APRIL 1, 1941 PHYSICAL REVIEW VOLUME 59

Neutrino Theory of Stellar Collapse

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(Received February 6, 1941)

At the very high temperatures and densities which must exist in the interior of contracting stars during the later stages of their evolution, one must expect a special type of nuclear processes accompanied by *the emission of a large number of neutrinos*. These neutrinos penetrating almost without difficulty the body of the star, must carry away very large amounts of energy and prevent the central temperature from rising above a certain limit. This must cause *a rapid contraction of the stellar body* ultimately resulting in a *catastrophic collapse*. It is shown that energy losses through the neutrinos produced in reactions between free electrons and oxygen nuclei can cause a complete collapse of the star within the time period of half an hour. Although the main energy losses in such collapses are due to neutrino emission which escapes direct observation. the heating of the body of a collapsing star must necessarily lead to the *rapid expansion of the outer layers* and the *tremendous increase of luminosity*. It is suggested that stellar collapses of this kind are responsible for the phenomena of *novae* and *supernovae*, the difference between the two being probably due to the difference of their masses.

Gamow and Schoenberg propose the "Urca Process" for rapid energy removal from collapsed SN via neutrino emission.

Urca is now demonstrated – what do we want to know from further SN observation? How does this drive the design if DUNE?

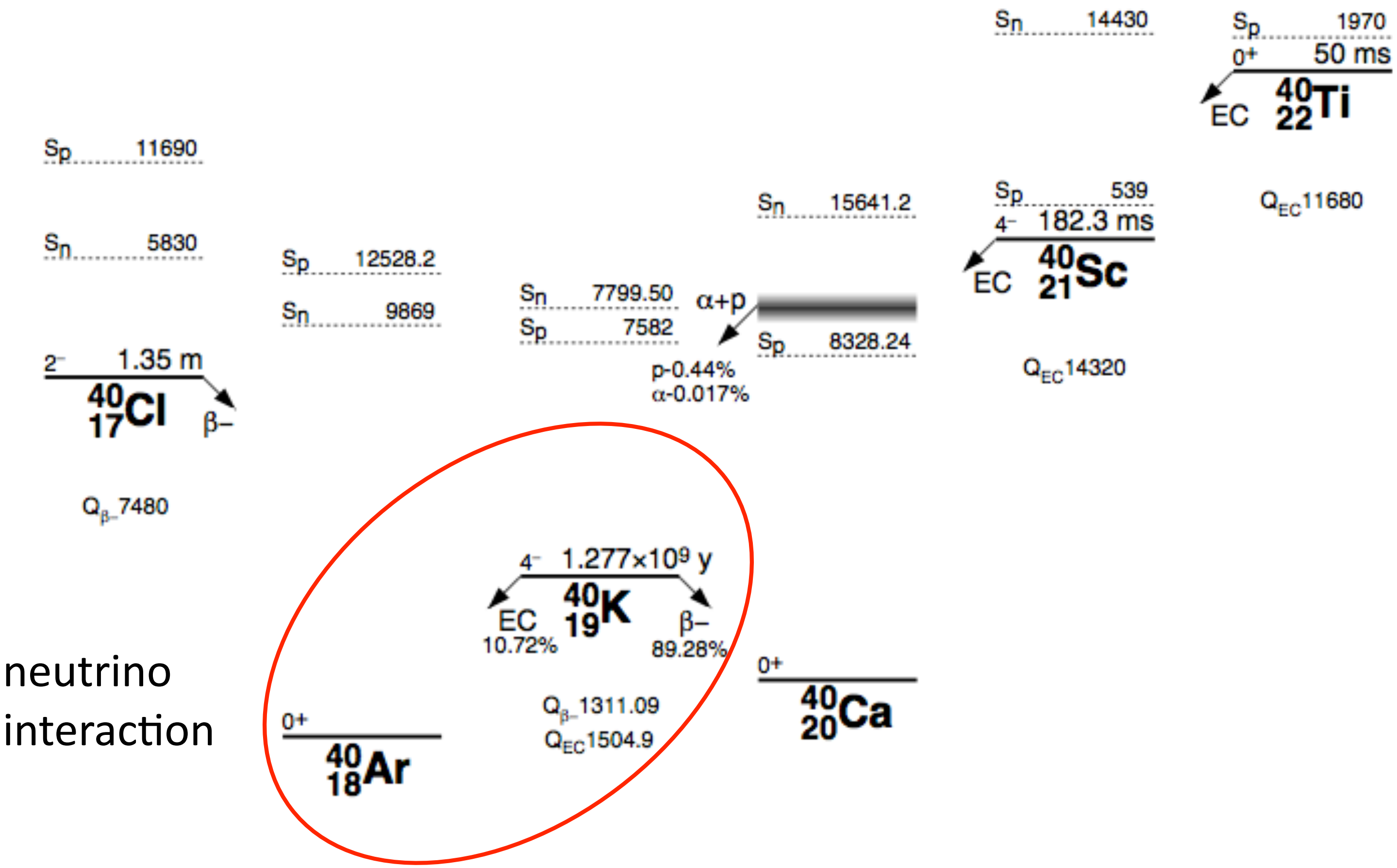
Casino da Urca in Rio

R.Svoboda, 30 September, 2015

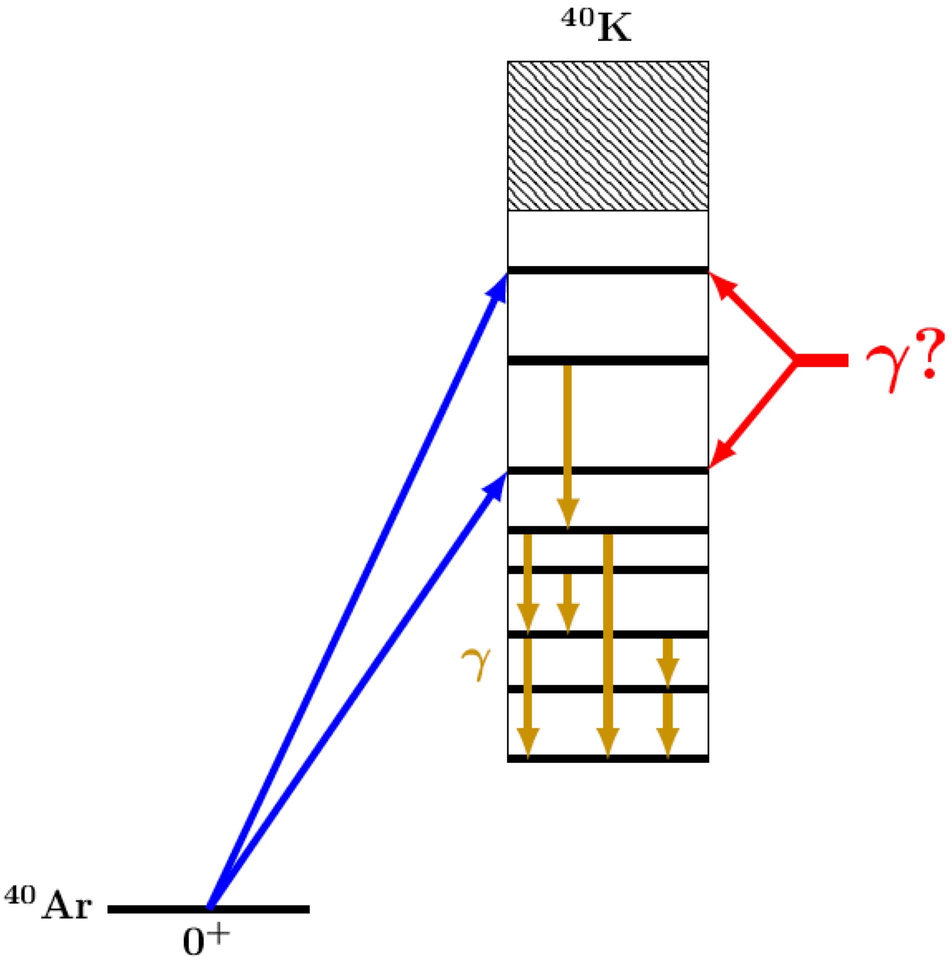
Need to Define SN Burst Neutrino Goals for DUNE

- What are the features we would like to observe?
- Burst rise time? Absolute timing? To what precision? What distance should we design for? Can't say "the best you can do" as resources are expensive and a zero sum game.
- NC/CC separation? To what level?
- Energy resolution? Gamma reconstruction?
- Background rejection?

$n_e + {}^{40}Ar \rightarrow {}^{40}K_{g.s.} + e^-$ has a low threshold, but rarely occurs due to $0^+ \rightarrow 4^-$ (3rd forbidden) transition. Most all of the cross section is into excited states of ^{40}K.



Predicting γ signal is difficult when there are no data



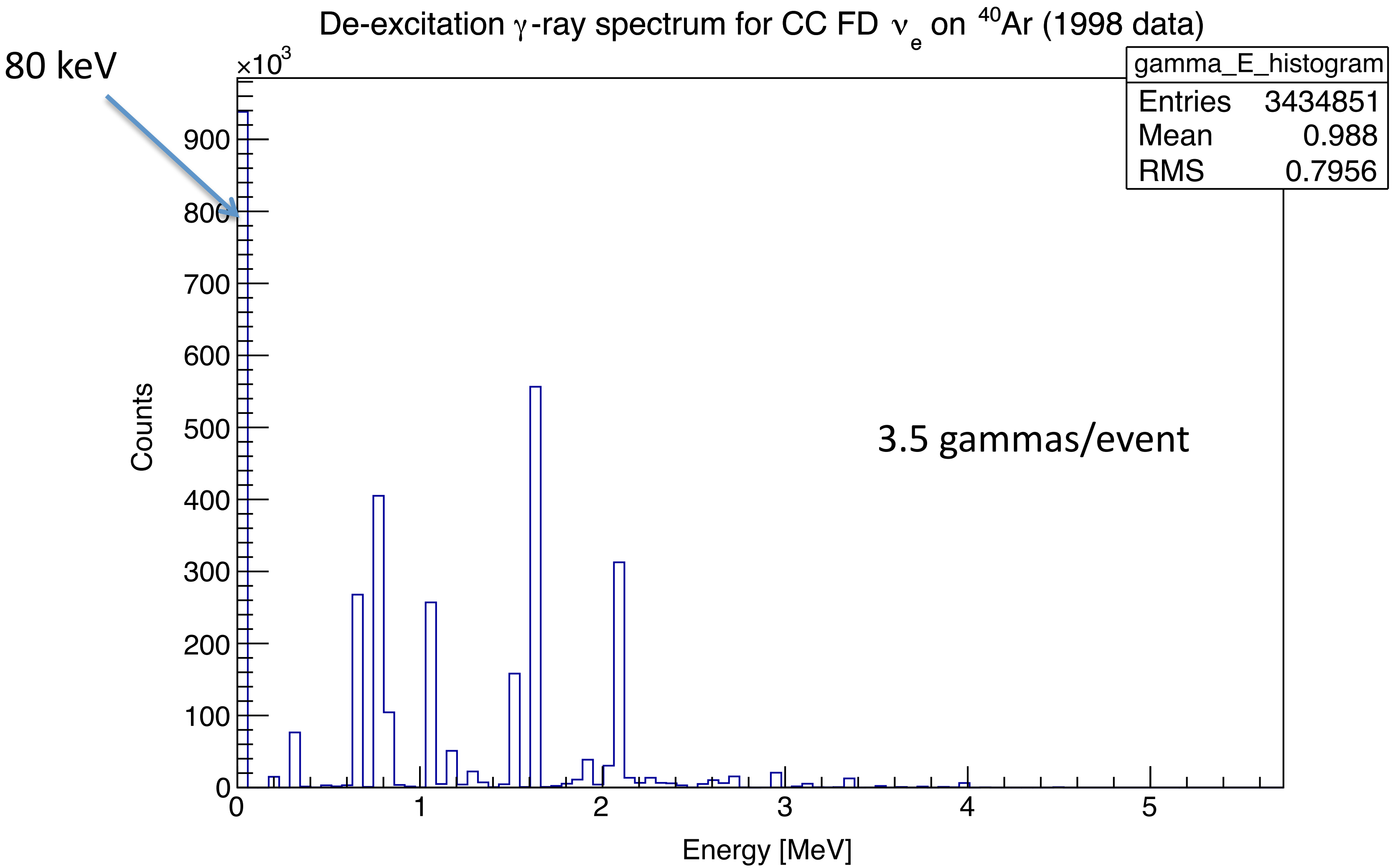
- Make educated guesses about level J^πs
- Use models (e.g., Weisskopf estimates) to approximate γ branching ratios
- Revert to ENSDF data whenever available

Another problem: Almost no data on other than 0+ or 1+ states as these are not filled by beta decay

S.Gardiner

MARLEY

Gamma Spectrum from SN: 40-Ti data



Gamma Spectrum from SN: (p,n) data

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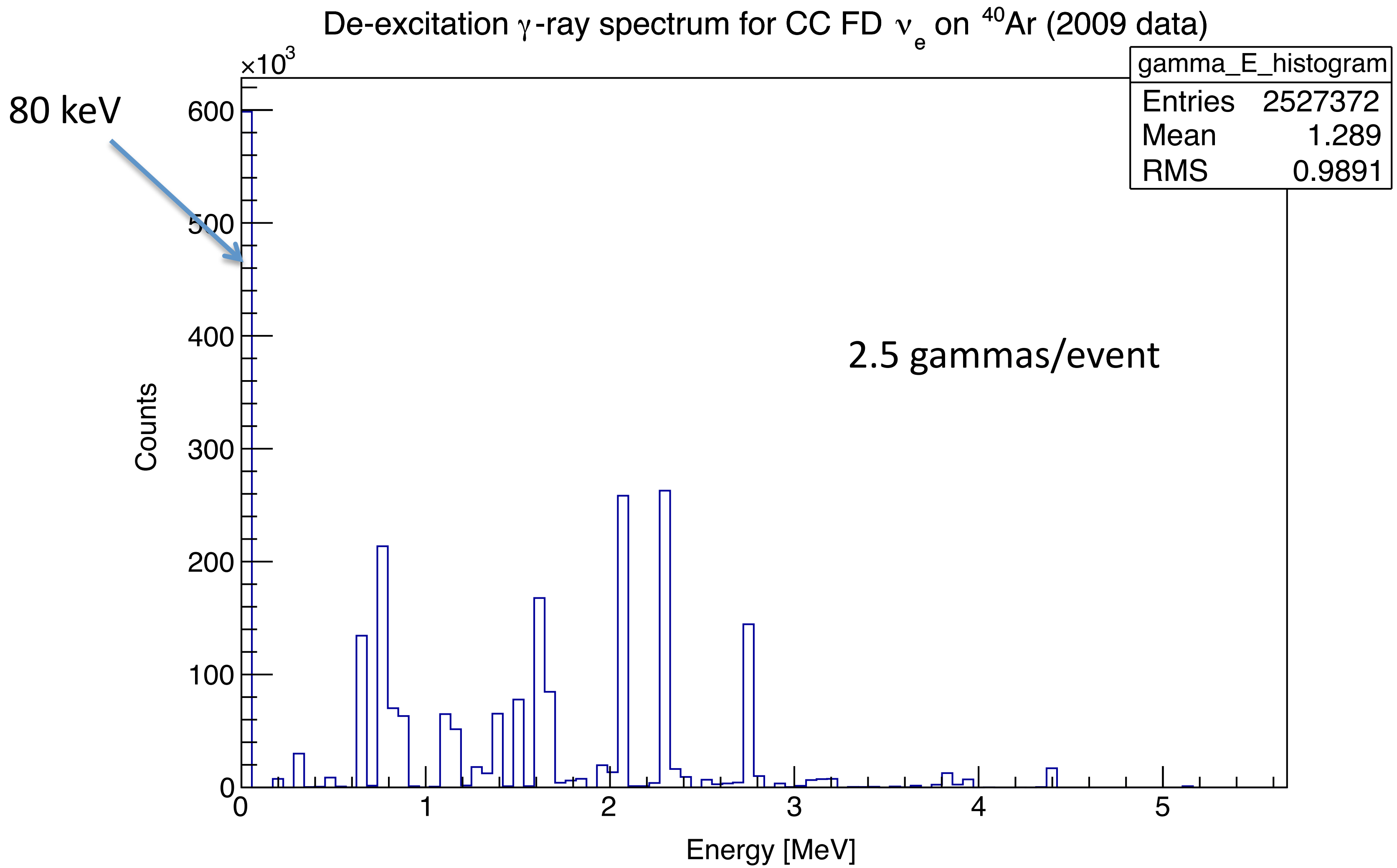

Urgent Need for Theorists to Take Charge of Guiding Experimentalists!

- We need definite recommendations as to what we should be looking for and why
- Alex Friedland has agreed to assemble a group of theorists in for video/phone discussions culminating in a 2-day workshop at SLAC this Fall. Thank you Alex!
- This workshop will result in a document that will likely guide DUNE in the design of the first detector and also inform immediate R&D efforts.