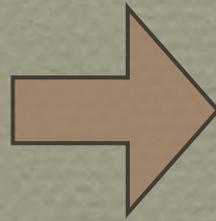
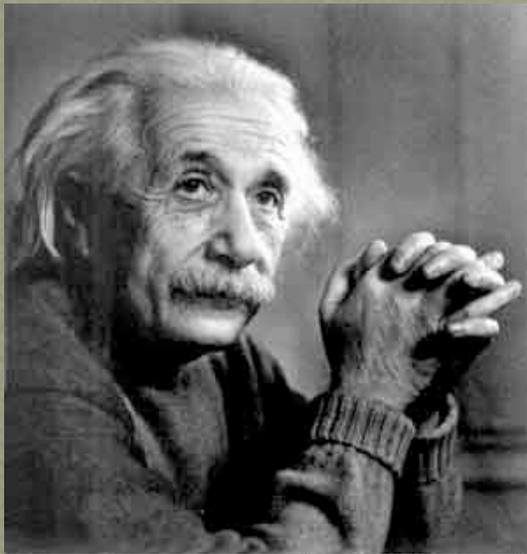


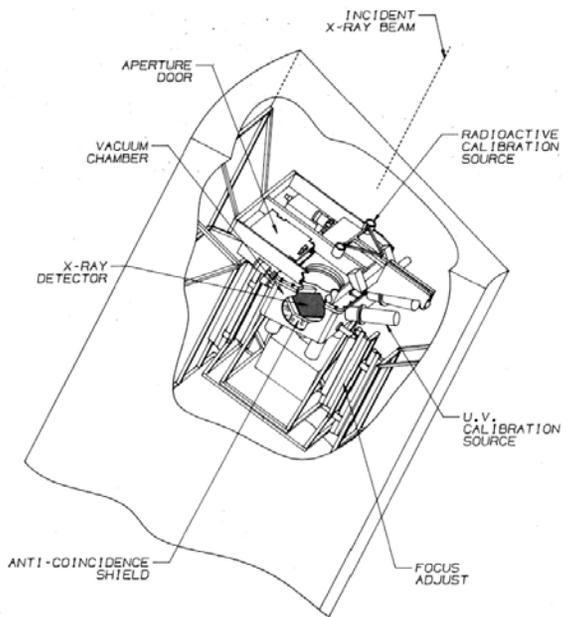


# HRI TO HRC

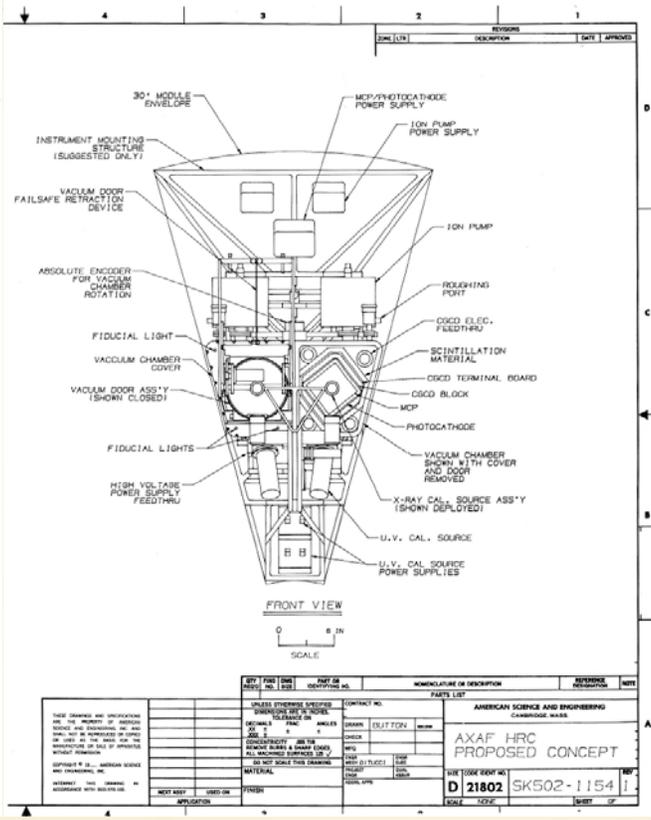


Einstein to Chandra

Stephen Murray



THE HIGH RESOLUTION CAMERA



1984: Fully Redundant 10x10 cm Imaging Detectors

1988: Adjacent 10x10 cm Detectors Imaging and LETGS Readout

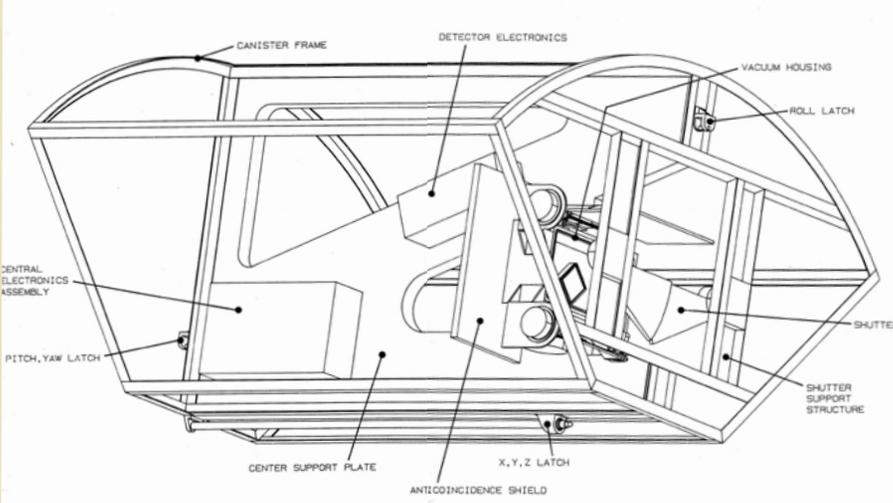


Figure 5.3 - Perspective View of HRC Instrument in TRW Configuration

Scale: 1/8

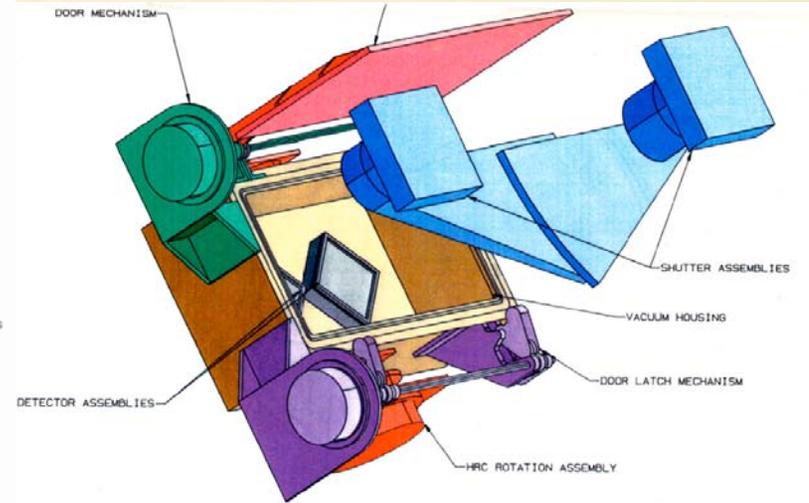


Figure 5.2 - Perspective View of the HRC Detector Assembly

5 INCHES

# The Real Deal ~1993: HRC-I and HRC-S

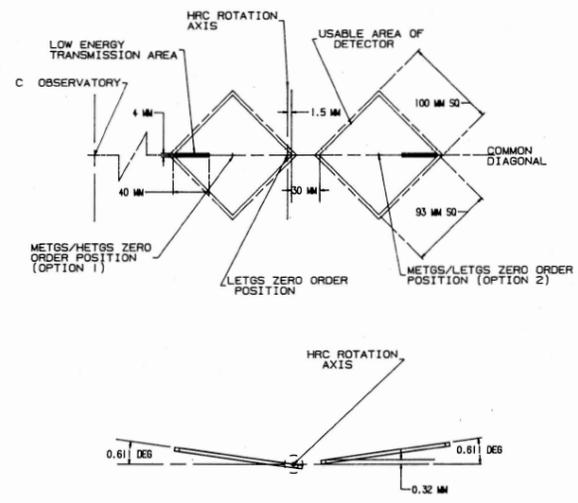
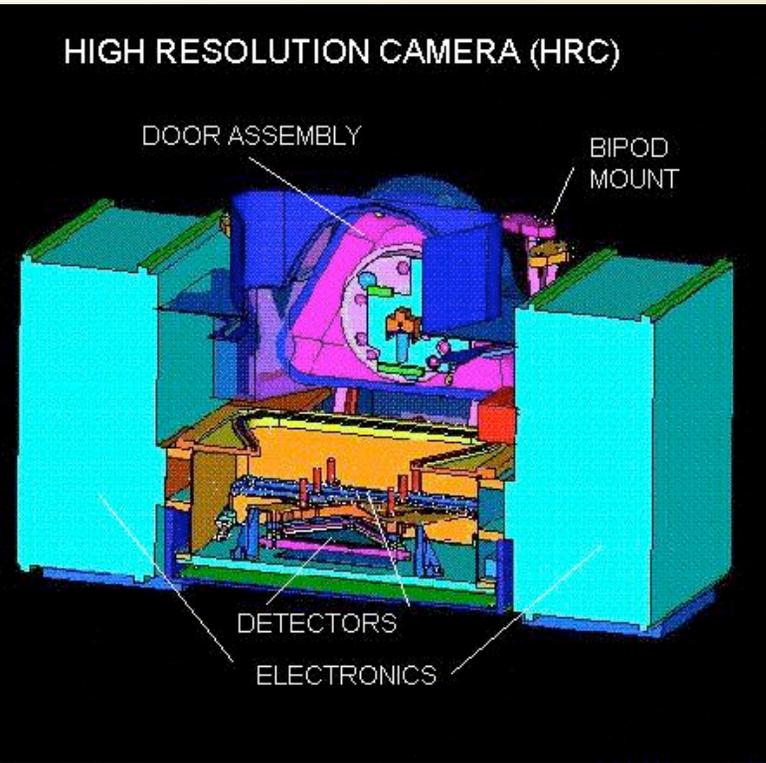
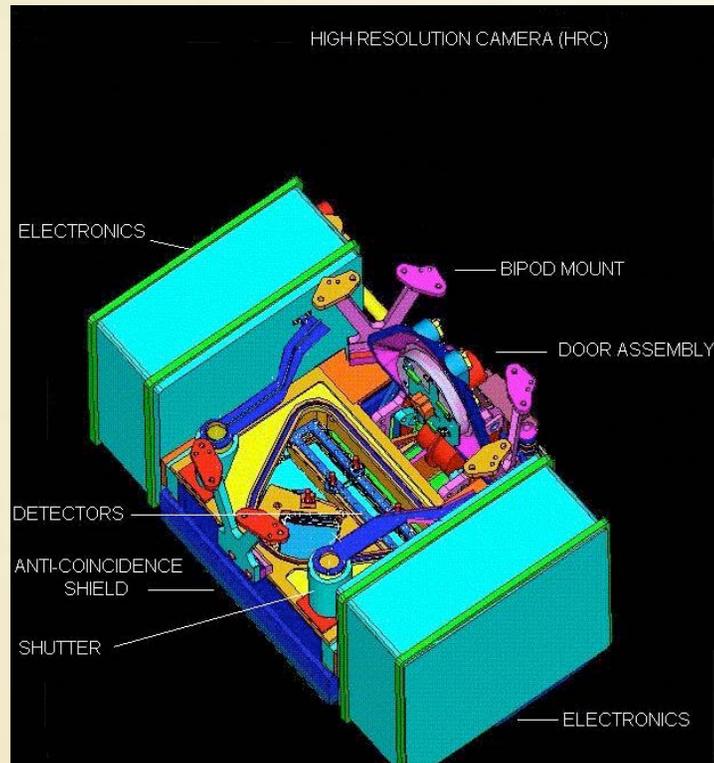
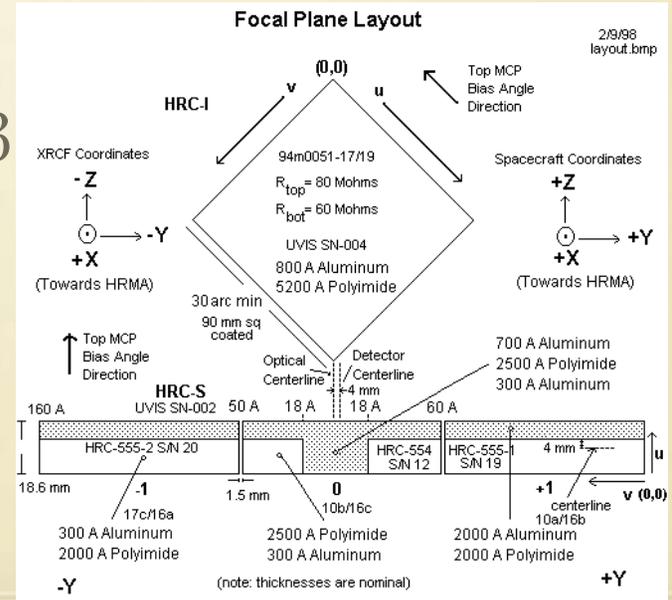
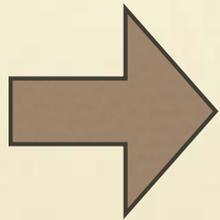


Figure 5.4 - The HRC UV/ion Shield Metalization Pattern

1988 ~1993



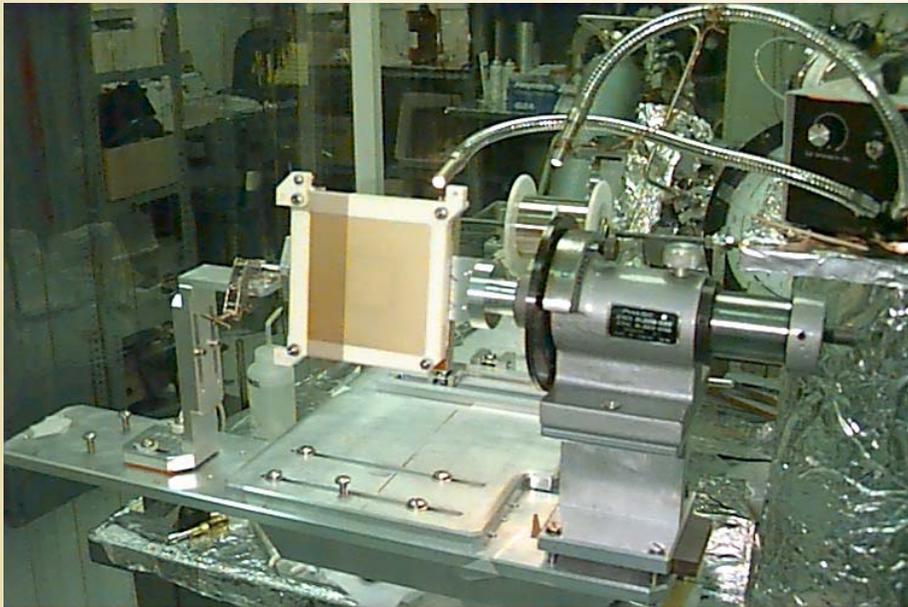
# Piece Parts



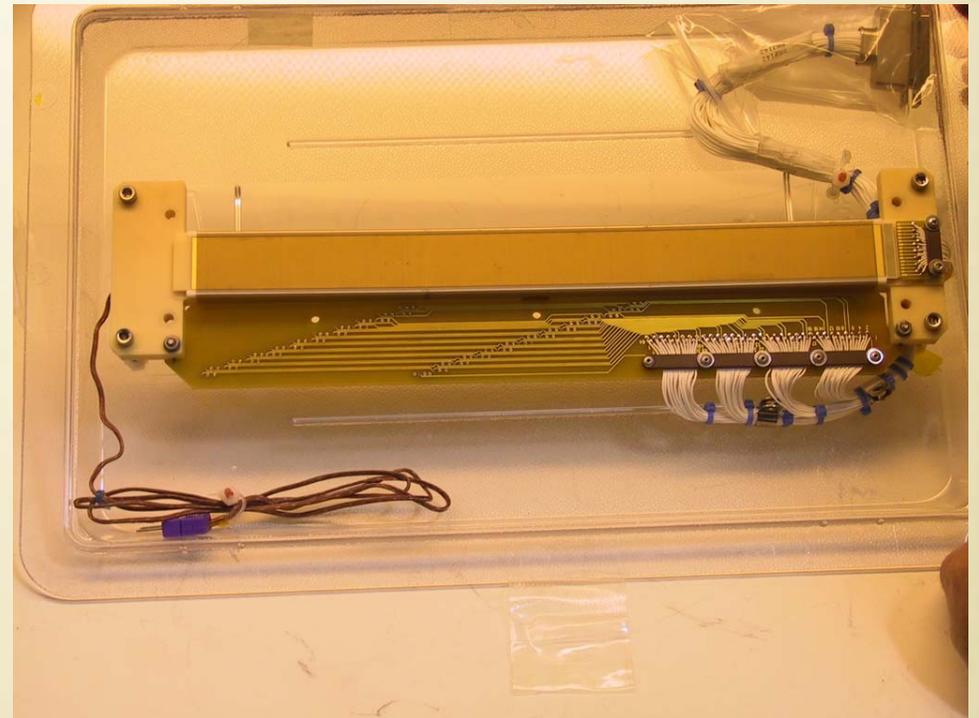
MCP Bias, which way are they pointing?



Bias Angle Society Meeting circa 1995



Crossed Grid Charge Detector Winding Machine

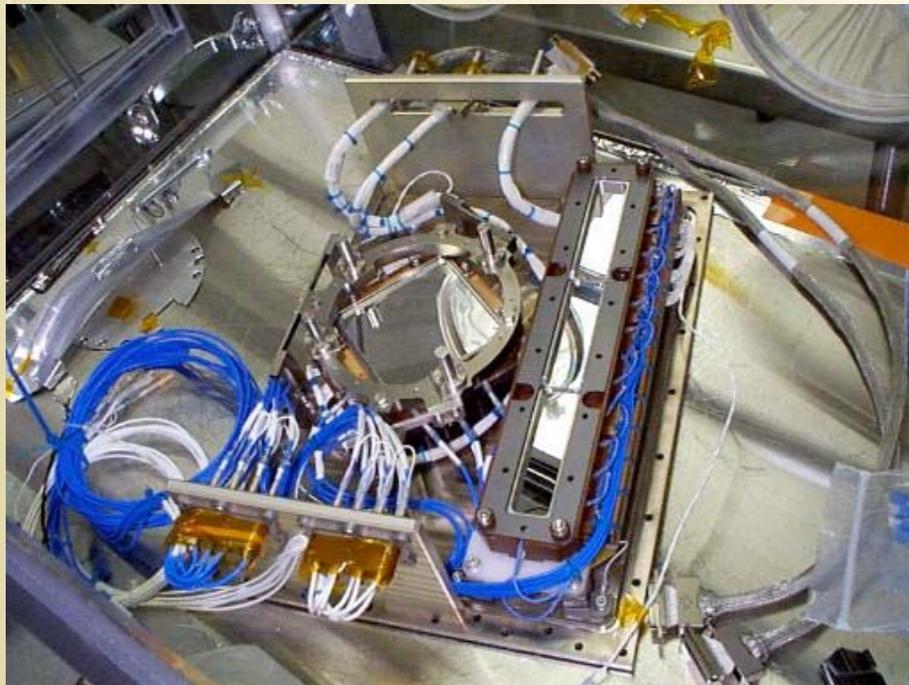


HRC-S Readout

# SOME ASSEMBLY REQUIRED



Austin and Murray at the glove box



Focal plane completed



Visible Light Image

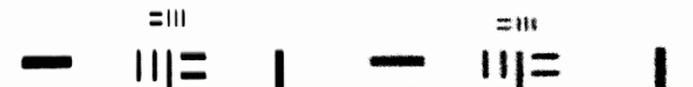
X-Ray Image



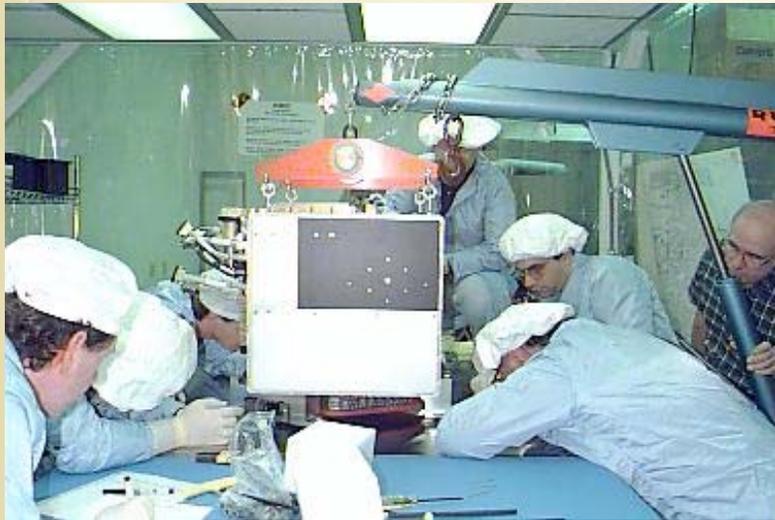
It Works!

YAS1-X

YAS1-X



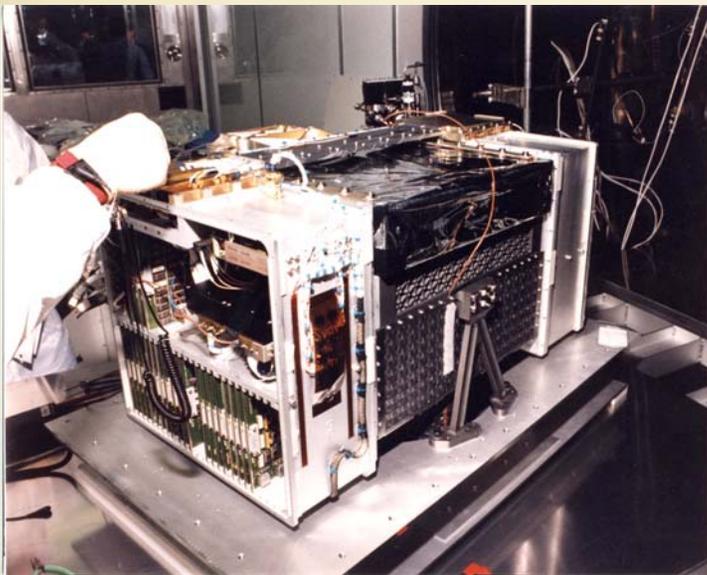
# The Traveling HRC Show



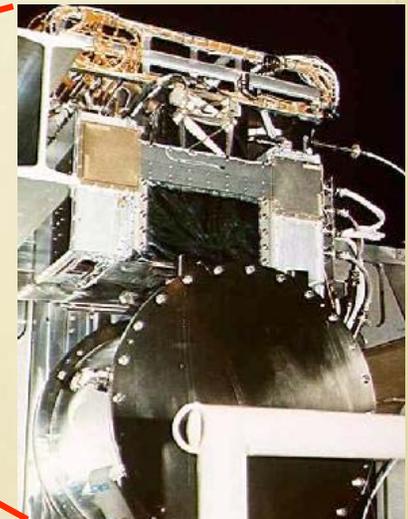
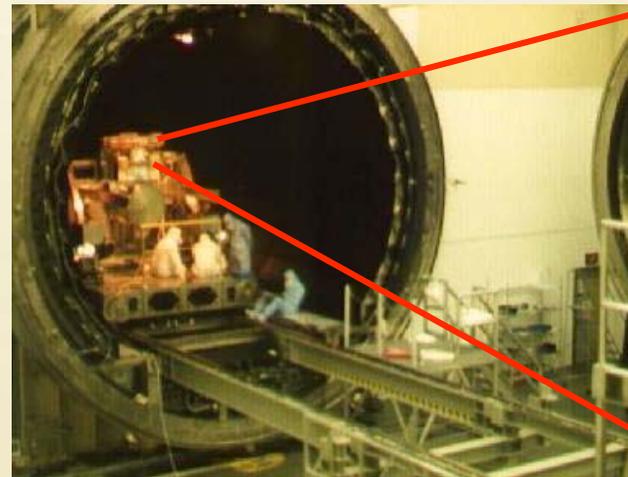
Leaving SAO 1996



SAO → XRCF → SAO → BALL → TRW → KSC

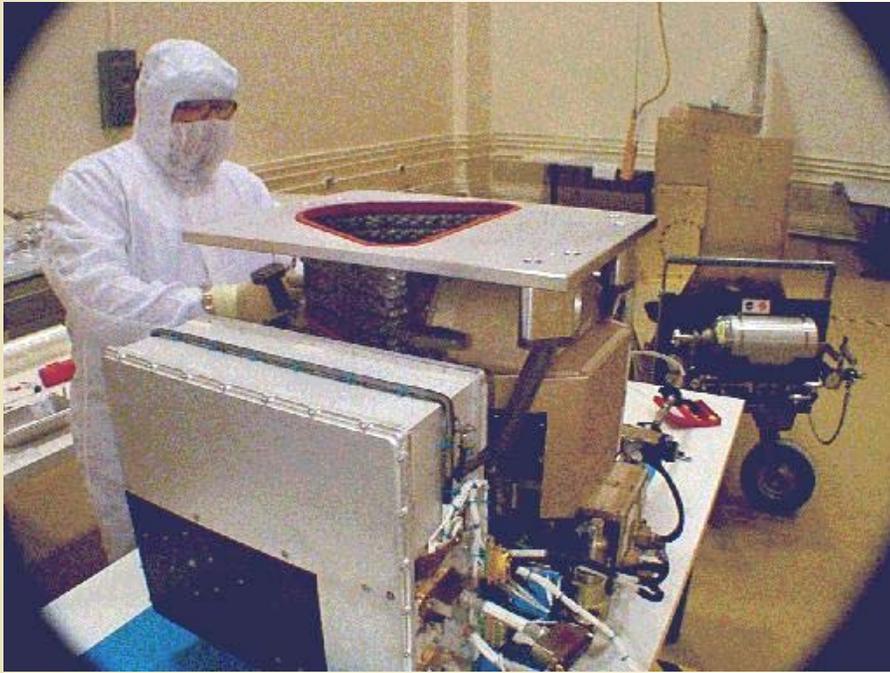


Bakeout at XRCF 1996

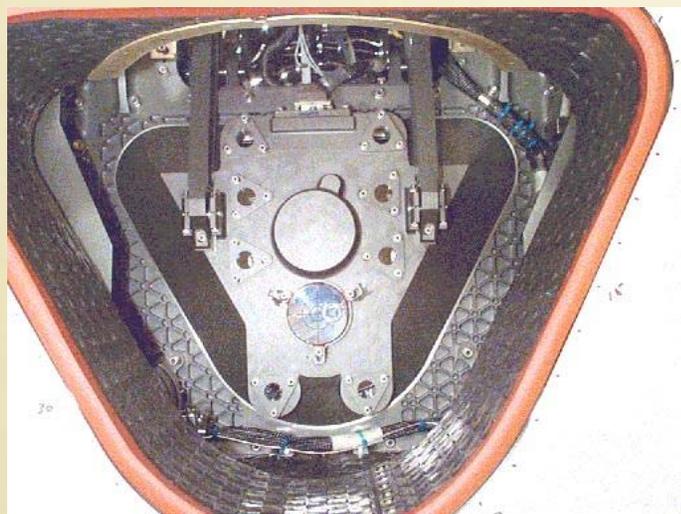
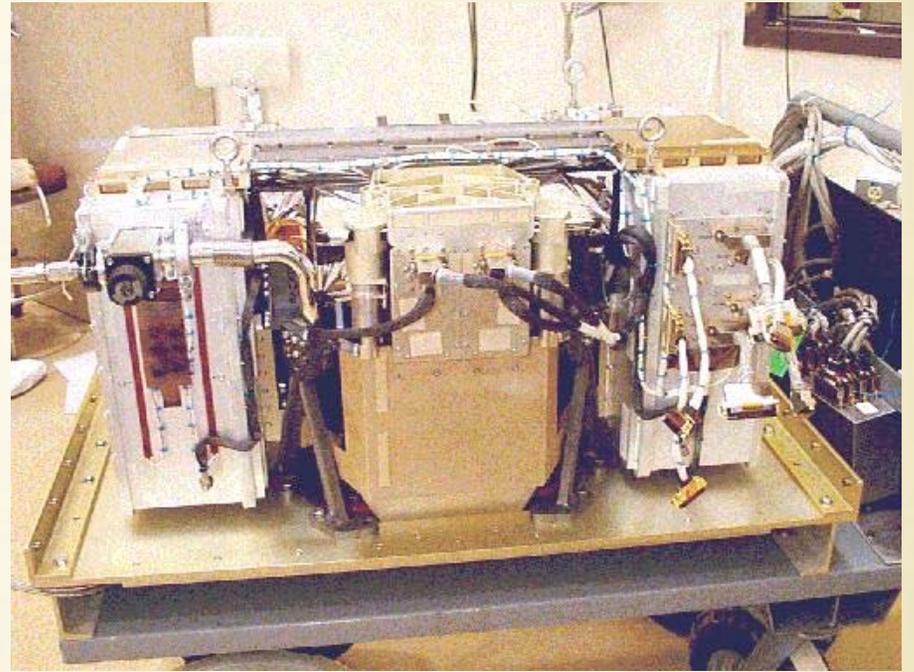


In the XRCF Chamber 1996

# HRC at Ball



Test fit onto SIM



Snout



Passed the T-V Sign off

# HRC at TRW



ISIM



T-V Chamber

# Final Testing at TRW



Start



End



# 30 Day T-V Test



# Last Look



# The "Real" Crew

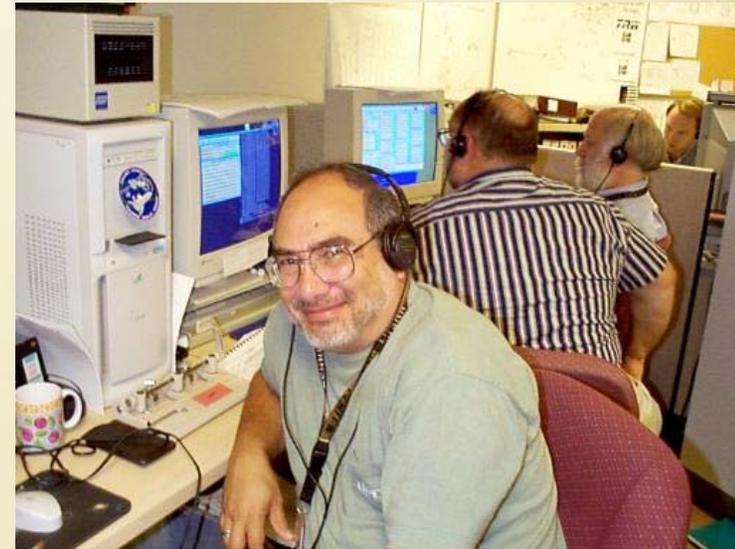


# START-UP PAINS

- Pesky Cosmic Rays
  - Rates were high, worried about HV breakdown
  - Not used to 100 square cm of area
- Anti-co Timing
  - HRC-I veto is fine, but HRC-S is not
  - High background for LETGS
- Time tagging wrong
  - One event slip



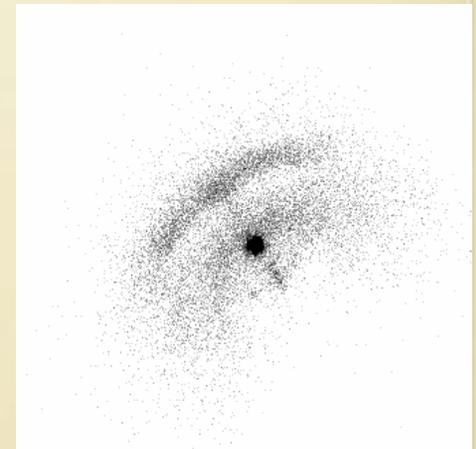
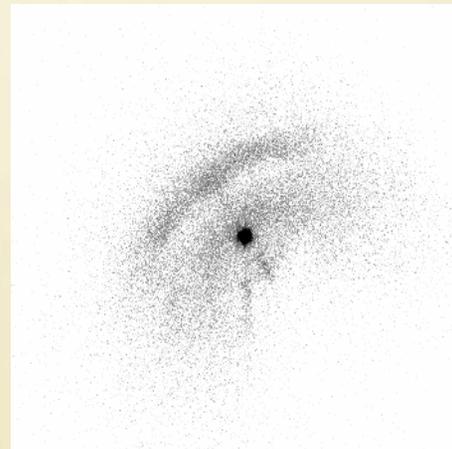
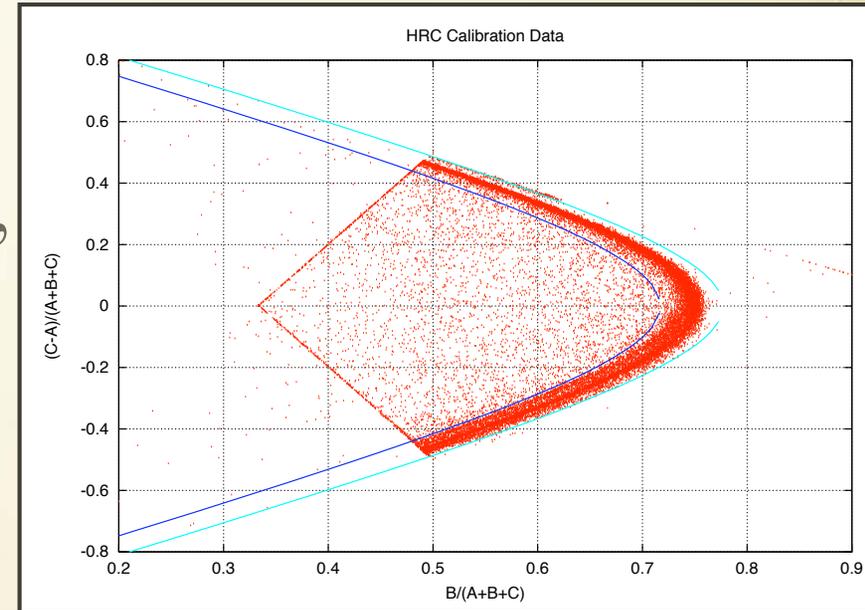
Moral Support



Victory

# ANOMALIES

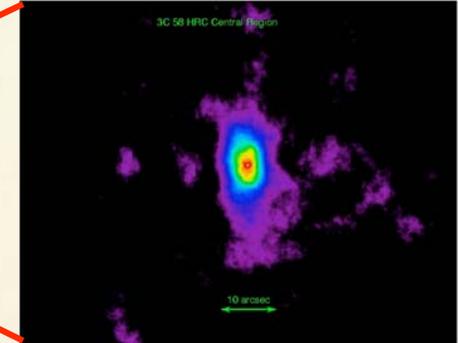
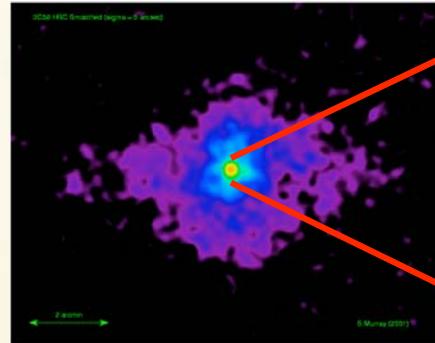
- Event Timing
  - Attached to the wrong event
  - Need to telemeter all events (i.e., no veto to limit the event rate)
  - Normally the non-veto rate exceeds the telemetry limit
  - Fix with HRC-S Timing Mode, uses center segment only
- High Background
  - Fix with event filtering in pipeline processing
- Ghosts
  - Fix with screening



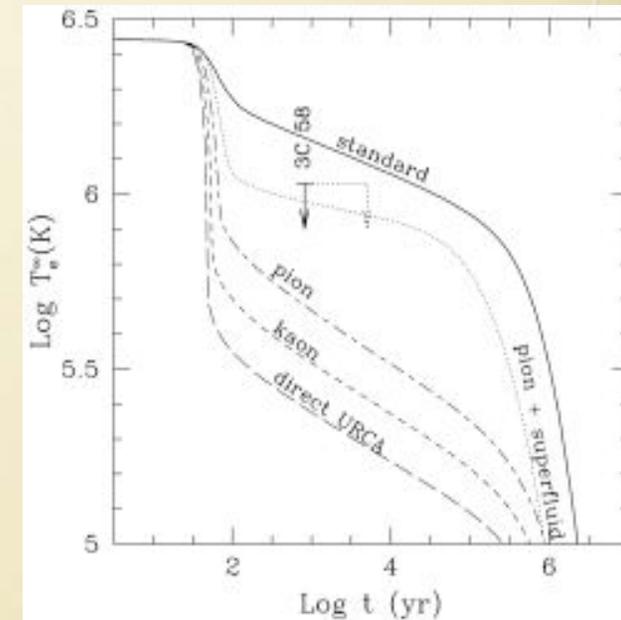
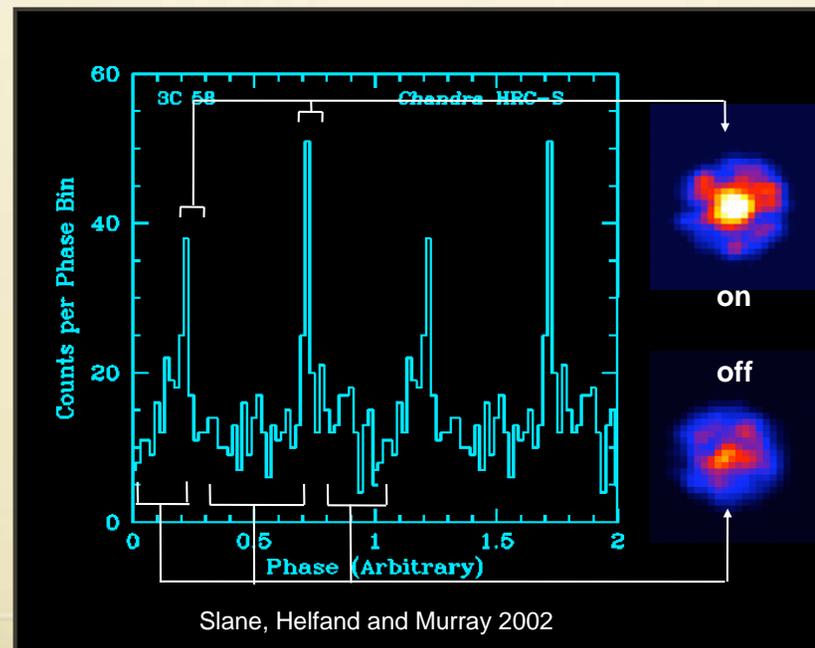
# SCIENCE EXAMPLES:

## 3C58

- Point source embedded in PWN embedded in SNR
- HRC-S timing selected 744 photons:  $P=65.6789$  msec
- RXTE:  $P=65.6592$  msec
- $P\text{-dot} = 1.935 \times 10^{-13} \text{ s s}^{-1}$
- $B=3.6 \times 10^{12} \text{ G}$
- Age: 820 (SN1181)
- $P_0=60.57$  msec
- $T^\infty < 1.13 \times 10^6 \text{ K}$

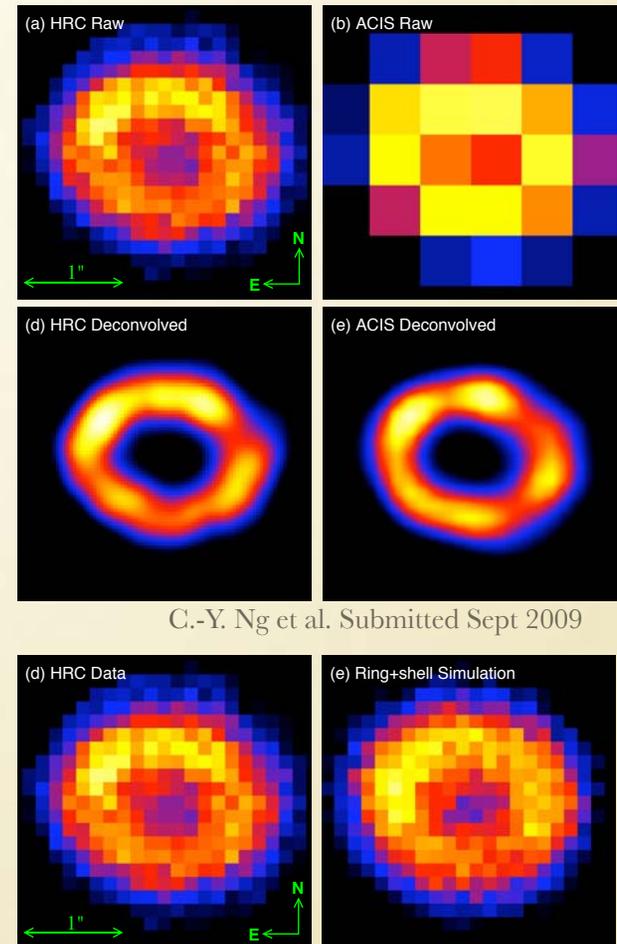


Murray et al. 2002



# SCIENCE EXAMPLES: SN 1987A

- Raw HRC(a) and ACIS(b)
- Lucy Deconvolved HRC(d)
- Sub-pixel and Lucy ACIS(e)
- Raw HRC(d) and Ring plus Shell Simulation(e)
- Outer radius  $0.96'' \pm 0.05 \pm 0.03$ 
  - Same as radio size, forward and reverse shocks are closely located
- CCO flux  $< 0.010$  HRC ct/s (99%)
  - $T^\infty < 2.5$  MK, close to needing fast cooling unless obscured





# CONCLUSIONS

- HRC evolved from a very simple instrument to a more complicated and more capable one over time.
- We had to relearn a lot between Einstein and Chandra, even with ROSAT between them.
- Some problems were not discovered until late and could not be fixed on the ground.
- Many problems were overcome by hard work and smart people. I am extremely fortunate to have a great team.
- HRC is a success. It is doing very well, and with the exception of the higher than expected background has met or exceeded expectations.