TWIST

The TRIUMF Weak Interaction Symmetry Test

Precision Muon Decay at TRIUMF

Nathan Rodning
University of Alberta

TWIST: Universities of Alberta, British Columbia, Northern British Columbia, Montreal, Saskatchewan; TRIUMF, Texas A&M, Valporaiso, KIAE - Russia

Outline

- **Progress since October, 2000**
- **Review questions related to:**
  - **Personnel**
  - **Construction**
  - **Upgrades**
  - **Calibration**
  - **Budget**

TWIST - Personnel

TRIUMF
- ❖ Willy Andersson
- ● Yuri Davydov
- ● Jaap Doornbos
- ❖ Wayne Faszer
- ● Dave Gill
- ● Peter Gumplinger
- ● Richard Helmer
- ● Robert Henderson
- ● John Macdonald
- ● Glen Marshall
- ● Art Olin
- ❖ David Ottewell
- ❖ Robert Openshaw
- ● Jean-Michel Poutissou
- ● Renee Poutissou
- ❖ Grant Sheffer
- ● Hans-Christian Walter
- ● Dennis Wright

Alberta
- ⌘ Andrei Gaponenko
- ● Peter Green
- ● Peter Kitching
- ⌘ Rob MacDonald
- ● Maher Quraan
- ● Nathan Rodning
- ❖ John Schaapman
- ⌘ Farhana Sobratee
- ❖ Jan Soukup
- ● Glen Stinson

British Columbia
- ⌘ Blair Jamieson
- ❖ Doug Maas
- ● Mike Hasinoff

Northern British Columbia
- ● Elie Korkmaz
- ● Tracy Porcelli

Montreal
- ● Pierre Depommier

Regina
- ● Ted Mathie
- ⌘ George Price
- ● Roman Tacik

Saskatchewan
- ● Bill Shin

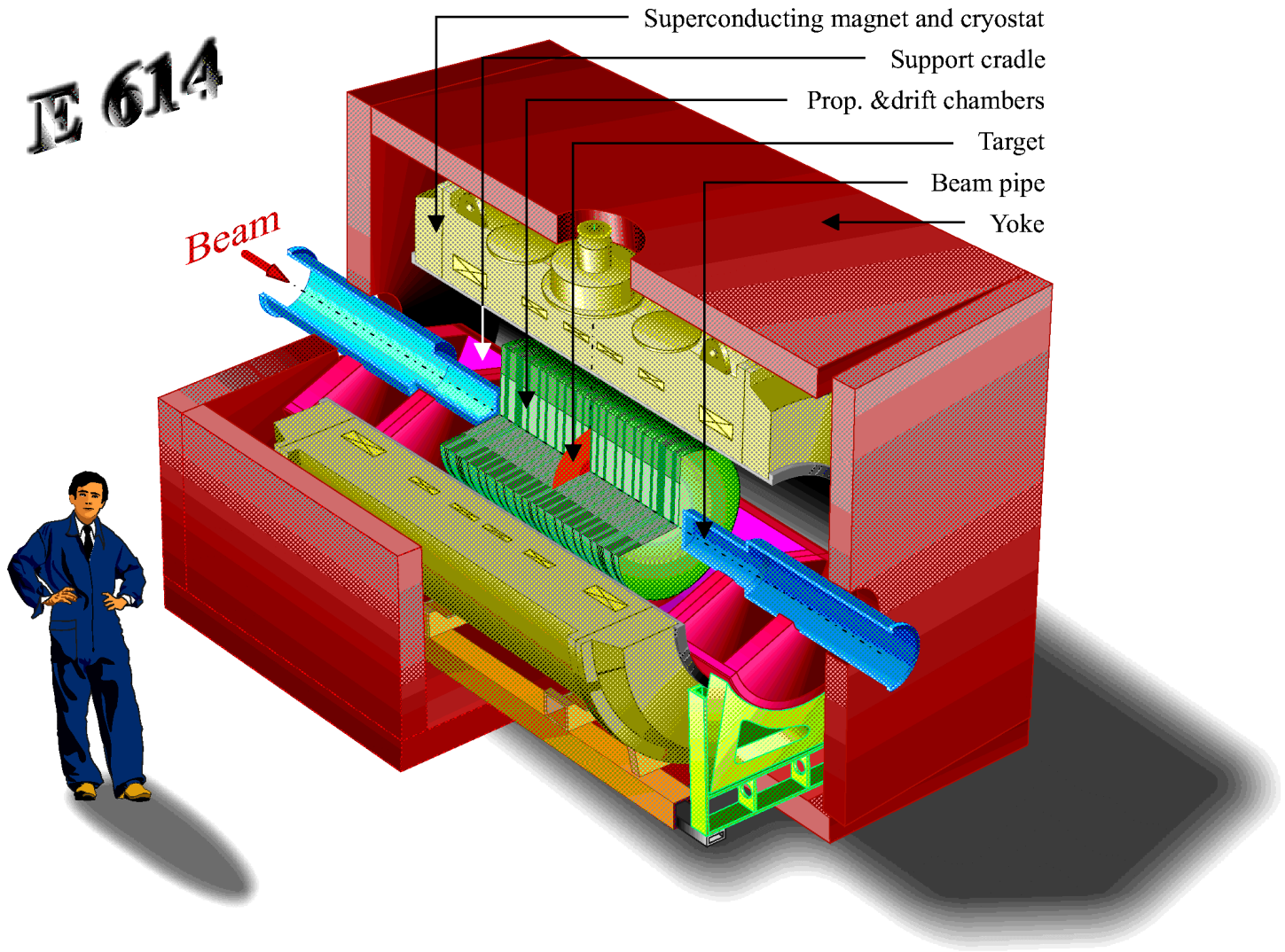
Texas A&M
- ● Carl Gagliardi
- ● John Hardy
- ⌘ Jim Musser
- ● Robert Tribble
- ● Maxim Vasiliev

Valparaiso
- ● Don Koetke
- ● Robert Manweiler
- ❖ Paul Nord
- ● Shirvel Stanislaus

KIAE (Russia)
- ● Arkadi Khruchinsky
- ● Vladimir Selivanov
- ● Vladimir Torokhov

⌘ Students
❖ Professional Staff

TWIST - Overview



TWIST – Recent Milestones

Recent Success:

- **Yoke delivery:** **8 December 2000**
- **Yoke assembly completed:** **22 December 2000**
- **Yoke alignment:** **mid January 2001**
- **Solenoid alignment:** **mid January 2001**
- **Solenoid commissioning:**
  magnet cool down **beginning 6 February 2001**
- **38 DC and 4 PC wire planes strung (of 56)**
  as of the end of January
- **86 preamps completed and delivered** **January, 2001**
- **First cosmic ray events in six plane stack** **November, 2000**
- **Cosmic ray events in dense stack (8 planes)** **January, 2001**

TWIST - Chambers

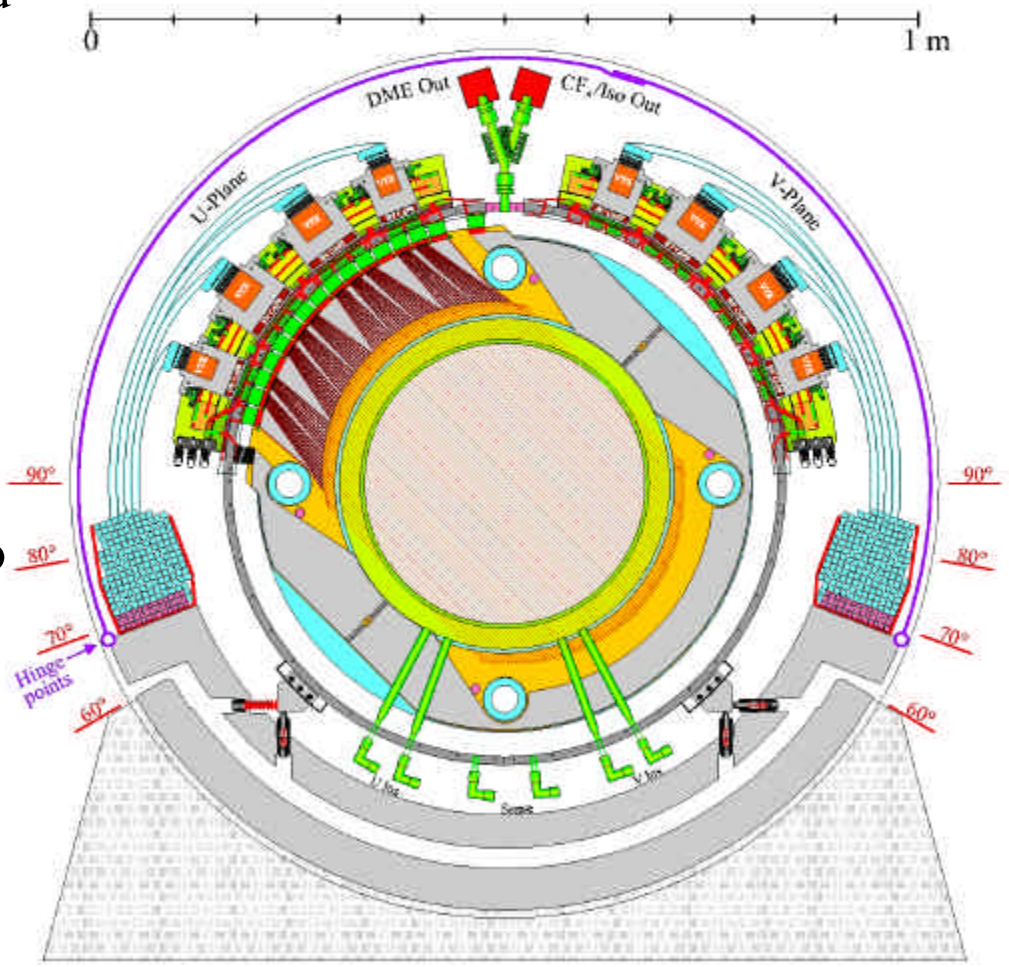
TWIST utilizes

- 44 drift chamber planes and
- 12 proportional chambers

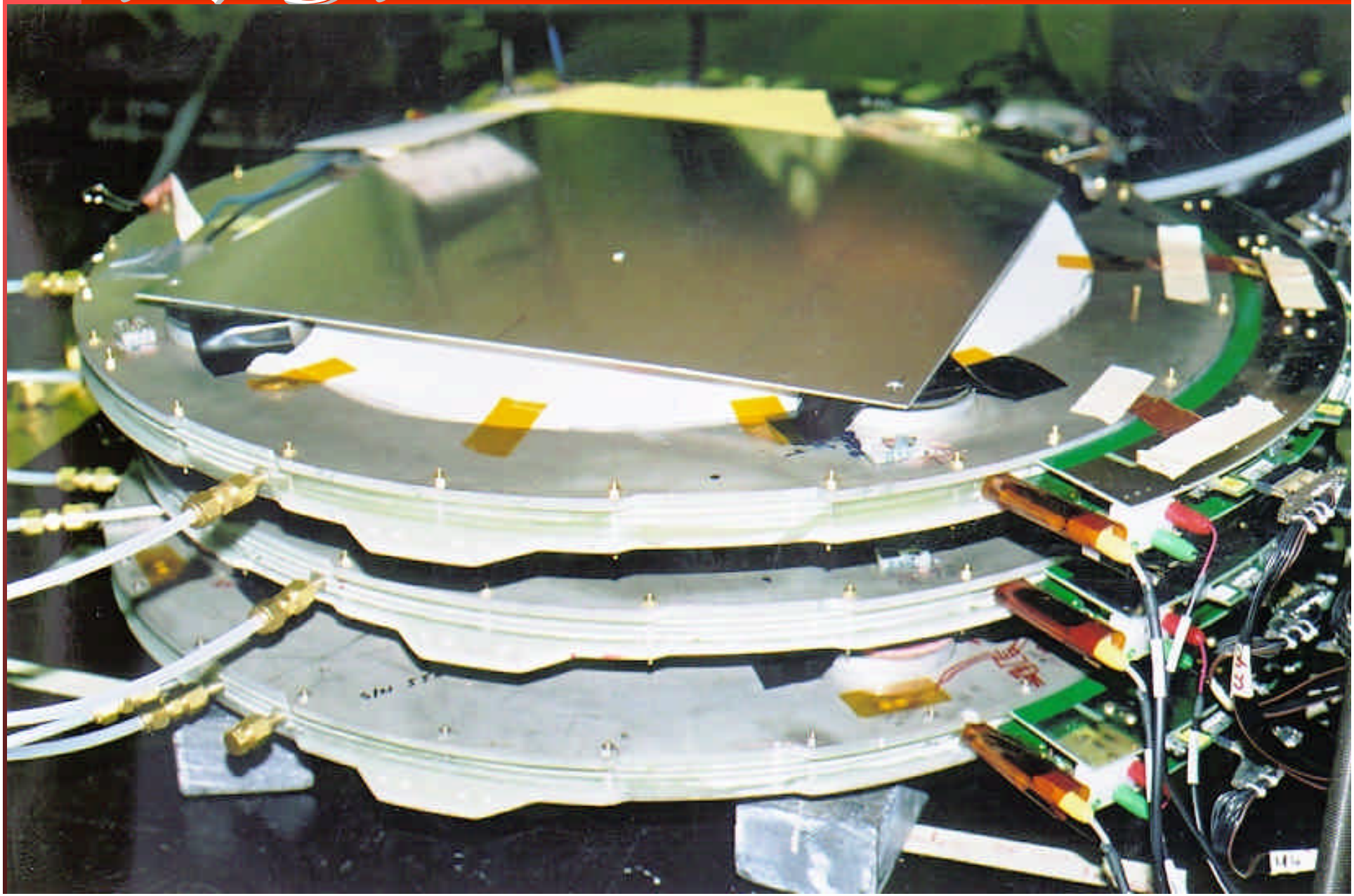
Status

- 14 drift planes have been tested with cosmic rays
- 38 (of 44) DC planes have been strung. Mounting into gas boxes continues
- 4 (of 12) PC planes have been strung

80 sense wires (20 μm Φ) + 2x3 guard wires at 4 mm distance. 22 pairs of drift chambers (each one U and V plane) with DME gas, 6 pairs of proportional chambers with CF_4 / Isobutane. ~5000 wires with VTX preamplifiers



TWIST - Chambers

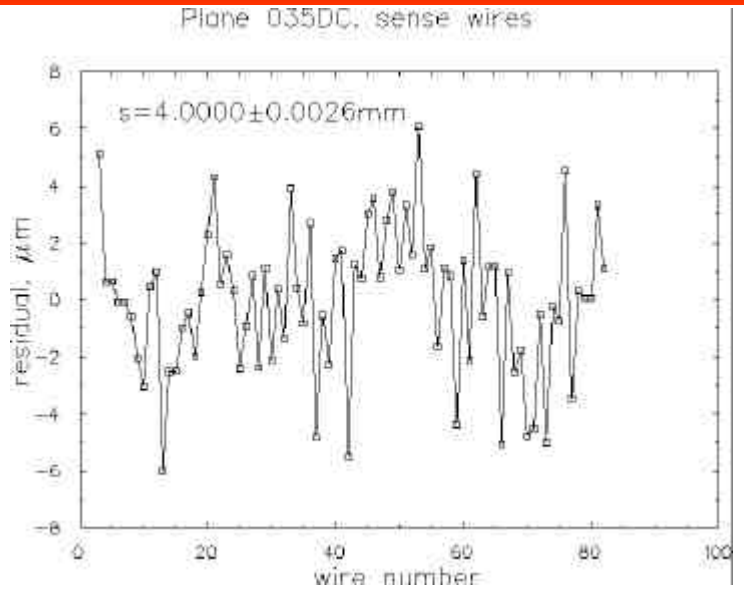


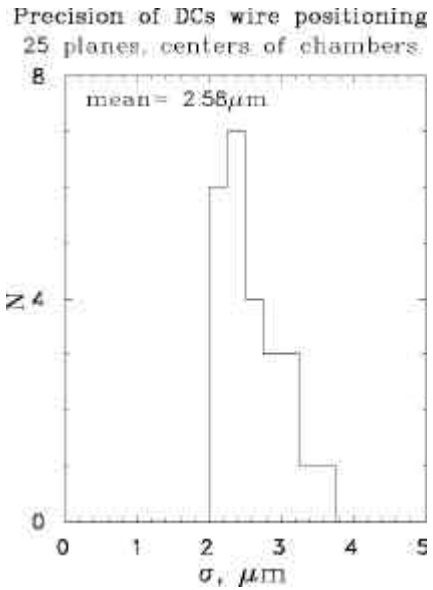
TWIST - Chambers

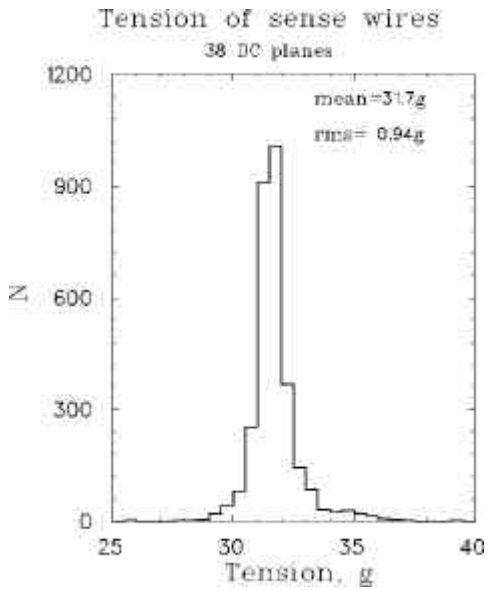
Quality Control on stringing of Wire Planes

The figures show:

1. Wire-to-wire variation in z position for a typical plane; $\sigma = 2.6\ \mu$
2. Average error in wire position over 25 drift planes; $\sigma = 2.58\ \mu$
3. Average wire tension over 38 drift planes; rms = 0.94g







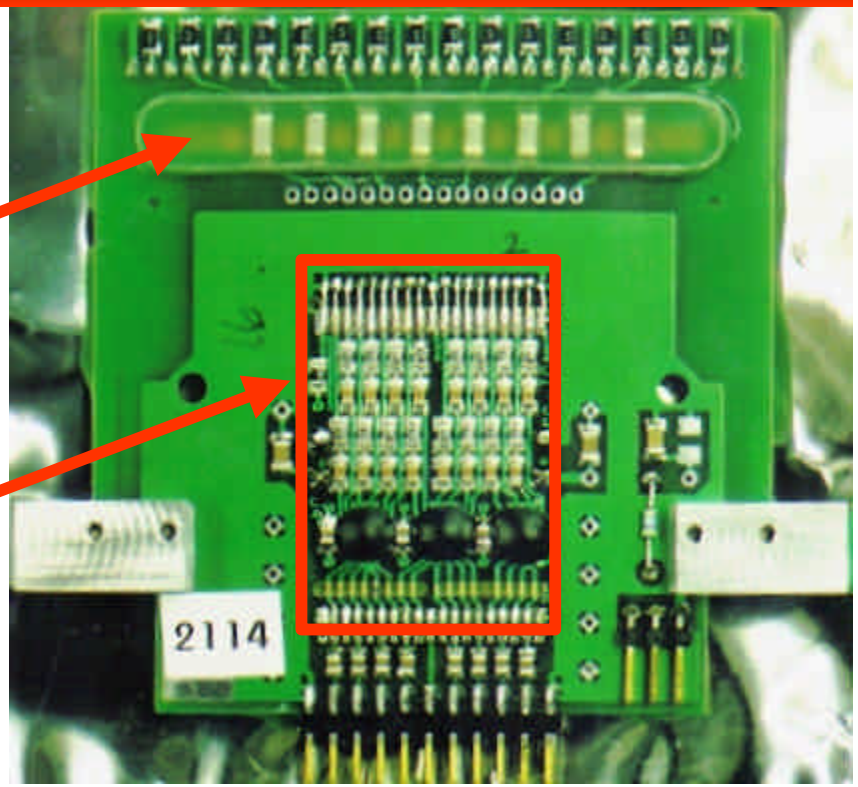
TWIST - Electronics

TWIST Requires

- 240 preamplifiers
- 268 postamplifiers
- 42 TDC's

Status

- 86 preamplifiers tested, 41 in mid-production
- 120 postamplifiers tested, 180 more in production
- 47 TDC's in hand



TWIST preamplifier

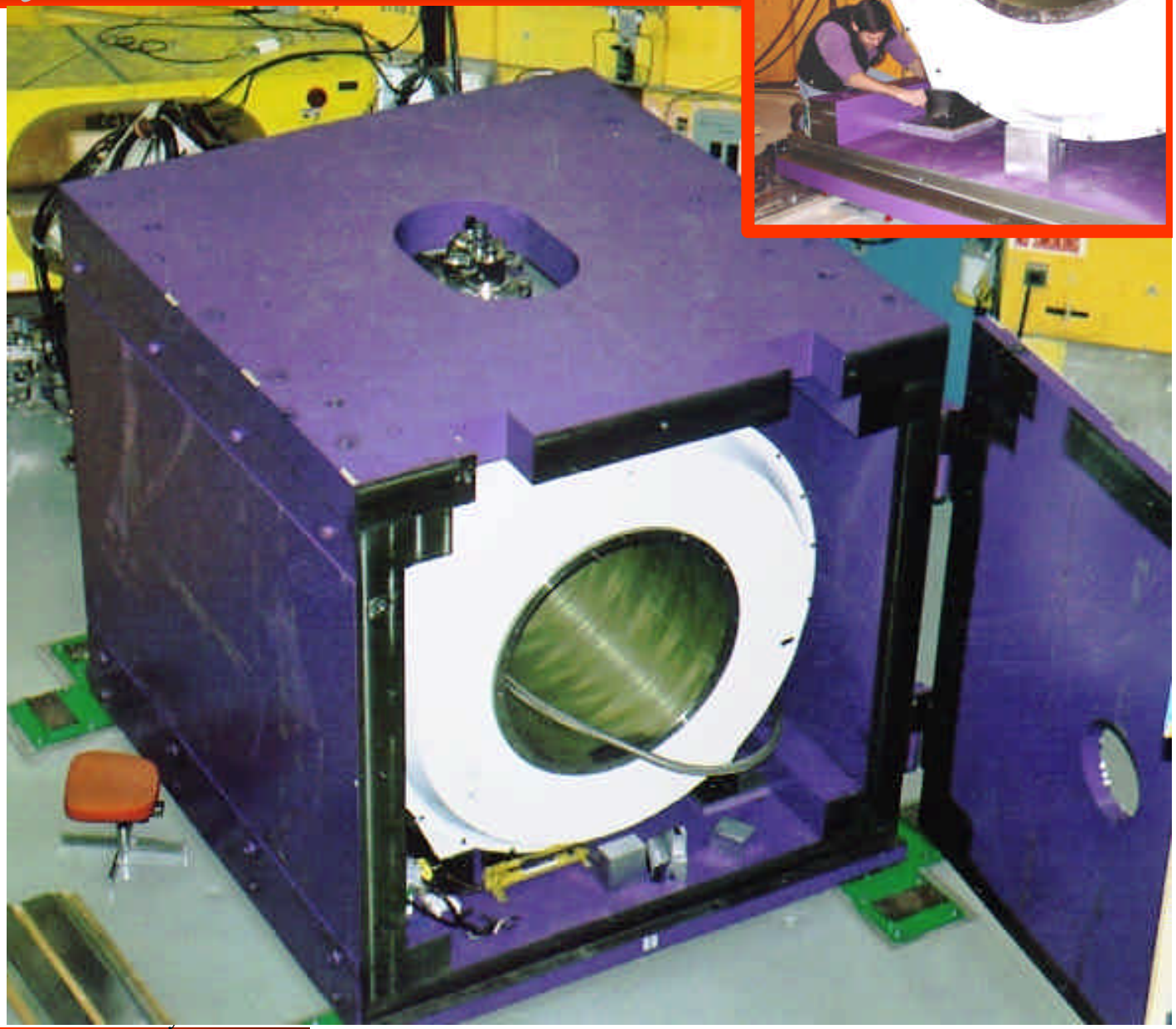
16 and 24 channel versions based on Fermilab CDF VTX boards

Cross talk is minimal (0.8% amplitude), and is easily rejected in software by cutting on pulse width

TWIST - Yoke

The TWIST yoke pieces were delivered and assembled before Christmas

Alignment was completed in the first week of January



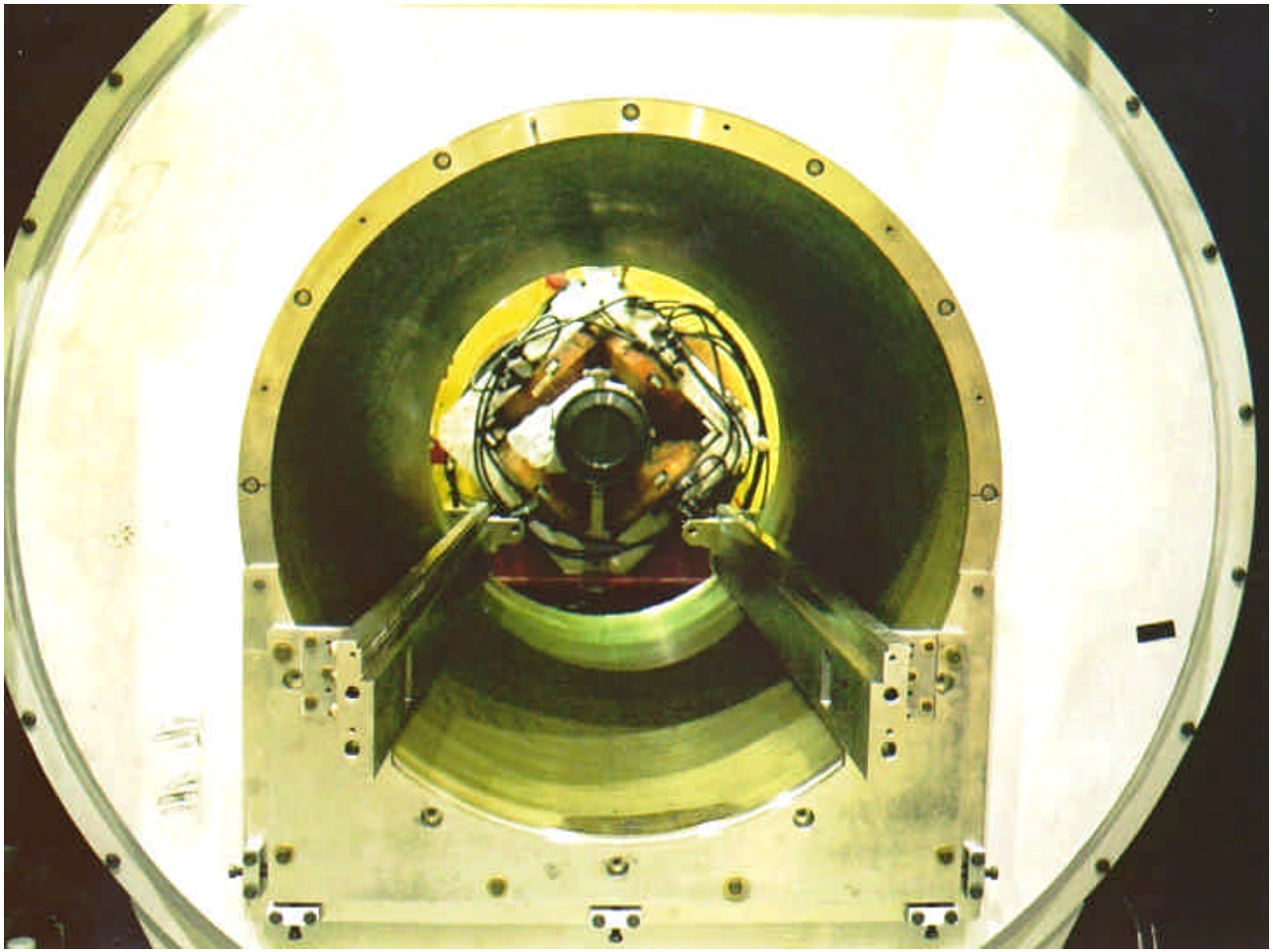
TWIST– Solenoid and WC track

Track is in place and aligned to accept detector cradle and stack

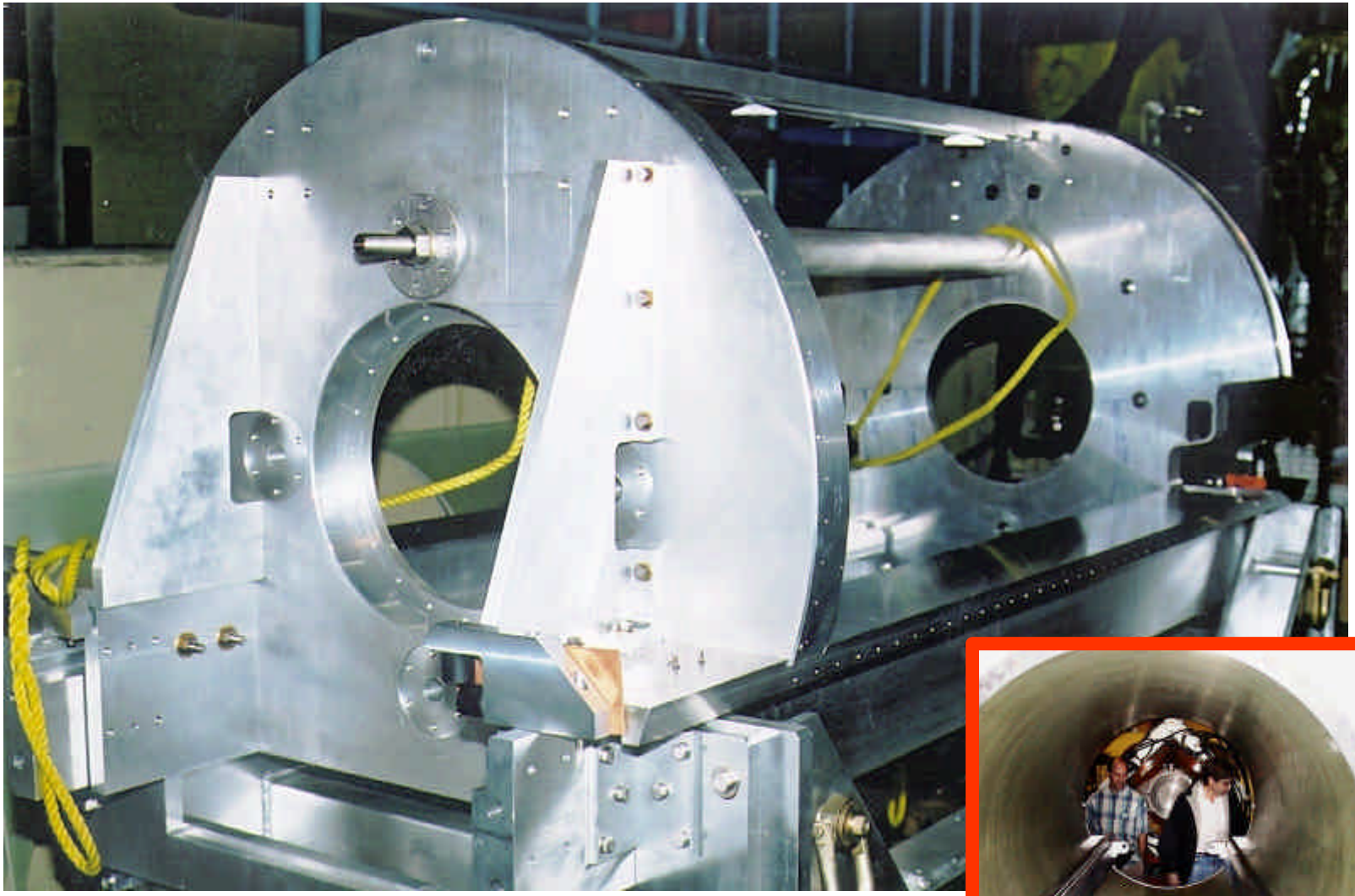
Magnet is cooling

Commissioning begins this week

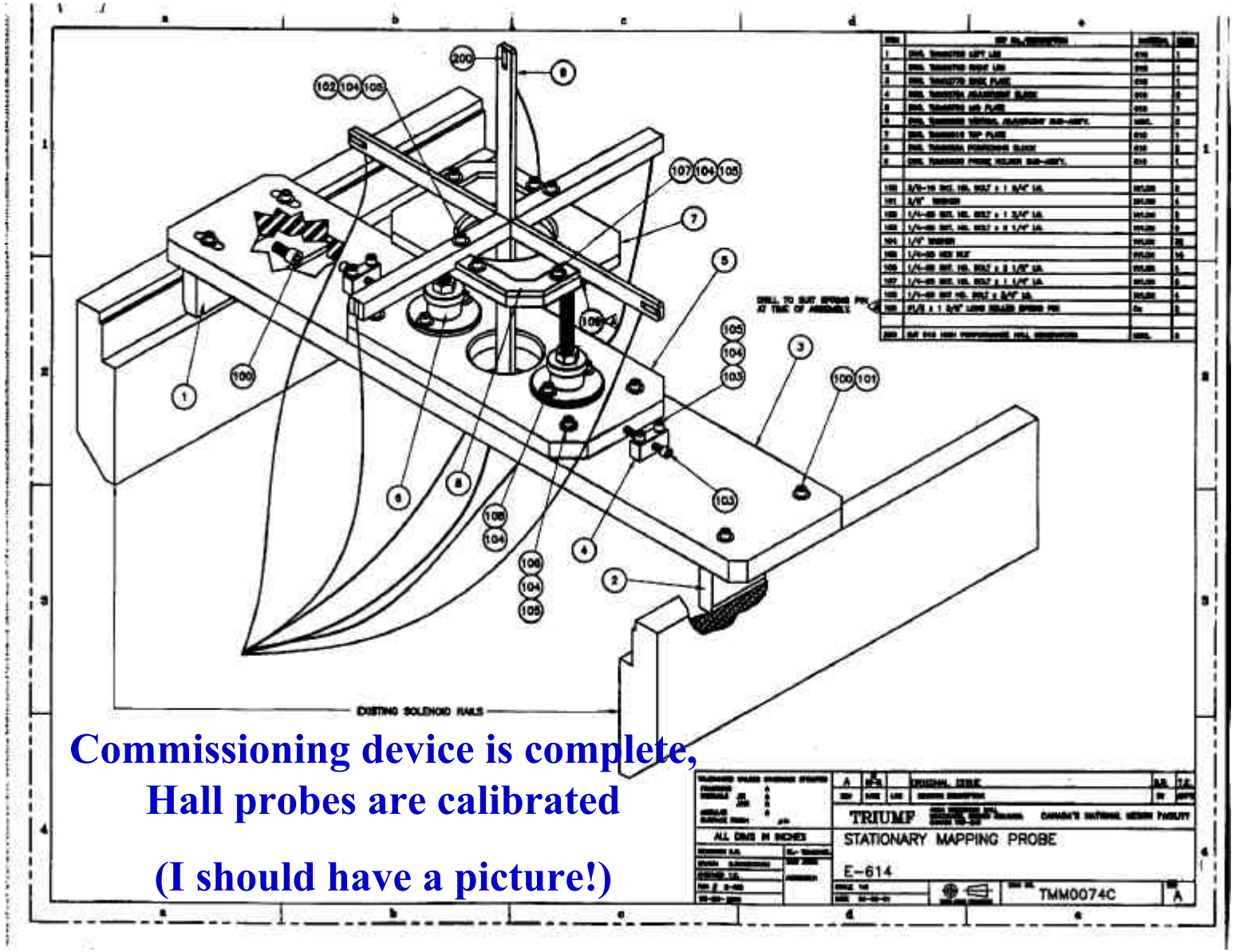
Mapping complete by end of March



TWIST – Chamber Support Cradle



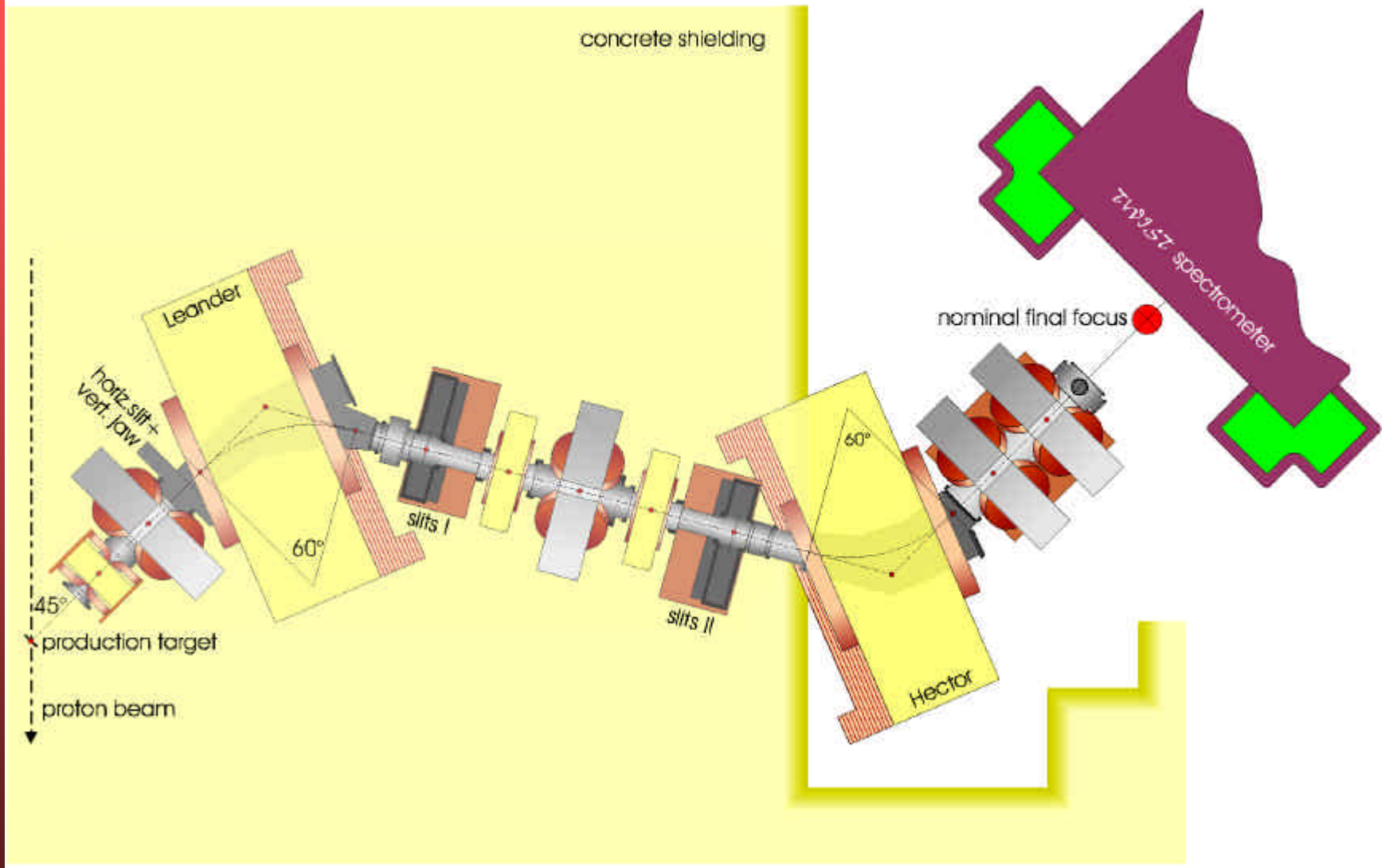
TWIST – Six-fold Hall Probe



Commissioning device is complete,
Hall probes are calibrated

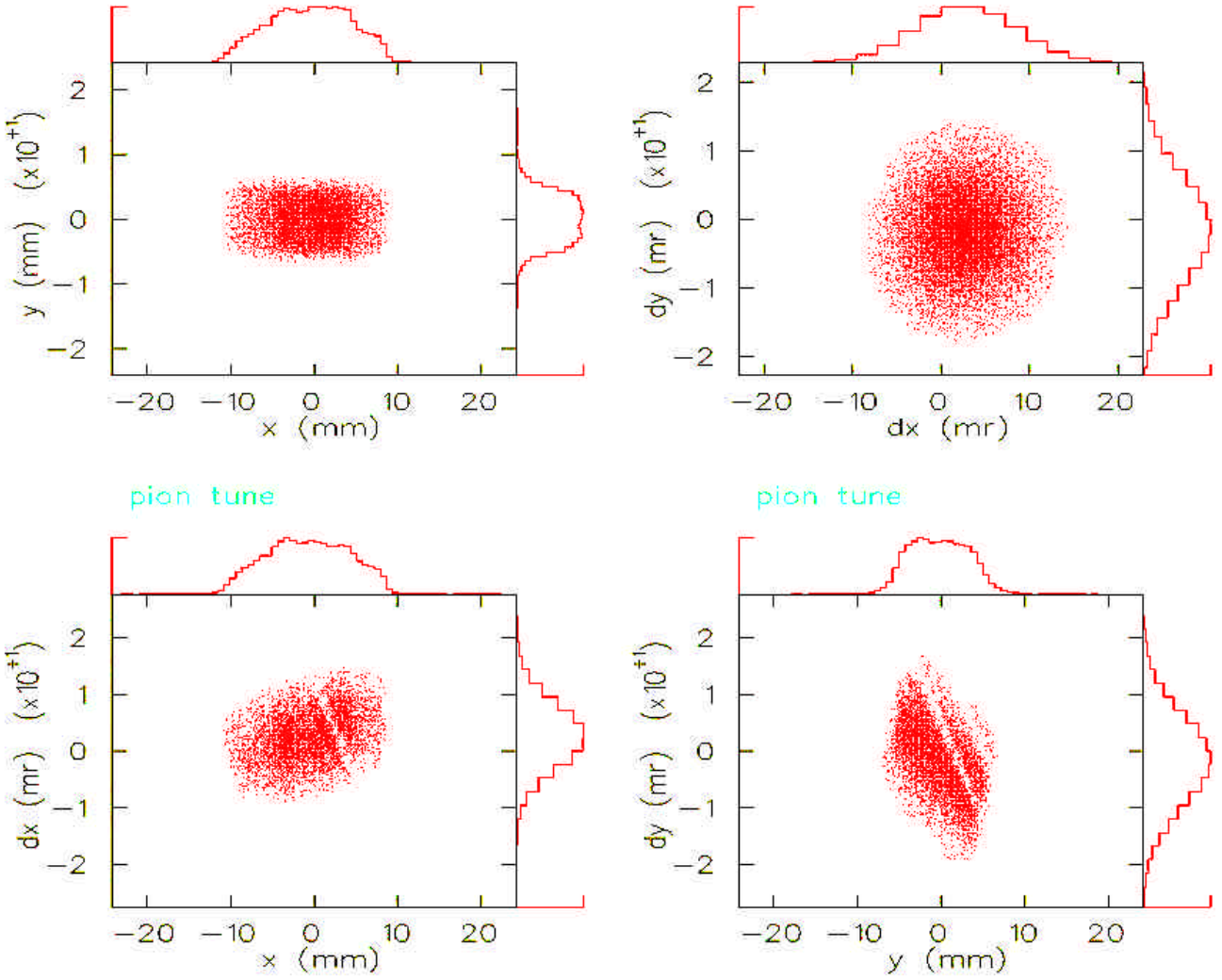
(I should have a picture!)

The M13 beam line used for TWIST at TRIUMF



TWIST - M13 Tuning

Emittance of high momentum (120 MeV/c) pion beam



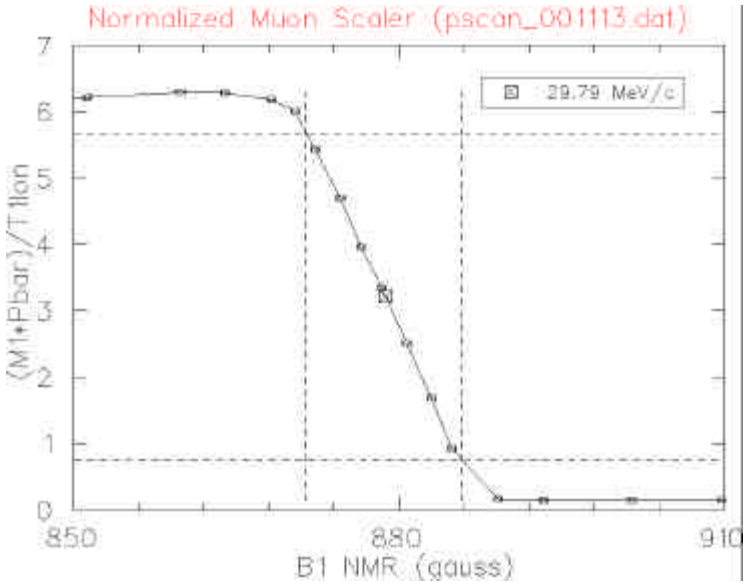
TWIST – Positron Background

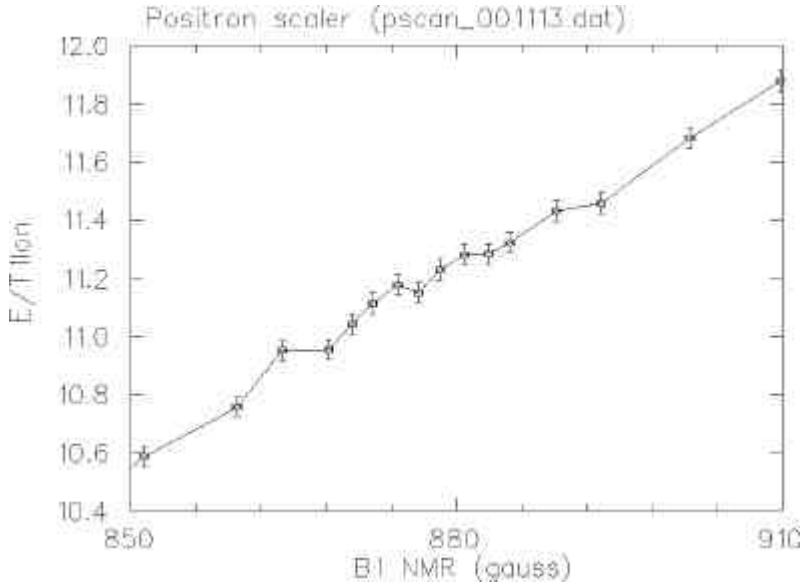
Beamline studies from
October/November 2000

- Backgrounds
  - Rates: $e^+/\mu^+ \sim 4$

    (as expected)

A pyrolytic graphite target will give us a 33% improvement in the rate relative to the positrons





TWIST – RF Cuts

Flight time through beamline

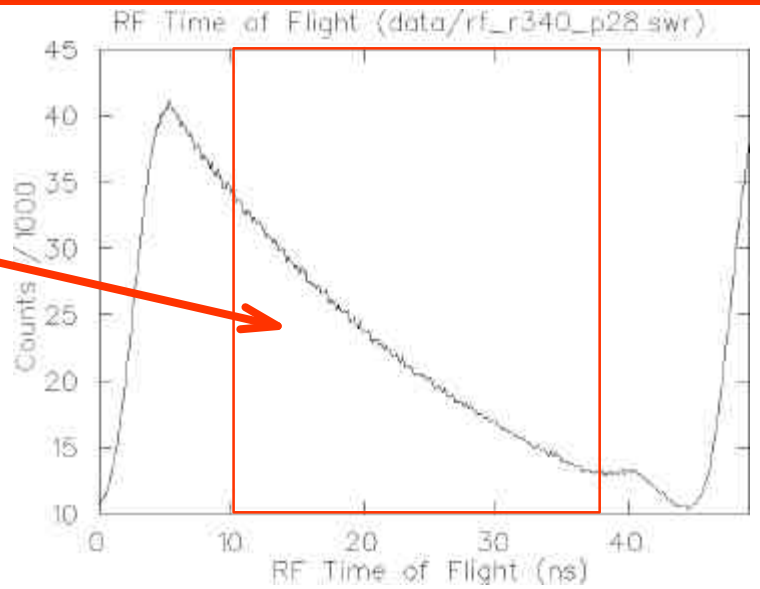
Surface Muons gated on cyclotron RF

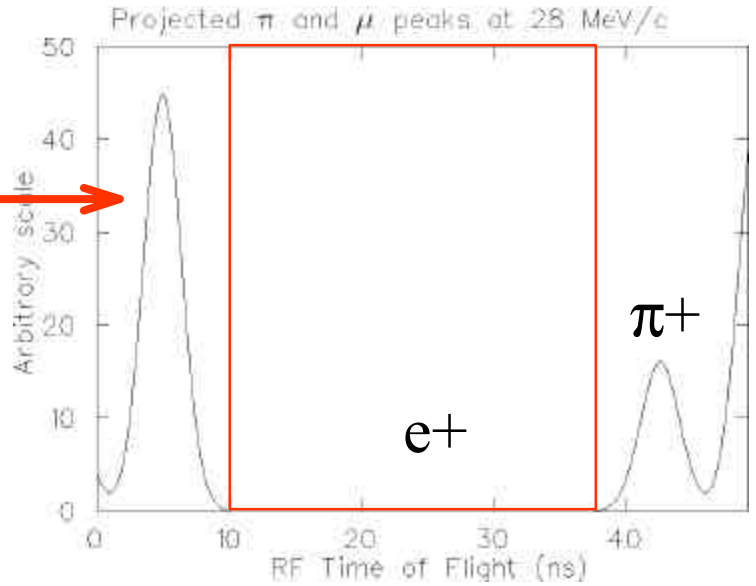
Time characteristic of π decay

Backgrounds (extrapolated from higher momentum)

Cloud Muons

Rate: 9% that of surface muons



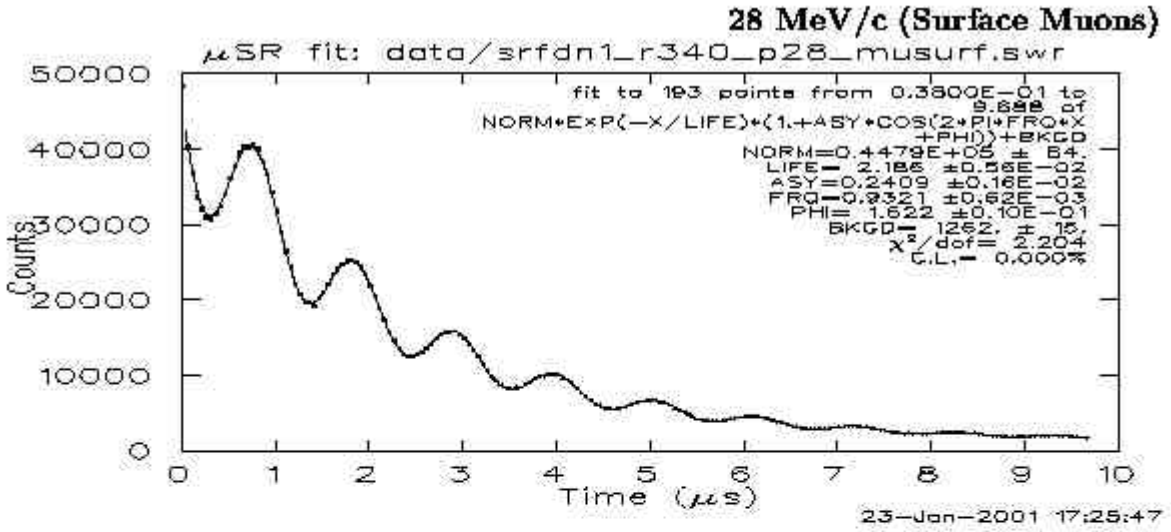


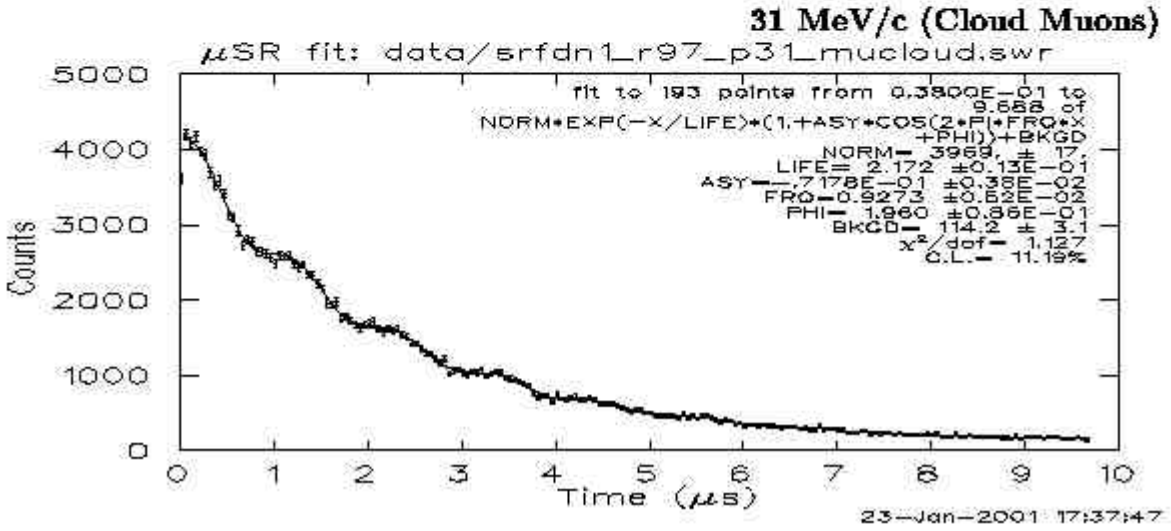
TWIST – Cloud muon polarization

Surface muons

Polarization of the cloud muons is approximately 0.30 (opposite to the surface muon polarization of –1.0)

Cloud muon flux is 9% that of the surface muons

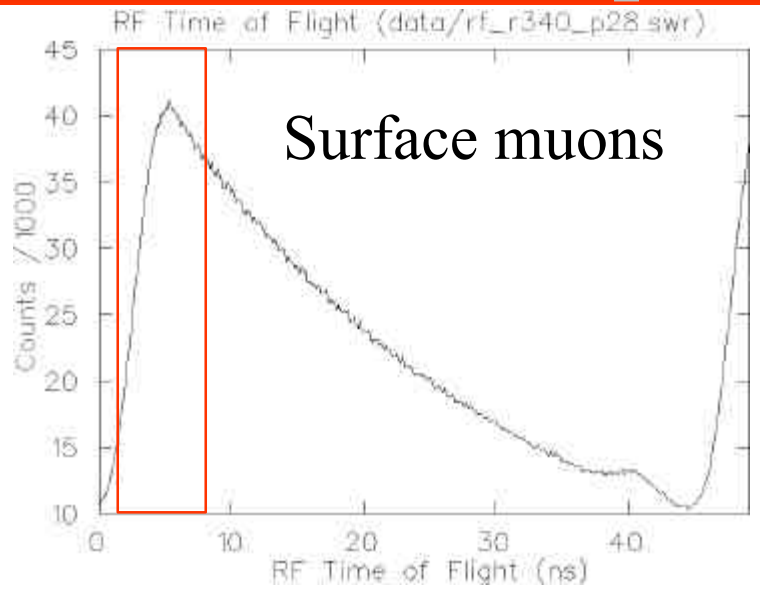


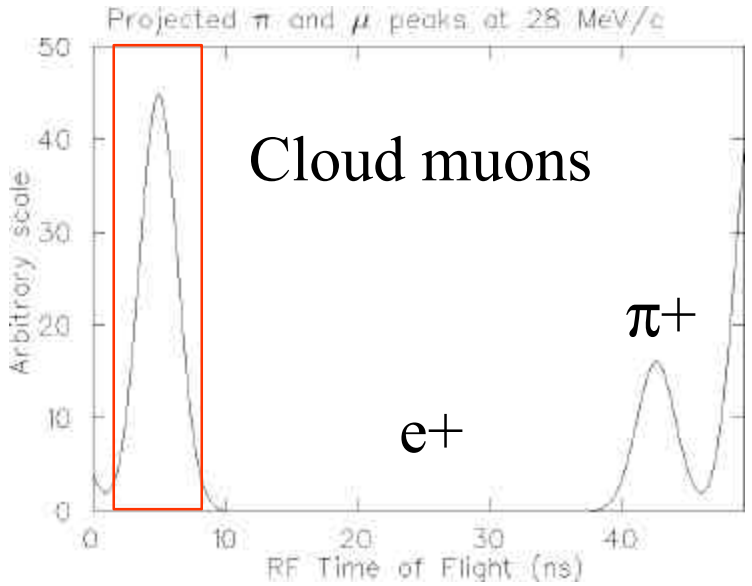


TWIST – Unpolarized data sample

Flight time through beamline

By selecting a data sample with an appropriate RF gate, we can select an unpolarized sample of muons





TWIST – NSERC Review Questions

- **Only selected questions are discussed here.**
  - **All questions are addressed in the written response.**

Gas Selection:

We feel we need DME to achieve the desired resolution

- DME has a small Lorentz angle (maximum of about 8 degrees)
  - CO2 has a maximum Lorentz angle of 18 degrees, and a small gas gain
  - DME has a very slow drift speed
  - The required resolution has been achieved in beam tests (with DME, without magnetic field)

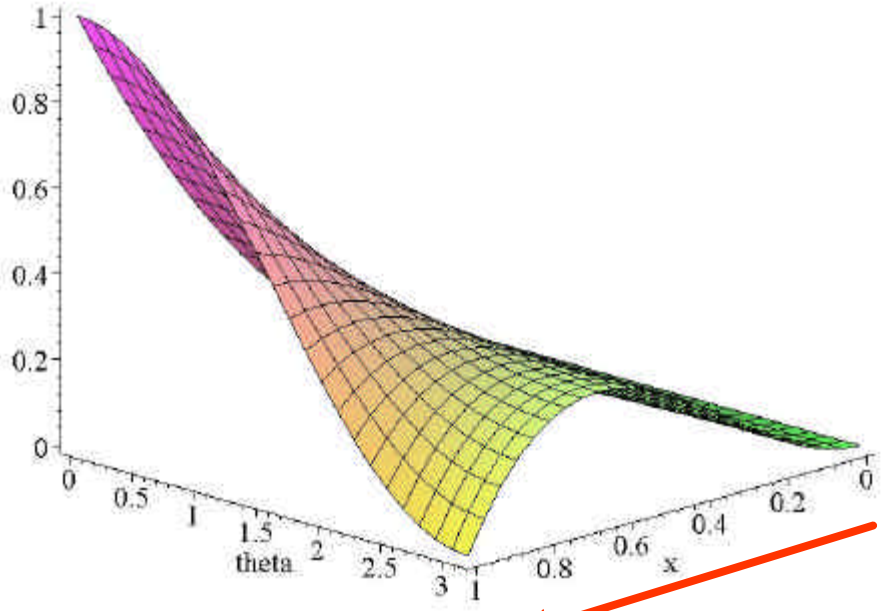
It is well known that DME is an aggressive gas (as is isobutane).
It is for that reason that extensive damage tests have been done. These tests have been used to avoid materials which interact significantly with DME.

- Even beam muons will deposit only about 5% of the test charge during the life of the experiment.

TWIST – Energy Calibration

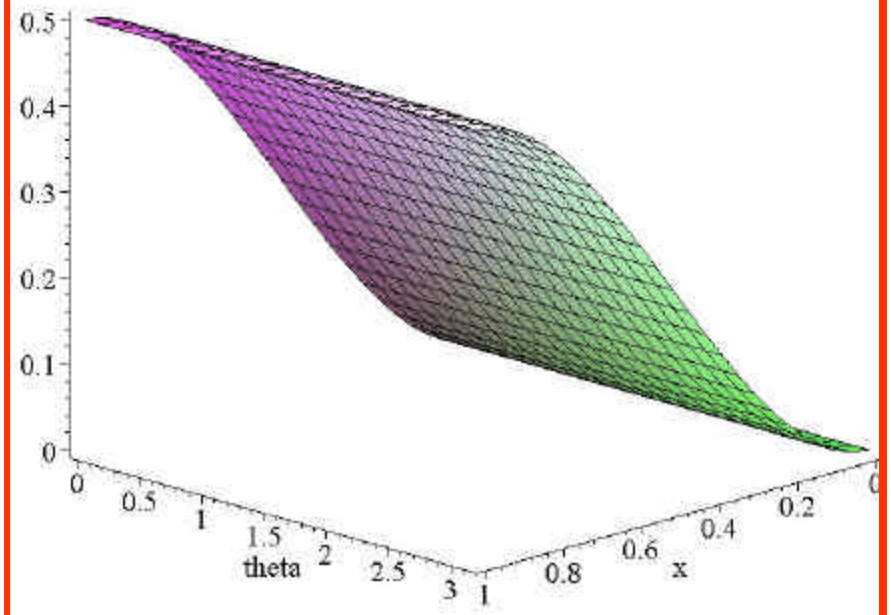
The edge of the distribution is used to calibrate the energy scale at large x

The polarized distribution has no edge at forward angles



52.8 MeV

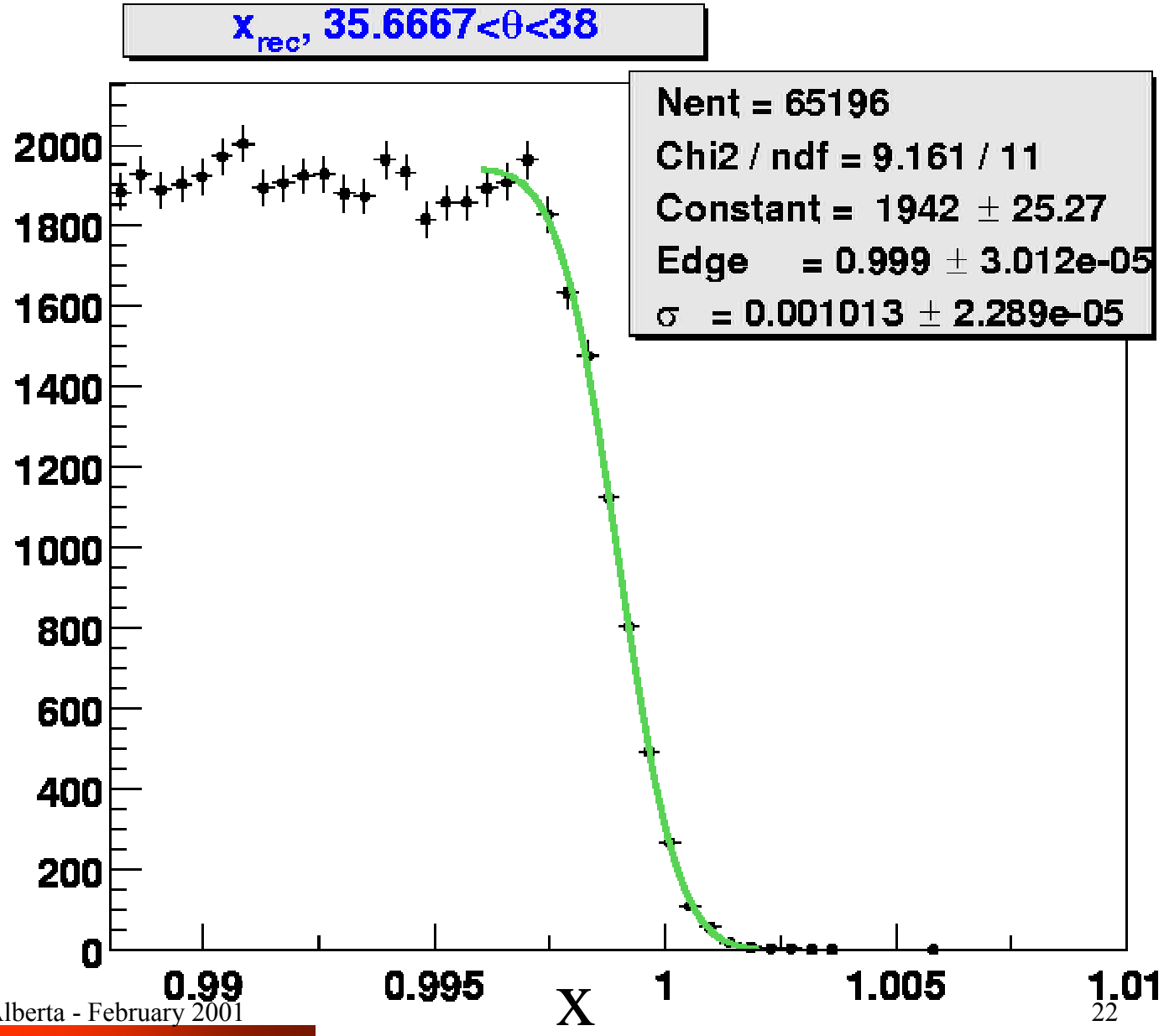
The unpolarized distribution will be used to calibrate the energy scale at all angles



TWIST – Energy Calibration

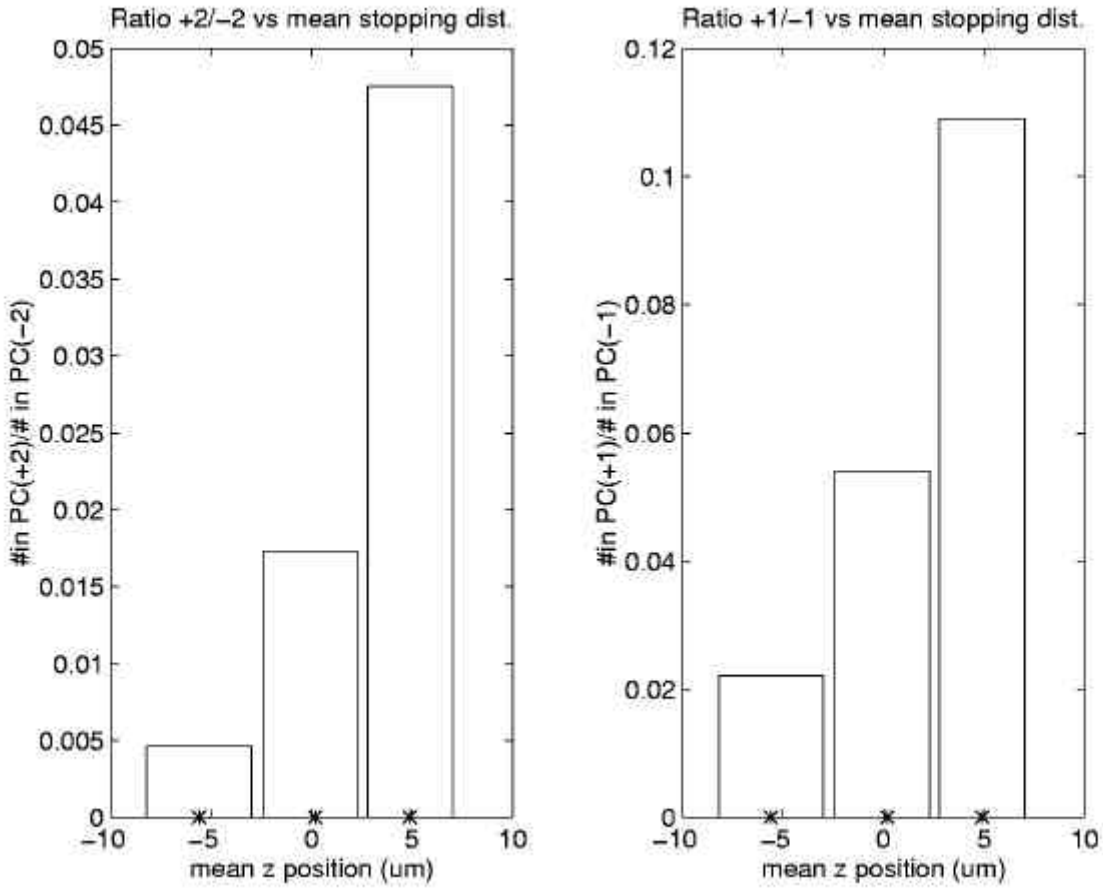
Endpoint energy calibrations can be done to a precision of approximately 2 keV (where ~10 keV is needed).

Unpolarized beam will be used to provide energy calibrations independent of angle.



TWIST– stopping distributions

Signal ratios in the target PC's can be used to monitor the stopping distribution



TWIST– TEC Design Concept

The TEC has been part of our planning since June 1998

Installation planned for Spring 2002

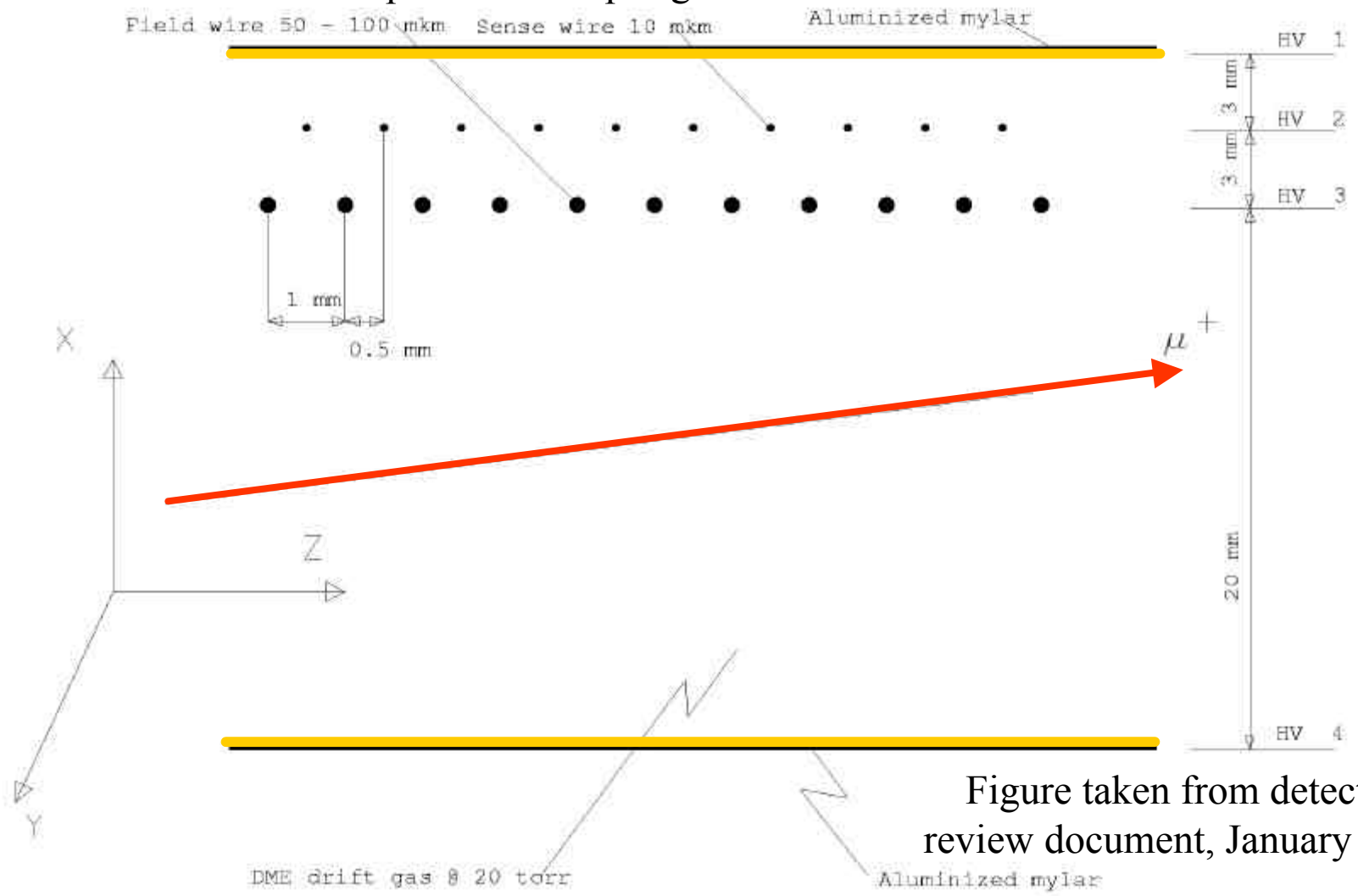
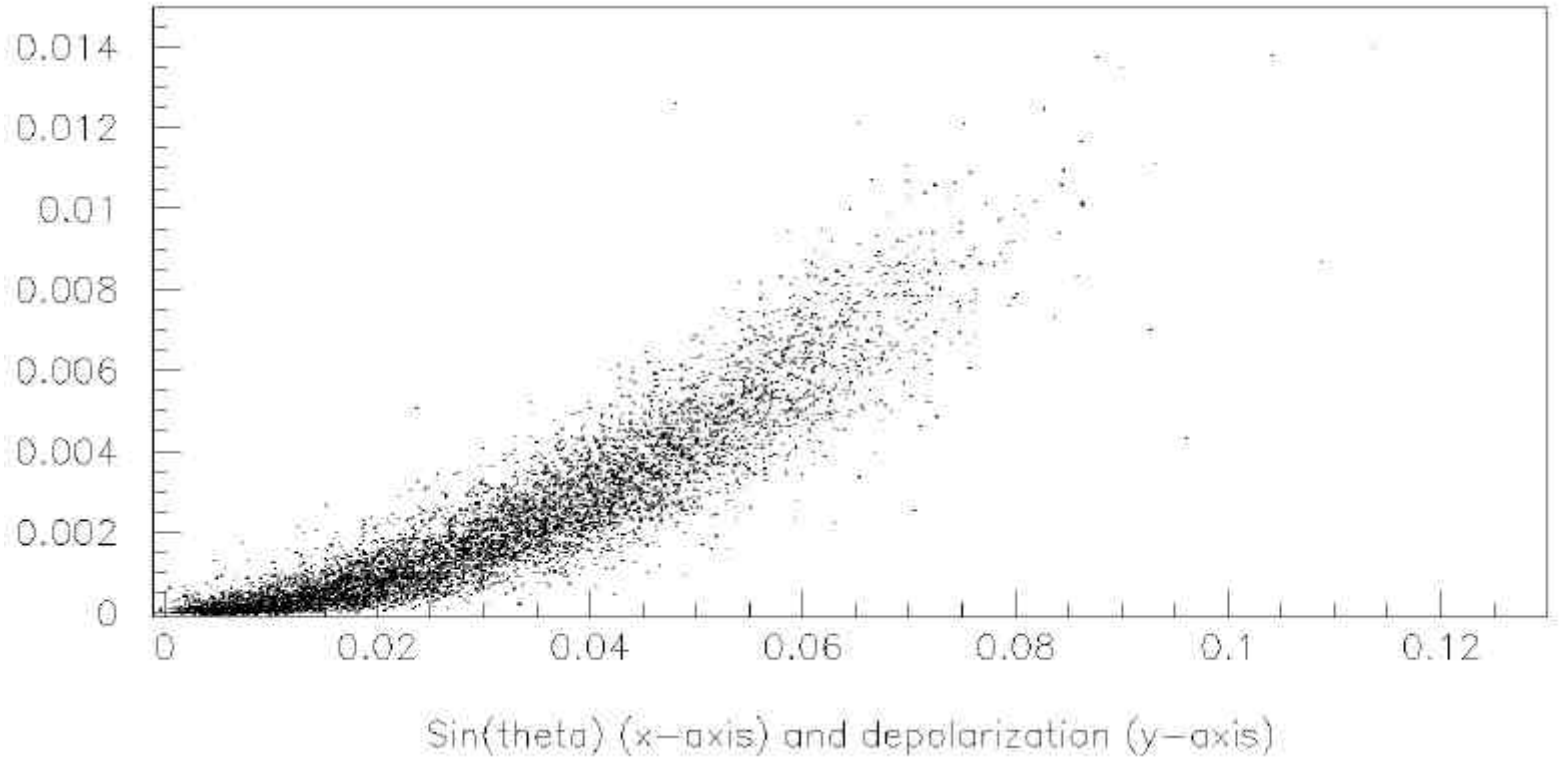


Figure taken from detector review document, January 1999

TWIST– TEC Projected Performance

Effective Depolarization vs. TEC Tracking Angle



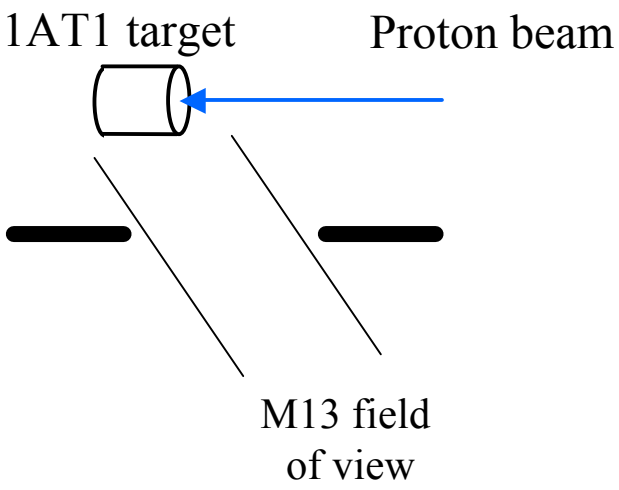
Correlation relies upon a highly convergent tune, focused at the peak in the radial fringe field

TWIST– 1AT1 modifications

The surface muon beam is produced in part on the surface at which the protons enter, and in part along the length of the target cylinder.

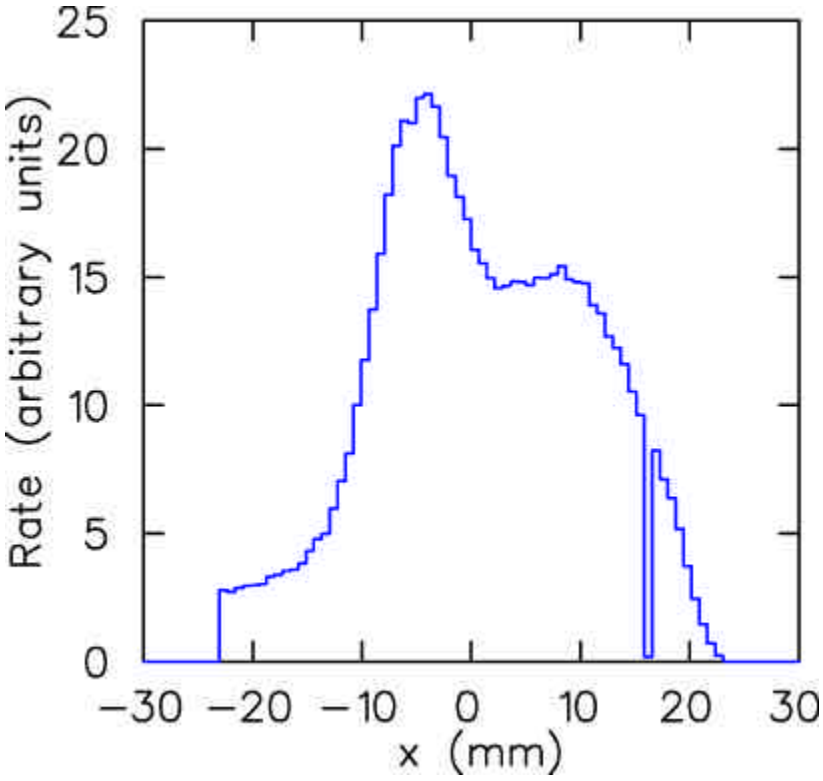
A shorter target would reduce the size of the beam spot

A hidden proton entry point would reduce sensitivity to wander in the proton beam



1AT1 target as imaged by M13

Surface muons



TWIST– Budget

The TWIST budget request is minimal

the detector has been built without accessing the 15% contingency set aside by NSERC

1) Support for Post-docs should be uniform.

TWIST has been funded for three NSERC post-docs

Given the size and complexity of the experiment, and the number of grant signators, this is less than normal

2) Graduate Students should not teach while taking data or building an experiment.

Nonetheless, our request builds in an assumption of one semester / year of teaching for graduate students.

We accepted one additional PhD student in January (Blair Jamieson, UBC).

We are not requesting support for any unnamed students.

3) We have been told to expect significant (perhaps 50%) increases in the cost of liquid Helium.

A contract protects us through 2001.

4) We have requested a minimal budget. If we are given less than 95% the requested amount, we prefer a one-year award.

TWIST– Goals

Summer 2001	**-**	**Commissioning data. Preliminary alignments and calibrations**
End of 2001	**-**	**Michel distributions on tape suitable for preliminary determination of** ρ **and** δ
2002	**-**	**Installation of the TEC**
	-	**Modified production target**
	-	**Beamline improvements, including realignments**
	-	**Improved Michel distributions based upon experience with alignments and calibrations**
	-	**Field alignment studies**
2003	**-**	**Studies of depolarization in the stopping target**
	-	**Preliminary** P_{mx} **data**
	-	**Precision measurements of** ρ, δ **and** η