UTA Participation in the PP2PP Experiment

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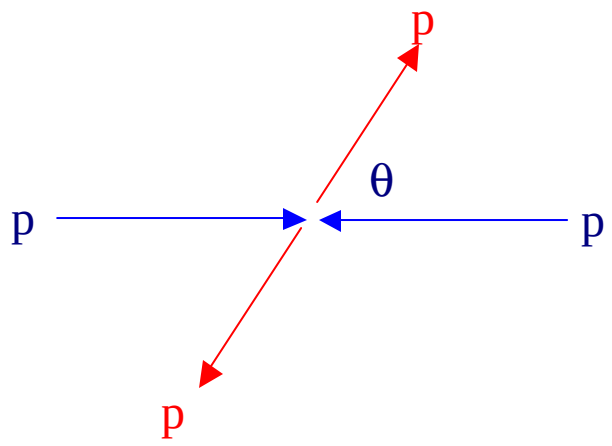
DoE Site Visit
November 2001

Outline

- **What is PP2PP?**
  - **A Comprehensive RHIC-Spin *pp* Elastic Scattering Experiment**



- **Theoretical Motivation**
- **Experimental Plan**
- **UTA Contributions**
- **Conclusion**

PP2PP Collaboration

Total and Differential Cross Sections, and Polarization Effects in pp Elastic Scattering at RHIC

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*** Spokesperson**

Physics Goals

- Study of total and elastic cross-sections in proton-proton scattering over a large kinematic range

$$50 \text{ £ } \sqrt{s} \text{ £ } 500 \text{ GeV}/c$$

$$4 \cdot 10^{-4} \text{ £ } |t| \text{ £ } 1.5 \text{ (GeV}/c)^2$$

- Measurments with transverse and longitudinally polarized protons to determine
  - the s-channel helicity amplitudes ϕ_I

$$\phi_1 \sim \langle ++ | M | ++ \rangle$$
$$\phi_2 \sim \langle -- | M | ++ \rangle$$
$$\phi_3 \sim \langle +- | M | +- \rangle$$
$$\phi_4 \sim \langle +- | M | -+ \rangle$$
$$\phi_5 \sim \langle ++ | M | +- \rangle$$

  - determine the nature of the mediator of the elastic interaction
- Measurements with unpolarized protons
- Measurements with (un-)polarized deuterons and helium
- Diffractive Scattering

Physics Capabilities

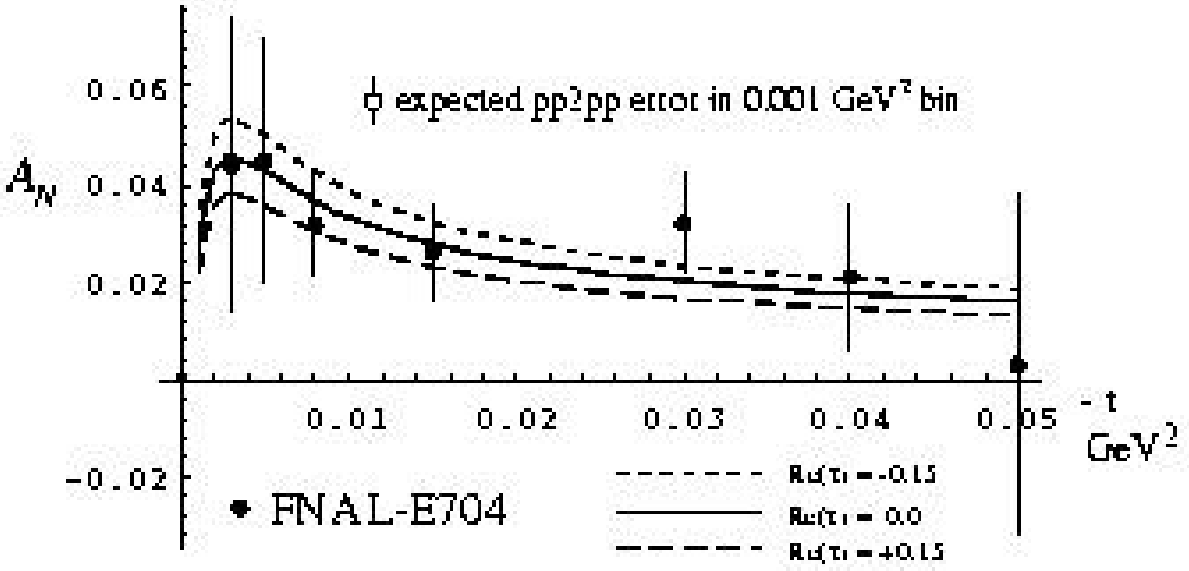
Unpolarized Proton-Proton Scattering

- s and t dependence of σ_{tot} and $d\sigma_{el} / dt$
- Ratio of real to imaginary part of forward scattering amplitude, **?** $(-t < 0.12\ \mathrm{GeV}^2/c^2)$
- s dependence of nuclear slope parameter, b
- Measurement in pQCD region at $-t > 1\ \mathrm{GeV}^2/c^2$

Polarized Proton-Proton Scattering

- Measurement of asymmetries A_N, A_{NN}, A_{LL}
- Measurement of cross-section difference **?** $\Delta\sigma_{tot} = \sigma^{-\uparrow} - \sigma^{--}$
- Measurement of A_N over large $-t$ range to find suitable kinematic region for polarimetry

Single Transverse Spin Asymmetry

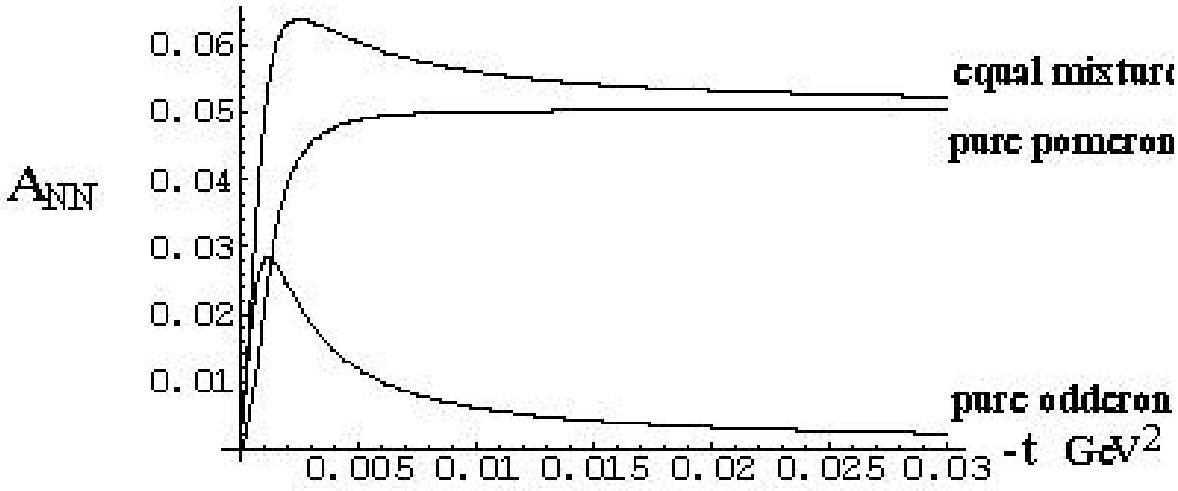


THE SPIN DEPENDENCE OF HIGH-ENERGY PROTON SCATTERING.
N.H. Buttimore, B.Z. Kopeliovich, E. Leader, J. Soffer, T.L. Trueman
Phys.Rev.D59:114010,1999

$$A_N(t) = \frac{1}{P\cos f}\,\frac{N_\uparrow(t) - N(t)_\downarrow}{N_\uparrow(t) + N_\downarrow(t)}$$

with ***?*** the azimuthal angle
and ***P*** the proton polarization

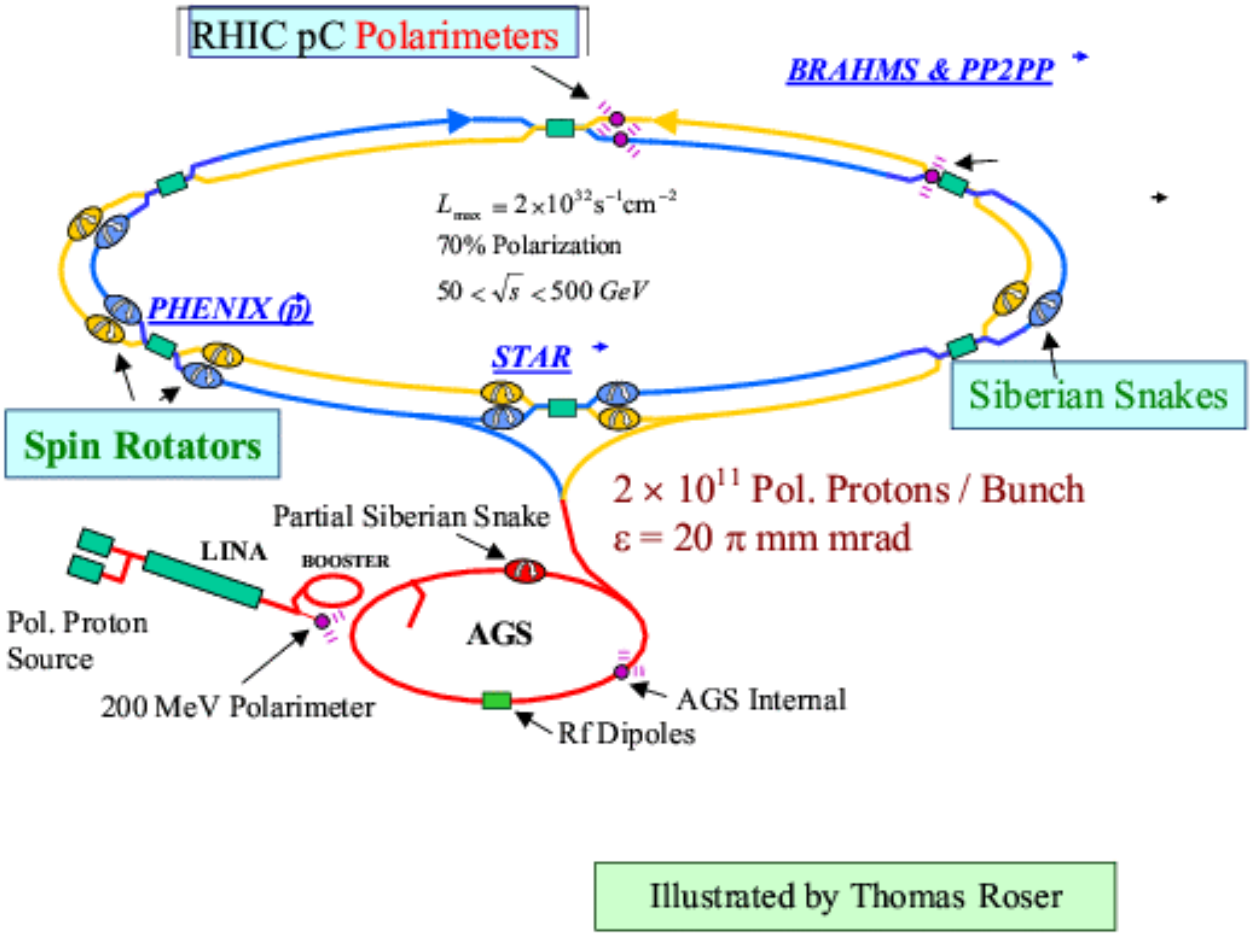
Double Transverse Spin Asymmetry



THE ODDERON AND SPIN DEPENDENCE OF HIGH-ENERGY PROTON-PROTON SCATTERING.
E. Leader, T.L. Trueman. Phys.Rev.D61:077504,2000

$$A_{NN}(t) = \frac{1}{P_1 P_2 \cos^2 f} \frac{N_{\uparrow\uparrow}(t) + N_{\downarrow\downarrow}(t) - N_{\uparrow\downarrow}(t) - N_{\downarrow\uparrow}(t}{N_{\uparrow\uparrow}(t) + N_{\downarrow\downarrow}(t) + N_{\uparrow\downarrow}(t) + N_{\downarrow\uparrow}(t}$$

PP2PP in RHIC



Illustrated by Thomas Roser

Measurement Technique

For small scattering angles the position of the protons at the detection point are directly proportional to the angle via the beam transport matrix:

$$y_{det} = a_{11}\, y^* + L_{eff}\, Q_{sc}$$

Parallel to point focusing: $a_{11} = 0$ and L_{eff} large

Dependence of t on beam parameters:

$$t_{min} \mu \frac{k^2 e p^2}{b^*}$$

Þ need **large** b^* **and small** e

For Coulomb region special tune is required:

b^* = **195 m** and low emittance e = **5**p **mm mrad**

RHIC Plans for 2001

No special conditions required:

L_{eff} = 20 m, Roman Pot position at 57 m from IP

Minimum experimental setup:

- One Roman Pot station in each outgoing beam pipe
- Veto counter system around IP

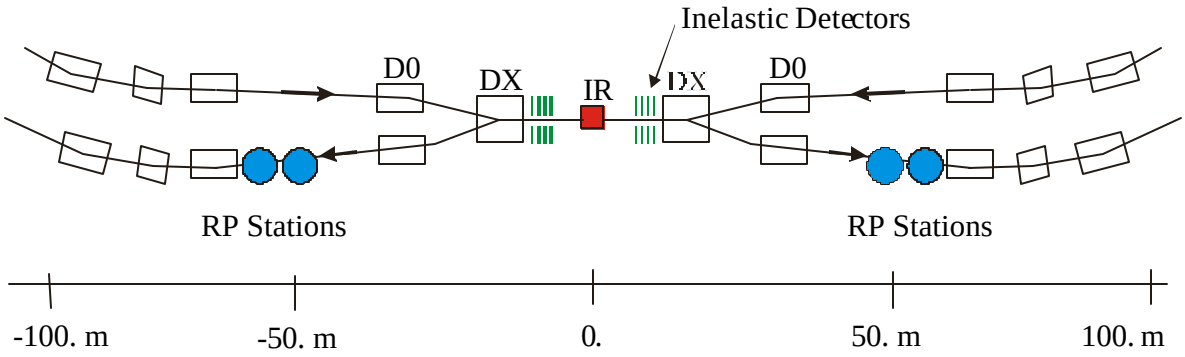
Kinematic coverage:

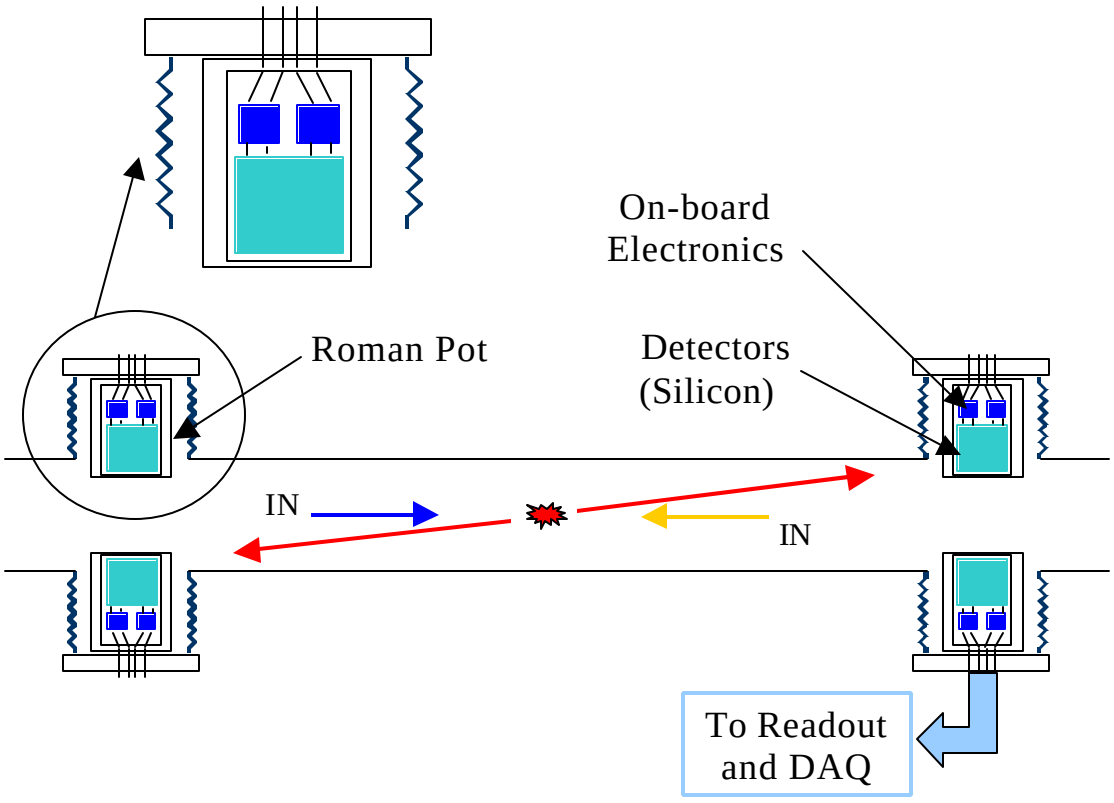
- at 100 GeV/c: **$0.003 < -t < 0.015$ (GeV/c)^2**
- at 250 GeV/c: **$0.006 < -t < 0.100$ (GeV/c)^2**

  (if running at this energy takes place)

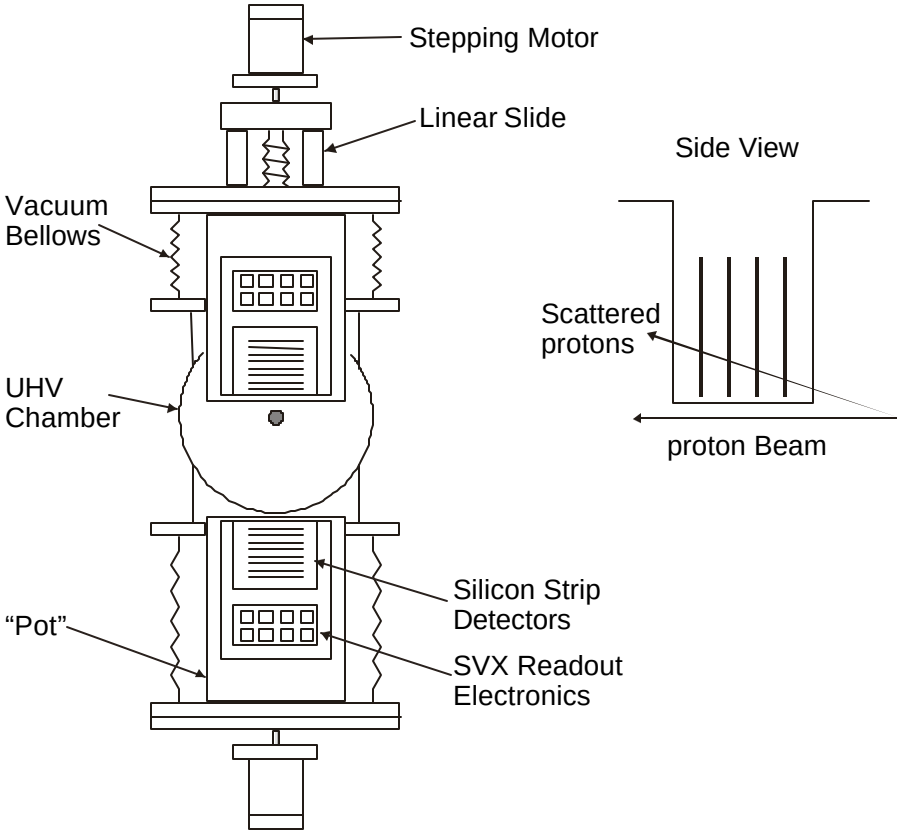
PP2PP Setup

RHIC Intersection Region with PP2PP Basic CB Setup





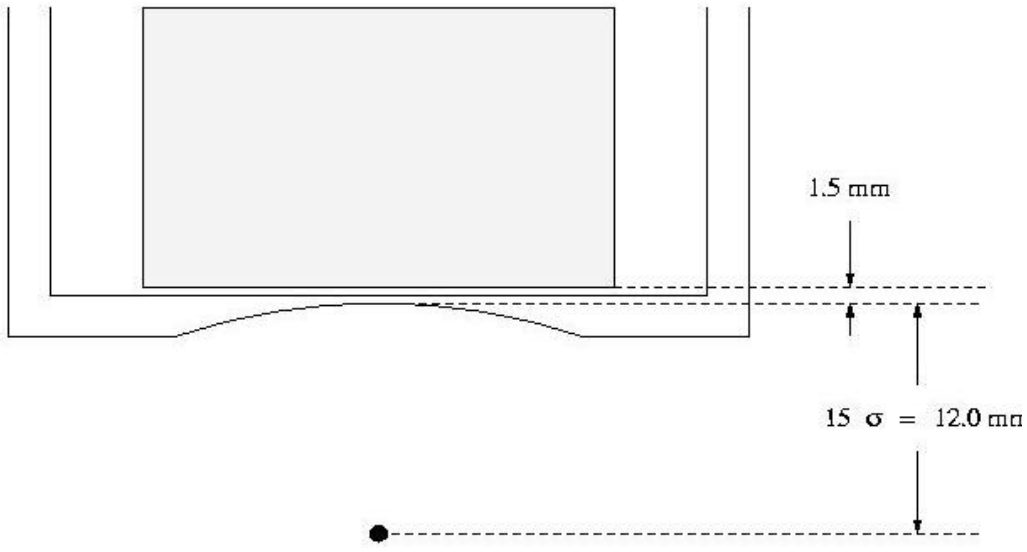
Detector Station



Roman Pot Detector System

Si Detectors

- 400 micron thick silicon microstrips covering 5 x 8 cm
- 70 micron wide strips with 100 micron pitch (good track resolution and limited occupancy)
- 2 X-detectors (768 strips of 45 mm length)
- 2 Y-detectors (512 strips of 75 mm length)
- High and uniform efficiency
- Close proximity of detector to beam (14 mm)



- 8 mm thick trigger scintillator behind silicon planes

UTA Contributions

- **Physics & Simulations**
- **Detector station support structure**
- **Roman pot design and prototype development**
- **Trigger counters**
- **Si readout - Guler's thesis**
- **Analysis tools, installation, shifts**

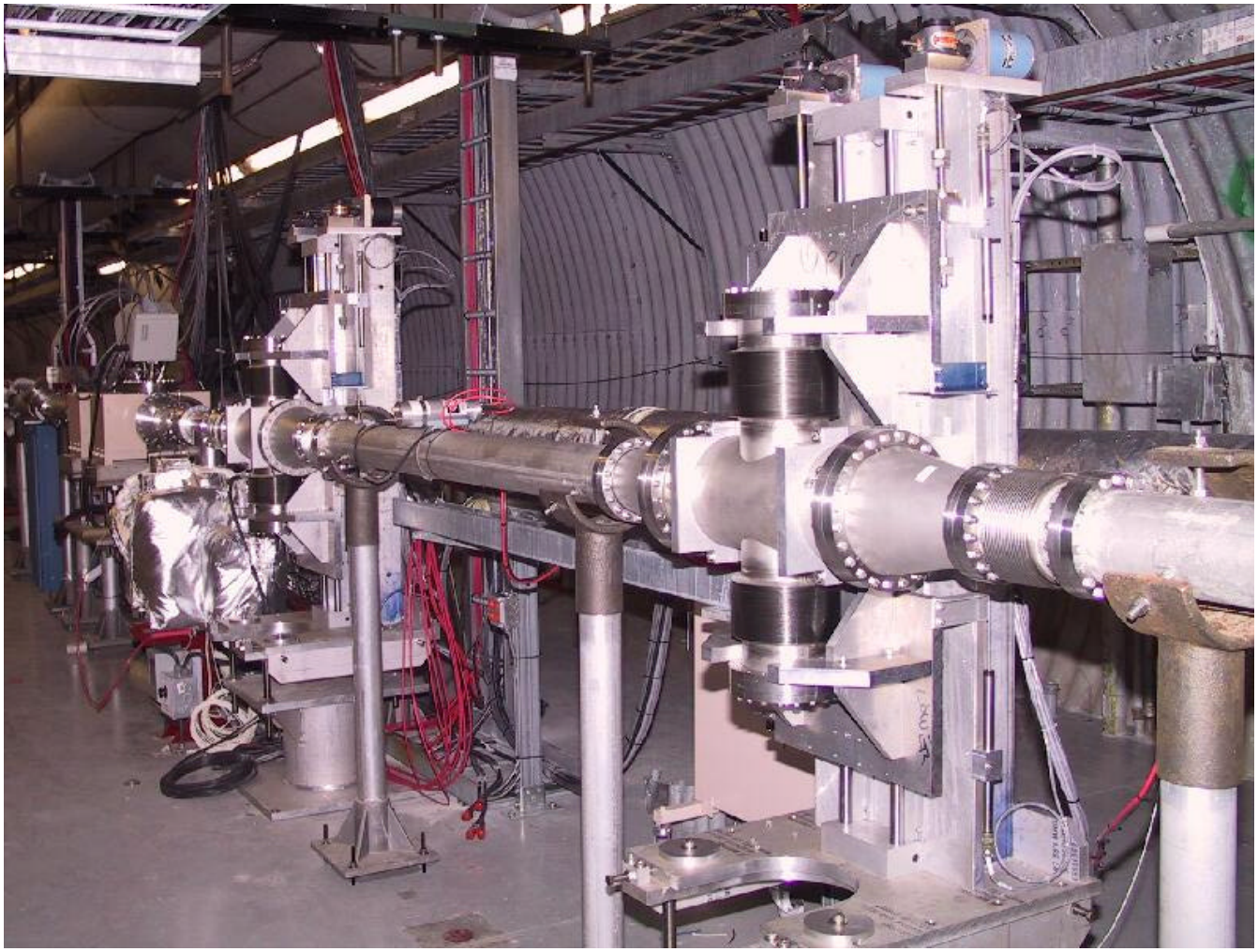
RHIC Schedule

1. Access during switch over from HI to proton 8 am Nov. 26 -2 pm Nov. 29, 2001

2. Three weeks of spin commissioning Nov. 30 - Dec 21, 2001

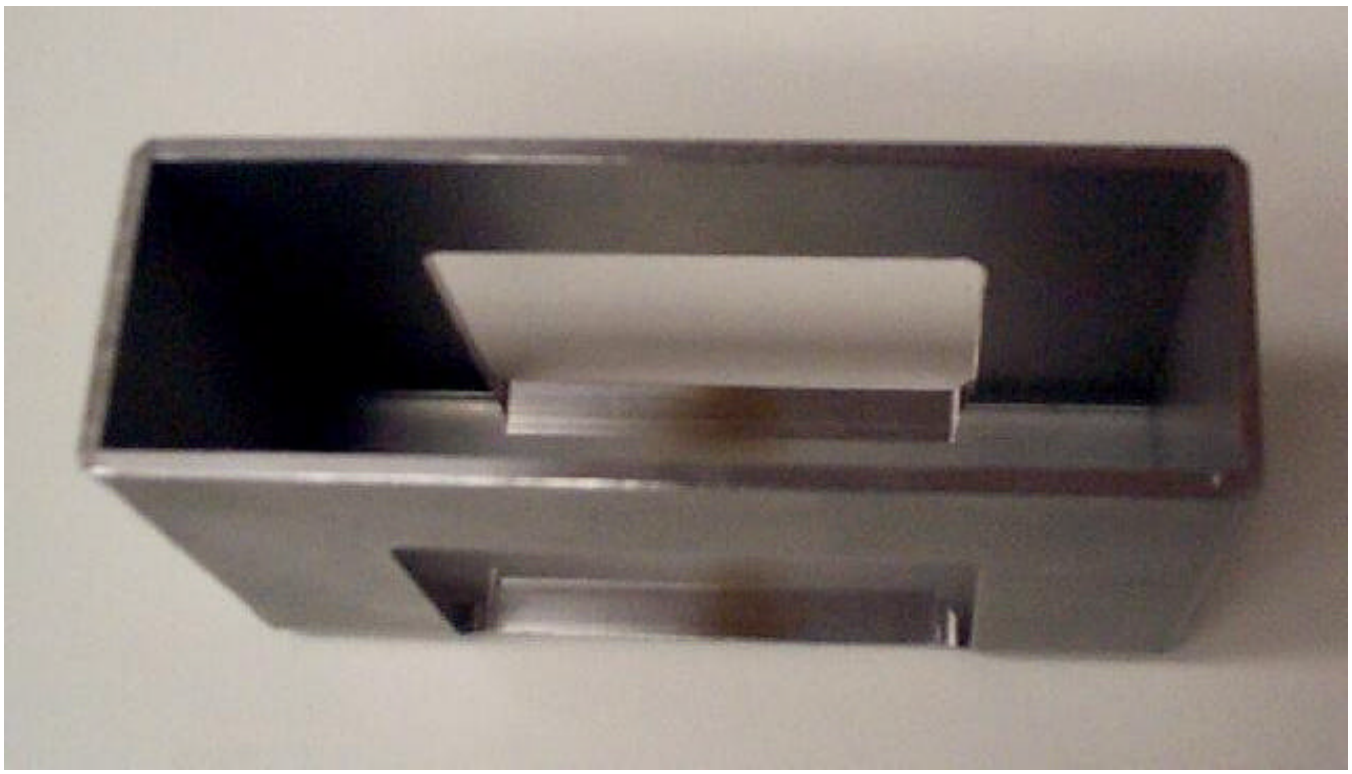
3. Five weeks running Dec 22, 2001 - Jan. 25, 2002

PP2PP Installed!

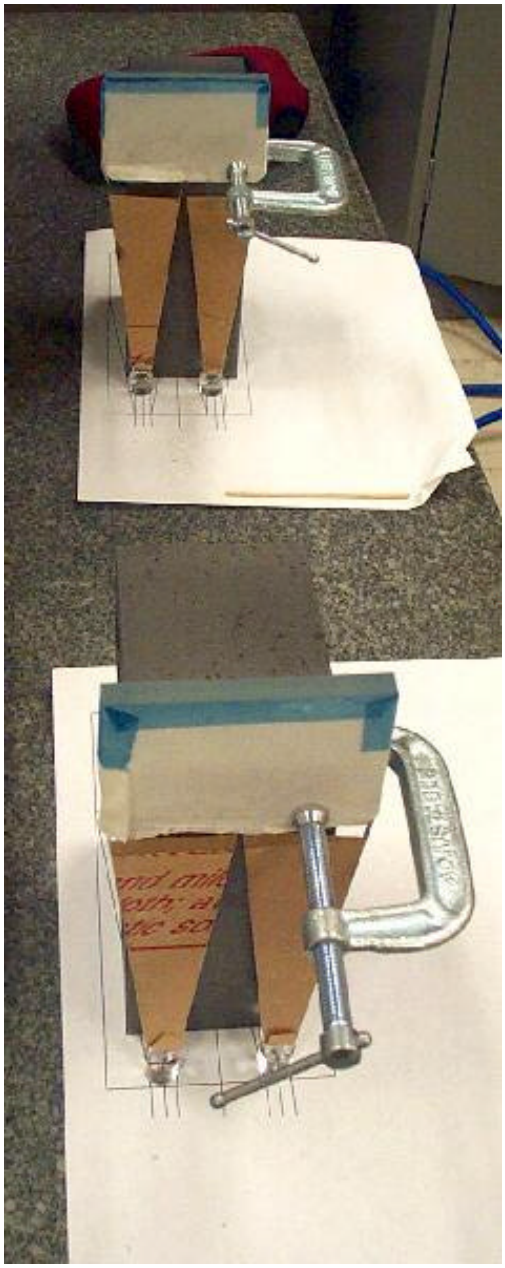


Prototypes Built at UTA

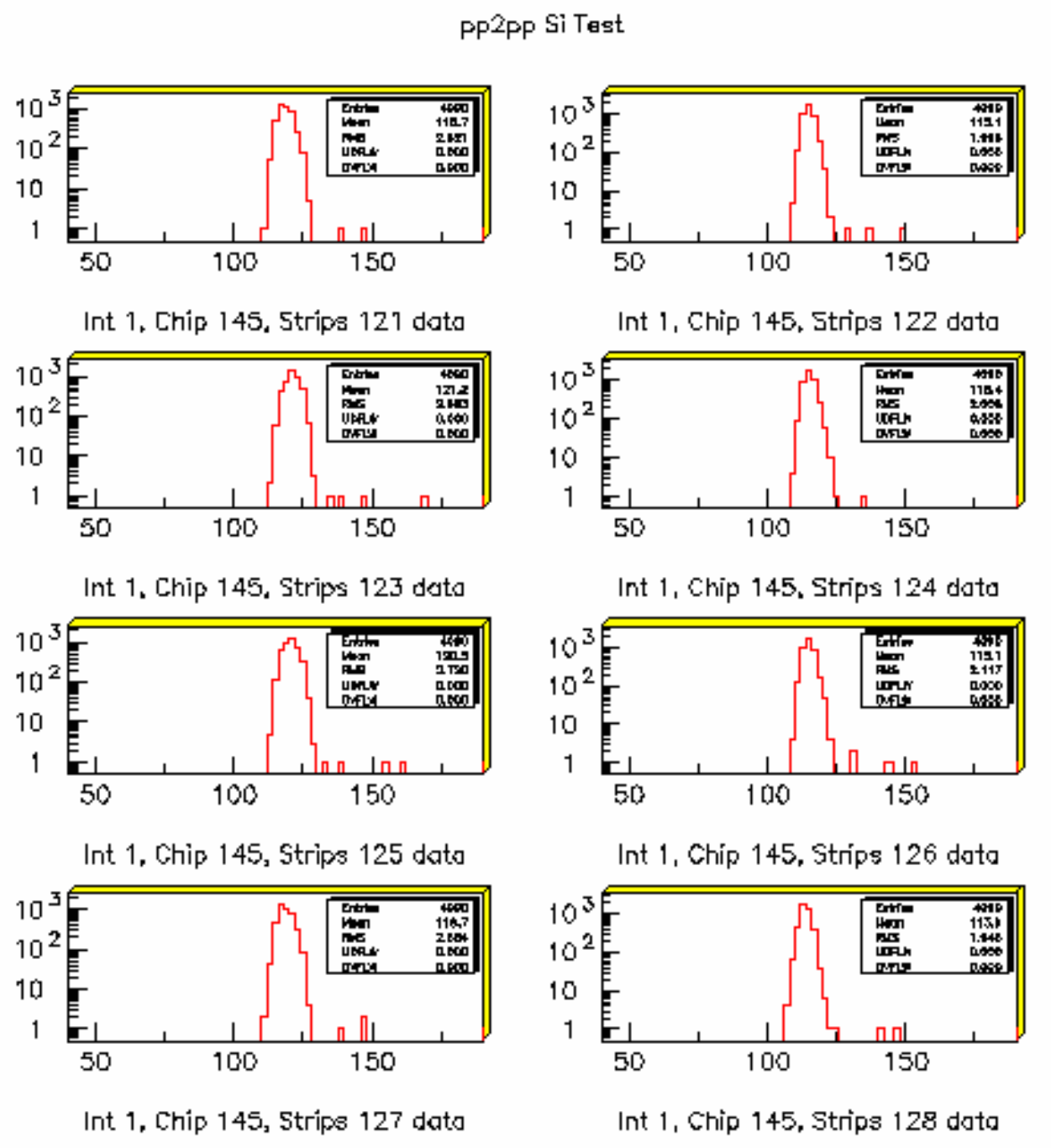
Design of Detector Box



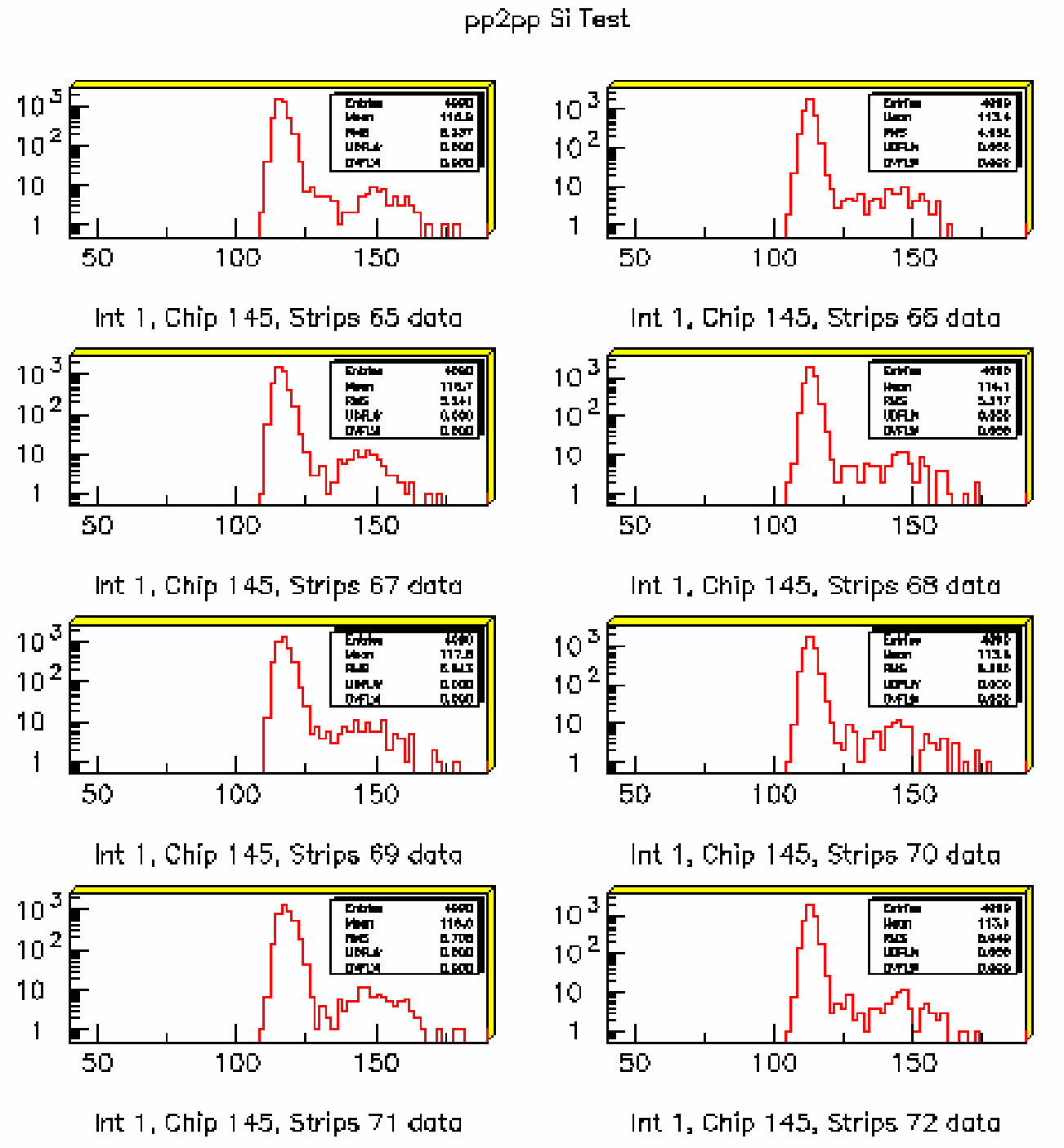
Trigger Scintillators



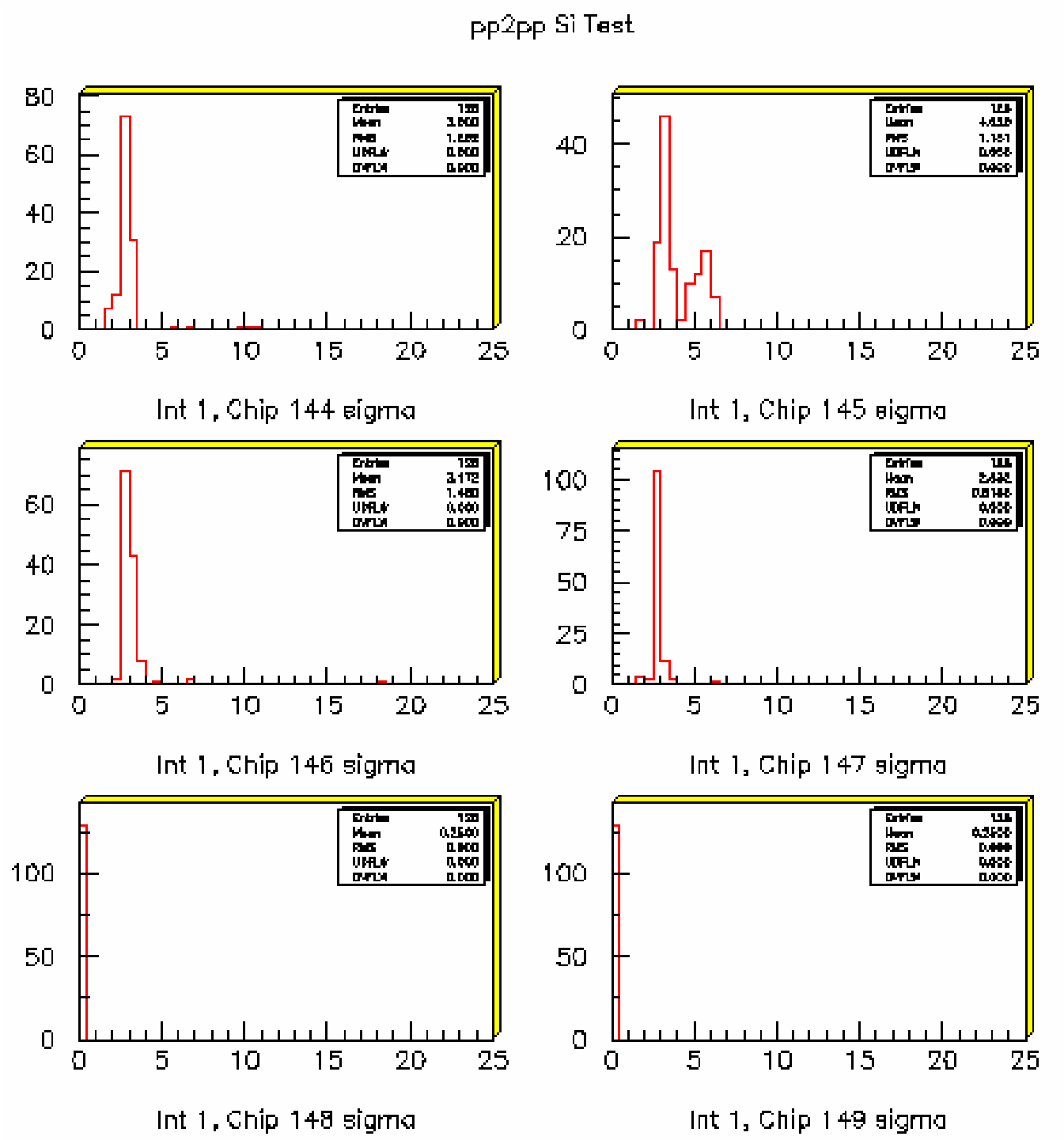
Si Performance Analysis



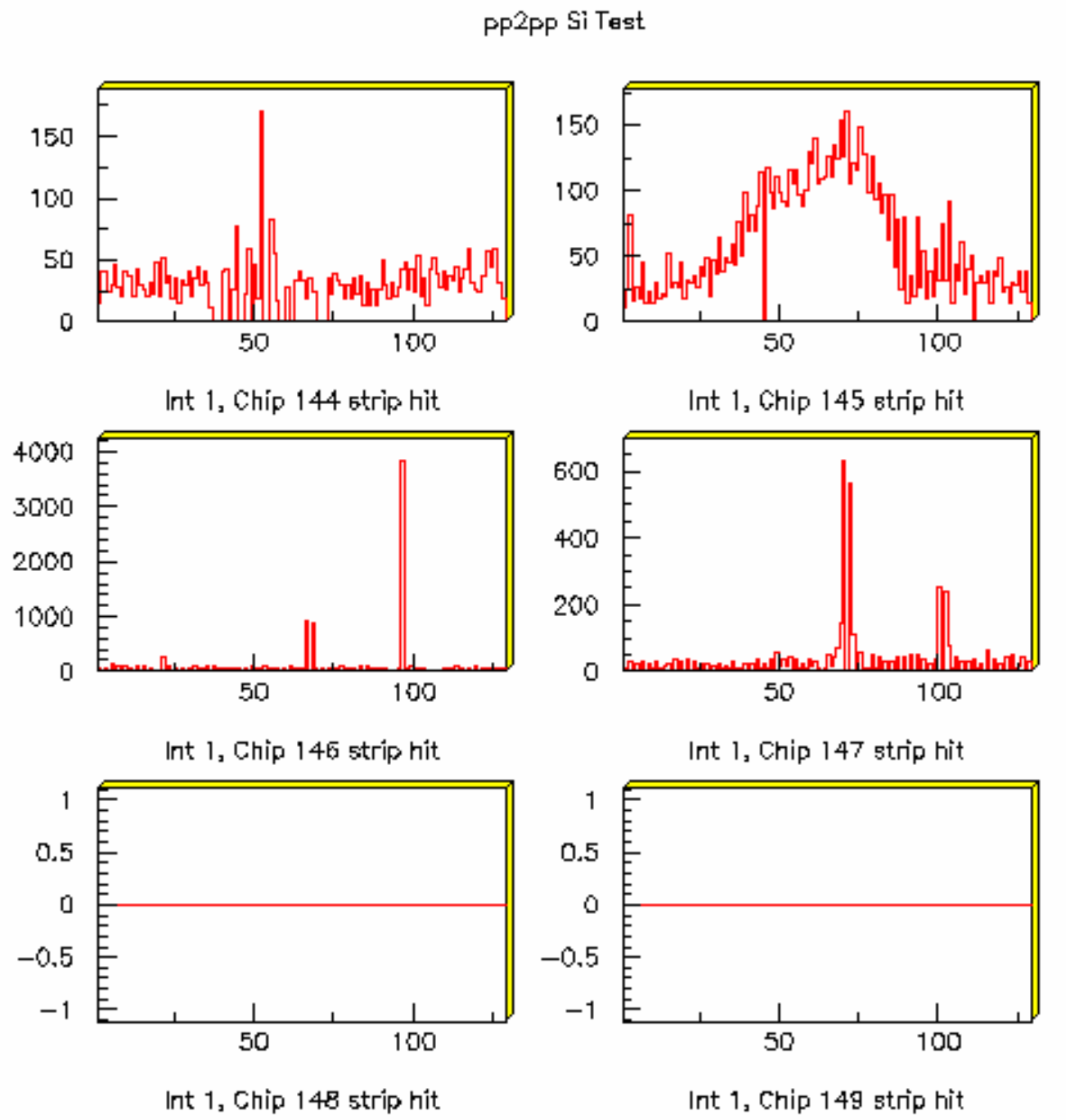
Beta Source


pp2pp Si Test
Int 1, Chip 145, Strips 65 data
Int 1, Chip 145, Strips 66 data
Int 1, Chip 145, Strips 67 data
Int 1, Chip 145, Strips 68 data
Int 1, Chip 145, Strips 69 data
Int 1, Chip 145, Strips 70 data
Int 1, Chip 145, Strips 71 data
Int 1, Chip 145, Strips 72 data

Distribution of Sigmas



Pattern of Hits



2001 Run Plan

- Study CNI region, s_{tot}, A_N, A_{NN}
- s dependence of the nuclear slope, b
- Measurement of A_N over large $-t$ range to find suitable kinematic region for polarimetry

Expected Run Plan

- Total Proton Intensity = $5 \cdot 10^{10}$ - 10^{11}

  $\Rightarrow$ $L \approx 1.2 \cdot 10^{28}$ cm^{-2} sec^{-1}

- 100 events / sec for ~10 mb elastic cross-section
- 1.4 million events for 10 hour ring filling (assume 40% efficiency)
- One or two days of special running most practical for us
- Accuracy $dA_N \approx 0.002$ - 0.003
- Accuracy $d?\ s_{tot} \approx 0.3$ mb

Long Term Plan

2003

- Extend measurements to **$0.1 < -t < 1.3$ (GeV/c)^2**

Beyond 2003

- Measure in CNI region, requiring special tune
  $0.0004 < -t < 0.12$ (GeV/c)^2
- Measure in large -t region
  $1.3 < -t < 5$ (GeV/c)^2
- Elastic scattering of proton-deuteron, deuteron-deuteron, and proton-^{4}He also possible

Conclusion

- Unique small experiment
- UTA has made big contributions with modest effort
- Good opportunity for student training
- Interesting physics results by next summer