Parallel Session: Molecular and Materials Science

Contributions

12:30 *Positron Annihilation: Using Anti-particles for Materials Characterization* – Peter Mascher (McMaster)

12:45 *Looking forward into the CMMS in the Meson Hall* – Syd Kreitzman (TRIUMF)

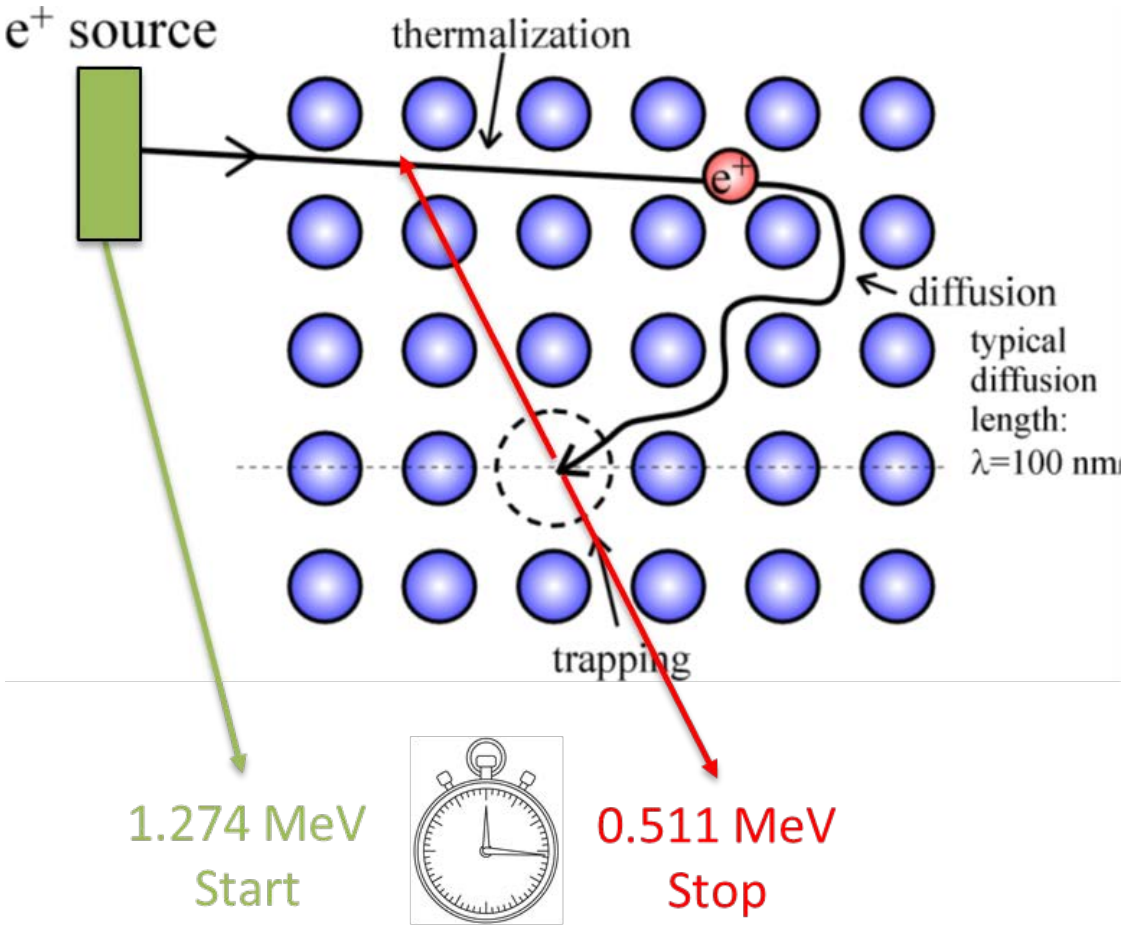
13:00 *The benefits of the off-line characterisation labs* – Adam Berlie (ISIS)

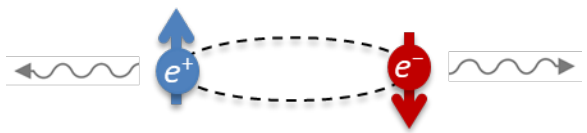
13:15 DISCUSSION

Development of the μSR Facility

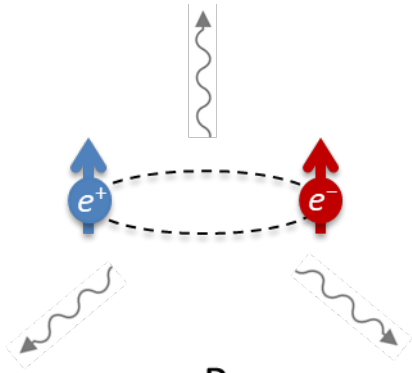
- New beam lines (M9A in 2021 & M9H in 2024)
  More beamlines increased → scientific scope
- Diamond T2 Target
  More muons → experimental precision
- M15 Revitalization
  Luminosity restoration → smaller samples
- SiPM based Spectrometers
  More bandwidth → broader impact

Positron Annihilation Spectroscopy

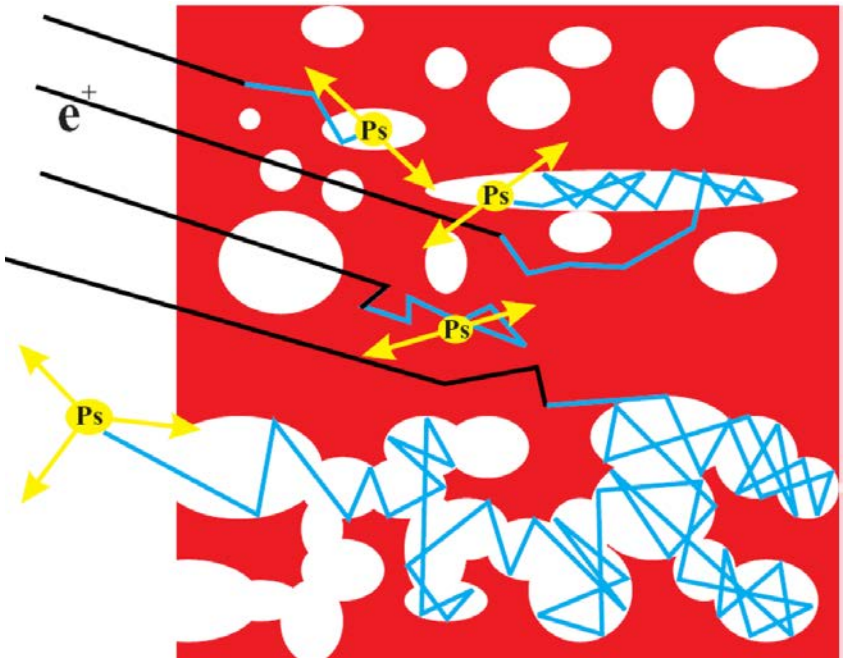




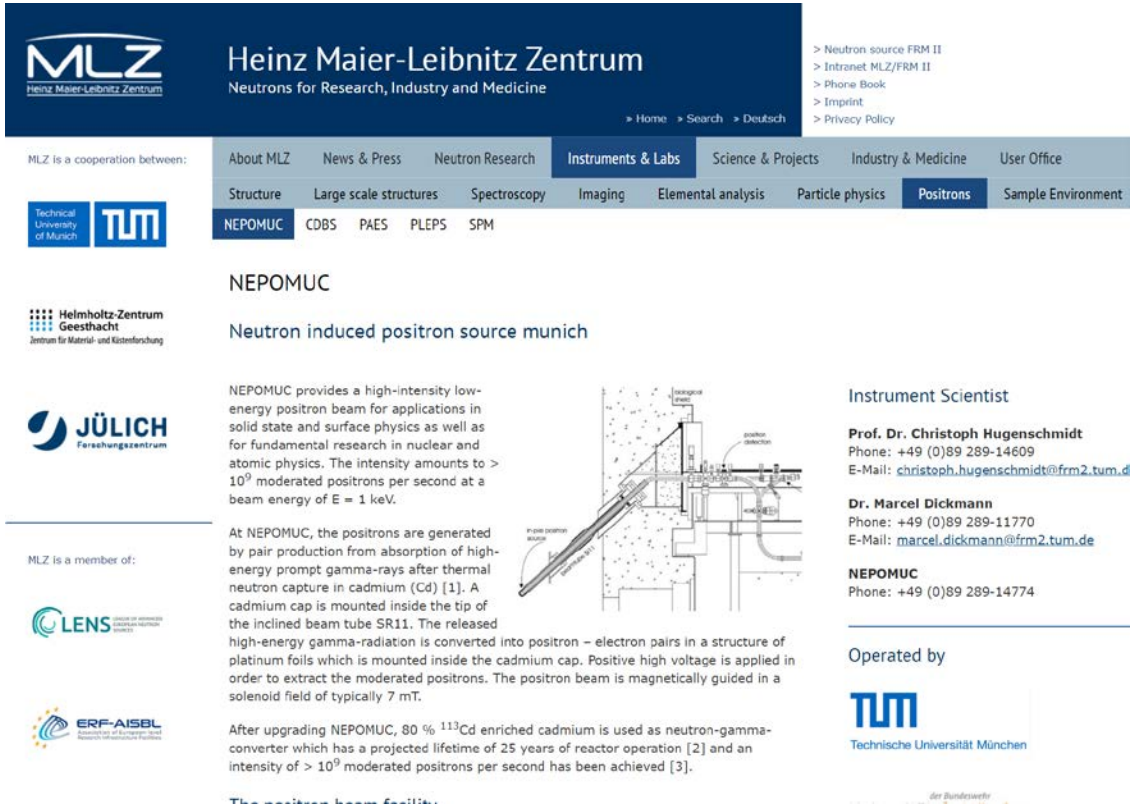
p-Ps
τ = 125 ps



o-Ps
τ = 147 ns



Current Positron Annihilation Spectroscopy Facilities

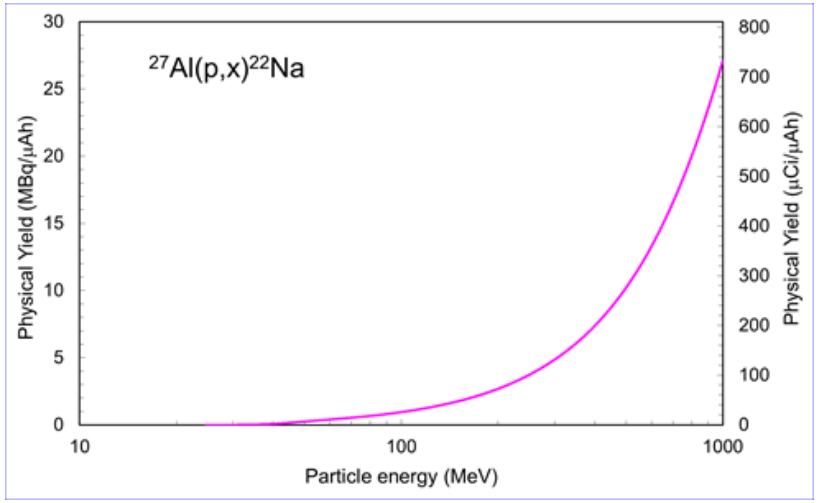


- Positron implantation energy: 0.5 – 20 keV
- Beam spot Ø ~ 1 mm
- Count rate: ~ 5000 – 10000 cps

Potential of a Positron Annihilation Facility at TRIUMF

Option 1

High intensity ^{22}Na source (2.6 yr) (1 Ci) by proton irradiation



Option 2

Irradiate materials with low-energy p or d

- ^{11}B(p,n)^{11}C (20 m)
- ^{12}C(d,n)^{13}N (10 m)

Moderator → 3 x 10^8 slow e^+/s, 5 mm diam.

High intensity → New experiments

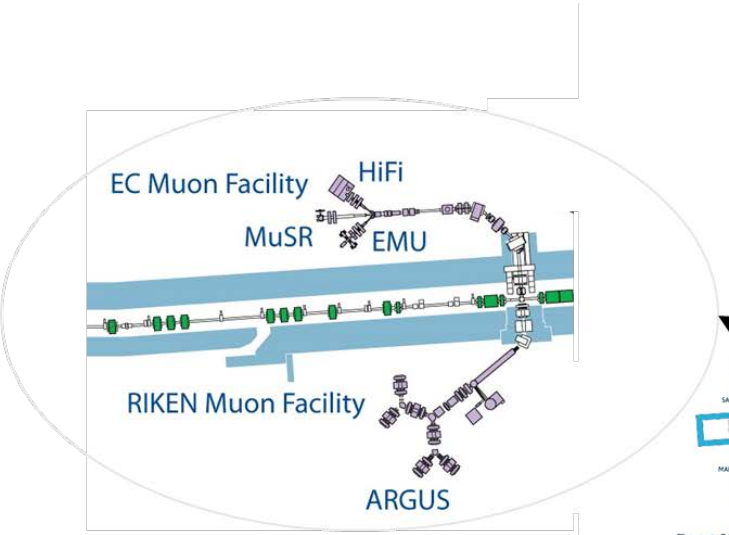
better facility than anywhere else

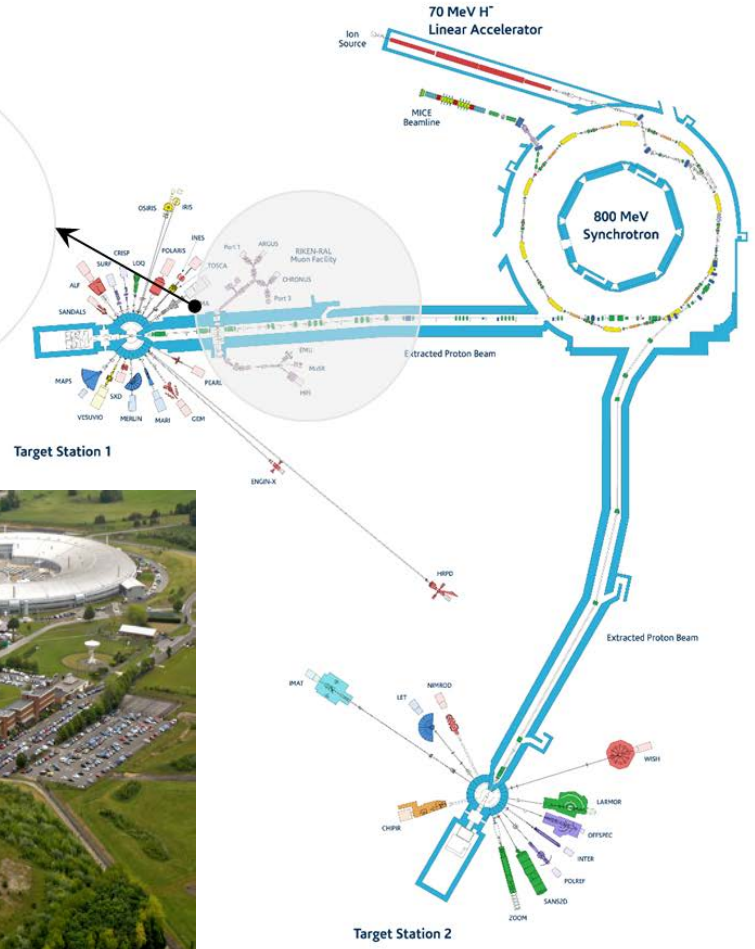
Pros and Cons of a Positron Annihilation Facility

- Complimentary technique to μSR and βNMR
- Attract new users (estimated 300 worldwide)
- Applications in condensed matter and atomic physics
- Industrial applications
- TRIUMF has skills and tools to make an outstanding facility

- No local champion
- Small number of current experts in Canada
- McMaster building a facility (delayed due to lack of CNSC approval)

ISIS Muon and Neutron Facility





- 38 Instruments
- 1000+ Experiments per year
- 4000+ Instrument-days per year
- 550+ Publications per year
- 100+ companies
- 1600+ strong user base
  - 775 PhD students
- 3300+ user-visits every year
- 4200+ other visitors

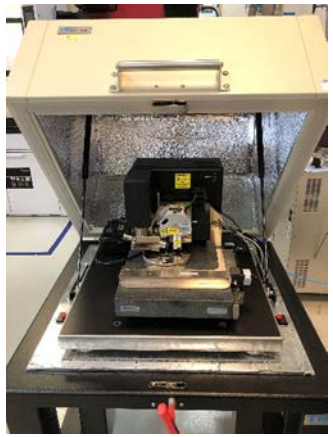
ISIS Sample Characterization Facility

- Started in 2010
- ~£7 M investment in the laboratory
- Over 300+ users per year
- Staff of 2 scientists + students

Materials Characterization Laboratory functions:

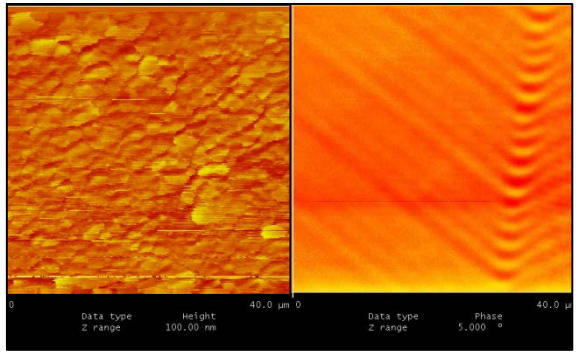
- Sample screening (20 %)
- Preliminary measurements for beamtime (20 %)
- Complimentary neutron/muon measurements (30 %)
- Follow up/completion measurements for publications (20 %)

Equipment – thin films



Atomic Force Microscope

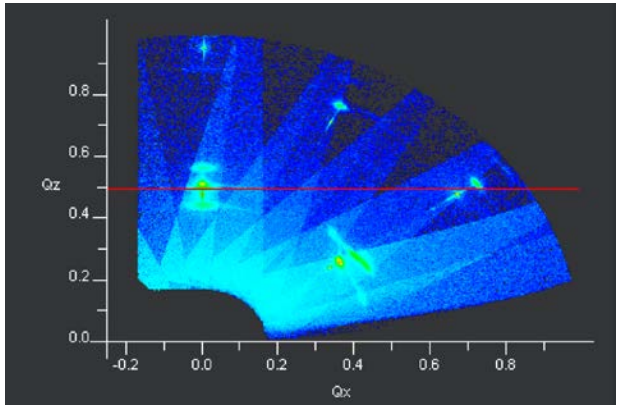
Surface topography (tapping mode) thin films, Si blocks etc. Can also perform MFM, C-FM and liquid surface AFM.



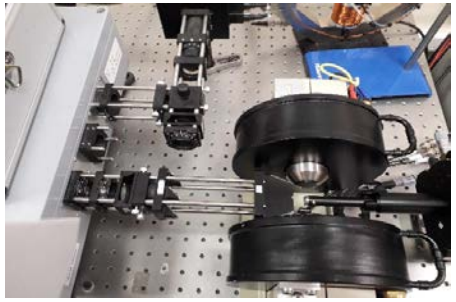
AFM/MFM image of a sample

Smartlab High resolution thin film diffractometer

High resolution XRD, Grazing incidence XRD, Pole figures, Reciprocal space mapping, X-ray reflectivity, 2D diffraction



Reciprocal space map of a NiFe/CoFe thin film



Magneto-optical Kerr effect microscope

Hysteresis loops and domain imaging of thin films or samples which have a reflective surface. Transverse, longitudinal and polar moke. Dipole and quadrapole magnet systems. Flow cryostat to 4 K.

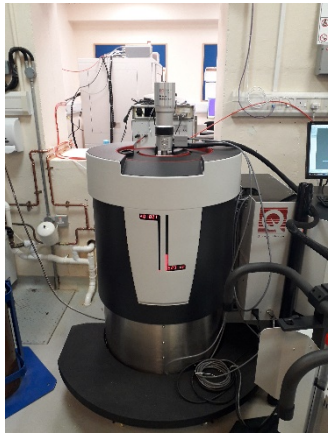
Equipment – Bulk Properties

Magnetic Property Measurement System (Squid) - ±7 T.

Capable of VSM, DC measurements. Options include ACMS, horizontal rotators, oven option (1000 K), 3He fridge (390 mK).

Physical Property Measurement System – ±9 T,

1.8-400 K. Measurement options include ACMS, Heat capacity, resistivity, Transport



Physical Property Measurement System Dynacool

Field ± 9 T 1.8-400 K. Measurement options include ACMS, Heat capacity, VSM, Thermal transport, Electrical transport, Resistivity, Ferromagnetic resonance. Dilution fridge.

Dilution fridge capable of 50 mK and performing the following measurements – Heat capacity, resistivity, ACMS.

Equipment – Chemical/Structural

Small Angle X-ray Scattering

Linkam stage (80 K), Autosampler, low noise flow cell, thermalized capillary, gel capsule for viscous liquids.

Smartlab High resolution powder diffractometer (rotating anode)

Available with sample environments-High temperature (1200°C) Cryostat (12 K) plus a new cold loading cryostat for quench cooling measurements. Air sensitive sample holders.

Laue Diffraction camera

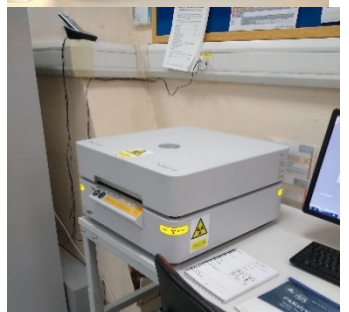
Can align large crystals ready for beamtime.

Miniflex Benchtop powder XRD

Quick and easy XRD used routinely for sample screening and crystal growers on-site. Can provide a dataset in 10 mins. (Cu Source)

Single Crystal diffractometer

Dual source (Mo and Cu)
cryostream (70 K)
N-Helix (28 K)



X-ray fluorescence

Elemental analysis

Stewart Blussom Quantum Matter Institute at UBC

Angle Resolved Photoemission spectroscopy (ARPES) and X-ray Photoemission Spectroscopy (XPS)	This state-of-the-art spectrometer allows mapping of the electronic structure of solids from room temperature down to 3K, with unprecedented energy and momentum resolution.
Custom Table-top Oxide Molecular Beam Epitaxy (MBE) System	With 3 effusion cells, oxygen cracker, RHEED gun, and heated manipulator we can grow a variety of oxides in ultra-high vacuum.
Quantum Design MPMS system	This commercial system has been the workhorse for characterizing all of our superconducting samples.
JEOL JBX-8100FS E-Beam Lithography Tool	State-of-the-art electron-beam lithography tool that enables device fabrication at the nanoscale.
Real time x-ray Laue camera, digital	This instrument allows us to orient a single crystal very rapidly.
Scanning Tunneling Microscopy (STM) and spectroscopy (STS) with picometer spatial resolution	This is a scanning tunneling microscope suite coupled to a materials preparation chamber that is able to produce atomically controlled layers of complex materials.
X-ray single crystal diffractometer, Philips X'Pert	The Philips X'Pert X-ray diffractometer is a versatile device used to characterize crystalline, as well as single crystal materials.

https://qmi.ubc.ca/industry-support/infrastructure

Geographical Considerations

What distance are people willing to travel?

41 Physics departments in the U.K.
Around ISIS:
Bath, Birmingham, Bristol, Cardiff, Coventry, Imperial college, London (King's College, Queen Mary, UCL), Oxford, Southampton….

Around TRIUMF:
UBC, SFU, UVIC, WWU

Pros and Cons of a Sample Characterization Facility

- Sample characterization required for μSR and βNMR
- Assist current μSR and βNMR users
- Attract outside users (lack of medium-scale infrastructure)
- Support operations on M9H with high-pressure characterization tools

- Users generally characterize samples well in advance of beam time
- Uncertainty as to who additional users would be
- Characterization tools available at QMI