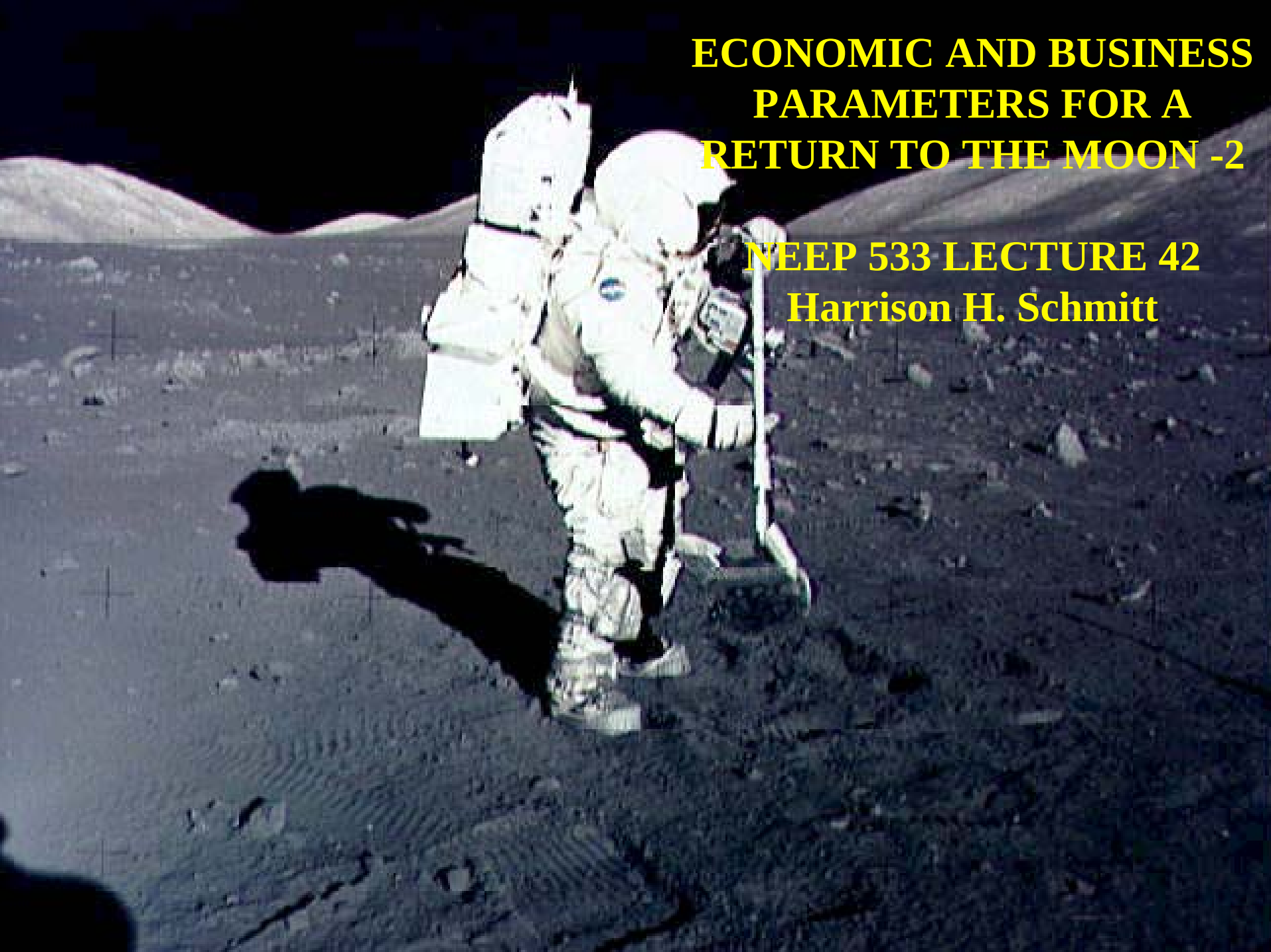


ECONOMIC AND BUSINESS PARAMETERS FOR A RETURN TO THE MOON -2

NEEP 533 LECTURE 42

Harrison H. Schmitt

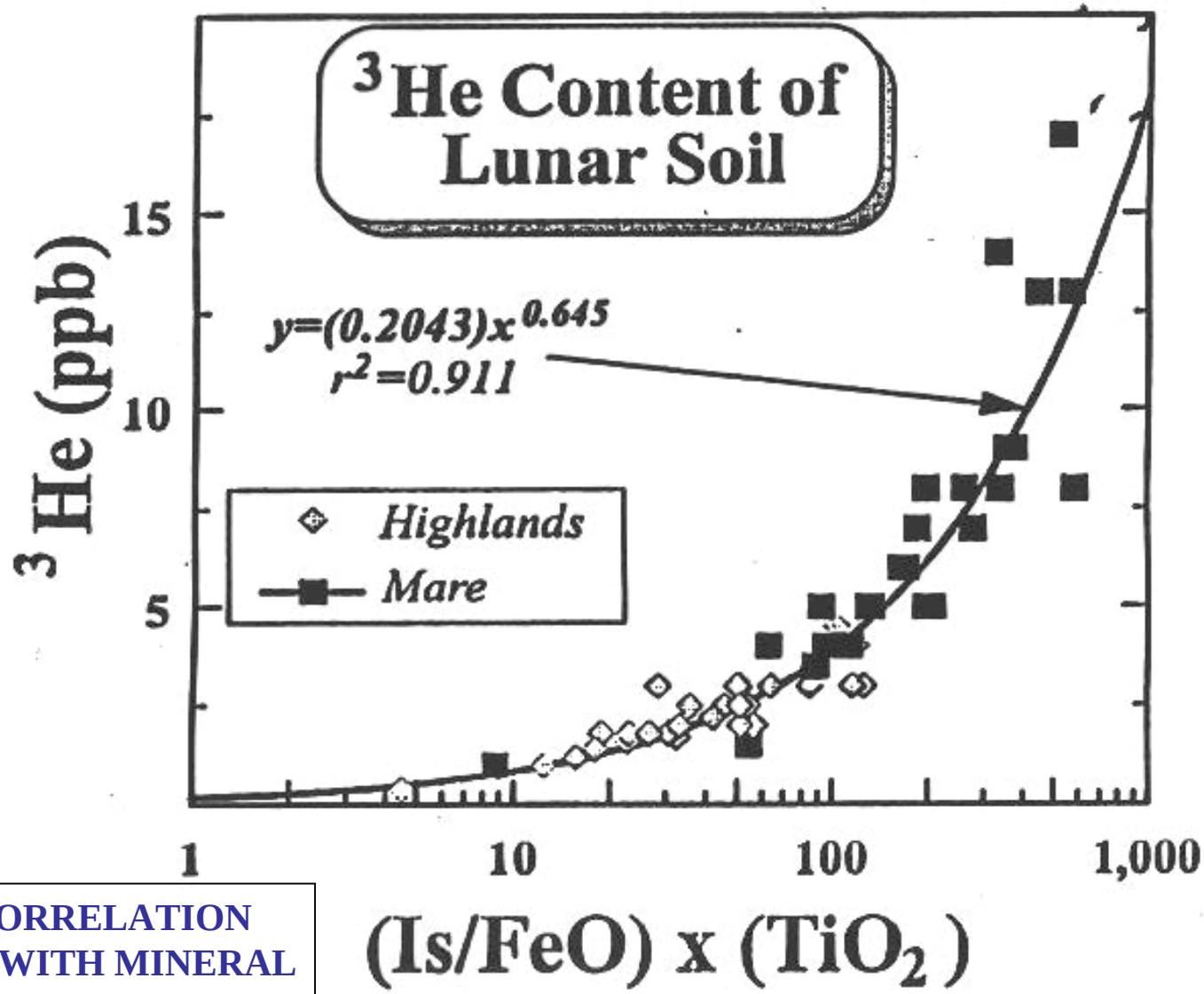
HELIUM-3 IN APOLLO 11 LUNAR REGOLITH -1

- **He-3 / He-4 = ~1/2400**
- **He-4 IN LOOSE (10084) SOIL**
  - **38 PPM AVE. OF 9 PORTIONS**
  - **16 PPB AVE. He-3**
- **He-4 IN IMPACT INDURATED SOIL**
  - **53 PPM AVE. OF 13 PORTIONS OF 9 SAMPLES**
  - **22 PPB AVE. He-3**
  - **APPARENT 27% LOSS DUE TO AGITATION**
- **MAX. He-4 IN IMPACT INDURATED SOIL**
  - **85 PPM**
  - **35 PPB He-3**
  - **POSSIBLE >37% LOSS DUE TO AGITATION**

HELIUM-3 IN APOLLO 11 LUNAR REGOLITH -2

- **NOTE: APPEAR TO BE TWO RETENTION SITES IN REGOLITH PARTICLES**
  - **LOOSE - RELEASED BY AGITATION**
  - **FIRM - RELEASED BY HEAT**
- **POSSIBLE THAT Ti CORRELATION RELATES ONLY TO "FIRM" RETENTION**
  - **ANALYSES OF SAMPLES FROM LOW Ti LOCATIONS MAY BE BIASED LOW DUE TO AGITATION LOSSES**
  - **LOOK AT INDURATED SOIL ANALYSES TO CHECK**

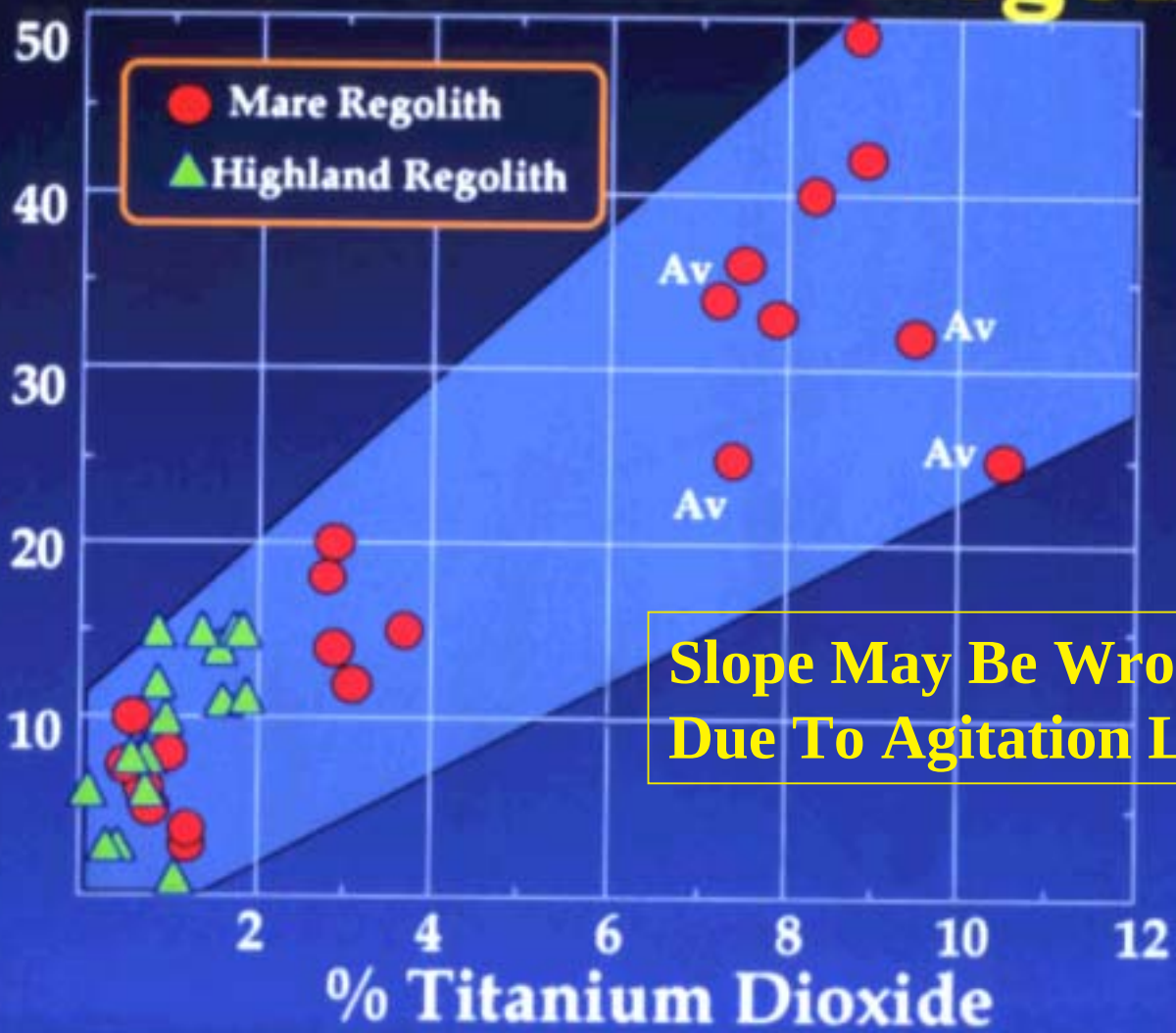
The Concentration of Helium-3 Correlates Quite Well With the Product of Maturity and Ti Content



NOTE: Ti CORRELATION COULD BE WITH MINERAL OXIDES STRUCTURE

Source: L. A. Taylor, p. 49 in 2nd Wisconsin Symposium on Helium-3 and Fusion Power, 1993

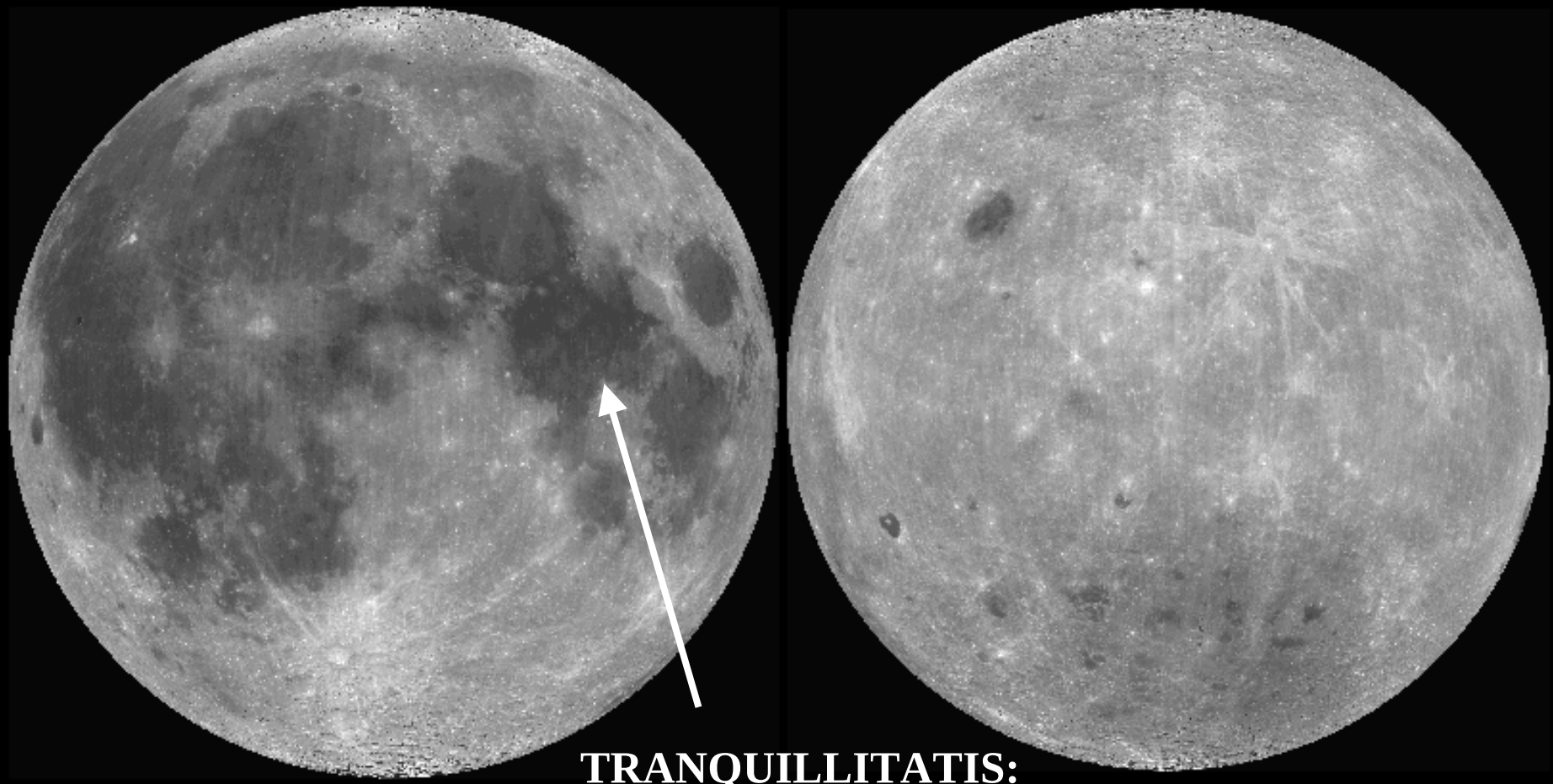
Correlation of Helium Content With TiO2 in Lunar Regolith

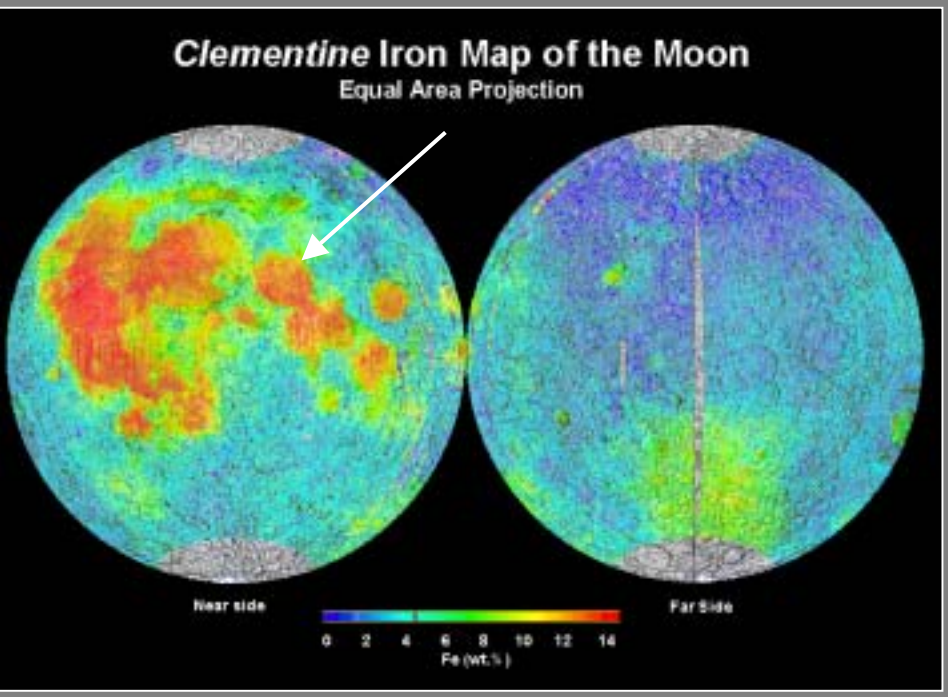


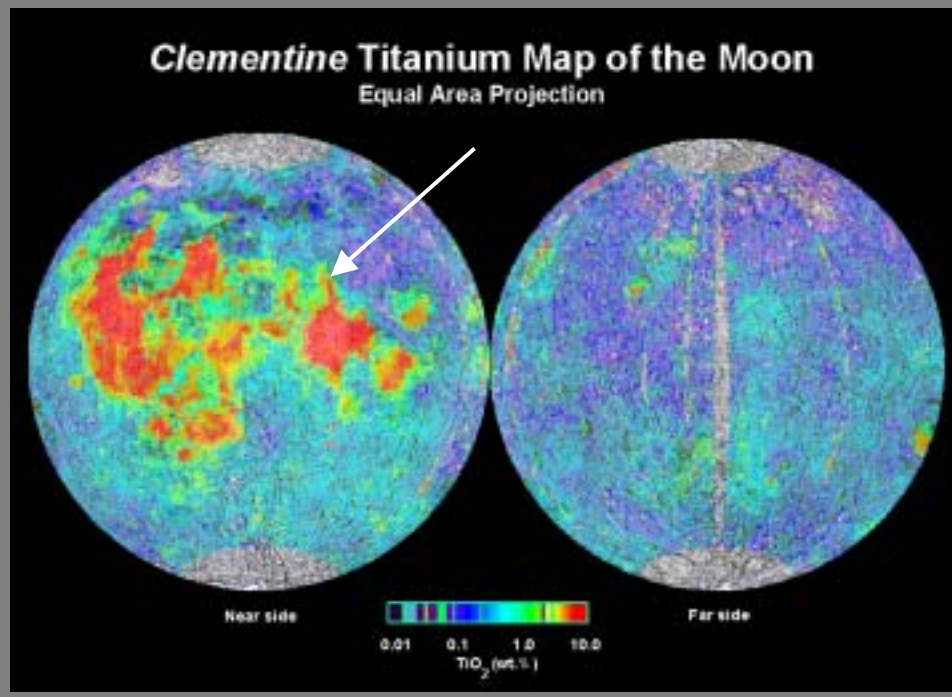
Slope May Be Wrong Due To Agitation Losses.

Clementine Global Albedo Images

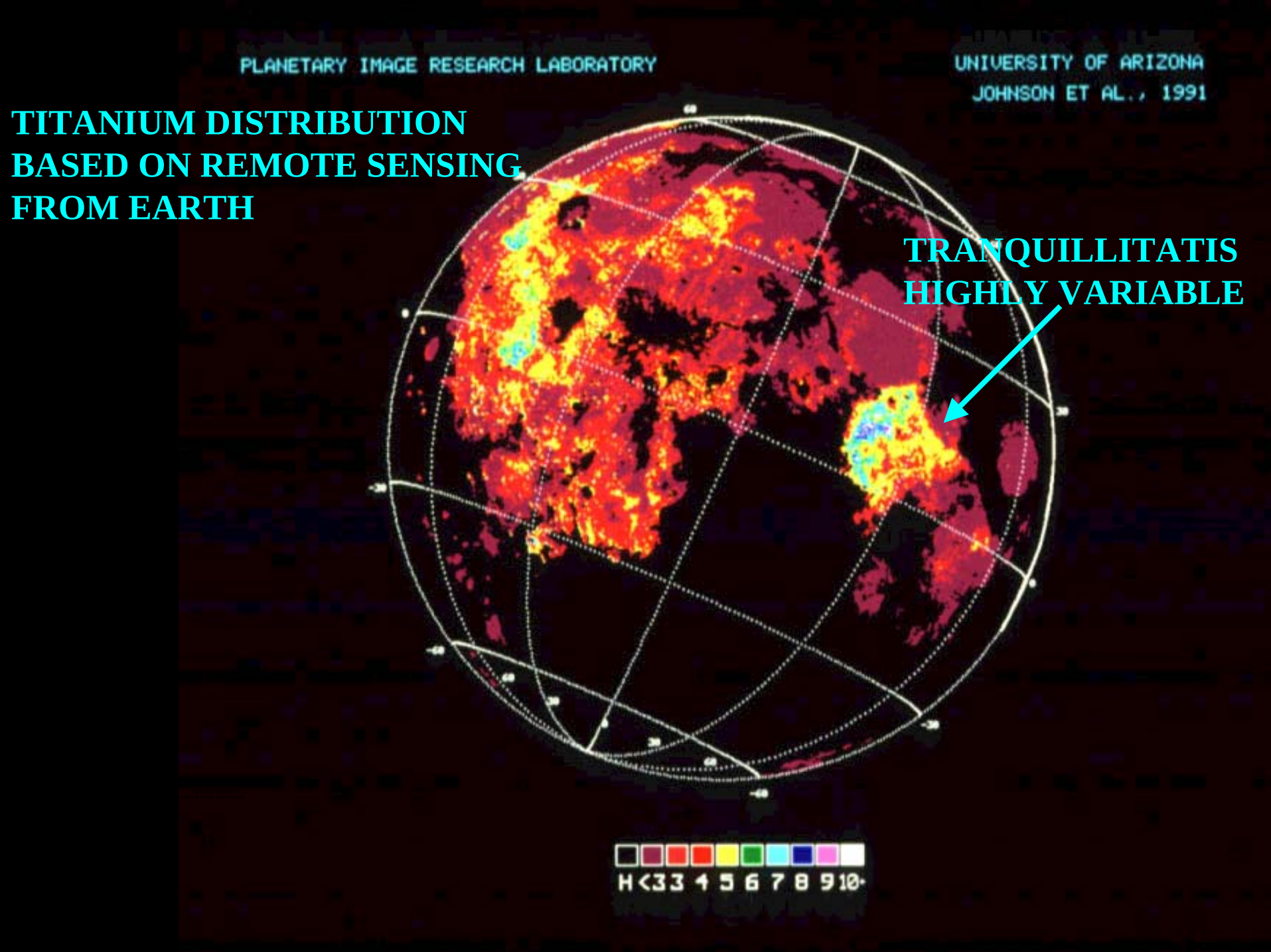
(750 nm filter)

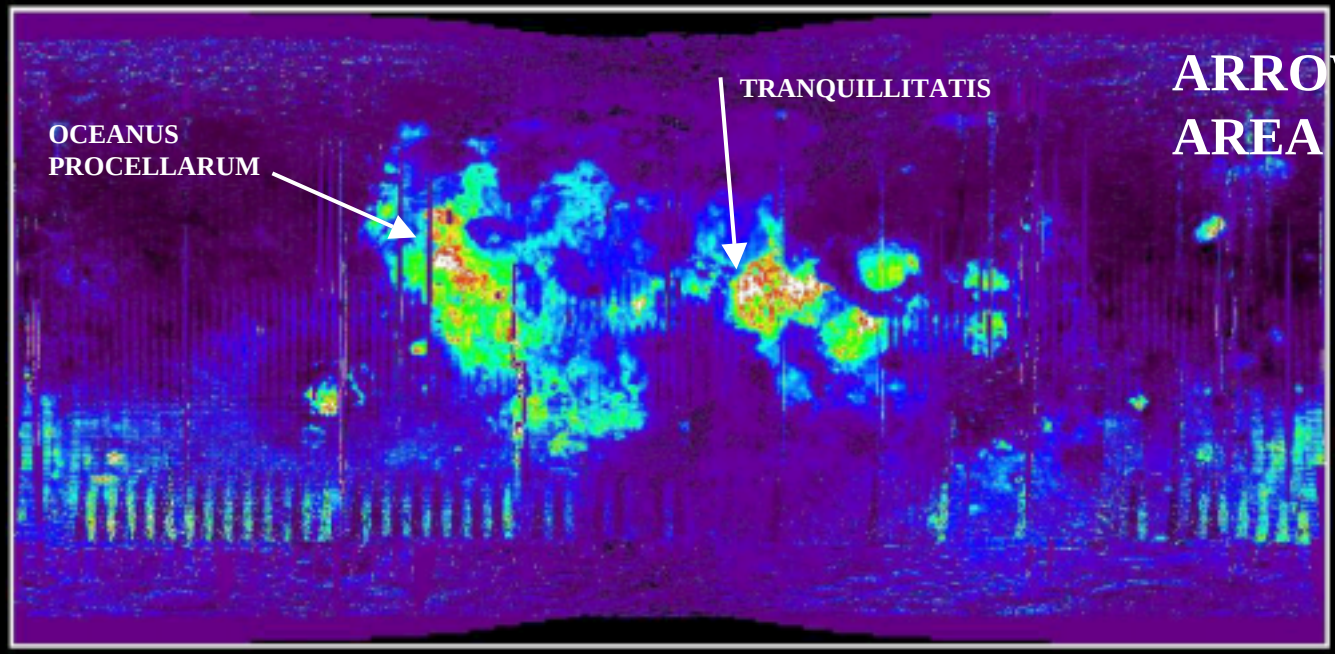






ARROW POINTS TO SERENITATIS BASIN.
NOTE THAT CENTER IS IRON-RICH BUT TITANIUM-POOR

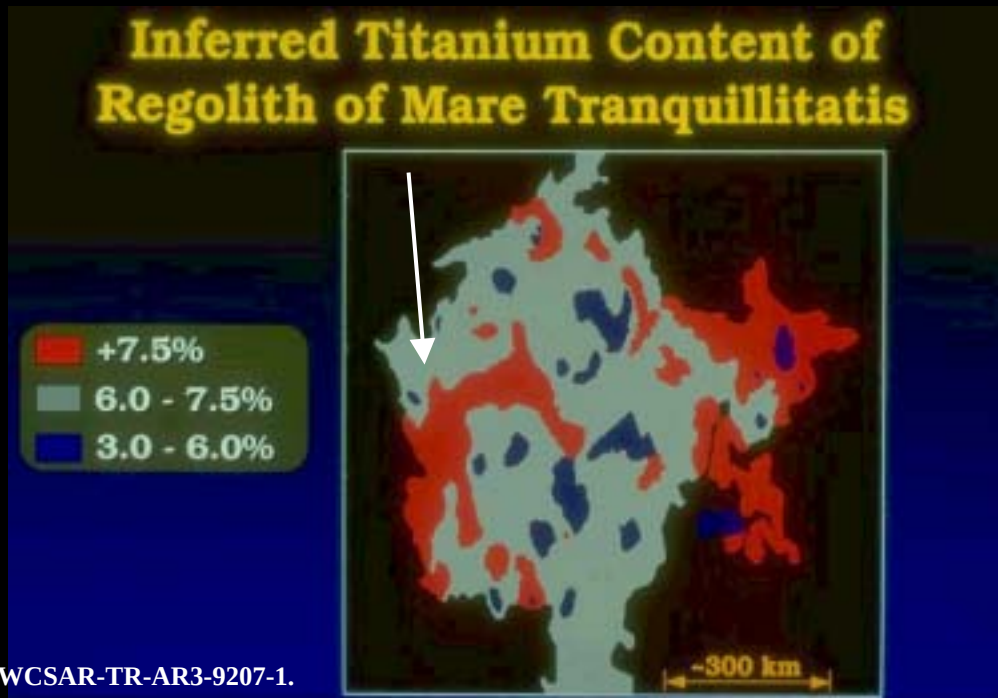

PLANETARY IMAGE RESEARCH LABORATORY
UNIVERSITY OF ARIZONA
JOHNSON ET AL., 1991
TITANIUM DISTRIBUTION
BASED ON REMOTE SENSING
FROM EARTH
TRANQUILLITATIS
HIGHLY VARIABLE
H<3 3 4 5 6 7 8 9 10+



Estimated Helium-3 Abundance

ARROWS INDICATE MAIN AREA OF AGREEMENT

JOHNSON, J.R., SWINDEL, T.D., AND LUCEY, P.G., 1999, GEOPHYSICAL RESEARCH LETTER, 26, 3, 385-388.



CAMERON, E.N., 1992, TECHNICAL REPORT, WCSAR-TR-AR3-9207-1.

POSSIBLE MINABLE "HIGH GRADE" HELIUM -3 ORE

(CAMERON, 1992)

- **84,000 KM^2 IS ESTIMATED MINABLE AREA IN MARE TRANQUILLITATIS**
  - **TiO_2 > 7.5%**
  - **UNMINABLE AREAS ELIMINATED**
    - **"FRESH" CRATERS >~20M DIAMETER, PLUS ONE CRATER DIAMETER**

HE-3 MINING ASSUMPTIONS

- **GEOTECHNICAL PARAMETERS**
  - **RECOVERABLE GRADE = 20 PPB**
  - **REGOLITH < 100μ = 50%**
    - **ROUGH AVERAGE AT APOLLO 11**
  - **MASS FINES PROCESSED = 5MT**
  - **SPECIFIC GRAVITY = 1.7**
    - **AVERAGE IN APOLLO 15 AND 17 3m CORES**
- **MINING RATES / 100 KG HE-3**
  - **MASS TOTAL REGOLITH MINED = 10MT**
  - **VOLUME MINED = 5.9 Mm^3**
  - **AREA MINED = ~2 KM^2**

HE-3 MINING RATES
100 KG/YR

- **MINED MASS / HR = ~3900 T**
  - **13, 10 DAY-MOS., 20 HR-DAYS (TWO SHIFTS)**
- **MINED VOLUME / HR = ~ 2200m^3**
- **AREA MINED / HR TO 3m DEPTH = ~750 m^2**
  - **28m X 28m / HR**
- **PROCESSED MASS / HR = ~1900 T**
- **PROCESSED VOLUME / HR = ~1100m^3**

- **NOTE: NIGHT MINING WOULD HALVE THE REQUIRED MINING RATE**

EARTH SHIPMENT MASS CONSIDERATIONS FOR HE-3

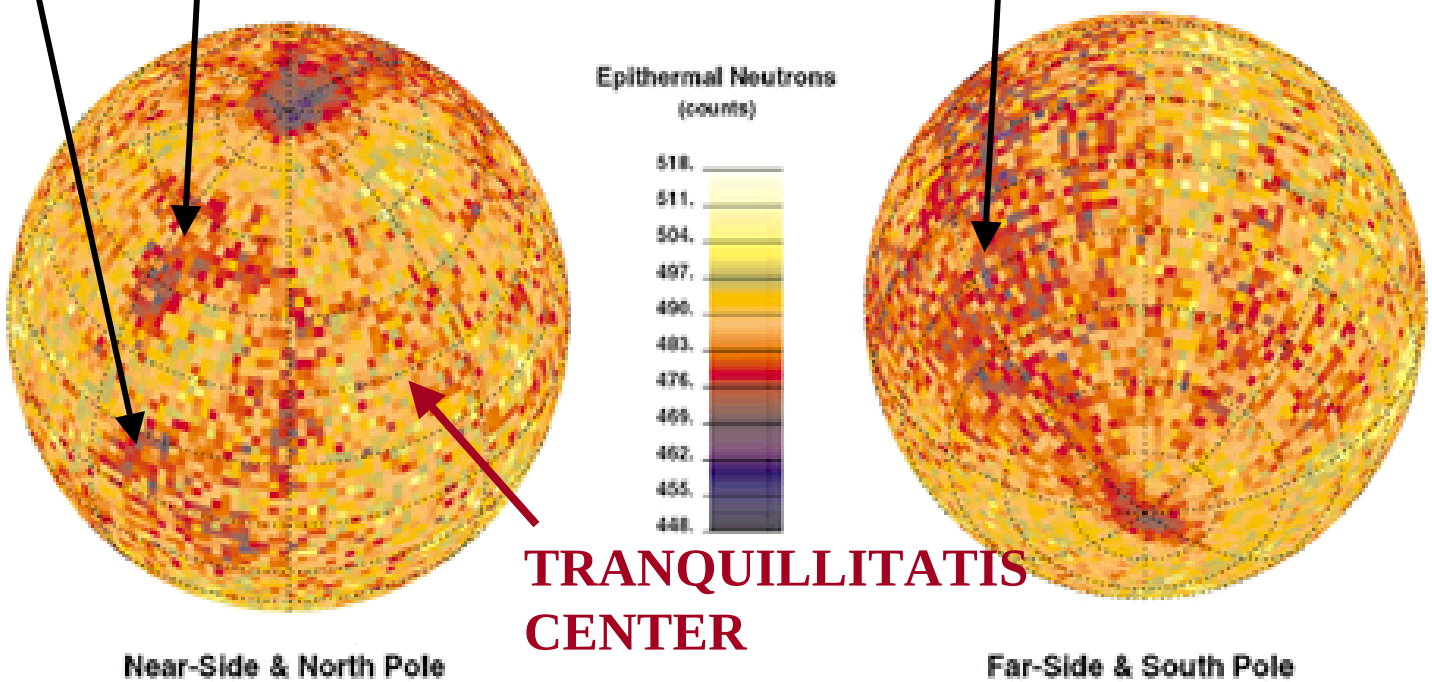
- VALUE / KG
- COST / KG TO SHIP VS. TOTAL MASS SHIPPED
- ASSESSMENT OF RISK OF A SECOND LOSS
  - INCLUDES CAUSE OF FIRST LOSS
- TIME TO REPLACE LOST MASS
  - INCLUDES EVALUATION OF SURGE CAPACITY
- COST / KG TO REPLACE LOST MASS
- LUNAR INVENTORY
- TERRESTRIAL INVENTORY
- RATE OF INCREASE OF TERRESTRIAL DEMAND
  - MORE PLANTS = MORE TOTAL INVENTORY ON EARTH

HYDROGEN + WATER BY-PRODUCT

Medium Energy Neutron Distribution
Lunar Prospector

MARIA CONCENTRATION

PLAGIOCLASE CONCENTRATION



TRANQUILLITATIS CENTER

Los Alamos National Laboratory

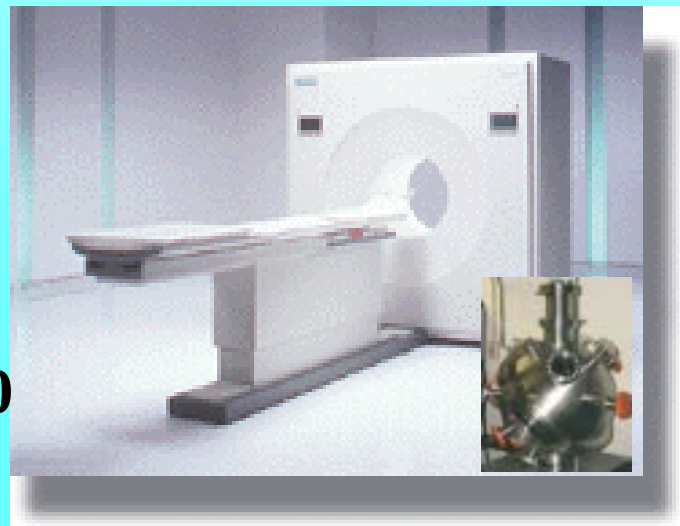
NOTE: REDUCTION IN NEUTRON COUNT IS MEASURE OF HYDROGEN DISTRIBUTION

THE ISOTOPES BUSINESS

POSITRON EMITTING ISOTOPES PRODUCTION

POSITRON EMISSION TOMOGRAPHY (PET)

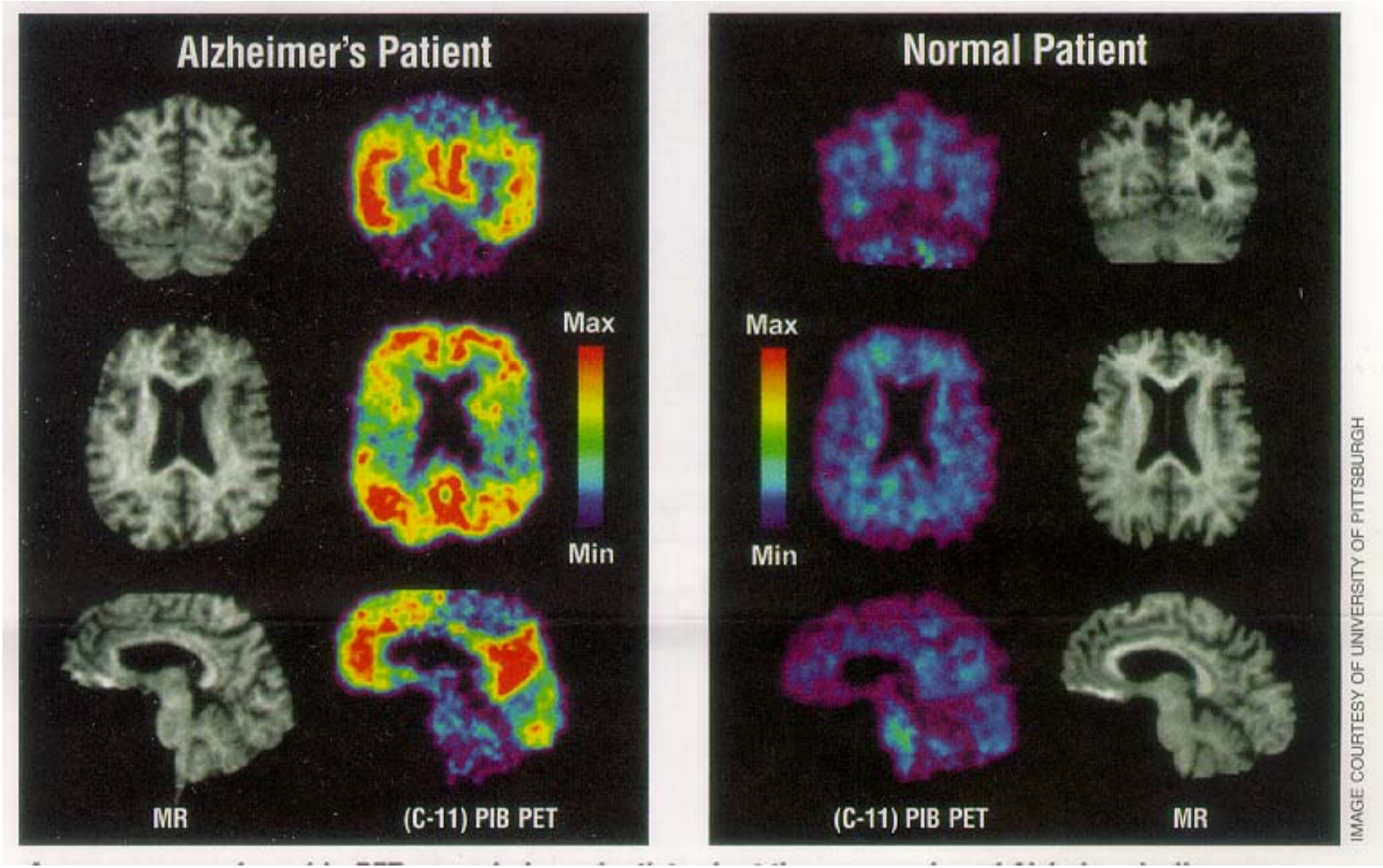
- **INCREASED DIAGNOSTIC SPECIFICITY**
- **DETERMINATION OF CANCER STAGE**
  - **HICFA APPROVED: PULMONARY NODULES, LUNG CANCER, MELANOMA, LYMPHOMA, COLORECTAL CANCER, BREAST CANCER**
- **REDUCTION IN OVERALL TREATMENT COSTS PER PATIENT**
  - **LUNG CANCER: >$1100**
  - **MYOCARDIAL PERFUSION: >$1800**
  - **OVARIAN CANCER: ~$8500**



POSITRON EMISSION TOMOGRAPHY (PET)

- **RECENT ANALYSES OF PET EFFECTIVENESS**
  - **SENSITIVITY (ABILITY TO FIND TUMORS)**
    - **84% (RANGE 84-87%)**
  - **SPECIFICITY OR STAGE (PRECISION IN TUMOR NAMING)**
    - **88% (RANGE 88-93%)**
  - **ACCURACY (QUALITY IN SENSITIVITY AND SPECIFICITY)**
    - **87-90%**
  - **DISEASE MANAGEMENT MODIFICATIONS**
    - **30% (RANGE 20-37%)**

Early Detection of Alzheimer's Disease



What is Needed is an Inexpensive, Portable Source of ^{11}C

Physicians Would Like a Shorter Half Life PET Isotope to Avoid Significant Post-diagnosis Irradiation of the Patient

- It takes ≈ 10 half lives for a radioactive isotope to "disappear".
- The problem of very short half life PET isotopes is the time to transport the isotope from its production point to the patient.
- There is a need for a portable source of short half life PET isotopes (i. e., an inexpensive, portable source of 10-15 MeV protons)

Examples of Positron Emitting Isotopes

Parent Isotope	Production Reaction	PET Isotope	Half Life
^{18}O	(p, n)	^{18}F	110 min
^{14}N	(p, α)	^{11}C	20 min
^{16}O ^{13}C	(p, α) (p,n)	^{13}N	10 min
^{15}N	(p, n)	^{15}O	2 min

ISOTOPES INC.

BUSINESS PLAN:
START-UP DEVELOPMENT

BUSINESS STRATEGY -1

- **ENTER RAPIDLY EXPANDING PET MARKET PLACE**
  - **PRODUCTION OF POINT-OF-USE FLUORINE-18 UNSERVED OR UNDERSERVED MARKET**
    - **110 MIN. HALF-LIFE LIMITS CYCLOTRON ECONOMICAL DELIVERY RANGE TO ~300 MILES**
  - **EXPAND INTO ACCELERATOR-SERVED MARKET**
    - **~$75M GROWING AT ~$55M PER YEAR IN 2000**

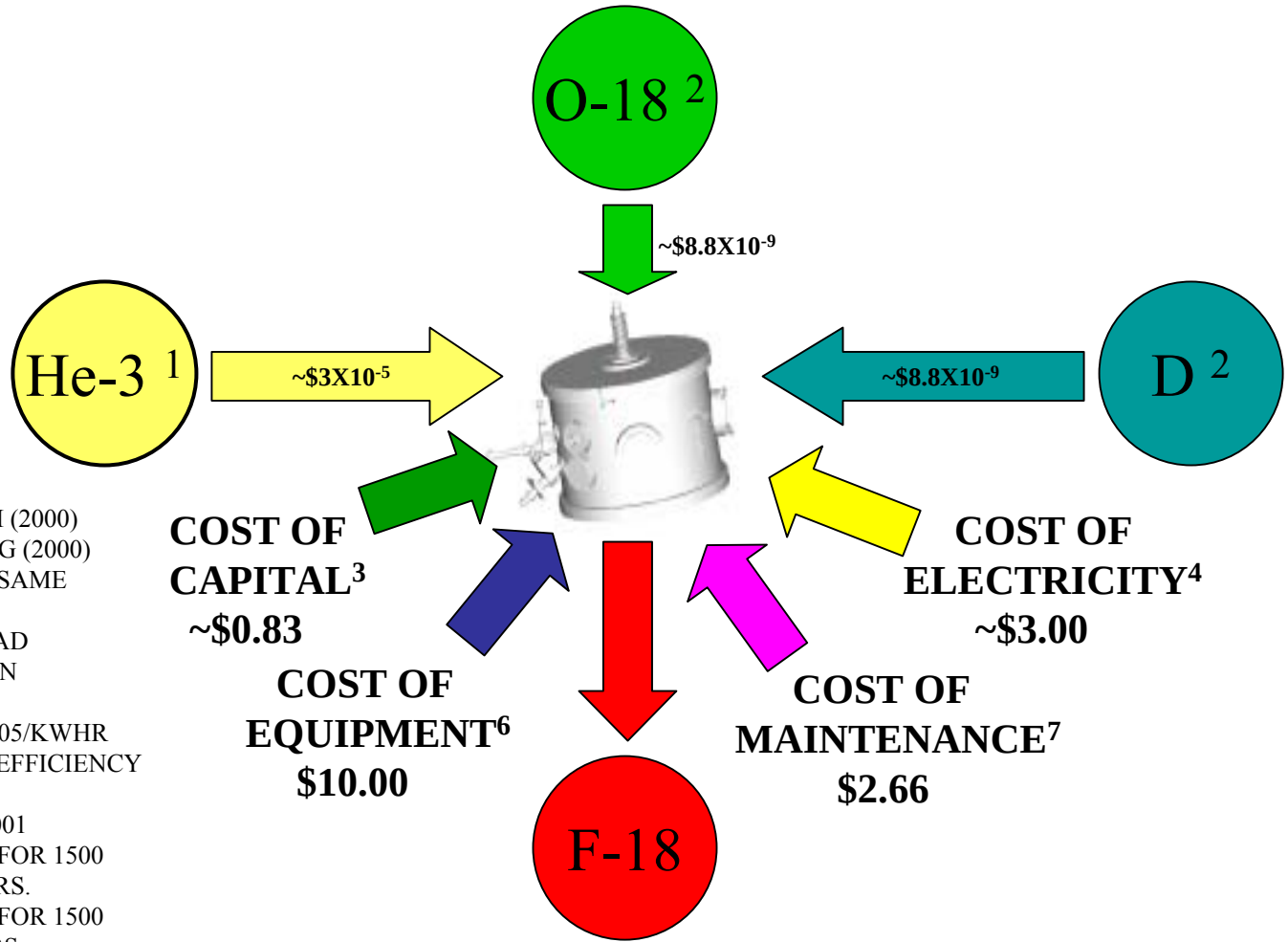
BUSINESS STRATEGY - 2

- **ADD NEW CAPABILITIES TO PET MARKET PLACE**
  - **PRODUCTION OF POINT-OF-USE NITROGEN-13**
    - **UNSERVED MARKET**
      - **10 MIN. HALF-LIFE REQUIRES POINT-OF-USE PRODUCTION**
    - **DIAGNOSTIC PROCEDURES FOR CHILDREN AND PREGNANT WOMEN**

IEC PRODUCTION OF FLUORINE-18

MATERIALS FLOW AND PRODUCTION COSTS

(10 MILLICURIE DOSE IN 2006)



1. HELIUM-3 ~$1000/GM (2000)
2. DEUTERIUM ~$440/KG (2000) OXYGEN-18 EST. AS SAME
3. ESTIMATED $20M @ 10% INTEREST SPREAD OVER 60,000 DOSES IN 2006
4. 10KW FOR 6HR @ $0.05/KWHR WITH PRODUCTION EFFICIENCY (Q) = ~10-4
5. MARKET PRICE IN 2001
6. $75,000 AMORTIZED FOR 1500 DOSES/YR OVER 5 YRS.
7. $10,000 AMORTIZED FOR 1500 DOSES/YR OVER 5YRS.
8. LEAKAGE OF ALL INPUT GASES BY FACTOR OF 10^3 WOULD INCREASE PRODUCTION COST BY ~$0.03.

FLUORINE-18 MARKET

- **>110,000 PET PROCEDURES/YEAR**
  - **>73,000/YEAR INCREASE CURRENTLY**
  - **FLUORINE-18 COSTS $650/PROCEDURE + TRANSPORT**
    - **10 MILLICURIES PER PROCEDURE (DOSE)**
- **FLUORINE-18 SUPPLIED BY ~50 CYCLOTRONS IN U.S.**
  - **~80 MORE WORLDWIDE**
  - **USED IN GLUCOSE-BASED PHARMACEUTICAL (FDG)**
- **CAPITAL COST OF CYCLOTRONS ~$2.5M**
  - **~ ONE CURIE PER DAY**
- **CAPITAL COST OF IEC DEVICE - $75,000 (EST.)**
  - **~ 30 MILLICURIES PER DAY**

ISOTOPES INC.

FINANCIAL PROJECTIONS

POST-DEVELOPMENT BUSINESS

YEAR	2005	2006	2007	2008	2009
UNITS	3	10	40	130	310
REVENUE	$0.0	6.5	39	126	302
COSTS	$3.3	7.4	20	54	121
MARGIN	(-ve)	(-ve)	50%	63%	65%
EBITDA	-$3.3	-0.27	20	94	236

$ IN MILLIONS

ISOTOPES INC.

^{18}F COMPETITION

- **EXCESS PRODUCTION FROM EXISTING CYCLOTRONS**
  - **MATCH PRICE / ADDED RELIABILITY**
- **NEW CYCLOTRONS (~$2.5M)**
  - **LOW CAPITAL COST / GROWTH WITH MARKET**
- **LINEAR ACCELERATORS (~ $1.0M)**
  - **LOWER CAPITAL COSTS / GROWTH WITH MARKET**
- **NO COMPETITION IN EXTREMELY SHORT LIVED ISOTOPES (E.G. NITROGEN-13)**

ISOTOPES INC.

COMPETITION-2

- **WISCONSIN TEAM APPEARS TO BE ALONE IN WORK ON IEC PROTON GENERATORS**
- **OTHER IEC DEVELOPERS**
  - **DAIMLER-BENZ / UNIVERSITY ILLINOIS**
    - **PREVIOUSLY "IN MARKET" WITH $50,000 NEUTRON GENERATOR**
      - **INDICATIONS BUSINESS HAS BE SOLD BUT MAY BE COMING BACK TO LIFE**
  - **WORK IN JAPAN**
    - **APPARENTLY NEUTRON GENERATORS ONLY**
  - **LOS ALAMOS NATIONAL LABORATORY**
    - **NEUTRON GENERATOR INITIALLY FOR "NEST"**
    - **NOW A RESEARCH PROGRAM**
  - **SANDIA NATIONAL LABORATORY - BEN CIPITI ?**
  - **NASA MARSHALL SPACE FLIGHT CENTER**
    - **PROPULSION RESEARCH (CURRENTLY UNFUNDED)**

ISOTOPES INC.

START-UP DEVELOPMENT OBJECTIVES

- **$3X10^{11}$ PROTONS PER SEC. (D/^{3}He) WITH LOW NEUTRON PRODUCTION IN MANUFACTURING PROTOTYPE IEC DEVICE**
  - **$4.5X10^{8}$/SEC TO DATE (D-^{3}He)**

- **MANUFACTURING PROTOTYPES OF ^{18}F AND ^{13}N ISOTOPE PRODUCTION KITS**
  - **PRODUCTION OF ^{18}F, ^{13}N AND ^{99}Tc DEMONSTRATED**

- **POST-DEVELOPMENT BUSINESS PLAN**

- **PROTOTYPE INTERNET "isotopes.com" CUSTOMER INTERFACE**
  - **MARKETING, SALES, TRAINING, AND DIAGNOSTICS AND MAINTENANCE**

DEVELOPMENT MILESTONES

FIRST YEAR	SECOND YEAR	THIRD YEAR
10^9 PROTONS/SEC	10^{10} PROTONS/SEC	10^{11} PROTONS/SEC
IEC PDR	IEC CDR	IEC PROTOTYPE
		$3X10^{11}$ PROTONS/SEC
	10 µC OF ^{18}F IN 5.5HR	10 mC OF ^{18}F IN 5.5HR
ISOTOPE PDR	ISOTOPE CDR	
	10 µC OF ^{13}N IN 0.5HR ???	10 mC OF ^{13}N IN 0.5HR ??
INTERNET PDR	INTERNET CDR	INTERNET PROTOTYPE
CEO HIRED	CFO HIRED	INITIAL TEAM HIRED
1ST DRAFT POST-BUS. PLAN	2ND DRAFT POST-BUS. PLAN	FINAL POST-BUS. PLAN

GREEN = RESEARCH RELATED
RED = COMMERCE RELATED
BROWN = MANAGEMENT RELATED

ISOTOPES INC.

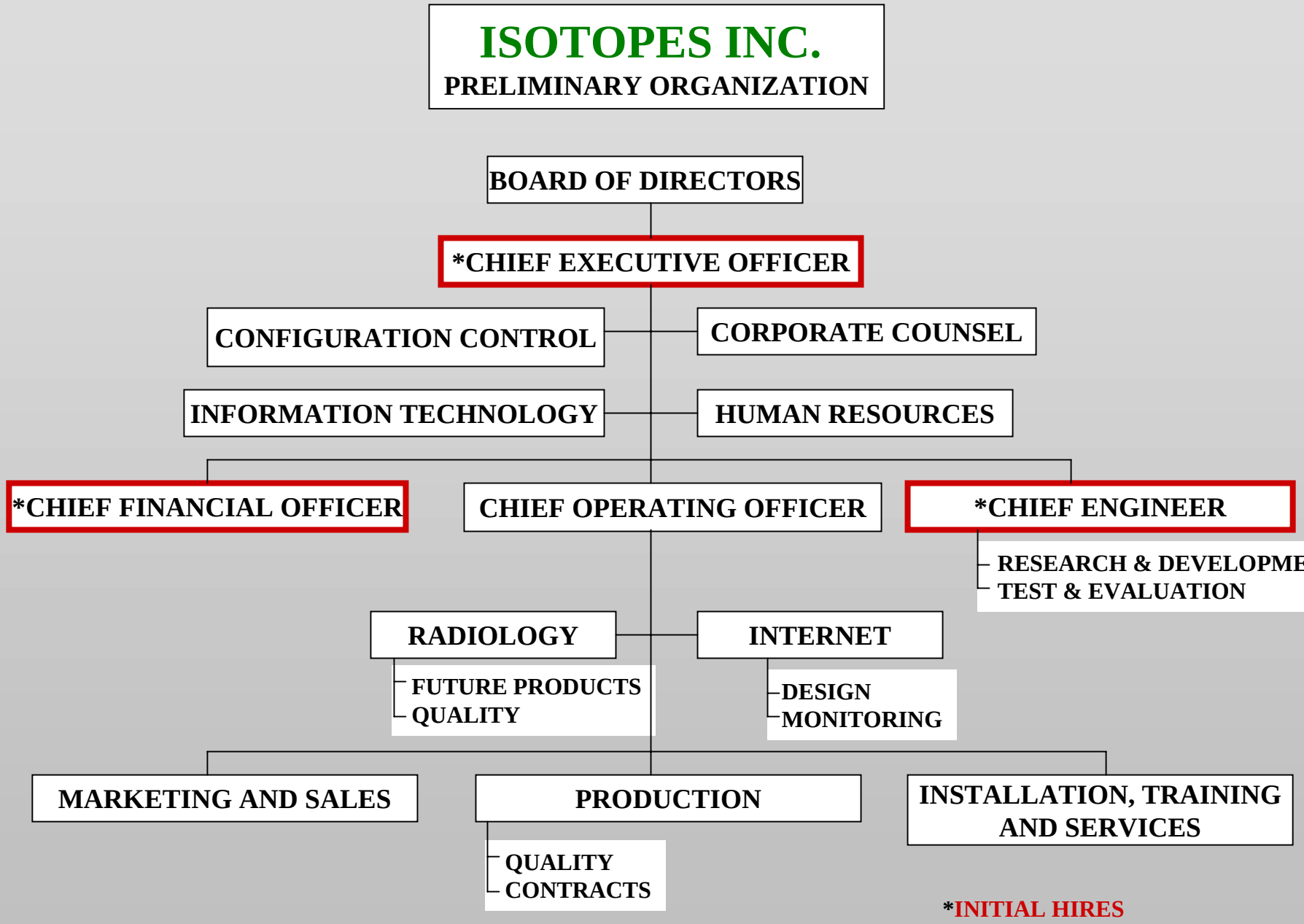
START-UP DEVELOPMENT BUDGET

OBJECTIVE	YEAR		
	2004	2005	2006
1. Proton-generating IEC device	**0.39**	**0.40**	**3.86**
2. Isotope Production Kit	0.10	0.10	0.50
3. Post-Development Business Plan	**0.15**	**0.15**	**1.35**
4. CAD/CAM Models	0.10	0.10	0.20
5. Internet Sales and Services Develop't	**0.10**	**0.10**	**0.20**
6. Internet Training Development	0.10	0.10	0.20
Project Management	**0.10**	**0.40**	**1.05**
Contingency (~20%)	0.20	0.27	1.30
Annual Totals	1.24	1.62	9.14

TOTAL THREE YEAR BUDGET = $12 MILLION

LONG-TERM IEC CONSIDERATIONS

- **SCALE-UP TO BREAKEVEN FUSION (Q>>1) FOR POWER PRODUCTION**
- **HE-3 DEMAND FOR LUNG IMAGING**
- **HE-3 SUPPLY / COST CONSIDERATIONS FOR RESEARCH NEEDS**
- **HE-3 SUPPLY FOR THE LONG-TERM**
- **NEUTRON SUPPRESSION**


ISOTOPES INC.
PRELIMINARY ORGANIZATION
BOARD OF DIRECTORS
*CHIEF EXECUTIVE OFFICER
CONFIGURATION CONTROL
CORPORATE COUNSEL
INFORMATION TECHNOLOGY
HUMAN RESOURCES
*CHIEF FINANCIAL OFFICER
CHIEF OPERATING OFFICER
*CHIEF ENGINEER
RESEARCH & DEVELOPMENT
TEST & EVALUATION
RADIOLOGY
INTERNET
FUTURE PRODUCTS
QUALITY
DESIGN
MONITORING
MARKETING AND SALES
PRODUCTION
INSTALLATION, TRAINING AND SERVICES
QUALITY
CONTRACTS
*INITIAL HIRES


NASA PHOTO