ANOMALOUS GAMMA-GAMMA INTERACTION

Philip Yock
University of Auckland
New Zealand

2007 INTERNATIONAL
LINEAR COLLIDER WORKSHOP
May 30 until June 3, 2007

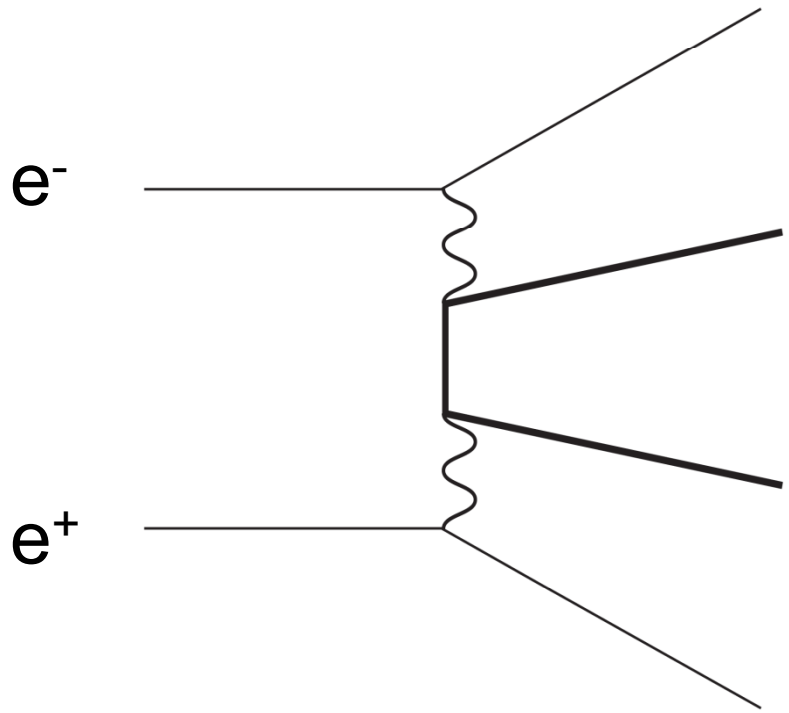
Worldwide Study of the Physics and Detectors for Future Linear e+e- Colliders

DESY

Thanks

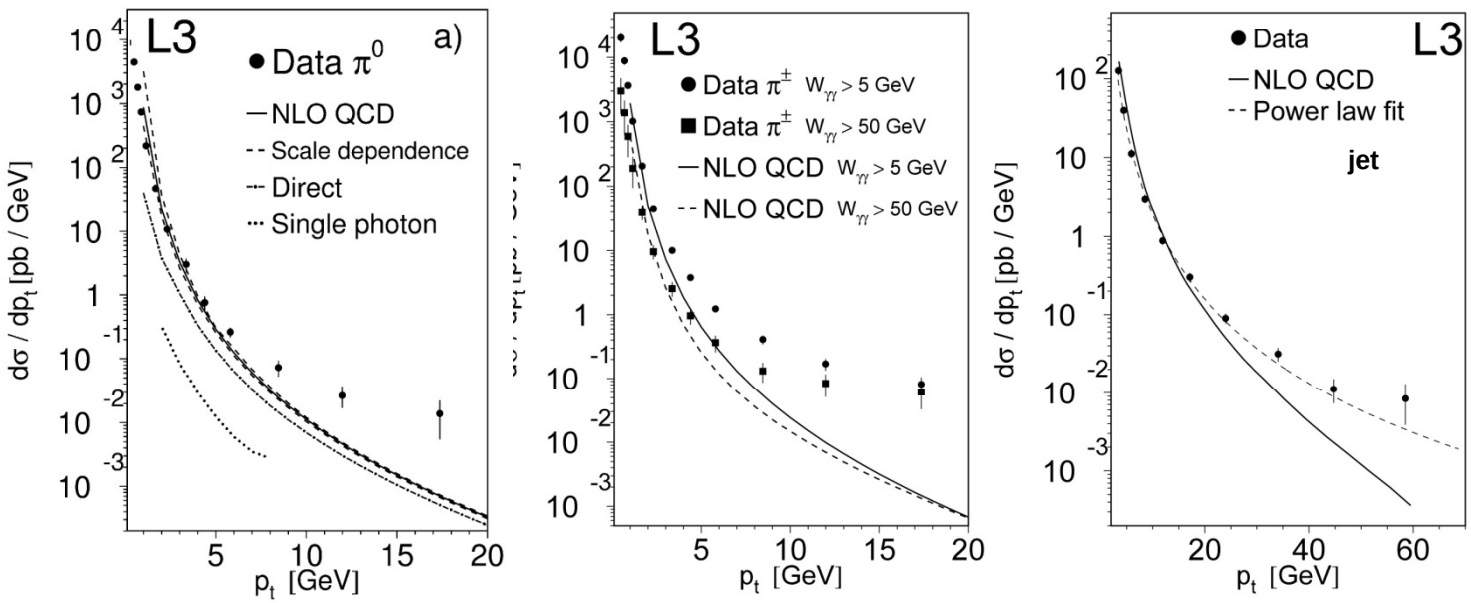
- To the gamma-gamma conveners for including this talk
- Some ideas are unconventional
- Proposed in a constructive light for the ILC.
- Apologies for many references to Rutherford – but he was a kiwi

Hadron production at high p_T in γ-γ interactions



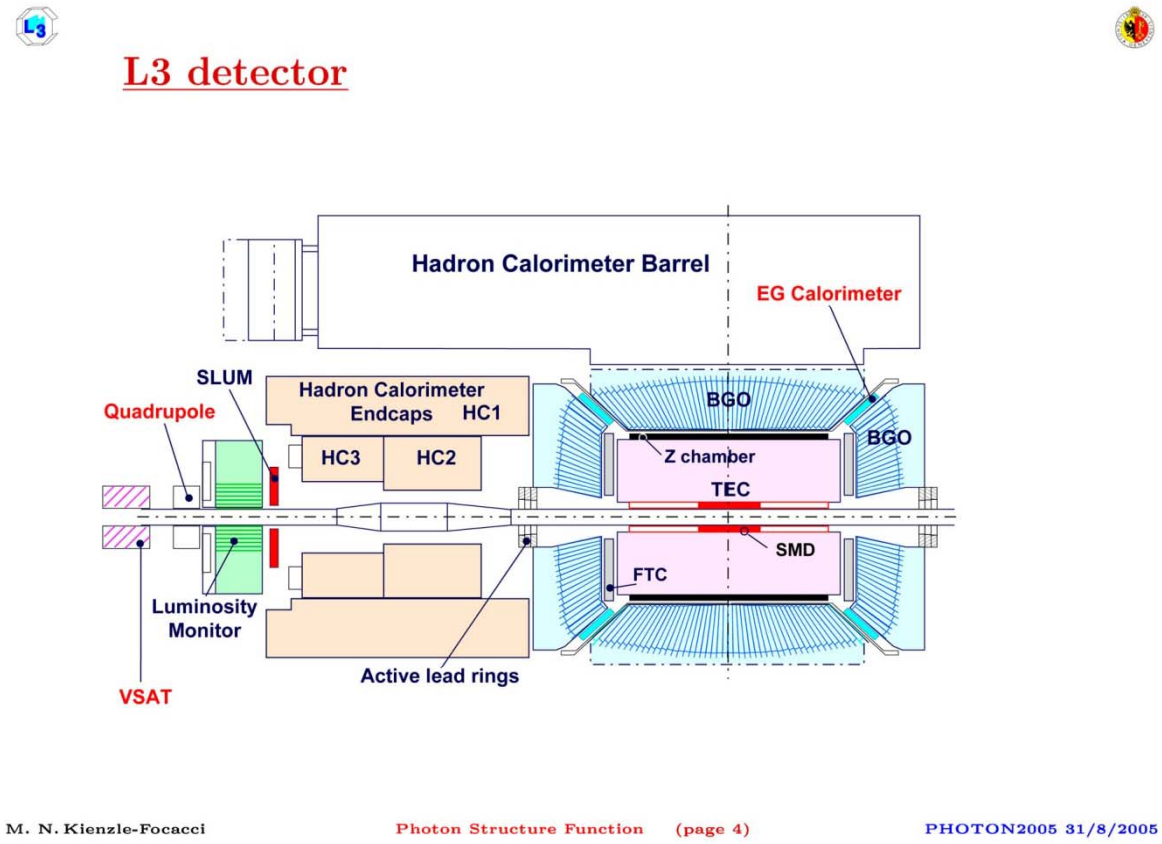
Results by L3

$\gamma\gamma \rightarrow \pi^0 + X$ $\gamma\gamma \rightarrow \pi^{\pm} + X$ $\gamma\gamma \rightarrow \text{jet} + X$



Physics Letters B, **524**, 44, 2002; **554**, 105, 2003; **602**, 157, 2004

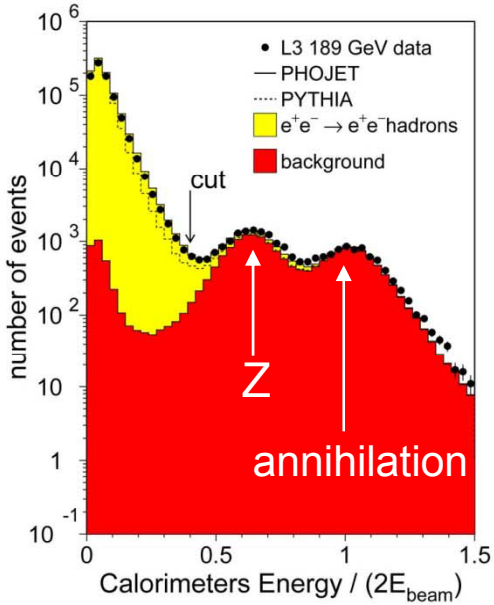
Experimental error?



Excellent calorimeters,
electromagnetic and hadronic

Experimental error?

Event selection $e^+e^- \to e^+e^-$ *hadrons*



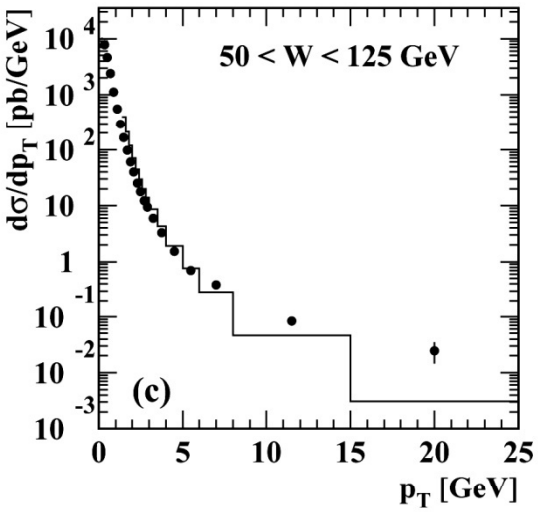
- $E_{tot} \leq 40\% \sqrt{s}$
- # particles ≥ 6
- Anti-tag :
  reject if E_{Lumi} >30 GeV
- $W^2_{vis} = (\sum_i E_i)^2 - (\sum_i \vec{p}_i)^2$
  $W_{vis} < W_{\gamma\gamma}$
  $W_{vis} > 5$ GeV

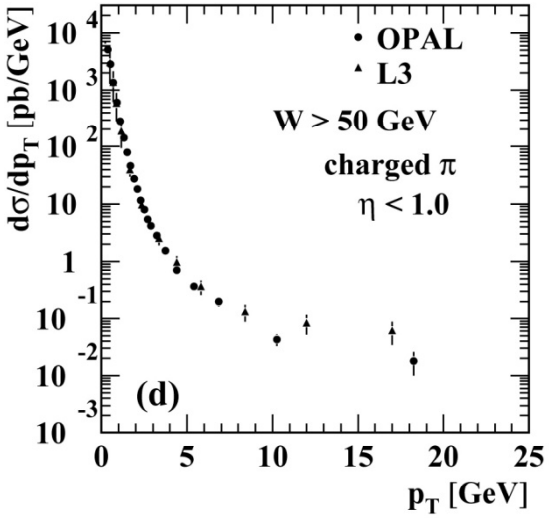
M. N. Kienzle-Focacci Jet and hadron production (page 2) Frascati 8/4/2003

Clean separation of background

Confirmation by OPAL

OPAL PR418, CERN-PH-EP/2006-038 and hep-ex/0612045





$$\gamma\gamma \rightarrow \pi^{\pm} + X$$

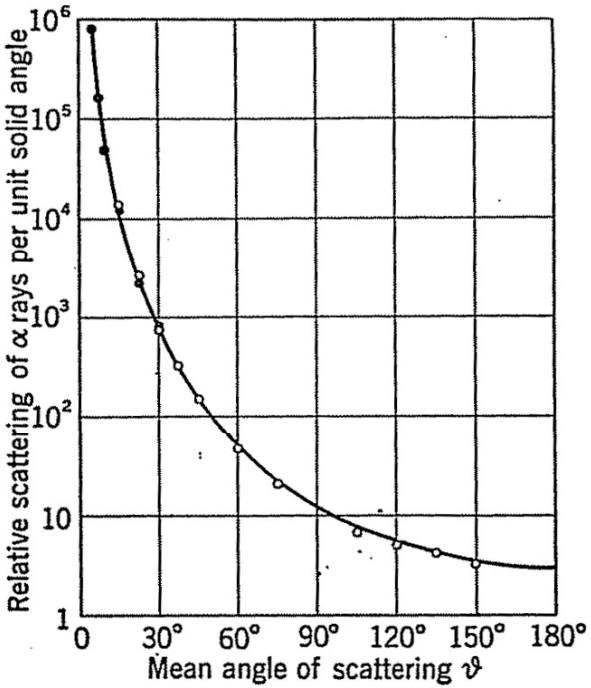
One channel only.
Agreement with L3 approximate only.

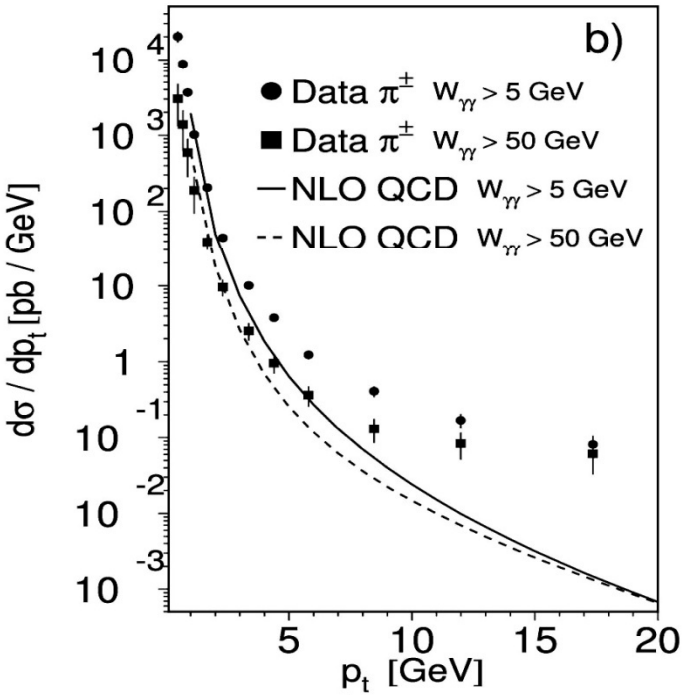
Further checks

- DELPHI and ALEPH could carry out similar checks
- ILC could provide an independent check, and increase energy and momentum transfer greatly
- Rutherford - “If your result needs a statistician, then you should design a better experiment”

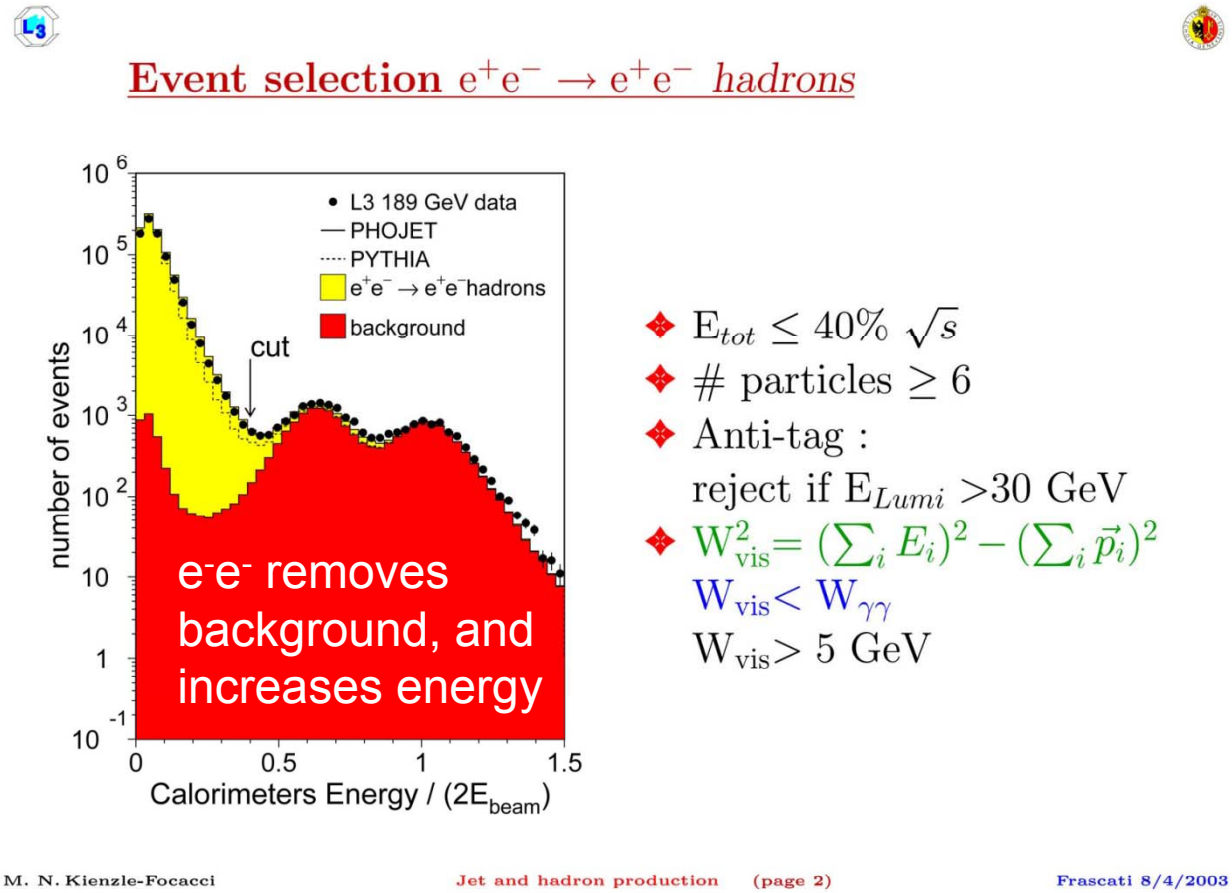
Rutherford supports ILC!

Rutherford connection



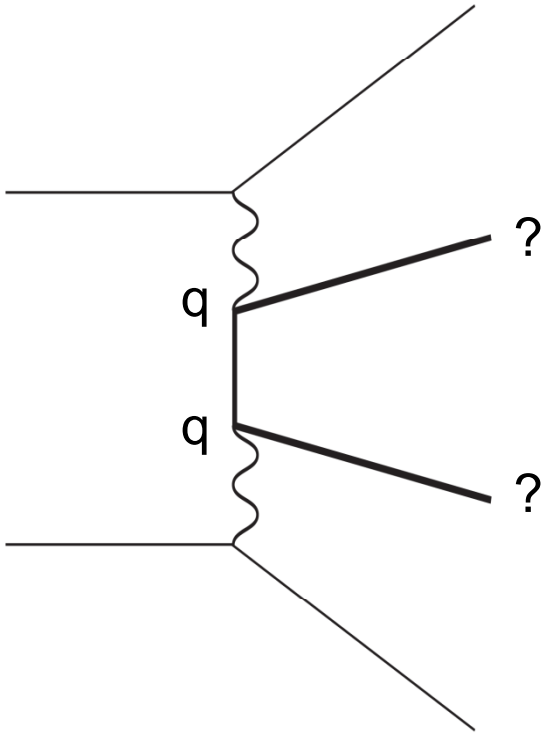


Check by ILC



Use e^-e^- (or γ-γ) beams to remove background.
Increase energy and momentum transfer 5 to 10$\times$.

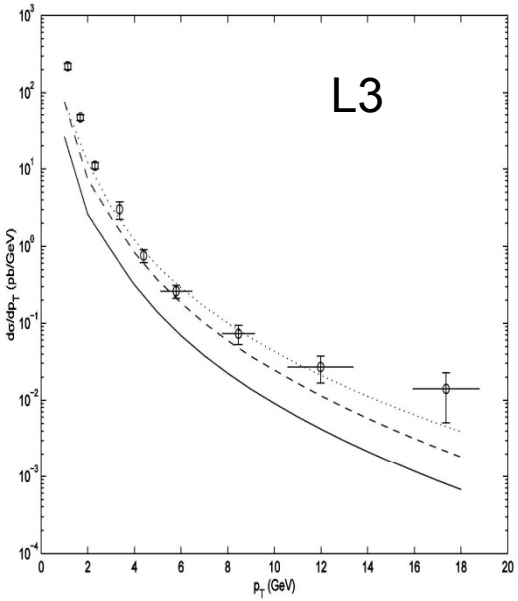
Physics implications ?



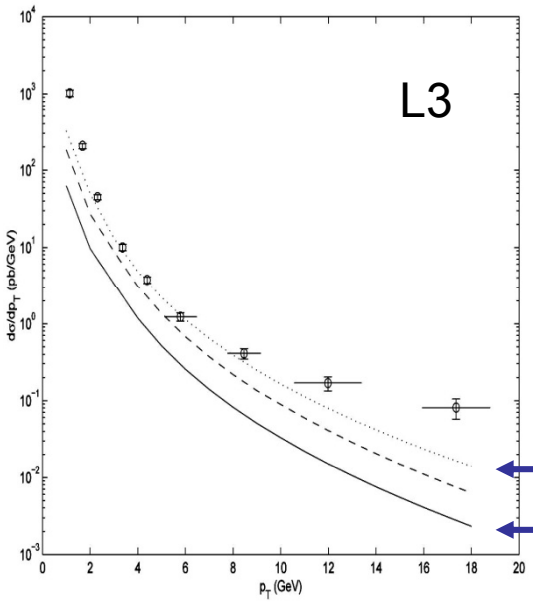
- Simple diagram
- High p_t
- Hadronization?
- Amplitude ~ q^2
- $\sigma \sim q^4$

Unit charged quarks?

M. Han & Y. Nambu, PRB 139, 1006, 1965; P. Ferreira, hep-ph/0209156



$\gamma\gamma \rightarrow \pi 0 + X$



$\gamma\gamma \rightarrow \pi\pm + X$

Unit charge
Fractional

Highly charged quarks?

- Schwinger proposed magnetic monopoles as quarks ("dyons") in 1969 – *Science* **165,** 757 (1969).
- Author independently proposed highly electrically charged quarks – assumed a physical solution of order unity to GML equation - *Int J Theor Phys* **2,** 247 (1969).
- Both assumed quark binding caused by strong em attraction – colour not needed and not assumed
- Both have inbuilt symmetry breaking – Higgs not assumed – best discriminator at present
- Proposals incomplete and speculative - but possibly physical – Rutherford precedent
- Very strong coupling - calculations not attempted - one prediction only – large em effects must occur eventually

Charge eigenvalue equations

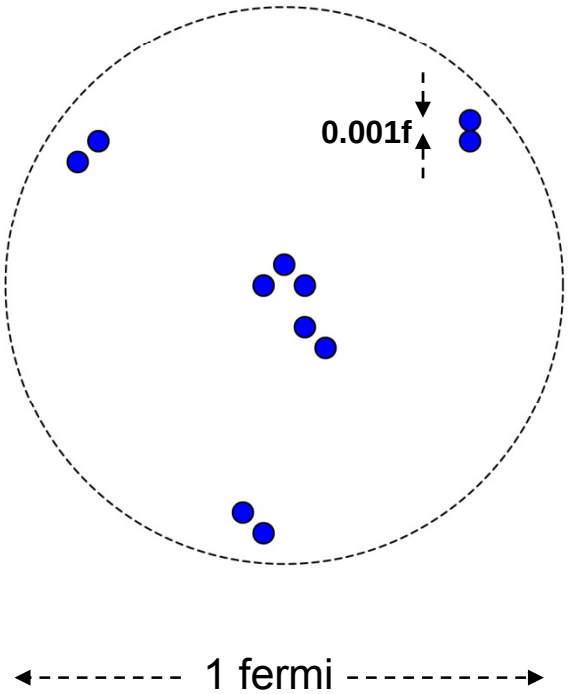
Tiny selection of publications

- Dirac (Proc Roy Soc **A133**, 60, 1931) – magnetic monopole.
- Dyson (PR **85,** 631, 1952) – QED with small charge unphysical – needs to be embedded in larger theory with other particles.
- Gell-Mann & Low (PR **95,** 1300, 1954) – bare charge e_o satisfies an eingenvalue equation, but renormalized charge e not determined.
- Johnson Baker & Willey (PR **163,** 1699, 1967) – perturbative derivation of eigenvalue equation for bare charge.
- Yock (IJTP **2,** 247, 1969) – Large coupling proposed to satisfy JBW equation….early gauge theory of strong interactions.
- Adler (PRD **5,** 3021, 1972) - Non-perturbative derivation of eigenvalue equation for renormalised charge.

Experimental resolution would be good!

Generalized Yukawa model

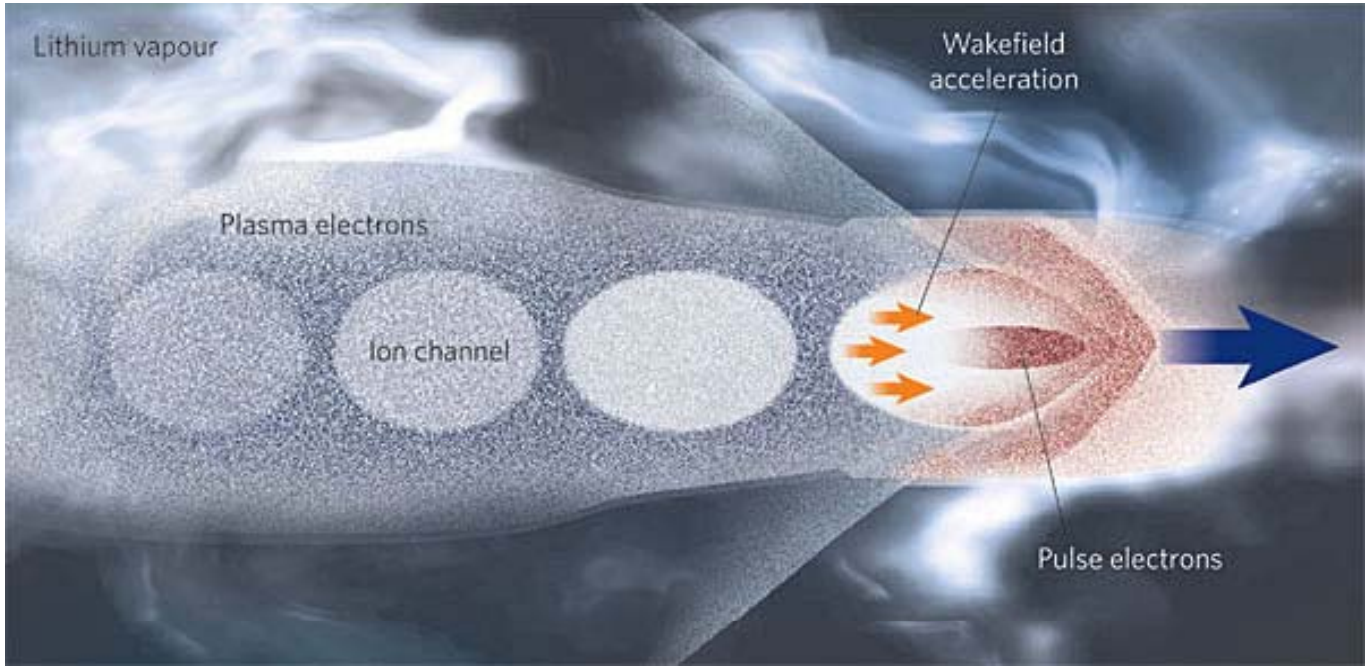
IJTP **41,** 1591, 2002



- Unit charge partons at low energies
- High charge partons at high energy
- Transition expected at ~ 300 GeV (1970)
- Onset seen at 100 GeV at LEP2 ?
- Effect may grow dramatically at ILC ?
- Lower luminosities sufficient ?

Plasma wakefield accelerator

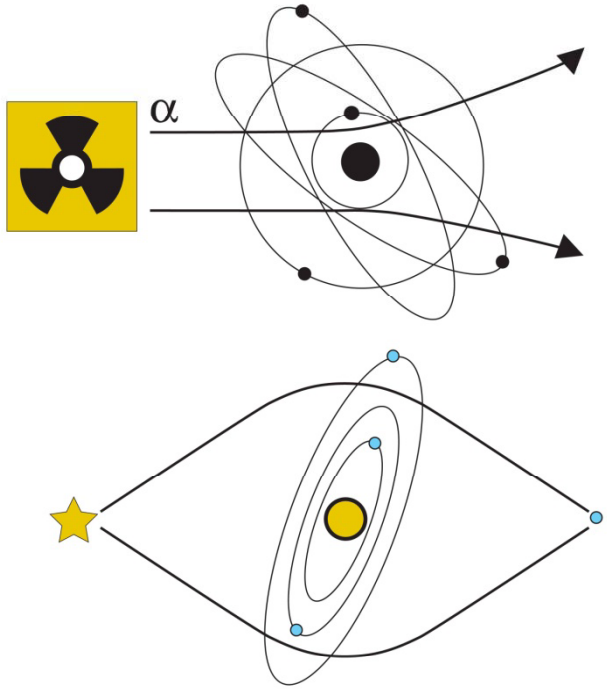
I. Blumenfeld et al, Nature 445, 741 (2007)

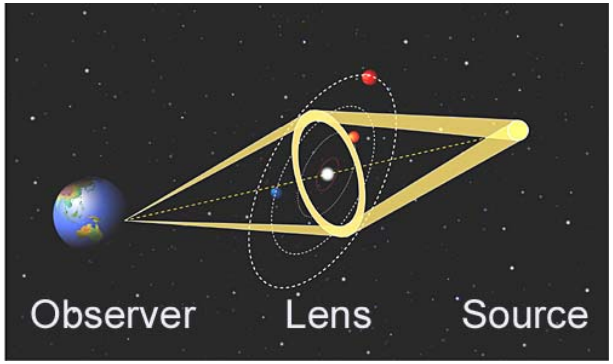


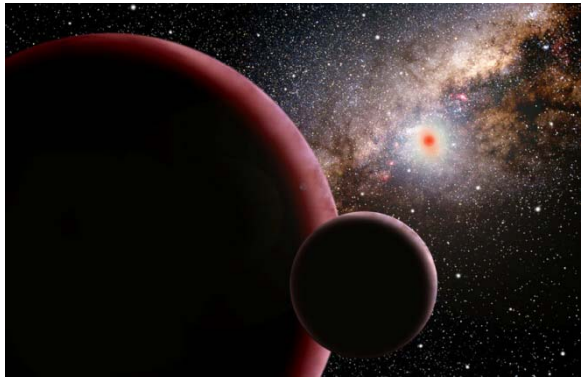
42 GeV ➔ 85 GeV electrons in 85 cm!
Nature lends a hand!
e^-e^- collider ➔ gamma-gamma collisions

Rutherford - “We haven't got the money, so we've got to think!”… Rutherford supports plasma wakefield accelerator!

Nature lending a hand







Magnification ~ 3000 observed
High magnification ~ high P_t

Conclusions

- Gamma-gamma interaction provides a sensitive and fundamental test of models. Measurements from LEP2 are inconsistent with the Standard Model. Suggestive of unit charged quarks, or larger. Results from LHC on the Higgs will be useful.

- Decisive results would be obtained with the ILC. A plasma wakefield collider might provide a natural option.

Acknowledgments

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- no blame for errors

32nd America's Cup

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