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ISIS

ISIS — Pulsed Neutron and Muon Source

David Findlay
Accelerator Division
ISIS Department
Rutherford Appleton Laboratory

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People:

D J Adams, G M Allen, M A Arnold, C J Barton, D L Bayley, R Brodie, T A Broome, J D Christie, M A Clarke-Gayther, M B Davies, P V Drumm, D C Faircloth, I S K Gardner, P E Gear, M G Glover, J A C Govans, N D Grafton, J W Gray, D J Haynes, S Hughes, H J Jones, A H Kershaw, M Krendler, C R Lambourne, A P Letchford, J P Loughrey, E J McCarron, A J McFarland, R P Mannix, T Noone, S J Payne, M Perkins, G J Perry, L J Randall, M J Ruddle, S J Ruddle, I Scaife, A Seville, A F Stevens, J W G Thomason, J A Vickers, S Warner, C M Warsop, P N M Wright

+ many, many more

Science & Technology Facilities Council
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ISIS

STFC
= CCLRC
+ PPARC

New UK Research Council

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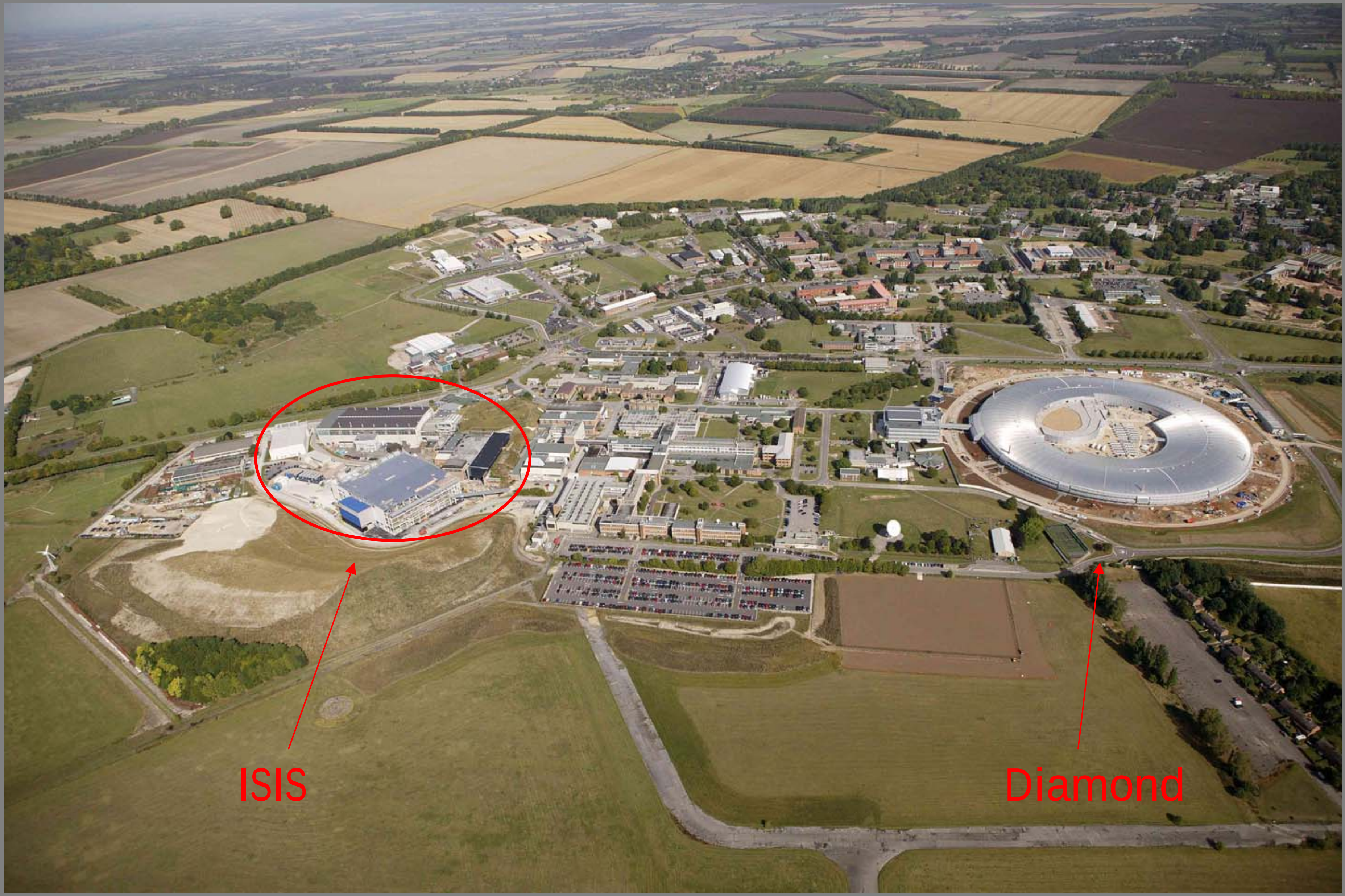
Oxfordshire

ISIS

Diamond



Rutherford Appleton Laboratory, looking north

ISIS — world's leading spallation neutron and muon facility

PSI
ISIS
SNS
J-PARC

↓ Decreasing beam power — at present

ISIS: 800 MeV protons on to tungsten target

200 µA → 300 µA, 160 kW → 240 kW

ISIS accelerators drive neutron and muon factory

- ~750 experiments/year
- ~1500 visitors/year (~4500 visits)

Typical machine parameter list

Machine parameters	
Mean radius (3 × ISIS)	78.0 m
Repetition frequency	50 Hz
Injection energy from ISIS	0.8 GeV
Extraction energy (option of 8 GeV)	3 GeV
Number of circulating protons	3.75×10^{13}
Ring acceptance	304 π mm mrad
Magnet lattice type	racetrack
Number of ring superperiods	2
Number of 3-cell periods per arc	5
Number of arc cells	2 × 15
Number of straight section cells	2 × 7
Number of main B dipoles	2 × 10
Number of secondary b dipoles	2 × 5
Number of main D quadrupoles	2 × 22
Number of trim d quadrupoles	2 × 12
Number of main F quadrupoles	2 × 22
Number of trim f quadrupoles	2 × 12
Gamma transition	13.8
Horizontal betatron tune	11.7
Vertical betatron tune	7.4
Bending angle for B dipoles	16.5°
Bending angle for b dipoles	3.0°
Bending angle for 3-cell arc periods	36.0°
Length of main B dipoles	5.940 m
Length of secondary b dipoles	1.080 m
Length of main D quadrupoles	1.036 m
Length of main F quadrupoles	1.200 m
Length of trim quadrupoles	0.200 m
RMS unnorm. injection trans. emittance	19 π mm mrad
100% unnorm. injection trans. emittance	125 π mm mrad
100% unnorm. 3 GeV trans. emittance	50 π mm mrad
100% unnorm. 8 GeV trans. emittance	25 π mm mrad
100% norm. longitudinal emittance	<1.0 eV sec

ISIS — key machine parameter list

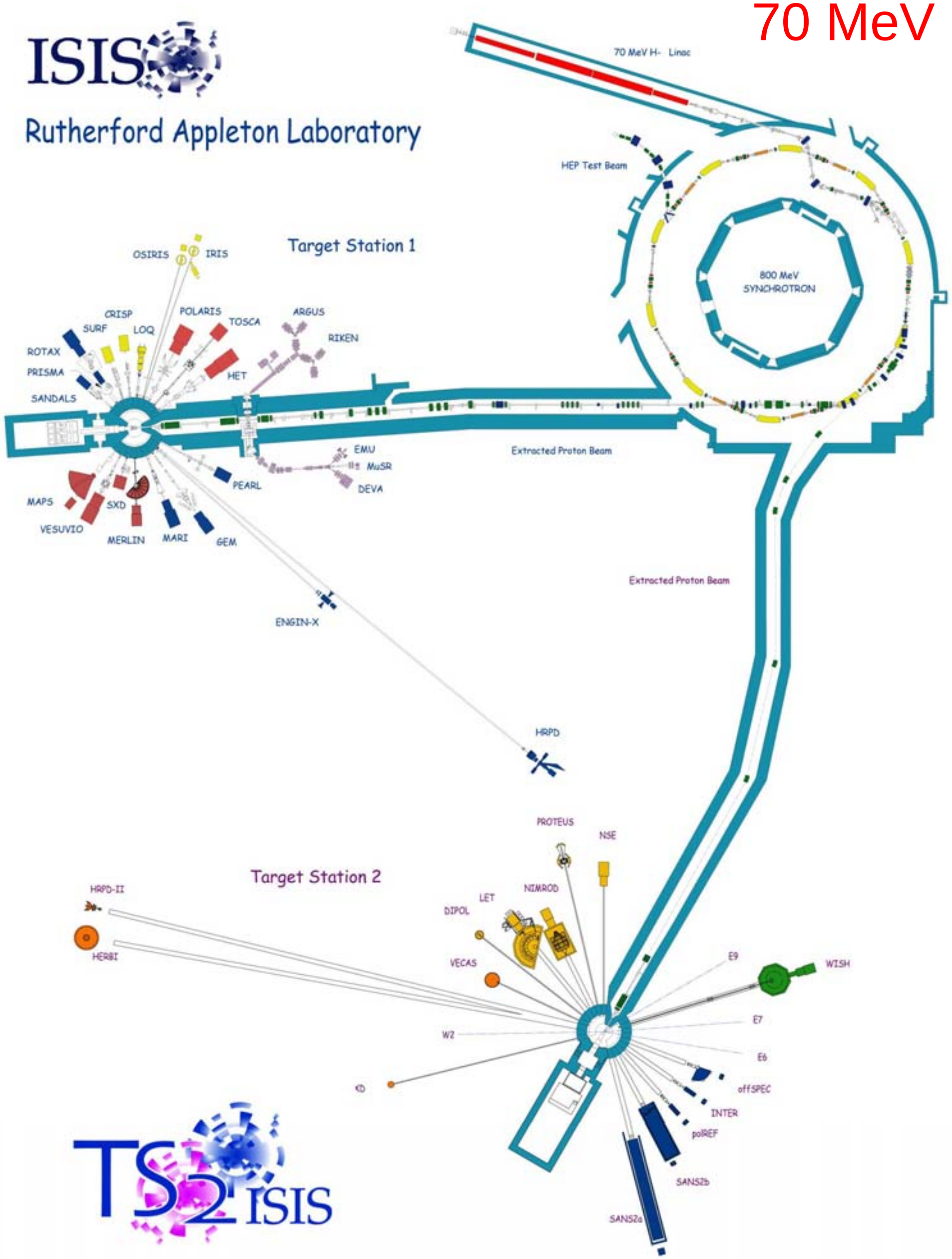
Reliability

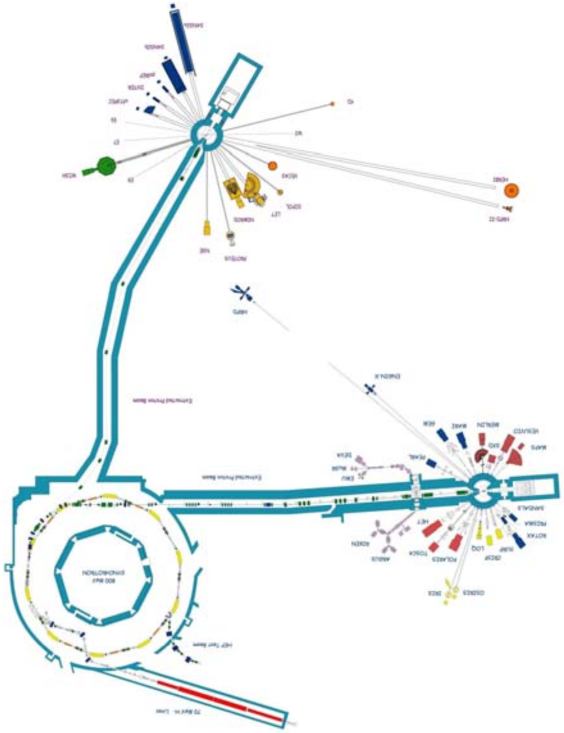
Output

70 MeV H⁻ linac

800 MeV proton synchrotron

TS-1





ISIS from air

TS-2

TS-1

ISIS from ground

View down north side of ISIS 70 MeV H^- MeV linac

Superperiods 9, 0 and 1 of the ISIS 800 MeV synchrotron

ISIS TS-1 experimental hall

ISIS TS-2 experimental hall

First ISIS beam 16 December 1984


ISIS
the most
powerful pulsed
neutron spallation
source in the
world
GUINNESS WORLD RECORDS
CERTIFICATE
The world's most powerful
pulsed neutron spallation source
is ISIS, at the Rutherford
Appleton Laboratory,
Oxfordshire, UK.
It is capable of producing

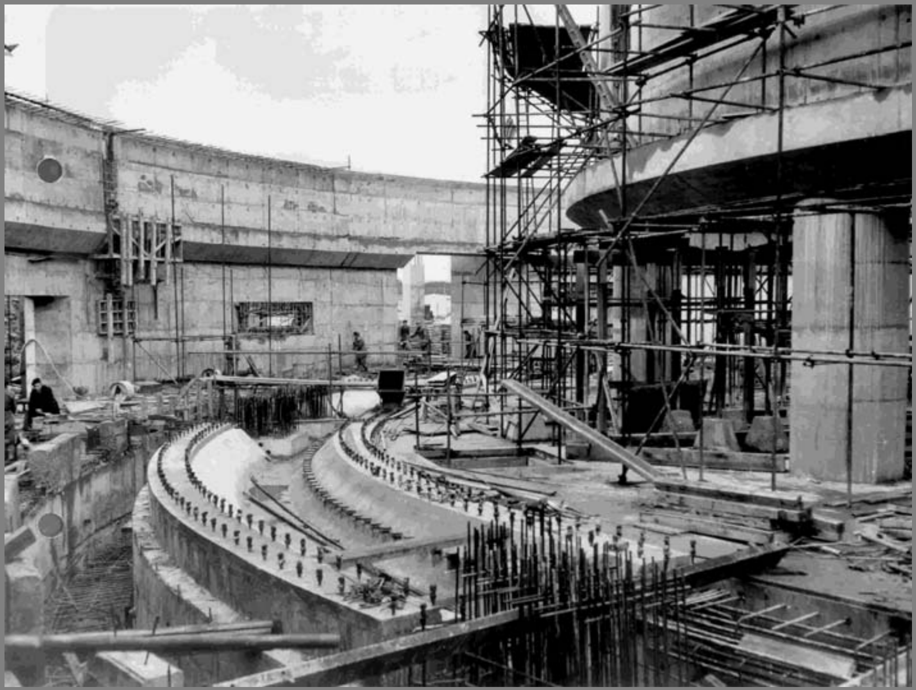
April 2004

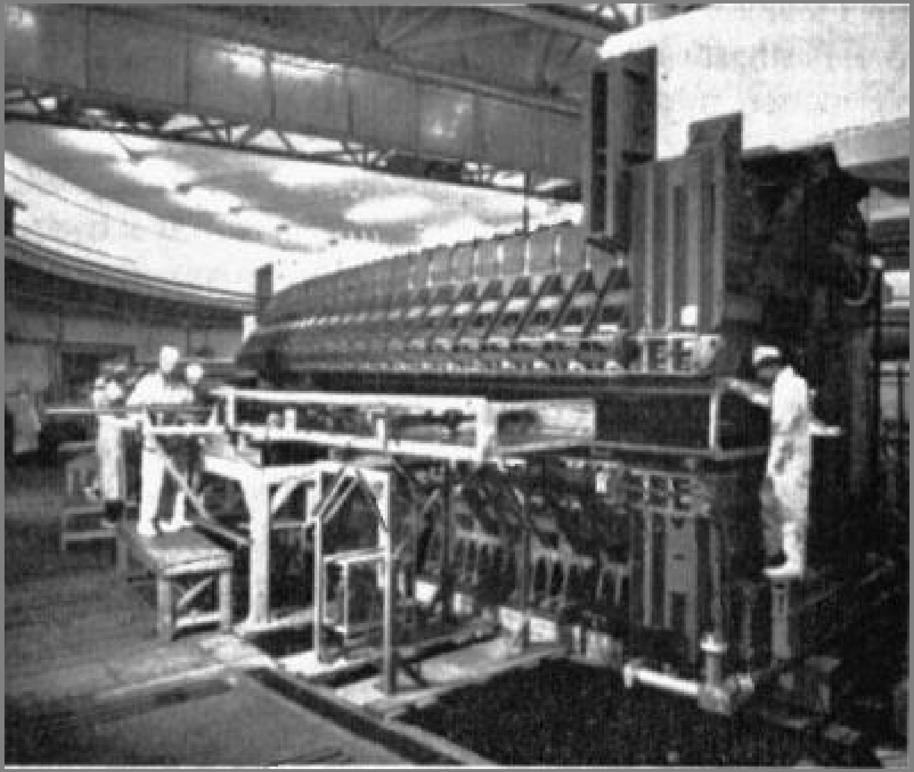
1st century AD

LONDINI AD FANVM ISIDIS

In London at the temple of Isis

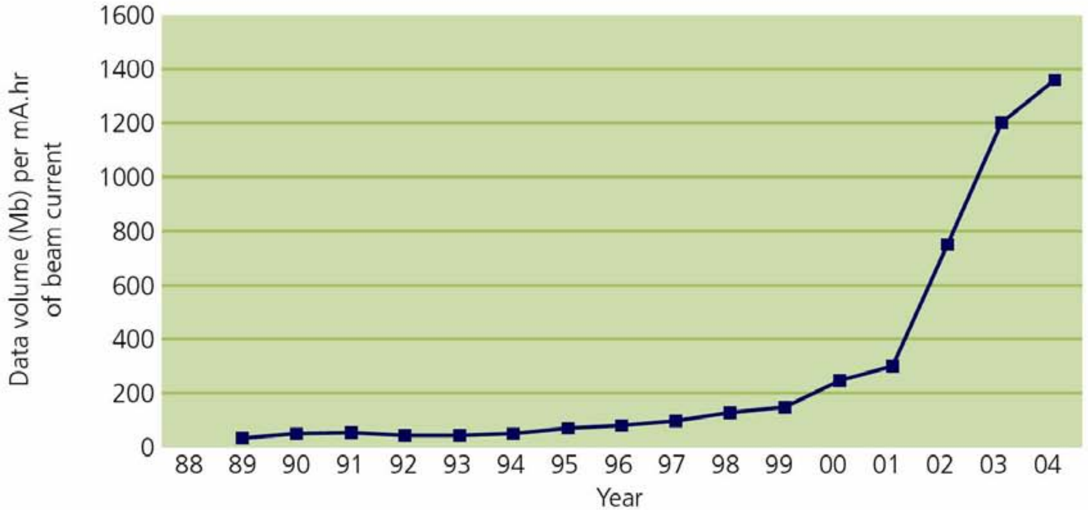
nom. ISIS
voc. ISIS
acc. ISIDEM
gen. ISIDIS
dat. ISIDI
abl. ISIDE





ISIS not first proton synchrotron at RAL
Nimrod, 7 GeV synchrotron, first beam 27 August 1963

Average ISIS beam current per cycle.

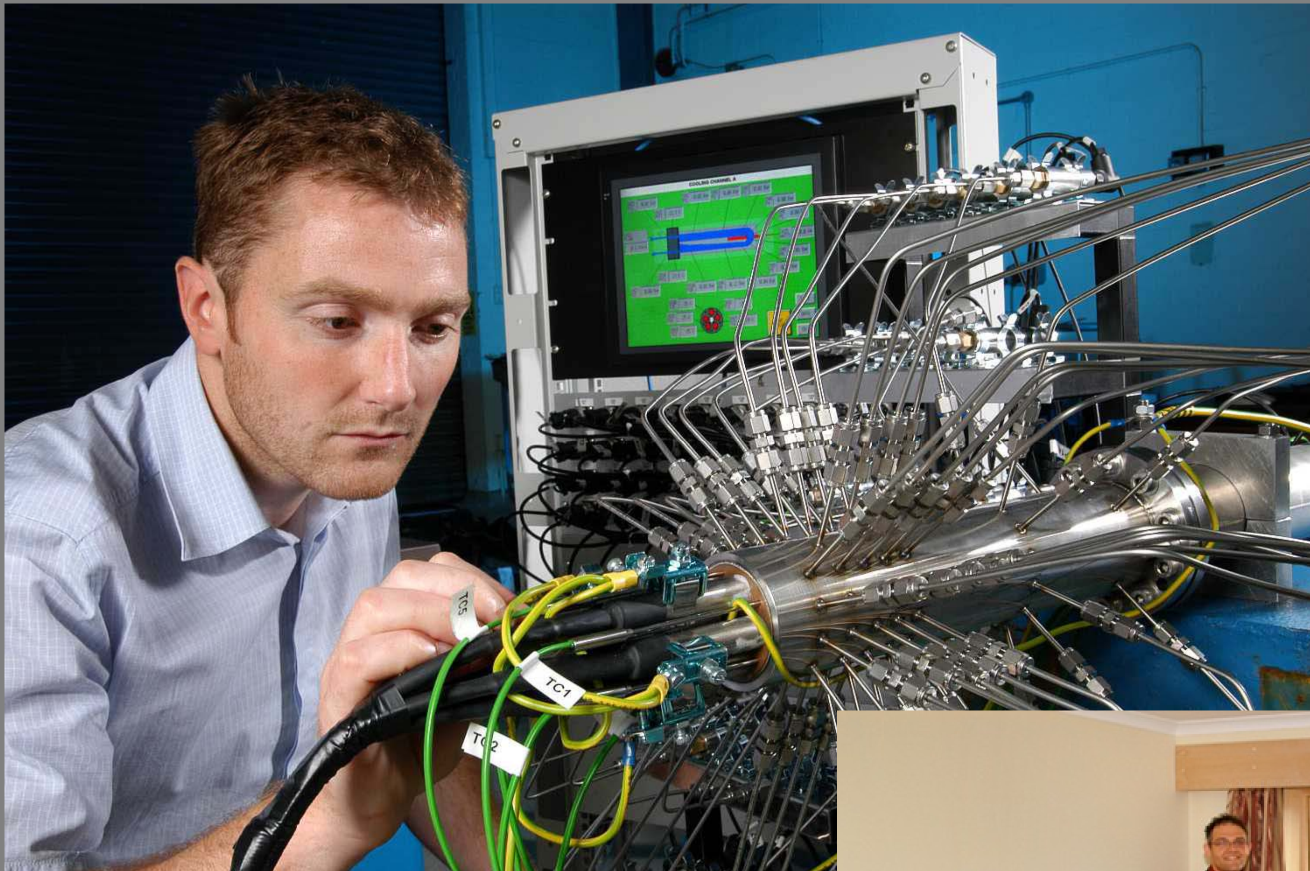


As ISIS instrument performance has increased, the amount of data taken per mA.hr of proton current has risen sharply.

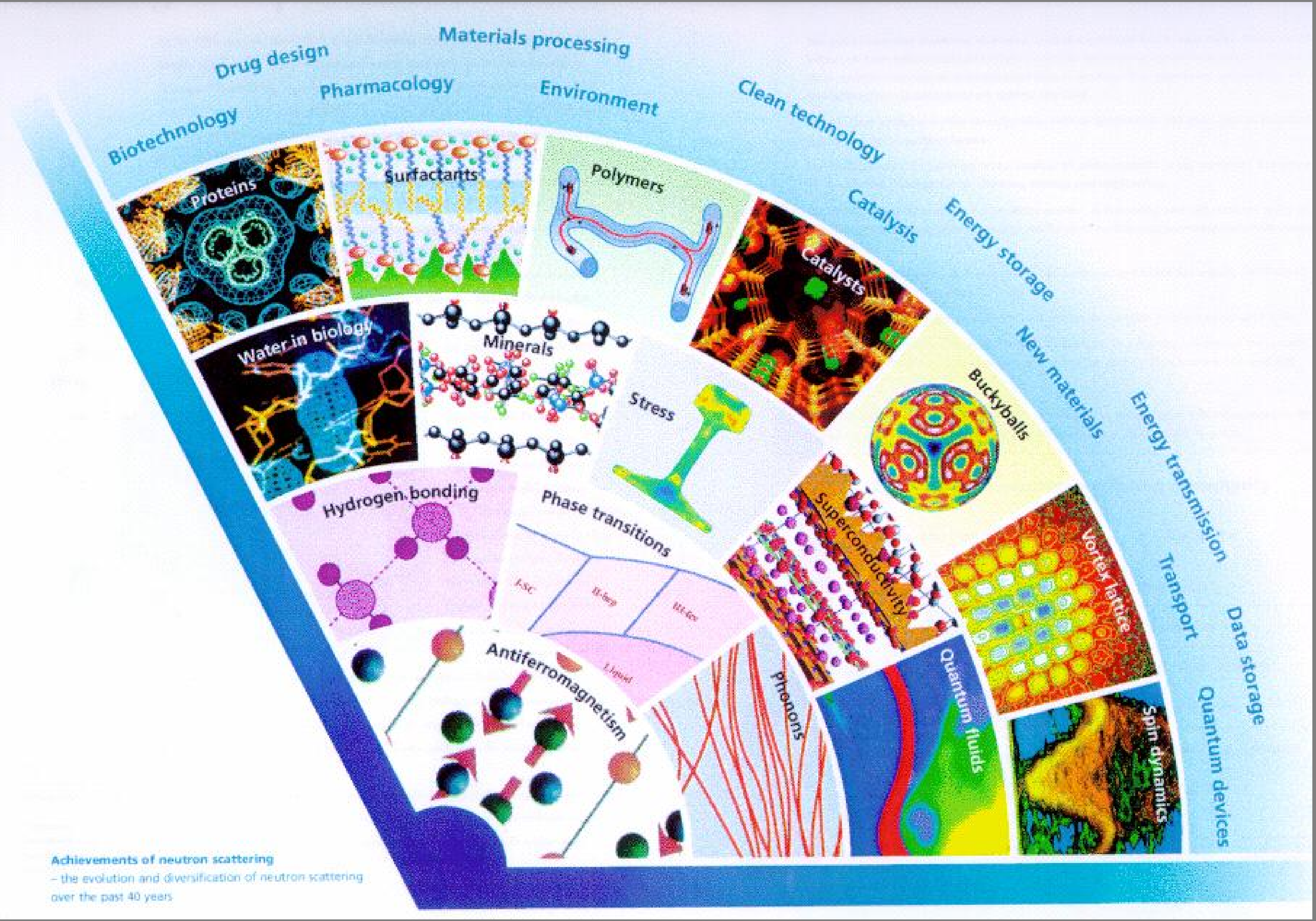
ISIS development from 1985 to 2005

Factors determining success of accelerator facility

- Beam power ← often wrongly consider only this
- Proton conversion to neutrons
- Reliability
- Instrumentation
- Innovation
- Investment
- Support facilities
- Support staff
- Cost effectiveness
- User community



New hostel at ISIS

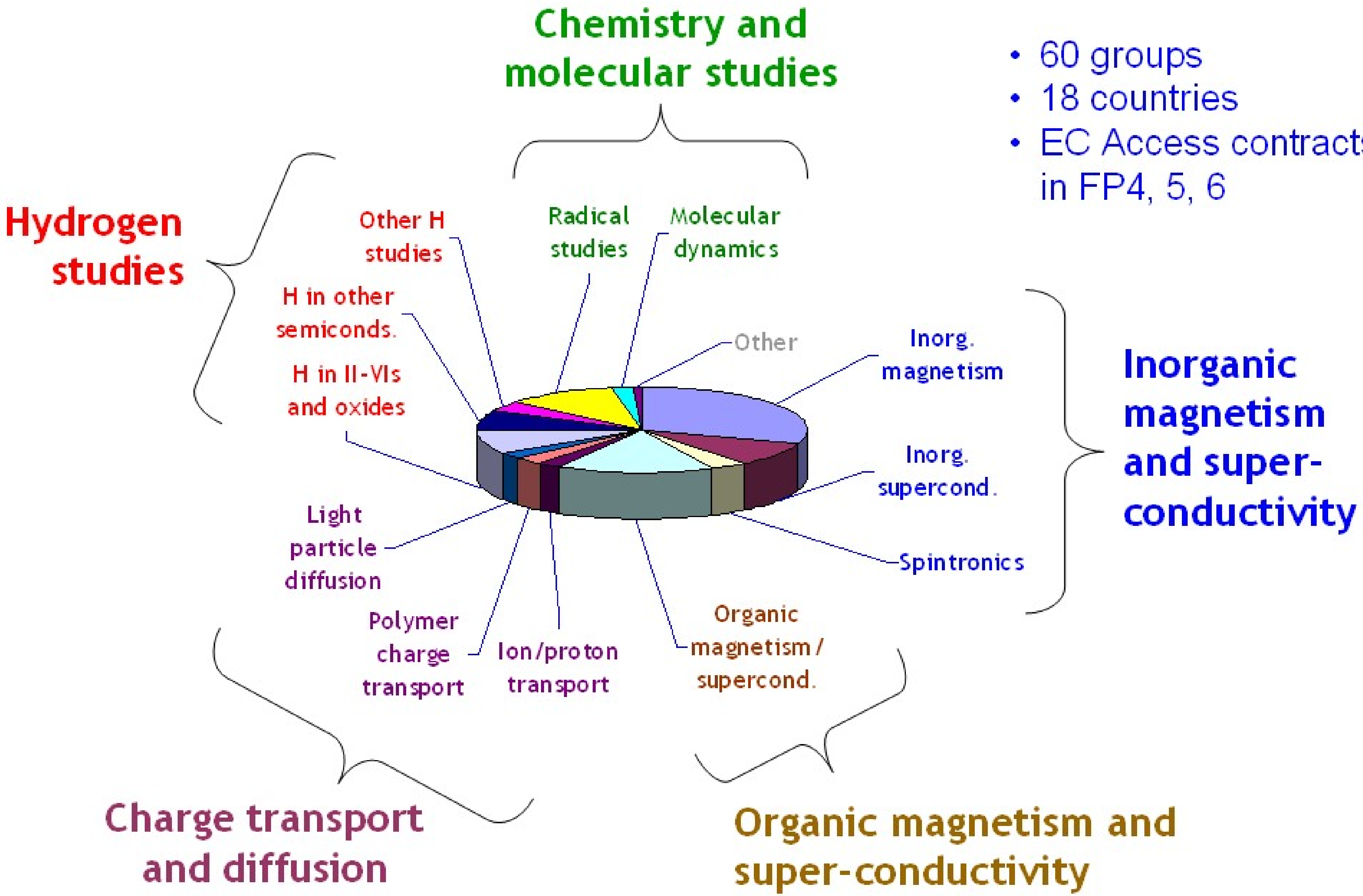


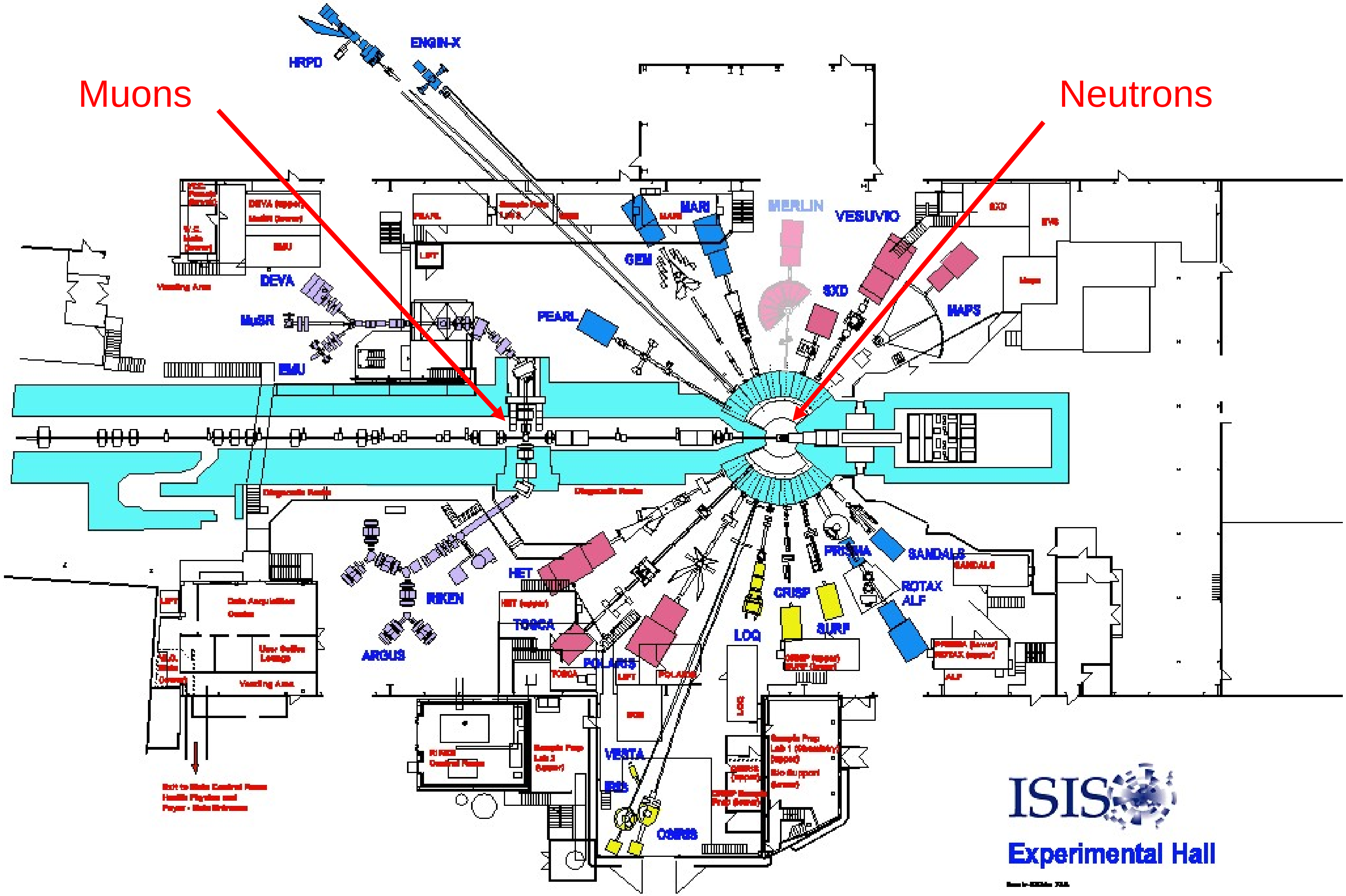
Achievements of neutron scattering
– the evolution and diversification of neutron scattering over the past 40 years

Neutron scattering

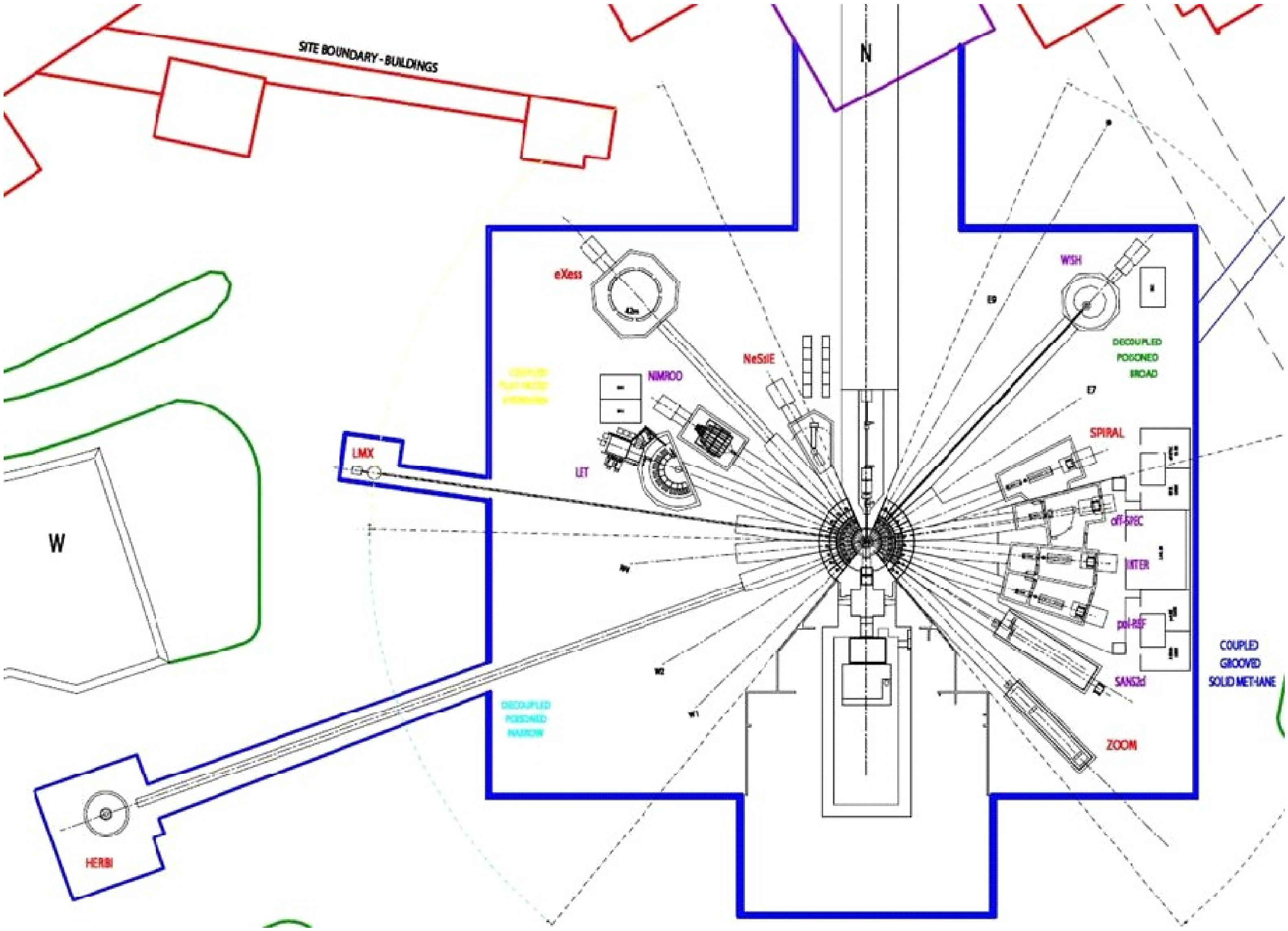
Science using ISIS Muons

- 60 groups
- 18 countries
- EC Access contracts in FP4, 5, 6





Layout of Experimental Hall 1



Layout of Experimental Hall 2

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ISIS

Neutron production

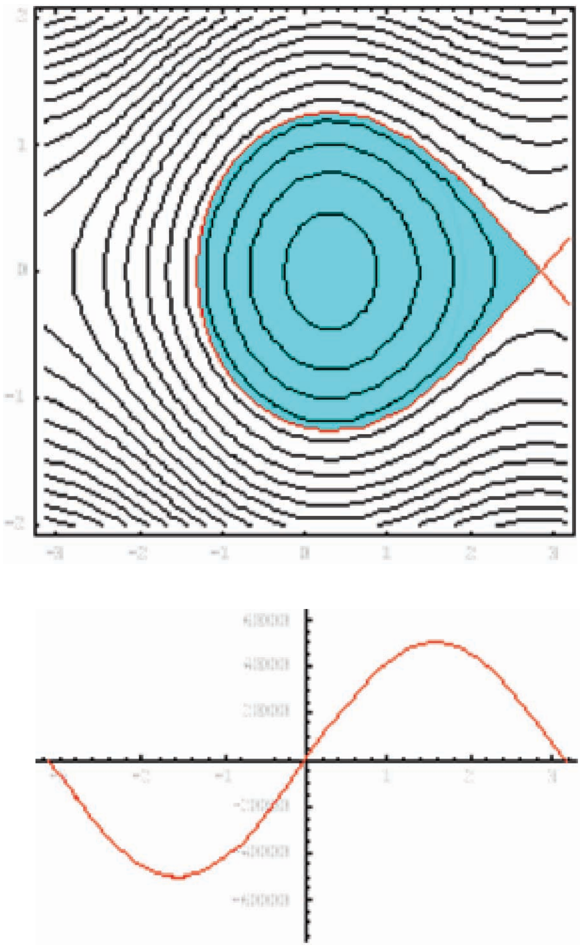
Hitherto: 50 pps, 4 μC/pulse, 200 μA, 800 MeV
160 kW mean beam power

With TS-2: 40 pps to TS-1, 10 pps to TS-2
TS-2 optimised for cold neutrons

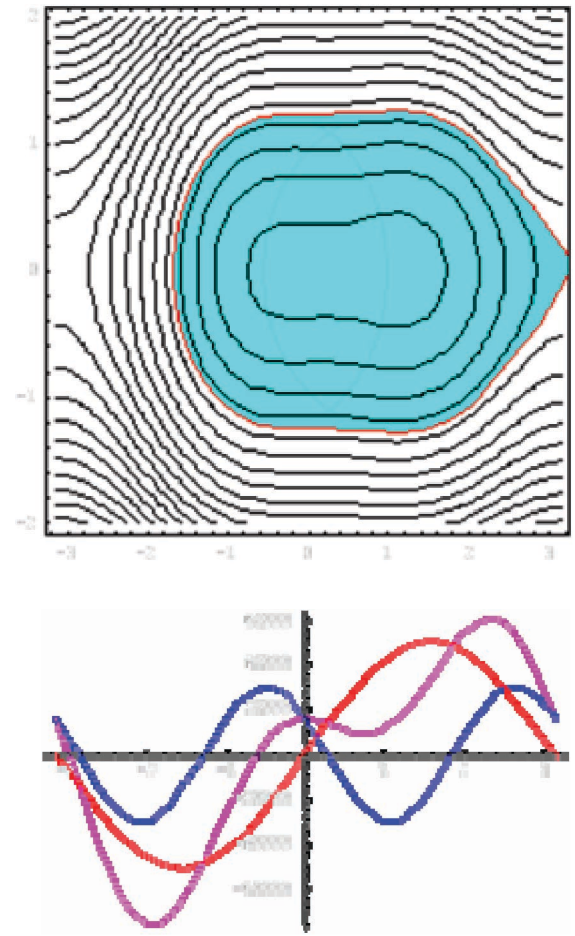
To prevent loss of performance on TS-1, beam current being increased

4 μC/pulse → ≥5 μC/pulse through substitution of RFQ for Cockcroft-Walton and conversion to dual harmonic synchrotron RF (DHRF)

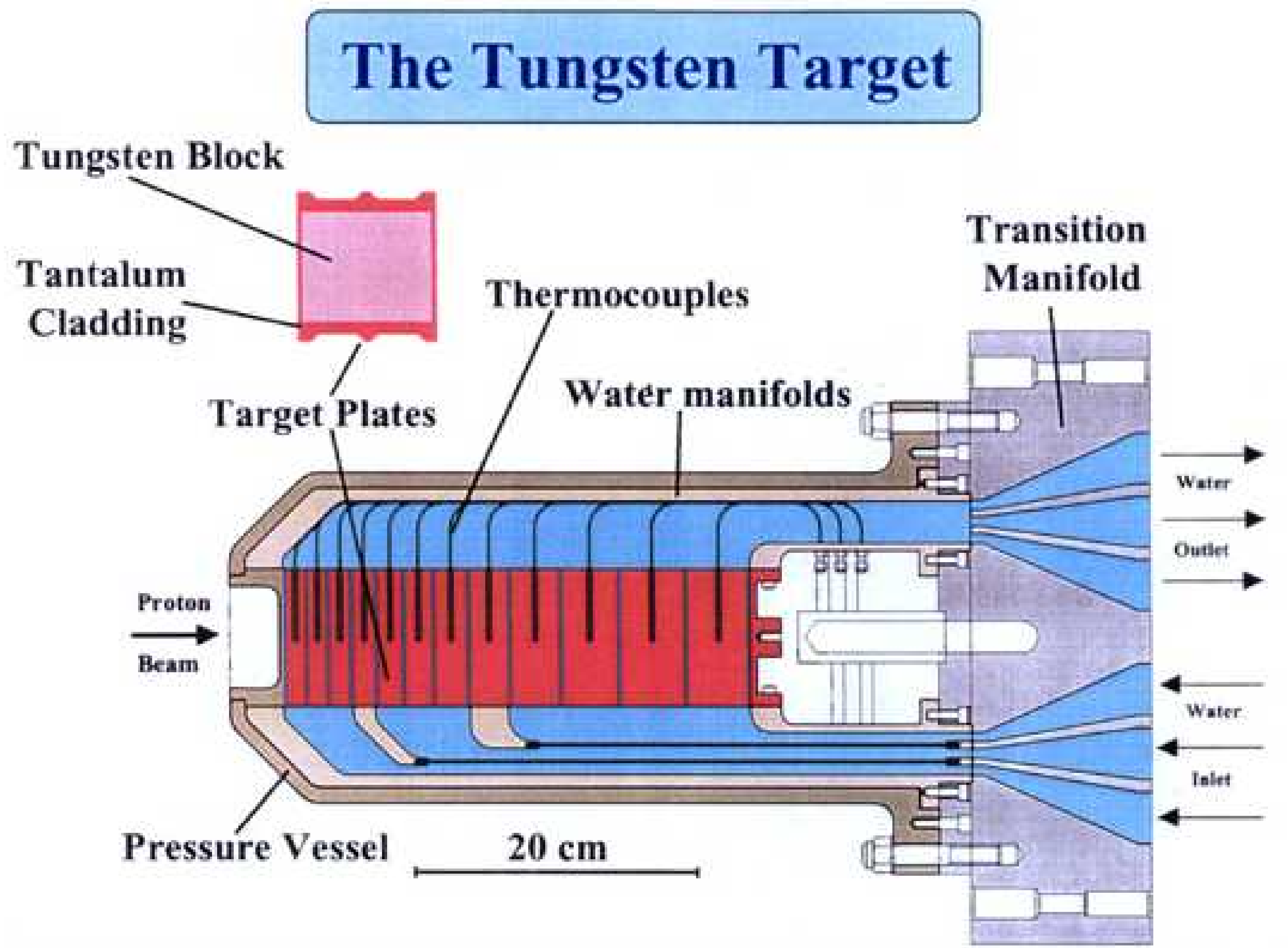
DHRF: poster TUPAN117



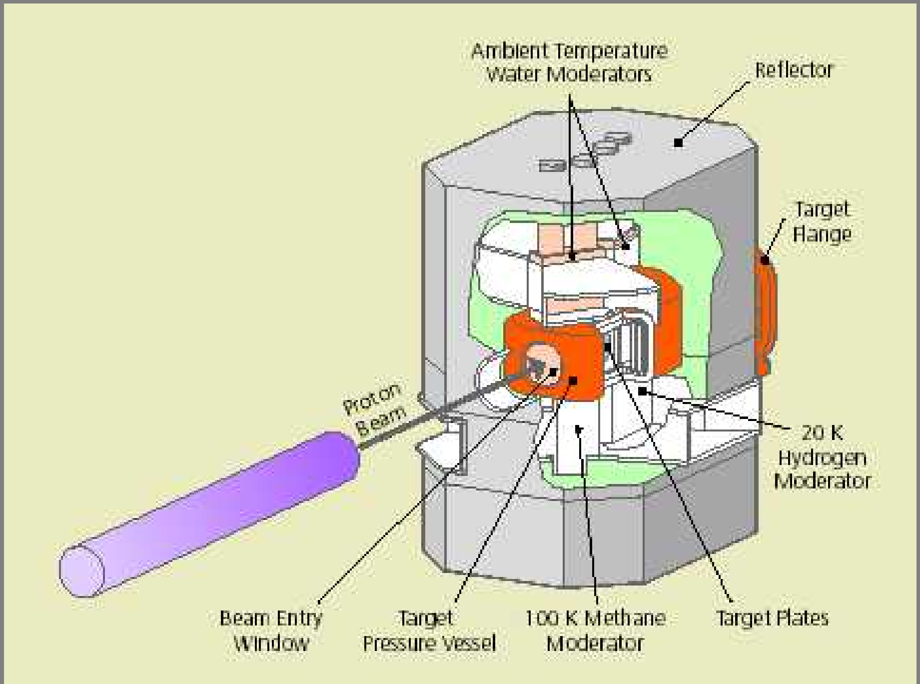
1RF: 4 µC in synch.



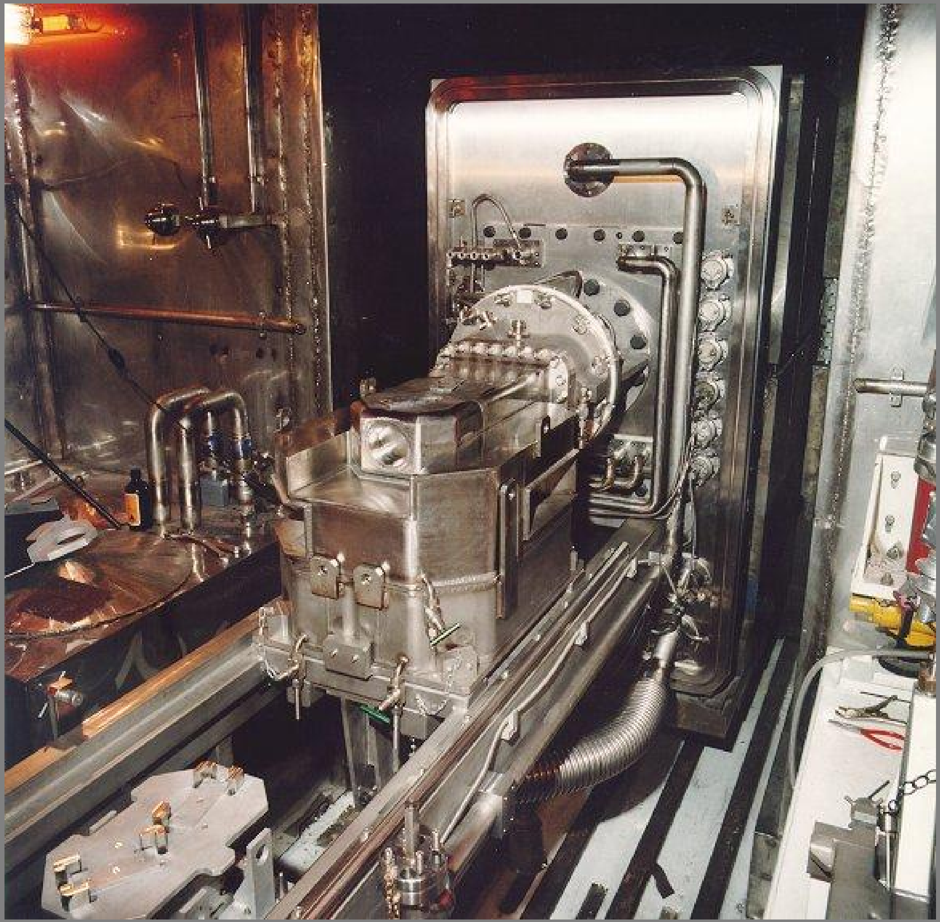
1RF + 2RF: 6 µC in synch.



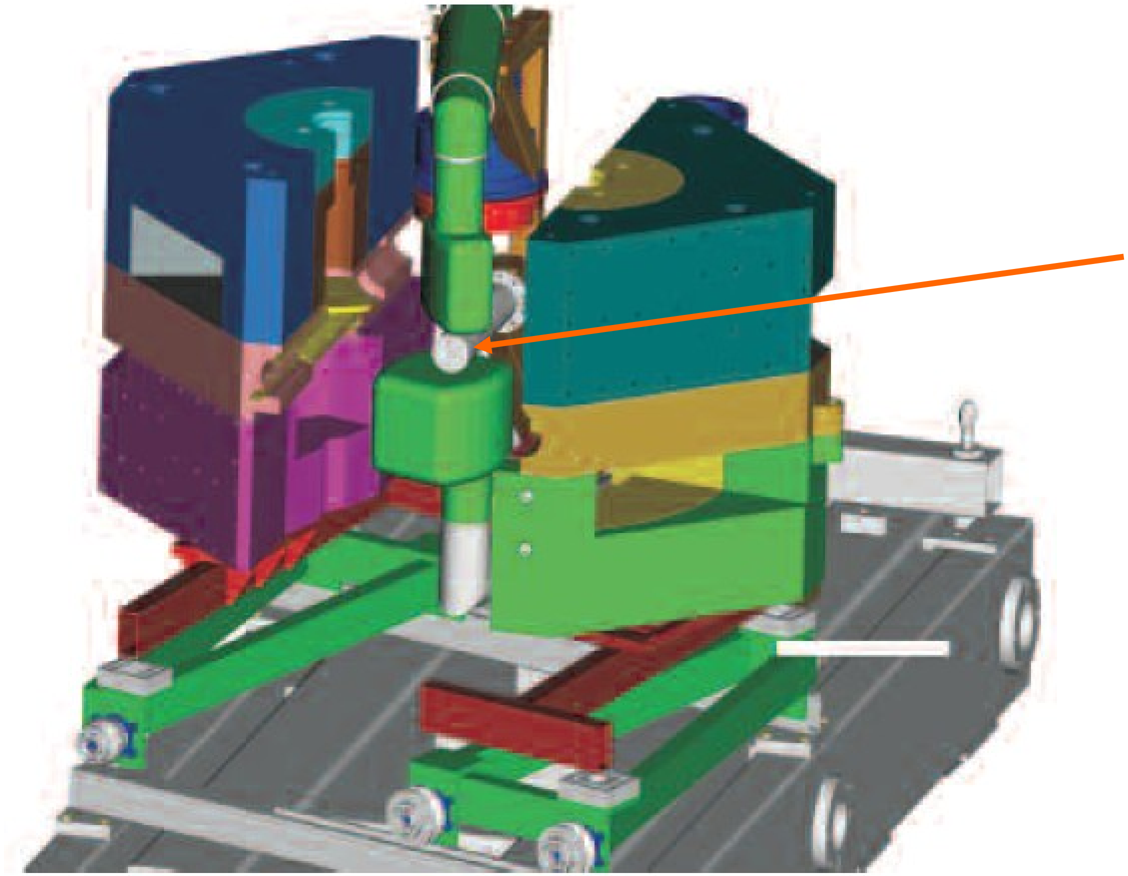
TS-1 tungsten target, tantalum coated, heavy water cooling



TS-1 target
and moderator
schematic



TS-1 target with
upper reflector
and moderators
removed



Solid tungsten cylinder, tantalum coated, surface cooled, 68 mm diameter — exploded view

TS-2 tungsten target, tantalum coated, heavy water cooling

Muon production

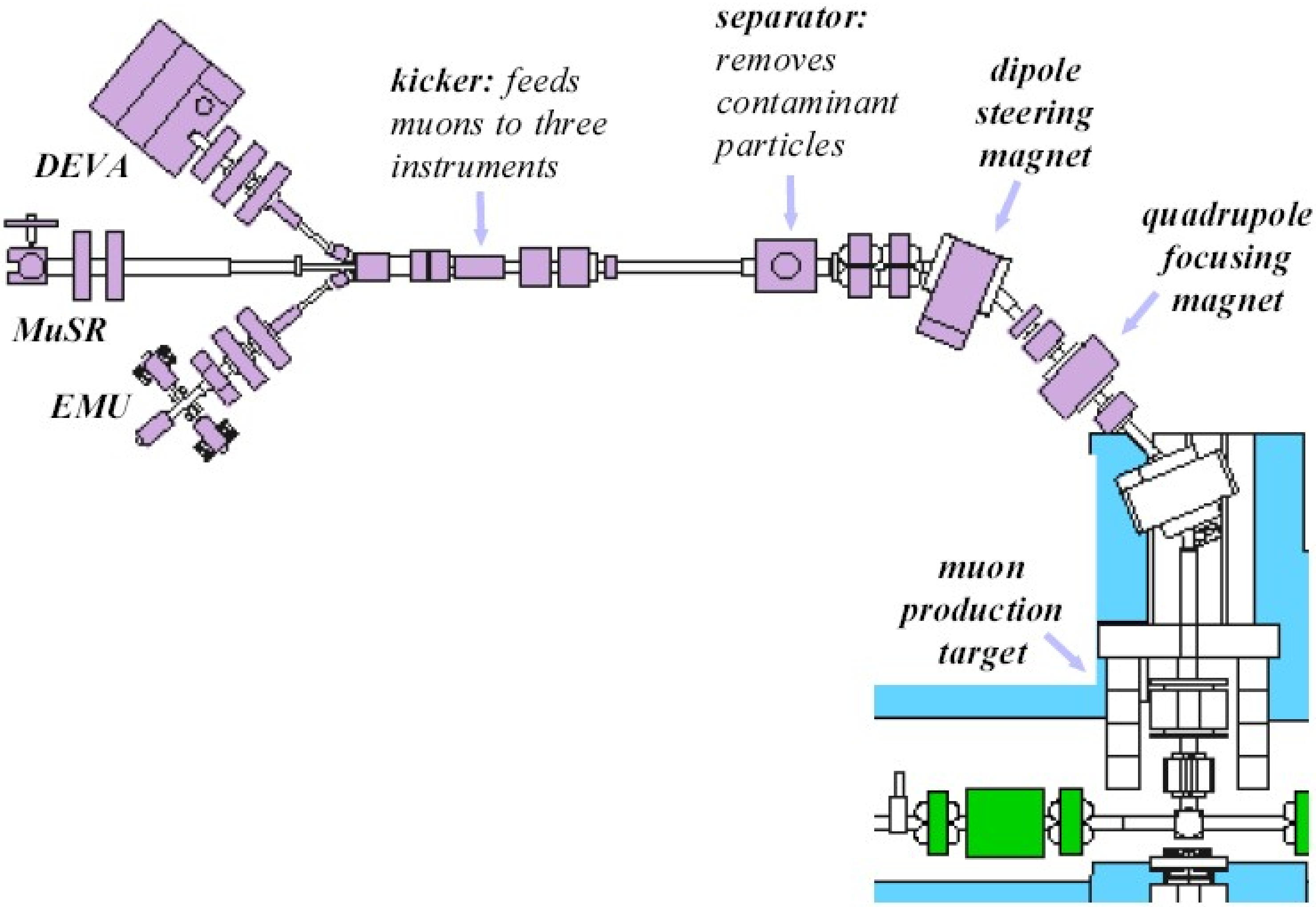
1 cm graphite target ~20 m upstream of main neutron-producing target

Target at 45° to beam, 2.5 g/cm^2

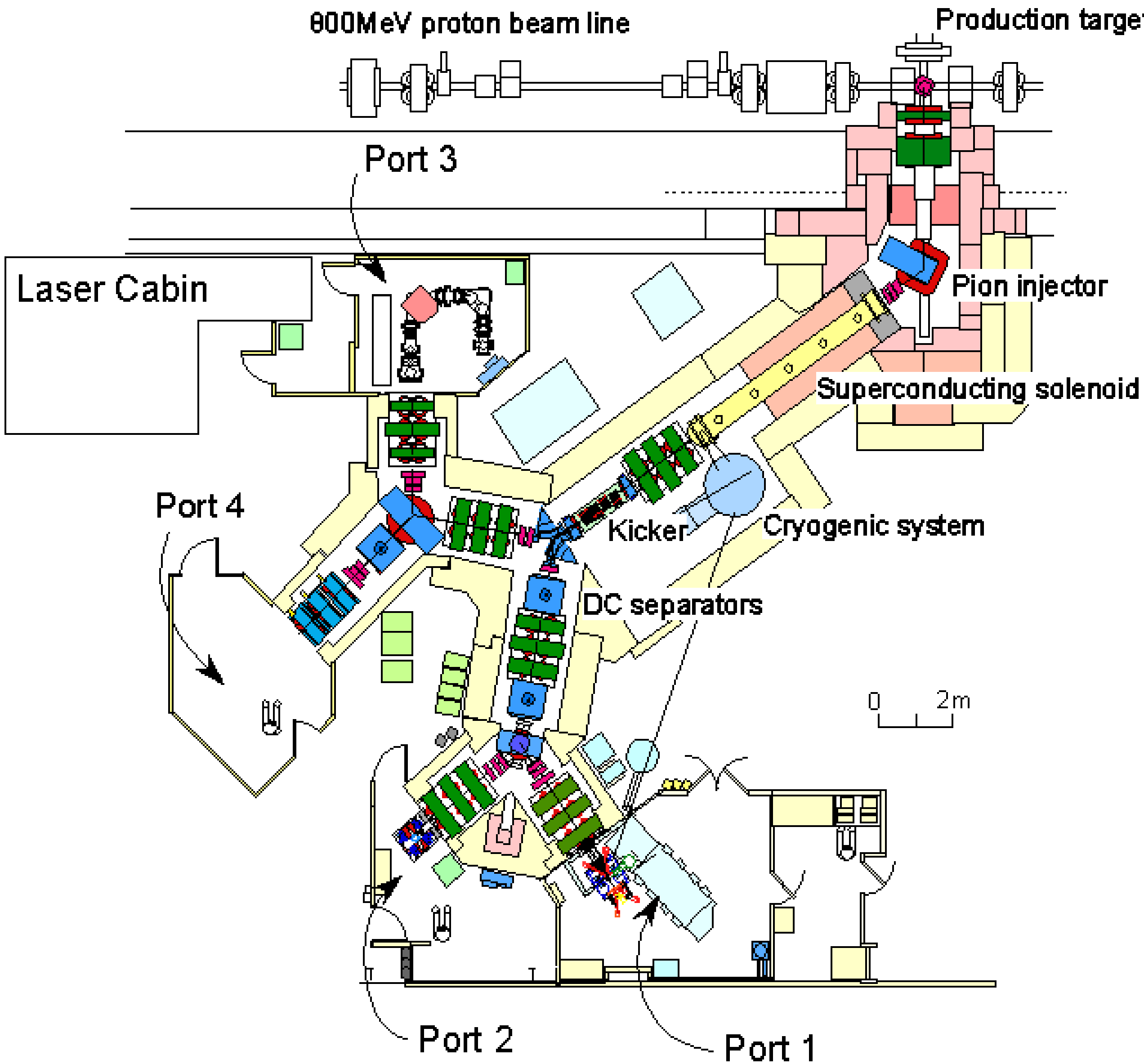
~3 mrad multiple scattering, ~1 kW power dissipation

Operational implications for activation of components downstream

First muons on ISIS: 23 March 1987



Muon production and transport — south side



The RIKEN-RAL Muon Facility

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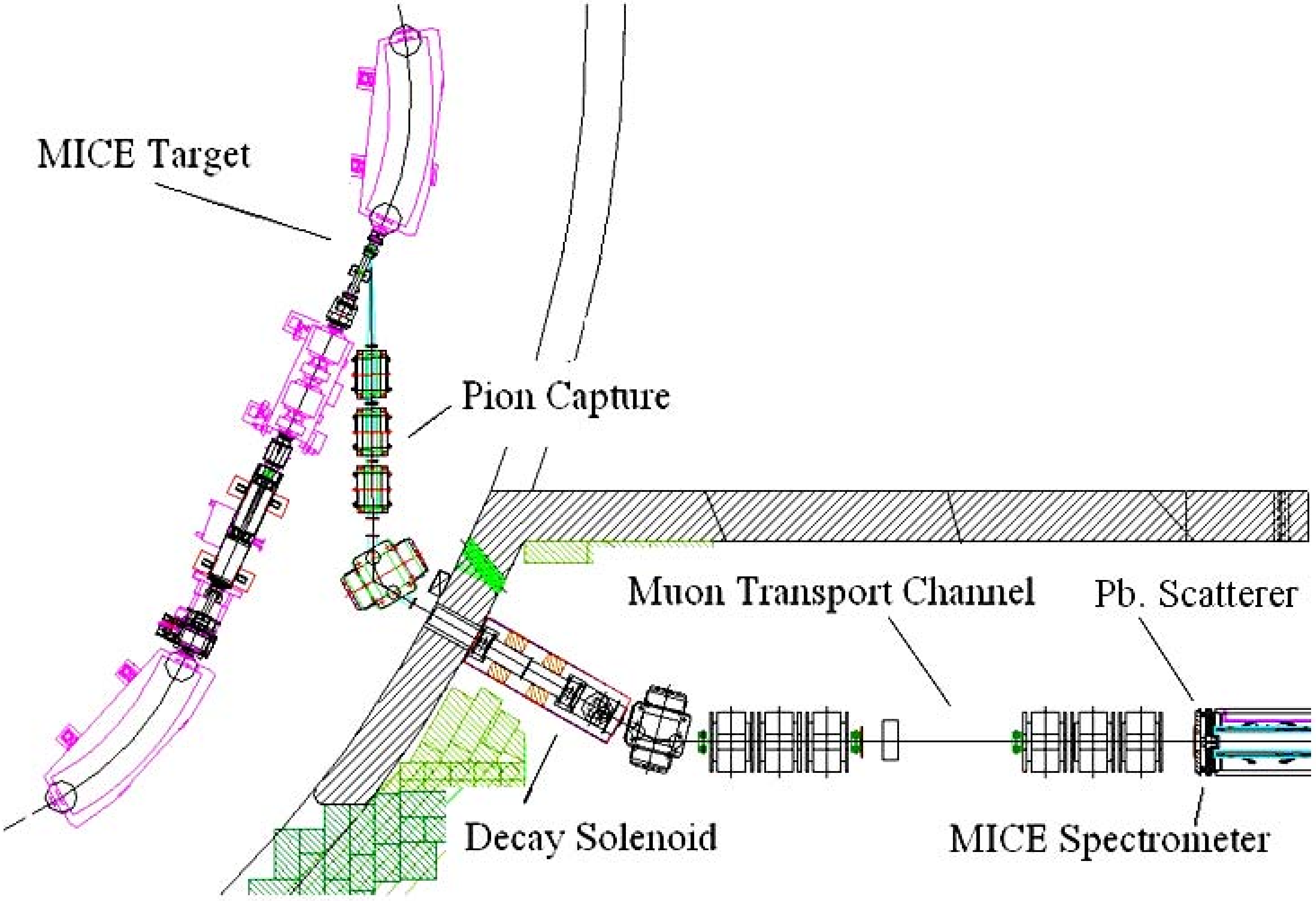
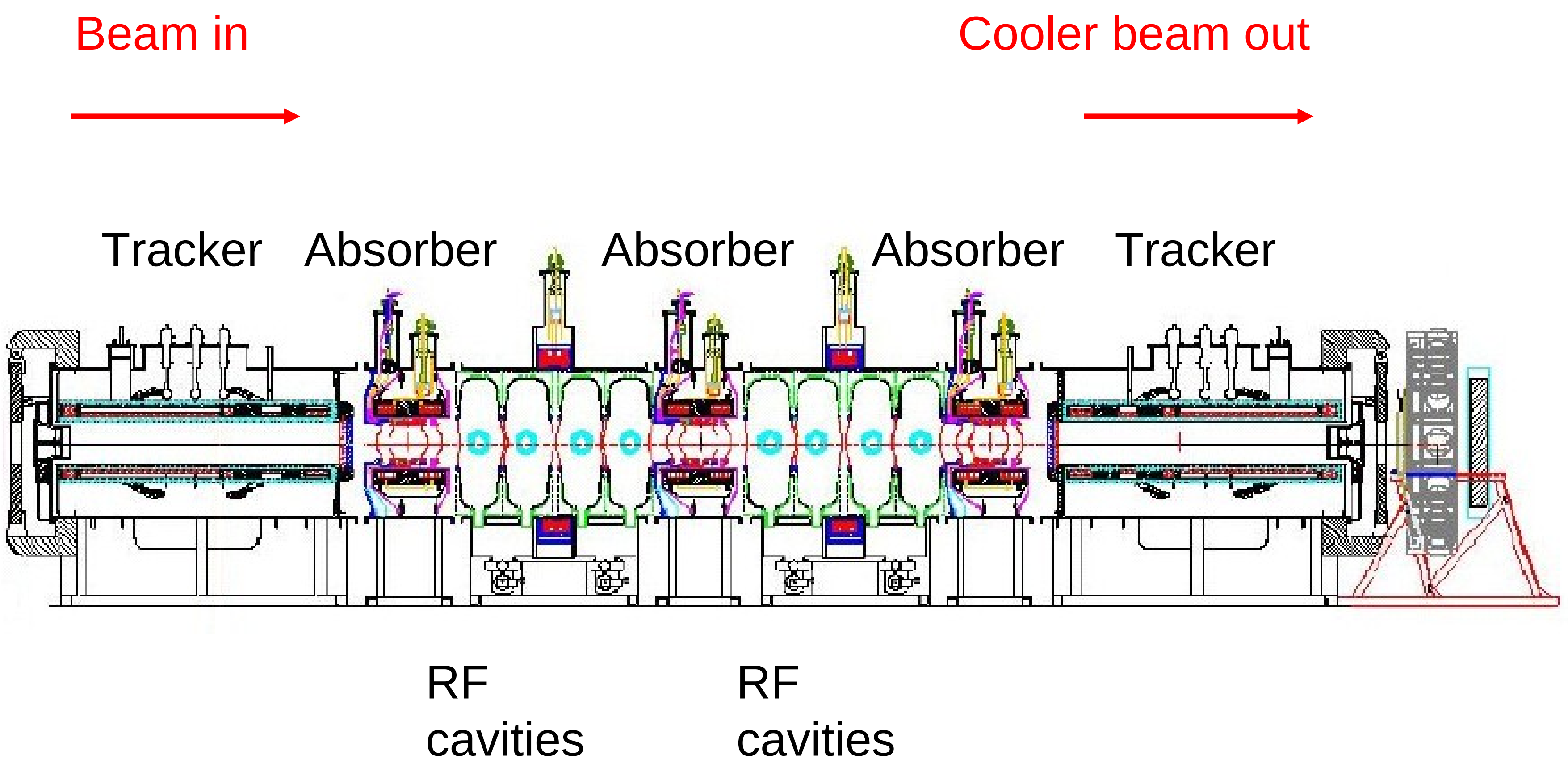
MICE — Muon ionisation cooling experiment

International collaboration using muons from parasitic target on ISIS synchrotron (UK, EU, CH, US, Japan)

Aim: to design, construct and operate a section of muon cooling channel for a neutrino factory



MICE beam line on ISIS synchrotron



MICE experimental cooling channel

Beam losses on ISIS

- Concentrated at one place — on collimators
- Imperative to keep beam losses low (~1 W/m)
- ISIS: ~1 kW lost, 163 m circumference, ~6 W/m
- ISIS only ~0.2 MW, but ×2 beam losses would make life very difficult (2–3 mSv annual dose limit)
- — FRPMN089

Replacement and upgrading of installed equipment

- Some ISIS equipment old — already second-hand when ISIS built in early 1980s
- Obsolescence mitigation programme running at ~5–10% of current asset value
  - New White circuit
  - New extraction kicker drivers
  - New anode power supplies
  - New interlock system
  - Etc., etc.
  - — MOPAN104, MOPAN105, WEPMN076

Accelerator R&D

Front End Test Stand — demonstration of high quality chopped H^- beams
— TUPAN111, TUPAN112, TUPAS002

Ring R&D — underpinning ISIS operations and future synchrotron / accumulator ring designs
— TUPAN113, TUPAS001

Megawatt ISIS upgrade options

Typical ISIS running pattern

Maintenance/shutdown
~1 week machine physics + run-up
~40-day cycle
~3-day machine physics

} ~5/year

Typically ~200 user-days per year

Availabilities: 89±5%

Crew: 5 teams of 3 — 24 hours/day, 365 days/year — even during shutdowns

Each team: Duty Officer
Assistant Duty Officer
Shift Technician
} mostly "electrical"

Duty Officer responsible for all operations on his shift — including user operations — RPS

Team of 5 health physicists — one of whom on call outside normal hours

Accelerator and target: 32 people on call at any one time 24 hours/day, 7 days/week — 45 names

Instruments, sample & environment: 14 people on call

Accelerators

17 kV H^- caesiated surface Penning ion source

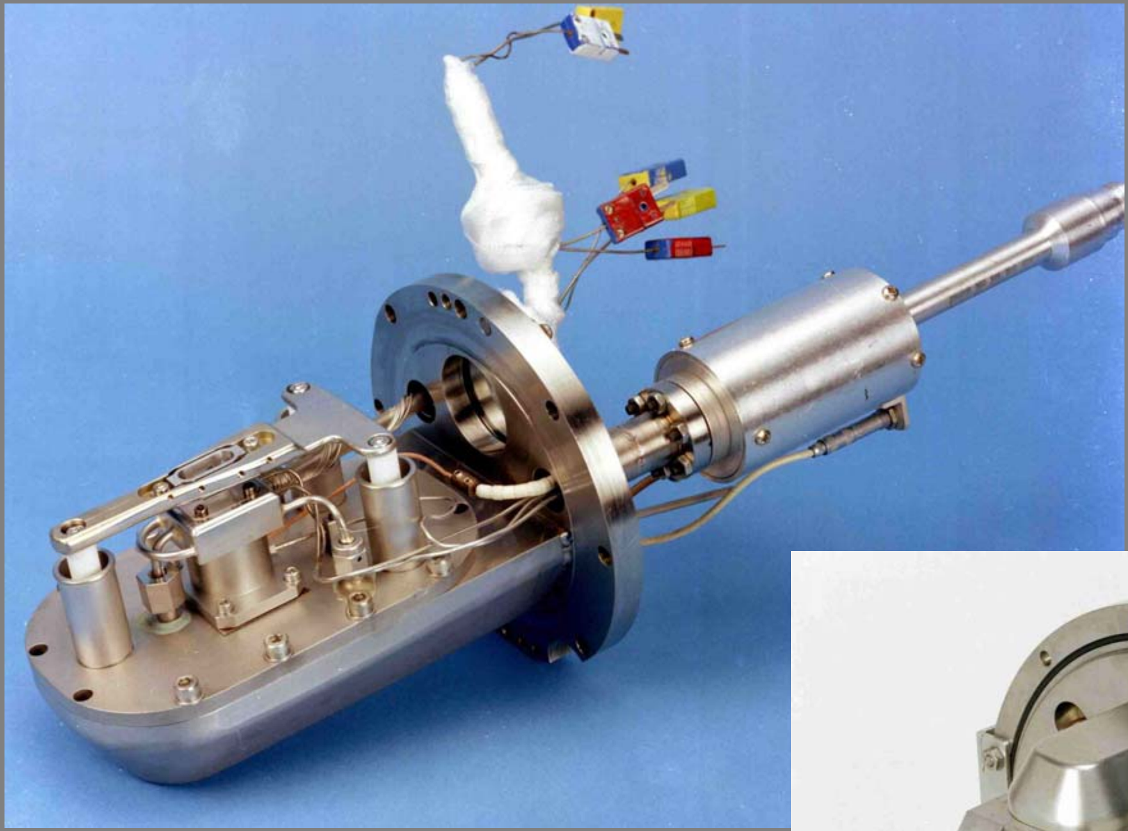
Three-solenoid magnetic LEBT

665 keV, 4-rod, 202.5 MHz RFQ

4-tank 70 MeV H^- linac
20–25 mA, 200–250 μs, 50 pps

Ten-superperiod 800 MeV proton synchrotron
163 m circumference, 10 ms acceleration cycle, h = 2 & 4, 1.3–3.1 and 2.6–6.2 MHz

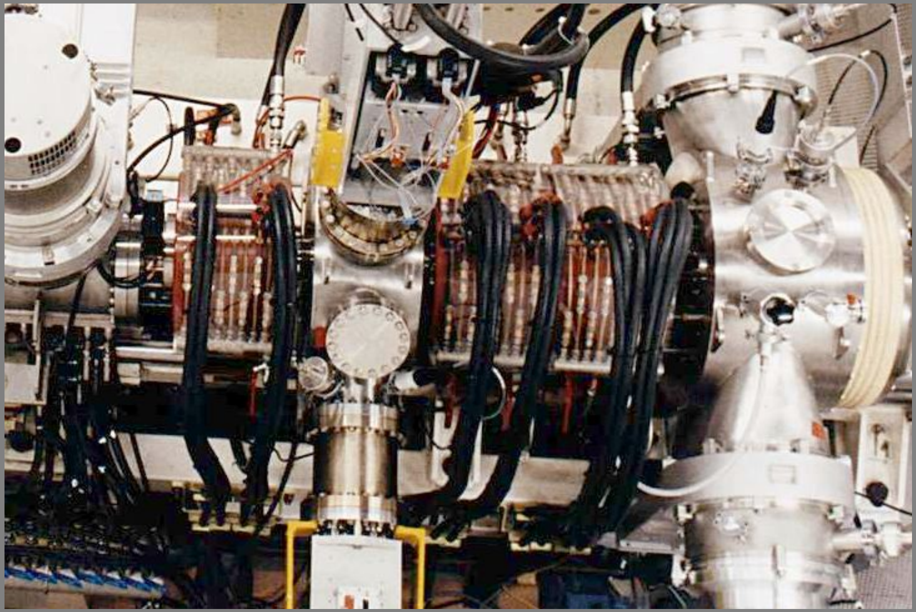
0.25 μm aluminium oxide stripping foil, anti-correlated painting



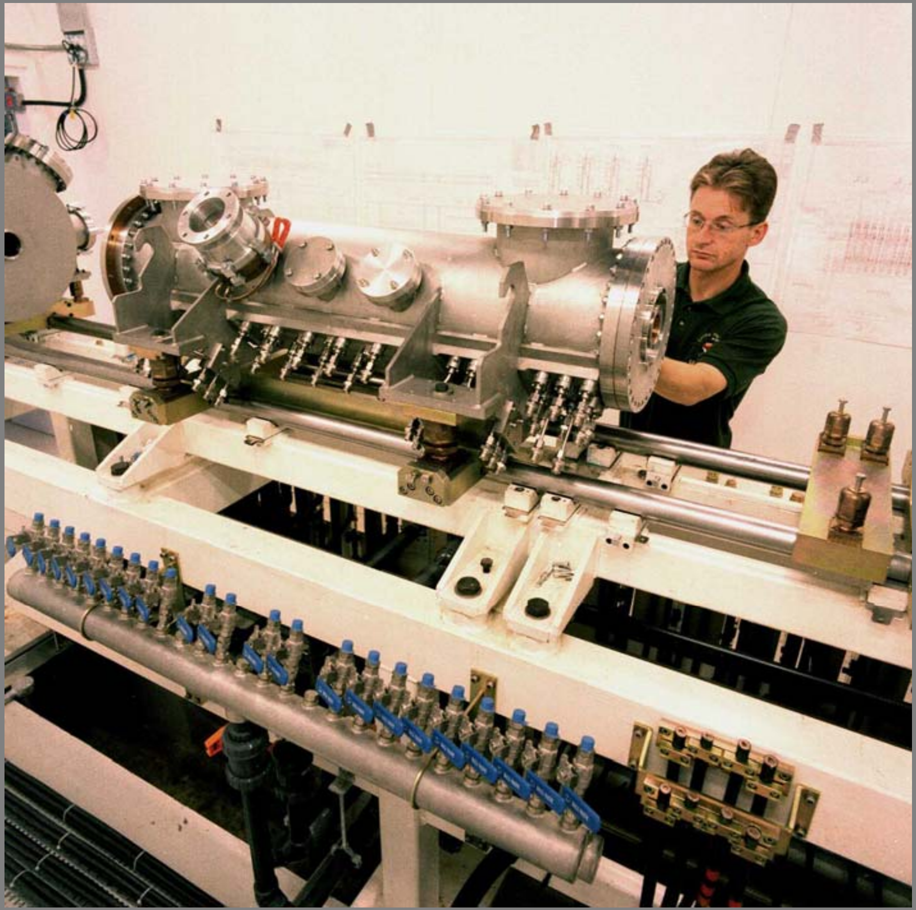
H^- ion source exchangeable "bucket"

4 weeks typical lifetime

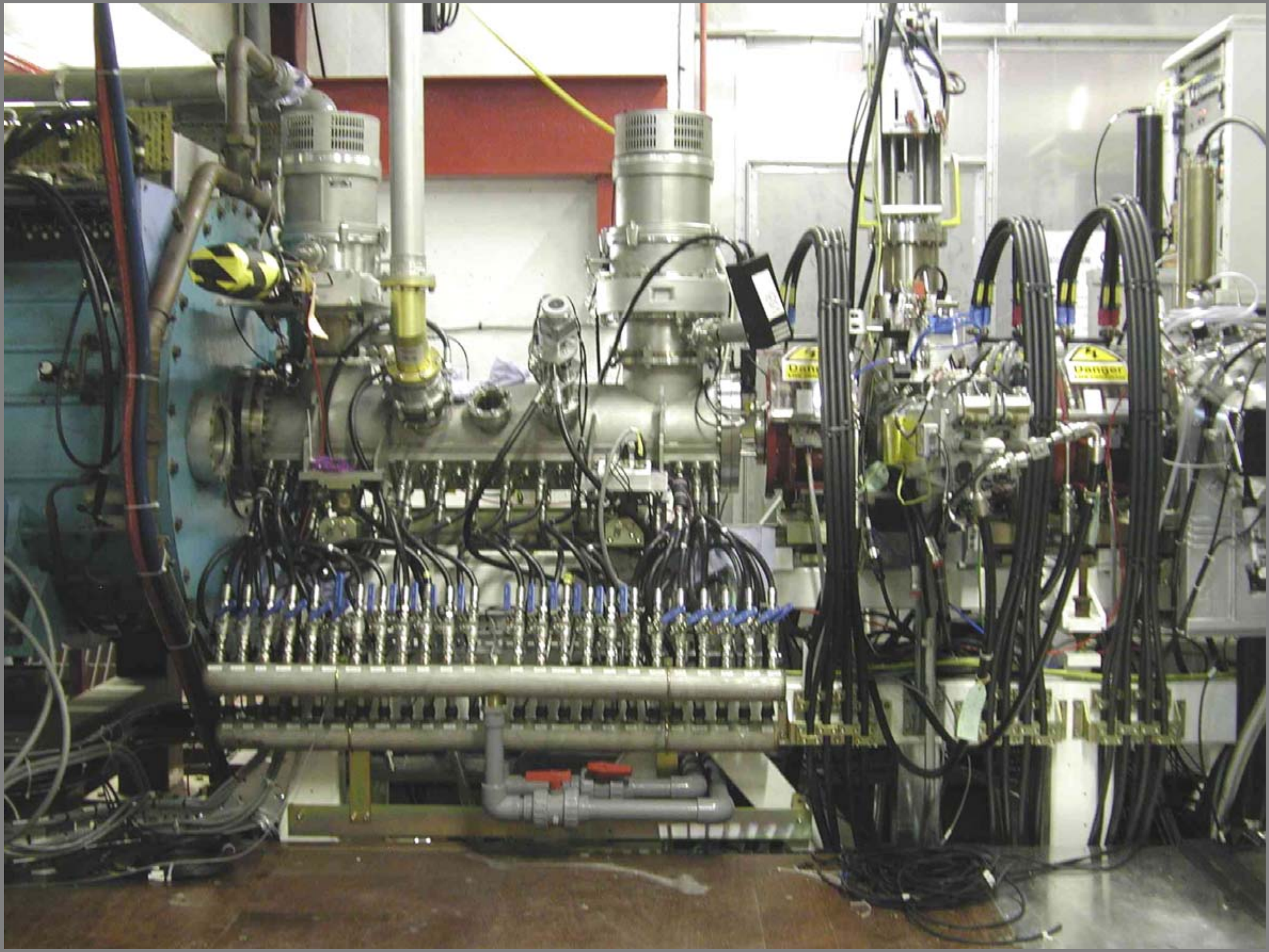
With separator magnet and cold box



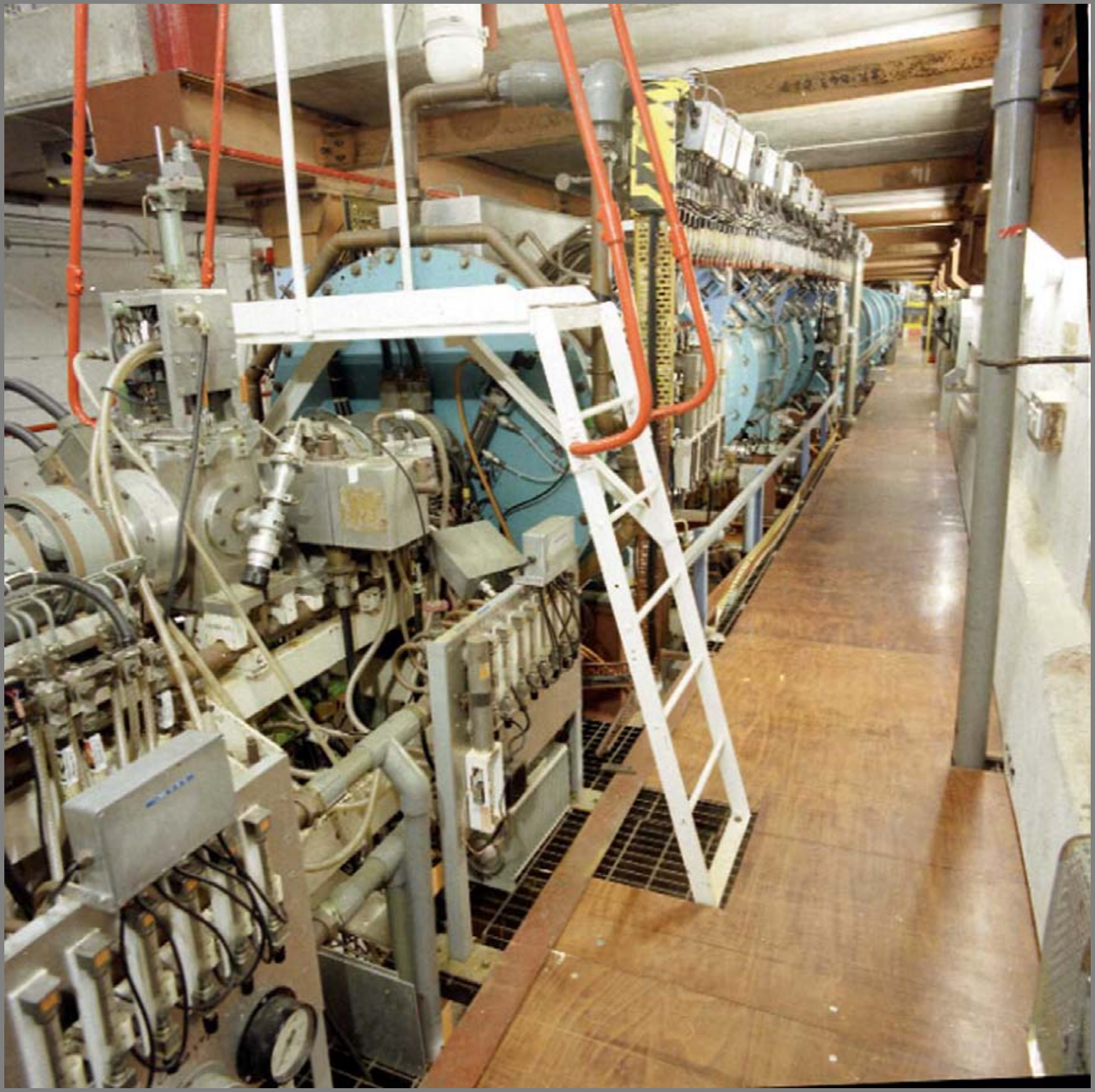
3-solenoid
LEBT



4-rod RFQ
vessel



RFQ and LEBT on ISIS

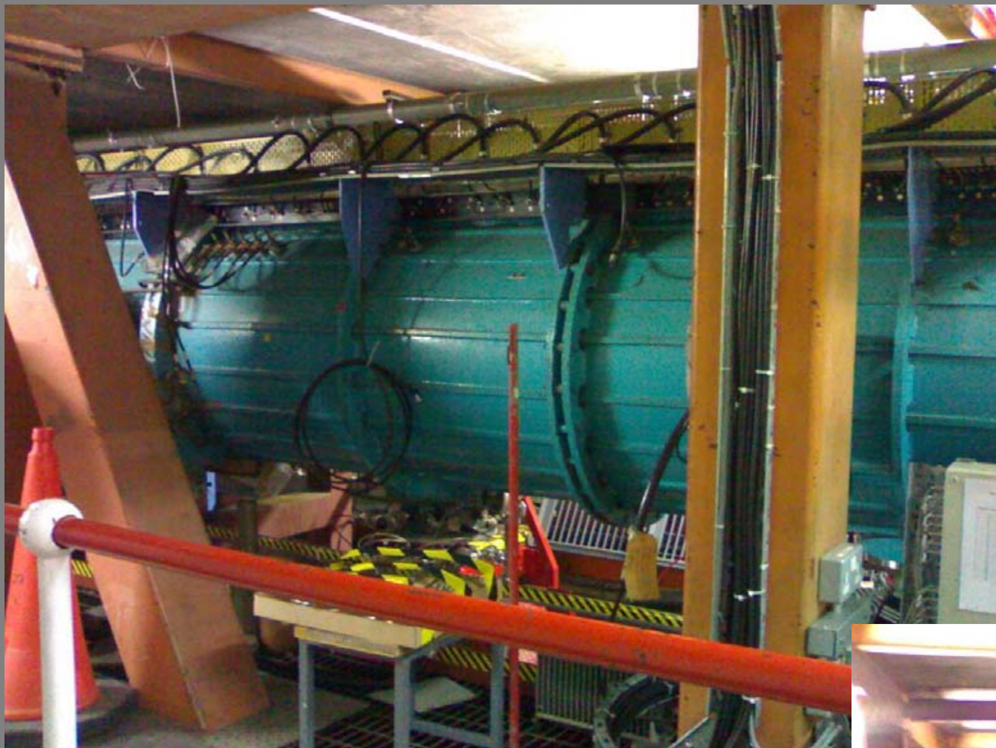


View down south side of 4-tank 70 MeV 202.5 MHz H^{-} linac

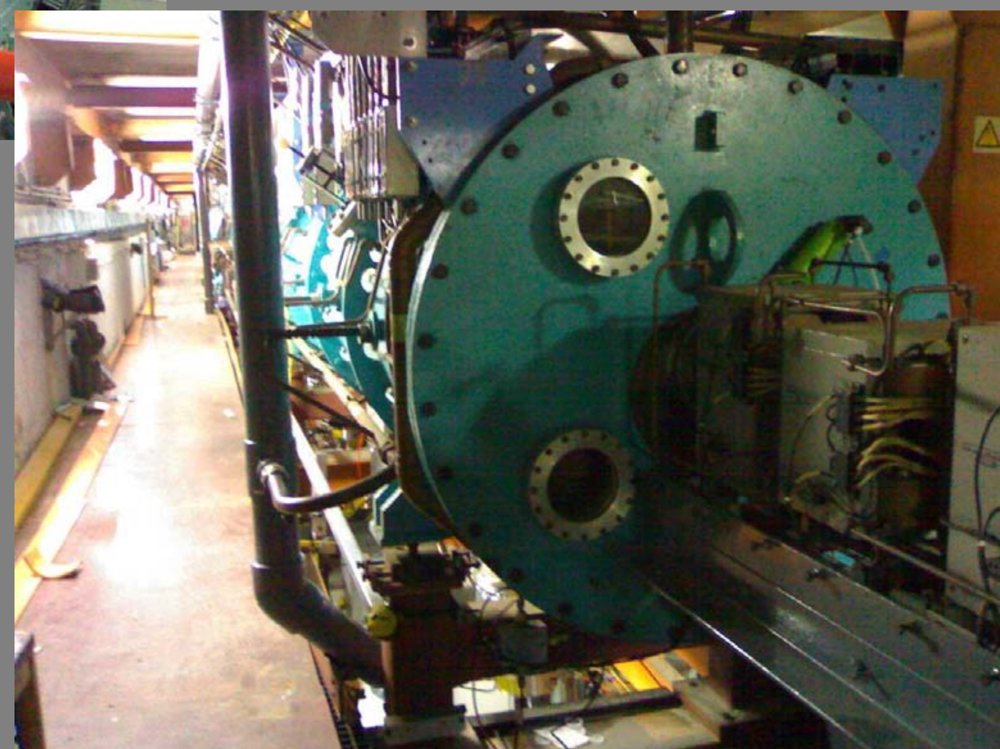
Two types of tank:

1. Old-type tank

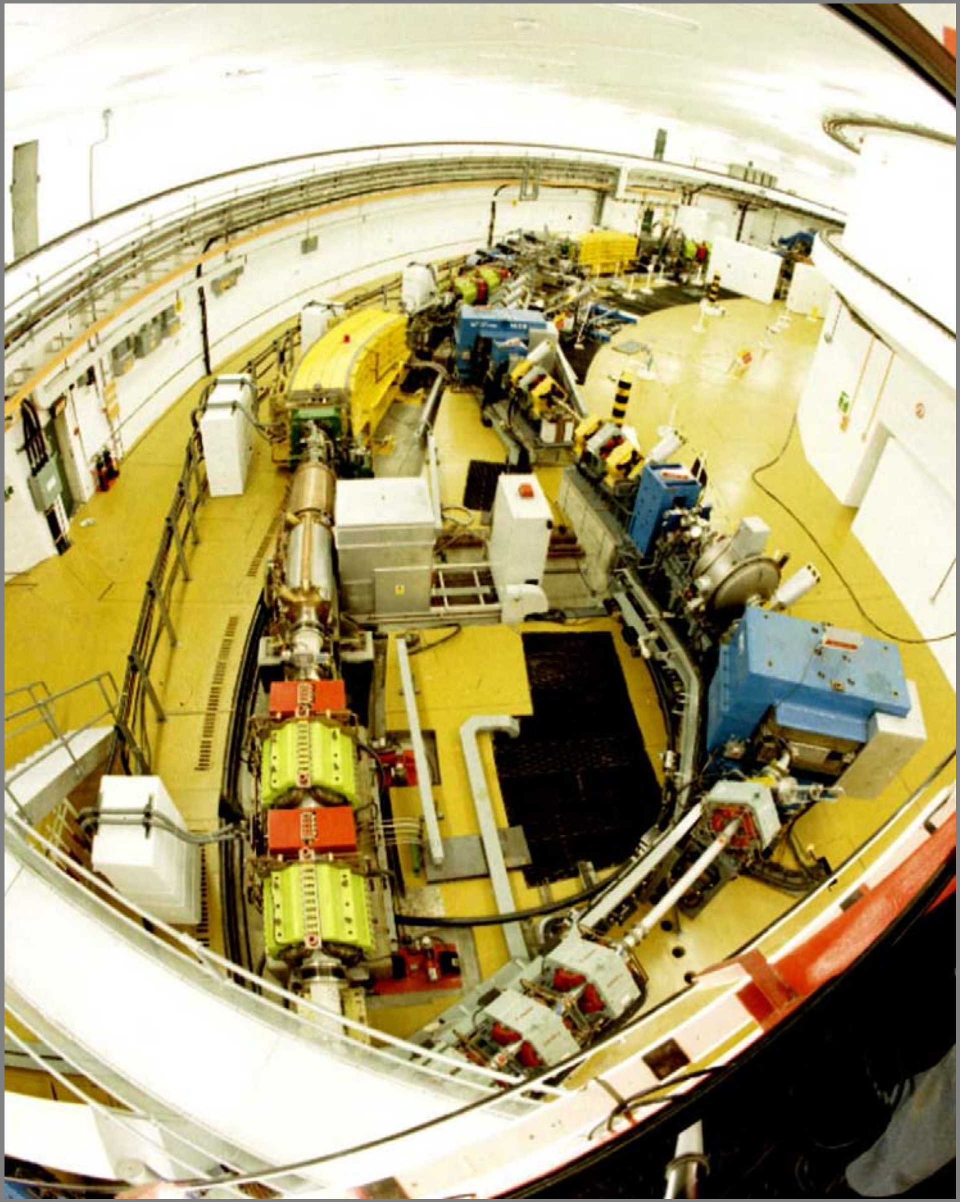
Top comes off — useful for fault-fixing

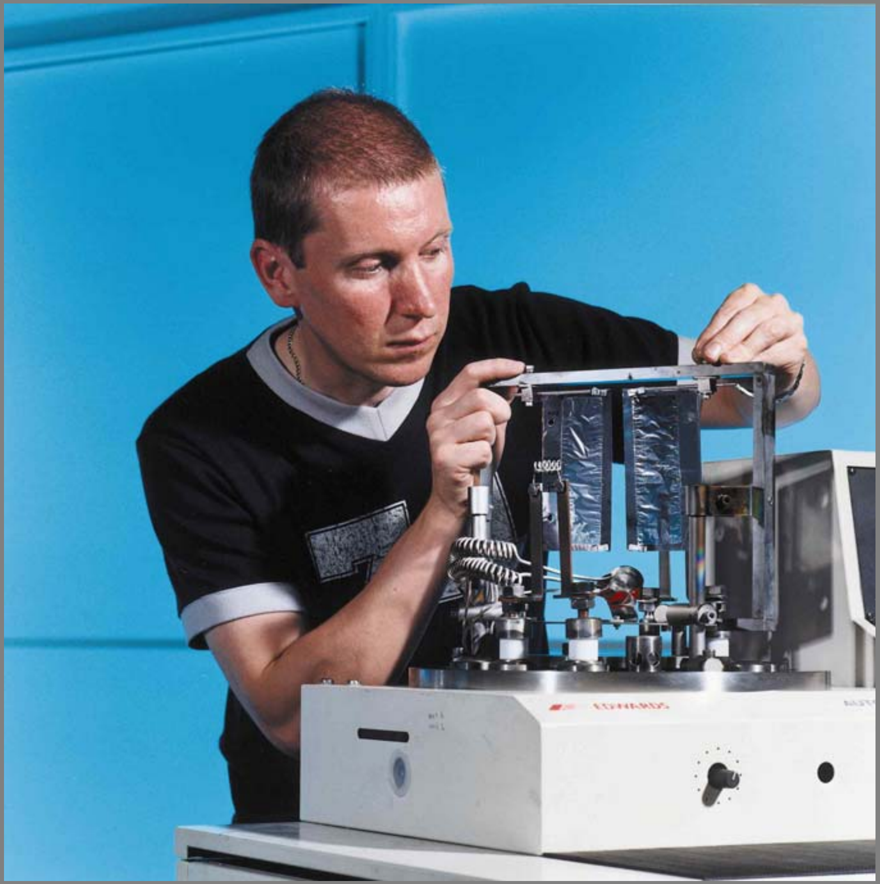


2. “New”-type tank



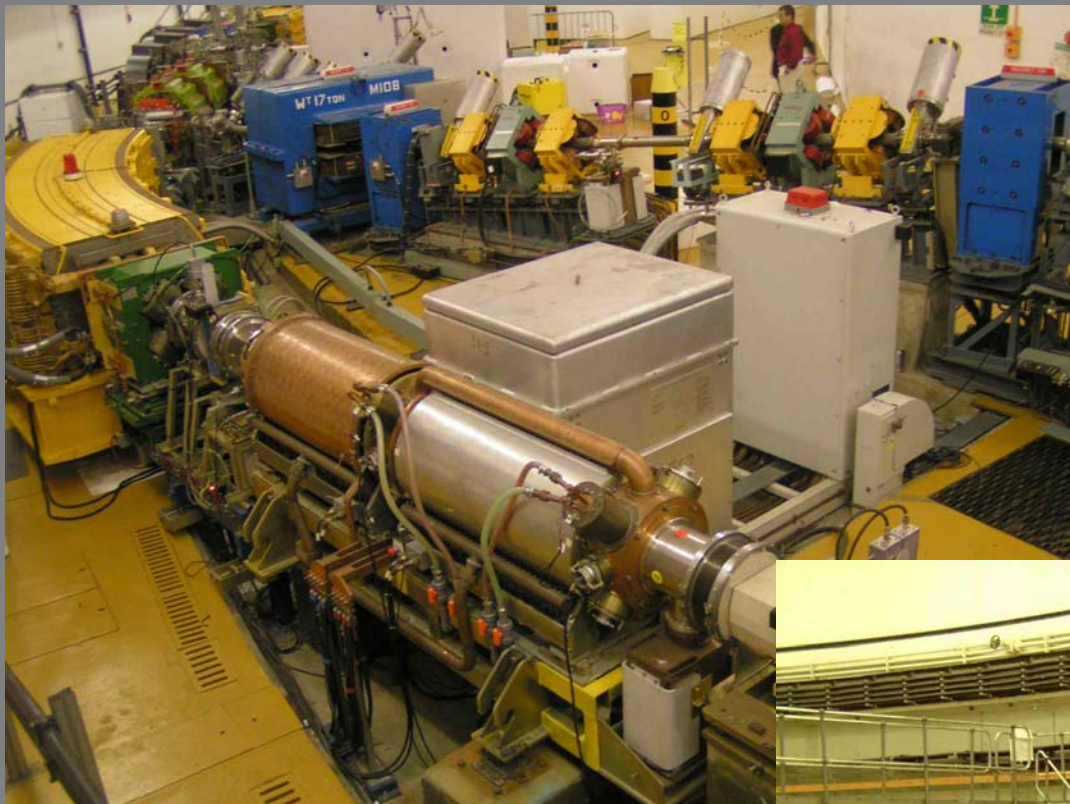
Ends comes off
— not so easy
for fault-fixing



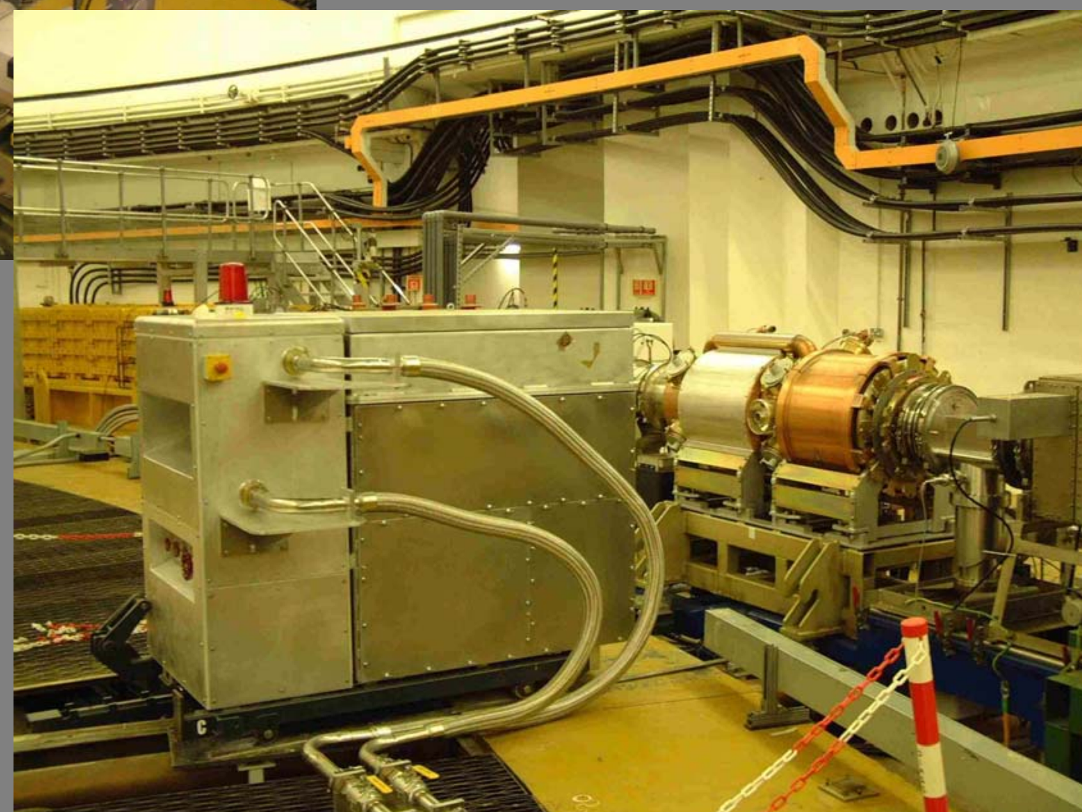


0.25 µm
aluminium oxide
stripping foils

800 MeV proton synchrotron and 70 MeV H^- injection line



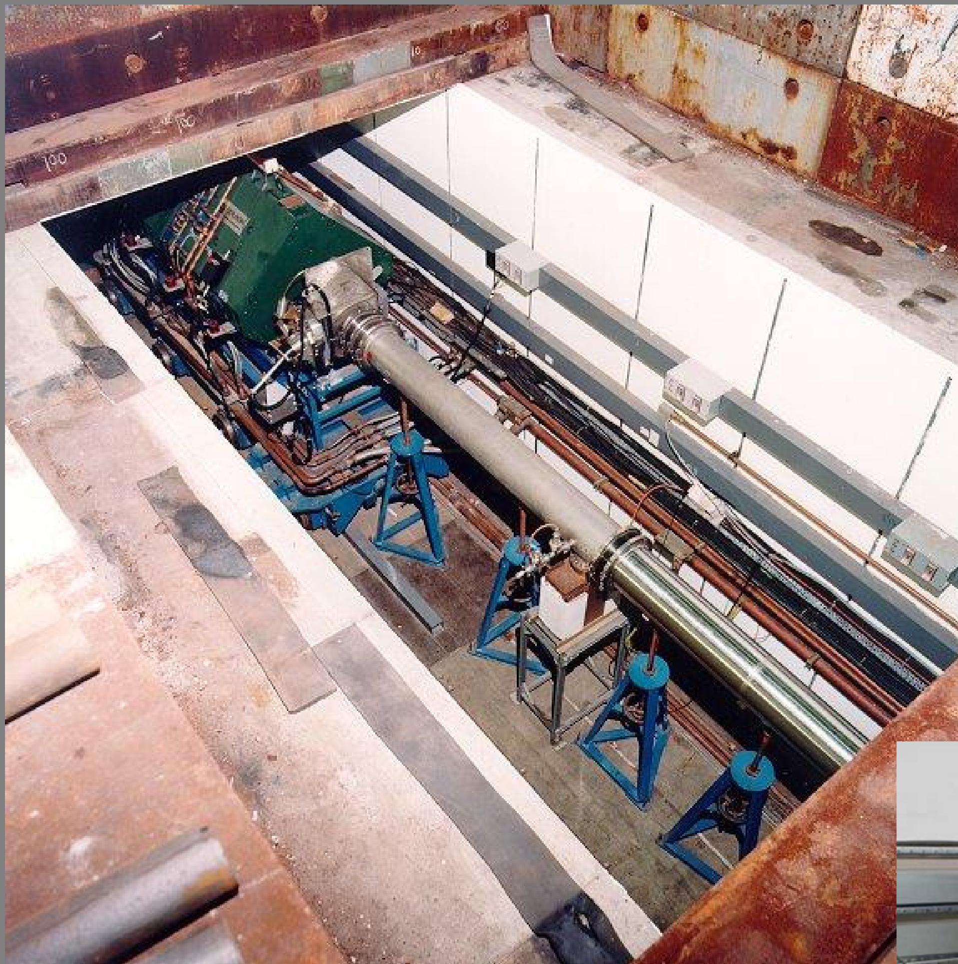
1RF accelerating cavity and high power RF driver



2RF accelerating cavity and high power RF driver

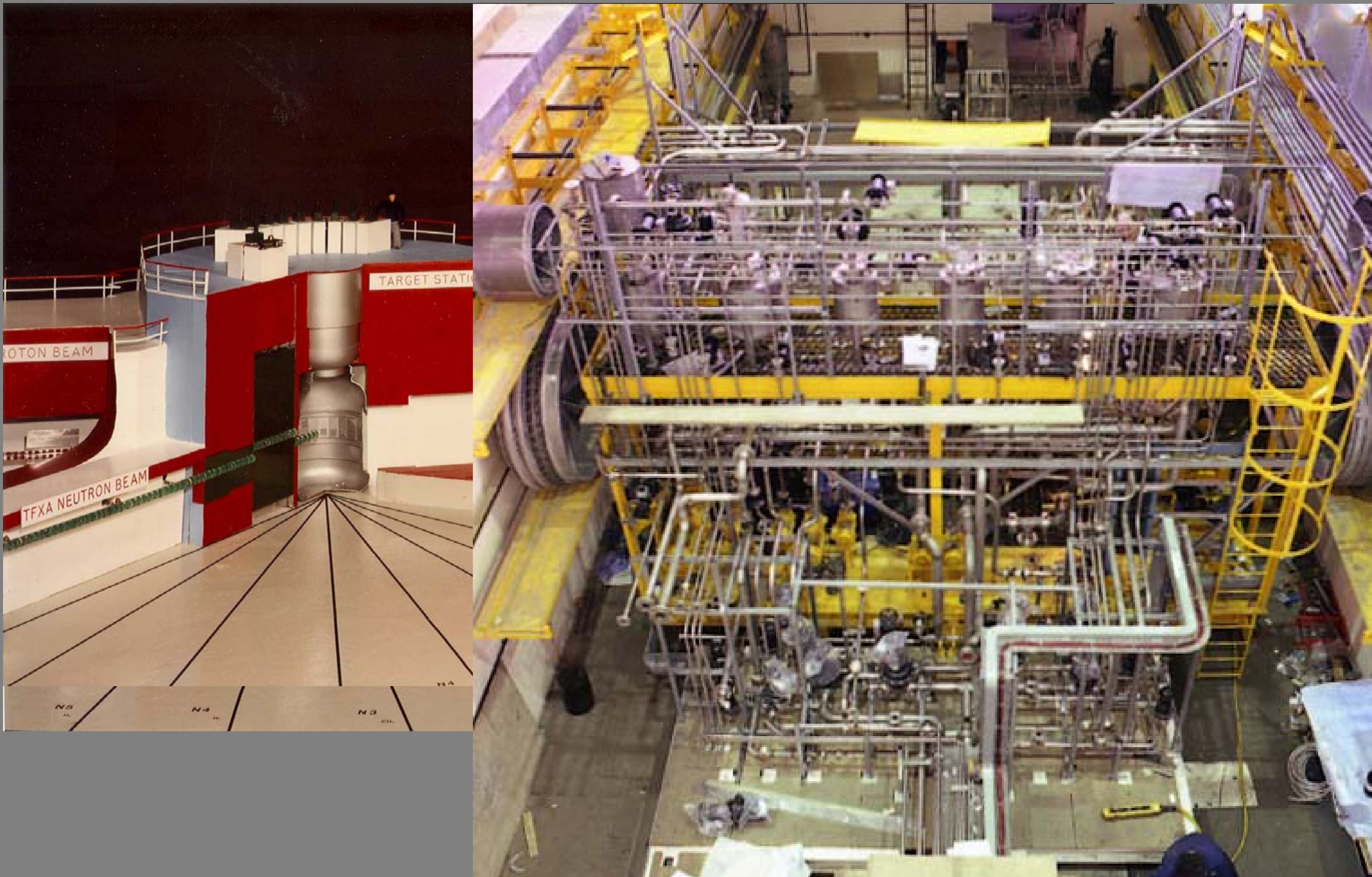
Synchrotron low power RF systems

Synchrotron high power RF systems

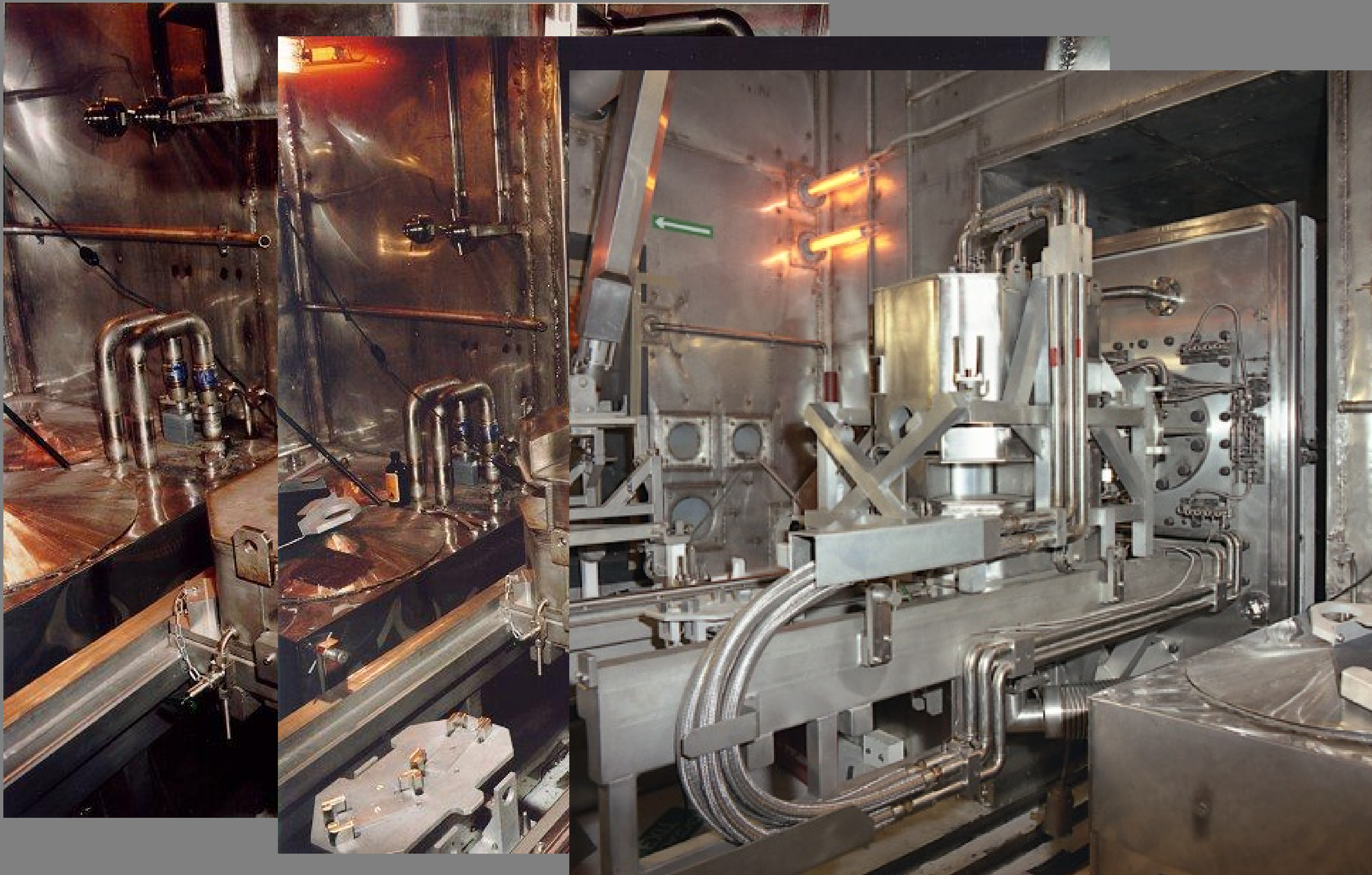


Extracted proton
beam line to TS-1

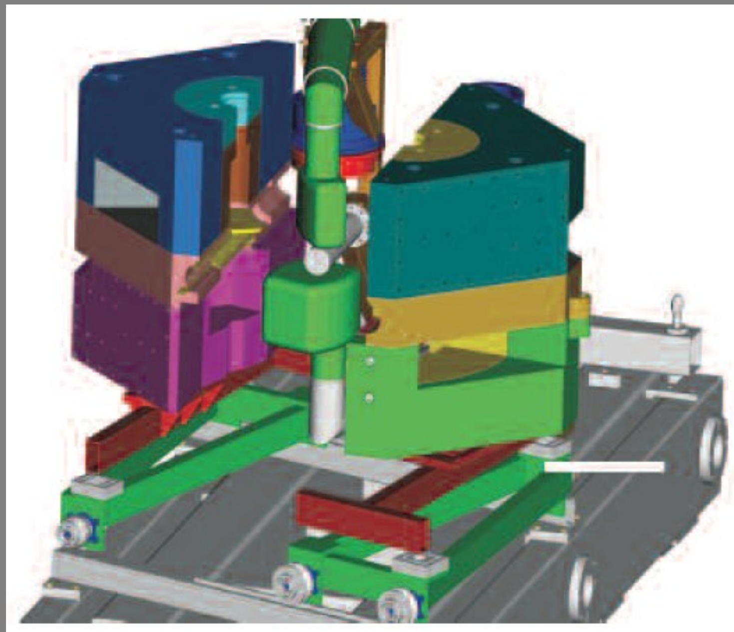
Extracted proton
beam line to TS-2



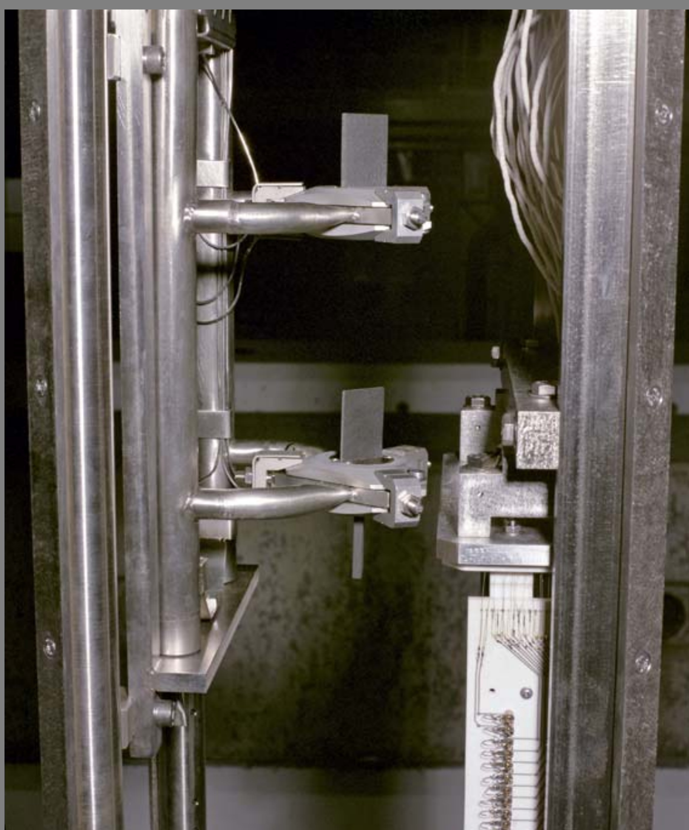
Neutron-producing target — TS-1 — overall arrangement

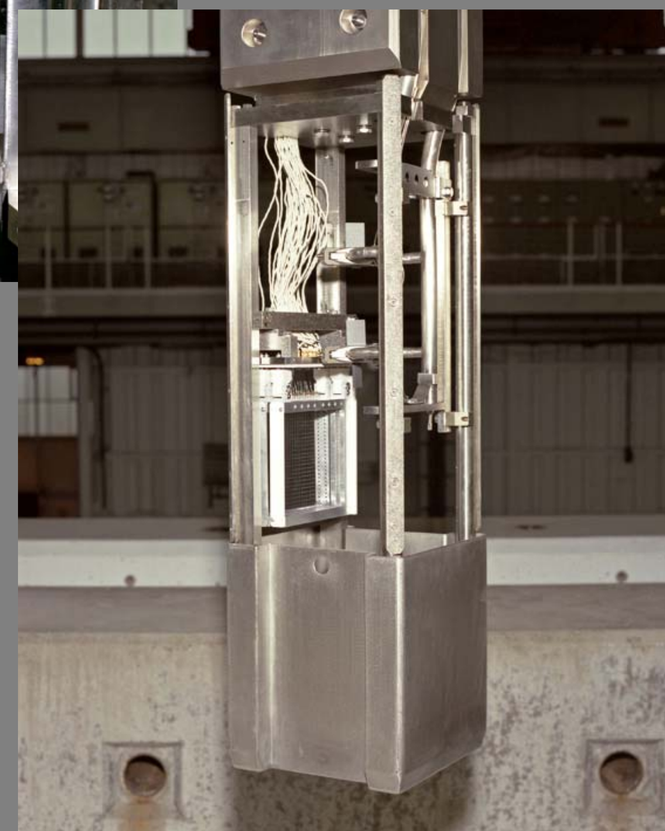


Neutron-producing target — TS-1



Neutron-producing target — TS-2





Muon-producing target (1)

Muon-producing target (2)

Current programme

- In middle of longest and most work-intensive shutdown ever
- October 2007, running again for users
- October 2008, running to TS-2

Future programme

- Refine options for ~megawatt upgrades
- Finally build upgrade — we hope

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