MuScat: The Muon Scattering Experiment

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

Aims

(1) Comparison with old data

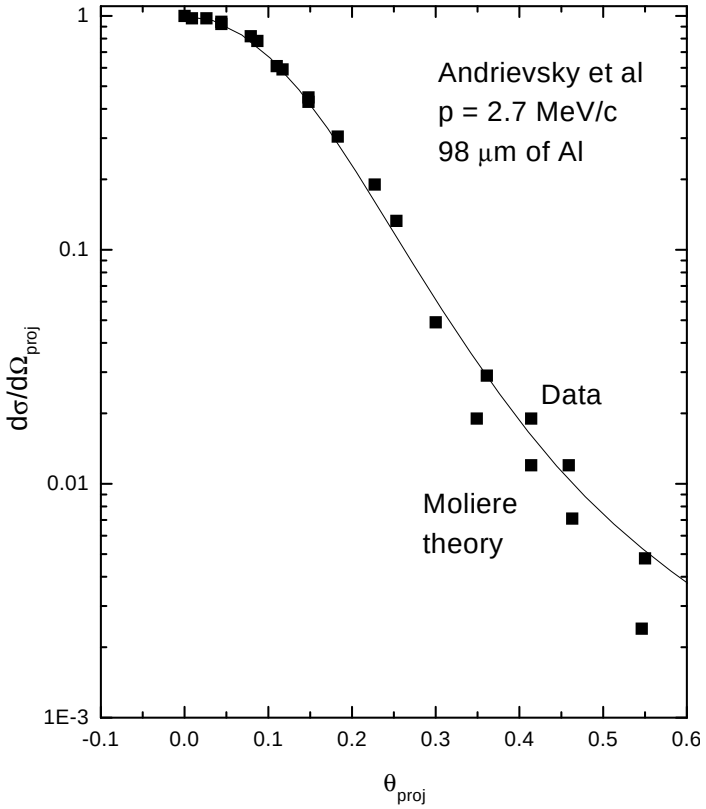
- Ionisation cooling is a balance between the cooling from dE/dx and the heating from multiple scattering:

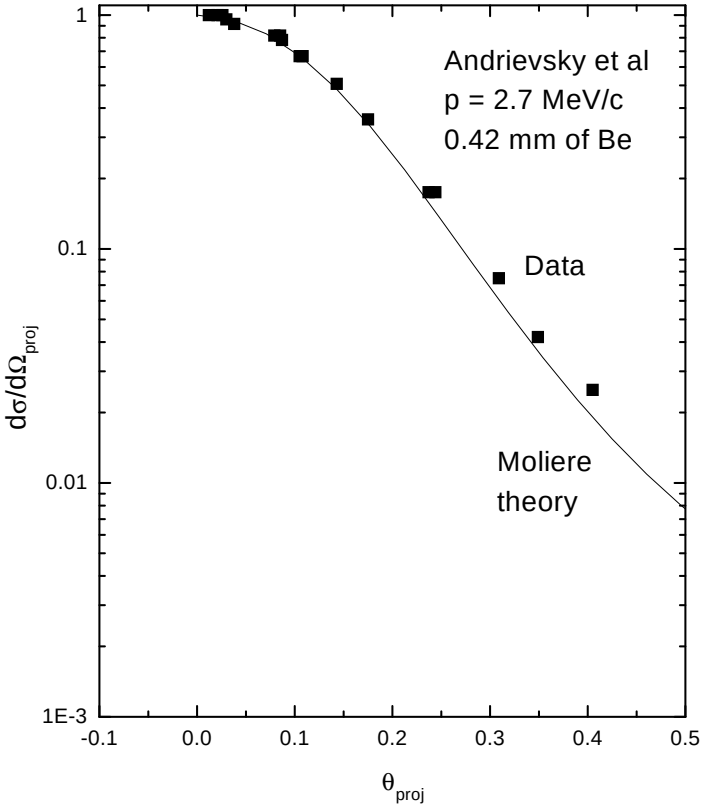
$$\frac{d\epsilon_n}{ds} = -\frac{1}{\beta^2}\frac{dE_\mu}{ds}\frac{\epsilon_n}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014)^2}{2E_\mu m_\mu L_R}$$

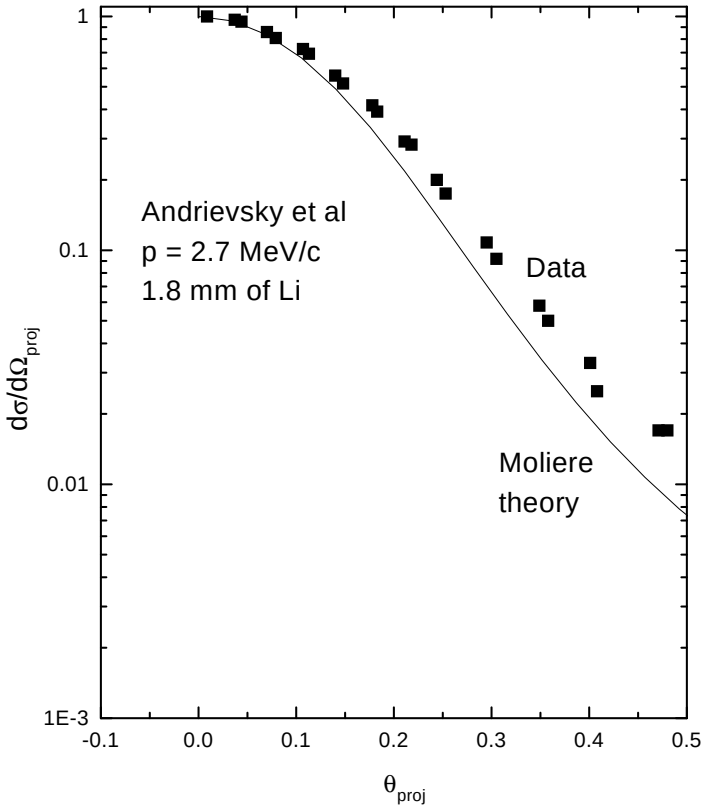
  L_R = radiation length $\Longrightarrow$ low Z materials required

- 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:





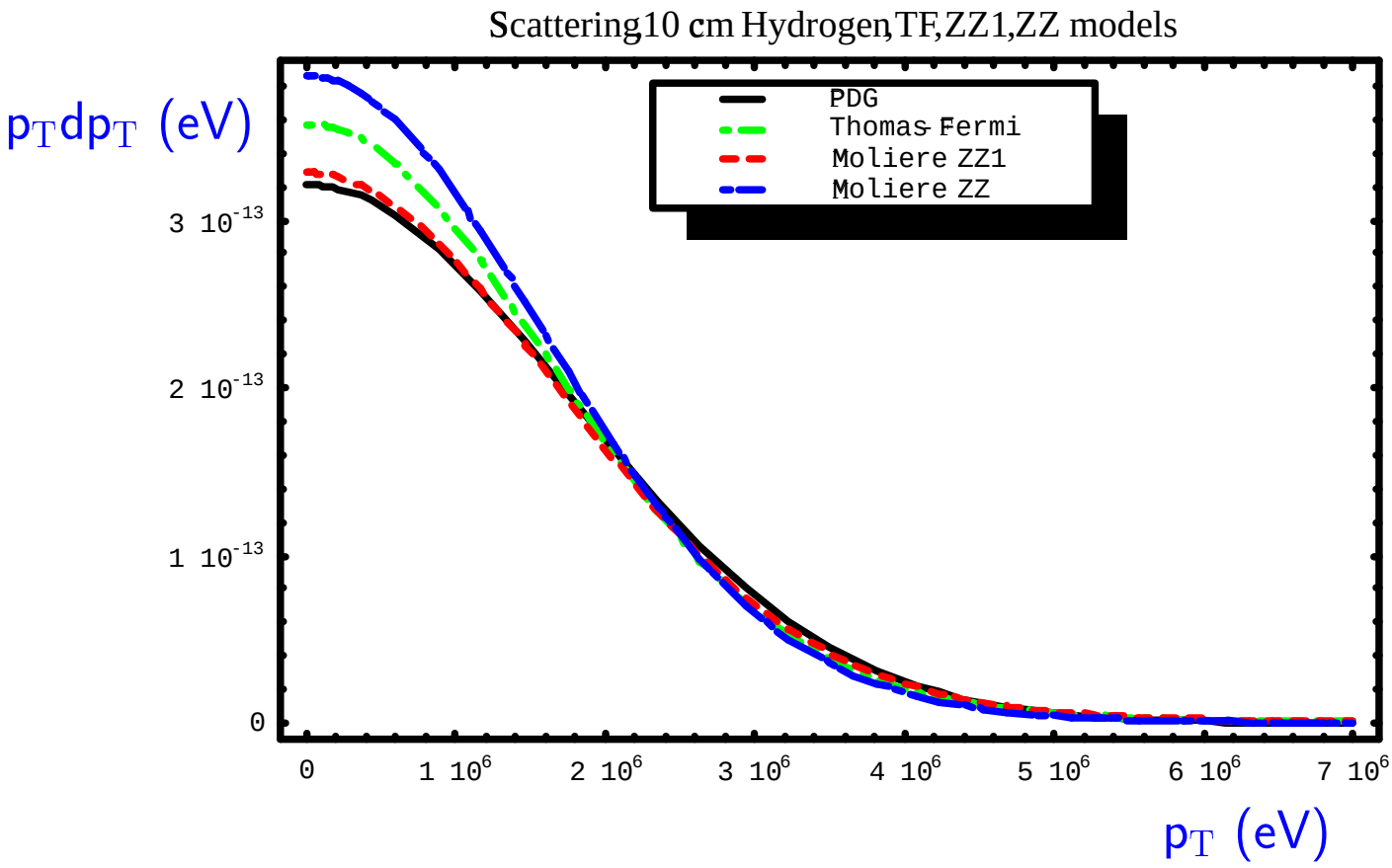


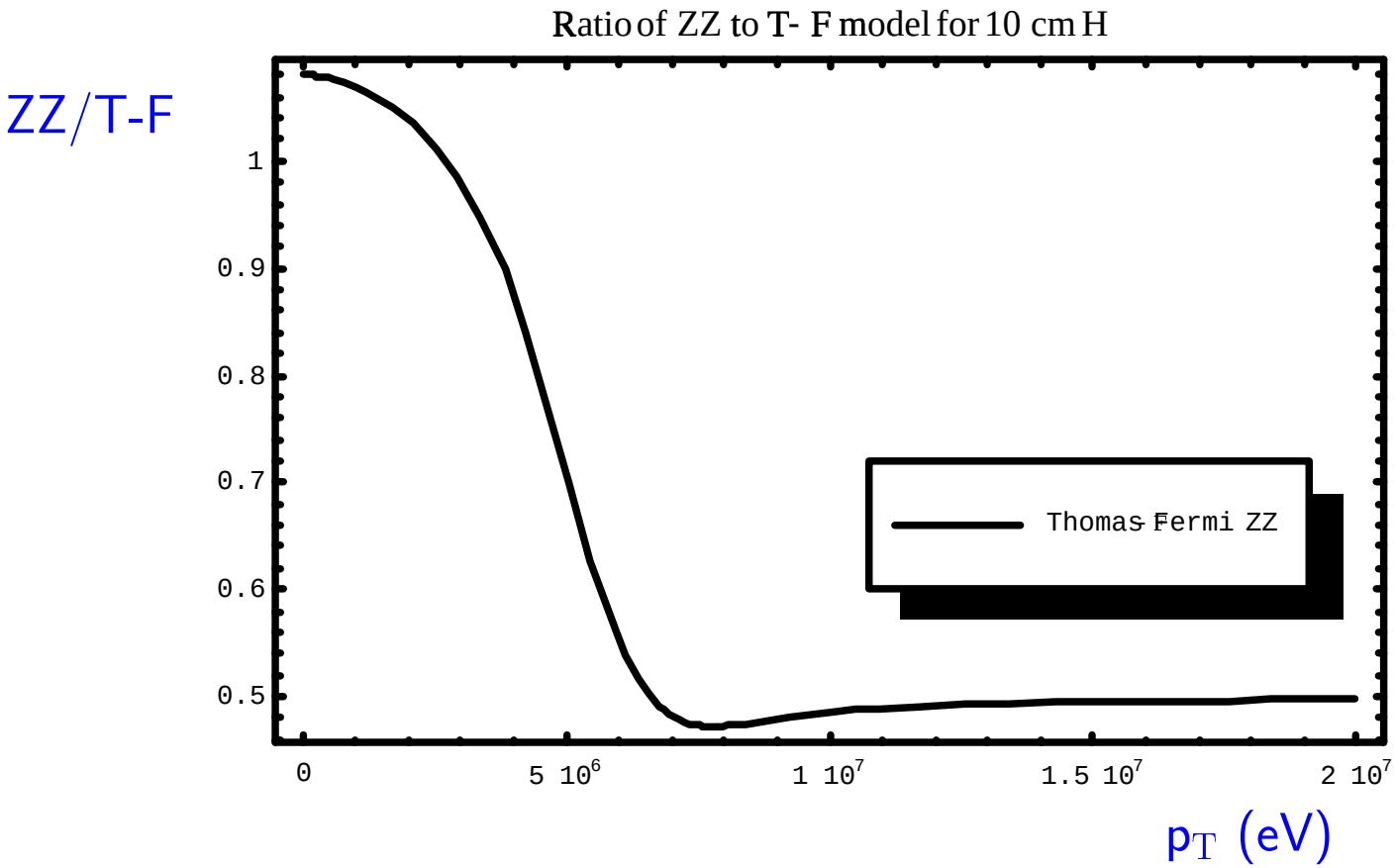
2.7 MeV/c electrons on

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

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

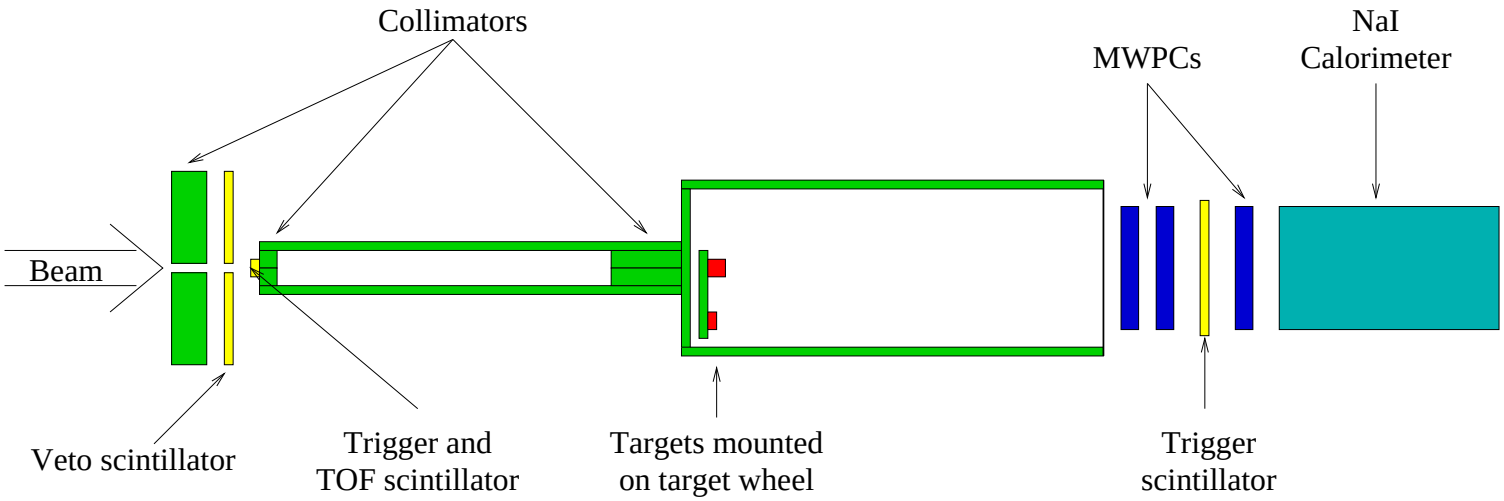
(2) Comparison with new scattering models





The Experiment

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

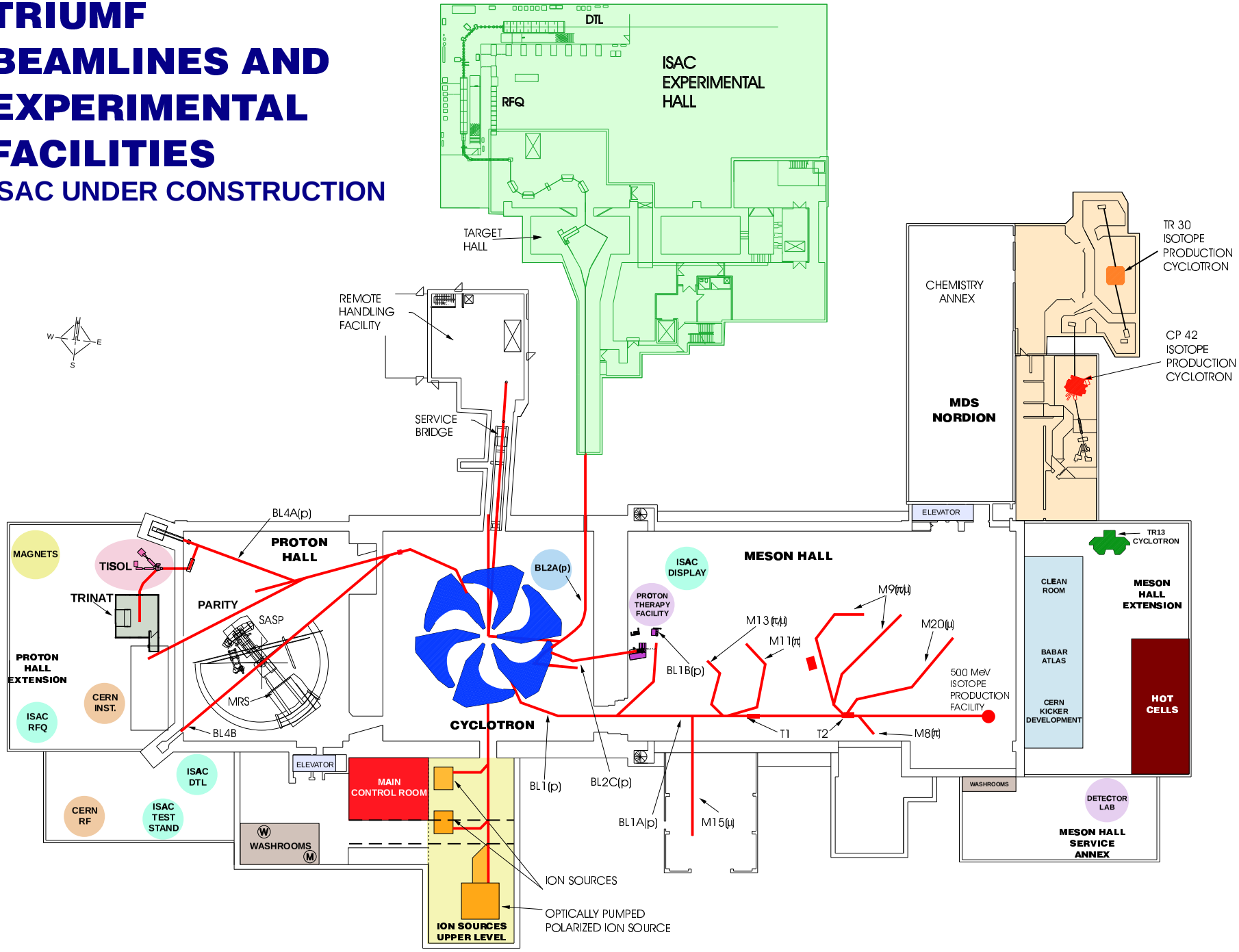


The Beam

- M11 beam at TRIUMF
  - Pion beamline $\Longrightarrow$ tof
- Running period: 21st June to 18th July
- Not charged against our proposal
- Three momenta used: 130, 150 and 180 MeV/c

TRIUMF BEAMLINES AND EXPERIMENTAL FACILITIES

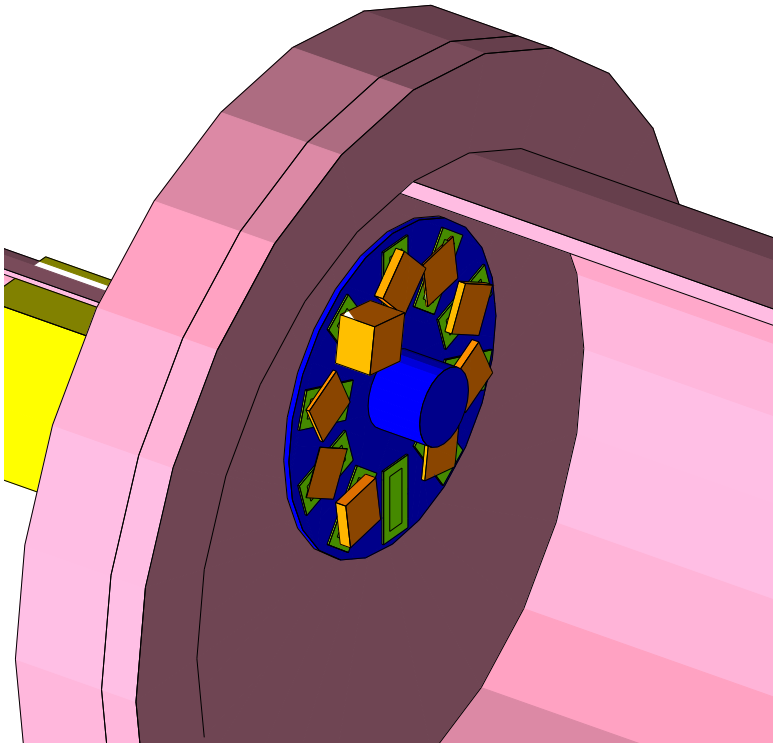
ISAC UNDER CONSTRUCTION



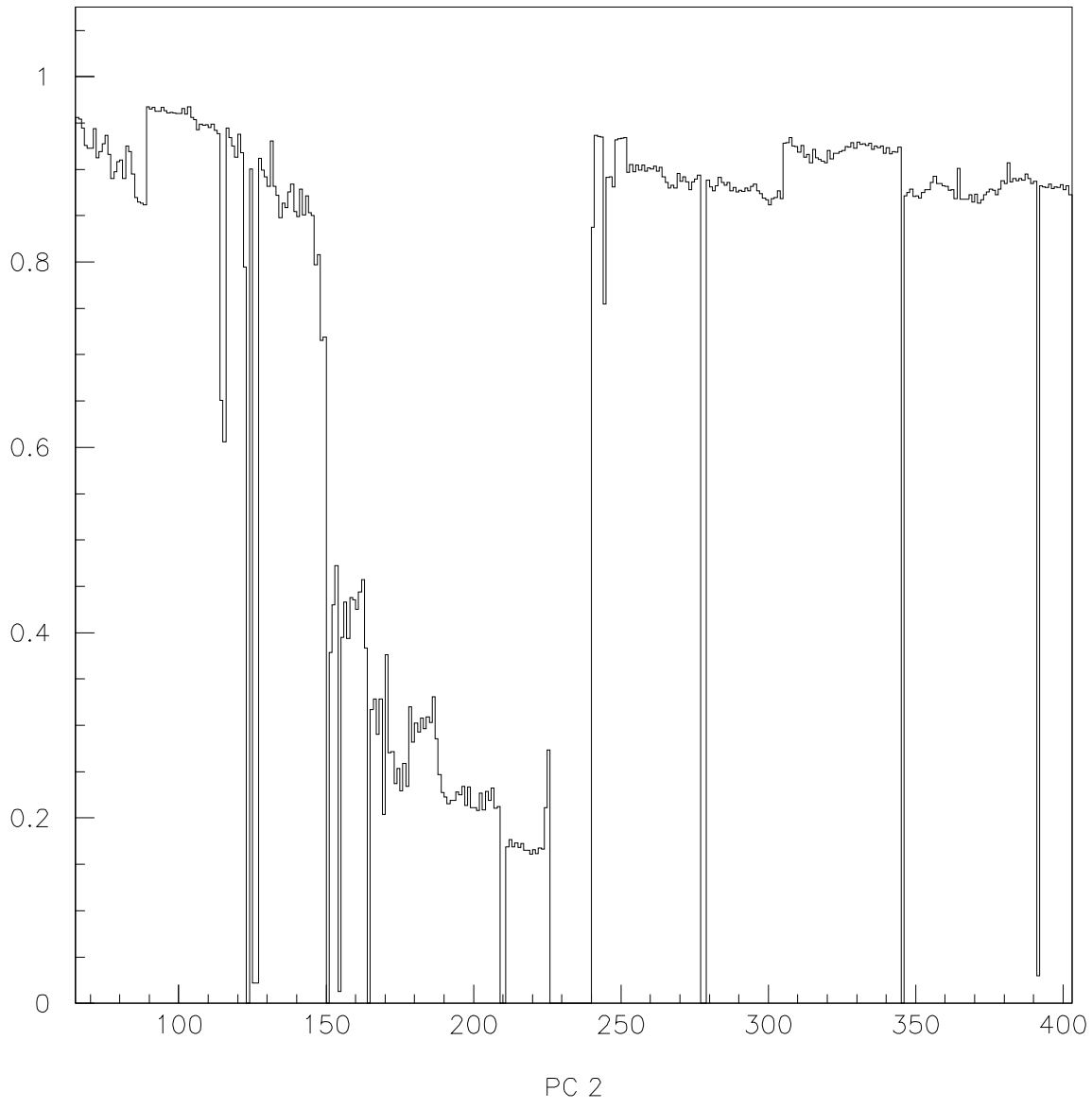
Performance

- Targets:
  - Low Z
  - Sufficient thickness to give reasonable mean scattering angle - 10 mrad
  - Not too thick - origin of scatter
  - Solid targets used in 2000:

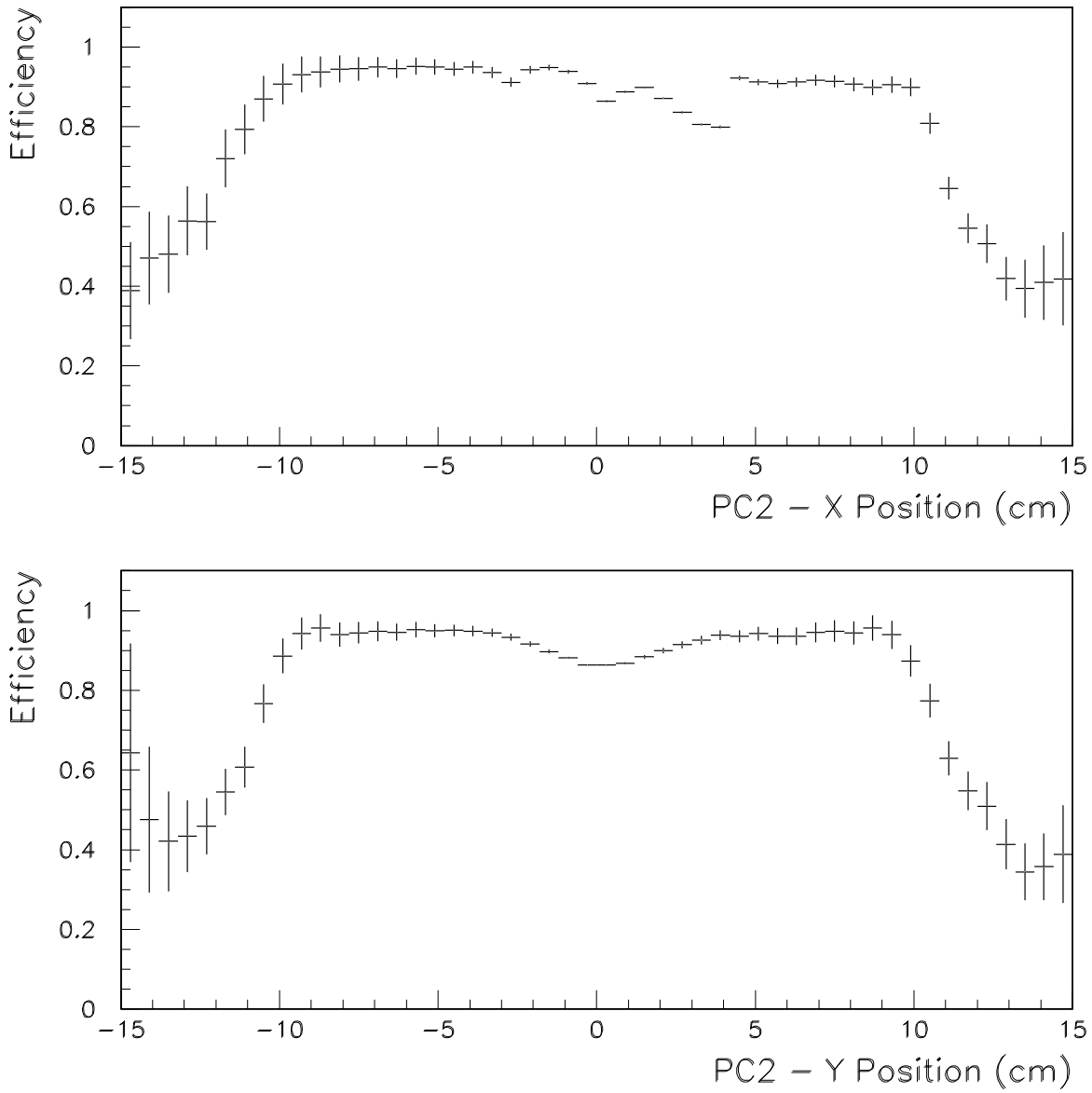
	Thickness (mm)
Li	2.5/10
Be	0.5/2.
C	2.5
Al	1.
CH_2	2.
Fe	0.15/2.



- Delay-line chambers:
  - MWPC with 2 cathode and 1 anode plane $\Longrightarrow$ 2-D
  - Resolution $\sim$ 0.8mm and 1-2mm
  - Readout: time from each end of delay-line
  - Big problem: rapid and non-uniform efficiency loss with time!



- Efficiency as a function of position, PC2, "good" run range:



- Most likely candidate: Methylal
- Data not useful for Physics
- However, very useful for checking experiment!

- Trigger and event rate:
  - Important because of collimation system
  - Event recording rate limited by deadtime

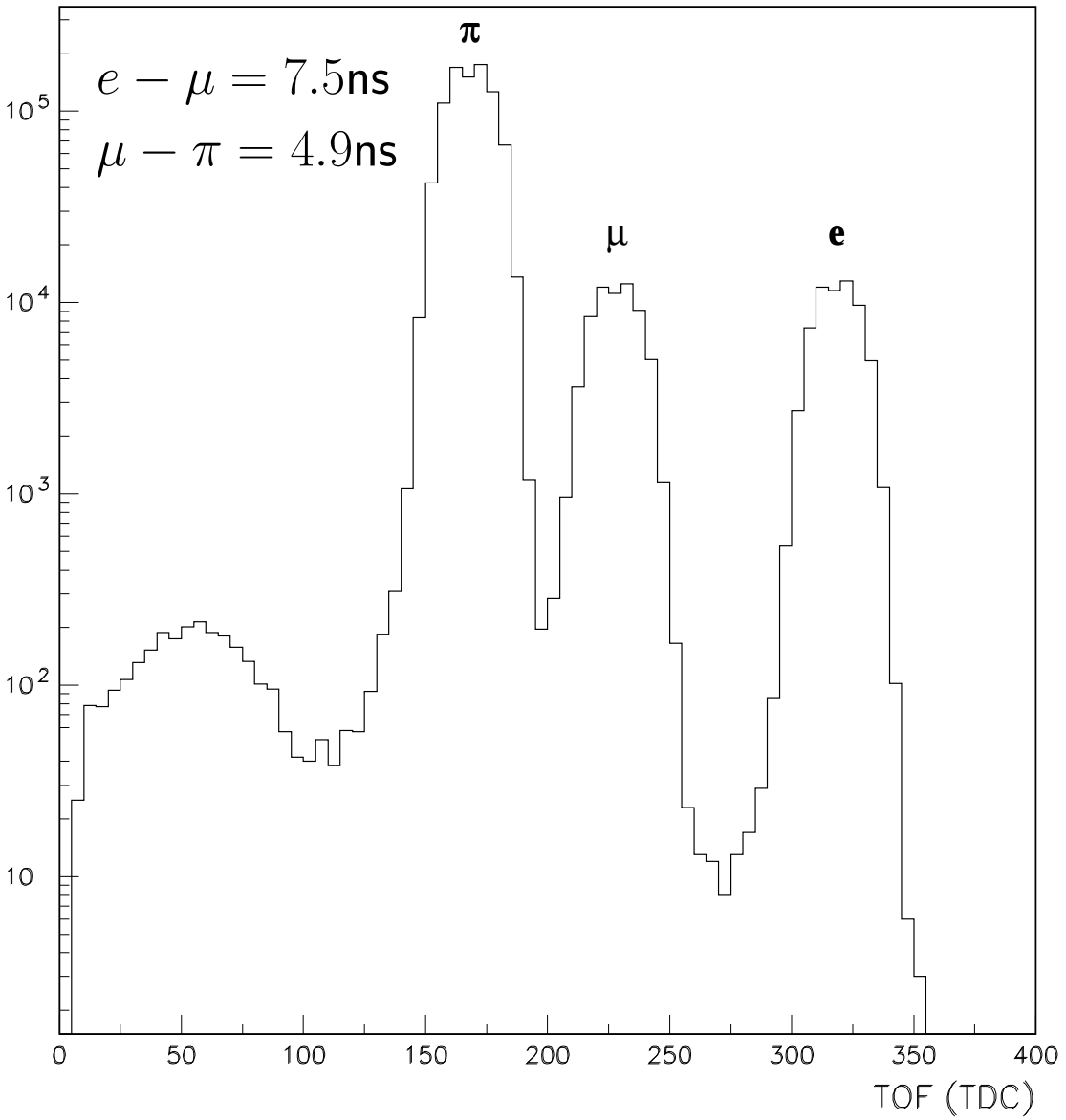
    $\Longrightarrow$ pions are a problem!
  - 1M muon events required per measurement

Beam momentum	130 MeV/c	150 MeV/c	180 MeV/c
Total rate (Hz)	210	270	550
Muon/total (%)	10	9	6
Muon rate (Hz)	21	24	33

$\Longrightarrow$ $\sim$10 hours per measurement

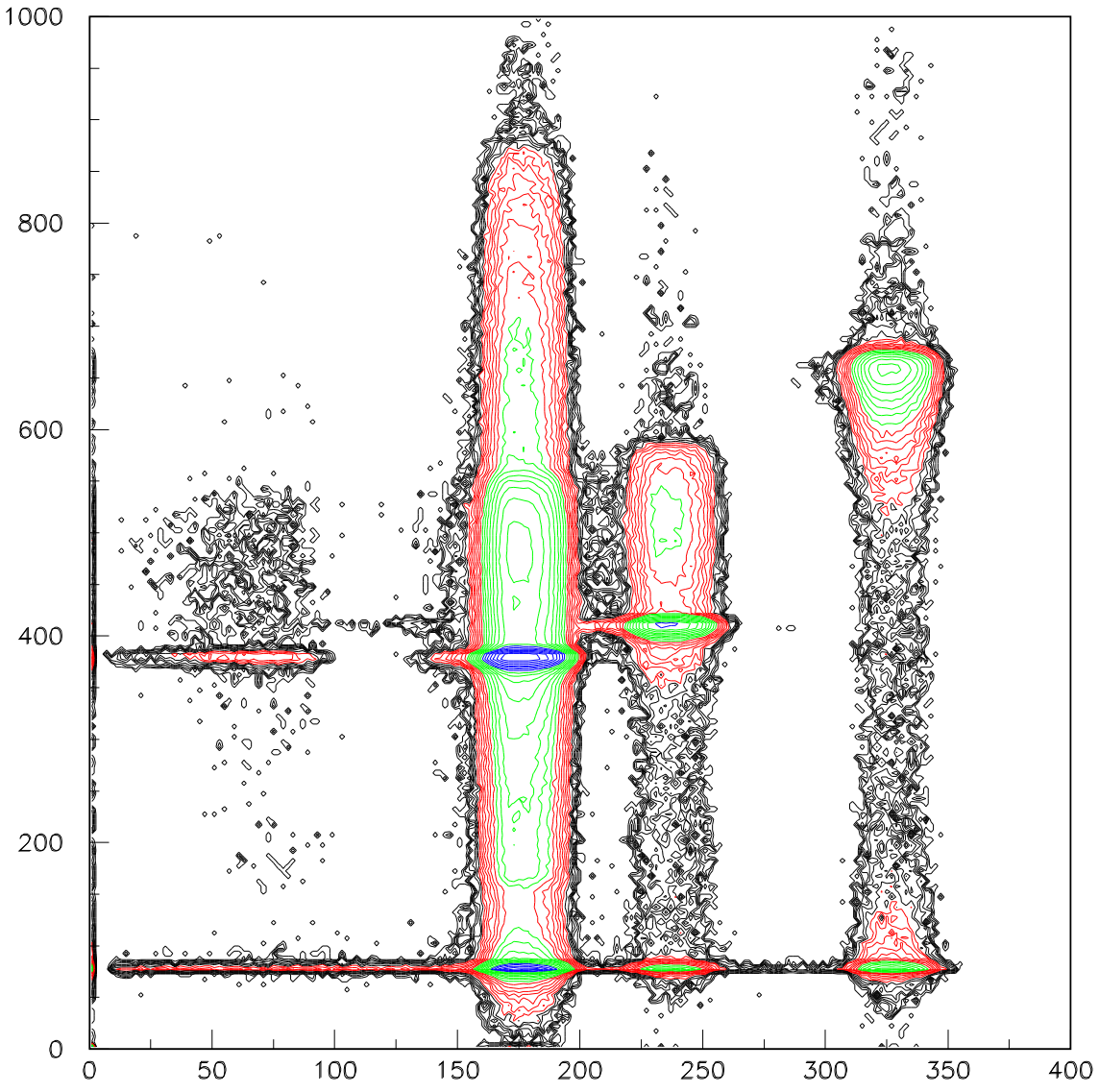
- Time-of-flight:
  - Important for particle id
  - Tof counter - 2 scintillators, 1mm(T)x3mm(H)x28mm(L)
    - overlapping by 3mmx20mm
    - time resolution $\sim$ 250ps
  - RF-bucket - square-wave, 1.9ns long, 43ns separation
    - smearing of edges $\sim$ 500ps

TOF at 180 MeV/c

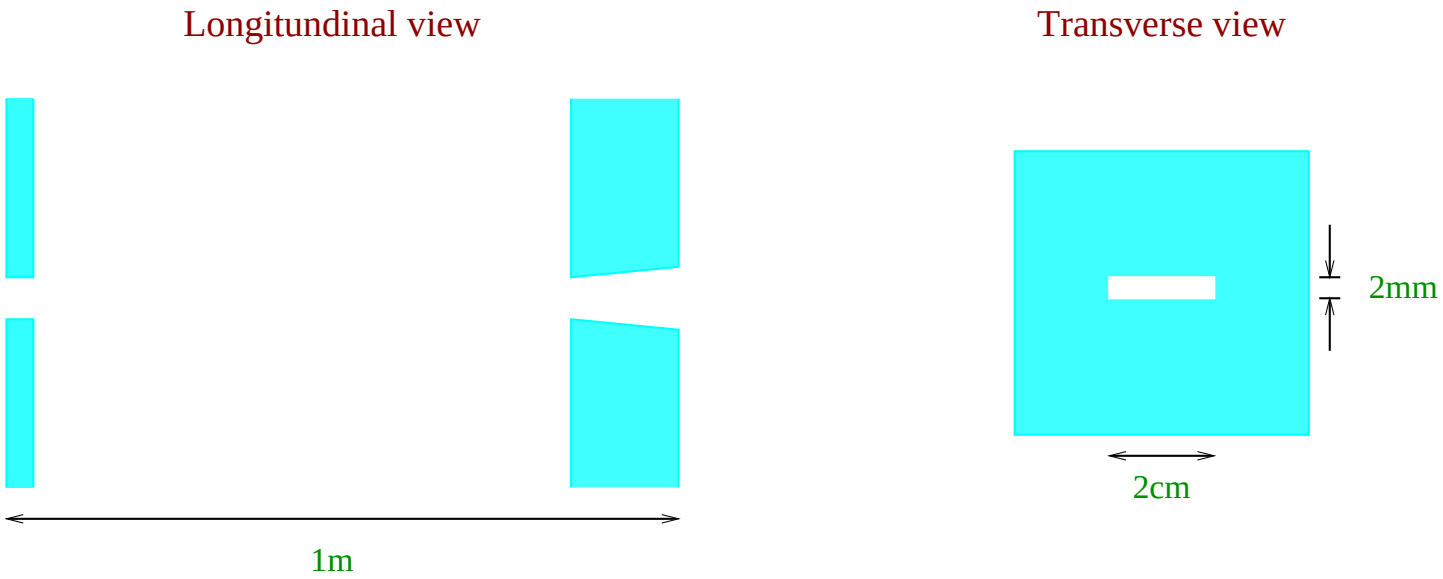


- MINA:
  - NaI calorimeter, 360mm Ø x 360mm deep
  - Resolution: 5.2% at 90 MeV, $\propto e^{-0.55}$
  - Provides additional particle-id and muon energy measurement

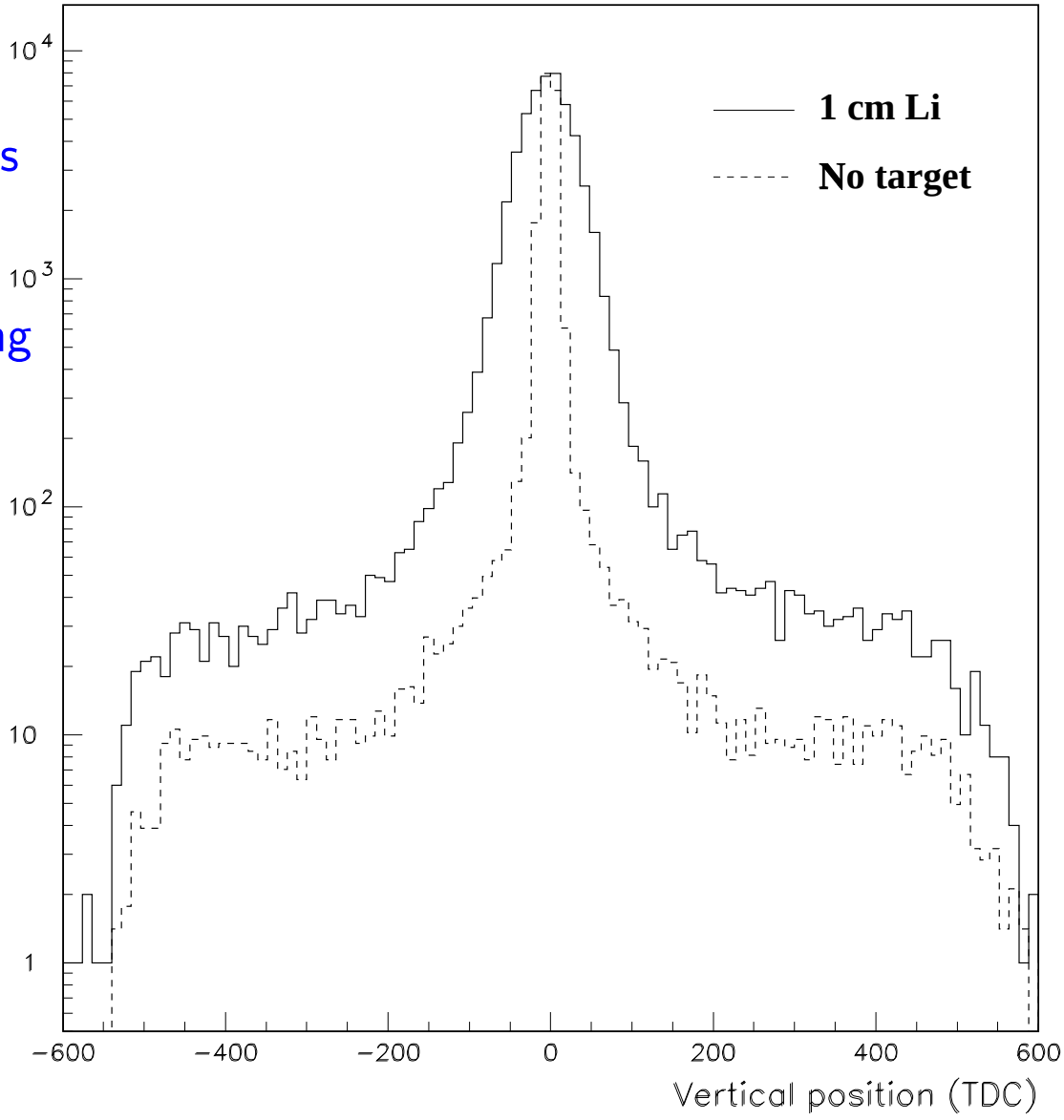
MINA at 180 MeV/c



- Collimation system:



- Not clear it works well enough yet!
- Requires unfolding test
- Coming soon!



What have we learnt?

- Try to use the same beam: M11 (or M20)
- New chambers required: scintillating fibre detectors
  - being designed and built at IC
  - position resolution $\sim 200\mu m$
  - timing resolution $\sim 150ps$
  - can be used in the vacuum chamber
- Targets:
  - re-measure solid targets (longer?)
  - add LiH
  - do LH2: 10cm and 15cm length
- Time-of-flight: works well!
- MINA: useful, but too small
  - try TINA: 46cm by 51cm
- Collimation system: not clear it is OK
  - improvements under study by simulation
  - possibility: add small scintillating fibre detector between last collimator and target