Hyperfine Interactions: historical reflections

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OUTLINE

- more than one century of hfi
- half a century of nuclear radiation hfi
- hfi applications
- hfi community
- decline ?
- conclusions

More than one century of hfi …

- end 19th century: optical "spectral lines" & their fine structure studied

- 1881: Michelson observes hyperfine structure
- 1913: Bohr's atom model explains spectral lines & their fine structure
- 1924: Pauli invents "spin" to interpret hyperfine structure
  hfi due to nuclear magnetic moment μ interacting with atomic shell
- 1935: Schiller & Schmidt propose Q and quadrupole interaction
  to explain anomalies in hyperfine spectra

- 1967: definition of second (unit of time) based on hyperfine splitting

Hyperfine interactions using nuclear radiation

- 1951: Frauenfelder: first perturbed angular correlation (PAC) experiment (1955: first TDPAC experiment)
- 1956: Wu uses low temperature nuclear orientation (NO) to demonstrate parity violation in nuclear beta decay
- 1957: 2 USA teams show also parity violation in muon decay leading to muon spin resonance technique (μ-SR)
- 1957: Mössbauer discovers recoil-free emission/absorption of nuclear radiation (Mössbauer Effect)
- 1965: Sugimoto develops β-NMR-technique using nuclear reaction induced orientation

Hyperfine interactions applied

- Wide range of fields of science:
  atomic, molecular, nuclear, particle physics,
  solid state physics (especially magnetism), chemistry, materials science, geology, biophysics, ….

- Hyperfine interactions very old and very modern at the same time:
  hfi-techniques, theoretical calculations and the applications in different fields of science evolve continuously

Hyperfine interaction community
Three major conference series

- *International Conference on Hyperfine Interactions (HFI)*
  every three years
  2007 Iguazu (largest group of participants from Japan !)
  2010 CERN Isolde

- *International Conference on the Mössbauer Effect (ICAME)*
  every two years
  2007 Kanpur
  2009 Vienna
  2011 Tokyo ! (Riken co-organiser)

- *International Conference on Muon Spin Rotation, Relaxation and Resonance*
  every three years
  2008 Tsukuba ! (Riken co-organiser)

Famous scientists (ICAME 2007)

Famous scientists (HFI 2007)

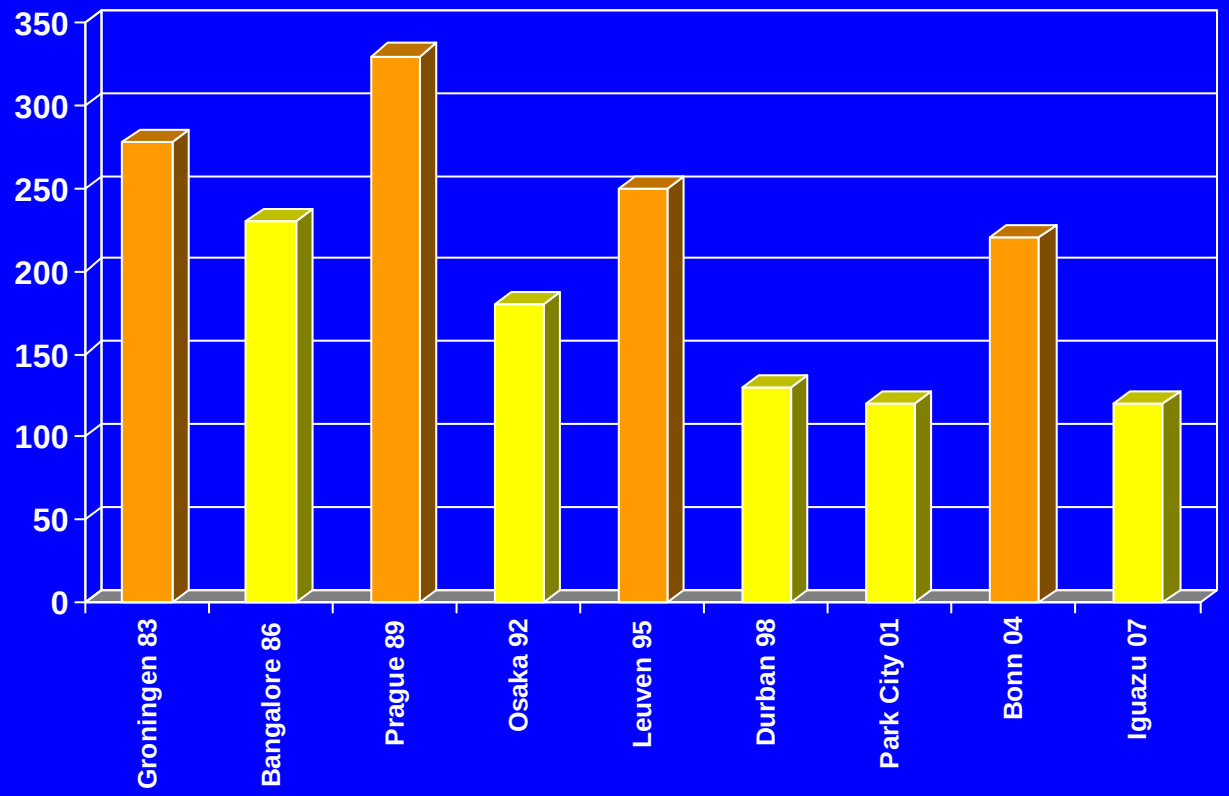
hfi conference highlights

- 1967 Asilomar Hyperfine fields in ferromagnetic hosts
  Ion implantation
  NO-NMR
  β-NMR
- 1970 Rehovot Transient fields
  Nuclear moments by recoil techniques
- 1973 Uppsala Muon spin resonance
- 1977 Madison Laser spectroscopy
- 1980 Berlin Tilted foil polarization
- 1983 Groningen Relaxation phenomena
  High-pressure HFI studies
- 1986 Bangalore On-line nuclear orientation
  Level mixing resonance
- 1989 Prague High Tc superconductivity
  Transient NMR on oriented nuclei
- 1992 Osaka Sub-nucleon degrees of freedom in nuclear moments
  Surface and interface physics

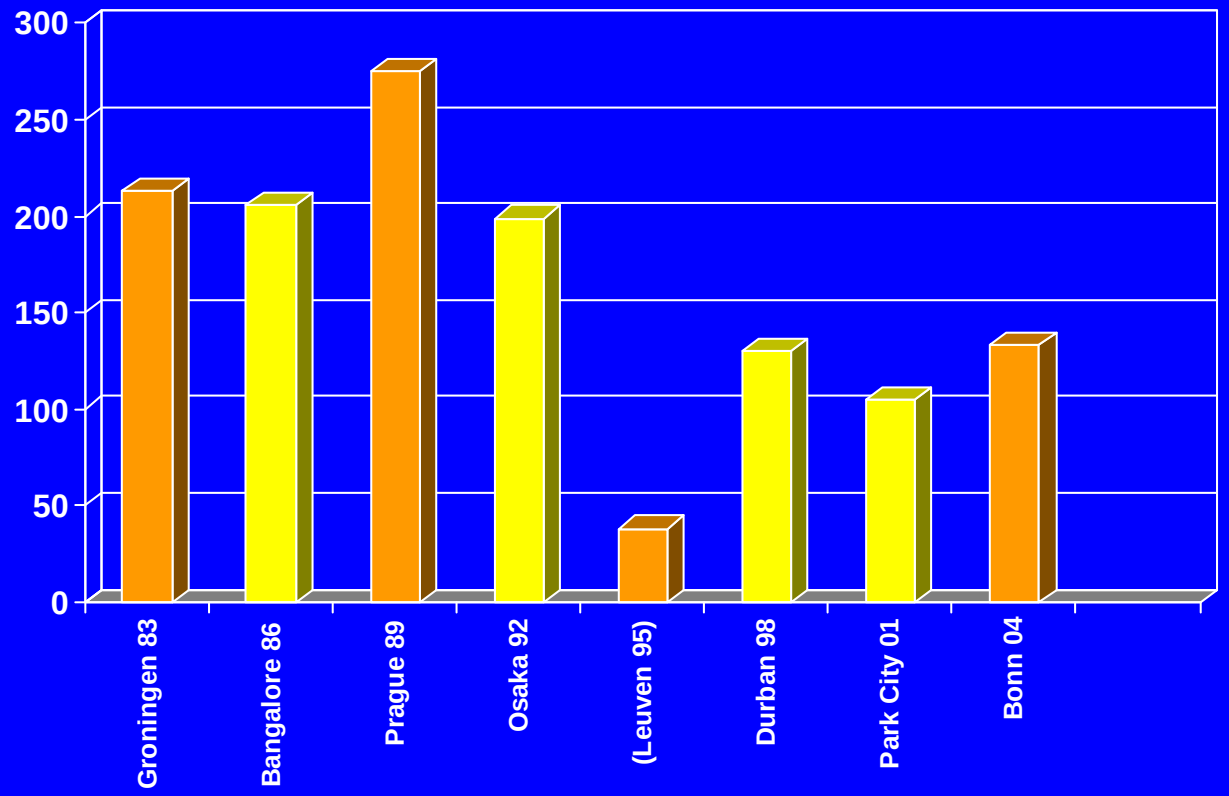
  1995 Leuven Slow polarized beams
  Trapped atoms
  Resonant scattering of synchrotron radiation

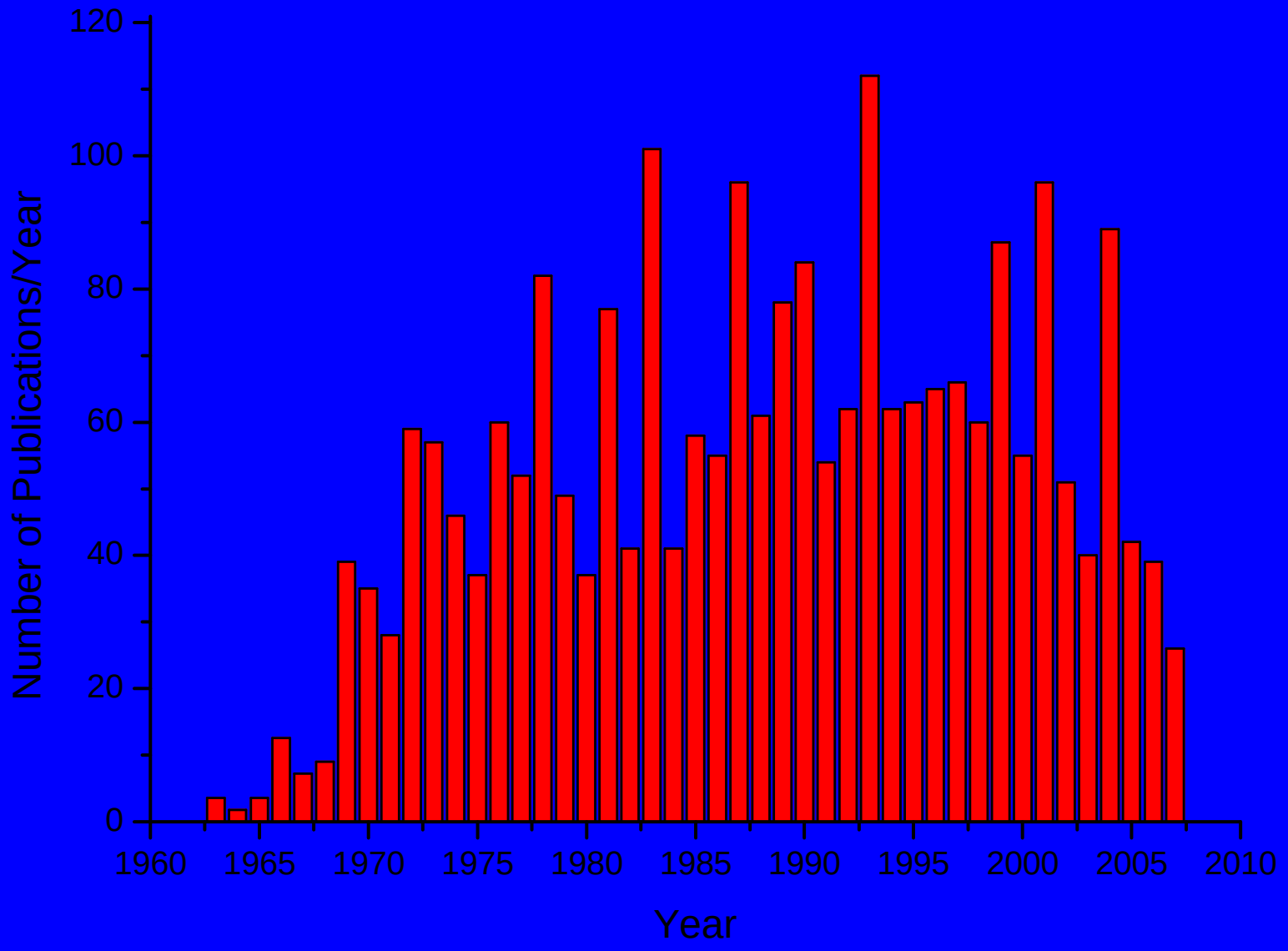
- and so on ….

HFI conference participants (+ NQI since 2004)



HFI published conference contributions (+ NQI since 2004)




Number of Publications/Year
120
100
80
60
40
20
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

decline ?

- slight decline in hfi publications & conference participation

- why ?
  - correlates with discontinuation of several hfi research groups created in 1960's and 1970's (especially in Europe)
  - competition from new techniques
  - "nuclear" less popular
  - more focus on topics where hfi really makes the difference

- stabilization ahead ?
  new teams in Asia, Latin America, …
  new methods (synchrotron radiation, exotic probe nuclei …)
  new interests (nano, environment, Mars, …)

conclusions

- retirement of first (nuclear) hfi generation leads to moderate decline

- hfi remains intrinsically very powerful
  e.g. substantial fraction of ISOLDE publication output in top journals
  (both in nuclear physics and materials science)

- to the attention of young scientists:

  hfi allows to obtain original atomic-scale information (below nano !)
  about the local atomic and electronic configuration,
  about magnetic fields and electric field gradients,
  at the site of (probe) atoms !

  applying hfi techniques to a modern scientific problem
  can really make the difference !!