Report from HEP2003, International Europhysics Conference on High Energy Physics (EPS)

(July 17th-23rd 2003) in Aachen, Germany

P. Skands

Overview

- Prompt Photons.
- Factorization in Photoproduction?
- Neutrino Status.
- Neutrino Cosmophysics.

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- Prompt Photons.
- Factorization in Photoproduction?
- Neutrino Status.
- Neutrino Cosmophysics.
- Pentaquarks!

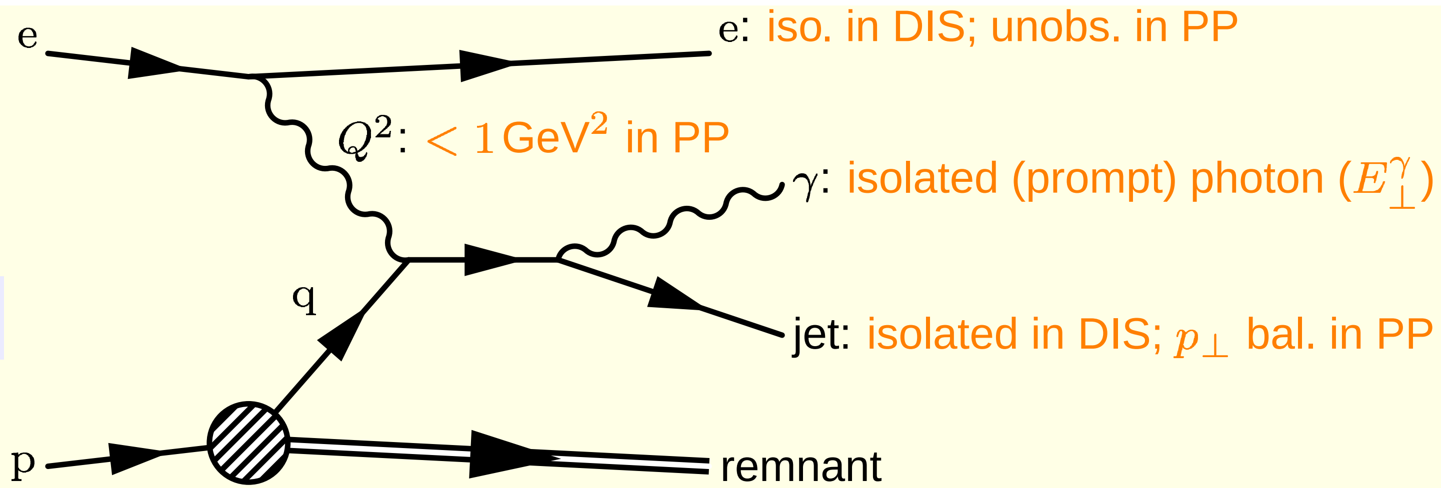
And now to...

Prompt Photons

Prompt photons at HERA

Inclusive and γ + jet ('96–'00 $\Rightarrow \mathcal{L} > 100\mathrm{pb}^{-1}$):

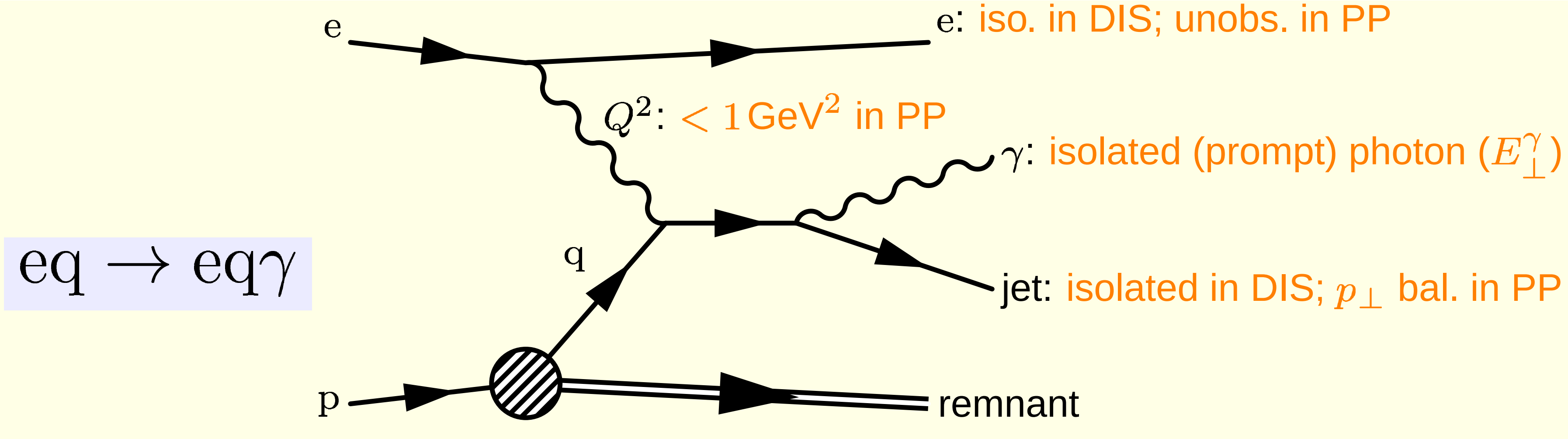
$$\mathrm{eq} \rightarrow \mathrm{eq}\gamma$$



Backgrounds: γ from electron ISR and FSR, from jet, and from decays.

Prompt photons at HERA

Inclusive and γ + jet ('96–'00 $\Rightarrow \mathcal{L} > 100\mathrm{pb}^{-1}$):



Backgrounds: γ from electron ISR and FSR, from jet, and from decays.

- DIS: First observation by ZEUS (+ comparison to MC and NLO).
- Photoproduction: New results from H1 (+ comparison to NLO)

$\rightarrow$ Saxon OHP's

Prompt photons at HERA

DIS:

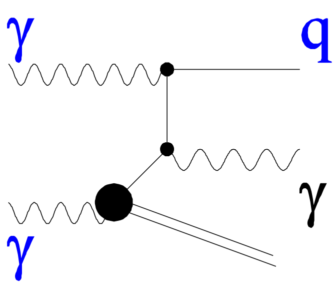
- PYTHIA and HERWIG differ on γ + jet. Neither gives a good description. Room for work?
- NLO calculations (Kramer & Spiesberger) agree better on rates and general trends.

Photoproduction:

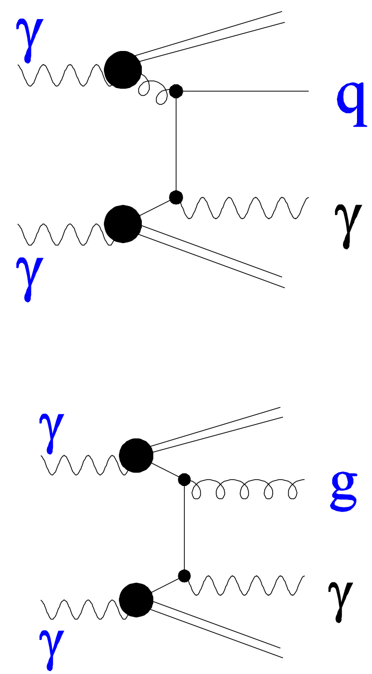
- Inclusive: well described by NLO (Fontannaz et al) and shapes by PYTHIA.
- γ + jet well described by NLO (with multiple interactions a la PYTHIA).

Prompt photons at LEP ($\gamma\gamma \to \gamma X$)

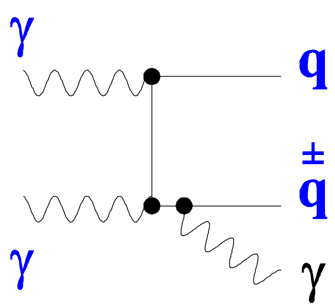
OPAL experiment



Single-resolved process



Double-resolved process



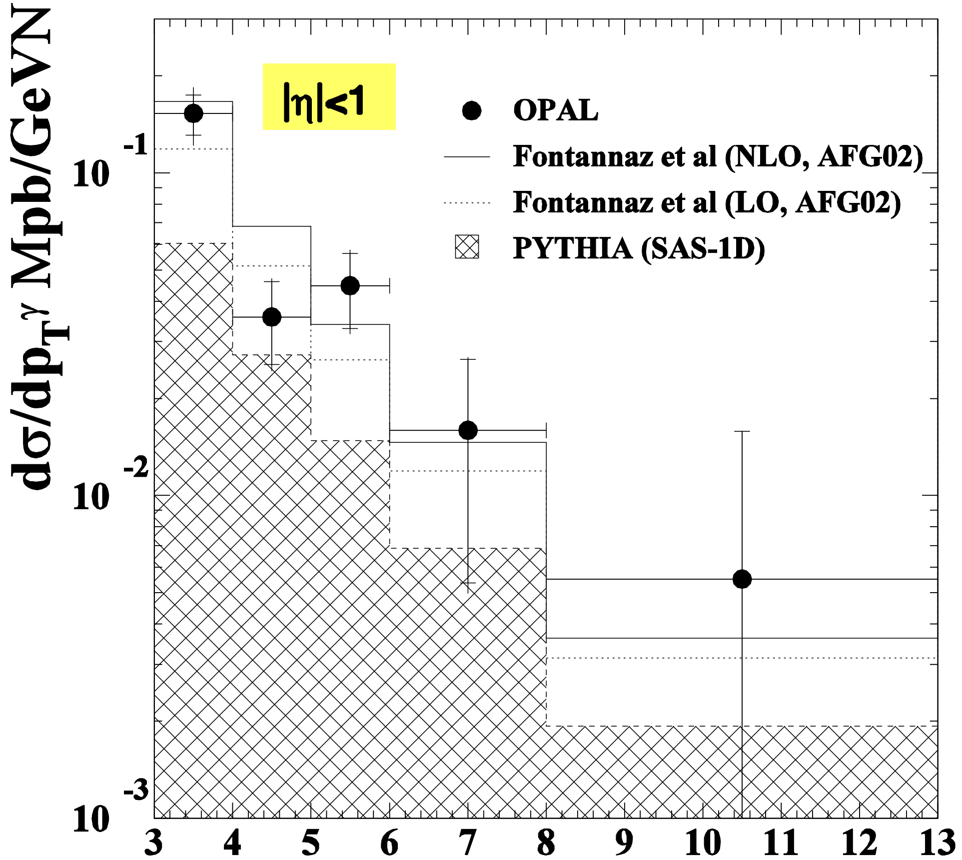
Direct process with FSR

(suppressed by isolation)

- After selection: 137 events in data. (CERN-EP/2003-023)

Prompt photons at LEP ($\gamma\gamma \to \gamma X$)

- Total and diff. cross sections:



$$\sigma_{\text{tot}} = 0.32 \pm \underbrace{0.04}_{stat} \pm \underbrace{0.04}_{sys} \text{ pb.}$$

PYTHIA describes the shape, but is a bit low.

NLO agrees in shape and normalization.

And now to...

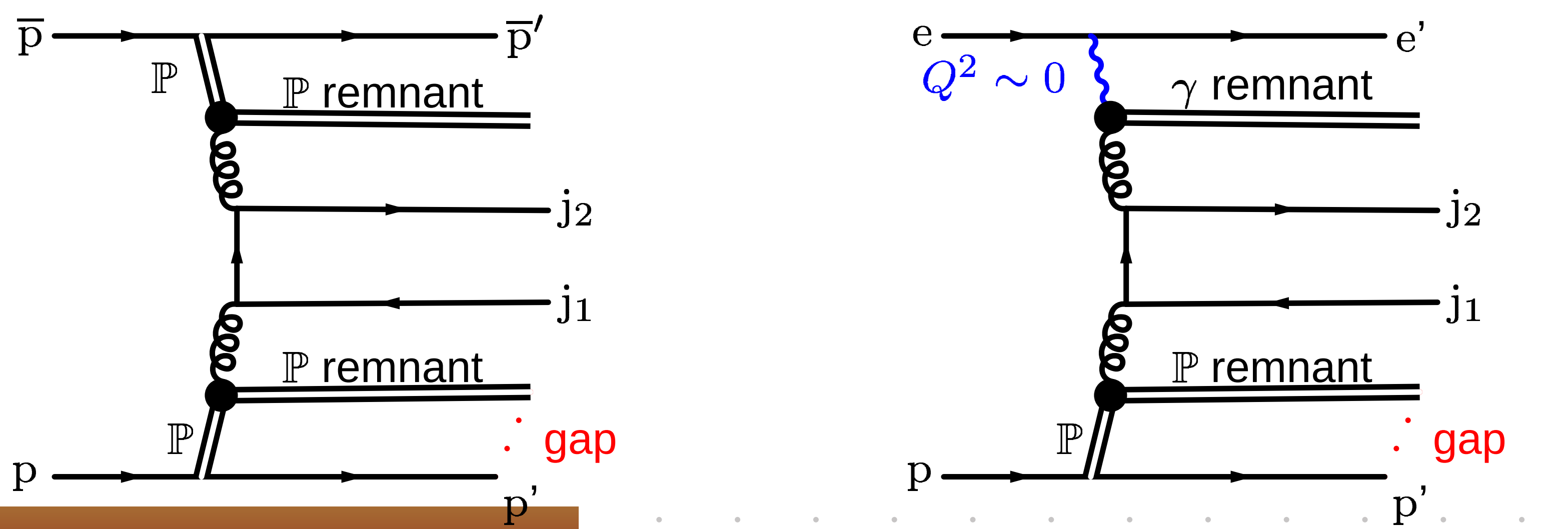
Factorization in Photoproduction?

Dijets and factorization breaking

- The problem: HERA pdf's used for diffractive dijets (w/ tagged $\overline{\mathrm{p}}$) at Tevatron $\Longrightarrow$ cross section 1 order of mag. above data!
- Due to presence of second hadron in initial state?
  (spectator interactions break up the $\overline{\mathrm{p}}$, $\Longrightarrow$ "rapidity gap survival probability")

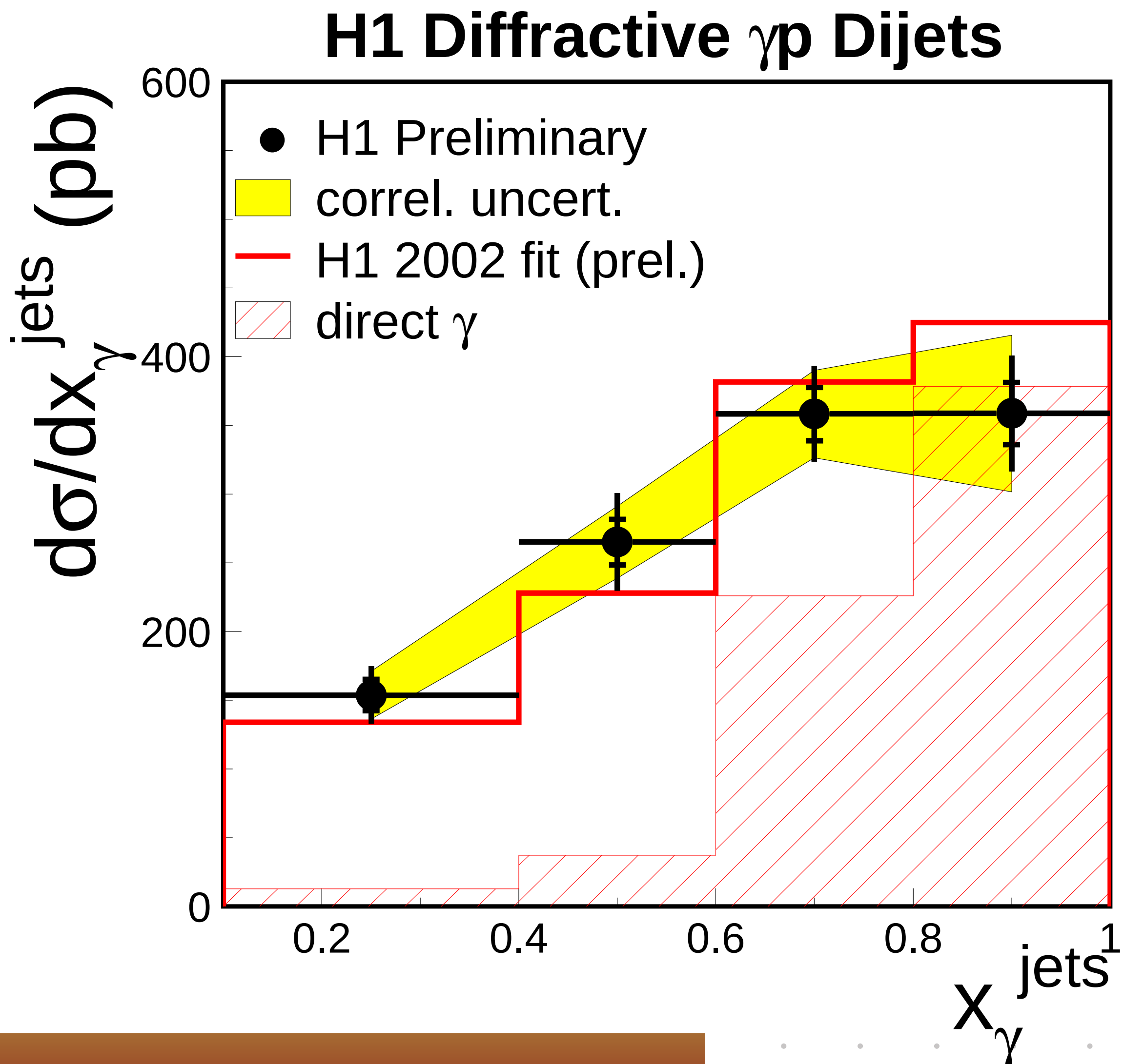
Dijets and factorization breaking

- The problem: HERA pdf's used for diffractive dijets (w/ tagged $\overline{\mathrm{p}}$) at Tevatron $\Longrightarrow$ cross section 1 order of mag. above data!
- Due to presence of second hadron in initial state? (spectator interactions break up the $\overline{\mathrm{p}}$, $\Longrightarrow$ "rapidity gap survival probability")
- If that is the reason $\Longrightarrow$ HERA pdf's ought to fail for photoproduction. (VMD photon $\sim$ hadron)



Factorization in Photoproduction?

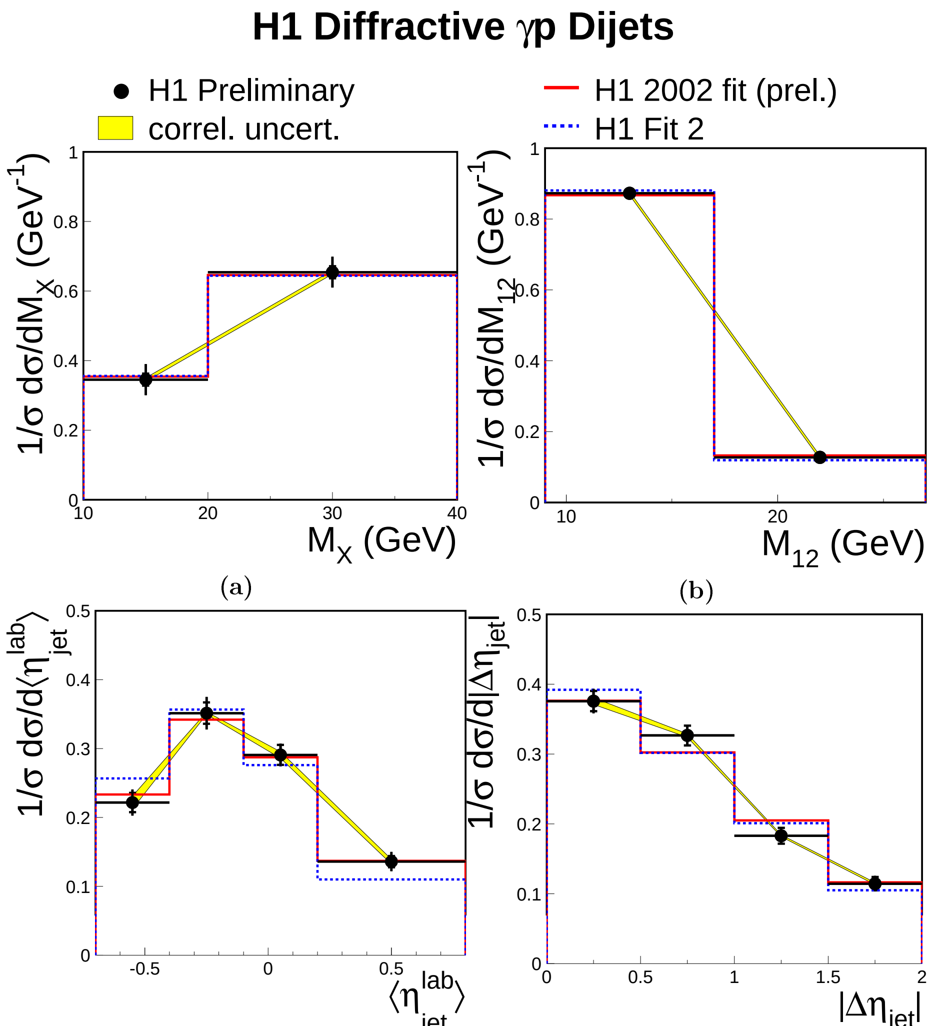
But:



New (2002) fit describes data!

Factorization in Photoproduction?

- Shapes (cross sections normalized):



Also well described!

Factorization in Photoproduction?

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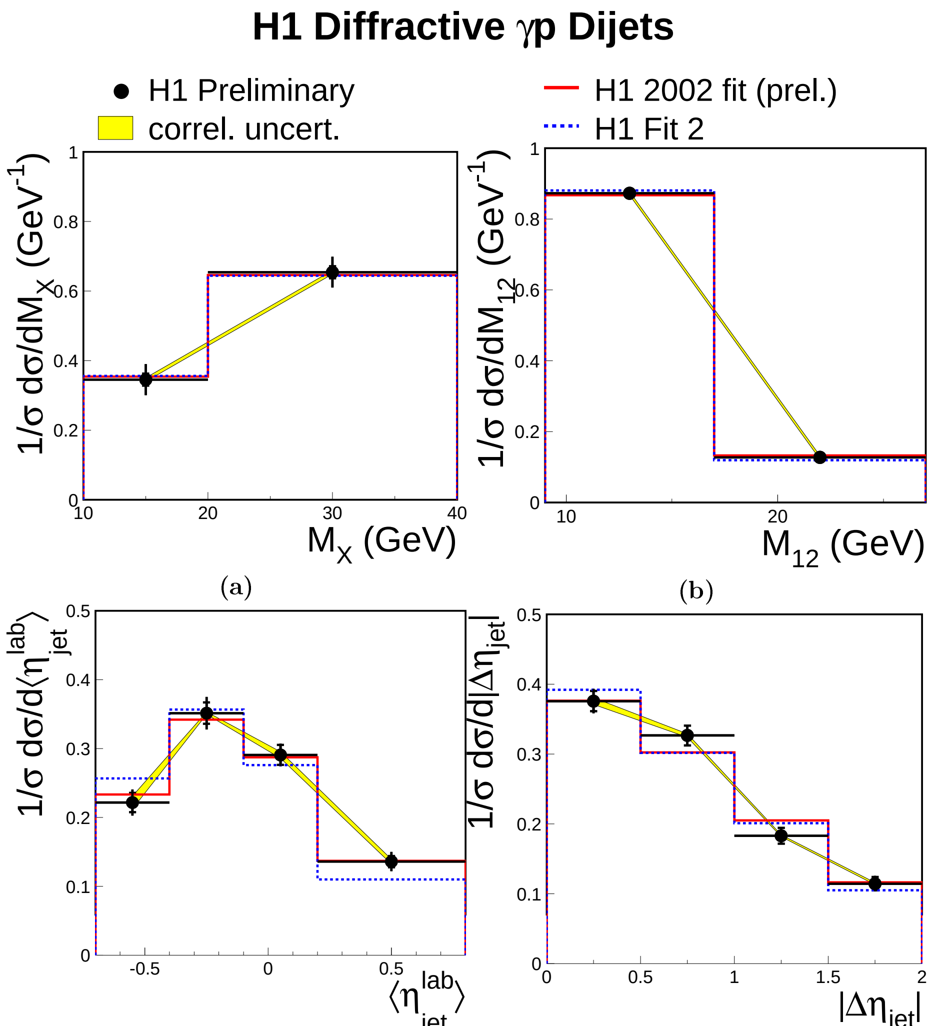


Also well described!

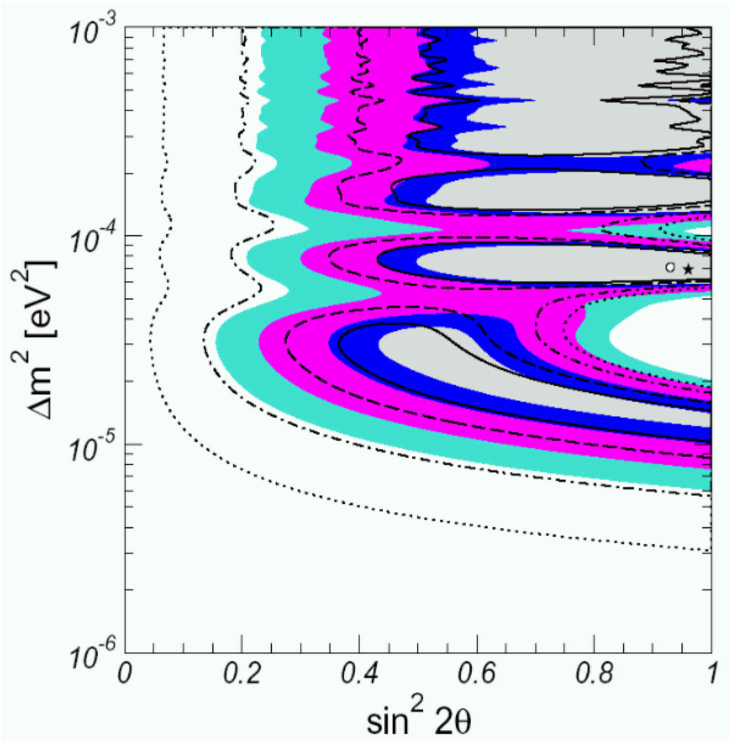
$\Longrightarrow$ Factorization works in (resolved) photoproduction?!

And now to...

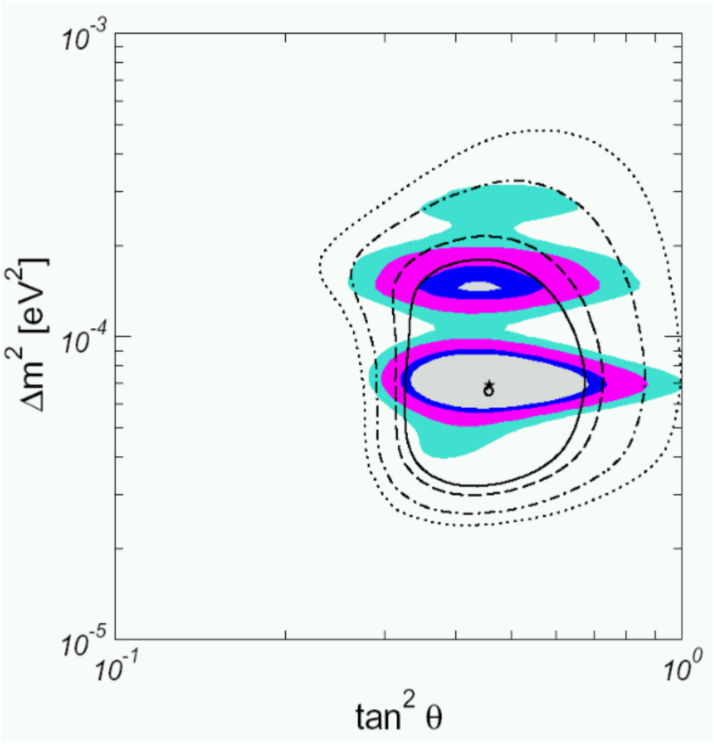
Neutrino Physics

The Solar Neutrino Anomaly

- December 2002: first KAMLAND results. (Phys.Rev.Lett.90:021802,2003), see also (hep-ph/0212129)



KAMLAND only

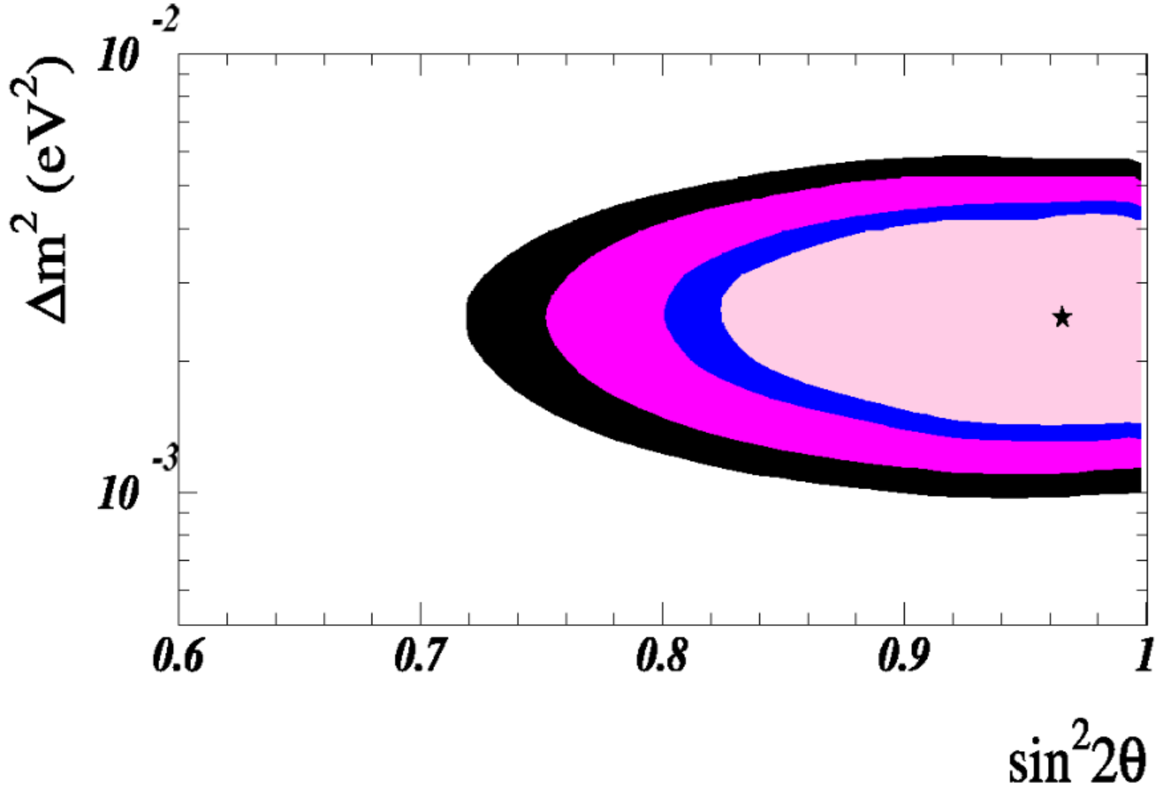


Chooz + KAMLAND + solar

- $\Longrightarrow$ Remaining part of low Δm^2 parameter space excluded.

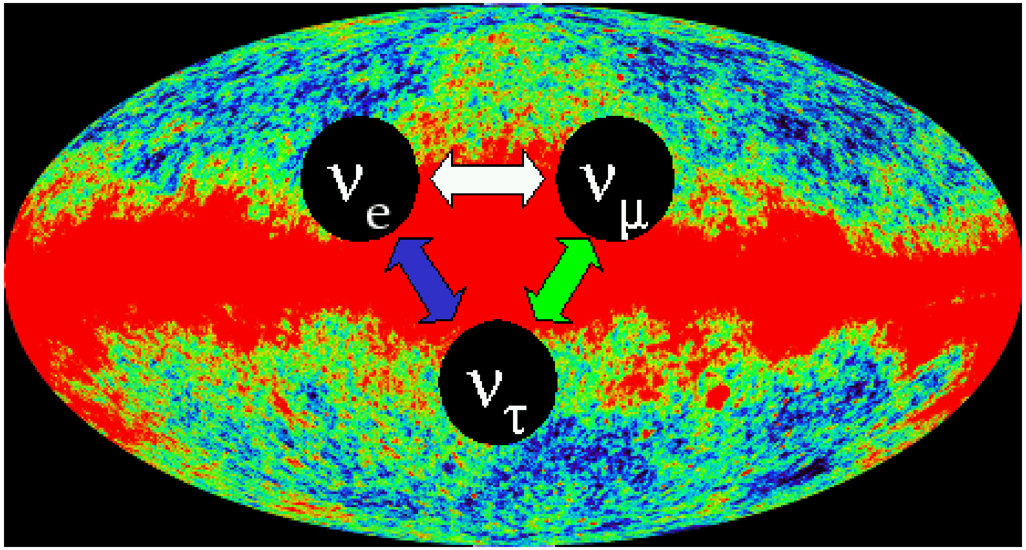
The Atmospheric Neutrino Anomaly

- Status: (hep-ph/0205216)



Super-K + IMB + Soudan2 + MACRO + Chooz

Neutrino Cosmophysics

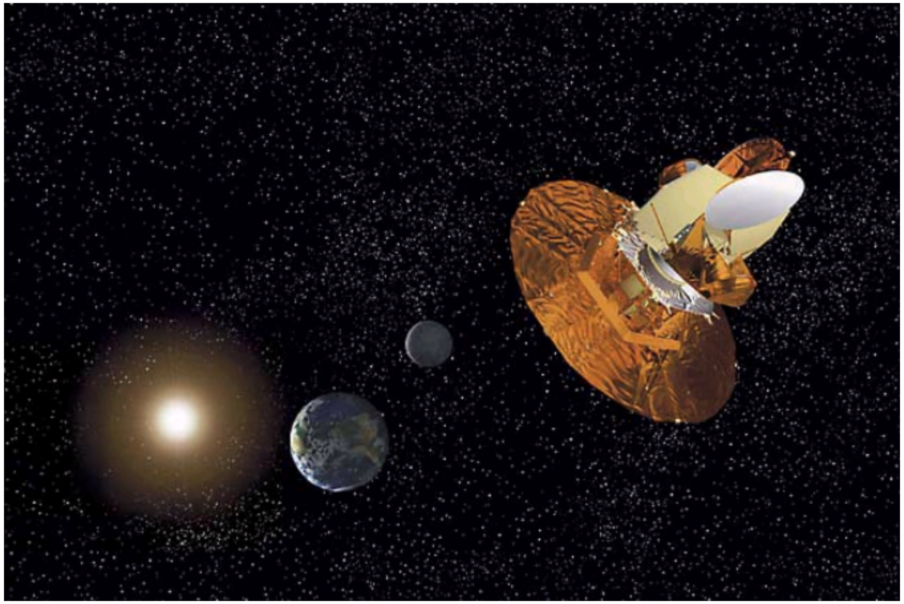


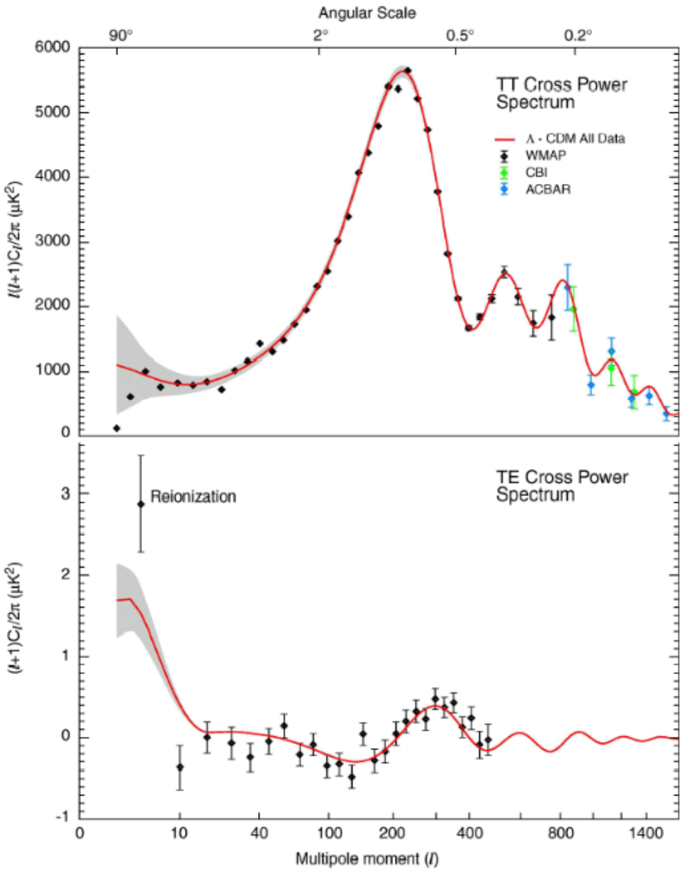
- CMB and large scale structure are sensitive to absolute neutrino masses.

- May '02: 2dF Galaxy redshift survey results.
- Feb. '03: WMAP results.

Wilkinson Microwave Anisotropy Probe

- WMAP: Measuring the CMB fluctuations.

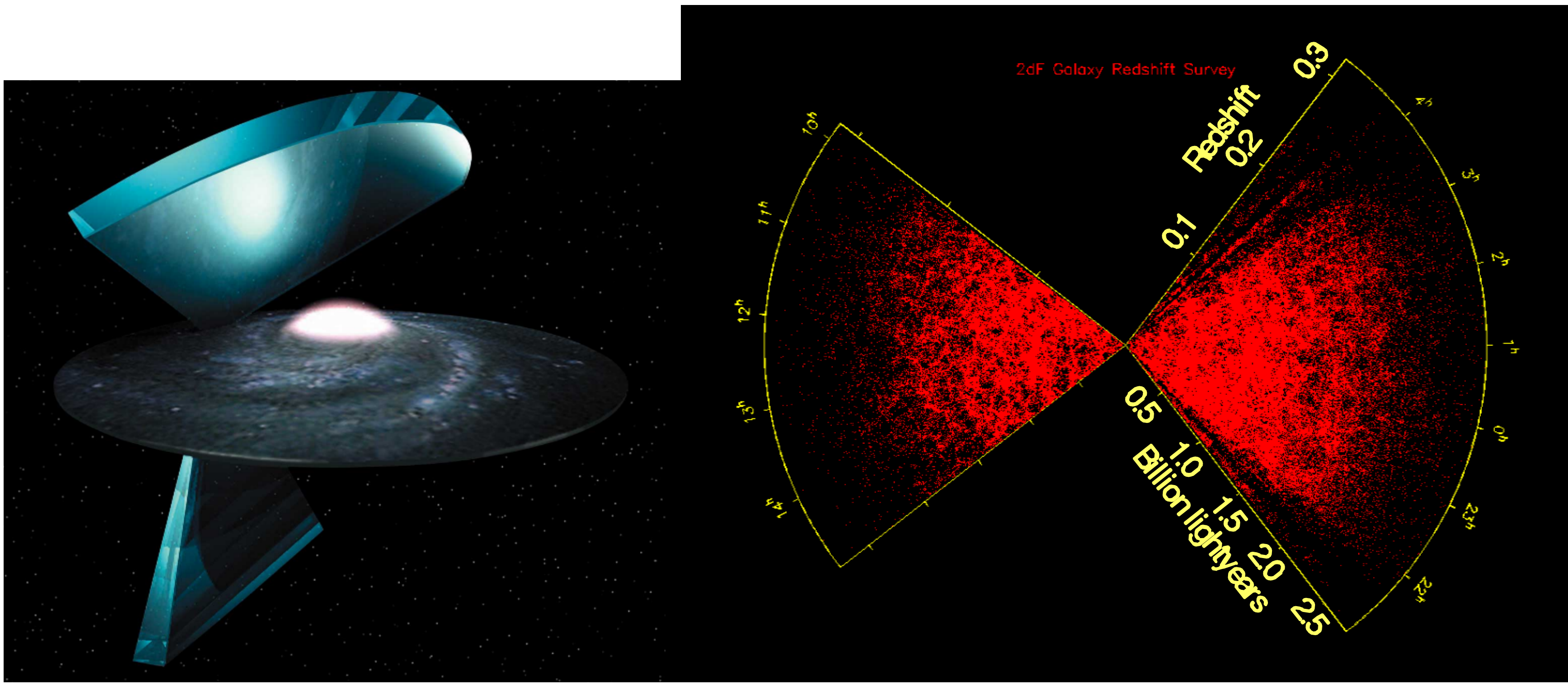




- + Balloons (Boomerang, TopHat), Interferometers (CBI, DASI), and Planck (2007).

The 2dF survey and beyond

- Redshifts of 250.000 galaxies in 2° “wedge”.



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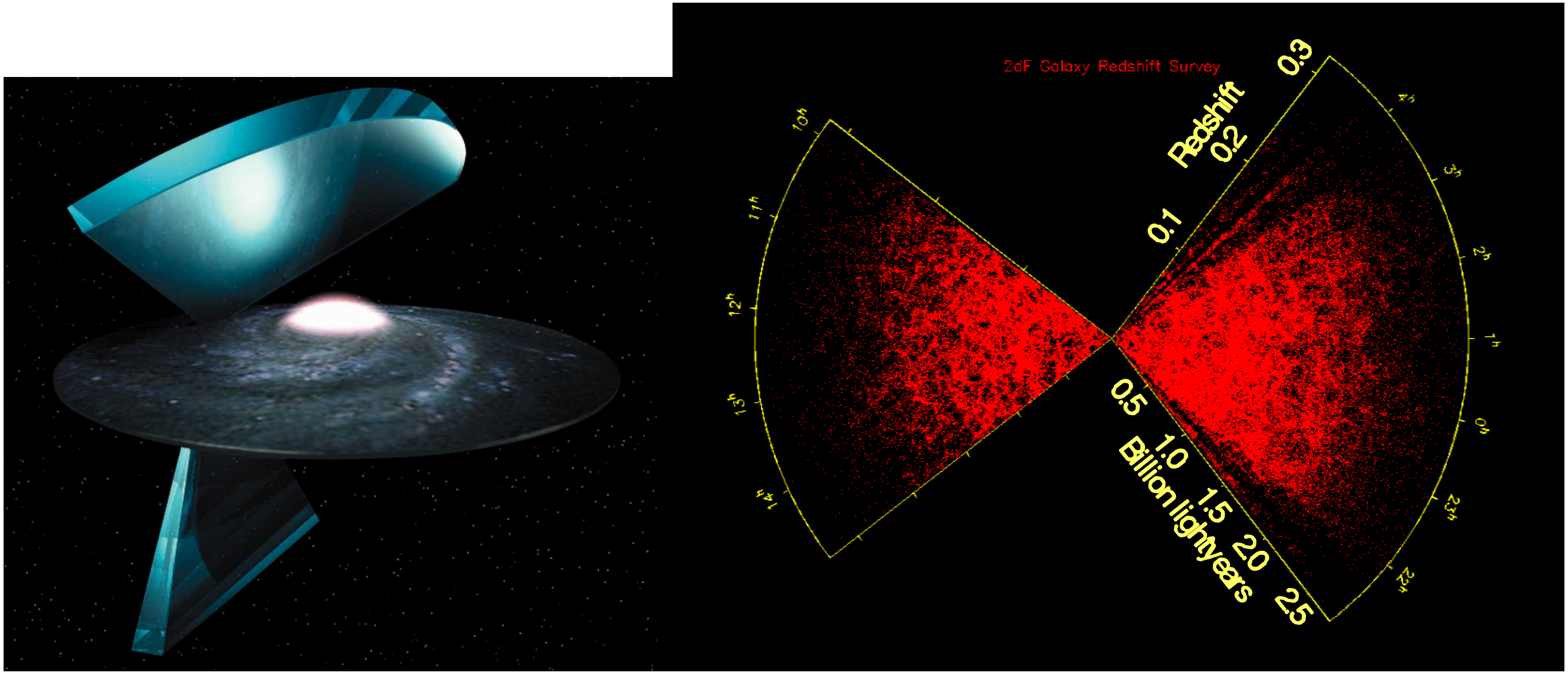
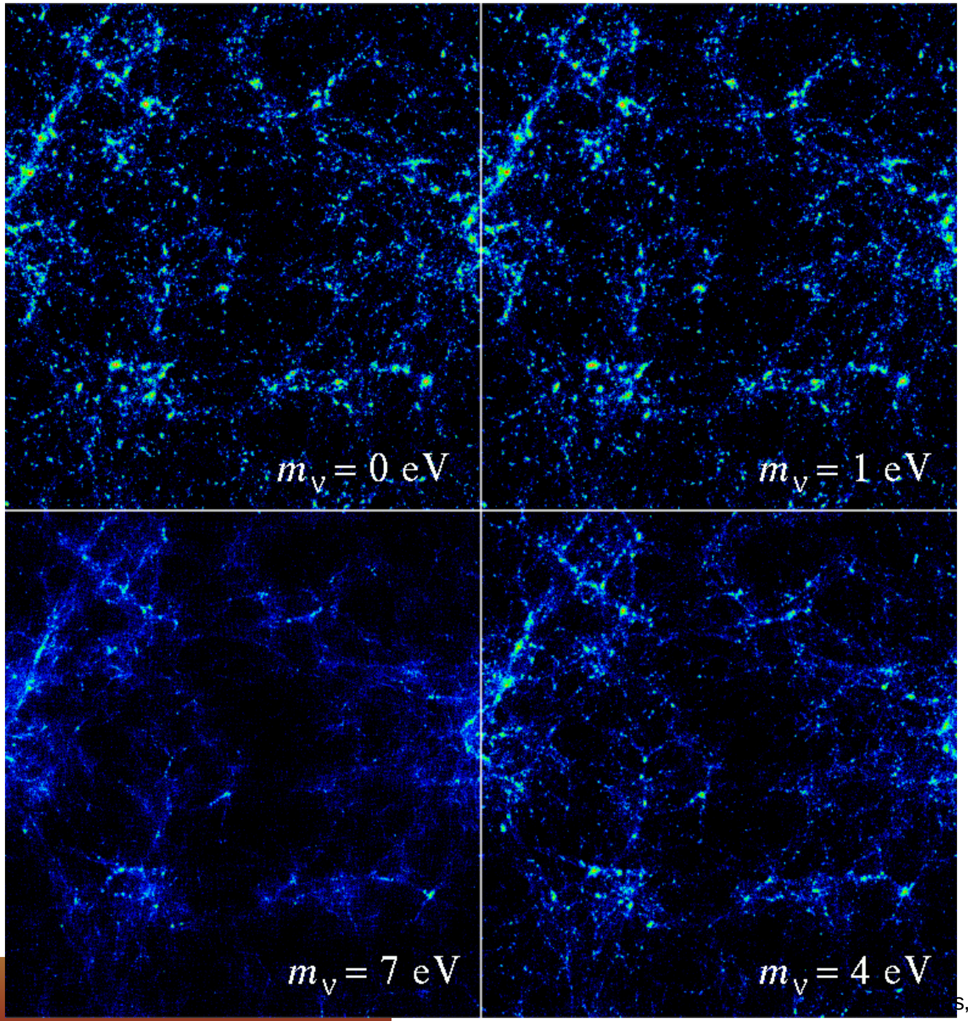


- + SSDS (1M galaxies!) (ongoing).

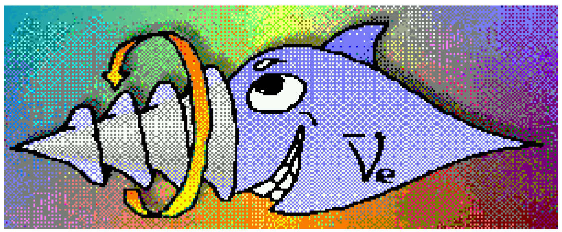
2dF, WMAP, and ν masses

- Free-streaming (massive) neutrinos affect survival of small-scale fluctuations, below $d_{FS} \sim 1200\ \mathrm{Mpc}/m_{\mathrm{eV}}$

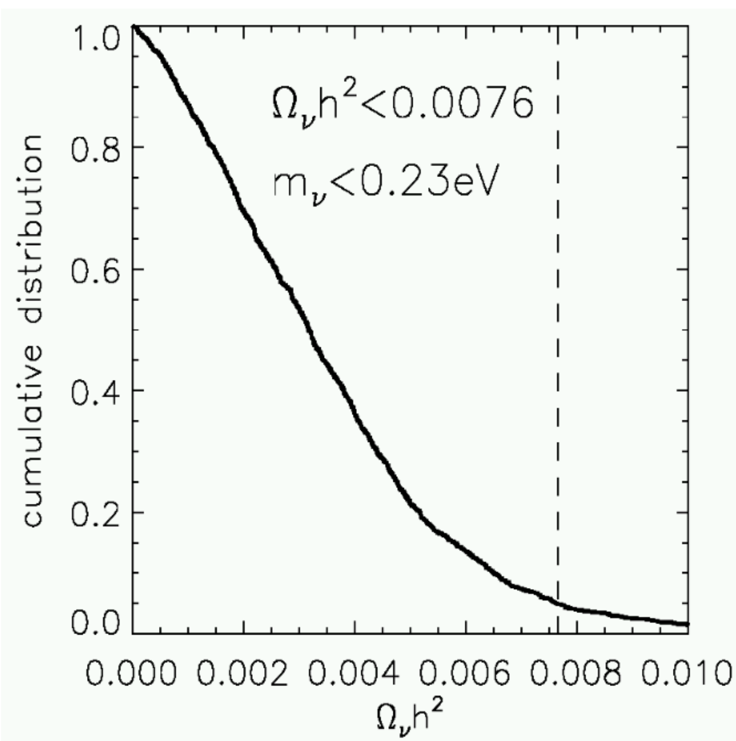


(see also astro-ph/9904001)

Neutrino mass bounds



- The MAINZ tritium β decay experiment: 1998 - 2001.
- Latest update: $m_\nu \leq 2.2\,\text{eV}$



- WMAP + 2dF + Lyα data
- astro-ph/0302209: $m_\nu \leq 0.23\,\text{eV}$

And now to...

PENTAQUARKS!

Pentaquarks!

- Sudden explosion of evidence for
  - Narrow K^+n resonance.
  - Mass 1540 MeV. Width: < 25 MeV SPRING8; < 15 MeV DIANA
- Reported by 5 experiments:

Spring-8	(LEPS)	Phys.Rev.Lett.91:012002,2003
DIANA	(ITEP)	hep-ex/0304040
CLAS	(JLAB)	hep-ex/0307018
SAPHIR	(Bonn)	hep-ex/0307083
HERMES	(DESY)	?

Pentaquarks: how to find them

- Spring-8 (LEPS) — nK^+ in $\gamma^{12}\mathrm{C} \to \mathrm{K}^+\mathrm{K}^- X$.

  with cuts to select quasi-free neutrons and with correction for Fermi motion.

- DIANA (ITEP) — pK_S^0 in low-energy $\mathrm{K}^+\mathrm{Xe} \to \mathrm{K}^0\mathrm{pXe}$.

  Since no known Σ^* at 1540 MeV, signal interpreted as Θ^+.

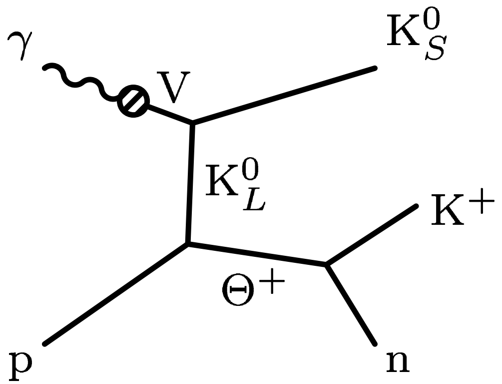
- CLAS (JLAB) — nK^+ in $\gamma\mathrm{d} \to \mathrm{nK}^+\mathrm{K}^-(\mathrm{p})$.

  Poor acceptance. Relying on rescattering of the K^- off the spectator proton.

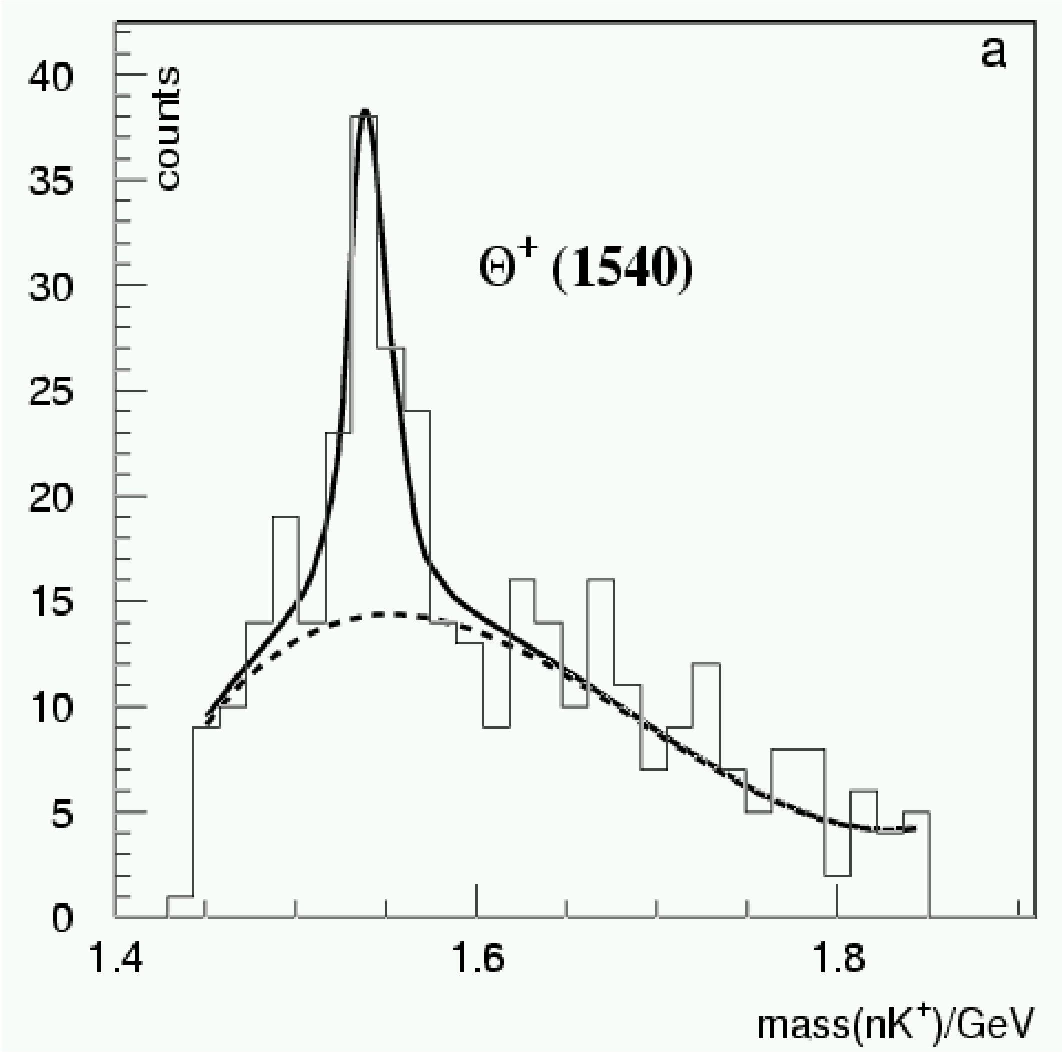
- SAPHIR (ELSA) — nK^+ in $\gamma\mathrm{p} \to \mathrm{nK}^+\mathrm{K}_S^0$.

  + absence of pK^+ peak in $\gamma\mathrm{p} \to \mathrm{pK}^+\mathrm{K}^-$!

SAPHIR (hep-ex/0307083)

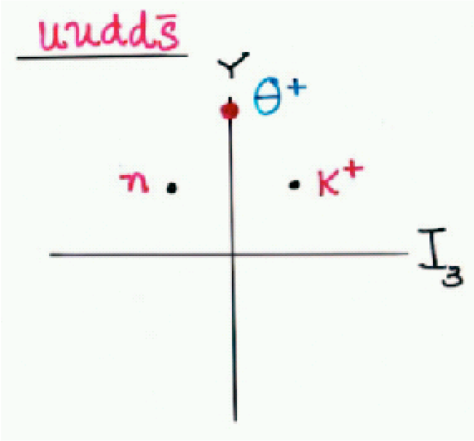


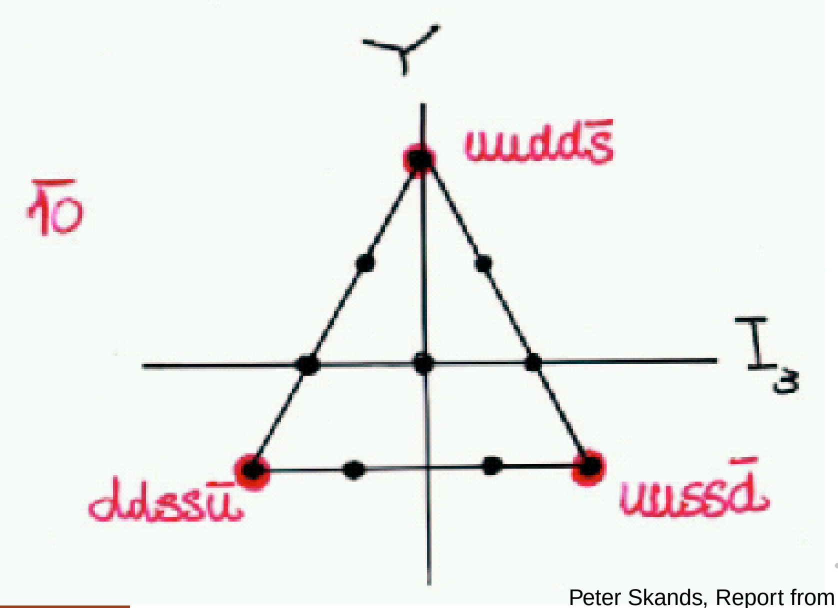
$\sigma \sim 300$nb



So what *are* these things?

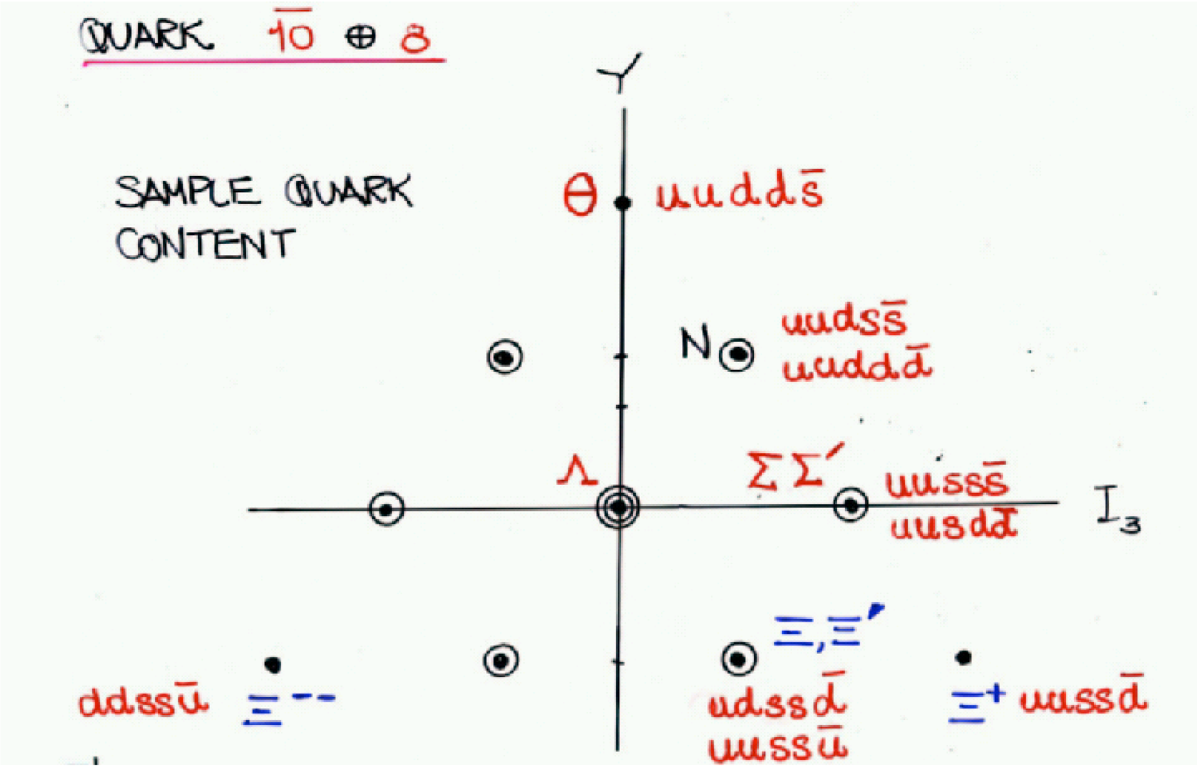
- Minimal Θ^+ content: $\mathrm{uudd\bar{s}}$
- $Y = 2$
  $I_3 = 0$
- Total I?
  No $K^+\mathrm{p}$ partner, so $I = 0$ (?)





Pentaquarks from quark models?

- Minimal Θ^+ content: $\mathrm{uud d\bar{s}}$
- Negative parity! (for S wave)



- Many states, some even lighter than Θ^+!

Pentaquarks from (di)quark models?

- More dynamics included in picture with quark pairs in $(\overline{\mathbf{3}}_F, \overline{\mathbf{3}}_C)$ bosonic states with short-range repulsion?
- If so, imagine bound states of 2 diquarks and one antiquark.
- Overall singlet $\Longrightarrow$ diquarks antisymmetric in colour $\Longrightarrow$ repulsion $\Longrightarrow$ spatial antisymmetry preferred $\Longrightarrow$ p-wave $\Longrightarrow$ **positive parity.**
- Same mass pattern as in ordinary quark model, but different parity predicted. (+ good candidates for many of the required states — the annyoing Roper!?!?)

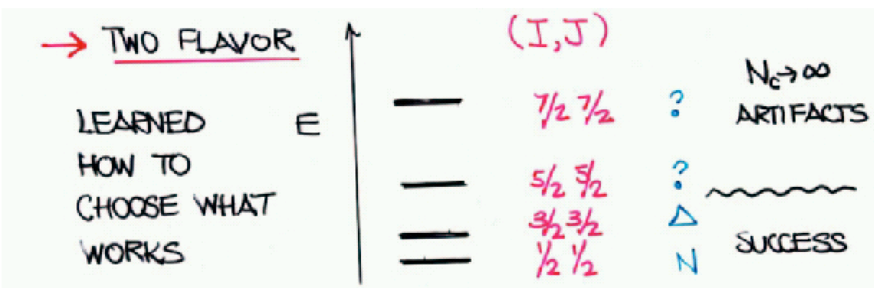
Skyrme phenomenology (hep-ph/0308114 + references)

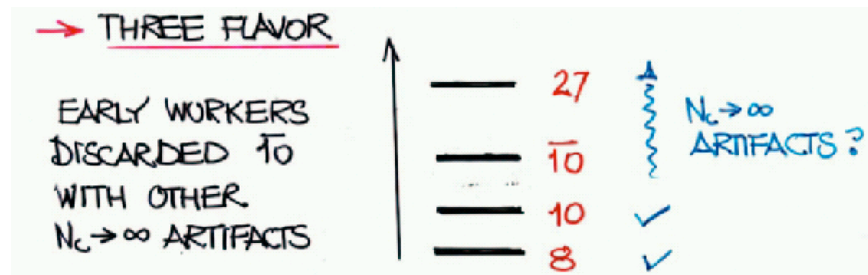
- Formally integrate out gluons from QCD.
- Approximate resulting (chirally symmetric) non-local quark theory by simple, quartic quark interactions.
- Skyrme Model ($N_c \to \infty$) and Chiral Quark Model, both devised to describe low-energy meson physics.
- However, baryons arise as soliton solutions, a nontrivial (hedgehog) *classical* configuration of the pion field.
- Allowed baryon representations (triality zero):

  $\mathbf{8}, \mathbf{10}, \overline{\mathbf{10}}, \mathbf{27}, \mathbf{35}, \overline{\mathbf{35}}, \ldots$

Skyrme phenomenology

- So Baryon number = topological quantum number of pion field.
- But Skyrme phenomenology has a mixed record:





- Some took it seriously...

Praszalowicz 1987: $M(\Theta^+) = 1530$ MeV!
Diakonov, Petrov, Polyakov 1997: $M(\Theta^+) = 1580$ MeV, influenced experimenters.

- NB: $\overline{\mathbf{10}}$ mass quite sensitive to parameters, mass *splittings* much better "predicted", since same (to LO) as in non–exotic multiplets.

Pentaquarks

Conclusions:

- Evidence for positive-strangeness exotic “baryon” at $M_{\Theta^+} = 1540$ MeV.
- The battle is raging: constituent quark vs. soliton vs. quasi-molecular interpretations of light baryons.
- Important to check parity.
- Important to check for other states. Quark models always have an extra exotic octet, soliton models don’t.
- All theories welcome at `http://arxiv.org/uploads`.