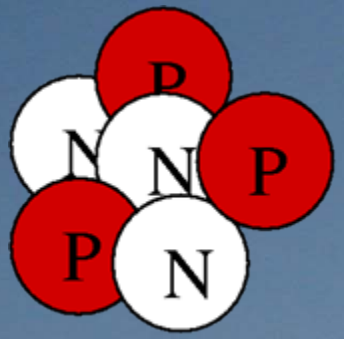
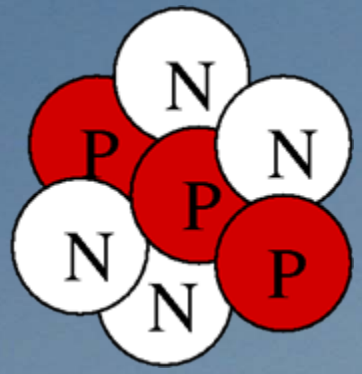
Photodisintegration of Lithium Isotopes





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- The Experiment
- Continuing Analysis and Preliminary Results
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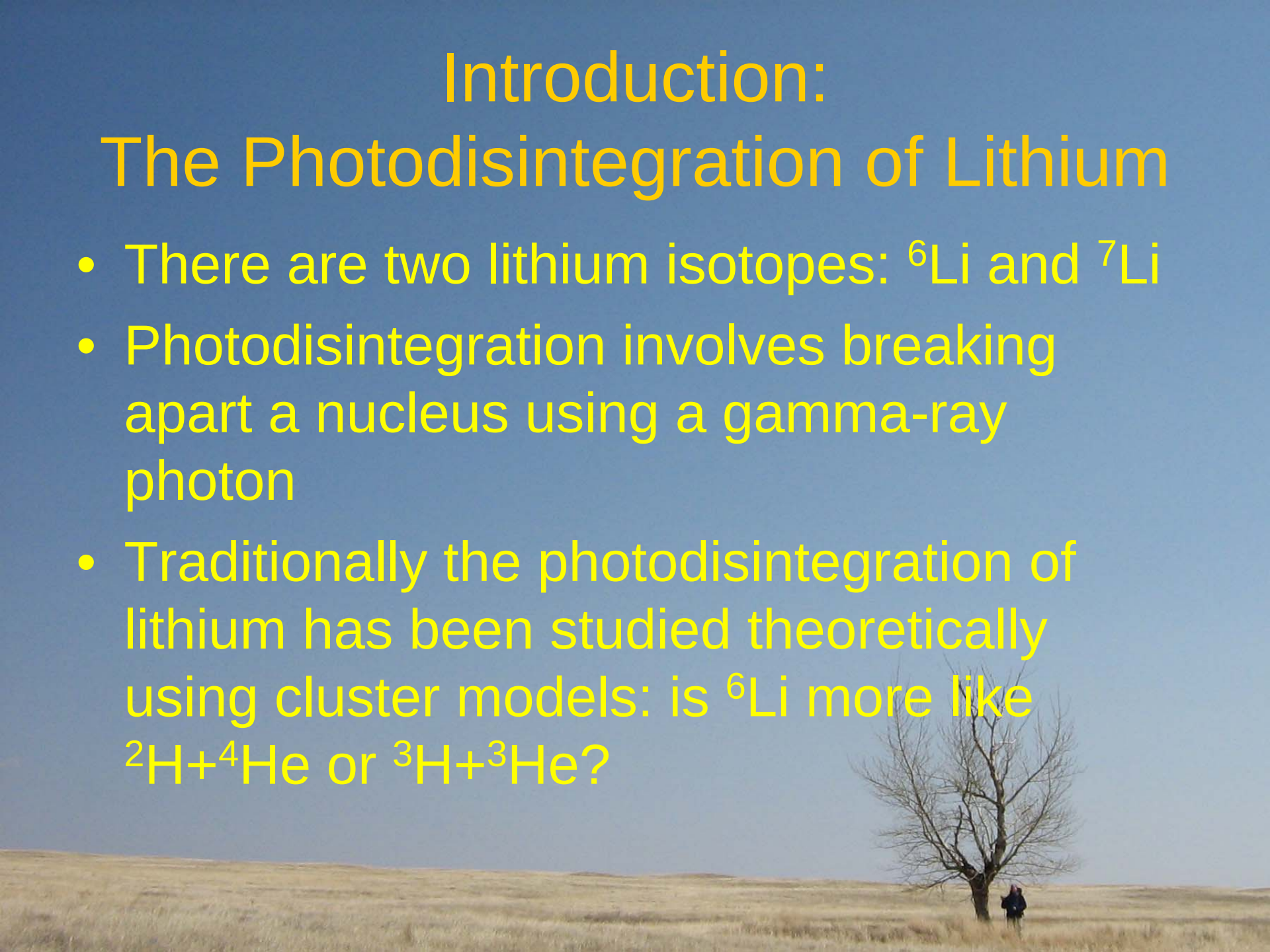
Introduction: The Photodisintegration of Lithium

- There are two lithium isotopes: ^{6}Li and ^{7}Li
- Photodisintegration involves breaking apart a nucleus using a gamma-ray photon
- Traditionally the photodisintegration of lithium has been studied theoretically using cluster models: is ^{6}Li more like ^{2}H+^{4}He or ^{3}H+^{3}He?

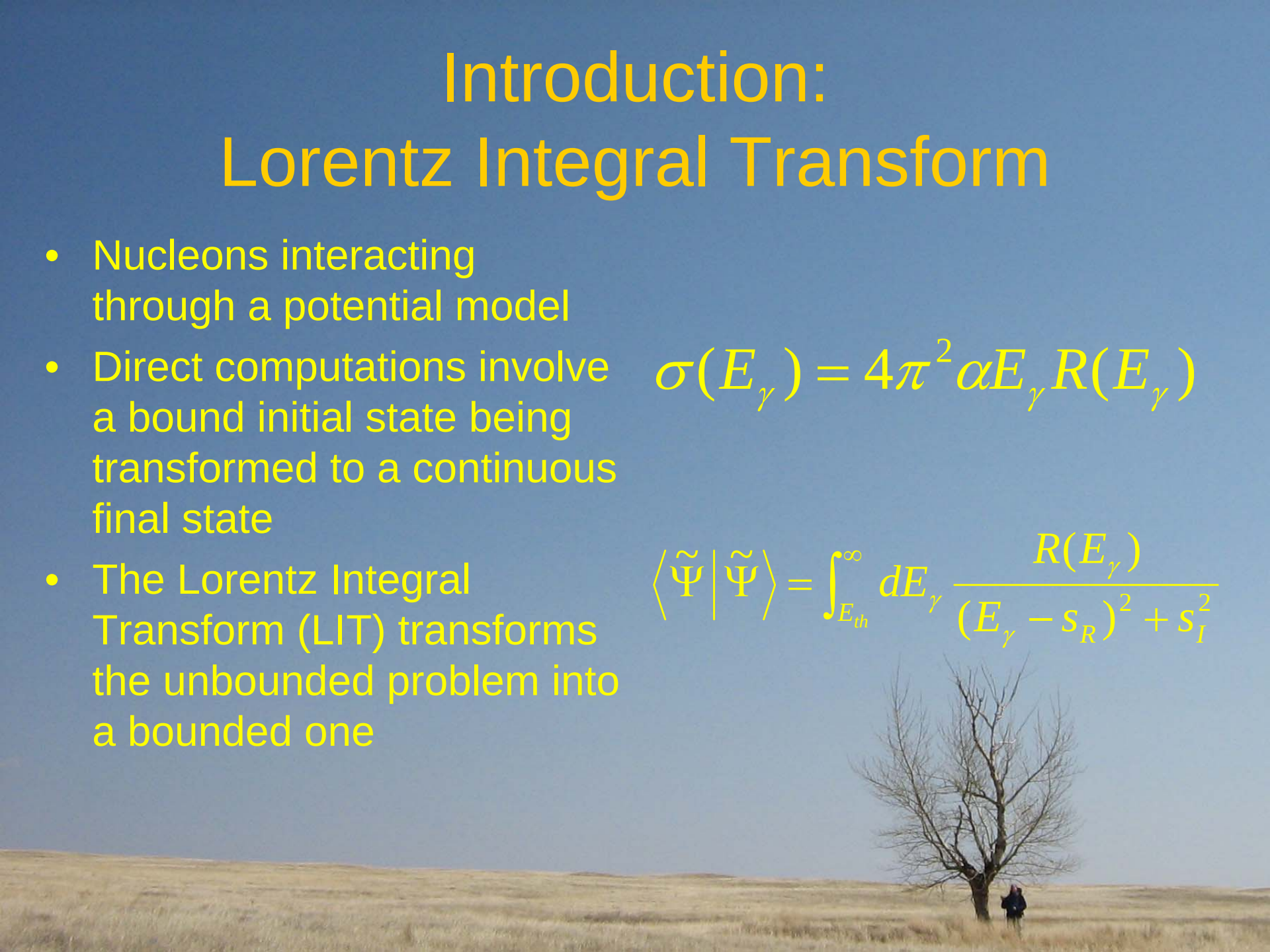


Introduction: Lorentz Integral Transform

- Nucleons interacting through a potential model
- Direct computations involve a bound initial state being transformed to a continuous final state
- The Lorentz Integral Transform (LIT) transforms the unbounded problem into a bounded one

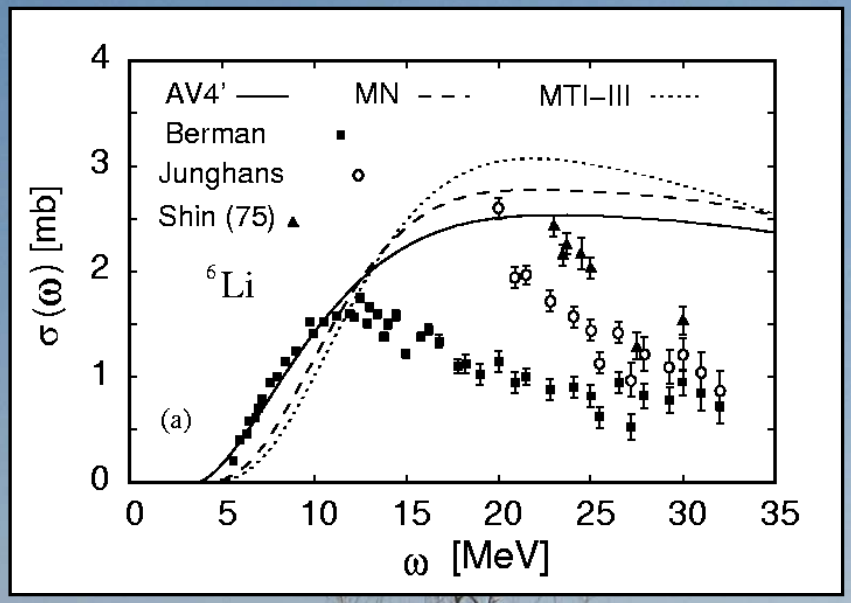
$$\sigma(E_\gamma) = 4\pi^2 \alpha E_\gamma R(E_\gamma)$$

$$\left\langle \tilde{\Psi} \middle| \tilde{\Psi} \right\rangle = \int_{E_{th}}^{\infty} dE_\gamma \frac{R(E_\gamma)}{(E_\gamma - s_R)^2 + s_I^2}$$



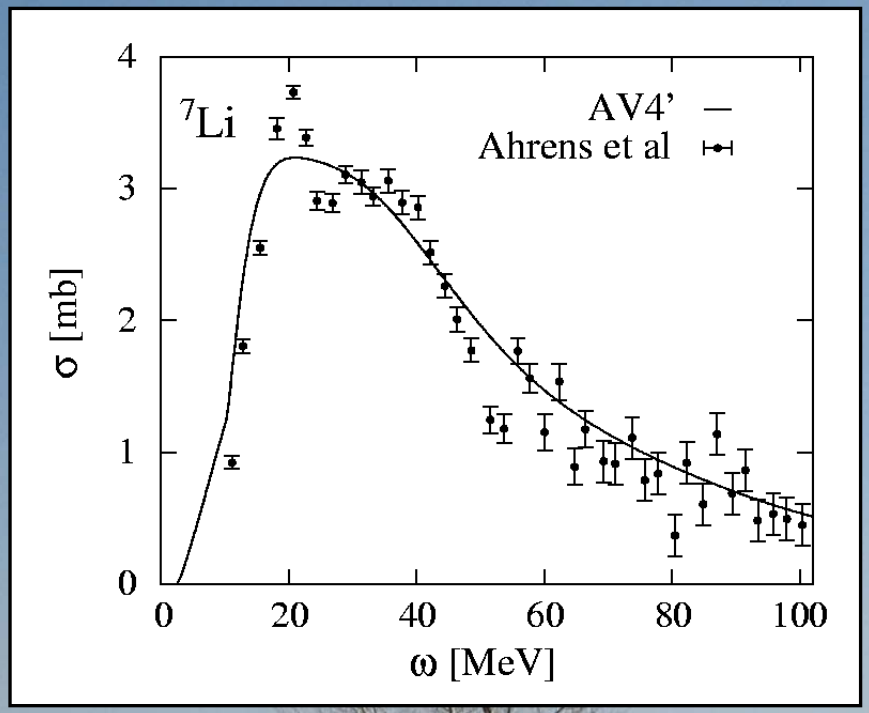
Introduction: The LIT and ^{6}Li

- Bacca, *et al*., Phys. Rev. C **69**, 057001
- Prediction of the total photodisintegration cross section using semi-realistic potentials
- Agreement with experiment is very poor
- New experimental data needed



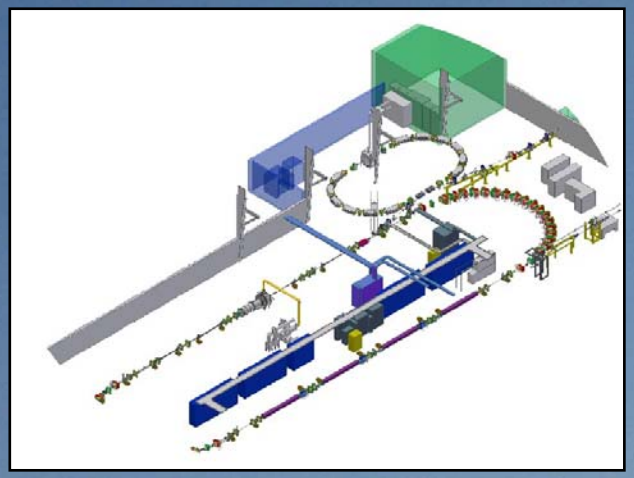
Introduction: The LIT and ^{7}Li

- Bacca, *et al*., Phys. Lett. B **603**, 159 (2004).
- Better agreement
- We cannot construct the total cross section using only neutrons
- We can construct cross sections for some reaction channels
- Very useful for motivating future predictions similar to those done for ^{4}He

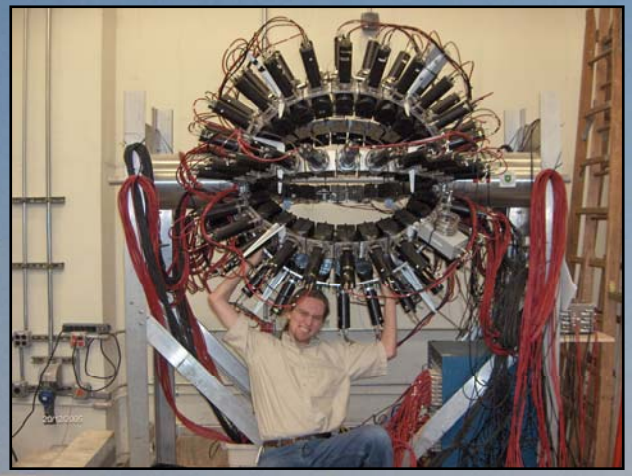


The Experiment: Apparatus

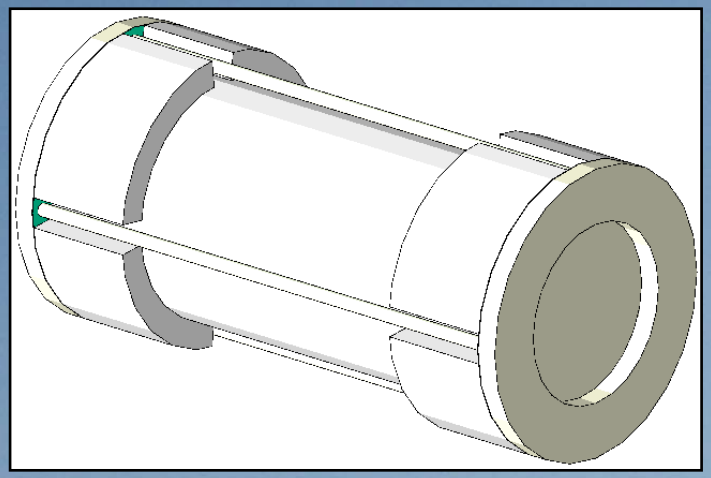
HIGS

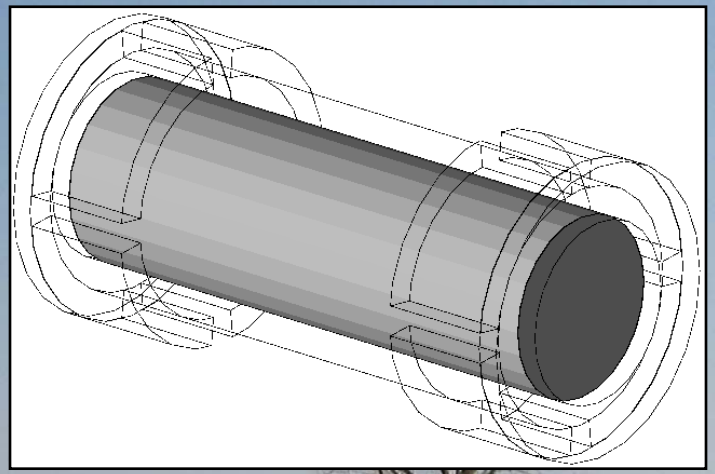


Blowfish



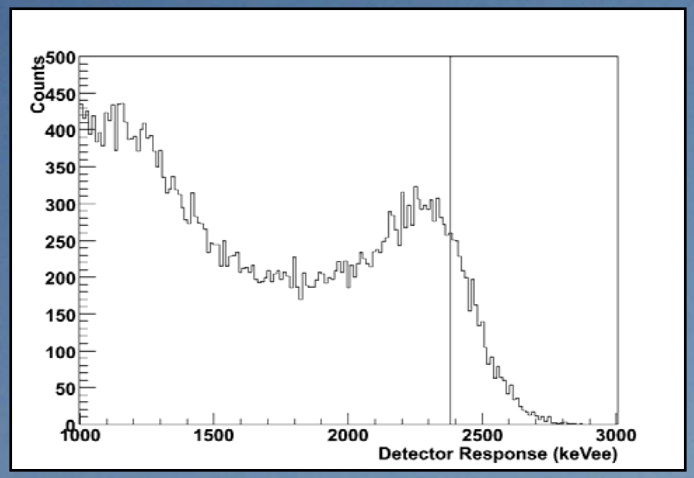
^{6}Li and Natural Lithium Targets



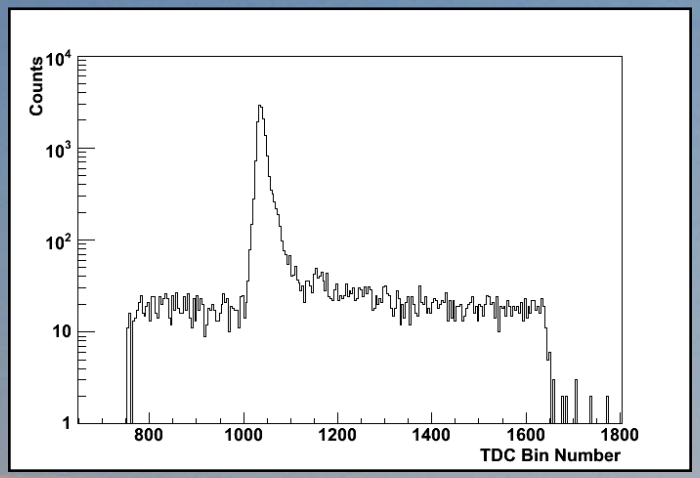


The Experiment: Measured Quantities

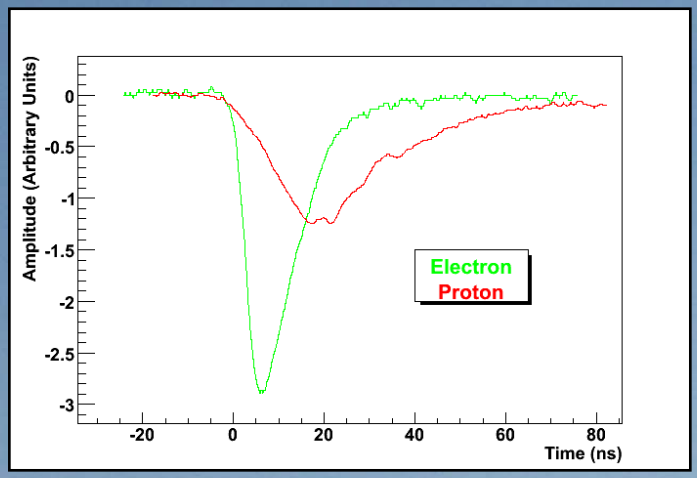
Scintillation Light Output

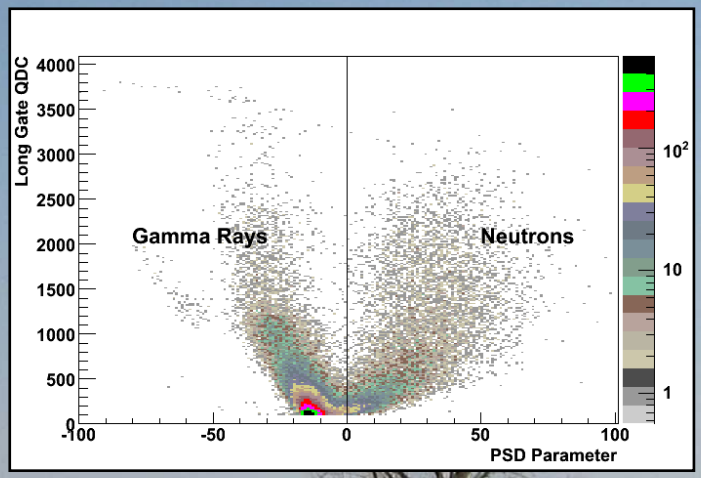


Time of Flight



Pulse Shape Discrimination

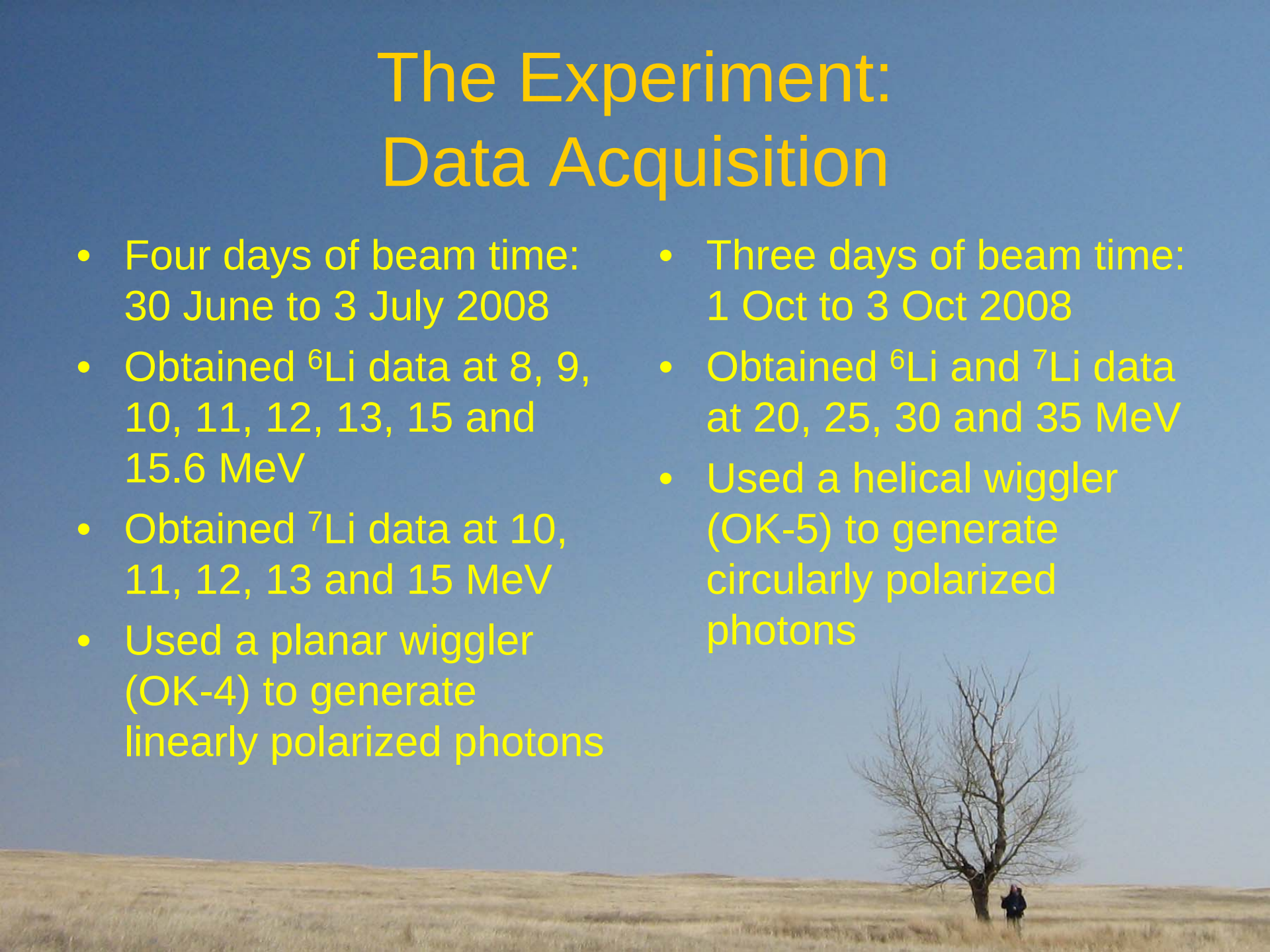




The Experiment: Data Acquisition

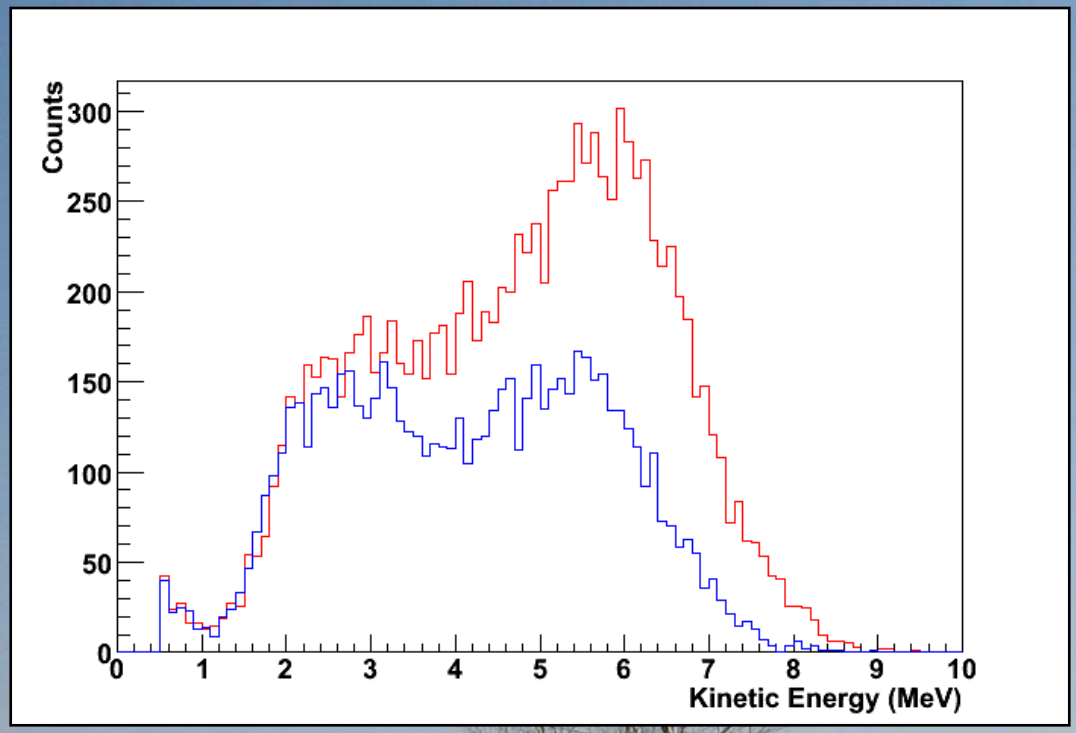
- Four days of beam time: 30 June to 3 July 2008
- Obtained ^{6}Li data at 8, 9, 10, 11, 12, 13, 15 and 15.6 MeV
- Obtained ^{7}Li data at 10, 11, 12, 13 and 15 MeV
- Used a planar wiggler (OK-4) to generate linearly polarized photons

- Three days of beam time: 1 Oct to 3 Oct 2008
- Obtained ^{6}Li and ^{7}Li data at 20, 25, 30 and 35 MeV
- Used a helical wiggler (OK-5) to generate circularly polarized photons



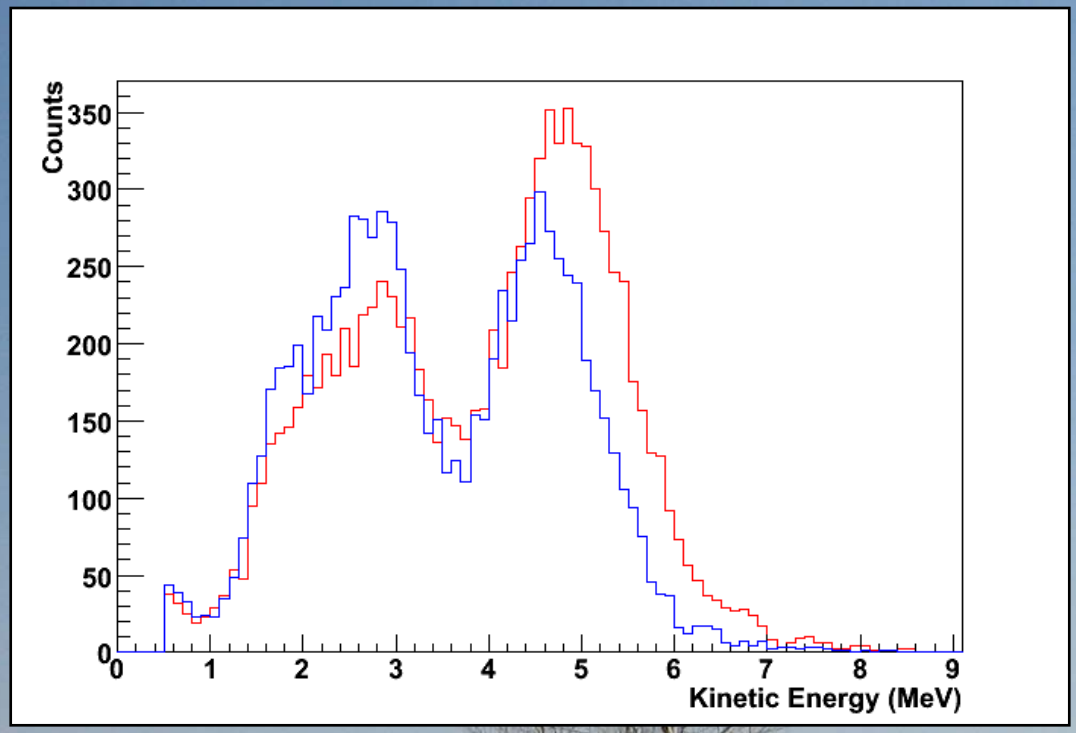
Analysis and Results: ^{6}Li Neutron Kinetic Energy Spectra

- Neutron kinetic energy spectra for detectors at 90^{O} to the beam axis and a photon energy of 13 MeV
- Red: Along polarization vector
- Blue: Right angle to polarisation vector



Analysis and Results: ^{7}Li Neutron Kinetic Energy Spectra

- Neutron kinetic energy spectra for detectors at 90^{o} to the beam axis and a photon energy of 13 MeV
- Red: Along polarization vector
- Blue: Right angle to polarisation vector



Analysis and Results: ^{6}Li Reaction Channels

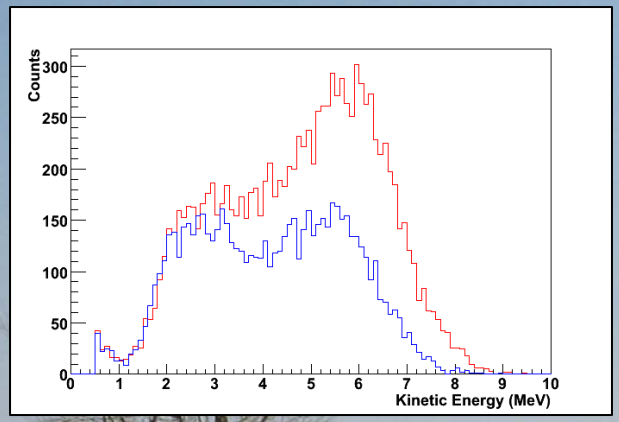
- We model the photodisintegration of ^{6}Li below 15.8 MeV as occurring through the following four reaction channels (TUNL evaluation)
- The three body decay is energetically allowed but does not appear to contribution substantially

$$^{6}\mathrm{Li}+\gamma \rightarrow n+{}^{5}\mathrm{Li}(\mathrm{g.s}) \rightarrow n+p+{}^{4}\mathrm{He}$$

$$^{6}\mathrm{Li}+\gamma \rightarrow n+{}^{5}\mathrm{Li}(1.49) \rightarrow n+p+{}^{4}\mathrm{He}$$

$$^{6}\mathrm{Li}+\gamma \rightarrow p+{}^{5}\mathrm{He}(\mathrm{g.s}) \rightarrow n+p+{}^{4}\mathrm{He}$$

$$^{6}\mathrm{Li}+\gamma \rightarrow p+{}^{5}\mathrm{He}(1.27) \rightarrow n+p+{}^{4}\mathrm{He}$$



Analysis and Results: ^{7}Li Reaction Channels

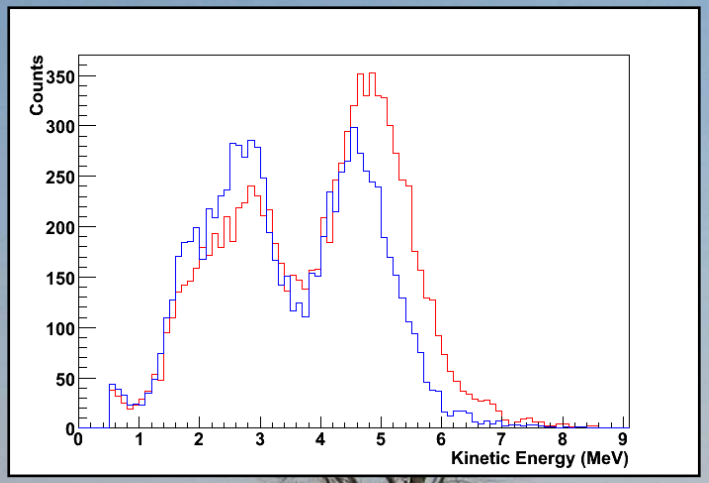
- The highest energy neutrons are all due to the single neutron knockout reaction to the ground state of ^{6}Li
- Not all reaction channels produce neutrons
- Many reaction channels to contend with

$$^{7}\mathrm{Li} + \gamma \rightarrow {}^{3}\mathrm{H} + {}^{4}\mathrm{He}$$

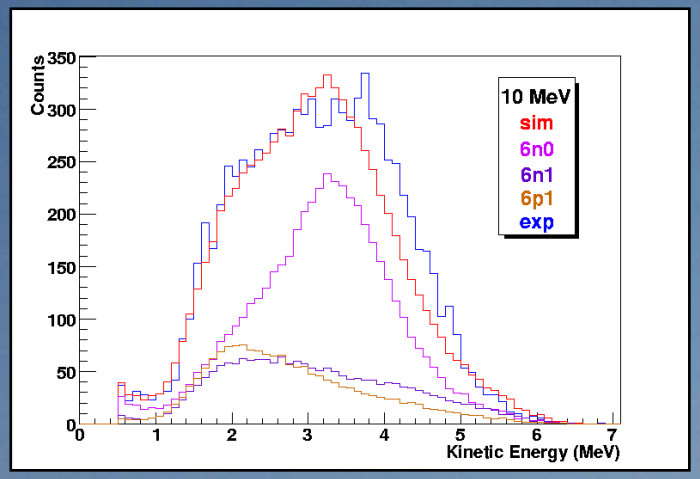
$$^{7}\mathrm{Li} + \gamma \rightarrow n + {}^{6}\mathrm{Li}$$

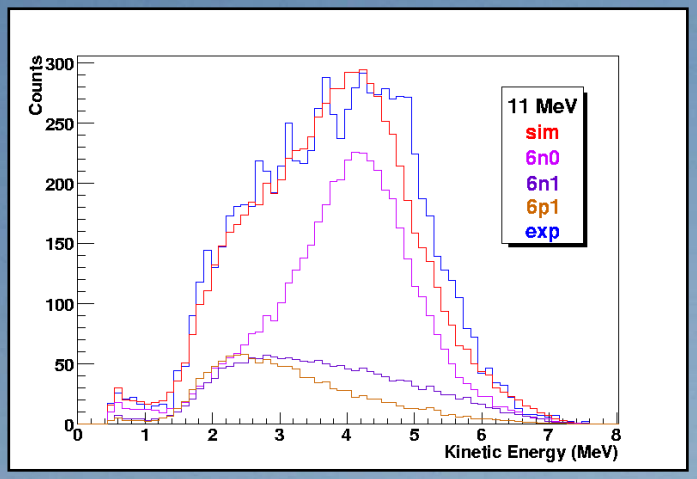
$$^{7}\mathrm{Li} + \gamma \rightarrow d + {}^{5}\mathrm{He} \rightarrow n + d + {}^{4}\mathrm{He}$$

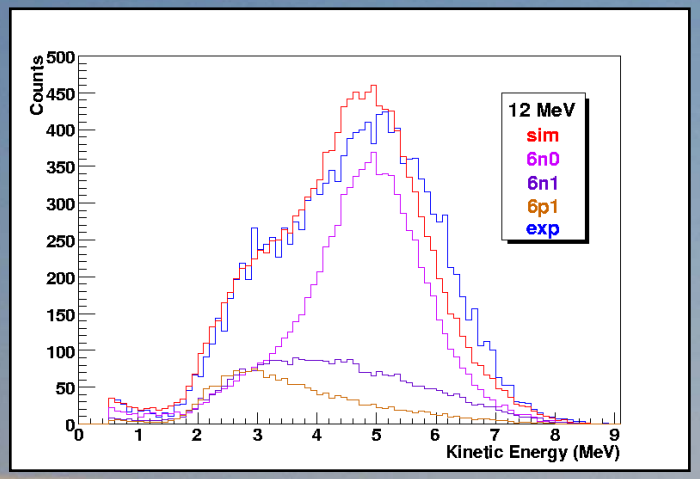
$$^{7}\mathrm{Li} + \gamma \rightarrow p + {}^{6}\mathrm{He}$$

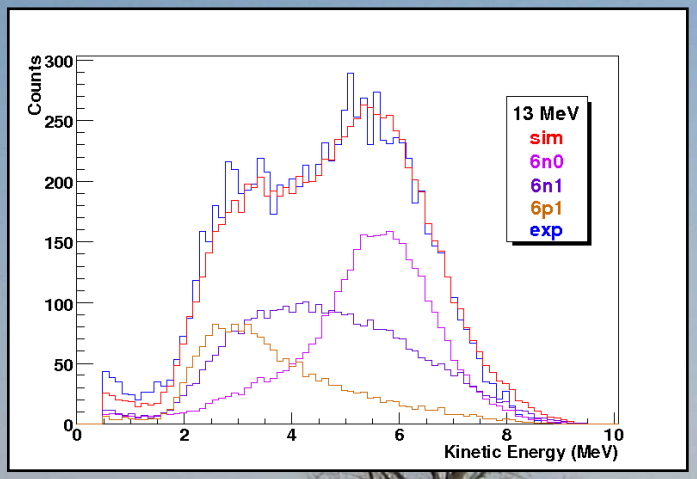


Analysis and Results: ^{6}Li Data Separation

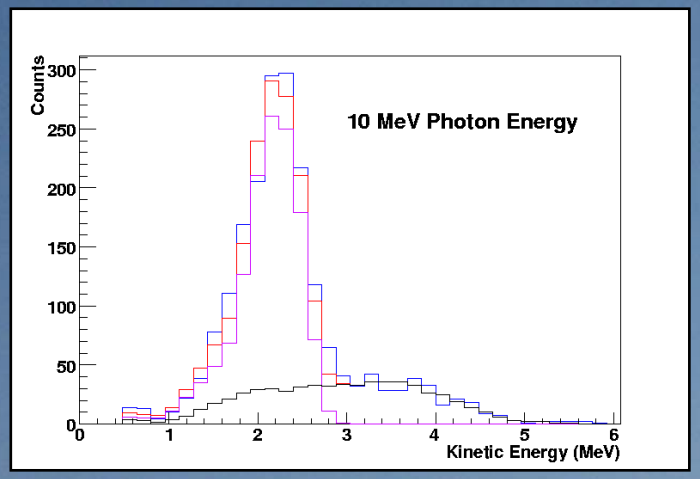


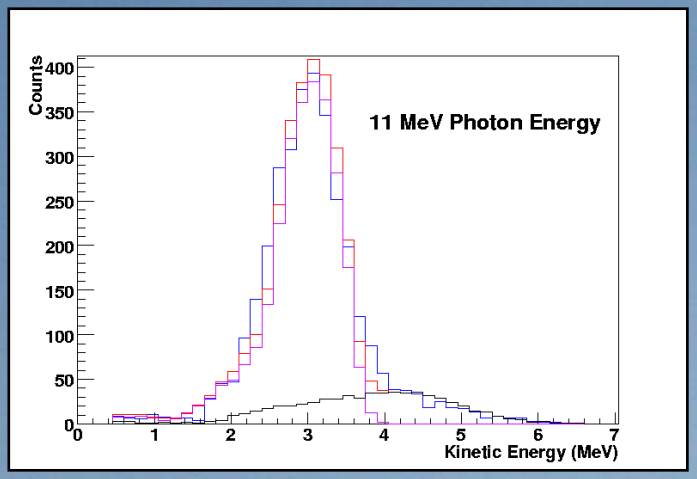


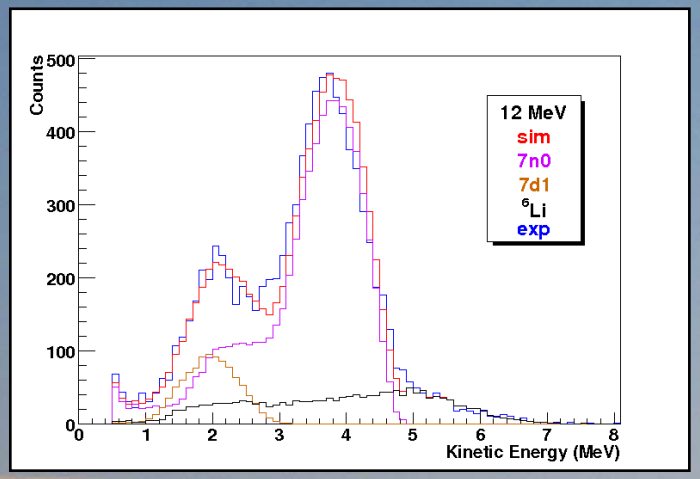


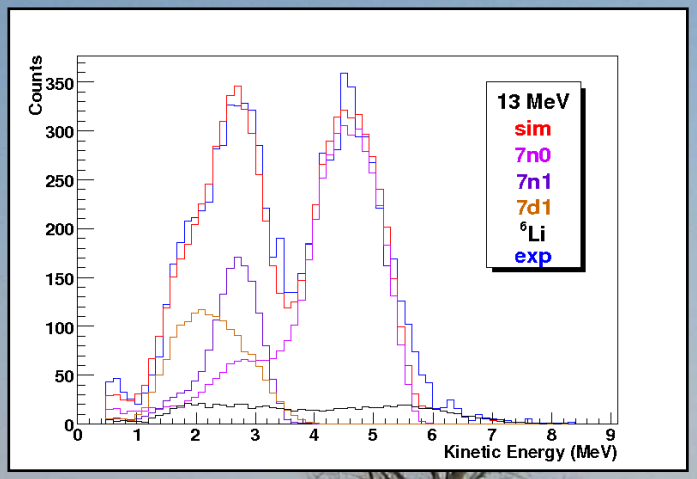


Analysis and Results: ^{7}Li Data Separation



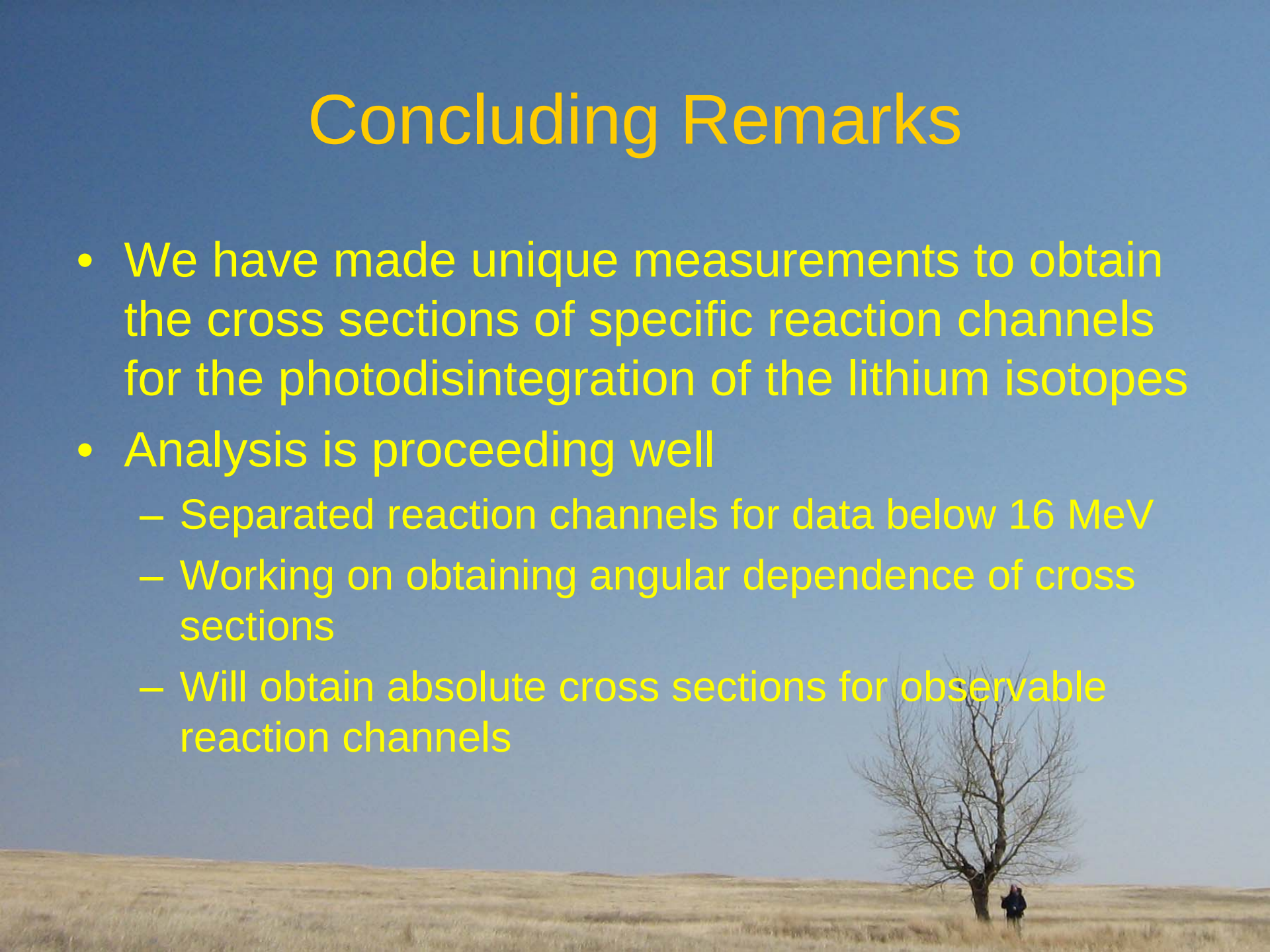






Concluding Remarks

- We have made unique measurements to obtain the cross sections of specific reaction channels for the photodisintegration of the lithium isotopes
- Analysis is proceeding well
  - Separated reaction channels for data below 16 MeV
  - Working on obtaining angular dependence of cross sections
  - Will obtain absolute cross sections for observable reaction channels



Questions