2nd ECFA/DESY Study on Physics and Detectors for a Linear Electron-Positron Collider

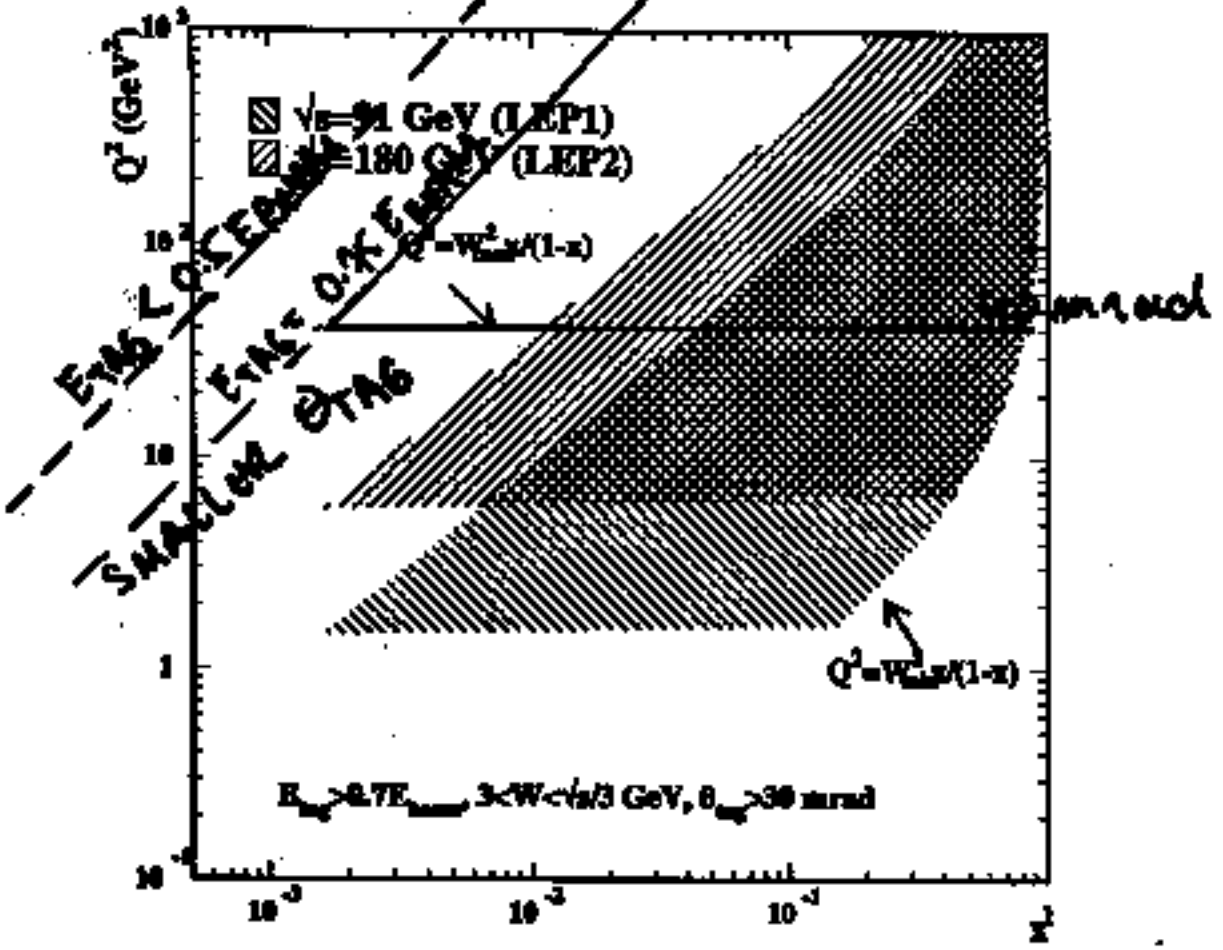
LAL - Orsay - France, April 5-7, 1998

Date : April 6, 1998 - 09:00

Parallel groups to plan tasks :

QCD

F_2^γ at LEP I and LEP II



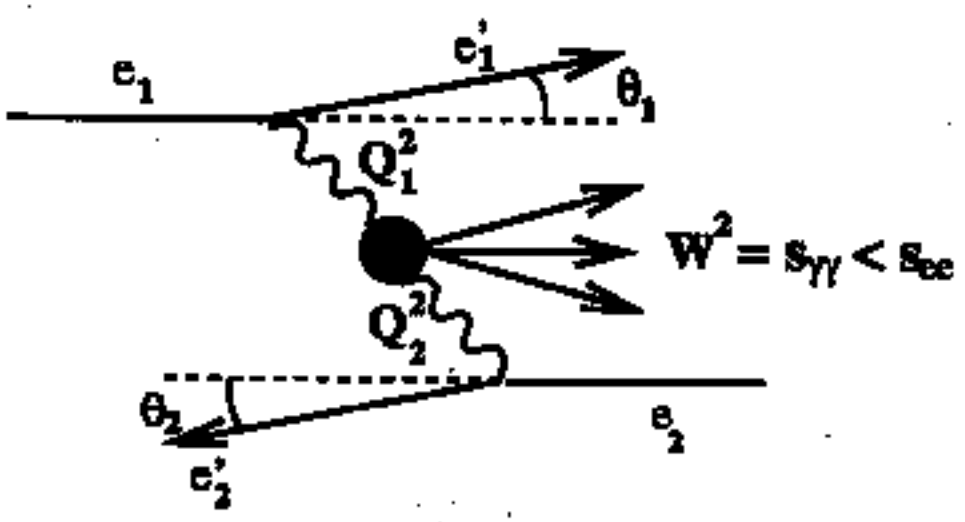
$$Q^2 \approx 2E_{\rm beam}E_{\rm tag}(1-\cos\Theta_{\rm tag})$$

Anti-tagging $\Theta_{\rm tag} < 33$ mrad corresponds to $Q^2 \approx 5-6$ GeV^2

→ F_2^γ AT LOW x ?

E_{TAG} LOW, θ_{TAG} LOW

→ F_L^γ ? LOW E_{TAG} (LARGE y)



$$Q^2_{1,2} \approx 2E_{\text{beam}}E'_{1,2}(1-\cos\Theta_{1,2})$$

$$W^2 = s_{\gamma\gamma} = (\Sigma_h\, E_h)^2 - (\Sigma_h\, \vec{p}_h)^2$$

1. $e\gamma$ **scattering ("single-tagged")**

   $Q^2 \equiv Q^2_1 >> 0$ **and** $P^2 \equiv Q^2_2 \approx 0$

2. $\gamma\gamma$ **scattering ("anti-tagged")**

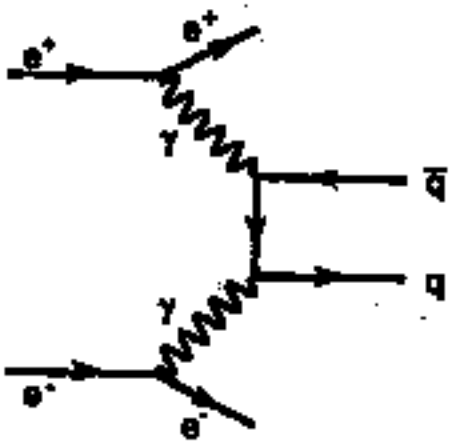
   $Q^2_1 \approx 0$ **und** $Q^2_2 \approx 0$

3. ee **scattering ("double-tagged")**

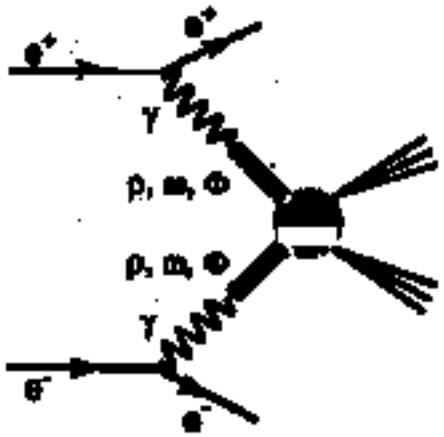
   $Q^2_1 >> 0$ **und** $Q^2_2 >> 0$

Some diagrams contributing to

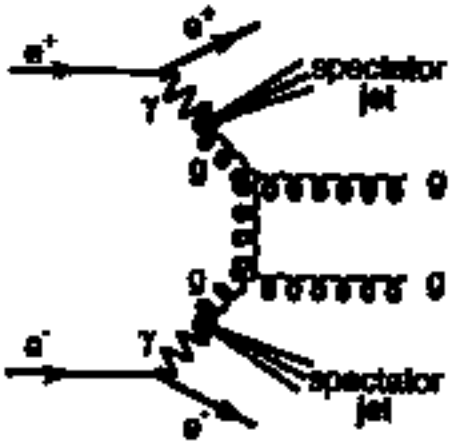
$$e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-\text{hadrons}$$



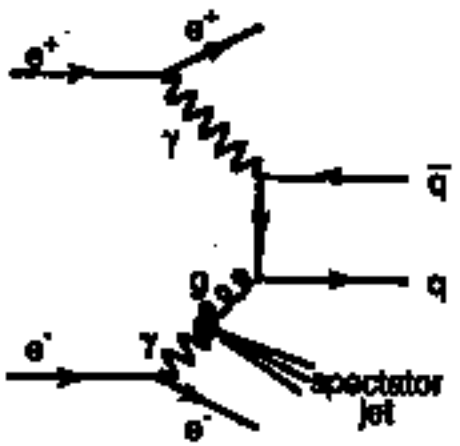
direct



diffractive, elastic

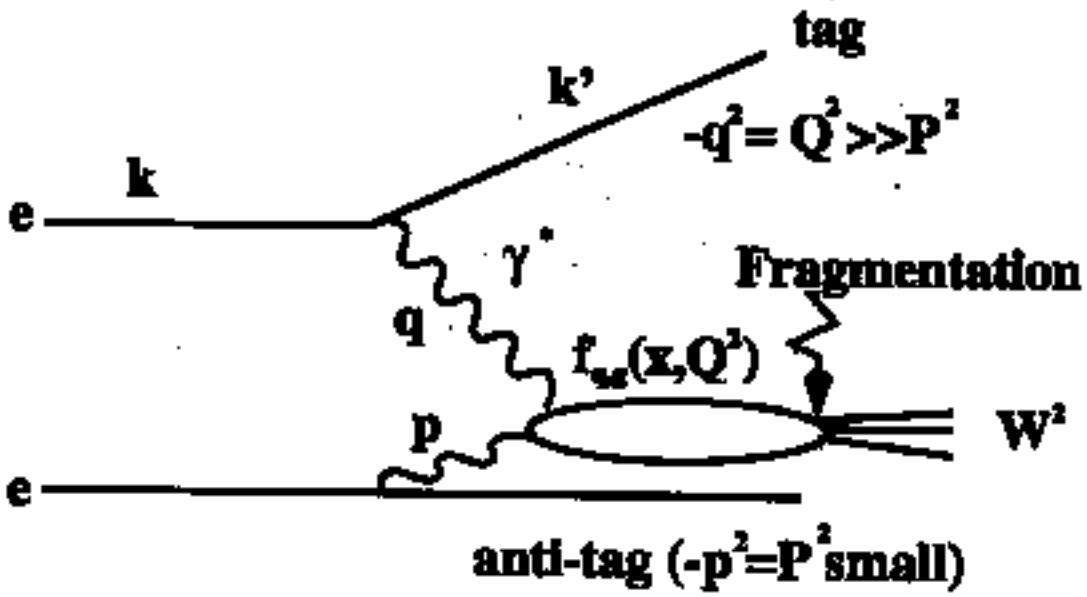


double resolved



single resolved

1.) Electron-Photon Scattering



$W^2 = (q+p)^2$ Hadr. inv. Mass

$Q^2 = -q^2 = -(k-k')^2$ -(Mass of the γ^*)^2

$x = \frac{Q^2}{2p\cdot q} = \frac{Q^2}{Q^2+W^2+P^2}$ Bjorken x

$y = \frac{p\cdot q}{p\cdot k}$ Inelasticity

$$\frac{d\sigma_{e\gamma}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[(1+(1-y)^2)F_2^\gamma - y^2 F_L^\gamma\right]$$

1. Q^2 reconstruktion (electron method)

$$E_{\rm tag} > 0.7 - 0.8 E_{\rm beam} \Rightarrow y \text{ small}$$

$$Q^2 \approx 2E_{\rm beam}E_{\rm tag}(1-\cos\Theta_{\rm tag}) \propto E^2_{\rm beam}$$

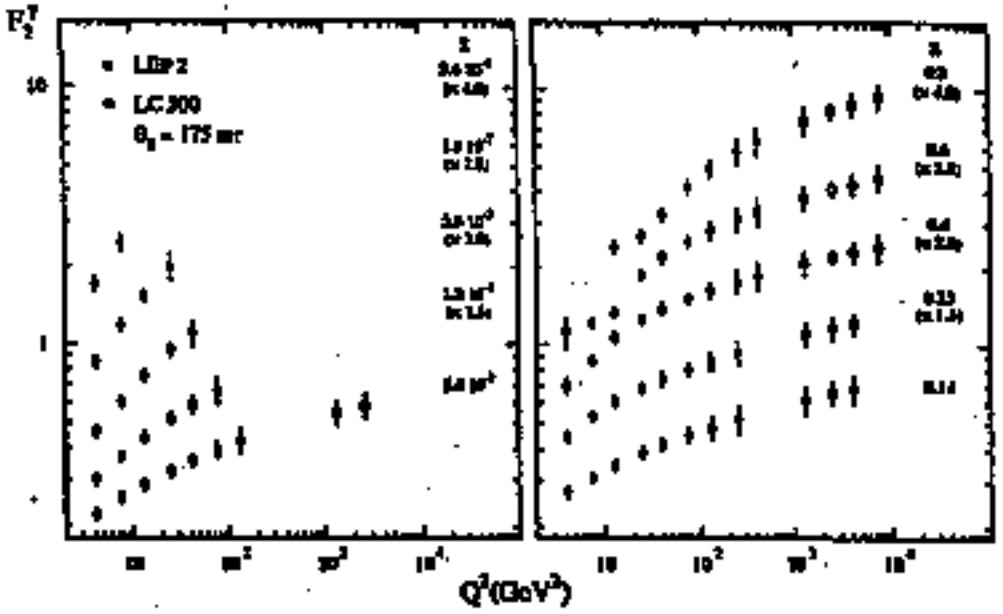
	Detector	Q^2(LEP1)
ALEPH:	Luminosity Cal.	4 – 30 GeV^2
	ECAL	50 – 2400 GeV^2
DELPHI:	Small Angle Tagger	4 – 30 GeV^2
OPAL:	SW Calorimeter	1.5 – 6 GeV^2
	Forward Detector	6 – 30 GeV^2
	Endcaps	60 – 400 GeV^2

L3 Low Q^2 Low x

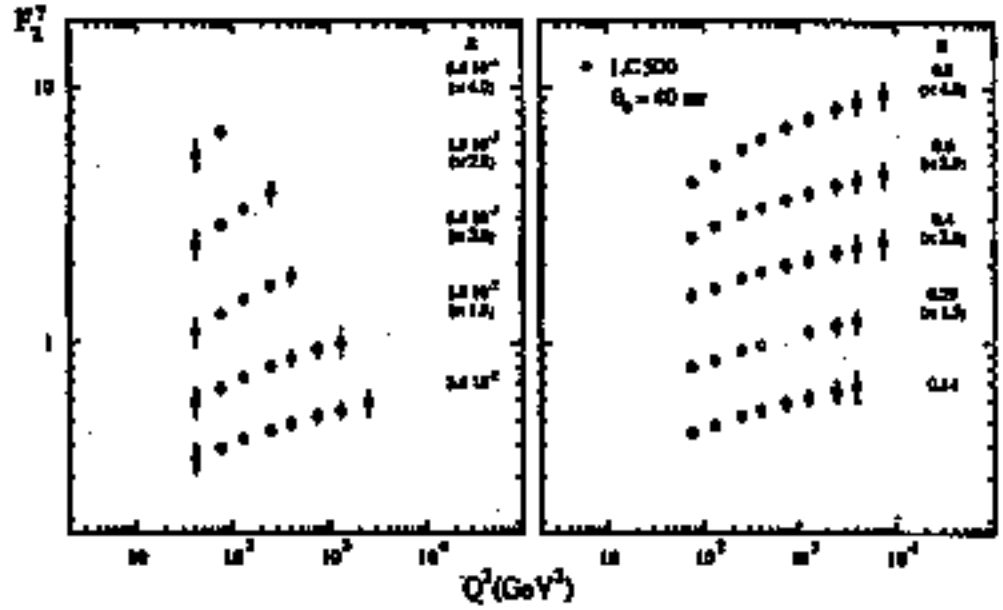
2. x reconstruktion (mixed)

$$x_{vis} = \frac{Q^2}{Q^2 + W^2_{vis}}$$

LC '96



(a)



(b)

Figure 11: *(a) Simulated data points for c tagging outside 175 mrad for 10 fb^{-1} at 500 GeV, compared with LEP2 expectations; Ref.[53]. (b) Simulated data points if tagging is feasible outside 40 mrad.*

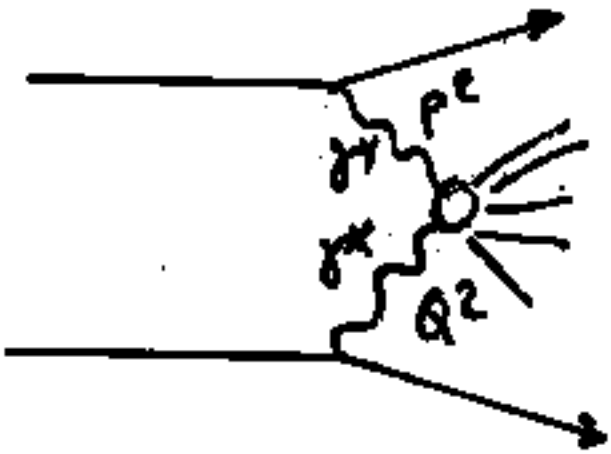
Work

* F_2 WITH HIGHER LUMI / SYSTEMATICS / NEW DETECTOR
* F_L ?
* Q^2 EVOLUTION OF $F_2 \rightarrow \alpha_S$

FURTHER

*) VIRTUAL PHOTON STRUCTURE

"ee SCATTERING" (DOUBLE TAGGED)



$P^2 \ll Q^2$

$\rightarrow F_2(x, Q^2, P^2)$

"STRUCTURE OF PHOTON WITH VIRTUALITY P^2"

$\rightarrow$ LOW $P^2 \rightarrow$ LOW E_{TAG} :

*) GLUON CONTENT OF PHOTON

↳ BOSON GLUON FUSION DIAGRAM (VIA JETS, CHARM)

... USED ALREADY AT HERA

$\rightarrow$ EXTRACT $x g(x)$

HUNTING FOR BFKL

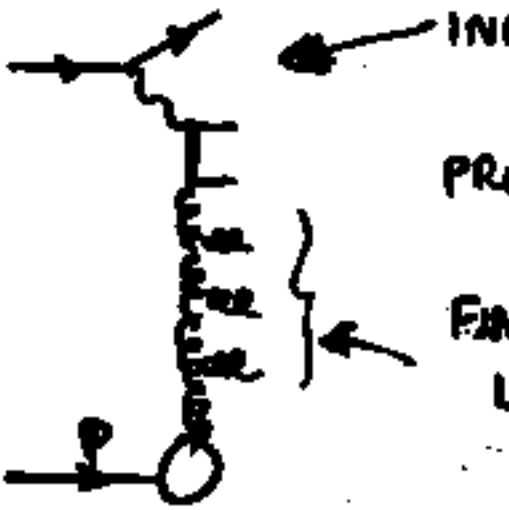
"SEEING THE DOMINANCE OF $\ln 1/x$ TERMS IN PQCD"

OR

"OBSERVE / STUDY THE BFKL POMERON"
HARD POMERON

→ NEED SMALL x
($LARGE\ W_{\gamma p}$)

STUDIED AT HERA

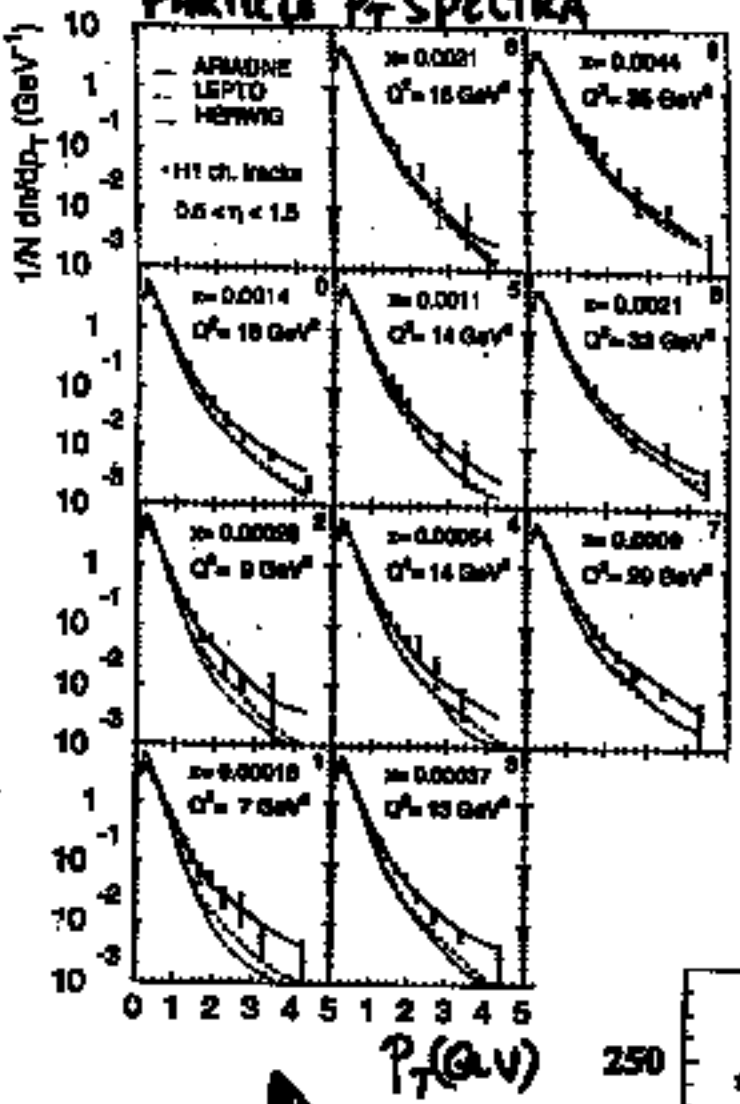


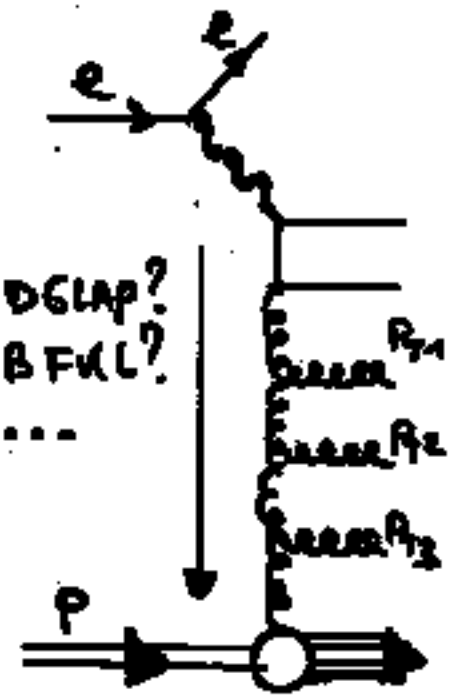
→

TO B_{FKL} OR NOT TO B_{FKL}?

LOW x FINAL STATES

PARTICLE p_T SPECTRA

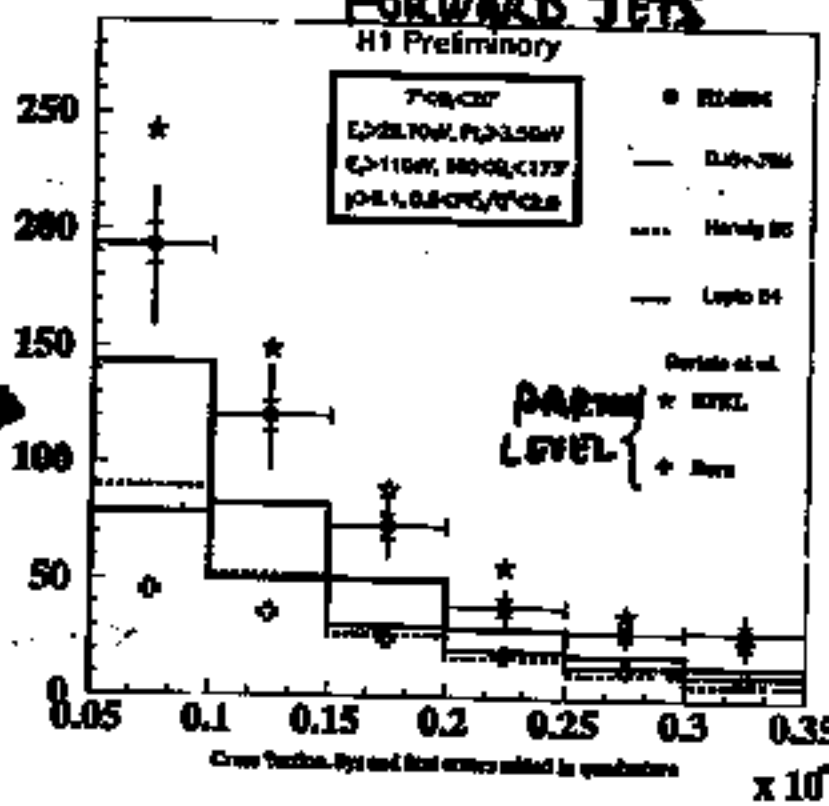




DGLAP: ORDERED ($R_{T1} > R_{T2} > R_{T3}$)
BFKL : UNORDERED

EXPECT MORE (p_T OR JETS) AWAY FROM THE CURRENT QUARK FOR BFKL COMP. TO DGLAP

FORWARD JETS



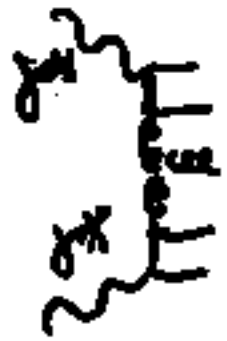
MODELS: COM LESS ORDERING THAN IN LEPTO OR HERWIG

→ PRESENT DATA: HINTS, HINTS ...

PROCESSES AT THE LC

1] TOTAL $\gamma^*\gamma^*$ CROSS SECTION

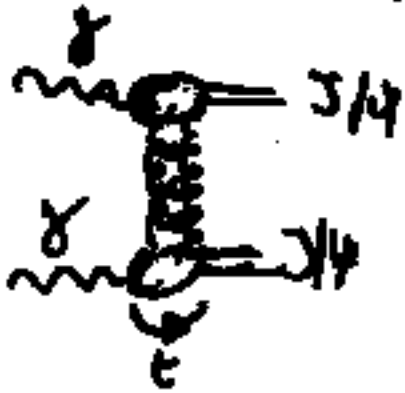
*) BARTELS, ADR
LOTTER, EWERZ
* BRODSKY SOPPER
HAUTMAN



→

STUDIED FOR '96 WORKSHOP
→ LOW E_{TAG} ESSENTIAL
... MORE RELAXED WITH NEW LUMI
WORK: DGLAP (LOG Q^2) BACKGROUND STUDY

2] VECTOR MESON PRODUCTION



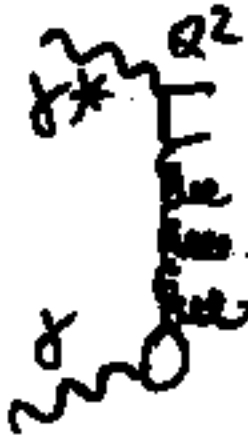
OR $\rho\rho$ AT LARGE t

→

L. WEST
ROYON
ADR
MUDNIER

WORK: BFKL / NO BFKL CROSS SECTIONS
DETECTOR REQUIREMENTS

3] "FORWARD JETS (PARTICLES) IN $e\gamma$



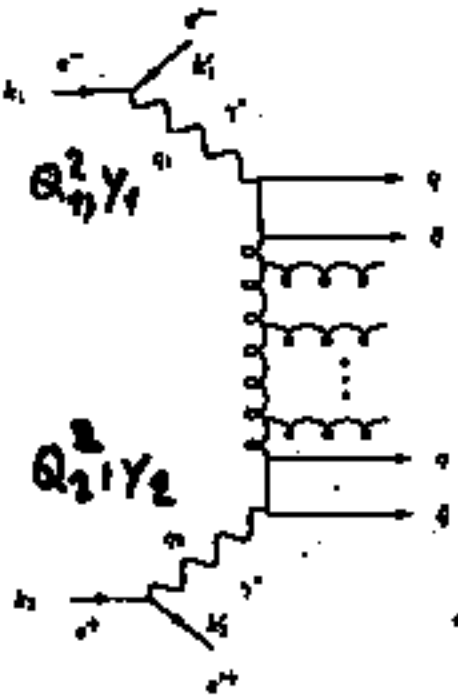
→ JET WITH $p_T^2 \sim Q^2$
(AS FOR HERA

WORK: * CROSS SECTIONS
* KINEMATICS / DET.
↳ BARTELS, ADR
WEESTHOFF

$\gamma^*\gamma^*$ SCATTERING

BARTELS, ADR, LOTTER
BRODSKY, SOPER, HAUTMANN

"OBSERVING BFKL"



$\ln \frac{S}{s_0} \propto \ln 1/x$

SIGNAL: DOUBLE TAGGED EVENTS

→ SIMILAR TO THE "FORWARD JET" MEASUREMENT AT HERA (CLEANER!)

NLC: HIGH LUMI
$\sqrt{S}$ LARGE → $\sqrt{S}$ LARGE → LARGER BFKL EFFECT

→ EVENTS WITH SMALL SCATTERING ANGLE NEED TO BE DETECTED

	exact	analytic	Born	$\theta_{tag,\,min}$	
EVENTS/YEAR (100% EFF) →	29500	36400	495	20 mrad	NLC
	51	68	2	60 mrad	
	1	1	0	100 mrad	

SIGNAL (BFKL)

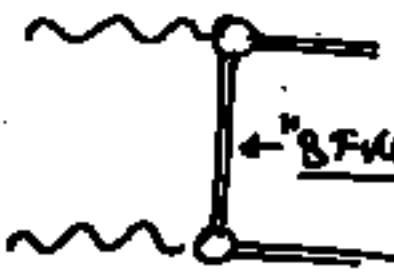
NO BFKL

$E_{TAG} > 20$ GeV
$2.5 < Q^2 < 200$ GeV^2
$\mathcal{L}_{NLC} : 10^{33}$ cm^{-2} s^{-1}

OTHER PROCESSES

EXCLUSIVE MESON PRODUCTION

$Q^2 =$



↳ SCALE $\sim M^2_{J/\psi}$ ($\sim \sigma^{tot}_{\gamma p}$)

LEP II WORKSHOP '96

process	W_{min} (GeV	$\lvert t\rvert_{min}$ (GeV^2)	θ_{min} (mrad)	LO	LLA Eq. (25)	LLA Eq. (26)
$\rho\rho$	15	0	-	0.8	180/140	
	15	4	87	9.2		
	15	4	175	2.4		
ρX	15	9	-	100	23000/18000	
	25	16	-	13	2300/2100	
	15	4	87	840		
	15	9	87	248		
$J/\psi J/\psi$	15	-	-	10	2500/2000	←
	15	4	87	1.4		570
	15	4	175	0.5		320
	25	4	87	0.5		440
	25	4	175	0.1		220
$J/\psi X$	15	-	-	120	26000/21000	←
$\pi^+ X$	10	5	-	180		

Table 2: *Number of expected events for LEP II with an integrated e^+e^- luminosity of 500 pb^{-1}. The calculation was done for anti-tagged e^+e^- events with $\theta_e \leq 30$ mrad.*

$$\frac{d\sigma}{dt} = f(W,t)\left(\frac{W^2}{W_0^2}\right)^{2\omega_0}$$

↳ "LN 1/x TERMS" IN PQCD

$1+\omega_0$ BFKL INTERCEPT

~ 1.5 (1.2?)

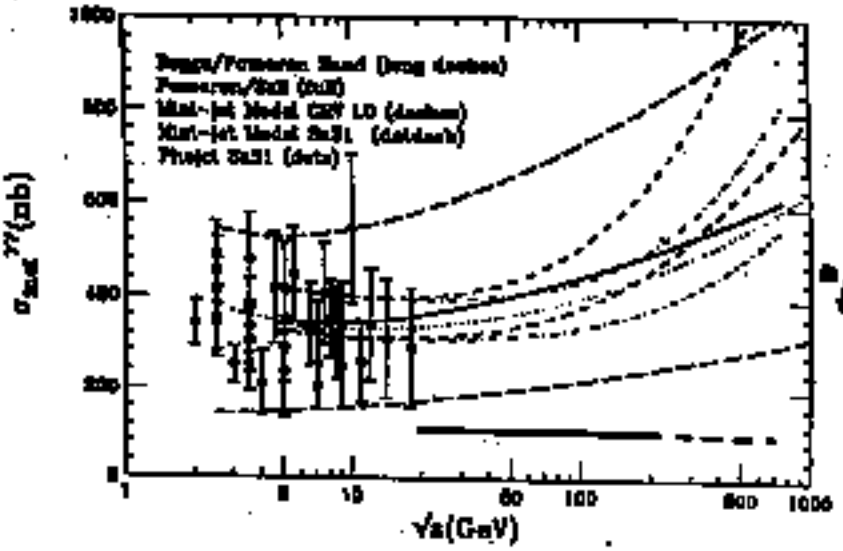
WORK

RATES AT LC?

(TRIGGER) DETECTION EFFICIENCY IN LC-L?

$\geq$ 2004 : **FAR FUTURE : LINEAR e⁺e⁻ COLLIDER !**

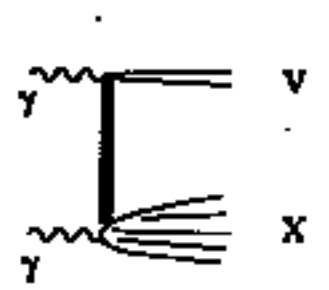
$e^+ \rightarrow \quad \leftarrow e^-$ $\sqrt{s}$ = 500 GeV (- 1 TeV)



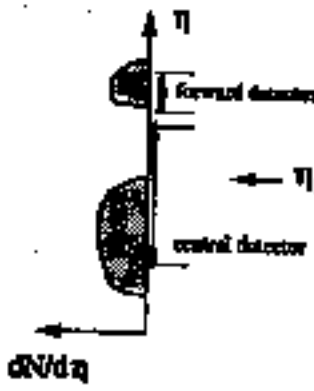
WORK : "MEASUREMENTS"

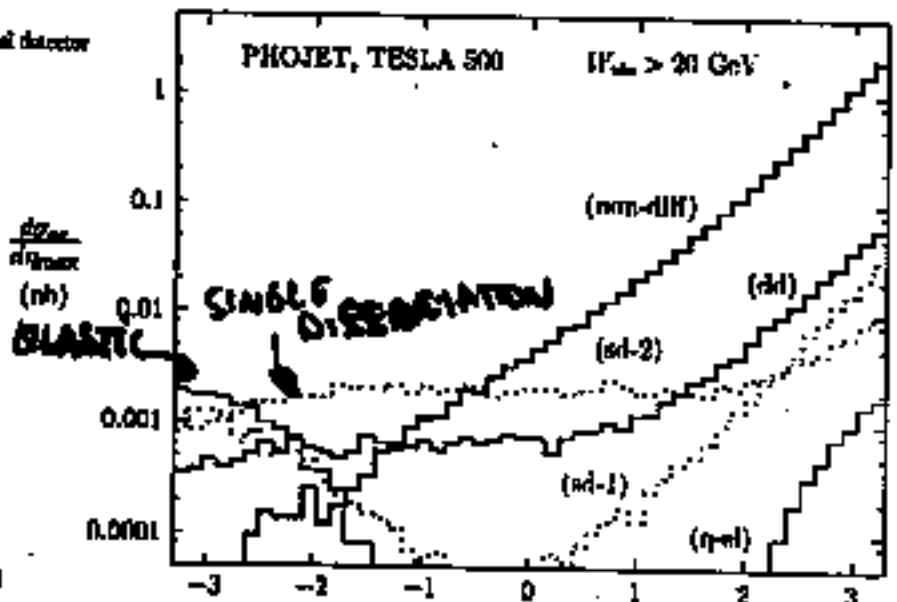
→ LABORATORY FOR $\gamma\gamma$ PHYSICS

→ DIFFRACTION, USING RAPIDITY GAP TECHNIQUE...



R. ENGEL
ADR
A. ROSTOVTSEV



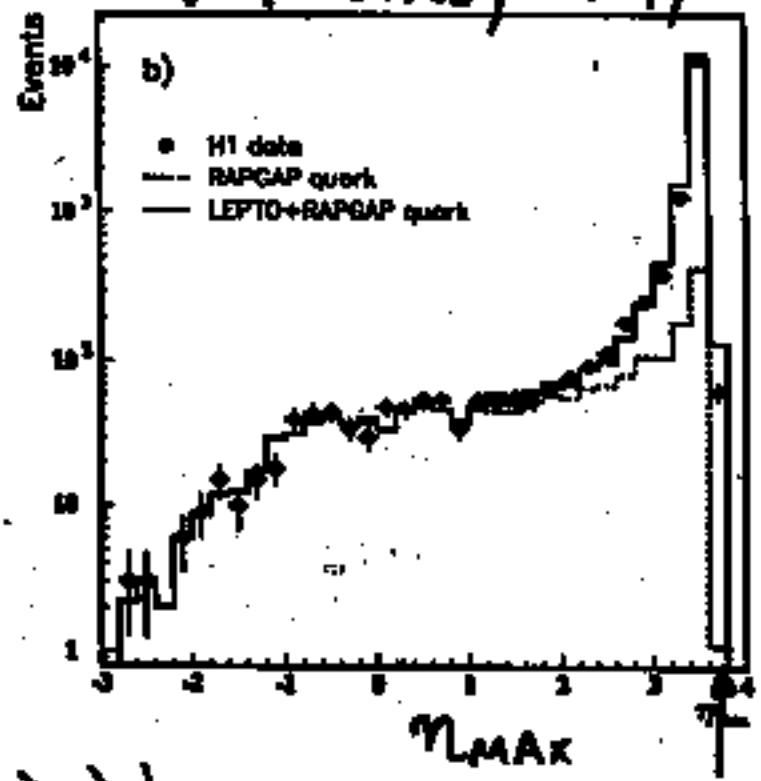


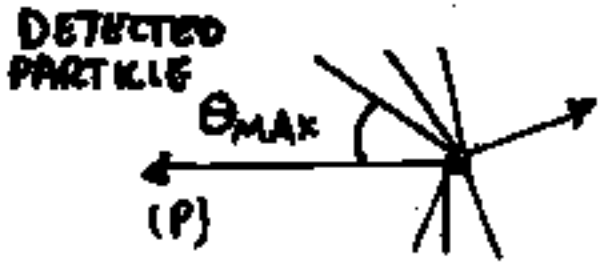
TOOL: PHOJET MOCA
WORK: NEEDS TO BE EXPLORED

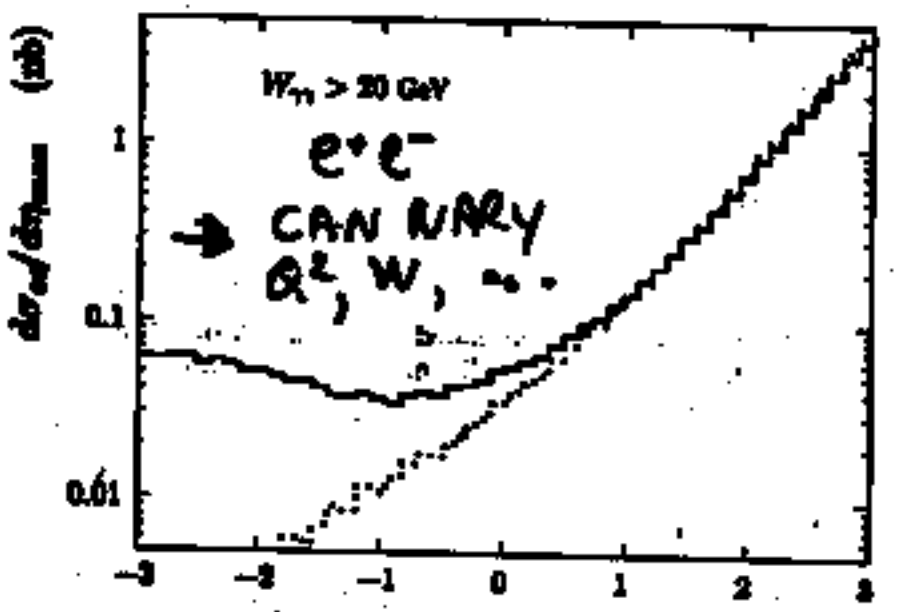
DIFFERENT SUBPROCESSES DOMINATE IN DIFFERENT REGIONS

DIFFRACTION

$\gamma^* p$ EARLY DAY







ENGEL ROSTOVTSEV

WORK : * STUDY SUBCHANNELS : SD, DD, ELASTIC ...
* WHAT CAN ONE LEARN ON THE POMERON ?
* DETECTOR EFFORTS
* F_2^{D} MEASUREMENTS ...