E906/SeaQuest Drell-Yan Experiment

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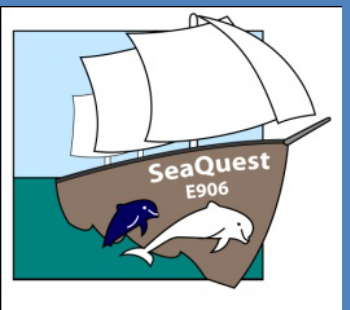
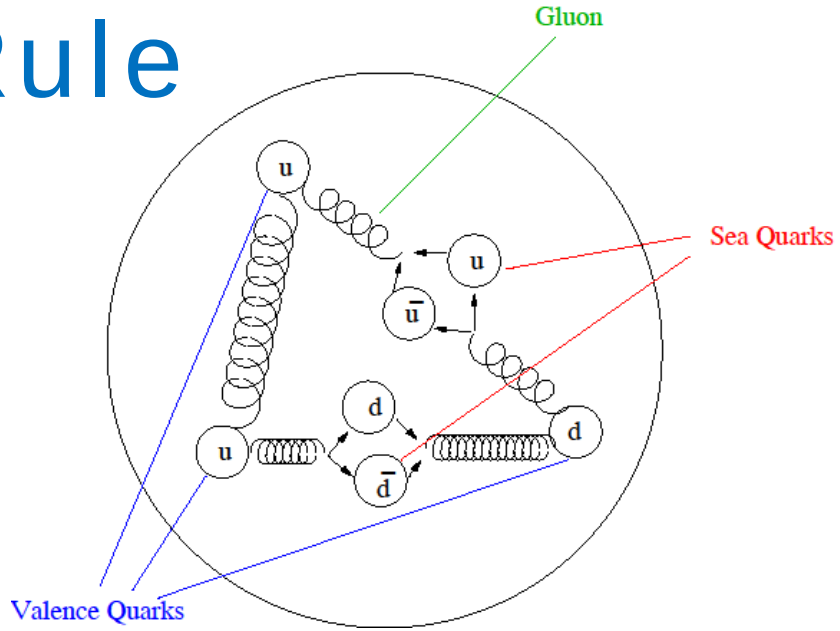
for the
E906 Collaboration
June 8th, RHIC/AGS User's Meeting



Gottfried Sum Rule



- Gottfriedt Sum Rule:

  $S_G = 1/3$ if $u = d$

$$S_G = \int_0^1 \left[F_2^p - F_2^n\right]\frac{dx}{x}$$

$$= \frac{1}{3} + \int_0^1 \frac{2}{3}\left[\bar{u} - \bar{d}\right]dx$$

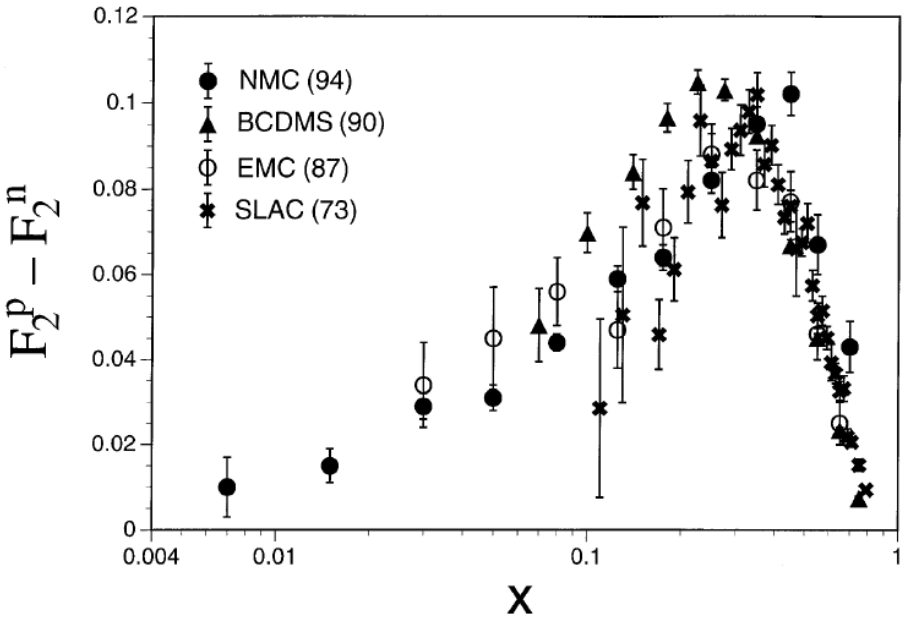
$$= \frac{1}{3}$$

Charge Symmetry

$$\bar{u} = \bar{d}$$

NMC Measurement

$0.004 < x < 0.8$



New Muon Collaboration (NMC), Phys. Rev. D50 (1994) R1

Extrapolate results over all x ($0 < x < 1$)

$S_G = 0.235 +/- 0.026$

Nuclear shadowing (double scattering of virtual photon from both nucleons in deuteron) ~ 4-10% effect on Gottfried sum ➔ disagreement with naive calculation of GSR remains

Reconciling the Disconnect

Three assumptions:

NMC:

1. Problems with extrapolation of NMC measurement to lower x?

   ↳ E665 experiment measured to lower x

GSR:

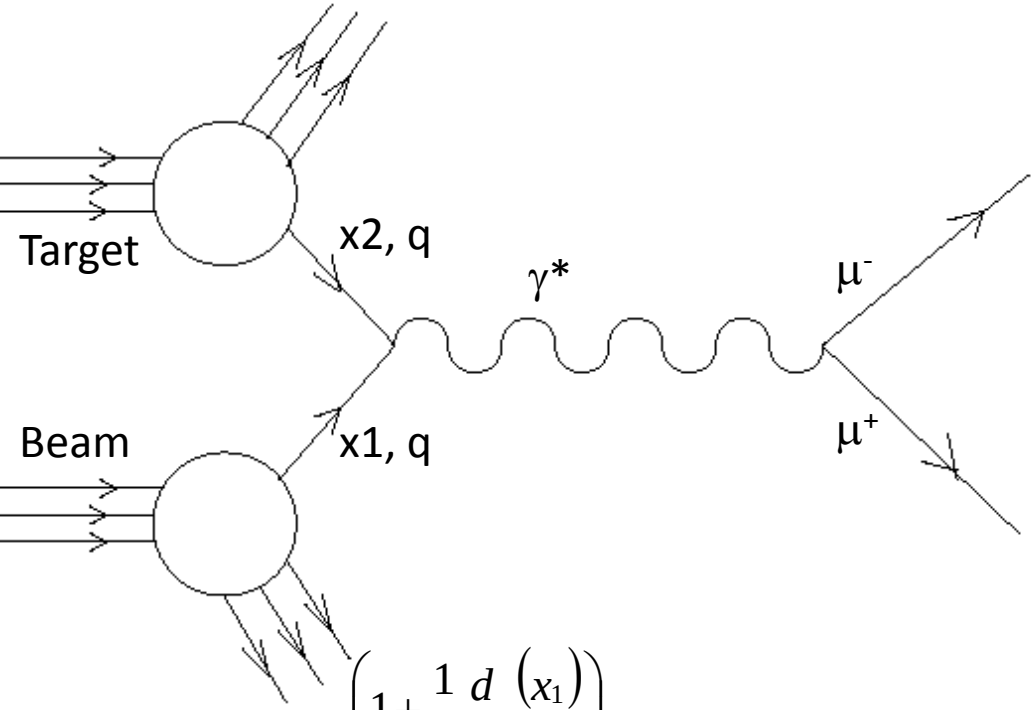
1. Charge symmetry does not hold?

   ↳ No signs of charge symmetry breaking

2. $\overline{u} \neq \overline{d}$?

   ↳ Directly measure through Drell-Yan

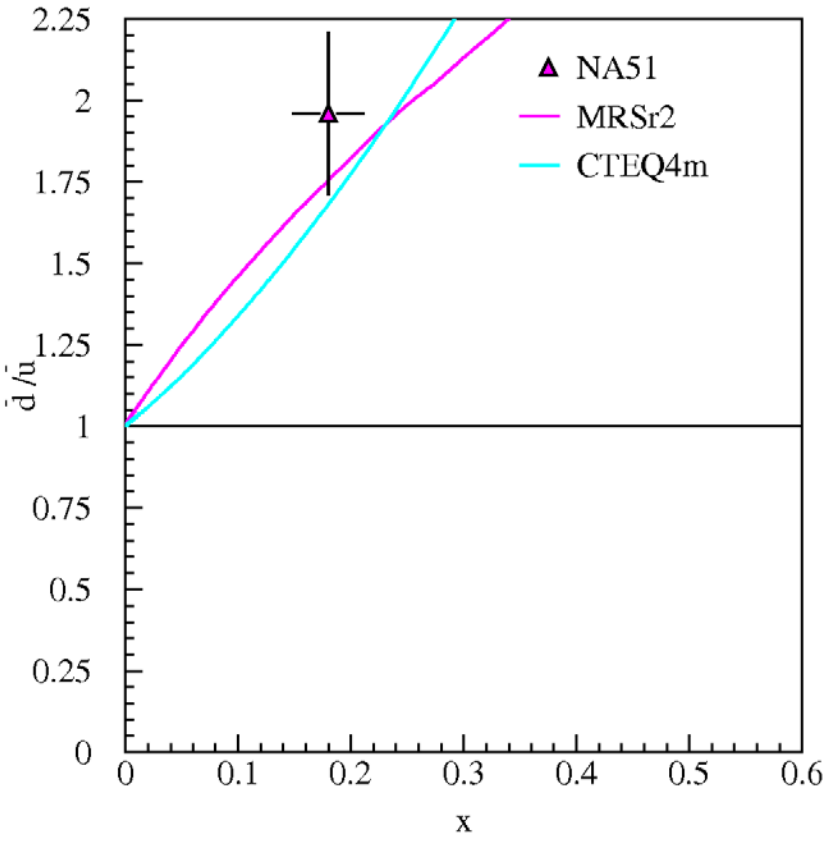
First Direct Measurement



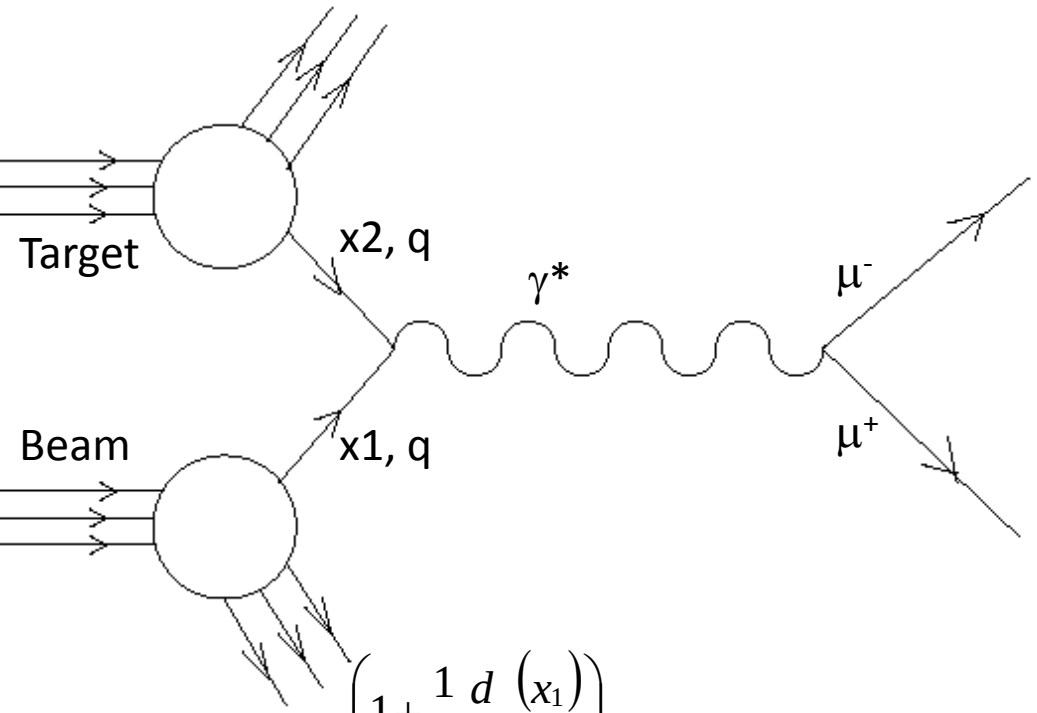
$$\left.\frac{\sigma^{pd}}{2\sigma^{pp}}\right|_{x_1 >> x_2} \approx \frac{1}{2}\frac{\left(1+\frac{1}{4}\frac{d}{u}(x_1)\right)}{\left(1+\frac{1}{4}\frac{d}{u}(x_1)\frac{\bar{d}}{\bar{u}}(x_2)\right)}\left(1+\frac{\bar{d}(x_2)}{\bar{u}(x_2)}\right)$$

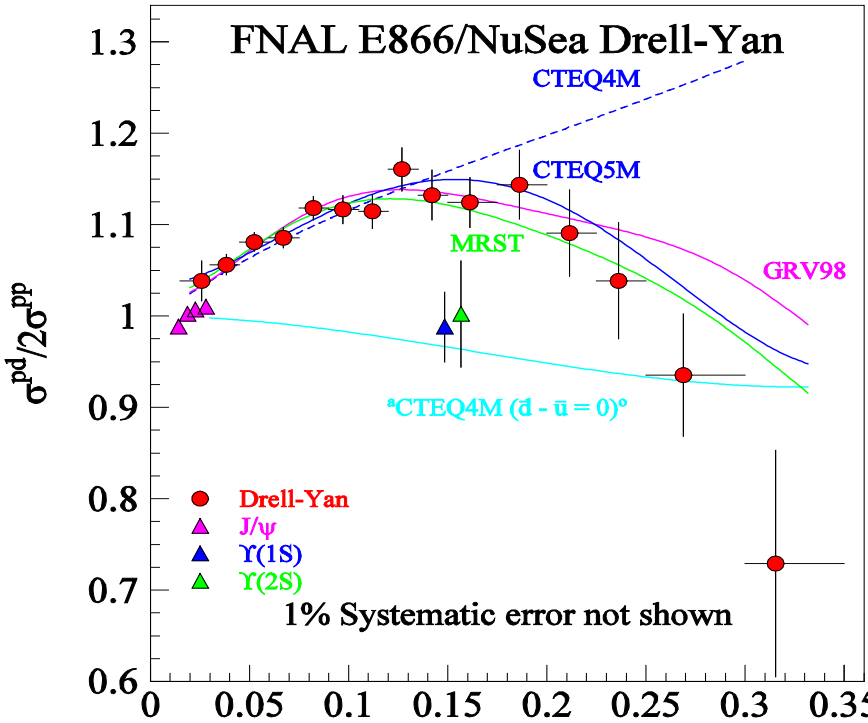
$$\approx \frac{1}{2}\left(1+\frac{\bar{d}(x_2)}{\bar{u}(x_2)}\right)$$

- NA51 (Drell-Yan) shows $u \neq d$



E866 Drell-Yan





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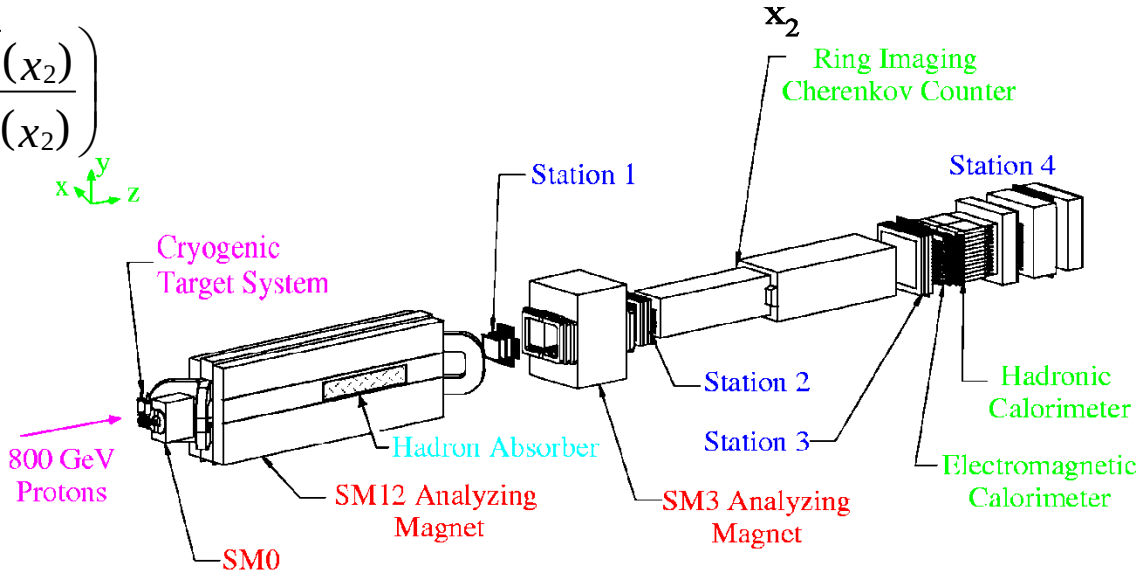
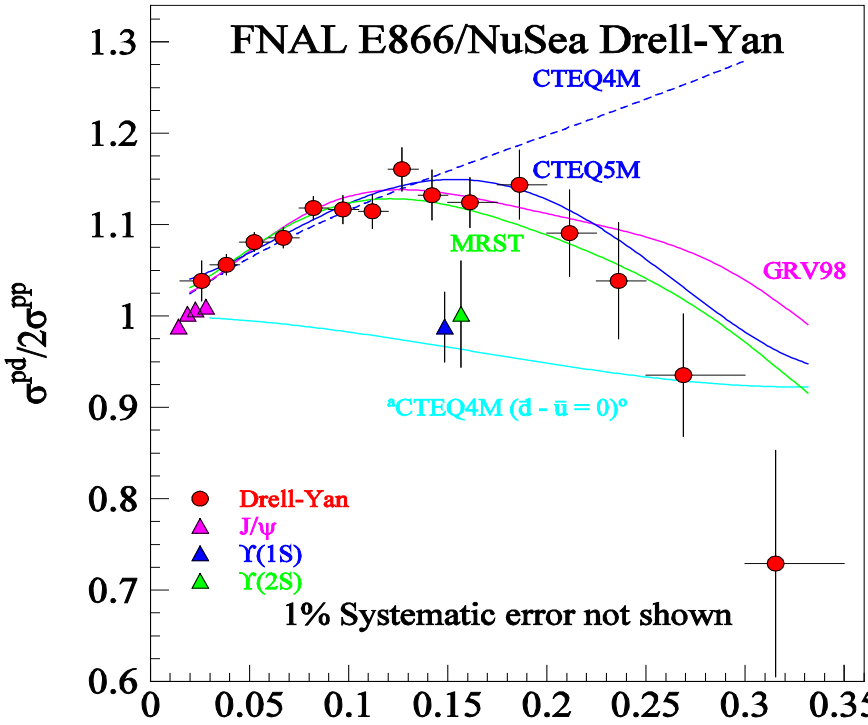
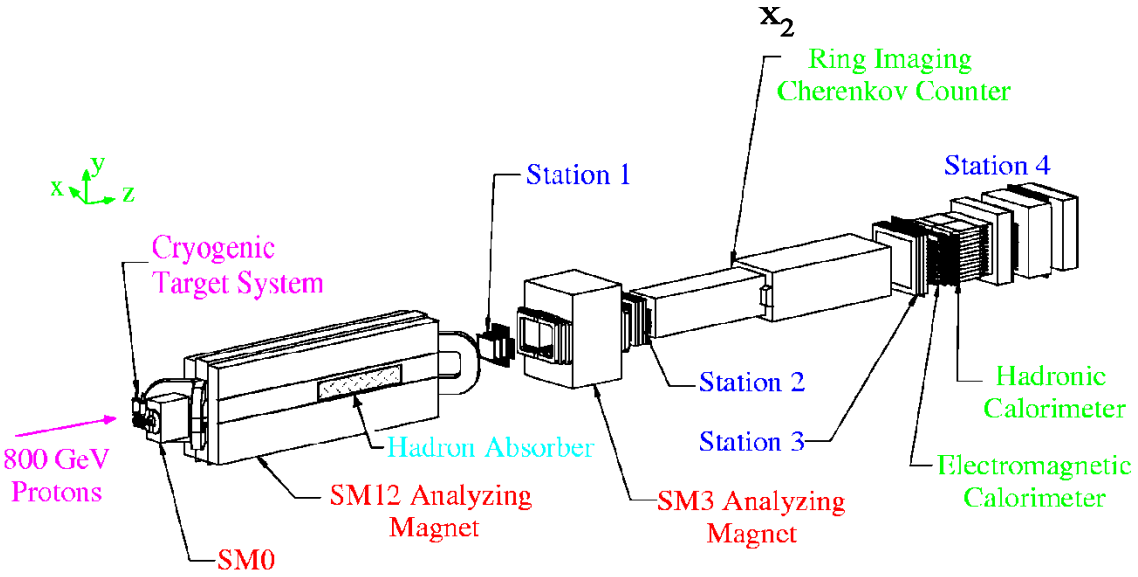
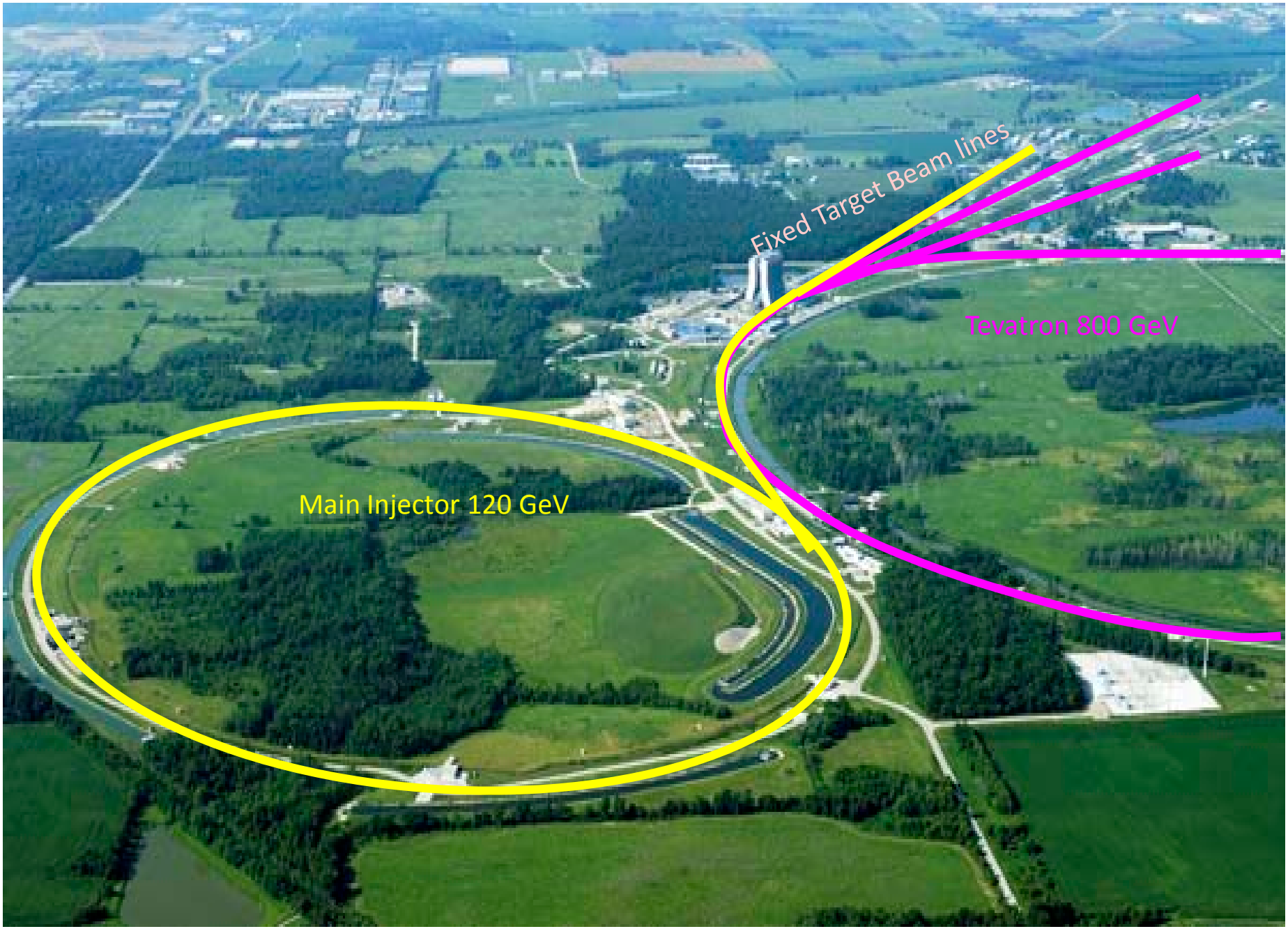


E866 Drell-Yan

- Fermilab NM4
- 800 GeV proton beam
- 0.04 < x < 0.35
- Uncertainties dominated by statistics (~1% systematic uncertainties in cross section ratio)






Fixed Target Beam lines
Tevatron 800 GeV
Main Injector 120 GeV

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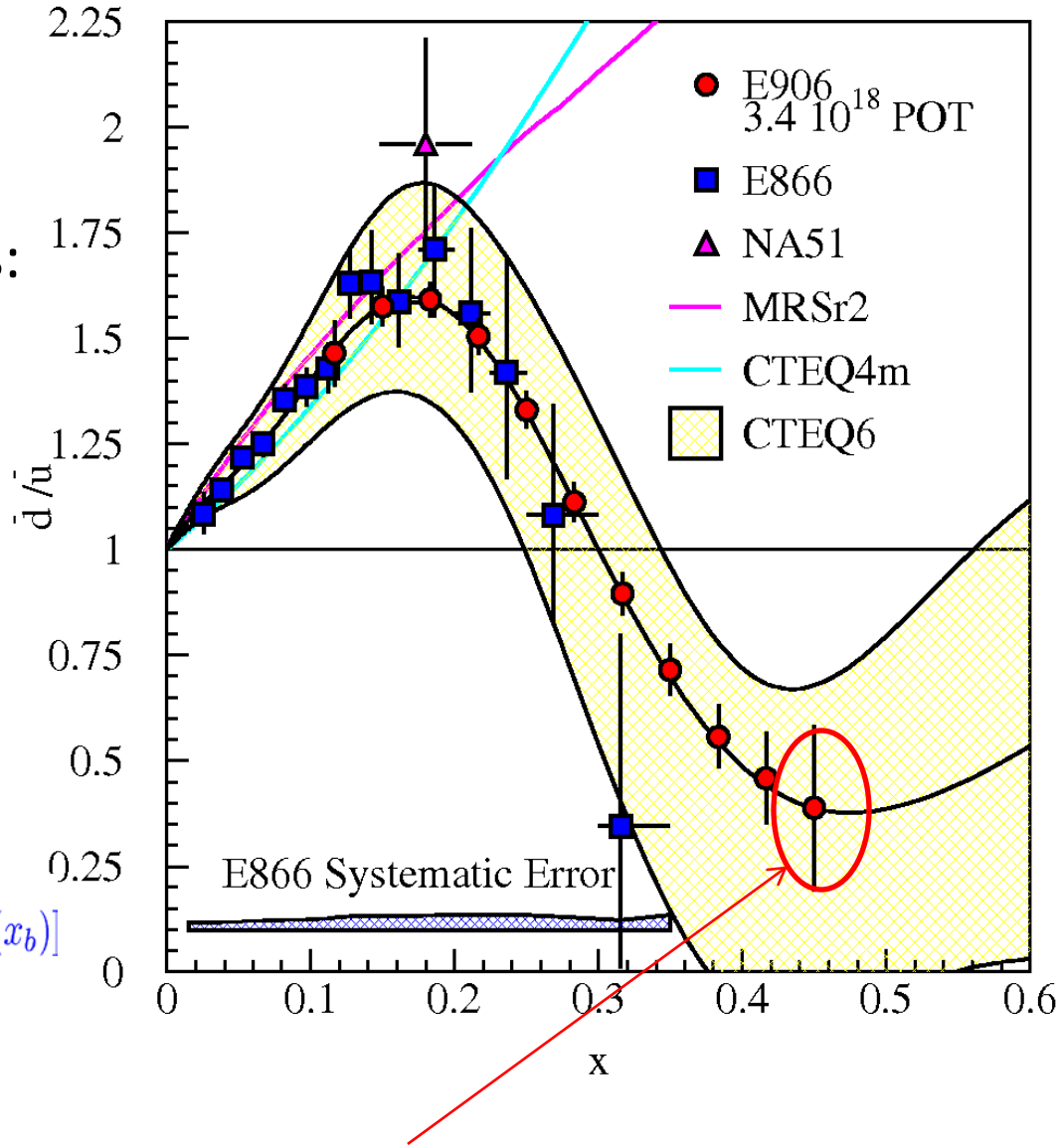
*Co-Spokespersons

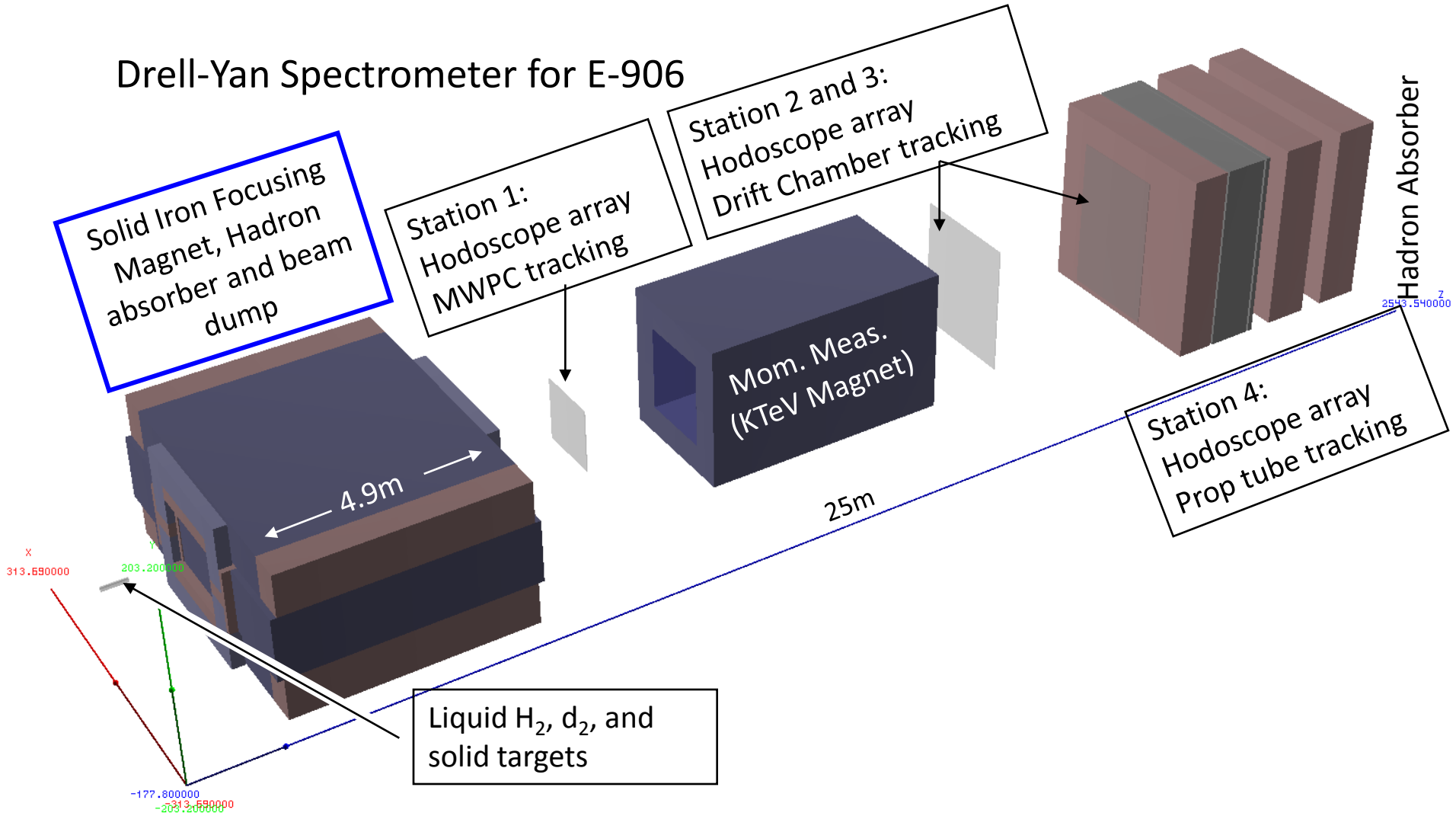
E906 Drell-Yan

- 120 GeV proton beam (E866: 800 GeV)
  - cross section scales as 1/s:
    7x statistics
  - background scales as s:
    7x luminosity
  - ➔50x statistics
- Systematic uncertainties ~1%

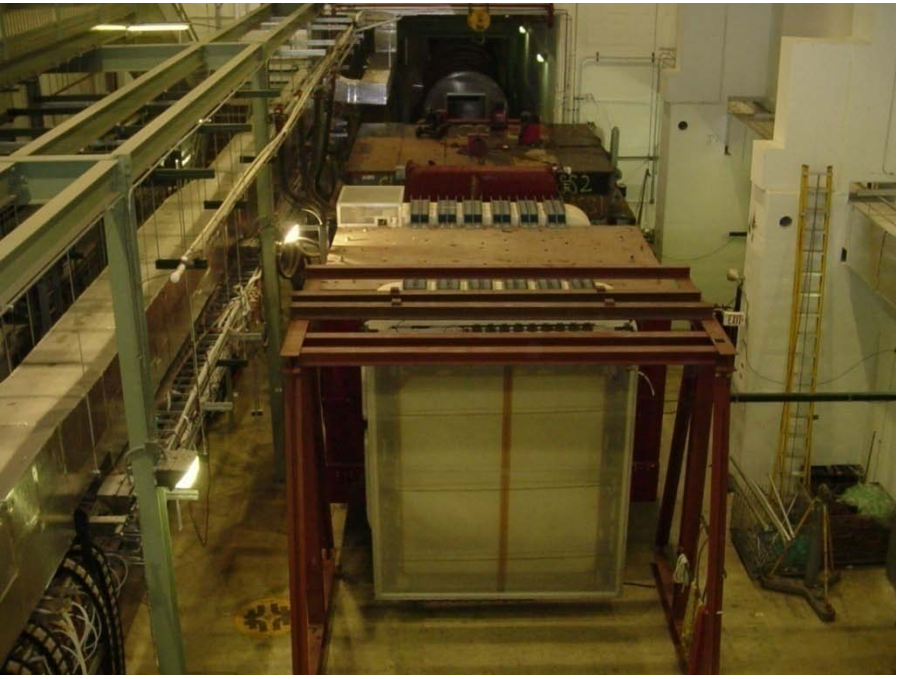
$$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha^2}{9x_1x_2}\frac{1}{s} \times \sum_i e_i^2 \left[q_{ti}(x_t)\bar{q}_{bi}(x_b) + \bar{q}_{ti}(x_t)q_{bi}(x_b)\right]$$

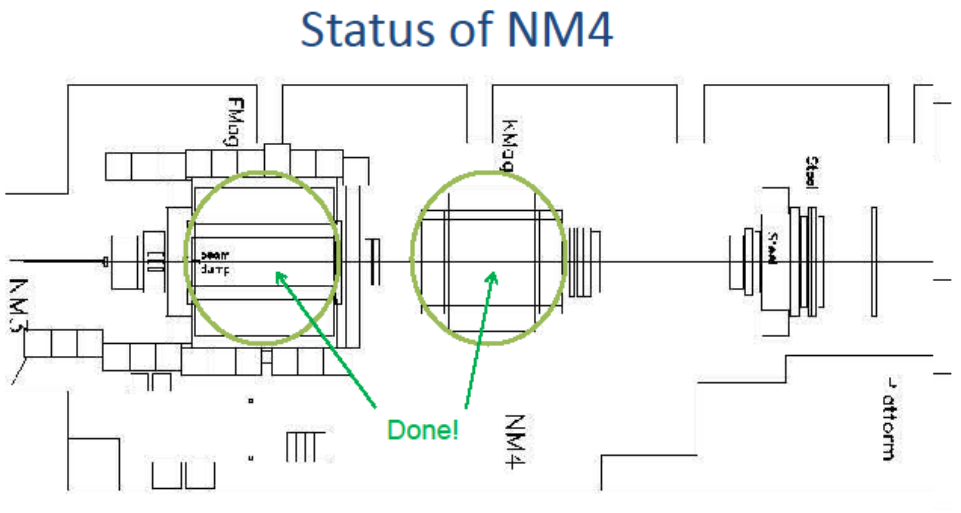


What happens at high x?


Drell-Yan Spectrometer for E-906
Solid Iron Focusing Magnet, Hadron absorber and beam dump
Station 1: Hodoscope array MWPC tracking
Station 2 and 3: Hodoscope array Drift Chamber tracking
Hadron Absorber
Mom. Meas. (KTeV Magnet)
4.9m
25m
Station 4: Hodoscope array Prop tube tracking
Liquid H_2, d_2, and solid targets

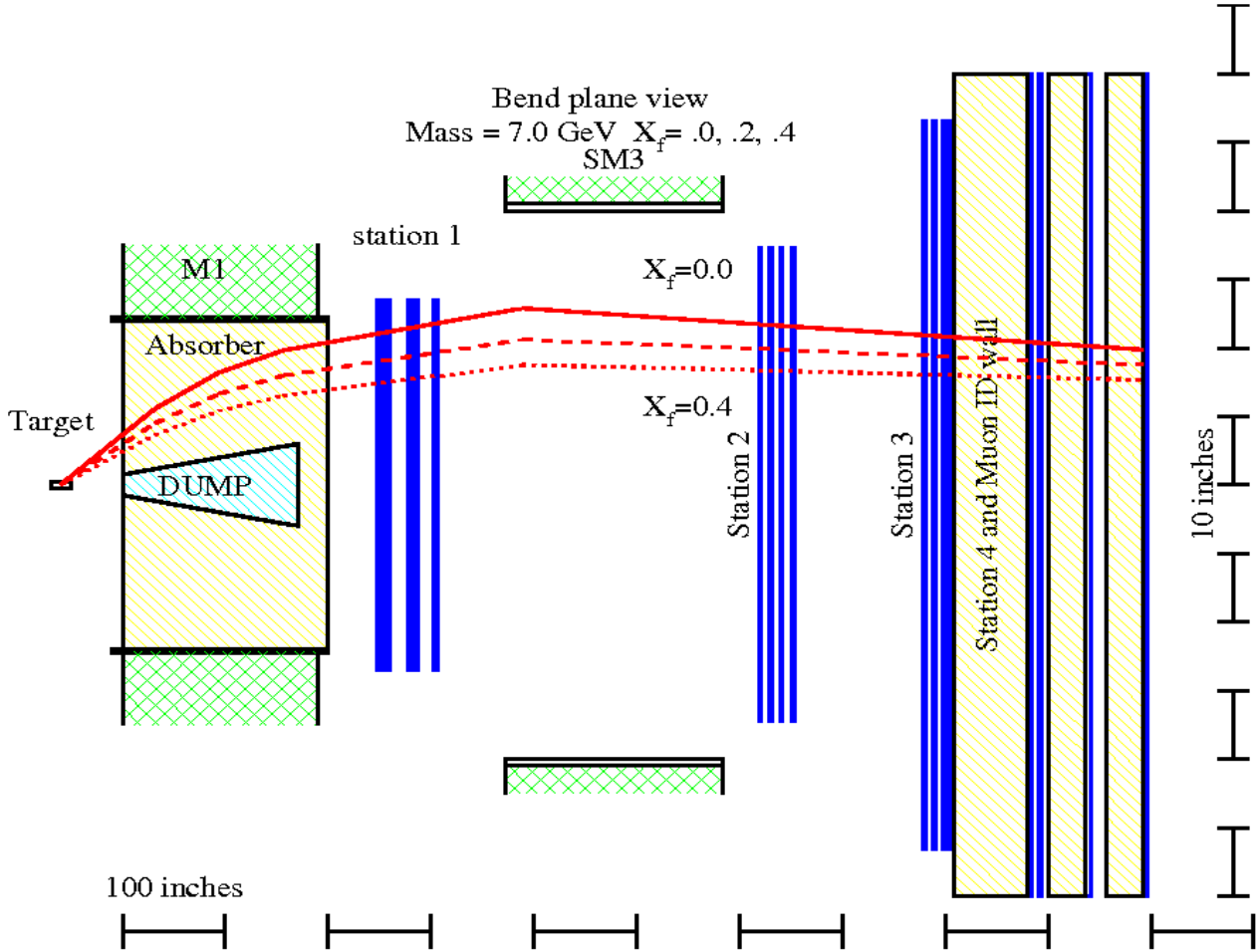
Magnet Installation





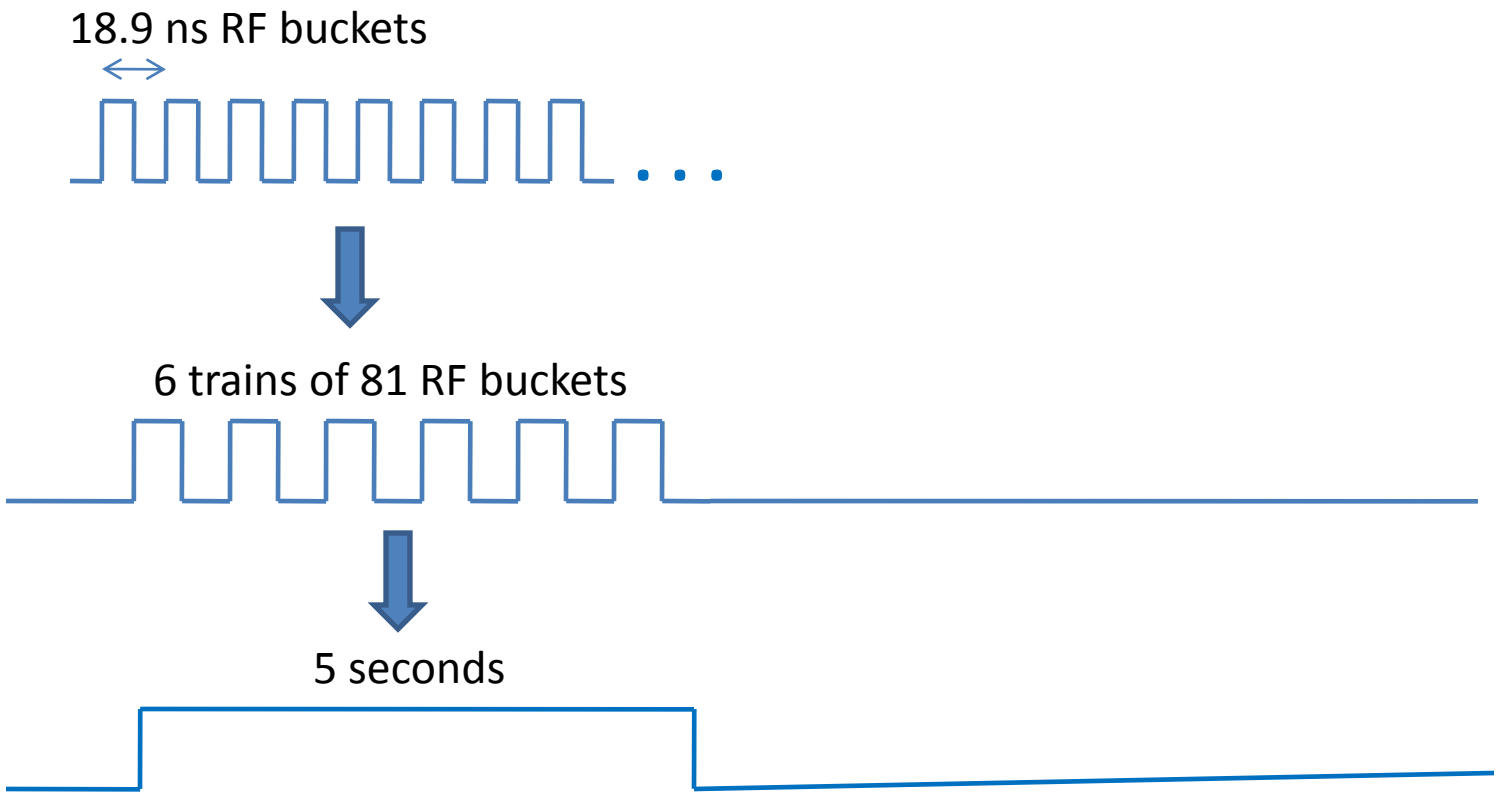
- Focusing magnet (FMAG) installed
- kTeV magnet (KMAG) installed
- Hadron absorber
- Beam dump (watch muons from J/ψ)

- Statistics are better, but some issues to keep in mind:
  - Lower particle energy ➔ increased muonic decay of hadronic background
  - Lower energy muons multiple scatter more readily in the hadron absorber



E906 Beam

- 53 MHz beam repetition frequency (18.9ns)
- 5 seconds every minute: 2 $\times 10^{12}$ protons/sec (5 W,1 $\times 10^{13}$ protons/min)
- 5.2 $\times 10^{18}$ total protons for experiment

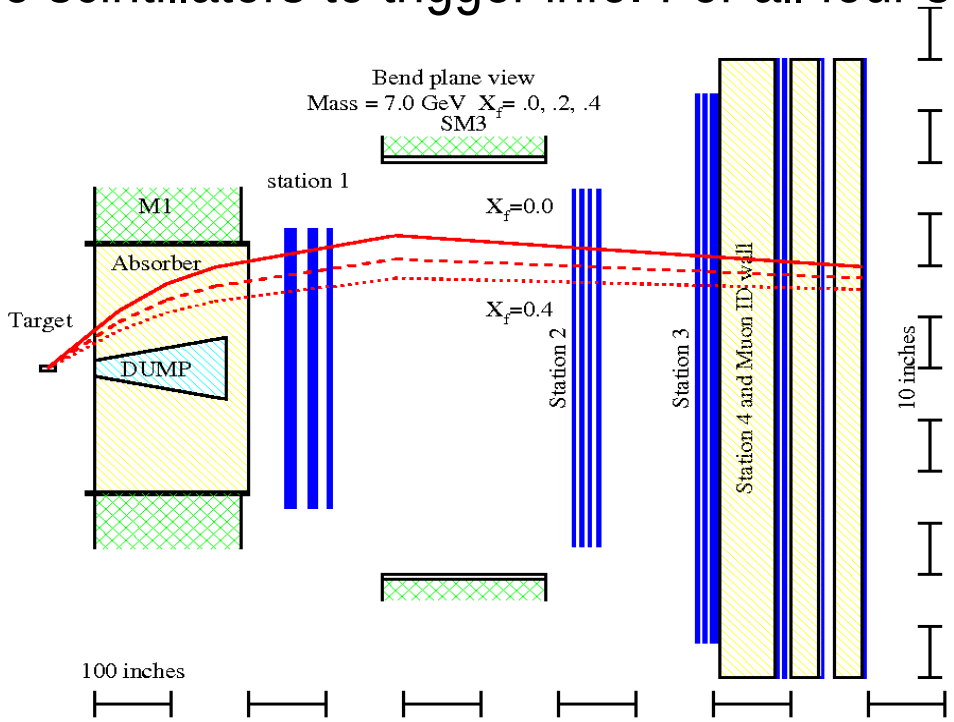


E906 Target

- 2 liter LH_2 and LD_2 target flasks
- Empty target for target systematics
- Solid targets (C, W, Ca)
- Targets on movable table: change targets between 5 sec pulses
- Closed circuit GM cryocoolers cools a condenser
- H_2/D_2 liquifies in condenser ➔ drips (fills) into target flask

Drift Chambers

- Station 1: MWPC (Multi-Wire Proportional Chamber)
- Station 2: E866 Station 2
- Station 3: Two halves
  - Lower half: E866 Drift Chamber
  - Upper half: Newly designed and constructed
- Station 4: Muon Prop. Tubes
- Hodoscope scintillators to trigger info. For all four stations



Schedule

- First commissioning beam in July (?) depending on machine schedule.
- Experiment with H_2/D_2 to begin late 2010.
- Run with full beam ~2 years
- Prospects for further Drell-Yan experiments at J-PARC (50 GeV proton beam)