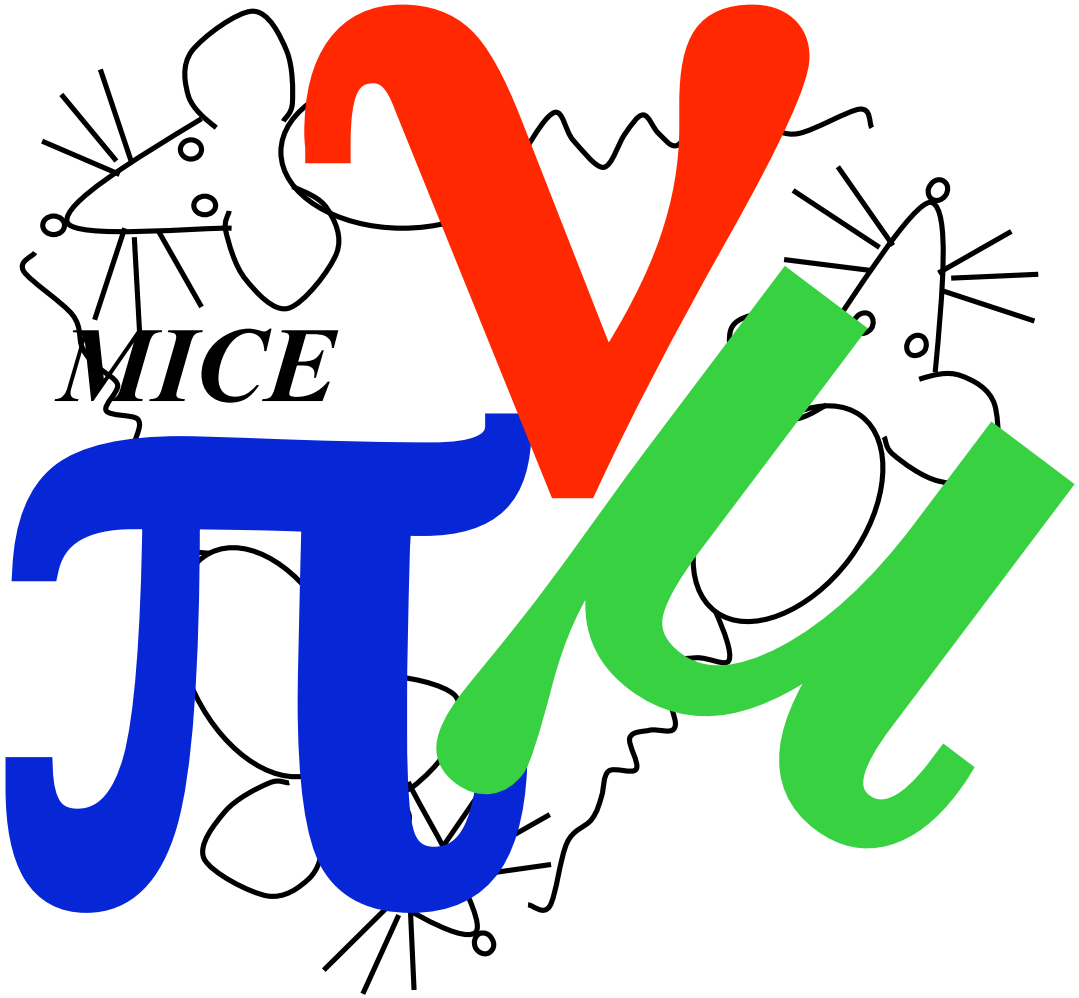
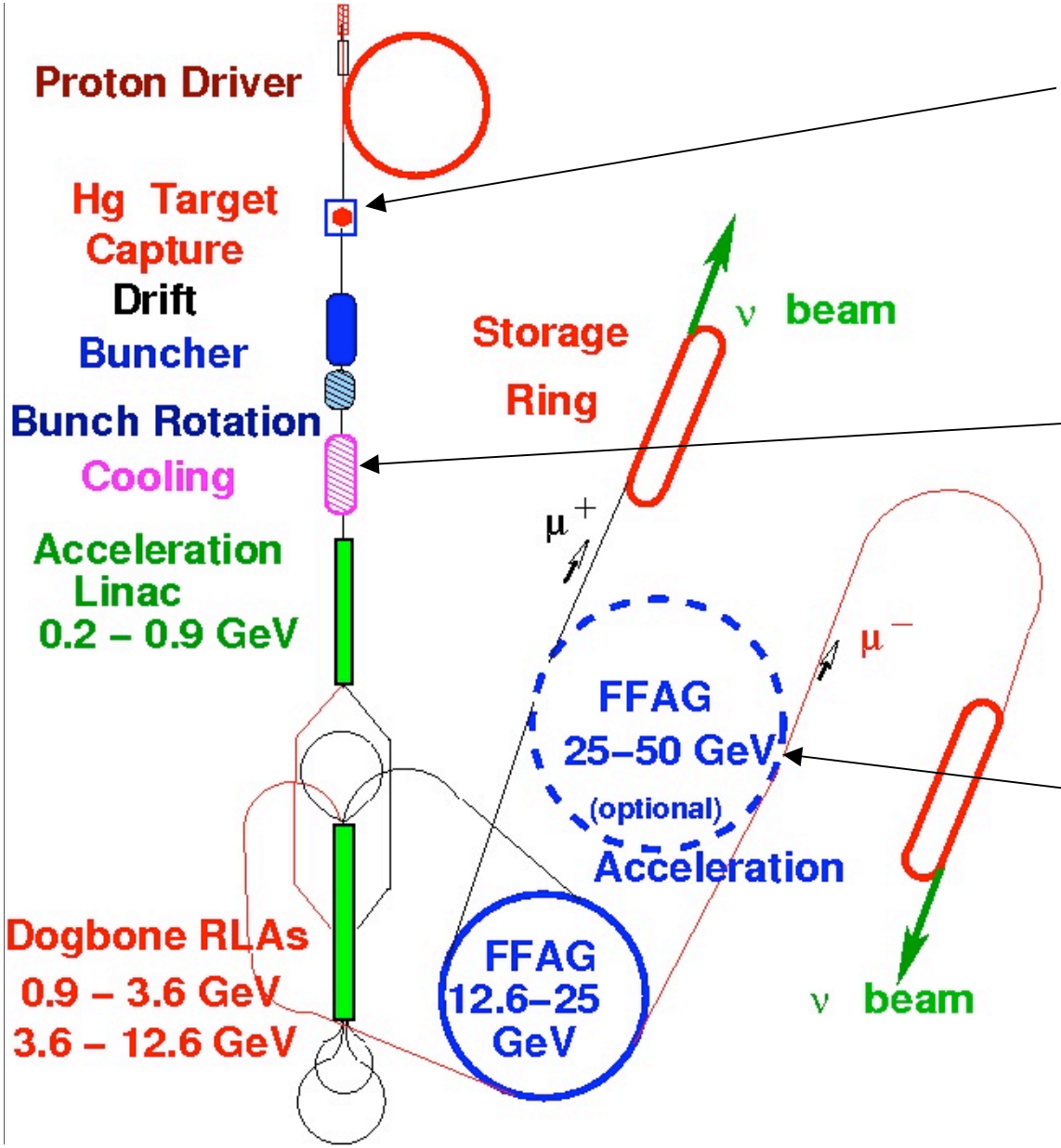
STATUS OF MICE



The International Muon Ionization Cooling Experiment

Major challenges tackled by R&D expts



High-power target
. 4MW
. good transmission
MERIT experiment (CERN)

Fast muon cooling
MICE experiment (RAL)

Fast, large aperture accelerator (FFAG)
EMMA (Daresbury)

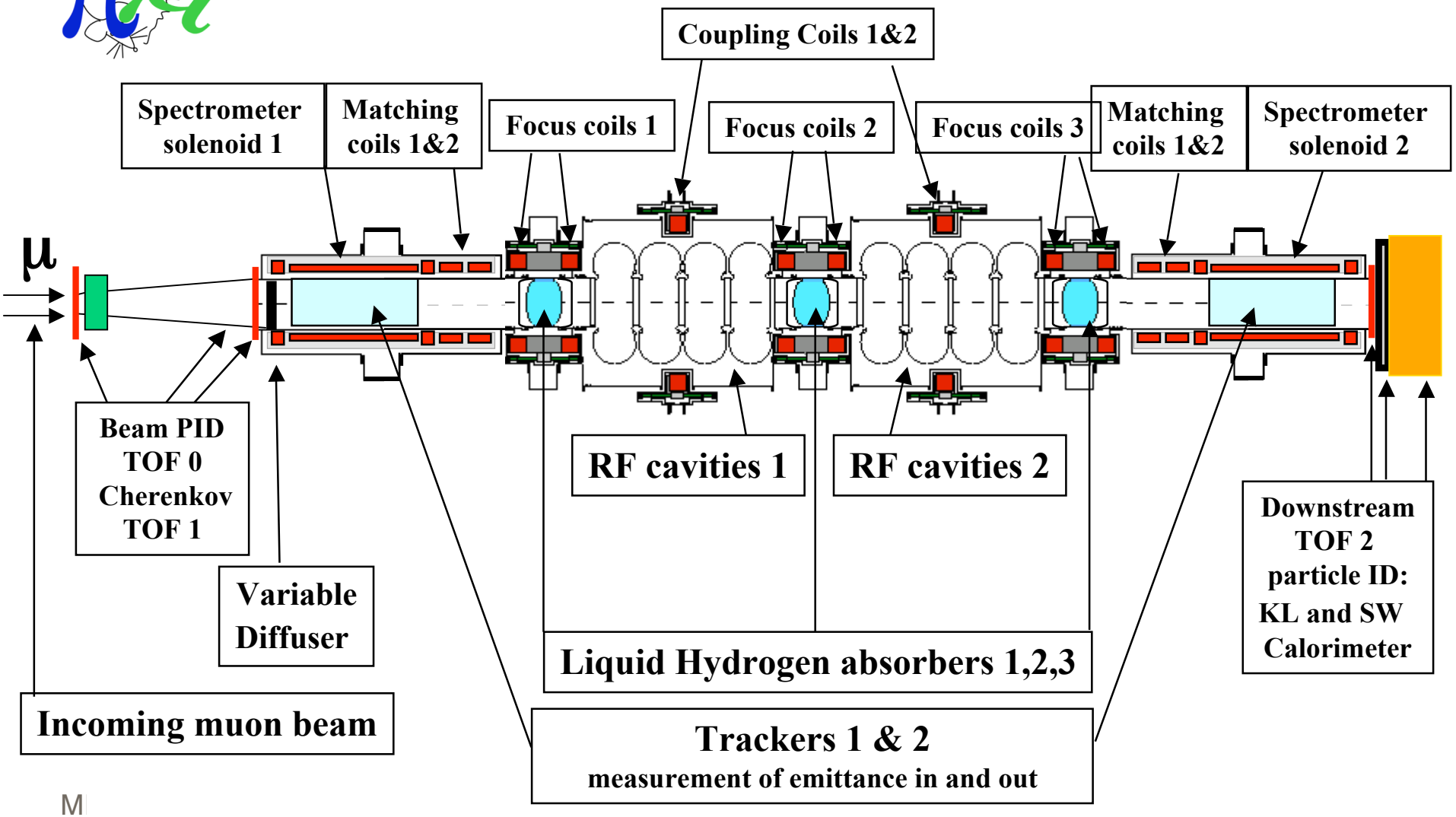
ISS baseline

10% cooling of 200 MeV/c muons requires ~ 20 MV of RF

single particle measurements =>

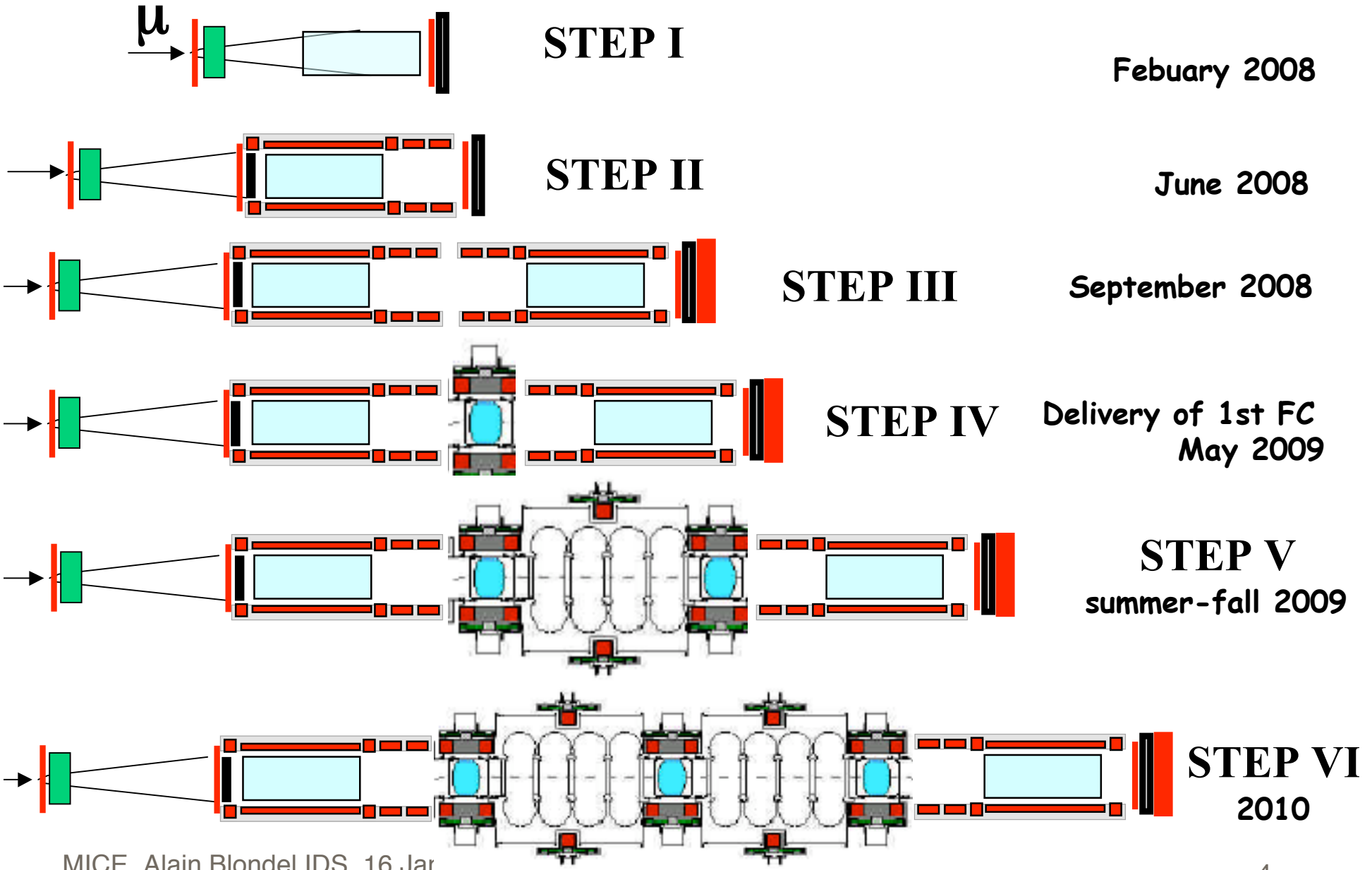
measurement precision can be as good as $\Delta (\varepsilon_{out}/\varepsilon_{in}) = 10^{-3}$

never done before either…



M

Aspirational MICE Schedule as of january 2008



Overview

MICE is about to begin the first steps.

Beam line construction is almost complete: hard limit set by closure of ISIS at end of January for ISIS exploitation run Feb 5- Mar 13.

Early February step I begins:
Main technical uncertainties concern the target, and the PSI solenoid
-- commissioning of target
-- establish operation mode with acceptable beam losses in ISIS
-- first test of beam line in pion mode
-- TOF0, CKOV,
-- beam line with quads, dipoles, but passive decay solenoid.
-- decay solenoid is in place, not connected to cryoplant yet. Expect first try in second half of February.
-- TOF1, KL and tracker will arrive in second half of February

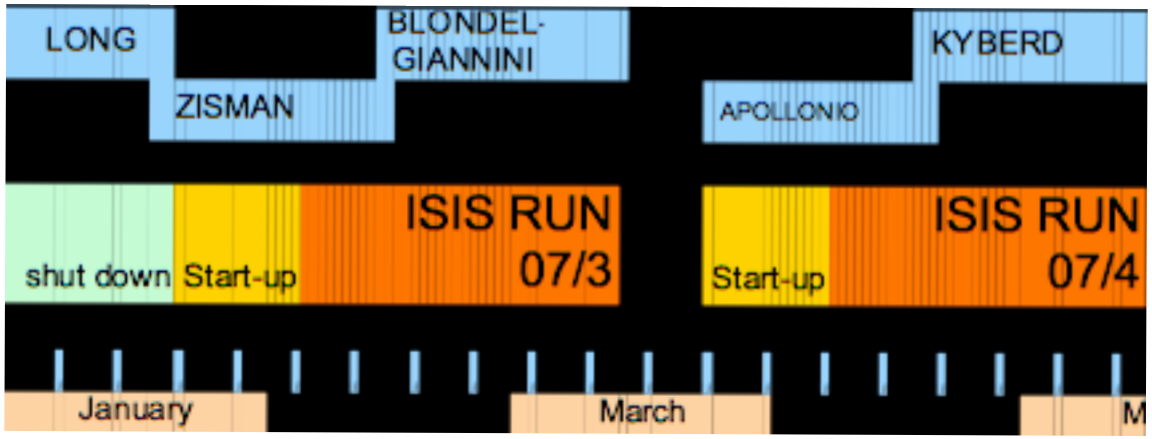
-- first spectrometer solenoid to arrive end of April ==> step II in June 2008.

-- thanks to the staging of MICE, damage to the overall schedule is limited

-- Funding has made substantial progress (especially in the USA) and the construction process for Phase II elements has begun. Worries for the UK PhaseII funding (focus pairs!)

MICE run 2008

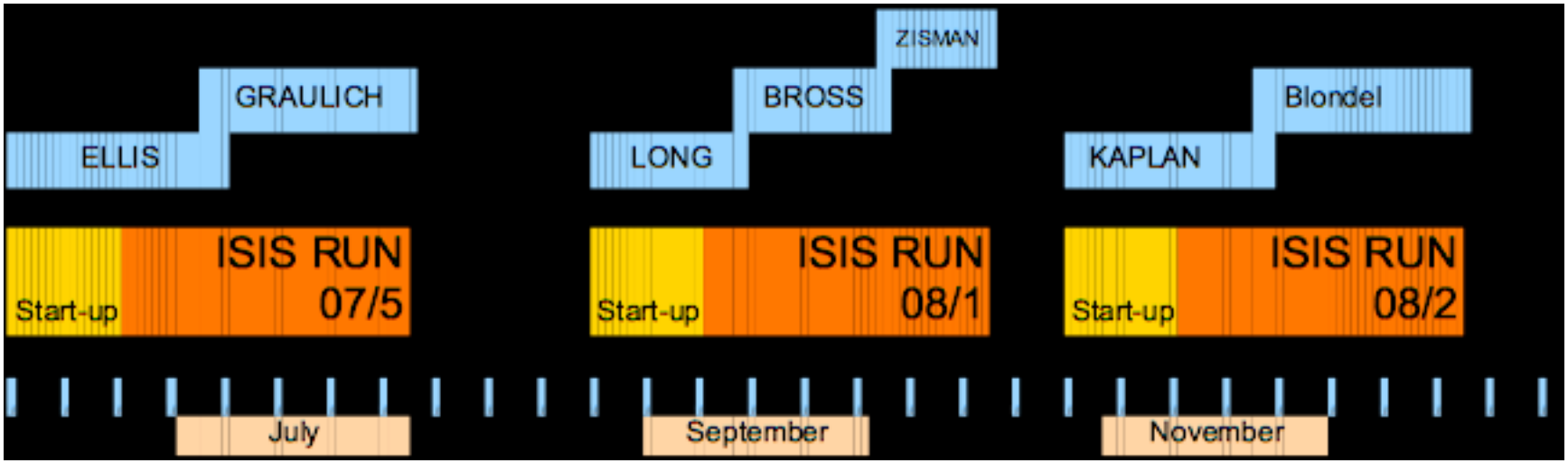
< ---------- STEP I ---------->



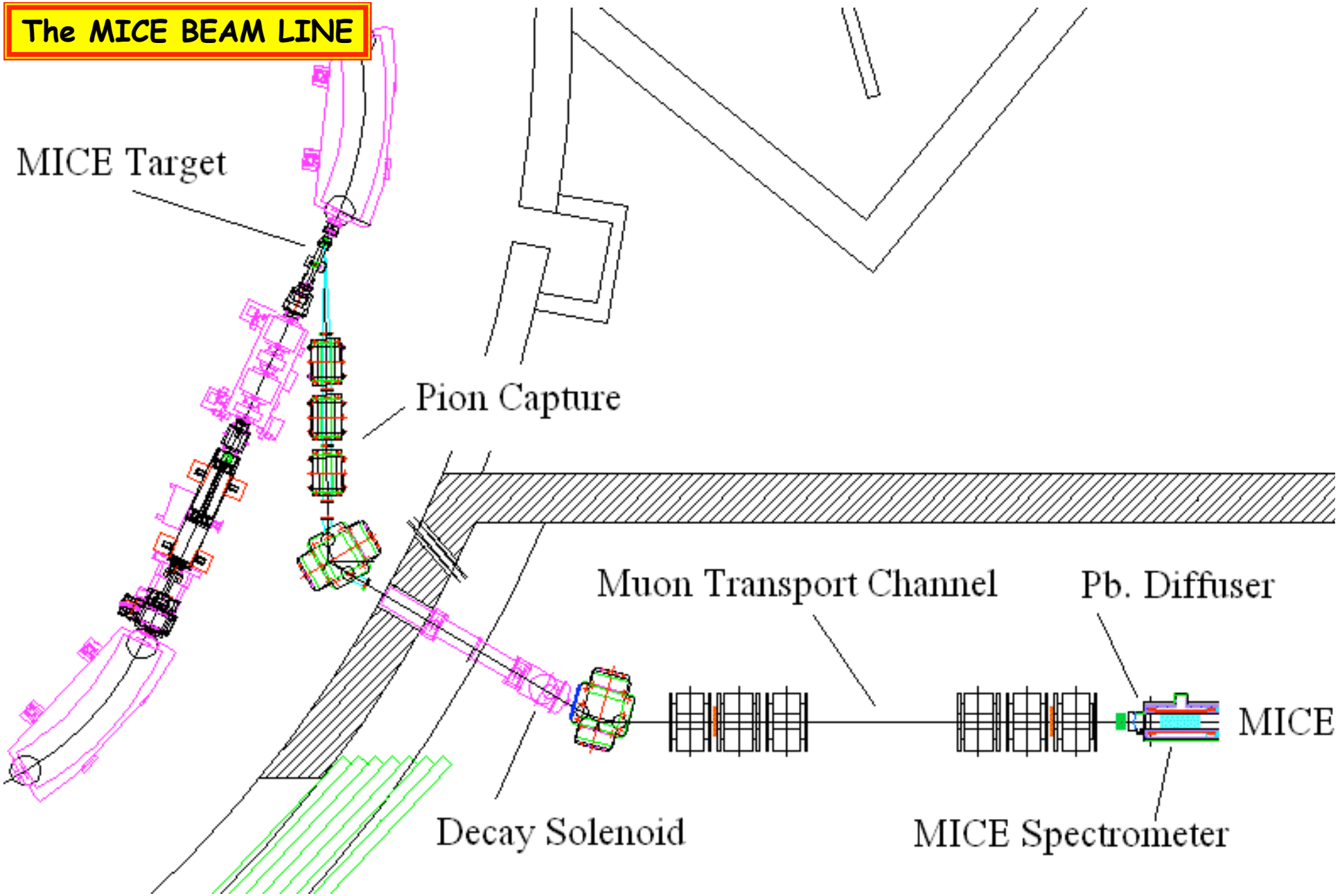
<-- STEP II ----->

<-- STEP III ----->

<-- STEP III.1 --->



The MICE BEAM LINE



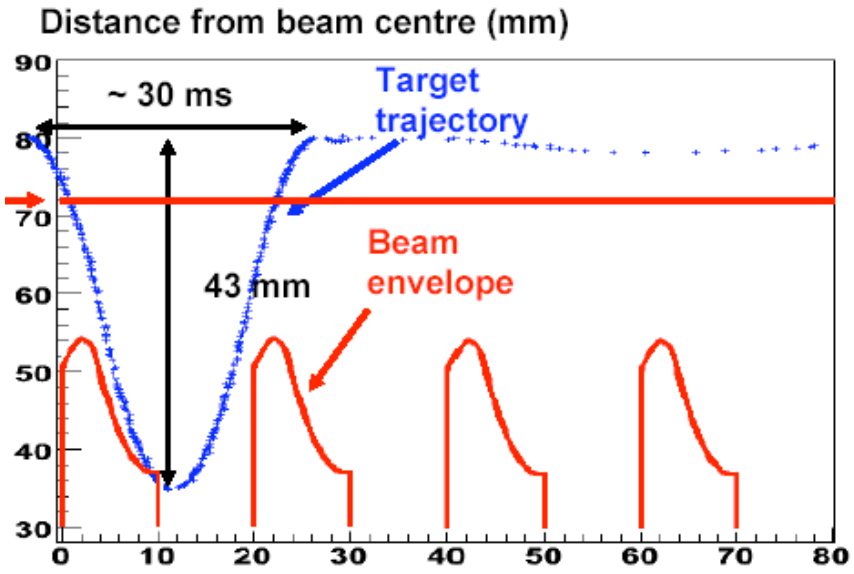
MICE Target (Sheffield)

Mechanism developed to dip Ti target into ISIS beam in the last ms of ISIS cycle

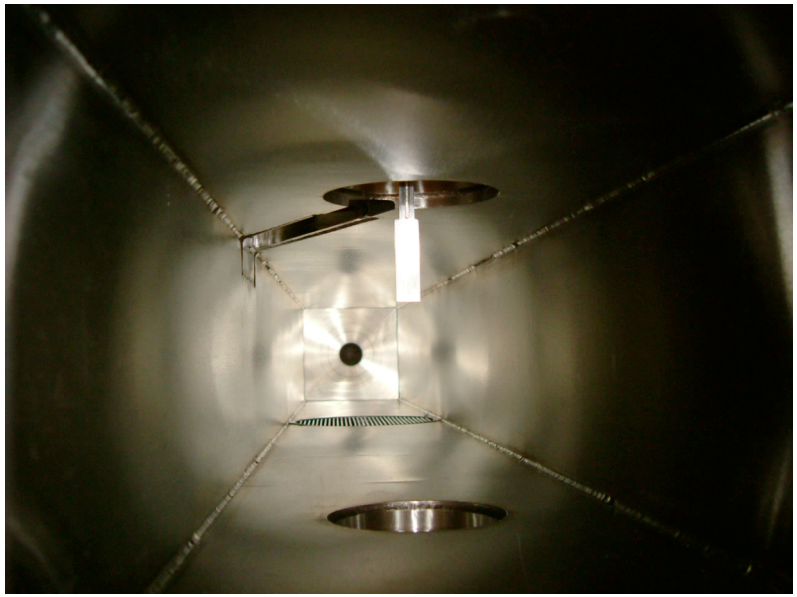
-- 80 *g* acceleration achieved reliably

-- 1 Hz rate

-- Tested with several M actuations

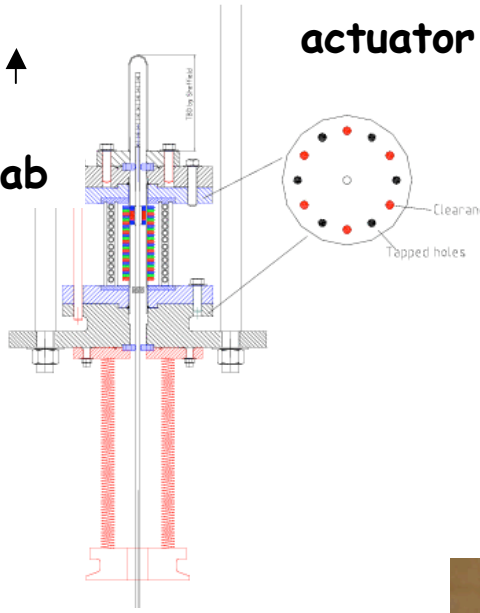


picture of a former target in ISIS



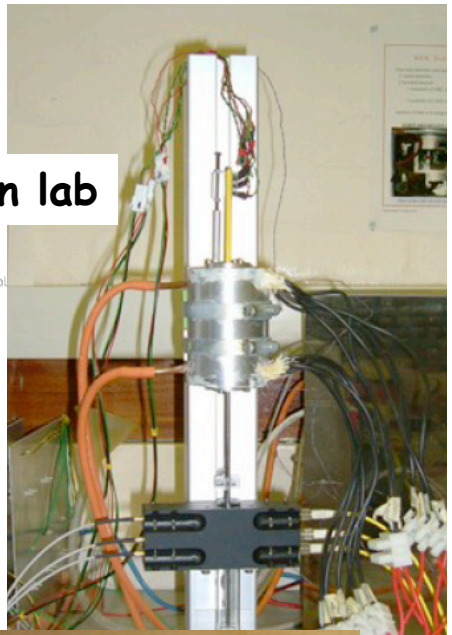
MICE Target

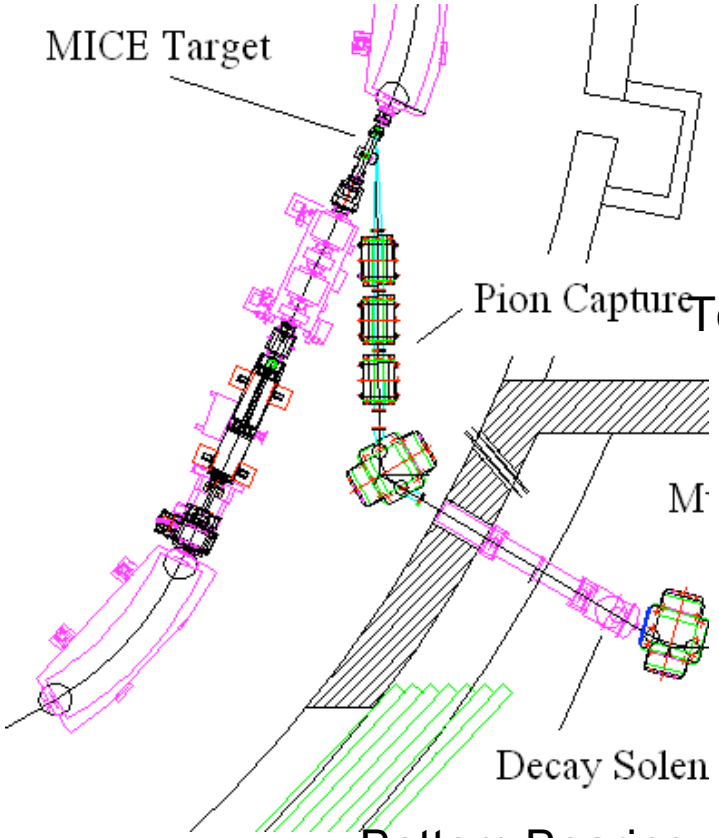
ISIS pulses at 50Hz with flat top for ~2ms. Electromagnetic driver dips target in and out in~3ms. Resp: Sheffield, Darsbury Lab

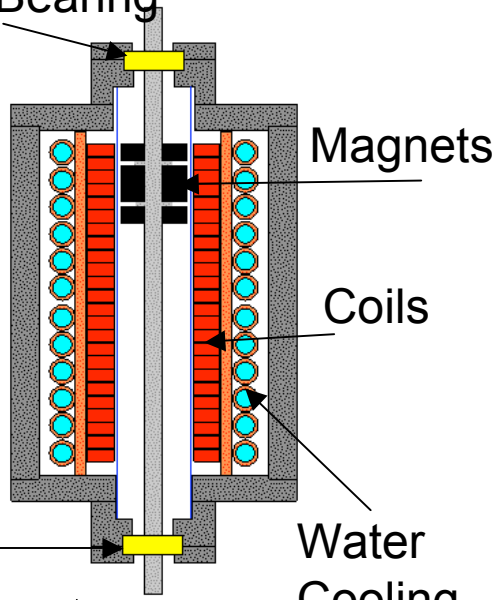


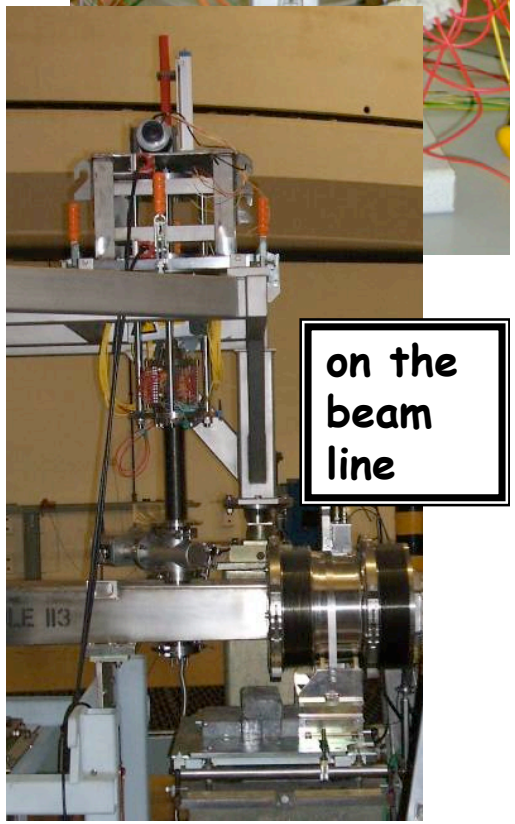
actuator:

in lab









on the beam line

Leaded bronze bearings after 1.5 M pulses

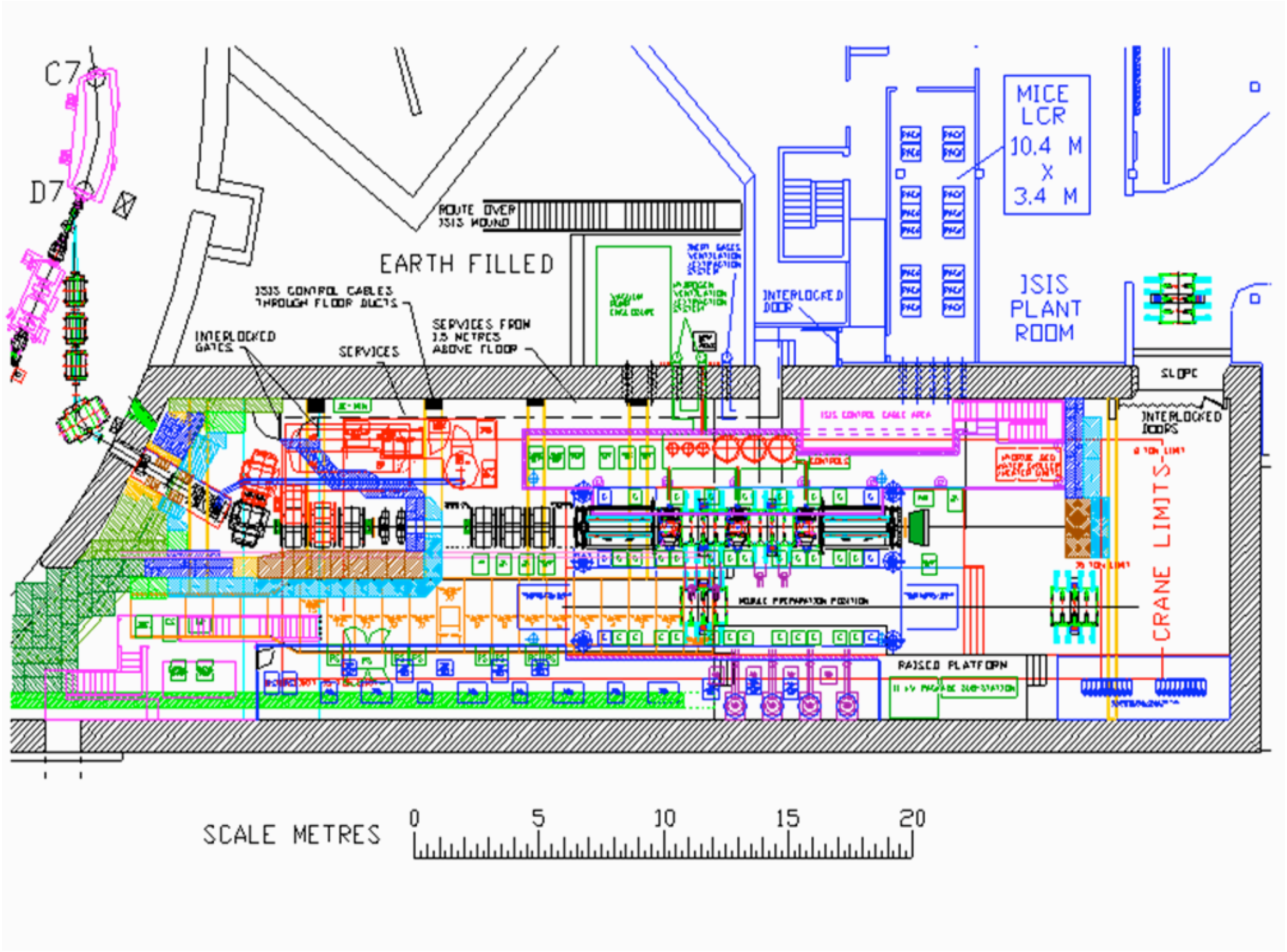
Dust at bottom of housing
(after 1.5 M operations)

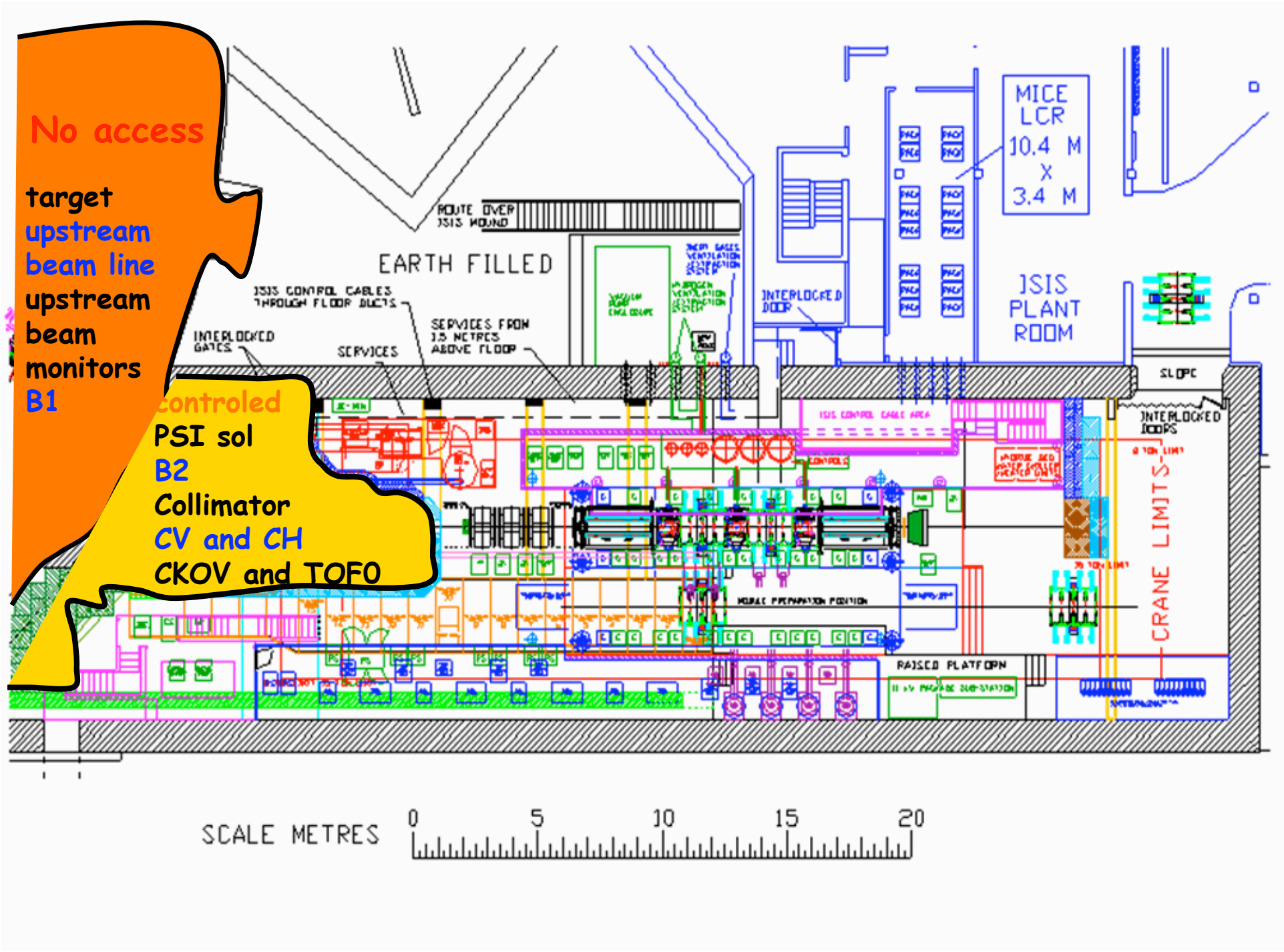
Target Issues:

1. Since target sits in ISIS, must be sure that it does not fail
2. Adequate target design finally reached with diamond-like bearings.
   Operated for many 10^6 pulses without dust or failure
3. Issue of heating and resulting chipping in vacuum is considered
4. Two target systems must be built and operated
   1. One in ISIS
   2. One at RAL nearby with a substantial advance to predict wear or failure
   3. Will only start when the second target has run long enough….
5. Depth o dip will be regulated by activation of ISIS --
   beam loss monitors limit set to 0.05V for first run.
   We do not know to which exact rate this will correspond

==> (6, 60 or 600 good muons/spill?)

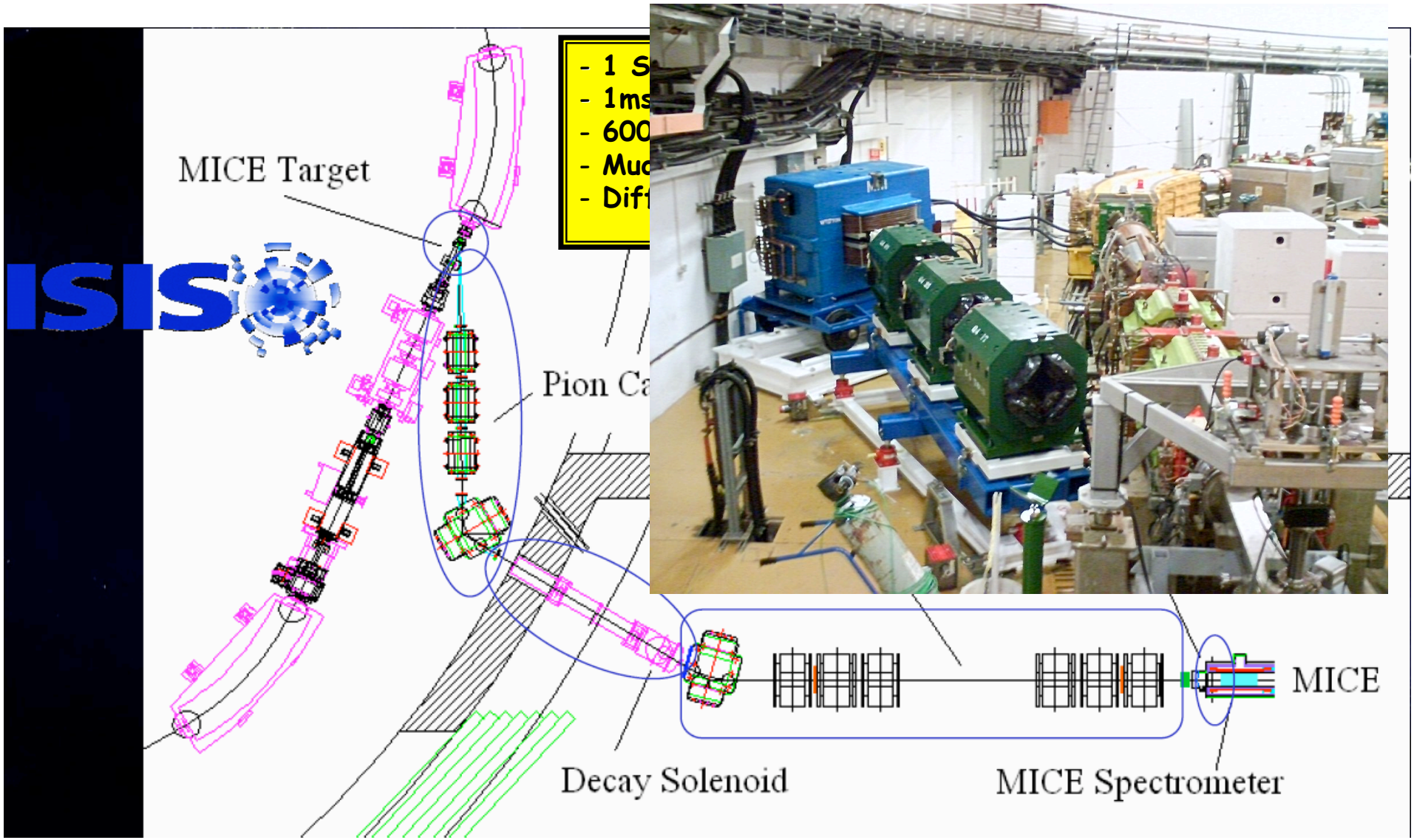
Answer in a few weeks! could be increased if activation is found acceptable

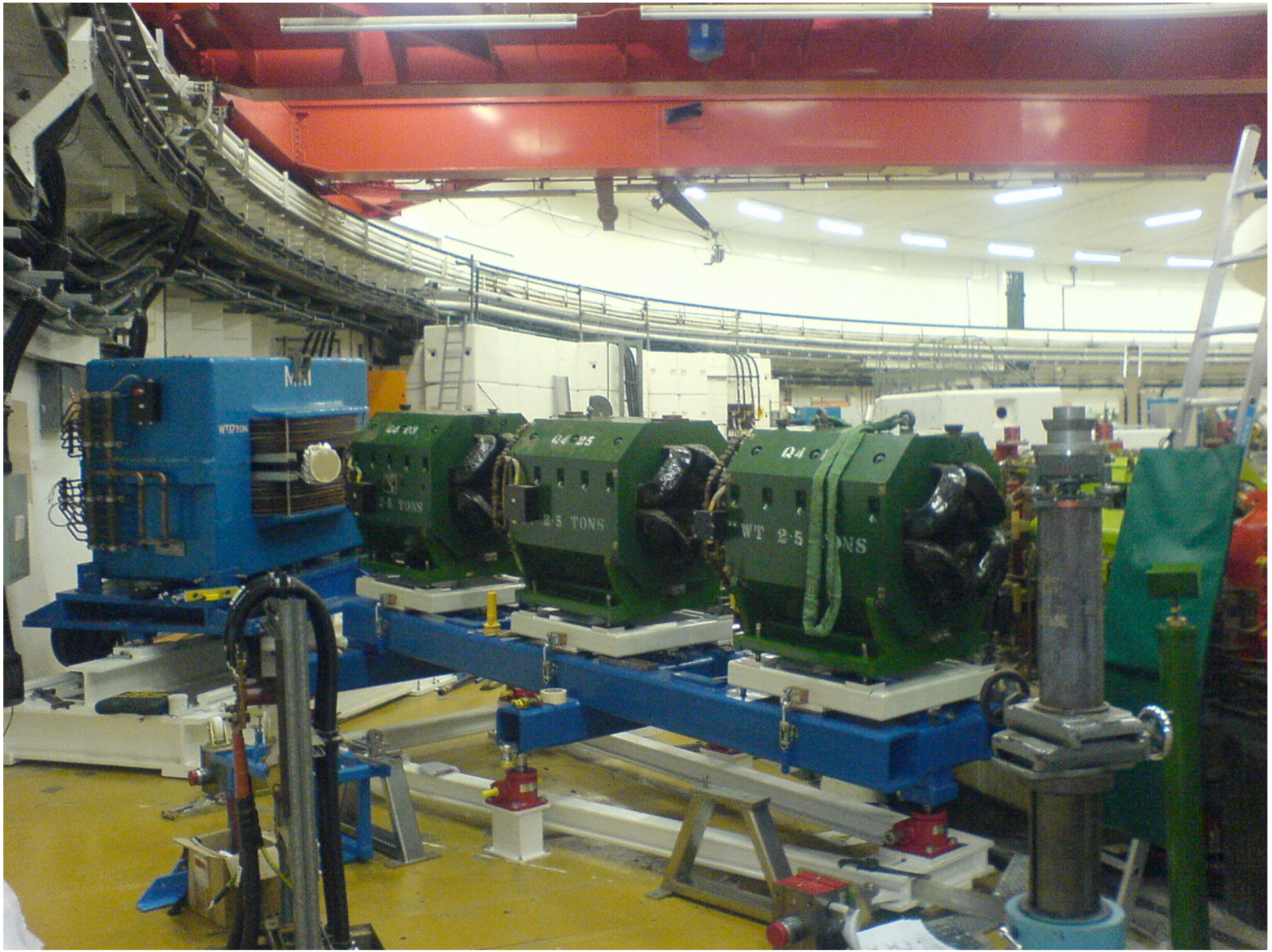

C7
D7
ROUTE OVER ISIS MOUND
EARTH FILLED
ISIS CONTROL CABLES THROUGH FLOOR DUCTS
SERVICES FROM 1.5 METRES ABOVE FLOOR
INTERLOCKED GATES
SERVICES
INTERLOCKED DOOR
MICE LCR 10.4 M X 3.4 M
ISIS PLANT ROOM
SLOPE
INTERLOCKED DOORS
CRANE LIMITS
RAISED PLATFORM
SCALE METRES
0
5
10
15
20


No access
target
upstream
beam line
upstream
beam
monitors
B1
controled
PSI sol
B2
Collimator
CV and CH
CKOV and TOF0
EARTH FILLED
ROUTE OVER ISIS MOUND
ISIS CONTROL CABLES THROUGH FLOOR DUCTS
INTERLOCKED GATES
SERVICES
SERVICES FROM 1.5 METRES ABOVE FLOOR
INTERLOCKED DOOR
MICE LCR 10.4 M X 3.4 M
ISIS PLANT ROOM
SLOPE
INTERLOCKED DOORS
CRANE LIMITS
RAISED PLATFORM
SCALE METRES
0
5
10
15
20

MICE Beam Line

Upstream beam line: magnets installed… beam line monitors




2·5 TONS

Decay (PSI) Solenoid

5T, 5m long 12cm ϕ

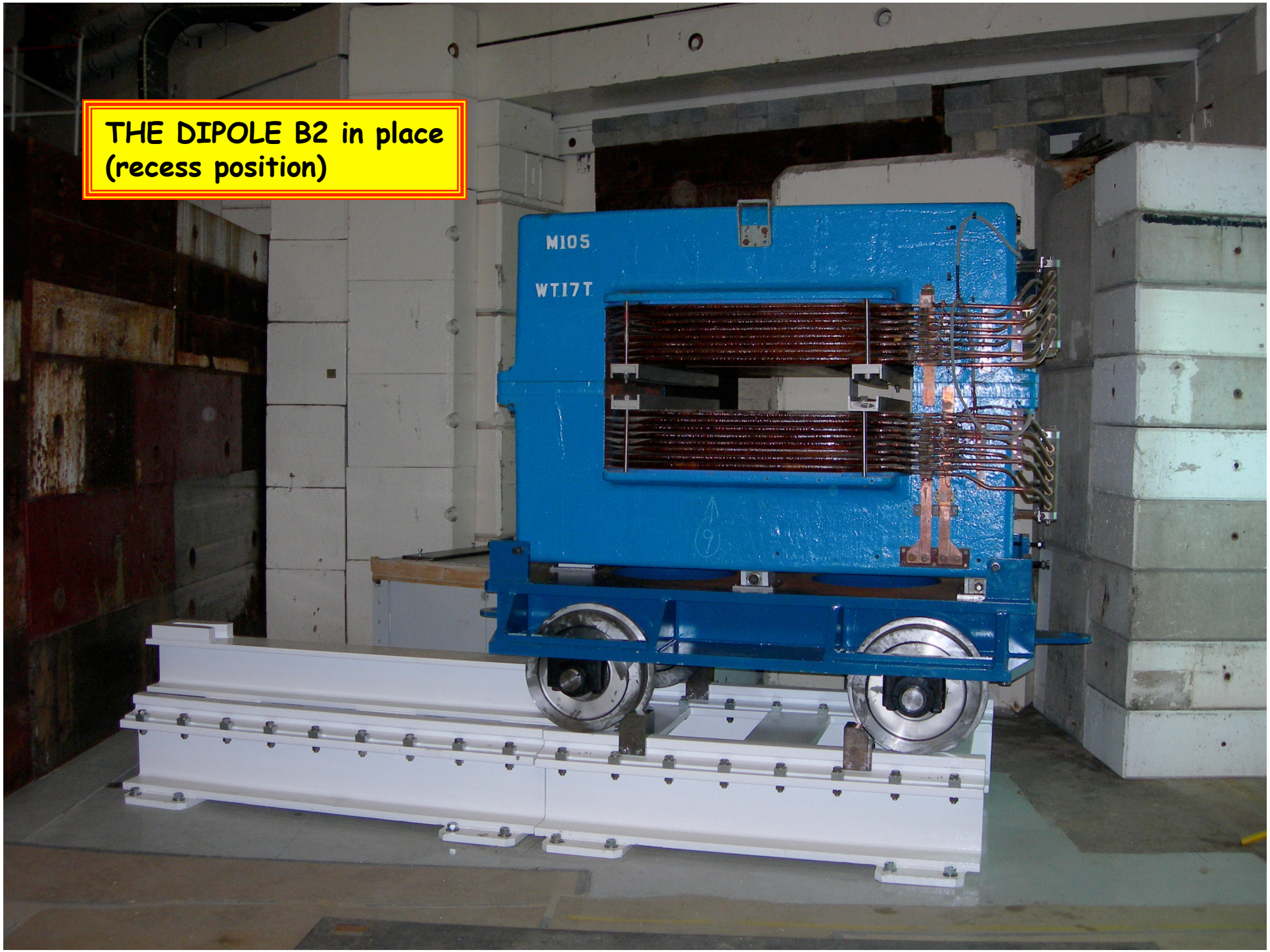
2-phase Liqu he SC

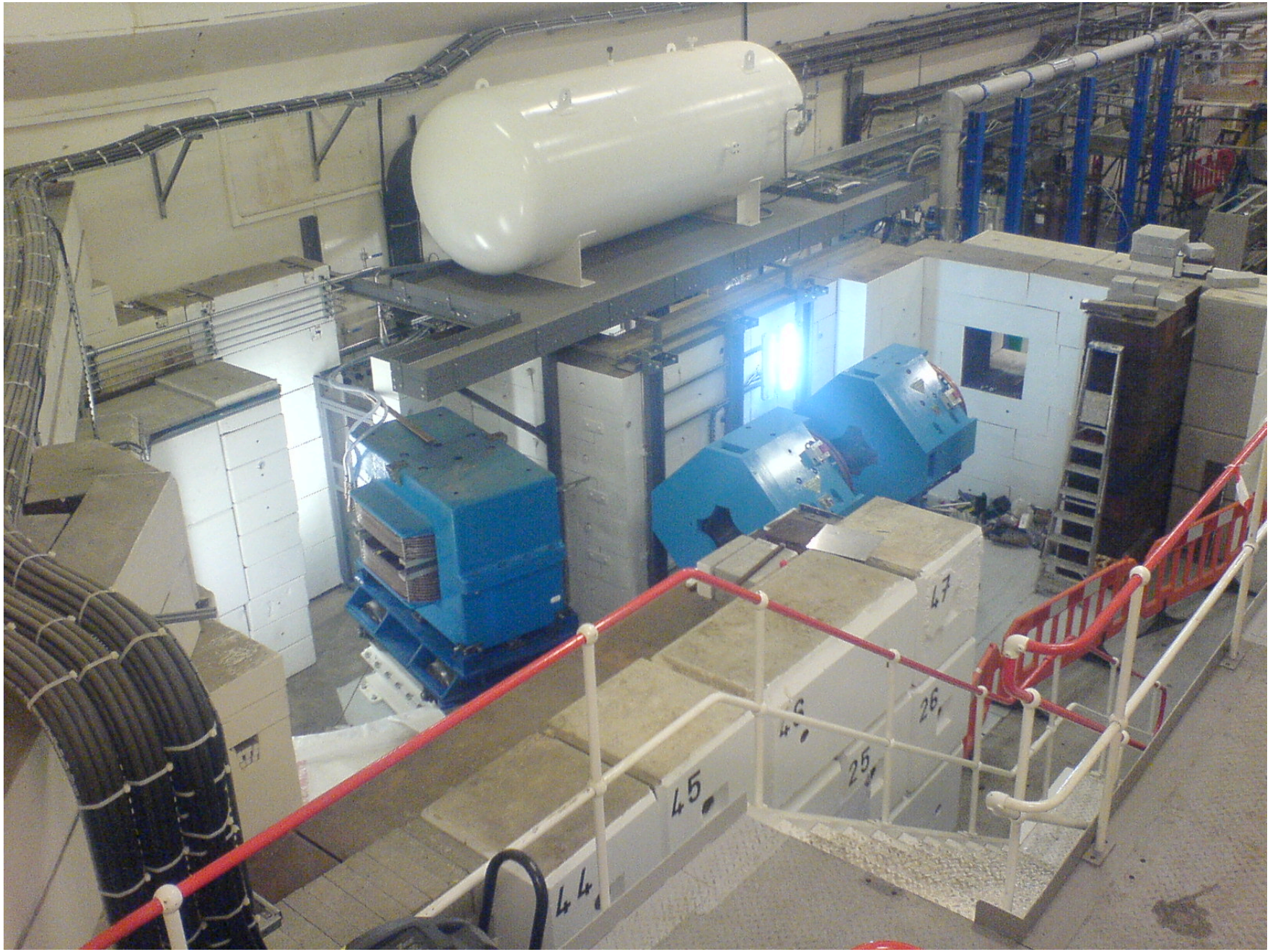
In position for testing (Dec07)

Transport to position

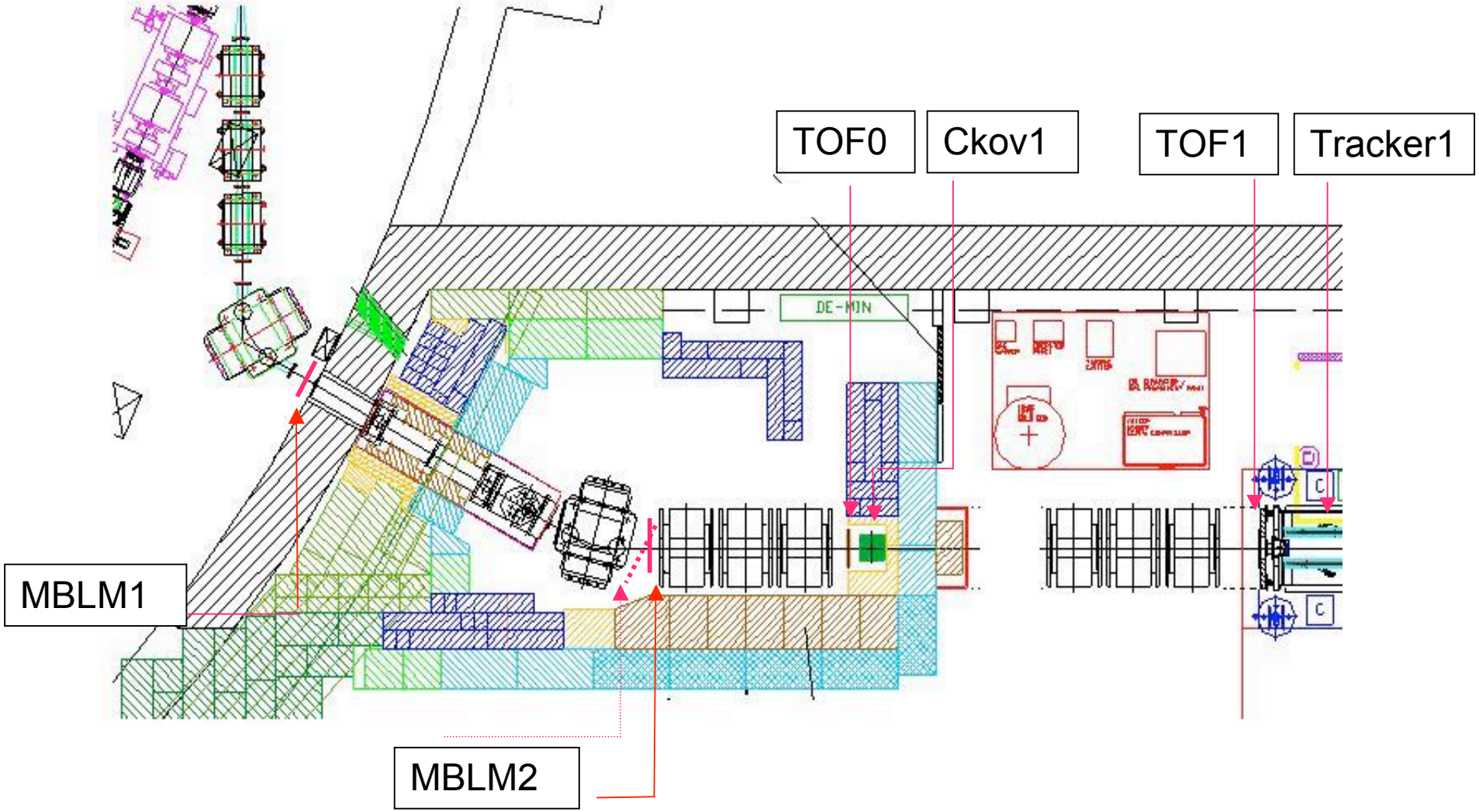
In place,
seen from ISIS

Tight passage between Q4, B2 and wall


THE DIPOLE B2 in place
(recess position)
M105
WT17T


47
45
44

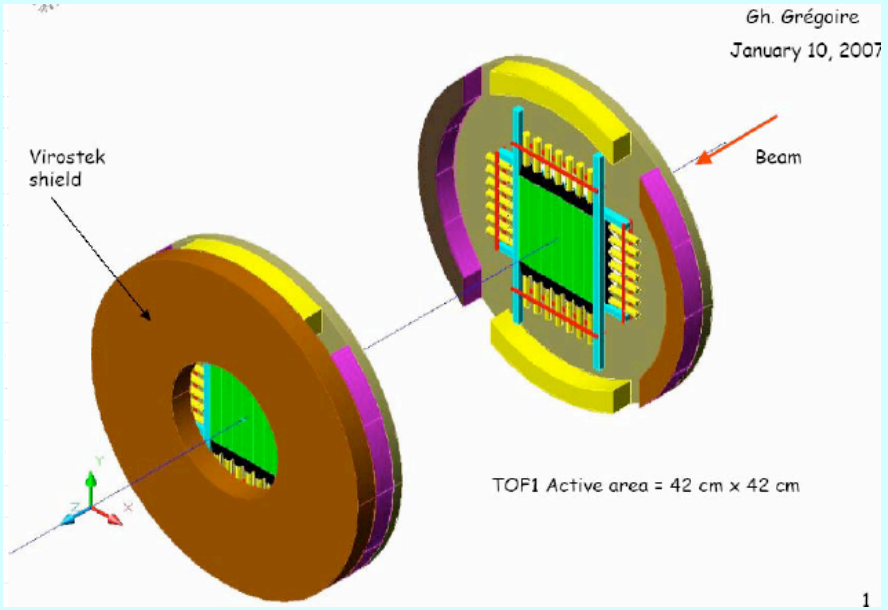
Detectors



TOF0, TOF1, KL; SW

TOF is Responsibility of M. Bonesini et al (INFN Milano, Pavia, Roma + Gva & Sofia)

Technically:
Two layers (x and y) of 4cm wide hodoscopes
60 ps resolution achieved in test beam
Phototubes/electronics/magnetic shield defined



construction of TOF0 and TOF1 underway
all phototubes and scintillator purchased
electronics purchased or
under construction

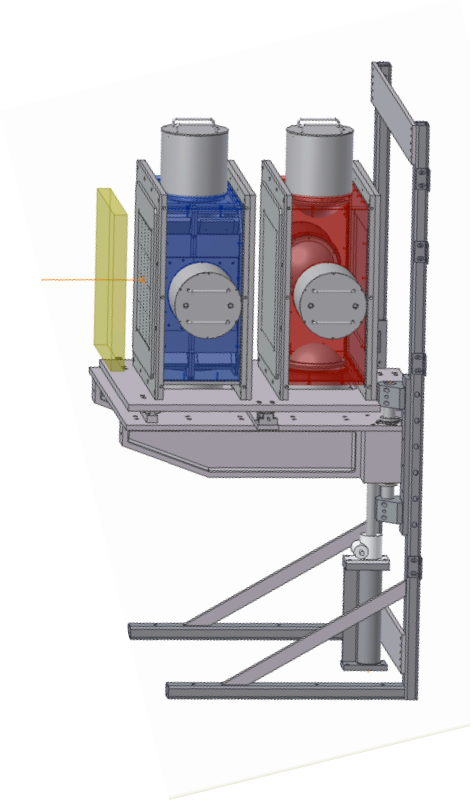
==> delivery at RAL in Jan Feb 2008
Very useful tools for beam diagnostics alignment etc…

KL calorimeter (4 X0 of lead sci-fibers sandwitch)→ first recognition of electrons
Under construction at ROMA III (L. Tortora) delivery Feb.07

SW calorimeter (100X100 X 80 cm deep scintillator ranger for positive muon ID)
First prototype layer under construction in Trieste (FNAL/Trieste/GVA collab.)
aim is to be operational in 2008 for full downstream PID capability

CKOV (Mississipi, Louvain)

Both Cherenkovs ready for installation in
Decay Solenoid Area (limited access)



TOF0

delivery at RAL end of Jan08 with laser calibration system
Common CKOV/TOF0 support in DSA.

KL, TOF1

Delivery at RAL in February08

DAQ (GVA)

Ready to take CKOV, TOF0, additional scintillators.

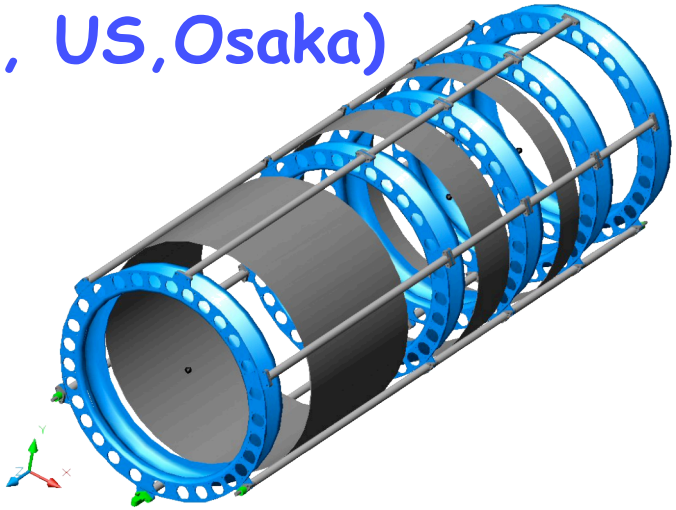
MICE Beam Line Monitors (FNAL, ICL)

Array of scintillator pads to be placed in vault
before the decay solenoid.

Combination of TOFs will allow determination of beam composition

and rates for pion beam (B1=B2)

TRACKER:(ICL, Brunel, Liverpool, US,Osaka)



Low mass Sci-Fi tracker inside solenoid

5 planes x 3 views

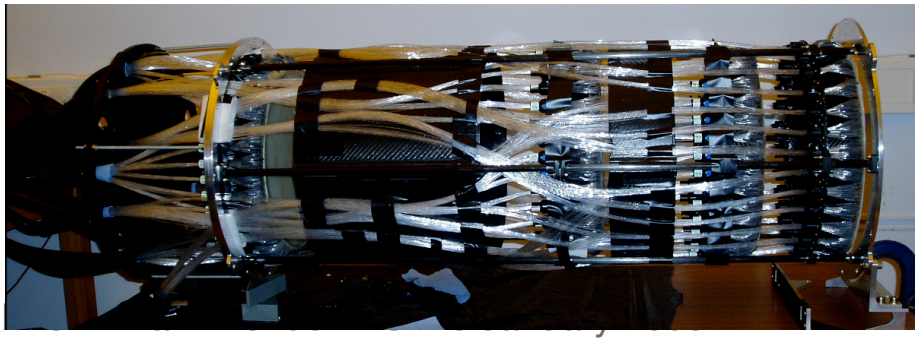
350 micron fibres + VLPC readout

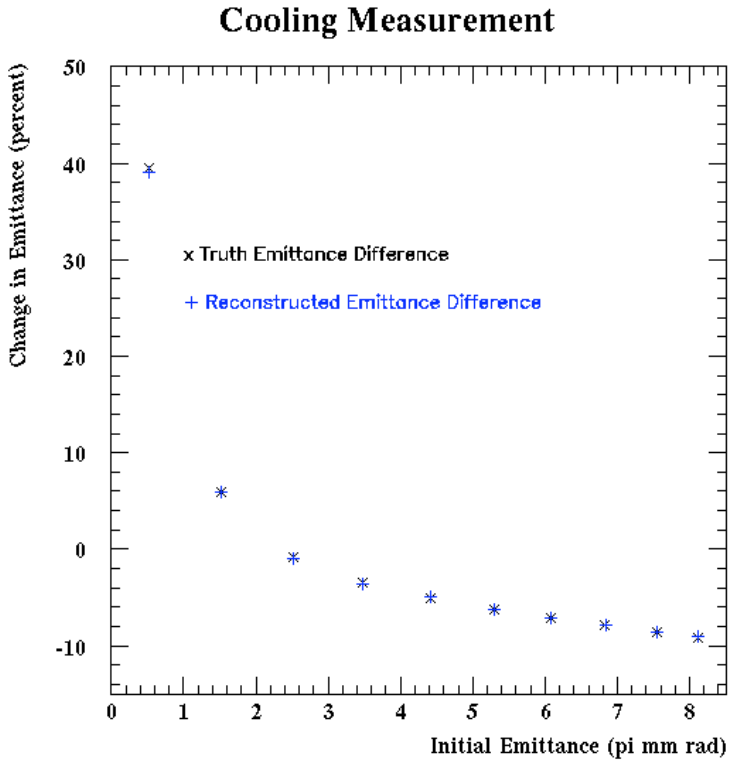
4-plane prototype tested at KEK

Data used as input to simulations

➔ can measure to $\delta\varepsilon/\varepsilon$ = 1/1000

Construction of Tracker I complete will be tested in Cosmic bench (R8) --> beam end February/March08



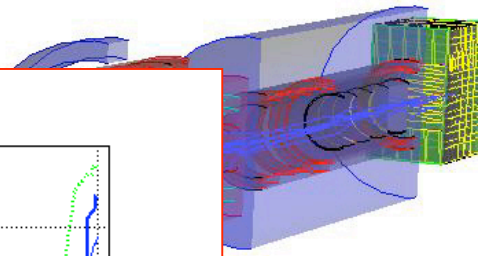


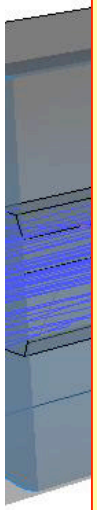
Preparing for PHASE I : software, analysis

1. Basic simulation and reconstruction of MICE is complete for the various steps Both G4MICE and ICOOL are used.

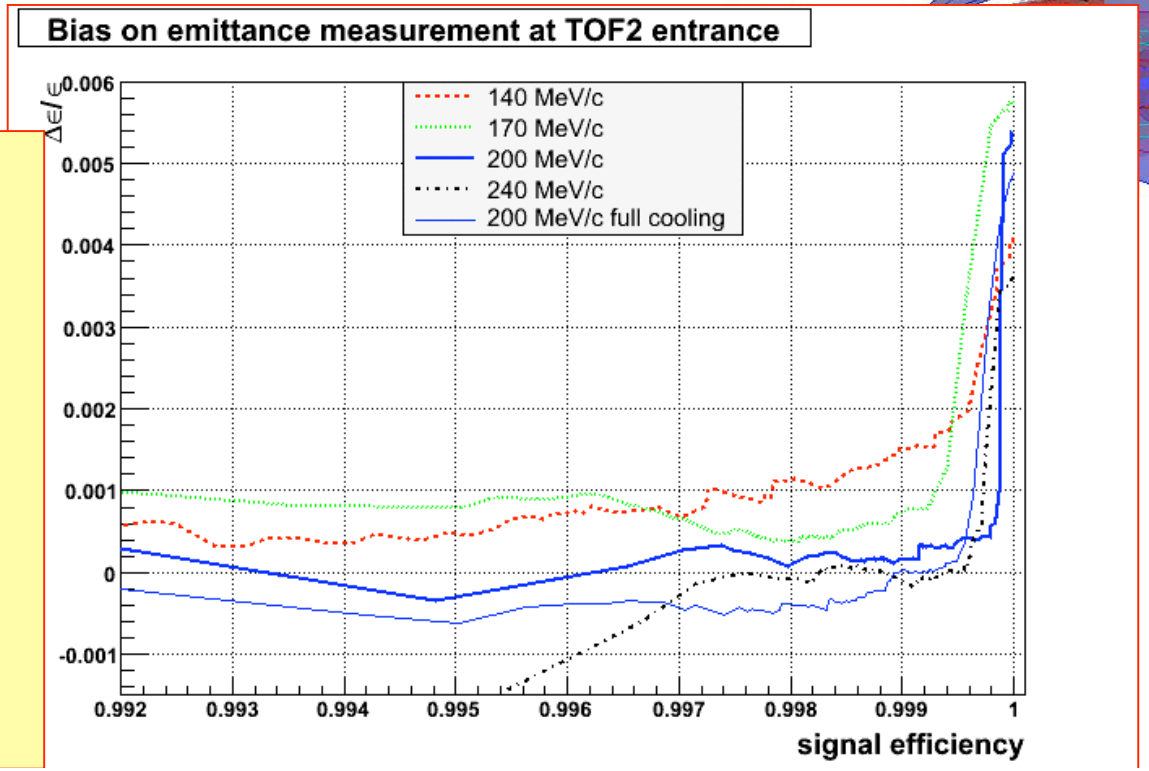
2. Putting it all together to do analysis (particle reconstruction, particle ID algorithms Single particle amplitude and emittance calculations, etc…) is ongoing.
Will aim at running online!

3. Real life test will take place with beam soon!

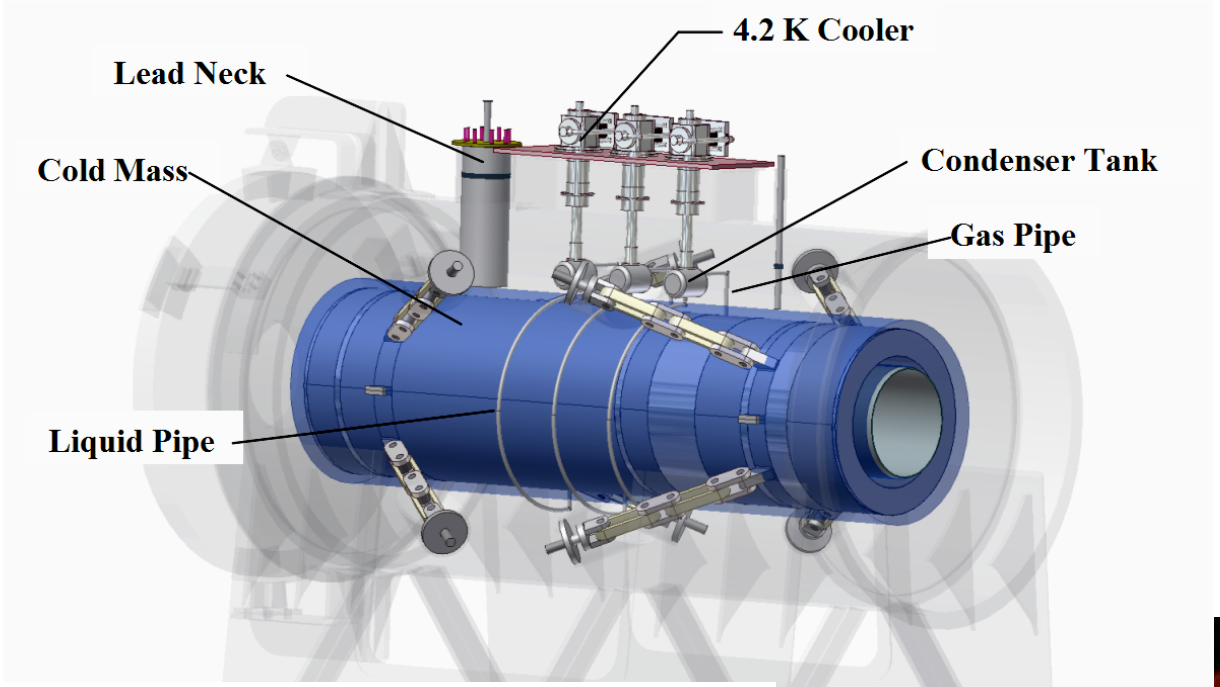




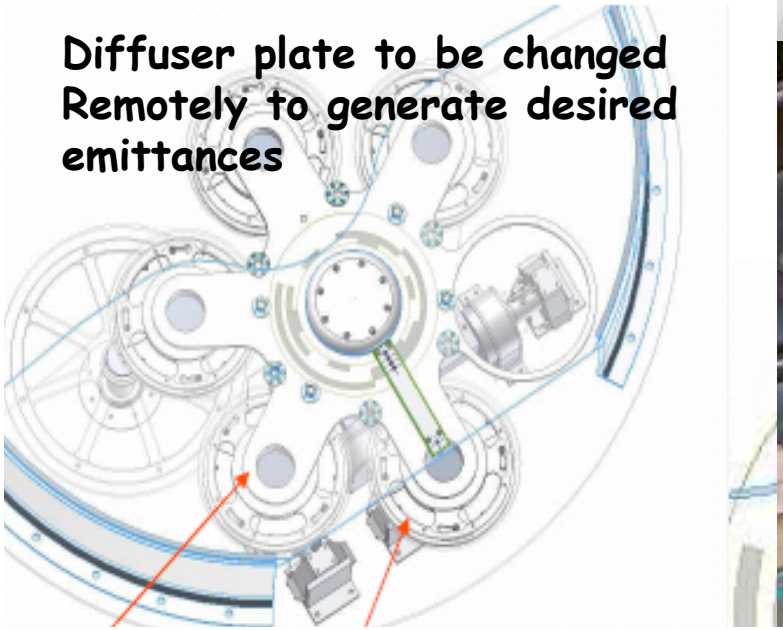
Example →
Bias on emittance due to muon decays
Would be ~0.5% (i.e. 5% error on cooling meast)
Reduced to <<0.1% by SW+ tracker (This uses tracker & TOF info and PID signals +Neural Network)



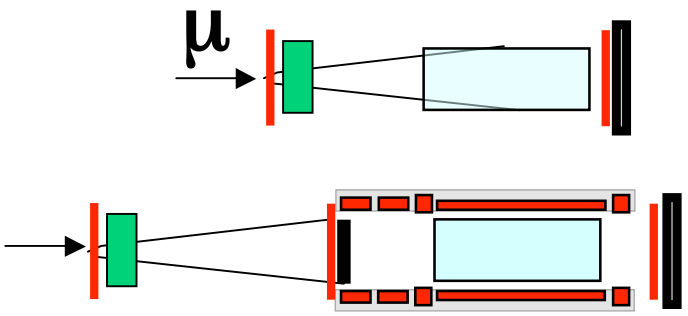
Spectrometer Solenoid (LBNL)



--First magnet complete and tested by end February
-- magnetic measurements at FNAL Mar-Apr08
-- Arrive RAL in Mai08
-- Begin step II in June08



Run plan -- steps I and II



STEP I
February-may 2008

STEP II
June-July 2008

Goal:
Establish beam match and whether we have all knobs necessary to draw emittance vs. transmission curve. Measure emittance

Runnng time:
Take 200-400 muons per 1ms spill once per second
In steps I-IV 1% (0.1%) emittance meas. will take <1 (<100) minute
10 times longer in steps V and VI where phase matters.

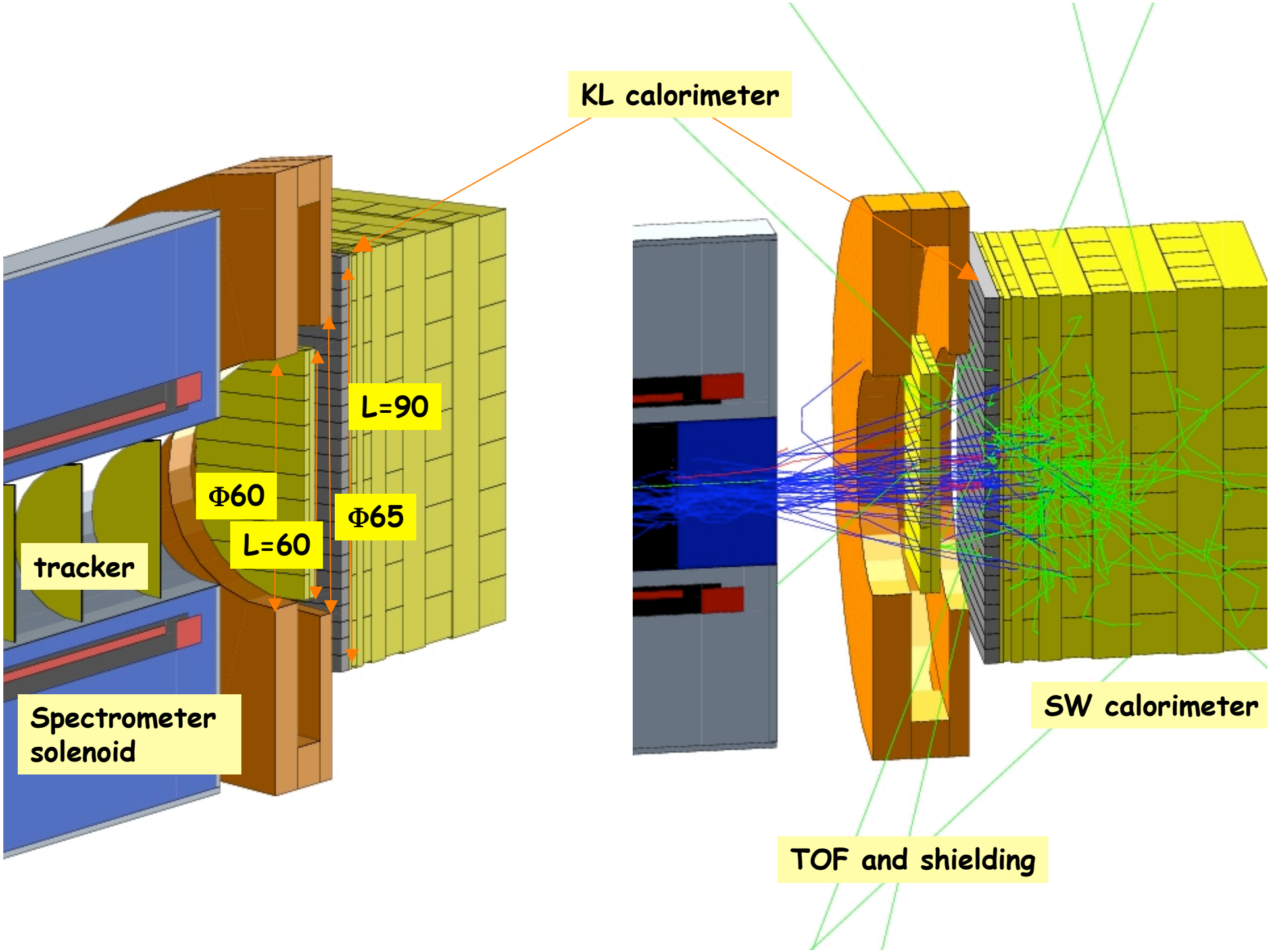
preliminary estimate

total for steps I & II: 70 days

STEP I requires 60 shifts (20 days of running)
beam line commissionning, target tuning (rates), DAQ and detector shakedown

STEP II requires 100 shifts (50 days, during 2008)
Alignment of beam x,x',y,y', (Lack of) dispersion,
check range of transverse emittance, and range of momenta
measure emittance and…

publish first paper


KL calorimeter
L=90
Φ60
Φ65
L=60
tracker
Spectrometer solenoid
SW calorimeter
TOF and shielding

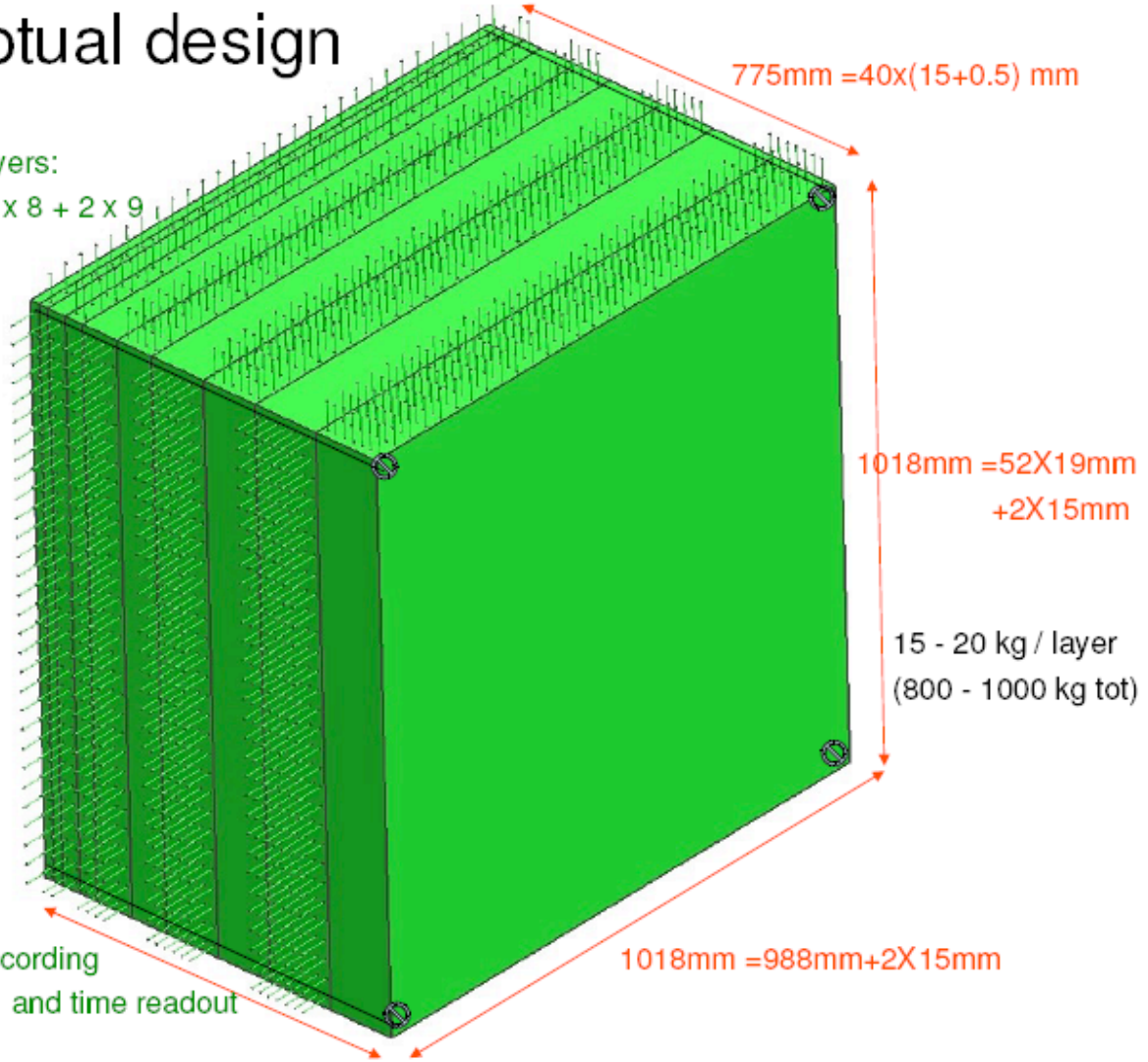
The unfunded PHASE I item: SW calorimeter

Conceptual design

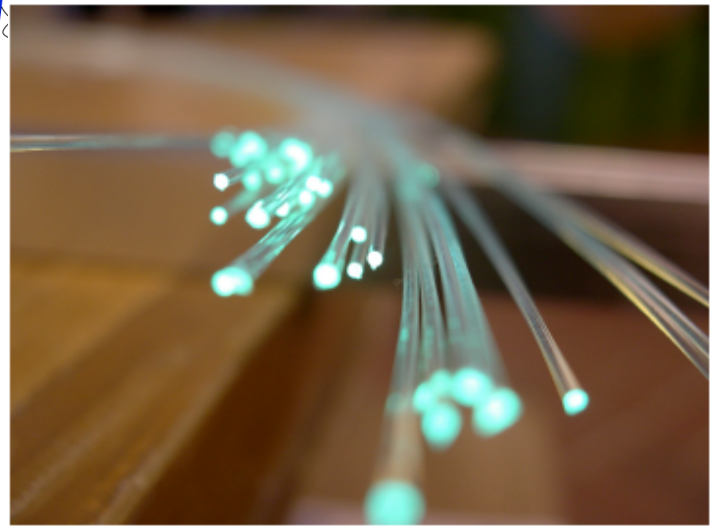
50 planes in
10 variable thickness layers:
2 x 1 + 2 x 2 + 2 x 5 + 2 x 8 + 2 x 9

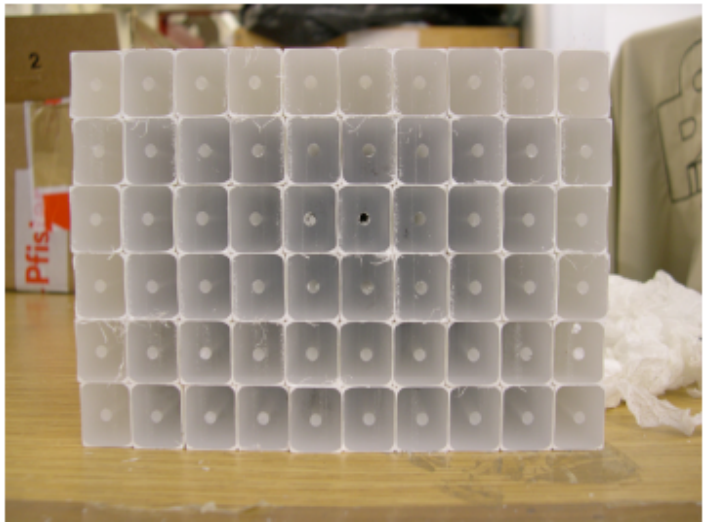
Lateral segmentation
according to rate!

Time measurements
MAY help with
coordinate
reconstruction.

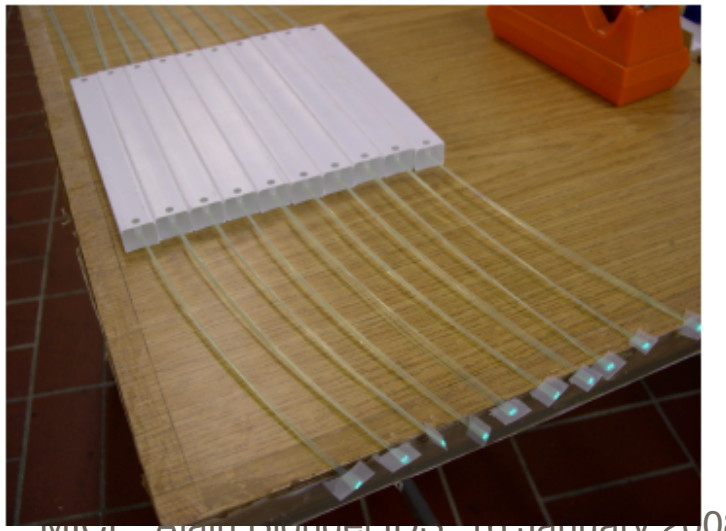


Flexible fiber bundling
Number of channels according
to lateral segmentation and time readout





Extrusion provided by Fermilab and mechanical assembly, gluing etc. at INFN Trieste
Photo-multipliers recuperated in Geneva (save $$$)



Estimated cost 50-100k$

Essential for full precision (10^{-3}) of the experiment over full momentum range (see next slide)

Preparing for phase II

LH_2 Absorber (UK, US, Japan)

AFC module (UK)

RF R&D (MuCool-NFMCC)

RF power (LBNL+ CERN → Daresbury lab → RAL)

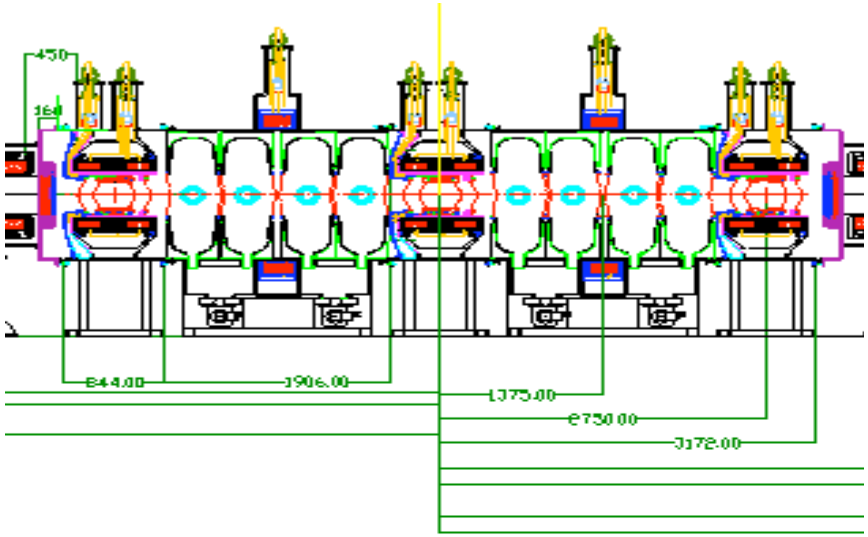
Coupling Coils (LBNL,Harbin ICST)

SW calorimeter (GVA-FNAL-Trieste)

The main technological uncertainty for MICE phase II is:
stable operation of the 201 MHz cavities at 8MV/m in the magnetic field of the MICE cooling channel.

By the end of the calendar year, the MuCool program hopes to test the prototype 201 cavity in a magnetic field that approximates what the cavity will see in MICE.
A more complete test of the cavity will occur when the coupling coil being fabricated for the MuCool program by ICST/Harbin arrives at Fermilab in early 2009.

The complete cell of the study II cooling channel is composed of



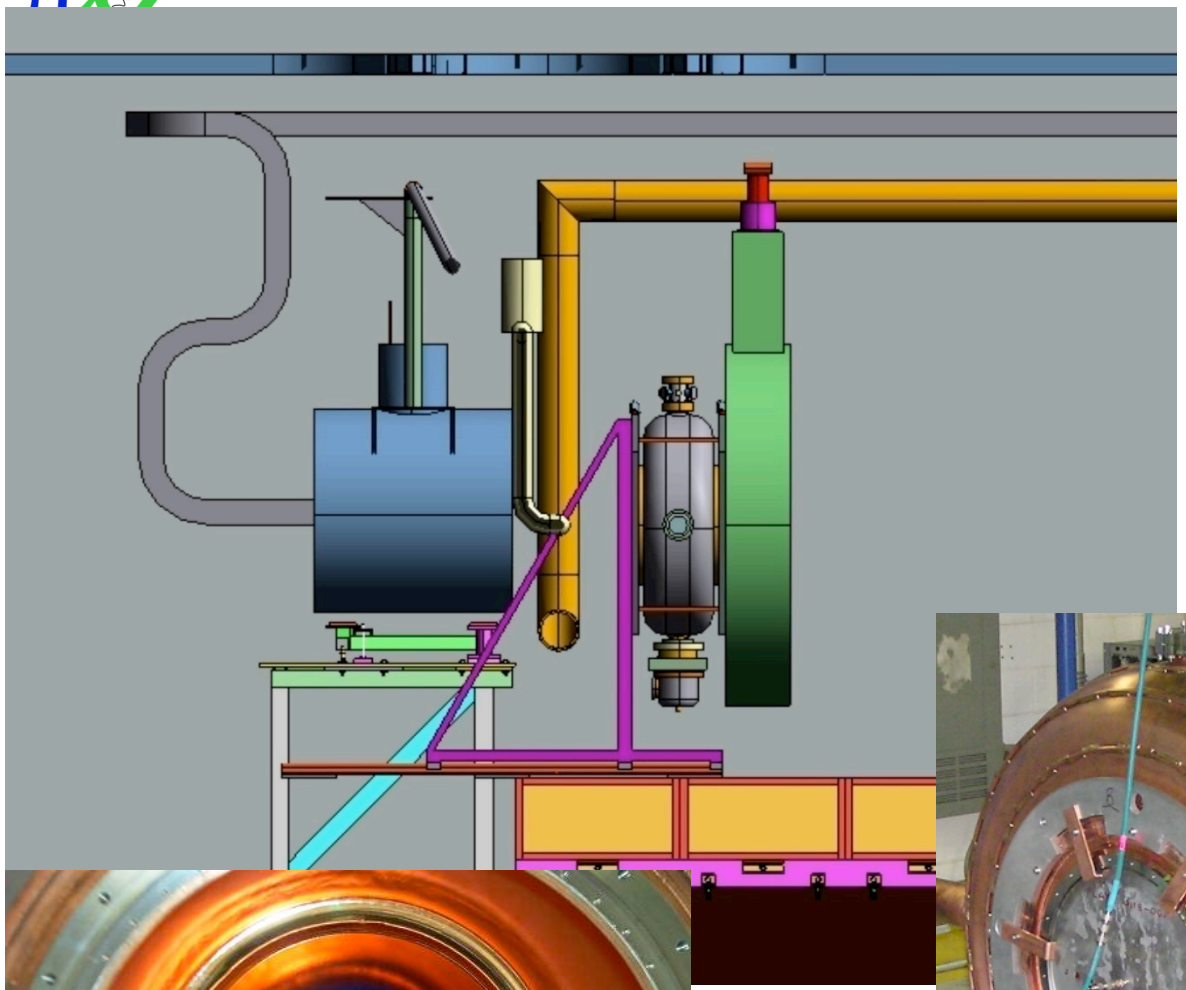
Front elevation of the Cooling Channel

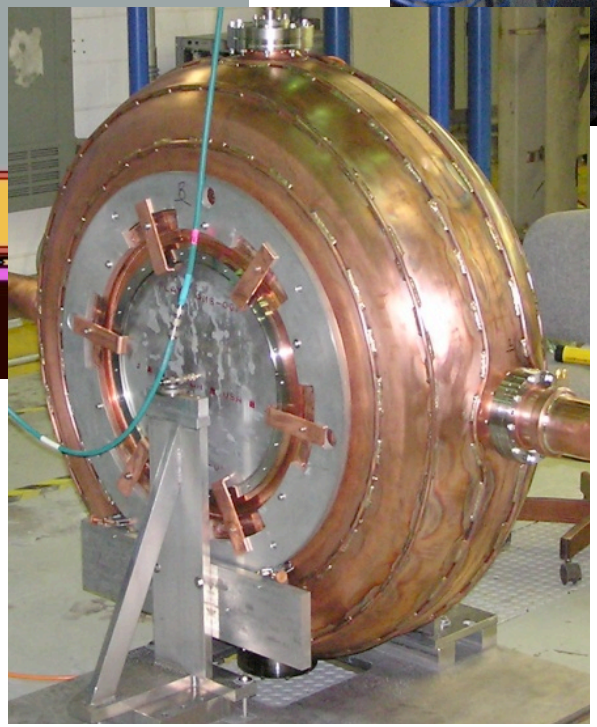
two RF coupling-coil modules with an absorber-focus pair module in the middle
This corresponds to step VI.

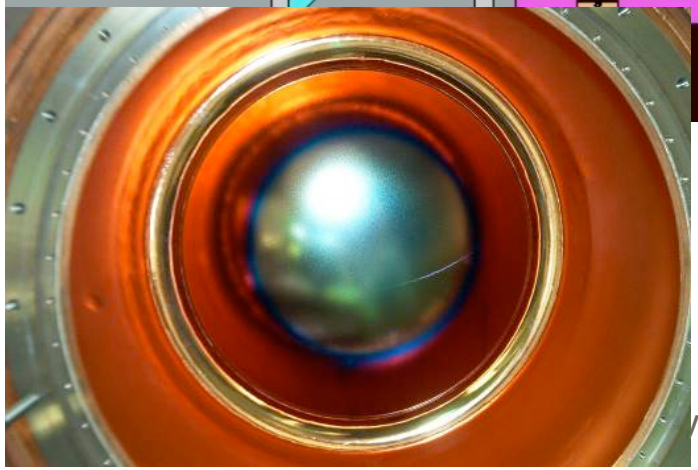
Permits study of
-- flip/non flip between two modules
-- longitudinal emittance growth

Construction of elemnts will start this year.
Already: prototype RF cavity at FNAL
Prototype H2 system, absorbers, windows
First coupling coil under construction in Harbin (China) --> october 2008
Refurbisment of RF power station at Dresbury and CERN --> 8MW power

Prototype RF cavity in MuCool Test Area







RF power system

completion of test stand in 2007 (Daresbury Lab)

relationship with CERN & phase 2

Hydrogen System

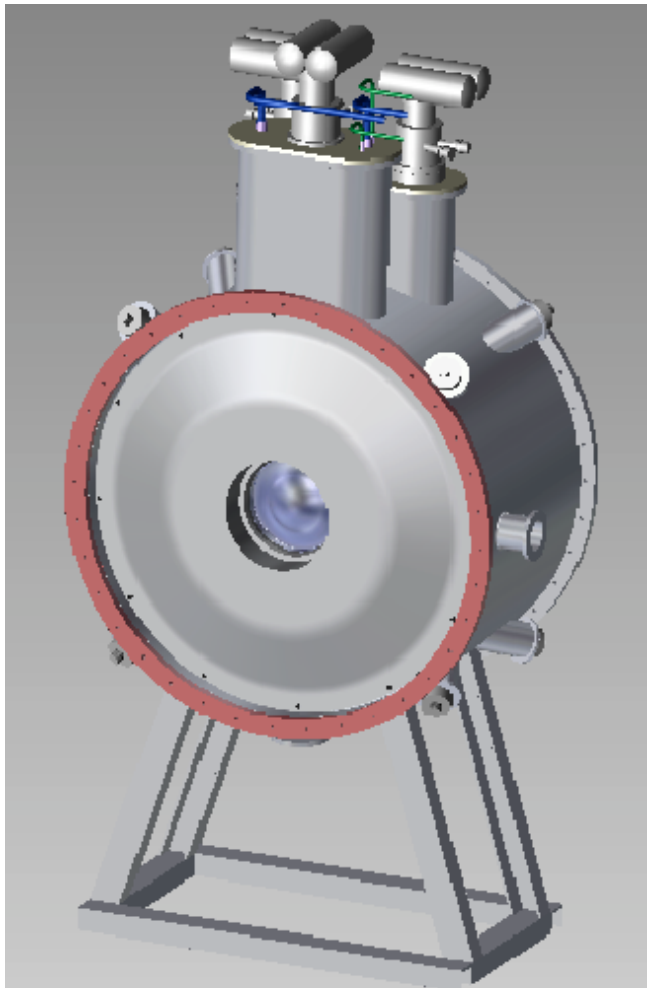
Vendor selected

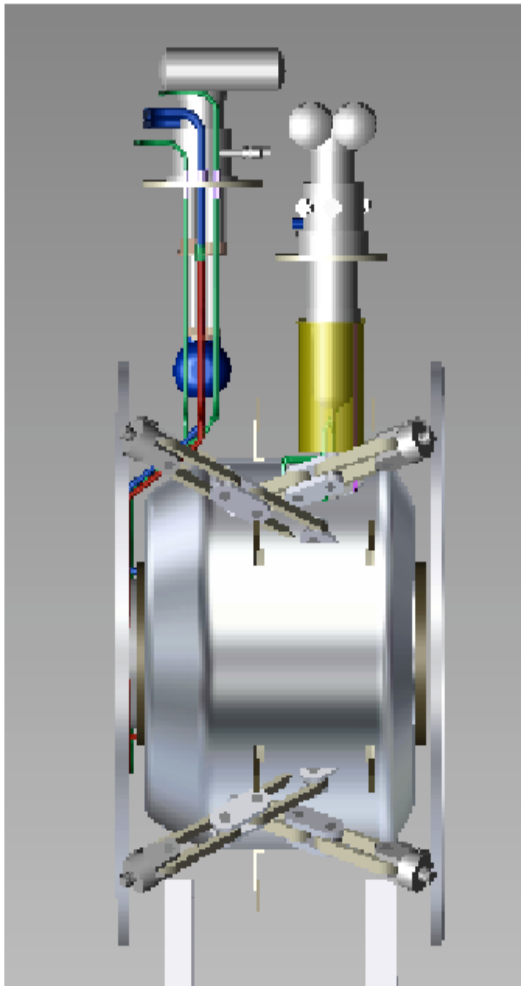
design issues resolving

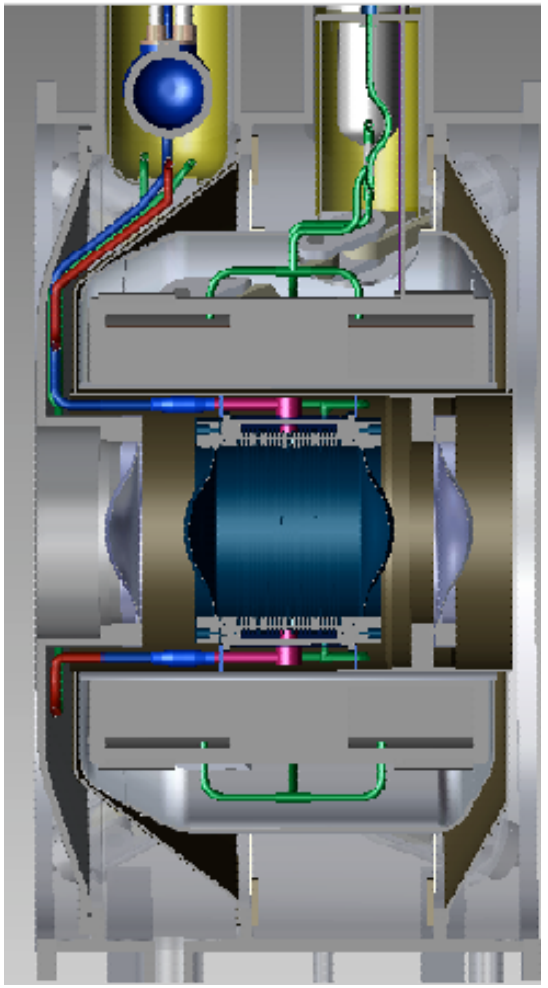
Safety review and HAZOP for H_2 system have been passed.

Metal hydride storage tank with capacity of 20 m^3 of hydrogen

FOCUS COIL 3D MODEL







Conclusions

MICE is in labor. Exciting time of birth coming soon!

Pending major upset: first beam in February 2008!

On schedule to demonstrate ionization cooling by 2010

Funding is essentially complete for Phase I and II
(BUT: UK Phase II, Japan, SW)

The MICE muon test facility represents a beautiful scientific investment!

Final Comment -- Beyond Phase II

Once PHASE II is completed, the MICE hall remains a facility with
-- spectrometers, TOF and PID able to measure emittance to 10^{-3}
-- 8 MW of 201 MHz RF power
-- 23 MV of RF acceleration
-- Liquid hydrogen infrastructure and safety system

MICE can become a facility to test new cooling ideas

Time scale for such experiments being 2011-2012,
proposals welcome in the near future