XXXIII INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS

ICHEP'06

Moscow,
July 26-August 2, 2006

Organization
- Russian Academy of Sciences (RAS)
- The Ministry of Education and Science of RF
- Federal Agency of Science and Innovations of RF
- Federal Atomic Energy Agency of RF
- Joint Institute for Nuclear Research (JINR)
- Moscow State University (MSU)

Highlights from the Summer Conferences

Agnieszka Zalewska

SPC, 17.10.2006, IFJ, 7.11.2006, Praha, 13.11.2006,
Warszawa, 17.11.2006, Wrocław, 8.12.2006

ICHEP conferences ≡ Rochester conferences

International Conferences on High Energy Physics

- Started by R.E. Marshak in Rochester in 1950
- The 1950 conference was attended by 50 physicists
- The first seven conferences were annual (with some irregularities) and organised in Rochester
- Since 1958 the „Rochester" conferences have been organised every two years and in different places (Geneva, Rochester, CERN, Dubna, Berkeley, Vienna, Kiev, FermiLAB, London, Tbilisi, Tokio, Madison, Paris, Leipzig, Berkeley, Munich, Singapore, Dallas, Glasgow, **Warsaw**, Vancouver, Osaca, Amsterdam, Beijing, Moscow)

Polish plenary speakers at the Rochester conferences

Oleg Czyżewski, Vienna, 1968

Andrzej K. Wróblewski: Kiev, 1970, Singapore 1990

Kacper Zalewski: London, 1974

Ryszard Sosnowski: Tokio, 1978

Jan Nassalski: Warszawa, 1996

Stefan Pokorski: Warszawa, 1996

Helena Białkowska: Vancouver, 1998

ICHEP06 in Moscow (26.07-2.08.2006)

- About 900 participants
- 27.07-29.07 – 14 thematic groups in five pararel sessions, about 360 presentations
- 31.07-2.08 – 24 plenary talks
- 30.07.2006 – excursion day

Observation of the B_s mixing at theTevatron was the most important experimental result presented at ICHEP06

but

there were many other interesting results as well

B_s mixing

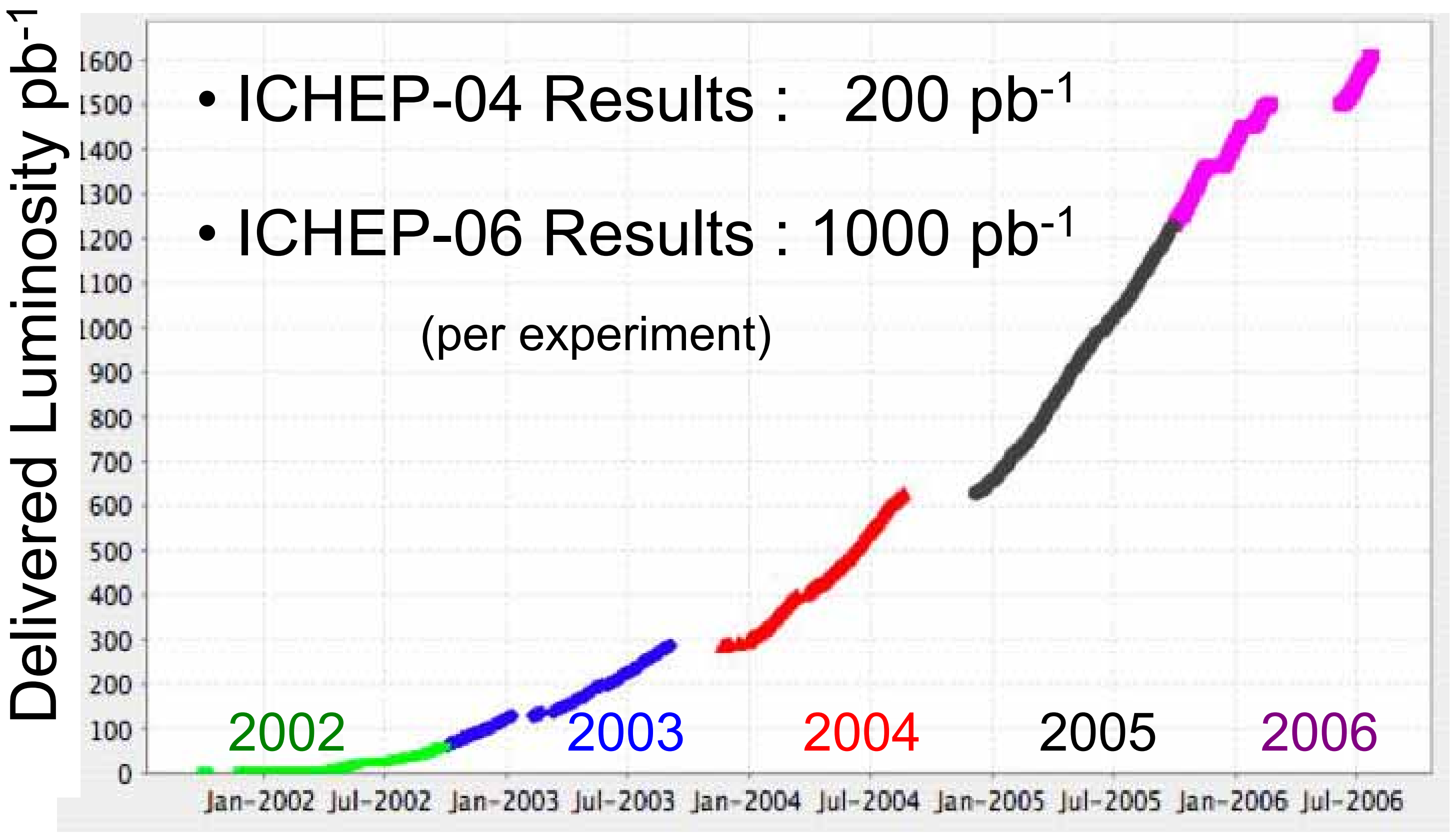
Tevatron Run-II

- Available data
- Physics

B_s mixing

- Basics
- Data sample
- Results

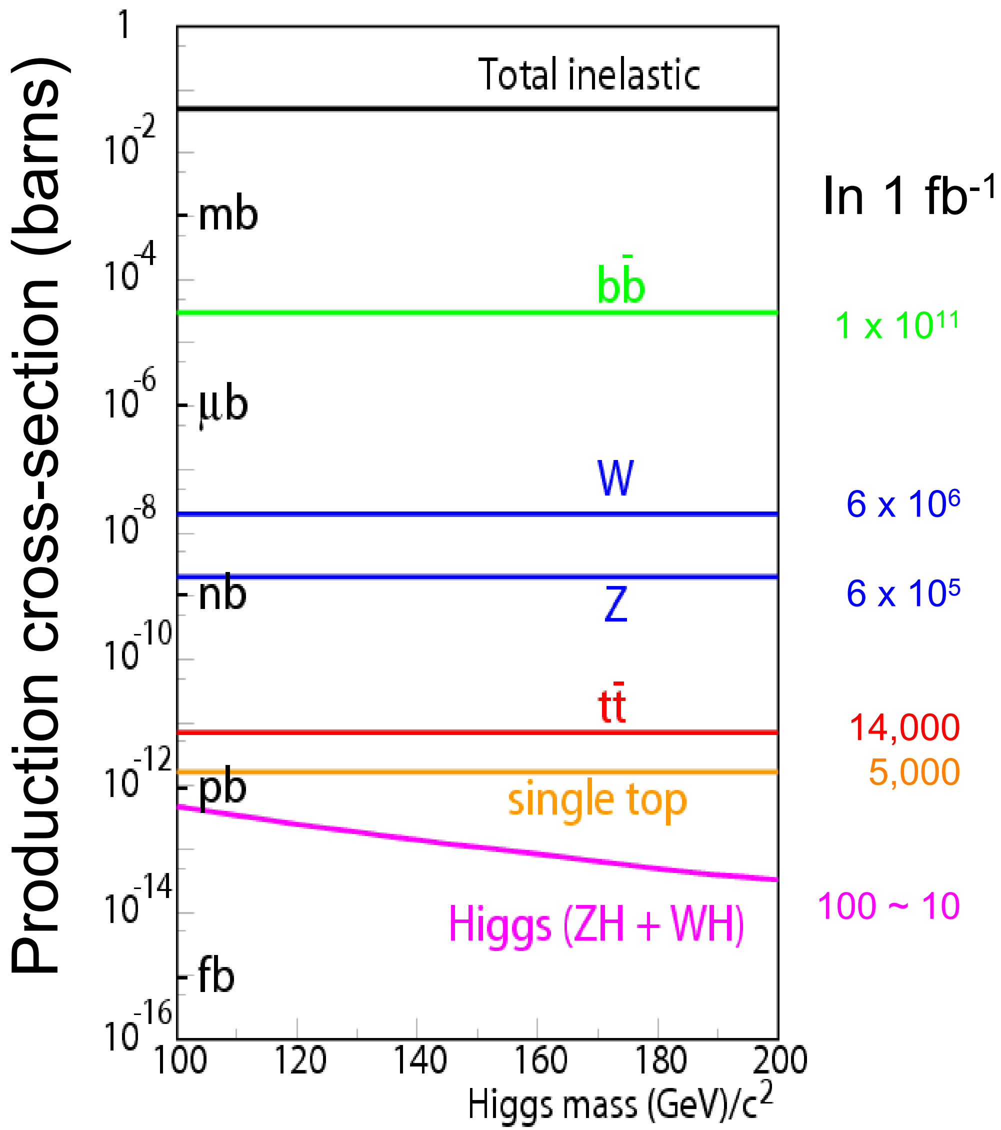
Tevatron Run-II



- Data set has doubled every year

D.Glenzinski

Tevatron Physics Program



- QCD
- Heavy Flavor
- Electroweak
- Top Quark
- New Phenomena

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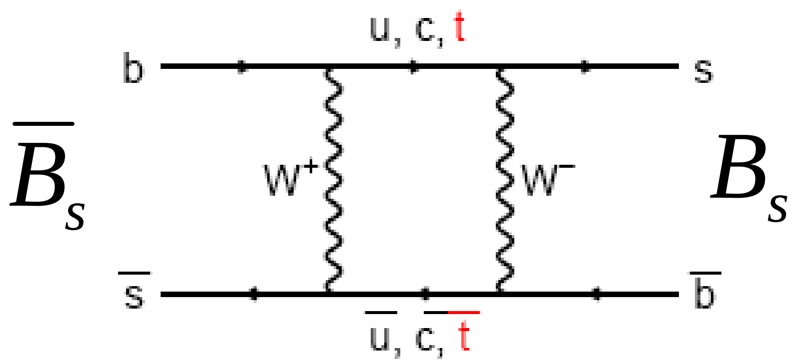
B_s Mixing: Basics



- Probability that B_s at t=0 decays as $\overline{B}_s$ at time t

$$P(\text{mixed}) = \frac{1}{2\tau} e^{-\frac{t}{\tau}} (1 - \cos \Delta m_s t)$$

- Experimentally, measure Asymmetry as a function of proper decay time

$$A(t) = \frac{\#\text{unmixed}(t)\ -\ \#\text{mixed}(t)}{\#\text{unmixed}(t)\ +\ \#\text{mixed}(t)}$$

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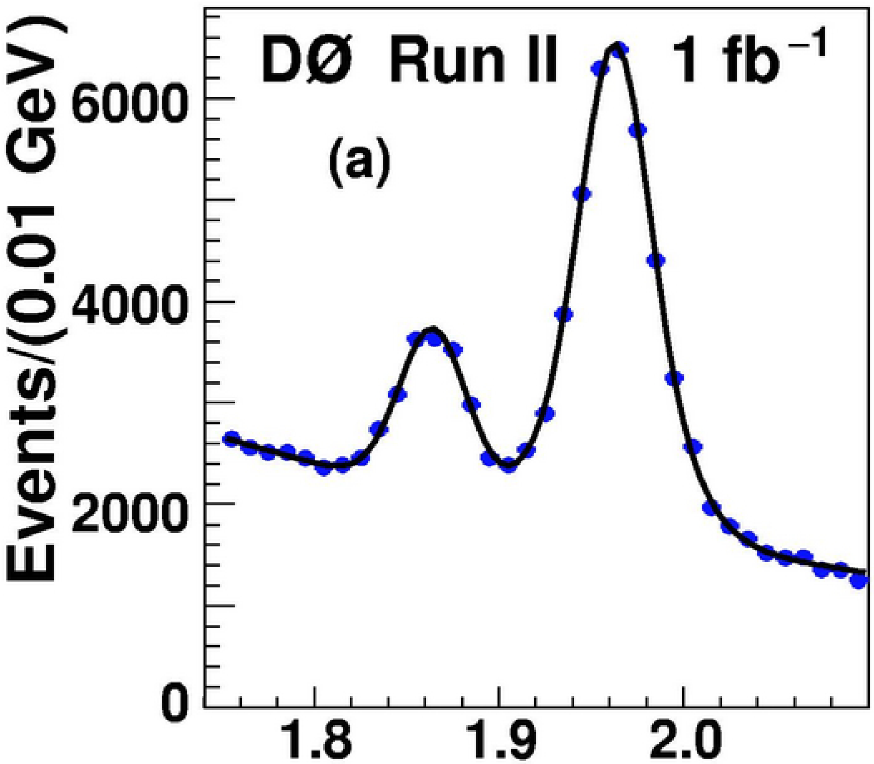
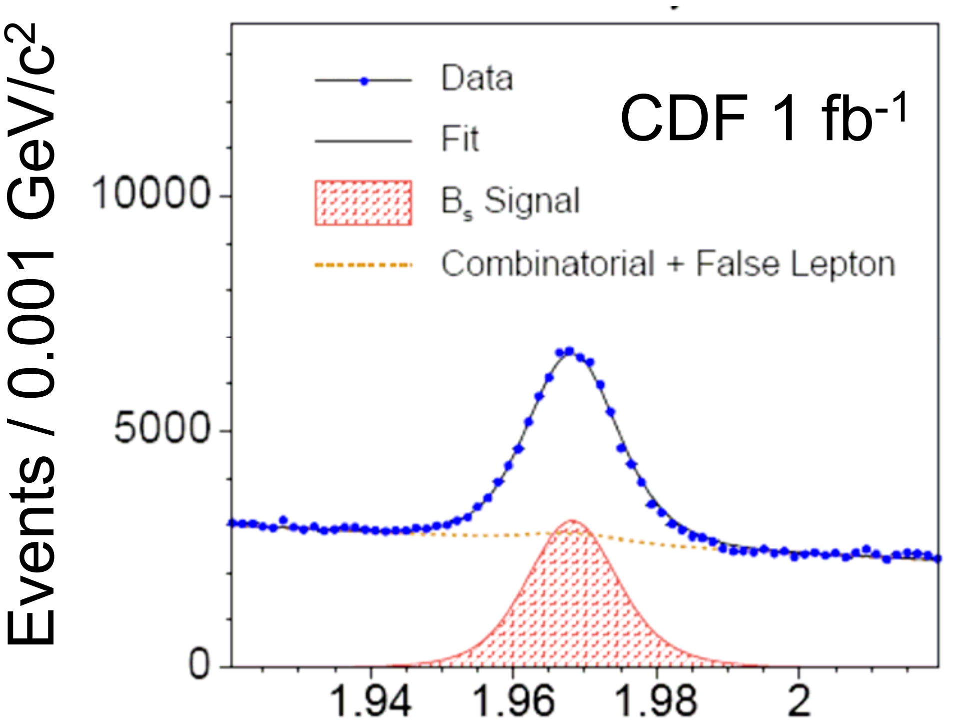
B_s Mixing: 1) Identify Sample

- B_s is reconstructed via semi-leptonic decays

$$B_s \to D_s^- e^+ \nu,\ D_s^- \mu^+ \nu$$





D_s mass [GeV/c^2]

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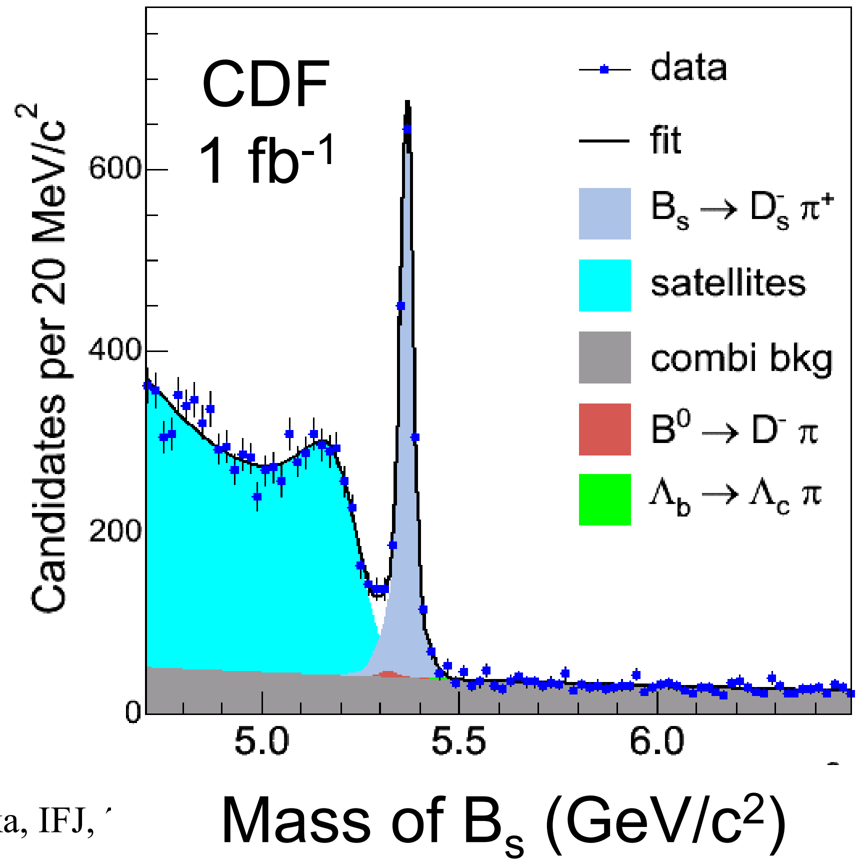
B_s Mixing: 1) Identify Sample

- B_s reconstructed via hadronic decays: unique to CDF

$$B_s \to D_s^- \pi^+,\ D_s^- \pi^+ \pi^- \pi^+$$



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B_s Mixing: 1 fb^{-1} Yields

	# reconstructed B_s	
	D0	CDF
Semi-leptonic	36,500	37,000
Hadronic	-	3,600

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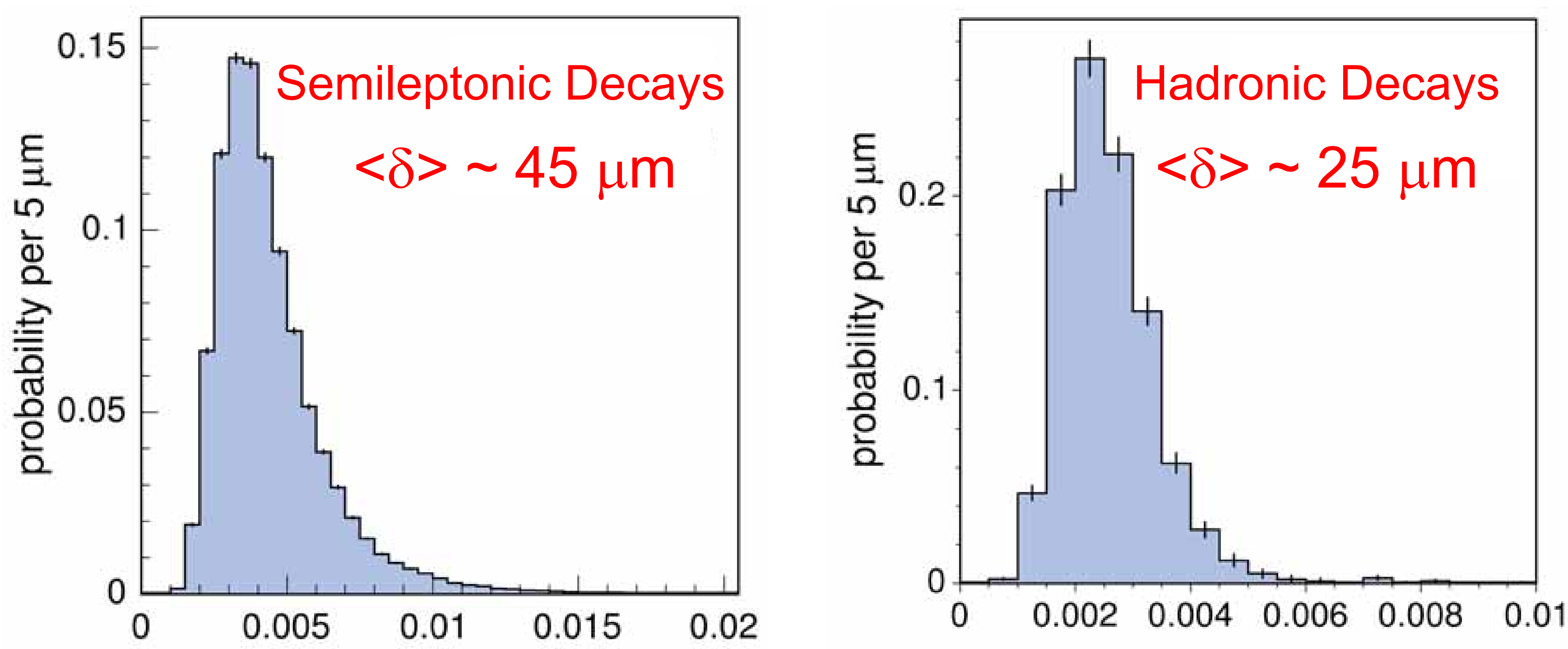
B_s Mixing: Decay Time Resolution

- Hadronic decays have excellent proper time resolution



proper decay time resolution (δ) / cm

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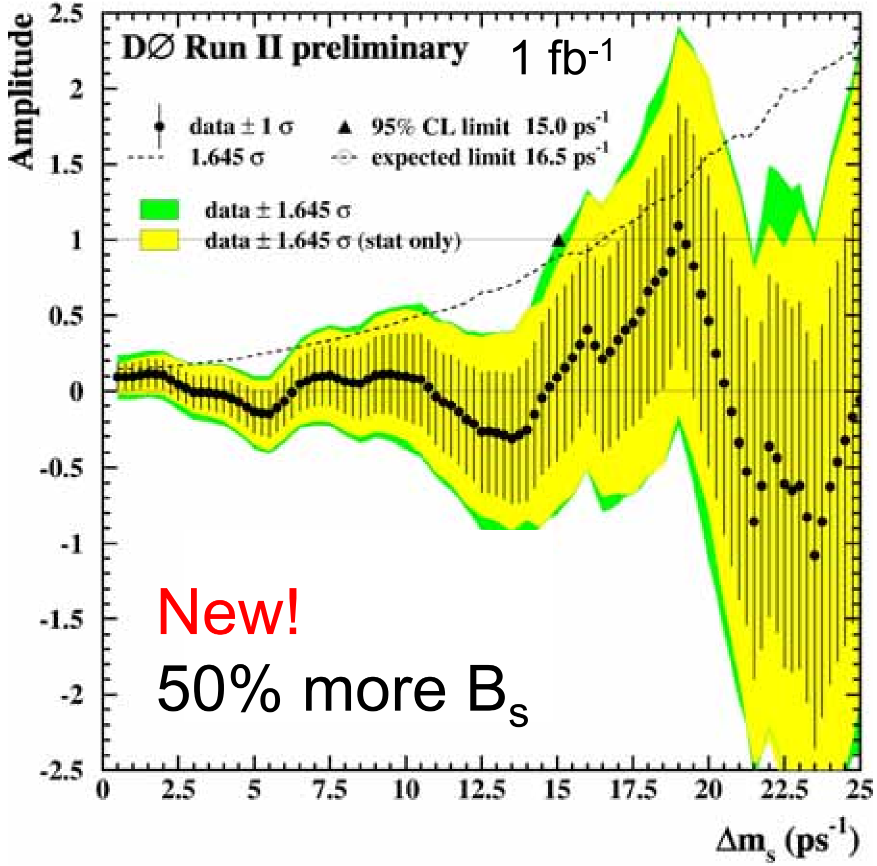
B_s Mixing: D0 Results (Aug-06)



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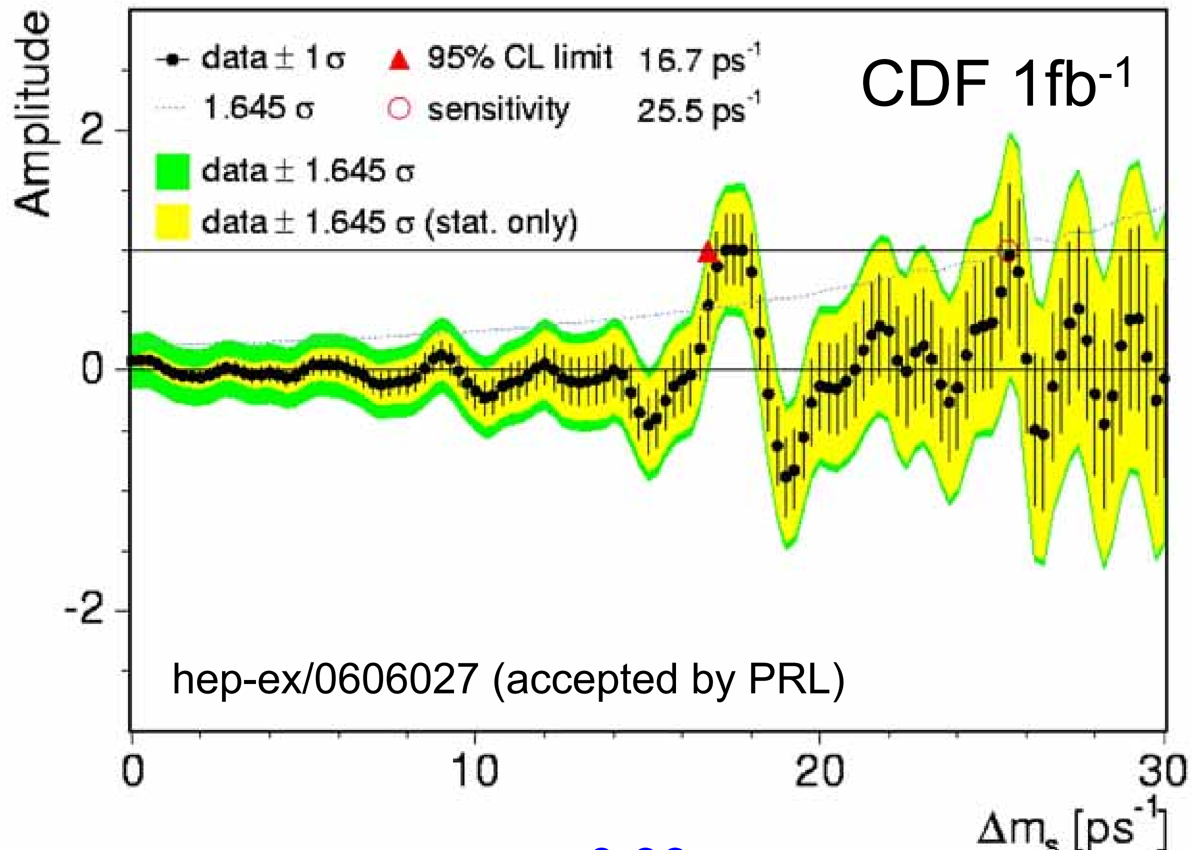
$17 < \Delta m_s < 21\ ps^{-1}$ @ 90% CL

8% probability Random tags would look as significant

For more details see the talk by T.Moulik.

B_s Mixing: CDF Results (Apr-06)



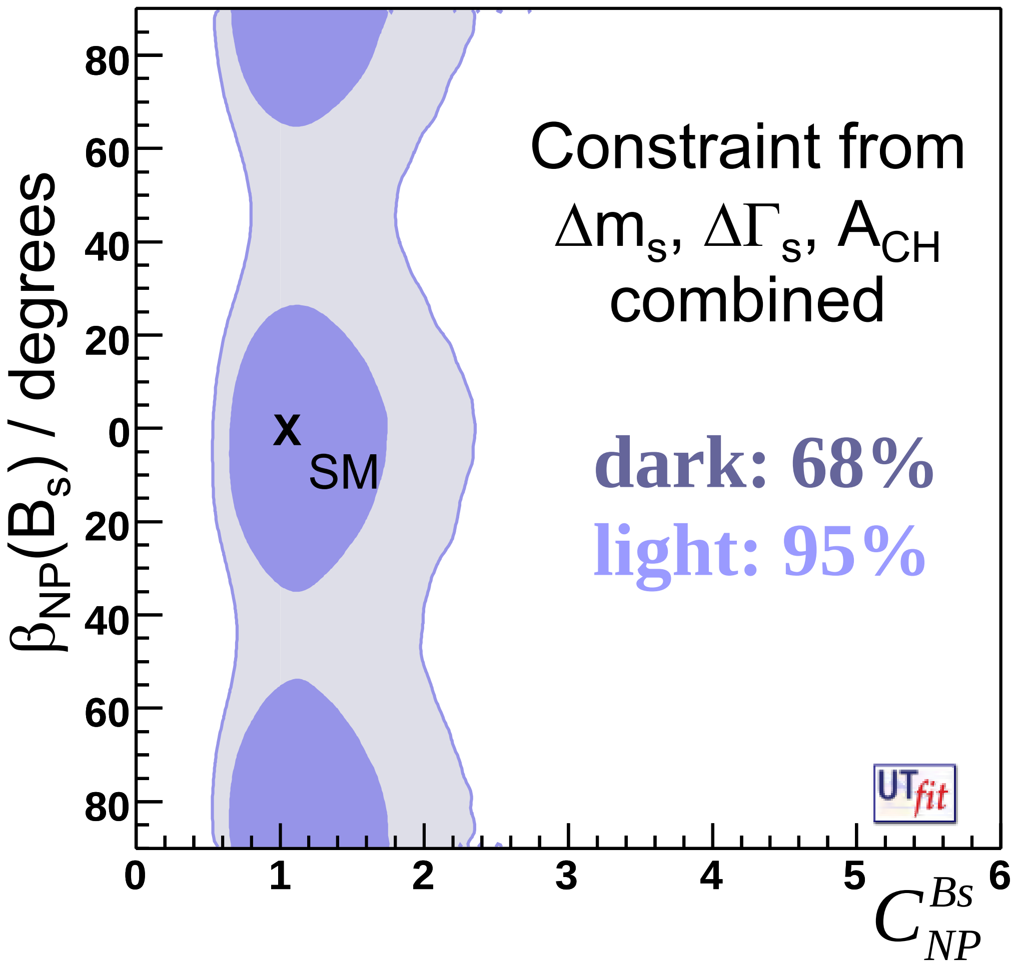
$$\Delta m_s = 17.31^{+0.33}_{-0.18}(\text{sta}) \pm 0.07\ (\text{sys})$$

0.2% probability Random tags would look as significant

For more details see the talk by S.Giagu.

D.Glenzinski

B_s Mixing: NP Constraints



- Recall

$$\Delta m_s = C_{NP} \cdot \Delta m_s^{SM}$$

$$\beta_{Bs} = \beta_{Bs}^{SM} + \beta_{NP}$$

For decails see:
hep-ph/0012219, hep-ph/0406300, hep-ph/0605028, talks by S.T'Jampens and V.Vagnoni

- Around LHC
- Electroweak physics
- Neutrino physics
- Astrophysics and cosmology
- CKM matrix and CP violation
- Spectroscopy
- Heavy ions
- News from theory
- HEP instrumentation

Around LHC

LHC for itself

- Prospects for 2007 and 2008

Tevatron vs LHC

- Analysis methods developed for LHC are successfully applied at Tevatron
- Who will find SM Higgs?

LHC for ILC

- Supersymmetry at LHC

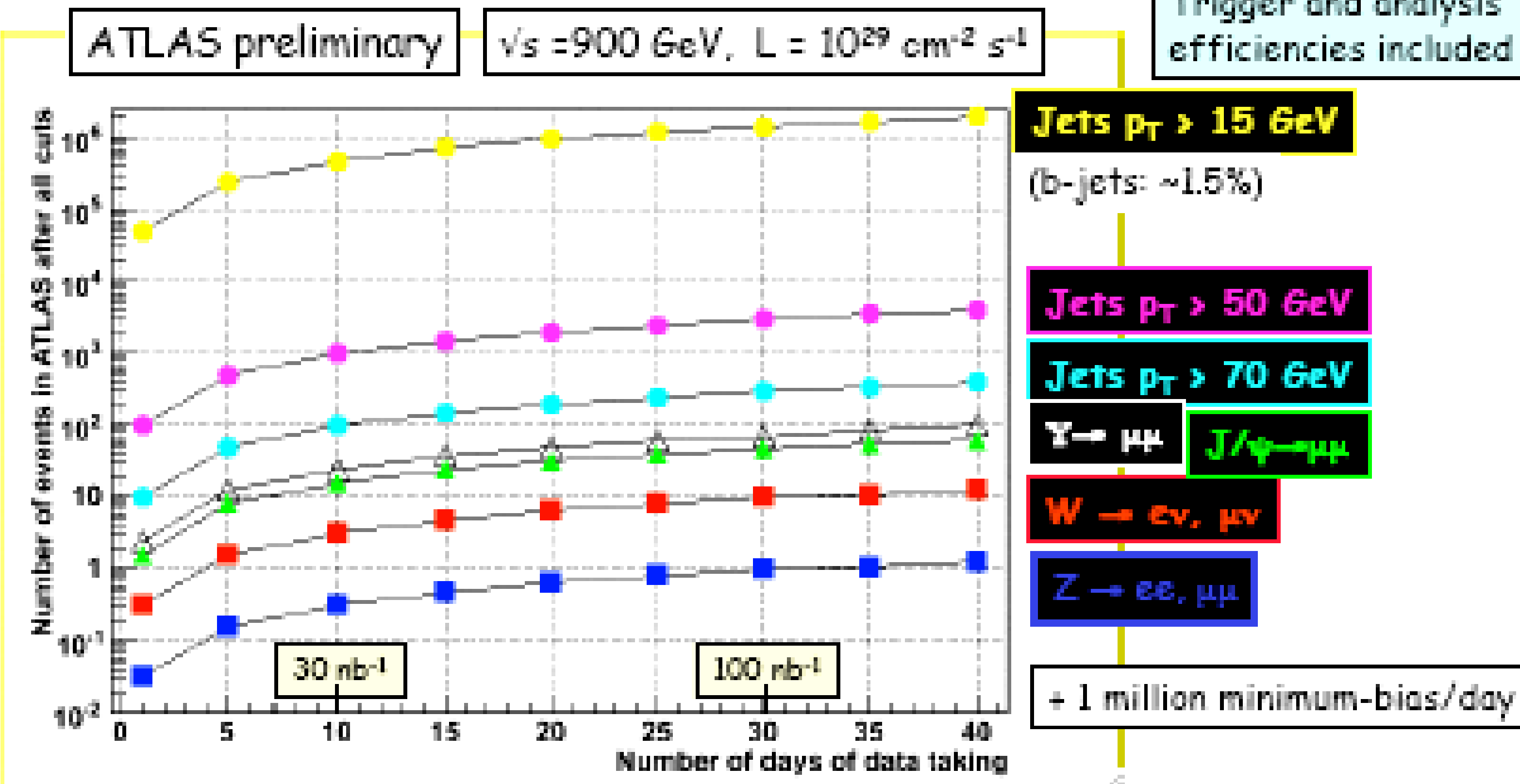
HERA for LHC

- PDF's from HERA are essential for LHC

2007

What data samples in 2007 ?

30% data taking efficiency included (machine plus detector)
Trigger and analysis efficiencies included



- Start to commission triggers and detectors with collision data (minimum bias, jets, ..) in real LHC environment
- Maybe first physics measurements (minimum-bias, underlying event, QCD jets, ...) ?
- Observe a few $W \rightarrow l\nu$, $\Upsilon \rightarrow \mu\mu$, $J/\psi \rightarrow \mu\mu$?

F.Gianotti

Expected data

2008

With the first physics run in 2008 ($\sqrt{s}$ = 14 TeV) ....

1 fb^{-1} (100 pb^{-1}) ≡ 6 months (few days) at L= 10^{32} $cm^{-2}s^{-1}$
with 50% data-taking efficiency
→ may collect a few fb^{-1} per experiment by end 2008

Channels (examples ...)	Events to tape for 100 pb^{-1} (per expt: ATLAS, CMS)	Total statistics from some of previous Colliders
$W \to \mu\nu$	~ 10^6	~ 10^4 LEP, ~ 10^6 Tevatron
$Z \to \mu\mu$	~ 10^5	~ 10^6 LEP, ~ 10^5 Tevatron
$t\bar{t} \to WbWb \to \mu\nu + X$	~ 10^4	~ 10^4 Tevatron
QCD jets p_T > 1 TeV	> 10^3	---
$\tilde{g}\tilde{g}$ m = 1 TeV	~ 50	---

With these data:

- Understand and calibrate detectors in situ using well-known physics samples
  e.g. - $Z \to ee, \mu\mu$ — tracker, ECAL, Muon chambers calibration and alignment, etc.
  - $t\bar{t} \to bl\nu\, bjj$ — jet scale from $W \to jj$, b-tag performance, etc.
- *Measure SM physics at $\sqrt{s}$ = 14 TeV* : W, Z, $t\bar{t}$, QCD jets ...
  (also because omnipresent backgrounds to New Physics)

→ prepare the road to discovery ...... it will take time ...

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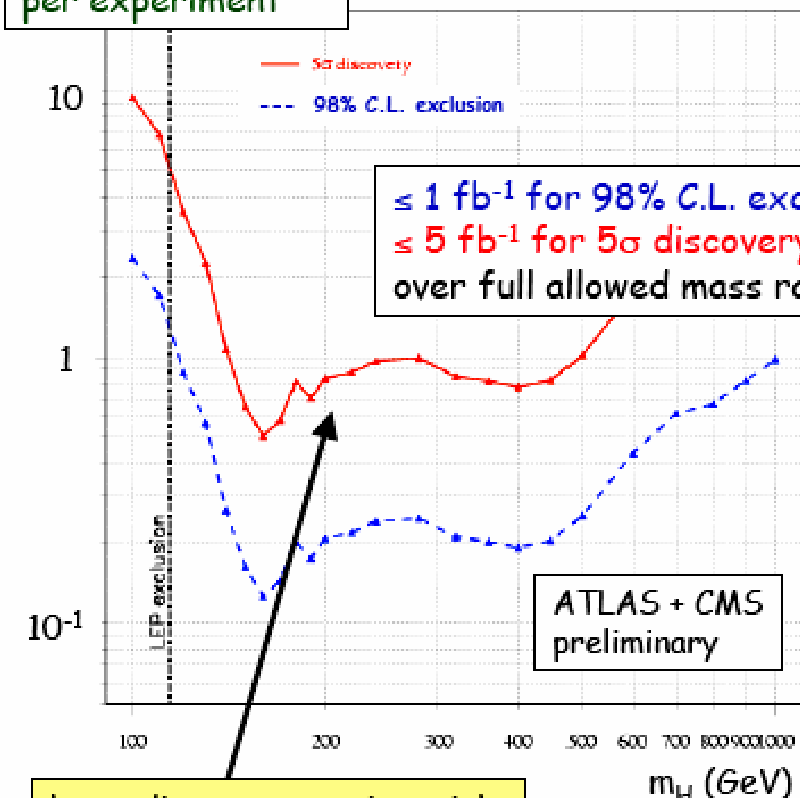
SM Higgs at LHC

2008?

Needed ∫Ldt (fb^{-1}) per experiment

What about the SM Higgs boson ?

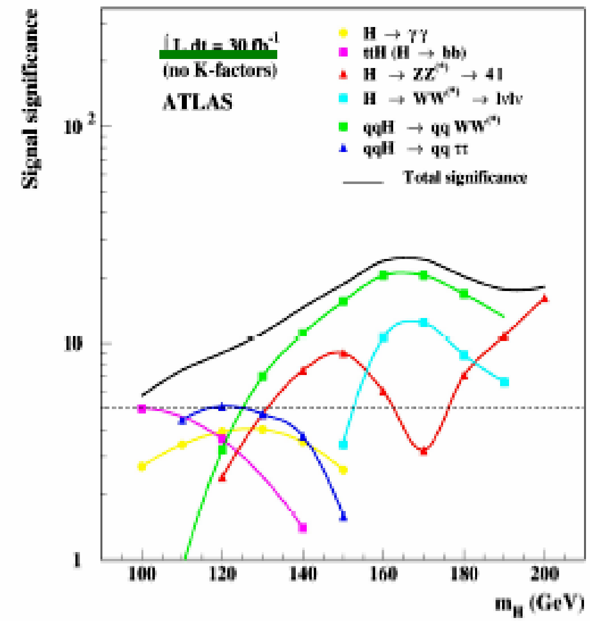


≤ 1 fb^{-1} for 98% C.L. exclusion
≤ 5 fb^{-1} for 5σ discovery
over full allowed mass range

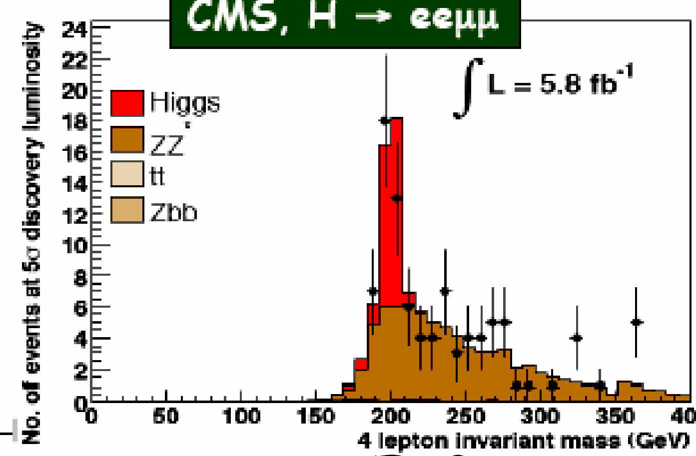
ATLAS + CMS preliminary

here discovery easier with gold-plated $H \to ZZ \to 4l$
→ by end 2008 ?

$H \to 4l$: narrow mass peak, small background
$H \to WW \to l\nu l\nu$ (dominant at the Tevatron): counting channel (no mass peak)



CMS, $H \to ee\mu\mu$



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SM Higgs at LHC Later than 2008

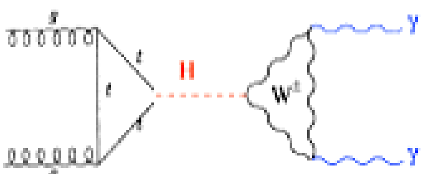
Light Higgs : more difficult ….

m_H ~ 115 GeV 10 fb^{-1} : $S/\sqrt{B} \approx 4$ ATLAS

K-factors ≡ σ(NLO)/σ(LO) ≈ 2
for H →γγ NOT included (conservative)

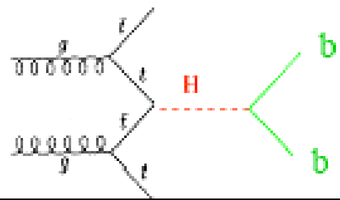
3 (complementary) channels with similar (small) significances:

$H \to \gamma\gamma$



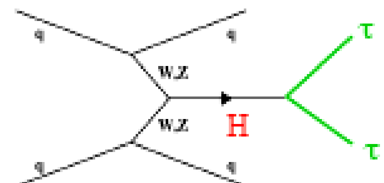
S=130, B=4300, $S/\sqrt{B}$=2

$ttH \to ttbb \to bl\nu bjjbb$



S=15, B=45, $S/\sqrt{B}$=2.2

$qqH \to qq\tau\tau$



S=10, B=10, $S/\sqrt{B}$=2.7

- different production and decay modes
- different backgrounds
- different detector/performance requirements:
  - -- ECAL crucial for H → γγ (in particular response uniformity) : σ/m ~ 1% needed
  - -- b-tagging crucial for ttH : 4 b-tagged jets needed to reduce combinatorics
  - -- efficient jet reconstruction over |η| < 5 crucial for qqH → qqττ : forward jet tag and central jet veto needed against background

All three channels require very good understanding of detector performance and background control to 1-10% → convincing evidence likely to come later than 2008 …

Note: WH→ lνbb (dominant at the Tevatron) provides less sensitivity than ttH at LHC

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Tevatron for LHC

- The LHC will inherit
  - Precise determination of Δm_s and constraints on CP phase in B_s sector β_{Bs}
  - Precision M_t ($\delta M_t = \pm 1.0\text{-}1.5$ GeV/c^2) and M_w ($\delta M_w = 15\text{-}25$ MeV/c^2)
  - A more restricted New Physics parameter space

  - A higgs mass

From conclusions of D. Glenzinski

➔ 95% CL exclusion for m_H = 115-185 GeV with 8 fb^{-1}

➔At 115 GeV needs ~3 fb^{-1}

➔At 160 GeV needs ~5 fb^{-1}

From G. Bernardi

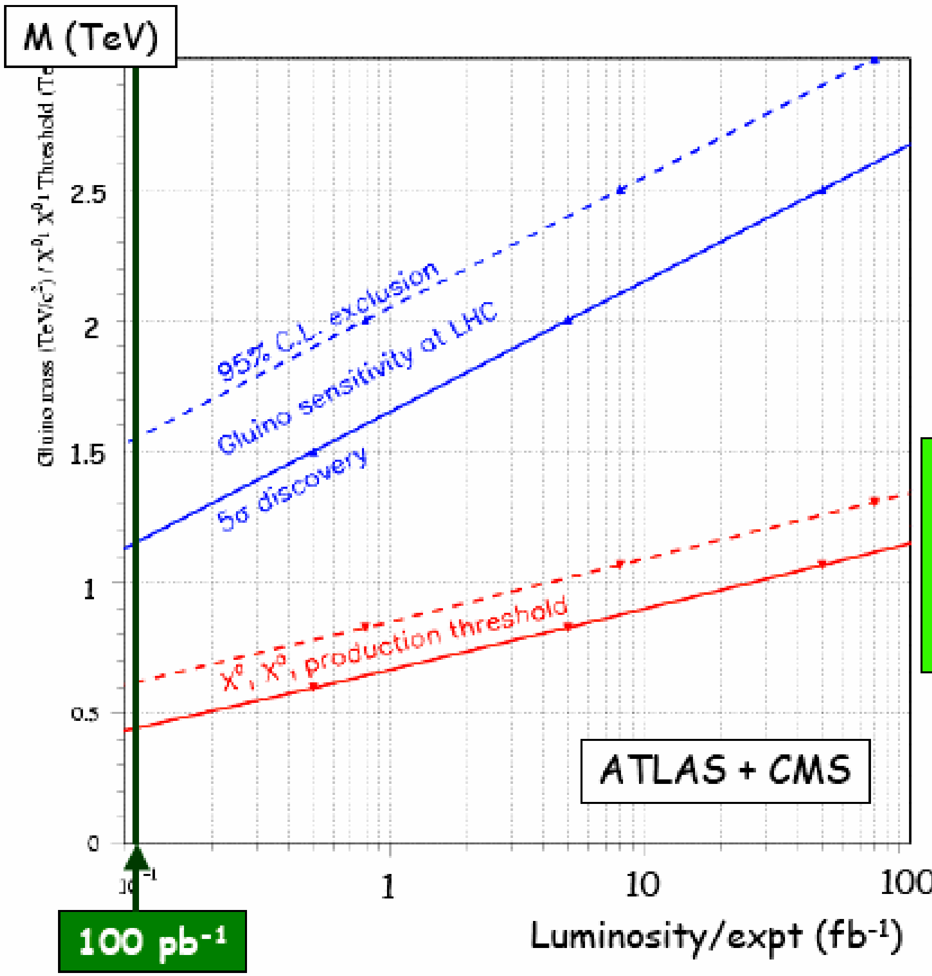
LHC for ILC

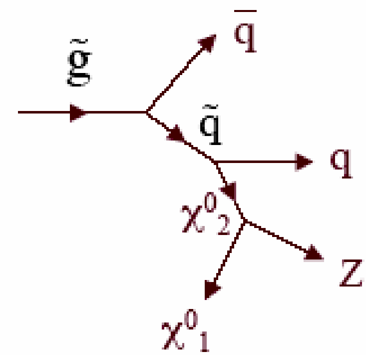
2008

Example of "early" discovery: Supersymmetry ?

If SUSY at TeV scale → could be found "quickly" .... thanks to:

- large $\tilde{q},\tilde{g}$ cross-section → ≈ 10 events/day at 10^{32} for $m(\tilde{q},\tilde{g}) \sim 1$ TeV
- spectacular signatures (many jets, leptons, missing E_T)





Our field, and planning for future facilities, will benefit a lot from quick determination of scale of New Physics. E.g. with 100 (good) pb^{-1} LHC could say if SUSY accessible to a ≤1 TeV ILC

BUT: understanding E_T^{miss} spectrum (and tails from instrumental effects) is one of the most crucial and difficult experimental issue for SUSY searches at hadron colliders.

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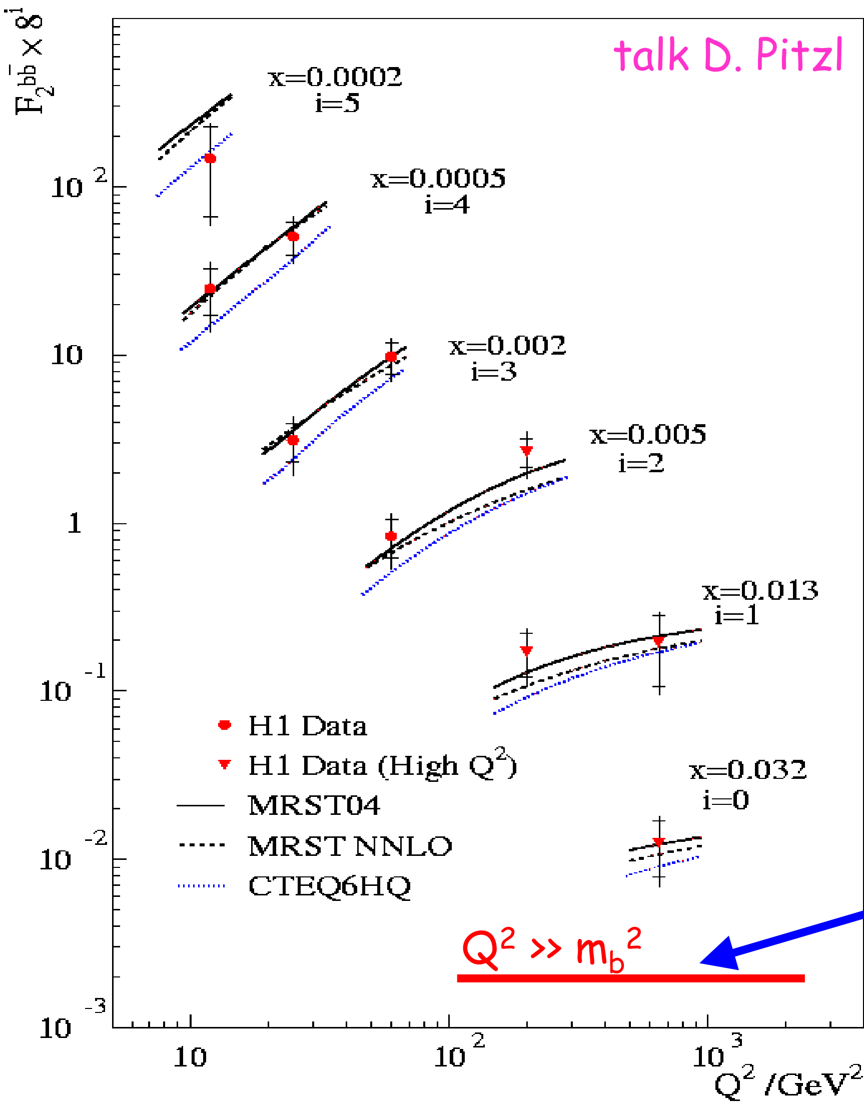
HERA for LHC → beauty contribution to F_2

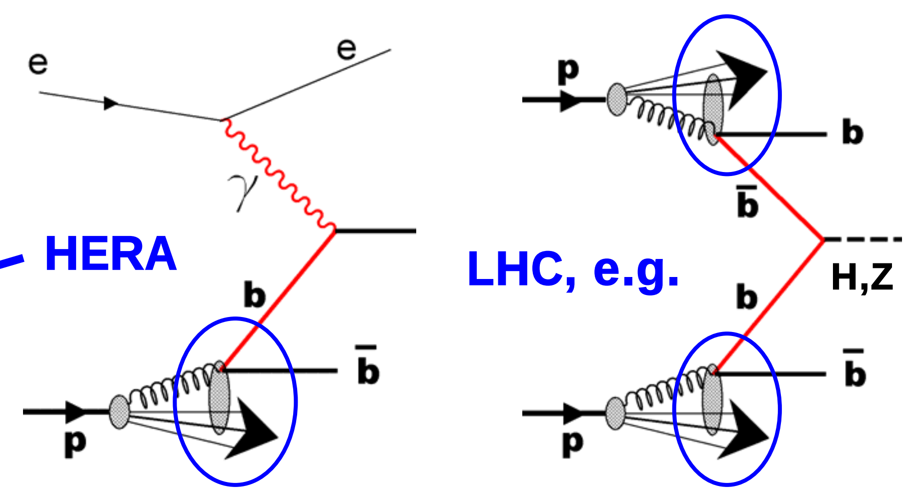


first measurement of F_2^{bb}

first NNLO calculation

data in agreement with NLO and NNLO

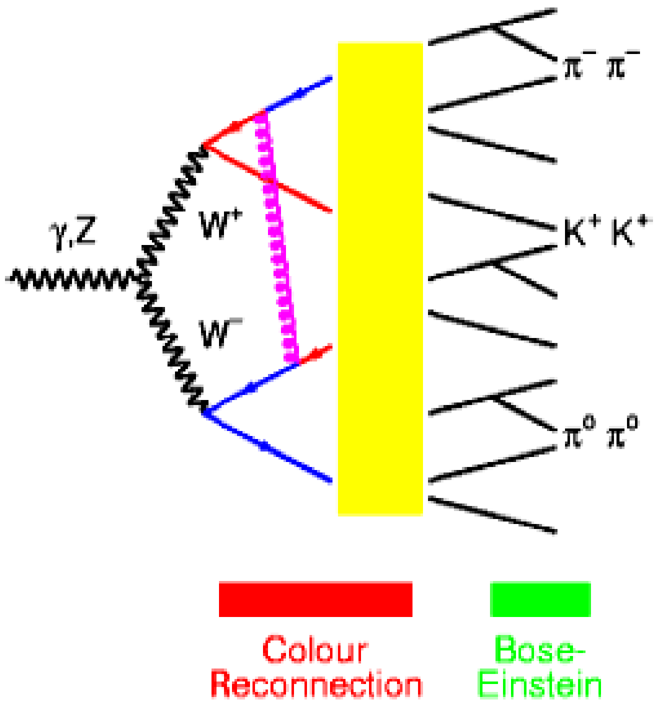
checks b PDF for LHC:

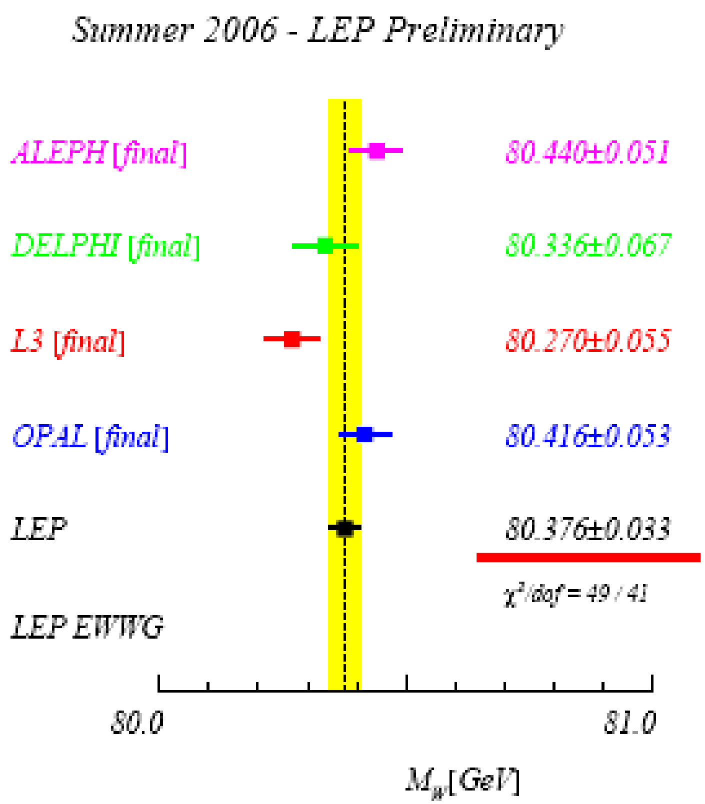


Electroweak physics

- W mass from LEP2
- Higgs mass from the global EW fit
- New measurements of τ lepton mass

W mass at LEP





prob. fit: 11.1%

- Main area of recent work: Final State Interactions (FSI)
  - Mainly effects qqqq channel
    - "color reconnection"
    - Bose-Einstein correlations

Difference between channels:

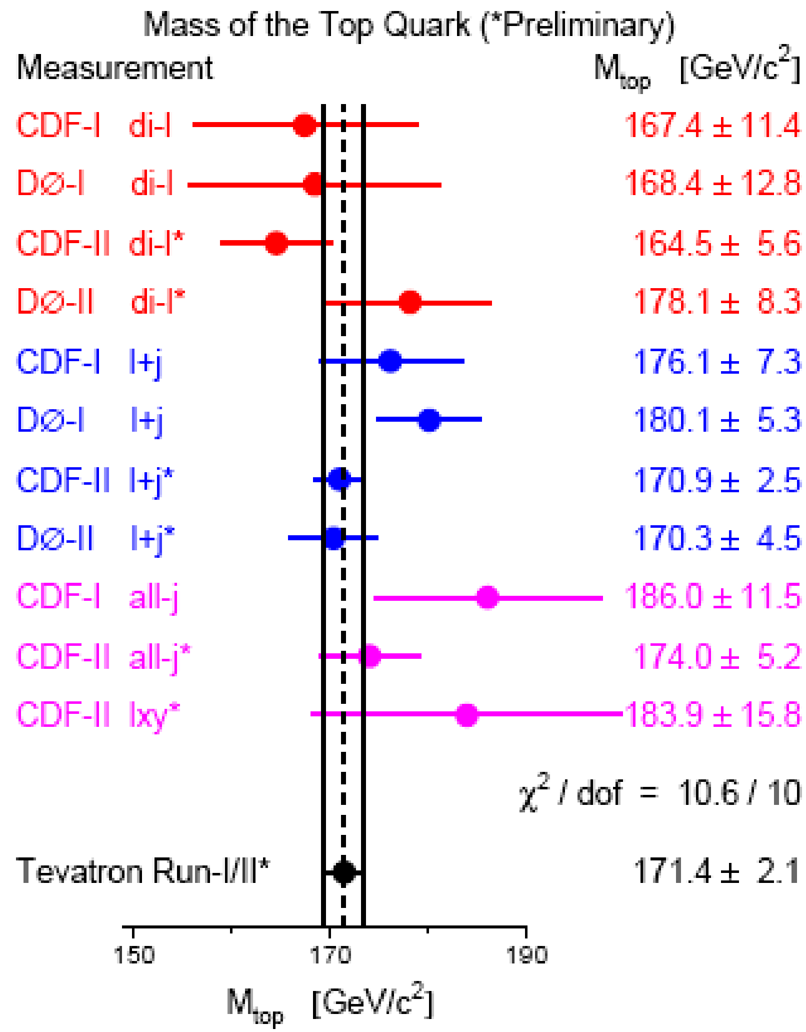
$M_W(4q\text{-}2q) = -11.7 \pm 44.6$ MeV/c2

Top quark mass

- Measured at the Tevatron in modes:
  - Dilepton $t\bar{t} \to \ell\nu\ell\nu b\bar{b}$
  - Lepton + jets $t\bar{t} \to \ell\nu jjb\bar{b}$
  - All jets $t\bar{t} \to jjjjb\bar{b}$
- Many new results since last year
- New preliminary Tevatron average:

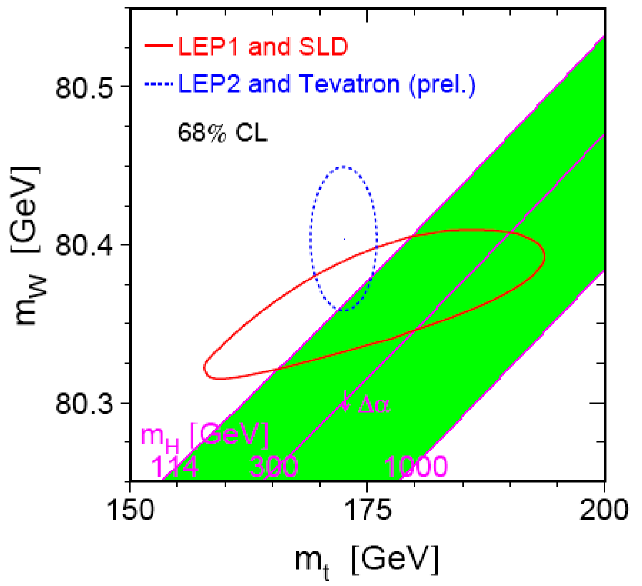
$$M_{top} = 171.4 \pm 2.1\ \mathrm{GeV}$$

See Doug Glenzinski's talk (following directly) for description of top mass measurements



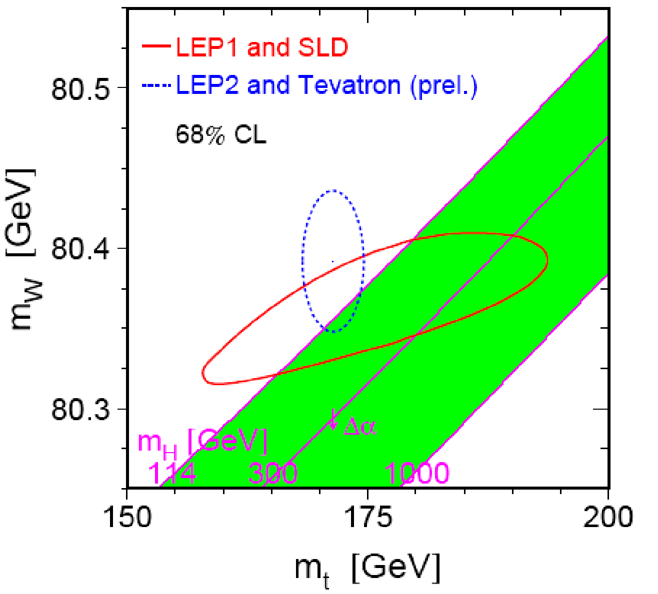
Global EW fit

Fit Constraints in M_W-M_t plane – March 06



8/1/2006 Darien Wood, ICHEP'06, "Electroweak Physics" 40

Fit Constraints in M_W-M_t plane – July 06

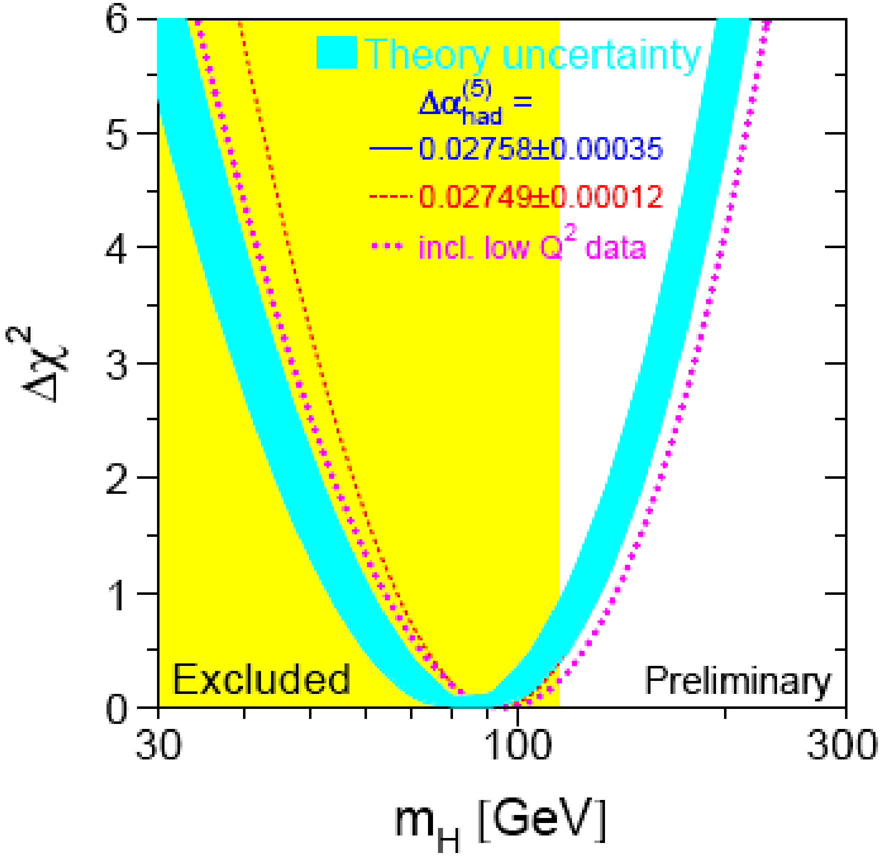


8/1/2006 Darien Wood, ICHEP'06, "Electroweak Physics" 39

t mass smaller, W mass smaller
→ Higgs mass smaller

SM Higgs Constraints

- EW fits alone, without theory uncertainties: $MH=85\pm^{39}_{28}$ GeV (68% CL)
- 95% one-sided CL including theory uncertainties ("blue band"):
  - **M_H<166 GeV (ignoring direct limit)**
  - **M_H<199 GeV (including 114 GeV limit)**
- Blue band uncertainties due to uncalculated higher order corrections, estimated by ZFITTER



τ Lepton mass

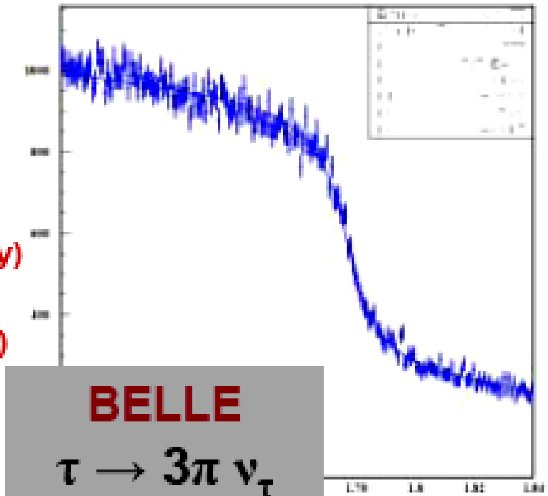
New preliminary measurement of the τ mass from lower energy e^+e^- experiments

- KEDR at VEPP-4M
- BELLE at KEK

$$M_\tau = 1776.71 \pm 0.13(\text{stat}) \pm 0.32(\text{syst})\ \text{MeV}$$ (BELLE, preliminary)

$$M_\tau = 1776.80 \pm^{0.25}_{0.22}(\text{stat}) \pm 0.15(\text{syst})\ \text{MeV}$$ (KEDR, preliminary)

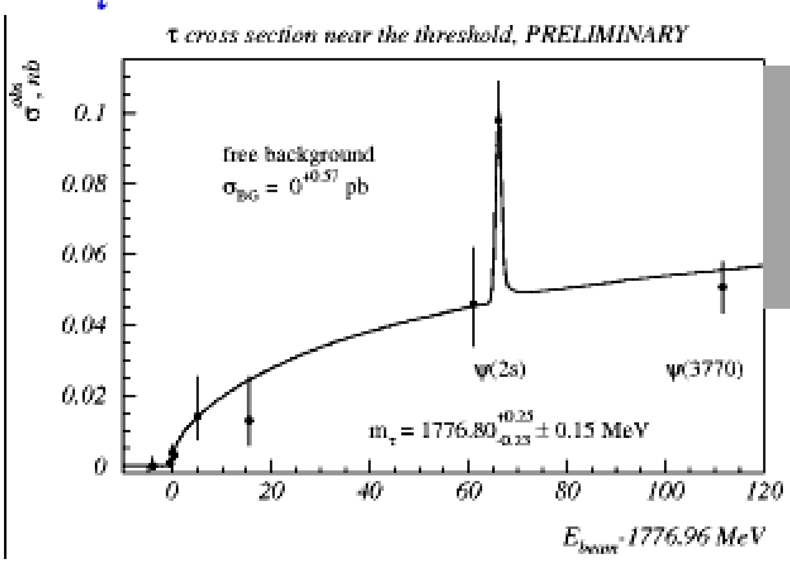
$$M_\tau = 1776.99 \pm^{0.29}_{0.26}\ \text{MeV}$$ (PDG)



BELLE

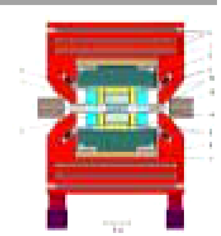
$\tau \to 3\pi\, \nu_\tau$

pseudomass reconstruction



KEDR

$\tau^+\tau^-$ cross section near threshold

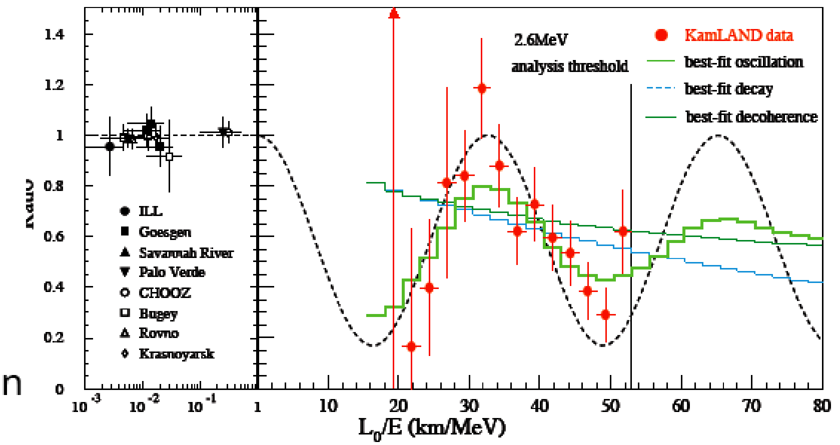


Neutrino physics

- Oscillations – status
- θ_{13} in reactor exp.: Double Chooz and Daya Bay
- SuperK III
- Solar neutrinos: Borexino and KamLAND
- MINOS – first year of data taking
- Prospects for OPERA
- Update of DONUT

Still waiting for MiniBooNE!

Neutrino oscillations



L_0=180km is used for KamLAND

results can be encoded in a Lorentz-invariant Lagrangian

$$
\begin{aligned}
L &= L_{SM} \\
&+ \delta L(m_\nu) \\
&+ \delta L
\end{aligned}
$$

1[st] evidence of physics beyond the SM after more than 30 years!

additional operators giving negligibly small contributions to ν propagation in present experiments

L_{SM} invariant under

$\text{local } SU(3)\otimes SU(2)\otimes U(1)$

global, non-anomalous

$$\frac{B}{3}-L_e, \quad \frac{B}{3}-L_\mu, \quad \frac{B}{3}-L_\tau$$

broken individually by **δL(mν)**
possible exception: (B - L)

either dim(δL)≥6 such as e.g.

$$\frac{c_1}{\Lambda^2}\psi\psi ll+\frac{c_2}{\Lambda^2}(lH)^+\gamma^\mu\partial_\mu(lH)+\ldots$$

or new particles in δL such as

$$\lambda\varphi\nu\nu+\ldots$$

new (pseudo)scalar

F.Feruglio

low-energy parameters in $\delta L(m_\nu)$

ν masses

[3 light active ν]

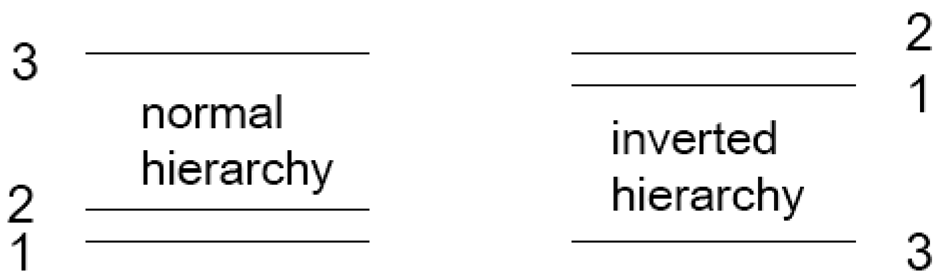
$$m_1, m_2, m_3$$

order $m_1 < m_2$

$$\Delta m^2_{21} < \left|\Delta m^2_{32}\right|, \left|\Delta m^2_{31}\right| \qquad [\Delta m^2_{ij} \equiv m^2_i - m^2_j]$$

i.e. 1 and 2 are, by definition, the closest levels

two, still open, possibilities:



Mixing matrix (analogous to V_{CKM})

$$U_{PMNS} = \begin{pmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{i\delta} \\ -s_{12}c_{23} - c_{12}s_{13}s_{23}e^{-i\delta} & c_{12}c_{23} - s_{12}s_{13}s_{23}e^{-i\delta} & c_{13}s_{23} \\ -c_{12}s_{13}c_{23} + s_{12}s_{23}e^{-i\delta} & -s_{12}s_{13}c_{23} - c_{12}s_{23}e^{-i\delta} & c_{13}c_{23} \end{pmatrix} \times \begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha} & 0 \\ 0 & 0 & e^{i\beta} \end{pmatrix}$$

$c_{12} \equiv \cos\vartheta_{12}, \ldots$

- only if ν are Majorana
- drops in oscillations

F.Feruglio

from data

F.Feruglio

[2σ errors (95% C.L.)]

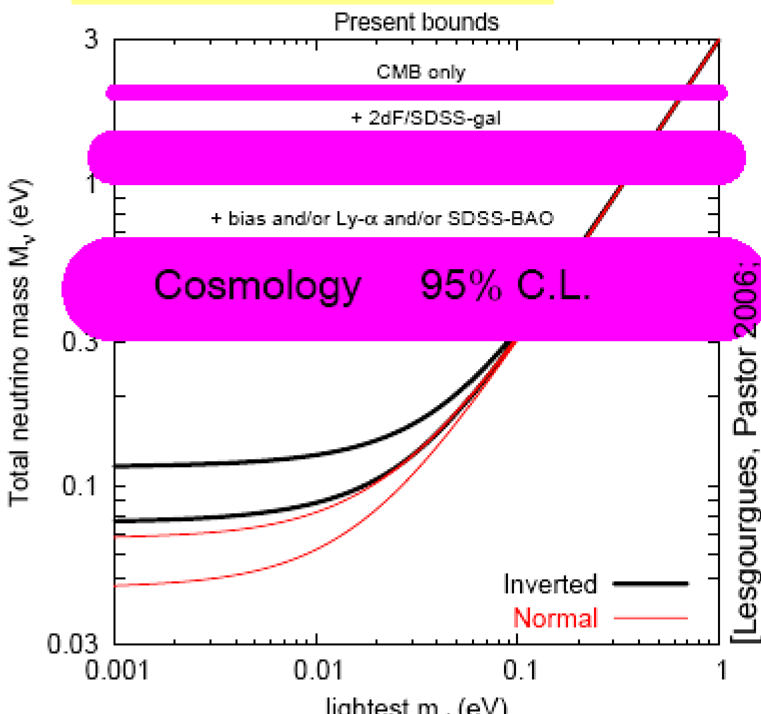
$$\Delta m^2_{sol} \equiv \Delta m^2_{21} = 7.92\,(1 \pm 0.09) \times 10^{-5}\ \mathrm{eV}^2$$

$$\Delta m^2_{atm} \equiv \left|\Delta m^2_{32}\right| = 2.4\,\left(1^{+0.21}_{-0.26}\right) \times 10^{-3}\ \mathrm{eV}^2$$

[Fogli, Lisi, Marrone, Palazzo, 0506083]

$\mathrm{sign}\,[\Delta m^2_{32}]$ unknown δ_{CP} **unknown**

$m_i < 2$ eV 95% C.L. [Tritium β-decay]



[Lesgourgues, Pastor 2006; Goobar, Hannestad, Mortsell, Tu 2006 Seljak, Slosar, Mc Donald 2006; Fukugita, Ichikawa, Kawasaki, Lahav 2006; Cirelli, Strumia 2006]

next CMB satellite + weak grav. lensing + improved galaxy survey $\sum m_i < (0.02 \div 0.08)$ eV (1σ) [2015?]

$$\sin^2 \vartheta_{12} = 0.314\,(1^{+0.18}_{-0.15})$$

$$\sin^2 \vartheta_{23} = 0.44\,(1^{+0.41}_{-0.22})$$

$$\sin^2 \vartheta_{13} = 0.9^{+2.3}_{-0.9} \times 10^{-2}$$

two lepton mixing angles are large

$V_{us} \approx \lambda \quad V_{cb} \approx \lambda^2 \quad V_{ub} \approx \lambda^3$

$\lambda \approx 0.22$

δ, α, β unknown

some parameters measured already quite precisely

$$\vartheta_{12} = (34.1\ ^{+1.7}_{-1.6})^0\quad [1\sigma]$$

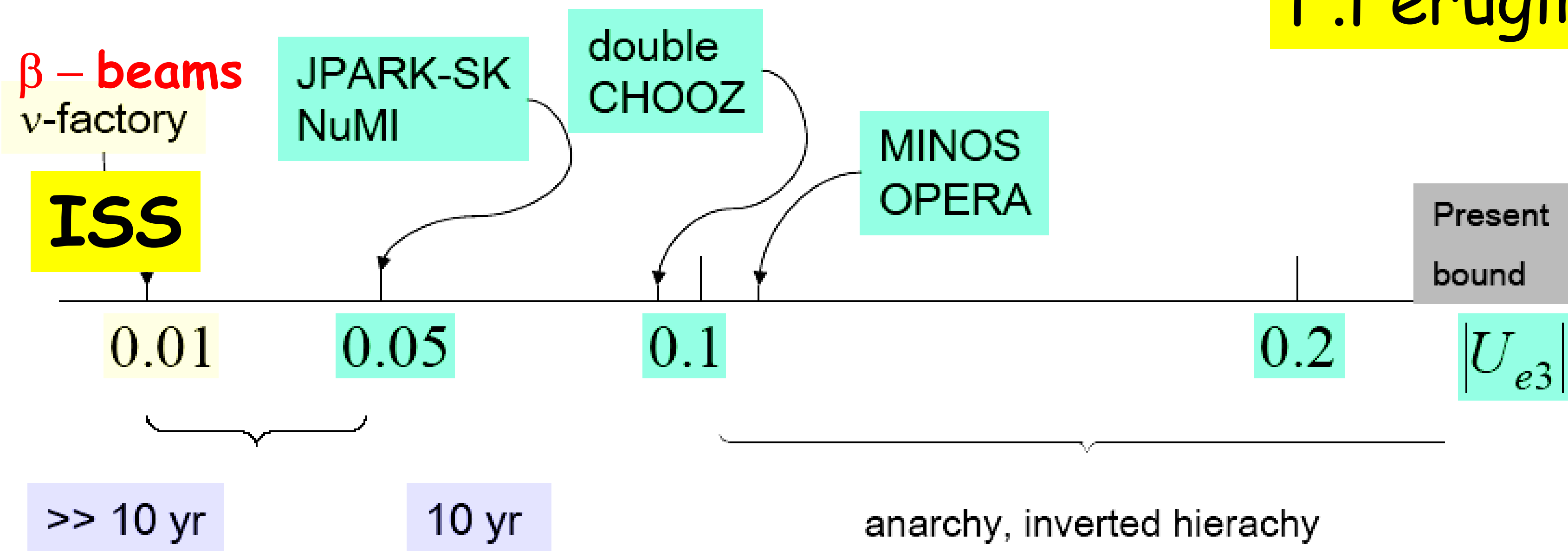
$$\vartheta_{12} + \underbrace{\vartheta_C}_{\text{Cabibbo angle}} = (47.0\ ^{+1.7}_{-1.6})^0$$

quark-lepton complementarity?

[Raidal 0404046
Minakata, Smirnov 0405088]

- Most of plausible range for Ue3 explored in 10 yr from now

based on F.Feruglio



|Ue3|<0.05 would select a very narrow (not empty) subset of existing models

θ_{13} – future

similar conclusion by:
Barbieri, Hambye, Romanino 0302118
Ibarra, Ross 0307051
Chen, Mahanthappa 0305088
Lebed, Martin 0312219
Joshipura @ NOON 2004

θ_{13} proposals

Reactor experiments

	Country	Reactor Power (GW_{th})	Distance (m)	Depth (mwe)	Far Target mass (t)	Sensitivity (90% u. l.)	Expected start date	Funding
Double CHOOZ	France	8.7	280 1050	80 300	10.2	0.03	2008 f 2009 f+n	○
KASKA	Japan	24.3	350 1600	90 260	8	0.025	2009/2010	△
RENO	Korea	17.3	150 1500	230 675	20x2	0.02	2009/2010	△
Daya Bay	China	11.6 17.4 (2011~)	360 (500) 1750	260 910	20x4	0.01	2009 n+m 2010 full	○
Angra	Brazil	4.1	300 1500	250 2000	500	0.005	-	-

Double CHOOZ – almost fully founded, Daya Bay – soon founded, is Double CHOOZ competitive?

A.Zalewska, SPC, 17.10.2006

K.Inoue

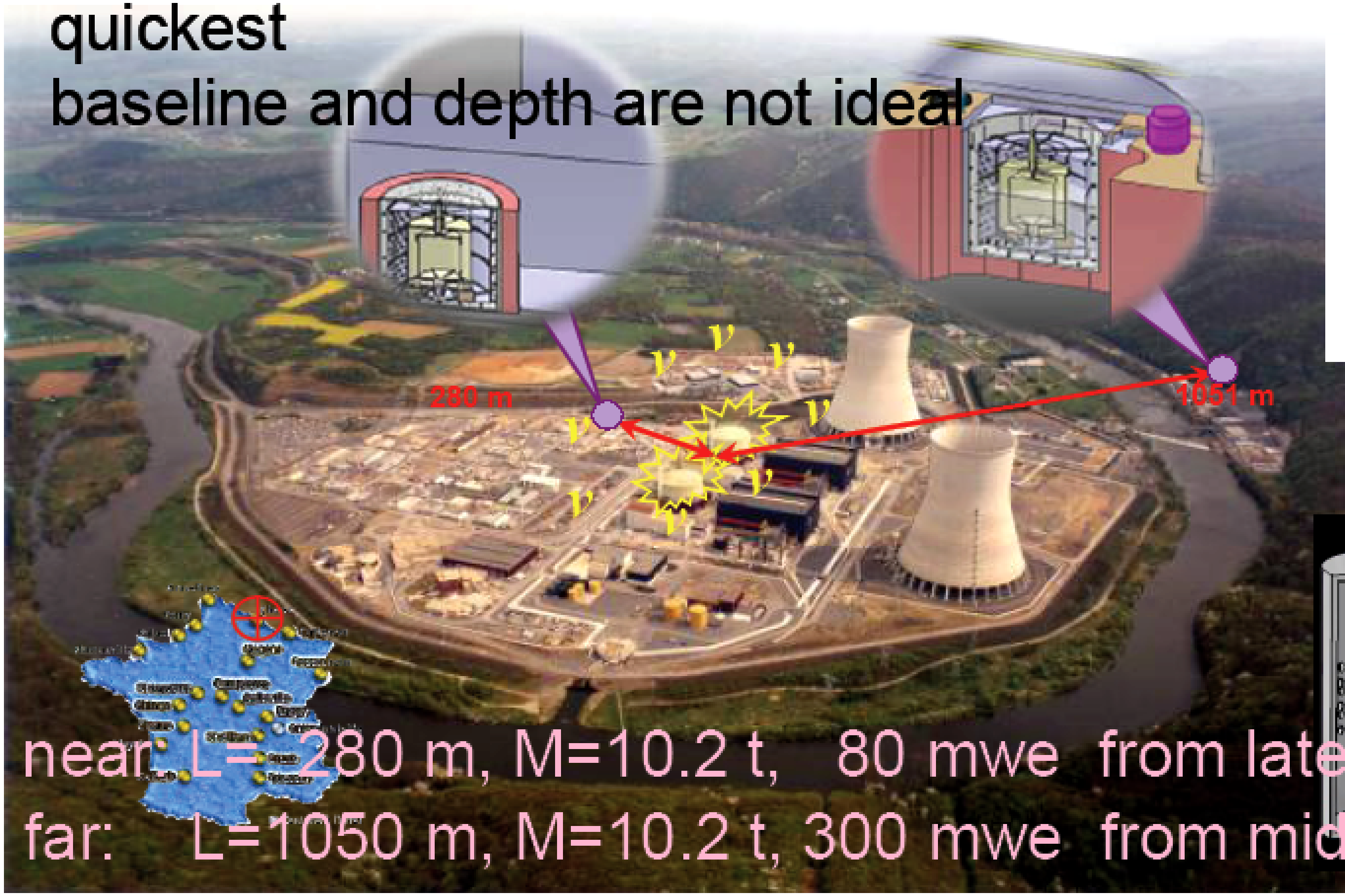
Double CHOOZ

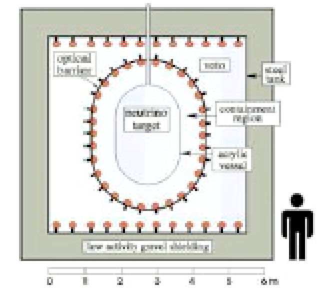
V.Sinev on July 29

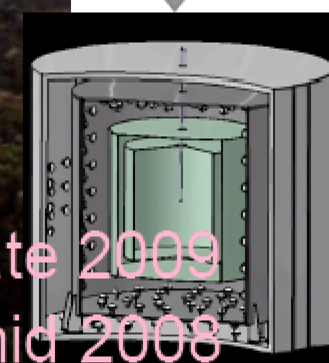
use existing far site

quickest

baseline and depth are not ideal







near: L= 280 m, M=10.2 t, 80 mwe from late 2009

far: L=1050 m, M=10.2 t, 300 mwe from mid 2008

statistical error 2.8% ⇨ 0.5%

systematic error 2.7% ⇨ ~0.6%

K.Inoue

Daya Bay **Layout of the experiment**

K.Inoue

Y.Wang on July 29

Near-Far detector schemes:

- To cancel reactor-related errors
- Residual error ~0.1%

Swap near-far detectors

- To cancel detector-related errors.
- Residual error ~0.2%

Detector deep undergrounds

- To reduce backgrounds
- B/S at near site: ~0.5%
- B/S at far site: ~0.2%

Fast Measurement

- DYB+Mid, 2008-2009
- Sensitivity (1 year) ~0.03

Full Measurement

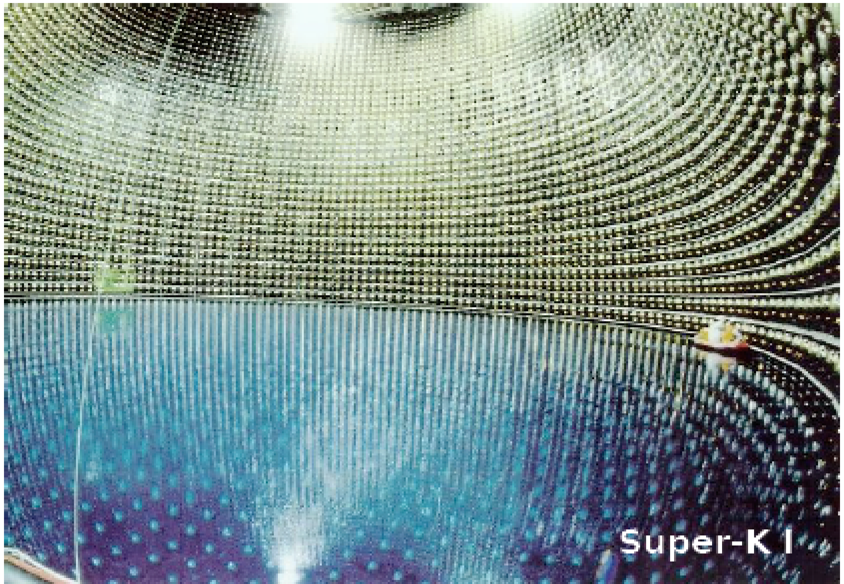
- DYB+LA+Far, from 2010
- Sensitivity (3 year) <0.01

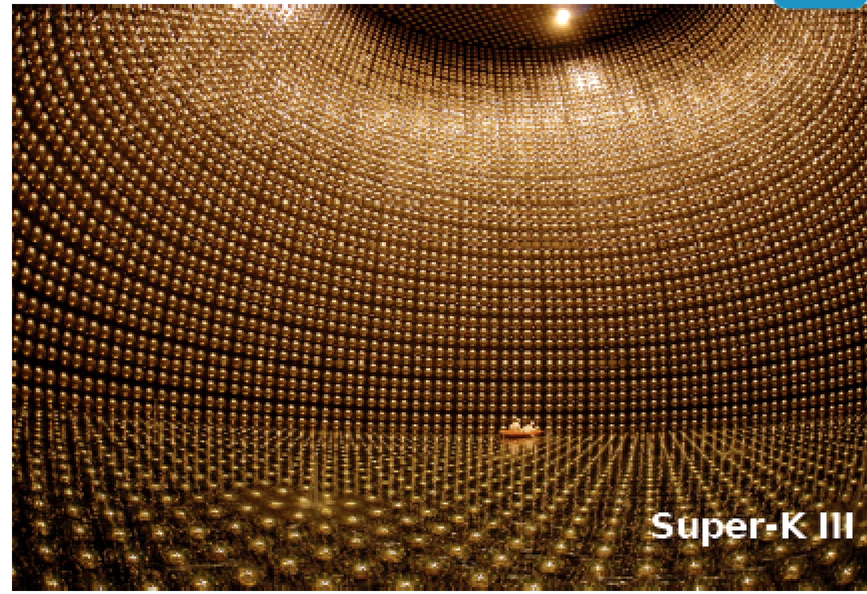
total sys.error 0.06~0.36%

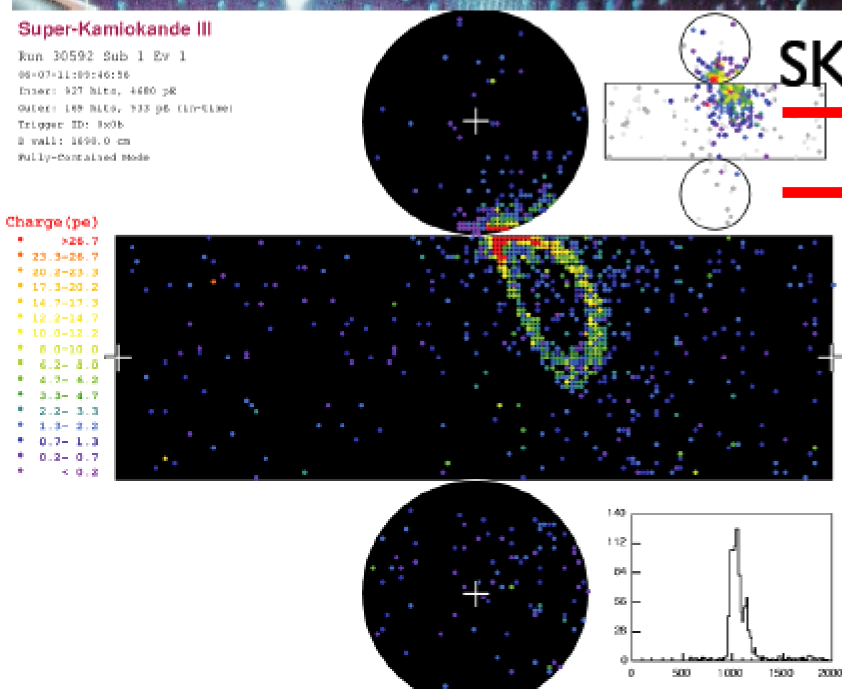
Baseline, depth are optimized.

SuperKamiokande

C.Walter on July 28







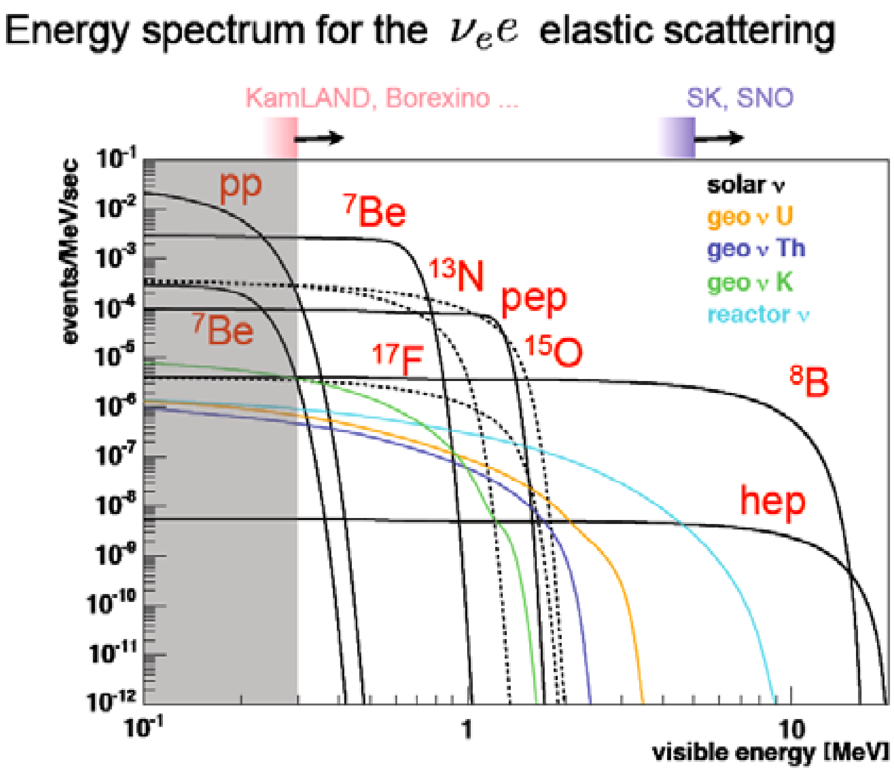
SK full restoration has been completed and water is full since July 11, 2006.

Detector calibration is going on.

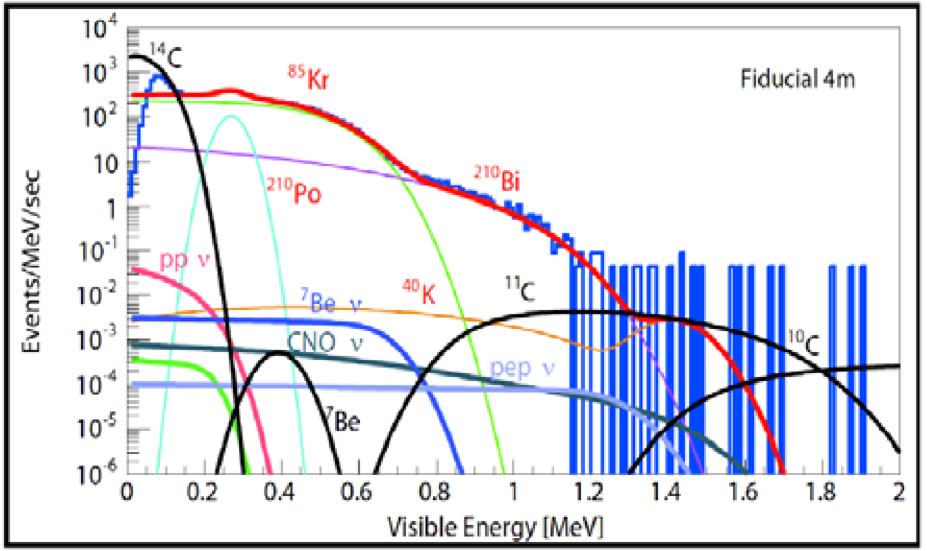
First event in SK-III

K.Inoue

Solar neutrinos: pp chain vs CNO cycle...
...coming back to Davis's original idea



present spectrum in KamLAND

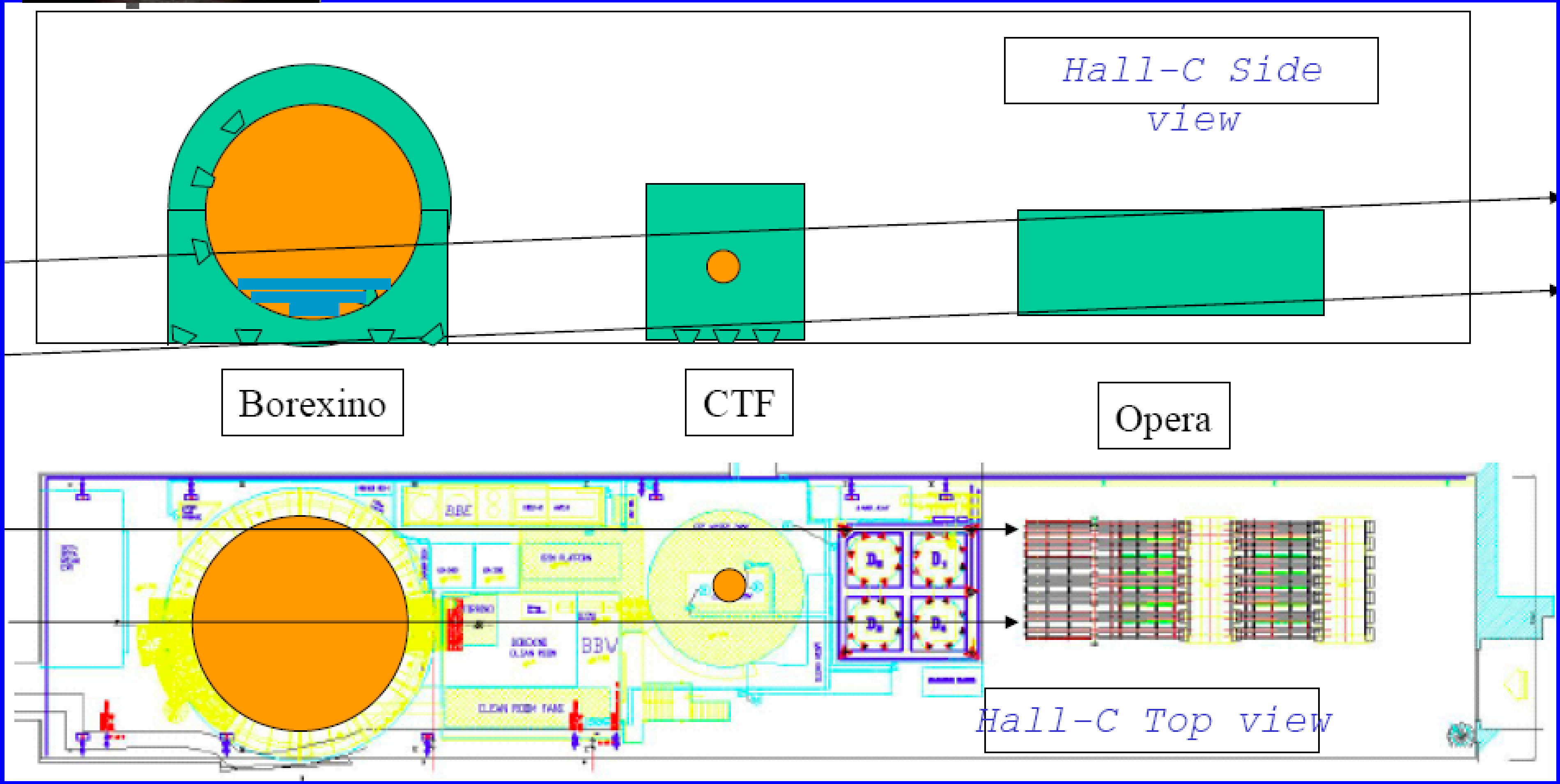


K.Inoue

Borexino is filled with water,
in September KamLAND has started cleaning its scintillator

BOREXINO sees neutrinos from CERN (August 2006) !

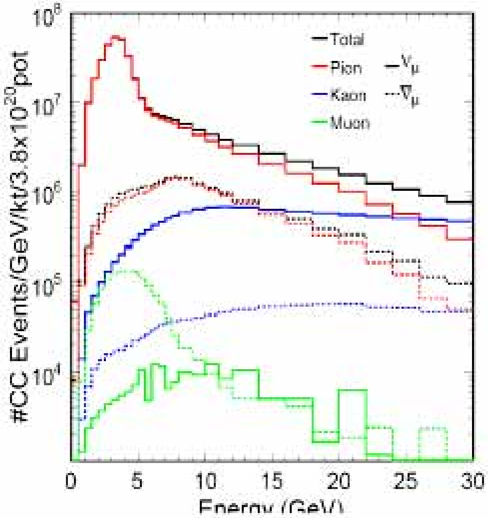
L.Oberauer

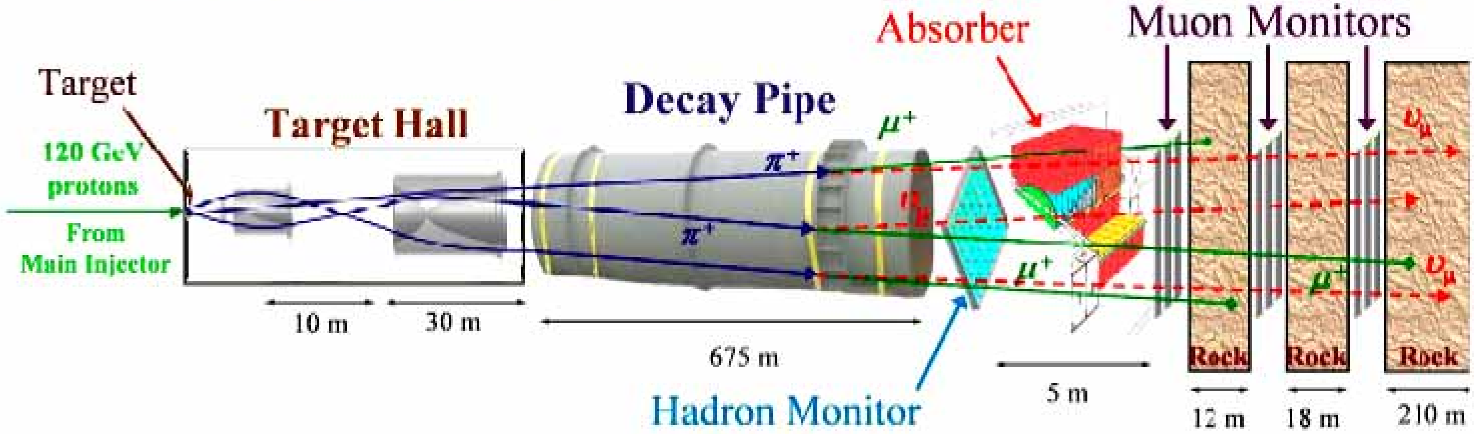


R.Rameika

NuMI - MINOS

Construction 1998-2004; operations 2005 - 2010..

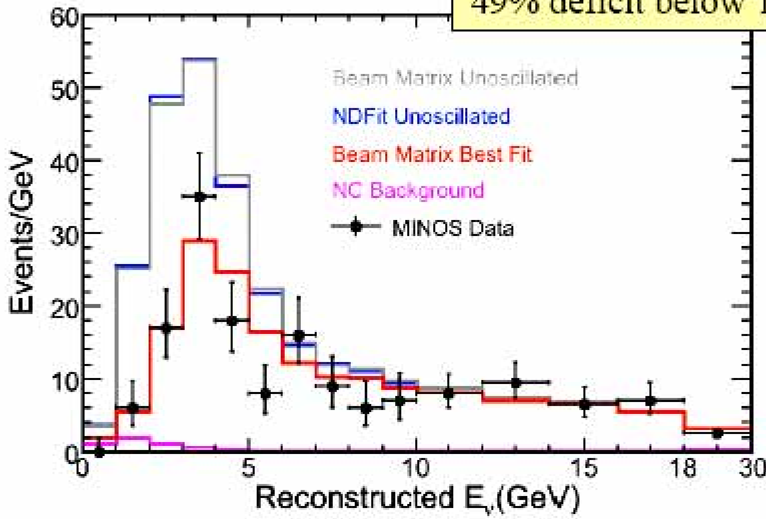


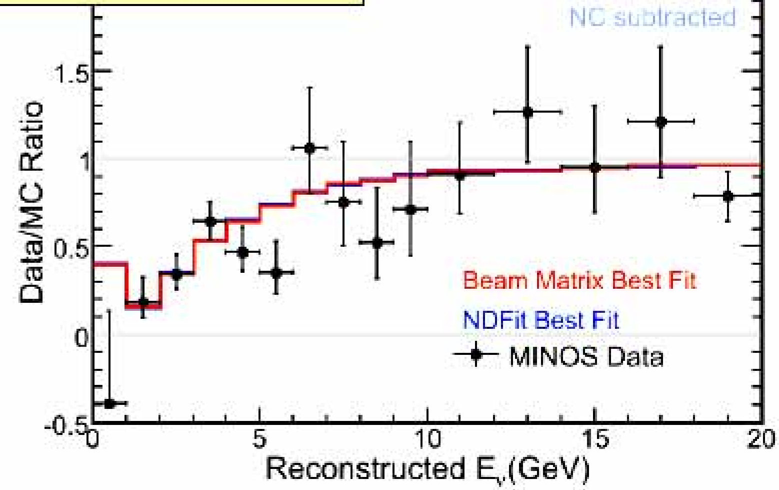


New Results from MINOS

Geoff Pearce, Rutherford Lab

49% deficit below 10GeV : 6.2σ significance

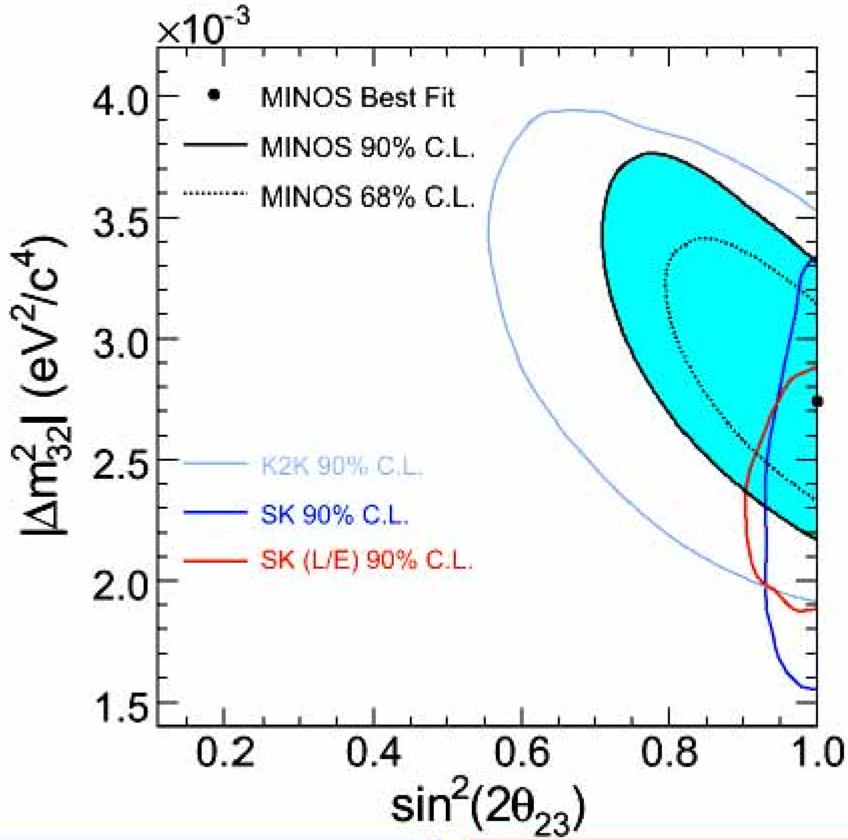




Data sample	Data	Expected (Unoscillated)	Data/MC
ν_μ (<30 GeV)	215	336.0±14.4	0.64±0.05
ν_μ (<10 GeV)	122	238.7±10.7	0.51±0.05
ν_μ (< 5 GeV)	76	168.4±8.8	0.45±0.06

Closing in on Δm^2_{32}

R.Rameika



Submitted to hep-ex archive:
hep-ex 0607088

$\Delta m^2_{32}=0.00274^{+0.44}_{-0.26}\times 10^{-3}\ eV^2/c^4$
$\sin^2(2\theta_{23})>0.87$ (68% C.L.)

R.Rameika

OPERA

τ decay channel	Signal		Background
	$\Delta m^2 = 2.4 \times 10^{-3}\ eV^2$	$\Delta m^2 = 3.0 \times 10^{-3}\ eV^2$	
$\tau \to \mu$	3.6	5.6	0.23
$\tau \to e$	4.3	6.7	0.23
$\tau \to h$	3.8	5.9	0.32
$\tau \to 3h$	1.1	1.7	0.22
ALL	12.8	19.9	1.0

full mixing, 5 years run @ 4.5×10^{19} pot / year

Higher Δm^2 from Minos very good for OPERA

Update from DONUT

R.Rameika

12 April 2001

PHYSICS LETTERS B

Physics Letters B 504 (2001) 218–224

Observation of tau neutrino interactions

DONUT Collaboration

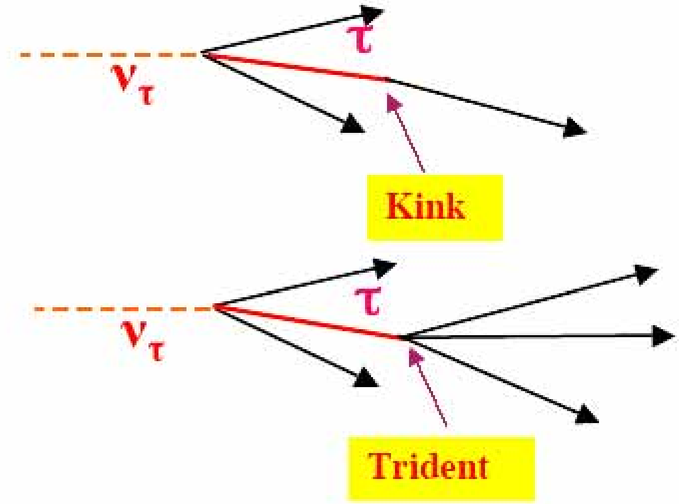
K. Kodama[a], N. Ushida[a], C. Andreopoulos[b], N. Saoulidou[b], G. Tzanakos[b], P. Yager[c], B. Baller[d], D. Boehnlein[d], W. Freeman[d], B. Lundberg[d], J. Morfin[d], R. Rameika[d], J.C. Yun[d], J.S. Song[e], C.S. Yoon[e], S.H. Chung[e], P. Berghaus[f], M. Kubantsev[f], N.W. Reay[f], R. Sidwell[f], N. Stanton[f], S. Yoshida[f], S. Aoki[g], T. Hara[g], J.T. Rhee[h], D. Ciampa[i], C. Erickson[i], M. Graham[i], K. Heller[i], R. Rusack[i], R. Schwienhorst[i], J. Sielaff[i], J. Trammell[i], J. Wilcox[i], K. Hoshino[j], H. Jiko[j], M. Miyanishi[j], M. Komatsu[j], M. Nakamura[j], T. Nakano[j], K. Niwa[j], N. Nonaka[j], K. Okada[j], O. Sato[j], T. Akdogan[k], V. Paolone[k], C. Rosenfeld[l], A. Kulik[k,l], T. Kafka[m], W. Oliver[m], T. Patzak[m], J. Schneps[m]

Received 8 January 2001; accepted 16 February 2001
Editor: K. Winter

Abstract

The DONUT experiment has analyzed 203 neutrino interactions recorded in nuclear emulsion targets. A decay search has found evidence of four tau neutrino interactions with an estimated background of 0.34 events. This number is consistent with the Standard Model expectation. © 2001 Published by Elsevier Science B.V.

PACS: 14.60.Lm



First 4 events published in Phys. Lett. B 504, 218(2001)

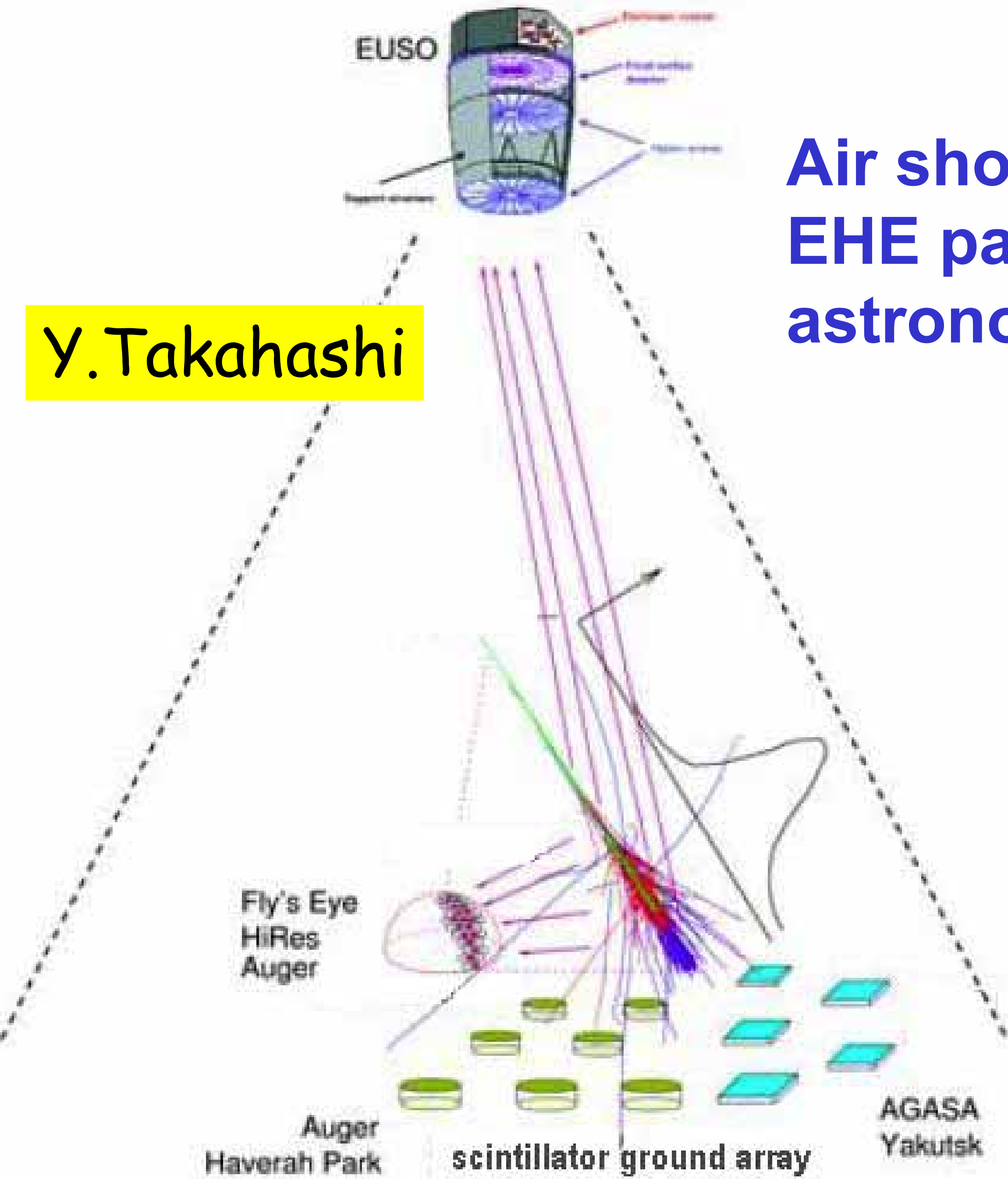
Now: 10 ν_τ candidates, publication of final results by end of 2006

Astrophysics and cosmology

- ➔ Updates of EHE Cosmic Rays at 10^{19-20} eV
- ➔ Searches for Dark Matter

Air shower observations for EHE particles → particle astronomy

Y.Takahashi



Volcano Ranch

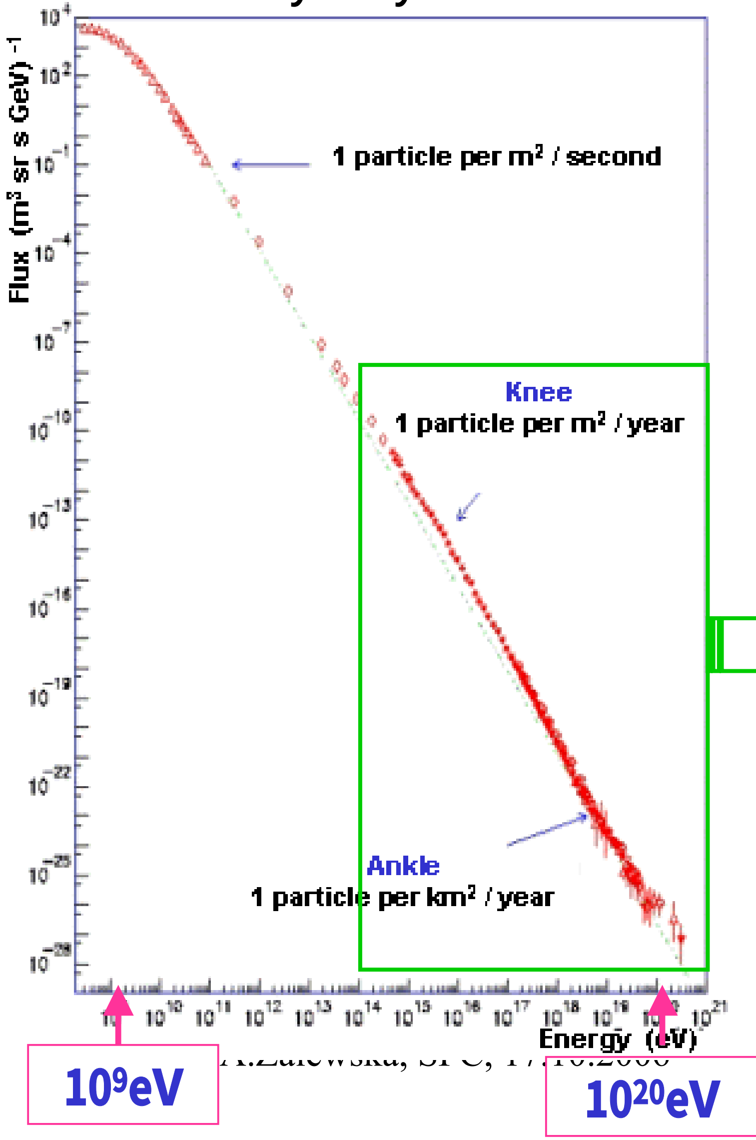
Ground-based arrays

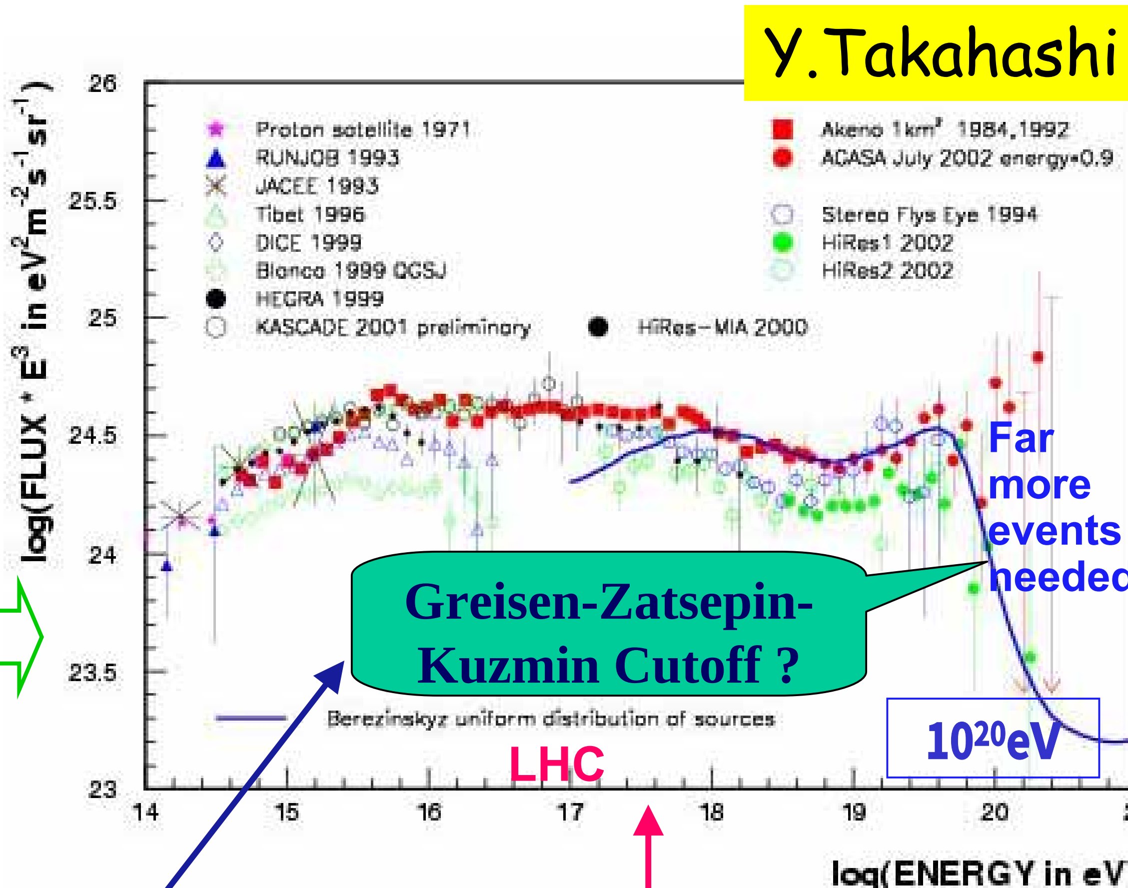
(1) Scintillator array

(2) Fluorescence telescope array

Energy Spectrum of Cosmic Rays

- LHC will comprehensively profile SUSY DM regime m < 7 TeV/c^2
- the mystery of the EHECR Origins remains and extends to m > 300 TeV/c^2 regime





$p + \gamma_{2.7K} \rightarrow e^+e^- + p$ above LHC $5\ 10^{17}$eV

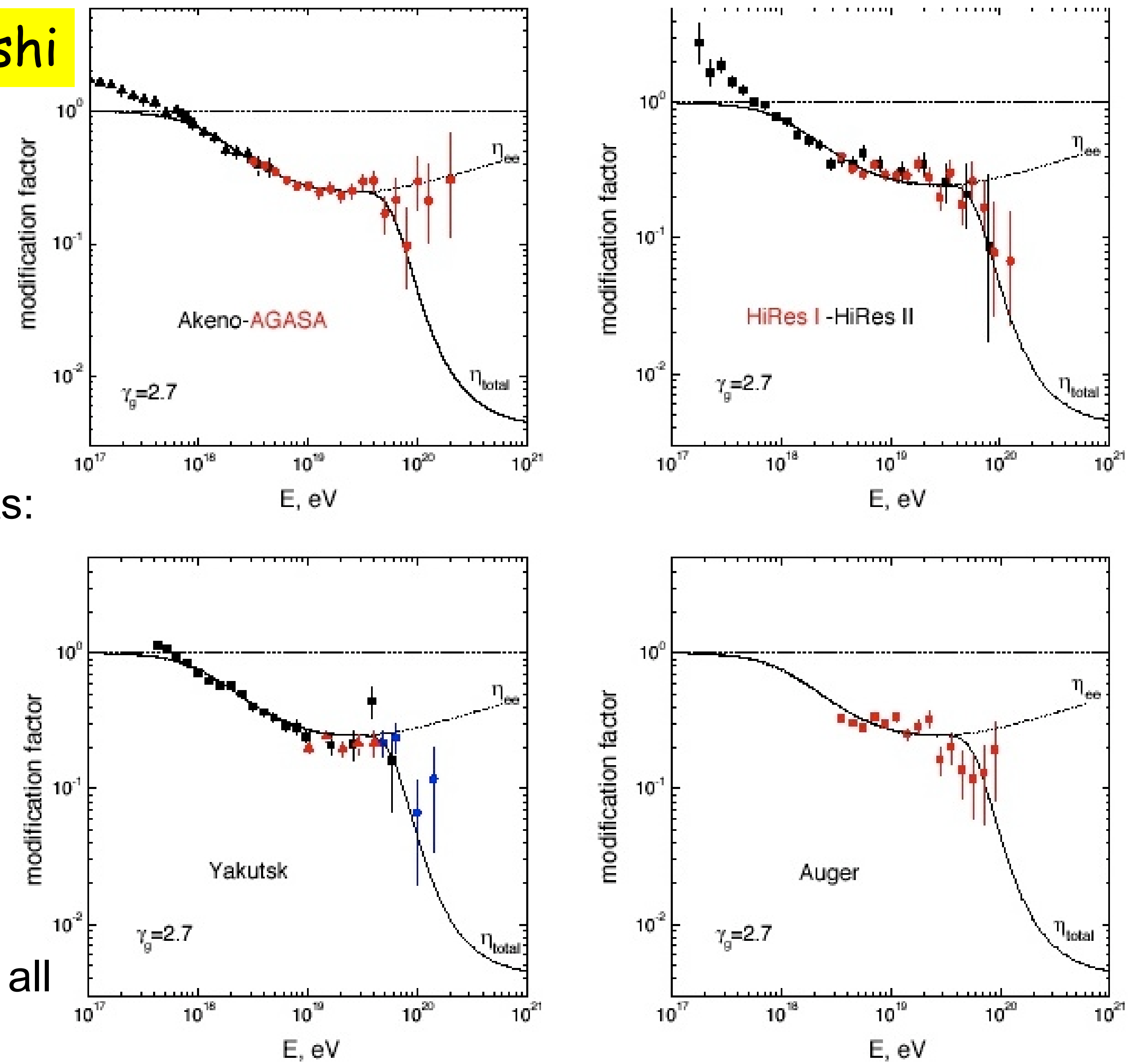
$p + \gamma_{2.7K} \rightarrow \Delta^+ \rightarrow n + \pi^+,\ p + \pi^0$

Y.Takahashi

4 EHE
Air Shower
Experiments:

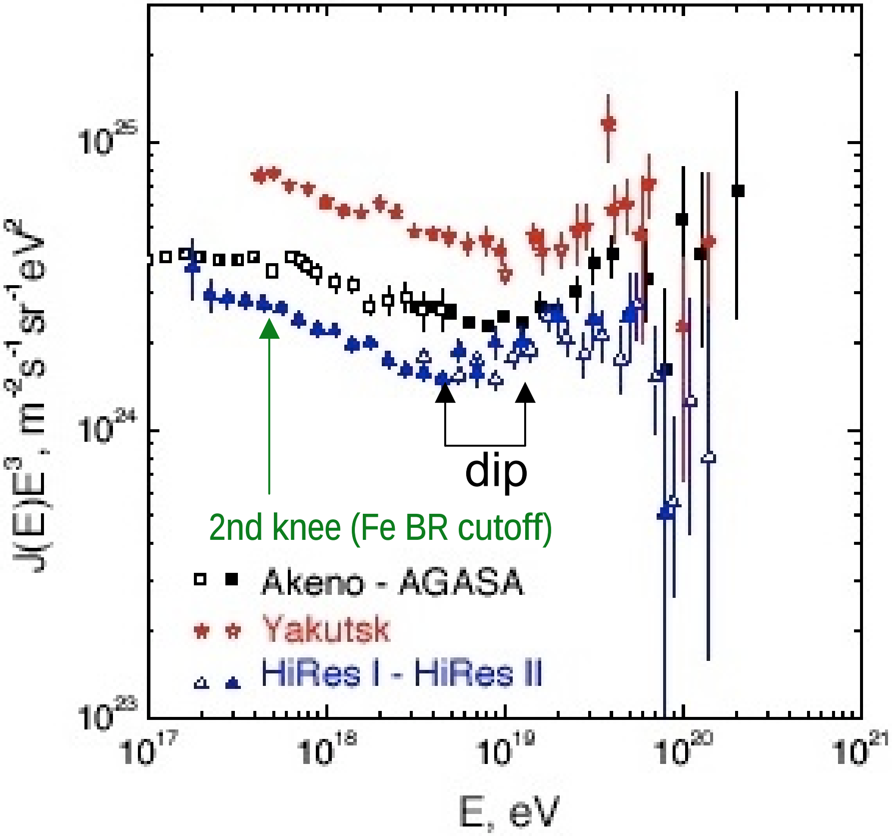
AGASA,
Hi-Res,
Yakutsuk,
Auger

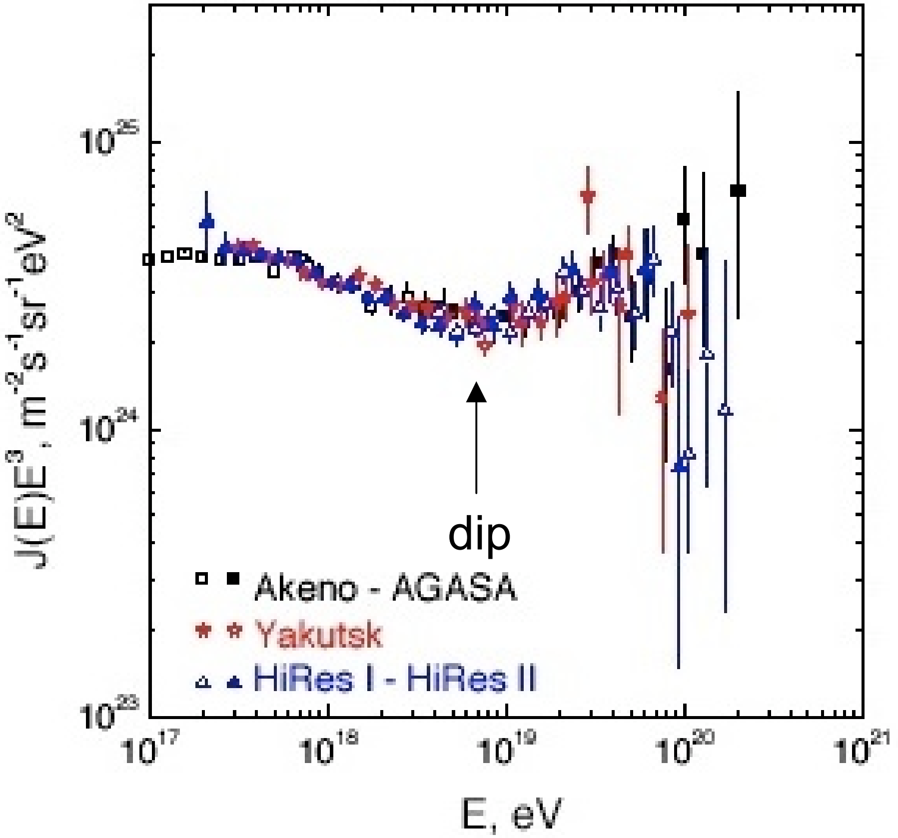
→ **Dip**
appears
common to all



Cf. Auger: insufficient energy range for dip

Data Adjusted by Hill-Schramm-Berezinsky dip



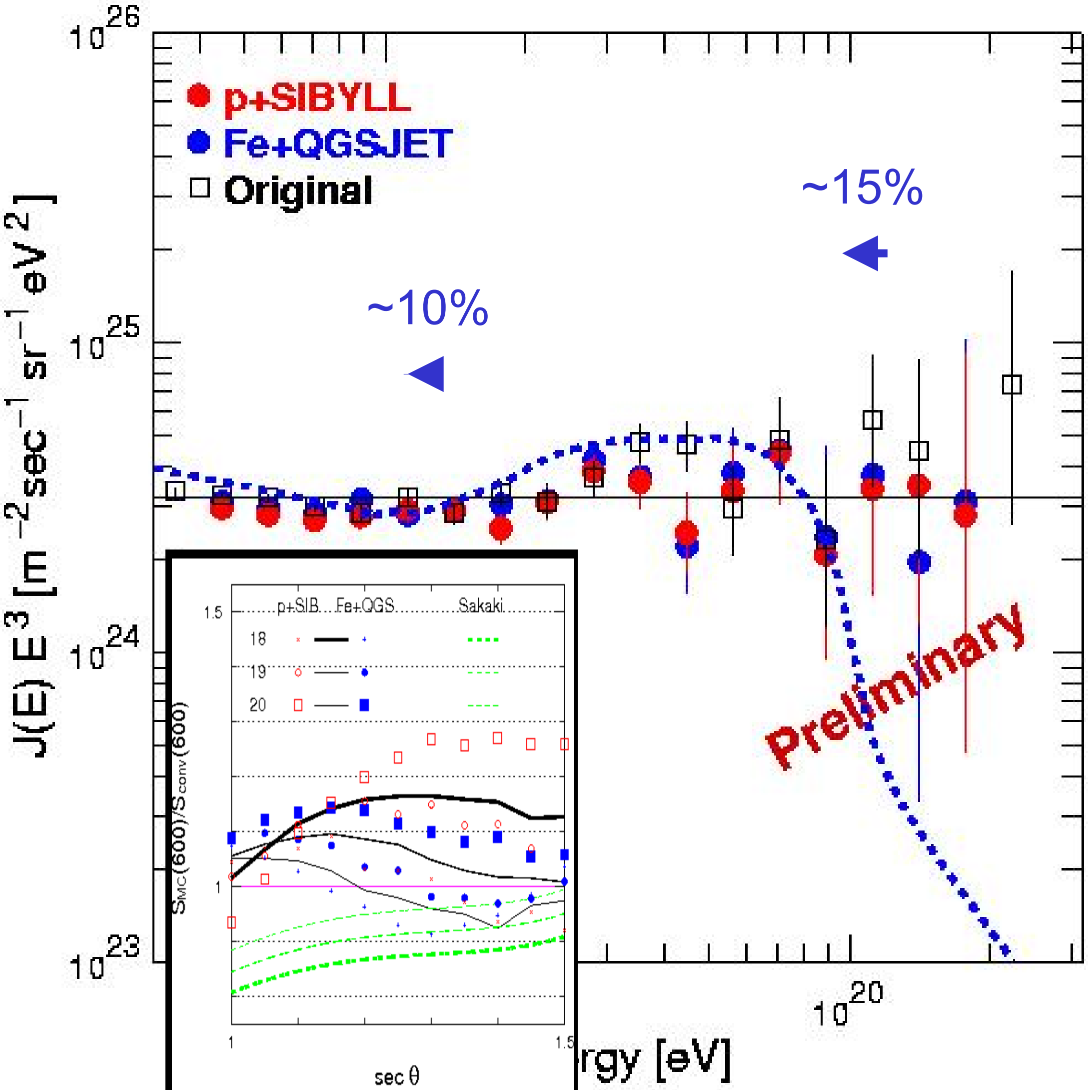


λ_{AGASA} =0.9, $\lambda_{Yakutsuk}$= 0.75, λ_{HiRes}= 1.2; Each χ^2/d.o.f = 1.0 - 1.2, adjusted for dips.
(Berezinsky et al. 2006 PRD in press)

Y.Takahashi

Confusing: AGASA *preliminary* new spectrum with recent Corsika simulator (Teshima)

Y.Takahashi



- Energy shift to lower direction
  ~10% at 10^{19}eV
  ~15% at 10^{20}eV
- Above 10^{20}eV
  11events ➔ 5~6 events

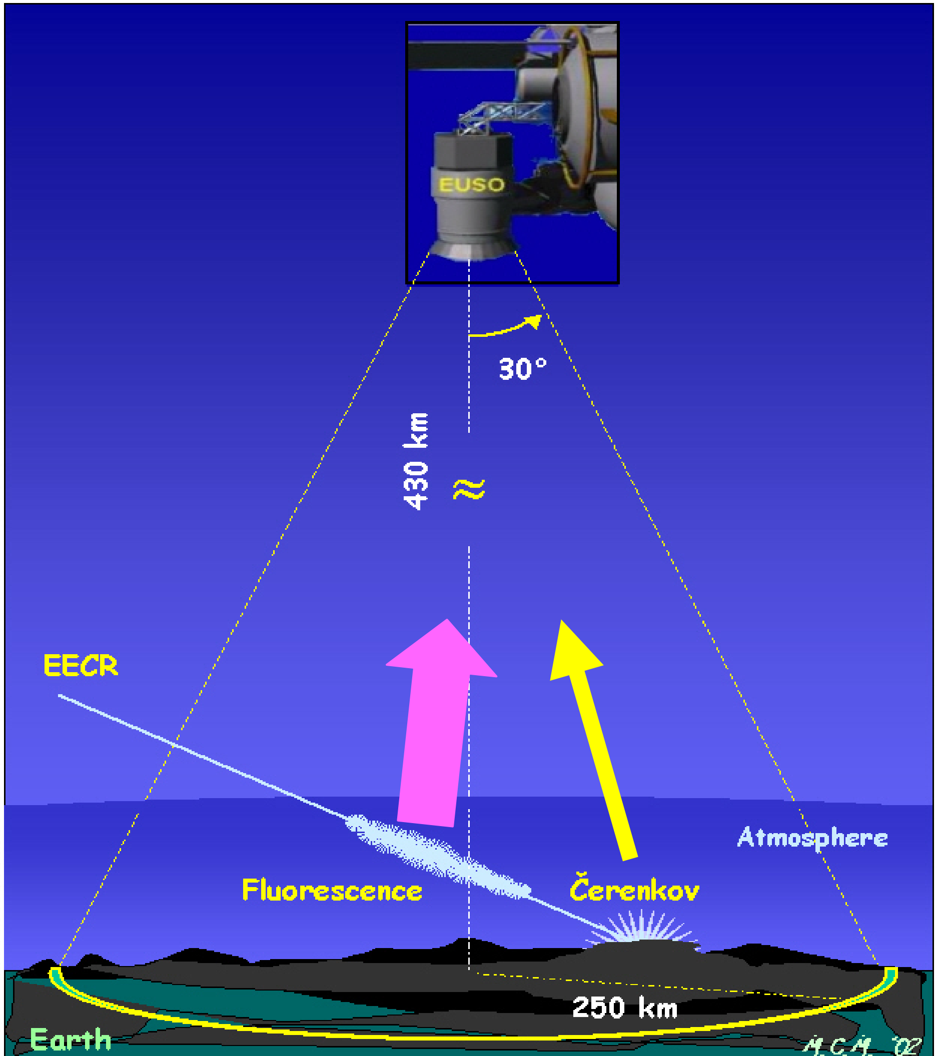
➢ Featureless spectrum very close to E^{-3}

➢ P-SIBYLL (above 10^{19}eV)
$\beta = 2.95 \pm 0.08$
(χ^2 / NDF = 8.5/11)

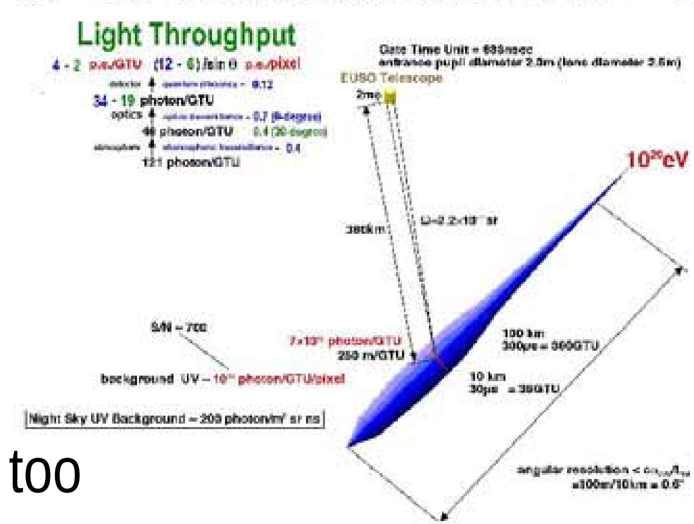
➢ Fe-QGSJET (above 10^{19}eV)
$\beta = 2.90 \pm 0.08$
(χ^2 /NDF = 8.5/11)

EUSO (Extreme Universe Space Observatory) on ISS JEM

Y.Takahashi



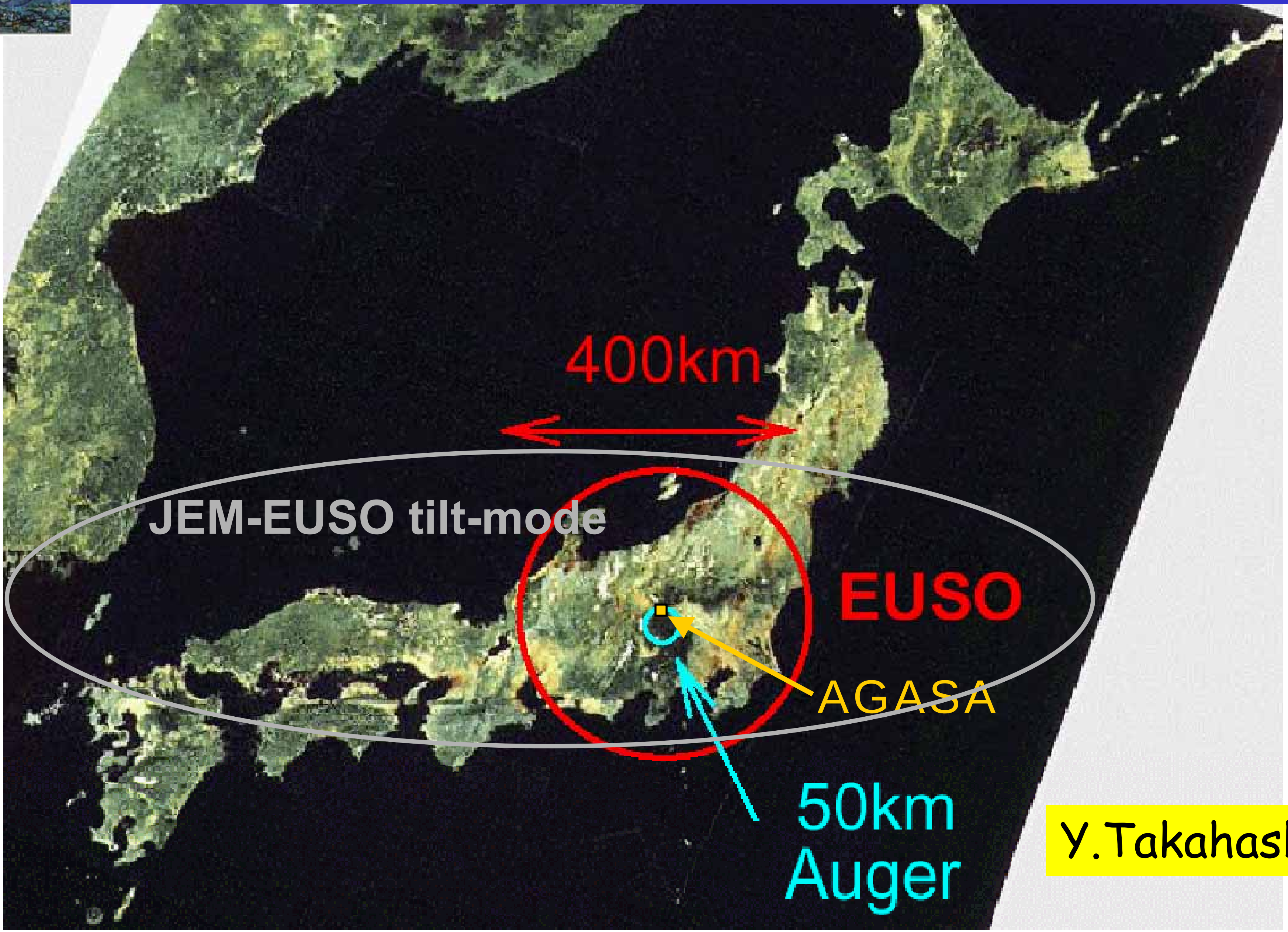
10^{19} eV Track volume has S/N ~ 70



NUV Fluorescence 300 - 400 nm; Cherenkov, too

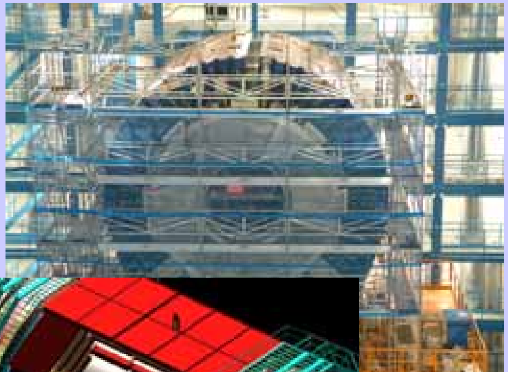
EUSO ~ 300 x AGASA ~ 10-50 x Auger

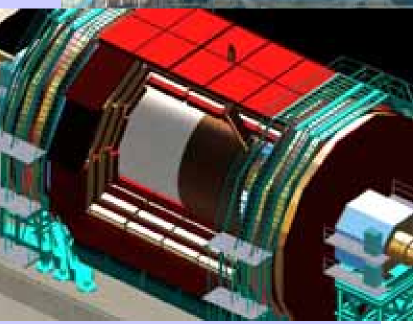
EUSO (Instantaneous) ~3000-15000 x AGASA ~ 100-500 x Auger



Dark Matter searches -complementary approaches

Hunt for dark matter in the dark needs a set of different weapons, in an integrated way





Indirect searches

gamma-rays etc. on satellite

Direct searches in underground labs

LHC experiments

neutrinos in ice

neutrinos deep underwater

gamma-rays on surface

A.Zalewska, SPC, 17.10.2006

A. Bettini

Principles of WIMP Detection

Target = Detector

Measure the energy deposited by the hit **nucleus**

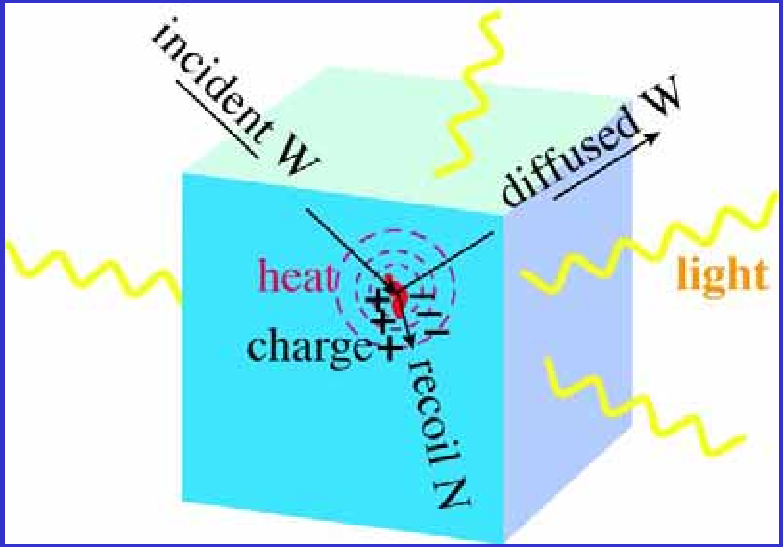
Part of this energy appears as **charge, light or heat**

Main challenges

- Signal rate is small
- Energy deposit is tiny (several keV)
- Signal spectrum decreases exponentially

•3 basic backgrounds

- electromagnetic (β & γ); dominant $\Rightarrow$ electrons
- neutrons (and WIMPs) $\Rightarrow$ nuclear recoil
- surface contamination (partial energy release)



Against backgrounds, in Underground **laboratory**

Search for characteristic signal: annual modulation (DAMA only)

Talk by P.L. Belli

Passive shielding. Against external backgrounds only

Active discrimination. Against external and internal background

Measure two quantities

Event by event rejection. Necessary for "zero" background

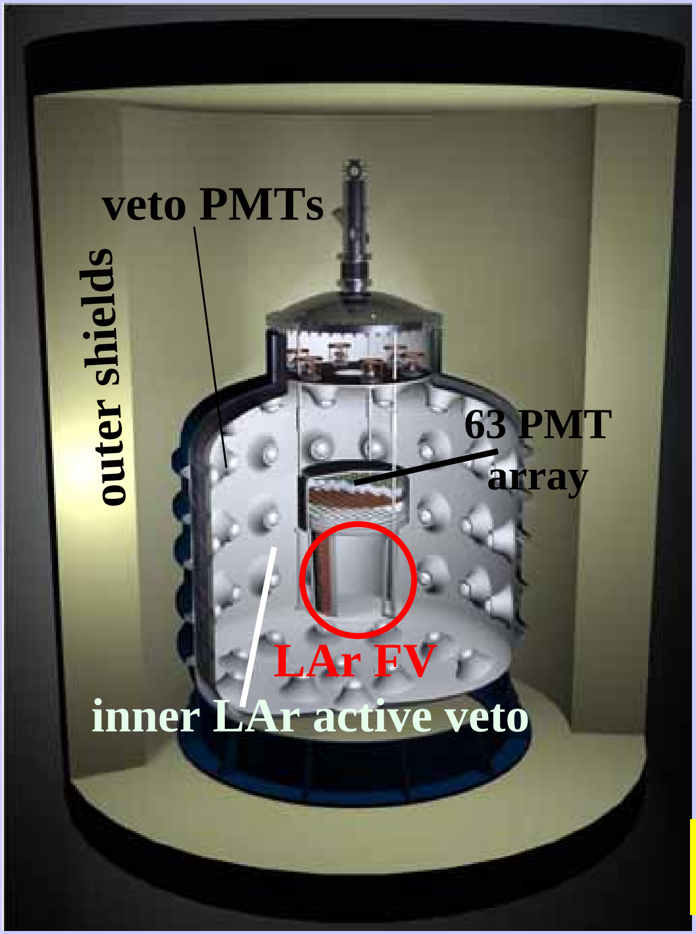
Statistical rejection not enough: background might be signal, in presence of residual background sensitivity proportional to square-root of exposure

A. Bettini

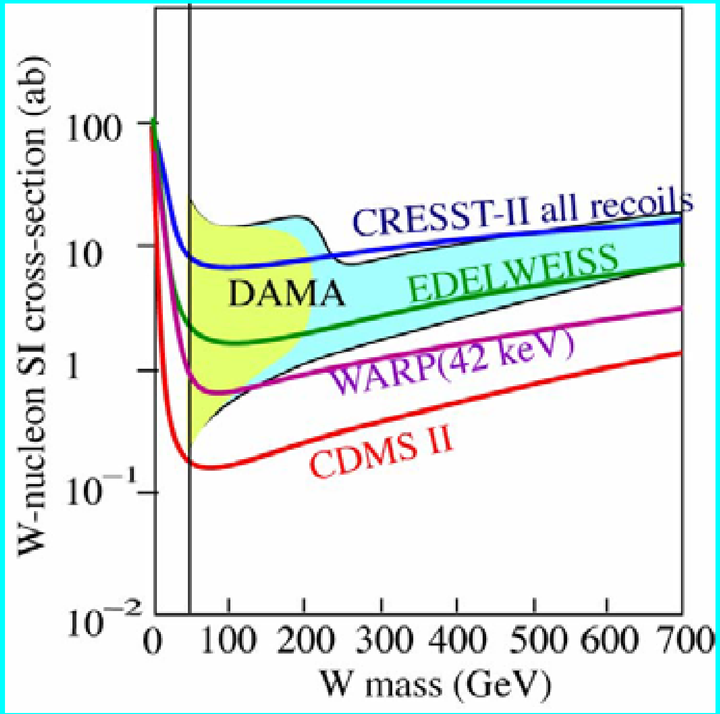
Liquid Argon. WARP @ LNGS

Fast/slow components of light pulse in Ar have very different lifetimes: 7 ns/1600 ns
⇒second powerful handle for discrimination
But huge intrinsic background: ^{39}Ar β decay @ 1 Bq/kg. Needs 10^{-8} rejection @10^4 kg d

140 kg TPC in construction @ LNGS



First tests (and physics) with 2.3 l prototype
Exposure = 96.5 kg d ⇒
Rejct power for 30<E<100 keV$_{ee}$ = 37-1×10^{-6}
0 events @ E>42 keV*ee* (5 events @ 30<E<42)
Caveat: Quenching factor not yet measured



A. Bettini

CKM matrix and CP violation

- ➔ B factories – fantastic performance
- ➔ CP violation in B decays – new measurements
- ➔ $|V_{ud}|$ from neutron lifetime measurement

No sign of New Physics

➔ but DD mixing is now considered to be a good probe of NP

- ➔ Future K experiments

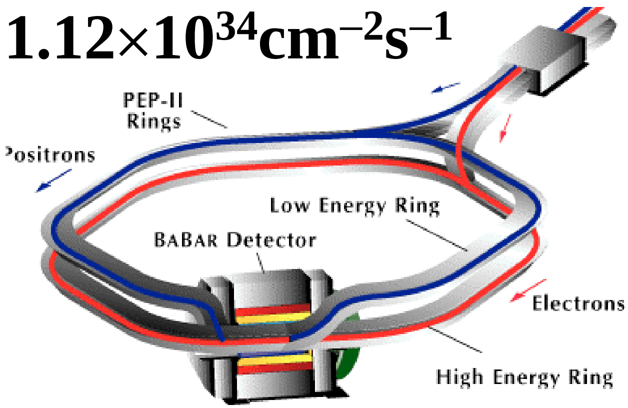
Two Asymmetric-energy *B* Factories

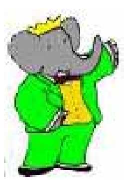
M.Hazumi

PEP-II at SLAC

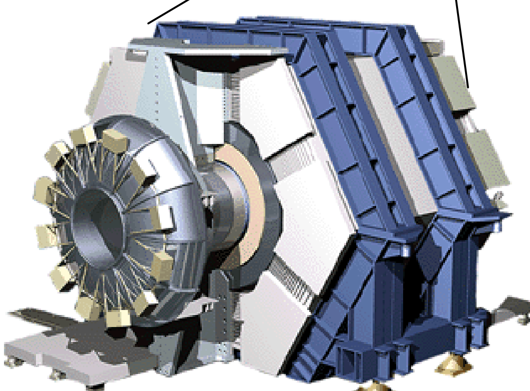
9GeV (e^-) × 3.1GeV (e^+)
peak luminosity:

$1.12\times10^{34}cm^{-2}s^{-1}$



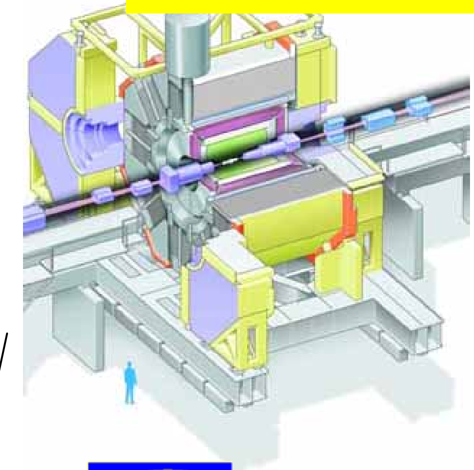


BaBar

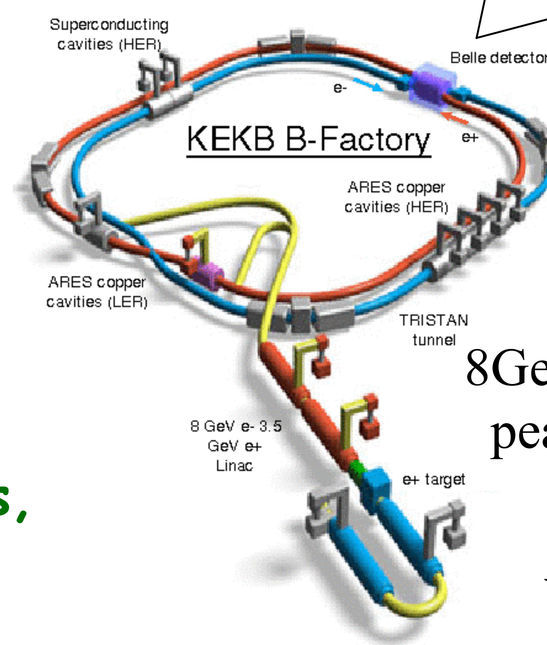


11 nations,
80 institutes,
623 persons

13 countries,
57 institutes,
~400 collaborators



Belle



KEKB at KEK

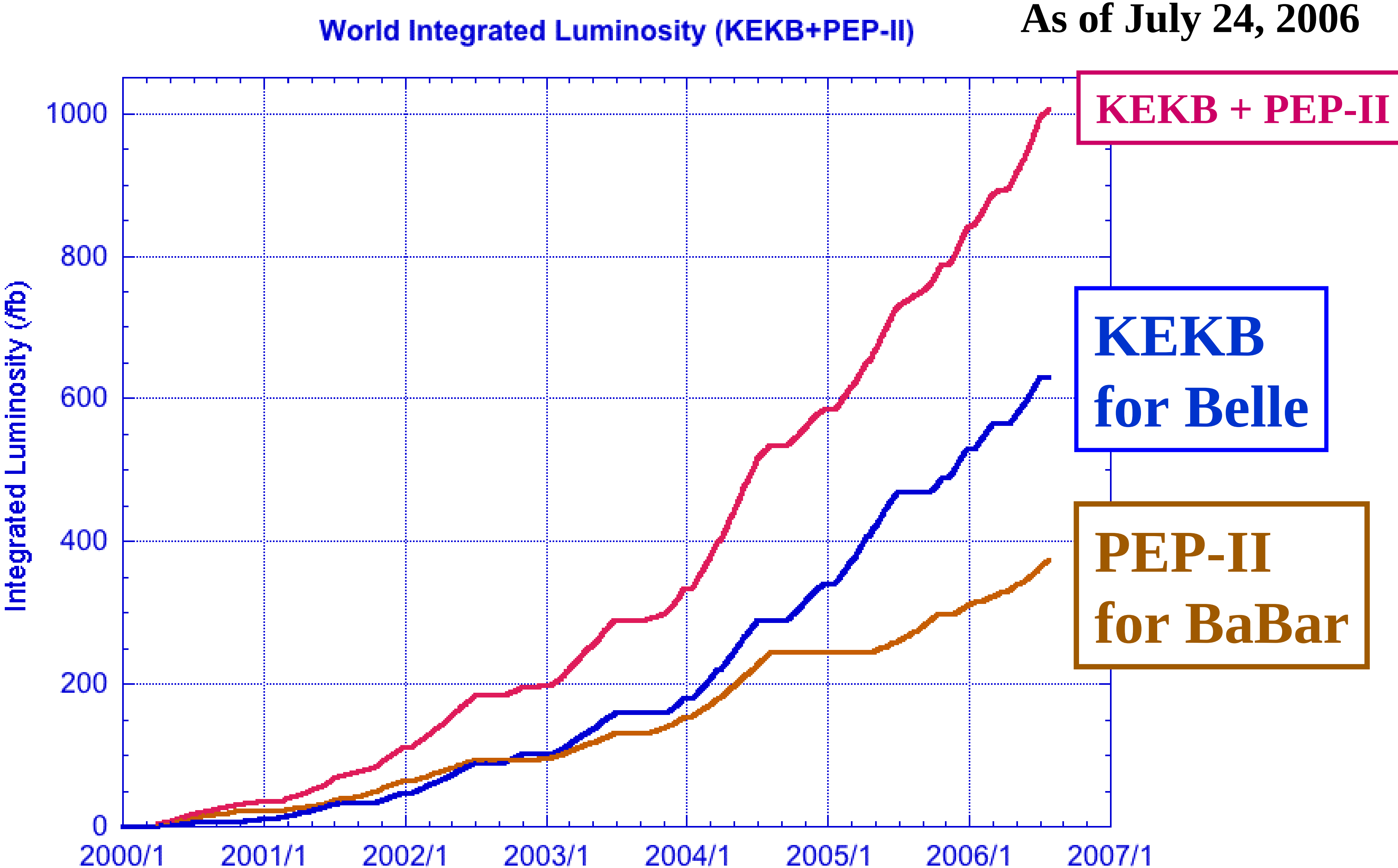
8GeV (e^-) × 3.5GeV (e^+)
peak luminosity:

$1.65\times10^{34}cm^{-2}s^{-1}$

world record

Integrated Luminosity

As of July 24, 2006



M.Hazumi

1000/fb !!

reached on July 13, 2006

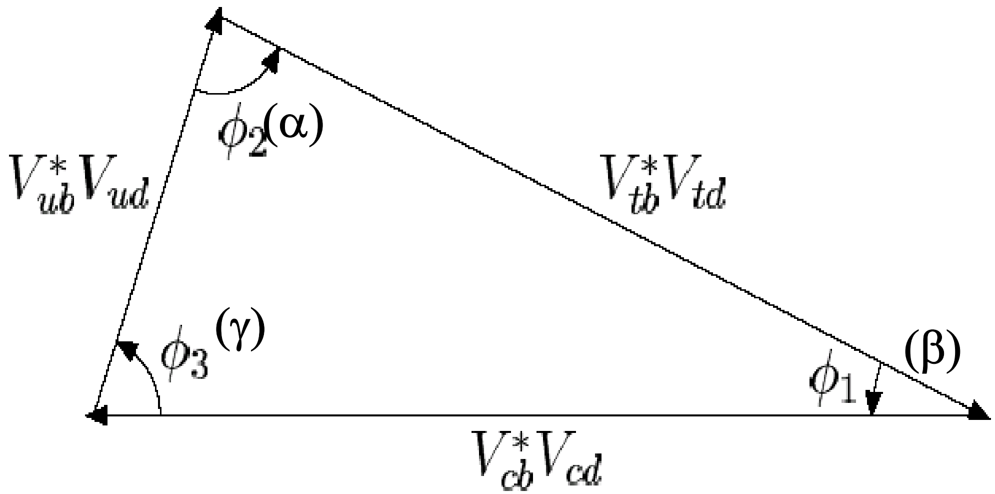
~ 1 Billion $B\bar{B}$ pairs

- **Far beyond the design luminosities of both proposals**
- **Triumph in accelerator science**

M.Hazumi

Unitarity triangle

Various observable quantities in B physics constrain the angles and lengths of the unitarity triangle.



Angle determination

ϕ_1/β: **CP asymmetries in b–>ccs modes – well measured**
ϕ_2/α: **CP asymmetries in B–>** $\pi\pi$, $\rho\rho$, $\rho\pi$. – **worse measured**
ϕ_3/γ : **CP asymmetries in B–>DK, etc. - practically unconstrained**
($2\phi_1+\gamma$)/($2\beta+\gamma$): CP asymmetry in B–>Dπ, etc

New measurements of ϕ_1

- ϕ_1 **with tree diagram (b → *ccs*)**
  - **BaBar: sin2β in $B^0 \to J/\psi K^0$, $\psi(2S)K_S$, $\eta_c K_S$, $\chi_{c1}K_S$, $J/\psi K^{*0}$**
  - **Belle: sin2ϕ_1 in $B^0 \to J/\psi K^0$**
- ϕ_1 **with penguin diagram (*b* → *sqq*)**
  - **BaBar: $B^0 \to K^+K^-K^0$, $\eta' K^0$, $K_S K_S K_S$, ωK_S, ρK_S, $\pi^0 K_S$**
  - **Belle: $B^0 \to \eta' K^0$, $\pi^0 K_S$**
  - **Belle: $B^0 \to \phi K^0$, $K^+K^-K_S$, $K_S K_S K_S$, $f^0 K_S$, ωK_S**

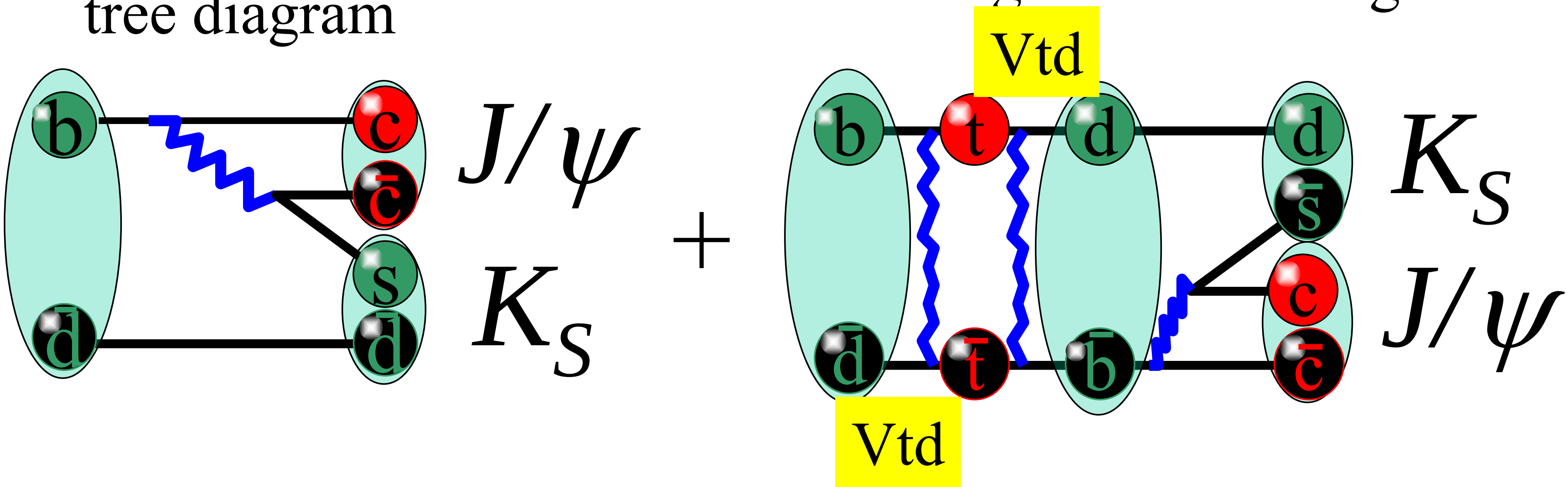
M.Hazumi

ϕ_1 Time-dependent *CP* violation (t*CP*V)

"double-slit experiment" with particles and antiparticles

Quantum interference b/w two diagrams

tree diagram   box diagram + tree diagram



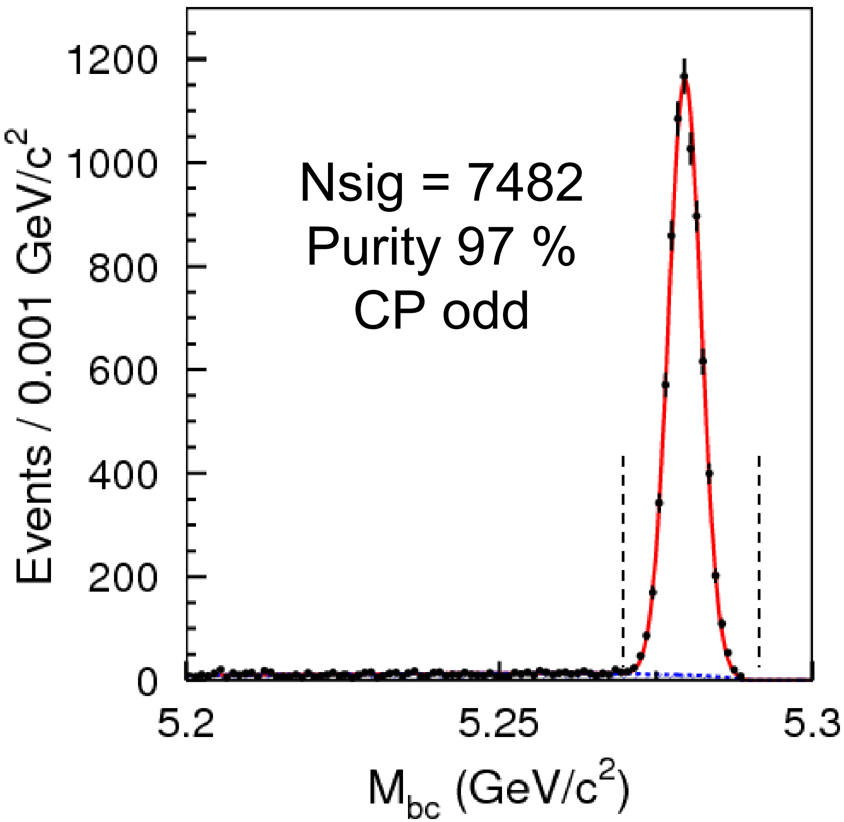
You need to "wait" (i.e. $\Delta t \neq 0$) to have the box diagram contribution.

M.Hazumi

O. Tajima

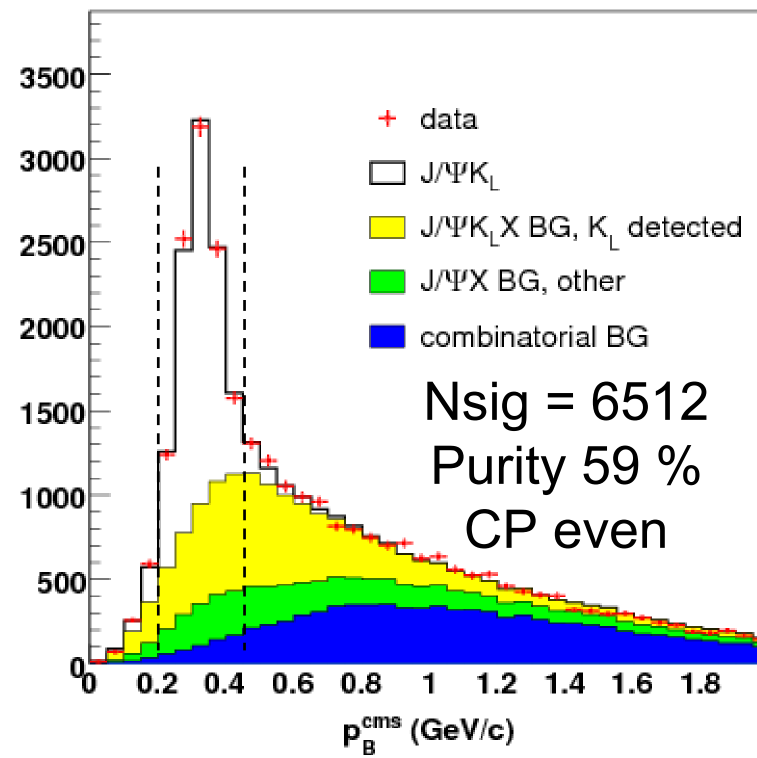
$B^0 \to J/\psi K^0$: 532 M $B\bar{B}$ pairs

$B^0 \to J/\psi K^0_S$



$$M_{bc} = \sqrt{E^{*2}_{beam} - P^{*2}_{J/\psi Ks}}$$

$B^0 \to J/\psi K^0_L$



p_{KL} information is poor
→ lower purity

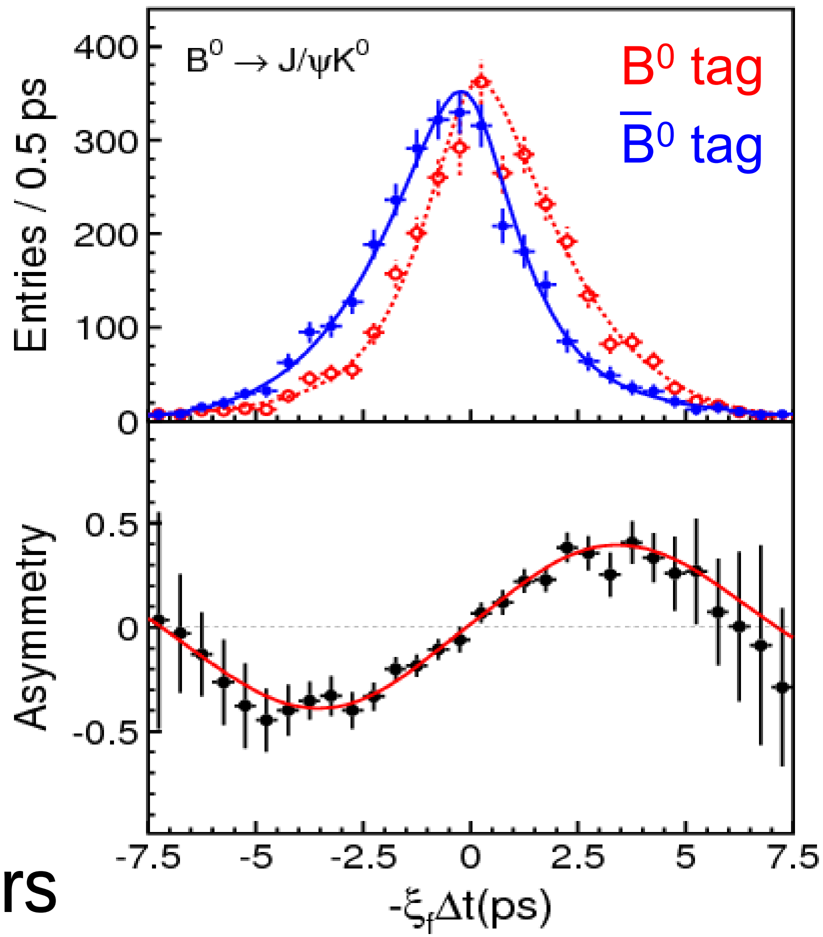
Belle preliminary

BELLE-CONF-0647

O. Tajima

$B^0 \rightarrow J/\psi K^0$: combined result

New !



Preliminary

532 M $B\bar{B}$ pairs

previous measurement
$\sin 2\phi_1 = 0.652 \pm 0.044$
(386 M $B\bar{B}$ pairs)

$\sin 2\phi_1 = 0.642 \pm 0.031$ (stat) ± 0.017 (syst)
$A = 0.018 \pm 0.021$ (stat) ± 0.014 (syst)

Belle preliminary

BELLE-CONF-0647

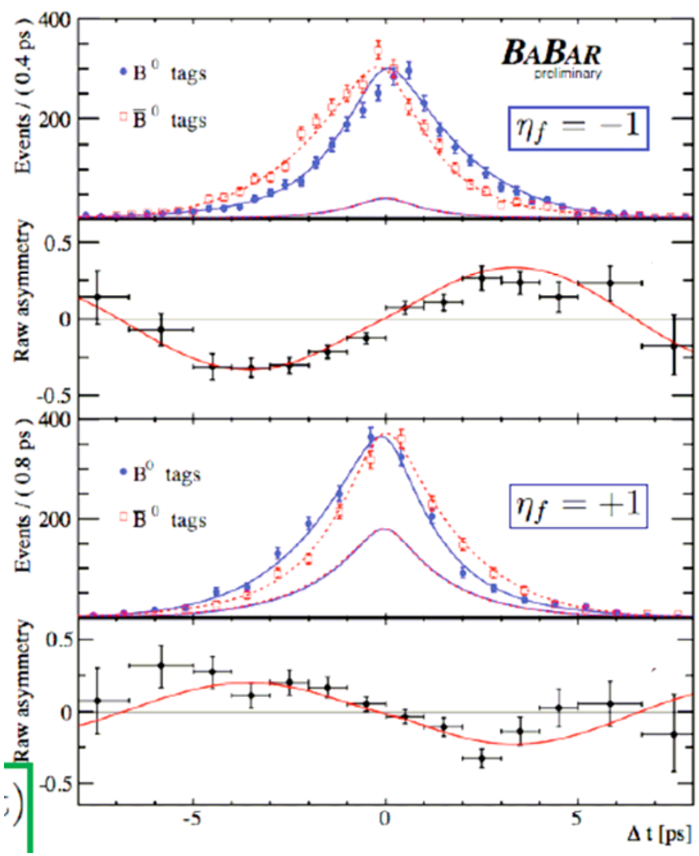
BaBar2006: sin2β in b → ccs

$$\sin 2\beta = 0.710 \pm 0.034(\text{stat}) \pm 0.019(\text{syst})$$

$$|\lambda| = 0.932 \pm 0.026(\text{stat}) \pm 0.017(\text{syst})$$

BABAR:CONF-06/036

Preliminary

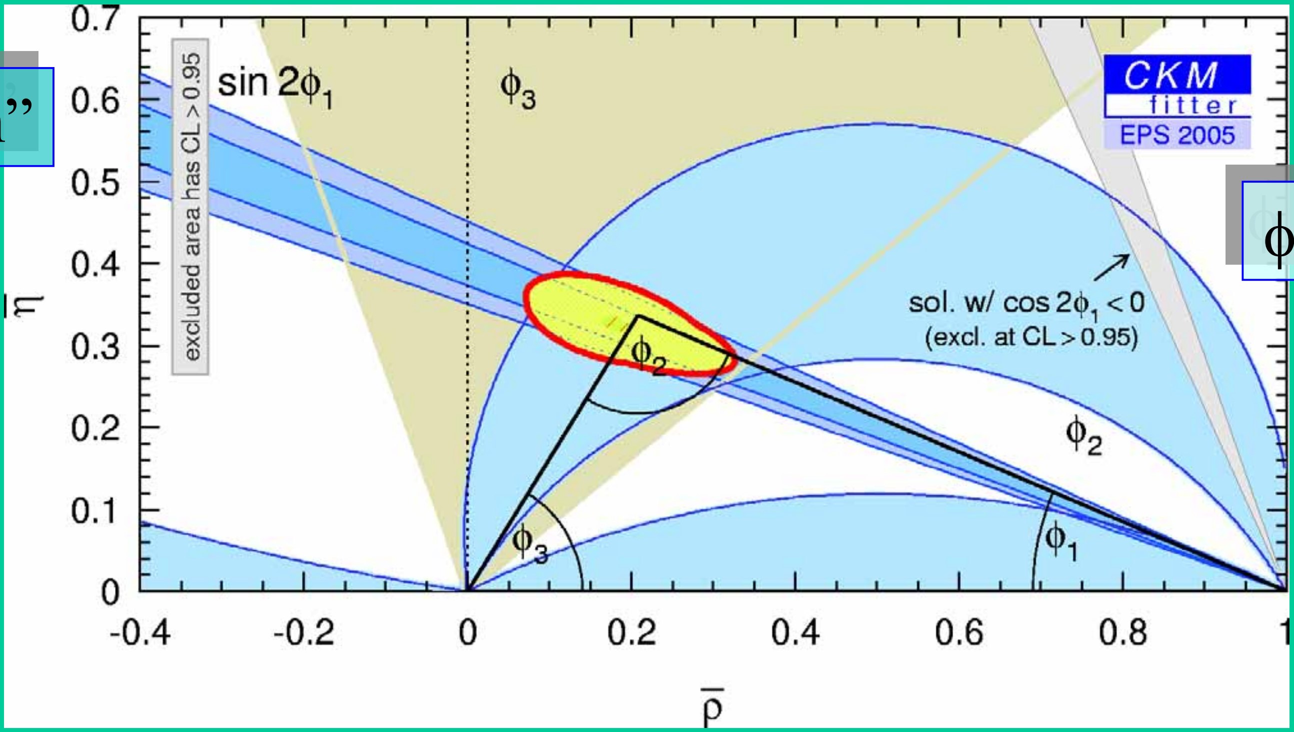


$$A = -0.07 \pm 0.028 \pm 0.018$$

$B^0 \to J/\psi K^0$,
$\psi(2S) K_S$,
$\eta_c K_S$,
$\chi_{c1} K_S$,
$J/\psi K^{*0}$

α/ϕ_2

ϕ_1 "beam"



ϕ_2 "banana"

$$B \rightarrow \pi^+\pi^-,\ \pi^\pm\pi^0,\ \pi^0\pi^0$$

$$B \rightarrow \rho^0\rho^0,\ \rho^\pm\rho^0,\ \rho^+\rho^-$$

$$B^0 \rightarrow (\rho\pi)^0$$

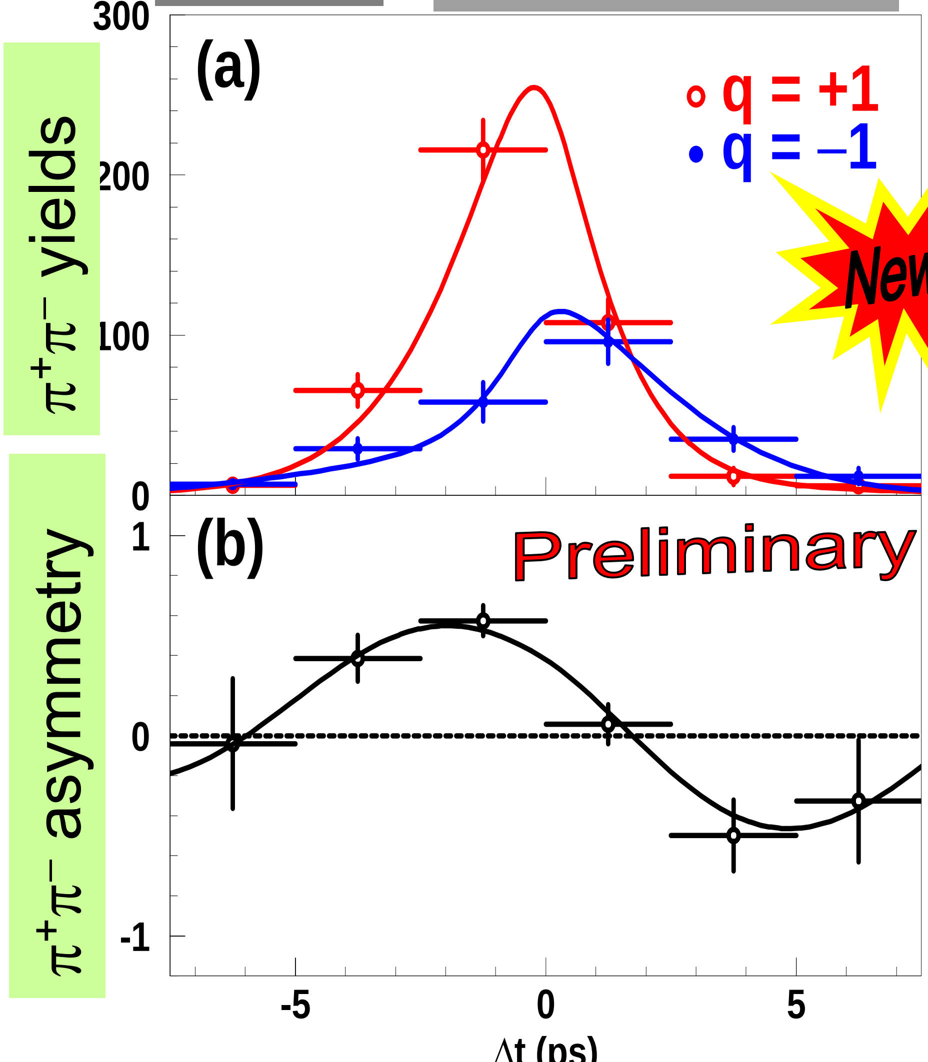
M.Hazumi

Belle 2006: $B^0 \to \pi^+\pi^-$ decay (CP asymmetry)

H. Ishino

532M $B\bar{B}$

BELLE-CONF-0649



background subtracted

1464±65 signal events

New !

$$A_{\pi\pi} = +0.55 \pm 0.08 \pm 0.05$$

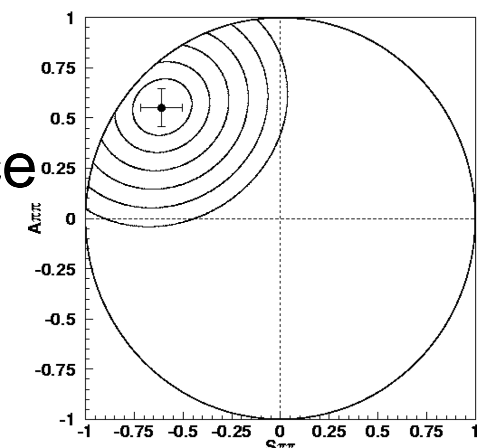
$$S_{\pi\pi} = -0.61 \pm 0.10 \pm 0.04$$

first error: stat., second: syst.

Large Direct CP violation (5.5σ)

Large mixing-induced CP violation (5.6σ)

confidence level contour



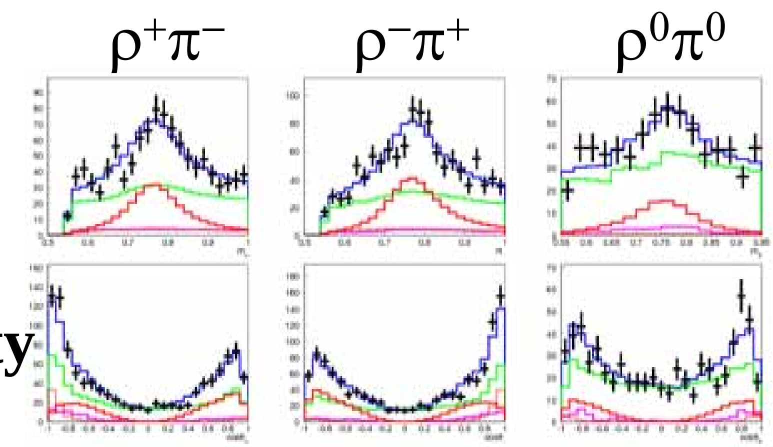
2 body π-K combinations

	BaBar		Belle	
	$BR \times 10^{-6}$	A_{cp}	$BR \times 10^{-6}$	A_{cp}
$B^+ \to \pi^+\pi^0$	$5.12 \pm 0.47 \pm 0.29$	$-0.019 \pm 0.088 \pm 0.014$	$6.6 \pm 0.4^{+0.4}_{-0.5}$	$+0.07 \pm 0.06 \pm 0.01$
$B^0 \to \pi^+\pi^-$	$5.8 \pm 0.4 \pm 0.3$	$+0.16 \pm 0.11 \pm 0.03$	$5.1 \pm 0.2 \pm 0.2$	$+0.55 \pm 0.08 \pm 0.05$
$B^0 \to \pi^0\pi^0$	$1.48 \pm 0.26 \pm 0.12$	$+0.33 \pm 0.36 \pm 0.08$	$1.1 \pm 0.3 \pm 0.1$	$+0.44^{+0.73+0.04}_{-0.62-0.06}$
$B^0 \to K^+\pi^-$	$19.7 \pm 0.6 \pm 0.6$	$-0.108 \pm 0.024 \pm 0.007$	$20.0 \pm 0.4^{+0.9}_{-0.8}$	$-0.093 \pm 0.018 \pm 0.008$
$B^0 \to K^0\pi^0$	$10.5 \pm 0.7 \pm 0.5$	$-0.20 \pm 0.16 \pm 0.03$	$9.2^{+0.7+0.6}_{-0.6-0.7}$	$-0.05 \pm 0.14 \pm 0.05$
$B^+ \to K^+\pi^0$	$13.3 \pm 0.56 \pm 0.64$	$+0.016 \pm 0.041 \pm 0.010$	$12.4 \pm 0.5^{+0.7}_{-0.6}$	$+0.07 \pm 0.03 \pm 0.01$
$B^+ \to K^0\pi^+$	$23.9 \pm 1.1 \pm 1.0$	$-0.029 \pm 0.039 \pm 0.010$	$22.9^{+0.8}_{-0.7} \pm 1.3$	$+0.03 \pm 0.03 \pm 0.01$
$B^0 \to K^0\overline{K^0}$	$1.08 \pm 0.28 \pm 0.11$	$0.40 \pm 0.41 \pm 0.06$	$0.86^{+0.24}_{-0.21} \pm 0.09$	$-0.57^{+0.72}_{-0.65} \pm 0.13$
$B^0 \to K^+K^-$	< 0.40		< 0.25	
$B^+ \to \overline{K^0}K^+$	$1.61 \pm 0.44 \pm 0.09$	$0.10 \pm 0.26 \pm 0.03$	$1.22^{+0.33+0.13}_{-0.28-0.16}$	$+0.13^{+0.23}_{-0.24} \pm 0.02$

M.Hazumi

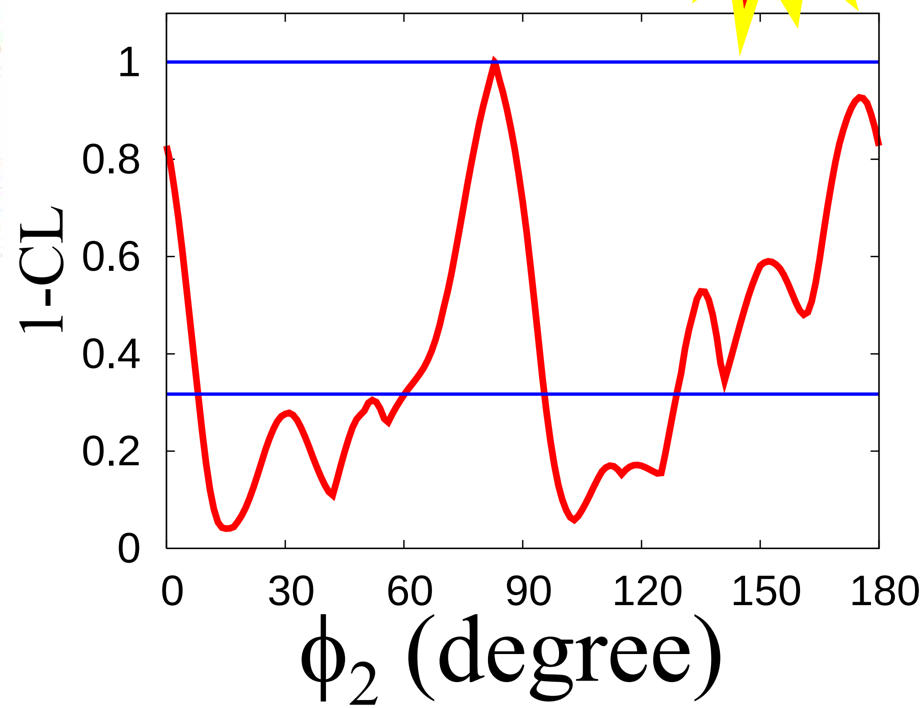
Belle 2006: ϕ_2 from B → ρπ
Dalitz analysis + isospin (pentagon) analysis

- 26(Dalitz) + 5(Br($\rho^\pm\pi^\pm$), Br($\rho^+\pi^0$), Br($\rho^0\pi^+$), $A(\rho^+\pi^0)$, and $A(\rho^0\pi^+$))



Preliminary

Results



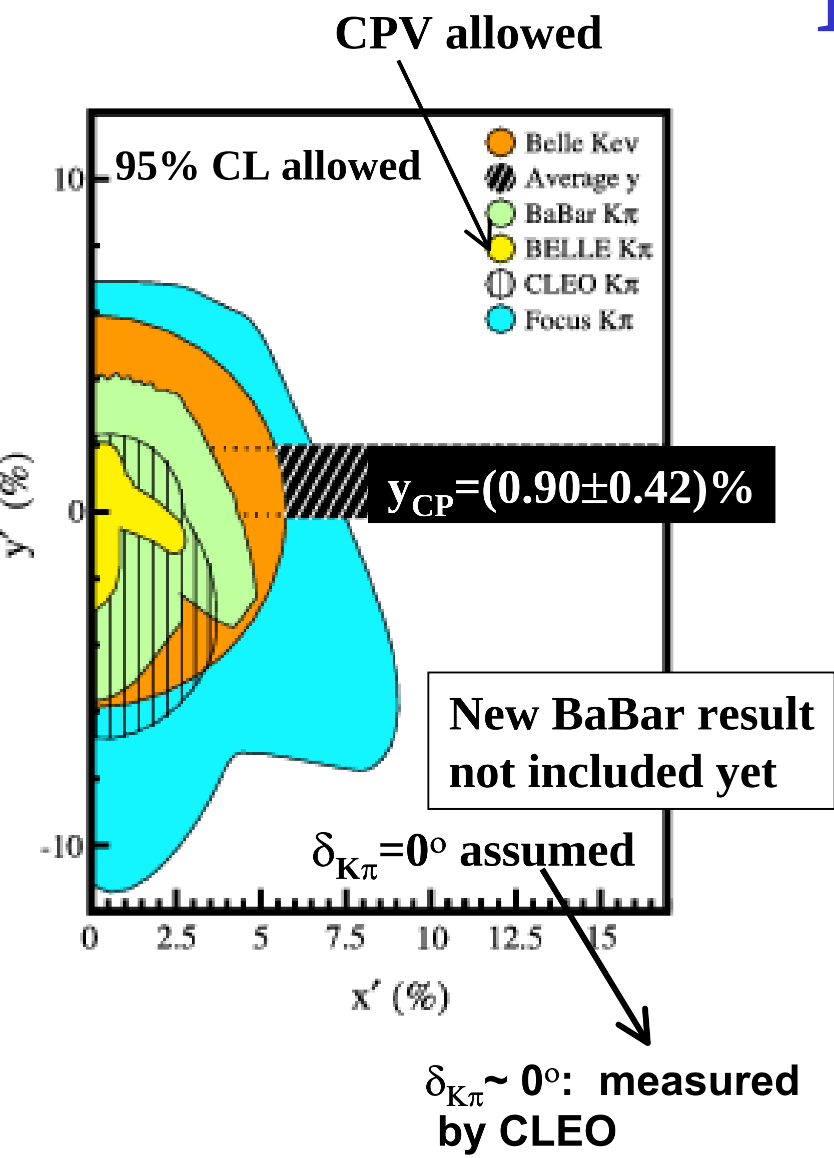
$$\alpha/\phi_2 = [83^{+12}_{-23}]^\circ$$ (1σ)

(no constraint at 2σ)

will be included in the world average

BELLE-CONF-0650

D^0-D^0 mixing status



NO MIXING (x,y)=(0,0) excluded:
- ✓ ~2.1σ Belle $D^0 \to K\pi$ (assuming no CPV)
- ✓ ~2.3σ BaBar $D^0 \to K2\pi/K3\pi$
- ✓ ~2.2σ Average y_{CP}

Many results coming soon:
- ➢BaBar $D^0 \to K\pi$
- ➢Belle $D^0 \to K2\pi/K3\pi$
- ➢BaBar & Belle updates of y_{CP} (5 × data set available)
- ➢BaBar semileptonic
- ➢BaBar & Belle $D^0 \to K_S\pi\pi$ (Dalitz)

CLEOc with projected data set can reach UL on R_M ~ few×10^{-4} (on x ~ 2%)

***D^0D^0* mixing observation may be on the horizon**

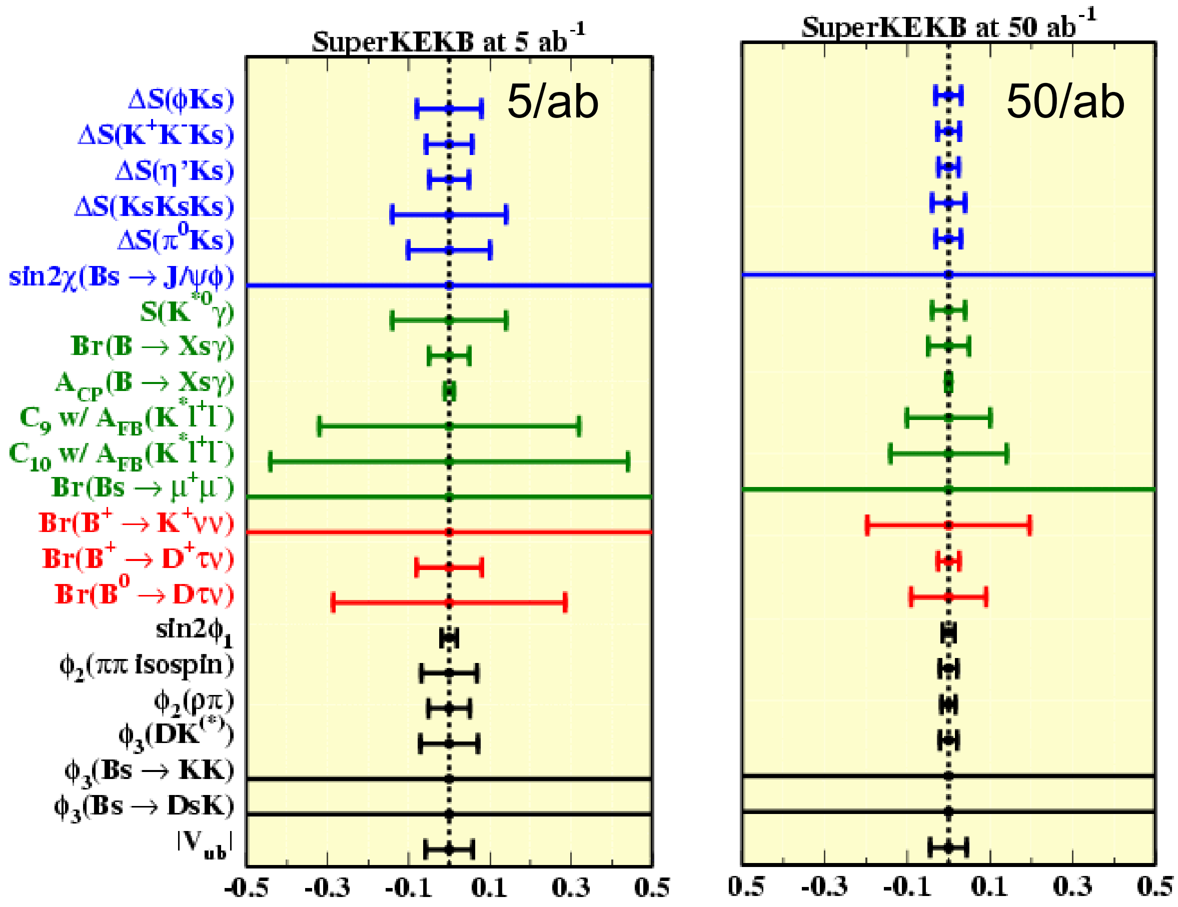
Super B factory

Current Belle+BaBar integrated luminosity: L(now)~1/ab

In many aspects asymmetric B factories are complementary to B physics in hadron machine (unique for neutrino and tau modes)

5X L(now)

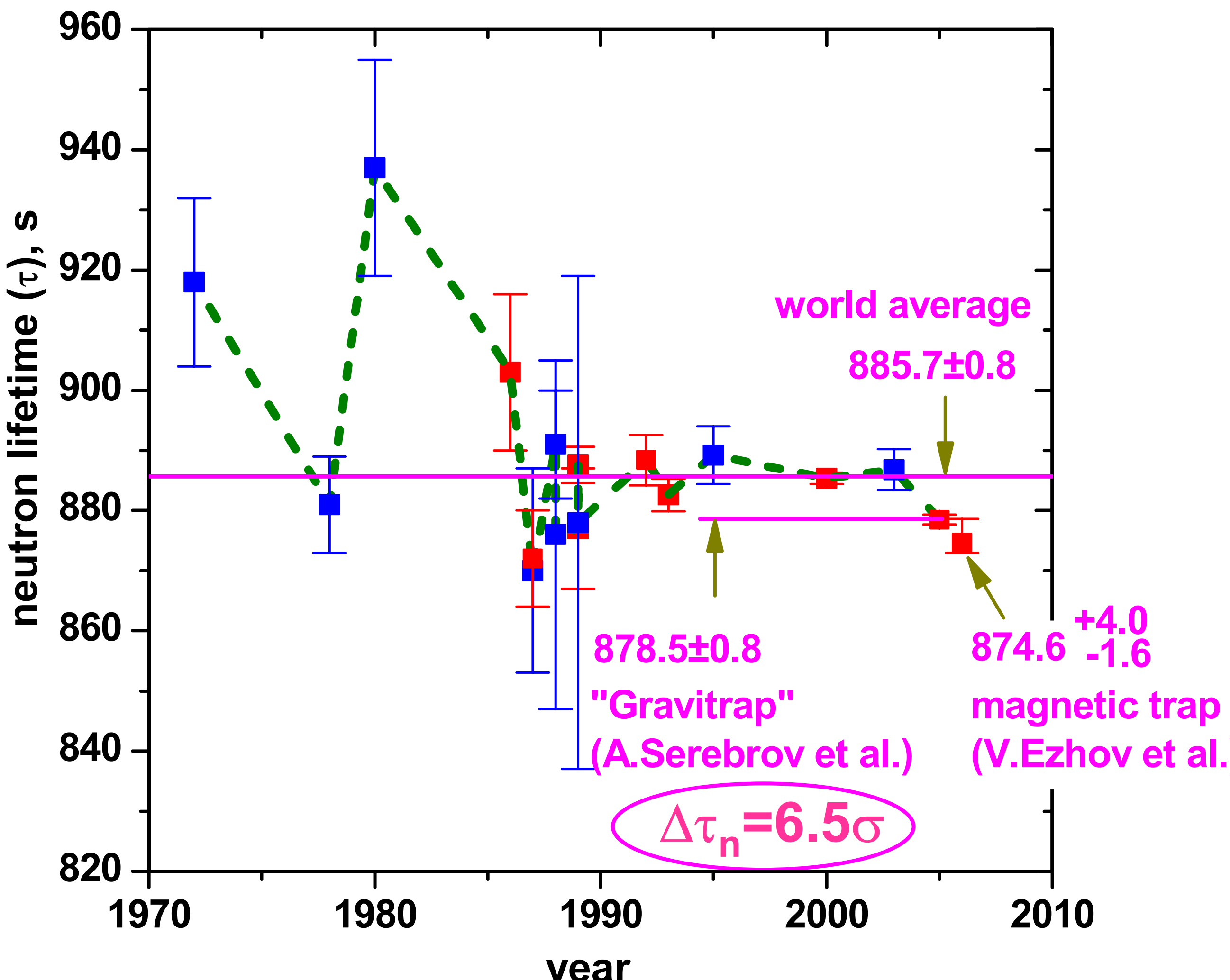
50X L(now)



Super KEK LoI

Neutron lifetime measurements → V_{ud}

A.Serebrov



A.Zalewska, SPC, 17.10.2006

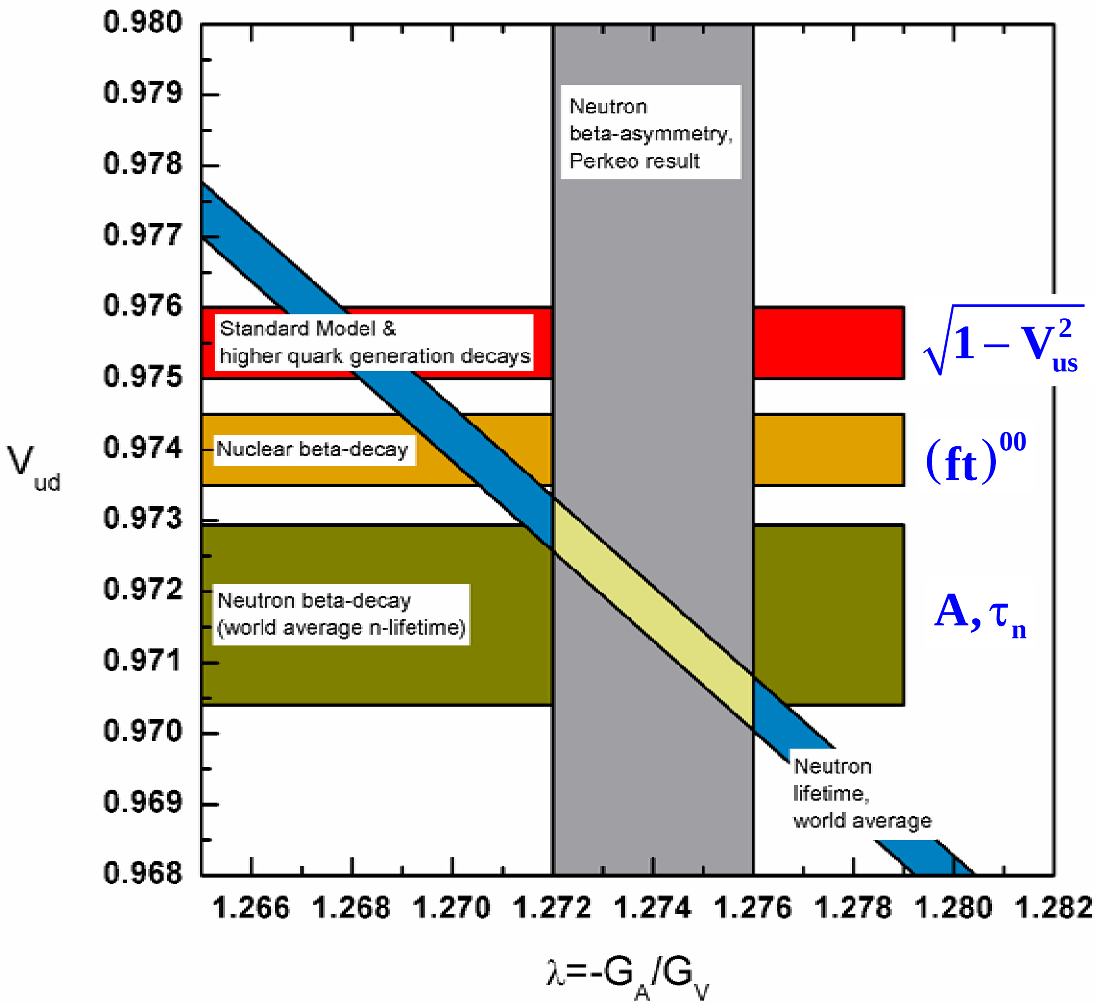
Neutron lifetime measurements with gravitational trap of ultracold neutrons

PNPI-ILL-JINR

Setup for the measurement of n-lifetime at ILL (Grenoble, France)

A.Serebrov

Neutron decay and Standard Model



A=-0.1189(8) PERKEO 2002

$\tau_n = 885.7 \pm 0.8$ **s PDG(2003)**

$^{n}V_{ud} = 0.9717(13)$

$^{00}V_{ud} = 0.9738(5)$

$V_{us} = 0.2196(23)$ **PDG(2003)**

$V_{ub} = 0.0036(9)$ **PDG(2003)**

$$\left|^{n}V_{ud}\right|^2 + \left|V_{us}\right|^2 + \left|V_{ub}\right|^2 = 1 - \Delta = 0.9924(28)$$

$$\Delta = 0.0076(28) = 2.7\sigma$$

$$^{n}V_{ud} - {}^{00}V_{ud} = -0.0021(26) = -0.8\sigma$$

A.Zalewska, SPC, 17.10.2006

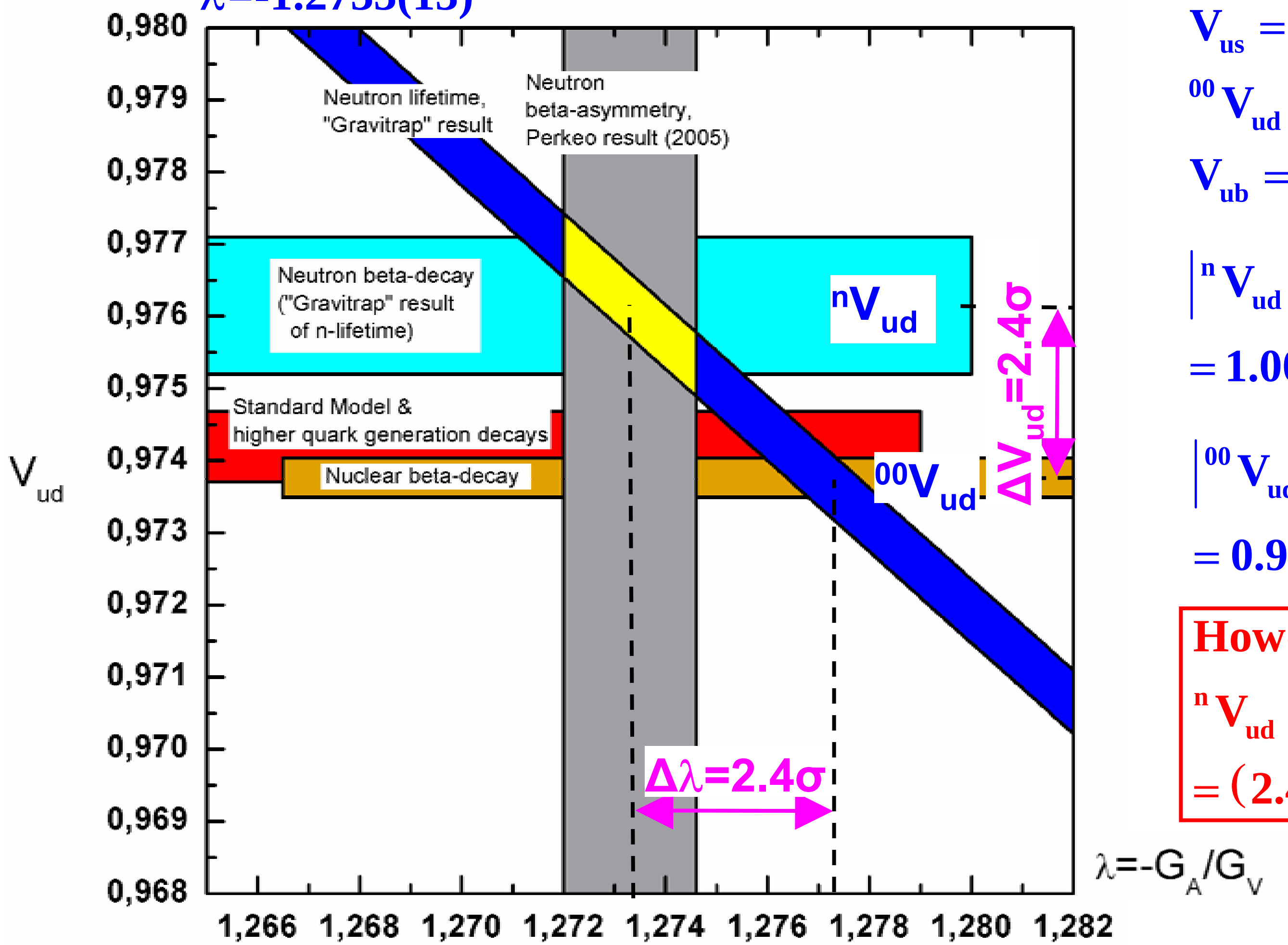
A.Serebrov

Data analysis with the most precise measurements of neutron decay

$\tau_n = 878.5 \pm 0.8$ s (A.Serebrov et al. 2005)

A=-0.1187(5) (PERKEO 2005)

λ=-1.2733(13)



$^nV_{ud} = 0.97614(95)$

$V_{ud} = \sqrt{1 - V_{us}^2} = 0.97420(47)$

$V_{us} = 0.2257(21)$ PDG06

$^{00}V_{ud} = 0.97377(27)$ PDG06

$V_{ub} = 0.0043(3)$ PDG06

$\left|^nV_{ud}\right|^2 + \left|V_{us}\right|^2 + \left|V_{ub}\right|^2 =$
$= 1.0038(28)$ Δ=-1.4σ

$\left|^{00}V_{ud}\right|^2 + \left|V_{us}\right|^2 + \left|V_{ub}\right|^2 =$
$= 0.9992(15)$ Δ=+0.5σ

However
$^nV_{ud} - ^{00}V_{ud} =$
$= (2.4 \pm 1.0) \cdot 10^{-3}$

2.4σ

The improvement of the accuracy of A-measurements (factor of 3 or more) is extremely important.

Neutron decay and cosmology

G. J. Mathews, T. Kajino, T. Shima, Phys. Rev. D 71, 021302(R) (2005)

$$(f\tau_n)^{-1} = \frac{G_F^2}{2\pi^3}\left(1+3g_A^2\right)m_e^5$$

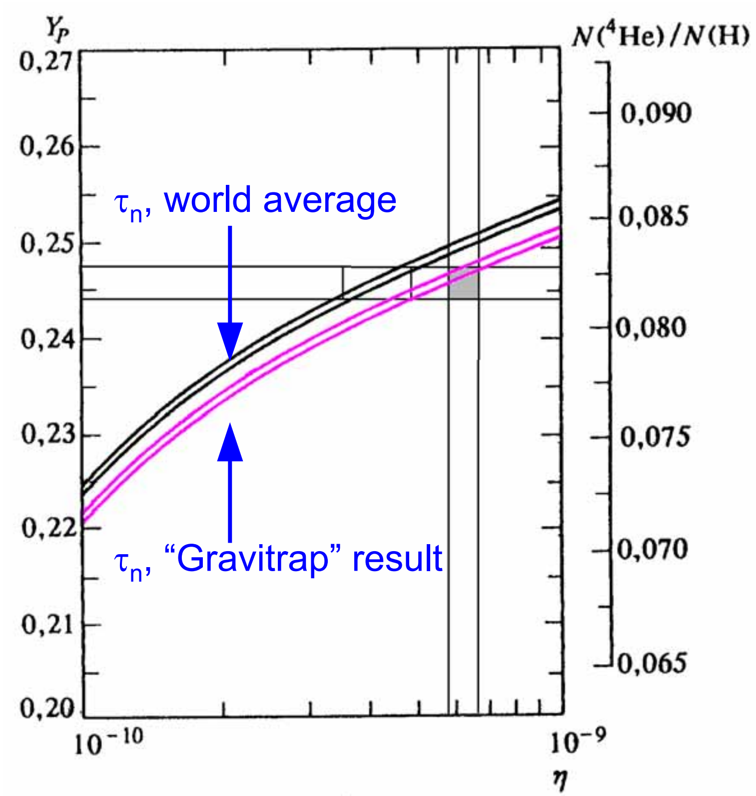
$$\Gamma = (7/60)\pi(1+3g_A^2)G_F^2T^5$$

$$H \approx [(8/3)\pi G\rho_\gamma]^{1/2}$$

$$\rho_\gamma = (\pi^2/30)g_* T^4$$

$$T_f \approx 1\ \mathrm{MeV}$$

$$n/p = \exp\{-\Delta m/T_f\}$$



$$Y_p \approx 2n/(n+p) = 2(n/p)/(n/p+1)$$

$$\Delta\tau_n = 1\% \quad\rightarrow\quad \Delta Y = 0.75\%\ (\pm 0.61\%)$$

$$\Delta\tau_n = 1\% \quad\rightarrow\quad \Delta\eta = 17\%\ (\pm 3.3\%)$$

New τ_n=(878.5±0.8) s confirms n_b/n_γ from CMB.

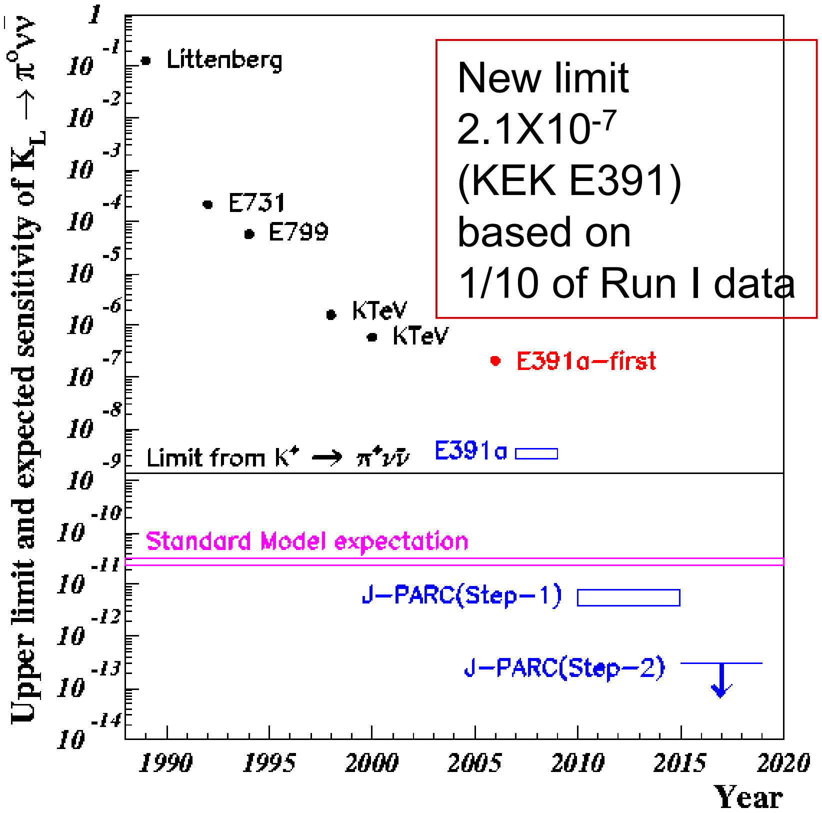
Future of Kaon physics

- $K^0_L \to \pi^0 \nu \nu$ **KEK E391=> JPARC**
  - **JPARC-P14**
- $K^+ \to \pi^+ \nu \nu$
  - **CERN-SPSC-P-326 (a.k.a. NA48/3)**

    65 signal, 9±3Bgds/year
  - **JPARC-P09**
- **Transverse μ polarisation in** $K^+ \to \pi^0 \mu^+ \nu$ **(T-Violation)**
  - **JPARC-P06**
- **Other Initiatives:**
  - **DANAE (Frascati)**
  - **OKA (Protvino)**

$K^0 \to \pi^0 \nu\nu$

M.Doroshenko



Spectroscopy - examples

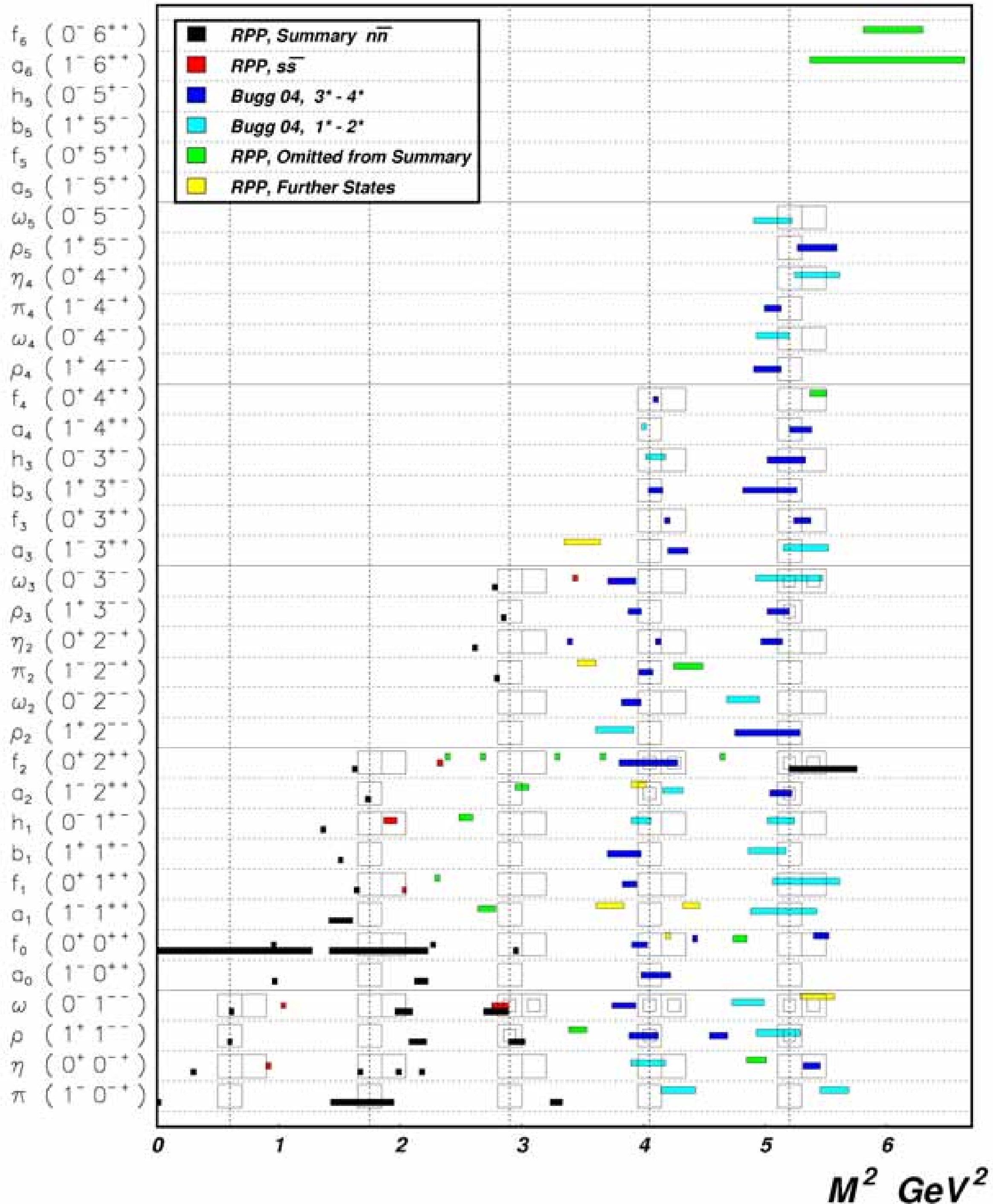
➔ Light quark states regularities

➔ Heavy charmonium-like states

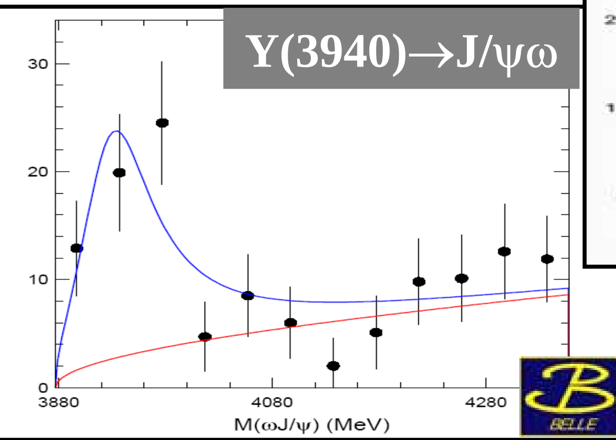
Striking regularities

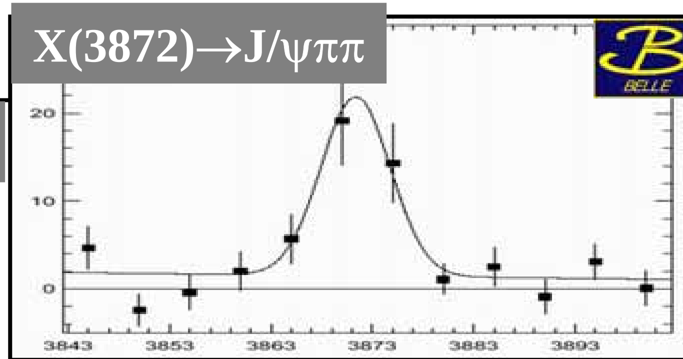
- At high M^2 and J:
- Trajectories are linear in (M^2,J) plane
- Trajectories are linear in (M^2,n) plane
- Trajectories are parallel
- The states $I^GJ^{PC}=0^+0^{++}$ are overpopulated
- The states $I^GJ^{PC}=0^+2^{++}$ are overpopulated
- Some states are suspicious: $\pi_2(1880)$, $\eta_2(1870)$ – candidates to hybrids (Anisovich, Bugg, 2004)
- ≈30 states are missed

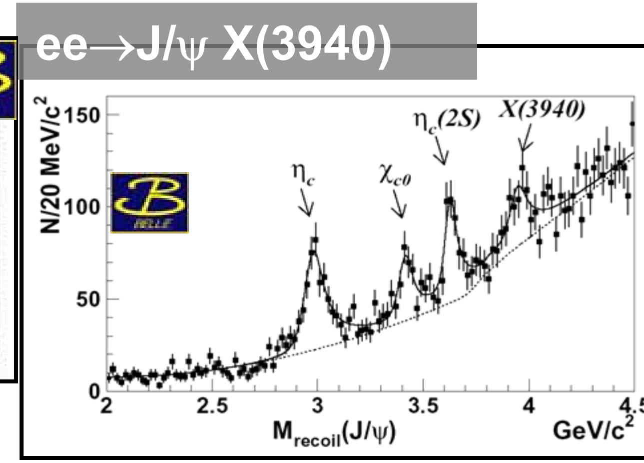
A.Zaitsev 2006

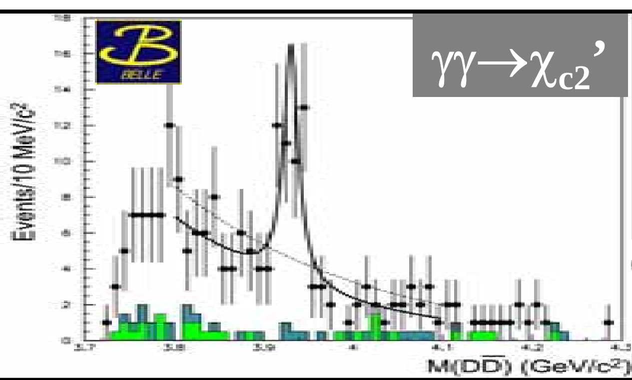


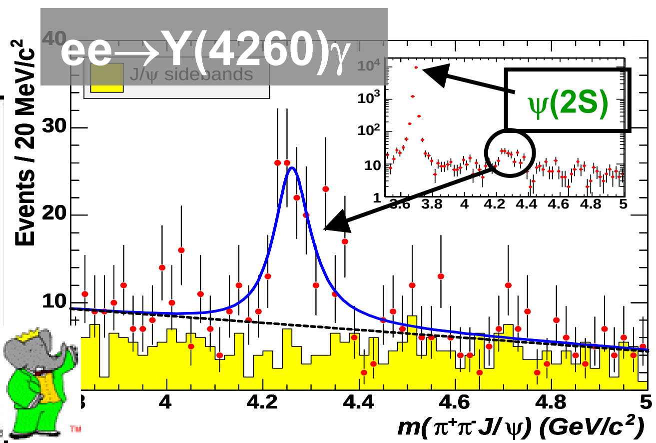
XYZ

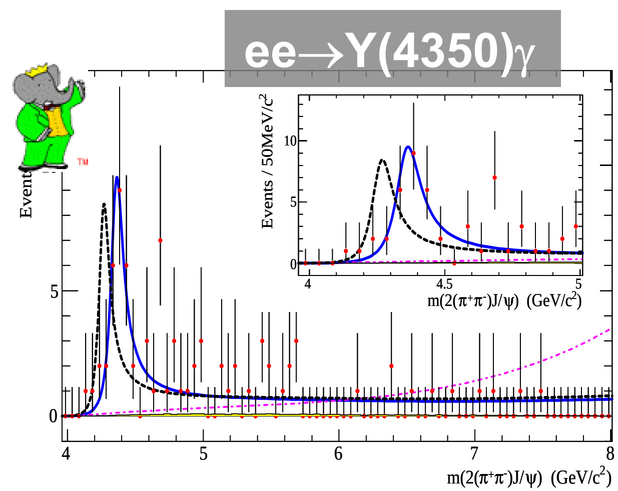












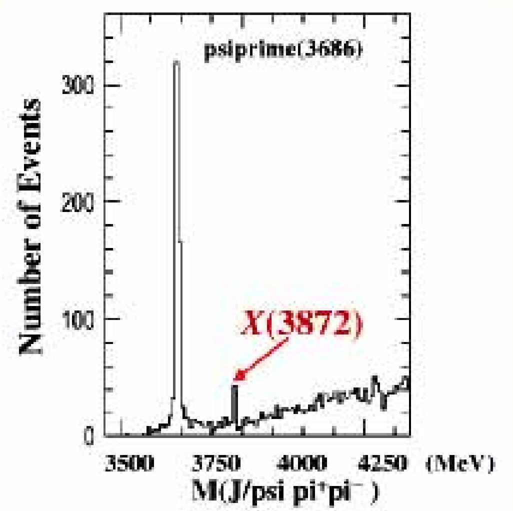
Many new charmonium states: 6 above DD threshold
+ 2 below (η_c(2S) and h_c) for last 4 years
Most of heavy charmonium like stares are not explained by theory

A.Zalewska, SPC, 17.10.2006

P.Pakhlov

Near or above the open flavour threshold exotic states are expected to appear in the spectrum: hybrids, molecular states, tetraquarks, ...

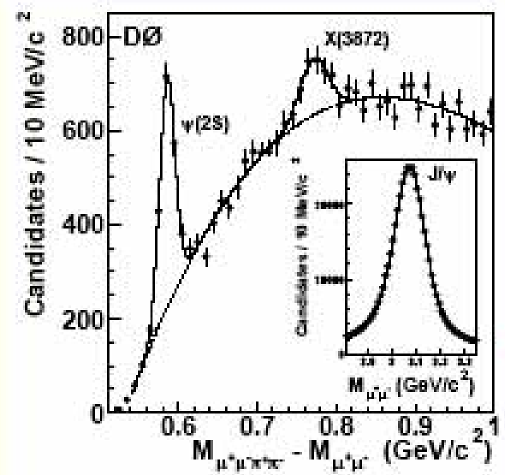
$X(3872)$



in $B \to KX \to K\pi^+\pi^- J/\psi$

$M = 3872.0 \pm 0.6 \pm 0.5$ MeV

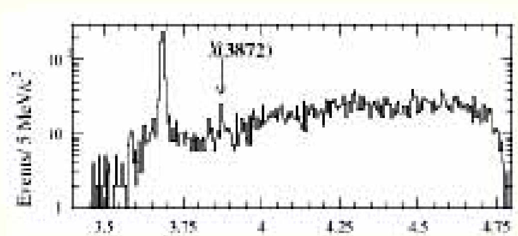
BELLE 03, Majumder @ ICHEP 06



in $p\bar{p} \to X$
$\to \pi^+\pi^- J/\psi$

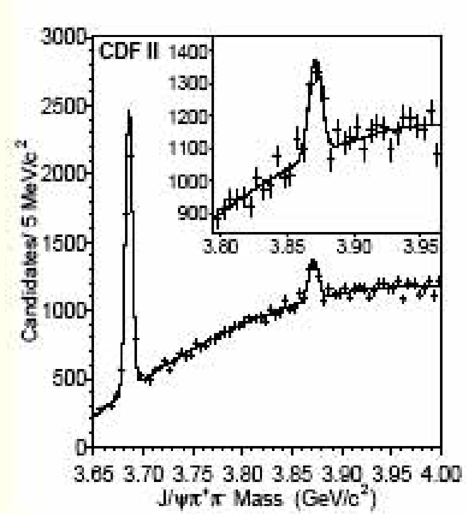
$M = 3871.8 \pm 3.1$
± 3.0 MeV

D0 04



$M = 3873.4 \pm 1.4$ (stat) MeV

BABAR 05, Lou @ ICHEP 06



$M = 3871.3 \pm 0.7$
± 0.4 MeV

CDF 04

Kreps @ ICHEP 06

A.Vairo

$X(3872)$: summary of properties

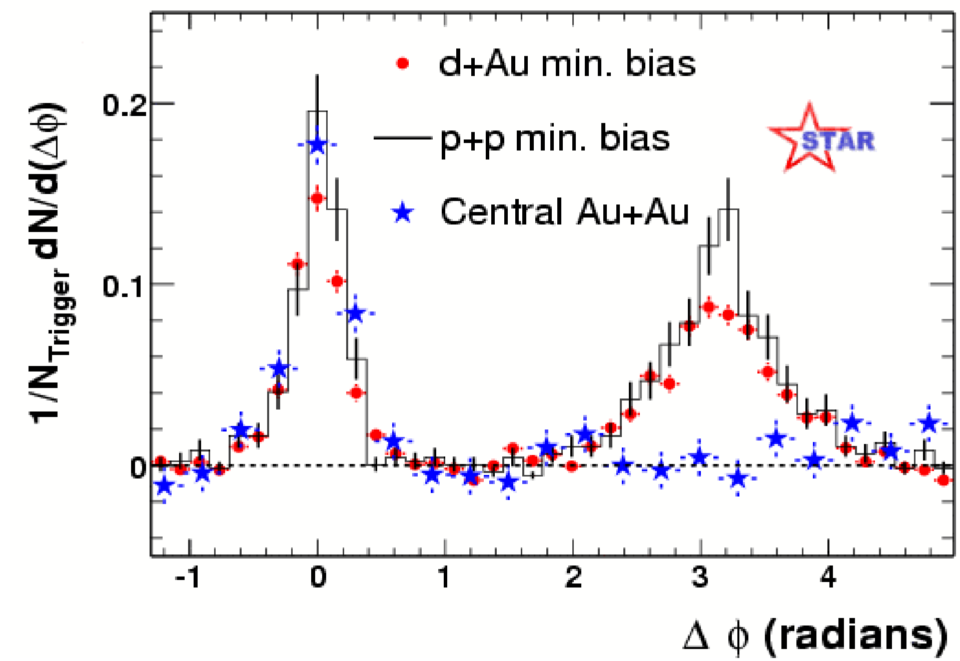
A.Vairo

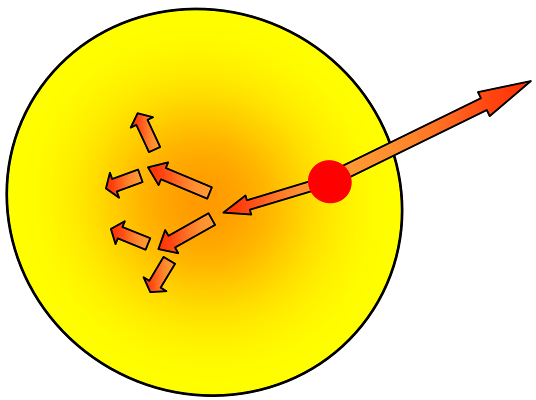
- $\Gamma_X < 2.3$ MeV (BELLE 03)
- Decay modes: $X \to \pi^+\pi^- J/\psi$ (discovery mode), $\pi^+\pi^-\pi^0 J/\psi$ (BELLE 05), $\gamma J/\psi$ (BELLE 05), $D^0 \bar{D}^0 \pi^0$ (BELLE 06).
- The dominant mode is: $\dfrac{\mathcal{B}(X \to D^0 \bar{D}^0 \pi^0)}{\mathcal{B}(X \to \pi^+\pi^- J/\psi)} = 9.4^{+3.6}_{-4.3}$ BELLE 06, but the threshold enhancement peaks at $3875.4 \pm 0.7^{+1.2}_{-2.0}$ MeV: is it $X(3872)$?
- $X \to \gamma J/\psi \Rightarrow C = +$.
- Angular distribution analyses favour the spin parity: $J = 1^+$ BELLE 05, CDF 05
- $\dfrac{\mathcal{B}(X \to \pi^+\pi^-\pi^0 J/\psi)}{\mathcal{B}(X \to \pi^+\pi^- J/\psi)} = 1.0 \pm 0.4 \pm 0.3$ BELLE 05 $\Rightarrow X$ is a mixture of $I = 1$ and $I = 0$ states.
- The substantial $I = 1$ component requires that X contains $u\bar{u}/d\bar{d}$ pairs in addition to hidden charm, which thus qualifies it as a four-quark state. Voloshin 06

Heavy ions

- RHIC - jet quenching
- J/ψ supression
- Phase transition

Suppression of away-side jet





$$\left(\frac{dE}{dx}\right)_0 \approx 13.8 \pm 3.9 \text{ GeV/fm} \Longleftrightarrow \left(\frac{dE}{dx}\right)_{\text{cold matter}} \approx 0.5 \text{ GeV/fm}$$

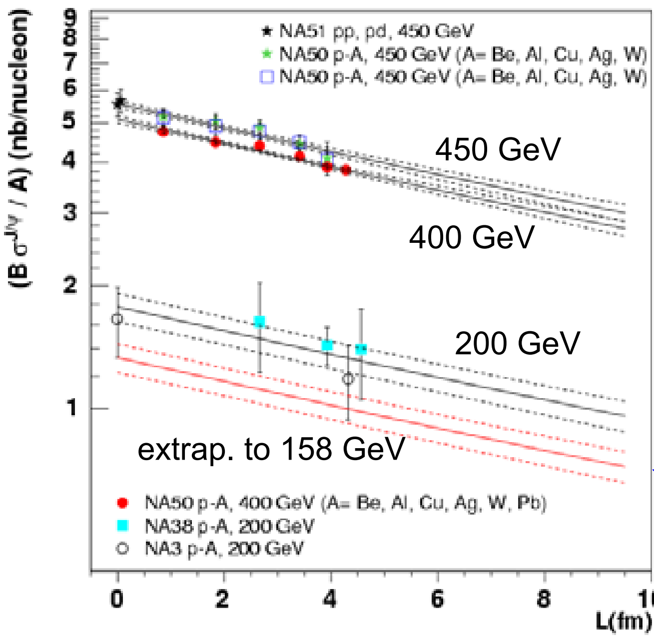
$$\tau_0 = 0.2 \text{ fm/c}$$

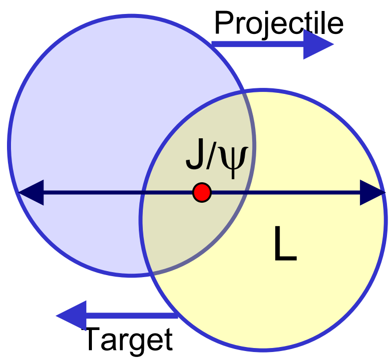
Initial Density about 30 times of that in a Cold Au Nucleus

X-N.Wang

J/ψ production from p-A to Pb-Pb collisions

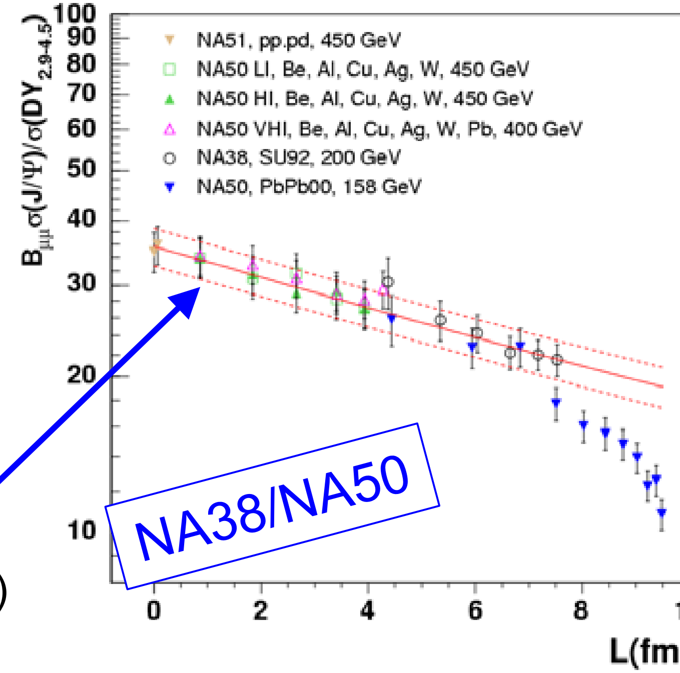
The study of J/ψ production in p-A collisions at 200, 400 and 450 GeV, by NA3, NA38, NA50 and NA51, gives a "J/ψ absorption cross-section in normal nuclear matter" of 4.18 ± 0.35 mb.





J/ψ normal nuclear absorption curve

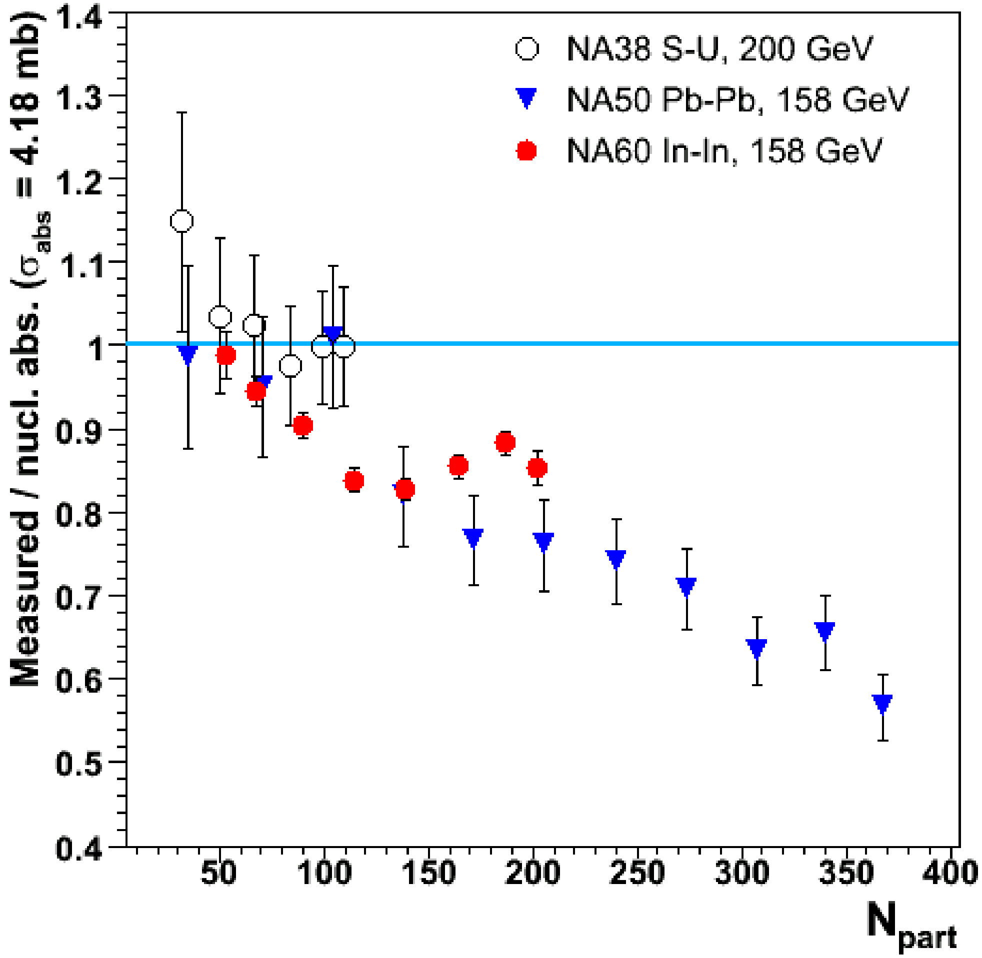
$S(J/\psi) \sim \exp(-\rho\, L\, \sigma_{abs})$



In S-U and *peripheral* Pb-Pb collisions, the data points follow this normal nuclear absorption, which scales with L, the length of nuclear matter crossed by the (pre-resonant) J/ψ.

In central Pb-Pb collisions the L scaling is broken and an "anomalous suppression" sets in.

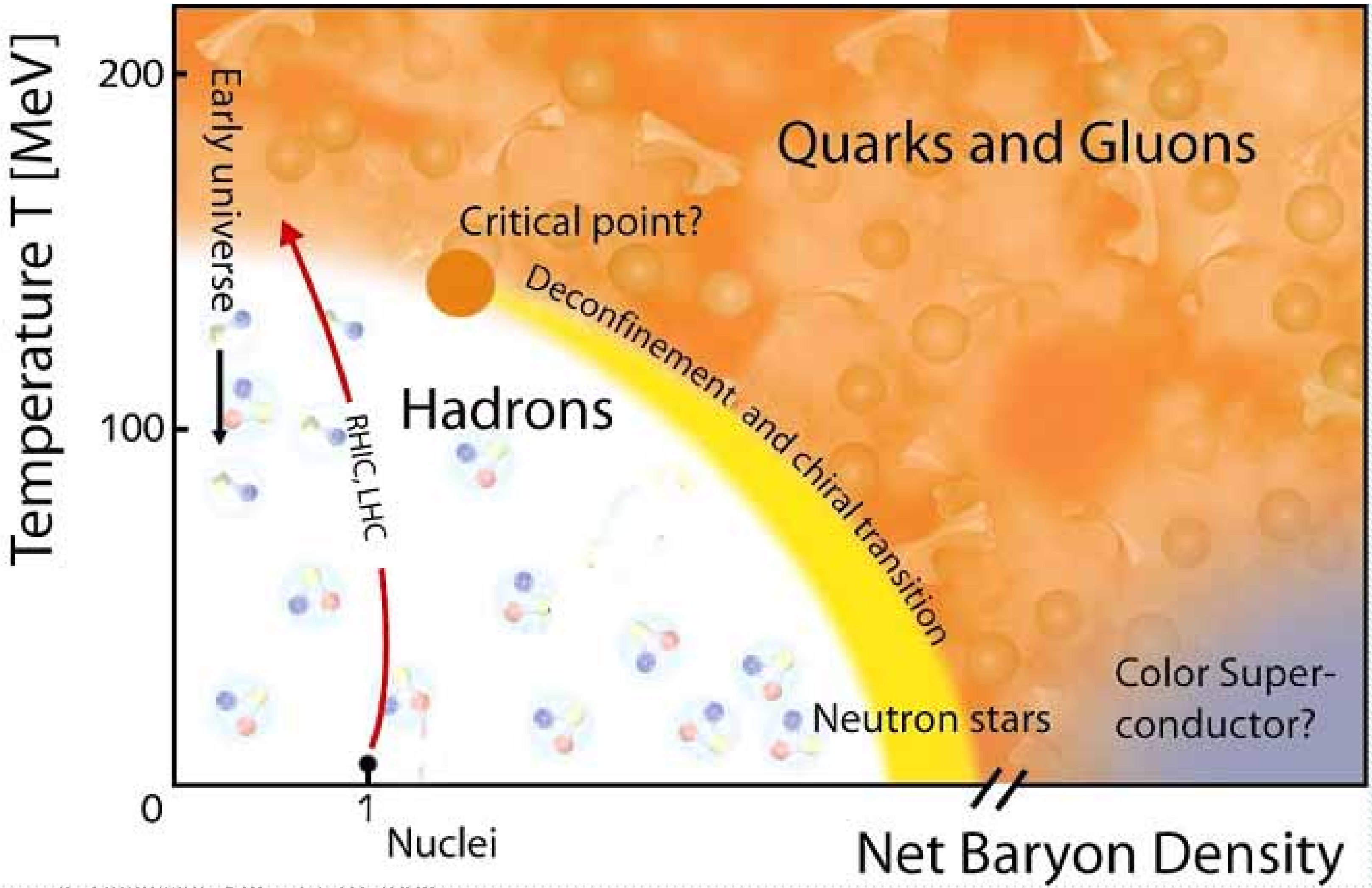
Comparison with other SPS results



The J/ψ suppression patterns are in fair agreement when plotted versus N_{part}

Woehri: ICHEP06

QCD Phase Diagram



News from theory

- ➔ Progress in „practical theory"
- ➔ Gravity/gauge correspondence
- ➔ Little Higgs model = a model of composite Higgs - often quoted in Moscow

On theory side:

V. Rubakov

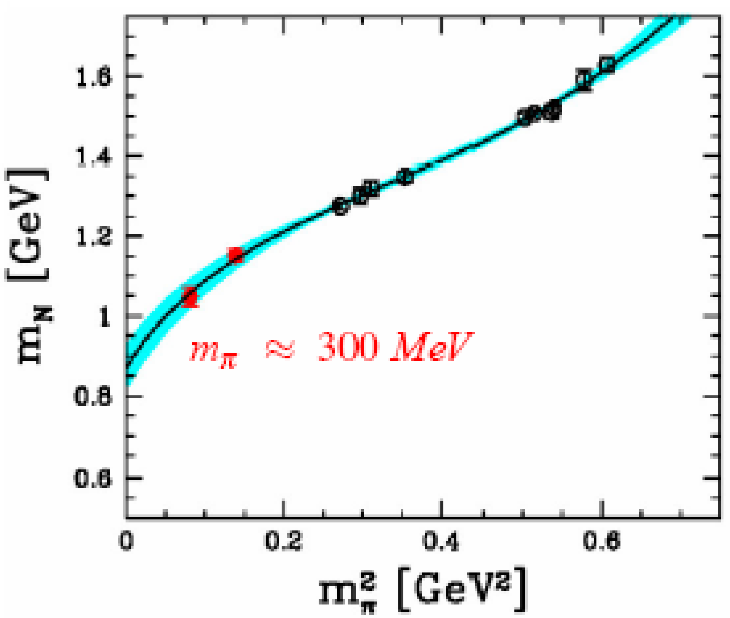
- Progress in "practical theory"
  - Impressive list of NLO results, crucial NNLO calculations

    Marchesini

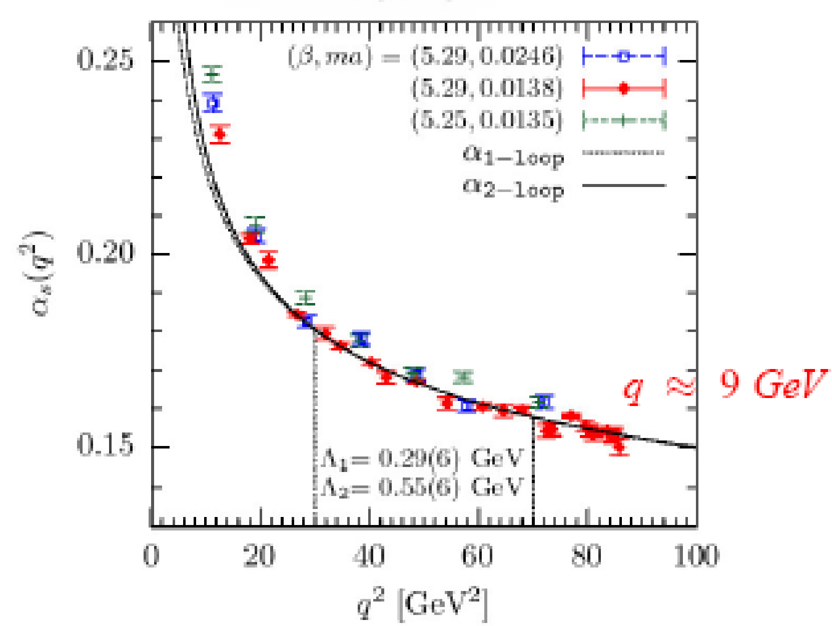
  - Lattice matches chiral limit and perturbative QCD domain. With dynamical quarks!

    Schierholz

Nucleon mass



$\alpha_s(q^2)$



- Gravity/gauge correspondence

Marchesini, Schomerus

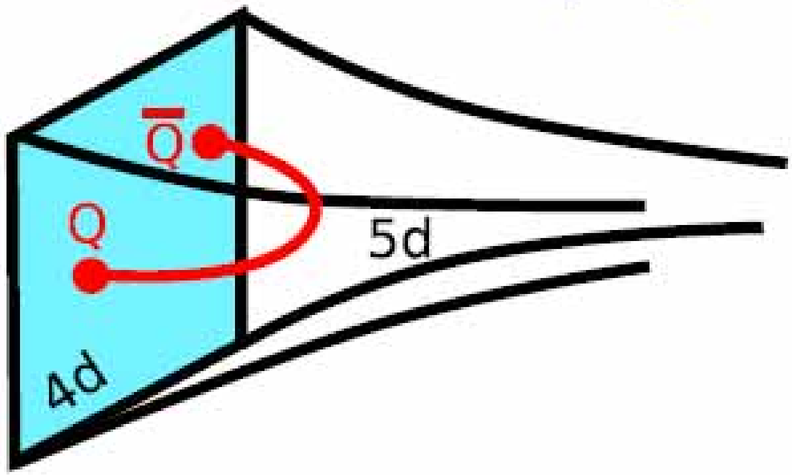
- Started up as "theoretical theory" conjecture

adS / CFT

String theory in anti-de Sitter (5+5)-dimensional space-time

$\mathcal{N}$=4 super-Yang-Mills in Minkowski 4-dimensional space-time

Weak coupling <=> Strong coupling

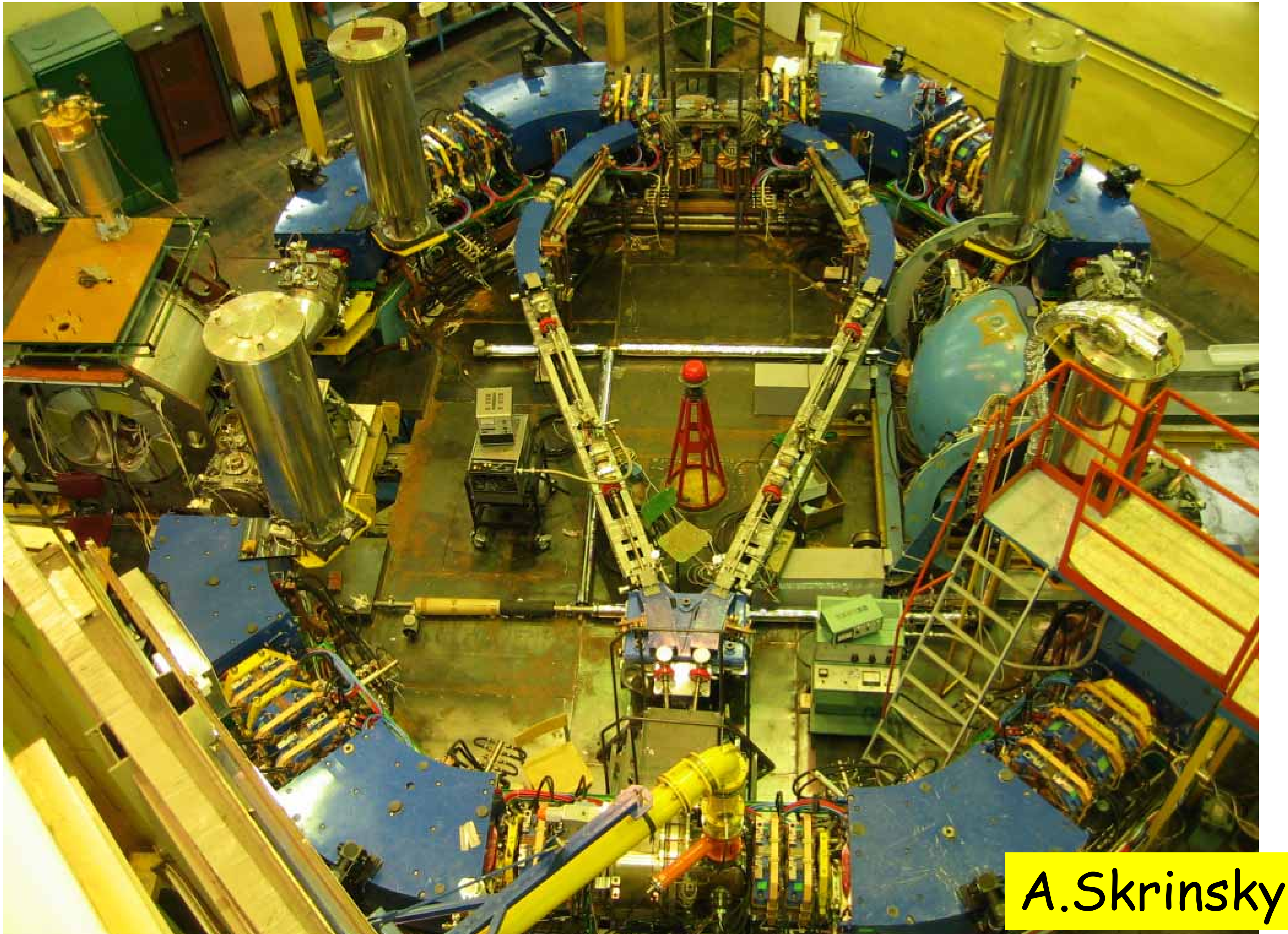


Calculable strongly coupled theory in 4d

V. Rubakov

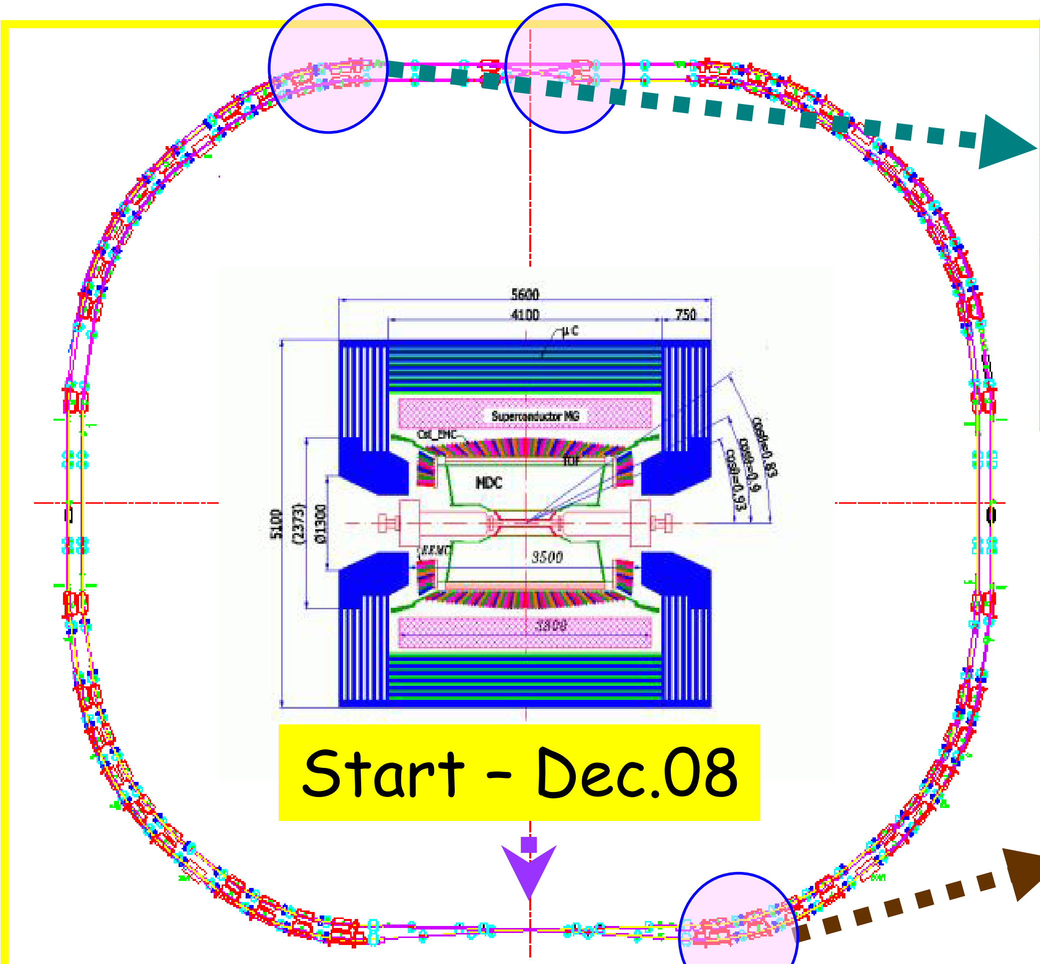
HEP instrumentation

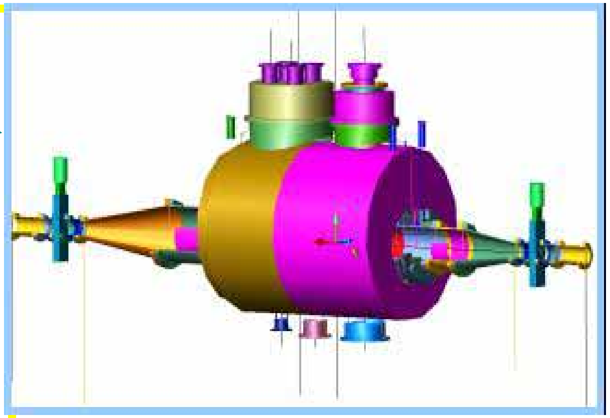
- Colliders – recent or near future machines
- ILC detector - particle flow calorimetry
- Conference on Instrumentation



New Novosibirsk e+e⁻ collider VEPP-2000

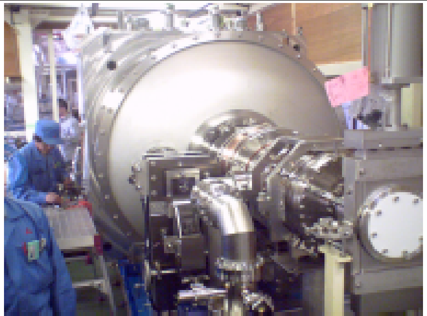
BEPCII: *a double–ring collider the aim is 4 GeV (tot), 1 ·10^{33}cm^{-2}s^{-1}*





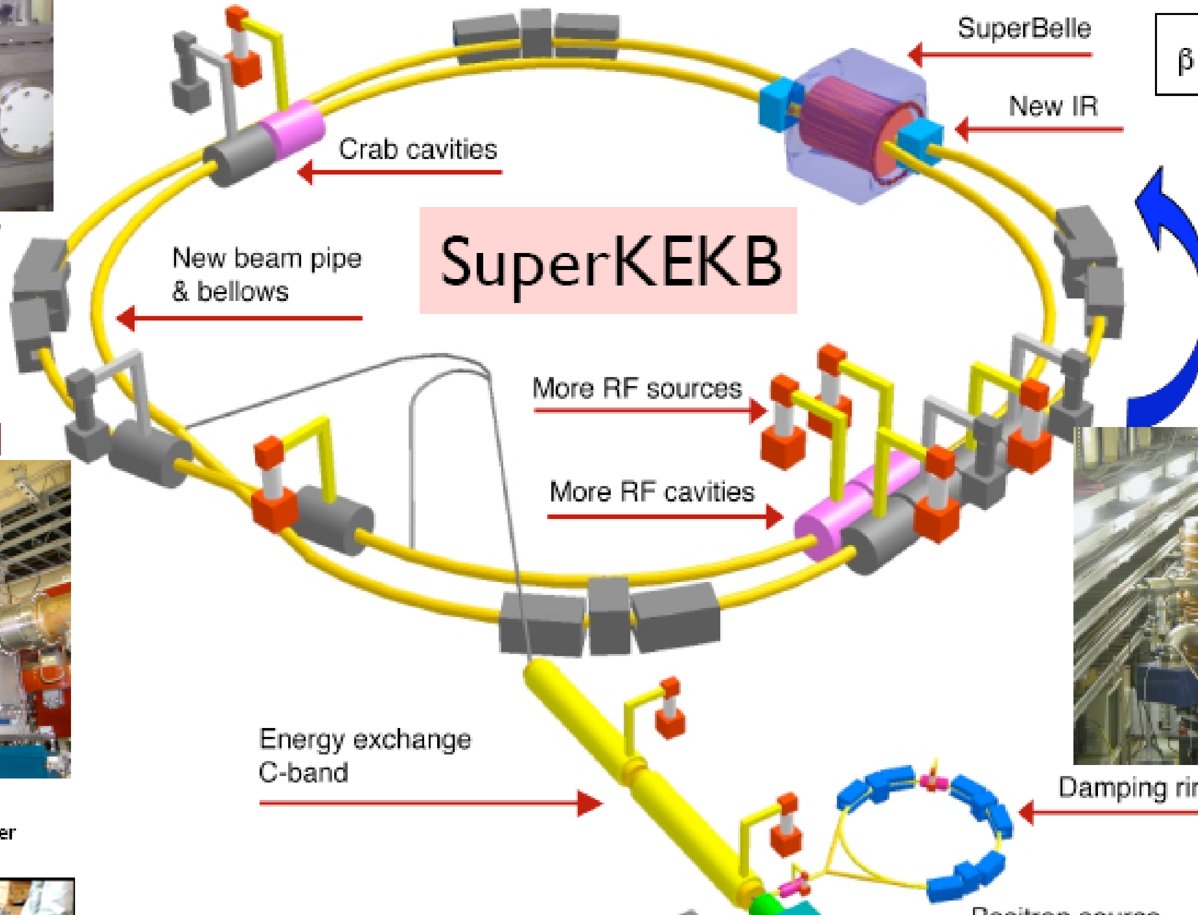
PAST: The BEPC was constructed (1984-1988) for both high energy physics and synchrotron radiation research. The machine operated successfully for more than 15 years since 1989. The peak luminosity was 1.2 ×10^{31} cm^{-2} s^{-1} @1.89 G
Detailed study of J//Ψ and Ψ' rare decays.

A.Skrinsky



Crab cavities will be installed and tested with beam in 2006.

SuperKEKB

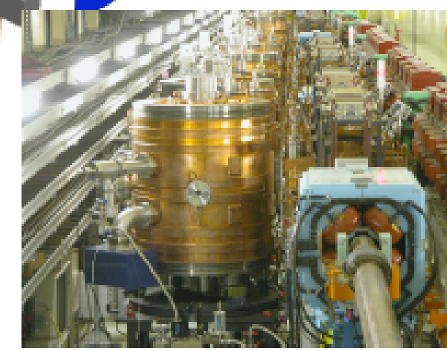


$\beta^*_y = \sigma_z = 3$ mm

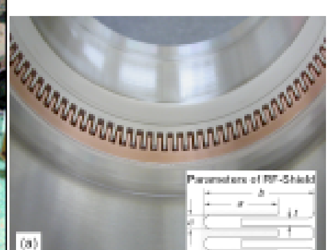
e- 9.4 A

e+ 4.1 A

The superconducting cavities will be upgraded to absorb more higher-order mode power up to 50 kW.



The state-of-art ARES copper cavities will be upgraded with higher energy storage ratio to support higher current.



The beam pipes and all vacuum comp
higher-current-proof design.

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

A.Skrinsky

will reach 8×10^{35} cm^{-2}s^{-1}.

CLIC for several TeV - is it real solution for lepton-antilepton collisions?

I suspect problems with too many beam-strahlung photons in collision, hence:

– too broad spectrum of e+e- collisions.

– lot of photon-photon “high energy” collisions producing lot of hadrons in each bunch-bunch collision;

Maybe, not much better than pp collisions of somewhat higher energy?!???

A.Skrinsky

Trends in technology *enable* advances in detectors

examples

- **Segmentation**
  - Vertex elements with 20 μm and smaller features
  - Calorimetry employing silicon elements
  - Micro Pattern Gas Detectors (MPGD) applications
- **Speed**
  - Faster electronics, low noise and low power
- **Integration**
  - Microelectronics
  - Mechanical sophistication
- **Materials**
  - Rad-hard, robust, thin, etc.
- **Radiation immunity**
  - Understanding damage mechanisms and annealing
  - design optimization

R.-D. Heuer

Challenges for an ILC Detector

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$

  ~1/5 $r_{beampipe}$, ~1/30 to 1/1000 pixel size (wrt LHC)

$$\sigma_{ip} = 5\mu m \oplus 10\mu m / p\sin^{3/2}\theta$$

- Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X; \text{incl.}\, h \to \text{nothing})$

  ~1/6 material, ~1/10 resolution (wrt LHC)

$$\sigma(1/p) = 5 \times 10^{-5} / \text{GeV}$$

- Jet energy (quark reconstruction) → calorimetry

  ~1/2 resolution (wrt LHC)

$$\sigma_E / E = 0.3 / \sqrt{E(\text{GeV})}$$

R.-D. Heuer

Particle Flow Calorimetry

- Detector designs are being optimized for the application of Particle Flow Algorithms

  → **Challenge: Calorimeters with very fine readout segmentation**

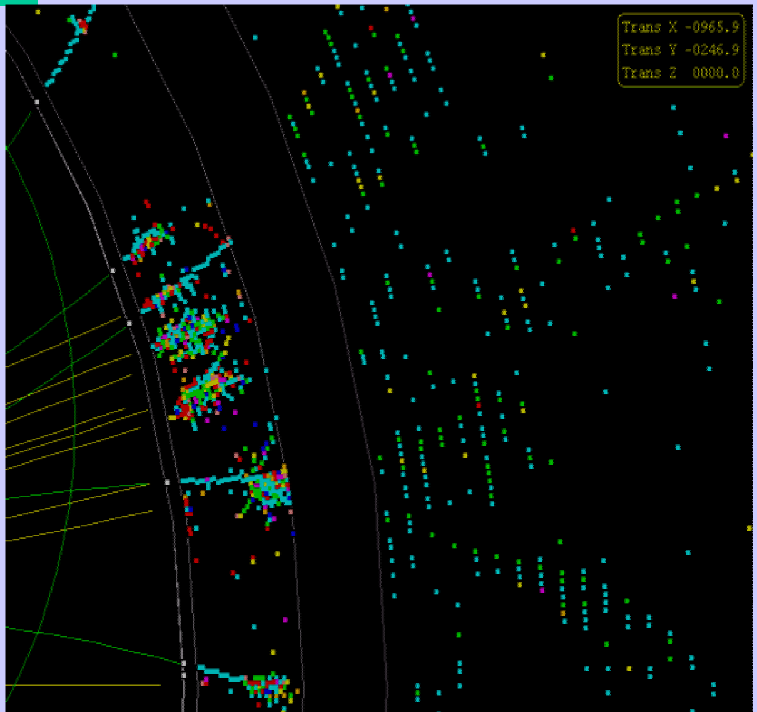
- The CALICE collaboration is building several such calorimeter prototypes

  a) Silicon – Tungsten
     Scintillator – Lead } Electromagnetic Calorimeter

  b) Scintillator
     RPC
     GEM } - Steel Hadronic Calorimeter

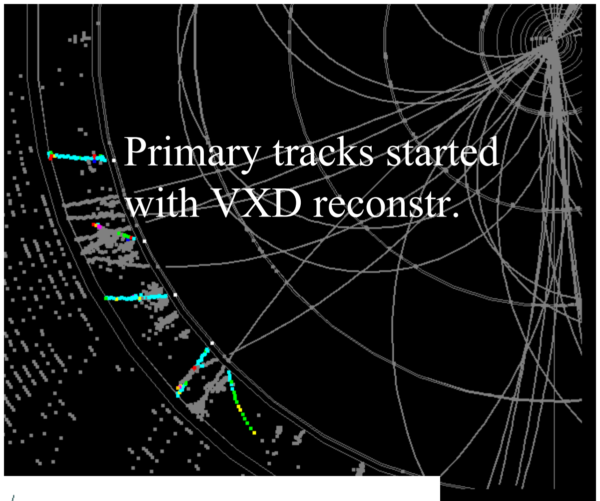
  c) Scintillator – Steel Tail Catcher/Muon Tracker

- Tests in particle beams at CERN and FNAL

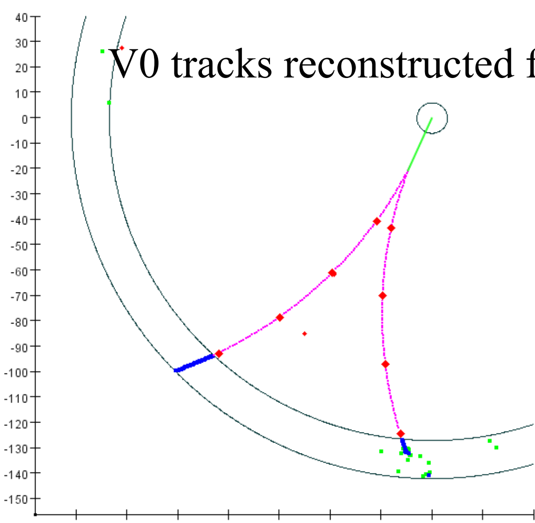


R.-D. Heuer

Si/W Cal. Assists for Tracking

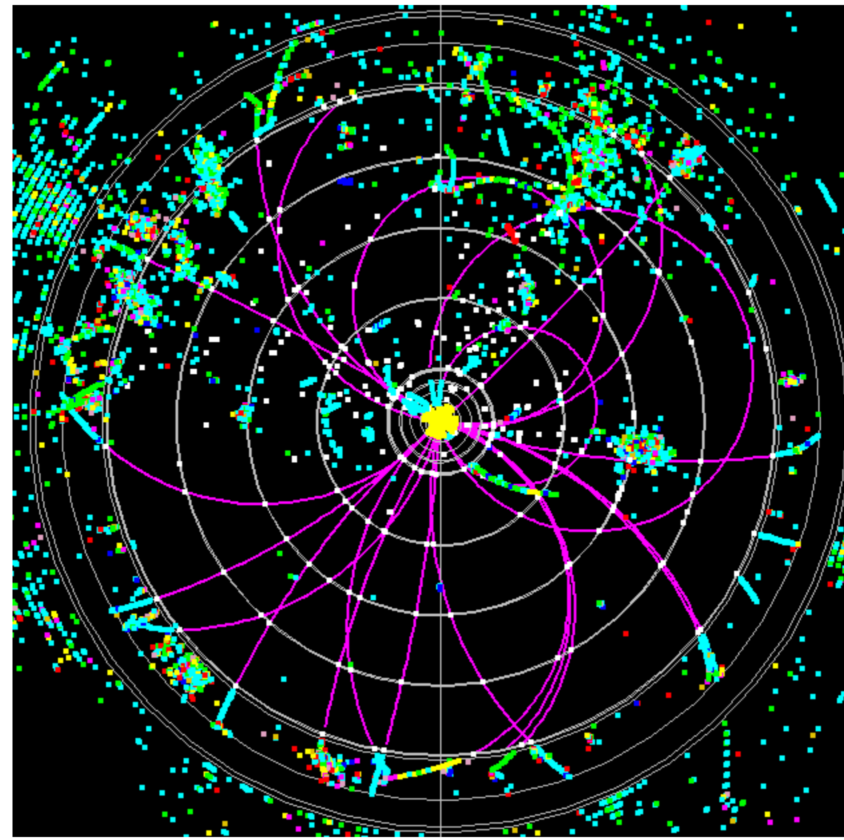


Primary tracks started with VXD reconstr.



V0 tracks reconstructed from ECAL stubs

A.Zalewska, SPC, 17.10.2006



A. Bondar

E. von Toerne

International Instrumentation Conference

C11 proposal:

- Discuss with organizers of successful existing instrumentation conferences whether they support the transition to a truly international conference. Clearly a better solution than creating a completely new conference.
- 2-year cycle of International Instrumentation Conference
- The intermediate year can be used for existing regional conferences.

G. Herten

Conclusion

The LHC start-up should be a highlight of ICHEP08