Nordic and Baltic Neutron Scattering Communities, 2006-2022

- a bibliometric study

Maja Krüger Lindholm, Daniel Lomholt Christensen and Kim Lefmann
Niels Bohr Institute
University of Copenhagen

13 October 2022

0. Perspective and scope of the investigation

This document presents and discusses the basic information needed to shed light on the present situation in the Nordic and Baltic scientific environment within neutron scattering science. The investigation is a part of a larger effort to establish the basis for the Nordic/Baltic involvement in the scientific part of the European Spallation Source (ESS). The investigation is organised by the Nordic Neutron Science Program, NNSP, under NordForsk.

We perform a bibliometric investigation of the publications produced by the five Nordic countries: Denmark, Norway, Sweden, Finland, and Iceland – as well as the three Baltic countries: Estonia, Latvia, Lithuania. Publications dealing with neutron scattering, including instrumentation, data collection and analysis are of interest. In addition, theoretical work is included if it is crucial to the experiments, i.e. prediction or modelling of experimental neutron data. However, the use of neutrons for fusion, nuclear and particle physics as well as for element analysis by nuclear activation analysis (NAA or PGAA) is excluded. The use of "ultra-cold" neutrons for e.g. fundamental studies of quantum mechanics is excluded as well. The present report is an update of a series of previous reports. The present work covers a 17-year period from 2006 to 2022, inclusive of both.

The report shows that there is in general a tendency for the publication output and the size of the scientific communities in neutron scattering, to increase in both Denmark and Sweden. The Swedish increase is concentrated to the universities, where the community has more than doubled over the last 4 years. In contrast, the numbers for staff at ESS have slightly decreased (due to a single event; explained later). The Danish increase is mostly steady, but smaller than found from Sweden. The community size in Norway shows a slowly increasing trend. The communities in Finland and Iceland are much smaller and constat. In the Baltic countries the communities are small, but Estonia has achieved a fair increase in the community size over the last few years.

1. Neutron Scattering articles

An analysis of neutron scattering papers published in the period of 1/1-2006 to 31/12-2022 is presented in this section. All peer-reviewed articles have been counted for every Nordic/Baltic country within each year, including the number of the articles published in the "top 20% high-profile" journals as defined by the Danish official "authority lists" from 2010 and 2016 (the 2016 list is used for the 2016-2021 publications; the 2010 list otherwise). The number of high-profile papers in this report is listed in the parentheses next to the total number.

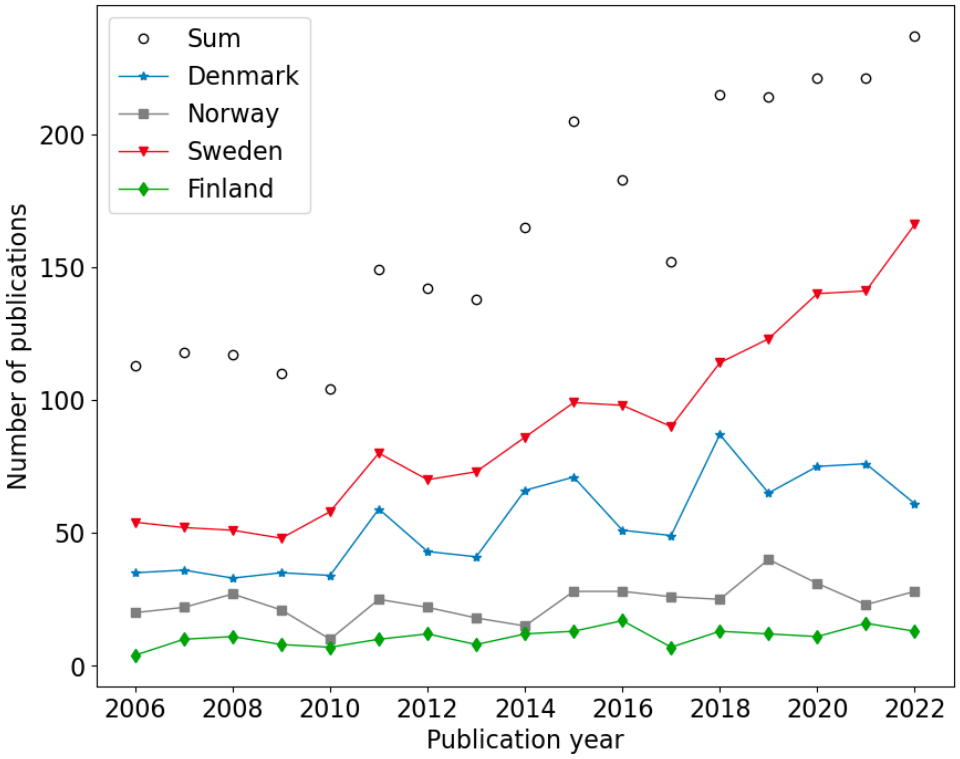
Most data have been found through ISI Web of Science: using a selection of neutron-related keywords. Abstracts were read to remove false searches and potential articles were studied further to be classified according to the type of neutron science they are based on and for the origin of the neutron sources used. In addition, the Journal of Neutron Research has been searched manually since this journal, until recently, did not appear in ISI Web of Science.

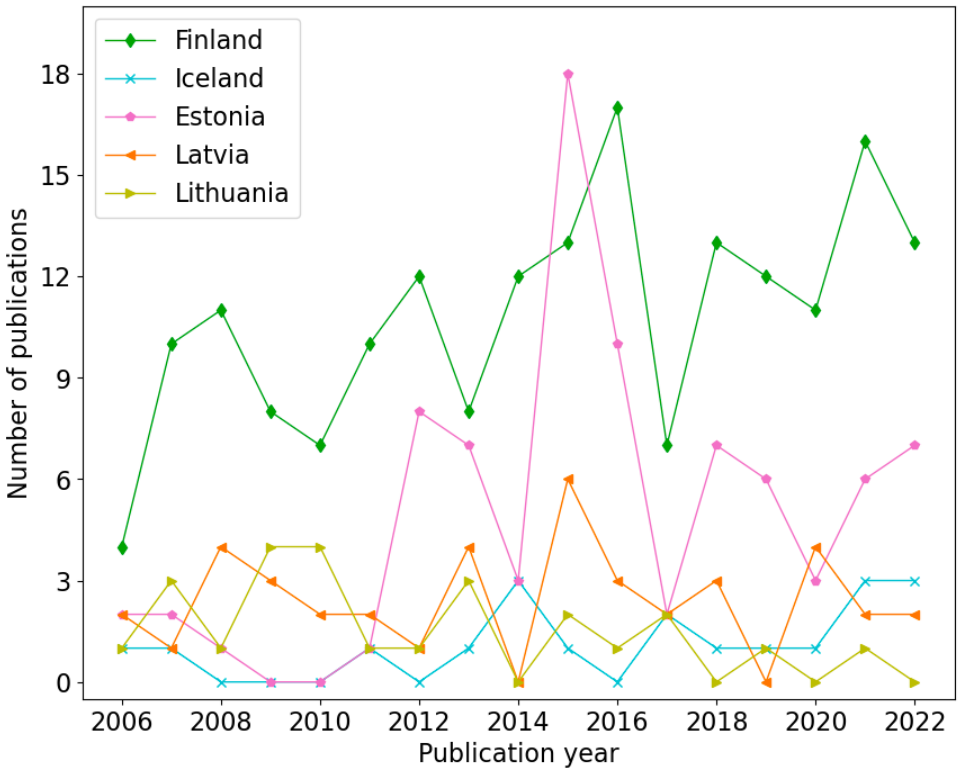
Meeting abstracts registered by ISI are included from the period of 2006-2018. For this reason, the present data cannot be compared directly with the reports from before 2019; the discrepancy levels are about 2%. Additionally, comparing this report to previously published, some changes in the numbers for Denmark will be seen. This is due to a re-count leading to a discovery of 14 additional articles written in collaboration with other Baltic and Nordic communities, which have now been added to the Danish count.

Articles from earlier years have been investigated, and some corrections have been made regarding number of articles, neutron sources, themes and methods. Thus, some numbers from this report will be marginally different from the 2021 report.

The table below contains articles from the last 5 years. In appendix 1.A the table shows from 2006-2022. In the period 2006-2022 our analysis found, in total, 2805 articles. The articles have been classified by country and year of publication. In the sum, publications with authors from more than one Nordic/Baltic country are counted only once. Nordic/Baltic collaborations and "double count correction" are discussed further in section 3.

Year/Country	2018	2019	2020	2021	2022	SUM (last 5 years)	SUM (all years)
DK	87 (36)	65 (27)	75 (23)	76 (30)	61 (22)	**364 (138)**	**917 (405)**
N	25 (6)	40 (9)	31 (7)	23 (5)	28 (11)	**147 (38)**	**409 (123)**
S	116 (25)	124 (28)	140 (27)	126 (41)	166 (63)	**672 (184)**	**1534 (510)**
FI	13 (2)	12 (4)	11 (6)	16 (2)	13 (8)	**65 (22)**	**184 (67)**
IS	1 (1)	1 (0)	1 (0)	3 (0)	3 (1)	**9 (2)**	**19 (7)**
ES	7 (0)	6 (1)	3 (0)	6 (4)	7 (3)	**29 (8)**	**83 (36)**
LV	3 (0)	0 (0)	4 (0)	2 (1)	2 (0)	**11 (1)**	**41 (5)**
LI	0 (0)	1 (1)	0 (0)	1 (0)	0 (0)	**2 (1)**	**25 (4)**
Double count	35 (11)	34 (8)	44 (8)	37 (12)	43 (15)	**193 (54)**	**407 (125)**
SUM	**217 (59)**	**215 (62)**	**221 (55)**	**216 (71)**	**237 (93)**	**1106 (340)**	**2805 (1032)**





The data from the table is presented in the two figures above. In the top figure, black represents the sum of all eight Nordic/Baltic countries, red represents Sweden, blue Denmark, grey Norway, and green Finland. In the bottom figure, Finland is green, while Estonia, Latvia, and Lithuania are pink, orange,

and olive, respectively. Cyan symbols represent Iceland.

It can be seen that Sweden has the largest publication number with Denmark being at approximately 60% of this value. Norway reaches 25% of Sweden, Finland is at 12%. Estonia is on average at 5%.

Many publications, 36% on average, are in the top-20% journals. This confirms the earlier observations that neutron scattering results often have a high scientific significance. This is likely due to the limited number of international neutron sources and the high demand for their use arising from it.

2. Neutron community, time development, and present location

The approximate size of the neutron scattering communities in the respective countries is listed here. The neutron community was defined to consist of the authors (total 640) with at least two neutron-related publication within the last 5 years. The authors were divided into three categories:

- **Infrequent users** with 2-4 publications. This would typically cover scientists new to the field, or where neutrons are one among several techniques, as well as PhD students close to the end of their studies.
- **Frequent users** with 5-9 publications. This would typically be professors or staff scientists working with neutrons as one of their research techniques, post docs within the field or very talented PhD students.
- **Expert users** with 10+ publications. This is typically professors or staff scientists with particular neutron expertise or post docs specializing in neutron scattering and with a strong scientific potential.

The list below covers the 5-year period from 2018 to 2022. The staff at ESS was separated from the rest of the Swedish scientists to highlight the direct effect of this facility. The sizes of the national communities are roughly proportional to the number of publications. The core of the Nordic/Baltic communities (the frequent and expert users) presently counts 194 scientists.

Author type	Infrequent (2-4)	Frequent (5-9)	Expert (10+)	**SUM**
Denmark	108	42	15	**165**
Norway	44	7	5	**56**
Sweden, excl. ESS	219	51	17	**287**
Sweden, ESS only	41	31	15	**87**
Finland	15	5	0	**20**
Iceland	1	1	0	**2**
Estonia	14	3	0	**17**
Latvia	4	2	0	**6**
Lithuania	0	0	0	**0**
SUM	**446**	**142**	**52**	**640**

The tables on the next pages cover the distribution of the communities in all 8 countries into their most recent affiliation. 16 institutions are found to have at least 10 neutron users.

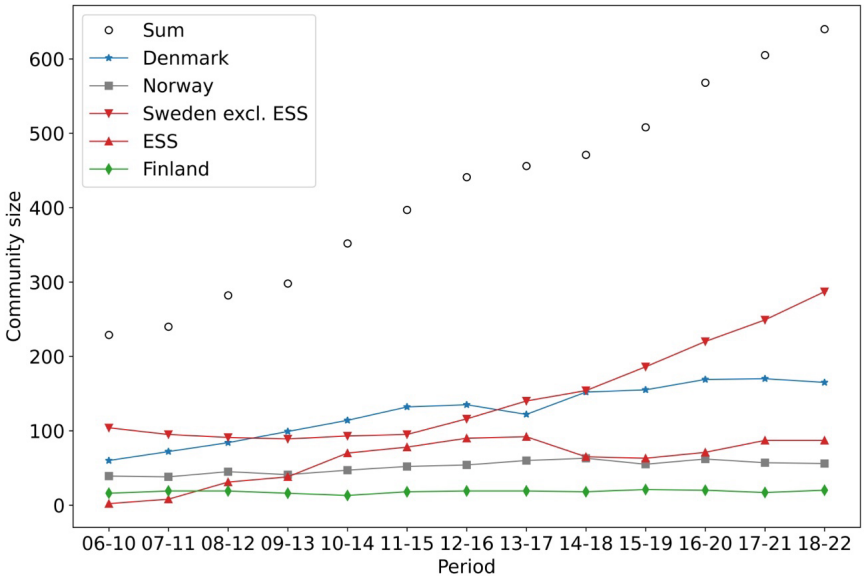
Affiliation	Infrequent (2-4)	Frequent (5-9)	Expert (10+)	SUM
DENMARK				
Univ. Aarhus	18	8	4	**30**
Univ. Copenhagen	42	18	8	**68**
Univ. South DK	1	1	0	**2**
DTU, Lyngby	29	6	2	**37**
ESS-Data Managem.	6	3	0	**9**
DK National Museum	0	0	0	**0**
Roskilde Univ.	4	2	0	**6**
Technol. Instit. (GTS)	1	3	1	**5**
Industry	3	0	0	**3**
Univ. Aalborg	4	1	0	**5**
NORWAY				
Inst. Energy Techn.	11	2	4	**17**
NTNU, Trondheim	13	0	0	**13**
Univ. Bergen	1	0	0	**1**
Univ. Oslo	17	5	1	**23**
Univ. Stavanger	2	0	0	**2**
SWEDEN				
Chalmers Tech. Univ.	26	7	1	**34**
ESS	41	31	15	**87**
KTH, Stockholm	28	8	2	**38**
Linköping Univ.	12	3	0	**15**
Luleå Univ.	1	0	0	**1**
Lund Univ.	61	9	4	**74**
Malmö Univ.	7	6	2	**15**
Stockholm Univ.	23	3	1	**27**
Umeå Univ.	2	2	0	**4**
Uppsala Univ.	51	11	7	**69**
University West	0	1	0	**1**
Karolinska Inst.	3	0	0	**3**

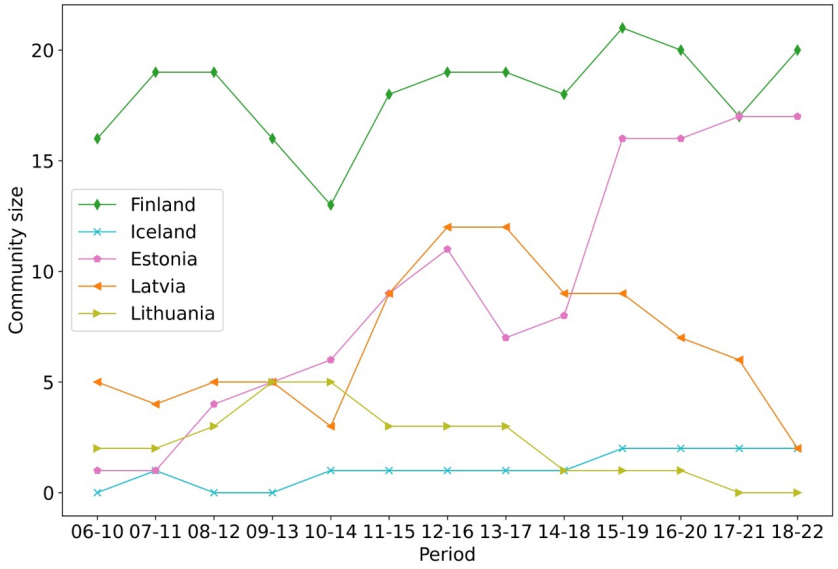
Affiliation	Infrequent (2-4)	Frequent (5-9)	Expert (10+)	SUM
Industry	5	1	0	**6**
FINLAND				
Aalto Univ. Techn.	8	3	0	**11**
Lappeenranta U. Techn	2	0	0	**2**
Oulu Univ.	3	0	0	**3**
Åbo Academy	1	1	0	**2**
Univ. Helsinki	0	1	0	**1**
VTT	1	0	0	**1**
ICELAND				
Univ. Iceland	1	1	0	**2**
ESTONIA				
NICPB, Tallinn	4	0	0	**4**
Univ. Tartu	10	3	0	**13**
LATVIA				
Riga Techn. Univ.	1	0	0	**1**
Univ. Latvia	3	2	0	**5**
LITUANIA				
Vilnius State Univ.	0	0	0	**0**

Below, the development of the Nordic/Baltic communities is shown over time. The numbers represent the total community, while the numbers in parentheses denote the sum of frequent and expert users.

Comm. size	2006-2010	2007-2011	2008-2012	2009-2013	2010-2014	2011-2015	2012-2016	2013-2017	2014-2018	2015-2019	2016-2020	2017-2021	2018-2022
Denmark	60 (22)	72 (23)	84 (28)	99 (29)	114 (32)	132 (40)	135 (43)	122 (43)	152 (45)	155 (52)	169 (45)	170 (49)	165 (57)
Norway	39 (14)	38 (12)	45 (15)	41 14)	47 (12)	52 (14)	54 (9)	60 (11)	63 (11)	55 (13)	62 (12)	57 (14)	56 (12)
Sweden, ex ESS	104 (32)	95 (27)	91 (25)	89 (24)	93 (26)	95 (28)	116 (30)	140 (36)	154 (43)	186 (44)	220 (59)	249 (59)	287 (68)
Sweden, ESS	2 (1)	8 (2)	31 (7)	38 (14)	70 (16)	78 (17)	90 (21)	92 (24)	65 (34)	63 (34)	71 (35)	87 (44)	87 (46)
Finland	16 (1)	19 (1)	19 (0)	16 (1)	13 (2)	18 (4)	19 (6)	19 (6)	18 (7)	21 (3)	20 (1)	17 (4)	20 (5)
Iceland	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	1 (0)	1 (0)	1 (1)	1 (1)	2 (0)	2 (0)	2 (1)	2 (1)
Estonia	1 (0)	1 (0)	4 (0)	5 (1)	6 (1)	9 (3)	11 (3)	7 (3)	8 (4)	16 (4)	16 (2)	17 (3)	17 (3)

Latvia	5 (1)	4 (0)	5 (0)	5 (0)	3 (0)	9 (0)	12 (0)	12 (0)	9 (0)	9 (0)	7 (0)	6 (0)	6 (2)
Lithuania	2 (1)	2 (0)	3 (0)	5 (0)	5 (0)	3 (0)	3 (0)	3 (0)	1 (0)	1 (0)	1 (0)	0 (0)	0 (0)
SUM	**229 (72)**	**240 (65)**	**282 (75)**	**298 (83)**	**352 (89)**	**397 (106)**	**441 (112)**	**456 (124)**	**471 (145)**	**508 (150)**	**568 (154)**	**605 (174)**	**640 (194)**





The data from the table is presented graphically in the two figures above. In the first plot, the black circles represent the sum of the Nordic and Baltic countries, other symbols are S, DK, N, FI, and ESS as shown

in the legend. In the second plot, Finland is presented along with Iceland and the three Baltic countries. The data show a clearly increasing tendency in the Nordic/Baltic communities, a 145% increase over the past 10 years. The increase is caused by 3 clear tendencies: 1) the community size for Denmark has almost tripled, 2) the numbers for Sweden, excl. ESS have more than doubled, and Norway's has increased by almost 50%, and 3) the number for ESS has increased from nearly 0 to 87. Estonia (pink) shows increase as well, although the absolute numbers are small. Finland (green), and Iceland (cyan), show hardly any significant changes over the period. Latvia (orange) and Lithuania (olive) have decreased quite significantly in the last five years.

By studying the numbers closer, the significant increase in Denmark's numbers is seen to be caused equally by the increase in PhD students and post docs as well as the attraction of new permanent staff. The slight dip in the 2017 numbers was related to a halt of activity of a few groups around 2012, which had an impact on the numbers only 5 years later due to the way the community is defined.

The initial decrease of "Sweden excl. ESS" is related to the close-down of the Studsvik reactor in 2005, with a recovery after around 10 years, followed by a healthy and steady growth. A similar behaviour was seen for the Danish community after the close-down of the Risø reactor in 2000. The strong initial increase of the ESS community follows the initial hiring of personnel at ESS combined with the fact that it takes a few years until the personnel have collected a sufficient number of publications with an ESS address. The particular decrease of the ESS community in 2018 is caused by a single factor: the ESS Technical Design Report from 2013, with around 400 authors, was no longer within the 5-year counting window.

3. Nordic-Baltic collaborations

The number of articles that feature authors from at least two Nordic/Baltic countries is listed here. As before, high-impact articles are listed in parentheses. Here are listed for the last 5 years, and in appendix 3.A the numbers are listed from 2006-2022.

Year	2018	2019	2020	2021	2022	SUM	SUM (all years)
Denmark/Norway/ Sweden/Finland	0 (0)	2 (1)	1 (0)	2 (1)	0 (0)	5 (2)	**5 (2)**
Denmark/ Norway/ Sweden	1 (1)	1 (0)	6 (1)	1 (0)	3 (1)	12 (3)	**20 (5)**
Denmark/ Norway/ Finland	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	2 (0)	**2 (0)**
Denmark/ Norway	3 (1)	4 (2)	1 (0)	6 (0)	2 (1)	16 (4)	**30 (9)**
Denmark/Sweden/ Lituania	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**2 (1)**
Denmark/ Sweden	24 (10)	12 (2)	22 (6)	25 (9)	23 (5)	106 (32)	**218 (68)**
Denmark/ Finland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**4 (0)**
Denmark/ Iceland	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	**1 (0)**
Denmark/ Estonia	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	1 (1)	**1 (1)**
Norway/Sweden/ Finland	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	1 (0)	**3 (0)**
Norway/Iceland/ Sweden	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	**1 (0)**
Norway/ Sweden	2 (0)	1 (0)	4 (1)	2 (0)	2 (1)	11 (2)	**45 (15)**
Norway/ Finland	1 (0)	1 (1)	1 (0)	0 (0)	0 (0)	3 (1)	**8 (2)**
Sweden/ Finland	1 (0)	2 (1)	1 (0)	2 (0)	6 (5)	12 (6)	**20 (12)**
Sweden/ Iceland	1 (1)	1 (0)	0 (0)	2 (0)	2 (0)	6 (1)	**8 (3)**
Sweden/ Estonia	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	**2 (1)**
Sweden/ Lithuania	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	1 (1)	**5 (1)**
Estonia/ Latvia	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	**7 (1)**
SUM	**34 (13)**	**26 (7)**	**37 (8)**	**43 (12)**	**40 (14)**	**180 (54)**	**382 (121)**

A significant number of collaborations between the countries can be seen. More than 14% of all publications in the investigations are of collaborative nature.

The largest number of collaborative works is on the axis Denmark-Sweden, although the Norway-Sweden combination is often seen as well. The Danish-Swedish collaboration seems to show a steady increase over most of the time span with a recent level of about 20 publications annually. The highest yet observed number was observed for 2021, reaching 25 collaborations.

We expect the collaboration patterns involving Norway to change due to the close-down of the Kjeller reactor and the coming establishment of the Norwegian activity at PSI.

4. Scientific themes

The distribution of all articles according to different scientific themes is presented here, as given by the ILL categorizing into "colleges". The categorizing is performed by our own judgement after studying the abstract of each article, or the full article in case of doubt. We have merged the ILL college 6: "glass and liquid dynamics" with college 7: "materials dynamics" and split the ILL college 1 into two: "Engineering/Geology" and "Instrumentation". As for the other ILL colleges: Theory (coll. 2) is not a separate field in this investigation: it is distributed in the corresponding scientific themes, whereas Nuclear Physics (coll. 3) is altogether not included in this report.

To illustrate the latest trends, a count of articles for the last five years (2018-2022) is shown in grey. High impact articles are listed in parentheses.

Category	Hard matter Structure	Materials Dyna-mics	Magnetic structure	Magnetic dyna-mics	Soft matter	Geology, enginee-ring	Life sci-ence	Instrumentation	Soft-ware	SUM
ILL coll.	**5a**	**6+7**	**5b**	**4**	**9**	**1a**	**8**	**1b**	**-**	**-**
Denmark	129 (49)	89 (43)	142 (93)	120 (90)	133 (63)	37 (8)	99 (25)	167 (31)	1 (0)	917 (402)
DK (2018-2022)	46 (19)	37 (21)	53 (24)	32 (27)	43 (16)	27 (5)	52 (10)	73 (16)	1 (0)	364 (138)
Norway	172 (57)	39 (4)	37 (12)	9 (7)	82 (27)	27 (8)	26 (4)	17 (4)	0 (0)	409 (123)
N (2018-2022)	40 (16)	18 (1)	16 (3)	2 (1)	26 (10)	22 (5)	14 (1)	9 (1)	0 (0)	147 (38)
Sweden	358 (112)	133 (63)	174 (73)	56 (42)	276 (103)	130 (32)	199 (51)	197 (30)	11 (4)	1534 (510)
S (2018-2022)	141 (40)	49 (18)	65 (20)	21 (13)	113 (38)	76 (22)	107 (24)	94 (7)	6 (2)	672 (184)
Finland	48 (22)	17 (11)	28 (10)	6 (3)	37 (13)	15 (5)	30 (2)	3 (1)	0 (0)	184 (67)
F (2018-2022)	13 (7)	3 (2)	9 (4)	3 (3)	12 (3)	9 (2)	14 (1)	2 (0)	0 (0)	65 (22)
Iceland	4 (1)	6 (5)	6 (1)	0 (0)	2 (0)	0 (0)	1 (0)	0 (0)	0 (0)	19 (7)
IS (2018-2022)	4 (1)	0 (0)	4 (1)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	9 (2)
Estonia	18 (10)	11 (5)	17 (10)	19 (10)	5 (0)	1 (1)	11 (0)	1 (0)	0 (0)	83 (36)
ES (2018-2022)	6 (3)	6 (3)	3 (1)	3 (0)	1 (0)	1 (1)	8 (0)	1 (0)	0 (0)	29 (8)
Latvia	5 (1)	4 (2)	9 (1)	0 (0)	3 (1)	12 (0)	0 (0)	7 (0)	1 (0)	41 (5)
LV (2018-2022)	0 (0)	1 (0)	0 (0)	0 (0)	1 (1)	7 (0)	0 (0)	1 (0)	1 (0)	11 (1)
Lithuania	4 (0)	3 (1)	2 (0)	1 (0)	8 (2)	1 (0)	6 (1)	0 (0)	0 (0)	25 (4)
LI (2018-2022)	0 (0)	1 (1)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
- double count	72 (30)	49 (19)	43 (19)	17 (10)	54 (14)	26 (9)	58 (11)	82 (11)	2 (0)	403 (123)
- double count (2018-2022)	28 (11)	24 (10)	27 (9)	8 (7)	16 (5)	19 (5)	33 (3)	33 (4)	1 (0)	189 (54)
SUM	666 (222)	253 (115)	372 (181)	194 (142)	492 (195)	197 (45)	314 (72)	310 (55)	11 (4)	2809 (1031)
SUM (2018-2022)	222 (75)	91 (36)	124 (44)	53 (37)	180 (63)	123 (30)	163 (33)	147 (20)	7 (2)	1110 (340)

The recent Danish activities are evenly spread over the topics with a large fraction of high-profile publications, particularly in magnetism and materials dynamics. Sweden has a similar spread as Denmark, although with more emphasis on materials structure/soft matter/life science and less on magnetic dynamics. The most frequent topic occurring in Danish neutron research is instrumentation, reaching 20% of the recent publications, whereas Sweden is relatively lower; at 14%. Norway has a clear strong point in structure of hard materials and in soft matter. Finland has some activity in hard matter structure, magnetism and soft matter. Estonia has a relatively large high-impact activity in magnetism and hard matter structure.

Overall, the research in Nordic/Baltic countries has most volume within hard matter structure, soft matter, and magnetic structure, whereas magnetic dynamics is rather low. Life sciences are well represented with 15% of the total publication volume, slightly higher than the international level (which is around 8%).

The high-impact (top 20%) publications are found in most categories, with the highest recent fractions found in magnetism (35% in structure, 70% in dynamics). Hard matter dynamics and soft matter have a very respectable high-impact rates of 40% and 35%. Instrumentation has the lowest fraction of high-profile publications (14%).

Looking at the numbers for all countries for the last five years compared to the total amount (17 years), there is a general increasing fraction of articles within magnetic dynamics, geology/engineering, life science and instrumentation. Especially within engineering and life science, the number of articles over the last 5 years account for over 60% of the total publications in this field. This is almost solely due to the expanding possibilities within neutron imaging. A decreasing trend within hard matter structure can also be seen. Each of the individual countries seem to follow the same overall trends.

5. Neutron scattering methods

The distribution of the articles on different neutron scattering methods is presented here. This division is mostly based upon the instrument classes. However, triple axis machines are grouped after their use: inelastic measurements or single crystal diffraction. When data for a publication has been taken by more than one technique, the "rarest" technique is noted. Instrumentation work that relates to measurement within another theme is here categorized under that theme, e.g. imaging instrumentation is counted under imaging.

The numbers in grey show the results for the last five years (2018-2022), with the number of High Impact articles in parenthesis.

Category	Powder diffract.	Single crystal diffract.	Stress /Strain diff.	SANS	Reflec-tometry	Inelastic scatte-ring	Ima-ging	Review, book, old data	Instru-men-ta-tion	Theor y	SUM
Denmark	118 (42)	79 (56)	6 (1)	145 (66)	49 (17)	188 (93)	47 (16)	77 (21)	102 (13)	106 (77)	917 (402)
DK (2018-2022)	57 (21)	29 (16)	4 (1)	52 (19)	26 (4)	70 (34)	31 (9)	35 (9)	38 (8)	22 (17)	364 (138)
Norway	162 (52)	18 (5)	11 (3)	89 (29)	16 (4)	41 (7)	7 (2)	32 (7)	11 (2)	22 (12)	409 (123)
N (2018-2022)	46 (46)	9 (9)	6 (6)	33 (33)	9 (9)	23 (23)	6 (6)	9 (2)	5 (5)	1 (1)	147 (147)
Sweden	342 (100)	57 (21)	57 (12)	279 (102)	213 (80)	189 (79)	68 (18)	88 (24)	142 (13)	99 (61)	1534 (510)
S (2018-2022)	119 (31)	30 (10)	23 (7)	151 (49)	97 (33)	81 (29)	43 (9)	34 (7)	71 (4)	23 (5)	672 (184)
Finland	41 (14)	20 (7)	2 (2)	37 (11)	7 (0)	17 (9)	2 (1)	16 (5)	2 (1)	40 (17)	184 (67)
F (2018-2022)	9 (4)	8 (3)	1 (1)	18 (3)	4 (0)	8 (5)	0 (0)	5 (2)	1 (0)	11 (4)	65 (22)
Iceland	3 (0)	0 (0)	0 (0)	2 (0)	6 (1)	1 (1)	0 (0)	0 (0)	0 (0)	7 (5)	19 (7)
IS (2018-2022)	1 (0)	0 (0)	0 (0)	1 (0)	6 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	9 (2)
Estonia	30 (17)	5 (3)	0 (0)	11 (2)	0 (0)	20 (7)	0 (0)	4 (2)	1 (0)	12 (5)	83 (36)
ES (2018-2022)	6 (3)	1 (0)	0 (0)	9 (2)	0 (0)	10 (3)	0 (0)	1 (0)	1 (0)	1 (0)	29 (8)
Latvia	7 (0)	0 (0)	0 (0)	4 (1)	1 (0)	5 (1)	10 (0)	4 (1)	6 (0)	4 (2)	41 (5)
LV (2018-2022)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	1 (0)	7 (0)	0 (0)	0 (0)	2 (0)	11 (1)
Lithuania	6 (0)	0 (0)	1 (0)	3 (1)	11 (3)	1 (0)	0 (0)	1 (0)	0 (0)	2 (0)	25 (4)
LI (2018-2022)	1 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
- double count	73 (26)	26 (11)	3 (1)	49 (16)	54 (13)	77 (20)	26 (12)	21 (8)	58 (8)	19 (12)	403 (123)
- double count	30 (12)	15 (5)	2 (0)	20 (5)	35 (4)	41 (14)	12 (4)	11 (4)	24 (7)	3 (1)	189 (54)

(2018-2022)											
SUM	636 (199)	153 (81)	74 (17)	521 (196)	249 (92)	385 (177)	108 (25)	201 (52)	206 (21)	273 (167)	2809 (1031)
SUM (2018-2022)	209 (63)	62 (26)	32 (10)	245 (81)	108 (35)	152 (60)	75 (16)	73 (16)	92 (5)	58 (26)	1110 (340)

Norway is seen to have a relatively high activity in powder diffraction, and some in SANS, which is reflective of the instrumentation that was present at the Kjeller reactor. Denmark has a high publication volume within SANS and inelastic scattering, reflecting the two Danish instruments working at PSI 2001-2018. Furthermore, Denmark and Sweden have much work within instrumentation related to ESS and within related theory. Sweden and Denmark also have significant activities within reflectometry, powder diffraction and inelastic scattering. Estonia has a relatively high activity within powder diffraction and inelastic scattering, while the Finnish activity is focused on powder diffraction, SANS and theory.

The fraction of high-profile publications is very high (46% to 61%) within single crystal diffraction, inelastic scattering and theory. The overall volume of publications in powder diffraction as well as SANS is very high making up 41% of all articles, with a lower fraction of high-profile publications (31% to 38%, which is still high taking into account this category counts only top 20% journals).

Looking at the activity of the last five years (2018-2022) compared to the total number (17 years), some new trends are showing. For Denmark, around 50% of articles published within powder diffraction, reflectometry and review have been published within the last 5 years. In the same country, the methods stress/strain and imaging, have had about 65% of the total articles published within the last 5 years. Sweden has a relative increase in all categories except theory, where only 23% of the articles are published within the last five years. The methods single crystal diffraction, SANS, reflectometry and inelastic scattering all have around 40% published within the last 5 years. Imaging has the largest increase with 55% of the publications being within the last 5 years, reflecting the large recent development in this fairly new field. In Norway single crystal diffraction, reflectometry, stress/strain, imaging, inelastic scattering and instrumentation have 50% or more published within the last five years. For the Baltic countries, no significant trend is seen due to low publication numbers.

In general, across 8 countries, there is a notable increase over the last five years in the number of publications within the methods stress/strain diffraction, reflectometry and especially, imaging.

6. Neutron sources

We here list the neutron sources used for the data in the Nordic/Baltic neutron publications. Experimental work as well as site-specific instrumentation is included. Some publications use data from several sources, in which case all used sources are counted. Only the publications that use original data are counted here; i.e. not theory and review papers. For all these reasons, the sums are different from the sums in the previous sections. Sources in parentheses are permanently closed. The numbers in the parenthesis show numbers for the last five years (2018-2022).

Source		DK	N	S	FI	IS	ES	LI	LV	Double count	SUM
ANSTO	AUS	31 (20)	9 (6)	61 (37)	3 (2)		2 (1)			11 (8)	**95 (58)**
BNC	H	8 (3)	2 (0)	5 (3)	3 (0)						**18 (6)**
(Chalk River)	CAN	4 (2)	1 (0)	4 (3)						3 (2)	**7 (3)**
CIAE	CHN		1 (1)								**1 (1)**
Delft	NL	9 (4)		9 (0)						5 (0)	**13 (4)**
Dhaka	BAN			1 (0)							**1 (0)**
Dhruva	IND			3 (1)	1 (1)						**4 (2)**
Dubna	RUS	1 (1)	9 (4)	4 (1)	3 (1)		7 (2)		6 (0)	3 (1)	**27 (8)**
ESS	S	55 (29)	4 (2)	55 (25)	1 (1)				2 (0)	34 (15)	**83 (42)**
FRM2	D	46 (24)	17 (10)	71 (33)	11 (6)		4 (4)	3 (0)		17 (10)	**135 (67)**
(GKSS)	D	7 (0)	7 (0)	18 (0)	1 (0)			1 (0)		6 (0)	**28 (0)**
HFIR	US	10 (3)	3 (3)	12 (5)	1 (1)		1 (1)				**27 (13)**
(HZB)	D	46 (19)	8 (1)	56 (28)	5 (2)		11 (6)	1 (1)	10 (1)	21 (10)	**116 (48)**
Swierk	PL			1 (1)							**1 (1)**
ILL	FR	217 (84)	59 (32)	358 (149)	52 (29)	6 (5)	20 (9)	3 (0)	5 (2)	123 (70)	**597 (240)**
(IPNS)	US	5 (0)		2 (0)	2 (0)					1 (0)	**8 (0)**
IRR1	ISR			3 (1)							**3 (1)**
ISIS	UK	98 (51)	58 (30)	300 (135)	14 (5)	3 (1)	3 (0)	5 (1)		69 (41)	**412 (182)**
J-PARC	JAP	7 (6)	3 (2)	15 (12)	1 (0)		1 (1)			4 (3)	**24 (19)**
JRR3	JAP	1 (0)		1 (0)							**2 (0)**
(Jülich)	D	3 (0)	2 (1)	7 (0)	3 (0)						**15 (1)**
KEK	JAP	2 (0)			1 (0)						**3 (0)**
(Kjeller)	N	11 (3)	126 (30)	7 (2)	4 (2)					21 (6)	**127 (31)**
LANL	US	6 (0)	7 (3)	16 (1)	7 (0)					2 (0)	**34 (4)**
(LLB)	FR	11 (6)	7 (3)	31 (15)	9 (0)		3 (1)	1 (0)	5 (1)	4 (2)	**64 (25)**
MURR	US	3 (1)									**3 (1)**
NIST	US	44 (23)	11 (5)	44 (13)		2 (1)	3 (1)	7 (0)		8 (7)	**103 (36)**
NPI	CZ	2 (0)	2 (0)	22 (12)	1 (0)					1 (0)	**26 (12)**
PNPI	RUS				2 (0)						**2 (0)**
PSI	CH	177 (51)	35 (15)	93 (29)	3 (0)		17 (3)	1 (0)	11 (5)	42 (10)	**295 (93)**

PULSTAR	US				1 (0)						**1 (0)**
(Risø)	DK	3 (0)		1 (0)						1 (0)	**3 (0)**
(SILOE)	FR			1 (1)							**1 (1)**
SNS	US	46 (26)	8 (4)	51 (27)	7 (5)	1 (1)	3 (2)			22 (16)	**94 (49)**
SNSC	CHN			2 (2)							**2 (2)**
(Studsvik)	S	3 (0)	6 (1)	68 (1)						7 (0)	**70 (2)**
Zarechny	RUS			3 (0)							**3 (0)**
SUM		**856 (356)**	**385 (153)**	**1325 (537)**	**136 (55)**	**12 (8)**	**75 (31)**	**22 (2)**	**39 (9)**	**405 (200)**	**2445 (951)**

The most overall used neutron sources are ILL, ISIS and PSI, together accounting for 53% of Nordic/Baltic activity.

For all years ILL is accounting for 24%, ISIS for 17% and PSI for 12%, but in the last 5 years ILL is still at 24% while ISIS has slightly increased to 19% and PSI has slightly declined to 10%. These differences are hardly significant.

We see the same trend for most Nordic countries, with ILL being the most used facility and ISIS and PSI coming in alternately as second and third, except for Norway, which over all have mostly used Kjeller (JEEP-3), that in the last 5 years has been overtaken by ILL. Denmark and Sweden are the largest ILL users (and so far the only members).

For the Baltic countries we see that the most used is also ILL and PSI but here followed by the now closed HZB in third place.

The world leading source J-PARC show low numbers even though it began user operation in 2009. This is partly because the typical time taken from data collection to publication is 2-3 years, partly because the distance to East Asia will hardly allow sources in this region to be the first choice of facility for any European experimental group, unless special instrumentation is required. That being said, around 80% of the publications based on J-PARC have been published within the last 5 years, showing increasing activity.

Comparing the last 5 years to all years we see noticeable (meaning 2% or more in change) increases in ANSTO, and as mentioned ISIS. We see noticeable decreases in the close-down sources at Jülich, Kjeller and Studsvik.

7. Conclusions

The Nordic/Baltic neutron scattering community counts 640 scientists who have in total published 2805 neutron-related articles over the last 17 years. There is a clear increasing tendency in the annual publication rate over the period of the investigation; this increase comes mainly from the staff at ESS and from Danish and Swedish universities. 14% of the publications are made in collaboration between two or more Nordic/Baltic countries, with a rather steady tendency.

36% of the publications appear in the 20% highest ranked journals and are spread over most of the "usual" scientific topics for neutrons. This means that the research is broadly spread in the different communities and that it is generally of a high international standard.

Notable development is found within the topics Geology and Engineering, where the publication volume was initially very low, but shows a healthy increasing: 70% of the total articles have been published within the last five years. Life sciences show an increasing trend as well, but have a potential for even further development, given the Nordic/Baltic countries' general high standing in this research area. Over the last five years, there has also been an increase of publications within the topic of materials dynamics, while the trend for magnetic dynamics is the opposite.

There have been some recent changes in the neutron scattering methods most commonly by the Nordic/Baltic communities. Powder diffraction, SANS and inelastic scattering are the methods used the most overall. However, a lot of methods have seen a more than 50% increase over the last 5 years, compared to all the years before. This is especially true in stress/strain diffraction, reflectometry and imaging, the latter with a 70% increase in publications.

The main neutron source used for obtaining the results is the ILL, which accounts for 24% of the (source-related) publications. In addition, Norway has had a strong use of JEEP-3 before its closure, Sweden of ISIS and Denmark of PSI. This reflects the facilities with which the countries have (had) a particular collaboration with due to an investment in and the operation of neutron instrumentation. These instrument operations are clearly linked to the scientific strong points of each country. We expect the planned Norwegian establishment at PSI to be reflected in this statistics in a few years.

When deciding upon the particular means for stimulating neutron scattering science in the Nordic and Baltic countries, it would be prudent to consider both strong points and fields with potential for development, including the clear variation in specialization between the countries.

8. Appendix

Here we have included tables from 2016 to present.

1.A – number of articles

Year/Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	SUM
DK	35 (18)	36 (23)	34 (14)	34 (28)	34 (21)	59 (30)	43 (23)	41 (20)	66 (22)	71 (37)	51 (15)	49 (16)	87 (36)	65 (27)	75 (23)	76 (30)	61 (22)	**917 (405)**
N	20 (6)	22 (7)	27 (3)	21 (6)	10 (4)	25 (10)	22 (6)	18 (8)	15 (9)	28 (8)	28 (9)	26 (9)	25 (6)	40 (9)	31 (7)	23 (5)	28 (11)	**409 (123)**
S	54 (14)	52 (16)	51 (23)	48 (24)	58 (30)	80 (25)	70 (29)	73 (36)	86 (37)	99 (29)	100 (40)	91 (23)	116 (25)	124 (28)	140 (27)	126 (41)	166 (63)	**1534 (510)**
FI	4 (2)	10 (5)	11 (2)	8 (1)	7 (5)	10 (5)	12 (4)	8 (3)	12 (6)	13 (3)	17 (8)	7 (1)	13 (2)	12 (4)	11 (6)	16 (2)	13 (8)	**184 (67)**
IS	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (1)	3 (2)	1 (0)	0 (0)	2 (2)	1 (1)	1 (0)	1 (0)	3 (0)	3 (1)	**19 (7)**
ES	2 (0)	2 (1)	1 (0)	0 (0)	0 (0)	1 (0)	8 (3)	7 (7)	3 (2)	18 (11)	10 (3)	2 (1)	7 (0)	6 (1)	3 (0)	6 (4)	7 (3)	**83 (36)**
LV	2 (0)	1 (0)	4 (0)	3 (0)	2 (1)	2 (0)	1 (0)	4 (1)	0 (0)	6 (0)	3 (1)	2 (1)	3 (0)	0 (0)	4 (0)	2 (1)	2 (0)	**41 (5)**
LI	1 (0)	3 (0)	1 (0)	4 (0)	4 (1)	1 (0)	1 (0)	3 (2)	0 (0)	2 (0)	1 (0)	2 (0)	0 (0)	1 (1)	0 (0)	1 (0)	0 (0)	**25 (4)**
Double count	6 (3)	9 (3)	11 (2)	9 (5)	11 (6)	30 (11)	15 (5)	17 (8)	20 (6)	33 (12)	25 (7)	28 (3)	35 (11)	34 (8)	44 (8)	37 (12)	43 (15)	**407 (125)**
SUM	**113 (37)**	**118 (49)**	**118 (40)**	**109 (54)**	**104 (56)**	**149 (59)**	**142 (60)**	**138 (70)**	**165 (72)**	**205 (76)**	**185 (69)**	**153 (50)**	**217 (59)**	**215 (62)**	**221 (55)**	**216 (71)**	**237 (93)**	**2805 (1032)**

3.A – Collaborations

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	SUM
Denmark/ Norway/ Sweden/ Finland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	1 (0)	2 (1)	0 (0)	**5 (2)**
Denmark/ Norway/ Sweden	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	2 (1)	1 (0)	2 (1)	0 (0)	0 (0)	1 (0)	1 (0)	1 (1)	1 (0)	6 (1)	1 (0)	3 (1)	**20 (5)**
Denmark/ Norway/ Finland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	**2 (0)**
Denmark/ Norway	0 (0)	2 (1)	1 (0)	0 (0)	1 (0)	4 (2)	0 (0)	1 (0)	2 (2)	0 (0)	1 (0)	2 (0)	3 (1)	4 (2)	1 (0)	6 (0)	2 (1)	**30 (9)**
Denmark/ Sweden/ Lituania	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**2 (1)**
Denmark/ Sweden	1 (0)	3 (2)	3 (2)	2 (2)	4 (3)	17 (5)	8 (2)	6 (1)	13 (2)	23 (11)	15 (4)	17 (2)	24 (10)	12 (2)	22 (6)	25 (9)	23 (5)	**218 (68)**

Den-mark/ Finland	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**4 (0)**
Den-mark/ Iceland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	**1 (0)**
Den-mark/ Estonia	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	**1 (1)**
Norway/ Sweden/ Finland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	**3 (0)**
Norway/ Iceland/ Sweden	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	**1 (0)**
Norway/ Sweden	3 (1)	3 (0)	3 (0)	5 (3)	0 (0)	2 (1)	3 (1)	4 (3)	1 (1)	2 (1)	4 (2)	4 (0)	2 (0)	1 (0)	4 (1)	2 (0)	2 (1)	**45 (15)**
Norway/ Finland	1 (1)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)	1 (0)	1 (1)	1 (0)	0 (0)	0 (0)	**8 (2)**
Sweden/ Finland	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	2 (1)	2 (2)	0 (0)	0 (0)	0 (0)	1 (1)	1 (0)	1 (0)	2 (1)	1 (0)	2 (0)	6 (5)	**20 (12)**
Sweden/ Iceland	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	1 (0)	0 (0)	2 (0)	2 (0)	**8 (3)**
Sweden/ Estonia	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	**2 (1)**
Sweden/ Lithuania	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	**5 (1)**
Estonia/ Latvia	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	3 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**7 (1)**
SUM	**6 (3)**	**9 (3)**	**10 (2)**	**9 (5)**	**9 (5)**	**28 (10)**	**14 (5)**	**15 (7)**	**18 (6)**	**31 (12)**	**26 (7)**	**27 (2)**	**34 (13)**	**26 (7)**	**37 (8)**	**43 (12)**	**40 (14)**	**382 (121)**