

Y2 Neutrino Physics

2009-10

Dr. N.K. Watson

"Office Hours"

Monday and Tuesdays, in the hour following lectures

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Course Material

Updated lecture by lecture on

<https://www.ep.ph.bham.ac.uk/twiki/bin/view/General/Y2Neutrinos>

WebCT is old material from 2007-8, has link to the above page

Outline

- Some changes to previous years
 - ▶ Have a better idea of your baseline from Y1 Into to PP&C
 - ▶ Can get onto more interesting material if background/basics already established
 - ▶ Need your active help, please tell me
 - ⇒ If I am showing you things you already know and understand
 - ⇒ If I assume you know material you do not understand/have not seen previously
- Introduction to PP (review)
 - ▶ Refresh what you know from Y1/background information
- Neutrino properties
- Detection and observation
- Solar neutrinos
- Atmospheric neutrinos
- Neutrino oscillations and mass
 - ▶ Will expanded this in 2009/10 compared to previous years
 - ▶ Various mass hierarchies, 3 flavour mixing
 - ▶ Matter effects
- Neutrinoless Double Beta Decay
- Future experiments and outlook
 - ▶ Much more active field since course first established
 - ▶ More running and in-build experiments
 - ▶ Still not a well-understood area of HEP

~Current neutrino experiments

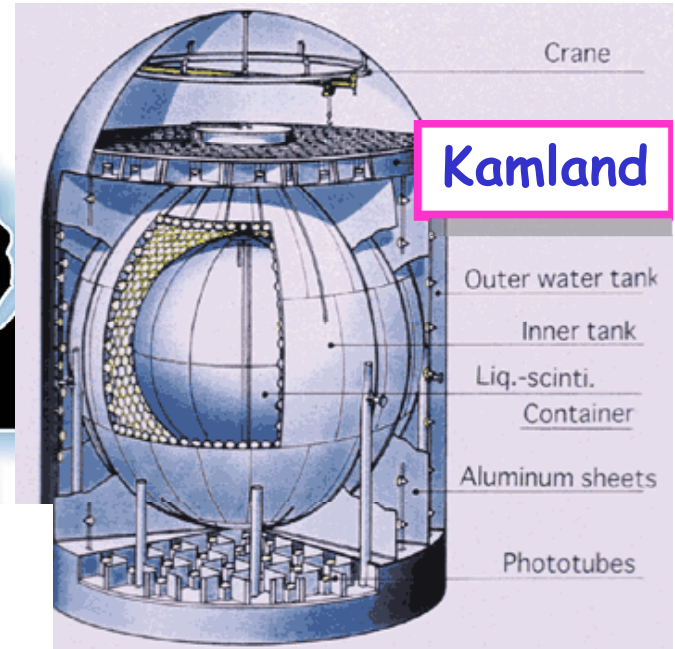
SNO



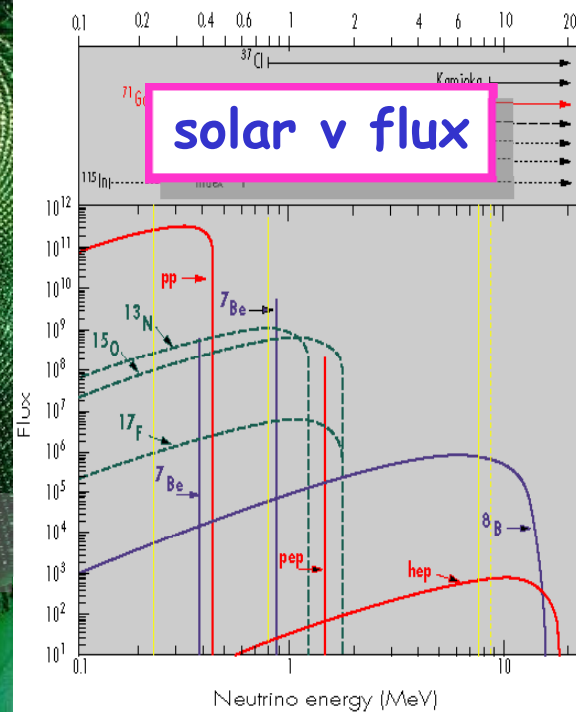
MINOS



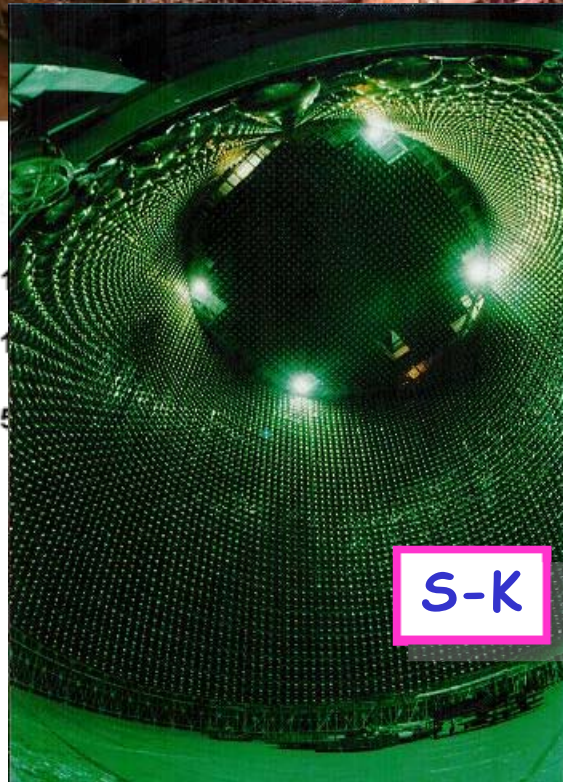
Kamland



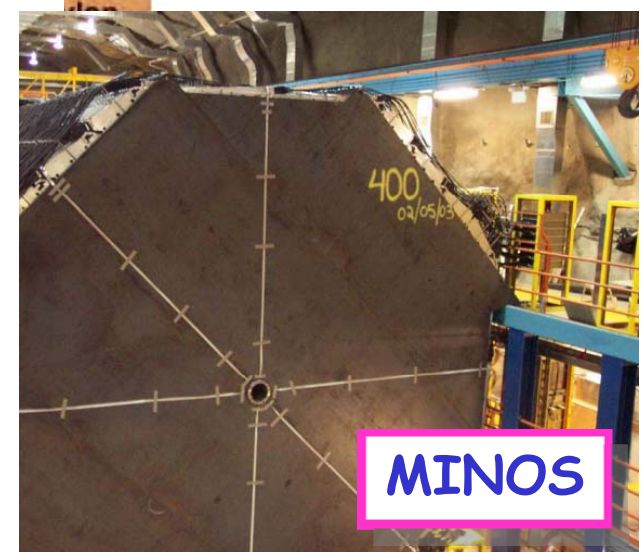
solar v flux



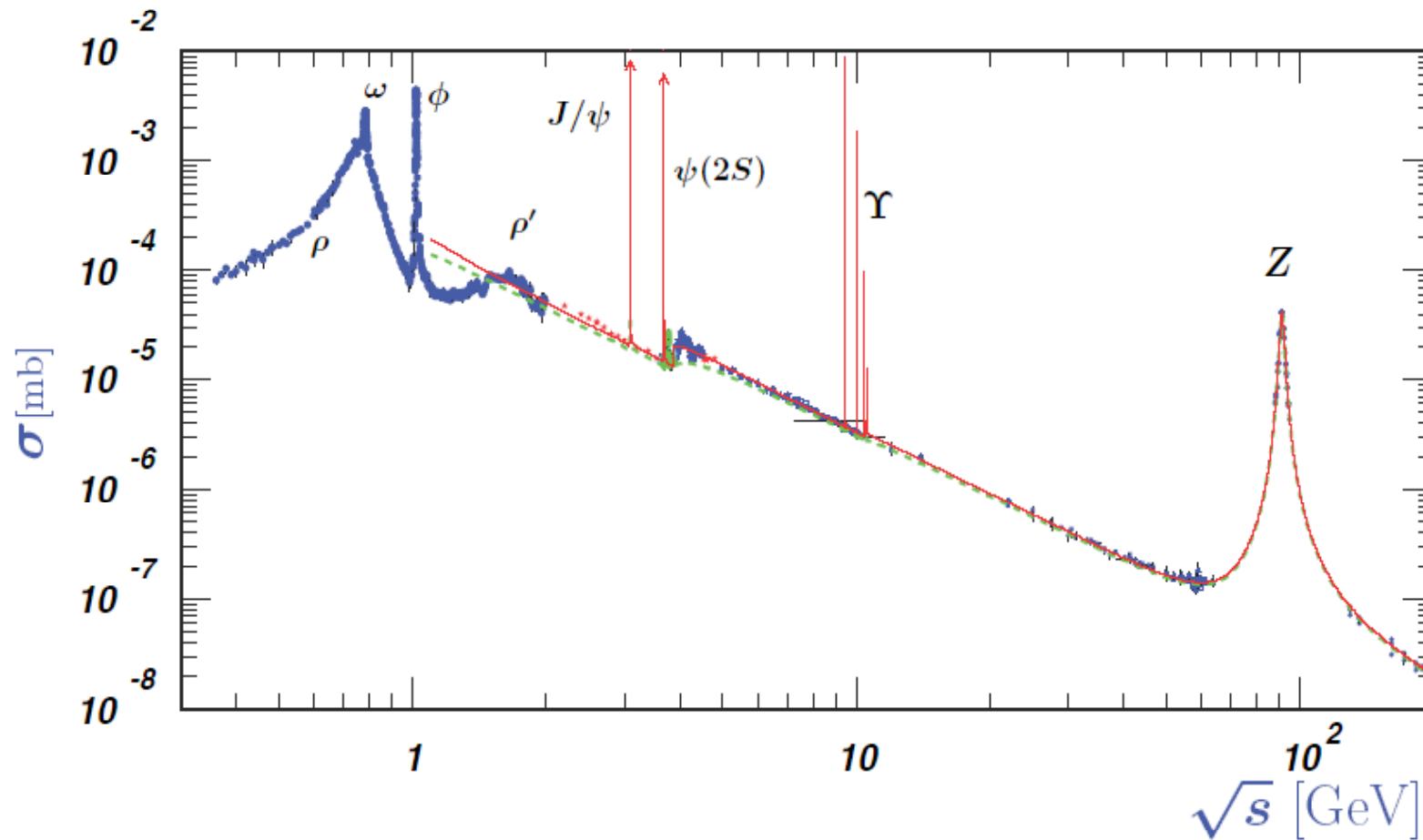
S-K



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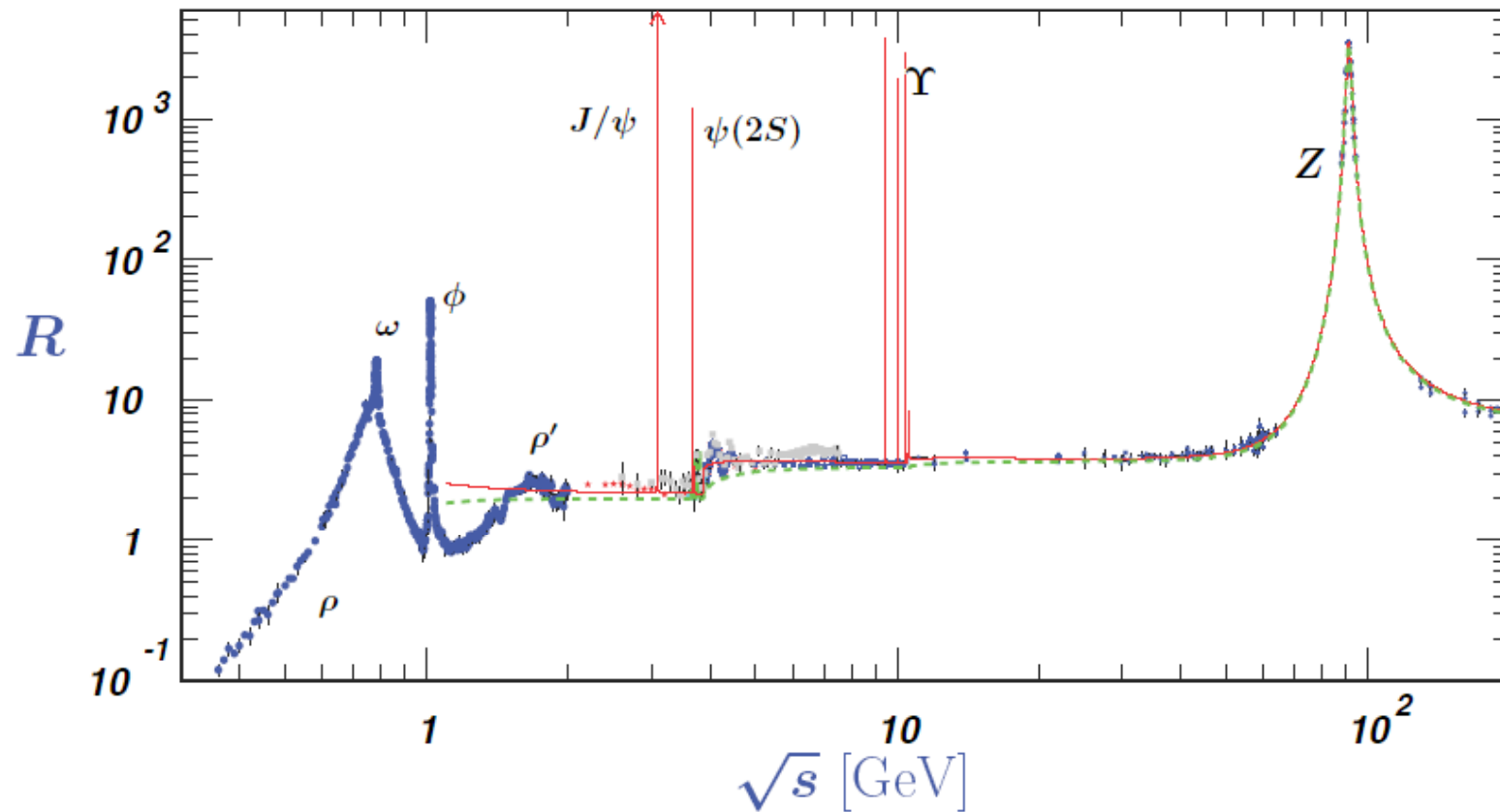


cross-section ($e^+e^- \rightarrow \text{hadrons}$)



<http://pdg.lbl.gov/2008/reviews/hadronicrpp.pdf>

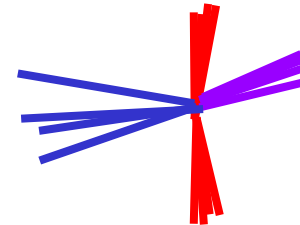
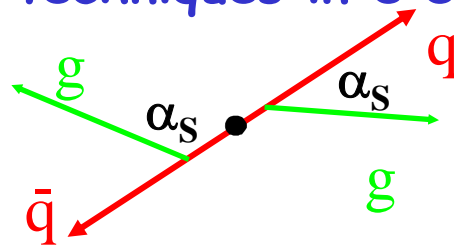
cross-section $(e^+e^- \rightarrow \text{hadrons}) / (e^+e^- \rightarrow \mu^+\mu^-)$



<http://pdg.lbl.gov/2008/reviews/hadronicrpp.pdf>

Strong Coupling "constant", α_s

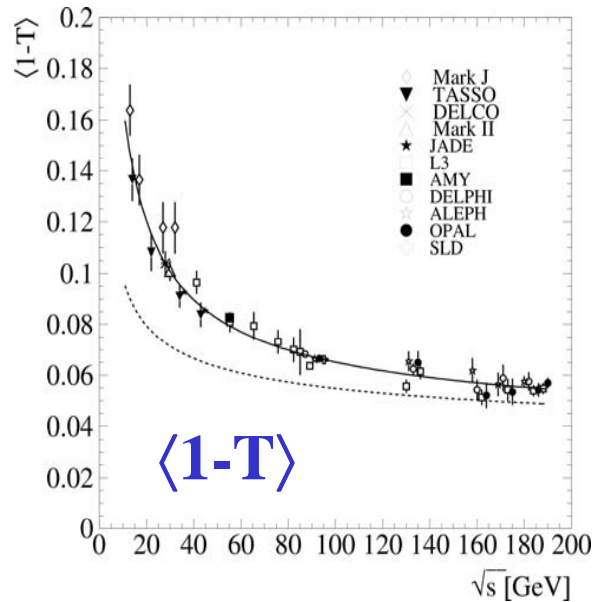
- α_s **the** fundamental, universal QCD parameter
- Standard Model predicts "momentum scale", Q ($\sim\sqrt{s}$) evolution, but not absolute value
 - ▶ Perturbative effects, varying as $\sim 1/\ln Q$
 - ▶ Non-perturbative effects, varying as $\sim 1/Q$
- Test: measure different processes, energies
- Intuitive techniques in e^+e^-



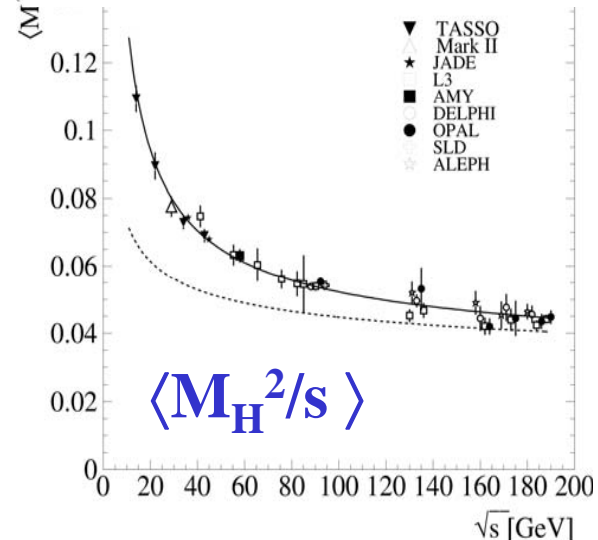
- Precision low, $\mathcal{O}(\%)$ cf. electroweak $\mathcal{O}(10^{-5})$

Global α_s measurements, various e^+e^- observables

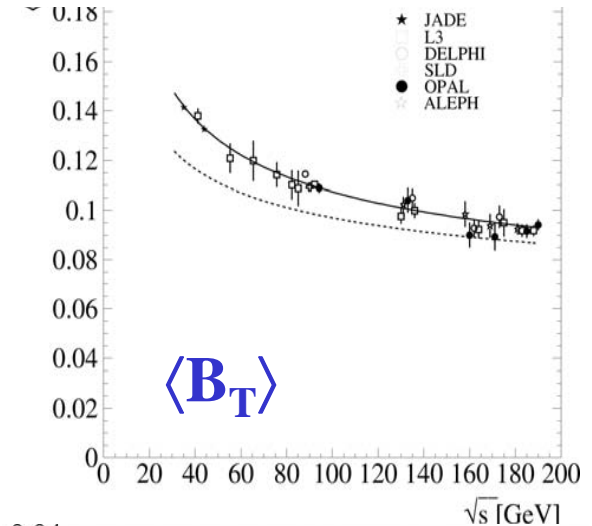
[From P.A. Movilla Fernandez et al., Eur.Phys.J.C22(2001)]



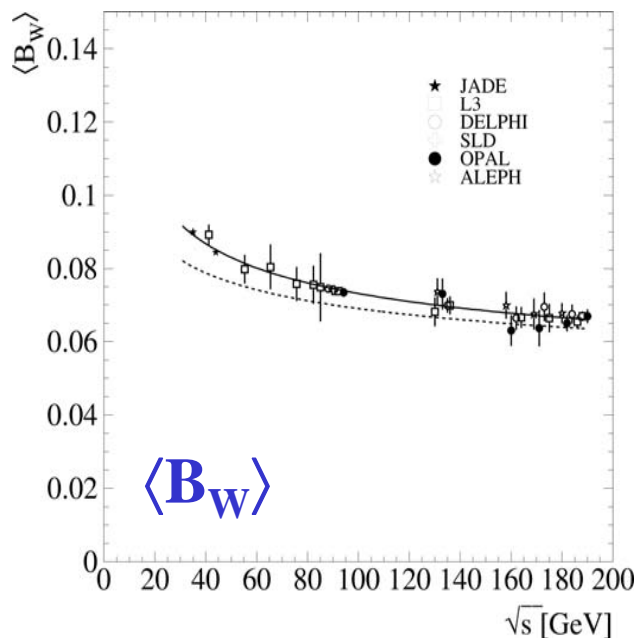
$\langle 1-T \rangle$



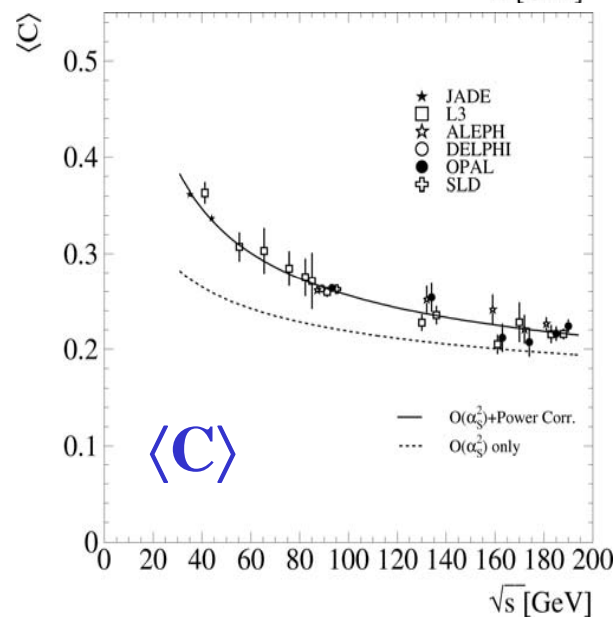
$\langle M_H^2/s \rangle$



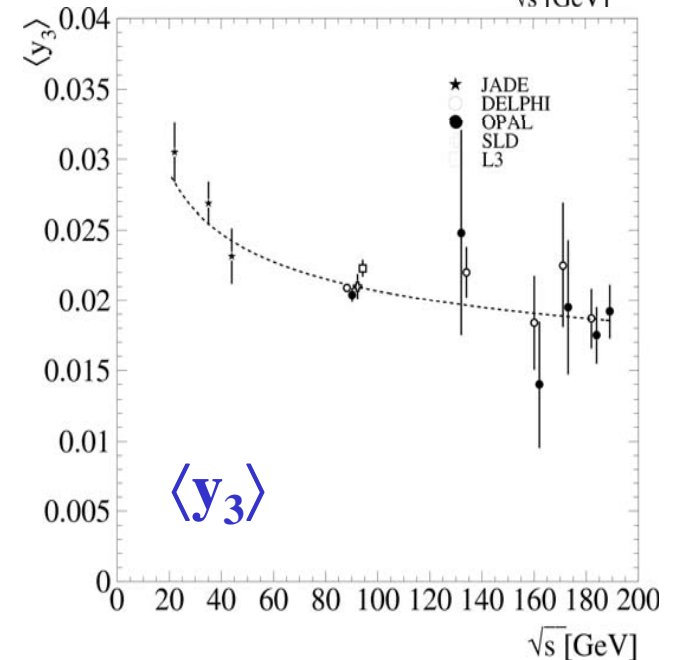
$\langle B_T \rangle$



$\langle B_W \rangle$

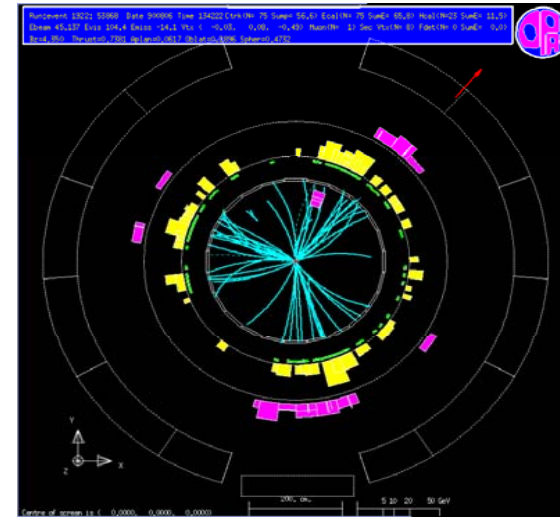
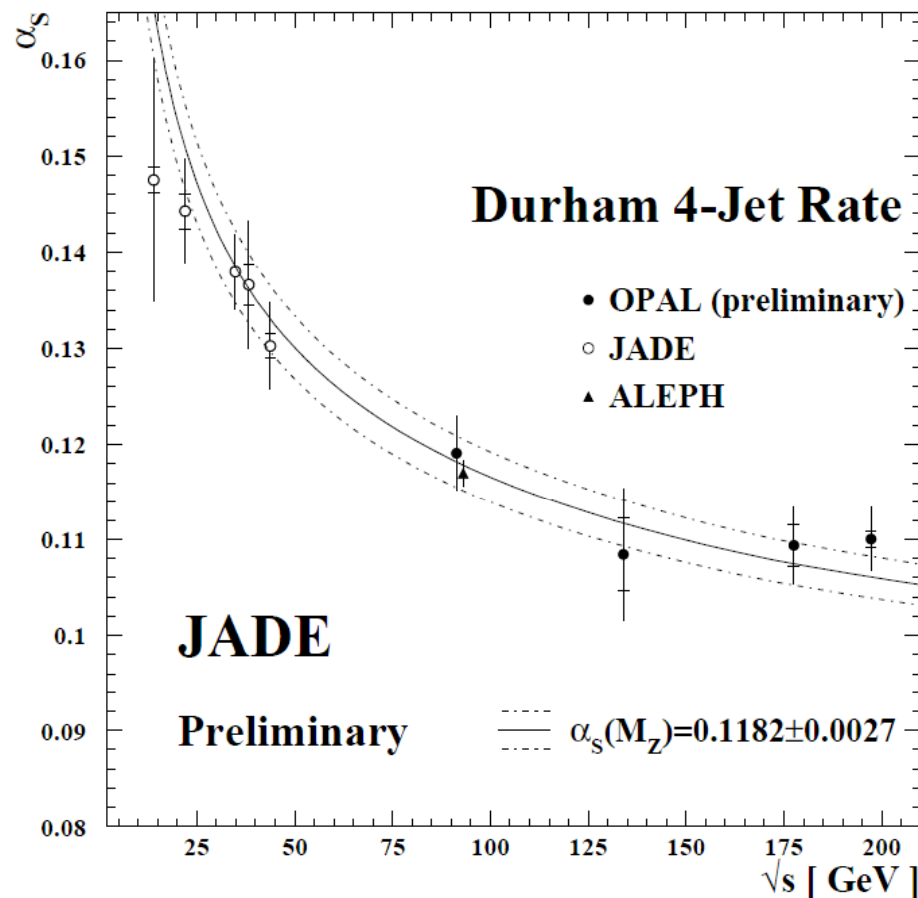


$\langle C \rangle$



$\langle y_3 \rangle$

Strong coupling constant



- α_s is strong force coupling constant
- Momentum scale-dependent value
 - ▶ Illustrate by measurement at different centre-of-mass energies in e^+e^- collisions