Ground Test Facilities

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Parameters for SET Tests

- probability occurrence
- LET / Energy threshold
- LET / Energy dependence
- amplitude
- rise and fall times
- trigger level
- etc.

Accelerator testing

- Most SEE including SET tested at accelerators
- Relatively low-energy ions (tens of MeV/amu)
- Limited accessibility of high-energy ion accelerators.
- Packaged parts delidded and mounted in a vacuum chamber.
- SEE cross-section: number of events divided by the ion fluence
- Error rate in space: cross-section combined with the space spectrum. Adequate for SETs but with great care (the same conditions etc.)

Beam parameters

Fluence:

sufficiently high so all the potential errors will occur during test.

Flux:

rather low to prevent pile ups (long runs if high fluences needed)

Dimensions:

depends on requirements. Covers the whole device, single component or its individual elements / structures

Energy / LET and penetration depth:

big enough to deposit enough energy to generate errors and to reach the sensitive parts of the component

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Features in accelerator tests

Disadvantages

- destructive nature of ions
- limited capability of providing both spatial/temporal information
- problems with synchronizing beam frequency with DUT clock
- vacuum operation if HI
- small penetration depth if HI
- access time and costs

Advantages

- semi-real conditions with ion penetration depth
- in p-case realistic conditions

Radioactive sources

Radioactive sources (Cf^{252} and Am^{241}) used for SET (pre)testing.

relatively inexpensive and set up in a laboratory.

Am^{241} - 5.5 MeV alpha particles; mean LET of 0.6 MeV.cm^2/mg

Cf^{252} - fission particles; masses 80-170 AMU; mean LET of 43 MeV.cm^2/mg.

- quick checks of SE sensitivity prior to accelerator testing.
- both radioactive sources emit ions with limited range
- technique does not provide spatial information
- some temporal information from time-of-flight measurements.

Microbeams

- Typical tests are without time or spatial information
- Focused ion beams (ion microprobes) can obtain more detailed spatial information.■
- Ion microprobes:
  - Sandia National Laboratories
  - Gesellschaft für Schwer Ionen Forschung (GSI), Germany

Selected Facilities

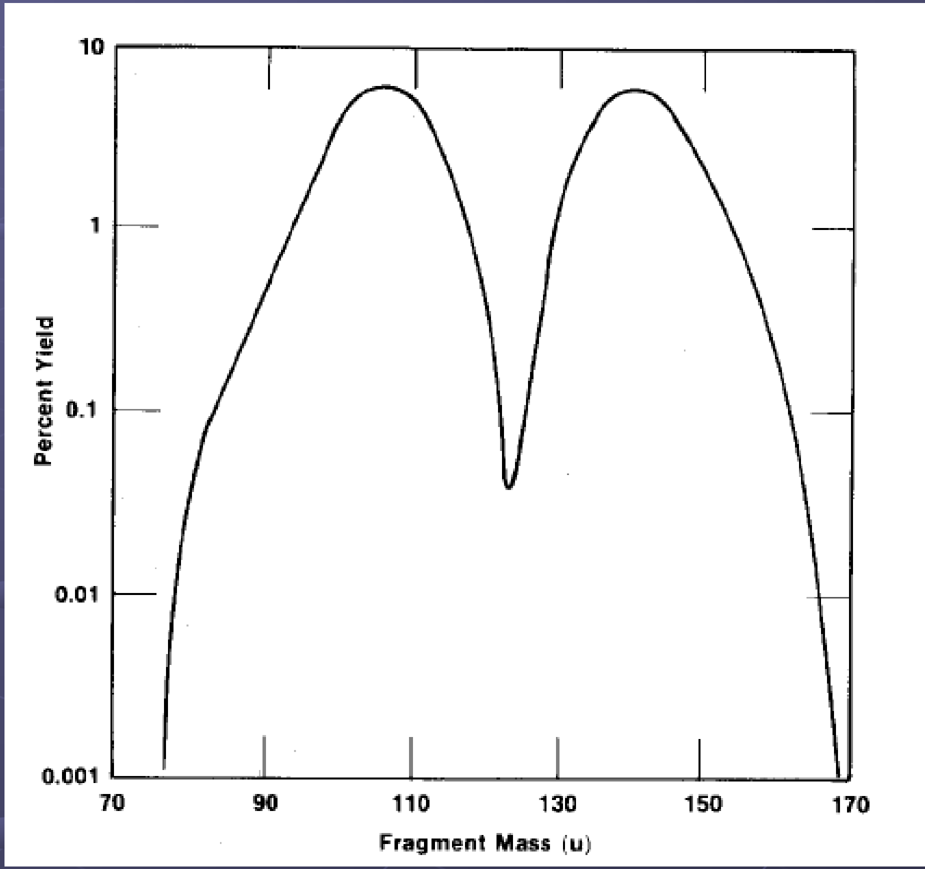
- European Component Irradiation Facilities:
  - HIF and LIF ++/ Belgium
  - RADEF / Finland
  - PIF / Switzerland
  - CASE / Netherlands
- Examples of other sites:
  - TSL / Uppsala / Sweden
  - GANIL / France
  - GSI / Germany
- Overseas etc.
- See list of world accelerators:
  - http://www-elsa.physik.uni-bonn.de/accelerator_list.html

CASE

- **C**alifornium **A**ssessment for **S**ingle event **E**ffects
- Location: ESA/ESTEC, Noordwijk NL
- Contact person: Bob Nickson
- Main purpose: DUT sensitivity assessment before main test
- Source ^{252}Cf:
  T½ = 2.645 y
  decays to: alphas 96.9%, fission products 3.1%
  (3.7 neutrons per fission with T_{aver}=2.3 MeV)
- <LET> = 43. MeV/(mg/cm), LET_{peak}= 46 MeV/(mg/cm)
- Typical activities below 10 μCi (~10^4 fission product/s in 4π)

CASE

- Emission of heavy ions
  A ≈ 106 and A ≈ 142
- Small penetration length
- Operation in vacuum
- Encapsulating of DUT needed
- CASA offers:
  - vacuum jar
  - various plates for DUT mounting
  - cable connectors
  - variable distance Source-DUT



Mass distribution for ^{252}Cf fission products

HIF and LIF

- Heavy Ion Facility and Light Ion Facility
- Location: Louvain-la-Neuve , Belgium
- Contact person: Guy Berger (see presentation Day 1)
- Acceleration:
  - protons up to 75 MeV ; 200 h/year
  - 0.6 MeV/AMU and 27.5 MeV/AMU ; 5 days/month
- LIF Protons: Energy 10 – 62 MeV, Flux: few 10^8 p/cm^2/s
- ECR source using cocktails with close M/Q ratio
- HIF Fast change of ion species
- Operation in vacuum

HIF and LIF

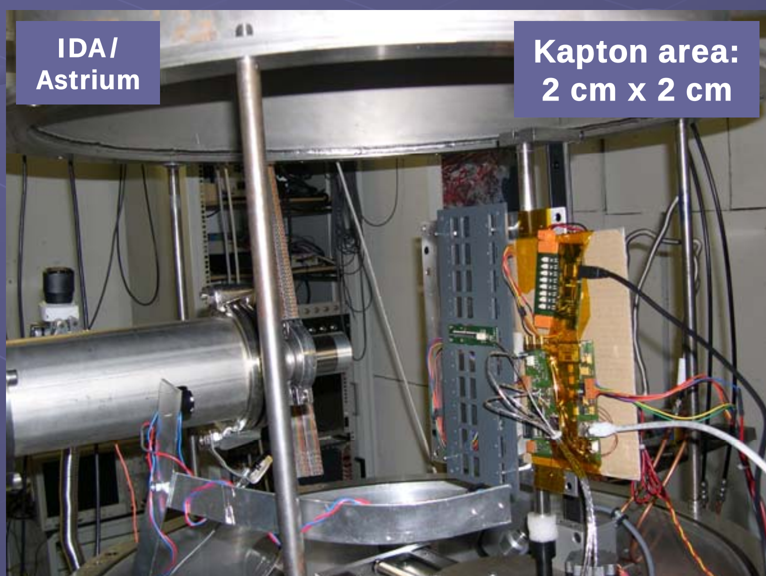
- Cocktails
  - M/Q ≅ 5
  - range 40 – 80 μm
  - LET 1.7 – 55.9 MeV/mg/cm^2
- High penetration
  - range 92 – 266 μm
  - LET 1.2 – 32.4 MeV/mg/cm^2
- Tilting, cooling
- Fluxes of 10^4 /cm^2/s
- Beam uniformity 10% for 25 mm diameter

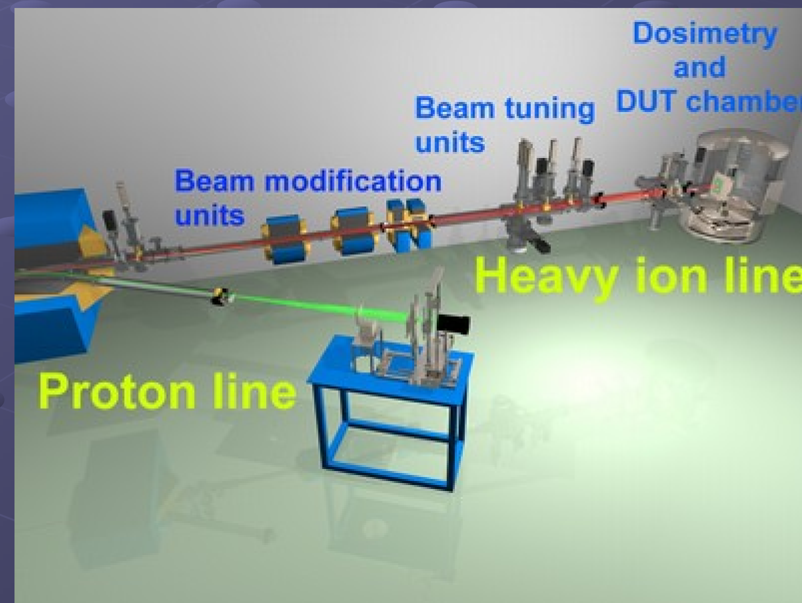
RADEF

- RADiation Effects Facility: both proton and heavy ion facility
- Location: Jyväskylä, Finland
- Contact person: Ari Virtanen (see presentation Day 1)
- Operation:
  - ca. 650 beam hours / year (up to 120 h/month) 9.3 MeV/AMU
- ECR source with fast change of ion spices in cocktail
- Cocktails with close M/Q ratio (≅3.7, 3.3)
  - range 89 – 202 μm
  - LET 1.8 – 60 MeV/mg/cm^2 (surface)
- Operation in vacuum

RADEF

- Tilting and cooling
- Fast change into proton line
- novelty: HI tests in air



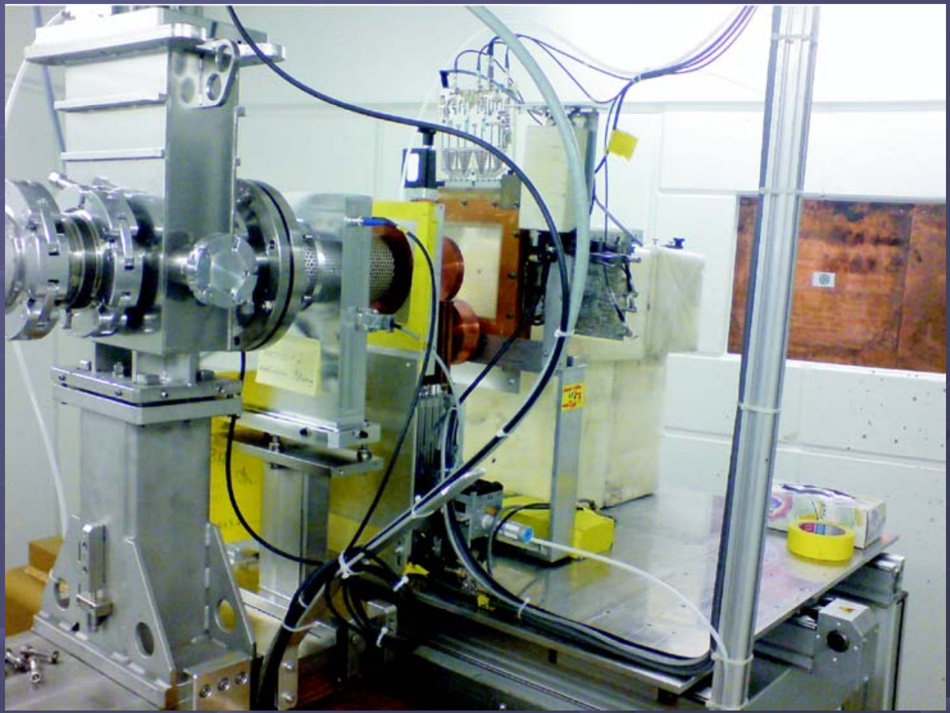


PIF

- Proton Irradiation Facility at PROSCAN biomedical cyclotron
- Location: Villigen PSI, CH
- Responsible: Wojtek Hajdas
- Initial energies: 235, 200, 150, 100, 70 MeV (any between)
- Other energies with a local degrader: down to ca. 10 MeV
- Beam intensity 2 nA (E > 200 MeV), 10 nA (E < 100 MeV)
- Flux at primary energy $10^2 – 5 \cdot 10^8$ p/sec/cm^2 (wide beam)
- Beam profiles Gaussian-form with FWHM ≅ 6 mm to 7-10 cm
- Exposures during weekends (Ca. 840 hours beam in 2008)
- Neutron and gamma dose background below 0.5% summed

PIF

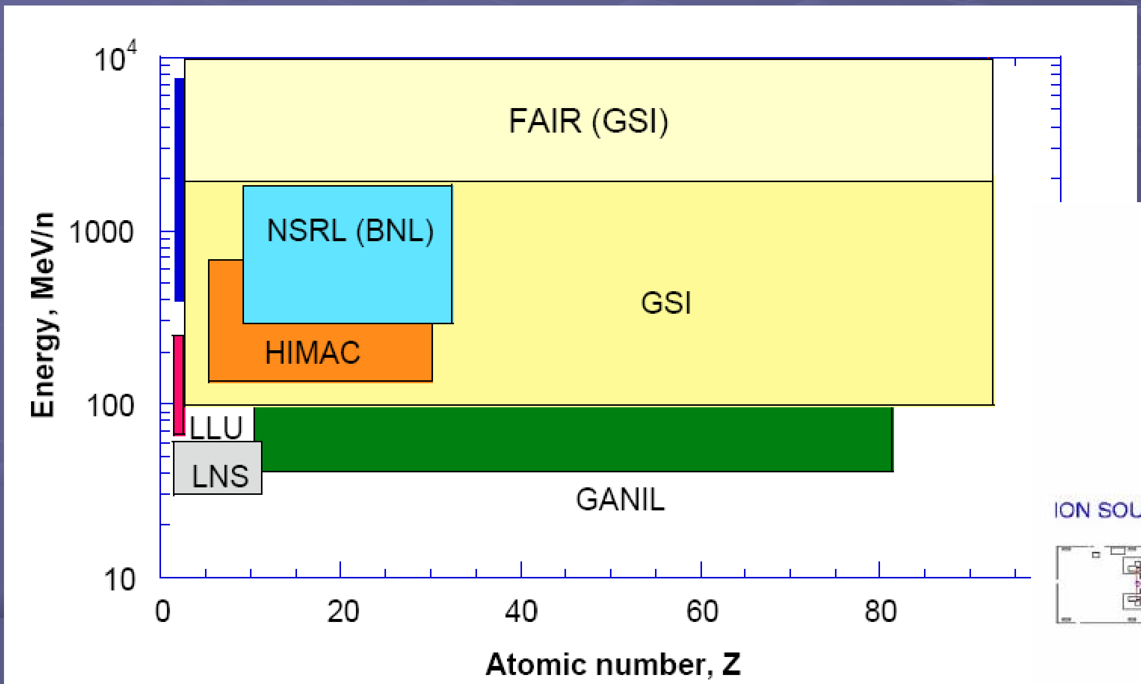
Wide and narrow beam profiles

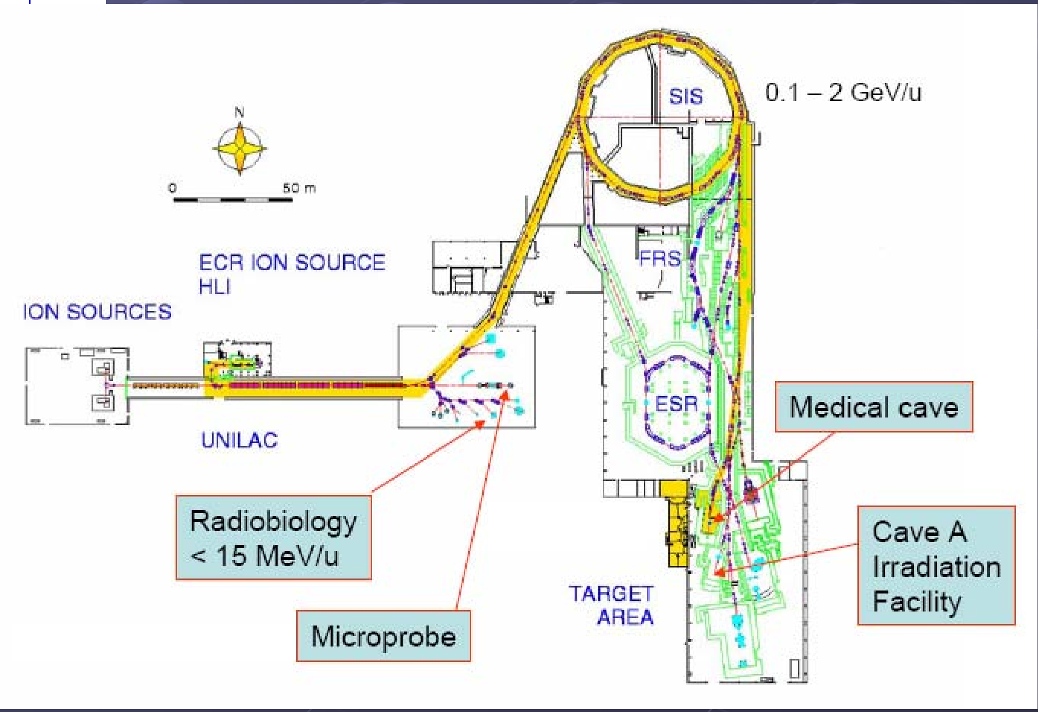


Beam line arrangement

Complex techniques to characterize transients:
'golden circuit' and comparison patterns with the irradiated one
pinning down with tests of the whole device and then individual components exposures

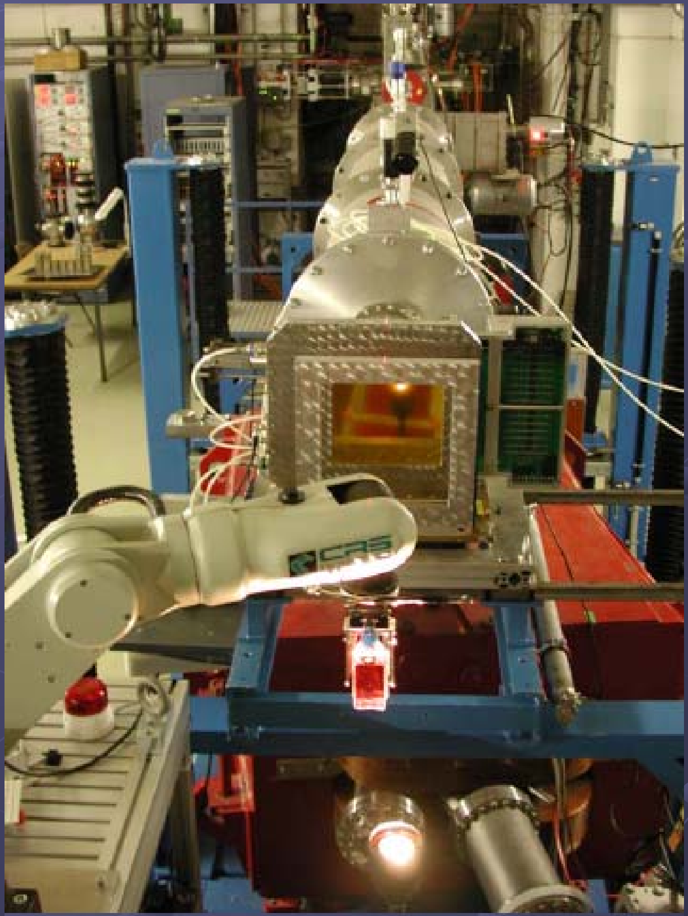
GSI and GANIL



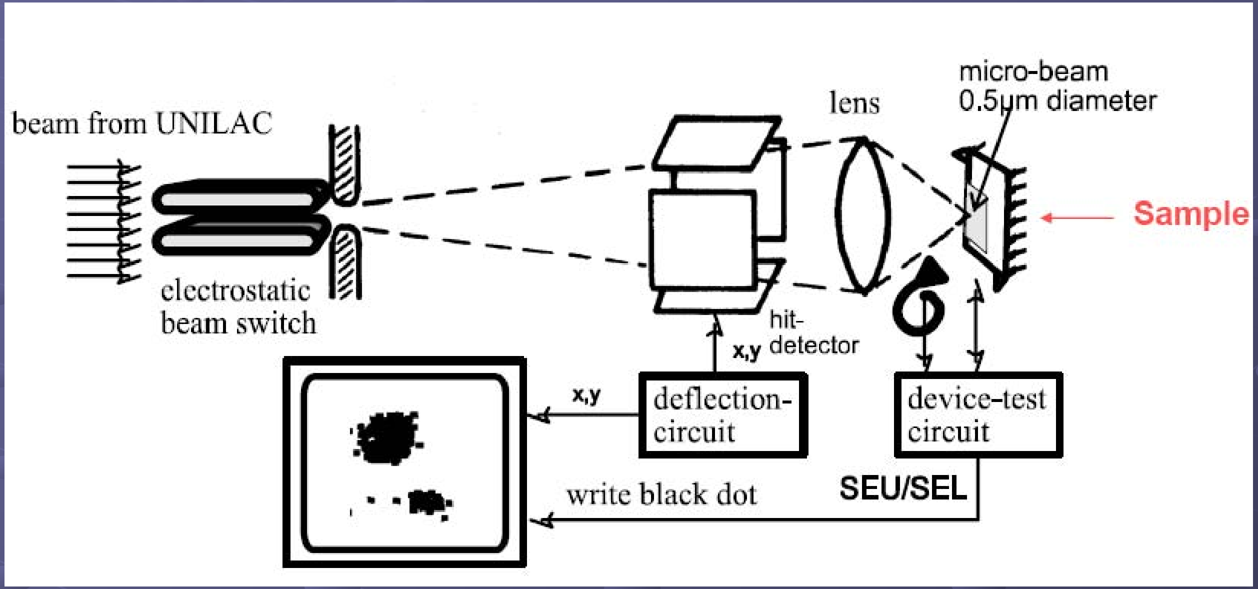


GSI – High Energy Test

- HE facility – Cave A
  - ions from H to U
  - energy 50 – 2000 MeV/AMU
  - field size 20 x 20 cm^2
- Beam on-line monitoring
- Flat beams
- Positioning lasers and tables



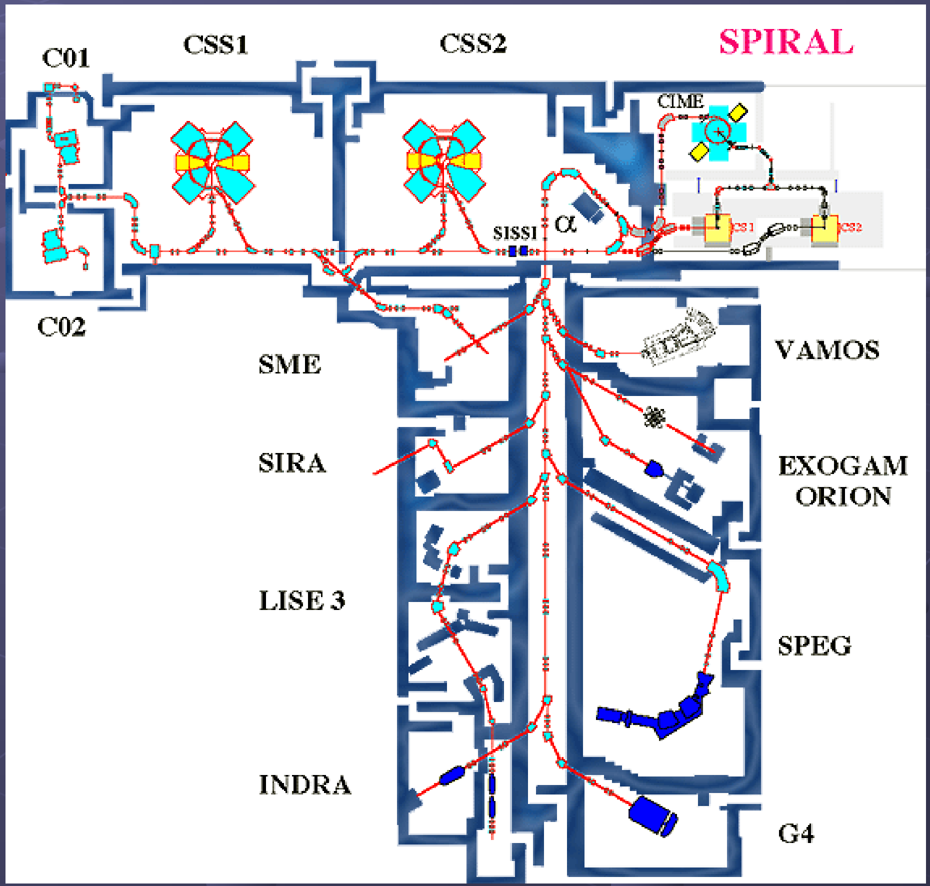
GSI – ION MICROPROBE



- End energy – 11.4 MeV/AMU
- Beam spot ≅ 0.5 μm diameter
- High intensity

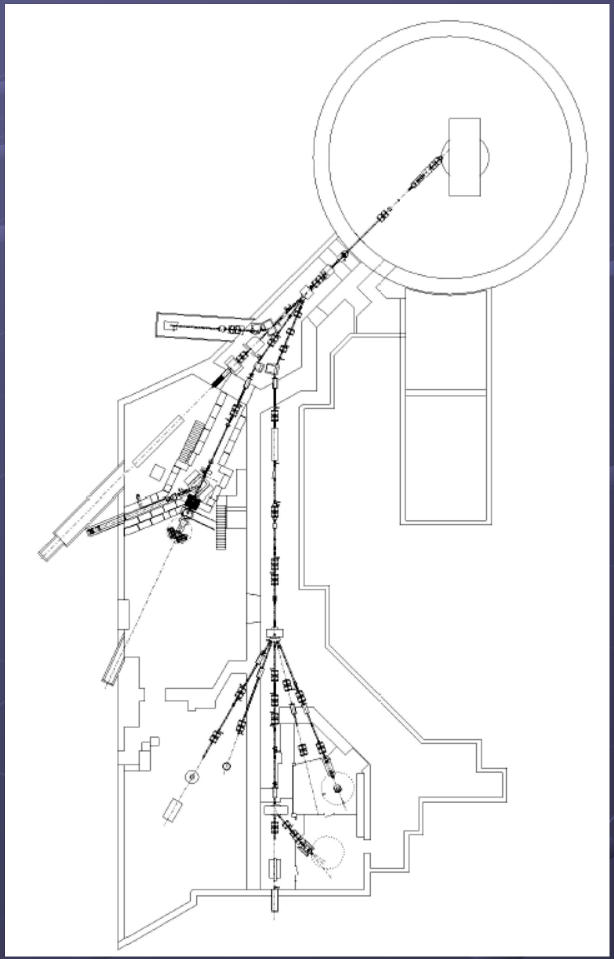
GANIL

- Interdisciplinary research in G4 area
- SAIF, GANIL's Industrial Applications Service
- Large area samples of 4x50 cm^2
- Any beam from GANIL accelerator



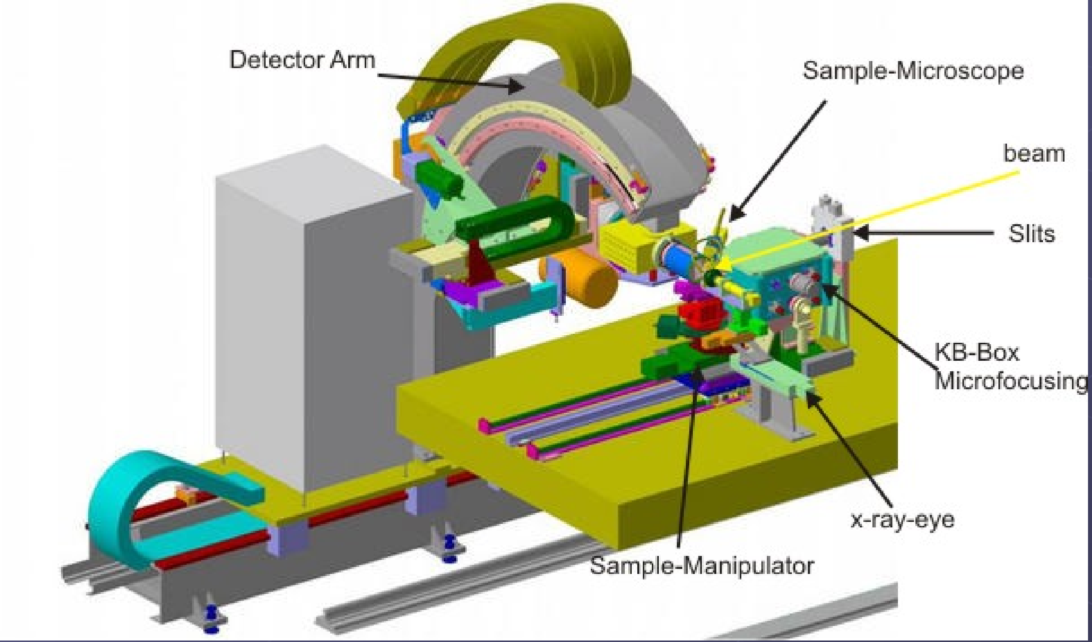
UPPSALA

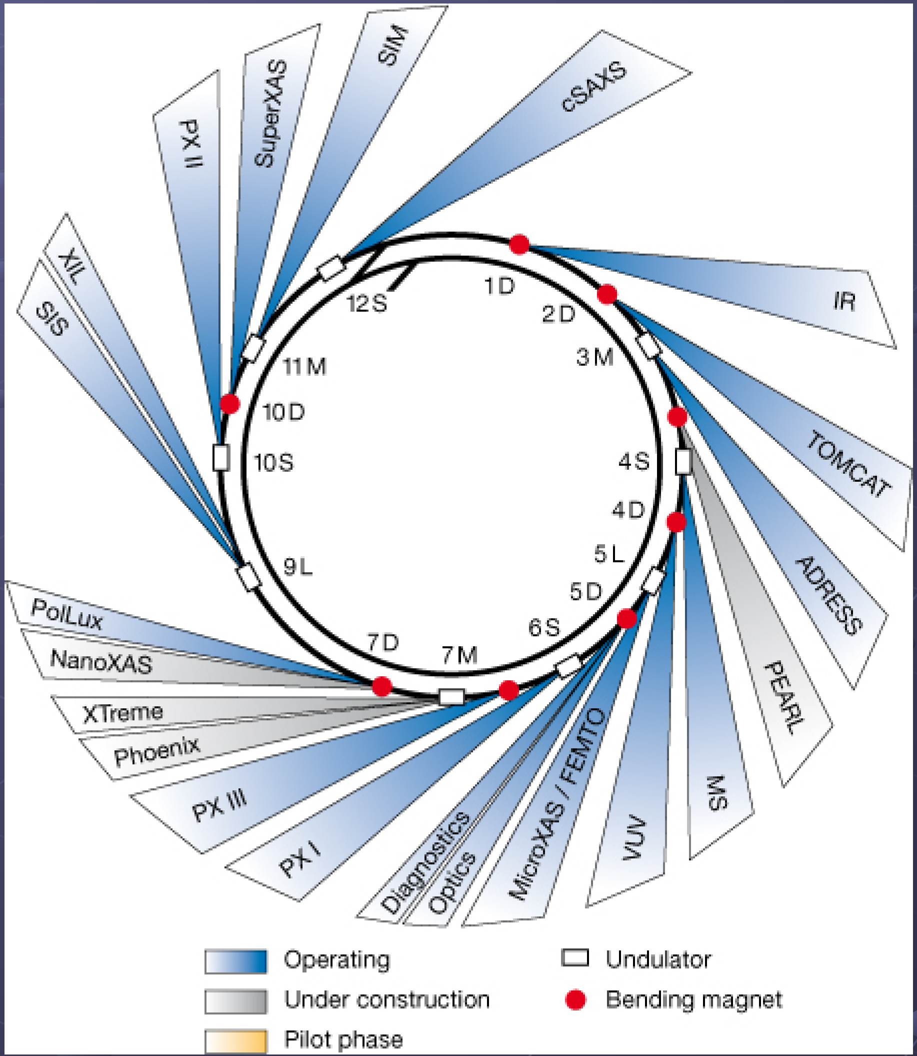
- Proton and neutron beams
- Location: Uppsala, Sweden
- Contact: Alexander Prokofiev
- Energy range 20 – 180 MeV
- Proton fluxes for 7.6 cm circular beam:
  - 10^{10} /cm^2/s at 25 MeV
  - $1.4 \cdot 10^9$ /cm^2/s at 180 MeV
- Wider diameter possible



SLS / microbeam

- Energy on sample 5 – 20 keV
- Flux $2 \cdot 10^{12}$ ph/s/400cmA
- Spot size 1 x 1 μm^2
- PSI SLS web to apply for beam

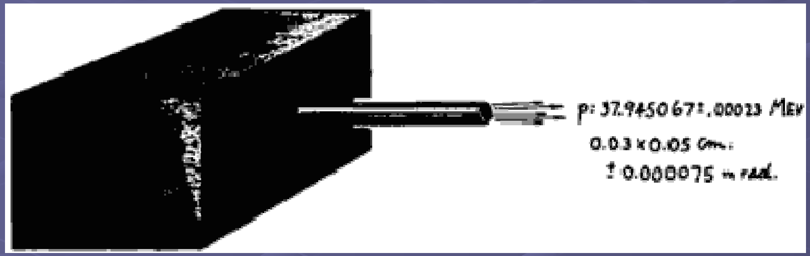




Summary

- Several accelerator facilities available for heavy ions and protons
- Number of facilities with similar beam features
- Suitability for SET depends on nature of tests
- Specialized facilities with very high energies of HI or microprobe beam exist but access is limited
- Other facilities with potential for SET studies:
  - synchrotron light (e.g. PSI SLS) with X-rays of ca. 10 keV, high photon flux and micrometer spot size

Thank You!



cyclotron ideal for research

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