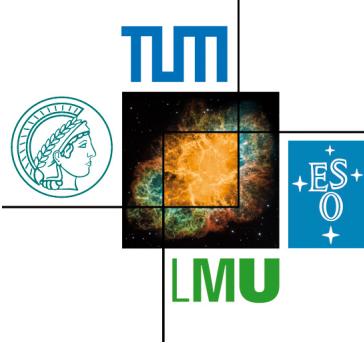




Technische Universität München

Transfer reactions at REX-ISOLDE

Vinzenz Bildstein and Kathrin Wimmer
for IS 454 and IS 470 Collaborations



Physik-Department E12, TU München



bmbf - Förderorschwerpunkt
Hadronen -
und Kernphysik
Großgeräte der physikalischen
Grundlagenforschung

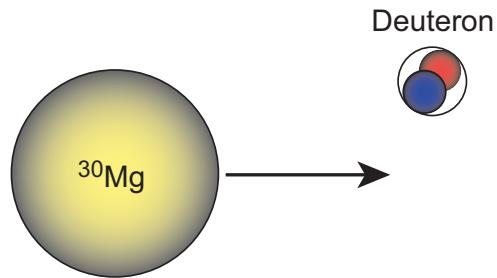
- Transfer Reactions in inverse Kinematics
- Setup
- Island of Inversion
- Results from $d(^{30}\text{Mg}, ^{31}\text{Mg})p$
- Two neutron transfer: $t(^{30}\text{Mg}, ^{32}\text{Mg})p$
- Outlook & Summary

Transfer Experiments with RIBs

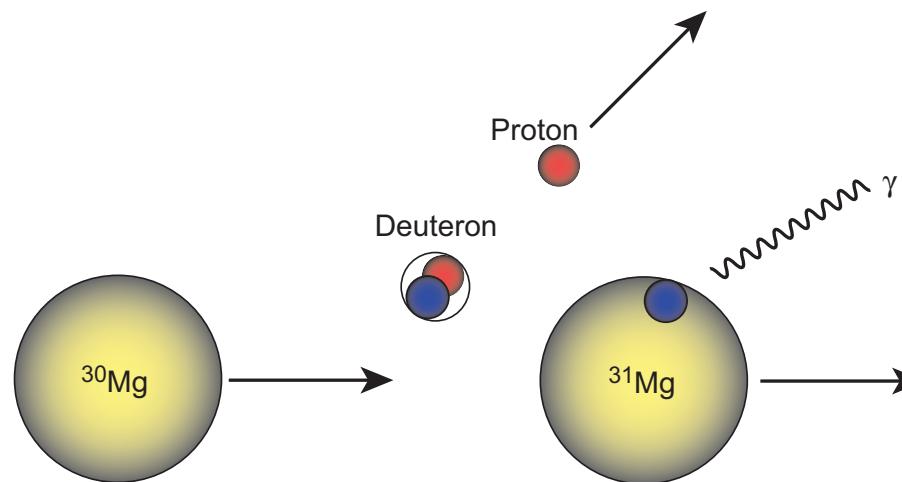
TUM

Technische Universität München

radioactive ion beam impinges on target
with deuterons (deuterated poly-ethylene)

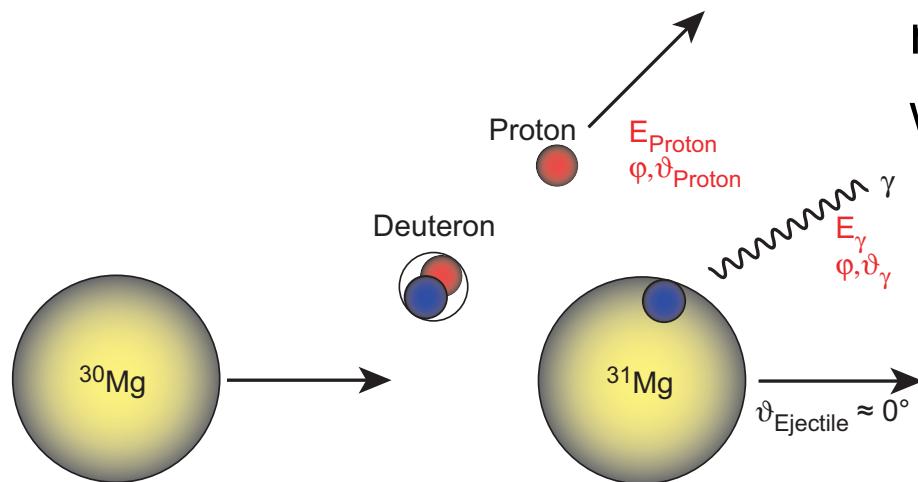


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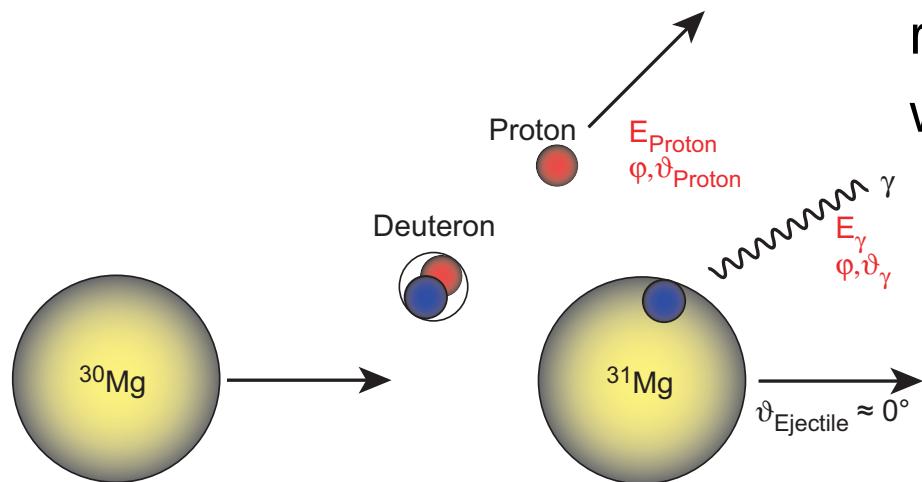


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Experimental Observables:

- compare measures cross sections with DWBA calculations
⇒ relative spectroscopic factors S
- particle angular distributions ⇒ orbital momenta l
- excitation energies ⇒ single particle energies
- γ angular distributions
- particle- γ -correlations ⇒ spins I

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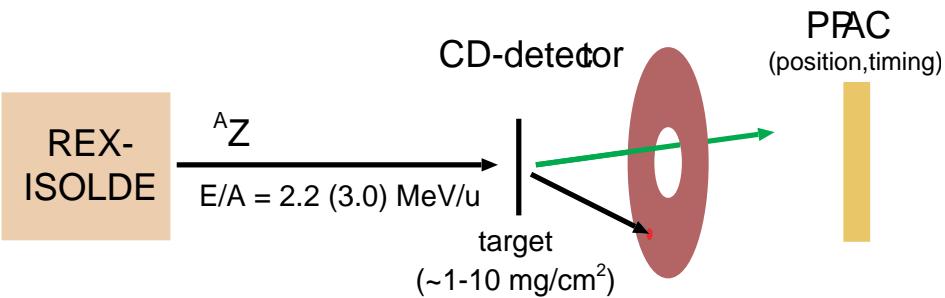
⇒determination of configurations by
comparison with shell model calcula-
tions

complementary to coulomb excitation
experiments

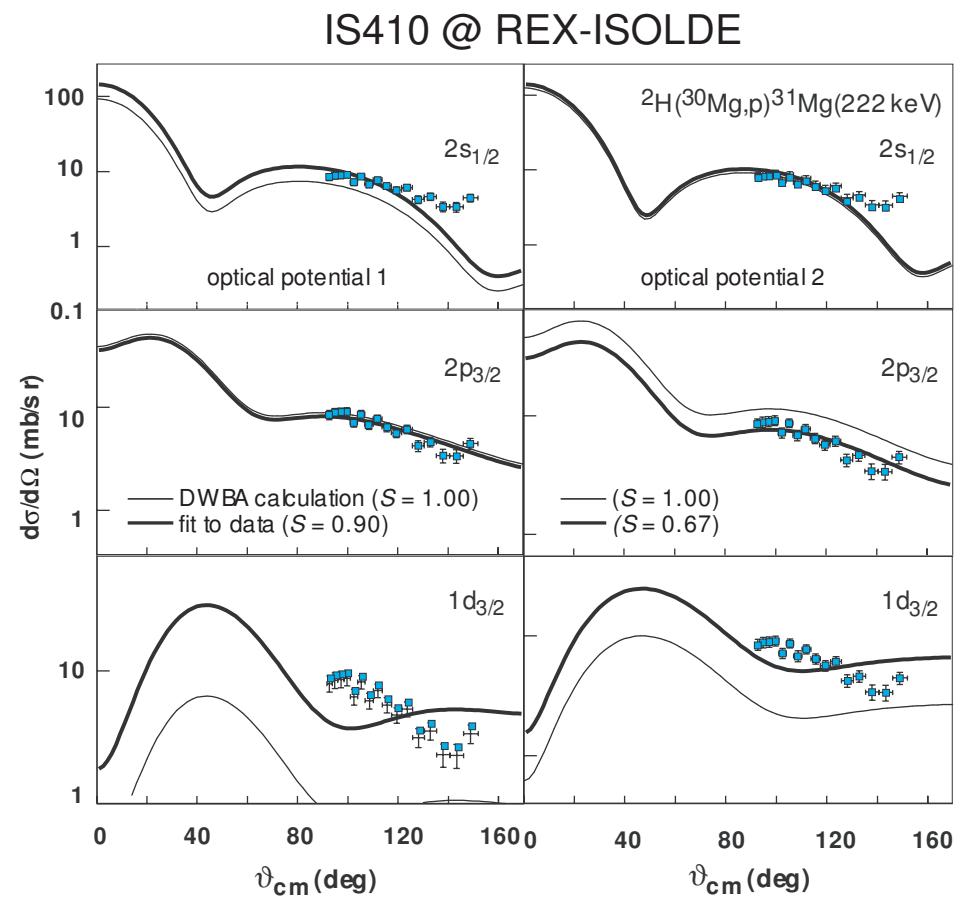
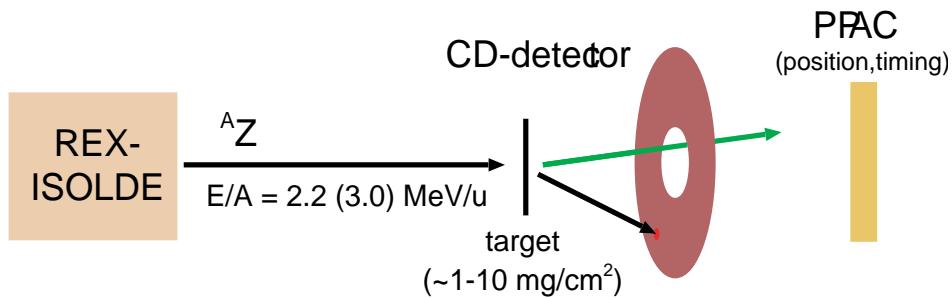
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Transfer with Coulex Setup

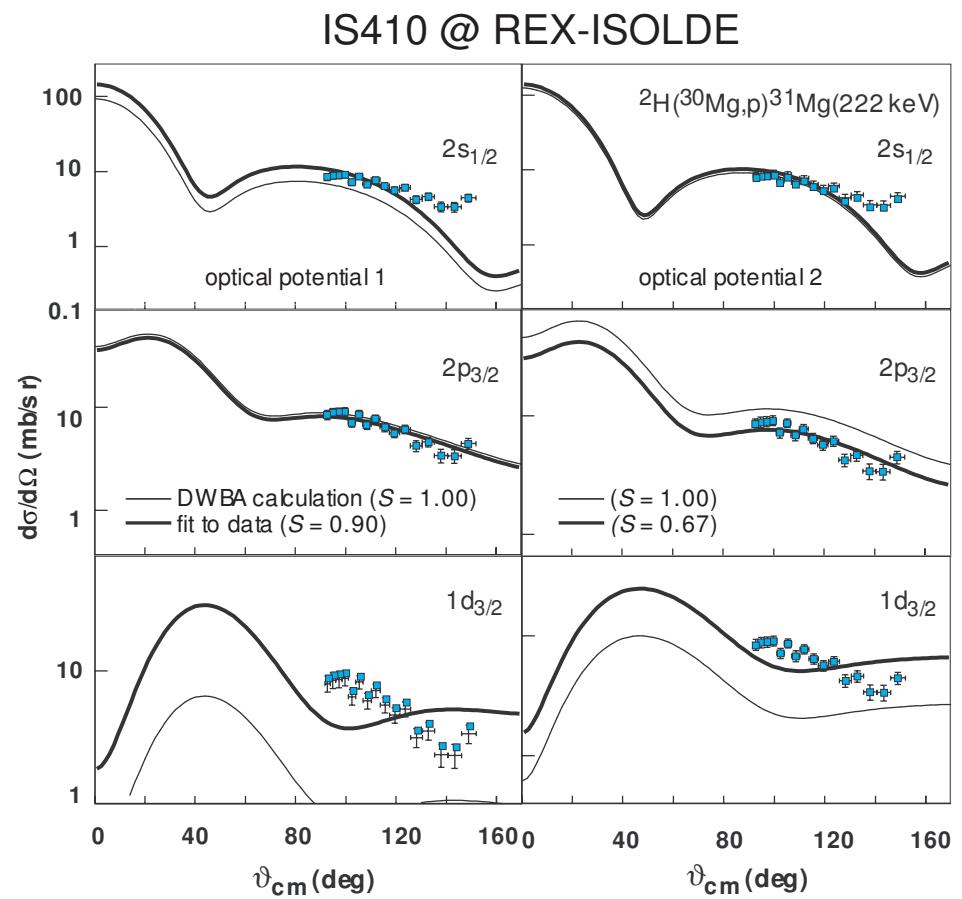
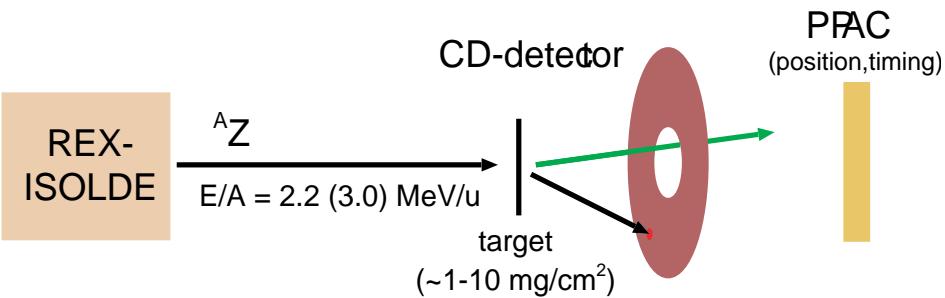


Transfer with Coulex Setup



M. Pantea, PhD Thesis (Darmstadt, 2005)
ongoing work: E. Tengborn (Chalmers)

Transfer with Coulex Setup

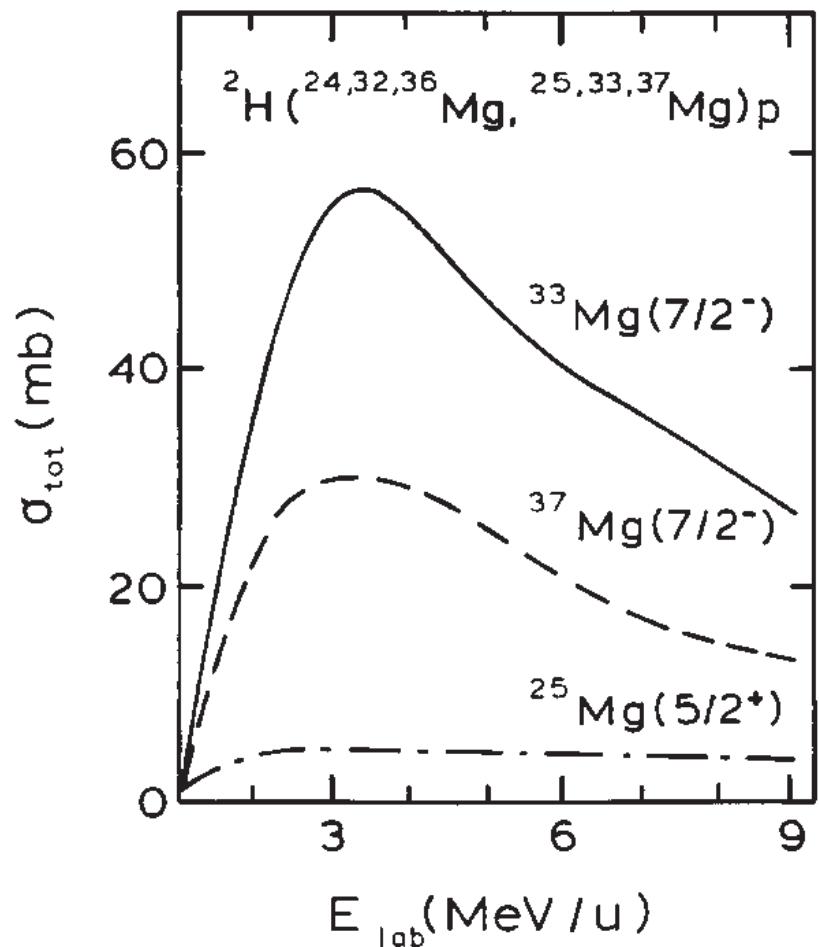


M. Pantea, PhD Thesis (Darmstadt, 2005)
ongoing work: E. Tengborn (Chalmers)

- interesting parts of angular distribution not covered by particle detectors
- E_{cm} is smaller than in normal kinematics \Rightarrow less pronounced angular distributions

Transfer Experiments with RIBs

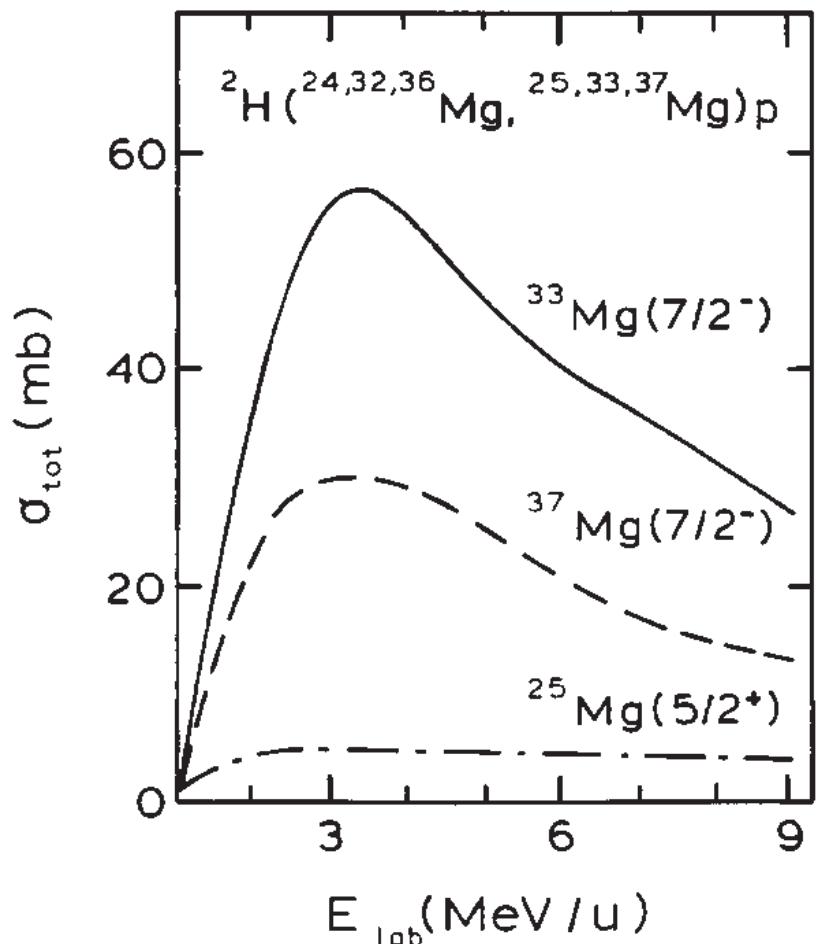
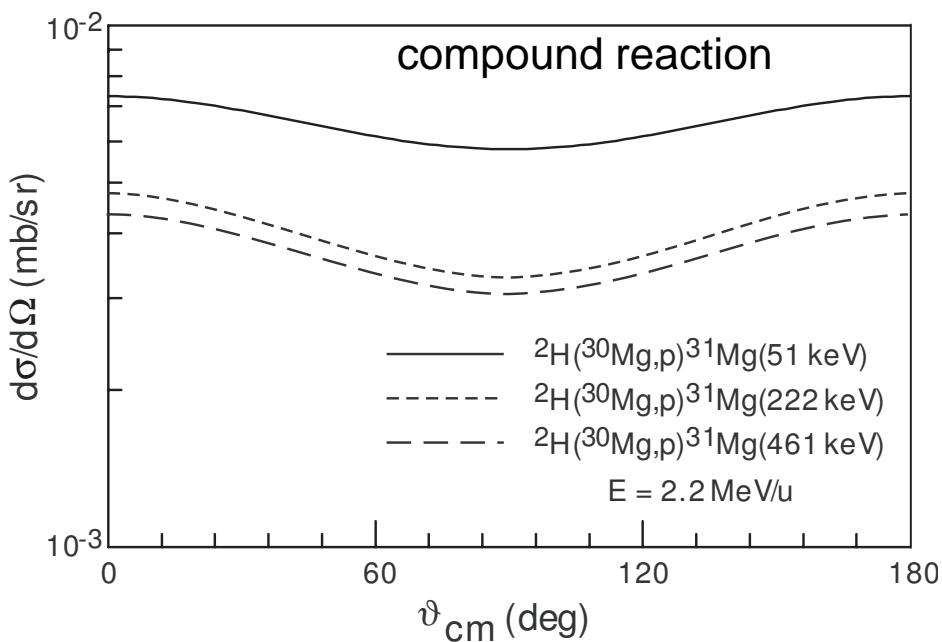
- better momentum matching \Rightarrow higher cross section (optimal around 3 MeV/u)



H. Lenske, G. Schrieder, EPJA 2, 41 (1998)

Transfer Experiments with RIBs

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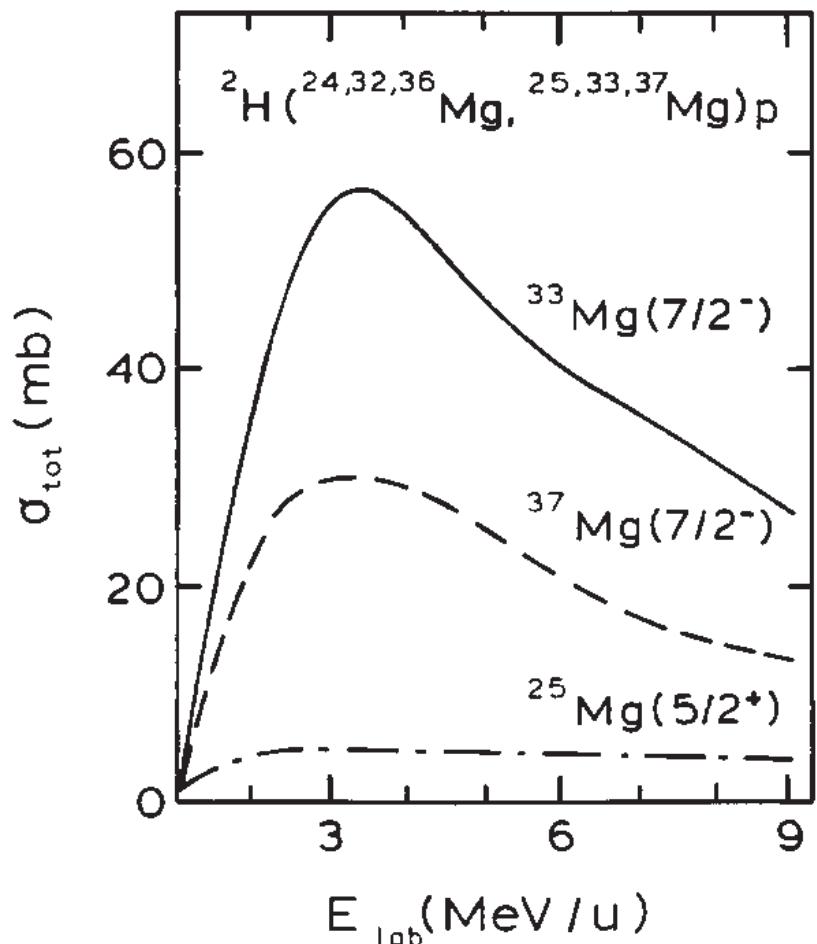
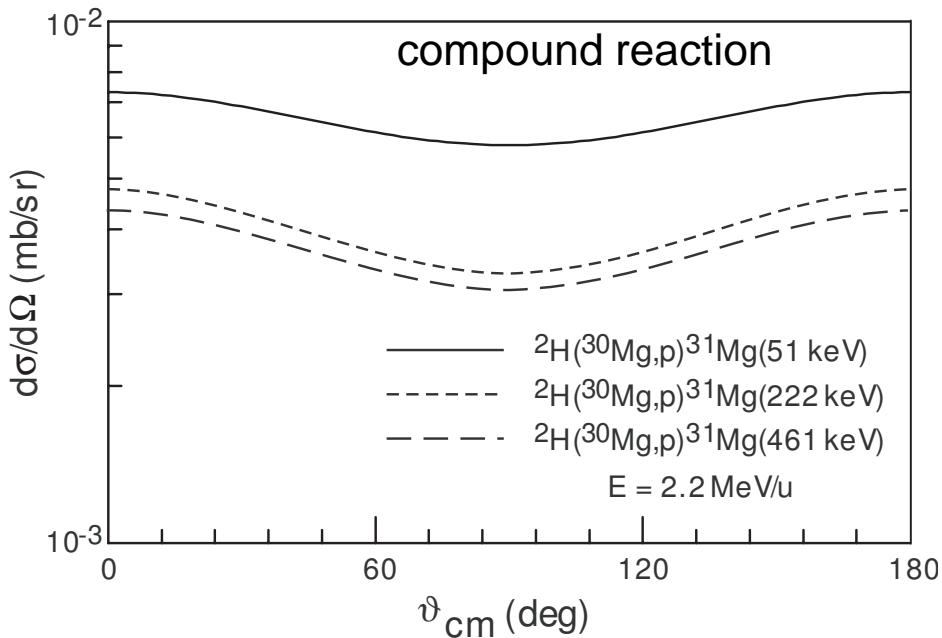
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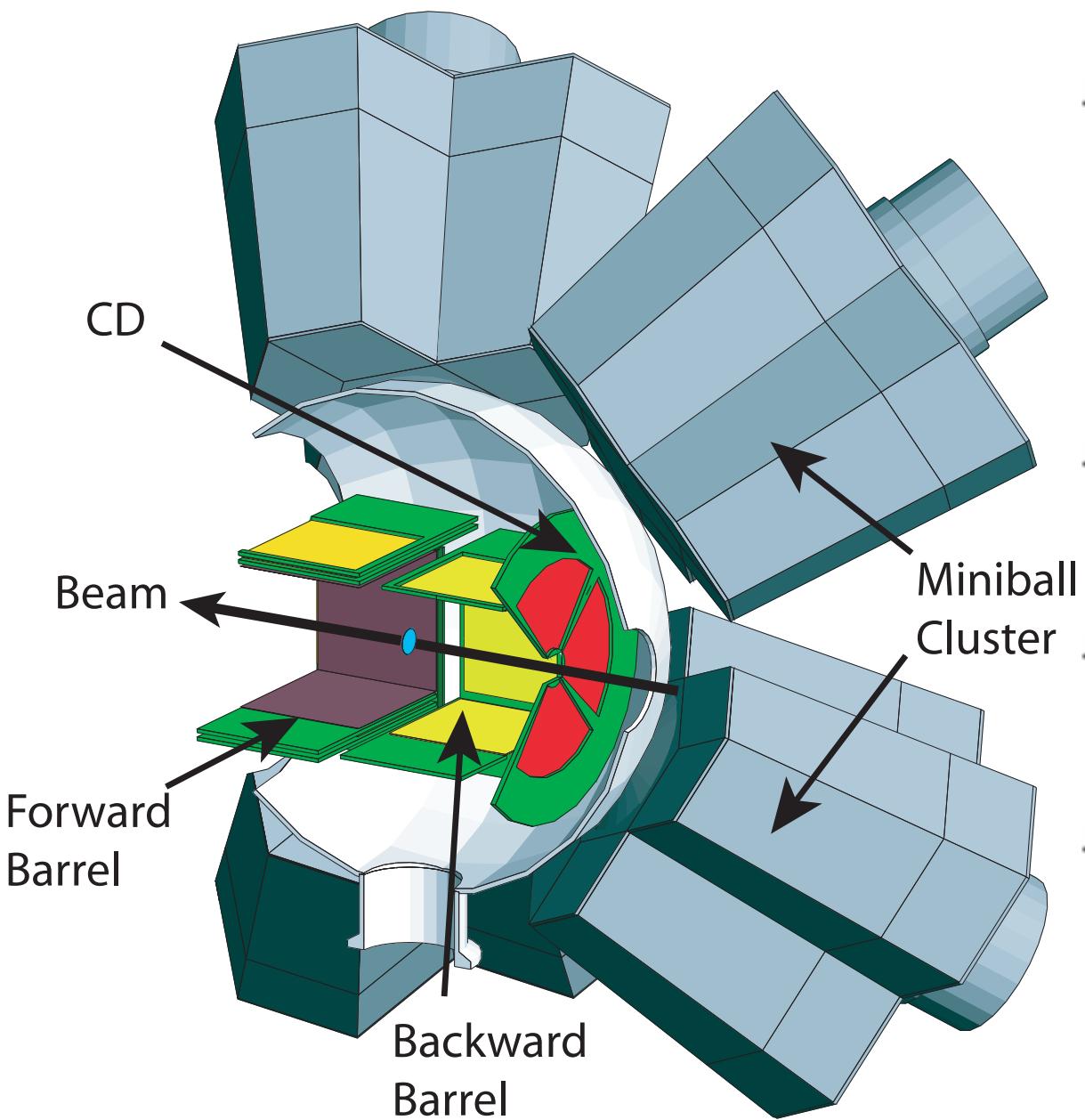
no such protons observed, can be explained by low neutron separation energy which favors *neutron evaporation*



H. Lenske, G. Schrieder, EPJA 2, 41 (1998)

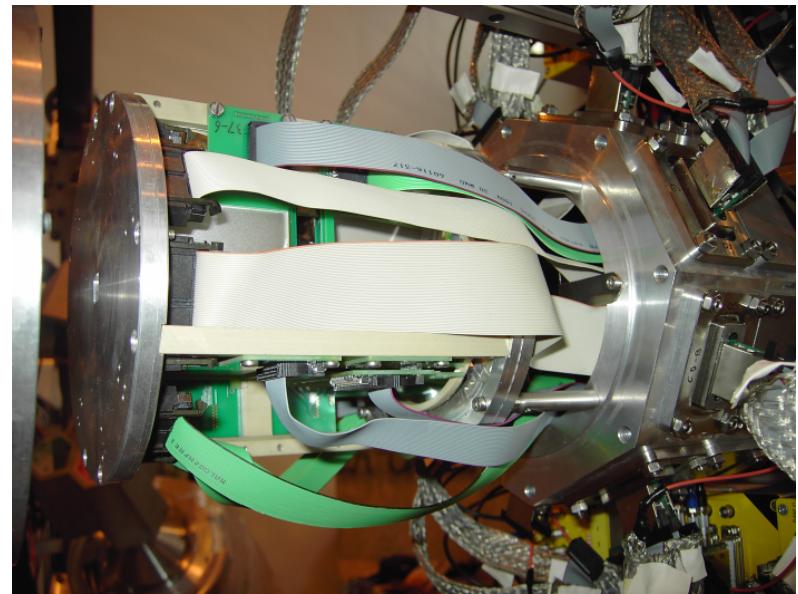
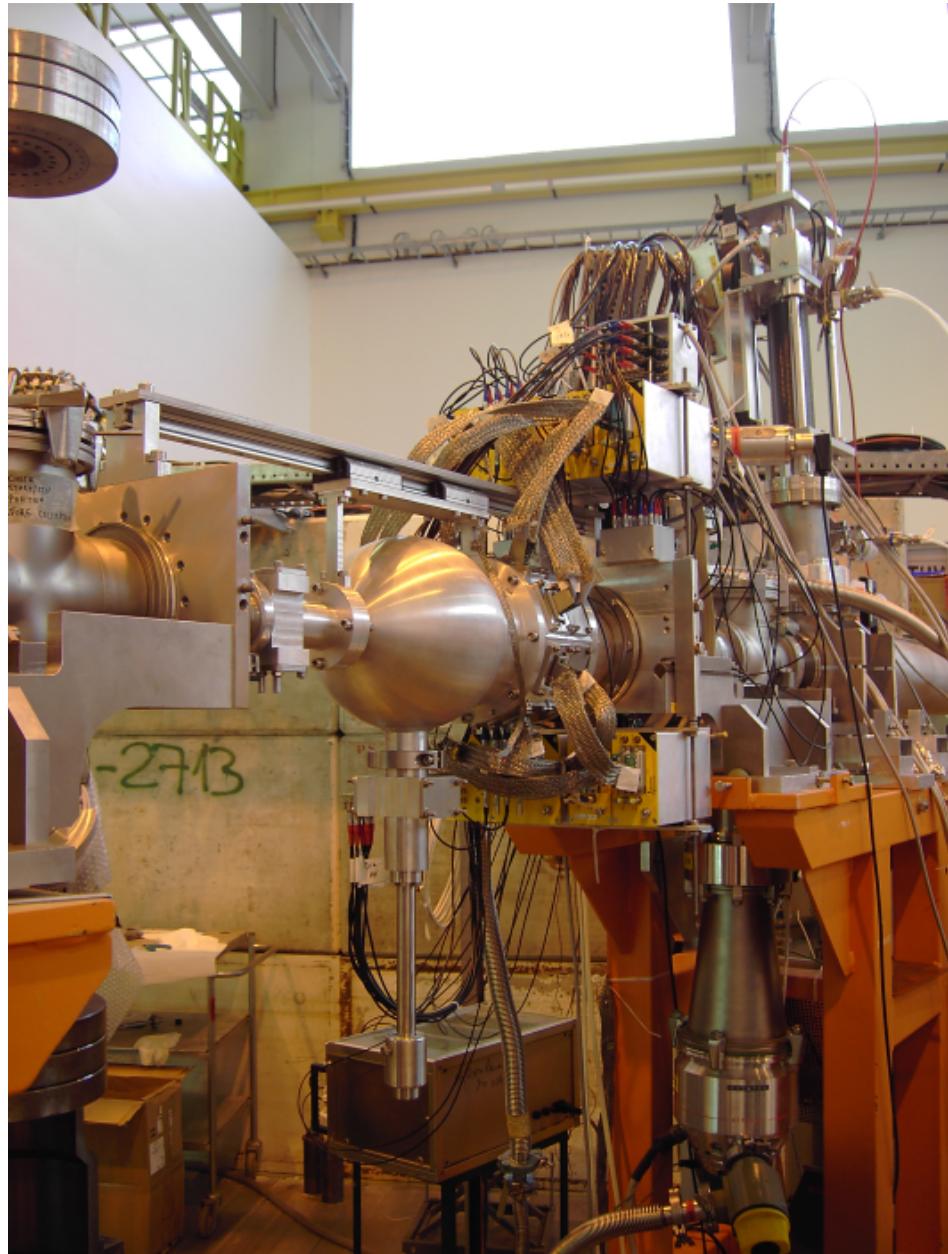
M. Pantea, PhD Thesis (Darmstadt, 2005)

New Setup 2007



- Miniball γ -spectrometer:
24 6-fold segmented
HPGe crystals in 8 triple
cluster
- forward barrel:
 $140/1000 \mu\text{m}$ silicon
- backward barrel/CD:
 $500 \mu\text{m}$ silicon
- target: 1 mg/cm^2
deuterated PE

Setup II



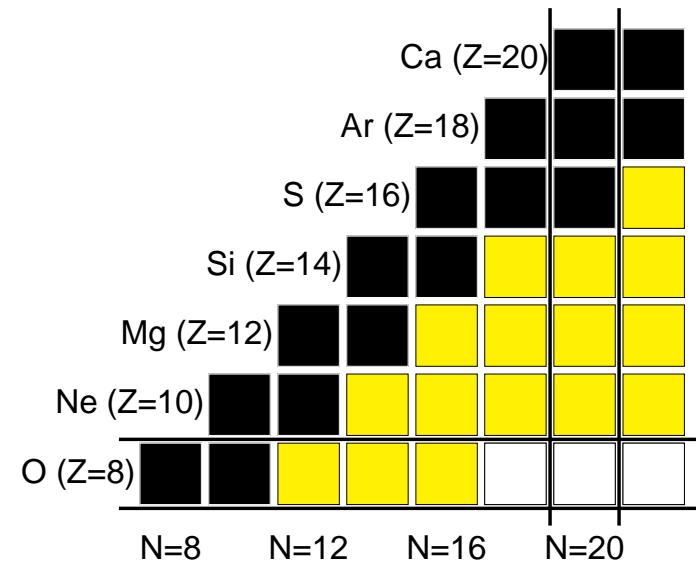
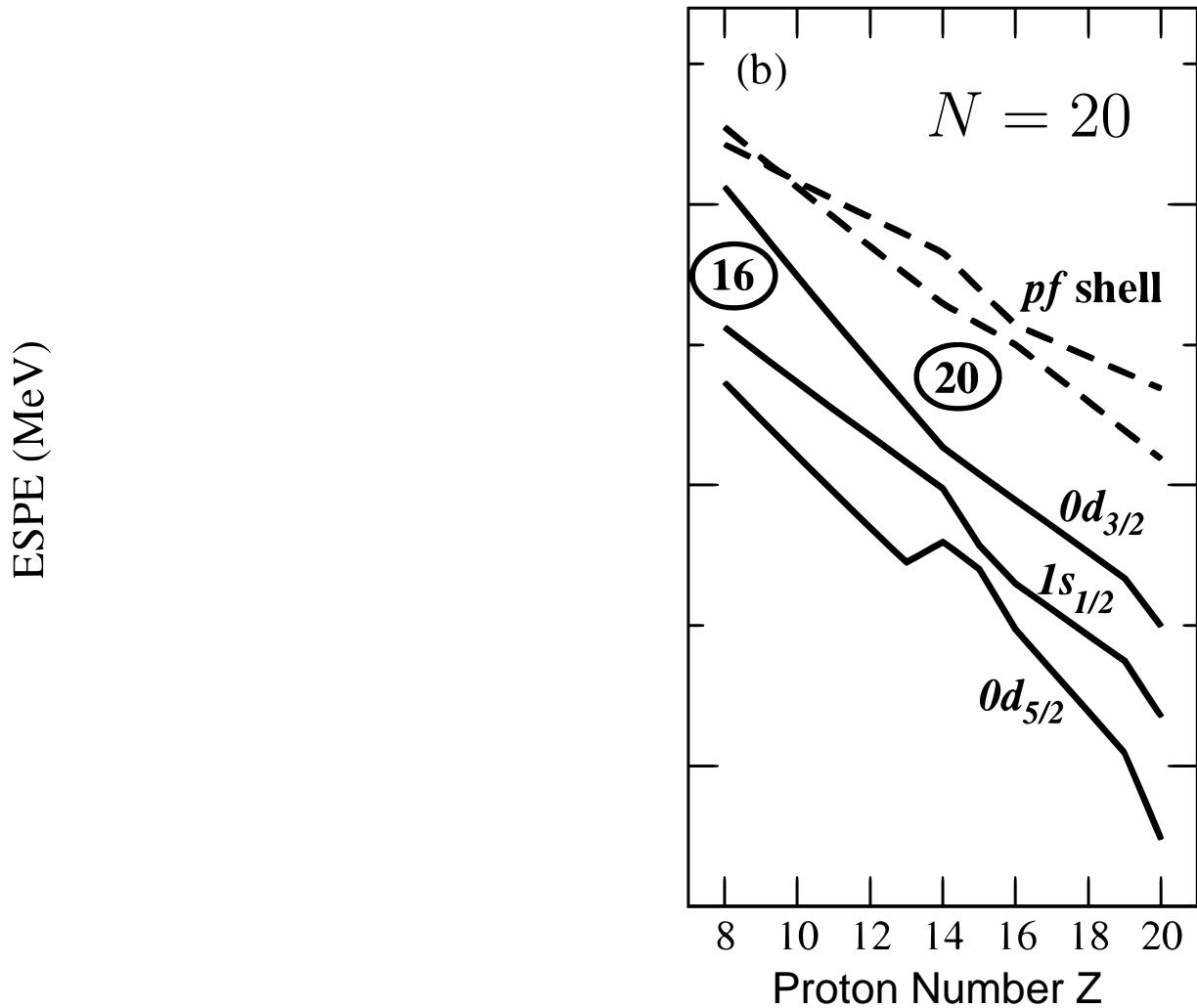
- build and tested in Munich
- detectors and electronics were funded by Leuven, Orsay and Munich
- first experiment with new transfer setup in fall 2007

Island of Inversion

Frontiers and challenges of nuclear shell model

T. Otsuka et al., Euro. Phys. Journal A 15, 151 (2002)

ESPE (MeV)

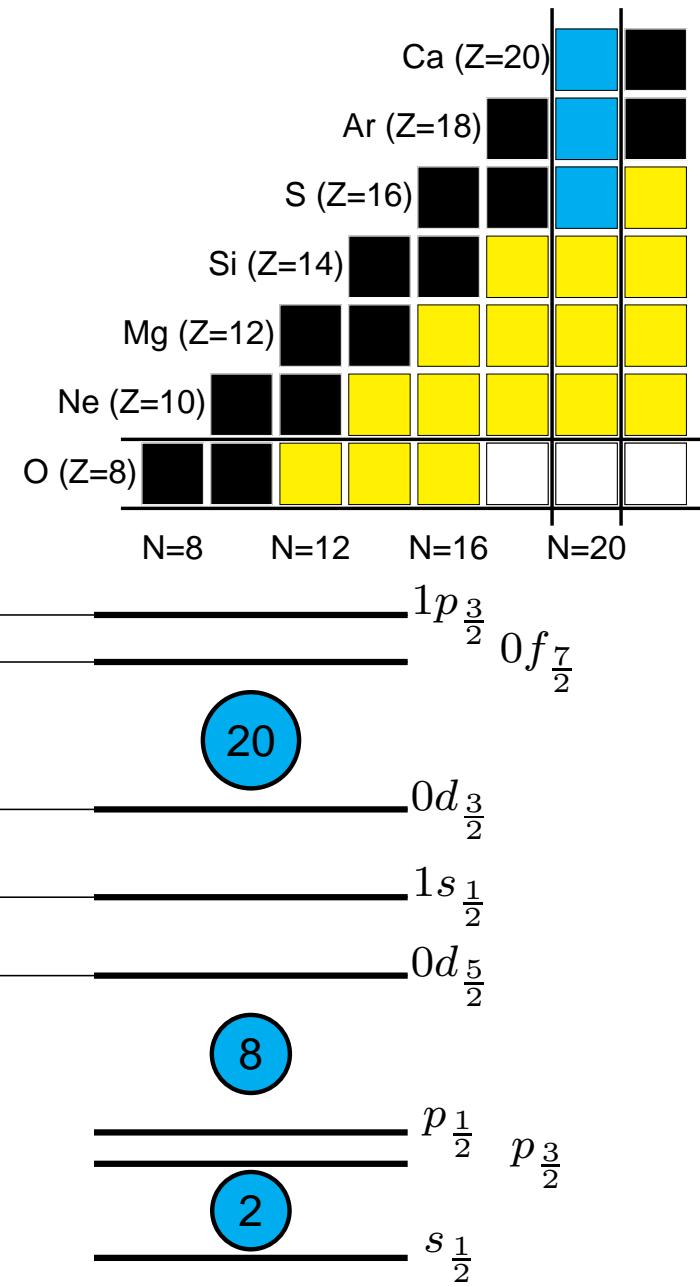
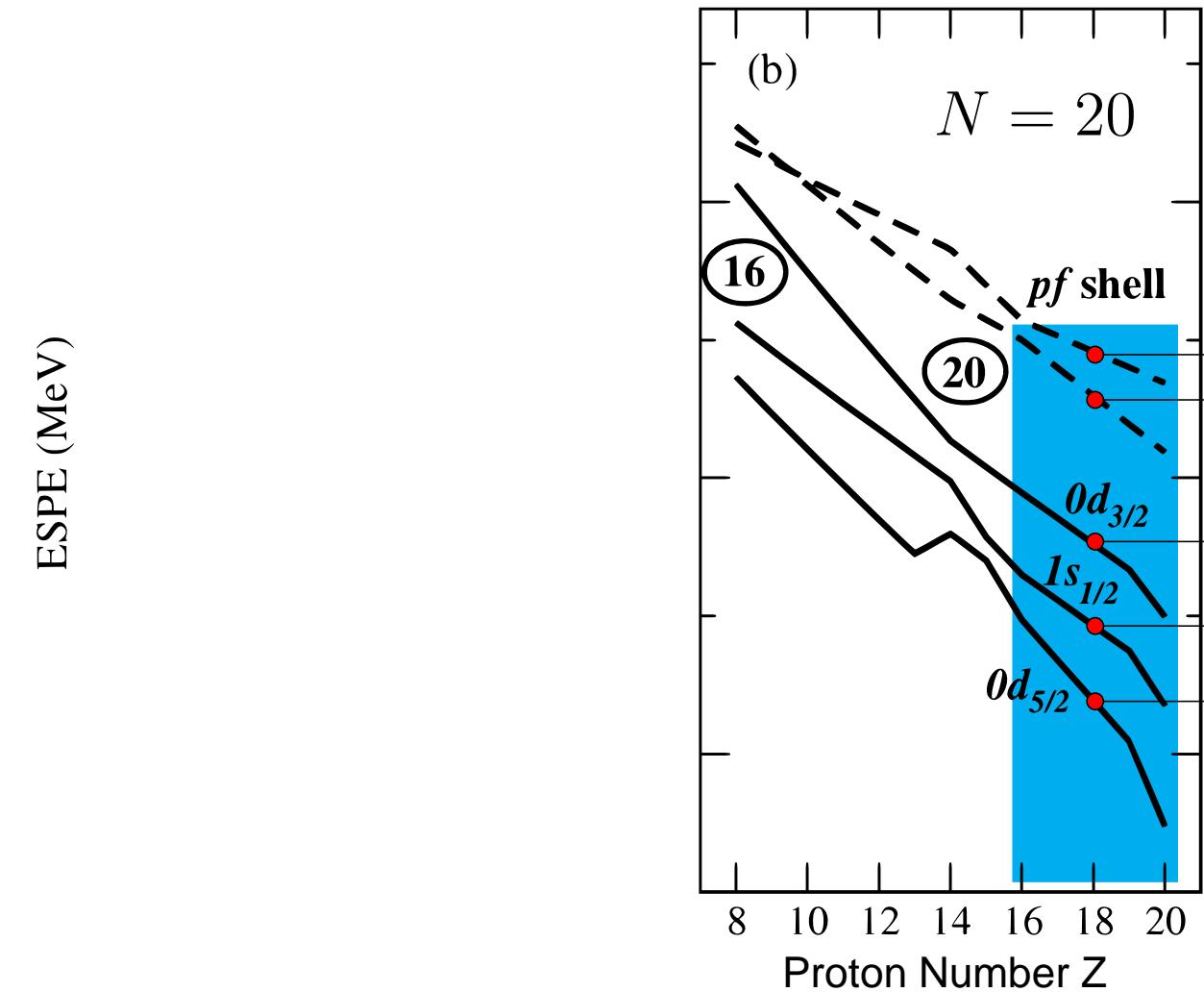


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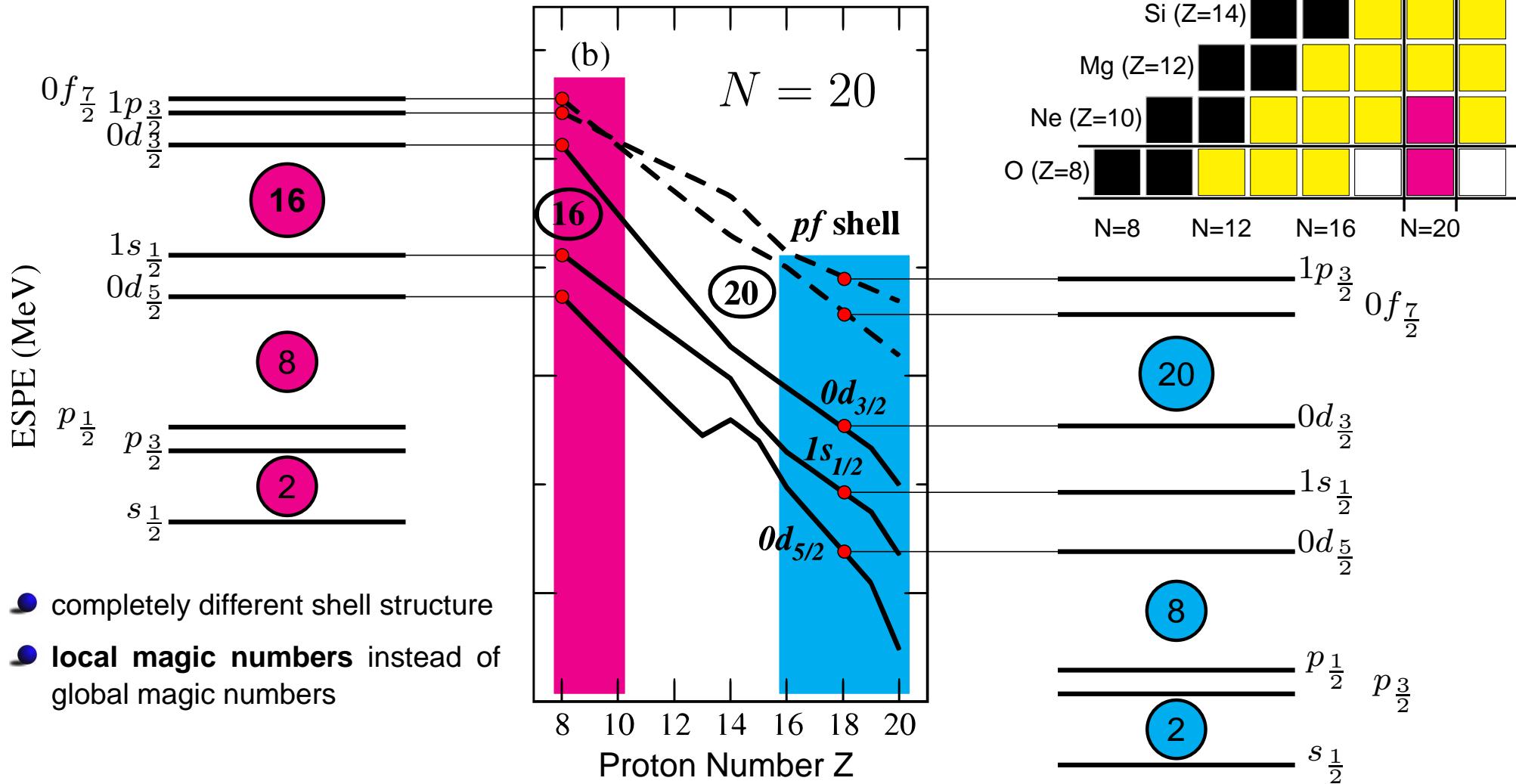
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Current Status of ^{31}Mg

IS410 @ REX-ISOLDE: “safe” Coulex

30Mg is OUTSIDE
and
32Mg is INSIDE
of the
“Island of Inversion”

many theories explain
this, but . . .

O. Niedermaier et al.,
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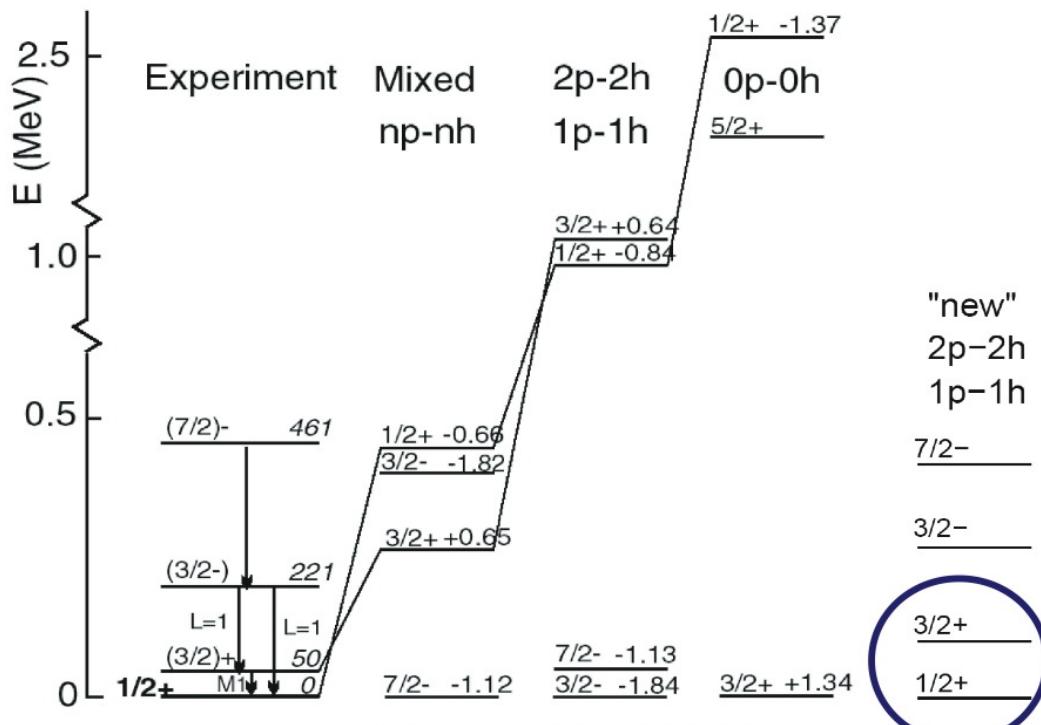
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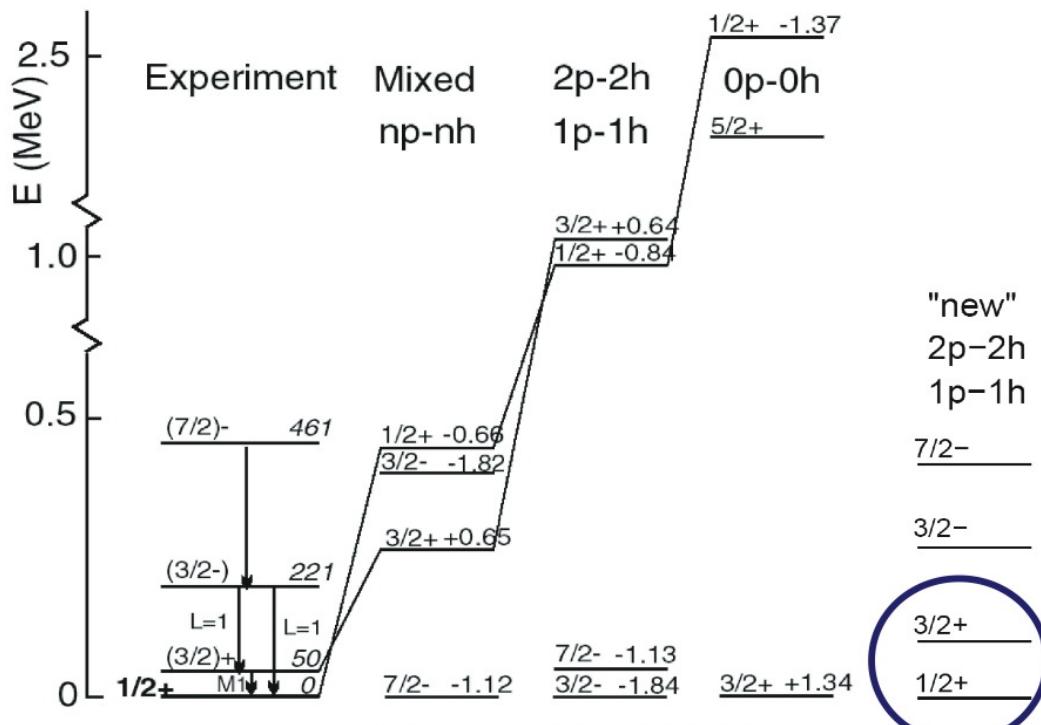
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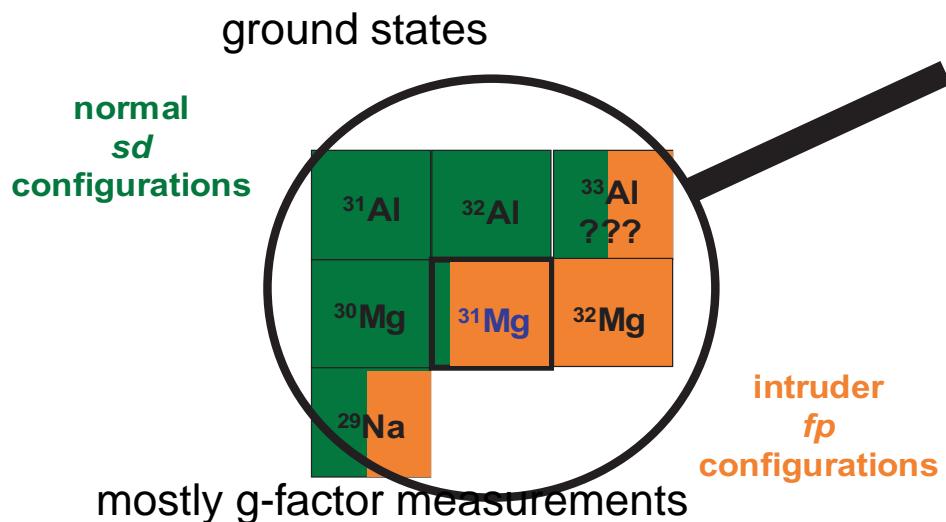
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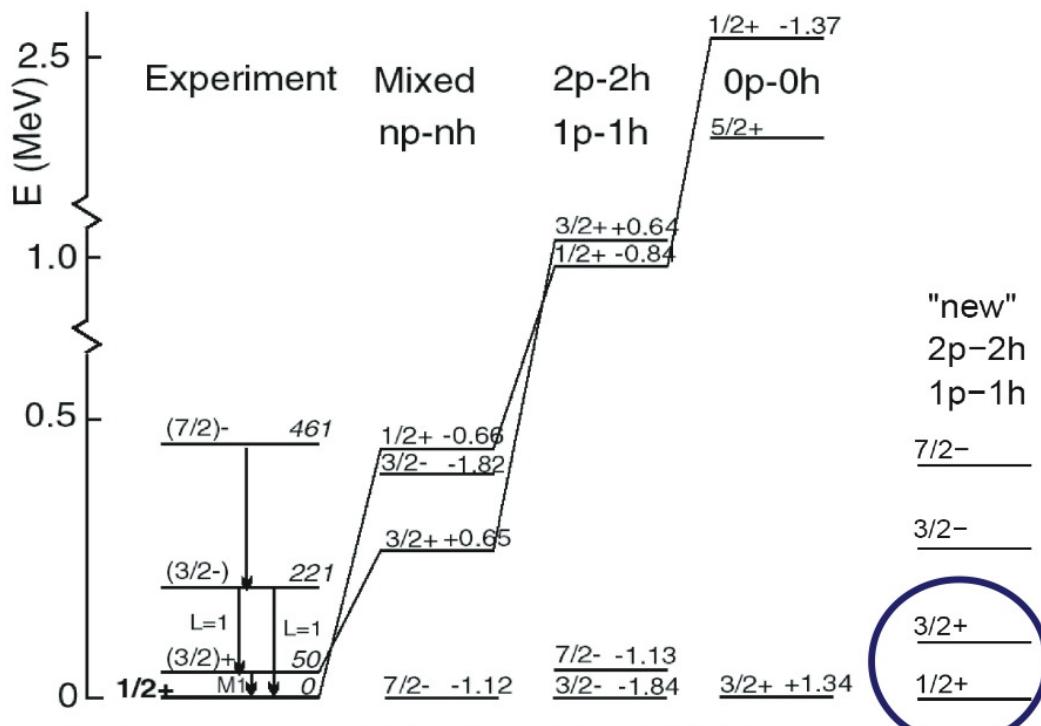
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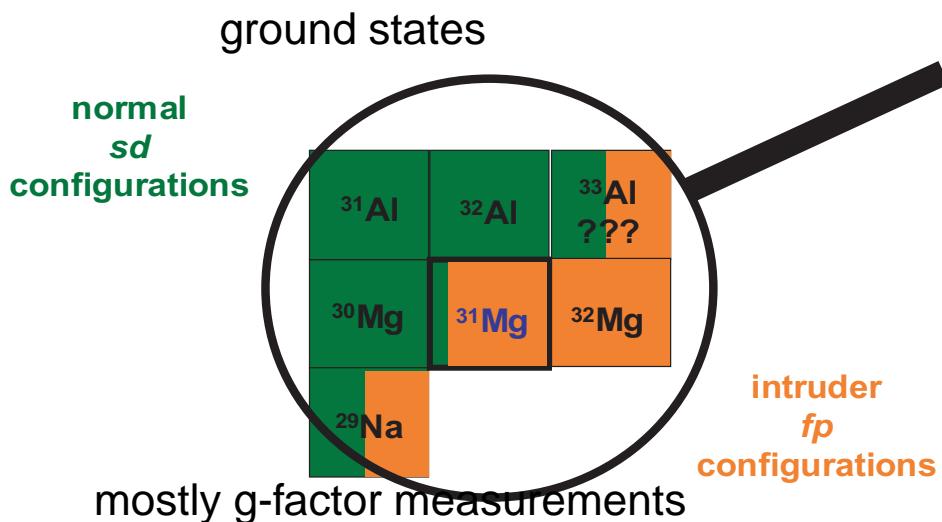
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Check the configurations of
the excited states with (d,p)
transfer reaction in inverse
kinematic.

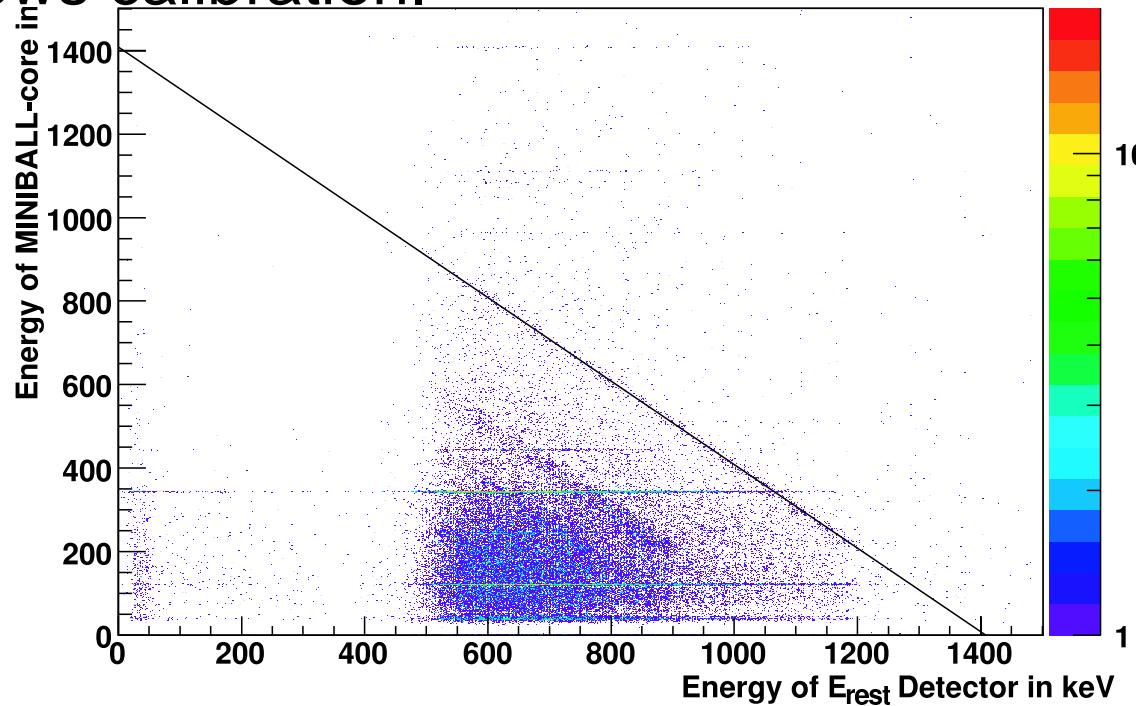


Calibration of E_{rest} Detectors

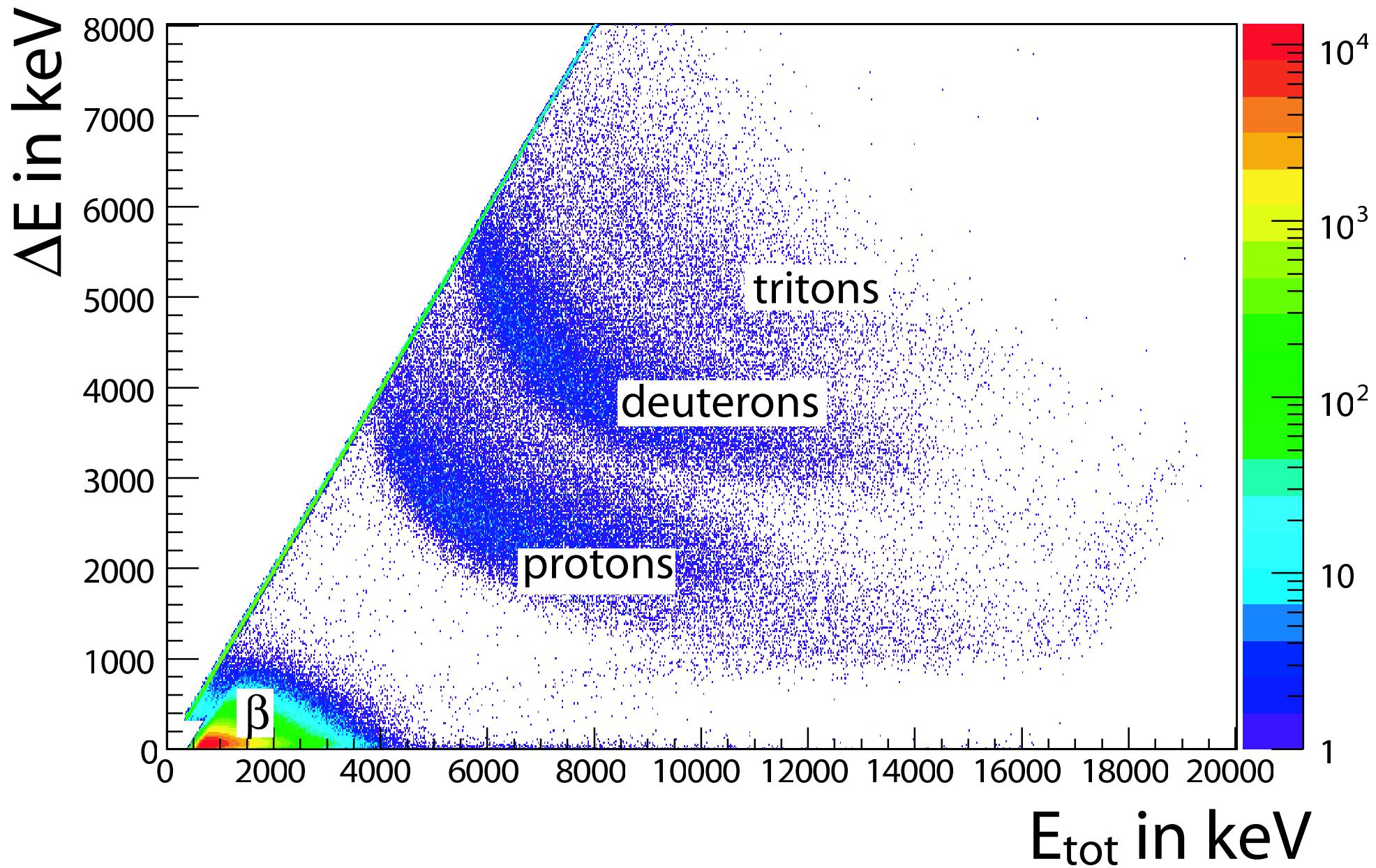
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Calibration with α -source not possible for E_{rest} detectors
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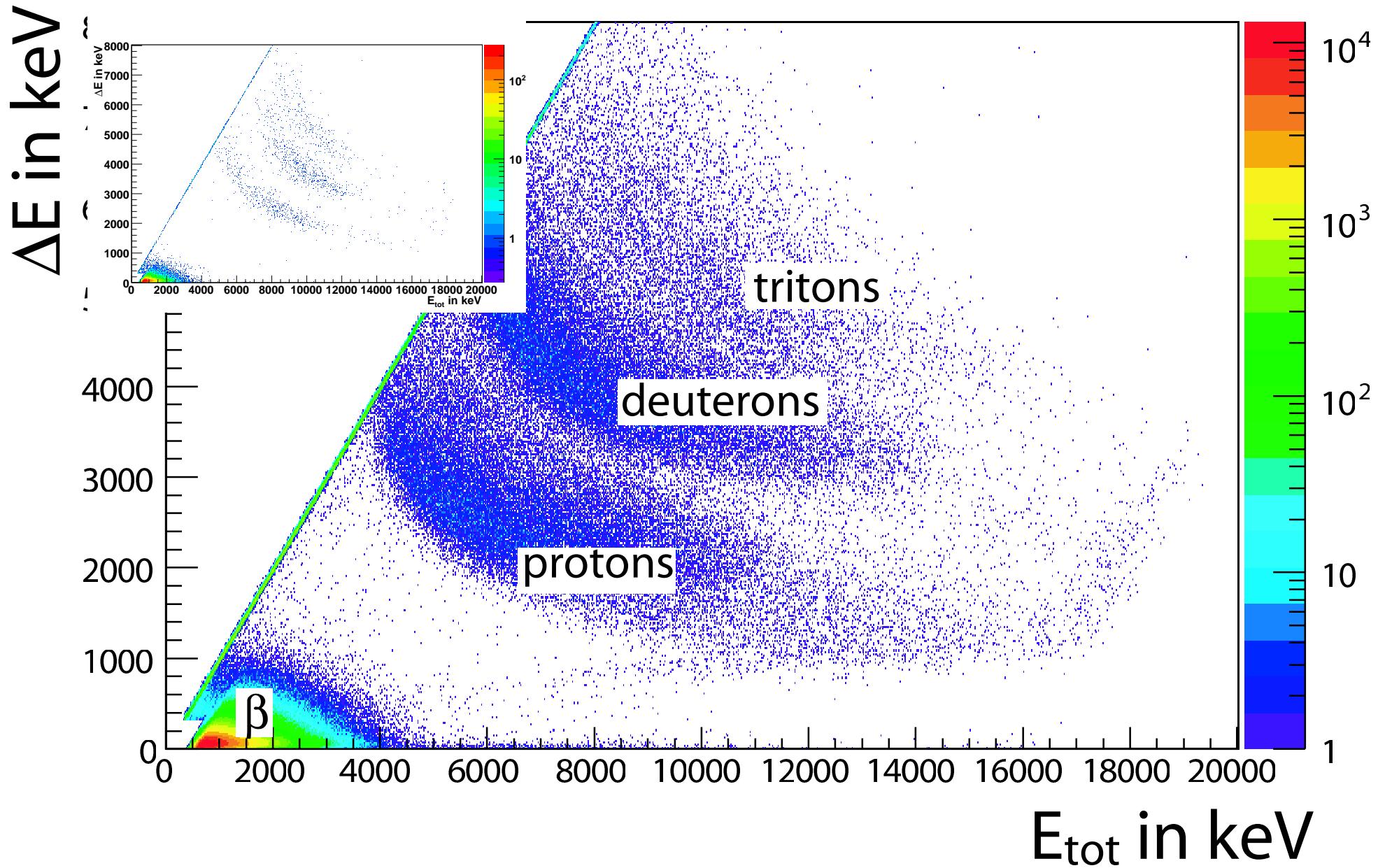
- Barrel detectors in forward direction are $\Delta E - E_{\text{rest}}$ telescopes:
Calibration with α -source not possible for E_{rest} detectors
because the ΔE -detectors in front of them stop the α particles.
- But detection of γ s (e.g. from a ^{152}Eu source), which were compton-scattered in the E_{rest} detectors, with the MINIBALL-array allows calibration.



Particle Identification

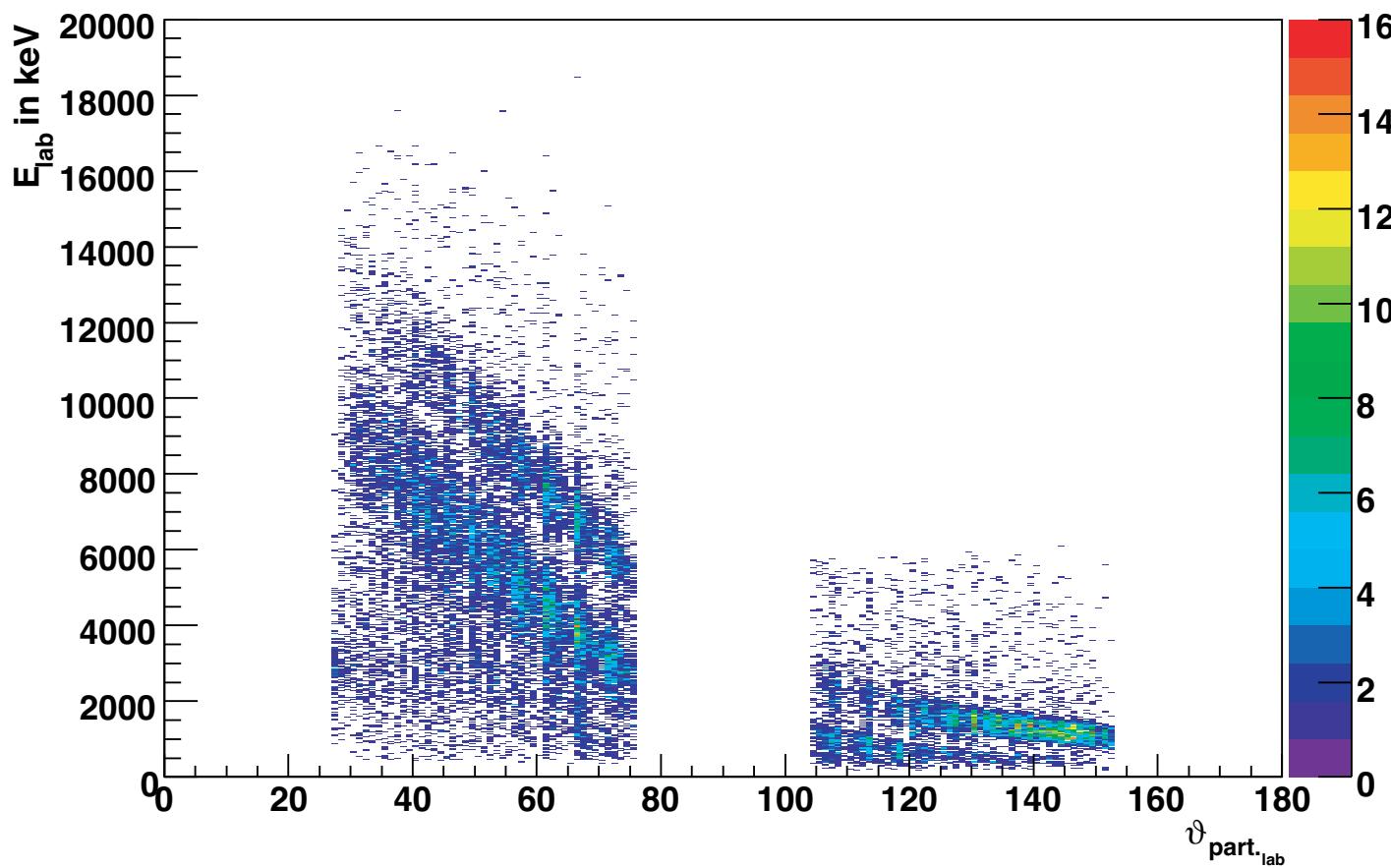


Particle Identification



$d(^{22}\text{Ne}, ^{23}\text{Ne})p$ reaction

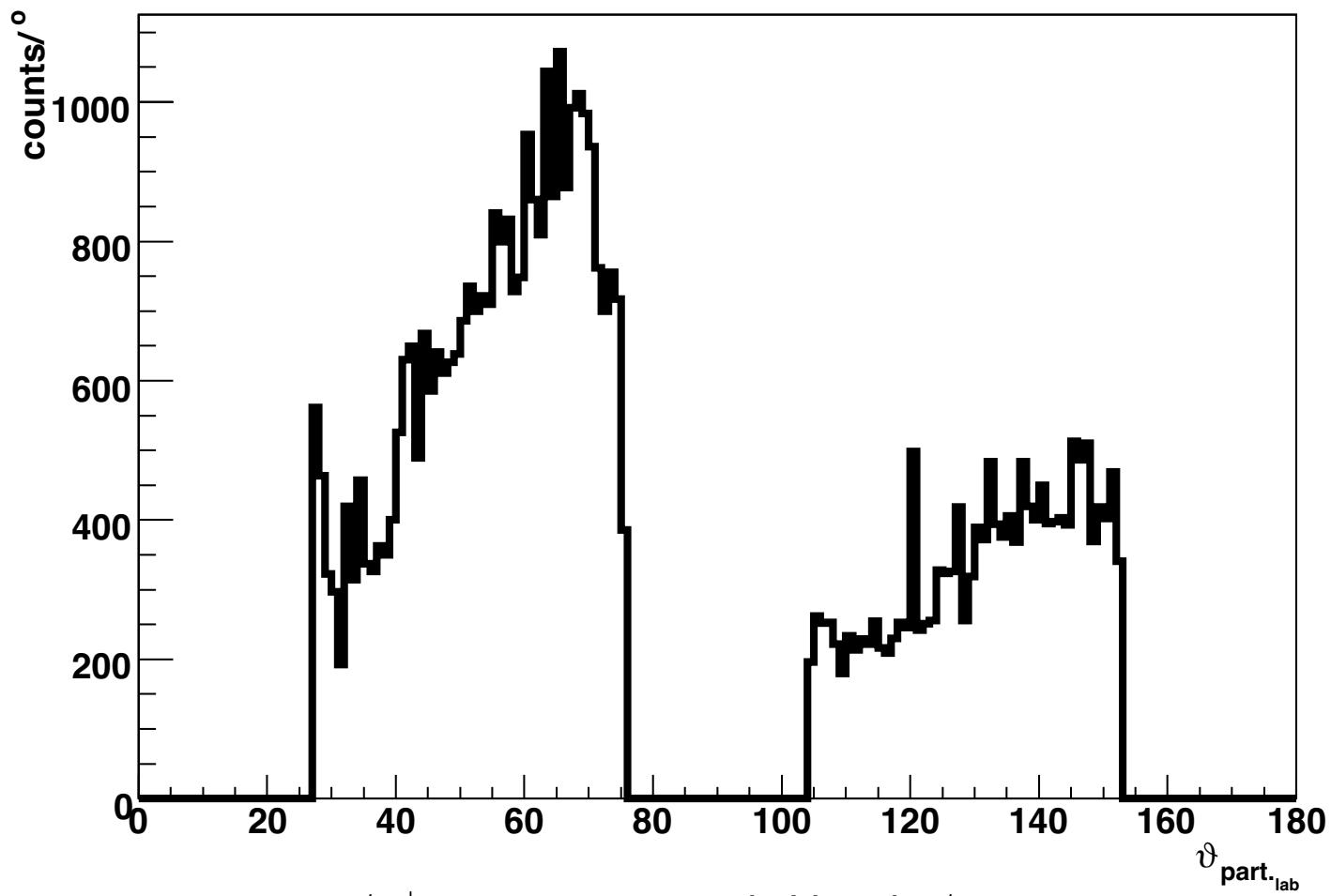
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- cut on prominent γ -line at 1016.95 keV



two components: $1/2^+$ state at 1016.95 keV and $3/2^-$ state at 3220.66 keV

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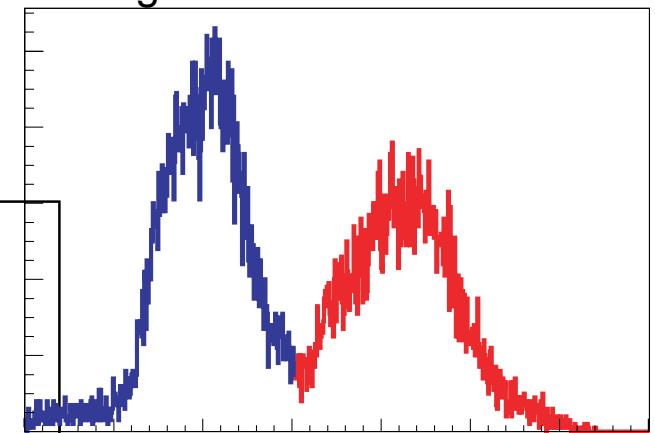
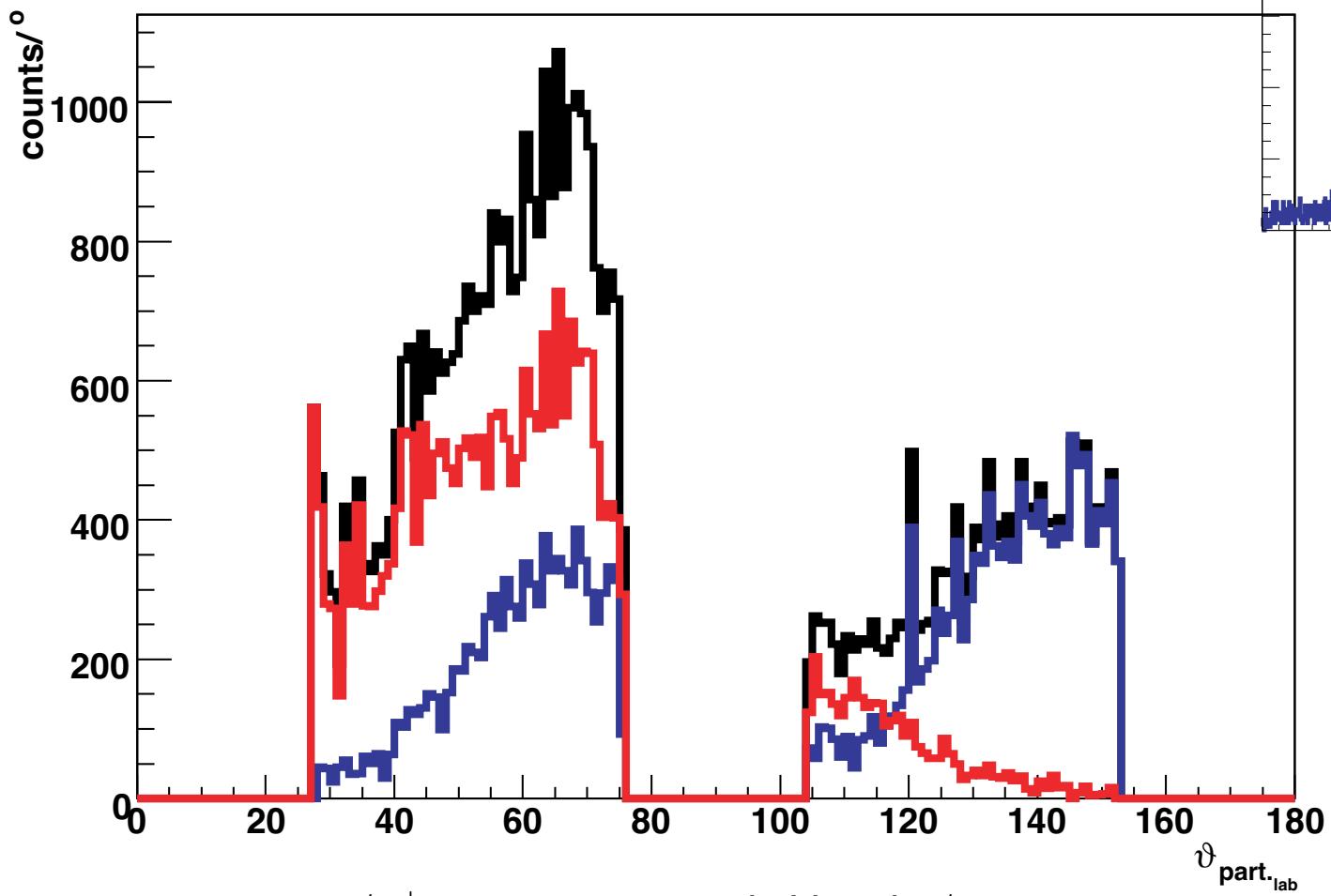
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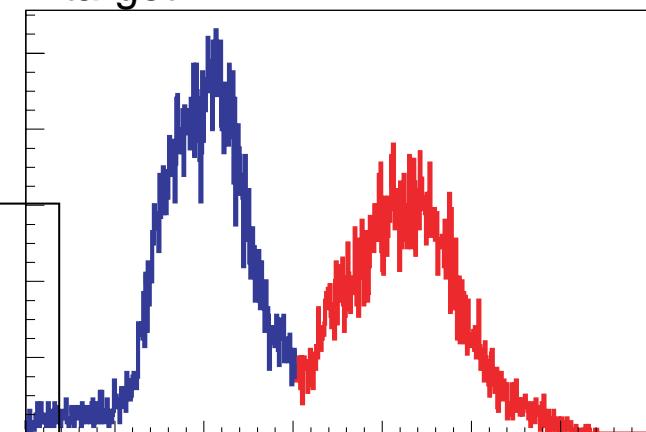
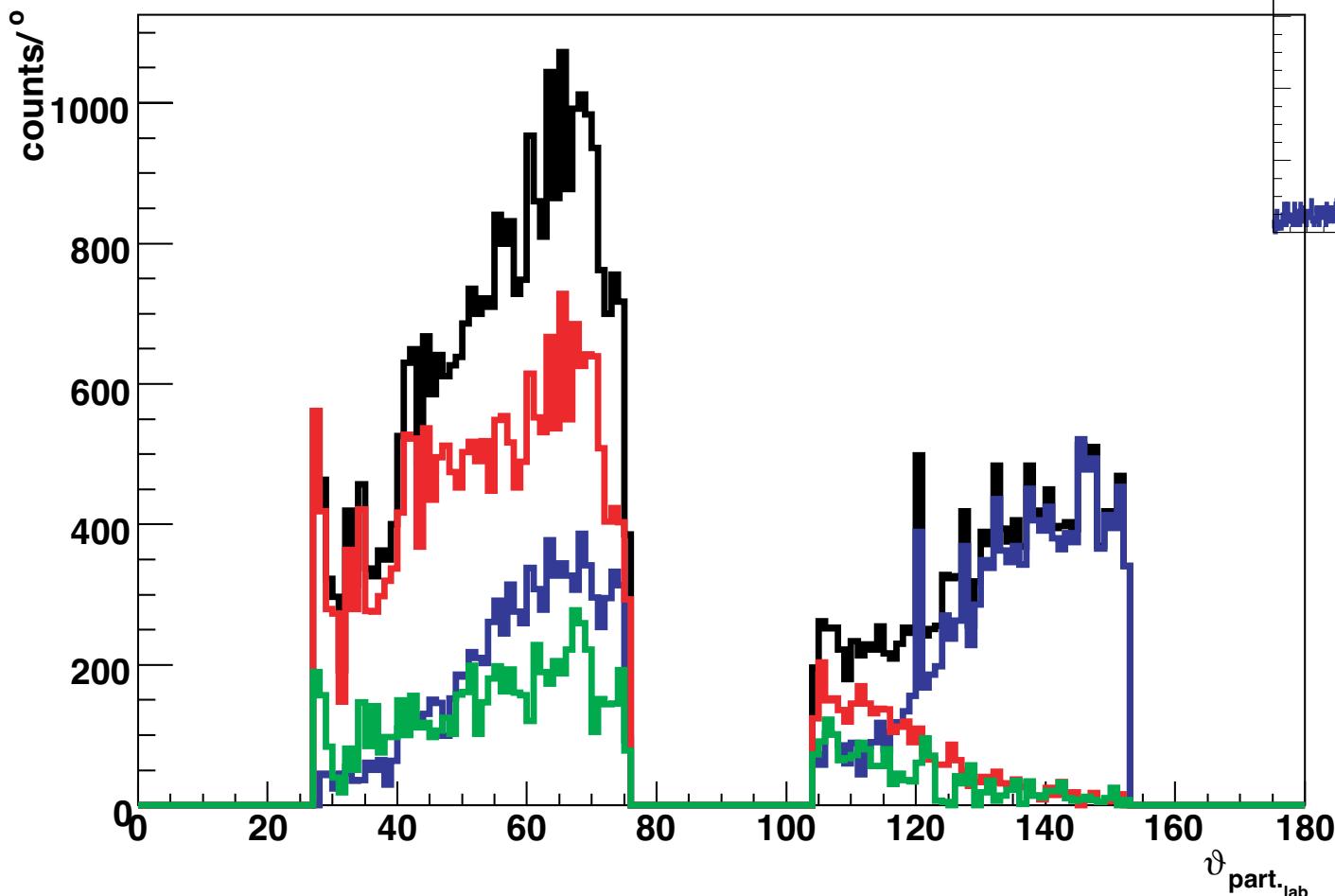
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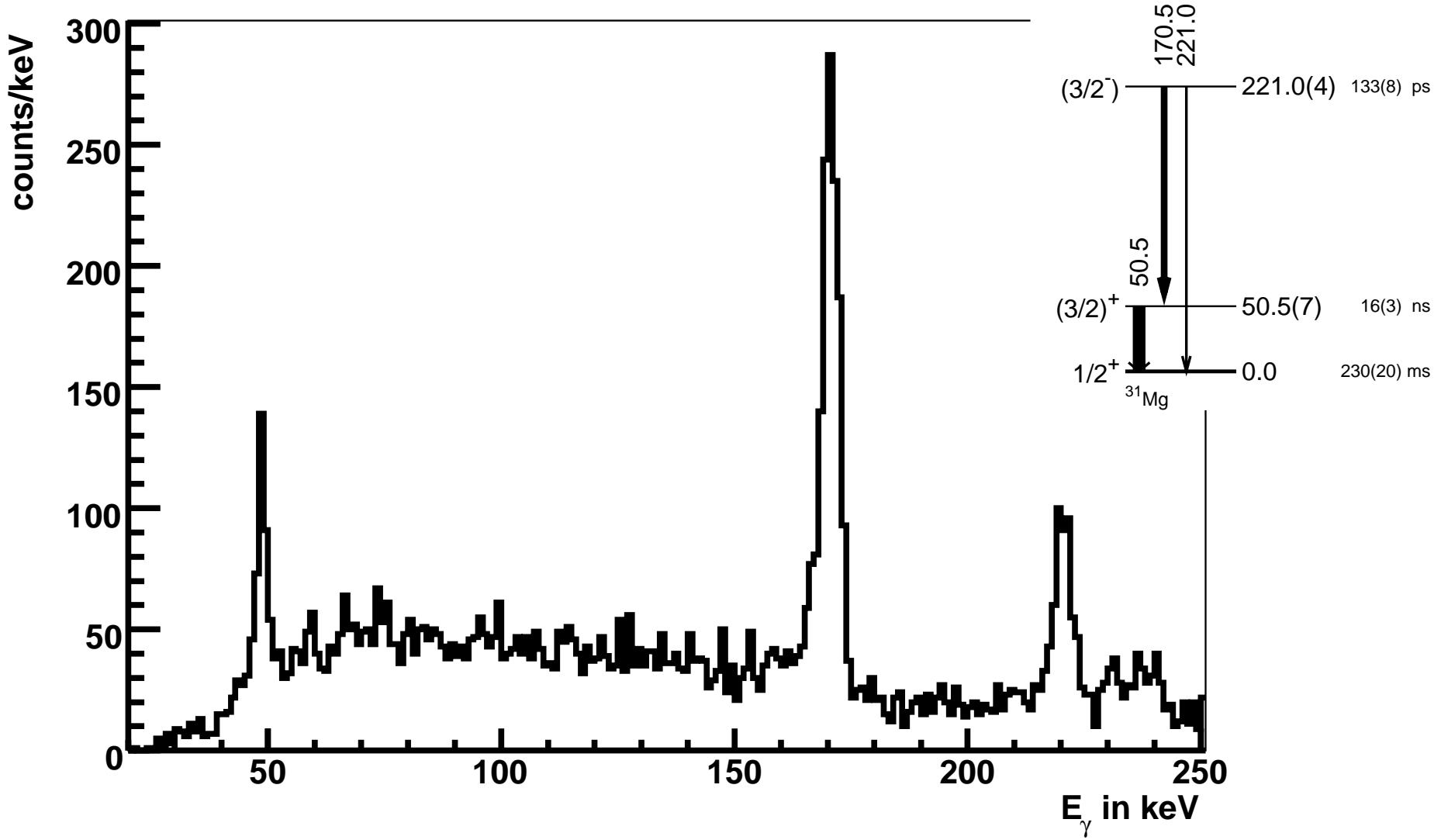
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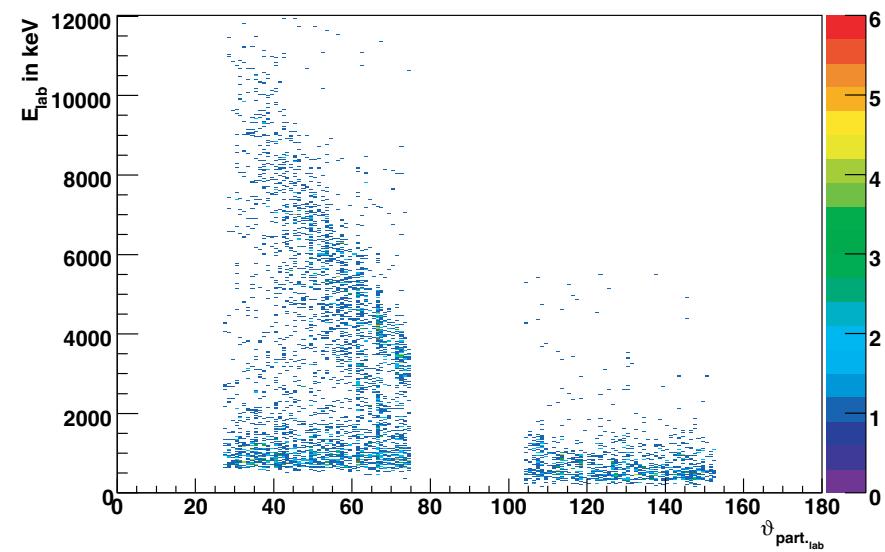
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γ -Spectrum

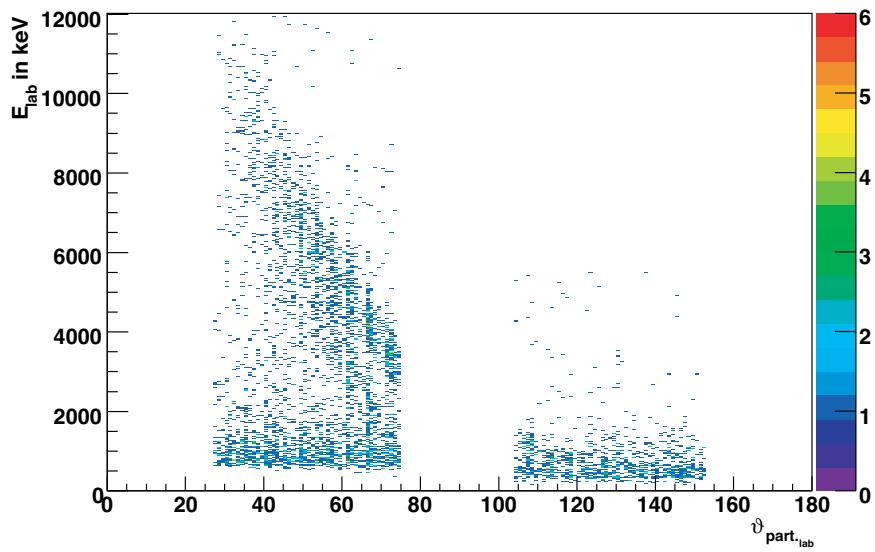
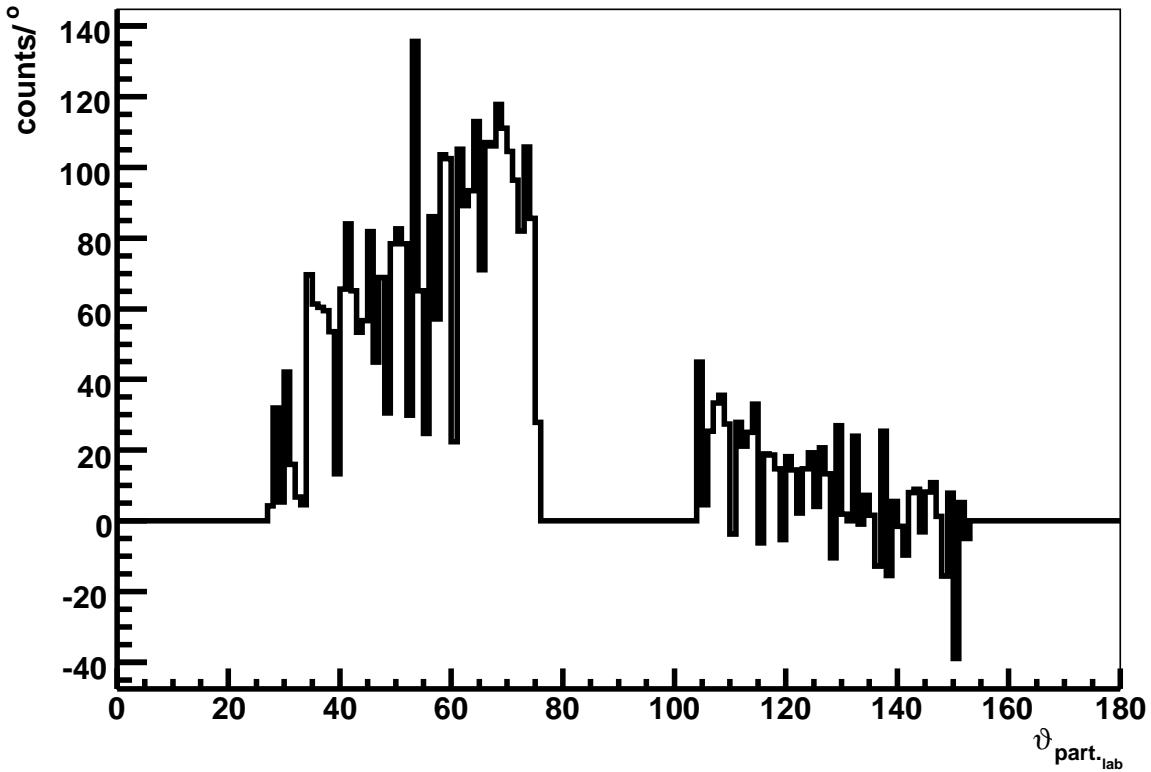


Cut on coincident protons, Doppler corrected with $\vartheta(^{31}\text{Mg}) = 0^\circ$

Angular Distributions of ^{31}Mg



Angular Distributions of ^{31}Mg



- cut on 170.5 keV (6 keV width)
- correction for background by average of two windows of same width at 160 and 180 keV
- no correction for feeding from higher states

Improvements

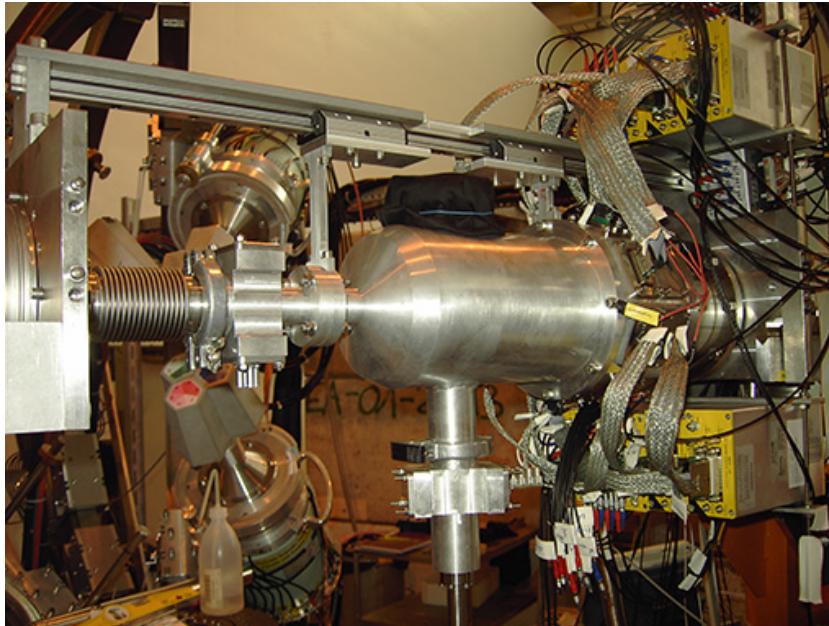
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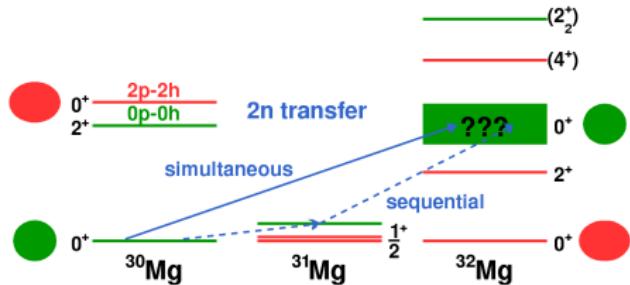
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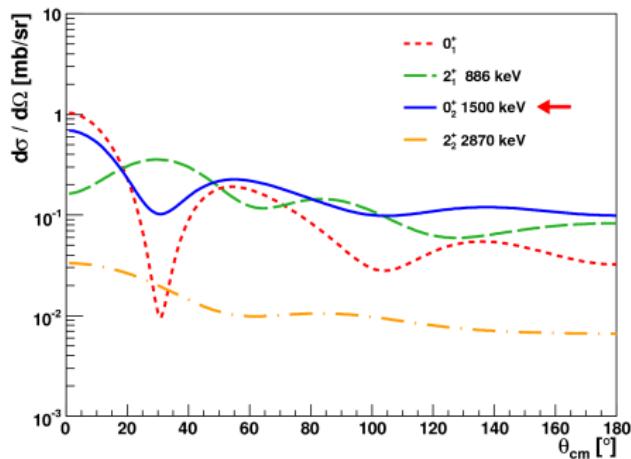


Shape coexistence in the "Island of inversion": Search for the 0_2^+ state in ^{32}Mg applying a two-neutron transfer reaction



similar particle-hole structure:

- large overlap of wavefunctions
- large spectroscopic factor for transfer
- selective population

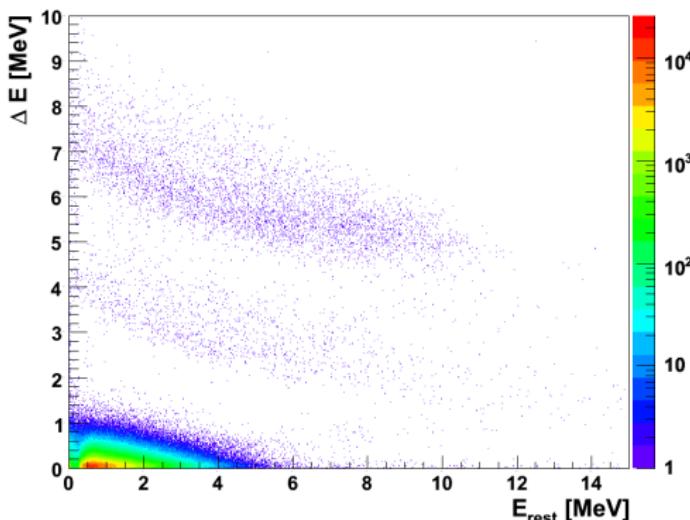


expected about 700 counts in 9 days for the 0_2^+ state

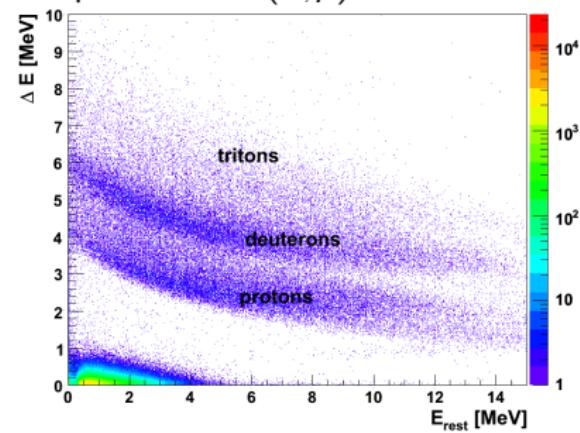
Experimental challenge: radioactive tritium target

- use of tritium loaded titanium foil
- low beam energy 55 MeV to avoid fusion with the titanium

Identify particles in forward direction by $\Delta E - E_{rest}$:

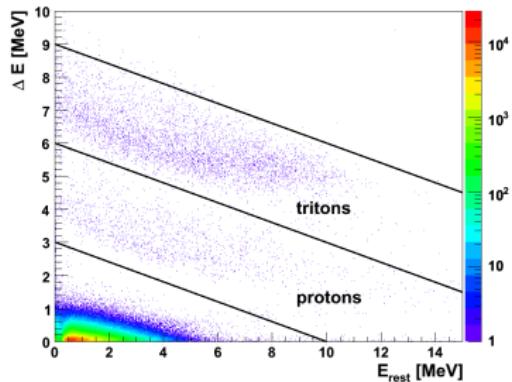


comparison with (d, p) run

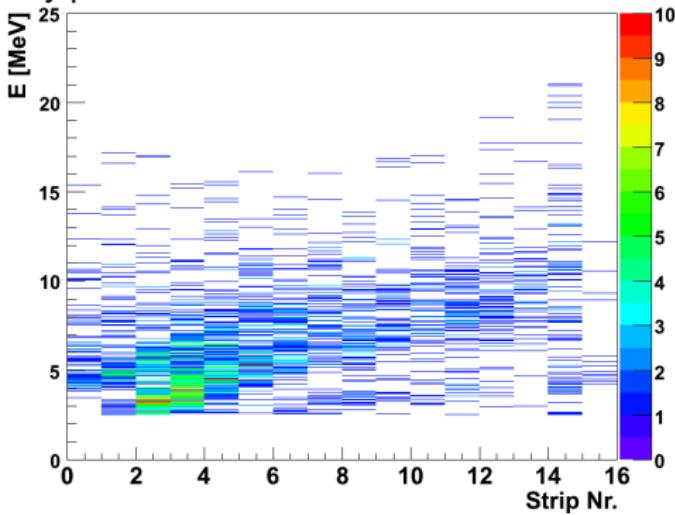


no deuterons, (t, d) reaction disfavored by large negative Q-value $Q = -3.9$ MeV

In forward direction cut on protons in $\Delta E - E_{rest}$ spectrum:



only protons from reactions



- about 2000 protons identified in 150 h of beam time
- elastic scattered protons are stopped in the ΔE detector
- two neutron transfer reactions in inverse kinematics work!
- 3 states visible?
- about 900 counts in each region consistent with our expectation

Summary & Outlook

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- further experiments were approved:
 - $d(^{66}\text{Ni}, ^{67}\text{Ni})p$ - proposed by KU Leuven
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 - more to come
- upgrade to HIE-ISOLDE:
 - higher beam energies will be available
 \Rightarrow transfer reactions with higher masses possible
 - 0° -spectrometer will allow direct measurement of the nuclei of interest

Collaboration

Physik-Department E12, Technische Universität München, Garching, Germany
Instituut voor Kern- en Stralingsfysica, Katholieke Universiteit Leuven, Belgium
CERN, Genève, Switzerland

Department of Physics and Astronomy, University of Edinburgh, Scotland, United Kingdom
Fundamental Physics, Chalmers Tekniska Högskola, Göteborg, Sweden

Electronic Engineering and Physics, University of Paisley, Scotland, United Kingdom
Sektion Physik, Ludwig-Maximilians-Universität München, Garching, Germany

Nuclear Physics Group, Department of Physics, University of York, United Kingdom
Nuclear Physics Group, Schuster Laboratory, University of Manchester, United Kingdom
Oliver Lodge Laboratory, University of Liverpool, United Kingdom

Institut für Kernphysik, Universität zu Köln, Germany

Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, Orsay, France

Institut für Kernphysik, Technische Universität Darmstadt, Germany

INRNE, Bulgarian Academy of Sciences, Sofia, Bulgaria

Dipartimento di Fisica, Università di Camerino, Camerino, Italy

CSIS, IEM Madrid, Madrid, Spain

Daresbury Laboratory, Warrington, United Kingdom

Lawrence Berkeley National Laboratory, Berkeley, USA

University of Aarhus, Aarhus, Denmark

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Thanks for your attention!