ISIS Muon Training School

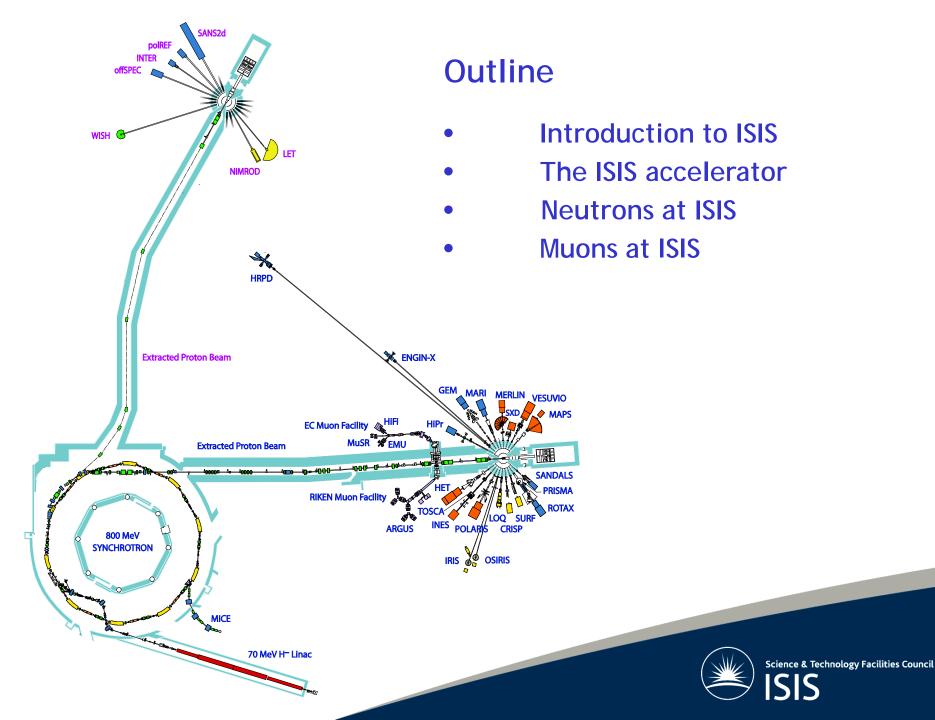


19-24 March 2012

ISIS and its Muon Facility

Philip King ISIS Muons





Introduction to ISIS

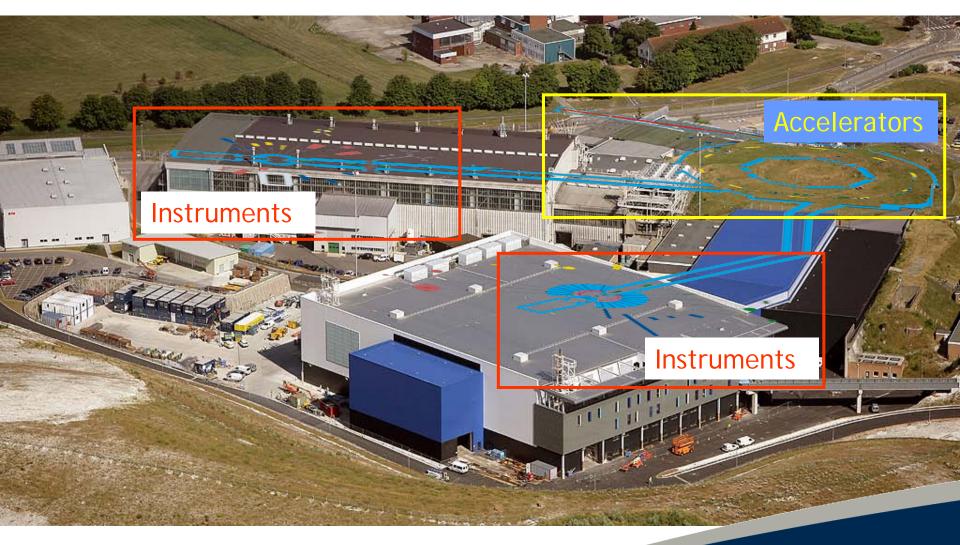




32 Instruments

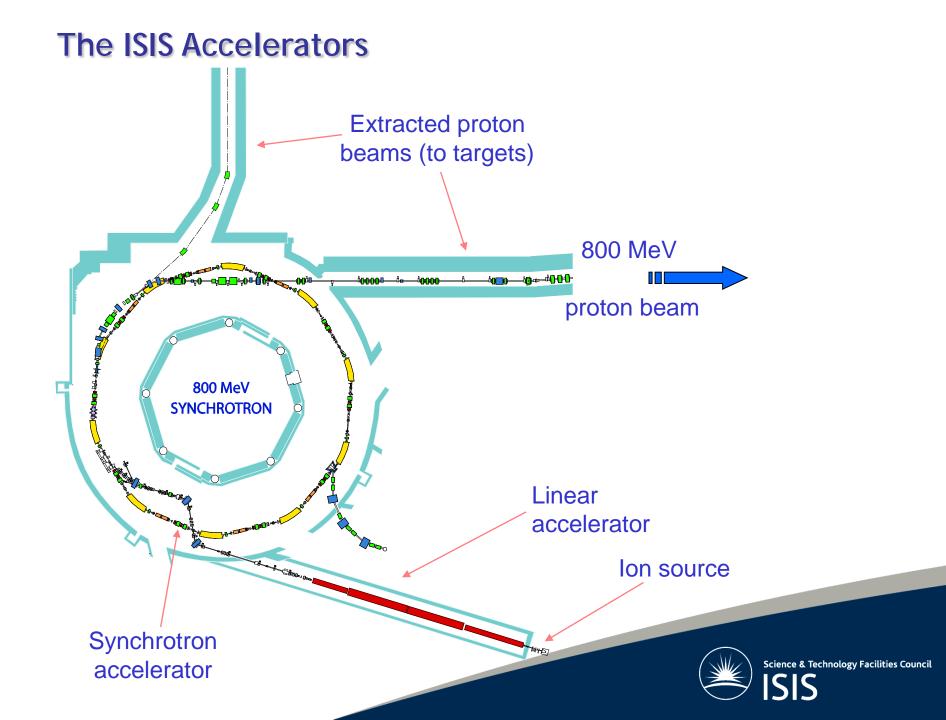
- 700 Experiments per year
- 3000 Instrument-days per year
- 500 Publications per year
- 2000-strong user base
- 2000 user-visits every year

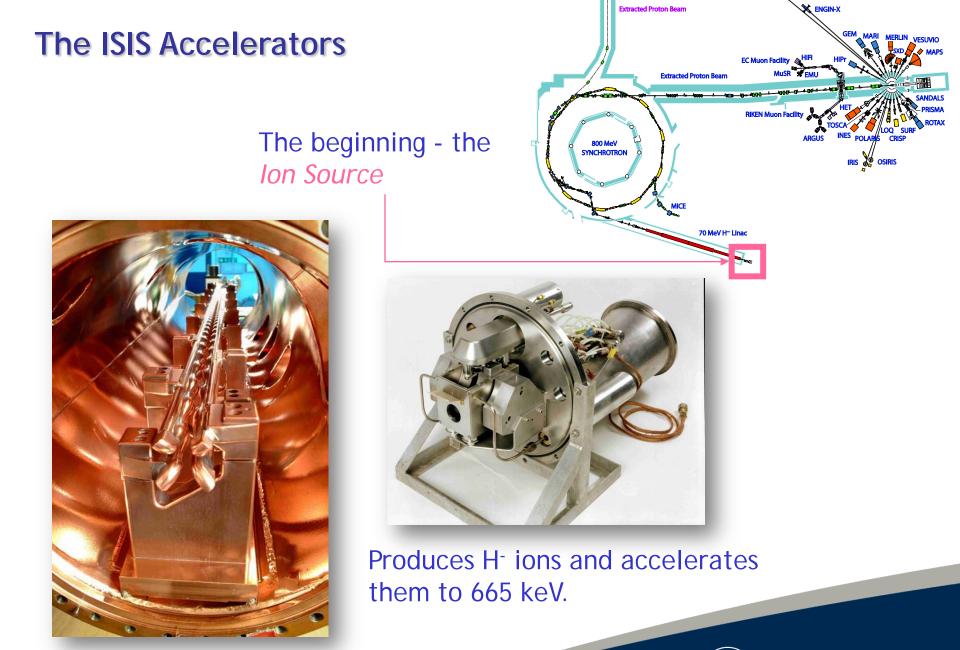
The ISIS Pulsed Neutron and Muon Source



A World Centre for Condensed Matter Science with Neutrons and Muons







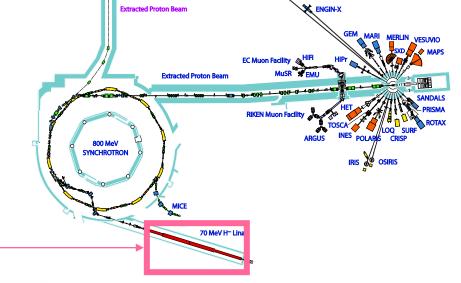


Science & Technology Facilities Council

SIS

The ISIS Accelerators

The middle - the *Linear Accelerator*





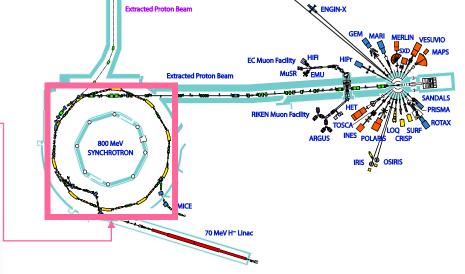
Accelerates the H⁻ ions to 70 MeV.



The ISIS Accelerators

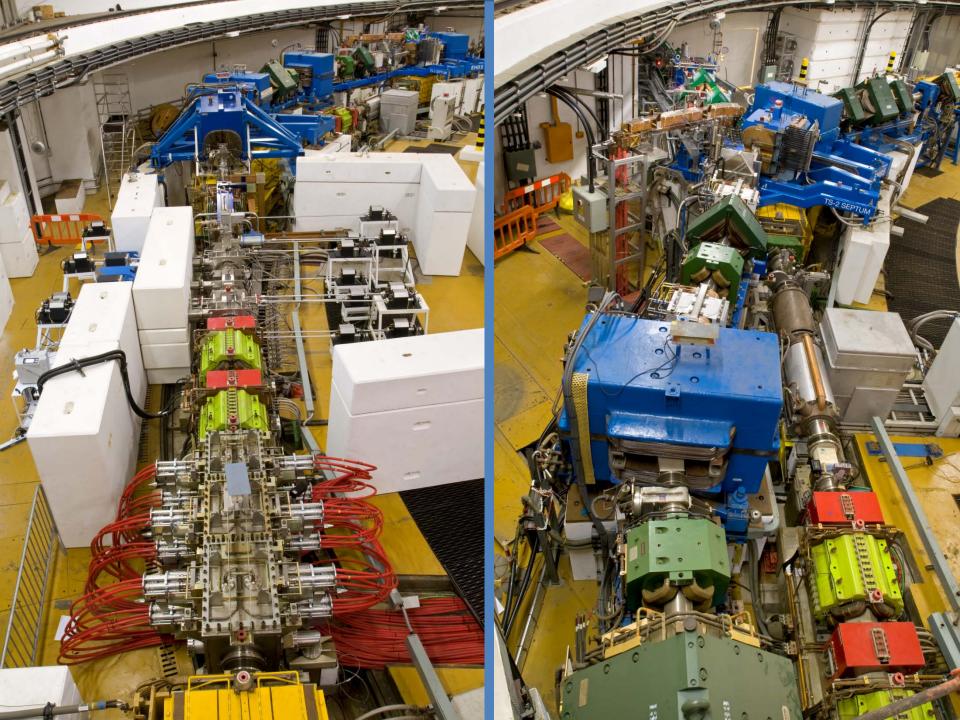
The final stage - the Synchrotron Accelerator





- H⁻ ions stripped to protons
- Protons travel ~10,000 times round
- Accelerated to 800 MeV (84% light speed)



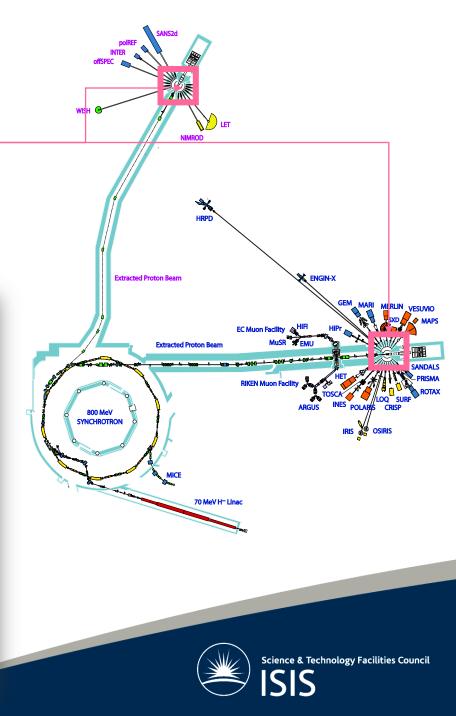


The ISIS Targets

- Tantalum targets
- Neutrons produced by 'spallation'

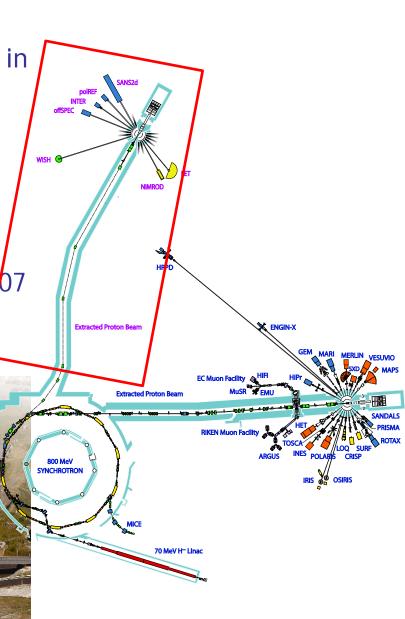
- The Neutron Targets
- Heat dissipation
 is 160 kW

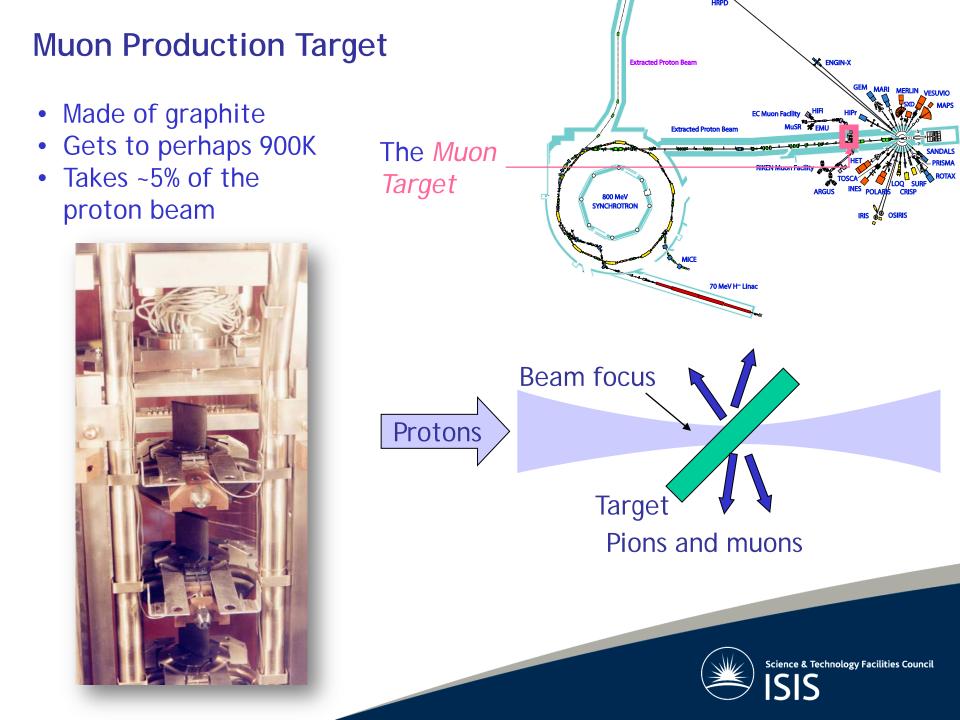


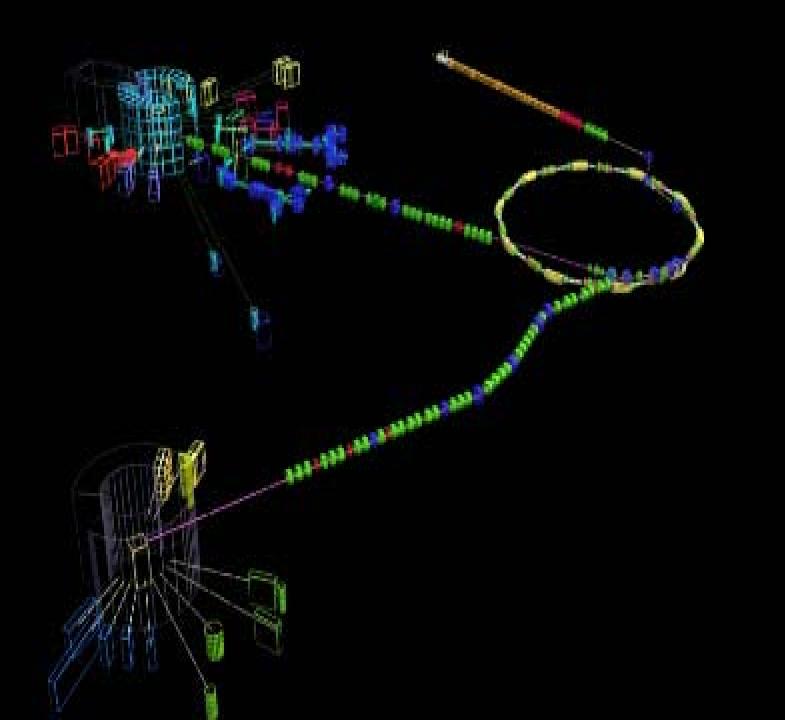


The Second Target Station Project

- £150M project
- Designed to meet future scientific needs in the key areas of:
 - Soft Matter
 - Advanced Materials
 - **Bio-molecular Science**
 - Nanoscience
- First proton beam to target area: Dec 2007
- First measured neutrons: August 2008
- First user experiment: May 2009





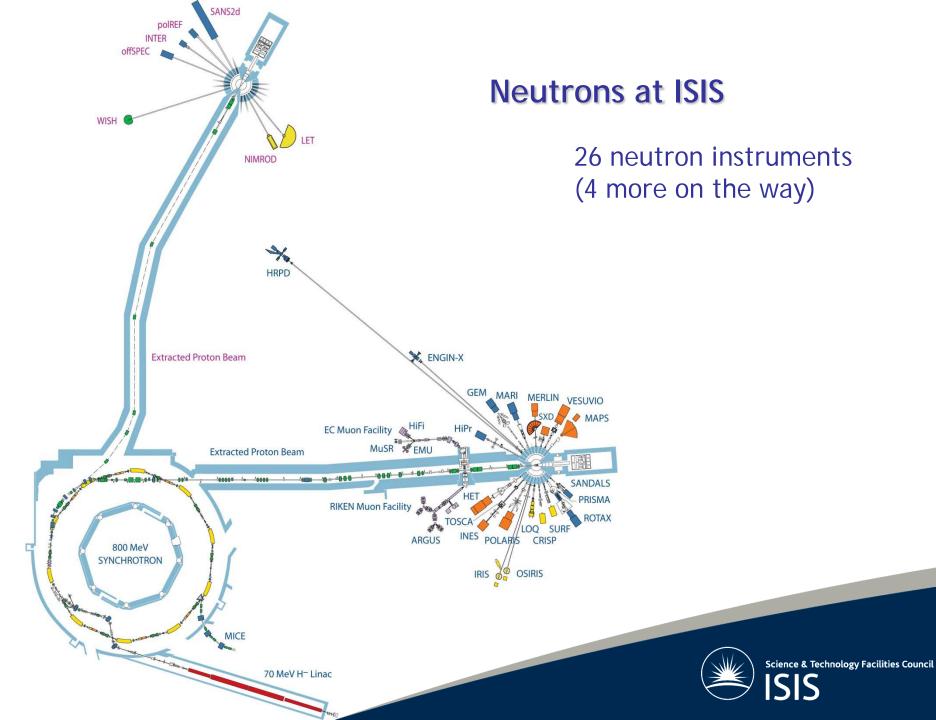


The ISIS Pulsed Neutron and Muon Source



- ISIS runs ~180 days per year
- It runs in 'cycles' of 30-40 days each
- ISIS is controlled from the Main Control Room – which is always staffed





The Nobel Prize in Physics 1994

Older G. Ball, 1077 Conduidge, Manualization, 13.5, souther new helf of the 1998 Hold Point in Physics. for bedapment of the neutron differences achaipen.



Model marks and of planates approximating i.e. of excession behicle change direction without being mergy when they collide with some

Because of the types mature of sectors, a diffusition pattern can be recented which indicates where in the sample fix stress and streams). Eases the placing of light electronic such a hydrogan is metallic hydrides, or hydrogen, colores and anappre in organic.

Shall also much our of this placesmanner in his measure differences to forlight.



and the first matching and the first subscription



Neutrons reveal structure and dynamics

Leutrons of an ruches and of mare

Neutrons show where atoms are

Induced II is included by photological sectors and sectors and the and States, States and Provide strange description and and the state of the state of the And in case of the local division of the loc Property in surveying the

Neutrona bounce agoinet atomic nucle-They also react to the magnetism of the SCOTTLE.

Floresarch reactor

Neutrons show what atoms do

techniques for studies of condensed matter.

Renters 10 Decisions, Middates Converses Manifest Ontorio, Canada, matters and half of the OHA Moled Price. he Physics for the development of minima spectrum type

The Royal Smellish Academy of Sciences has awarded the 1994 Nobel Prize in Physics for planaeting contributions to the development of neutron scattering



DevictAssume stands one of inelastic scattering i.e. of summers, which change both distortion and courses where they callide with storm. They there start or traced atomic traillateness in crystals and social many summing in logater. and males. Nonemen can also account with spine more in magnets.

Wah his 3-min spectroscopy Daviddenne mentared energies of phonors (positie clinational and marganic lossignatic waved. He also gradied how annual executions ha

Neutrons tell you where atoms are 3-processories with

and what atoms do'

Distantiant control the distant of the subdrary and a strengther patient is stimpted. The pattern player, the painting of the states received in the second data

10.

Name in a



Naustroom show what anyone encreenibles a series that we say and what to found and party from their size has not a first take Platester control manual continues Barry Stational Conference Stations Subsect in proc. ALC: NO DECIDENT 100 provide a first provide the second

the own before then been be persons of the state of weather the time. It is a point whether of a principal of a special later with the party states Contraction of the Contract of the Contract

Course the serie and References the second of In the local sectors with 010000-00000 Finish Industry

Hard Historiani,

Socialized and Stard reals that powering new instance as the first success to allow in the USA and Canada lines for the (14% and 1987). It was that that the measure of the measure Instates middle for printing without

Thomas int committeepers

Thistands if wanted as one costing a fir card Anterest second, devices denoughes a line second. New and team antonyod population and every insufficiency have been had and service data private and in Hamping the U/UA and Adap Data more ages housed as the standard at making the structure of ters contain repetulanitation, itsilarisha chemistania caserious of anyway by contributions, the same of serarticizette and the committee formula the machine and the clickly preparents of performant

Dates in the samp of the section as loss an abundant of size promptified in potent.

NAME OF TAXABLE PARTY. The sumple from start of traction succession in the original of the heisihininin biritake gifterheihe ger Pageona thay Formaduce Rose Fill share dealer. Performing the philometers

> and the tradema. For Statistics And in case of the local division of the loc



Carlos Brents in the by the And in the other Distance in the

For Contracting

community and the Owners The Common Appellance South Taxabarran and the New York, The 127 (1981)

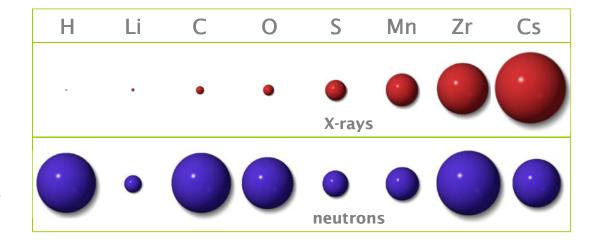
statistic stations of the second

feeders' strength of the rade

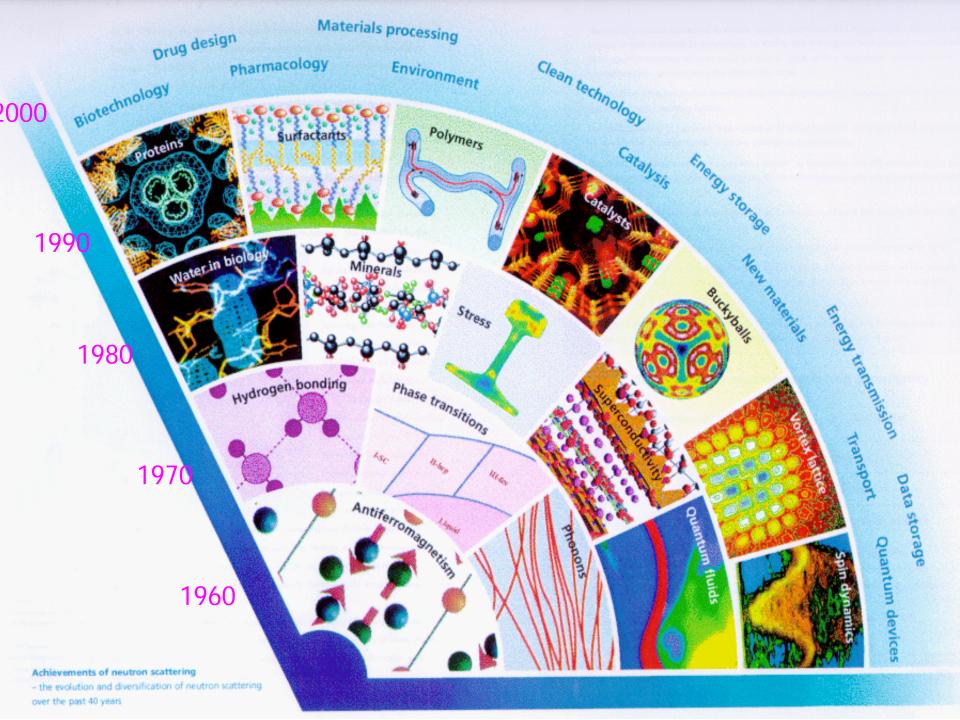
second in the second

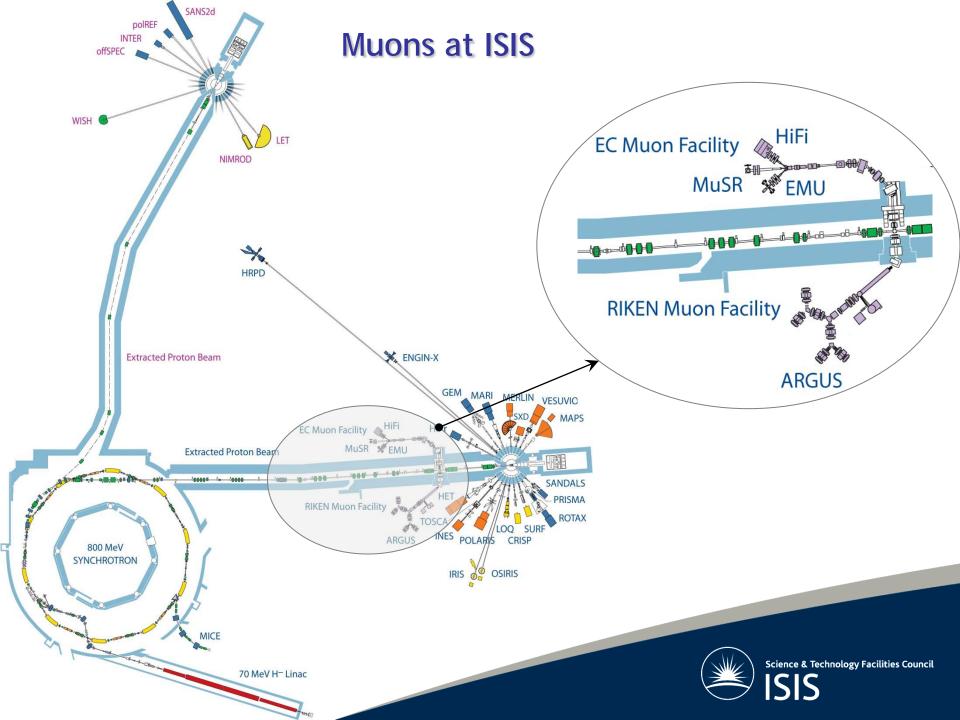
Neutrons - a tailor-made probe

- Neutron wavelength and energy 'just right' (25meV ~ 1.8 Å)
 - structure and dynamics
- Neutron cross-section
 - -isotopic dependence
- H / D contrast
 - -nuclear form factor
- Magnetic Moment
 - -magnetic order & excitations
- Weak probe
 - -theoretical interpretation
- Highly penetrating
 - -bulk probe
 - -complex SE











RIKEN-RAL Muon Facility

Largest UK-Japan science collaboration

First muons 1994

4 experimental areas

- condensed matter
- other 'exotic' uses of muons



RIKEN-RAL Muon Facility

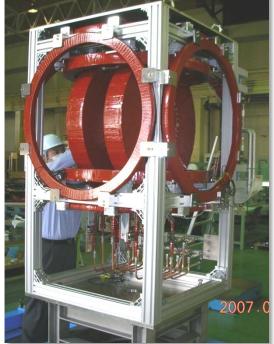
ARGUS (Port 2)

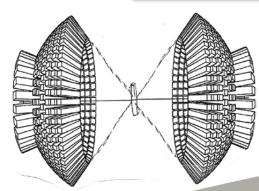






New spectrometer - Chronus (Port 4)



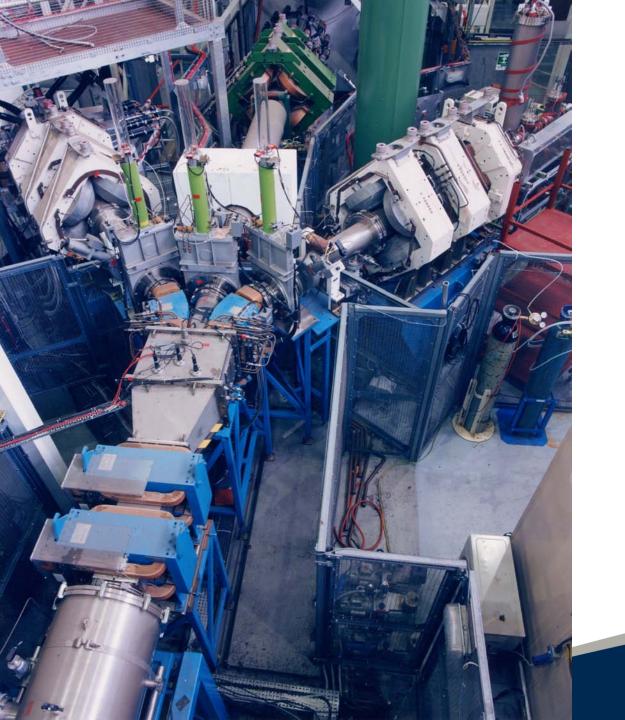




Science & Technology Facilities Council

SIS

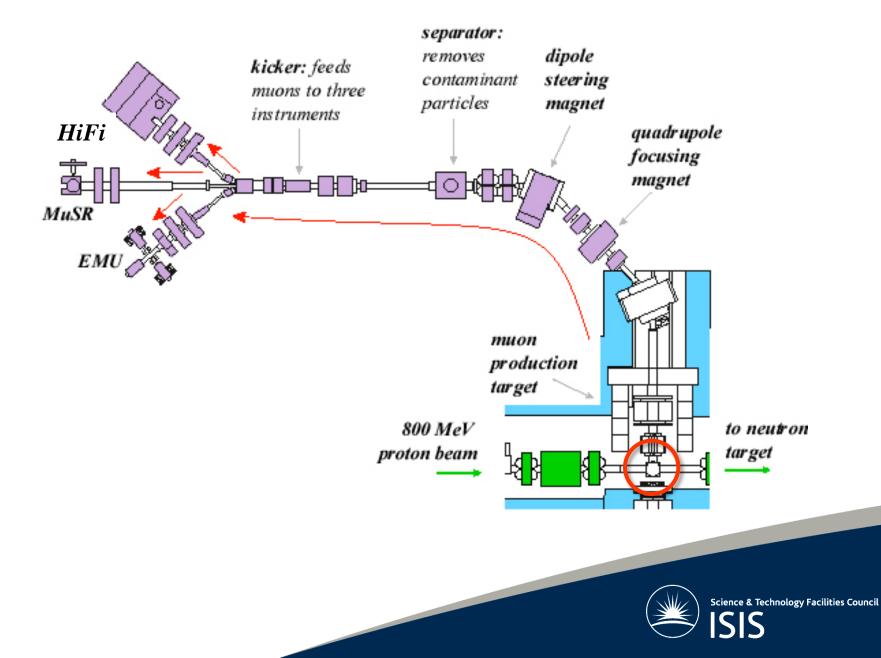
- pressure studies
- laser stimulation



The European Muon Facility



The EC Muon Facility



'Surface' muons

- Proton collisions produce *pions*, e.g. $p + p \quad \overrightarrow{p} + n + \pi$
- Some pions stop in the target
- They decay to muons, which escape if formed near the target surface

μ

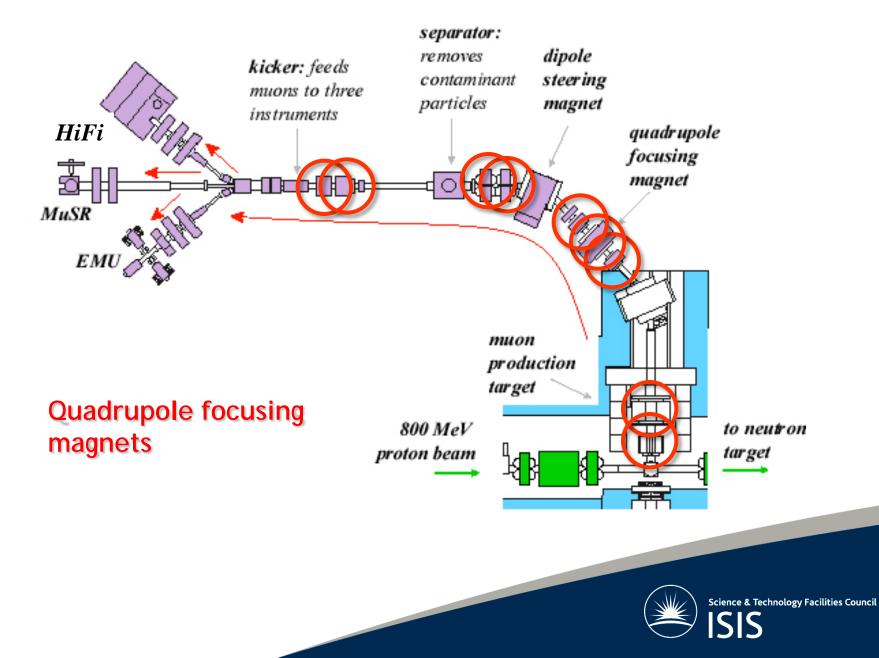
- Muons collected into the beam line
- Polarisation 100%

р





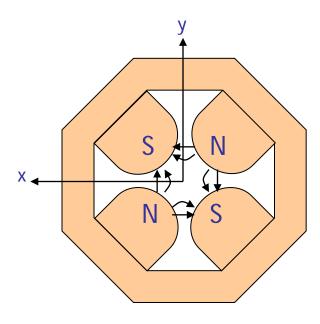
The EC Muon Facility



Focusing the beam - quadrupole magnets

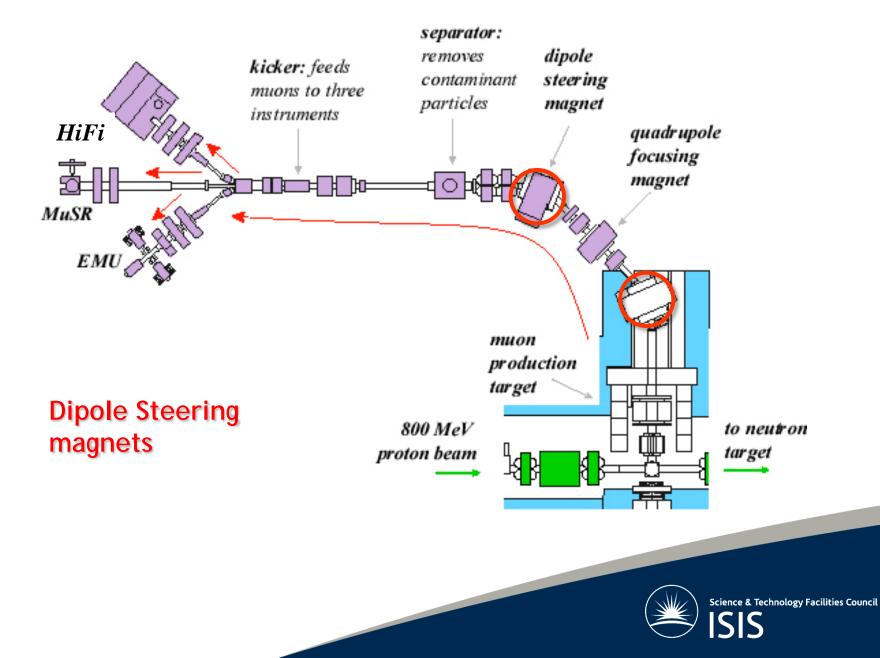
- Quadrupole magnets focus in one direction, defocus in the other.
- So they appear in our beamline in 2's or 3's
- Allow tuning of the beam by varying the current







The EC Muon Facility

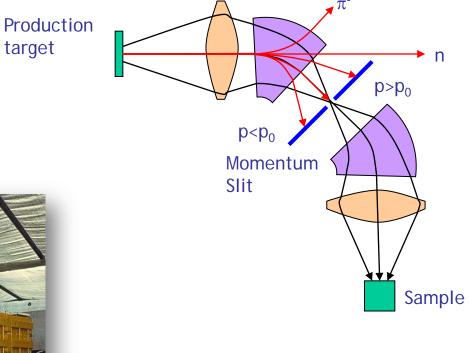


Bending the beam - dipole magnets



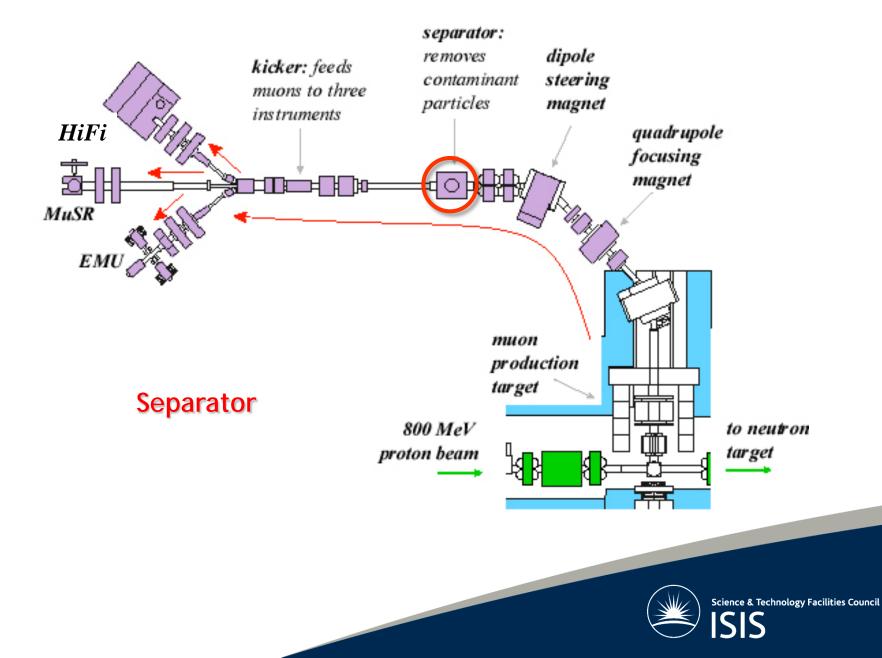
- Also exclude neutral particles or those of the wrong charge
- Act as a momentum filter





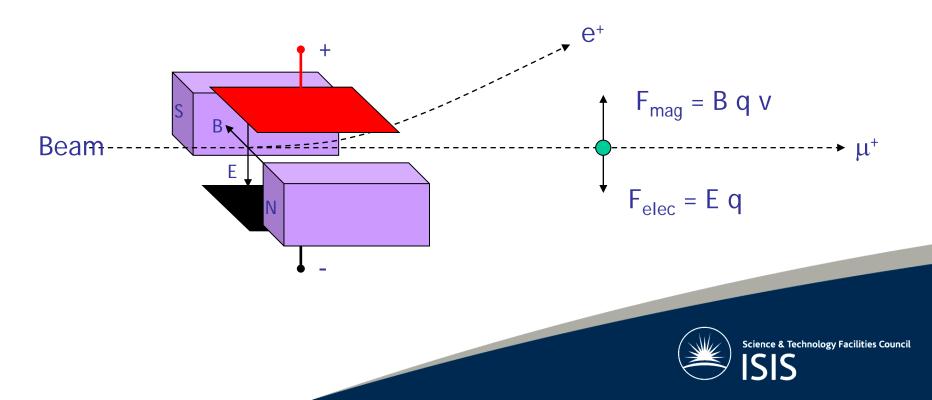


The EC Muon Facility

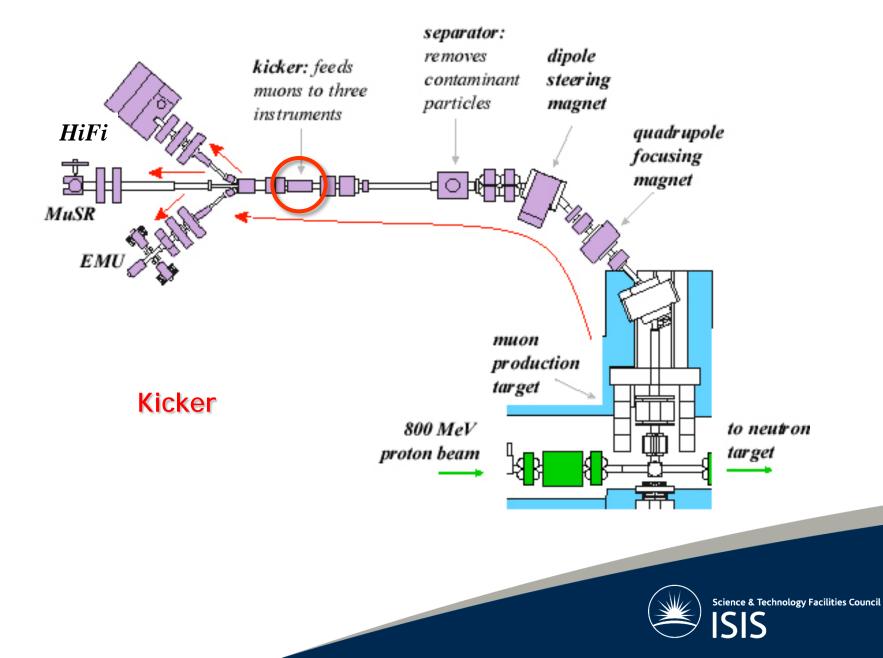


Cleaning the beam - the separator

- E and B fields, mutually perpendicular
- Acts as a velocity filter
- E and B field forces cancel for particles of the correct velocity
- Gives a 6° spin rotation



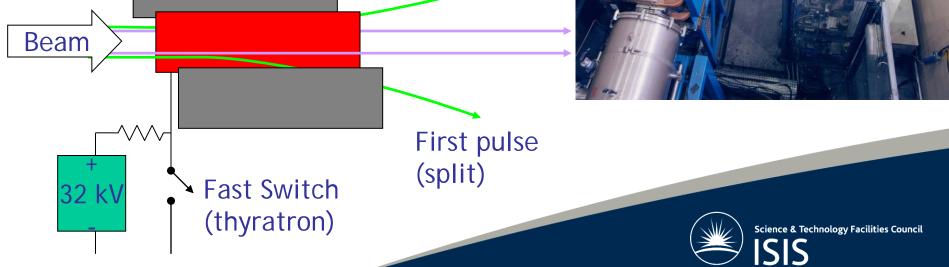
The EC Muon Facility



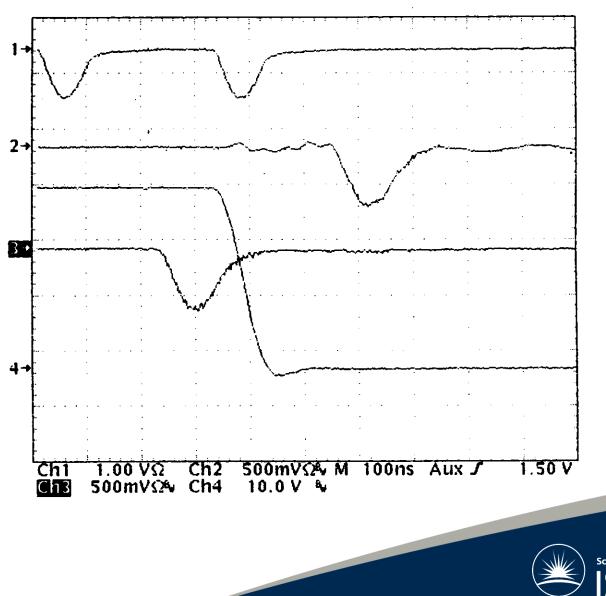
Splitting the beam - the kicker

- Central electrode
- Charged positively for first muon pulse
- Splits the first pulse in two
- No voltage for second muon pulse
- Second pulse goes straight through





Splitting the beam - the kicker



A Brief History of EC ISIS Muons

1985: Construction - EC, UK, Italy, France, Germany, Sweden

1987: First muons - single beamline (MuSR)

1991: Construction of beamline upgrade – EC-funded

1993: 3 beamlines operational (MuSR, EMU, DEVA)

1996 - 2008: €3.9M in EC Access funding

1998-2000: DEVA RF-spectrometer built (EPSRC)



2007: 20th birthday!

2009: HiFi completed

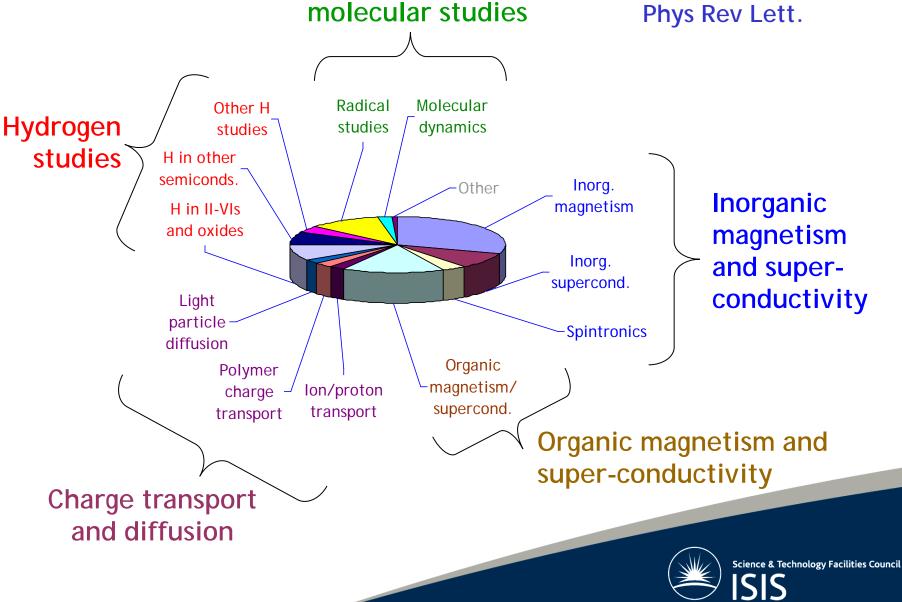
2012: 25th birthday!





Usage of EC ISIS Muons

Over 500 publications since 2000, over 40 in Phys Rev Lett.



Chemistry and

