



*QinetiQ*

## Report Documentation Page

*Form Approved  
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>01 MAR 2007</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>The High Power Microwave Facility: Orion</b>		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>QinetiQ Malvern Technology Centre St. Andrews Road, Great Malvern Worcestershire, WR14 3PS U.K.</b>		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>			
13. SUPPLEMENTARY NOTES <b>See also ADM202427., The original document contains color images.</b>			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	<b>UU</b>
			18. NUMBER OF PAGES <b>31</b>
			19a. NAME OF RESPONSIBLE PERSON



# The Orion High Power Microwave Facility & Operational Test Sources

Brian A Kerr

A presentation to: Tactical Implications of High Power  
Microwaves - SCI-119 Workshop

Date : 12:06:2002



# Presentation Overview

- Orion HPM Source
  - Cathode Research
- Other RF Sources: Operational Test Sources
  - Microwave Pulse Compressor
  - CW / Pulse Magnetron
  - Marine Radar
- UWB Sources
  - Crazy Horse
  - 16 Element Array



# Orion HPM System





# Introduction: HPM Research Facility

- Orion was designed and constructed by PI in the USA to a UK specification
- Extremely versatile HPM source
- Valuable research system
  - Source Development
  - Cathode Research



# High Power Microwave Facility: Orion





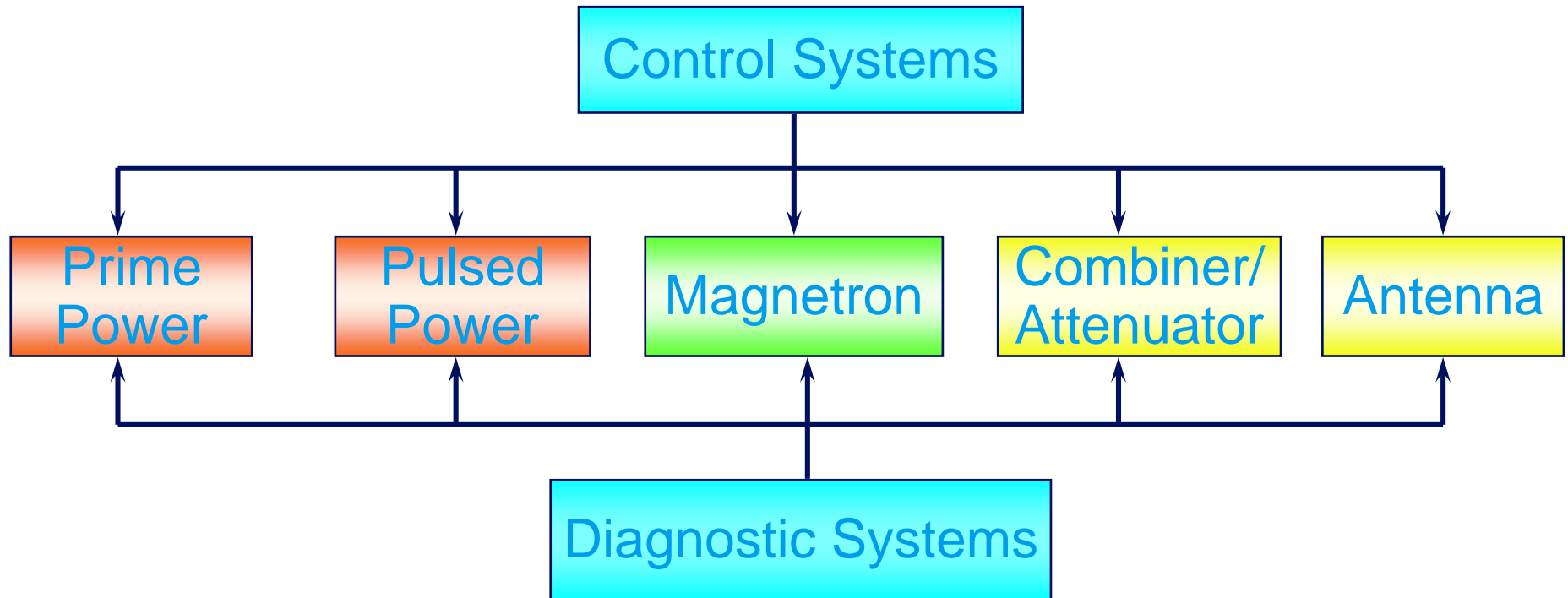
# HPM Source Specifications

- **Frequency**
  - Tuneable across the range 1.07GHz to 3.00GHz
- **Electrical Pulse Duration**
  - Variable from 50ns to 500ns in 50ns steps
- **Power**
  - 350MW peak across the entire frequency range
  - Max peak power +1GW
- **Repetition Rate**
  - Variable single shot to 100Hz



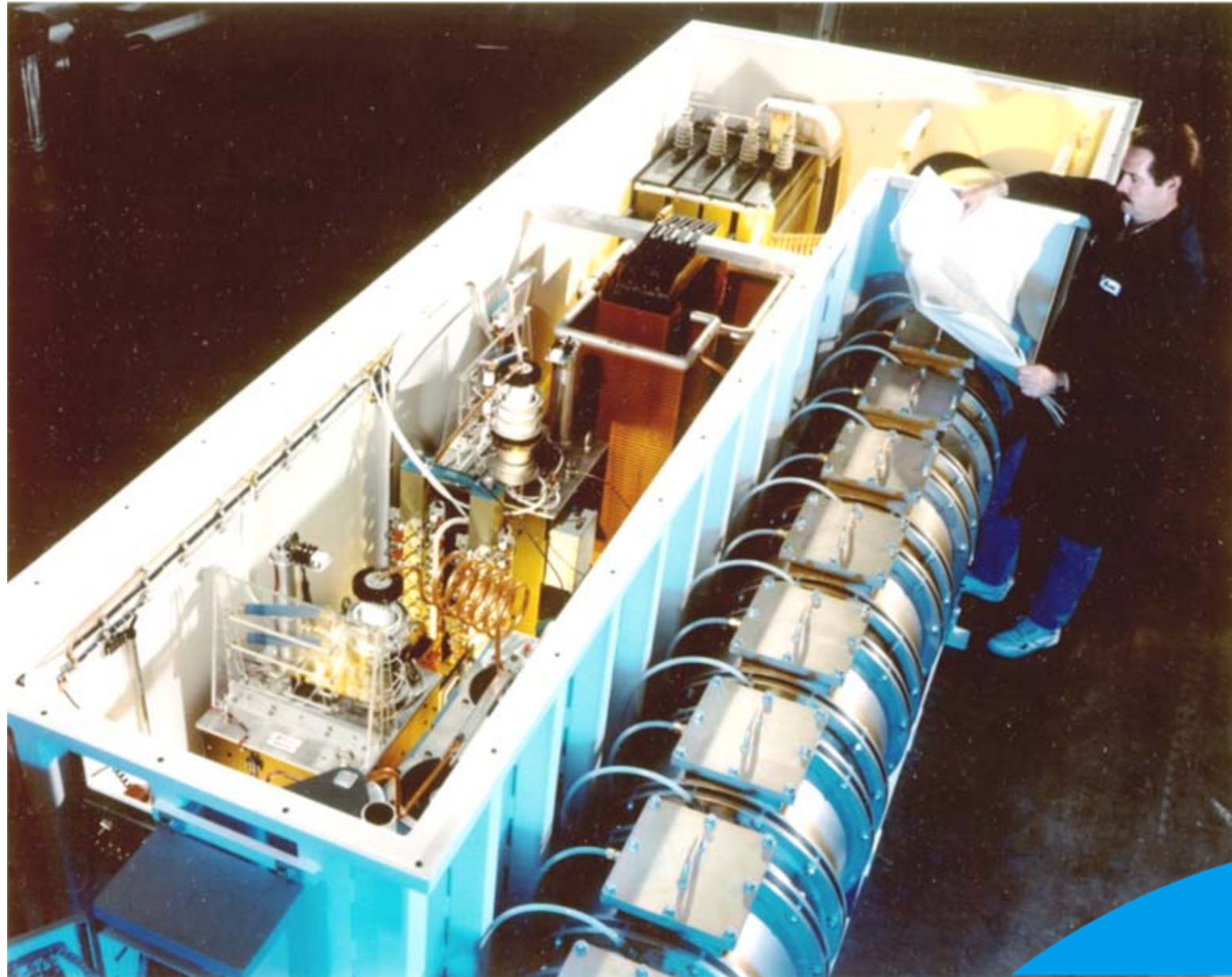


# Schematic of Orion System



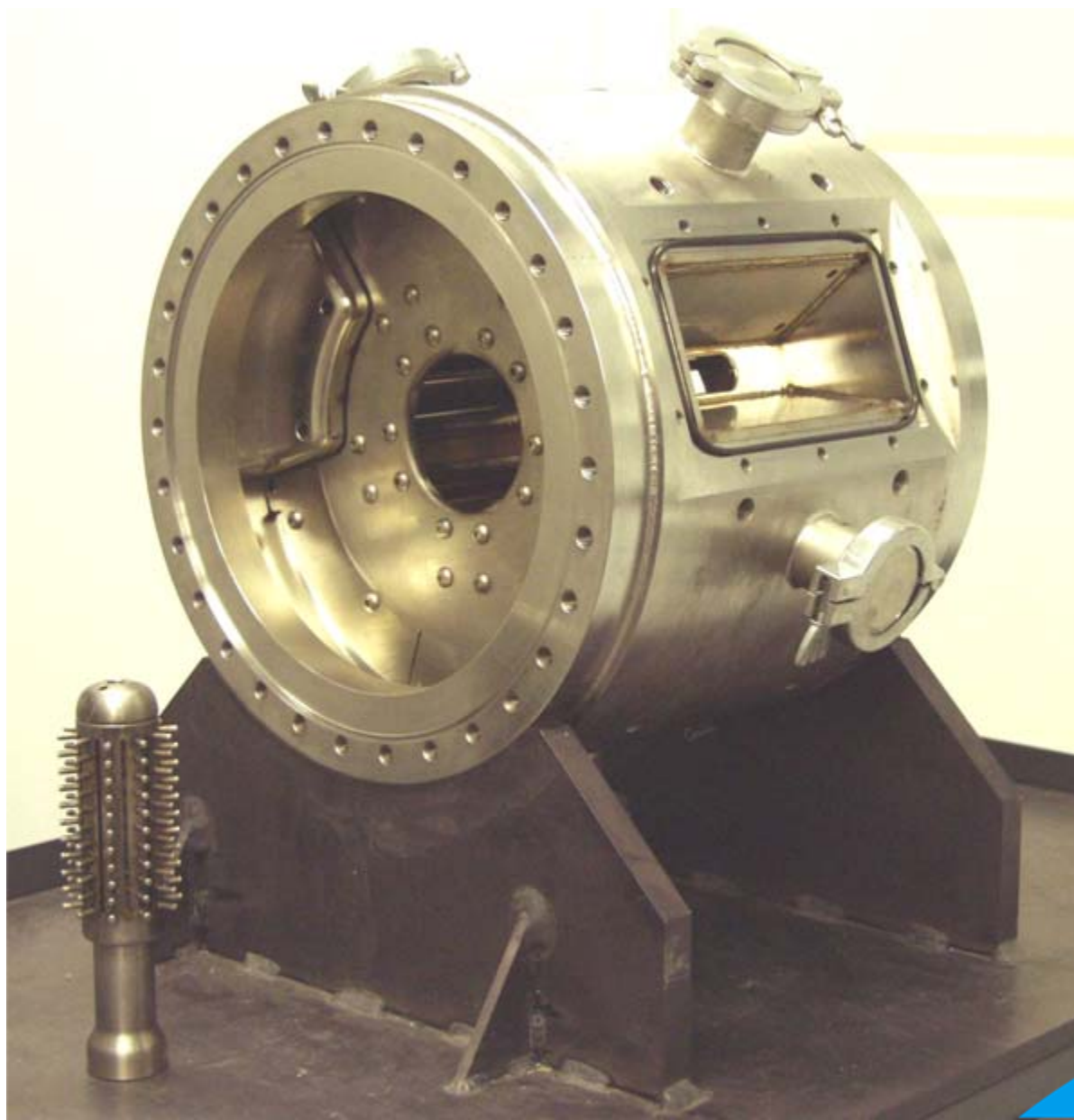


# Orion Modulator





# Relativistic Magnetron



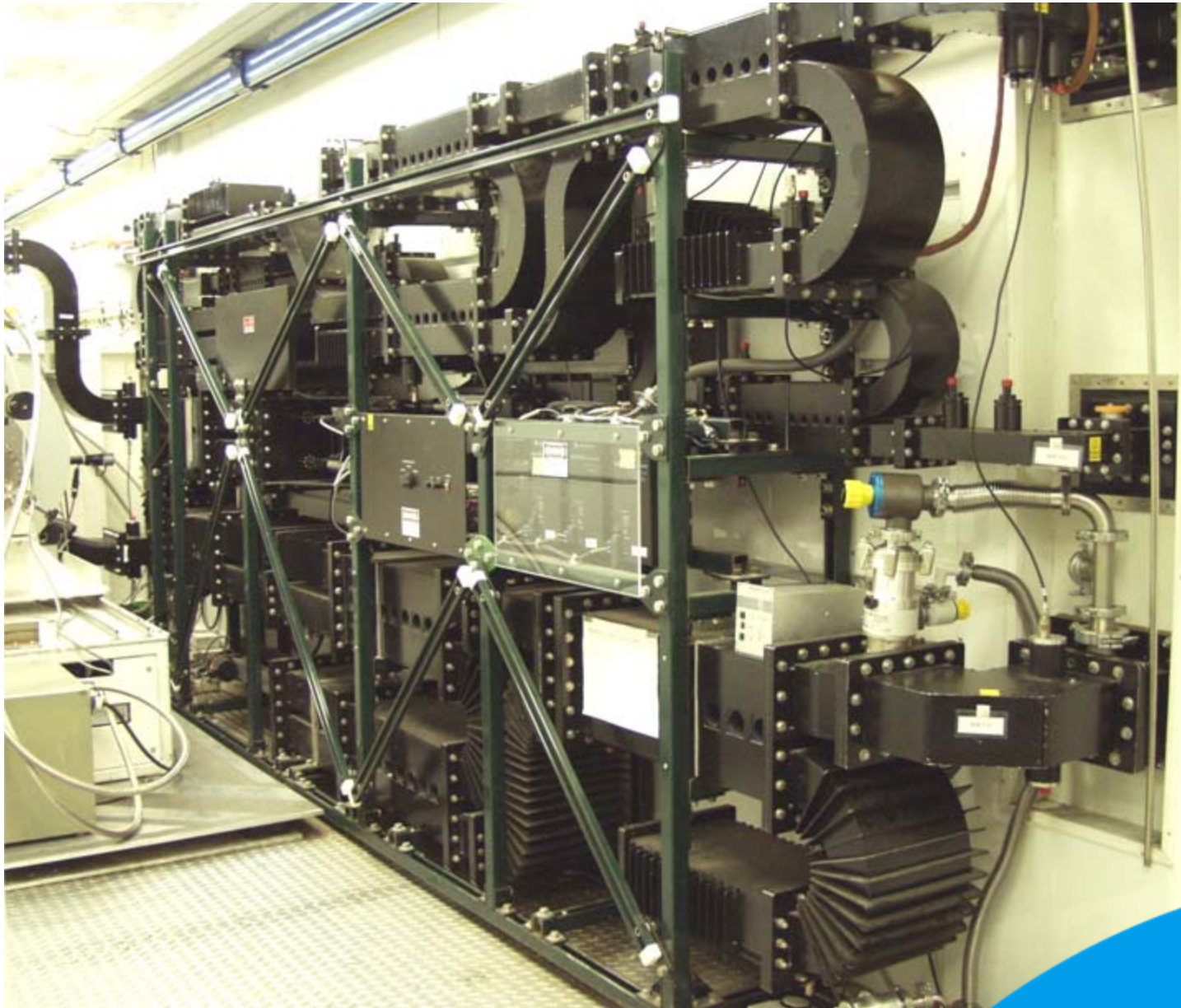


# Orion Source





# Waveguide Combiner / Attenuator





# Antenna System

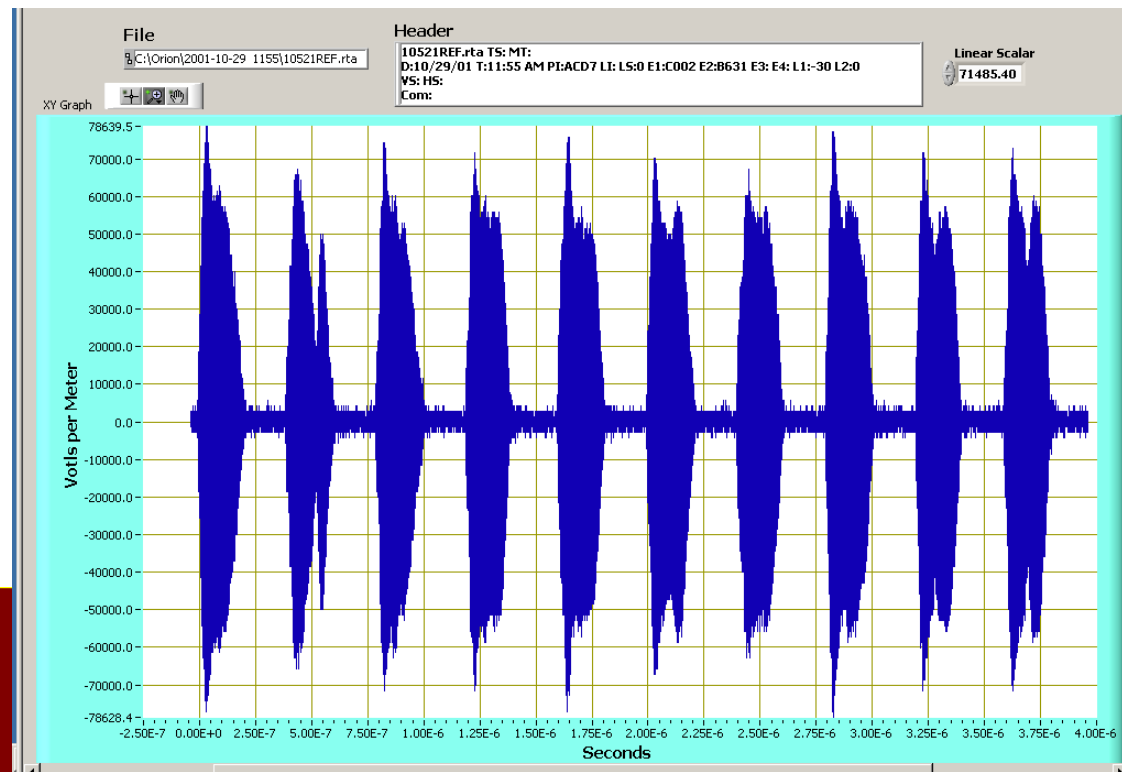




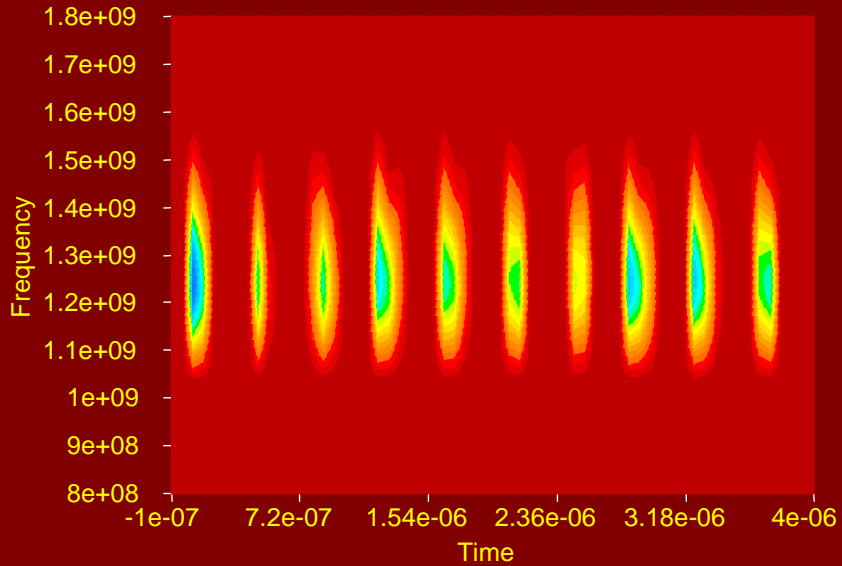
# Control and Diagnostic Systems



# Radiated Pulses

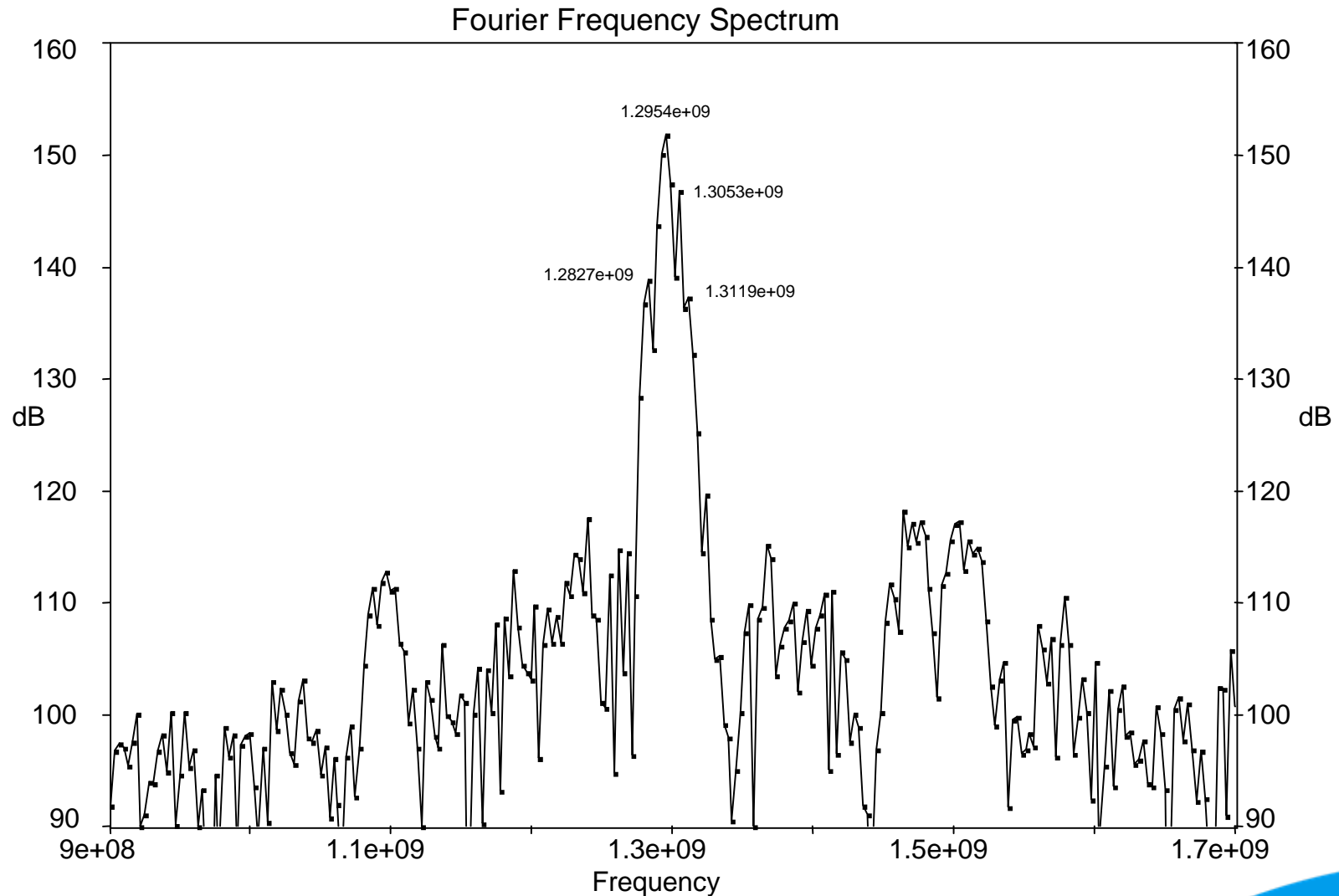


Short-Time Fourier Transform Frequency Spectrum





# HPM Radiated Pulses Frequency Spectrum



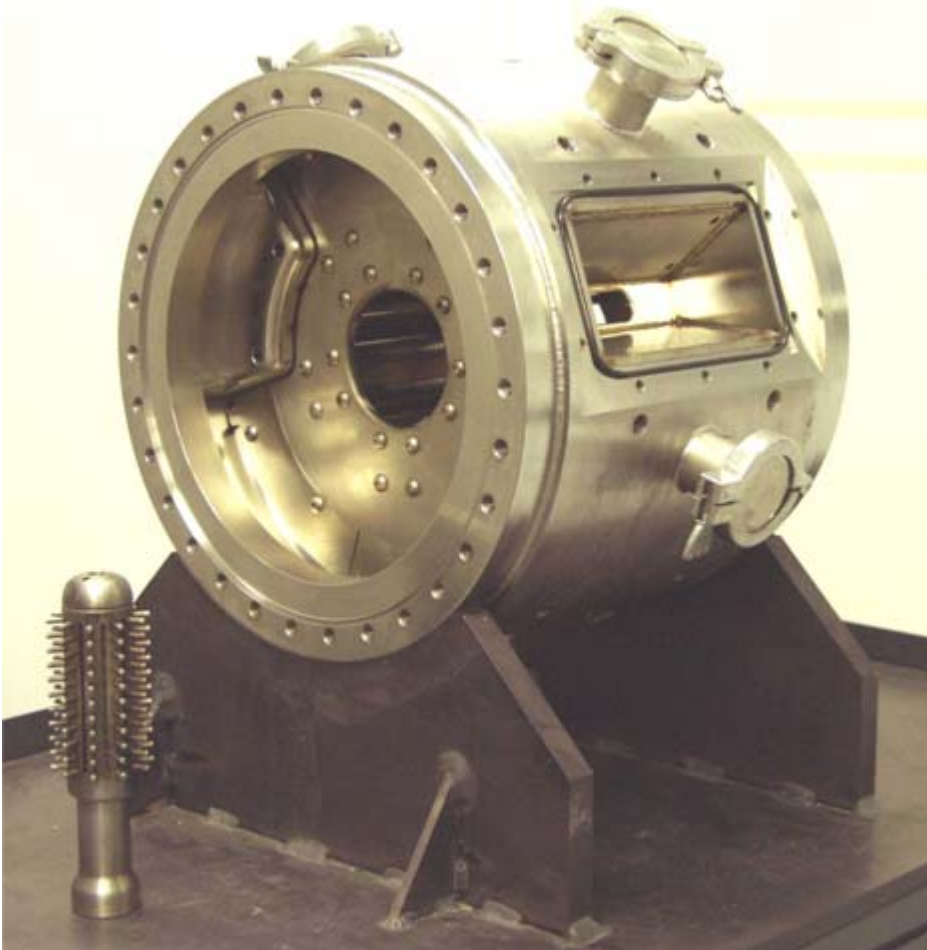


# Cathode Research



# Cathode Research (St. Andrews University)

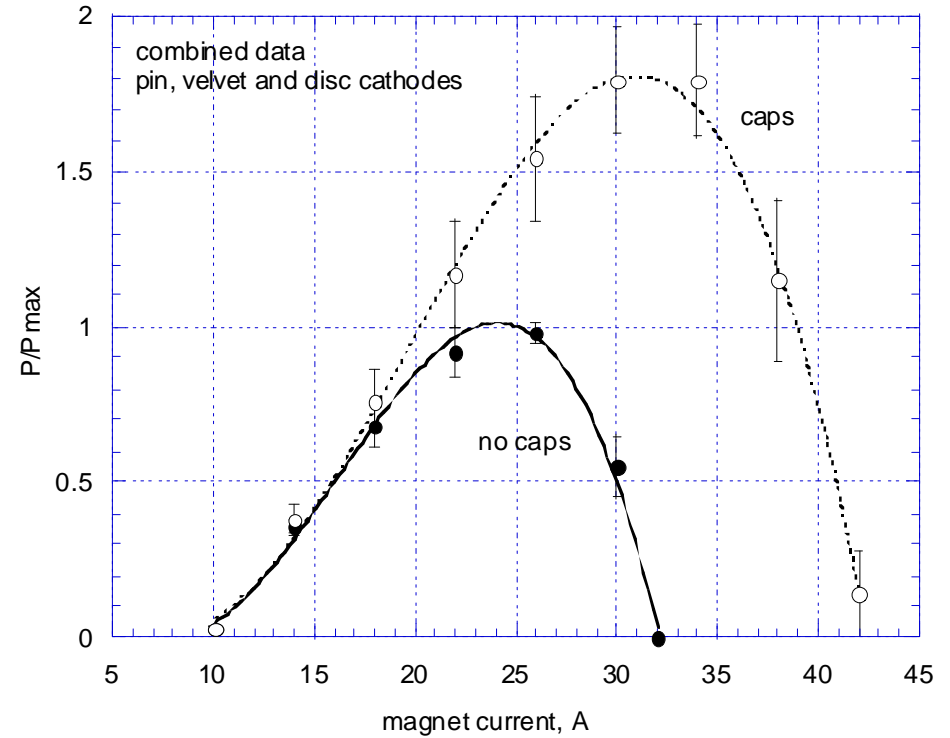
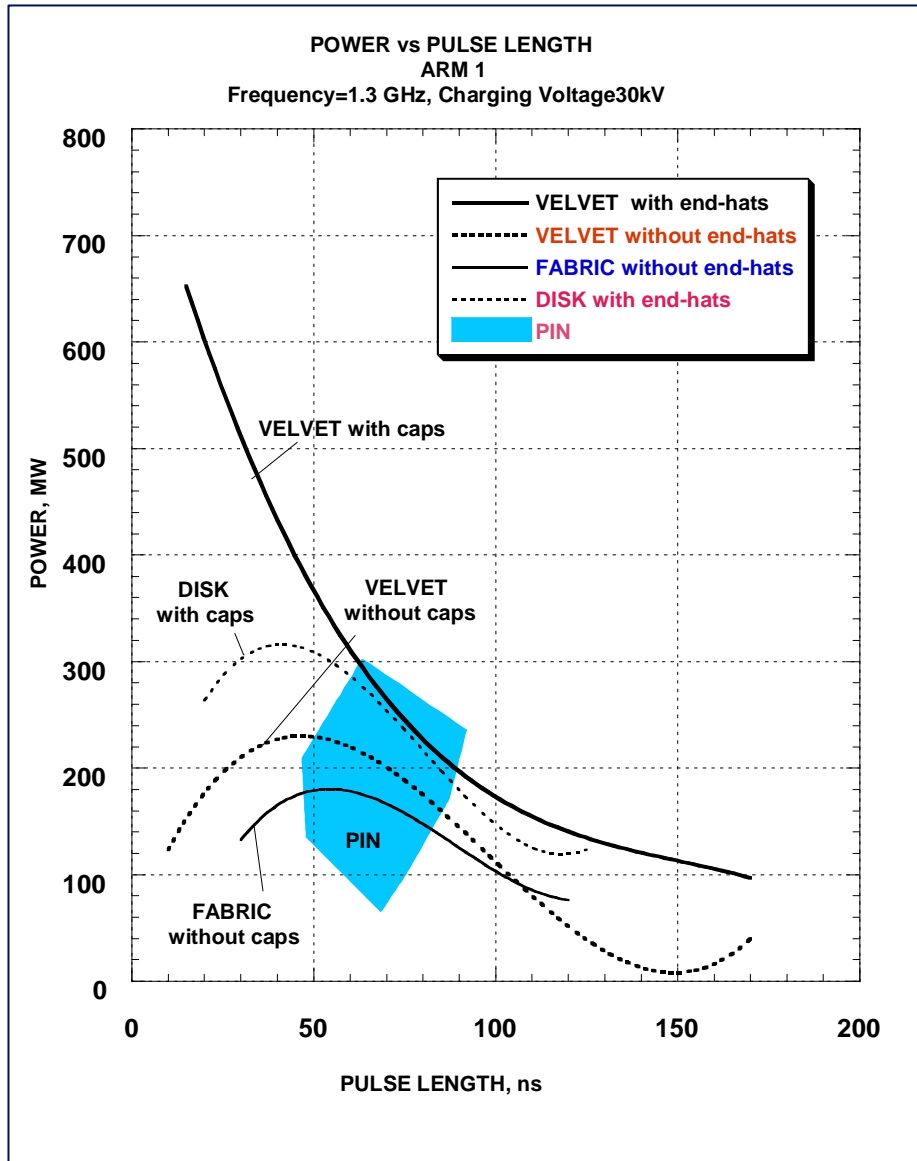
## Orion Cathodes



## Research Cathodes



# Cathode Research (St. Andrews University)



**Peak power doubled**



# Other RF Sources

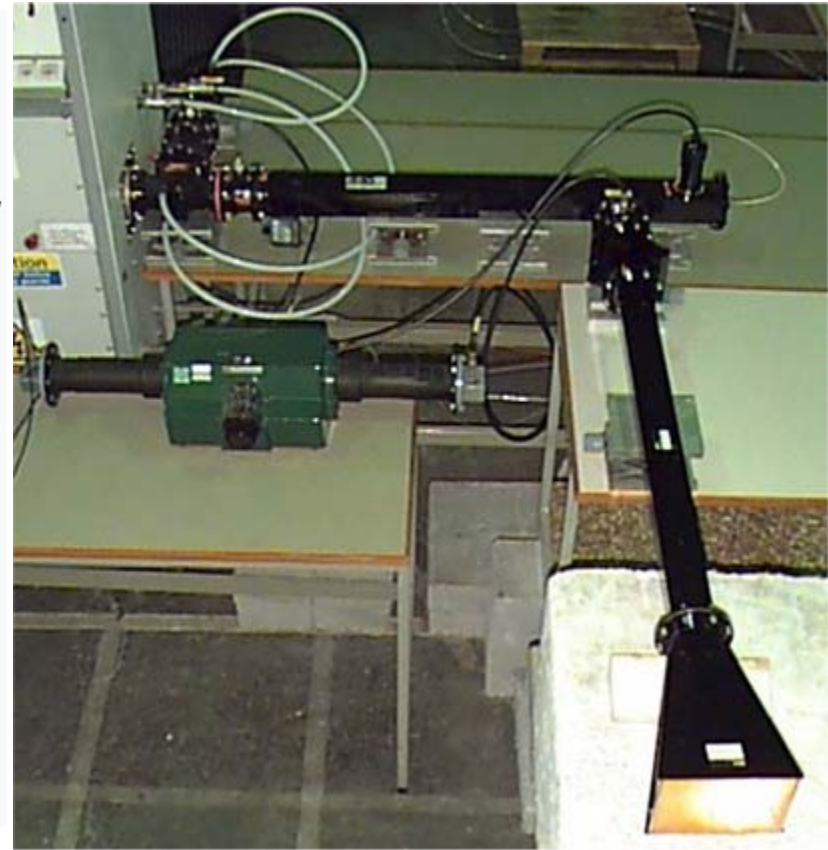
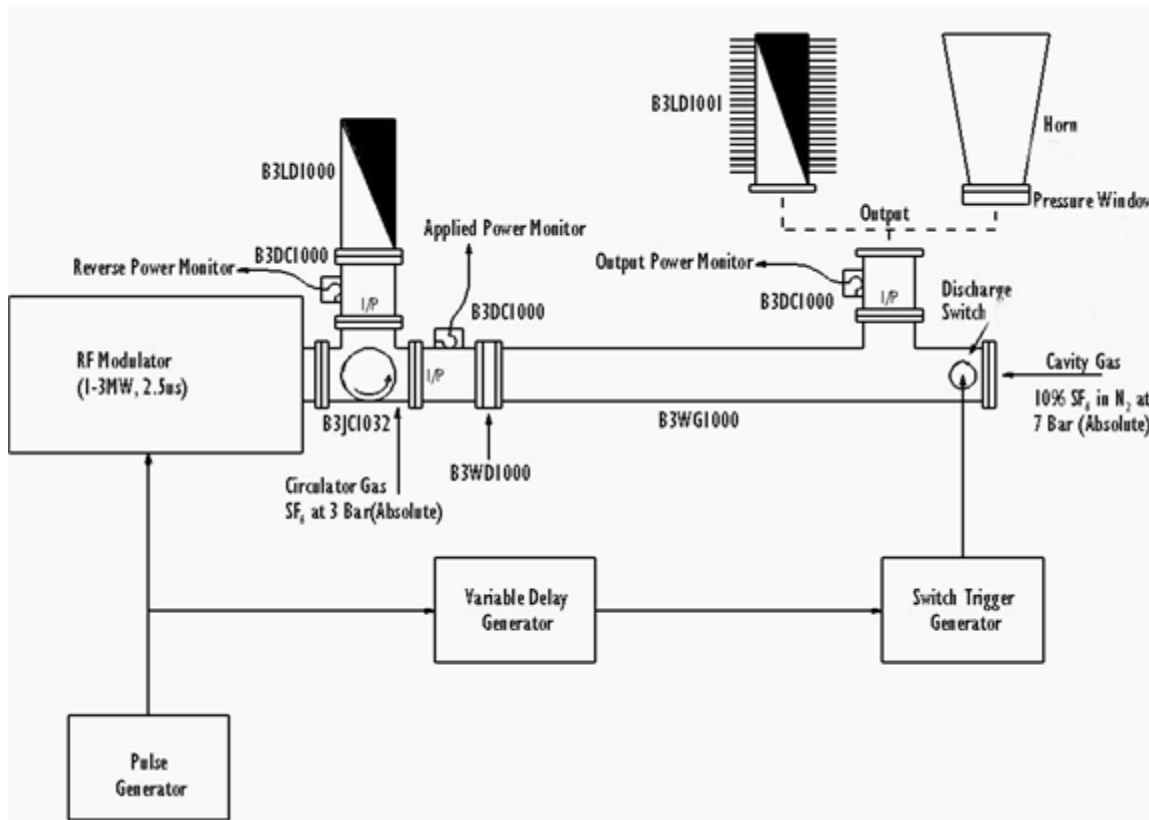




## Other RF sources

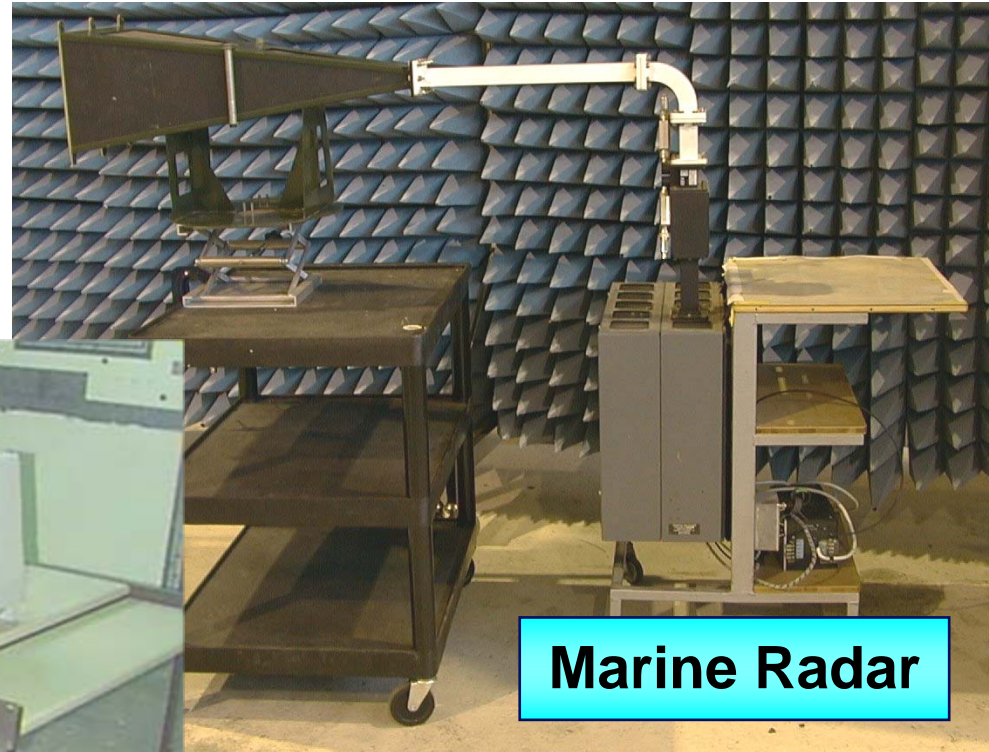
- Other methods of producing high power microwaves are being investigated.
- Systems that are part of the UK HPM capability are:
  - RF Pulse Compressor
  - CW / Pulse Magnetron
  - Marine Radar

# 3.0 GHz, 200 MW Microwave Pulse Compressor





# Microwave Sources



**Marine Radar**



**Pulsed Magnetron**



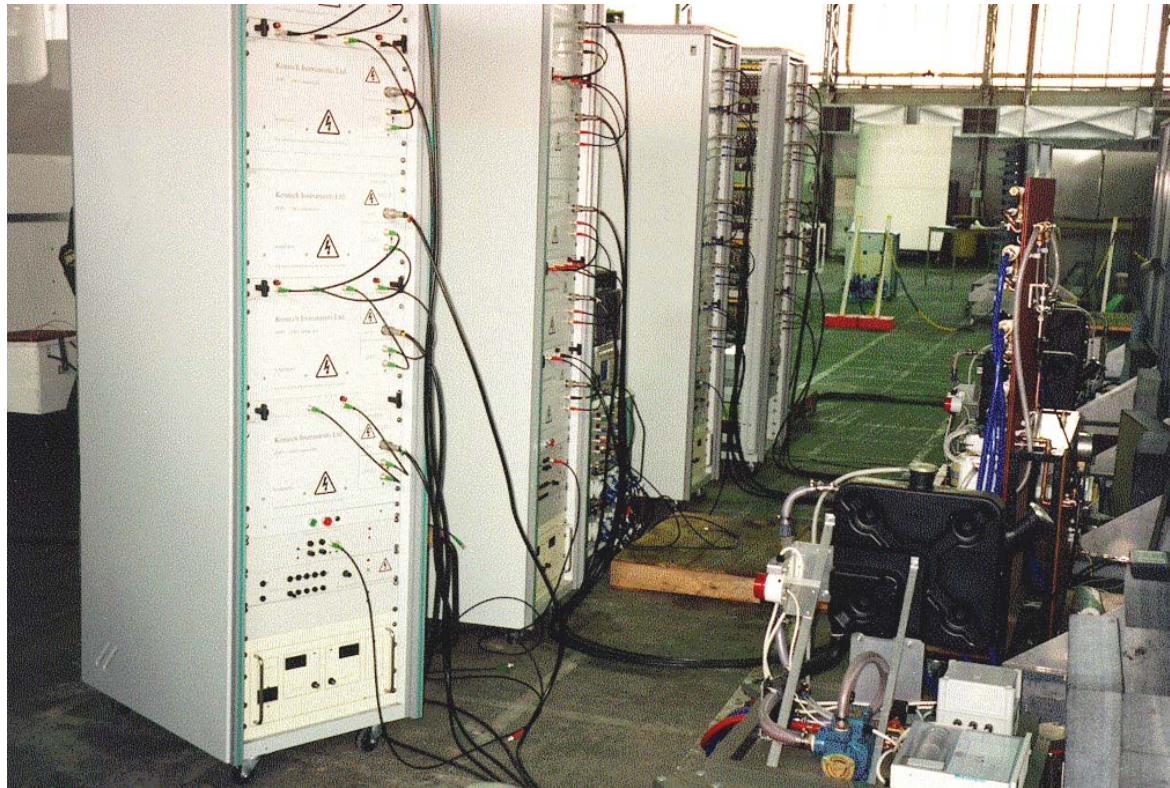


# Ultrawideband

- The UK has a range of Ultrawideband sources
- These include:
  - Crazy Horse UWB Array
  - 16-Element UWB Array

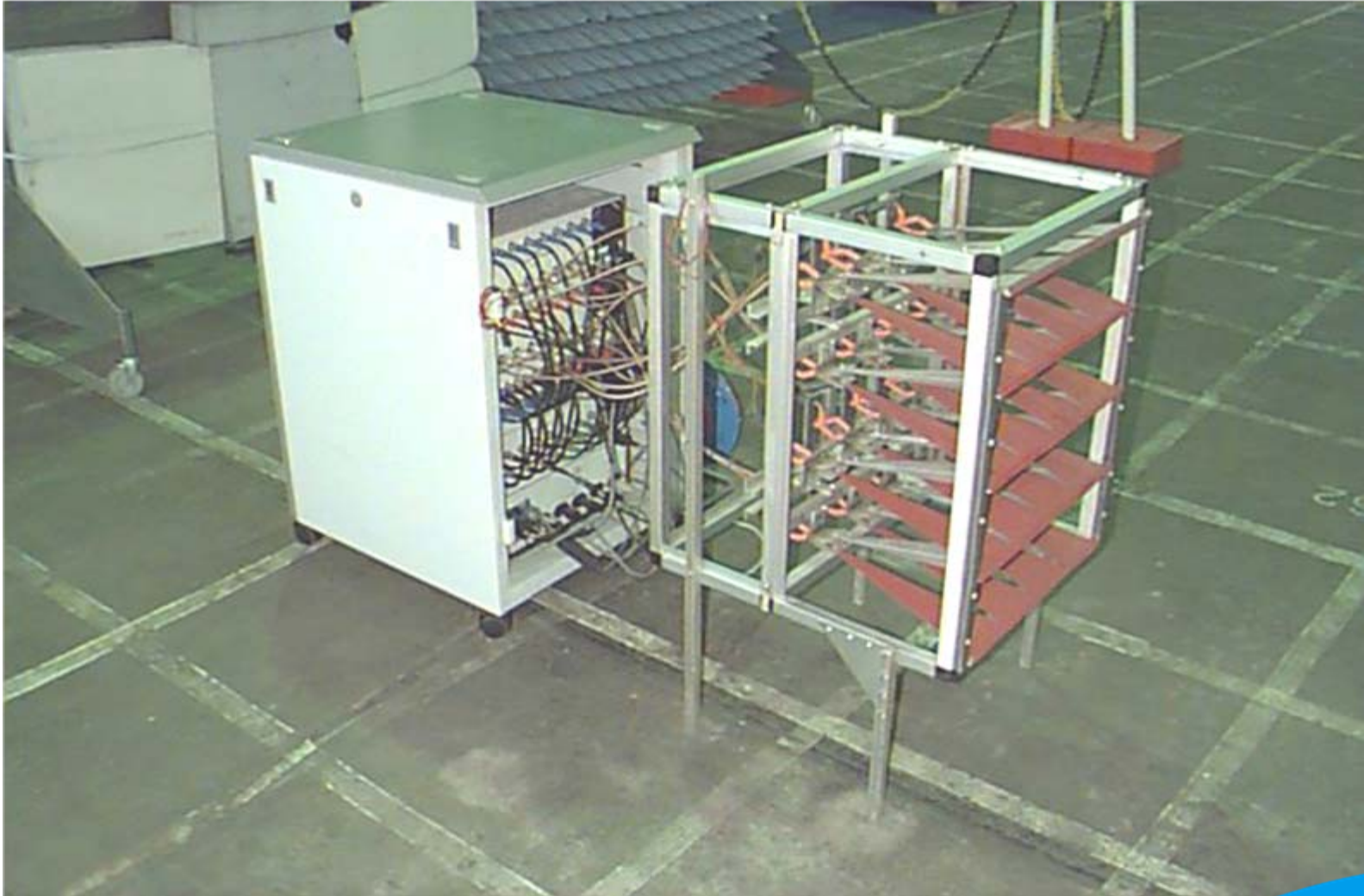


# Crazy Horse UWB Source & Antenna Array





# Ultrawideband 16 Element Array





# Summary





# Summary

- **Versatile HPM & UWB sources:**
  - **Power**
  - **Frequency**
  - **PRF**
- **Orion Source is available for joint collaborative research programmes or ‘hire’**



# Acknowledgment

- Orion is a UK Ministry of Defence (MoD) facility which is operated by QinetiQ with funds provided from the MoD Corporate Research Programme (CRP)

## The High Power Microwave Facility: Orion

**Brian A. Kerr / Stephen N. Spark / Mark I. Harbour / Steve C. Douglas**

QinetiQ Malvern Technology Centre  
St. Andrews Road, Great Malvern  
Worcestershire, WR14 3PS  
U.K.

The Orion high power microwave facility was designed and constructed by Physics International (PI), San Leandro, California, USA, to a design specification which arose within the UK. This presentation will provide an overview of the HPM system capabilities.

Orion is capable of generating HPM radiation across a continuous tuneable bandwidth of 1.07GHz to 3.00GHz. This is achieved via four tuneable magnetrons each capable of operating over a 30% bandwidth via a proprietary tuning technique developed by PI. To meet the requirements of the UK specification, Orion is capable of generating typically +300MW of RF power over the entire operating band. With a magnetron efficiency between 10% to 20%, the pulsed power system has been designed to deliver 5GW of electrical power into the 50 ohm magnetron load.

The operational principles of the HPM system will be described, highlighting the versatility of the source in four key areas; frequency of operation, output power, pulse duration and pulse repetition frequency. The key characteristics of the source are listed in table 1.

**Table 1: Specification of the Orion HPM system**

Parameter	Specification
Operating Frequency	Tuneable from 1.07GHz through to 3.00GHz
Modulator Peak Power	5GW
Peak Voltage	500kV (Magnetron)
Impedance	50 ohms
Electrical Pulse Duration	50 to 500ns in 50ns Steps (Modulator)
Pulse Repetition Rate	Single Shot to 100Hz
Burst Duration	10 seconds (Maximum)
Inter Burst Delay	8 minutes (Minimum)
Prime Power	500kW Average

### ACKNOWLEDGEMENTS

Orion is a UK Ministry of Defence (MoD) facility, operated by QinetiQ with funds provided from the MoD Corporate Research Programme (CRP).

© Crown copyright 2002.

Kerr, B.A.; Spark, S.N.; Harbour, M.I.; Douglas, S.C. (2002) The High Power Microwave Facility: Orion. In *Tactical Implications of High Power Microwaves* (pp. 26-1 – 26-2). Meeting Proceedings RTO-MP-SCI-119, Paper 26. Neuilly-sur-Seine, France: RTO. Available from: <http://www.rto.nato.int/abstracts.asp>.

## SYMPOSIA DISCUSSION – PAPER NO: 26

**Discussor's Name: Unknown**

**Question:**

Magnetrons tuned? Can freqs be changed?

**Author's Name: Kerr**

**Author's Response:**

Tunable, but

**Discussor's Name: Römer**

**Question:**

Pulse duration 500 ns?

**Author's Name: Kerr**

**Author's Response:**

If narrow, 30 ns – 300 ns.