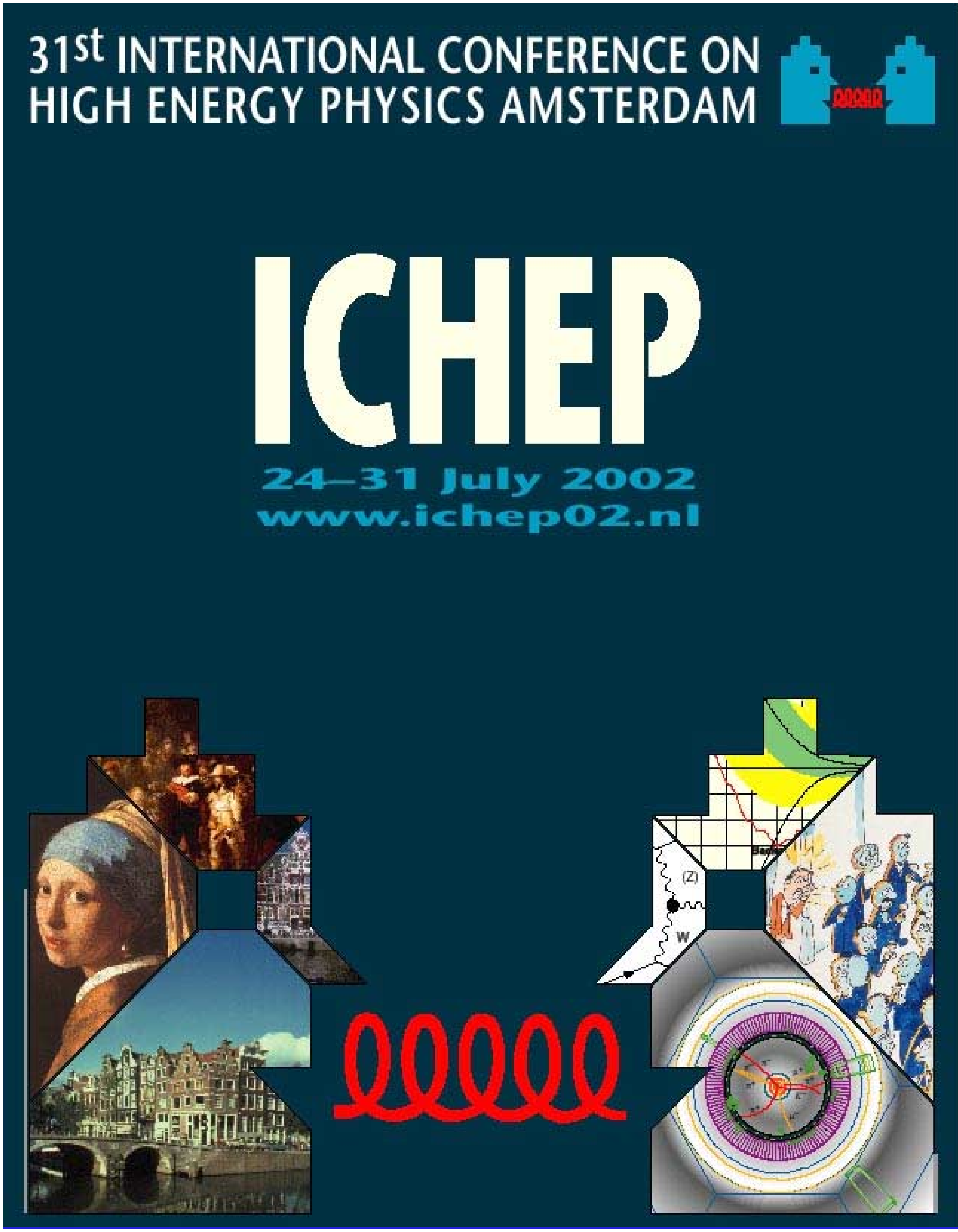
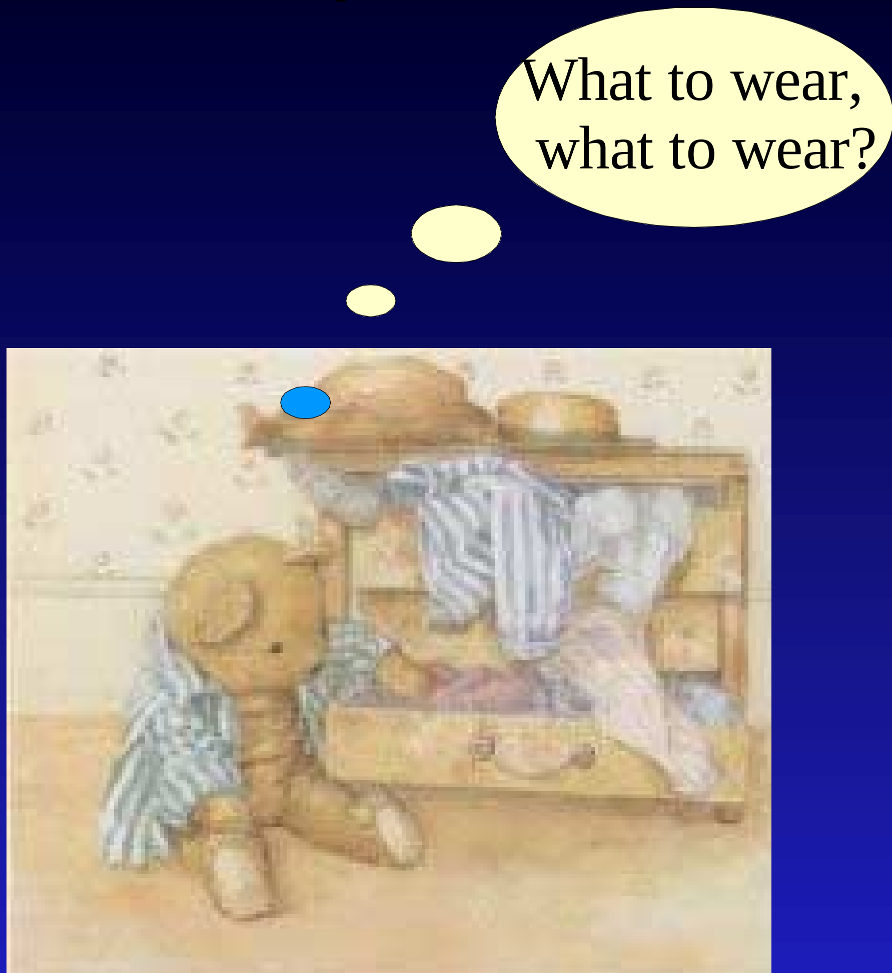


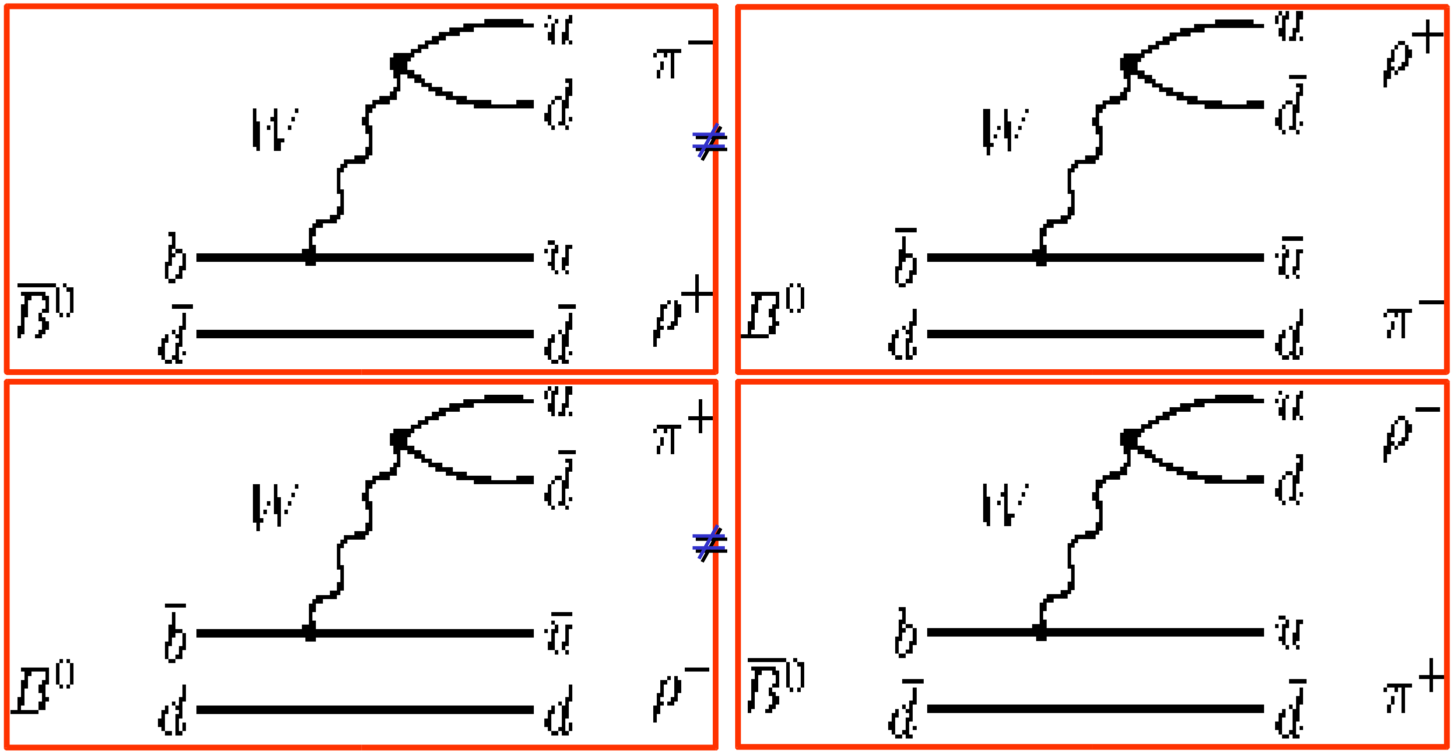
Experimental Summary

Katarzyna Klimek

ICHEP2002: Subjective Experimental Summary...



- Neutrino masses&mixing
- Quark matter
- Astrophysics&cosmology
- Electroweak physics
- QCD: hard interactions
- QCD: soft interactions
- CPV&CKM matrix
- Heavy quark hadrons
- Spectroscopy&exotics
- Beyond Standard Model
- Computational QFT
- Strinags&math. QFT
- Future accel.&detectors

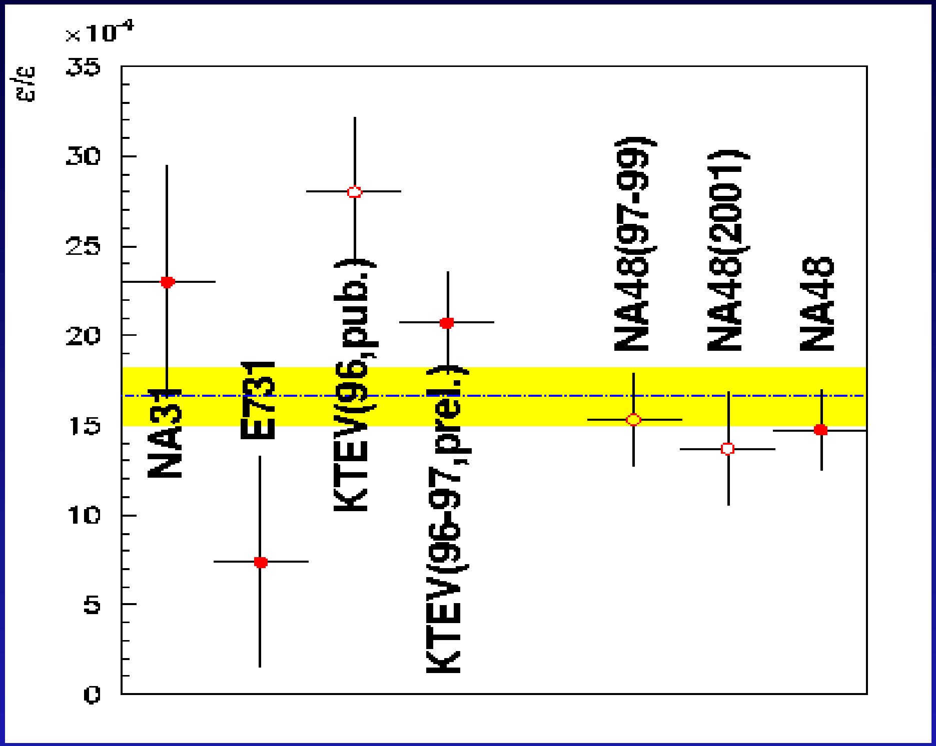


CP Violation

talks by:
T.Baker, Y. Karyotakis, G. Unal, D. Wright, M. Yamauchi

Direct CPV in Kaon System: ε'/ε

$$R \equiv \frac{\Gamma(K_L \to \pi^0\pi^0)\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_S \to \pi^0\pi^0)\Gamma(K_L \to \pi^+\pi^-)} = 1 - 6\mathrm{Re}(\epsilon'/\epsilon)$$



NA31: $(23.0 \pm 6.5)10^{-4}$

E731: $(7.4 \pm 5.9)10^{-4}$

KTeV: $(20.7 \pm 2.8)10^{-4}$
(preliminary)

NA48: $(14.7 \pm 2.2)10^{-4}$

World average: **ε'/ε = $(16.6 \pm 1.6)10^{-4}$**

CP Violation: dominated by BaBar & Belle

CKM Matrix

$$\begin{bmatrix} d' \\ s' \\ b' \end{bmatrix} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} \begin{bmatrix} d \\ s \\ b \end{bmatrix}$$

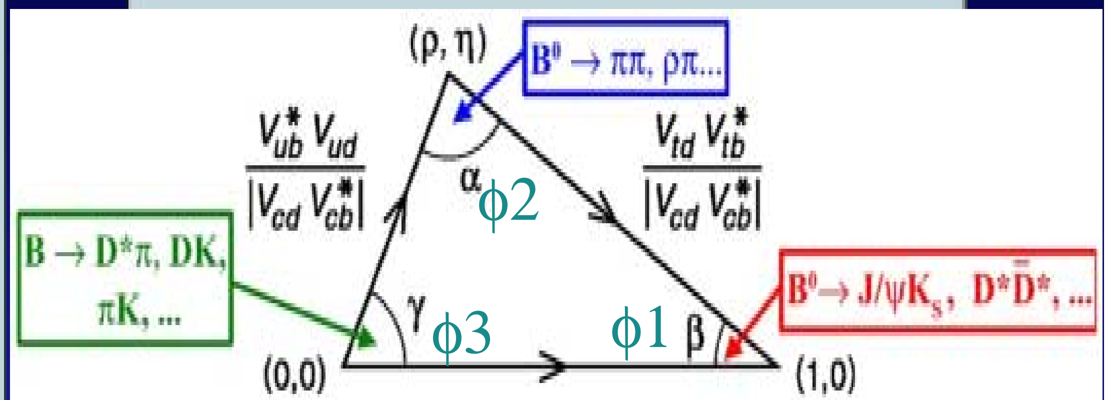
$V^{\dagger}V = I$, and quark phases

$\Rightarrow$ 4 parameters

$$\begin{bmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{bmatrix} + O(\lambda^4)$$

Unitarity Triangle

$$V_{ud}V_{ub}^{*} + V_{cd}V_{cb}^{*} + V_{td}V_{tb}^{*} = 0$$



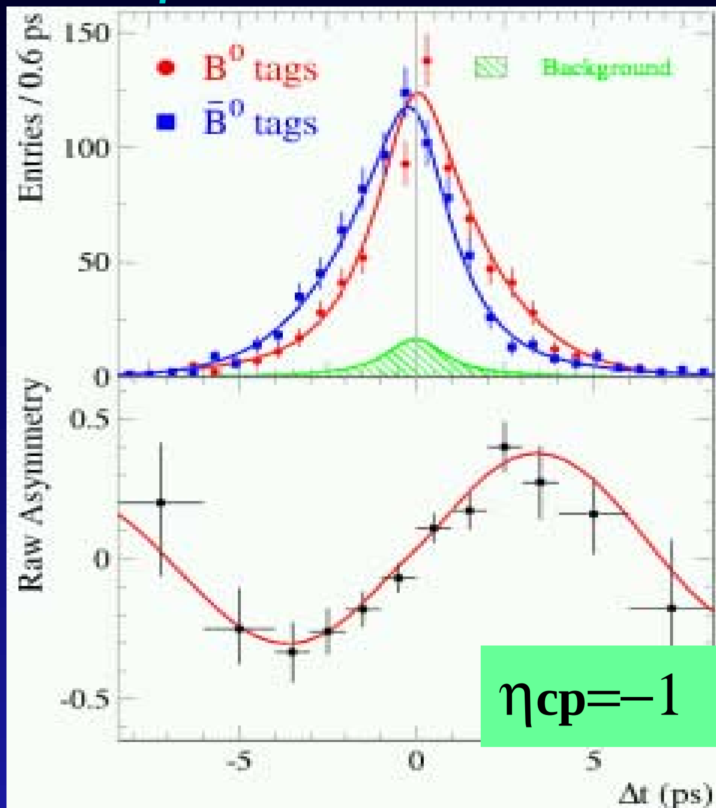
All angles related to η and ρ

New physics, ex: coupling between super−symmetric and SM fields introduce new phases which may reshape UT

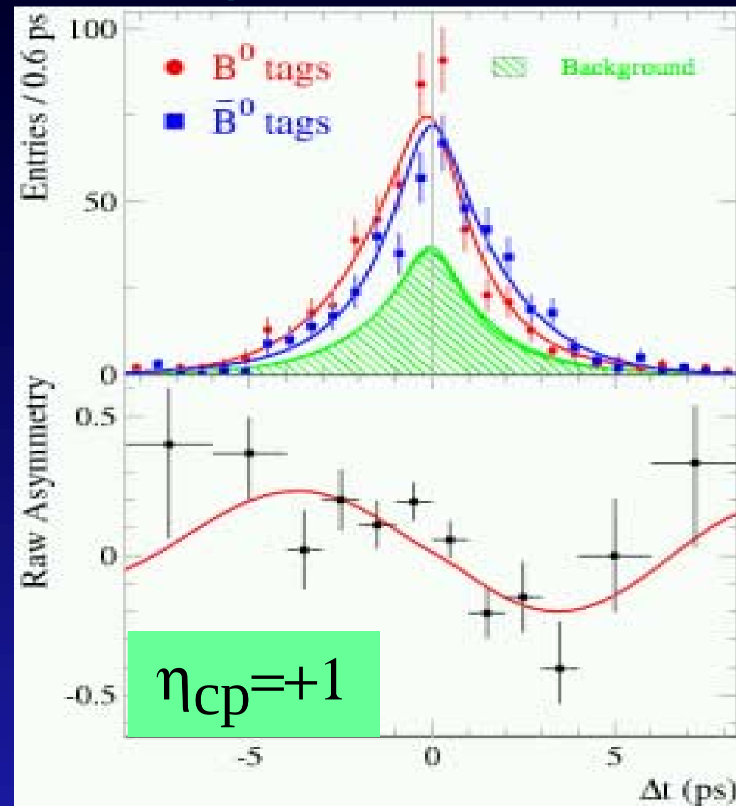
CP asymmetries: BaBar

Submitted to PRL, hep−ex/0207042

$\sin 2\beta = 0.755 \pm 0.074$



$\sin 2\beta = 0.723 \pm 0.158$

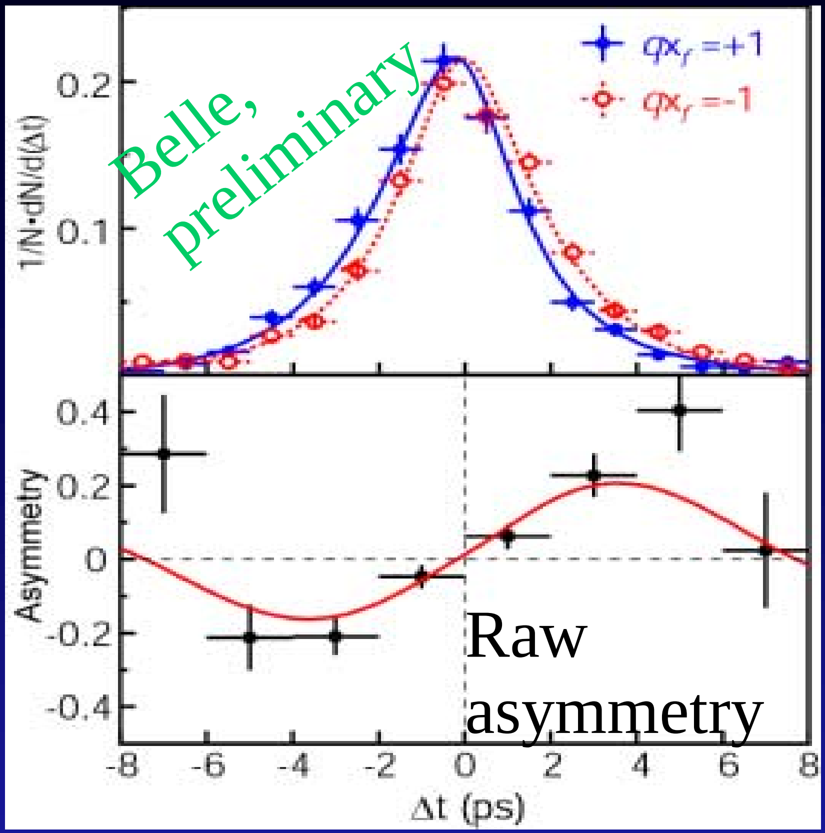


$\sin 2\beta = 0.741 \pm 0.067$ (stat) $\pm\ 0.033$ (syst)

$|\lambda| = 0.948 \pm 0.051$(stat) $\pm\ 0.017$ (syst)

New result of sin2ϕ_1

BELLE−CONF−0201 (ABS688)



sin 2ϕ_1 =

= 0.719±0.074±0.035

$|\lambda|$=0.950±0.049±0.026

Coherent picture of CP Violation in SM

No direct CPV signal yet

The CKM people at work……

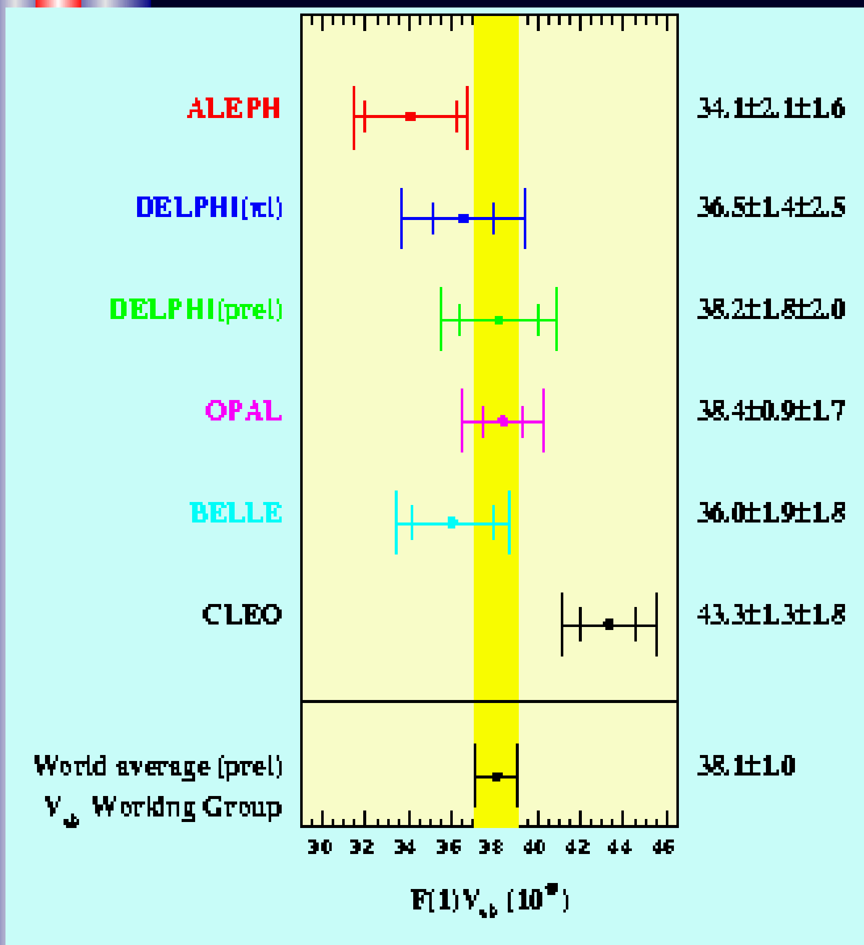
H.Bosch Players of GO

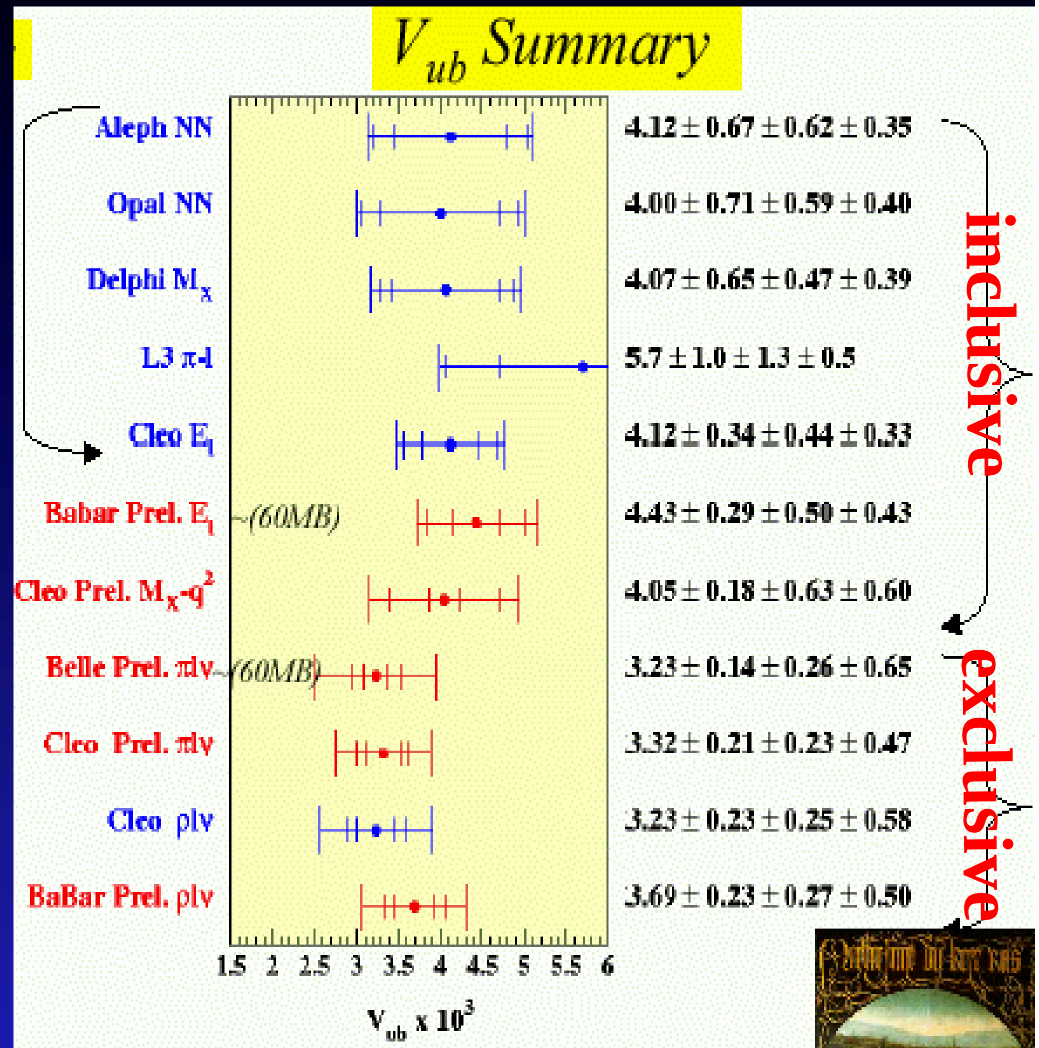
碁

talks by:
M. Battaglia, A. Stocchi

V_{cb} and V_{ub} Working Groups

V_{cb} Summary





V_{cb} = (40.9 +/− 0.8) 10^{-3}

V_{ub} − work continues

Oscillations in B System

The probability that the meson B^0 produced (by strong interaction) at $t = 0$ transforms (weak interaction) into $\overline{B^0}$ (or stays as a B^0) at time t is given by :

$$P_{B_q^0 \rightarrow B_q^0(\overline{B_q^0})} = \frac{1}{2} e^{-t/\tau_q} (1 \pm \cos \Delta m_q t)$$

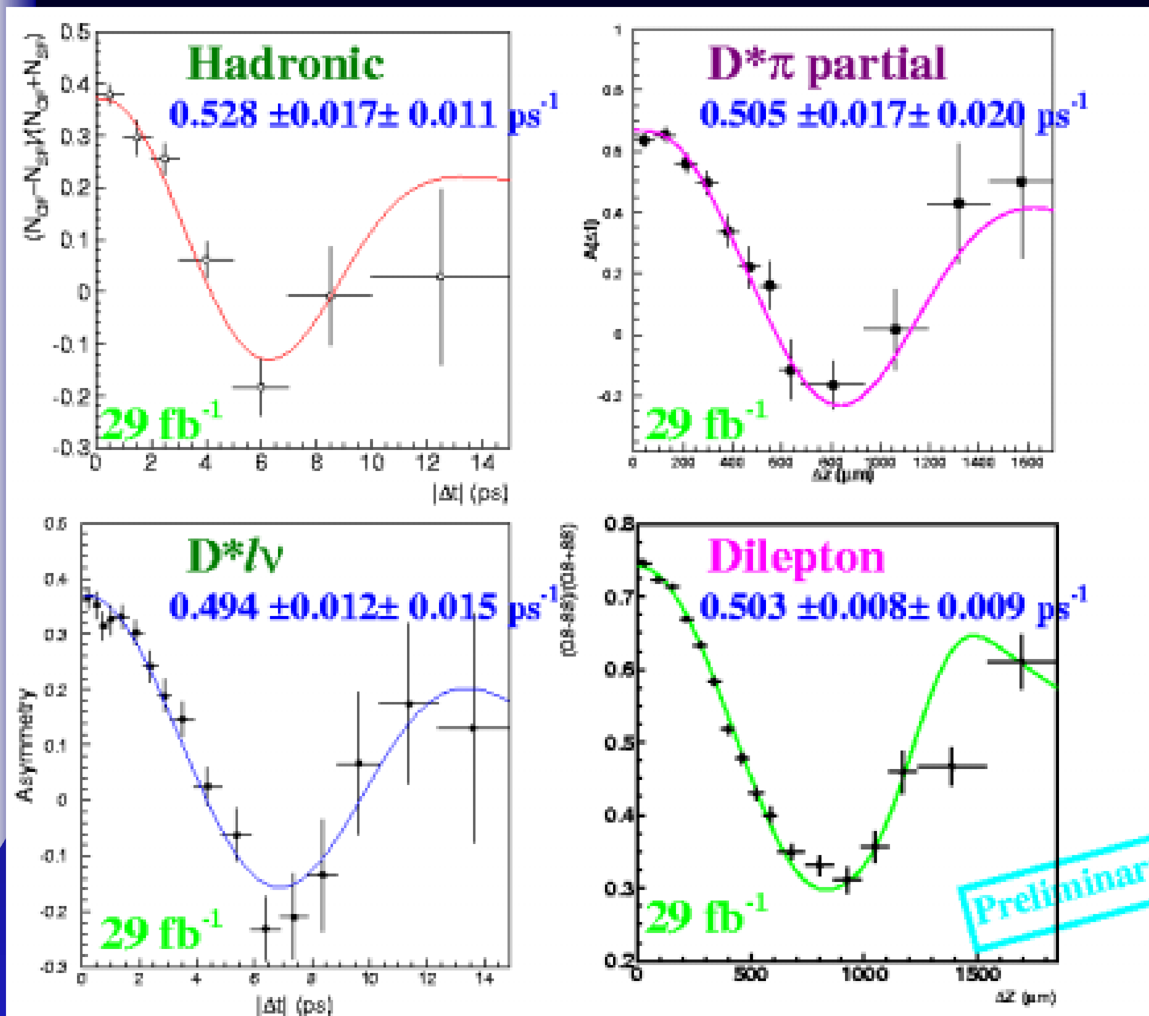
Δm_q can be seen as an oscillation frequency : 1 ps^{-1} = 6.58 10^{-4} eV

$$\frac{\Delta m_d}{\Delta m_s} \propto \frac{f_{B_d}^2 B_{B_d}}{f_{B_s}^2 B_{B_s}} \lambda^2 \; ((1-\rho)^2 + \eta^2)$$

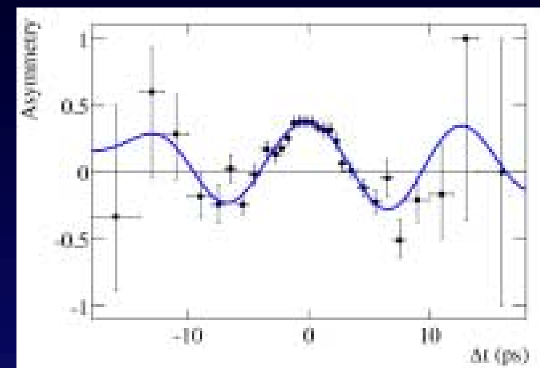
$\Delta m_d / \Delta m_s$ performant contraint for ρ and η

Δm_d

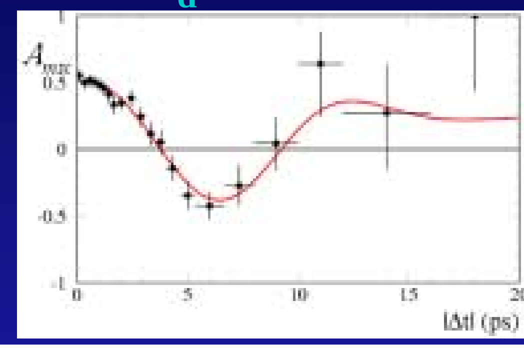
Many new measurements : 4 from Belle and 3 from Babar



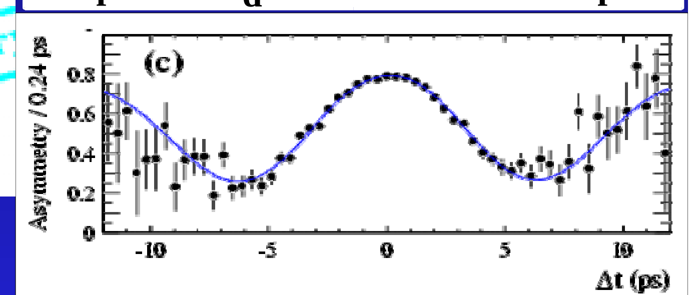
*D*lν* Δm_d=0.492±0.018±0.013ps^{-1}



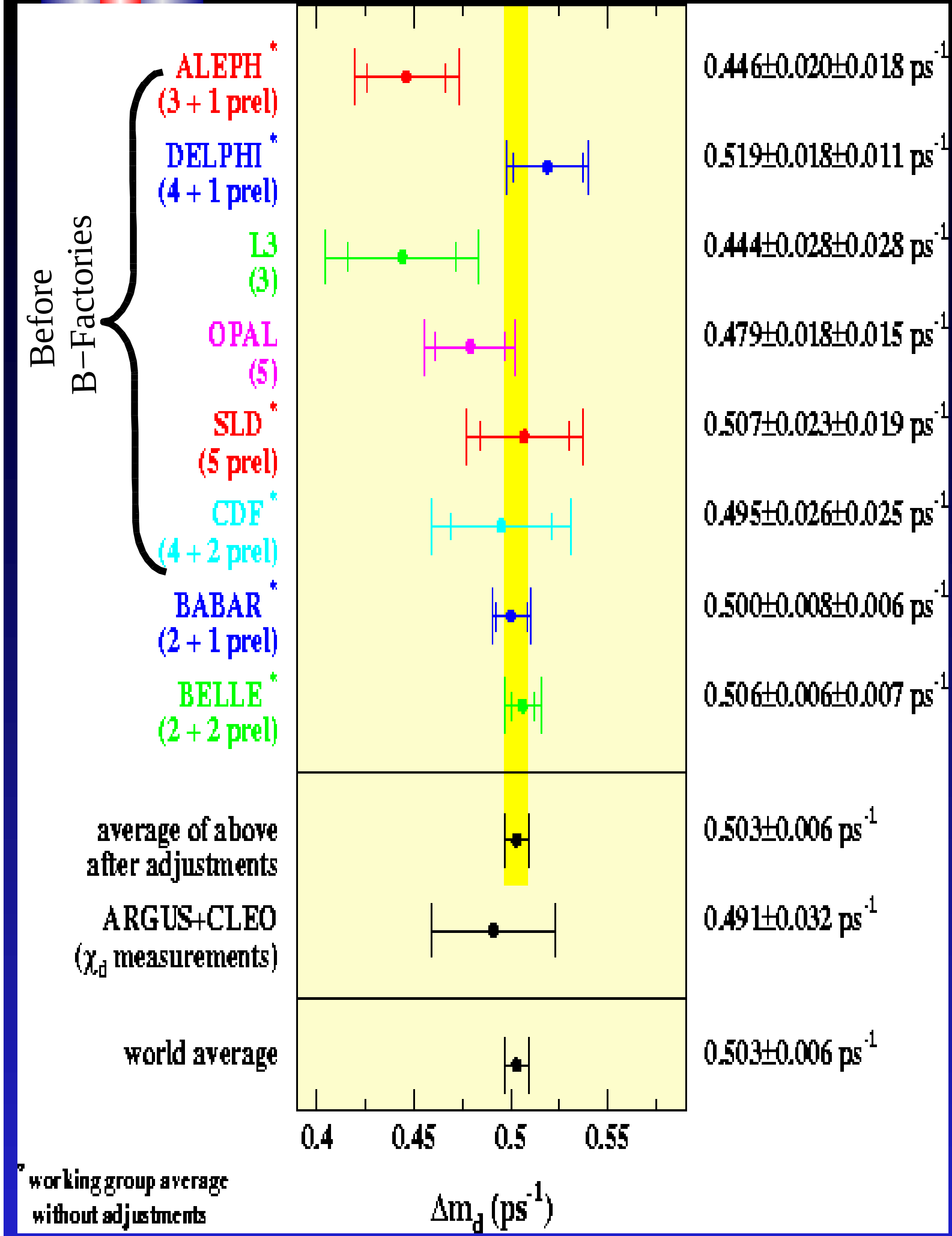
Hadronic Δm_d= 0.516±0.016±0.010 ps^{-1}



Dileptons Δm_d= **0.493±0.012±0.009 ps**$^{-1}$



Δm_d



Δm_d **= 0.498 ± 0.013 ps^{-1}**

LEP/SLD/CDF (2.6 %)

B−factories precision by a factor 2

Δm_d = 0.503 ± 0.006 ps^{-1}

LEP/SLD/CDF/B−factories:1.2%

Δm_s

Measurement of A at each Δm_s

$$P_{B_s^0 \to B_s^0 (\overline{B}_s^0)} = \frac{1}{2} e^{-t/\tau_s} (1 \pm A \cos \Delta m_s t)$$

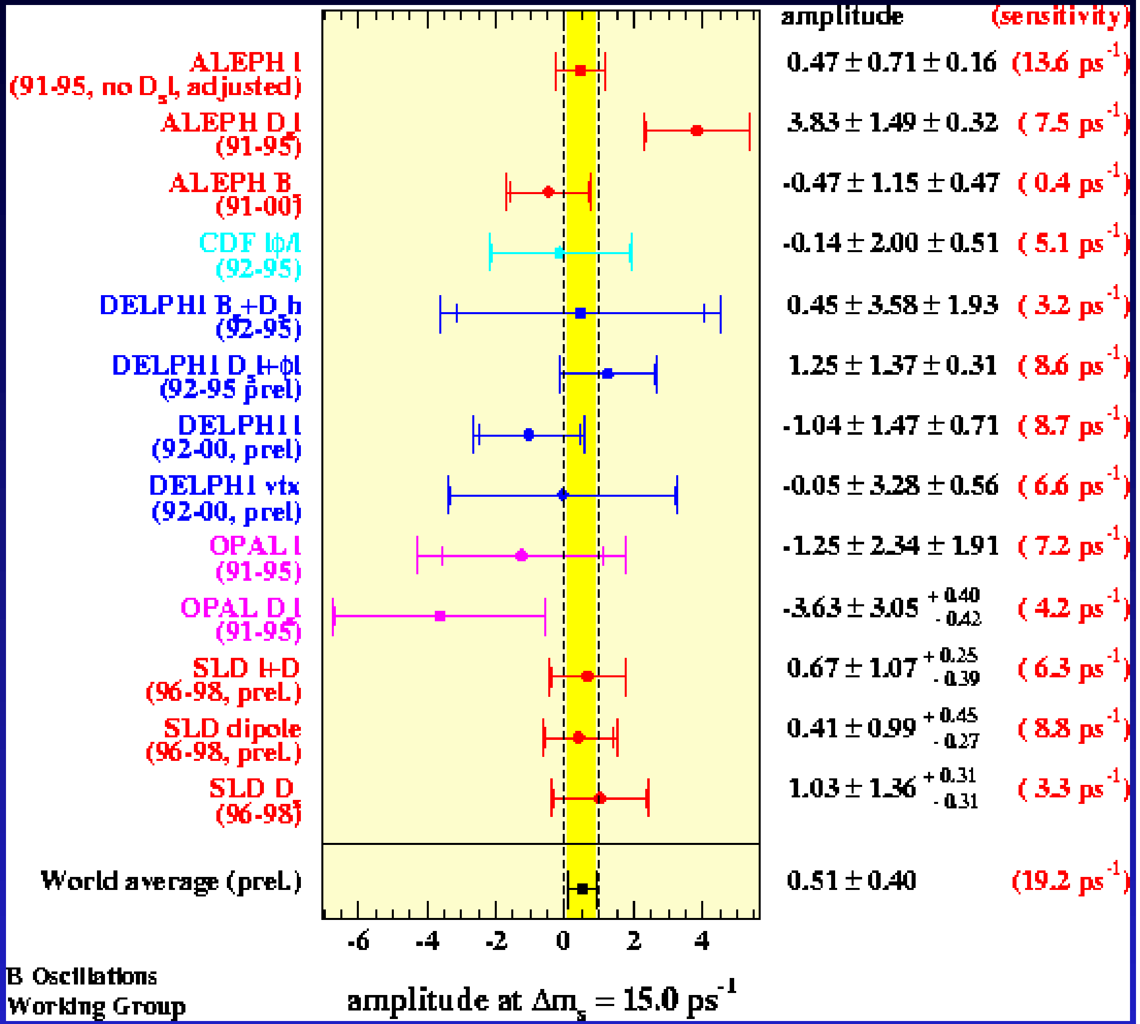
At given Δm_s

A = 0 no oscillation

A = 1 oscillation

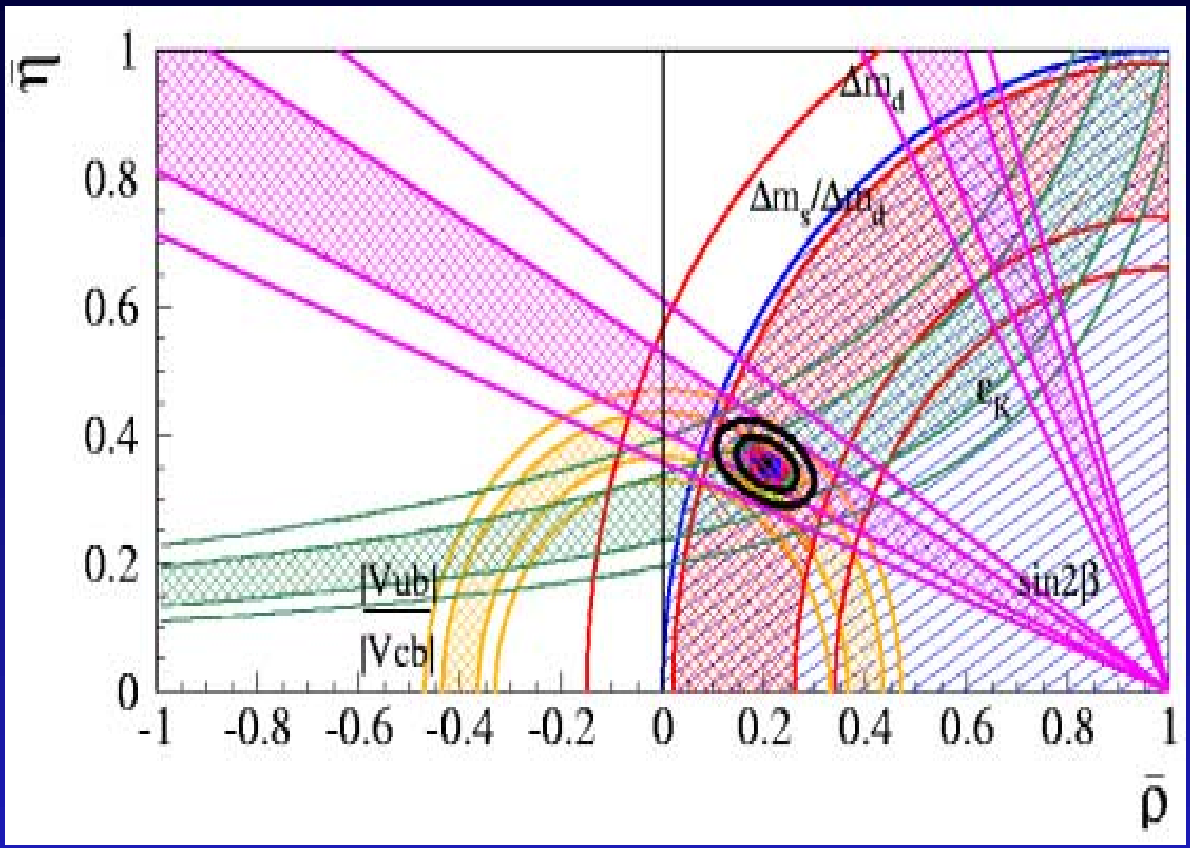
Δm_s excluded at 95%CL

$$A + 1.645\sigma_A < 1$$



Constrains of UT

Constraints : V_{ub} , V_{cb} , ε_K , Δm_d , Δm_d , $\sin 2\beta$



$V_{cb} = (40.4 \pm 0.8)10^{-3}$

$\bar{\rho} = 0.203 \pm 0.040$

$\bar{\eta} = 0.335 \pm 0.027$

$\sin 2\beta = 0.734^{+0.045}_{-0.034}$

$\gamma = (59.5^{+6.5}_{-5.5})^\circ$

$\sin 2\alpha = -0.20^{+0.23}_{-0.20}$

$\Delta m_s = 17.6^{+2.0}_{-1.3}\ ps^{-1}$

Welcome to the world of charm and beauty

H. Bosch (1504)
The garden of Earthly Delights

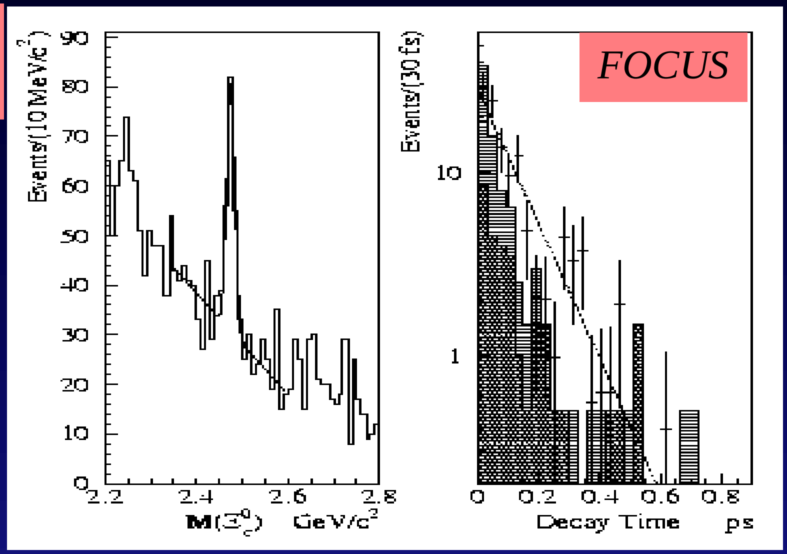
Heavy Quark Hadrons

talks by A. Stocchi, M. Yamauchi

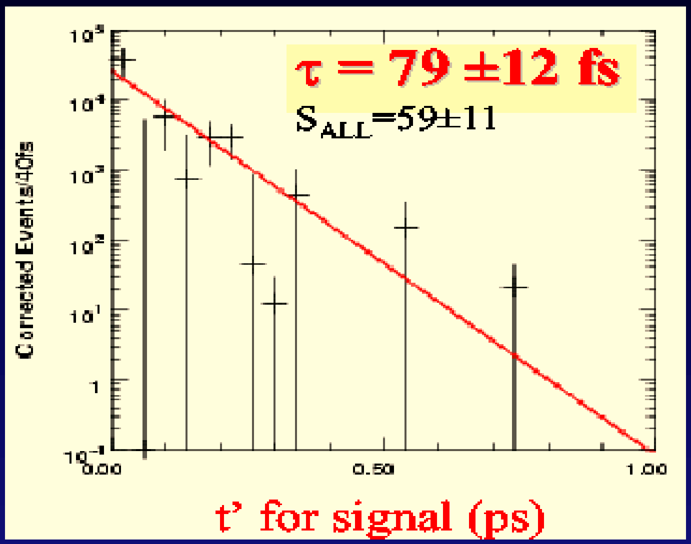
New Results on Charmed Baryons

$\Xi^0_c \rightarrow \Xi^- \pi^+$ *and* $\Omega^- K^+$

Ξ^0_c



Ω_c



$\tau(D^+)/\tau(D^0) = 2.53 \pm 0.02$

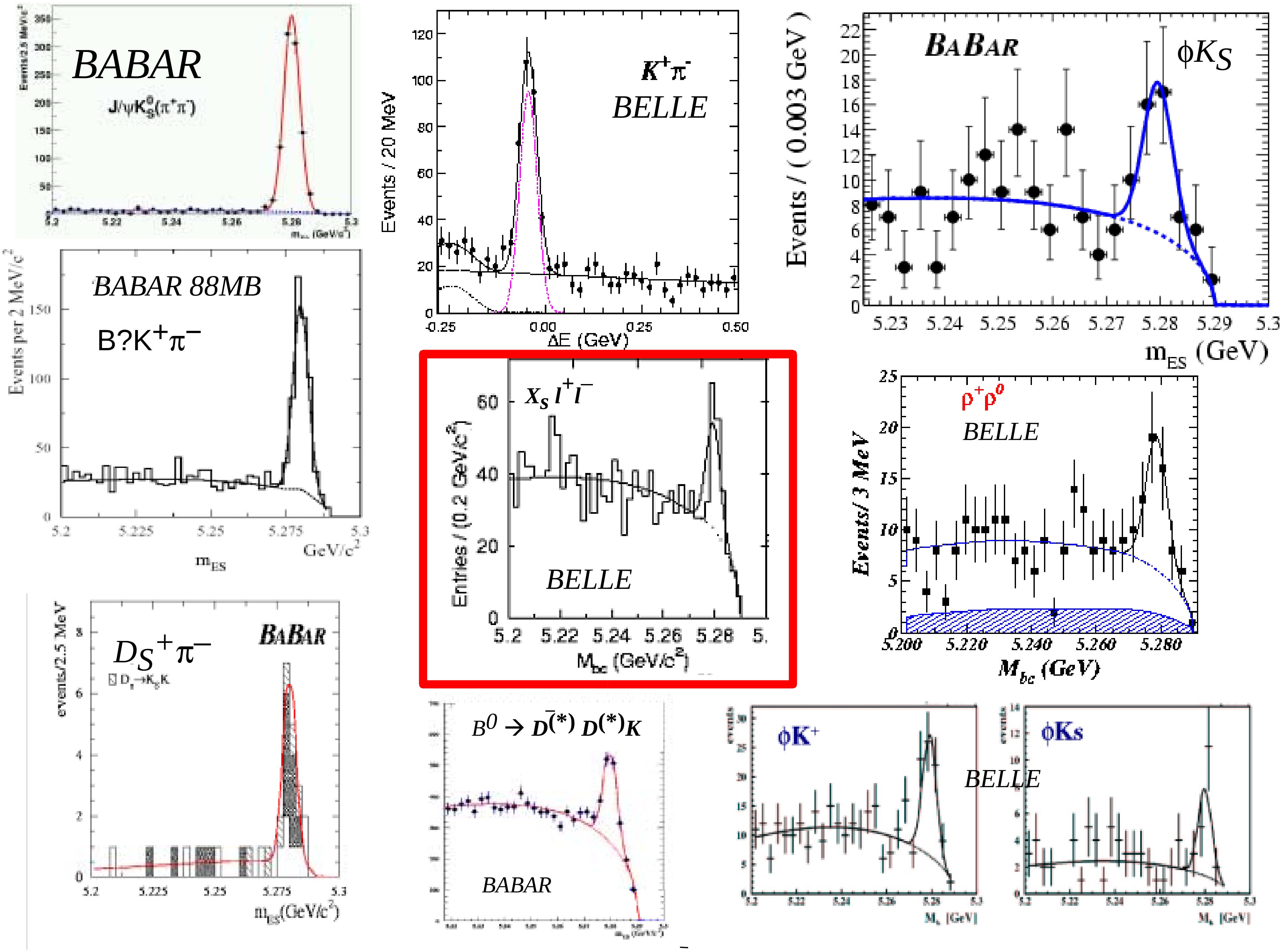
A.S. averages $\tau(D_s)/\tau(D^0) = 1.19 \pm 0.02$

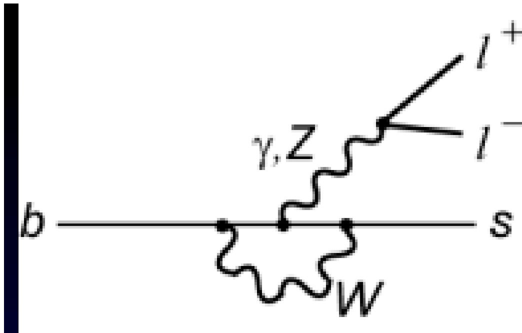
$\tau(\Lambda_c)/\tau(D^0) = 0.49 \pm 0.01$

$\tau(\Xi^+_c)/\tau(\Lambda_c) = 2.11 \pm 0.14$

NEW $\tau(\Omega_c)/\tau(\Xi^0_c) = 0.72 \pm 0.13$

in baryonic sector
expected hierarhy

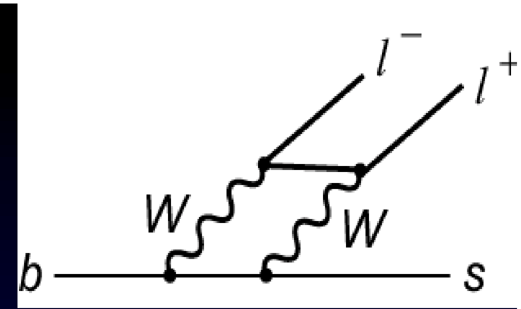

BABAR
J/ψK^0_S(π⁺π⁻)
K⁺π⁻
BELLE
Events / 20 MeV
ΔE (GeV)
BABAR
φK$_S$
Events / (0.003 GeV)
m$_{ES}$ (GeV)
BABAR 88MB
B?K⁺π⁻
Events per 2 MeV/c²
m$_{ES}$
GeV/c²
X$_S$ l⁺l⁻
BELLE
Entries / (0.2 GeV/c²)
M$_{bc}$ (GeV/c²)
ρ⁺ρ⁰
BELLE
Events/ 3 MeV
M$_{bc}$ (GeV)
D$_S$⁺π⁻
BABAR
events/2.5 MeV
m$_{ES}$(GeV/c²)
B⁰ → D̄⁽*⁾ D⁽*⁾K
BABAR
φK⁺
φKs
BELLE

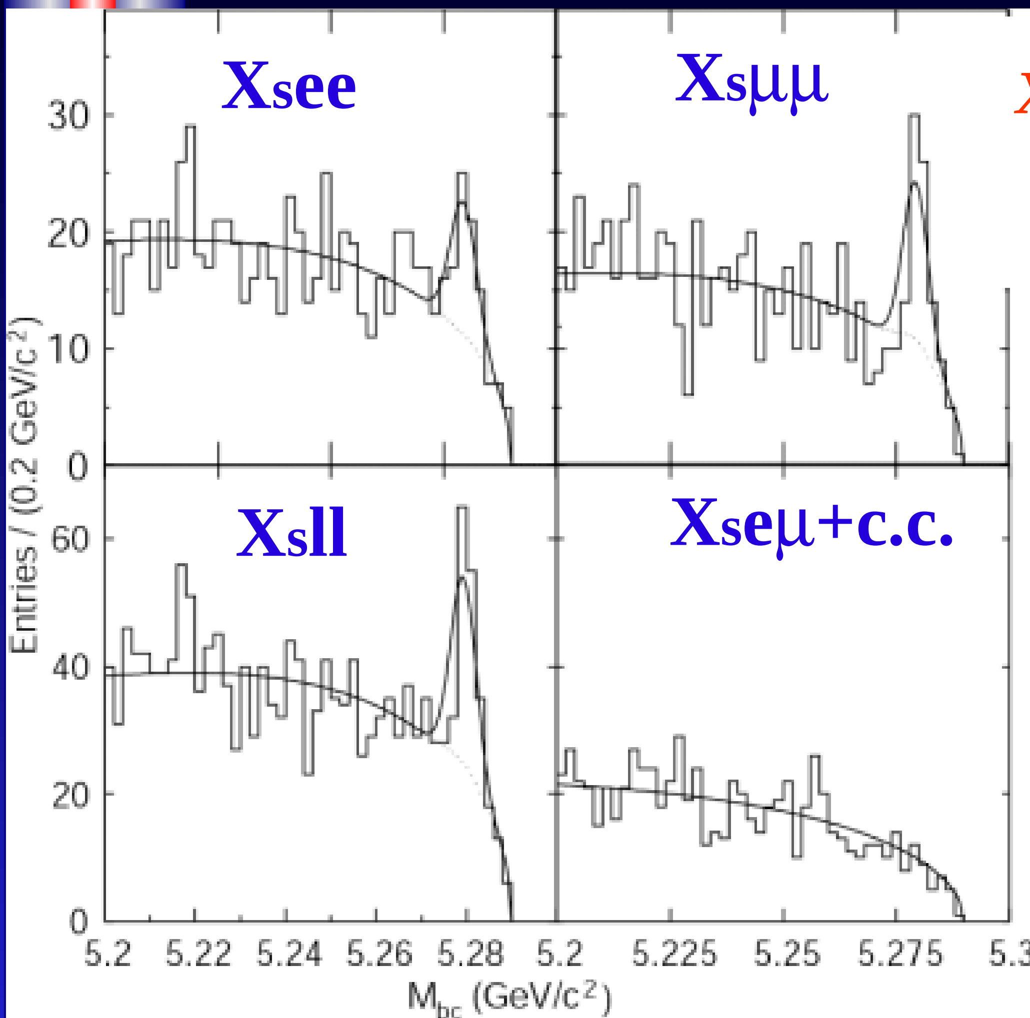


Measurement of B®$X_s l^+ l^-$

model independent probe for

new physics





X_S : $K^{\pm}$ or K_S with 0~4 π's (0 or $1\pi^0$)

covers ~78% of *b*®*sll*.

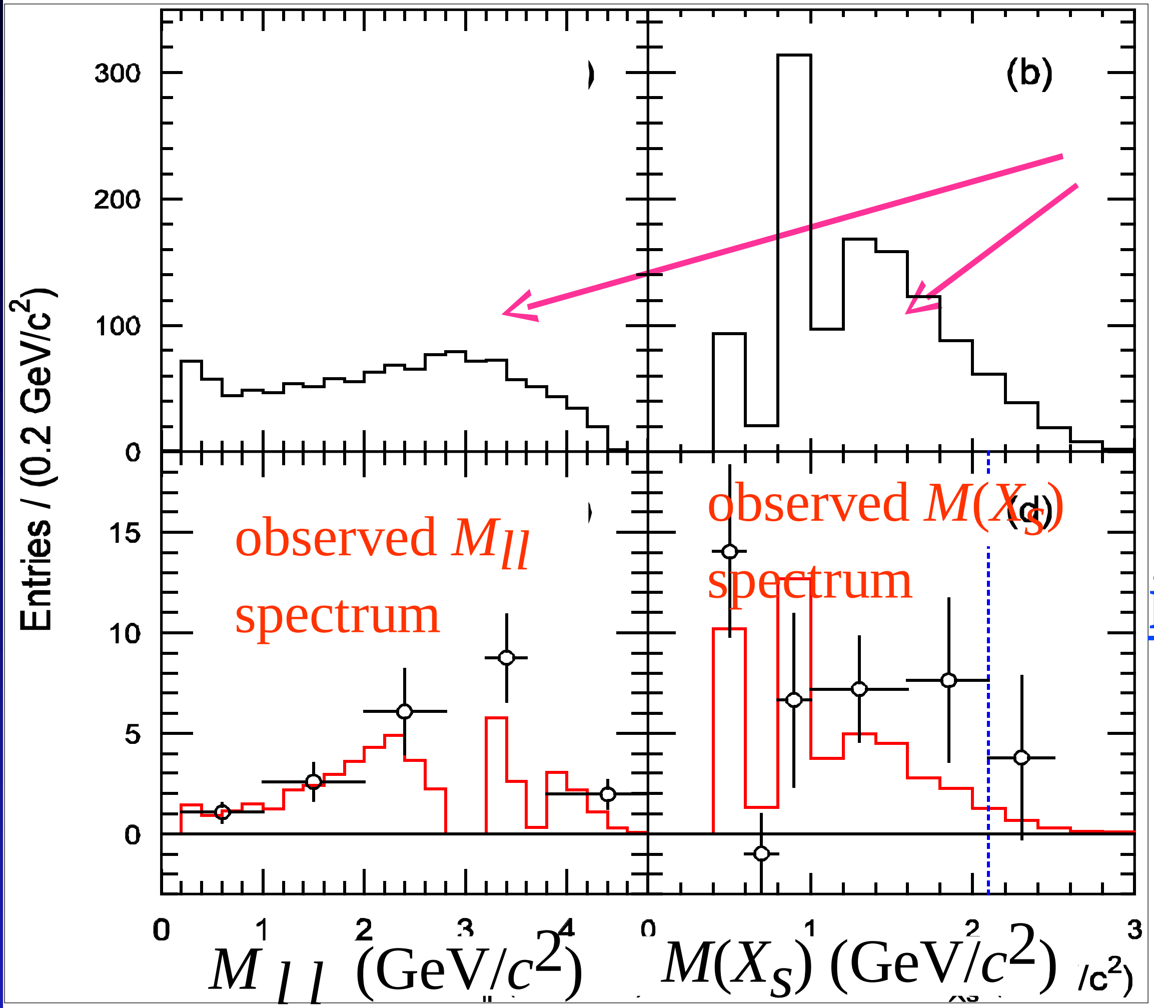
Preliminary

B(B®$X_s l^+ l^-$)

= $(6.1 \pm 1.4 \,^{+1.3}_{-1.1})$ x 10^{-6}

for $M_{ll} > 0.2$ GeV/c^2

M_{ll} and $M(X_s)$ distributions



Mass spectra assumed in MC

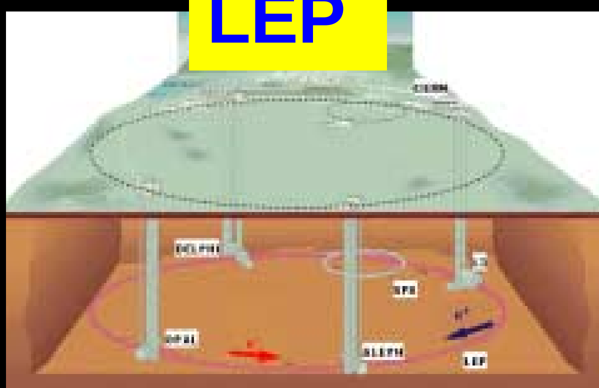
Model by A.Ali et al.

in agreement with SM

Beyond the Standard Model

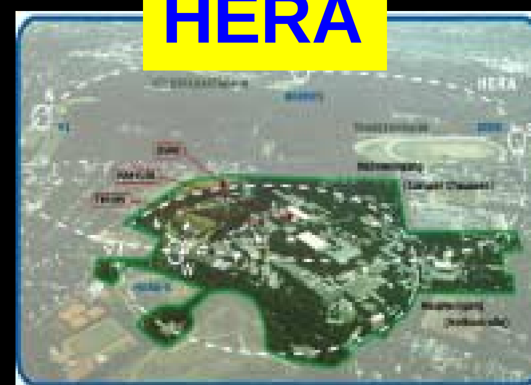
talk by R. McPherson

LEP



Tevatron

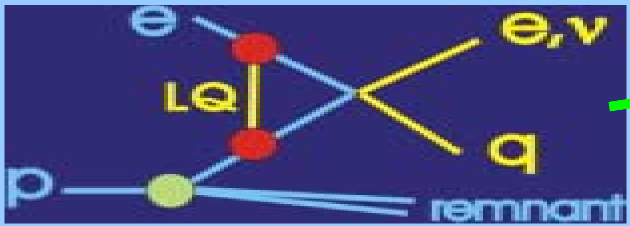
HERA



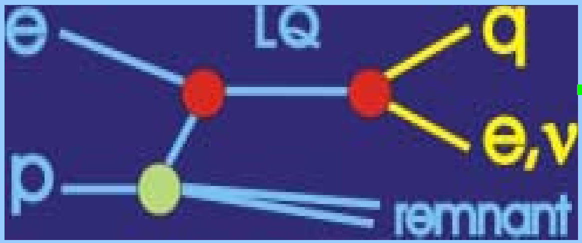
Example: Leptoquark Limits

LEP Indirect

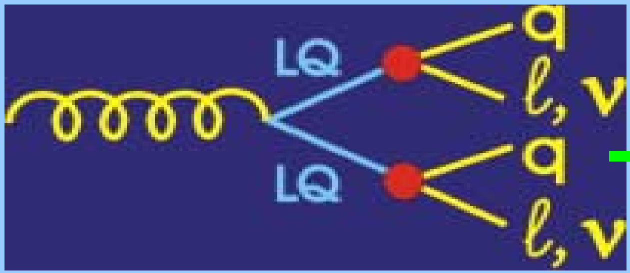
HERA Indirect



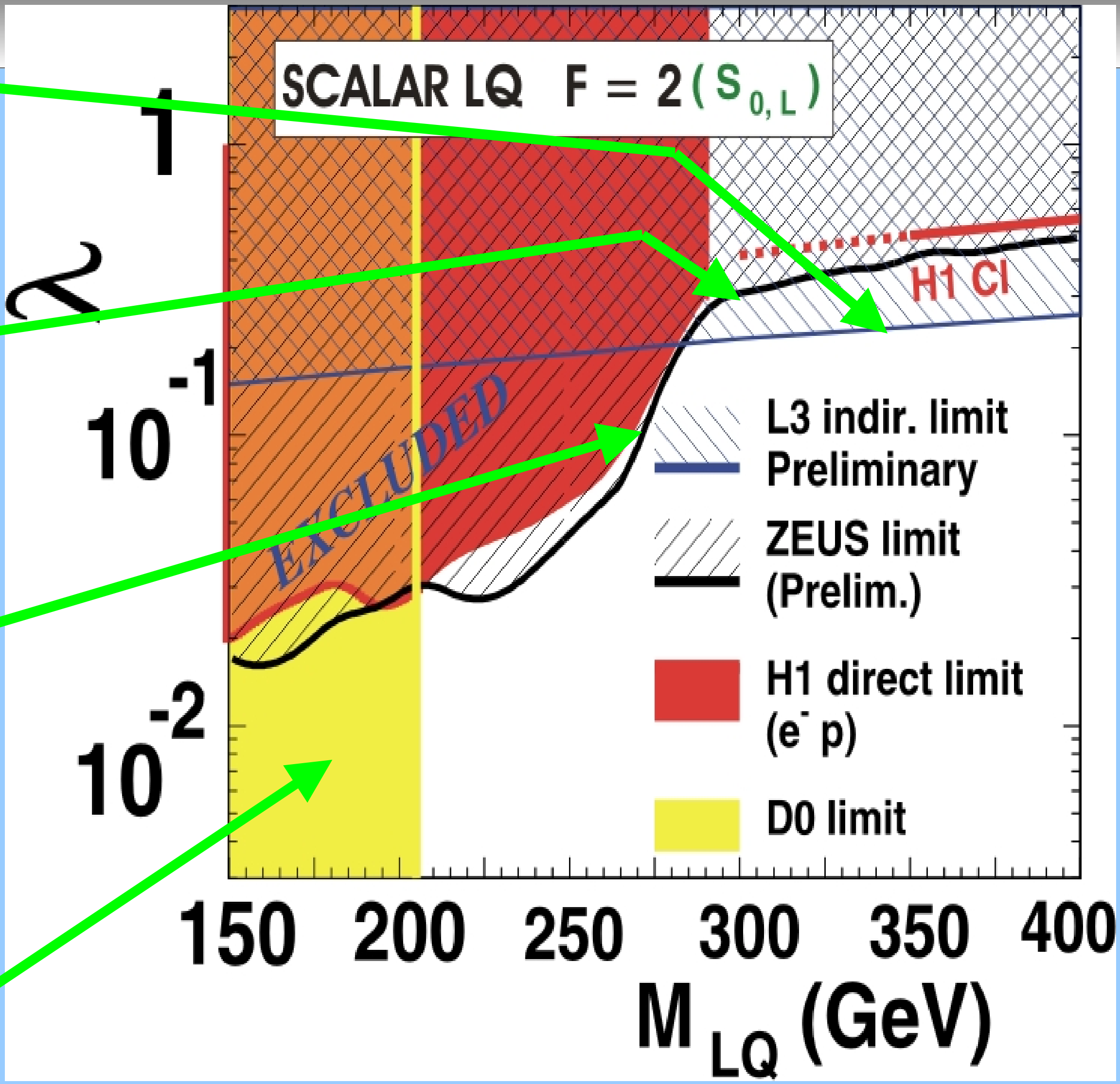
HERA Direct



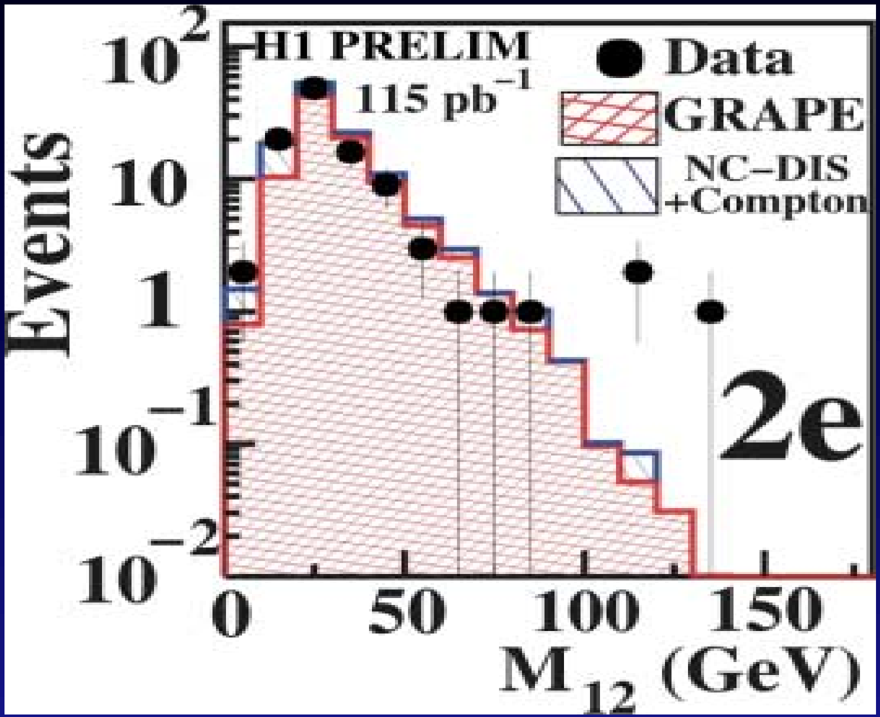
Tevatron Pair Prod.

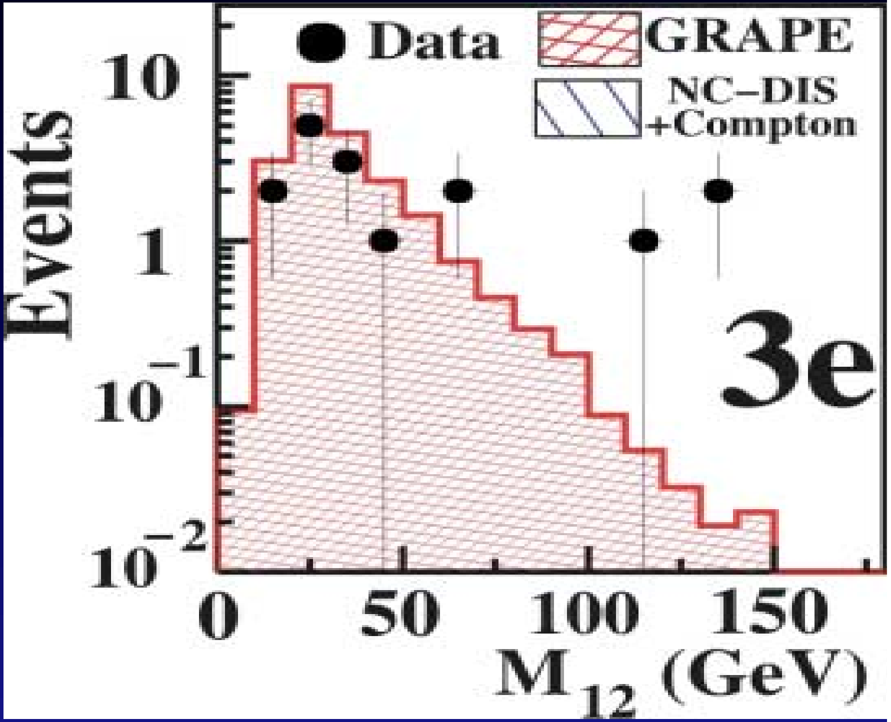


Q=1/3, BR(LQ→eq) = 1/2



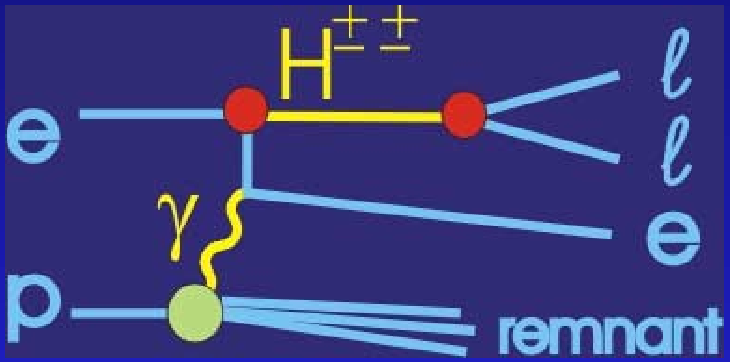
Multi–Lepton H1 Results





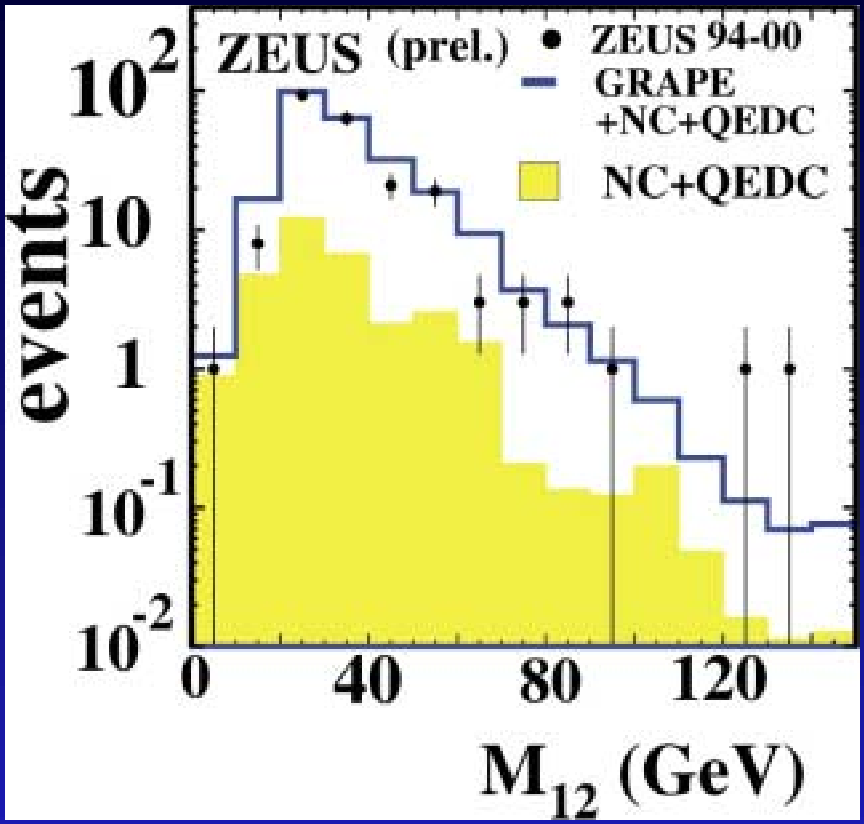
selection	Data	SM
2e $M>100$	3	0.25 ± 0.05
3e $M>100$	3	0.23 ± 0.04

?



Multi–Lepton ZEUS Results

ZEUS: 94–00, 130 pb^{-1}



selection	Data	SM
2e $M > 100$	2	0.77±0.08
3e $M > 100$	0	0.37 ±0.04
Both	2	1.14±0.09

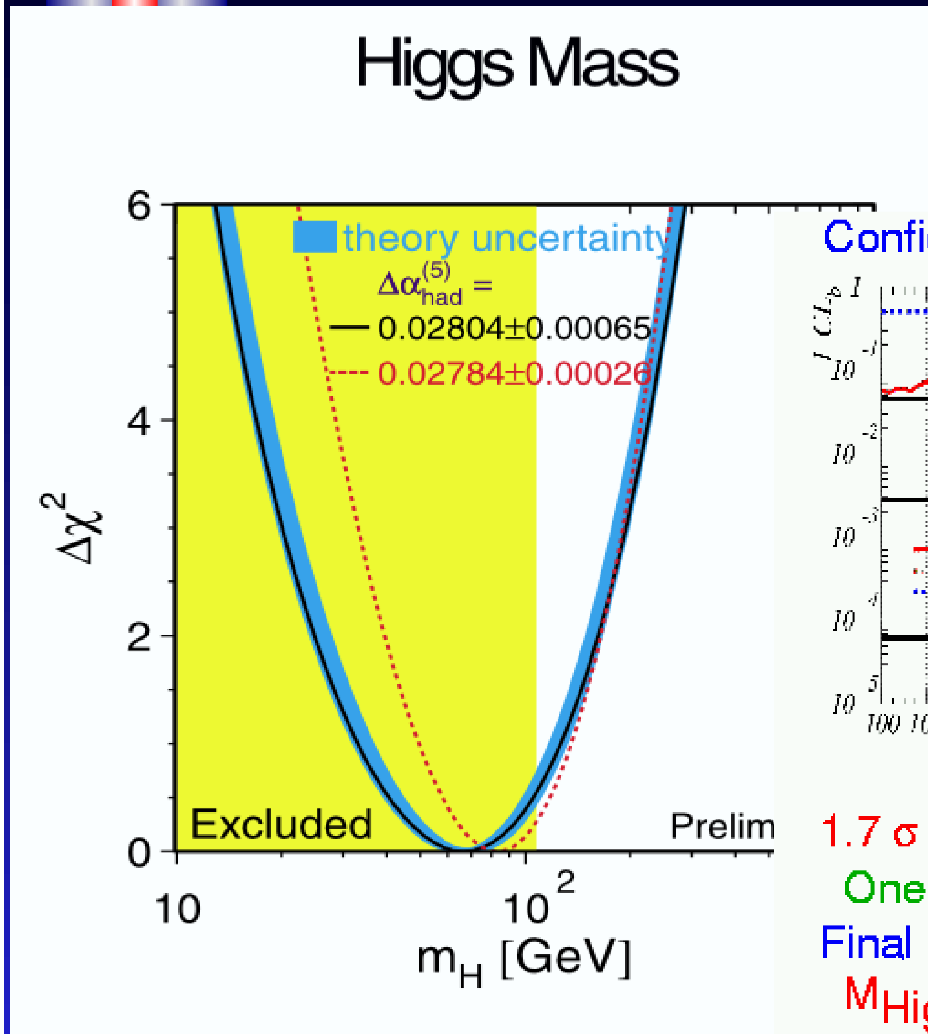
⇒ ***Good agreement with SM***

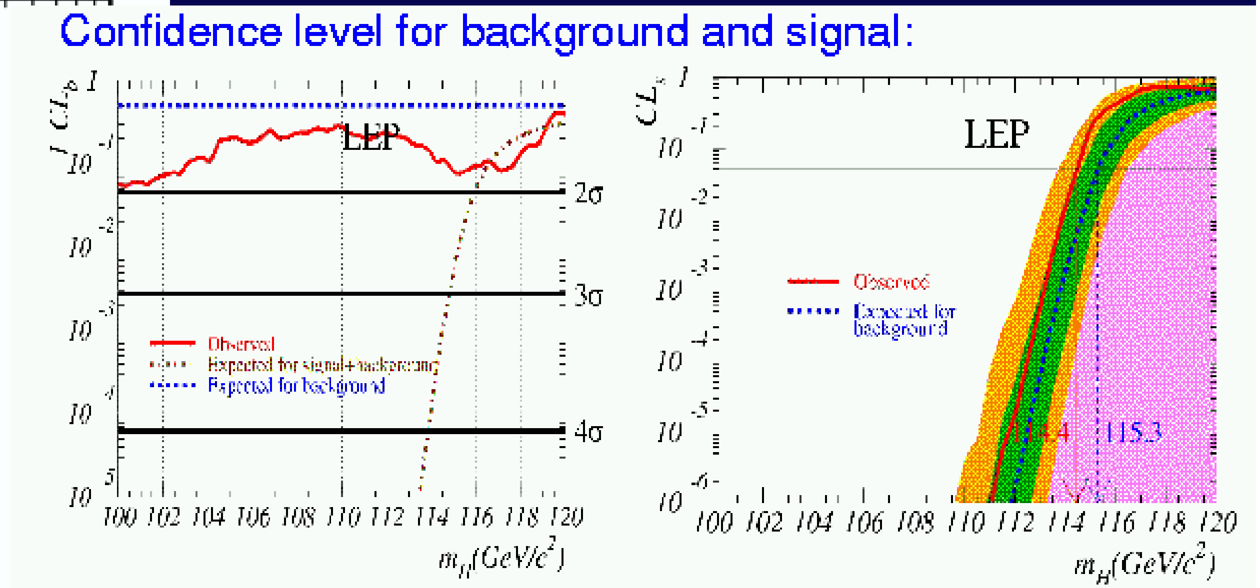
talk by M. Grünewald

Electroweak Physics

Searches for SM Higgs

still one particle of SM missing





1.7 σ excess (P=8%) over expected SM background

One experiment (ALEPH, 2.8-3.0 σ), one channel (qqbb)

Final LEP-2 SM Higgs-boson mass limit (95% C.L.):

M_{Higgs} > 114.4 GeV (expected limit: 115.3 GeV)

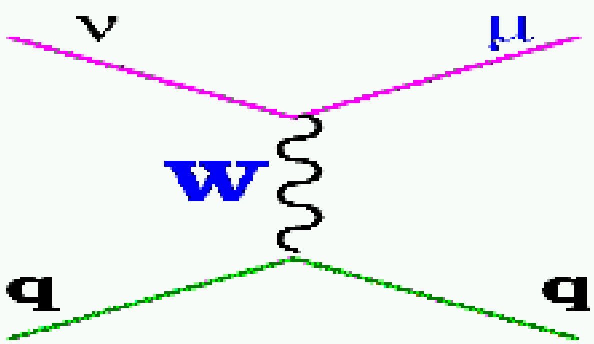
35

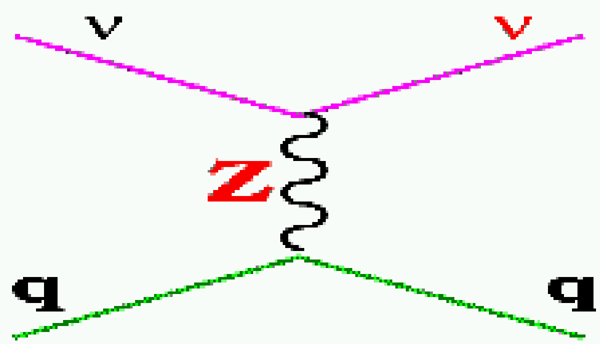
Do We Live in Perfect SM EW World?

NuTeV Neutrino-Nucleon Scattering

Muon-(anti-)neutrino quark scattering:

charged current (CC) neutral current (NC)





Paschos-Wolfenstein relation (iso-scalar target):

$$R_{-} = \frac{\sigma_{NC}(\nu)-\sigma_{NC}(\bar{\nu})}{\sigma_{CC}(\nu)-\sigma_{CC}(\bar{\nu})} = 4g^{2}_{L\nu}\sum_{q_{V}}\left[g^{2}_{Lq}-g^{2}_{Rq}\right] = \rho_{\nu}\rho_{ud}\left[\frac{1}{2}-\sin^{2}\theta_{W}^{(on-shell)}\right]$$

+ electroweak radiative corrections

Insensitive to sea quarks

Charm effects only through d_V quarks (CKM suppressed)

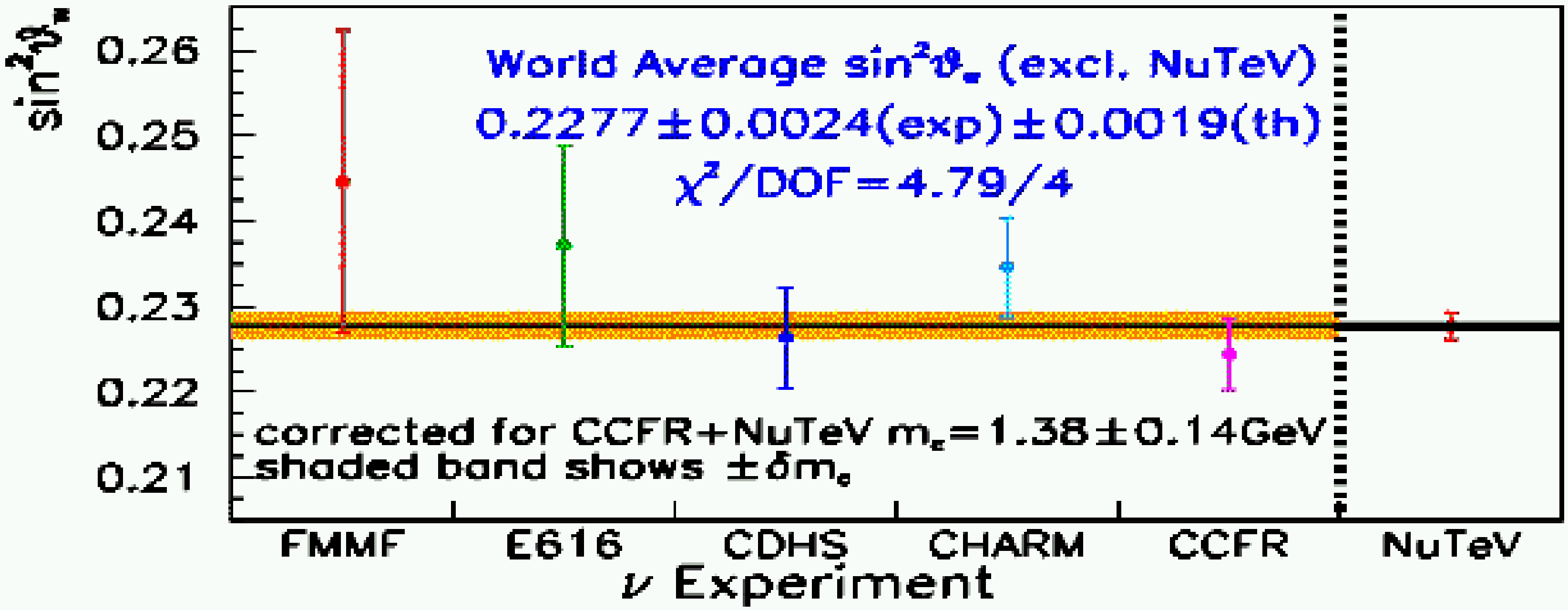
Need neutrino and anti-neutrino beam!

NuTeV Results:

$$\sin^2\theta_W^{(on-shell)} = 1 - \frac{M_W^2}{M_Z^2} = 0.2277 \pm 0.0013(stat.) \pm 0.0009(syst.)$$

$$- 0.00022\frac{M_{top}^2 - (175\,GeV)^2}{(50\,GeV)^2} + 0.00032\ln\frac{M_{Higgs}}{150\,GeV} \qquad [\rho = \rho_{SM}]$$

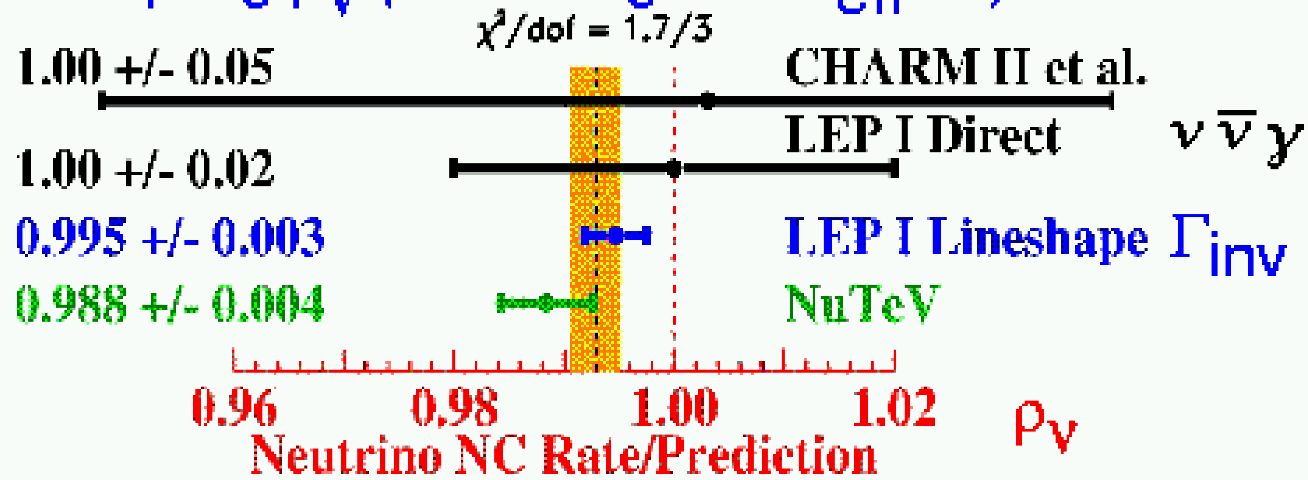
Factor two more precise than previous νN world average



Global SM analysis predicts: 0.2227(4) Difference of 3.0 σ!

Possible Explanations

Strength of ν coupling ρ_ν (assuming $\sin^2\Theta_{eff}$ ok):



Various explanations, old and new physics:

- Theory uncertainty (LO PDFs)
- Isospin violating PDFs
- Strange (charm) sea asymmetry (quark-antiquark)
- Nuclear shadowing asymmetry (W-Z)

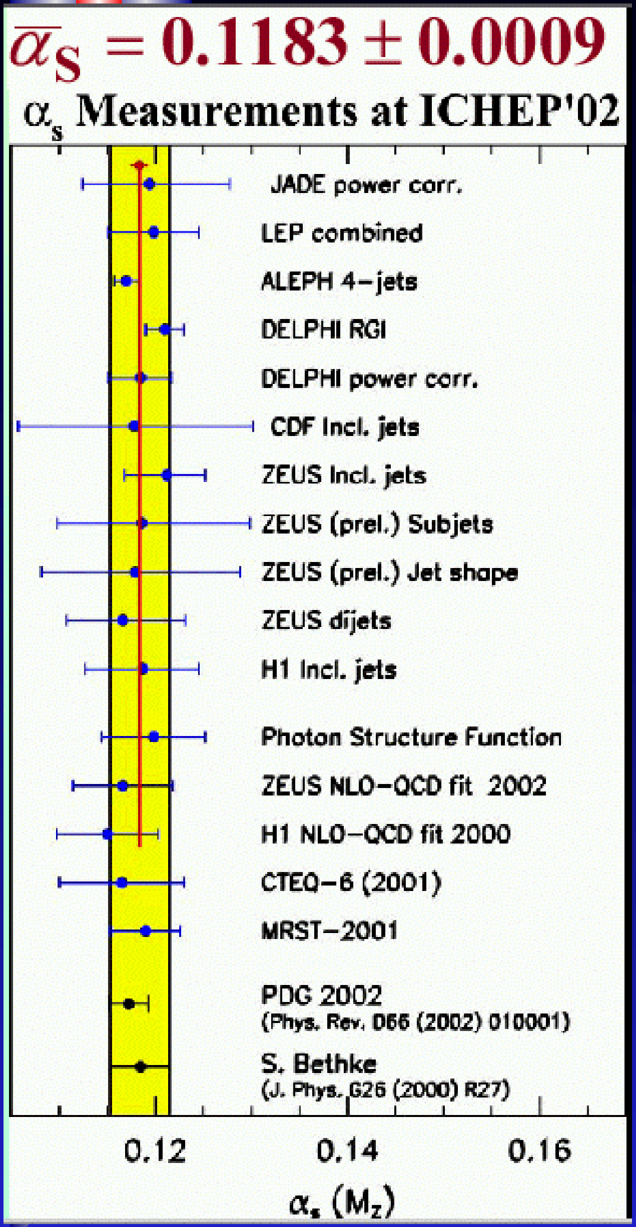
New physics:

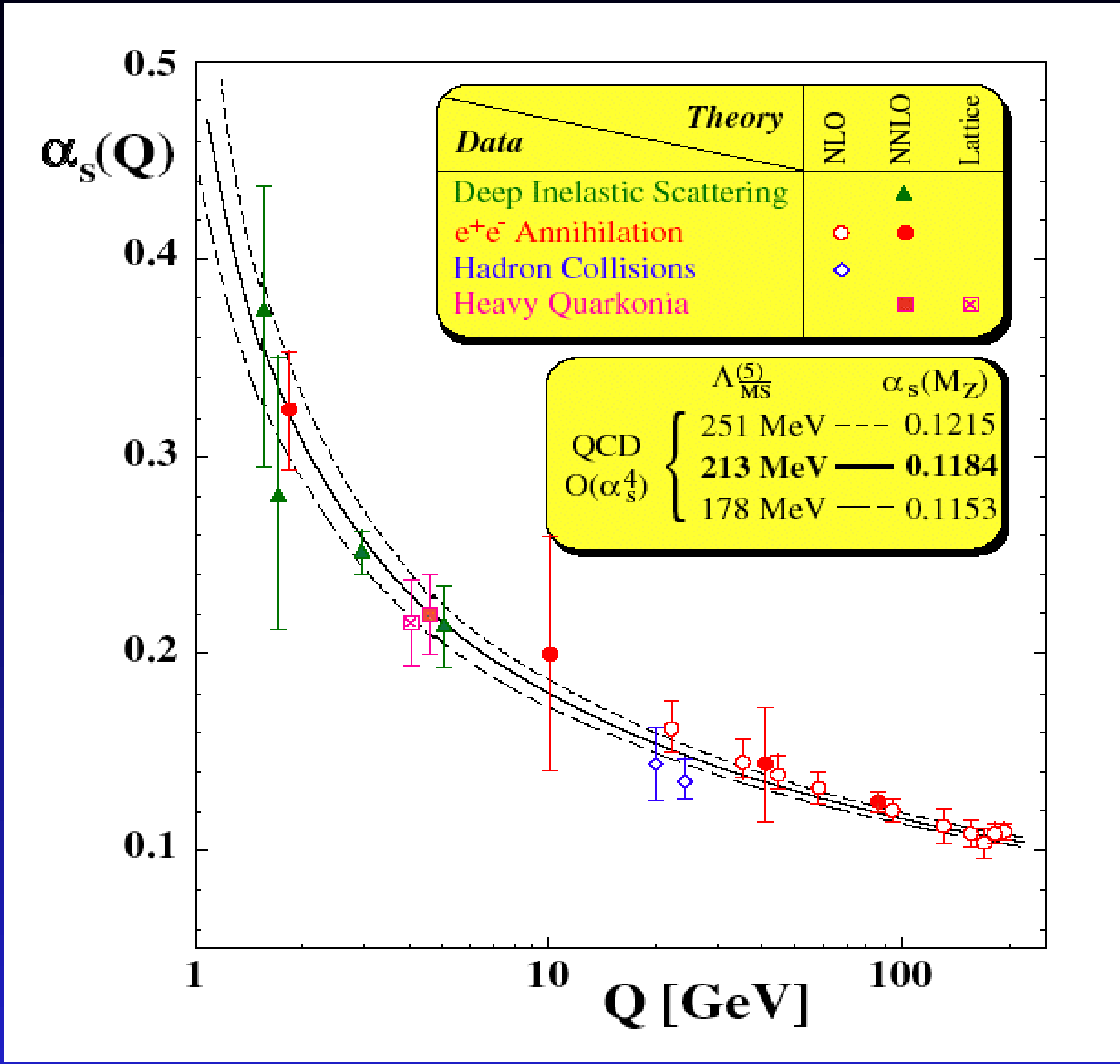
- Z', contact interactions, lepto-quarks, new fermions, neutrino oscillations, . . .

QCD at High Energy

talks by: V. Chiochia, P. Kreuzer, K. Long, C. Paus, S. Roth, F. Wilczek

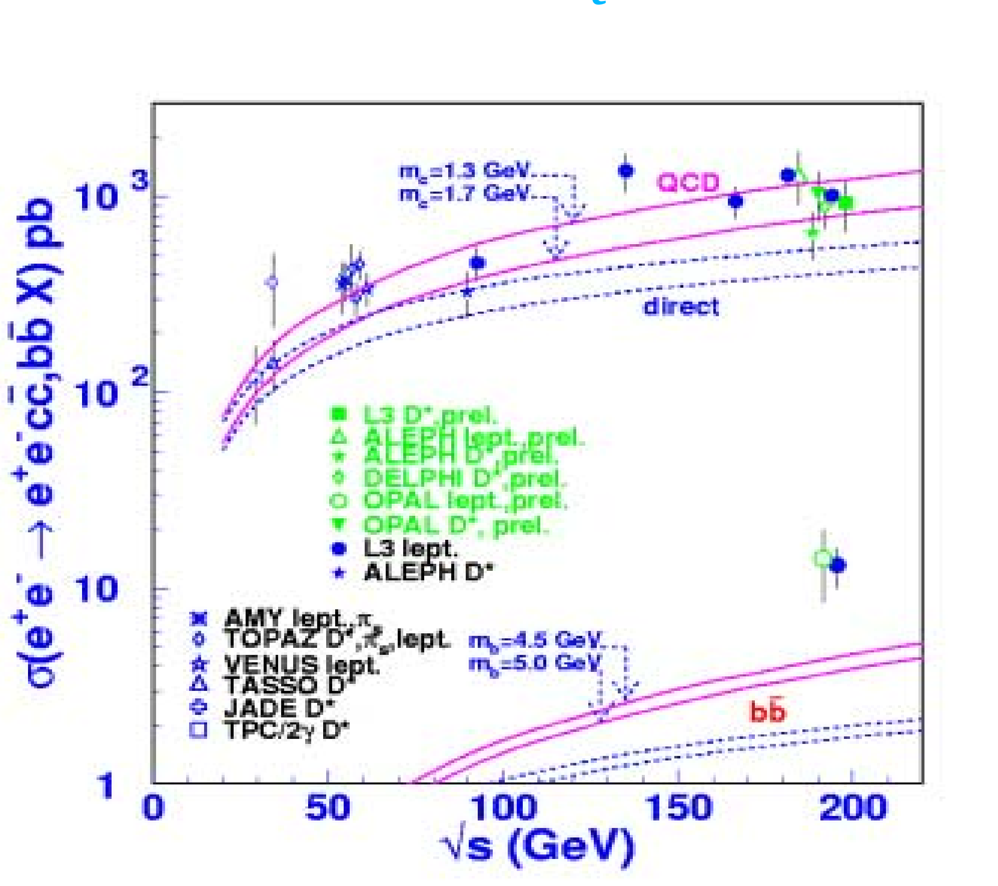
α_s Determination – QCD success





Beauty puzzle: does pQCD describe heavy quark production?

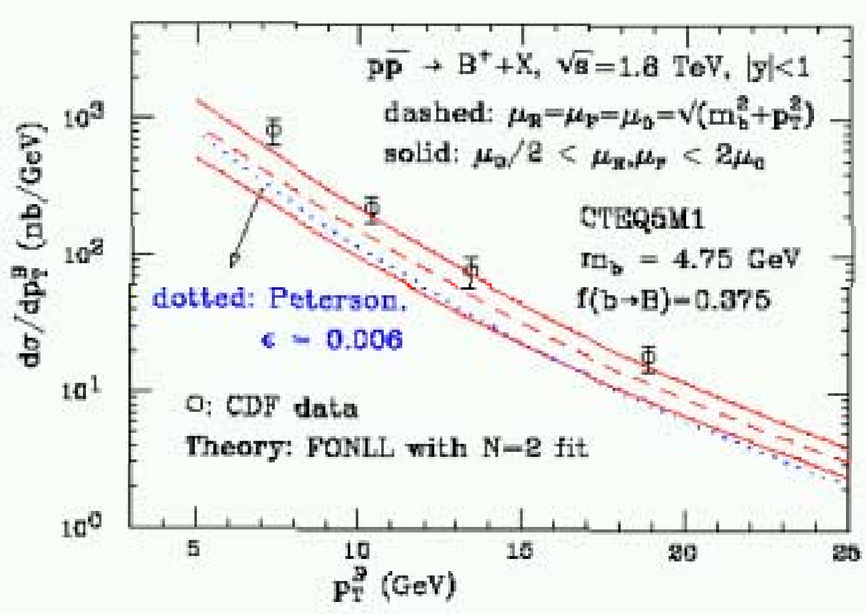
LEP: $\gamma\gamma$ events+p_t^{rel} method



Charm OK

Beauty too high

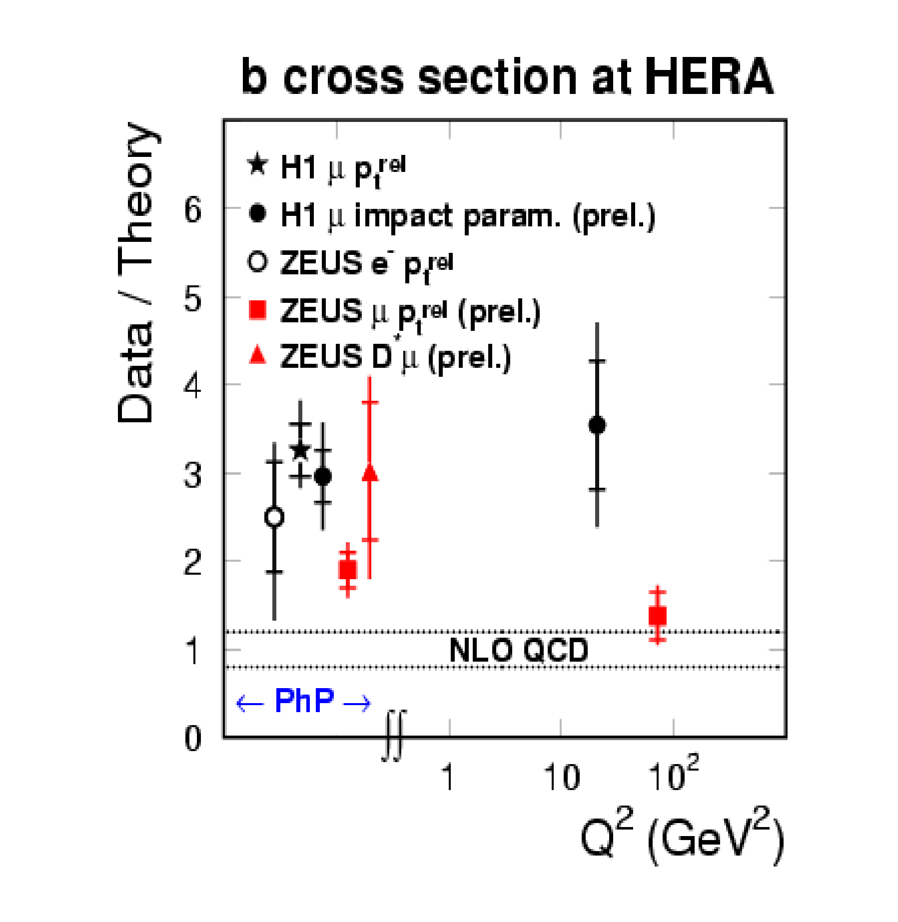
CDF



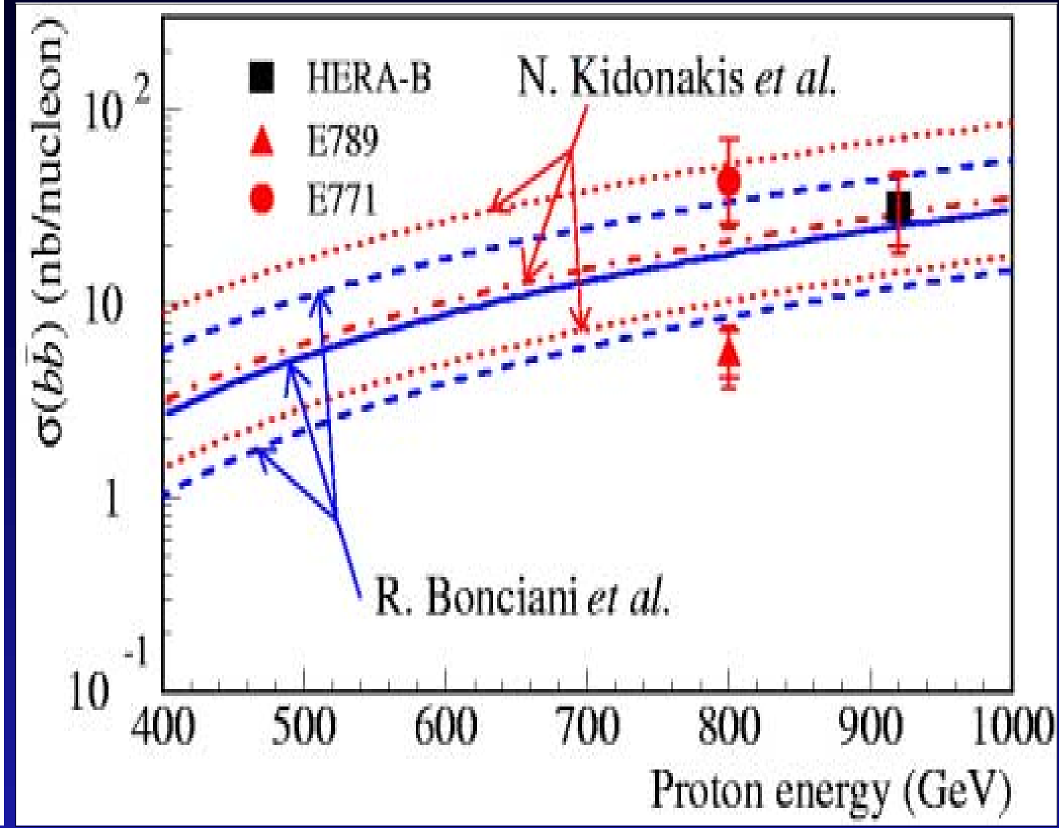
Updated theory

- Peterson fragm. tuned for LL
- different parameter: $\varepsilon_b = 0.002$
- better even different fragm.
- theory update FONLL Cacciari, Nason
- $\sigma_{data}/\sigma_{theory} = 1.7$
- data do not contradict theory

Beauty puzzle: HERA



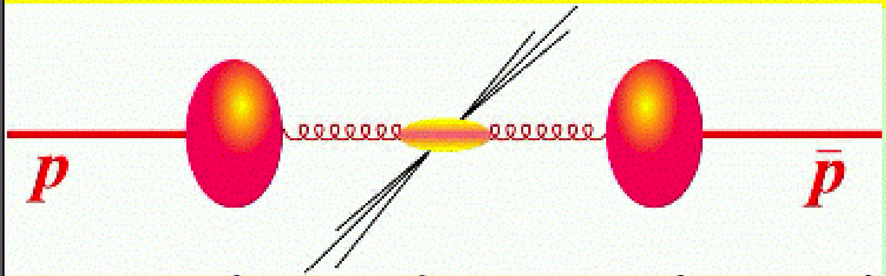
HERA B: $B \to J/\psi\ X \to l^+l^- X$



CASCADE (CFFM & unintegrated gluons) also describes ZEUS DIS data

agreement with recent calculations beyond NLO

Inclusive jet cross section in $p\bar{p}$



$$\Delta\sigma \propto f_p(x_p, Q_p) \otimes \hat{\sigma} \otimes f_{\bar{p}}(x_{\bar{p}}, Q_{\bar{p}})$$

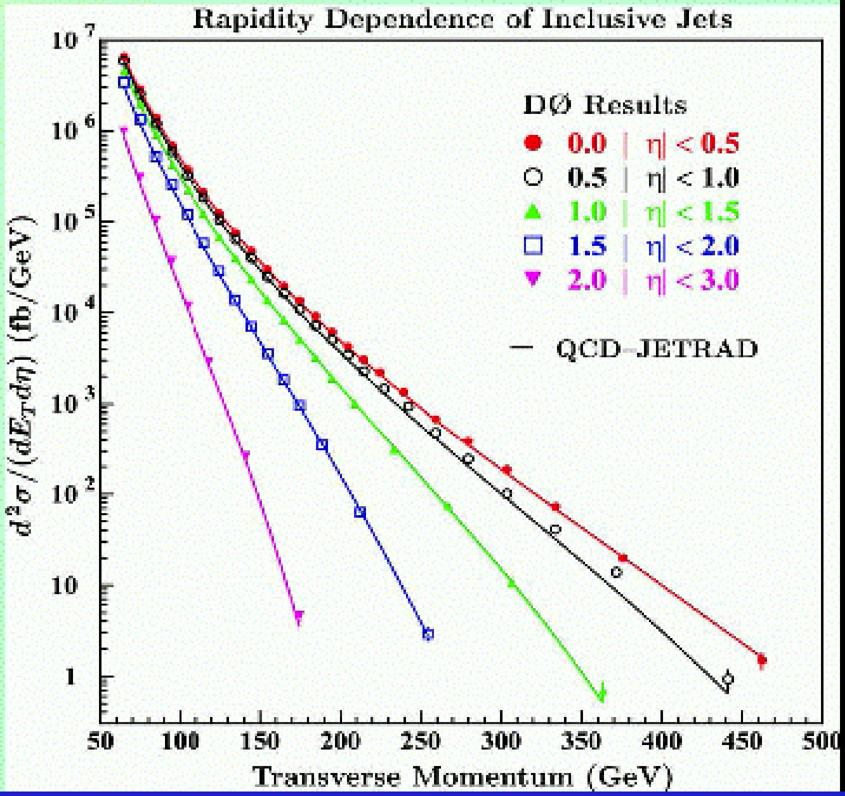
Tevatron jets:

- QCD at very high scales
- Partons at high x and very high Q^2

- D0: inclusive jet cross section as a function of pseudorapidity

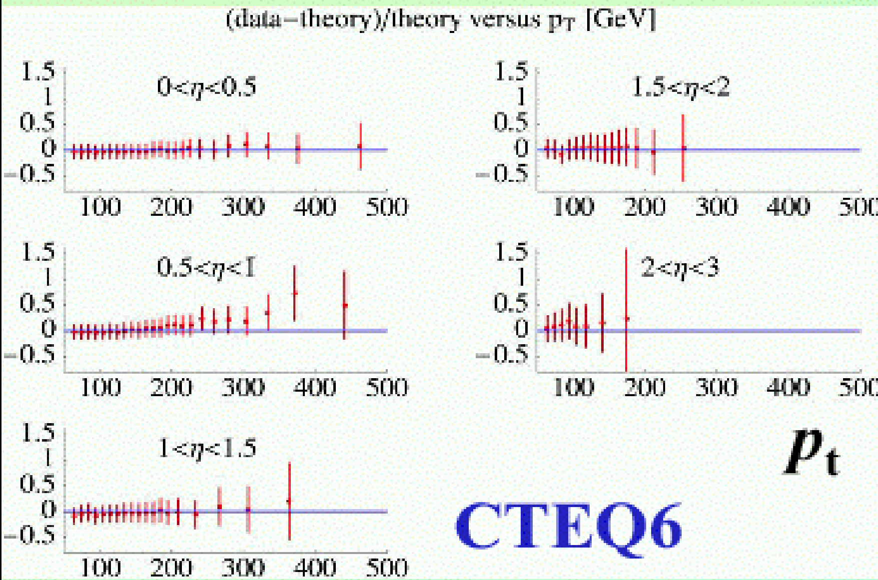
$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$

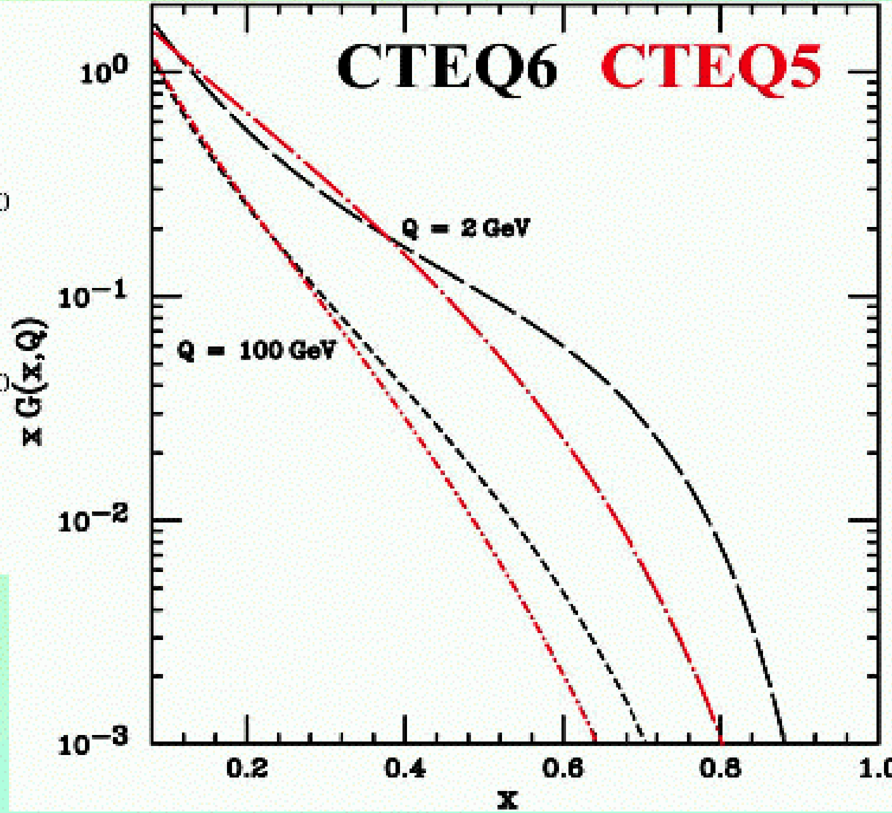
- NLO QCD gives good description of E_T and η dependence



Inclusive jets in $p\bar{p}$

- CTEQ/MRST groups: inclusion of D0 data in global fit to determine parton distributions





- Good description over full p_t and η range

- Main difference in new fits is enhanced gluon at high *x*

Physics at "Low" Q^2

Exploring Structures in Non−perturbative QCD at (Relatively) Hard Scales

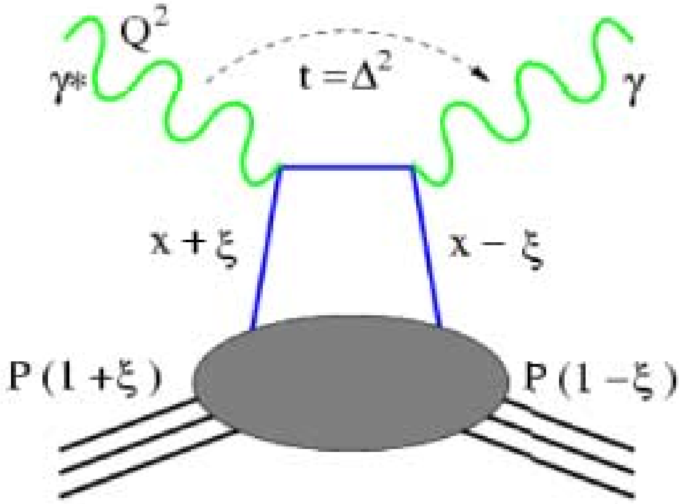
talk by N. Makins

Generalized Parton Distributions

Analysis of *hard exclusive processes* leads to a new class of parton distributions.

Cleanest example: Deeply Virtual Compton scattering

DVCS



"handbag diagram"

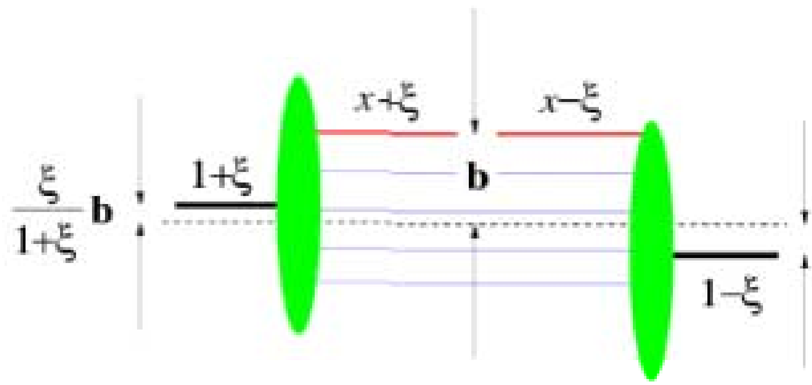
Four new distributions:

helicity conserving $\rightarrow H(x,\xi,t), E(x,\xi,t)$
helicity-flip $\rightarrow \tilde{H}(x,\xi,t), \tilde{E}(x,\xi,t)$

***Bjorken* x** : average quark momentum fraction

"skewing parameter" ξ

$\rightarrow$ mismatch between quark momenta
$\Rightarrow$ sensitive to partonic ***correlations***



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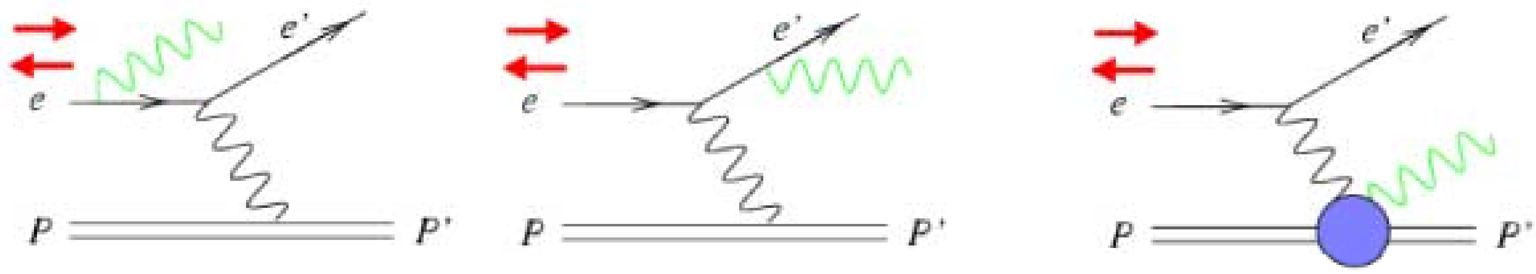
DVCS: Beam-Spin Azimuthal Asymmetry

At intermediate energies, Bethe-Heitler cross-section $\gg$ DVCS ...
⇒ explore *interference* , using ***polarized beams***



Beam-Spin Asymmetry ➡

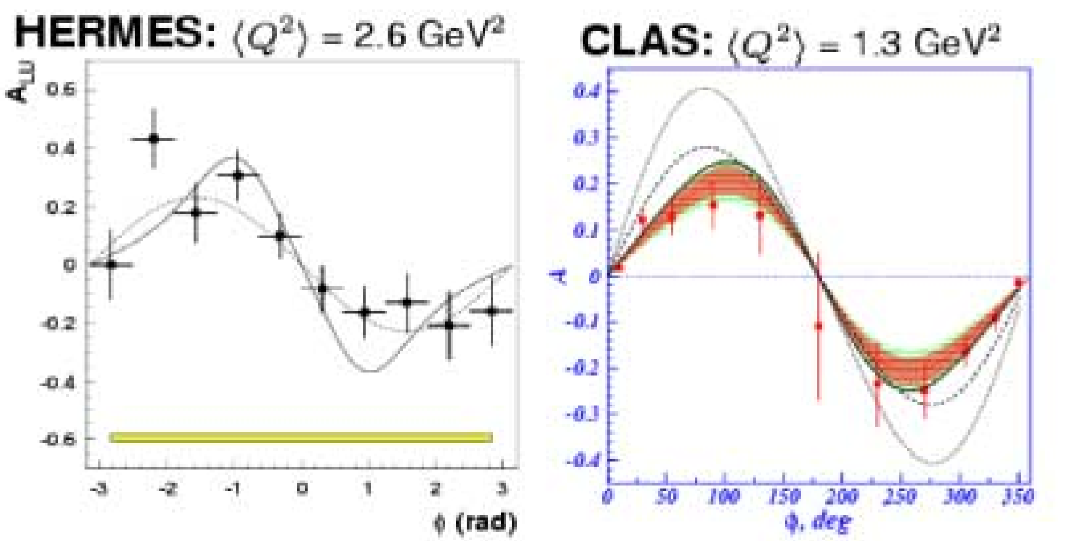
$$A_{\mathrm{LU}}(\phi_\gamma) = \frac{\sigma_{\rightarrow} - \sigma_{\leftarrow}}{\sigma_{\rightarrow} + \sigma_{\leftarrow}}$$

$$\sim \mathbf{Im}\,(\mathbf{BH} \cdot \mathbf{DVCS}^*)\,\sin\phi_\gamma$$

Beam-Charge Asymmetry

$$\sim \mathbf{Re}\,(\mathbf{BH} \cdot \mathbf{DVCS}^*)\,\cos\phi_\gamma$$

also measured, at HERMES



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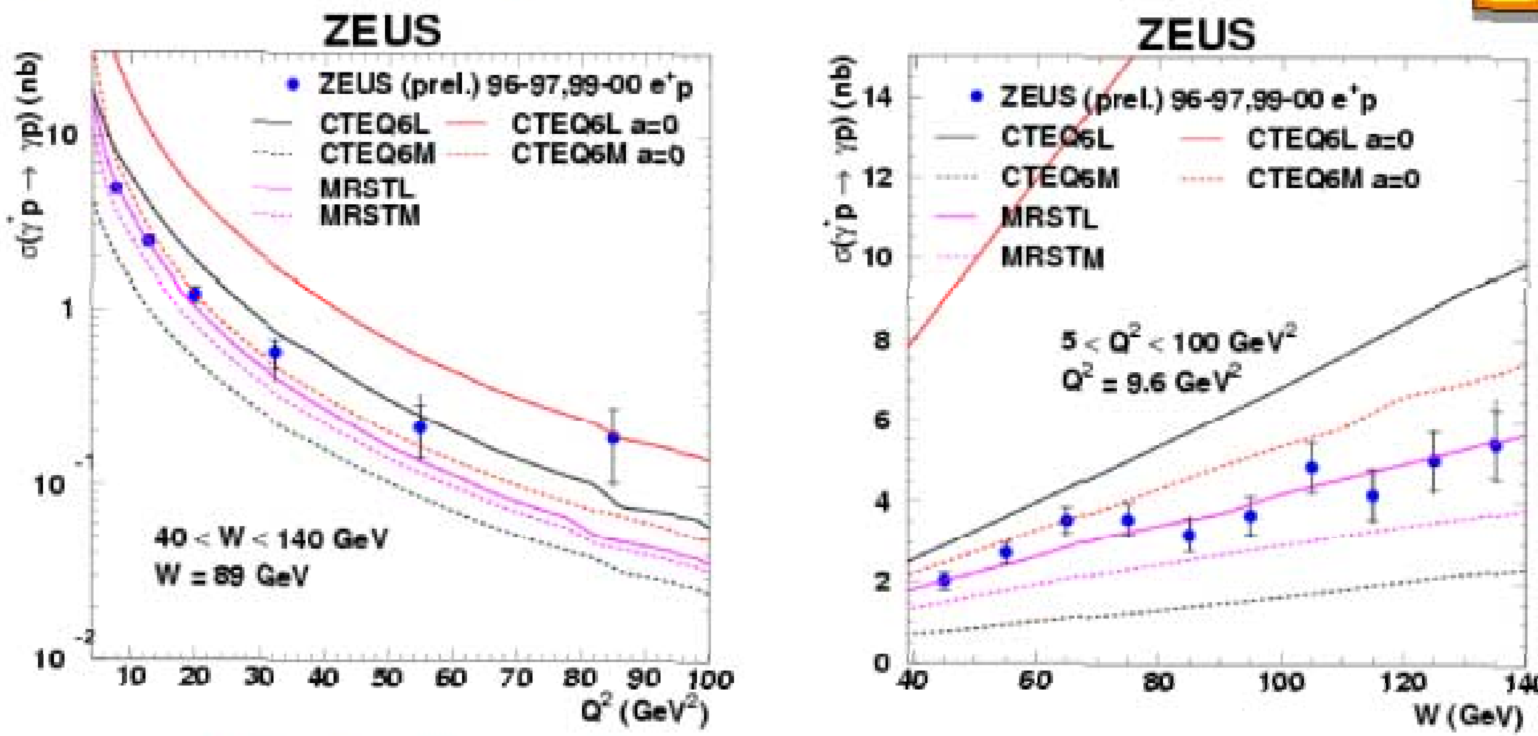
DVCS: Comparison with GPD Calculations



Precise new data have potential to constrain GPD's

- Calculations by Freund & McDermott, based on LO (solid) and NLO (dashed) PDF's
- explore ***correlation parameter*** **a:** $\sim x$-range over which quarks are correlated

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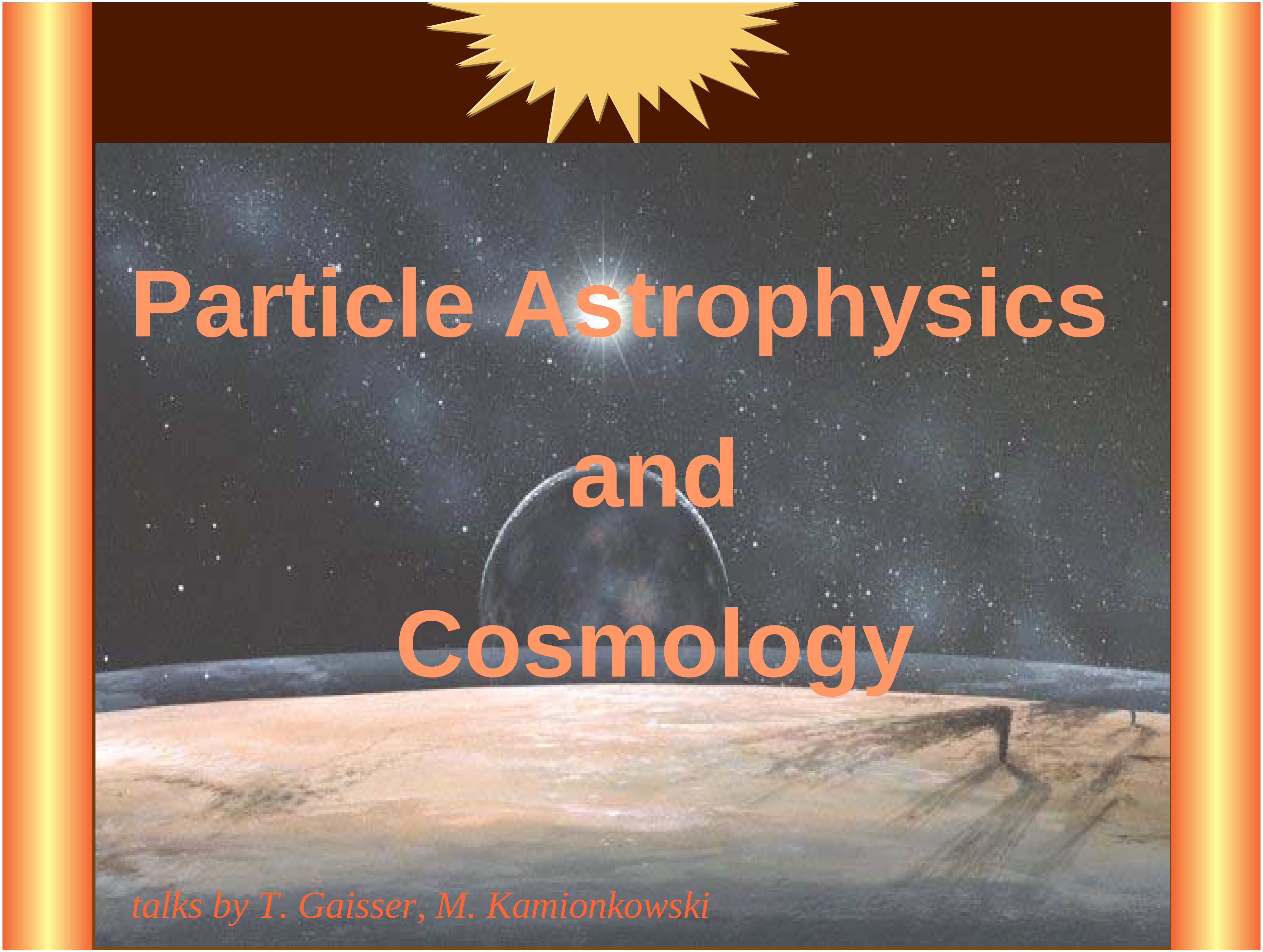
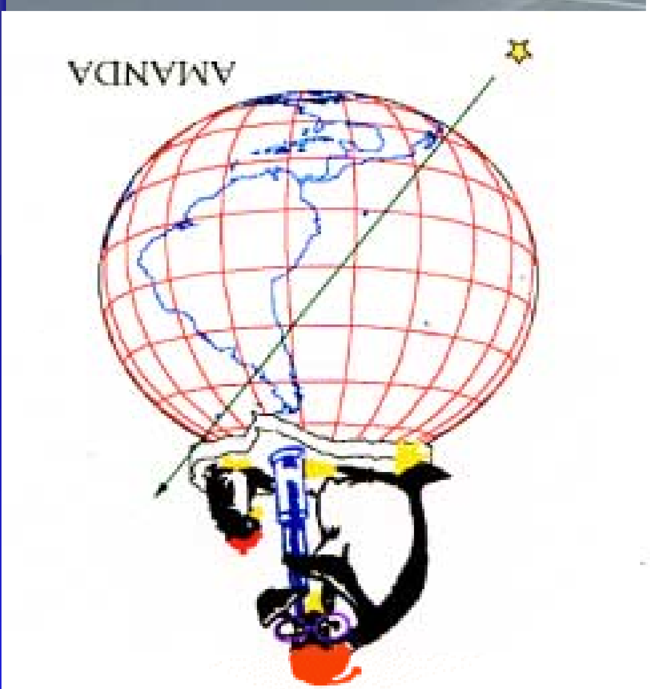
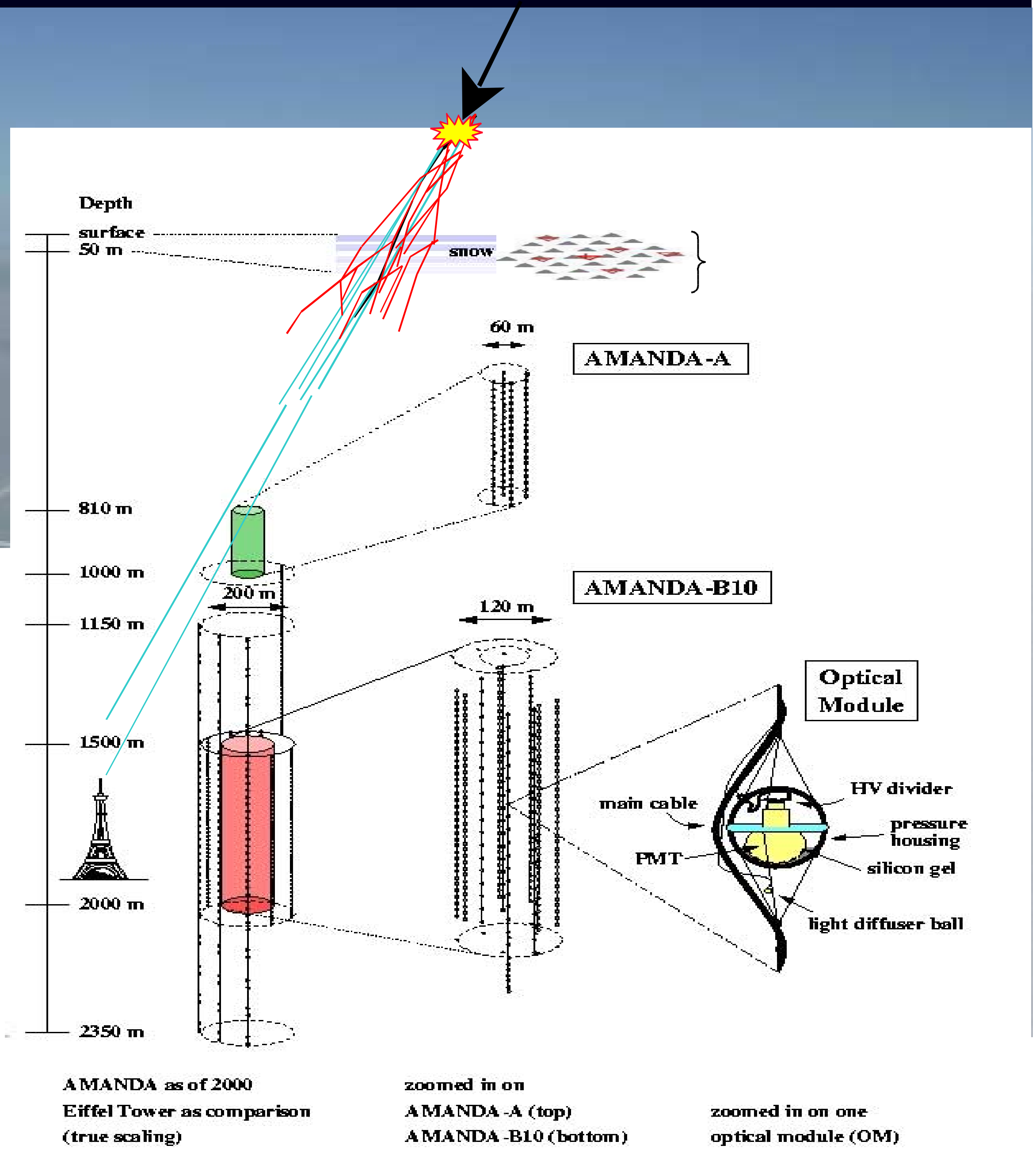
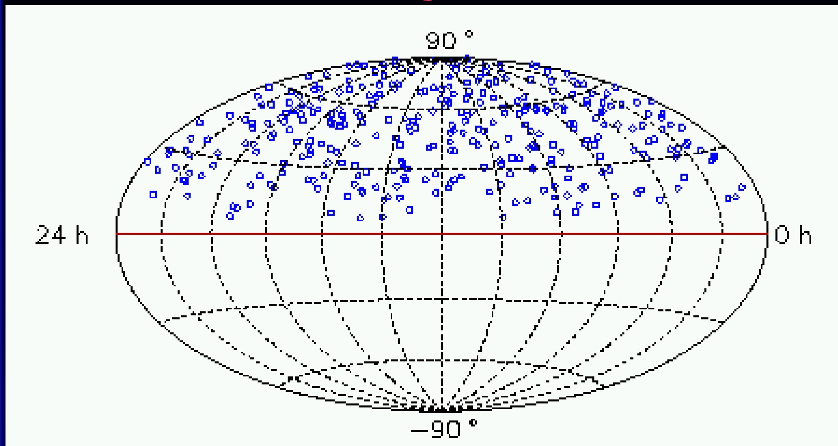

Particle Astrophysics
and
Cosmology
talks by T. Gaisser, M. Kamionkowski

Neutrino Astronomy: Baikal, Amanda

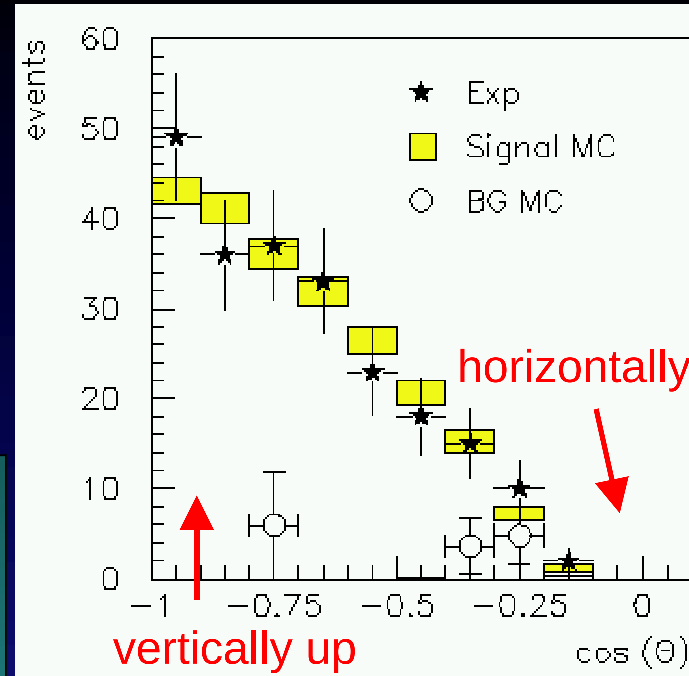


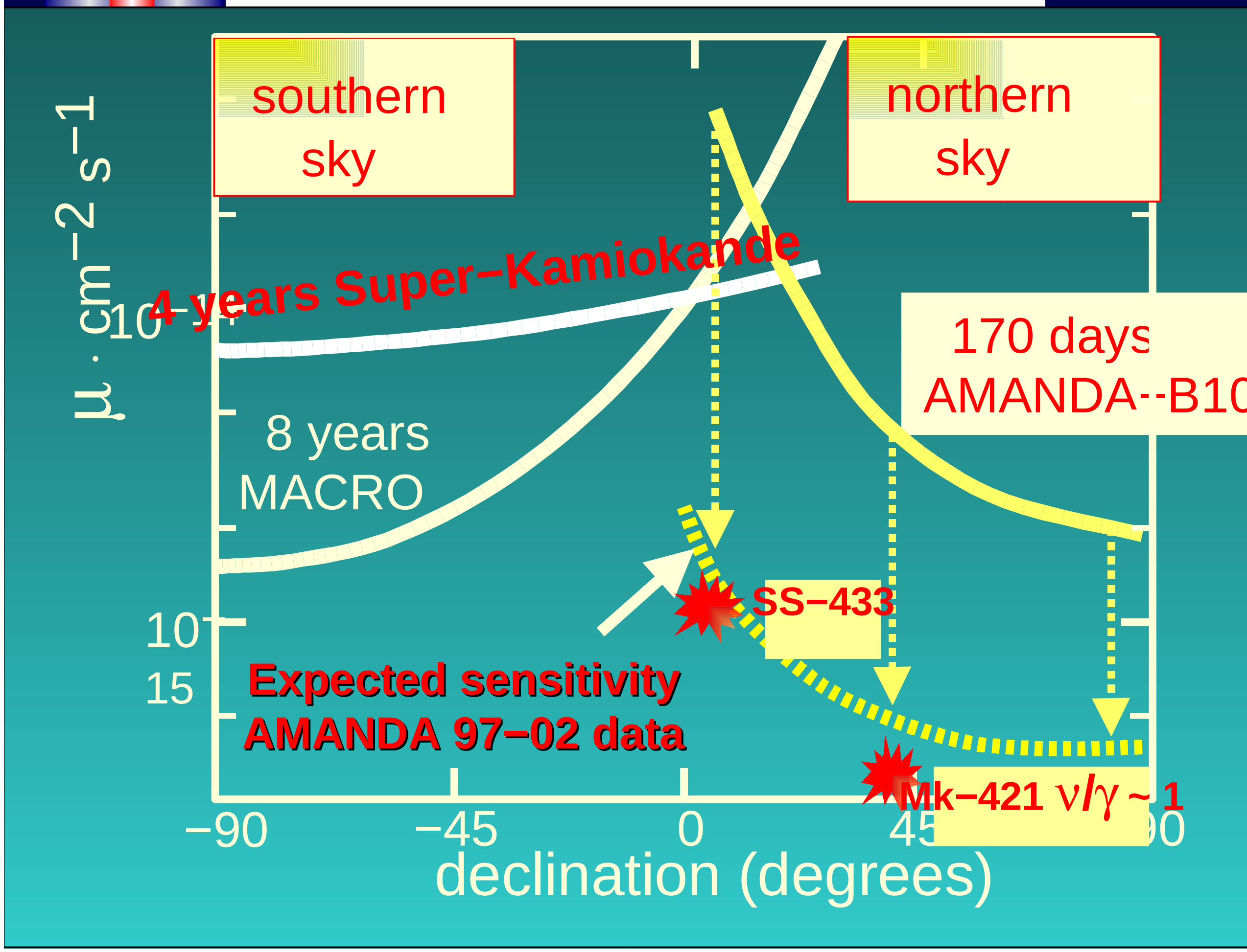


AMANDA: skyview



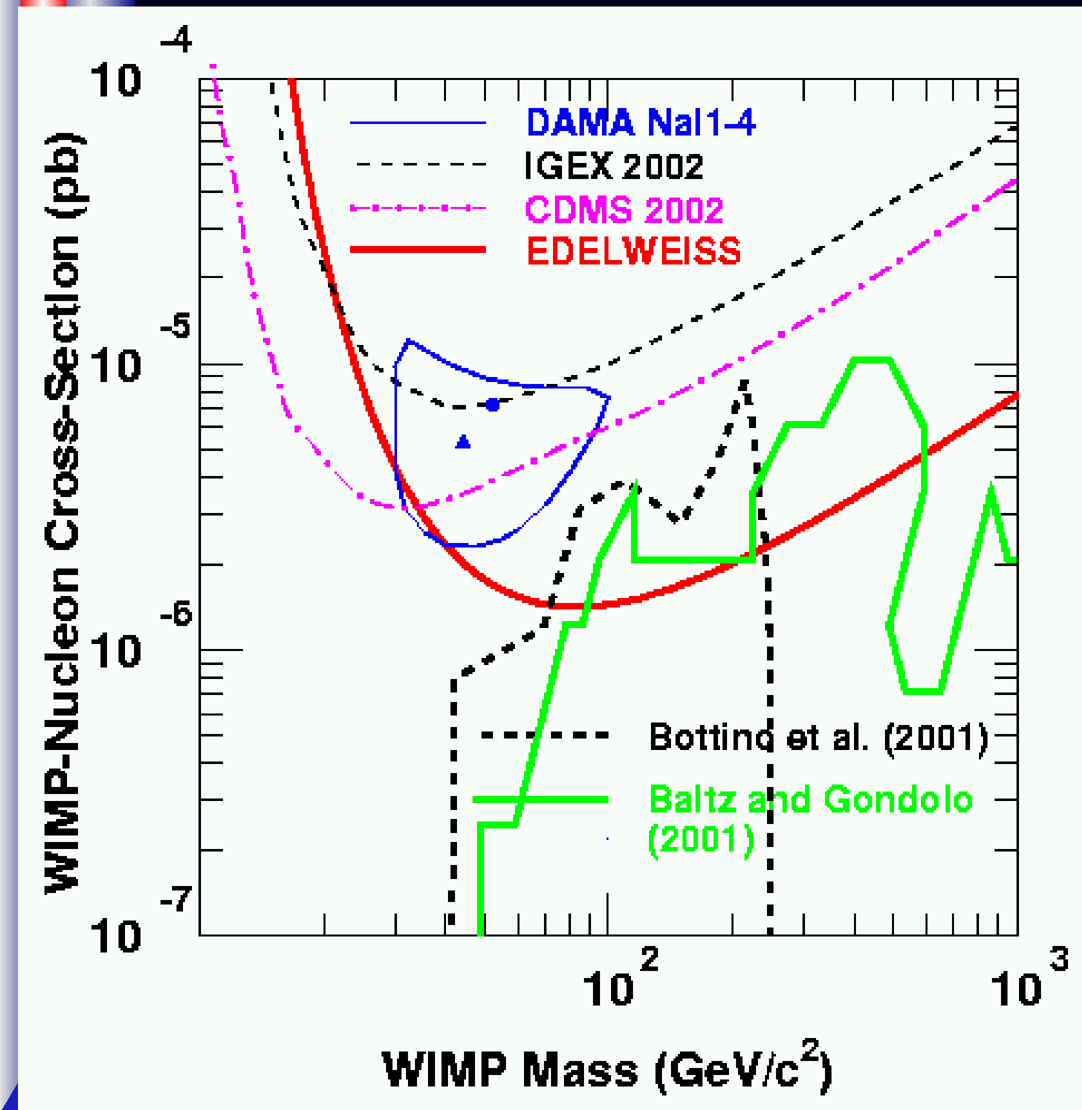
AMANDA: atmosferic ν

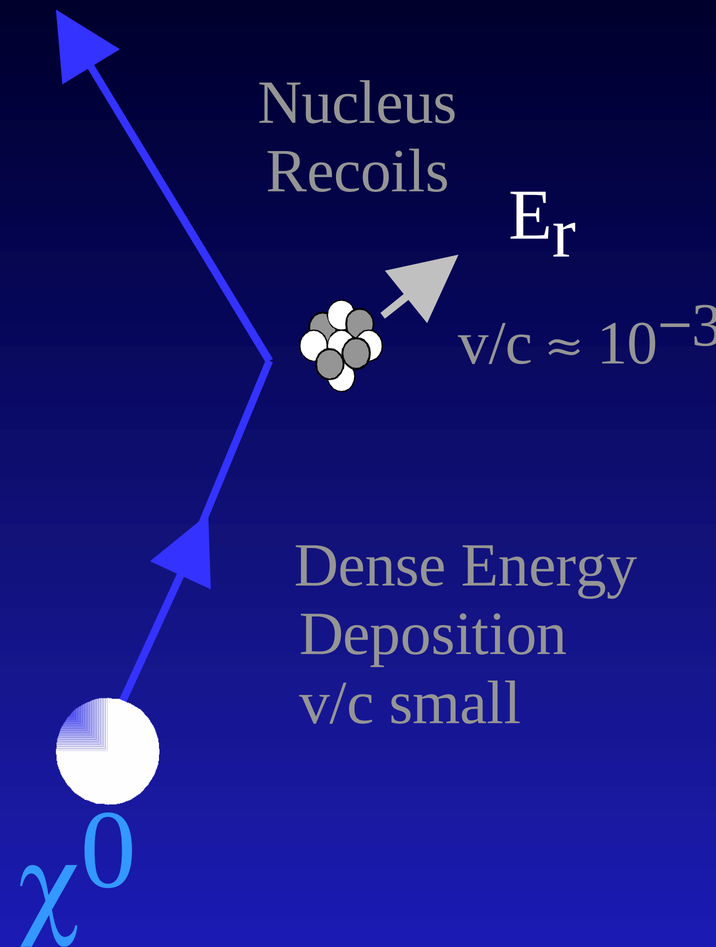




- ***many ongoing & future projects***
  - *neutrinos*
    - *atmosferic*
    - *from active gal.*
    - *from γ−ray bursts*
  - *WIMPS*

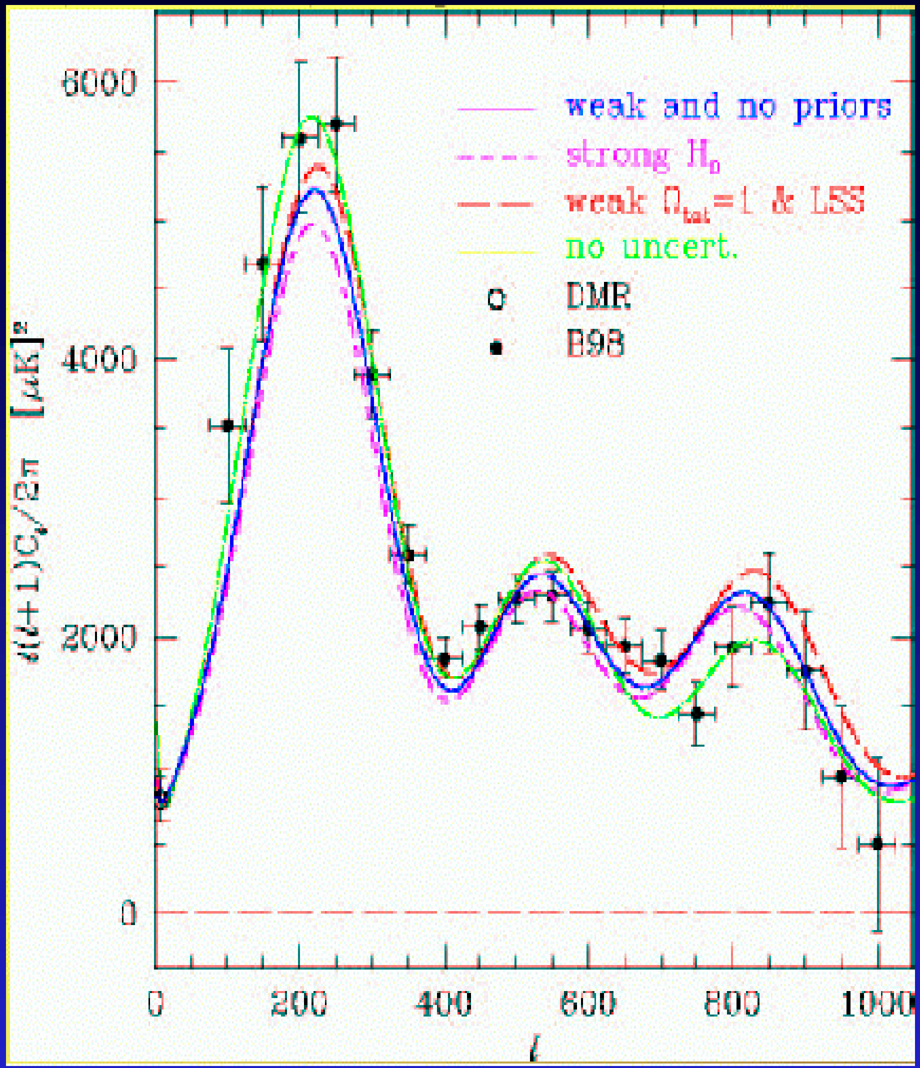
Dark Matter Searches: Summer 2002





Microwave Background and Inflation

BOOMERanG Results



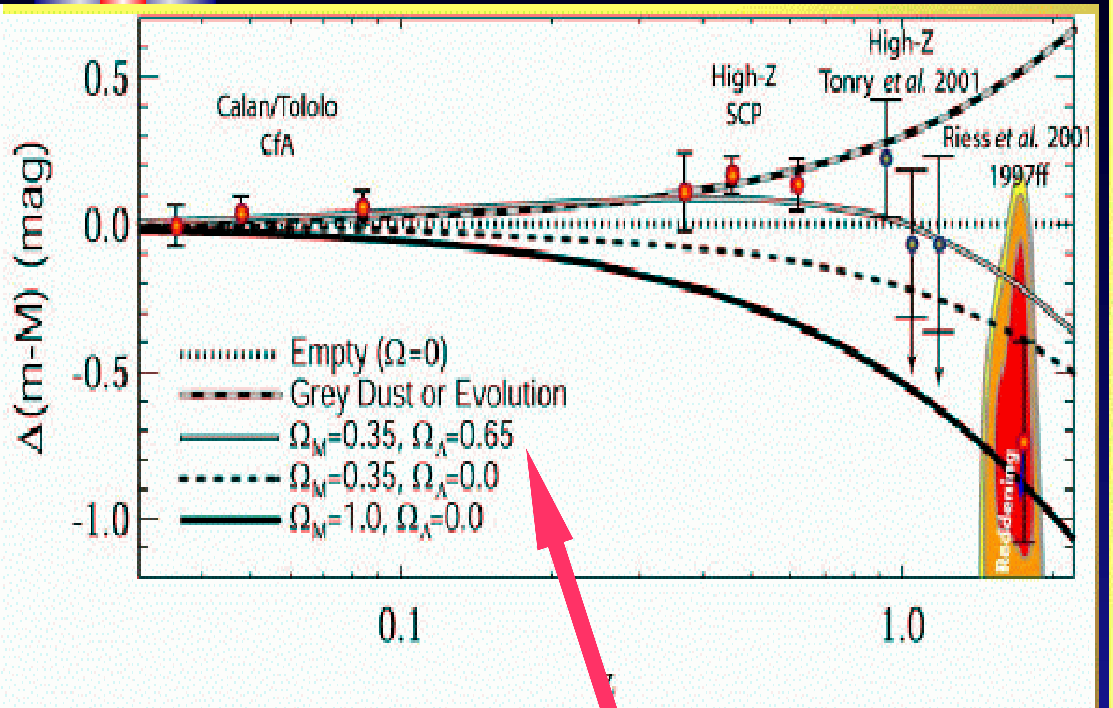
Current results:

- **flat Universe**
- **give primodial seeds for large scale struct.**

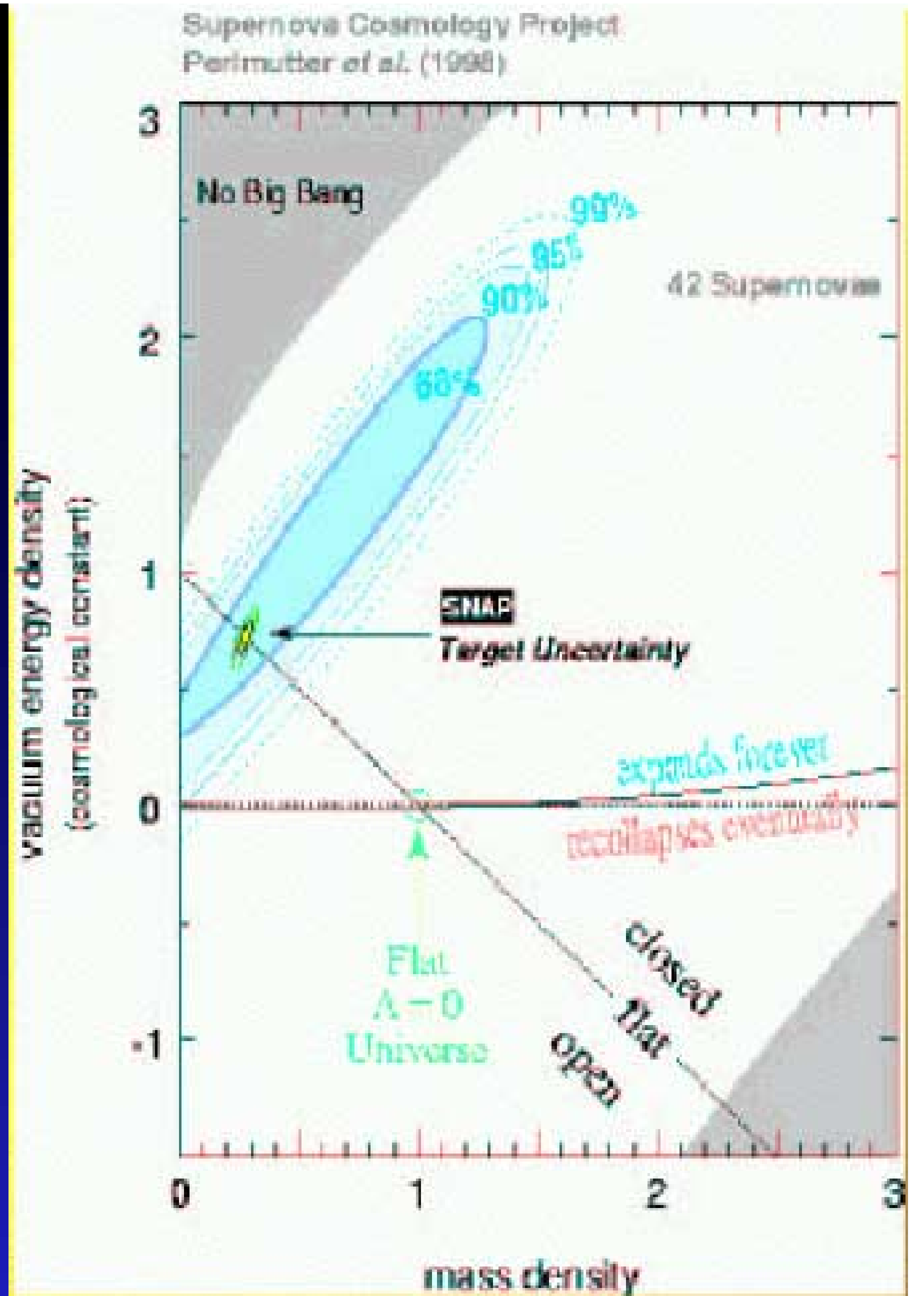
⇒ inflation!

- **verify BB nucleosyn.**
- **existance of nonbaryonic dark matter**
- **70%negative presure dark energy**

What is Universe made of?...



Courtesy P. Garnavich (High-z Supernova Search Team)
(results also from Supernova Cosmology Project)



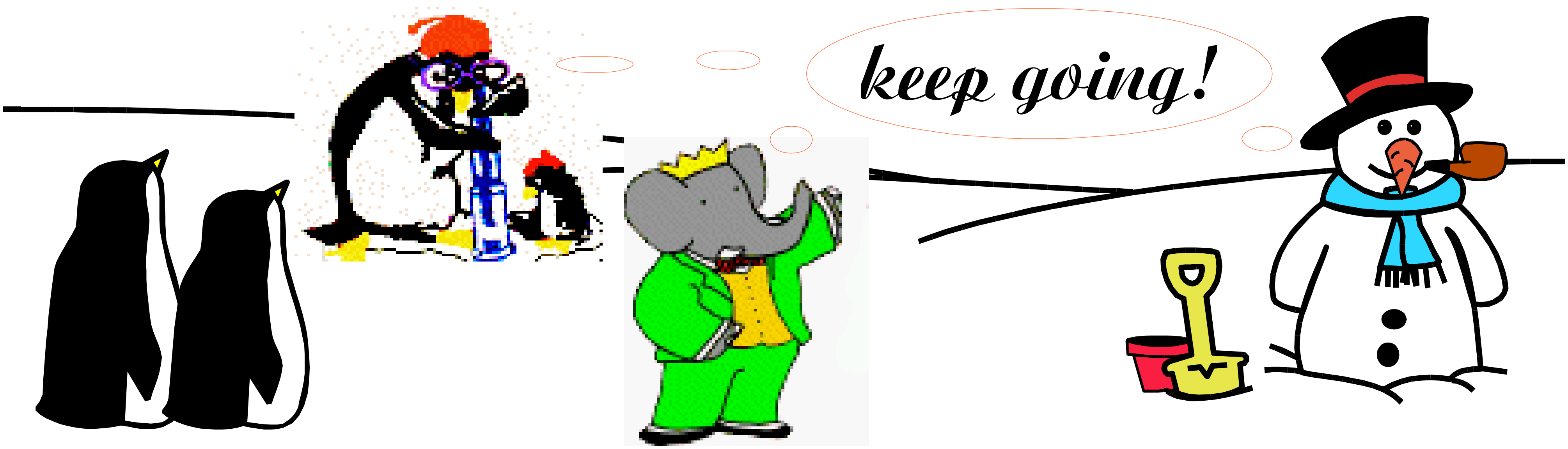
65% of dark energy!

What is the Universy we live in like? A Summary?

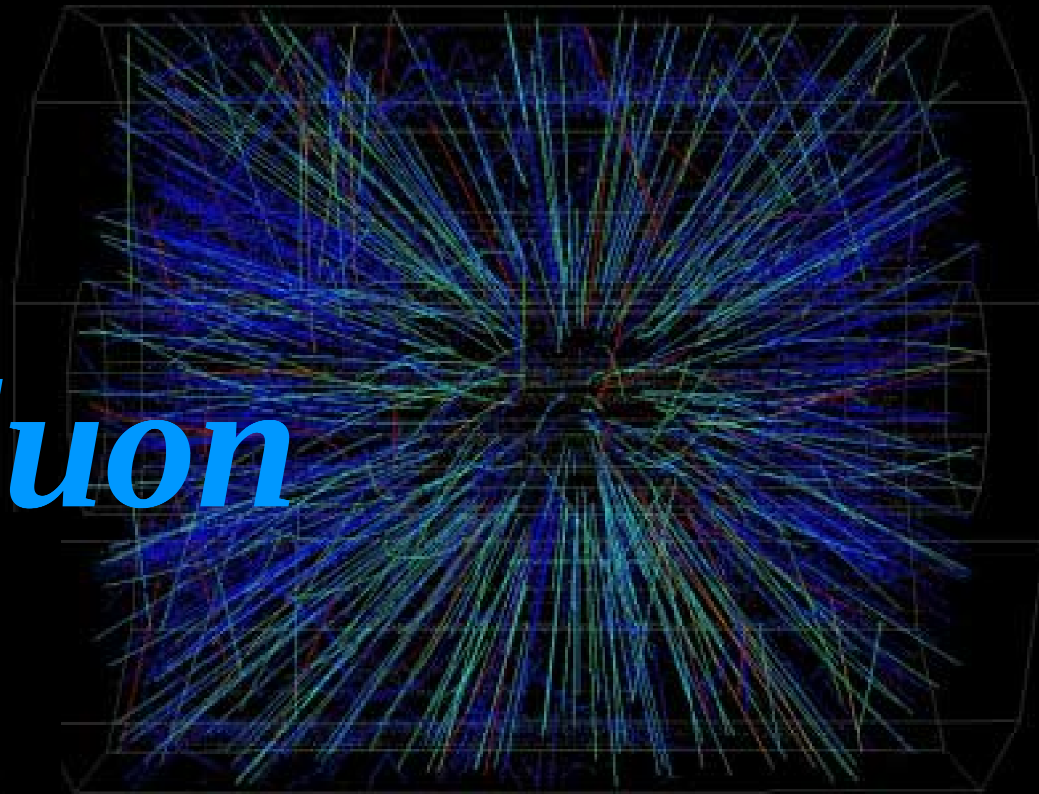
- flat, after inflation
- ~65% dark energy
- CPV, no direct CPV yet
- full of objects to search for and misteries to discover...

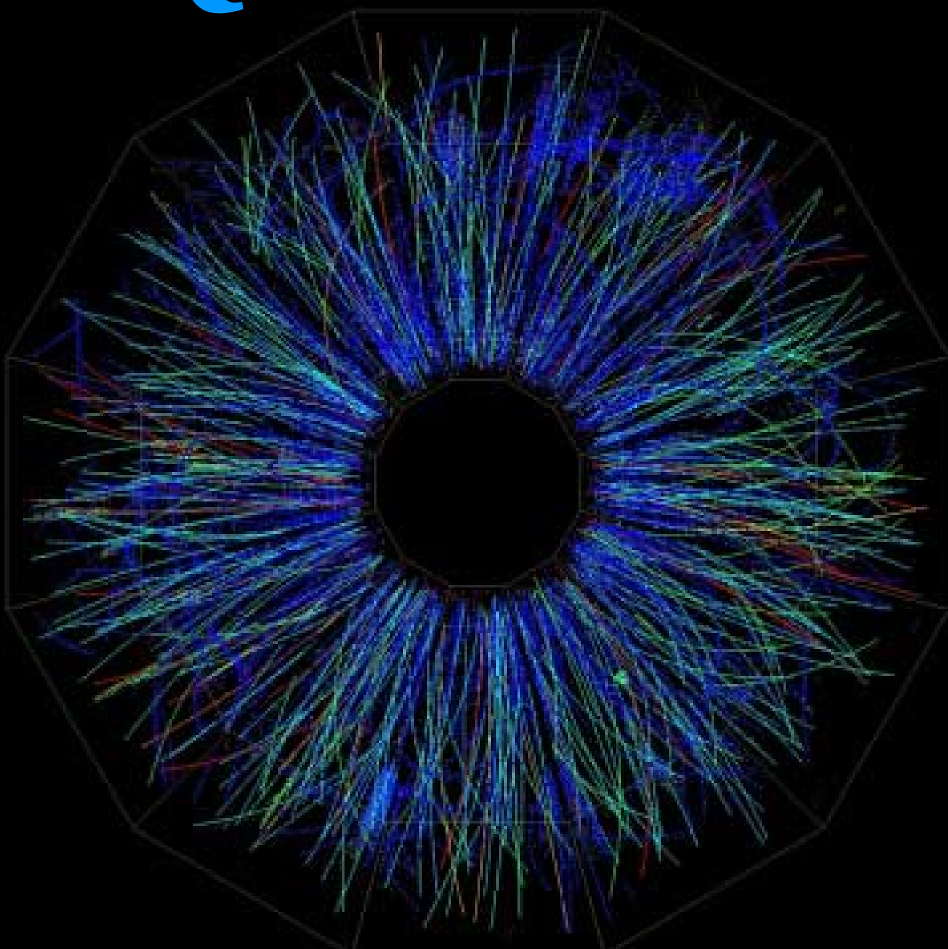
- SM particles found (almost)
- SM agrees (almost)
- QCD works (almost)
- no new physics (yet)

where do we go from here?...



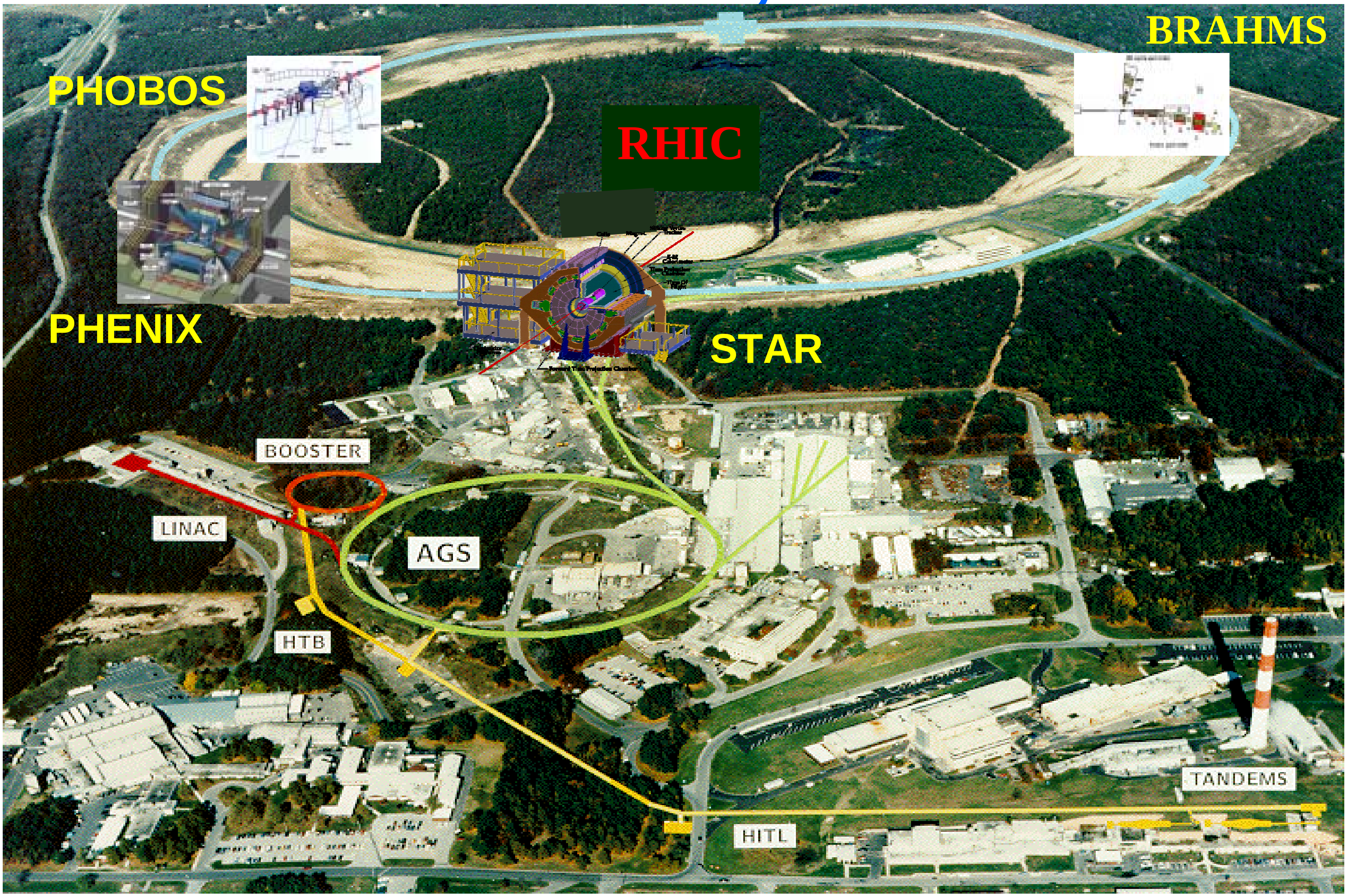
Quark−Gluon



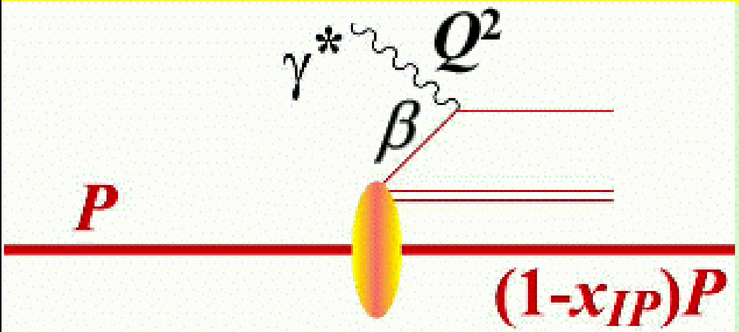


Plasma

Relativistic Heavy Ion Collider



Inclusive Diffraction



Factorisation (Collins)

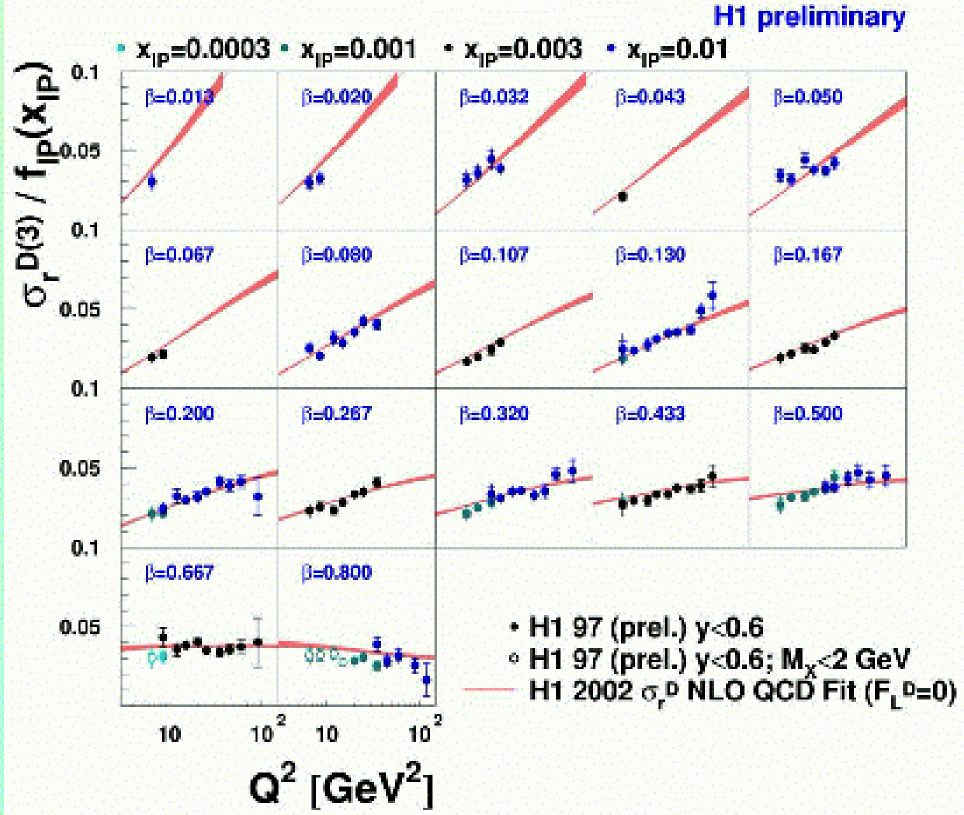
$$\sigma_i\left(x_{IP},t;\beta,Q^2\right)\sim q_i^{\rm Diff}\left(x_{IP},t;\beta,Q^2\right)\otimes\hat{\sigma}_{\gamma^* q_i}\left(\beta,Q^2\right)$$

Data **consistent with 'Regge' factorisation:**

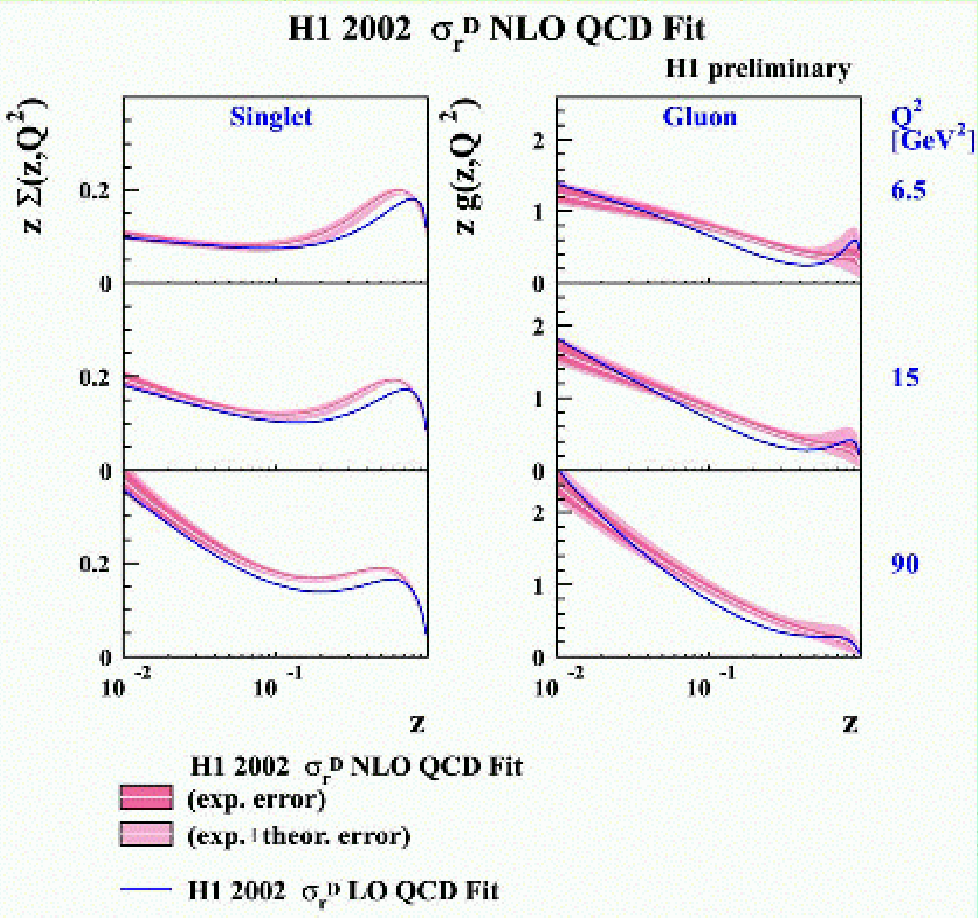
$$\sigma_r^{D(3)}\sim f_{IP/p}(x_{IP},t)\bullet F_2^{IP}\left(\beta,Q^2\right)$$

$$f_{IP/p}(x_{IP},t)=\frac{\exp(-b|t|)}{x_{IP}^{2\alpha(t)-1}}$$

- **Good description of data**
- **Positive scaling violations ($\beta < 0.6$) → *diffractive* PDFs are gluon dominated**



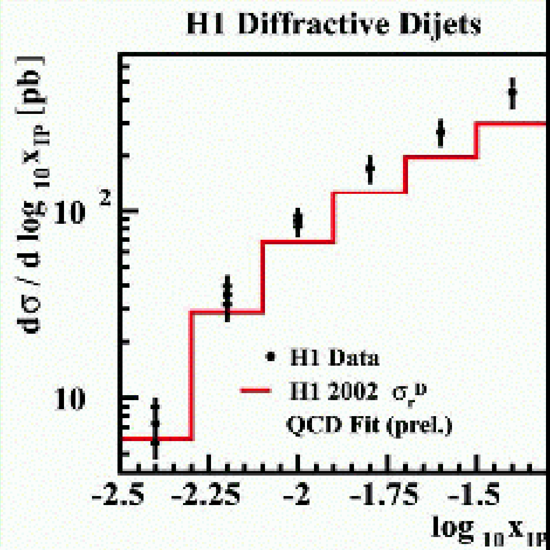
Diffractive parton densities



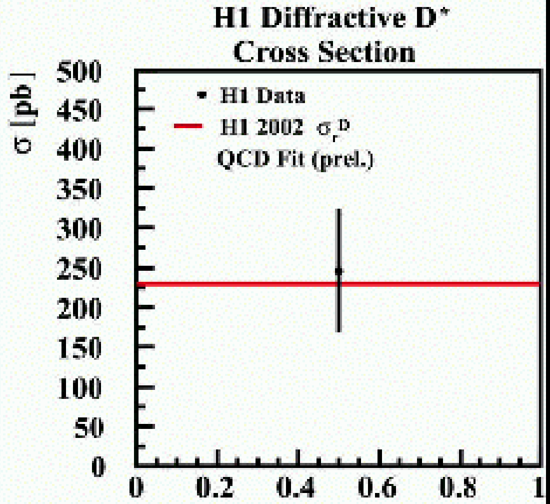
First set of diffractive PDFs!

Predictive?

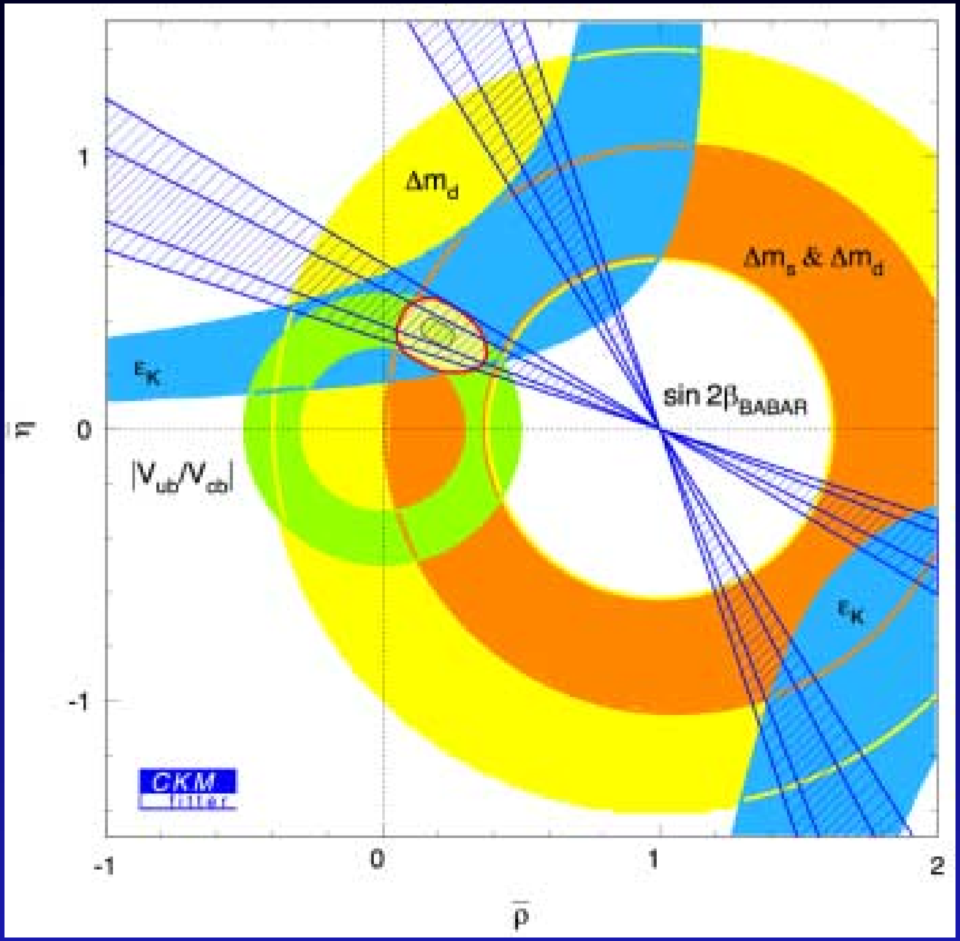
Diff. dijets



Diff. D*



Standart Model Comparison



one solution for 2b in excelent agreement with measurements of UT

CP Violation

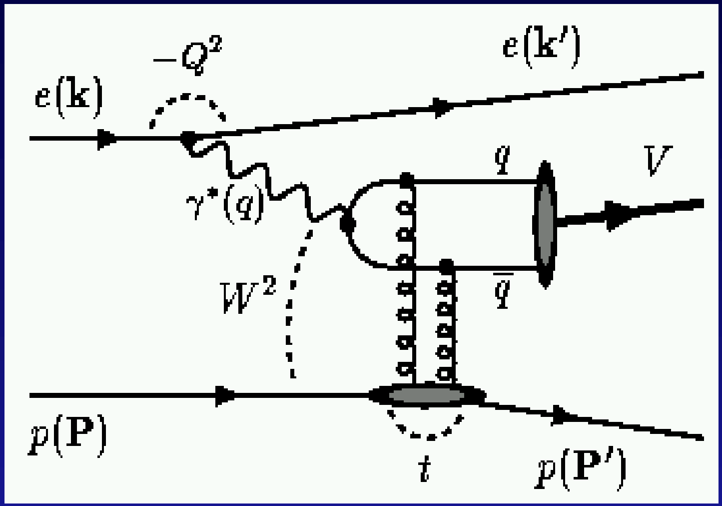
Very important in reducing the allowed region

Coherent picture of CP Violation in SM

Hard Scales

pQCD applicable in presence of hard scale

- example: Diffractive Vector Meson Production



3 scales:

- **Q : photon virtuality**
- **m : vector meson mass**
- **t : mom. transfer to target**

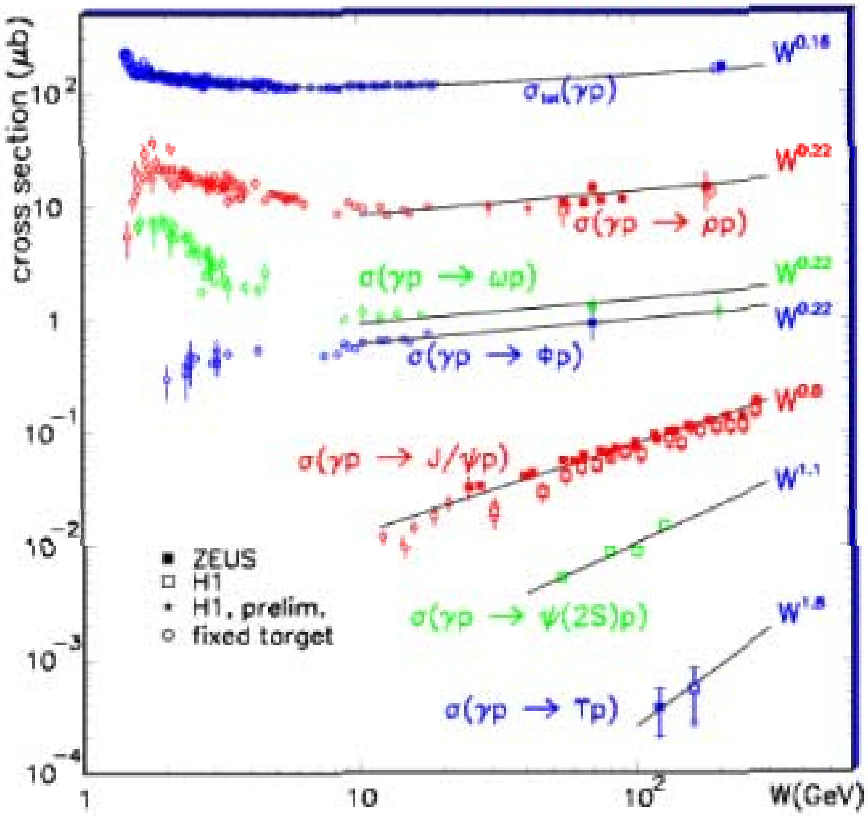
pQCD picture: 2−gluon exchange

fast rise of xsec with W: $\sigma_L = W^{0.8}$

Soft → Hard Transitions

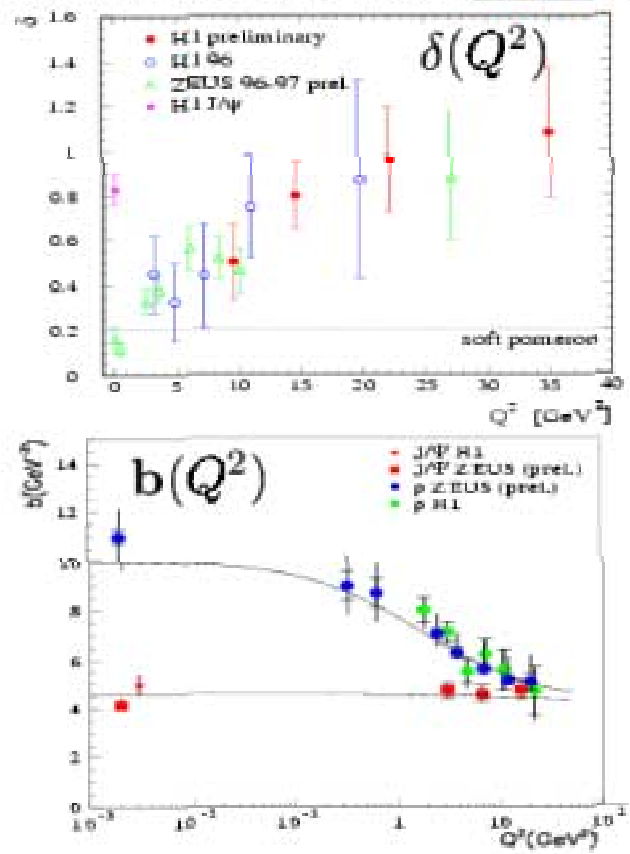
Photoproduction ($Q^2 = 0$)

onset of hard behavior: ***charm mass*** (J/ψ)



Diffractive ρ production

onset of hard behavior: ***high Q^2***



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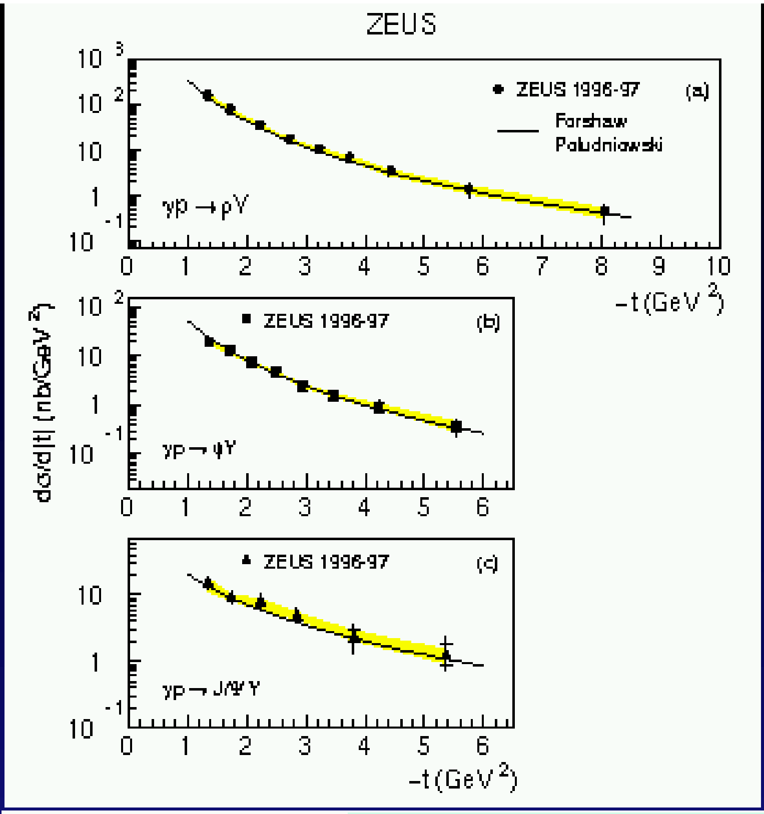
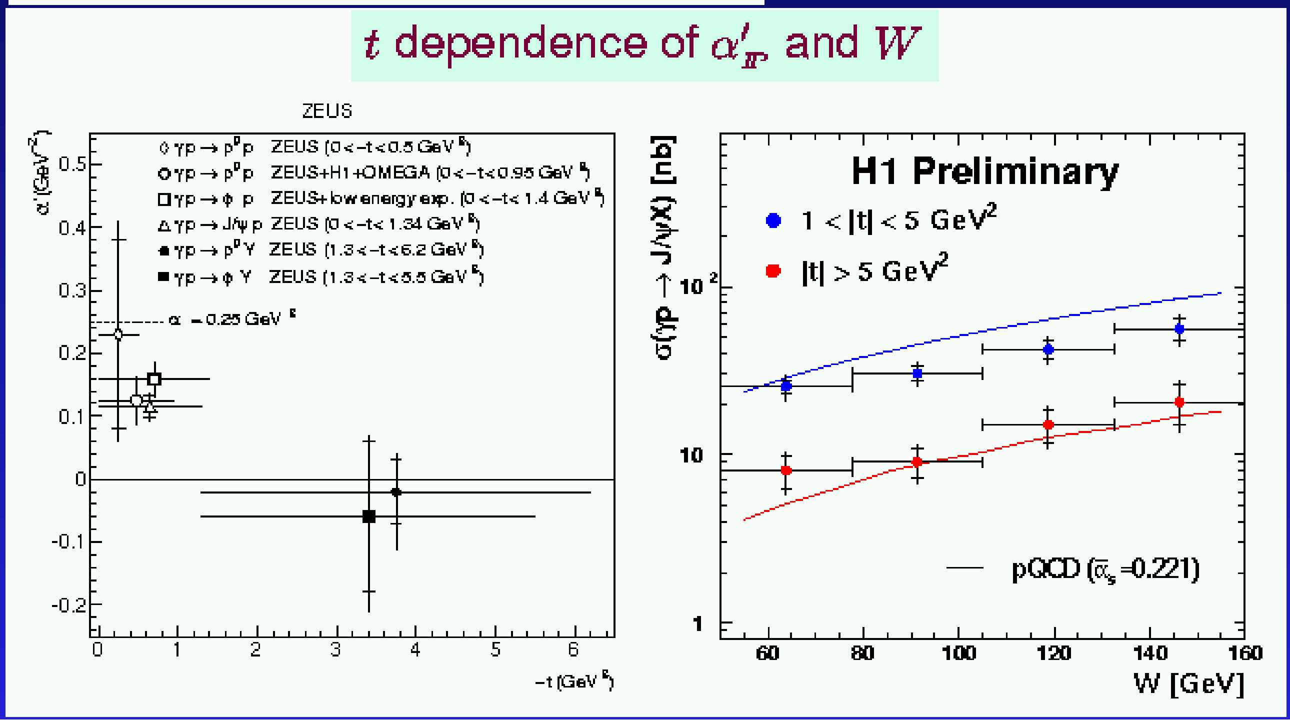
Diffractive Photoproduction

onset of hard behavior: large t



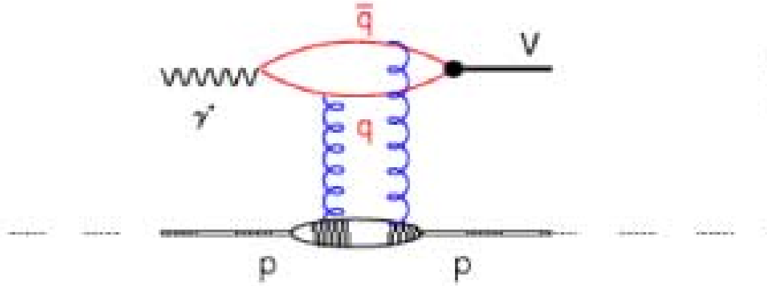
- power−like dσ/dt behavior, not exponential!
- dσ/dt described by BFKL calc.



- α’~0 consistent with pQCD
- W dependance consistent with pQCD

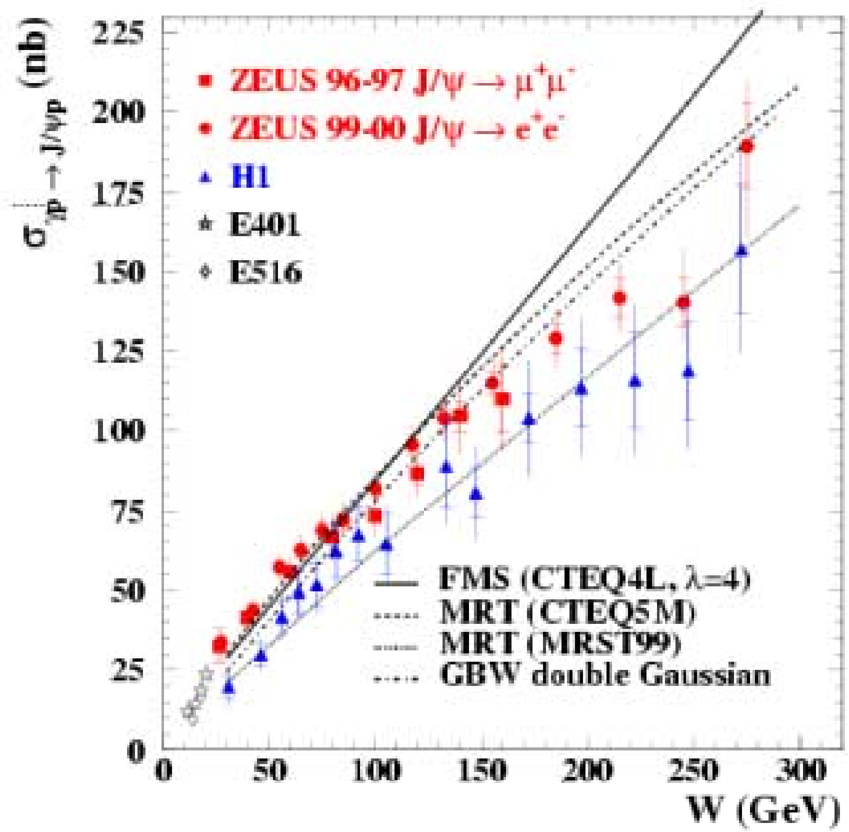
Gluon Density from $\gamma p \rightarrow J/\psi\, p$

Diffractive J/ψ production well described by pQCD 2-gluon exchange models



Should be possible to extract $g(x)$!

- $W = 250$ GeV $\rightarrow x = 10^{-4}$
- data precise enough to distinguish between different PDF sets ➡
- ... but theoretical uncertainties make extraction impossible at present: higher-twist correc's and ***skewing*** ...



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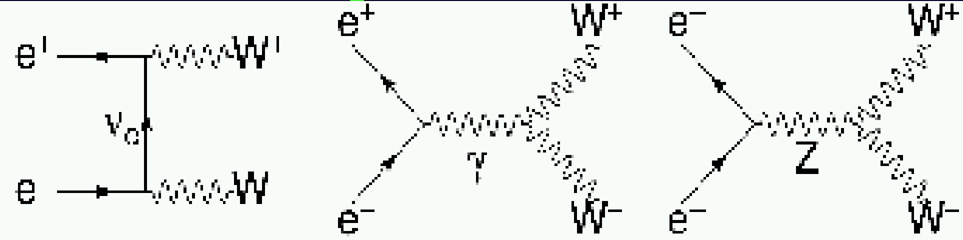
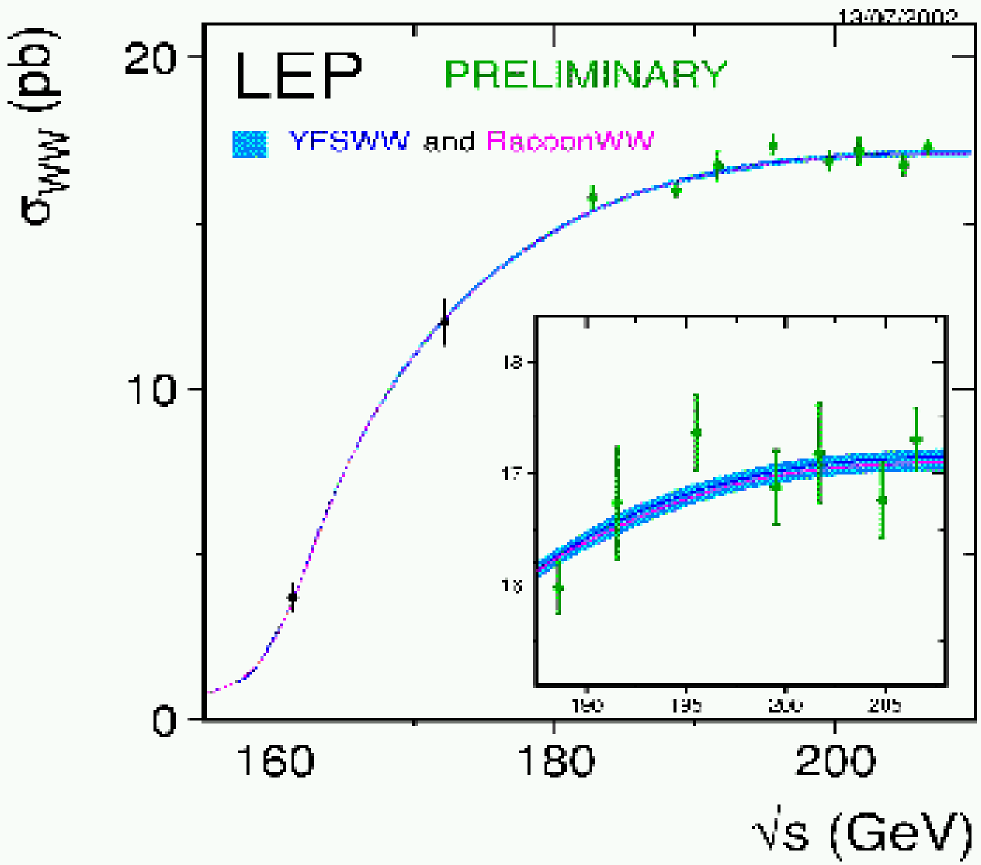
Where is matter???
What Can Be Dark Matter?

- oridinary matter – not enough
- massive neutrinos? not enough
- baronic MACHOS? not enough
- WIMPS?
  - axial?
  - LSP? neutralino?

Success of SM in EW Sector

Exmple: W–Pair Production





Correlated average of:

$\sigma_{meas}/\sigma_{theory}$:

0.997(11) YFSWW

0.999(11) RacoonWW

Test at the 1% level!

Uses O(α) corrections:

-2.5(0.5)% on σ_{theory}

Effect on differential cross sections and on γWW / ZWW gauge couplings?