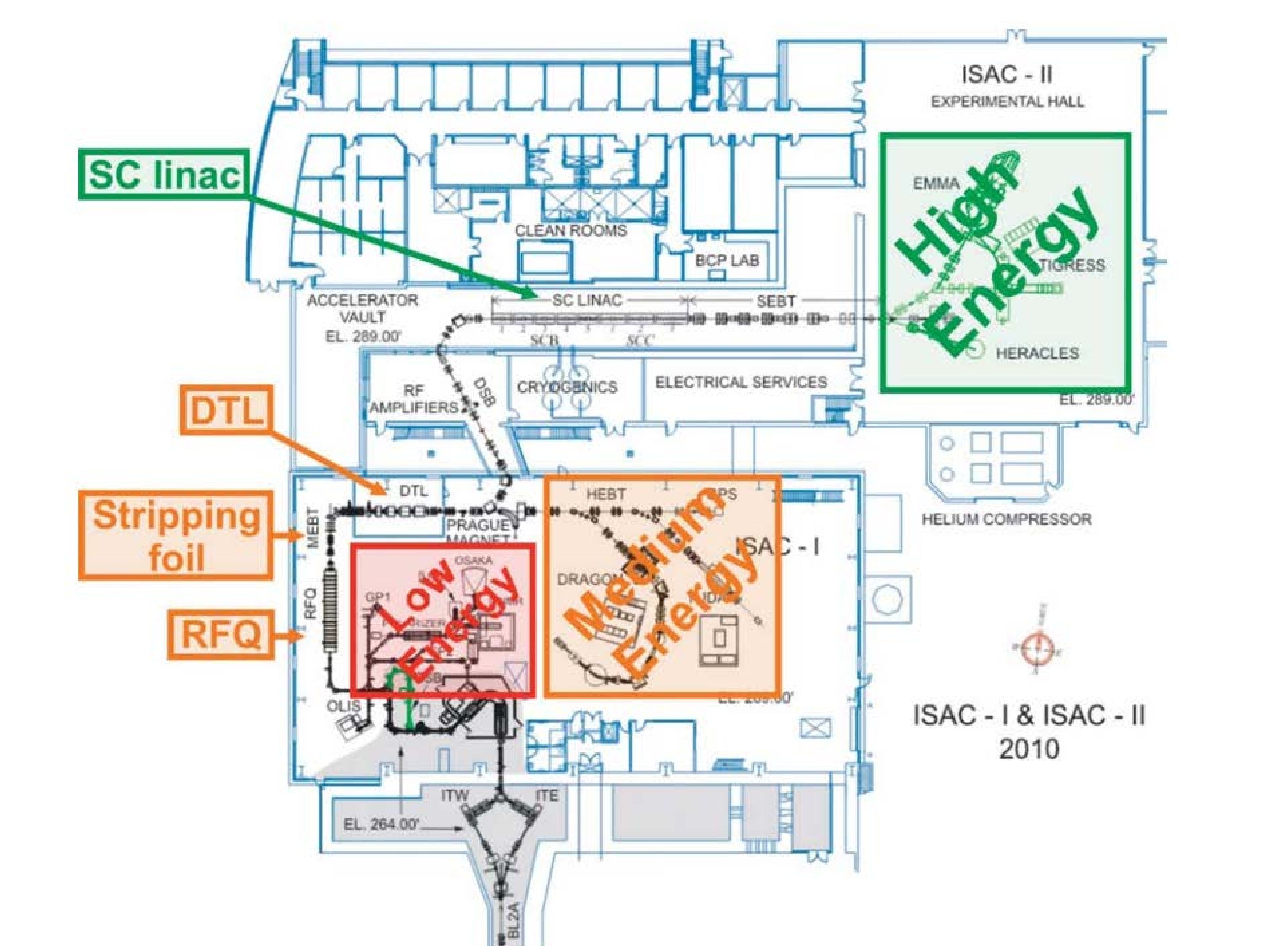
Visualizing Tunes

Or:

How I Learned to Stop Worrying and Love Theory

Olivier Shelbaya

Isotope Separator and Accelerator (ISAC)



Background

- Two on-line target stations, one off-line
- 17 experiments
- 15 separate beam paths

- ~4500h/y (~188d) off-line source availability
- ~3100h/y (~130d) on-line RIB to experiments

- Roughly one setup per 10 days (usually with different A/q's)

TRIUMF

Our Mission

Deliver beam:

- On schedule
- With a stable tune
- In a systematic and reproducible manner

We're particularly concerned with incorrectly set beamline optics values, as this is a completely preventable source of downtime
(and within our control)

TRIUMF

ISAC Beamlines

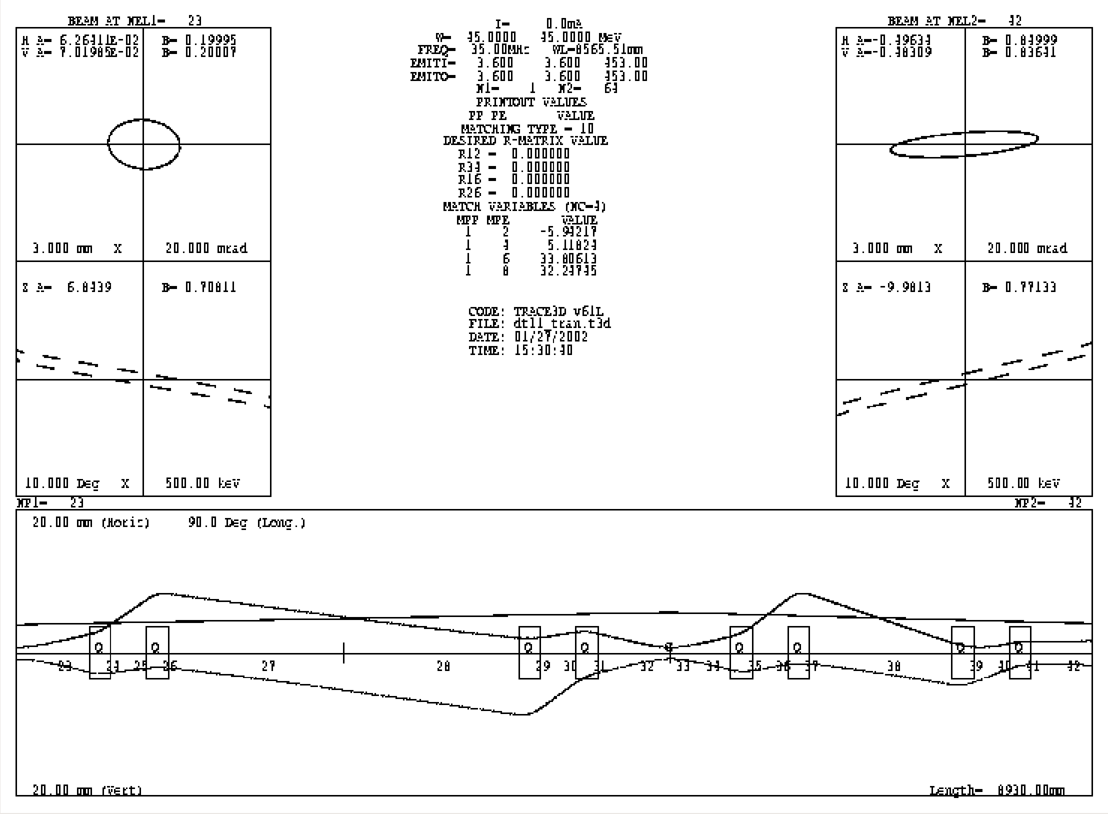
Three main types of beamlines:

- Matching sections
- Transport sections
- RF/Accelerator cavities

Transport Sections

Transport sections make up most of our beam paths.

- Require specific input emittance and geometry.
- Should <u>not</u> be tuned, only set.

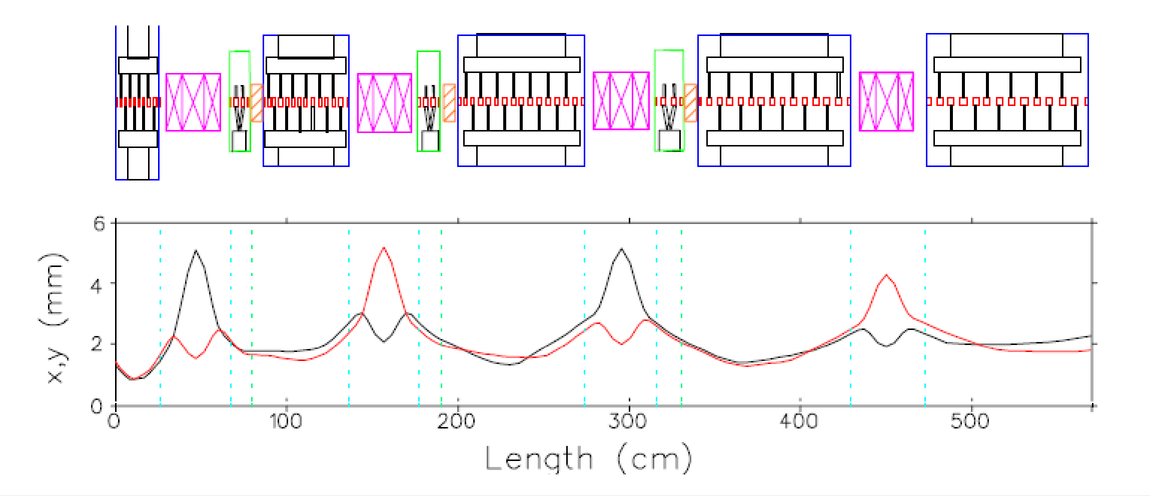


Example ISAC-I transport section (HEBT).

Matching Sections

Matching sections allow us to shape the beam for optimal transmission through transport sections.

These can be tuned to your heart's content*.

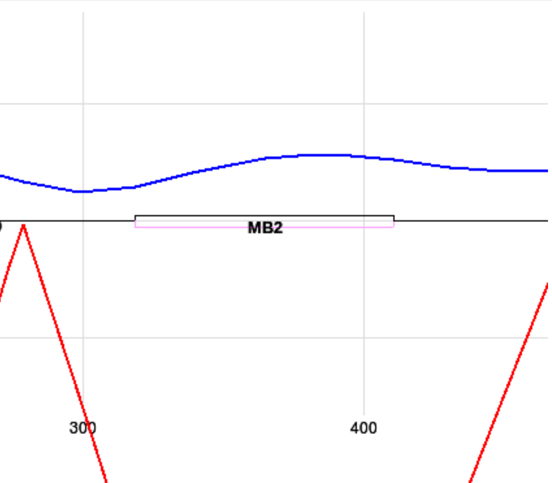


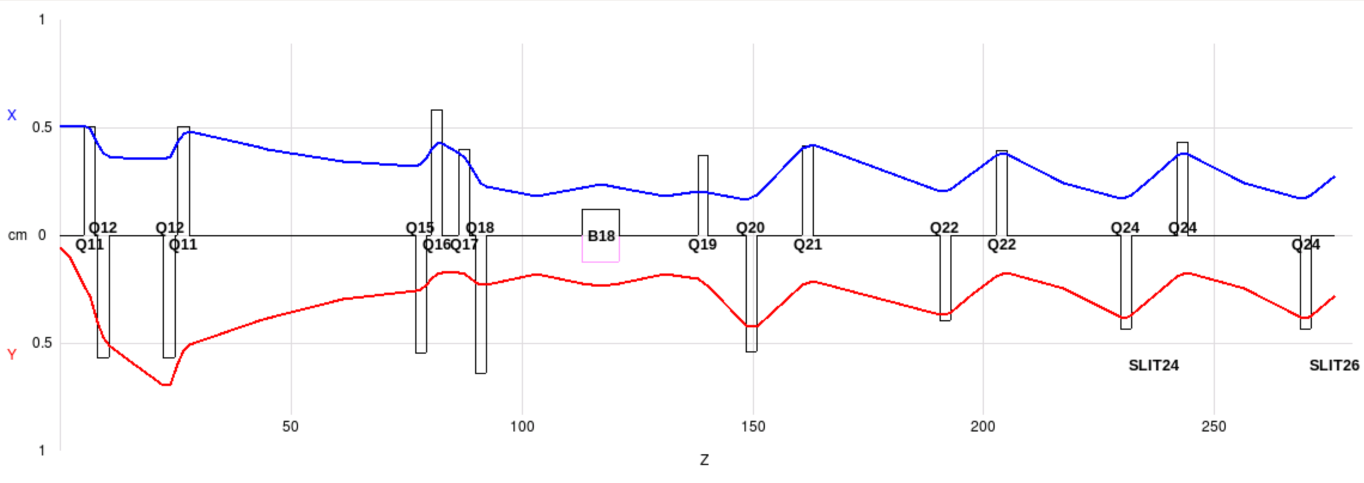
ISAC DTL – the pink quad triplets act as matching sections into the IH RF tanks.

*within reason

What Makes a Good Tune?

- Centered (x,y) beam (no ‘slalom’ steering)
- Quads on theory, esp. in transport sections
- Quads do not steer beam
- Matching optics tuned as little as possible





TRIUMF

What a Good Tune Does

- It can be scaled from one A/q to the next
- It has good transmission

  (it minimizes radioactive beam dumped along its path)
- It makes troubleshooting easier
- It crosses several operator shifts seamlessly

Good tunes save time

TRIUMF

How Tunes are [ideally] Established

- Exp't specifies requirements (e.g. beam spot size, intensity, purity)
- ISAC Ops loads theoretical quad. values.
- Matching sections tuned for transmission/beam profile
- Experiment proceeds

Tune for Match through Buncher to RFQ

RIB OLIS

Beam Extraction voltage = 26.000 kV

Change

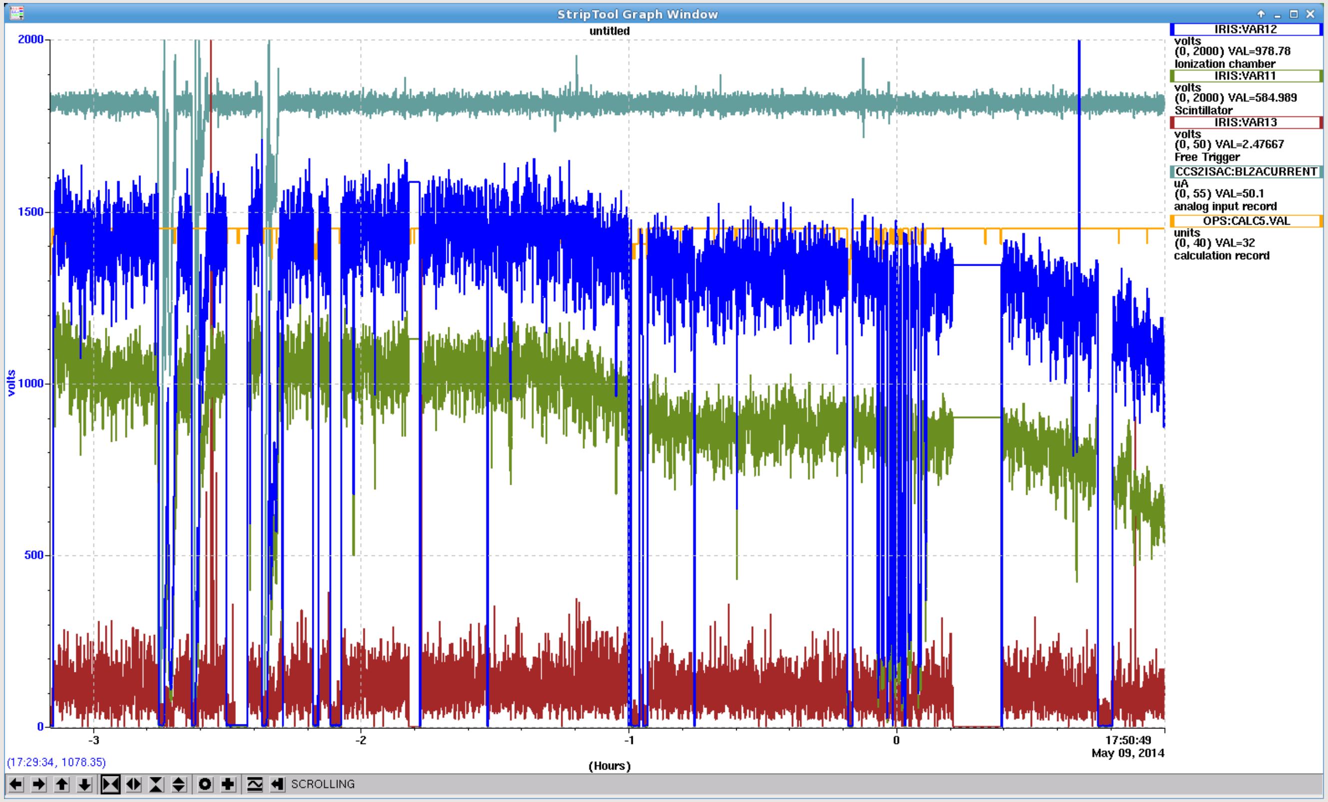
Name	Tune A	tune B
ILT:Q34	.996	.994
ILT:Q35	3.271	4.060
ILT:Q36	2.045	3.456
ILT:Q37	.000	1.164
ILT:Q41	.996	.994
ILT:Q42	.425	
ILT:B43:POS	3.628	
ILT:B43:NEG	4.216	
ILT:Q43	1.996	
ILT:Q44	.922	
ILT:B46:POS	3.628	
ILT:Q48	.882	
ILT:Q50	.751	
IRA:Q1	.620	
IRA:Q2	1.033	
IRA:Q3	1.805	
IRA:Q4	1.282	

Rick Baartman
Last modified: Wed Dec 5 23:44:37 PST 2001

Transport section theory values

What Can [non-ideally] Occur…

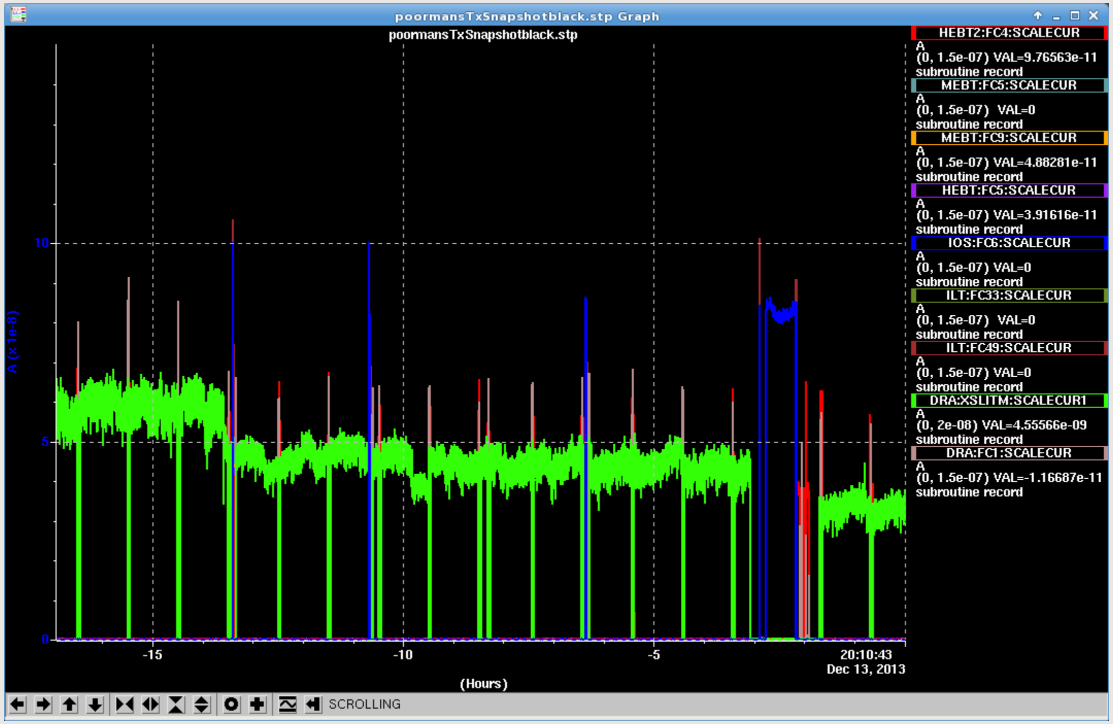
-Tune established to exp't.



…Counts start dropping (temperature, transients, etc..)

What Can [non-ideally] Occur… (cont'd)

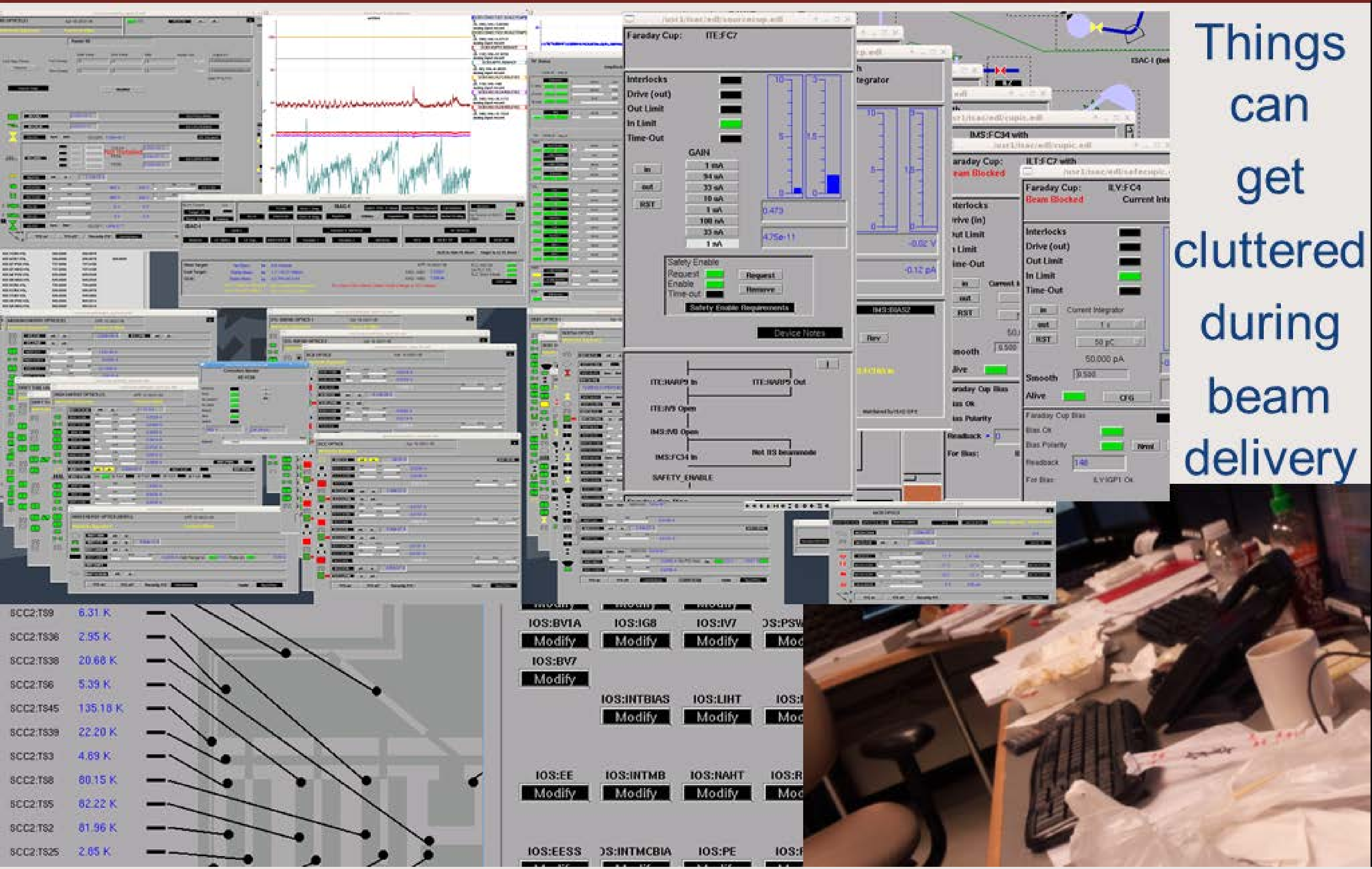
- On-line tuning brings counts back



Tune deteriorates over time, as several shifts tune different segments, each responding to different causes of transmission loss.

TRIUMF

Challenge: Information Density



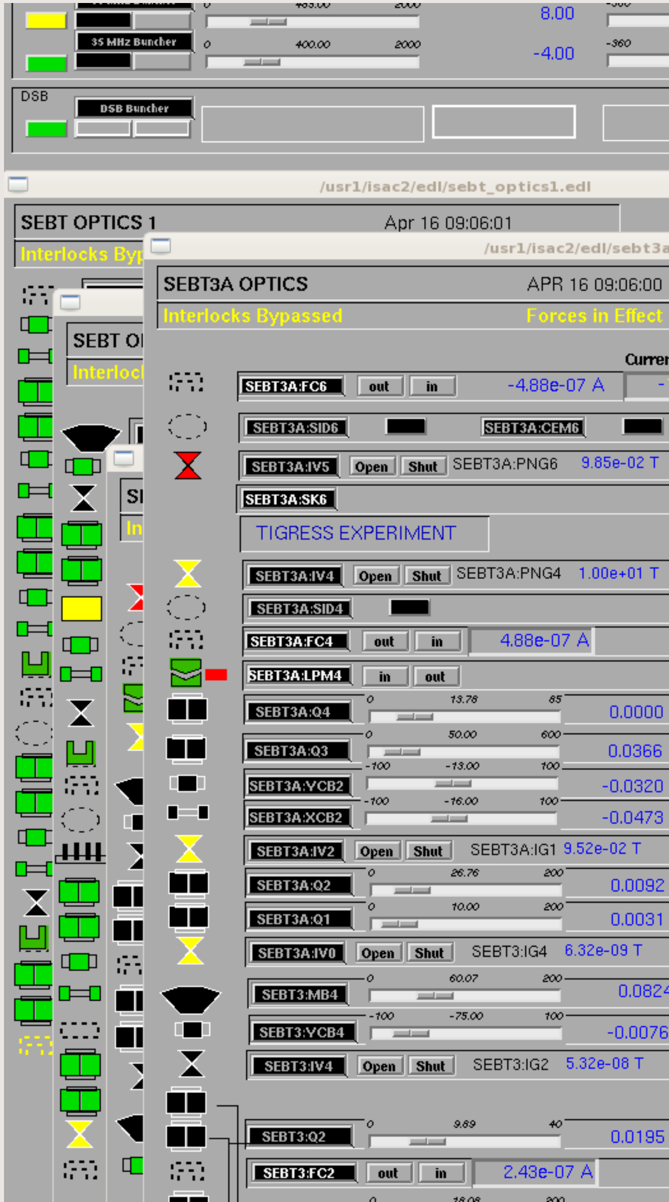
Things can get cluttered during beam delivery

Information Density

- Up to 300 elements in some beam paths
- Up to 50 open pages

(on several machines)

- No automatic A/q ‘loader’
- Possibility of human error



TRIUMF

The Problem

Previously, we couldn't quickly visualize the status/quality of a tune.

Transmission to experiment dropping.

What's going on?

What's the tune look like?

Are transport sections at theory?

Are matching sections over/under tuned?

TRIUMF

TuneDisplay

TuneDisplay generates a visual representation of the tune & <u>its overall quality & steering</u>

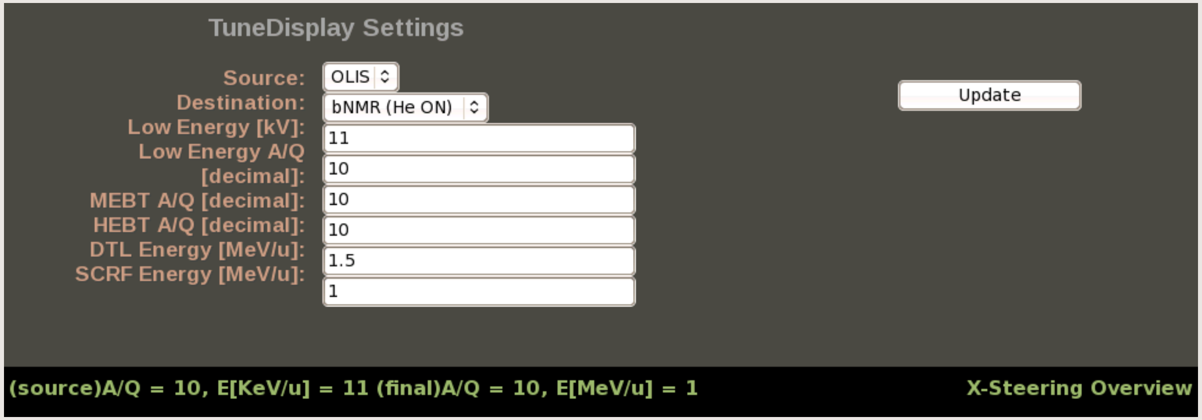
<u>Tune quality</u>: % deviation between quad setpoint and theoretical value.

Intended to make:

- troubleshooting easier
- tunes more transparent

About TuneDisplay…

- Is Perl based
- Requires user input (isotope, a/q, energy)



- Computes theory values for quads & compares them to current values.
- HTML plotting based on HighCharts API

Quadrupole Theory Values

Theory values – electrostatic for LE, magnetostatic for HE (post RFQ accelerator).

Quad voltage/current [U]:

$$U_Q = m_0 + m_1 \left|\frac{A}{q}C\right| + m_2 \left|\frac{A}{q}C\right|^2 + m_3 \left|\frac{A}{q}C\right|^3 + m_4 \left|\frac{A}{q}C\right|^4$$

where:

$C = \nabla V$ for electrostatics [kV/cm], or

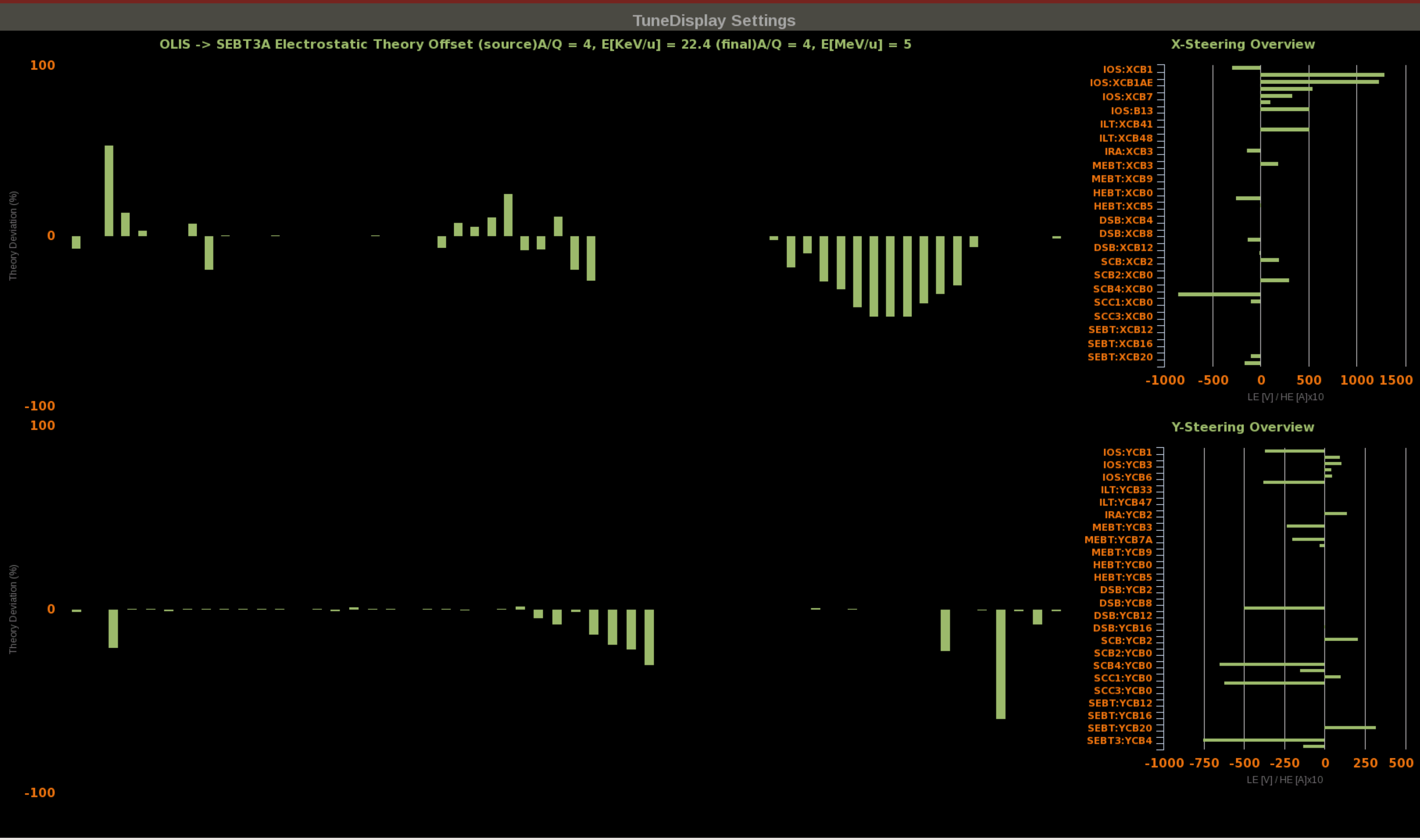
$C = \nabla A$ for magnetostatics [kG/cm].

m_i are quadrupole parameters, specific to quad geometry

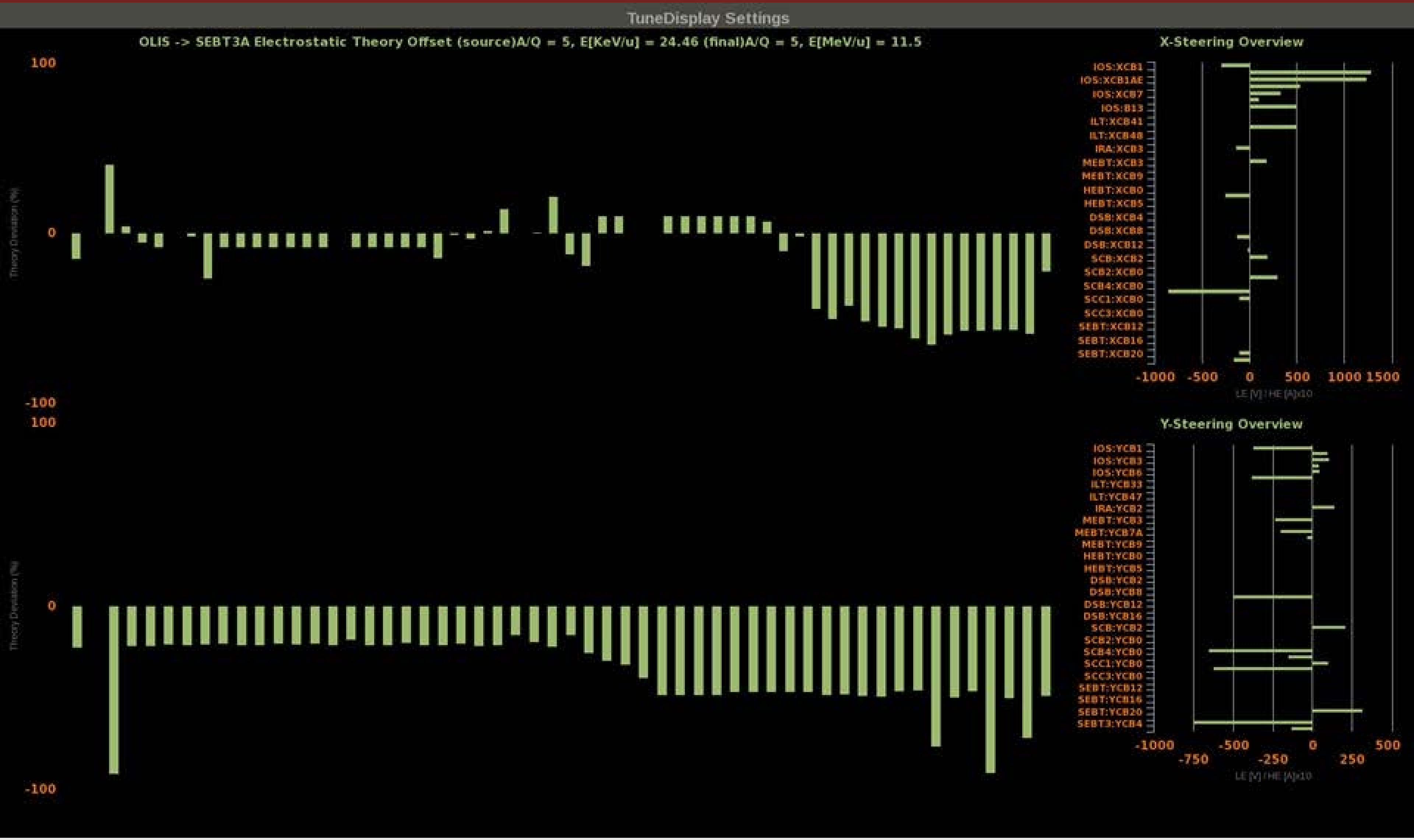
EPICS polling

- EPICS is polled once/min along selected path
- Polling accomplished via BurtRB (c++)
- Polling takes ~4sec
- Polled values divided by theory values, multiplied by 100 for a % difference from theory
- Quads w/ theory = 0 are not polled (for now).

Example: A Good Tune



Example: A [very] Bad Tune



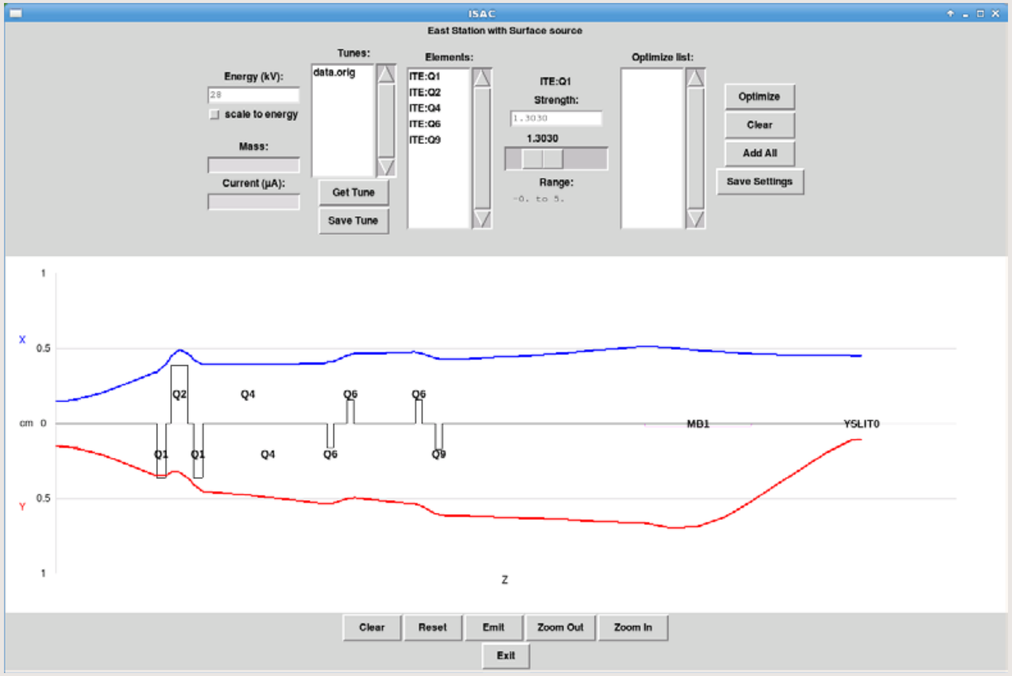
Planned Developments

#0 Fix bugs

#1 Elegant element name display

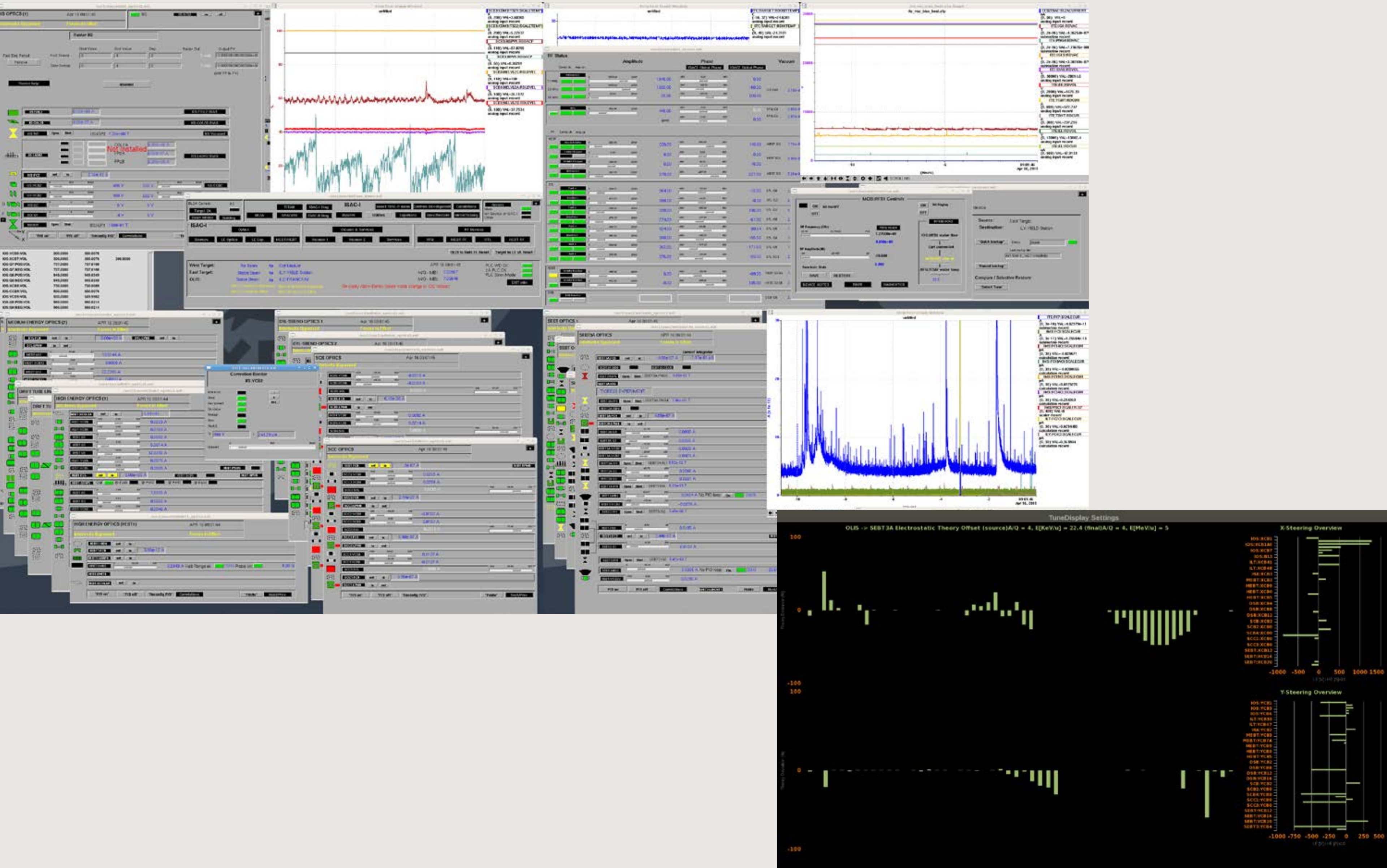
#2 Superimpose cup readings

#3 Tie-in with ISAC ops beam envelope calculator



TRIUMF

Conclusion



Thank you!
Merci

TRIUMF: Alberta | British Columbia | Calgary | Carleton | Guelph | Manitoba | McGill | McMaster | Montréal | Northern British Columbia | Queen's | Regina | Saint Mary's | Simon Fraser | Toronto | Victoria | Western | Winnipeg | York