TRIUMF / CMMS (new) Facilities
MuSR 2011, Cancun

People:

Facility Scientists:

1. Bassam Hitti : Operations Manager
   i. Experimental Setup, Operations and User support
   ii. L-He Coordination
   iii. MRO Coordination
   iv. Scheduling and User Coordination
   v. Device electromagnetic simulation (i.e. Opera)
   vi. Semiconductor Solid State Physics

2. Gerald Morris*: Admin. Deputy Manager
   i. M20 project management
   ii. βNMR Management & beam line coordinator
   iii. Experimental Setup and User support
   iv. CMMS Experimental Safety reviews
   v. Subsurface layer CM Physics

3. Donald Arseneau: Facility IT /DAQ & Programming Management
   i. Experimental Setup and User Support
   ii. Facility IT, DAQ and programming
   iii. Spectrometer design
   iv. Common Account Assessment Management
   v. Physical Chemistry and Fundamental Kinetics

4. Iain McKenzie: Facility Outreach
   i. Outreach Planning and Implementation (Long Term & Triumf CMMS Summer Institute)
   ii. M9A spectrometer coordination
   iii. Experimental Setup and User Support
   iv. Physical Chemistry of Soft Materials Structure and Dynamics of Free Radicals

5. Syd Kreitzman*: Facility Manager
   i. Final stopper of the Buck
   ii. Liaison with TRIUMF Management and User Community
   iii. M9A beamline project management
   iv. M20 project budget management
   v. Experimental Setup and User Support
   vi. MuSR Techniques ,Tools & Toys with some Spin Relaxation Theory

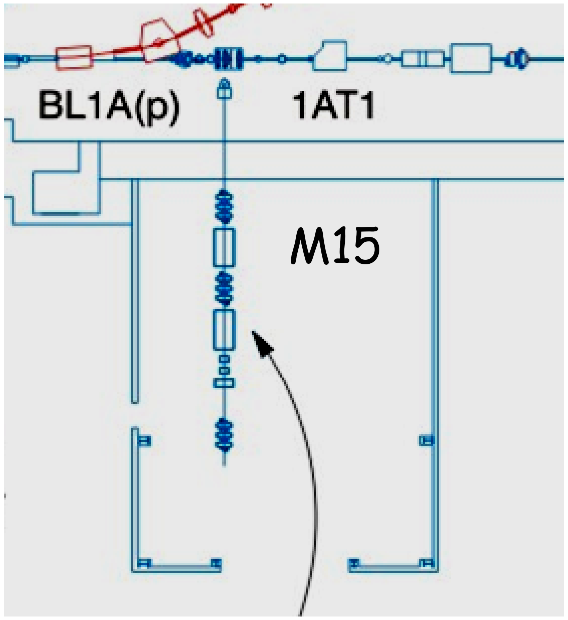
Facility Technicians:

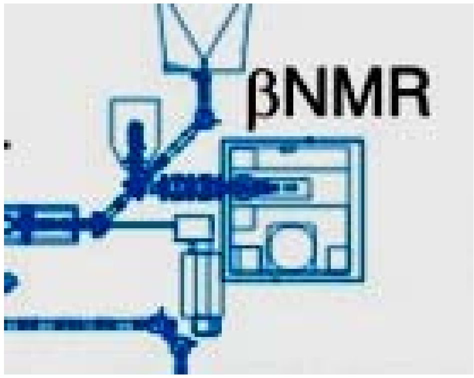
1. Rahim Abasalti: High Vacuum Specialist
2. Mike McLay: Design Technologist
3. Deepak Vyas: Millwright Journeyman & Site Safety Coordination

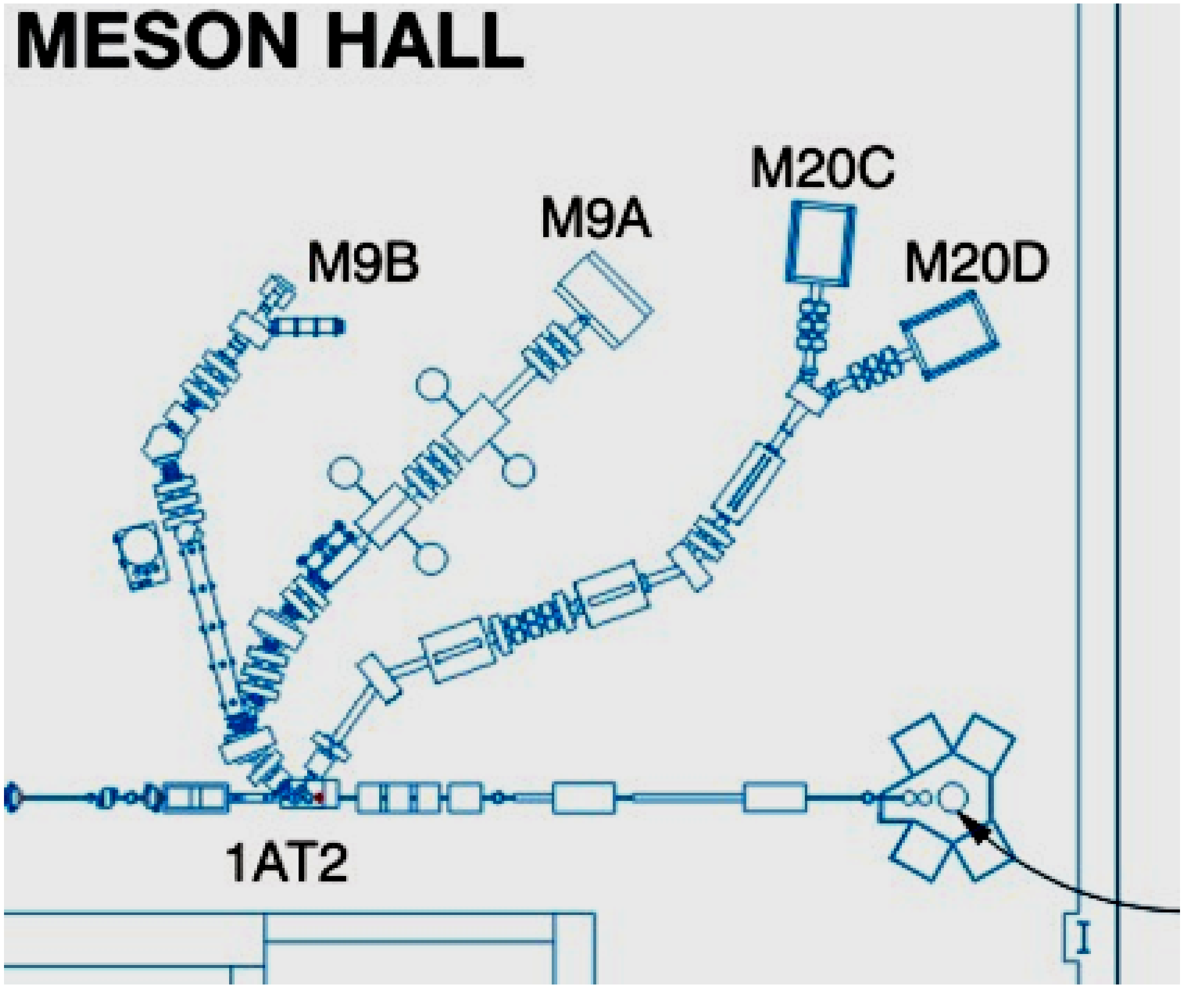
* TRIUMF funded. All other personnel funded by an NSERC MRS grant

TRIUMF Centre for Molecular and Materials Science

CMMS Beamlines (as of 04-2012)







HiTime the HTR/HTF 7T spect.

Muon & Active Coll-imator Detector Array

Compact 7T Magnet

1.6K Cryostat

Positron & Muon-Veto Detectors

TRIUMF Centre for Molecular and Materials Science

CMMS

Helios … the workhorse

Standard experimental facilities, like the general purpose Helios rig at right, provide well known high production environments.

.

DR … MuSR from 12mK @ 5T

The dilution refrigerator (DR) spectrometer provides a very low temperature environment for experiments in:

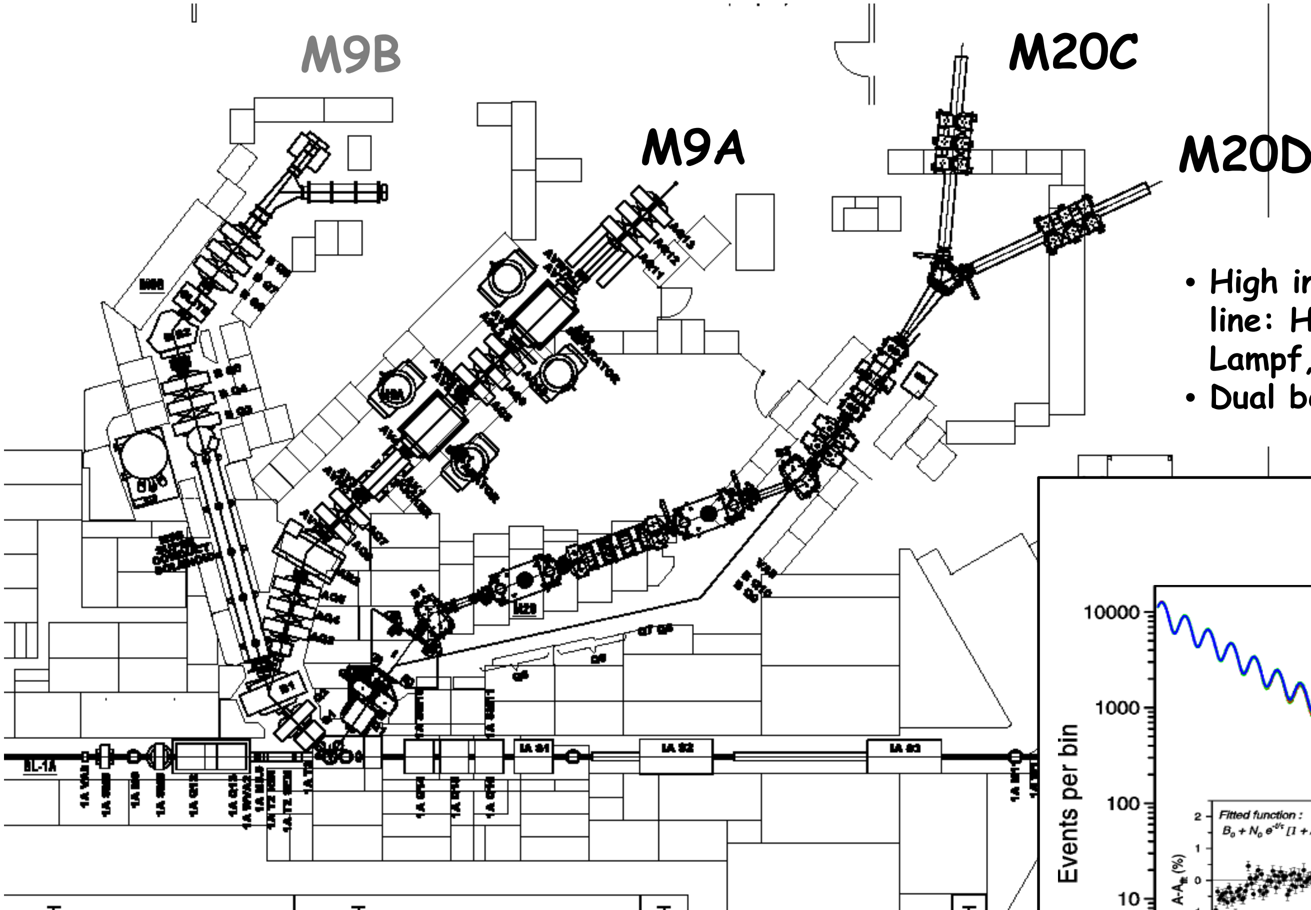
quantum diffusion
frustrated magnetism
- Kagomé spin systems
- rare earth pyrochlores
exotic superconductivity and magnetism
- heavy fermion systems
- Kondo effects
- vortex states
- spin liquid behavior in spinels
magnetism & HTc superconductivity
magnetism in open shell polymers

LAMPF, a “traditional” General Purpose MuSR rig

A general purpose uSR rig built around a .4T magnet originally used in the (now lost) Los Alamos Muon Facility.

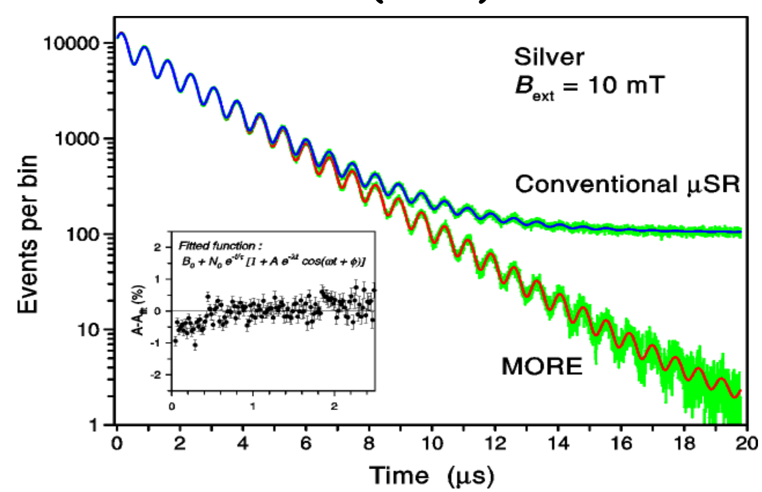
An ultra low background (ulb) capability is available on this instrument allow-ing measurements for samples as small as $3mm^2$.

The New CMMS μSR Beam T2 Lines



M20C/D
- High intensity general purpose beam line: Helios, Omni, SFUMU, Omni', Lampf, Virgin (VSU DR),
- Dual beam line with (or without) MORE

Muons on Request (MORE)



http://lmu.web.psi.ch/facilities/more.html

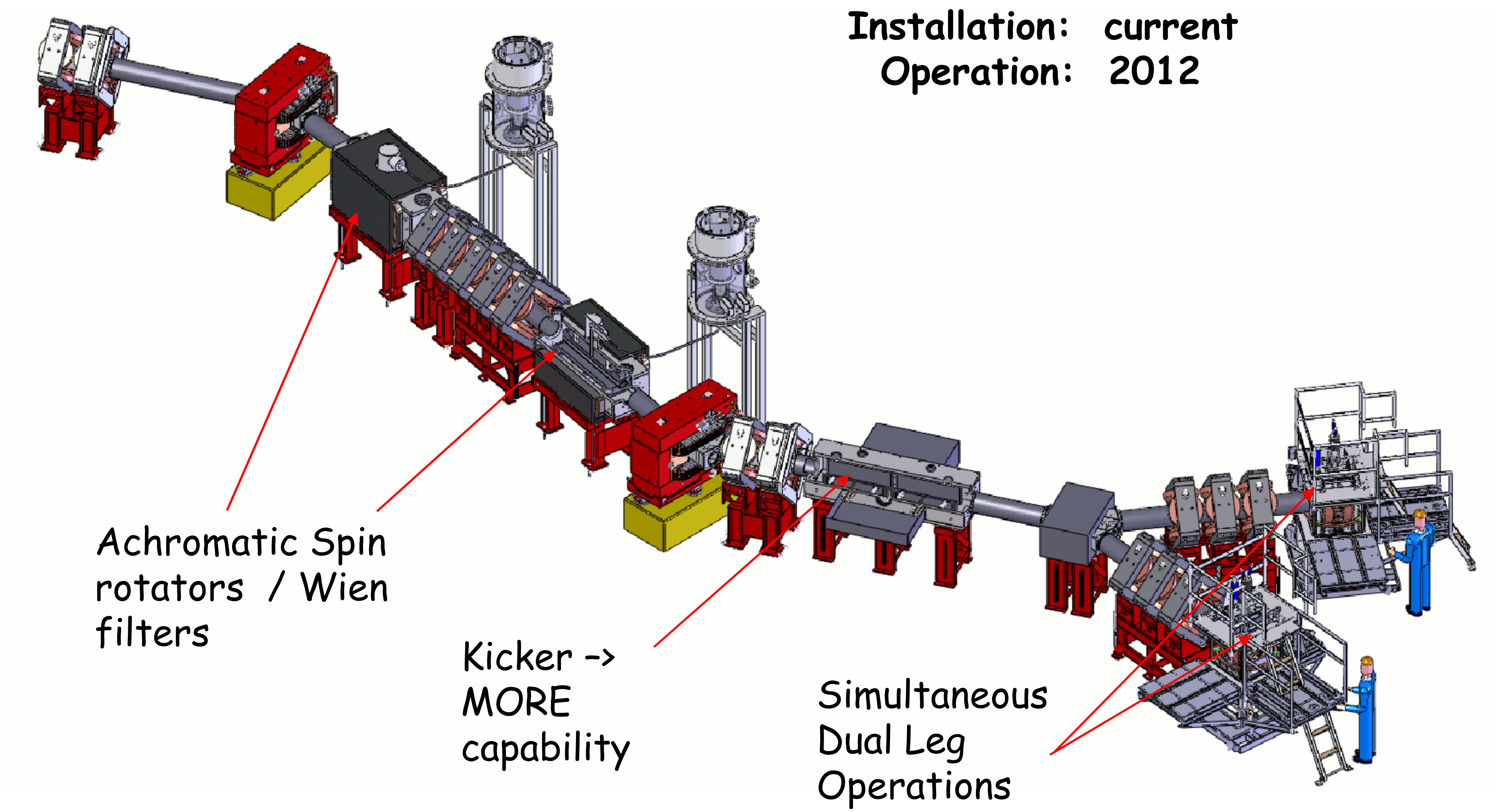
M9A
- Generalized condensed matter spectrometer: 3T magnet /w axial (TF) & side (LF) access
- Single beam line with MORE

M9B
- Decay μ+/-
- Spin rotated Pμ>80MeV/c

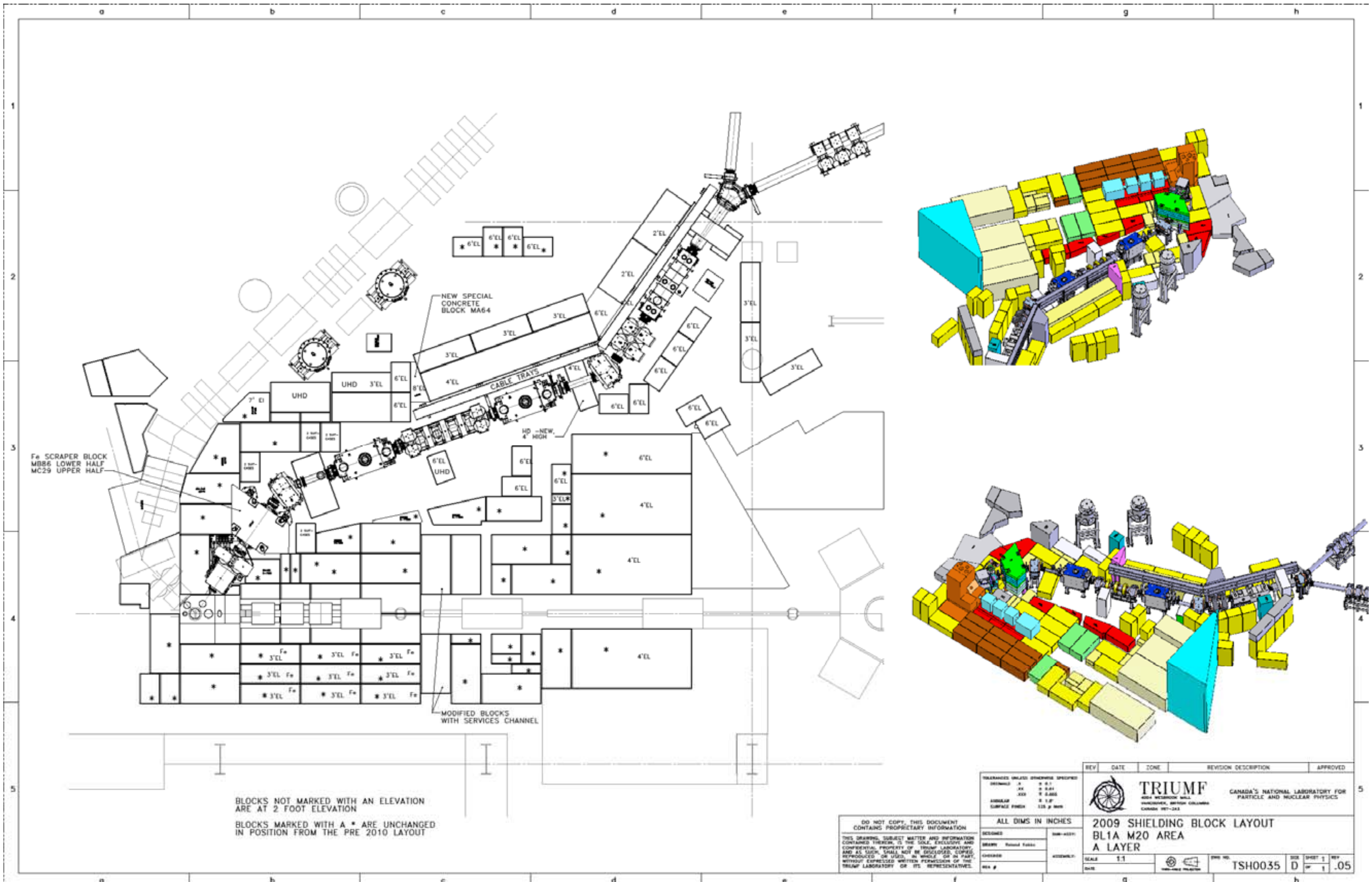
- ~Dual operation with M9B @ 60MeV/C pions

TRIUMF Centre for Molecular and Materials Science

The New M20s in Theory



Layout /w shielding of new M20

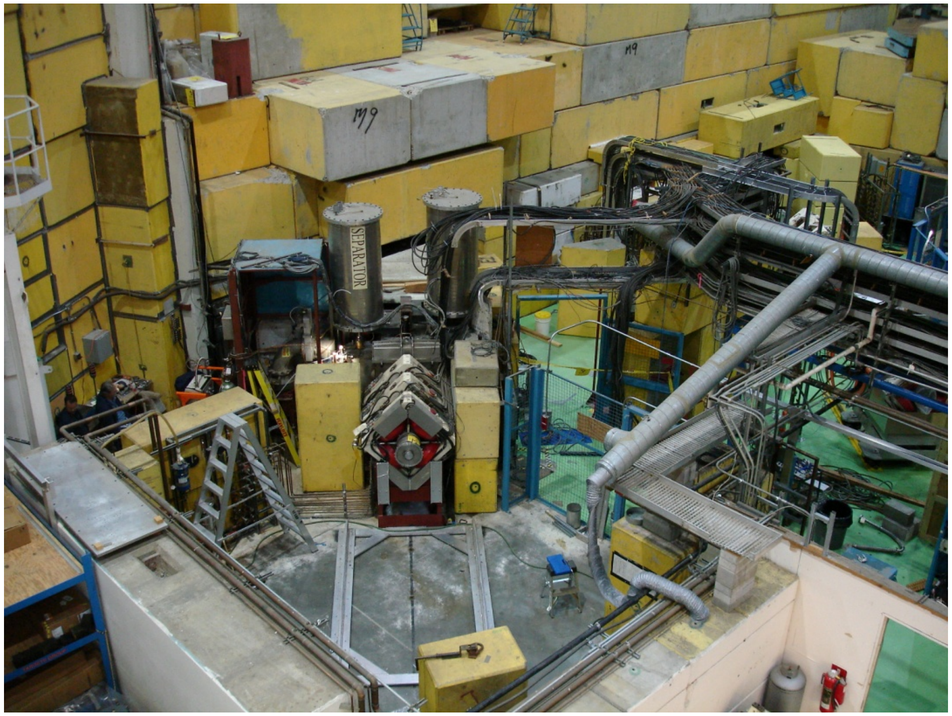


The M20s in Reality

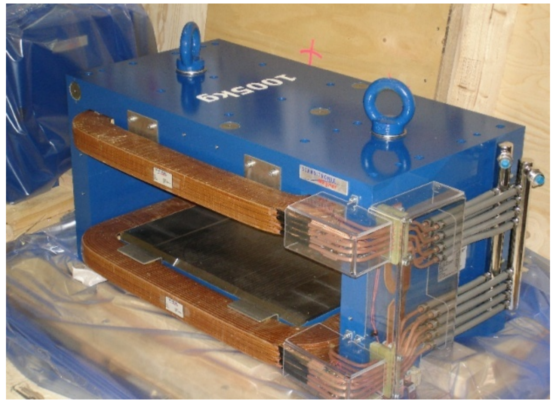
Present

and

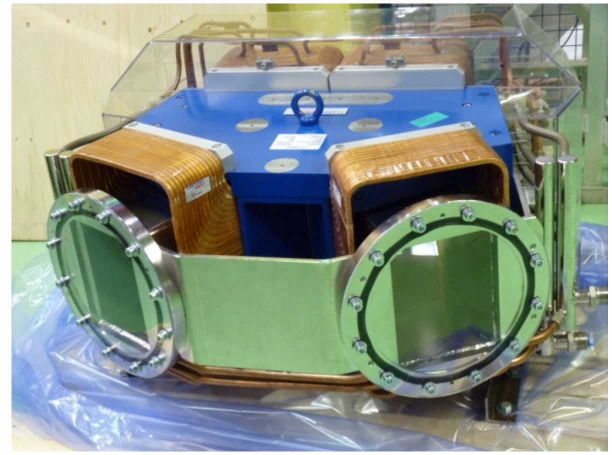
Old



Some new M20 Major Bits & Bites



Two dipoles



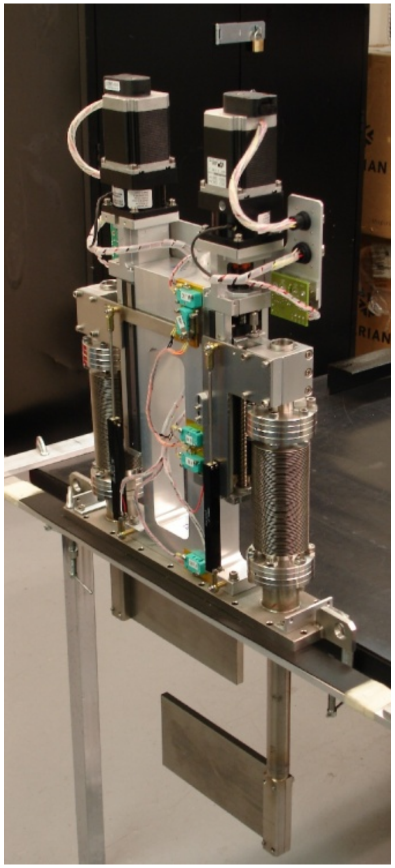
Septum magnet

Massive Iron Shielding

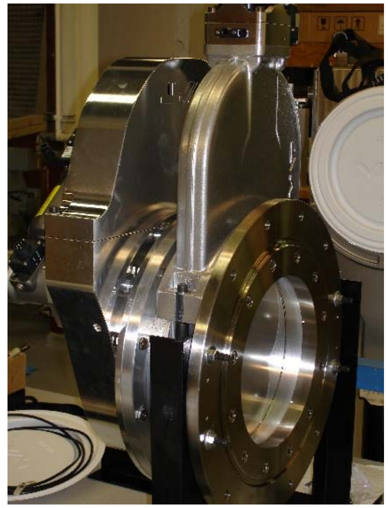
Eight quads

Wien Filter

new M20 Bling & Blingers



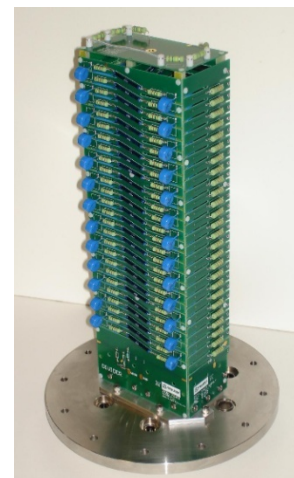
Adjustable Slits
Assemblies



Beamline Gate & Window
Valve Assemblies

High Stability (.01%)
Dipole Power
Supplies

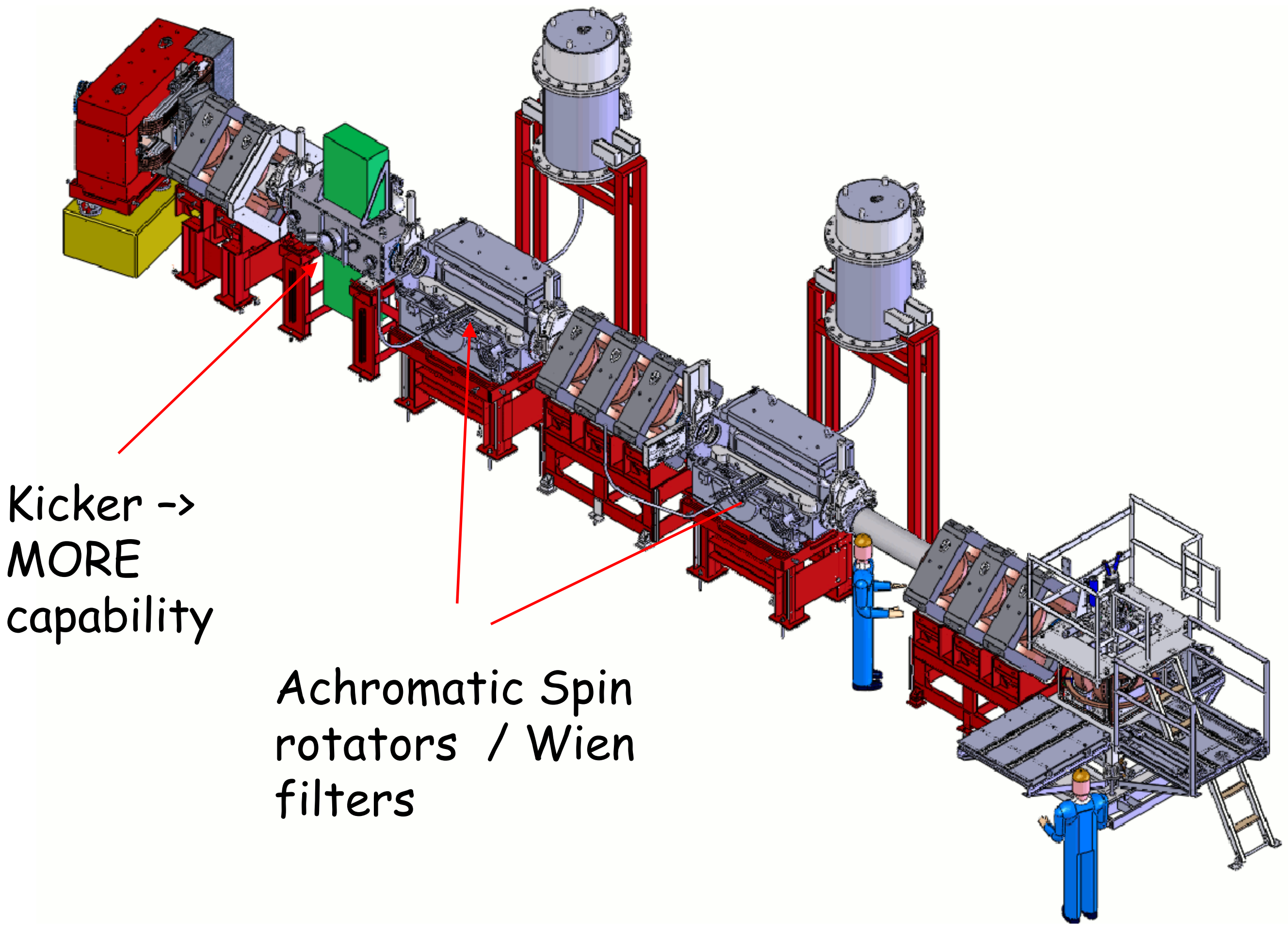
The Usual
Suspects



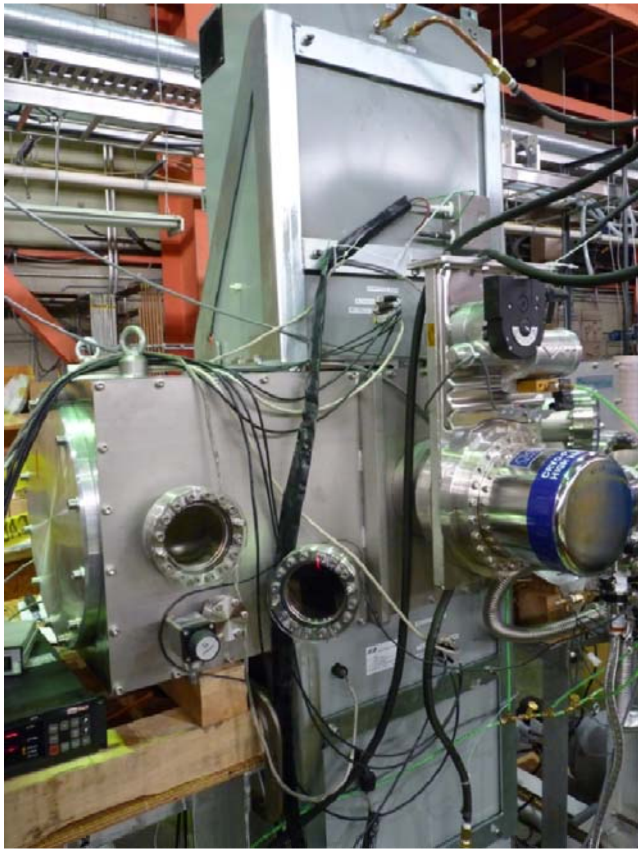
±210kV Wien Filter
Power Supply Stacks

The New M9A

Installation: current
Operation: 2012



M9A new Devices



Fast Electrostatic Kicker

1. ± 0 ↔ ± 10KV/8cm Electric Field generation
2. Rise & Fall time total latency 200ns from control pulse

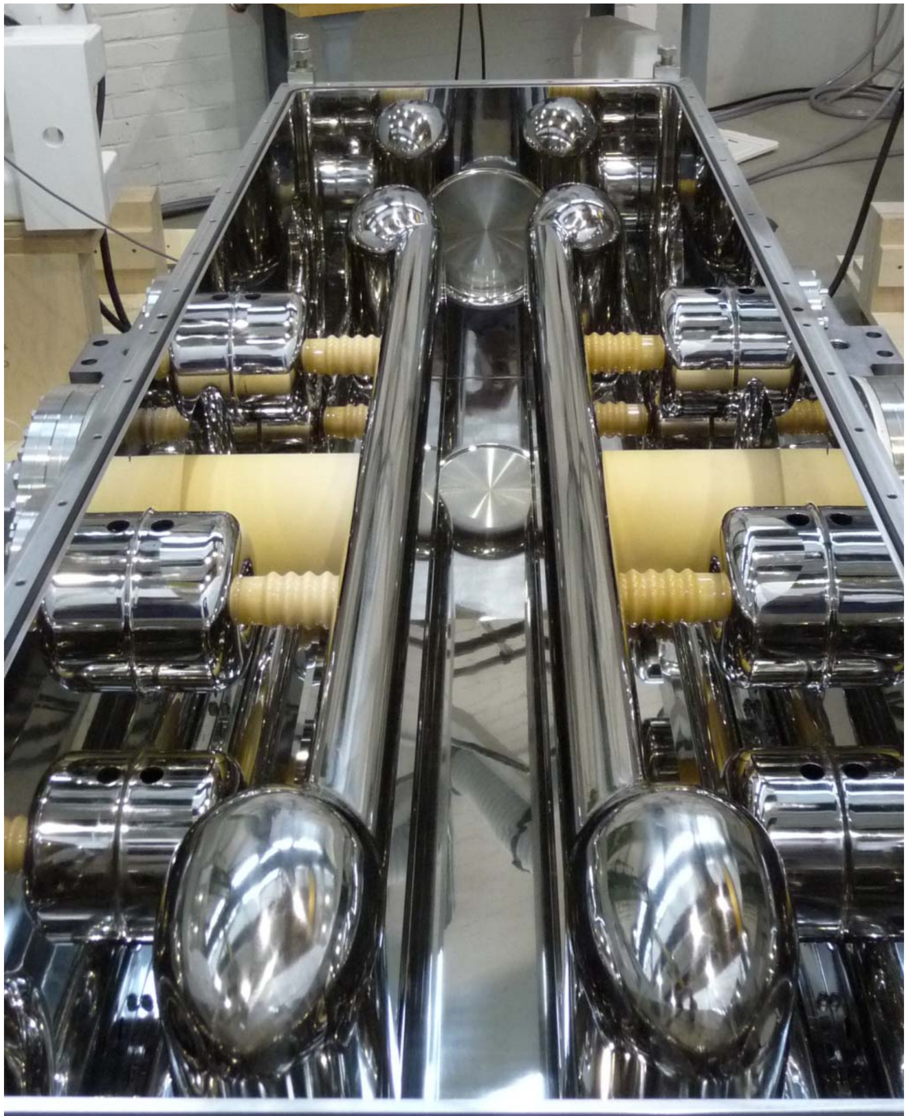
Wien Filter/Spin Rotator

1. 65KV/cm E-Field design limit
2. SF6 insulated feed throughs
3. 42.5KV/cm between pTi lates
4. Conditioned to ±270KV/12cm at TRIUMF in ~36 active hours
5. Extended design, fabricate and debug cycle (honorable mention PSI's Thomas Rauber and Konrad Deiters for assistance)

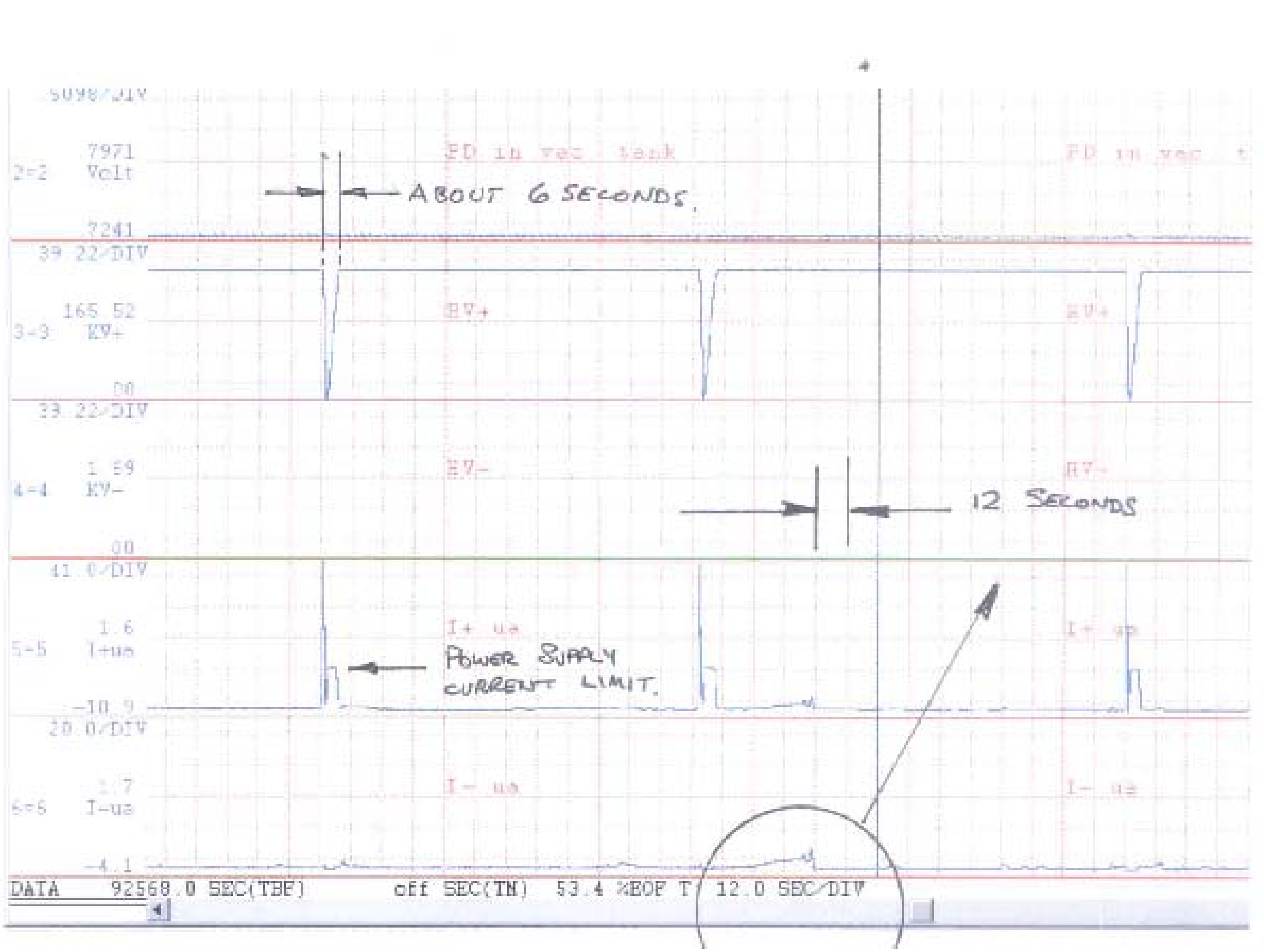
← What's under the hood

Now testing in the M15 area

The Beauty … nice Curves, n'ect pas?

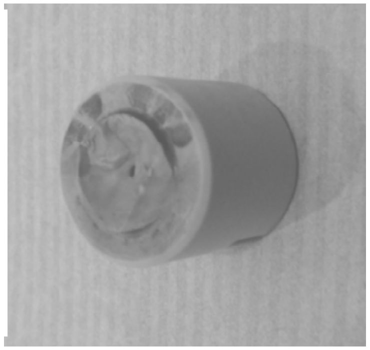


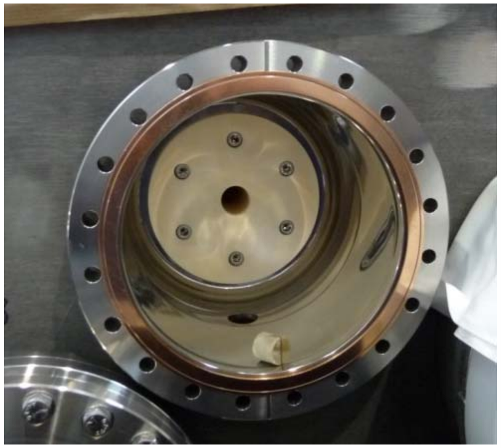
Or the Beast ?



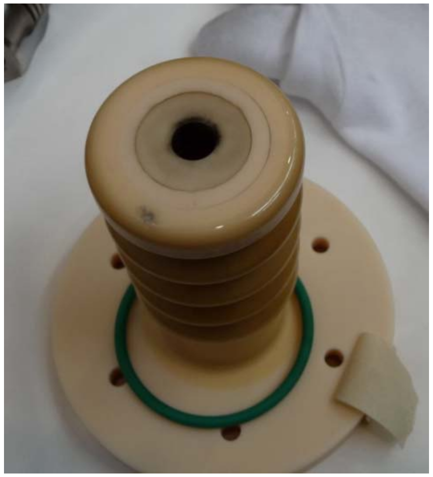
ABOUT 6 SECONDS.
12 SECONDS
POWER SUPPLY
CURRENT LIMIT.
7971
Volt
7241
165.52
KV+
1.6
I+ua
-10.9
I-ua
-4.1
FD in vac tank
HV+
HV-
I+ ua
I- ua
DATA 92568.0 SEC(TBF) off SEC(TN) 53.4 %EOF T 12.0 SEC/DIV

with its… explosive temperament



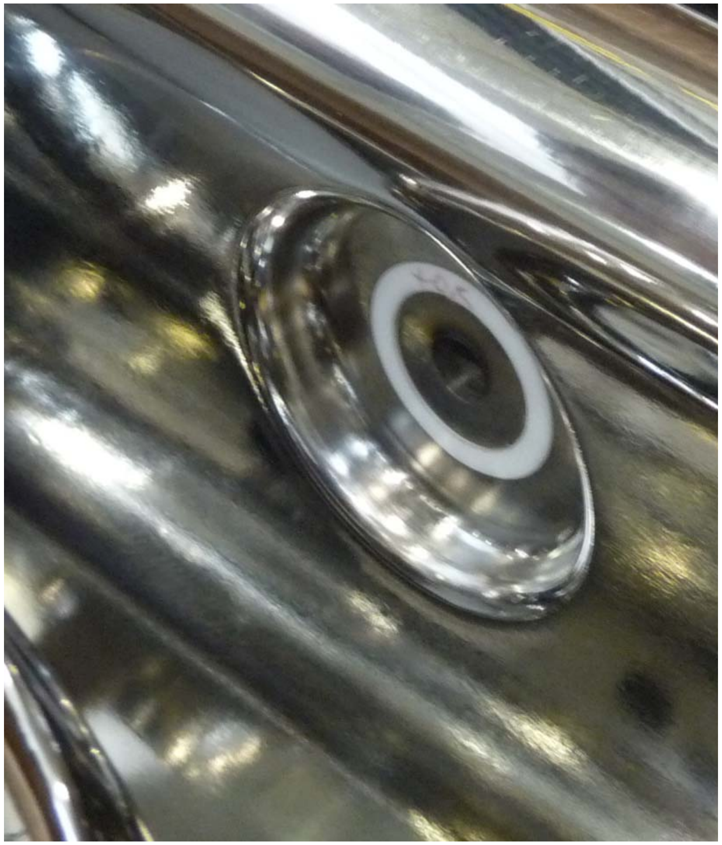


and the clandestine Culprit



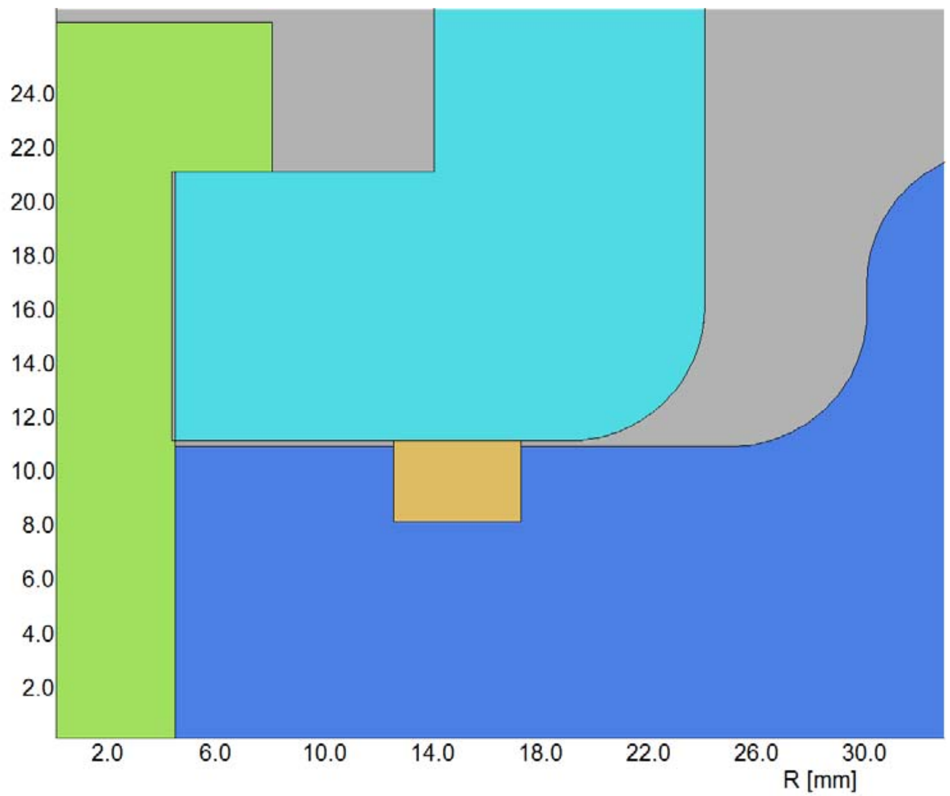
Ceramic standoff insulator

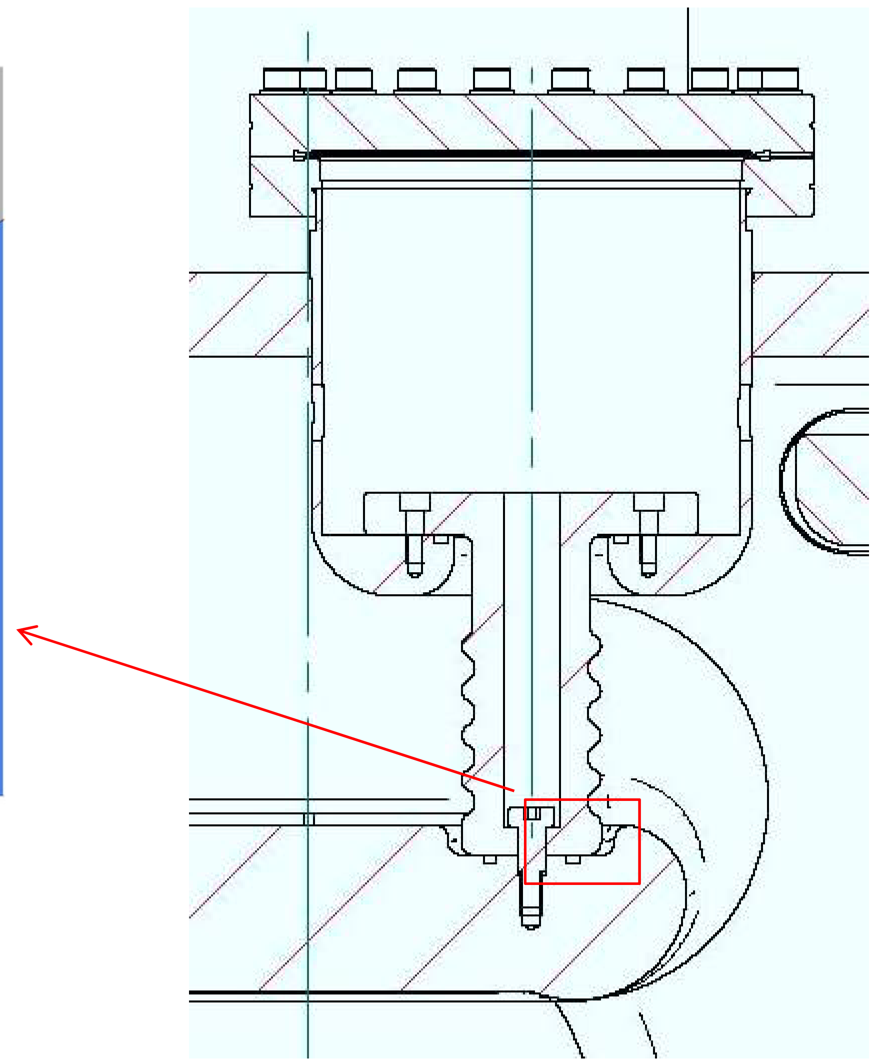
Teflon spacer & discharge marks



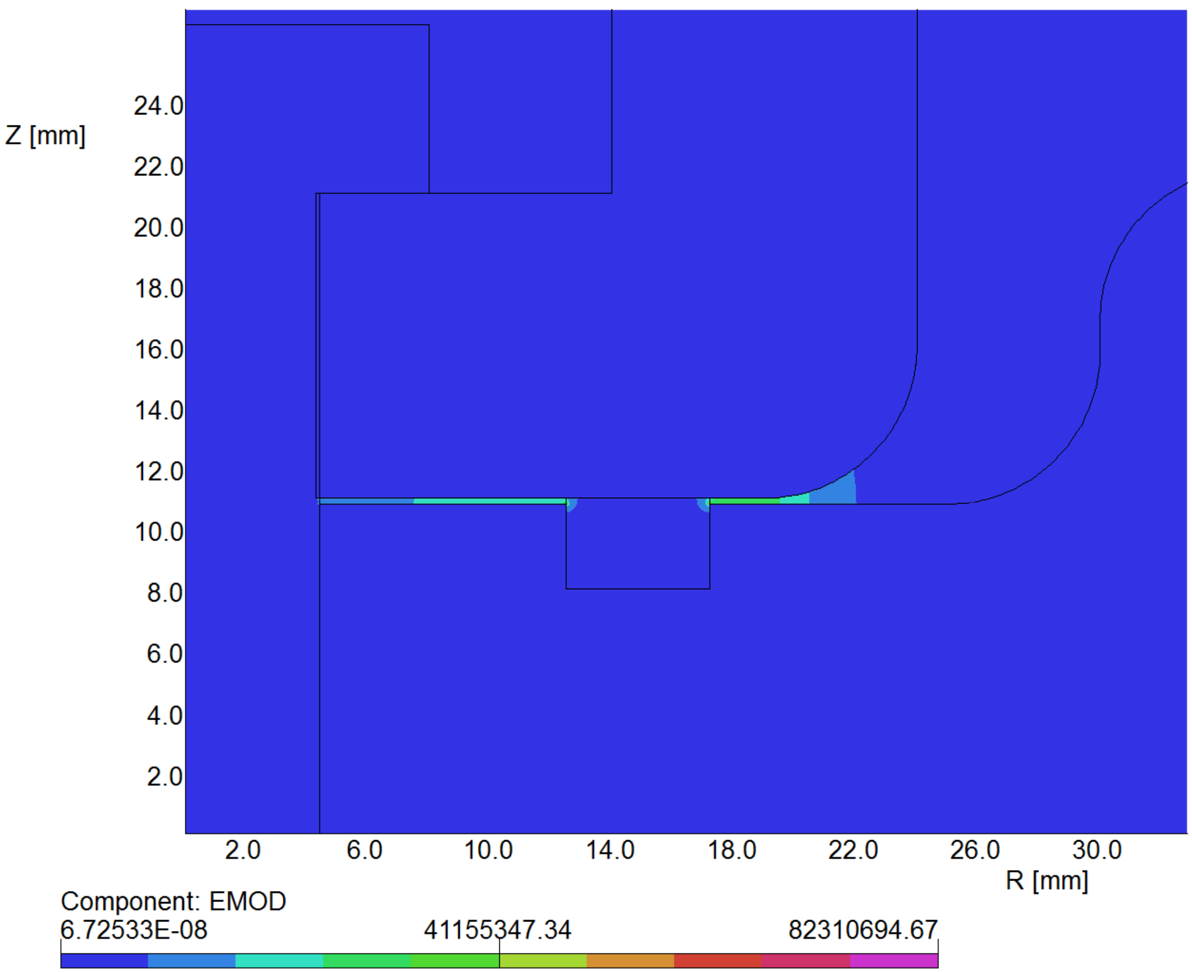
Inadvertent "engineering" /assembly contamination

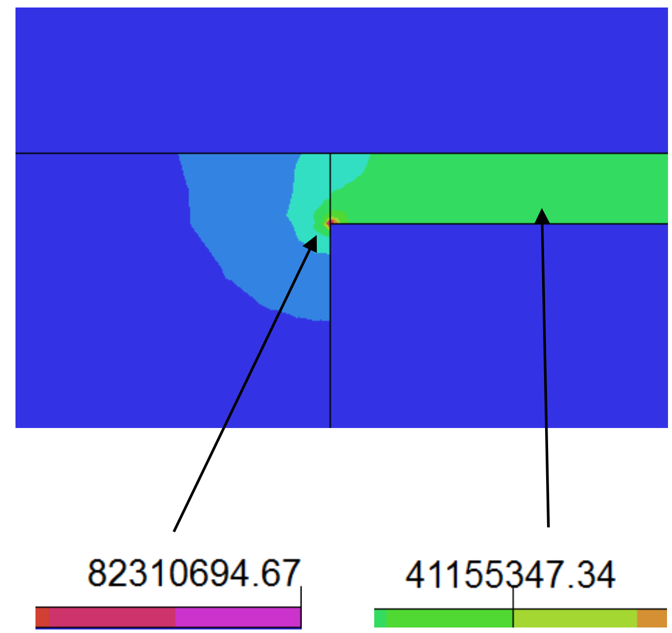
viz. the (hidden) anatomy of a Triple Point





Pushing to a Mega-V/cm, ouch *!*

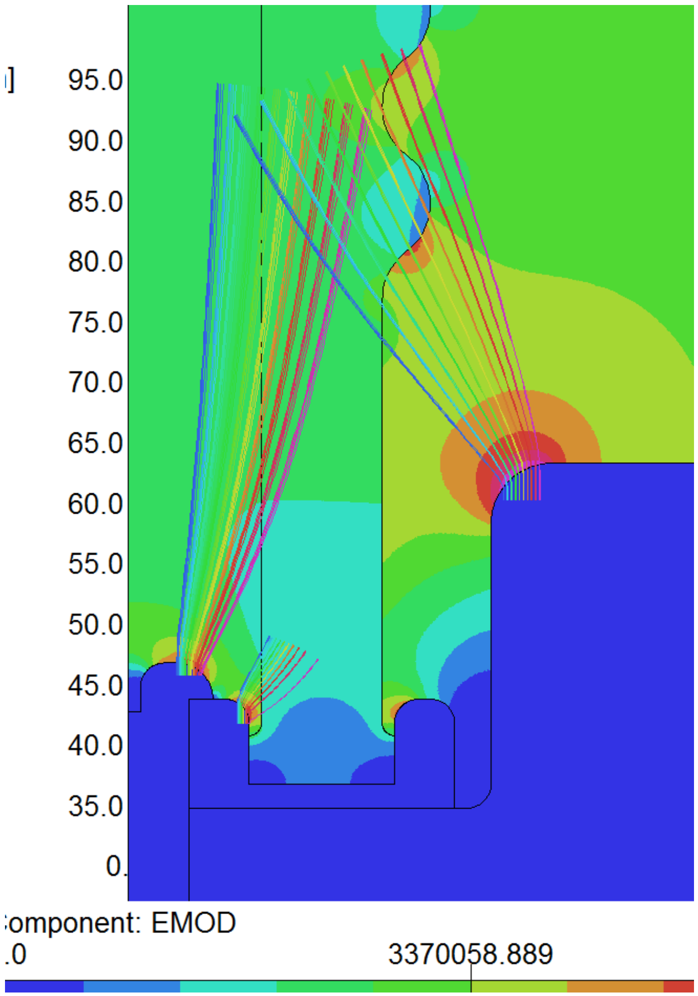


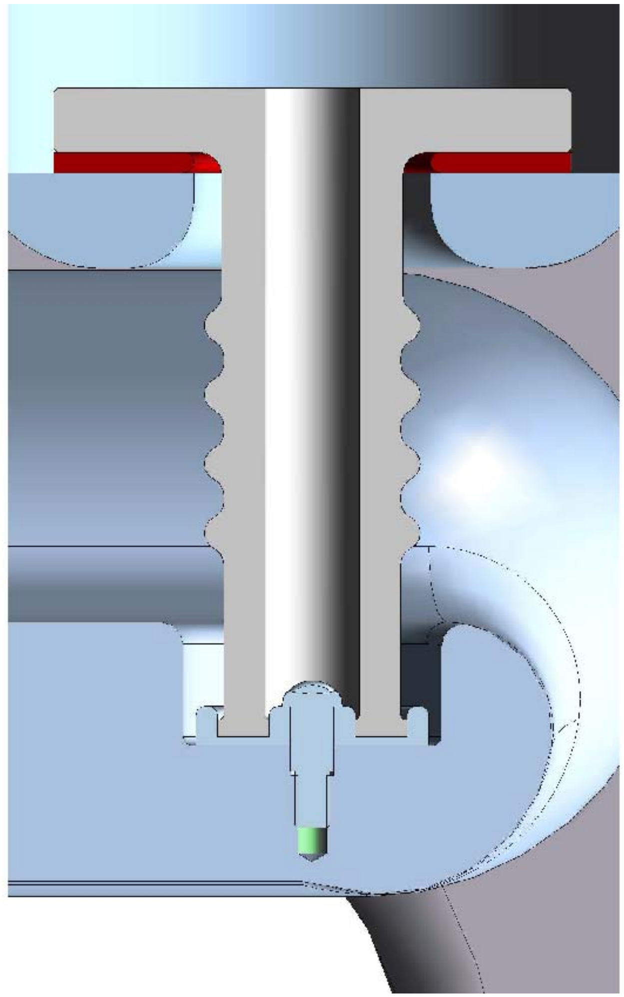


~ε x gap voltage

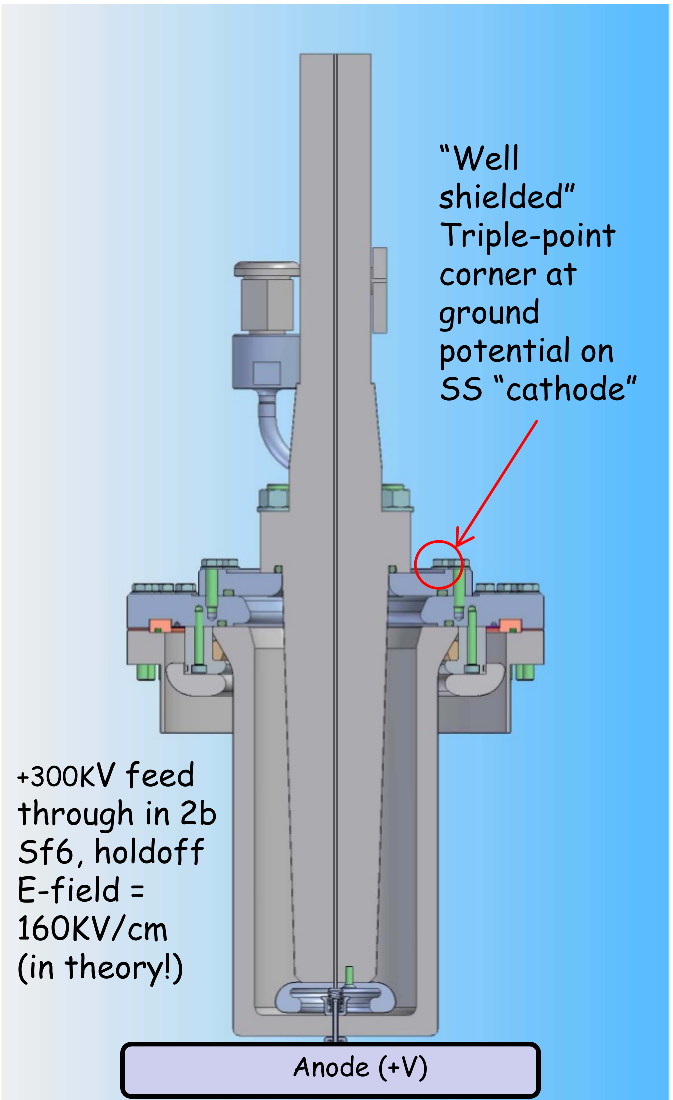
Desgin … Design … Design

via Bassam Hitti

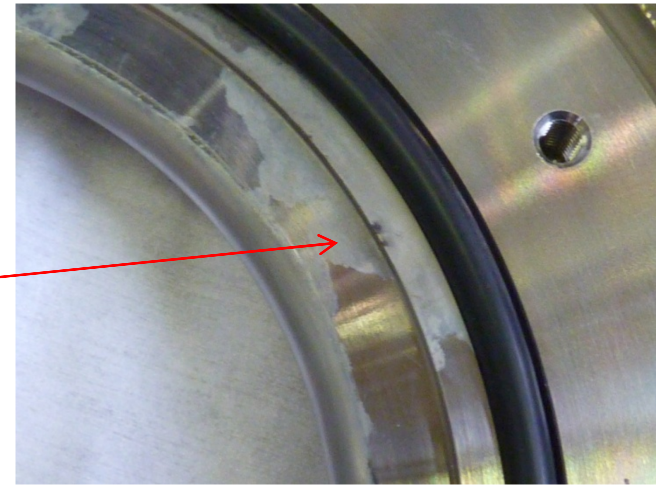


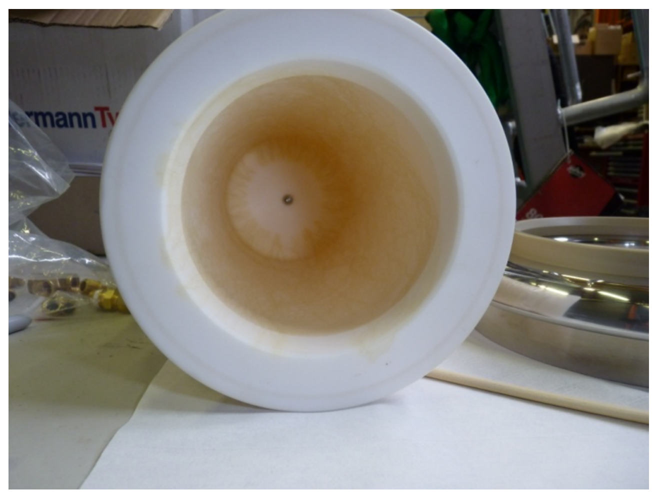


also, Beware of lurking Triple Points at Ground Potential



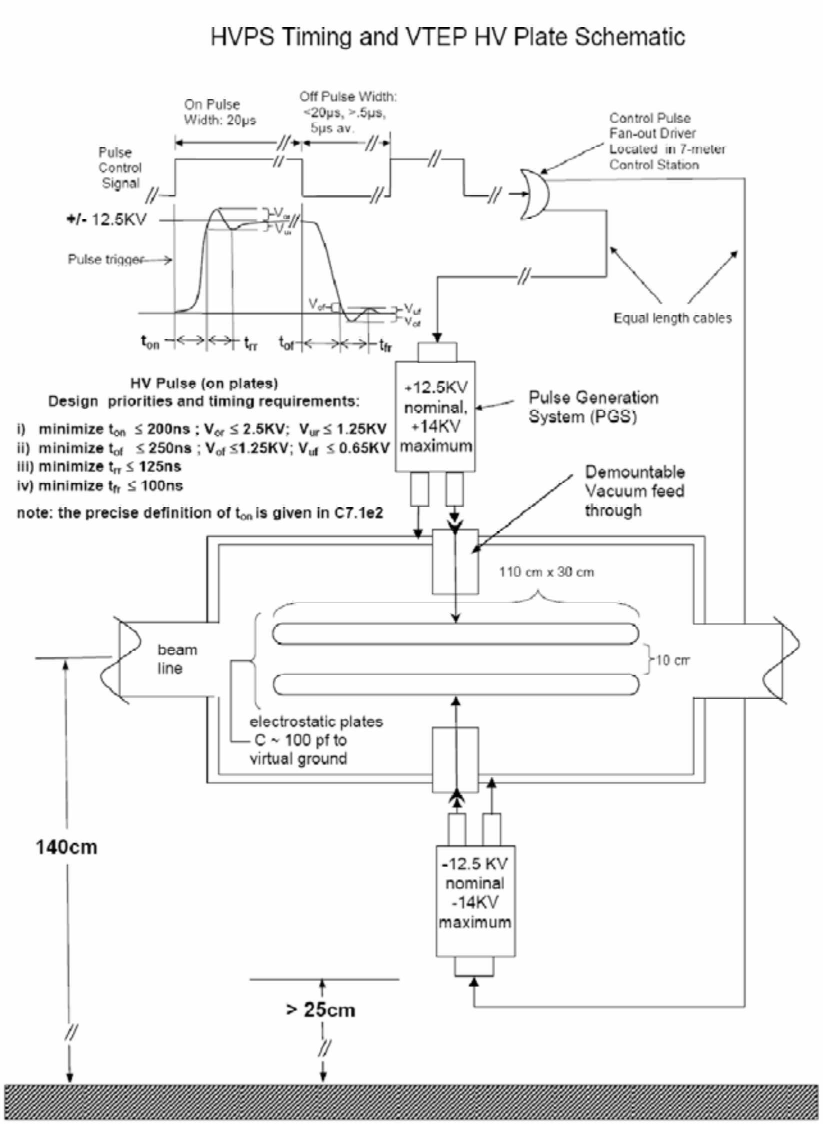
Arcing "burn & discharge" marks on rim of ground flange

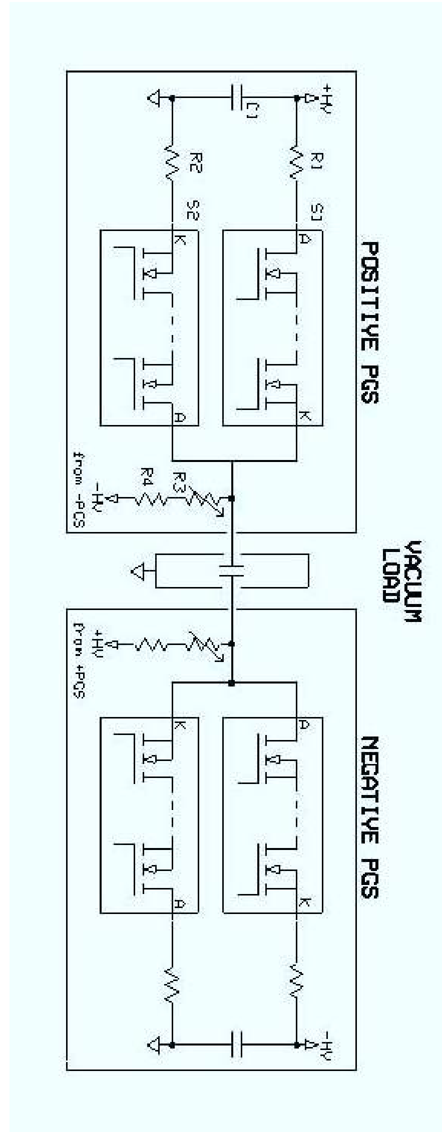




Tracking (i.e. surface flashover) and SF6 decomposition marks in interior of feed through

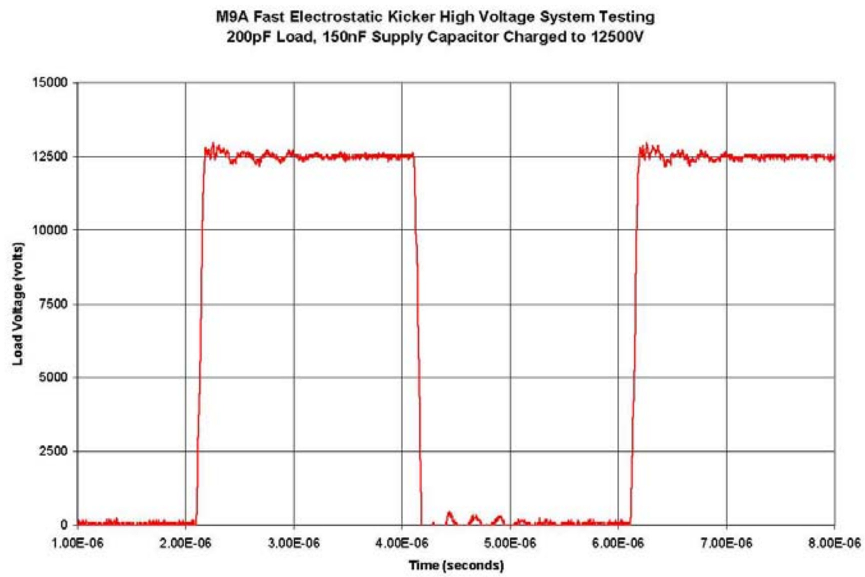
M9A Fast Electrostatic Kicker Timing & Schematic

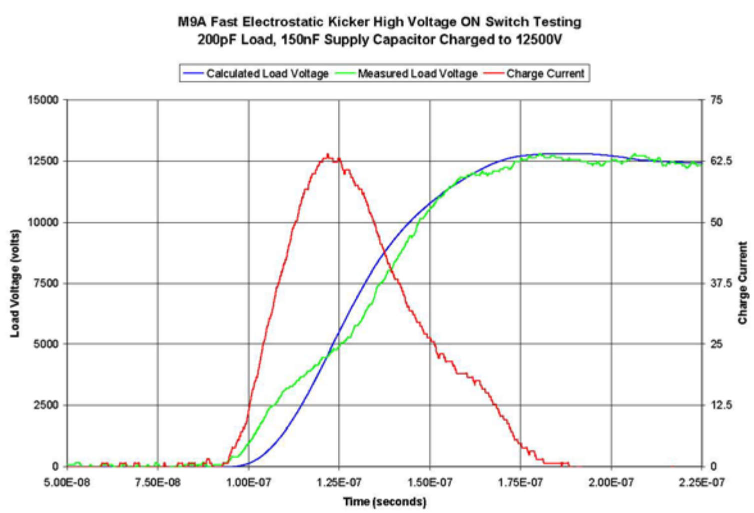


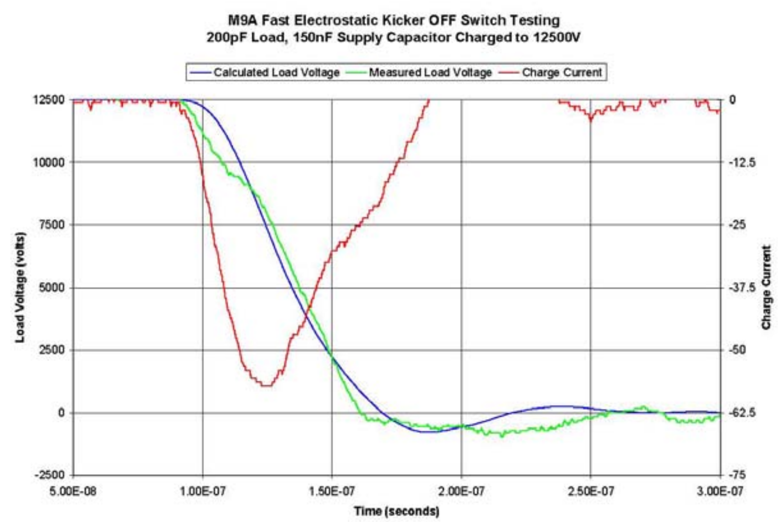


CMMS

Kicker Testing Performance







is appealing and looks nice, but

easily
undergoes
a
metamorphosis
into

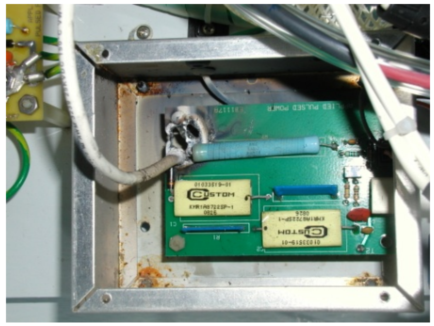
The Big Corona

Credit & Copyright: Fred Espenak (NASA /GSFC)

Or, what a 40Kz, 6×10^{10} dV/dt Kicker is Really Really Like

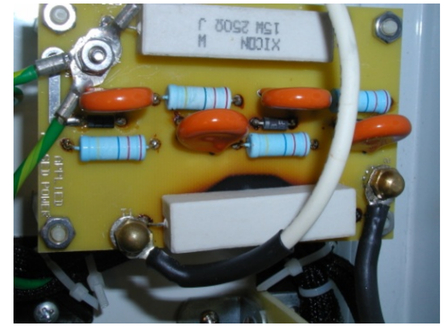
(during development)

V monitor 6/2009

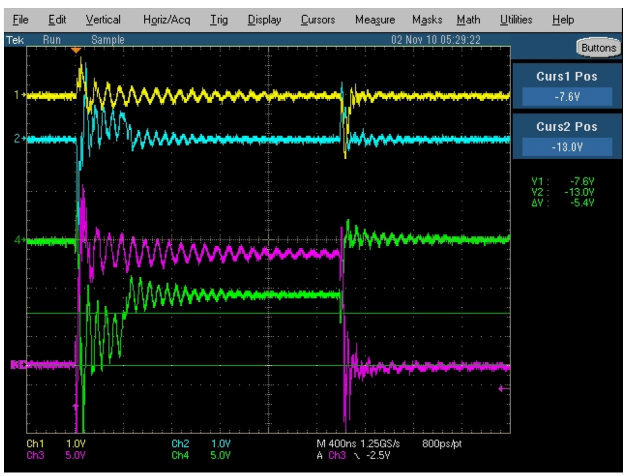


V monitor 12/2009

RF Distribution 1/2010

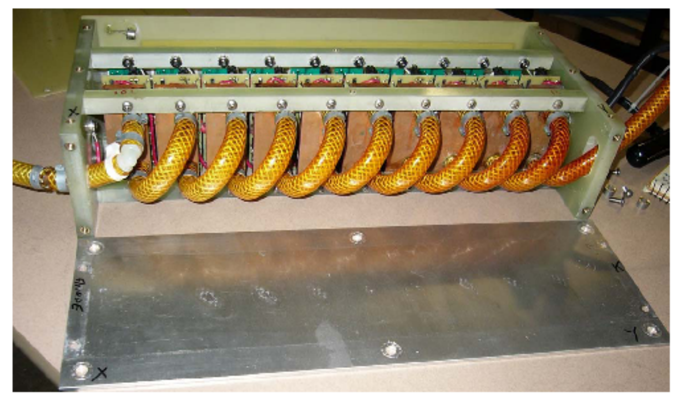


HV Conditioning Board 6/2010



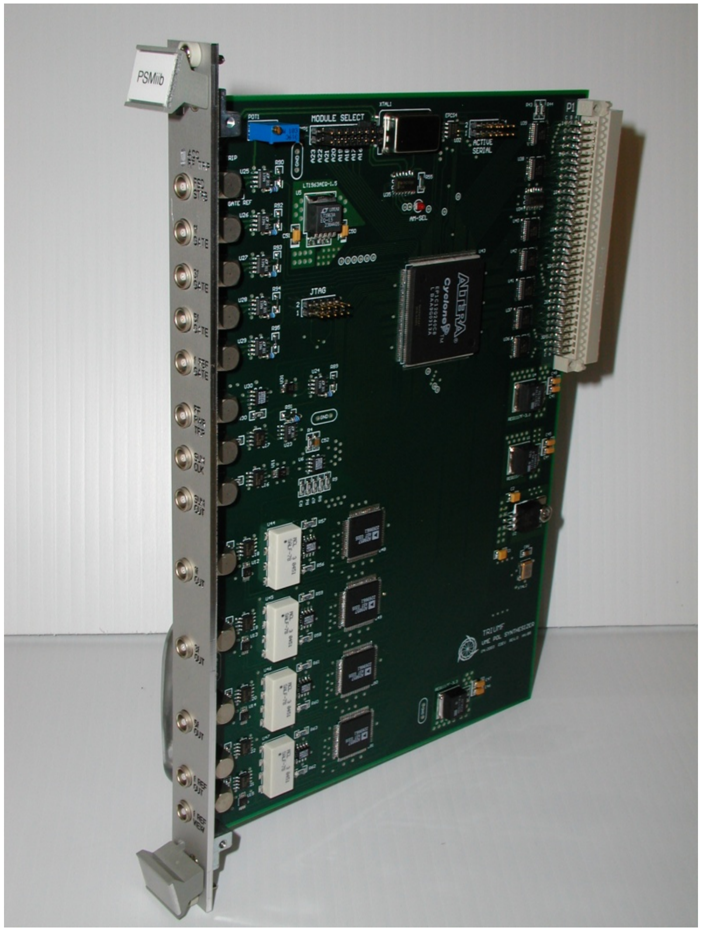
V- off switch 10/2010

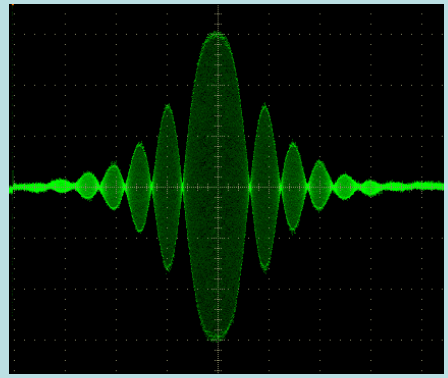
V- HV Relay Resistor 10/2010



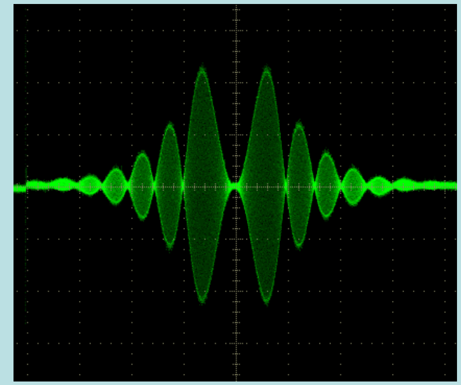
V- On / OFF Switch Hose & Arcing circa 11/2010 after ~1000 hours operation

for βNM/QR crowd, a nice toy to have



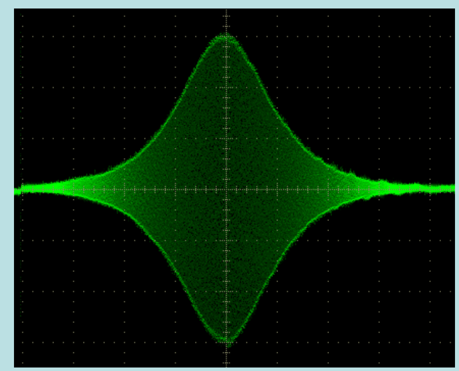


+



Complex Ln-sech adiabatic inversion amplitude/frequency modulated pulse

=



$$sech(bt)\cdot\cos[u\cdot\ln(sech(bt))] + i\cdot sech(bt)\cdot\sin[u\cdot\ln(sech(bt))] = sech(bt)(1+iu)$$

βNM/QR RF Digital Frequency Synthesizer developed by the TRIUMF Electronics Group

TRIUMF Centre for Molecular and Materials Science

CMMS

The old CMMS MuSR DAQ System

The *Most Time Consuming Problem* with the old system stems from the incontrovertible and irreconcilable circumstance that

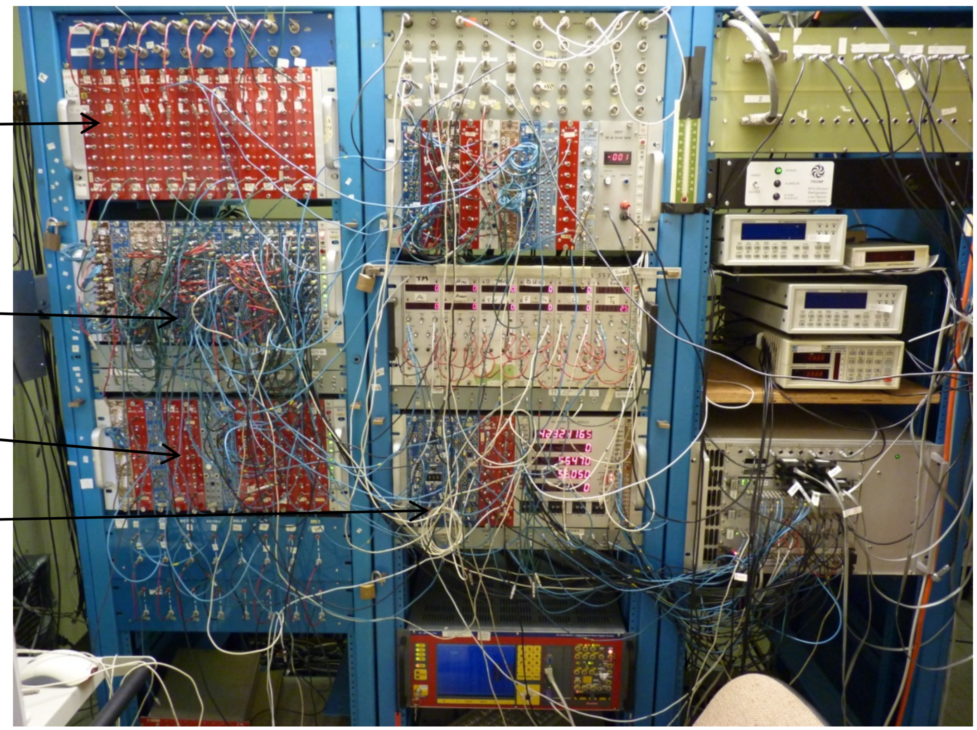
Human Life Requires Oxygen

Delay line toggle switches

Coincidence unit push button definitions

More delay line switches

In fact … any *fuddle-duddling** switch



* Pierre Trudeau circa 1971. Note: When the Right Honorable Trudeau visited TRIUMF 1n 1979 to christen the lab he said (according to DF's elephantic memory): **"I don't know what a cyclotron is, but I am sure glad we have one"**.

Toward a New MuSR DAQ System

Requirements:

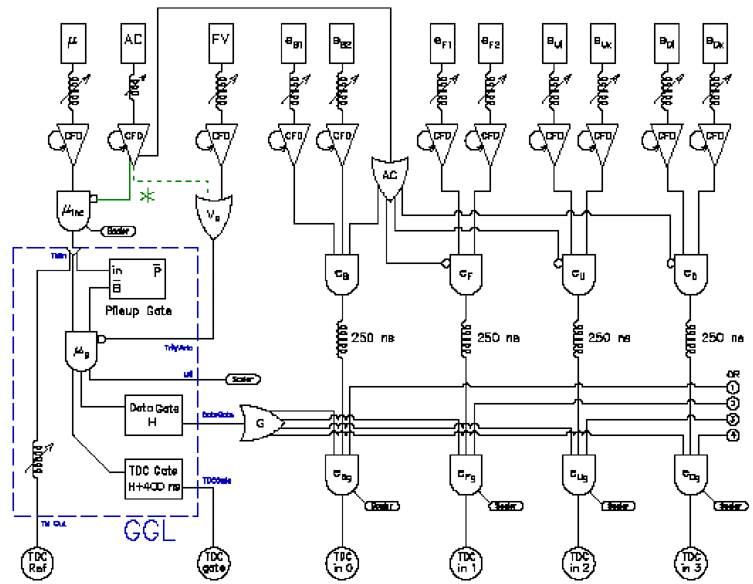
i) Switchless
ii) Software Configurable
 (for all Spectrometers)
iii) Variable Electronic Delay Lines
iv) Debuggable
v) Small physical footprint
vi) Easy migration path from
 current hardware

To Get There:

i) Front end configurable delays
 (0-8ns to feed hardware coincidences →
 only one hit/channel for a good event)
ii) Fast hardware coincidences /w
 leading edge veto
iii) Continuous time stamping TDC
 with fast second hit rejection
iv) Everything else in software

Current OTS technology can do all this!

Wiring logic for side—access μLB



TIMING:
1) Set AC to a moderate delay
2) Adjust μ to be vetoed by AC (at GGL or at μ_{inc})
3) Adjust FV to veto μ_{inc} at GGL
4) Adjust each e telescope to match AC

*) AC may veto either μ—stop or μ—gated, depending on which problem is worse: If too many muons scatter off the edge of the hole in the AC to stop in the μ counter, then the AC should veto μ_g (fan in with FV). Usually, the bigger problem is that some decay positrons trigger the μ counter, causing a "step" at early times; then the AC should veto μ_{inc}.

MuSR DAQ in a single VME CRATE
(similar but simpler than PSI's configuration)

The SiPM call of the Sirens
to enthrall an new generation of
MuSR Detectors & Spectometers

Current Detector issues:

1. PMT based … generally cannot operate in a magnetic field →
   a) long light guides
   b) so-so timing resolution
   c) bulky assembly and shielding requirements
2. If mesh-dynode PMTs are used (<5 KG) to get closer for shorter light guides and better timing resolution:
   a) expensive (>3K each)
   b) still require relatively low fringe fields … i.e. either small magnets (High Time) or shielding (DR)
3. Photonis no longer in the PMT business
   (must pay the Hamamatsu piper … ~x2 cost for TRIUMF standard PMT)

Typical specs for a SiPM*:

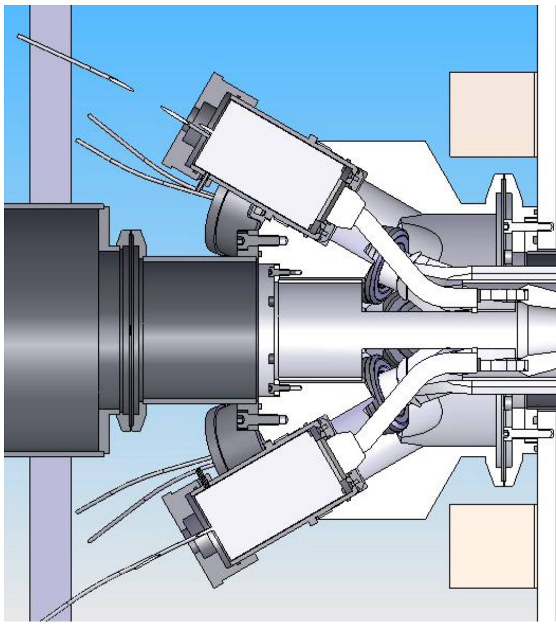
1. Total quantum efficiency~ 50%; > PMT
2. Gain (G) is also similar to a PMT ~ 10^6.
3. G vs Vb dependence is linear, does not follow a power law in the case of PMT
4. Timing jitter optimized to have a photon arrival time resolution < 50 ps
5. Signal decay time is inversely proportional to square root of photoelectrons number within an excitation event (less good than PMT)
6. The signal parameters are practically independent on external magnetic fields, contrary to vacuum PMTs
7. Small dimensions permits extremely compact, light and robust mechanical design

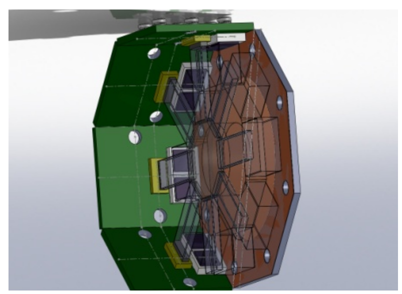
*http://en.wikipedia.org/wiki/Silicon_photomultiplier

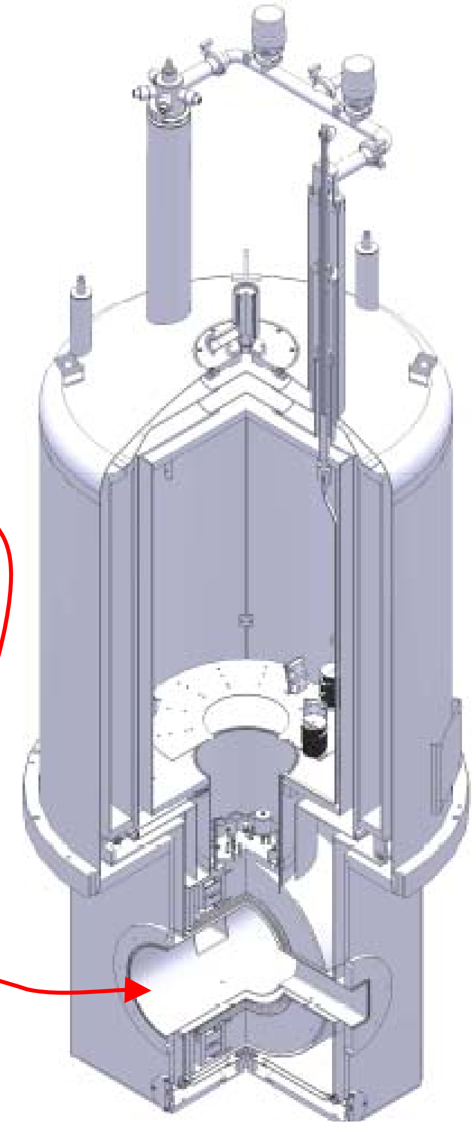
8. TRIUMF has SiPM uber expertise

The New Face of μSR Spectrometers

3T Superconducting, dual access port, ultra high homogeneity M9A magnet







Previously considered 2nd Generation High Timing Front End for new 3T Super-Omni Spectrometer destined for M9A. ...

… now will deploy SiPMT technology in the bore of the magnet

The Next 5 Years

For MuSR @ CMMS the way forward is clear:

1. Develop the (new) beam lines into highly automated and efficient science production facilities:
   a) new spectrometers with SiPM technology
   b) new DAQ system with "one click" set up and remote capabilities
   c) in house Helium liquefaction capabilities
2. Expand the user community with emphasis on those scientists which will benefit from using the technique as one (of many) available tools to conduct their research.
   a) devote an experienced outreach facility scientist to the task
   b) promote MuSR education with i.e. summer schools
   c) deploy "light" facility access procedures for occasional users
   d) increase facility staff levels to allow "full" support for new users

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

TRIUMF: Alberta | British Columbia | Calgary | Carleton | Guelph | Manitoba | McMaster | Montréal | Northern British Columbia | Queen's | Regina | Saint Mary's | Simon Fraser | Toronto | Victoria | York

Thank you!
Merci!