Muon Scattering Experiment

Birmingham, CERN, IC, RAL, Riken, TRIUMF and UCLA

- Aims
- The Experiment
- Muon Beam
- Performance
- Future Plans

Aims

(1) Comparison with old data

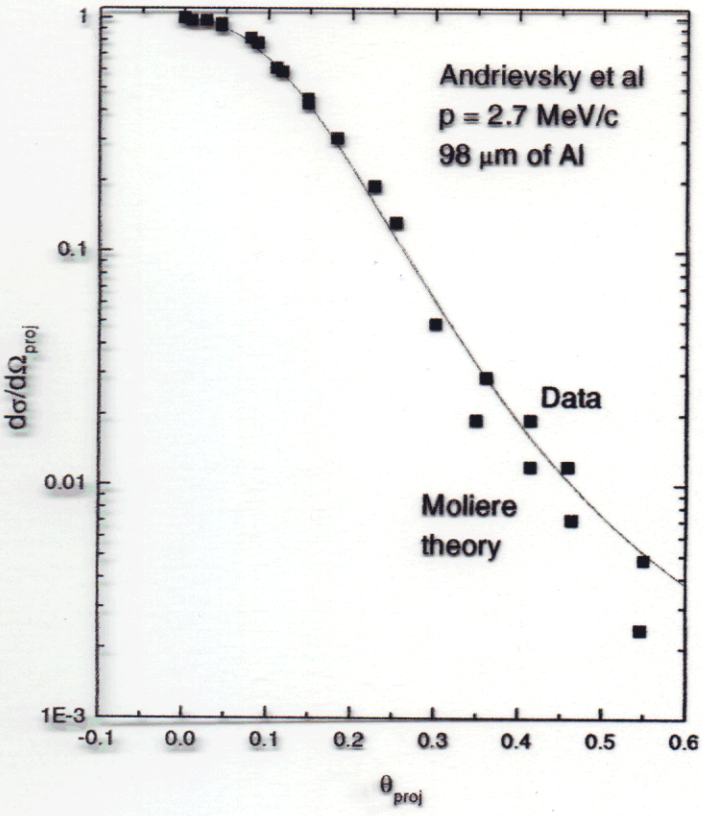
- Ionisation cooling is a balance between the cooling from dE/dx and the heating from multiple scattering:

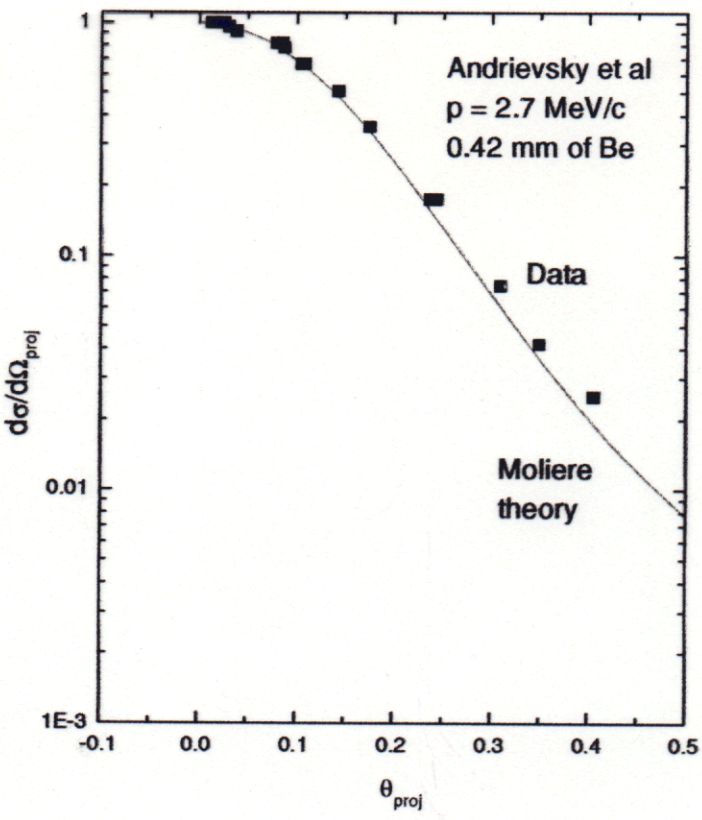
$$\frac{d\epsilon_n}{ds} = -\frac{1}{\beta^2}\frac{dE_\mu}{ds}\frac{\epsilon_n}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014)^2}{2E_\mu m_\mu L_R}$$

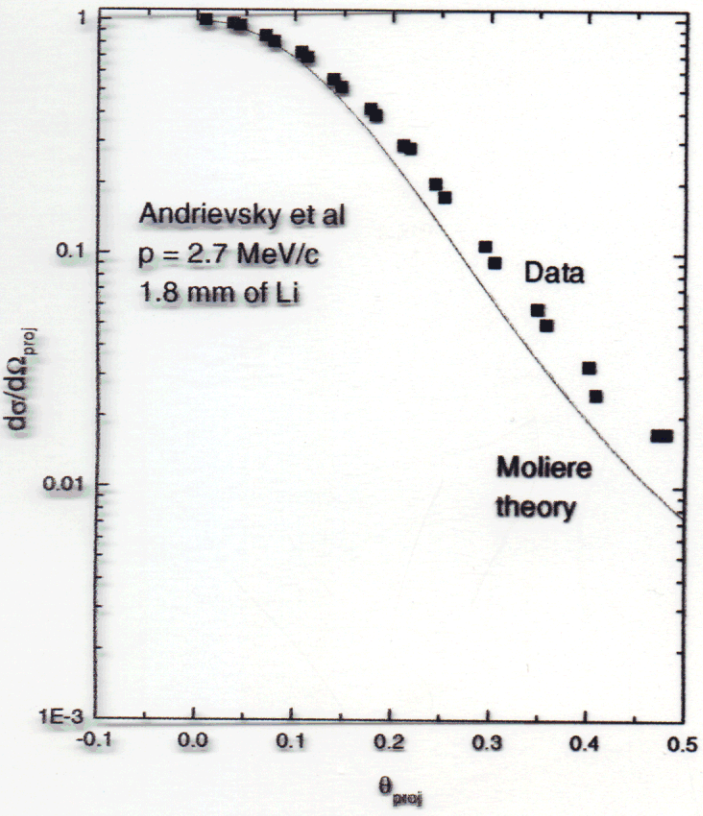
  L_R = radiation length $\Longrightarrow$ low Z materials required

- No directly relevant experimental measurements
- Important to measure the scattering and compare with the theory being used because
  - low angle $\Longrightarrow$ required cooling not achieved
  - wide angle $\Longrightarrow$ muons lost from the beam
- 55 year old electron scattering suggests there may be a problem for low Z materials

Electron scattering measurements:





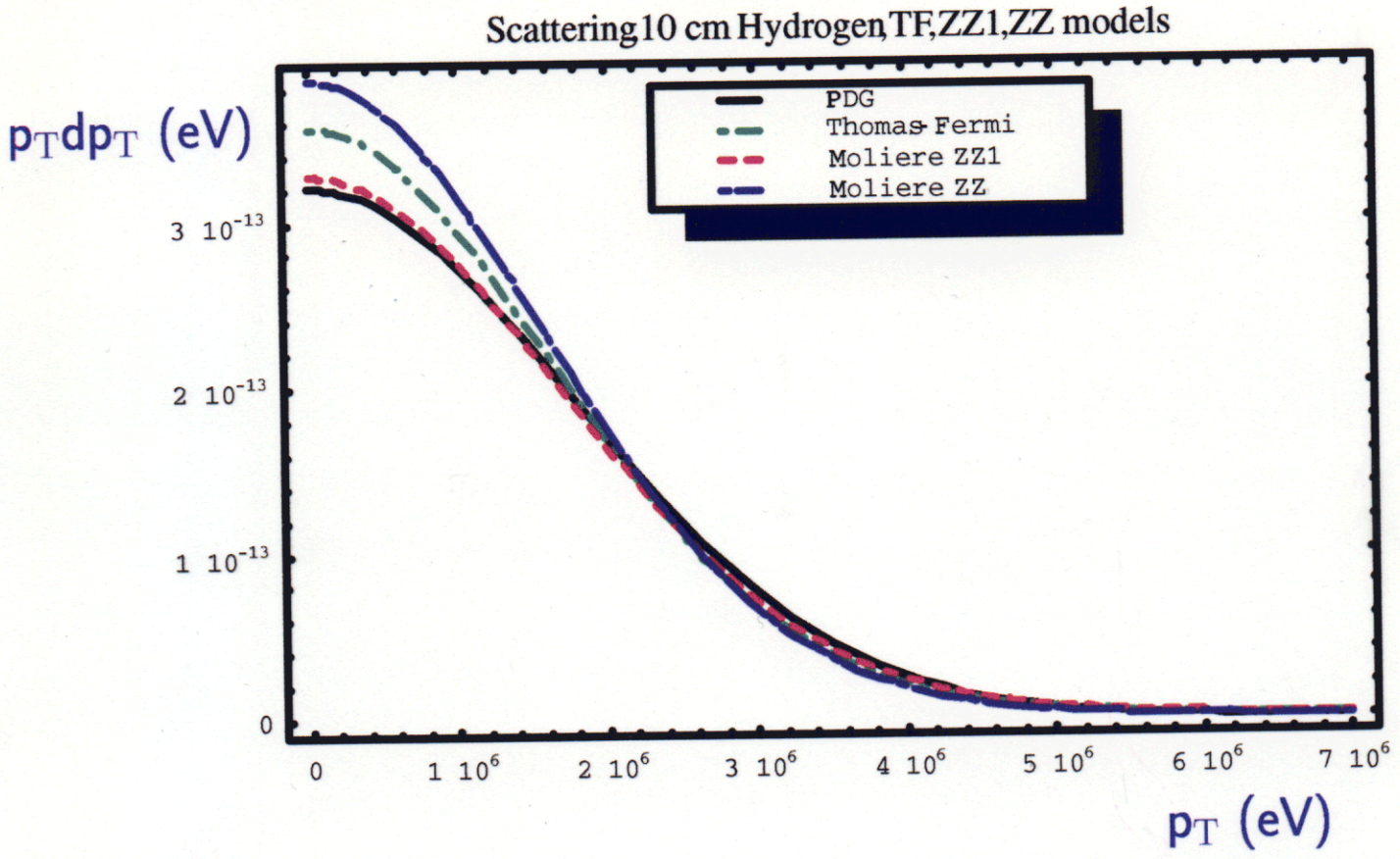


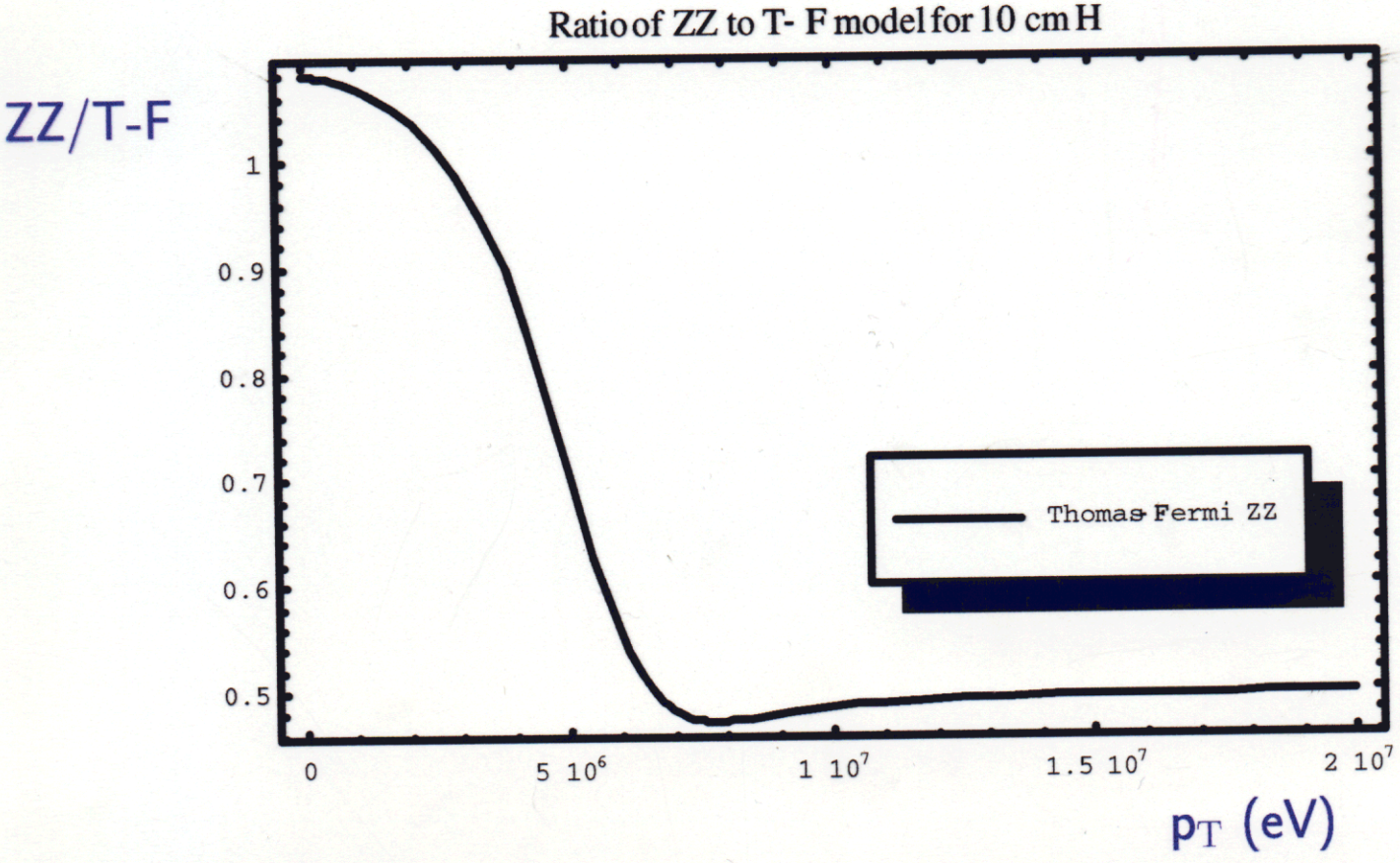
2.7 MeV/c electrons on

- 98μm of aluminium
- 0.42mm of beryllium
- 1.8mm of lithium

from: **Andrievsky et al, J. Phys 6 (1942) 278**

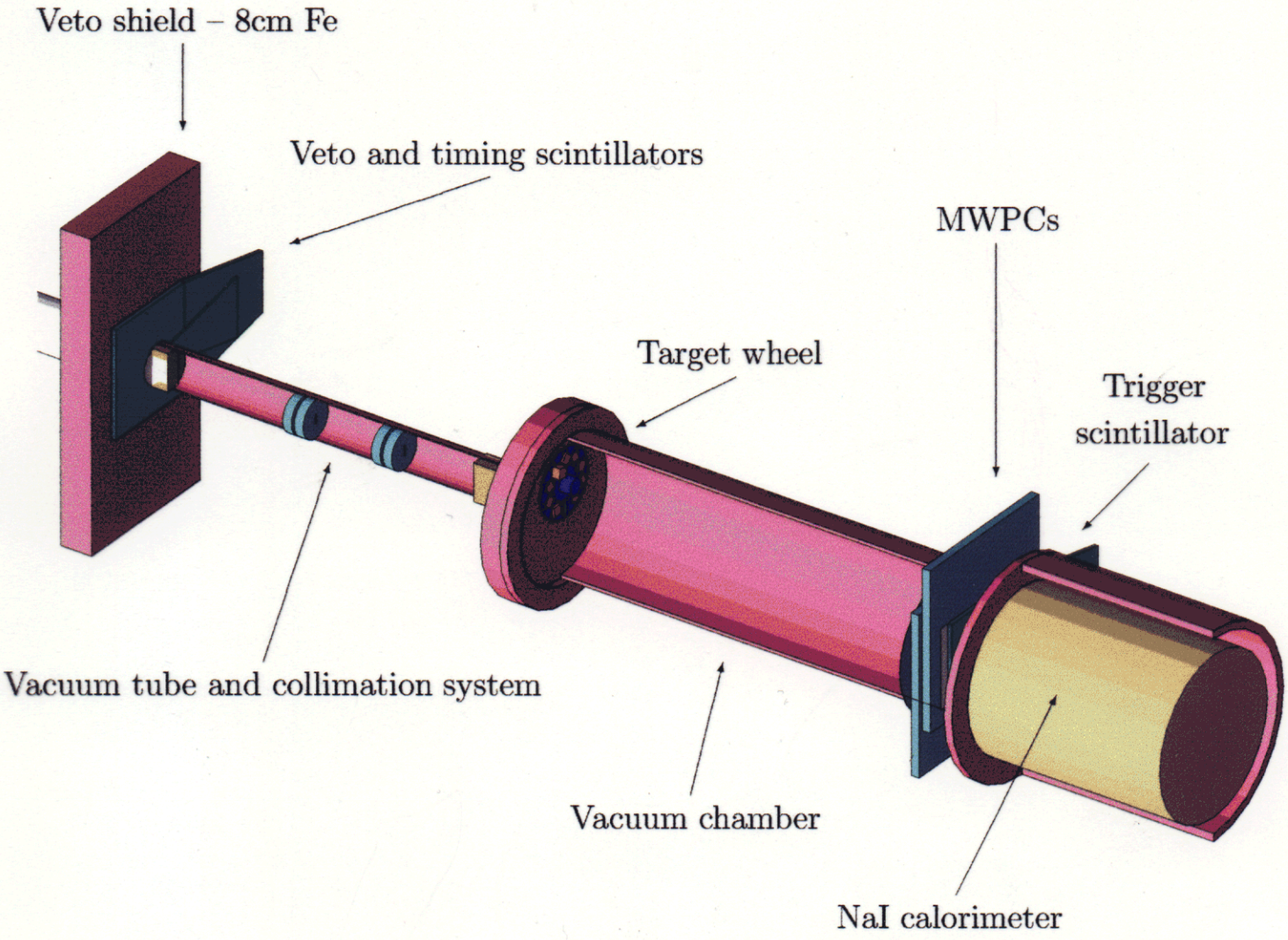
(2) Comparison with new scattering models





The Experiment

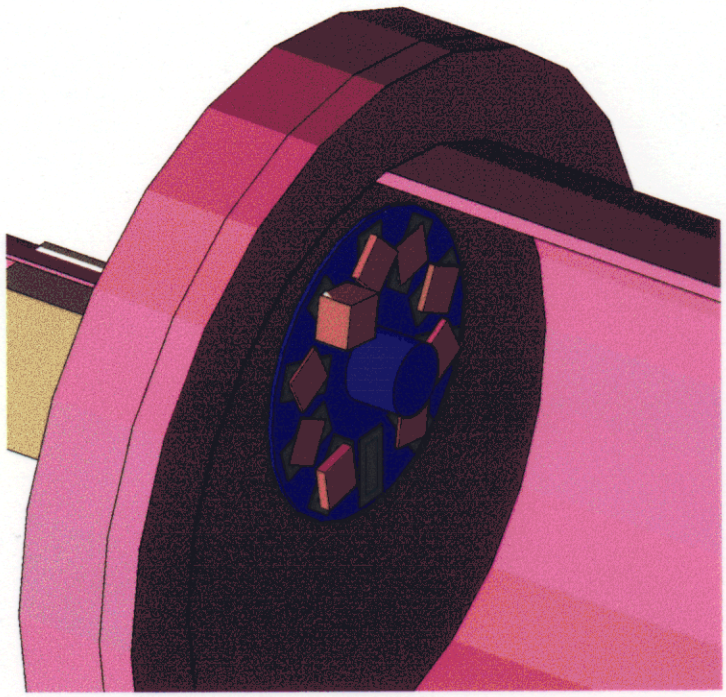
- **Constraints:**
  - Minimum material $\Longrightarrow$ tracking not possible
  - Beam origin well-defined $\Longrightarrow$ collimation system
  - Good background rejection $\Longrightarrow$ tof system



Targets

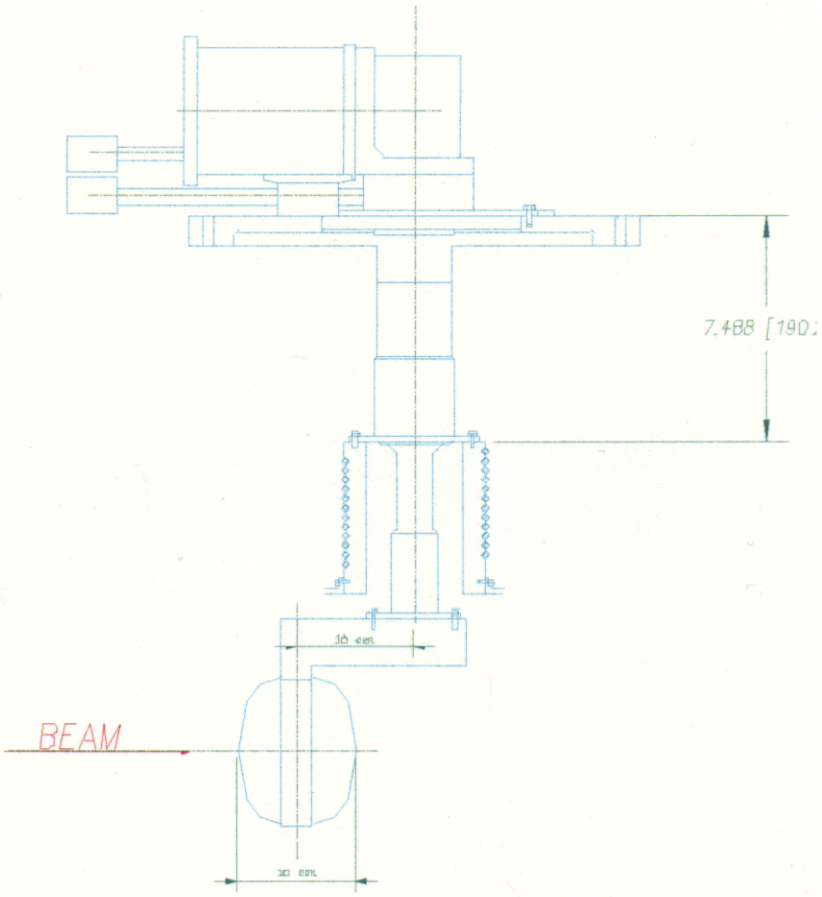
- **Constraints:**
  - Low Z
  - Sufficient thickness to give reasonable mean scattering angle - 10 mrad
  - Not too thick - origin of scatter
- **Solid targets:**

	Thickness (mm)
Li	4/10
Be	0.5/2
C	2.5
Al	1.0
CH_2	3.0
Fe	0.15
Scint	3.0



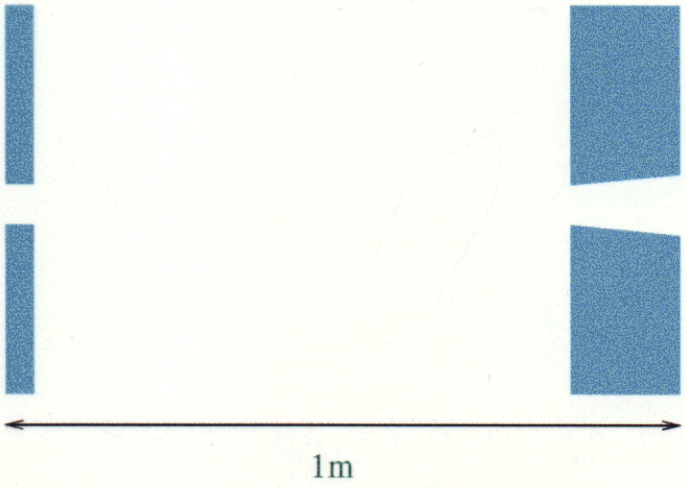
- **Liquid targets:**

H_2 100/150

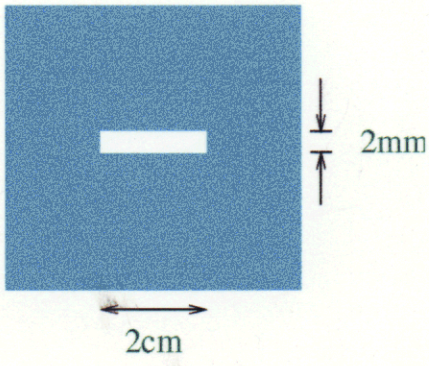


Collimation system

Longitundinal view



Transverse view



Location

- Experiment has been approved at TRIUMF
- 2/3 running periods in M11/M9B beam lines
- Approved in M11 from 22nd June till 17th July

Parameter	M11	M9B
Beam type	Pion	Muon
Momentum range (MeV/c)	80 - 415	20 - 100
Intensity (Hz)	2×10^5	1.4×10^6
Pion/muon	50!	0.01
Momentum resolution	1%	3.4%

- Main disadvantage: $\pi/\mu \Longrightarrow$ TOF
- Main advantage: Momentum range

  But

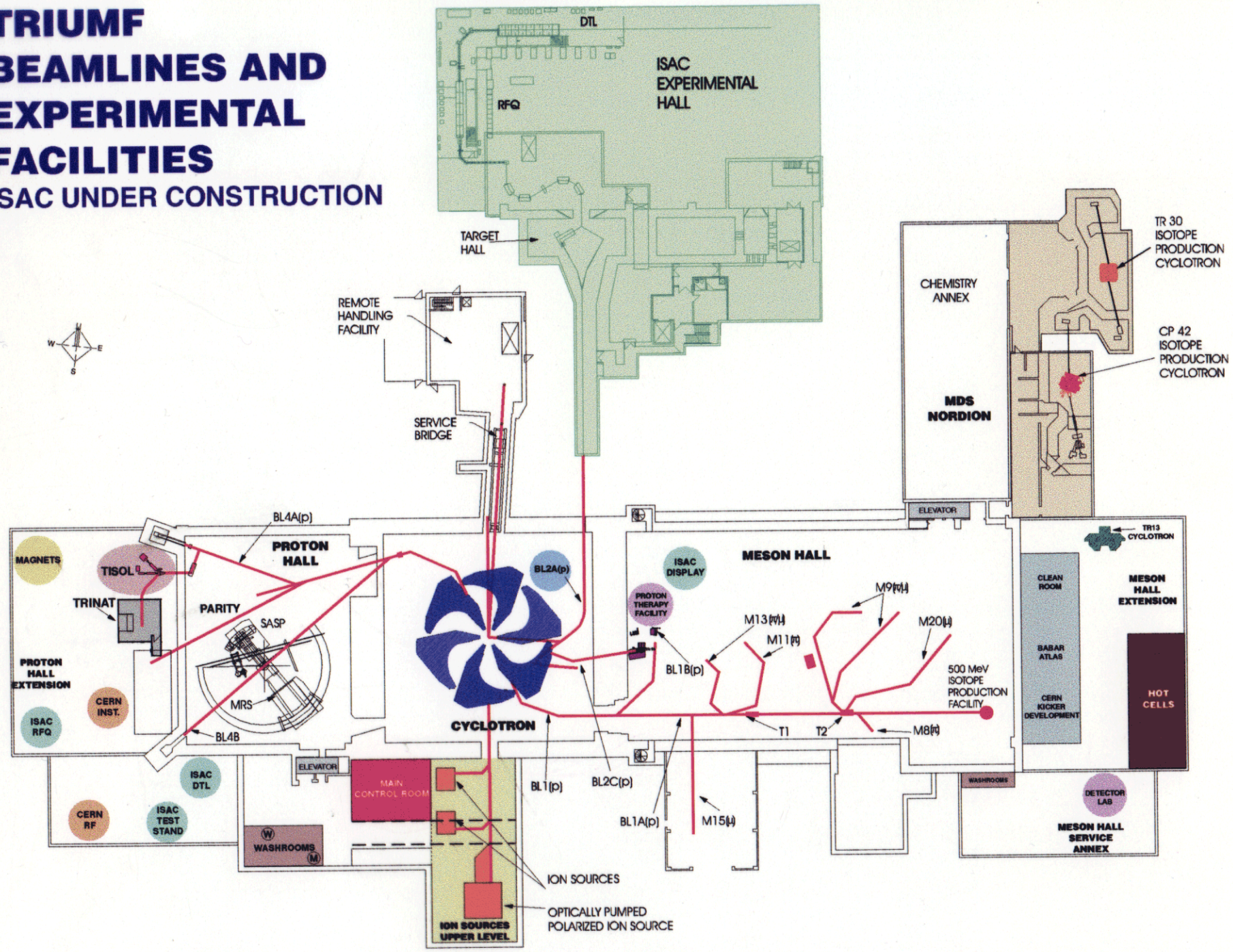
  TOF

  Scattering angle

  Penetration

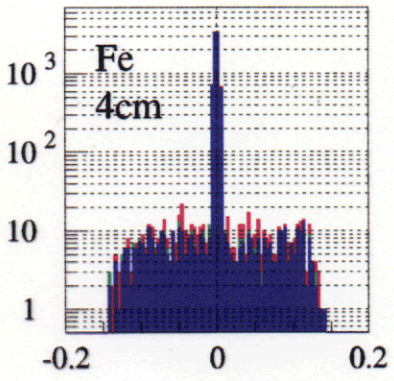
TRIUMF BEAMLINES AND EXPERIMENTAL FACILITIES

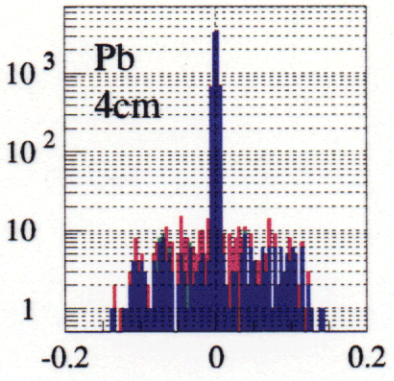
ISAC UNDER CONSTRUCTION

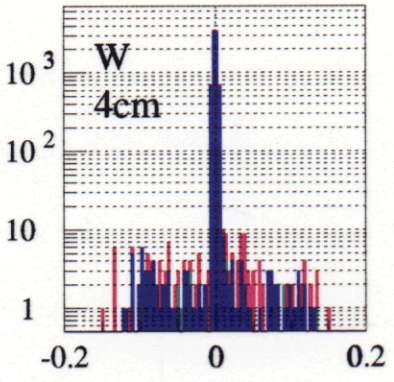


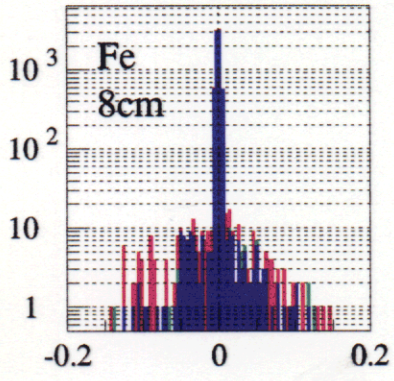
Performance

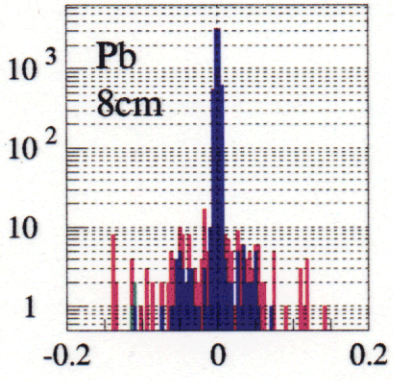
(1) Collimation system

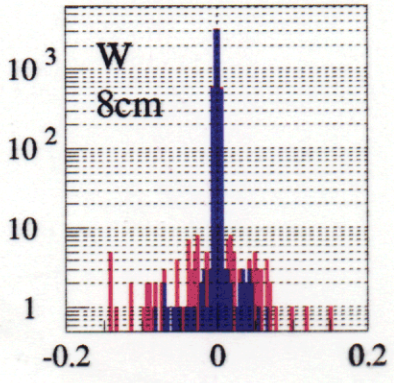


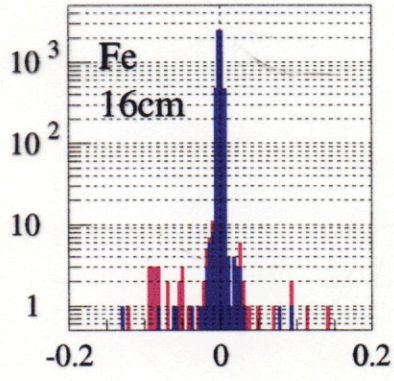


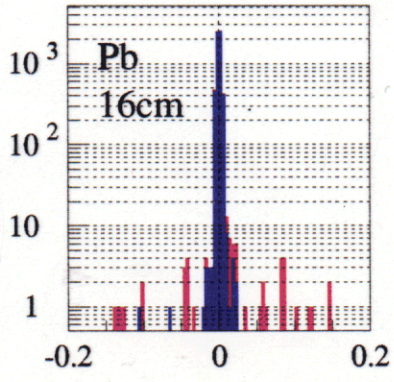


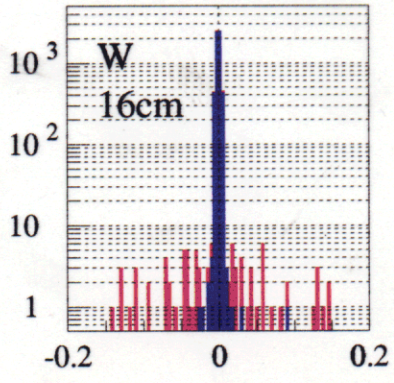




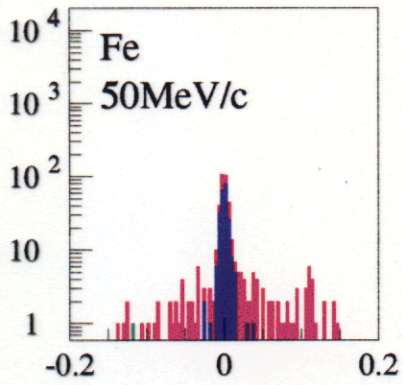




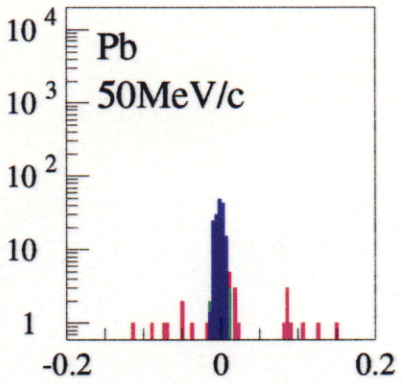




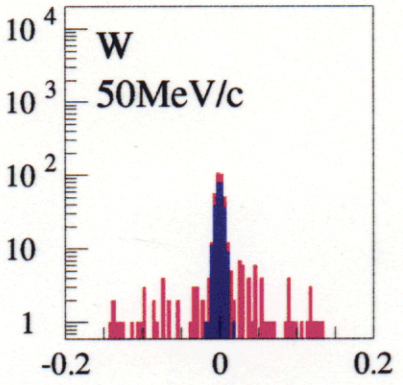
Momentum dependence



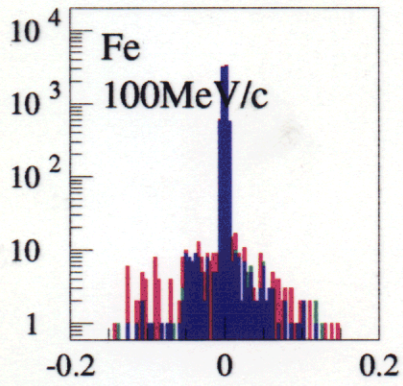
Event Triggered Hit positions



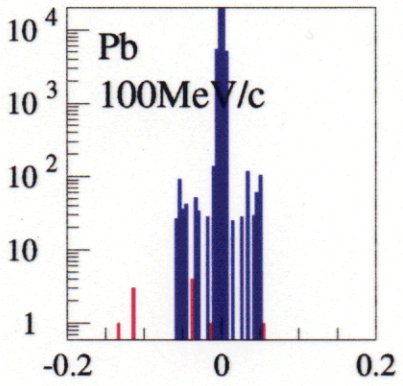
Event Triggered Hit positions



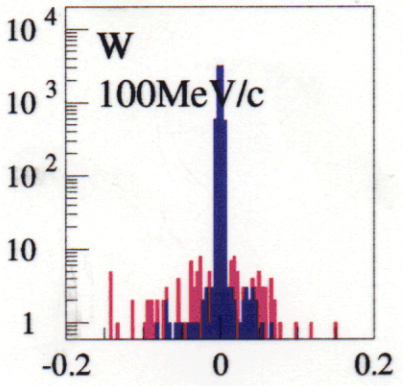
Event Triggered Hit positions



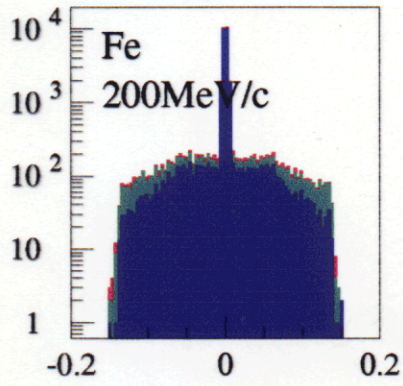
Event Triggered Hit positions



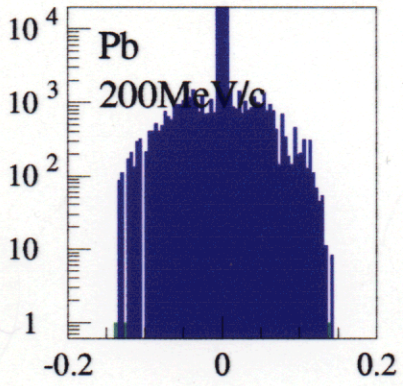
Event Triggered Hit positions



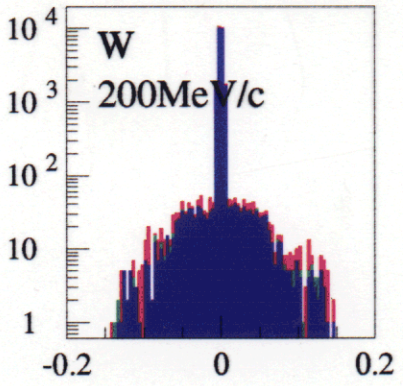
Event Triggered Hit positions



Event Triggered Hit positions

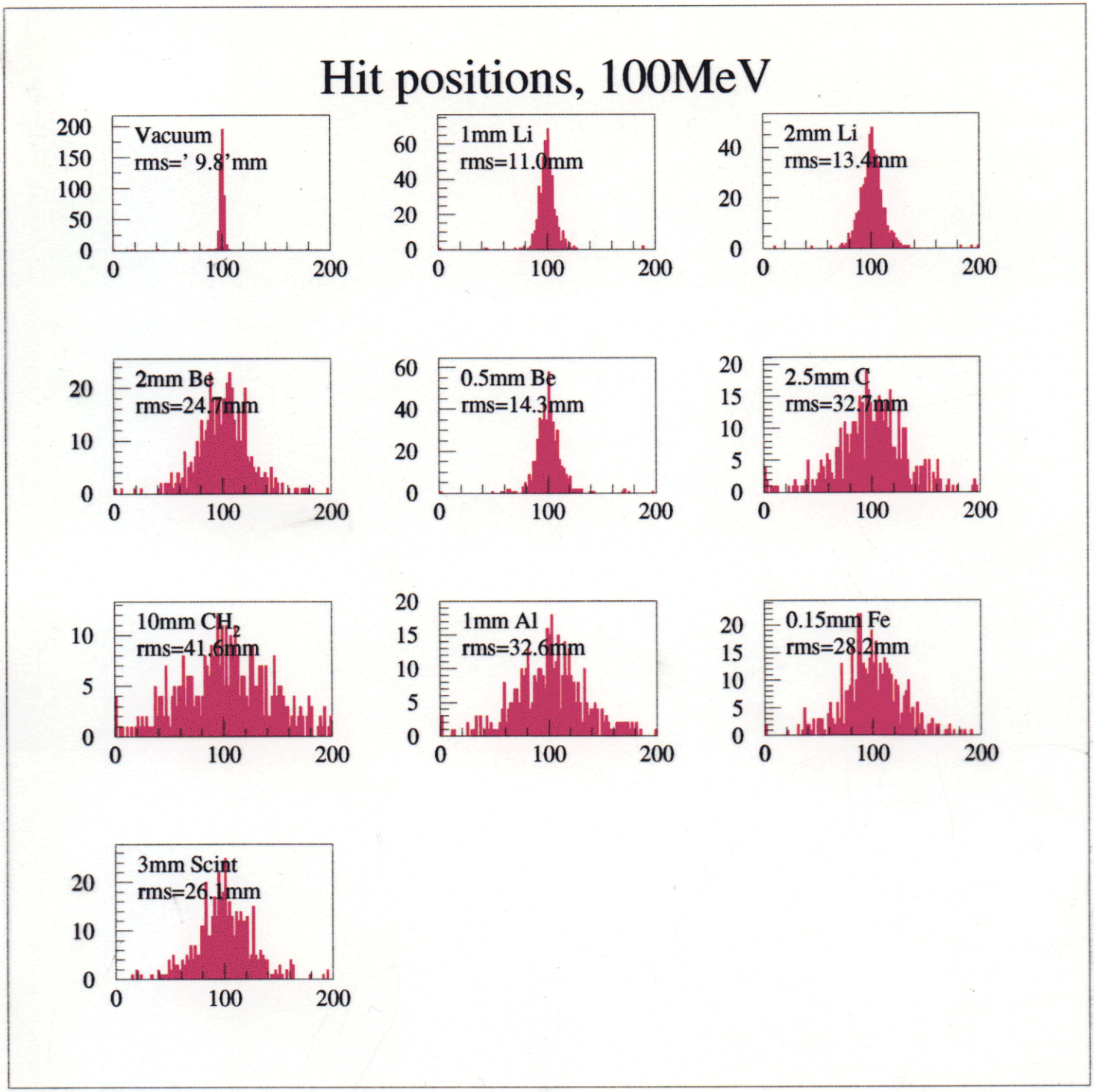


Event Triggered Hit positions

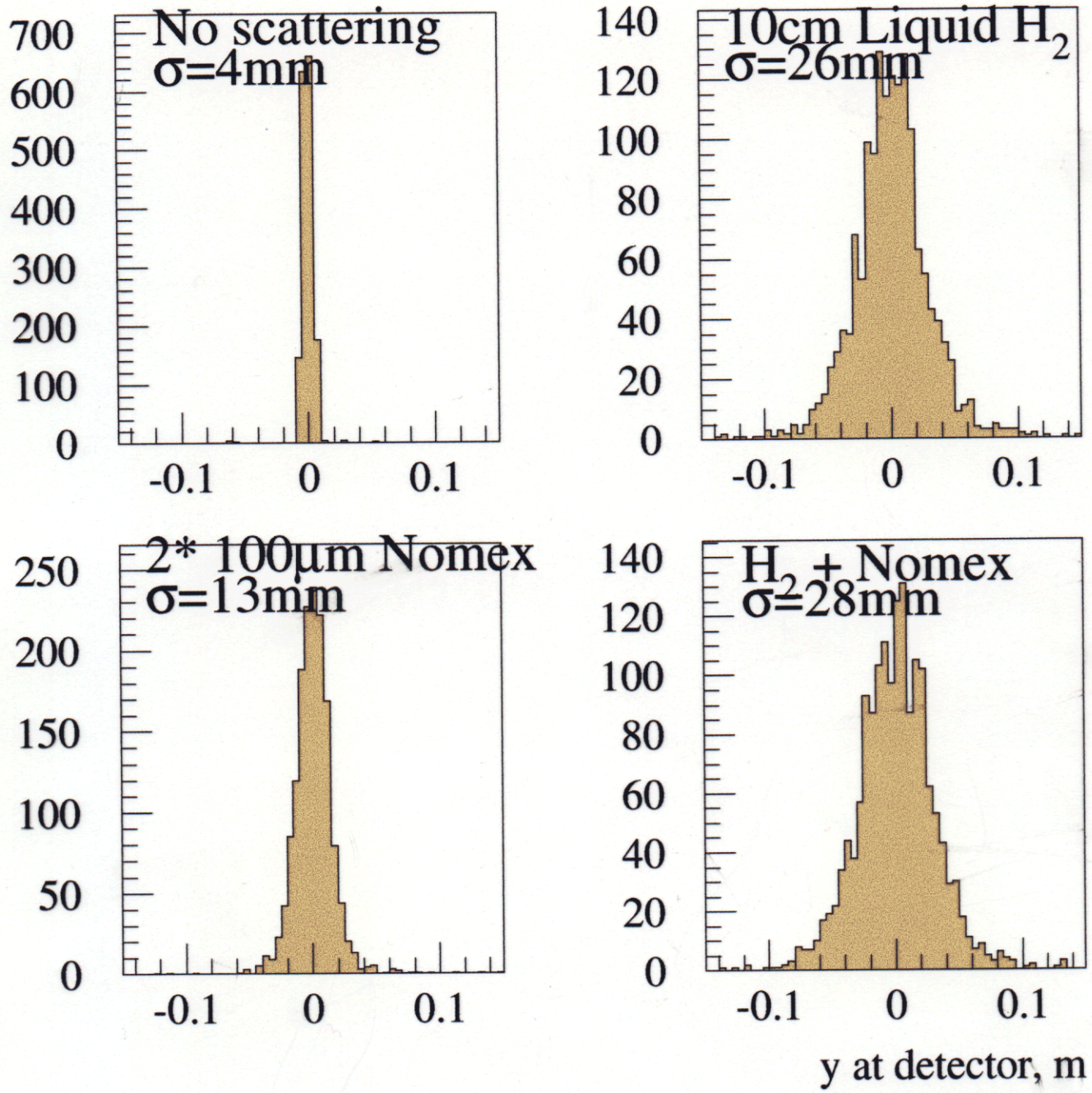


Event Triggered Hit positions

Comparison with all solid targets



Comparison with LH2 target



(2) Time-of-Flight

- Crucial for π/μ separation - 10^4

p (MeV/c)	80	90	100	110	120	130	140	160	170
$< \theta >$ (mrad)	31.3	25.9	22.0	19.1	16.8	15.0	13.5	11.3	10.5
μ^+ (s^{-1})	32	49	57	106	148	182	209		
μ^- (s^{-1})	5	6	7	11	20	32	37		
$\Delta t\ (\pi - \mu)$ (ns)	16.5	14.1	12.2	10.7	9.4	8.3	7.4	6.0	5.4
$\Delta t\ (\mu - e)$ (ns)	30.7	25.3	21.1	18.1	15.5	13.5	11.8	9.3	8.3

- Beam pulse: 1.9 ns
  Scintillator timing resolution: $\sim$ 1 ns

(3) Detector resolution

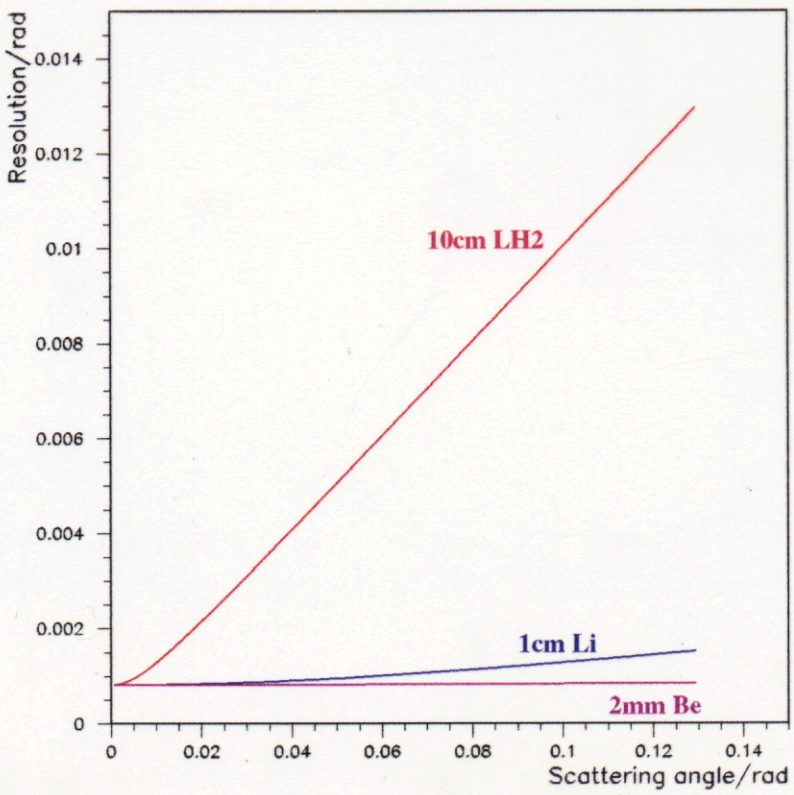
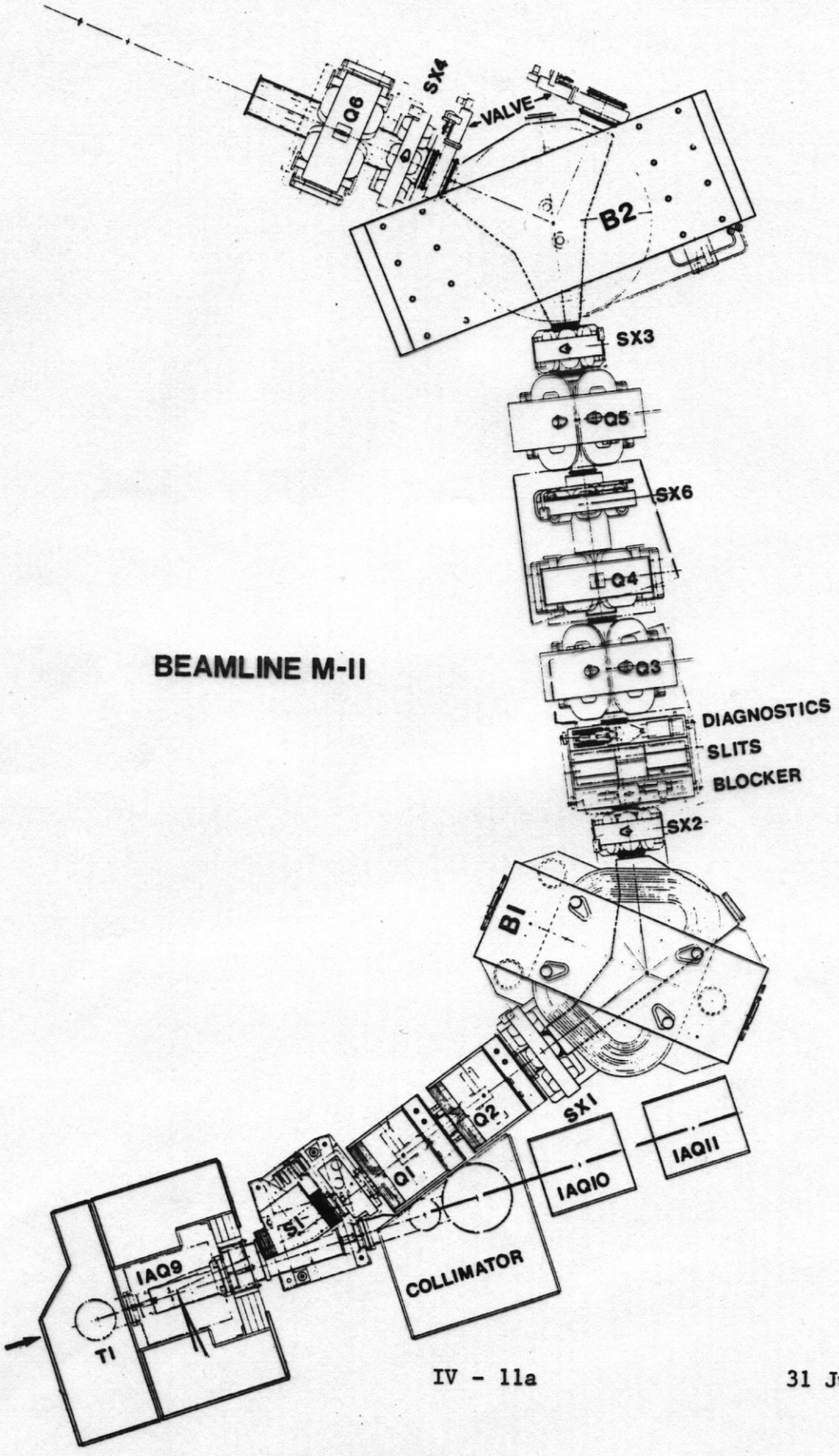


Figure 4.1.6.A Layout of the M9 pion channel



Future Plans

(1) Demonstration of "ionisation cooling"?

- Via an upgrade of scattering experiment

(2) A muon beamline for cooling, phase rotation, etc studies