

---

# BEAM TUBE SOURCE SELECTION

PRESENTATION TO  
BEAM TUBE SOURCE SELECTION BOARD  
NOVEMBER 17, 1995

# OVERVIEW

---

- OVERALL SCOPE OF BEAM TUBE TASK
  - » DESIGN AND QUALIFICATION (DESIGN PHASE)
    - BEAM TUBE REQUIREMENTS
    - BEAM TUBE DESIGN
    - QUALIFICATION TEST
  - » FABRICATION, INSTALLATION AND ACCEPTANCE (OPTION PHASE)
    - CONTRACT SCOPE AND TECHNICAL APPROACH
- CONTRACTING HISTORY AND STRATEGY
- REVIEWS
- RECOMMENDATION

# SCOPE OF BEAM TUBE WBS

---

- THE LIGO VACUUM SYSTEM IS DIVIDED INTO TWO DISTINCT WBS ELEMENTS
  - » VACUUM EQUIPMENT (WBS 1.1.1)
    - VACUUM CHAMBERS
    - PUMPS
    - MANIFOLDS AND VALVES
  - » BEAM TUBE (WBS 1.1.2)
    - BEAM TUBE SECTIONS AND MODULES
    - TUBE SUPPORTS
    - TUBE ALIGNMENT
    - OPTICAL BAFFLES

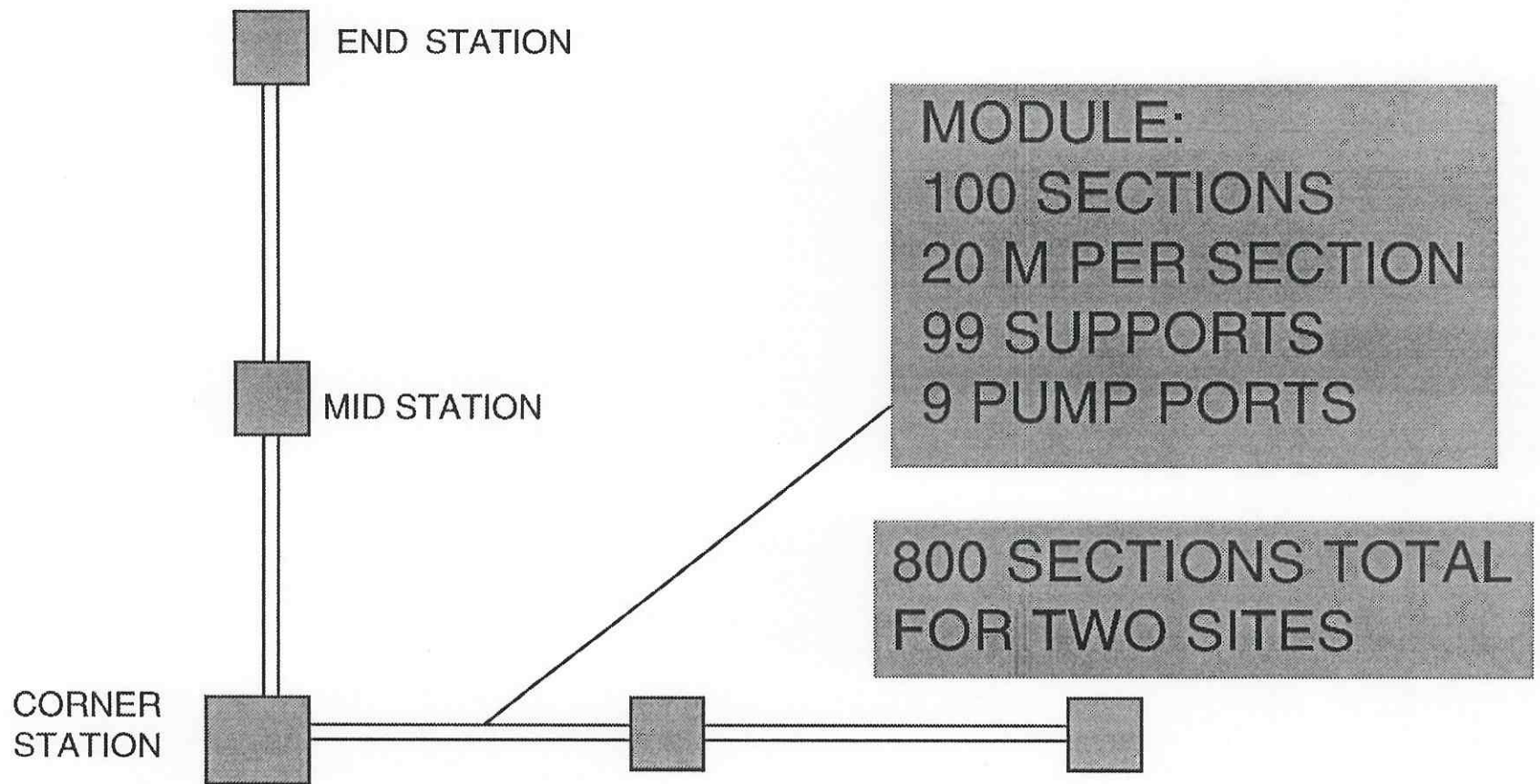
# BEAM TUBE TASK

---

- PHASED TASKS
  - DESIGN-QUALIFICATION PHASE
  - FABRICATION, INSTALLATION AND ACCEPTANCE PHASE
- THE DESIGN-QUALIFICATION TEST PHASE HAS BEEN SUCCESSFULLY COMPLETED
  - REQUIREMENTS
  - DESIGN SUMMARY
  - QUALIFICATION TEST RESULTS
- THE FABRICATION, INSTALLATION AND ACCEPTANCE PHASE IS THE ESSENCE OF THIS PROCUREMENT ACTION

# BEAM TUBE MODULES

---



# DESIGN-QUALIFICATION PHASE SUMMARY

---

- CONTRACT WAS AWARDED IN AUGUST 1993
- REVIEWS
  - REQUIREMENTS REVIEW, SEPTEMBER 1993
  - PRELIMINARY DESIGN REVIEW, DECEMBER 1993
  - FINAL DESIGN REVIEW, APRIL 1994
- QUALIFICATION TEST WAS CONDUCTED IN FEBRUARY-MARCH 1995
  - ALL TEST OBJECTIVES WERE SUCCESSFULLY MET
  - QUALIFICATION TEST REVIEW COMPLETED IN APRIL 1995

# BEAM TUBE REQUIREMENTS

---

- MECHANICAL/OPTICAL

- 16 KM OF BEAM TUBE (8 MODULES @ 2KM EACH)
- UNOBSTRUCTED APERTURE OF 1 METER

- VACUUM

- CLEAN, LESS THAN 1 MONOLAYER OF HYDROCARBON/MONTH
- LEAK FREE
  - $1 \times 10^{-9}$  TORR LITERS/SEC (AT MODULE LEVEL)

- OPERATIONAL

- CAPABILITY TO ISOLATE BEAM TUBES FROM CHAMBERS
- MINIMAL TUBE WALL MOTION (NO SLIP-STICK SUPPORTS)
- ADJUSTABLE SUPPORTS TO ALLOW FOR REALIGNMENT
- 20 YEAR LIFE TIME

# BEAM TUBE DESIGN

---

- **TUBE SECTIONS (800 EA)**
  - SPIRAL WELDED; 3 mm THICK, 304L STAINLESS STEEL
  - 1.24 M DIAMETER, 20 M LONG
  - WELDED STIFFENING RINGS, 0.76 M SPACING
  - MACHINED/WELDED SUPPORT RINGS AT EACH END
- **EXPANSION JOINTS (400 EA)**
  - 6 CONVOLUTIONS
  - 2.7 mm THICK MATERIAL FOR ADDED ROBUSTNESS
- **SUPPORTS**
  - ALTERNATE FIXED AND GUIDED SUPPORTS
  - ADJUSTABLE, VERTICALLY AND HORIZONTALLY (+/- 7.5 CM)



# QUALIFICATION TEST

---

- CONDUCTED IN FEBRUARY-MARCH 1995
  - FABRICATED AND ASSEMBLED 40 M OF TUBE SECTIONS
  - TEST ASSEMBLY INCLUDED PUMP PORT, EXPANSION JOINT, FIXED AND GUIDED SUPPORTS
  - OPERATED UNDER VACUUM FOR 45 DAYS
  - CONDUCTED A 28 DAY BAKE-OUT TEST (150 C)
- SUCCESSFULLY DEMONSTRATED
  - DESIGN FABRICATION AND ASSEMBLY OF TUBE SECTIONS
  - ACCEPTABLE LEAKAGE  $<1 \times 10^{-10}$  EXP-10 T\*L/S
  - LOW HYDROGEN OUTGASSING  $<1 \times 10^{-13}$  T\*L/S\*CM<sup>2</sup>
  - LOW WATER OUTGASSING  $<1 \times 10^{-16}$  T\*L/S\*CM<sup>2</sup>

# LESSONS LEARNED

---

- DESIGN PHASE WAS MORE OF AN R&D TASK
  - MANY USEFUL TECHNICAL ISSUES WERE RESOLVED
  - CBI WAS EXTREMELY COOPERATIVE AND TECHNICALLY COMPETENT
- SPIRAL WELD TECHNOLOGY
  - CBI's SUBCONTRACTOR WAS ABLE TO PRODUCE HIGH QUALITY THIN WALLED TUBING
- CLEANING AND LEAK TESTING
  - CLEANING PROCEDURES WERE STRENGTHENED
  - DEVELOPED NON-CONVENTIONAL LEAK HUNTING METHODOLOGY

# OPTION PHASE CONTRACT REQUIREMENTS

---

- THIS PHASE COMBINES PROCESS AND PERFORMANCE

- » PROCESS

- CONTRACTOR IS REQUIRED TO FOLLOW DETAILED WRITTEN PROCEDURES DEVELOPED BY CBI AND APPROVED BY LIGO
  - STAINLESS STEEL BAKE
  - TUBE CLEANING
  - HYDROCARBON RESIDUES

- » PERFORMANCE

- CONTRACTOR IS RESPONSIBLE FOR
  - CLEAR APERTURE (1.2 M DIAMETER)
  - LOCALIZE AND SEAL LEAKS LARGER THAN TWO TIMES THE SMALLEST LEAK MEASURABLE ( $1 \times 10^{-5}$  T\*L/SEC MAX)

# CONTRACT SCOPE

---

- **COMPLETE REMAINING DESIGN TASKS**
  - TERMINATION DESIGN
  - DESIGN UPDATES
- **FABRICATE AND ASSEMBLE TUBE SECTIONS**
  - SPIRAL WELD TUBES
  - STIFFENERS AND SUPPORT RINGS
  - EXPANSION JOINTS AND PUMP PORTS
  - CLEAN AND LEAK TEST ALL TUBE SECTIONS
- **INSTALL AND ALIGN EIGHT MODULES**
  - EACH MODULE IS TWO KILOMETERS LONG
  - FOUR MODULES PER SITE
- **LEAK TEST MODULES**
  - ACCEPTANCE TESTING

# FABRICATION

---

- QUALIFY EQUIPMENT PRIOR TO FABRICATION
- PROCURE SPIRAL MILL
  - TUBETEC WAS UNABLE TO MEET SCHEDULE AND QA REQUIREMENTS
  - PACIFIC ROLLER DIE INC. PROVIDES AUTOMATED PROCESS CONTROL AND QUALIFICATION TRAINING
- SET UP MILL IN WASHINGTON; AFTER COMPLETION, MOVE TO LOUISIANA
- FABRICATE ALL TUBE SECTIONS IN LEASED FACILITIES NEAR THE TWO SITES
- TRANSPORT COMPLETED SECTIONS TO SITE

# INSTALLATION

---

- **STARTING AT MID STATION, PROCEED TO CORNER AND END STATION**
  - TWO TUBES SECTIONS PER DAY
  - MAINTAIN CLEAN AIR FLOW THROUGH TUBES AT ALL TIME
- **SELF CONTAINED WELD/LEAK TEST STATIONS**
  - BUTT WELD SECTIONS, PURGE GAS MANAGEMENT
  - LEAK CHECK CIRCUMFERENTIAL WELD
- **PORTABLE CLEAN ROOMS**
  - ONE FOR EACH MODULE
  - PROTECTS TUBE INTERIOR
  - PROVIDES ENTRY INTO TUBE
  - CONTAINS GAS CYLINDERS FOR WELDING AND LEAK CHECK

# ACCEPTANCE TEST

---

- **OUTGASSING AND CLEANLINESS**

- ACCEPTABLE HYDROGEN OUTGASSING IS ASSURED BY FOLLOWING THE LIGO DEVELOPED STEEL BAKE PROCESS AND IS VERIFIED BY COUPON TESTS
- CLEANLINESS IS CONTROLLED BY PROCEDURES WHICH WERE VALIDATED DURING THE DESIGN PHASE

- **LEAK TESTING**

- LIGO IS RESPONSIBLE TO PROVIDE THE SOFTWARE WHICH LOCALIZES LEAKS TO A DESIGNATED AREA OF  $\pm 100$  FT
- CONTRACTOR IS RESPONSIBLE FOR LOCATING AND SEALING LEAKS WITHIN THE DESIGNATED AREA
  - ALL LEAKS LARGER THAN 2 TIMES THE LOWEST MEASURABLE SIZE ( $1 \times 10^{-5}$  T\*L/S MAX ALLOWED)

# CONTRACTING HISTORY

---

- THE ORIGINAL 1992 RFP WAS COMPETITIVE
  - DESIGN PHASE
  - FABRICATION/INSTALLATION PHASE AS AN UNPRICED OPTION
- THE CONTRACTOR SELECTION WAS BASED ON
  - PROPOSERS TECHNICAL APPROACH
  - COST FOR BOTH PHASES OF THE PROPOSALS
  - AWARDEE HAD TO BE QUALIFIED FOR BOTH CONTRACT PHASES
- DESIGN PHASE WAS AWARDED TO CBI (1993)
  - DESIGN PHASE IS COMPLETE
- THE PRESENT PROCUREMENT ACTION IS FOR THE OPTION PHASE



# 1993 DESIGN PHASE AWARD

---

- **FOUR PROPOSALS WERE RECEIVED**
  - THREE PROPOSALS WERE QUALIFIED
  - EVALUATION CRITERIA WERE UNDERSTANDING OF TECHNICAL CHALLENGE AND COST OF OPTION PHASE
- **CBI'S SELECTION WAS BASED ON**
  - TECHNICAL UNDERSTANDING AND SUPERIOR WELD TECHNOLOGY
  - THE LOWEST OPTION PHASE COST ESTIMATE
- **CONTRACT STRATEGY**
  - WORK WITH CBI TO GUIDE THE DESIGN PHASE TO AN AFFORDABLE OPTION COST
  - UP-DATE OPTION COST ESTIMATE AT PDR, FDR AND QTR
  - REDUCE RISK BY EXERCISING THE OPTION AFTER QTR

# STATUS AT QTR

---

- DESIGN STATUS
  - COMPLETED AN ACCEPTABLE DESIGN
- TECHNOLOGY STATUS
  - CBI GAINED CONSIDERABLE TECHNOLOGY “KNOW HOW” DURING THE DESIGN AND QUALIFICATION PHASE
  - SPECIALIZED PROCESSES FOR CLEANING, COUPON TESTING LEAK ASSESSMENT HAVE BEEN WORKED OUT DURING THE DESIGN PHASE AND CBI HAS VALIDATED THESE PROCESSES DURING THE QUAL TEST PHASE
- COST ESTIMATE
  - THE ESTIMATED OPTION COST INCREASED BY 10%

# CONTRACTING OPTIONS

---

- EXERCISE THE OPTION AND NEGOTIATE BEST PRICE WITH CBI
  - LOWEST TECHNICAL RISK, DESIGN AND PROCESSES HAVE BEEN VALIDATED
  - NO SCHEDULE INCREASE DUE TO PROCUREMENT DELAYS
  - MINIMAL COMPETITION WITH THE POSSIBILITY OF UNFAVORABLE PRICE
  
- RE-COMPETE THE OPTION PHASE
  - HIGHER TECHNICAL RISK, DESIGN REQUIRES VERIFICATION
  - SERIOUS ADDITIONAL SCHEDULE DELAYS DUE TO LONGER PROCUREMENT PROCESS AND DESIGN VERIFICATION
  - UNCERTAINTY OF RESPONSES DUE TO THE SMALL NUMBER OF QUALIFIED CONTRACTORS
  - POTENTIAL FOR LOWER COST THROUGH COMPETITION

# CONTRACTING APPROACH

---

- APRIL 1995, LIGO DECIDED TO EXERCISE THE OPTION WITH CBI
  - PROVIDED NOTICE OF INTENT TO CBI (NON BINDING)
  - ISSUED RFP IN JUNE 1995
  - RECEIVED CBI PROPOSAL IN AUGUST 1995
- DECISION WHETHER TO NEGOTIATE OR TO RE-COMPETE BASED ON
  - PROPOSAL COST
  - POTENTIAL FOR COST NEGOTIATION
  - MAINTAINING RE-COMPETE OPTION DURING NEGOTIATION
- LIGO DECIDED TO NEGOTIATE WITH CBI IN AUGUST 1995

# DECISION BASIS

---

- **NEGOTIATED PRICE FOR CBI OPTION**
  - NEGOTIATED PRICE \$ 39.545 M
  - ADJUSTED FOR LIGO COST COMPARISON \$ 41.161 M
- **LIGO IN-HOUSE COST ESTIMATE**
  - BUDGETED COST \$ 36.904 M
- **COST DIFFERENTIAL**
  - HIGHER THAN BUDGETED COST \$ 4.257 M
- **COST INDEPENDENT OF VENDOR**
  - SPIRAL TUBE MILL \$ 1.300 M
  - HANFORD SITE AGREEMENT \$ 1.000 M

# COST ANALYSIS

---

- CBI COST SUMMARY

- » CBI COSTS SUBSTANTIATED BY LIGO

- MATERIALS \$ 13.7 M

- EQUIPMENT \$ 9.7 M

- » CBI COST ABOVE LIGO ESTIMATE

- LABOR \$ 16.1 M

- » TOTAL COST \$ 39.5 M

- COST EXPOSURE FOR RE-COMPETING THE OPTION

- DESIGN VALIDATION AND SCHEDULE ESCALATION \$ 2.5 M

- OTHER UNKNOWN COST AND RISKS

# DECISION ARGUMENTS

---

- RE-COMPETING THE OPTION INCREASES BOTH TECHNICAL AND SCHEDULE RISK
- MARKET SURVEY INDICATED LIMITED INTEREST
  - LOCKHEED, DISBANDED THEIR CAPABILITY
  - PSI, DID NOT BID ON DESIGN PHASE
  - GRUMMAN, SAID NO
  - PDM, EXPRESSED MARKETING INTEREST
- TO WARRANT THE CONSIDERABLE INCREASE OF SCHEDULE AND TECHNICAL RISK INCURRED BY RE-COMPETING, REQUIRES
  - A \$ 2 M TO \$ 4 M COST SAVINGS TO BE COMPETITIVE WITH CBI
  - AN EQUALLY WELL QUALIFIED CONTRACTOR

# DECISION ARGUMENTS

---

- THE PROSPECT OF RECEIVING A QUALIFIED PROPOSAL AT THIS REDUCED PRICE IS JUDGED TO BE LOW
  - COST OF MATERIALS AND EQUIPMENT IS PRIMARILY BASED ON VENDOR QUOTES
  - THE POTENTIAL FOR COST SAVING WOULD BE IN LABOR
- A “NO BID” MUST BE CONSIDERED AS A POSSIBLE OUTCOME

**LIGO DECIDED TO EXERCISE THE OPTION WITH CBI**



# LIGO REVIEWS

---

- BEAM TUBE REVIEW BOARD

LEW ALLEN (CHAIR)	FORMER DIRECTOR, JPL
GENE GIBERSON	RET. JPL ASST. LAB DIRECTOR
JOSE LOPEZ-TIANA	GOV'T SUBCONTRACTS, CIT
YASMIN MERALI	ASST. PURCHASING MGR. CIT
CHARLES PECK	DIVISION CHAIR, PMA
BILL TYLER	QA MGR. JPL

- THE BOARD MET ON OCTOBER 26, 1995 TO REVIEW THE TECHNICAL AND CONTRACTUAL APPROACH AND CONCURRED WITH THE LIGO DECISION TO CONTRACT WITH CBI FOR THE BEAM TUBE TASK

# NSF PROGRAM REVIEWS

---

- FEEDBACK FROM THE OCTOBER 9-11, 1995 TECHNICAL REVIEW, CLOSE OUT SESSION
  - THE COMMITTEE COMPLIMENTED LIGO ON THEIR SUCCESS IN DEALING WITH THE TECHNICAL ISSUES AND HIGHLIGHTED CBI's WILLINGNESS TO PROCURE THE NEEDED SPIRAL TUBE MILL

# RECOMMENDATION

---

- UNDER THESE CIRCUMSTANCES, IT IS DEEMED IN THE BEST INTEREST OF LIGO, CALTECH AND THE NSF, TO EXERCISE THE OPTION, PLACING THE BEAM TUBE FABRICATION AND INSTALLATION CONTRACT WITH CBI