Eight-Pack Project Systems Review
February 22, 2002

X-Band PPM Klystron
Klystron Block Diagram

ES&H X-Rays

Conventional Facilities LCW

RF Distribution System

11424 MHz 75 MW/3.2 µs

LLRF Input Drive

11424 MHz 1 kW

Vacuum System

X-Band PPM Klystron

Systems Review

11424 MHz ∼1 mW

Control System

Lead Shielding

11424 MHz 600 MW/.4 µs

Modulator

Temperature Monitoring

X-Ray Shielding

Klystron

TWTA

WR90
Klystron Requirements and Specs
1 of 2

• Major Requirements:
  – When Provided 270 Amps at 490 kV from the Modulator:
    • Produce 75 MW of 11424 MHz RF for 3.168 Microseconds
    • Utilize No More Than One kW of Drive from the TWTA
    • Operate at a Maximum Repetition Rate of 120 Hz

• Other Requirements
  – 35 GPM of LCW Must be Provided for Cooling
  – Self-Contained Vacuum Pumps, Thermistors, and Thermocouples
    Must be Powered and Monitored for Protecting the Klystron
  – Other Systems Must Provide Mechanical Support and Radiation
    Protection Not Provided by the Klystron
  – Klystron Must be Removable for Servicing
  – Modulator Oil Must Provide Sufficient Insulation
Klystron Requirements and Specs
2 of 2

- Open Items:
  - Outline Drawing for Klystron Not Available
    - Design Will Most Likely Migrate Over Time
  - Amount of Radiation Shielding Unknown
  - System for Controlling and Aligning the Mating of Klystron Output Flange to RF Distribution Flange Not Engineered
  - Magnet Chilled Water Supply Temperature May Need Lowering
  - Unplanned Low Klystron Efficiency May Cause the Modulator to Reach Voltage Limit
  - Number of Individual Vacuum Circuits May Decline
  - Number of Temperature Monitoring Points May Increase
• Model Designated as XP3 is Culmination of Over a Decade of X-Band Klystron Research
  – 50 MW at 1.5 Microseconds at X-Band is Now a “Production” Device (Solenoid-Focussed XL-4)
  – Last Design Before XP3 Could Not be Tested to Full-Pulse Width or Full Repetition Rate
  – Average RF Power in XP3 (28,500 Watts) Due to NLC Shift to Times Eight Compression is Most Challenging Area
• First XP3 (XP3-1) is in RF Test
  – Tube is Clean of Glitches and Instabilities
  – DC Performance to Date: 3.2 µsecs at 480 kV at 60 Hz
  – RF Performance
    • 50 MW at 1.5 µsecs Coincident with DC Performance Above
    • 75 MW at 2.8 µsecs at 10 Hz
Klystron Development Status
2 of 2

- **Second Klystron (XP3-2) is on Bakeout**
  - Incorporates RF Section (and Magnetic Stack) Produced by CPI
  - Should be Ready for Test When XP3-1 is Completed

- **Third Klystron (XP3-3)**
  - All Parts on Hand but No Assemblies Started
  - Holding for Results on XP3-1

- **Reviews**
  - Program Status Reviewed Weekly (Thursday 1:30 PM)
Klystron Schedule/Manpower Status

• **Schedule**
  – First Tube, XP3-1, Complete on March 15, 2002
  – Second Tube, XP3-2, Complete on May 17, 2002
  – Third Tube, XP3-3, Complete on August 15, 2002

• **Manpower Status**
  – Dress and Test Technician Manpower Adequate
  – Dress and Test Engineering Manpower Adequate
  – For Klystron Vacuum Envelope (Prior to Bakeout):
    • Technician Manpower is Tight Due to Structure and PEP-II Work
    • Engineering Manpower is Adequate Unless XP3-1 Has Fundamental Technical Problems
Klystron Interfaces

- ES&H X-Rays
- Control System
- LLRF Input Drive
- Vacuum System
- Lead Shielding
- Conventional Facilities LCW
- RF Distribution System
- Temperature Monitoring
- 11424 MHz
  - 75 MW/3.2 µs
- TWTA
- 1 kW
- Modulator
- X-Ray Shielding

- 11424 MHz
  - 600 MW/.4 µs
- Klystron
- X-Ray Shielding

- 11424 MHz
  - ~1 mW
- X-Band PPM Klystron Systems Review

John Cornuelle
2/22/02
Slide 8
# Klystron Interfaces/Treaty Points

<table>
<thead>
<tr>
<th>Interfacing System</th>
<th>Treaty Point</th>
<th>Applicable Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWTA</td>
<td>WR90 Flange</td>
<td>One kW of RF at 11424 MHz</td>
</tr>
<tr>
<td>Vacuum</td>
<td>Pump High Voltage Feedthrough</td>
<td>Ion current at ~ 3 kV</td>
</tr>
<tr>
<td>Modulator</td>
<td>Tank Lid, High Current Sockets, Temperature Sensing Wires</td>
<td>Thermistor and Thermocouple Resistance; Heater Current</td>
</tr>
<tr>
<td>Conventional</td>
<td>Water Hoses to Water Manifold</td>
<td>Low Conductivity Water</td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF Distribution</td>
<td>WR90 Output Flange</td>
<td>75 MW of RF at 11424 MHz</td>
</tr>
<tr>
<td>System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-Ray Shielding</td>
<td>I.D. of Shielding</td>
<td>None</td>
</tr>
<tr>
<td>End Station A Area</td>
<td>Boundary of Radiation Area</td>
<td>Periodic Radiation Surveys</td>
</tr>
</tbody>
</table>

**Interfacing System**

- TWTA
- Vacuum
- Modulator
- Conventional Facilities
- RF Distribution System
- X-Ray Shielding
- End Station A Area

**Treaty Point**

- WR90 Flange
- Pump High Voltage Feedthrough
- Tank Lid, High Current Sockets, Temperature Sensing Wires
- Water Hoses to Water Manifold
- WR90 Output Flange
- I.D. of Shielding
- Boundary of Radiation Area

**Applicable Signals**

- One kW of RF at 11424 MHz
- Ion current at ~ 3 kV
- Thermistor and Thermocouple Resistance; Heater Current
- Low Conductivity Water
- 75 MW of RF at 11424 MHz
- None
- Periodic Radiation Surveys
## Klystron Document Status

<table>
<thead>
<tr>
<th>ICD’s</th>
<th>Status</th>
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<tbody>
<tr>
<td>Klystron-Modulator 4.3_4.4</td>
<td>“Complete”</td>
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<tr>
<td>Klystron-RF Distribution 4.5_4.4</td>
<td>In-Process</td>
</tr>
<tr>
<td>Klystron-Vacuum Electronics 4.6.2_4.4</td>
<td>“Complete”</td>
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<tr>
<td>Klystron-Conventional Facilities 4.2_4.4</td>
<td>In-Process</td>
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<tr>
<td>Klystron-TWTA</td>
<td>Not Planned</td>
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<tr>
<td>Klystron-Fixed X-Ray Shielding on Modulator</td>
<td>Not Planned</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Status</th>
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<tr>
<td>X-Band 75 MW PPM Klystron</td>
<td>Complete</td>
</tr>
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## Klystron Remaining Issues and Action Plans

### Page 1 of 2

<table>
<thead>
<tr>
<th>Principal Remaining Issues</th>
<th>Action Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Klystron Outline Drawing</td>
<td>Started Upon Completion of First Klystron</td>
</tr>
<tr>
<td>Radiation Shielding Requirement Not Available</td>
<td>Determined Upon Completion of First Klystron</td>
</tr>
<tr>
<td>Design, Especially Dress Parts, May Change</td>
<td>Design Mating Interfaces Accordingly</td>
</tr>
</tbody>
</table>

### Other Risks

<table>
<thead>
<tr>
<th>Other Risks</th>
<th>Action Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>XP3 Design Cannot Handle Average Power</td>
<td>Operate Appropriately Below 120 Hz</td>
</tr>
<tr>
<td>XP3 Develops Fatal Mechanical Problems</td>
<td>Rebuild; Schedule Delay (Note: Only Parts for Three and One-Half Tubes on Hand)</td>
</tr>
<tr>
<td>XP3 Develops Fatal Electrical Problems</td>
<td>If Fabrication Cause Then Rebuild; If Design Cause Then Determine Course of Action at That Time</td>
</tr>
<tr>
<td>XP3 Design Proves Excessively Troublesome</td>
<td>Need to Review at That Time Engineering Staffing</td>
</tr>
<tr>
<td>Other Remaining Issues</td>
<td>Action Plans</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Flange-to-Flange Mating with RF Distribution System</td>
<td>Engineering Continues; Resolved at XP3-1 Installation</td>
</tr>
<tr>
<td>Temperature Monitoring Points May Increase</td>
<td>Case by Case Basis – May Just Need Monitoring</td>
</tr>
<tr>
<td>Lower Magnet Water Supply Temperature</td>
<td>Add Pre-Planned Chiller to Water Circuits</td>
</tr>
<tr>
<td>Klystron Efficiency May be Too Low to be Remedied With Higher Voltage</td>
<td>No Simple Solution</td>
</tr>
<tr>
<td>Some Trip Level Details Yet to be Set</td>
<td>Determine Prior to Start of Operations</td>
</tr>
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