NuPECC survey on experimental Nuclear Physics

Outlook for a Nuclear Physics career in Europe

Joaquín Gómez Camacho
Centro Nacional de Aceleradores & Universidad de Sevilla.

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1. NuPECC survey
2. Global results for Experimental Nuclear Physics in Europe
3. Distribution of countries per research lines
4. Distribution of countries per researcher status and gender
5. Final Remarks

Data collected

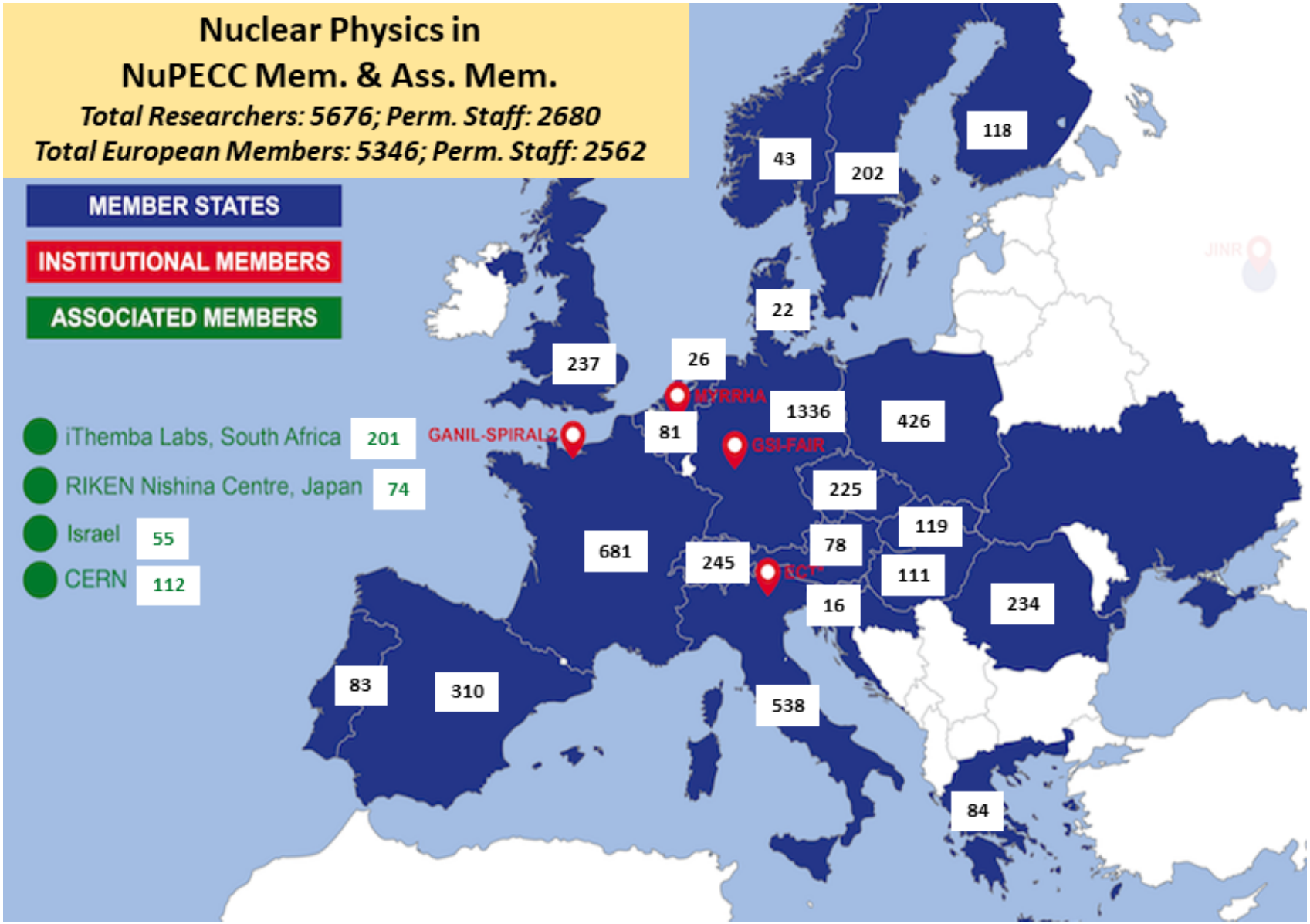
- Data obtained: Jun-October 2023. 6x6 table with number of experimental nuclear physics researchers, affiliated to research institutions, per NuPECC European country or associate (25x36 numbers).
- 6 columns: Professional status, separated by gender.
  Staff Male and Female
  Researchers in Permanent positions with PhD degree
  Non-permanent Male and Female
  Researchers in temporary positions with PhD degree
  PhD student Male and Female
  Researchers enroled in a PhD program
- 6 rows: Research areas.
  NSR: Nuclear structure and reactions
  NAP: Nuclear astrophysics
  HIP: Heavy Ion Physics.
  HAD: Hadron physics
  SYM: Nuclei as laboratories/symmetry tests
  APP: Applications of nuclear science

General tables

Countries	Population (millions)	Nuclear experiment	Ratio
Austria,	8,9	53	5,96
Belgium,	11,6	61	5,26
Chequia,	10,5	179	17,05
Denmark,	5,8	18	3,10
Finland,	5,5	77	14,00
France,	64,5	**551**	8,54
Germany.	83,4	**930**	11,15
Greece,	10,4	71	6,83
Hungary,	9,7	198	20,41
Italy,	59,2	**428,5**	7,24
Netherlands,	17,5	26	1,49
Norway,	5,4	31,4	5,81
Poland,	38,3	**309**	8,07
Portugal,	10,3	60	5,83
Romania,	19,3	179	9,27
Slovakia,	5,4	105	19,44
Slovenia,	2,1	16	7,62
Spain	47,5	193	4,06
Sweden,	10,5	173	16,48
Switzerland	8,7	234	26,90
UK	67,3	213	3,16
Total NuPECC Europe	**501,8**	**4105,9**	**8,18**

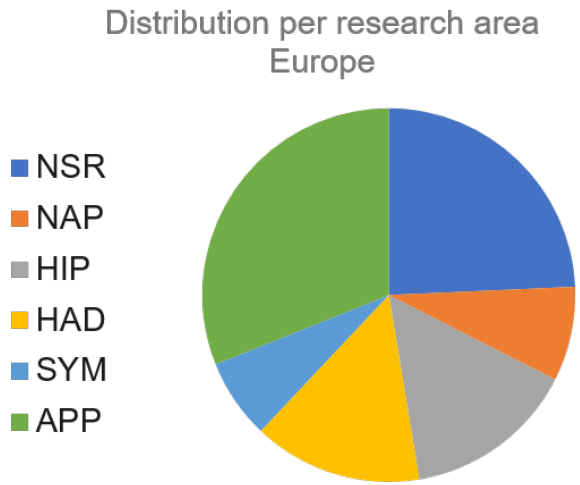
- Germany, France, Italy and Poland have the largest number of researchers
- Switzerland, Hungary, Chequia, Slovakia largest as ratio to population
- Global numbers are stable. or slightly increasing, with time.
- Experiment 4106 . Theory (previous survey) 1240. Ratio Exp/Theory 3.3

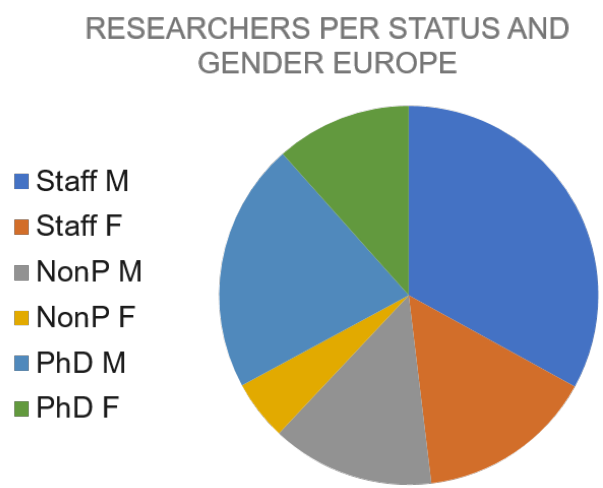
Map incl. Theory



Experimental Nuclear Physics in Europe

Research field	Staff M	Staff F	Non per M	Non per F	PhD M	PhD F	Total
NSR	389,7	113	113,9	42,1	239	106	1003,7
NAP	127,4	51,5	37,9	19,3	61,7	36	333,8
HIP	220,6	70	84,9	20,7	145	71	612,2
HAD	230,4	44,1	92	26	159,4	45	596,9
SYM	101,4	6,5	51,2	13,3	80	28	280,4
APP	499,7	199,5	120,5	77,8	252,6	128,8	1278,9
Total	1569,2	484,6	500,4	199,2	937,7	414,8	4105,9





Sustainability of Experimental Nuclear Physics in Europe

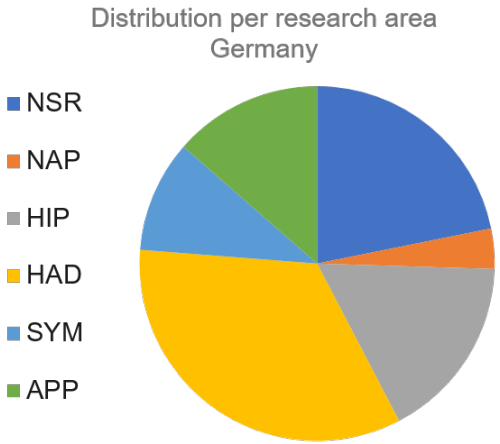
Experimental Nucl Phys	Staff	Non-P	PhD
Present researchers (2023)	2054	700	1352
Average Duration (yr)	30	5	4
Open Positions required per year	68	140	338
Potential candidates (from europe)	140	338	-
Coverage ratio	**2.0**	**2.4**	-

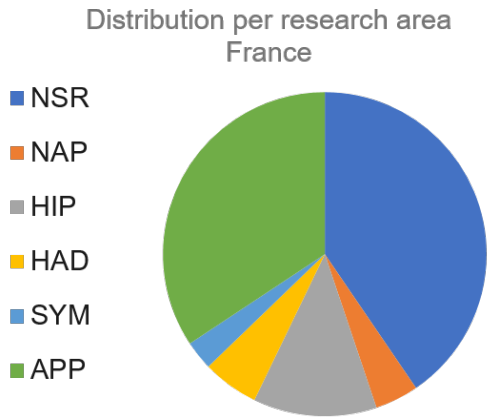
Coverage ratio per line	Staff	Non-P
Nuclear structure and reactions	1.9	2.8
Nuclear Astrophysics	1.8	2.2
Heavy Ion Physics	2.2	2.6
Hadron physics	2.6	2.2
Symmetry	3.6	2.1
Applications	1.8	2.2

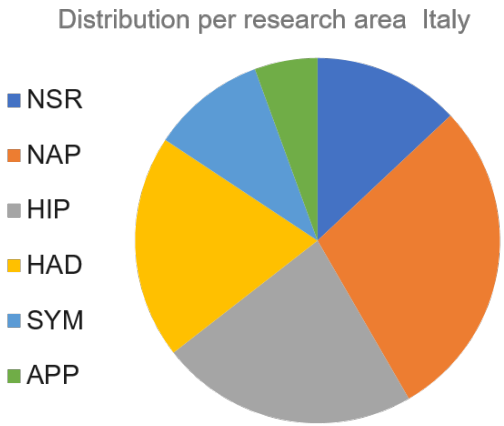
Statistical analysis for the country distribution

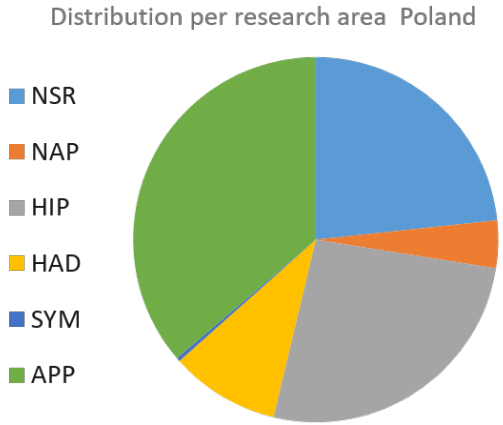
- The purpose is to evaluate how the number of researchers in a given line and in a given country n_c^l, differ from the expected values given European averages $\lambda_c^l = N_c p_e^l$, where $p_e^l = \frac{N^l}{N_e}$ is the european probability of doing research in a given line.
- The Poisson distribution with a mean λ_c^l gives the expected values of the probabilities of n_c^l provided that they are fully consistent with the european probabilities.
- For each country, the vector $\vec{v}_c$ with components $v_c^l = \frac{n_c^l - \lambda_c^l}{\sqrt{N_c}}$, has expectation values $\langle v_c^l \rangle = 0$ and $\langle |\vec{v}_c|^2 \rangle = \frac{\sum_l \lambda_c^l}{N_c} = 1$, in the Poisson distribution.
- A principal component analysis on $\vec{v}_c$ allows to determine the principal components v_c^p, combinations of v_c^l which explain a larger part of the variance.
- Countries for which $\sum_p (v_c^p)^2 \leq 1$ are consistent with the Poisson distributions and thus do not differ significantly from the european distribution. This is indicated in the red line.

Distribution of countries per research lines



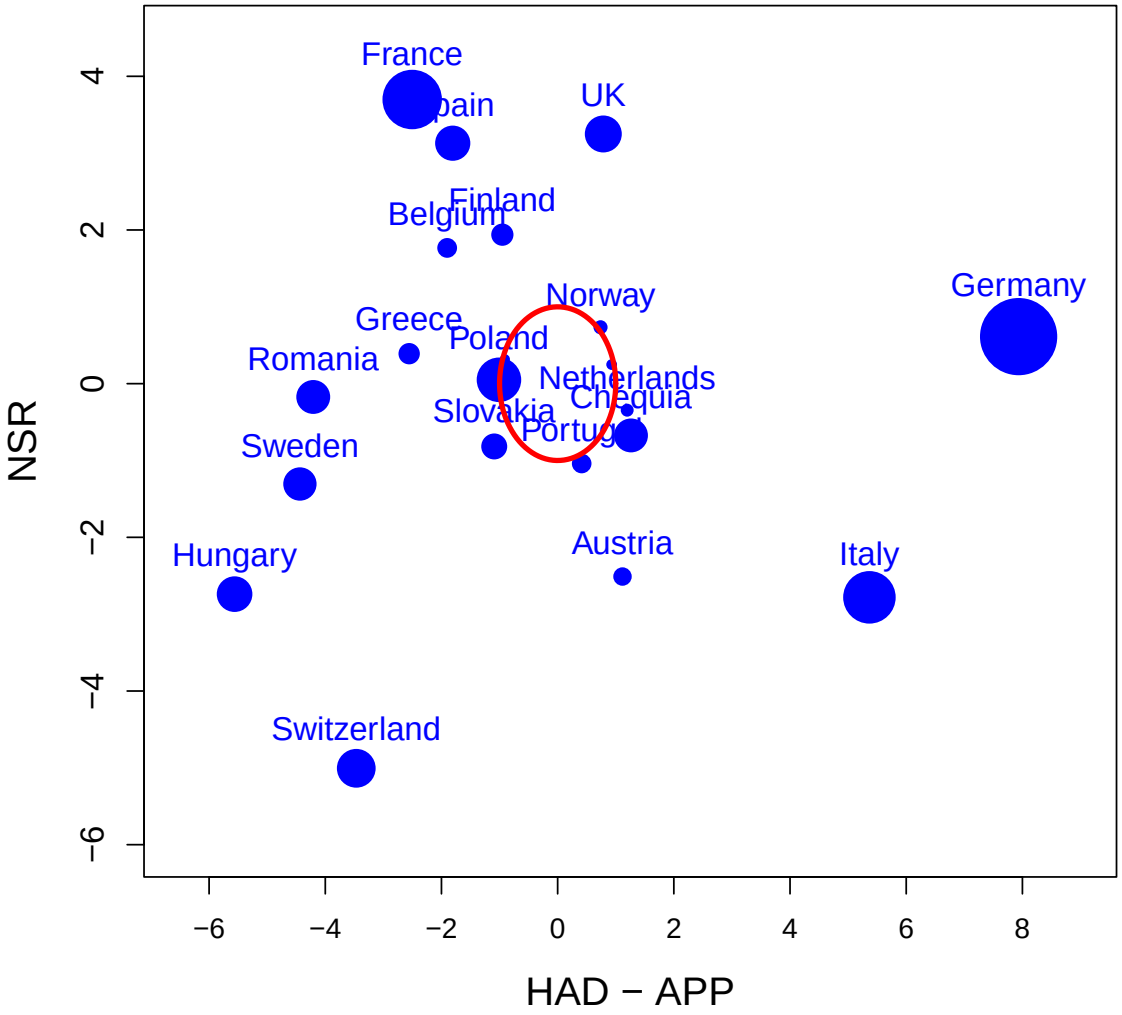




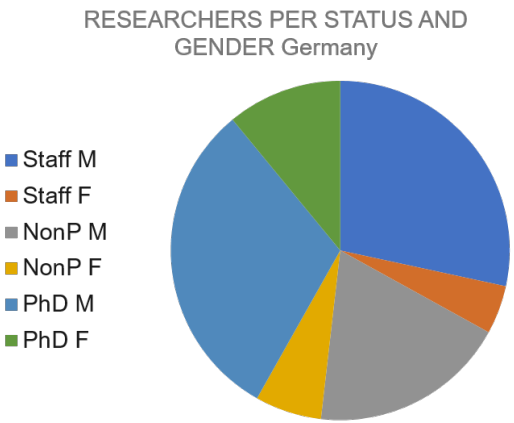


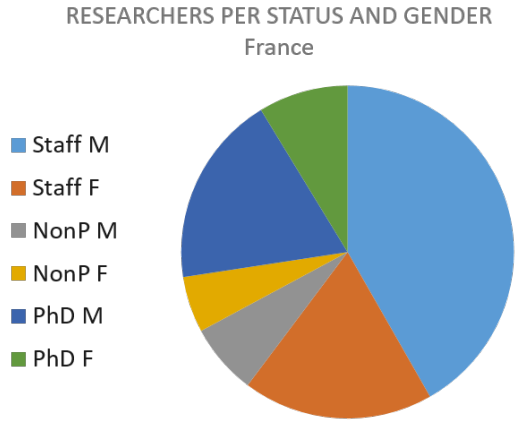
- Germany has a stronger impact in Hadronic Physics
- France has a strong contribution in Nuclear Structure and Reactions
- Italy has a strong contribution in nuclear astrophysics
- Poland follows the european average in research lines

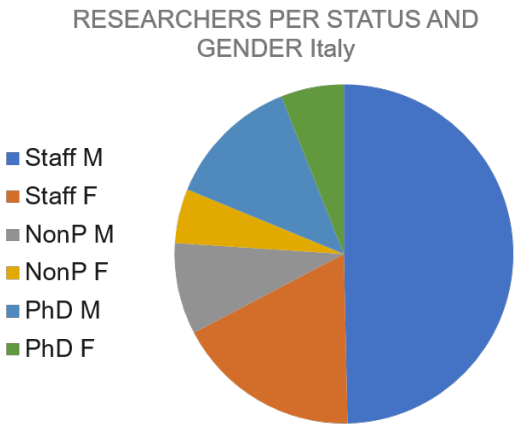
Principal component analysis per research lines

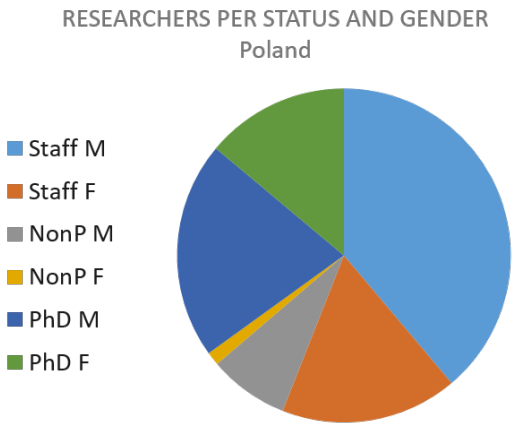


Distribution of countries per researcher status and gender



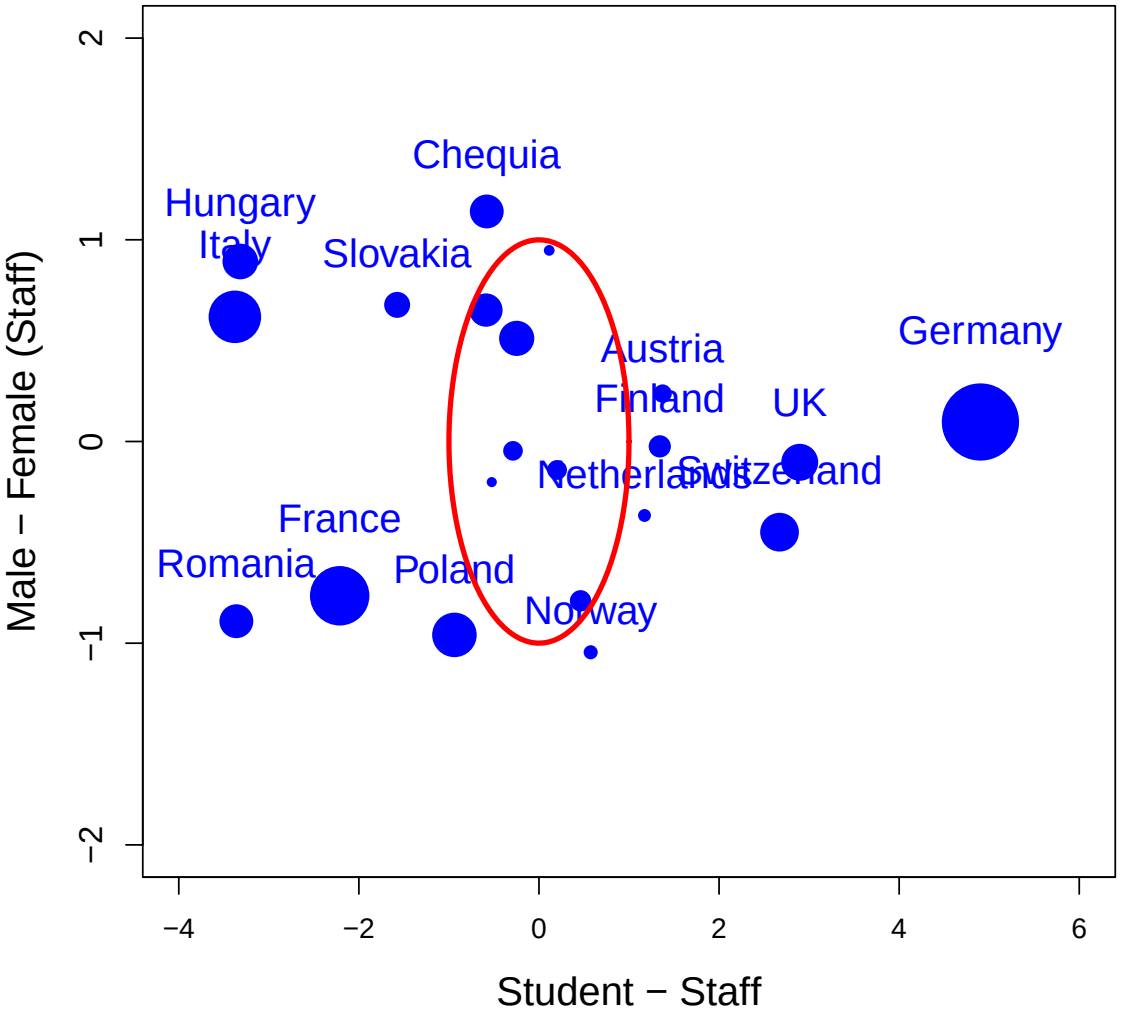






- Germany has a large number of PhD and Non-Permanent positions, relative to the staff.
- Italy has a small number of PhD students.
- Germany has a small fraction of female staff.
- Poland has a small fraction of female non-permanent.
- Italy and France have larger fractions of female researchers.

Principal component analysis per research status



Gender ratios and personnel contributions

Gender ratio M/F	Staff	Non-P	PhD
Europe	3.2	2.5	2.3
Germany	6.1	3.0	2.8
France	2.3	1.3	2.1
Italy	2.8	1.7	2.1
Poland	2.3	6.0	1.5

Gender ratio for EU scientists and engineers **1.44** (Eurostat 2020).

Contribution to Europe %	Staff	Non-P	PhD	Researchers
Germany	14.9	**33.4**	**28.8**	22.6
France	16.2	9.7	11.1	13.4
Italy	14.0	8.5	6.0	10.4
Poland	8.4	4.0	7.9	7.5

Some personal thoughts, inspired by the previous numbers

- Nuclear physics has a robust and stable experimental community in Europe, well coordinated with theory. Reduction in some countries is compensated by increase in others.
- Experimental nuclear physics in Europe covers six research areas. Most european countries contribute to all areas, with different intensities.
- There are enough early- and mid-career scientists to allow for the sustainability of the field. Academic careers in experimental nuclear physics are demanding, although feasible, for young scientists.
- Germany plays a crucial role in Europe as provider of 29 % of PhD and 33 % of Non-permanent positions.
- Experimental Nuclear physics is male dominated, although it may become less so in the future, provided that promotion is gender-neutral. There are significant variations per country and status.
- A detailed study of the Non-permanent stage will be very relevant. What are the contract duration? How are the economic conditions? How is the balance of work vs personal life? Do female PhD shun temporary positions in some countries?

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