Collective Thomson Scattering Diagnostic on Wendelstein 7-X

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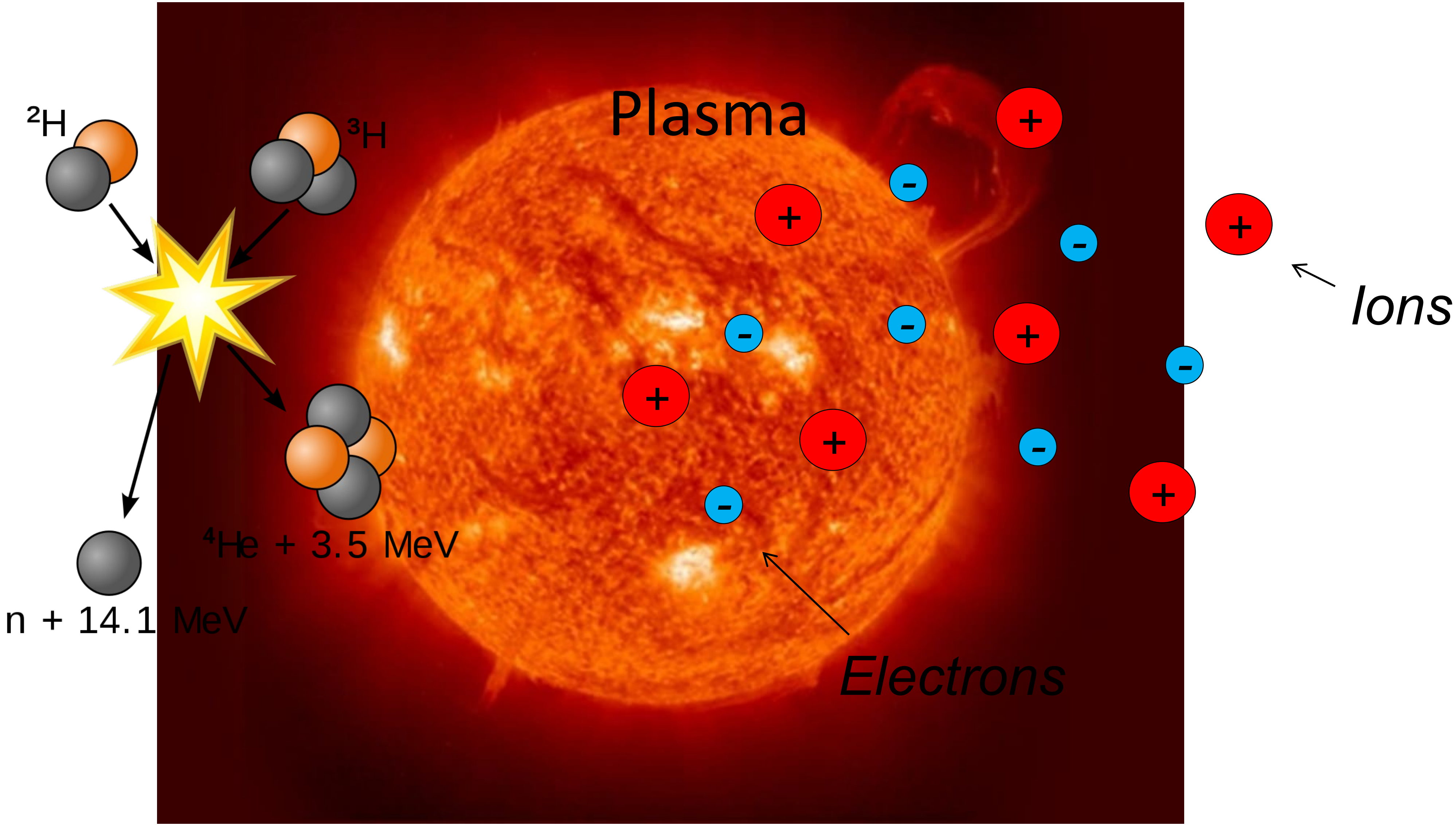
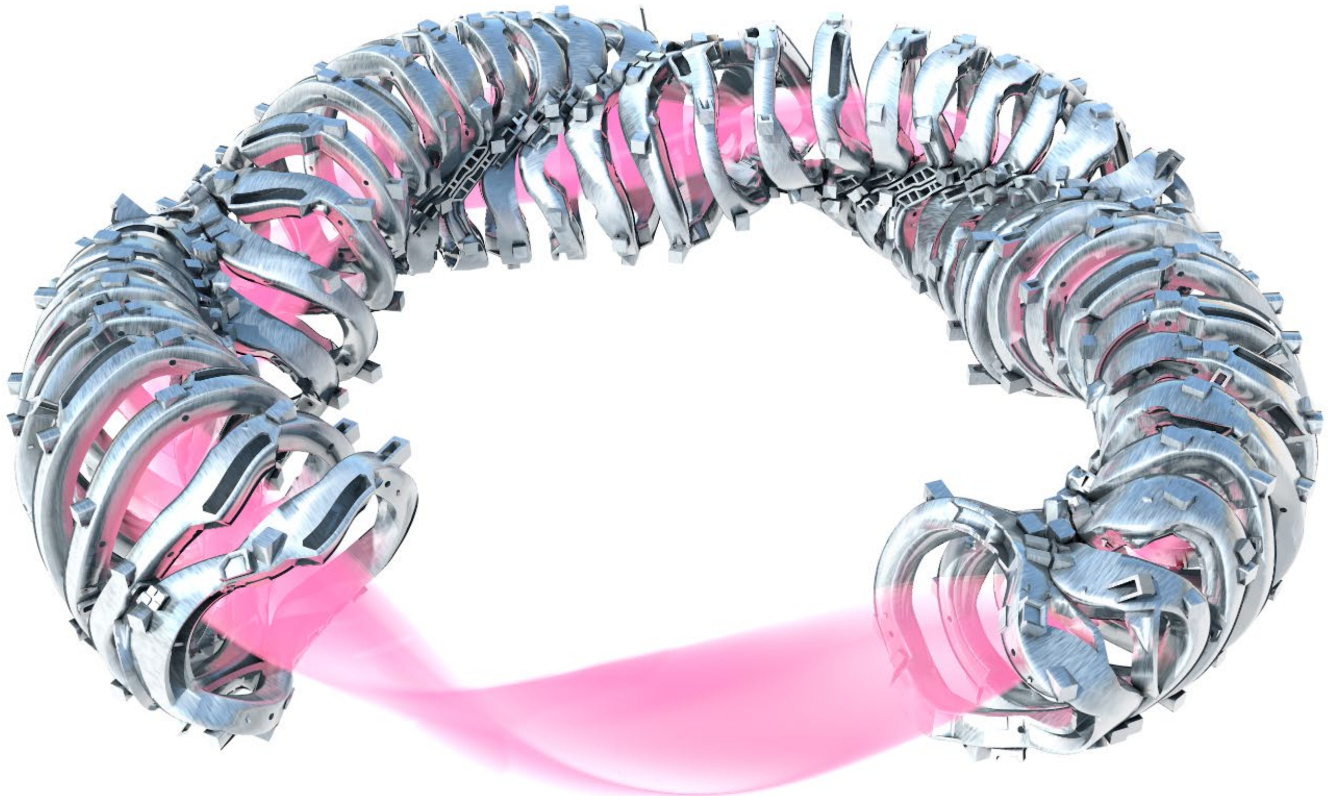
Nuclear Fusion

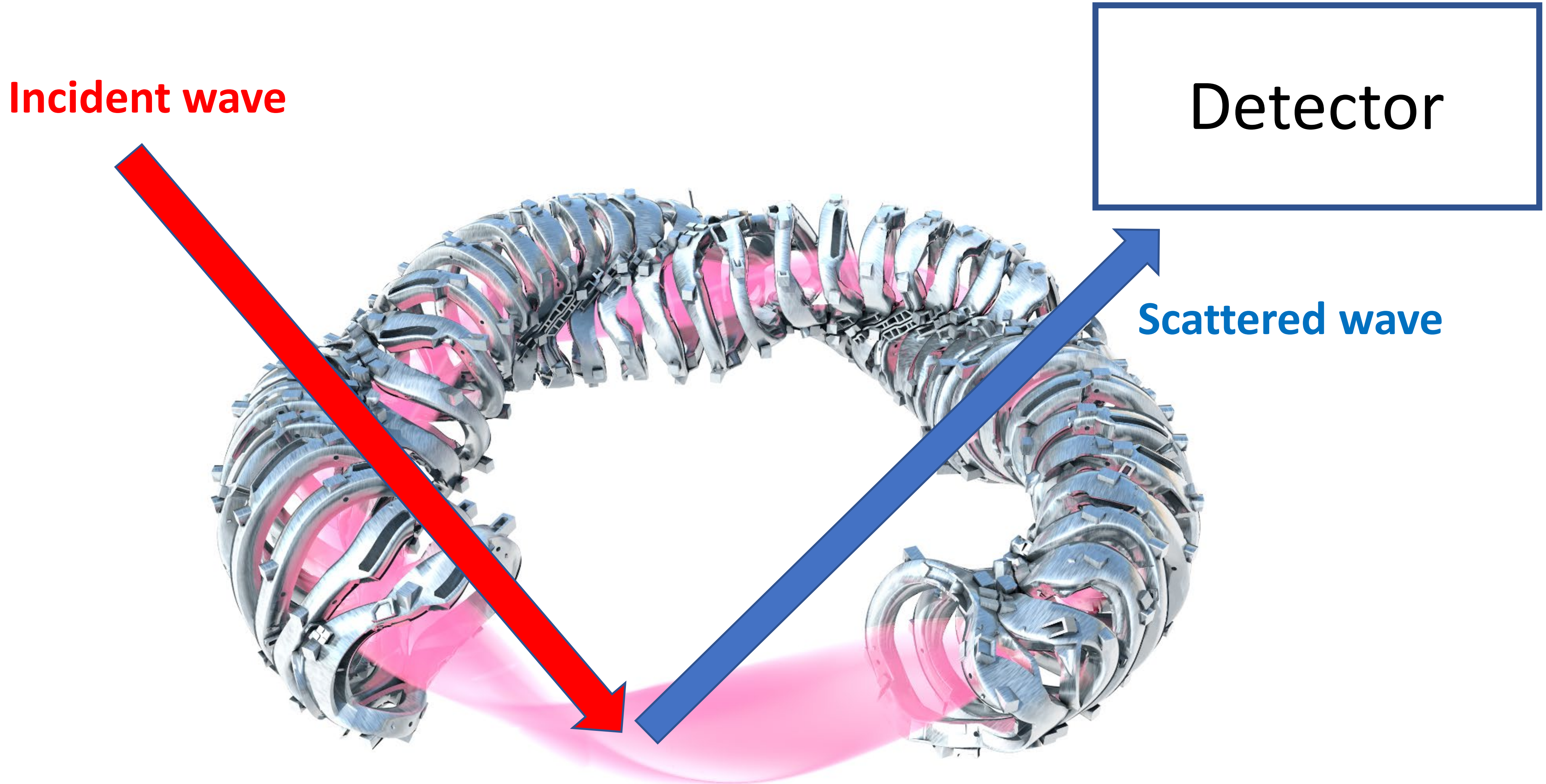


Bringing the Sun to Earth - How do we do it?

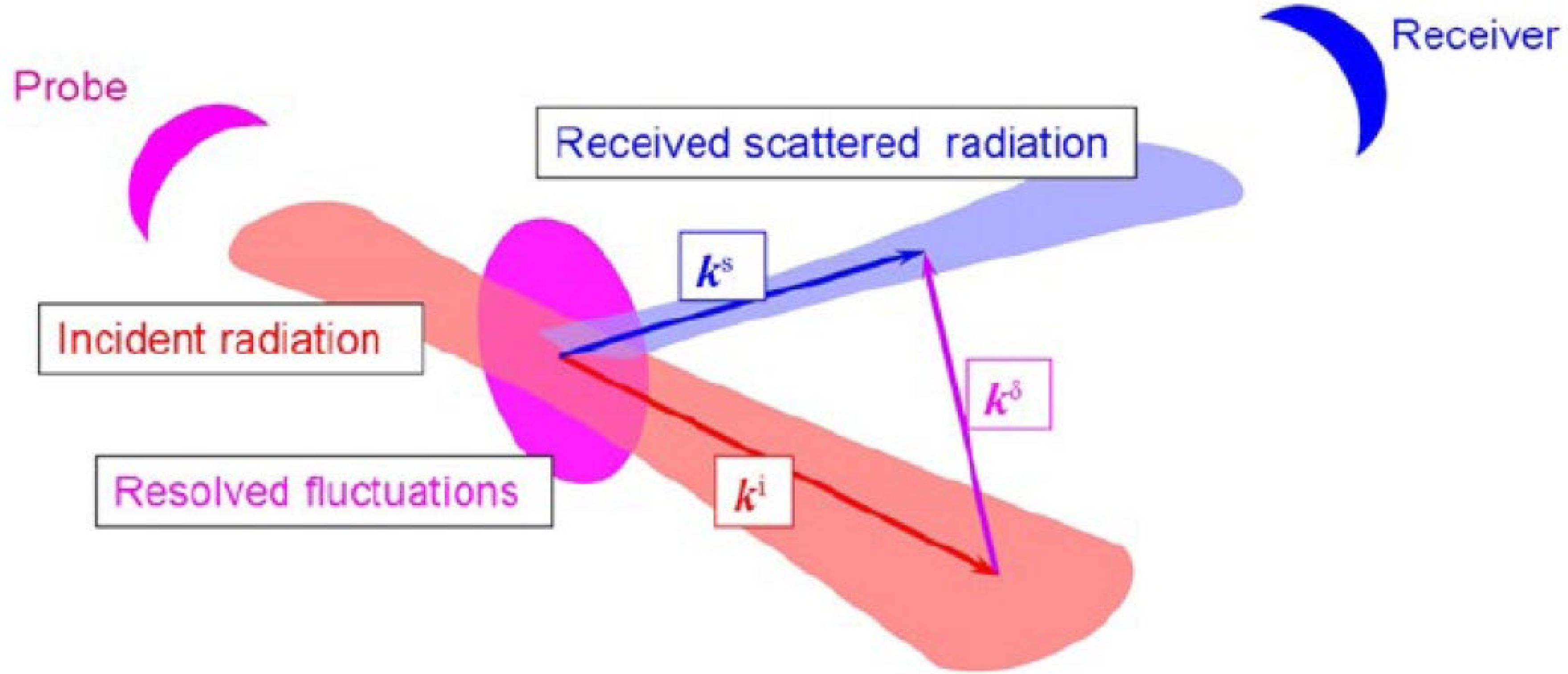


Images: Eurofusion, T. Stange

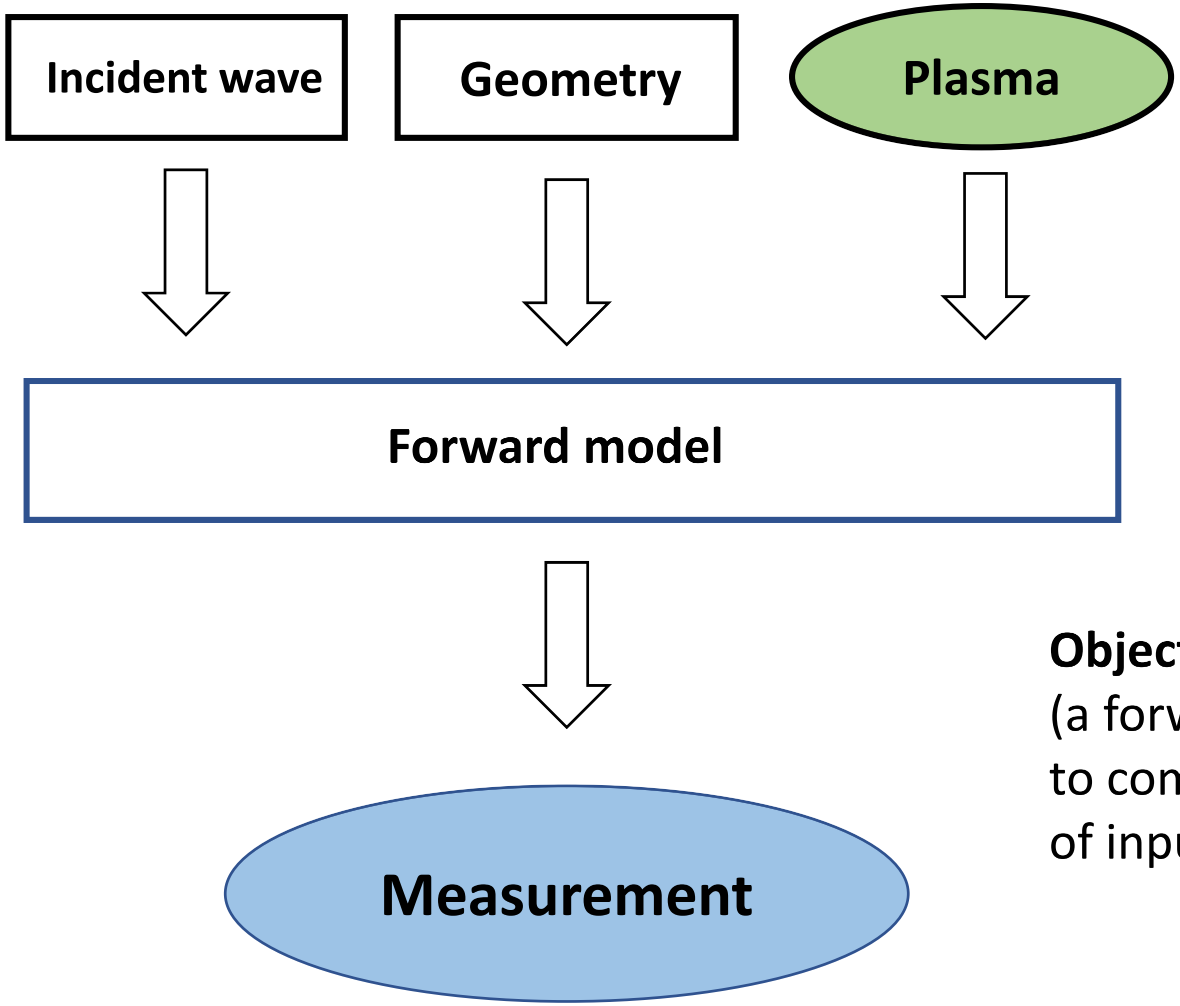
Collective Thomson Scattering (CTS)



Collective Thomson Scattering (CTS)

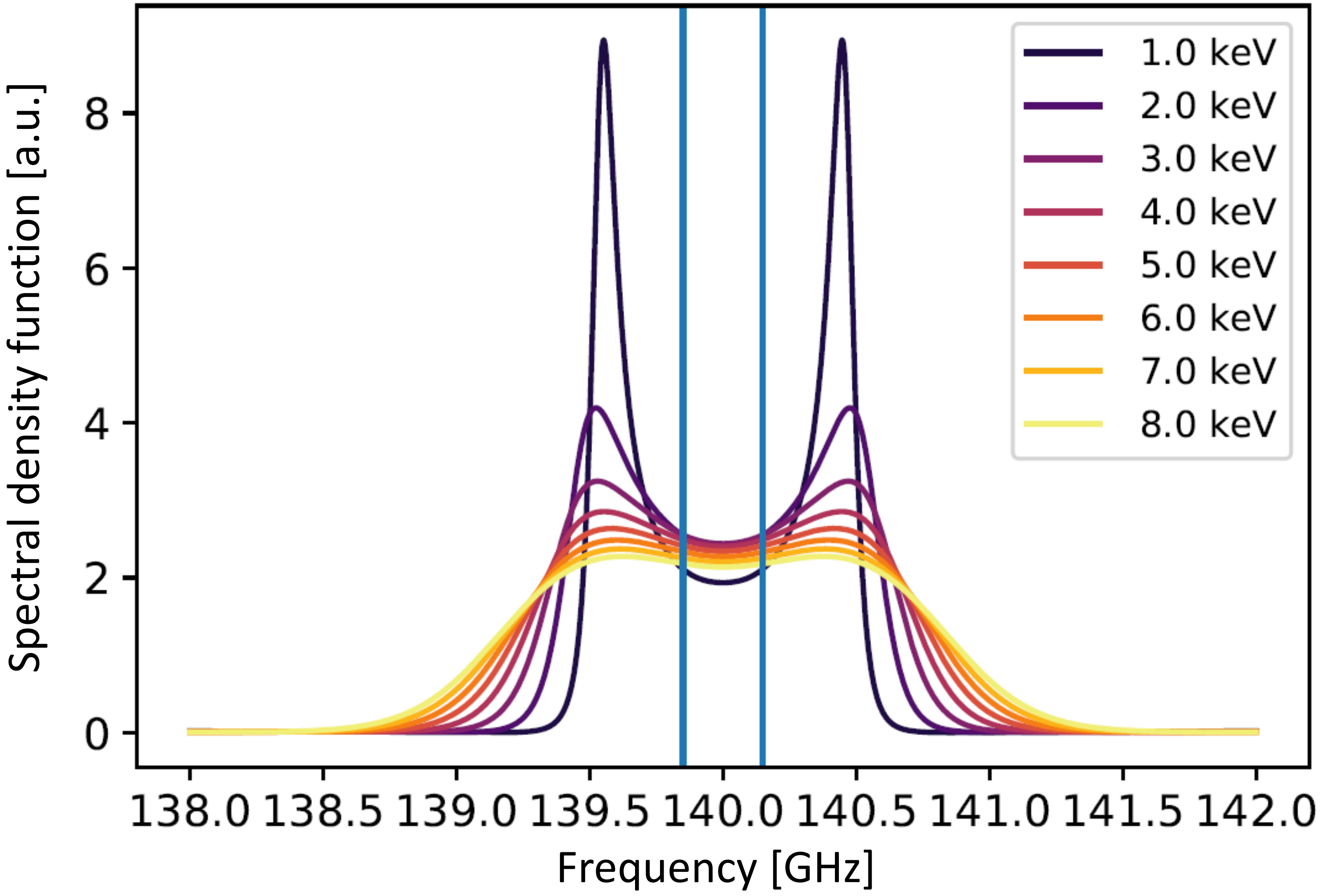


The Forward Problem



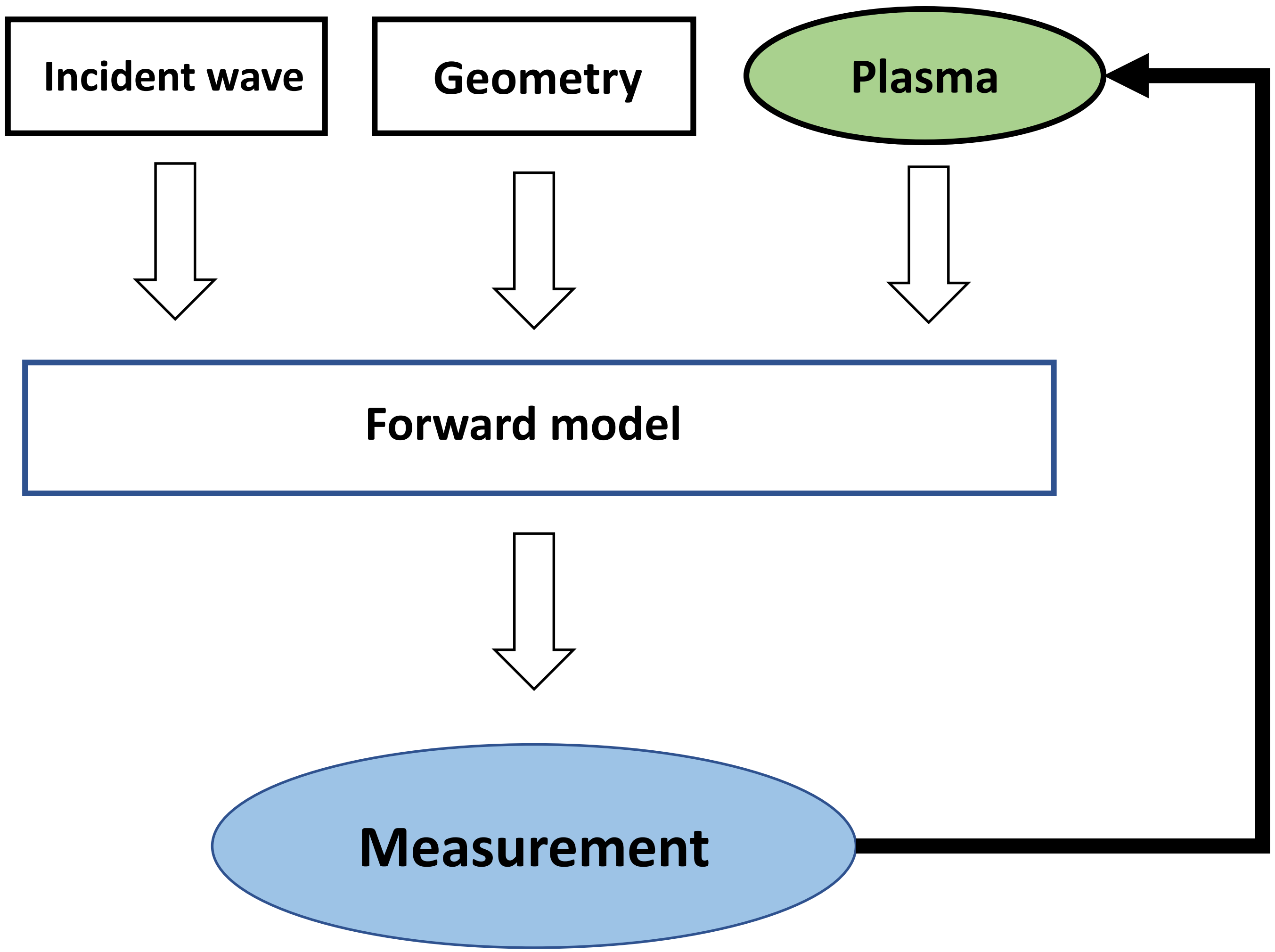
Objective: Development of a computer code (a forward model), based on a theoretical model, to compute measurement outcomes for sets of input parameters

The Forward Problem



The shape of the curve changes as the input ion temperature is changed

The Inverse Problem



Objective: Use the developed forward model to solve the inverse problem by means of Bayesian inference and machine learning

Bayesian Inference

Image: espn.co.uk

Niki Lauda or James Hunt?

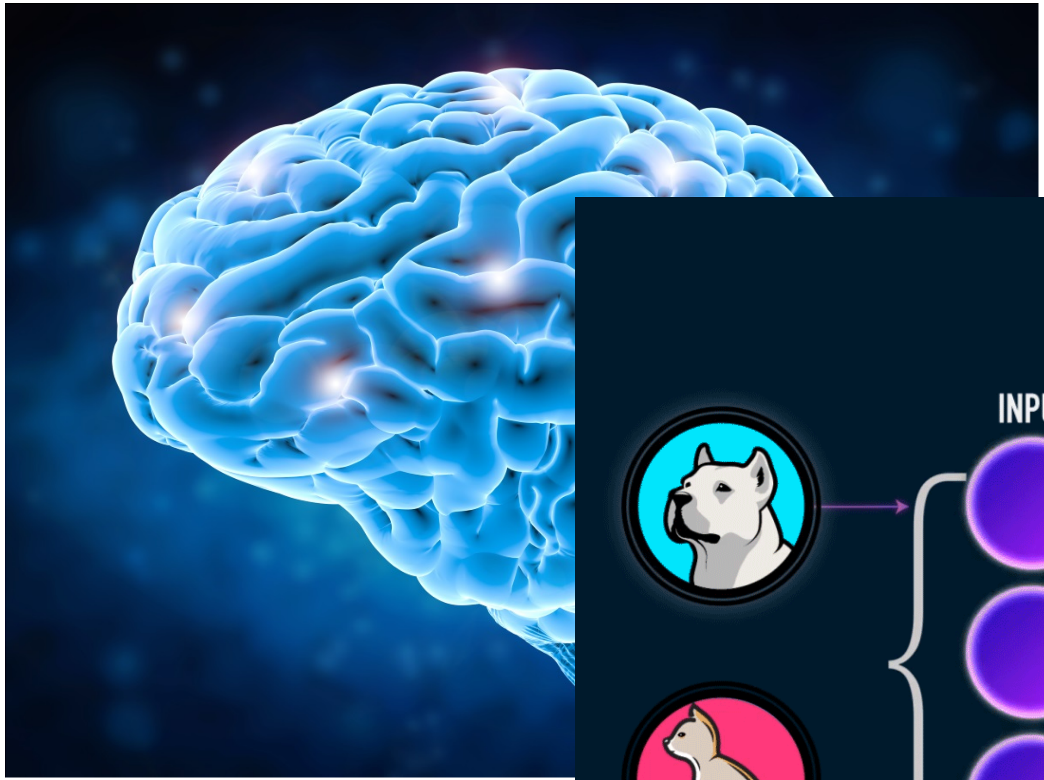
Minerva – Bayesian scientific framework

- Integration of the forward model
- Bayesian inference
- Access to data from other diagnostics

Artificial Neural Networks

- Nuclear Fusion
- How do we do it?
- Wendelstein 7 - X
- Collective Thomson Scattering
- The Forward Problem
- The Inverse Problem
- **<u>Bayesian Inference and Neural Networks</u>**
- First Results
- Additional Work
- Summary

Image: Shutterstock/ Phonlamai Photo



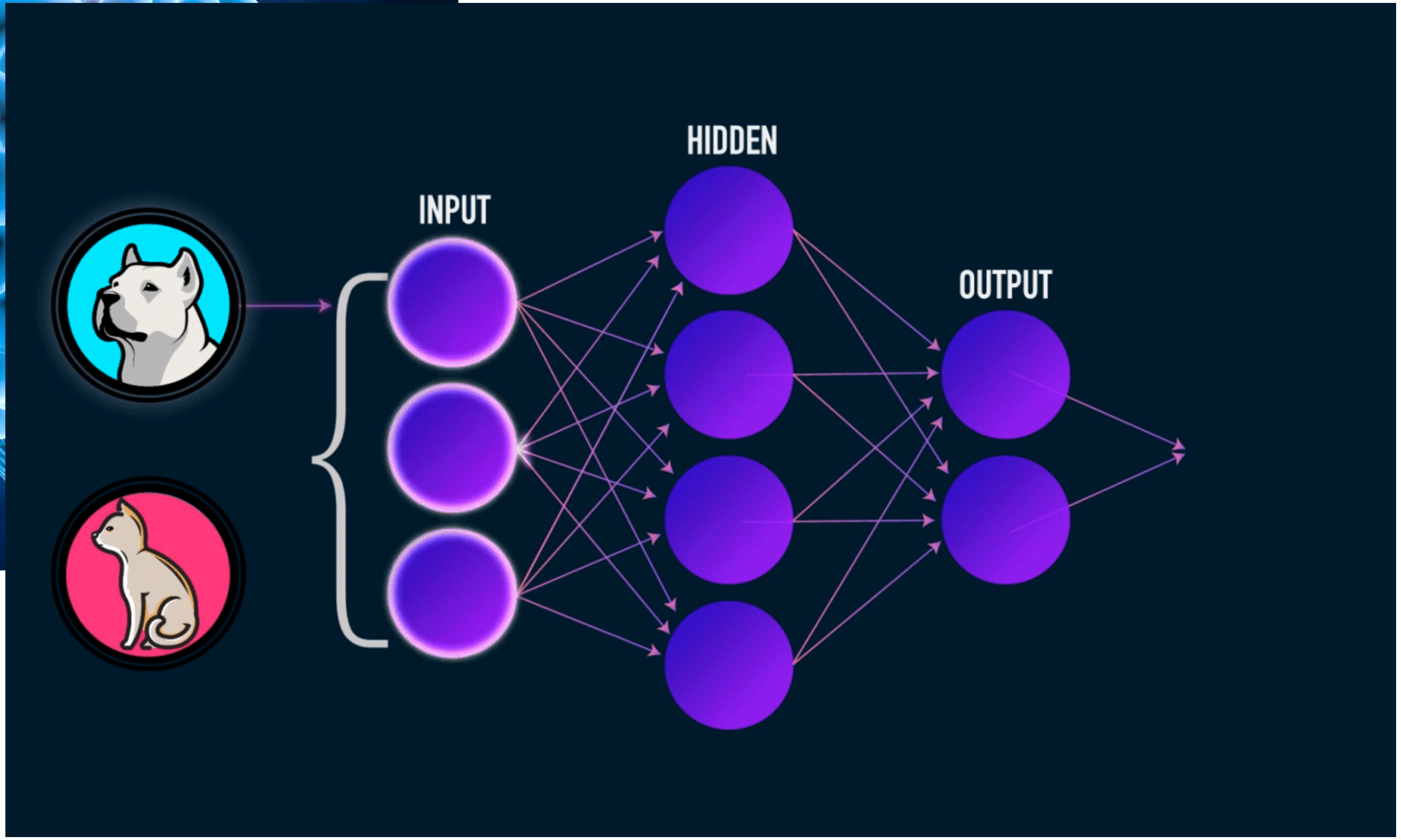
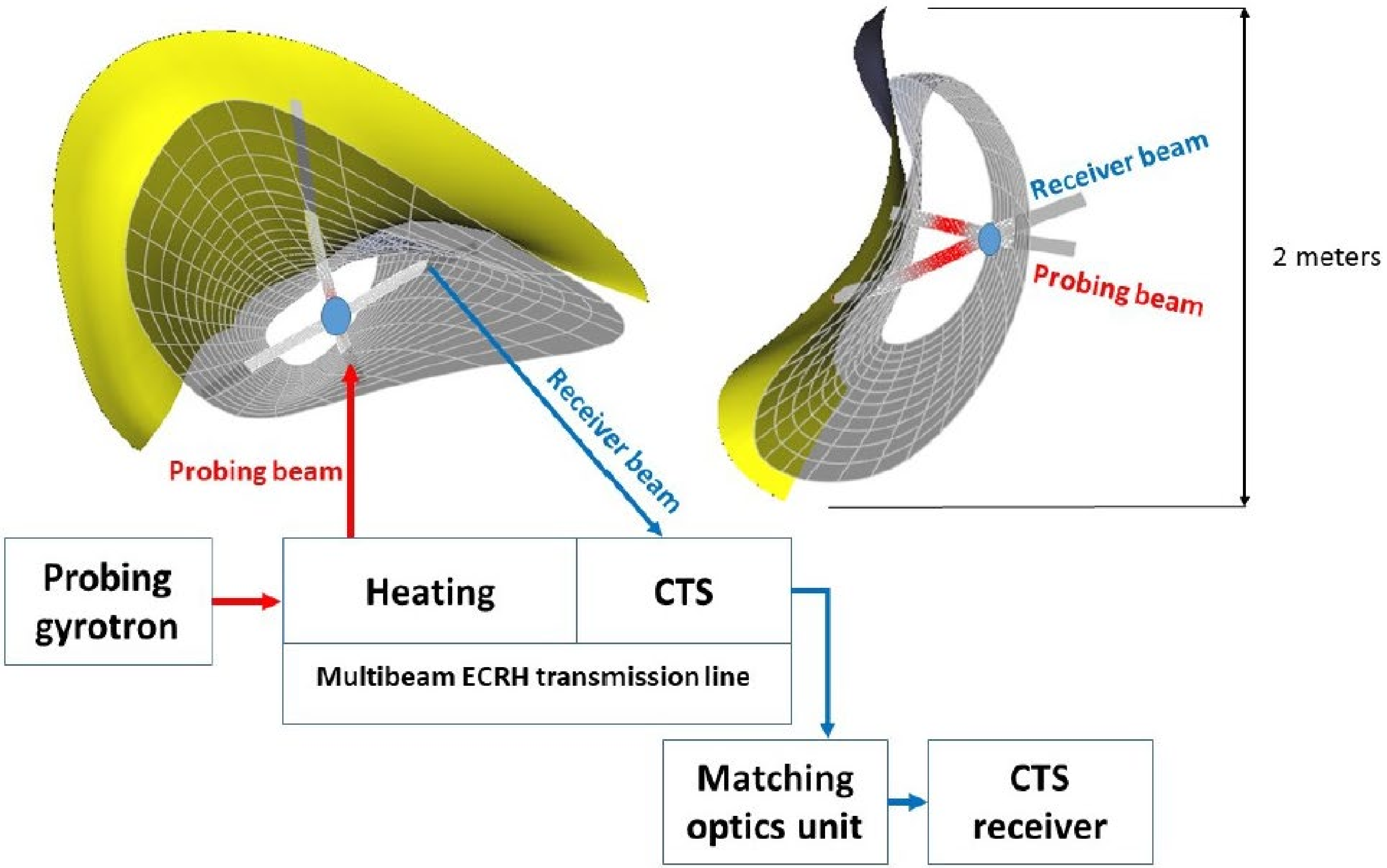


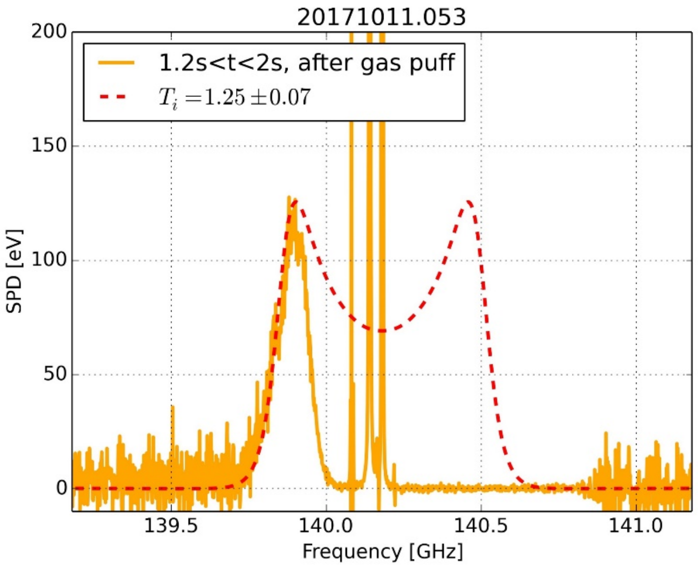
Image: towardsdatascience.com

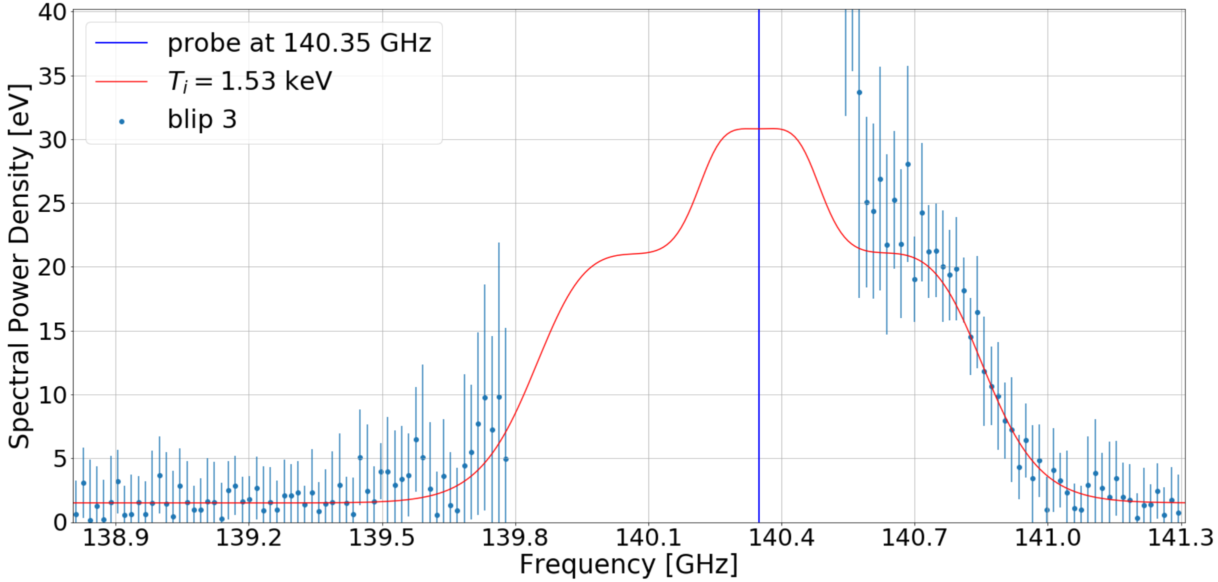
First Experimental Results

- Nuclear Fusion
- How do we do it?
- Wendelstein 7 - X
- Collective Thomson Scattering
- The Forward Problem
- The Inverse Problem
- Bayesian Inference and Neural Networks
- **First Results**
- Additional Work
- Summary



First Experimental Results - Bean

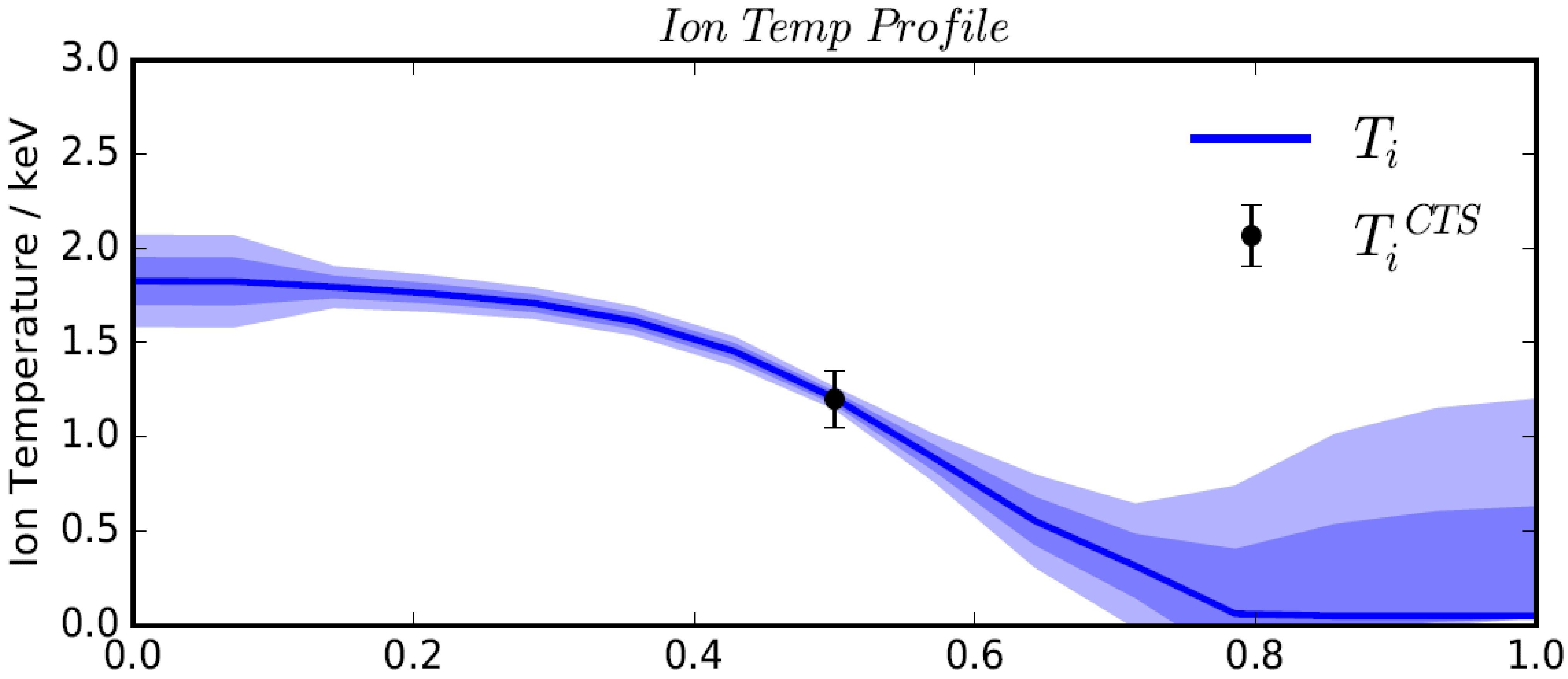




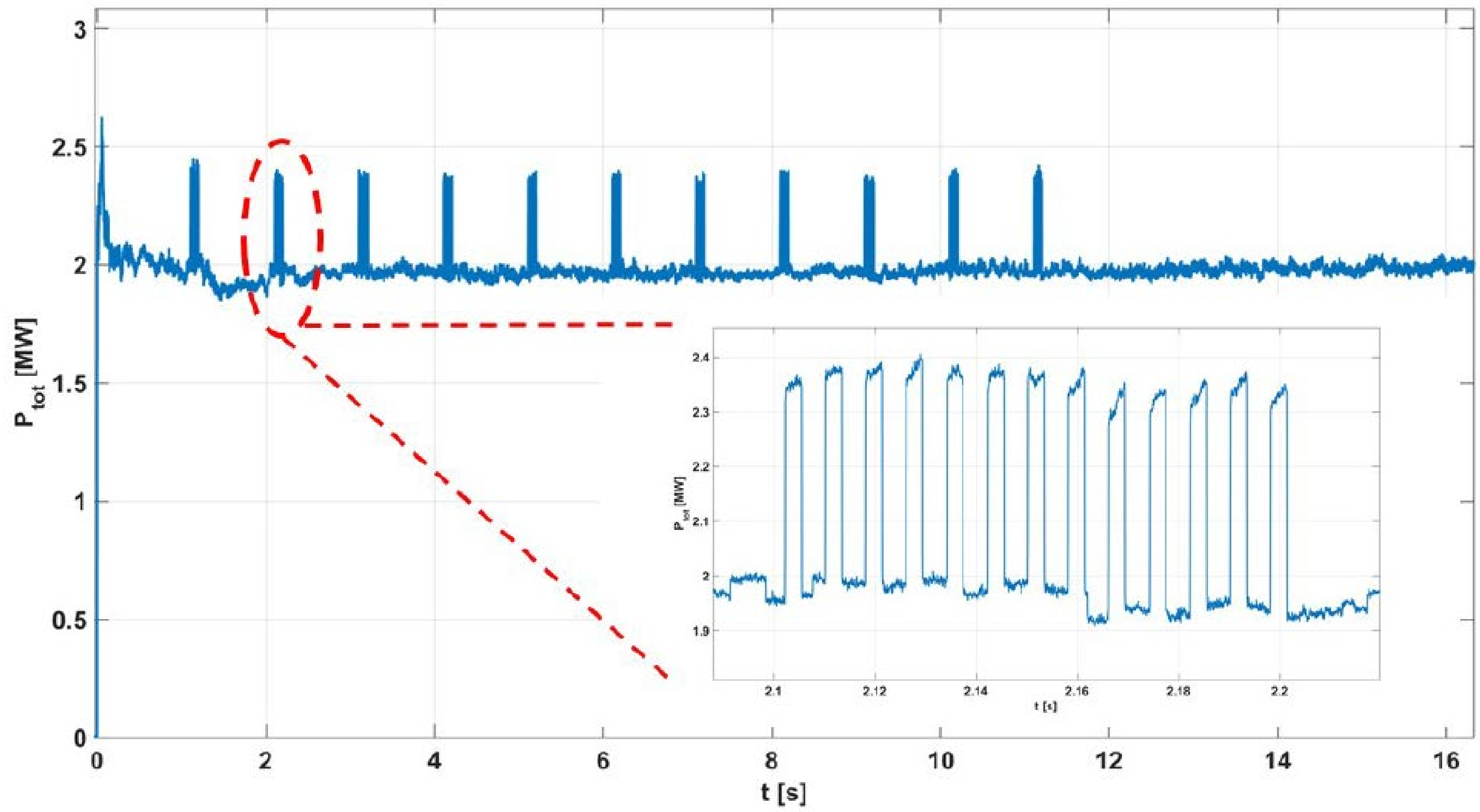
Objective: Analyze experimental data using the forward-model-based Bayesian inference in the Minerva framework

✓

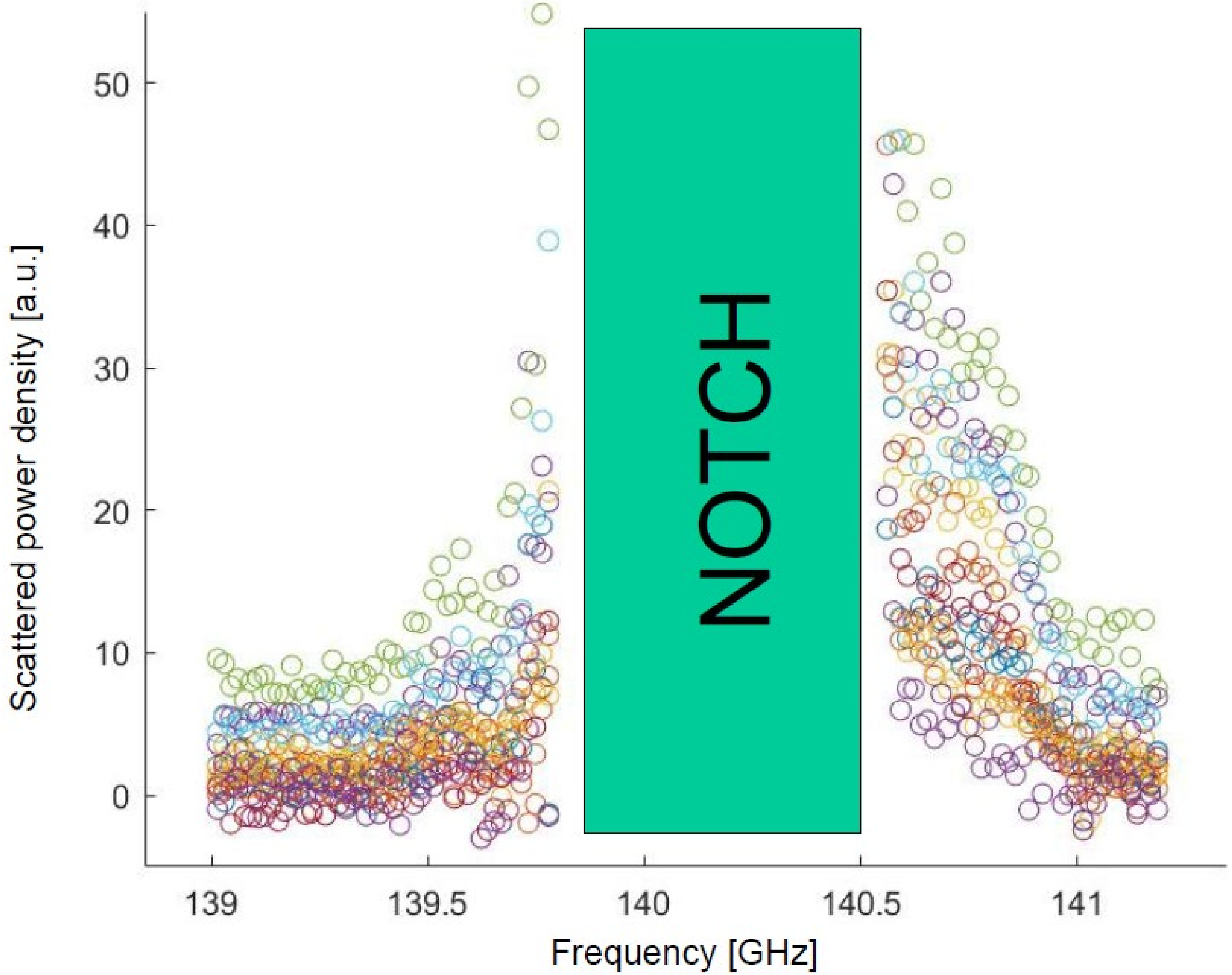
First Experimental Results - Bean



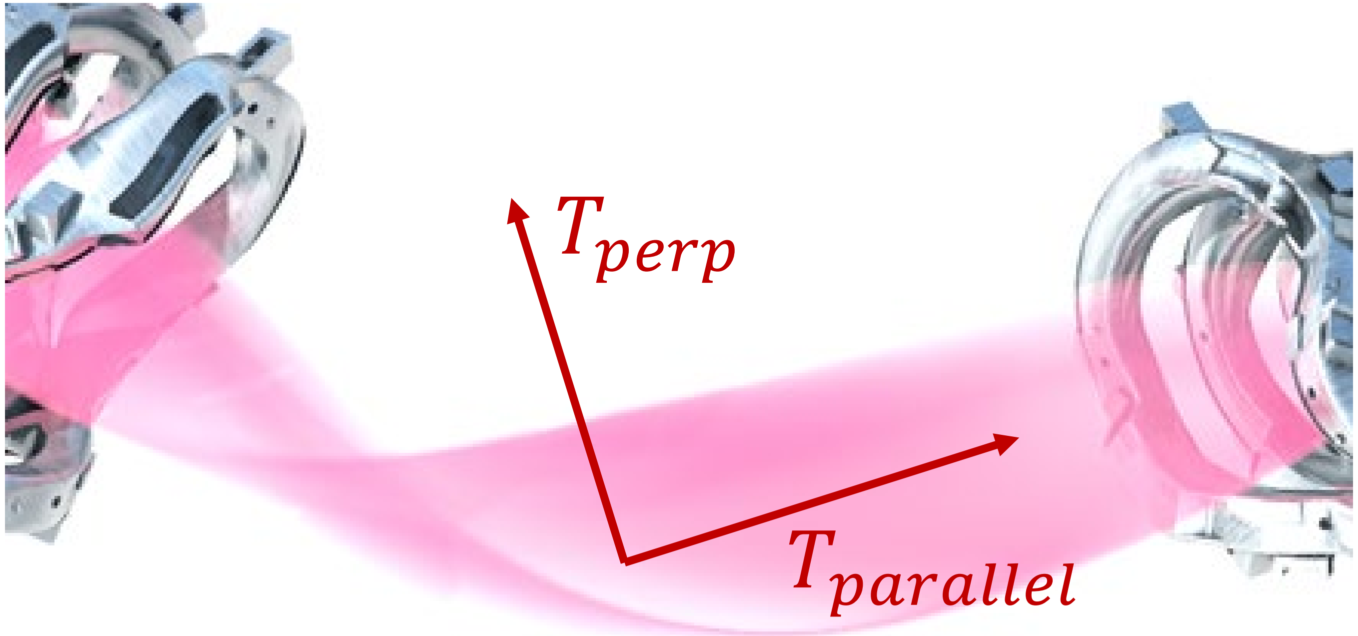
First Experimental Results - Triangular



First Experimental Results - Triangular



Last but not least ...



Objective: Extend the forward model to calculate CTS in a two temperature plasma.

Summary

- A collective Thomson scattering diagnostic was developed and installed on Wendelstein 7-X
- A forward model was developed allowing calculations of the measurement result given the experimental conditions
- The inverse problem of extracting the desired parameter value from measurements was tackled in two ways:

  Bayesian inference

  machine learning
- The forward model and the inference methods were used to analyze the first CTS measurements obtained on this device
- The forward model was extended to enable calculations in plasmas with two temperatures