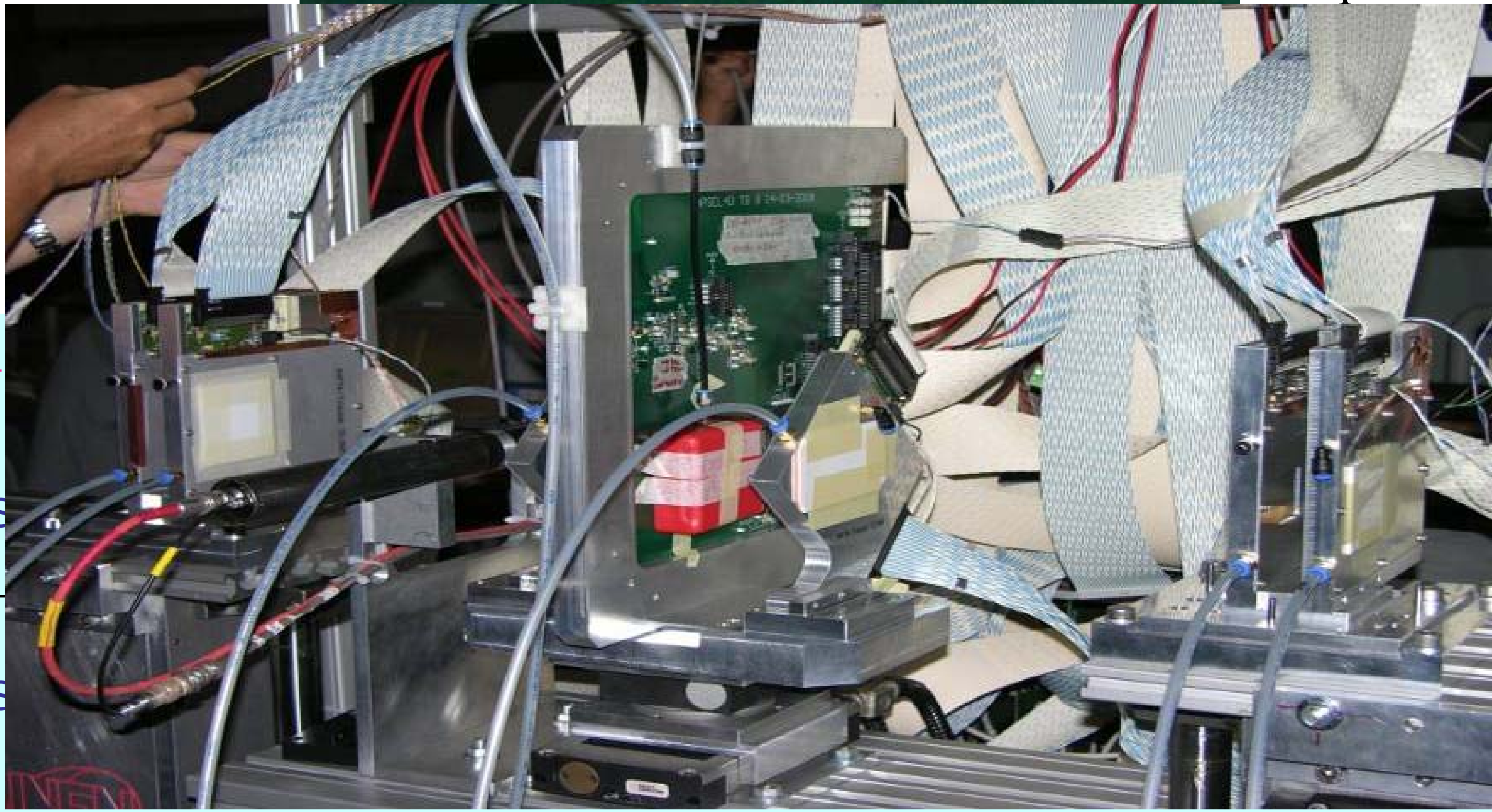
0.424% X_0

Example of physics studies: Δt resolution in $B \rightarrow \pi\pi$ decays *vs* L_0 X_0(%) 10 μm intrinsic detector resolution

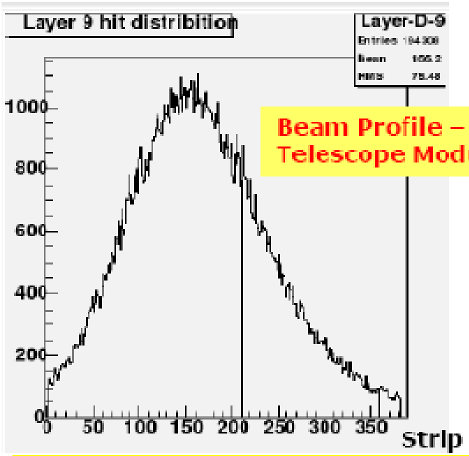


..and R&D for new

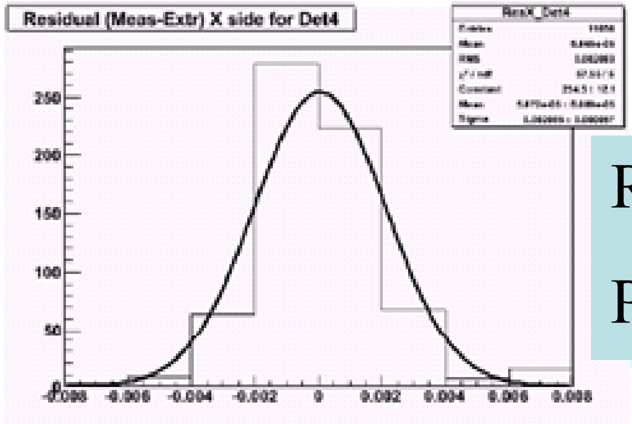
- Beam test september '08 @ CERN (T9). Main goals:



beam



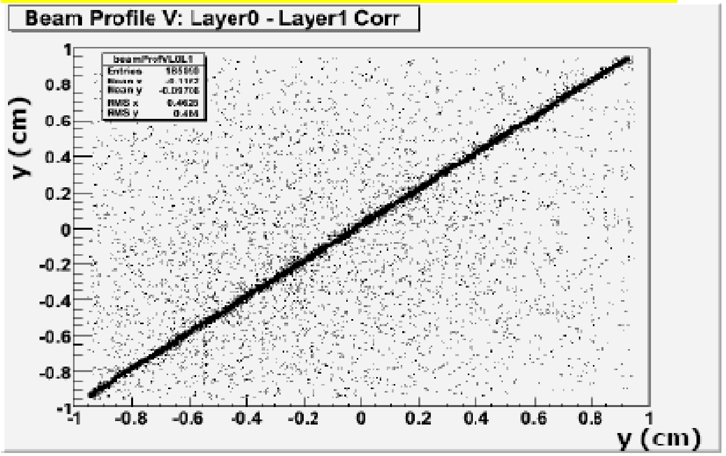
Beam Profile – Telescope Module



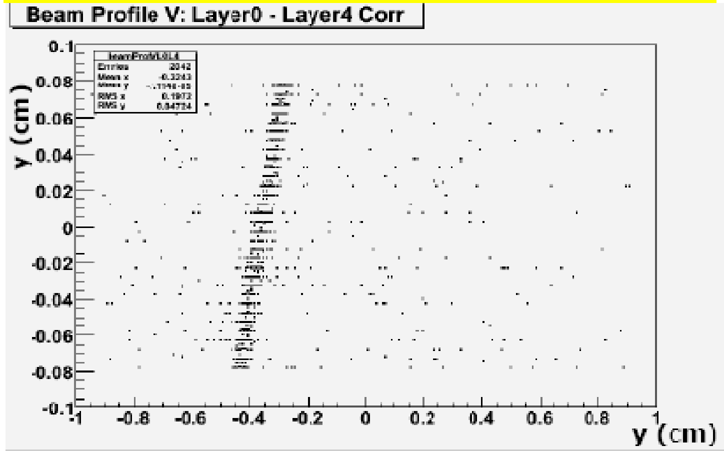
Resolution ≤ 18μm

Pixel size 50μm x 50 μm

Y hit correlation Telescope T2 vs T1



Y hit correlation MAPS vs Telescope T1



Efficiency plateau 80÷90%

My Conclusion

Next decade will be very exciti

My ...es:

- New P... Ch
-
- New ... ts

NEW PH... tories!

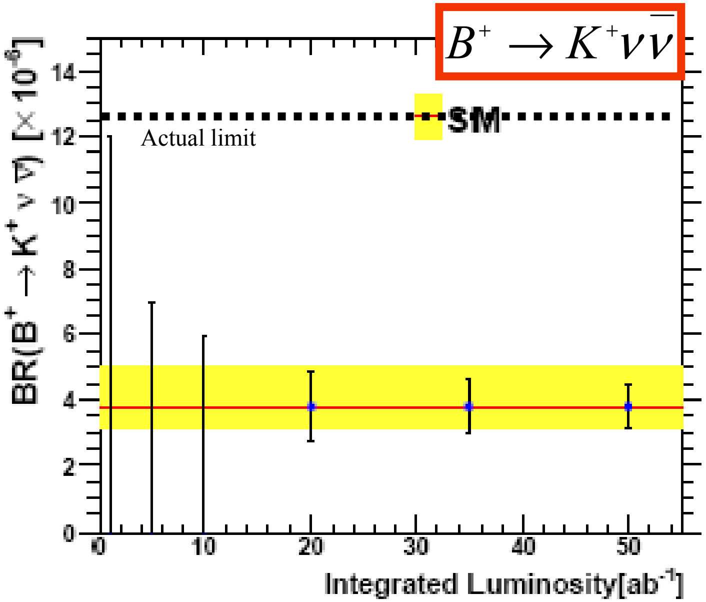
(I... ast

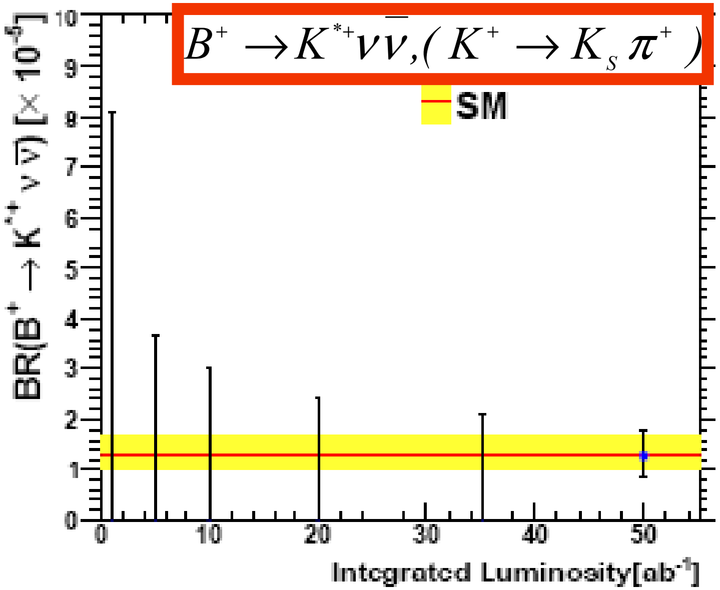
SuperB will have polarization and possibility of running at Charm threshold!

They are all co...plementary and..

END

Some comparison: Current→ 10ab^{-1}→ 75ab^{-1}





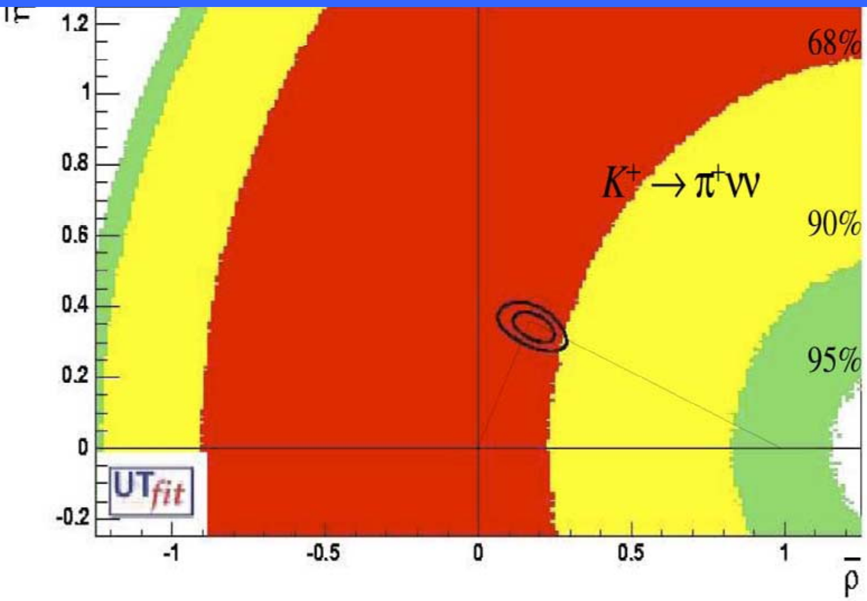
Mode	Sensitivity		
	Current	Expected (10 ab^{-1})	Expected (75 ab^{-1})
$\mathcal{B}(B \to X_s \gamma)$	7%	5%	3%
$A_{CP}(B \to X_s \gamma)$	0.037	0.01	0.004–0.005
$\mathcal{B}(B^+ \to \tau^+ \nu)$	30%	10%	3–4%
$\mathcal{B}(B^+ \to \mu^+ \nu)$	not measured	20%	5–6%
$\mathcal{B}(B \to X_s l^+ l^-)$	23%	15%	4–6%
$A_{\mathrm{FB}}(B \to X_s l^+ l^-)_{s0}$	not measured	30%	4–6%
$\mathcal{B}(B \to K \nu \overline{\nu})$	not measured	not measured	16–20%
$S(K_S^0 \pi^0 \gamma)$	0.24	0.08	0.02–0.03

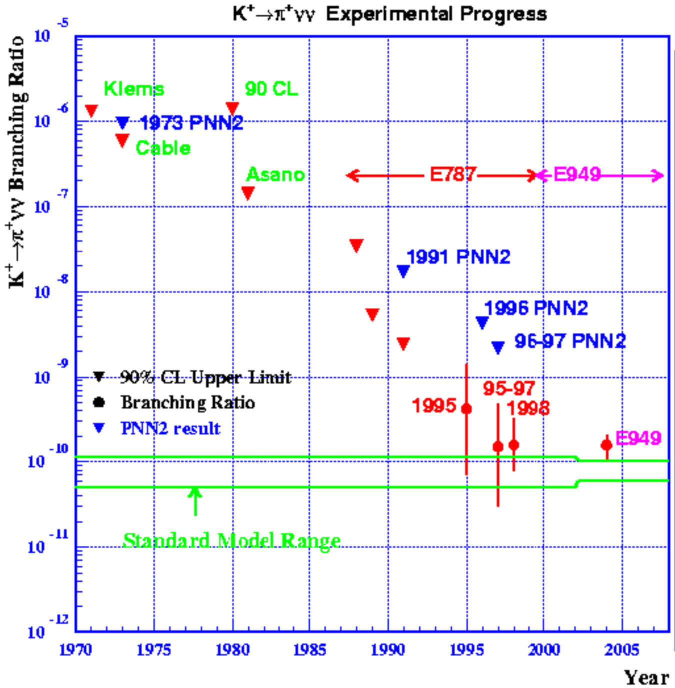
Present situation $K^+ \to \pi^+\nu\nu$

on (ρ ,η) plane

$$BR(K^+)^{exp} = (1.47^{+1.9}_{-0.9}) \cdot 10^{-10}$$

E787+E949 [BNL]





BR(SM) = $(8.5 \pm 0.7)\cdot 10^{-11}$

Non-parametric theoretical uncertainty ~ **5%** (11% overall)

No kinematic constraints. VETO !!!

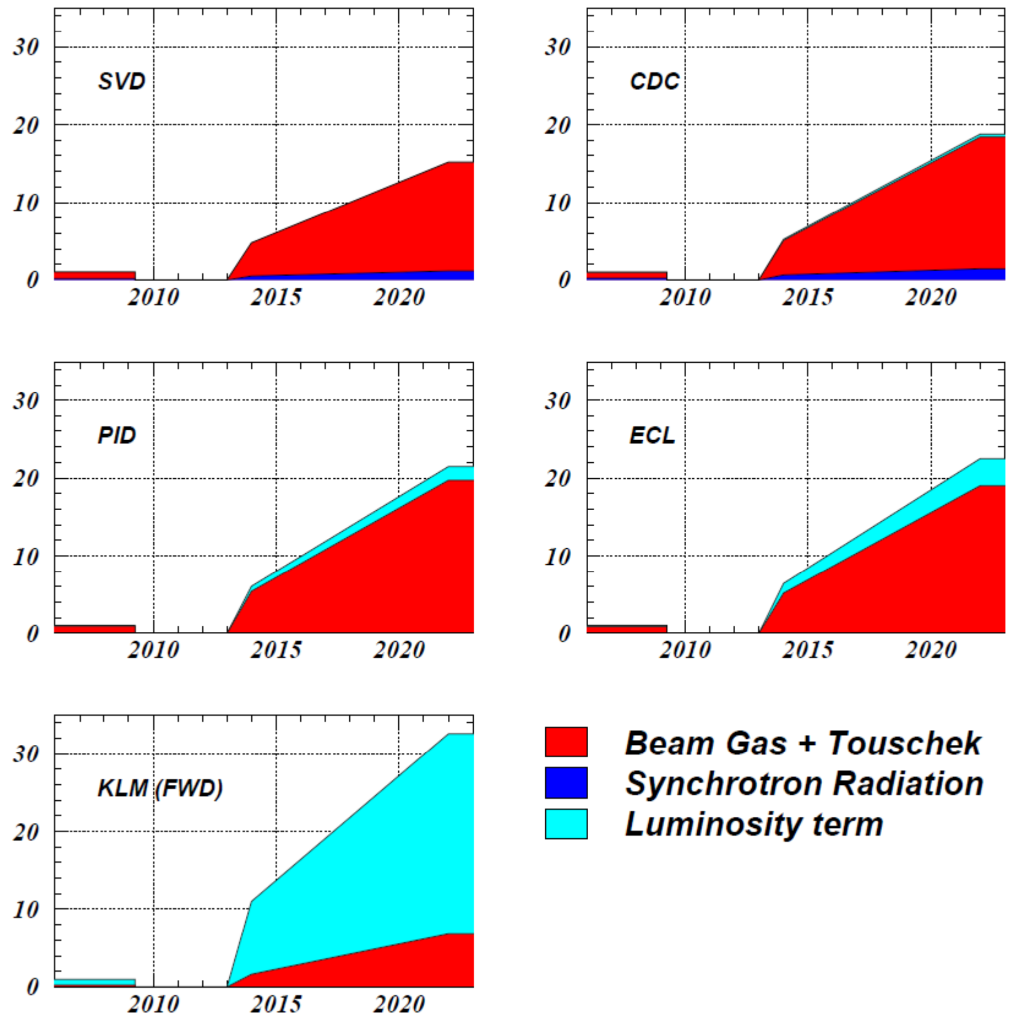
Background suppression 10^{11}: redundancy is a must.

Stopped K: separated beam, high effective decay rate, kinematics.

Measured @ BNL (3+4 events).

In-flight K: high veto efficiency, high acceptance.

Beam Background (extrapolation)



Prepare against 20x

Ideas to reduce background:
- Neutron shield for KLM
- Improve vacuum
- Cu chamber near IR
- Careful IR design