Perspectives and Reflections on this Workshop

29 March 2012

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Thanks to the Organizers

- Not for asking me to give this talk, but rather:
- Special thanks to Angela and Nigel for organizing an excellent meeting in a great location
- Thanks to the **Organizing Committee** (Bracco, Cunsolo, De Angelis, Di Pietro, Gibelin, Gramegna, Lanza, Pierroutsakou, Pollarolo, Spitaleri, Viviani) and the **Advisory Committee** (Aoi, Aumann, Blumenfeld, Chulkov, Davids, Descouvemont, Freeman, Keeley, Moro, djm, Oberteli, Rogachev, Vitturi) for putting together a fantastic program
- Thanks to the secretaries and assistants for their support and a smoothly running meeting

Conference Summary Talk – How to proceed?

- Mention something from every talk?

  Calculation: 25 min/(49 talks + 2 overview talks)

  = ~ 30 seconds for material from each talk

  N.B. the time for 6 talks already gone, sorry for that!

- Also I should mention:
  - Poster Session (Tuesday)
  - Informal Instrumentation Discussion Session (Tuesday)
  - Informal Reaction theory Discussion Session (Tuesday)

- Plan for this summary:
  - Perspectives on the program – relation to DREB1
  - What did I hear?
  - Statistics, Quotes

Comparison to Past: DREB "1"

- 24 July 1999 organized by Blumenfeld, Hanson, djm

(Friday afternoon through Sunday morning, 5 sessions)

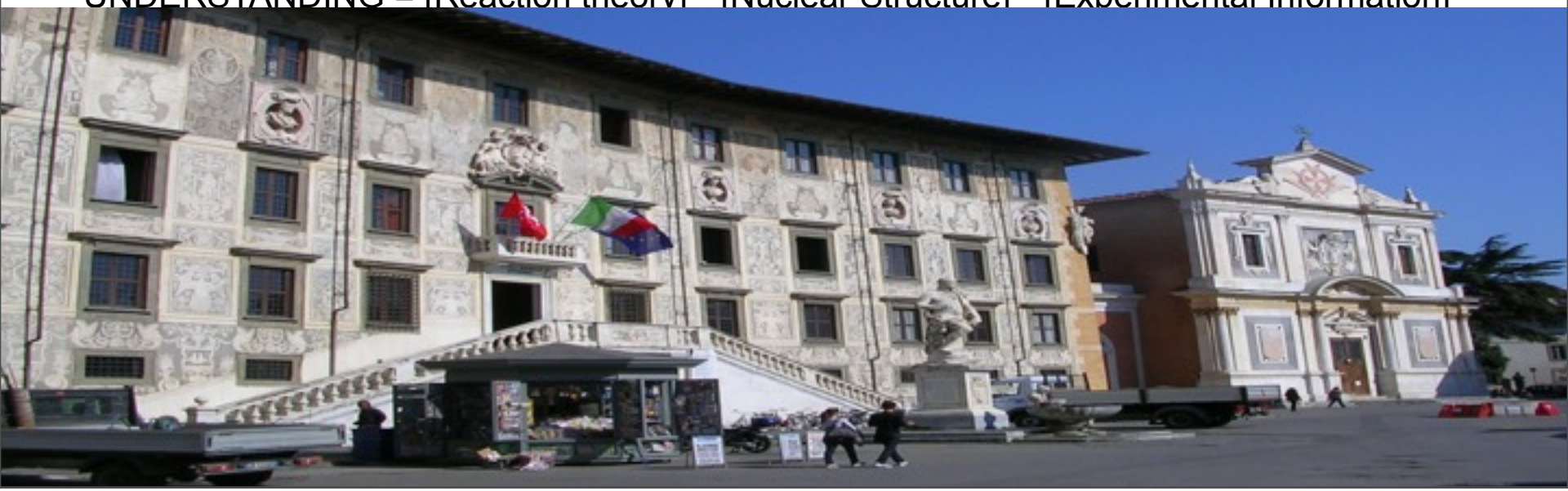
- Introduction
  - » (Kemper)
- Elastic & Inelastic Scattering 1
  - » (Petrovich, Amos, Bauge, Alamanos, Suomijarvi)
- Knockout Reactions
  - » (Navin, Hansen, Tostevin, Sakharuk, Vitturi, Esbensen)
- Elastic & Inelastic Scattering 2
  - » (Rusek, Typel, Colo)
- Direct Rxn's of Astrophysical Interest
  - » (Tribble, Beaumel, Nunes, Kolata)
- Nucl. Structure through Transfer Rxn's
  - » (Rehm, Fortier, Sidortchouk, Janecke)
- Post-sessions (a) Detectors, (b) Coulomb Excitation

- 22 talks then, Overlap integral in "speaker-space" = 1/(22+51) = 0.014
- Overlap Integral in "session-space" ? 100% + many new topics

The Conference Framework

- Monday – Session 1 – Overview
  - Andrea Vitturi "Open Questions and Perspectives in DREB Physics" Theory
    - » *Provided a hierarchy of 10 types of reactions depending on complexity*
    - » *"need to have a consistent approach to reactions and structure"*
    - » *Reminded us of Schiffer's comments: "need a simple ways to treat data … build on past knowledge and not get bogged down in complexity "*
  - Wilton Catford "Open Questions and Perspectives in DREB Physics" Experiment
    - » *Provided an overview of important icons and a glimpse of the future*
    - » *Noted that RIB's are so precious that we have been pushed to 4π coverage … correlations in exclusive data now hindrance but should be exploited in future*

UNDERSTANDING = [Reaction theory] * [Nuclear Structure] * [Experimental Information]



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UNDERSTANDING = [Reaction theory] * [Nuclear Structure] * [Experimental Information]

Vitturi Scale of reactions:

1-radiative capture
2-"safe" coulex
3-elastic scattering
4-inelastic scattering
5-pygmy resonances
6-one-particle transfer
7-two-nucleon knockout
8-two-nucleon transfer
9-sub-barrier fusion
10-multinucleon transfer

Catford scale of apparatus/analysis:

I-Simple (inclusive)
II-Manageable
III-Complex (fully exclusive)

Monday at the Conference, a

- Session 2 – Direct Reactions in "Theory"
  - Ab initio calculations of light-ion reactions – *Petr Navratil*
    - » *Goal: Predictive power – showed results for S-factor ^{7}Be+p (N_V=1 Viturri unit) and d+t fusion, going towards ^{3}He+^{4}He (N_V 9) … supercomputer work*
  - Interior and Exterior Contributions to Transfer Cross Sections – *Ian Thompson*
    - » *Ongoing controversy "surface vs. volume" , "Post vs. Prior", "ANC vs. Spectroscopic Factors" focussed on (d,p) and (d,n) reactions (N_V 6), new approach to calculate resonances*
  - (microscopic calculation of) ^{3}He(α,γ)^{7}Be reaction rate – *Thomas Neff*
    - » *subbarrier fusion reaction (N_V 9), excellent agreement with "very old" data and even suggested that mirror reaction data be checked*
  - Overlap integrals, spectroscopic factors and asymptotic normalization coefficients for one-nucleon transfer reactions – *Natalia Timofeyuk*
    - » *(N_V 6) and described "an attempt to go back to simplicity" and argued to drop the complicated wavefunctions in the interior*

Monday at the Conference, b

- Session 3 – Low Energy RNB Experiments
  - Elastic & inelastic proton scattering of ^{21}Na in inverse kinematics – *David Jenkins*
    - » *Goal: Breakout from CNO cycles, ^{15}O(p,γ) – (N_V 1) very hard expt.,*
      ^{18}Ne(^{4}He,p)^{21}Na (N_V 10) via ^{21}Na+CH_2 in large array (N_C III)
  - Indirect studies of astrophysical reaction rates - a study of the ^{18}Ne(α,p)^{21}Na reaction using the TIGRESS and SHARC detector – *Christian Diget*
    - » *Closely related work, e.g., ^{6}Li(^{20}Na, ^{4}He) ^{22}Mg* (N_V 10, N_C III) with gamma rays*
  - New Results with TECSA - The d(^{26}Al^{m},p)^{27}Al experiment – *Brian Roeder*
    - » *Goal: new detector for transfer reactions with RNB's ^{26}Mg(p,n)^{26}Al (N_V 0),*
      Some issues with isomeric beam, compared to "old (d,n) literature" (N_C II)
  - Measurement of Gamow-Teller transitions from ^{56}Ni – *Masaki Sasano*
    - » *B(GT) in ^{56}Ni using (d,n) reaction (N_V 6, N_C II), turned up a poor nuclear structure calculation used in Nuclear Astrophysics*

Monday at the Conference, c

- Session 4 – Experiments to Determine Reaction Rates at Stellar Energies
  - First Measurement with Trojan Horse Mechanism using a Radioactive Ion Beam – *Marisa Gulino*
    - » Goal: *$^{18}F(p, \alpha)^{15}O$ (N_V 8) carried out via $^{18}F(d, n, \alpha)^{15}O$ (N_C II)*
  - LUNA: Laboratory for Underground Nuclear Astrophysics – *Davide Trezzi*
    - » *Goal: $^{17}O(p,\gamma)^{18}F$, N_V 0 $^{17}O(p,\alpha)^{14}N$, N_V 10 $^{2}H(\alpha,\gamma)^{6}Li$, N_V 8?, serious BKG reduction = N_C III*
  - Low-energy d+d fusion reactions via the Trojan Horse Method – *Tumino Auroro*
    - » *Goal: $^{2}H(d,p)^{3}H$ and $^{2}H(d,n)^{3}He$ N_V 6, particularly a "hole" in literature data,*
      Carried out $^{3}He + CD_2 = {}^{3}He+p\ (+n)$, $= {}^{3}H+p\ (+p)$ N_C II
- Tour of VIRGO
  - *Goal: Prove Einstein wrong*
    (that gravity waves cannot be detected)
    N_C off-scale ?

Tuesday at the Conference, a

- Session 5 – Two-nucleon Reactions
  - Fingerprints of core polarization in two-nucleon transfer reactions of halo nuclei – *Riccado Broglia*
    - » *"We should be able to calc. absolute cross sections, difficult but important."*
      Requested that $^{3}H+^{9}Li = ^{11}Li+p$ N_V 8 be done to investigate 2n transfer strength
  - Multi-nucleon transfers using two-neutron halo ^{6}He on ^{12}C at 30 MeV using the SHARC and TIGRESS arrays at TRIUMF ISAC-II – *Frederic Sarazin*
    - » *Can (^{6}He,^{4}He) replace (t,p) ? N_V 8 … $^{12}C(^{6}He,^{4}He)^{14}C$ N_C III*
  - Nuclear response to two-neutron transfer via the (^{18}O,^{16}O) reaction – *Diana Carbone*
    - » *(^{18}O,^{16}O) on a host of stable targets, N_V 8 N_C I .. Modern reference for calc's*
  - Study of neutron rich nuclei via heavy-ion double charge exchange reaction – *Hiroaki Matsubara*
    - » *HeavyIonDoubleChargeExchange, HIDCX: $^{12}C(^{18}O,^{18}Ne)^{12}Be$ N_V 0 N_C I limited applicability*

Tuesday at the Conference, b

- Session 6 – Techniques and Analyses
  - Electron Scattering: Hofstadter's experiment for short-lived nuclei – *Toshimi Suda*
    - » *SCRIT – new facility to do (e,e') reactions N_V -1? reactions N_C IV !*
    - » *Need 10^7 /s in trap for 50 ms for measurement, multiply or divide yield by 0.050 ?*
    - » *We look forward to first results at DREB-2o14 !*
  - Direct Reactions and Decay Spectroscopy using the MSU High Resolution Array – *Jenny Lee*
    - » *Series of reactions with HiRA device, decay spectroscopy ^{69}Br, ^{8}C decay*
    - » *p(^{A}Ar,)d N_V 6, N_C III obtained C^2S in a uniform framework, sparked large discussion*
  - Reactions on light neutron rich nuclei with CHIMERA detector at LNS – *Giuseppe Cardella*
    - » *Very interesting idea, reuse a 4π detector for direct reactions, ^{2}H(^{10}Be, X)Y N_V ?, N_C III*
  - Experiments with a Double Solenoid System – *Rubens Lichtenthaler*
    - » *RIBRAS (double solenoid) ^{6}He Elastic Scattering N_V 3, among other things*
  - Digital Signal Processing for Physics Applications – *Matteo Angarano*
    - » *And now a word from our sponsor – new implementation of digital signal processing*

Wednesday the Conference, a

- Session 7 – Reactions Reaching Beyond the Neutron Drip Line
  - Structure of the unbound systems ^{10}Li and ^{13}Be – *Giacomo Randisi*
    - » *Invariant mass spectroscopy $^{12}C(^{14}B,^{13}Be)x \rightarrow$ ^{12}Be+n N_V 7 N_C III*
    - » *Argument is Rxn mechanism is "simple" so they get at nuclear structure, expt. is complex*
  - First observation of ground state di-neutron decay: ^{16}Be – *Artemis Spyrou*
    - » *Invariant mass spectroscopy $^{9}Be(^{17}B,^{16}Be)x \rightarrow$ (^{15}Be+n) $\rightarrow$ ^{14}Be+2n N_V 7 N_C III*
    - » *Indication of g.s. properties of ^{15}Be along the way*
    - » *Argument continues mechanism is "simple" so they get n-n correlation, expt. is complex*
  - Evidence for the ground-state resonance of ^{26}O – *Zachary Kohley*
    - » *Invariant mass spectroscopy $^{9}Be(^{27}F,^{26}O)x \rightarrow$ (^{25}O+n) $\rightarrow$ ^{24}O+2n N_V 7 N_C III*
    - » *Argument still continues mechanism is "simple" so get ^{26}O g.s., insight into n-efficiency*
  - Multi-neutron detection, reaction mechanism and the quest for ^{7}H – *Haik Simon*
    - » *Next generation Invariant mass spectroscopy, neuLand N_V ? N_C III+*
    - » *30x2x50 bars 5x5x250 cm^3*

Wednesday the Conference, b

- Session 8 - High Energy Reactions “The GSI Session”
  - Angular-momentum content of momentum profile in a neutron knockout from ^{14}Be – *Leonid Chulkov*
    - » *Introduced a new observable in knock-out reactions, momentum profile, providing a signal for the L-component of the decay energy*
  - Nuclear Breakup of ^{17}Ne and its Two-Proton Halo Structure – *Felix Wamers*
    - » *“unsafe” coul-ex of ^{17}Ne by Pb, nuclear breakup by C to view 2-p halo, N_V 2? N_C III*
    - » *40% s-wave in ^{19}F ground state*
  - Shell evolution in neutron-rich Al isotopes around N=20 – *Chiara Nociforo*
    - » *One-neutron knockout of $^{33\text{-}35}$Al, N_V 7, N_C II*
    - » *Complicated sums of s, p, d, & f states, odd-Z nuclei many levels*
  - Exclusive measurements of (p,pX) neutron and proton knockout reactions on ^{57}Ni – *Alina Movsesyan*
    - » *Measurements of ^{57}Ni(p,p X) at high energies, detect all particles, N_V 7, N_C III*

Wednesday at the Conference, c

- Session 9 Collective Response of Exotic Isotopes
  - Investigations of the excitation of the core and the halo of ^{11}Li – *Rituparna Kanungo*
    - » *^{11}Li(p,t)^{9}Li, N_V 8 N_C III – shows excitation of the ^{9}Li core*
      other follow up reactions like ^{9}Li(d,d')^{9}Li and ^{11}Li(p,p')^{11}Li (no soft dipole)
  - Unbound states of the drip-line nucleus ^{24}O from (p,p') scattering – *Simon Boissinot*
    - » *^{24}O(p,p')^{24}O also ^{22}O(p,p')^{22}O, N_V 3,4 N_C II*
  - Measurement of the Giant Monopole and Quadrupole Resonances in ^{68}Ni using the Maya Active Target – *Marine Vanebrouck*
    - » *^{68}Ni(d,d')^{68}Ni also (α,α'), in a gas-filled active target detector, track analysis N_V 3,4 N_C III*
  - Experimental results on the Coulomb excitation of exotic nuclei at the R3B-LAND setup – *Dominic Rossi*
    - » *"unsafe" coul-ex of ^{68}Ni, ^{32,34}Ar, by Pb for pDR, N_V 2? N_C III, some hint, under analysis*

Wednesday at the Conference, d

- Session 10 Knockout Reactions – the details
  - Dynamical limits of nucleon knockout at intermediate energy – *Freddy Flavigny*
    - » *p-knock out and n-knock out from ^{16}C, ^{14}O N_V 7, N_C II*
    - » *Gave differently shaped momentum spectra → momentum cutoff at low E/u*
  - Correlations in direct two-proton knockout and details of the reaction mechanism – *Katerin Wimmer*
    - » *^{9}Be(^{28}Mg,^{26}Ne)2p fully exclusive, N_V 7, N_C III*
      including a general discussion of reaction theory and Dalitz plots
  - Eikonal reaction theory for one- and two-neutron removal reaction – *Kosho Minomo*
    - » *"Fully microscopic framework for reaction analysis" ^{31}Ne, ^{6}He breakup in literature*
  - Study of ^{16}C by neutron knockout – *Jongwon Hwang*
    - » *^{17}C(H, pn)^{16}C* , n+γ+fragments N_V 7, N_C III, evidence for a new state*
- DREB 2012 Dinner, Toastmaster: Ian Thompson

Thursday at the Conference, a

- Session 11 Transfer reactions to light, neutron-rich nuclei
  - Study of ^{10}He by the ^{11}Li(d,^{3}He) transfer reaction – *Adrien Matta*
    - » *Calibration ^{9}Li(d,^{3}He)^{8}He, ^{11}Li(d,^{3}He)^{10}He, N_V 6, MUST2 detector, N_C III*
    - » *<^{8}He|^{9}Li> = 0.2 in good agreement with previous work, <^{10}He|^{11}Li> vs. BKG?*
  - Studies of neutron rich Beryllium isotopes using transfer reactions – *Jacob Johansen*
    - » *Set of reactions ^{11}Be(d,p) , (d,t), (d,d') with T-Rex (silicon) & Miniball (Ge) N_V 6, N_C III*
    - » *Need γ's / use γ's to separate the states, some question about role of breakup*
  - Neutron sd-shell excitations for light nuclei with N ≥ 8 – *Alan Wuosmaa*
    - » *^{12}B(d,p)^{13}B, ^{15}C(d,p)^{16}C, ^{13}B(d,p)^{14}B in HELIOS spectrometer, N_V 6, N_C III*
    - » *Generally show that these are "good" shell model nuclei, halo-state 1- in ^{14}B*
  - Transfer reactions into the Island of Inversion – *Vinzenz Bildstein*
    - » *^{30}Mg(d,p)^{31}Mg) with T-Rex (silicon) & Miniball (Ge) N_V 6, N_C III*
    - » *Noted: forward detectors are "useful" due to kinematics, use* g*'s to sort out states*

Thursday at the Conference, b

- Session 12 Study of the evolution of nuclear structure continues
  - Proton-neutron interactions around N=40 studied at ISOLDE – *Dennis Muecher*
    - » *^{72}Zn(t,p) , (t,d), CoulEx on Ti(support), 3-in-1expt. T-rex & MiniBall, N_V 2,6,8, N_C III*
    - » *Looking for evidence for mixed symmetry states*
  - Evolution of the shell structure in medium mass nuclei: search for the neutron $2d_{5/2}$ orbital in ^{69}Ni – *Mohamad Moukaddam*
    - » *^{68}Ni(d,p)^{69}Ni with MUST2, ExoGam , N_V 6, N_C III*
    - » *Observed the g.s. and 2 excited states, two entrance, two exit channel formulations*
  - Test of the asymmetry of reduction factors with one nucleon transfer reaction on ^{14}O – *Alain Gillibert*
    - » *^{14}O(d,^{3}He)^{13}N, ^{14}O(d,^{3}He)^{13}N, MUST2, VAMOS, N_V 6, N_C III*
    - » *Very carful analysis to extract C^2S, appears to be "flat" with ΔS …*
  - Asymptotic normalization coefficients of mirror states in ^{21}Al – *Beatriz Fernandez-Dominguez*
    - » *Analysis of ^{20}O(d,p)^{21}O in ANC framework to predict mirror states in ^{21}Al – narrow states!*

Thursday at the Conference, c

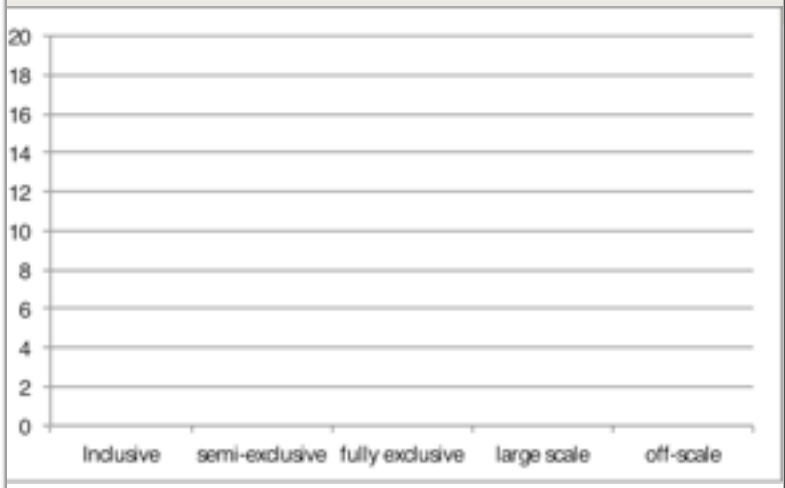
- Session 13 Transitions to the continuum and fusion
  - Analysis of breakup channel for the ^{11}Li+^{208}Pb reaction at energies around the Coulomb barrier – *Juan Pablo Fernandez-Garcia*
    - » *^{208}Pb(^{11}Li,^{11}Li) and breakup, N_V 2,10, N_C III*
    - » *Probability for breakup approaches 40% as function of (lab) angle*
  - Structure and reactions of three-body exotic nuclei using discretization methods – *Manuela Rodriguez-Gallardo*
    - » *4-body CDCC calc. e.g., ^{208}Pb(^{6}He,^{6}He), ^{208}Pb(^{11}Li,^{11}Li) at low E, N_V 2,10*
  - Exploring the coupling to nucleon transfer in fusion involving neutron-rich Sn nuclei at energies near the Coulomb barrier – *Felix Liang*
    - » *^{132,124}Sn + ^{40,48}Ca, ^{132,124}Sn + ^{58,64}Ni, N_V 9, N_C II looking for fusion enhancement*

    Highest ^{40}Ca with positive Q-values for n transfer but more than ^{58}Ni with similar Q's
  - Scattering of ^{8}He on ^{208}Pb at energies around the Coulomb barrier – *Gloria Marquinez-Duran*
    - » *^{208}Pb(^{8}He,^{8}He), and breakup N_V 3, Si system N_C III, comparison of σ-el/σ-R for heliums*

Thursday at the Conference, d

- Session 14
  - Coulomb Excitation of ^{8}Li on a ^{197}Au Target – *Marlete Assuncao*
    - » *^{197}Au(^{8}Li,^{8}Li), N_V 2, RIBRAS facility at 26 MeV N_C III*
  - Fusion reactions and neutron transfer in collisions induced by Li isotopes on Sn targets – *Maria Fisichella*
    - » *^{A} Li + ^{A}Sn, N_V 9, N_C II looking for fusion enhancement*
  - Summary Talk, *djm*

Statistics of the Workshop



- Excellent and diverse program – demonstrates DREBs are making important contributions to nuclear science with challenging problems
- Many open Issues and many promising experiments
- The field is becoming mature with sophisticated experiments and reaction models making significant nuclear structure studies possible.

Quotes from DREB 2012 (Pub Quiz)

1. “I don’t have conclusions, I have questions.”
2. “People somewhat ignore nuclear structure information in astrophysical calculations.”
3. Who said their work was relevant to nuclear fusion power?
4. Who reminded experimenters to “measure neutrons”?
5. Who said that they got a $19M gift?
6. Who said they were going to give a rock star talk, i.e., no results?
7. Who said their results were low statistics but high exclusivity?
8. Who said “Since I have the microphone, …”?

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Broglia, Jenkins, Tumino, Thompson, Suda, Roeder, Boissinot, Orr

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