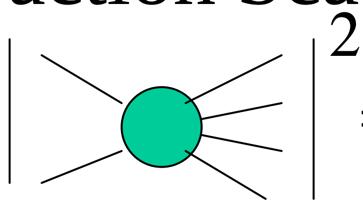
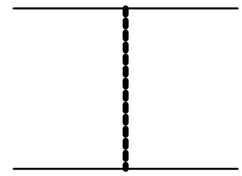
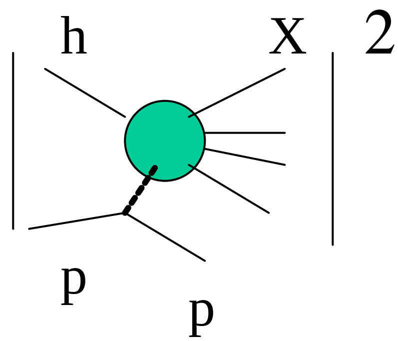
Diffraction in pA at RHIC

- Extension of ep, $p^{-}p$ program to "Pomeron- nucleus collisions"
- Diffractive Tags in pA collisions
  - "gap" and leading particle in collider mode
  - recoil technique with an internal target
- "A-side" tags, Luminosity, rates

Diffraction Scattering:

diagrams-

total: $\sigma_{tot} =$  $= \text{Im}$  t=0

Single Diffractive: 

Classical Optics Analog:

$$|h> = \sum_{n=0} c_n | \Psi_n >$$

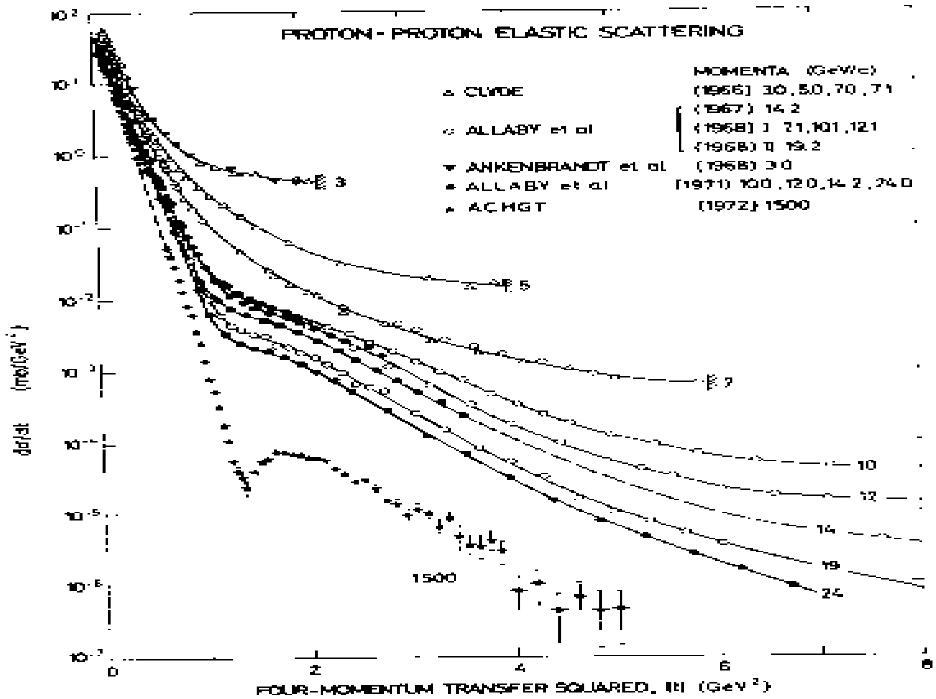
Single Diffraction filters other components of the hadron" into existence". Diffractive Peak so long as

$$\Delta p_l, \Delta p_t \leq 1/R_{target}$$

Diffraction Scattering:

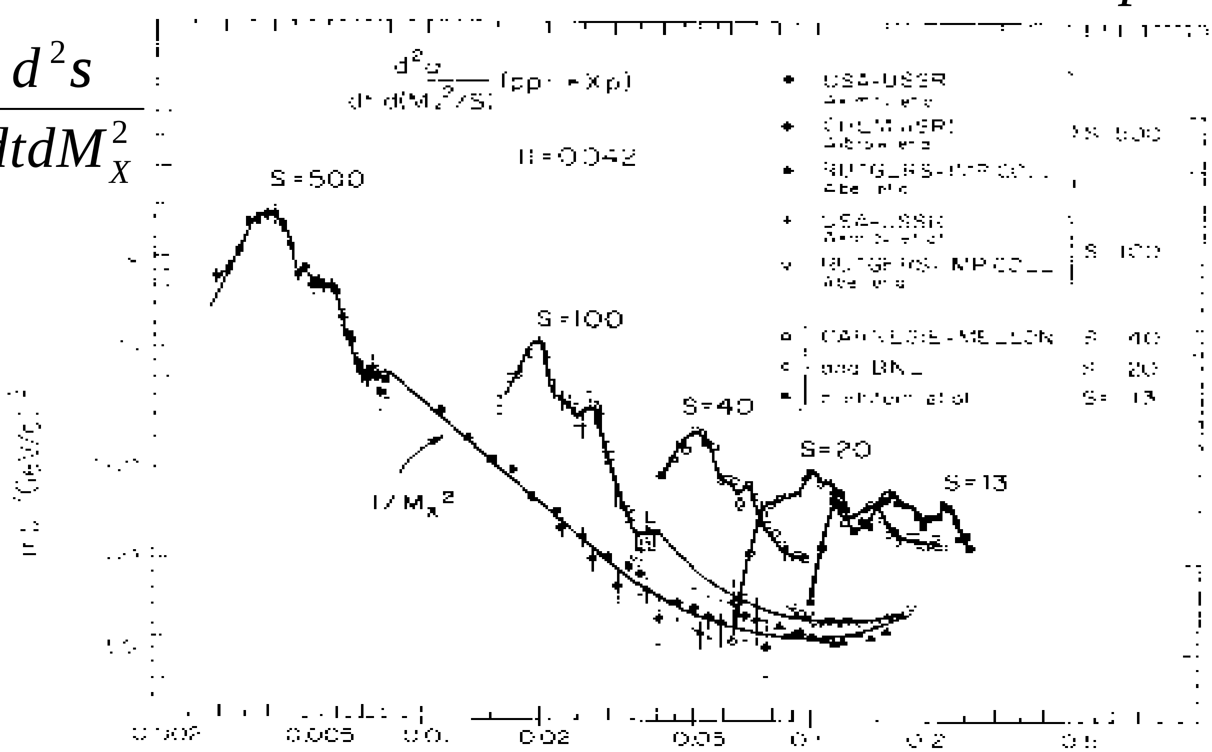
Data

$$\frac{d\sigma^{el}}{dt}$$



$$t \cong -p_t^2$$

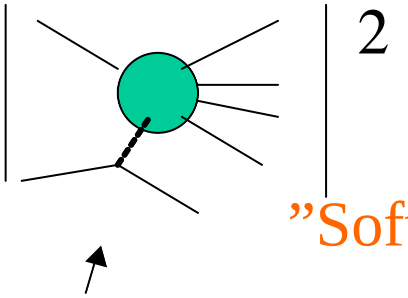
$$\frac{d^2\sigma}{dt\,dM_X^2}$$



$M_X^2/S = 1 - x_F$

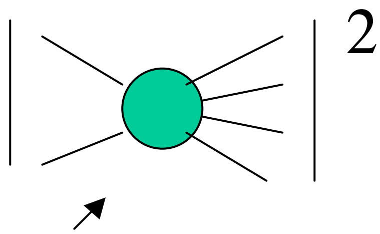
Oct.28,2000

”Soft” Diffraction:



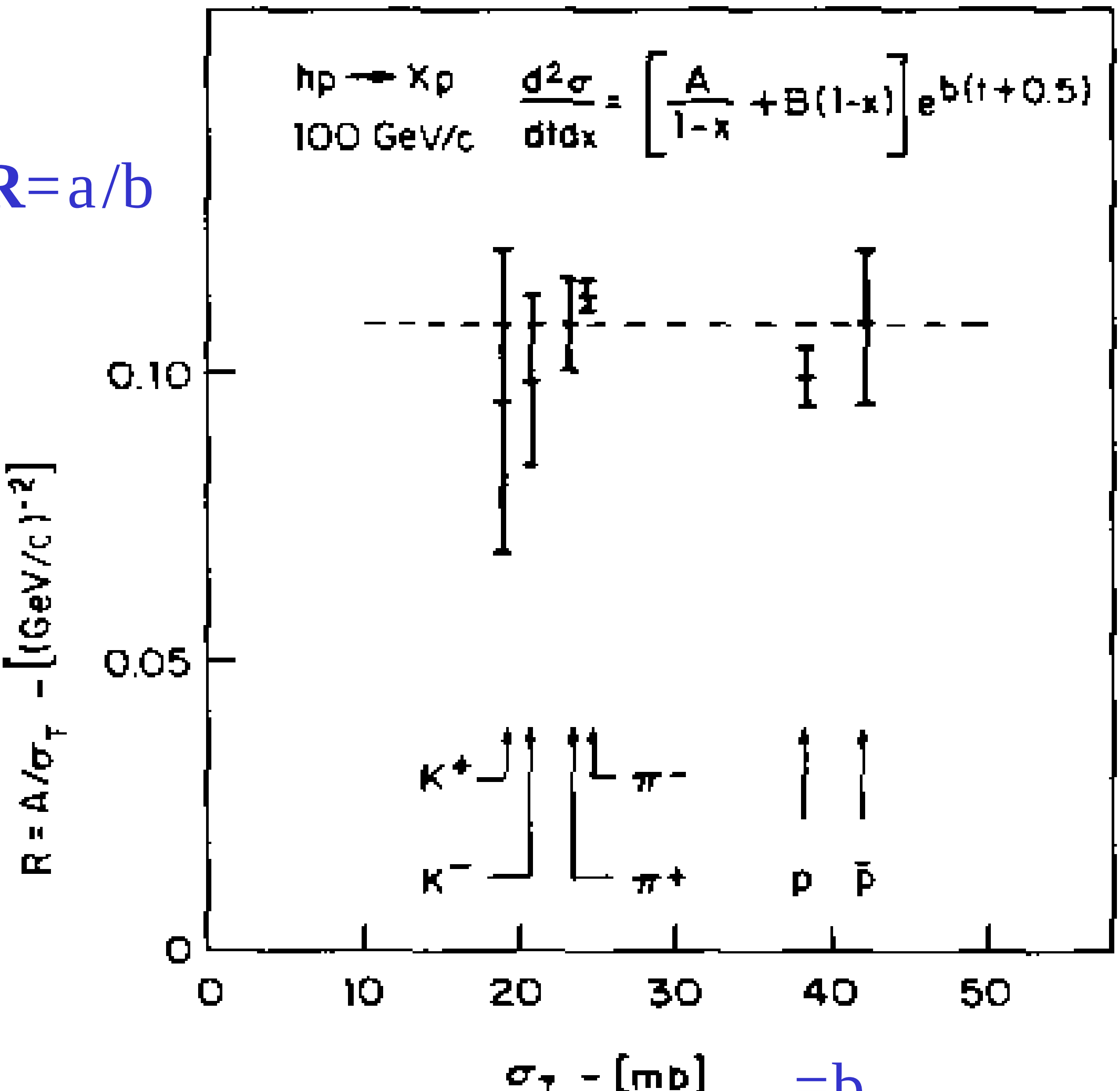
α

Vs.



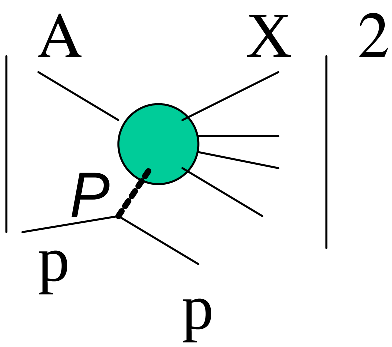
β

R=a/b



=b

“Hard Diffraction” terminology



$$x_{p} = 1 - x_f = M_X^2 / s = x$$

$$f_{P/h} = \frac{b^2}{16p} F^2(t)(x_P)^{1-2a(t)}$$

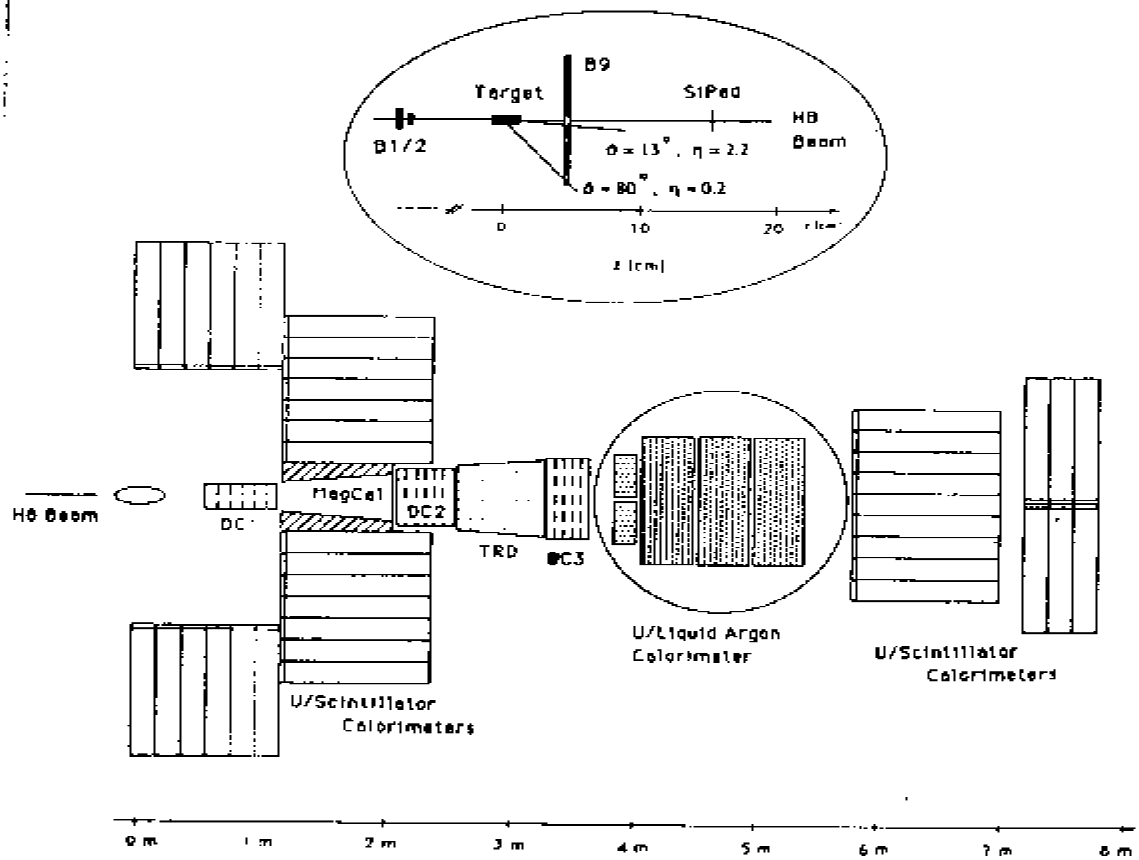
Define “flux” :

$$f_{P/p}(x_P, t) = \frac{ds \big/ dx_P dt}{s\,(Pp \to X)}$$

See ie Ingelman &Bruni, Phys. Lett. B 311(‘93)317 diffractive W/Z production. Then:

$$\frac{ds}{dx_P dt dx_1 dx_2} \propto f_{P/p}(x_P, t) \bullet f_{q/P}(x_1) \bullet f_{q/p}(x_2) \bullet \hat{s}\,(q\bar{q} \to W/Z)$$

Diffraction Dissociation with p beam and Nuclear targets



Quality of measurements best for large t and M^2_x

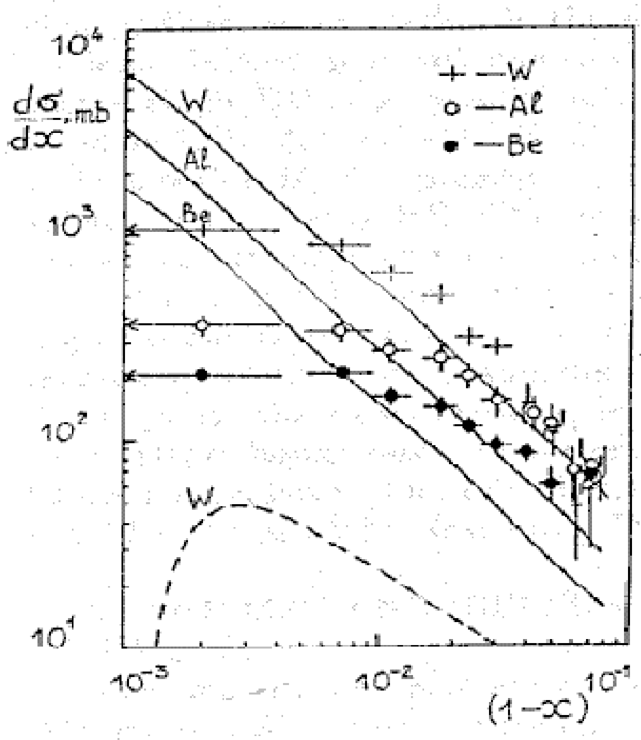
Helios Expt at CERN

- t, x_F measured with forward tracking spectrometer
- t dependence same as in pp (ie ~e^{6t})
- M_x^2 and Target dependence not anticipated

Prior Measurements

Helios at CERN
(pA->pX)
measured t, x
dependence

cp. MST , V.Zoller



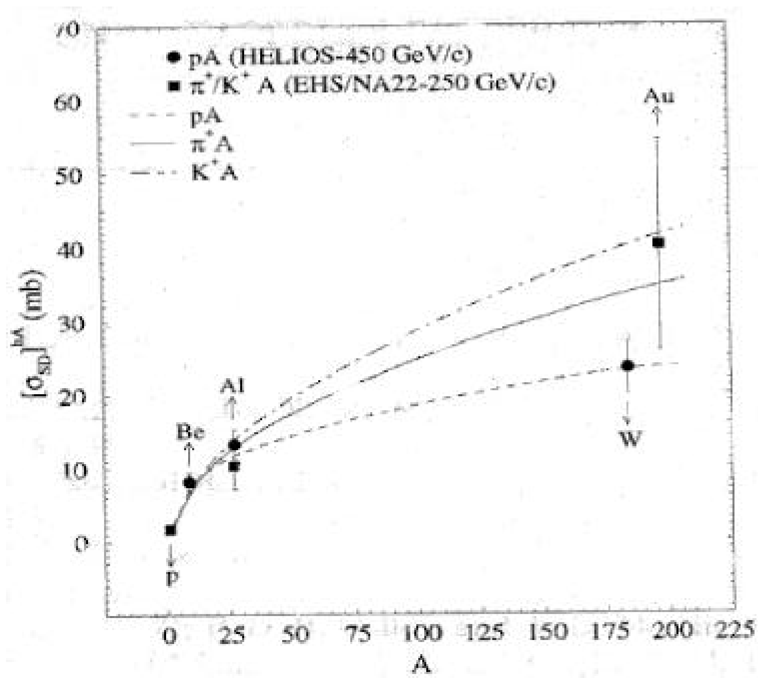
$=M_x^2/s$

Helios + EHS, CERN

not simple $A^{2/3}$ dependence

Batista&Covolan

$$\cong \frac{\sigma^{hA}_{n=1}}{\sigma^{hp}_{inel}} \sigma^{hp}_{SD}$$



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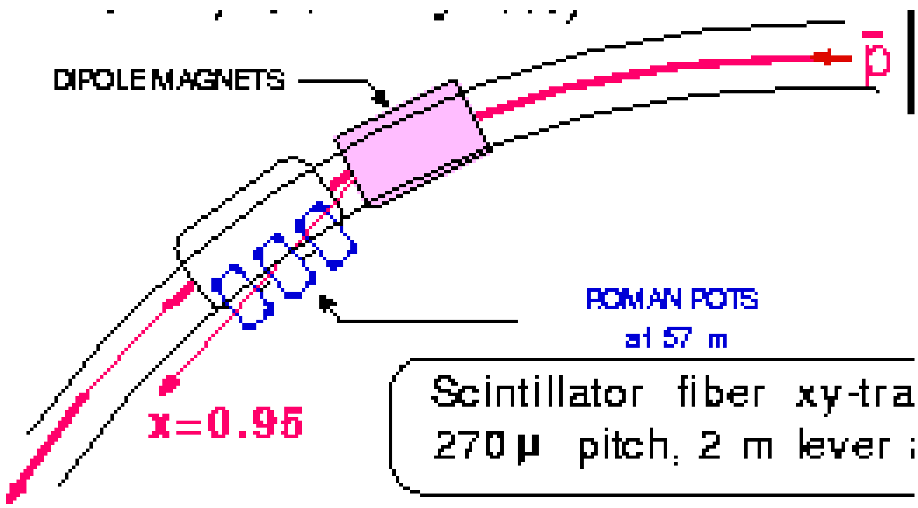
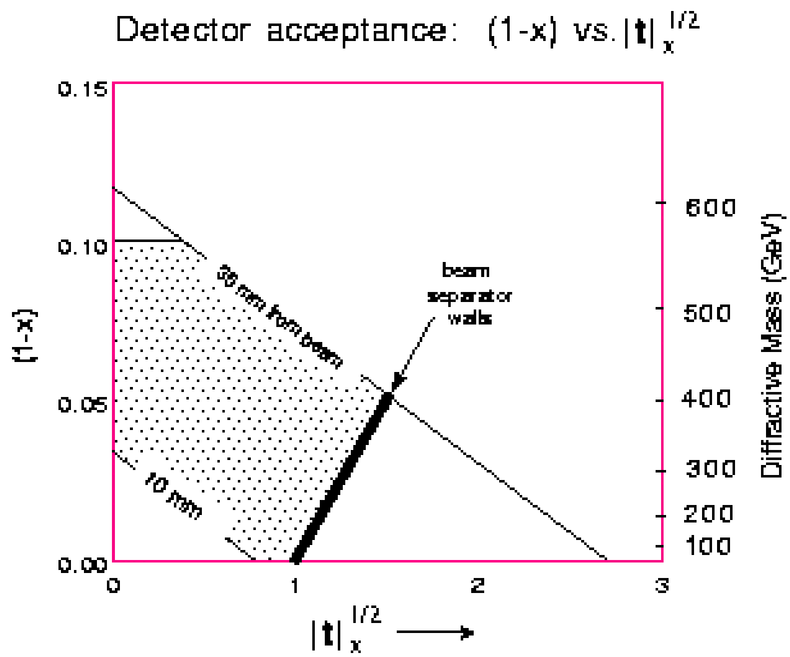
Collider Measurement at RHIC



•Leading Particle Measurement

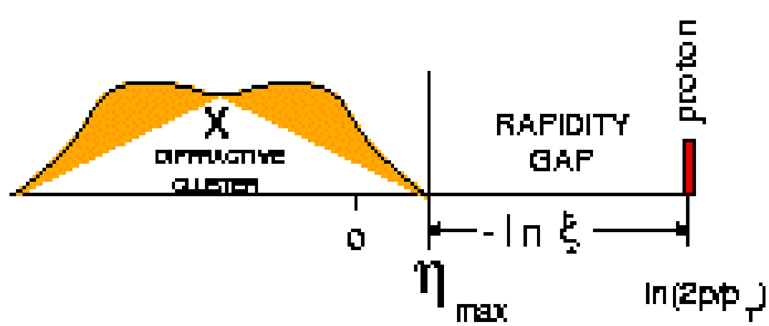
$1\text{-}x=M^2/s$

Roman Pots in bend plane



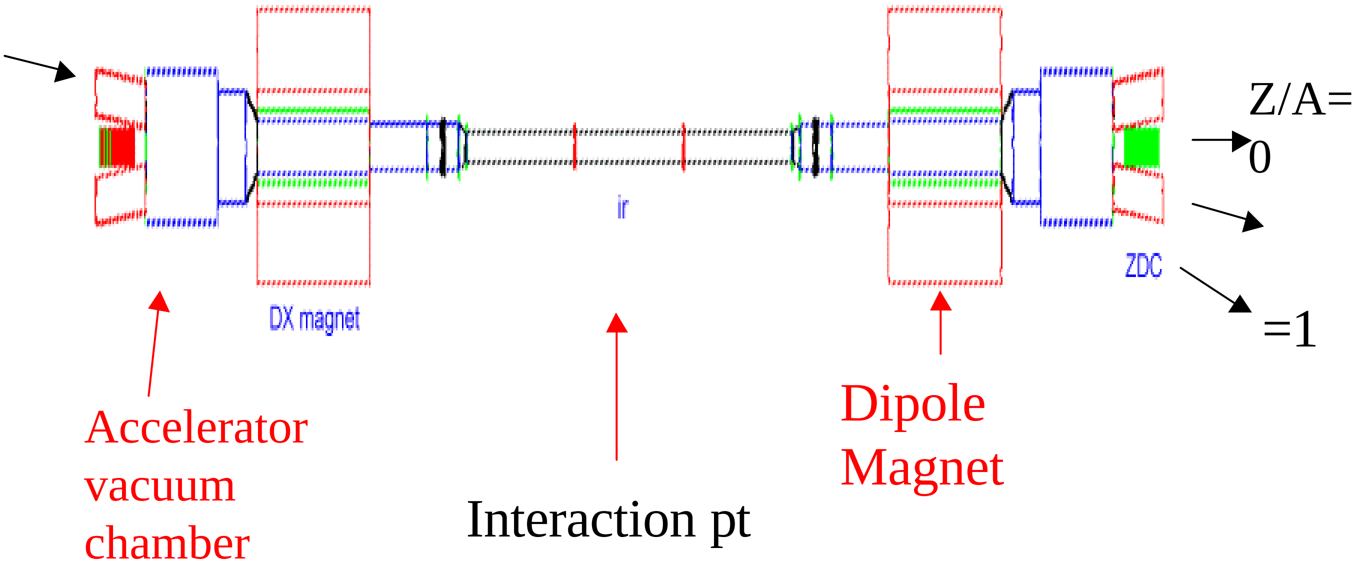
•Couples Acceptance in
t, x

•Measure M^2/s from topology (gap method)

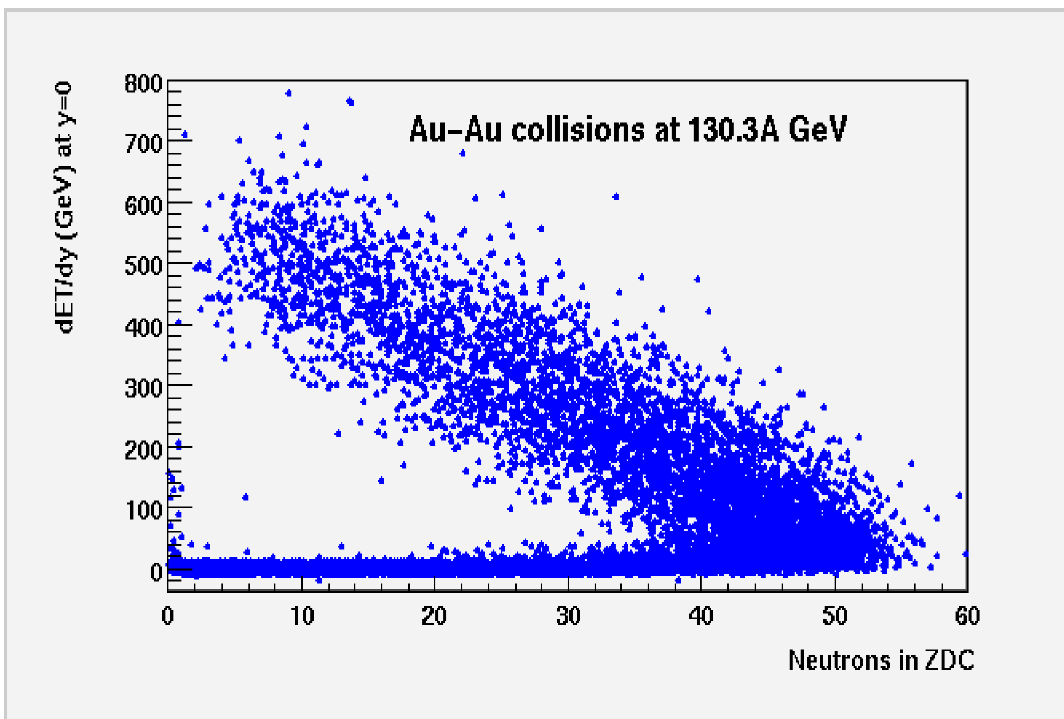


A-side tag

Zero Degree Cal.



Et vs ZDC in AA collisions



Hard Diffraction @ RHIC

rapidity gap events pA-> jets, heavy flavors J/Psi..

Rates :

1) "flux factor" $$f^{'}(x_{P},t) \rightarrow f(x_{P},t)\frac{s^{pA}_{n=1}}{s^{pp}_{inel}}$$

2) cross sections $$f_{q/P}(x_1)\,f_{q/A}(x_2)$$

Luminosity measurement

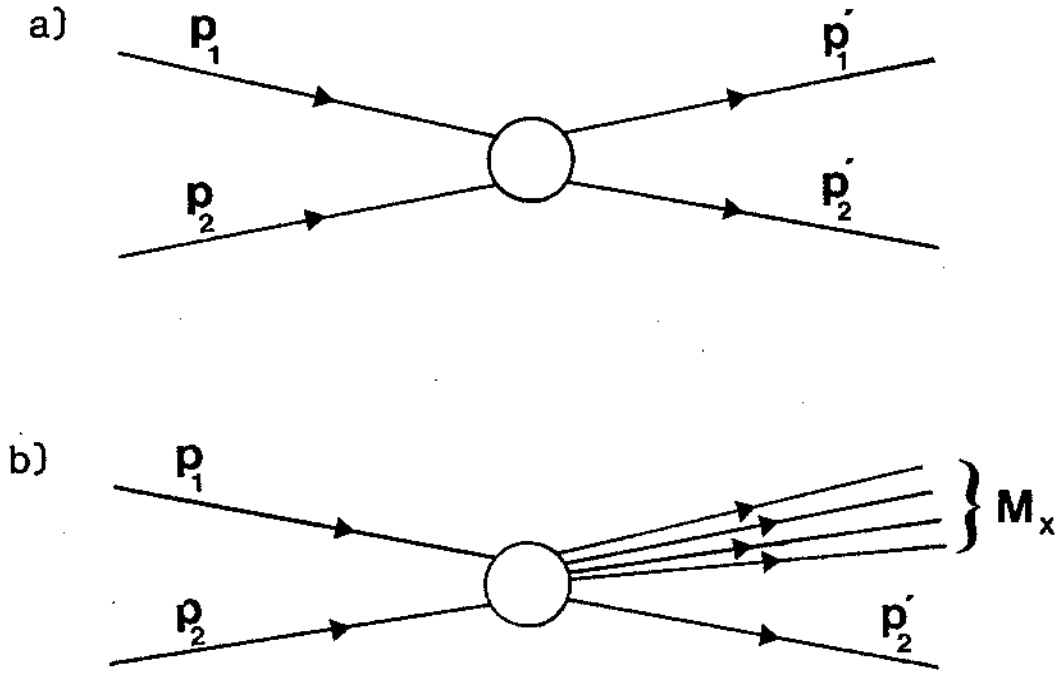
- Current Strategy with AA
  - pick 1(or 2) triggers as monitors
  - Measure rates
  - calculate L($\sigma_{x,y}$,N/bunch)
  - calibrate “ to <5%
- luminosity for pp, pA
  - adopt second monitor(BBC)
  - calibrate from L_{accel}

RHIC Parameters

$$\sqrt{s} = 200 - 300 * \sqrt{A} * GeV$$

- $L_{pAU}*\sigma = 10^{29}*(10\text{-}30*10^{-27})$
  - Increases for lighter species
- p Spectrometer(pots) in x (bend plane)
- Collision Axis@3.8mr (100x100) a problem for A-side tags
- Prefer (100x250) solution

Kinematics(recoil technique, internal target)



$$t = -p_1 p_1' \sin^2\theta = -2 m_2 T_2$$

$$M_X^2 - m_1^2 = 2 p_1 \sqrt{t}\left(\cos\theta - \frac{\sqrt{t}}{2m_2}\right)$$

$$p_1 = p_{beam}, m_2 = m_{target} = m_p$$

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

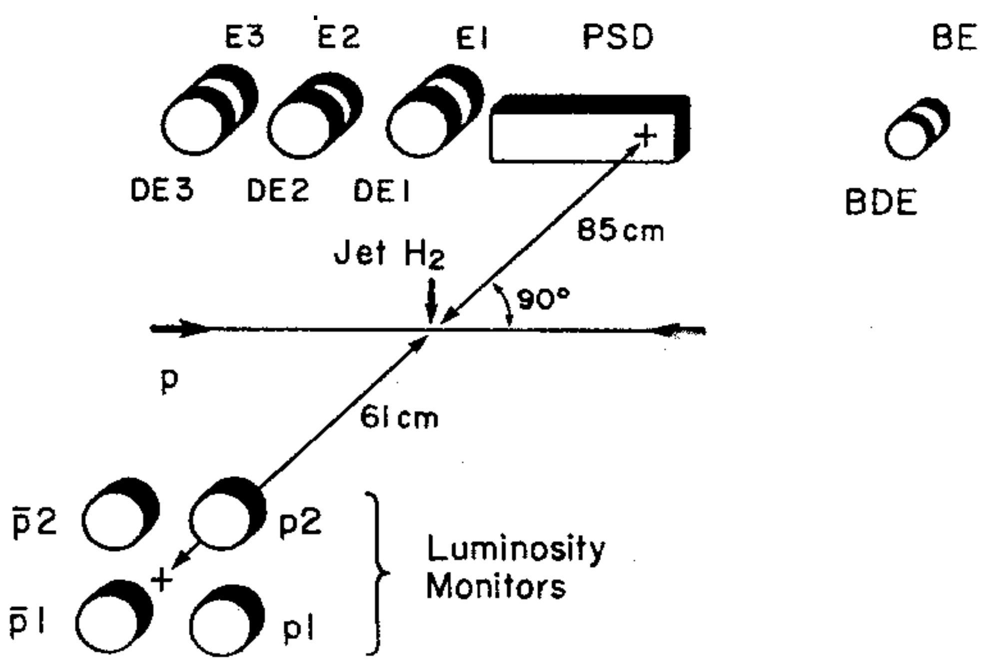
UA6 Experiment

SPSC/80-33
SPSC/P 148
19 August 1980

PROPOSAL FOR THE STUDY OF e^+e^-, γ, π^0 AND HYPERON PRODUCTION IN $\bar{p}p$ REACTIONS AT $\sqrt{s}$ = 22.5 GeV USING AN INTERNAL JET TARGET AT THE SPS

CERN[1]–Lausanne[2]–Michigan[3]–Rockefeller[4] Collaboration

J. Antille[2], R. Cool[4], L. Dick[1], C. Dukes[3], J. Dworkin[3], J.B. Jeanneret[1], C. Joseph[2], K. Jenkins[4], W. Kubischta[1], J.F. Loude[2], O.E. Overseth[3], J.P. Perroud[2], J. Silverman[4], D. Steiner[2], M.T. Tran[2] and S. White[4]



Measured quantities:

let t=.01, then T=.01/2/m_p =5 MeV

$$q = \cos^{-1}\left(\frac{\Delta M_X^2}{2 p_{beam}\sqrt{|t|}} + \frac{\sqrt{t}}{2m_t}\right)$$

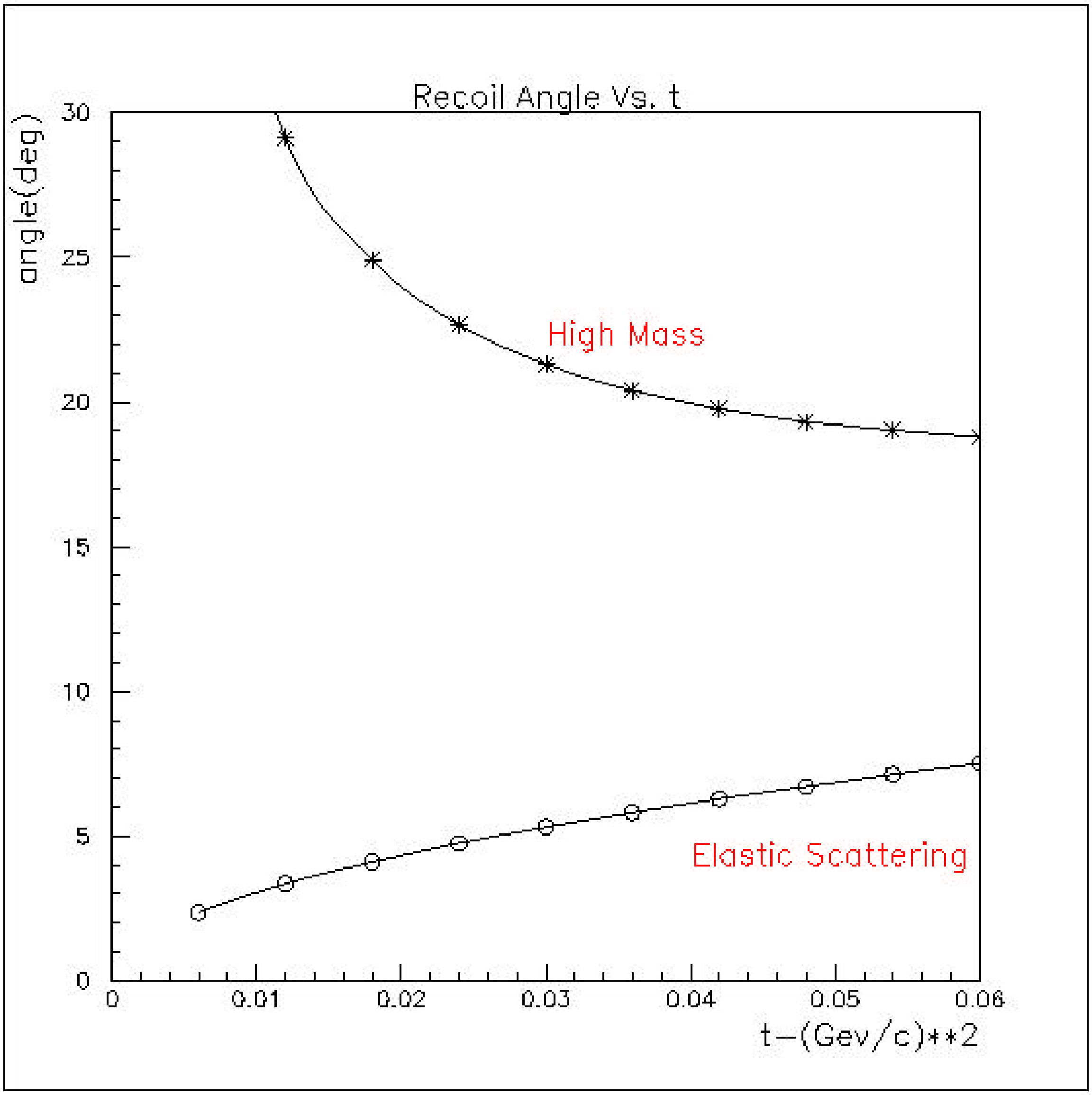
Measurement Errors:

$$d(\Delta M_X^2) = \frac{\Delta M_X^2}{p_{beam}} * dp_{beam}$$

$$d(\Delta M_X^2) = \left|\frac{M_X^2}{2|t|} - \frac{1}{2}\frac{p_{beam}}{m_p}\right| * dt$$

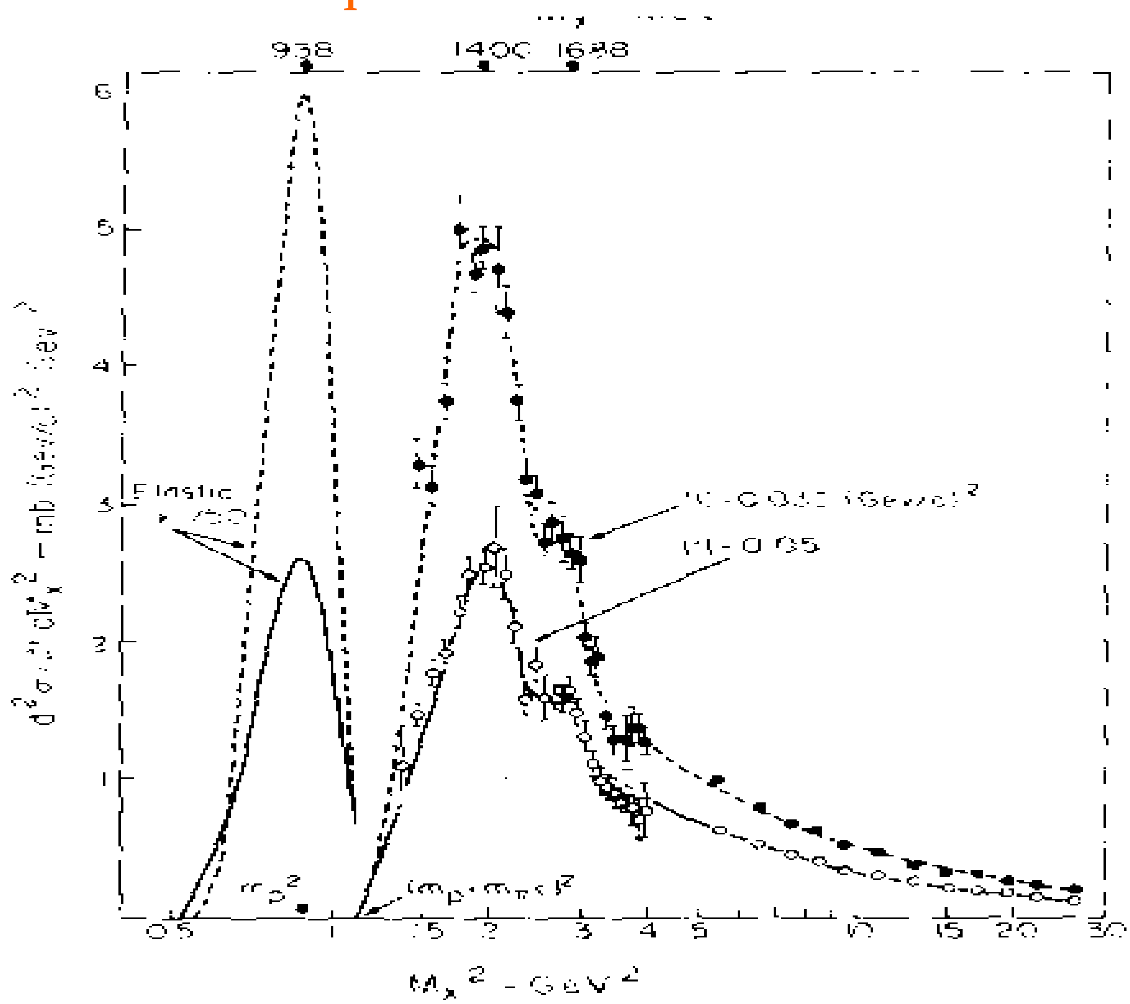
$$d(\Delta M_X^2) = 2 p_{beam}\sqrt{t}\left(1 - \left(\frac{M_X^2}{2 p_b \sqrt{t}} + \frac{\sqrt{t}}{2m_p}\right)^2\right)^{1/2} * dq$$

Recoil Angle= θ–90 deg



Recoil Mass resolution with a 0.8 cm long Jet and typical(100keV) resolution of Solid State detecors sufficient to separate Elastic and Single diffractive.

Leading Particle Mass spectrum measured with Recoil technique:



Luminosity,rates w.H_2 jet

$$L_{pA} = \rho_{jet} \bullet l_{jet} \bullet N_A \bullet \nu_{rev}$$

$$3 \bullet 10^{11} \rightarrow 3 \bullet 10^{14} \qquad 10^9 \rightarrow 2 \bullet 10^{11}$$

cm^{-3} Particles/bunch

- With Molecular(dense) jet $L_{pp} \sim 3*10^{32}$, Counting rates typically 10 Hz/ detector in UA6 design
- With Ion beams rates lower by factor of 10-100 than for pp
- Rates 3 orders of magnitude lower with polarized jet.

Summary

- pA@RHIC significant increase in E, access to hard diffraction with nuclei
- detailed measurement of (1-x),A dependence with internal target
- Nuclear Diffraction Dissociation with LPS w. similar parameters to Tevatron
  - forward tracking in horizontal plane
- Proton Diffraction on A by rapidity gaps