Summer Internship report:

Aging Studies On Layer 00

CDF – Fermilab Group

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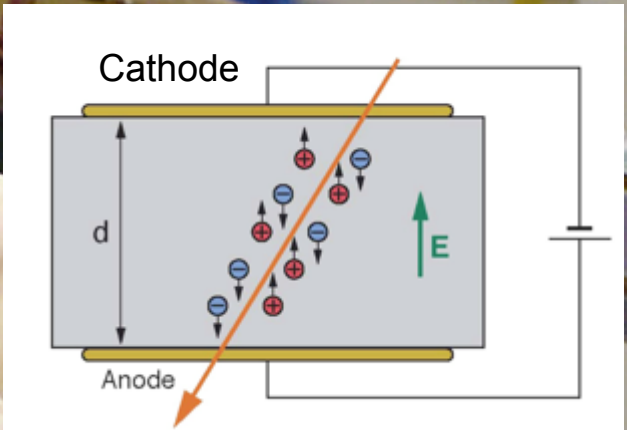
FNAL

Overview

- Silicon detectors
- Radiation damages – Bias Scan
- Layer 00
- Importance of Radiation Dose
- Depletion voltage trend
- Corrections : Beam Position
- Results

Silicon Detectors

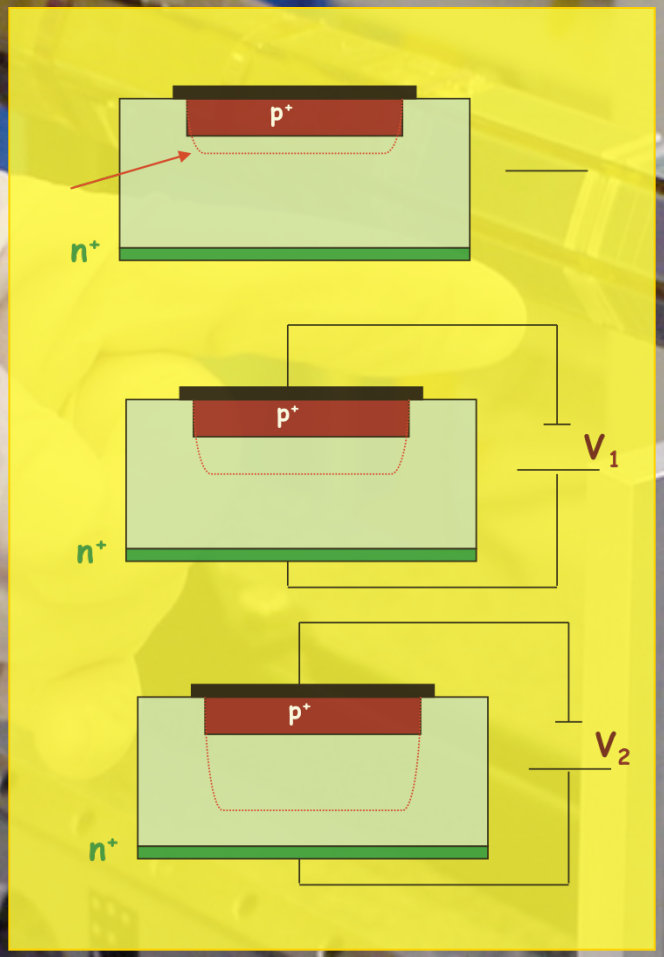


Particles traveling through a silicon sensor can produce free charges.

P-N Junction creates an electric field depleted from free charges.

Charges can be collected thanks to the electric field.

Silicon Detectors



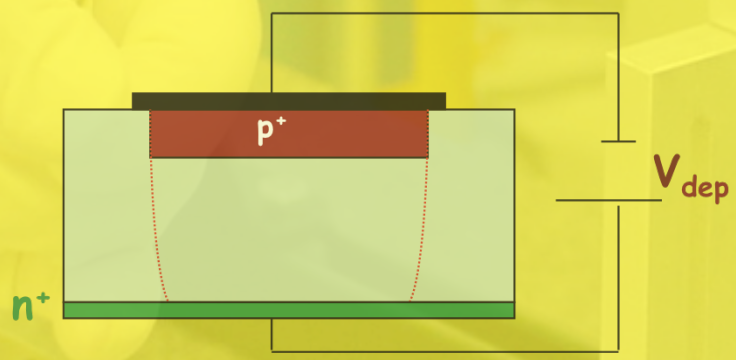
Without bias voltage only charges in dep. region are collected.

An Extenal Potential (BIAS) is applied to extend this region into the bulk.

The higher voltage is the wider electric field is.

Silicon Detectors

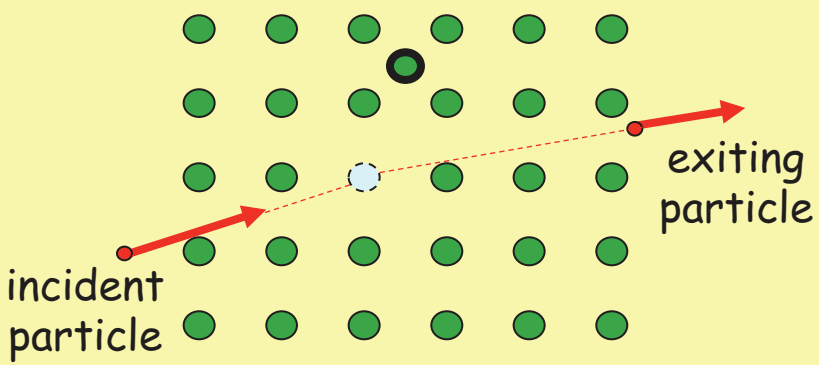
To fully deplete, apply V_{dep}



DEPLETION VOLTAGE:

The voltage required to extend the E field across the whole bulk (i.e. to collect all the charges produced)

Radiation Damages



Interstitial and vacancy defect creation.

BULK DAMAGES: Besides ionization, Hadrons can **DISPLACE** lattice atoms;

Results in new interstitial or vacancy in the doped silicon bulk

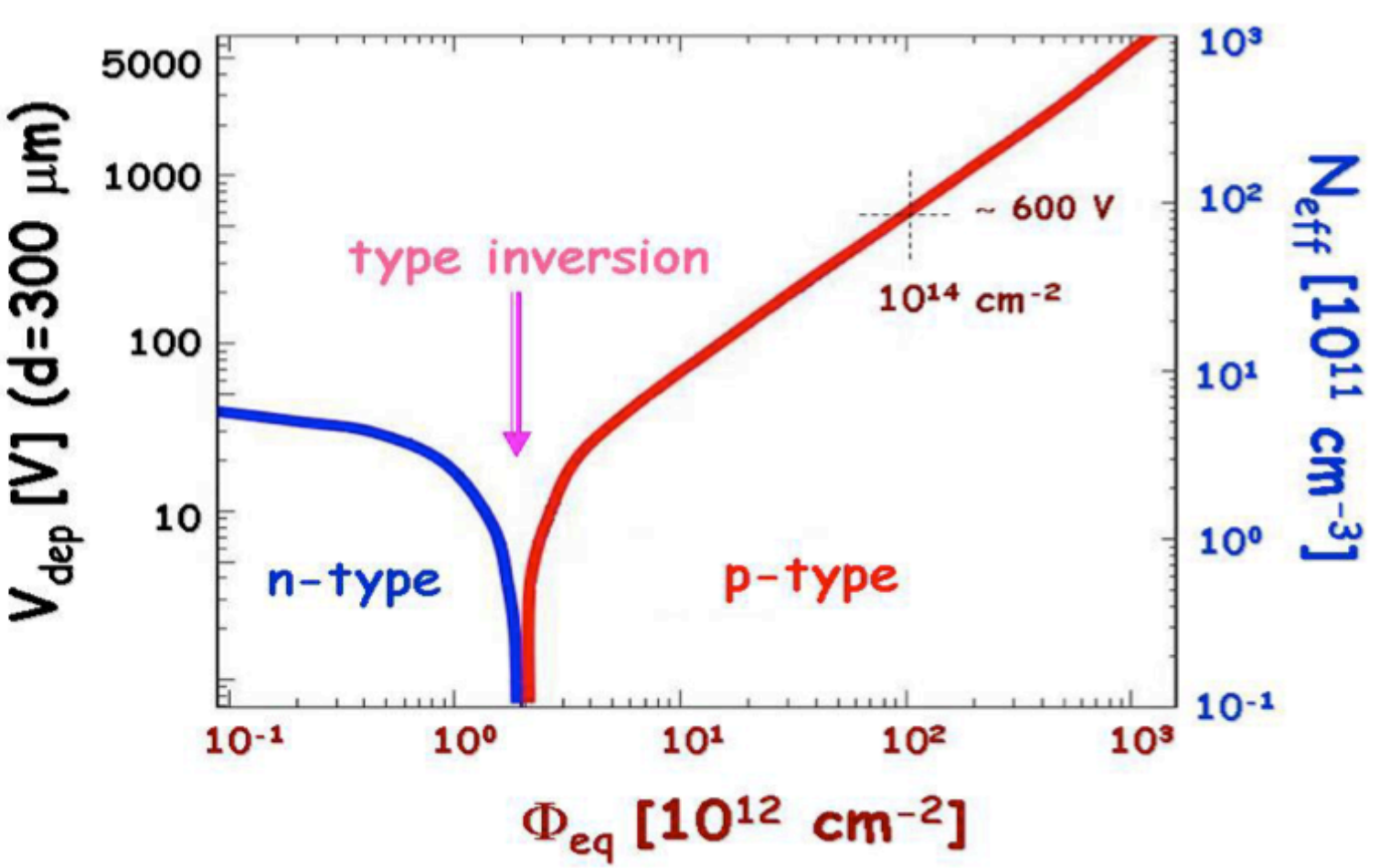
Radiation Damages

HAMBURG MODEL: complex
THE OVERALL EFFECT: changes in the depletion voltage

REMEMBER THAT: Radiation affects all devices (detectors, chips …)

*Jeffery Wyss – Exposure to radiation damage: concepts, quantities, environments - http://agenda.infn.it/conferenceTimeTable.py?confId=3245

Evolution of Dep. Volt.



Signal Bias Scan

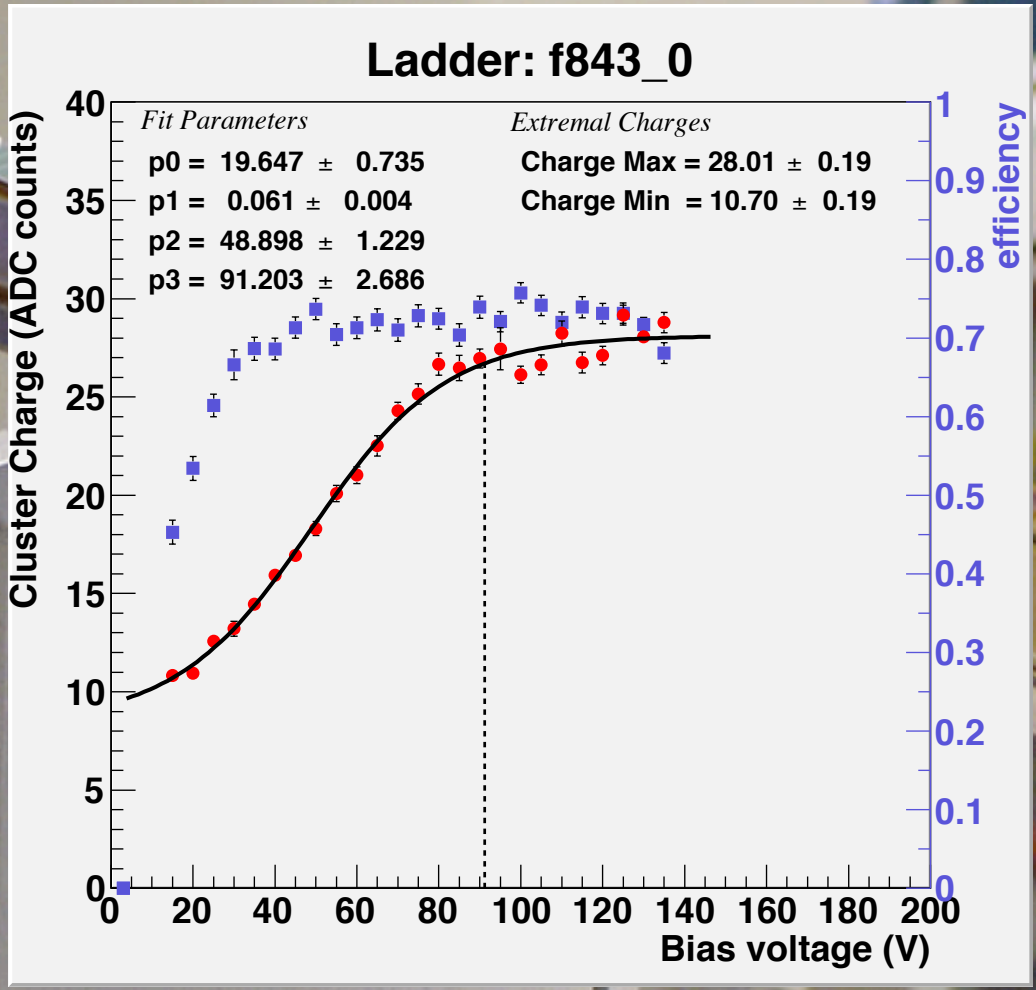
WHAT: Procedure to measure the silicon sensor depletion voltage;

WHEN: at CDF is performed about every 6 months;

HOW: measure the collected chage at different bias voltages

Signal Bias Scan

Fit => Depletion voltage: 95% of charge is collected



Radiation Dose

What is the relation between Absorbed Dose and Delivered Luminosity?

$$D(KRad) = \frac{1.5}{r^{1.5}} L(fb^{-1})$$

If |z| < 50 cm

Measured using 916 dosimeters placed in the detector

* Tesarek, R. J.; D'Auria, S.; Hocker, A.; Kordas, K.; McGimpsey, S.; Worm, S. NIM A 514 p. 188

Layer 00

We will restrict our analysis to Layer 00:

- It's the closest layer to the beampipe
- It recieves highest radiation doses
- The radiation dose received by L00 is sensitive to changes in beam position

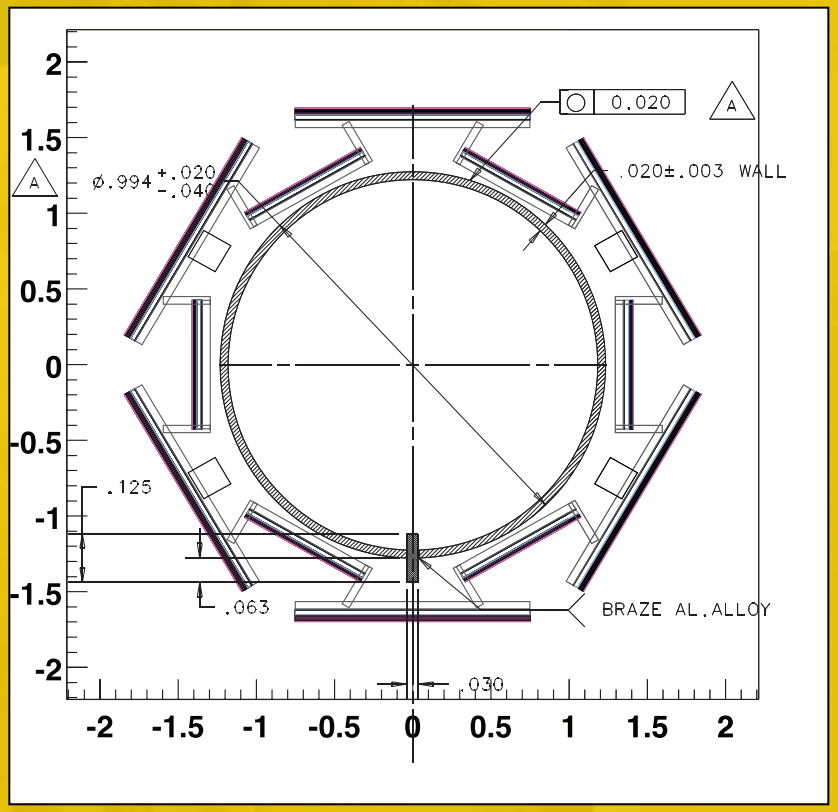
Layer 00

Y-Z PLANE

2 Barrels of three segment each
94 cm long

72 Ladders
Wides: Hamamatsu - Narrows: SGS Thompson - Narrows Oxygenated: Micron

Layer 00

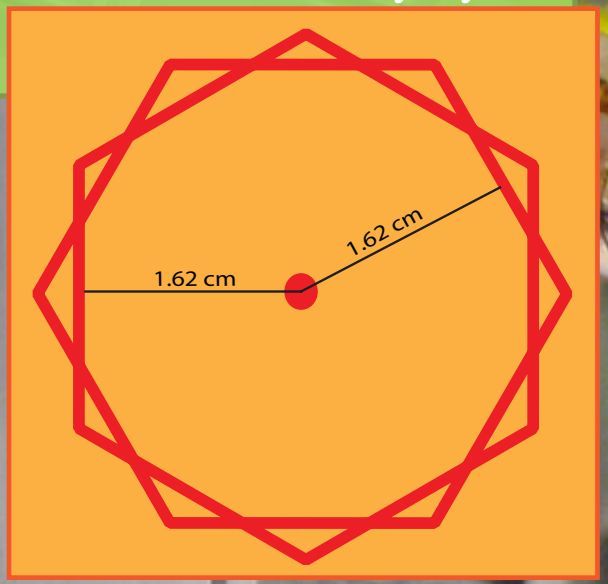


X-Y PLANE

- *6 Wedges*
- *12 Ladders*
  - *6 Wides*
  - *6 Narrows*

Approximation 0

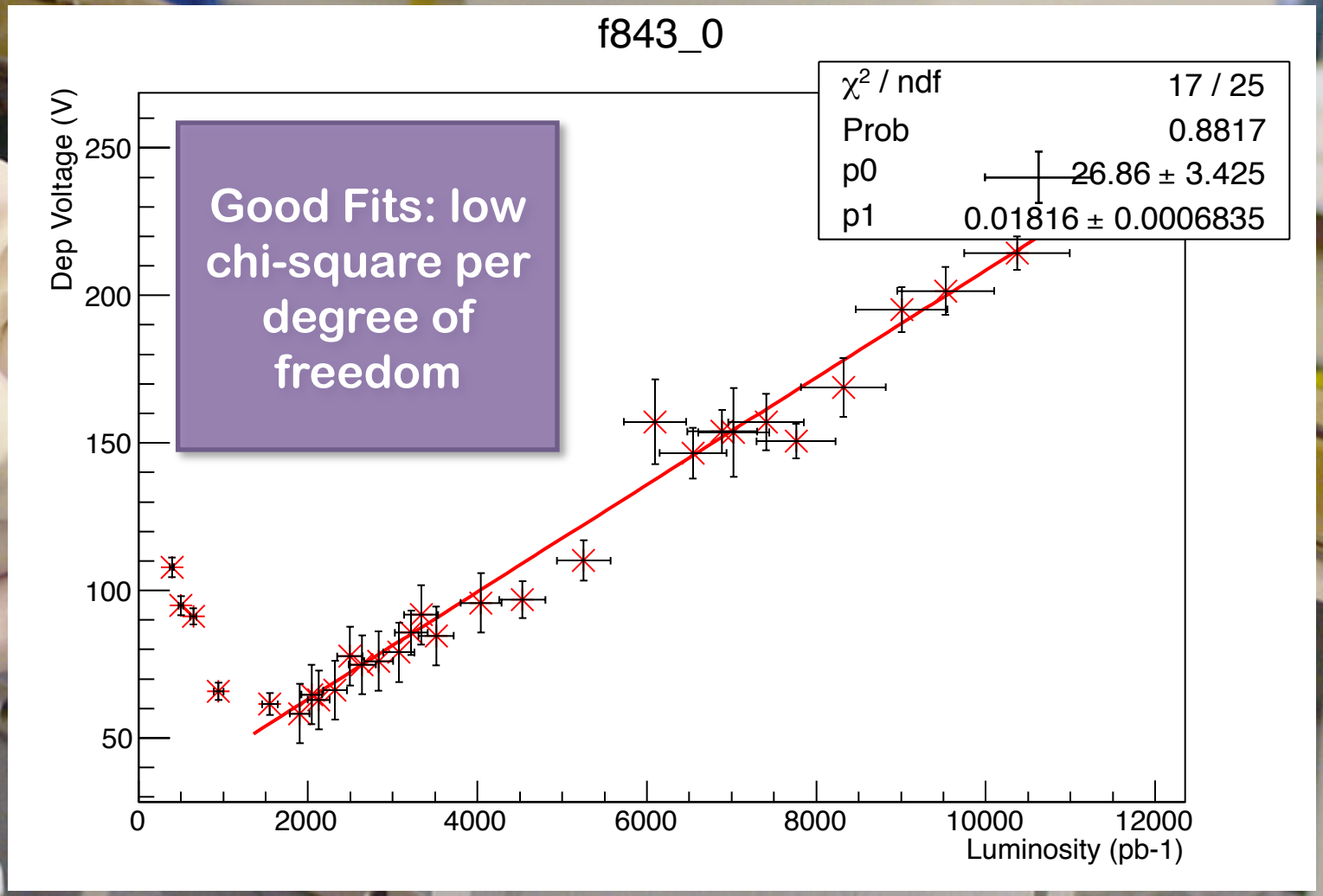
- *All the ladders are in the same position*
- *The beam is in the center of the beam-pipe*



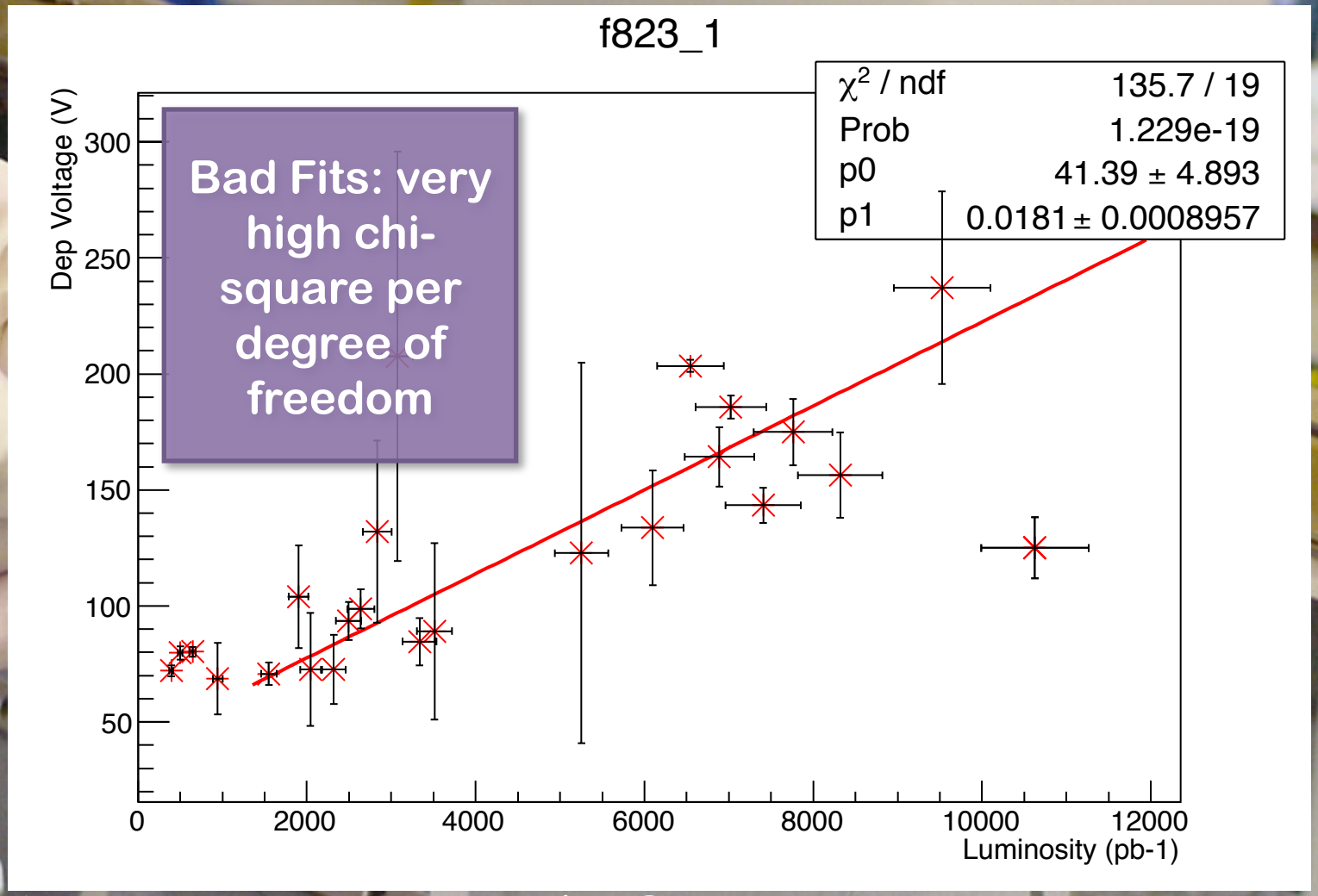
LUMINOSITY ⇔ DOSE

(i.e. no differences between a DepVolt vs Luminosity plot and a DepVoltage vs Dose)

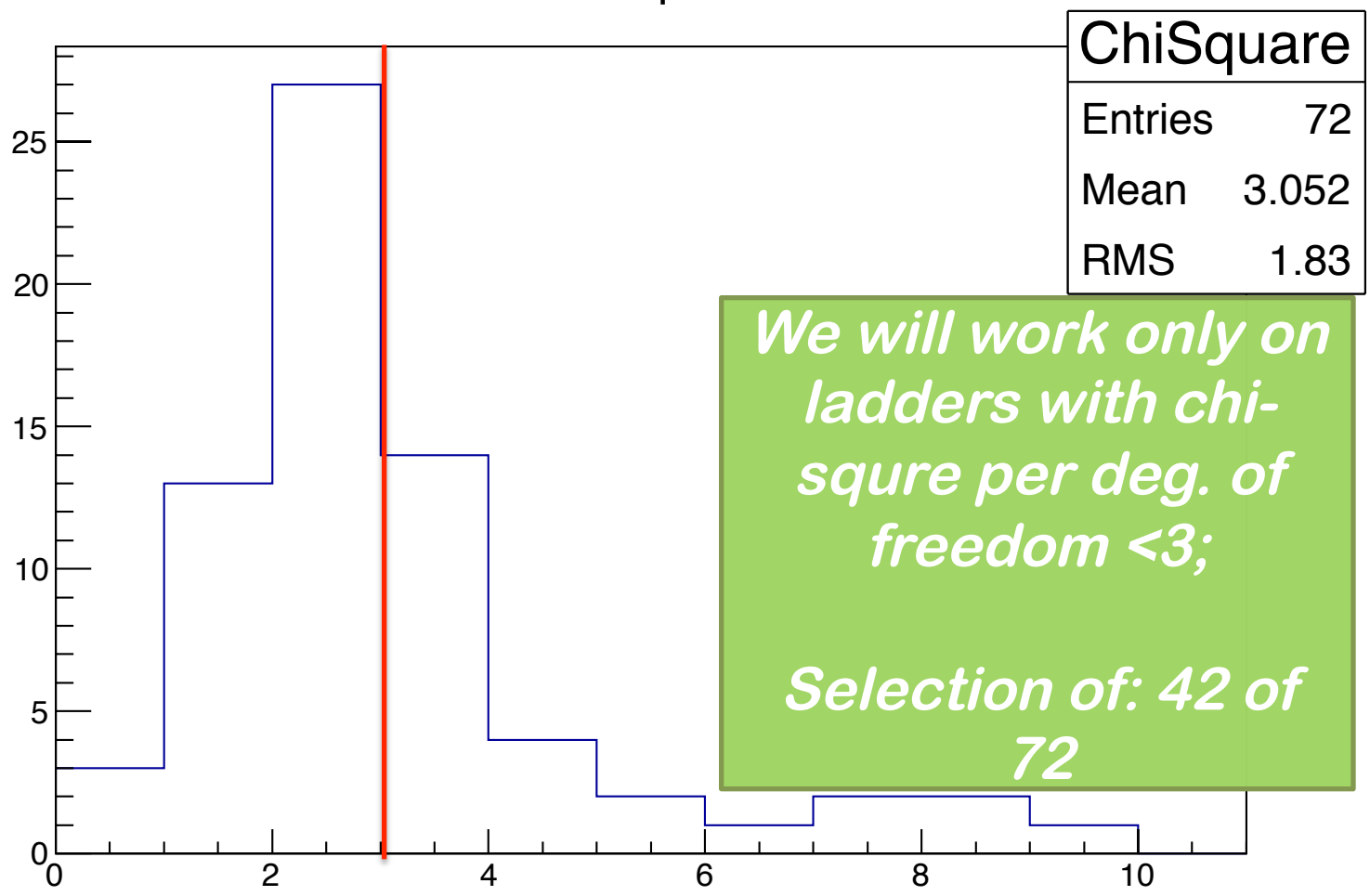
Approximation 0



Approximation 0



Radiation Dose



We will work only on ladders with chi-squre per deg. of freedom <3;

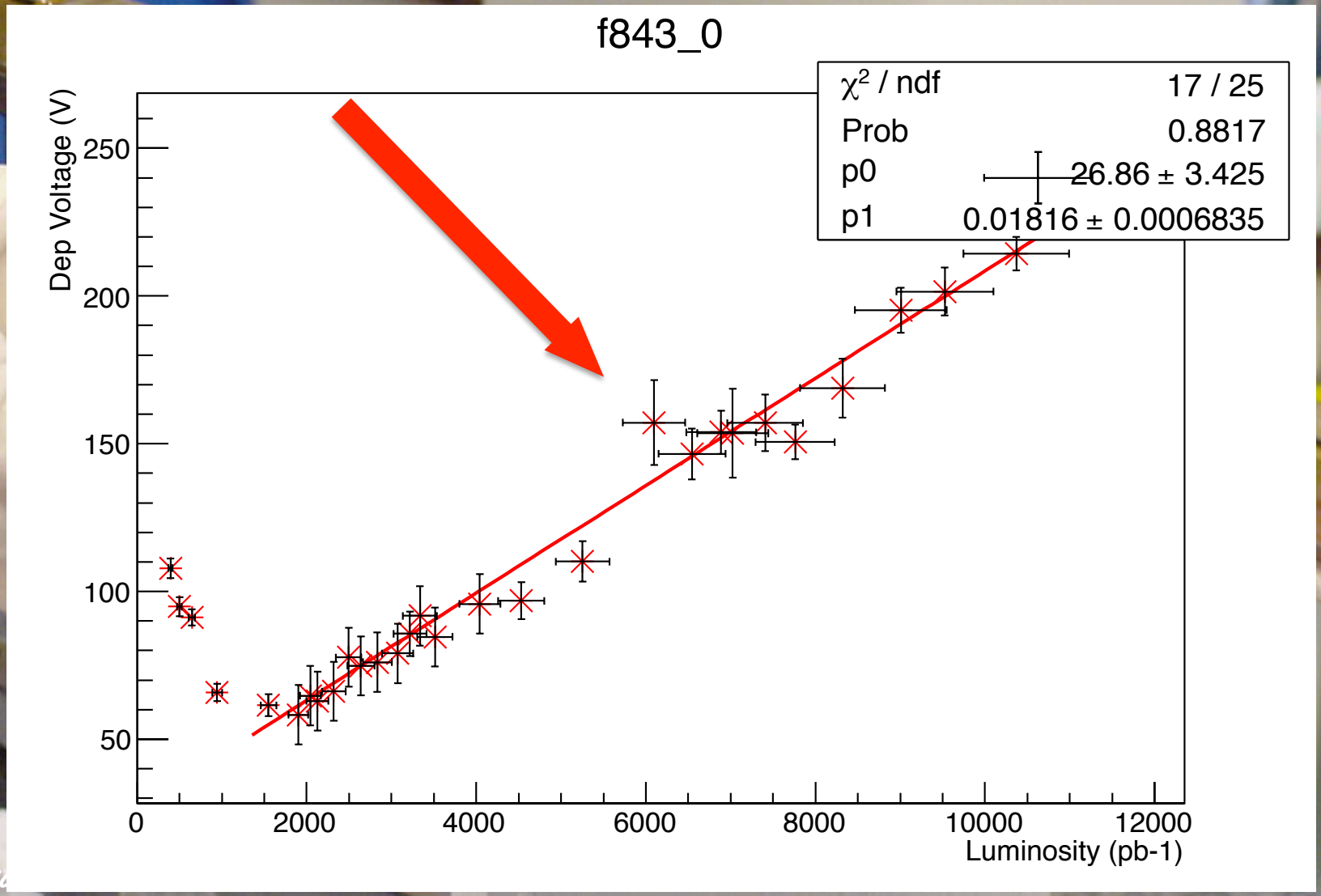
Selection of: 42 of 72

Expected Corrections

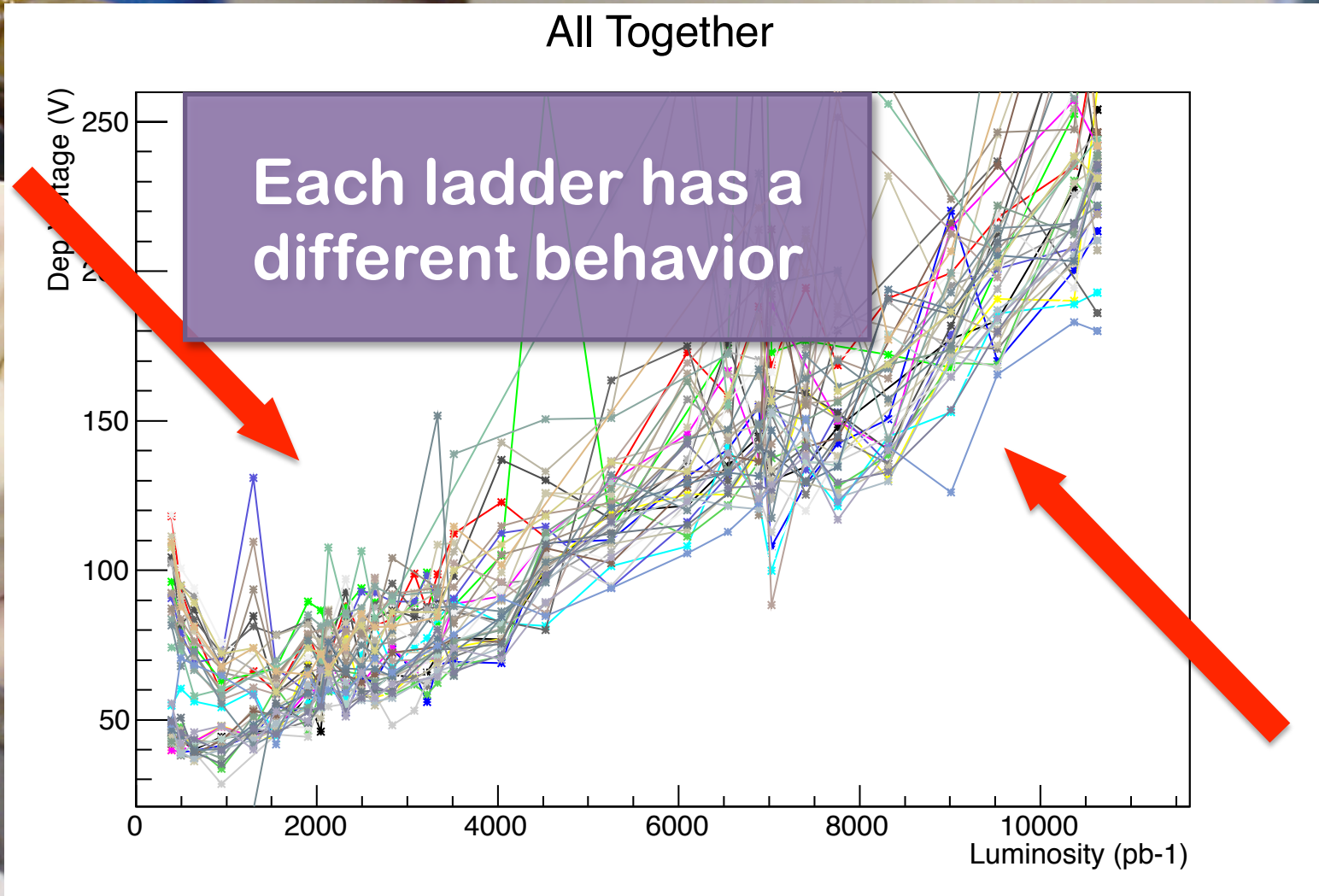
Some error bars don't cross the fitted line.

Is that systematics or is it caused by our approximation?

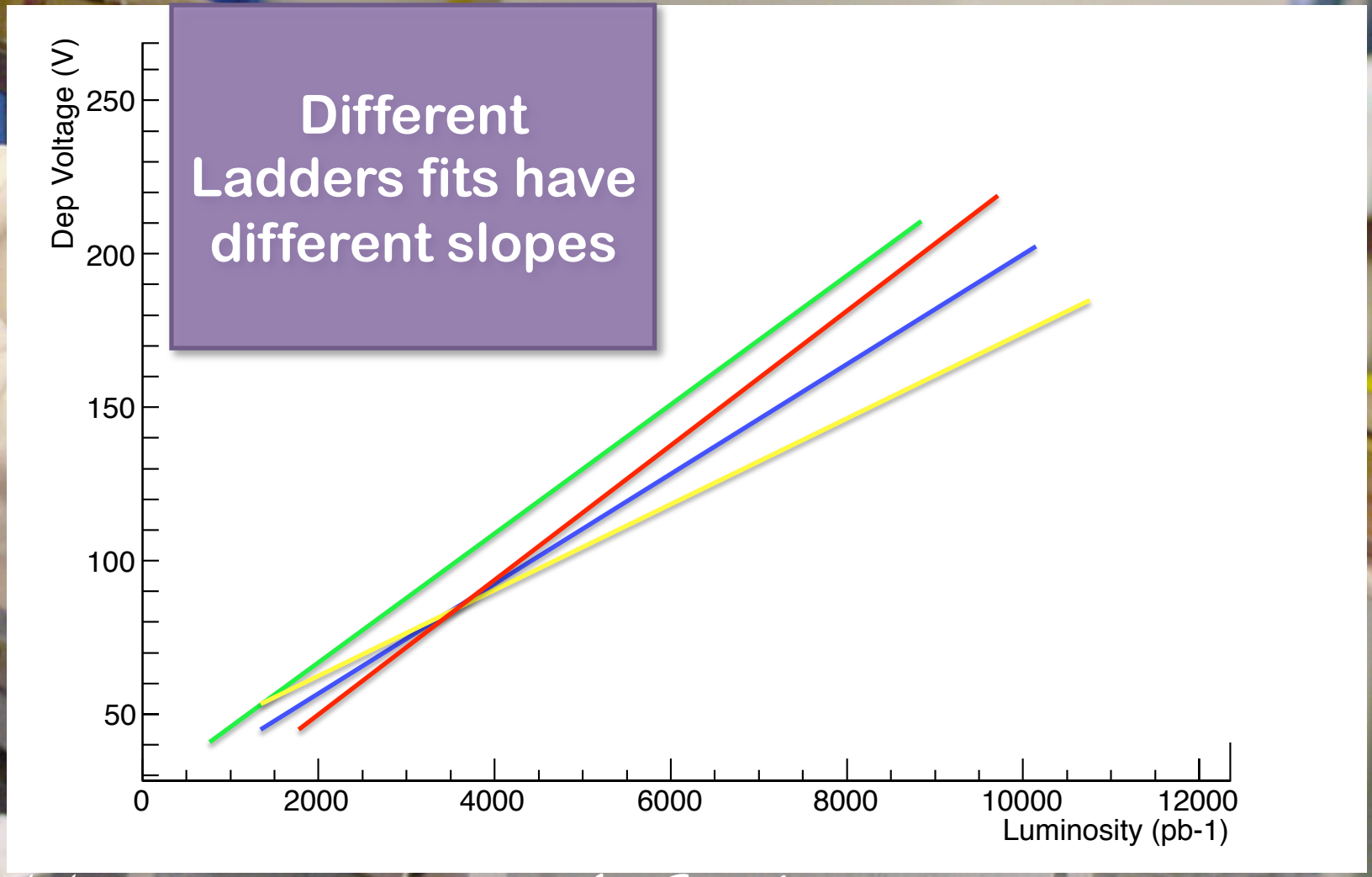
Expected Corrections



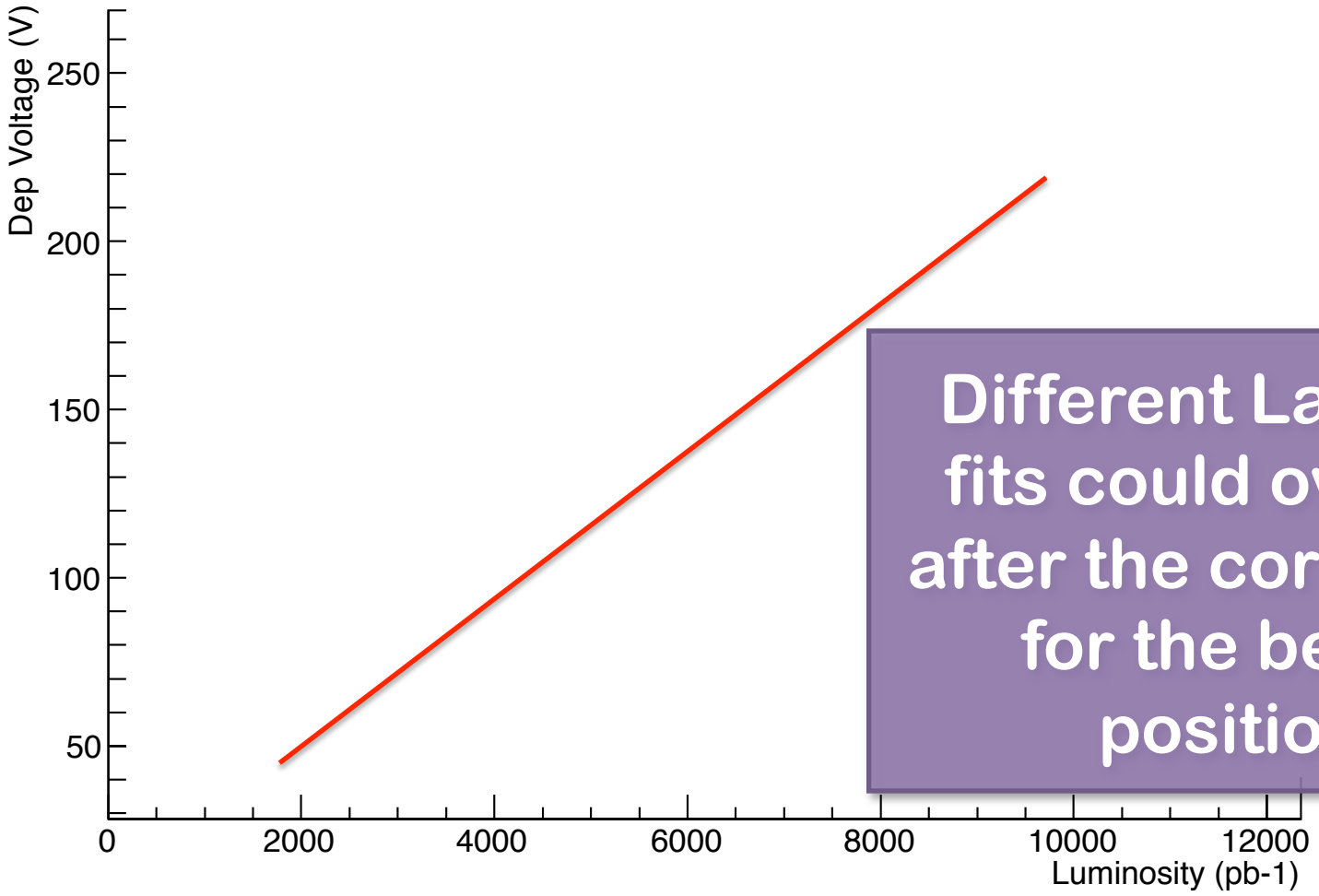
Expected Corrections



Expected Corrections

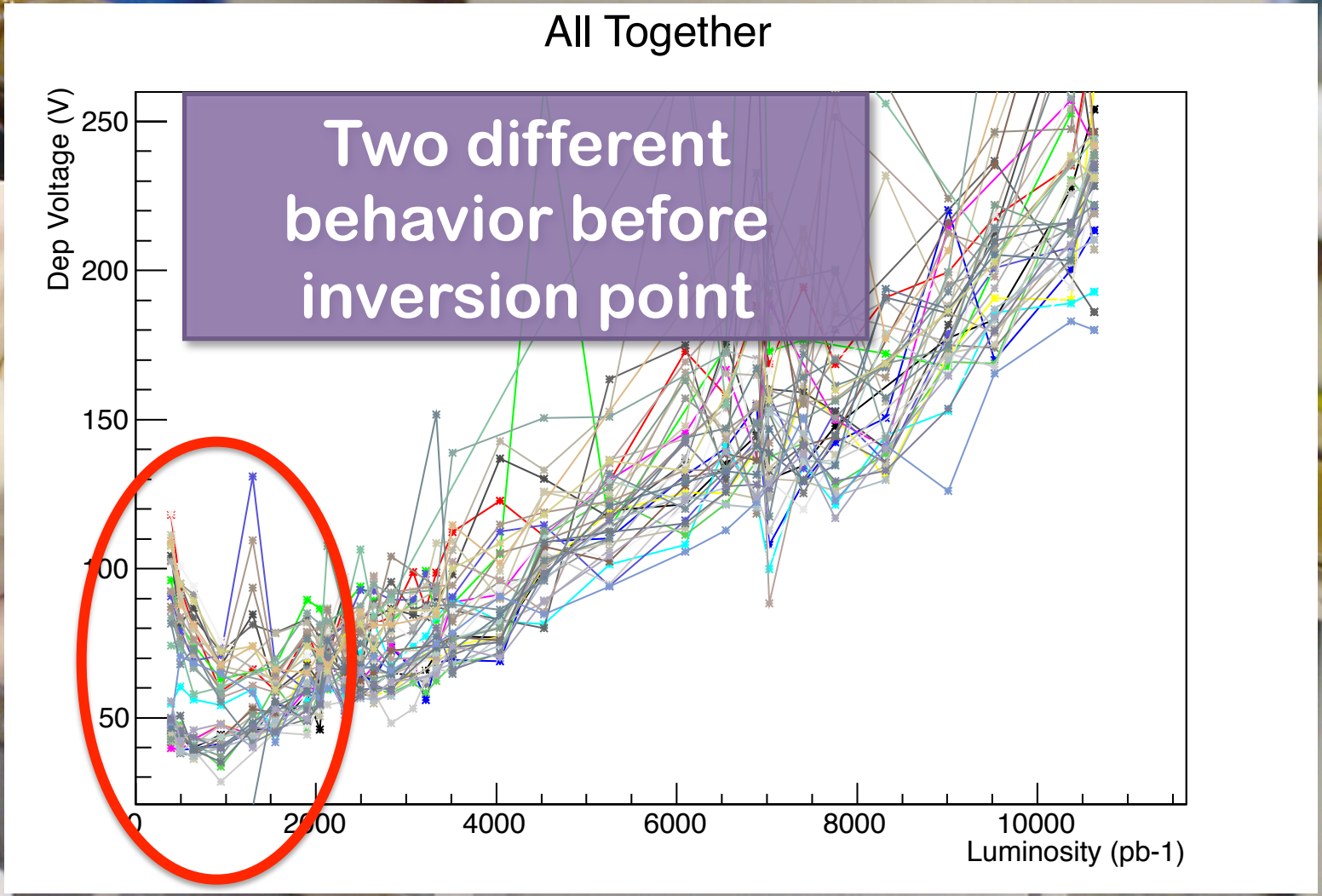


Expected Corrections



Different Ladders fits could overlap after the correction for the beam position

Expected Corrections



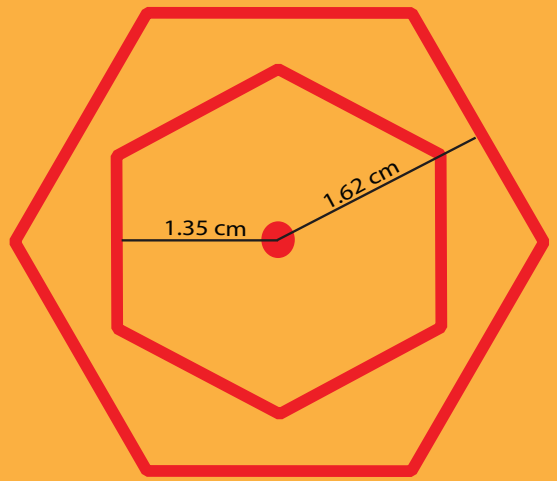
Expected Corrections

Let's check by starting to take into account some details, if we can, to improve our fits.

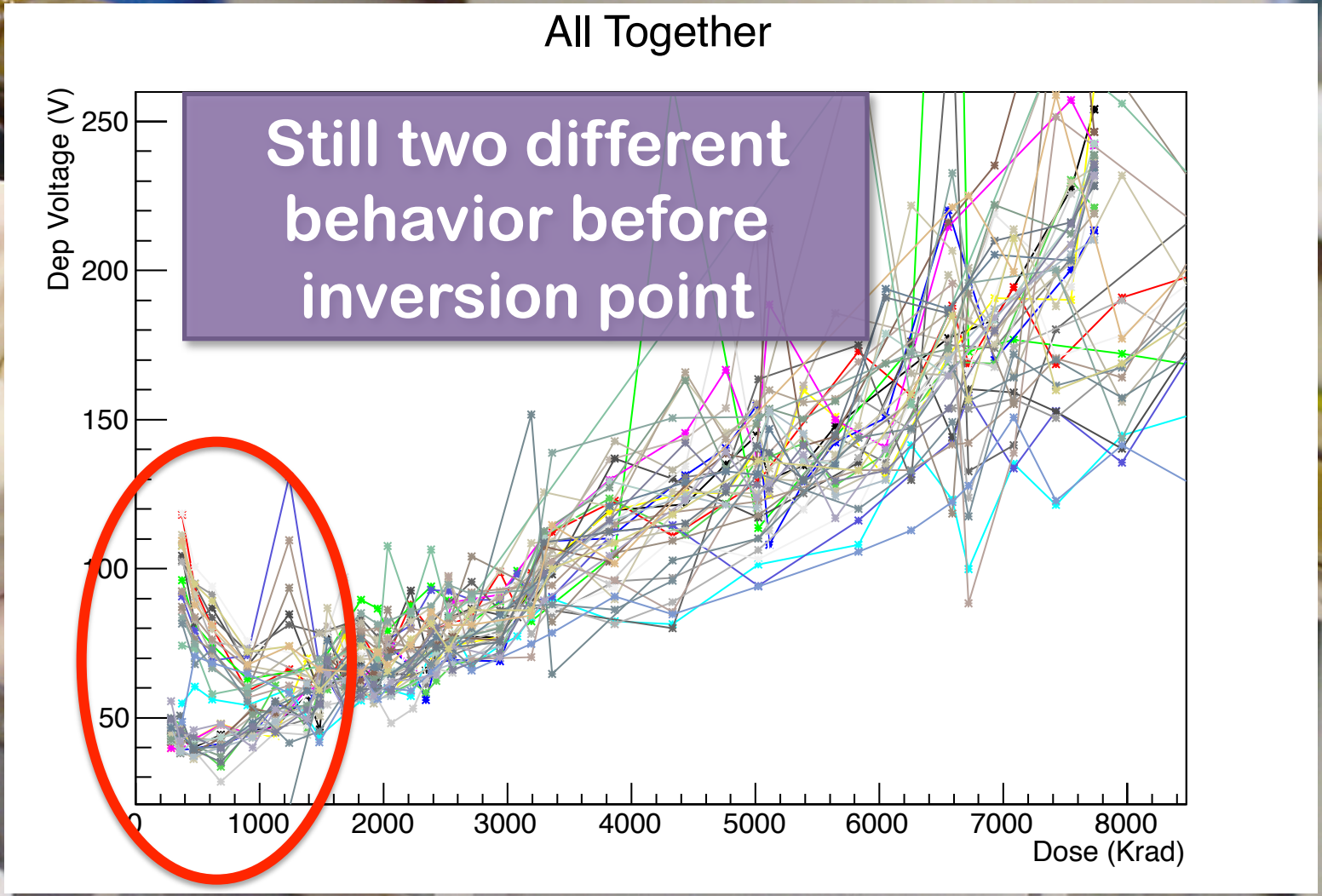
Approximation 1

- *Wide and Narrow Ladders have different radii*
- *The beam is in the center of the beam-pipe*

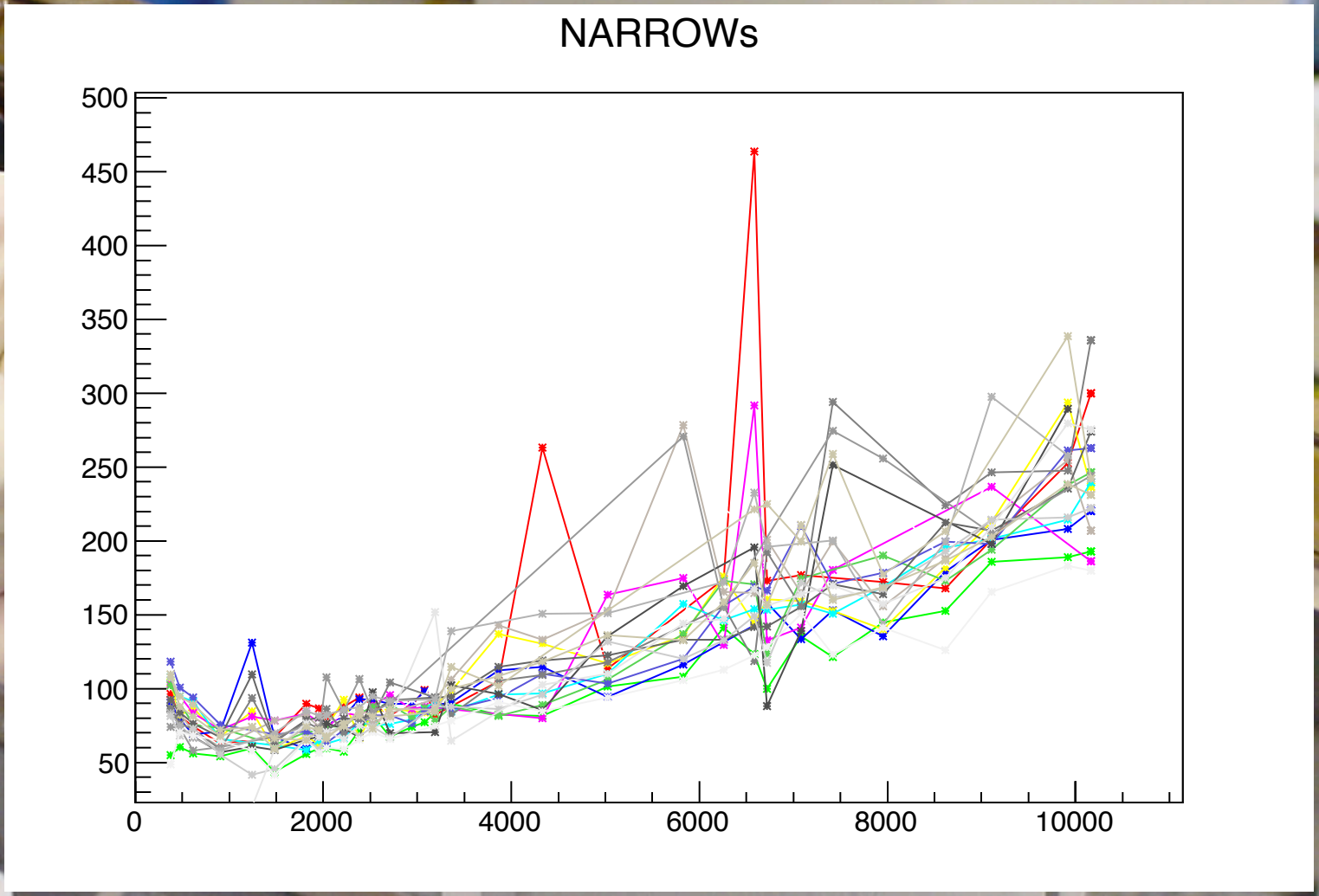
Conversion of Scan Luminosity to dose



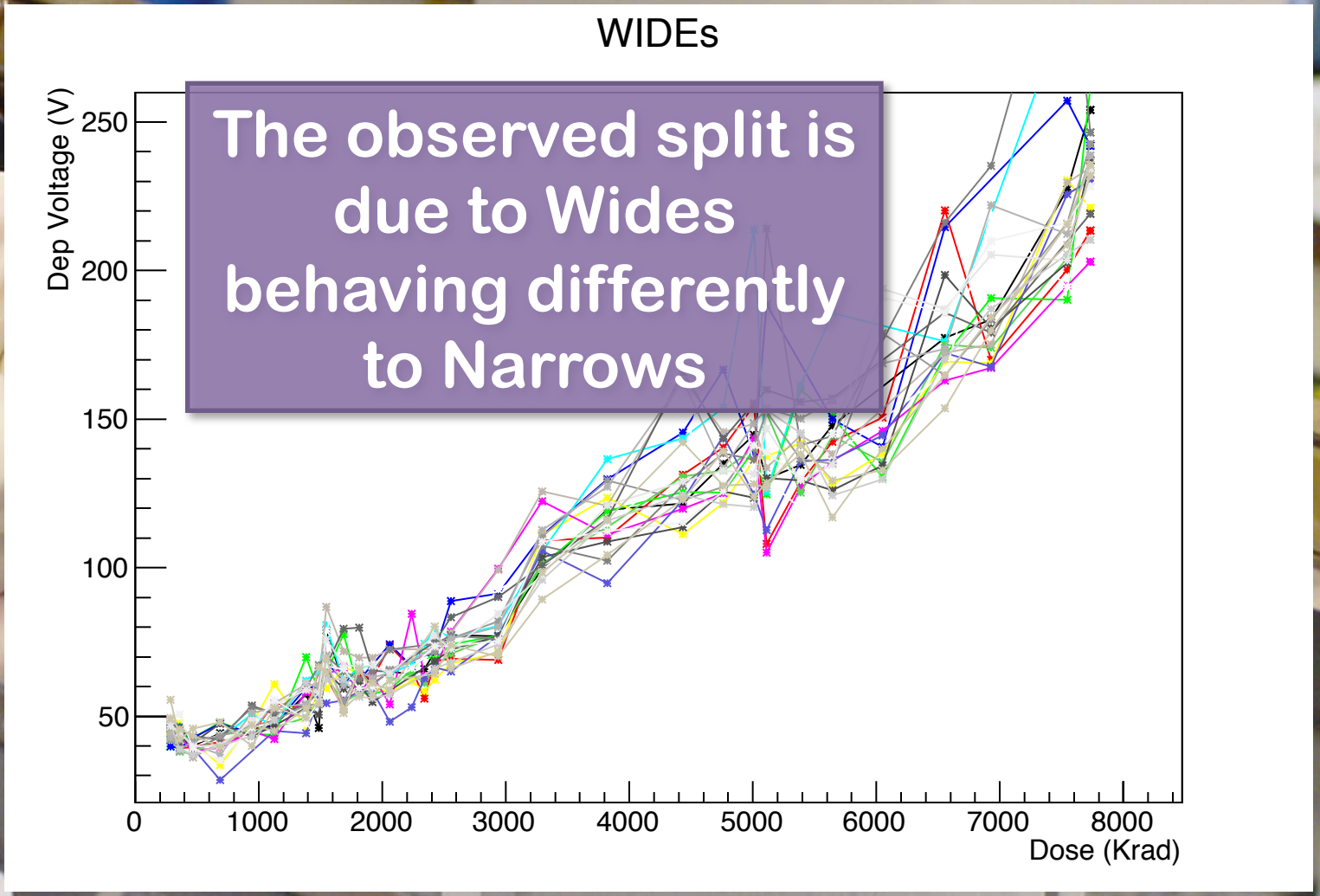
Expected Corrections



Narrow Ladders



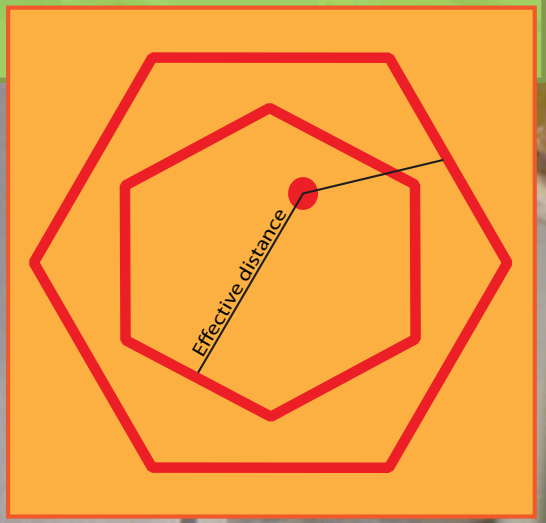
Wide Ladders



Approximation 2

- *Use the real position of the ladders*
- *Consider the real position of the beam*

Changes in the beam-ladders distance means changes in the absorbed dose

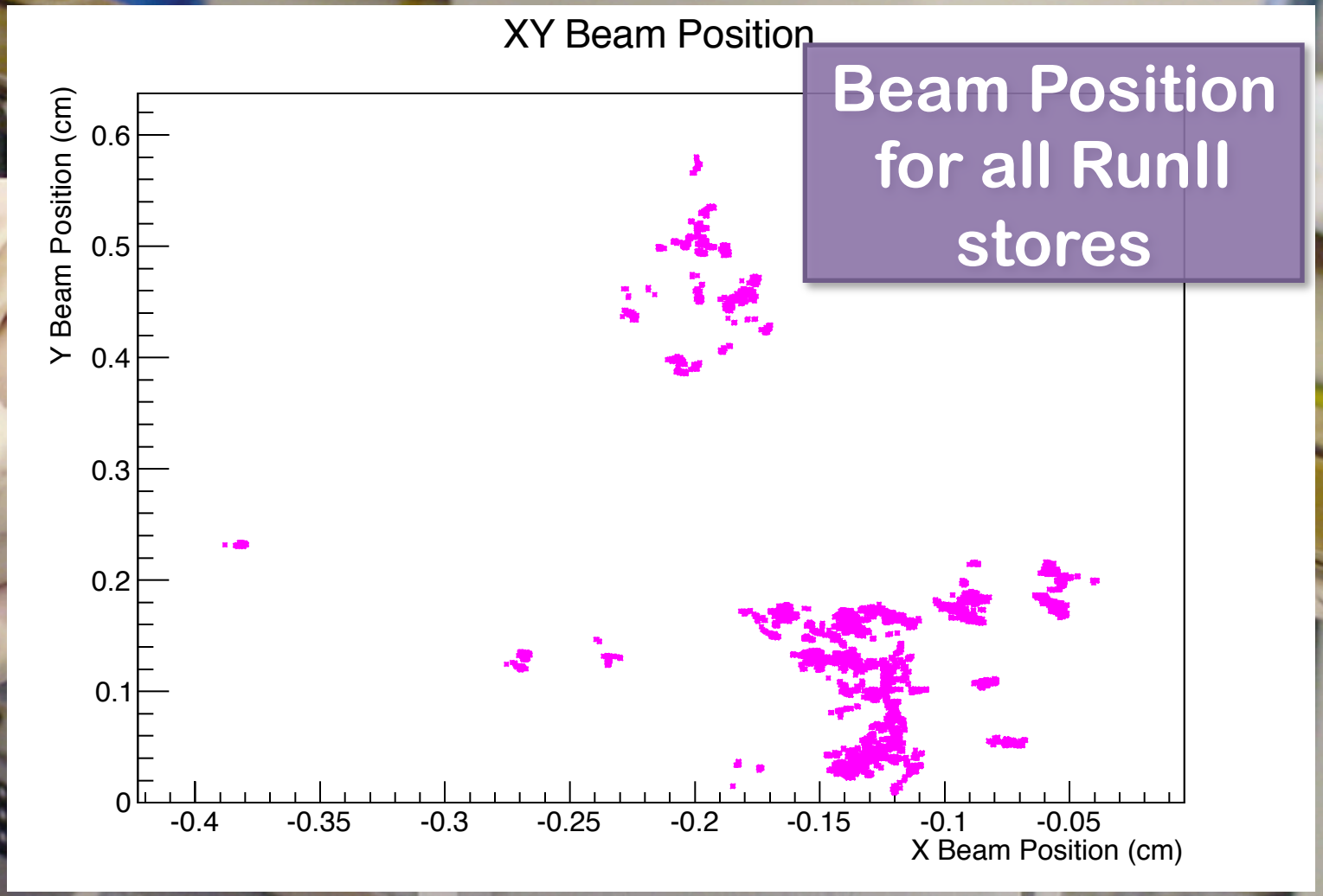


Beam Position

The DepVoltage depends on the absorbed dose.
The absorbed dose depends on the beam position between two scans.

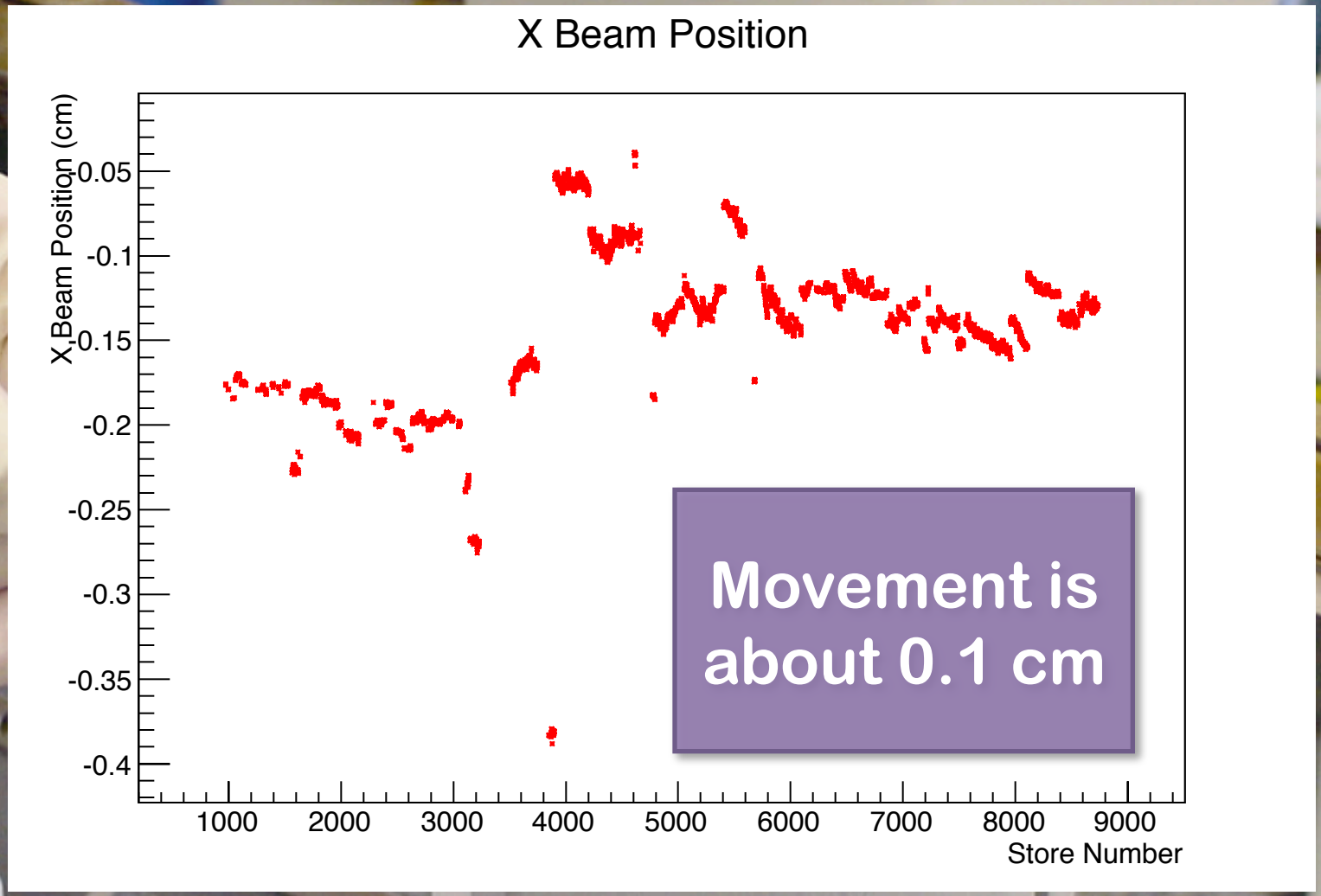
$$D(KRad) = \frac{1.5}{r^{1.5}} L(fb^{-1})$$

Beam Position

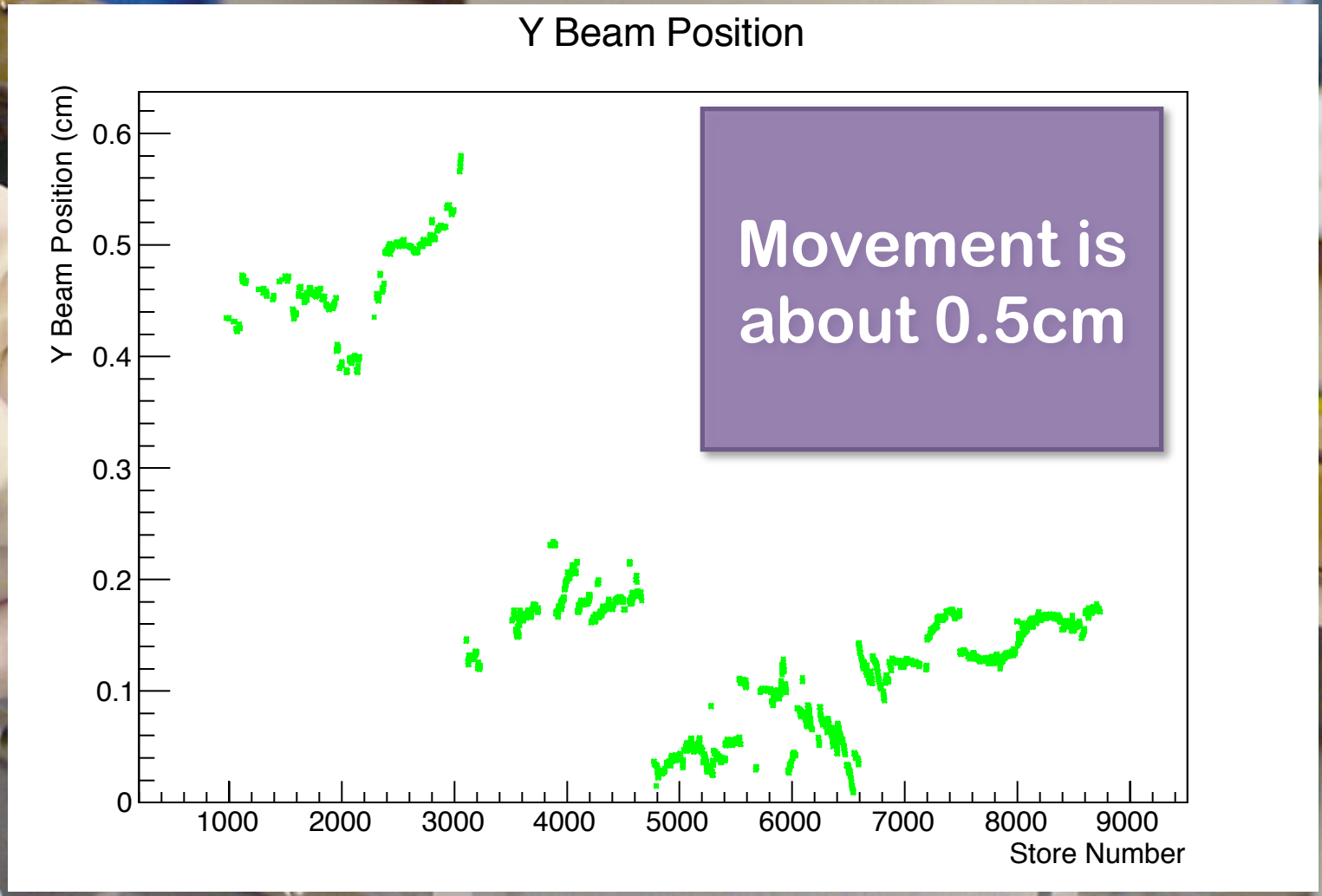


Beam Position for all RunII stores

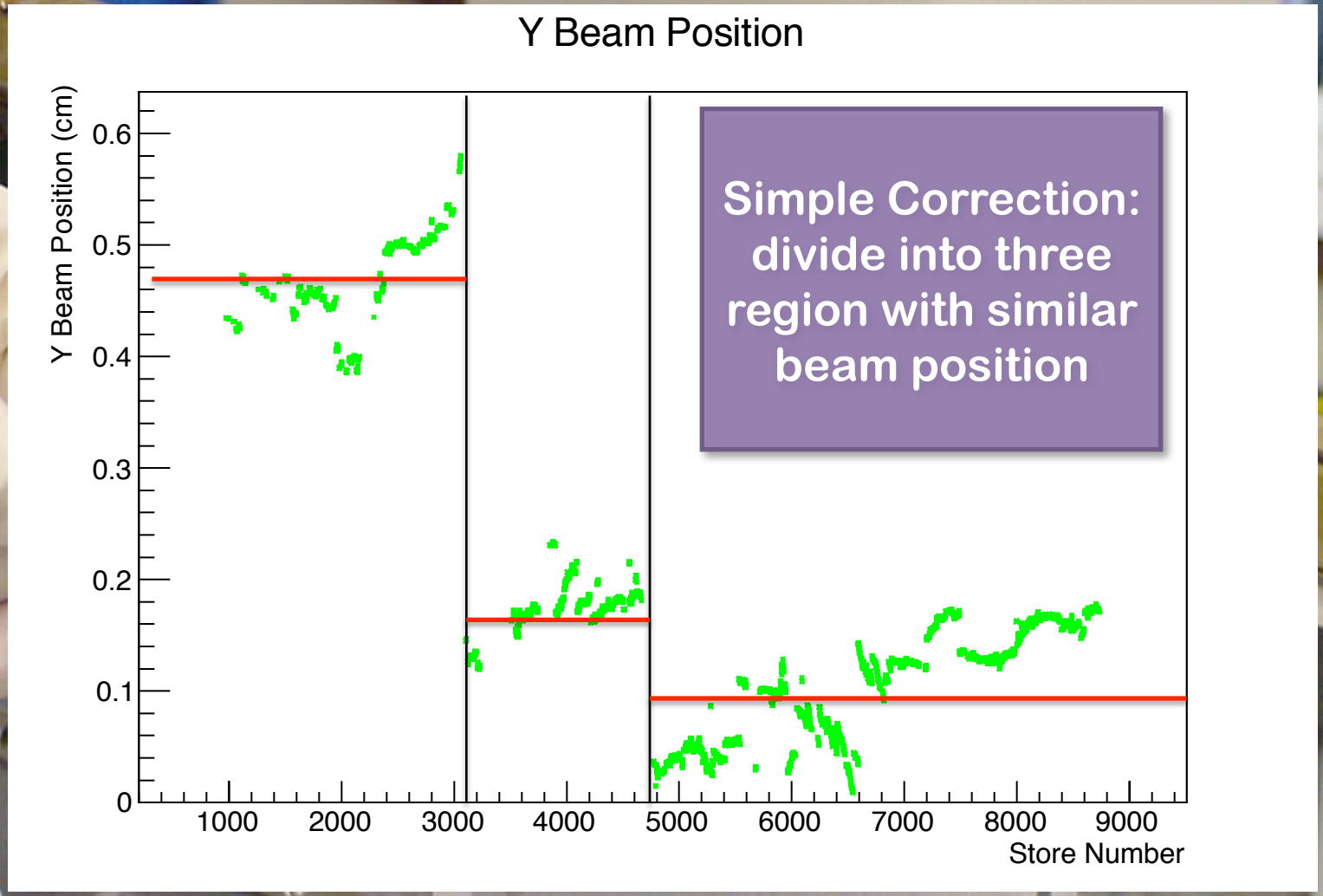
Beam Position

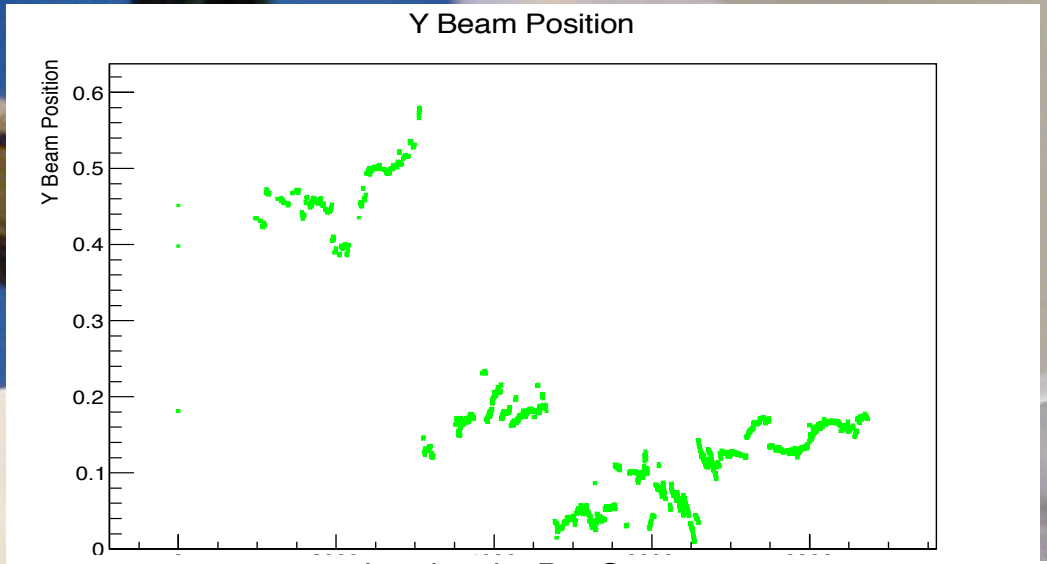


Beam Position

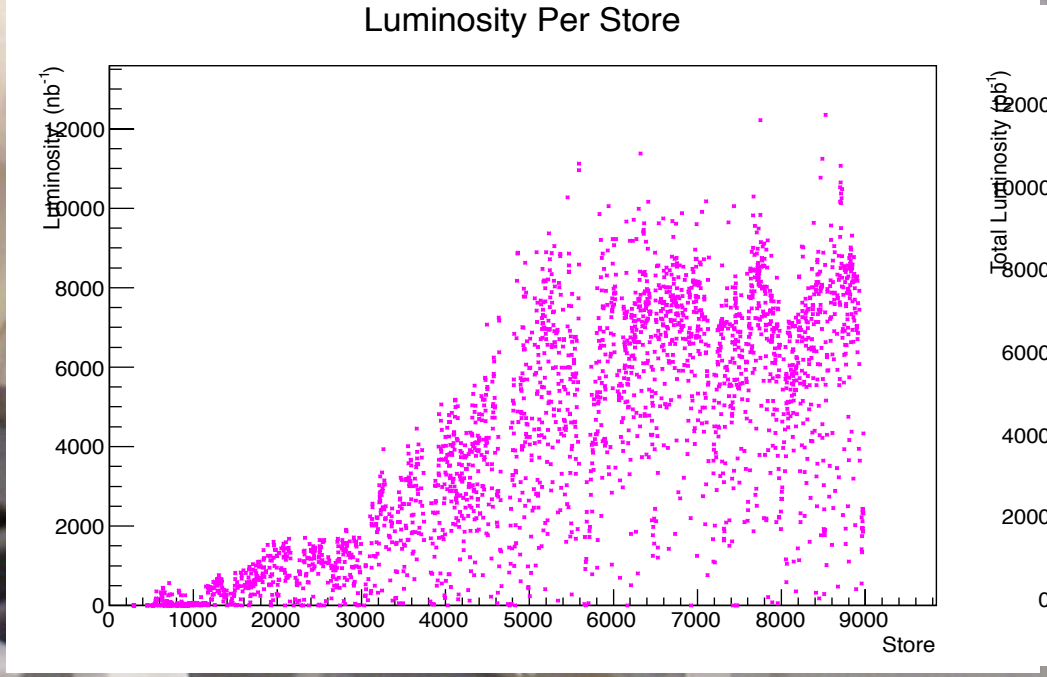


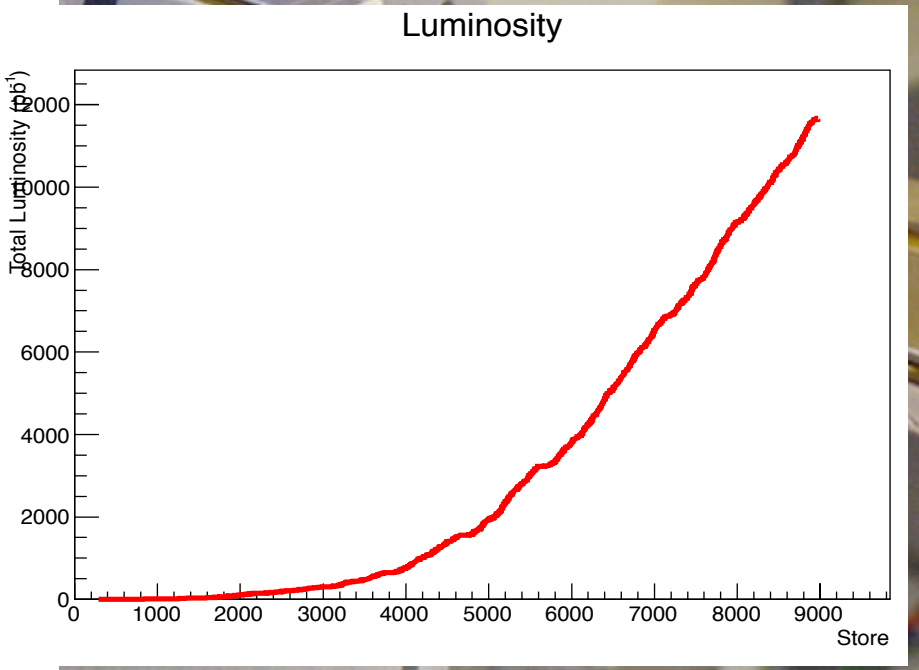
Beam Position

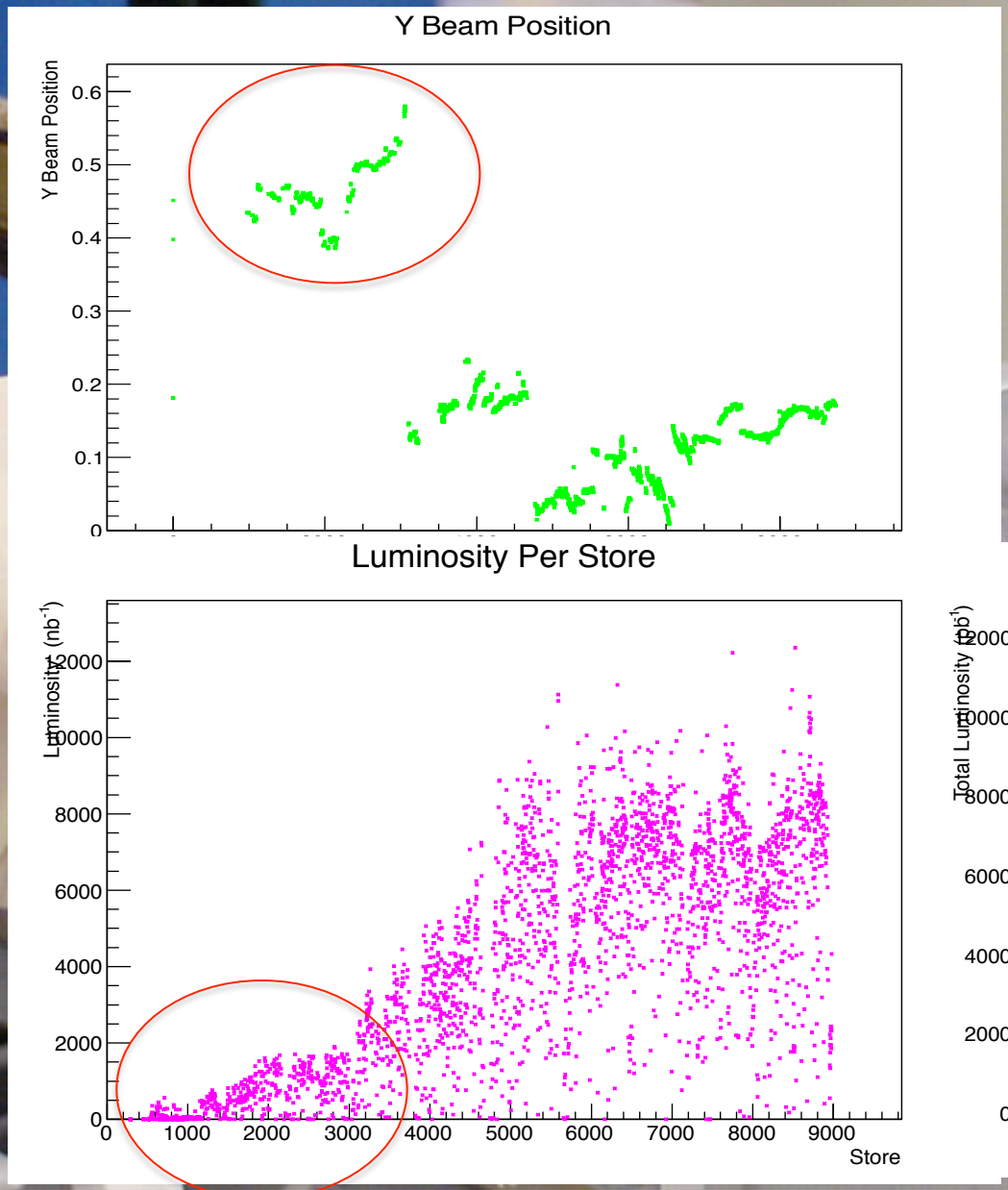




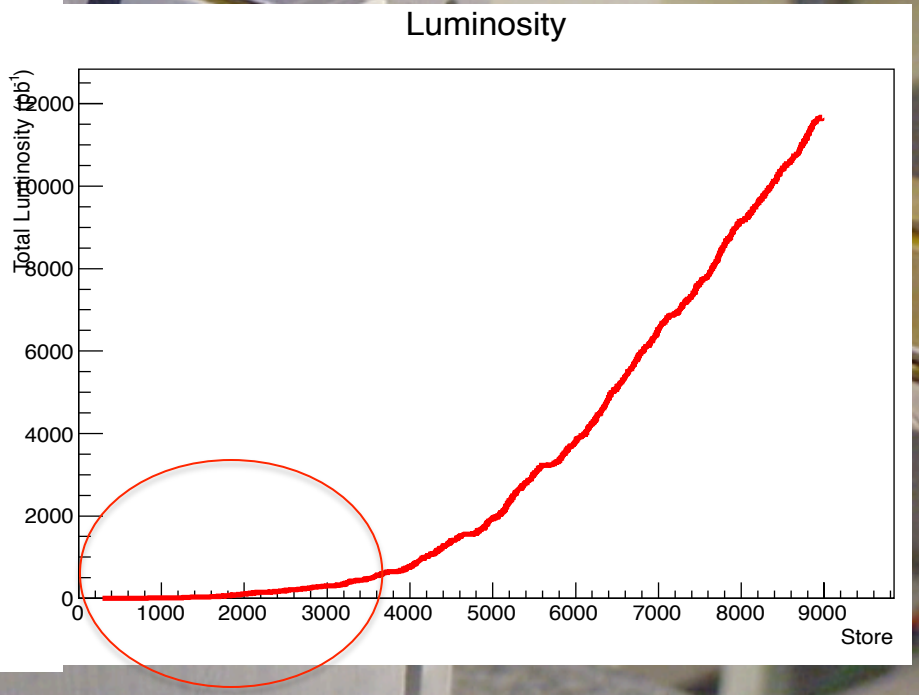
Last beam positions have more influence







Large beam offset had negligible contribution

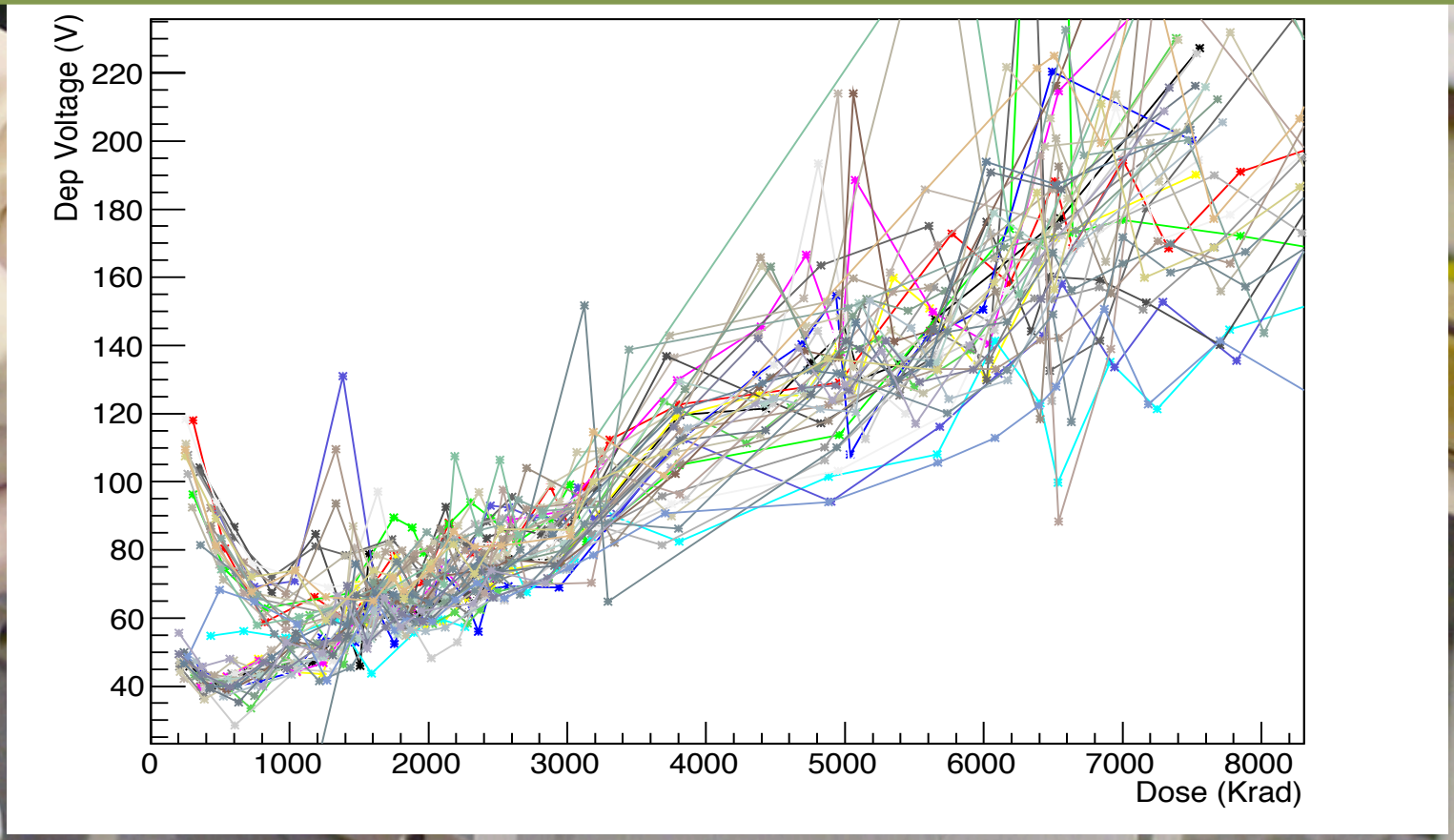


Good Runs

- *We have the beam position of all runs;*
- *We have to check these runs with a list of good runs.*
- *The good run list used is: goodrun_qcd_si.list*

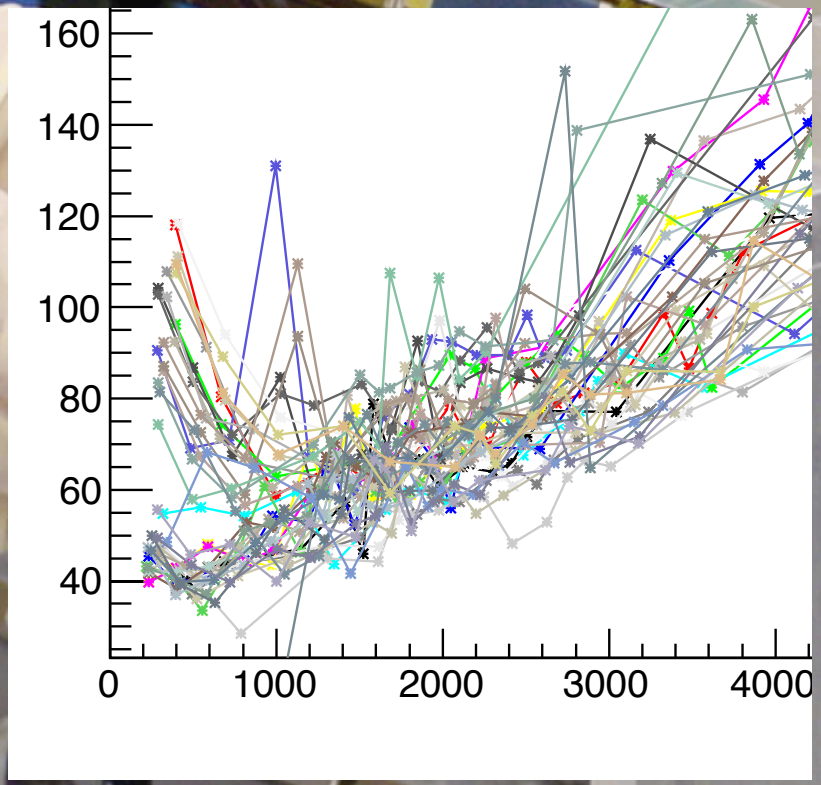
Results

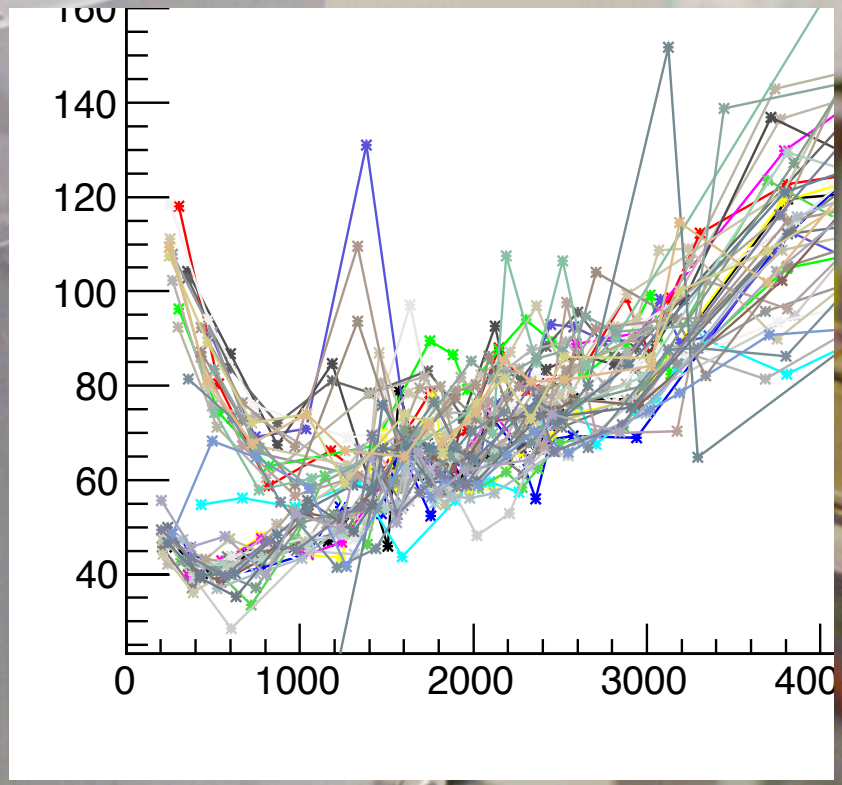
Reduction of point spread at low luminosity; no effect at high luminosities.



Results

Non Corrected – Corrected



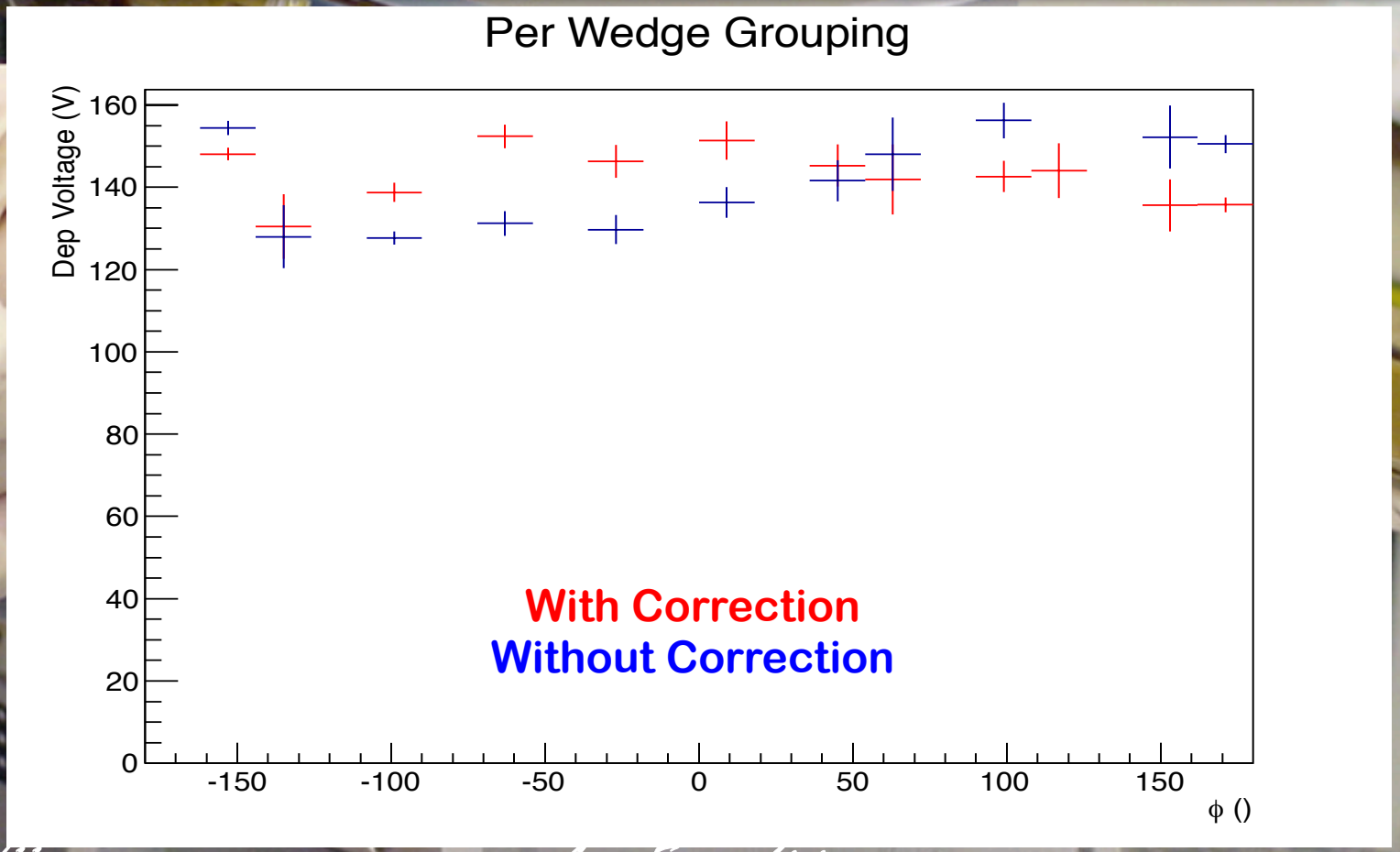


Results

The increase of integrated luminosity has a larger effect compared to changes of beam position

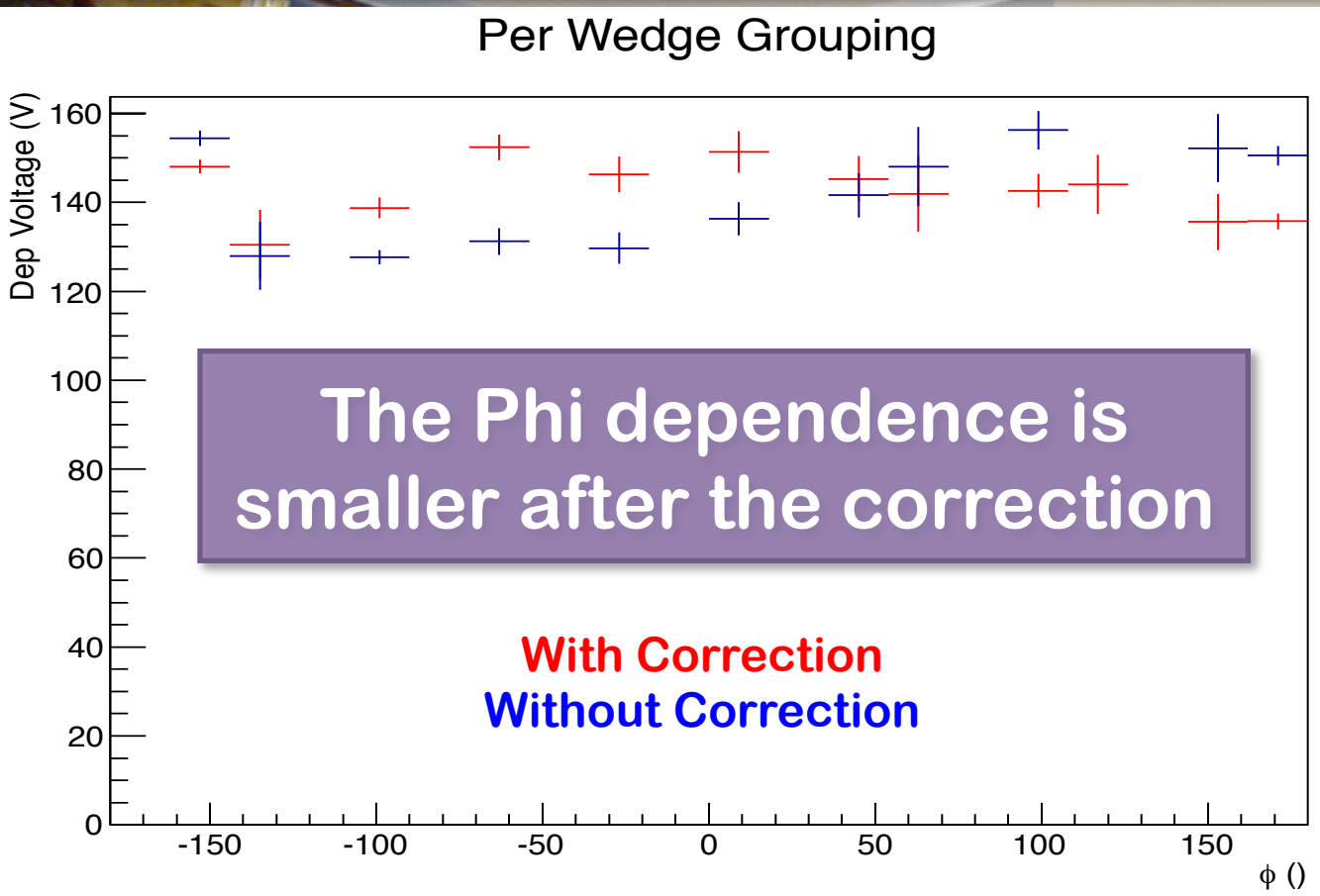
Phi Dependence

Plot @ a fixed dose of 6000 krad;



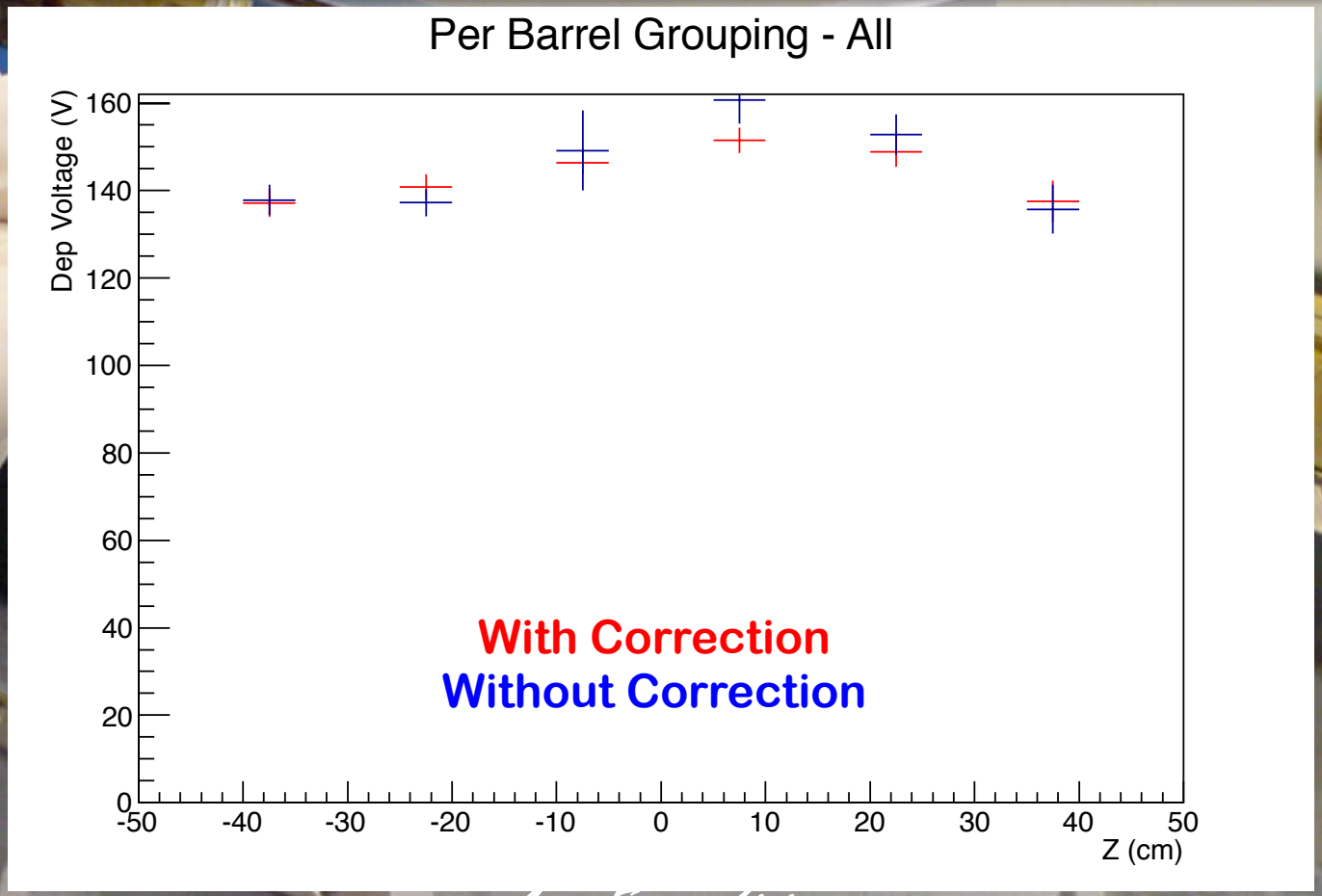
Phi Dependence

Plot @ a fixed dose of 6000 krad;



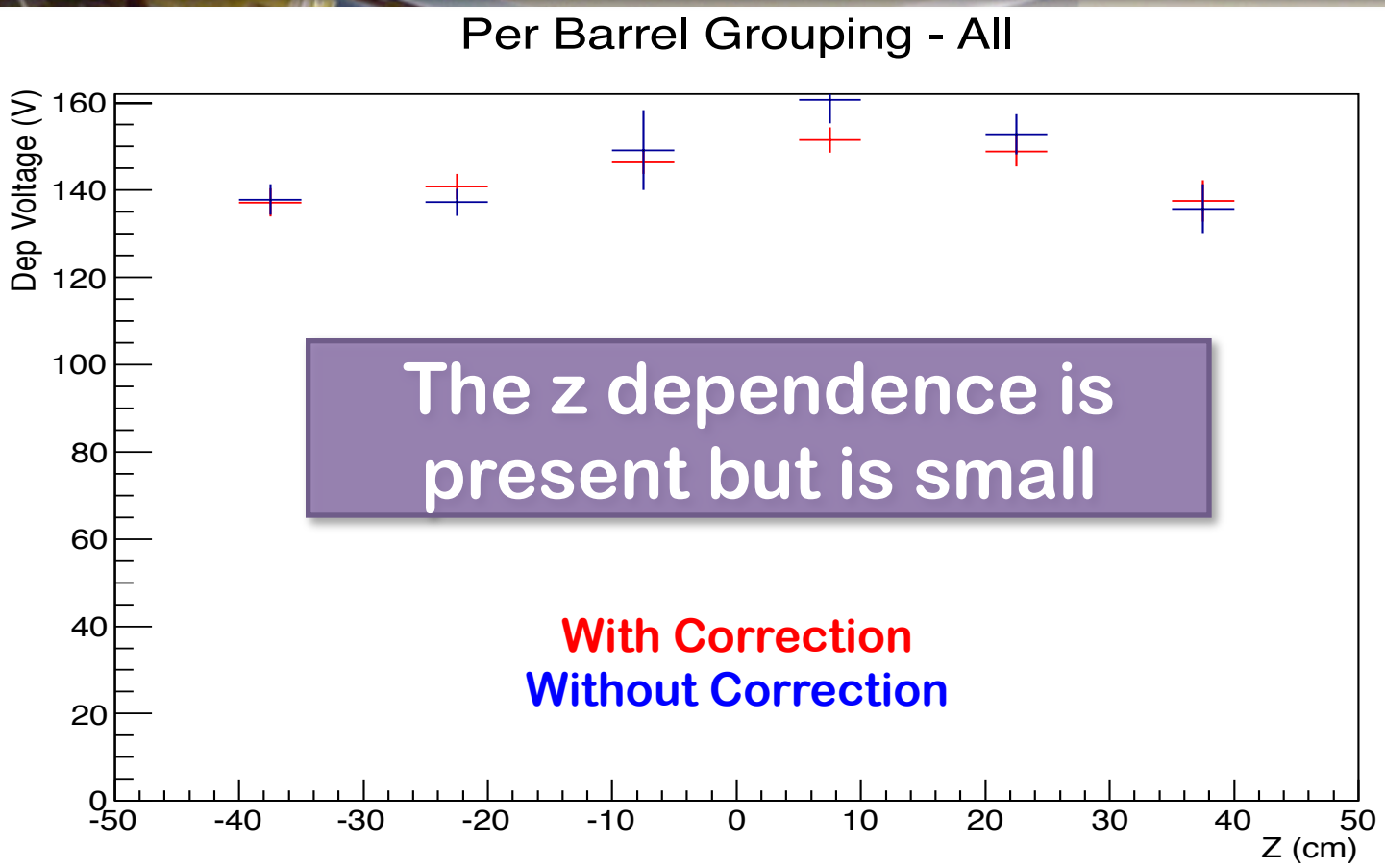
Z Dependence

Plot @ a fixed dose of 6000 krad;



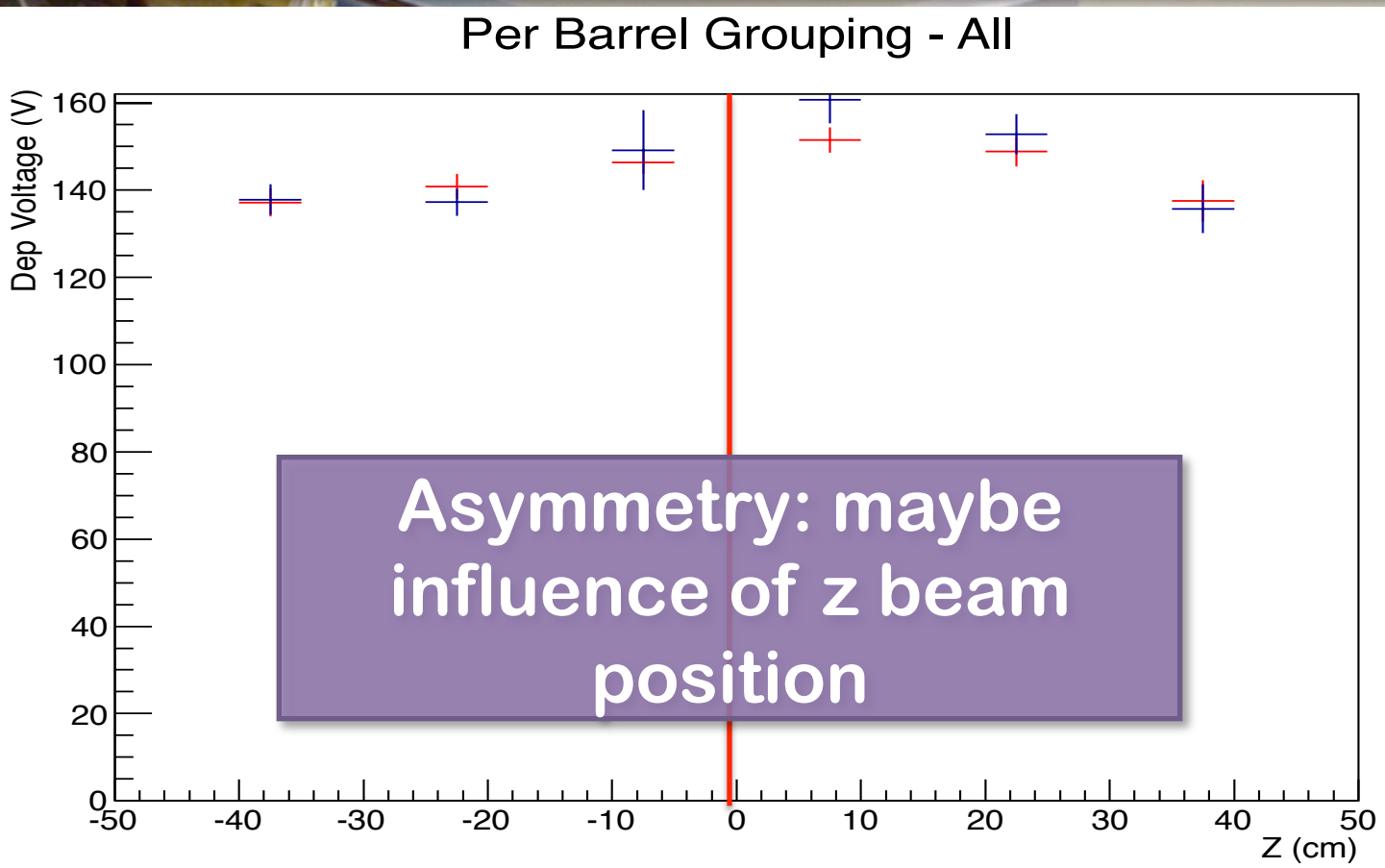
Z Dependence

Plot @ a fixed dose of 6000 krad;



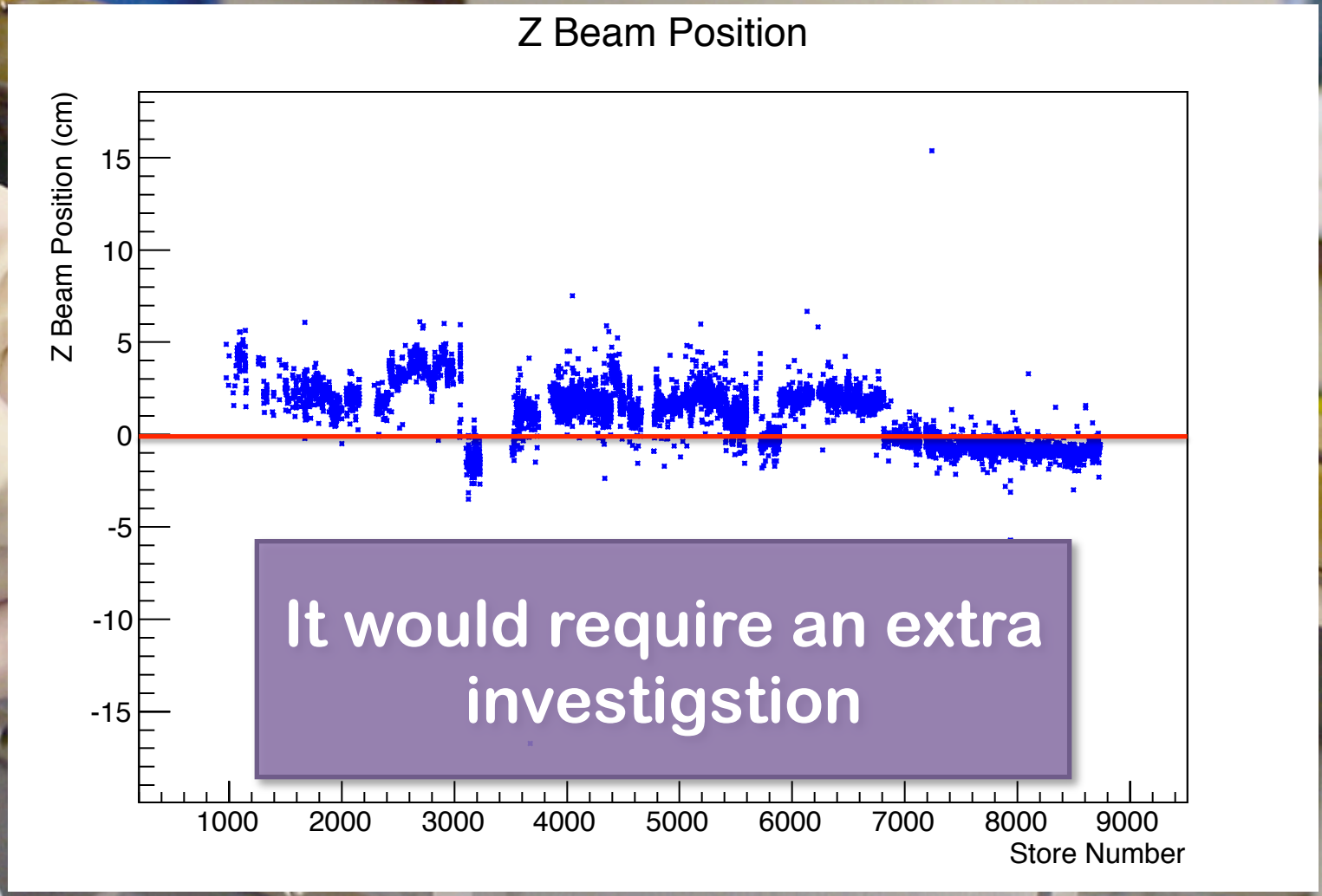
Z Dependence

Plot @ a fixed dose of 6000 krad;



Asymmetry: maybe influence of z beam position

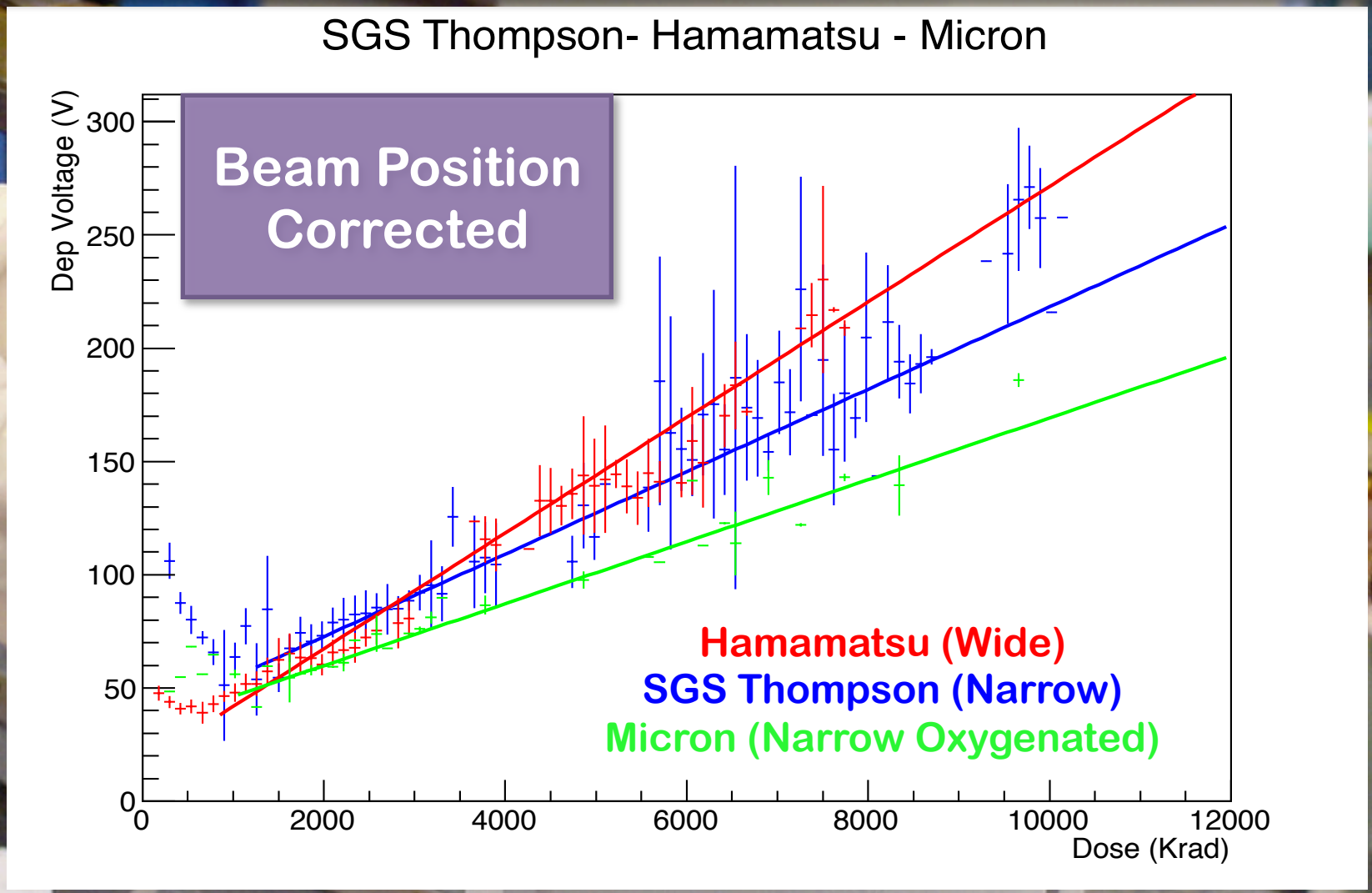
Beam Position



Manufacturer

An important difference appears in the behaviour of ladders of different manufacturer

Manufacturer



Manufacturer

Oxygenated ladders:

- **Inversion point at higer dose**
- **Smaller slope**
- **Live ≈ twice as long as Hamamatsu**

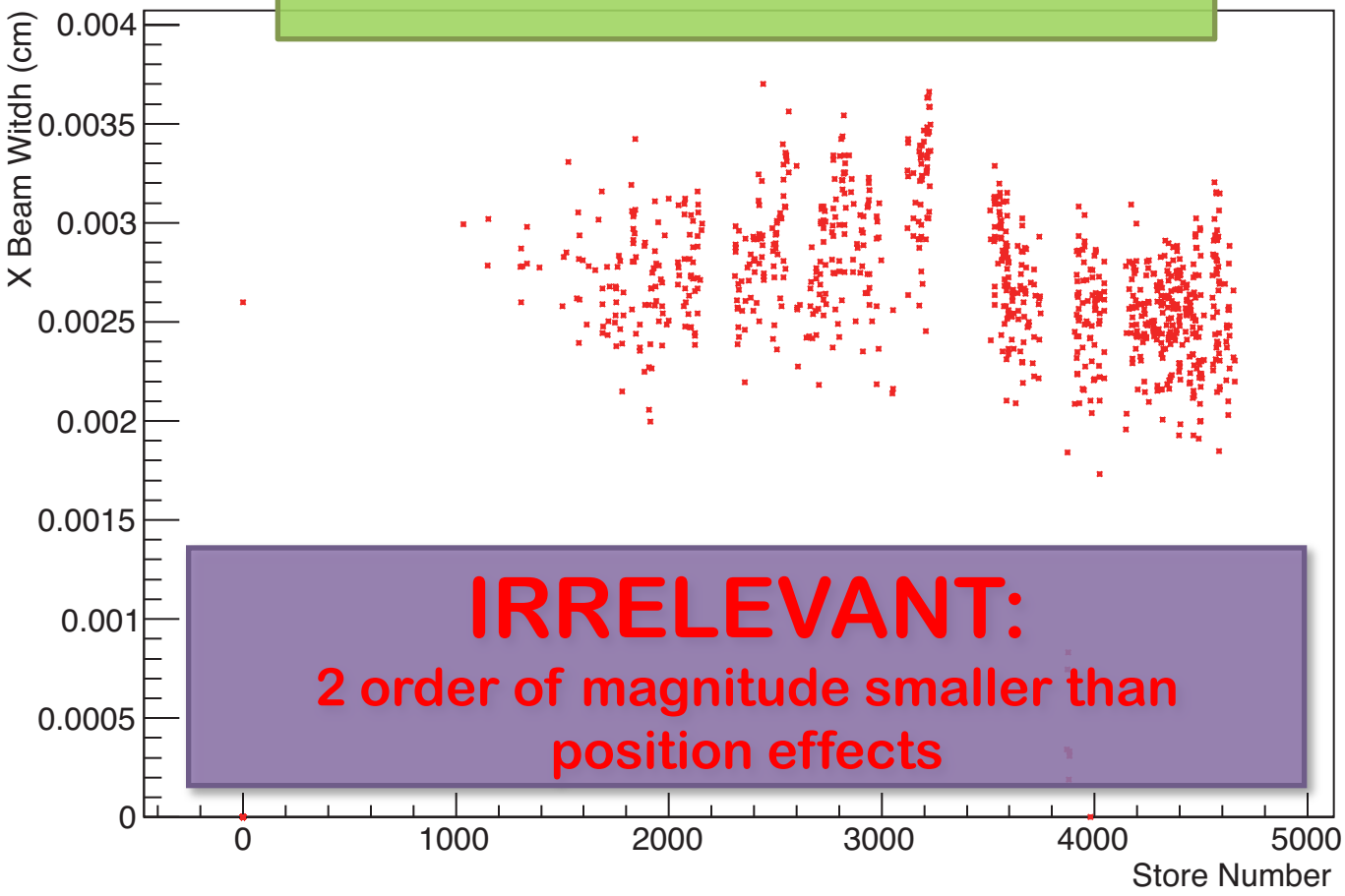
SLOPES (10^{-2} V/KRad):

Hamamatsu: 2.49 ± 0.01
SGS – Thompson: 1.78 ± 0.01
Micron (Oxygenated): 1.366 ± 0.006

Oxygenateds have a longer life!!

Other Corrections

X BEAM WIDTH

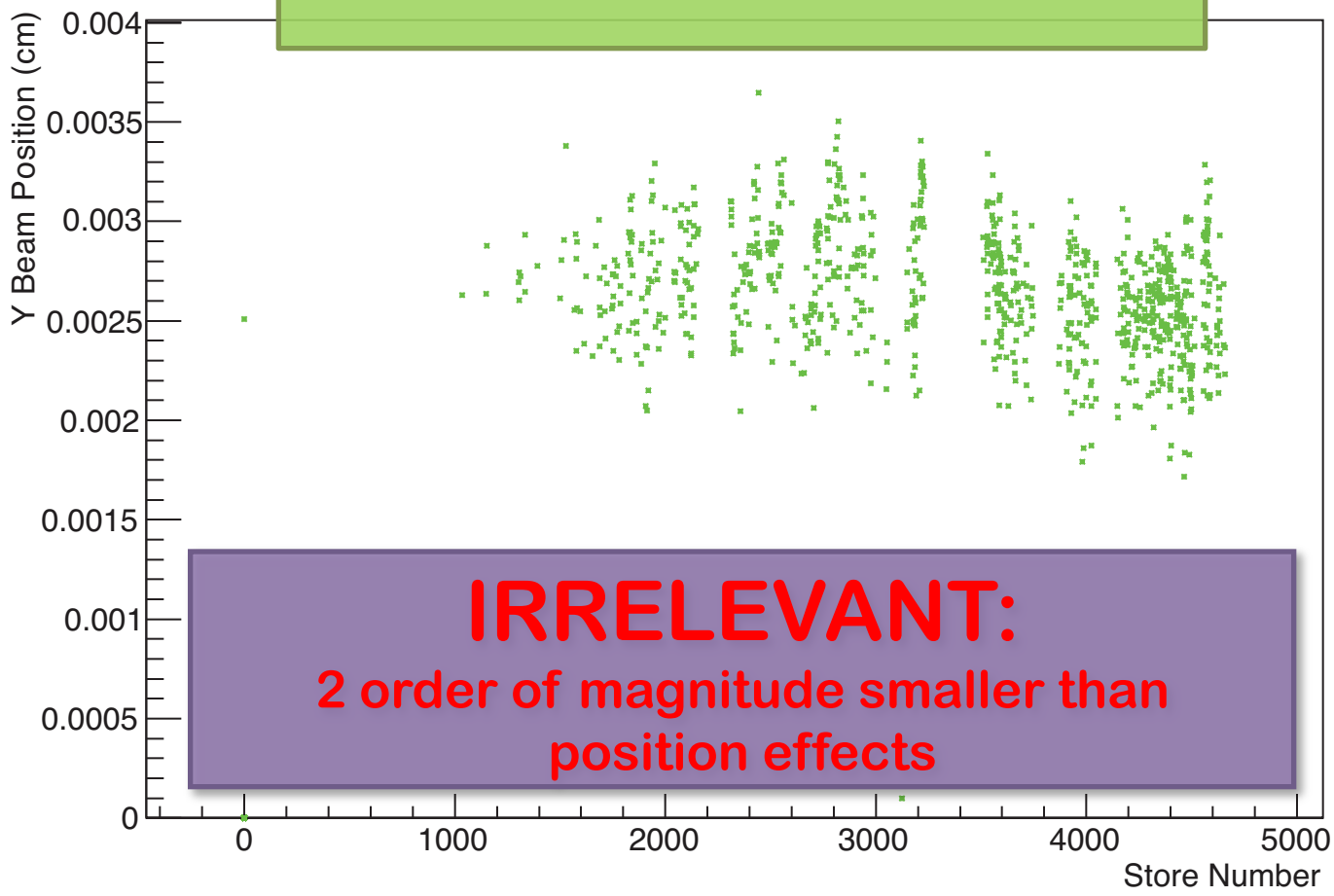


IRRELEVANT:

2 order of magnitude smaller than position effects

Other Corrections

Y BEAM WIDTH

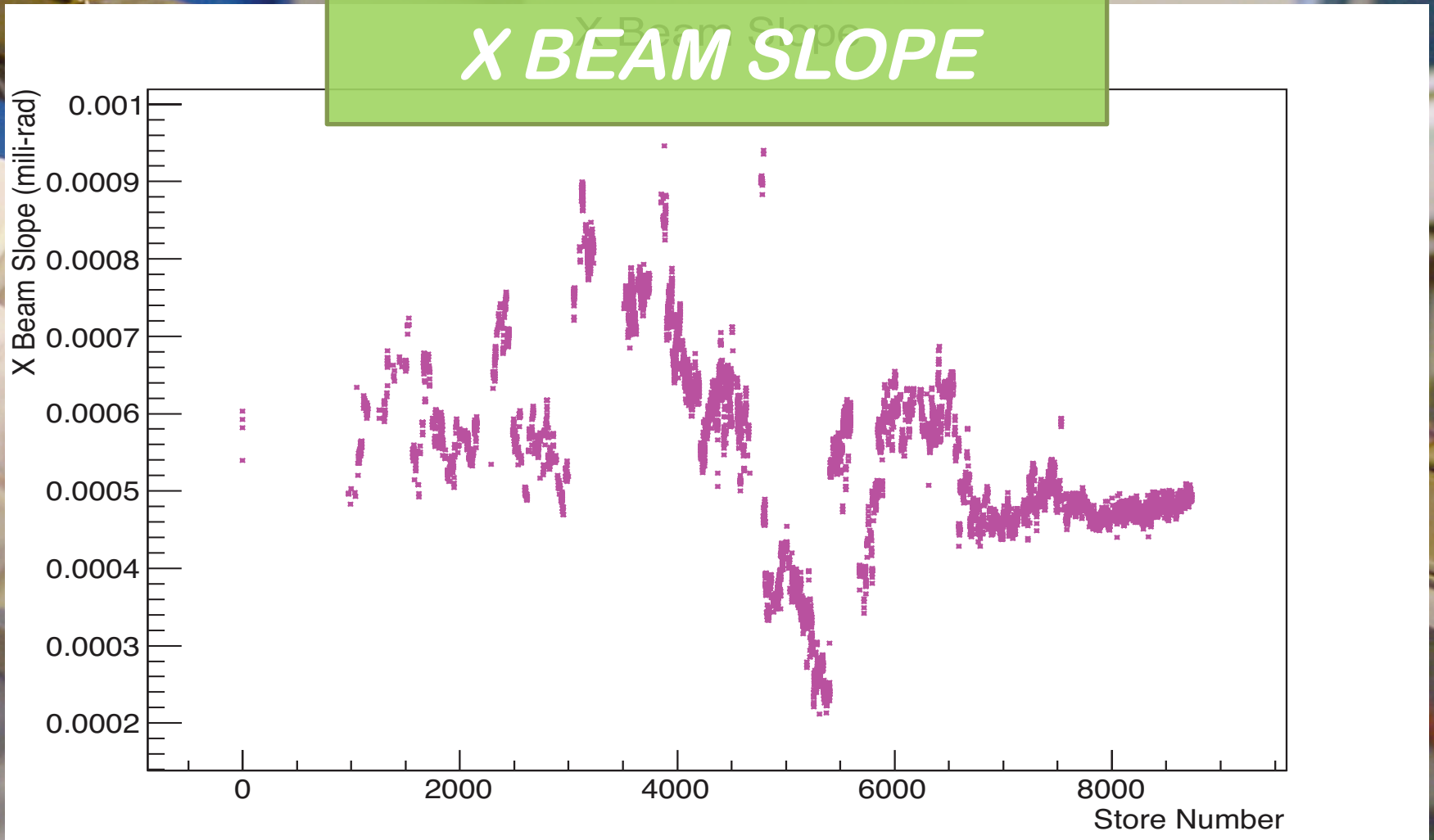


IRRELEVANT:

2 order of magnitude smaller than position effects

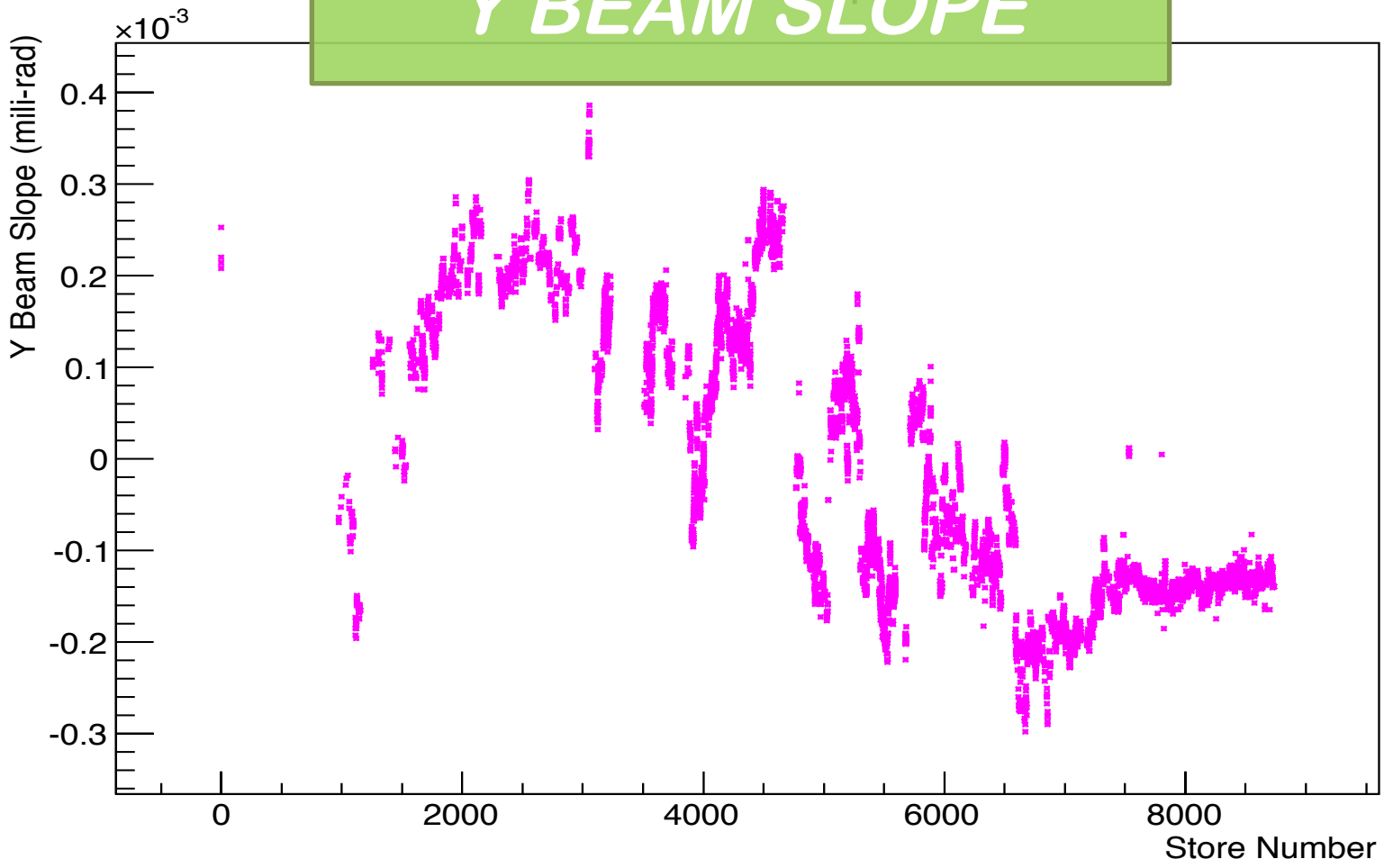
Other Corrections

X BEAM SLOPE



Other Corrections

Y BEAM SLOPE



Slope to Distance

*R = tan(slope) * 94 cm*

≈ 0.4 – 1 micron

IRRELEVANT:

3 order of magnitude smaller than position effects

Conclusions

- BeamLine – Detector distance, for aging effects, is relevant only at low doses
- At higher doses the trend is driven by luminosity
- X-Y Slope and beam width are not relevant
- Great differences come from manufacturers
- Oxygenated ladders introduce great improvements

Further Investigations

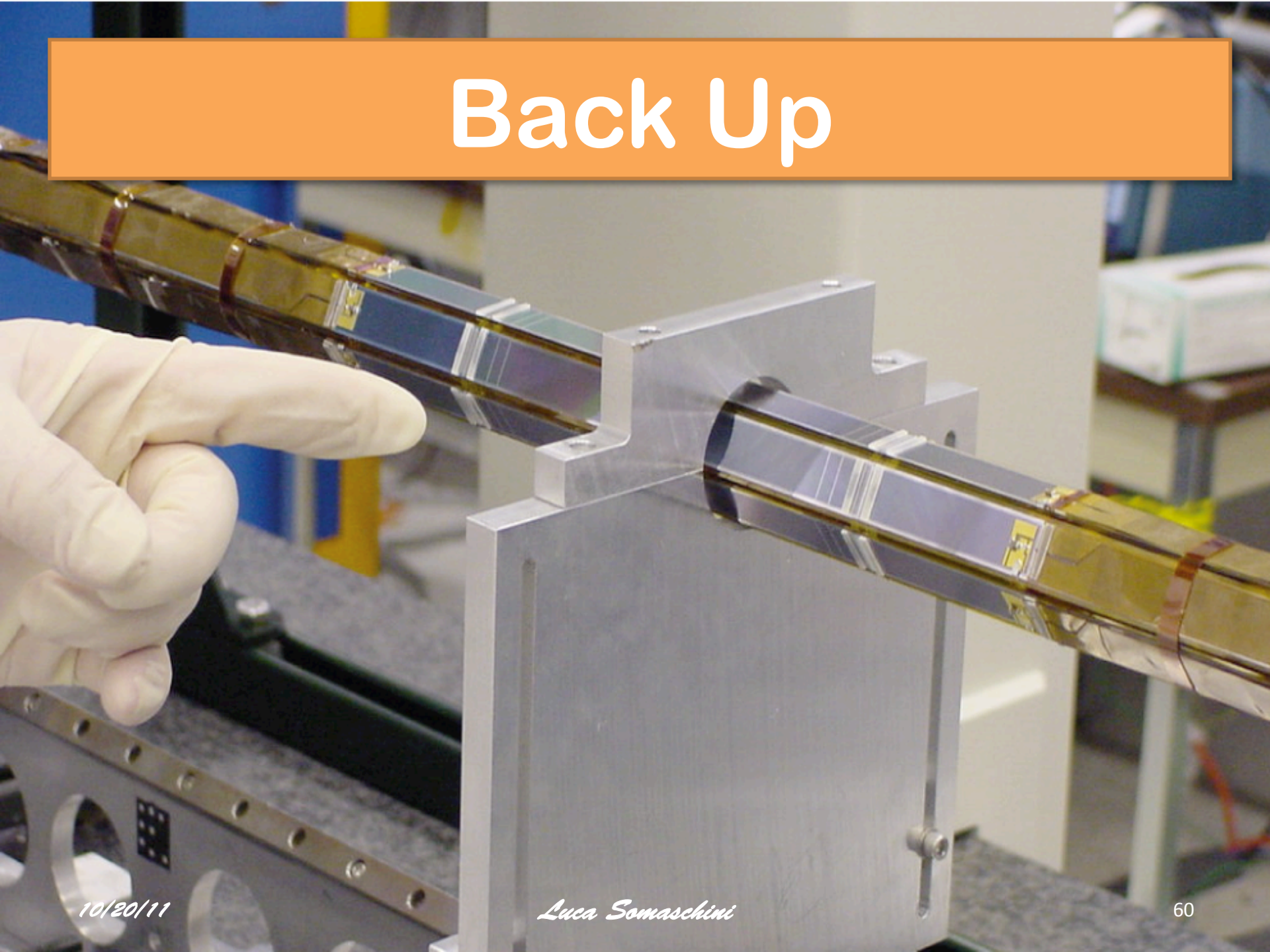
- Influence of dose derived from beam losses and quenches
- Influence of temperature changes

Thanks to

Fermilab Staff

for the opportunity of this summer

Back Up



Signal Bias Scan

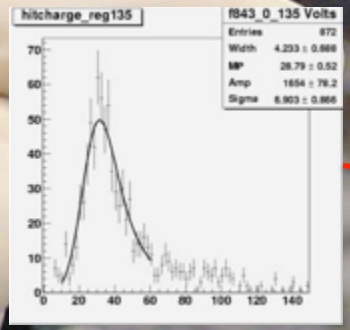
This gives one couple of values:
DEPLETION VOLTAGE vs
DELIVERED LUMINOSITY

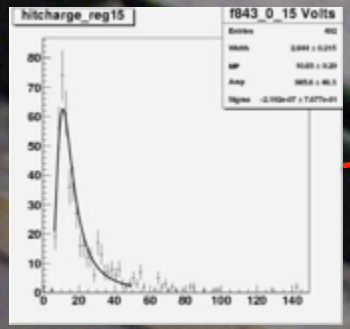
For:

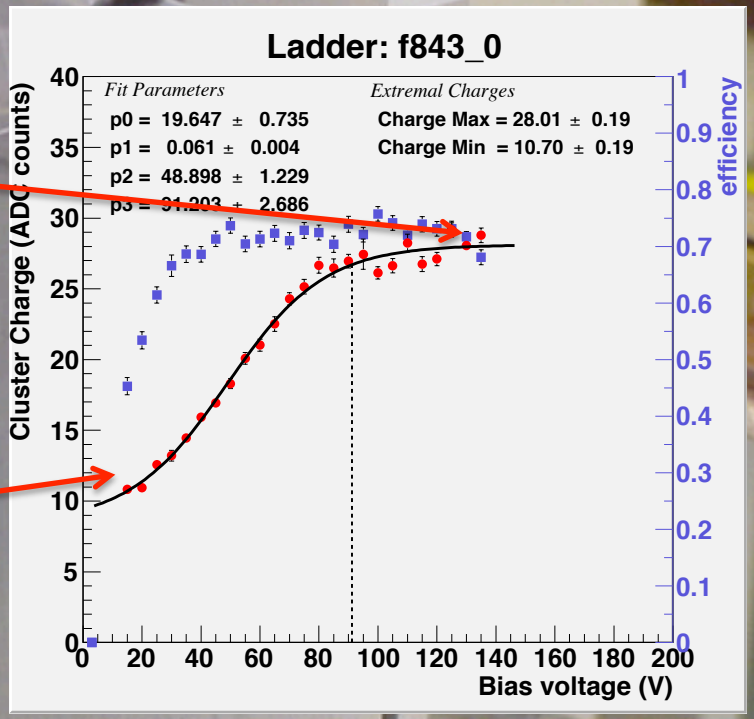
- Each Ladder
- Each Bias scan

Bias Scan

Each Landau X Gauss Gives a point at a different voltage;

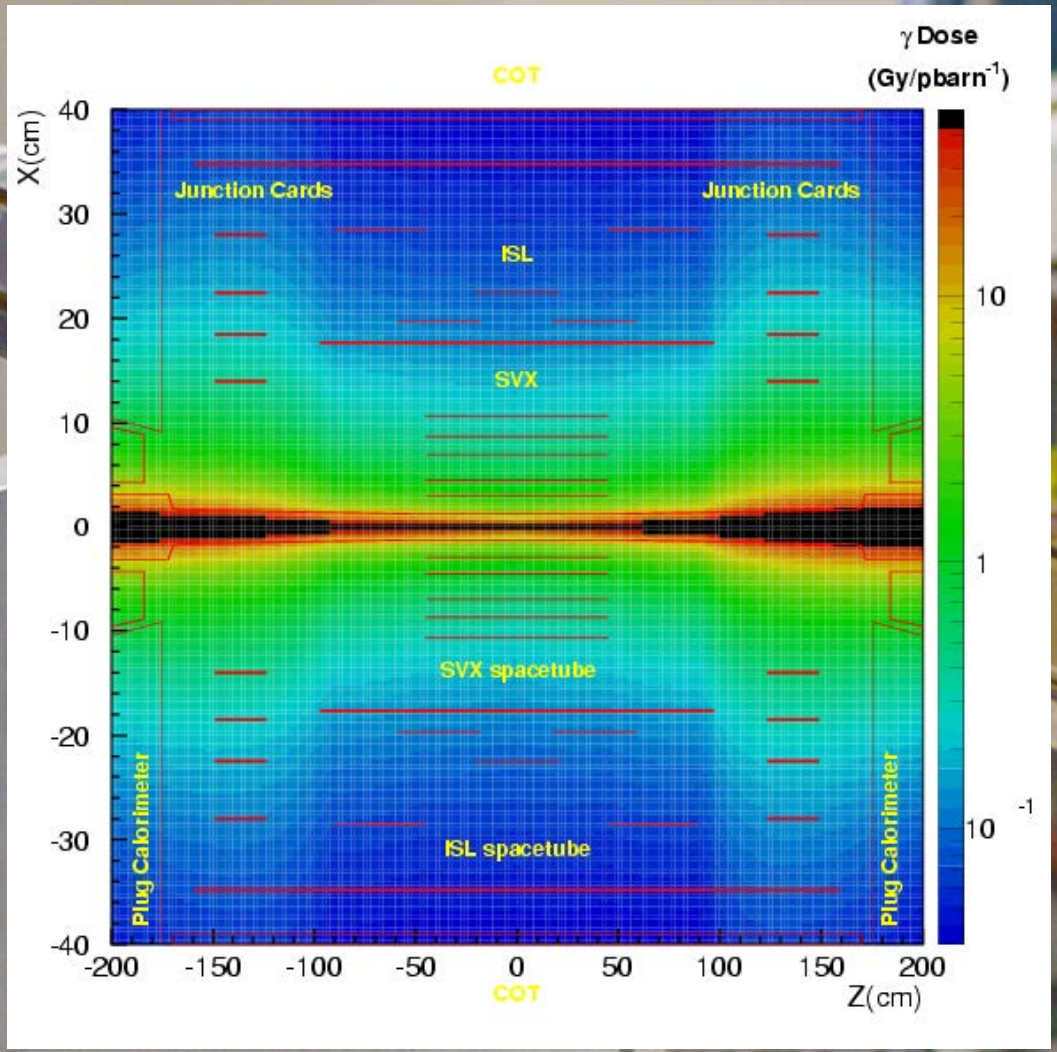






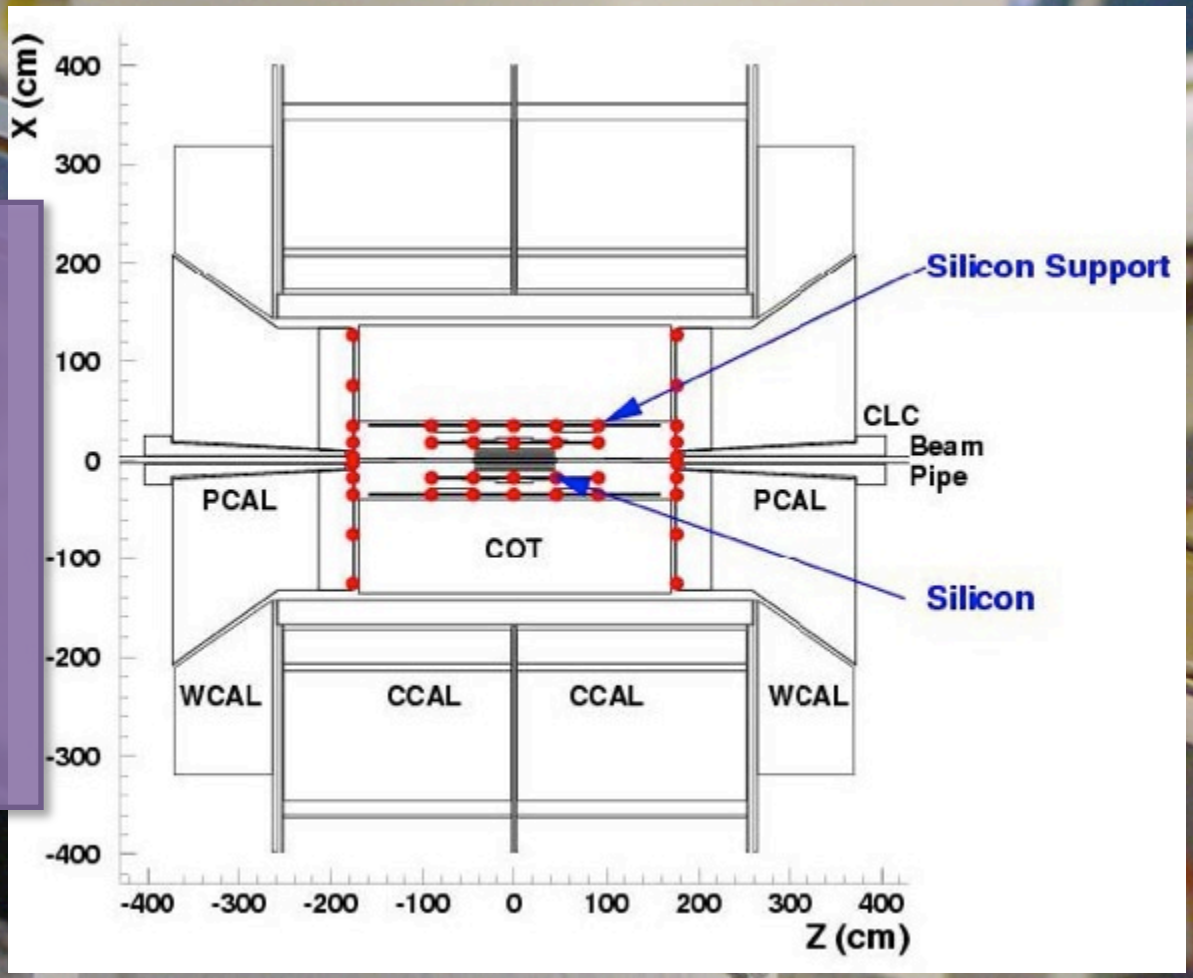
Dose Mapping

Distributio of Dose obtained with 916 dosimeters

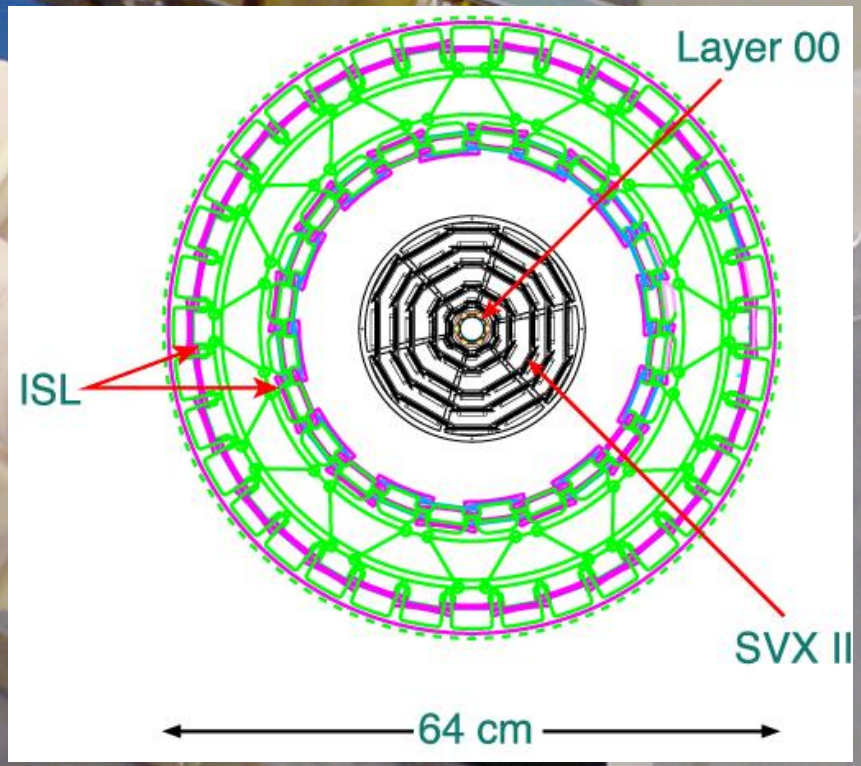


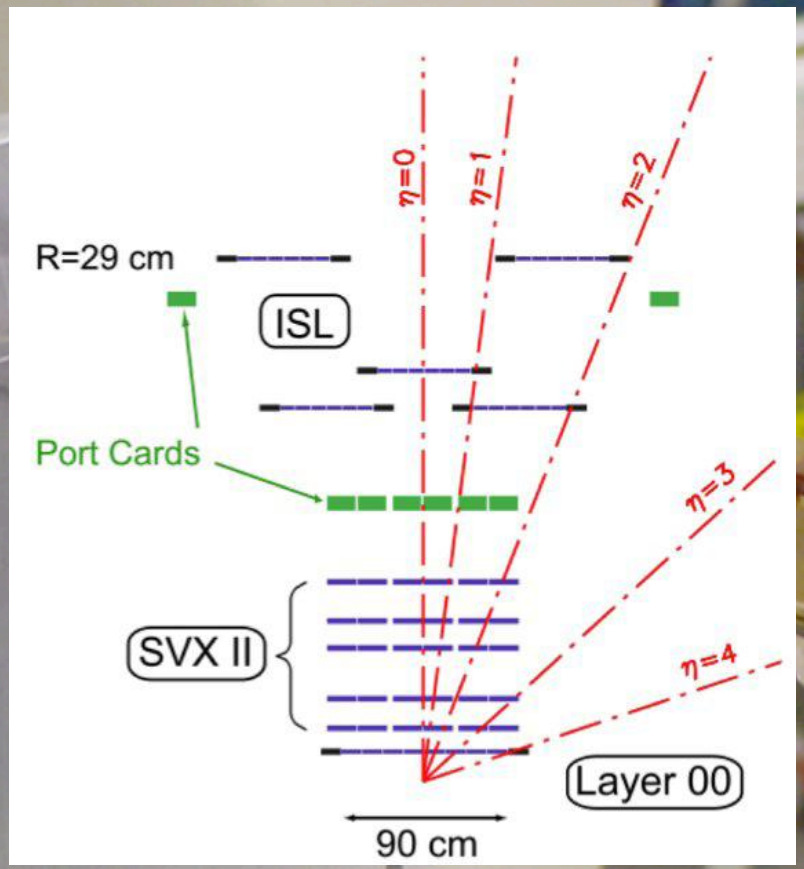
Dosimeters Mapping

Dispalcement of the 916 dosimeters



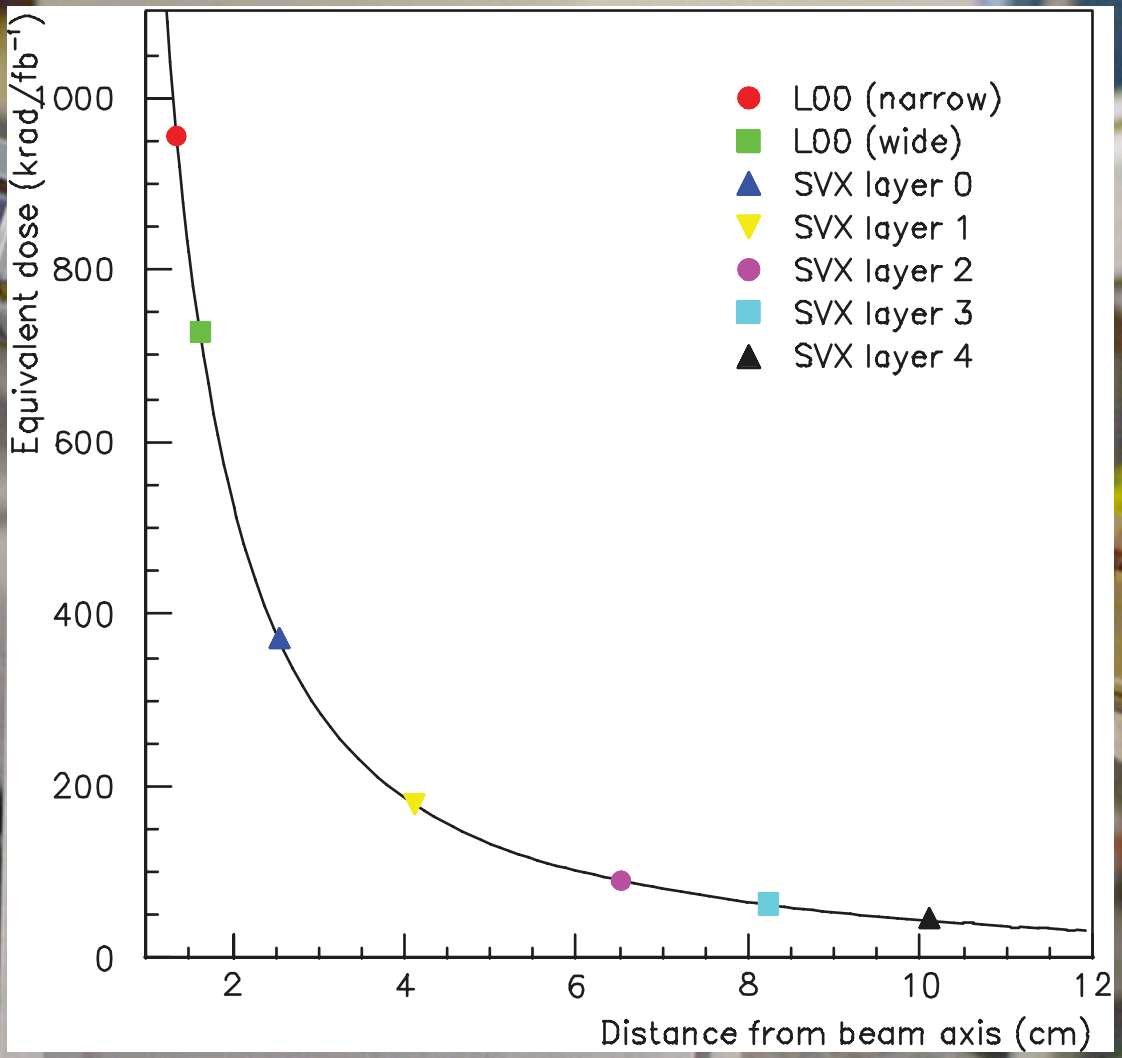
CDF Overview





Dose vs Radius

Evolution of equivalent dose with distance from the beam



Dose vs Radius

Official CDF plot.
Dep Voltage vs Luminosity.

NO CORRECTIONS