Parton densities

Parton densities are very important to be measured.

HERA has provided data down to x values of $\sim 10^{-4}$ for Q^2 of several GeV^2

FELIX will extend these measurements to x values below 10^{-6} via

- di-leptons from Drell-Yan
- low-mass dijets
- low-mas jet-photon systems

carrying large longitudinal momenta

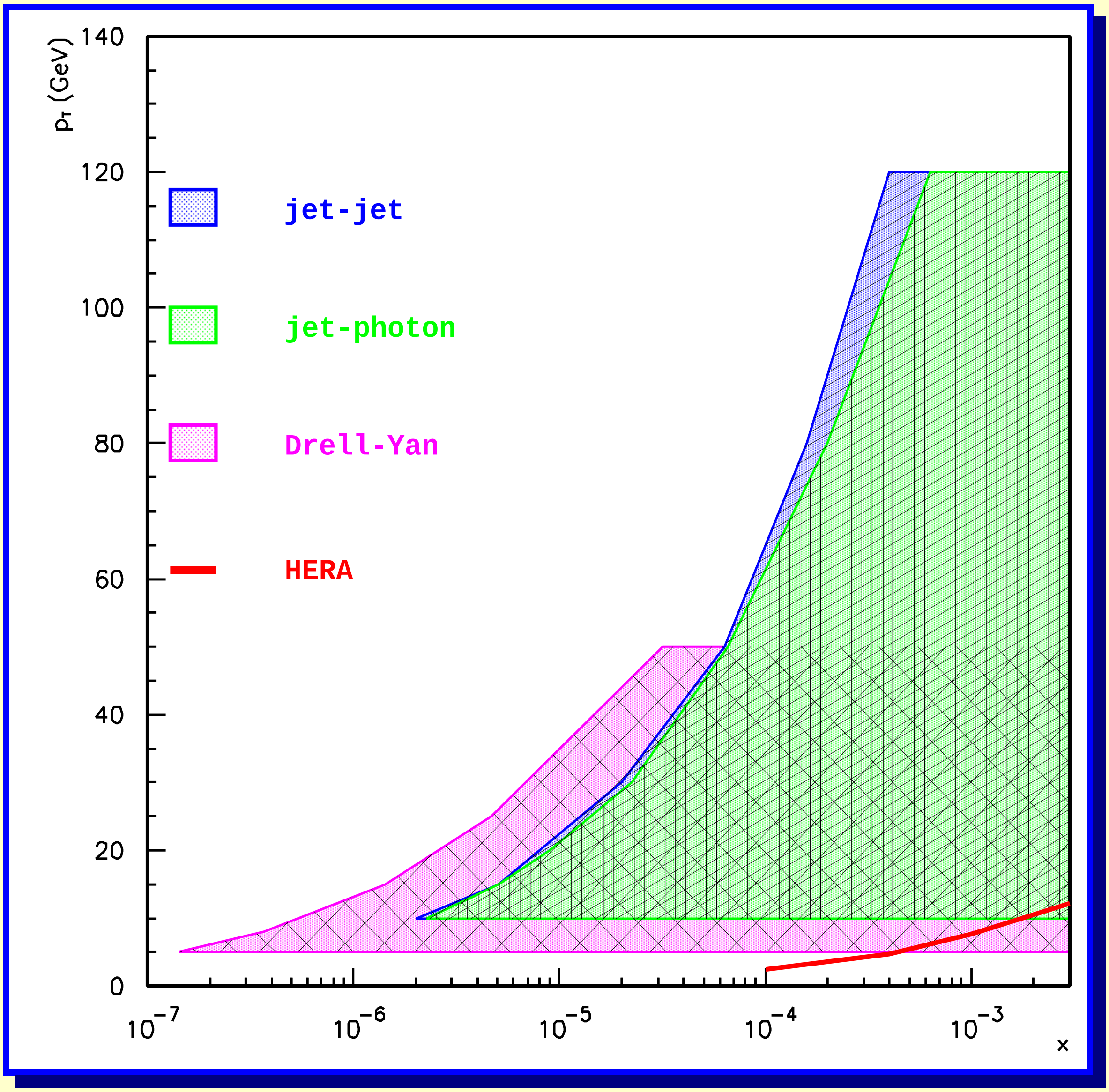
$$x_1 \geq \frac{4p_t^2}{x_2 s} \Longrightarrow$$

$$x_{min} \sim 10^{-7} - 10^{-6}$$

- gluon distributions from
  jet-jet and jet-photon
- quark distributions from
  Drell-Yan and $c\bar{c}$

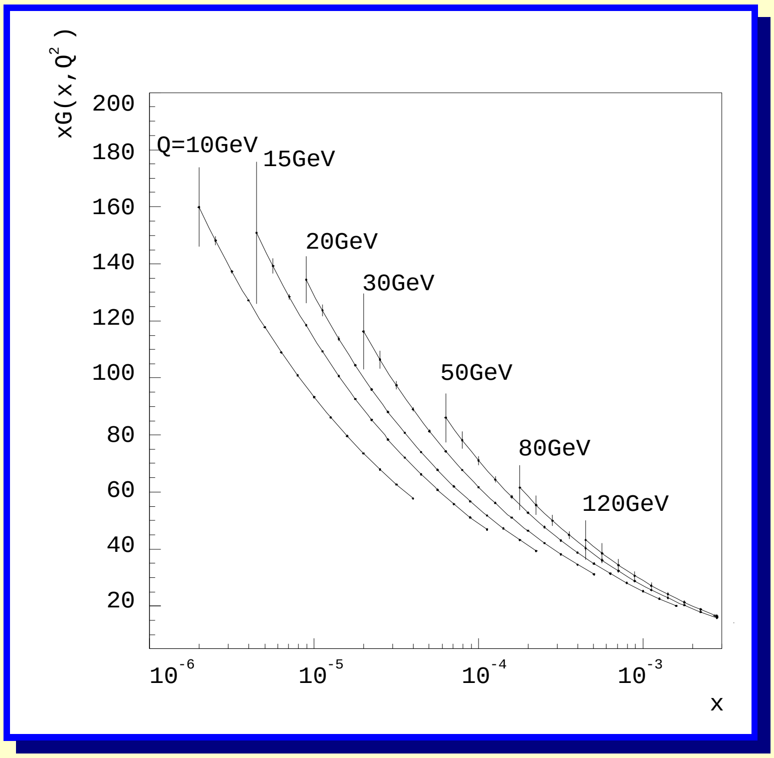
Small-x Parton Measurements (structure functions)

excellent jet, γ, μ, measurements in forward cones are needed



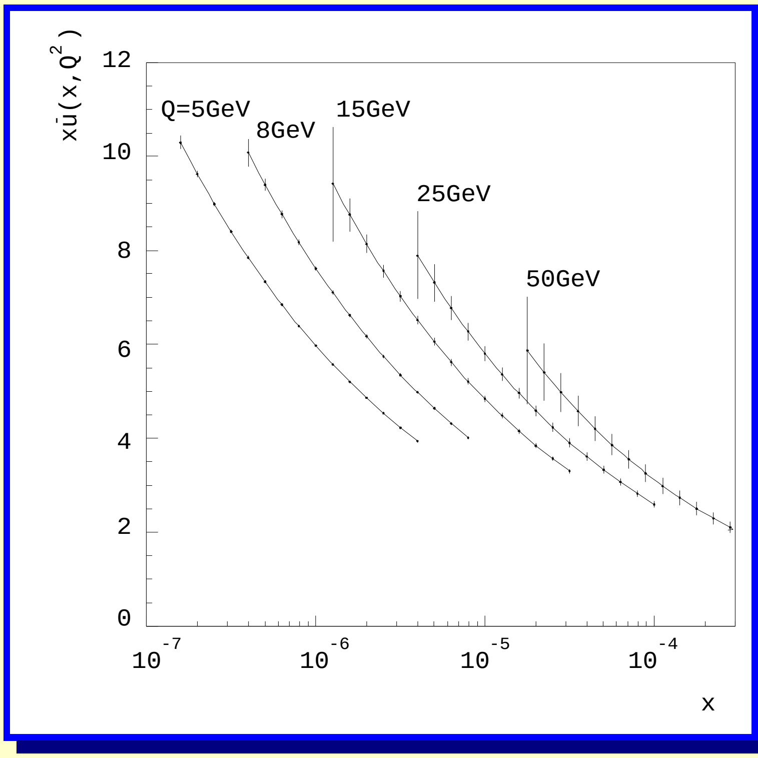
Qualitative changes are expected ...

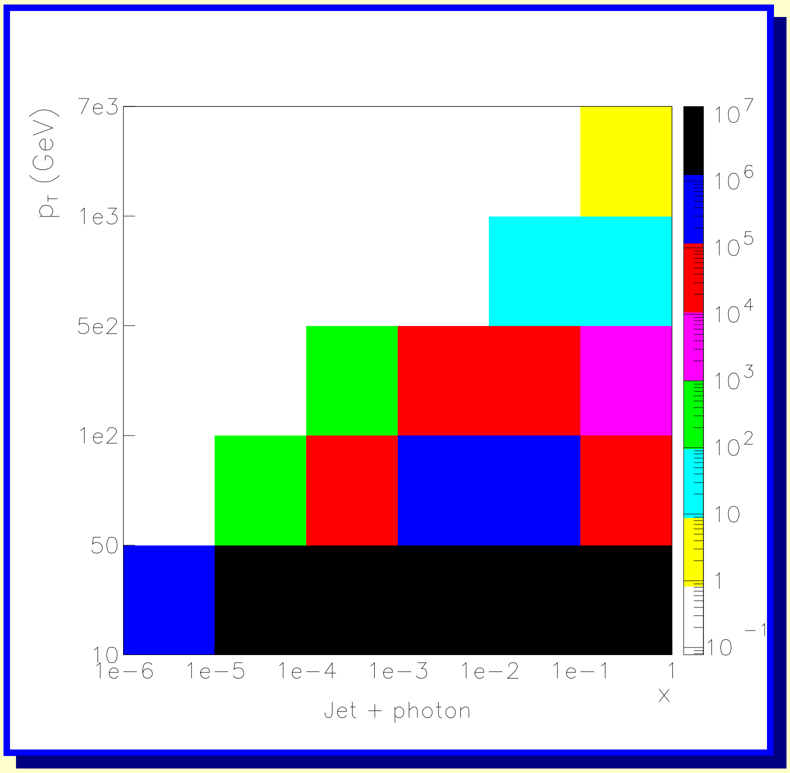
Parton densities become large...



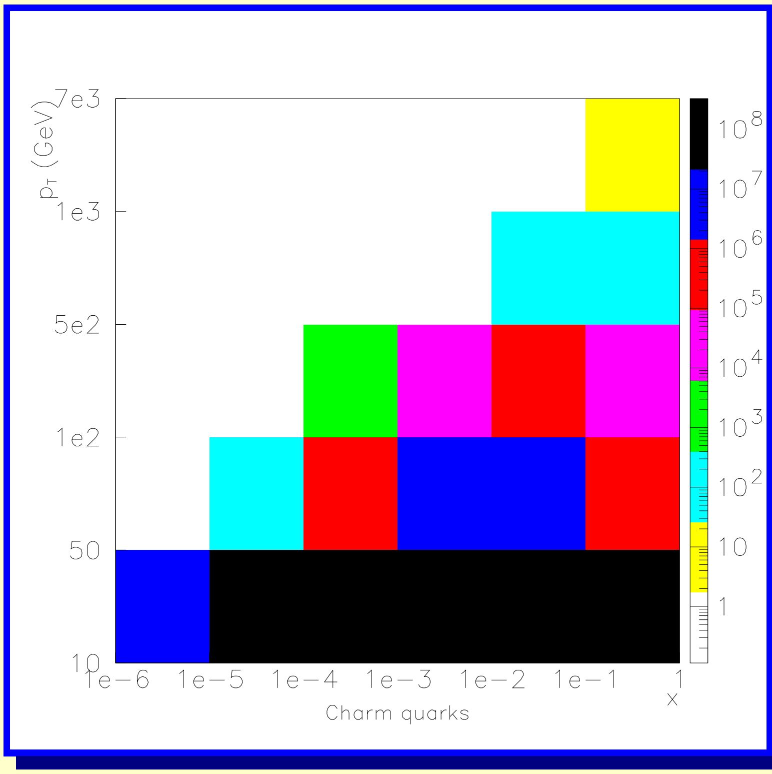
Gluon momentum distribution, as determined from the jet+γ cross-section.

The antiquark momentum distribution, as calculated from the Drell-Yan cross-section





Number of events in (p_T, x) bins for jet $+ \gamma$ production for an integrated luminosity of 100 pb^{-1}



Number of events in (p_T, x) bins for charm quark production for an integrated luminosity of 100 pb^{-1}

Diffractive final states are endemic...

...many are important, and some are spectacular

Diffraction is the class of phenomena associated with non-exponentially suppressed rapidity gaps.

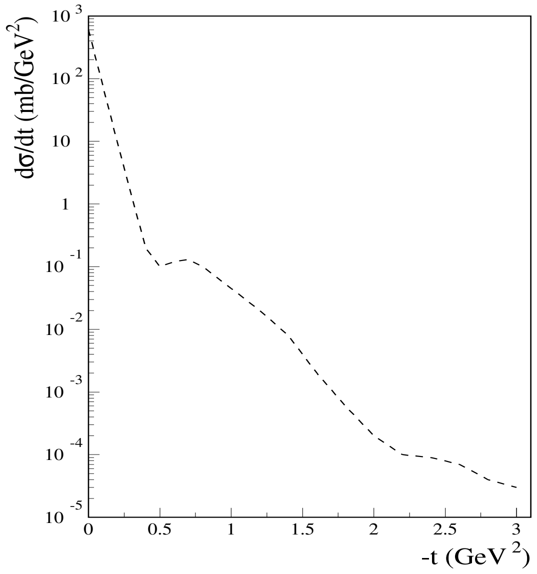
About half of all hadronic collisions should be diffractive (elastic scattering + inelastic diffractive dissociation).

Diffraction processes represent a primary challenge to theorists: how to understand the phenomena from first principles.

Highlights of the FELIX program include:

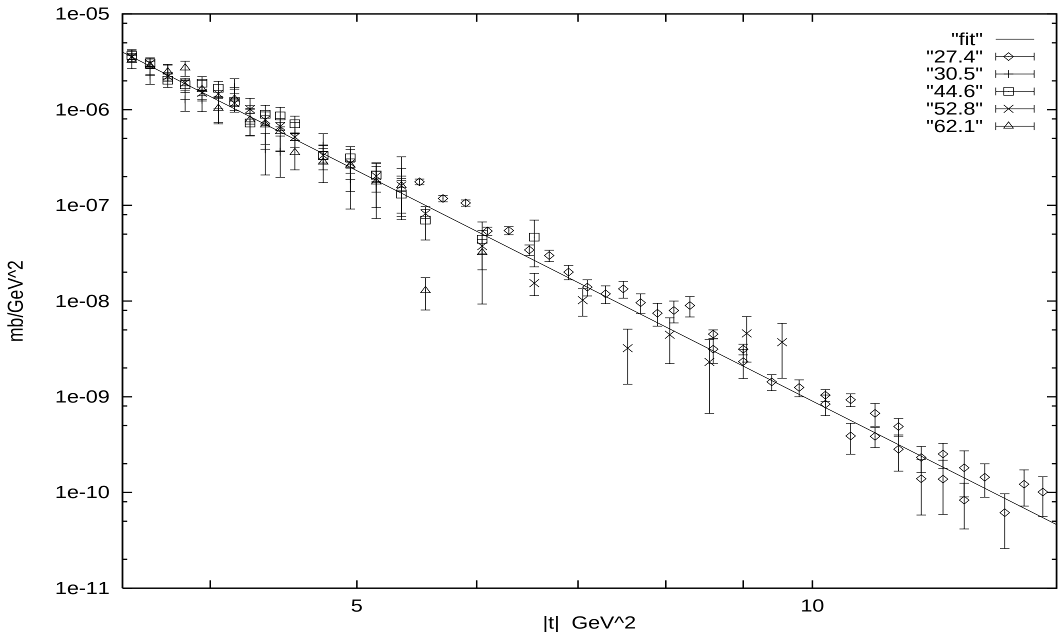
- pp elastic scattering
- a multitude of basic hard diffraction event classes
- diffraction into 3 jets
- pion diffraction into 2 jets
- π p (K p) elastic and inelastic scattering

Elastic Scattering



Exchange of a soft Pomeron, measurement of the slope $B(s,t)$
Determination of optical point $(t = 0)$
$\Longrightarrow \sigma_{tot}$

$$5 \cdot 10^{-3}\ \text{GeV}^2 < t < 10 - 20\ \text{GeV}^2$$



t^{-8} behaviour at large t (ISR)
three valence quarks scatter independently
link to perturbative QCD, hard Pomeron

Elastic Scattering

$$y(s) = v_y(s) \cdot y^* + L_y^{eff} \cdot \Theta_y^*$$

$$L_y^{eff} = \sqrt{\beta_y \beta^*} \sin \Delta\mu(s)$$

$$v_y = \sqrt{\frac{\beta_y}{\beta^*}} \cos \Delta\mu(s)$$

$$\Delta\mu(s) = \int \frac{1}{\beta(s)} ds$$

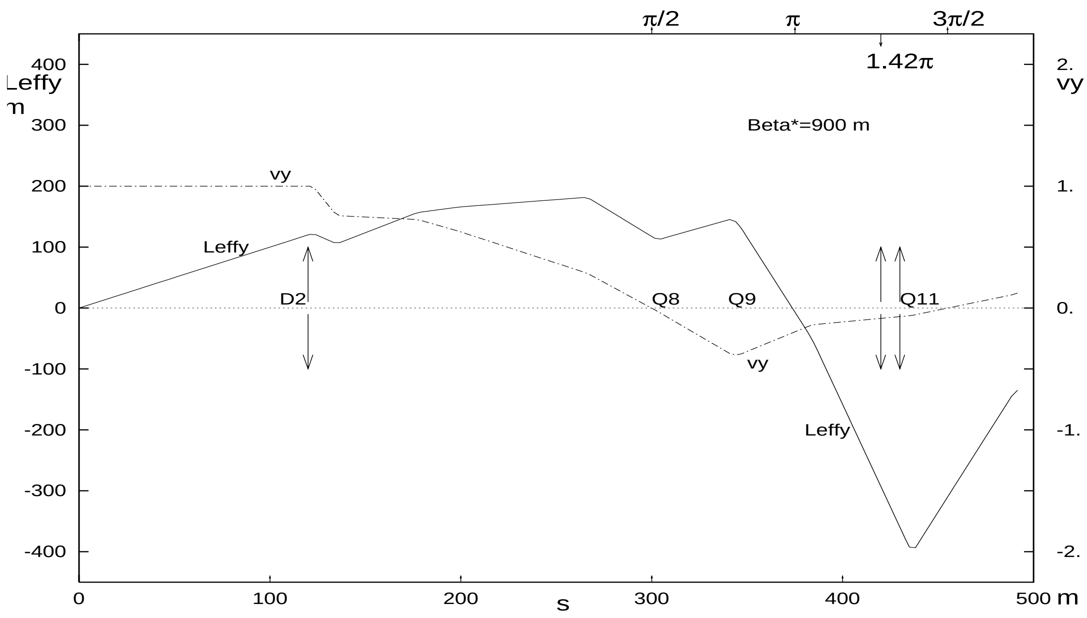
parallet-to-point focussing $\Delta\mu(s) = \frac{\pi}{2}, \frac{3\pi}{2} ....$

$$v = 0,\ L_y^{eff} = max$$

$$10^{-2} GeV^{-2} \Longrightarrow \Theta = 14\mu rad$$

precision given by the beam divergence

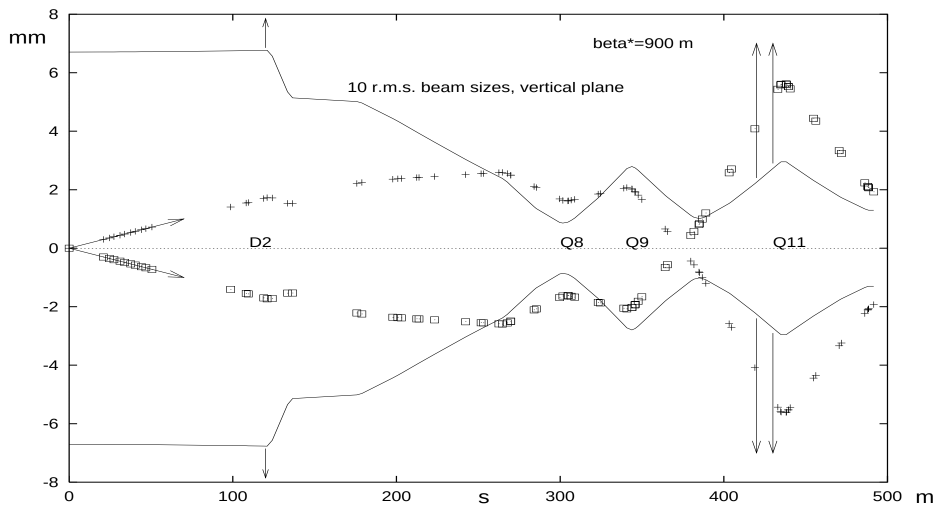
$$\Theta_{beam} = \sqrt{\epsilon/\beta^*} = 0.7\mu rad$$



Elastic Scattering

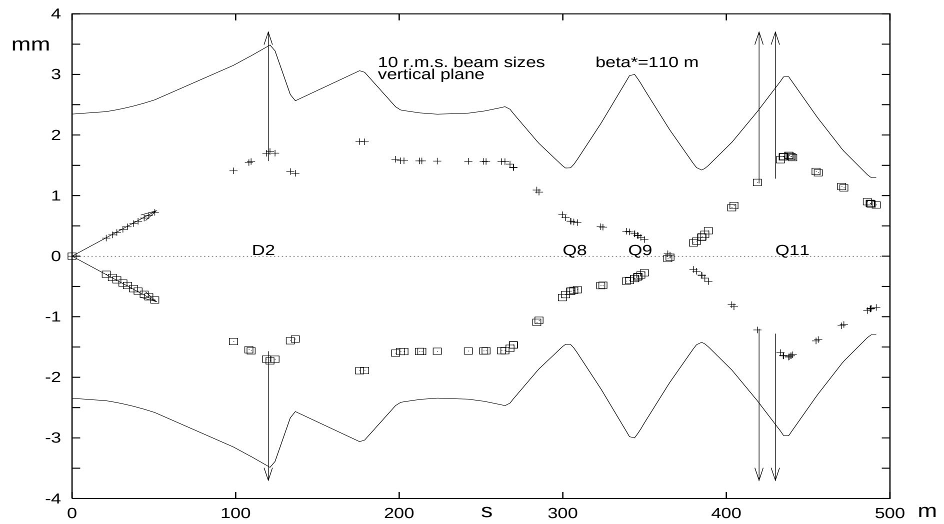
10σ beam profile in the vertical plane, trajectory of a scattered proton ($\Theta = 14\mu rad$; $t = 10^{-2}GeV^{-2}$)

β^*=900 m



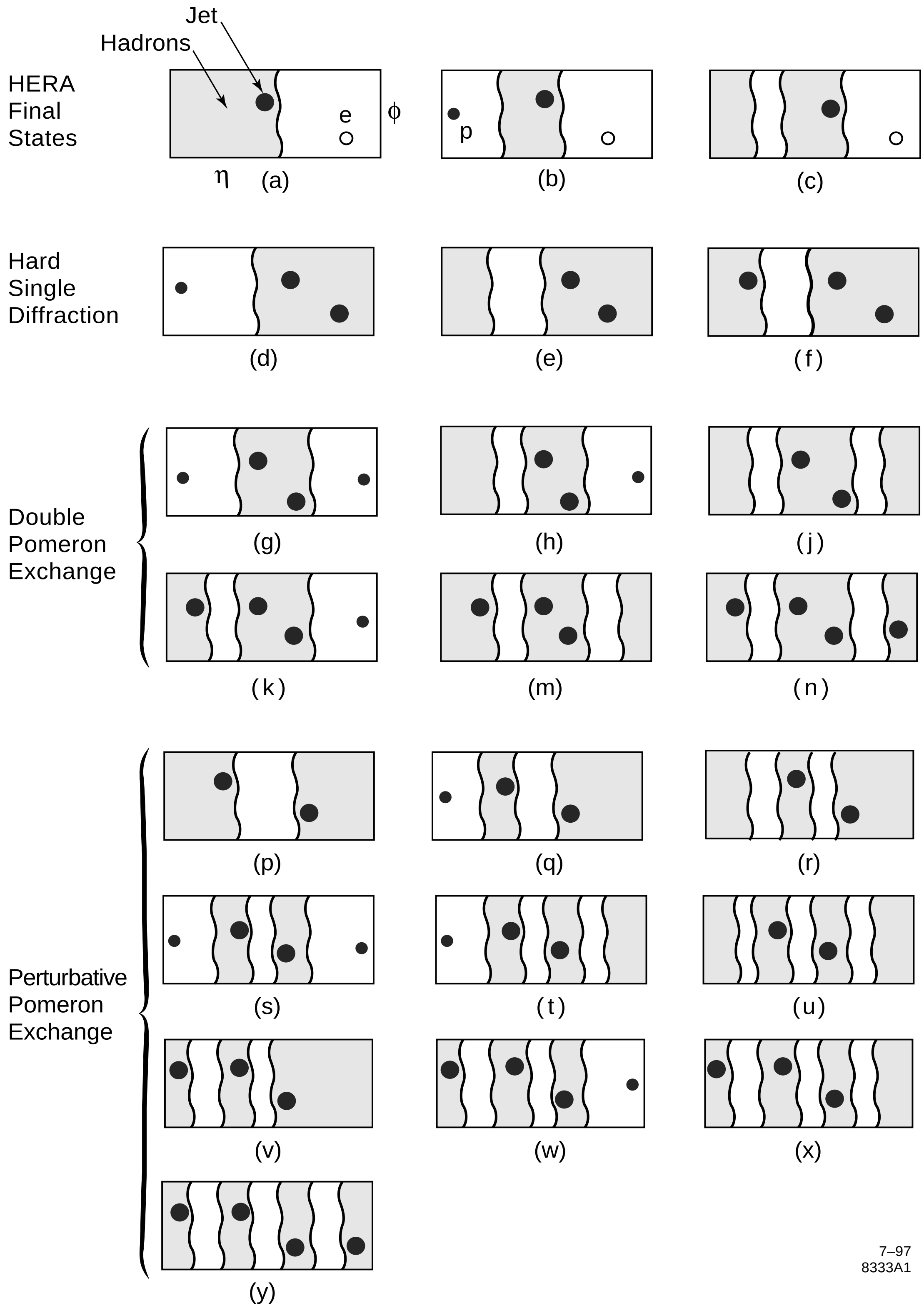
The optical functions are optimized at s=430 m to reach the smallest t-value $t = 3 \cdot 10^{-3}$ GeV^2

β^*=110 m



The near stations ($s < 120m$) accept all elastic scattered protons with $t > 4 \cdot 10^{-2}$ GeV^2

Basic hard diffraction



Diffraction

characterized by two variables:

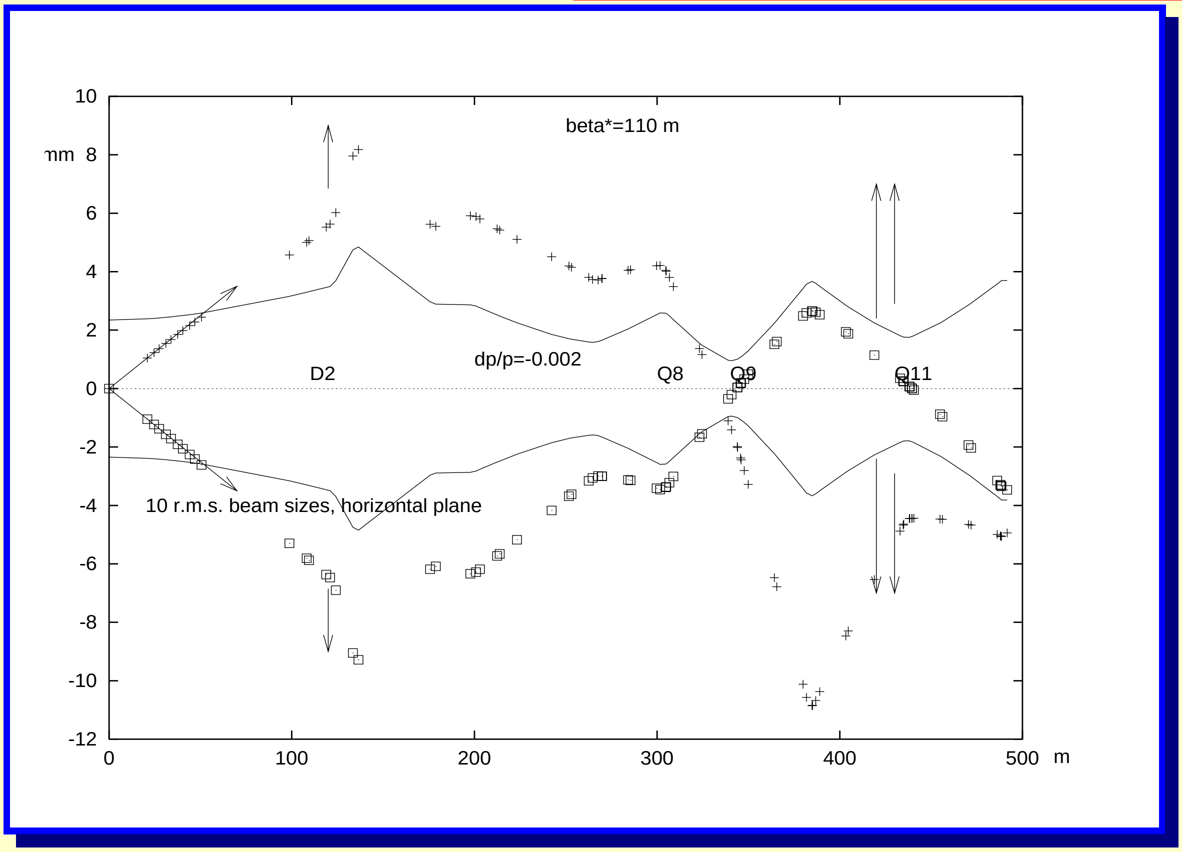
$$t = -p_0 p_{rec} \Theta^2, \;\; \xi = \frac{\Delta p}{p} = \frac{M_X^2}{4p_0^2}$$

Elongation of a diffractive proton in horizontal plane:

$$x(s) = v_x(s) \cdot x^* + L_x^{eff} \cdot \Theta_x^* + \xi D(s)$$

$$D(s = 430m) \sim 1.3m$$

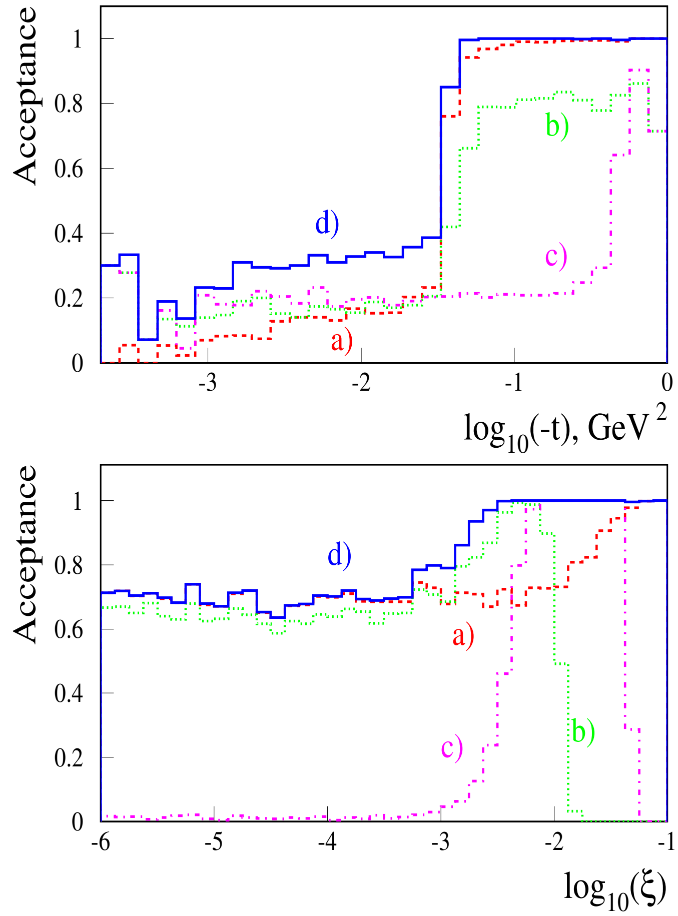
β^*=110 m, horizontal plane



10σ profile and trajectory of a proton with
Θ =50 μrad and $\xi = 2 \cdot 10^{-3}$

Diffraction

Proton acceptance as a function of t and ξ



a) near station

far stations

b) at Q11

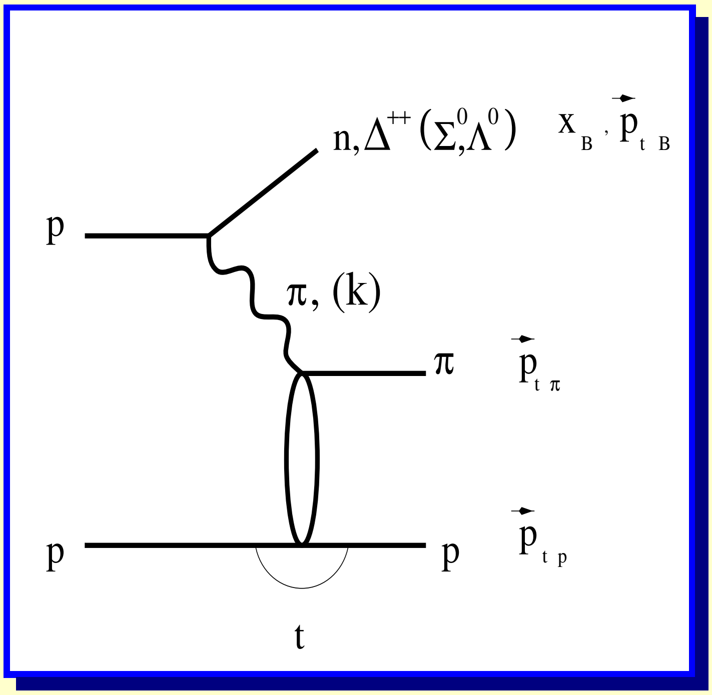
c) at Q9

d) all stations

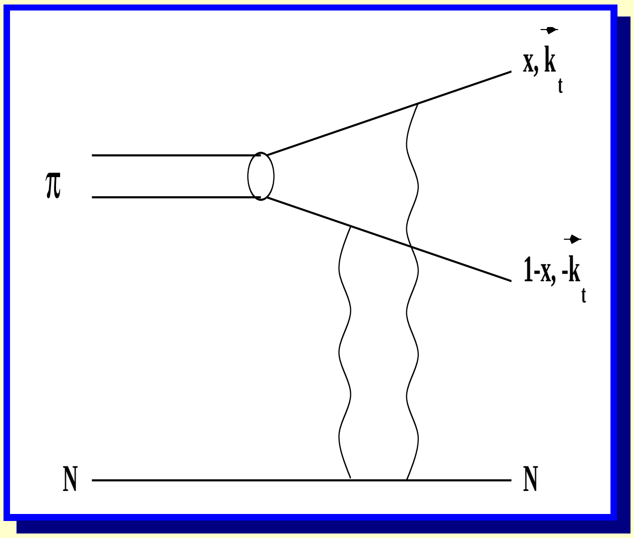
- $\sim$ 80% of all diffractive protons are detected
- protons are momentum analyzed for $\xi >$ few $\cdot\ 10^{-3}$ with a resolution of $\sigma(p)/p \sim$ few $\cdot\ 10^{-4}$

Leading baryons ($x_B > 0.9, p_{tB}^2 < 0.1\mathrm{GeV}^2$)

Tagged particle beams



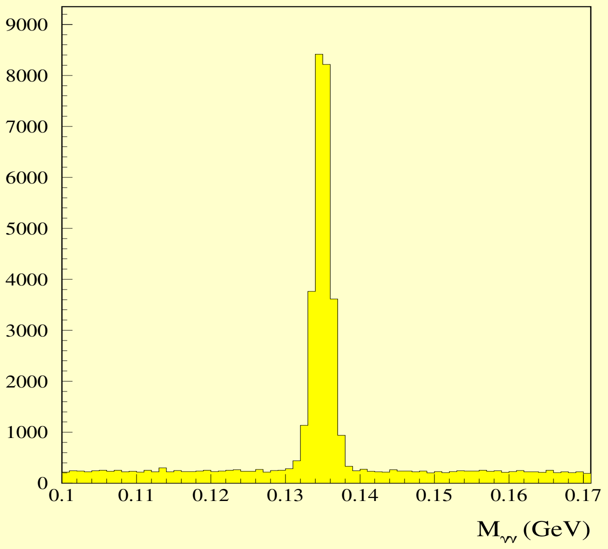
Pion diffraction into two forward jets



Proton diffraction into three forward jets

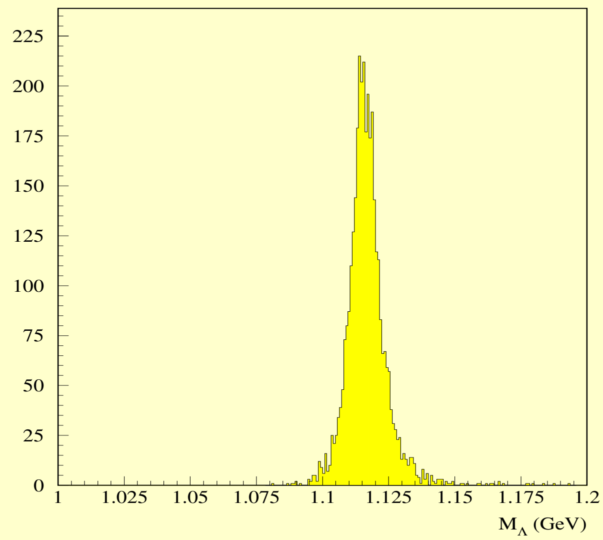
$$\sigma_{3jets} \sim (10^{-4} - 10^{-5}) \left(\frac{5\mathrm{GeV}}{P_{tjet}}\right) \mathrm{mb}$$

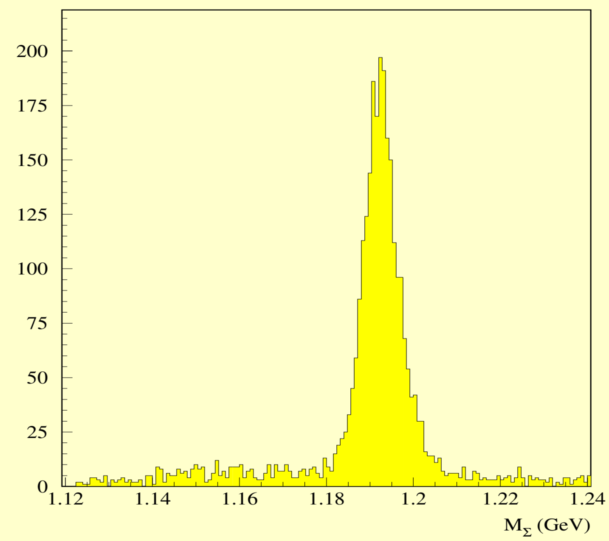
Mass reconstruction



$\gamma\gamma$ mass spectrum in the π^0 region

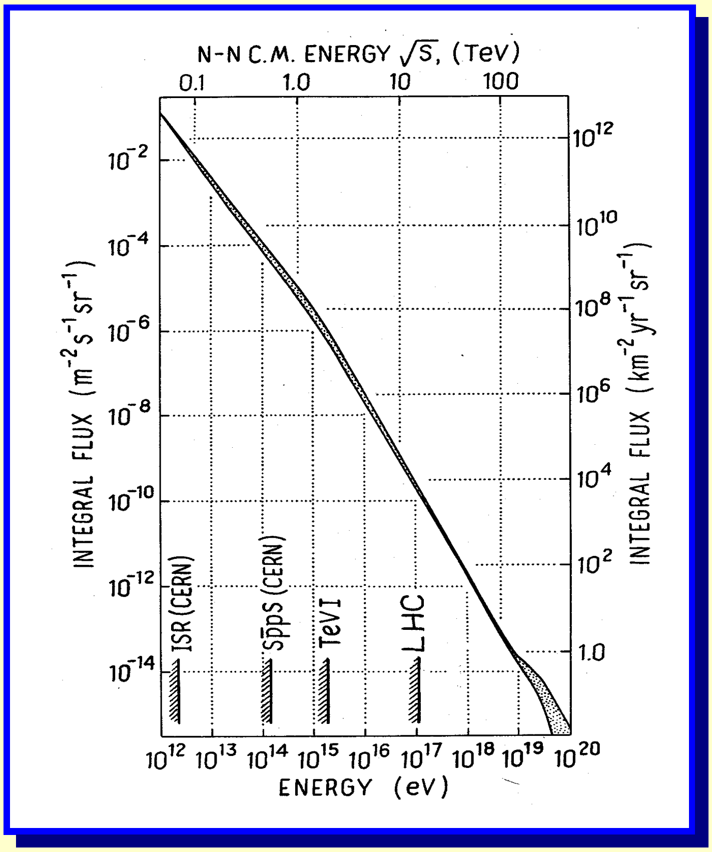
$\Lambda \rightarrow n\pi^0$





$\Sigma^0 \rightarrow n\pi^0\gamma$

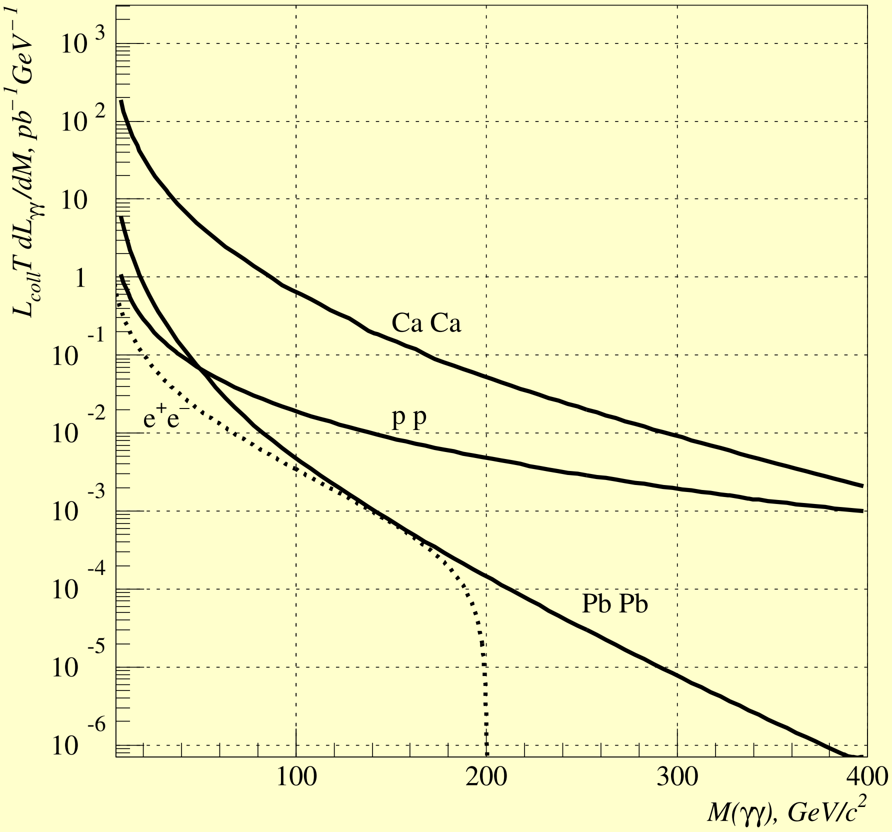
The astroparticle connection



Integral flux of high energy cosmic rays

- Change of slope at $\sqrt{s} \sim 5$ TeV
- Measurements of the very forward energy flux (including diffraction) are essential for the understanding of cosmic ray events
- Anomalies in cosmic rays:
  - Centauros and Anticentauros
  - Multimuon bundles
  - Long flying component
  - Abundant heavy flavour production
  - • • •

$\gamma\gamma$ physics



TL$_{coll}$:

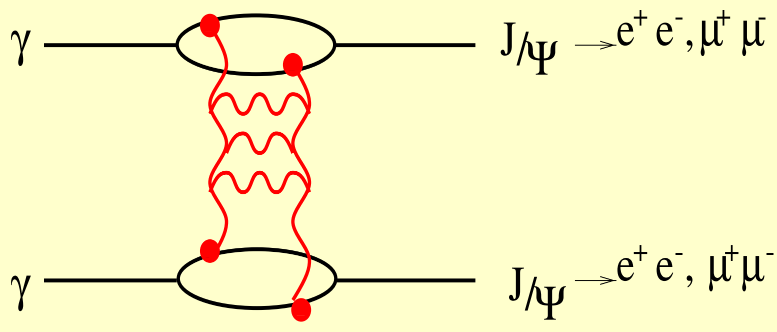
pp $\rightarrow 10^3$ pb^{-1}

CaCa $\rightarrow 4$ pb^{-1}

PbPb $\rightarrow 10^{-4}$ pb^{-1}

e$^+$e$^-$ $\rightarrow 100$ pb^{-1}

Test of BFKL:



$J/\psi \sim$ pointlike

enhancement due to BFKL $\sim$ 100

FELIX history & future

May 1991	J. D. Bjorken, "A full acceptance Detector for the SSC", Int. J. Mod. Physics, A7 (1992)4189
Nov. 1994	LHCC Workshop about future Physics talks by J. D. Bjorken and K. Eggert on forward p-p and p-A physics
Feb. 1995	LHCC recommendation *"The LHCC noted the interest in diffraction, and expects that such studies may also form part of the LHC experimental programme. The committee encourages interested parties to work together on an integrated approach towards this physics, whilst bearing in mind the LHC physics priorities already established"*
Summer '95	Possibility for a new interaction region in I4
Since then	Several workshop about pp, pA and $\gamma\gamma$ physics Extensive design studies to establish • the magnetic architecture • the beam lines
1 Aug. 1997	Submission of the FELIX LOI to the LHCC
5 Sept. 1997	LHCC nominates referees for FELIX
Nov. 1997	Public presentation of the LOI

Detector costs:	$\sim$ 50 MCHF
Integration into the LHC:	$\sim$ 24 MCHF
(beam line, magnets, infrastructure)	

COLLABORATORS ARE WELCOME!

joint spokespersons:

Karsten Eggert	CERN	karsten.eggert@cern.ch
		Tel. 0041 22 767 6313
Cyrus Taylor	CWRU	cct@po.cwru.edu
		Tel. 001 216 368 3710