NUCLEAR FUSION & PROTON DETECTION

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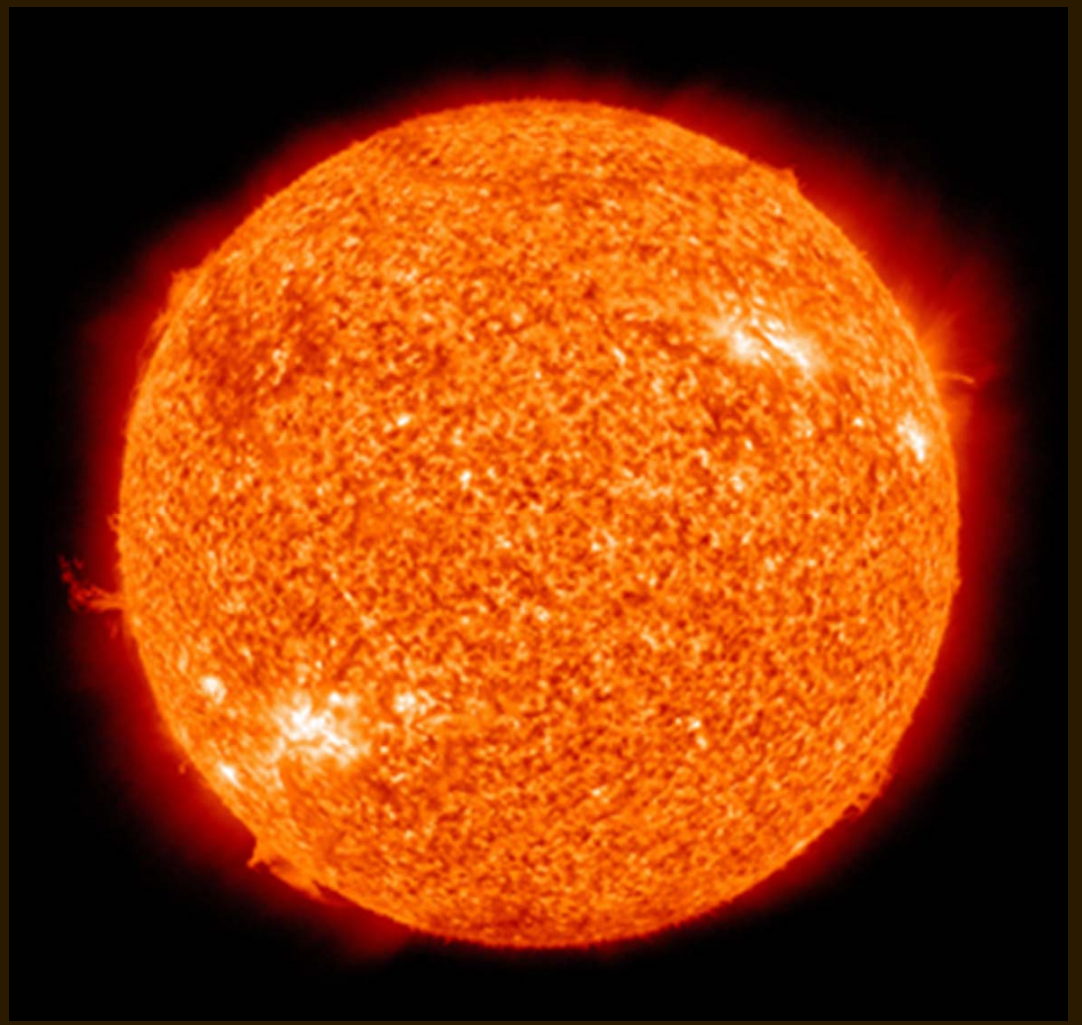
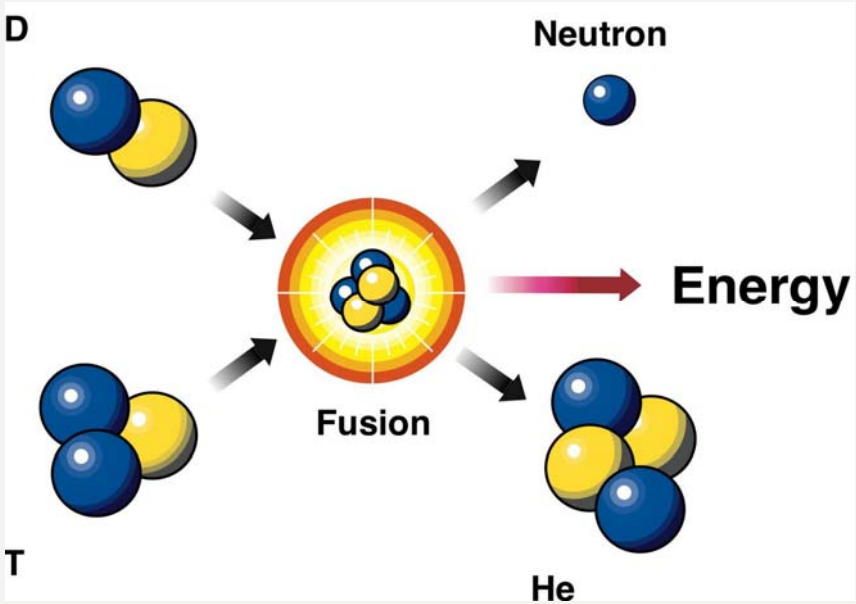
NUCLEAR FUSION

ENERGY SOURCE OF THE STARS



NUCLEAR FUSION (SIMPLIFIED)

- Combination of two or more light nuclei forming a heavier nucleus and subatomic particles, release of energy



WHY STUDY FUSION?

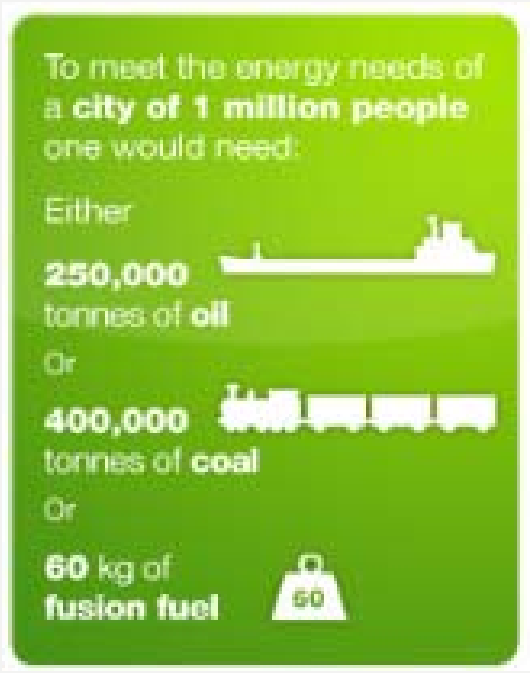
- Increase in global energy requirements
  - Increase of 33% from 2011 to 2035[1]

- Decrease CO2 emissions from other energy sources like fossil fuels
  - Primary cause of global warming[2]

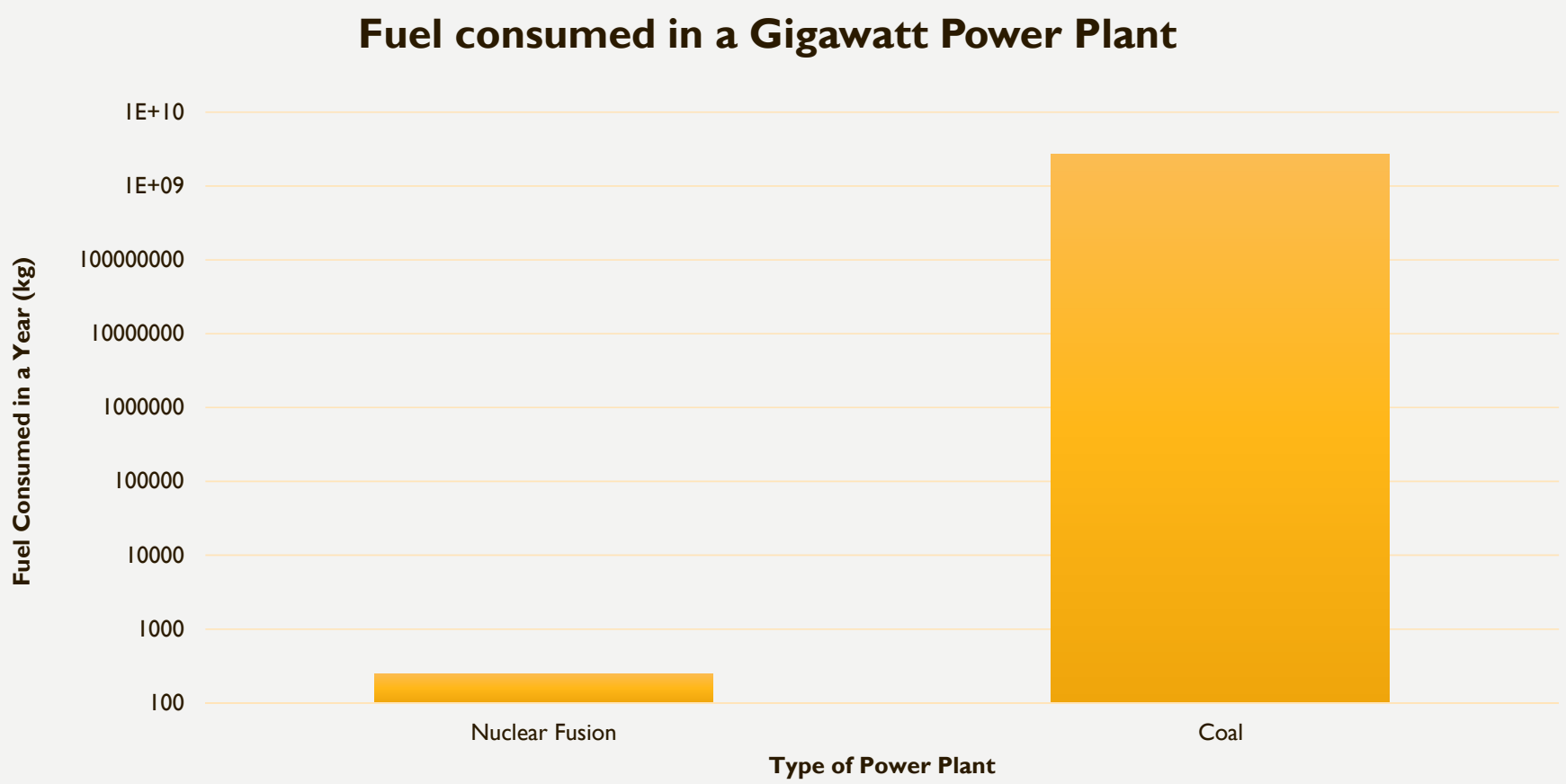
- Requires less fuel
  - 7 orders of magnitude less than coal![3]

GLOBAL ENERGY DEMANDS ARE INCREASING

- Causes:
  - Population growth, electricity introduced to developing countries
- Fusion provides more energy than coal or nuclear fission for equal amounts of fuel[4]
  - Four million times more than coal
  - Four times more than fission reactions



RESOURCE COMPARISON



ENVIRONMENTAL IMPACTS

COAL & NUCLEAR FISSION

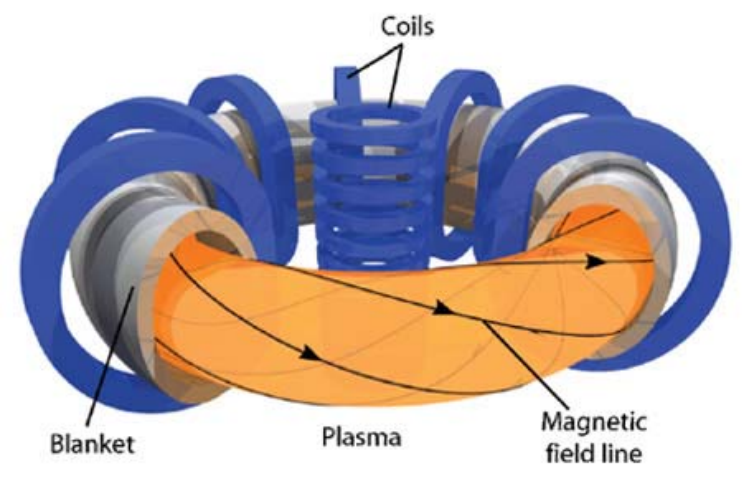
- Coal emits CO_2 into the atmosphere
  - 1Gigawatt power plant =1.2 million cars[2]
- Fission radioactive waste
  - Plutonium half-life = 24,000 years[5]
- Fission reactor meltdown possibility

FUSION

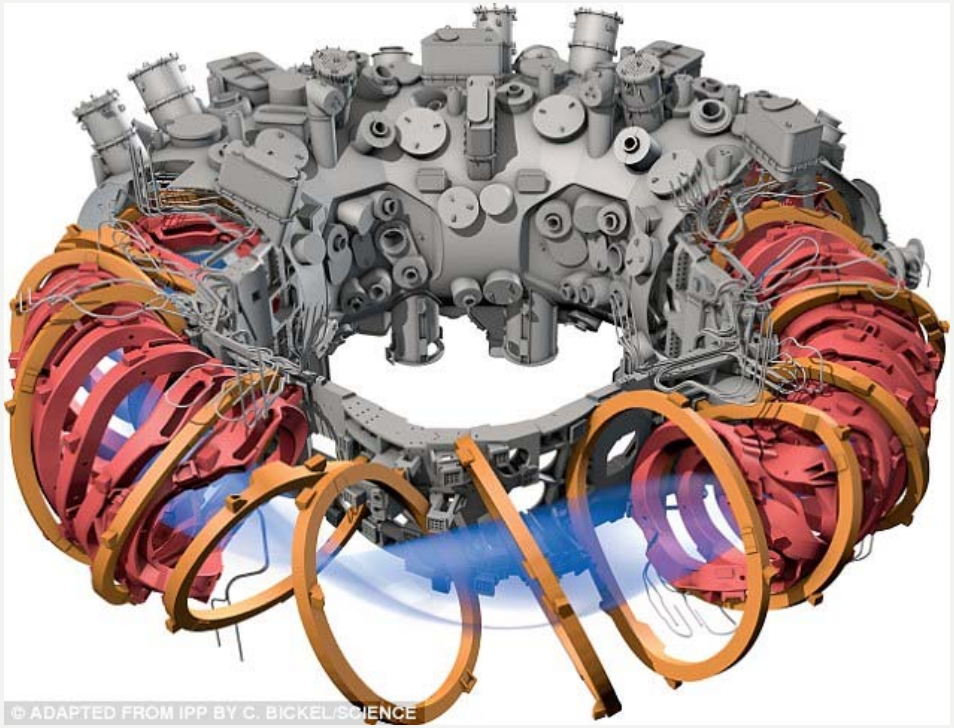
- Emits helium into the atmosphere (non-toxic)[6]
- Fusion radioactive waste
  - Reuseable within a century
- No possibility of reactor meltdown
- Plentiful resources
  - Deuterium from water
  - Tritium from lithium from water

FUSION REQUIREMENTS[7]

- Plasma – "electrically-charged gas"
- High temperature (heat gas to150 million degrees Celsius)
- High pressure to keep plasma away from container walls
- Most popular design is the donut-shaped tokamak



STELLERATOR: WENDELSTEIN 7-X



- 1.1 million hours of work to assemble[8]
- 250 access ports
- 16 meters wide
- 50 superconducting coils, each weighing six metric tonnes

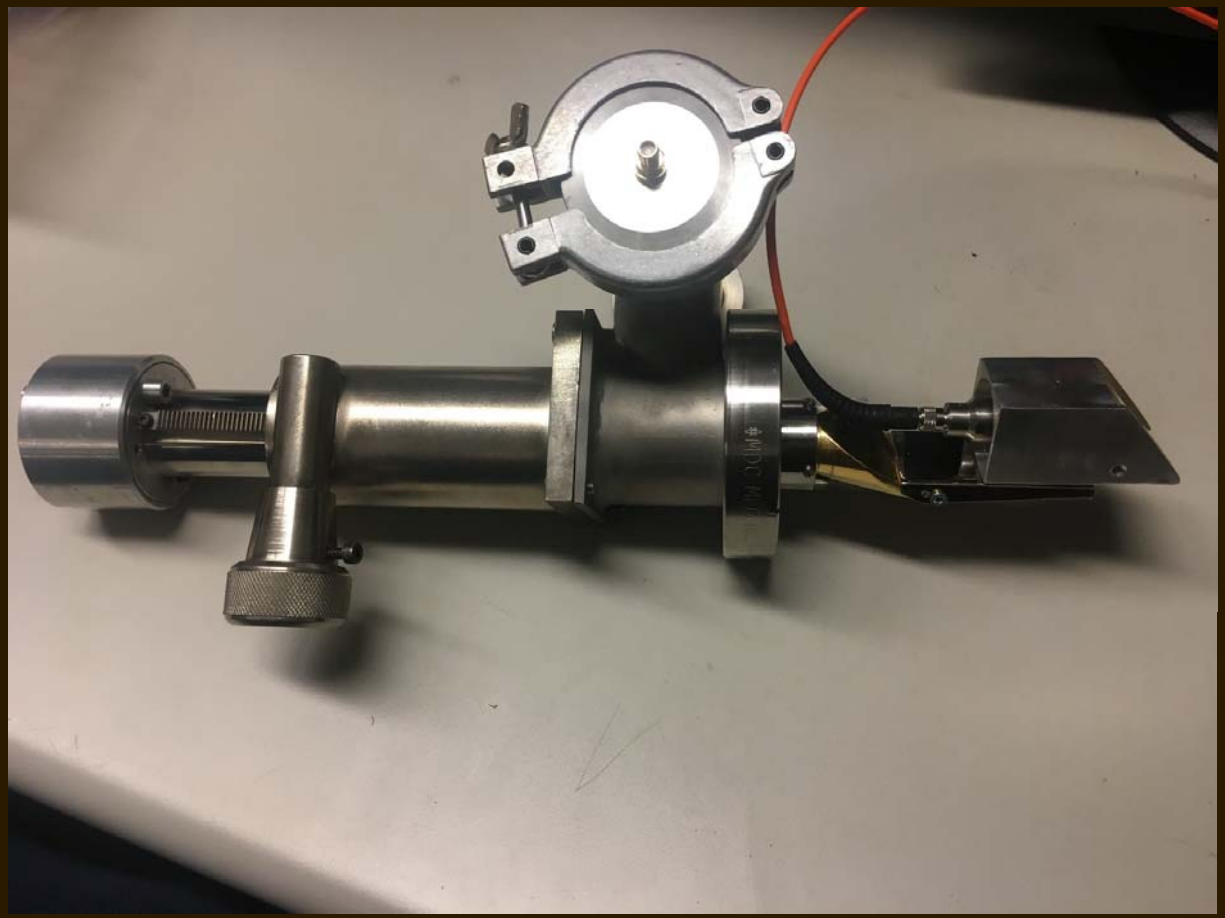
iter

china eu india japan korea russia usa

- "The Way"
- 35 countries working together to create the world's largest tokamak fusion reactor in France
- Set to produce ten times more power than is input
- Construction began in 2010, production is scheduled for December 2025

PROTON DETECTION

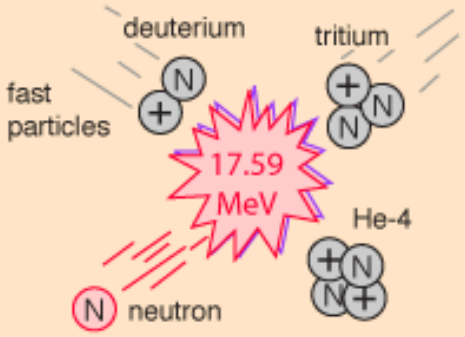
WHY DETECT PROTONS?



TWO PRIMARY FUSION REACTION TYPES[9]

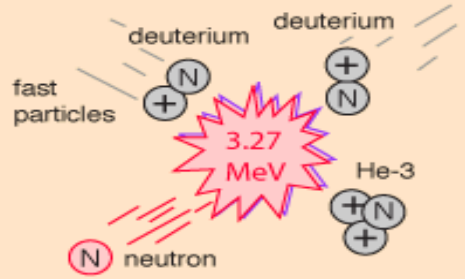
$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + 17.59MeV$$

Deuterium-tritium Fusion

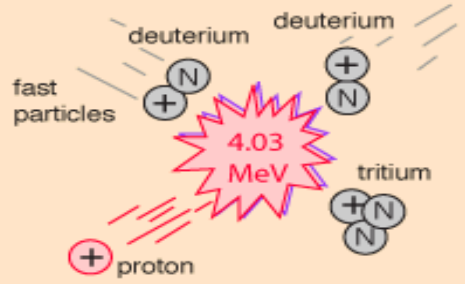


$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n + 3.27MeV$$

Deuterium-deuterium Fusion



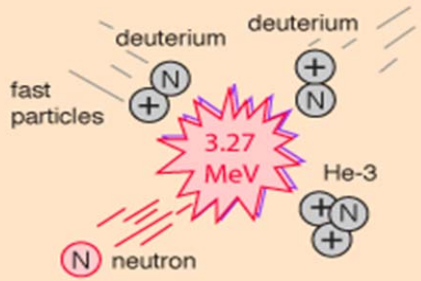
$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H + 4.03MeV$$



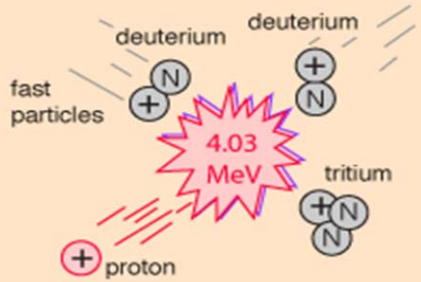
D-D FUSION

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n + 3.27MeV$$

Deuterium-deuterium Fusion



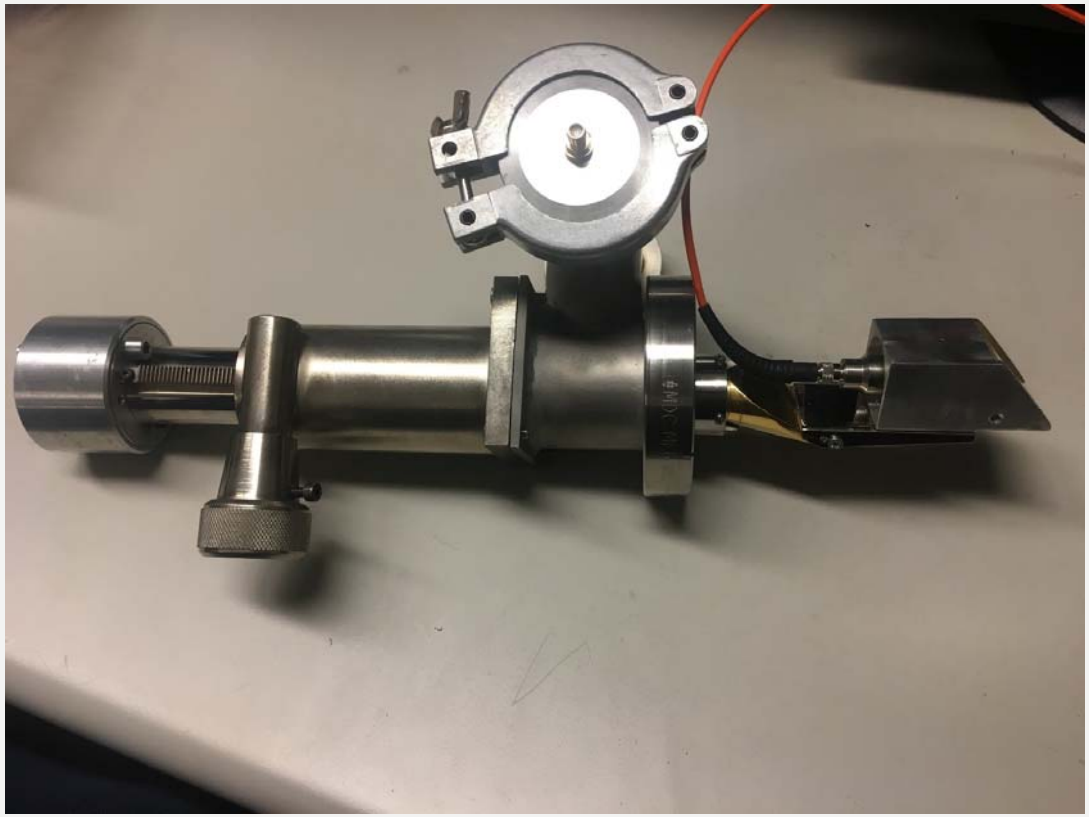
$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H + 4.03MeV$$

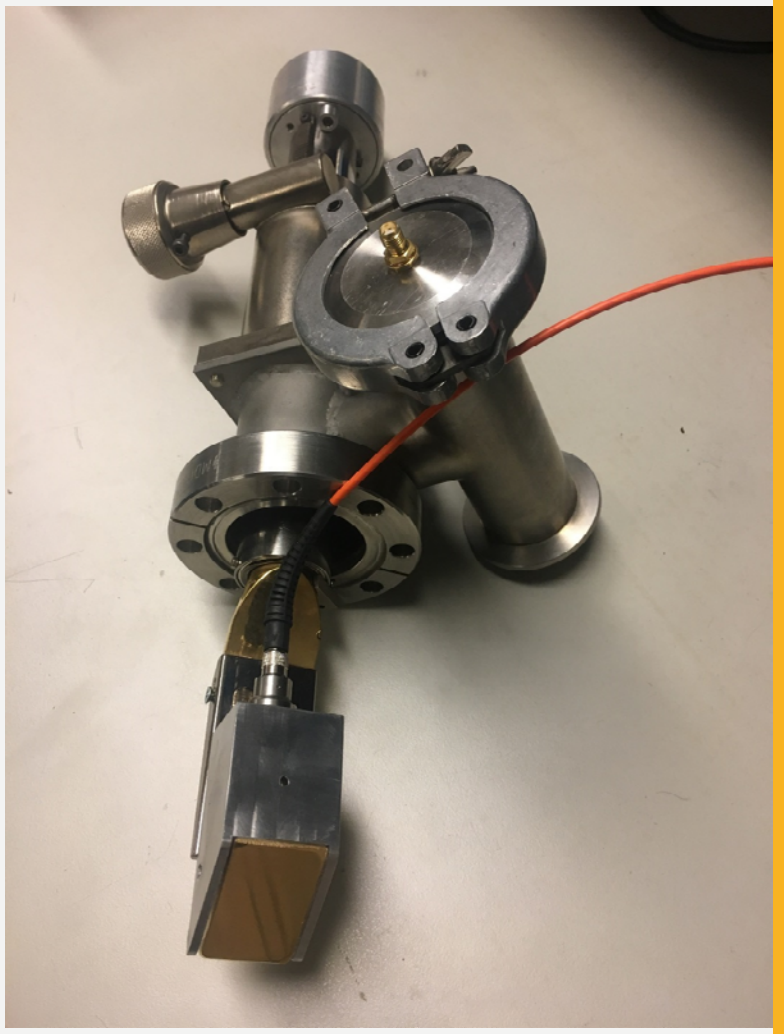


- If D-T reactions are more promising, then why bother with D-D?
- ITER's goal of tritium breeding[3]

$$^{6}_{3}Li + ^{1}_{0}n \rightarrow ^{4}_{2}He + ^{3}_{1}H + 4.8MeV$$

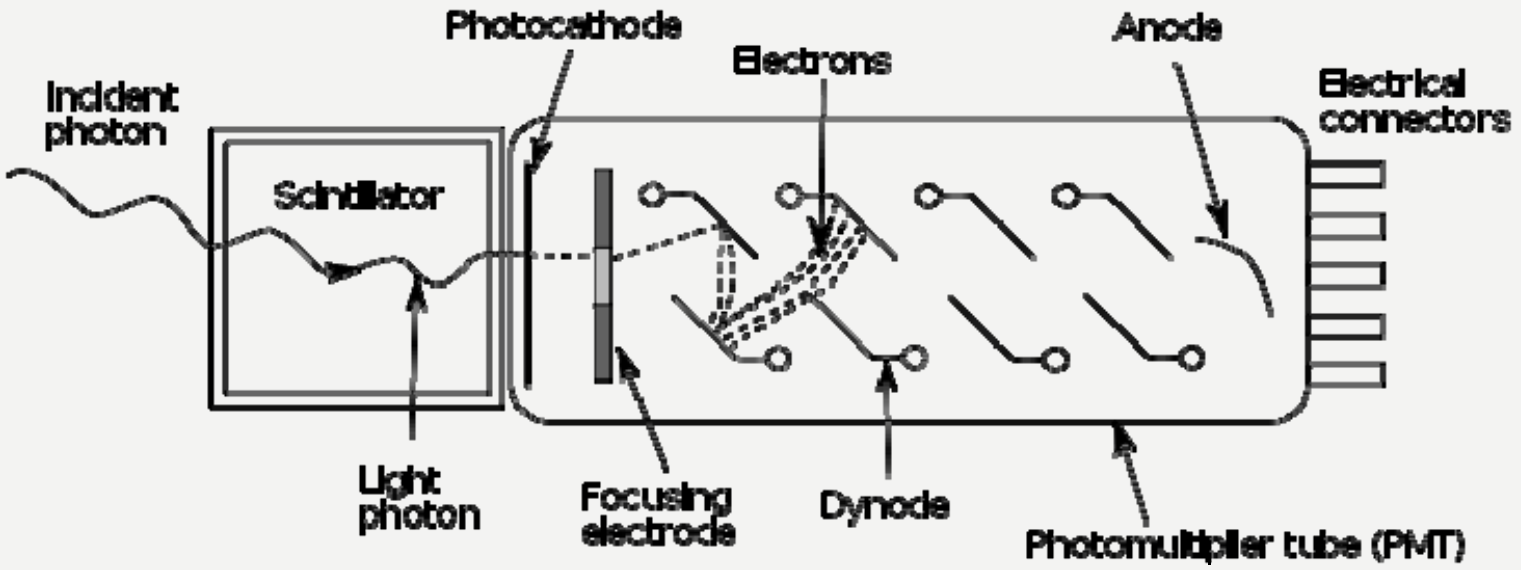
THE DETECTOR





SCINTILLATOR & PHOTOMULTIPLIER TUBE

- What are they?

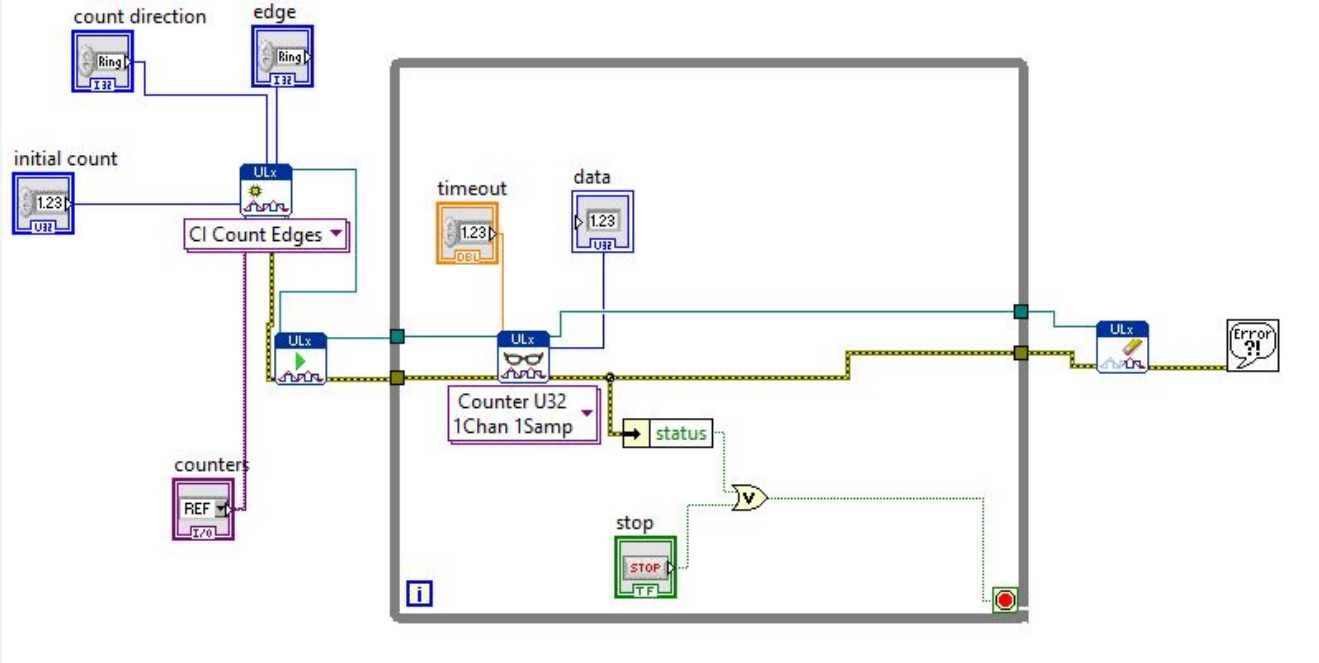


MODIFYING THE SIGNAL

- Amplification and Discrimination

DATA COUNT

- Data Acquisition Device & the Virtual Instrument



QUESTIONS?

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REU PARTICIPANTS

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REFERENCES FOR IMAGES IN ORDER OF SLIDES

- Slide 1:

  -"The Sun." *The Sun*. Nine Planets, n.d. Web. 10 Aug. 2016.

- Slide 3 and 5:

  - "The Merits of Fusion." *Fusion for Energy*. European Joint Undertaking for ITER and the Development of Fusion Energy, 2015. Web. 24 July 2016

- Slide 4:

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- Slide 8:

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- Slide 10:

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- Slides 13 and 14:

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