Focal Plane Scanner

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for the scanner working group

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Outline

- **Overview**
  - -----motivation for using focal plane scanner
  - -----design criteria
- **Geant4 simulation**
  - -----detector performance and some results
  - -----rates estimation
- **Prototyping test**
  - -----1-tube prototype assembly
  - -----cosmic ray tests with one-tube prototype
  - -----some results and problems
  - -----2-tube prototype design
- **Status and plan**

Motivation for Focal Plane Scanner

- **Momentum transfer determination, background studies, will be performed at 1 nA beam current using the tracking system**

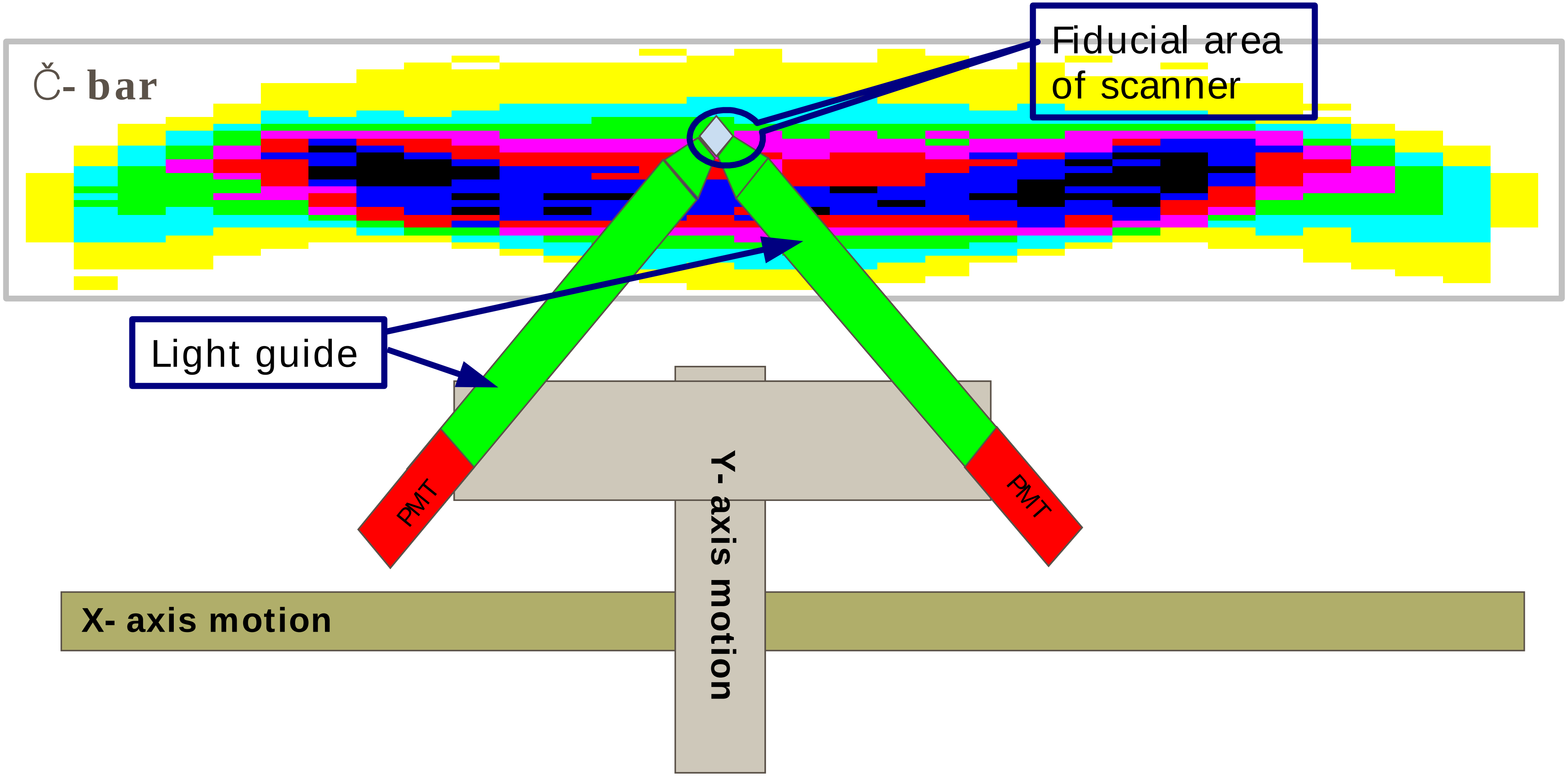
- **Region III is operable up to 100 nA**

- **Production run will be at 180 μA. Tracking detectors are inoperable at such a high rate.**

- **Need a way to extrapolate the low current measurements to the high current situation (over 3 orders of magnitude!).**

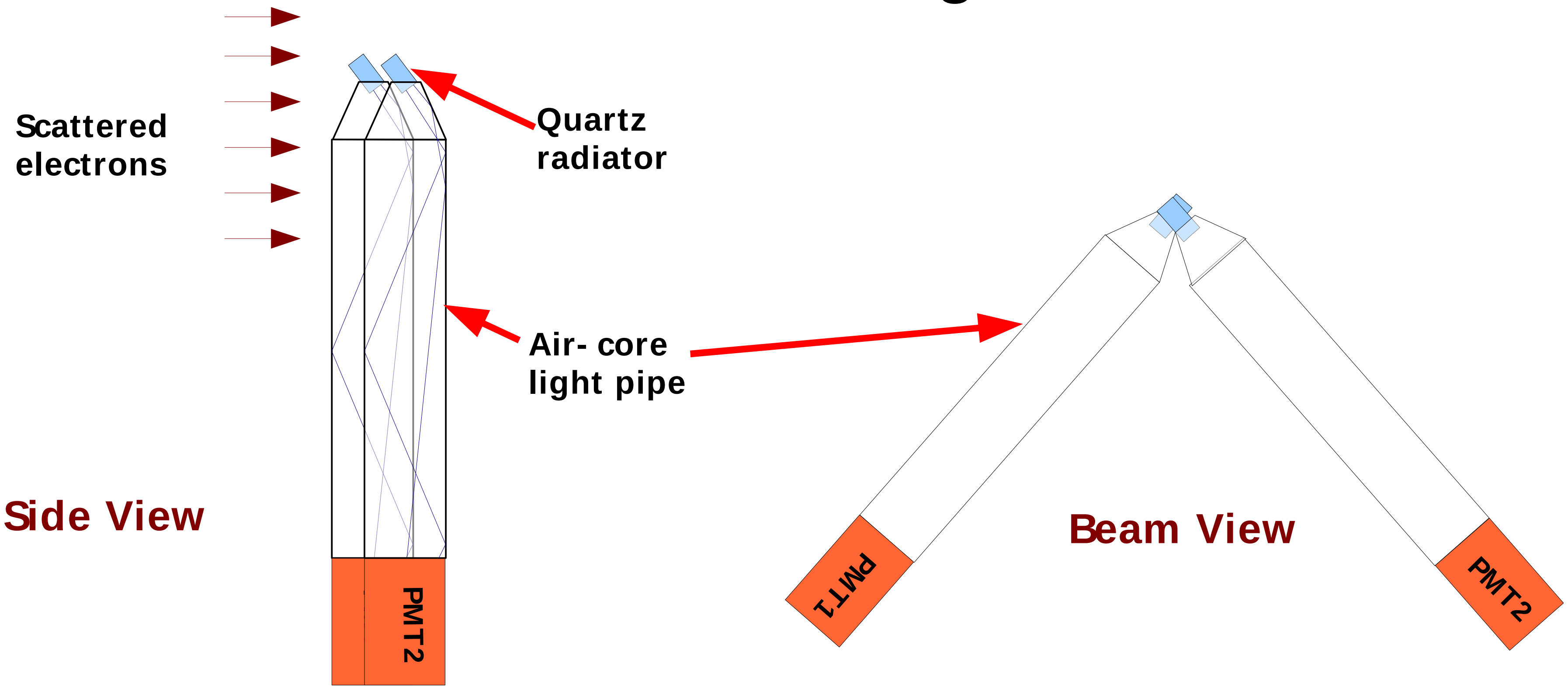
- **Idea: use a small, scanning detector to perform the extrapolation ==> "FOCAL PLANE SCANNER"**

Focal Plane Scanner



A scanning Cherenkov detector mounted on the focal plane with very small active area is used to sense high- energy electrons so as to determine the electrons spatial distribution in focal plane, operable at all beam currents.

Scanner Design



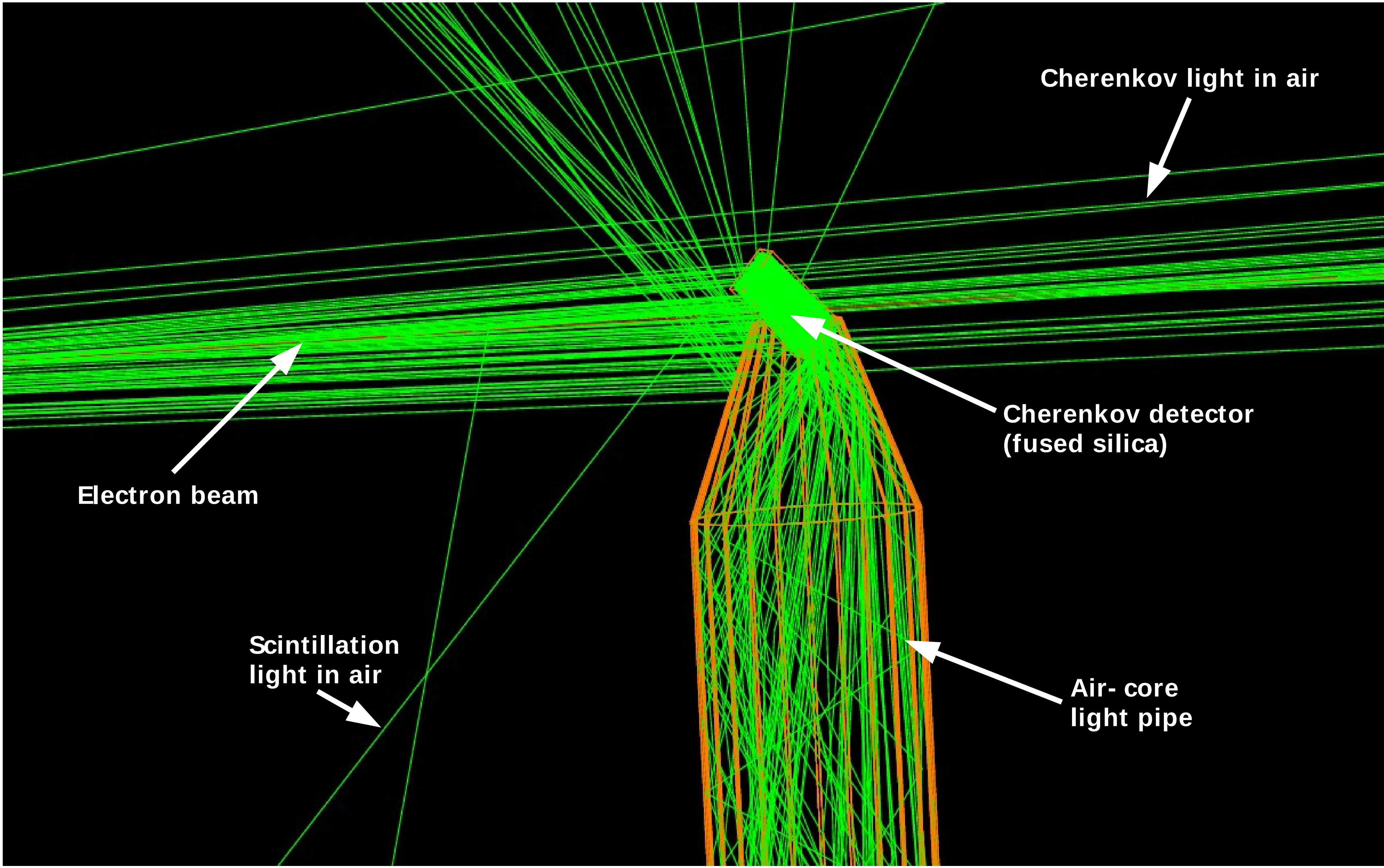
Design criteria:

- Small (1 cm^2) active area
- 1 MHz max rate allows operation in counting mode with two PMTs.
- Operable at both high and low current.
- Coincidence to reduce background

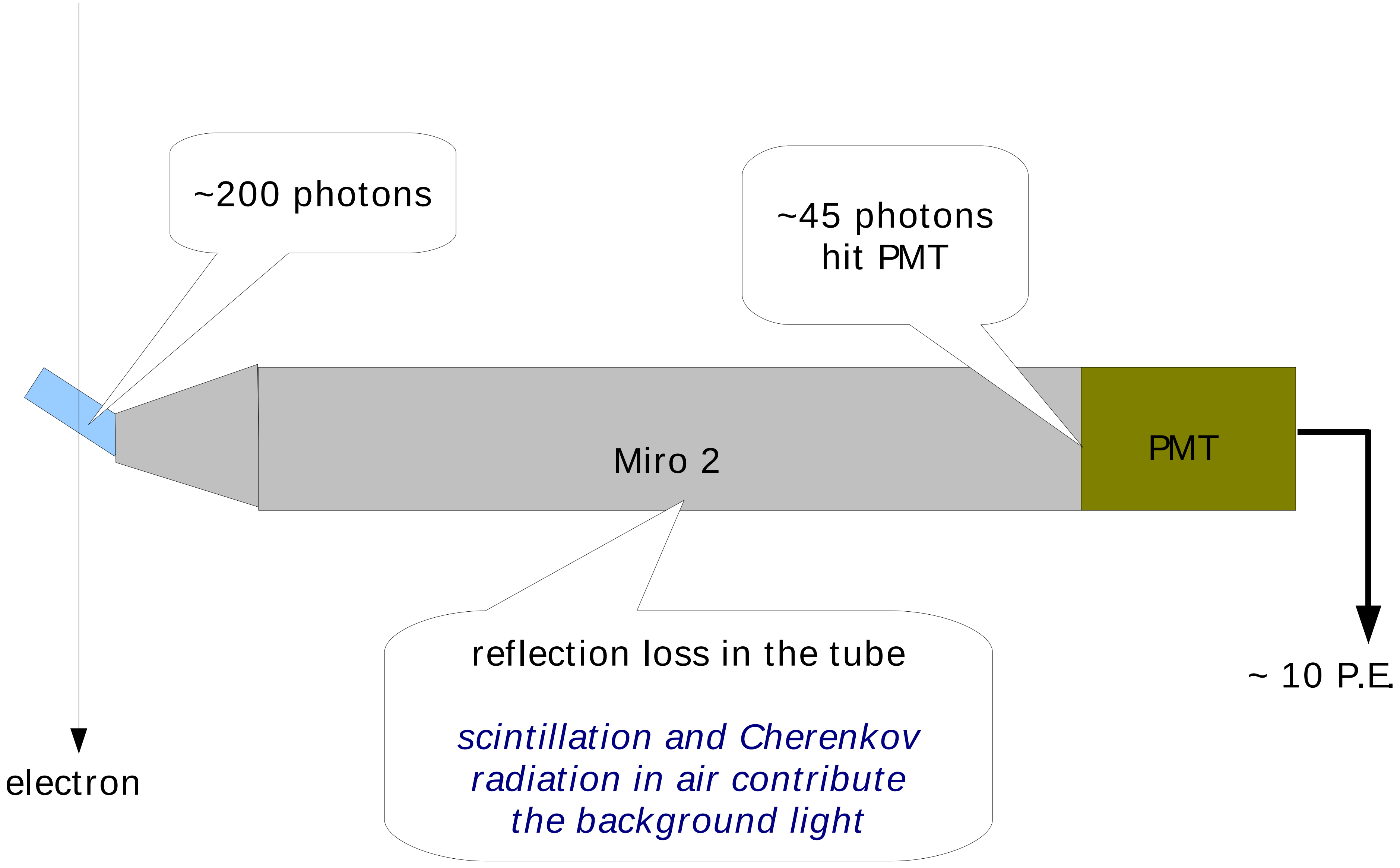
Scanner also needs:

- Readout electronics
- 2D linear motion system

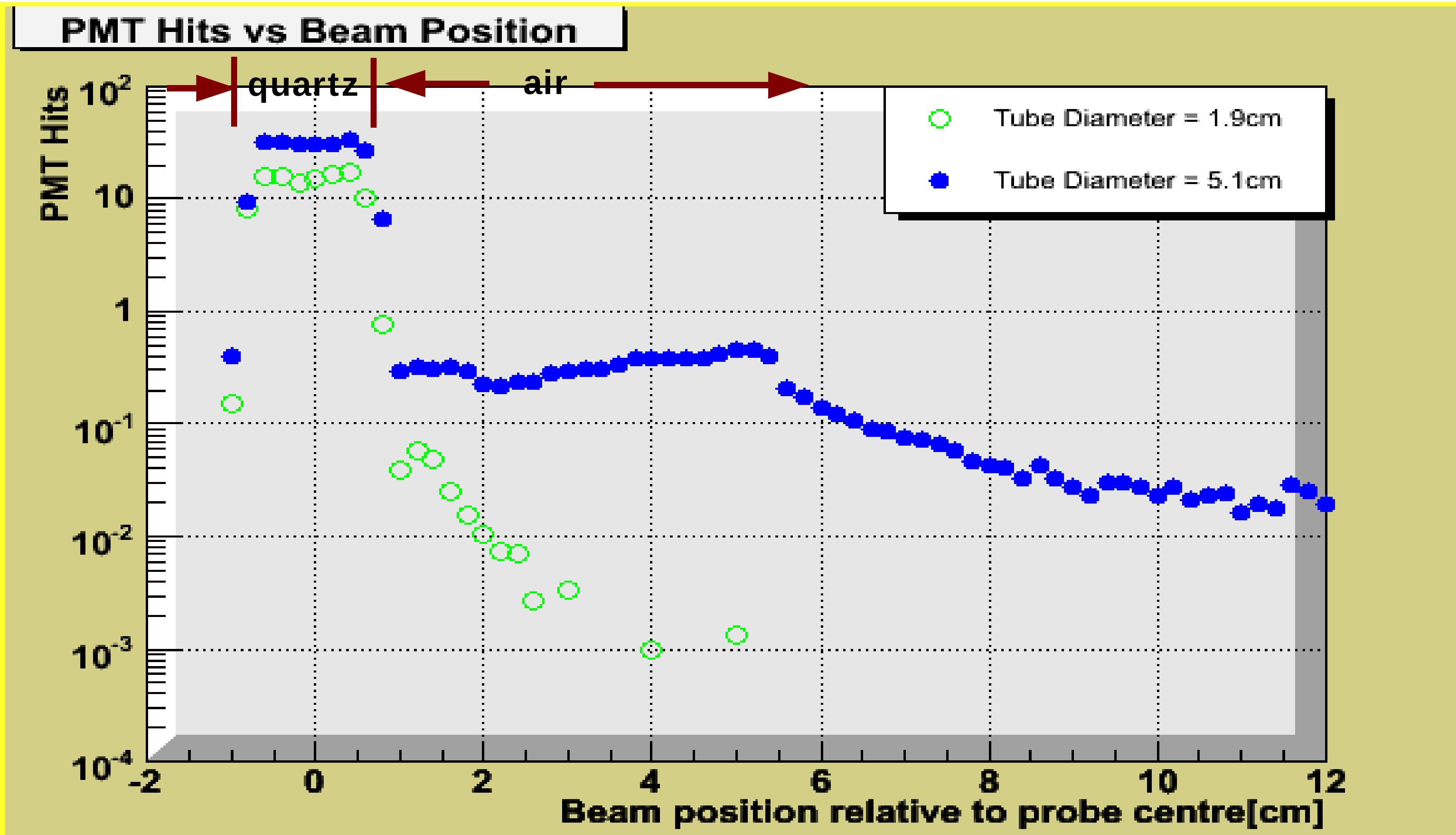
Geant4 Monte Carlo Simulation for Scanner Performance



Light production and propagation in scanner



Simulation Results

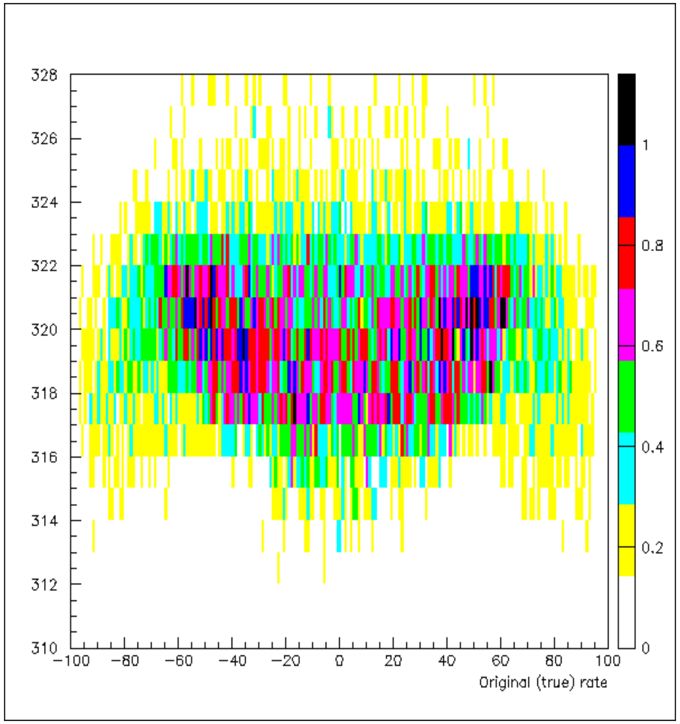


- Very little background from air- core light pipe
- Light yield quantitatively understood

Calculating Singles and Accidental rate

(ongoing work by Laura Cobus)

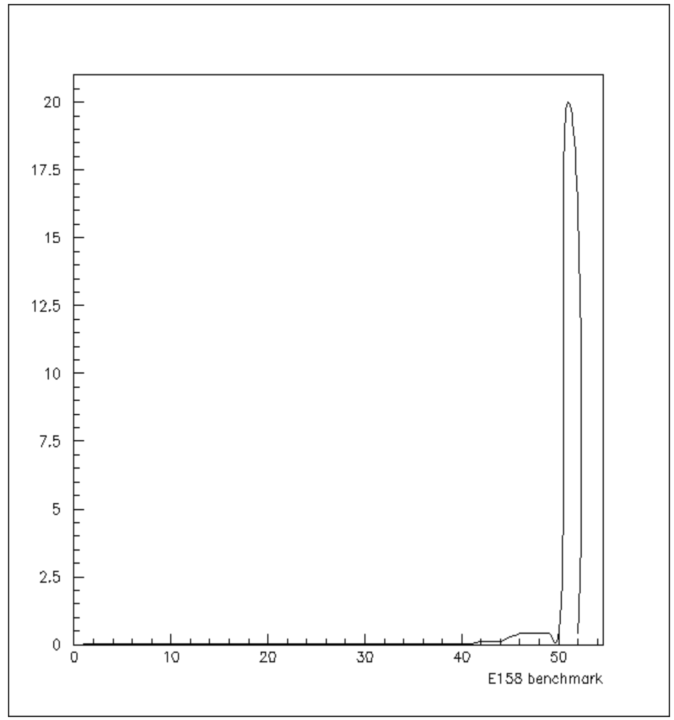
R_{true}



Qweak G3 simulation

The rate on the unit area of the bar R_i

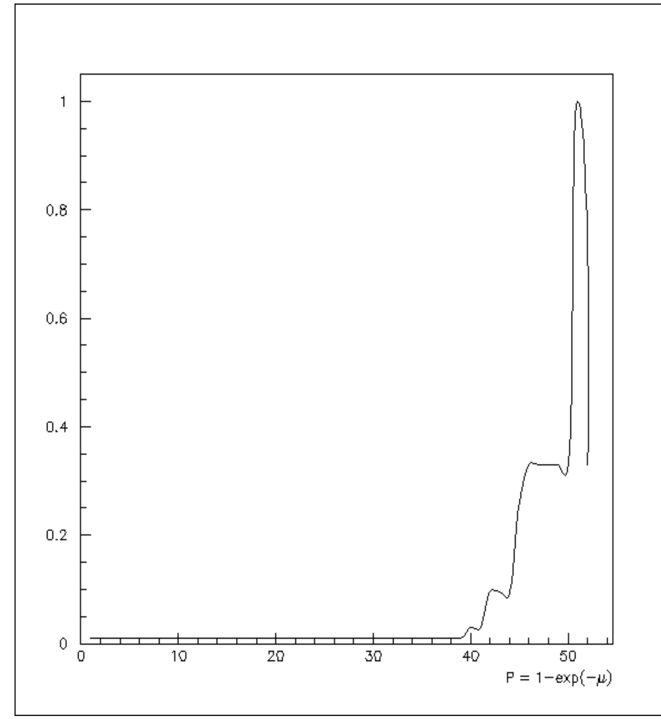
μ



Scanner G4 simulation

Mean of the PMT hit L_k

$P(n \geq 1) = 1 - e^{-\mu}$



Poisson distribution

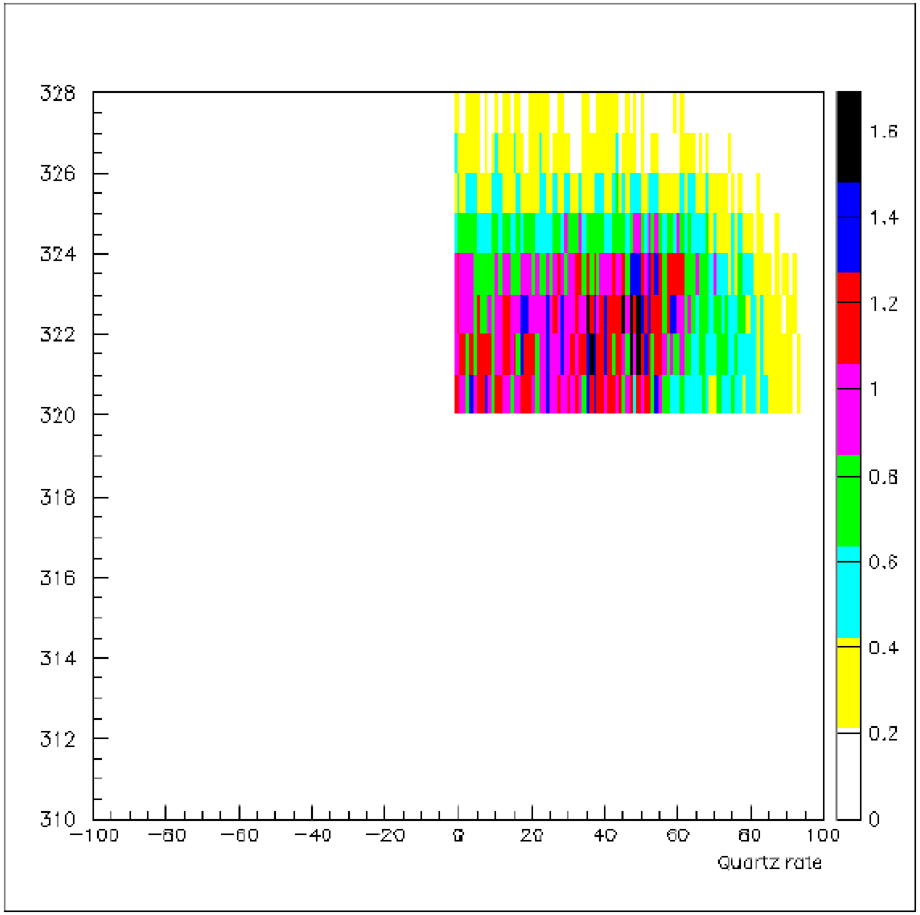
Probability of getting more than one PMT hit P_L

$$\mathbf{R_{singles} = R_{true} * P}$$ **- - - - >**

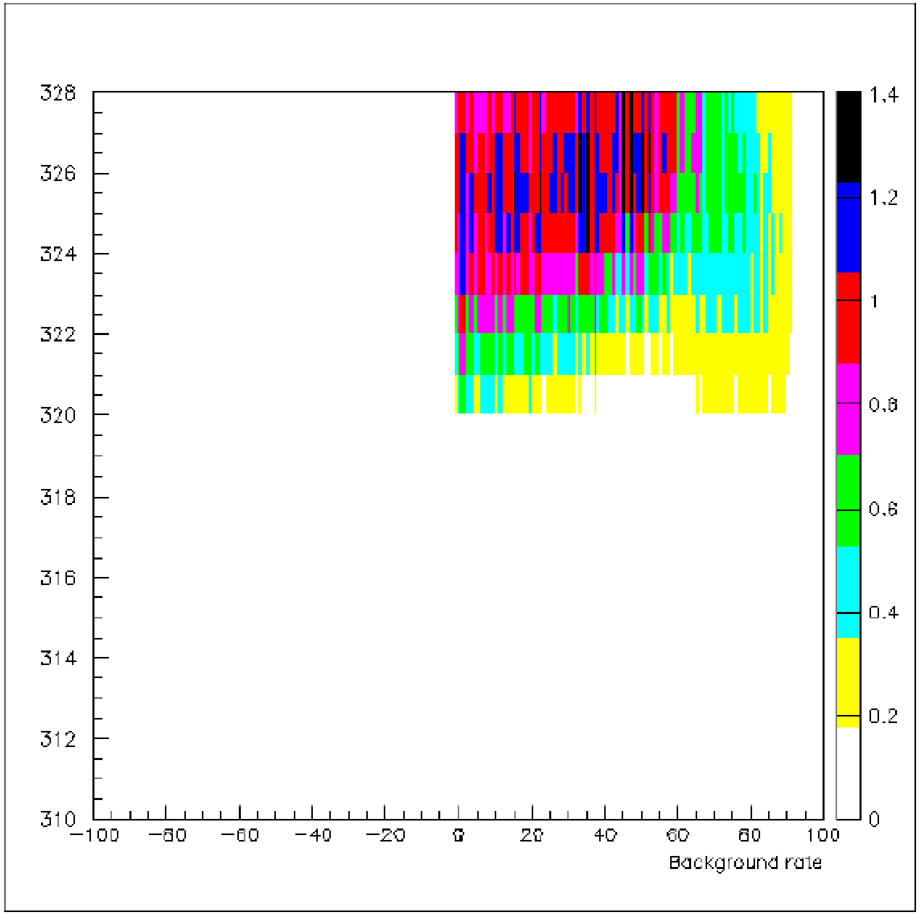
Total scanner PMT hits at position q is

$$\mathbf{L_q = \Sigma_{(k)} R_i L_k P_L}$$

Comparing rate on quartz to rate on background



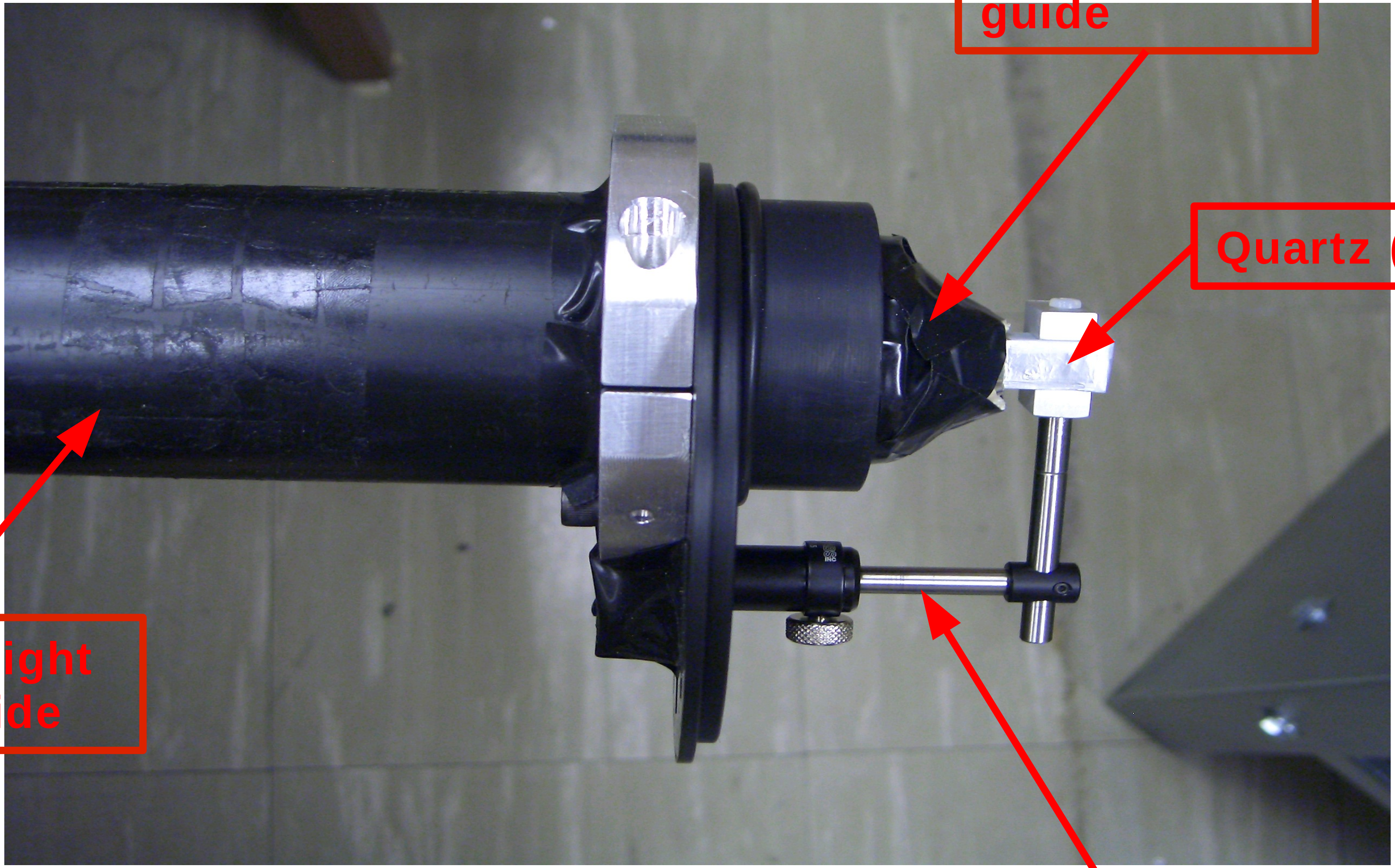
Rate on quartz



Rate on background

$$\boxed{R_{accidental} = R_{singles1} * R_{singles2} * \tau_{12}}$$

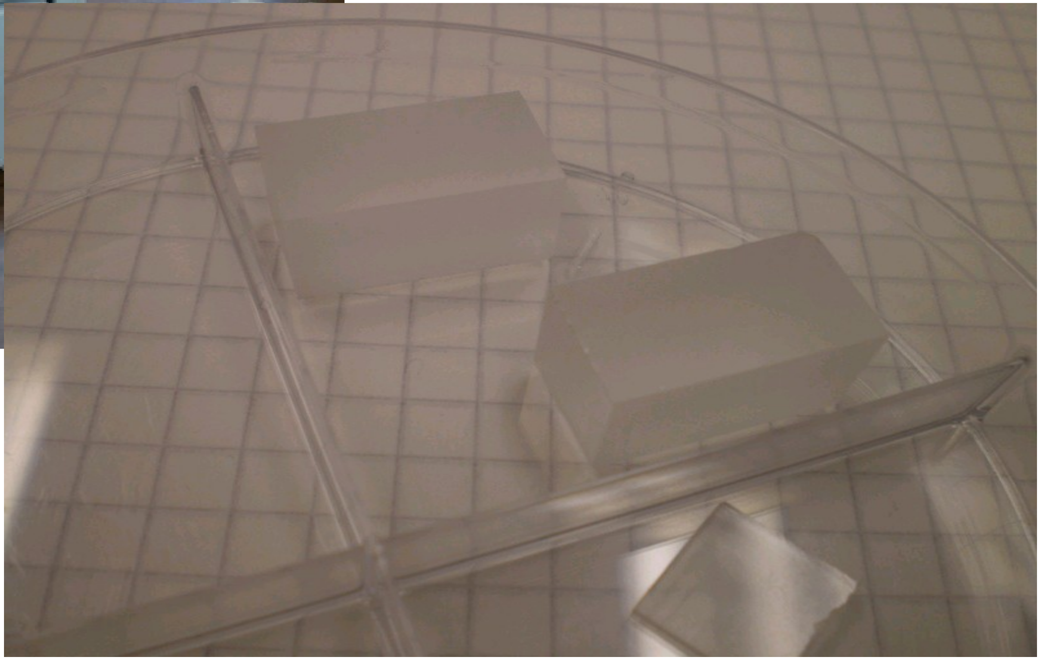
Prototype - one tube assembly only



Cutting Quartz With Precise Saw

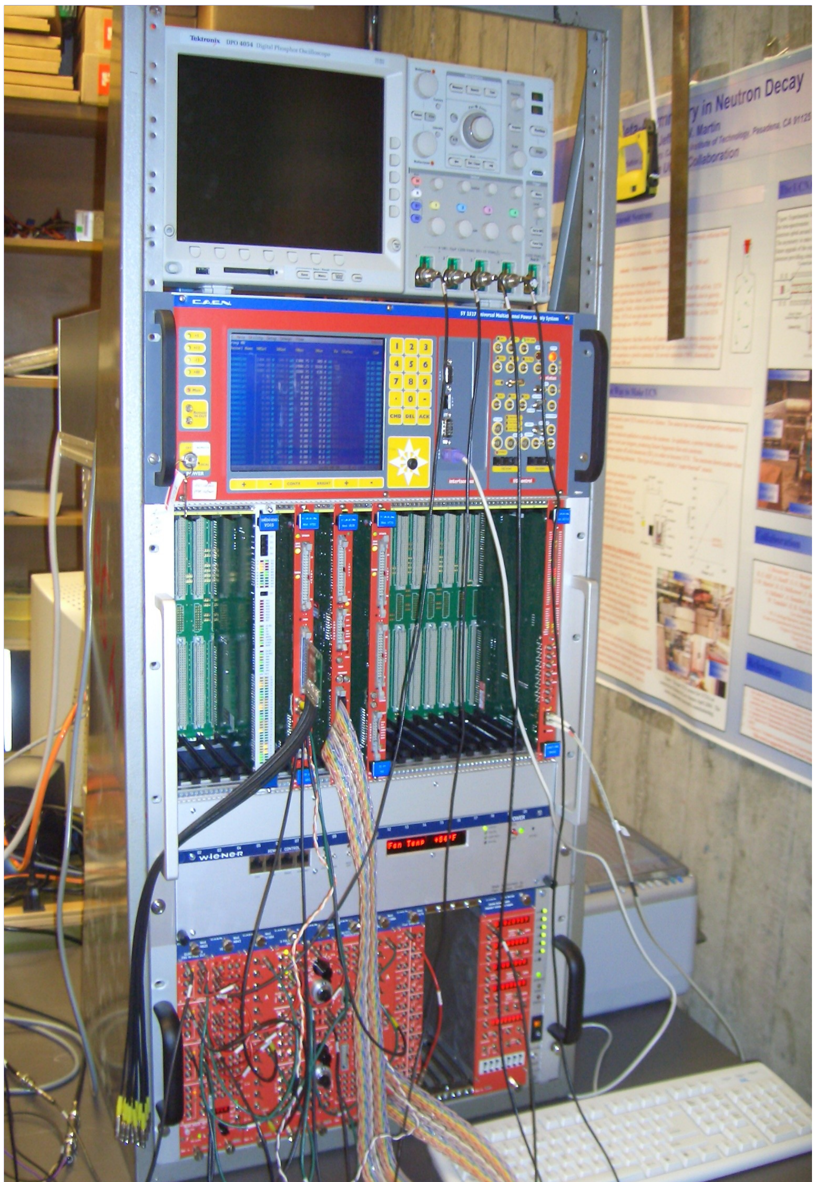
NSFL at Univ. of Manitoba

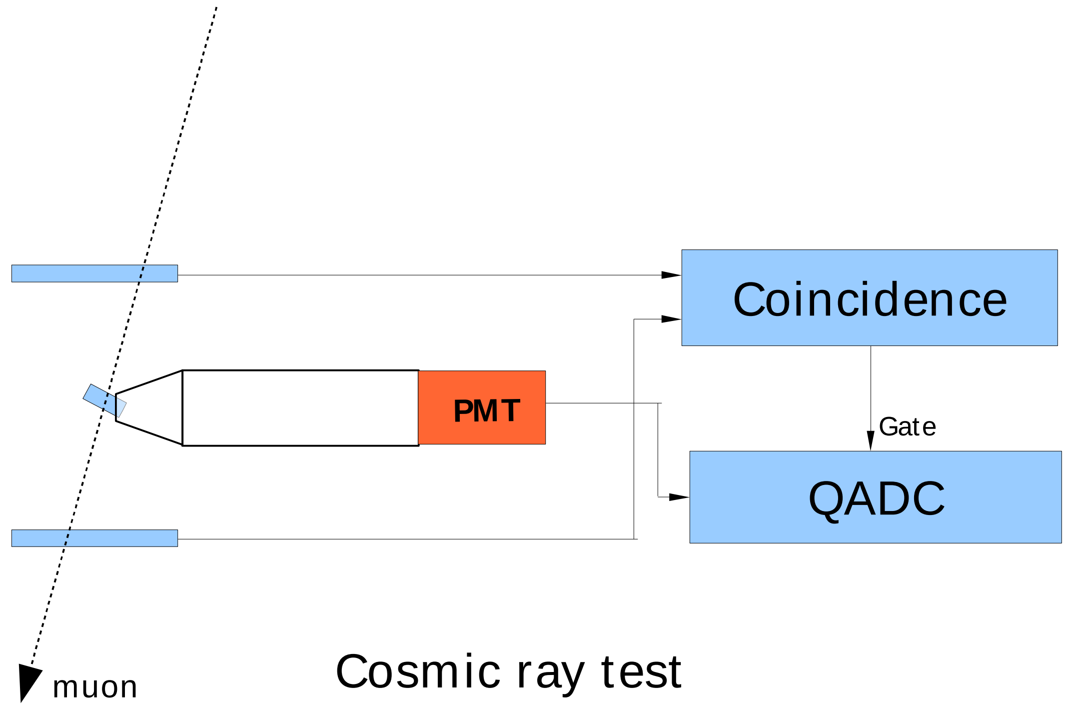
unpolished quartz,
1 cm x 1 cm x 2 cm



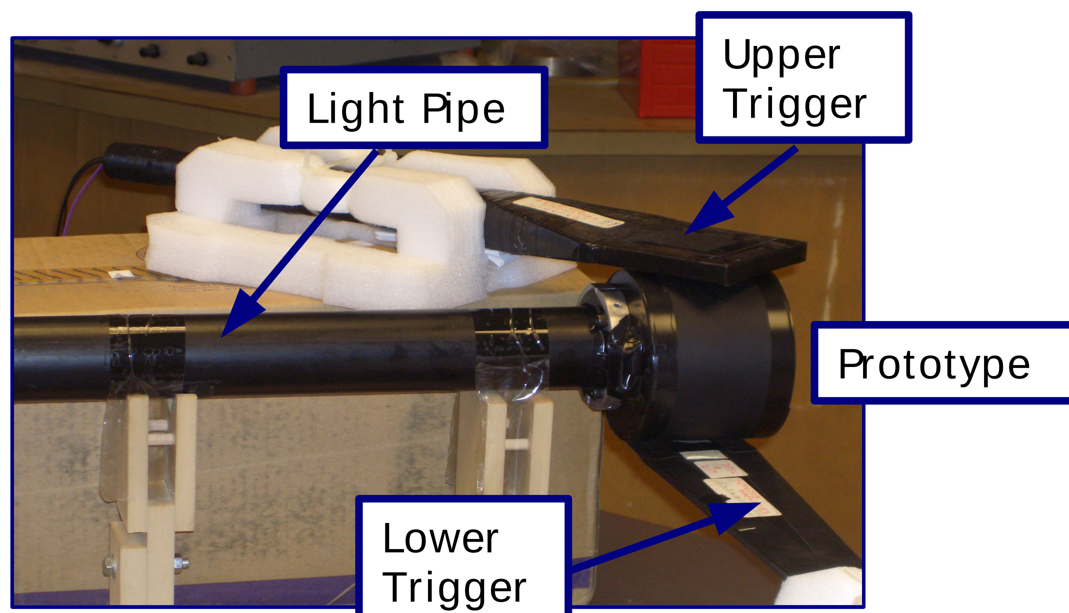
Prototyping Test

Electronics (VME& NIM)

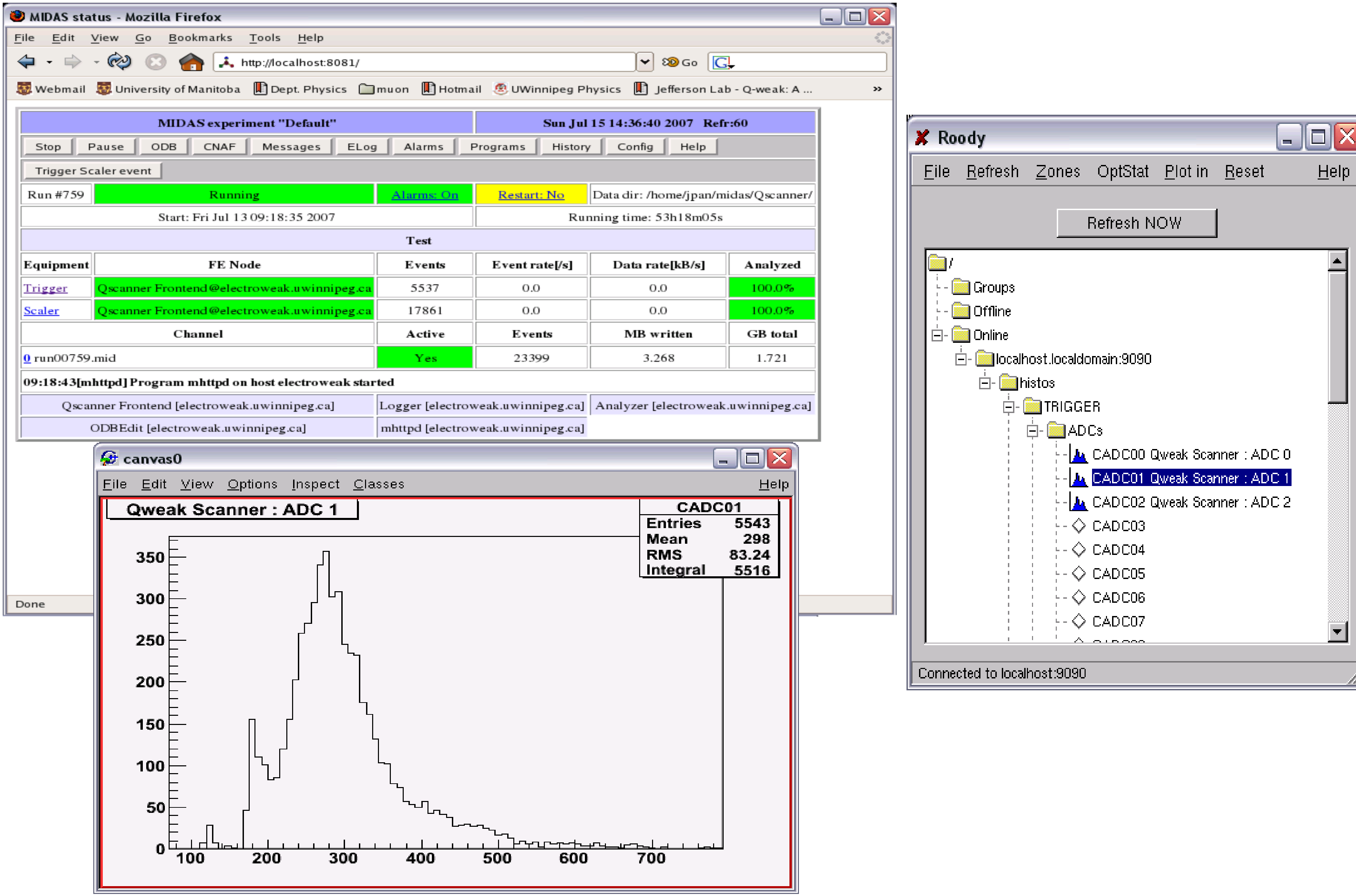




Cosmic ray test



DAQ – MIDAS based, online histogram / offline analysis

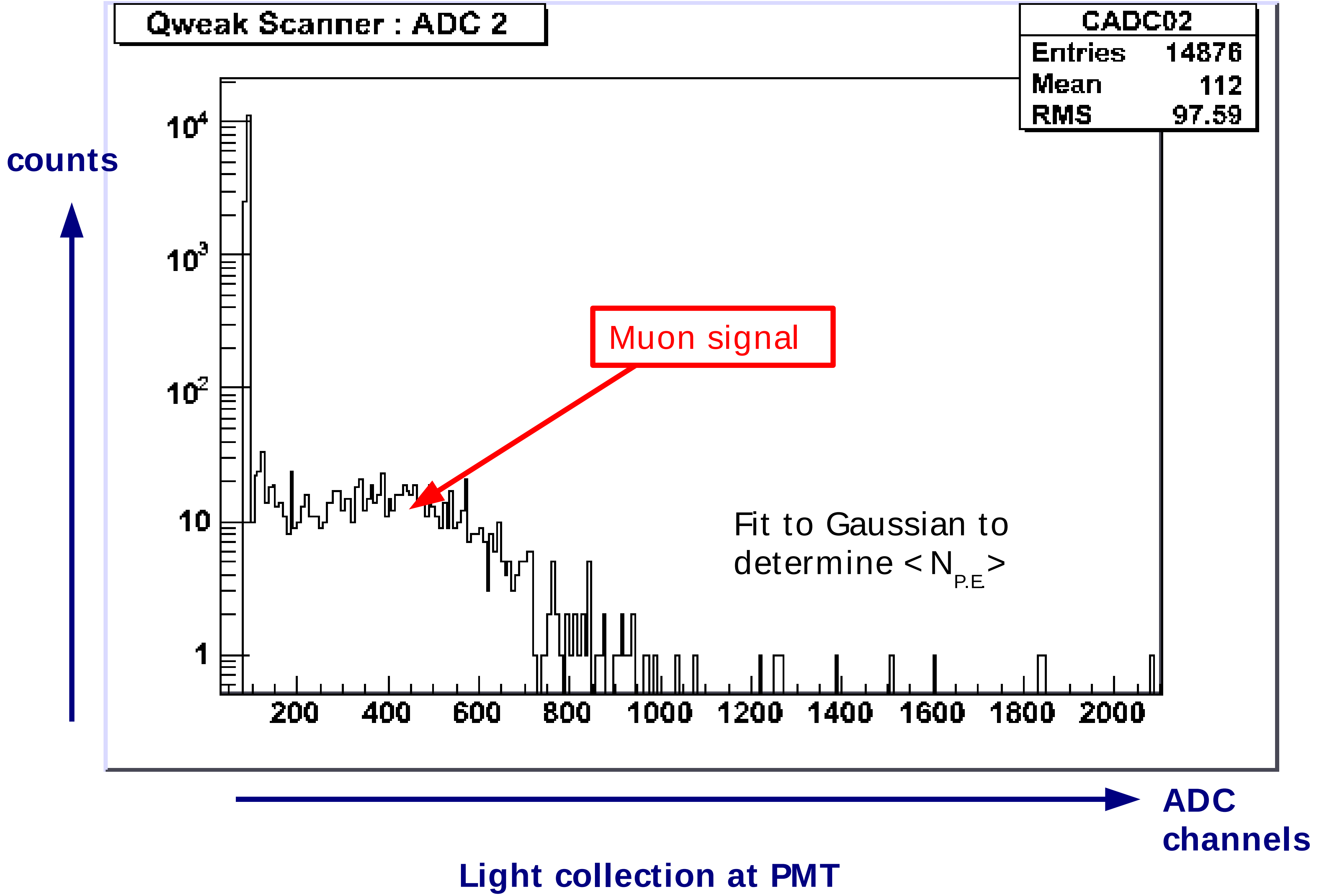


Cosmic ray tests with one- tube assembly

- 2” diameter, 50 cm long air core light guide
- Reflection material “Miro 4”   (ALANOD)
- XP2020Q PMT (2 inch)
- A “crude” quartz (~ 0.8cm*1.2cm*2cm, partially polished)
  & a “fine” quartz (1cm*1cm*2cm, polished)
- Quartzes are wrapped by Aluminum foil
- Top & bottom trigger paddles provide coincident trigger signal
- HV on PMT = 2300V

Prototyping Test

-- Light yield optimization in prototype underway



Some experiment results

Crude quartz:

tilt angle	# P.E.
45 deg	10.2 ± 0.5
0 deg	9.6 ± 1.7
- 45 deg	7.8 ± 0.5

Fine quartz:

tile angle	# P.E.
45 deg	8.5 ± 1.2
0 deg	7.2 ± 0.7

Simulation:

tilt angle	# P.E.
45 deg	8.8 ± 0.2
0 deg	5.1 ± 0.1

<<== Compare to experiment

Key problem: low light yield

Total light yield from quartz is low + reflection loss + PMT quantum efficiency ==>> only ~10 photo- electrons

It CAN be discriminated from background/ noise, but with some difficulty (prone to be hidden in noise)

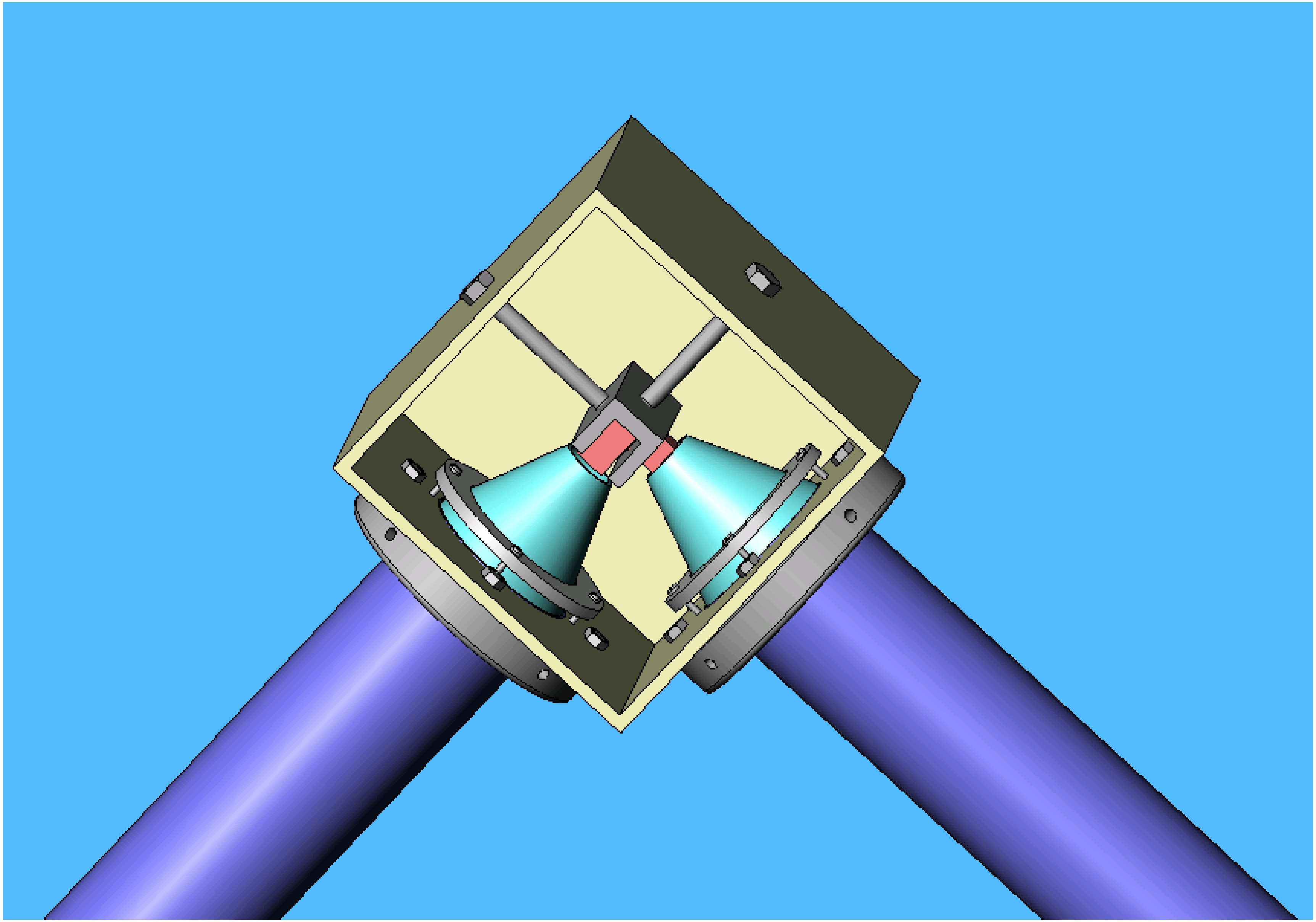
Considering:

Increase light yield from quartz ==>> use pre- radiator?
use white paint or white paper wrap?

Decrease reflection loss ==>> use the best reflect material
choose different geometry?

Reduce background ==>> use vacuum tube?
fill CO_2 in the tube?

2- Tube Solidworks Model



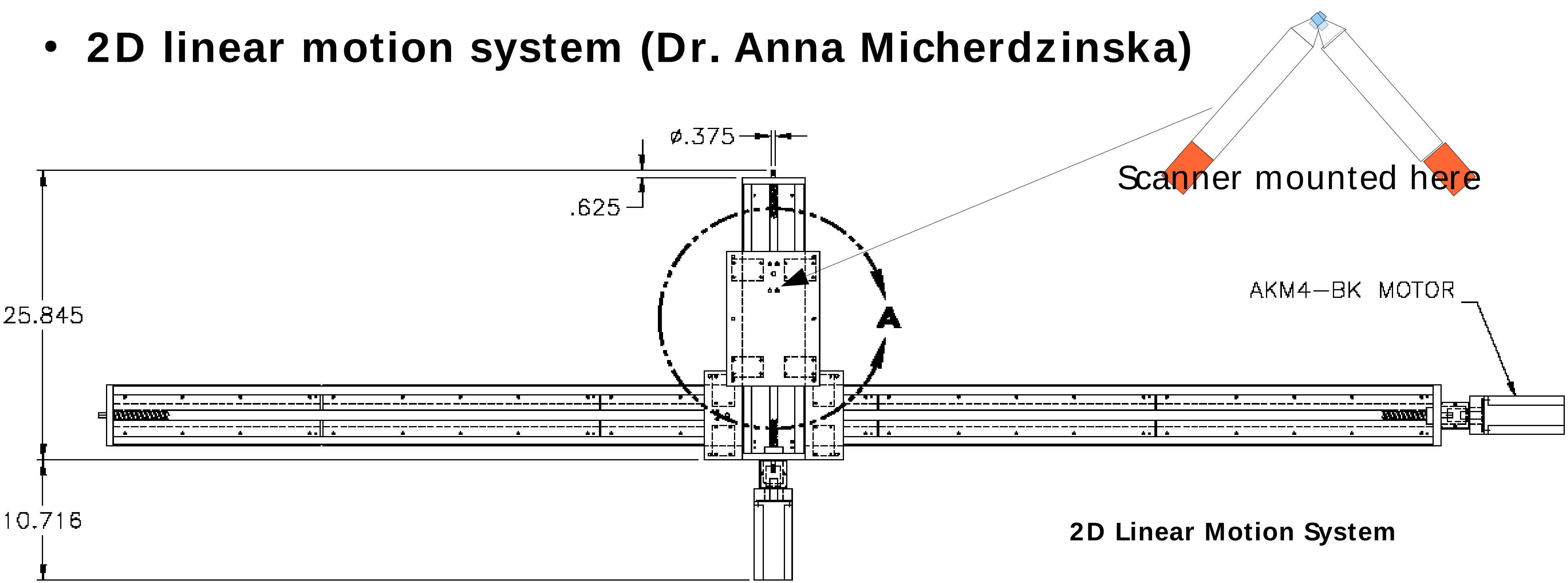
Prototype will be constructed in the mechanical shop at U of M or TRIUMF

Status and plan

- **The simulation for detector performance has been benchmarked.**
  We'll concentrate on simulation about pre- radiator and rate estimation.

- **Cosmic ray tests with 1- tube prototype are ongoing.**
  continue 1- tube prototype tests
  construct 2- tube assembly prototype, do cosmic ray tests and then do beam test with it.

- **2D linear motion system (Dr. Anna Micherdzinska)**



2D Linear Motion System