Almost No Simulations

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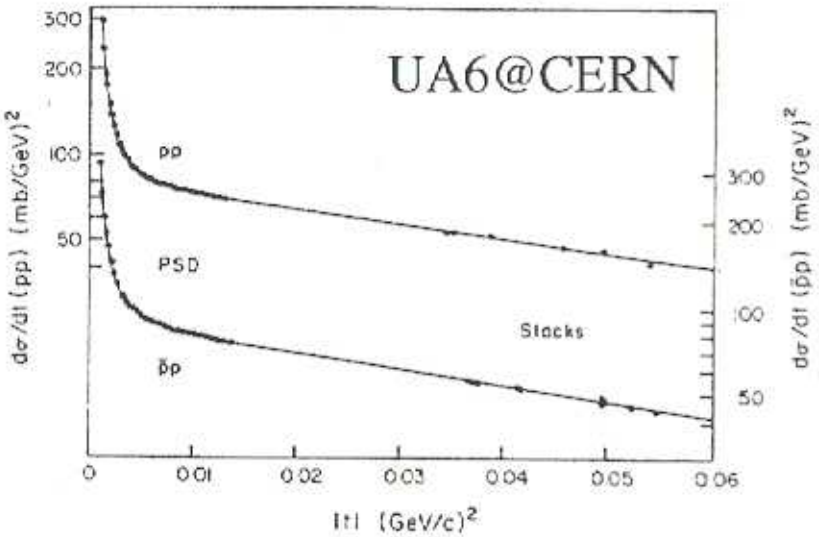
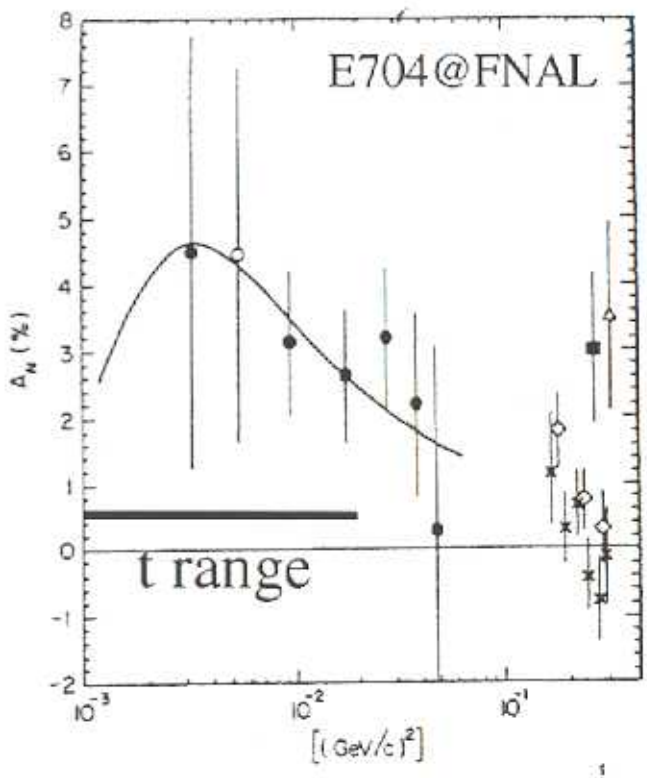
RHIC Spin Coll. Meeting VIb

- Introduction
- Rates
- Elastic pp kinematics
- Backgrounds
- Recoil detector
- Conclusions

Elastic *pp* dσ / d*t* & A_N



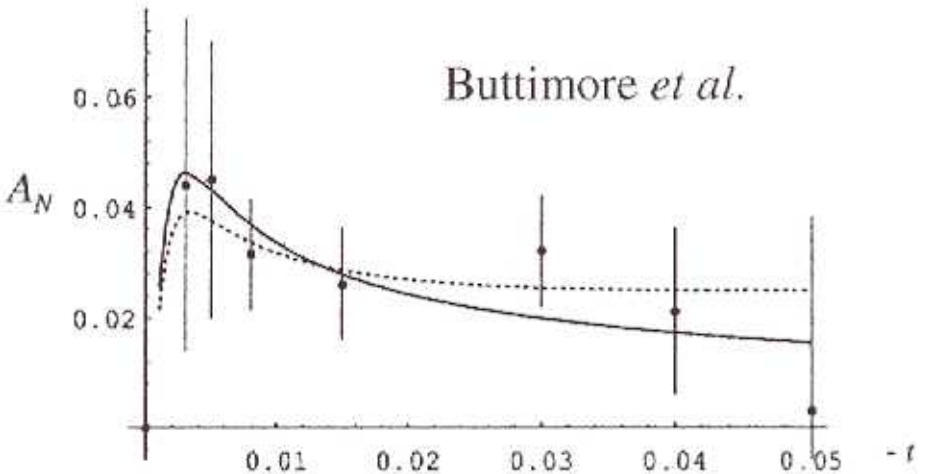


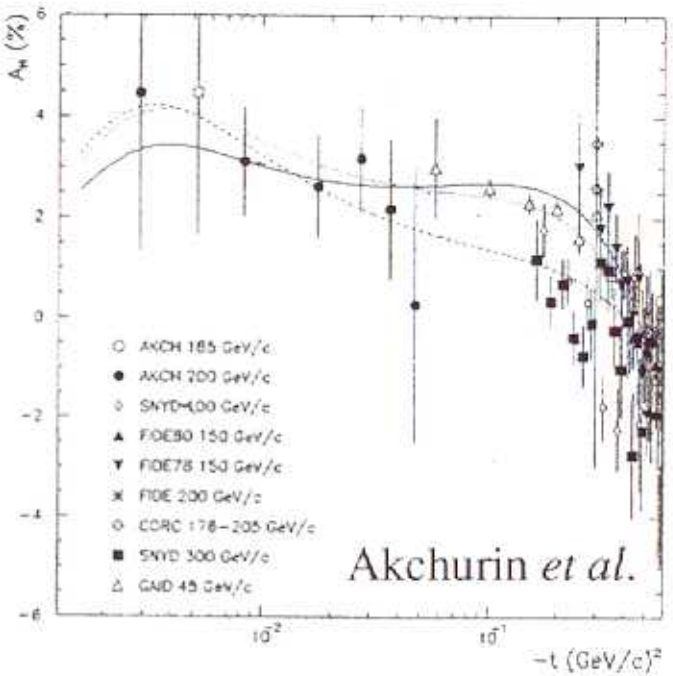
$0.001 < |t| < 0.02$ GeV^2

$\langle\sigma\rangle = 3$ mbarn

$\langle A_N \rangle = 0.03$

CNI & hadronic spin-flip





- If no pronounced maximum in CNI t region, any t region as good as CNI region
- With recoil detector & roman pots can cover broad t range

Comparison of different t regions

Figure of Merit = $< A_N >^2 < \sigma >$

	CNI	Small |t|	Medium |t|	Large |t|	Elastic ep
|t| range (GeV^2)	$10^{-3} - 2\ 10^{-2}$	$2\ 10^{-2} - 0.1$	$0.1 - 0.4$	$0.7 - 1.4$	
$< \sigma >$ (cm^2)	$3\ 10^{-27}$	$3\ 10^{-27}$	$2\ 10^{-27}$	$3\ 10^{-30}$	
$< A_N >$	0.03	0.02 – 0.03	0.02 – 0.03	0.1	
f. o. m.	$2.7\ 10^{-30}$	$1.8\ 10^{-30}$	$0.8\ 10^{-30}$	$2\ 10^{-33}$	

Procedure

- Measure A_N with unpolarized beam and polarized target

$$\Delta P_{beam} / P_{beam} < 0.05 \Rightarrow \begin{cases} \Delta A_N < 10^{-3} \\ \Delta P_{targ} / P_{targ} < 0.02 \\ \text{background} < 1\% \end{cases}$$

- Measure P_{beam} using A_N with polarized beam and unpolarized target

- Continous monitoring with polarized beam and polarized target

  $\rightarrow$ A_{NN} for free

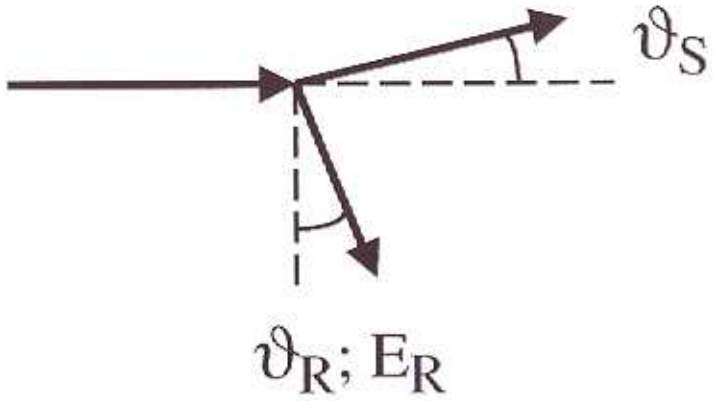
NB *Self-Calibration* works with elastic scattering only

RATES

BEAM	TARGET
$2\ 10^{11}$ p / bunch 120 bunches 78 kHz	$3\ 10^{11}$ atoms / cm^2

- $\mathcal{L} = 2\ 10^{11} \times 120 \times 78\ 10^{3} \times 3\ 10^{11} = 5.6\ 10^{29}\ cm^{-2}s^{-1}$
  $= 4.7\ 10^{27}\ cm^{-2}s^{-1}$ / bunch
- $N = \mathcal{L} \langle\sigma\rangle\ acc\ (\Delta\varphi = 30^{\circ}/2\pi) = 140$ evt s^{-1}
  $\sim$ 1 evt s^{-1} / bunch
- in 3 hours can collect 1.5×10^{6} events

Kinematics



t : 0.001 – 0.02 GeV^2
ϑ_R : 16. – 75. Mrad
T_{kin} : 0.5 – 10 MeV
p_R : 30. – 140 MeV

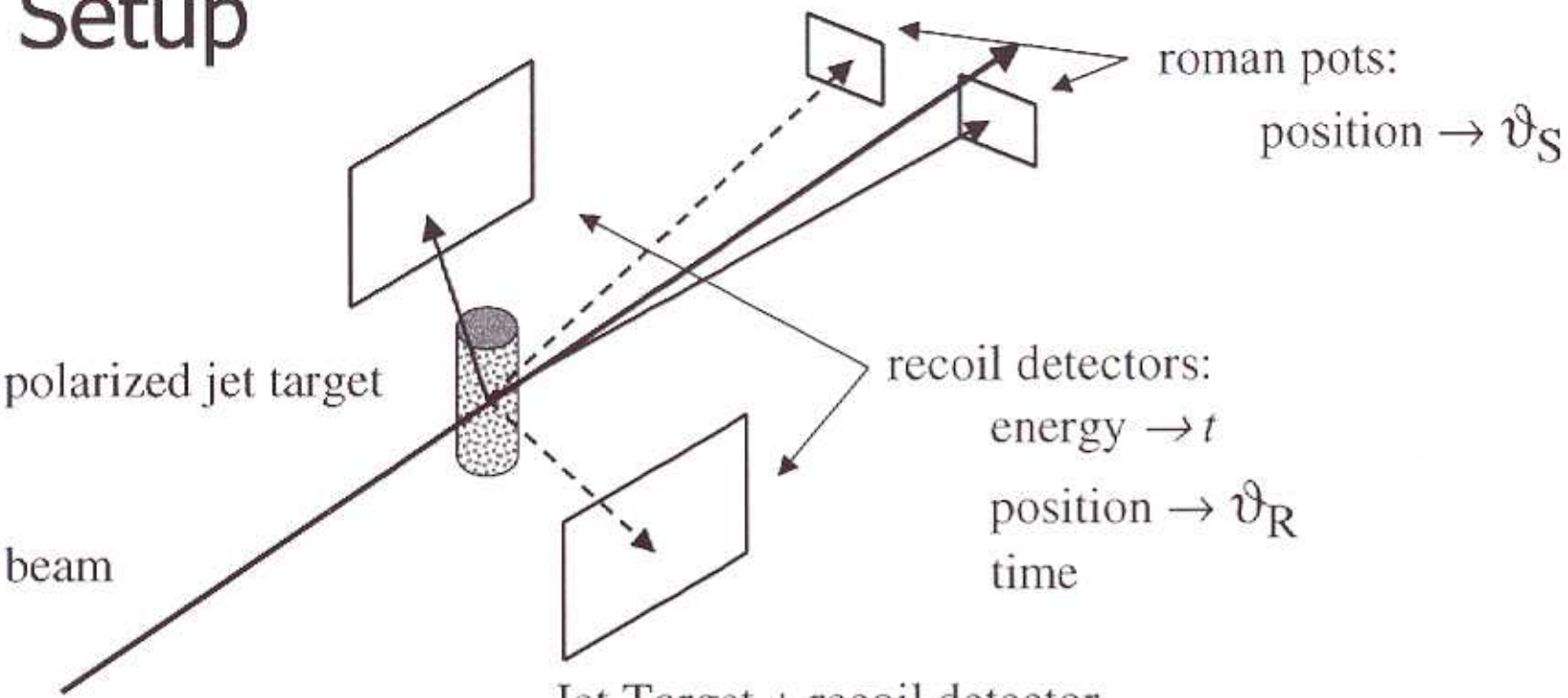
Essentially 1 free parameter: t (+ φ) ⇒

elastic *pp* kinematics fully constrained

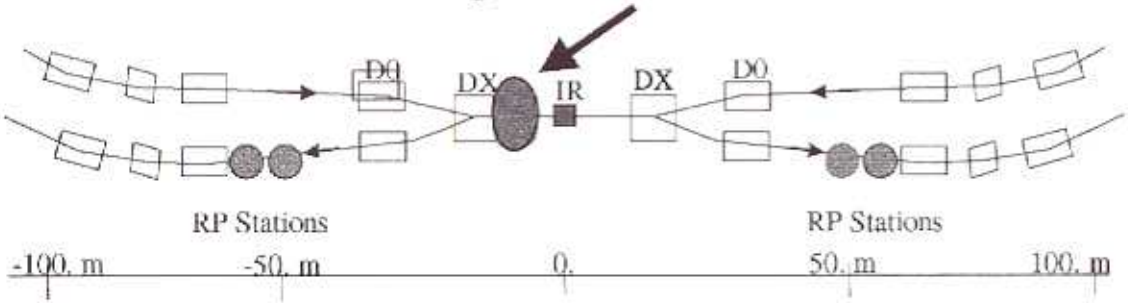
$$\sin\vartheta_R = \left(1+\frac{m_p}{p_{beam}}\right)\frac{\sqrt{|t|}}{2m_p} \qquad t = -2m_p T_{kin}$$

measure position and energy of recoil => ϑ_R and t

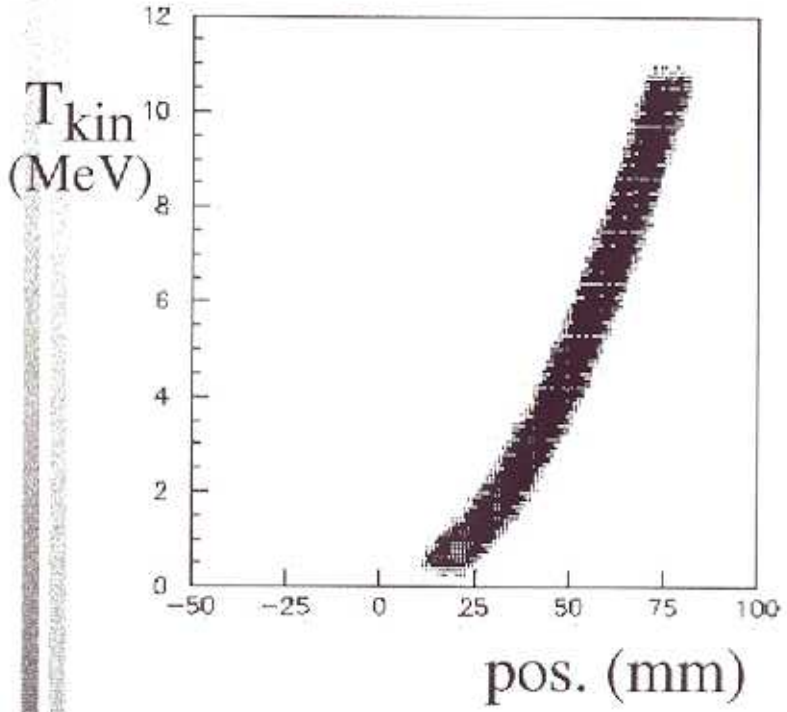
Setup



Jet Target + recoil detector



Recoil energy vs position



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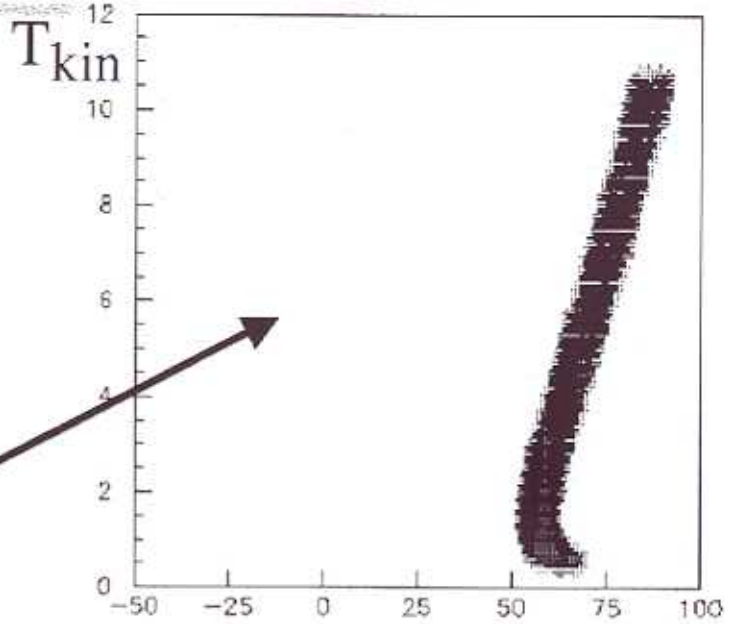

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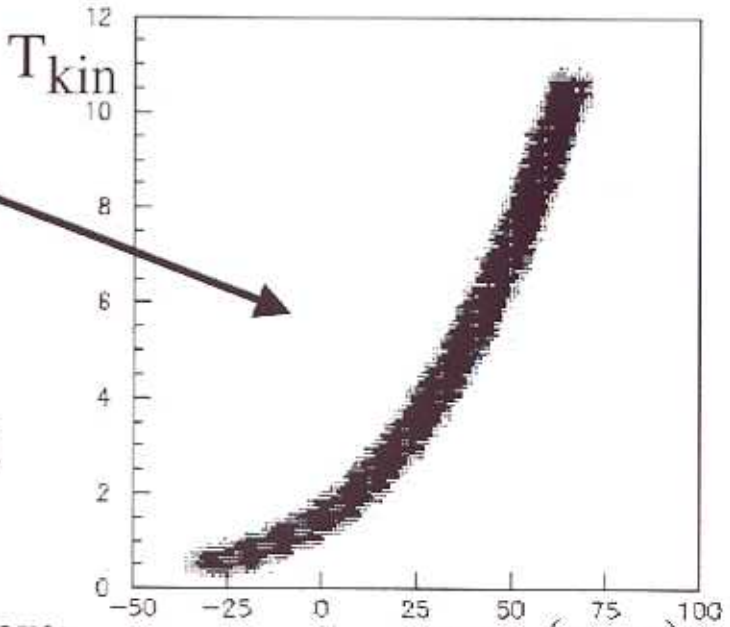
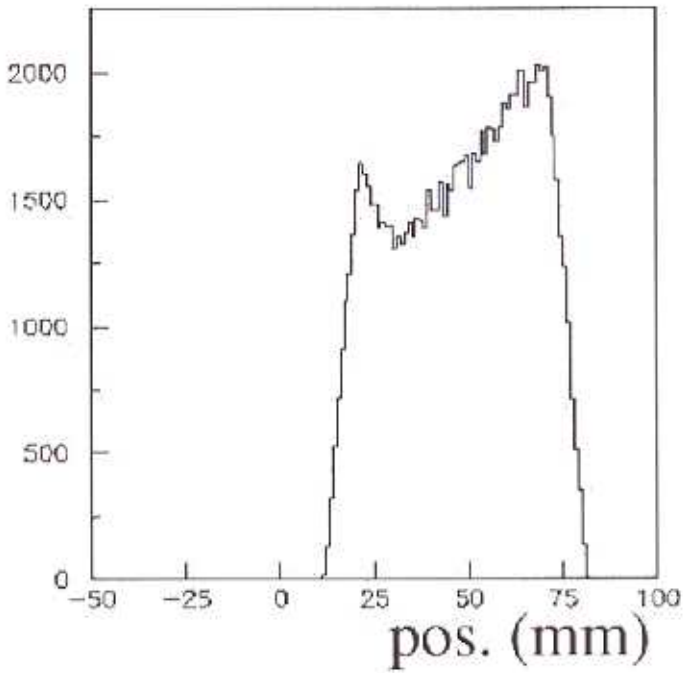


Effect of target holding field
Bdl ~ 0.005 – 0.01 Tm

Recoil hit profiles @ 1 m



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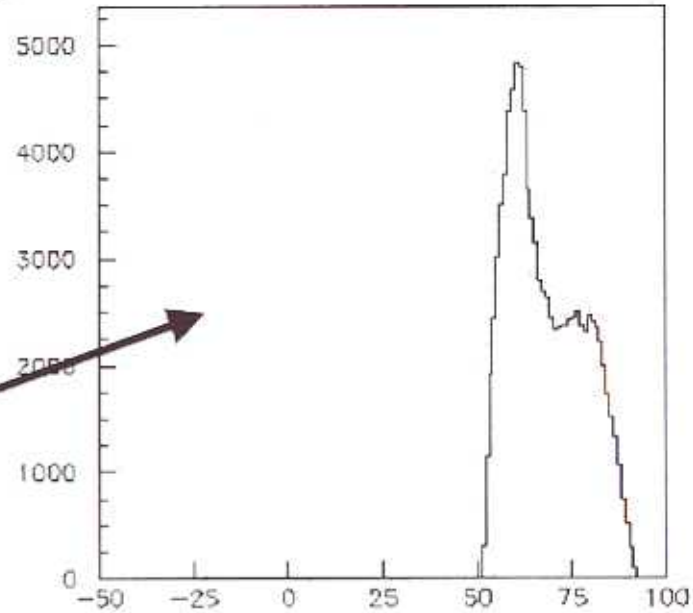

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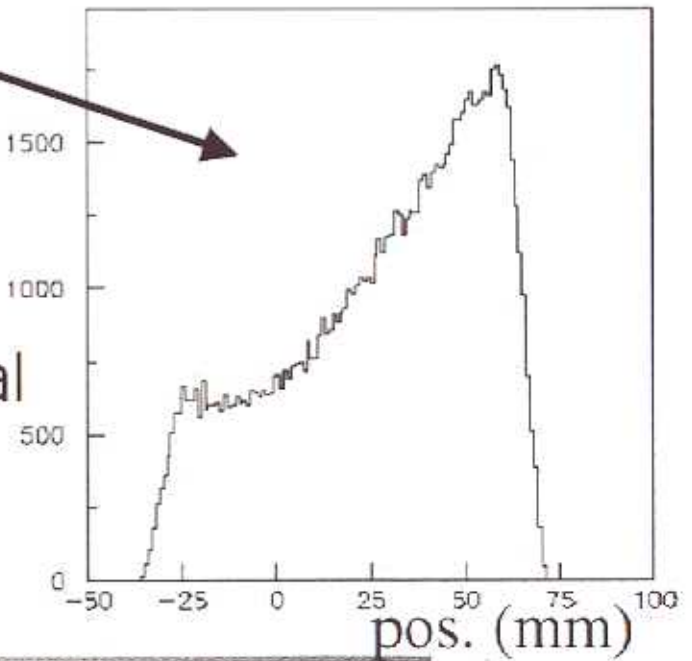


$acc^{\uparrow}_{left} \neq acc^{\downarrow}_{left}$

under P_{targ} reversal

$acc^{\uparrow}_{right} \neq acc^{\downarrow}_{right}$

Asymmetry Extraction

$$N_r^{\uparrow} = \sigma_0 \cdot L^{\uparrow} \cdot acc_r^{\uparrow} \left(1 + A_N P_{t\arg} \cos\varphi\right)$$

$$N_l^{\downarrow} = \ldots$$

$$\ldots$$

$$A_N = \frac{1}{\langle \cos\varphi \rangle} \cdot \frac{1}{\langle P_{t\arg} \rangle} \cdot \frac{\sqrt{N_l^{\uparrow} \cdot N_r^{\downarrow}} - \sqrt{N_r^{\uparrow} \cdot N_l^{\downarrow}}}{\sqrt{N_l^{\uparrow} \cdot N_r^{\downarrow}} + \sqrt{N_r^{\uparrow} \cdot N_l^{\downarrow}}}$$

Luminosities $L^{\uparrow\downarrow}$ and acceptances $acc_{l/r}$ cancels in the geometric mean provided that

$acc^{\uparrow}_{left} = acc^{\downarrow}_{left}$ and $acc^{\uparrow}_{right} = acc^{\downarrow}_{right}$

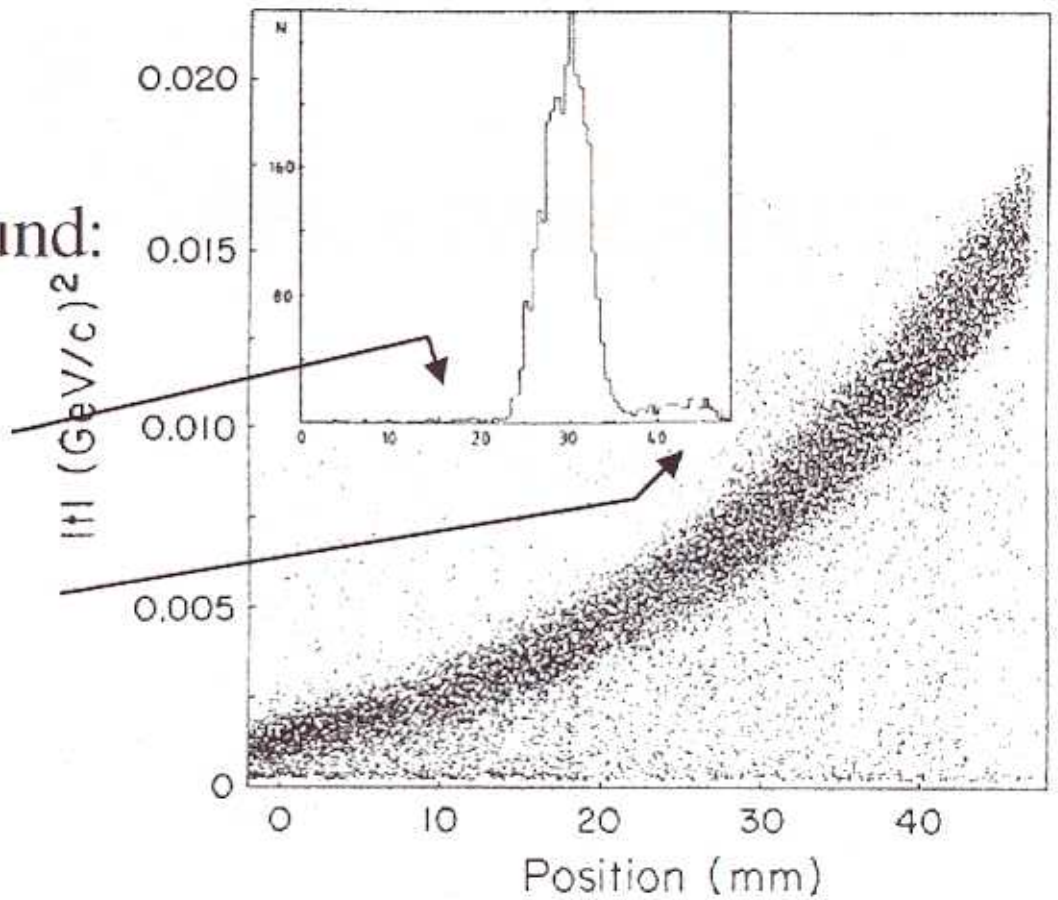
$\Rightarrow$ Introduce compensating field for target holding field ?

|t| vs pos. from UA6 → background

two sources of background:

a) beam gas interactions
   < 1%

b) beam proton dissociation
   < 1% below elastic peak



Background !? We have to live with it !

- Mainly two sources of background:
  - Beam gas interactions: at 10^{-9} torr, ~ 10^{7} atoms / cm^3
  - Proton dissociation $pp \rightarrow Xp$ dissociation

- Acceptable level of background:

$$A_N^{mes} = A_N - \left(A_N - A_N^{BG} \right) \cdot R \qquad R = \frac{N^{BG}}{N^{S} + N^{BG}}$$

$$\Delta A_N < 10^{-3} \;\Rightarrow\; \left| A_N - A_N^{BG} \right| \cdot R < 10^{-3}$$

For $A_N^{BG} \sim 10\%$, $R \sim 1\%$ acceptable

- Otherwise Background Subtraction

For $R \sim 5\%$ (2%) $\rightarrow$ $\Delta R \sim$ 5% (2%) OK for $A_N^{BG} \sim 30\%$

For $R \sim 2\%$ $\rightarrow$ $\Delta R \sim$ 10% OK for $A_N^{BG} \sim 30\%$

$pp \rightarrow Xp$ Dissociation

Kinematically quite different from elastic process

$$\sin\vartheta_R^{Xp} = \frac{M_X^2 - m_p^2}{2p_b\sqrt{|t|}} + \sin\vartheta_R^{el} \quad > \quad \sin\vartheta_R^{el}$$

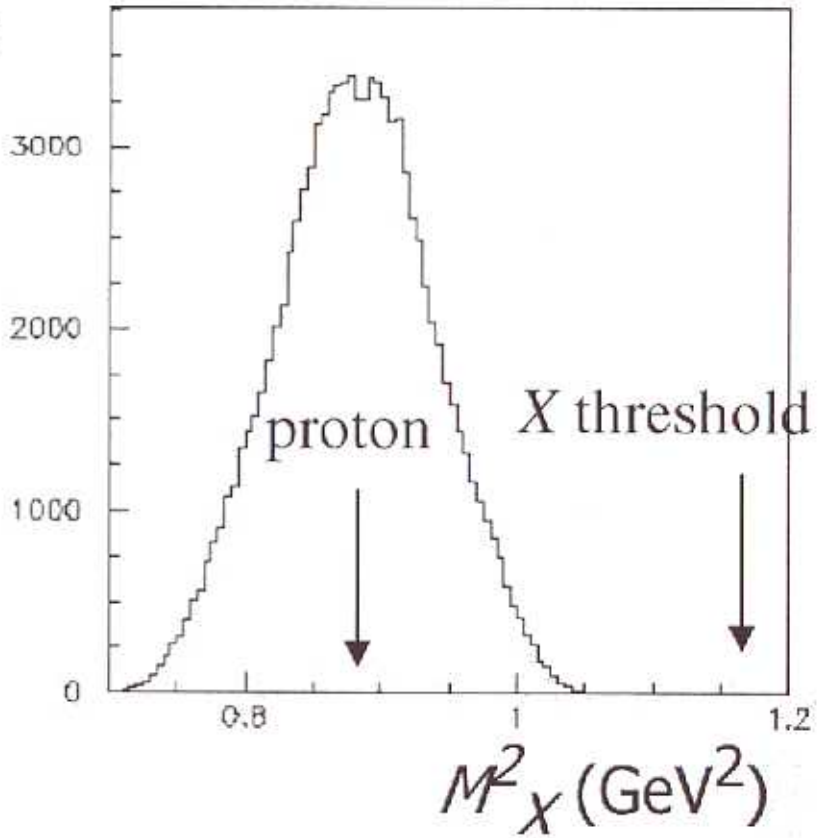
Suppresion of $pp \rightarrow Xp$ depends on how well one can reconstruct M_X

$$\Delta M_X^2 \approx 2p_b\sqrt{|t|}\,\Delta\vartheta_R$$

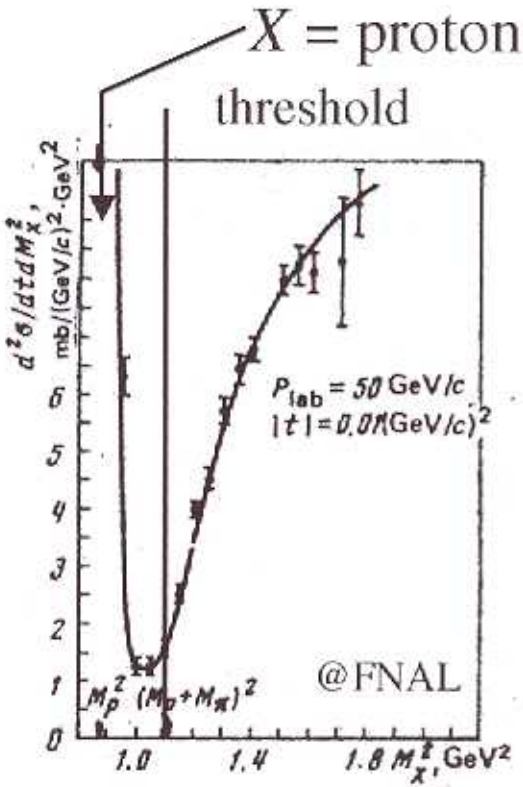
if $\Delta M_X^2 << (m_p + m_\pi)^2 - m_p^2$ OK

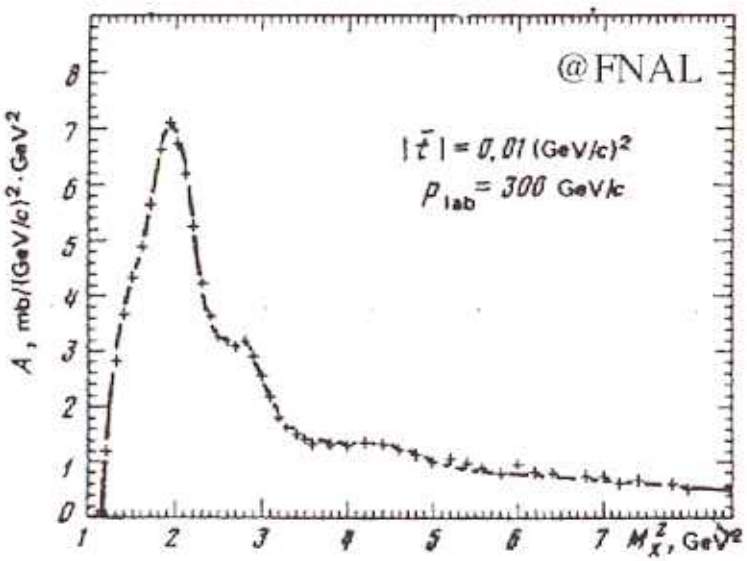
resolution on ϑ_R depends on distance from target and target long. ext.

NB at threshold coplanarity doesn't help !



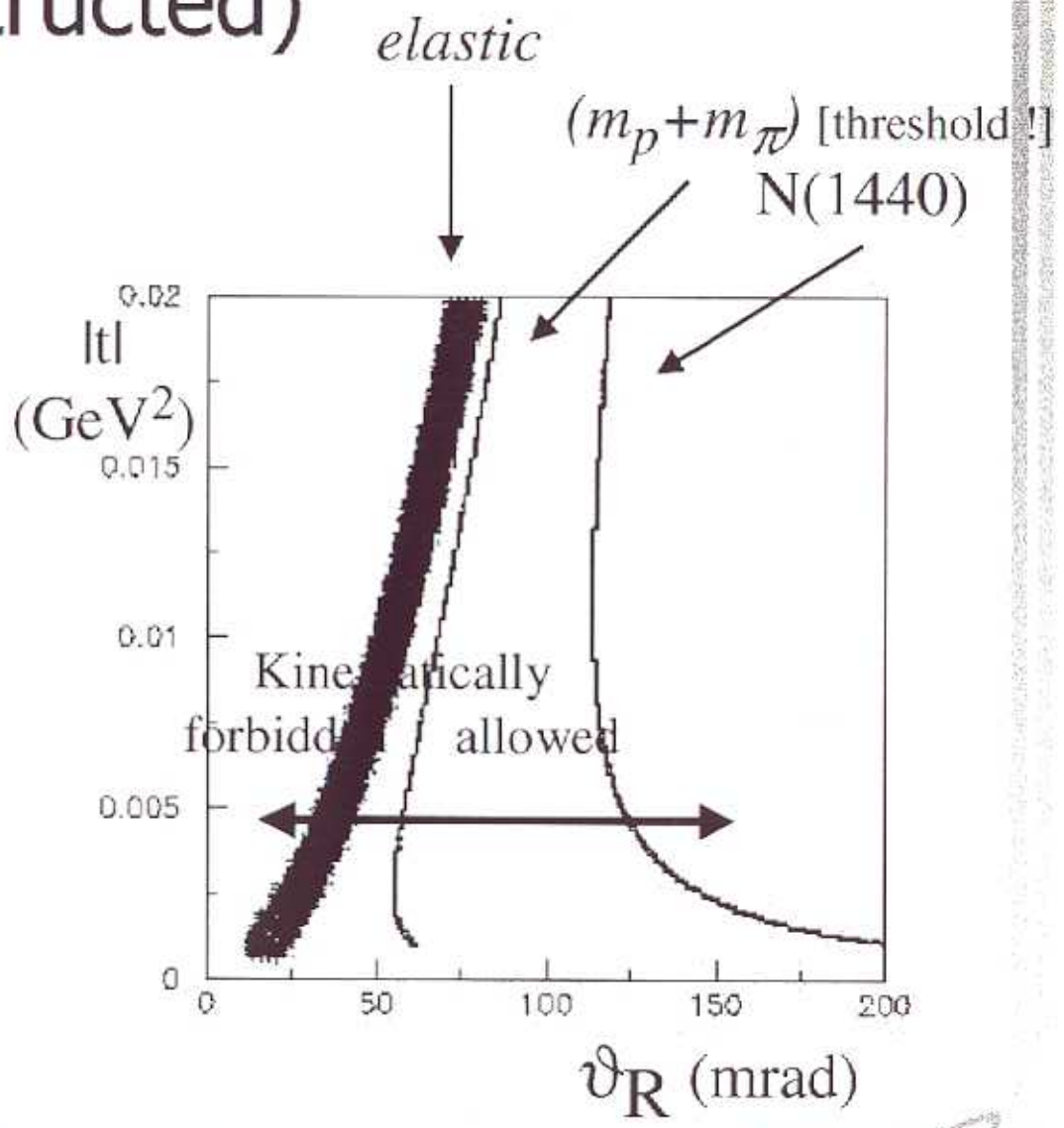
$\Delta\sigma / dM^2_X$





σ (*elastic*) ~ 100 x σ ($pp \rightarrow Xp$) at threshold !

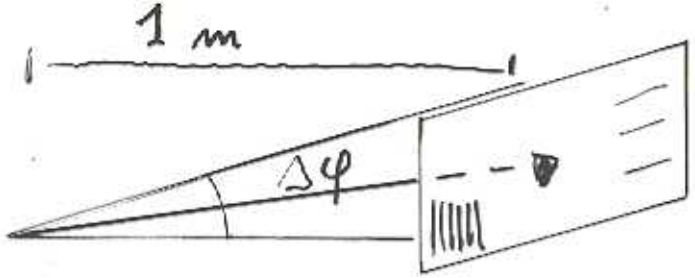
t vs ϑ_R (reconstructed)



$\Delta\vartheta_R$= targ. ext. / dist.
~ 5 mrad

$t = 2\, m_p\, T_{kin}$
$\Delta\, T_{kin} < 0.1$ MeV

Recoil Detector ?



requirements

- good energy resolution $\Delta E < 0.1$ MeV
- space resolution $\Delta x \sim$ mm
- time resolution $\Delta t \sim 1-2$ ns

$\Delta\varphi = 15^\circ \Rightarrow 80\,(h) \times 250\,(v)$ mm^2

+ay 5 Si detectors of 80×50 mm^2

⇓

{ vertical segmentation ~ 3 mm

{ horizontal segment. ~ 10 mm $\Rightarrow \delta\varphi = 10$ mrad

Thickness: 10 MeV p $\Rightarrow$ ~ 1 mm (quite thick)

use instead stack of Si detectors

Conclusions

- Comfortable statistics (10^6 events in ~ 3 hours)
- $\Delta p_{beam} / p_{beam} < 5\%$
  $\Rightarrow \Delta A_N < 10^{-3}$ ... feasible, but $\Delta p_{targ} / p_{targ} \sim 2\%$
- Background under control (not too bad !)
  - Roman pots not really necessary in CNI region
  - Roman pots essential for larger *t* (use *pp2pp*)
- Holding field $\Rightarrow acc^{\uparrow}_{left} \neq acc^{\downarrow}_{left}$ ($acc^{\uparrow}_{right} \neq acc^{\downarrow}_{right}$)
  - compensating field?
- Recoil detector based on existing technology
- Don't forget: also very interesting physics !!!

ep-POLARIMETER FOR RHIC REVISITED

F. Meissner, LBNL, November 2001

for
RHIC Spin Collaboration Meeting VI (Part 2)
RIKEN BNL Research Center