Neutron stars

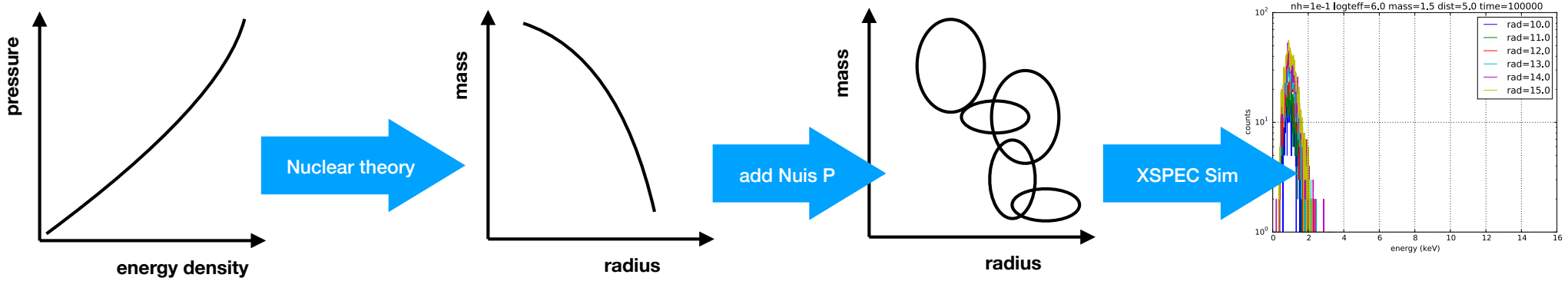
The problem

Equation of State (4 params)

Mass-Radius relation (2 params: M,R)

Star parameters
2 params: (mass, radius)
3 nuis params (dist, temp, dust)

Neutron Star X-ray data
(1024 chan,80% empty)



Training data

Fixed EOS, sample of (M,R) pairs
For each M,R pair, add 3 nuisance param
generate sample spectra

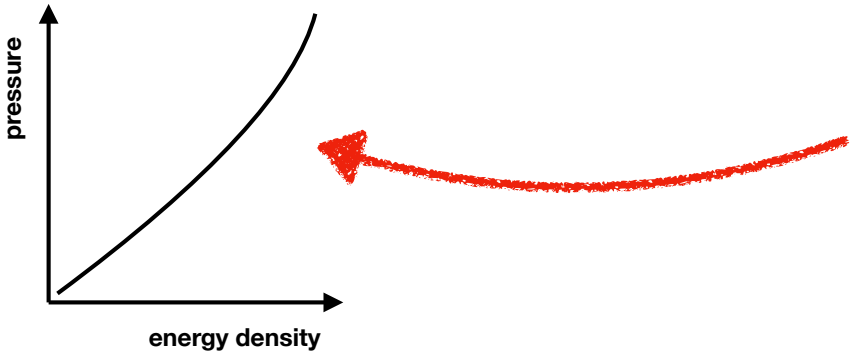
Inference

End-to-end: spectra -> EOS
Also might try: spectra-> star
star -> EOS

MLLR method: ttps://arxiv.org/abs/2002.04699

Uncertainties (1)

Equation of State (4 params)



Neutron Star X-ray data
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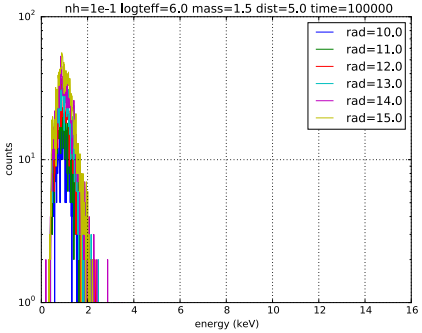


<u>Statistical uncertainty</u>

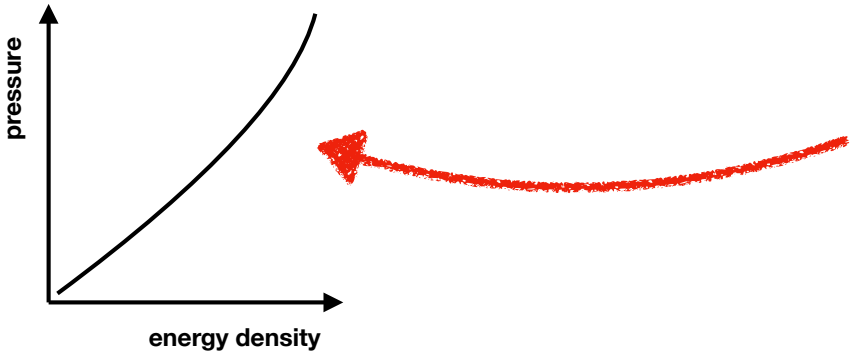
- due to Poisson noise in spectrum
- Make 100 copies of spectrum with additional noise
- Use variance in output as estimate of statistical uncertainty

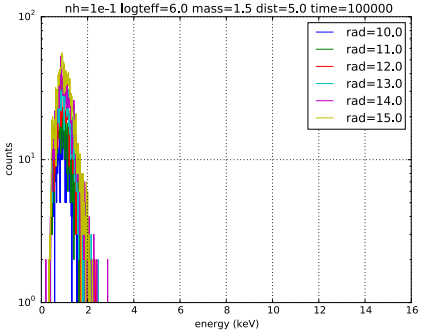
Uncertainties (2)

Equation of State (4 params)

Star parameters
2 params: (mass, radius)
3 nuis params (dist, temp, dust)

Neutron Star X-ray data
(1024 chan,80% empty)





<u>Systematic uncertainty</u>

- Spectrum affected by NPs as well as POIs
- Parameterize network in NP **https://arxiv.org/abs/1601.07913**
- Input: spectrum + NP
- Output: EOS
- Application: get EOS as function of NP
- Can then fold in various priors on NP; establish an envelope for EOS