First Beam at Fermilab SeaQuest/E906: Status and Plans

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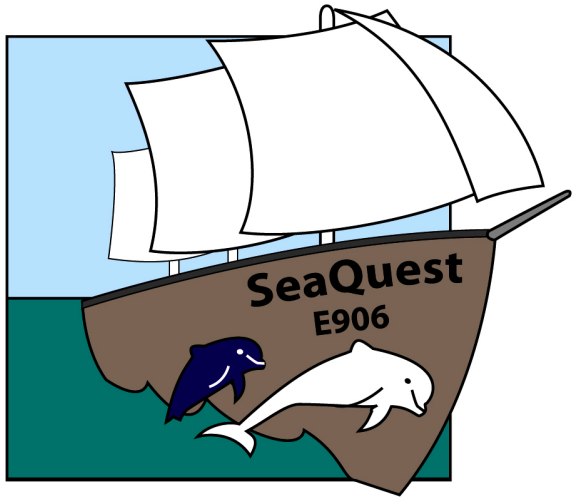

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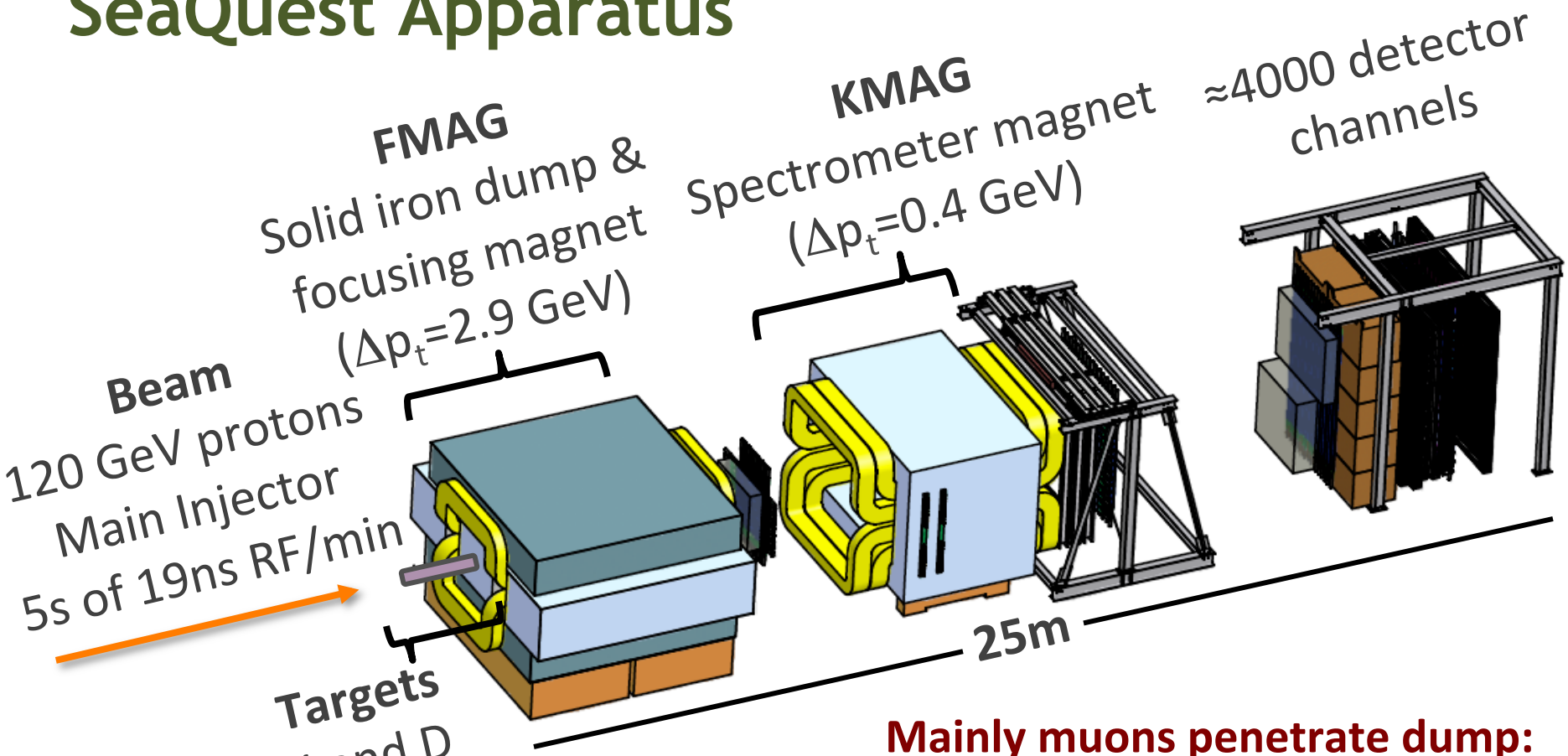
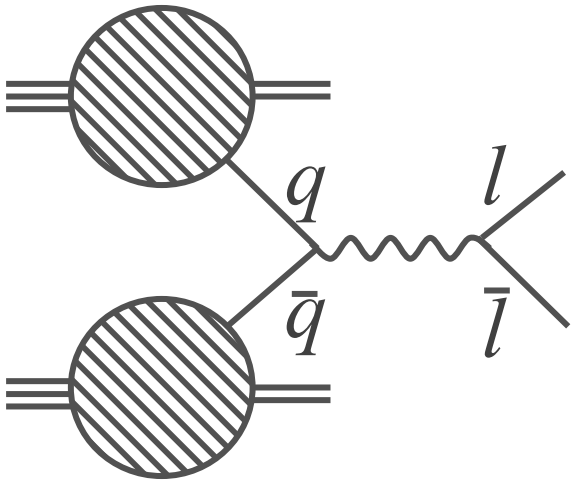
SeaQuest Apparatus

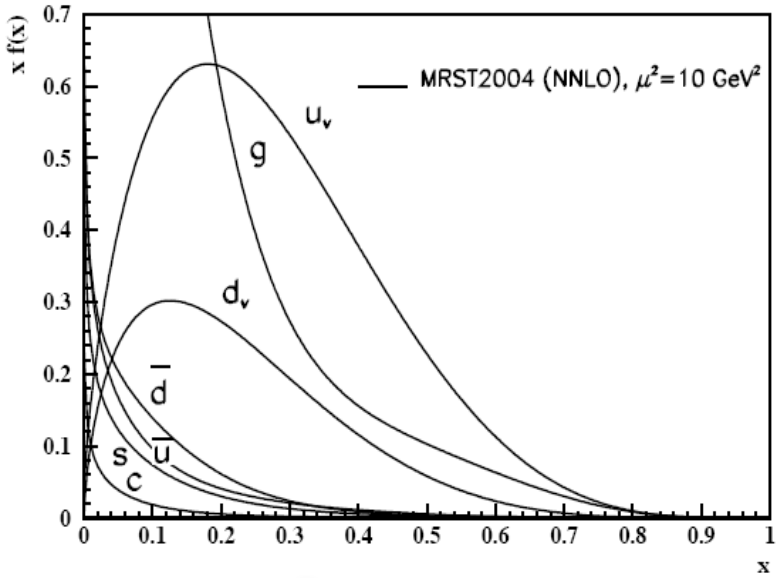


Mainly muons penetrate dump:

- Dimuon Pairs
  - Drell-Yan
  - J/ψ decay
- Single Muons
  - hadron decay

Fixed Target Drell-Yan Scattering: A Laboratory for Studying Sea Quarks





Fixed target favors large x_f (= $x_b - x_t$) →

$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_t x_b}\frac{1}{s}\sum_q e_i^2[\bar{q}_t(x_t)q_b(x_b) + q(x_t)\bar{q}(x_b)]$$

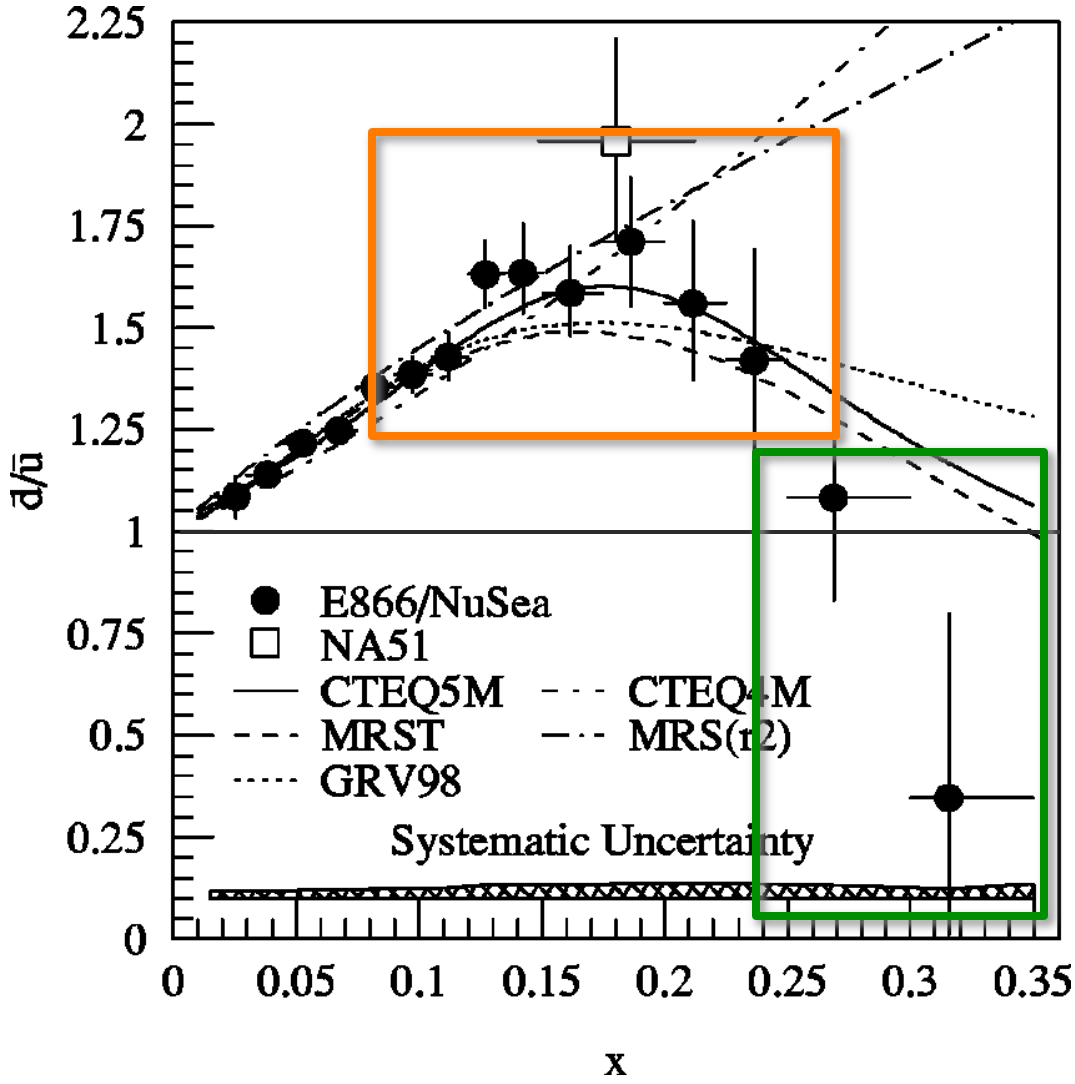
Beam antiquark densities negligible for large x_b

- **Sensitive specifically to antiquarks in the target!**
- **Complements DIS results**

Measuring the Light Sea Asymmetry

$$\left.\frac{\sigma^{pd}}{2\sigma^{pp}}\right|_{x_b \gg x_t} \approx \frac{1}{2}\left[1 + \frac{\bar{d}(x_t)}{\bar{u}(x_t)}\right]$$

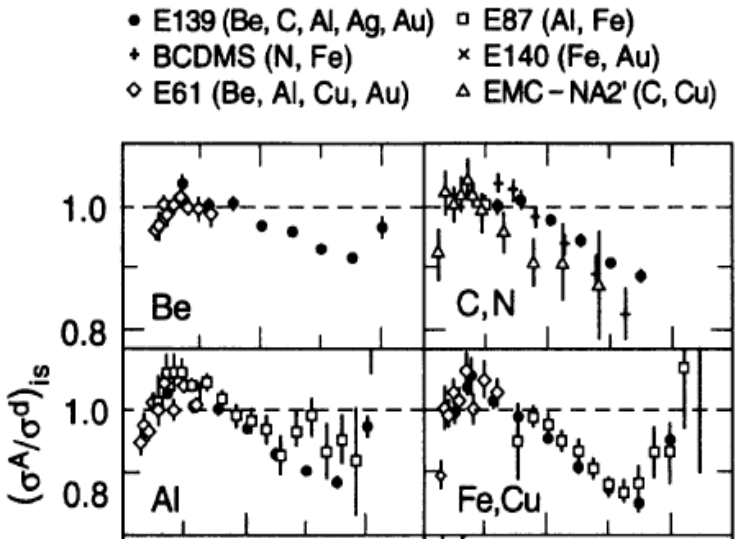
- What is the origin of the quark sea?
- Naïvely expect flavor symmetry
- E866 measured an asymmetric light quark sea
- Caused by influence of valence quarks? Virtual mesons?

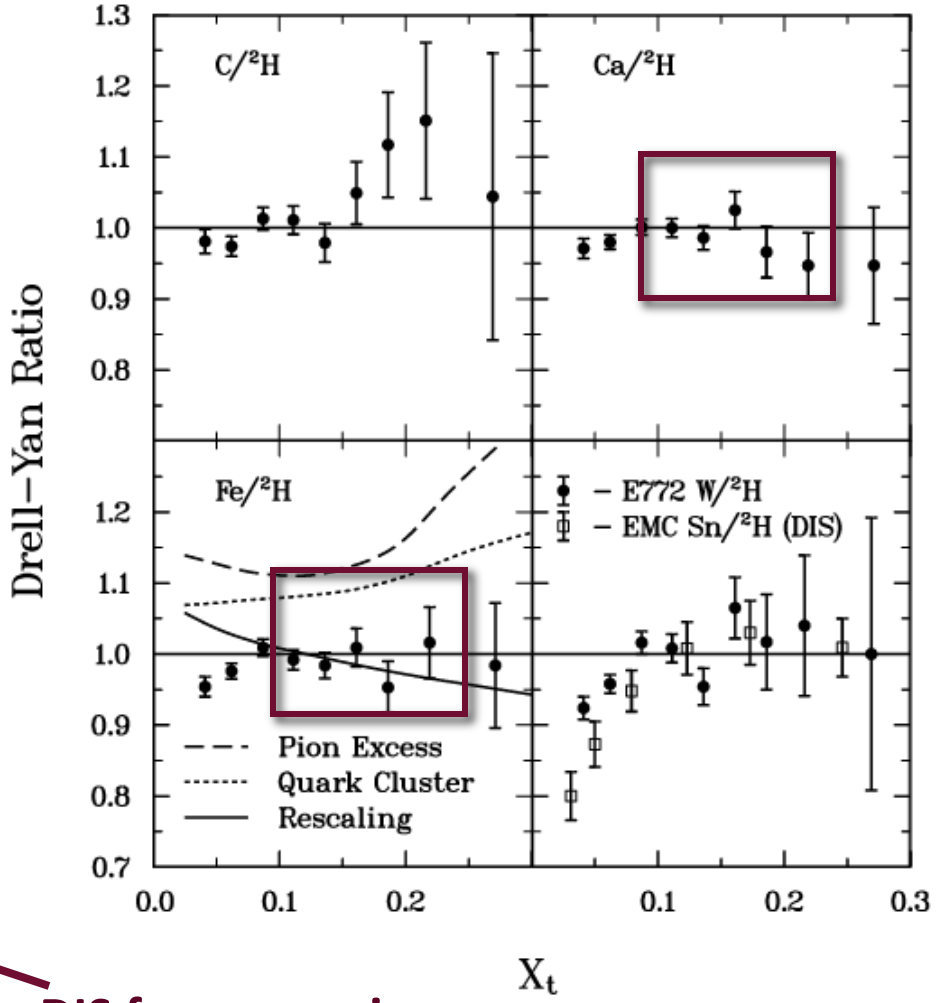


PHYSICAL REVIEW D, VOLUME 64, 052002

Nuclear Dependence of Drell-Yan - Exciting mysteries!

- **E772 produced results on several nuclear targets**
- **No evidence of DIS-like anti-shadowing for sea-quarks.** ***Interesting...***





DIS for comparison

Alde *et al* (Fermilab E772) Phys. Rev. Lett. **64** 2479 (1990)

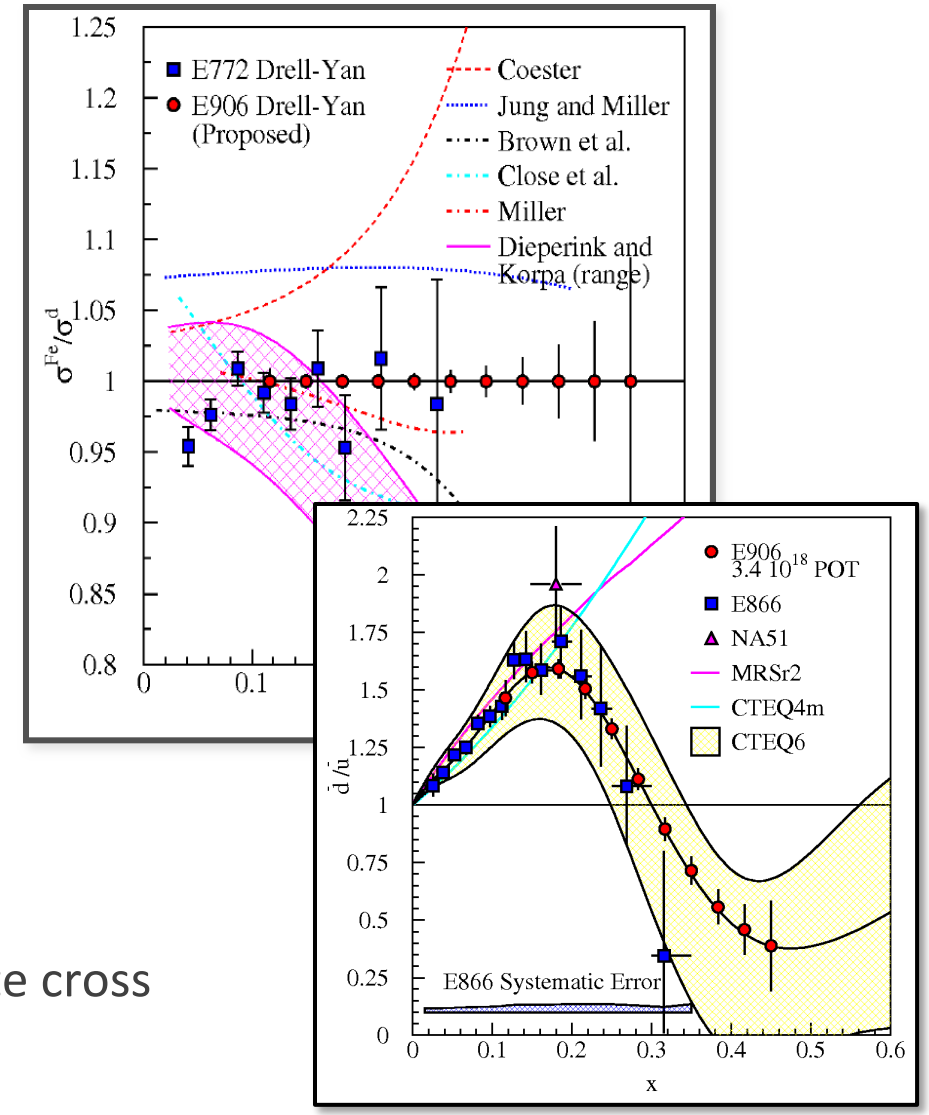
E906/SeaQuest – D-Y Comparison with E866

120 GeV protons from FNAL main injector (vs. 800GeV @ E866)

$\sigma^{\text{Drell-Yan}}$ falls off as 1/s

J/ψ background proportional to s

50x relative increase in precision!

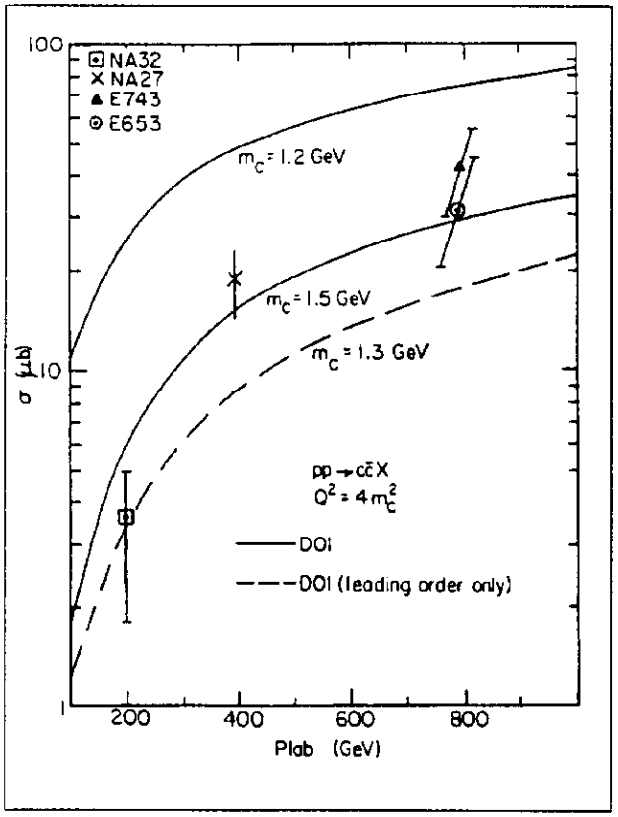


And other PDF related topics… absolute cross sections, partonic energy loss.

Charm at SeaQuest

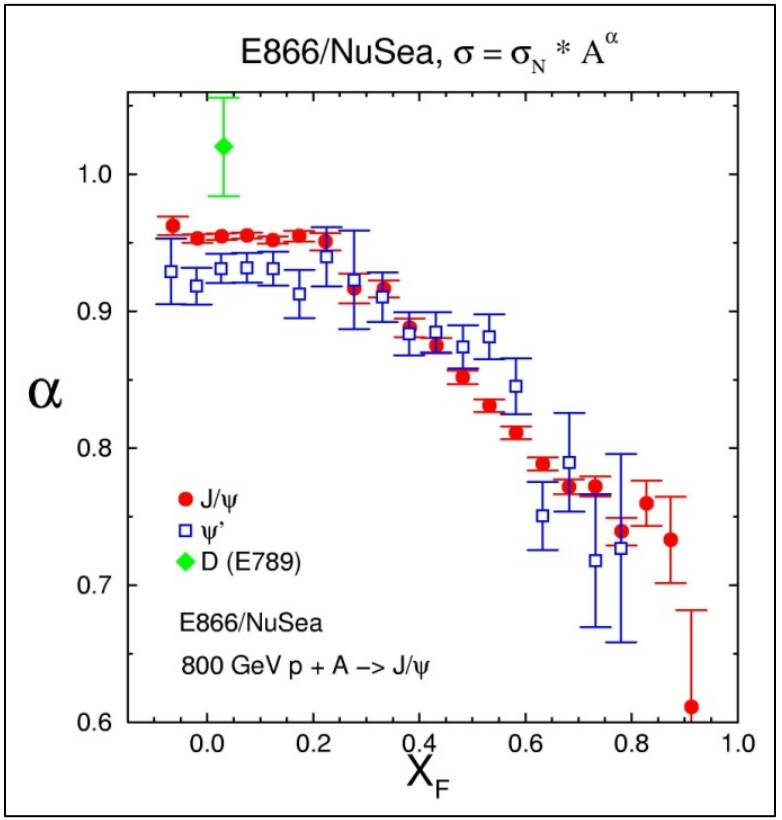
- J/ψ is the (large!) background for the Drell-Yan analyses
- D-mesons dominate singles rate at large angles

cross section changes rapidly



Ann.Rev.Nucl.Part.Sci. 42 (1992) 367-399

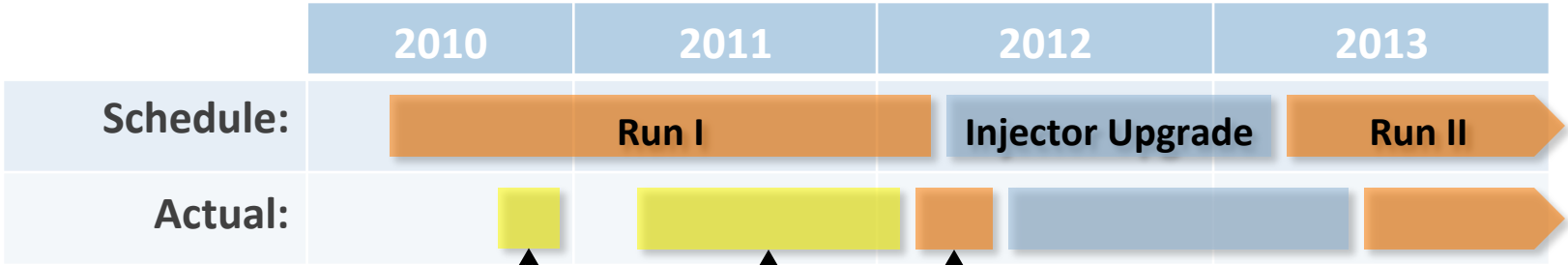
nuclear dependence Effect of nuclear matter?

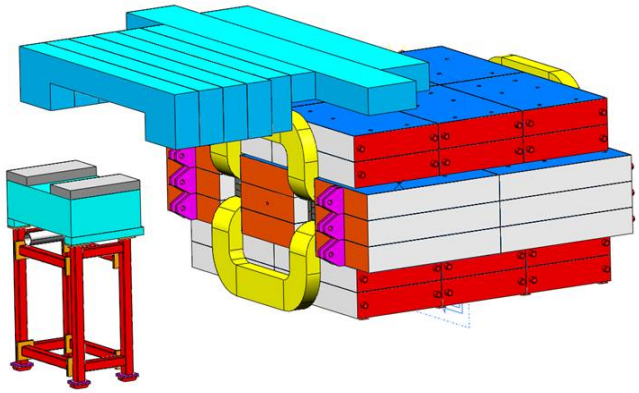


Phys.Rev.Lett. 84 (2000) 3256-3260

The SeaQuest Timeline - Some Unexpected Difficulties

The Fermilab Main Injector is currently shut down to upgrade intensity





- Beamline loses vacuum
- Last delivered beam to KTEV
- 760' pipe buried under berm
- *Ultimately* leak controlled and reasonable vacuum was possible

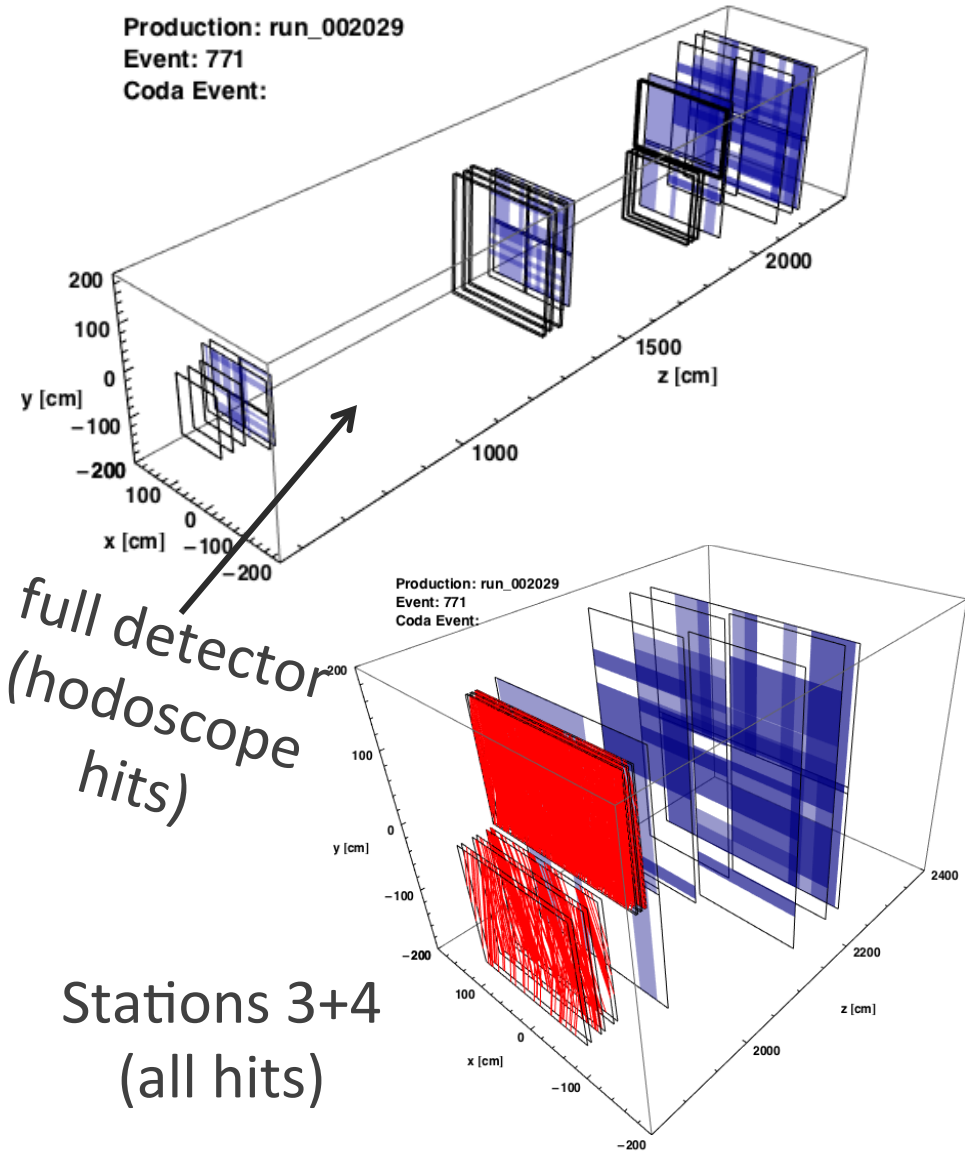
- Additional radiation shielding required
- 500 tons of concrete and steel
- 14 tons of steel on movable cart

Run I became a short commissioning run

Commissioning Run (~two months)

- First protons arrived in hall on March 8, 2012
- Run ended April 30, 2012 with beginning of shutdown
- **All systems worked!**
  - Typical issues with mapping and timing resolved quickly
  - Some challenges with TDC microcode – modules rolled-back to a prior software version, zero-suppression moved to VME CPUs.
    → relatively long dead-times (>1ms)
- Unexpectedly large hit multiplicities with dimuon trigger – termed **"splat events"**

“Splat” Events

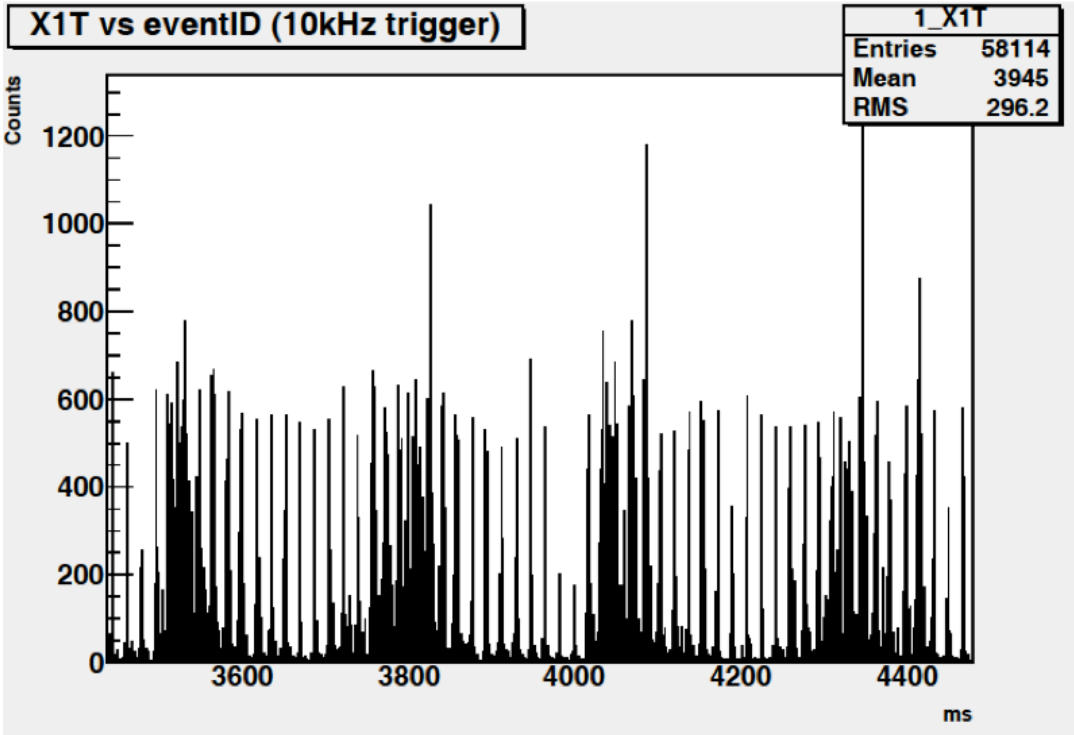


Symptoms and Clues:

- Very large hit multiplicity for dimuon trigger events for both matrix and simple NIM triggers
- All systems: hodoscopes, chambers, and prop. tubes swamped
- Single trigger (1*2*3*4) provides clean single tracks
- *Average* intensity normal, measured by beamline instrumentation

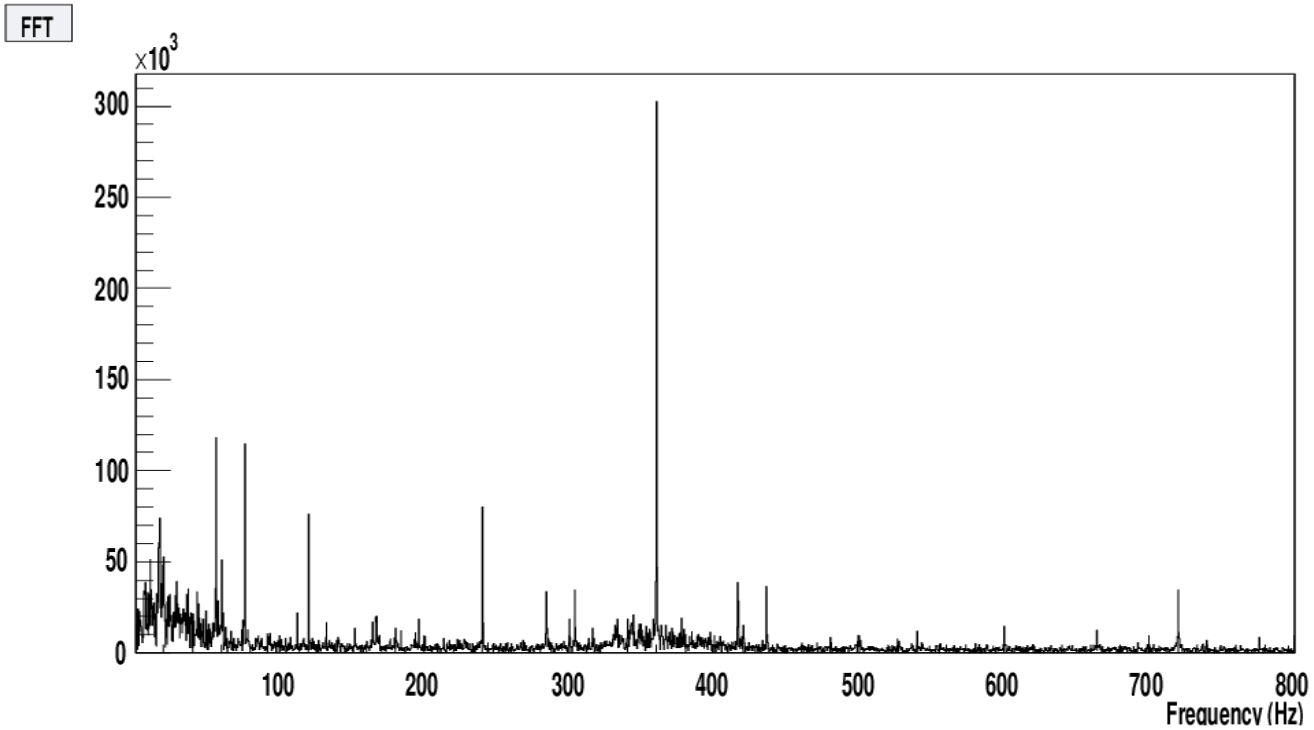
“Splat” Events - Understanding the Beam

- Independent 10kHz pulsed DAQ read out raw hodoscope rates
- Bins are integrated counts over 100µs (≈5000 RF buckets)
- Large variation in Instantaneous intensity, duty factor very low.
- Periodic structure



“Splat” Events - Understanding the Beam - FFT

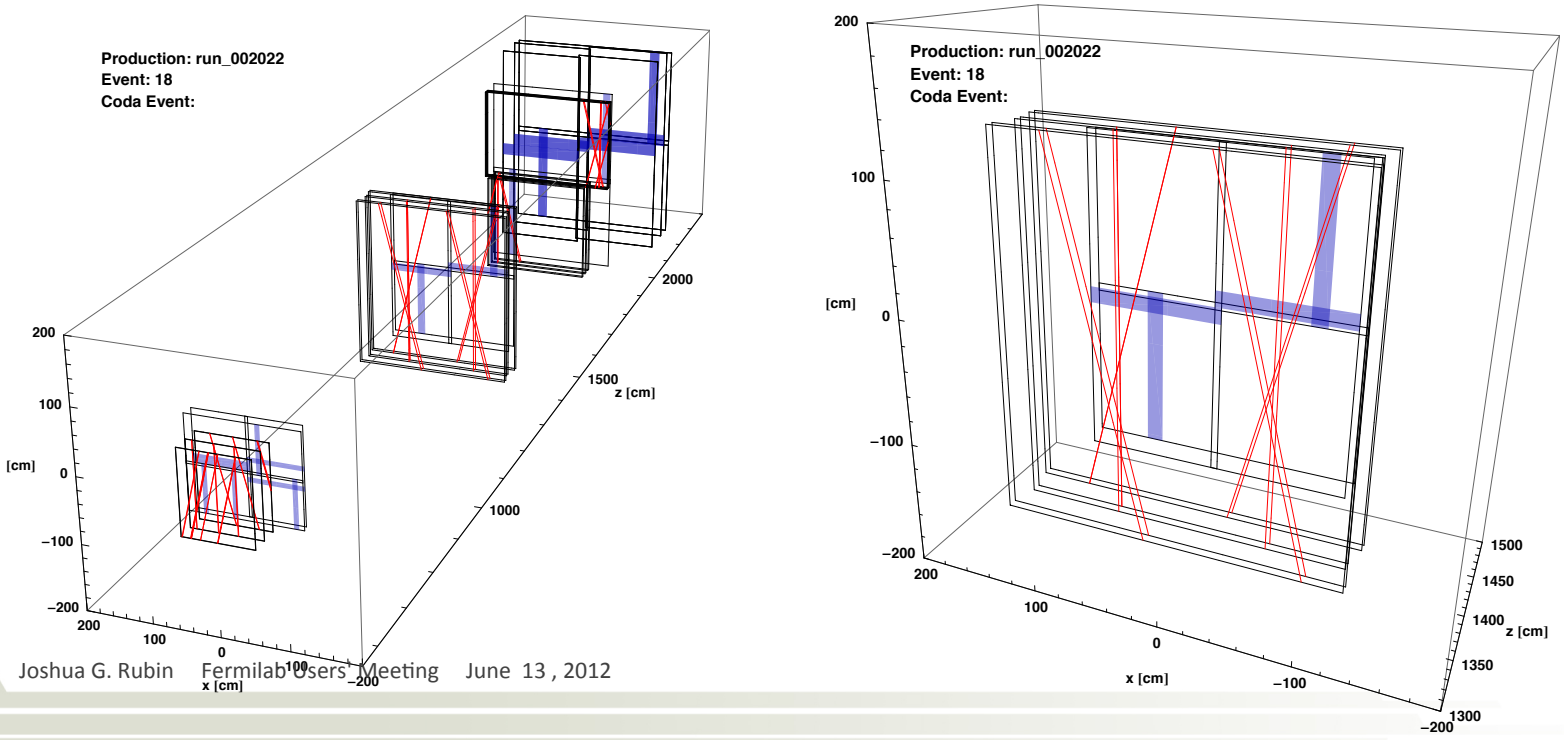
- Several clear resonances: 60Hz and harmonics, 360Hz
- Fine grained feedback for the accelerator control room.



- Injector power supplies? Slow extraction procedure?

The Splat-Block Card

- A card was developed to keep a running average of the multiplicity over a 160 ns window (8 RF buckets).
- If average multiplicity above threshold, raises a trigger veto
- Luminosity greatly reduced, but trigger suppresses windows of time with large beam intensities.



Run I Summary

- Short run, **problems solved or understood**
  - **The shutdown gives us the opportunity to address remaining problems properly**
  - **Full luminosity (≈10^{19} POT) will still be delivered by end of Run II.**
- Approximately two weeks of **analyzable production data** taken with splat-block
- **Dimuon pairs observed and reconstructed!**
- Data taken with several target species (H, D, C, Fe, and W)
- Luminosity too low to make a meaningful Drell-Yan analysis, but J/ψ cross section much larger
- We expect to produce *at least* 120GeV relative J/ψ cross sections on nuclear targets.
- Offline analysis underway… tracking, alignment, chamber calibration, data quality, etc.

Run II Improvements

- Upgraded Stations 1 and 3- will expand acceptance to larger x_t
- Transistorized PMT bases to address possible voltage sagging in Station 1 due to larger than expected rates
- Zero suppressed TDCs – improve live time significantly.
- Possible beamline Cerenkov to monitor individual bunch intensity
  - Feedback to the accelerator control room
  - Generate DAQ veto
  - Produce accurate luminosity

And beyond!

- SeaQuest with polarized Main Injector has ben proposed to study transverse-momentum dependent distributions

Special thanks for an *extraordinary* effort from the Fermilab team!