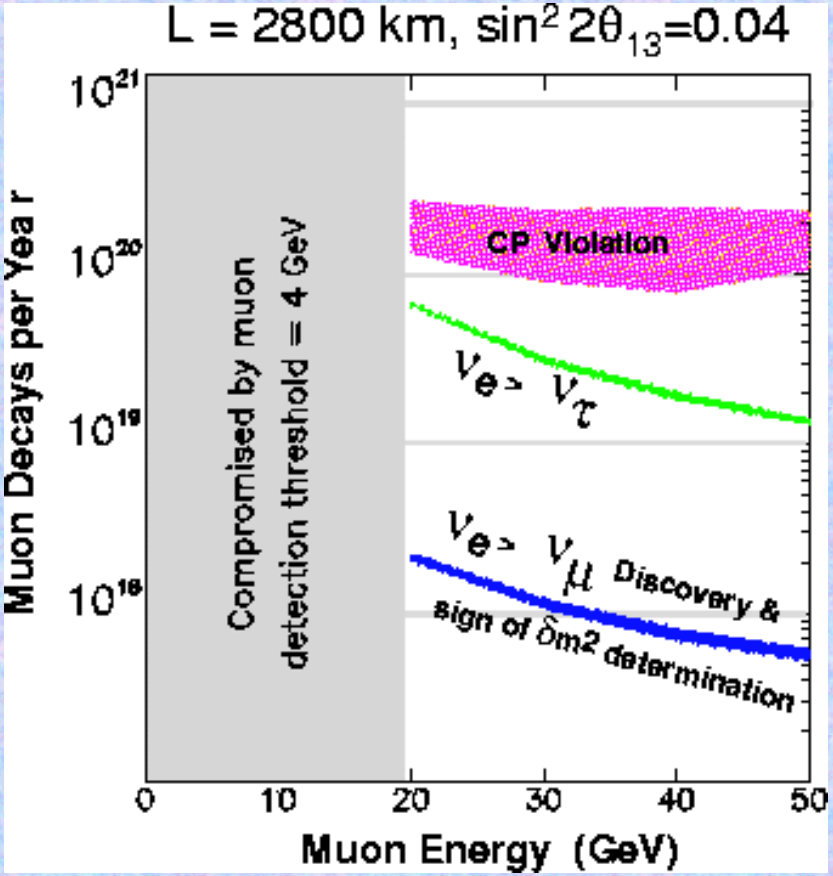
MICE: the international Muon Ionisation Cooling Experiment

Malcolm Ellis
on behalf of the MICE collaboration
DPF Meeting
Riverside, August 2004

Motivation: Ionisation cooling

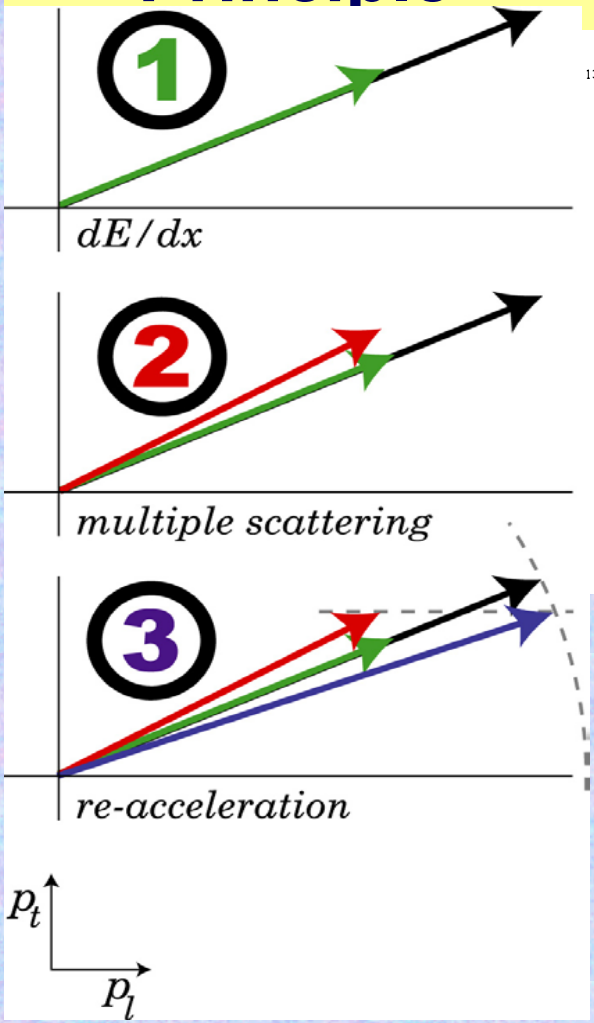


- **Physics reach increases with neutrino flux**
- **Maximise stored muon intensity**
- **Implies:**
  - **Require to capture and store as many of the 'decay' muons as possible**
    ⇒ *Cool muon beam*

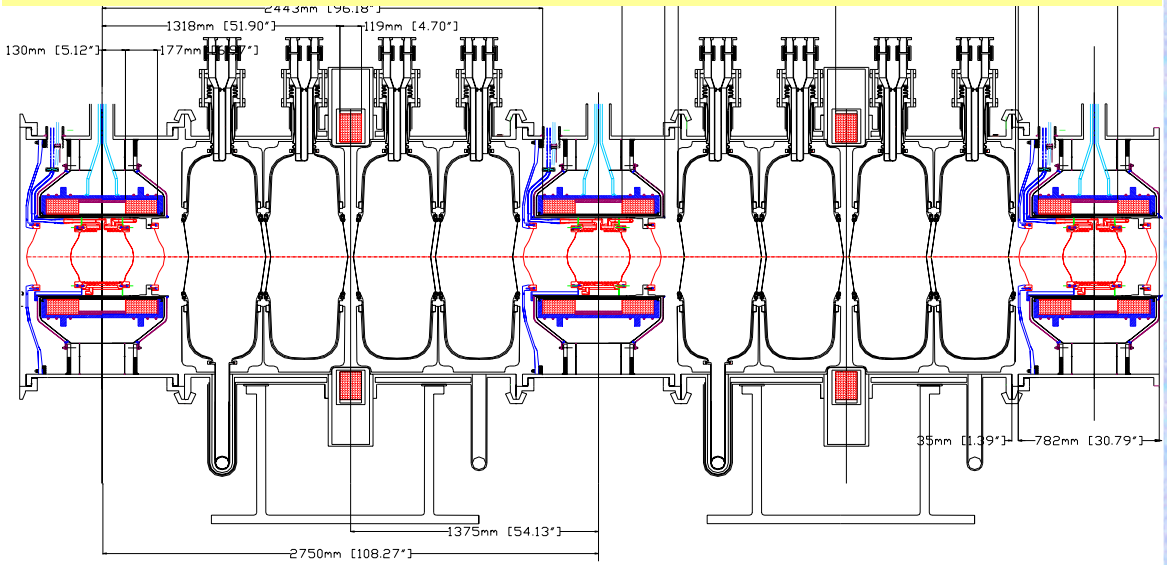
Short muon lifetime requires novel technique:
IONISATION COOLING

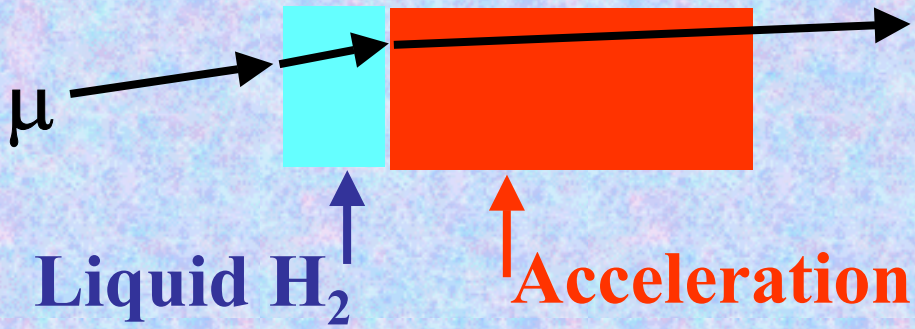
Ionisation Cooling

Principle



Practice





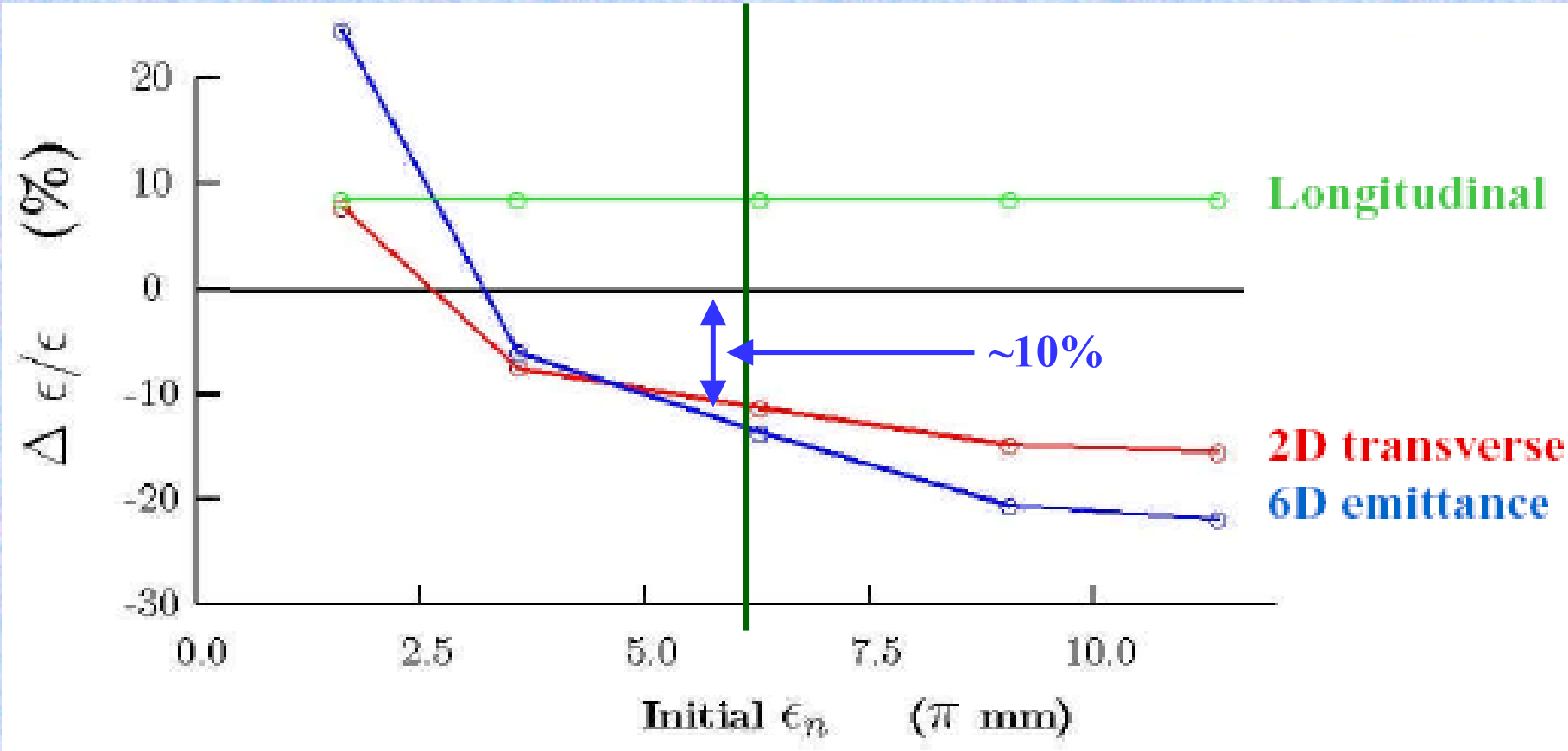
Muon Ionisation Cooling Experiment

- MICE:
  - Design, build, commission and operate a realistic section of cooling channel.
  - Measure its performance in a variety of modes of operation and beam conditions.
- Results will allow the optimisation of a Neutrino Factory complex.

MICE Collaboration

- Europe:
  - **Louvain la Neuve, Saclay, Bari, LNF Frascati, Genova, Legnaro, Milano, Napoli, Padova, Roma III, Trieste, NIKHEF, Novosibirsk, CERN, Genève, ETH Zurich, PSI, Brunel, Edinburgh, Glasgow, Imperial College, Liverpool, Oxford, RAL, Sheffield**
- Japan:
  - **KEK, Osaka University**
- United States of America:
  - **ANL, BNL, FNAL, IIT, Chicago, Enrico Fermi Institute, LBNL, UCLA, NIU, Mississippi, Riverside**
- 142 authors, 37 institutes, 3 continents

Measurement Precision



$$\Rightarrow \sigma\left(\frac{\Delta\varepsilon}{\varepsilon_{in}}\right) << 0.1 \qquad \text{Goal}: \sigma\left(\frac{\Delta\varepsilon}{\varepsilon_{in}}\right) = 0.001$$

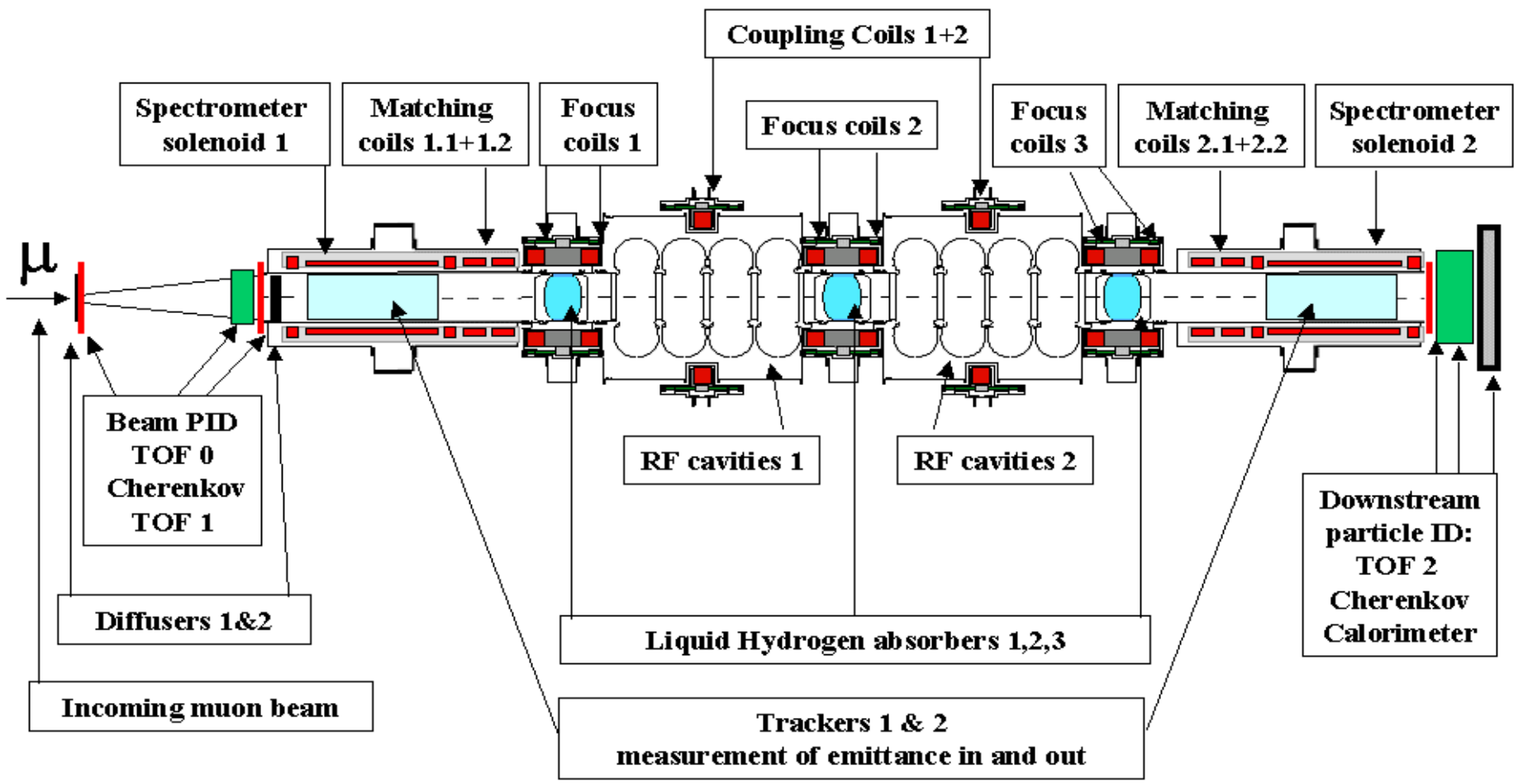
Approval and funding: status

- Proposal:
  - Submitted to CCLRC and PPARC 10th January 2003
- Peer review:
  - International Peer Review Panel (Chair: Astbury):
    - Report of IPRP 20th May 2003: 'strongly recommends approval of the project'
  - UK: PPARC Projects Peer Review Panel:
    - 3rd June 2003: Recommended appropriate funding for UK contribution
- Research Councils UK:
  - Allowed project to proceed to the Gateway process...

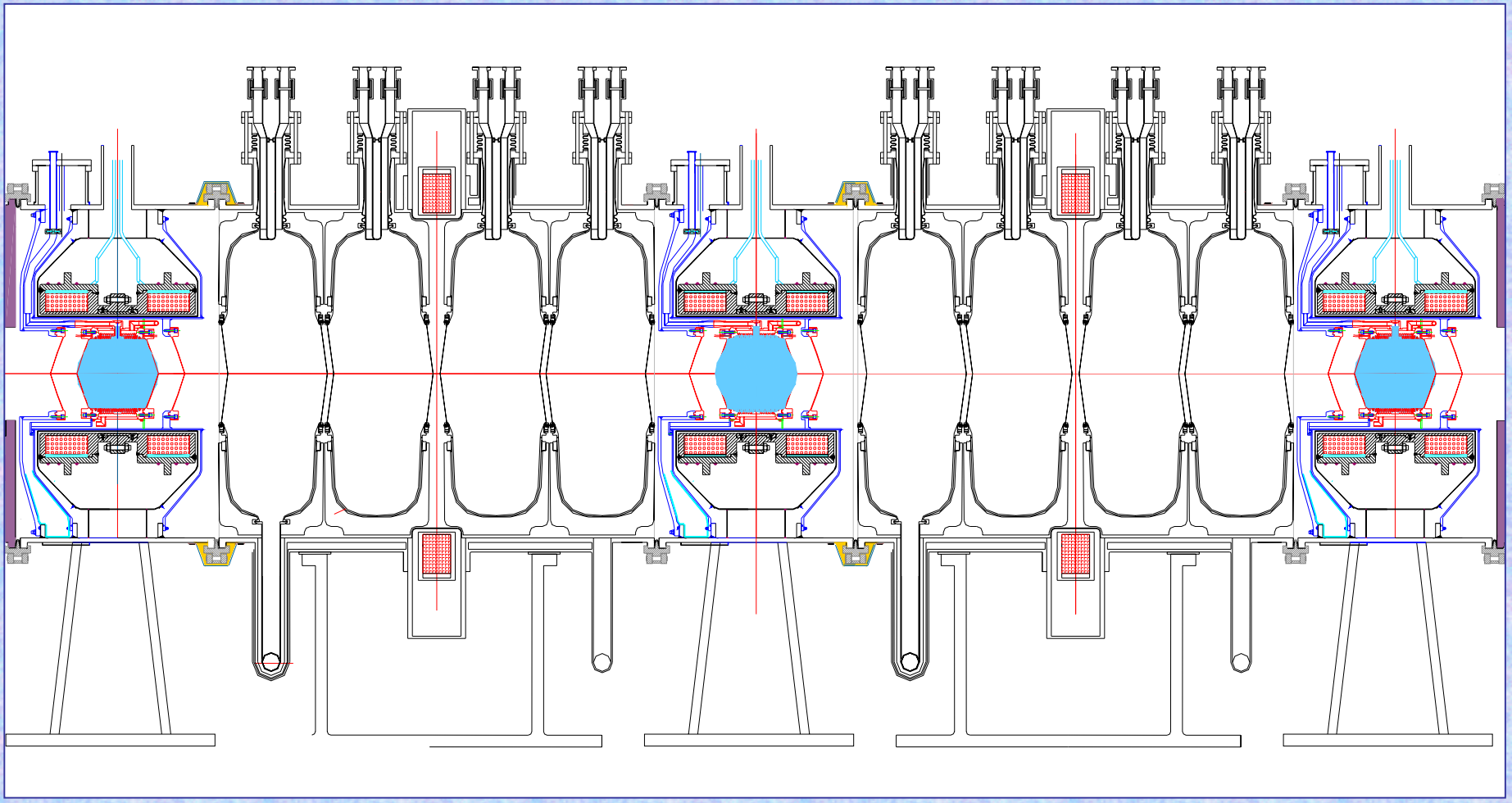
Approval and funding: status

- CCLRC (24 October 2003):
  - ‘Accepts the strong endorsement of the proposal by the Astbury panel and consequently considers the proposal to have full scientific approval’
  - ‘Approves the project subject to satisfactory passage through the Gateway’
- Office of Science and Technology:
  - Gateway process (UK procedure for large capital projects):
    - Gateway 0: ‘Business need’ – passed
    - Gateway 1: ‘Business case’ – passed on amber
    - Gateway 2/3: ‘Procurement strategy’ – goal is summer/fall of 2004; requires indications of international support.

Apparatus

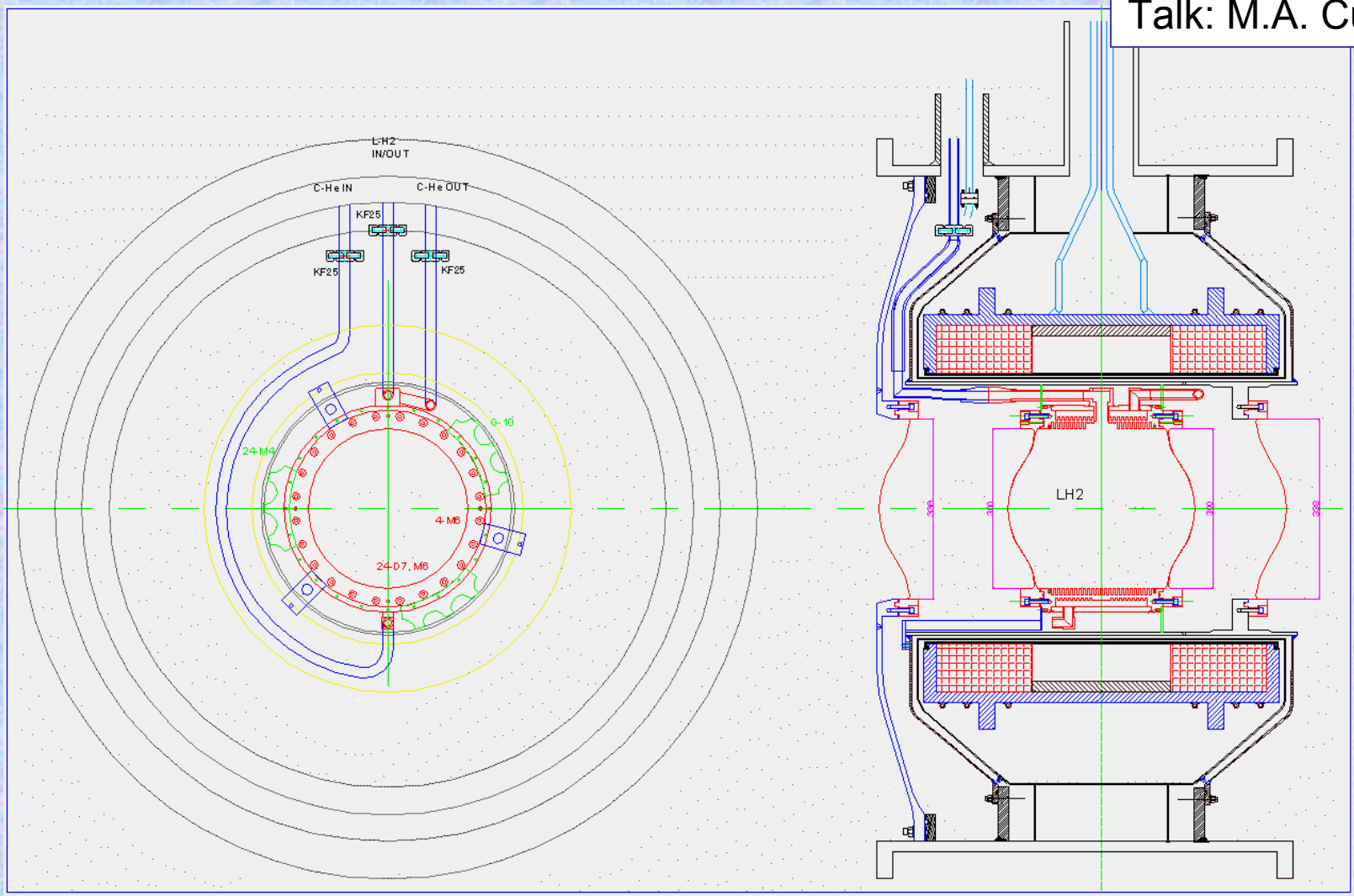

Coupling Coils 1+2
Spectrometer solenoid 1
Matching coils 1.1+1.2
Focus coils 1
Focus coils 2
Focus coils 3
Matching coils 2.1+2.2
Spectrometer solenoid 2
μ
Beam PID
TOF 0
Cherenkov
TOF 1
RF cavities 1
RF cavities 2
Downstream particle ID:
TOF 2
Cherenkov
Calorimeter
Diffusers 1&2
Liquid Hydrogen absorbers 1,2,3
Incoming muon beam
Trackers 1 & 2
measurement of emittance in and out

Cooling channel



Absorber/Focus coils

Talk: M.A. Cummings

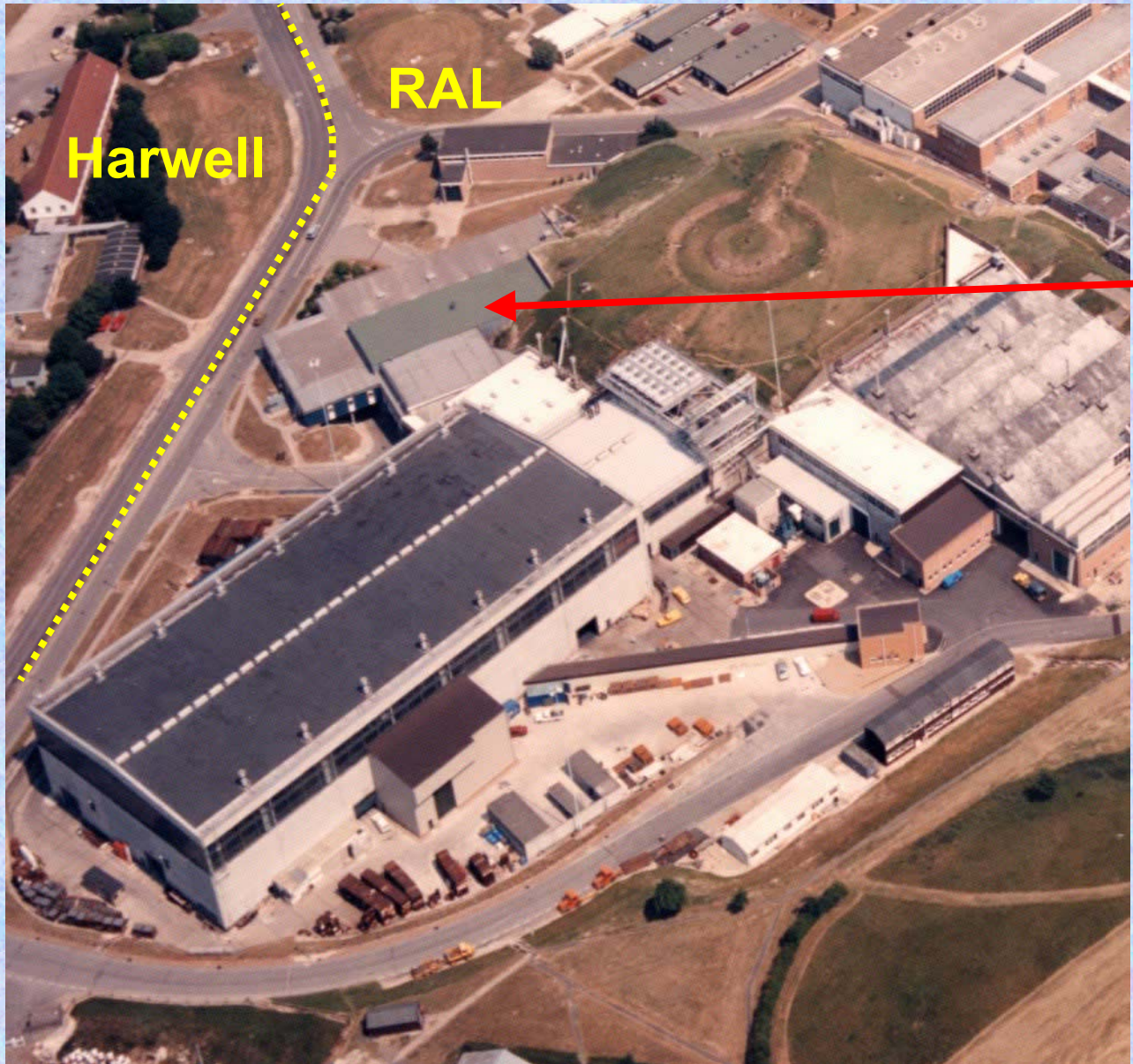


RF Cavities

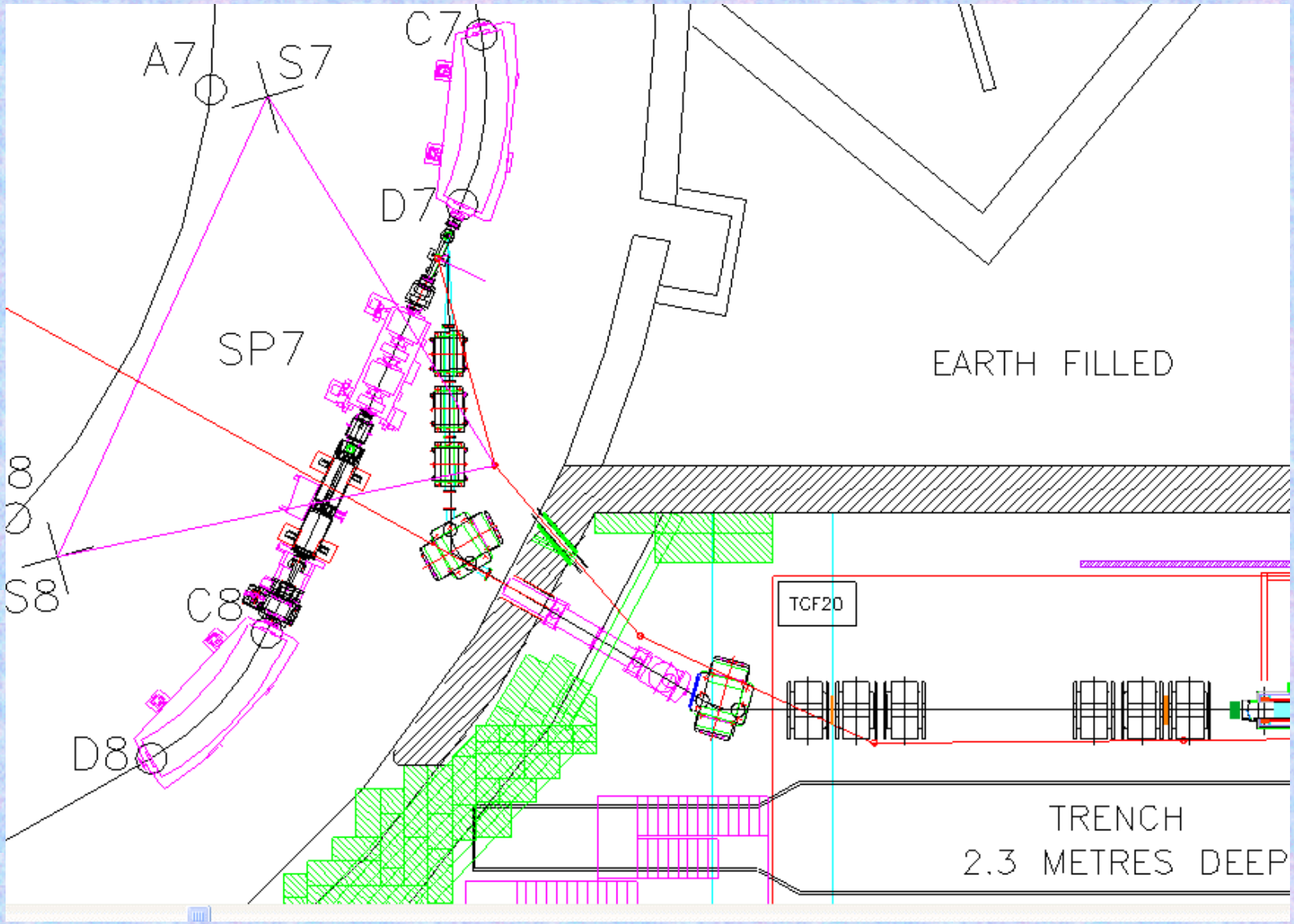
Talk: Y. Torun

- Specification:
  - 201.25 MHz, 8 MV/m
- Principal challenges:
  - Operation in strong magnetic field.
  - Large aperture, require window.

MICE at RAL

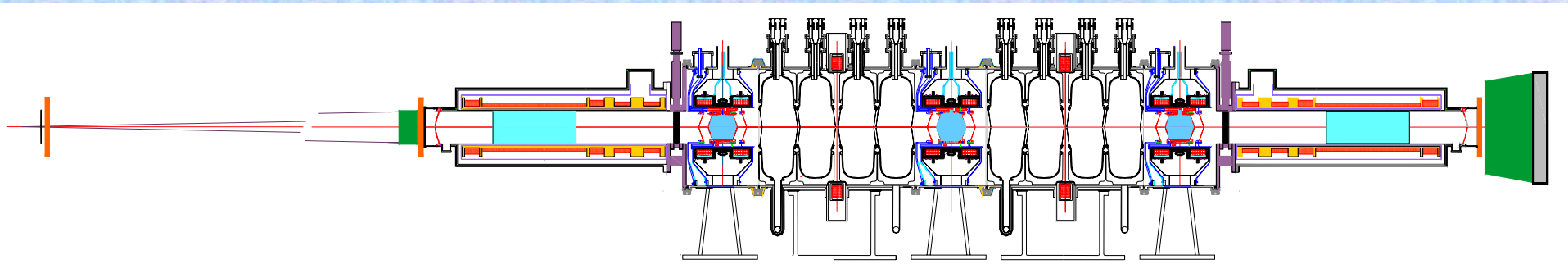


MICE Beam


A7
S7
C7
D7
SP7
EARTH FILLED
S8
C8
D8
TCF20
TRENCH
2.3 METRES DEEP

MICE Detectors

- Tracking – Scintillating fibre trackers in 4T solenoid magnet.
- Particle ID:
  - Time of flight walls before and after cooling channel
  - Cherenkov detectors before and after cooling channel
  - Calorimeter after channel.

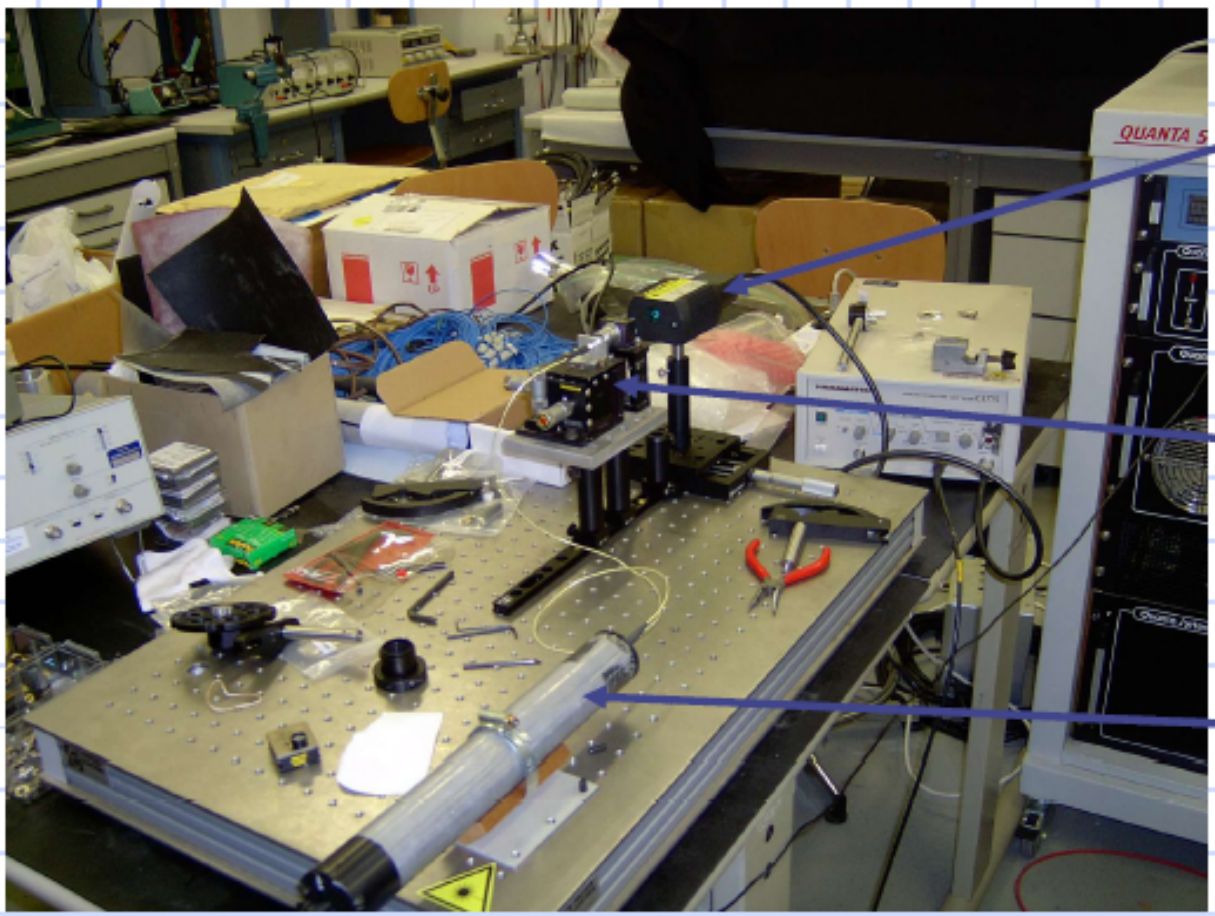


Time of Flight

- Specification: time difference resolution 70 ps.
- Tasks:
  - TOF0 – TOF1: π/μ separation
  - TOFs: measurement of muon phase with respect to the RF
  - Trigger and trigger time
- Principle challenges:
  - Rate in upstream TOFs
  - Time-difference resolution

TOF R&D

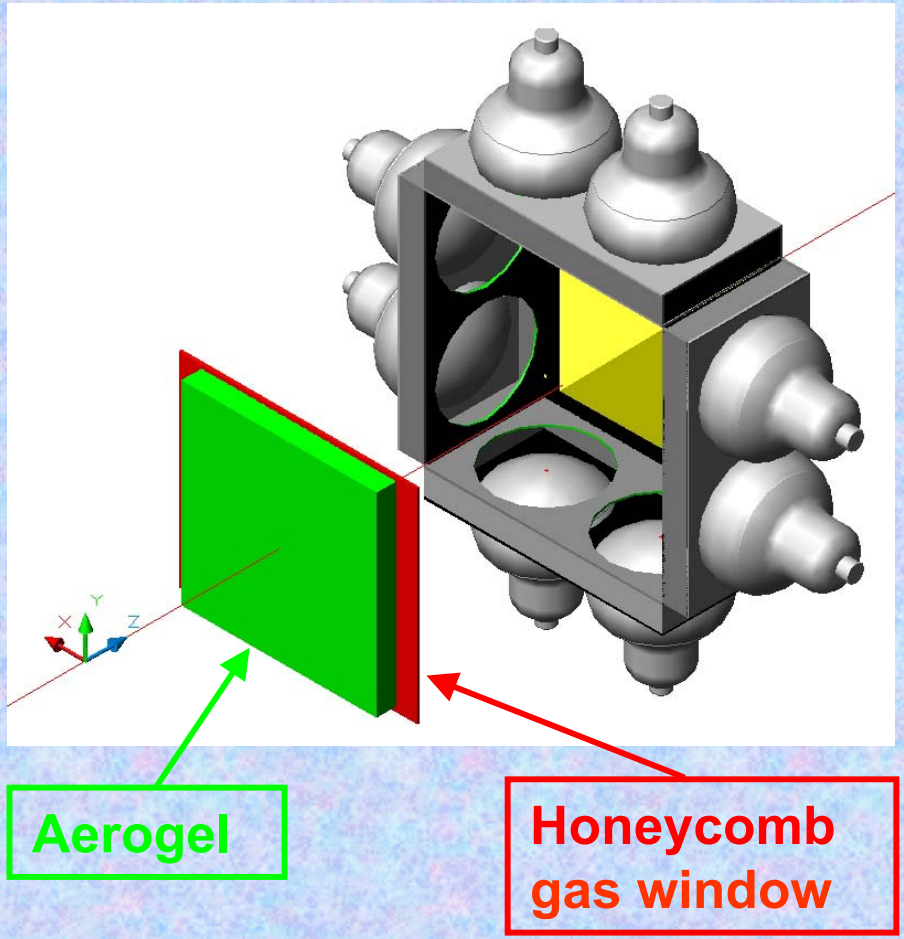
Test setup for study of rate effects



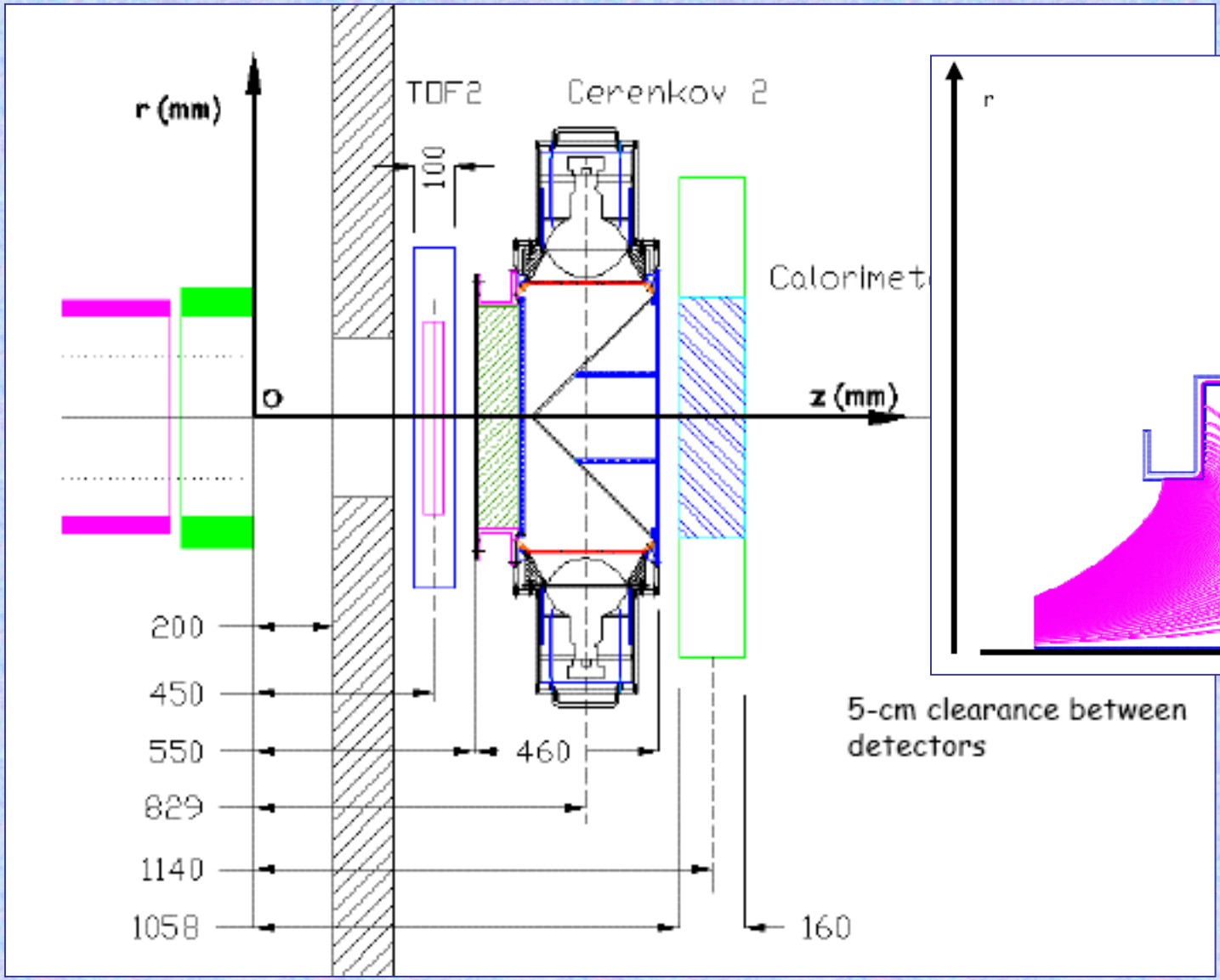
- Light source: Hamamatsu fast laser ($\lambda \approx 405$ nm, FWHM 35 ps, .17 mW power)
- Optical system: x,y,z micrometric movement to inject light into a CERAM/OPTEC multimode fiber (spread 14 ps/m)
- PMT under test (R7761, ...), output to SILENA MCA
- All tests to be redone at LASA with B-field

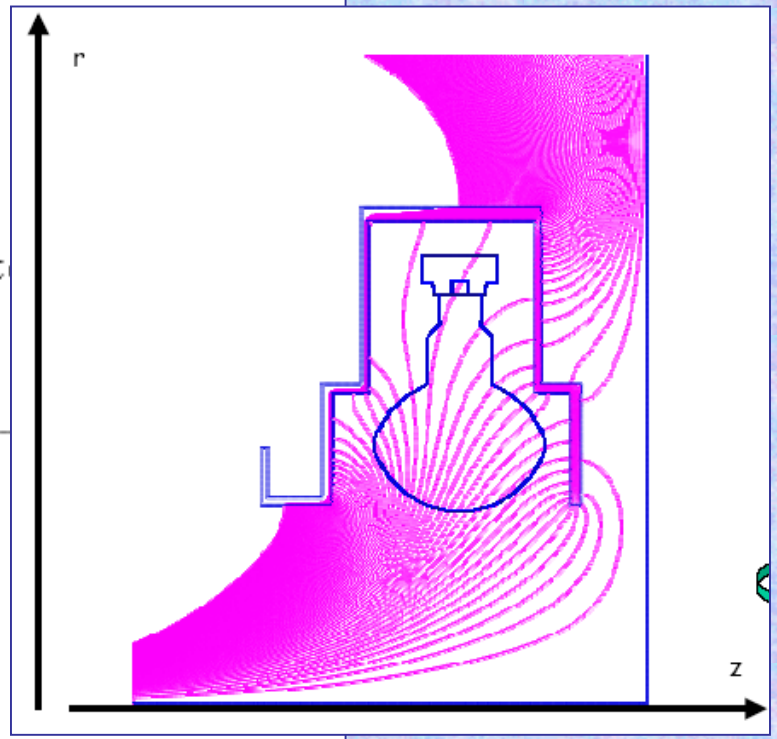
Cherenkov

- Upstream:
  - π/μ separation
- Downstream:
  - μ/e separation
- Challenge:
  - Operation in fringe field of tracker solenoid



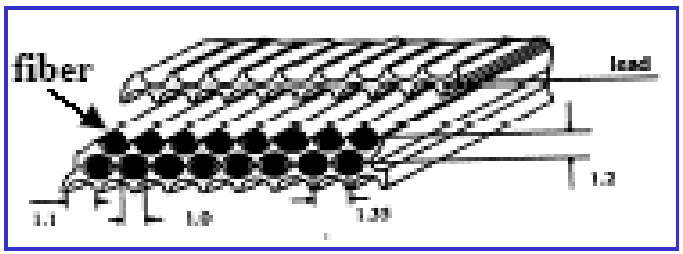
Cherenkov: Layout and Shielding

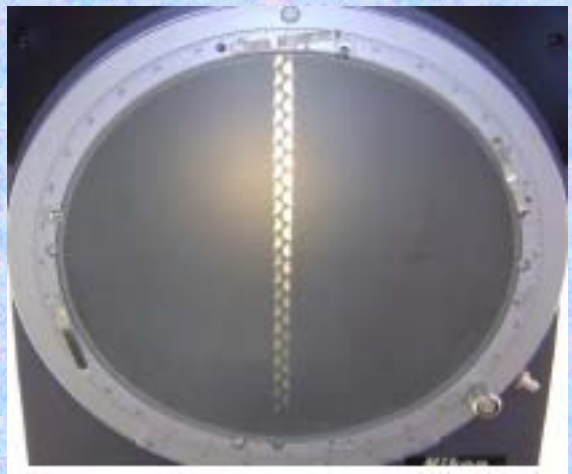




Muon Calorimeter

- Task:
  - μ/e separation
- Construction:
  - 0.3mm lead; 1mm fibre
  - Scintillating fibres embedded in grooved lead layers.

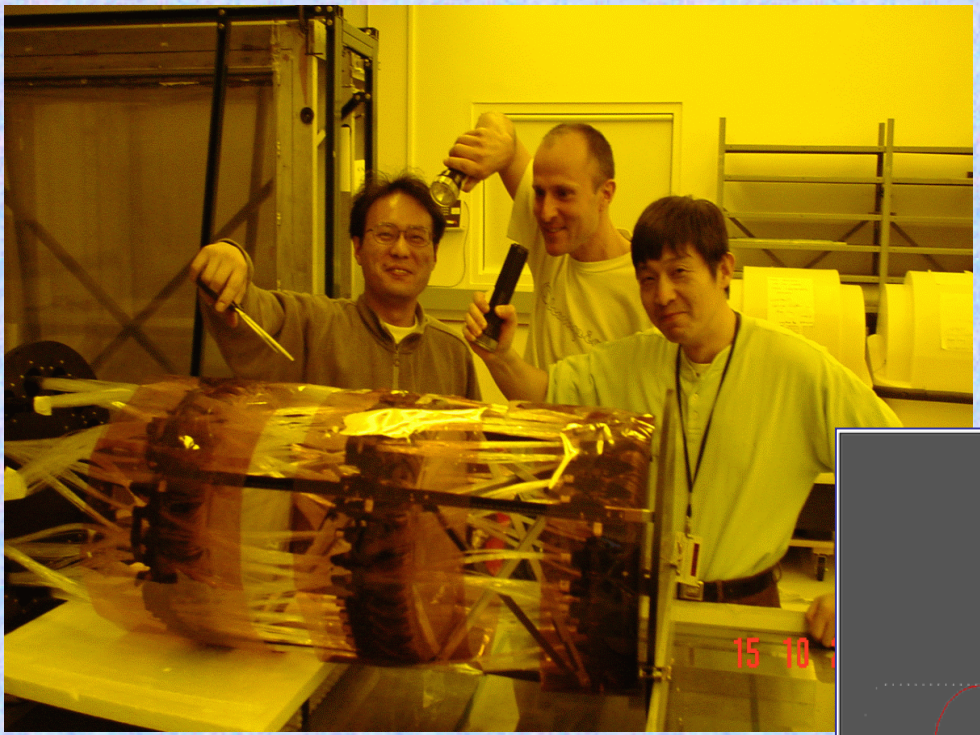


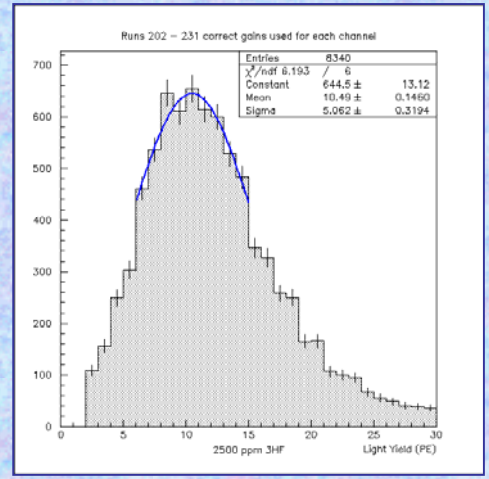


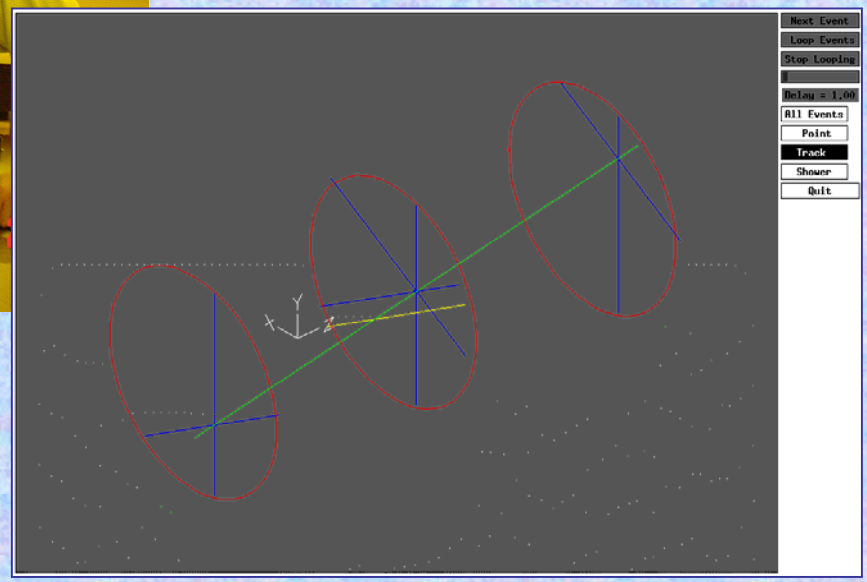
Spectrometers

- Tasks:
  - Muon momentum and position measurement
  - Emittance measurement.
- Solenoid Specification:
  - 4T field, 40cm bore
- Challenge:
  - High background from RF cavities.
- Design:
  - 5 measurement planes of 350 micron scintillating fibre, read-out using VLPCs.

Scintillating Fibre Tracker prototype







Outlook