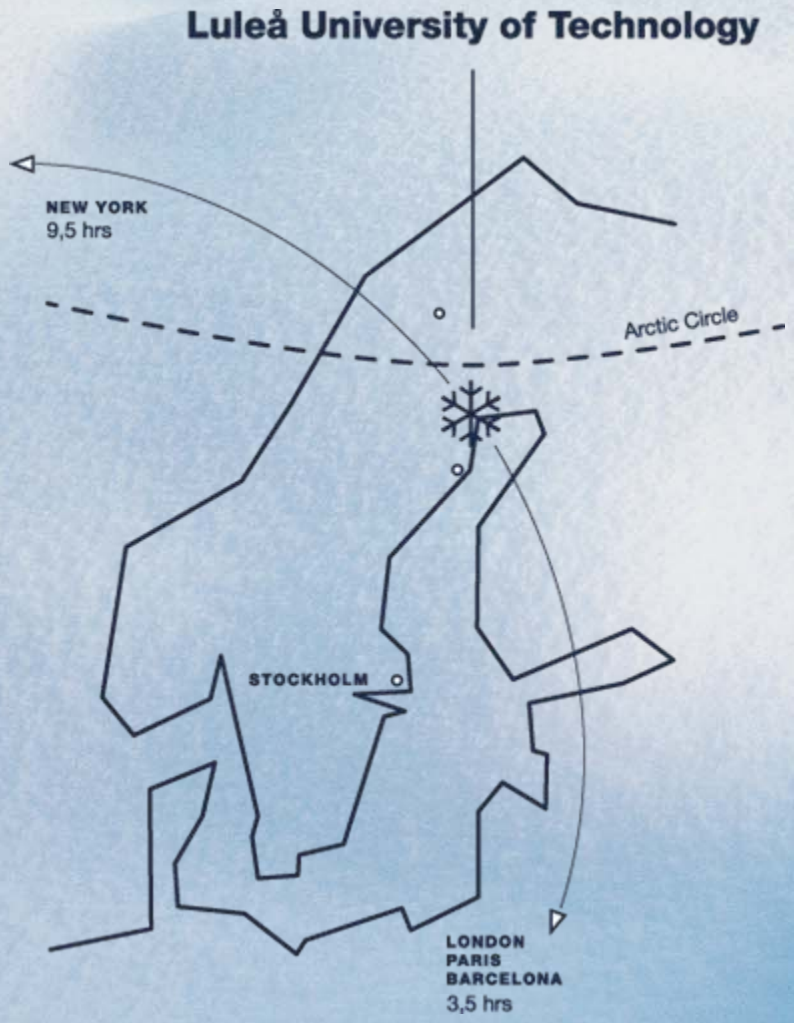



- Personnel: 1,400
- Students: 12,200
- Turnover: EUR 106 million

# Students 12,200

| | |
|---|---|
| •MSc in engineering | 2 400 |
| •BSc in engineering | 300 |
| •Other programmes in engineering | 500 |
| •Business administration, economics and | 1 400 |
| •social sciences | |
| •Health sciences | 1 200 |
| •Interdisciplinary educations | 200 |
| •Music, media and drama | 600 |
| •Teacher education | 1 000 |
| •Singe subject courses | 4 600 |

•(about 600 exchange students are included in the total amount of students)

# Programmes 09/10
# Engineering – MSc programmes

- Architectural engineering
- Civil engineering
- Computer science and engineering
- Engineering physics and electrical engineering
- Industrial and management engineering
- Industrial design engineering
- Materials science and engineering
- Mechanical engineering
- Natural resources engineering
- Space engineering
- Sustainable energy engineering
- Sustainable process engineering
- Engineering (common entrance)

LULEÅ UNIVERSITY OF TECHNOLOGY

# Department of Space Science = IRV

The northernmost University of Technology in Scandinavia
**World-class research and education**

# Space activity in Kiruna

- Department of Space Science, IRV
- Swedish Institute of Space Physics, IRF
- Esrange, sounding rocket and ballonbase
- EISCAT, incoherent scattering radar
- ESA Salmijärvi satellite station

# IRV

- IRV is a small department with about 20 persons
- Founded in Kiruna about 18 years ago


# Educations at IRV

Civil engineering program in space technology 5 year,
2.5 year in Luleå
+ 2.5 year at IRV in Kiruna

Space Master Erasmus Mundus, 2 year,
LTU, Würzburg, Cranfield, Helsinki,
Paul Sabatier, Prague.

Doctoral studies, space physics,
space technology, and atmospheric
physics. LTU-IRF research school.

# Why educations at IRV in Kiruna?

1. Space Environment, many space actors in Kiruna

2. Connect actors to our students at IRV

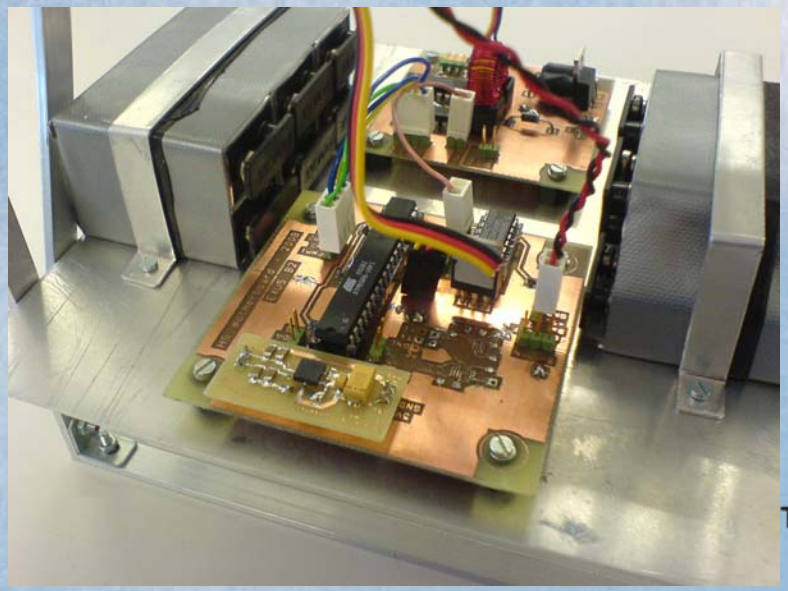
3. Guest lecturers, Degree projects, and EXUS, REXUS and BEXUS

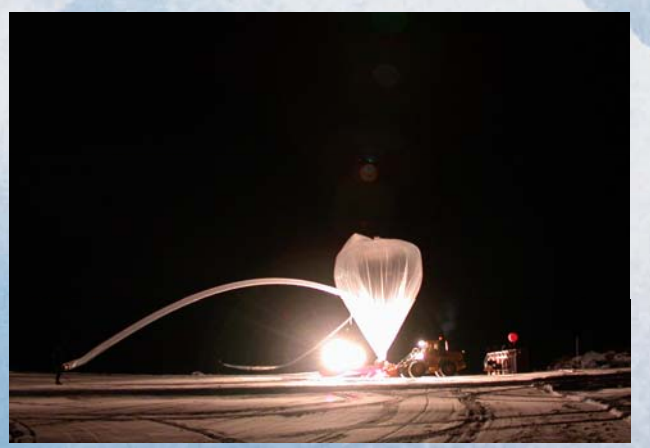
Above: smoke trace after REXUS 3 winter 2006

# Student projects

'Hands-on experience'

- REXUS: Rocket Experiments for University Students
- BEXUS: Balloon Experiments for University Students
- Eurolaunch: Swedish Space Board and DLR in cooperation with ESA och SSC Esrange
- Our own ballons EXUS



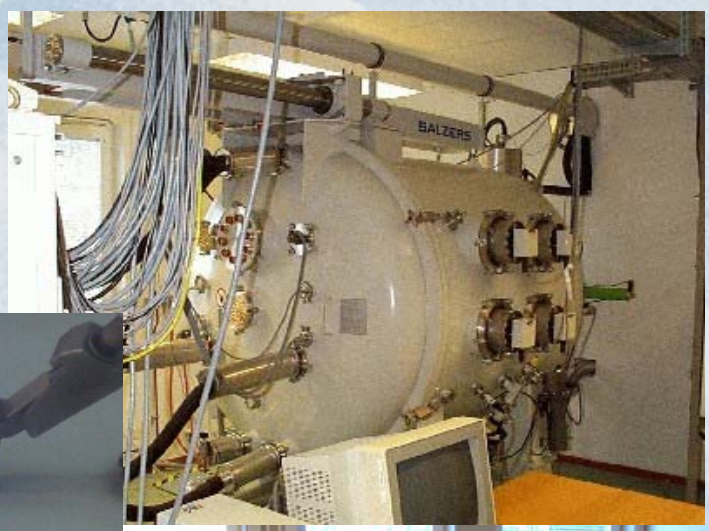


# Student projects ”Hands-on”

## Our rooms support student projects

Left: project lab,
Below: EXUS project room

# Access to equipment





Here our students tests their constructions in IRF's vacuum chamber.

Left: Our shaker equipment.

LULEÅ UNIVERSITY OF TECHNOLOGY

# Student project EXUS, 2008

The northernmost University of Technology in Scandinavia
**World-class research and education**

# Structure of SpaceMaster

- Two years research-oriented Master course following the Bologna concept
- All teaching and textbooks in English (except at UPS during the second year where there will be a mixture of most French and some English)
- Double Master's Degrees from two European countries
- The first year is common for all students, starting in Würzburg and continuing in Kiruna
- 5 engineering and 3 science tracks during the second year

LULEÅ UNIVERSITY OF TECHNOLOGY

# Erasmus Mundus Master Course in Space Science and Technology – SpaceMaster 120 ECTS

Education and Culture
Erasmus Mundus

**2005 – 2011, 2010-2016**

- **Luleå University of Technology, Department of Space Science** (Space Technology and Instrumentation, Atmospheric and Space Science)
- **Cranfield University, UK** (Dynamics and Control of Systems and Structures)
- **Czech Technical University, Prague, Czech Republic** (Space Automation and Control)
- **Aalto University, School of Science and Technology, Finland** (Space Robotics and Automation)
- **Julius-Maximilian Universität Würzburg, Germany** (Automation, Control and Communication of Space Robotics)
- **Université Paul Sabatier Toulouse, France** (Space Technique and Instrumentation, Astrophysics, Space Science, Planetology)
- **The university of Tokyo, Graduate School of Science, Japan** (Earth and Planetary Science)
- **Utah State University, USA** (Mechanical and Aerospace Engineering)

**Master of Science and Technology with a Major in Space Technology, 120 ECTS**
**Double MSc Degree**

The northernmost University of Technology in Scandinavia
**World-class research and education**

Education and Culture
Erasmus Mundus

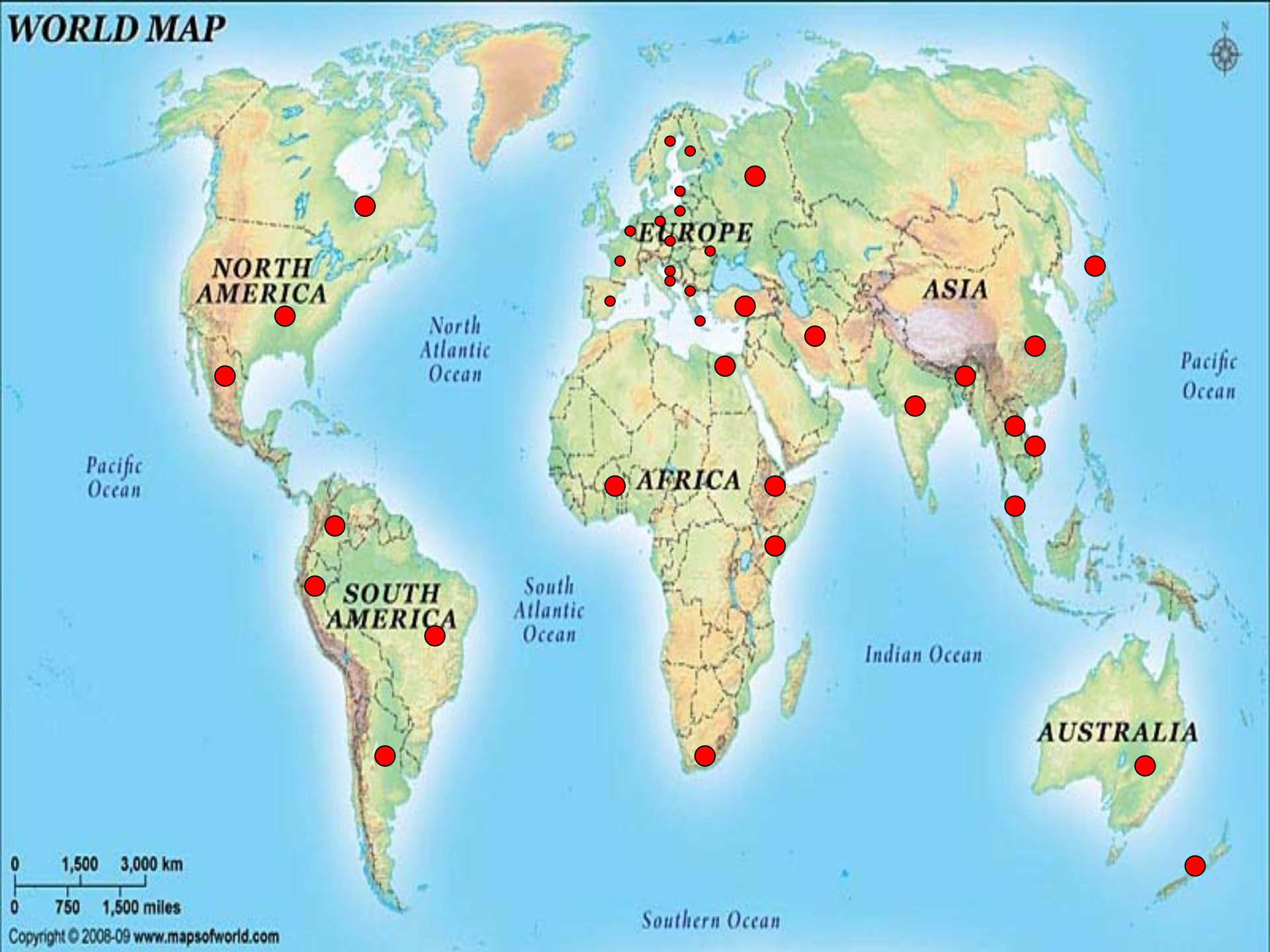
# SpaceMaster, 120 ECTS

Semester 1 **All students at JMUW**
Core modules and optional modules in German language
**30 ECTS**

Semester 2 **All students at LTU, Kiruna Space Campus**
Core modules and optional modules in Swedish language
**30 ECTS**

Semester 3 **LTU- Kiruna Space Campus, JMUW, CU, CTU, Aalto, UPS**
Core and optional modules
**30 ECTS (15 ECTS – CU)**

Semester 4 **LTU- Kiruna Space Campus, JMUW, CU, CTU, Aalto, UPS, USU, UT**
Work on the Master Thesis
**30 ECTS (45 ECTS – CU)**


WORLD MAP
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
North Atlantic Ocean
South Atlantic Ocean
Pacific Ocean
Pacific Ocean
Indian Ocean
Southern Ocean
0 1,500 3,000 km
0 750 1,500 miles
Copyright © 2008-09 www.mapsofworld.com

# Space Master

Number of students (year 1, 2)

- Rond 1, 2005: 48(1) 39(2) 25 non-EU 14 EU 10 women
- Rond 2, 2006: 43(1) 42(2) 30 non-EU 12 EU 4 women
- Rond 3, 2007: 39(1) 33(2) 22 non-EU 11 EU 4 women
- Rond 4, 2008: 36(1) 33(2) 19 non-EU 13 EU 9 women
- Rond 5, 2009: 37(1) 36(2) 18 non-EU 18 EU 3 women

# MSc Programme in Space Engineering 300 ECTS = 5 year

- 2 ½ year in Luleå: maths, physics and other basic courses
- 2 year space engineering and science courses in Kiruna, 10 – 15 students
- ½ year master degree projects, usually out in industry, space organisations, or other universities.

# Courses in Kiruna 2010/2011

F7004R Atmospheric Physics 7.5 hp
R7016R Space Flight Dynamics: Attitude Dynamics 7.5 hp
R7015R Space Flight Dynamics: Attitude Dynamics 7.5 hp
P7004R Degree Project Master in Space Technology 30.0 hp
R7012R Remote Sensing 7.5 hp
R0001R Introduction to Space Technology with Projects 7.5 hp
F7011R Climate Physics 7.5 hp
F7007R Cosmology 7.5 hp
F7002R Numerical Methods 7.5 hp
F7003R Optics and Radar Based Observational Technique 7.5 hp
F7010R Plasma Physics 7.5 hp
E7003R Space Electronics 7.5 hp
E7001R Space Electronics 7.5 hp

R7004R Spacecraft-Environment Interaction 7.5 hp
R7008R Space Vehicle Systems 7.5 hp
R7017R Space Physics 7.5 hp
R7013R Space Instruments 7.5 hp
F7001R Space Plasma Physics 7.5 hp
P7005R Space Technology Project 1 7.5 hp
P7006R Space Technology Project 2 7.5 hp
P7001R Space Technology Project II 15.0 hp
F7006R Solar Physics 7.5 hp
F7008R Solar System Physics 7.5 hp
E7002R Telecommunication Physics 7.5 hp

Space Master students (in their first year master) and MSc in space engineering students (in their third year) both take the course

**Spacecraft-Environment Interaction, 7.5 Credits = 5 week = 200 hours**

containing an overview of space environment (neutral, plasma, particle/MMOD, and radiation)

and its interaction with the spacecraft, resulting in effects like drag, AO erosion, glow, sputtering, outgassing, contamination, charging, radiation damage, particle impacts, etc

- In the course the students shall do a 1 week practical using SPENVIS in groups of 1 or 2 students
- resulting in a written report
- that are corrected with Approved/Not Approved
- but have influence on the grade of the course for borderline cases

- The students choose an

- existing or planned s/c orbit based e.g. on TLE (two-line element) or
- an own invented orbit

- They are encouraged to choose an interesting orbit

# Example of choosen satellites 2010:

- Chandra X-ray Observatory
  a = 80787.981 km  e= 0.801707  i = 28.4678˚
- ESA Proba-2
  a = 7096.95 km  e = 0.00139  i = 98.31˚
- ISS
  n = 16.0506 rev/day  e = 0.012536  i = 51.5908˚
- Soyuz TMA
  a = 6718.7 km  e = 0.000009  i = 51.6373˚
- Molnyia-1
  p/a alt = 500 km / 40000 km  i = 63.4˚
- TOPEX/Poseidon
  p/a alt = 1332 / 1342 km  i = 66.04˚

- ENVISAT
  p/a alt = 780 km / 820 km  i = 98.55°
- MetOp
  n = 14.215 rev/day  e=0.0001217  i = 98.7°
- RADCAL
  p/a alt = 758 km / 887 km  i = 89.52°
- Own invented Molniya
  p/a alt = 600km / 40000 km  i = 63.4°
- MOST
  p/a alt = 826 km / 840 km  i = 98.72°
- RADARSAT-I
  p/a alt = 793 km / 821 km  i = 98.58°
- STRV-1b (picosat.)
  p/a alt = 300 km / 36 000 km  i = 7.4°

# Tasks for SPENVIS practical

- Choose orbit!
- Describe the mission!
- Characterize the environment the s/c is expected to meet in its various phases and estimate its importance for the s/c!
- Verify the above with data from SPENVIS! Usally illustrated with diagrams from SPENVIS.

- Study specifically effects of the radiation environment:
- 1 How thick must a cover glass of a solar array be in order for 1 MeV electron equivalent fluence not to exceed a certain predefined value?
- 2 If a box contains a silicon device that can take 1.0 Mrad before it stops working, how thick must the wall of the box be?
- 3 What will the Single Event Upset rate be for four different memory chips? For three of them, the cross section is described by a Weibull function, where parameter values are given. For the fourth, experimental values are given when different monoenergetic ions are radiated towards the device. From that the parameters of the Weibull function are to be determined.

## Experimental values:

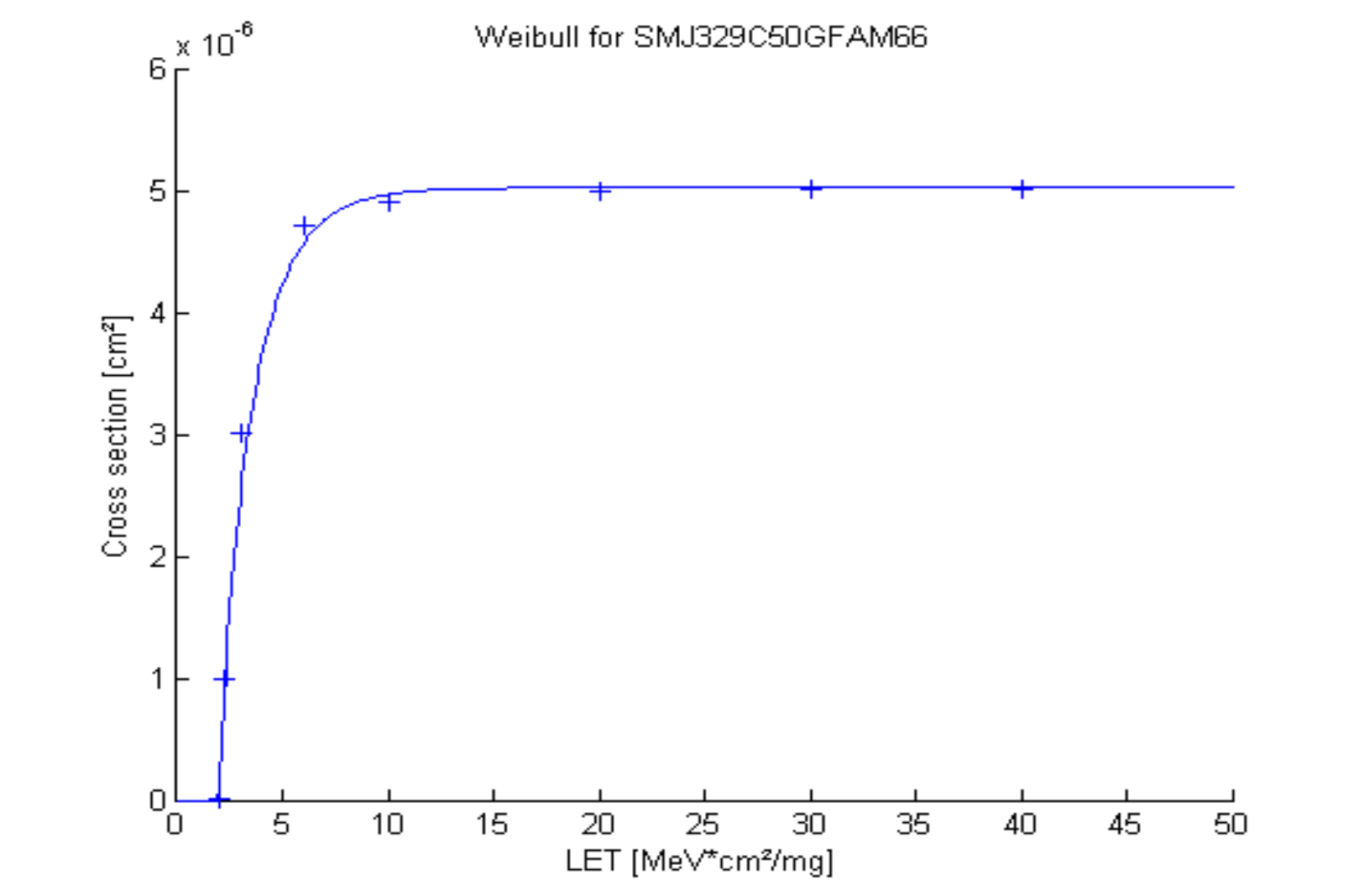
| Ion | Energy of Beam [MeV] | Flux of particles [cm-2s-1] | Exposure Time [minutes] | Number of Flips |
|---|---|---|---|---|
| C-12 | 0.60 | 25 *10^6 | 5 | 8 |
| C-12 | 0.72 | 25 *10^6 | 5 | 7497 |
| C-12 | 9.6 | 25 *10^6 | 5 | 22514 |
| O-16 | 4.8 | 17 *10^6 | 5 | 23986 |
| Ar-40 | 20 | 23 *10^6 | 5 | 33810 |
| Fe-56 | 56 | 10 *10^6 | 10 | 29991 |
| Kr-84 | 84 | 7 *10^6 | 10 | 21022 |
| Xe-131 | 786 | 4 *10^6 | 15 | 18043 |

# Weibull function

$$\sigma(L) = 0 \qquad , \qquad L < L_0$$

$$\sigma(L) = C_s \left( 1 - e^{-\left( \frac{L - L_0}{W} \right)^s} \right), \qquad L \geq L_0$$

should result in something like this:



having obtained the Heinrich flux from SPENVIS they finally shall obtain the SEU by integrating (MATLAB):

$$\frac{dU}{dt} = \int_0^{2\pi}\int_0^{\pi} \sin\theta \int_0^{\infty} \sigma(LET,\theta,\phi)\cdot \sum_{Z=1}^{92} h(LET)\,d(LET)\,d\theta\,d\phi$$

# Experience of using SPENVIS as a pedagogical tool:

- *Encourage independent seeking of information*
- *Visualization fascilitates understanding, especially of 3-dim objects*
- *Students motivated by usage of ”sharp” program used by space engineering community*
- *Suitable for students with different backgrounds*
- *Speeds up learning*

Our home page:
www.ltu.se/irv


www.irf.se

www.ssc.se