University of South Carolina

BEACH 2008

South Carolina

The 8th International Conference on Hyperons, Charm and Beauty Hadrons Symposium 2008

Summary

Disturbing the Universe

Patrizia Cenci – INFN Perugia (Italy)

Thanks and Apologies

- A lot of beautiful talks at this conference
- Very interesting results were shown

⇨ Flavour Physics is a very active field!

- Too much to cover at the level they deserve
- Personal choice for selection:
  - *my apologies if your bit of BEACH 2008 has not been used*
  - *the selection was restricted only for lack of time*
- Thank you all: credit goes to you, errors and omissions are mine

Aims and Outline

Discuss the current status and prospects for Flavour Physics, as shown by speakers

- *connection between measurements in flavour sector and physics beyond the Standard Model*
- *facilities: past, present and future*
- *most recent experimental results and theoretical developments*
- *the future of flavour physics*

Focus on: Beauty, Charm, Kaons and Hyperons, Heavy Leptons

Flavour Physics: the quest for New Physics

- Rabi question: *"Who ordered the muon?"*
  - *Flavour understanding as a bridge toward new physics at that time and now*
  - *Flaws in present description of Flavour Physics: a tool to access new physics beyond SM*
- Flavour Physics is one of the most appealing sector of study in particle physics
- Its main purpose is now to reveal new physics effects in flavour mixing, CPV and rare decays

⇨Let's hopefully disturb the (Standard) Universe in the very near future

Flavour parameters in Standard Model

- 6 quark masses
- 3 quark mixing angles + 1 phase
- 3 + 3 lepton masses
- 3 lepton mixing angles + 1 phase

N.B. with neutrino mass

⇨ quite a simple view, successfully described by the CKM mechanism in Standard Model, but…

Issues in Flavour Physics - I

- Families: 3 pairs of quarks and 3 pairs of leptons
  - ⇨ *Why 3 generations?*
- Hierarchies:
  - – $m(t) > m(c) > m(u)$, $m(b) > m(s) > m(d)$
  - – $m(\tau) > m(\mu) > m(e)$, $m(\nu_\tau) > m(\nu_\mu) > m(\nu_e)$
    - ⇨ *What is the origin of particle masses?*
    - ⇨ *How to explain the pattern of quark masses?*
    - ⇨ *How to explain the smallness of neutrino masses?*

Issues in Flavour Physics - I

- Mixing and couplings: no FCNC, Universality
  - ⇨ *How to explain the pattern of quarl mixing?*
  - ⇨ *Why a small quark mixing and a large lepton mixing?*
- Violation of simmetry laws:
  - P / C violation, CP / T violation
  - Lepton Flavour violation
    - ⇨ *What is the origin of simmetry violation?*
    - ⇨ *Where are the right handed neutrinos?*
    - ⇨ *How to explain matter-antimatter asimmetry in the Universe?*

Tools

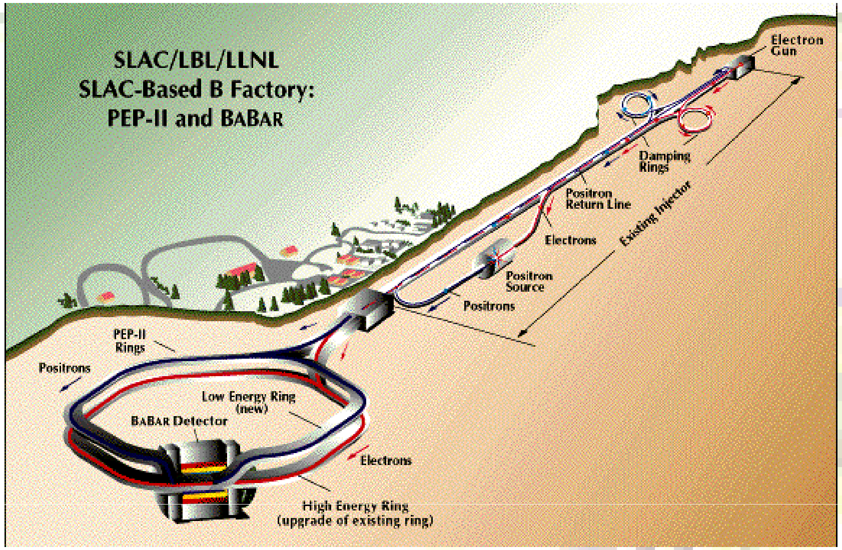
Flavour Physics machines

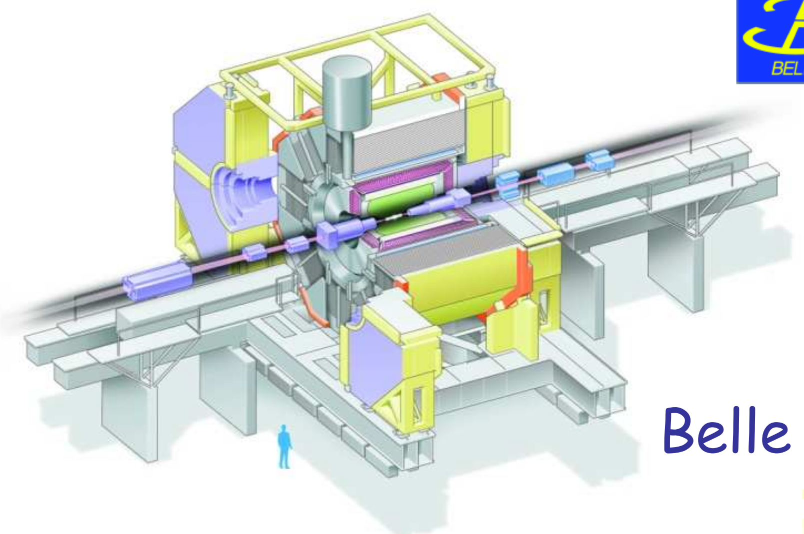
- Fixed target and symmetric colliders featuring hadron beams
- Symmetric and asymmetric colliders featuring electron-positron beams
- Complementarity of the high intensity and the high energy frontiers
- Aiming at:
  - discovery of new particles
  - precision studies of their properties

Two existing B-factories

KEK

SLAC



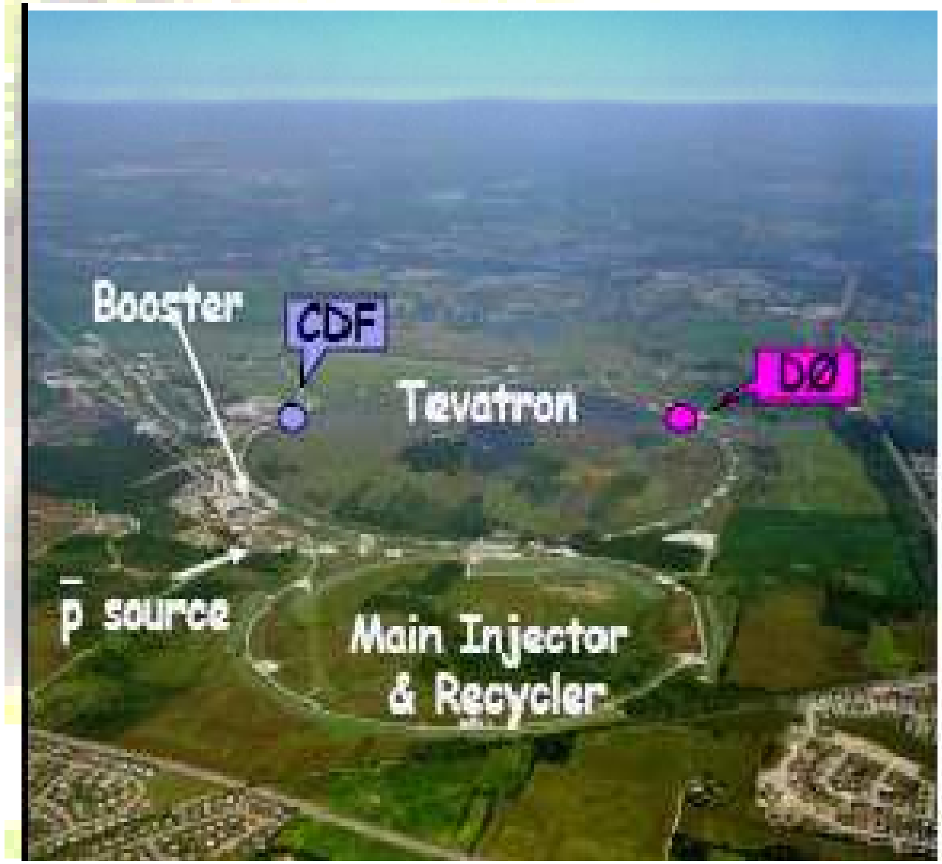


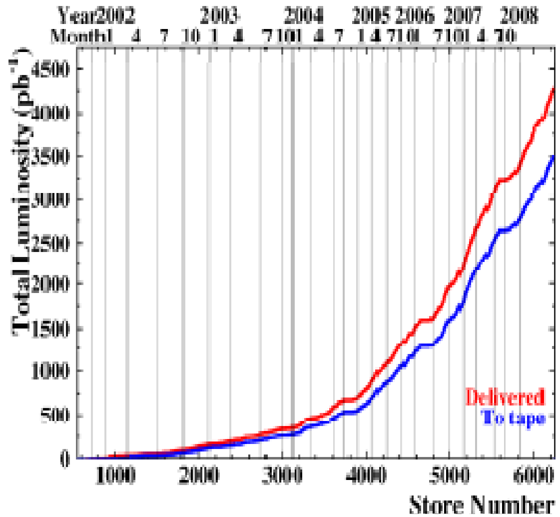
Belle

BaBar

FNAL: Tevatron and extracted beams

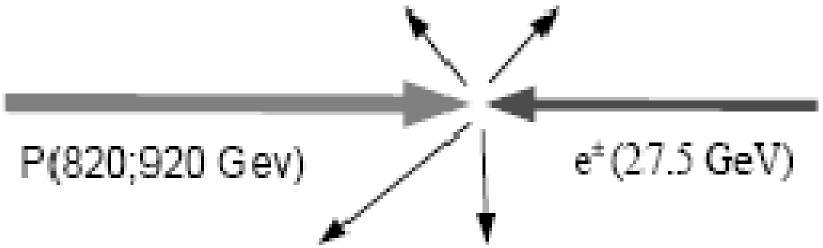
- The CDF and D0 experiments at the Tevatron
- Experiments at the extracted hadron beams:
  - FOCUS and E791; E907 (MIPP), HyperCP



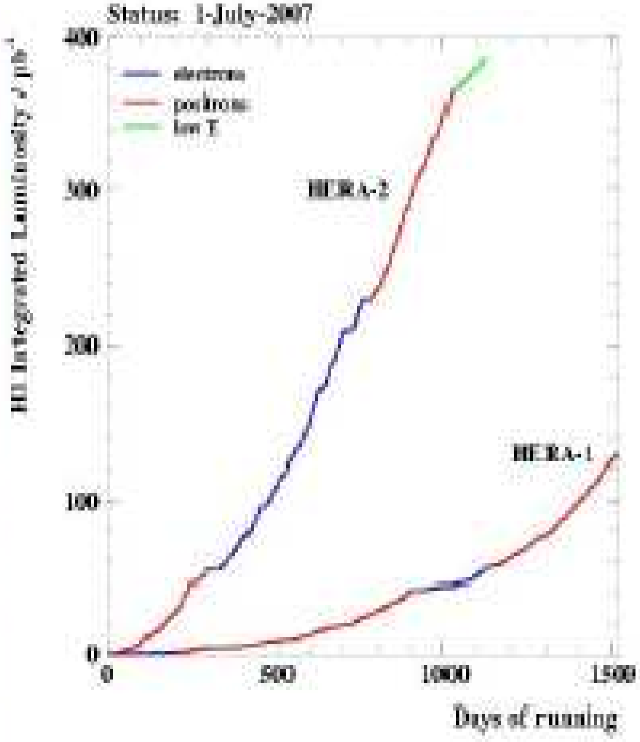


- Tevatron: $p\bar{p}$ collisions at 1.96 TeV
- Run II started in March 2001
- Peak Luminosity: 2.85 x 10^{32} cm^{-2}s^{-1}
- Delivered: 4.2 fb^{-1} (~3.5 fb^{-1} on tape)
- 6 fb^{-1} expected by April 2009
- 8 fb^{-1} by end of FY2010

HERA



Data taking periods:
HERA I : 1992-2000
HERAII : 2002-2007

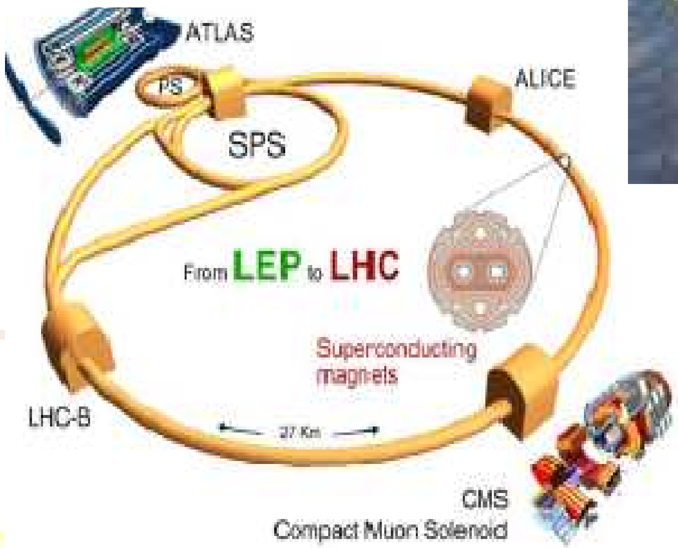


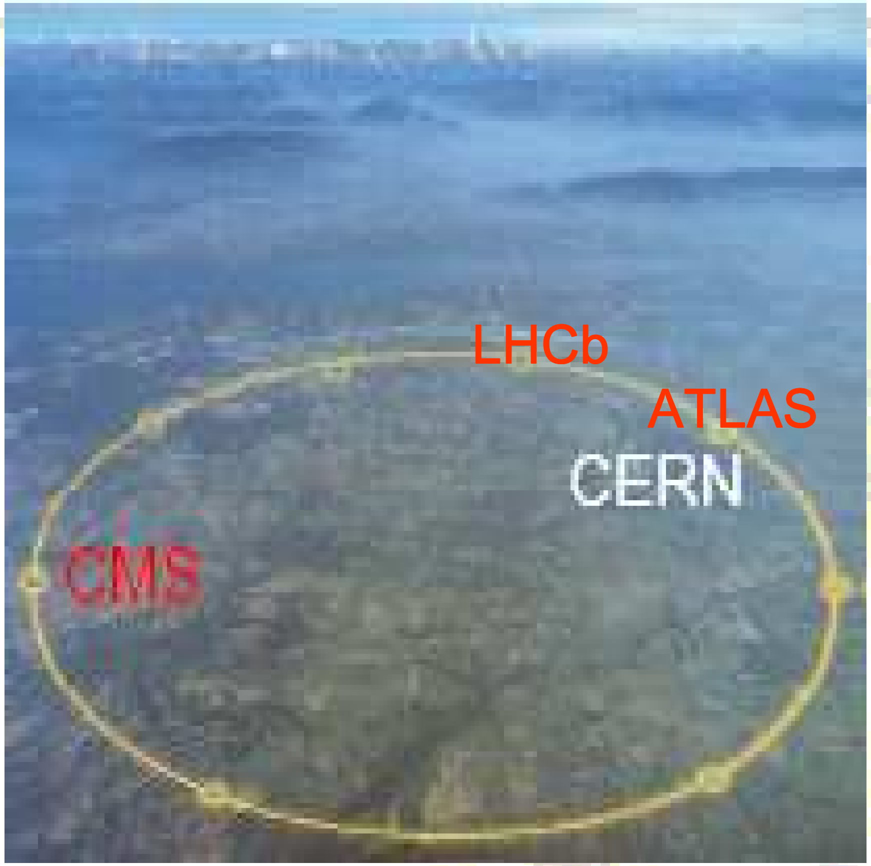
~0.5 fb^{-1} per experiment

CERN: LHC and fixed target

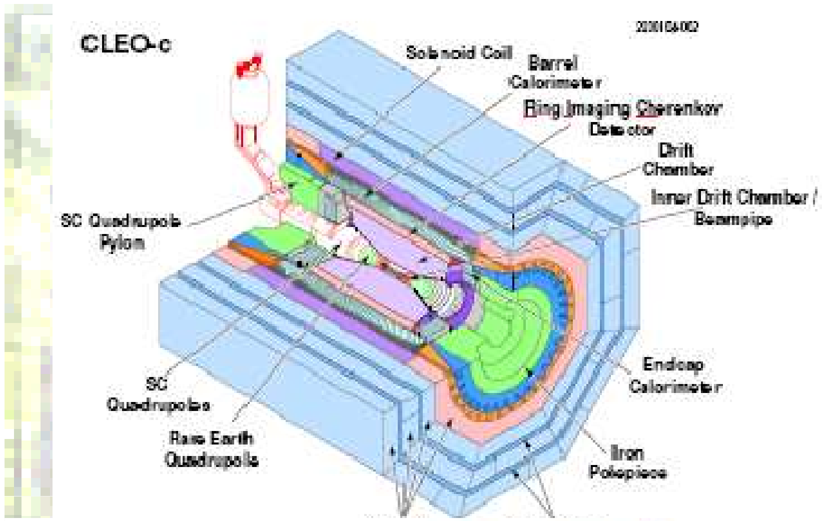
The Large Hadron Collider

- pp collisions at $\sqrt{s} = 14\ \mathrm{TeV}$
- Design luminosity $10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
  - $\sim 100\ \mathrm{fb}^{-1}$/year
- Bunch crossings every 25 ns
- Expect 10 – 20 minimum bias interactions per crossing
- $\sim$ 1000 charged tracks per crossing

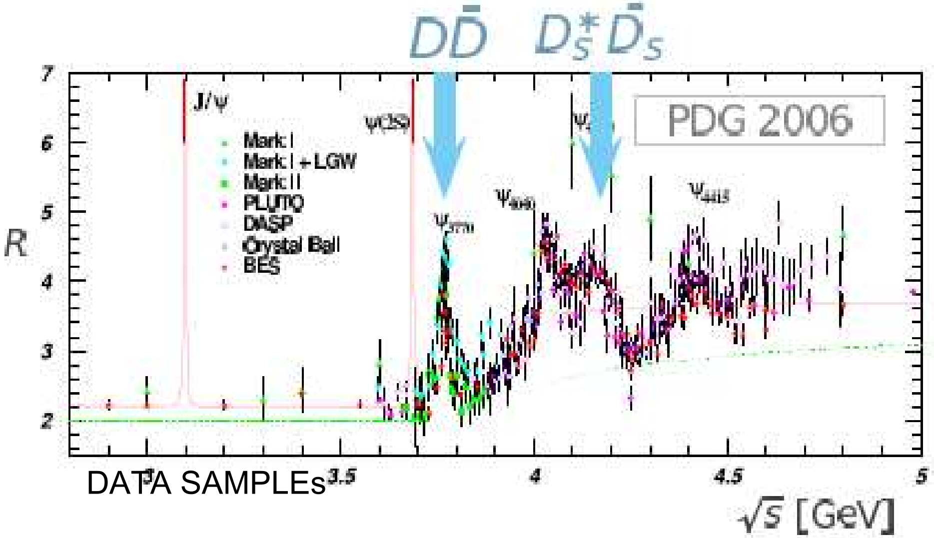




The Cornell Electron Storage Ring



The CLEO-C experiment

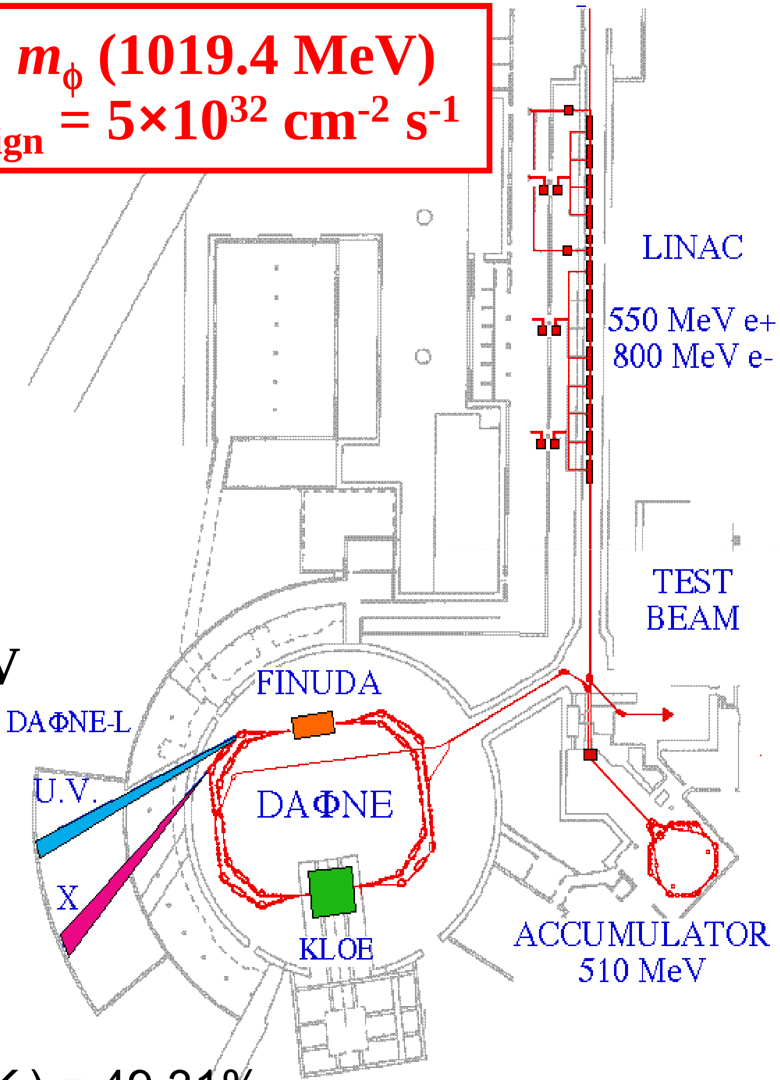


DATA SAMPLEs

- $D\bar{D}$ @ 3770 : 818 pb^{-1} (281 pb^{-1} $\sim 1.8 \times 10^6 D\bar{D}$);
- $D_s^*\bar{D}_s$ @ 4170 : 602 pb^{-1} (298 pb^{-1} $\sim 0.29 \times 10^6 D_s^*\bar{D}_s$)

The DAΦNE e^+e^- collider

$W = m_\phi$ **(1019.4 MeV)**
$\mathcal{L}_{design} = 5\times10^{32}\ \mathrm{cm^{-2}\ s^{-1}}$



Collisions at cm energy around m_ϕ: $\sqrt{s}$ ~ **1019.4 MeV**

Angle between the beams @ IP: **α ~ 12.5 mrad**

Residual laboratory momentum of ϕ: **p_ϕ ~ 13 MeV**

Cross section for ϕ production @ peak: **σ_ϕ ~ 3.1 μb**

K from Φ Decays: BR($\Phi\rightarrow K_LK_S$) = 34.3%   BR($\Phi\rightarrow K^+K^-$) = 49.31%

tagged K decays from $\Phi \rightarrow \overline{K}K$ ⇒ pure K beams

→ *clean investigation of K decays and precision measurements*

Theoretical tools

- Sharpen theoretical tools to achieve stringent evidence for new effects eventually due to new physics
- Theories, models and phenomenological approaches at different energy scales, interpretation of data and possible hits for new physics
- Results on:
  - Lattice QCD:
    - *Hyperons: resonances, axial couplings and form factors, semileptonic decays*
    - *B mesons: semileptonic decays and mixing*
  - Non Relativistic QCD:
    - *polatization of J/ψ at Tevatron,*
    - *solution for the e+e-⟶ J/ψ ηc puzzle at B factories*
  - AdS/QCD: a link between gauge theories anfd gravitational theories
  - Chiral Perturbation Theory : precision tests up to higher orders (O(p6))
  - Constituent Quark Model : accounts for B barion masses
  - Anomalies: a new class of SM interactions
  - The global effort of the european FlaviaNet network

and many others

Karliner, Smith, Passemar, Hill, Lunghi, Lee, Carlson, Lin, Gamiz

B physics

- Aymmetric B factory to measure decay time in $e^+e^- \to \Upsilon(4S) \to B^0 \overline{B^0}$
  $\to$ world record luminosity

Wang Martinez-Vidal Suzuki Gao Yabsley Kinoshita Brown Santoro Etzion T'Janmpens

- Complementary and different informations from hadron machines

Giurgiu Ulmer Fisk Brock Garcia-Guerra De La Cruz-Burelo

- Interesting results shown: many update of existing measurements and several new ones
  - *Some measurements approaching the accuracy needed to test SM*
  - *Possible hints of new physics beyond SM?*
  - *Some point deserves thorough studies*

Karliner Smith Hill Lunghi Lee

- Future prospects

Personal selection

1977

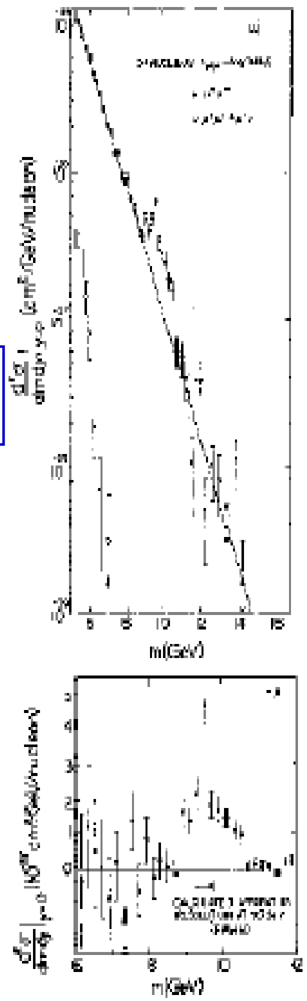


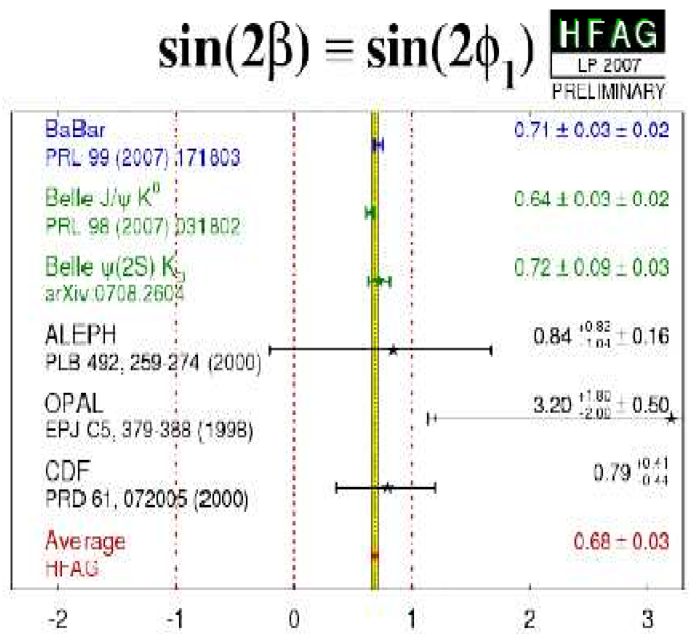
FIG. 5. (a) Measured dimuon production cross sections as a function of the invariant mass of the muon pair. The solid line is the continuum fit outlined in the text. The equal-sign-dimuon cross section is also shown. (b) The same cross sections as in (a) with the smooth exponential continuum fit subtracted in order to reveal the 8–11-GeV region in more detail.

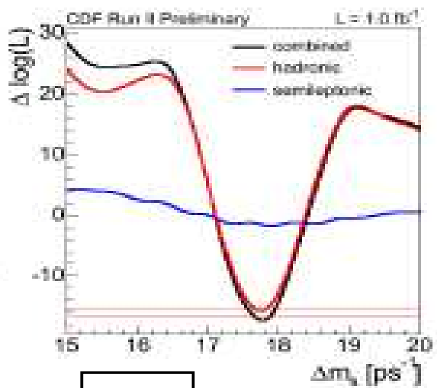
B- factories: physics reach

- Direct CPV:
  - Golden mode: b to ccs tree diagram
  - Also: charmless rare decays
- Unitarity Triangle and CKM constraints
- B Mixing:
  - large mixing probability
  - large mixing in Bs
- Rare decays
- Charm and charmonium, Tau

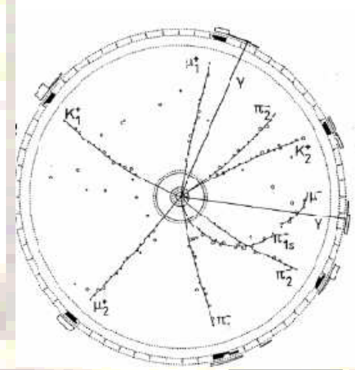
and much more

Compilation of results



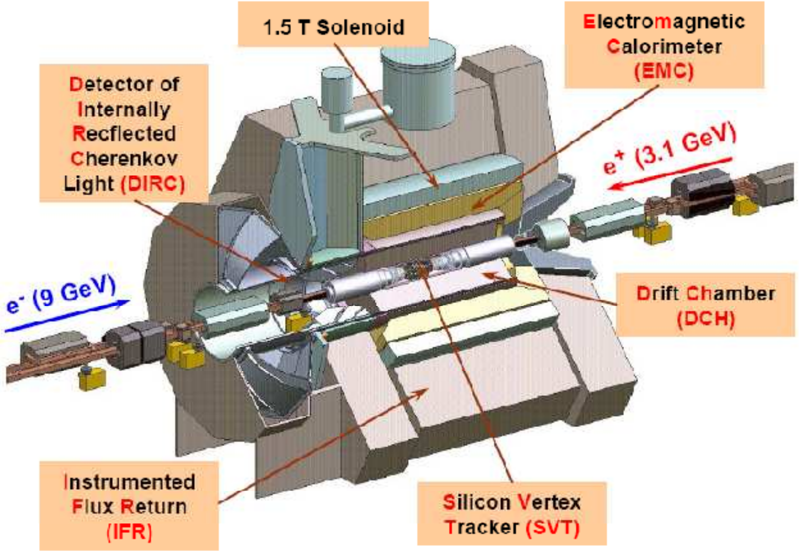


2006



1987

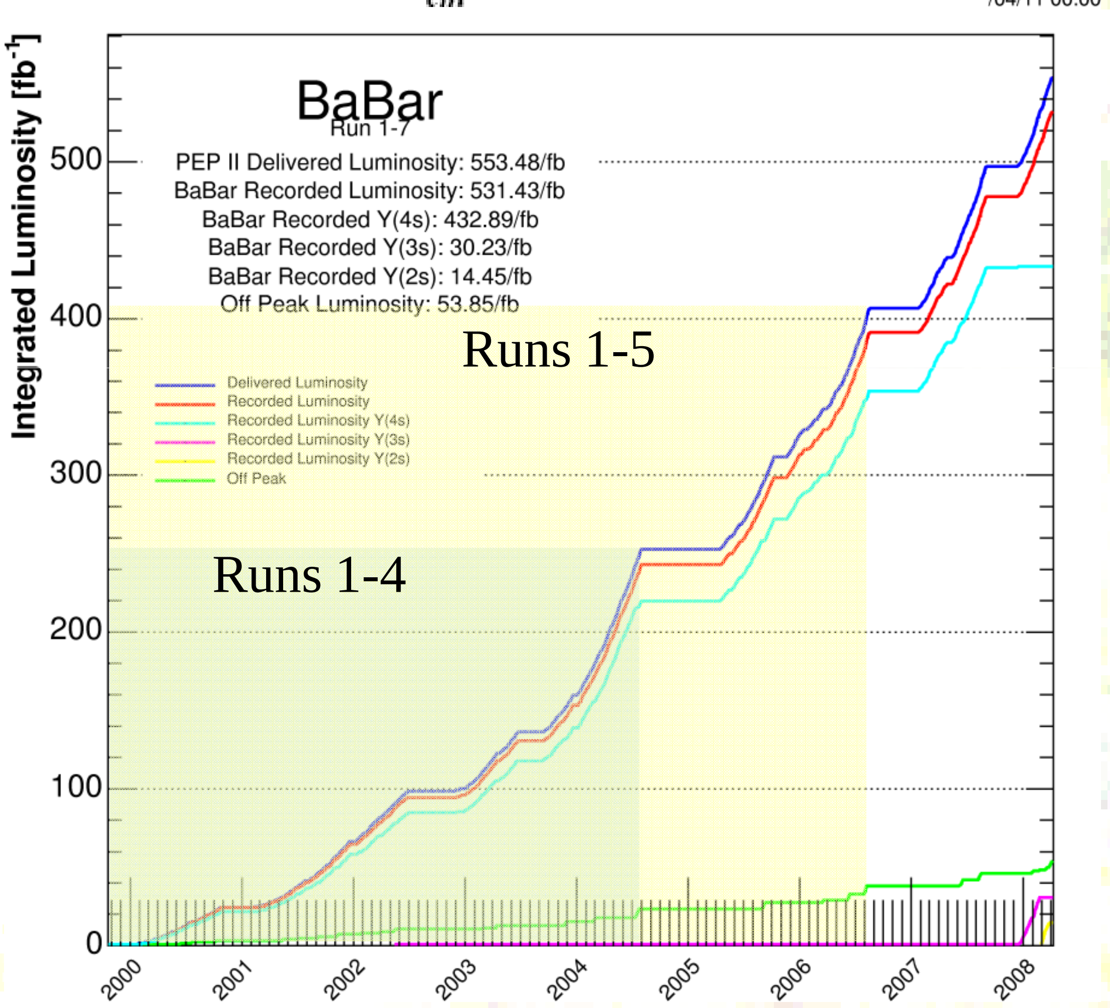
The Babar running period



First collision: May 26, 1999
Final collisions 12:43pm, Monday 7 Apr 2008

$$e^+e^- \to \Upsilon(4S) \to B^0\bar{B}^0,\ B^+B^-$$

$$E_{cm} = 10.58\ \mathrm{GeV}$$

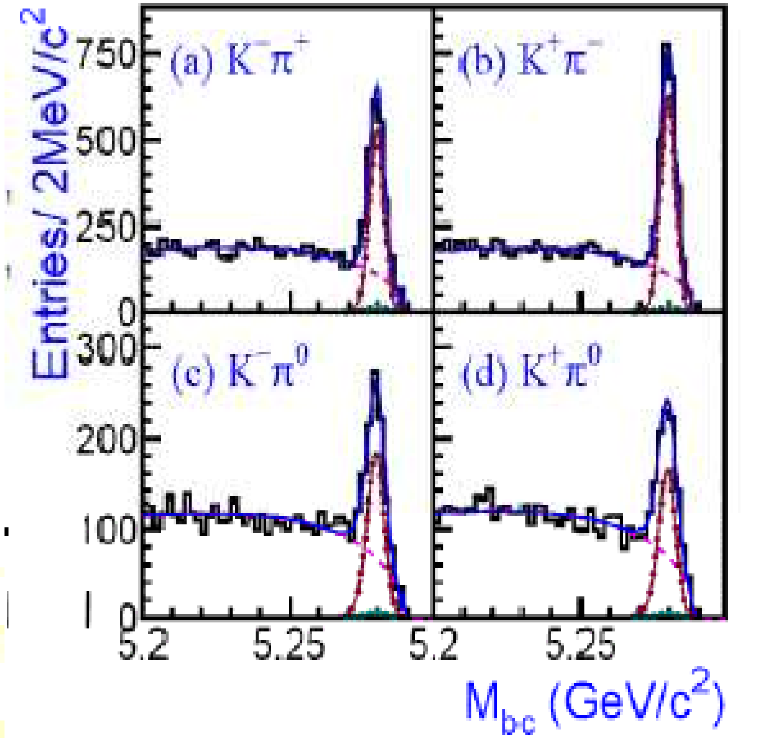


(final run cut short by 6 months)

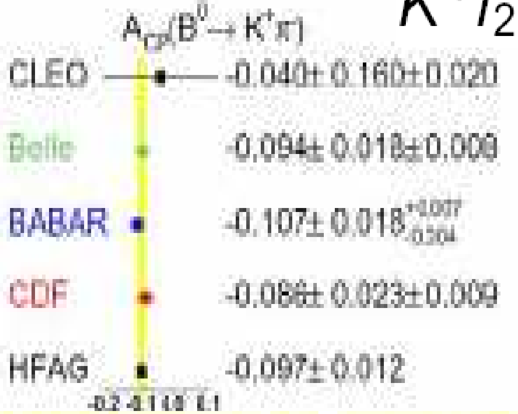
Direct CP Violation in B → K π

Wang
Suzuki

- Dominant process in B decays: b → c
- Rare (charmless) B decays: good searching ground for DCPV
- CPV well established in B → K π asimmetry measurement (Belle, 2008): $\Delta\mathcal{A} \equiv \mathcal{A}_{K^\pm\pi^0} - \mathcal{A}_{K^\pm\pi^\mp} = +0.164 \pm 0.037$

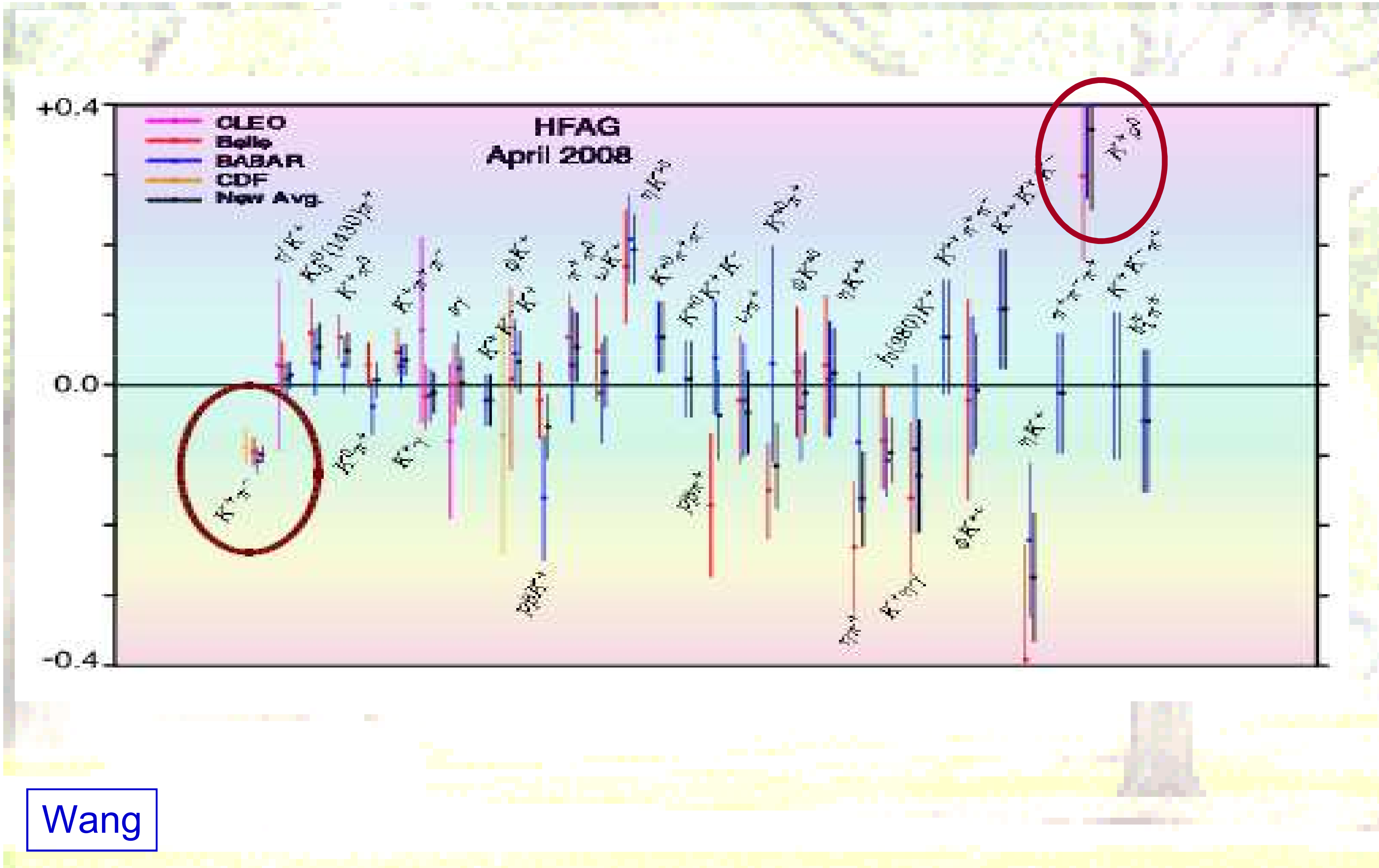


- 4σ evidence for $B^+ \to K^+\pi^+\pi^-$ (Babar 2008, Dalitz analysis)
  - Acp: $K^+\rho^0$: $0.44 \pm 0.10^{+0.06}_{-0.14}$
    $K^+ f_2$: $-0.85 \pm 0.22^{+0.26}_{-0.13}$

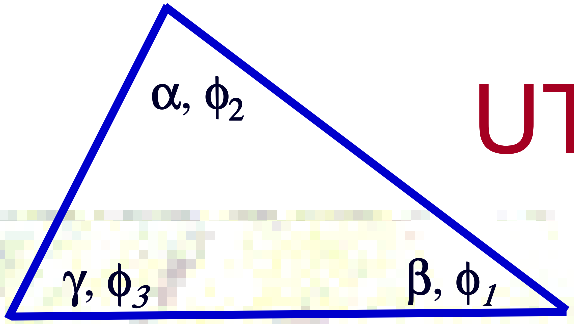


$$A_f = \frac{\Gamma(M^- \to f^-) - \Gamma(M^+ \to f^+)}{\Gamma(M^- \to f^-) + \Gamma(M^+ \to f^+)}$$

CP Asymmetry in charmless B decays



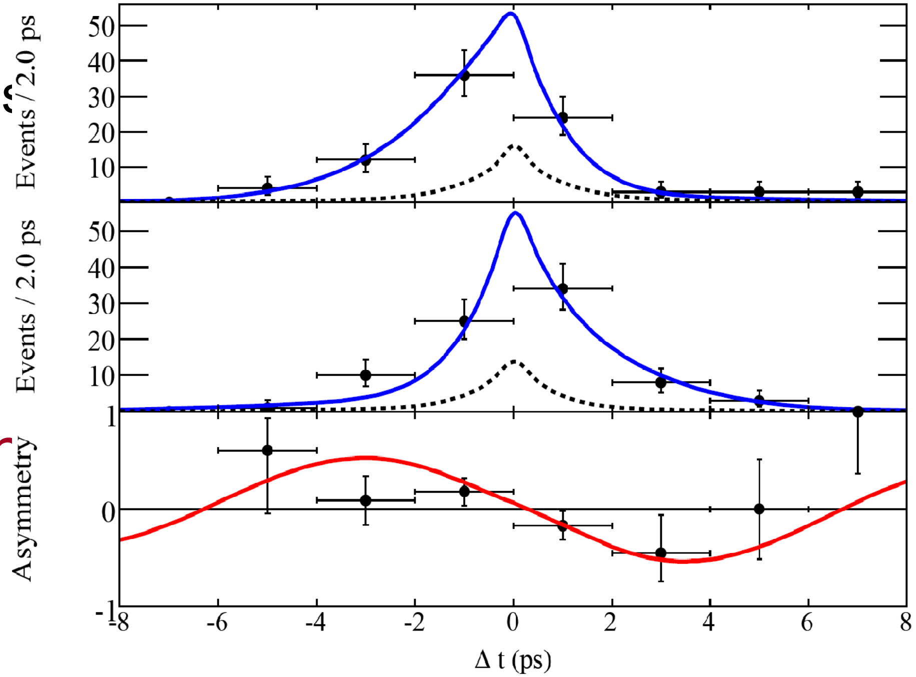
Wang



UT angles at BABAR

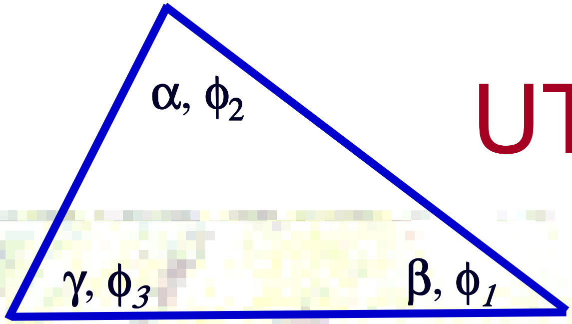
Martinez-Vidal

- Measuring β: b→ccs decays ("golden modes")
- b→ccd decays: new result
  - If penguins with additional phases do not contribute, SM predicts S=sin2β, C=0
  - new 4σ evidence for CPV in $B^0 \rightarrow J/\psi\pi^0$



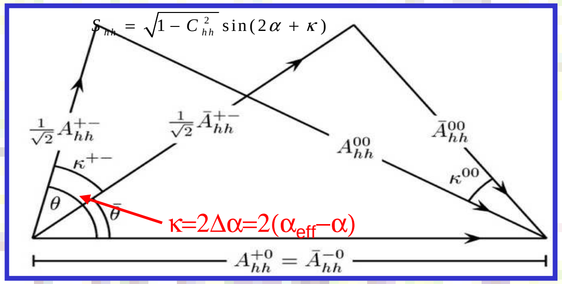
$$BF = (1.69 \pm 0.14 \pm 0.07) \times 10^{-5}$$
$$S = -1.23 \pm 0.21 \pm 0.04$$
$$C = -0.20 \pm 0.19 \pm 0.03$$

- β in charmonium is a precision measurement:
  - $\delta(\sin 2\beta)$~0.035 (2%) approaching accuracy of SM calculations (~1%)
- All β measurements in many different channels are consistent



UT angles at BABAR

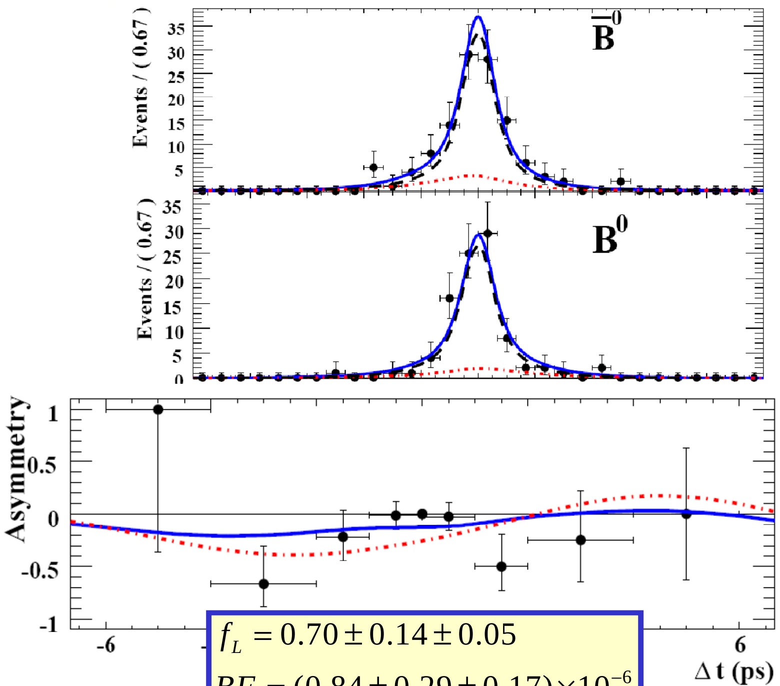
- Measuring α: interference of b→u decay (γ) with B^0-$\bar{B}^0$ mixing (2β) complicated by penguin contribution
  - Triangle construction: difference $\alpha_{eff} - \alpha$



α from $B^0 \to \pi^+\pi^-$: no news
  - still 2.1σ discrepancy between Babar-Belle

α from $B^0 \to \rho^0\rho^0$, isospin analysis:
  - first measurement (2007 result) of the time dependent CP asymmetries in $\rho^0\rho^0$
  - Isospin analysis to extract α (2007)

α from $B^0 \to \pi^+\pi^-\pi^0$: time dependent Dalitz analysis assuming isospin simmetry (2007)



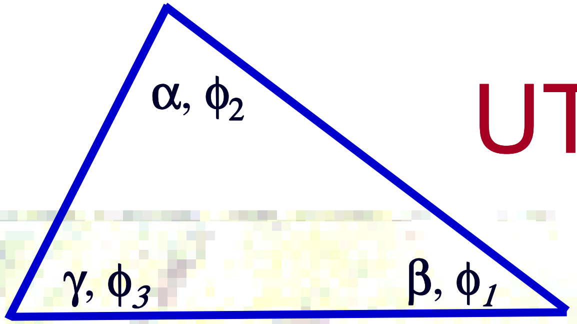
$f_L = 0.70 \pm 0.14 \pm 0.05$

$BF = (0.84 \pm 0.29 \pm 0.17) \times 10^{-6}$

$S_{L,00} = 0.5 \pm 0.9 \pm 0.2$

$C_{L,00} = 0.4 \pm 0.9 \pm 0.2$

Martinez-Vidal



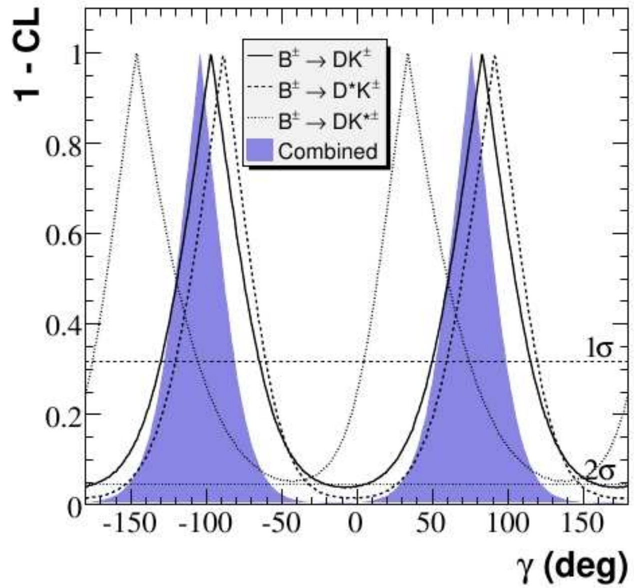
UT angles at BABAR

- Measuring γ: theoretically clean measurement from $B \to D^{(*)}K^{(*)}$:
  - use interference between $b \to cus$ and $b \to ucs$ decay processes: relative weak phase is γ
  - NEW RESULT 2008: measurement from $B^+ \to D^{(*)}K^+$
    - Improved Dalitz plot analysis
    - 3σ significance of direct CPV

$$\gamma = (76^{+22}_{-23} \pm 5 \pm 5)^{o}$$

$$\gamma = (76^{+12}_{-13} \pm 4 \pm 9)^{o}$$

stat exp model



Martinez-Vidal

Radiative B meson decays

- Sensitive probes of BSM physics:
  - Important to reduce the experimental uncertainty
- Most precise updated measurement:

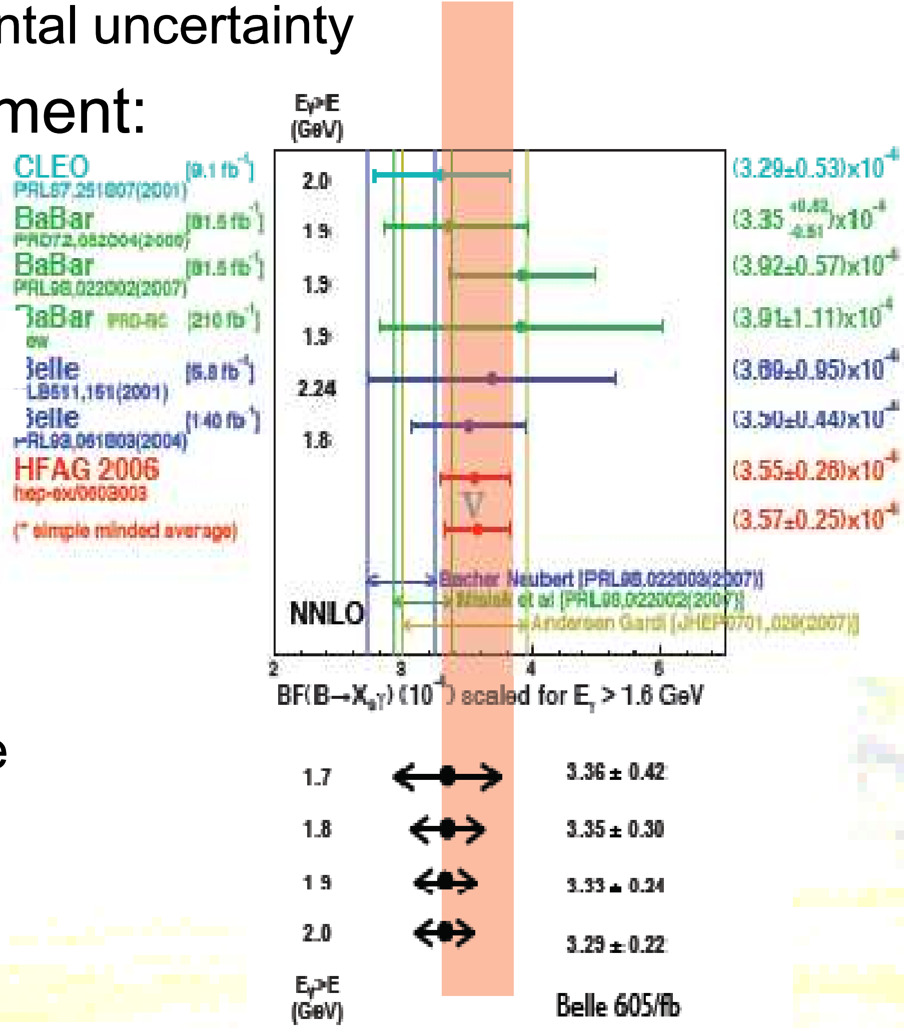
$$\mathcal{B}(B \to X_s\gamma)|_{E_\gamma > 1.7\,\mathrm{GeV}} =$$

$$= (3.31 \pm 0.19 \pm 0.37 \pm 0.01) \times 10^{-4}$$

stat sys boost

(preliminary)

  - Tighter constraints on NP
  - Reduced uncertainty on m_b → improve UT knowledge
  - Inclusive measurements well done only at e+e- machines



Kinoshita

Open points in charmless B decays

- CP violating Asymmetry puzzle: $\Delta A_{CP}(B \to K\pi)$

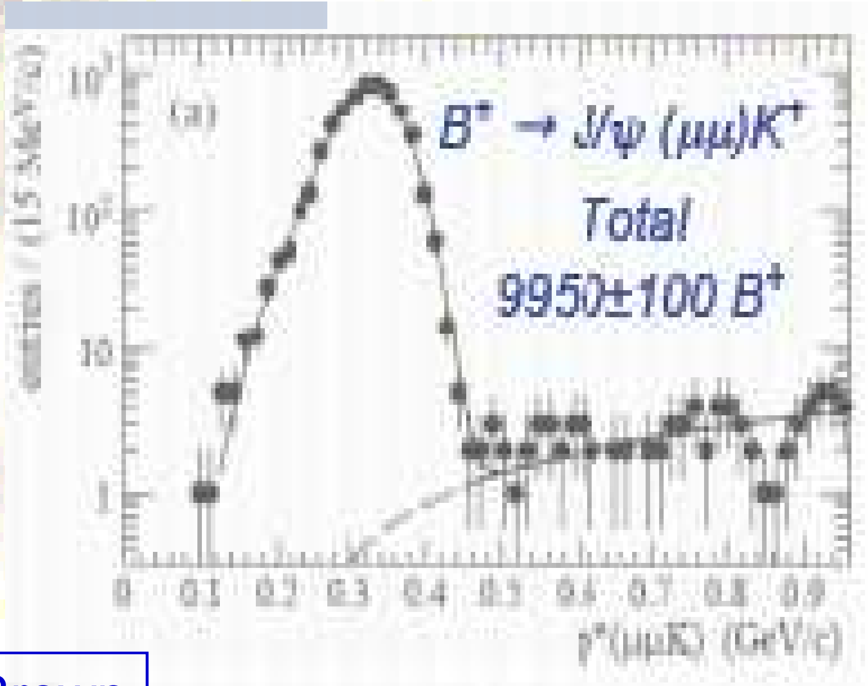
  ΔS puzzle
- polarization puzzle in decays to two Vectors
- threshold enhancements in all charmless baryonic B decays

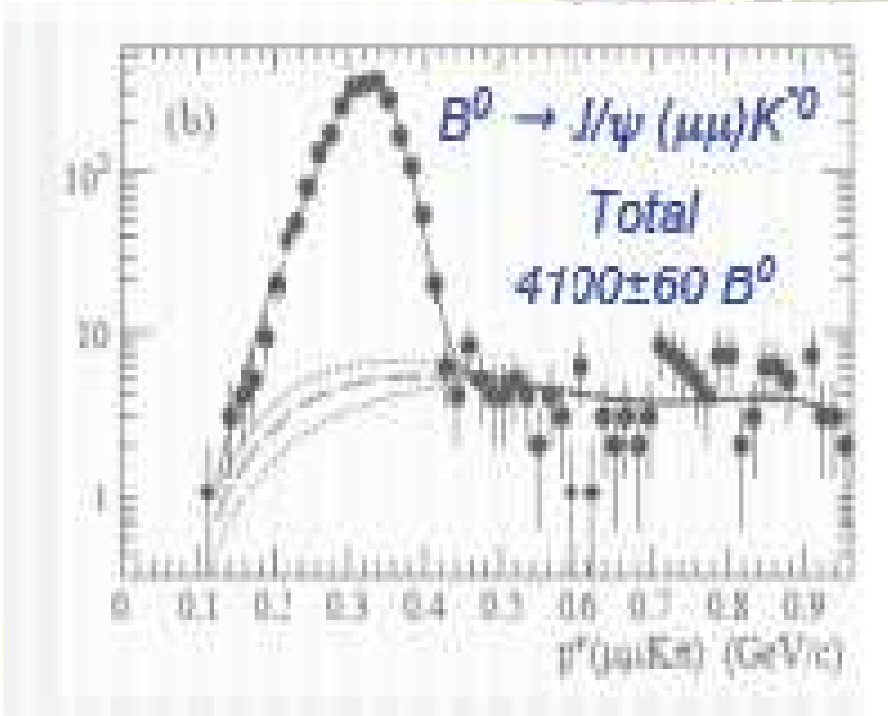
⇨ Need theoretical inputs

Wang
Suzuki
Gao

Among other results….

- First observation of e+e- →pp̄pp̄ (BABAR)
  - Previously unobserved, production mechanism to be understood
- B^0-B^+ mass difference established at the 5σ level (BABAR)

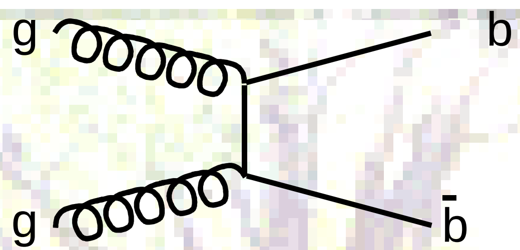




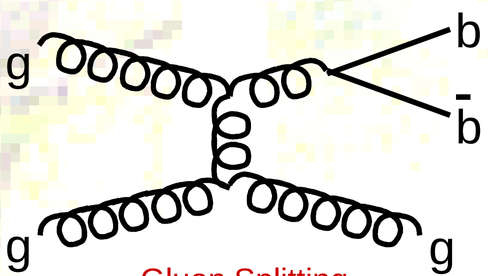
Brown

B Physics at the Tevatron

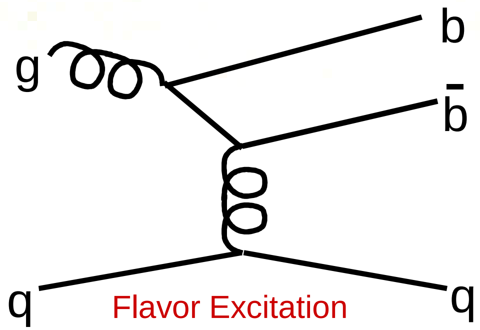
- Mechanisms for b production in $p\bar{p}$ collisions at 1.96 TeV



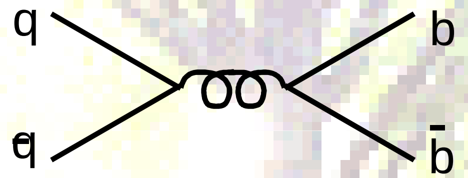
Flavor Creation (gluon fusion)



Gluon Splitting



Flavor Excitation



Flavor Creation (annihilation)

- At Tevatron, b production cross section is much larger compared to B-factories
  $\rightarrow$ Tevatron experiments CDF and DØ enjoy rich B Physics program

- Plethora of states accessible only at Tevatron: B_s, B_c, Λ_b, Ξ_b, Σ_b…
  $\rightarrow$ complement the B factories physics program

- Total inelastic cross section at Tevatron is ~1000 larger than b cross section
  $\rightarrow$ large backgrounds suppressed by triggers that target specific decays

Mass and lifetime of B_c

- Measurement of B_c mass in $B_c \to J/\psi\ \pi$
  - CDF (2.4 fb^{-1}):

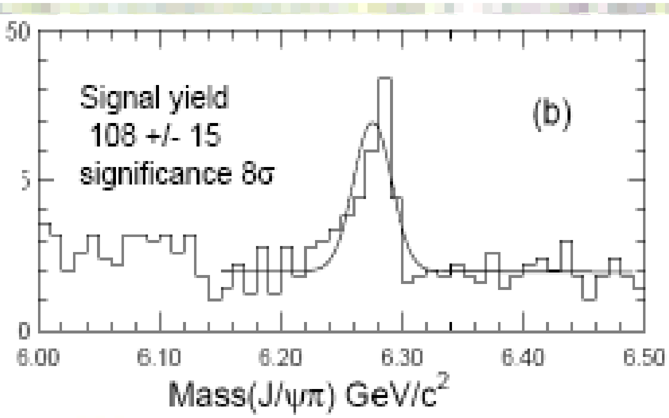
    $$6275.6 \pm 2.9\ (\text{stat.}) \pm 2.5\ (\text{syst.})\ \text{MeV}/c^2$$

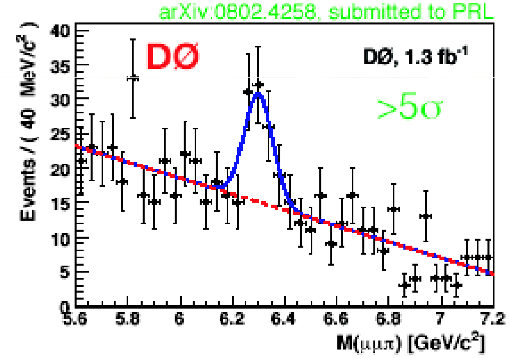
  - D0: $\boldsymbol{m(B_c^+) = 6300 \pm 14 \pm 5\,\text{MeV}}$
- Measurement of B_c lifetime in $B_c \to J/\psi$ leptons
  - CDF (1 fb^{-1}) $\tau = 0.459 \pm 0.037$ ps

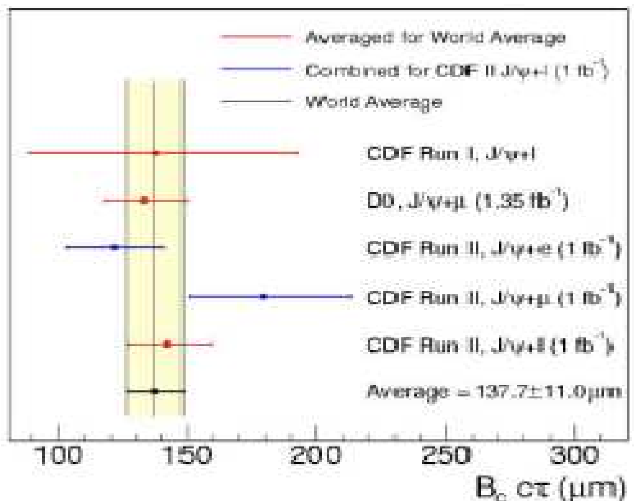
    $$c\tau = 142.5^{+15.8}_{-14.8}\ (\text{stat.}) \pm 5.5\ (\text{syst.})\ \mu\text{m}.$$

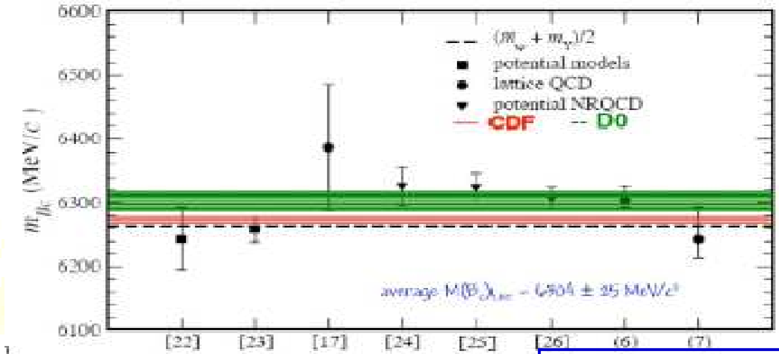
  - D0:

    $\tau(B_c) = 0.448\ {+0.038}/{-0.036}(\text{stat}) \pm 0.032(\text{sys})$ ps





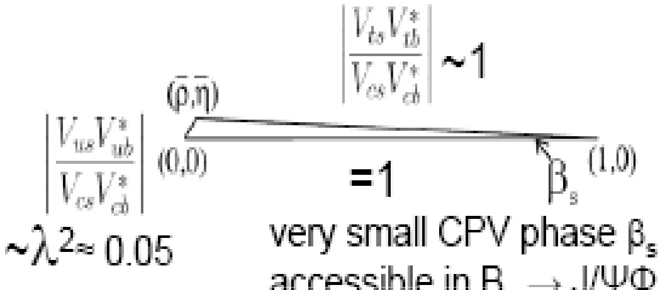




Fisk, Giurgiu

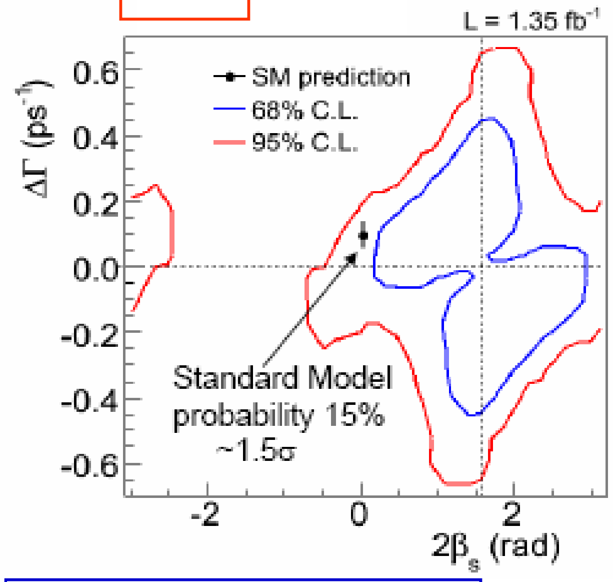
CP Violation in $B_s \to J/\psi\ \Phi$

- CP Violation studied using $B_s \to J/\psi\ \Phi$ decays
- Both CDF and D0 analysis results deviated from Standard Model
- New physics or only fluctuations?
- Soon HFAG combined CDF+D0 results

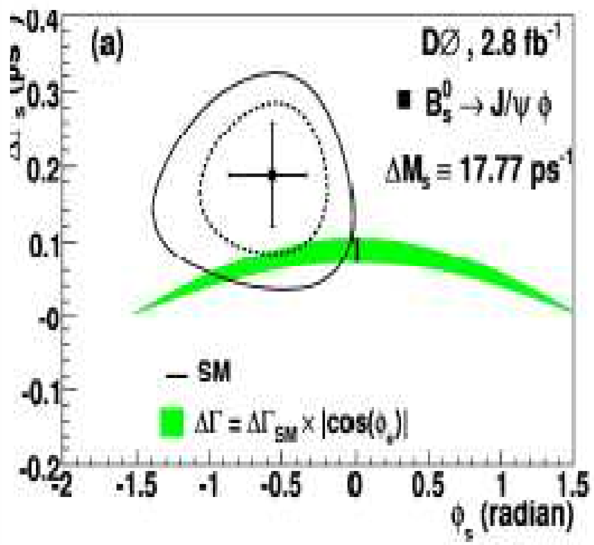


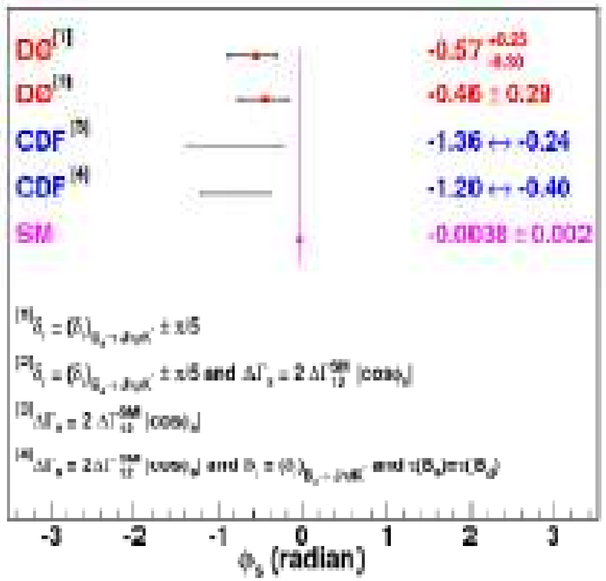
very small CPV phase β_s
accessible in $B_s \to J/\Psi\Phi$ decays

CDF



D0





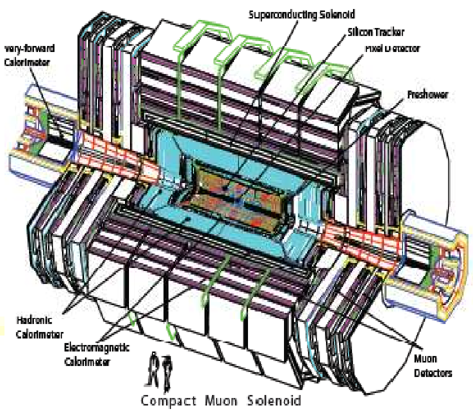
Garcia-Guerra, Giurgiu

B physics at LHC

T'Jampens, Smith, Etzion, Ulmer, De La Cruz Burelo

- One dedicated experiment (LHCb)
- Two multipurpose experiments (ALTLAS and CMS):
  - Large $b\bar{b}$ cross section $\sigma_{b\bar{b}} \sim 500\mu b$ (5×10^{11} $b\bar{b}/\mathrm{fb}^{-1}$)
    - ~ 10 times larger than at the Tevatron
    - $\sim 500,000$ times larger than at the B-factories
  - Best prospects for flavor physics in "low luminosity" start up
    - Initial $\mathcal{L} = 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ after checkout (~ 1 $\mathrm{fb}^{-1}/\mathrm{yr}$)
    - Proceed to ramp up to $\mathcal{L} = 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ (~ 100 $\mathrm{fb}^{-1}/\mathrm{yr}$)

CMS Detector



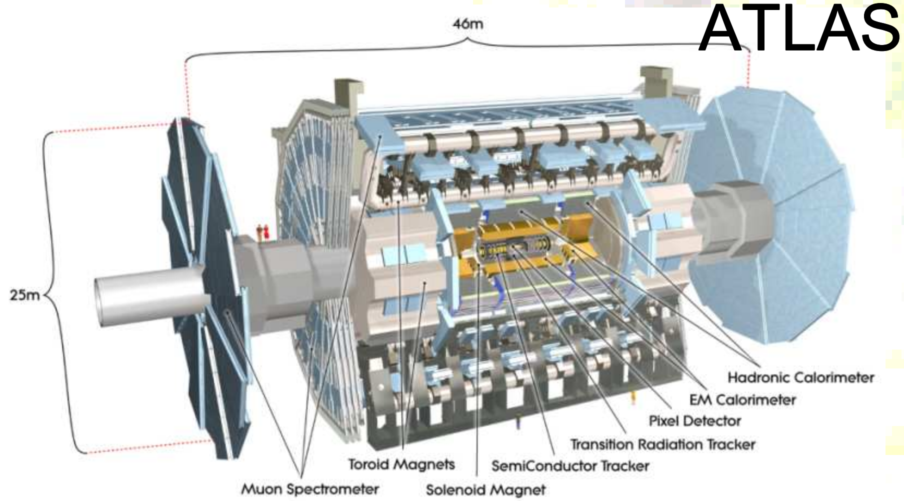
magnet:
4 Tesla superconducting solenoid
successfully tested

calorimeters:
ECAL: 76000 crystals of $PbWO_4$
HCAL: brass absorber + scintillator sandwich

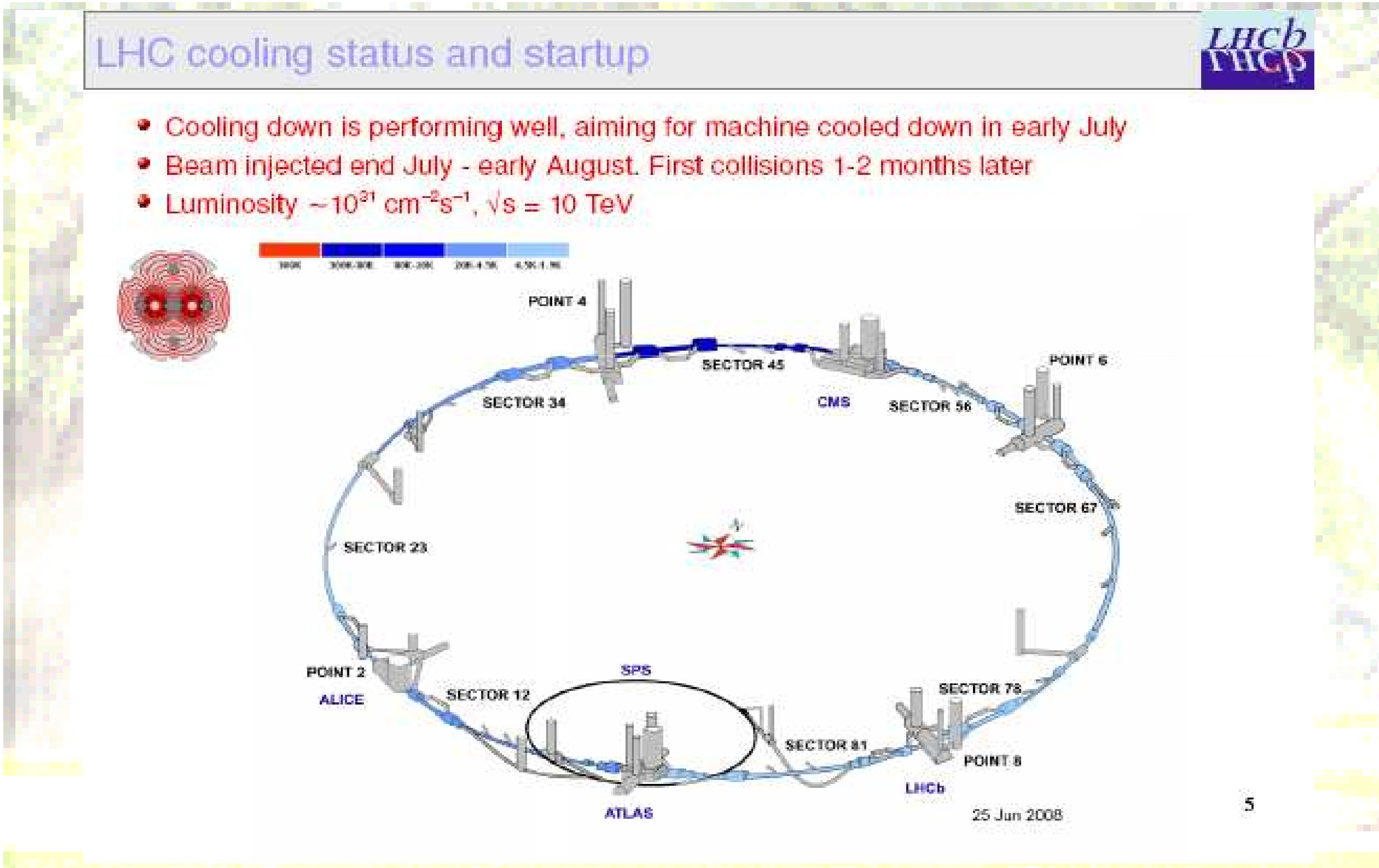
muon system:
barrel: drift tubes
endcap: cathode strip chambers
barrel+endcap: resistive plate chambers

trigger:
40 MHz bunch crossing rate reduced to 100Hz by Level-1 and High Level Triggers

ATLAS



Status of LHC: running soon….



The LHCb experiment

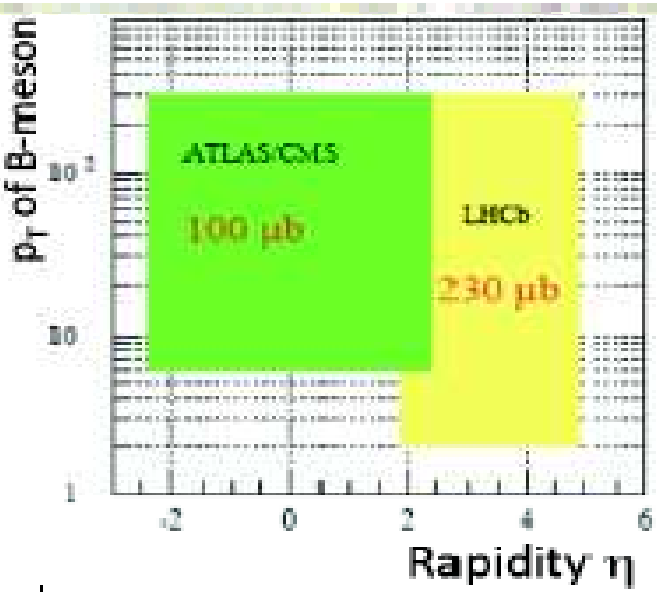
large cross section:

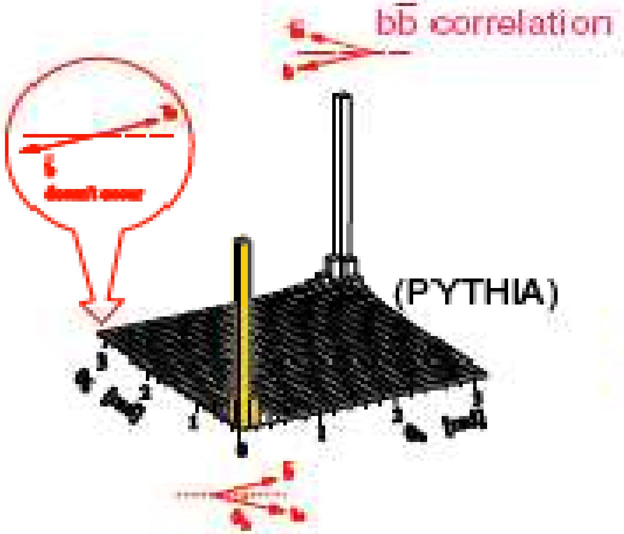
- 500 μb (230 μb in 4.9 > η >1.9 (forward region))

All species of B hadrons produced:

- ($B^{\pm}$, B_d, B_s, B_c, b-baryons) [40%,40%,10%,0.1%,10%]

$\sigma_{bb}/\sigma_{inel}$ = 0.6% at LHC: trigger is a major issue

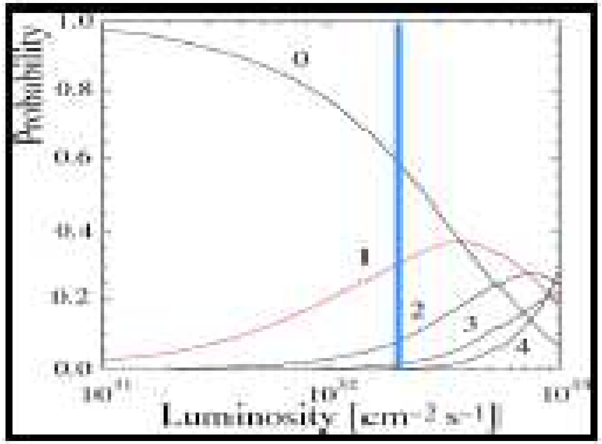




$b\bar{b}$ production correlated and sharply peaked forward backward:
single-arm spectrometer is OK since b quarks are correlated
➔ important for tagging

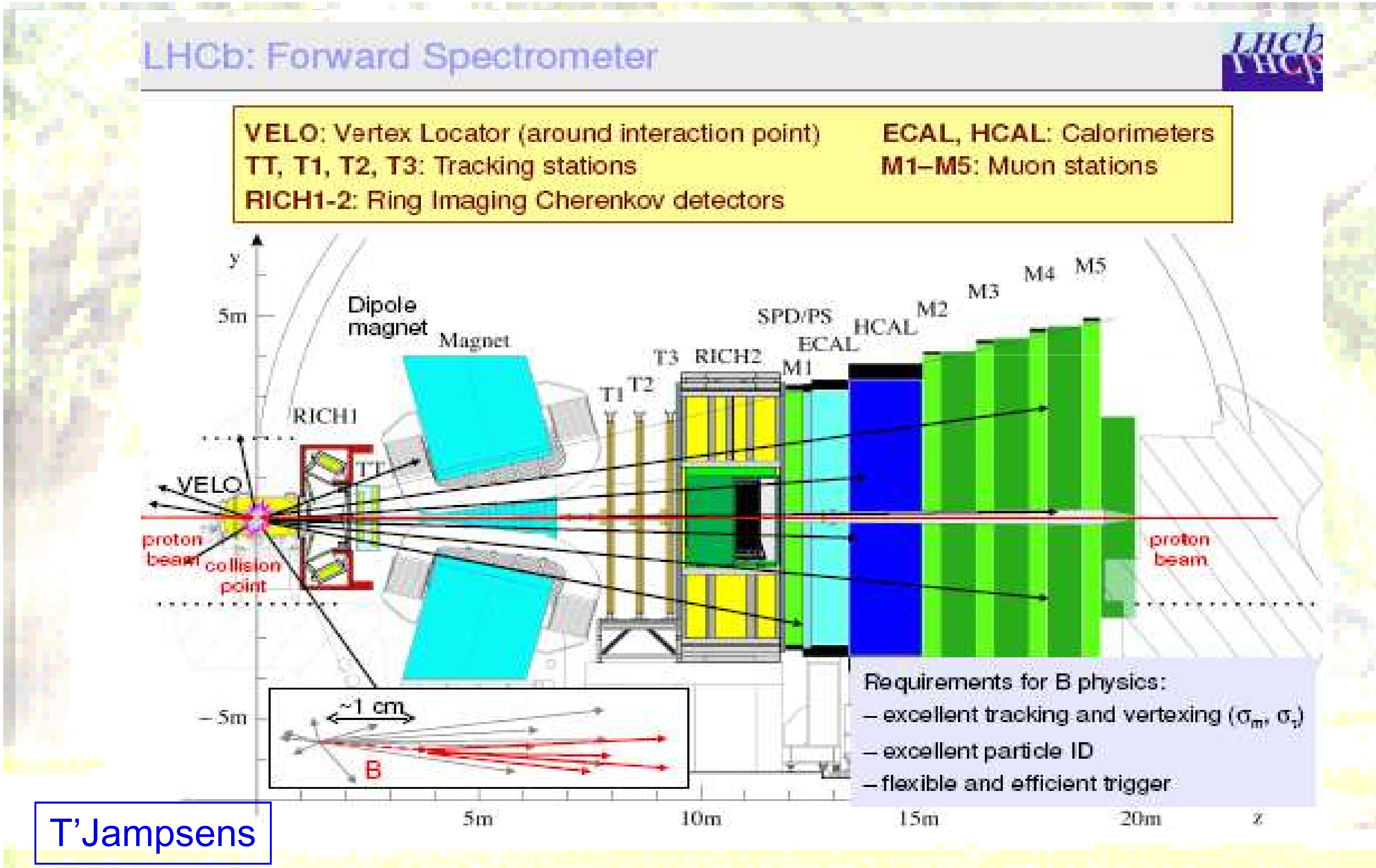
Luminosity $\mathcal{L}=2\times10^{32}$ cm^{-2}s^{-1} (de-tuned beams):

- clean environment ($\langle n \rangle$ = 0.5)
- less radiation damage
- 5 10^{11} B hadrons (in acceptance) in 10^7 sec (1 year, 2 fb^{-1})
- 10 fb^{-1} by 2013



T'Jampsens

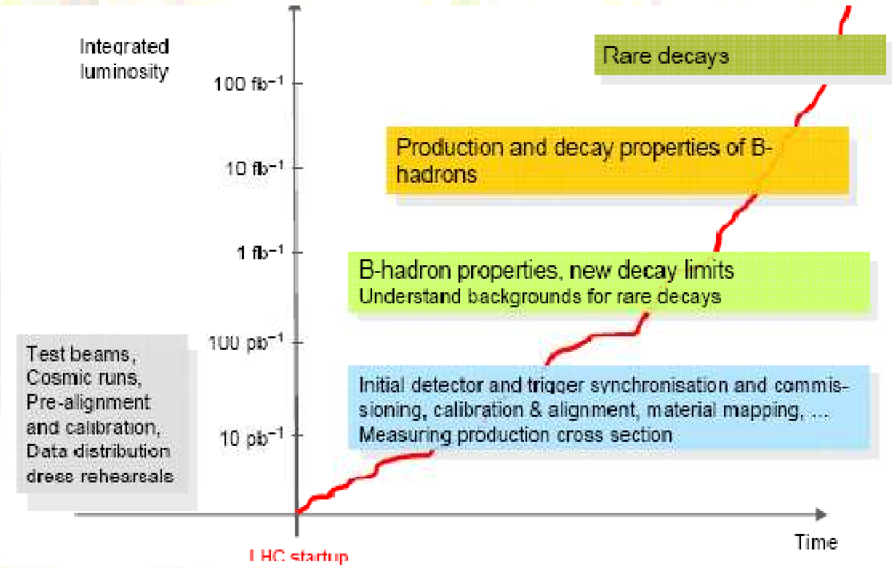
The LHCb detector



T'Jampsens

B physics at ATLAS and CMS

- Both experiment well suited for a wide range study of heavy flavor physics with large B and t cross sections and high luminosity, since startup
- B-physics time-line program and benchmark analyses (ATLAS):



Some benchmark analyses.

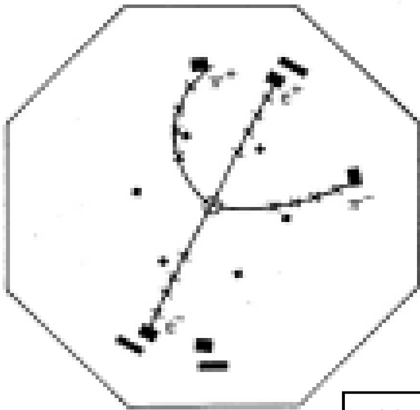
- Cross sections of beauty, charm hadrons and onia → QCD models for the LHC
- B^+, B_d, B_s, B_c, Λ_b lifetimes
- Λ_b polarization and other properties
- $B_d \to K^{0*}\mu^+\mu^-$, $B_s \to \Phi\mu^+\mu^-$, $B^+ \to K^+\mu^+\mu^-$, $B^+ \to K^{+*}\mu^+\mu^-$, $\Lambda_b \to \Lambda^0\mu^+\mu^-$
- $B_{s(d)} \to \mu^+\mu^-$
- B_s oscillation and CP violation studies

- Measure lifetimes at the world average precision with first data
- Measure B hadron properties within 10-20 fb^{-1} (CPV, Bs oscillations)
- From 100 fb^{-1} rare decays accessible
- Crucial role in search for new physics: SM Higgs decays (bb),SUSY decay chains (bb final states)

Smith, Etzion, Ulmer, De La Cruz Burelo

Charm Physics

- Neutral D mesons:
  - the only chance to study mixing among up quarks
- CP violation in the D system is tiny in SM
  - probe of new physics
- FCNC in decays also accessible
- Results from some of charm physics experiments
  - Series of experiments at FNAL
  - CLEO-C experiment at Cornell
  - B factory experiments (Belle, Babar)

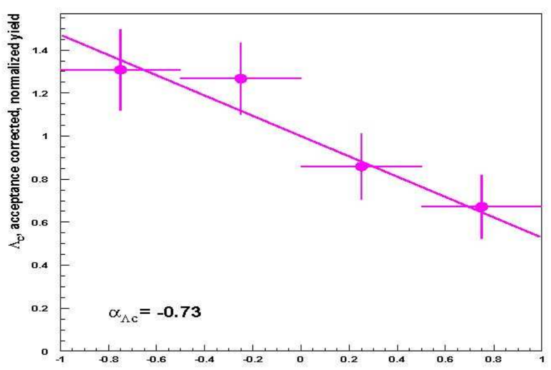


1974

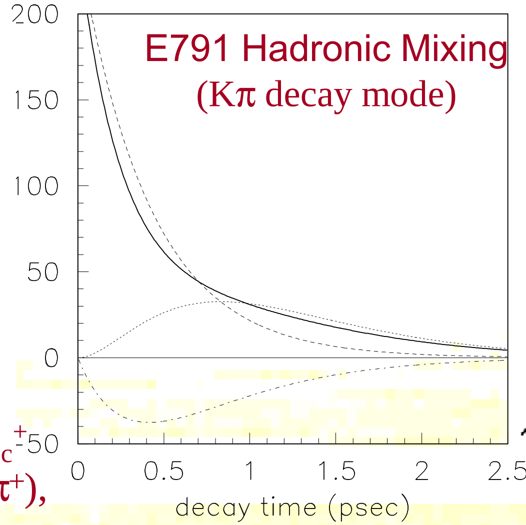
FNAL: fixed target hadron experiments

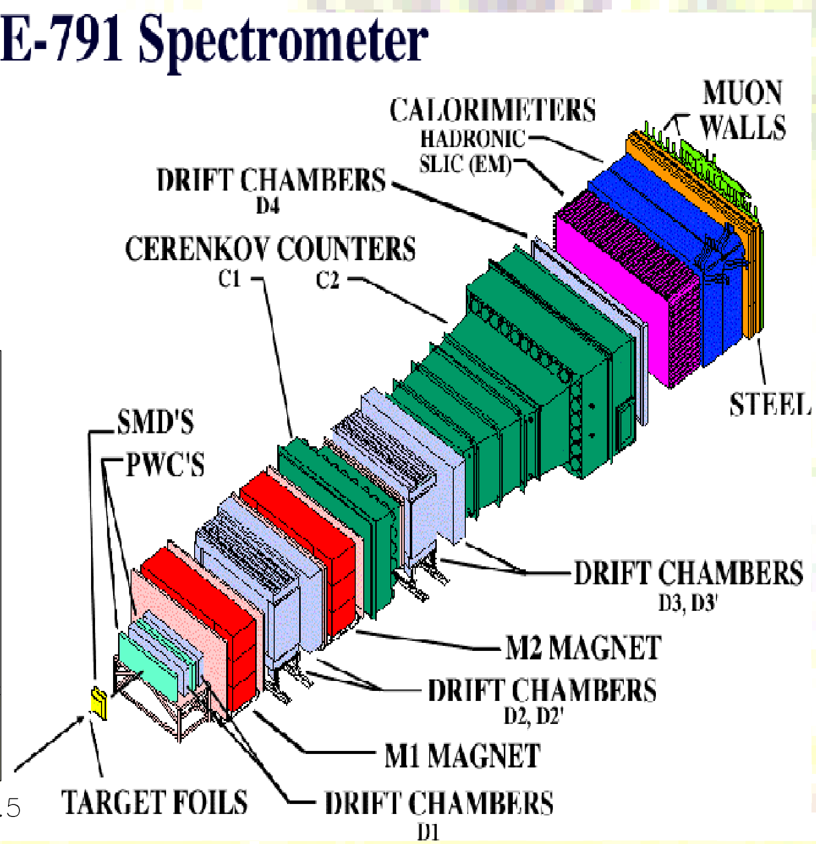
- Review of concepts and results from FOCUS and E791 (analysis and papers completed) on charm physics:
  - *D^0-$\overline{D^0}$ mixing*
  - *Searches for CP violation*
  - *Searches for rare decays*
  - *Semileptonic decays*
  - *Baryons*
  - *Dalitz plot based analyses*
  - *Charm production*

Milind Purohit



FOCUS determination of the Λ_c^+ decay asymmetry parameter ($\rightarrow \Lambda\pi^+$),





Charm results from CLEO-C

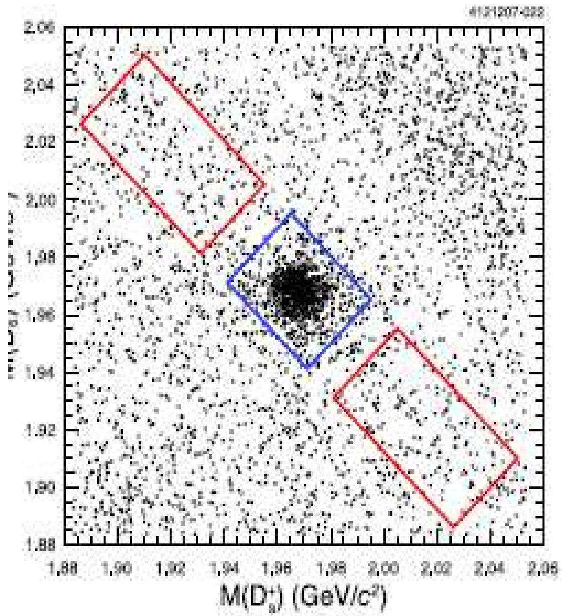
Qing He

- Results on:
  - Hadronic decays (double tagging technique, à la MARKIII)
  - Leptonic decays
  - CLEO impact on the UT angle γ measurement:
    - Use interference between b→c and b→u transitions
    - Model independent binned Dalitz analysis of $D^0/\bar{D}^0 \to K_S^0\pi^+\pi^-$
      - CP eigenstates in CLEO data plays an important role

D_s hadronic branching fractions

Mode	$\mathcal{B}(\%)$	PDG 2007
$K_S^0K^+$	$1.49 \pm 0.07 \pm 0.05$	2.2 ± 0.4
$K^-K^+\pi^+$	$5.50 \pm 0.23 \pm 0.16$	5.3 ± 0.8
$K^-K^+\pi^+\pi^0$	$5.65 \pm 0.29 \pm 0.40$	-
$K_S^0K^-\pi^+\pi^+$	$1.64 \pm 0.10 \pm 0.07$	2.7 ± 0.7
$\pi^+\pi^+\pi^-$	$1.11 \pm 0.07 \pm 0.04$	1.24 ± 0.20
$\pi^+\eta$	$1.58 \pm 0.11 \pm 0.18$	2.16 ± 0.30
$\pi^+\eta'$	$3.77 \pm 0.25 \pm 0.30$	4.8 ± 0.6
$K^+\pi^+\pi^-$	$0.69 \pm 0.05 \pm 0.03$	0.67 ± 0.13

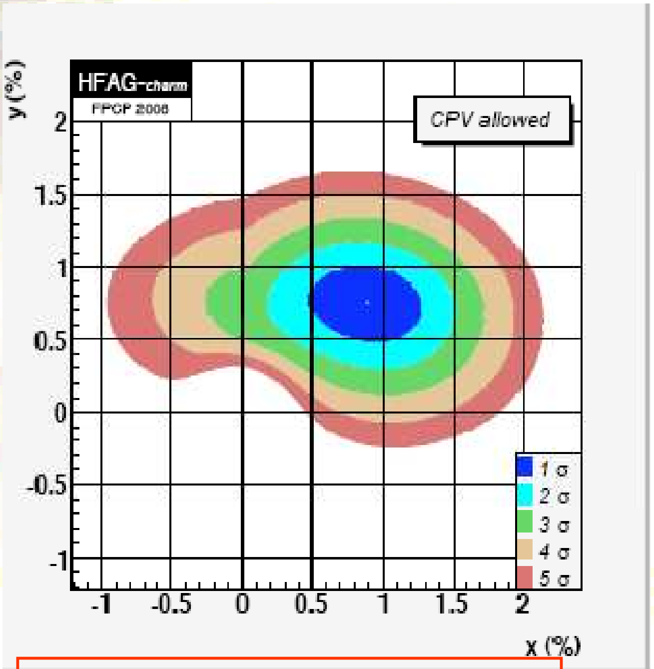
- $\sigma(e^+e^- \to D_s^+D_s) =$ $0.98 \pm 0.05 \pm 0.02 \pm 0.01$ nb
- The last error is due to luminosity measurement.
- PRL 100, 161804 (2008)



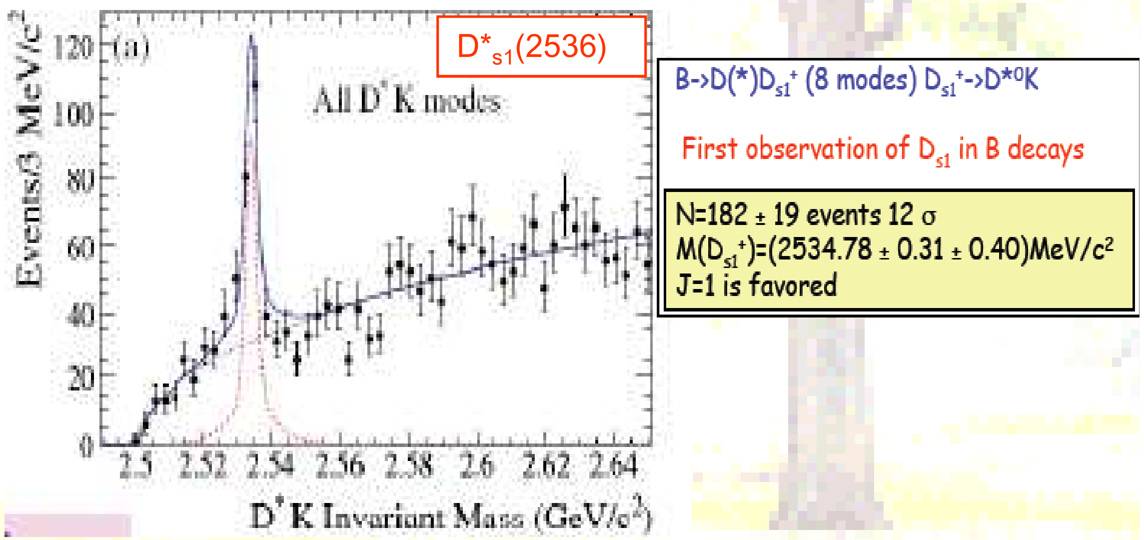
Charm at B-Factories

Santoro
Yabsley

- D^0-D^0 Mixing:
  - Several ways to measure D mixing, according to D decays and analysis method
  - Combined world average inconsistent with no-mixing at 6.7 σ
  - No evidence for CPV in charm mixing
- Charm spectroscopy: several new states discovereded in the last years, some of them still to be classified within quark model

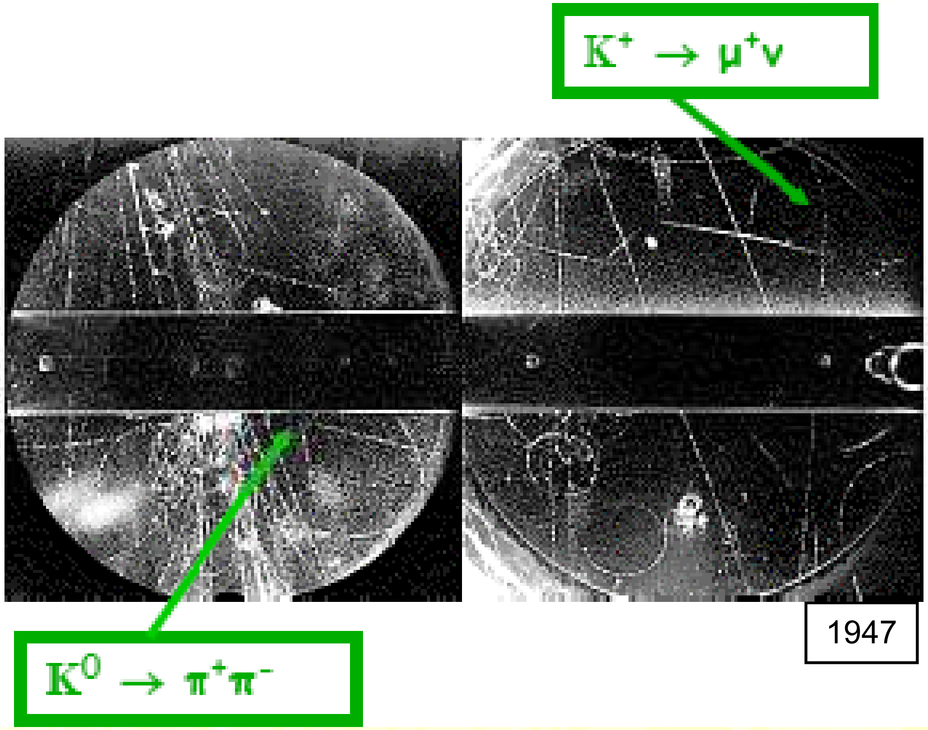


Average of mixing measurements



Kaon Physics

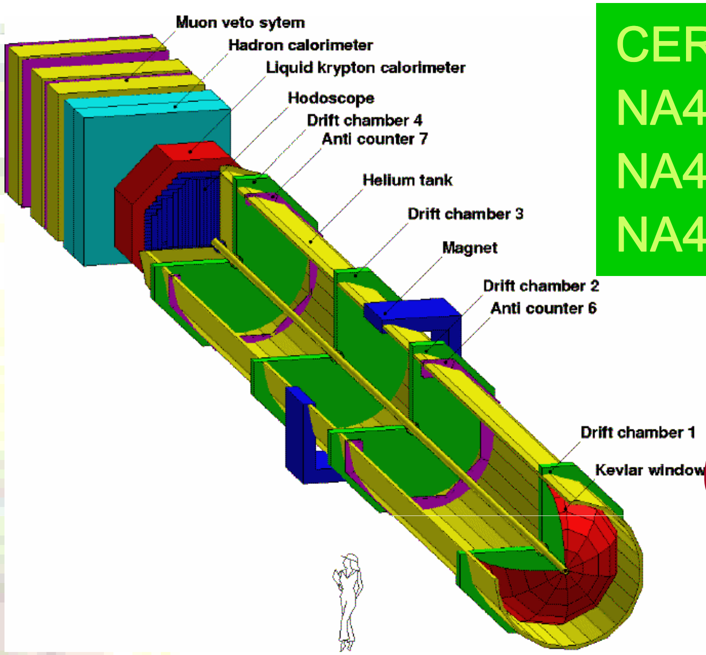
- Some update and new results
- Comparison data-theory
- Future experiments



Kaon Physics: landmark results

- Concept of strangeness → quark model → basis of QCD
- First hint of Parity Violation → chiral nature of weak gauge forces
- Absence of FCNC → charm quark and GIM structure of flavour dynamics
- Discovery of CP Violation → matter-antimatter asymmetry → 3-generation structure of nature and KM description

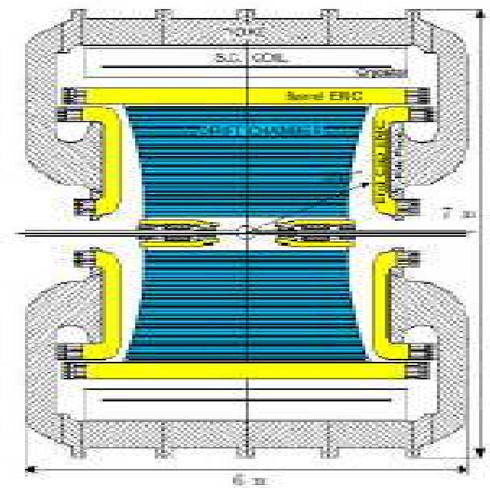
(Some of) Present experiments with Kaons



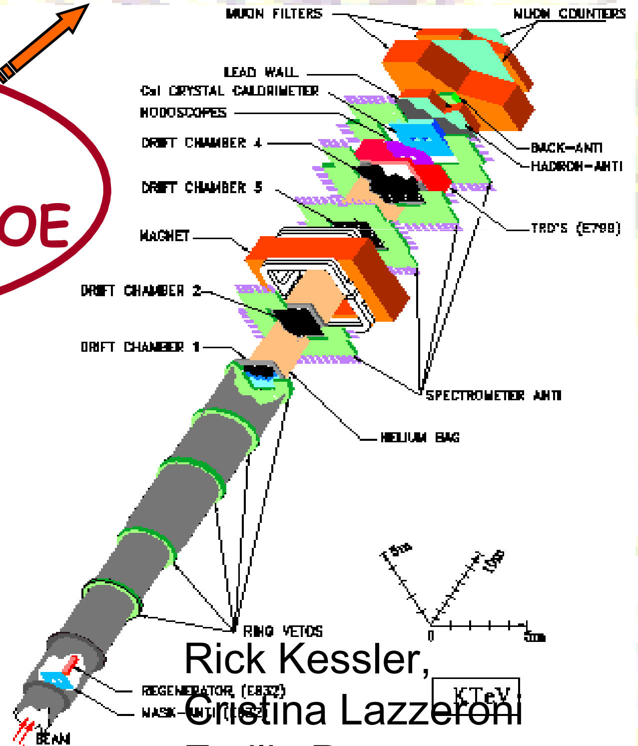
CERN
NA48 1997-2001 K_L,K_S
NA48/1 2000,2002 K_S
NA48/2 2003-2004 $K^{\pm}$

Fermilab
KTeV (E832, E799)
1997,1999 K_L,K_S

Results (and comparison): NA48/2, KTeV, KLOE



Frascati - DaΦne
KLOE 2000-2006
KLOE2 from ?
K_S ,K_L ,$K^{\pm}$



Michael Akashi-Ronquest, Rick Kessler,
Cristina Lazzeroni, Bernard Peyaud,
Tommaso Spadaro, Emilie Passemar

Rick Kessler,
Cristina Lazzeroni
Emilie Passemar,
Bernard Peyaud
Michael Akashi-Ronques
Tommaso Spadaro

Test of ChPT

- Kaon radiative decays: γ in the final state are well suited probes of the intrinsic dynamic of the process
  $\rightarrow$ Important inputs to ChPT up to $O(p^6)$ and stringent tests
- Many recent and new results from the NA48/2, KTeV and KLOE experiments, among which:
  - New results (NA48/2): $K^\pm \rightarrow \pi^\pm e^+ e^-$
  - New results (KTeV), also simmetry related:
    - $K_L \rightarrow \pi^0 \gamma\gamma$ and $K_L \rightarrow \pi^0 e^+ e^- \gamma$
  - Final results (KLOE): $K_S \rightarrow \gamma\gamma$
    - 3σ discrepancy wrt NA48

Lazzeroni
Akashi-Ronquest

NA48: $K^{\pm} \rightarrow \pi^{\pm}e^{+}e^{-}$

New result (preliminary): BR in full kinematic range and first measurement of the CPV parameter $\Delta(K^{\pm}_{\pi ee})$

Including uncertainty due to the model dependence,

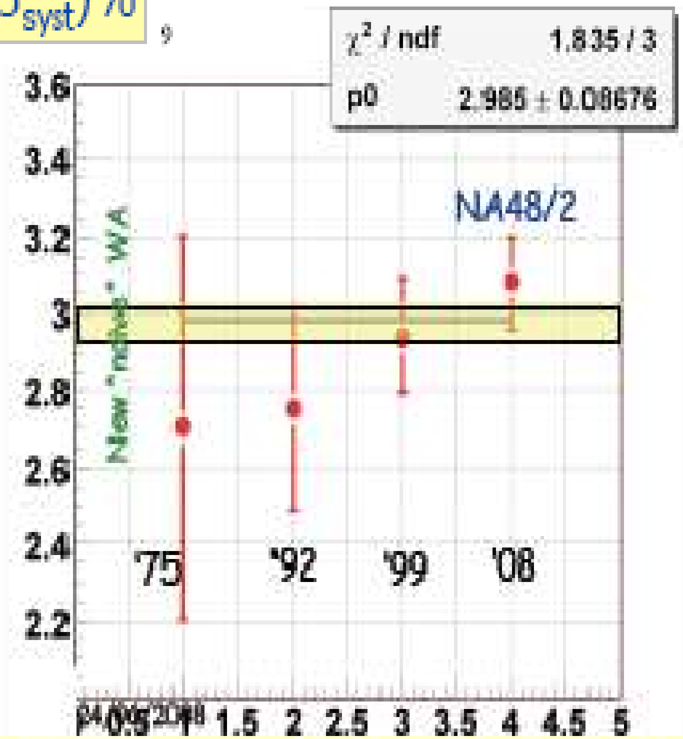
$$BR = (3.08 \pm 0.04_{stat} \pm 0.04_{syst} \pm 0.08_{ext} \pm 0.07_{model}) \times 10^{-7} = (3.08 \pm 0.12) \times 10^{-7}$$

CPV parameter (first measurement! correlated K^+/K^- uncertainties excluded):

$$\Delta(K^{\pm}_{\pi ee}) = (BR^{+} - BR^{-}) / (BR^{+} + BR^{-}) = (-2.1 \pm 1.5_{stat} \pm 0.3_{syst})\%$$

Lazzeroni

Measurement	Sample	BR×10^7
Bloch et al., PL 56 (1975) B201	41 (K$^+$)	2.70±0.50
Alliegro et al., PRL 68 (1992) 278	500 (K$^+$)	2.75±0.26
Appel et al. [E865], PRL 83 (1999) 4482	10,300 (K$^+$)	2.94±0.15
NA48/2 preliminary (2008)	7,100 (K$^{\pm}$)	3.08±0.12



In agreement with ChPT and other measurements

First limit on CPV asymmetry obtained

New simmetry related results from KTeV

Akashi-Ronquest

Analysis related to the CPC contributions to $K_L \rightarrow \pi^0 e^+e^-$

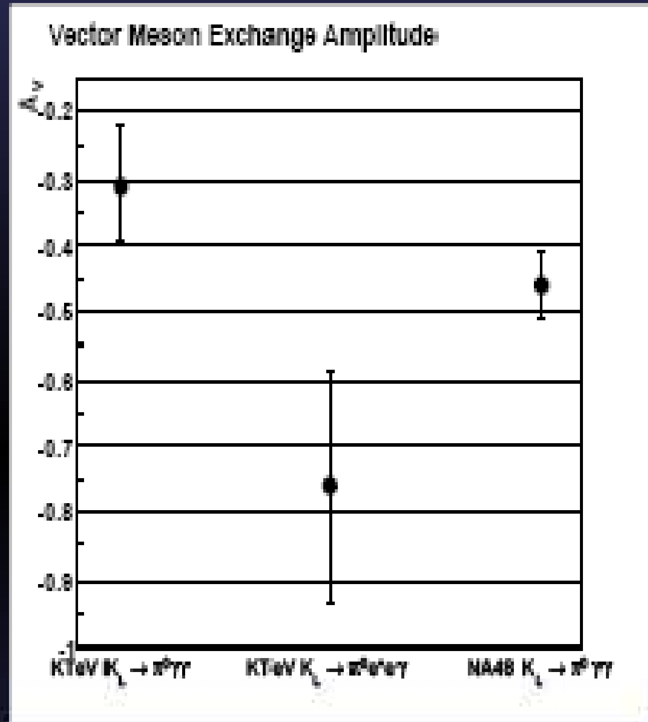
⇨ confirms the presence of important CPV terms

$K_L \rightarrow \pi^0\gamma\gamma$ + $K_L \rightarrow \pi^0 ee\gamma$

- Excellent tests of χPT
  - No free parameters in branching ratio to $O(p^4)$
  - $O(p^6)$ terms include Vector Meson exchange terms (strength of which is described by A_V)
    - $O(p^6)$ terms increase branching ratios by factor of 2-3

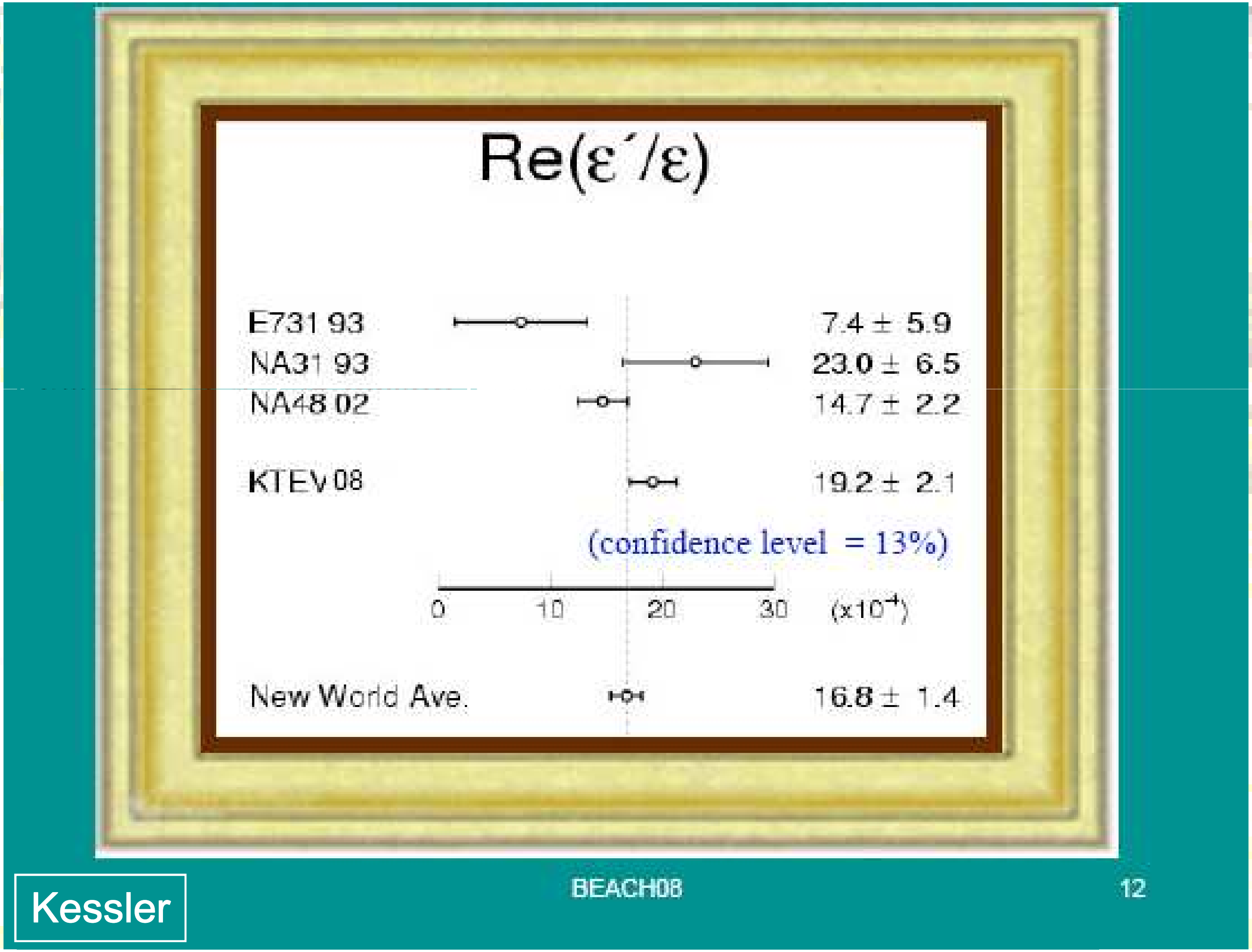
- A_V determines CP conserving part of $K_L \rightarrow \pi^0 l^+l^-$
  - CP conserving part is from $K_L \rightarrow \pi^0\gamma^*\gamma^*$
- Indirect CP violating part of $K_L \rightarrow \pi^0 l^+l^-$ determined by $Br(K_S \rightarrow \pi^0 l^+l^-)$

Results for A_V



- Values imply that $K_L \rightarrow \pi^0 l^+l^-$ is indeed dominated by CPV terms

The final value of Re(ε′/ε) in KTeV



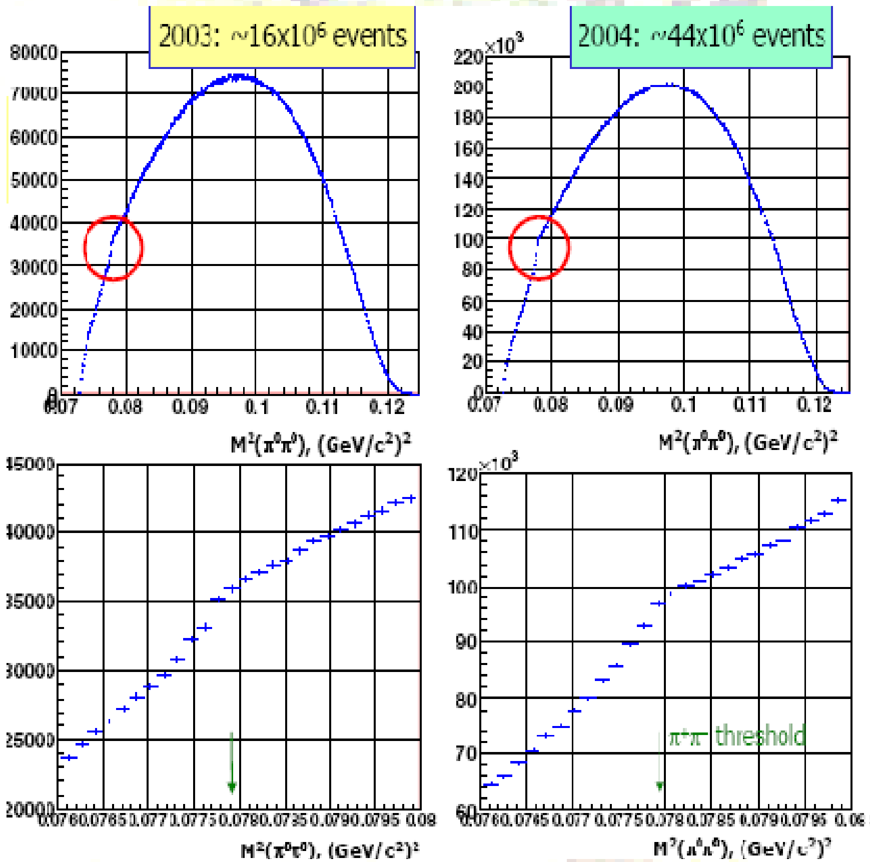
- Fundamental quantities measured with kaons:
  - Pion-Pion scattering (NA48/2, KTeV)
  - Pion parity (KTeV)

Passemar
Peyaud
Kessler
Akashi-Ronquest

Pion-pion scattering - I

- S-wave scattering lenghts a_0 and a_2 in $\pi\pi$ system are essential parameters of ChPT to investigate spontaneous simmetry breaking:
  - sensitivity to quark condensate
- The measurement of $\pi\pi$ scattering lenghts a_0 and a_2 is done in NA48/2 with the study of $\pi\pi$ near threshold in $K^{\pm} \rightarrow \pi^{\pm}\,\pi^0\pi^0$ (cusp effect) and $K^{\pm} \rightarrow \pi^{\pm}\pi^{-}e^{+}\nu$ ($\delta_{\pi\pi}$ phases and form factors)
- NA48/2 precision at the level of theory
- Data and theory agree well:
  - the π mass is dominated (94%) by the quark condensate i.e. spontaneus breakdown of ChPT (G. Colangelo)

Evidence of cusp strycture in NA48/2 data



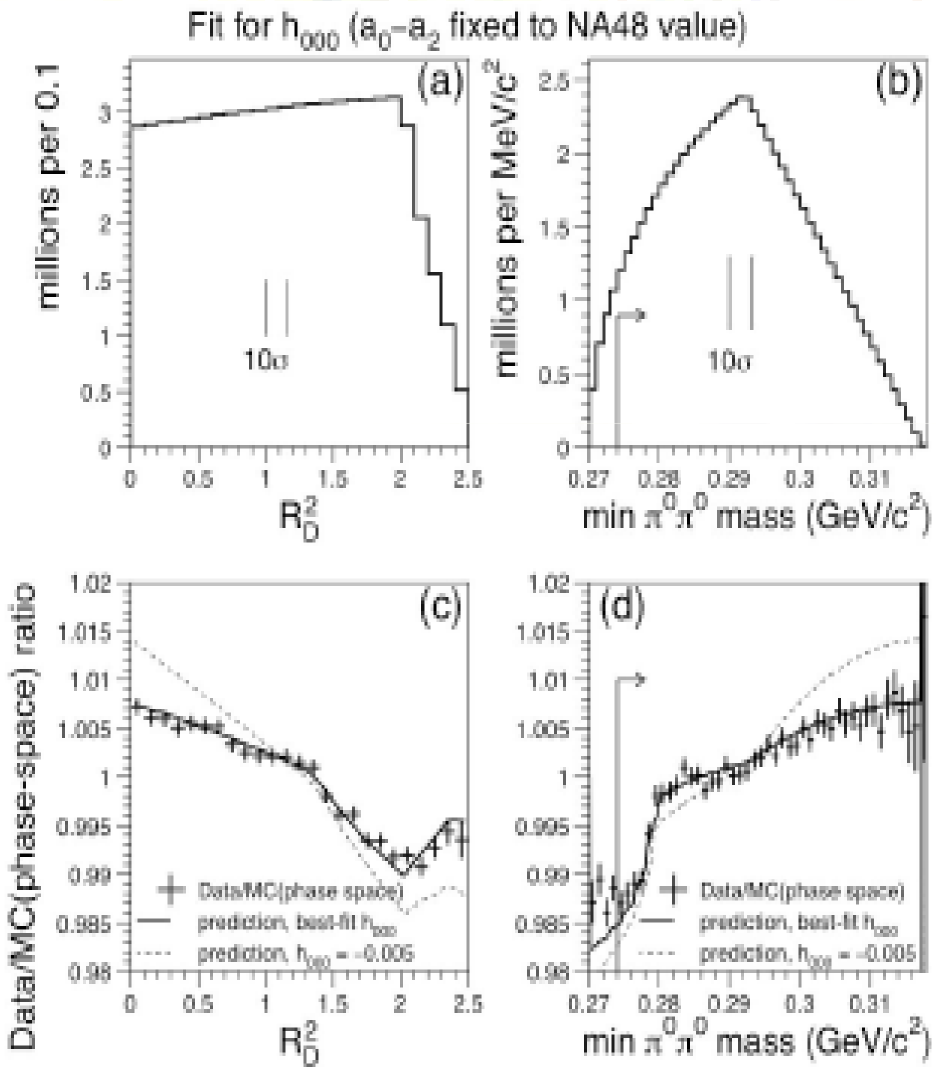
Peyaud

Pion-pion scattering - II

Cusp effect visible in $K_L \to 3\pi^0$ data (KTeV)

Compatible with Cabibbo Isidori model (JHEP 503, 21 (2005))

Larger error (isospin decomposition favors charged K)



Kessler

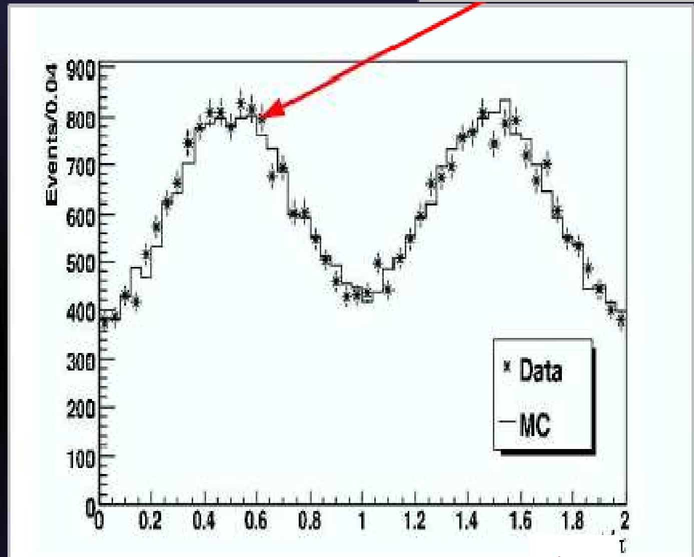
The parity of the pion (KTeV)

A new precise evidence of the parity of π^0

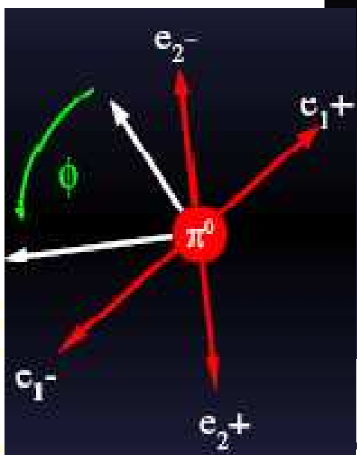
- The previous was 46 years old, hardly significant (3.6σ)
- Select $\pi^0 \to \gamma\gamma \to e^+e^- e^+e^-$ double dalitz decays from π^0 produced in $K_L \to 3\pi^0$
- Measure the angle Φ between the decay planes of the two γ

$\pi^0 \to e^+e^-e^+e^-$

Dalitz pairs prefer to be orthogonal! Parity =-1



ϕ/π



30511 events
0.6% residual background

$Br(\pi^0 \to e^+e^-e^+e^-) = (3.26 \pm 0.18) \times 10^{-5}$

Akashi-Ronquest

Lepton Flavour Violation

KAONS:

- New limits from searches in KTeV:
  - $K_L \to \pi^0 \mu e$, $\pi^0 \pi^0 \mu e$; $\pi^0 \to \mu e$

Akashi-Ronquest

- Test of lepton μ/e universality in K_{l2} and K_{l3} decays:
  - Results from NA62 and KLOE
  - Theoretical predictions and comparison with experimental data (Flavianet)

Saracino
Spadaro
Smith
Passemar

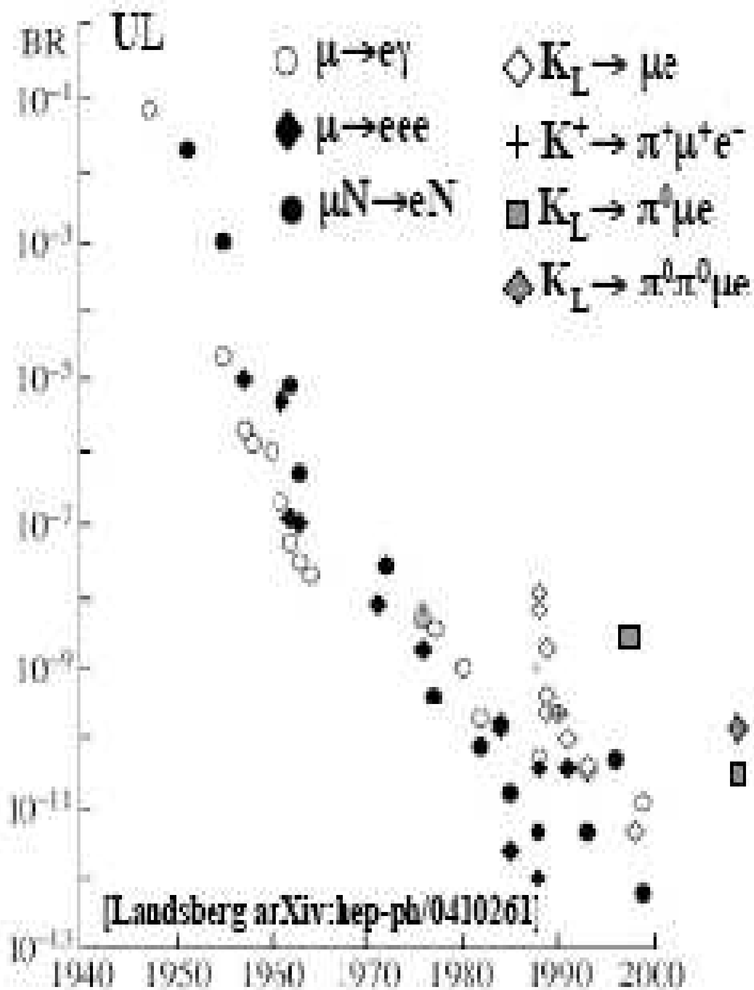
MUONS:

- The MEG experiment: LFV in $\mu \to e\gamma$

Dussoni

Lepton Flavour Violation: history

- Direct searches for LFV:
  - identify signals from processes forbidden or highly suppressed in the SM
  - Sensitivity smoothly increasing with time



The NA62 experiment (phase 1) at CERN

NA62, phase I:

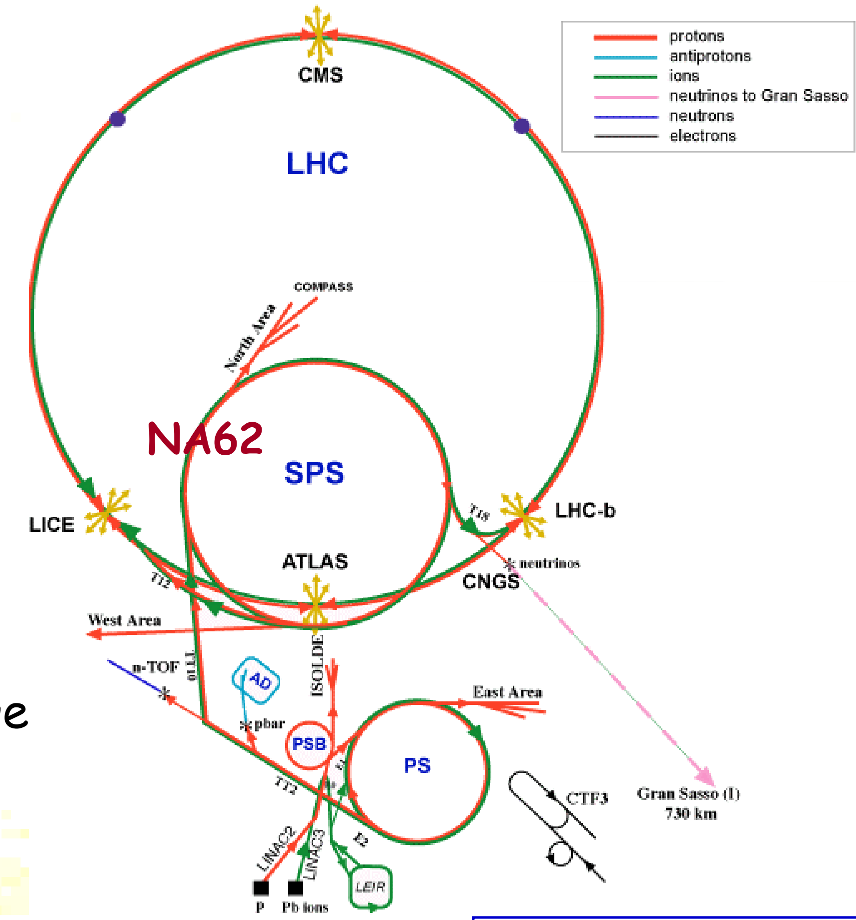
the measurement of $R_k = \Gamma(K\rightarrow e\nu_e)/\Gamma(K\rightarrow\mu\nu_\mu)$ with 0.5 % error

- *test lepton flavor universality*
- *use the existing NA48/2 apparatus*
- *data taking: 2007*

NA62 phase II:

the measurement of $\boxed{K^+ \rightarrow \pi^+\nu\bar{\nu}}$

- *rare "golden" decay: B.R (SM) ~ 10^{-10}*
- *~ 80 events (2 years), S:B = 10:1*
- *new detector*
- *waiting for approval*



Fixed Target: 400 GeV/c protons on Be targe
high intensity $K^{\pm}$ 75 GeV/c momentum
Not separeted beam (K/π =8%)

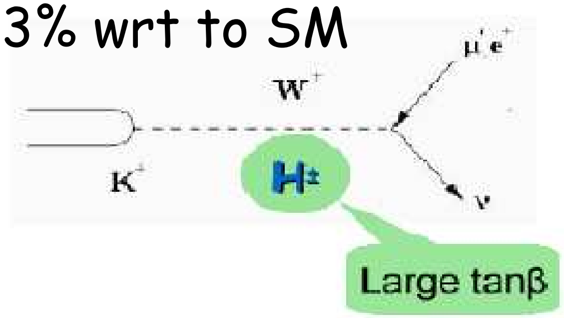
K^+ and K^- can be provided simultaneously or individually

Giulio Saracino

The measurement of $R_k = \Gamma(K\rightarrow e\nu_e)/\Gamma(K\rightarrow \mu\nu_\mu)$

Precision test of leptonic universality and V-A coupling: LFV SUSY ($\tan\beta$~50, M_{H+}~500 GeV/c^2) enhance the R_k value of 2-3% wrt to SM

(Masiero, Paradisi, Petronzio, hep-ph/0511289 PRD74,2006)



World average (2006) (based on 1970s experiments)

$R_K^{PDG}(2006) = (2.45 \pm 0.11)\cdot 10^{-5}$ $\delta R_K / R_K = 4.5\%$

Past value

Saracino Spadaro

NA48/2
- Run 2003
  final sample: $(4670 \pm 77_{stat})$ K_{e2} candidates
- Run 2004
  final sample: $(3407 \pm 63_{stat})$ K_{e2} candidates

$R_K = (2.455 \pm 0.045 \pm 0.041)\cdot 10^{-5}$

$\delta R_K/R_K \sim 2\%$

KLOE (preliminary 2007)

~ 8k K_{e2} candidates

(70% of available statistic)

[arXiv:0707.4623]

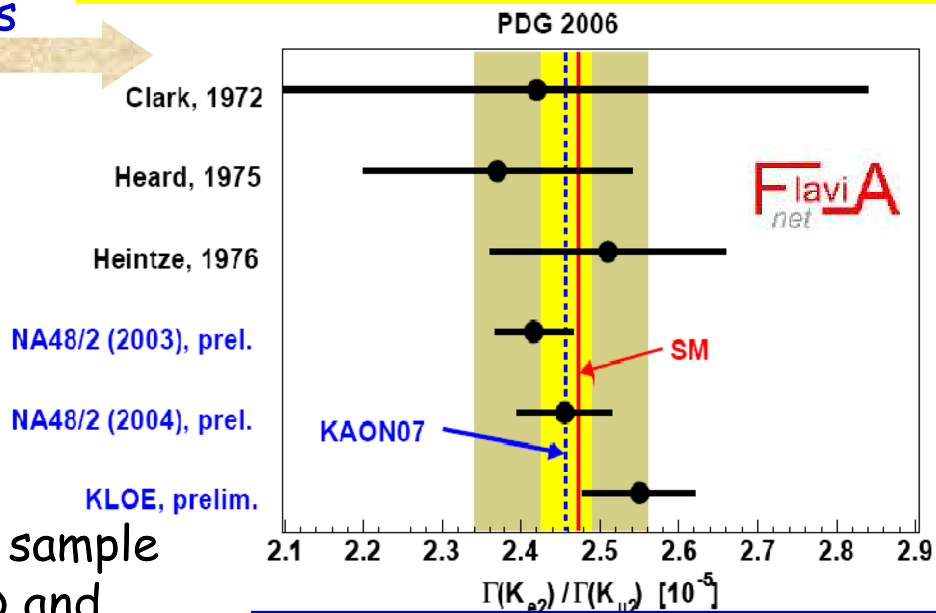
$R_K = (2.55 \pm 0.05 \pm 0.05)\cdot 10^{-5}$

$\delta R_K/R_K \sim 2.7\%$

target: 1%

Present values

$$R_K = (2.457 \pm 0.032)\cdot 10^{-5} \qquad (\chi^2/ndf = 2.44/3)$$



New precise results coming soon:

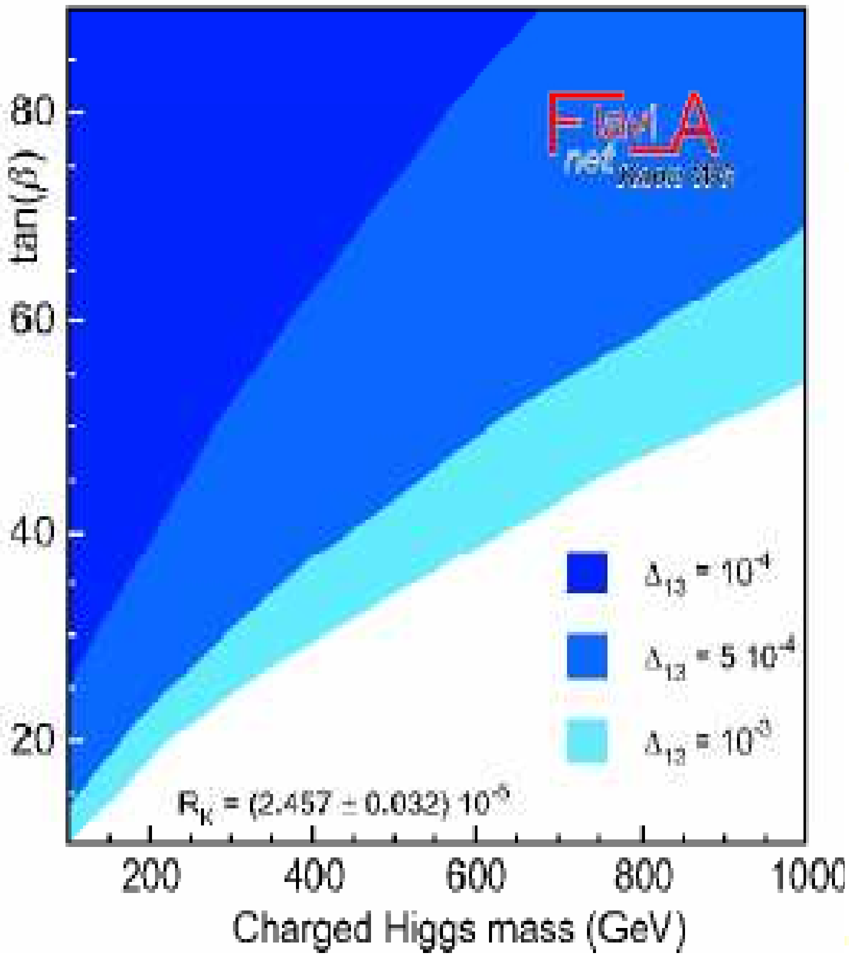
NA62: >100k K_{e2} collected in 2007

0.5% dR_K/R_K achievable, soon results!

KLOE: 1% dR_K/R_K achievable (full data sample and optimized analysis: better particle ID and background reduction)

$R_k = (2.477 \pm 0.001) \times 10^{-5}$ SM

R_K : sensitivity to LFV theories



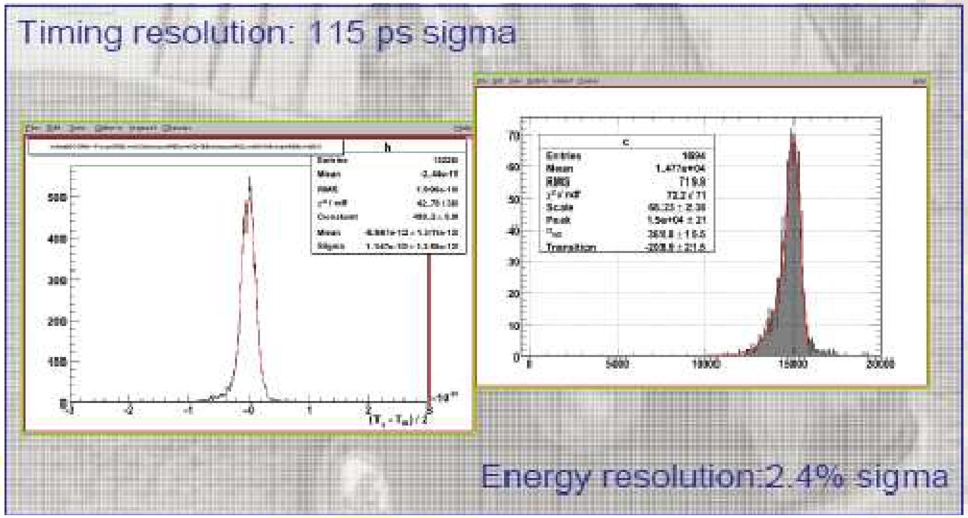
FLAVIANET: sensitivity to possible breaking of LF simmetry via R_K shown as 95% C.L. excluded regions in the $\tan\beta - M_{H+}$ plane, for fixed values of the 1-3 slepton-mass matrix element, Δ_{13} = **10^{-3}**, **$0.5\text{x}10^{-3}$**, **10^{-4}**

Passemar

The MEG experiment at PSI

Search for LVF in $\mu+ \rightarrow e\gamma$ decay with a sensitivity $O(10^{-13})$

- All LFV processes such as $\mu \rightarrow e\gamma$ are completely clean from SM backgrounds: $BR_{\mu \rightarrow e\gamma} \sim 10^{-48}$, in beyond-SM frameworks $BR_{\mu \rightarrow e\gamma}$ up to 10^{-11}
- Exploit the intense μ beam at the PSI accelerator complex
- In 2008: first data taking for physics data
- Soon results

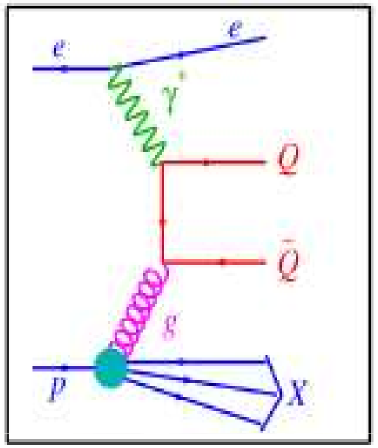


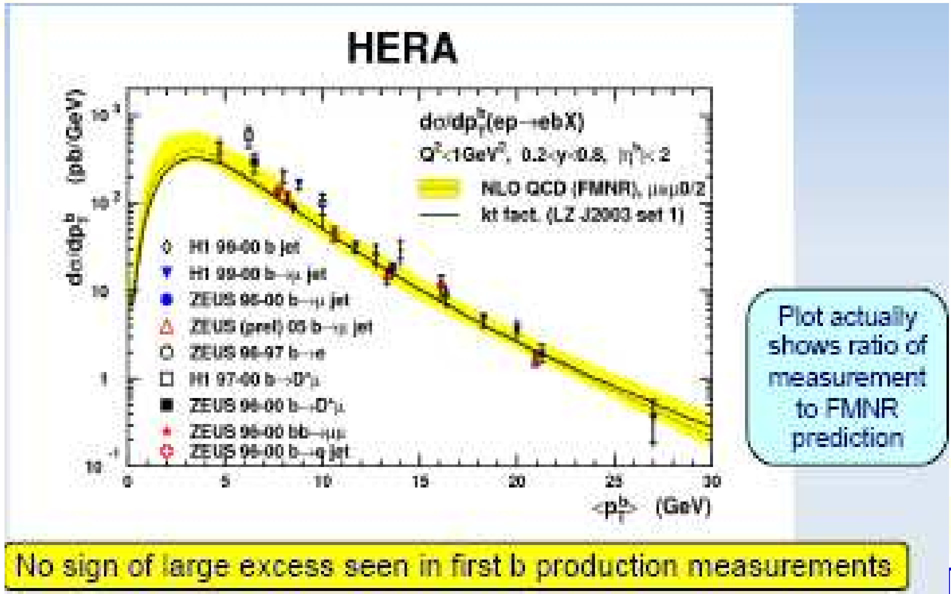
Dussoni

Performance of the electromagnetic LXe calorimenter

Heavy Flavour Physics at HERA

- Data taking ended in 2007: ~0.5 fb^{-1} per experiment
- Main HF production mechanism: boson-gluon fusion
- Results from studies of b and c production mechanisms (photoproduction and DIS) and strangeness production
- Results on Fragmentation (c quark)
- Spectroscopy: competitive with other world measurements
- Summary of b photoproduction:





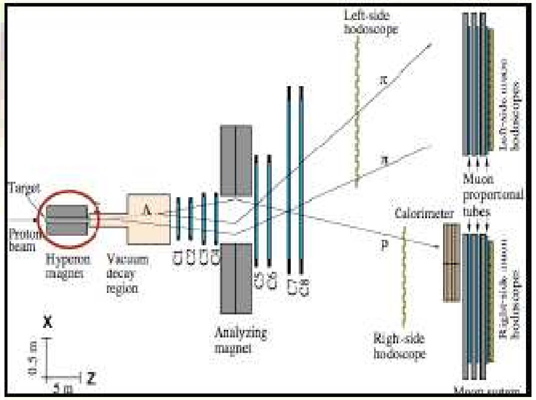
- HERA (ep):
  - p: 920 (820) GeV
  - e: 27.5 GeV
- $Q^2 = -q^2 = (k-k')^2$
- $Q^2 < 1\ GeV^2$
  - Photoproduction
- $Q^2 > 1\ GeV^2$
  - DIS

Brock, Ozerov

HyperCP at FNAL

Search for *CP* Violation in Ξ and Λ Hyperon Decays with the Hyper*CP* Spectrometer at Fermilab

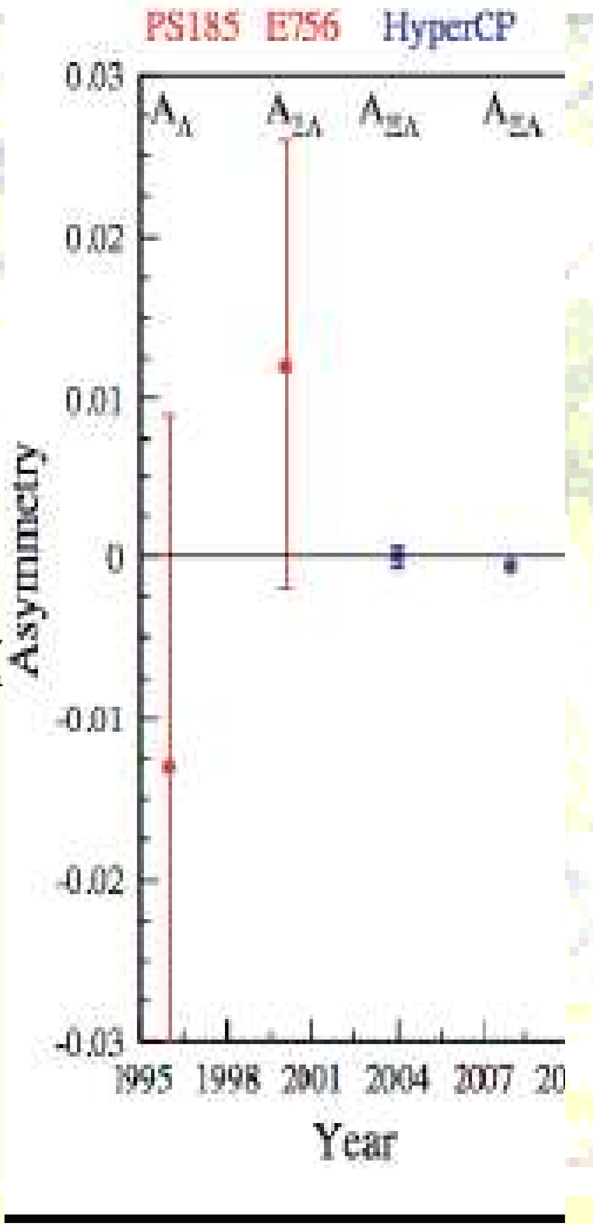
- Designed for CP violation searches
  - Further investigation of CP Violation and fundamental measurements with hyperons



Charged Hyperon Beam

- 800 GeV/c protons on 2 mm x 2 mm target
- Secondary beam: 167 GeV/c
- Alternate -/+ beam polarity

- Using the largest sample of hyperon decays ever amassed by a particle physics experiment, the HyperCP collaboration is making precision searches for *CP* violation from exotic sources
- We measured the *CP* observable $A_{\Xi\Lambda}$ and present a new preliminary result with greater precision
  - $A_{\Xi\Lambda} = [0.0 \pm 5.1(stat) \pm 4.2(syst)] \times 10^{-4}$ (with a 15% of data)
  - $A_{\Xi\Lambda} = [-6.0 \pm 2.1(stat) \pm 2.1(syst)] \times 10^{-4}$ (Preliminary with all data)
- Hyper*CP* measurements are over 40X more precise than results from other experiments



The Compass experiement at CERN

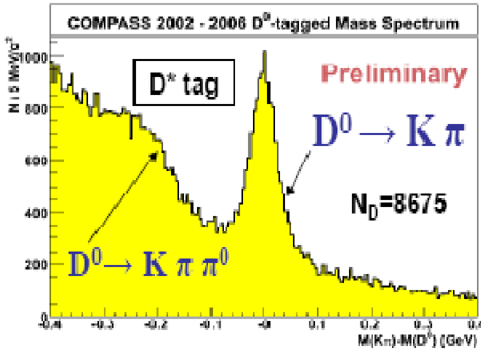
Kouznetsov

Physics program of COMPASS

Detector is advantageously located at M2 SPS beam line with a variety of high intensity μ & h beams

- *Runs with muon beam* (2002-2004,2006-2007)
  - Gluon polarization $\Delta G/G$
  - g_1 spin structure function
  - Flavor decomposition of spin distributions
  - Transverse spin effects
  - Spin transfer in Λ-hyperon production
  - Vector meson production
- *Runs with hadron beams* (2008-2009)
  - Diffractive production
  - Search for new exotic states, glueballs or hybrids
  - Light meson spectroscopy
  - Production of doubly charmed baryons
  - Pion and kaon polarizabilities

Open charm



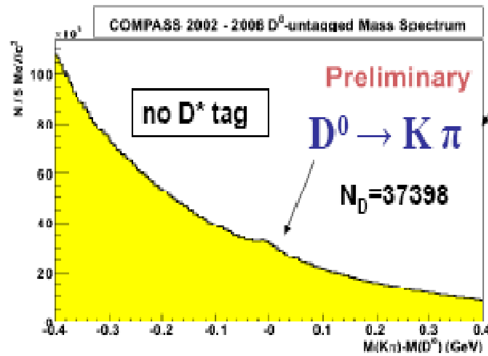
$D^{*+} \to D^0 \pi^+_{soft}$

BR ≈ 68%

$D^0 \to K^- \pi^+$

BR ≈ 4%

only



- golden channel, weak MC dependence
- small statistics, no vertex detector → no primary/secondary vertex separation

Gluon Polarization Result

(Preliminary, 2002-2006):

$\Delta G/G$ = -0.49 ± 0.27 (stat) ± 0.11 (syst)

Hadron physics program starting this year

Future programs under study

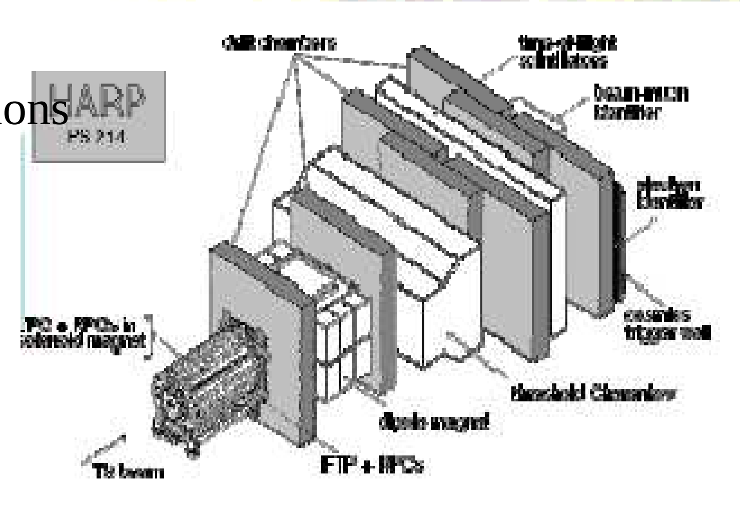
Hadron production measurements

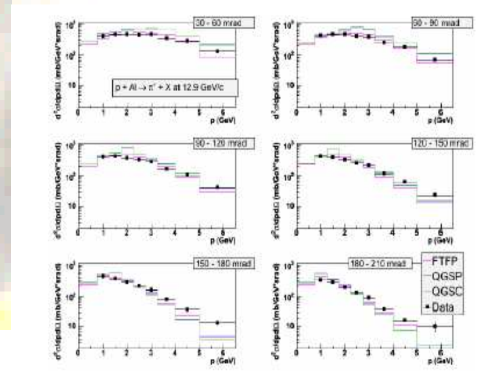
Many motivations for hadron production measurements

- Hadron production uncertainties have big impact on neutrino flux predictions
  - neutrino physics now moving from discovery to precision measurements
  - limits in phenomenological parametrizations over wide angle and energy ranges
  - hadron production data as input for MC generators

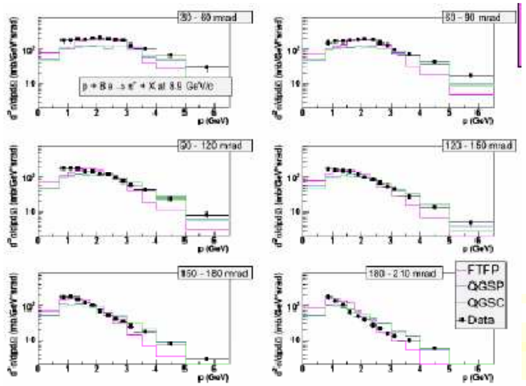
HARP experiment at CERN:

- Physics goal: Neutrino factory studies, ν flux predictions for ν-based experiments, atmospheric ν predictions, input for hadron generators (GEANT4)
- HARP data compared to models:





- p-Al at 12.9 GeV/c HARP vs GEANT4



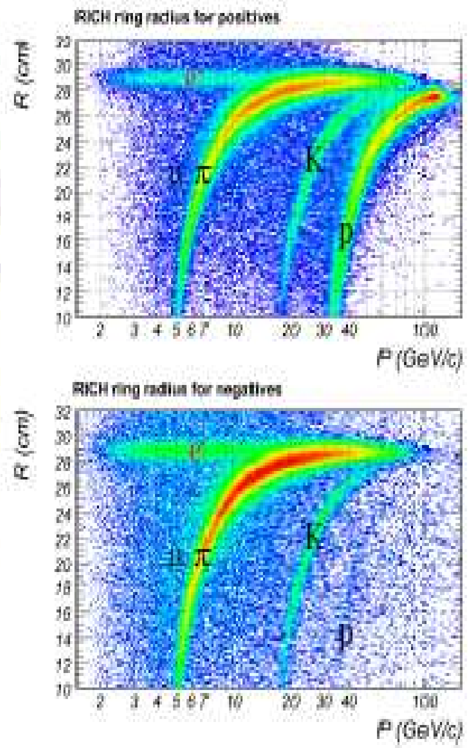
- p-Be → π+ + X at 8.9 GeV/c HARP vs GEANT4

Harp is a large angle spectrometer designed to measure hadron production from various targets and a range of incident beam momenta

Coney

The MIPP experiment at FNAL

- Use 120 GeV/c Main Injector protons to produce:
  - secondary $\pi^{\pm}$, $K^{\pm}$ and $p^{\pm}$ beams , 5 to 90 GeV/c
  - 120 GeV/c proton beam
- Measure particle production cross sections on fixed target
  - Various nuclei, including hydrogen and NuMI target
- Approved in 2001, 14 months physics run (end in 2006): 18 M events
- Eccelent particle ID: dE/dx, ToF, diff. Cherenkov and RICH technologies
- Physics overview: unbiased high statistics data with complete particle ID for hadronic interactions and nuclear physics studies (low E hadron dynamics, non perturbative QCD), among which:
  - Precise measurement of $K^{\pm}$ masses: ChPT test
- Also service measurements
- Upgrade under consideration → N. Solomey talk



Rich particle ID::

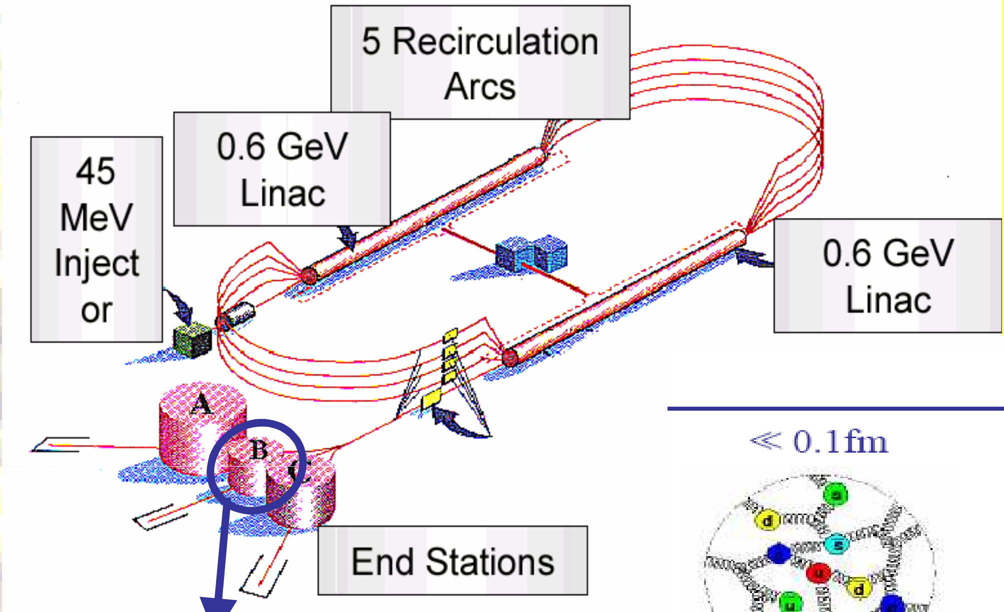
e/μ/π up to 12 GeV/c

π/K/p to 100 GeV

Meyer

The 6 GeV CW Electron Accelerator at JLab

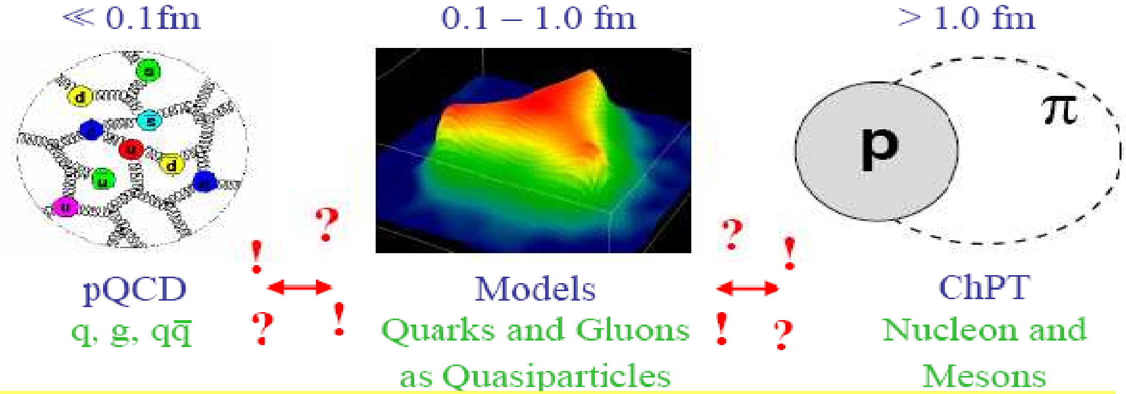
To be upgraded soon to 12 GeV



CLAS: the Cebaf Large Acceptance Spectrometer

E_{max}	~ 6 GeV → 12 GeV
I_{max}	~ 200 μA
Duty Factor	~ 100%
σ_E/E	~ 2.5 10^{-5}
Beam P	~ 85%
E_γ (tagged)	~ 0.8 - 5.5 GeV

Physics Goals

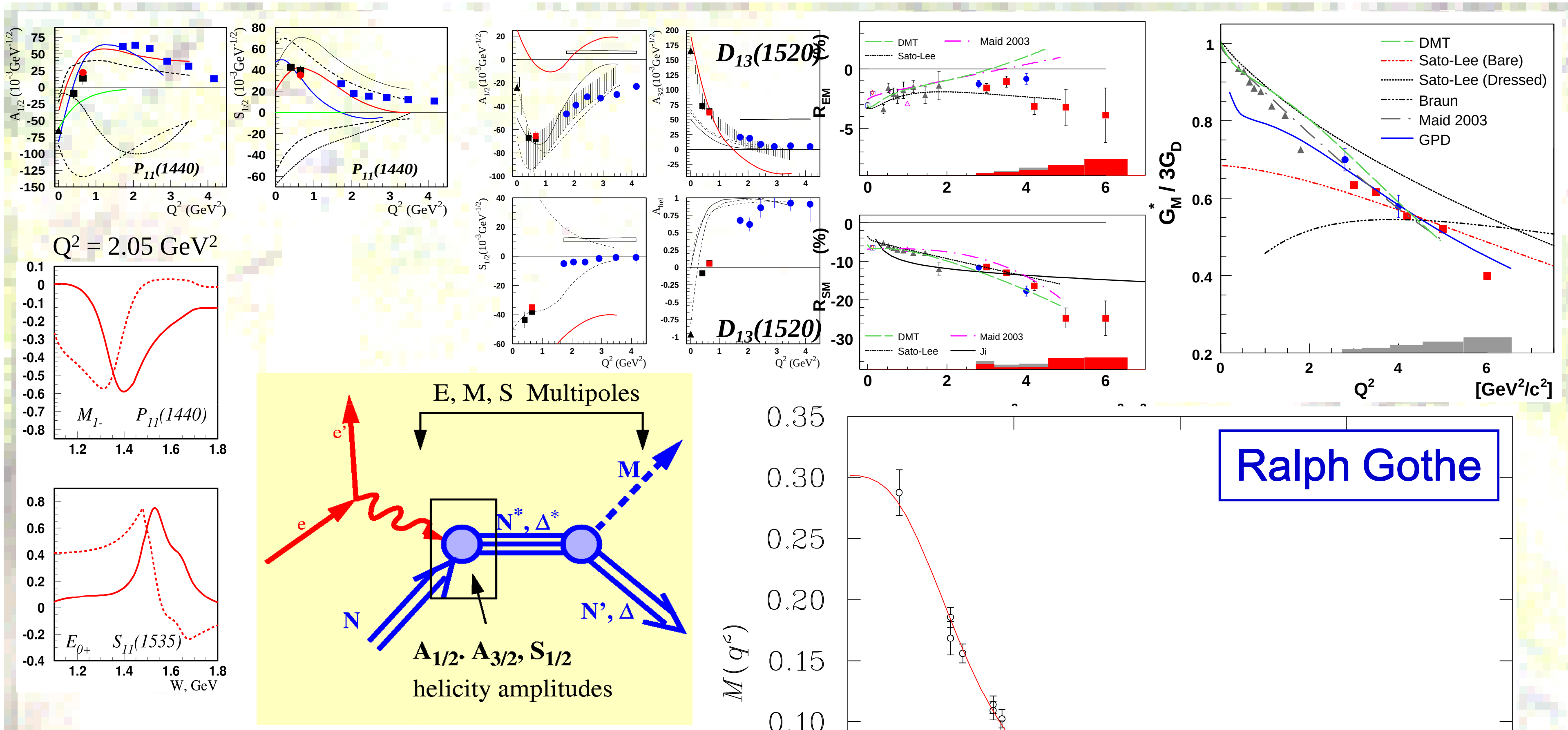


Many experimental results:
- CLAS/JLab, Bates/MAMI, BES/BEPC, LEG/BNL
- comparison with theory (Lattice QCD, DSE, …)
- the future: CLAS12

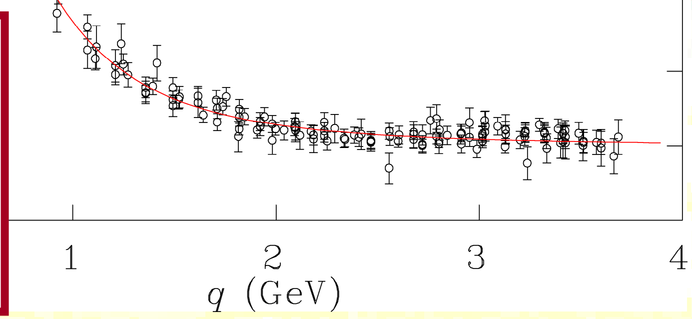
Understand QCD in the full strong coupling regime:
- extract transition form factors to nucleon excited states from meson electro-production data:
  → *relevant degrees-of-freedom*
  → *wave function and interaction of the constituents*

Ralph Gothe

Exclusive Electron Scattering: results



$\Rightarrow$ Exclusive Electron Scattering:
a powerful tool to investigate QCD
at varying distance scale

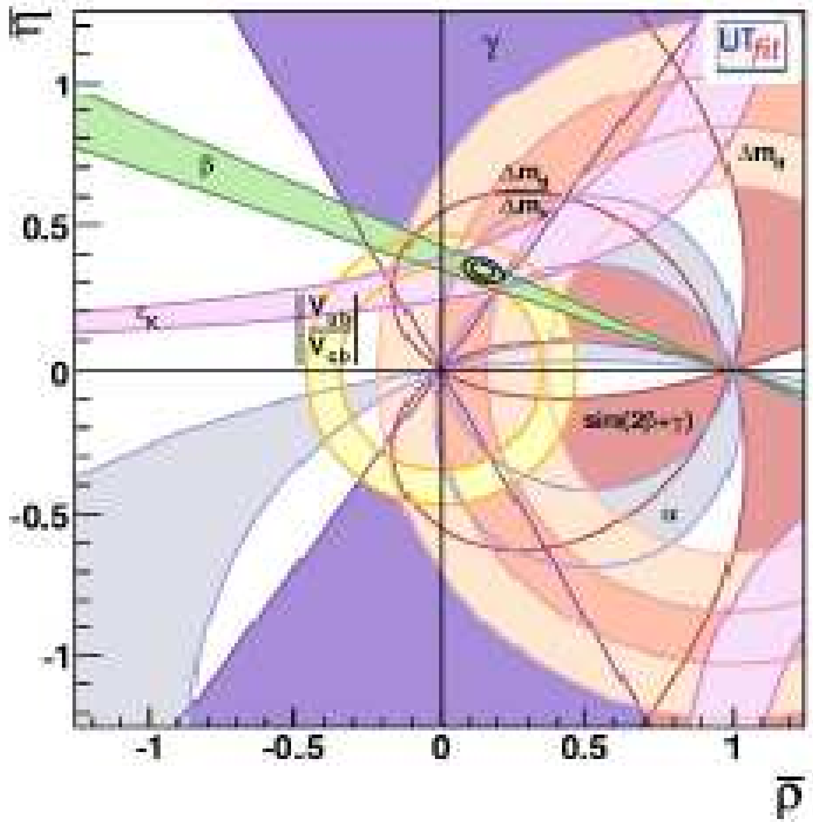


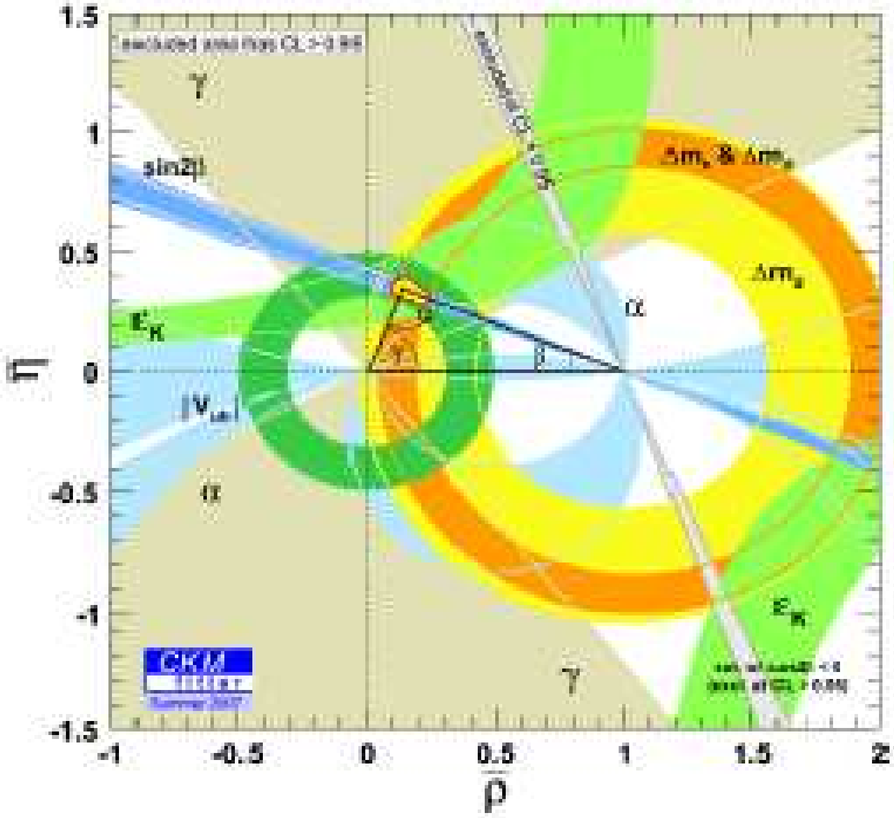
Hints for New Physics?

Present view of UT and CKM

B. Global CKM fits and constraints on New Physics

Flavianet members contribute to CKMfitter and UTfit analyses:





Hints of a large new physics phase in b→s transitions?

Smith

Where to test Standard Model?

FLAVOUR COUPLINGS
(⟶ decreasing SM contribution ⟶)

ELECTROWEAK STRUCTURE
(⟵ decreasing SM contribution ⟵)

FCNC	$b \to s\ (\sim\lambda^2)$	$b \to d\ (\sim\lambda^3)$	$s \to d\ (\sim\lambda^5)$
$\Delta F = 2$	ΔM_{Bs} $A_{CP}(B_s \to \psi\phi)$	ΔM_{Bs} $A_{CP}(B_d \to \psi K)$	$\Delta M_K, \varepsilon_K$
$\Delta F = 1$ 4-quark	$B_d \to \phi K, \pi K, \ldots$	$B_d \to \pi\pi, \rho\pi, \ldots$	ε'/ε, $K \to \pi\pi\pi, \ldots$
gluon penguin	$B_d \to X_s\gamma$, $B_d \to \phi K, \pi K, \ldots$	$B_d \to X_d\gamma, \pi\pi, \ldots$	ε'/ε, $K_L \to \pi^0\ell^+\ell^-, \ldots$
γ penguin	$B_d \to X_s\gamma, X_s\ell^+\ell^-$, $B_d \to \phi K, \pi K, \ldots$	$B_d \to X_d\ell^+\ell^-$, $B_d \to X_d\gamma, \pi\pi, \ldots$	ε'/ε, $K_L \to \pi^0\ell^+\ell^-, \ldots$
Z^0 penguin	$B_d \to X_s\ell^+\ell^-$, $B_s \to \mu^+\mu^-$, $B_d \to \phi K, \pi K, \ldots$	$B_d \to X_d\ell^+\ell^-$, $B_d \to \mu^+\mu^-$, $B_d \to \pi\pi, \ldots$	ε'/ε, $K \to \pi\nu\bar{\nu}, \ldots$ $K_L \to \pi^0\ell^+\ell^-, \mu^+\mu^-$
H^0 penguin	$B_s \to \mu^+\mu^-$	$B_d \to \mu^+\mu^-$	$K_L \to \pi^0\ell^+\ell^-$, $K_L \to \mu^+\mu^-$

Smith

Gino Isidori's table of FCNC observables

New Physics hints in Unitarity Triangle?

From the conclusions of E. Lunghi talk:

- Theoretical undestandig of QCD issues related to UT analysis improved
- Large new physics effects
  - *UT fit (new lattice-QCD results)*
  - *CP asymmetries in b→sss modes*
  - *Bs mixing: model independent analyses of B→J/ψΦ*
  - *Ds→lν, asymmetries in B→K*μμ*

…..

⇨ a possible NP scenario envisaged

Unitarity triangle: an update

Lunghi

- Time dependent CP asymmetries:
  - *new phases in Bd sysytem?*
    (mixing and b→sss amplitudes)

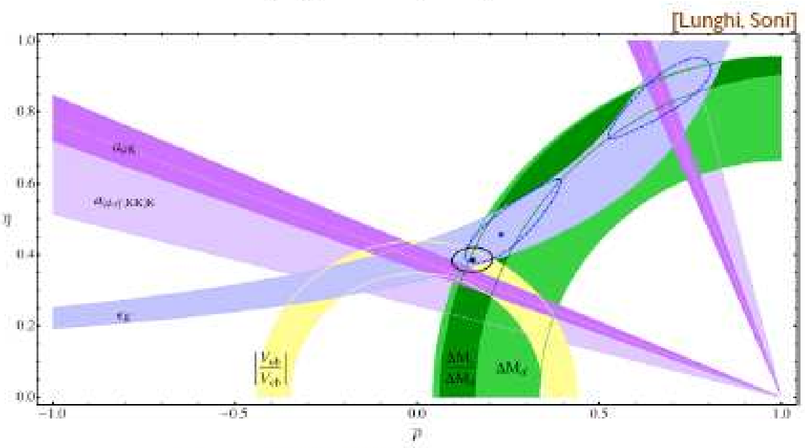
Direct vs indirect sin(2β)

mode	experiment	no V_{ub} 0.87 ±0.09	with V_{ub} 0.75 ±0.04
$a_{\psi K_S}$	0.681 ± 0.025	$2.1\ \sigma$	$1.7\ \sigma$
$a_{\phi K_S}$	0.39 ± 0.17	$2.5\ \sigma$	$2.1\ \sigma$
$a_{\eta' K_S}$	0.61 ± 0.07	$2.3\ \sigma$	$1.8\ \sigma$
$a_{(\phi+\eta')K_S}$	0.58 ± 0.06	$2.7\ \sigma$	$2.5\ \sigma$

- |Vub|: updated value and extraction of sin(2β):
  - Discrepancy do not depends critically on |Vub|

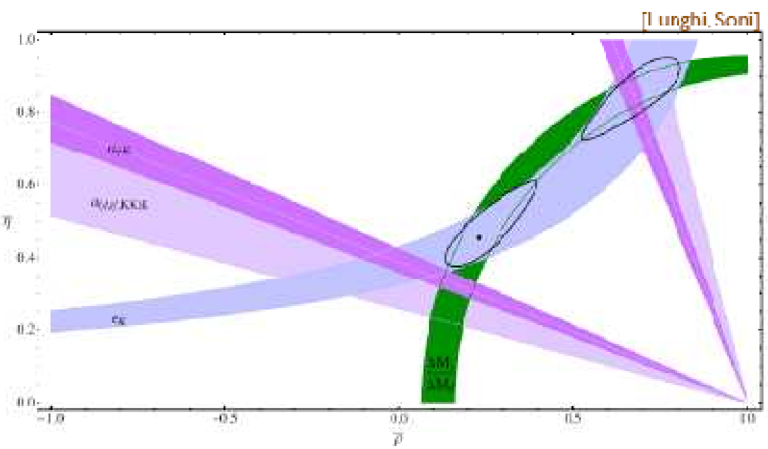
⇨Possible new physics phases in Bd system

Extraction of sin(2β) with |Vub|



$[\sin(2\beta)]^{\text{prediction}}_{\text{full fit}} = 0.75 \pm 0.04$

Extraction of sin(2β) without using |Vub|



$[\sin(2\beta)]^{\text{prediction}}_{\text{no } V_{ub}} = 0.87 \pm 0.09$

The Future of Flavour Physics

- B sector:
  - New B-factories

Hitlin
Kinoshita

- C Sector:
  - FNAL: extracted beams

Schwartz

- K Sector:
  - NA62 (phase 2), JPark, Project-X

Jensen

Super B Factory Motivation

- Physics beyond the Standard Model (SM) must exist.
  - LHC may find TeV-scale New Physics
- If the LHC finds New Physics at the TeV scale,
  - Its flavor structure must be examined experimentally. A Super B Factory is the best tool for this purpose.
- If the LHC finds nothing except for a SM-like Higgs,
  - Studying/searching for deviations from the SM in flavor physics will be one of the best ways find new physics. (remember particle physics history !)

The super-high luminosity

Stored current:

1.34 / 1.8 A (KEKB)

→ 4.1 / 9.4 A (SuperKEKB)

Beam-beam parameter:

0.057 (KEKB)

→ 0.19 (SuperKEKB)

Crab cavity

Lorentz factor

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

Classical electron radius

Beam size ratio

Geometrical reduction factors due to crossing angle and hour-glass effect

Luminosity:

0.15 $\times 10^{35}$ cm^{-2}s^{-1} (KEKB)

4 $\times 10^{35}$ cm^{-2}s^{-1} (SuperKEKB)

Vertical β at the IP:

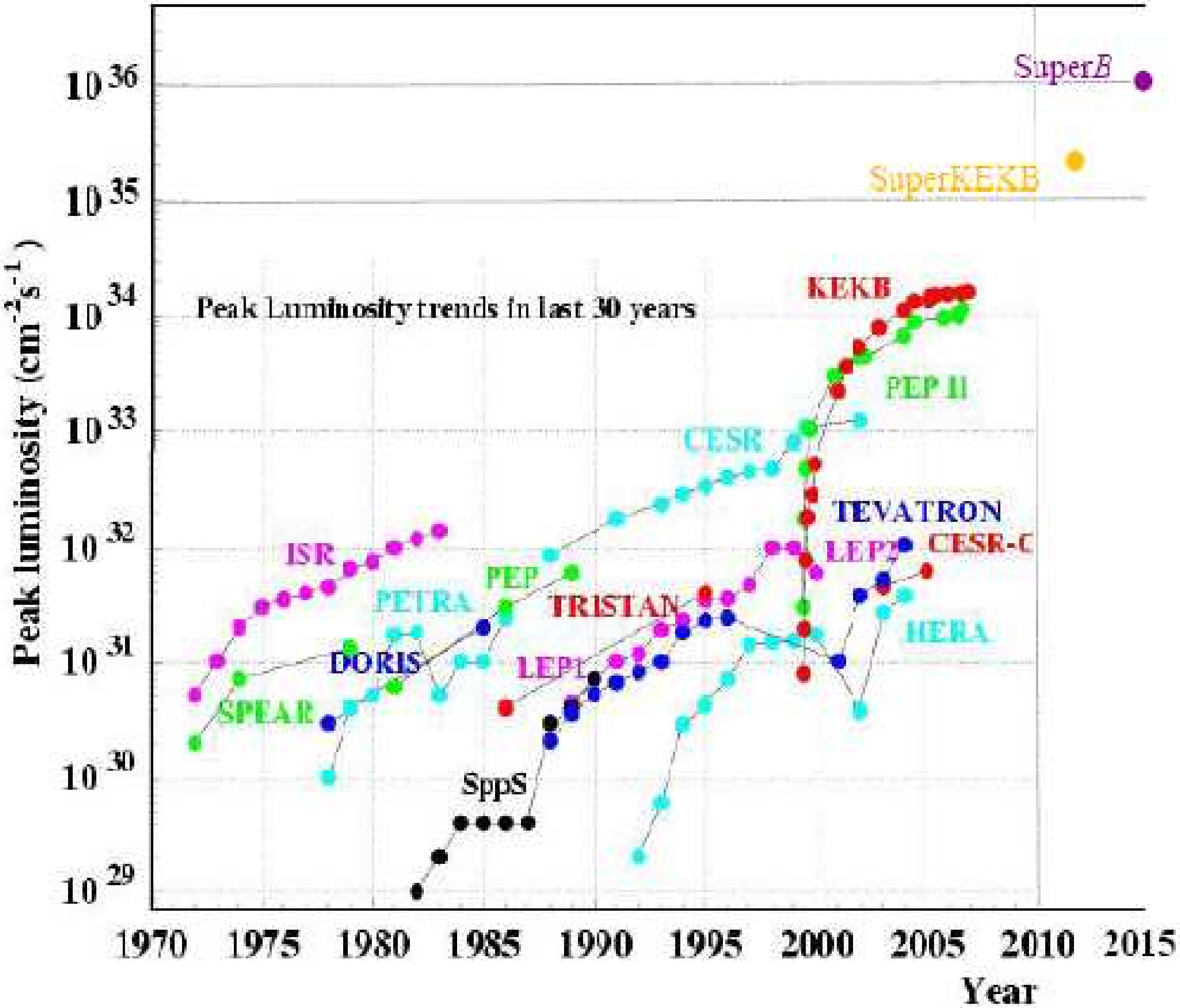
5.2/6.5 mm (KEKB)

→ 3.0/3.0 mm (SuperKEKB)

Bunch length (σ_s)

7 ~ 9 mm -> 3 mm

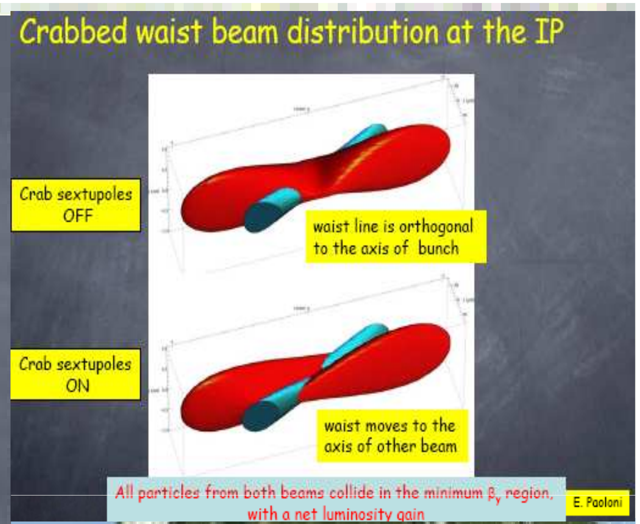
Peak luminosity trends



The Super B-Factory - I

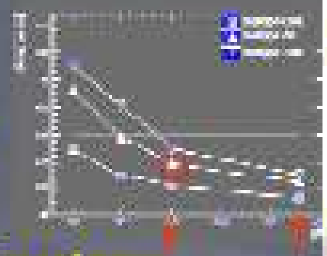
Q&A

- Is there a motivation to continue e^+e^- flavor physics studies with a Super B factory beyond the *BABAR*/Belle/(LHCb) era ?
  - Yes – provided that new measurements have sensitivity to New Physics in b, c and τ decay
- What size data sample is required to provide this sensitivity ?
  - 50-75 ab^{-1} (*BABAR*+Belle total sample is <2 ab^{-1})
- What luminosity is required to gather a sample of this size in five years ?
  - At least 10^{36} $cm^{-2}s^{-1}$
- Can an asymmetric collider with this luminosity be built ?
  - Yes, using an innovative new approach: a low emittance collider, based on concepts developed for the ILC damping rings, and employing a new type of final focus – a "crabbed waist". The machine is called Super$B$
- Can a detector be built that can withstand the machine backgrounds ?
  - Yes. The beam currents are less than those at PEP-II and KEKB
- In this era of increasing energy prices, can you pay the power bill ?
  - Yes. The wallplug power, 17MW, is less than half that of KEKB (40mw)



The Super B-Factory - II

SuperB One Pager



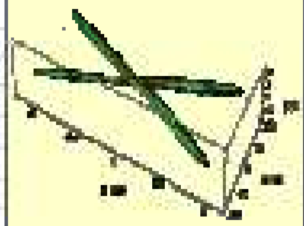
- SuperB is a Super Flavor Factory with very high initial luminosity, 10^{36}, which can be upgraded to 4×10^{36} in a straightforward manner
- It is asymmetric : 4 on 7 GeV
- Most of the ring magnets can re reused from PEP-II, as can the RF systems, many vacuum components, linac and injection components - as well as BABAR as the basis for an upgraded detector
- The high energy beam can be linearly polarized to ~85% , using the SLC laser gun
  - This is particularly important for confronting New Physics in τ decays
- The primary E_{CM} will be the $\Upsilon(4S)$, but SuperB can run elsewhere in the Υ region, and in the charm &tau threshold regions as well, with a luminosity above 10^{35}
  - One month at the $\psi(3770)$, for example, yields 10x the total data sample that will be produced by BEPCII
- SuperB will be built on the campus of the Rome II University at Tor Vergata
  - There is an FEL already in early stages of construction on the site
  - Tunneling will continue to dig the SuperB tunnel, funded by Regione Lazio
- Time scales
  - (Successful) conclusion of the European Roadmap process (INFN, ECFA, CERN Strategy Group) by the end of 2008, followed by INFN→Ministry
  - TDR effort is beginning: construction 5 years : luminosity in 2015

Super B parameters

Current SuperB Parameters

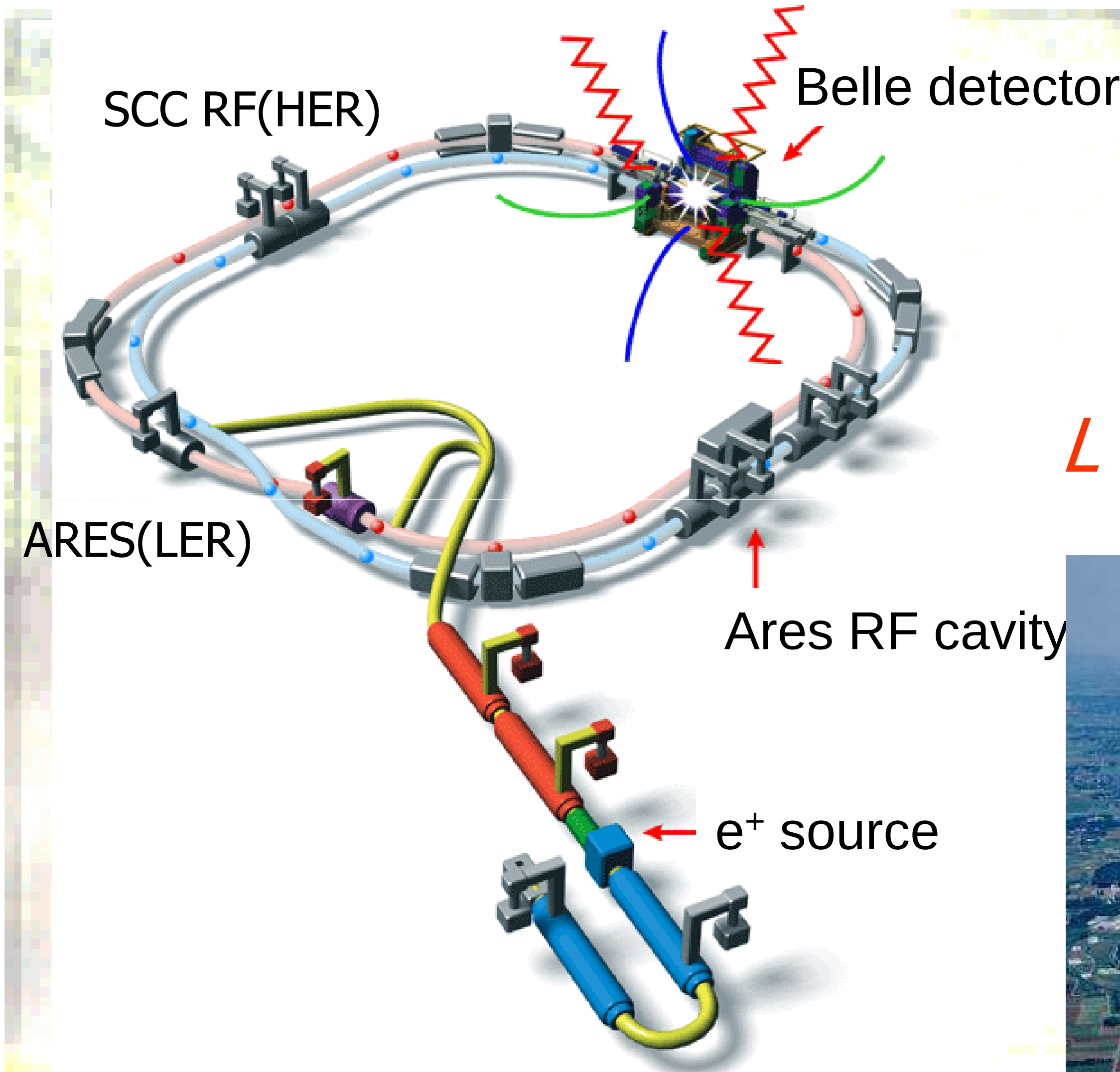
PARAMETER	Nominal LER (e+)	Nominal HER (e-)	Upgrade LER (e+)	Upgrade HER (e-)	Ultimate LER (e+)	Ultimate HER (e-)	SuperKEKB LER (e+)	SuperKEKB HER (e-)
Energy (GeV)	4	7	4	7	4	7	3.5	8
Luminosity x 10^{36}	1.0		2.0		4.0		0.8 (0.4)	
Circumference (m)	1800	1800						
Revolution frequency (MHz)	0.167							
Eff. long. polarization (%)	0	80						
RF frequency (MHz)	476							
Momentum spread ($\times 10^{-4}$)	7.9	5.6	9.0	8.0				
Momentum compaction ($\times 10^{-4}$)	3.2	3.8	3.2	3.8				
Rf Voltage (MV)	5	8.3	6	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 ($\times 10^{10}$)	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			45	
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)	6		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 ($\times 10^{11}$) (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)

The KEKB Collider

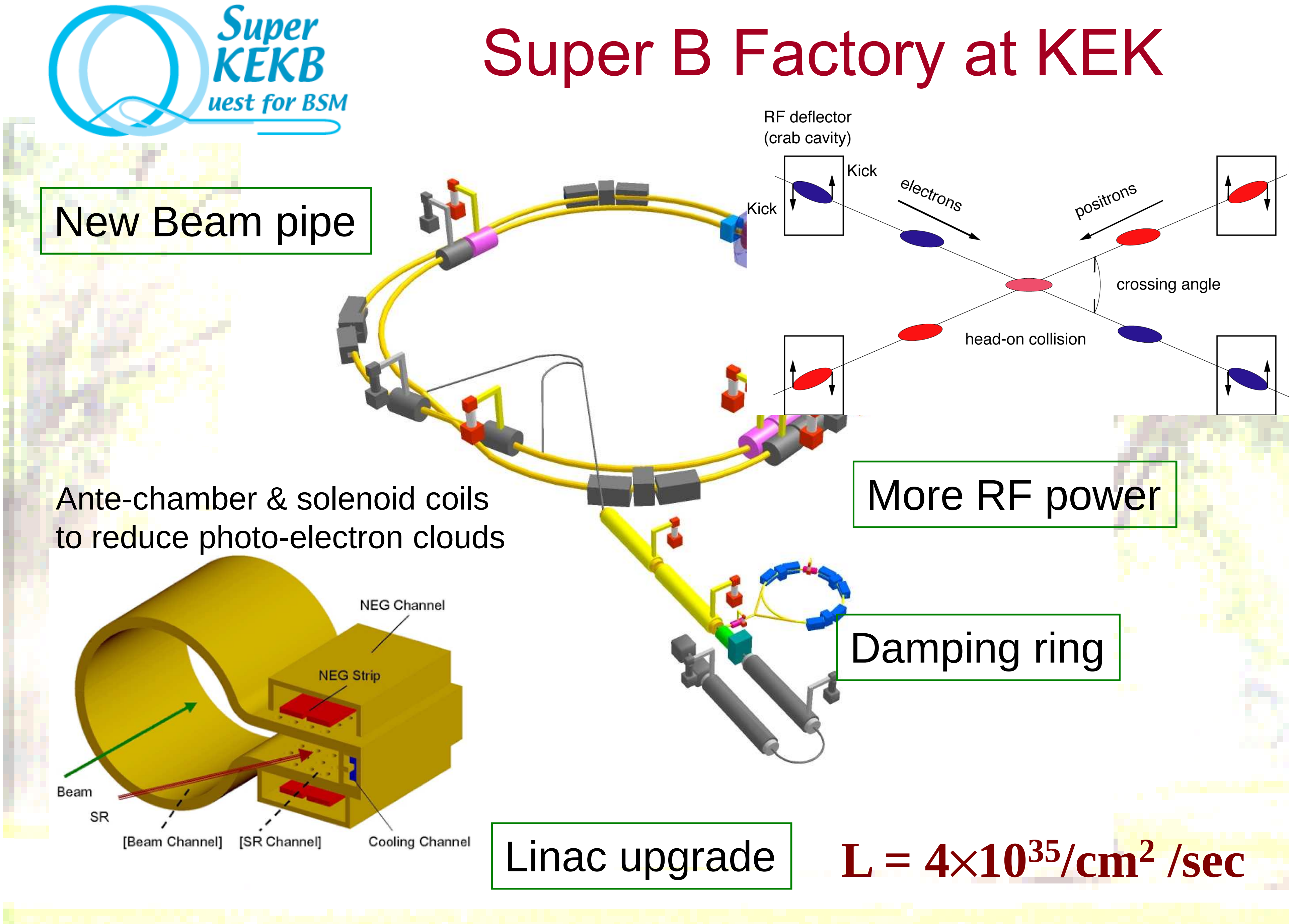


8 x 3.5 GeV
22 mrad crossing angle

World record:

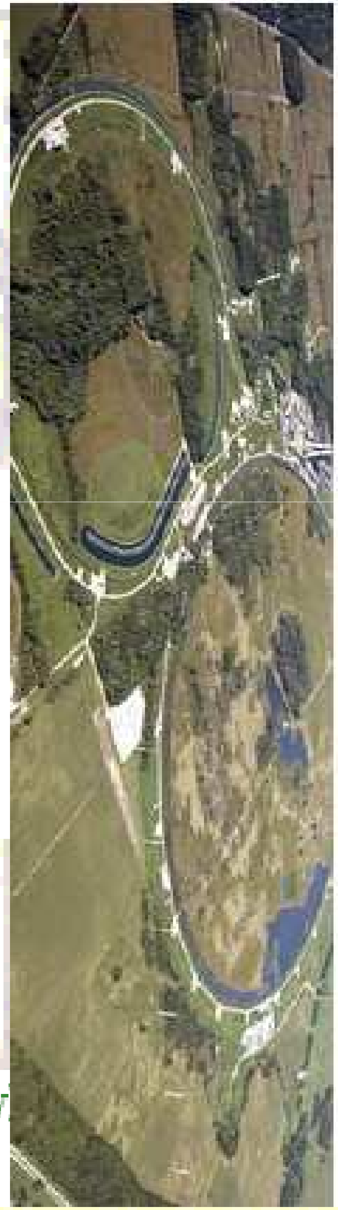
$L = 1.6 \times 10^{34} / cm^2 / sec$

Super B Factory at KEK



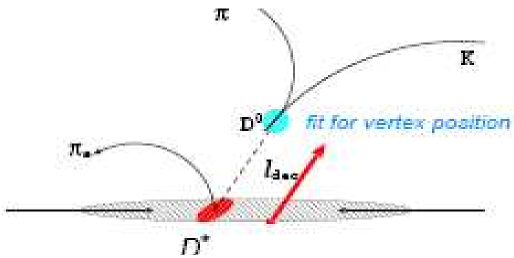
$L = 4\times10^{35}/cm^2\ /sec$

Future charm physics: the Tevatron



A high statistics charm mixing experiment using the Tevatron

- Better sensitivity than all B factory data
- Can significantly improve sensitivity to CPV in charm system, help un-tangle whatever signals appear at Tevatron or LHC
- Experimental method: back to fixed target
- Concepts:
  - Slow spill beam on target *a la E691, E769, E791, E687, E831, E789, E771* (proton beam, p ~800 GeV/c)
  - Initial flavor of $D^0(t)$ is determined from $D^{*+} \to D^0\pi^+$ or $D^{*-} \to D^0\pi^-$
    This also greatly reduces background: $Q = m_{K\pi\pi} - m_{K\pi} - m_\pi$ only 6 MeV/c
    (*i.e.*, for D^* decays: very near threshold)
  - D^0 proper decay time $\Delta t = (d_{dec}/p)\ x\ (m/c)$ measurement:



  - "modern" detector: pixels/striplets for vertexing, RICH detector for (very high π/K discrimination, processor farm for triggering

The future of Kaon Physics

Golden Modes (FCNC)

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

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

- The current expermental results are:

$$K^+ \rightarrow \pi^+ \nu \bar{\nu} = (1.5^{+1.3}{}_{-0.9})x10^{-10}\ BNL949\_3Events$$

$$K^0 \rightarrow \pi^0 \nu \bar{\nu} < 6.7x10^{-8}(90\%CL)KEK391a$$

Experiments – past and present

Much discussion among experimenters

- K^+
  - BNL Results reported above
  - (CKM) – Fermilab MI Proposal, approved, canceled
  - NA 62 - Approved (Feb 07, phase 1)
- K^0
  - KTeV Complete 38 PhD's, 50 publications
  - KEK E391 Results noted above
  - Jparc E14 Recommended for Approval by PAC
  - (KAMI) - Fermilab MI Proposal, not approved - TEST
  - (KOPIO) – BNL - canceled

Kaons: Rare Decays

- an almost-Minimal Flavor Violation World
  - Measuring small deviations from SM – of great importance.
    - SUSY breaking scale, Flavor symmetries related to unification, Compositeness, extra dimensions, etc.
  - Directly complementary to central physics program at LHC.
  - Experimental focus – theoretically & experimentally clean
    - Small errors: ~ a few %; require ~1,000 clean Kaon events

$K^+ \rightarrow \pi^+\nu\nu$	#evnts	$K_L \rightarrow \pi^0\nu\nu$	#evnts
CERN NA48 (by 2012)	~160	J-PARC I (by 2012)	~4
		J-PARC II (by ~2016)	~100
Potential FNAL (w/o Proj.X)	~600	Potential FNAL (w/o Proj.X)	~200
Potential FNAL (w/ Proj.X)	~1500	Potential FNAL (w/ Proj.X)	~1000

(FNAL: 5 year running)

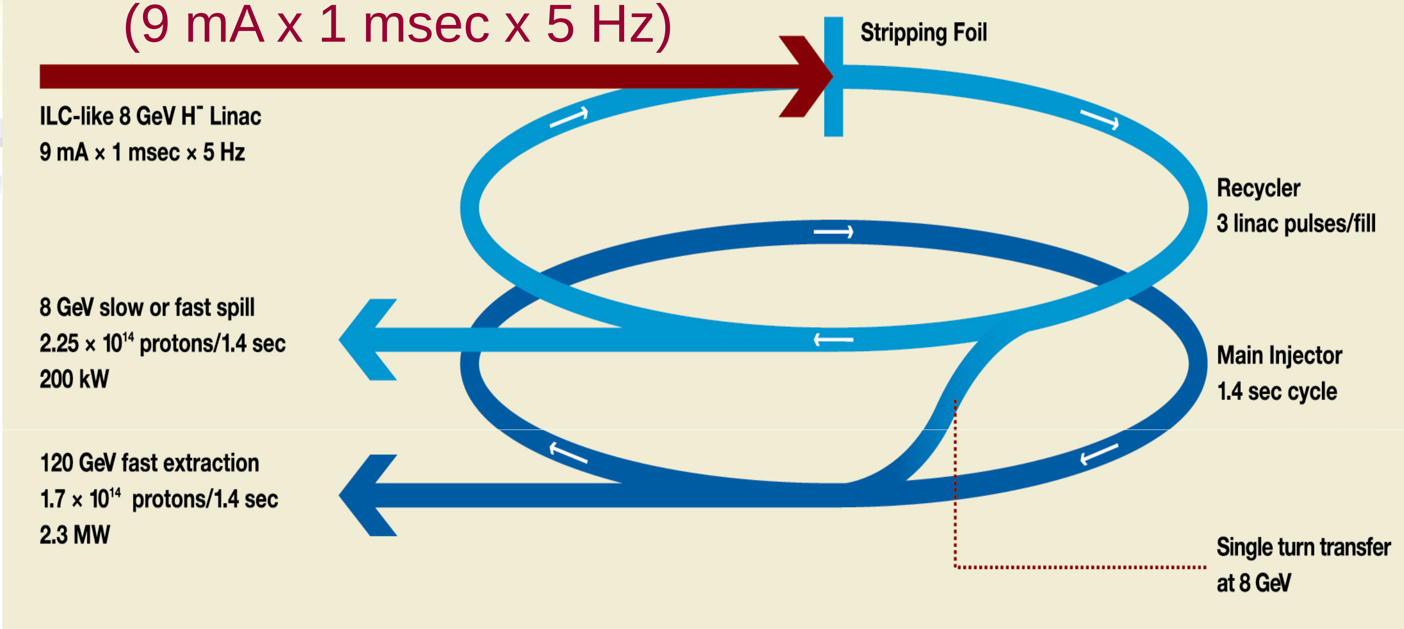
What is Project-X ?

- The basic scheme is an 8 GeV linac operating with ILC-like parameters (9mA x 1mS x 5Hz)
  - 0.6 GeV Front End linac
  - 0.6 – 8 GeV ILC style linac
- Stripping and accumulation in the Recycler
- Beam distributed
  - to the Main Injector for acceleration to (up to) 120 GeV
  - to an 8 GeV program.
- May use accumulator / debuncher rings

Project X: Properties

8 GeV H$^-$ Linac with ILC Beam Parameters: ~1.5% ILC Linac

(9 mA x 1 msec x 5 Hz)



100 – 200 kW
at 8 GeV

+

>2.0 MW
at 50-120 GeV

Linac:

No ILC (< 0.6 GeV)

ILC-like (0.6 ~ 2.4 GeV) – 15 crymodules

ILC-identical (2.4 ~ 8 GeV) – 24 crymodules

Cavities, Cryomodules,

RF and Cryogenic Distribution

Vehicle for National & International Collaboration

Beam Sharing

- Primary Focus of Project X is ν physics
  - 120 GeV protons to make ν's to NOvA
  - Neutrinos to DUSEL
- Protons left over for 8 GeV physics
  - μ–e conversion (P5 Support)
  - Kaon physics
  - g – 2

Concluding Remarks

- The precision experimental programme has to be considered within a coherent flavour effort complementary to the high energy frontier
- The precise SM predictions and the sensitivity to New Physics makes the continuation of precision measurements of rare decays compelling

Now waiting for the first LHC results to understand the direction to better investigate and disturb the Universe….

Summary and outlook

"The standard model of fundamental interactions is remarkably successfull, but leave an unfinished agenda. Several major questions seem ripe for exploration in the near future. I anticipate that the coming decade will be a Golden Age of discovery in fundamental physics."

Frank Wilczek, *"Anticipating a New Golden Age", arXiv:0708.4236v3 [hep-ph]*

We also hope so, thus disturbing soon
the too quiet Standard Universe…

MANY THANKS again to:
the BEACH2008 organizers and all partecipants.
See you in Perugia, at next edition of BEACH, in 2010