MCP ANALYSIS ON ALPHA

Howard Chiao

What Is ALPHA?

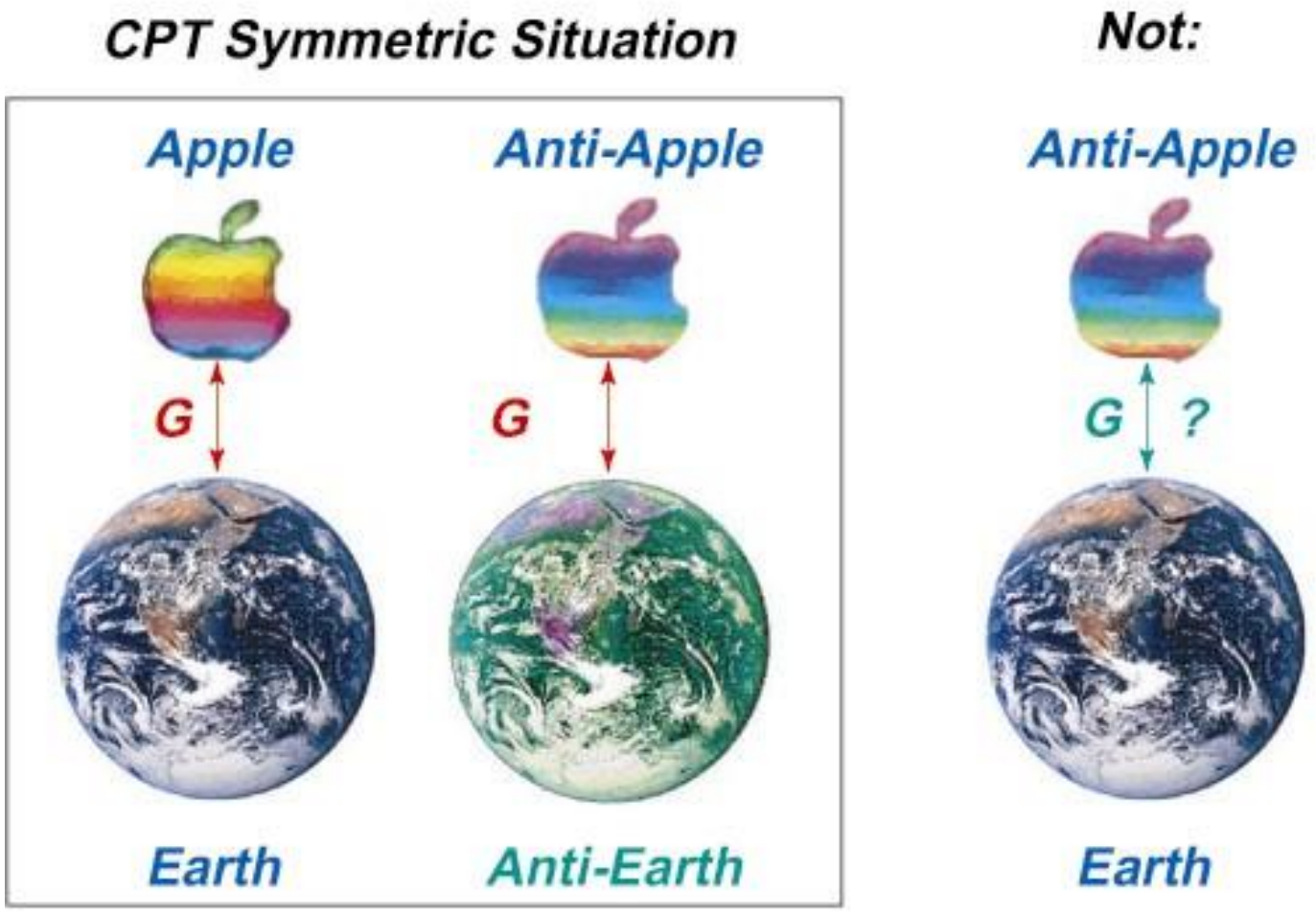
- **A**ntihydrogen
- **L**aser
- **PH**ysics
- **A**pparatus

- Located at the Antiproton Decelerator (AD), a storage ring at CERN
- Collaboration between 14 universities and 7 countries

What Does ALPHA Do?

- Mixing positrons and antiprotons to create antihydrogen in low temperature
- Trap antihydrogen in a magnetic trap
- Test CPT symmetry through comparison of the atomic spectra
- Find out the interaction between gravity and antimatter

What Does ALPHA Do?



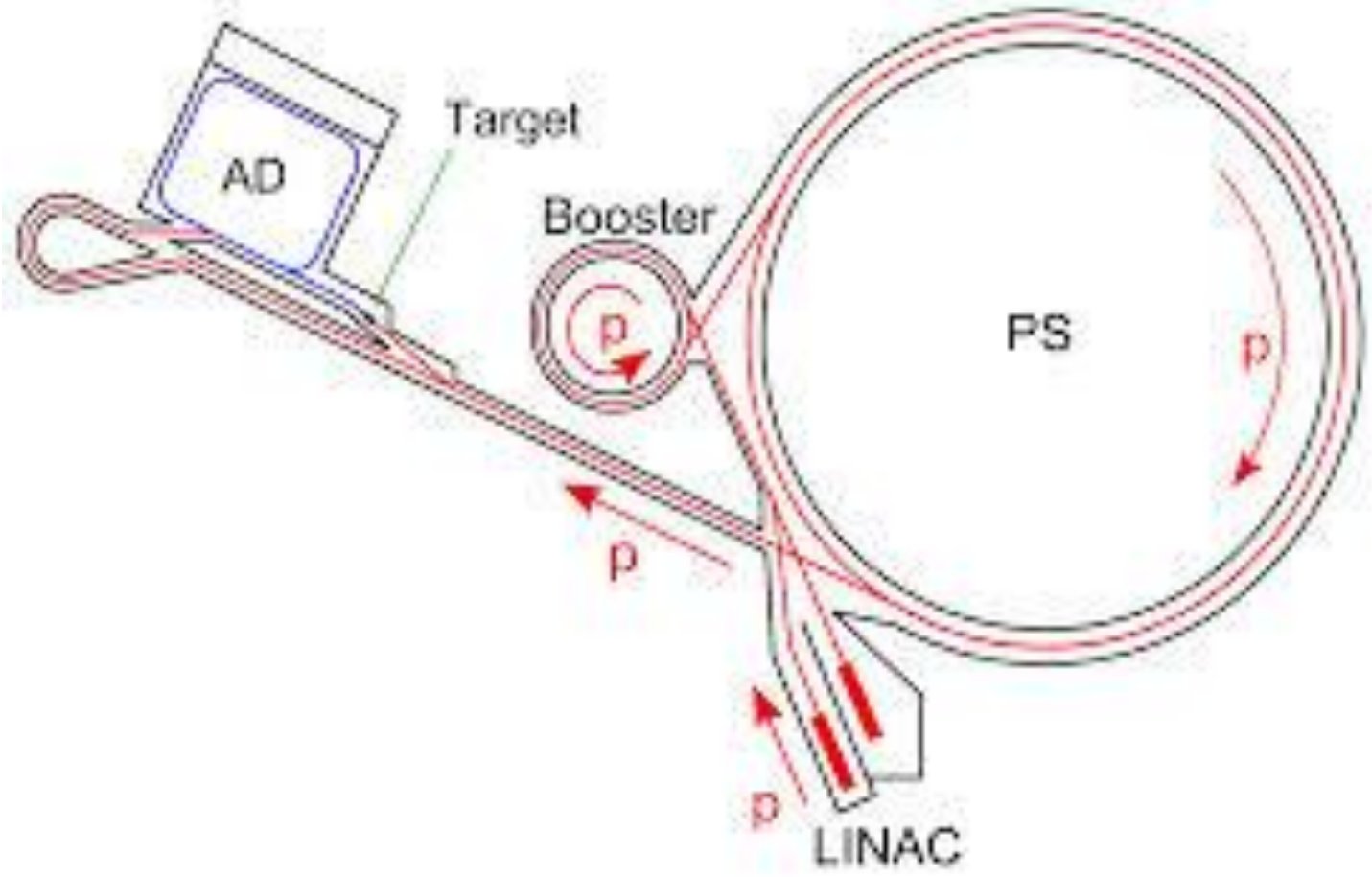
How To Get Positron?

- ALPHA uses the positron produced in the beta-plus (e^+) decay of sodium-22 atoms.

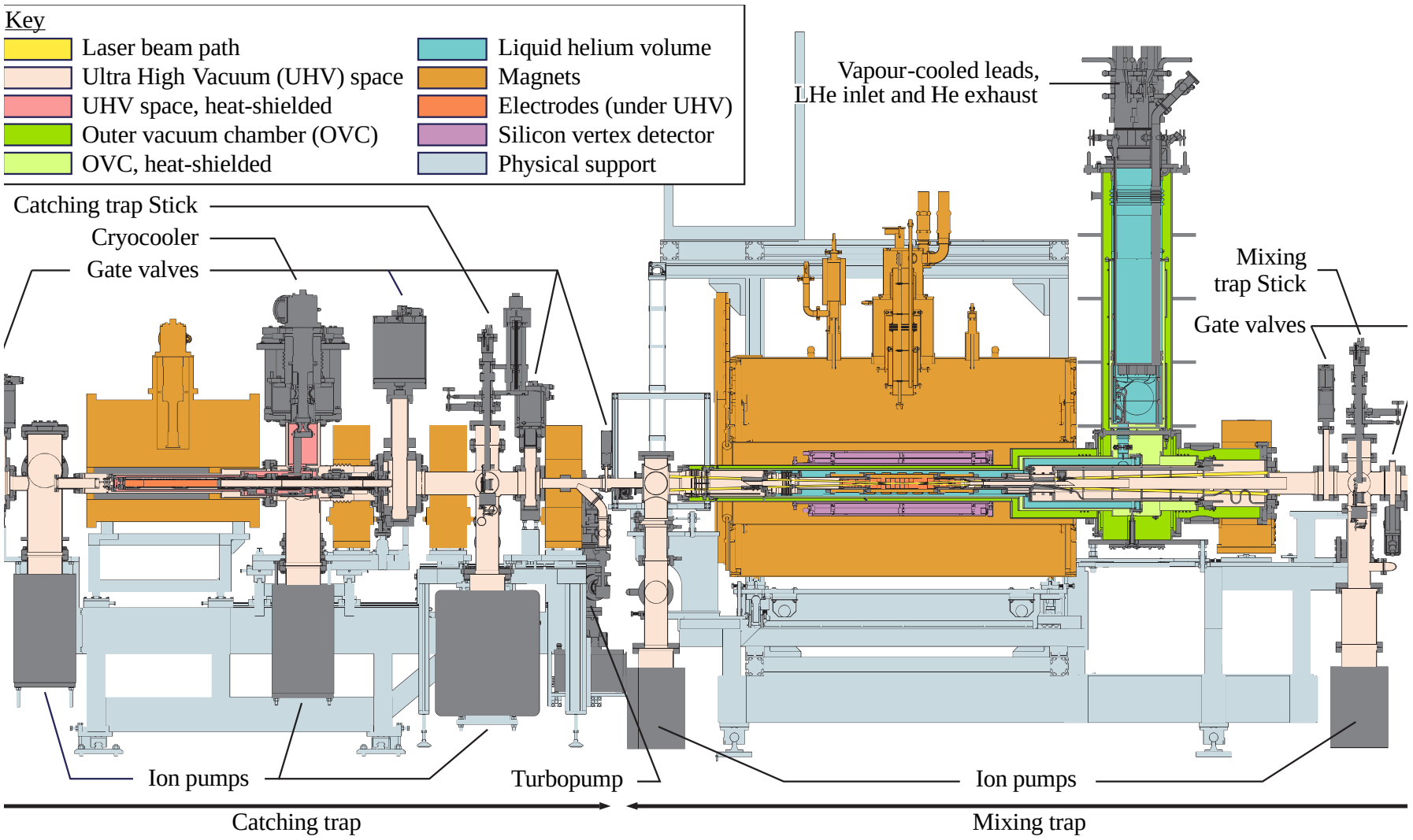
$$^{22}_{11}\mathrm{Na} \rightarrow {}^{22}_{10}\mathrm{Ne} + {}^{0}_{1}e^{+} + \nu_e.$$

- Collides with nitrogen molecules to lose energy by producing an excitation of nitrogen.
- Positrons are then sent to the accumulator.

How To Get Antiproton?

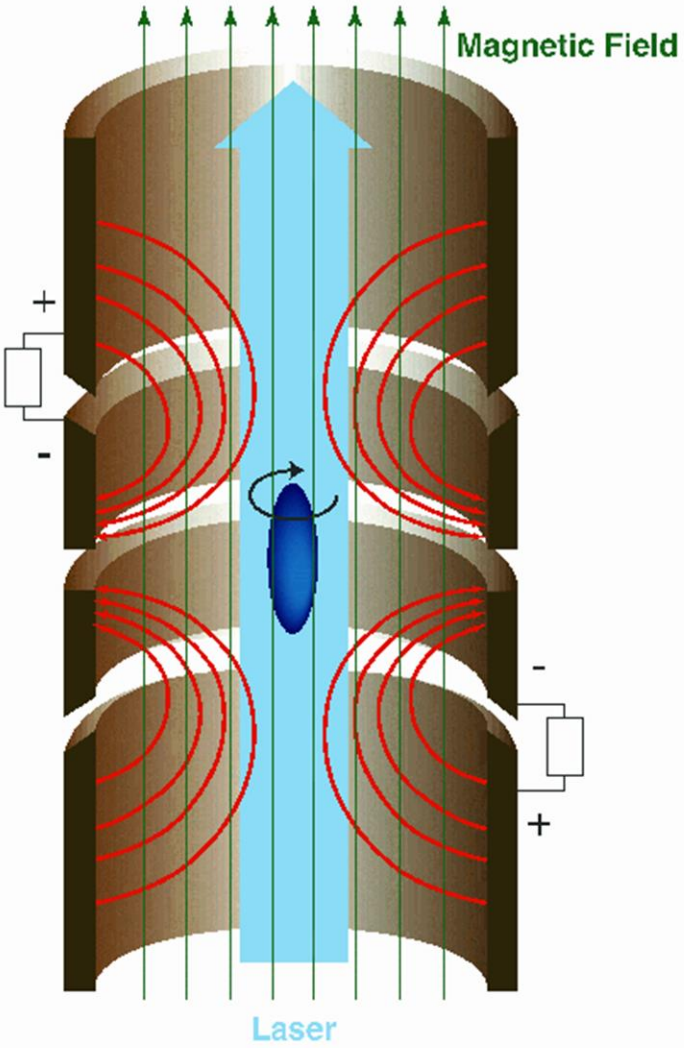


The Setup of ALPHA Apparatus



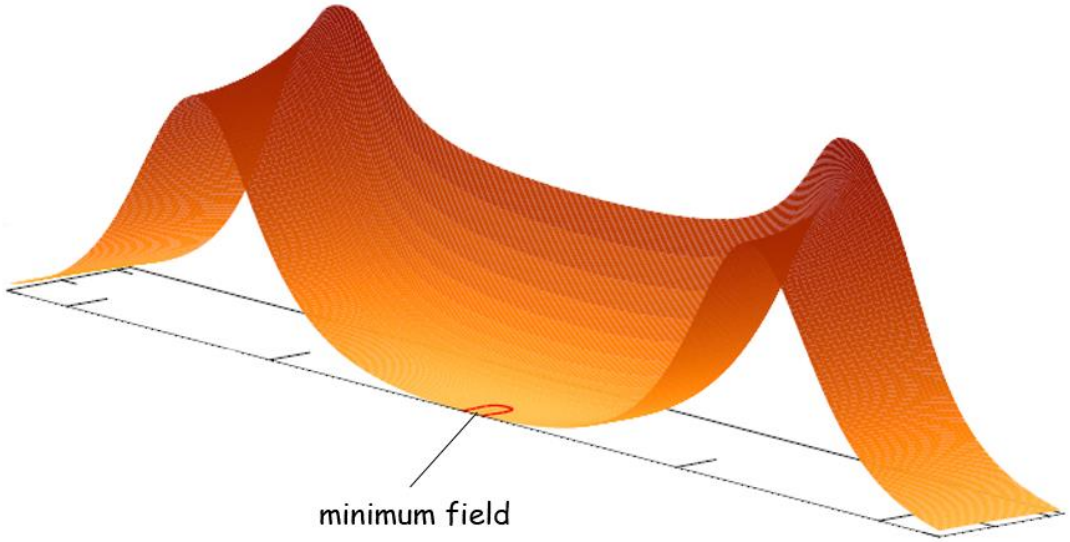
Penning Trap

- A widely-used charged particle trap
- Uniform magnetic field
- Quadratic electric potential



Magnetic Trap

- Trapping neutral particles with magnetic dipole moments (ex. Antihydrogen)
- Only antihydrogen with temperature lower than 0.5K can be trapped.

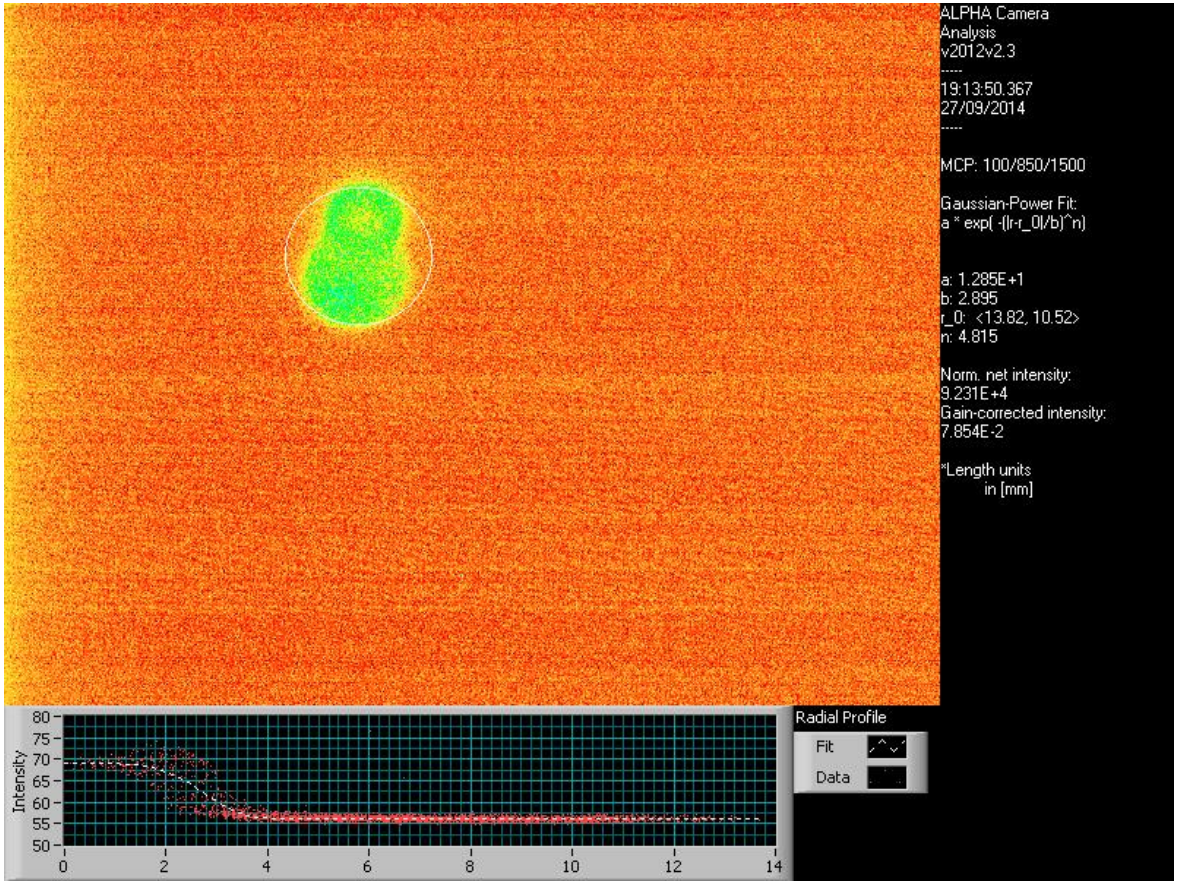


Microchannel Plate Detector (MCP)

- The “camera” of particle beams.
- An array of small electron multipliers
- Large potential difference across
- Particles are accelerated onto a phosphor screen to produce light.

My Project

- Image recognition and analysis for two circles

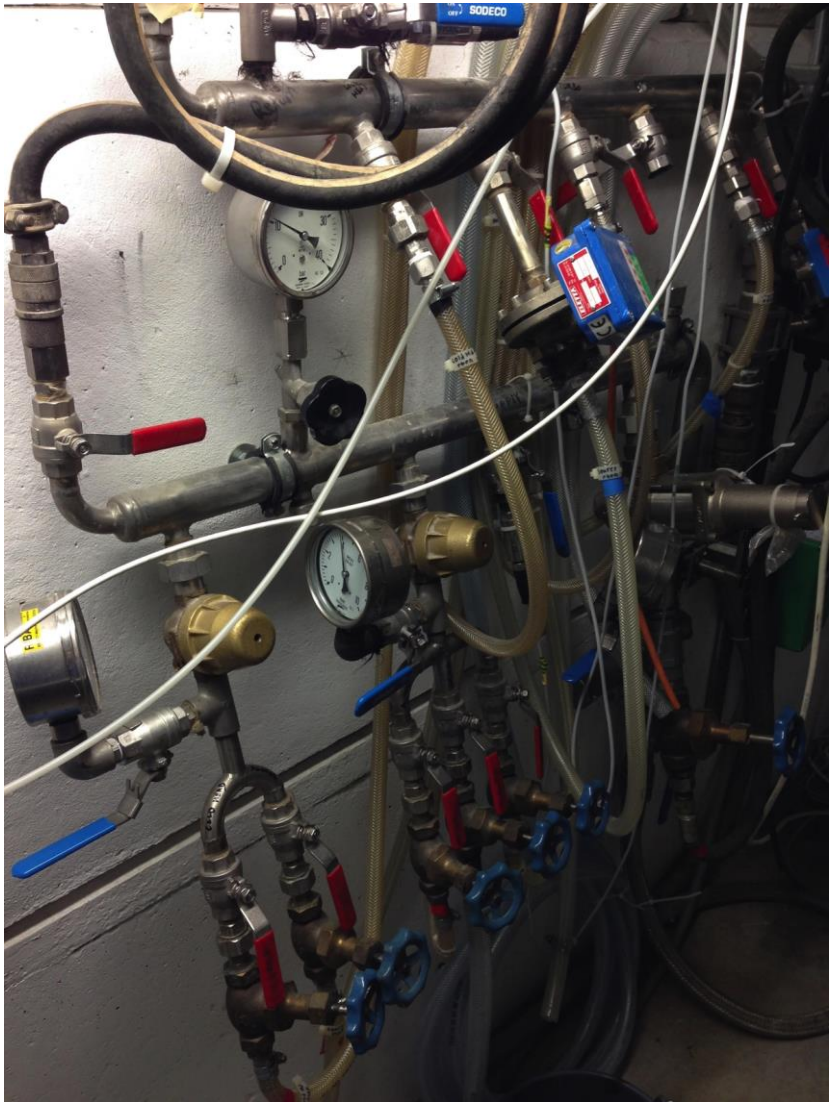


Other Responsibilities

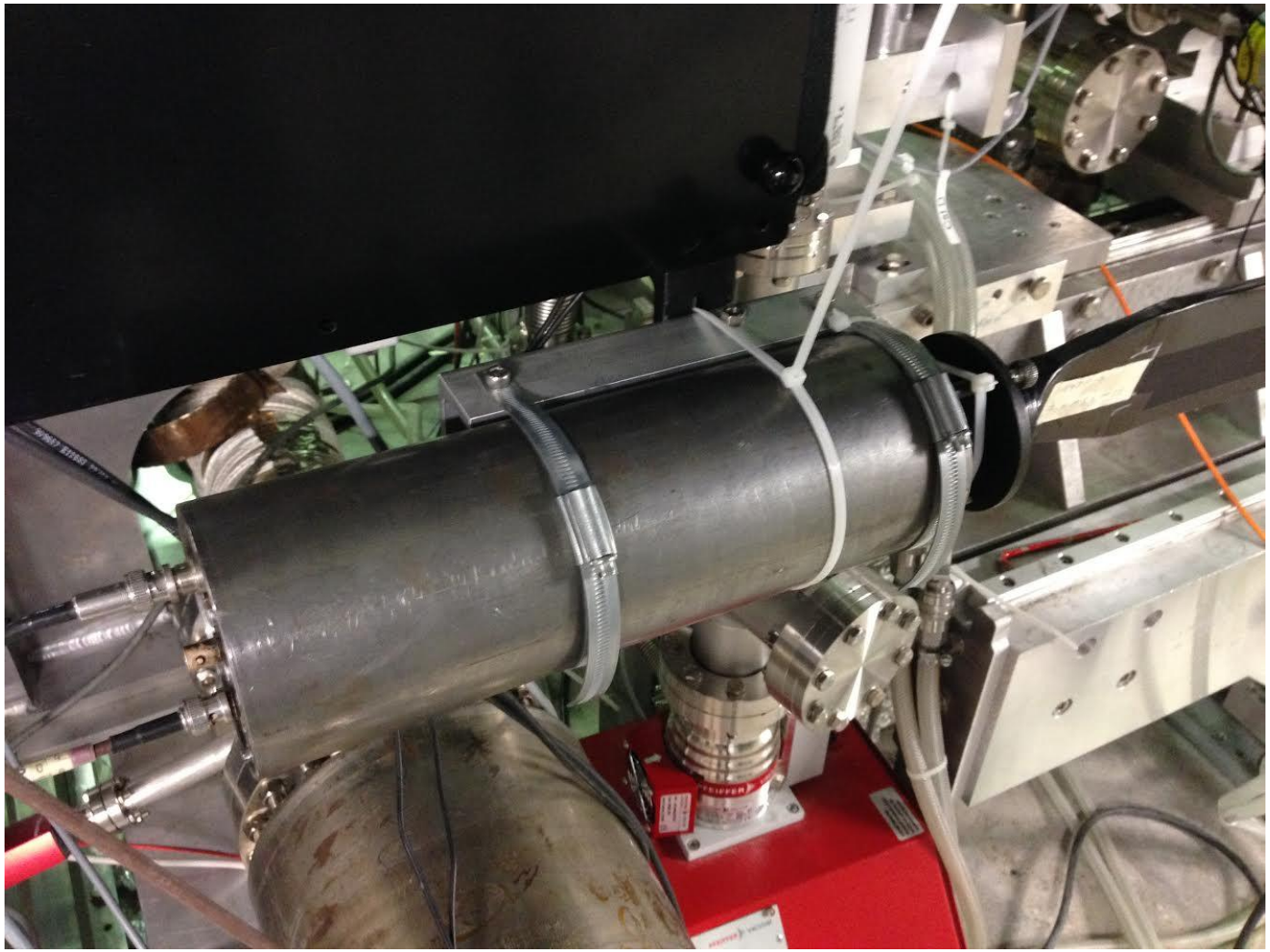
- Taking shifts
- Assembling zombie computers
- Helium transfer
- Hardware setup (e.g. MCP Voltage Test, PMT, Soldering, Plumbing, etc.)
- Optimize beam (e.g. Running Sequences)
- Temperature Analysis for Pbar and e+
- Trapping Analysis for antihydrogen
- Baselines

Helium Transfer

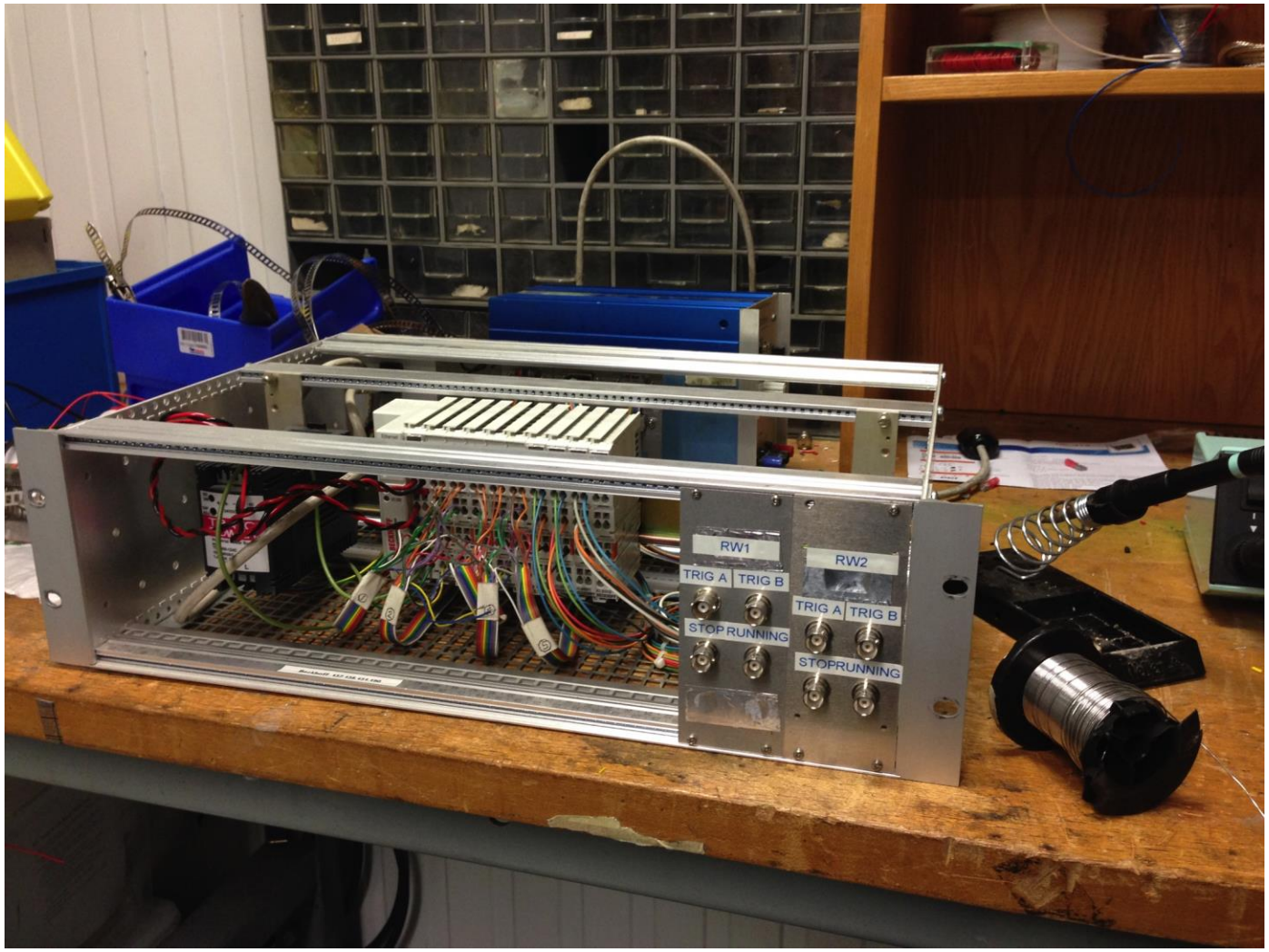
Plumbing



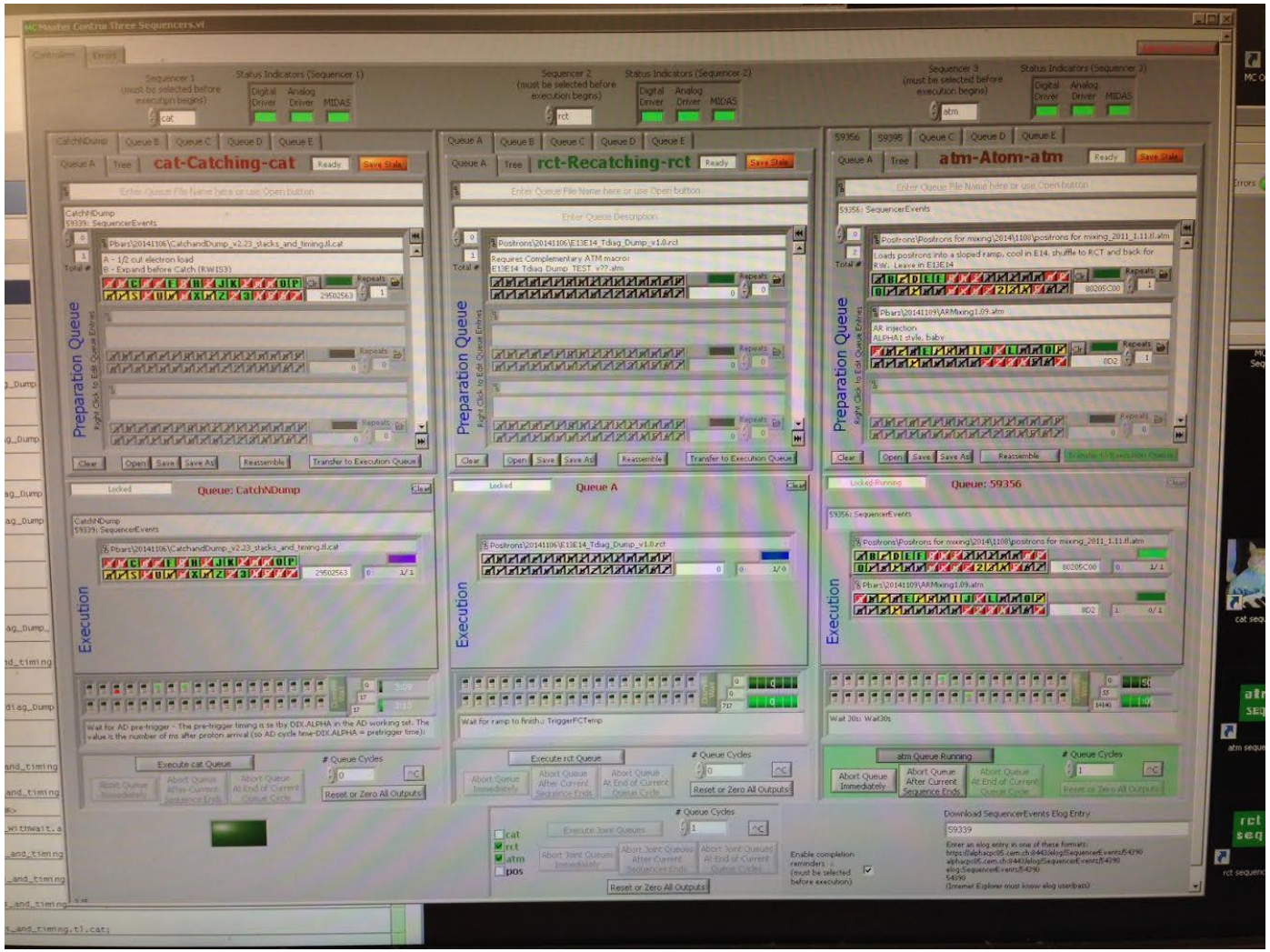
Setting Up PMT9



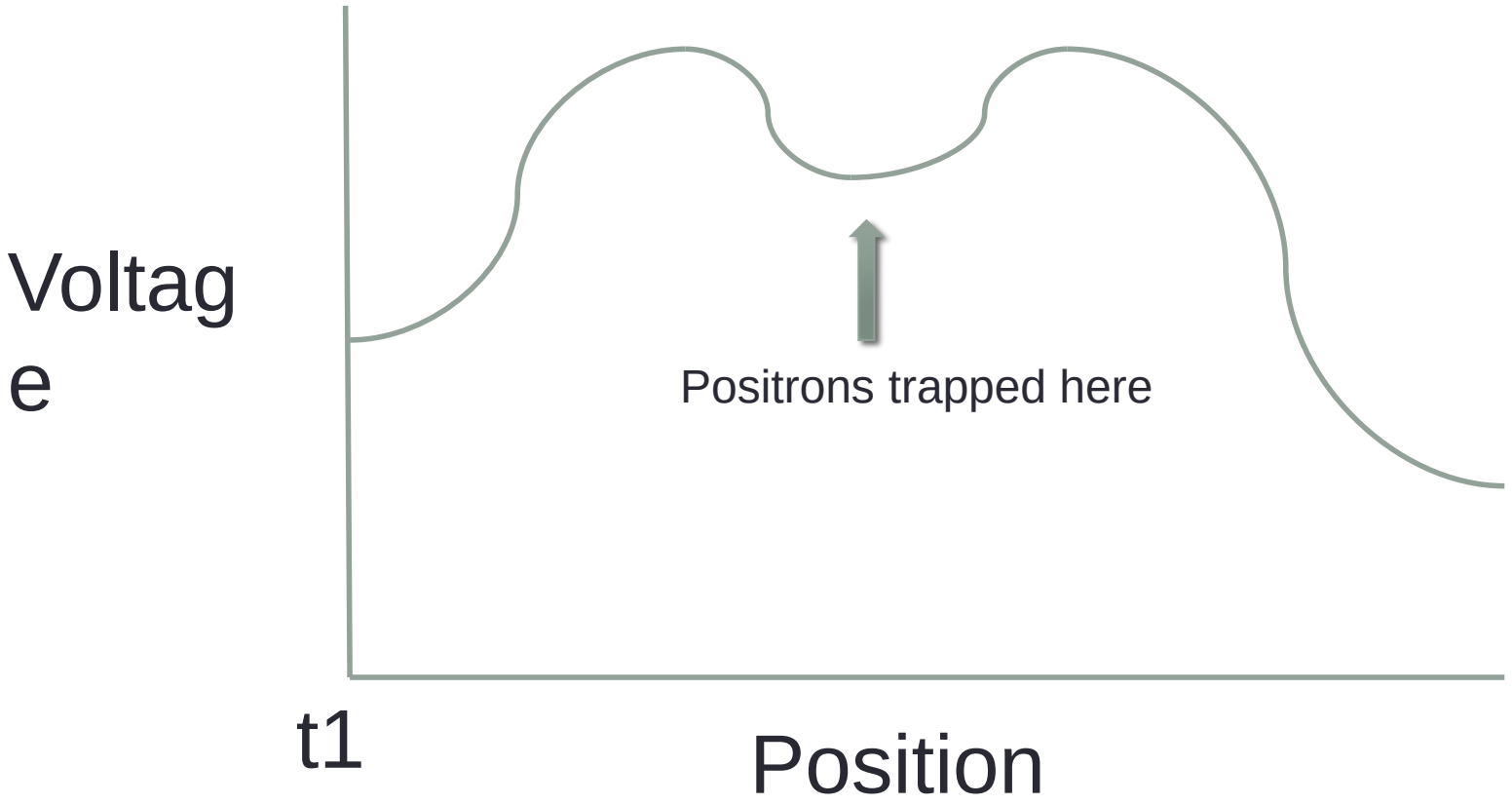
Soldering



Sequencer


MC Master Control Three Sequencers.vi
Sequencer 1 (must be selected before execution begins)
Status Indicators (Sequencer 1)
Digital Driver
Analog Driver
MIDAS
cat
Sequencer 2 (must be selected before execution begins)
Status Indicators (Sequencer 2)
rct
Sequencer 3 (must be selected before execution begins)
Status Indicators (Sequencer 3)
atm
CatchNDump
Queue A
Queue B
Queue C
Queue D
Queue E
Queue A
Tree
cat-Catching-cat
Ready
Save State
Enter Queue File Name here or use Open button
Preparation Queue
Right Click to Edit Queue Entries
Clear
Open
Save
Save As
Reassemble
Transfer to Execution Queue
Queue A
Tree
rct-Recatching-rct
Ready
Save State
Enter Queue File Name here or use Open button
Enter Queue Description
Preparation Queue
Right Click to Edit Queue Entries
Clear
Open
Save
Save As
Reassemble
Transfer to Execution Queue
59356
59395
Queue C
Queue D
Queue E
Queue A
Tree
atm-Atom-atm
Ready
Save State
Enter Queue File Name here or use Open button
Preparation Queue
Right Click to Edit Queue Entries
Clear
Open
Save
Save As
Reassemble
Transfer to Execution Queue
Locked
Queue: CatchNDump
Clear
Execution
Locked
Queue A
Clear
Execution
Locked/Running
Queue: 59356
Clear
Execution
Execute cat Queue
Queue Cycles
Abort Queue Immediately
Abort Queue After Current Sequence Ends
Abort Queue At End of Current Queue Cycle
Reset or Zero All Outputs
Execute rct Queue
Queue Cycles
Abort Queue Immediately
Abort Queue After Current Sequence Ends
Abort Queue At End of Current Queue Cycle
Reset or Zero All Outputs
atm Queue Running
Queue Cycles
Abort Queue Immediately
Abort Queue After Current Sequence Ends
Abort Queue At End of Current Queue Cycle
Reset or Zero All Outputs
cat
rct
atm
pos
Execute Joint Queues
Queue Cycles
Abort Joint Queues Immediately
Abort Joint Queues After Current Sequences Ends
Abort Joint Queues At End of Current Queue Cycles
Reset or Zero All Outputs
Enable completion reminders (must be selected before execution)
Download SequencerEvents Elog Entry
59339

TDiag – Temperature Measurement



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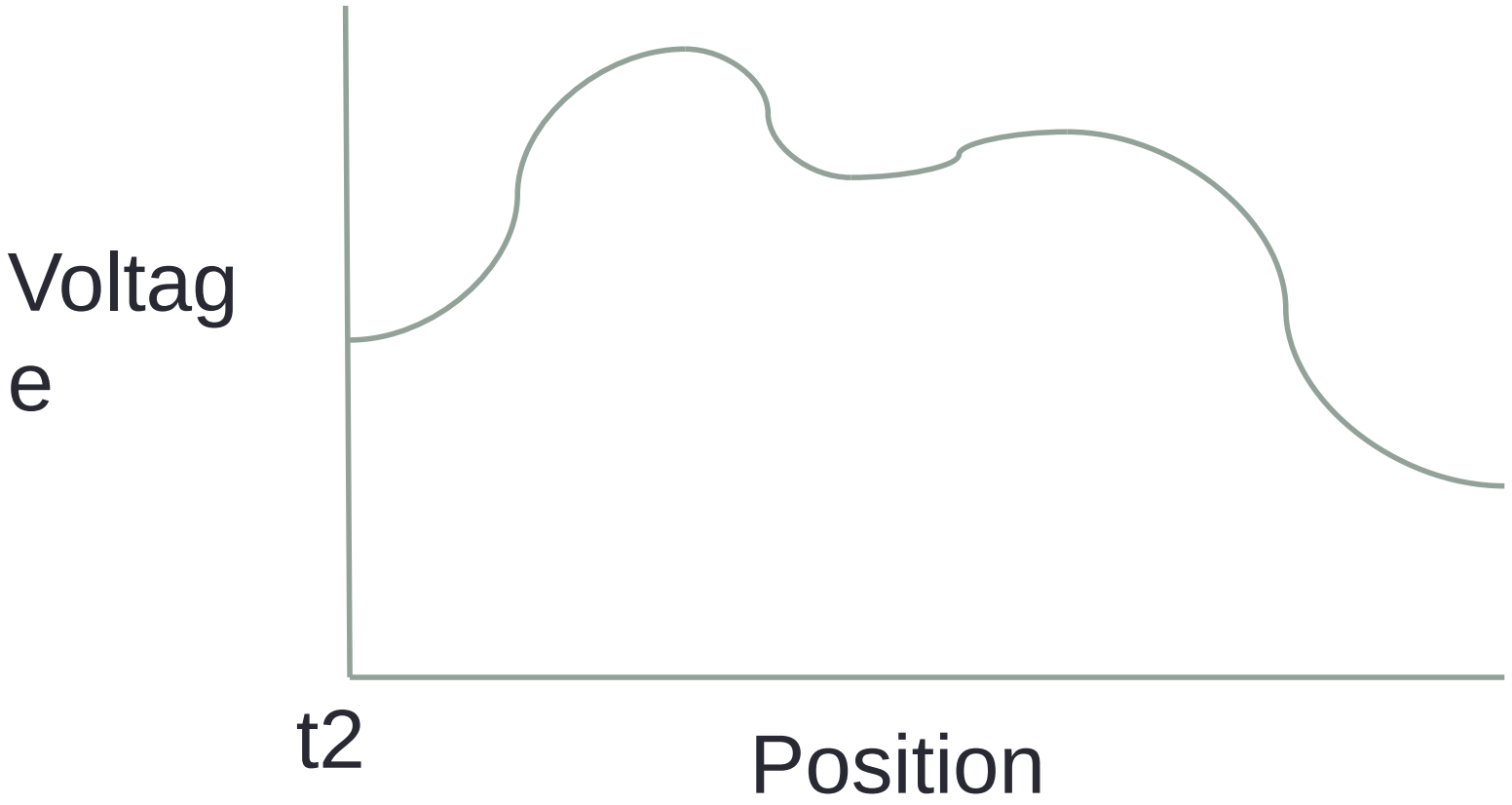
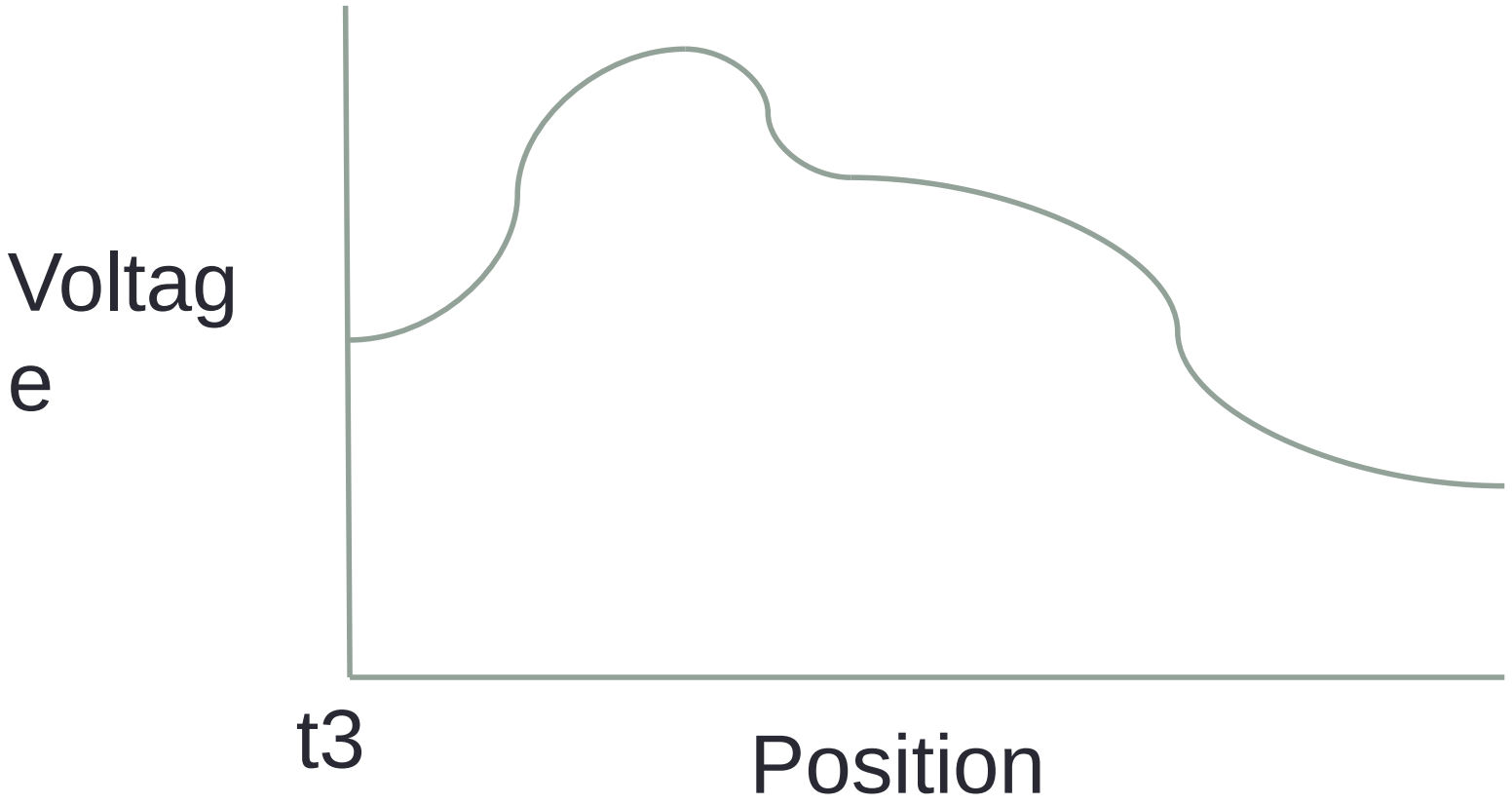
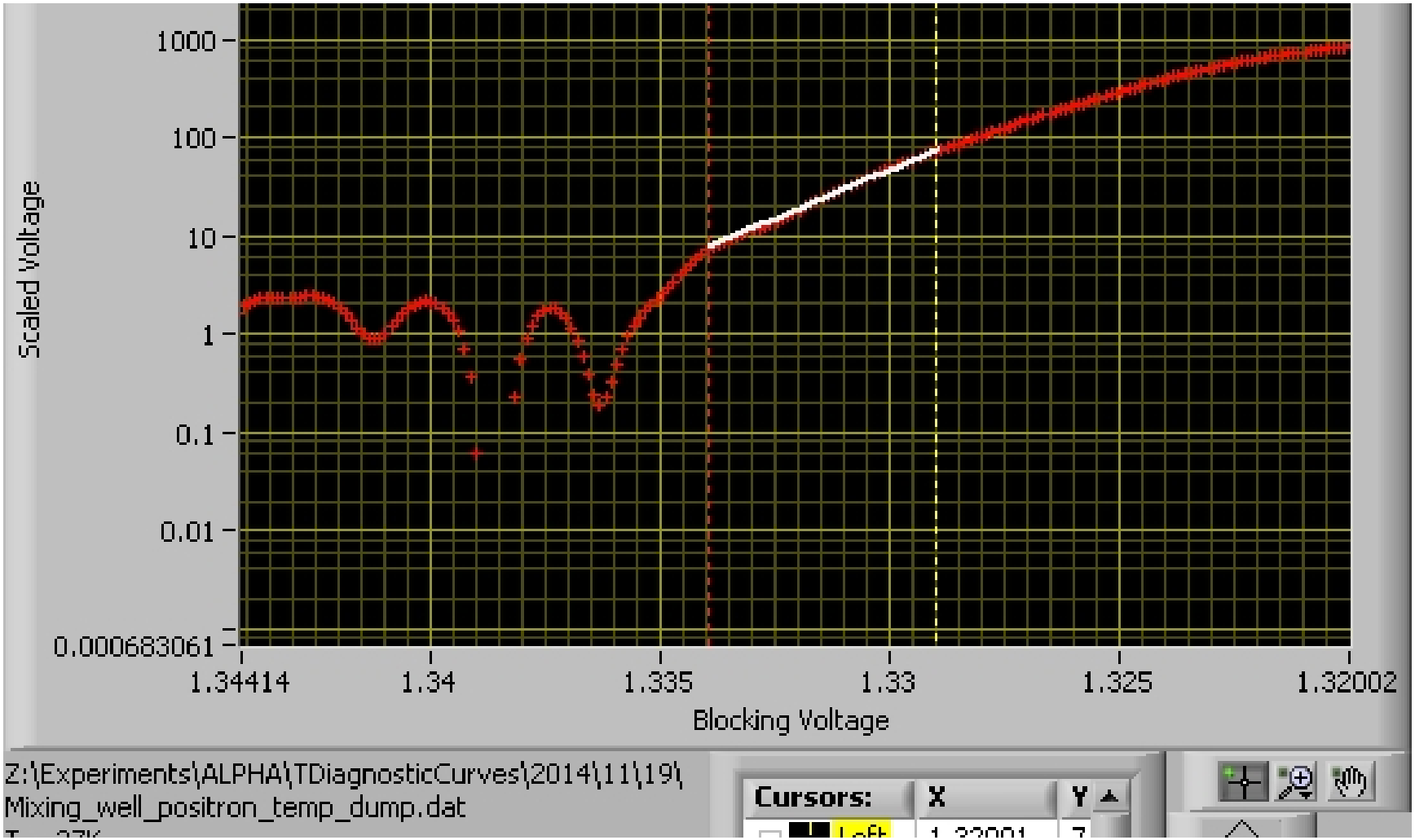


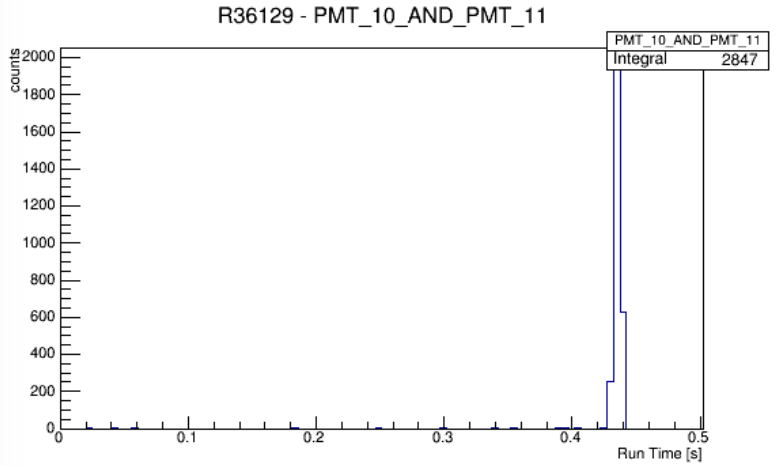
TDiag – Temperature Measurement

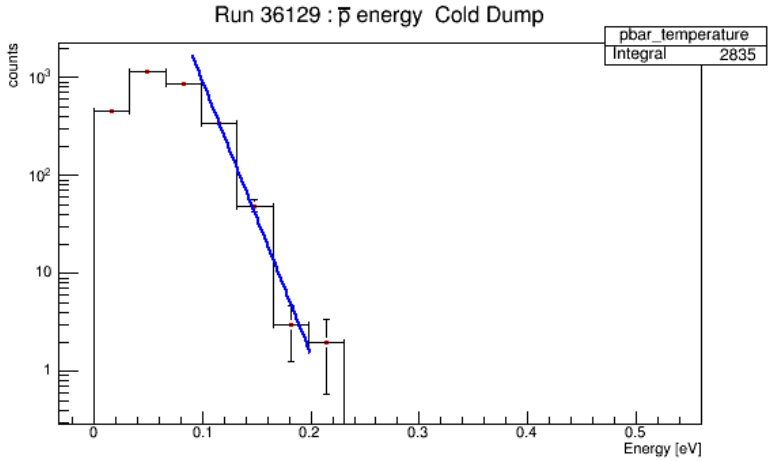


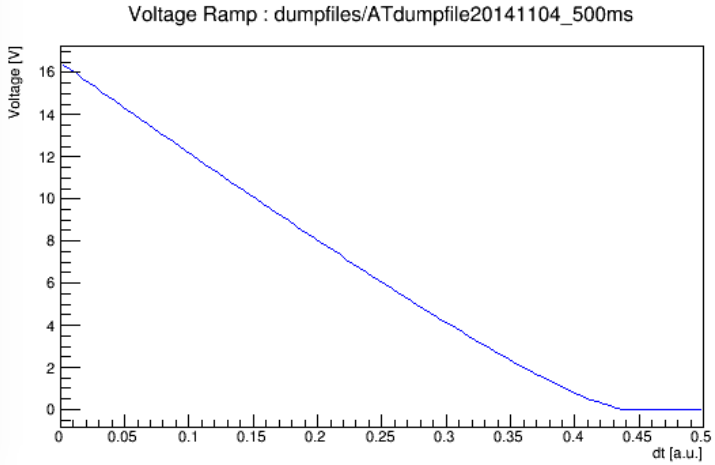
Half Load, RW, EVC 100%, TDiag



Full Xfer, Cool, RW, Ekick, TDump







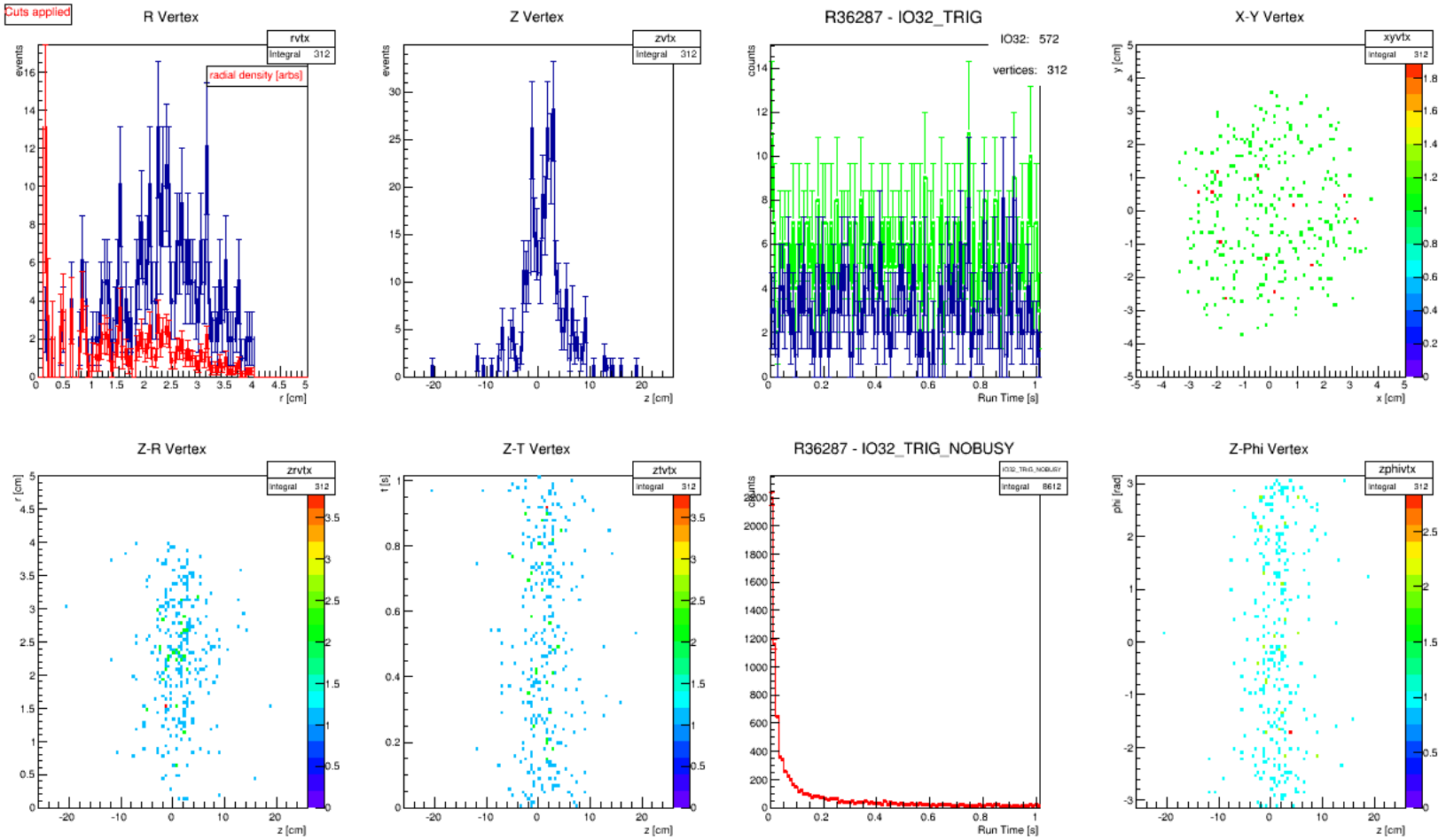
Energy Resolution 164.8 meV

Integral 2830.0

$\bar{p}$ temperature

(180.76 ± 10.43) K

Analyzing Trapping Data



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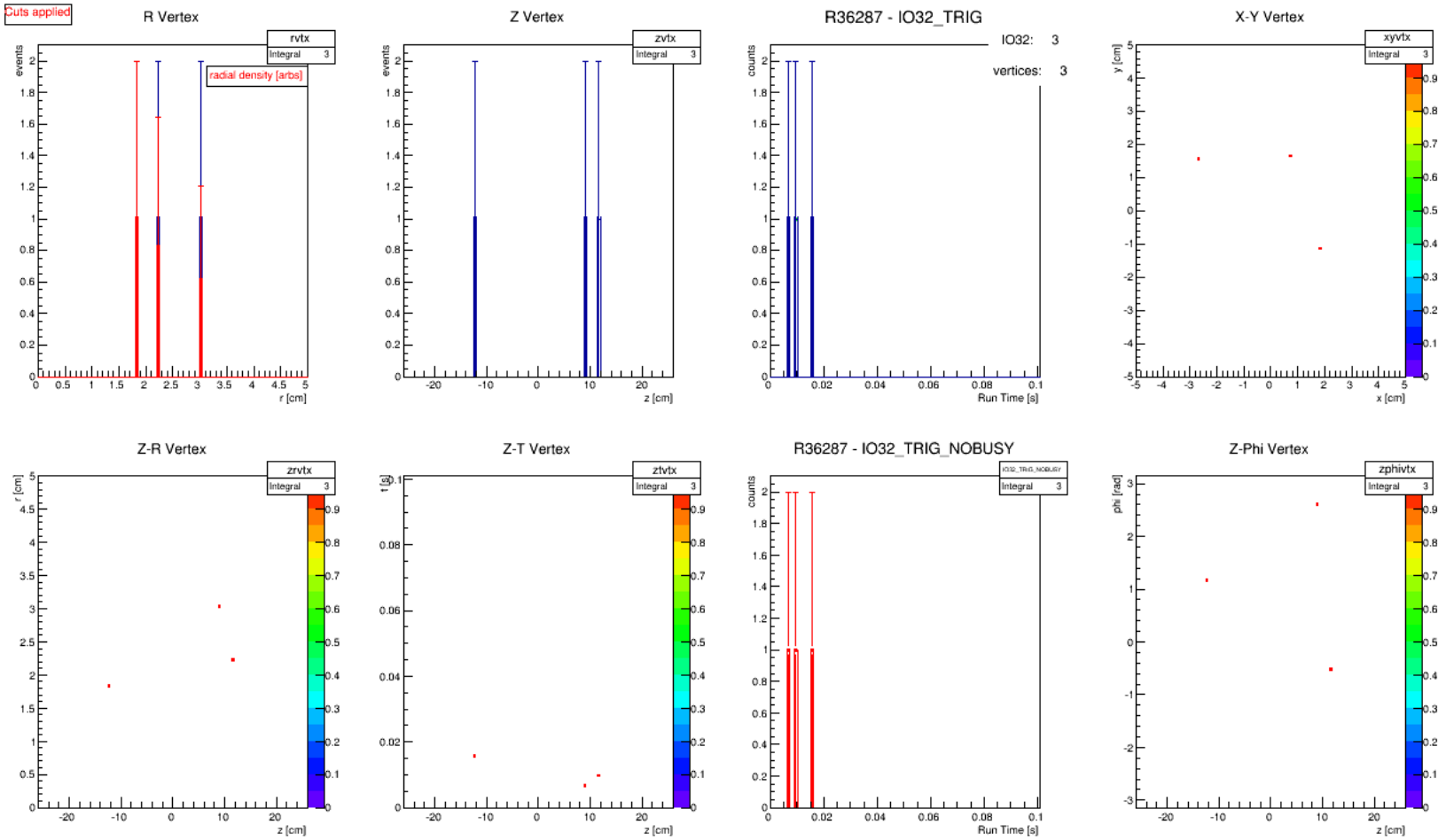
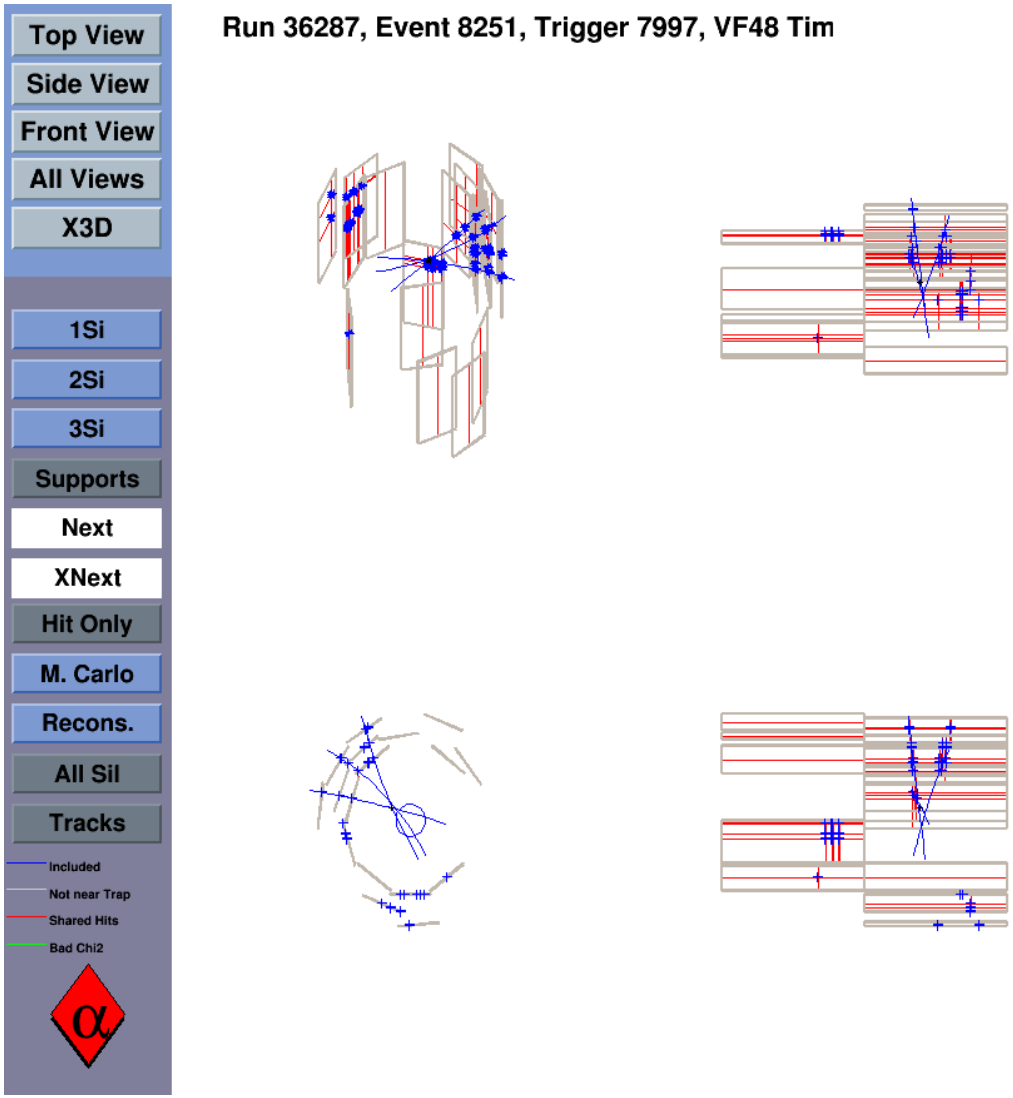
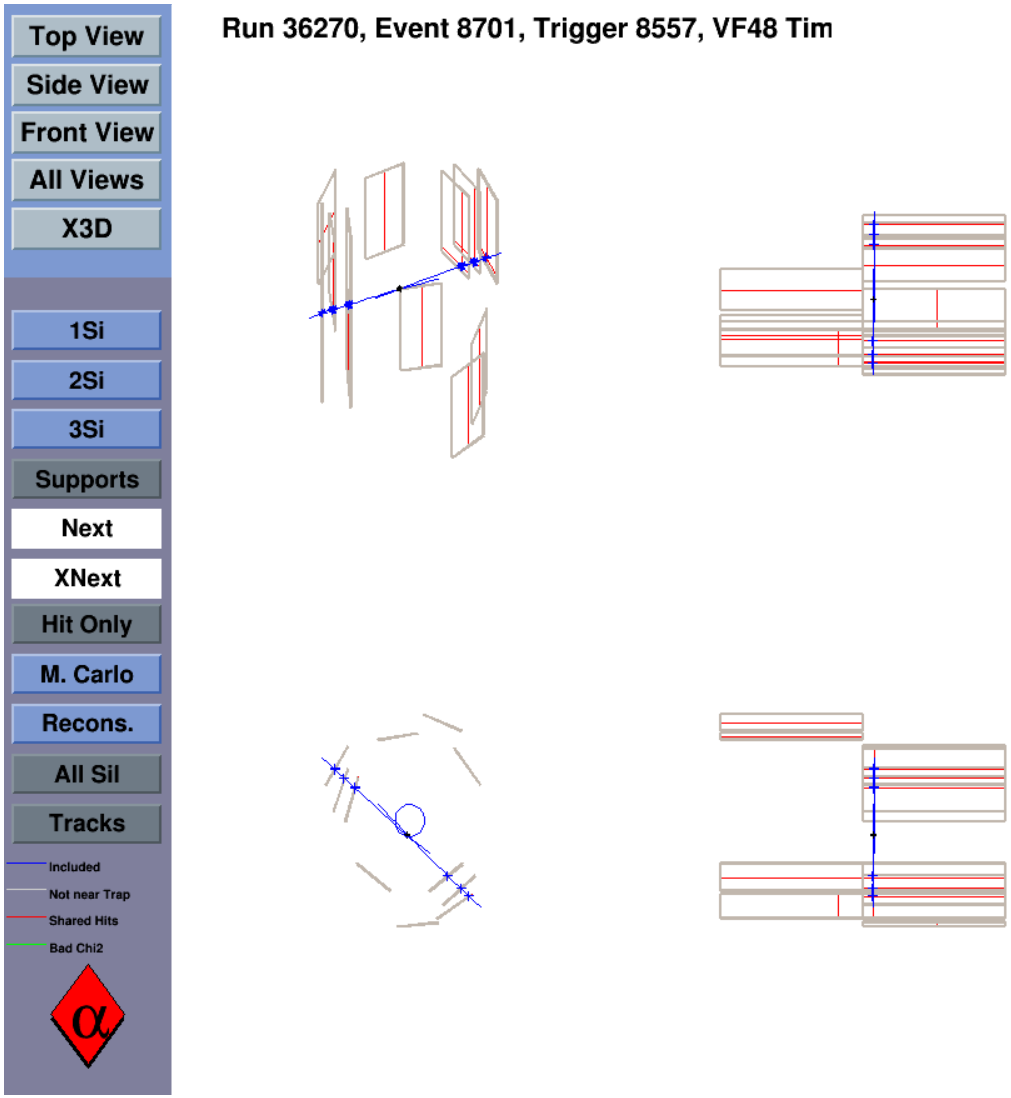


Passed-Cut


Top View
Side View
Front View
All Views
X3D
1Si
2Si
3Si
Supports
Next
XNext
Hit Only
M. Carlo
Recons.
All Sil
Tracks
Included
Not near Trap
Shared Hits
Bad Chi2
α
Run 36287, Event 8251, Trigger 7997, VF48 Tim

Cosmic Ray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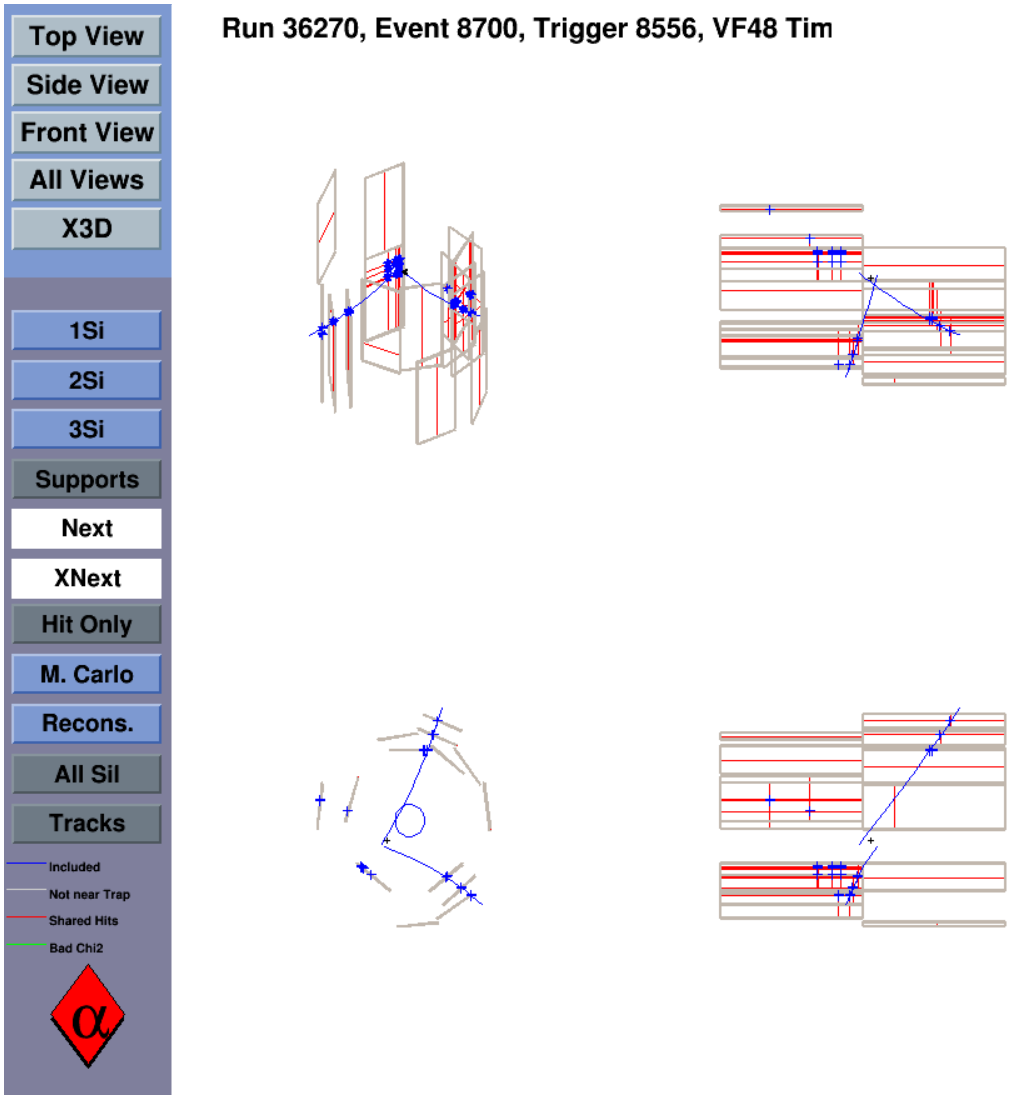
α
Run 36270, Event 8701, Trigger 8557, VF48 Tim

Non-Trivial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Tracks
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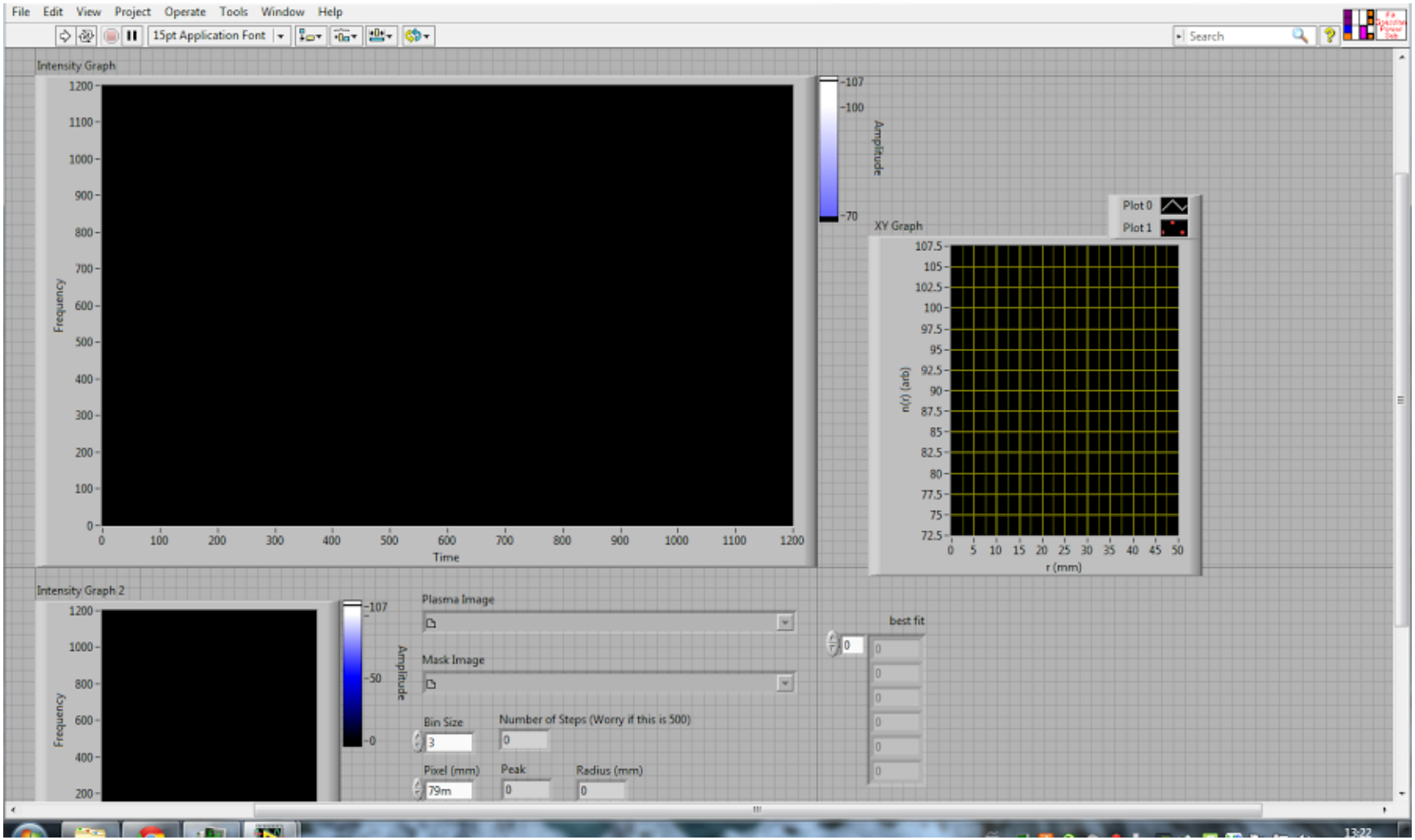
Bad Chi2
α
Run 36270, Event 8700, Trigger 8556, VF48 Tim

Working on: CUDA for Faster Analysis

- A parallel computing platform and programming model invented by NVIDIA.
- Enables dramatic increases in computing performance by harnessing the power of graphical processing unit.

Current GPU Analysis Interface



Thank you, Steven and Jean, for giving me this enriching experience, precious time in Europe and exposure to the best antihydrogen experiment in the world.

Thank you, my fellows, for teaching me useful conversational English and make me laugh all the time together.