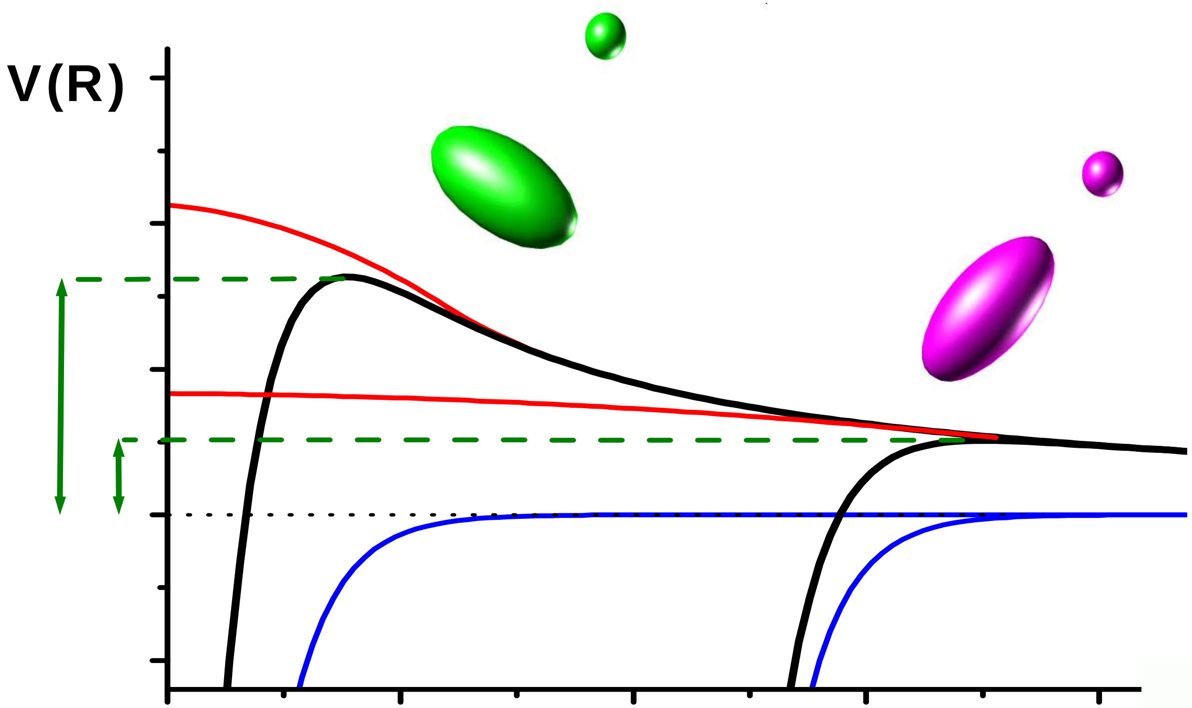
Rozkłady wysokości barier: pytania i odpowiedzi

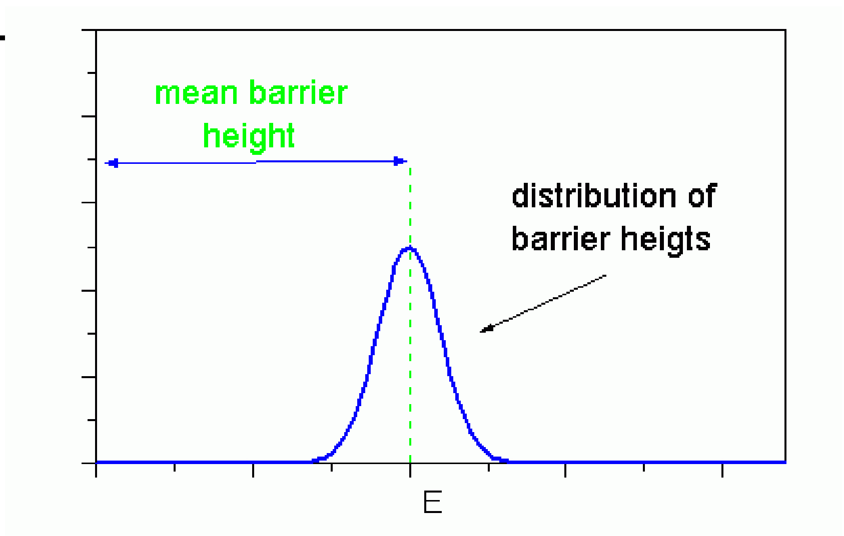
Eryk Piasecki

for the Barrier Collaboration

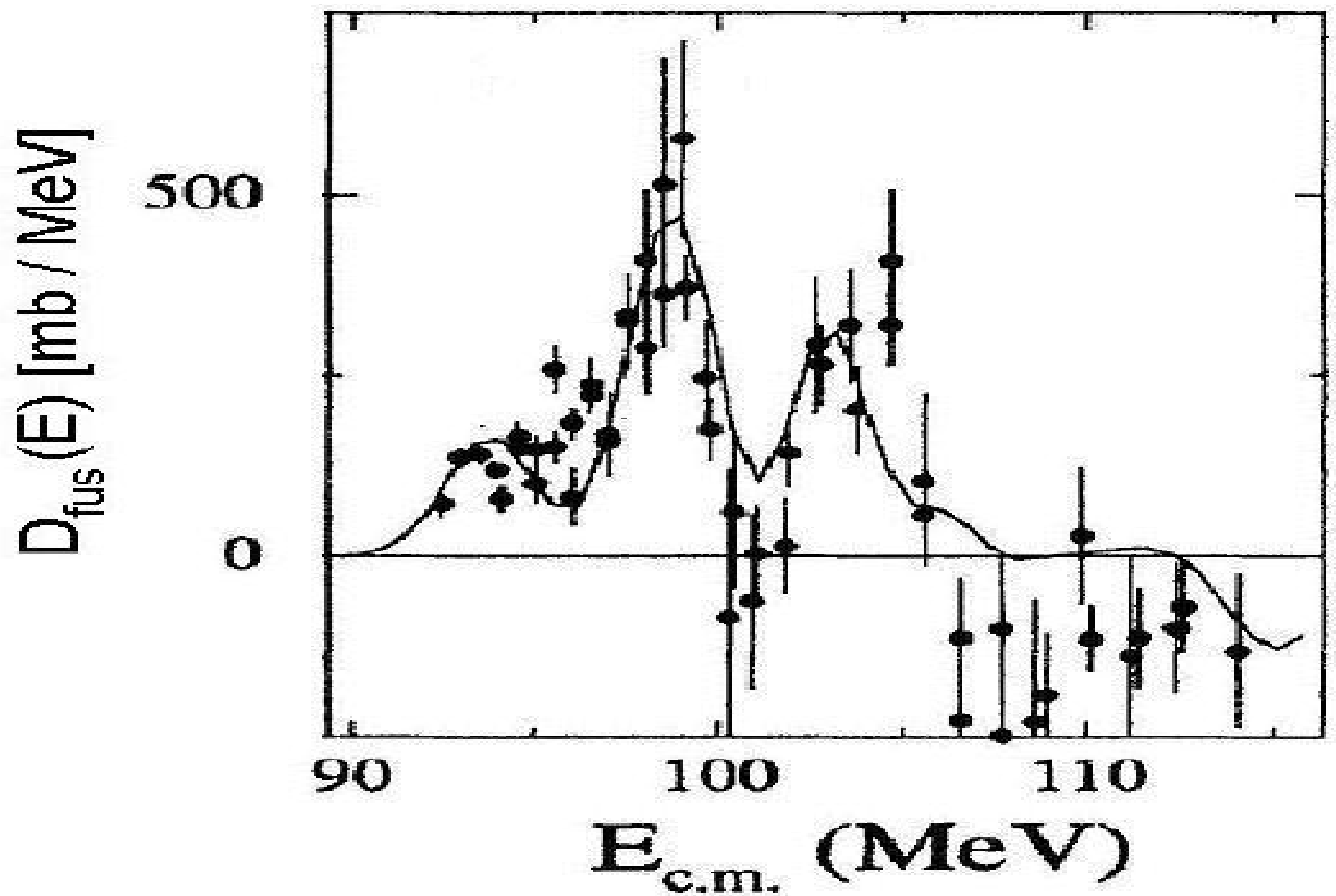
Warszawa, Styczeń, 2010

barrier height distribution



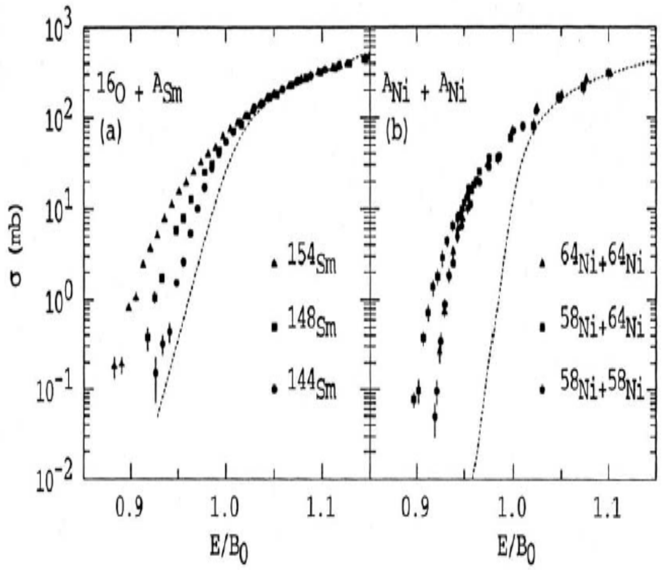


$^{58}Ni + ^{60}Ni$



A.M.Stefanini et al., Phys.Rev.Lett. 74(1995)864

Motivati ons

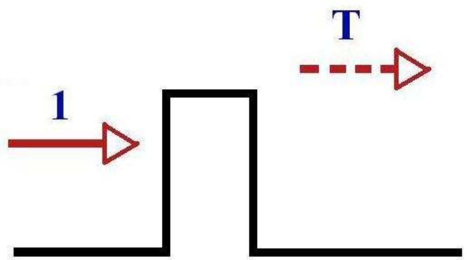


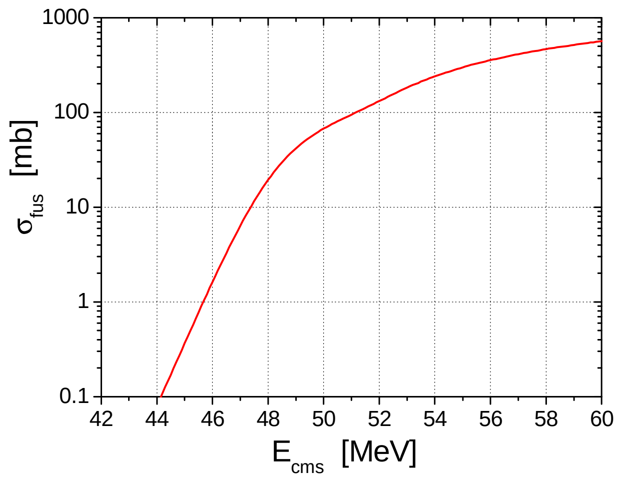
- tunneling through the barrier is influenced by environment (in nuclear phys. „environment” = nuclear structure)
- the structure influences reaction channels and couplings between them *(e.g. seen in fusion cross section enhancement)*
- barrier distribution is a fingerprint of the couplings
- theory testing: Coupled Channels Method with strong channels(*) explicitly taken into account

(*) *strong channels = connected with collective state excitations*

Two experimental methods:

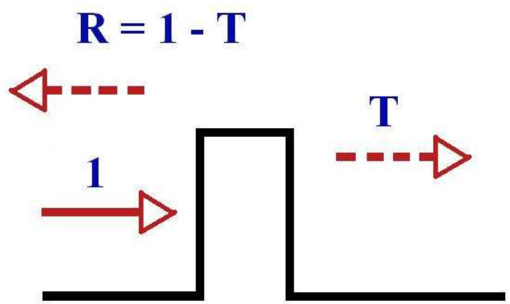
FUSION

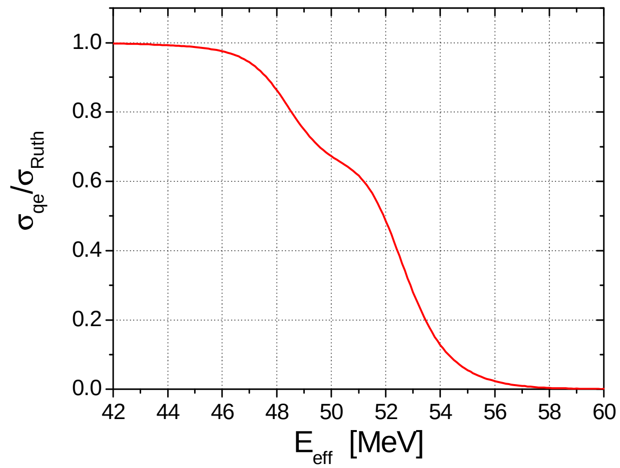




$$D_{fus}(E) = \frac{d^2}{dE^2}\left(E\sigma_{fus}\right)$$

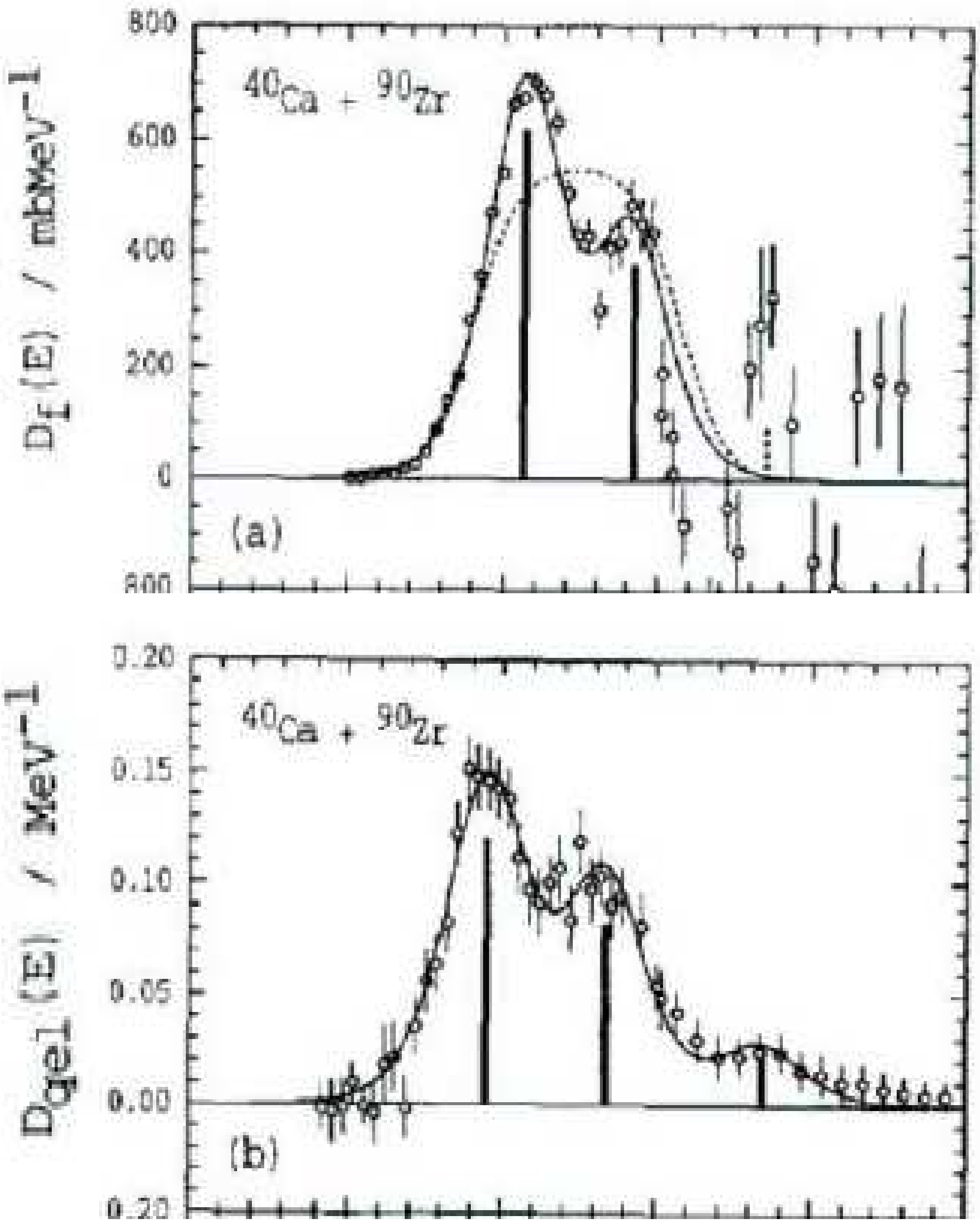
QUASI-ELASTIC BACKSCATTERING





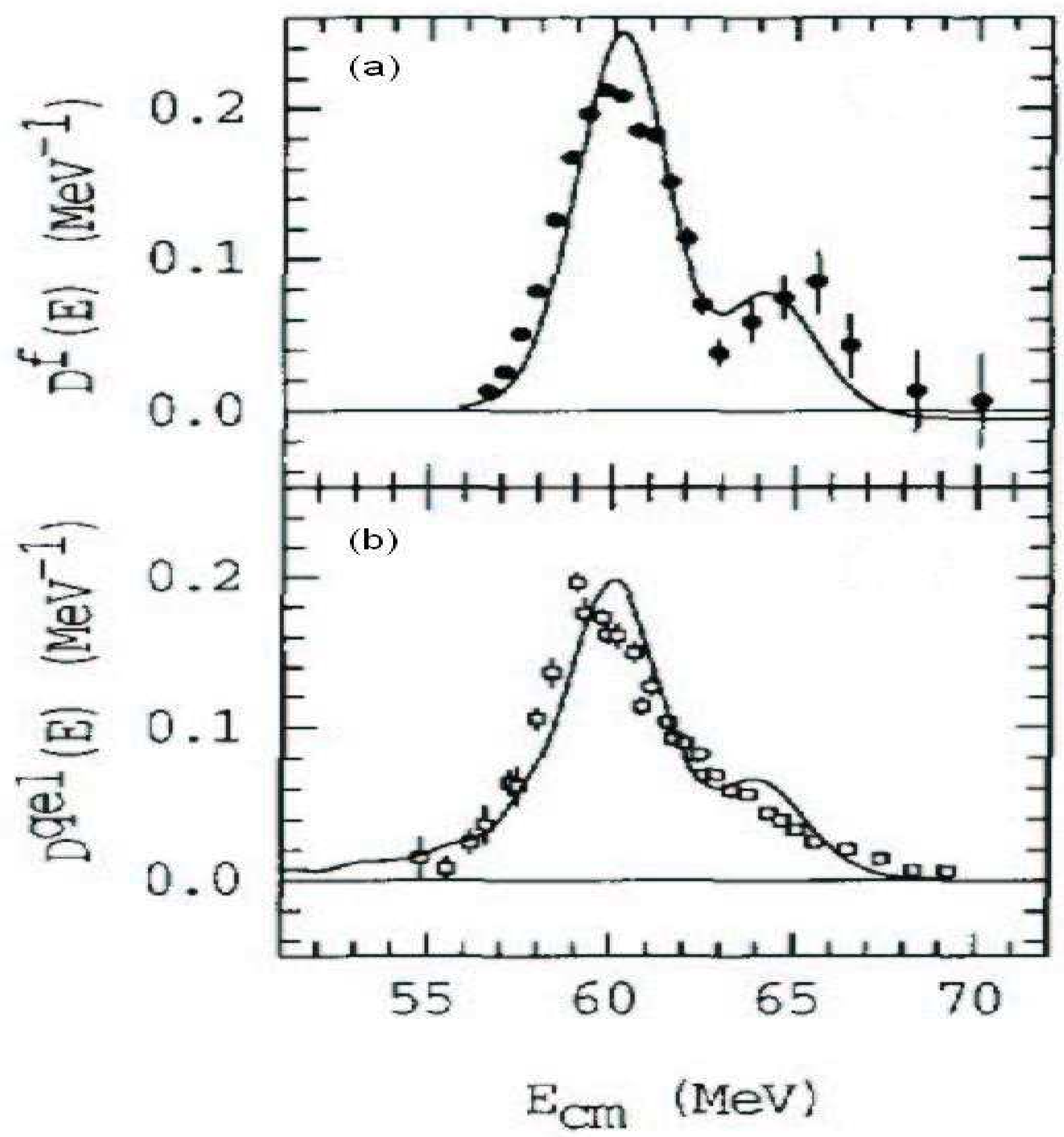
$$D_{qe}(E) = -\frac{d}{dE}\left(\frac{\sigma_{qe}}{\sigma_{Ruth}}\right)$$

Are the methods equivalent?



H.Timmers et al., NP A 633(1998)421

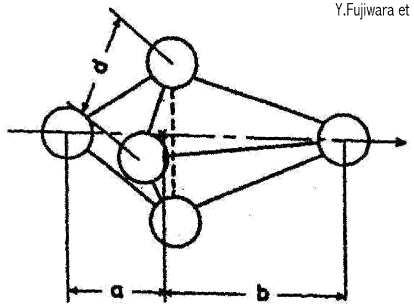
$^{16}O + ^{144}Sm$



H.Timmers et al., NP. A584(1995)195

Predictions of Coupled Channels Theory for $^{20}Ne + ^{118}Sn$ (CCFULL code)

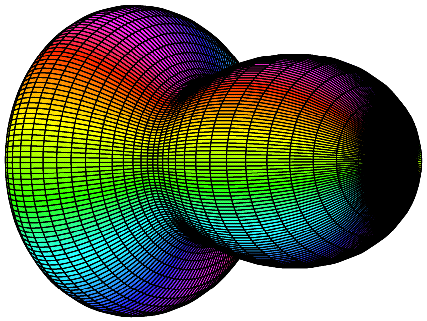
Y.Fujiwara et al., Suppl.Progr.Th.Phys. 68(1980)111



5α configuration of the basis intrinsic wave function in the α-^{12}C-α GCM; d is the distance between two α in ^{12}C-like core, and a and b are treated as the generator coordinates.

Cluster model

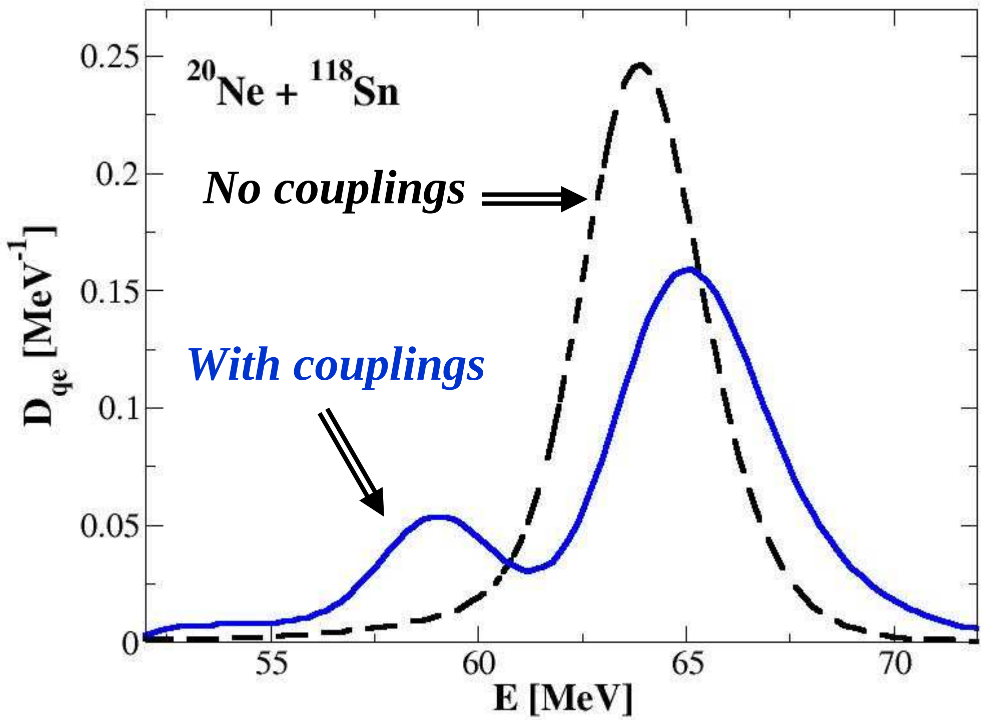
Shape of ^{20}Ne



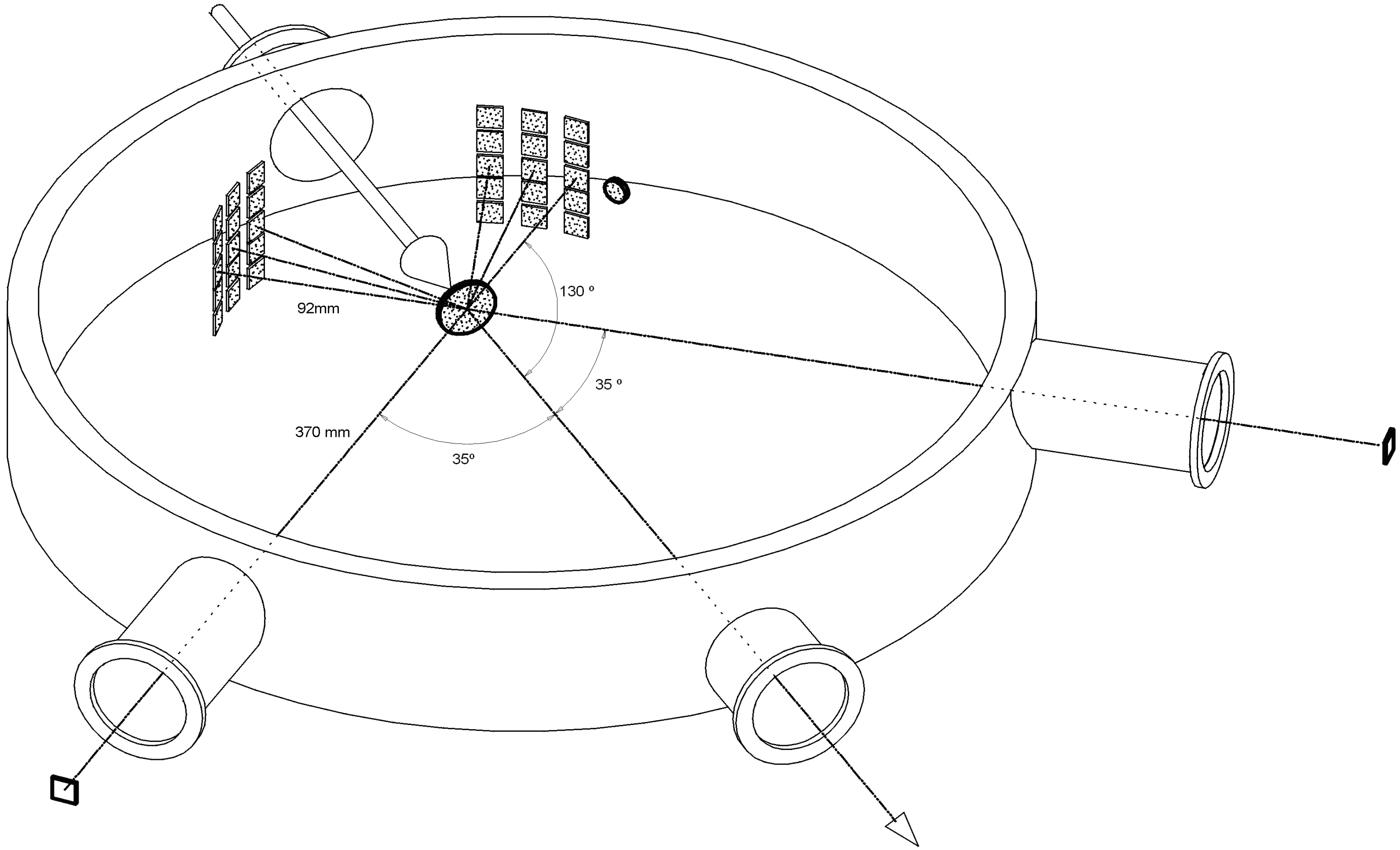
$\beta_2 = 0.46$

$\beta_3 = 0.39$

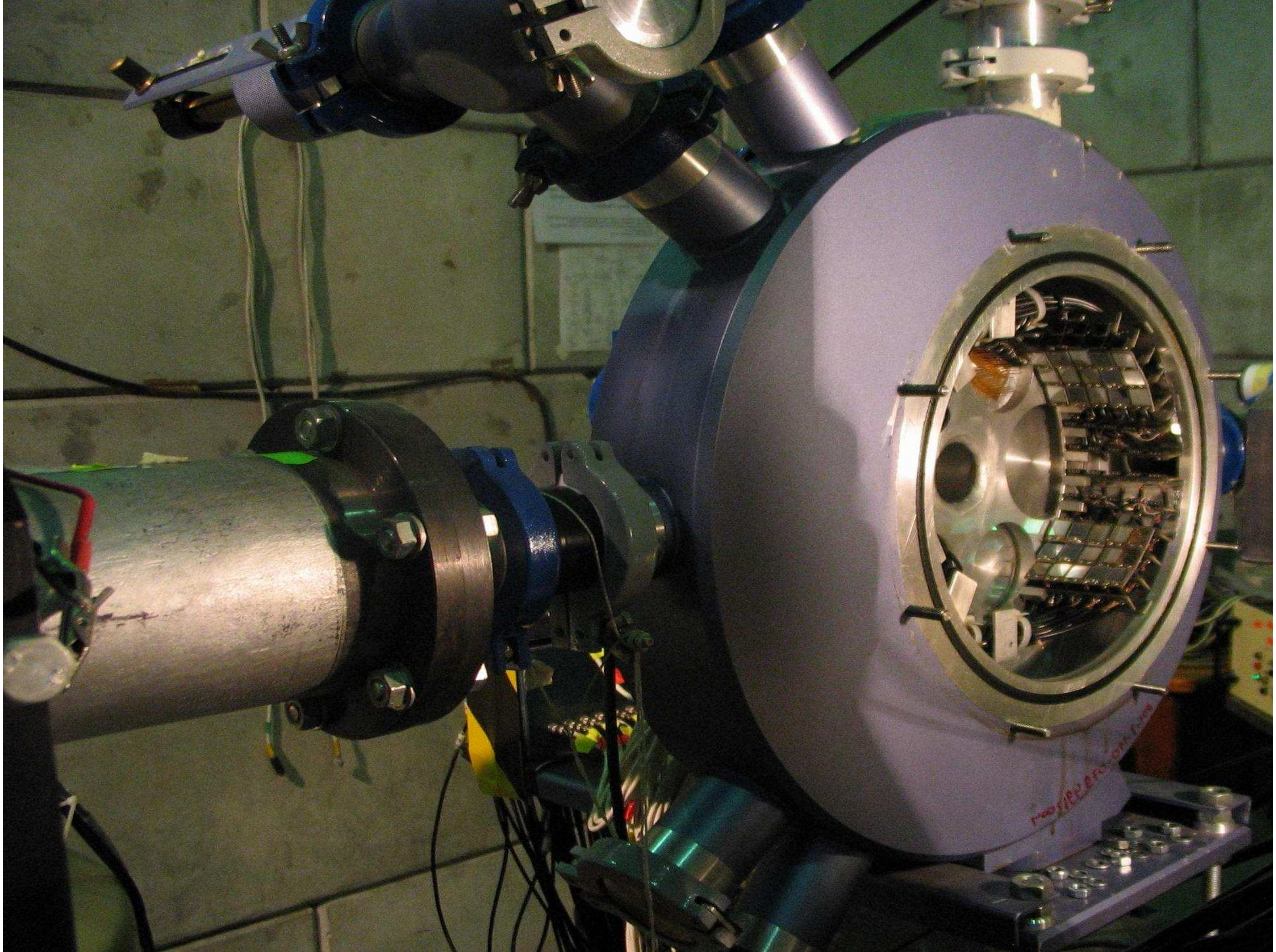
$\beta_4 = 0.27$

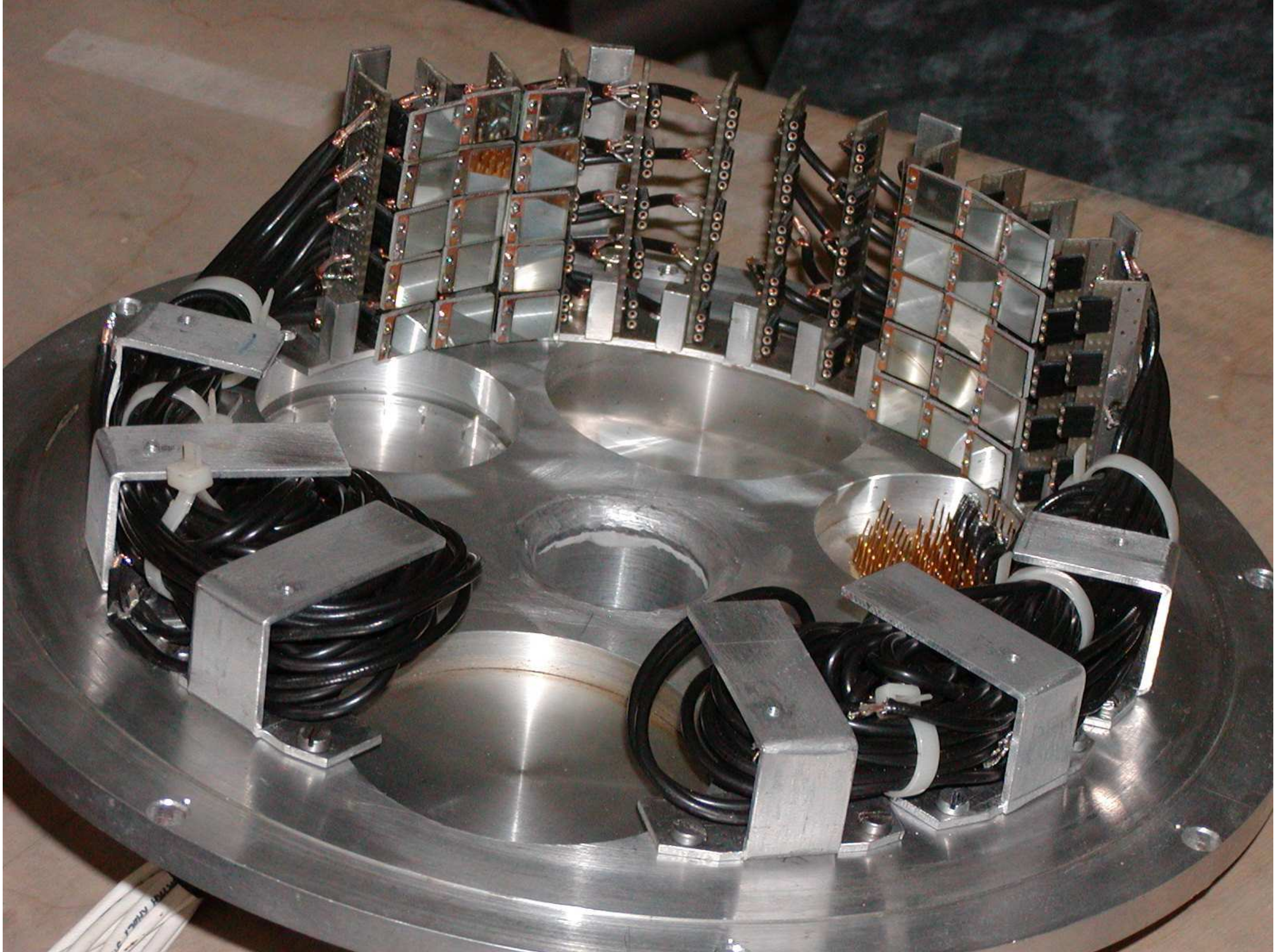


Realisation of the QE method in the Warsaw Cyclotron experiments



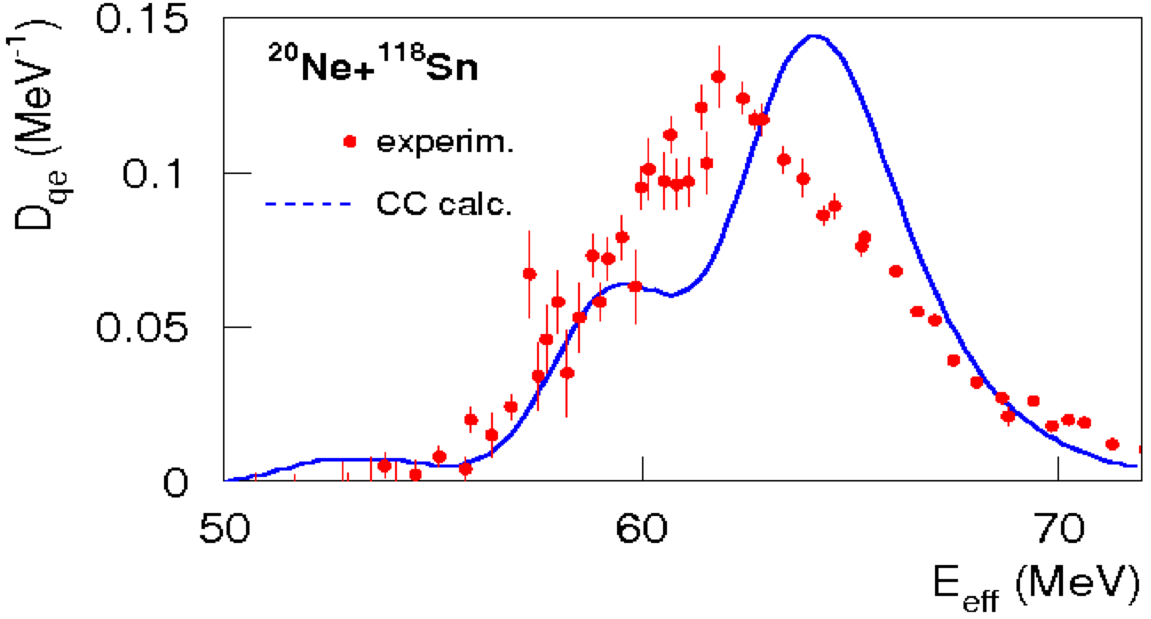
$$D_{qe}(E) = -\frac{d}{dE}\left(\frac{\sigma_{qe}}{\sigma_{Ruth}}\right)$$





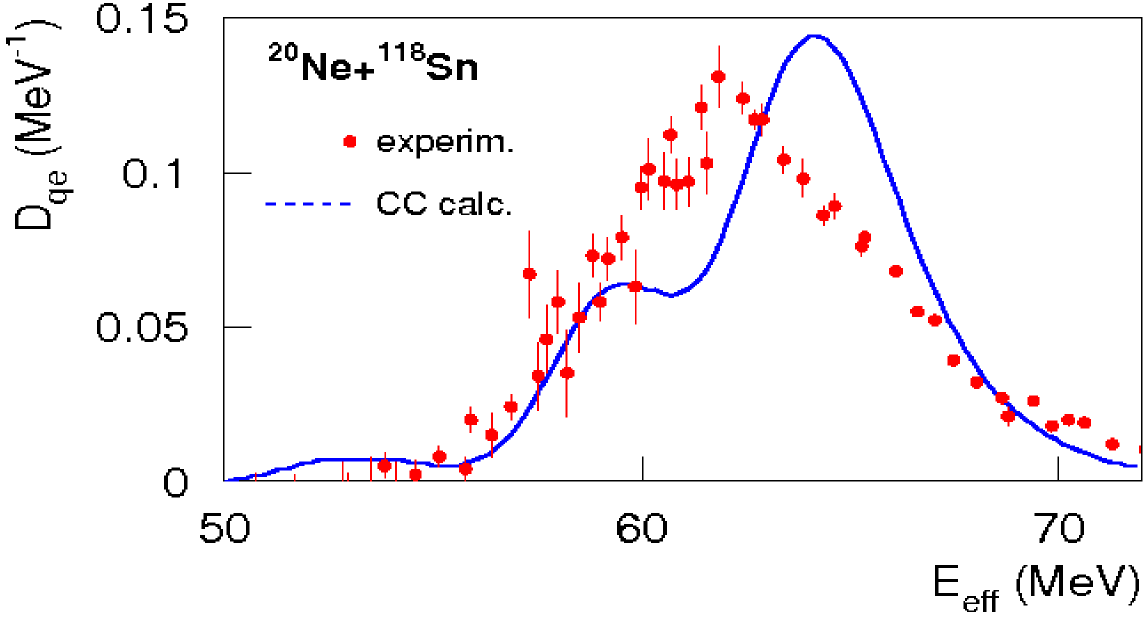
Results of measurements:

For ^{118}Sn:
no “structure”
no agreement with theory

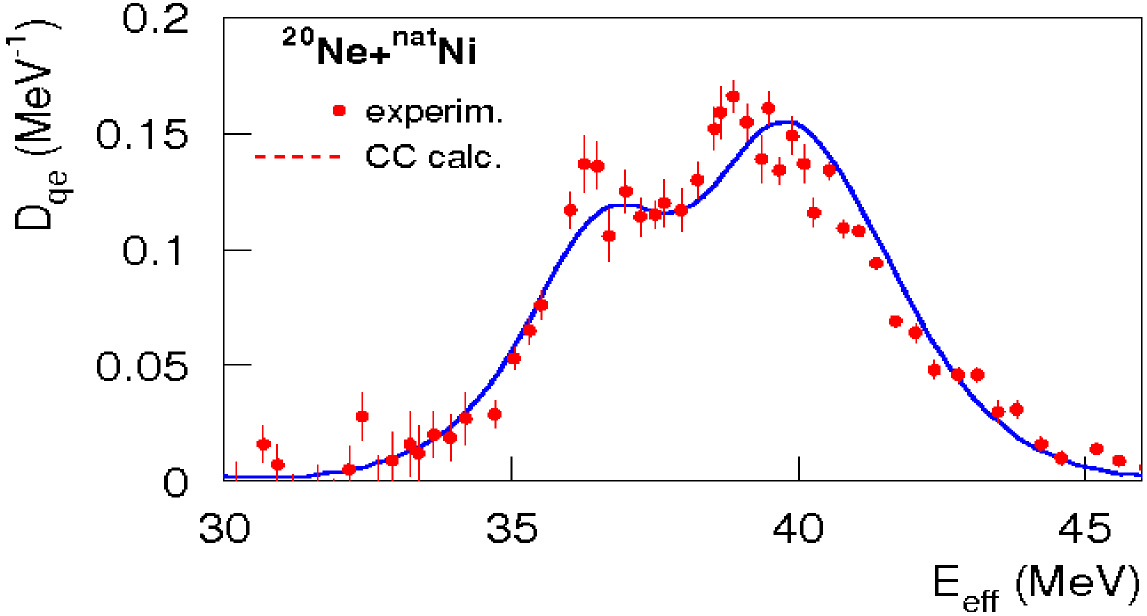


Results of measurements:

For ^{118}Sn:
no “structure”
no agreement with theory



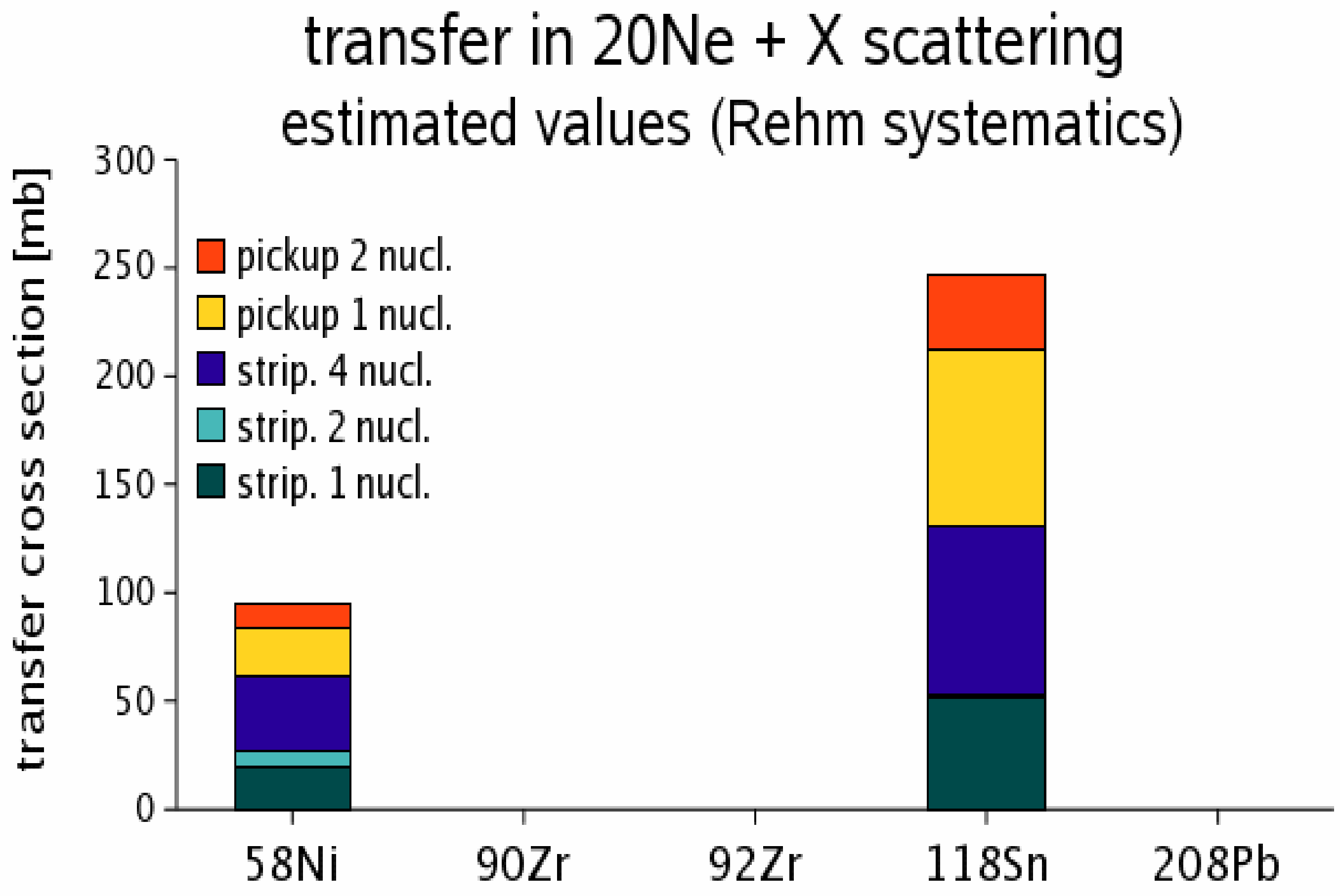
for ^{nat}Ni:
visible “structure”
good agreement with theory



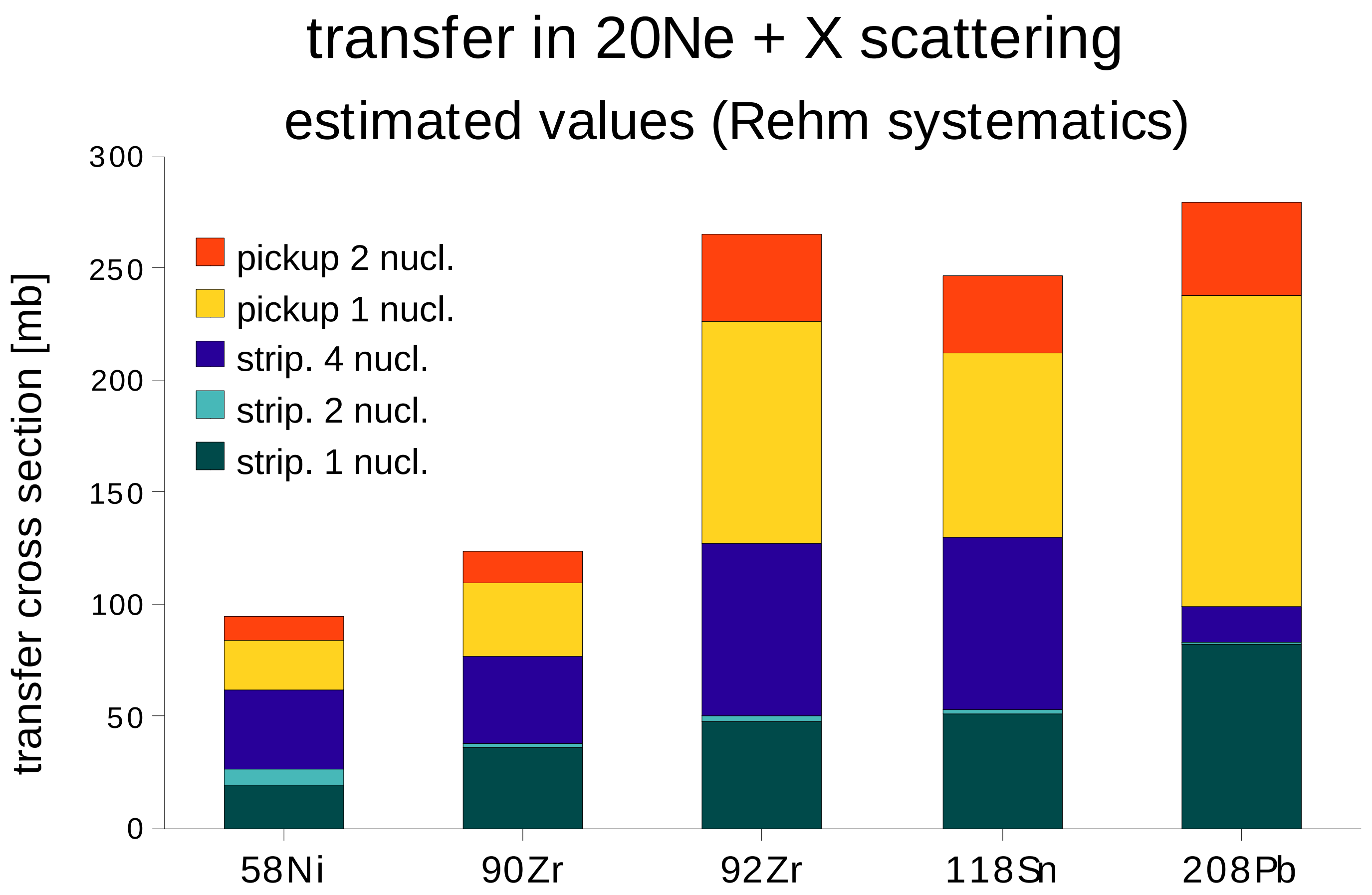
What causes smoothing out of structure in the case of the Sn targets?

Hypothesis: p, n, α **TRANSFER** during ^{20}Ne scattering

- disregarded in the CC calculations
- stronger in the Sn than in the Ni case


transfer in 20Ne + X scattering
estimated values (Rehm systematics)
transfer cross section [mb]
300
250
200
150
100
50
0
pickup 2 nucl.
pickup 1 nucl.
strip. 4 nucl.
strip. 2 nucl.
strip. 1 nucl.
58Ni
90Zr
92Zr
118Sn
208Pb

Next candidate for study: Zr



Expectations & experimental results:

^{20}Ne + ^{90}Zr:

small transfer prob.

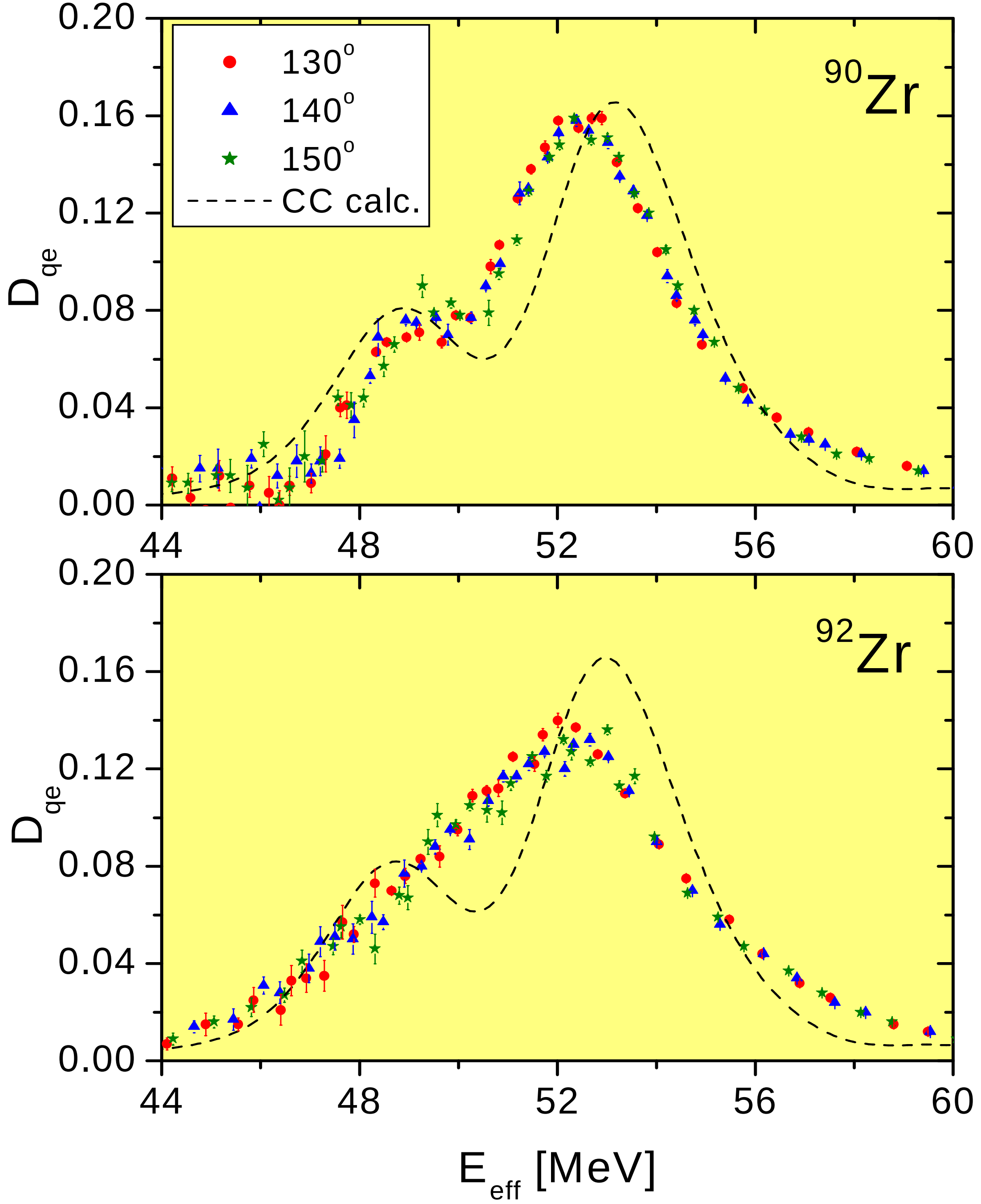
barrier structure

^{20}Ne + ^{92}Zr:

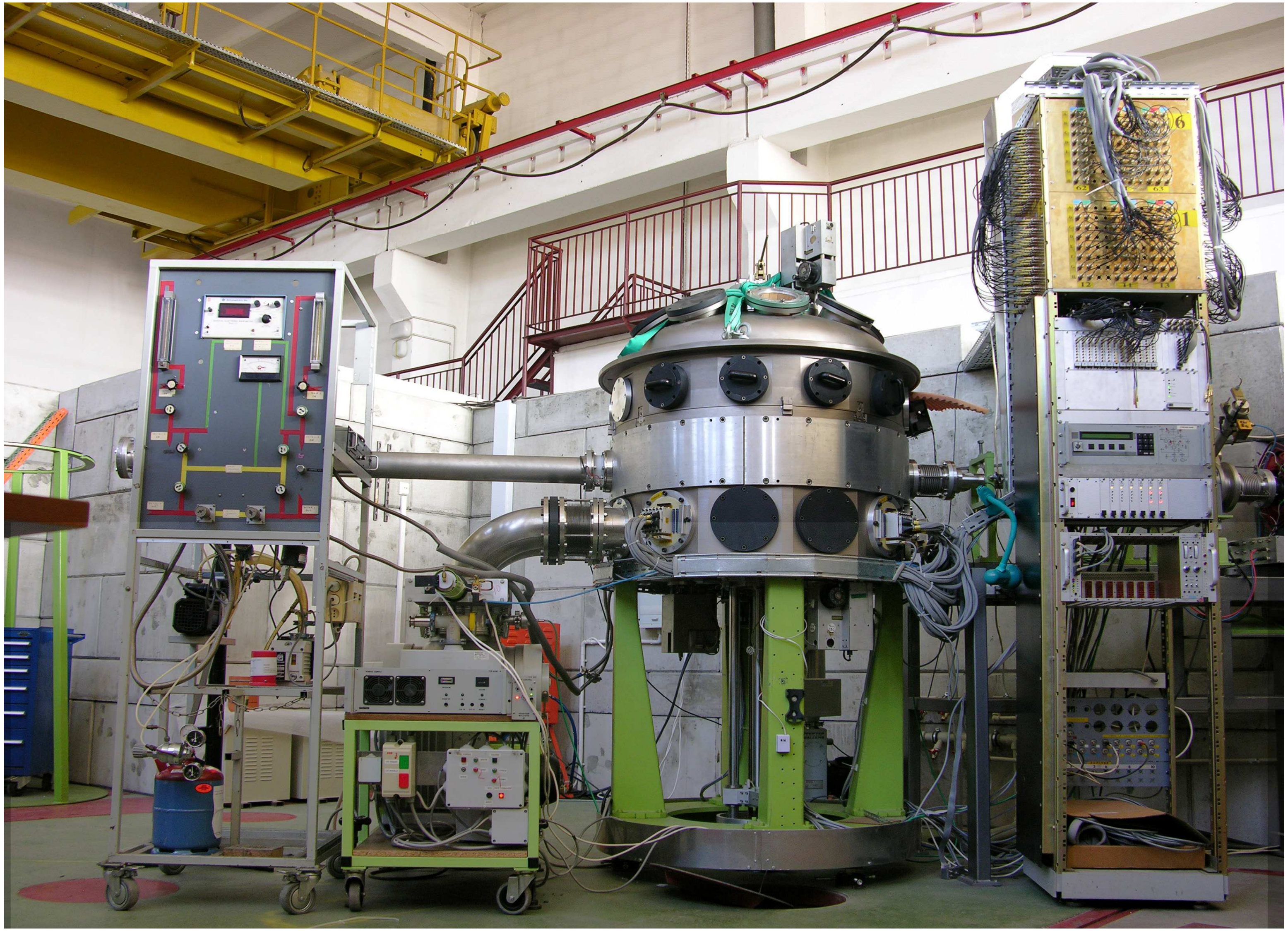
larger transfer prob.

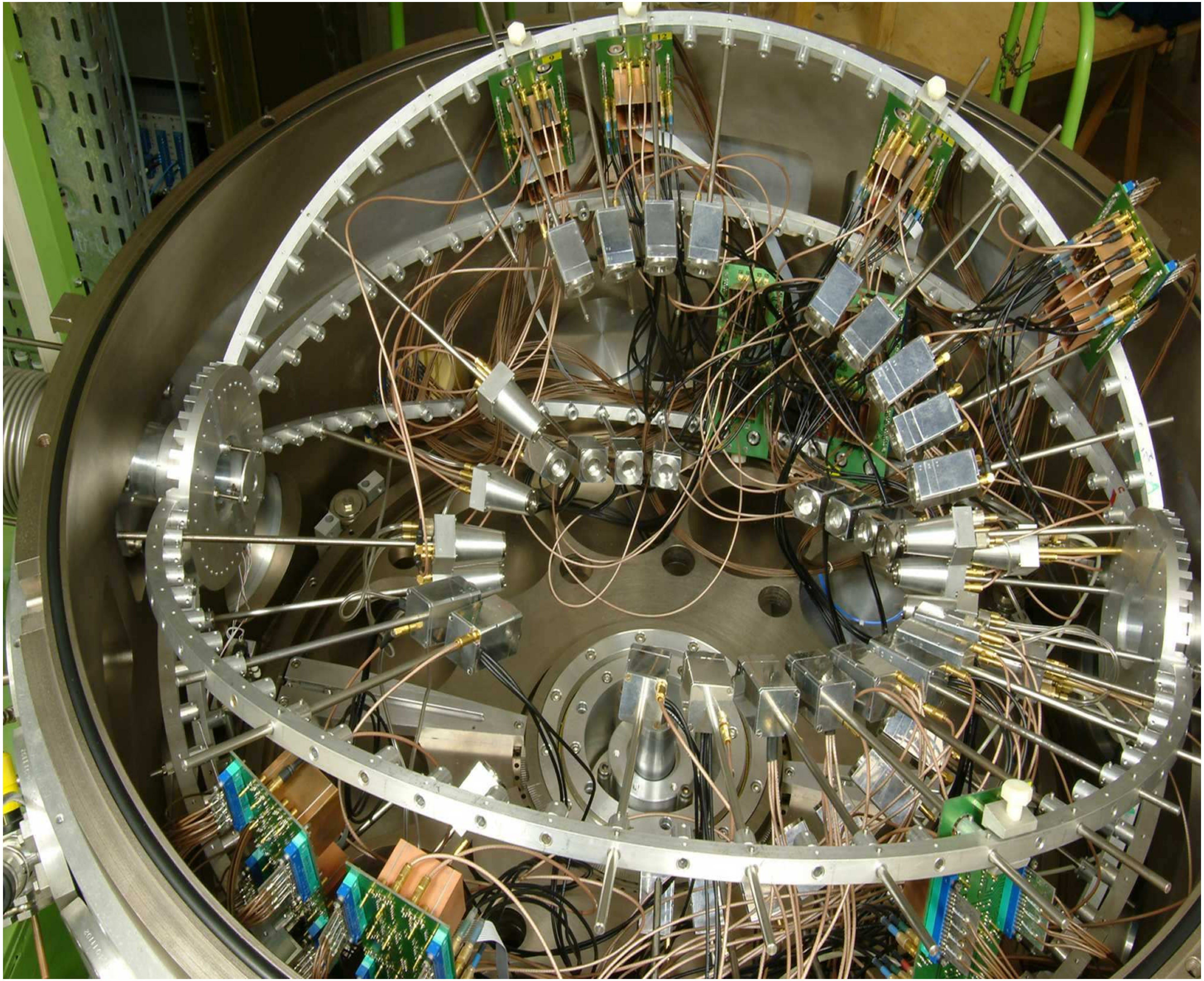
no structure

wider barrier distribution

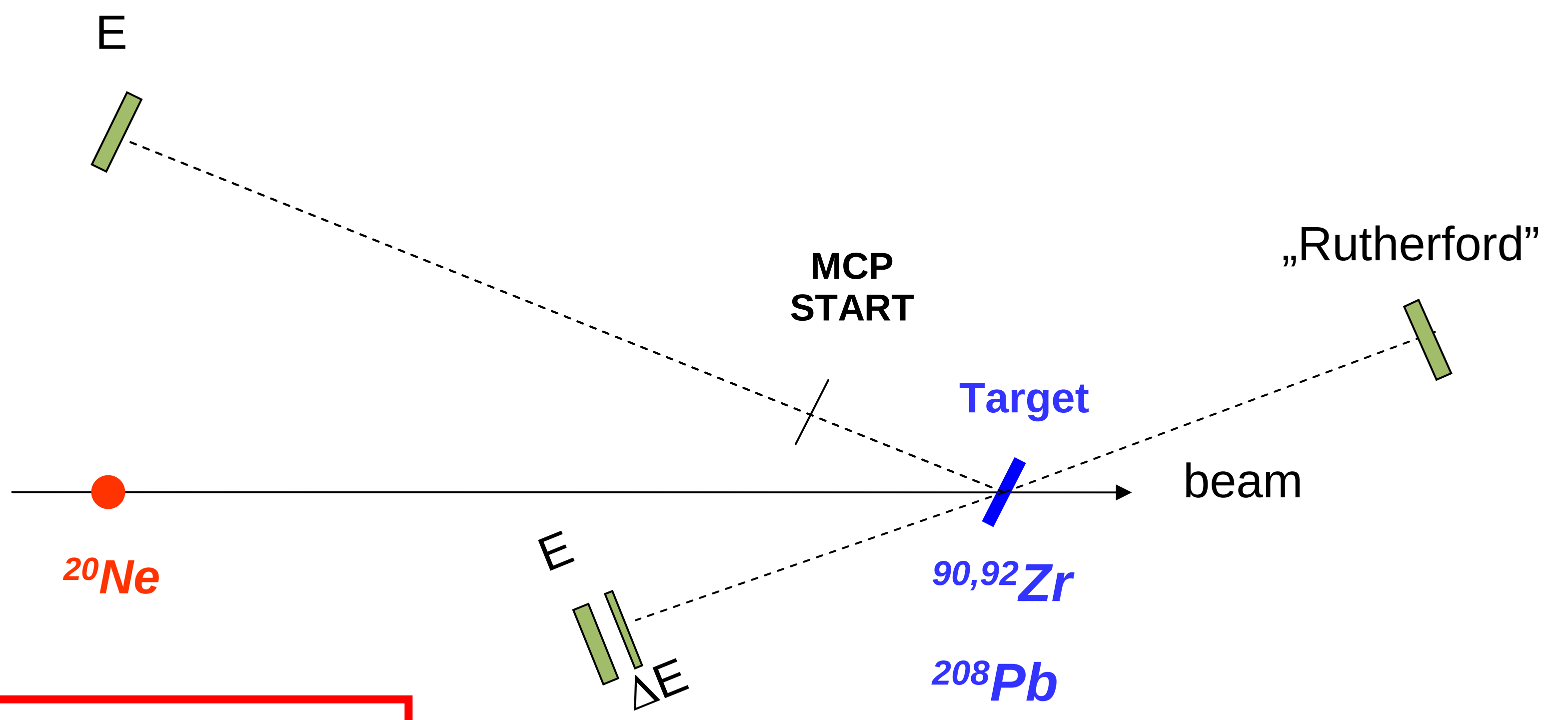


Transfer probablity measurements: ICARE @ HIL





ToF method - experimental set-up

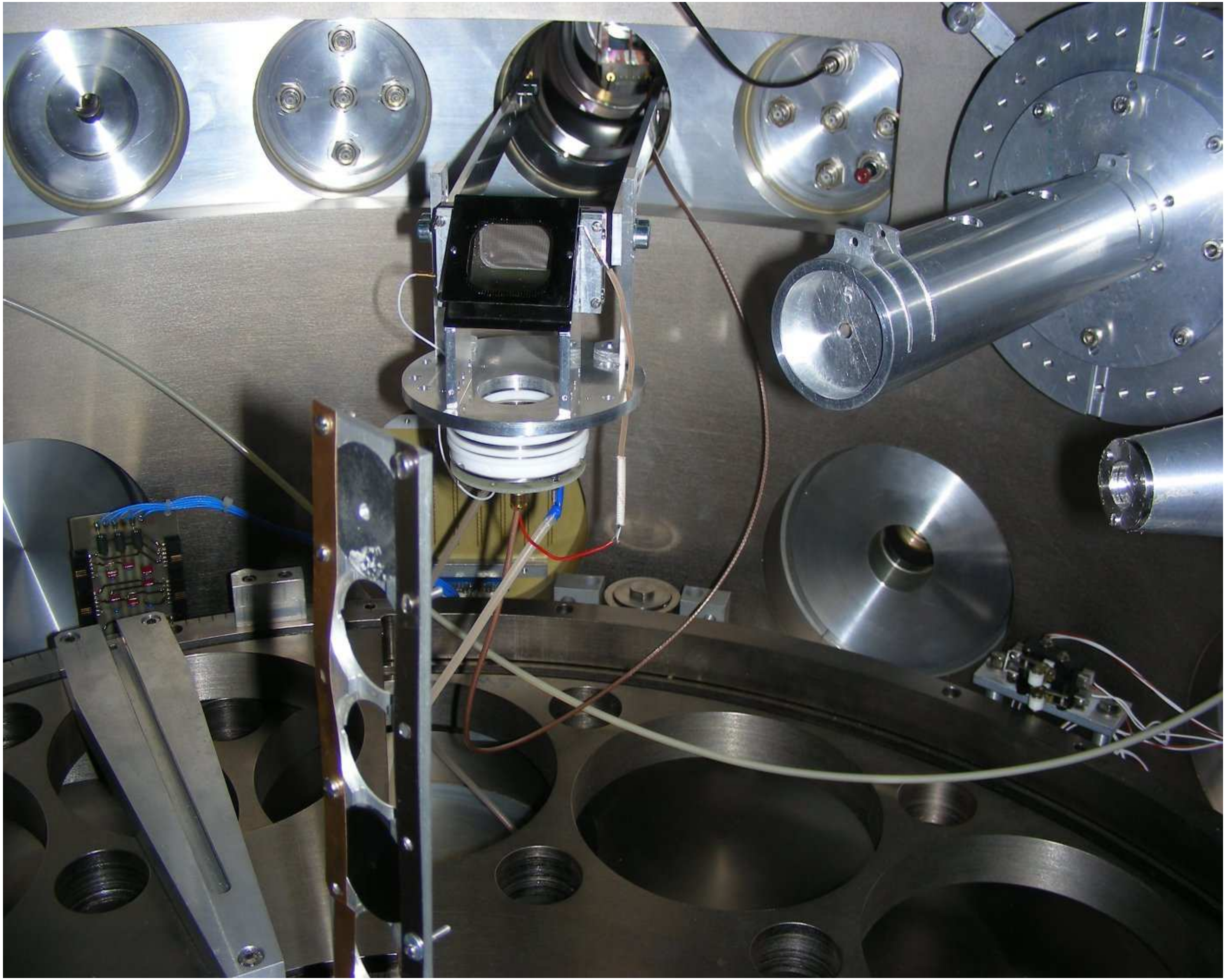


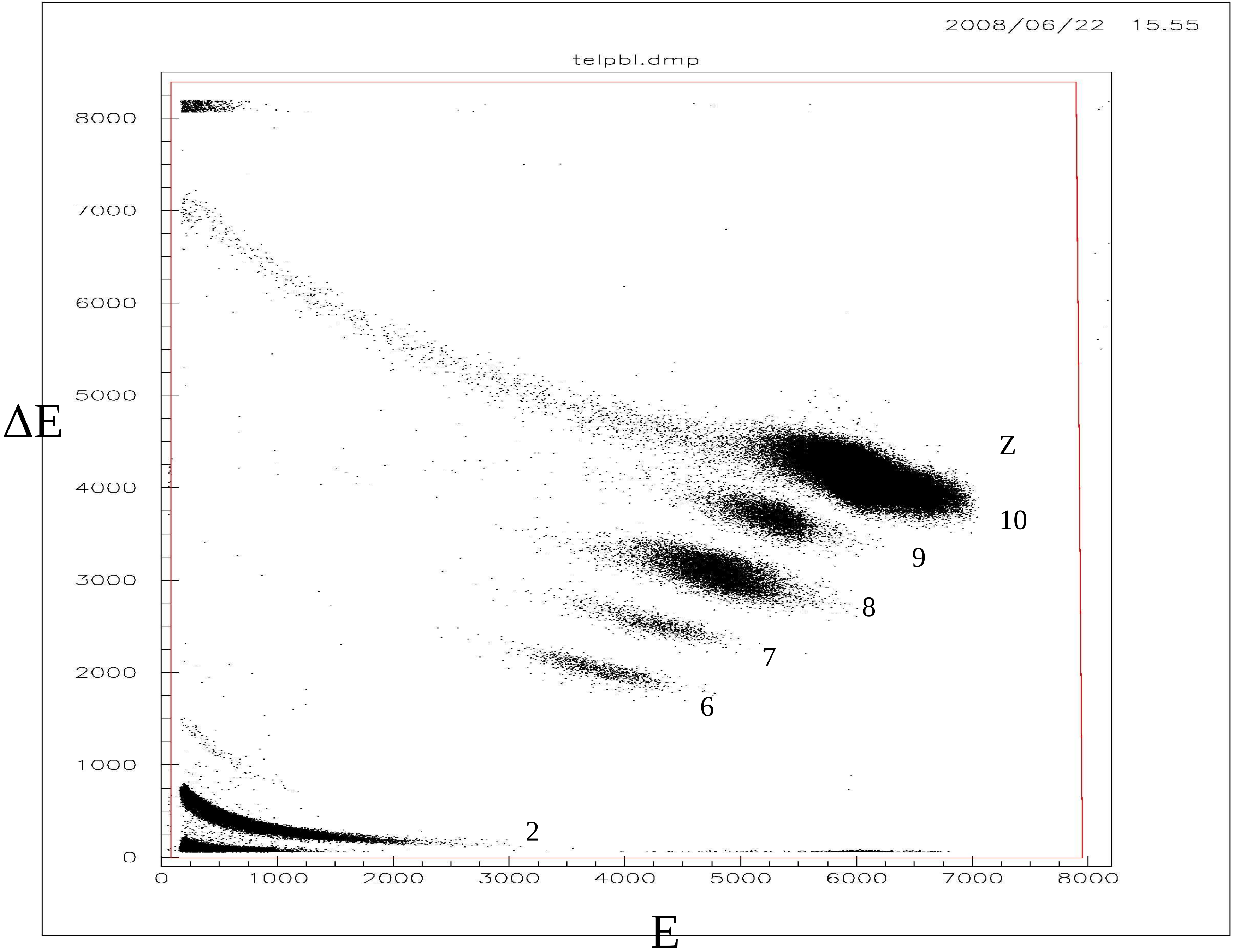
(E,ToF) → A

L_{ToF} = 75cm

$FWHM_{ToF} \approx$ 200ps

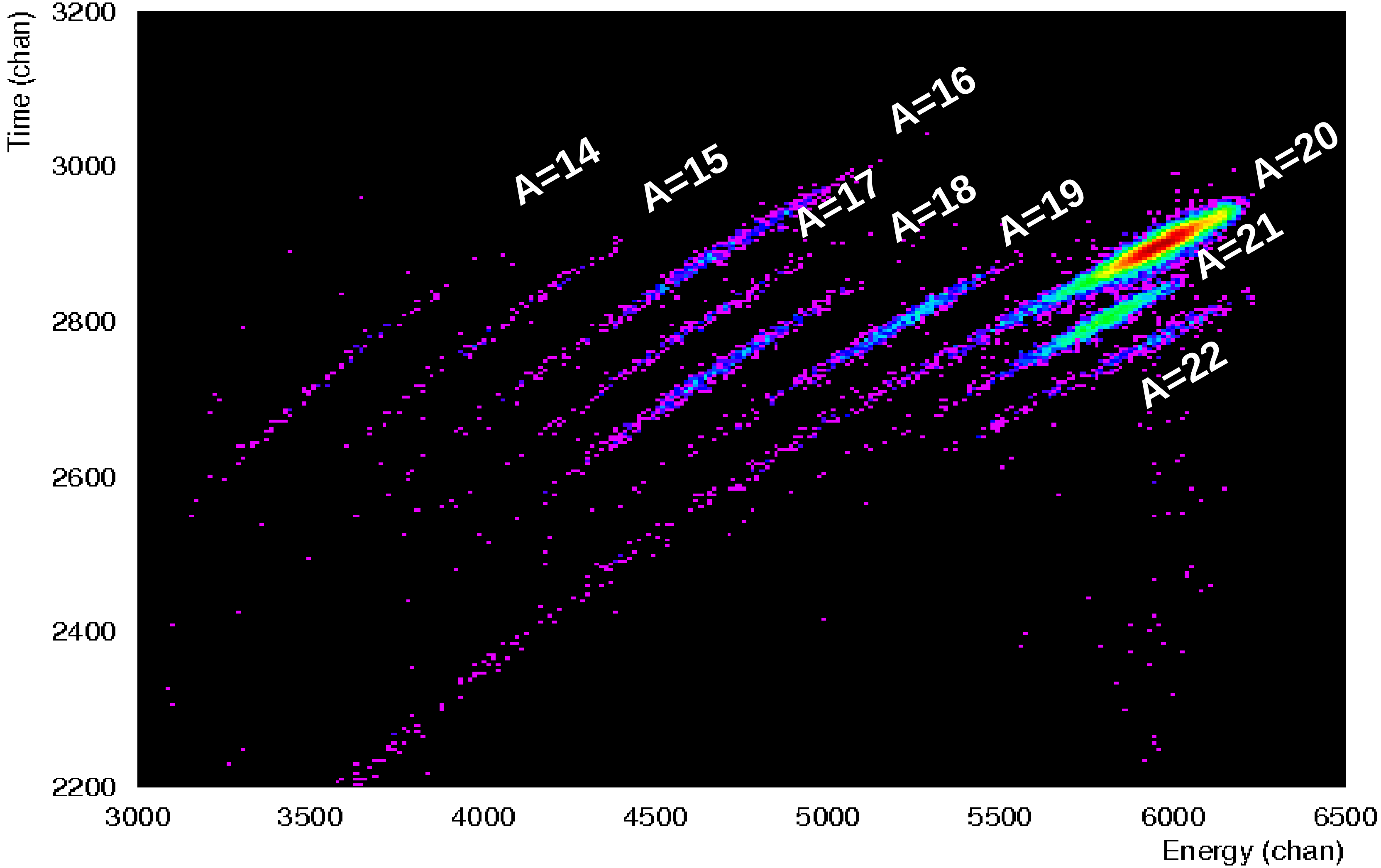
ICARE @ HIL, Warsaw 2008





2008/06/22 15.55
telpbl.dmp
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
ΔE
E
Z
10
9
8
7
6
2

Example of ToF vs energy spectrum



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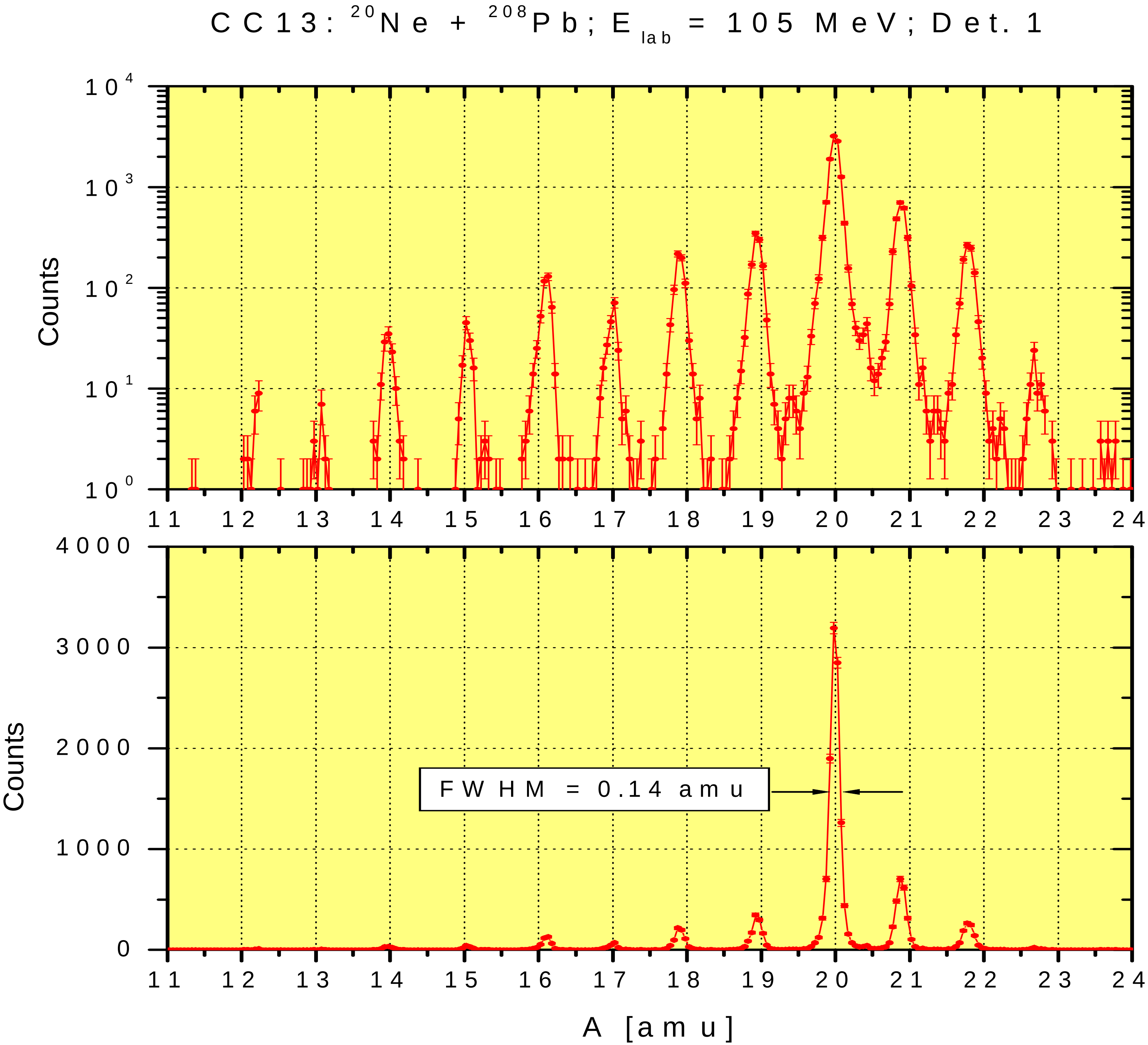
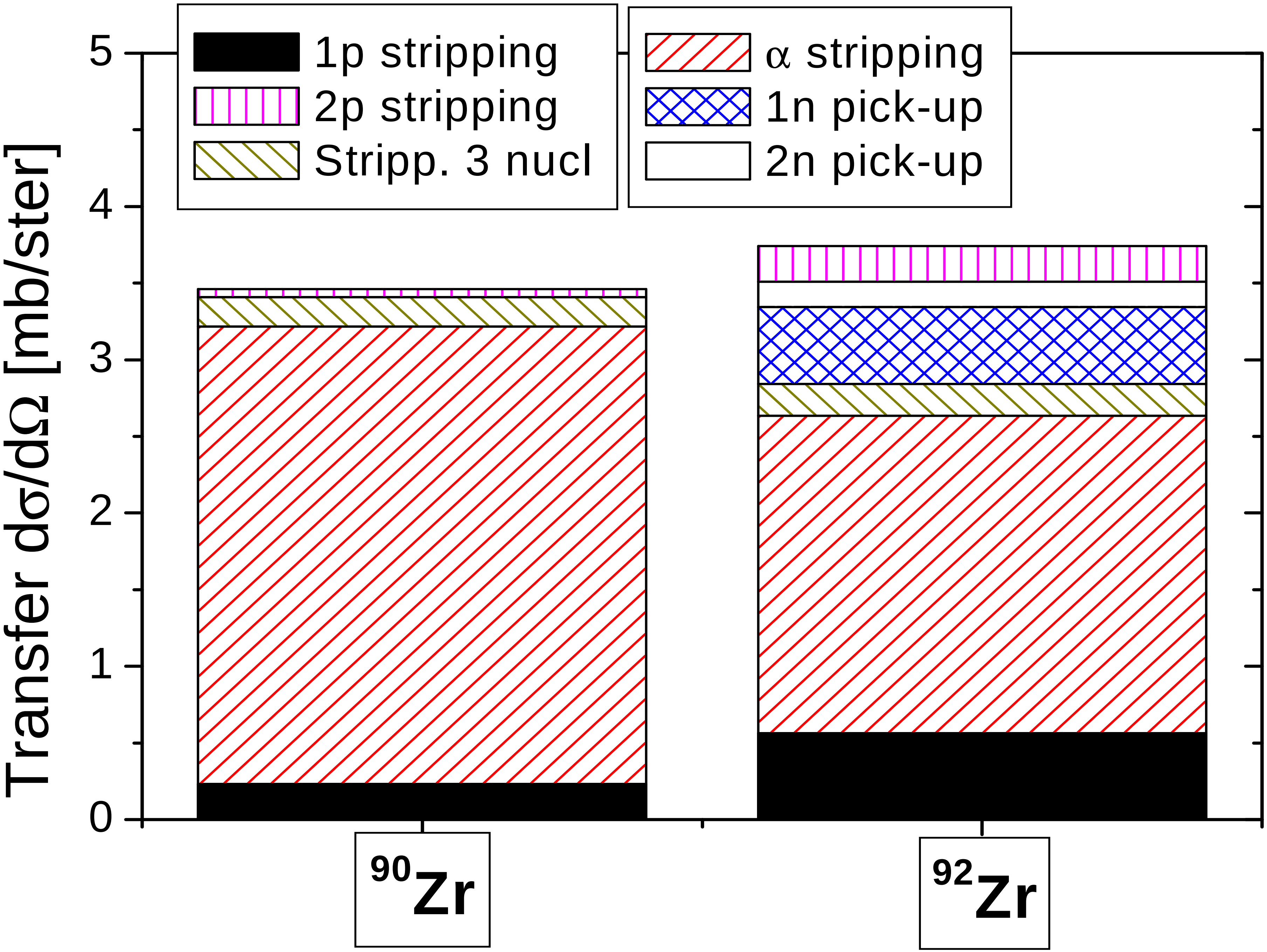
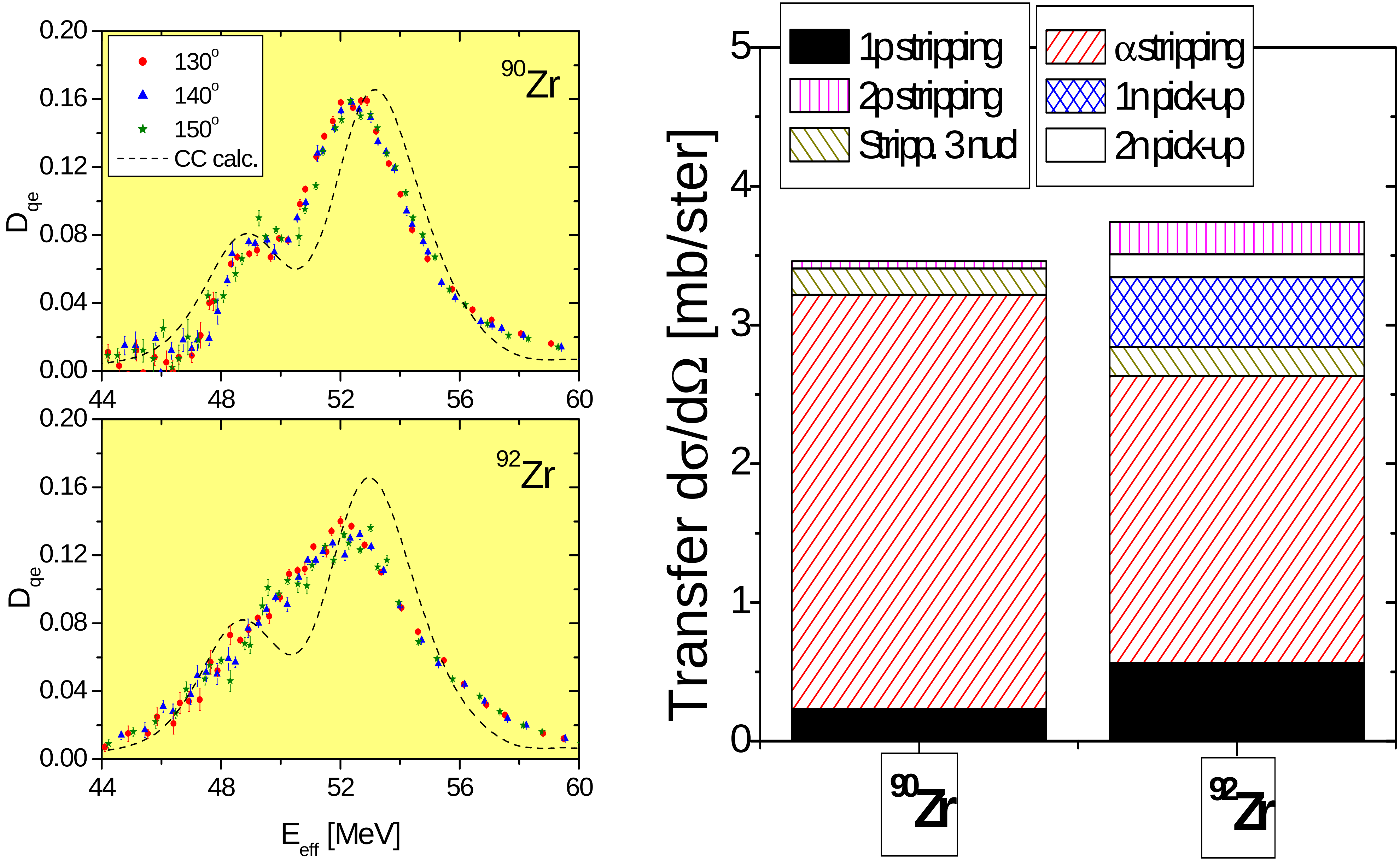
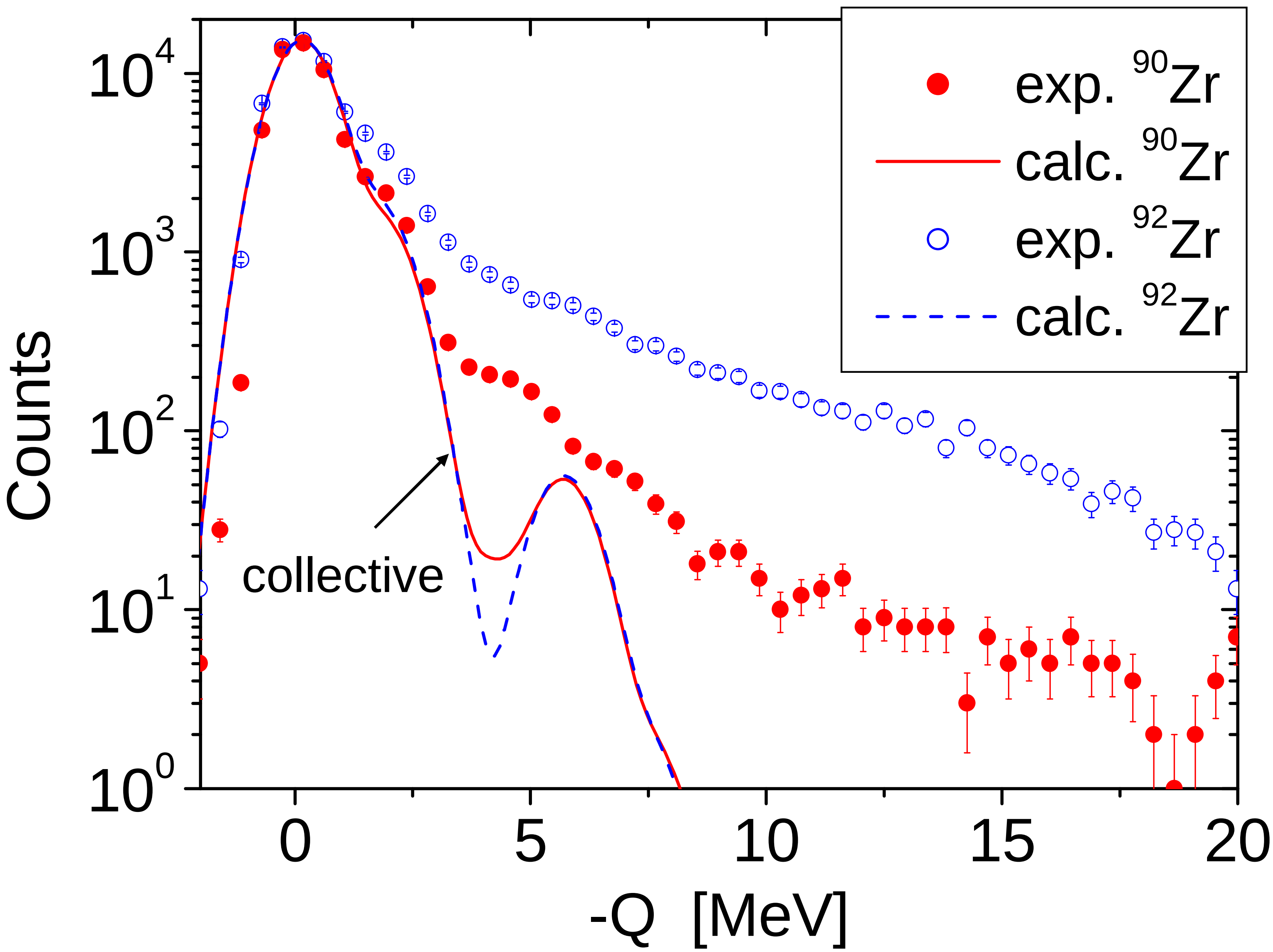


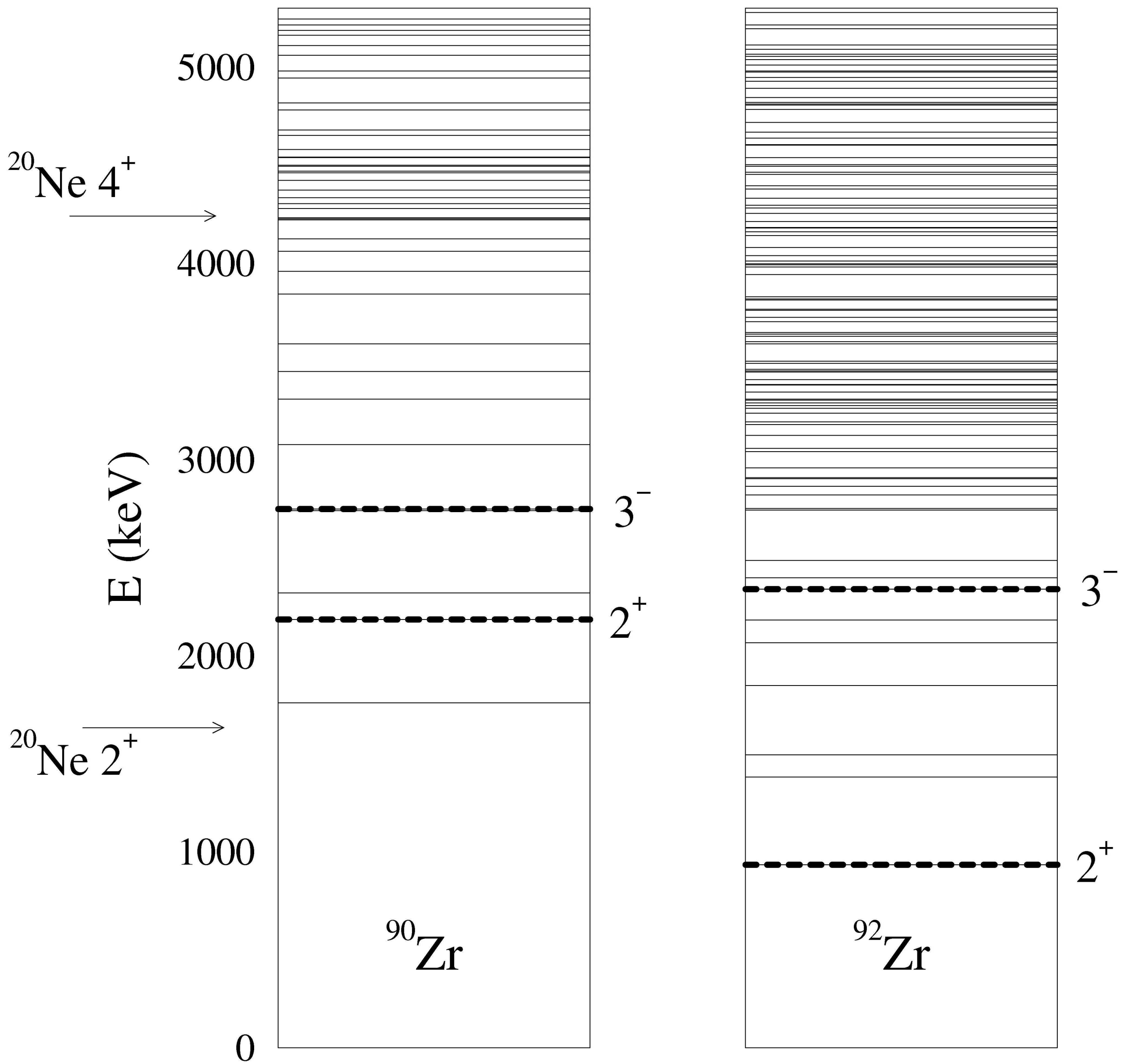

1p stripping
2p stripping
Stripp. 3 nucl
α stripping
1n pick-up
2n pick-up
Transfer dσ/dΩ [mb/ster]
0
1
2
3
4
5
90Zr
92Zr



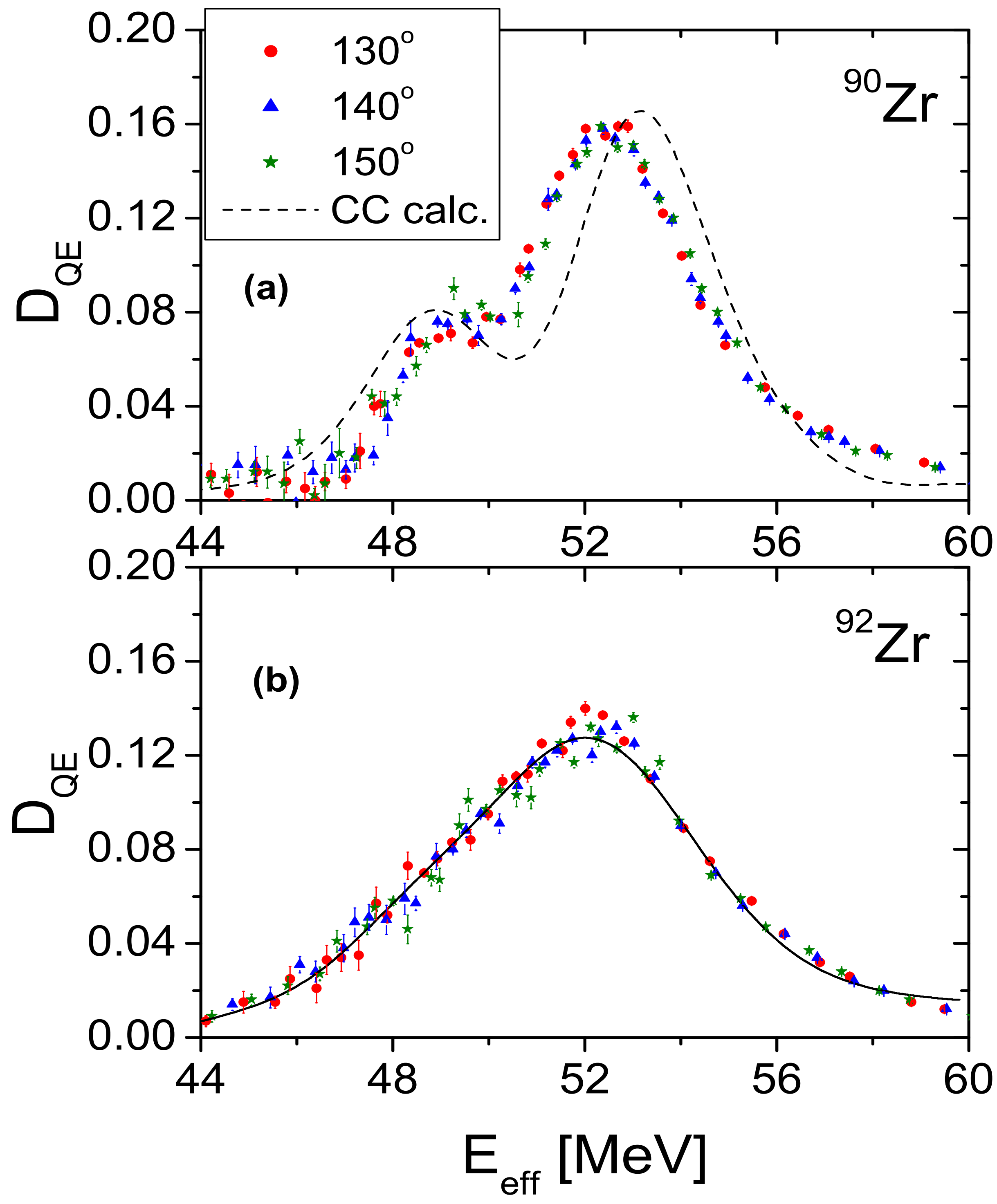
0.20
0.16
0.12
0.08
0.04
0.00
130°
140°
150°
CC calc.
90Zr
92Zr
D_qe
44
48
52
56
60
E_eff [MeV]
Transfer dσ/dΩ [mb/ster]
0
1
2
3
4
5
1p stripping
2p stripping
Stripp. 3 nucl
α stripping
1n pick-up
2n pick-up
90Zr
92Zr

Non-transfer backscattering $^{20}Ne + ^{90,92}Zr$





5000
4000
3000
2000
1000
0
E (keV)
20Ne 4+
20Ne 2+
3−
2+
90Zr
92Zr

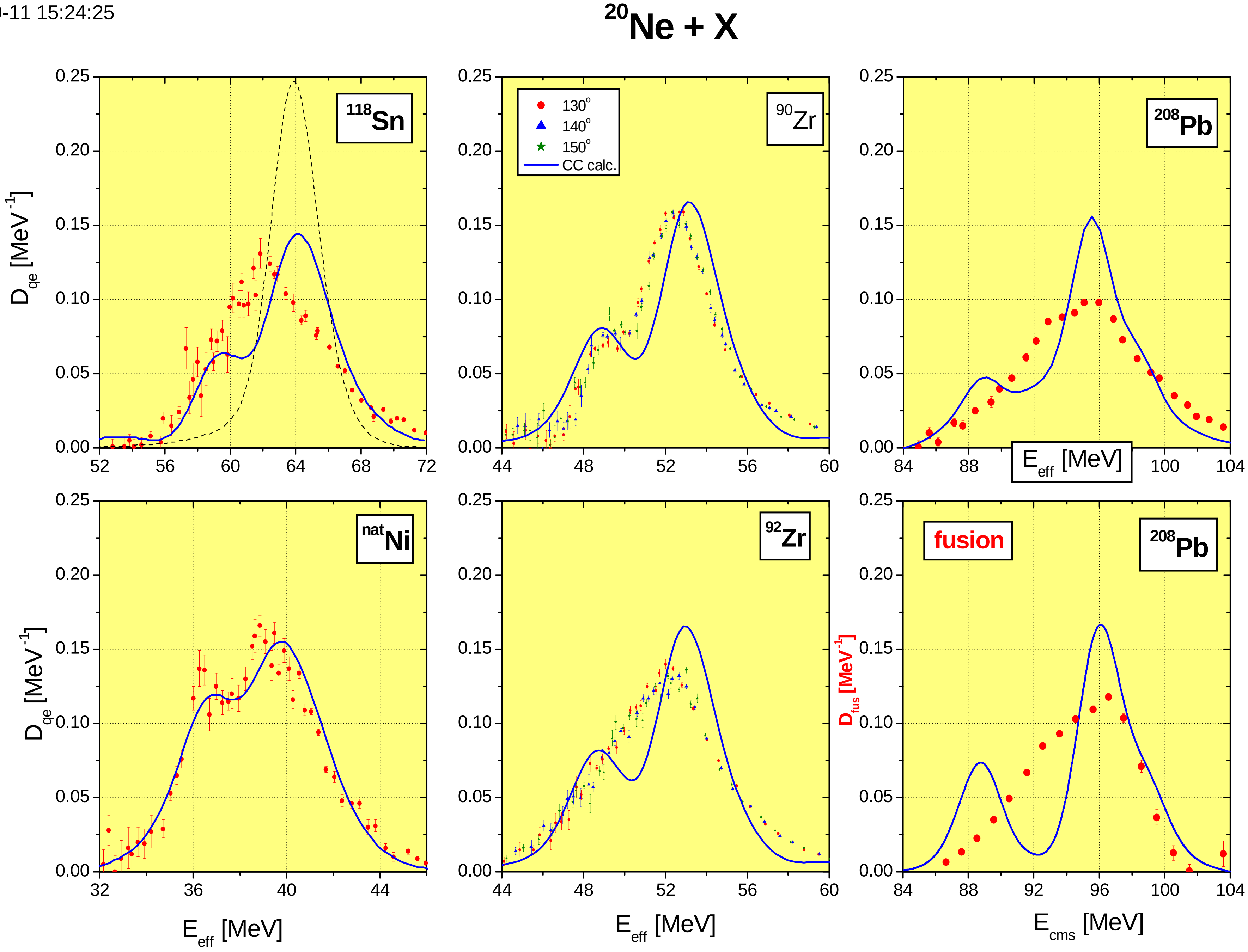

130°
140°
150°
CC calc.
^{90}Zr
(a)
D_{QE}
0.20
0.16
0.12
0.08
0.04
0.00
44
48
52
56
60
^{92}Zr
(b)
D_{QE}
E_{eff} [MeV]

Preliminary conclusion

Apparently QE barrier distributions can be smoothed by a large number of weakly populated **single-particle excitations**

How about D_{fus}?

2008-09-11 15:24:25



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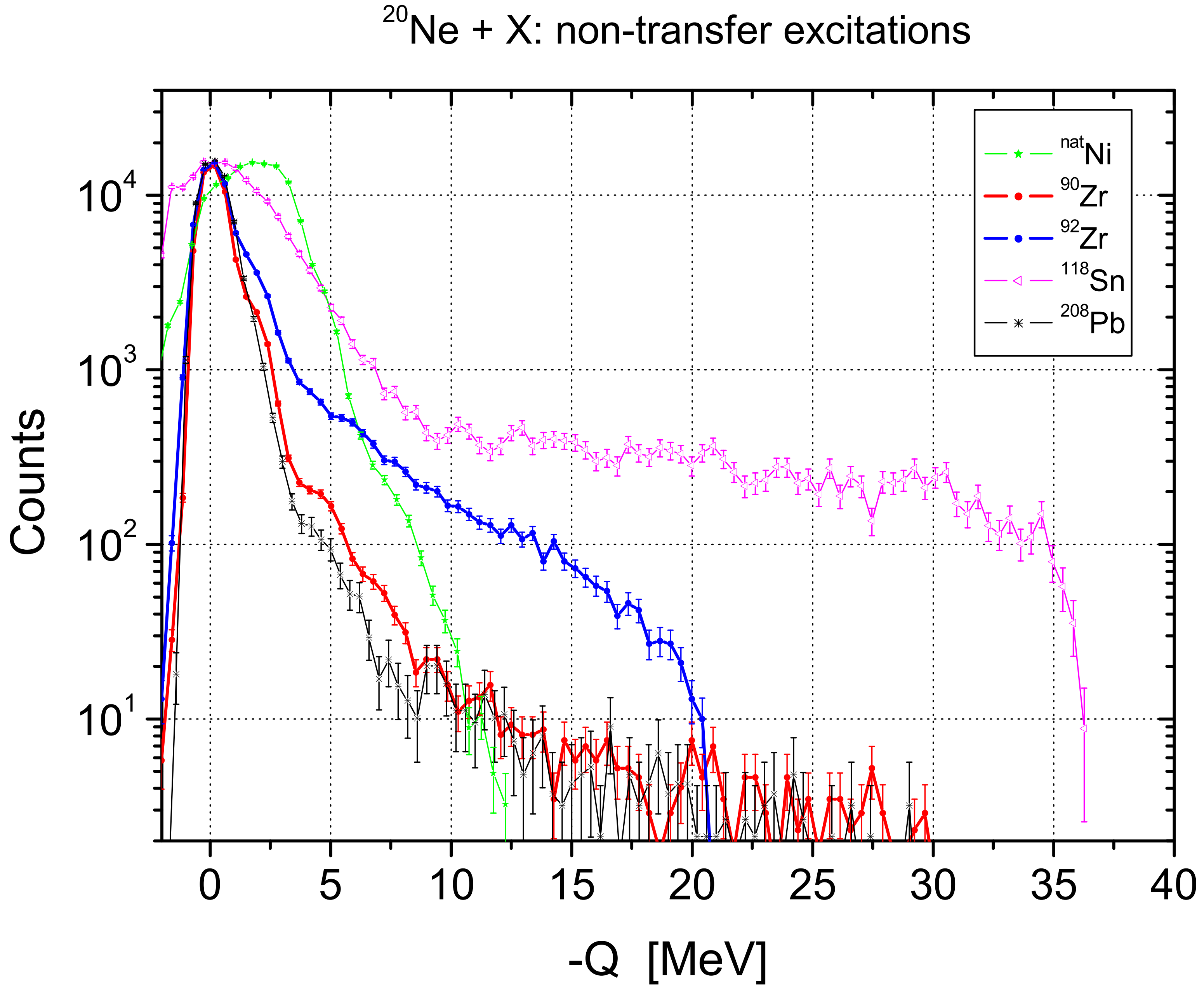

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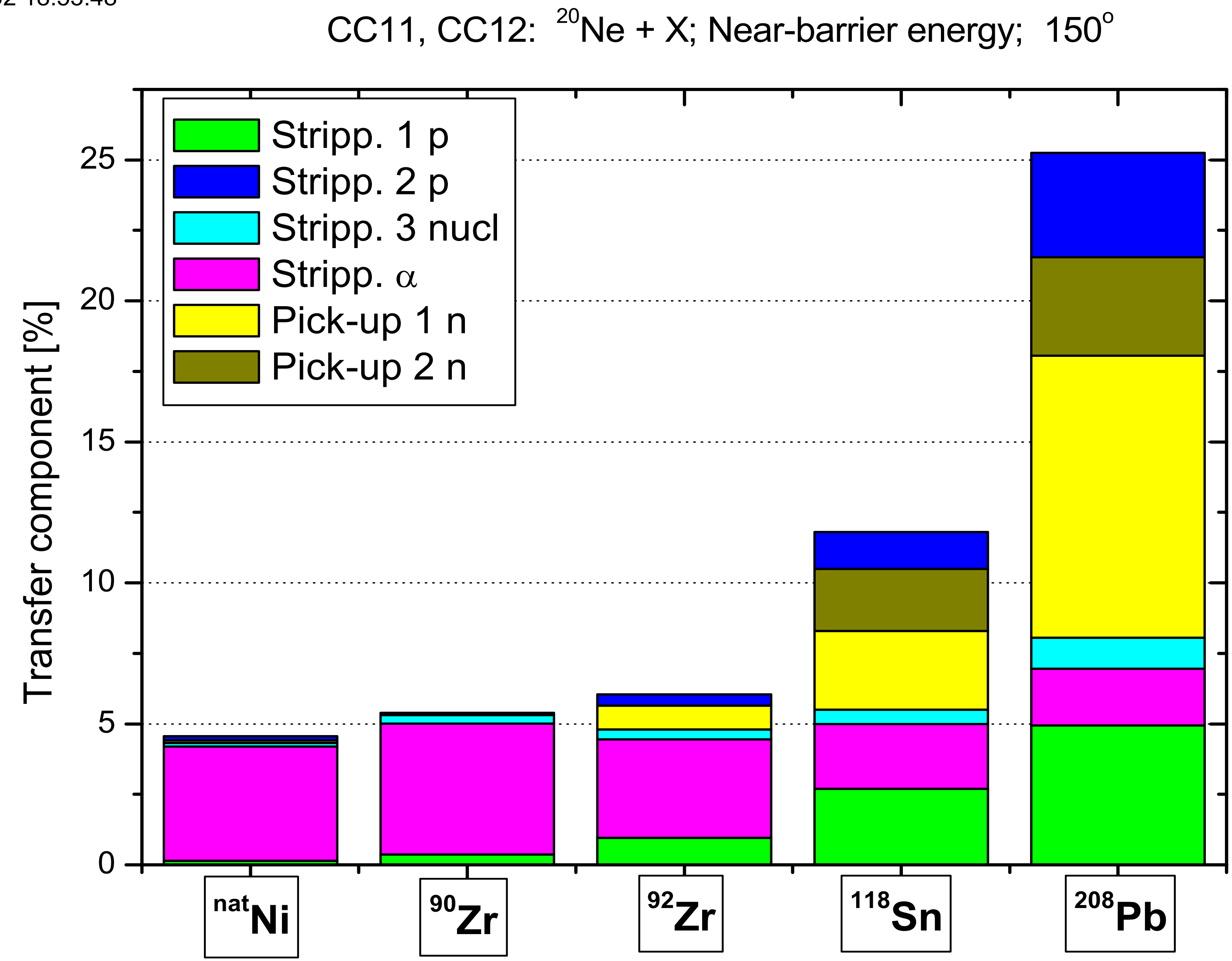
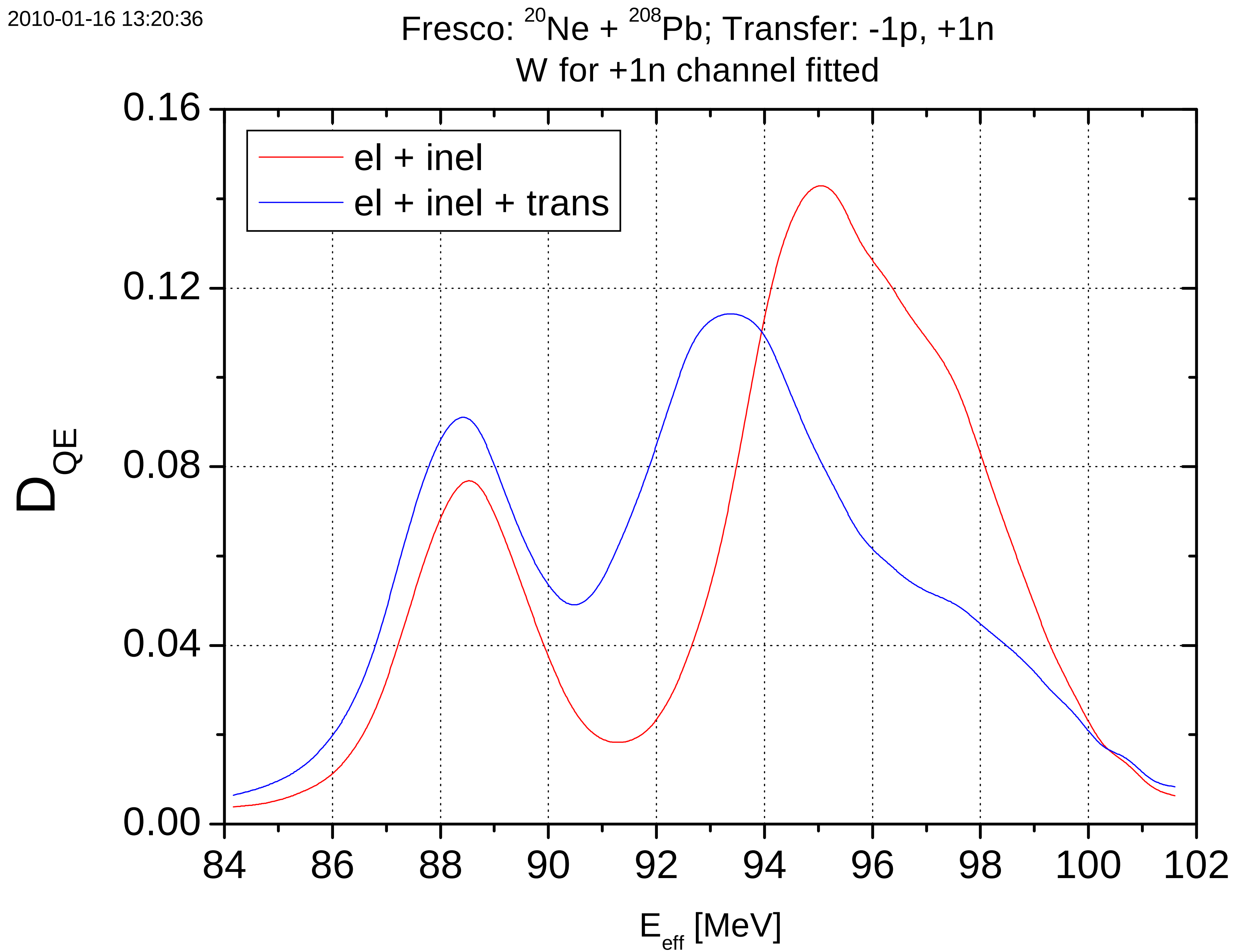
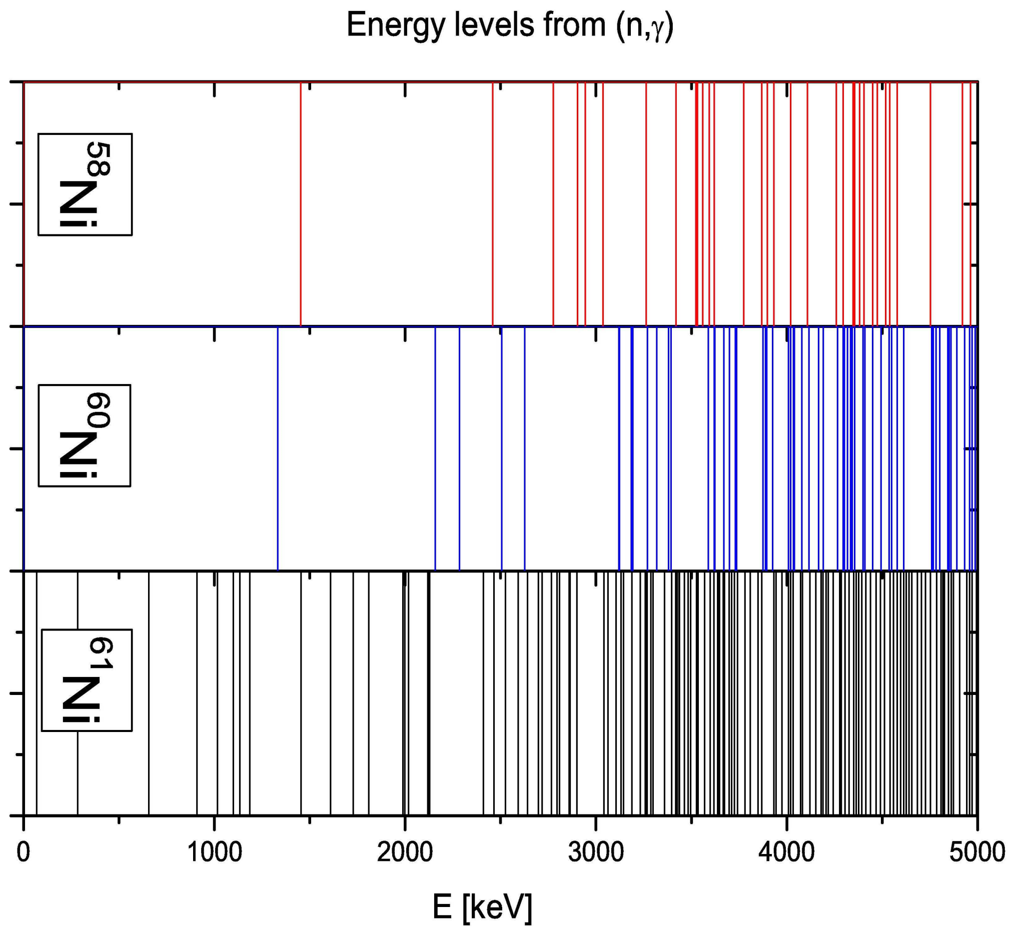



2010-01-16 13:20:36
Fresco: 20Ne + 208Pb; Transfer: -1p, +1n
W for +1n channel fitted
el + inel
el + inel + trans
D_QE
0.00
0.04
0.08
0.12
0.16
84
86
88
90
92
94
96
98
100
102
E_eff [MeV]

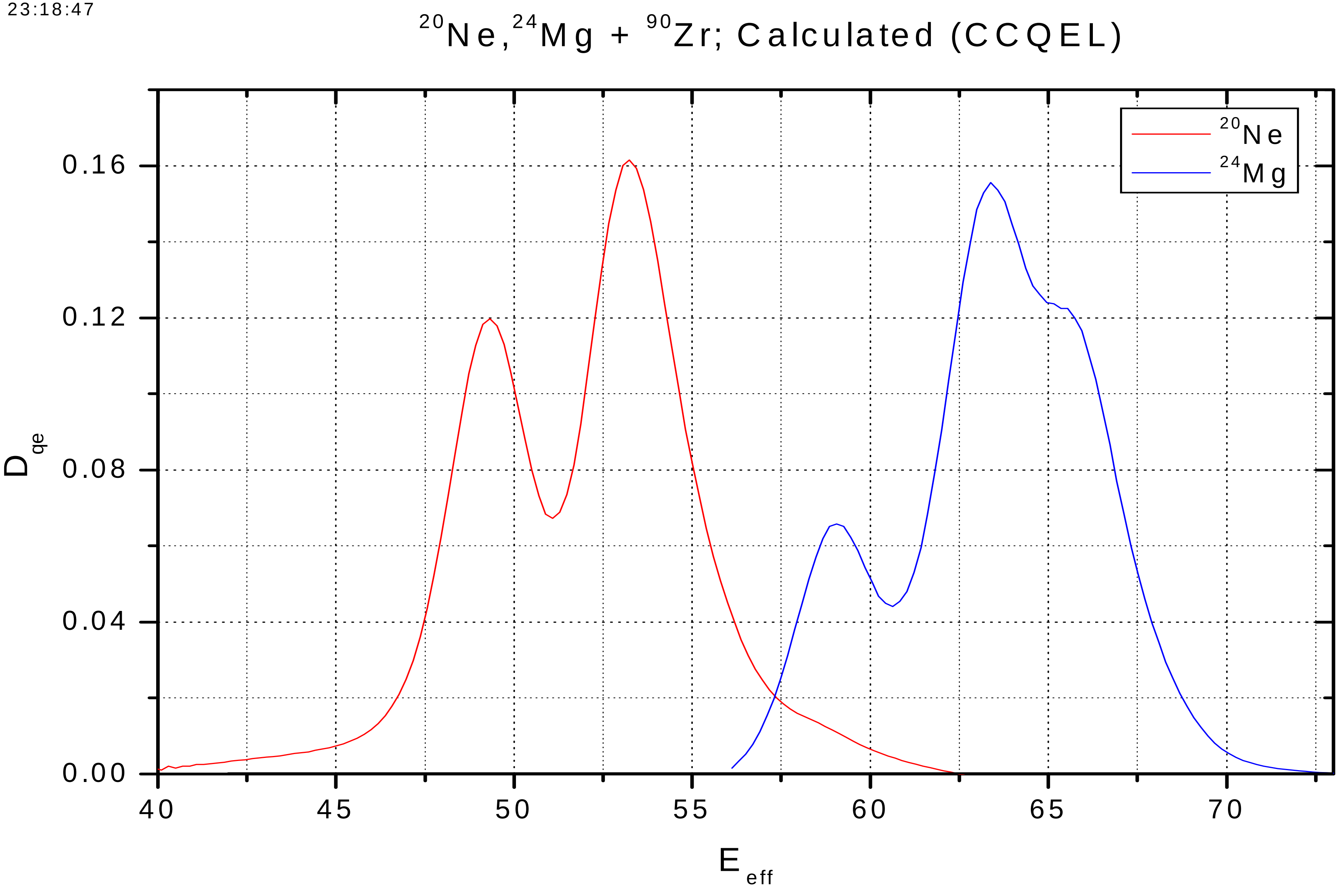


Energy levels from (n,γ)
58Ni
60Ni
61Ni
0
1000
2000
3000
4000
5000
E [keV]

Projects for the future:

- D_{fus} for ^{20}Ne + ^{90,92}Zr
- D_{qe} for ^{20}Ne + ^{58,60,61}Ni
- D_{qe} for $^{24,....}$Mg + ^{58}Ni,^{90,92}Zr

2008-11-18 23:18:47



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