### RADAR?

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# Radio Detection And Ranging

### RADAR



# Nature's done it already





### James Clerk Maxwell

The Maxwell Equations showed that electricity and magnetism are two aspects of the same force.



### Heinrich Rudolf Hertz

Hertz proved that electricity can be transmitted by electromagnetic waves.



### Heinrich Rudolf Hertz



### Guglielmo Marconi

Inventor of the radio telegraph system; first transatlantic radio transmission on 12 December 1901 at 820 kHz.

### Ionised Layer

#### Oliver Heaviside



In 1902, Heaviside and Kennelly independently predicted an ionised layer in the upper atmosphere that would reflect radio waves.

(17 December 1861 – 18 June 1939)

Arthur E Kennelly

### Edward Appleton

Appleton and his colleagues were one of two teams to prove the existence of a reflecting layer at a height of about 100 km (E layer), soon followed by the discovery of the F layer at around 250 km.



(6 September 1892 – 21 April 1965)

#### Ionosonde

G Breit and M A Tuve, A radio method of estimating the height of the conducting layer, Nature, 116, p. 357, 1925.

(14 July 1899 - 11 September 1981)



#### Gregory Breit Merle Tuve

# Regular Ionograms



Radio Research Station Slough, Buckinghamshire 27th December 1933, <u>10:30–11:00 UTC and 11:30–12:00 UTC.</u>

# Sodankylä Ionosonde



# Detecting Aircraft



Denge, Dungeness, Kent, UK

### Robert Watson-Watt

Daventry Experiment on 26 Feb. 1935; patent for RADAR on 2 Apr.; by June detecting aircraft at 27 km.





(13 April 1892 – 5 December 1973)

### Chain Home

#### Venthor, Isle of Wight Multi-freq 12 m, 200 km range CHlow 1.5 m



### Christian Hülsmeyer

#### Invented RADAR ... ... but no-one noticed.

Das TELEMOBILOSKOP 1904 VON CHRISTIAN HÜLSMEYER, DÜSSELDORF, D.R.P. 165546,169154 Gerät zur Feststellung und Entfernungsbestimmung bewegter metallischer Gegenstände im Nebel (Schiffe, Wracks, Unterseeboote u.s.w.) durch hör- und sichtbare Signale. DRP Nr. 165546 v. 30.4.1904, u.169 154 v.11.11.1904, Coldation. Red ASAMA BR Fia3 Sender Hohissian Fig & Employes-listinging Fuel Kompass-Fer Empfänger mit Zeitsperre ....Sellung Alorm Stolland 14 1 1 1 1 1



### Freya

German radar op. 1938.
Portable(ish).
120-130 MHz (2.5-2.3 m).
PRF 500 Hz, 3 µs pulses.
Rotates 360°, 160 km range.

Countermeasures:
Moonshine: re-emit amplified pulses (8 a/c = 100 bombers).
Jamming: 9 a/c create a 200-mile (320 km) gap.



### September 1939

More or less rudimentary but operational radars:

Britain, France, Germany, Hungary, Italy, Japan, the Netherlands, Russia, Switzerland, and the USA.

### Cavity Magnetron

- Invented at U Birmingham, UK, by John Randall and Henry Boot.
- By mid-1940 cavity magnetron developed into a small, light-weight transmitter (3 GHz at 15kW).
  10x improvement over other radar.





### Status after WWII

- RADAR had evolved from prototypes to a multitude of different systems.
- Microwave signal generation had become practical.
- Advances in aerials, transmitters, receivers, displays etc. led to wide-spread use in communications and radar applications.

# ... fast forward ...

Does the Future of Incoherent Scatter look like this?

# EISCAT\_3D

#### Welcome aboard!

