LP09: Lepton Photon Conference

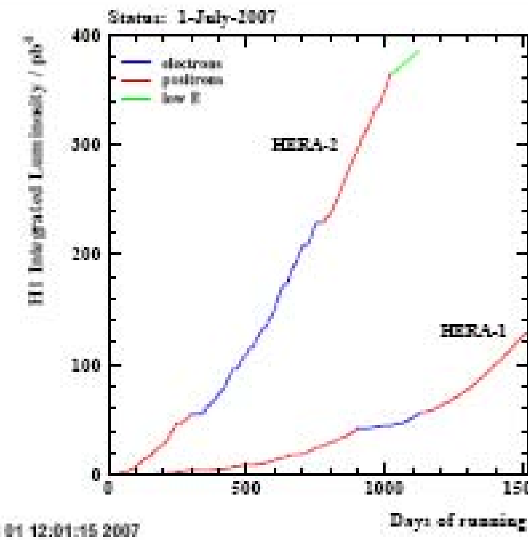
- Hamburg
- 17-22 August 2009
- All talks Plenary (48)
- Quiet meeting
- Pre LHC…. but lots of interest.

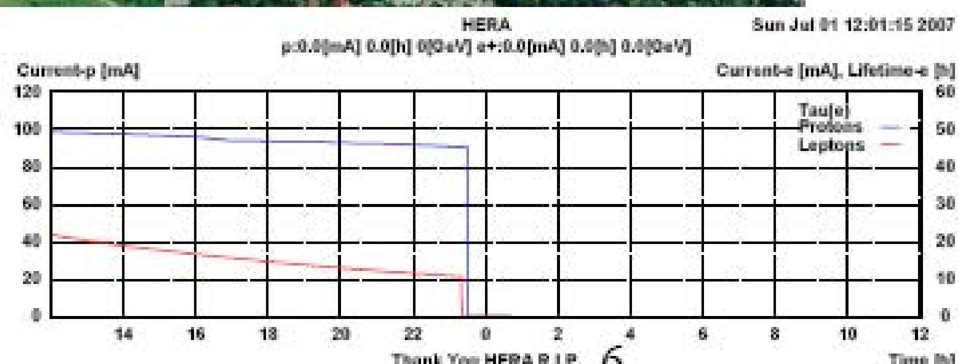
LP09 programme

Time	Monday August 17	Tuesday August 18	Wednesday August 19	Thursday August 20	Friday August 21	Saturday August 22
08:00						
09:00		Session 4: Heavy Ion Collisions	Excursions	Session 7: Future Projects I	Session 11: Electroweak and Top Physics	Session 15: Flavour and Neutrino Physics
	Opening Session					
10:00	Coffee Break	Coffee Break		Coffee Break	Coffee Break	Coffee Break
11:00	Session 1: LHC	Session 5: Searches I		Session 8: Future Projects II	Session 12: Dark Matter and Dark Energy	Session 16: Neutrino Physics
12:00						Closing Session
13:00						
14:00	Session 2: QCD I	Poster Session		Session 9: Astroparticles	Session 13: Flavour Physics I	
15:00	Coffee Break	Coffee Break		Coffee Break	Coffee Break	
16:00	Session 3: QCD II	Session 6: Searches II		Session 10: Gravitation and Cosmology	Session 14: Flavour Physics II	
17:00						
18:00				Dinner		
19:00	Welcome Reception Town Hall	Concert			Public Lecture	
20:00						
21:00						
22:00						

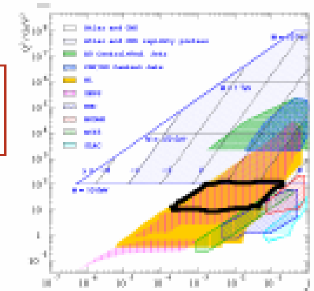
HERA, H1 and ZEUS. 1992-2007.

$E_e \times E_p$=27.5×920 GeV^2
$\sqrt{s}$ = 318 GeV
L= $5\cdot10^{31}$cm^{-2}s^{-1}
e beam polarisation.

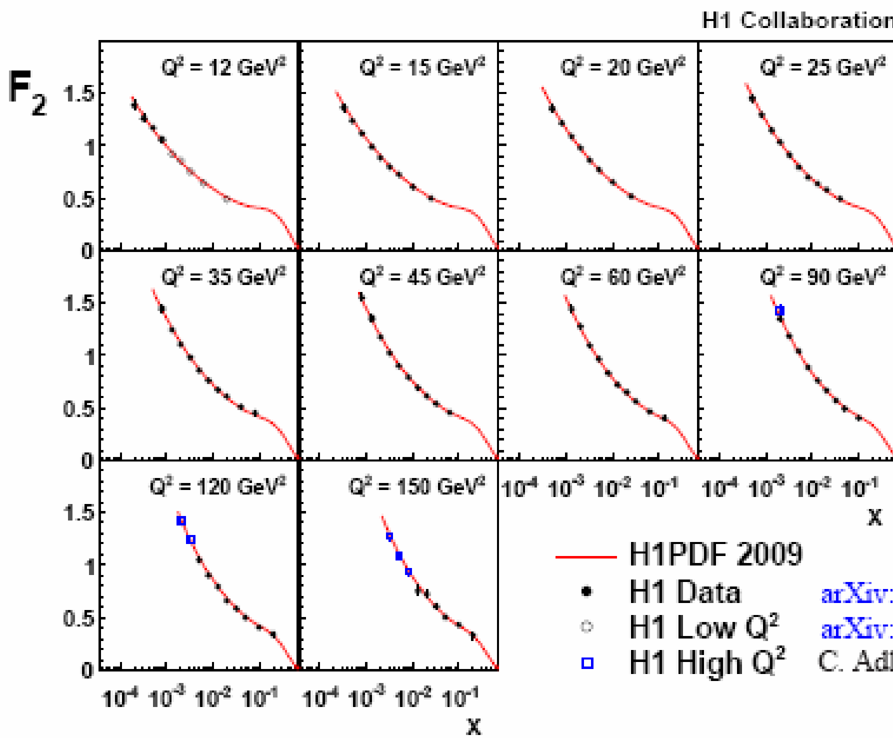




Proton structure, Alexander Glasov (DESY)



Structure Function F_2 at low x, medium Q^2



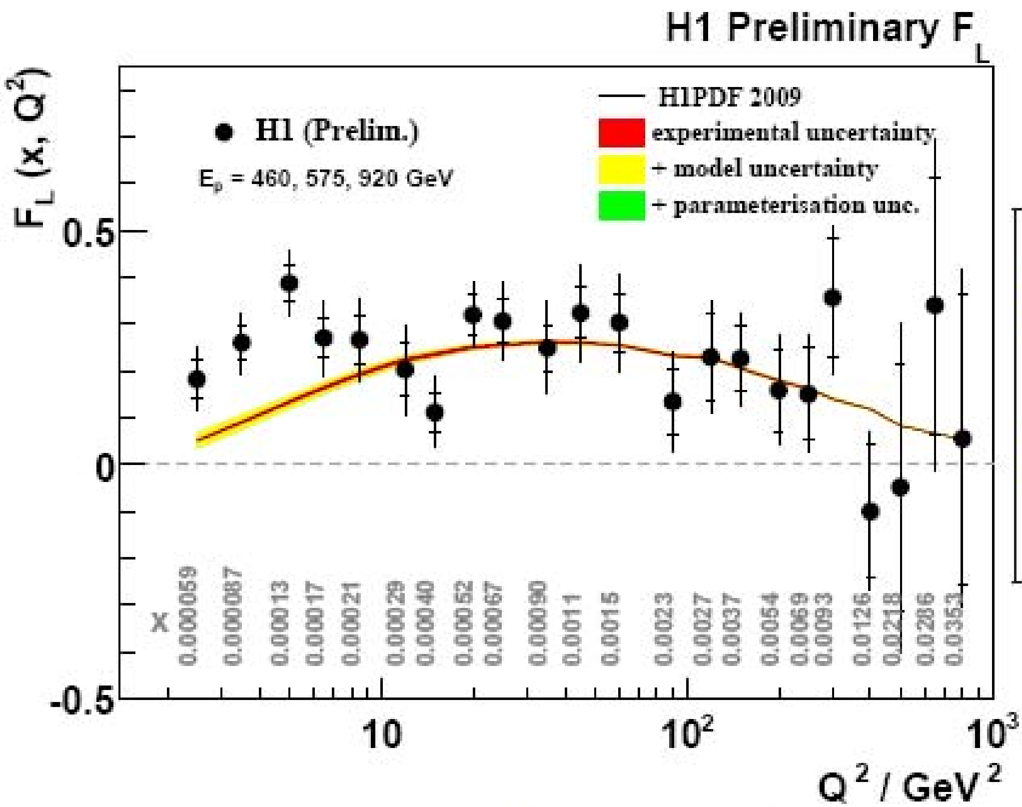
H1PDF 2009
H1 Data arXiv:0904.3513, submitted to EPJ
H1 Low Q^2 arXiv:0904.0929, submitted to EPJ
H1 High Q^2 C. Adloff *at al.* Eur.Phys.J. C30, 1 (2003)

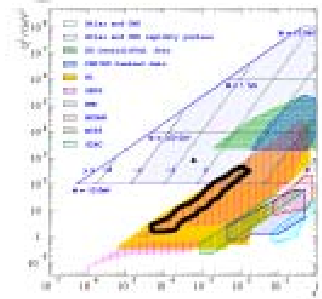
- Measurement of F_2 in perturbative region.
- HERA-I data, ~ 1.3% total precision.

$F_2(x, Q^2)$ shows strong rise as $x \to 0$, the rise increases with increasing Q^2.

First measurement of F_L

F_L measured by H1



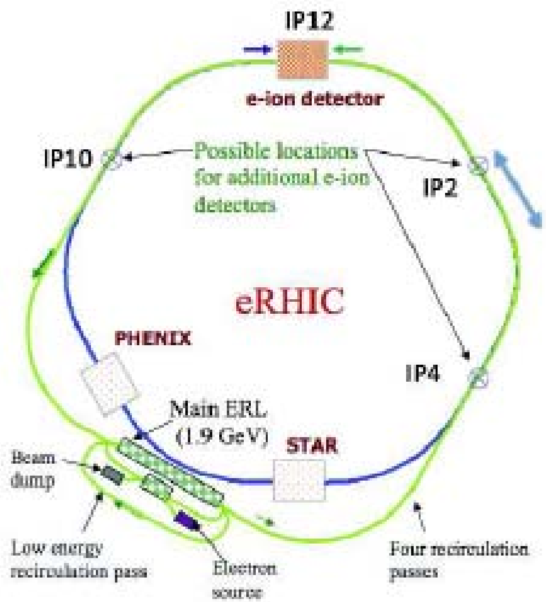


Extension to high $Q^2 \geq 90$ GeV^2 using LAr calorimeter and to low $Q^2 \leq 12$ GeV^2 using dedicated silicon tracker.

H1 measurements cover $2.5 \leq Q^2 \leq 800$ GeV^2 and $0.00005 \leq x \leq 0.04$ range
For $Q^2 \geq 10$ GeV^2, agree well with H1PDF 2009 prediction.

Beyond HERA

Medium energy *ep* collider EIC: eRHIC and ELIC



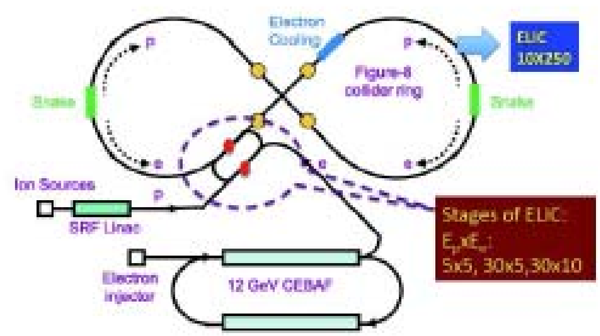
Jlab ELIC, using $E_e = 12$ GeV. Stages in $E_p \times E_e$ of 5×5, 30×5, 30×10 GeV^2. Nominal operation at 250×10 GeV^2.

Luminosity: 0.5-4.5 $\times 10^{33}$ $\mathrm{cm}^{-2}\mathrm{s}^{-1}$

BNL eRHIC staged design, using $E_p = 250$ GeV:

- $E_e = 4$ GeV linac
- $E_e = 10 - 20$ GeV ring, up to $E_e = 30$ GeV.

Luminosity: 3×10^{33} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$.



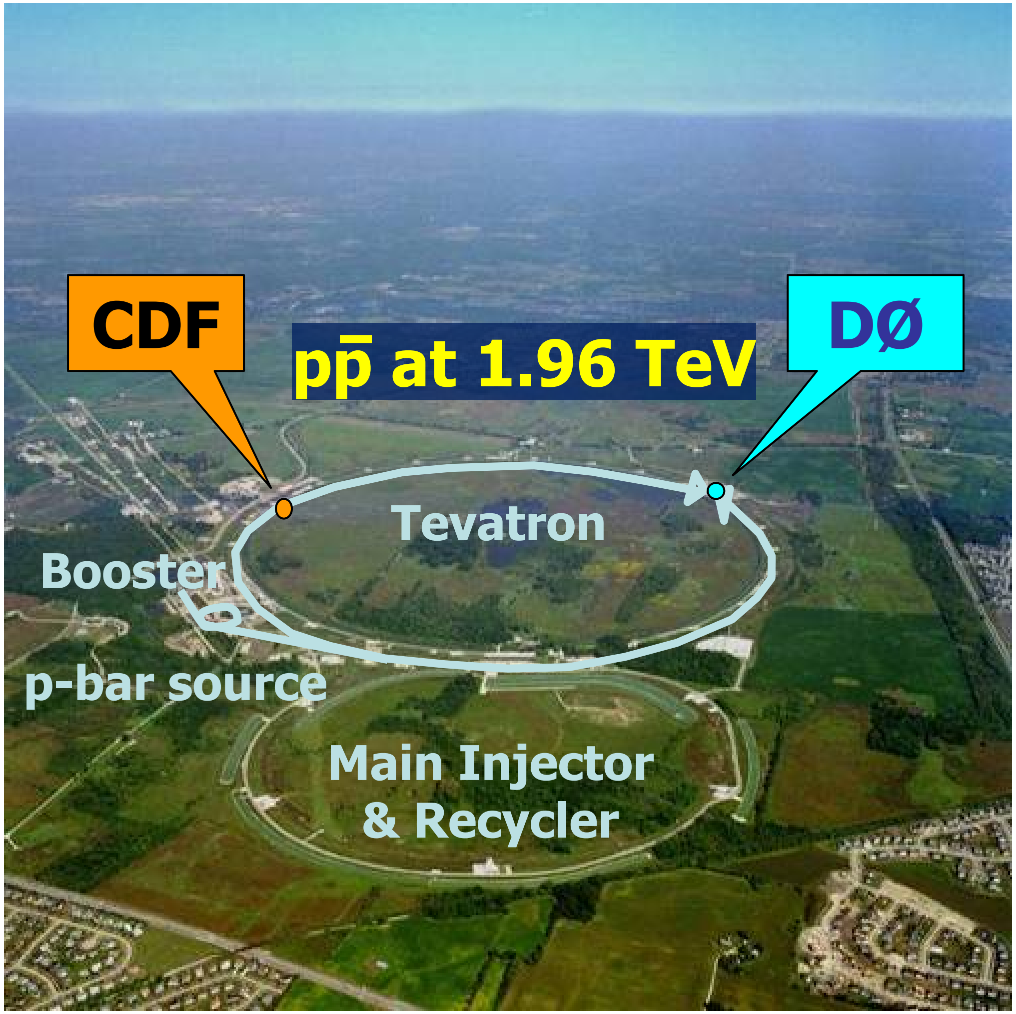
HERA: ongoing physics

Summary

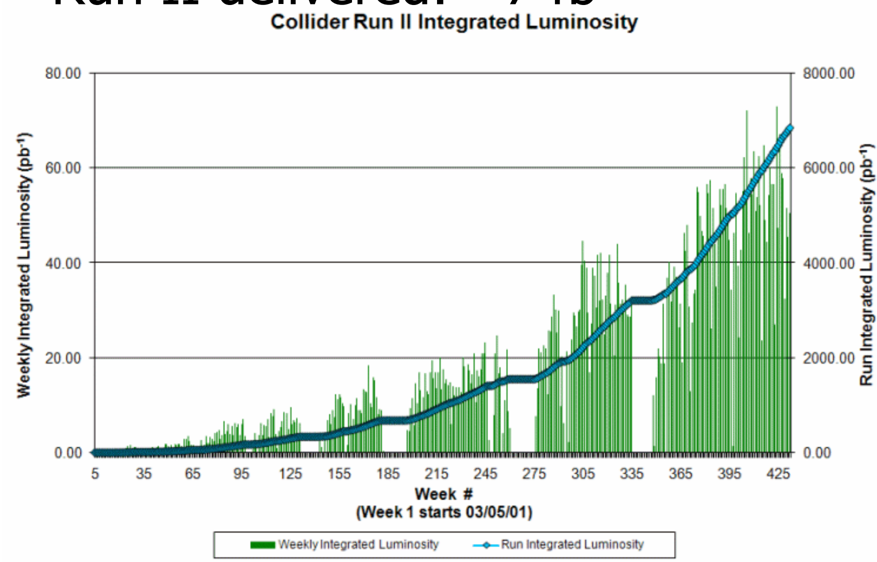
- Combination of H1 and ZEUS published HERA-I data gives ultimate precision at low x.
- First measurements of F_L at low x.
- Results based on complete HERA sample improve precision at high Q^2.
- New determination of α_S based on jet cross section measurement.
- New results for s, c, b PDFs.
- Precision NLO QCD analyses and novel fit techniques: more reliable predictions for the LHC.
- New colliders at Jlab, BNL and CERN are being developed for polarised and high Q^2/low x ep physics.

  $\rightarrow$ DIS has great future as part of HEP exploring the Terascale.

Fermilab Tevatron - Run II



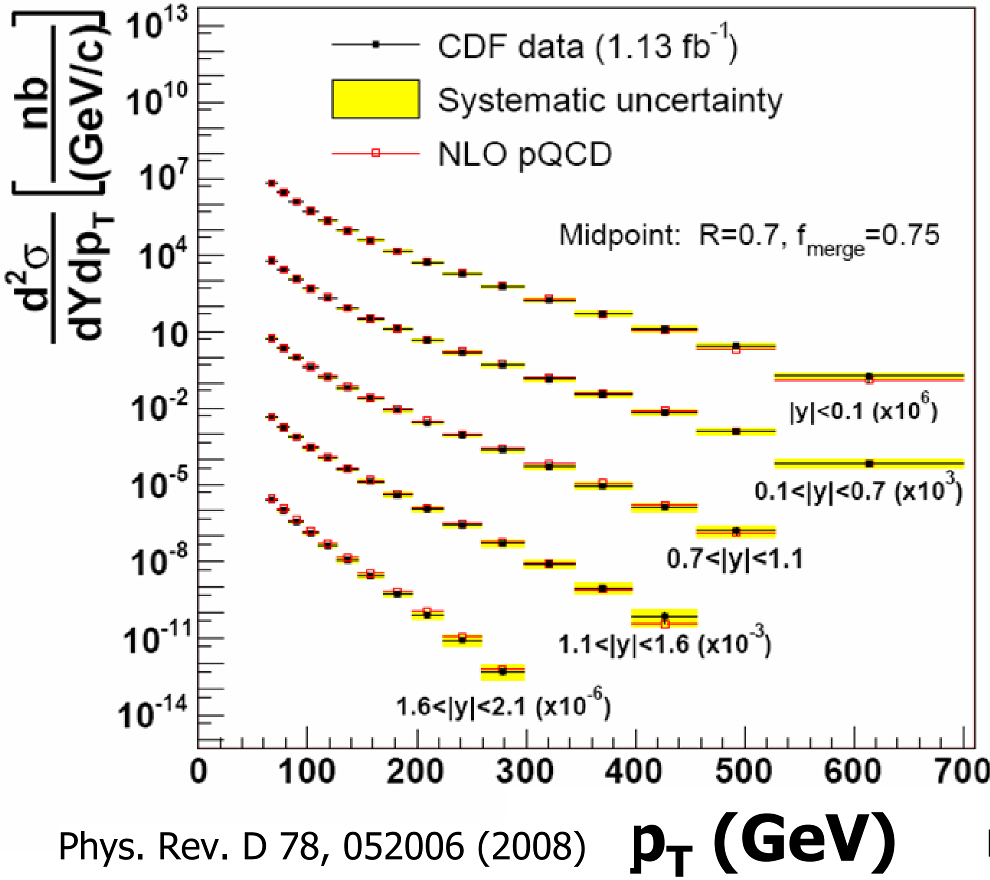
- 36x36 bunches
- bunch crossing 396 ns
- Run II started in March 2001
- Peak Luminosity:3.5E32 cm^{-2} sec^{-1}
- Run II delivered: ~7 fb^{-1}



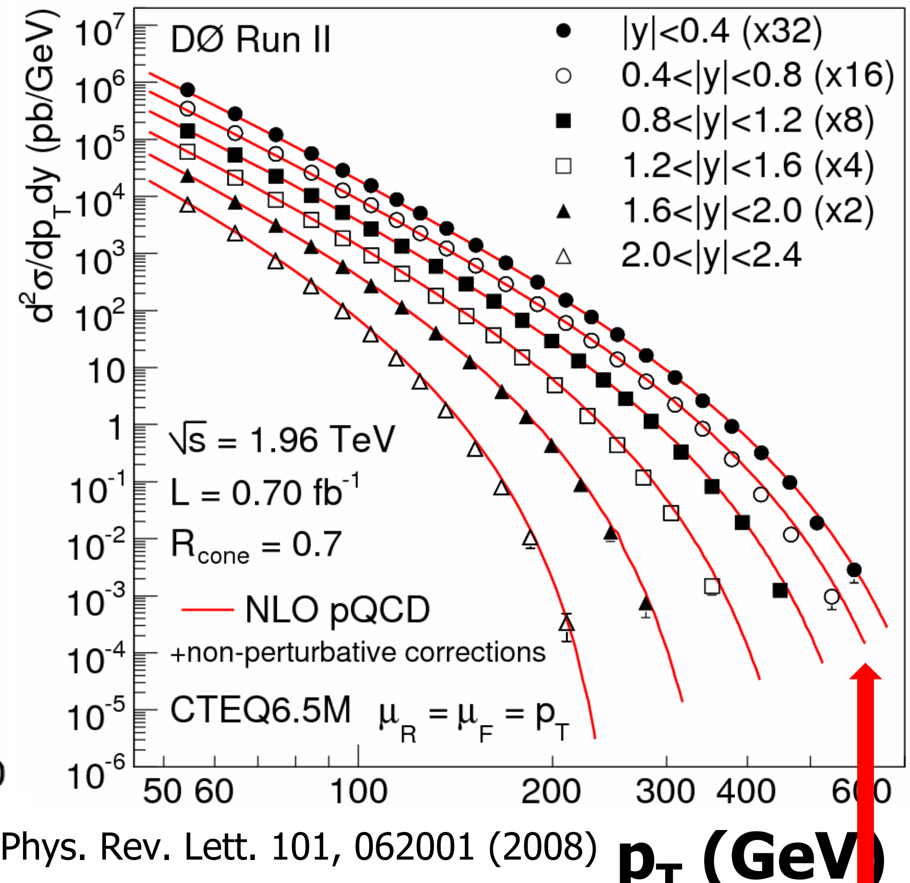
- Run II Goal: 12 fb^{-1} end of 2011

presented results up to 2.7 fb^{-1}

Inclusive Jets



Phys. Rev. D 78, 052006 (2008)



Phys. Rev. Lett. 101, 062001 (2008)

benefit from:

- high luminosity in Run II
- increased Run II cm energy → high p_T
- hard work on jet energy calibration

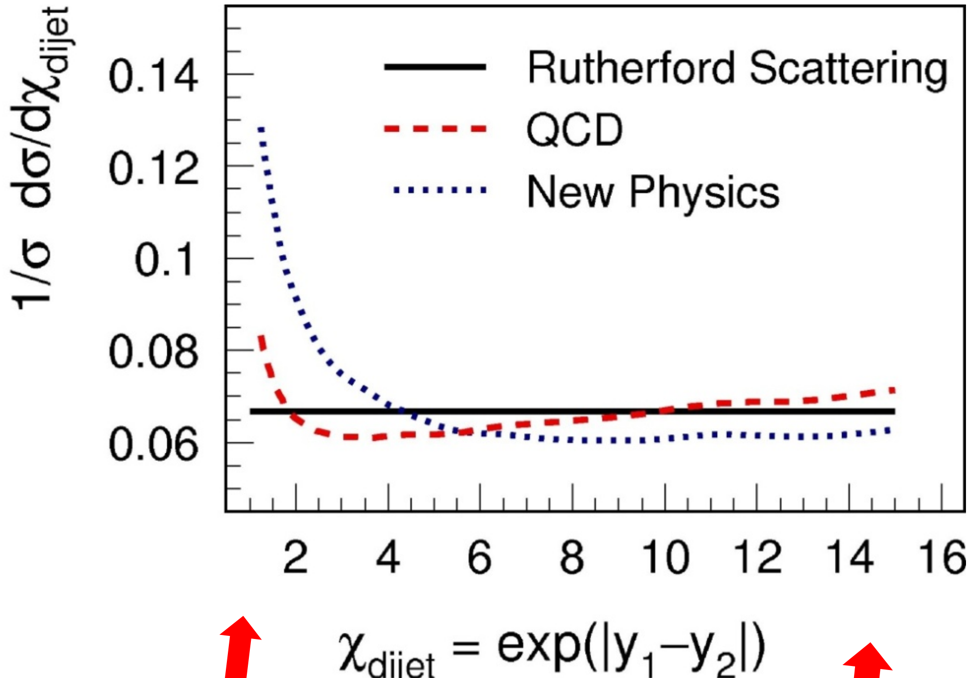
steeply falling p_T spectrum:

1% error in jet energy calibration

→ 5—10% (10—25%)

central (forward) x-section

Dijet Angular Distribution



variable:

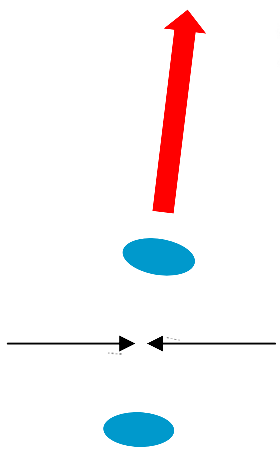
$$\chi_{\rm dijet} = \exp(|y_1 - y_2|)$$

at LO, related to CM scattering angle

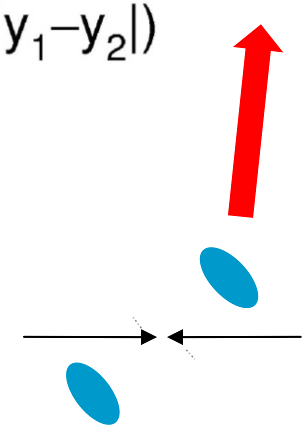
$$\chi_{\rm dijet} = \frac{1+\cos\theta^*}{1-\cos\theta^*}$$

- flat for Rutherford scattering
- slightly shaped in QCD
- new physics, like
  - quark compositeness
  - extra spatial dimensions

  → enhancements at low $\chi_{\rm dijet}$



small □y



large □y

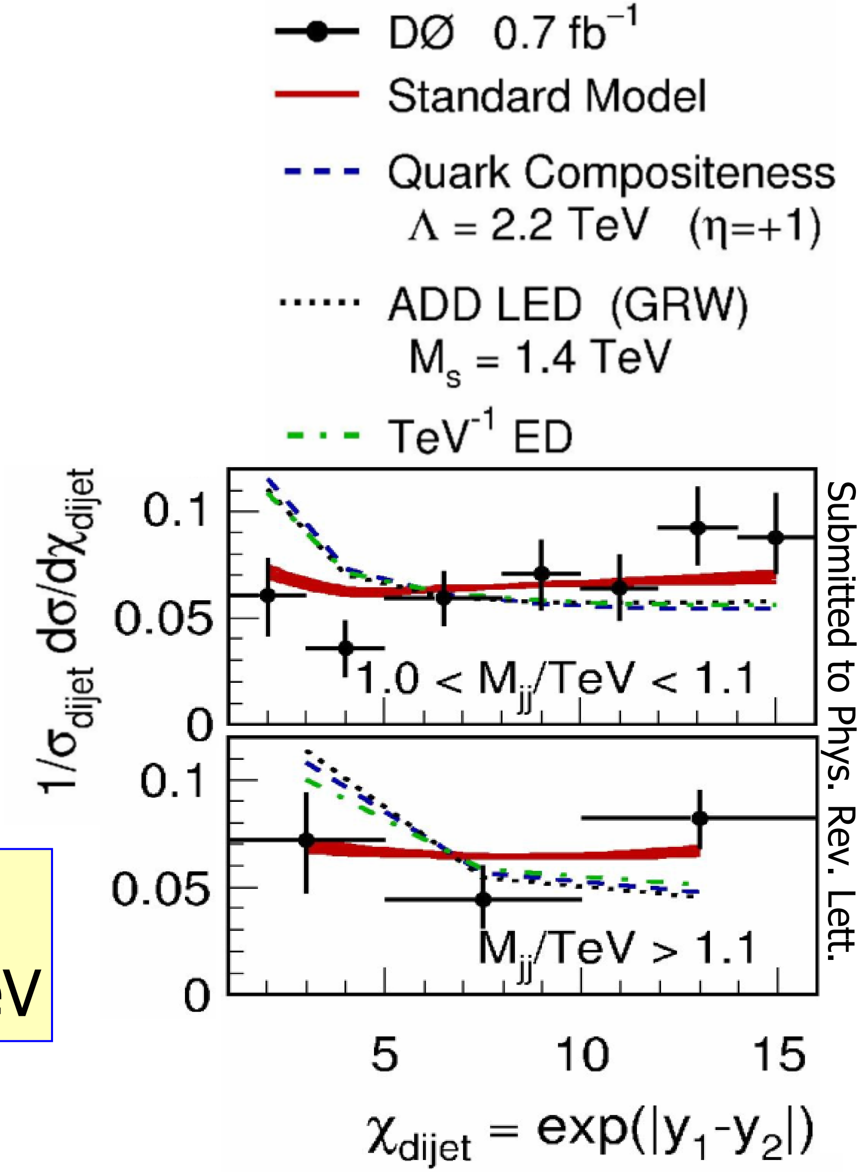
Dijet Angular Distribution

→ normalized distribution $\frac{1}{\sigma}\frac{d\sigma}{d\chi_{\text{dijet}}}$

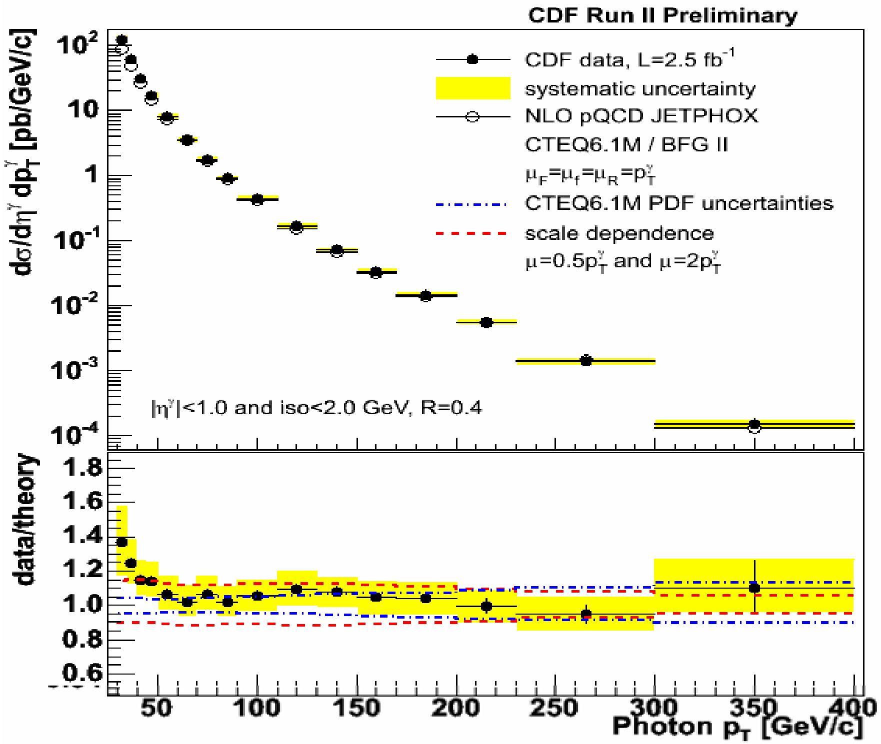
→ reduced experimental and theoretical uncertainties

Measurement for dijet masses from 0.25 TeV to >1.1 TeV

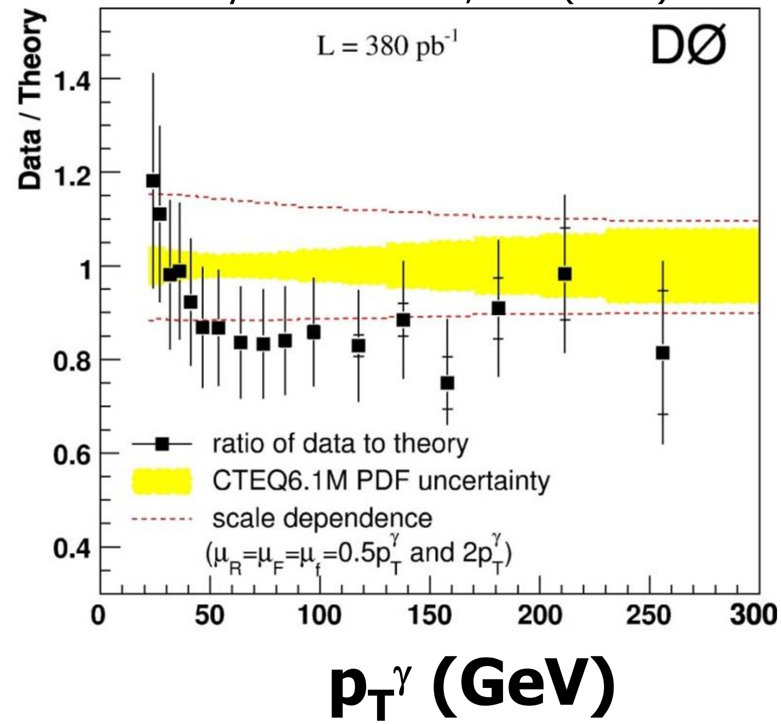
First time:
Rutherford experiment above 1TeV



Incl. Isolated Photons



Phys. Lett. B 639, 151 (2006)



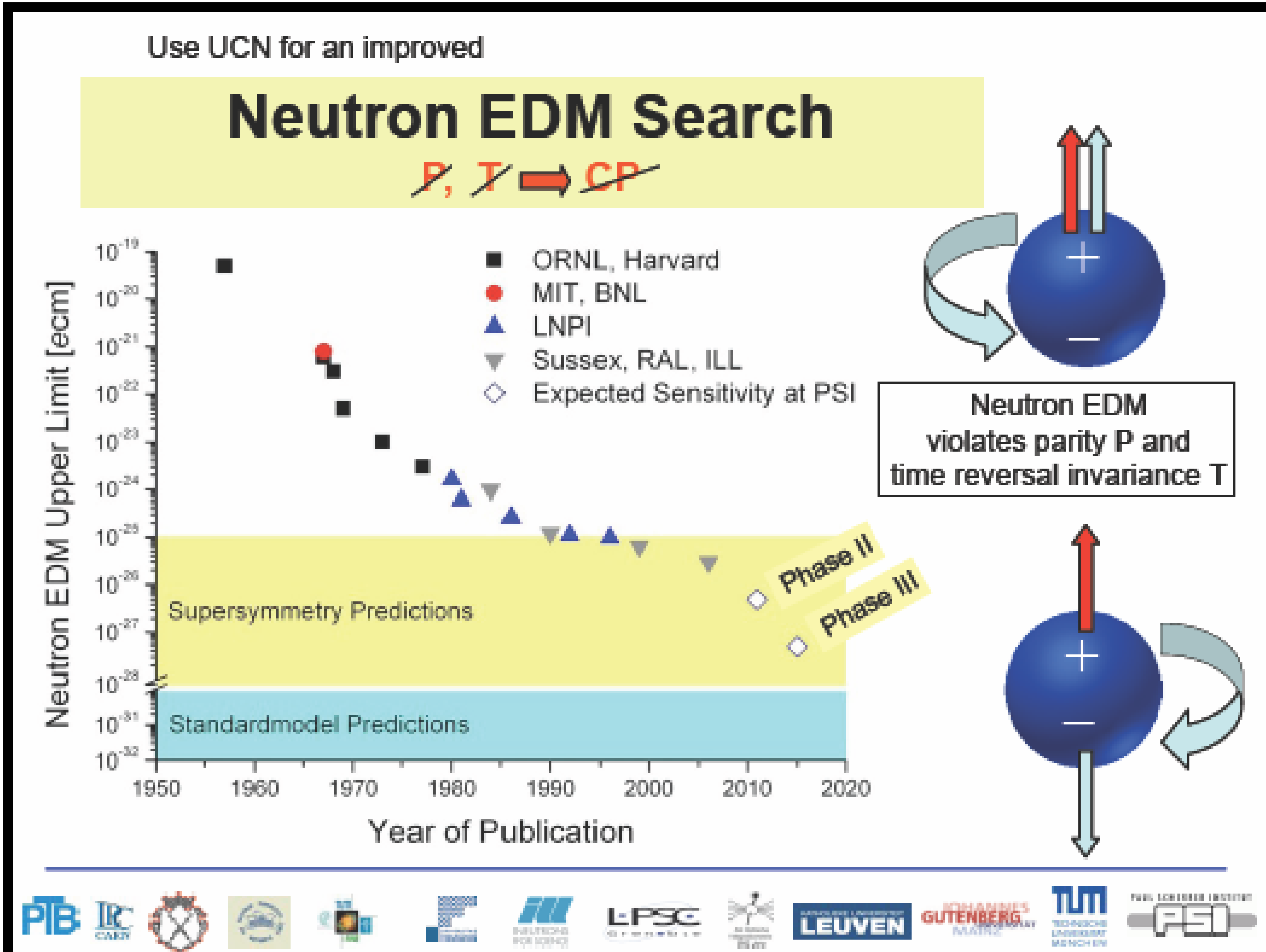
- CDF and D0 measurements: 20< p_T <400GeV → agreement
- data/theory: difference in low p_T shape
- experimental and theory uncertainties > PDF uncertainty
  → no PDF sensitivity yet
- first: need to understand discrepancies in shape

Summary

→ **precision measurements** of fundamental observables @2TeV
→ **consistent results** from CDF and D0

- **underlying event / multiple parton interactions**
  → strong constraints: tune/improve phenomenological models
- **Z/W + jet production (p_T spectra :: angular distributions)**
  → many distributions for pQCD tests and for model tuning
- **photon production (inclusive :: plus jet :: plus HF jet)**
  → need to find missing pieces in theory
- **jet production (inclusive p_T :: dijet mass :: dijet angle)**
  → first look into physics in the TeV regime
  → strongest constraints on high-x gluon – for some time

Rare muon decays + EDM   Toshi Mori (Tokyo)

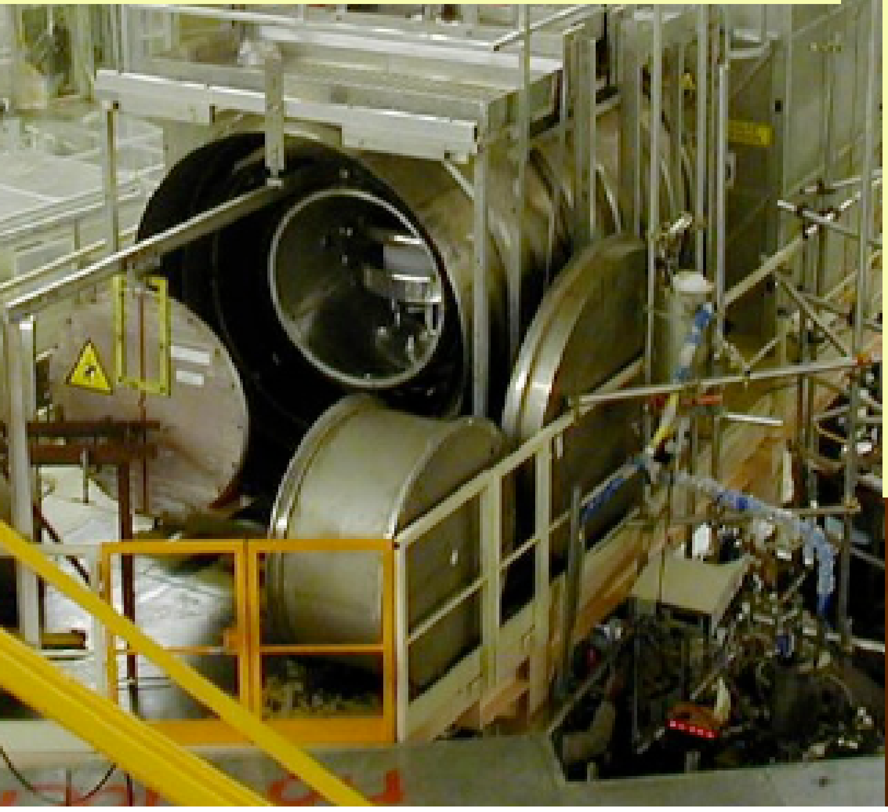


Neutron EDM Search

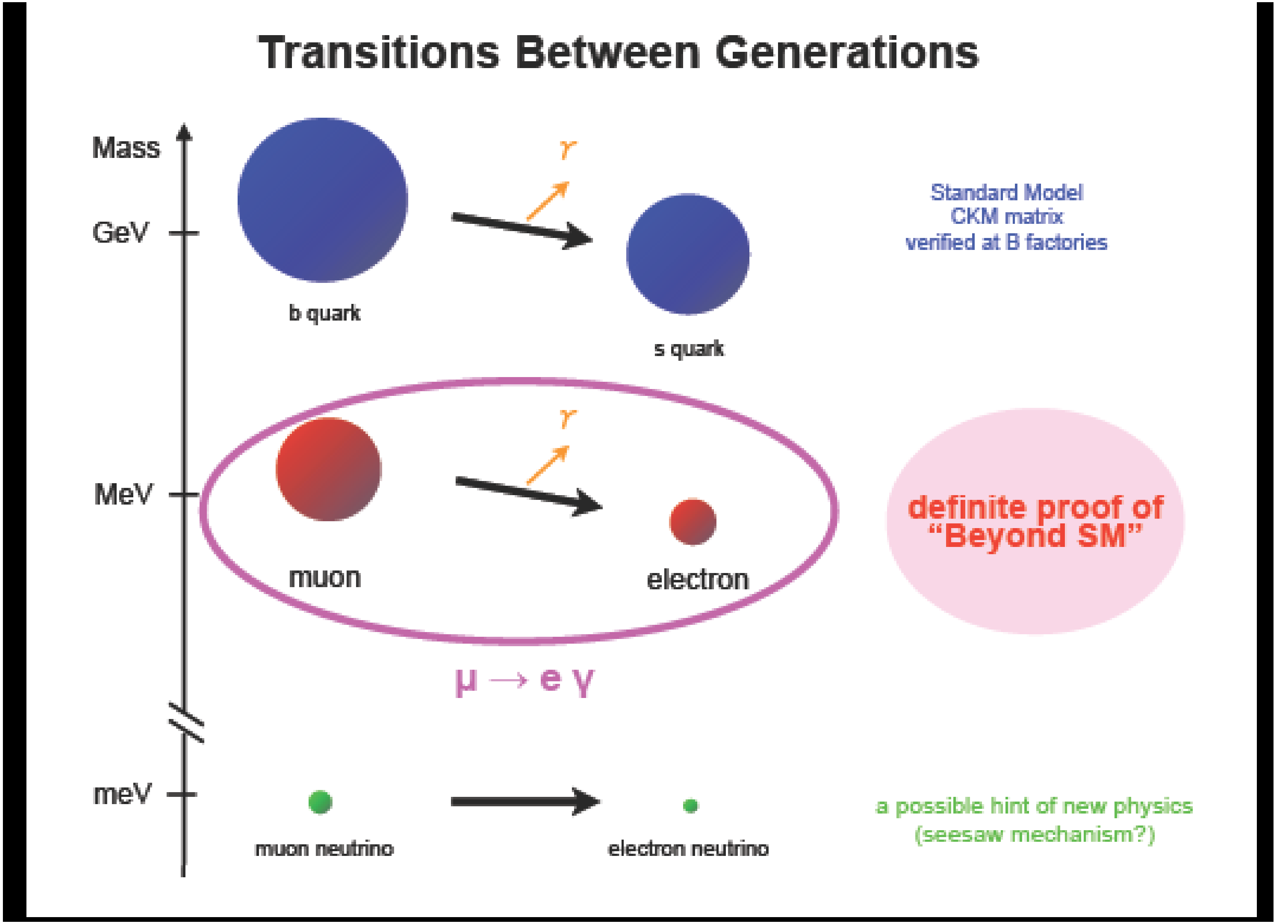
~~P~~, ~~T~~ → ~~CP~~

Strategy: Experiment with
- UCN in vacuum
- apparatus at ambient temperature
- double UCN chamber (phase III)
- co-magnetometry
- multiple external magnetometers

- Present best limit: $d_n < 2.9 \times 10^{-26}$ ecm
  Sussex-RAL-ILL collaboration
  C. A. Baker et al., PRL 97 (2006) 131801
- nEDM collaboration nedm.web.psi.ch
  15 groups, 50 people
- Moved from ILL to PSI March 2009
- Data taking at PSI 2010 – 2011 (Phase II)
  Sensitivity goal: 5×10^{-27}ecm (95% C.L.)
- Operation of new n2EDM apparatus 2012 – 2015 (Phase III)
  Sensitivity goal: 5×10^{-28}ecm (95% C.L.)



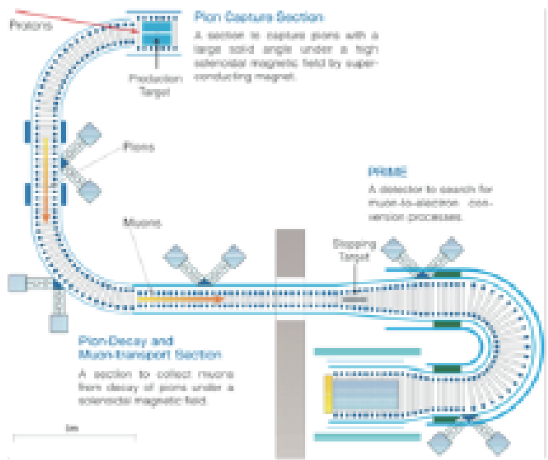
Muon decay

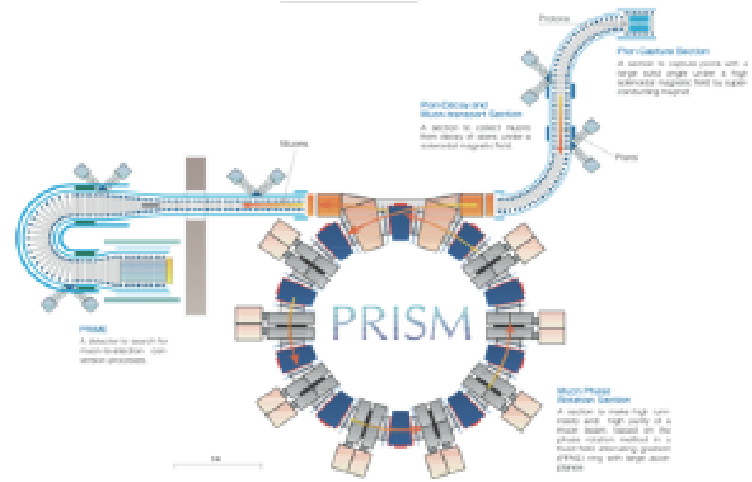


Transitions Between Generations
Mass
GeV
MeV
meV
γ
b quark
s quark
Standard Model
CKM matrix
verified at B factories
γ
muon
electron
definite proof of
“Beyond SM”
μ → e γ
muon neutrino
electron neutrino
a possible hint of new physics
(seesaw mechanism?)

Muon decays on nuclei

COMET | Early Realization → Phase II | PRISM





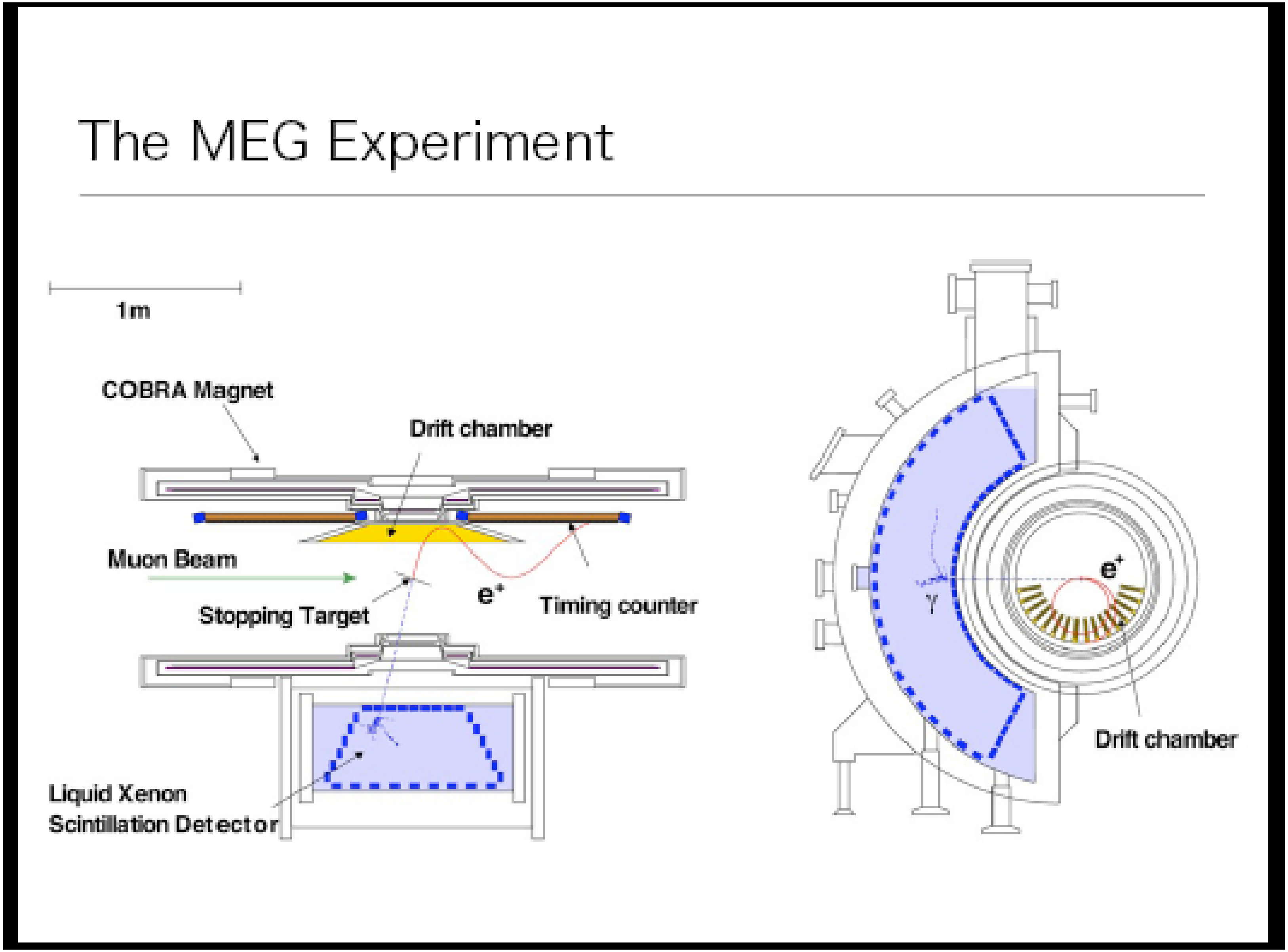
$$B(\mu^- + Al \rightarrow e^- + Al) < 10^{-16}$$

- Extension of MECO
- Requires a slow-extracted, pulsed - beam
- done at the J-PARC NP Hall.
- regarded as phase I
- Early realization

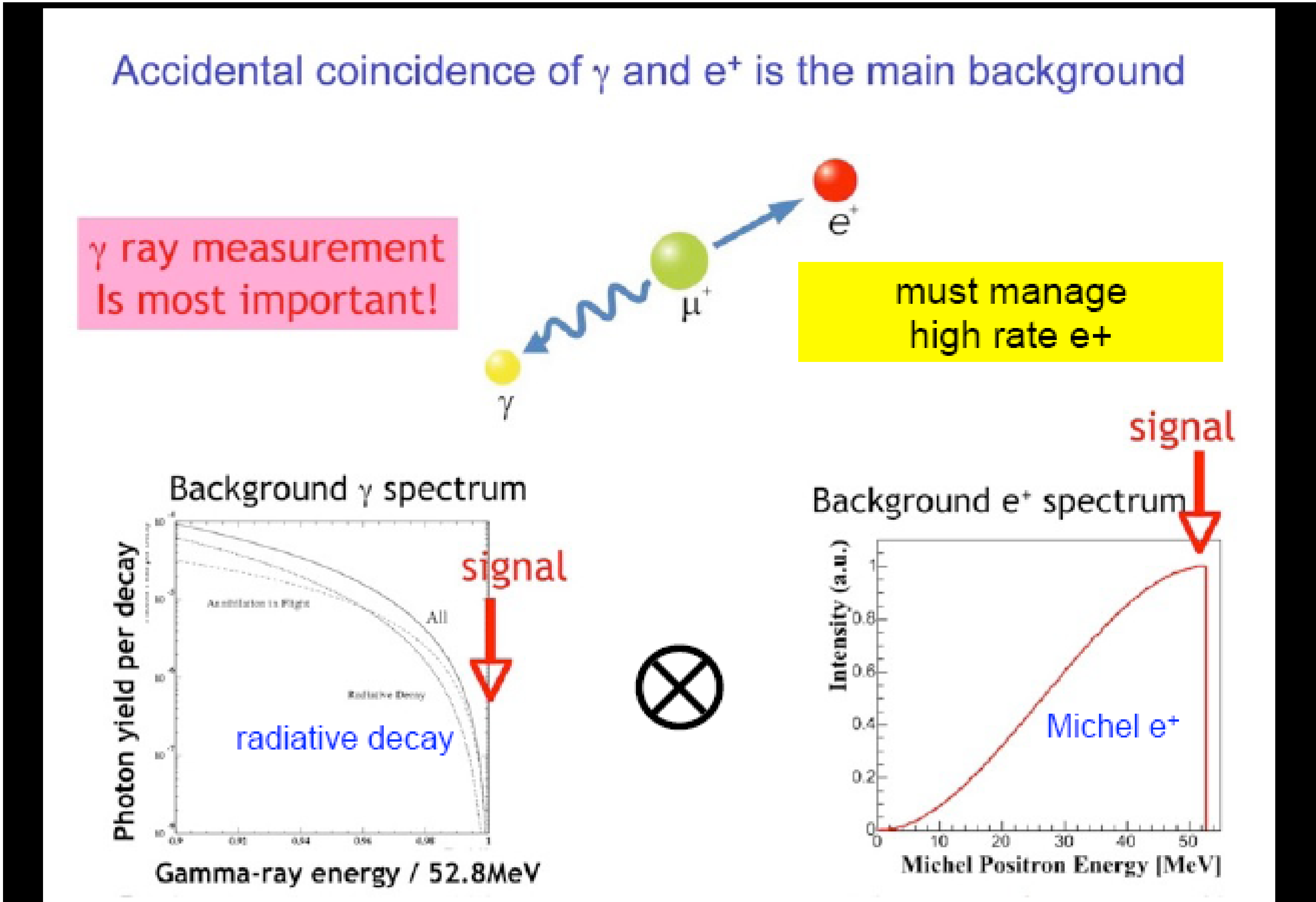
$$B(\mu^- + Ti \rightarrow e^- + Ti) < 10^{-18}$$

- Requires a fast-extracted, pulsed-beam.
- Requires a new beamline and hall.
- Experience and components of Phase I used
- Extends the reach by 100

At PSI : decays of stopping muons



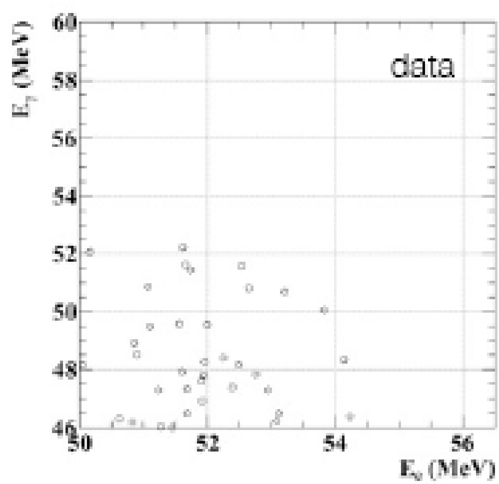
Muon decay kinematics

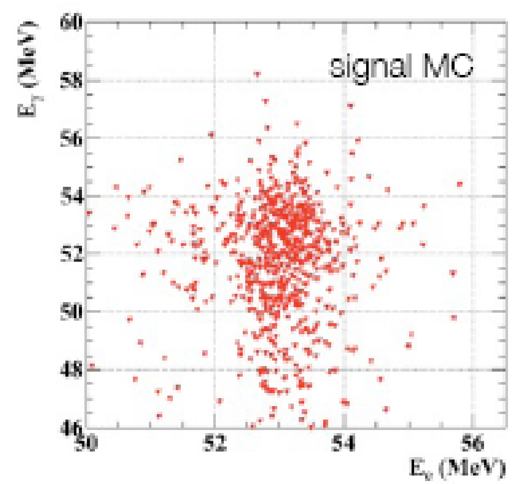


MEG results

The Preliminary 2008 Data Result

$$\mathrm{BR}(\mu^+ \to e^+\gamma) < 3.0 \times 10^{-11}$$





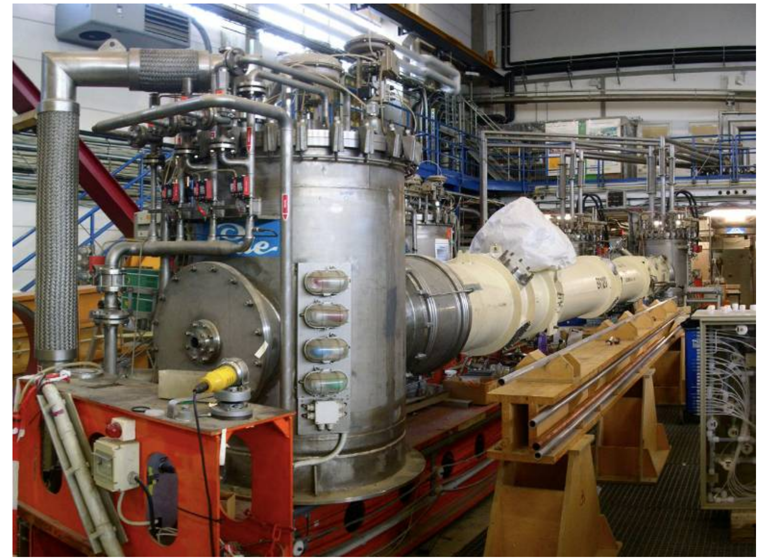
Note: all the other parameters are cut to select ~90% of signal events in these plots

Example:

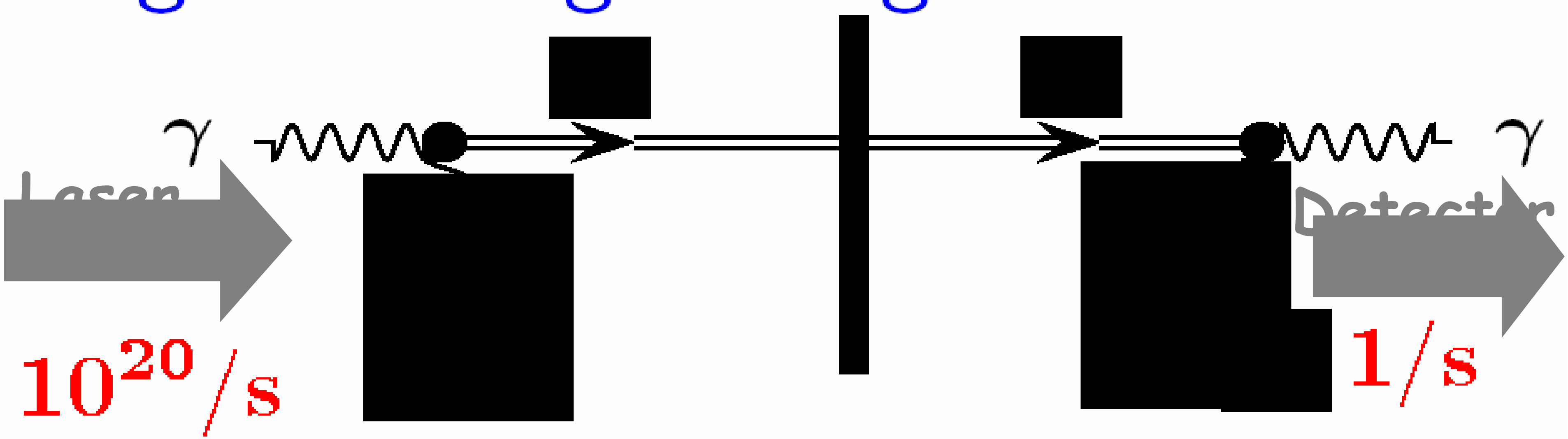
ALPS@DESY=

Axion-like particle search

Any-light particle search



"Light shining through a wall"

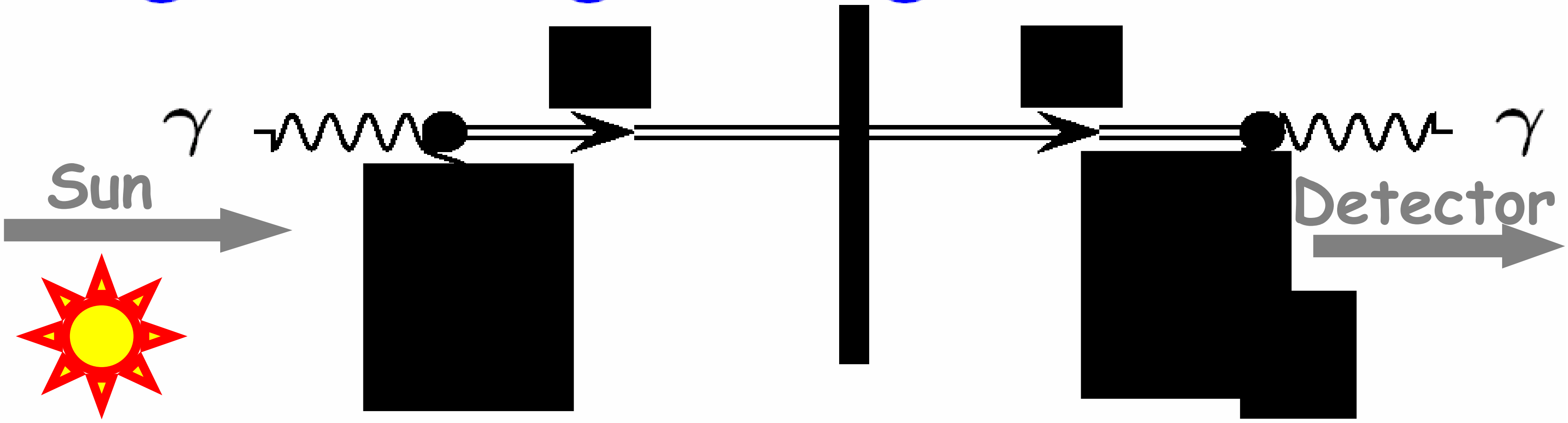


Helioscopes

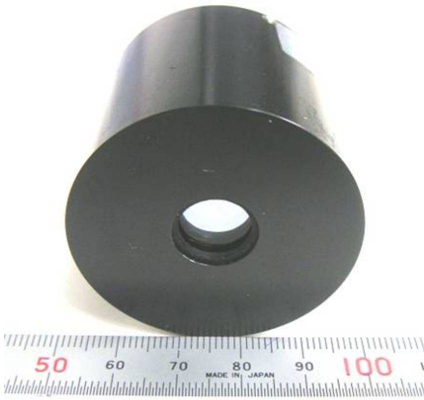
CAST@CERN

SUMICO@Tokyo

"Light shining through a wall"



MCP-PMT (Microchannel Plate)

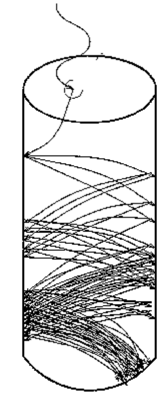


R3809

- Amplification in micro capillary
  - 1photon counting
  - QE ~ 25 %
  - Gain ~ 10^6
  - B field OK (~1.5 T)
  - Position resolution ~5mm typ (multi-anode)
  - Fast !
    - tts (transit time spread) ~ 50 ps or less
    - □ σ_t = 6.2 ps measured (w/ electronics)
      - At #photon ~ 180 (quartz radiator)
      - 4.7 ps intrinsic
      - Hamamatsu R3809U-50, ϕ6μm hole

Channel
← ϕ~10μm

↔ ~400μm

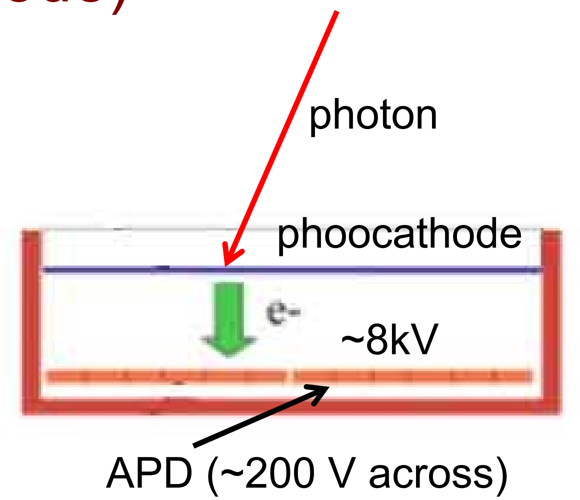


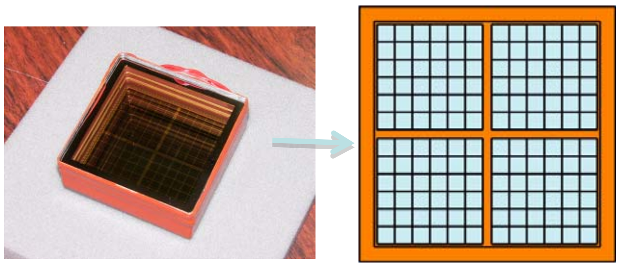
- Applications
  - X-ray cameras, image intensifiers, etc.
  - Cerenkov photon detections (e.g. DIRCs)

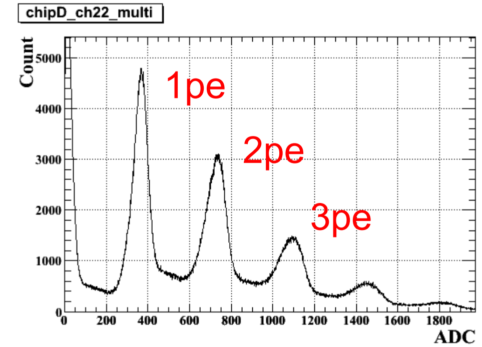
HAPD

(Hybrid Avalanche PhotoDiode)

- APD replaces the micro capillary of MCP
  - Amplification by
    - Accelerated e^- hits APD (~10^3)
    - APD itself (~40)
  - Typical total gain ~ 4×10^4
- Example
  - 144ch HAPD for Belle-II Forward RICH
    - 72x72 mm^2 , 5x5 mm^2 cell
    - Fill factor 67%
    - QE ~ 25% (→43% by UBA)
    - 1γ counting: good energy resolution
      - Much better than typical PMT
      - Thanks to the large 1st stage gain
    - B ~ 1.5T OK
    - flat
    - compact

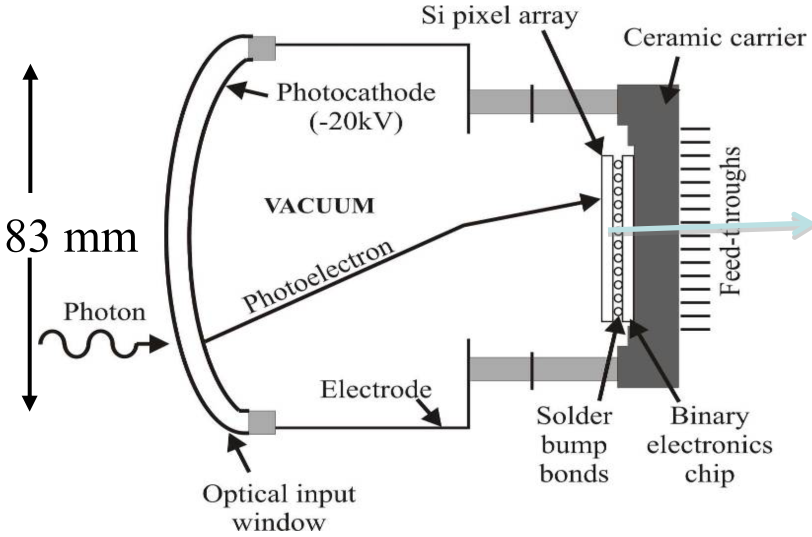


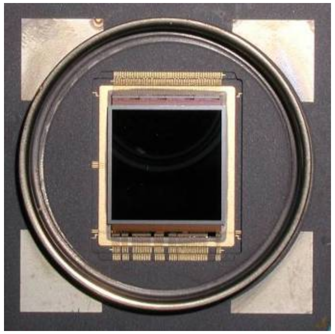




HPD (PD = pixel sensor)

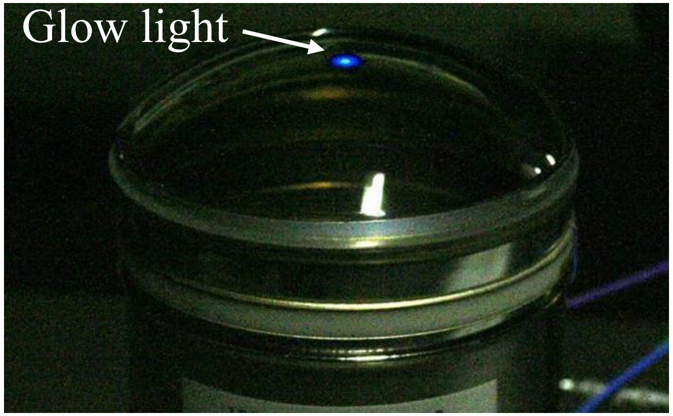
- Replace APD of HAPD by pixel sensor
  → imaging photon detector
- Example : HPD for LHCb RICH (collaboration with Photonis)





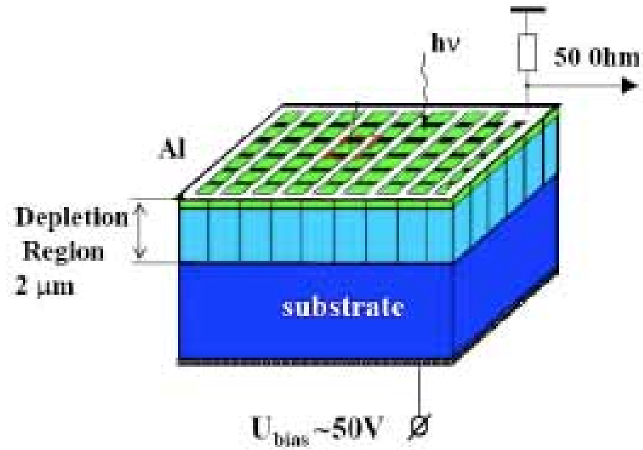
Hybrid pixel sensor
$0.5x0.5mm^2$
x 8192 pixels
8 or → 1024 chs

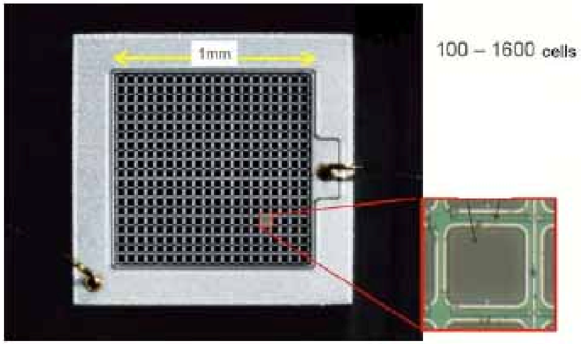
- 18 KV applied
- 1/5 demag mapping
- All installed
- Issue: ion feed back
  - Replace them (2% /yr)



Geiger-mode APDs
(SiPM, MPPC, PPD…)

- Divide APD into small cells and equip each with quenching resister. Operate them in Geiger mode and gang the outputs.
  - Quick enough recovery time
  - Output ∝ number of fired cells
- Invented in Russia
  - Standard MOS process
  - Now produced worldwide
    - CPTA/Photonique (Moscow/Geneva)
    - MEPhI/Pulser (Moscow)
    - Amplification Technologies (Orlando)
    - Hamamatsu Photonics (Japan)
    - ….
  - They use their own names.

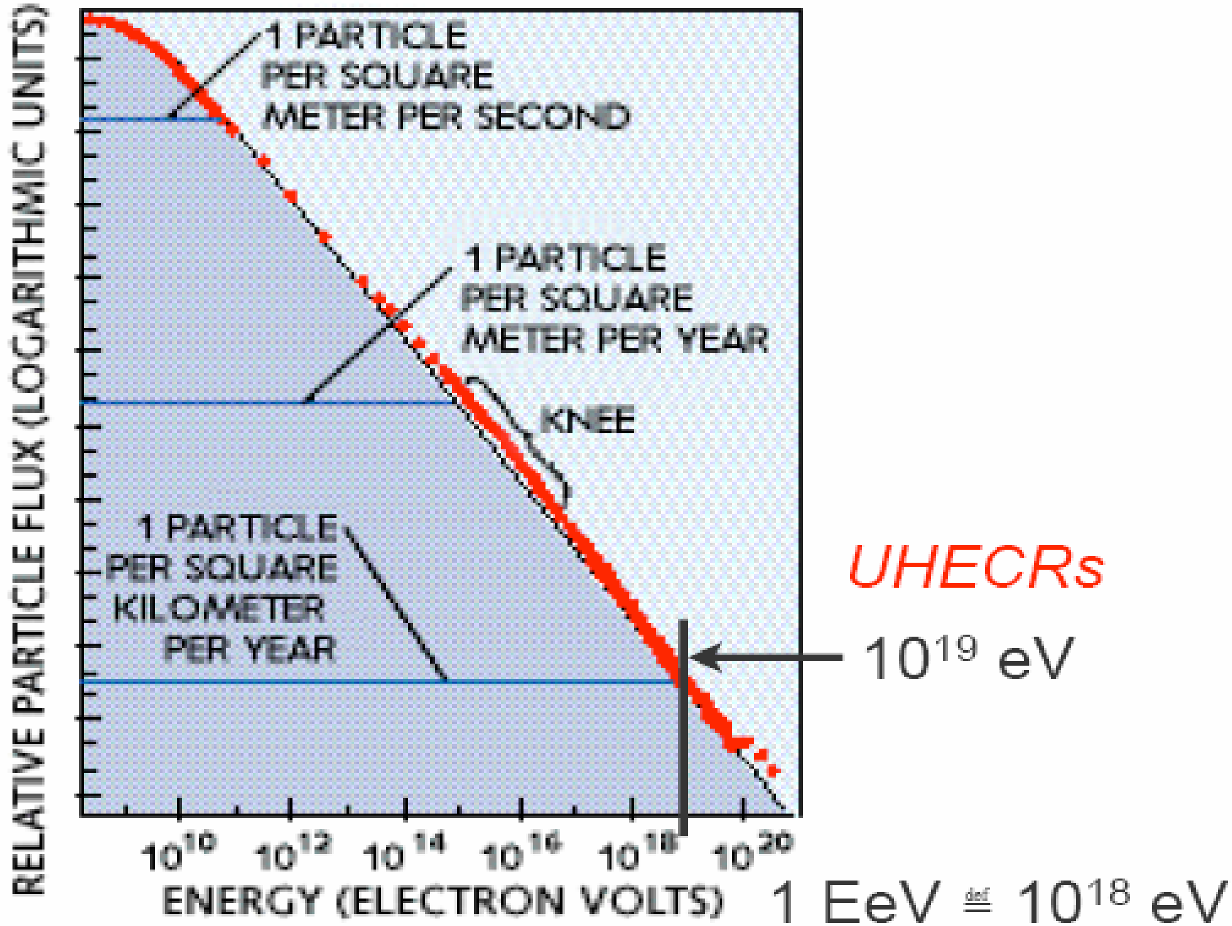




Hamamatsu MPPC

High energy cosmic rays   Miguel Mostafa (Colarado)

Ultra-High Energies



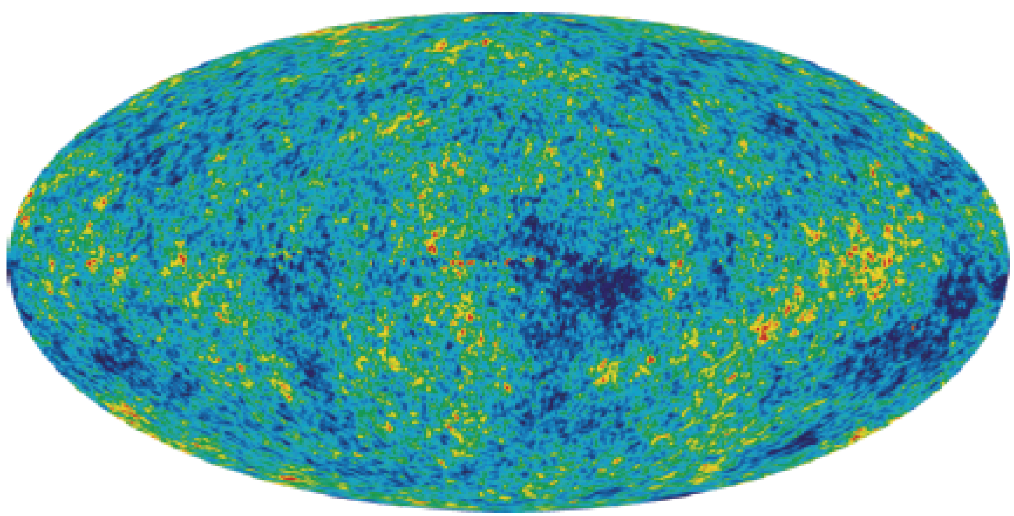
High energy protons

Scientific Motivation

They should not be there!

$$\gamma + p \rightarrow \Delta^+ \rightarrow p + \pi^0$$

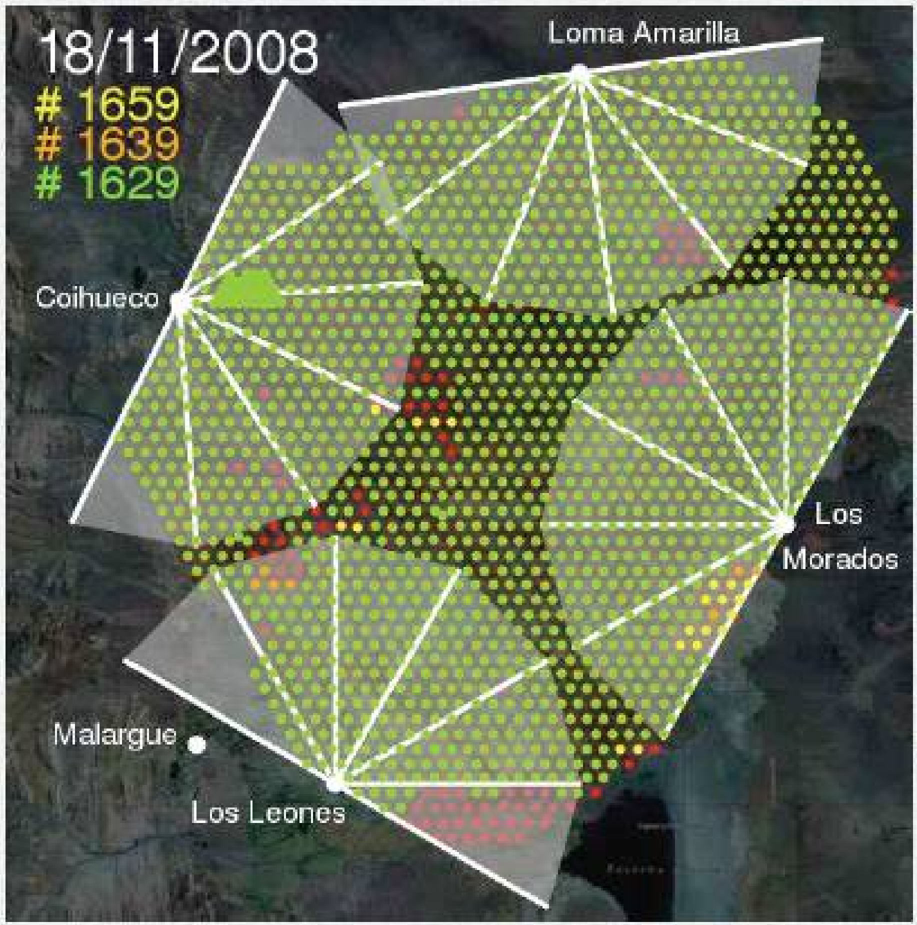
$$\gamma + p \rightarrow \Delta^+ \rightarrow n + \pi^+$$



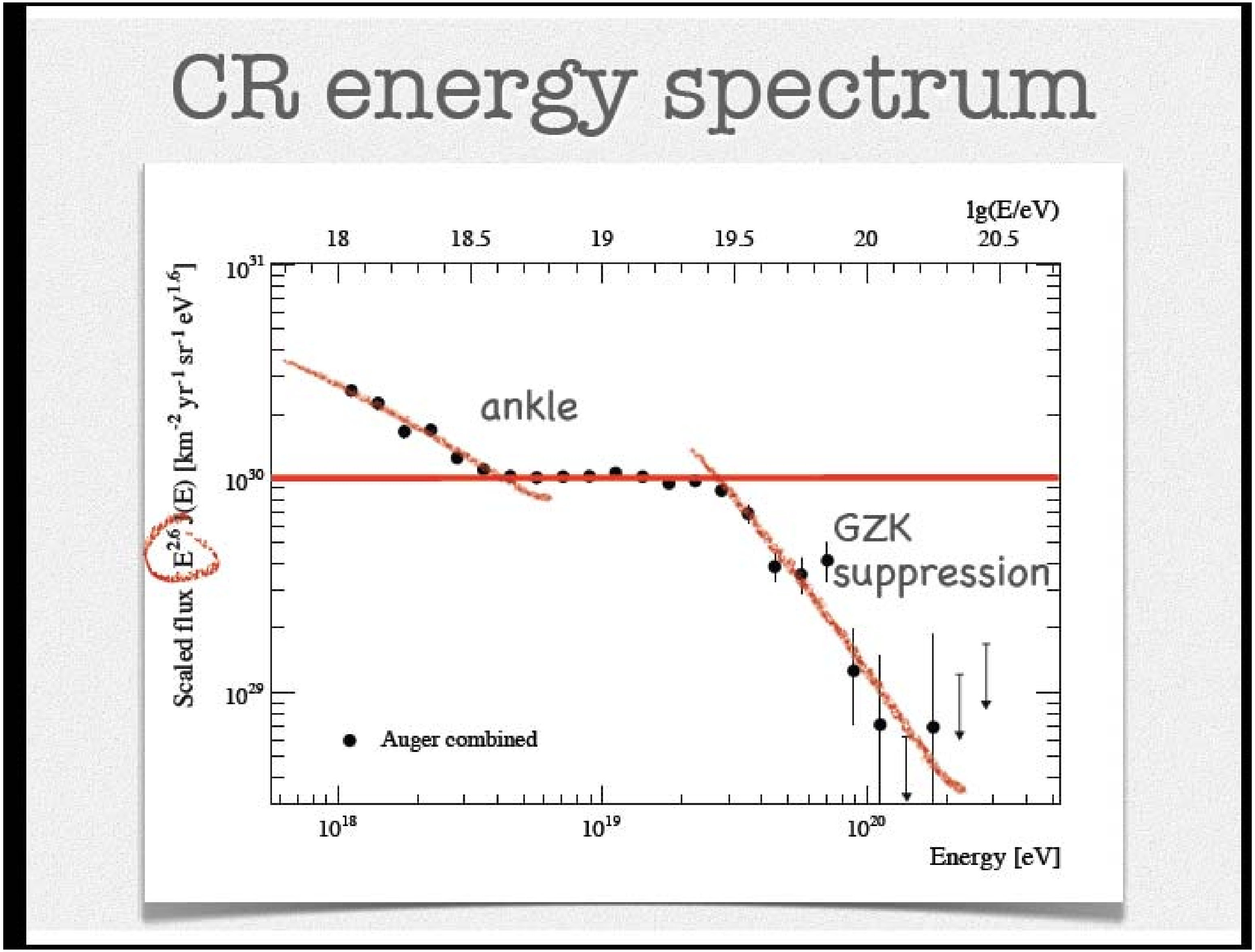
Cosmic Microwave Background

Large scale experiment in Argentina

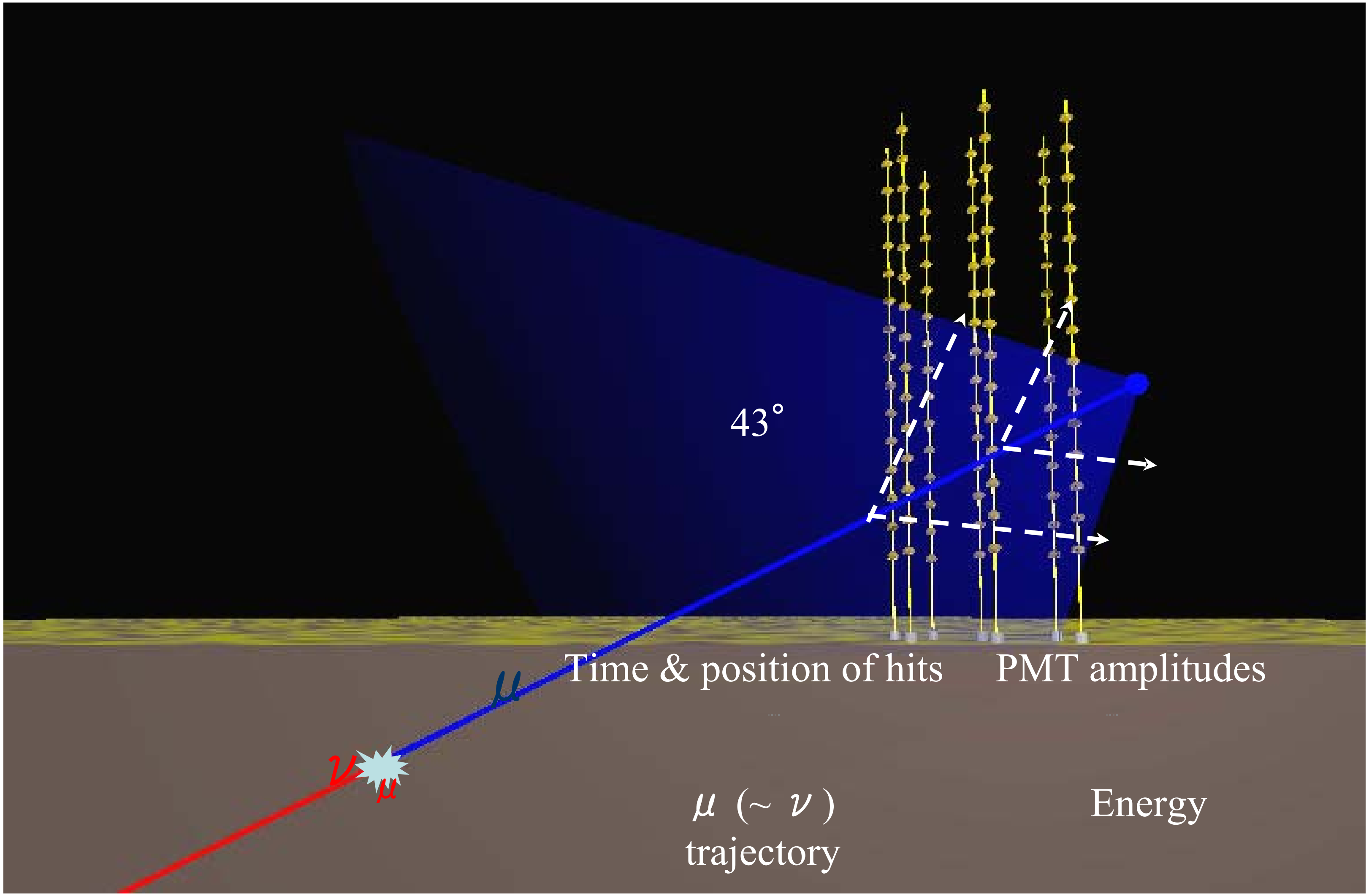
Auger South size & status



Observe cut-off due to interaction with CMB



Principle of neutrino detection



High Energy Neutrino telescopes

Baikal

Mediterranean sea
ANTARES+NEMO+NESTOR:

Joint effort for km^3-scale detector KM3NeT

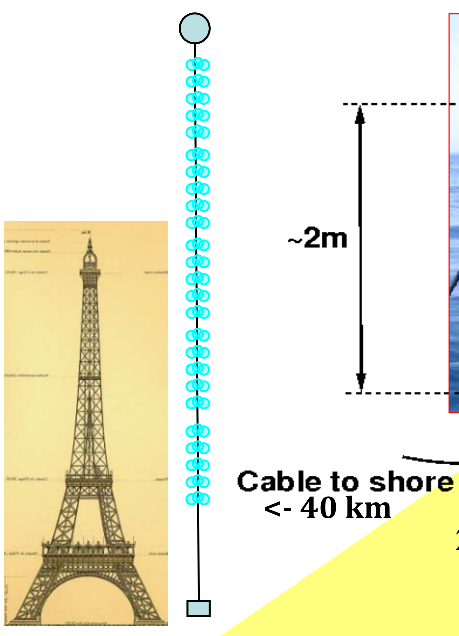
South Pole

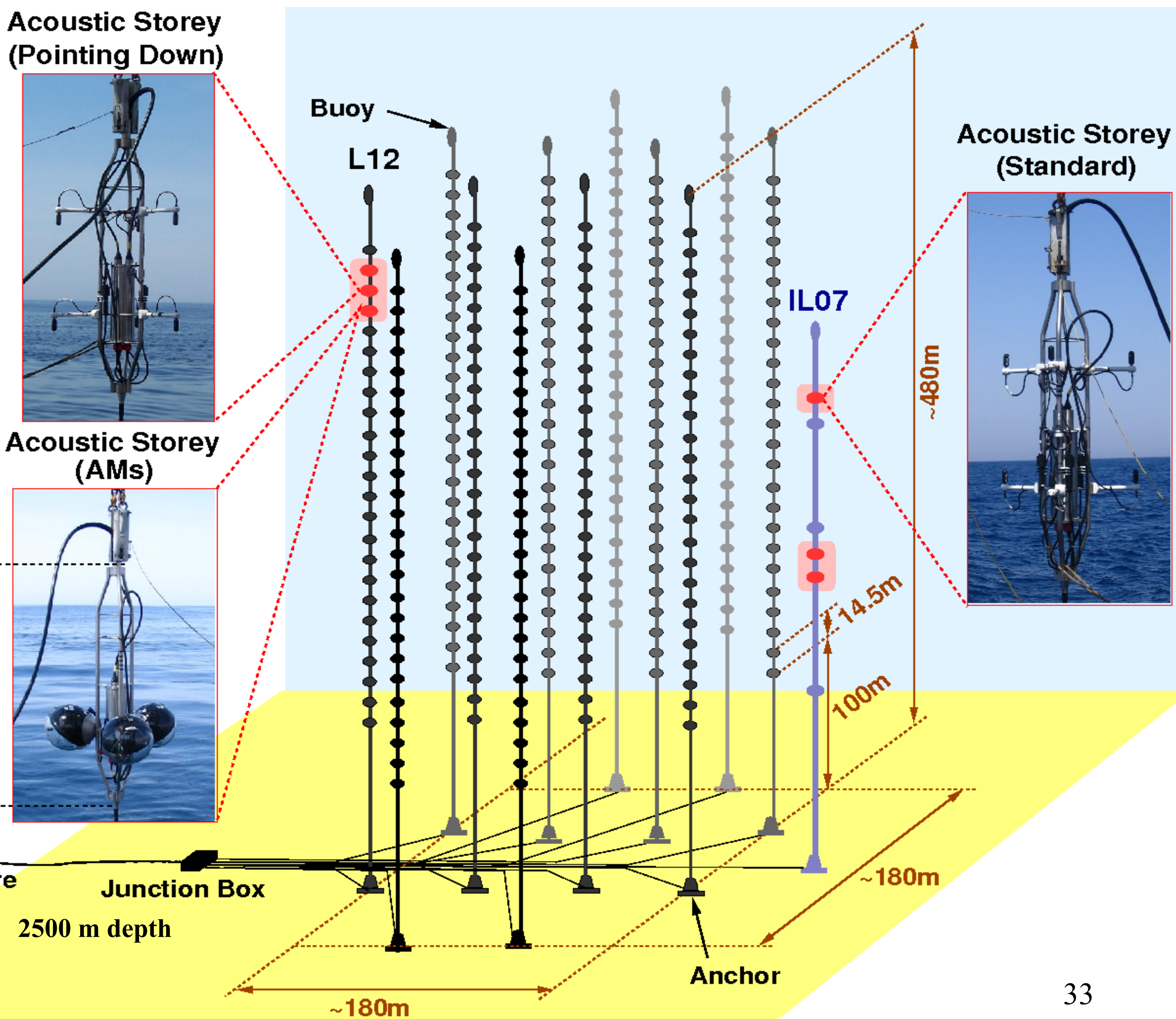
AMANDA/IceCube

ANTARES

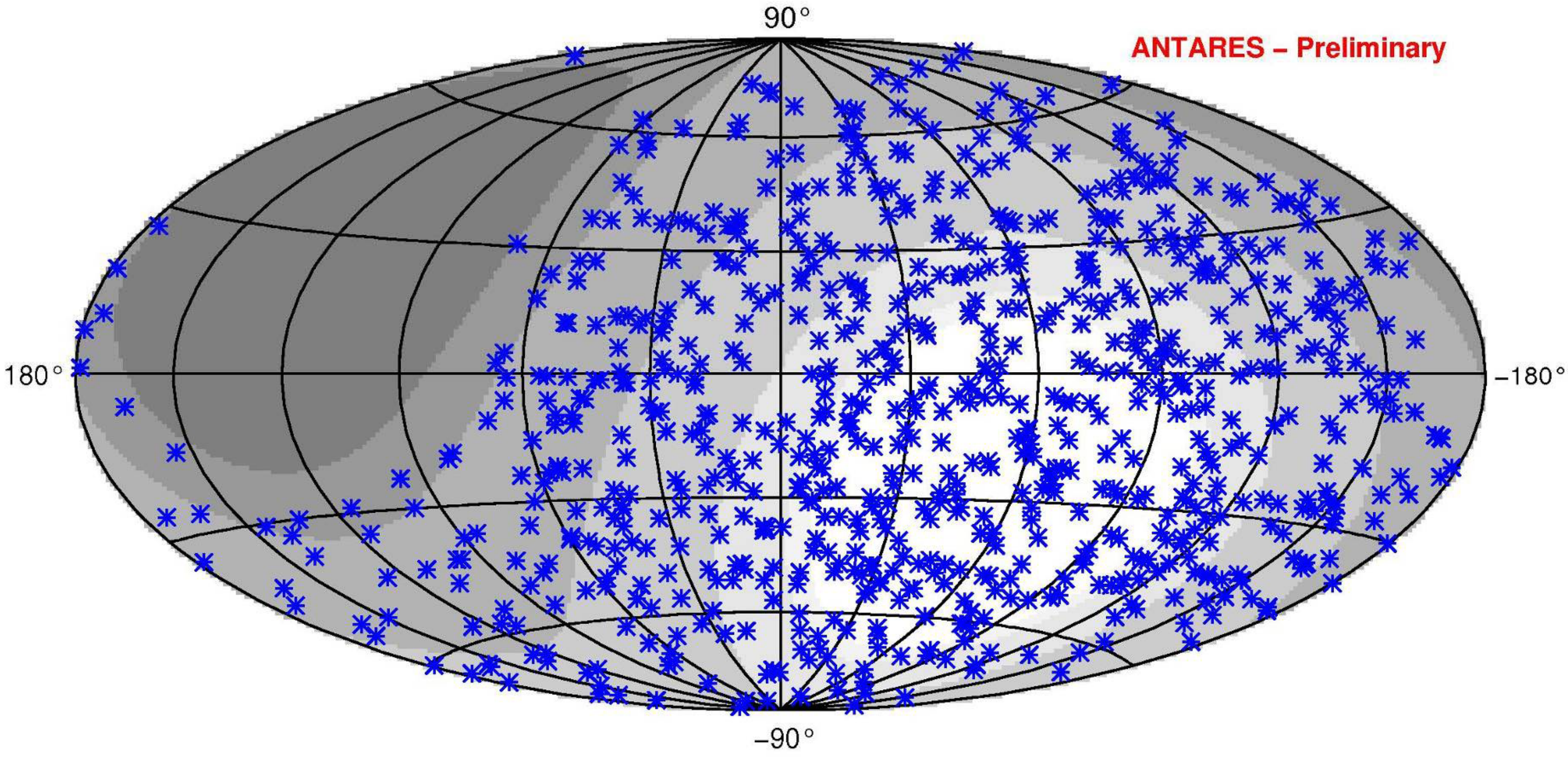
Installation:
Junct.Box - Dec 2002
Line 1 - March 2006
Line 5-10 - Dec 2007
Line 11-12- May 2008

900 Optical modules
12 lines
25 storeys / line
3 PMTs / storey



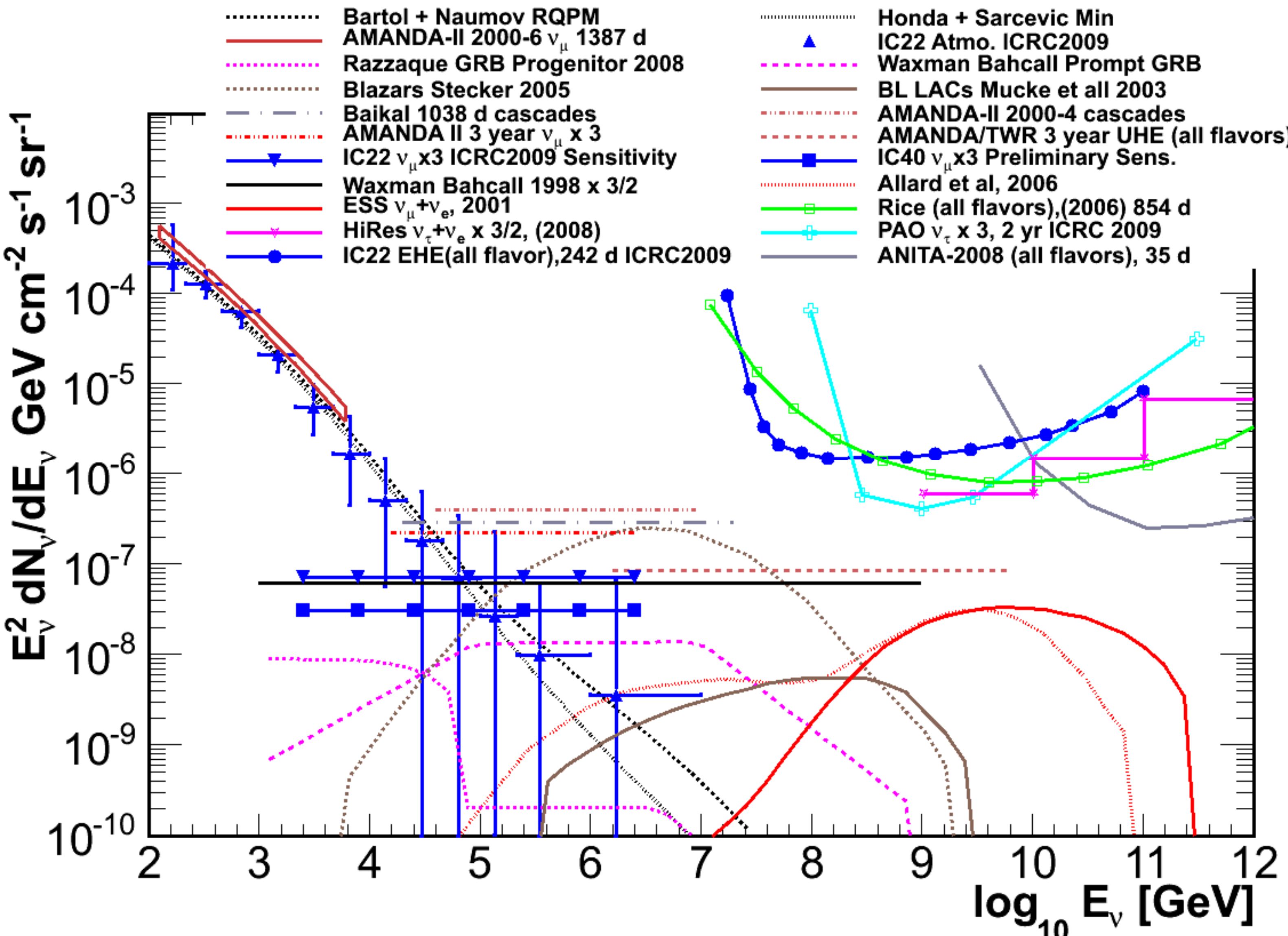


Scrambled 2007+2008 Skymap



750 upgoing neutrinos (multi-line)
Unblinding once reprocessed with final alignment

Looking for diffuse fluxes above the background of atmospheric neutrinos

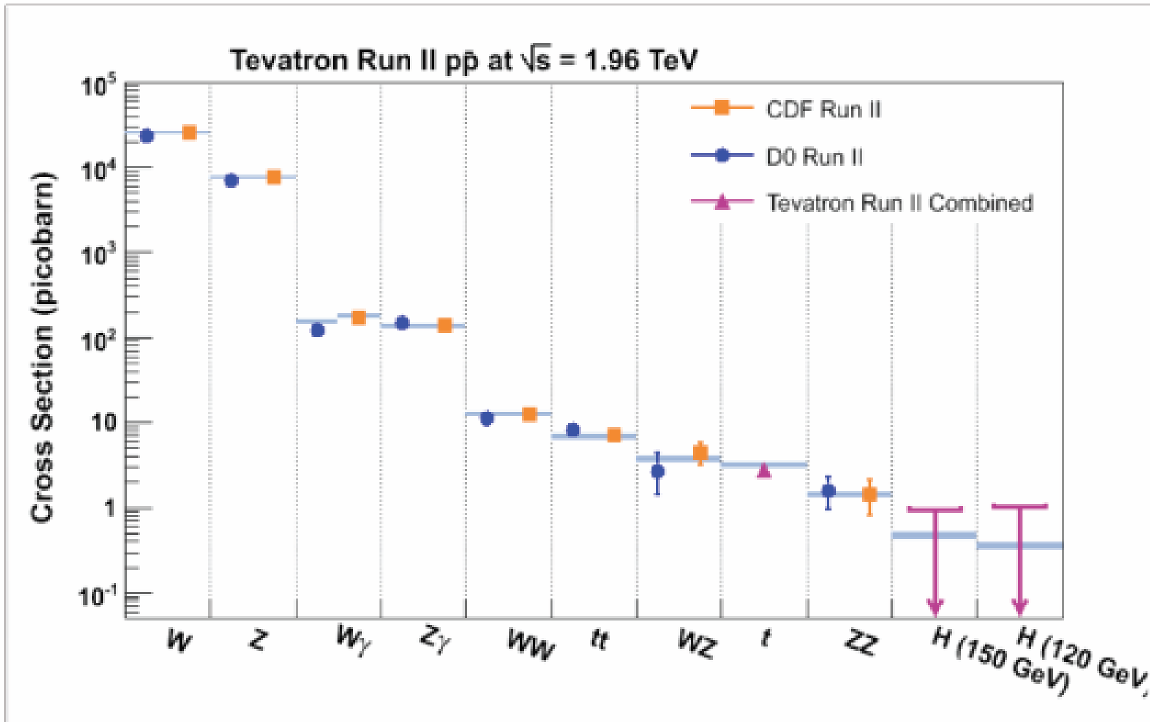


Excursion to Lubeck : Hanseatic city and home of marzipan

Top and EW physics at high E Fiorencia Canelli (Fermilab)

Electroweak an

- Span over a wide range of cross sections



- Until the past year only cleaner channels were observed: small background, lower statistics $W\gamma \rightarrow l\nu\gamma$ $Z\gamma \rightarrow ll\,\gamma$ $WW \rightarrow l\nu l\nu$ $WZ \rightarrow l\nu ll$ $ZZ \rightarrow llll$

Hadron Collider

Hera, Desy

- 319 GeV proton – electron collider
- Run 1992-2007
- Accumulated luminosity ~200 pb^{-1} in e^-p and ~300 pb^{-1} in e^+p

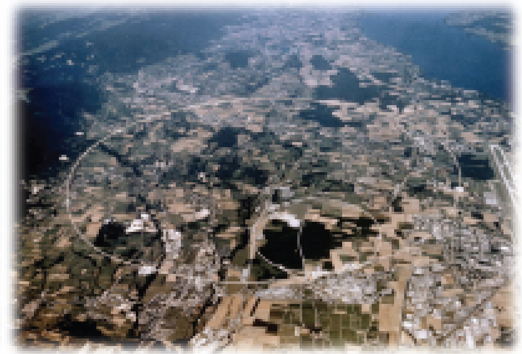
Some results

Tevatron, Fermilab

- 1.96 TeV p-anti p collider
- Run II started in 2002
- Has delivered ~7 fb^{-1} of data since 2002, and running smoothly: expect ~12 fb^{-1} by end of 2011

Most of the results

LHC, Cern



- ≤ 14 TeV p-p collisions
- Expect to turn on late 2009 at 7 TeV
- Expect up to 200 pb^{-1} in the early run

Some prospects

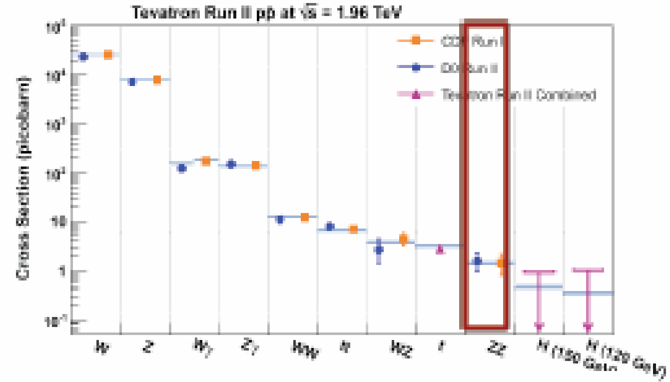
ZZ

- Smallest cross section of SM diboson states
- ZZ→llll striking signature !
  - First observation by D0 , 5.3 σ significance

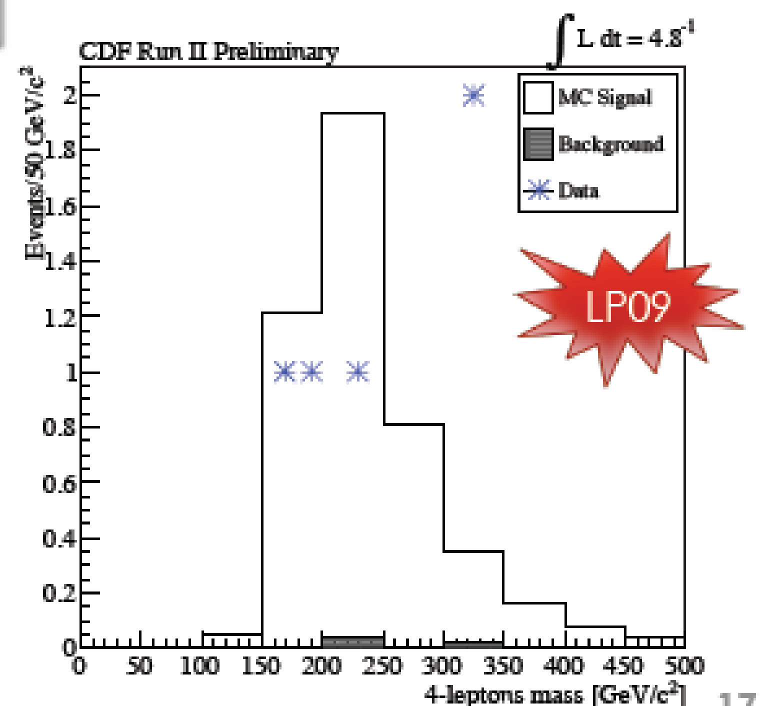
CDF (4.8 fb^{-1}):
$\sigma(ZZ) = 1.56^{+0.80}_{-0.63}$ (stat.) ± 0.25 (syst.) pb

  - 5.7 sigma significance

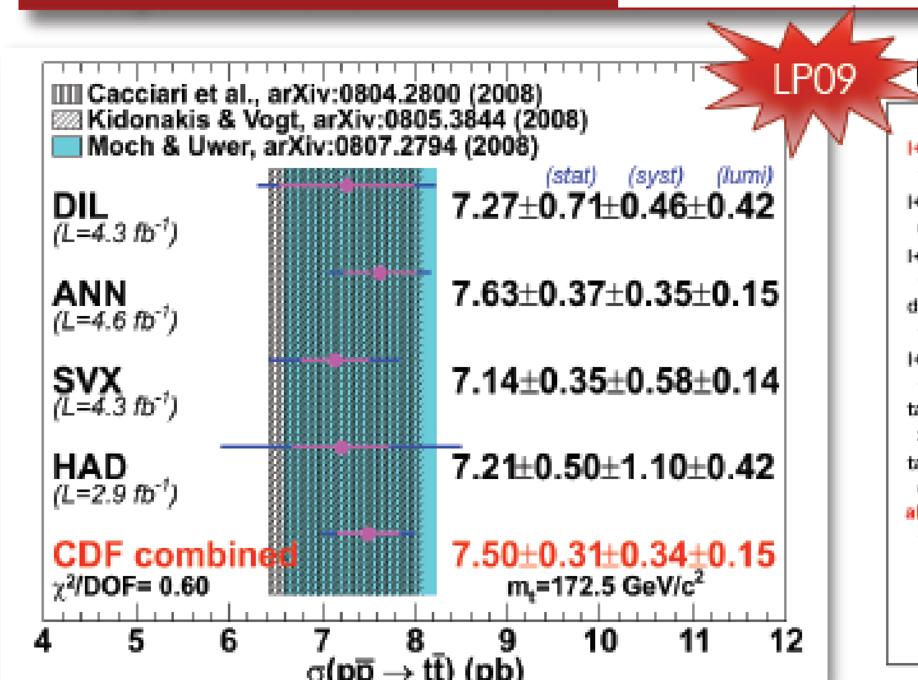
- ZZ→lljj or ZZ→vvjj mode not observed yet at the Tevatron
  - Important benchmark for Higgs searches (ZH)

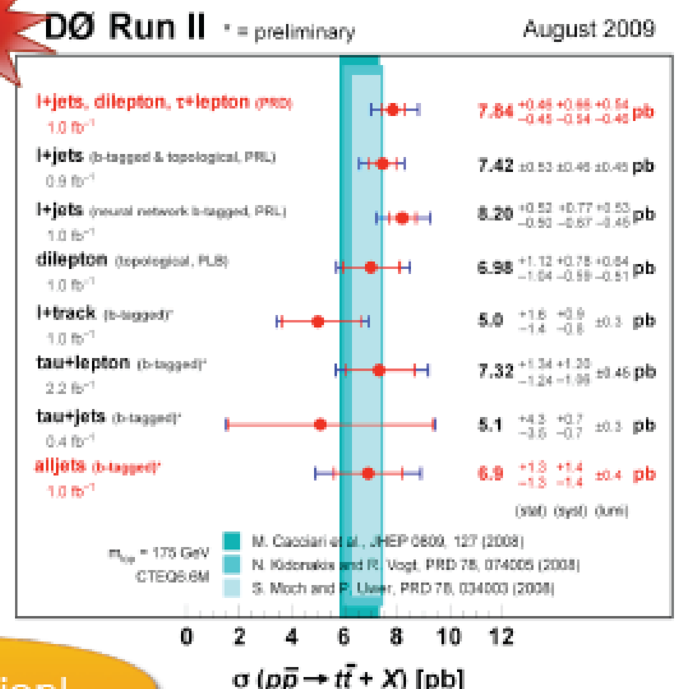


SM predicts $\sigma(p\bar{p} \to ZZ) = 1.4 \pm 0.1$ pb



Top Quark Pairs





6% precision!

- Most CDF measurements with more than 4 fb^{-1} !
- Measurements in all channels
- All channels are consistent with each other and with theory
- Different methods to measure σ_{tt} produce consistent results
- Tevatron combination underway

Single Top Quar

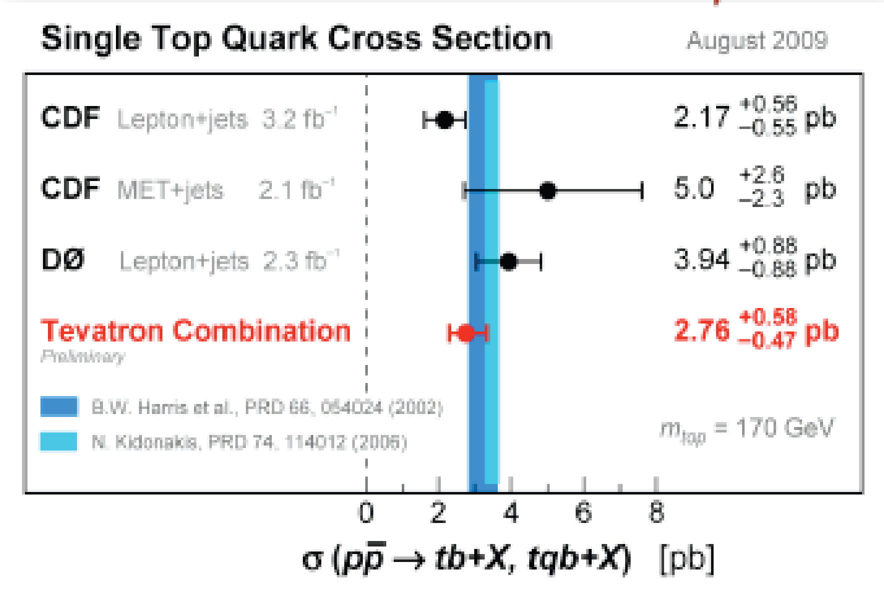
- In March 2009 the Tevatron experiments reported observation of with about **5σ** significance (to be published in PRL this week)

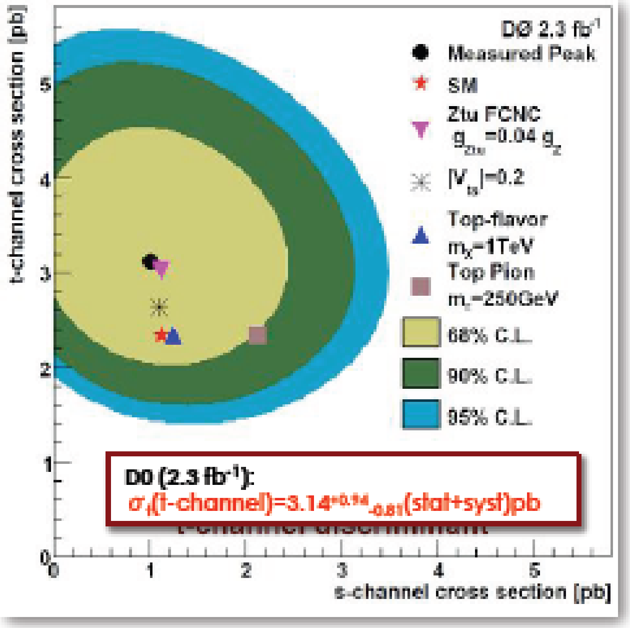
- CDF and D0 combined their results using a Bayesian approach:

Tevatron (3.2 fb^{-1}):
σ_t =2.76 $^{+0.58}_{-0.47}$ (stat+syst) pb

LP09

Tevatron (3.2 fb^{-1}), PRD66 054024, 2002:
$|V_{tb}|$=0.91 ± 0.08 (stat+syst)



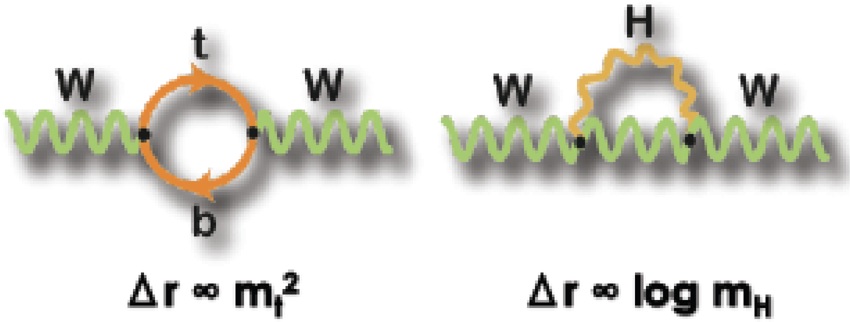


D0 (2.3 fb^{-1}):
σ_t(t-channel)=3.14$^{+0.94}_{-0.81}$(stat+syst)pb

13% improvement

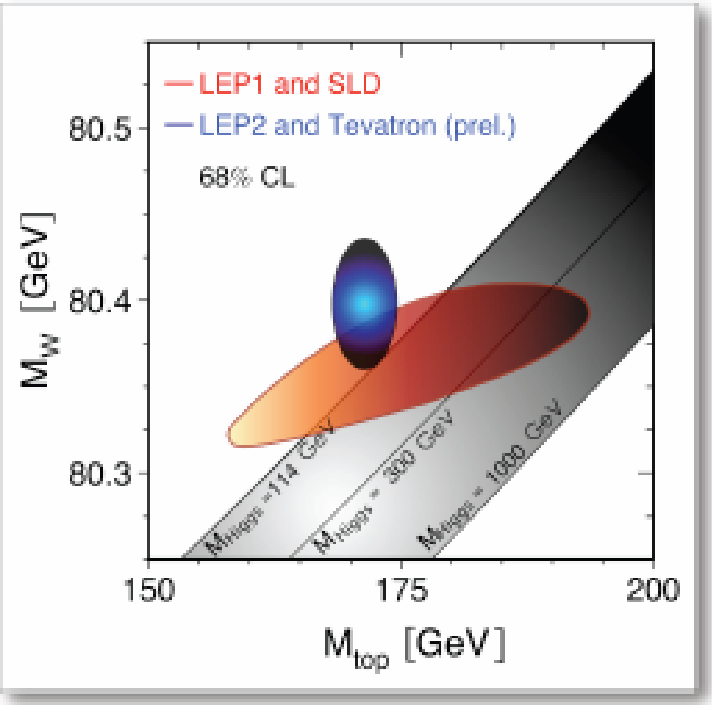
W Boson, Top Q

- Measuring the W boson mass and top quark mass precisely allows for prediction of the mass of the Higgs boson



- Constraint on Higgs can point to physics beyond the standard model

- Constrains the Higgs mass now, precision check of the EW theory after/if Higgs is found



W Boson Mass: F

- Limited by the size of the Z sample. Will improve with more data
- Tevatron measurements improving the precision of parton distributions functions (ex. W charge asymmetry previously shown)

D0 m_W Systematic Uncertainties (1 fb^{-1})

Systematic Source	δm_W (MeV)
Electron energy scale	34
Electron energy resolution model	2
Electron energy nonlinearity	4
W and Z electron energy loss differences	4
Recoil model	6
Electron efficiencies	5
Backgrounds	2
PDF	9
QED	7
Boson p_T	2
Total	**37**

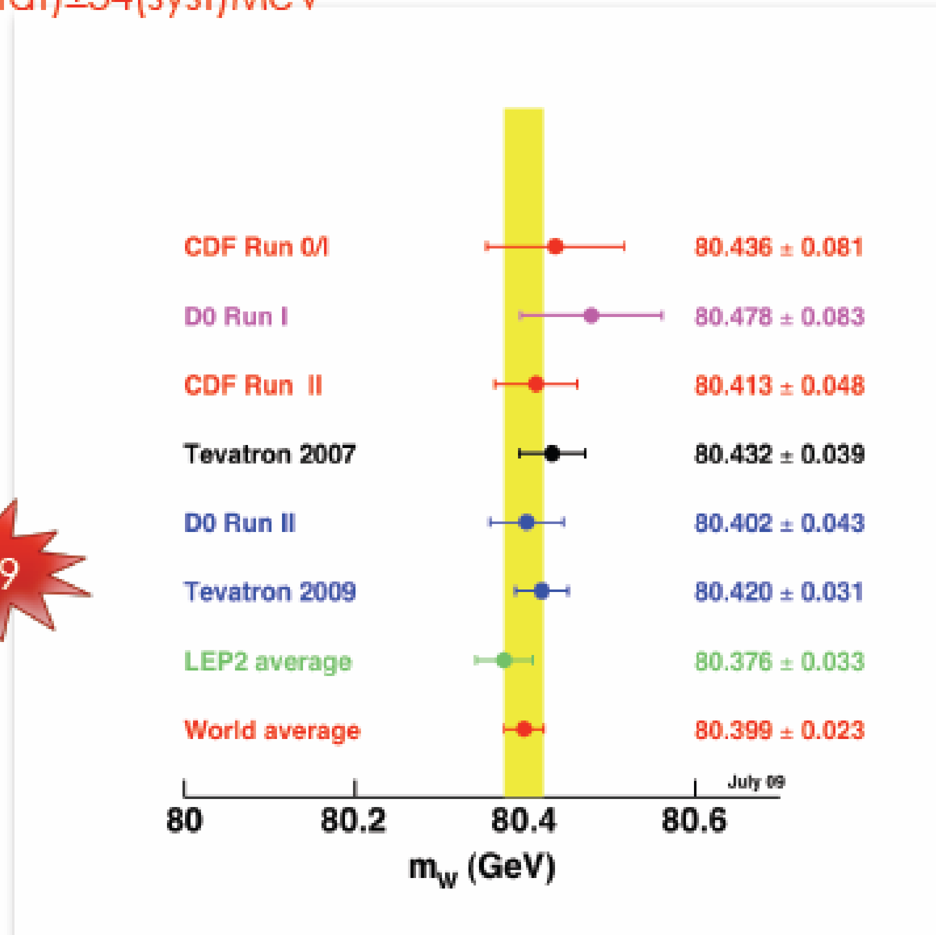
W Boson Mass:

- Combine previous results, including CDF Run II measurement using 200 pb^{-1}: m_W = 80413±34(stat)±34(syst)MeV

Tevatron Average:
m_W=80420±31MeV

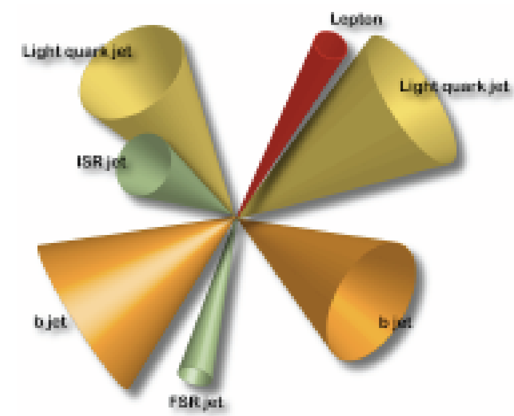
LP09

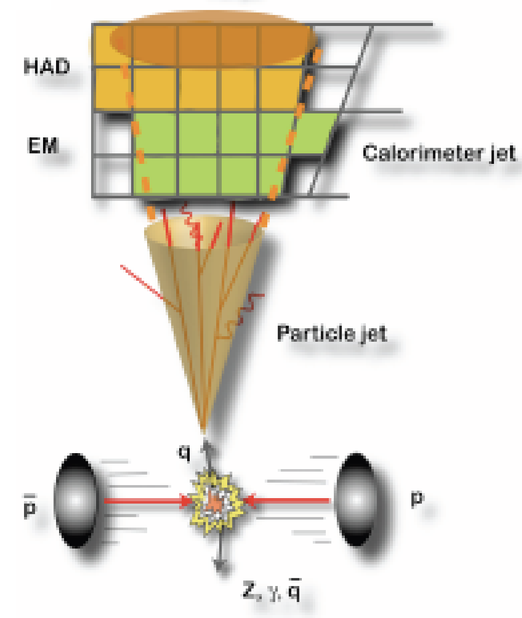
World Average:
m_W=80399±23MeV

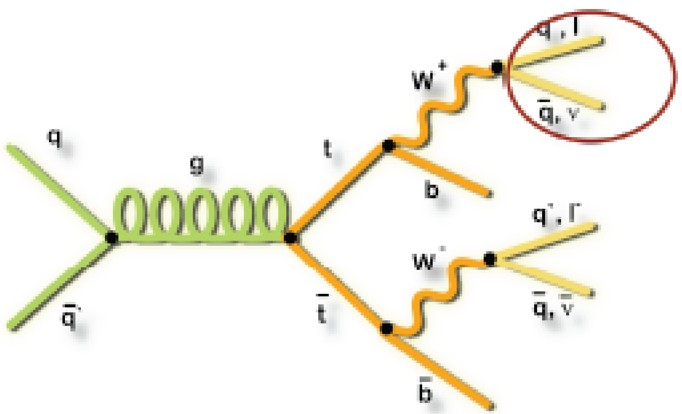


Top Quark Mass

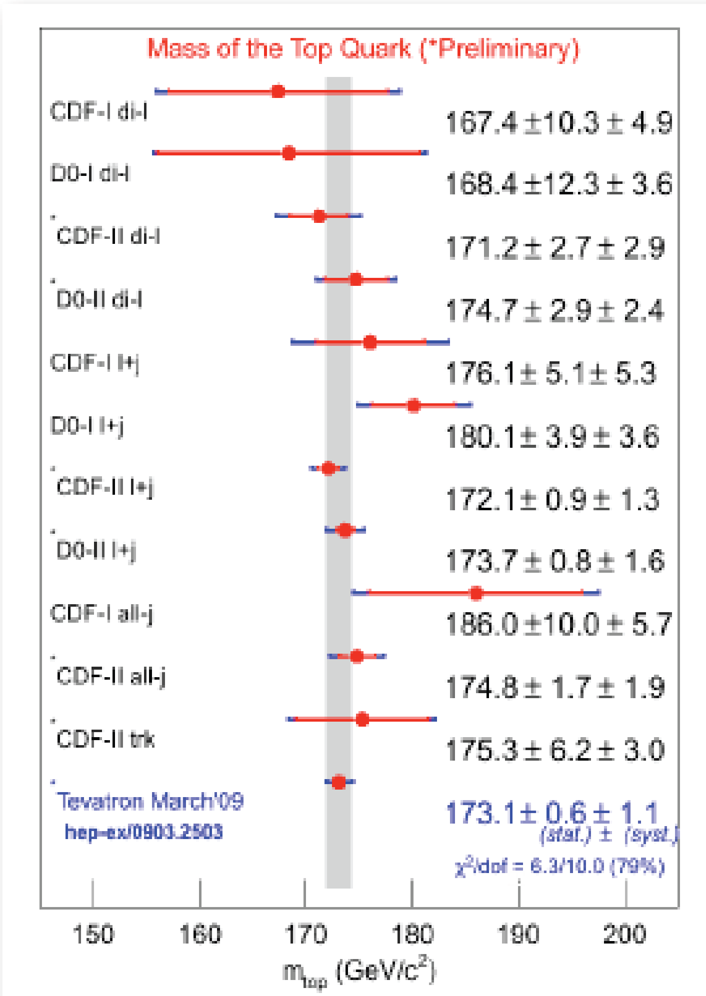
- Measurements in the 3 channels: dilepton, lepton +jets, all-hadronic
- Different difficulties than in W mass measurement
  - Can only measure jets resulting from quarks
  - Jet-parton assignment
  - QCD radiation
- Jet energy scale (JES) uncertainty dominates [~3%]
  - Can be reduced via *in situ measurement from hadronic W mass*







Top Quark Mass



Tevatron (Winter 09):

m_t=173.1 ± 0.6 (stat) ± 1.1 (syst) GeV

m_t=173.1 ± 1.3 (stat+syst) GeV

- Channels are consistent with each other
- Different methods to measure m_t produce consistent results
- Working on improving systematic uncertainties: are all effects covered, are they covered more than once ?

Experimental constraints on the SM Higgs Boson

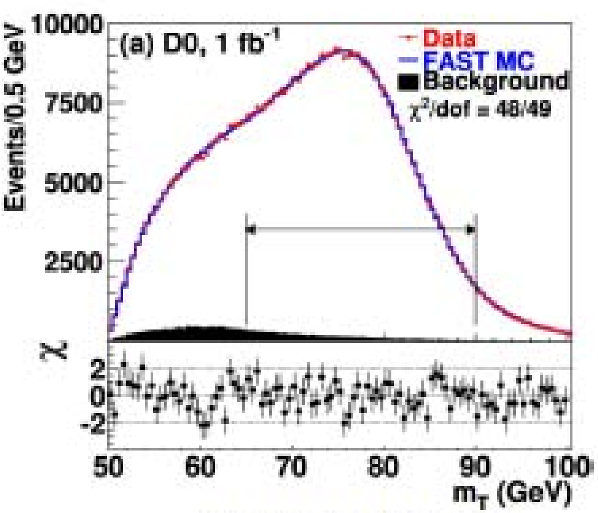
Direct searches at LEP II:

m_H>114.4 GeV @ 95% CL

Indirect constraints:

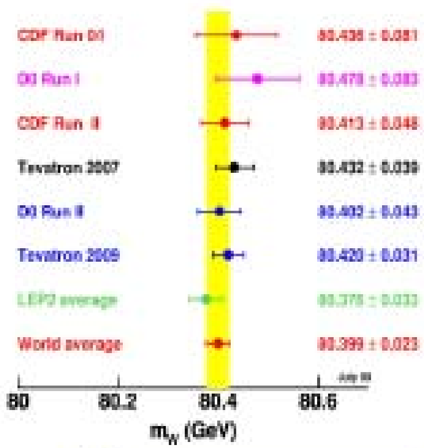
Top, W-boson mass

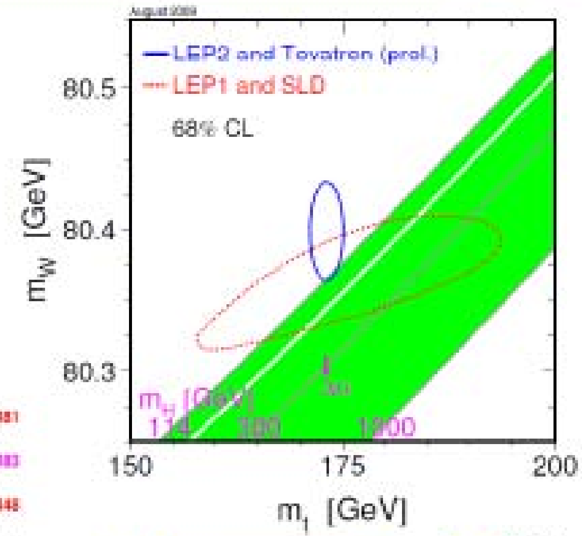
➔ new W mass measurement

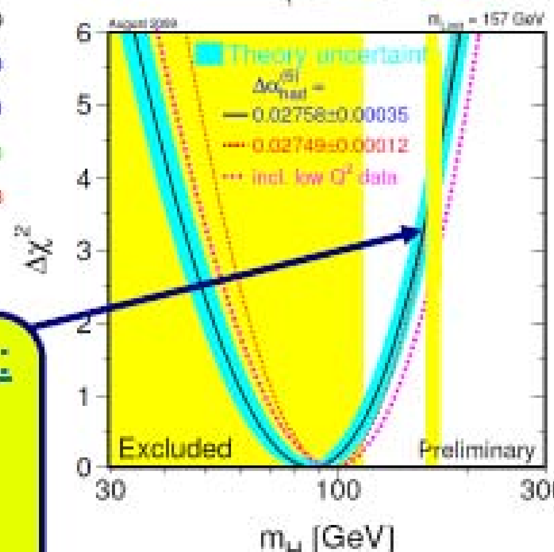


m_W = 80.401±0.043 GeV

See F. Canelli talk on friday







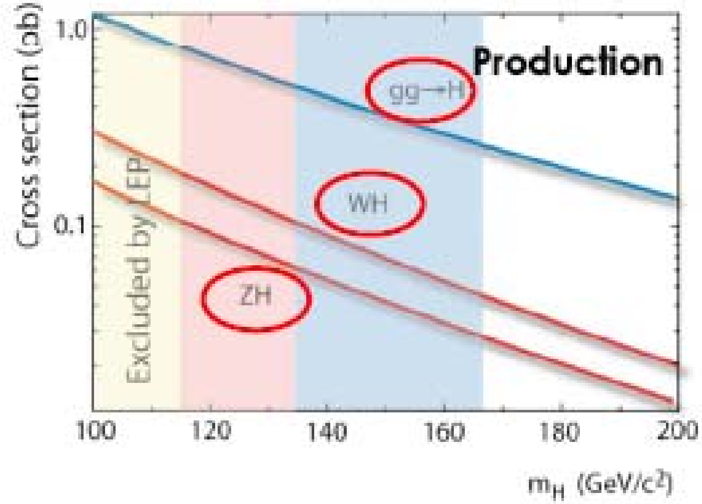
Precision EW fit:

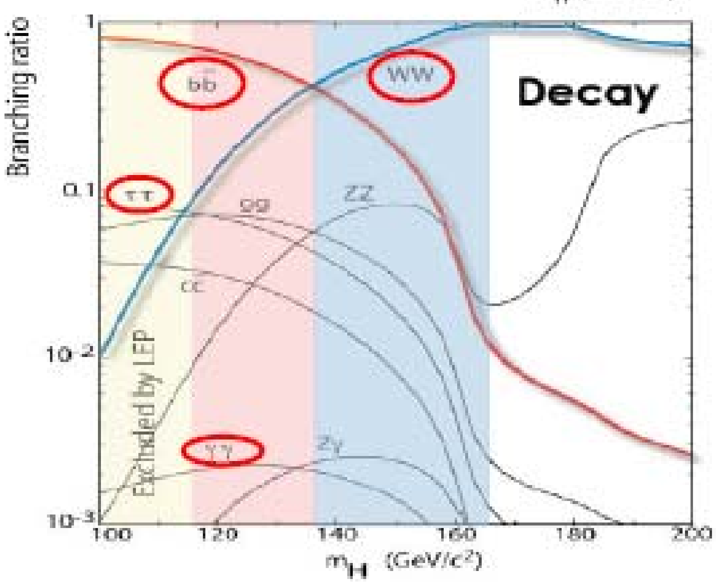
m_H < 157 GeV

@95%CL

(<186 GeV with LEPII Limit)

Higgs Production and Decay at the Tevatron

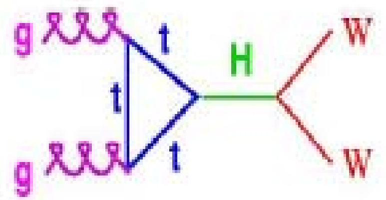




High mass (m_H > 135 GeV) dominant decay:

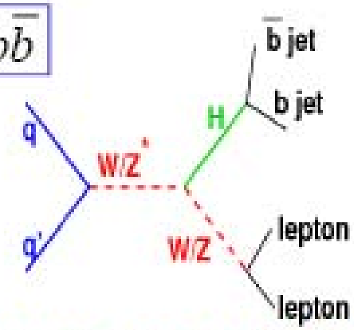
$$H \to WW^{(*)}$$

$$WW \to \ell\nu\ell'\nu'$$



Low mass (m_H < 135 GeV) dominant decay:

$$H \to b\bar{b}$$



$$WH \to \ell\nu b\bar{b}$$

$$ZH \to \ell^+\ell^- b\bar{b}$$

$$ZH \to \nu\bar{\nu}b\bar{b}$$

use associated production modes to get better S/B

These are the main search channels, but there is an extensive program of measurement in other channels to extend the SM and BSM sensitivities.

Conclusions

SM Higgs is excluded by Tevatron direct searches in the mass range

from 160 to 170 GeV @ 95% CL

More likely to be below 160 GeV (indirect constraints)

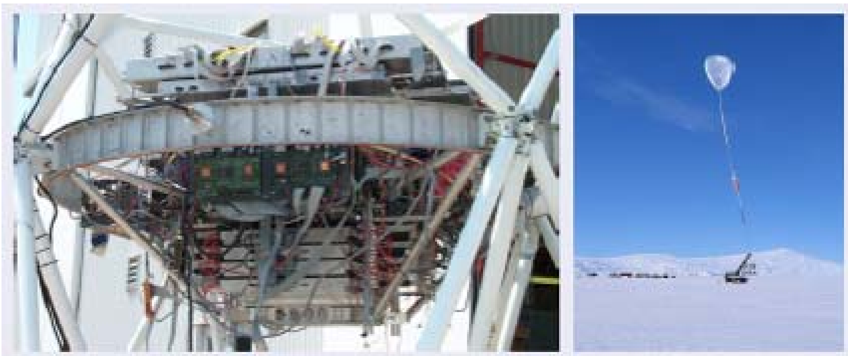
Tevatron progressing both in high and low mass Higgs searches

- The machine continues to work very well with an expected delivered luminosity of 12 fb^{-1} with the 2011 run
- Sensitivity continues to improve faster than luminosity scaling
- Rapid incorporation of new data and analysis improvements

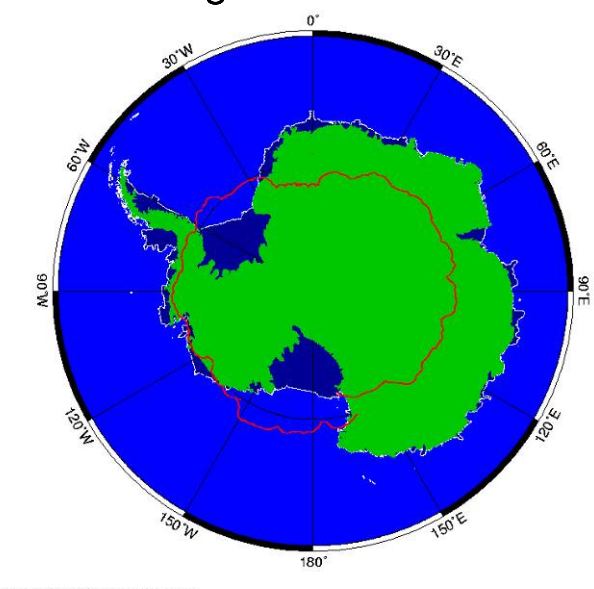
➔ Looking forward to seeing the first hints of the SM Higgs...
or directly exclude @ 95%CL the SM Higgs between 115 and 185 GeV

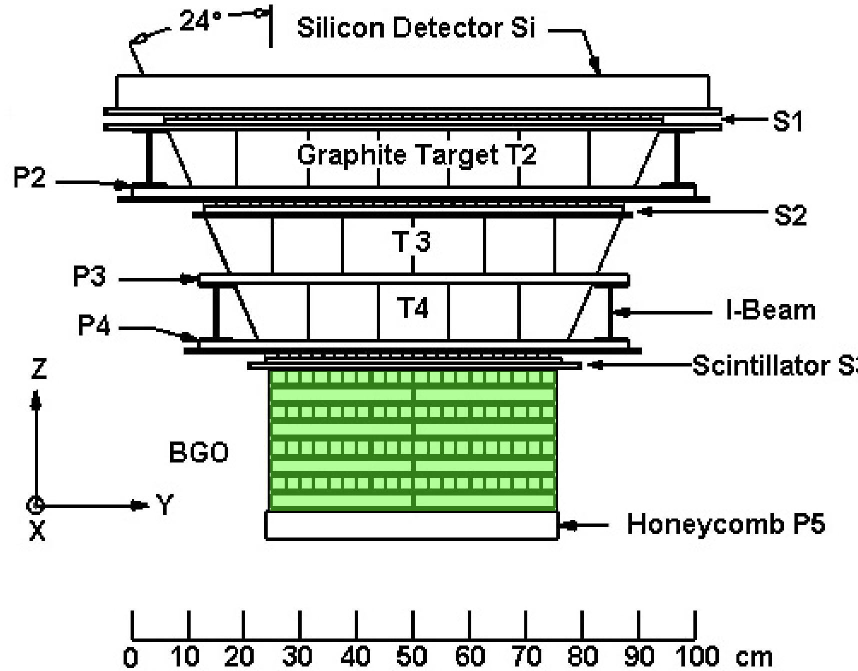
Good sensitivity also to MSSM Higgs and more exotics Higgs.
For MSSM, we will probe tanβ below 30

The ATIC Instrument & Program



ATIC 2 Flight from McMurdo 2002



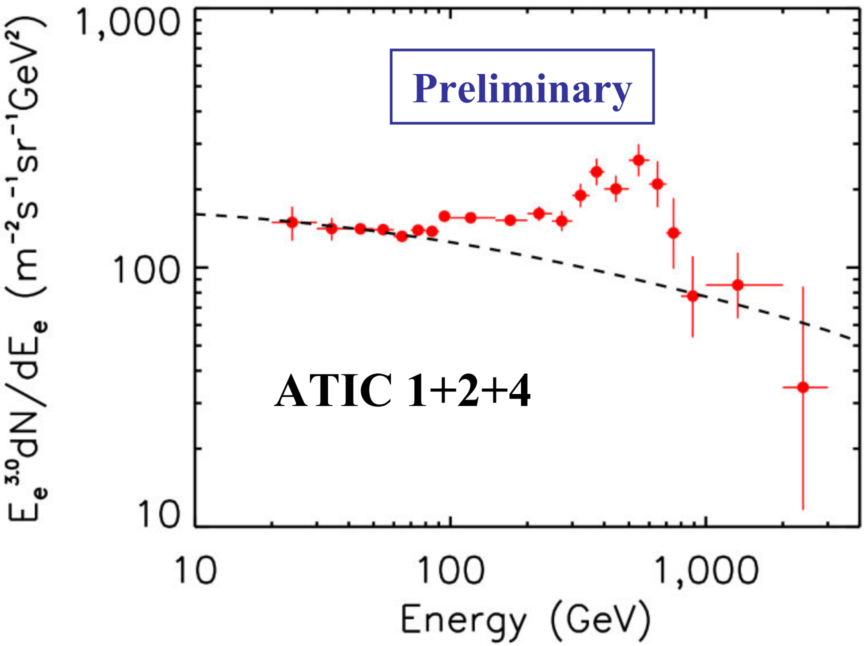


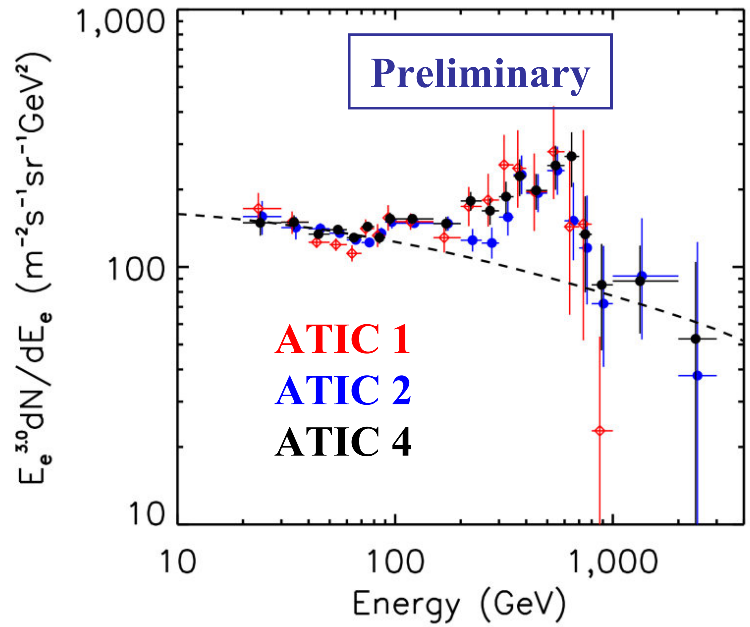
Total of 4 flights – 3 successful

Goal: measure CR fluxes of electrons, protons, and nuclei to ~ 1 TeV

Instrument not optimized for electron detection.

All 3 Successful ATIC Flights



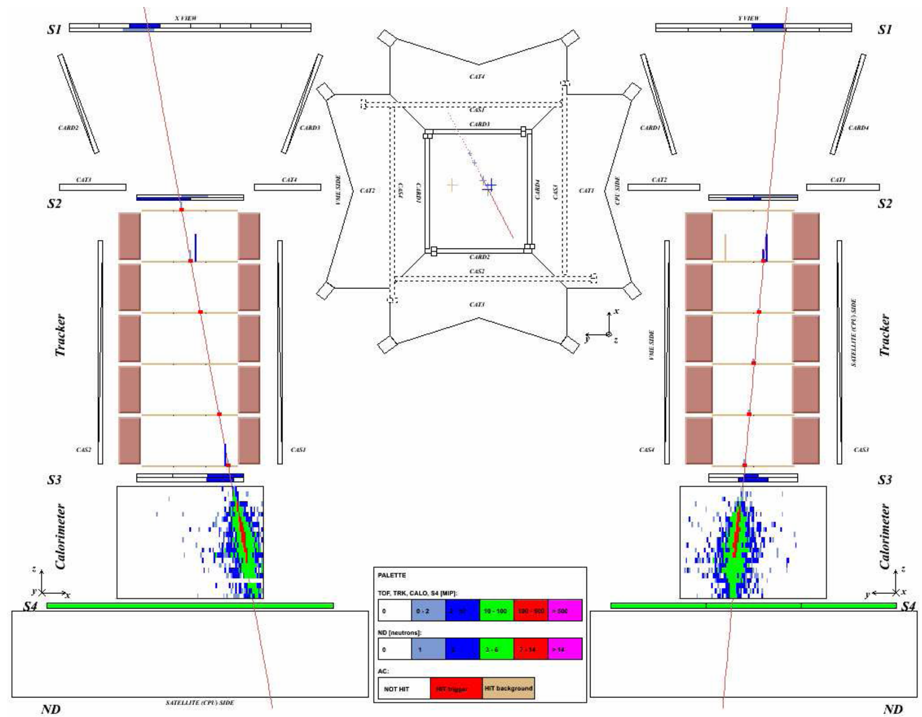


- Significance of bump for ATIC1+2 is about 3.8 σ
- This caused considerable excitement and speculation.
- **Recently analyized Flight 4 data shows same "bump" and significance of ATIC1+2+4 is 5.1σ**
- Dashed line indicates expected electron spectrum extrapolated from lower energy

PAMELA Satellite Experiment

Launched in Spring 2007

A High Energy Electron Event



Magnetic Spectrometer measure sign of charge and momentum

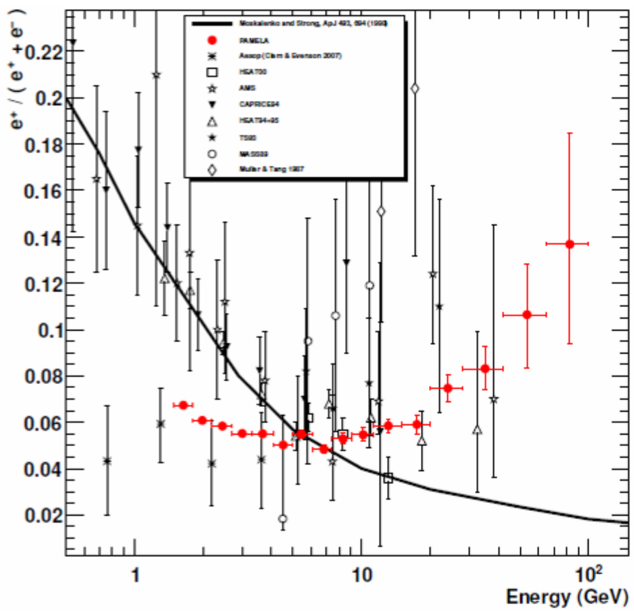
Goal: measure e+/e-, p/$\bar{p}$, He/anti-He, etc. as well as spectra

PAMELA Positron Fraction

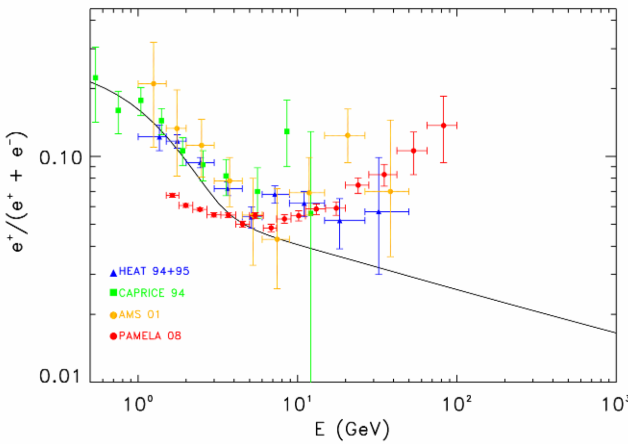
Unexpected!
Positron fraction increases above 10 GeV!

Note that Geomagnetic cut-off of primary cosmic rays is O(10 GeV)

Data below 10 GeV is dominated by trapped radiation and fluxes are sensitive to Solar Cycle

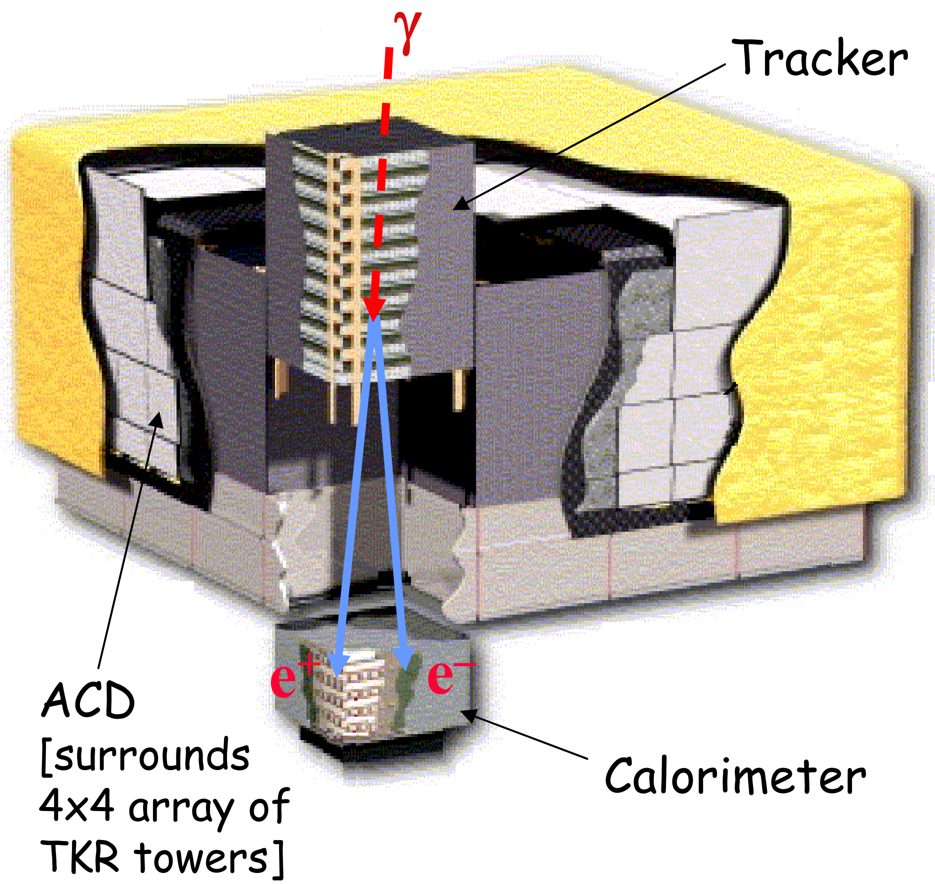


ATIC Electron Spectra & PAMELA e^+ Fraction caused excitement in 2008!



- **More than 200 papers in the last year**
- **Local source of electrons – Astrophysical? Dark Matter?**

Overview of the Fermi Large Area Telescope (LAT)

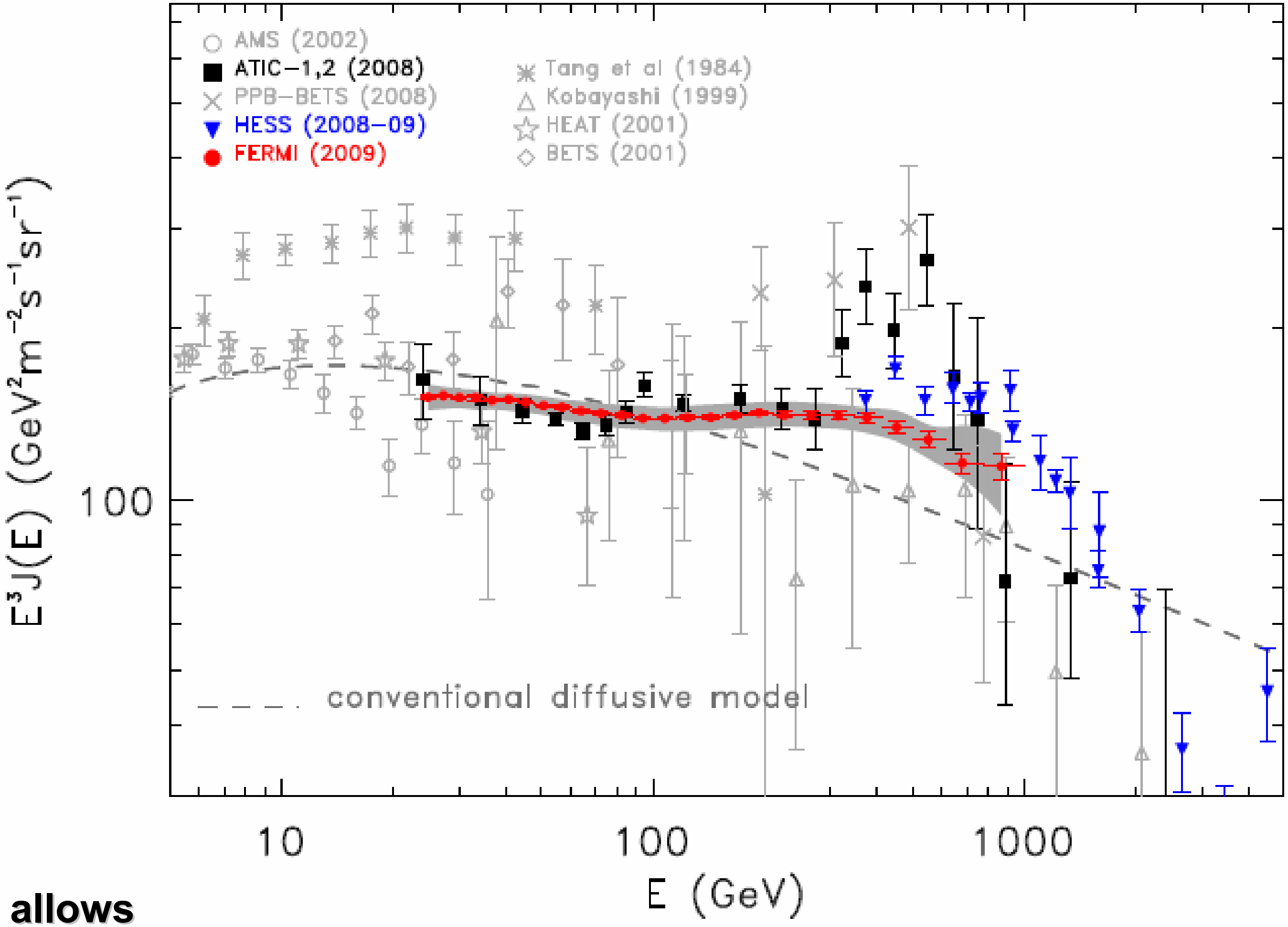


Systems work together to identify and measure the flux of cosmic gamma rays AND (e^{+}+e^{-}) with energy 20 MeV ⇨ > 300 GeV.

The Fermi-LAT $e^{+}+e^{-}$ Spectrum

Large number of events seen in the LAT

- 1500 electron events/day above 100 GeV
- 1 LAT day ~ year for PAMELA
- 1 LAT day ~ ATIC Balloon Flights



J. Chang et al., Nature 456, 362 (2008)

F. Aharonian et al., Phys. Rev. Lett. **101**, 261104 (2008)

A. A. Abdo et al., Phys. Rev. Lett. **102**, 181101 (2009)

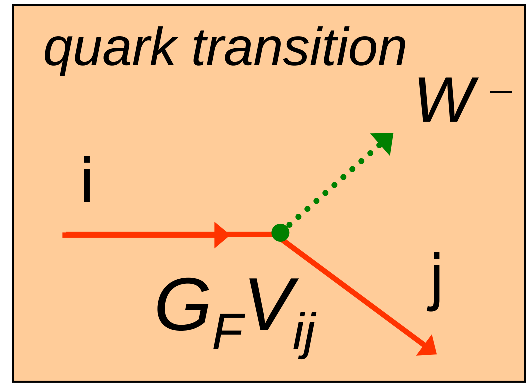
F. Aharonian et al., arXiv:0905.0105v1

Large number of events allows for detailed systematic studies

The CKM Matrix

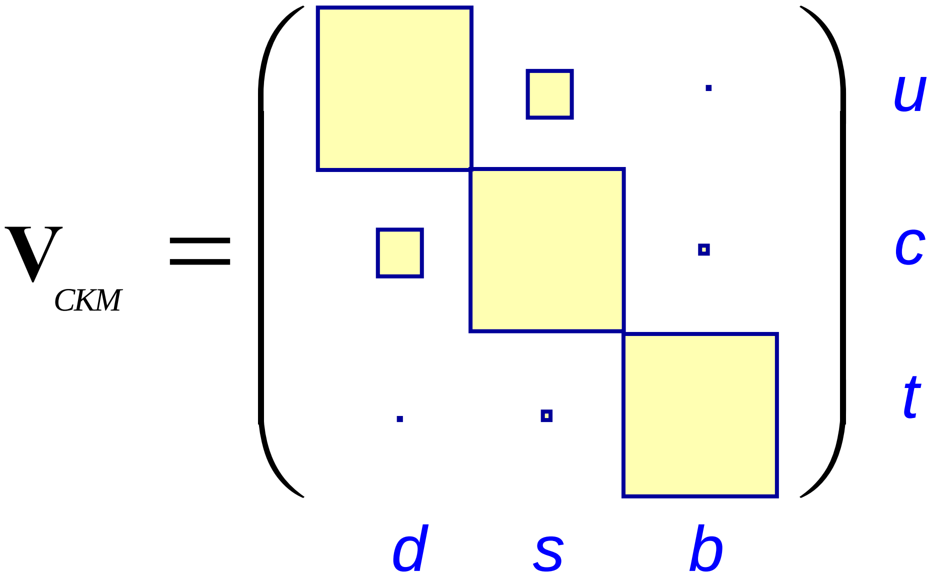
- V connects quark mass eigenstates to weak interaction eigenstates and thus describes coupling strength of quarks to charged current weak interaction

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = V \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$



$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

The CKM Matrix

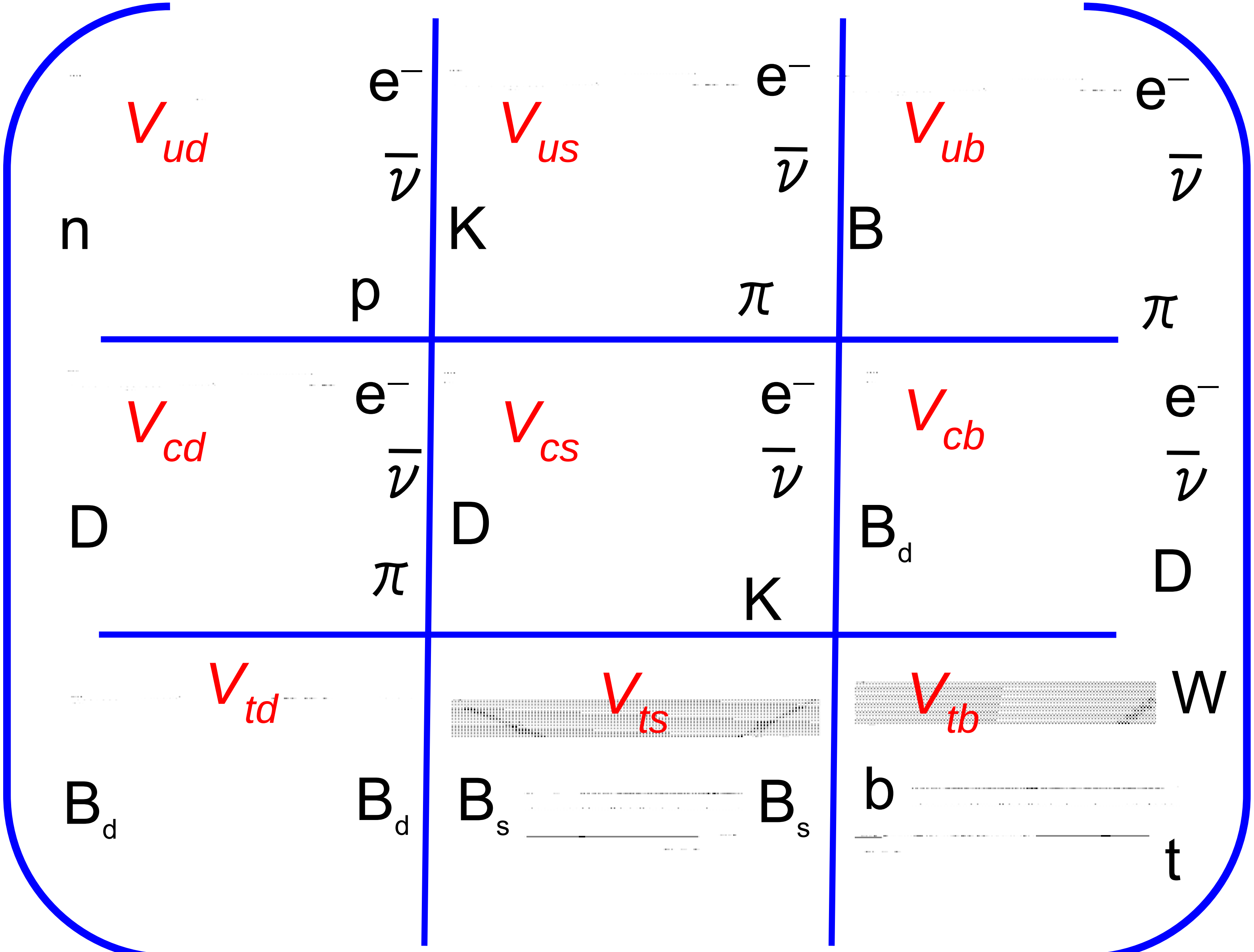


… reflects size of matrix elements

(areas of squares proportional to $|V_{ij}|^2$)

- In 3-generation Standard Model CKM matrix is a unitary 3x3 matrix
- Search for physics beyond the SM by testing unitarity of CKM matrix !

CKM Matrix Element Magnitudes



$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

CKM matrix unitarity check

Inputs:			
	$\|V_{ud}\| = 0.97424 \pm 0.00022$	$\|V_{us}\| = 0.2252 \pm 0.0009$	$\|V_{ub}\| = (4.07 \pm 0.38) \times 10^{-3}$
	$\|V_{cd}\| = 0.231 \pm 0.010$	$\|V_{cs}\| = 1.03 \pm 0.04$	$\|V_{cb}\| = (40.6 \pm 1.3) \times 10^{-3}$
	$\|V_{td}\| = (8.1 \pm 0.6) \times 10^{-3}$	$\|V_{ts}\| = (38.7 \pm 2.3) \times 10^{-3}$	$\|V_{tb}\| = (1.00 \pm 0.10) \times 10^{-3}$

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 - 1 = -0.0004 \pm 0.0007 \quad (-0.6\sigma)$$
$$|V_{cd}|^2 + |V_{cs}|^2 + |V_{cb}|^2 - 1 = +0.11 \pm 0.08 \quad (+1.3\sigma)$$
$$|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2 - 1 = +0.00 \pm 0.20 \quad (+0.0\sigma)$$
$$|V_{ud}|^2 + |V_{cd}|^2 + |V_{td}|^2 - 1 = +0.003 \pm 0.005 \quad (+0.6\sigma)$$
$$|V_{us}|^2 + |V_{cs}|^2 + |V_{ts}|^2 - 1 = +0.11 \pm 0.08 \quad (+1.4\sigma)$$
$$|V_{ub}|^2 + |V_{cb}|^2 + |V_{tb}|^2 - 1 = +0.00 \pm 0.20 \quad (+0.0\sigma)$$

Magnitudes of CKM matrix elements fulfill unitarity well

From V_{cb} and V_{ts}

$$A\lambda^2 = (40.1 \pm 1.1) \times 10^{-3}$$

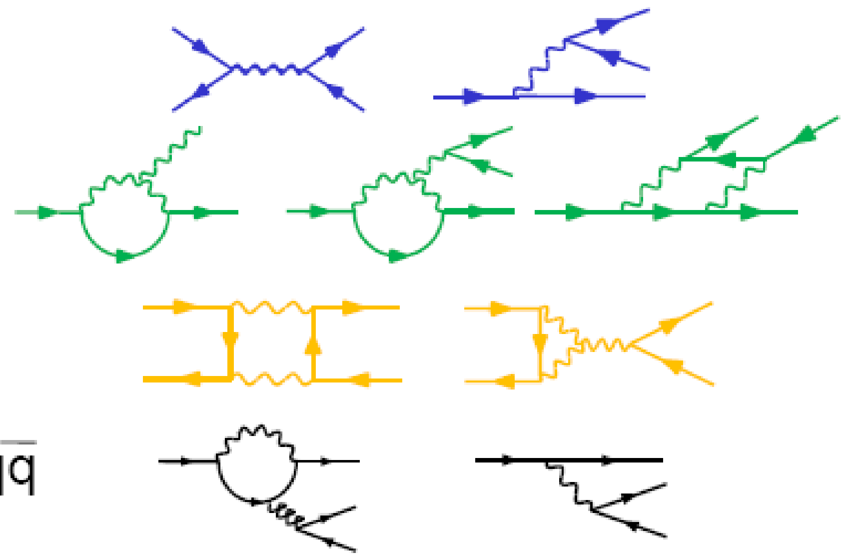
Rare B decays   Toru Iijima (Nagoya)

Talk Outline

There are many places to look for NP in rare B decays.

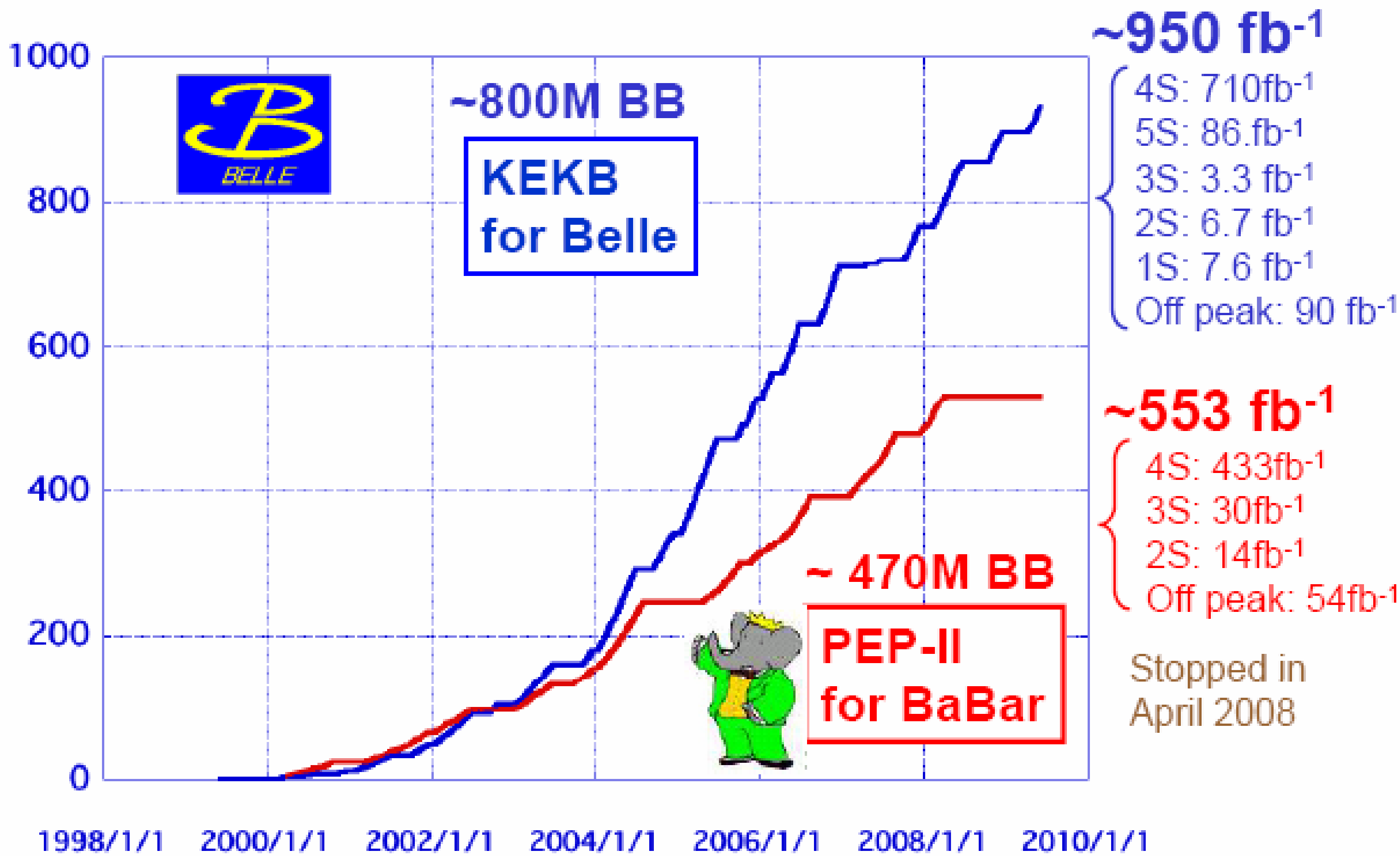
Review the present status of NP search in

- $B \to l\nu$, $\tau\nu$, $D\tau\nu$
- $b \to s\gamma$
- $b \to sll$
- $B_{s,d} \to ll$
- $b \to sg + b \to uq\bar{q}$



Results are from

Luminosity at the B-factories



$c\underline{s}$ mesons

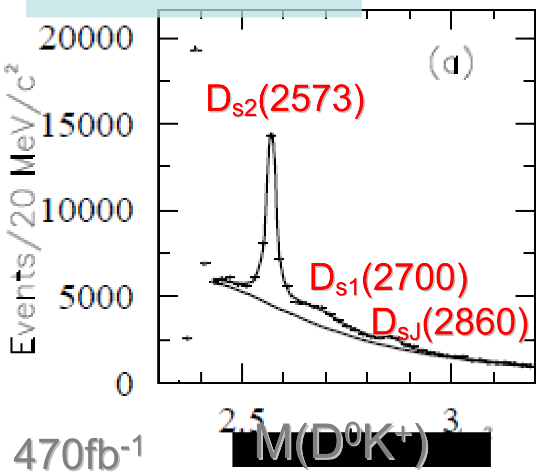
- Recently observed:

$D^*_{s0}(2317)$ $D_{s1}(2460)$ inconsistent with model predictions

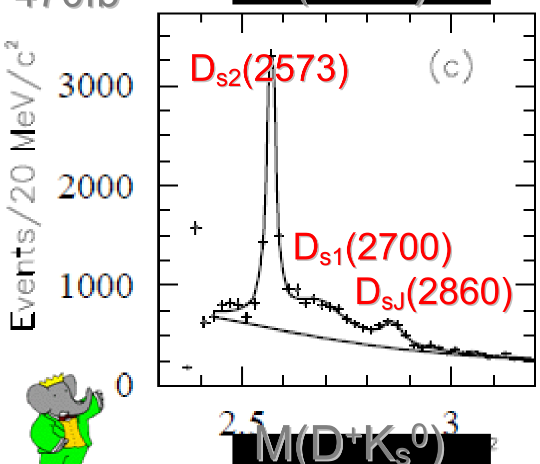
$D_{s1}(2700)\rightarrow DK$ in $B\rightarrow \underline{D}DK$, $D_{sJ}(2860)\rightarrow DK$ in $e^+e^-\rightarrow DKX$

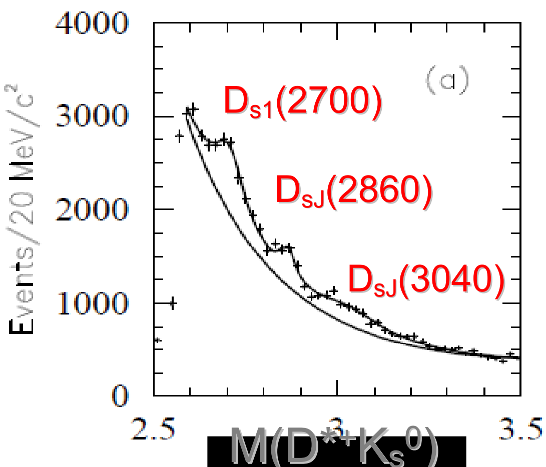
- New study of inclusive $D^{(*)}K$ from $e^+e^-\rightarrow D^{(*)}KX$

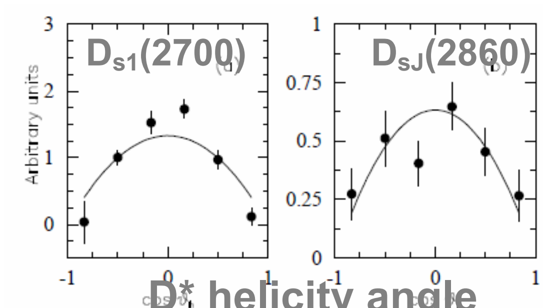
arXiv: 0908.0806



470fb⁻¹







⇨ Fit to M(DK) and M(D*K):

$D_{s1}(2700)$ confirmed in D*K

$$M = 2710 \pm 2^{+12}_{-7} \text{ MeV}$$

$$\Gamma = 149 \pm 7^{+39}_{-52} \text{ MeV}$$

$D_{sJ}(2860)$ confirmed in D*K

$$M = 2862 \pm 2^{+5}_{-2} \text{ MeV}$$

$$\Gamma = 48 \pm 3 \pm 6 \text{ MeV}$$

$D_{sJ}(3040)$ new, only in D*K

$$M = 3044 \pm 8^{+30}_{-5} \text{ MeV}$$

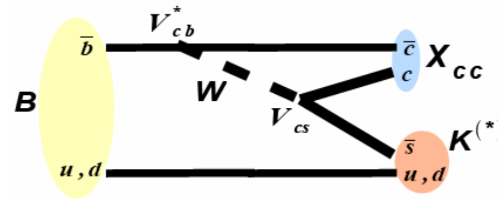
$$\Gamma = 239 \pm 35^{+46}_{-42} \text{ MeV}$$

⇨ $D_{s1}(2700)$ and $D_{sJ}(2860)$ have natural $J^P=1^-,2^+,3^-$...
$D_{sJ}(3040)$ not seen in DK ⇨ unnatural $J^P=0^-,1^+,2^-$...

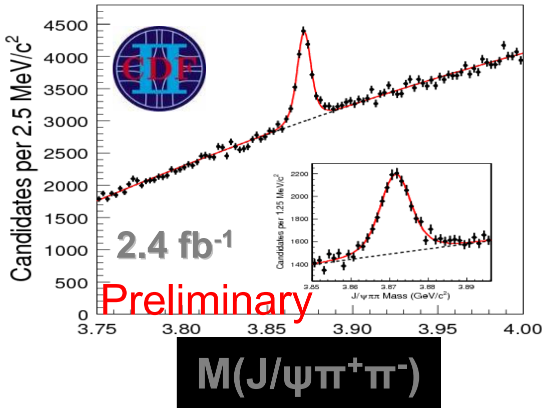
Interpretation: n=2 radial excitations? L=2 orbital excitations?

X(3872)

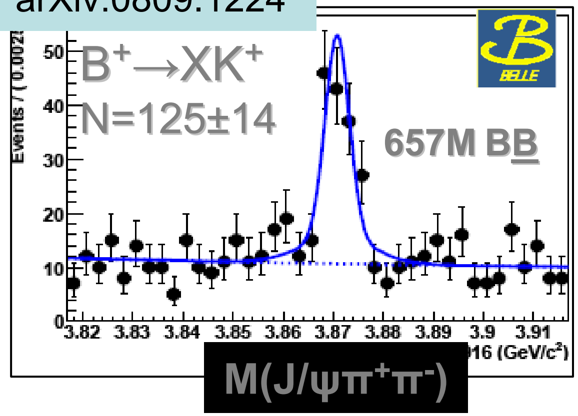
- X(3872)→J/ψπ⁺π⁻ observed in B→XK by Belle
- Confirmed by Babar, CDF, DØ



$\Gamma_{X(3872)} < 2.3$ MeV

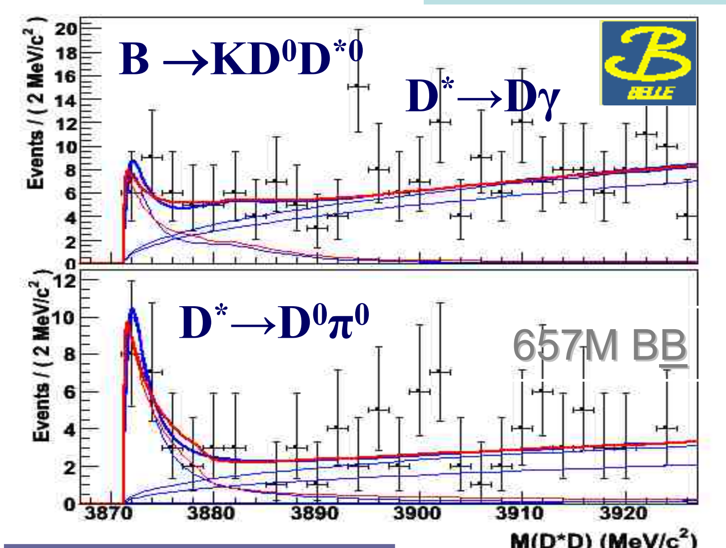


arXiv:0809.1224



Mode	Mass [MeV]
$X(3872) \to J/\psi\pi\pi$ PDG07	3871.4 ± 0.6
$X(3872) \to J/\psi\pi\pi$ Belle	$3871.46 \pm 0.37 \pm 0.07$
$X(3872) \to J/\psi\pi\pi$ CDF	$3871.61 \pm 0.16 \pm 0.19$
$M_{D^0} + M_{D^{*0}}$	3871.8 ± 0.4
$X(3872) \to D^0\overline{D}^{*0}$ Belle	$3872.6^{+0.5}_{-0.4} \pm 0.4$
$X(3872) \to D^0\overline{D}^{*0}$ Babar	$3875.1^{+0.7}_{-0.5} \pm 0.5$

arXiv:0810.0358



- X(3872) mass below or above D^0D^{0*}?
- Peak at D^0D^{0*} threshold is from X(3872)?

$$\frac{Br(X \to DD^*)}{Br(X \to J/\psi\,\pi\pi)} \sim 10$$

Y family

- Y(4008), Y(4260), Y(4360), Y(4660)

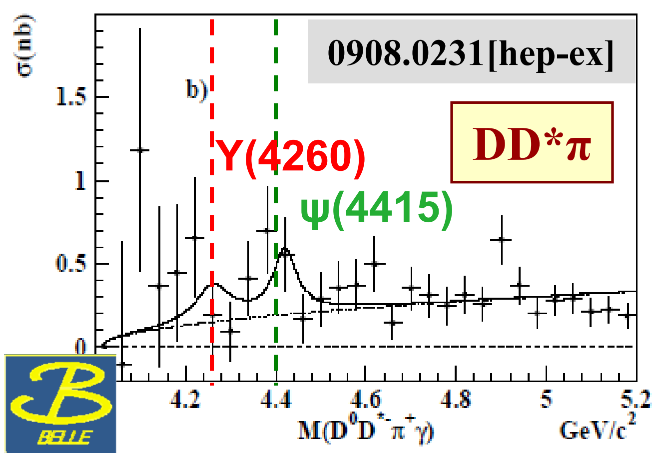
don't match the peaks in $D^{(*)}D^{(*)}$ x-sections

- 90%CL limits for Y(4260):

$$\frac{Br(D\overline{D})}{Br(J/\psi\pi\pi)}<1 \qquad \frac{Br(D^*\overline{D})}{Br(J/\psi\pi\pi)}<34 \qquad \frac{Br(D^*\overline{D}^*)}{Br(J/\psi\pi\pi)}<40$$

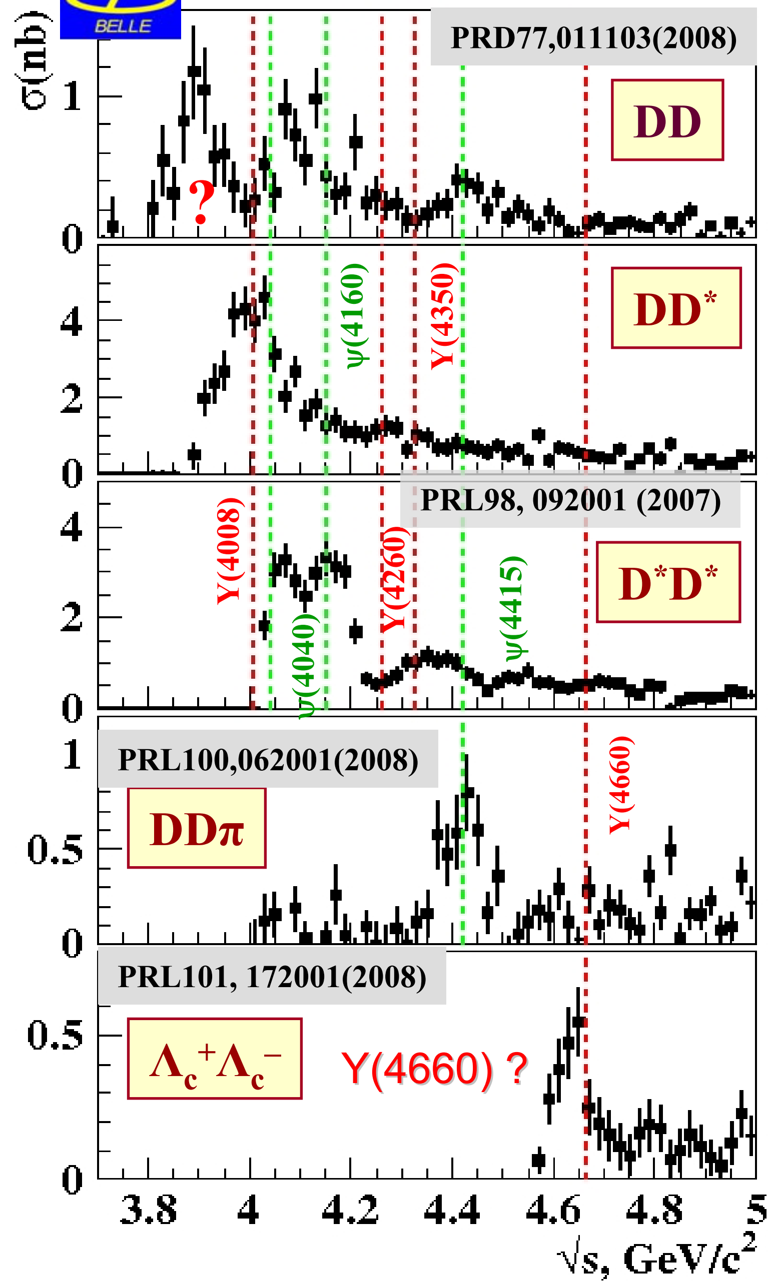
PRD79,092001(2009)

- Widths for ψππ transition too large for conventional charmonia
- Y(4260) is $D\underline{D}_1$ molecule, $c\underline{c}g$ hybrid? $D\underline{D}_1$ [→DD*π] decay should dominate but no signal found



$$\frac{Br(Y(4260)\to D\overline{D}^*\pi)}{Br(Y(4260)\to J/\psi\pi\pi)}<9$$

e⁺e⁻→open charm γ_ISR



$Z(4430)^{\pm} \rightarrow \psi(2S)\pi^{\pm}$

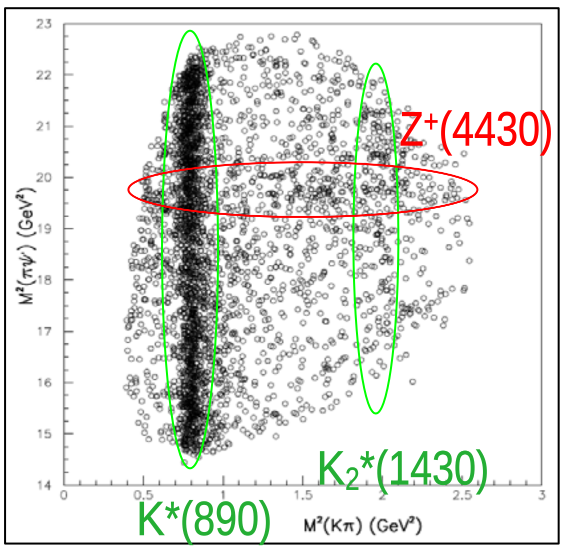
PRL100, 142001 (2008)

- Found in $\psi(2S)\pi^+$ from $B \rightarrow \psi(2S)\pi^+K$. Z parameters from fit to $M(\psi(2S)\pi^+)$
- Confirmed through Dalitz-plot analysis of $B \rightarrow \psi(2S)\pi^+K$

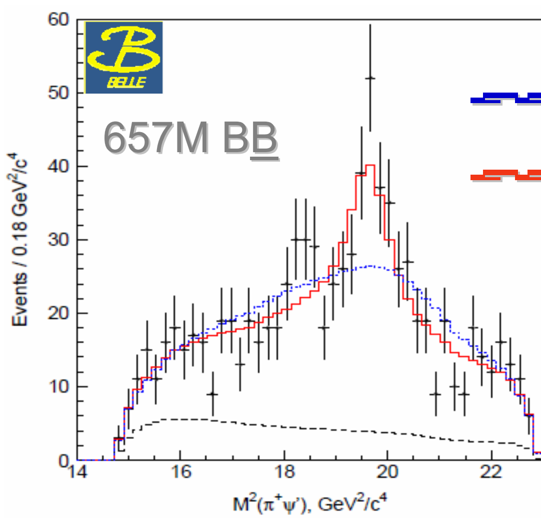
⇨

Significance: 6.4σ

$M^2(\psi(2S)\pi^+)$



$M^2(K\pi^+)$



$M^2(\psi(2S)\pi^+)$ after K* veto

fit for model with K*'s only

fit for model with K*'s and Z

$$M = 4433^{+15}_{-12}{}^{+19}_{-13}\ MeV$$

$$\Gamma = 107^{+86}_{-43}{}^{+74}_{-53}\ MeV$$

PRD80, 031104 (2009)

[cu][cd] tetraquark? neutral partner in $\psi'\pi^0$ expected

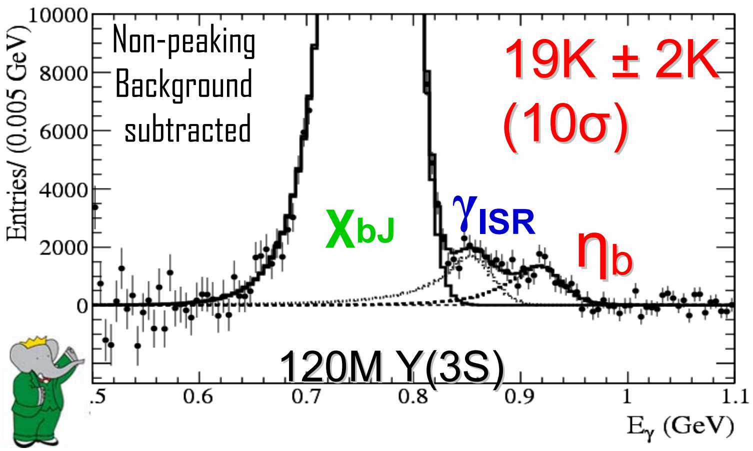
- **$D^*\underline{D}_1(2420)$ molecule? should decay to $D^*\underline{D}^*\pi$**

Discovery of η_b

- Expected production: M1 transition from Υ(3S), Υ(2S)→$\gamma\eta_b$
  ⇨ monochromatic line in inclusive γ spectrum

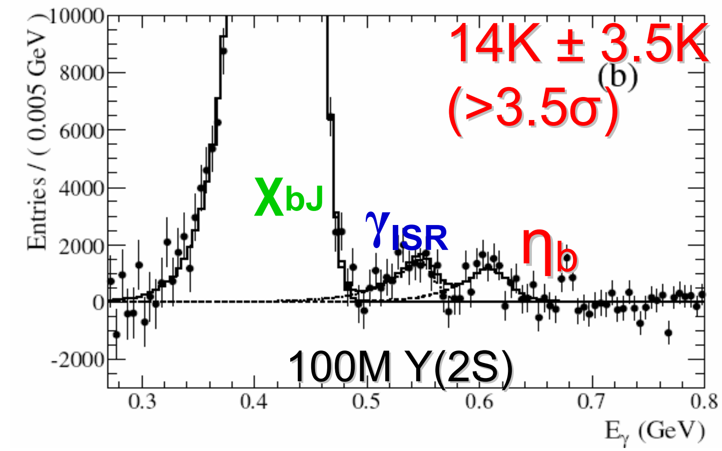
$$E_\gamma = \frac{s - m^2_{\eta_b}}{2\sqrt{s}}$$

PRL 100, 06200 (2008)



$$M(\eta_b) = 9388.9^{+3.1}_{-2.3} \pm 2.7\,\mathrm{MeV}$$

arXiv:0903.1124



$$M(\eta_b) = 9392.9^{+4.6}_{-4.8} \pm 1.8\,\mathrm{MeV}$$

Peaking background:

Υ(nS)→$\chi_{bJ}\gamma^{soft}$

└→Υ(1S)γ^{hard}

$e^+e^-\to\gamma_{ISR}$Υ(1S)

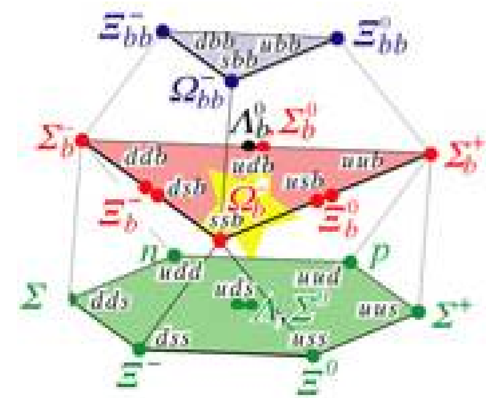
- combined result:

$$M(\eta_b) = 9390.4 \pm 3.1\,\mathrm{MeV}$$

$$M(\Upsilon(1S)) - M(\eta_b) = 69.9 \pm 3.1\,\mathrm{MeV} \quad \mathit{Theory} \sim 60\,\mathrm{MeV}$$

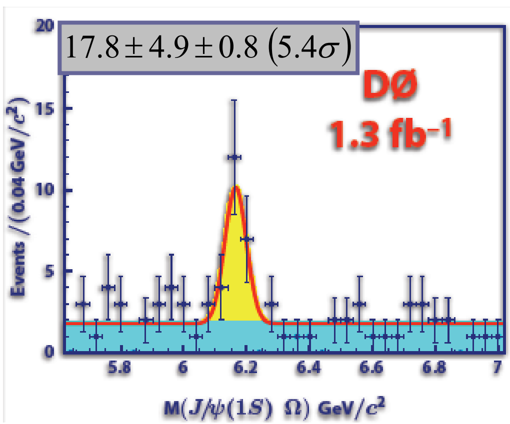
- Exclusive search difficult: hadronic decays BF~10^{-5} (η_b→gg→q$\underline{q}$: OZI suppression), large multiplicities

b-baryons at Tevatron



- Σ_b^+: CDF in 2006 Ξ_b^- : CDF,DØ in 2007
- Observation of Ω_b^- [ssb] by DØ

$\Omega_b^- \to J/\psi\Omega^-$ fully reconstructed, special tracking for long lived particles, production rate wrt $\Xi_b^- \to J/\psi\Xi^-$

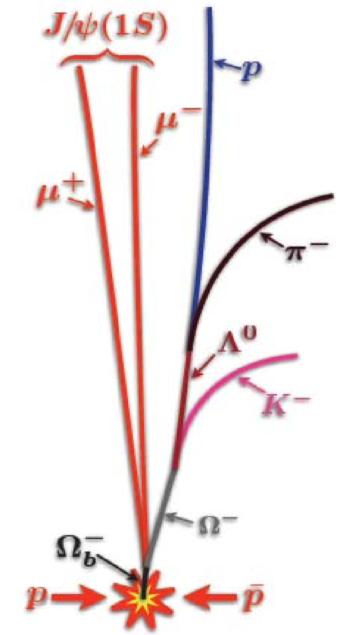


$$M(\Omega_b) = 6165 \pm 10 \pm 13\,\mathrm{MeV}$$

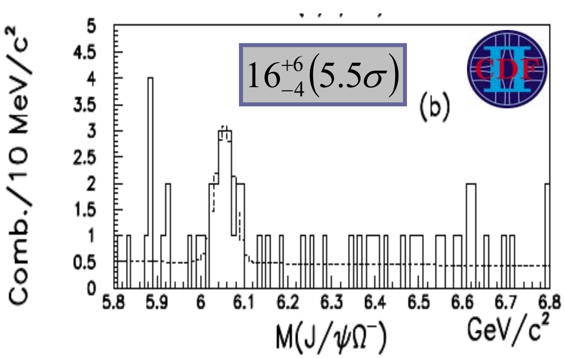
$$Theory: 5.94 < M(\Omega_b) < 6.12 GeV$$

$$\frac{f(b \to \Omega_b) Br(\Omega_b \to J/\psi\Omega)}{f(b \to \Xi_b) Br(\Xi_b \to J/\psi\Xi)} = 0.80 \pm 0.32^{+0.14}_{-0.22}$$

PRL101, 232002 (2008)



- Ω_b^- in CDF (4.2 fb^{-1}): simultaneous mass vs lifetime fit



$$M(\Omega_b) = 6054.4 \pm 6.8 \pm 0.9\,\mathrm{MeV}$$

$$\tau(\Omega_b) = 1.13^{+0.53}_{-0.40} \pm 0.02\,ps$$

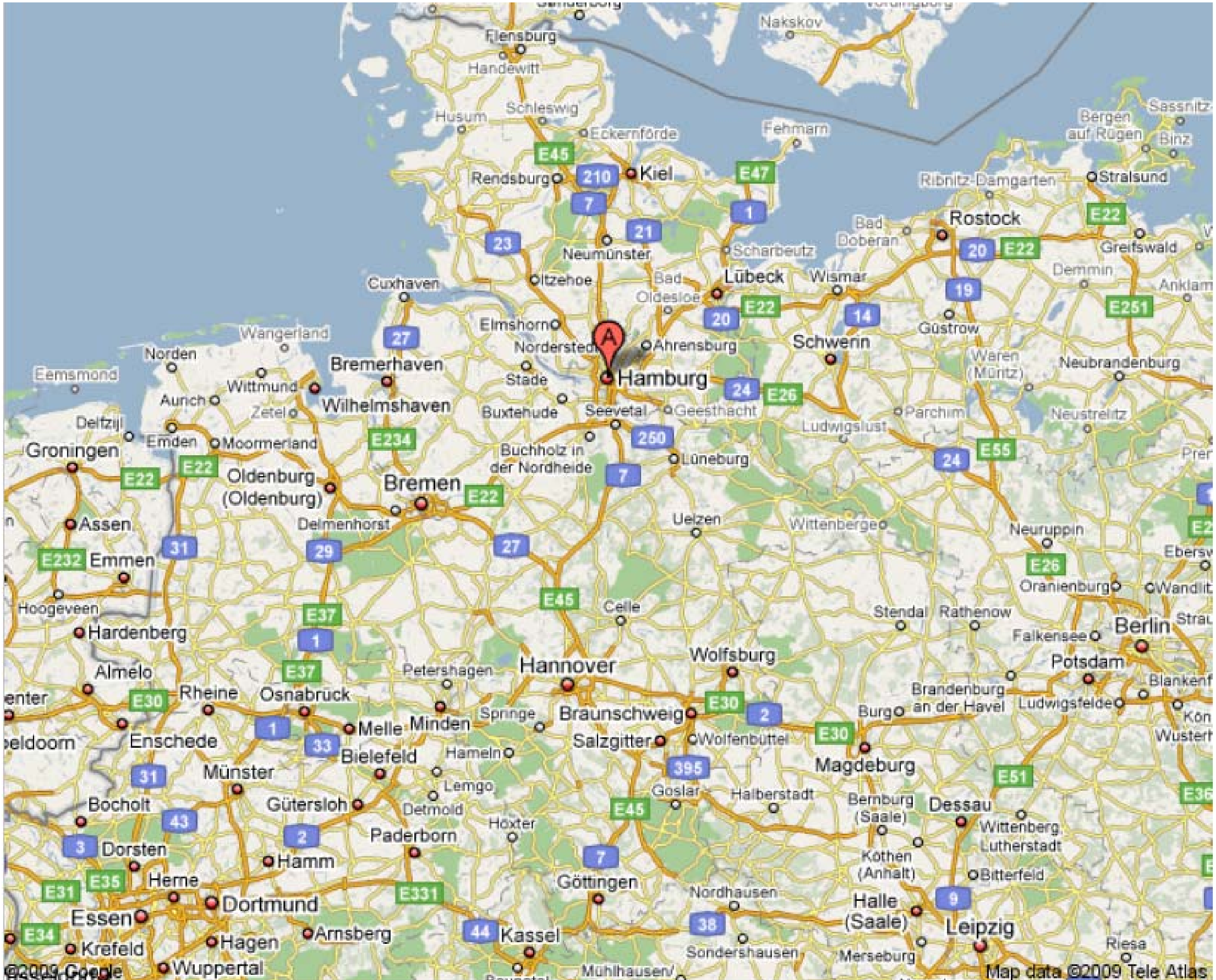
$$Theory: 0.83 < \tau(\Omega_b) < 1.67\,ps$$

arXiv:0905.3123

Ω_b^- mass from CDF and DØ different. The same baryon observed?

Conference dinner

Hamburg: international seaport

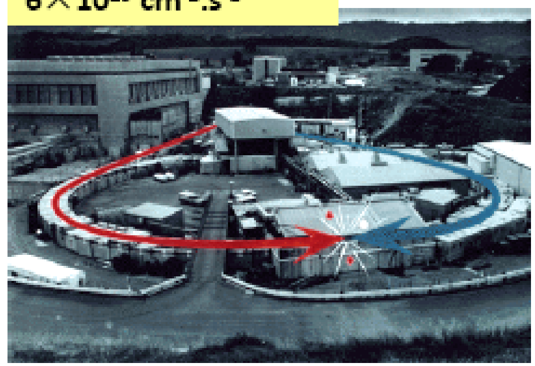


Recent results on tau and charm Yifang Wang (IHEP, Beijing)

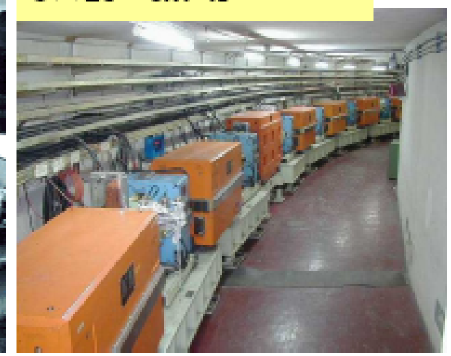
Tau & charm from dedicated colliders

ADONE, FRASCATI '69-'90

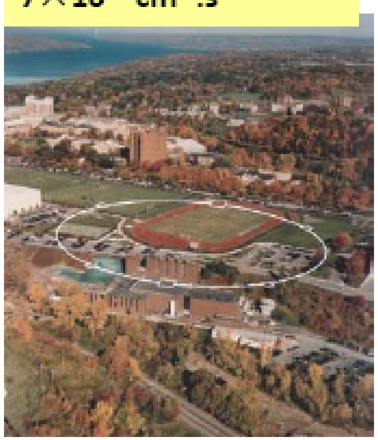
SPEAR, SLAC, '72-'90
6×10^{29} cm^{-2}.s^{-1}



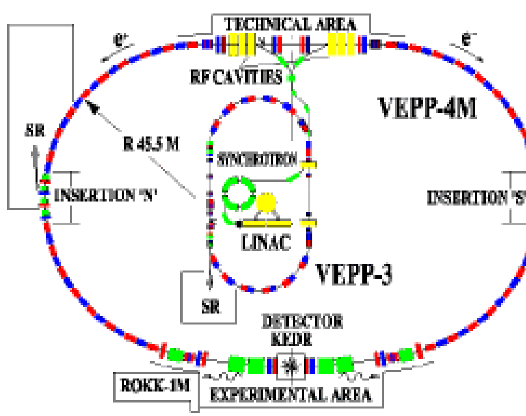
BEPC, IHEP, '90-'04
5×10^{30} cm^{-2}.s^{-1}



CESRc, Cornell, '04-'08
7×10^{31} cm^{-2}.s^{-1}



VEPP-4M, Novosibisk, '02-'12(?)
1×10^{30} cm^{-2}.s^{-1}



BEPCII, IHEP, '08-'18(?)
1×10^{33} cm^{-2}.s^{-1}

First observation of $\psi(2S) \to \bar{\Omega}^{+}\Omega^{-}$

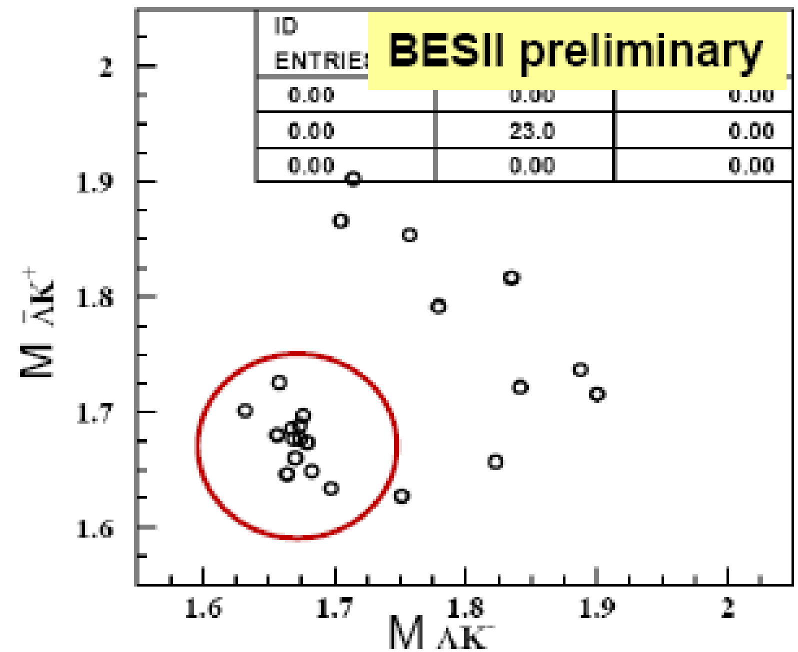
- This decay mode is thought to be mainly produced from the annihilation of three gluons into *ss* pair.

$$B(\psi(2S) \to \overline{\Omega}^{+}\Omega^{-}) = \frac{N_{obs}^{data}}{N_{\psi(2S)} \cdot B(\Omega \to \Lambda K)^{2} \cdot B(\Lambda \to \pi p)^{2} \cdot \varepsilon}$$

$$= (3.21 \pm 1.25 \pm 0.86) \times 10^{-5}$$

Statistical significance ~ 5σ

X,Y,Z type of particles in ss system ?
Hint: Y(2175) ?
BESIII will answer these questions with help from theorists



BESIII Commissioning and data taking milestones

Mar. 2008: first full cosmic-ray event

April 30, 2008: Move the BESIII to IP

July 19, 2008: First e^+e^- collision event in BESIII

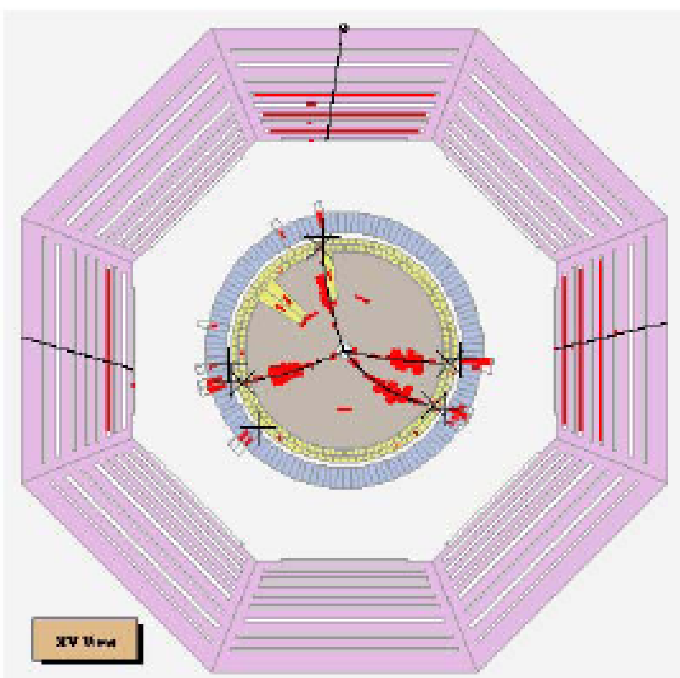
Nov. 2008: ~ 14M $\psi(2S)$ events collected

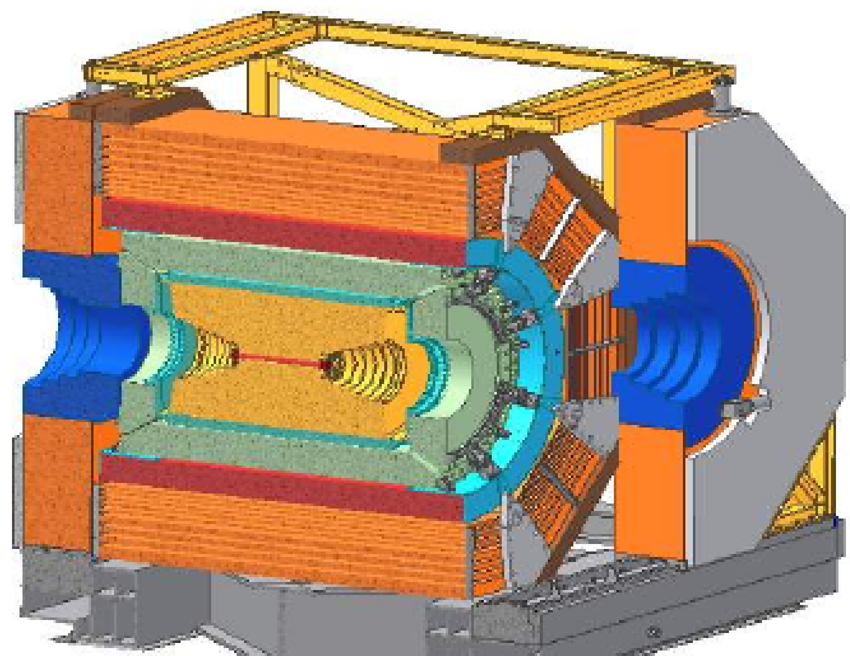
April 14, 2009 ~110M $\psi(2S)$ events collected(×4 CLEOc)

May 30, 2009 42 pb^{-1} at continuum collected

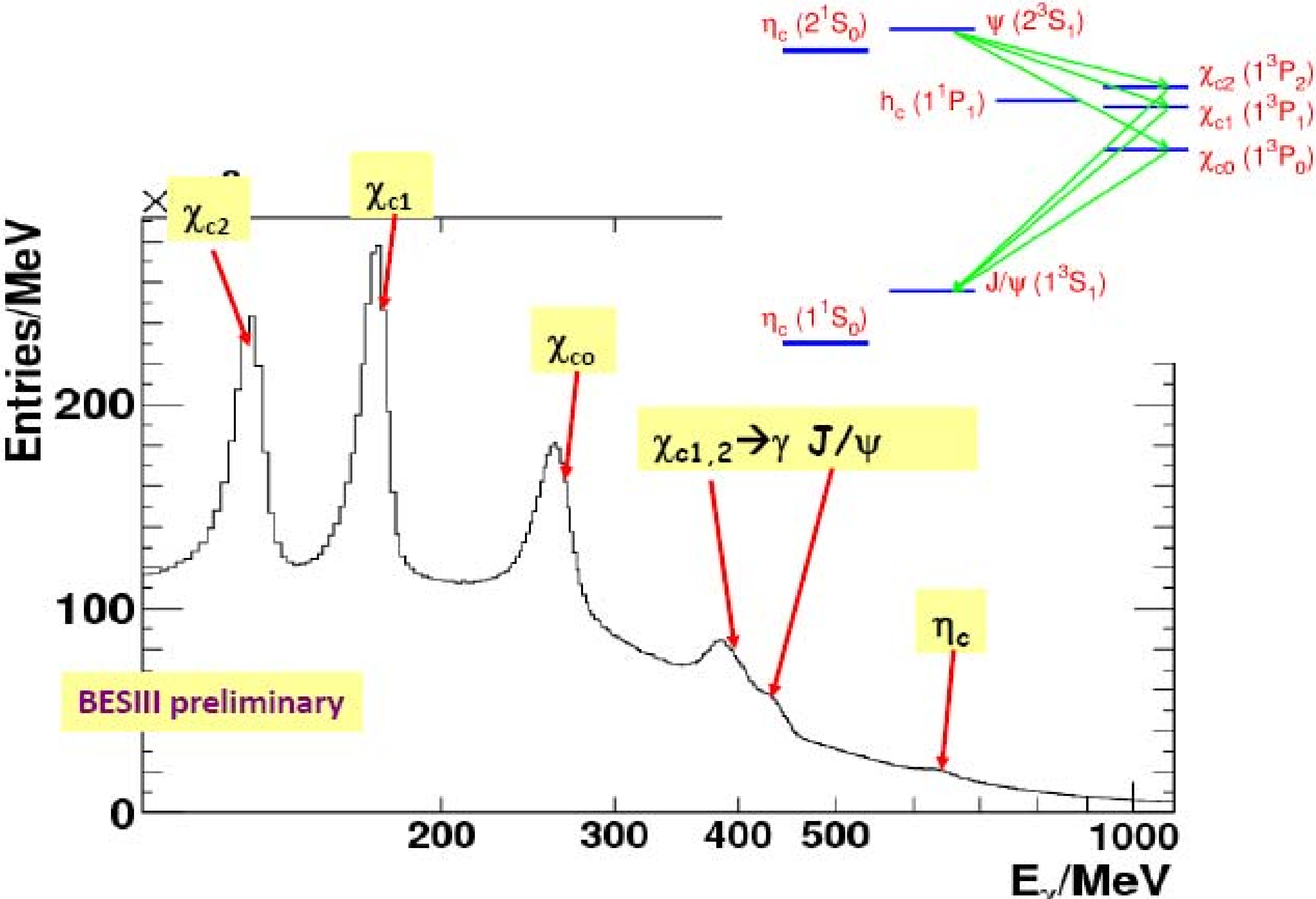
July 28, 2009 ~200M J/ψ events collected(×4 BESII)

Peak Lumi. @ Nov. 2008:
$1.2 \times 10^{32} cm^{-2}s^{-1}$
Peak Lumi. @ May 2009:
$3.2 \times 10^{32} cm^{-2}s^{-1}$ →
×5 CESRc
×30 BEPC



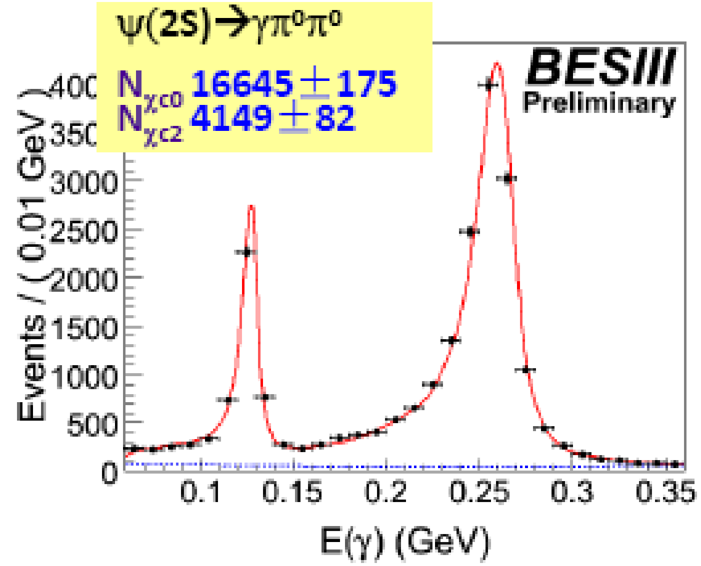


EM transitions: inclusive photon spectrum

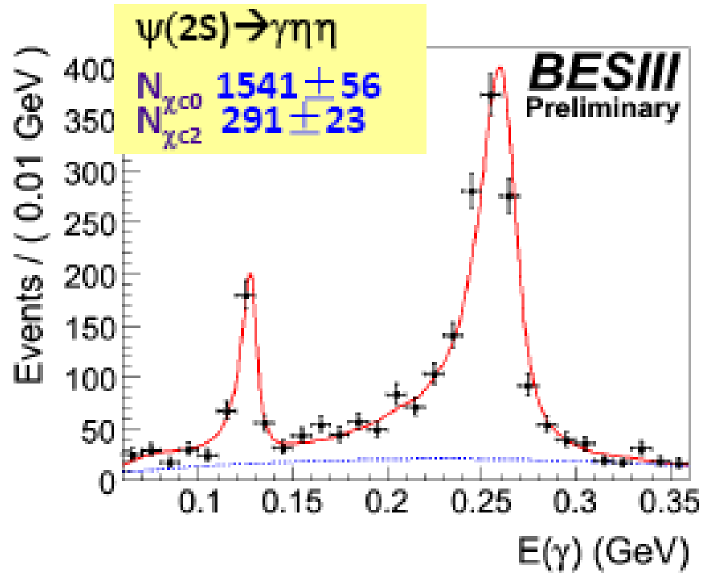


Study of $\psi(2S) \to \gamma\pi^0\pi^0$, $\gamma\eta\eta$ ($\eta \to \gamma\gamma$, $\pi^0 \to \gamma\gamma$)

- Interesting channels for glueball searches
- Based on 110M $\psi(2S)$
- BK study from 100M inclusive MC sample and 42pb^{-1} continuum sample
- Unbinned Maximum Likelihood fit:
  - Signal: PDF from MC signal
  - Background: 2nd order Poly.



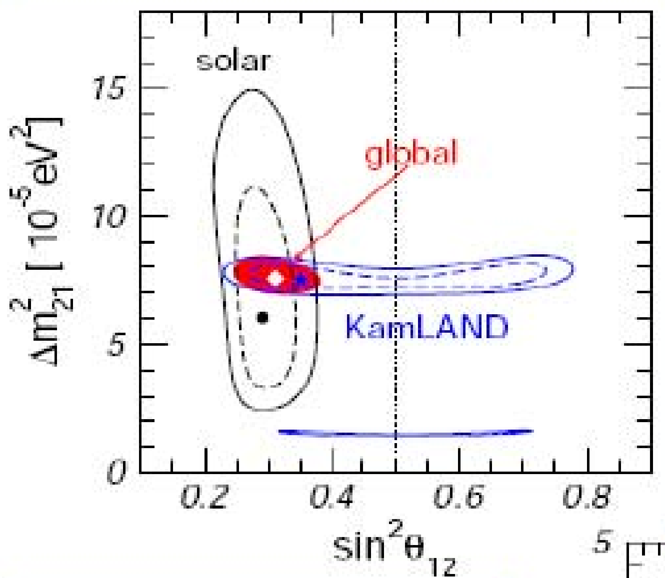
BR (10^{-3})		χ_{c0}	χ_{c2}
$\pi^0\pi^0$	BESIII	3.25 ± 0.03(stat)	0.86 ± 0.02(stat)
	PDG08	2. 43 ± 0.20	0.71 ± 0.08
	CLEO-c	2.94 ± 0.07 ± 0.35	0.68 ± 0.03 ± 0.08
$\eta\eta$	BESIII	3.1 ± 0.1(stat)	0.59 ± 0.05(stat)
	PDG08	2.4 ± 0.4	<0.5
	CLEO-c	3.18 ± 0.13 ± 0.35	0.51 ± 0.05 ± 0.06

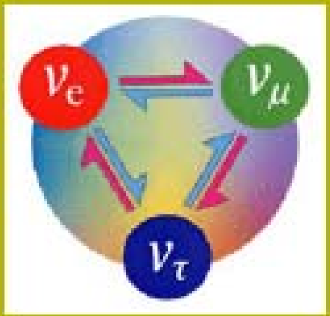


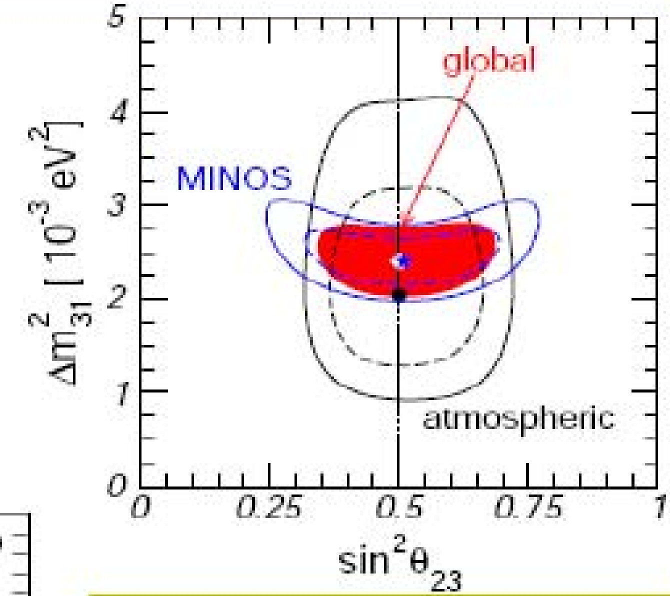
CLEO-c arxiv:0811.0586

NEUTRINO OSCILLATIONS 2009

Schwetz et al, NJP 10 (2008) 113011 [rev. Maltoni et al, NJP 6 (2004) 122]



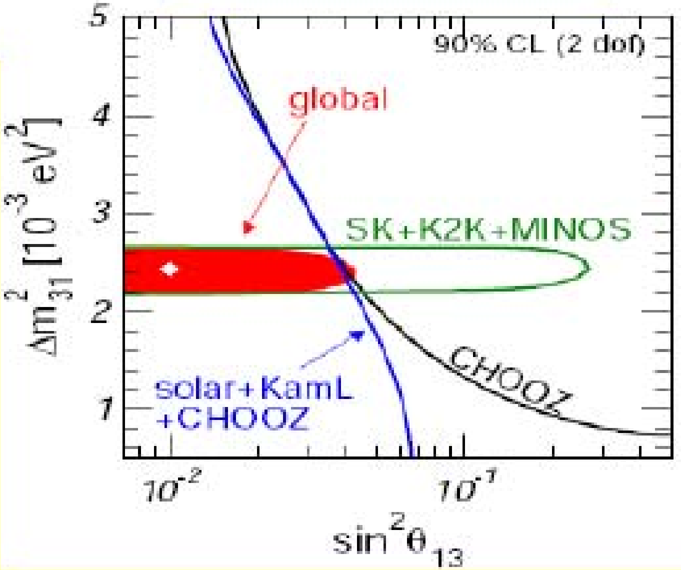




Homestake, SAGE+ GALLEX/GNO, Super-K, SNO

Borexino

KamLAND (180 Km)



... Super-K

K2K (250 Km)

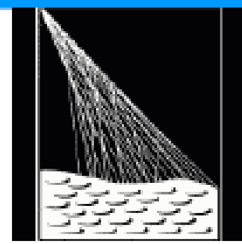
MINOS (735 Km)

Neutrino mass Christian Weinheimer (Munster)

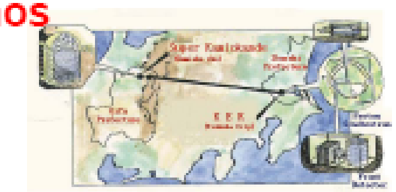
Westfälische Wilhelms-Universität Münster

Positive results from ν oscillation experiments

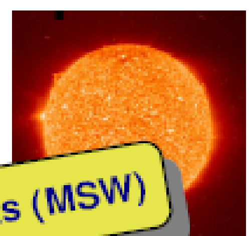
atmospheric neutrinos
(Kamiokande, Super-Kamiokande, ...)



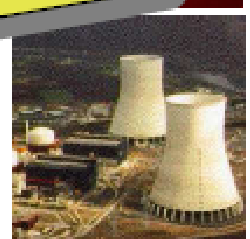
accelerator neutrinos
(K2K, MINOS, LSND, MiniBoone)



solar neutrinos
(Homestake, Gallex, Sage, Super-Kamiokande, SNO, Borexino)



Matter effects (MSW)



reactor neutrinos
(KamLAND, CHOOZ, ...)

⇒ **non-trivial ν-mixing**

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \cdot \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

with:

$0.79 < |U_{e1}| < 0.88$ maximal !
$0.47 < |U_{e2}| < 0.61$ large !
$|U_{e3}| < 0.20$ $\neq 0$?
$7.3 \cdot 10^{-5}\ eV^2 < \Delta m_{12}^2 < 9.3 \cdot 10^{-5}\ eV^2$
$1.6 \cdot 10^{-3}\ eV^2 < |\Delta m_{23}^2| < 3.6 \cdot 10^{-3}\ eV^2$

⇒ **$m(\nu_j) \neq 0$, but unknown !**

up to now: description by 2-flavour oscillation sufficient

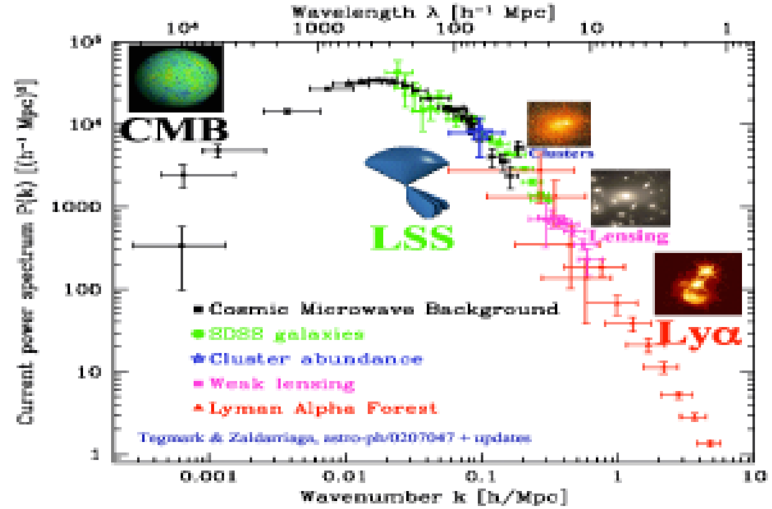
Three complementary ways to the absolute neutrino mass scale

1) **Cosmology**

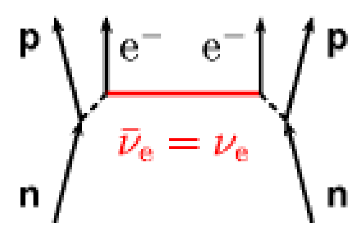
very sensitive, but model dependent

compares power at different scales

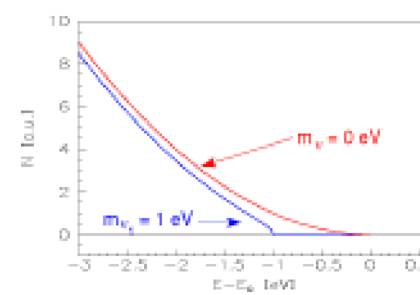
current sensitivity: $\Sigma m(\nu_i) \approx 0.4 - 1$ eV



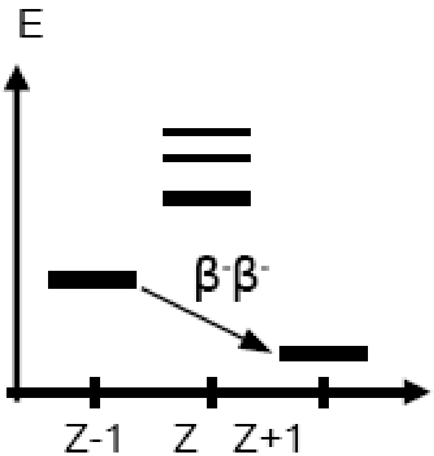
2) **Search for 0νββ**



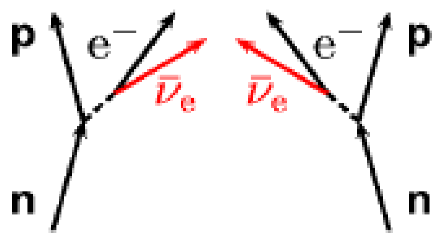
3) **Direct neutrino mass determination:**



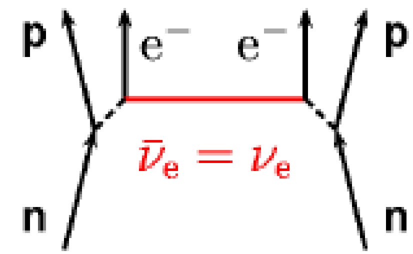
Double β decay



normal ($2\nu\beta\beta$)



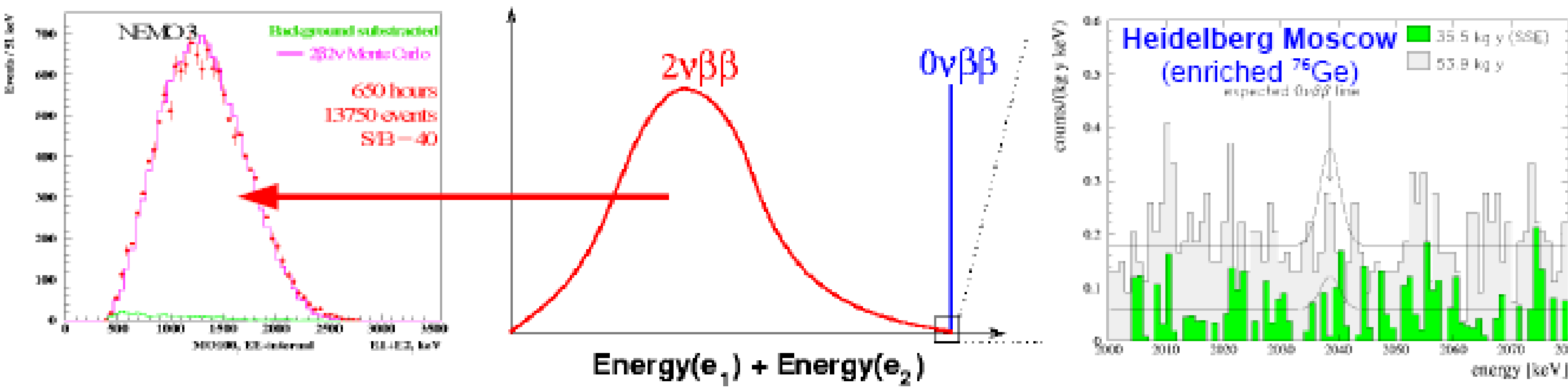
neutrinoless ($0\nu\beta\beta$)



needed: a) $\bar{\nu} = \nu$ (Majorana)

b) helicity flip: $m(\nu) \neq 0$

or other new physics



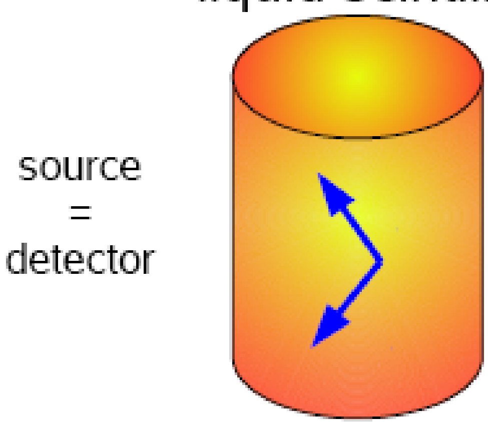
Current and future double β decay experiments

$m_{ee} \sim (1/\text{enrichment})^{1/2} \cdot (\Delta E \cdot bg/M \cdot t)^{1/4}$

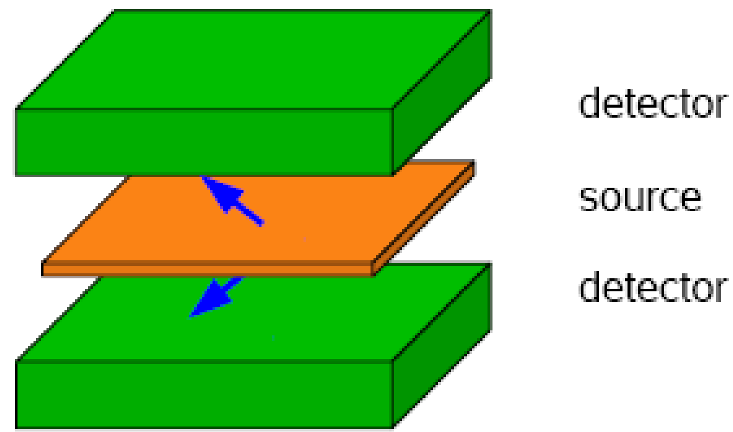
⇒ mass → 1t, high enrichment, very low background *bg*

2 ways to measure both β-electrons:

semiconductor,
cryogenic bolometer
liquid scintillator



tracking calorimeter



running: CUORICINO
setting up: GERDA, CUORE, EXO-200
planned: Majorana, EXO, COBRA, SNO+ ..

running: NEMO-3
setting up: SuperNEMO
planned: MOON

Westfälische Wilhelms-Universität Münster

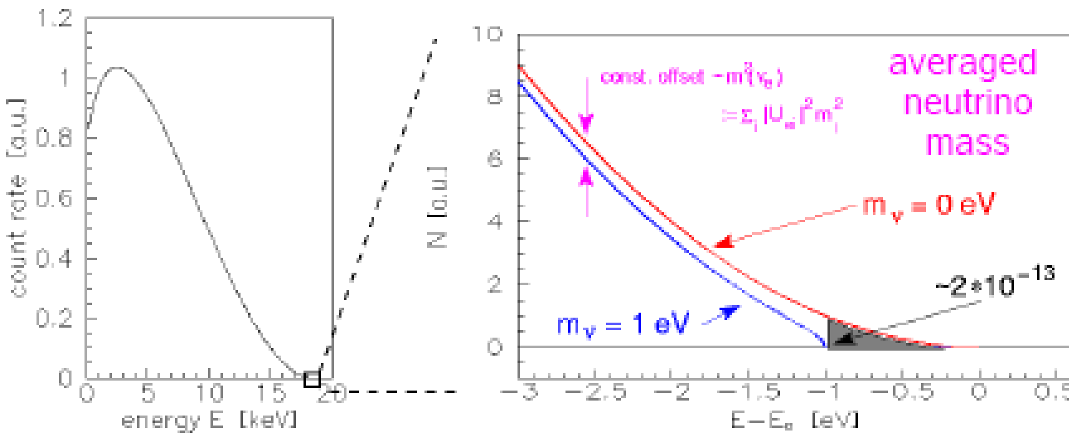
Direct determination of $m(\nu_e)$ from β decay

β decay: $(A,Z) \rightarrow (A,Z+1)^{+} + e^{-} + \bar{\nu}_e$

β electron energy spectrum:

$$dN/dE = K\ F(E,Z)\ p\ E_{tot}\ (E_0-E_e)\ \Sigma\, |U_{ei}|^2 \sqrt{(E_0-E_e)^2 - m(\nu_i)^2}$$

(modified by electronic final states, recoil corrections, radiative corrections)



E.W. Otten & C. Weinheimer
Rep. Prog. Phys. 71 (2008) 086201

Need: **low endpoint energy** ⇒ **Tritium ^3H, (^{187}Re)**

very high energy resolution &
very high luminosity &
very low background ⇒ **MAC-E-Filter**
(or bolometer for ^{187}Re)

Westfälische Wilhelms-Universität Münster

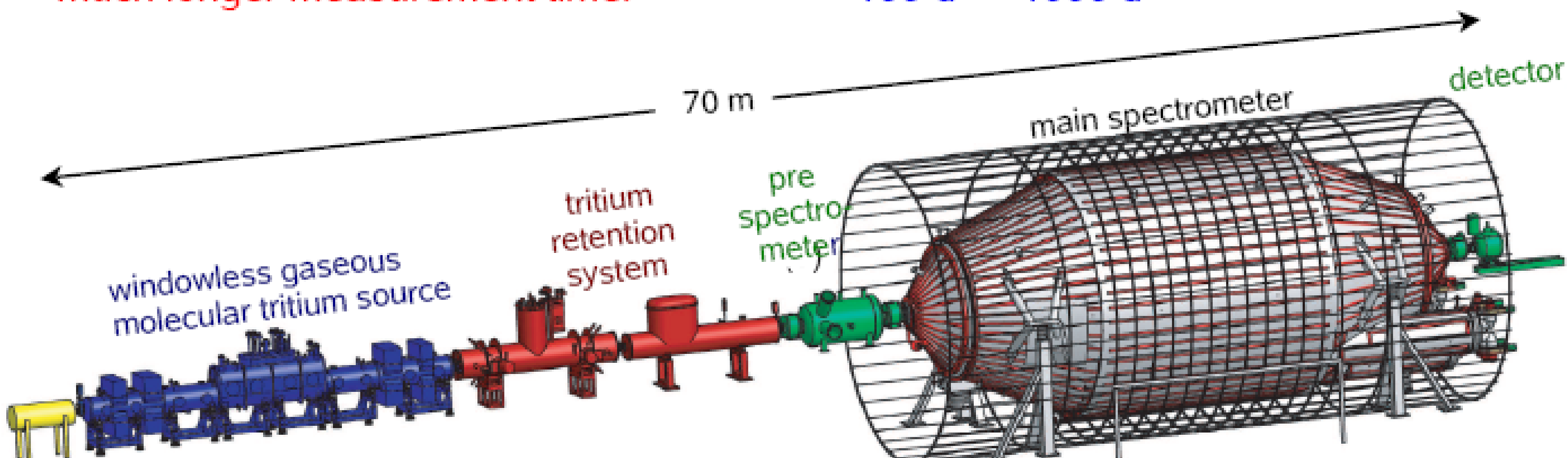
The <u>Ka</u>rlsruhe <u>Tri</u>tium <u>N</u>eutrino experiment KATRIN

is being set up at the Forschungszentrum Karlsruhe

Physics Aim: $m(\nu_e)$ sensitivity of 0.2 eV (currently 2 eV)

- higher energy resolution: $\Delta E \approx$ 1eV
  since $E/\Delta E \sim A_{spectrometer}$ ⇒ larger spectrometer
- relevant region below endpoint becomes smaller
  even less rate $dN/dt \sim A_{source} \sim A_{spectrometer}$ ⇒ larger spectrometer

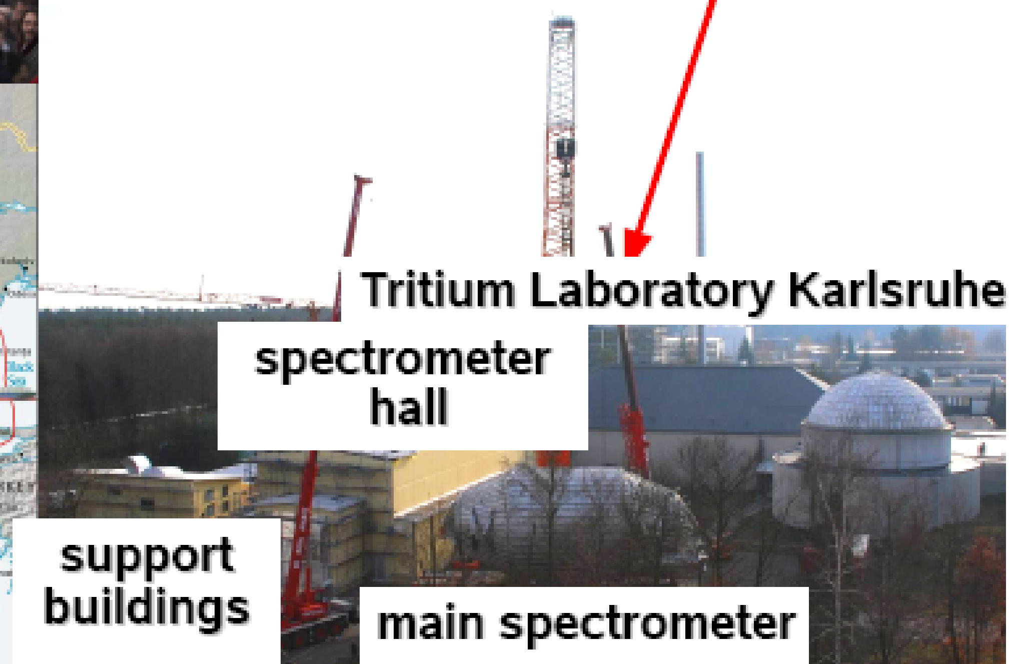
  } ⌀10m
- small systematics ⇒ windowless gaseous tritium source
- much longer measurement time: 100 d → 1000 d



(Scientific Report FZKA 7090)

Westfälische Wilhelms-Universität Münster

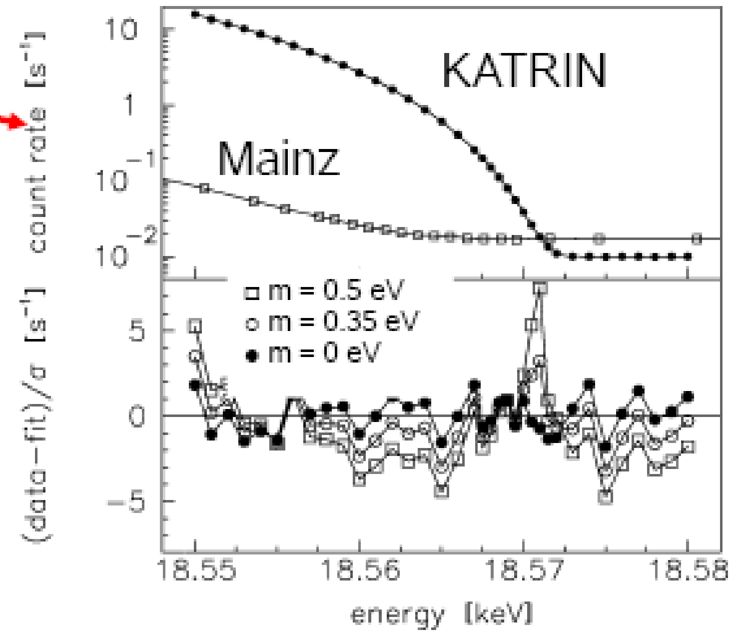
Main Spectrometer – Transport to Forschungszentrum Karlsruhe



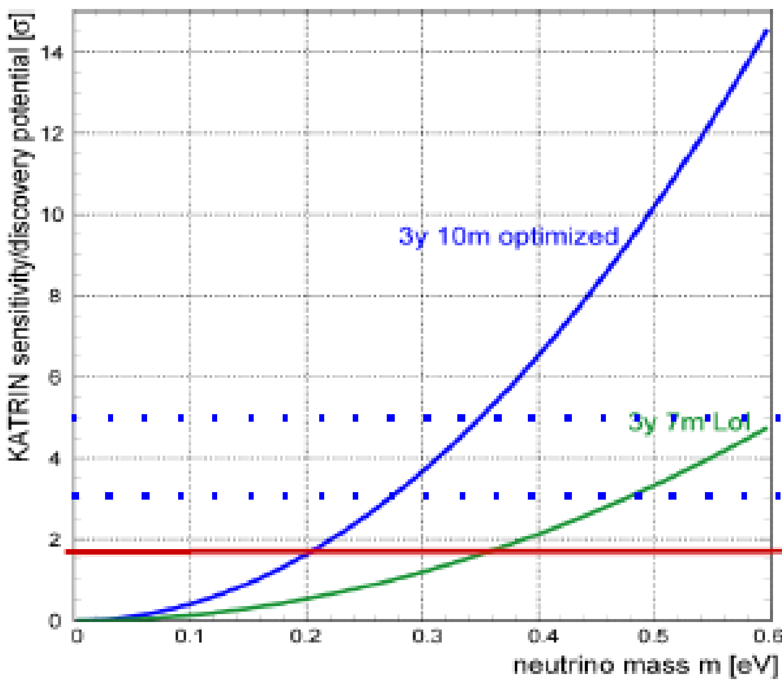
Westfälische Wilhelms-Universität Münster

KATRIN´s sensitivity

Example of KATRIN simulation & fit
(last 25eV below endpoint, reference):



Expectation for 3 full beam years: $\sigma_{syst} \sim \sigma_{stat}$



discovery potential:

m_ν = 0.35eV (5σ)

m_ν = 0.3eV (3σ)

sensitivity:

m_ν < 0.2eV (90%CL)

My Conclusions

- Very educational conference!
- Results illustrate the power of high statisics and long running expts (HERA, CDF/D0, BESII, BaBar etc
- MUCH in PP is of interest and great importance outside the LHC regime.
- With its marked concentration on LHC, is UK PP aligned on right lines?

Extra /spare slides

- Not shown in the talk.

Recombination algorithms

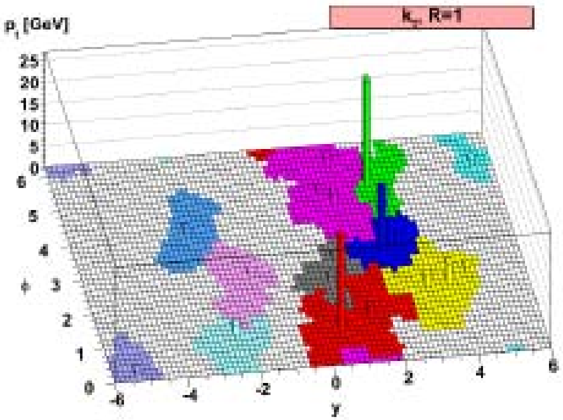
Compute the smallest "distance" d_{ij} or d_{iB} and either cluster i and j together or identify i as a jet

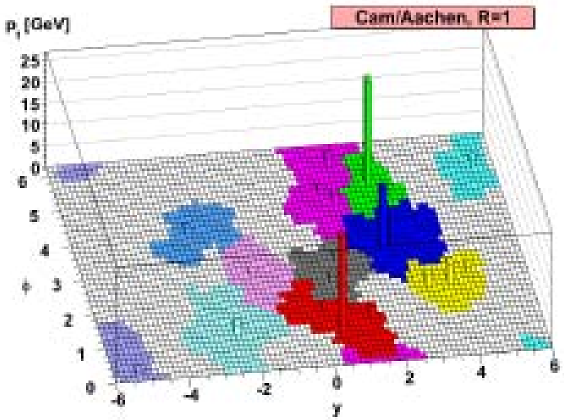
$$d_{ij} = \min\{k^p_{Ti}, k^p_{Tj}\}\Delta R_{ij}/R, \qquad d_{iB} = k^p_{Ti}$$

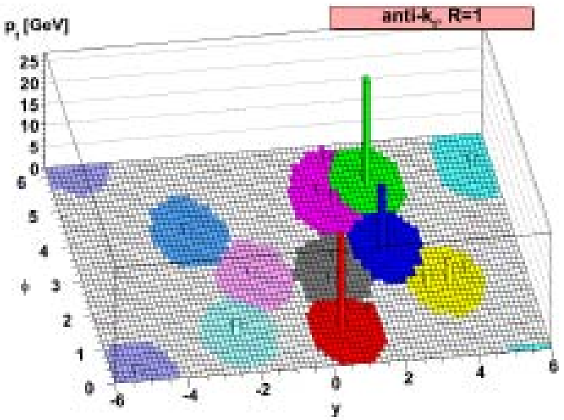
$$\Delta R^2 = \Delta\eta^2 + \Delta\phi^2$$

Algorithm	p	clusters first	comment
k_T/Durham	> 0	softest	leads to very irregular jets includes a lot of underlying event hard to get jet energy scale right
Cambridge/Aachen	$= 0$	closest	still leads to very irregular jets similar problems to kT algorithm
anti-k_T	< 0	hardest	shape of jet insensitive to soft particles ✓ cone-like jets ✓ may be easier to get jet energy scale right ✓

Recombination algorithms

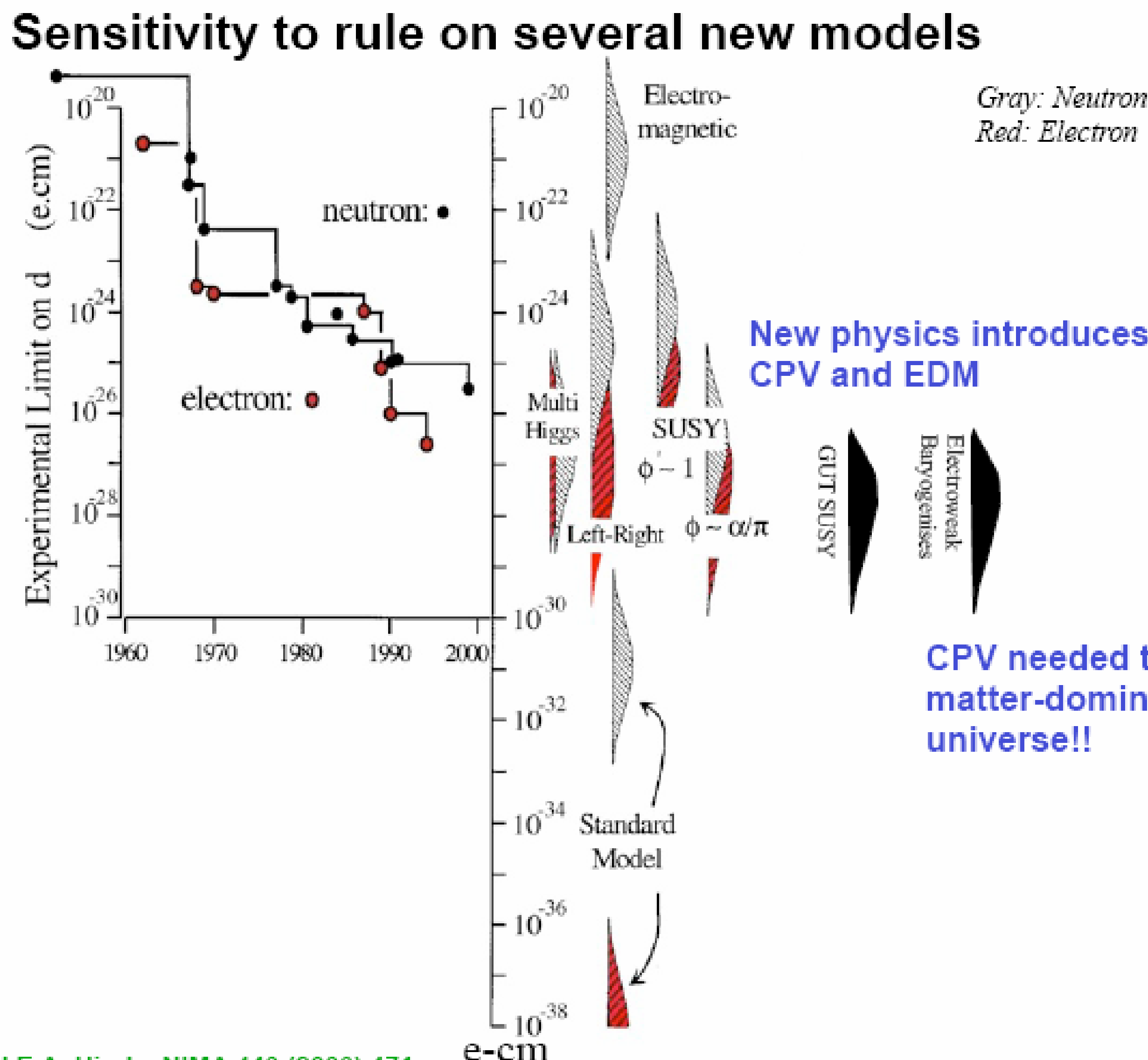






Visible benefits of anti-k_T algorithm!

Fundamental measurement



New physics introduces CPV and EDM

CPV needed to matter-dominant universe!!

J.M.Pendlebury and E.A. Hinds, NIMA 440 (2000) 471

Ratios of cross-sections at 7/10 and 10/14 TeV for processes induced by gg and qq

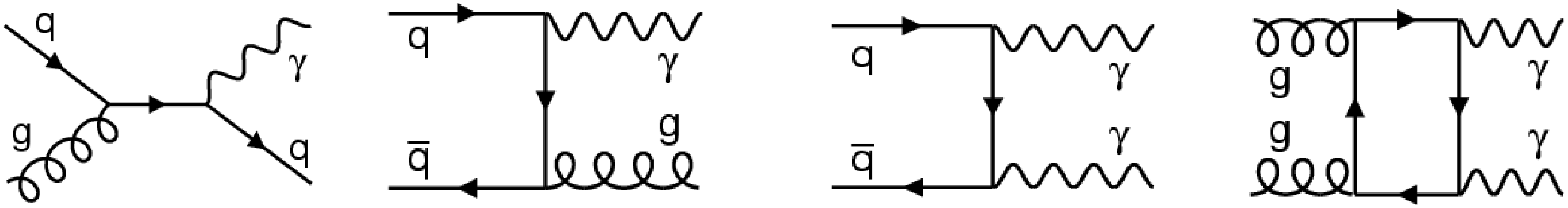
J.Stirling

J.Stirling

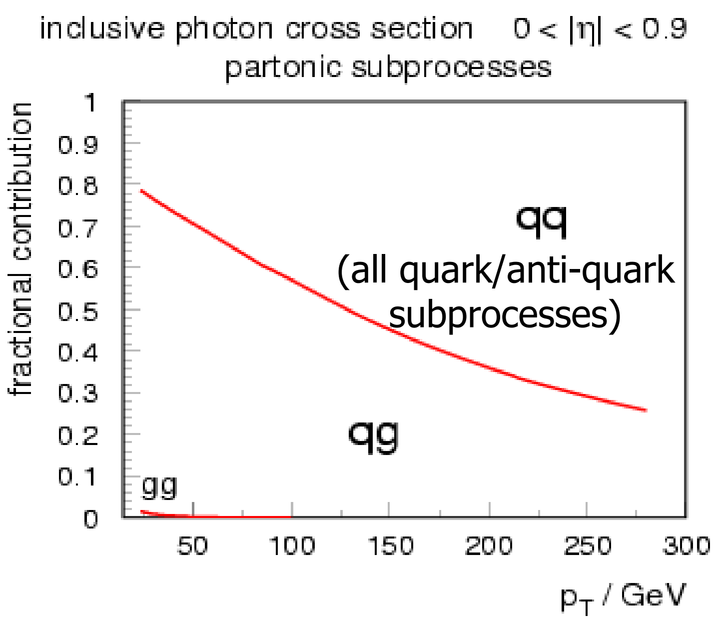
- Going from 14 to 10 TeV, more difficult to create high mass objects …
- Going from 10 to 7 TeV, another similar suppression factor applies
- Examples of suppression of cross sections going from 14 to 7 TeV

  W, Z ~45%   120 GeV Higgs ~30%   1 TeV Z' ~18%

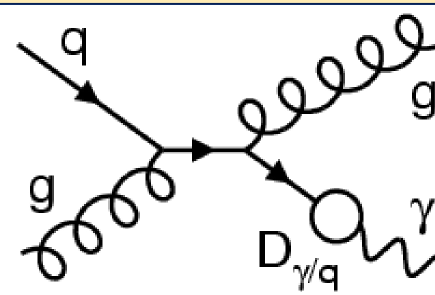
Direct Photon Production



direct photons emerge unaltered from the hard subprocess
→ direct probe of the hard scattering dynamics
→ sensitivity to PDFs (gluon!) …but only if theory works



also fragmentation contributions:



suppress by isolation criterion
→ observable: **isolated** photons

Isolated Photon + Jet

investigate source for disagreement

→measure more differential:

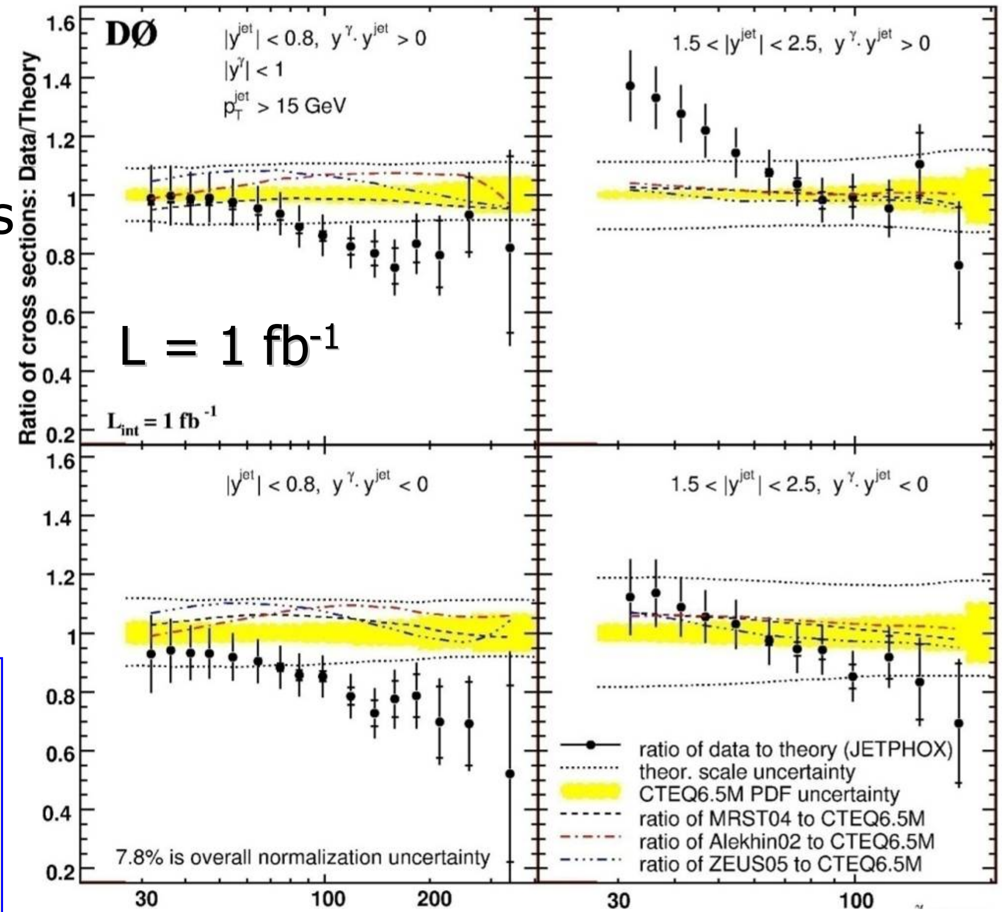
- tag **photon and jet**
  → reconstruct full event kinematics

- measure in 4 regions of y^{γ} / $y^{\mathbf{jet}}$
  - photon: central
  - jet: central / forward
  - same side / opposite side

discrepancies in data/theory
→ figure out what is missing…

- higher orders?
- resummation?
- …???

Phys. Lett. B 666, 2435 (2008)



p_T^{γ} (GeV)

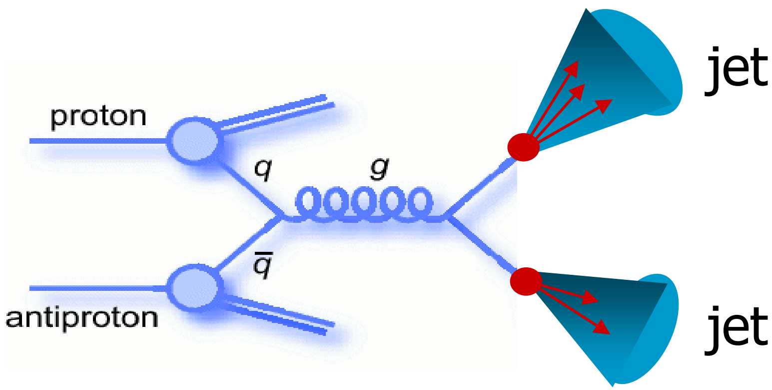
Jet Production

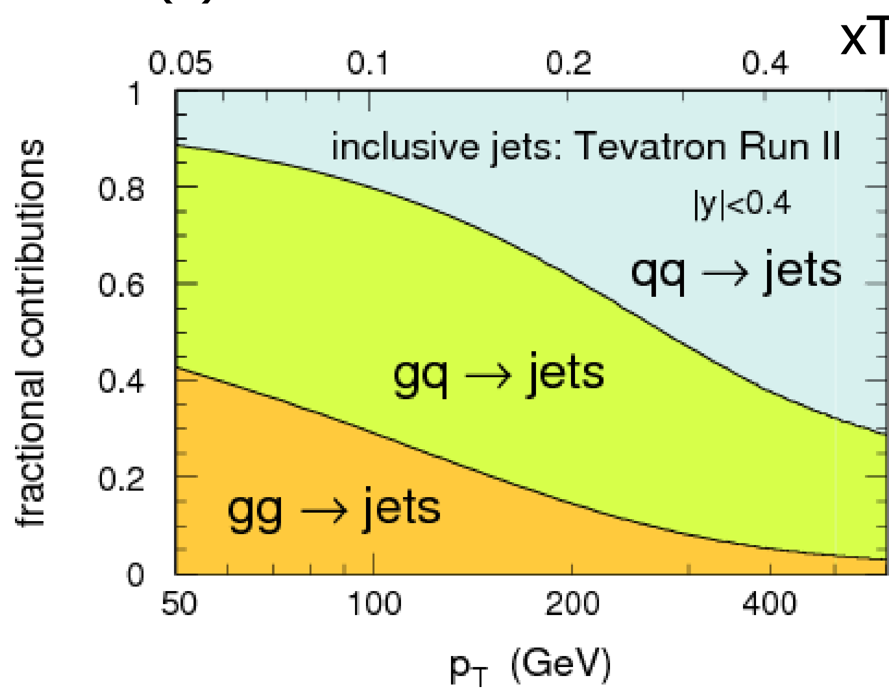
largest high pT cross section at a hadron collider

→ **highest energy reach**

Unique sensitivity to **new physics**:

- new particles decaying to jets,
- quark compositeness,
- extra dimensions,
- …(?)…





In the absence of new physics:

theory @NLO is reliable (±10%)

→ **Precision phenomenology**

- sensitivity to PDFs → high-x gluon
- sensitive to α_s

Summary

- **Solid methods**
- **Precision results**
- **Consistency between experiments**

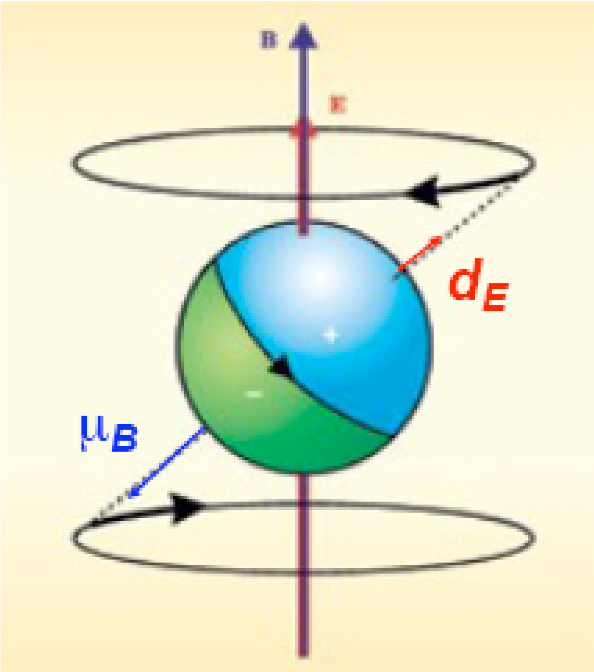
→ Impact!

And we have only started:

- This talk: results with up to 2.7 fb^{-1}
- More to come → 7 fb^{-1} delivered / 12 fb^{-1} by 2011

Measuring an Electric Dipole Moment

Basic technique: measure precession in external fields



- Larmor frequency: $\omega_B = -\dfrac{2\mu_B B}{\hbar}$

  (~ 50 Hz for B ~ 0.1G)

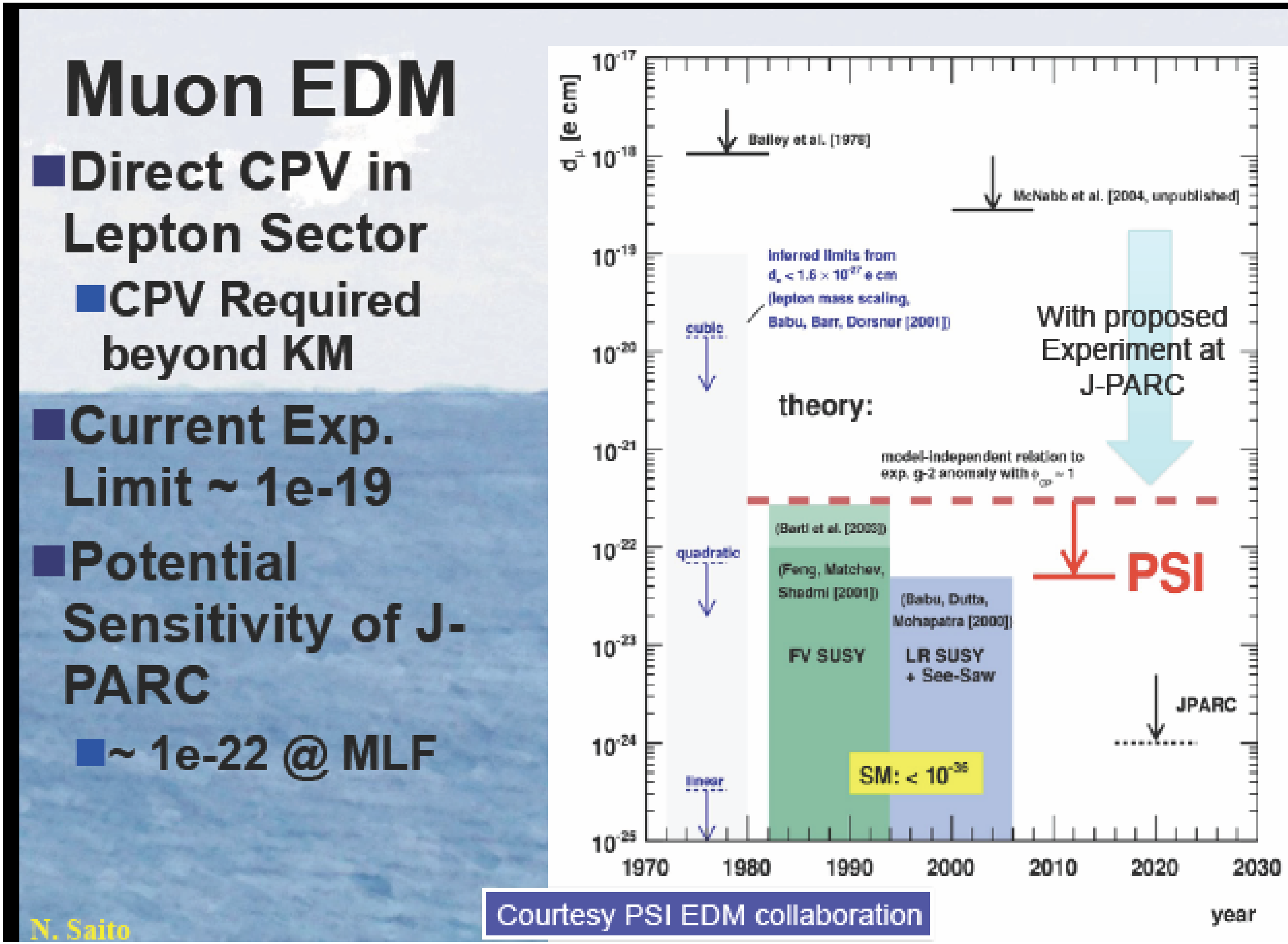
- d_E: additional precession: $\omega_E = \dfrac{2d_E E}{\hbar}$

$$\omega_{E \parallel B} - \omega_{E\,anti-\parallel B} \equiv \boxed{\Delta\omega = \frac{4d_E E}{\hbar}}$$

- Apply static B, $E \| B$

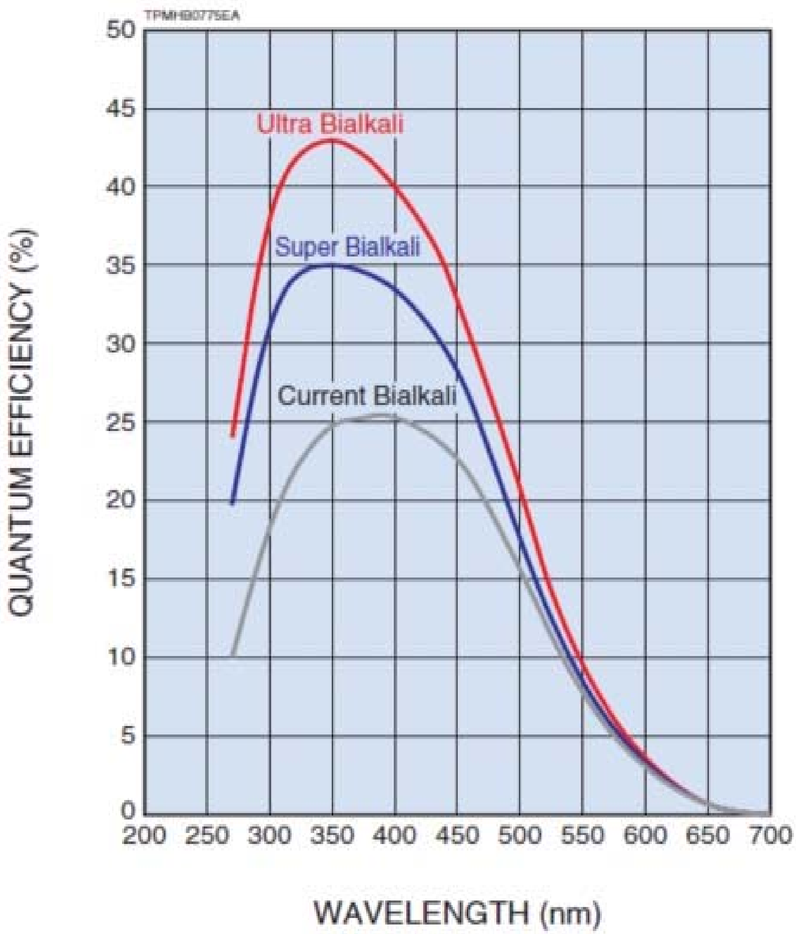
- Look for $\Delta\omega$ on reversal of E

Measuring EDM of muon



Novel Detector Technologies Hitoshi Yamamoto (Tohoku)

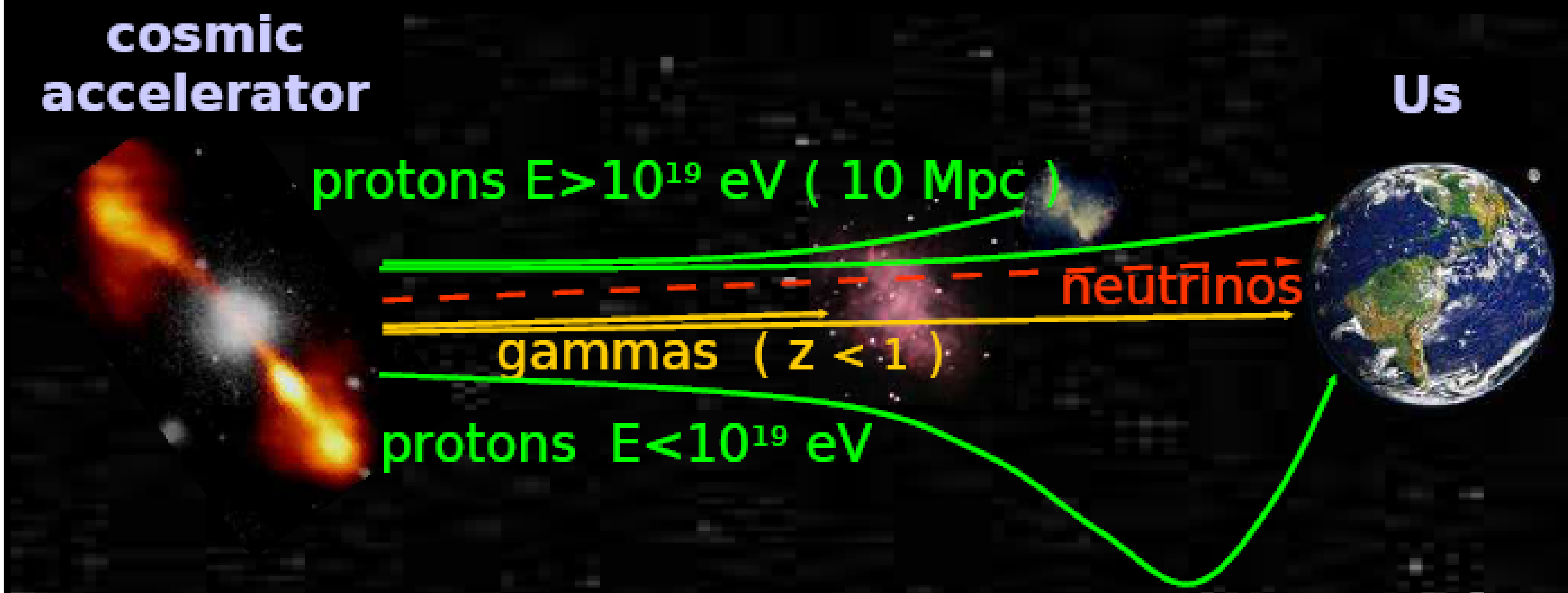
(Photomultiplier Tubes)



- Some new developments (Hamamatsu)
  - Low temperature operation
    - Operation in Liq. Xe (-110 deg C) etc.
    - Avoid photocathode current saturation
    - Now PMT can be directly immersed in Liq Ar, Liq Xe. (e.g. Dark Matter experiments)

Auger South size & status

Multi-messenger observations of the Cosmos



protons/nuclei: Deviated by magnetic fields, Absorbed by radiation field (GZK)

photons: Absorbed by dust & radiation field (CMB)

neutrinos: Difficult to detect

⇒ Three "astronomies" possible...

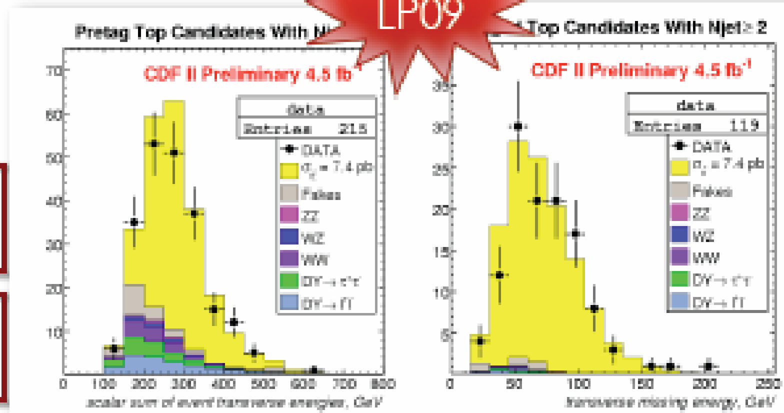
Top Quark Pairs:

- Measure cross section in a tagged and pre-tagged dilepton sample => good test of signal model

CDF (4.5 fb^{-1}, m_t= 172.5 GeV), b-tagged:
$\sigma_{t\bar{t}}$(dil)=7.3±0.7(stat)±0.4(syst)±0.4(lumi)pb

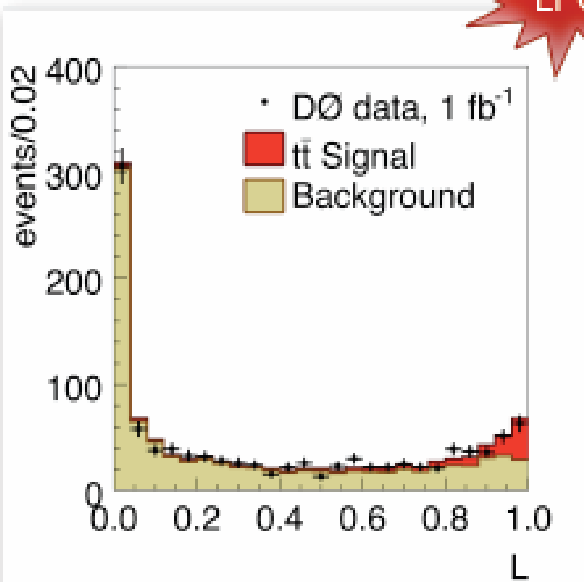
CDF (4.5 fb^{-1}, m_t= 172.5 GeV), pre-tagged, :
$\sigma_{t\bar{t}}$ (dil)=6.6±0.6(stat)±0.4(syst)±0.4(lumi) pb

LP09



- Consistent results

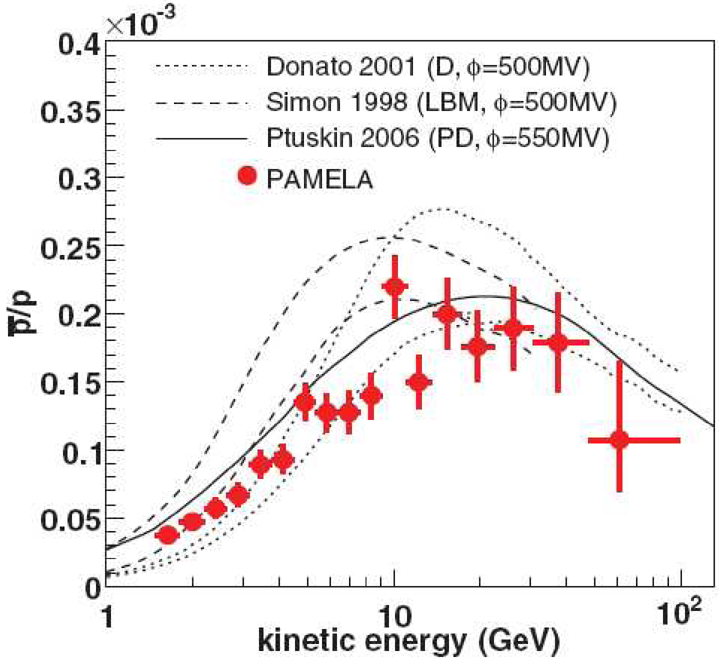
LP09

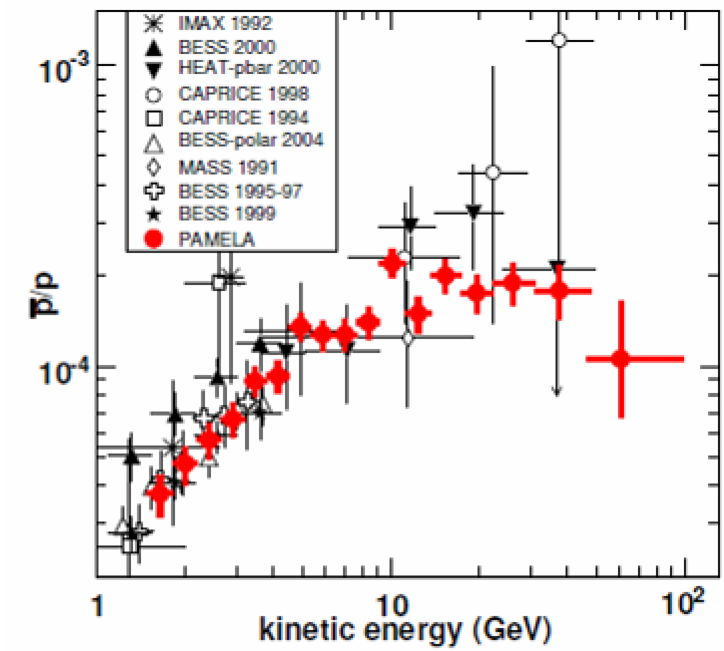


- Measure cross section in a background dominated sample
- Background is hard to model
  - Poorly known cross sections
  - Data driven background model
- Train NN on signal and background to purify the sample

CDF (2.9 fb^{-1}, m_t= 172.5 GeV):
$\sigma_{t\bar{t}}$ (all-had)=7.2±0.5(stat) ±1.5(syst)±0.4(lumi)pb
D0 (1 fb^{-1}, m_t= 175 GeV):
$\sigma_{t\bar{t}}$ (all-had)=6.9 ±1.3(stat)±1.4(sys)±0.4(lumi)pb

Anti-Proton Fraction



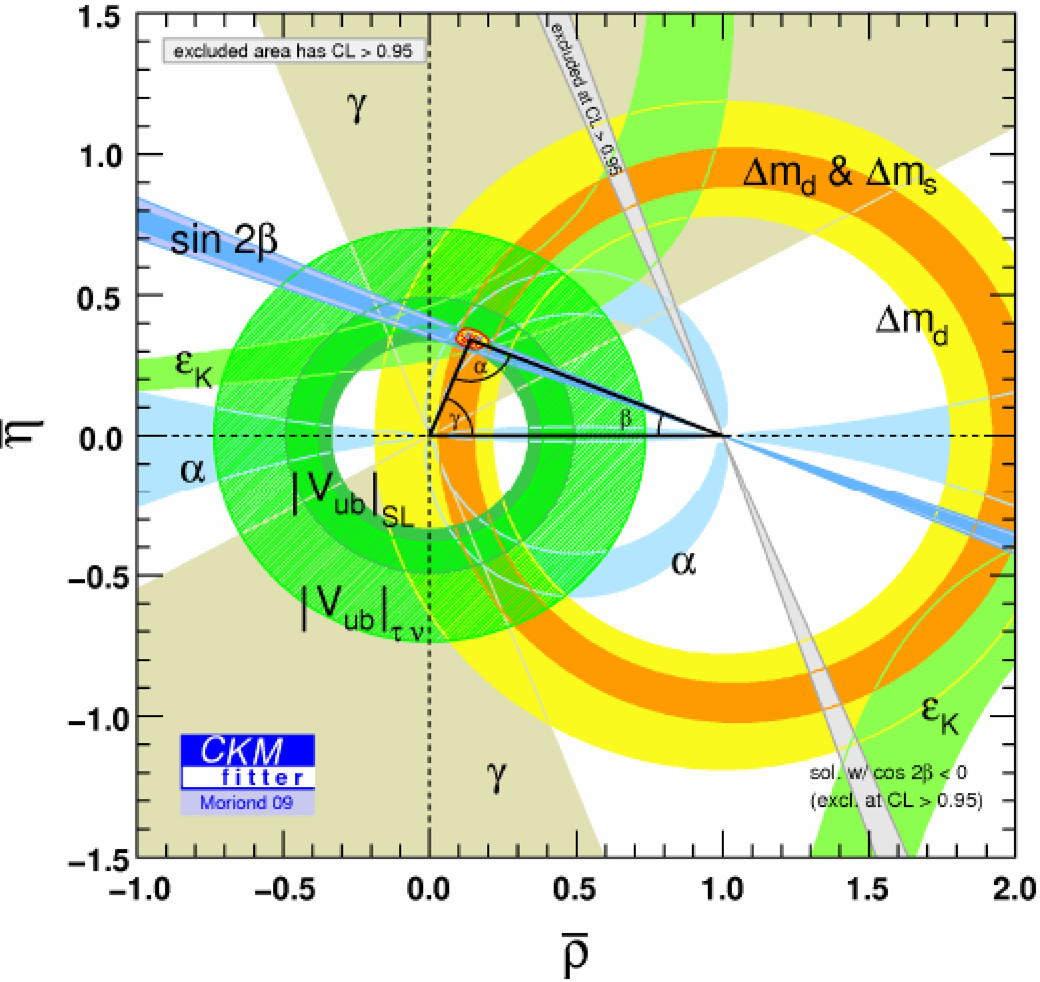


Nothing surprising seen in anti-proton / proton ratio

Anti-proton abundance consistent with expectations for secondary CR production off the Interstellar Medium

Global CKM Fit

All constraints



$$\alpha = \left(89.0^{+4.4}_{-4.2}\right)^o$$

$$\beta = \left(21.1 \pm 0.9\right)^o$$

$$\gamma = \left(75 \pm 12\right)^o$$

$$\alpha + \beta + \gamma = \left(185 \pm 13\right)^o$$

Consistency of angles and sides from global fit

- Overall good fit (CKMFitter: global p-value 45%)
- ~2σ tension between sin2β and ε_K / V_{ub}

UTFit: $\bar{\rho} = 0.154 \pm 0.022$ $\quad \bar{\eta} = 0.342 \pm 0.014$

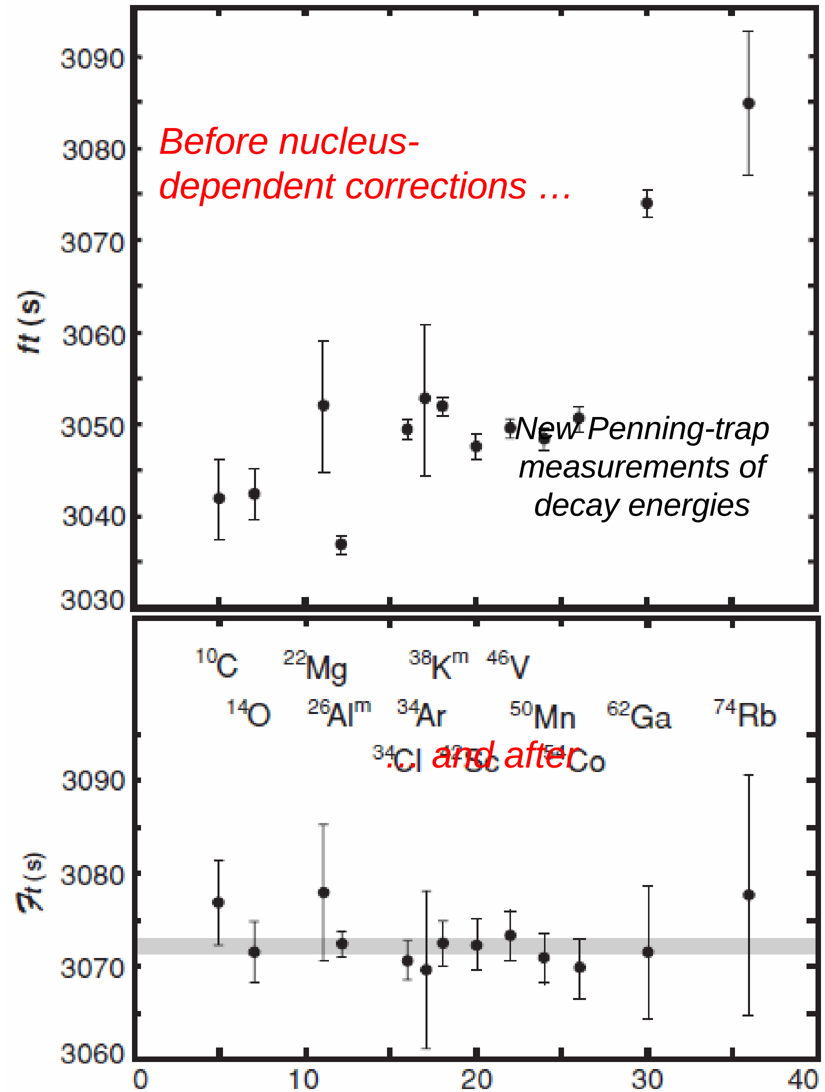
CKMFitter: $\bar{\rho} = 0.139^{+0.025}_{-0.027}$ $\quad \bar{\eta} = 0.341^{+0.016}_{-0.015}$

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

V_{ud} from nuclear β Decays

- $0^+ \rightarrow 0^+$ super-allowed nuclear β-decays within same isospin multiplet (pure V decays)
- Other V_{ud} measurements compatible, but (7-10 x) less precise

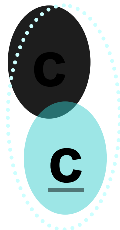
$$|V_{ud}| = 0.97425 \pm 0.00022$$



$$Ft \equiv ft(1+\delta_R^{'})(1+\delta_{NS}-\delta_C)$$

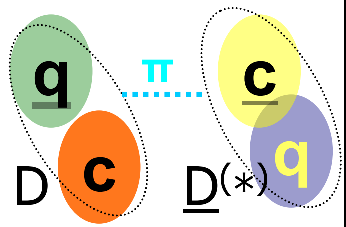
Neutral cc-like states:

conventional



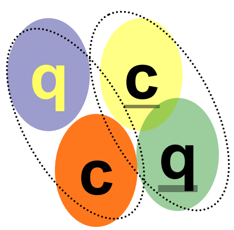
- If properties conventional
- If empty slot in $c\underline{c}$ spectrum

molecular



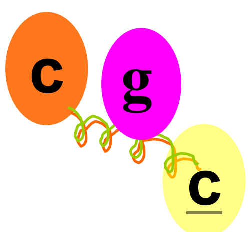
- Meson and antimeson loosely bound by pion exchange
- Mass ≈ sum of meson masses
- Decay: dissociation into constituent mesons

tetraquark



- „Coloured" quarks tightly bound by gluon exchange
- Decay: rearrange into „white" mesons → dissociation

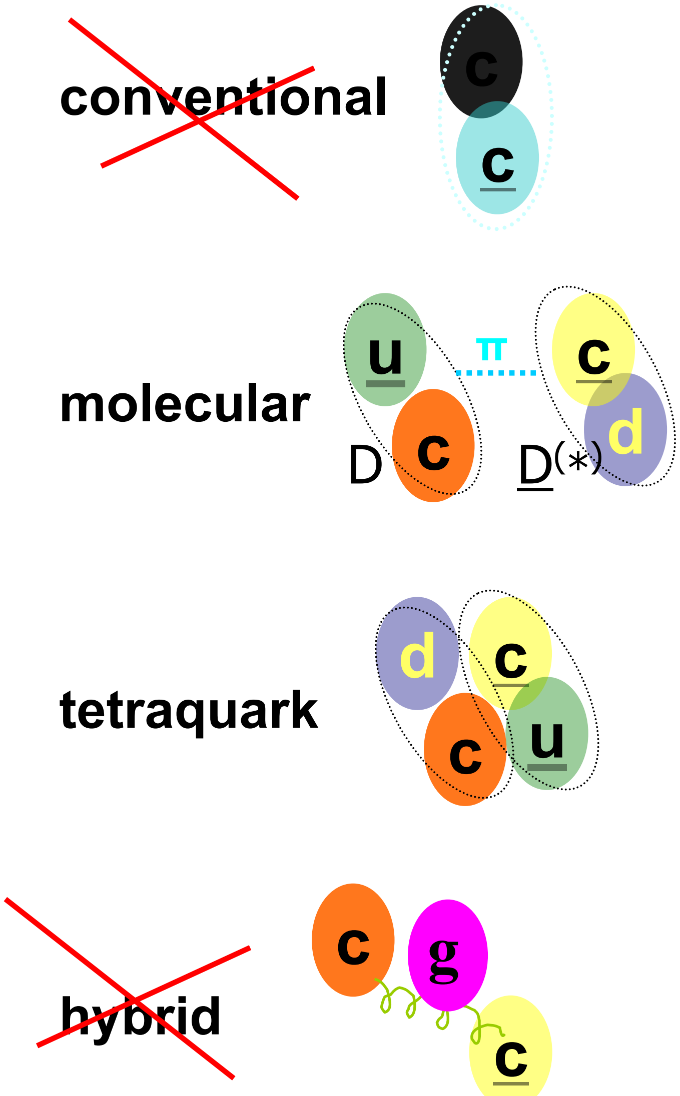
hybrid



- Lattice QCD: hybrids > 4.2GeV
- Possible exotic J^{PC} : 0^{+-}, 1^{-+}, 2^{+-}...
- Large hadronic transitions (ψππ, ψω,...)

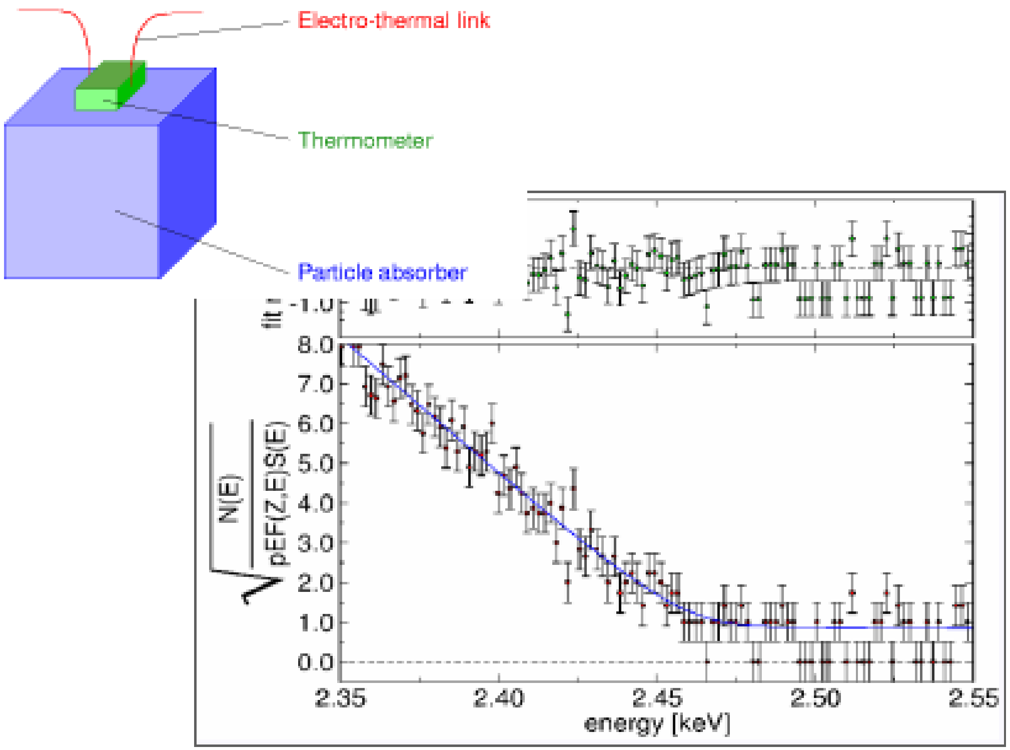
Charged cc-like states:

minimal quark content: [ccud]
⇨ must be exotic!



WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER

Cryogenic bolometers with ^{187}Re MIBETA (Milano/Como)



Parameters

detectors: 10 ($AgReO_4$)

rate each: 0.13 1/s

energy res.: $\Delta E = 28$ eV

pile-up frac.: $1.7\ 10^{-4}$

$M_\nu^2 = -141 \pm 211_{stat} \pm 90_{sys}\ eV^2$

$M_\nu < 15.6$ eV (90% c.l.)

(M. Sisti et al., NIMA520 (2004) 125)

MANU (Genova)

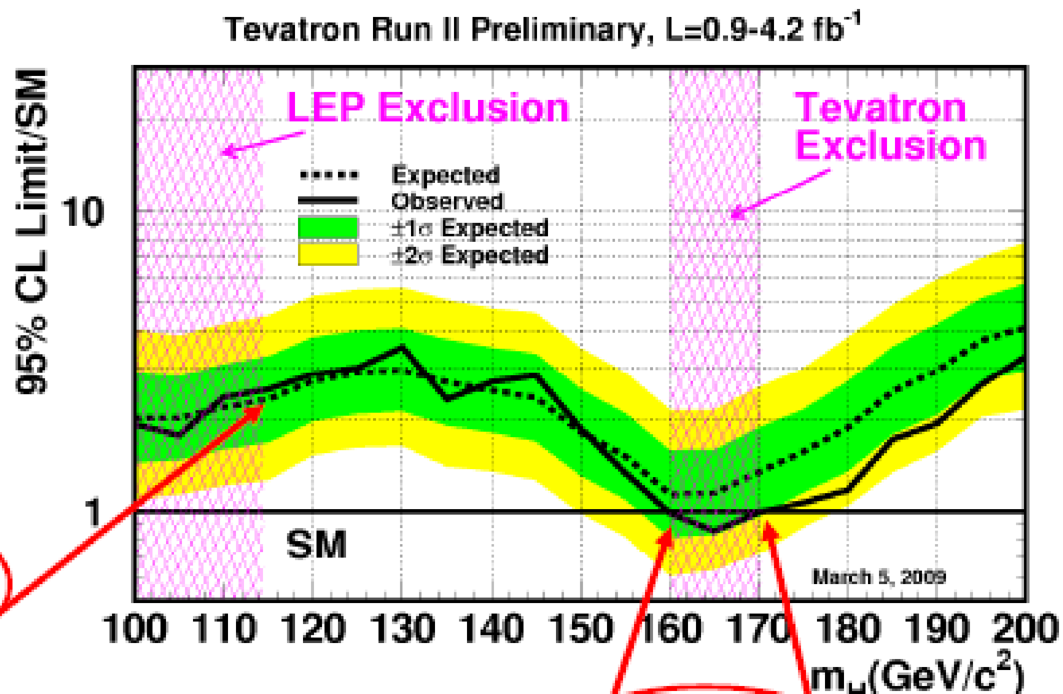
- Re metalic crystal (1.5 mg)
- BEFS observed (F.Gatti et al., Nature 397 (1999) 137)
- sensitivity: $m(\nu) < 26$ eV (F.Gatti, Nucl. Phys. B91 (2001) 293)

Moriond '09 Tevatron Combination

Low Mass analyses:
L = 0.9 – 2.7fb^{-1}

(results with more luminosity as presented before are **NOT** yet included in this combination)

@ M_H=115
Observed → 2.5xσ_{SM}
Expected → 2.4xσ_{SM}



High Mass analyses:
Higgs cross sections use most recent theoretical inputs including MSTW 2008 NNLO PDF set

Bayesian	150	155	160	165	170	175	180	185
Expected	1.8	1.5	1.1	1.1	1.4	1.6	1.9	2.2
Observed	1.9	1.4	0.99	0.86	0.99	1.1	1.2	1.7

We exclude the SM Higgs from 160 to 170 GeV at 95% C.L.

These Moriond '09 CDF-DØ combined limits are obtained with an "effective" luminosity of 2.5/4.0 fb^{-1} at low/high mass