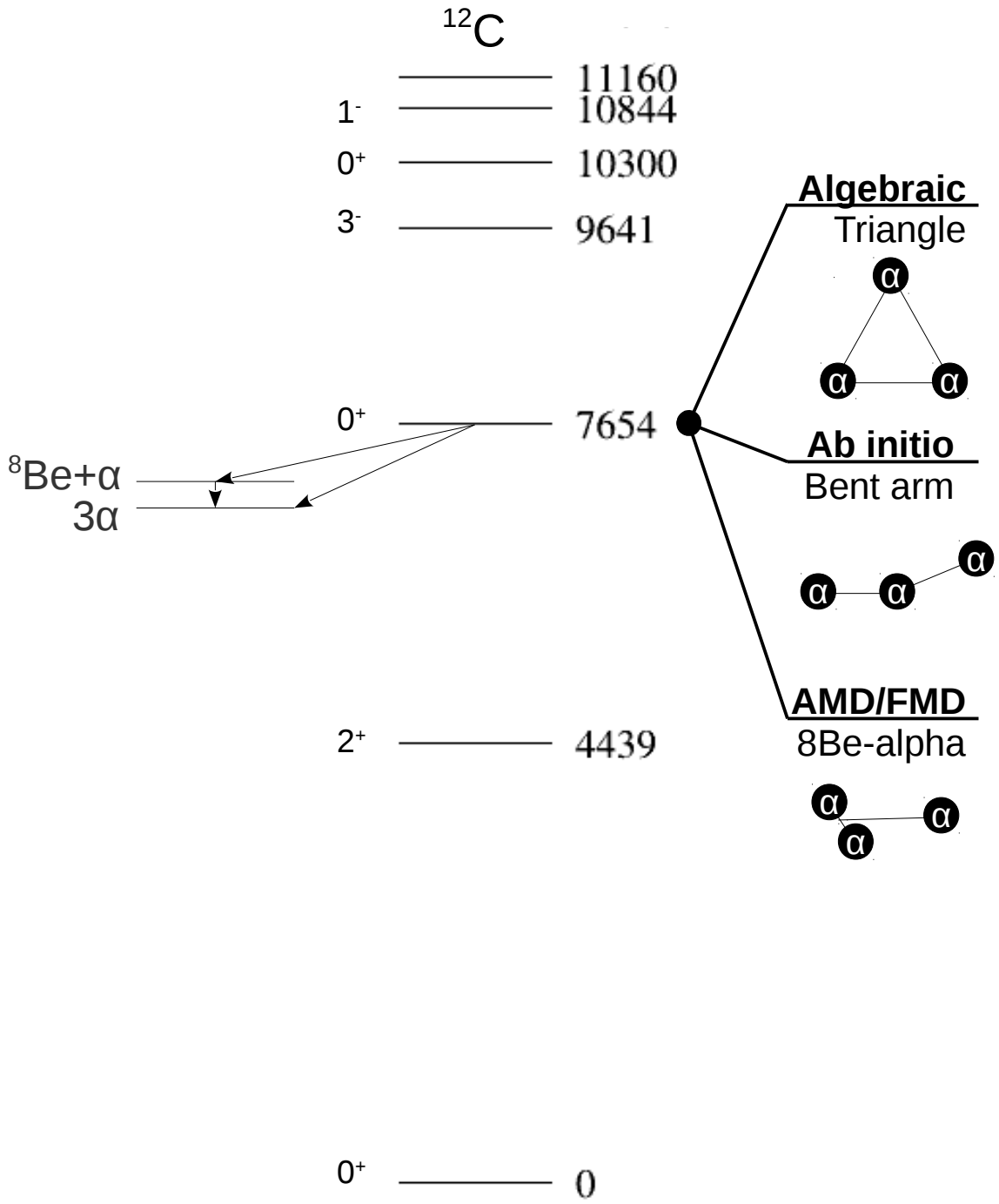
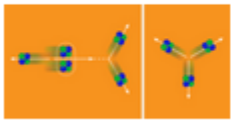
Exploring in-medium structure with particle-particle correlations in heavy-ion collisions

Diego Gruyer
Laboratoire de Physique Corpusculaire, Caen, France.


12C
11160
1-
10844
0+
10300
3-
9641
0+
7654
8Be+α
3α
2+
4439
0+
0
Algebraic
Triangle
Ab initio
Bent arm
AMD/FMD
8Be-alpha
α

Physics Viewpoint: Watching the Hoyle State Fall Apart



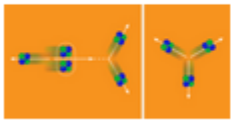
Two experiments provide the most precise picture to date of how an excited state of carbon decays into three helium nuclei.

Show Abstract +

Proportion of direct decay

Direct reactions : <0.043 % (Dell'Aquila, PRL 2017)

Physics Viewpoint: Watching the Hoyle State Fall Apart



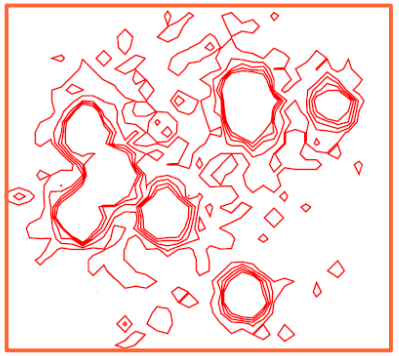
Two experiments provide the most precise picture to date of how an excited state of carbon decays into three helium nuclei.

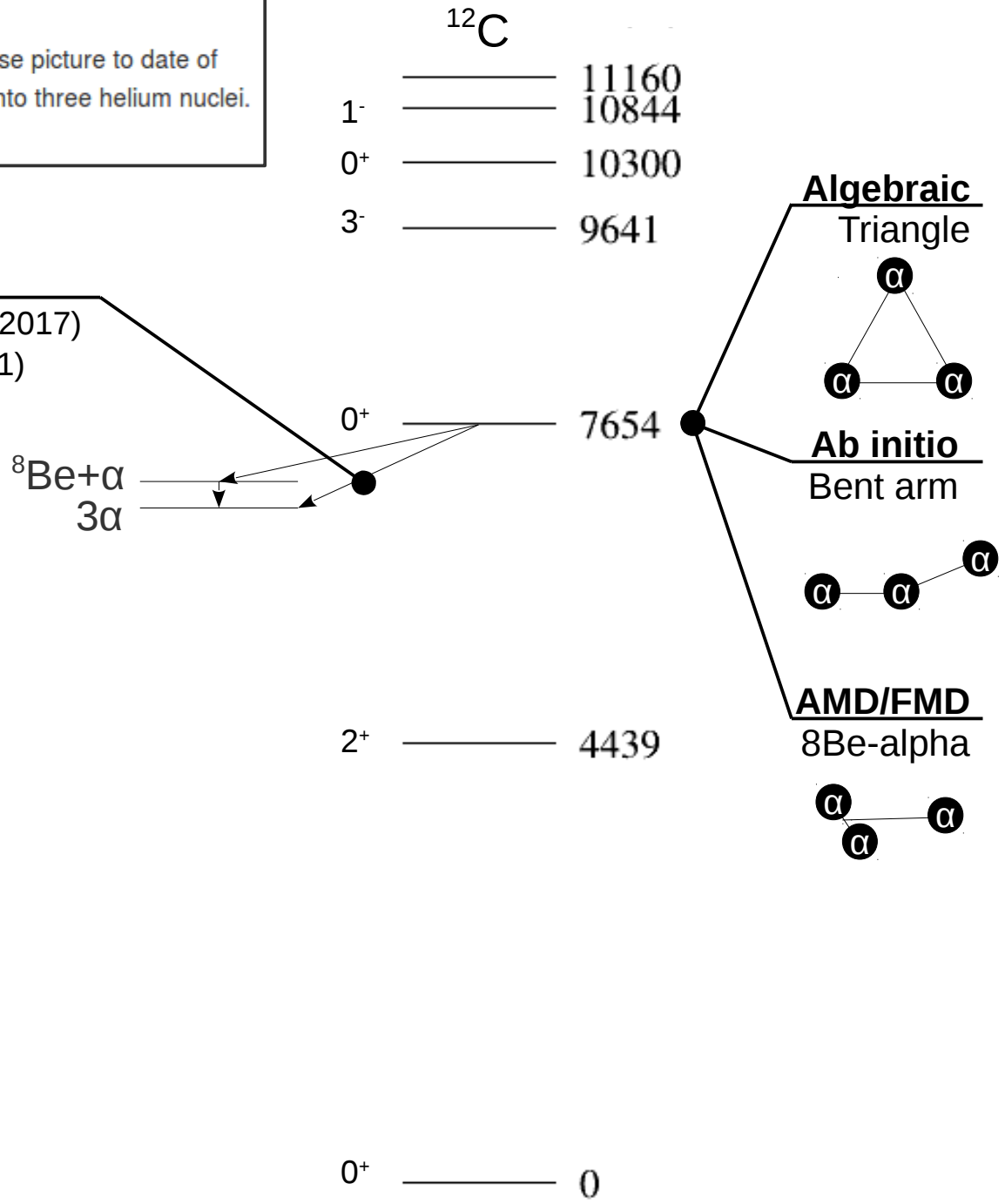
Show Abstract +

Proportion of direct decay

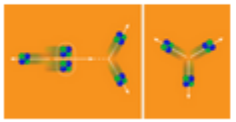
Direct reactions : <0.043 % (Dell'Aquila, PRL 2017)

Fragmentation : ~17 % (Raduta PLB 2011)





Physics Viewpoint: Watching the Hoyle State Fall Apart



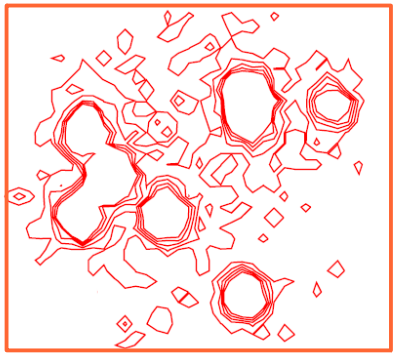
Two experiments provide the most precise picture to date of how an excited state of carbon decays into three helium nuclei.

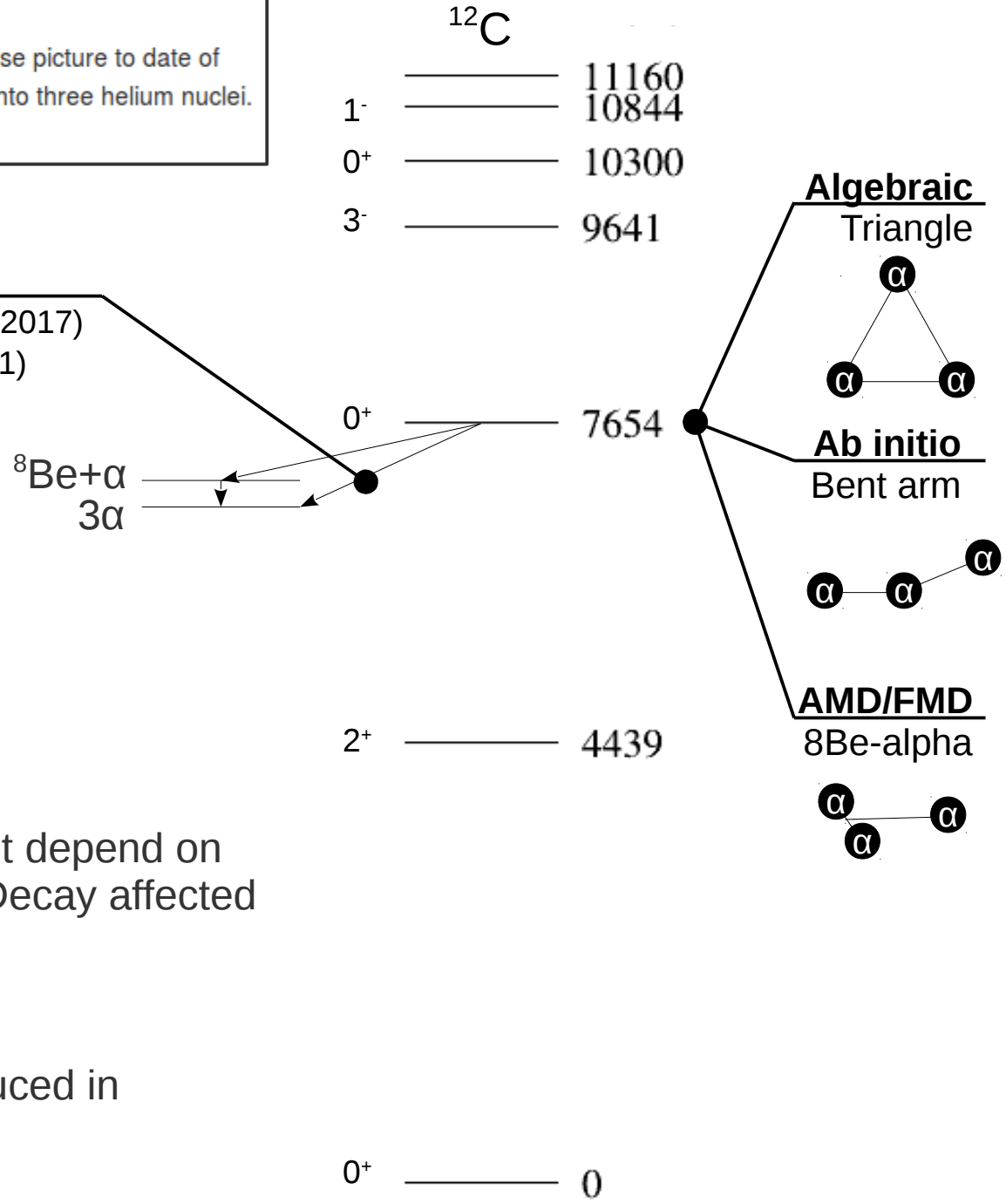
Show Abstract +

Proportion of direct decay

Direct reactions : <0.043 % (Dell'Aquila, PRL 2017)

Fragmentation : ~17 % (Raduta PLB 2011)





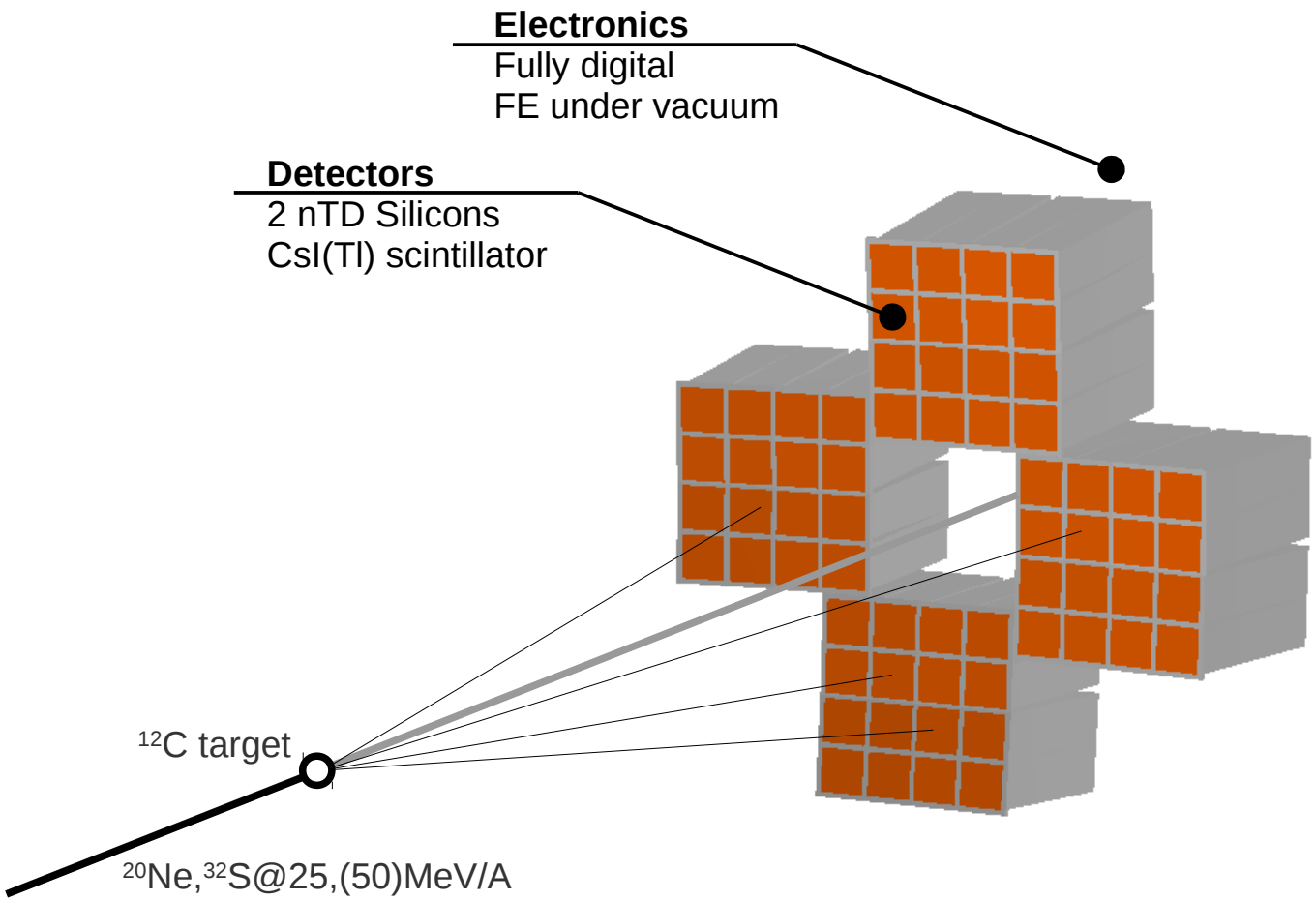
3-α decay of the Hoyle state.

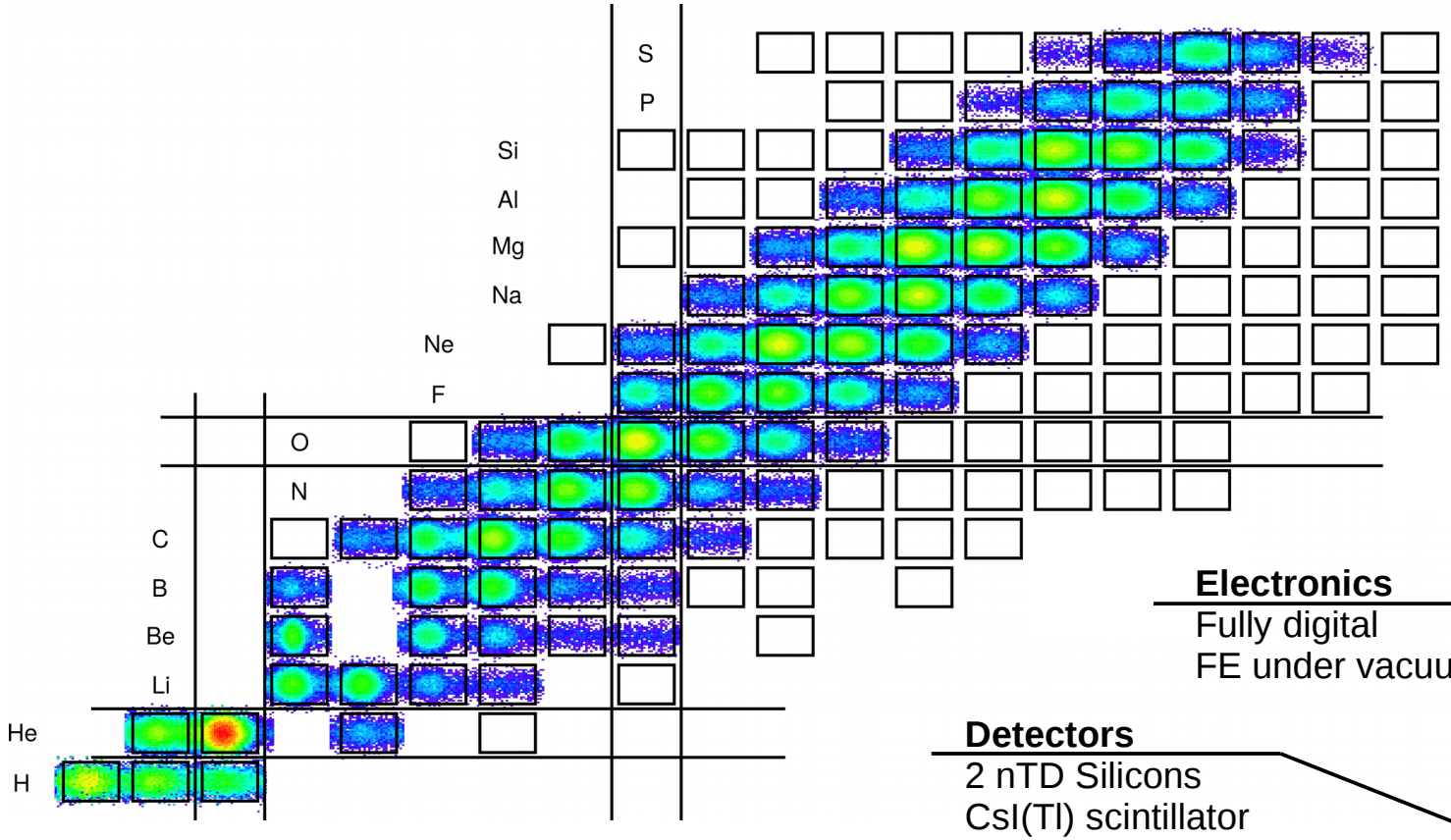
Proportion of direct decay cannot depend on the way the $^{12}C^{*}$ has been produced. Decay affected by the environment in fragmentation?

Experimental test.

Compare the decay of $^{12}C^{*}$ produced in different environment.

FAZIACOR@LNS. Compare Hoyle state decay produced in various fragmentation reactions: ^{20}Ne and ^{32}S at 25,50 MeV/nuc on ^{12}C target.



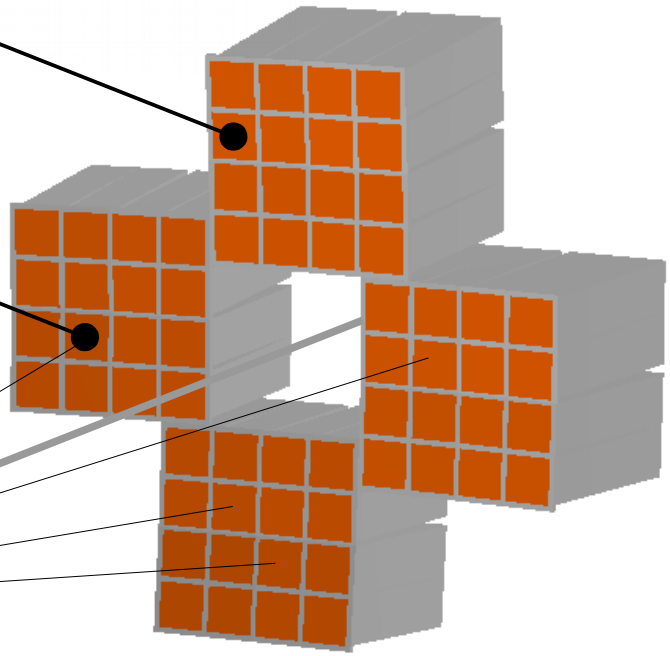


FAZIACOR@LNS. Compare Hoyle state decay produced in various fragmentation reactions: ^{20}Ne and ^{32}S at 25,50 MeV/nuc on ^{12}C target.

Electronics
Fully digital
FE under vacuum

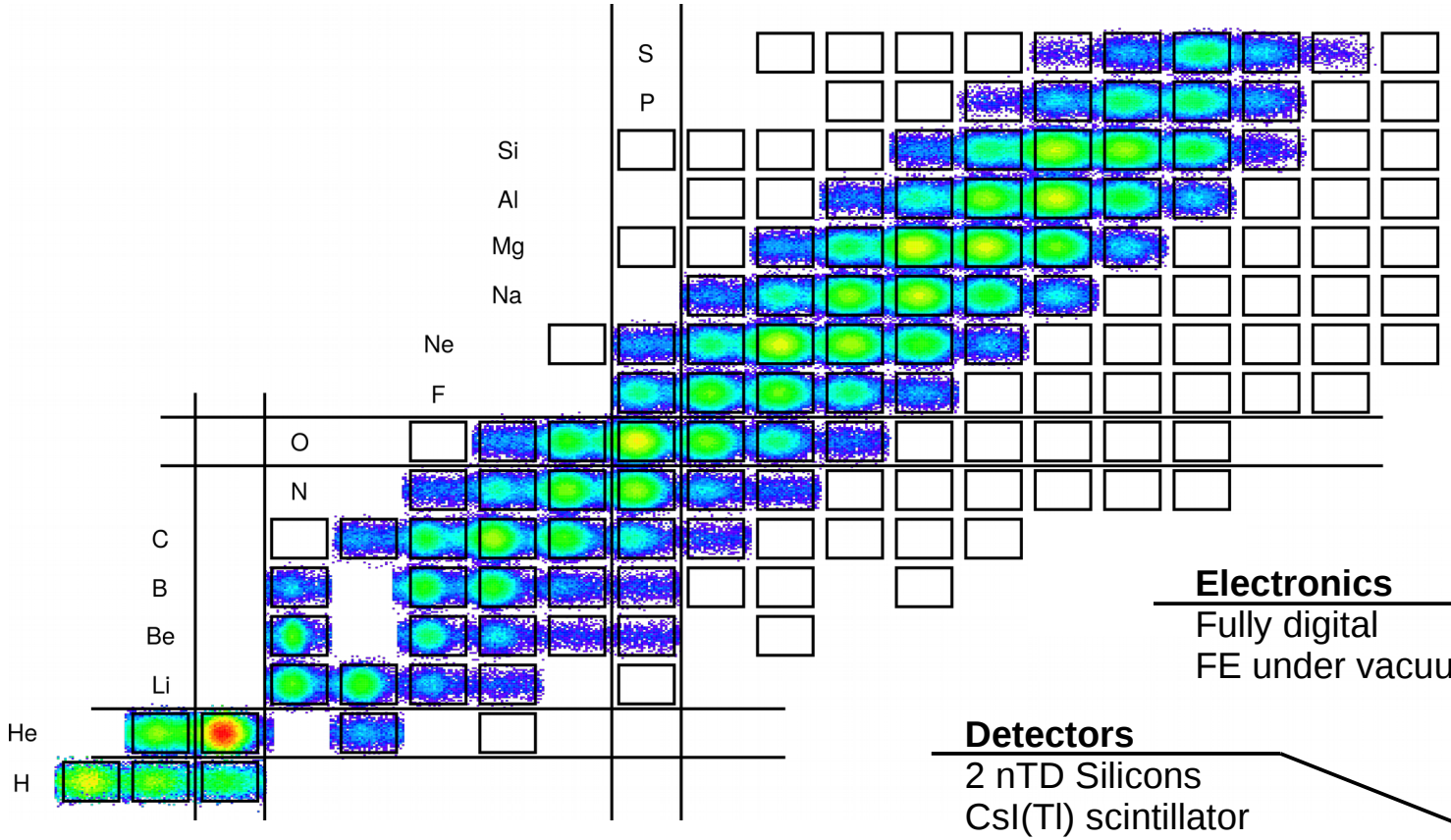
Detectors
2 nTD Silicons
CsI(Tl) scintillator

Identification
Pulse Shape Analysis
DeltaE – E
Full isotopic identification



^{12}C target

^{20}Ne,^{32}S@25,(50)MeV/A

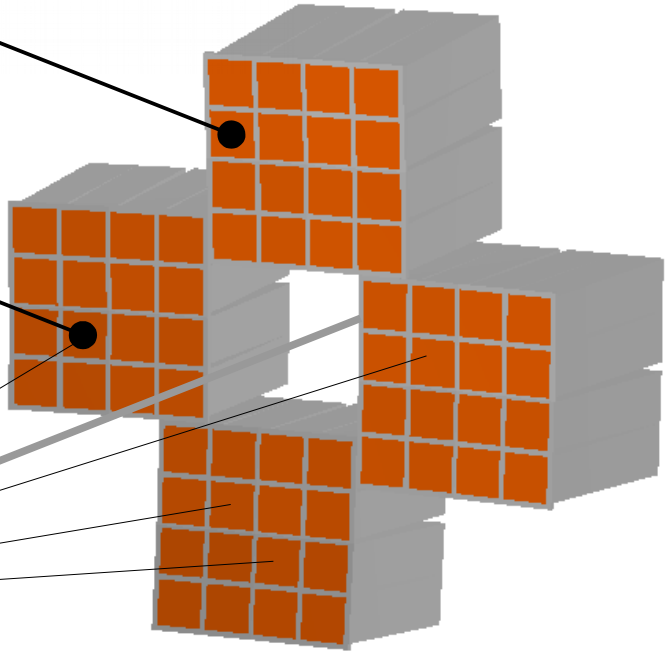


FAZIACOR@LNS. Compare Hoyle state decay produced in various fragmentation reactions: ^{20}Ne and ^{32}S at 25,50 MeV/nuc on ^{12}C target.

Electronics
Fully digital
FE under vacuum

Detectors
2 nTD Silicons
CsI(Tl) scintillator

Identification
Pulse Shape Analysis
DeltaE – E
Full isotopic identification

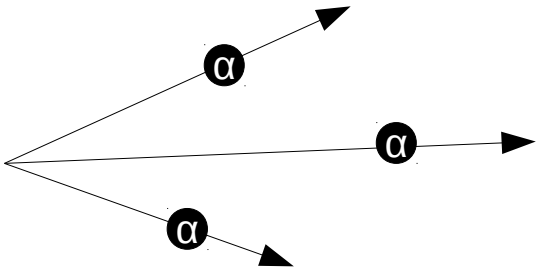


^{12}C target

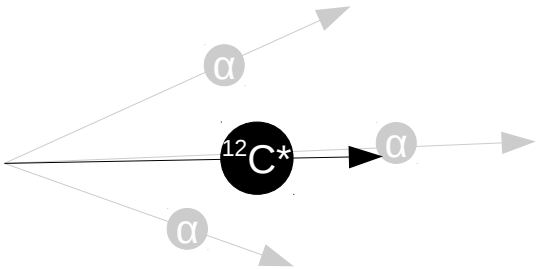
^{20}Ne,^{32}S@25,(50)MeV/A

Data reduction. Experiment done last March. All identifications performed. Silicon detectors calibrated. Still fighting with CsI calibration (safe for Z>1)

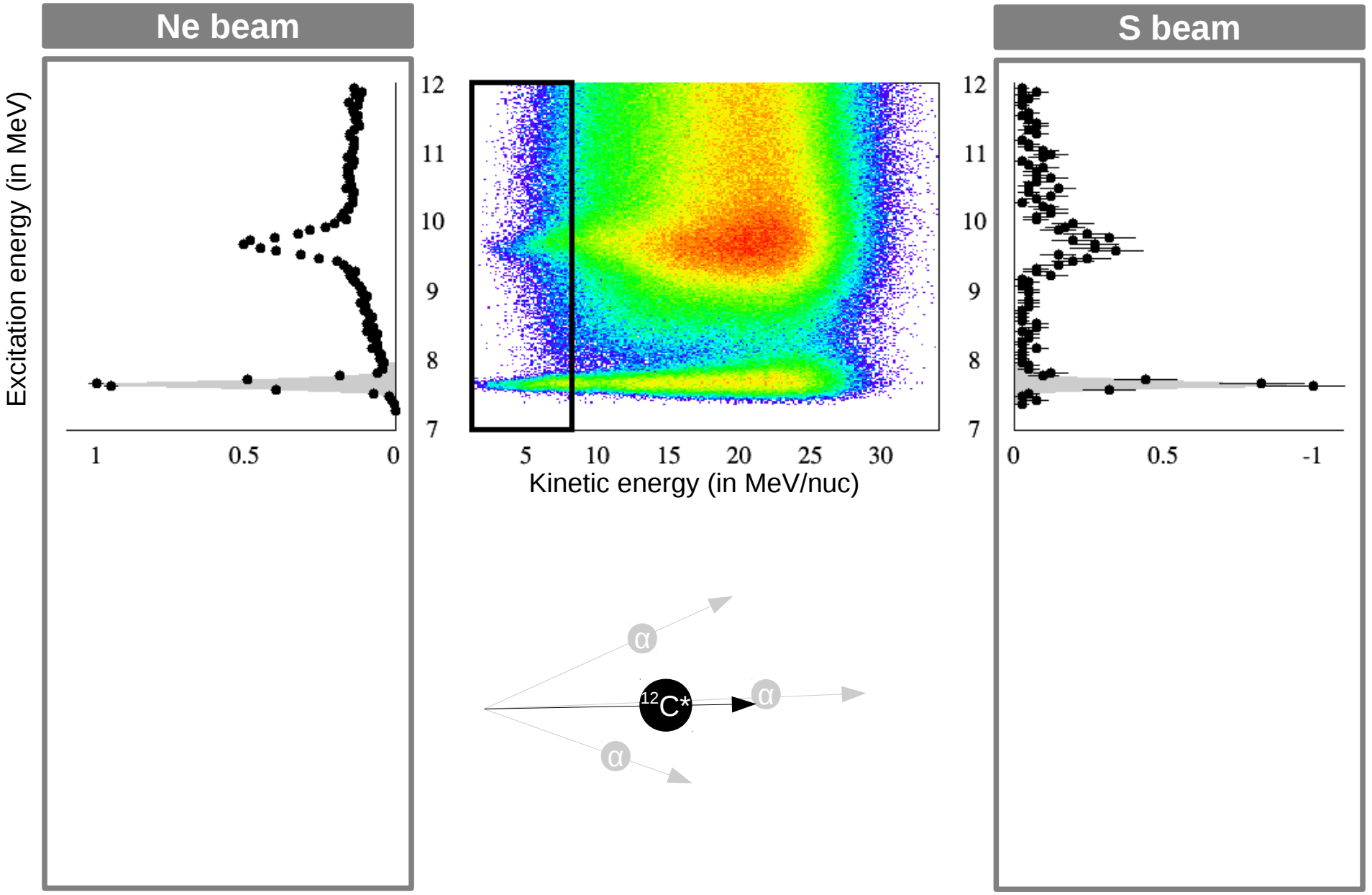
Hoyle state decay reconstruction



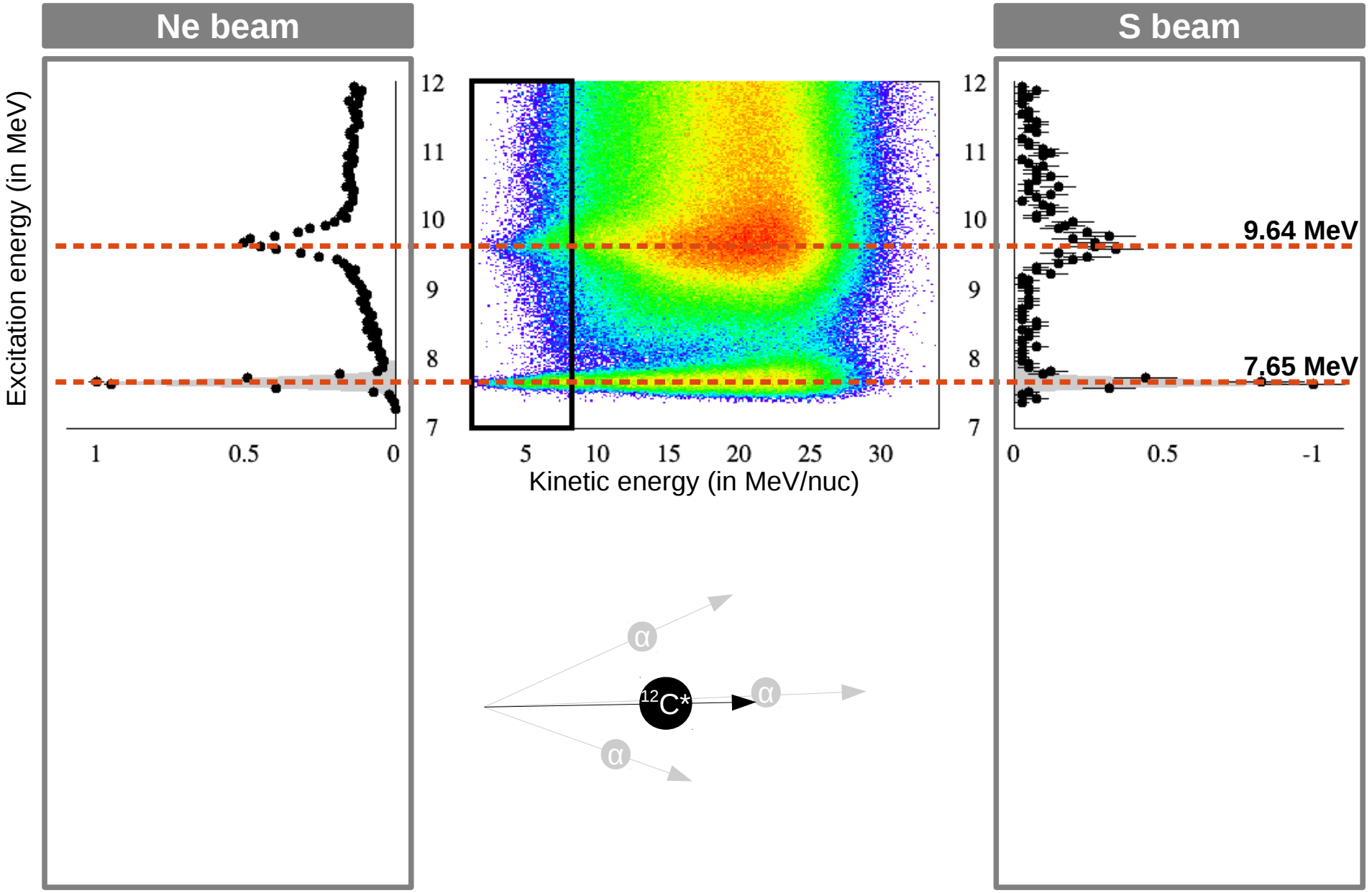
Hoyle state decay reconstruction



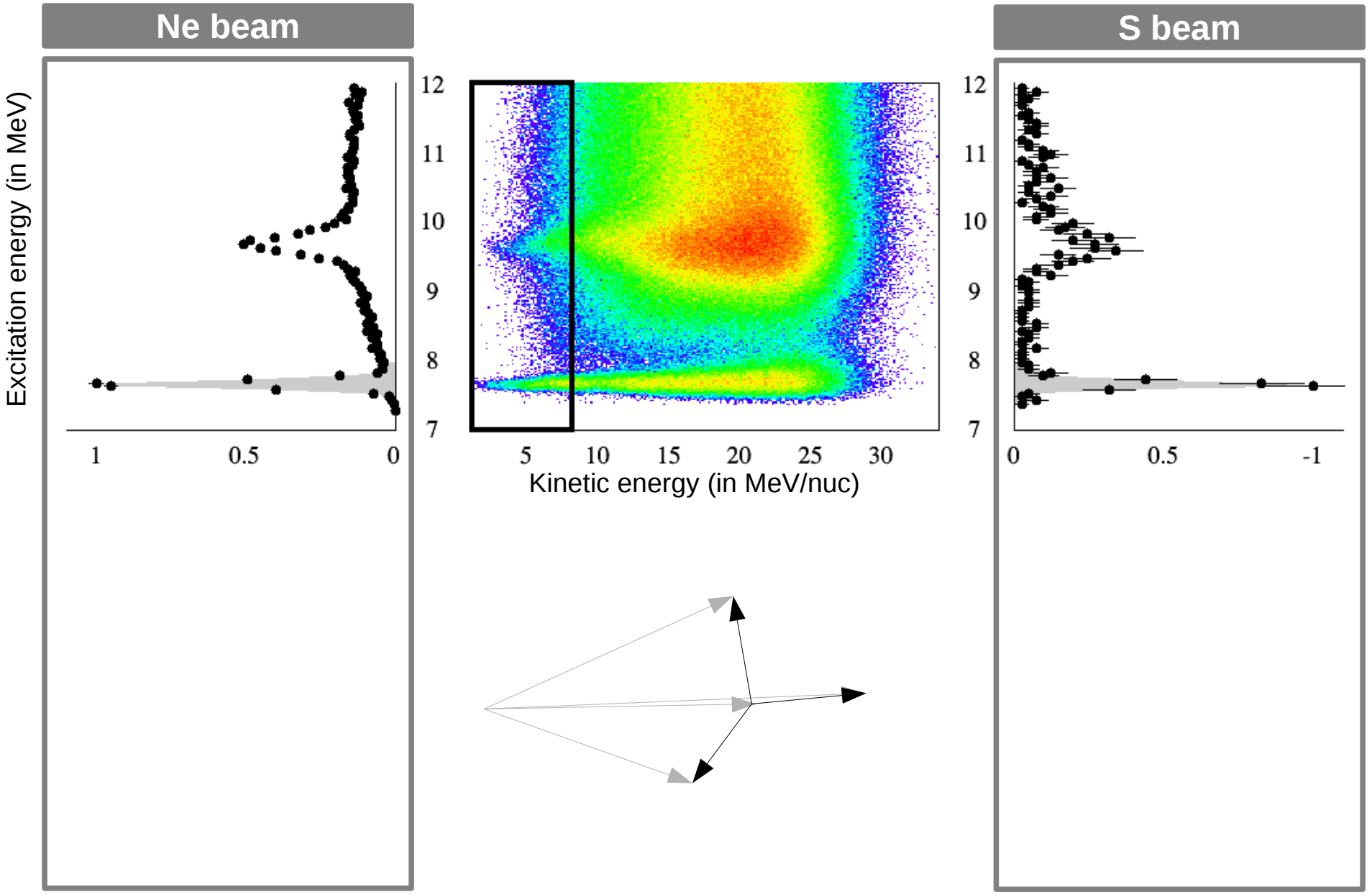
Hoyle state decay reconstruction



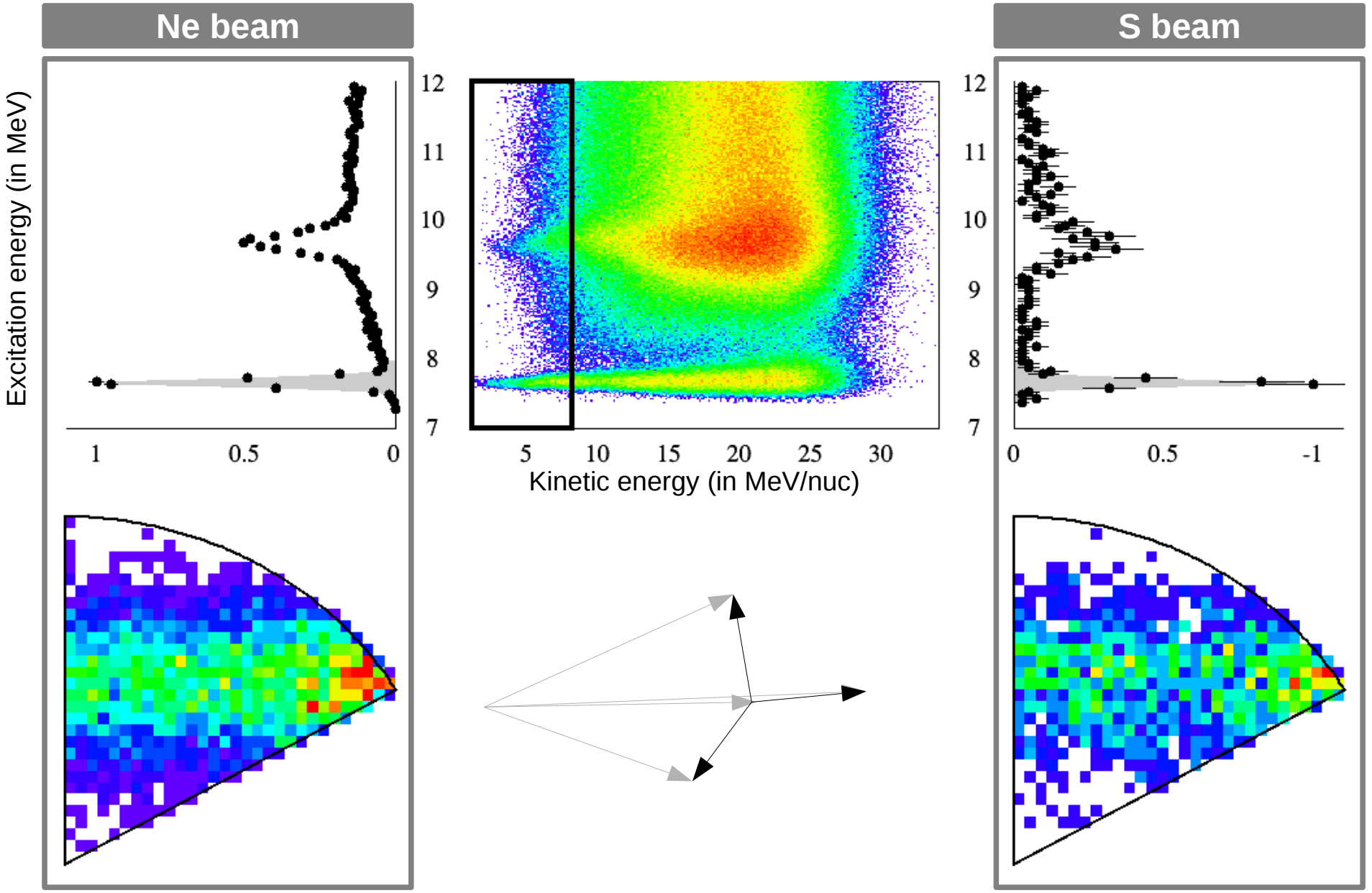
Hoyle state decay reconstruction



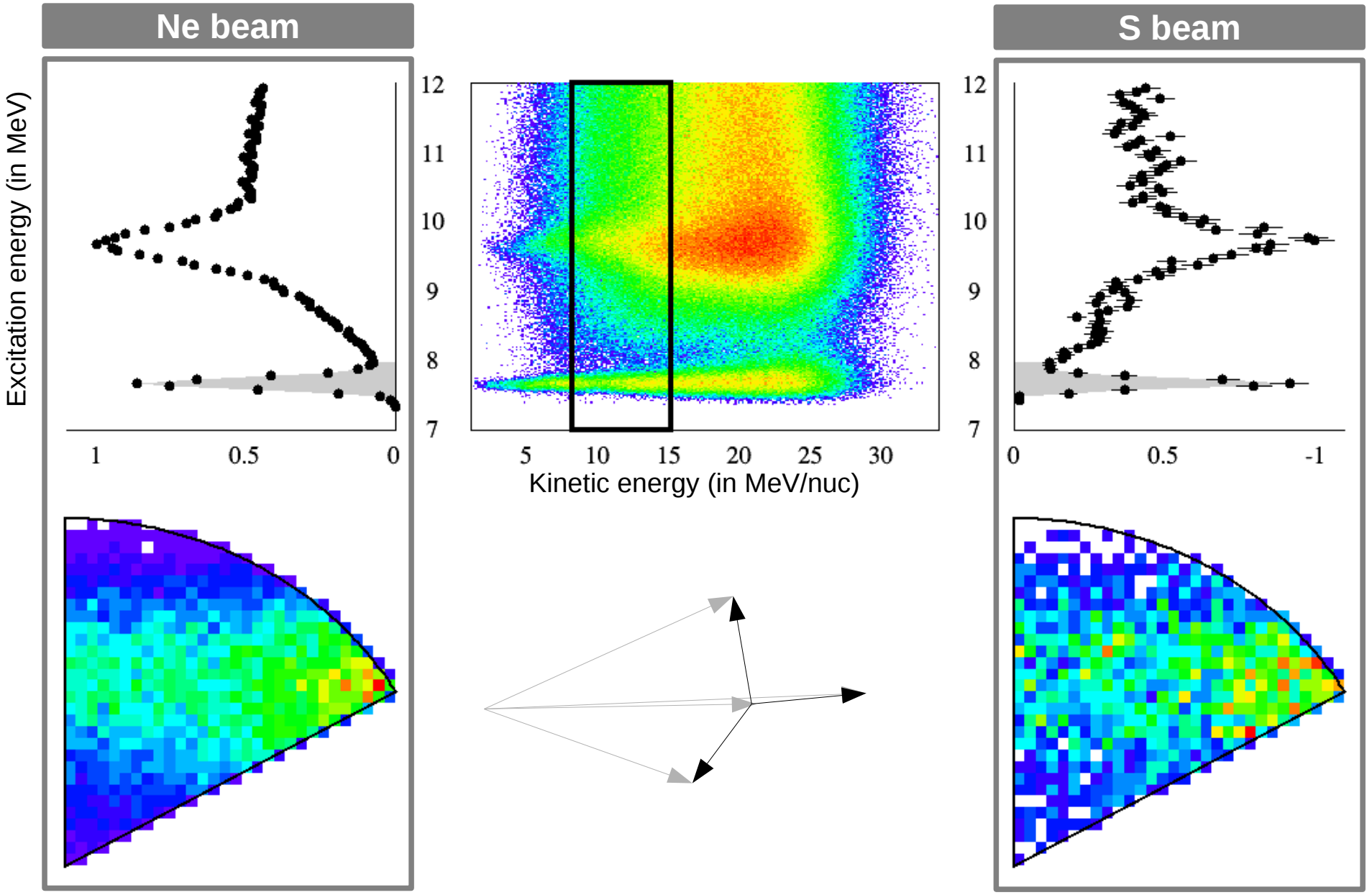
Hoyle state decay reconstruction



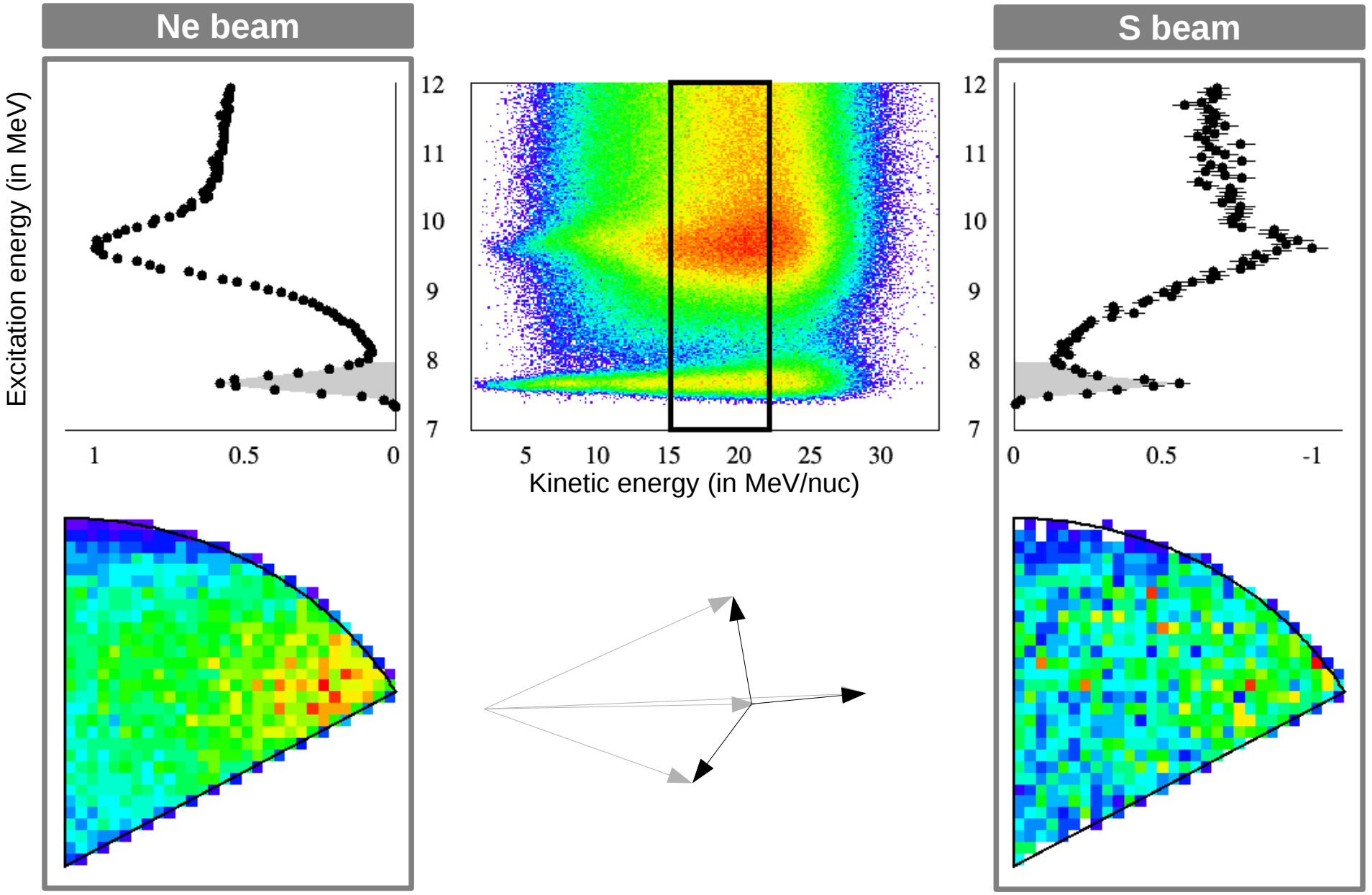
Hoyle state decay reconstruction



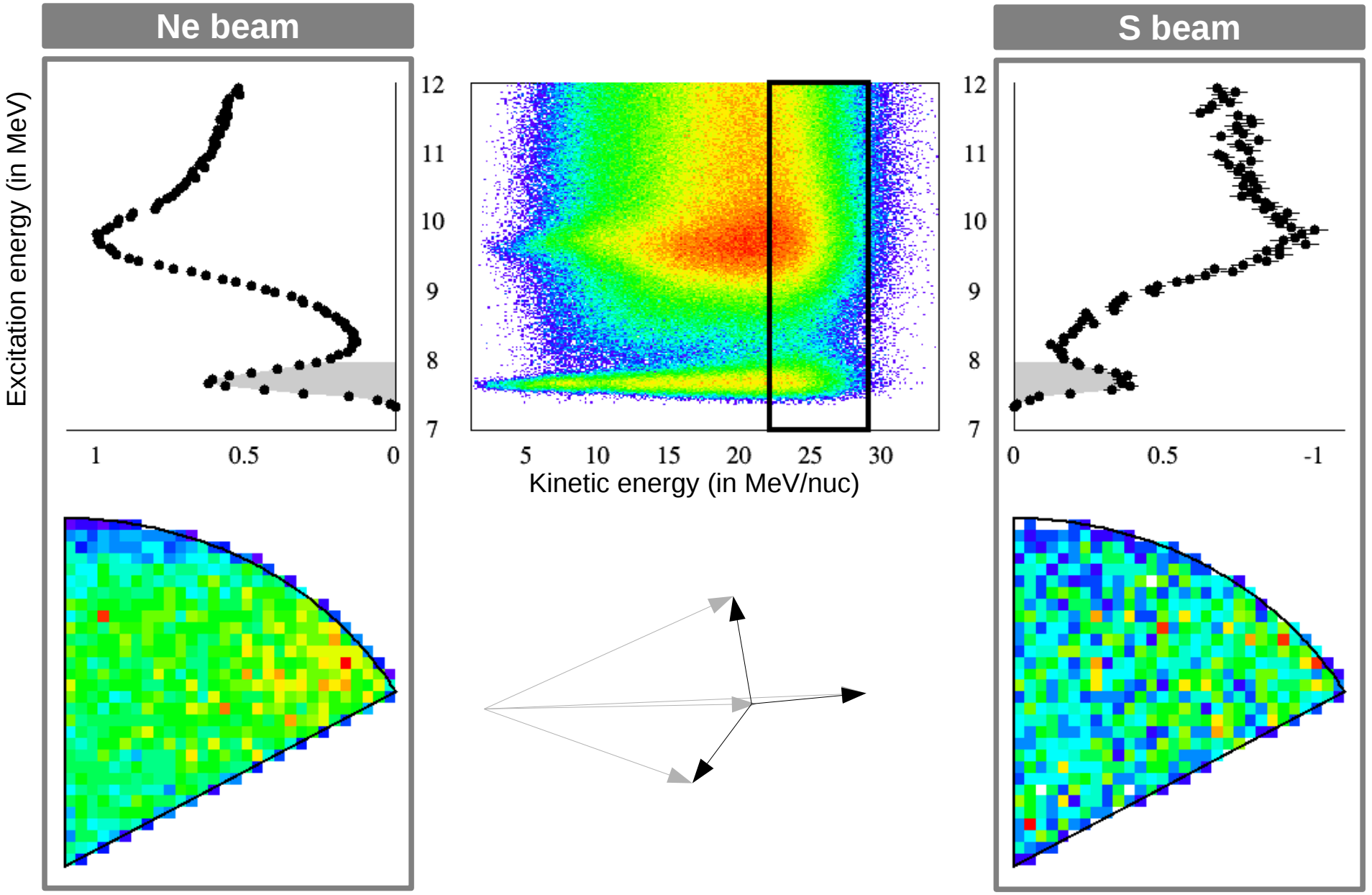
Hoyle state decay reconstruction



Hoyle state decay reconstruction



Hoyle state decay reconstruction



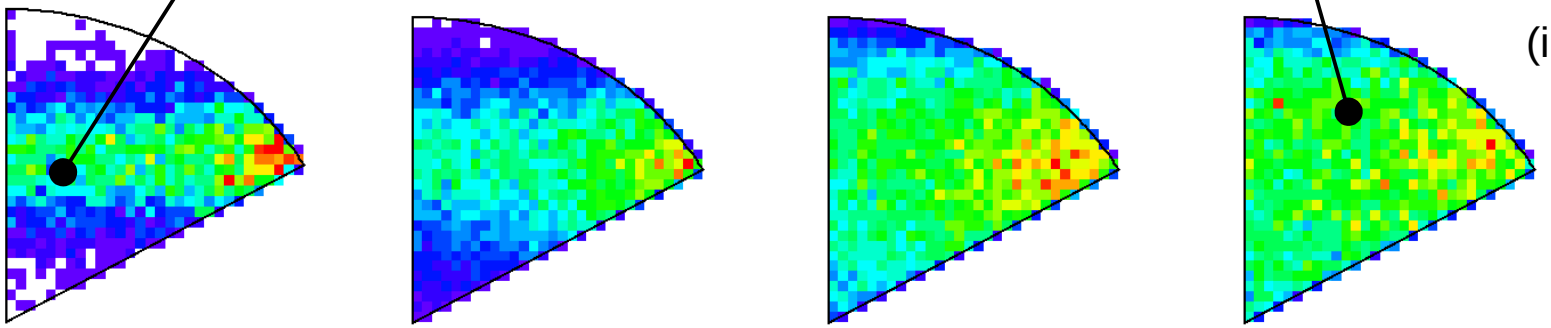
Fast carbon 12
Direct decay pattern
Resolution effects ?

Slow carbon 12
Sequential decay pattern
BR to be estimated (~1 %)

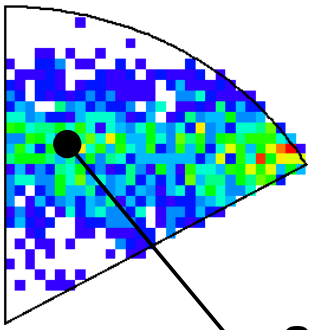
5 11 17 23

^{12}C kinetic energy
(in MeV/nuc)

Ne



S



System size dependance
No qualitative difference
between the two systems

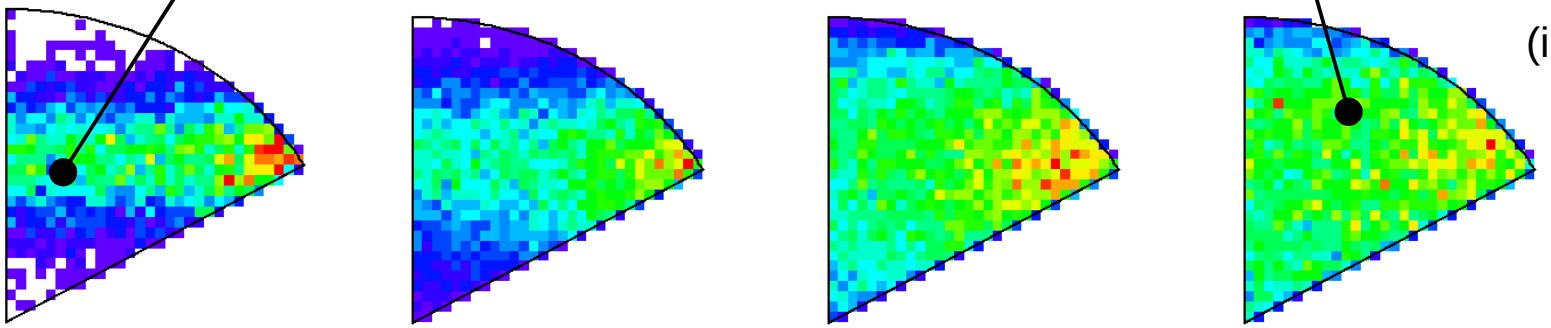
Fast carbon 12
Direct decay pattern
Resolution effects ?

Slow carbon 12
Sequential decay pattern
BR to be estimated (~1 %)

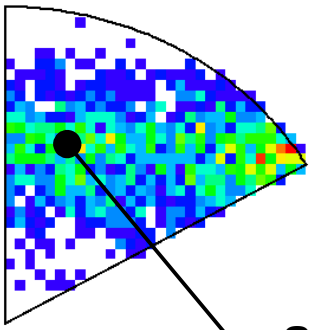
5 11 17 23

^{12}C kinetic energy (in MeV/nuc)

Ne



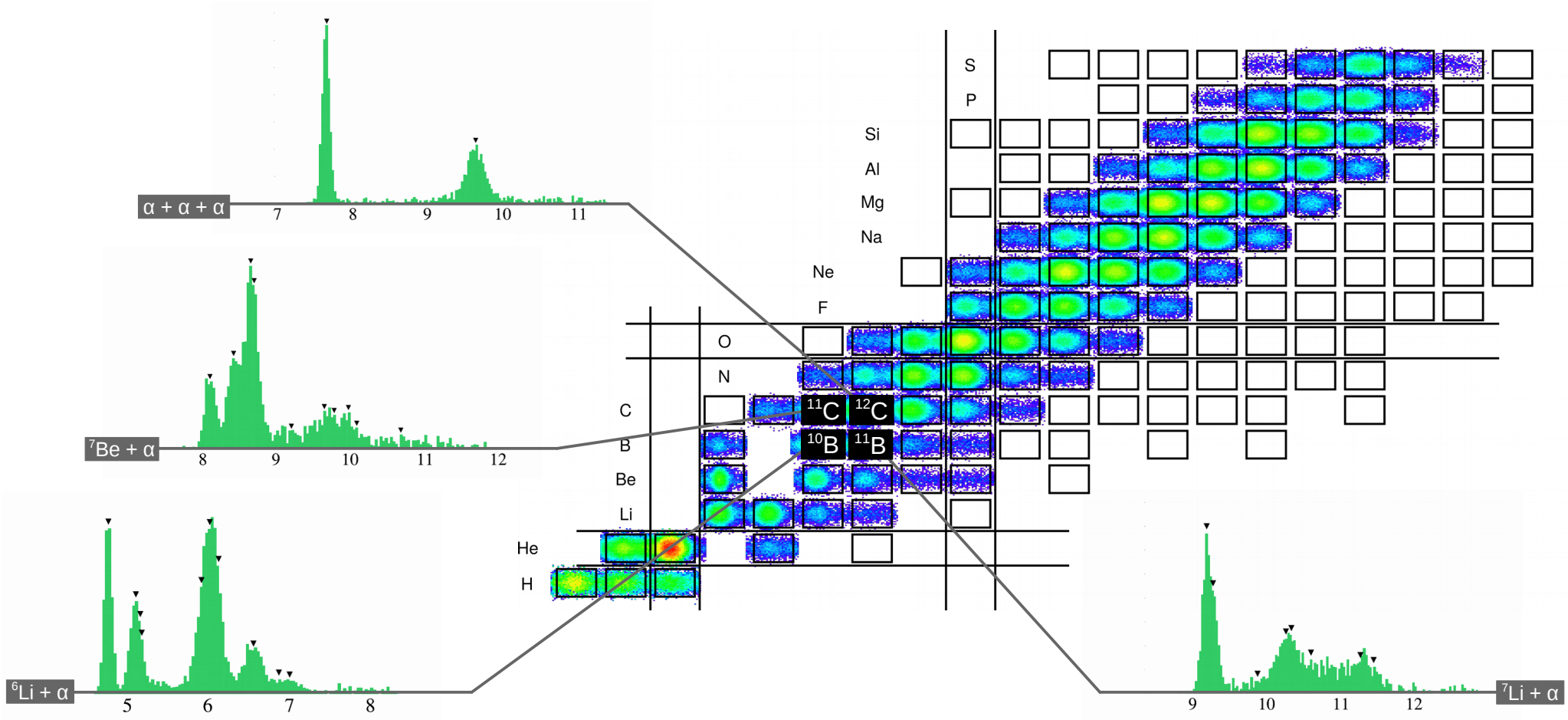
S



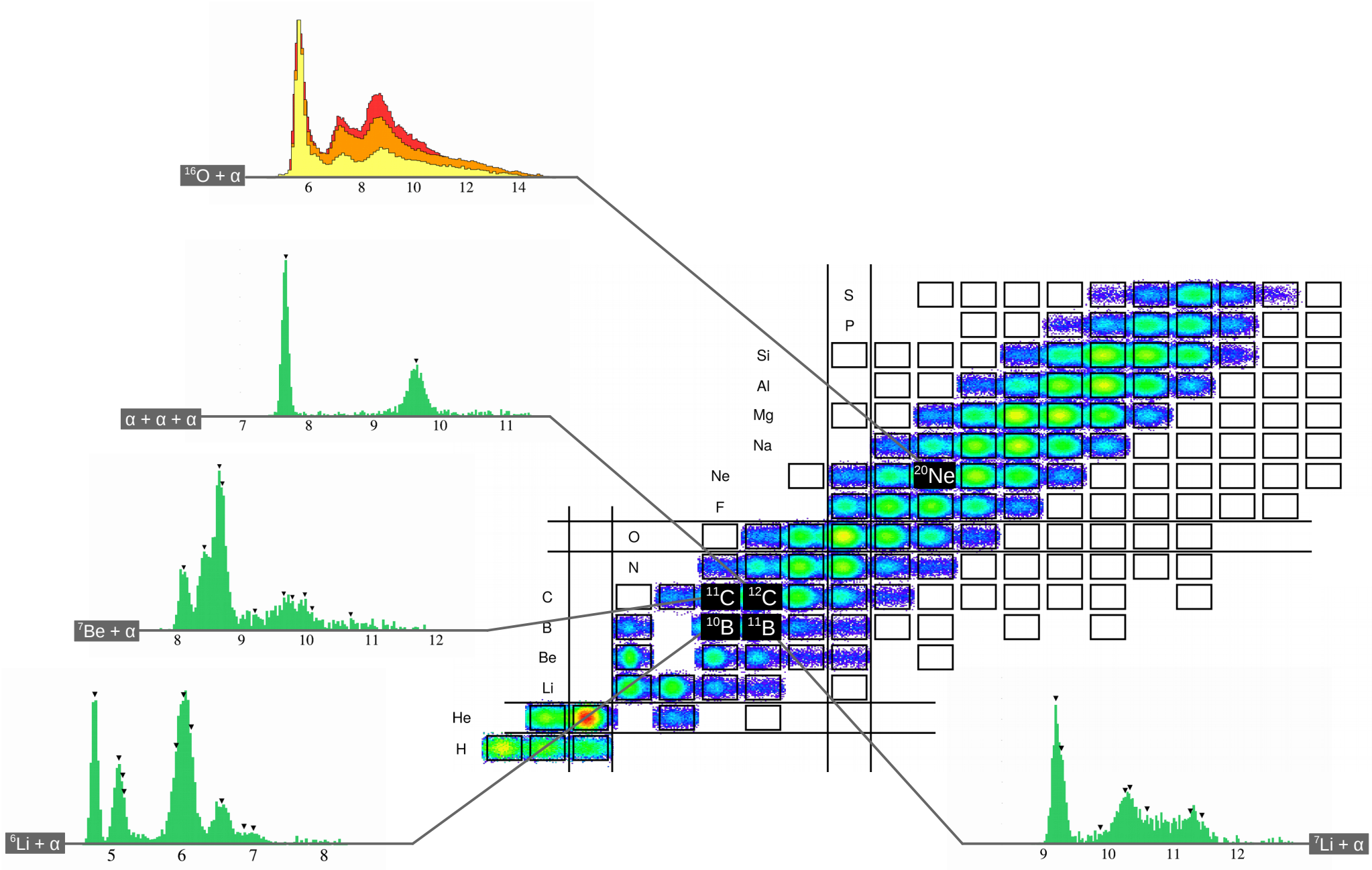
System size dependance
No qualitative difference between the two systems

What's next ?
Quantify all these qualitative observations : finalize CsI(Tl) calibration and perform simulations to account for experimental resolution and efficiency. Proper background estimation...

Prospects with this dataset

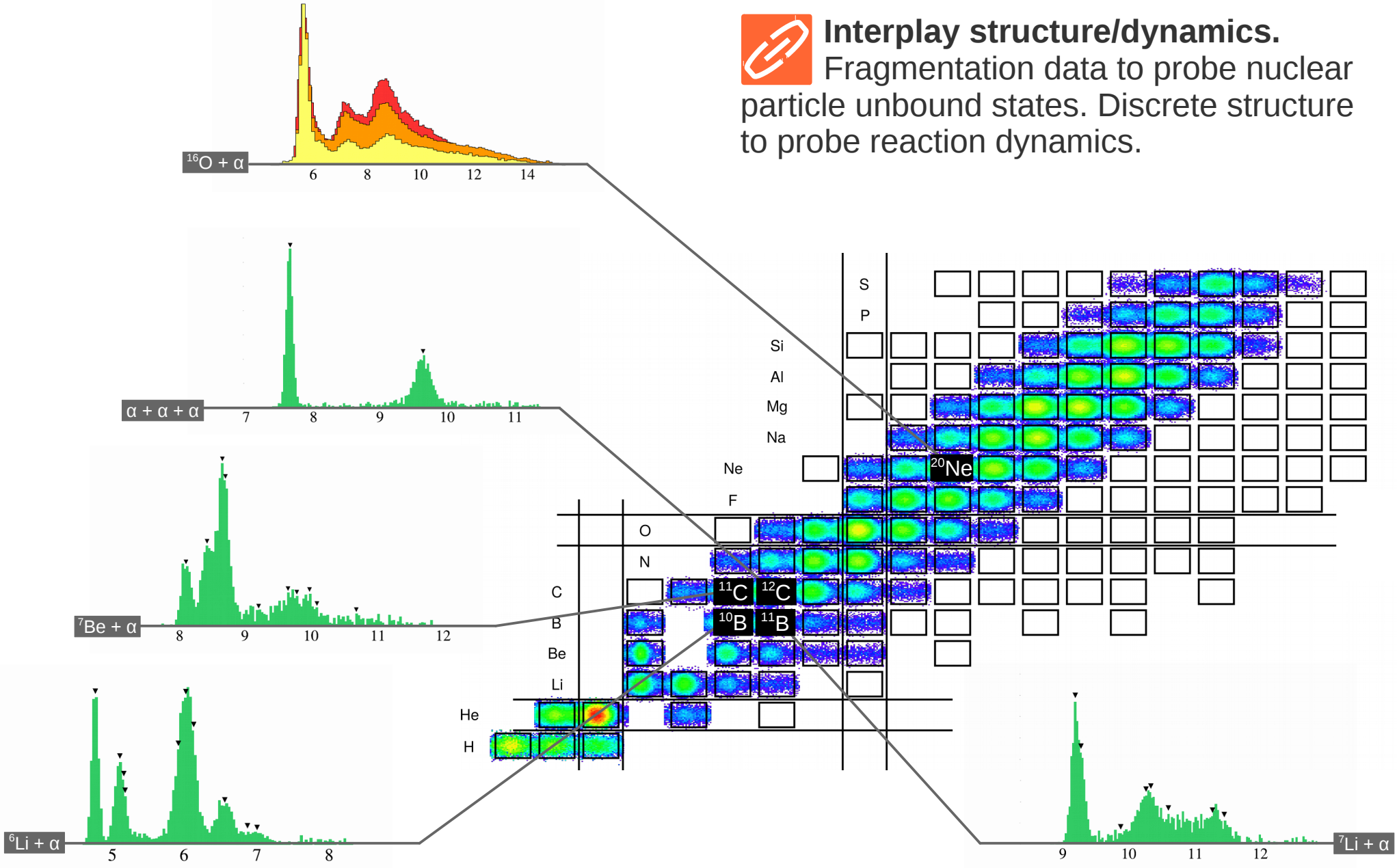


Prospects with this dataset

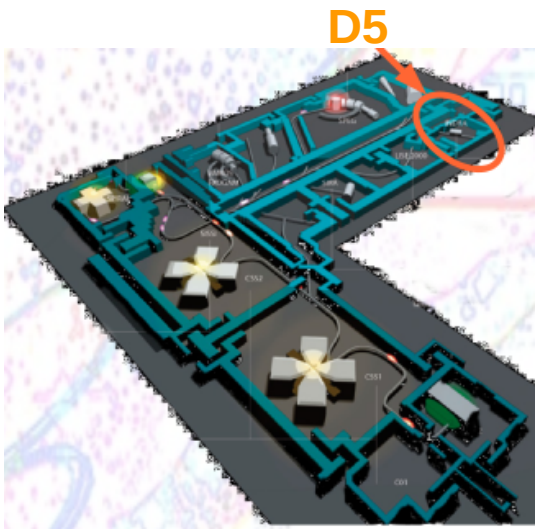


Prospects with this dataset

Interplay structure/dynamics. Fragmentation data to probe nuclear particle unbound states. Discrete structure to probe reaction dynamics.



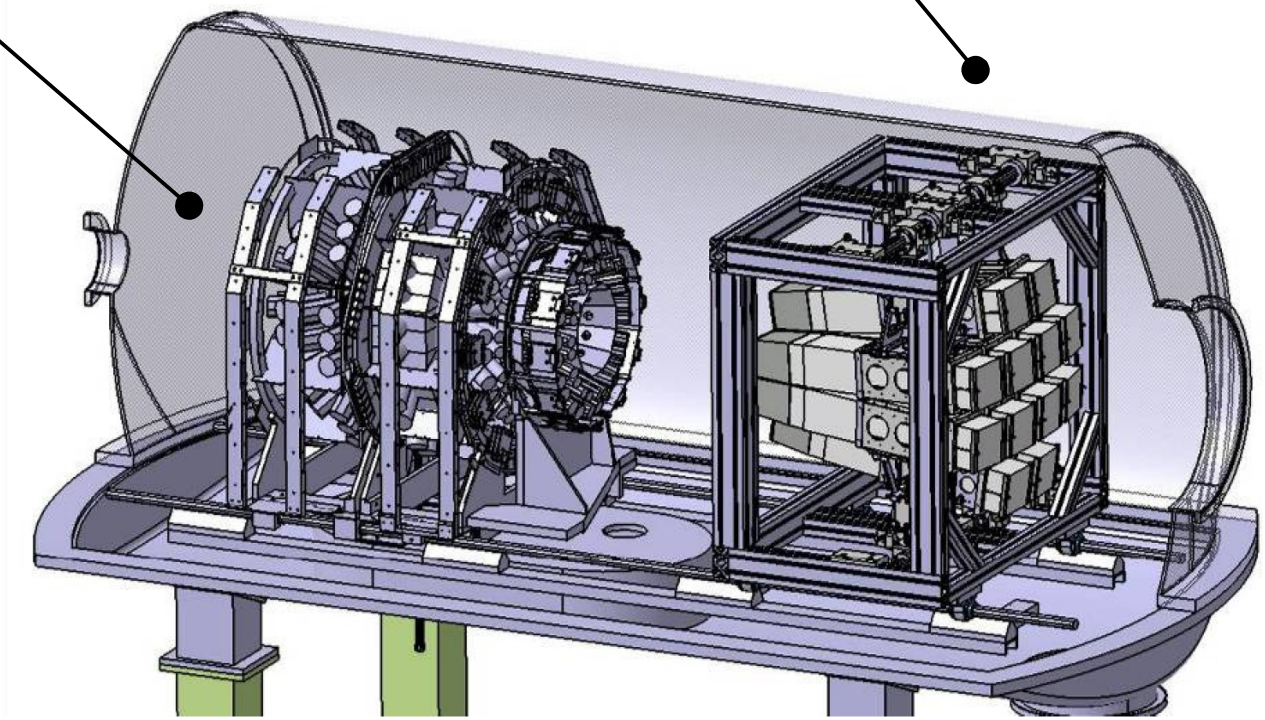
Future of FAZIA at GANIL



Physics program at GANIL.
Nuclear matter transport properties.
Nuclear Equation of state for astrophysics.
Clusters in structure and dynamics.

FAZIA 12 blocks
Isospin sensitive observables
Charged particle correlations
Quantum thermometer...

INDRA -5 rings
Impact parameter selector

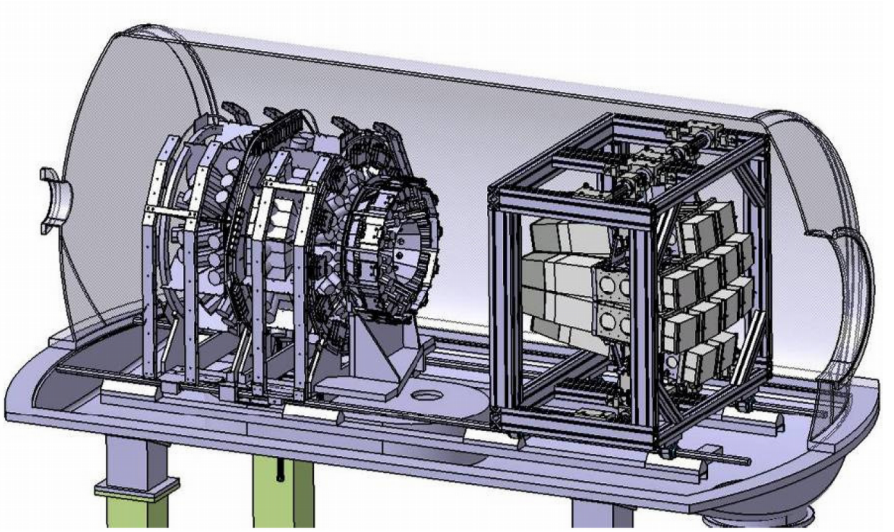


Thanks

G.Verde[1,16], D.Gruyer[7,2],
B.Borderie[1], P.Napolitani[1],
S.Barlini[2], M.Bini[2,3], G.Casini[2],
A.Olmi[2], G.Pasquali[2,3],
G.Pastore[2], S.Piantelli[2],
G.Poggi[2,3], A.Stefanini[2,3],
S.Valdrè[2], R.Alba[4],
M.Colonna[4], C.Maiolino[4],
D.Santonocito[4], M.Bruno[5],
L.Morelli[5], E.Bonnet[6],
A.Chbihi[6], J.Frankland[6],**Q. Fable[6]** R.Bougault[7], **M.Henri[7]**,
N.LeNeindre[7], O.Lopez[7],
M.Parlog[7], **E.Vient[7]**,
M.Cinausero[8], F.Gramegna[8],
J.Mabiala[8], T.Marchi[8],
M.Degerlier[1,9], J.Duenas[10],
D.Fabris[11], A.Kordyasz[12],
T.Kozik[13], D.Dell'Aquila[14],
L.Francalanza[14], R.LaTorre[14],
I.Lombardo[14], A.Ordine[14],
G.Spadaccini[14], M.Vigilante[14],
F.Aksouh[15], K.Kezzar[15],
L.Quattrocchi[17]
(FAZIA Collaboration)

[1]IPN Orsay and Univ. Paris-Sud, France
[2]INFN - Firenze, Italy
[3]Univ. of Firenze, Italy
[4]INFN LNS - Catania, Italy
[5]Univ. and INFN - Bologna, Italy
[6]GANIL, France
[7]LPC Caen, France
[8]INFN LNL - Legnaro, Italy
[9]Nevsehir Univ. Physics Department, Turkey
[10]Univ. of Huelva, Spain
[11]INFN - Padova, Italy
[12]Univ. of Warsaw, Poland
[13]Jagellonian Univ., Poland
[14]Univ. Federico II and INFN - Napoli, Italy
[15]Kind Saud Univ, Saudi Arabia
[16]INFN - Catania, Italy
[17]INFN - Catania Gr. Coll. Messina

Thanks



^{16}O + α
6
8
10
12
14
α + α + α
7
8
9
10
11
^{7}Be + α
8
9
10
11
12
^{6}Li + α
5
6
7
8
S
P
Si
Al
Mg
Na
Ne
F
O
N
C
B
Be
Li
He
H
^{20}Ne
^{11}C
^{12}C
^{10}B
^{11}B
9
10
11
12
^{7}Li + α



Very preliminary results