Out of this World Antenna Measurements

SAREX Behind the Scenes

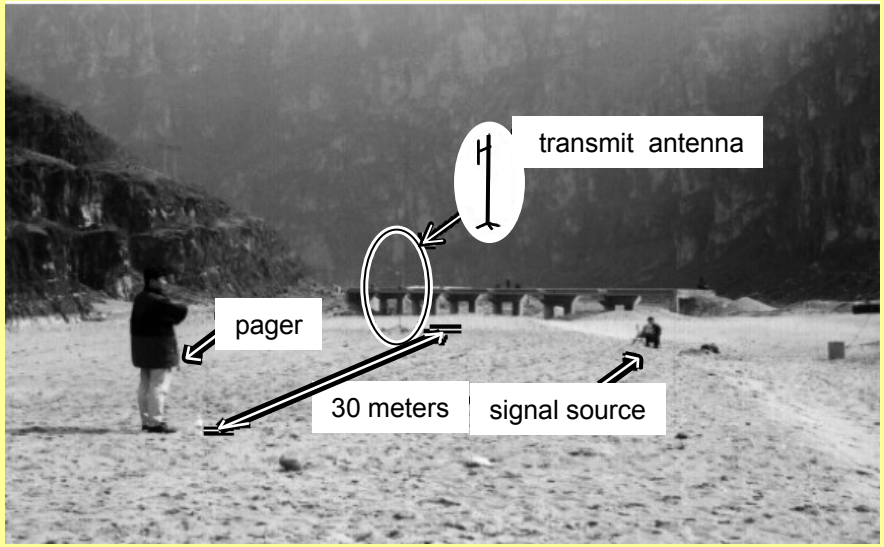
2014 July 9

Kai Siwiak, KE4PT

prepared for the South Florida DX ASSOCIATION

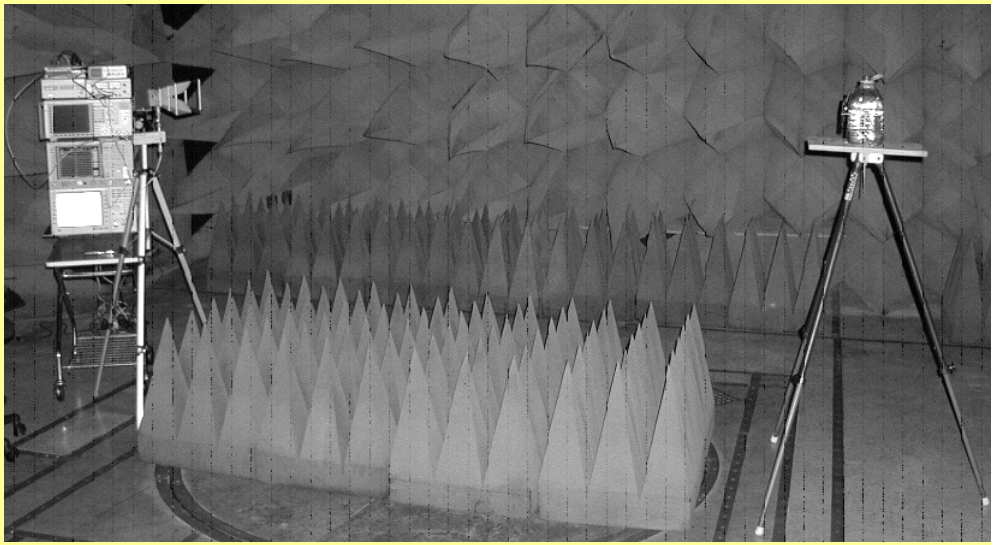
Part – I: Antenna Ranges

Typical OATS antenna range:



… In a river bed in China

Typical indoor anechoic range:



… in Boca Raton, Florida

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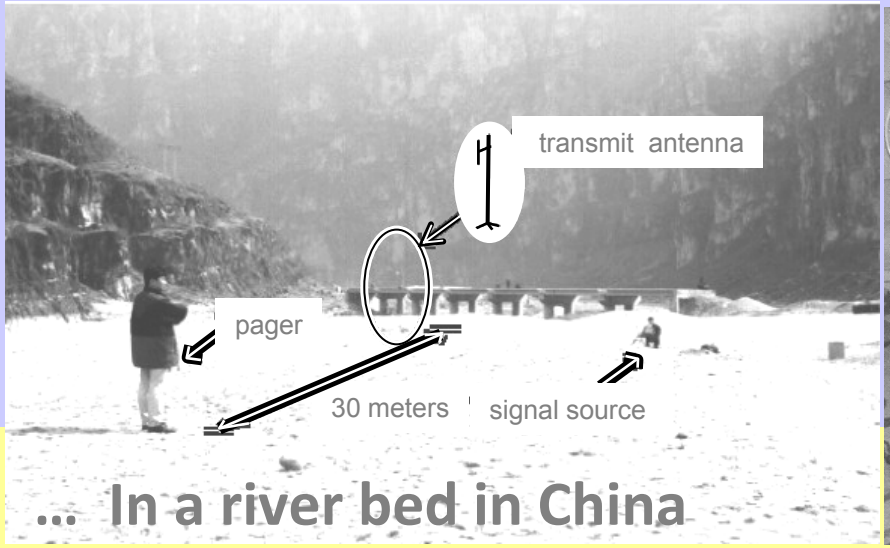

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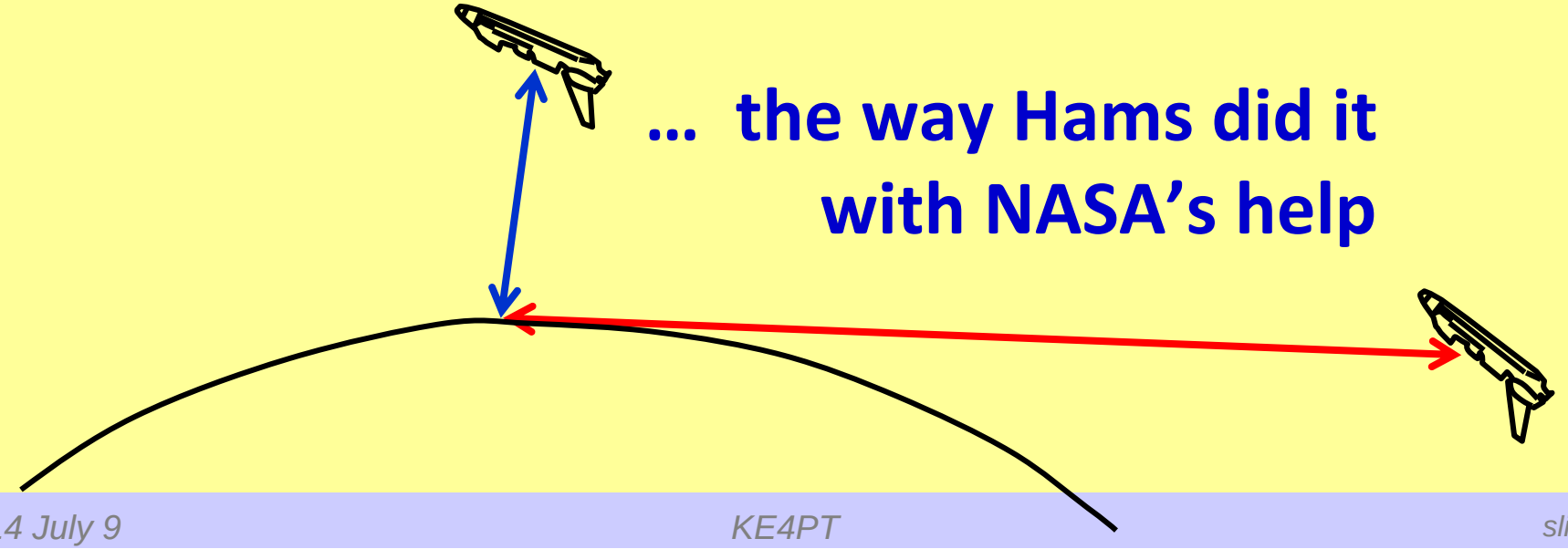
Typical indoor anechoic range:

… in Boca Raton, Florida



… the way Hams did it with NASA's help

Background: SAREX (now ARISS)

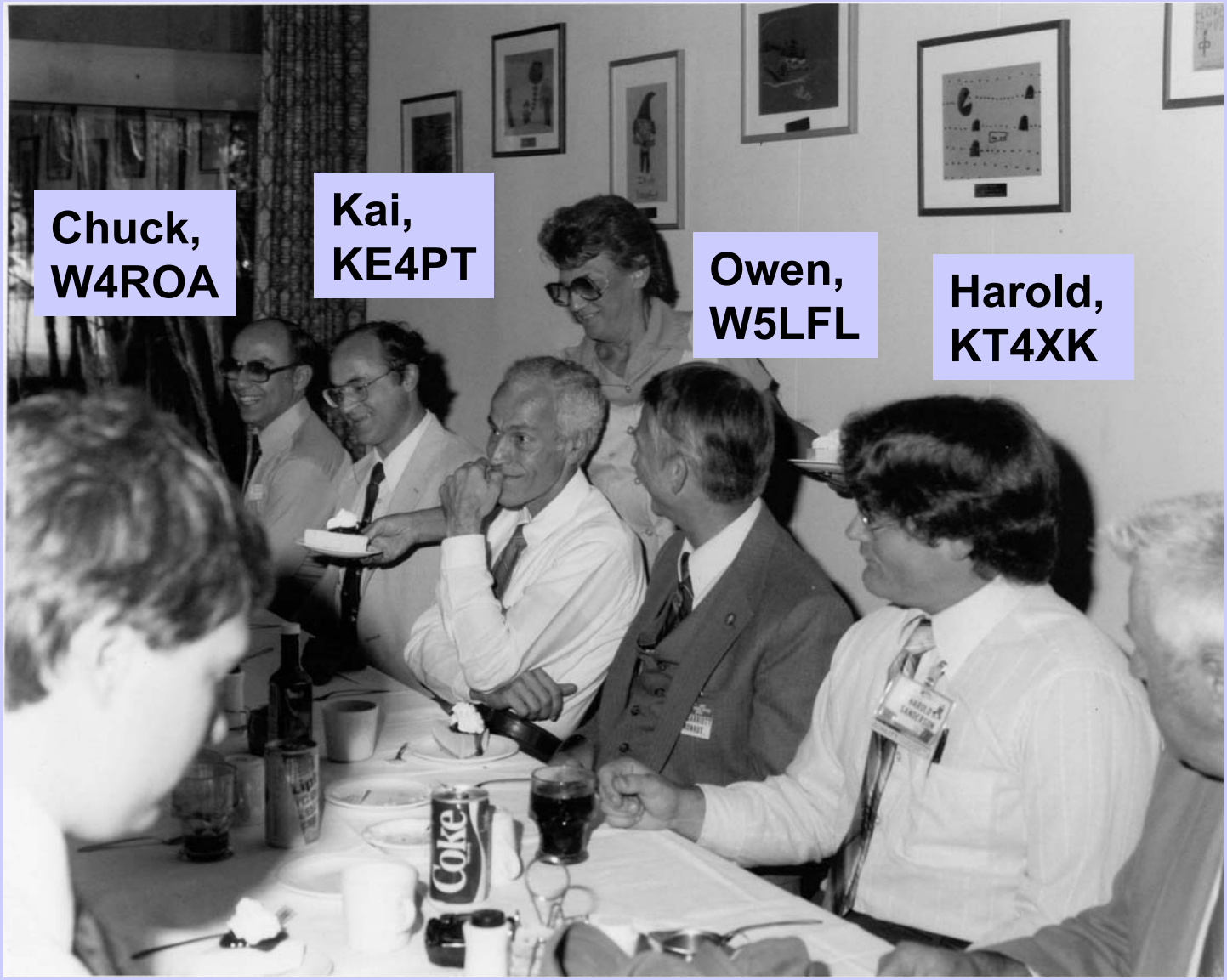
- **In the Public Eye**
  - Random contacts with Hams World Wide
  - Contacts and Educational activities with schools and youth groups
  - Visibility for NASA
- **Behind the Scenes**
  - SAREX support for missions and new capabilities
  - Crew phone patches with Family
  - Special propagation experiments
  - Ham ATV experiments

Year	Mission					
1983	STS-9					
1985	STS-51F	STS-61A				
1990	STS-35					
1991	STS-37					
1992	STS-45	STS-47	STS-50			
1993	STS-55	STS-56	STS-57	STS-58		
1994	STS-59	STS-60	STS-64	STS-65		
1995	STS-63	STS-67	STS-70	STS-71	STS-74	
1996	STS-76	STS-78	STS-79	STS-80	STS-81	
1997	STS-83	STS-94				
1999	STS-93					

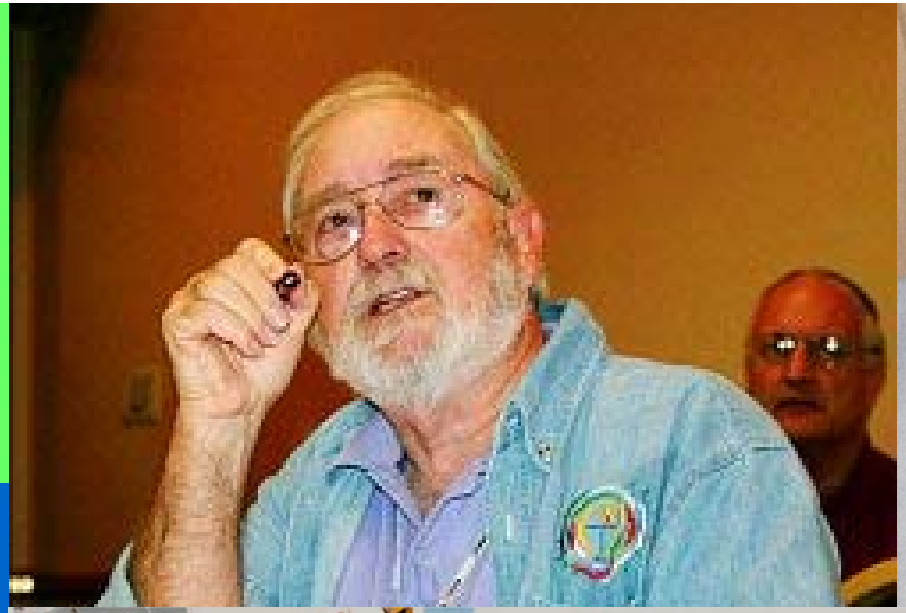
Columbia
Challenger
Atlantis
Discovery
Endeavor

More details : http://ct1eat.no.sapo.pt/sarex/sarexm_e.html

SAREX Started After STS-9



SAREX Kick–off Meeting



top, left to right … ↑→

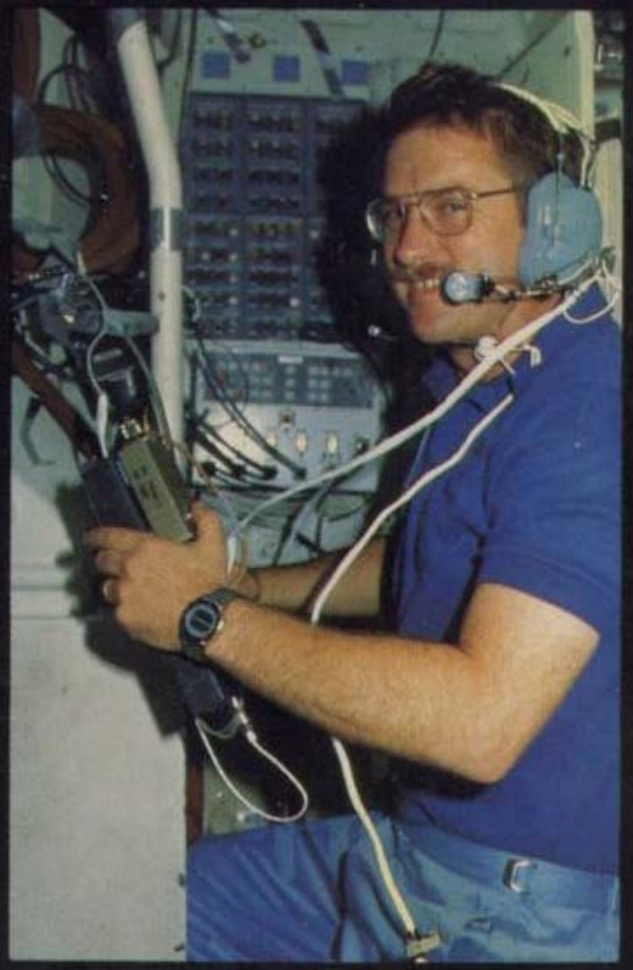
Lou, W5DID, [SAREX P.I.]
Kai, KE4PT, [Volunteer]
Owen, W5LFL, [Astronaut]

←Kai on OV-102 Columbia with STS-9 antenna

...The cast included hundreds!

JOHN-DAVID • W4NYZ
GORDO • Ex-WN7RQR
OWEN • W5LFL
LOUIS • W5DID
GIL • WA5NOM
JOHN • WD5EEV
KEN • W5OBR
CANDY • KA5UKJ
KENT • W5OJ
CHUCK • KC5RG
DOUG • WA5SFY
JACK • KE5TY
OTIS • NV5F
DICK • W5AVI
PAUL • WA3VJB
BILL • N2CF
AL • WB5AYF
FROSTY • N6ENV
BILL • WA6ITF

ELLIS • W5QPT
ROY • K6DUE
BILL • W3XO
PATTY • N6BIS
ART • K8BVI
EARL • W5EZ
ROBERTO • KA8HLG
MICHAEL • AK8Y
ALAN • N8DZD
KAI • KE4PT
HAROLD • WB4TTA
TIM • N4GIJ
BRUCE • WB4YUC
DAVE • KUØR
WESS • AF4N
JD • W4GNC
JOHN • WB6DCN
RICK • KE6DO
GSFC ARC • WA3NAN
JSC ARC • W5RRR



WØORE

FROM THE SPACE SHUTTLE *"CHALLENGER"*

STS MISSION 51-F/SPACELAB 2

Year	Mission					
1983	STS-9					
1985	STS-51F					
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COLUMBIA Window Antenna Gain Test

More details : http://ct1eat.no.sapo.pt/sarex/sarexm_e.html

The Experiment

- **NASA asked Hams to measure gain of SAREX window antenna**
- **Motorola-ARC and IBM-ARC responded with detailed measurements**
- **Many Hams sent signal reports**

More Cast Members

STS-55, Shuttle *Columbia*, April 26-May 6, 1993

Crew: Commander Steve Nagel, N5RAW; Pilot Terrence "Tom" Henricks; Payload Commander Jerry Ross, N5SCW; Mission Specialist Charles Precourt, KB5YSQ; Mission Specialist Bernard Harris; Payload Specialist Hans Wilhelm Schlegel, DG1KIH; Payload Specialist Ulrich Walter, DG1KIM

On April 30, the crew conducted an experiment during Orbits 61 and 62 comparing the performance of the SAREX window-mounted antenna to the SAFEX antenna, mounted on Spacelab in the shuttle's cargo bay. The following amateurs and schools participated by collecting data, which is being analyzed by the Motorola ARC: KE3I, WM3O, AB4DQ, AD4BL, K4GFG, KB4CUR, KD4AKW, KD4BCX, KD4DRA, KD4HXT, KD4SRD, KD4VFR, KE4PT, KI4FN, KN4JN, KO4HD, KO4HX, KO4ZT, KP4BJD, KQ4AV, N4CU, N4EEB, N4IBU, N4NSU, N4PYB, N4XGI, W4EWB, W4JMX, W4ROA, WB4YUC, WD4AHZ, WD4DML, WD4EVD, KG5IT, N5FYJ, WH6AMX, K8UYU, KA8YDB, W8TWJ, K9BCT, K9ES, N0UBW, W0RAO, TG9AJR, David Beardsley, the students at South Seminole Middle School (Florida) and Discovery Elementary School (Florida).

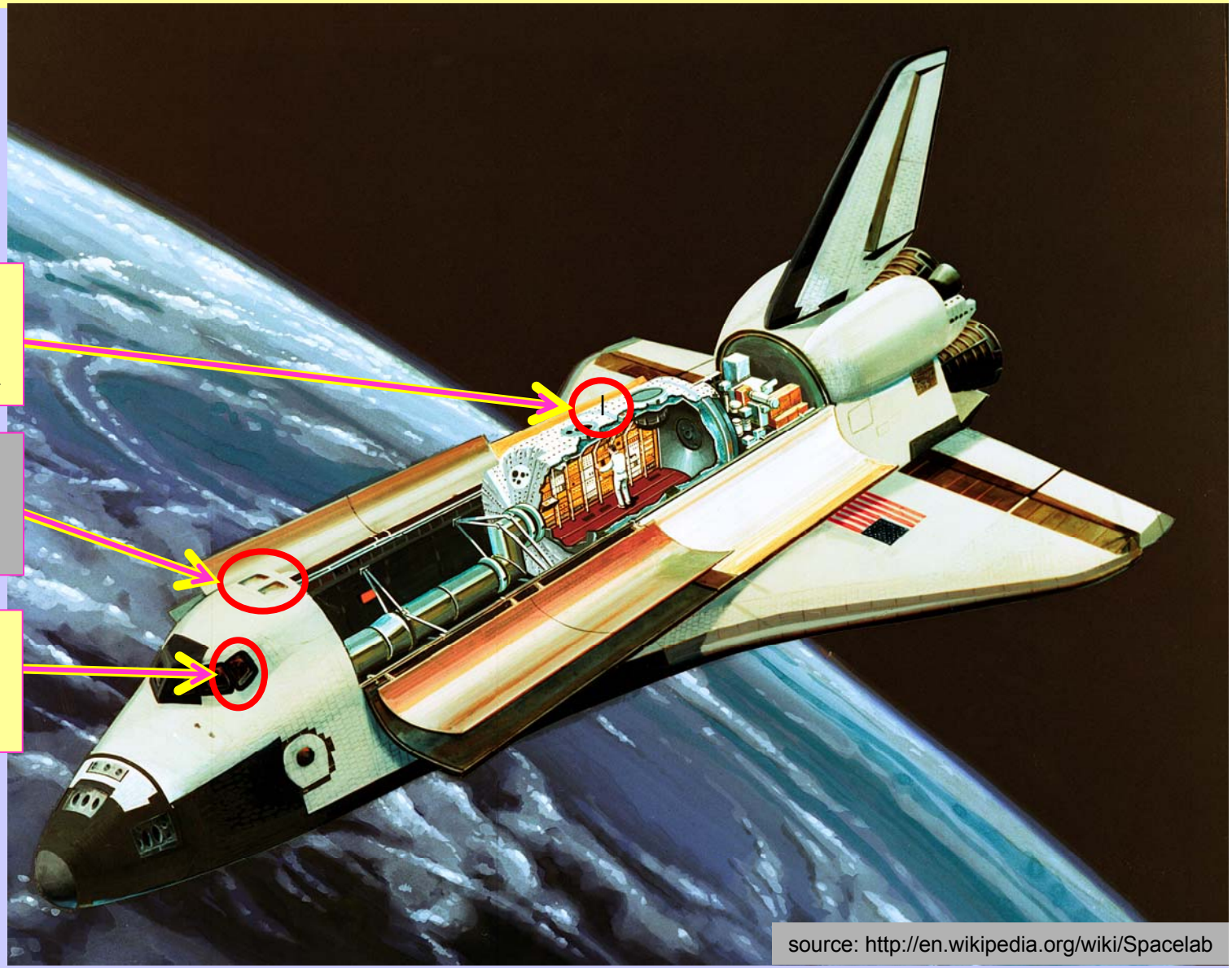
Source: *QST* Oct 1993 p53-55

Space Lab Module on Columbia

Space Lab D2 antenna

[old STS-9 antenna]

SAREX antenna

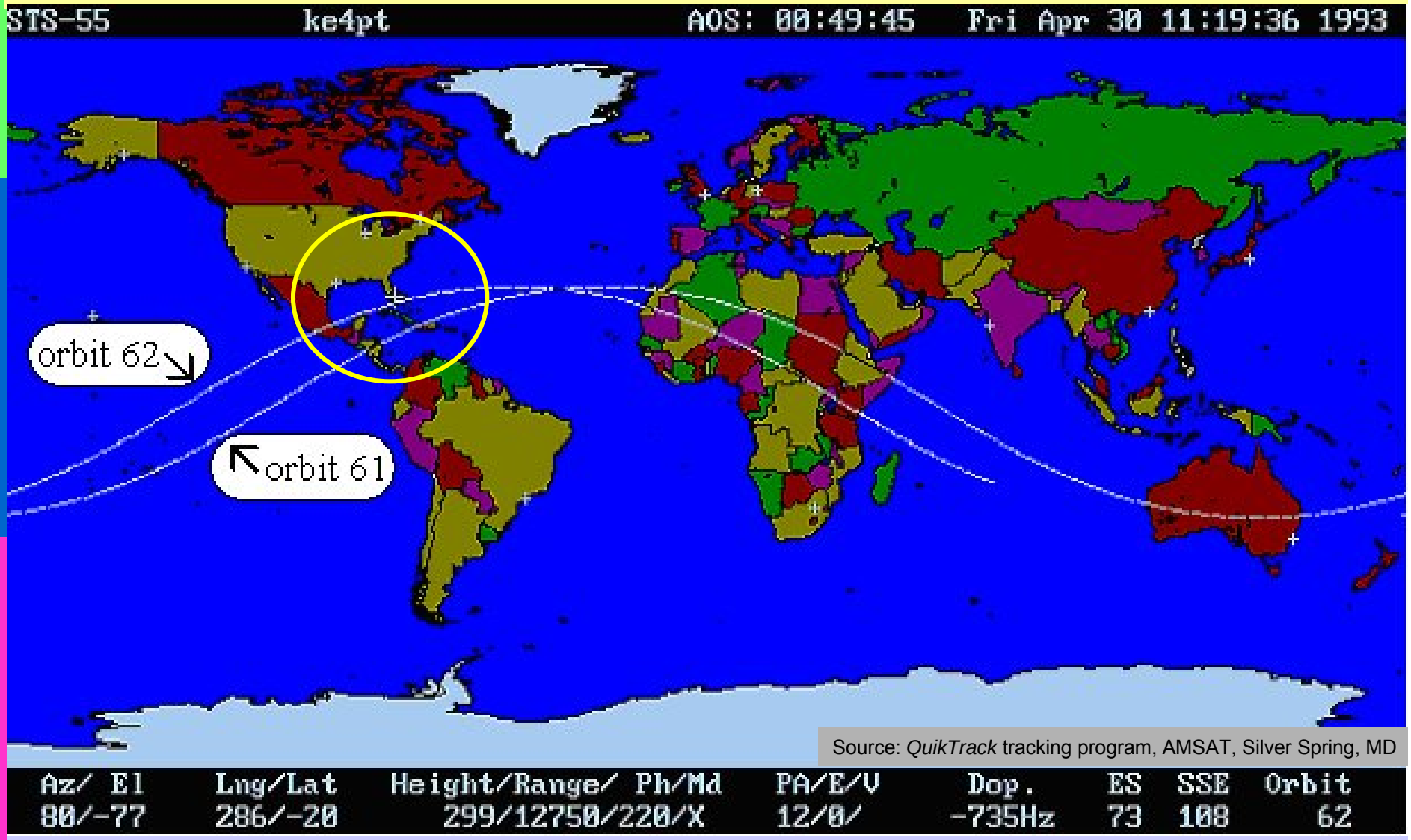


source: http://en.wikipedia.org/wiki/Spacelab

Space Shuttle Windows

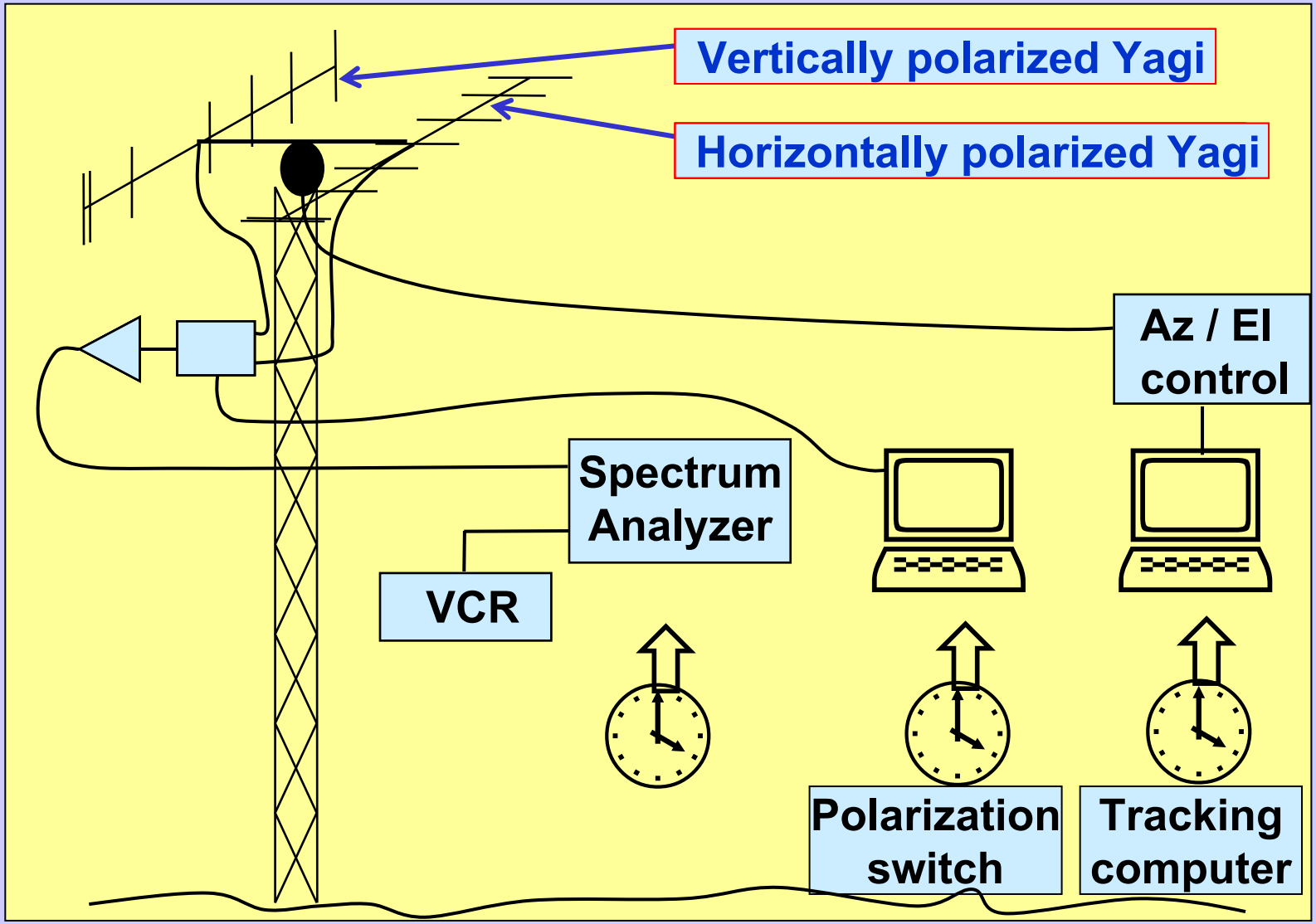
source: framework.latimes.com/2012/09/12/space-shuttle-endeavour/

We Used Two Consecutive Orbits Visible From Plantation, FL



Source: *QuikTrack* tracking program, AMSAT, Silver Spring, MD

Configuration for Test



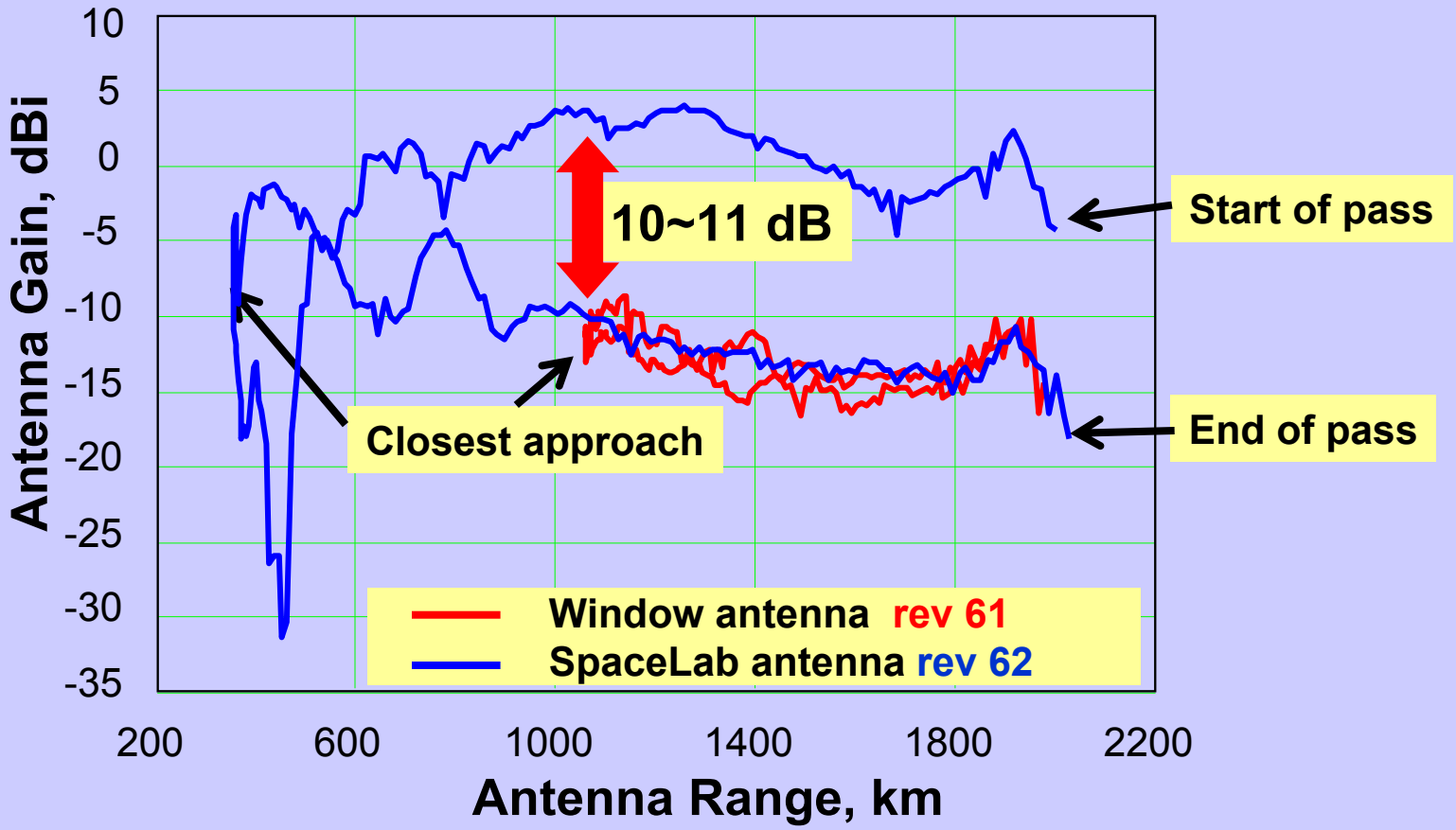
Source: K. Siwiak & Y. Bahreini, **Radiowave Propagation and Antennas for Personal Communications, Third Edition**, Norwood, MA: Artech House, 2007

What We Found

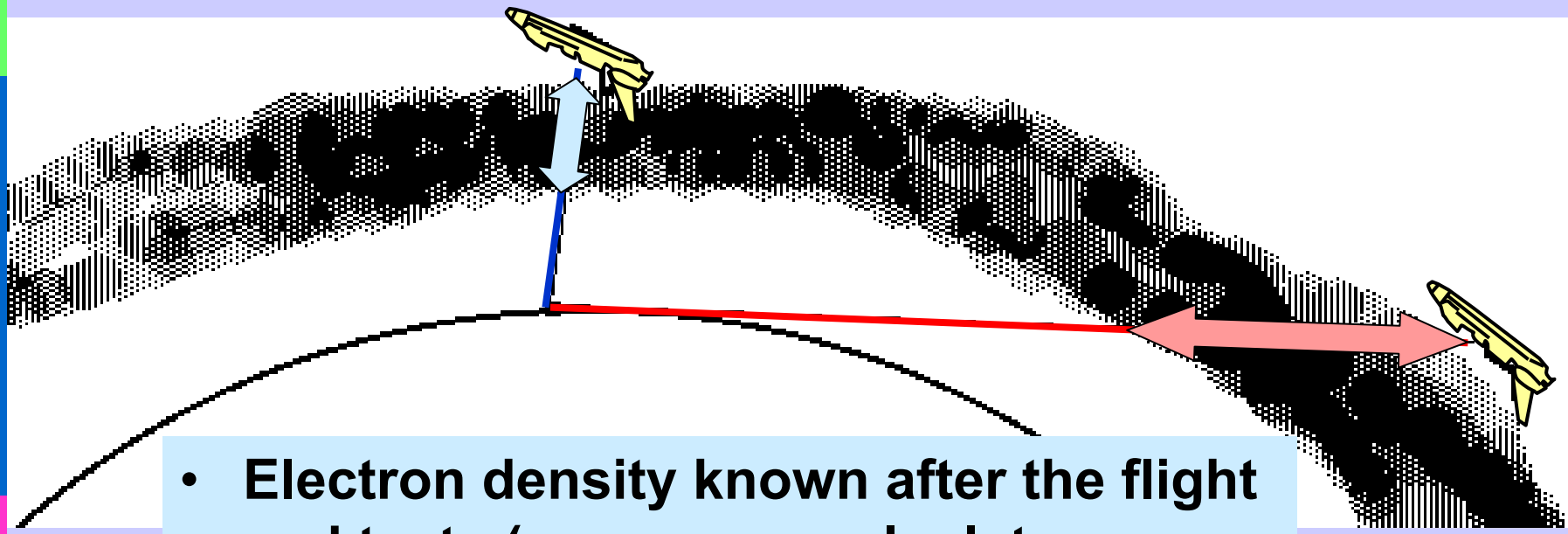
- We measured signal strength in two polarizations with:
  - Astronaut using the Window antenna (rev 61)
  - Astronaut using D2 Spacelab antenna (rev 62)

- **Calculated Antenna Gain**
- **Calculated Faraday Rotation** (the rotation of polarization as a signal passes through the charged ionosphere under influence of Earth's magnetic field)

Using the 2nd Longest Antenna Range in the Solar System to Measure Gain



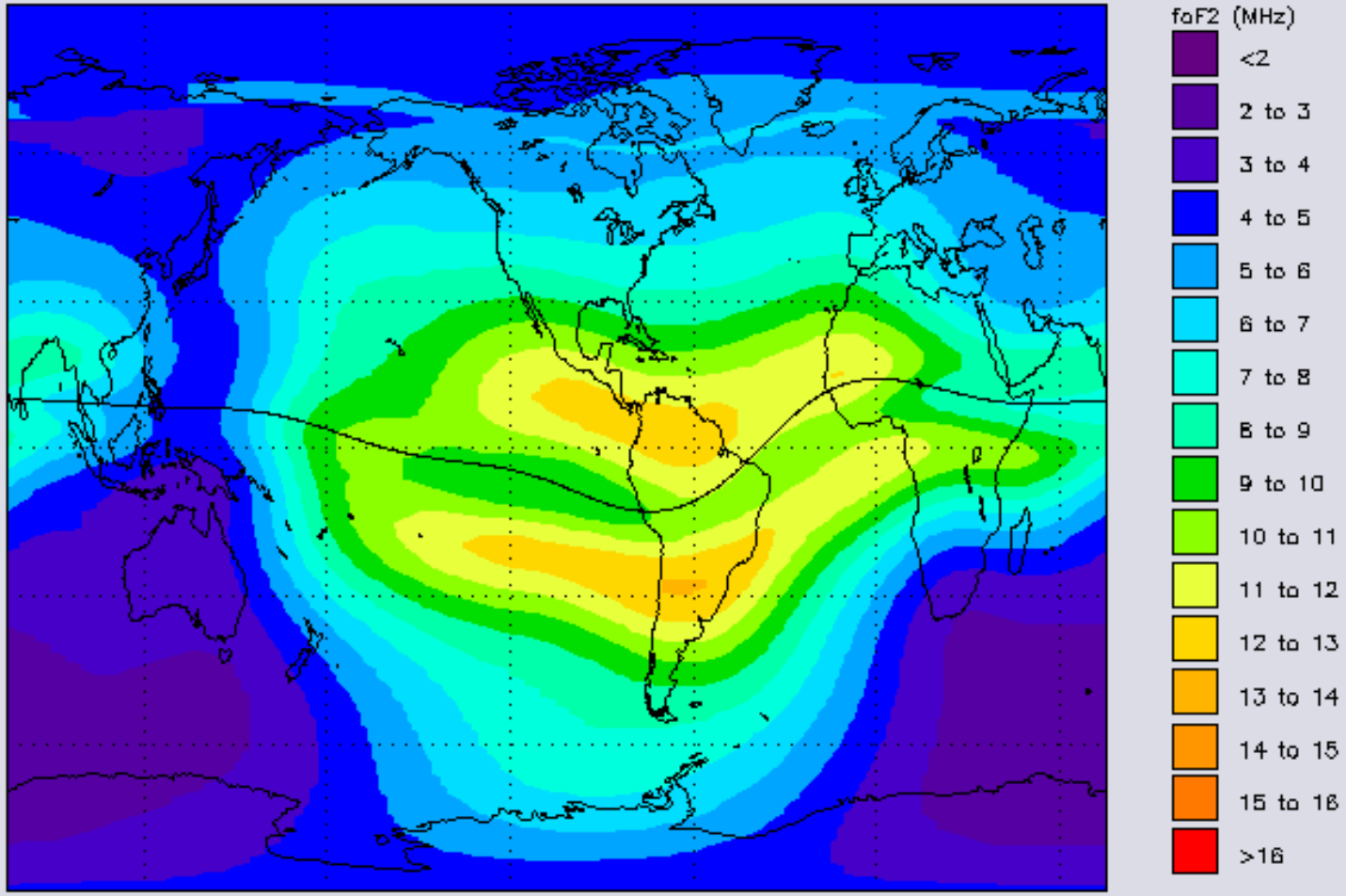
Paths through the Ionosphere



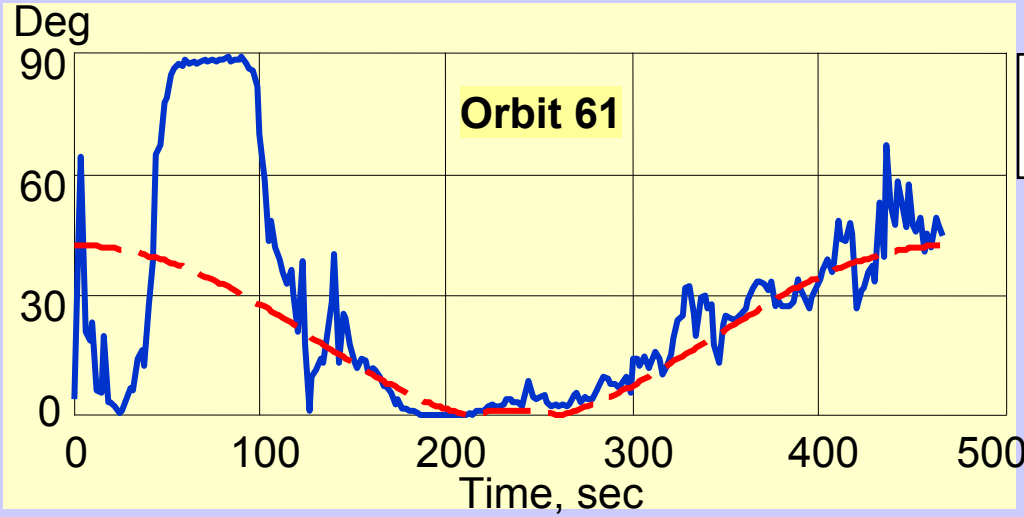
- **Electron density known after the flight and tests (so, we can calculate Faraday Rotation)**
- **Different path lengths result in different amount of Faraday rotation**

Ionosphere during rev 61/62 gives us electron density

$$N_{mF2} = 1.24(foF2)^2 \times 10^{10} \quad electrons/m^3$$

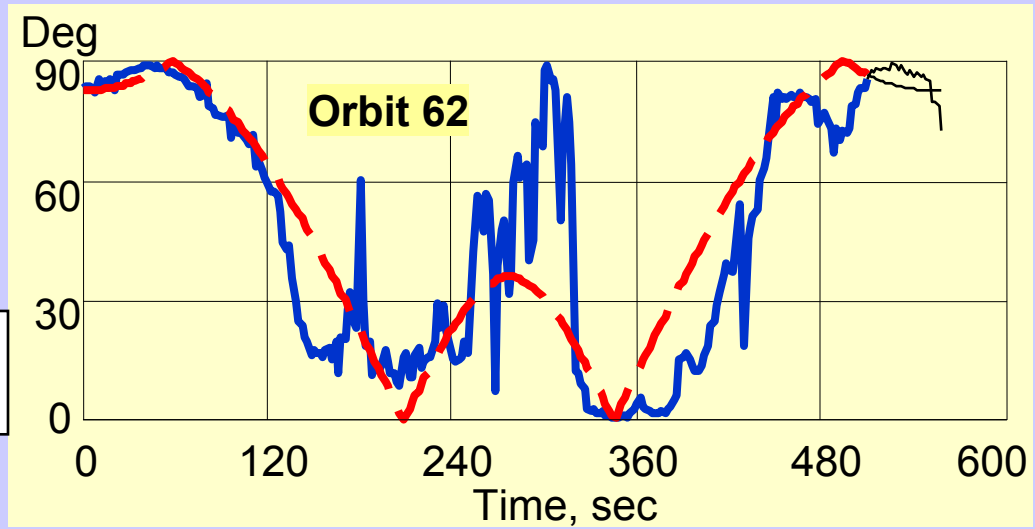


Bottom Line:



Calculated: about a ¼ turn
Measured: about a ¼ turn

$$Turns = \frac{e_e^3 B_0 \int_z N_{mF2}(z)dz}{2c\varepsilon_0 (m_e 2\pi f)^2 2\pi}$$



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Measured

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Bottom Line...

- Antenna Range DX was 180 – 1800 miles
- The Window VHF antenna was –10 dBi
- Faraday rotation is significant!

- Consequence:

  Today's ARISS contacts use **gain antennas** and **circular polarization**

The Longest Antenna Range?

- SAREX STS-55 was my 2nd Longest Antenna Range Measurement (300 km to 2,200 km)
- My “best DX” antenna gain measurement was on a 720,000 km (447,000 mile) range, and at HF
  [That’s Part – II: for another day!]

Thanks for your attention!

Kai, KE4PT

ke4pt@amsat.org

Download: www.qsl.net/k4fk/presentations.htm