PAVIA

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ELECTROWEAK REACTIONS ON STABLE AND EXOTIC NUCLEI

- quasielastic electron and neutrino-nucleus scattering
- electron scattering on exotic nuclei

QUASIELASTIC ELECTRON AND NEUTRINO-NUCLEUS SCATTERING

- electron scattering: electron is a probe to investigate nuclear properties
- neutrino experiments aimed to determine neutrino properties
- nuclei used as neutrino detectors
- nuclear effects must be well under control
- models developed for electron scattering and tested in comparison with electron scattering data have been applied to neutrino scattering
- different relativistic descriptions of final-state interactions are compared
- the results of the models have been compared with CCQE and NCE MiniBooNE data

QUASIELASTIC ELECTRON AND NEUTRINO-NUCLEUS SCATTERING

A. Meucci, J.A Caballero, C. Giusti, J.M. Udias PRC (2011) 83 064614

A. Meucci, M.B. Barbaro, J.A. Caballero, C. Giusti, J.M. Udias PRL (2011) 107 17250

C. Giusti, A. Meucci, J. of Physics: Conference Series 336 (2011) 012025

A. Meucci, C. Giusti, F.D. Pacati PRD (2011) 84 113003

B. Meucci, C. Giusti PRD 85 (2012) 093002

C. Giusti, A. Meucci EPJ Web of Conferences 38 (2012) 14004

A. Meucci, C. Giusti, M. Vorabbi, arXiv:1305.5466

COMPARISON OF RELATIVISTIC MODELS FOR FSI

collaboration with J.A. Caballero (Sevilla)
J.M. Udias (Madrid)
M.B. Barbaro (Torino)

INCLUSIVE QUASIELASTIC SCATTERING (e,e')

- only scattered electron detected
- all final nuclear states are included
- in the QE region the main contribution is given by the interaction on single nucleons and direct one-nucleon emission

INCLUSIVE SCATTERING: FSI

DWIA RDWIA

sum of 1NKO where FSI are described by a complex OP with an imaginary absorptive part does not conserve the flux

PWIA RPWIA

FSI neglected

REAL POTENTIAL

rOP rROP

only the real part of the OP: conserves the flux but it is conceptually wrong

RMF

RELATIVISTIC MEAN FIELD: same real energy-independent potential of bound states

Orthogonalization, fulfills dispersion relations and maintains the continuity equation

GF RGF

GREEN'S FUNCTION complex OP conserves the flux consistent description of FSI in exclusive and inclusive QE electron scattering

FSI for the inclusive scattering : Green's Function Model

- the components of the inclusive response are expressed in terms of the Green's operator
- under suitable approximations can be written in terms of the s.p. optical model Green's function
- the explicit calculation of the s.p. Green's function can be avoided by its spectral representation that is based on a biorthogonal expansion in terms of the eigenfunctions of the non Herm optical potential V and V^+
- matrix elements similar to DWIA
- scattering states eigenfunctions of V and V^+ (absorption and gain of flux): the imaginary part redistributes the flux and the total flux is conserved
- the model does not include only one-nucleon knockout, the imaginary part can recover contributions from inelastic channels which are not included in other models based on the IA
- consistent treatment of FSI in the exclusive and in the inclusive scattering

Comparison with MiniBooNe CCQE data

First Measurement of the Muon Neutrino Charged Current Quasielastic Double Differential Cross Section, PRD 81 (2010) 092005

$$\nu_\mu + {}^{12}\mathrm{C} \longrightarrow \mu^- + \mathrm{X}$$

Measured cross sections larger than the predictions of the RFG model and of other more sophisticated models.

Unusually large values of the nucleon axial mass must be used to reproduce the data (about 30% larger)

Models based on the impulse approximation with the standard value of the axial mass and including only 1NKO underpredict the CCQE MiniBooNE cross section

Differences between Electron and Neutrino Scattering

- electron scattering :

  beam energy known, cross section as a function of ω

- neutrino scattering:

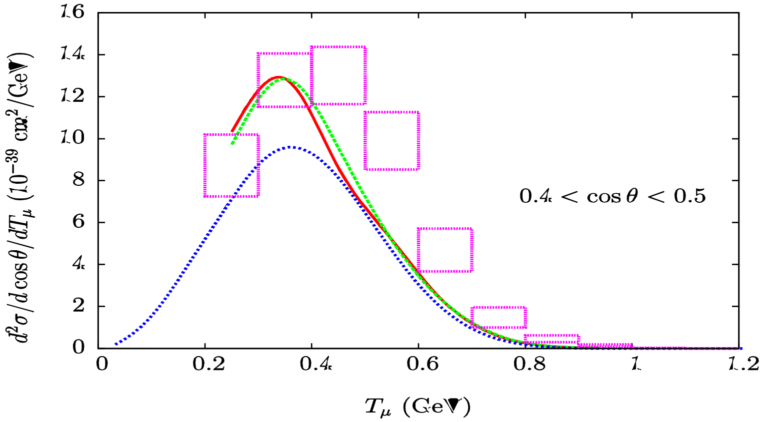
  axial current

  beam energy and ω not known

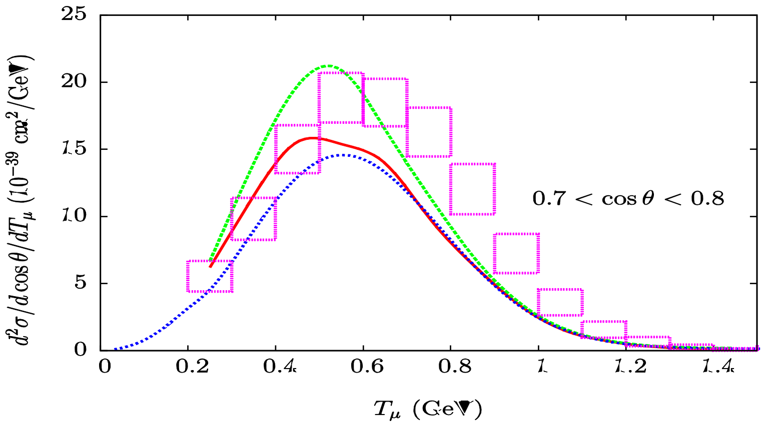
  calculations over the energy range relevant for the neutrino flux

the flux-average procedure can include contributions from different kinematic regions where the neutrino flux has significant strength, contributions other than 1-nucleon emission

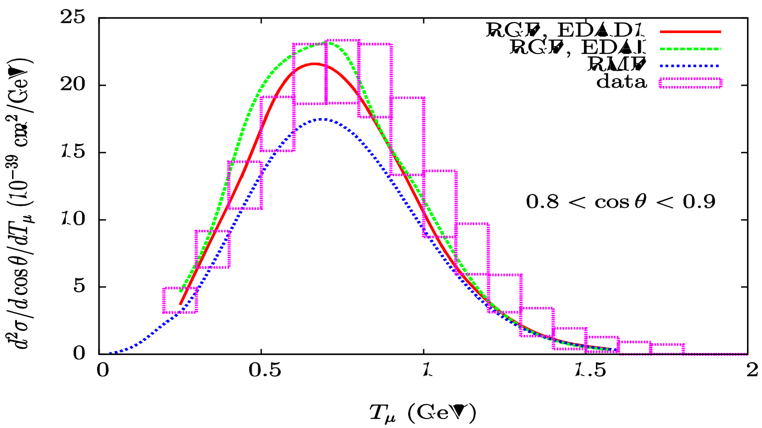
Comparison RGF-RMF with MiniBooNe CCQE data



$0.4 < cos\theta_\mu < 0.5$



$0.7 < cos\theta_\mu < 0.8$



$0.8 < cos\theta_\mu < 0.9$

Different optical potentials

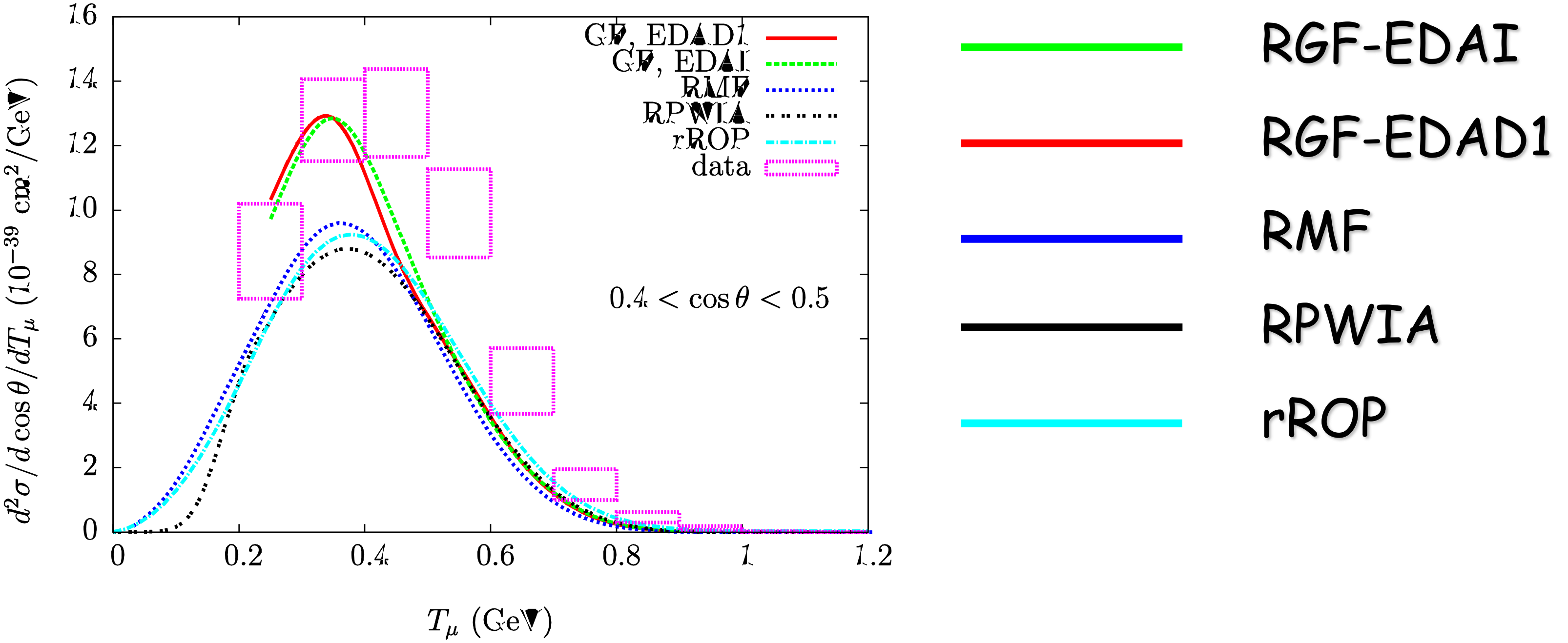
RGF-EDAI

RGF-EDAD1

RMF

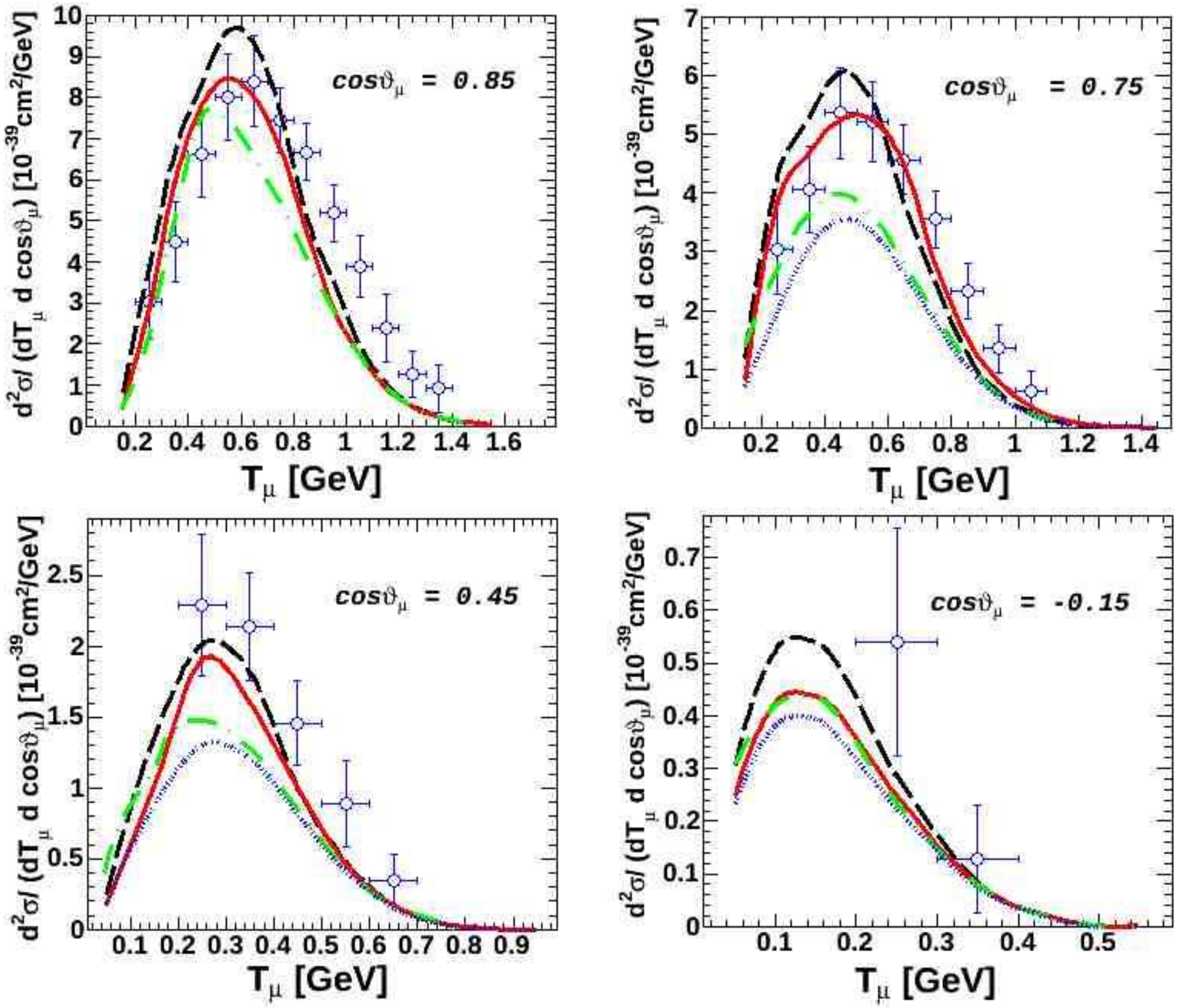
Comparison with MiniBooNe CCQE data

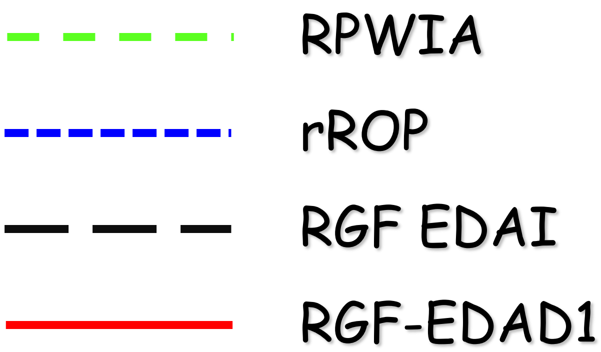
$0.4 < cos\theta_\mu < 0.5$



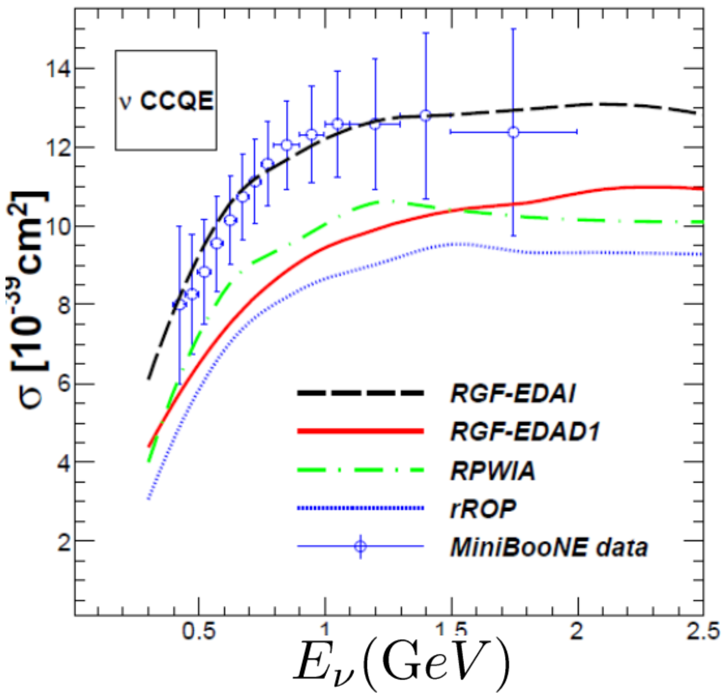
CCQE antineutrino scattering

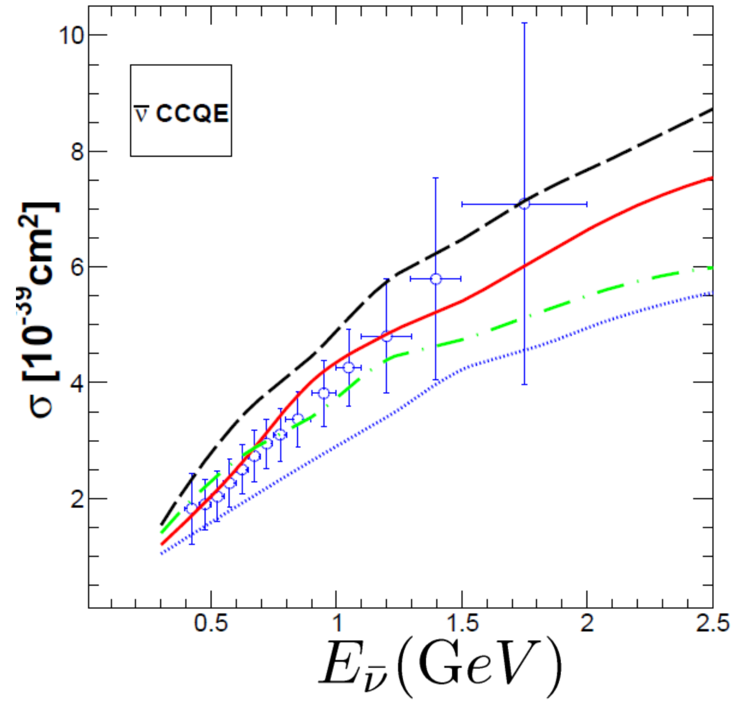
$^{12}C(\bar{\nu}_\mu, \mu^+)$



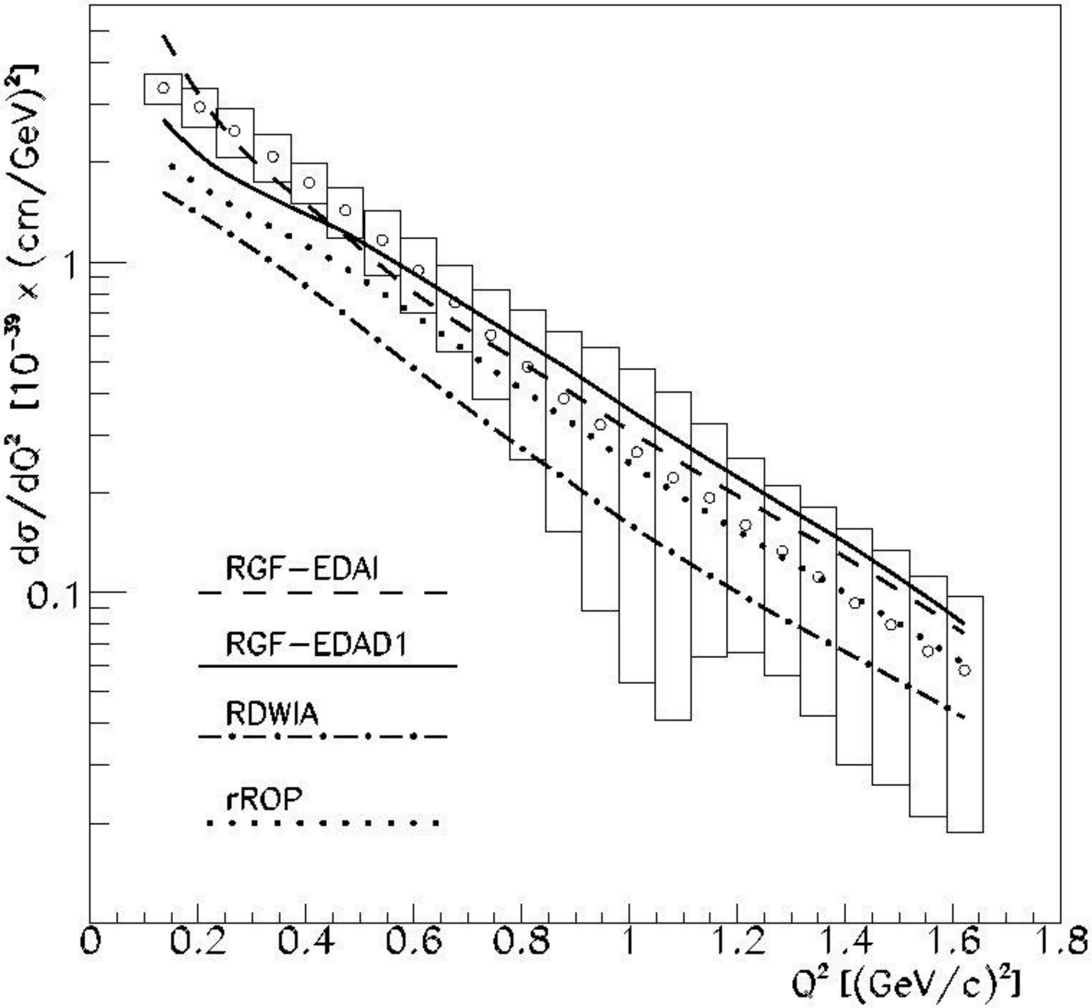


Comparison CCQE neutrino-antineutrino scattering

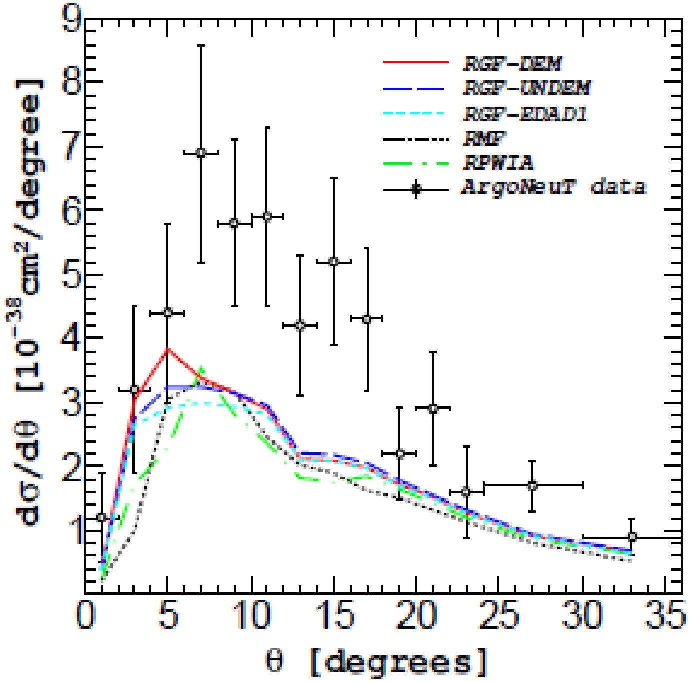




Comparison with MiniBooNE NCE data



Comparison with ArgoNeuT CC data



ELECTRON SCATTERING ON EXOTIC NUCLEI

- Quasifree (e,e'p) reactions on Nuclei with Neutron Excess: C. Giusti, A. Meucci, F.D. Pacati, G. Co', V. De Donno, PRC 84 (2011) 024615
- Electron-Induced Proton Knockout from Neutron-Rich Nuclei: C. Giusti, A. Meucci, F.D. Pacati, G. Co', V. De Donno, J. Phys. Conf. Ser. 366 (2012) 012019
- Mean Field Calculations of the Ground States of Exotic Nuclei: G. Co' V. De Donno, P. Finelli, M. Grasso, M. Anguiano, A.M. Lallena, C. Giusti, A. Meucci, F.D. Pacati PRC 85 (2012) 024322
- Elastic and Quasi-Elastic Electron Scattering off Nuclei with Neutron Excess: A. Meucci, **M. Vorabbi**, C. Giusti, P. Finelli, F.D. Pacati PRC 87 (2013) 054620

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Matteo Vorabbi's talk

MOTIVATION

- understanding the evolution of nuclear properties as a function of N/Z
- nuclear reactions main source of information on nuclear properties
- direct reactions give insight into the s.p. properties
- advantages of the elm probe can be extended to study exotic nuclei
- in the next years advent of RIB facilities will provide data on unstable nuclei
- electron RIB colliders that use storage rings under construction (GSI, RIKEN) will offer unprecedented opportunities to study exotic nuclei with electron scattering (ELISe at FAIR, SCRIT at RIKEN)
- elastic scattering: global properties nuclear density distributions
- quasi-elastic: dynamical properties, proton-hole states, 1hSF (exclusive) integral of 1hSF over all the final states (inclusive)

EXOTIC NUCLEI

collaboration with P. Finelli (Bologna)

G. Co' (Lecce)

V. De Donno (Lecce)

M. Grasso (Orsay)

M. Anguiano (Granada)

A. Lallena (Granada)

Mean Field Calculations of Exotic Nuclei Ground States

Predictions of three mean field theoretical approaches (non relativistic HF with both zero and finite-range interactions, relativistic Hartree) in the description of the ground state properties of some spherical nuclei far from the stability line (O, Ca Ni, Sn isotopes) . Binding energies, s.p. particle spectra, density distributions, charge and neutron radii

Elastic and Quasielastic Electron Scattering on Nuclei with Neutron Excess

Results are presented for the elastic and QE cross sections and for the parity-violating asymmetry The calculations are performed within the framework of the DWBA and the proton and neutron density distributions are evaluated with a relativistic Dirac-Hartree model. The results of the models are tested in comparison with some of the data available on ^{16}O and ^{40}Ca. Then, the evolution of some nuclear properties is investigated as a function of the neutron number. A comparison with the PVES parameter obtained by the PREX Collaboration on ^{208}Pb and a prediction for the future experiment CREX on ^{48}Ca are presented.