The Danish Neutron Scattering Community, 2010-2017 (1st half)

- a bibliometric study

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0. Perspective, scope, and main findings

In this document, we present and discuss basic information needed to investigate the present situation in the Danish scientific environment within neutron scattering science. The investigation is a part of the follow-up on the national Danish strategy of preparing for the emergence of the European Spallation Source, ESS [strategy15].

We base this report on a recent bibliometric investigation of the publications in the Nordic-Baltic countries [naver17]. To keep the data material up to date, we have added new bibliometry data for Denmark for the first half of 2017. We consider publications dealing with neutron scattering, including instrumentation, data taking, and data analysis. In addition, theoretical work is included if it lies close to the experiments, i.e. prediction or modelling of experimental data. We exclude use of neutrons for fusion, nuclear and particle physics, and for element analysis by nuclear activation (known as PGAA). In addition, we exclude the use of "ultra-cold" neutrons.

We find that the past growth of the Danish neutron scattering user community has stopped - and even slightly decreased during the first half of 2017. Thereby, the community of the middle of 2017 is below the official goal for the development for 2016. On the other hand, the number of experienced neutron researchers in Denmark shows a healthy, slowly increasing rate.

We diagnose the cause of the negative development in the Danish neutron community to be twofold:

a) A large number of casual users among permanent staff has left the community (i.e. they have been inactive in the last 5 years). We find no single cause for this decrease of activity. Apparently, for these scientists neutron activities have been less attractive than using other methods.

b) The start-up rate of new (publishing) staff, post docs and ph.d. students within the field has been somewhat lower than usual in 2016 and 2017.

Although the slight decrease in itself could be cause by statistical fluctuations, the growth in 2017-2019 will need to be very large to fulfil the official 2019 goals.

1. The Danish ESS strategy

A set of goals has been formulated for the development of the Danish neutron scattering community, in relation to the emerging research possibilities, gradually opening at the ESS in the time frame 2019-2025 [strategy15]. The precise definition of the first category of goals are formulated in this report as [melander16]:

- New neutron users; understood as researchers using neutrons at least casually as one of many techniques. This definition of a neutron user is in our report defined as one that publishes at least 2 neutron-related articles over a 5 year time frame.
- New neutron researchers; understood as a researcher that has neutron scattering as a central research tool. This definition of neutron researcher is in our report defined as one that publishes at least 5 neutron-related articles over a 5 year time frame.
- New permanently employed neutron users. This corresponds to universities hiring researchers that are already neutron users – or to permanent university staff taking up neutron scattering as a tool. We have in our report for clarity separated these two definitions.
- Neutron researchers in new fields. This goal is not investigated here, since the precise meaning of "new fields" has not been sufficiently discussed.
- Development of neutron courses. The present report concentrates purely on bibliometry, so the course goal falls out of our scope.

These goals are quantified as [strategy15]:

Goal / Year	2016	2019	2021	2023	2025
1. New Neutron users	10	90	110	130	180
2. New neutron researchers	4	45	55	65	90
3. New neutron users in permanent positions	3	20	40	50	60
4. Neutron researchers in new fields	0	30	15 (*)	70	90
5. Development of courses			X		

(*) This number is likely a misprint in the strategy report [strategy15]; probably, the intended number was 50.

In this report, we will monitor the goals 1, 2, and 3 above, in half year intervals. We will use the number for 1st January 2015 as our baseline. First, however, we will present our basic bibliometric material.

2. Neutron Scattering articles

We here present the neutron scattering publications published 1/1-2010 to 30/6-2017, with at least one author with a Danish affiliation. We have divided the time period into half-year blocks.

The publications were taken from the work presented in the Nordic/Baltic investigation [naver17], updated by article counts for Denmark for the first half of 2017.

We have counted all peer-reviewed articles and further counted how many of these are published in "top 20% high-profile" journals, defined by the Danish official "authority lists" from 2010 and 2015 (we use the 2015 list for the 2015-2017 publications; the 2010 list otherwise).

Most data has been found using ISI Web of Science using a selection of neutron-related keywords. Abstracts were read to remove false searches. In addition, the Journal of Neutron Research has been searched manually, since this journal does not appear in ISI Web of Science.

The table below contains all 368 "Danish" publications in the 7.5 year counting period:

Half year	**Total number**	**High impact**
2010/1	15	5
2010/2	19	16
2011/1	29	14
2011/2	28	16
2012/1	23	13
2012/2	19	10
2013/1	25	12
2013/2	16	8
2014/1	27	9
2014/2	33	11
2015/1	34	15
2015/2	30	20
2016/1	23	9
2016/2	25	7
2017/1 *	22	8
SUM	**368**	**173**

* The numbers for 2017/1 may turn out slightly higher, as some journals appear delayed on Web of Science.

We see that there are fluctuations in the total publication number over the time span, with the 2014-2015 numbers being the highest. The magnitude of these fluctuations are as expected from dealing with discrete events (applicable for article publications).

Many publications, 47% on average, are in the top-20% journals. This confirms earlier observations that neutron scattering results often reach high-ranked journals. This is likely due to the limited number of neutron facilities and the competitive nature of access to experimental time, leading to a pre-screening of neutron projects to be carried out

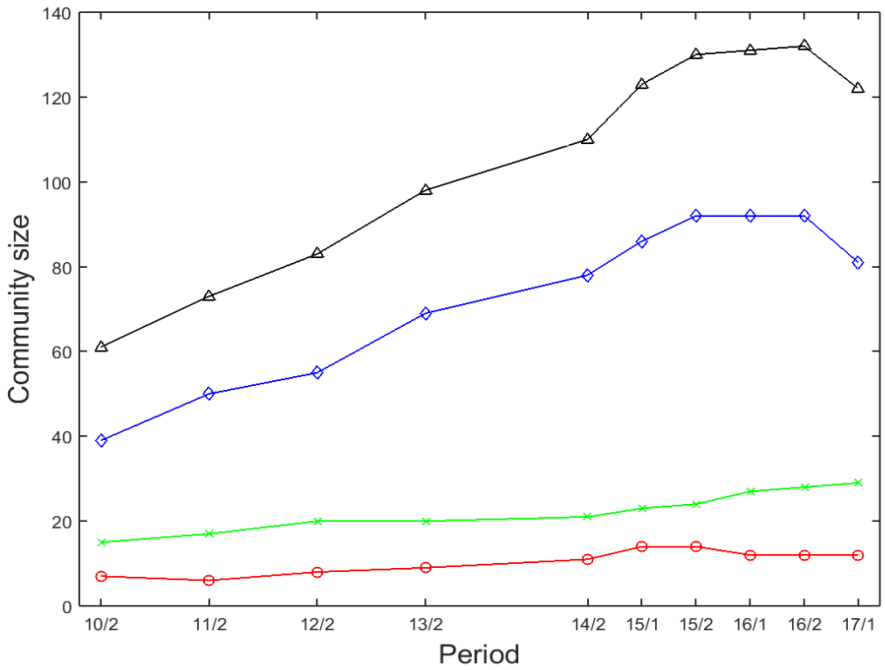
3. Neutron community, time development, and present location

We here list the size of the Danish neutron scattering community. We have here defined the neutron community to consist of authors with at least 2 neutron-related publication within a 5-year counting period. We further divide the community into three categories:

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

The list below covers the 5-year periods starting with the period (2006/1 to 2010/2)

Period / User type	Infrequent (2-4)	Frequent (5-9)	Expert (10+)	**SUM**
2006 to 2010	39	15	7	**61**
2007 to 2011	50	17	6	**73**
2008 to 2012	55	20	8	**83**
2009 to 2013	69	20	9	**98**
2010/1 to 2014/2	81	21	11	**113**
2010/2 to 2015/1	86	23	14	**123**
2011/1 to 2015/2	92	24	14	**130**
2011/2 to 2016/1	92	27	12	**131**
2012/2 to 2016/2	92	28	12	**132**
2012/2 to 2017/1	81	29	12	**122**



The data from the table is presented graphically in the figure above. In the figure, black represents the sum of the categories, blue infrequent users, green frequent users, and red expert users. The data show a strongly increasing tendency, more than doubling the community size from January 2011 to July 2015, then a level off, followed by a decreasing tendency in the first half of 2017. However, the number of experienced users (the sum of the frequent and expert categories) continue its increase.

The two tables below cover the distribution of the Danish community into their (most recent) affiliation. The tables present the situation a) in the reference period (2010/1 to 2014/2) – which is the reference number of January 2015 - and b) in the period ending June 2017. Numbers in parentheses give the number of permanent staff, excluding adjoint staff employed abroad..

Affiliation / category Jan 2015	**Infrequent (2-4)**	**Frequent (5-9)**	**Expert (10+)**	**SUM**
DENMARK				
Univ. Aalborg	1 (1)			**1 (1)**
Univ. Aarhus	16 (6)	3 (2)	3 (3)	**22 (11)**
Univ. Copenhagen	30 (7)	13 (5)	5 (4)	**48 (16)**
DTU, Lyngby	26 (14)	5 (4)	3 (2)	**34 (20)**
ESS-Data Managem.	1 (1)			**1 (1)**
Roskilde Univ.	2 (2)			**2 (2)**
Univ. Southern DK	5 (4)			**5 (4)**
SUM	**81 (35)**	**21 (11)**	**11 (9)**	**113 (55)**

Affiliation / category July 2017	Infrequent (2-4)	Frequent (5-9)	Expert (10+)	SUM
DENMARK				
Univ. Aalborg	1 (1)			**1 (1)**
Univ. Aarhus	9 (3)	3 (1)	2 (2)	**14 (6)**
Univ. Copenhagen	40 (11)	17 (4)	8 (6)	**65 (21)**
DTU, Lyngby	23 (12)	9 (6)	2 (2)	**34 (20)**
ESS-Data Managem.	1 (1)			**1 (1)**
Roskilde Univ.	3 (2)			**3 (2)**
Univ. Southern DK	1 (1)			**1 (1)**
DK National Museum	2 (2)			**2 (2)**
XNOVO (private)	1 (1)			**1 (1)**
SUM	**81 (34)**	**29 (11)**	**12 (10)**	**122 (55)**

We see that the increase in community is strong (17 researchers) at Univ. Copenhagen, of which 7 fall in the category of experienced users. A part of the reason for this development is the stimulation of the Univ. Copenhagen scattering environment through the large (DKK 25M) internal KU2016 grant.

We notice that the ESS Data Management and Software Center (DMSC) appears with only one person in the defined community. The reason for this is that the present basic software activities at the ESS-DMSC result in very few publications, and therefore are invisible to a bibliometric investigation.

We notice that the Danish National Museum has entered the community. This has happened through an imaging study of museum artifacts; one of the predicted potential growth areas.

We also notice that one private company appear in the community in 2017. This represents one permanent staff, formerly employed at DTU, moving to a start-up company (XNOVO). It is likely that this company will remain interested in neutrons in relation with ESS.

4. Developments in the Danish neutron community 2011-15 and 2015-16

We have further investigated the details in the developments of the Danish community. We first discuss the remarkable 80% increase of the community from Jan. 2011 to the reference date Jan. 2015. We have here combined frequent and expert users into one group and have monitored the transitions of researchers from one group to another:

Transitions 2011\2015	**5+**	**2+**	**< 2**	**SUM 2011**
2011: 5+	12	5	5	**22**
2011: 2+	8	12	19	**39**
2011: < 2	12	64	-	**(76)**
SUM 2015	**32**	**81**	**(24)**	**61 → 113**

We see that the of the 22 researchers that were in the "neutron researchers" category 5+ in 2011, only 12 were in the same category in 2015, while 20 new researchers have appeared here (to reach the new total of 32). Furthermore, of the 61 "neutron users" (5+ and 2+) in 2011, 24 were no longer users in 2015, while 76 new neutron users appeared. This is a remarkable exchange in the community in only 4 years, and we therefore dwell a little on this aspect to describe it in more detail.

Losing neutron researchers: 10 researchers with 5+ publications in 2011 had less than 5 publications in 2011. The distribution among these are:

- Permanent staff retiring: 4
- Permanent staff moving abroad: 1
- Permanent staff reducing use of neutrons: 4
- Post doc getting different job: 1

Gaining neutron researchers: 20 researchers with less than 5+ publications in 2011 had 5 or more publications in 2015. The distribution among these are:

- New permanent staff: 3
- Permanent staff increasing use of neutrons: 6
- Post docs: 5
- Ph.D. students: 6

Seen from these figures, the main reason for the increase of the number of neutron researchers is the large increase in active post docs and Ph.D. students, with a total of 11 researchers. Of these 2 were funded by DANSCATT and 2 by the Danish in-kind contributions to the ESS pre-construction.

Losing neutron users: Even more dramatic, of the 61 strong neutron user community in 2011, no less than 24 persons had left the community in 2015. The distribution among these are:

- Permanent staff retiring: 2
- Permanent staff moving abroad: 3
- Permanent staff reducing use of neutrons: 10
- Post docs getting different job: 4
- Ph.D.s finishing: 5

Gaining neutron users: In return, no less than 76 new neutron users have appeared since 2011. The distribution among these are:

- New permanent staff: 7
- Permanent staff increasing use of neutrons: 18
- Post docs: 20
- Ph.D. students: 21
- M.Sc. students: 2

We see from these figures that the main reason for the 52 person increase in community size is new post docs and Ph.D. students (32 persons). Another reason is more permanent staff using neutrons as one of their tools (a net effect of 8 persons). Around 25% of the new users can directly be related to the ESS; mostly (16 persons) to the design upgrade program. We must expect the effect of this to decay in the coming years, since the ESS has entered the construction phase, where there is a more limited use of new post docs and Ph.D. students. The direct effect of this will be a loss in the Danish community of around 10-15 users – everything else being equal.

To understand the changes in the user community, we perform a similar analysis for the first 2.5 years of the strategy period. The transition table is shown below:

	5+			**2+**			**<2**	**SUM**
Jan 2015	32			81			-	**113**
2015 Q1+Q2		← 6	1 →		← 12	2 →		
July 2015	37			86			-	**123**
2015 Q3+Q4		← 2	1 →		← 14	7 →		
Jan 2016	38			92			-	**130**
2016 Q1+Q2		← 4	3 →		← 6	5 →		
July 2016	39			92			-	**131**
2016 Q3+Q4		← 3	2 →		← 11	10 →		
Jan 2017	40			92			-	**132**
2017 Q1+Q2		← 2	1 →		← 5	15 →		
July 2017	41			81			-	**122**

The numbers with the arrows show the amount of researchers moving from one group to another between the half-year intervals, for example 6 researchers moved from the 2+ group to the 5+ group during 2015 Q1+Q2.

We see that the group of 5+ researchers is fairly constant (or slightly increasing) and the exchange of researchers in this group is rather small. In contrast, the last few half-years show an increase in researchers leaving the community from the 2+ group, and a simultaneous decrease in researchers entering this group from the outside.

To investigate this further, we have tabulated the different transitions into and out of the community and distributed this on different types of transitions. (in this table, adjoint professors and private employees count as staff)

Category	Move in/out of community	2011/1-2015/1	-2015 July	-2016 Jan	-2016 July	-2017 Jan	-2017 July	**SUM 2.5 y**
Staff	Retired	**-2**			-1		-2	**-3**
Staff	Left Denmark	**-3**						**-0**
Staff	Decreased activity	**-10**	-1	-3	-2	-6	-10	**-22**
Post Doc	(changed job)	**-4**	-1	-3	-1	-3	-1	**-9**
PhD stud.	(graduated)	**-5**		-1	-1	-1	-2	**-5**
Msc stud.	(graduated)	**-0**						**-0**
SUM	**Out of community**	**-24**	**-2**	**-7**	**-5**	**-10**	**-15**	**-39**
Staff	New employee	**7**	2	4	1			**7**
Staff	Increased activity	**18**	3	3	2	6	3	**17**
Post doc	(recently employed)	**20**	3	3	1	1	1	**9**
PhD stud.	(recently employed)	**21**	3	4	1	3	1	**12**
Msc stud.		**2**	1		1	1		**3**
SUM	**Into community**	**68**	**12**	**14**	**6**	**11**	**5**	**48**

We see that the decreasing activity among staff has been anomalously high over the last year, while the number of entering PhD and post docs have fallen to below the average for the full period. Together, these two effects explain the observed decrease in neutron community.

For completeness, we give the similar table for the movement into and out of the 5+ category:

We see in the table below that the experienced part of the community is growing slowly, in particular due to post docs and PhD students.

Category	Move in/out of community	2011/1-2015/1	2015 July	2016 Jan	2016 July	2017 Jan	2017 July	**SUM 2.5 y**
Staff	Retired	**-4**						**0**
Staff	Left Denmark	**-1**						**0**
Staff	Decreased activity	**-4**	-1		-1	-2	-1	**-5**
Post Doc	(changed job to outside community)	**-1**						**0**
PhD stud.	(graduated and empoyed outside community)			-1	-2			**-3**
Msc stud.	(graduated and employed outside community)							**0**
SUM	**Out of 5+community**	**-10**	**-1**	**-1**	**-3**	**-2**	**-1**	**-8**
Staff	New employee	**3**			1	1		**2**
Staff	Increased activity	**6**	2			1	1	**4**
Post doc	(recently employed)	**5**			1	1		**2**
PhD stud.	(recently employed)	**6**	4	2	1		1	**8**
Msc stud.					1			**1**
SUM	**Into 5+ community**	**20**	**6**	**2**	**4**	**3**	**2**	**17**

5. Hiring and retiring of neutron users in permanent positions

We have further investigated the 65 Danish neutron users in permanent positions plus the 7 retired in the time frame 2008-2017. The table below shows the year where the permanent staff in Danish community 1/7-2017 obtained their permanent contract, the red numbers show when the retirees retired. Staff moving from one Danish institute to another is registered with their first date of permanent contract. The 4 persons in adjoint positions with main contracts abroad are not counted.

Institute	retired	< '08	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	**SUM**
AAU Phys-Chem		1											**1**
AU Phys		3											**3**
AU Chem		6				2		1		1		1	**11**
DTU Chem	1	2					1						**1**
DTU Chem Techn.		1											**1**
DTU Energy	1	4		1		1	2			1	1		**8**
DTU Nano		1		1				1					**3**
DTU Nutech		2									1		**3**
DTU Phys	3	6	1 1	1			1 1		1				**6**
ESS DMSC									2				**2**
KU Chem	1	5				2		1	1	1		1	**9**
KU NBI	1	6		1				1			1		**7**
KU Neuro-Pharma		1											**1**
KU Plant		1		1									**2**
RUC Nature		3		1									**4**
SDU Phys-Chem		2	1		1								**4**
XNOVO									1				**1**
SUM	**7**	**45**	**1**	**6**	**1**	**5**	**1**	**2**	**1**	**1**	**3**	**2**	**67**

We see that the hiring of new neutron users over the last 9 years has taken place at a rather constant rate of in average 2.5/year. The retiring rate has been much lower (0.8/year), but will increase to (estimated) around 1.3/year in the next decade. With this hiring/retiring rate, the number of neutron users with permanent contracts will increase by only 10 over the next decade.

Among the universities, 8 of the 21 new permanent neutron users were hired at DTU, whereas 6 was hired at KU and 2 at each of AU, SDU, and DMSC.

We perform the same analysis for “neutron researchers”; 5+ publications, with permanent contracts. Here, the persons are distributed on much fewer institutes at AU, KU, and DTU. The distribution on institute and hiring year is the following:

Institute	retired	< '08	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	**SUM**
AU Chem		2							1				**3**
DTU Energy		1											**1**
DTU Nutech											1		**1**
DTU Phys	1	2	1	1			1						**4**
KU Chem		2										1	**3**
KU NBI	1	4		1							1		**5**
KU Plant				1									**1**
SUM	**2**	**11**	**1**	**3**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**1**	**18**

We see that there is a fairly steady hiring rate of 1.0 researchers/year. The expected retiring rate over the next decade is 0.2 researchers/year. In a decade from now, the number of neutron researchers in permanent positions should increase from 18 to 26, with the current rate.

Of the new neutron researchers, 4 were hired at DTU, 4 at KU, and 1 at AU.

6. Relation to the Danish strategy

In all the investigation period, except the last year, we see a clearly increasing tendency in the size of the Danish community. This is in general a positive sign, although the present decrease in community size must be seen as a warning to keep the development under investigation.

Below, we compare the actual situation medio 2017 to the strategic goals presented in 2015:

Goal / Year	Status primo 2015	Status medio 2017	**Change 2015 to medio 2017**	Goal 2016	Interpolated goal medio 2017	Goal 2019	**Diffe-rence medio 2017**
1. Neutron users	110	122	**+ 12**	+ 10	+ 50	+ 90	**- 38**
2. Neutron researchers	32	41	**+ 9**	+ 4	+ 25	+ 45	**- 16**
3. Neutron users in permanent positions	42	53	**+11**	+ 3	+ 12	+ 20	**-1**

The increase of neutron users is 12; 2 above the 2016 target, but 38 below the interpolated goal of 50 (midway between 2016 and 2019). The increase of new neutron researchers is 9, 16 below the

interpolated goal of 25. On the other hand, the increase of new neutron users among permanent staff is 11, only 1 below the interpolated goal.

To reach goal 1 and 2 at the end of 2019, the present development for neutron users and researchers needs to accelerate dramatically, to become 78 and 36, respectively. This is an almost impossible goal. Furthermore, it should be recalled that the change of the nature of Danish involvement in ESS instrumentation will on the short term will result in a small, but visible loss of Ph.D.s and post docs.

Even if funding for a massive community increase (the ESS Lighthouse program) would become available immediately, the lead time of recruitment, research, publishing would mean that the effects were visible only around three years later (in 2021). The lighthouse program (or a similar earmarked long-term investment) is, however, clealy instrumental to obtain the 2023 goals.

In general, the increase in the Danish community should be done by spreading the growth to all universities. One possibility is to invest in targeted post doc and Ph.D. programmes, which would engage not only the students and post docs, but also their supervisors. In addition, it is very important to provide startup funding that can attract (and maintain) expertise at Danish universities among the talented post docs that are presently very visible in the data, but will soon begin to be looking for permanent carreer opportunities. All this could be done as a part of the Lighthouse program, but the universities must collaborate to make permanent positions available.

7. Conclusions

The Danish neutron scattering community presently counts 122 scientists, who have in total published 368 neutron-related articles over the last 7.5 years. Roughly 50% of these publications appear in the top-20% journals. This demonstrates that the research is generally on a high international standard.

A clear and increasing tendency in the community size is over the last year stagnated, to begin falling. The decrease is likely a statistical fluctuation rather than a tendency, but it will in any case be close to impossible to reach the ambitious 2019 goals in the Danish strategy.

To maintain a healthy growth in the Danish neutron community, and to reach the goals for 2023, a broad and long-term stimulation package is needed in order to promote talents to permanent positions, and to attract new PhD students and post docs, at the same time engaging their supervisors. The suggested ESS Lighthouse program would be able to cover all of these aims.

Literature

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