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Dosimetry Inside the CDF Tracking Volume

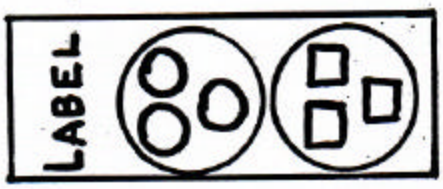
Goal: Use thermoluminescent dosimeters (TLDs) to measure the radiation field in the CDF tracking volume.

⇒ Correlate information w/ beam

⇒ Predict radiation damage to inner devices.

Implementation:

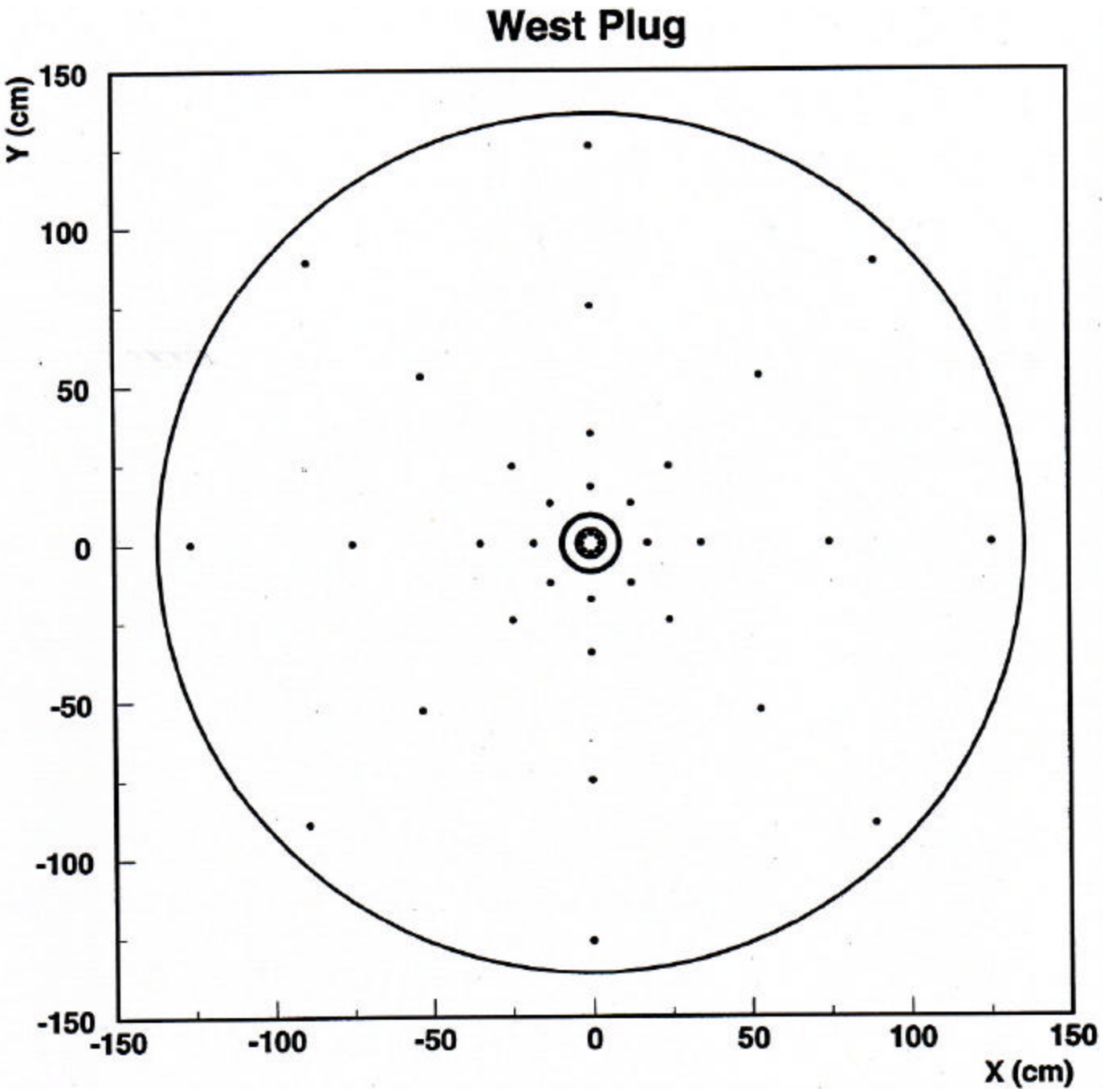
- 2 types of TLDs measure γ, $\gamma + n$ doses
- Response variation < 3%
- 145 locations on plug faces, SVX, ISL spacetubes

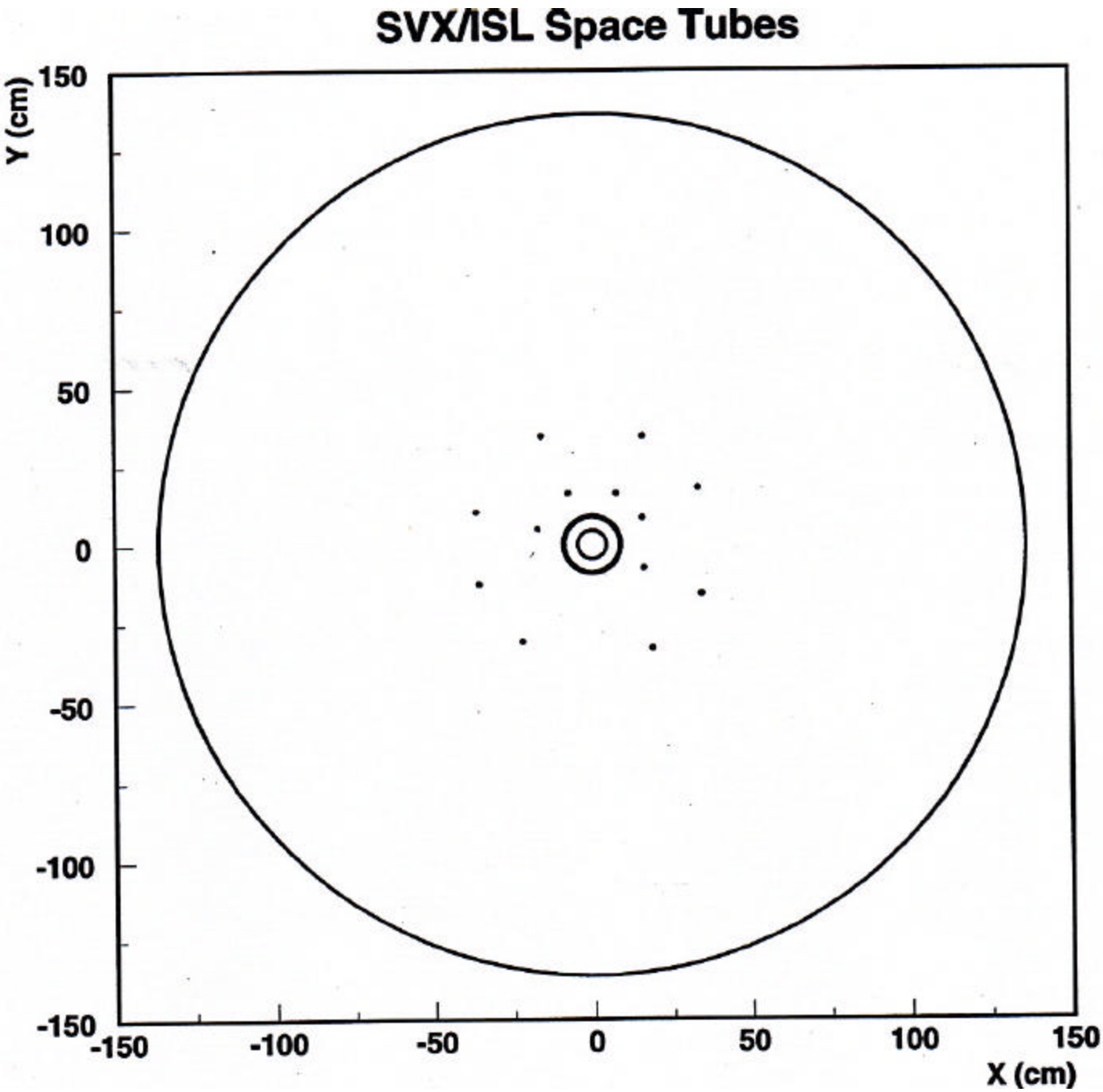


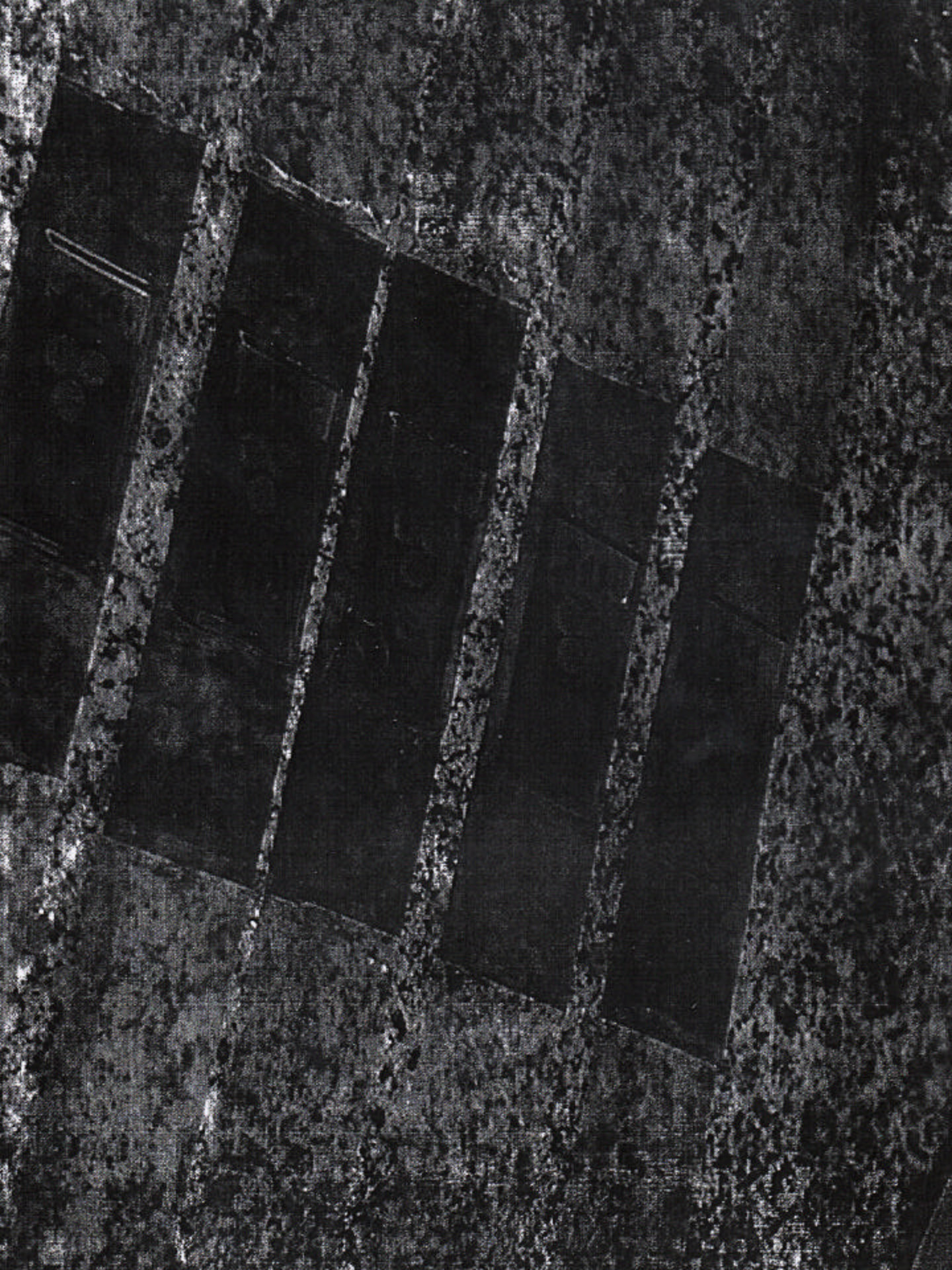
Status: Work in progress!

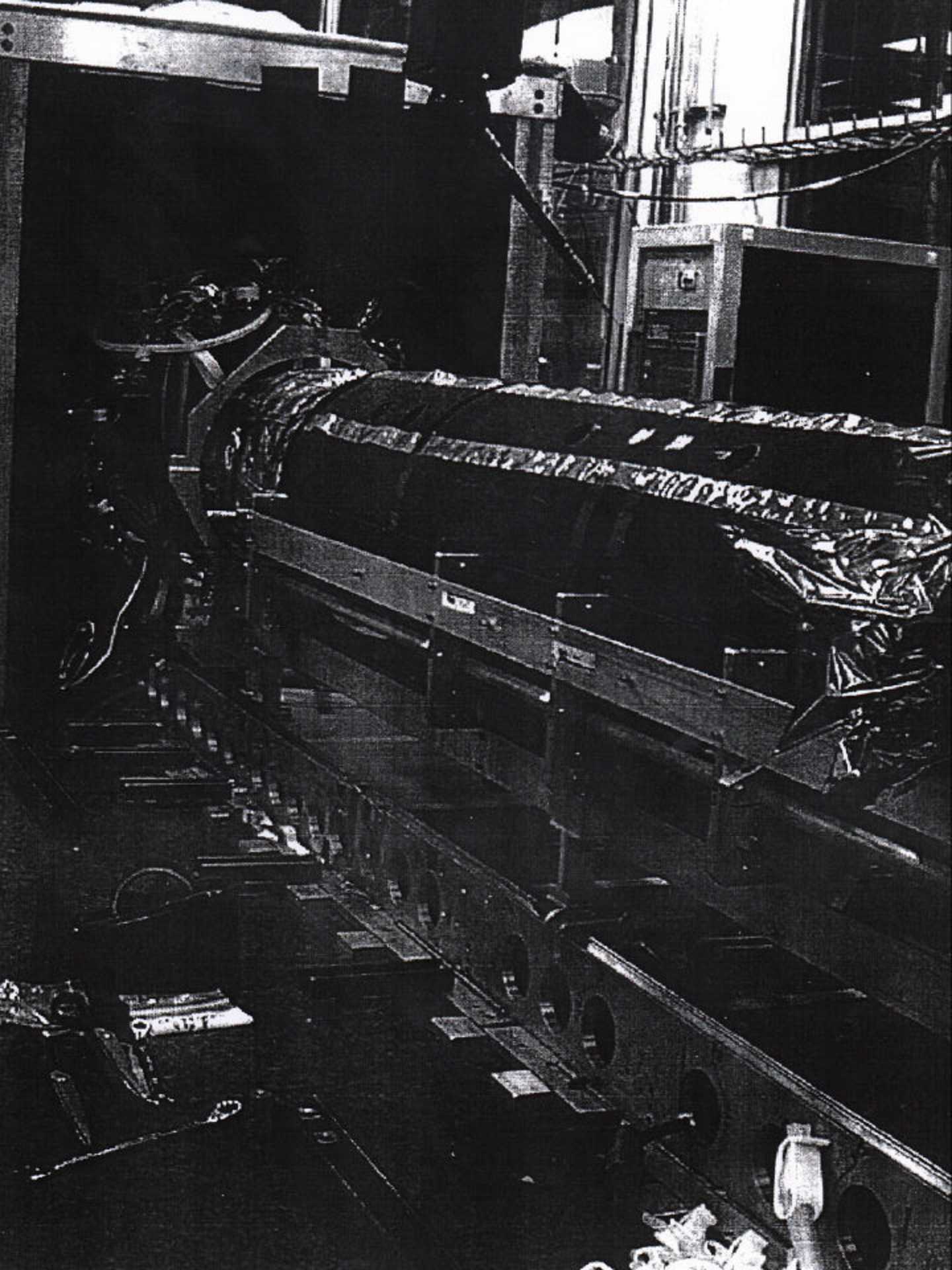
+ 2 exposures Feb-May May-Oct.
+ All readings in hand
− No neutron calibration

⇒ Only γ measurements now


West Plug
Y (cm)
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150
X (cm)


SVX/ISL Space Tubes
Y (cm)
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150
X (cm)





Calibration + Dosimetry

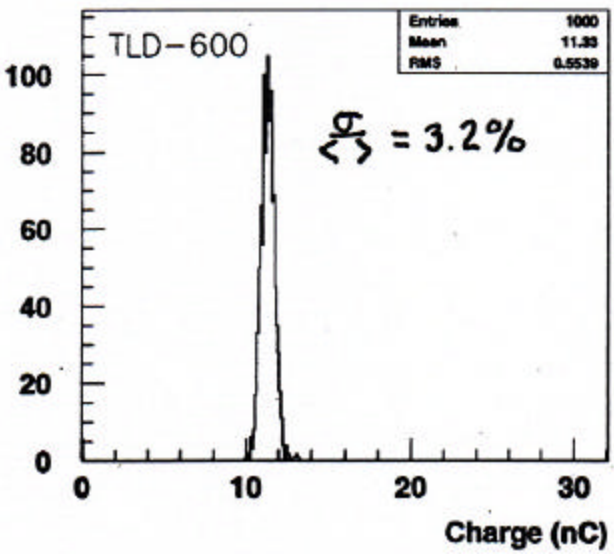
- All dosimeters of each type from a single batch
- All dosimeters γ response calibrated w/ 1 Rad exposure to ^{137}Cs source.
  - + Reproducibility < 1% variation
  - + Absolute scale ≈ 1% uncertainty
  - + Uncalibrated response variation ≈ 3%

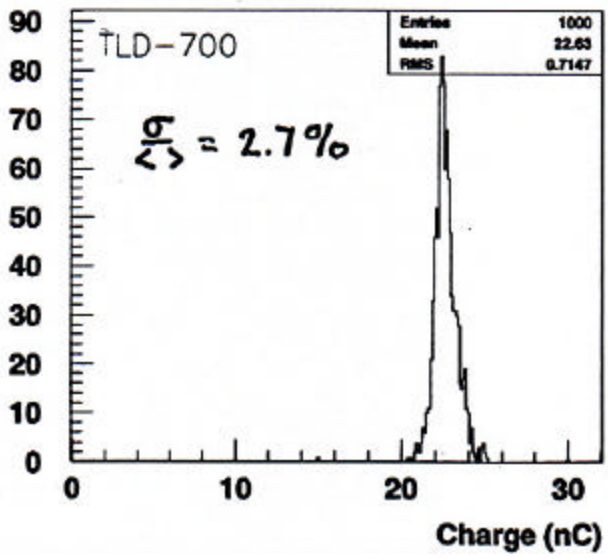
Dosimetry

k = 1/1 Rad response (Rad/nC)
R = TLD reading (nC)
C = Non-linearity correction
D_c = Control Dose (Rad)

$$D = R * k * C(R*k) - D_c \quad \text{(Rad)}$$

1 Rad TLD response





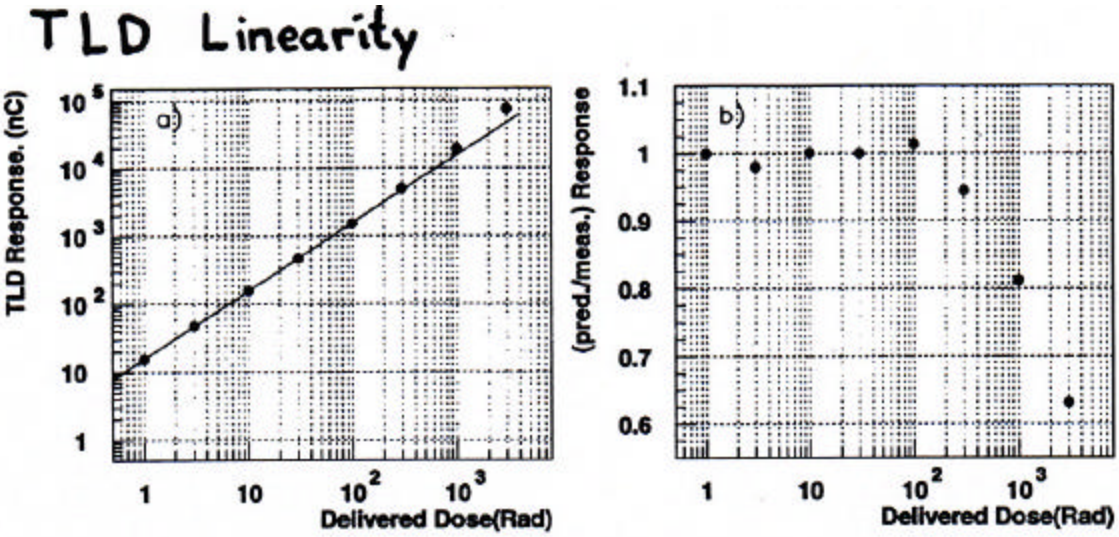


Figure 5: a) TLD-700 response measured in nC as a function of delivered dose. The line indicates the response predicted assuming a linear response model described in the text. b) Ratio of TLD-700 predicted/measured response as a function of delivered dose. The predicted dose assumes the linear response model described in the text.

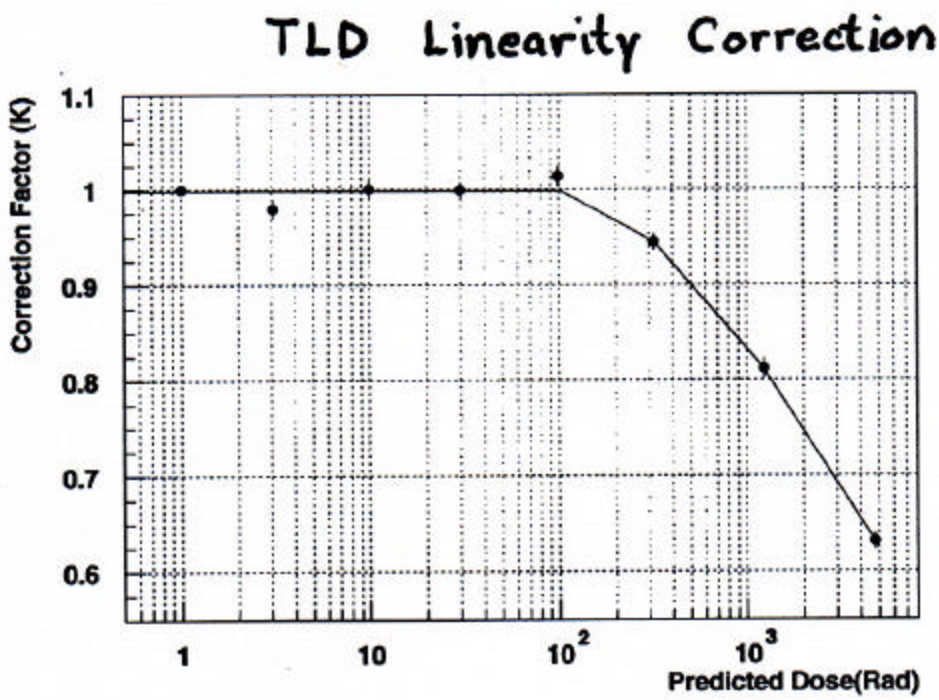


Figure 6: Linearity correction factor (K) as a function of the dose predicted assuming a linear TLD response model. The solid curve shows the factor used to correct the raw TLD data.

CDF note: 5723

Exposure Statistics

	Feb-May	May-Oct	units
protons	0.0703	1.56	10^{19}
antiprotons	0.0082	0.137	10^{19}
* p-losses	15.3	40.9	10^{9} counts
* $\bar{p}$-losses	2.02	10.2	10^{9} counts
Luminosity	0.058	10.7	pb^{-1}

* BØALOS and BØPLOS were used for these measurements

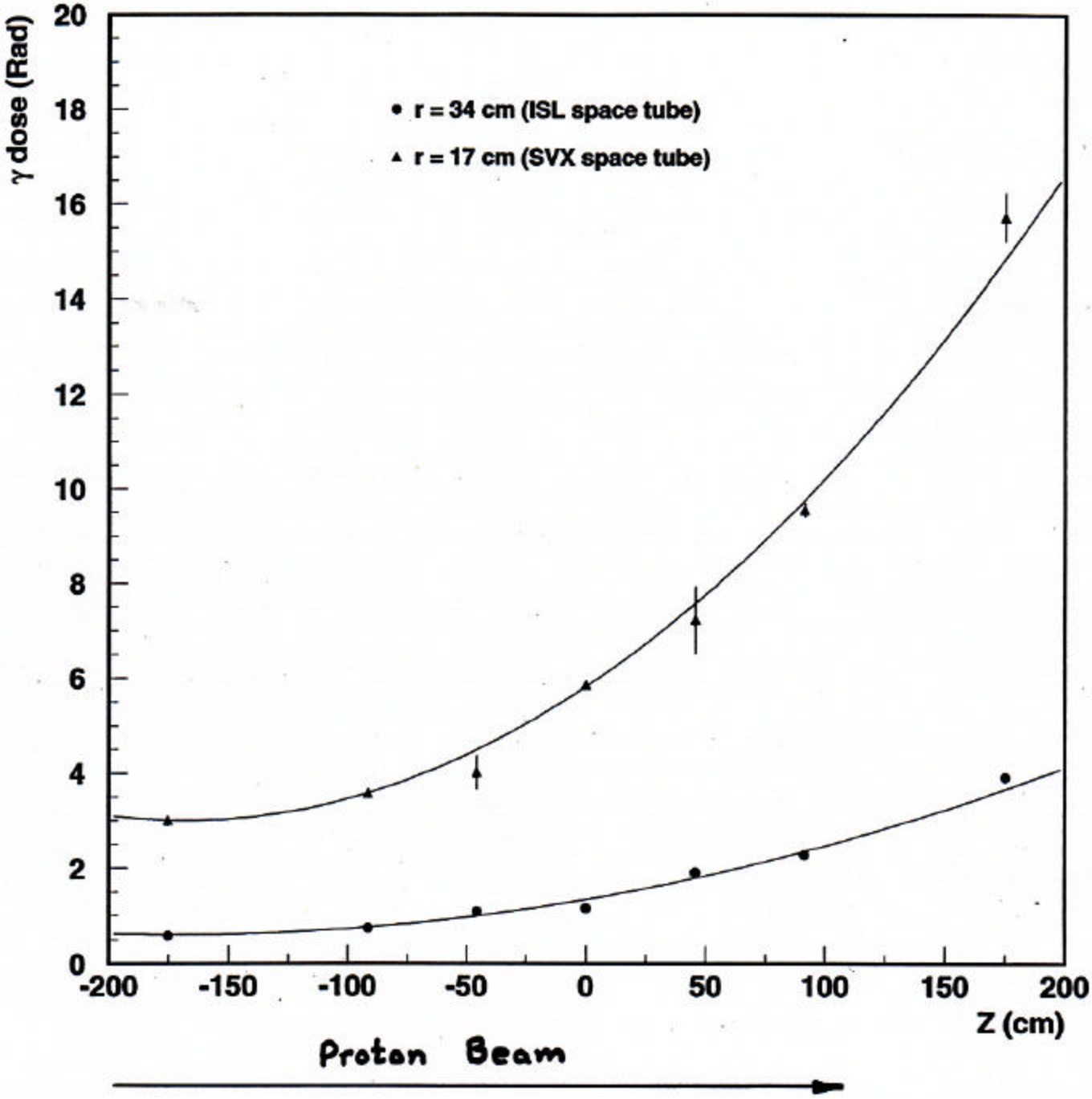
Beam Loss Monitors (BLM):

	Feb-May		May-Oct		
	Inner	Outer	Inner	Outer	
East	241	224	286	305	units = Rad
West	7.0	6.1	85.9	14.0	units = Rad

+ Feb.-May exposure loss dominated
+ May-Oct. exposure collision dominated
- BLMs insensitive to collisions

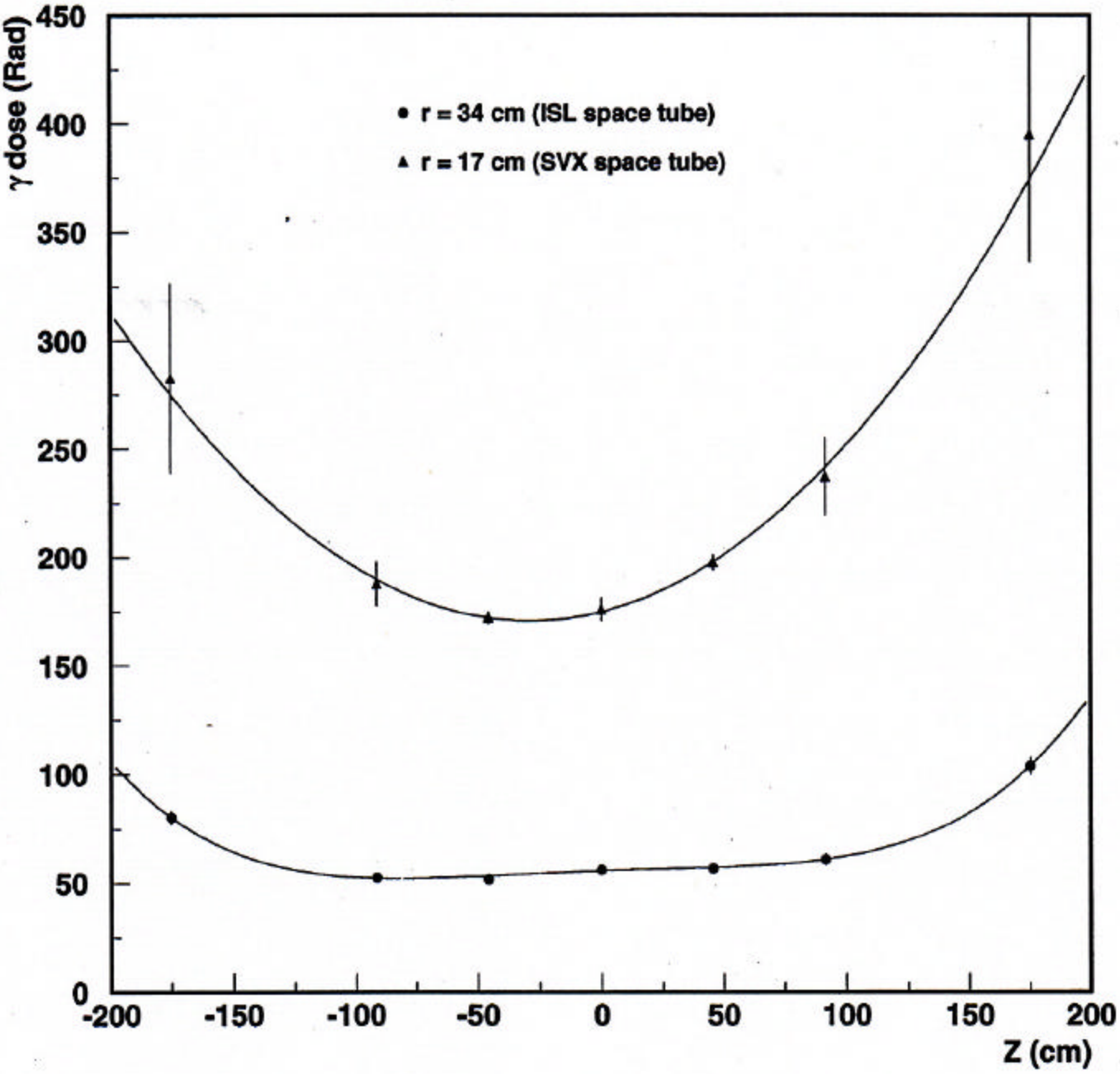
2001/09/26 10.42

Feb. – May Data



2001/10/25 20.35

May - Oct. Data



Protons Anti protons

Separating Collisions and Losses

Motivation:

- Dose different for collisions/losses
- Collisions should dominate losses even more in the future.

$\Rightarrow$ Better predictions of radiation field.

Method: Simple model:

$$D_1 = L_1 d_\ell + C_1 d_c$$
$$D_2 = L_2 d_\ell + C_2 d_c$$

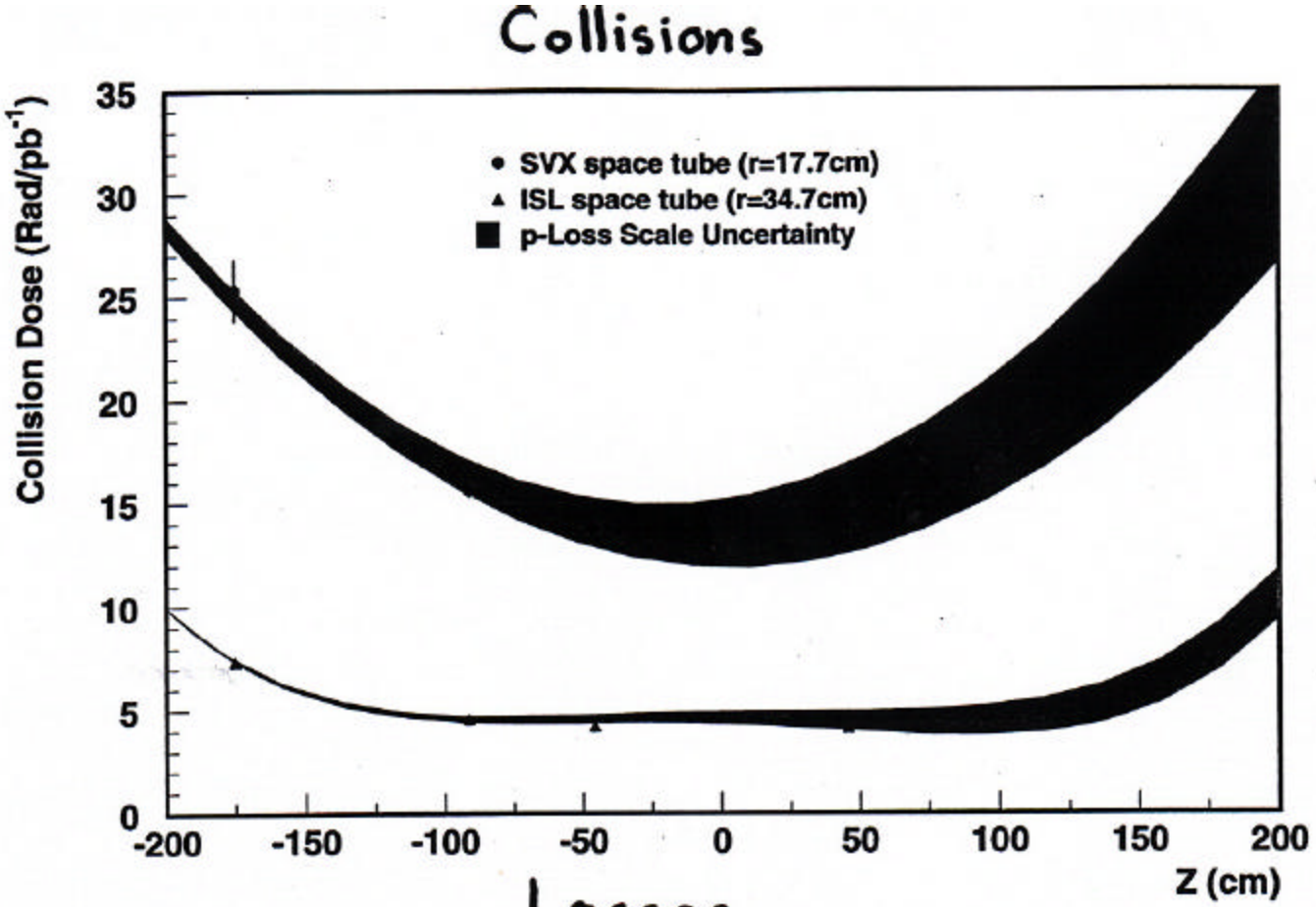
L_i - measured losses

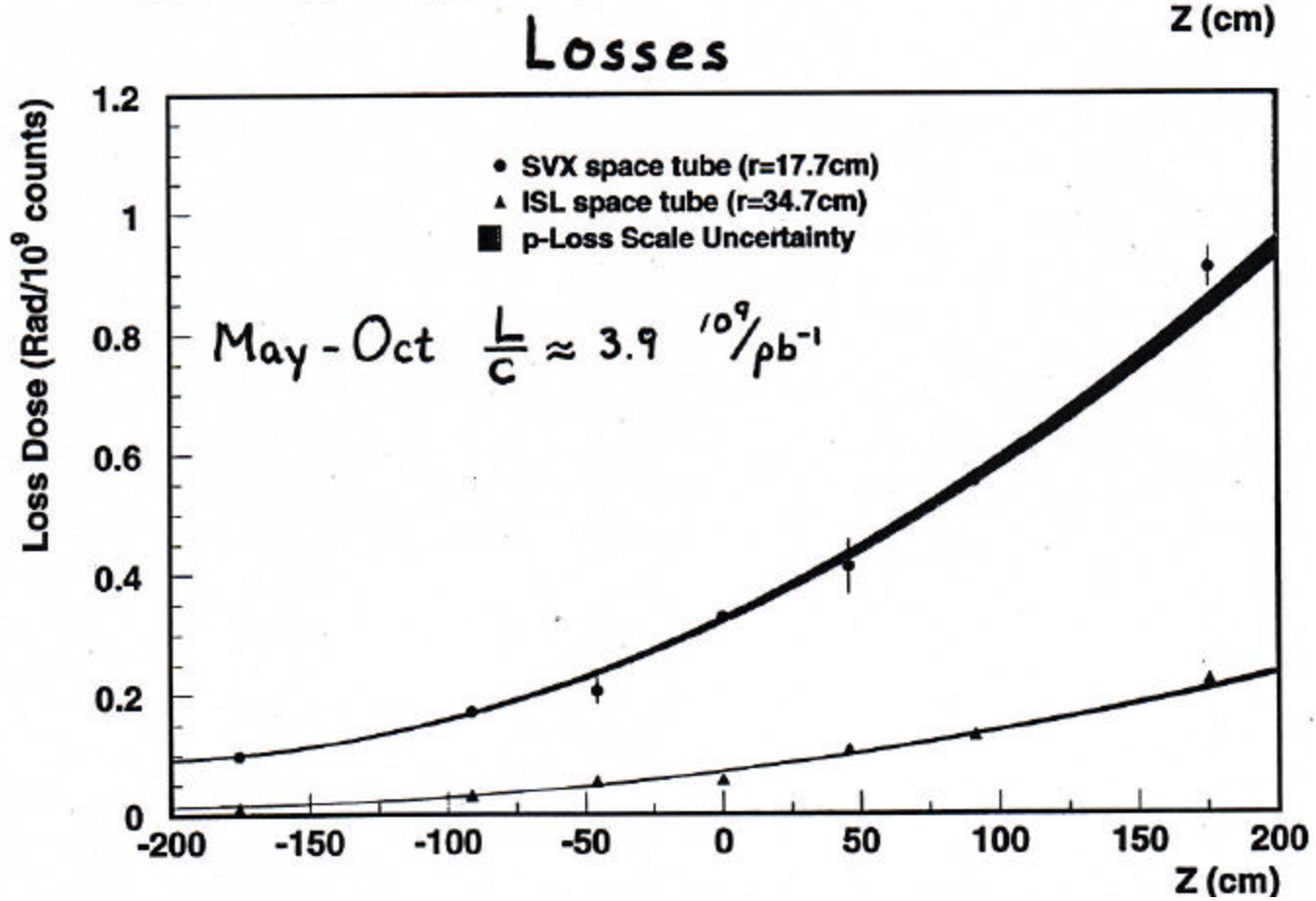
C_i - measured collisions (luminosity)

d_ℓ - dose/unit losses

d_c - dose/unit luminosity

Solve for d_ℓ and d_c.


Collisions
Collision Dose (Rad/pb^{-1})
SVX space tube (r=17.7cm)
ISL space tube (r=34.7cm)
p-Loss Scale Uncertainty
Z (cm)


Losses
Loss Dose (Rad/10^9 counts)
SVX space tube (r=17.7cm)
ISL space tube (r=34.7cm)
p-Loss Scale Uncertainty
May - Oct $\frac{L}{c} \approx 3.9$ $10^9/pb^{-1}$
Z (cm)

Modelling:

Use previous experience to build a simple model of the radiation field. *

Assumptions:

- Radiation has cylindrical symmetry about the beam.
- Field follows a power law in $1/r$.

Fit the data to the following form:

$$D = A * \left\{ (x-x_0)^2 + (y-y_0)^2 \right\}^{-\alpha/2}$$

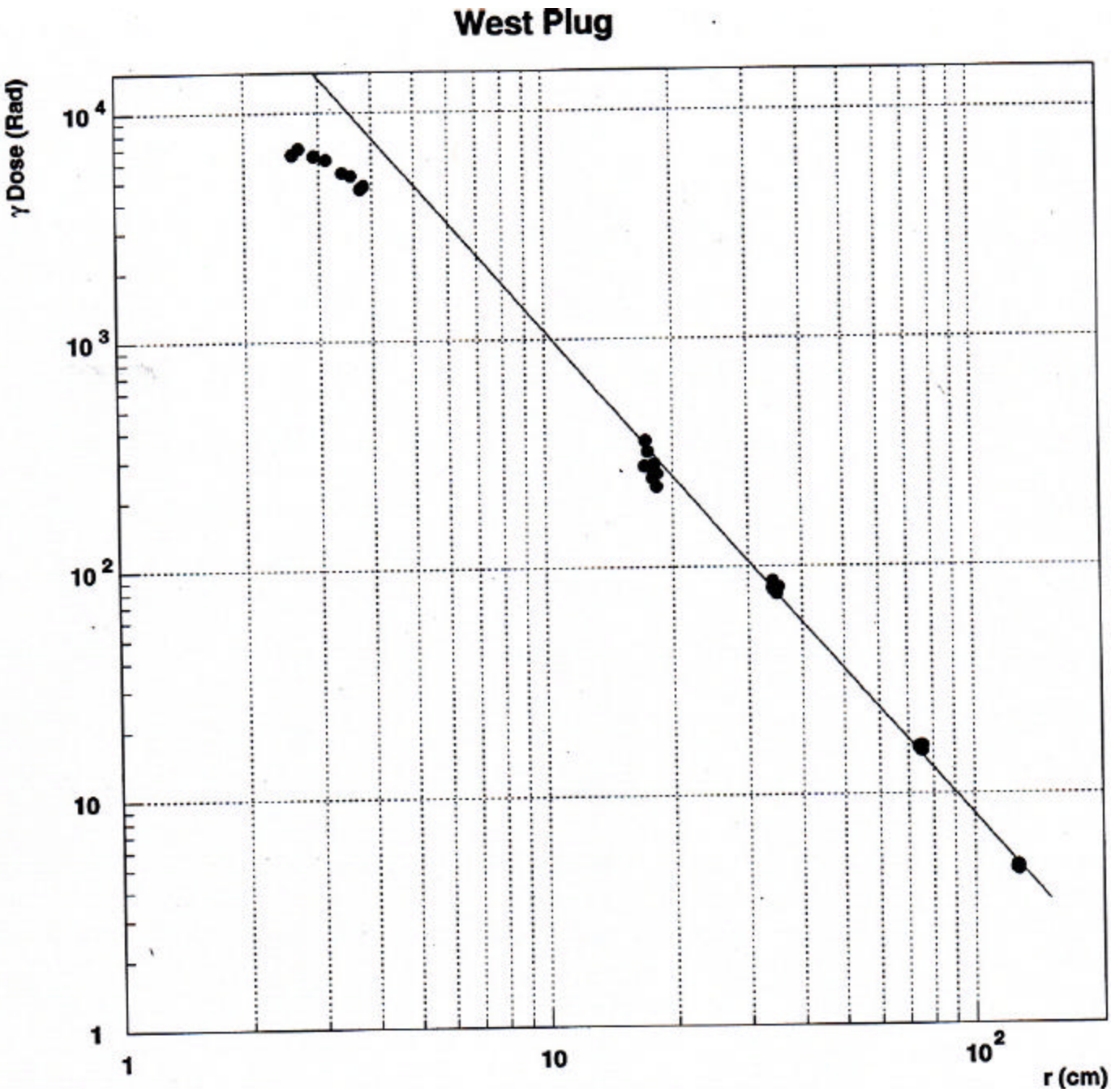
$D(x,y)$	Radiation dose
A	Absolute normalization
(x_0, y_0)	Beam position offset relative to TLD locations.
α	Power law exponent.

Note: *Run I radiation damage profile* $\alpha = 1.6 - 1.7$

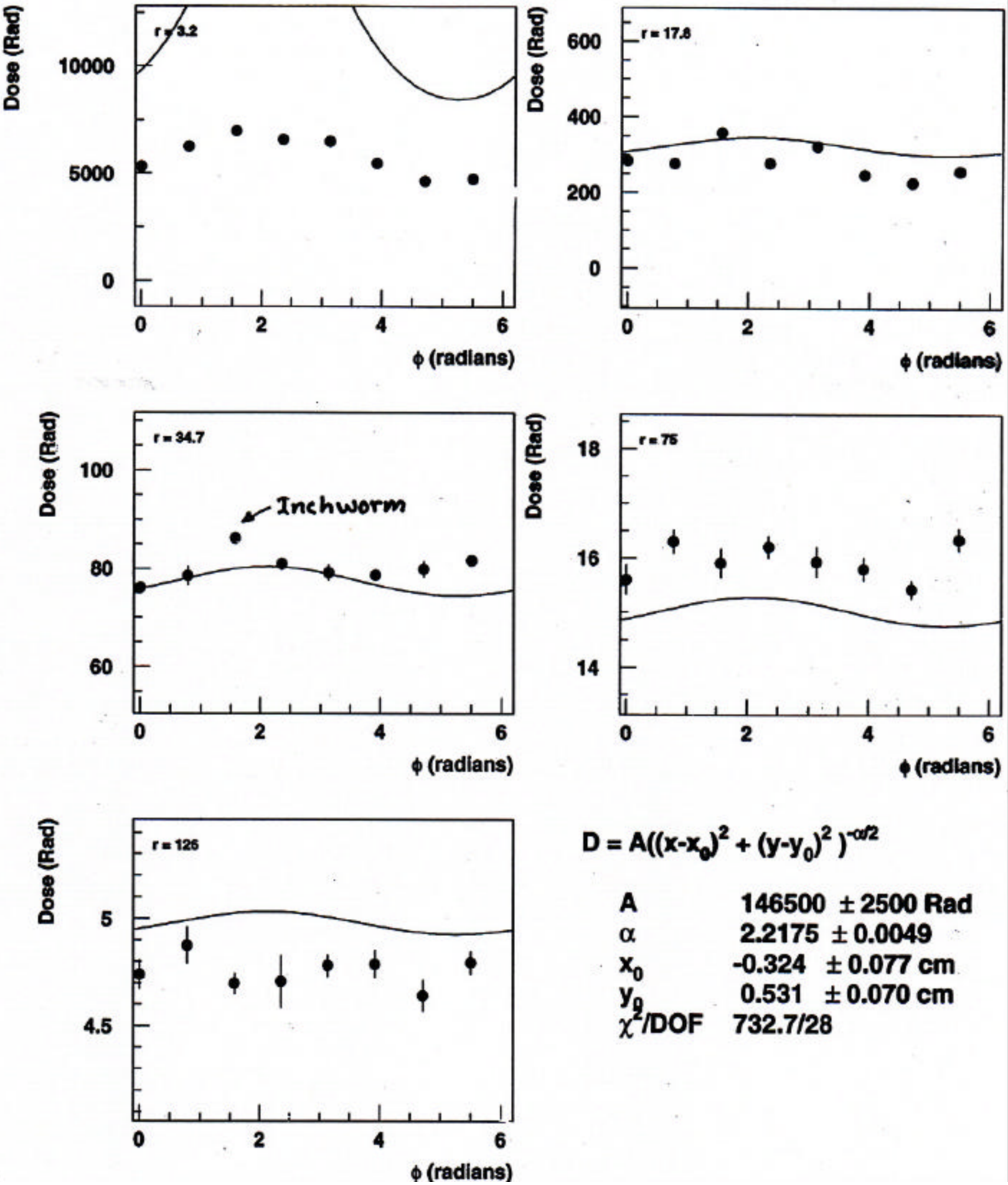
Commissioning run dosimetry $\alpha = 1.2$

* D. Amidei, et al., NIM A320 (1994) 73.

CDF note: 5723

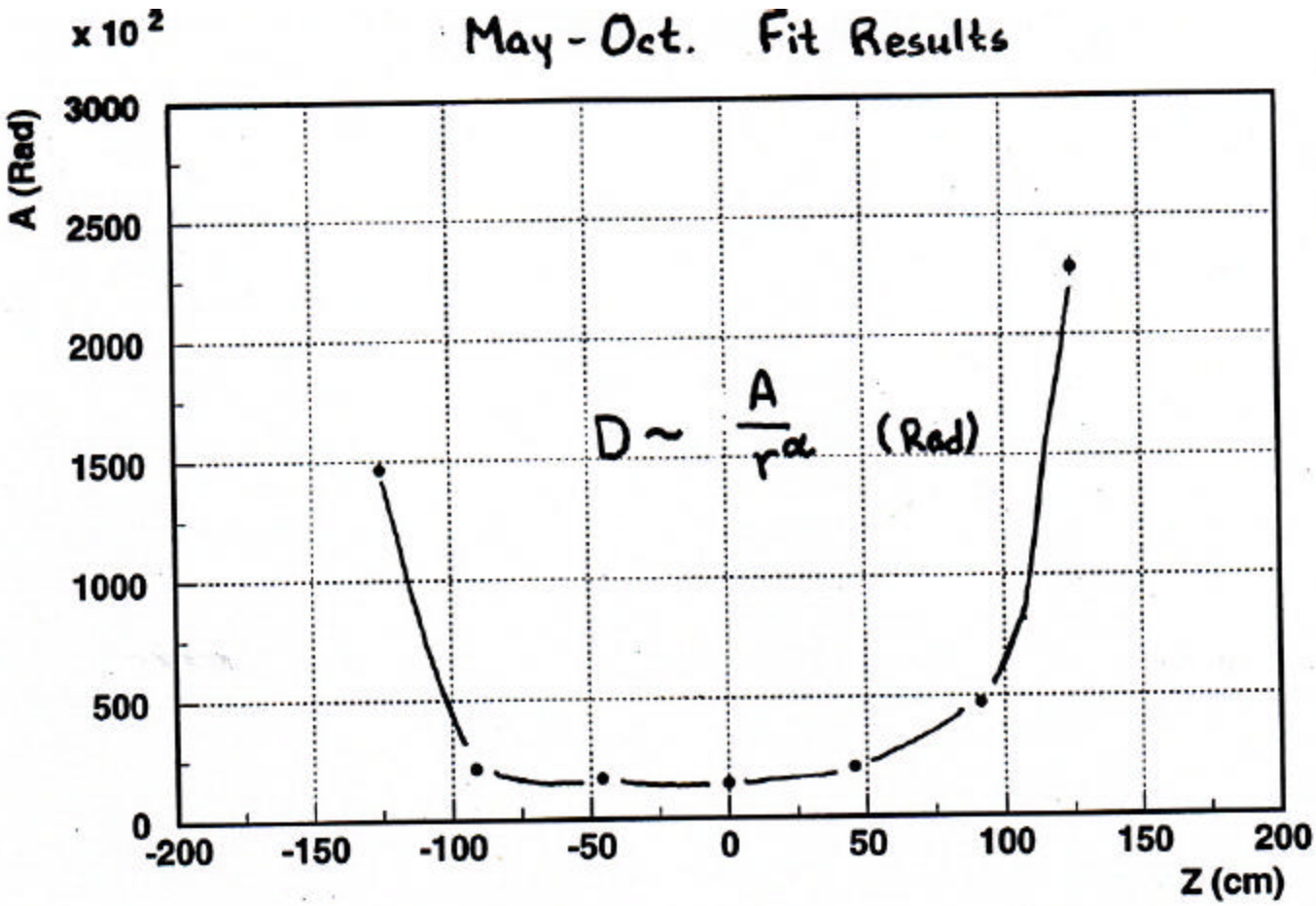

West Plug
γ Dose (Rad)
10 4
10 3
10 2
10
1
1
10
10 2
r (cm)

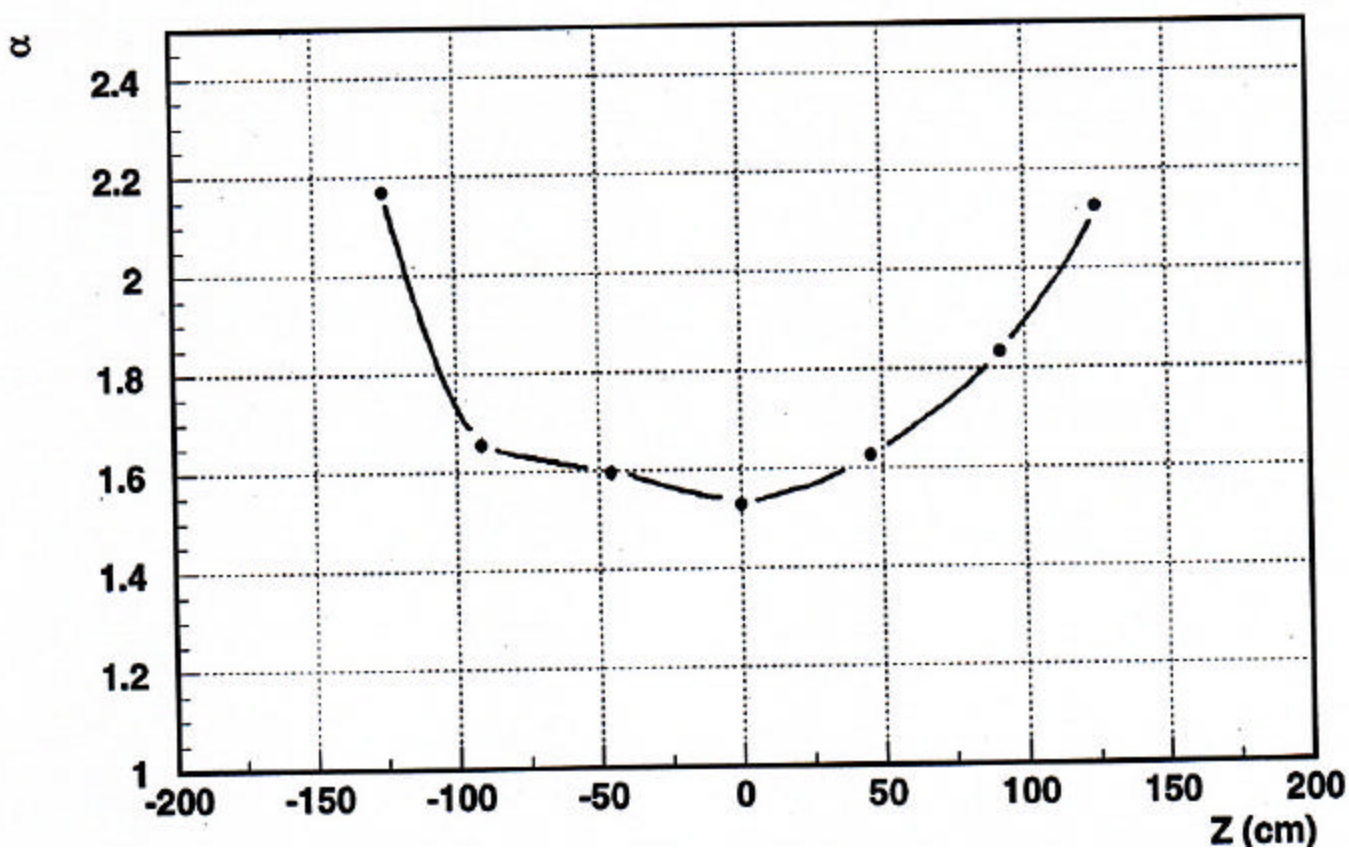
West Plug



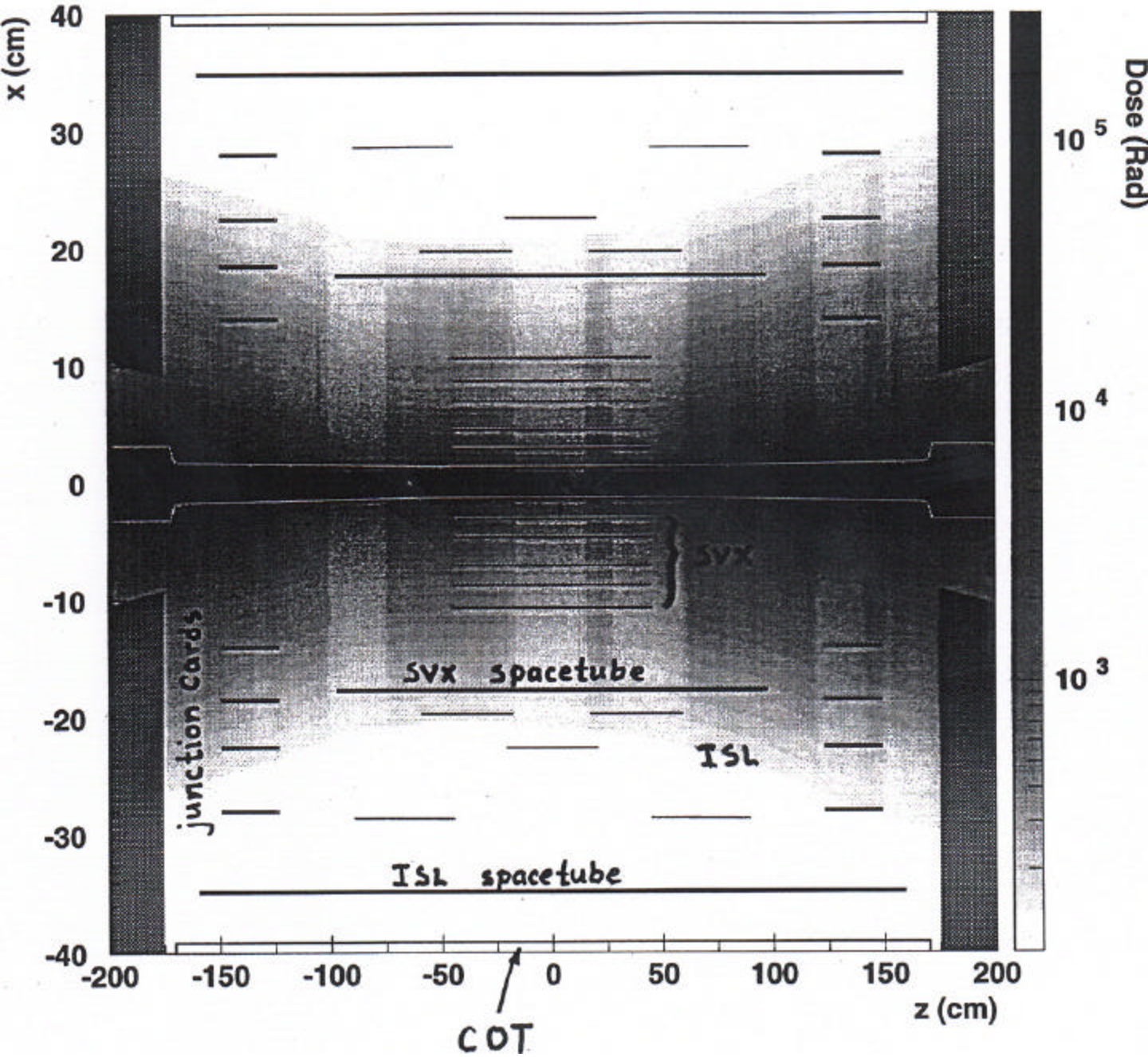
$$D = A((x-x_0)^2 + (y-y_0)^2)^{-\alpha/2}$$

A	146500 ± 2500 Rad
α	2.2175 ± 0.0049
x_0	-0.324 ± 0.077 cm
y_0	0.531 ± 0.070 cm
χ^2/DOF	732.7/28


x 10 2
May - Oct. Fit Results
A (Rad)
3000
2500
2000
1500
1000
500
0
-200
-150
-100
-50
0
50
100
150
200
Z (cm)
D ~ A / r^α (Rad)


α
2.4
2.2
2
1.8
1.6
1.4
1.2
1
-200
-150
-100
-50
0
50
100
150
200
Z (cm)

Ionizing Radiation Map.



Summary:

- All TLD data from 2 exposures in hand.
- Initial analysis of γ dosimetry.
  - + Feb – May loss dominated
  - + May – Oct. collision dominated
  - – BLMs insensitive to collisions
- Preliminary results
  - + Separate contributions from losses and collisions

Using a power law in $1/r$ for radial dependence

$$D \approx \frac{A}{r^{\alpha}}$$

  - + Exponent behavior $1.5 < \alpha < 2.1$ (observed z dependence for α)
  - + Preliminary dose @ LD ($r = 3$ cm) ~ 3 kRad