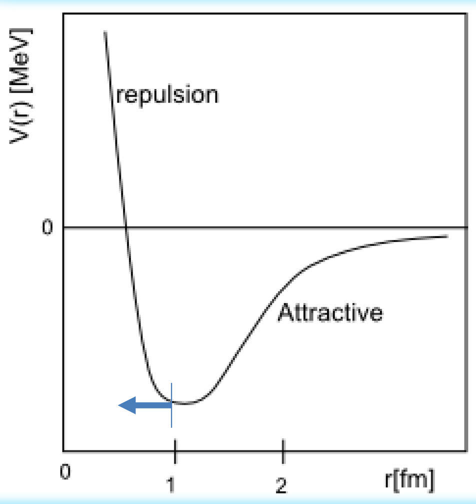
The Nucleon-Nucleon Short Range Correlations: Recent Result on $^4He(e,e'p_{recoil})$

Navaphon Muangma [Massachusetts Institute of Technology]

What are Short Range Correlations (SRCs)?

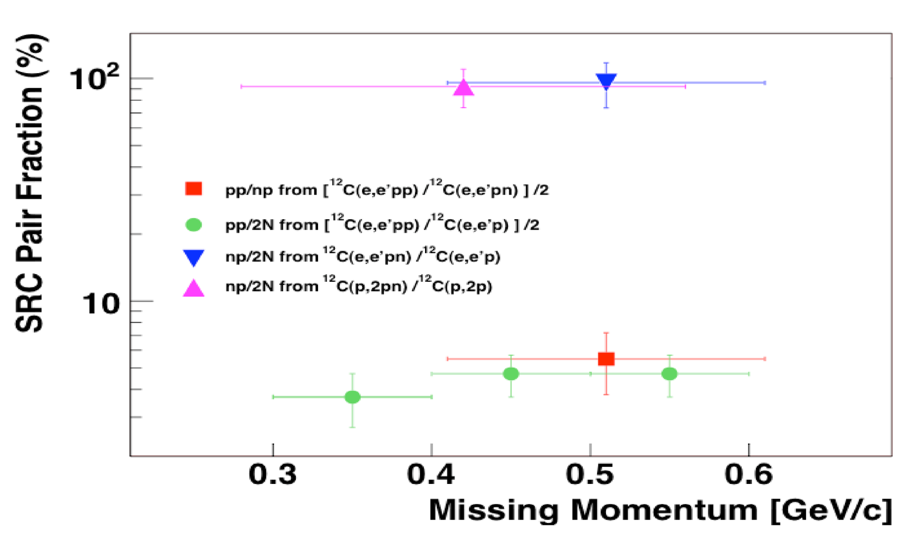


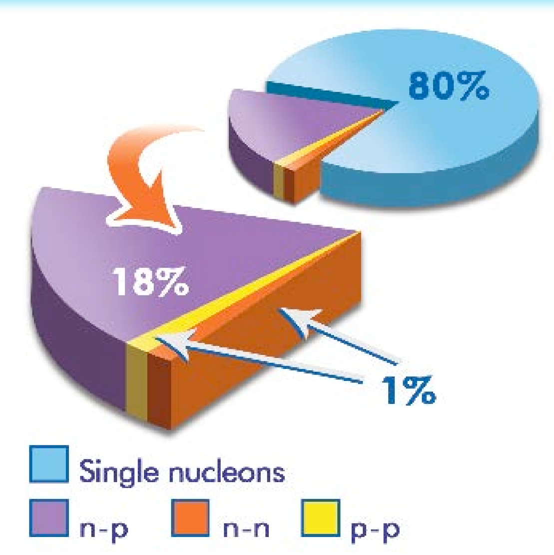
The two nucleon potential is attractive when the two nucleons are far apart but repulsive when they are closer together.

Nucleon-Nucleon Short Range Correlations (NN-SRCs) are phenomena when the two nucleon wave functions are strongly overlapped in the initial-state, causing two back-to-back high-momentum nucleons to be observed in the final state.

In this experiment, we have probed up to the limit of the repulsive core of the nucleon-nucleon potential illustrated by the arrow.

Previous Result from E01-005.



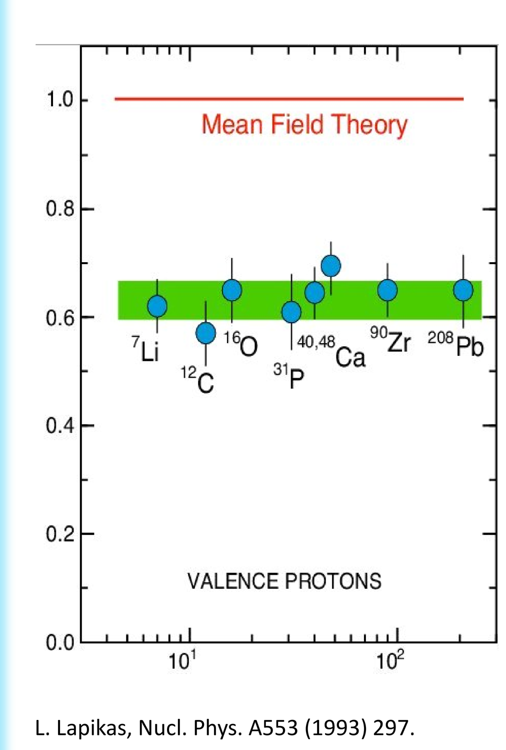


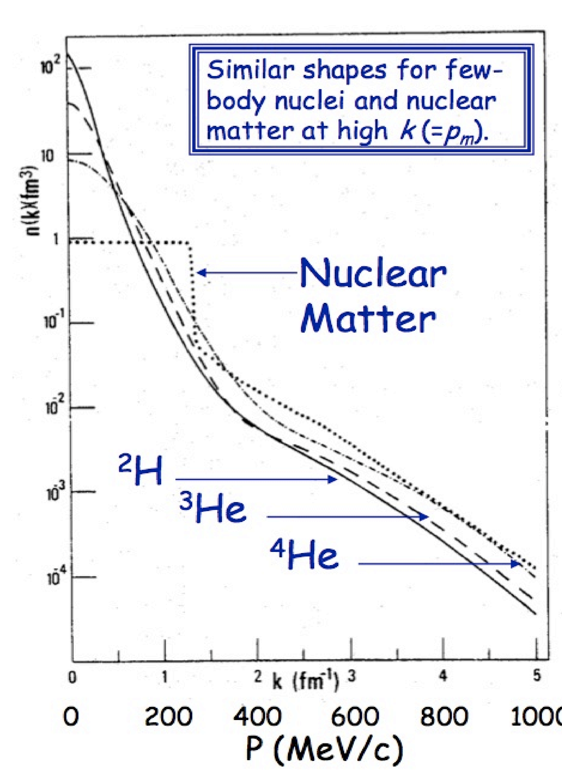
Experiment E01-015 measured the SRC pair fraction in ^{12}C nuclei. Results are shown above. By including the inclusive (e,e') study of the SRC, we learn that within the missing momentum range 300-600 MeV/c, 20% of momentum distribution is the NN-SRC pair: 18% are np pairs, 1% are pp pairs, and 1% are nn pairs.

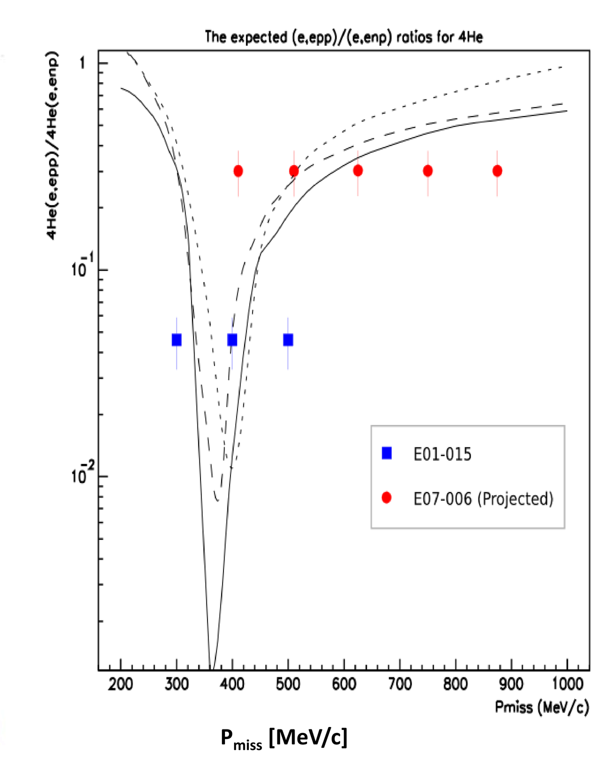
[*R. Subedi et al., Science* ***320*** *(2008) 1476*]

Why are SRCs interesting?

1. In the study of the nucleon ***spectral function***, the shell model can only predict 60%. Long range correlations provide additional 20%. Short range correlations are believed to contribute the remaining 20%.
2. The measurement of nucleon momentum distributions for various nuclei yields a similar ***high momentum tail***. Along with the shell model, the existence of NN-SRC pairs within the nuclei is believed to explain this behavior.
3. The study of the NN-SRCs within the nucleus can also provide insight into cold, dense nuclear matter such as that found in ***neutron stars.***



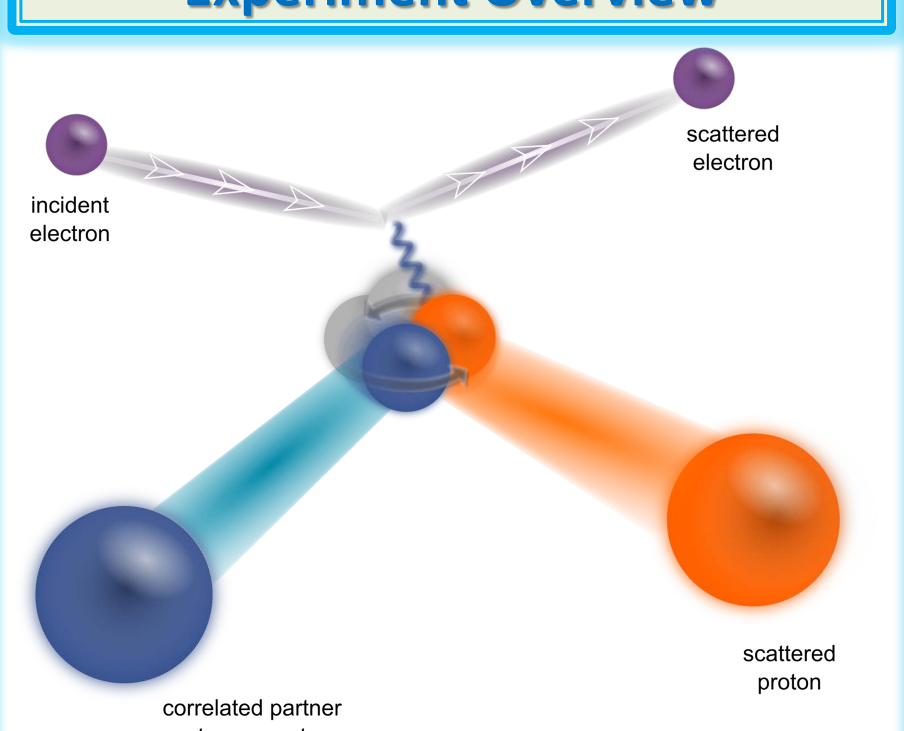




Our experiment will provide the new additional set of the experimental data for p_{miss} 500 to 900 MeV/c which we can use to compare to many existing theoretical predictions.

EO7-006 Experiment

Experiment Overview

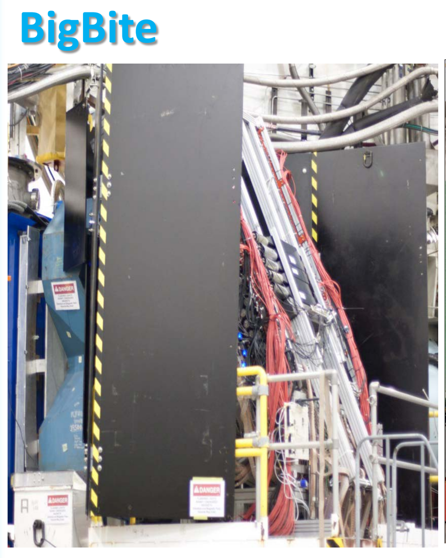


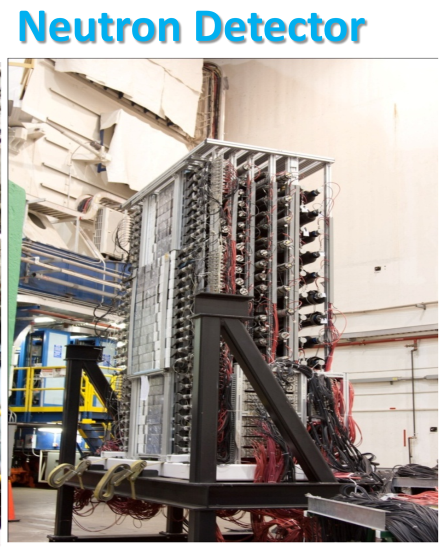
Our experiment studies short-range correlations through the triple coincidence $^4He(e,e'pN)$ reaction.

A 4.4 GeV electron beam was used to knock-out one of the protons from ^4He nuclei. The scattered electrons and knocked-out protons were detected by the Hall A High Resolution Spectrometers (HRSs) along with any recoiled nucleons in the backward direction from SRC-pairs by either BigBite or the Hall A Neutron Detector (HAND).

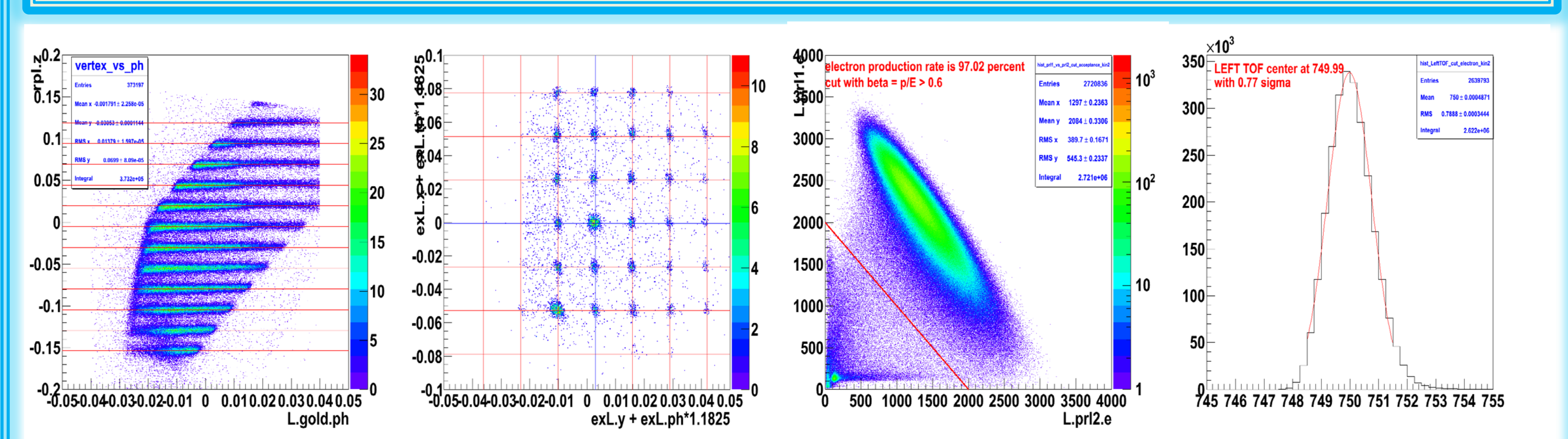
With high four-momentum transfer $[Q^2 = 2\ (GeV/c)^2]$, x>1, and nearly anti-parallel kinematics, we minimize Meson Exchange Current (MEC), suppress isobar contribution and Final-State Interactions (FSI), which are the competing reactions. The missing momentum we covered are from 400 to 800 MeV/c of (e,e'p) reaction.

BigBite **Neutron Detector**



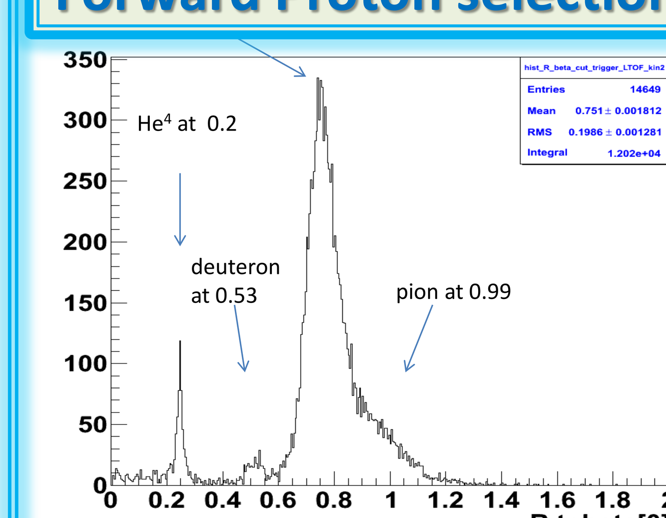


Electron Selection



a) Vertex reconstruction with high resolution after optics calibration. *b) Sieve reconstruction shows both in-plane and out-of-plane angle optics calibration.* *c) Electron selection using pion rejector which provide 97% electron production rate.* *d) Time-Of-Flight for electron with sigma 0.77 ns (using 0.5 ns TDC)*

Forward Proton selection



Beta distribution for forward proton calculated from S1&S2 scintillators at momentum setting 1.2 GeV. Each particle can be identified as shown.

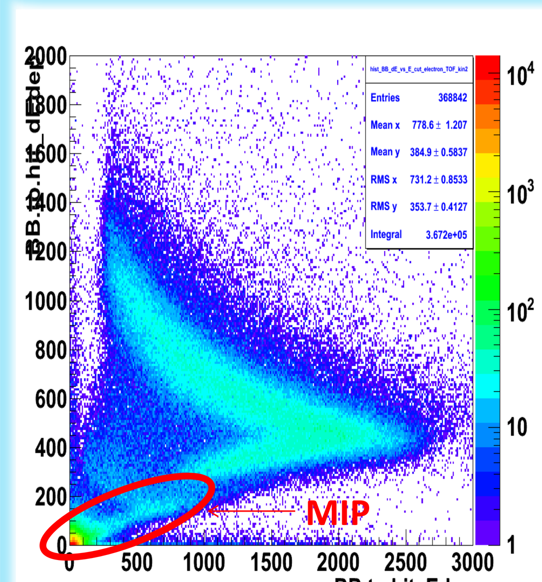
Experiment Goals

The study of the triple reaction $^4He(e,e'pN)$ will provide the ratio of the np to pp SRC-pairs in the high missing momentum region.

The $^4He(e,e'N_{recoil})$ reaction is being studied to identify nucleon in SRC-pairs without tagging the forward proton. This will improve the statistics and simplify the future experimental design.

The thorough examination of the cross section for A(e,e'pN), $A(e,e'N_{recoil})$, A(e,e'p) will give an almost complete picture of the dynamics of the contribution from various reaction processes.

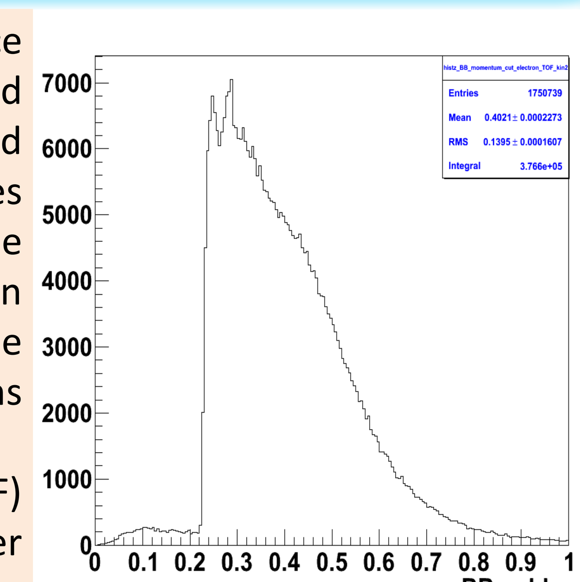
Recoil Proton Result



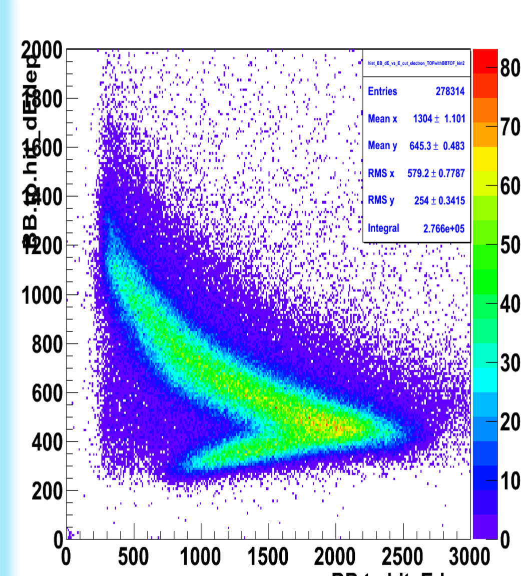
a) dE vs E energy deposited using cut on electron event and electron TOF

With a cut on the coincidence time between BigBite proton and HRS electron, the random and the minimum ionized particles (MIP) are eliminated from the BigBite particle identification (PID) process. This reduces the further need to identify protons detected in BigBite.

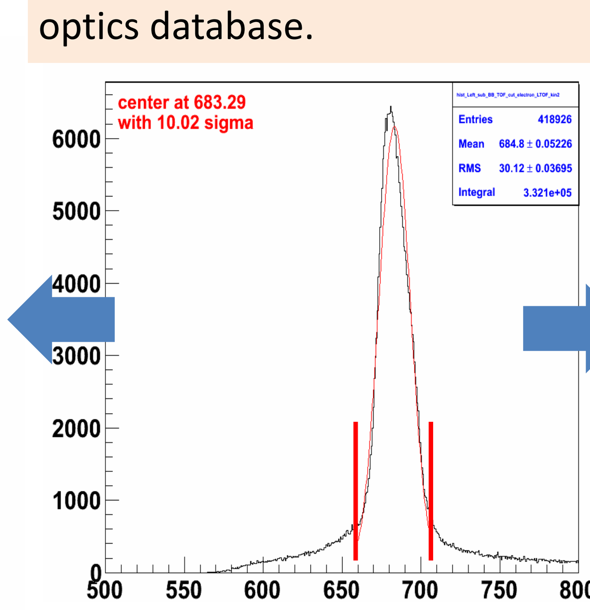
The BigBite Time-Of-Flight (TOF) can be further improved after applying time walk corrections. The momentum reconstruction also can be improved with a new optics database.



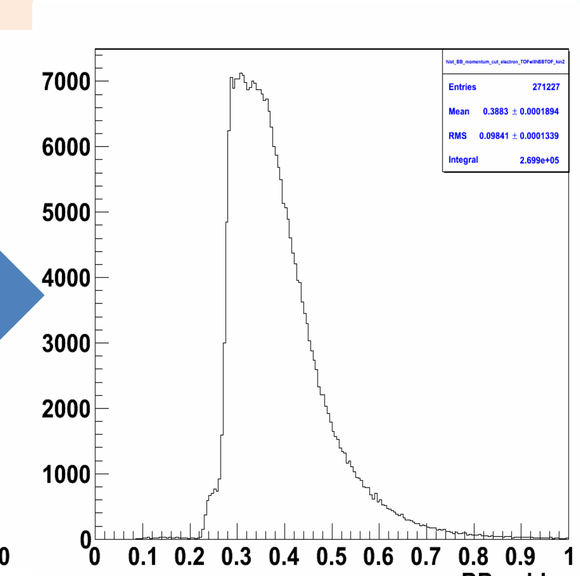
b) Momentum reconstruction with only cut on electron selection



c) dE vs E energy deposited using cut on electron event and coincidence TOF between electron and BigBite proton



d) coincidence TOF between electron and BigBite proton Peak.



e) Momentum using cut on electron event and coincidence TOF between electron and BigBite proton

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(1)MIT (2)Jefferson Laboratory (3)Tel Aviv University (4)Kent State (5)Saint Marry's