ROADMAP TO THE FUTURE

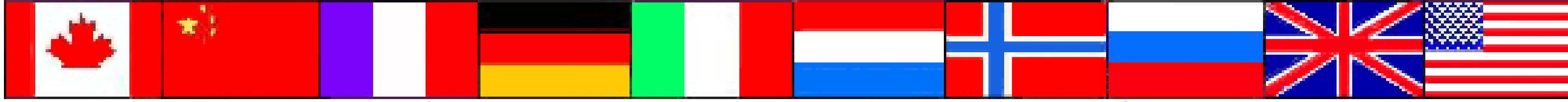
Marcello A. Giorgi

at

DOE Program Review

Outline

- BaBar Collaboration
- BaBar Mission
- From now toward the end of this decade
- Roadmap to the future beyond this decade



The *BaBar* Collaboration

10 Countries

77 Institutions

593 Physicists

USA [38/300]

California Institute of Technology
UC, Irvine
UC, Los Angeles
UC, Riverside
UC, San Diego
UC, Santa Barbara
UC, Santa Cruz
U of Cincinnati
U of Colorado
Colorado State
Florida A&M
Harvard
U of Iowa
Iowa State U
LBNL
LLNL
U of Louisville
U of Maryland
U of Massachusetts, Amherst
MIT
U of Mississippi
Mount Holyoke College
SUNY, Albany
U of Notre Dame
Ohio State U
U of Oregon
U of Pennsylvania
Prairie View A&M U
Princeton U
SLAC
U of South Carolina
Stanford U
U of Tennessee
U of Texas at Austin
U of Texas at Dallas
Vanderbilt
U of Wisconsin
Yale

Canada [4/20]

U of British Columbia
McGill U
U de Montréal
U of Victoria

China [1/5]

Inst. of High Energy Physics, Beijing

France [5/51]

LAPP, Annecy
LAL Orsay
LPNHE des Universités Paris VI et VII
Ecole Polytechnique, Laboratoire Leprince-Ringuet
CEA, DAPNIA, CE-Saclay

Germany [4/31]

Ruhr U Bochum
Technische U Dresden
Univ Heidelberg
U Rostock

Italy [12/101]

INFN, Bari
INFN, Ferrara
Lab. Nazionali di Frascati dell' INFN
INFN, Genova & Univ
INFN, Milano & Univ
INFN, Napoli & Univ
INFN, Padova & Univ
INFN, Pisa & Univ & ScuolaNormaleSuperiore
INFN, Perugia & Univ
INFN, Roma & Univ "La Sapienza"
INFN, Torino & Univ
INFN, Trieste & Univ

The Netherlands [1/5]

NIKHEF, Amsterdam

Norway [1/3]

U of Bergen

Russia [1/11]

Budker Institute, Novosibirsk

United Kingdom [10/66]

U of Birmingham
U of Bristol
Brunel U
U of Edinburgh
U of Liverpool
Imperial College
Queen Mary , U of London
U of London, Royal Holloway
U of Manchester
Rutherford Appleton Laboratory

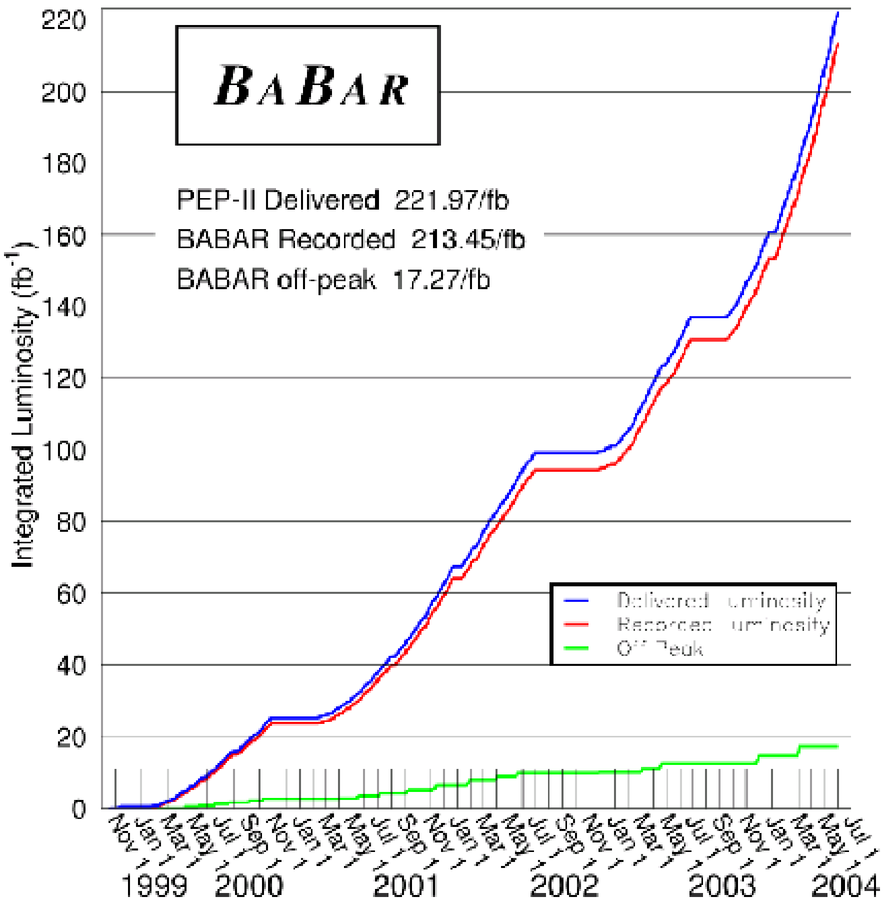
BABAR

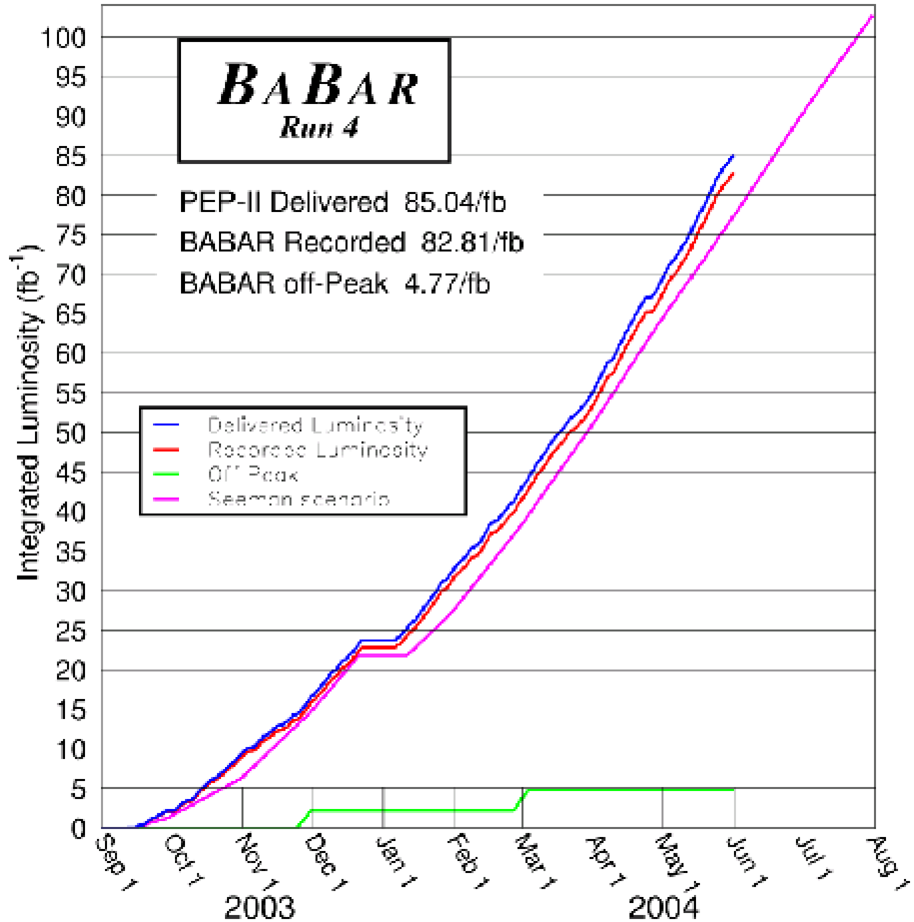
May 3, 2004

Our Survey started in nov 2003 in European and US institutions of BABAR indicates that Operations are guarateed in the long period (Detector maintenance,Machine Detector Interface, Computing, Detector Operations)

FTE distribution for BABAR OPERATIONS (projections up to 2009)

Operations	'04	'05	'06	'07	'08	'09
US Universities	63	60	56	52	52	50
SLAC	33	32	30	26	26	24
NON US	65	63	62	60	60	57

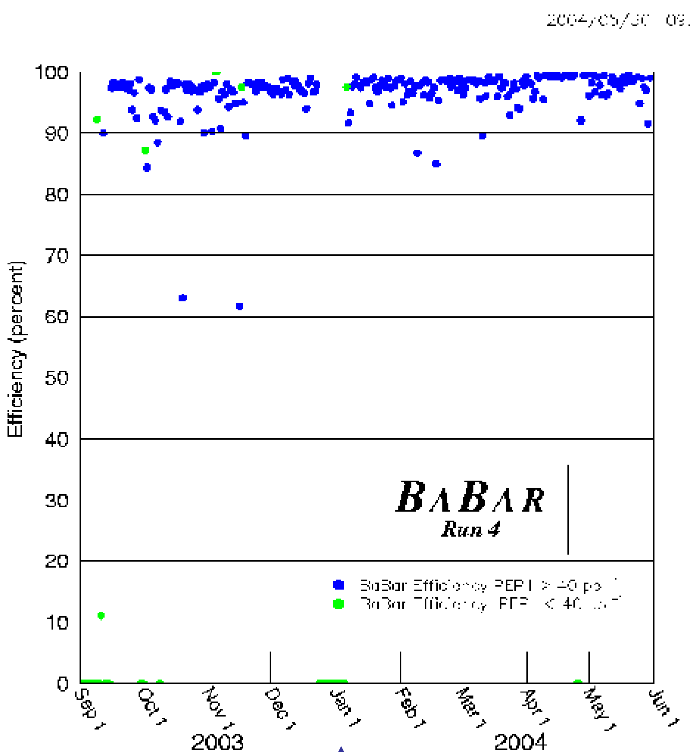


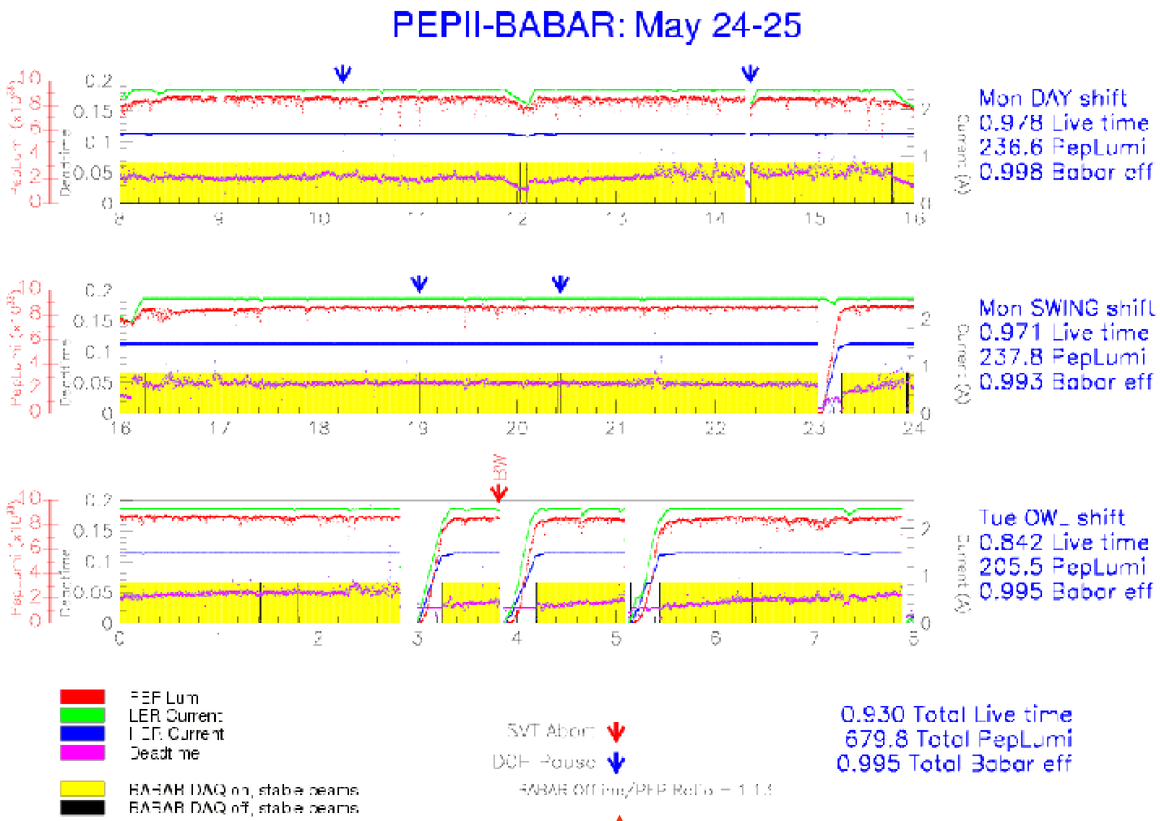


PEPII peak Luminosity (5/21/04) 9.213x10^{33} cm^{-2} sec^{-1}

Data sample collected: 212.01 fb $^{-1}$

1999	2000	2001	2002	2003	2004
1.62	23.76	40.05	31.32	56.71	58.55





BaBar efficiency>99-8%

With Trickle injection in LER & HER the stability of the machine has been substantially improved.

Revised calculation of the integrated lumi

As a simplified formula for luminosity integrated over one year is generally assumed

$\int L\, dt = L_{peak}\,(cm^{-2}\, s^{-1}) \times Conventional\ Year\ (\, s\,)$

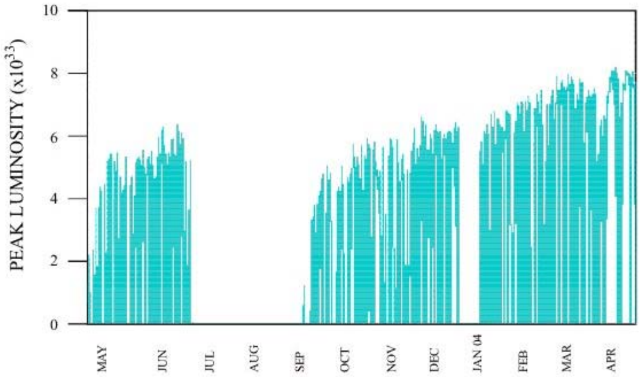
where *Conventional Year* is:

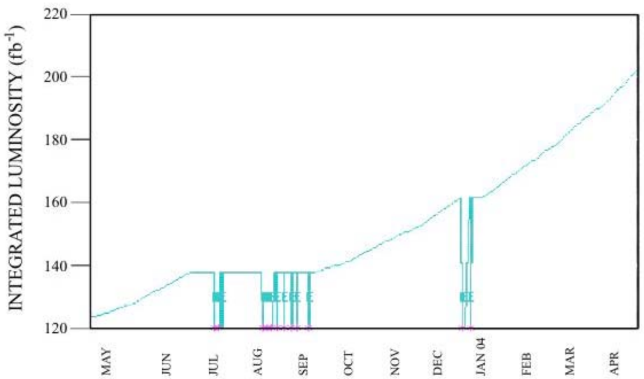
1 Year (s) × Overall Efficiency *(Machine& Detector uptime , deadtime..)*
After Snowmass 1988 and according to ***Cleo/CESR*** *experience the* ***Conventional Year*** *was assumed* ***= 10 ^{7} s*** *and also called* ***Snowmass Year***.

Based on the success of continuous injection for PEPII *and* KEKB and the very high BaBar efficiency for us the conventional year is now close to 1.4 10^{7} s

New correction to Snowmass Year in Luminosity calculation is 1.4

PEP-II performance April 2003-April 2004 (Dec 03 Trickle LER, Feb 04 Trickle HER)





The Detector is behaving very well........

The Muon Detector will be upgraded starting this summer 2004 (RPC will be replaced by LST and brass absorber will be added in the barrel to improve the muon filtering) and completed in the summer 2005.

SVT *is behaving well since the first installation in 1999, without any significant deterioration of its performance.*

However in september a decision will be taken on a possible intervention in 2005 to replace some modules in view of the higher luminosity condition from then until the end of the decade.

The spare modules of SVT (about 50% of the entire detector) are ready and are sitting quietly in the shelves of Pisa and UCSB since 2002.

From the original BaBar mission to.......

The original physics goal was the discovery of CP violation also in the b sector

- Discovered by BaBar in July 2001 with the first measurement

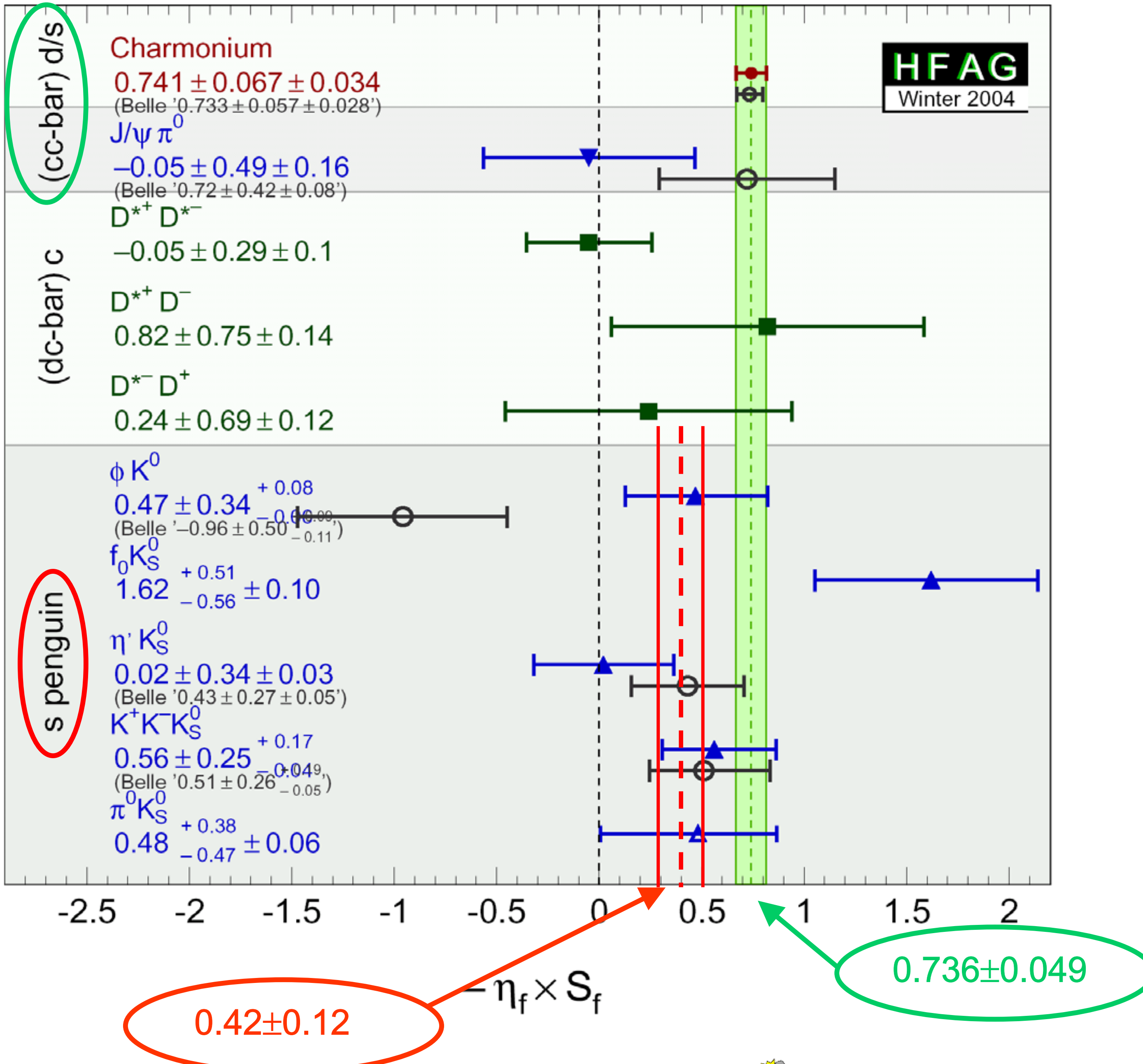
of $\sin 2\beta$.

Now $\sin 2\beta$ has become a scientific program to challenge the precision of the SM predictions.

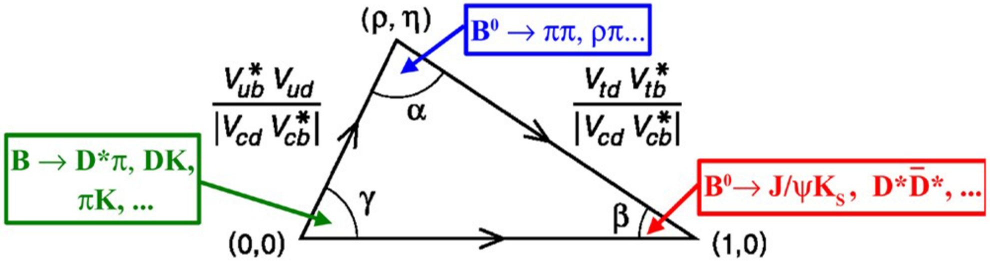
In addition to CP parameters measurement, BaBar in Spring 2003 has profited of the abundance of $c\bar{c}$ pairs produced in PEPII for discovering the new and intriguing charm particle $D_{sJ}(2317)$ and pioneering a new spectroscopy

(Later on new contributions to the field came from CLEO and Belle) .

STATUS of Sin2β Program



UNITARITY TRIANGLE: towards α and γ



Measuring angles α and γ is far and requires a very high statistics since observables (time dependent asymmetries) are "polluted" by the interference between of tree and penguin amplitudes that contribute to the involved B decays. The result is a presence of a strong phase δ that makes the measured value $\alpha_{eff}/\gamma_{eff}$ different from the angle α/γ of the unitarity triangle that one intends to measure. Several techniques as isospin analysis for α extraction or ADS or GW for γ have been suggested and studied.

As α is concerned it was suggested by Grossman&Quinn a way based on measurements of "relative" channels BF (for $B^0 \rightarrow \pi^+\pi^-$ it is $B^0 \rightarrow \pi^0\pi^0$ BF) to bound the value of $(\alpha - \alpha_{eff})$

The first measurement from BaBar (summer 2003) of the BF allows for a too loose bound for α from ππ.

$$\overline{B}(B^0 \rightarrow \pi^0\pi^0) = 2.10 \pm 0.6 \pm 0.3 \times 10^{-6}$$

$|\alpha - \alpha_{eff}| < 48^o$ at 90% c.l.

BUT……….

Extraction of α from $B \rightarrow \rho^+\rho^-$

ρ's polarization was measured they were found 100% longitudinally polarized (therefore in a CP even eigenstate)

The time dependent analysis has given:

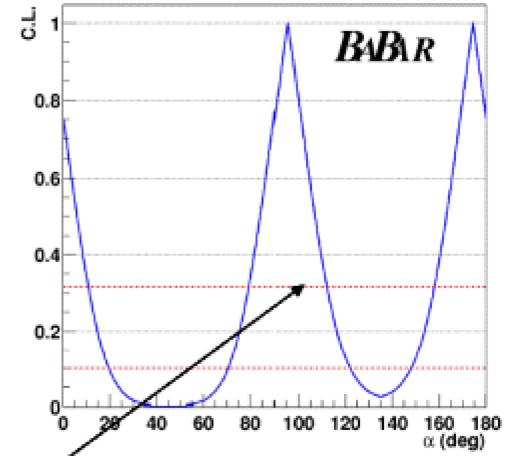
S_L=-0.19±0.33(stat) ±0.11(syst)

C_L=-0.23 ±0.24(stat) ±0.14(syst)

One example of new results

From Lydia Roos at Moriond

- Main systematics: CPV in B bkg
- Detailed study of B background: 209 B decay modes simulated

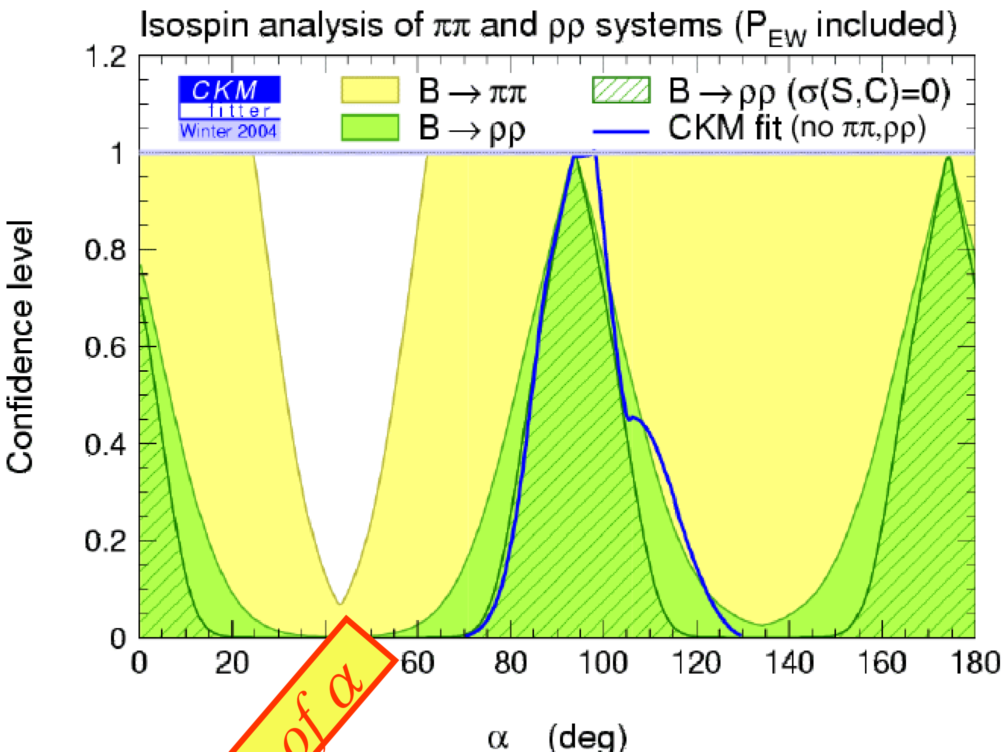


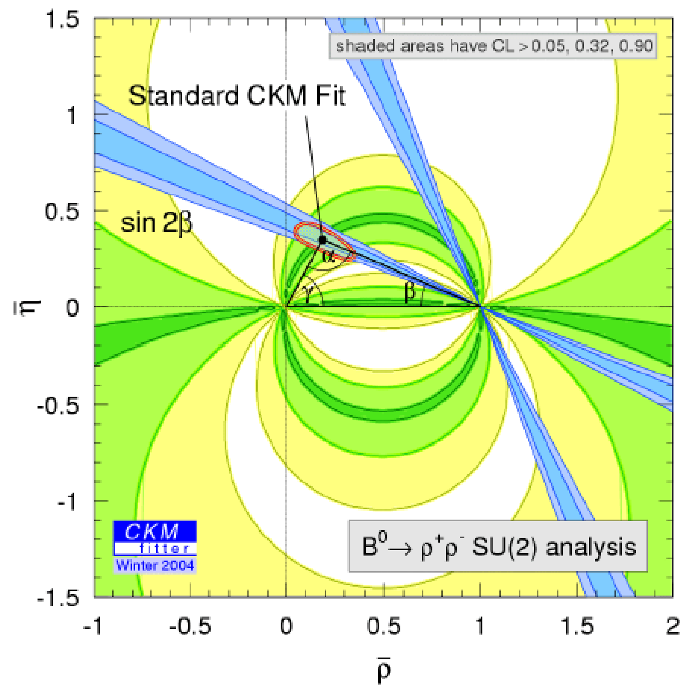
$\alpha = (96 \pm 10_{stat} \pm 4_{syst} \pm 13_{peng})^{\circ}$

- Isospin analysis: interference, NR contributions, I=1 amplitudes neglected

Plots from CKM fitter group: I-spin analysis of $B \to \rho^+\rho^-$

Presented by Lydia Roos at Moriond EW (not official BABAR plots)





first measurement of α

81fb^{-1} submitted	113 fb^{-1} preliminary
$S_{long} = -0.42 \pm 0.42_{stat} \pm 0.14_{syst}$	$S_{long} = -0.19 \pm 0.33_{stat} \pm 0.11_{syst}$
$C_{long} = -0.17 \pm 0.27_{stat} \pm 0.14_{syst}$	$C_{long} = -0.23 \pm 0.24_{stat} \pm 0.14_{syst}$

- Constraint on α in perfect agreement with the Standard Fit;

$$\alpha = (96 \pm 10_{stat} \pm 4_{syst} \pm 13_{peng})^\circ$$

PRODUCTIVITY: publications: *BABAR* vs. Belle (published or submitted)

	BABAR	Belle
<2003	34	54
2003	47	28
2004 (June)	16	9
Total	97	91

From Spires: published in 2003

	BABAR	BELLE	CLEO
P.R.L.	22	14	2
P.R.D.	11	6	9
TOTAL	33	20	11

Key analyses for Run4/Summer 2004 (preliminary list & data samples still under discussion)

BLACK DIAMOND (data up to mid-July)

sin2β from charmonium
$B \to \pi^+\pi^-$ (incl. $K^+\pi^-$, K^+K^-)
$B \to \phi K_S$
one more from list below?

BLUE SQUARE (data up to mid-June)

- $B \to K^+K^- K_S$
- $B \to K_S \pi^0$
- $B \to f_0 K_S$
- $B \to \eta' K_S$
- $B \to \rho^0 K_S$
- $B \to \rho^+\rho^-$
- $B \to \rho^+\pi^-$ Dalitz
- $B \to \pi^0 \pi^0$
- $B \to \rho^0\rho^0$
- $B \to \phi K^*$ angular analysis

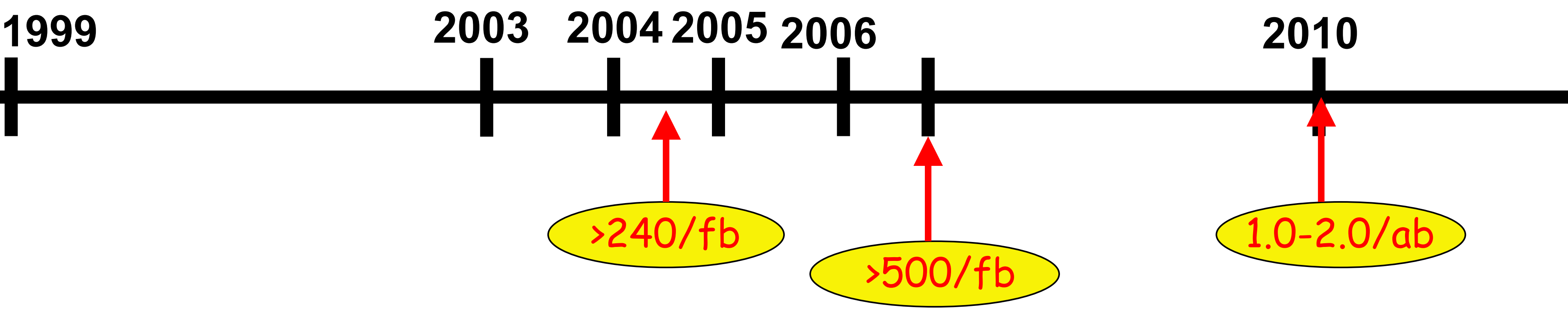
(Items $B \to K^+K^- K_S$ through $B \to \rho^+\pi^-$ Dalitz: CP(t))

From Jeff Richman

GREEN CIRCLE (data up to May 1)

- $B \to D^*D^*$ CP(t) [Full reco & incl D*]
- $B \to J/\psi K\pi$ cos(2β) CP(t)
- $B \to \pi^+\pi^0$, $K^+\pi^0$
- $B \to K^+K^0$, $K^0\pi^+$; $B \to K^0K^0$
- $B \to h^+ h^- h^0$ Dalitz
- $B \to K_S\pi^0\gamma$ CP(t)
- $B \to \rho\gamma$
- $B \to K^* l^+ l^-$
- $B \to D^*\pi$: CP(t), sin(2β+γ) [full & partial D*]; Tag side CPV
- $B \to D^0(CP-)K^-$
- $B \to D(K\pi) K$ (ADS)
- $B \to D^0$ (3 body) K^- Dalitz (?)
- $B \to D\rho$ (?)
- $B \to D_s(^*)(\rho, a_1)$
- $\tau \to \mu\gamma$

The BaBar physics program will be centered on the precision measurements of the parameters of the Unitarity Triangle to challenge the SM predictions at the level of the expected theoretical uncertainties



$\int L dt = 130 \text{ fb}^{-1}$ (June 30, 2003)

$\int L dt = 500 \text{ fb}^{-1}$ (End 2006)

$\int L dt > 1 \text{ ab}^{-1}$ (PEP-II ultimate)

Projections on angles

Unitarity Triangle Angles [degrees]3.8-6.3	e^+e^- [ab^{-1}]		
Measurement	0.5	1	2
$\alpha(\pi\pi)$ ($S_{\pi\pi}$, $B\rightarrow \pi\pi$ BR's+ isospin)	16.5	11.6	8.2
$\alpha(\rho\pi)$ (Isospin, Dalitz) (syst $\geq 3°$)	7.3-5.6	5.2-4.0	3.7-2.8
α ($\rho\rho$) (penguin, isospin, stat+syst)	6.9 7%	4.8 5.0%	3.4 3.6%
$\beta(J/\psi K_S)$ (all modes)	0.73 3.2%	0.51 2.3%	0.37 1.6%
$\gamma(B\rightarrow D^{(*)}K)$ (ADS)	8.9-13.4	6.3-9.5	4.5-6.7
γ(all methods)	5.4-8.9	3.8-6.3	2.7-4.5

Theory: α ~ 5%, β ~ 1%, γ ~ 0.1%

1% means : 0.5 – 2.0 %, it is a %

All BaBar institutions in US and in EUROPE are committed with the present BaBar program until 2006.

What next?

After the startup of LHC some individuals or institutions will leave (asymptotically no more than 30% if the BaBar/PEPII program is still competitive)

New people and institution will join from proliferation of BaBar (BaBar Children).

We expect the same number of Physicists for all this decade.

Will resources be provided to crunch data?

BaBar has been the first experiment with a real distributed computing model based on 5 different TierA centers:

SLAC, IN2P3/Saclay Tier A in Lyon, RAL in UK, Gridka in Karlsruhe, INFN TierA in Padova.

French, italian and UK communities and agencies confirm their intention to keep the Computing support for BaBar at least at the present level if not increased ($$ and Manpower) up to 2009, providing that the scientific program remains competitive as it is now.

Germany is somehow different and I expect a gradual decrease of commitments after 2006 .

PRIORITIES

- **Laboratory and community planning priorities**
  - Linear collider is priority for SLAC and KEK, and it is indeed a priority for the international community
  - Need to explore other physics opportunities nevertheless as linear collider situation develops

The SLAC study on the Scenarios for future has considered also the Super *B* option

- Super B is emerging as a main onsite option

Roadmap to the Future

The Collaboration has decided to set up a Committee to explore physics case, but also time , technical feasibility of Machine and Detector competive in the era of LHC when presumibly LHCb and BTeV will run and take data.

Committee:

F.Forti, M.Giorgi (Chair), D.Hitlin, H.Jawahery, Y.Karyotakis, D.MacFarlane, S.Playfer, S.Robertson, A.Roodman, R.Schindler, J.Seeman, J.Smith, M.Sullivan, C.Touramanis, R.Waldi, W.Wisniewski

Is there a future in the next decade beyond 2010 for the B Physics?

We should consider the following questions:

1) Is there a compelling case for physics?
2) In an era when the hadron machine B physics experiments will run (LHCb and BTeV with high statistics and easy measurement of Bs mixing) could an e+e- experiment be competitive?
3) Does the detector technology provide a solution for an experiment at very high luminosity?
4) There is a phisicists community ready to start a new adventure with an e+ e- machine?

After having discovered the CP violation in B sector and having constrained with high precision the Unitarity Triangle parameters, the new mission of the next decade for e+e- Bfactories with high luminosity would be :

Study the effects of new physics beyond the SM on the flavour sector.

Namely measure the effects (Couplings and PHASES) of the new quanta that presumibly would be discovered at LHC if the new mass scale is of the order TeV.

Phases belonging to off diagonal elements of a new mixing matrix can only extracted through precision measurements of asymmetries.

A program of 5 years starting in fall 2011 focussed on the measurement of CP asymmetries and Branching Fractions of rare decays can accomplish the goal of investigating the new physics, providing that the luminosity is adequate to challenge the precisions of the order of few % that we expect at that time for the Theoretical calculations based on SM.

CP Violation in b→s penguins

Rare Decays, New Physics, *CPV* [%]		e^+e^- [ab^{-1}]		
Measurement	Goal	3	10	50
$S(B^0\to\phi K_S)$	SM: <5	16	8.7	3.9
$S(B^0\to\phi K_S+\phi K_L)$	SM: <5			
$S(B\to\eta' K_s)$	SM: <5	5.7	3	1
$S(B\to K_s\pi^0)$	SM: <5	8.2	5	4
$S(B\to K_s\pi^0\gamma)$	SM: <2	11.4	6	4
A_{CP} $(b\to s\gamma)$	SM: <0.5	2.4	1	0.5
$A_{CP}(B\to K^*\gamma)$	SM: <0.5	0.59	0.32	0.14
CPV in mixing (|q/p|)		<0.6		

More Rare decays precision

Rare Decays – New Physics		e^+e^- [ab^{-1}]		
Measurement	Goal	3	10	50
$\Gamma(b\to d\gamma)$ / $\Gamma(b\to s\gamma)$				
$B(B\to D^{(*)}\tau\nu)$	SM:8×10^{-3}	10.2%	5.6%	2.5%
$B(B\to s\nu\nu)$ $(K^{-,0},K^{*-,0})$	SM: ~5% 1 excl: 4×10^{-6}			~3σ
$B(B\to$ *invisible*$)$		$<2\times10^{-6}$	$<1\times10^{-6}$	$<4\times10^{-7}$
$B(B_d\to\mu\mu)$		-	-	
$B(B_d\to\tau\tau)$		-	-	
$B(\tau\to\mu\gamma)$			$<10^{-8}$	

$b \to s l^+ l^-$ precision

New Physics – Kl^+l^-, sl^+l^- [%]		e^+e^- [ab^{-1}]		
Measurement	**Goal**	**3**	**10**	**50**
$\mathrm{B}(B \to K\mu^+\mu^-)$ / $\mathrm{B}(B \to K e^+ e^-)$	SM: 1	~8	~4	~2
$A_{CP}(B \to K^* \lambda^+ \lambda^-)$: all	SM: <5	~6	~3	~1.5
$A_{CP}(B \to K^* \lambda^+ \lambda^-)$: high mass	SM: <5	~12	~6	~3
$A^{FB}(B \to K^* \lambda^+ \lambda^-)$: s_0 $A^{FB}(B \to K^* \lambda^+ \lambda^-)$: A_{CP}	SM: ±5	~20	~9	9
$A^{FB}(B \to s \lambda^+ \lambda^-)$: $\hat{s}_0$		27	15	6.7
$A_{FB}(B \to s \lambda^+ \lambda^-)$: C_9 , C_{10}		36-55	20-30	9-13

What kind of machine and what kind of detector?

The Roadmap Committee has explored several scenarios for machine and detector, with a carefull evaluation of the detector technologies available at present, the R&D needed to develop new detector systems based on present knowledge of the detector working principles and the time for R&D expected for the development of detectors based on new principles, as for example MAPS pixels of thickness <<100μm (sensor+readout electronics).

A machine of nominal initial peak lumi of $5x10^{35}$ starting in Oct 2011 and running the first year with ½ of peak before reaching the nominal value and after Oct 2013 going to can allow the time for developing a conceptually new vertex-tracker and gives headroom to reach by the end of 2016 if not earlier the required precision to satisfy the physics goals.

The new "efficiency factor" of 1.4 can be applied in the calculation of the integrated luminosity

Comment on the preferred scenario

"Tunable Start"

- Major upgrades are required to detector and machine, but without needs for basic development
- Headroom for both detector and machine up to 5 x 10^{35}; with Vertex –Tracker all silicon, it allows R&D for thin pixels
- As we learn more about machine and detector backgrounds and performance, can fine tune goals and plans within this framework

Some geopolitical considerations

The KEKB/ Belle community is also considering a Super B for the future.

They have prepared already an LOI !

My understanding is:

a new High Energy Physics enterprise in the next decade should have an international signature! (BaBar is already a good example of an international collaboration .)

For the future either there will be ONE Super BFactory or NONE!

One machine here and one in Japan is unconceivable.

So we must find soon a basis of collaboration with KEKB/BELLE on Physics at SuperB and also on the common R&D needed for the design of a robust detector.

Conclusions

•The Report of the Roadmap committee is almost ready

•The management of the experiment will soon explore the possibility of setting up a joint study group with the other big collaboration working at an e+e- Bfactory **(BELLE) and open to people coming from outside the present communities,** to evaluate together the physics case , agree on common values for the precision needed, on timescales.

•Later an accurate study of the detector parameters and of the R&D will be required.

•…………………

BACKUP

4 scenarios explored

- **Start dates for data and initial efficiencies**
  - LHCb: Jan 2008, 50% for 2 years
  - BTEV: Jan 2010, 50% for 2 years
  - Scenario 1, 1.5×10^{35}: Oct 2010, 50% for 1 year
  - Scenario 2, 2.5×10^{35}: Oct 2011, 50% for 1 year
  - Scenario 3, 7×10^{35}: Oct 2012, 50% for 1 year
  - Scenario 4, 2.5×10^{35} in Oct 2011, 5×10^{35} in Oct 2012, and 7×10^{35} from Oct 2013 onwards
- **Reconstruction efficiencies, effective tagging efficiencies, asymmetry errors taken from published simulations or our data**
  - BTEV per event sensitivities appear to be anomalously good; effective tagging is also claimed to be much better than LHCb

Preferred scenario: Detector Upgrades

- **Replace inner layers of present SVT with segmented strips**
  - Should be viable to about 5×10^{35}
  - Develop thin pixels and replace inner SVT at an appropriate time to go higher in luminosity
- **Replace DCH with all silicon tracker**
- **Replace DRC SOB and bar boxes due to smaller radius for EMC**
  - Not at all clear that DRC will work at these luminosities
- **Replace EMC with either radiation hard crystals or liquid xenon**
- **Replace IFR forward endcap**

Projections on angles

Unitarity Triangle Angles [degrees]	e^+e^- [ab^{-1}]			Hadronic b [1yr]	
Measurement	0.5	2	3	LHCb	BTeV
$\alpha(\pi\pi)$ ($S_{\pi\pi}$, $B\to\pi\pi$ BR's+ isospin)	16.5	8.2	6.7	-	-
$\alpha(\rho\pi)$ (Isospin, Dalitz) (syst $\geq 3°$)	7.3, 5.6	3.7,2.8	3.0,2.3	2.5 - 5	4
α $(\rho\rho)$ (penguin, isospin, stat+syst)	6.9 7%	3.4 3.6%	2.8 2.9%		
$\beta(J/\psi K_S)$ (all modes)	0.73 3.2%	0.37 1.6%	0.3 1.3%	0.57	0.49
$\gamma(B\to D^{(*)}K)$ (ADS)	8.9,13.4	4.5,6.7	3.7,5.5	~10	<13
γ(all methods)	5.4,8.9	2.7,4.5	2.2,3.6		

Theory: α ~ 5%, β ~ 1%, γ ~ 0.1%

CP Violation in b→s penguins

Rare Decays, New Physics, *CPV* [%]		e^+e^- [ab^{-1}]			Hadronic b [1yr]	
Measurement	**Goal**	**3**	**10**	**50**	**LHCb**	**BTeV**
$S(B^0 \to \phi K_S)$	SM: <5	16	8.7	3.9	16 (?)	7 (?)
$S(B^0 \to \phi K_S + \phi K_L)$	SM: <5					
$S(B \to \eta' K_s)$	SM: <5	5.7	3	1		
$S(B \to K_s \pi^0)$	SM: <5	8.2	5	4		
$S(B \to K_s \pi^0 \gamma)$	SM: <2	11.4	6	4		
A_{CP} $(b \to s\gamma)$	SM: <0.5	2.4	1	0.5		
$A_{CP}(B \to K^* \gamma)$	SM: <0.5	0.59	0.32	0.14	-	-
CPV in mixing (|q/p|)		<0.6			-	-

More Rare decays precision

Rare Decays – New Physics		e^+e^- [ab^{-1}]			Hadronic b [1 yr]	
Measurement	**Goal**	**3**	**10**	**50**	**LHCb**	**BTeV**
$\Gamma(b \to d\gamma)$ / $\Gamma(b \to s\gamma)$					-	-
$B(B \to D^{(*)}\tau\nu)$	SM:8×10^{-3}	10.2%	5.6%	2.5%	-	-
$B(B \to s\nu\nu)$ $(K^{-,0}, K^{*-,0})$	SM: ~5% 1 excl: 4×10^{-6}			~3σ	-	-
$B(B \to \textit{invisible})$		$<2 \times 10^{-6}$	$<1 \times 10^{-6}$	$<4 \times 10^{-7}$	-	-
$B(B_d \to \mu\mu)$		-	-		1-2 evts	1-2 evts
$B(B_d \to \tau\tau)$		-	-		-	-
$B(\tau \to \mu\gamma)$			$<10^{-8}$		-	-

$b \to s l^+ l^-$ precision

New Physics – Kl^+l^-, sl^+l^- [%]		e^+e^- [ab^{-1}]			Hadronic b [1 yr]	
Measurement	Goal	3	10	50	LHCb	BTeV
$B(B \to K\mu^+\mu^-)$ / $B(B \to Ke^+e^-)$	SM: 1	~8	~4	~2	-	-
$A_{CP}(B \to K^*\lambda^+\lambda^-)$: all	SM: <5	~6	~3	~1.5	~1.5	~2
$A_{CP}(B \to K^*\lambda^+\lambda^-)$: high mass	SM: <5	~12	~6	~3	~3	~4
$A^{FB}(B \to K^*\lambda^+\lambda^-)$: s_0 $A^{FB}(B \to K^*\lambda^+\lambda^-)$: A_{CP}	SM: ±5	~20	~9	9	~12	
$A^{FB}(B \to s\lambda^+\lambda^-)$: $\hat{s}_0$		27	15	6.7		
$A_{FB}(B \to s\lambda^+\lambda^-)$: C_9 , C_{10}		36-55	20-30	9-13		