

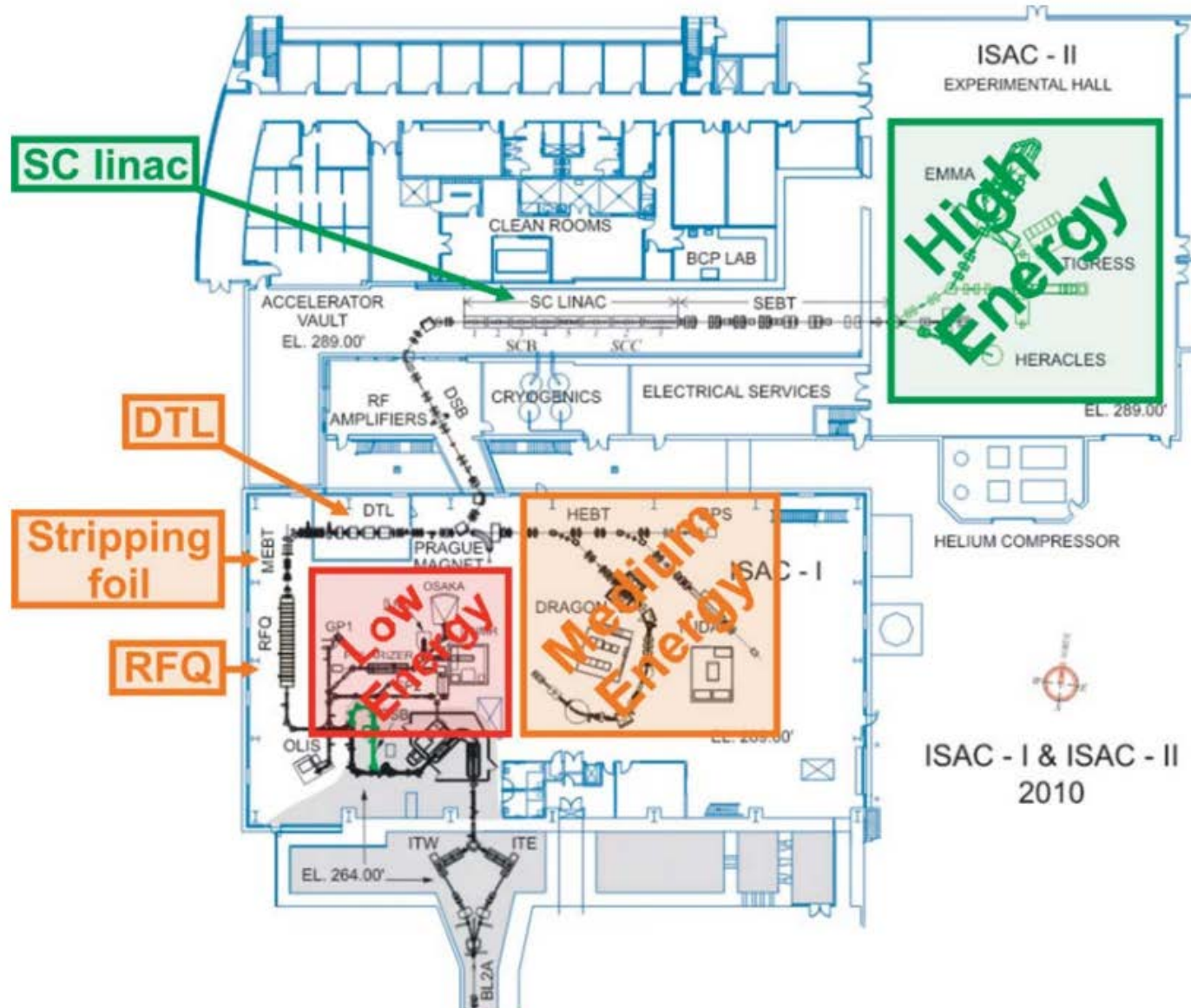
Visualizing Tunes

Or:

How I Learned to Stop Worrying and Love Theory

Olivier Shelbaya

Isotope Separator and Accelerator (ISAC)



- 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)

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)

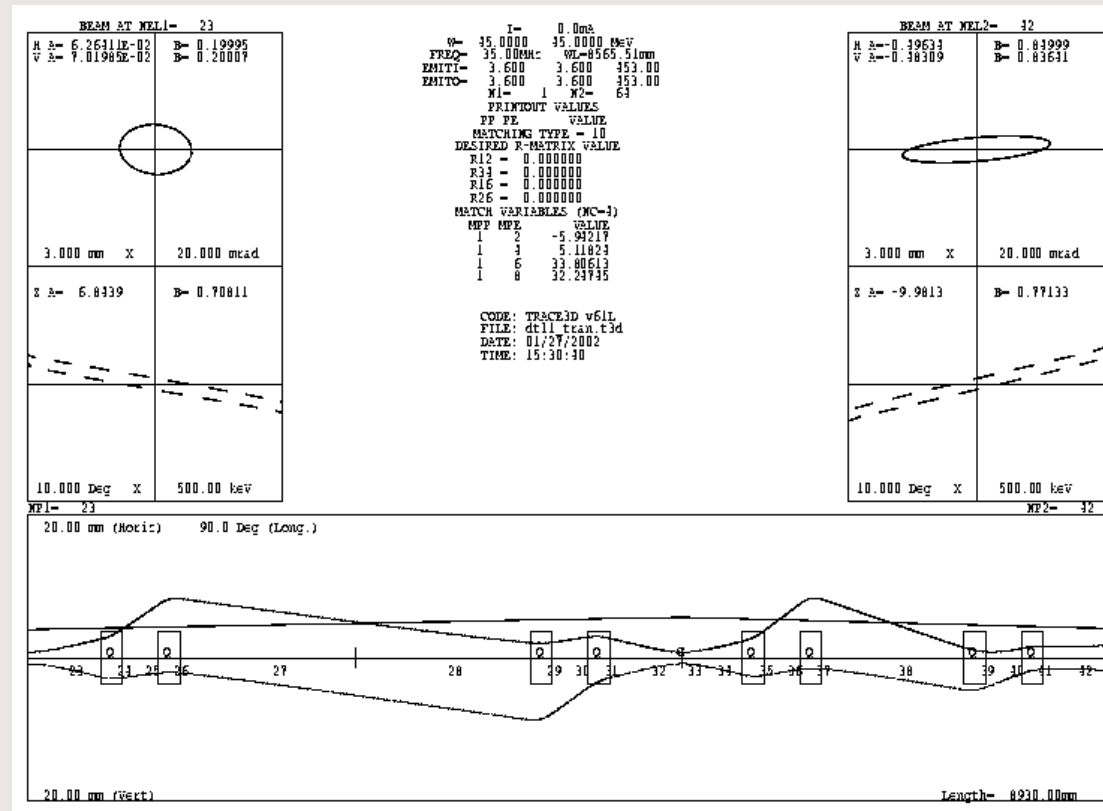
Three main types of beamlines:

- 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 not be tuned, only set.

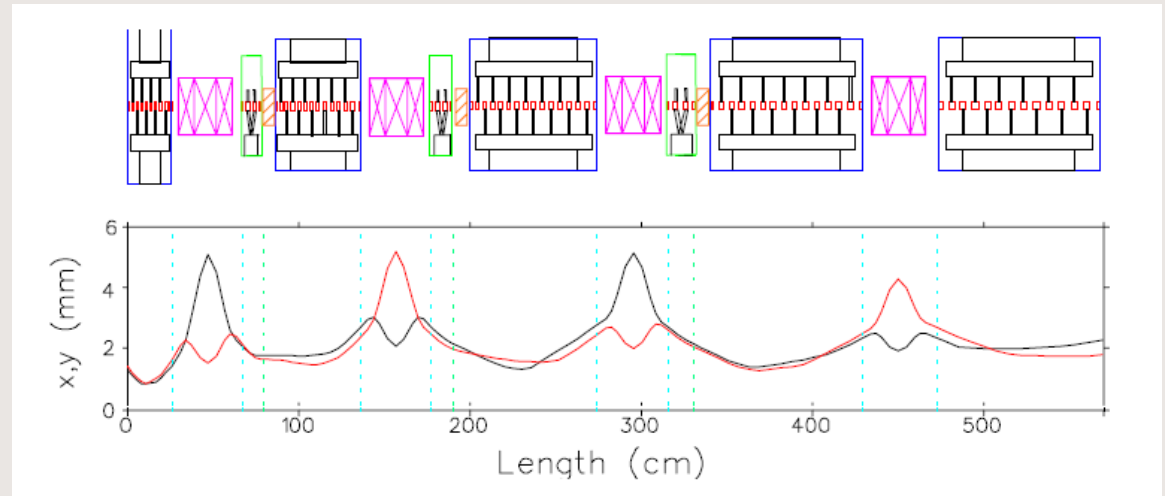


Example ISAC-I transport section (HEBT).

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*.

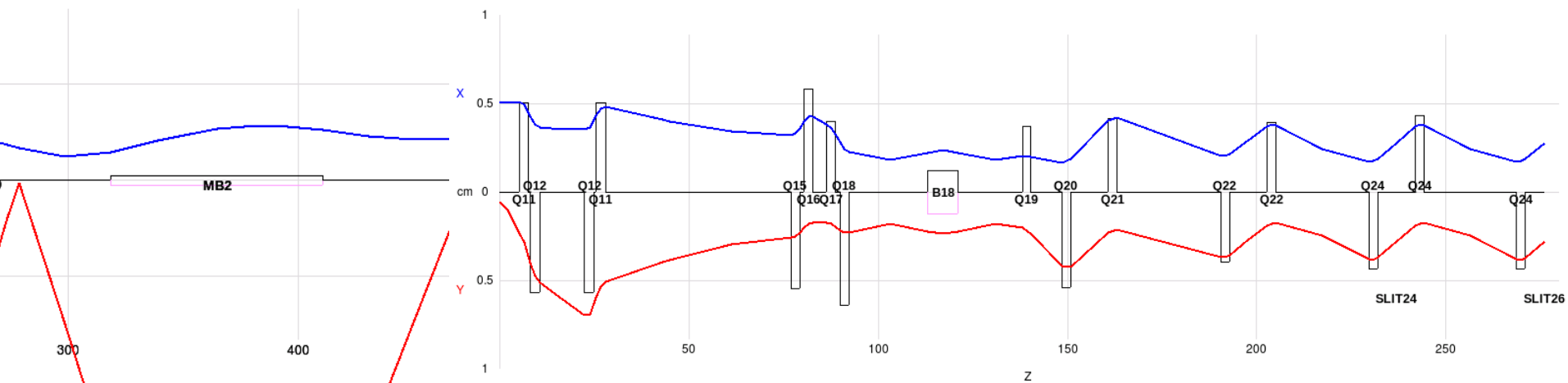


ISAC DTL – the pink quad triplets act as matching sections into the IH RF tanks.

*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



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

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 = kV

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	

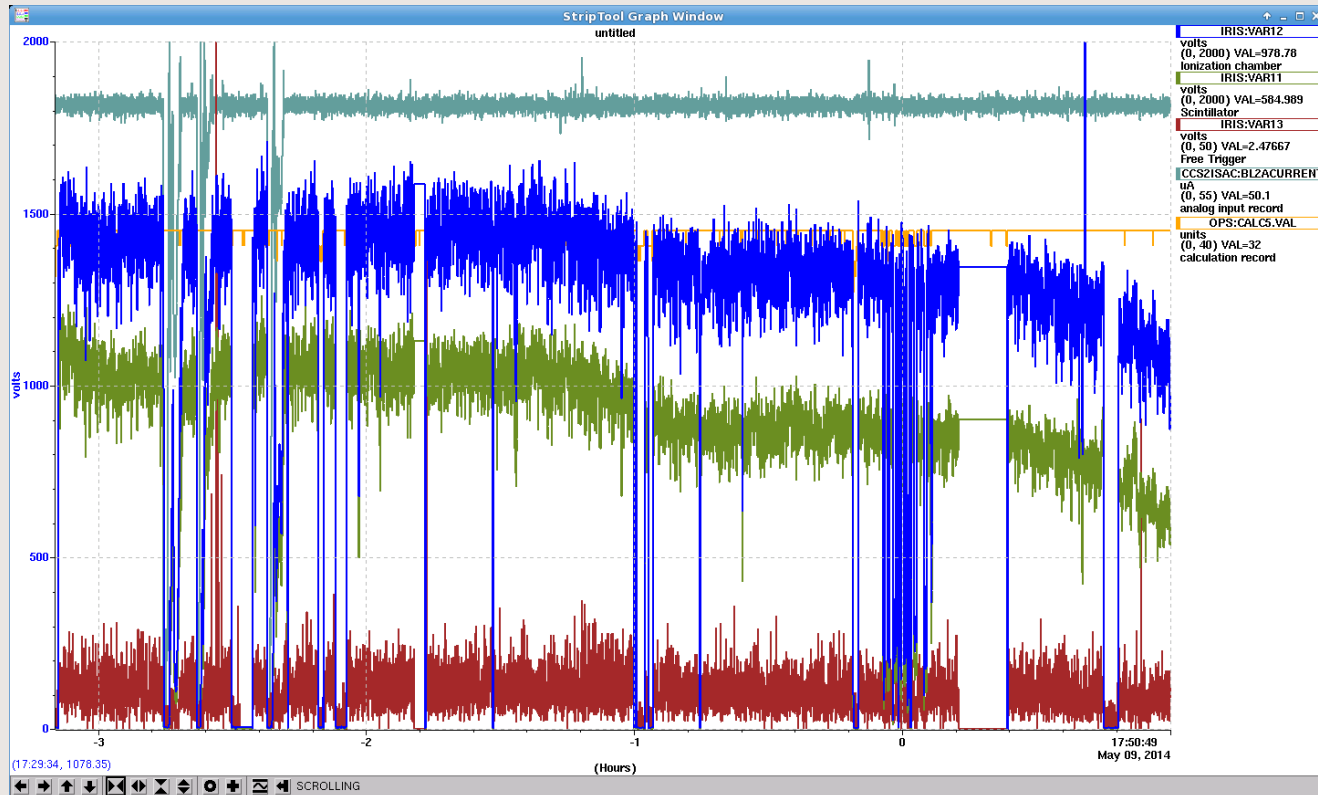
[Rick Baartman](#)

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

Transport section theory values

What Can [non-ideally] Occur...

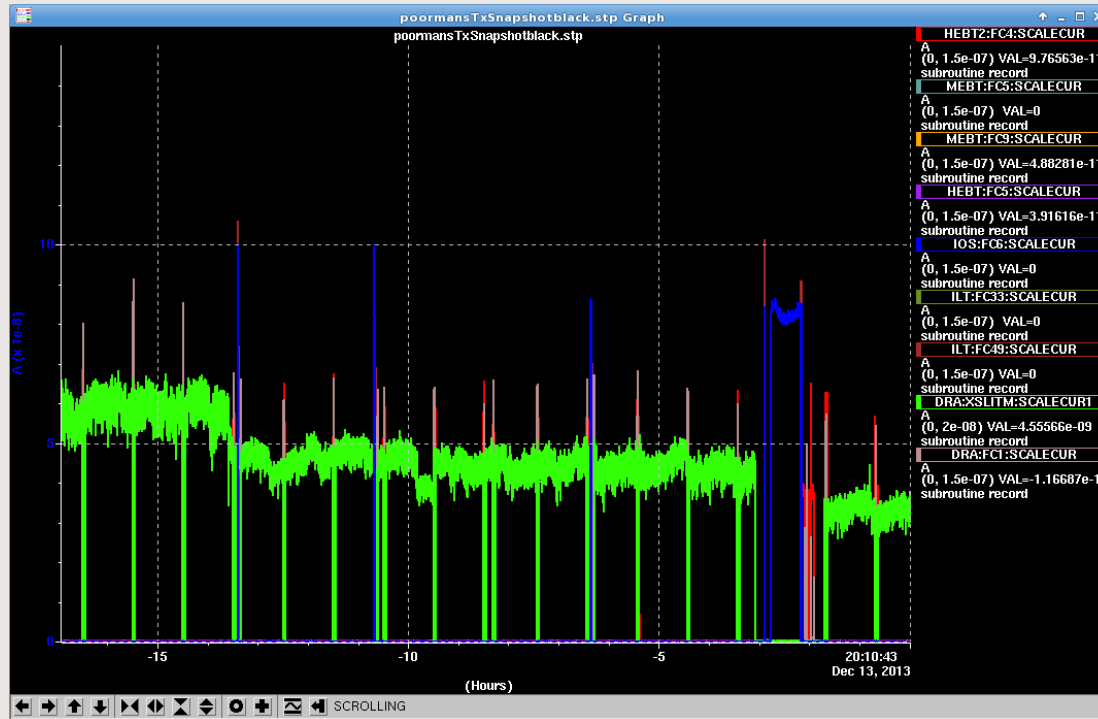
-Tune established to exp't.



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

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

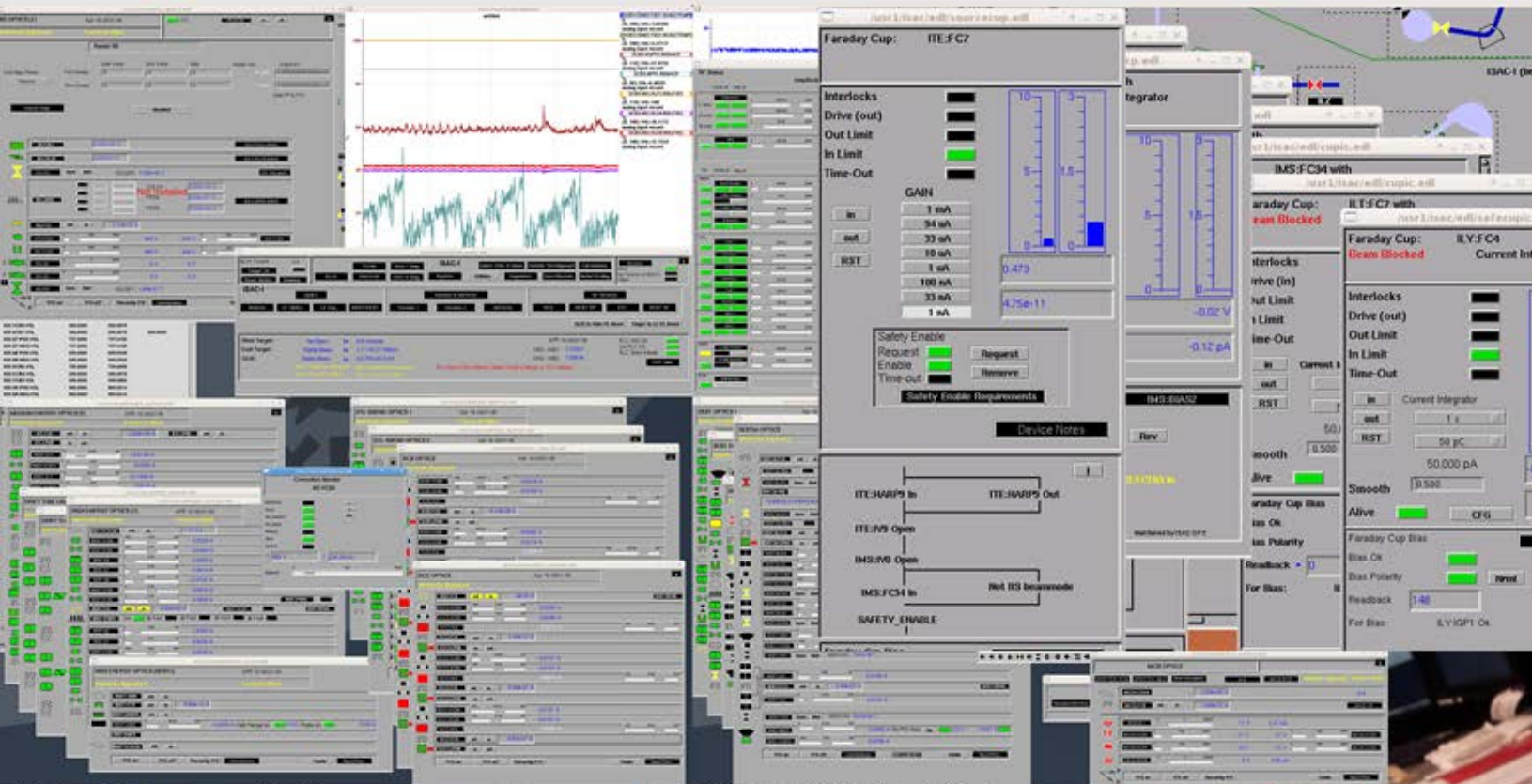
- On-line tuning brings counts back



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

Challenge: Information Density

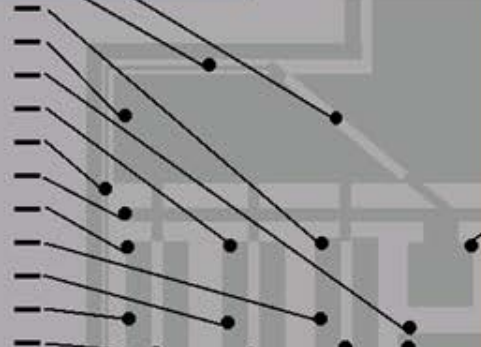
Things can get cluttered during beam delivery



The collage shows multiple overlapping windows from a control system. Key elements include:

- Faraday Cup: ILE-FC7**: A control panel with interlock status (Drive, Out Limit, In Limit, Time-Out), gain settings (1 nA to 100 nA), and safety enable options.
- Current Integrator**: Displays numerical values like 0.473 and 4.75e-11.
- Beam Monitors**: Shows status for components like IMS-FC34 and ILE-FC4.
- Graphs**: Several plots showing beam current and position over time.
- Control Buttons**: Numerous buttons for 'Request', 'Enable', 'Remove', and 'Safety Enable Requirements'.

9CC2:T99	6.31 K
9CC2:T96	2.95 K
9CC2:T98	20.68 K
9CC2:T96	5.39 K
9CC2:T945	135.18 K
9CC2:T939	22.20 K
9CC2:T93	4.89 K
9CC2:T98	80.15 K
9CC2:T95	62.22 K
9CC2:T92	61.96 K
9CC2:T925	2.85 K

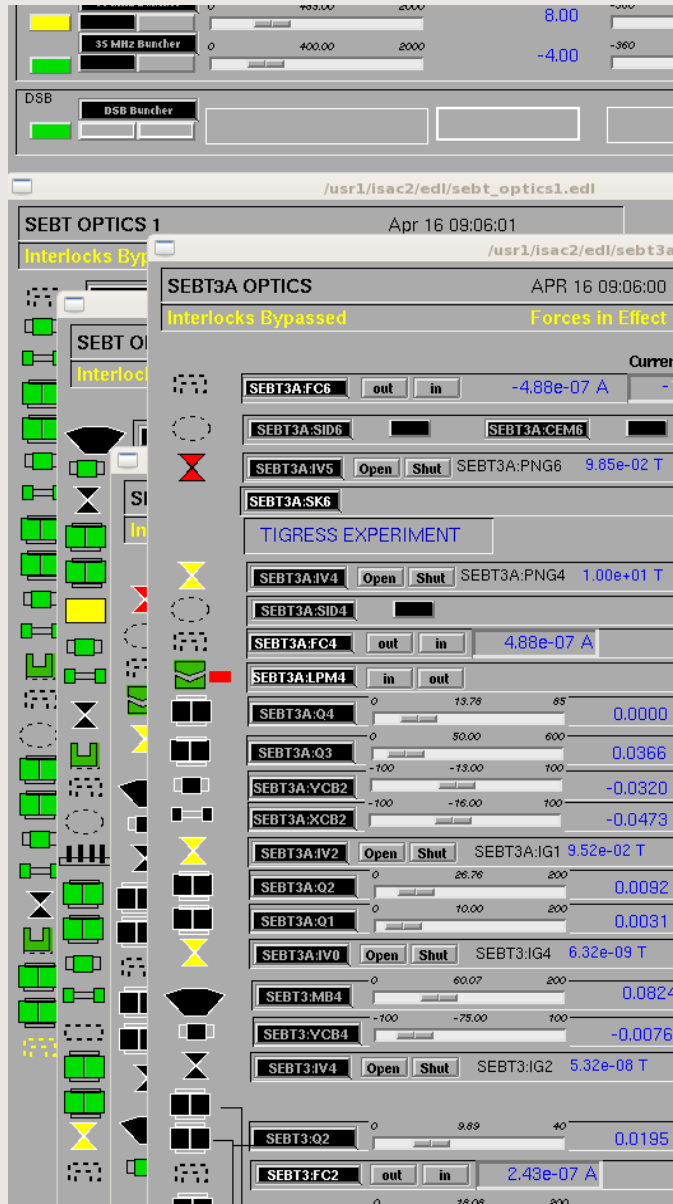


IOS:BV1A	IOS:IG8	IOS:IV7	IOS:PSW
Modify	Modify	Modify	Mod
IOS:BV7			
Modify			
IOS:INTBIAS	IOS:LIHT	IOS:	
Modify	Modify	Mod	
IOS:EE	IOS:INTMB	IOS:NAHT	IOS:R
Modify	Modify	Modify	Mod
IOS:EES	IOS:INTMCBIA	IOS:PE	IOS:



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



The screenshot displays the SEBT OPTICS control interface, showing various parameters and controls for the TIGRESS EXPERIMENT. The interface is divided into several sections, including a top control panel, a main parameter list, and a bottom control panel.

Top Control Panel:

- 35 MHz Buncher: 8.00, -4.00
- DSB Buncher: 400.00, 2000

Main Parameter List:

Component	Control	Value	Unit
SEBT3A:FC6	out in	-4.88e-07	A
SEBT3A:SID6			
SEBT3A:IV5	Open Shut	SEBT3A:PNG6	9.85e-02 T
SEBT3A:SK6			
TIGRESS EXPERIMENT			
SEBT3A:IV4	Open Shut	SEBT3A:PNG4	1.00e+01 T
SEBT3A:SID4			
SEBT3A:FC4	out in	4.88e-07	A
SEBT3A:LPM4	in out		
SEBT3A:Q4		13.78	65 0.0000
SEBT3A:Q3		50.00	600 0.0366
SEBT3A:YCB2		-100 -13.00	100 -0.0320
SEBT3A:XCB2		-100 -16.00	100 -0.0473
SEBT3A:IV2	Open Shut	SEBT3A:IG1	9.52e-02 T
SEBT3A:Q2		26.76	200 0.0092
SEBT3A:Q1		10.00	200 0.0031
SEBT3A:IV0	Open Shut	SEBT3:IG4	6.32e-09 T
SEBT3:MB4		60.07	200 0.0824
SEBT3:YCB4		-100 -75.00	100 -0.0076
SEBT3:IV4	Open Shut	SEBT3:IG2	5.32e-08 T
SEBT3:Q2		9.89	40 0.0195
SEBT3:FC2	out in	2.43e-07	A

Bottom Control Panel:

- SEBT3:Q2: 9.89, 40, 0.0195
- SEBT3:FC2: 2.43e-07 A

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?

TuneDisplay generates a visual representation of the tune & its overall quality & steering

Tune quality: % 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)

TuneDisplay Settings

Source:	<input type="text" value="OLIS"/>		
Destination:	<input type="text" value="bNMR (He ON)"/>	<input type="button" value="Update"/>	
Low Energy [kV]:	<input type="text" value="11"/>		
Low Energy A/Q [decimal]:	<input type="text" value="10"/>		
MEBT A/Q [decimal]:	<input type="text" value="10"/>		
HEBT A/Q [decimal]:	<input type="text" value="10"/>		
DTL Energy [MeV/u]:	<input type="text" value="1.5"/>		
SCRF Energy [MeV/u]:	<input type="text" value="1"/>		

(source)A/Q = 10, E[KeV/u] = 11 (final)A/Q = 10, E[MeV/u] = 1
X-Steering Overview

- 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].

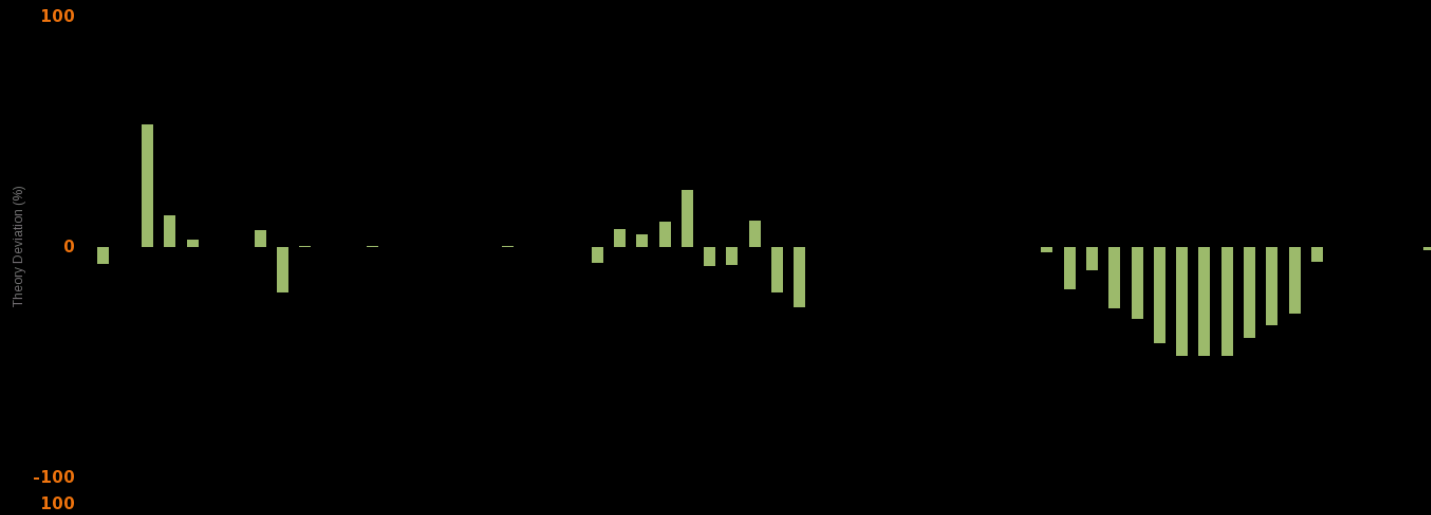
m_i are quadrupole parameters, specific to quad geometry

- EPICS 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).

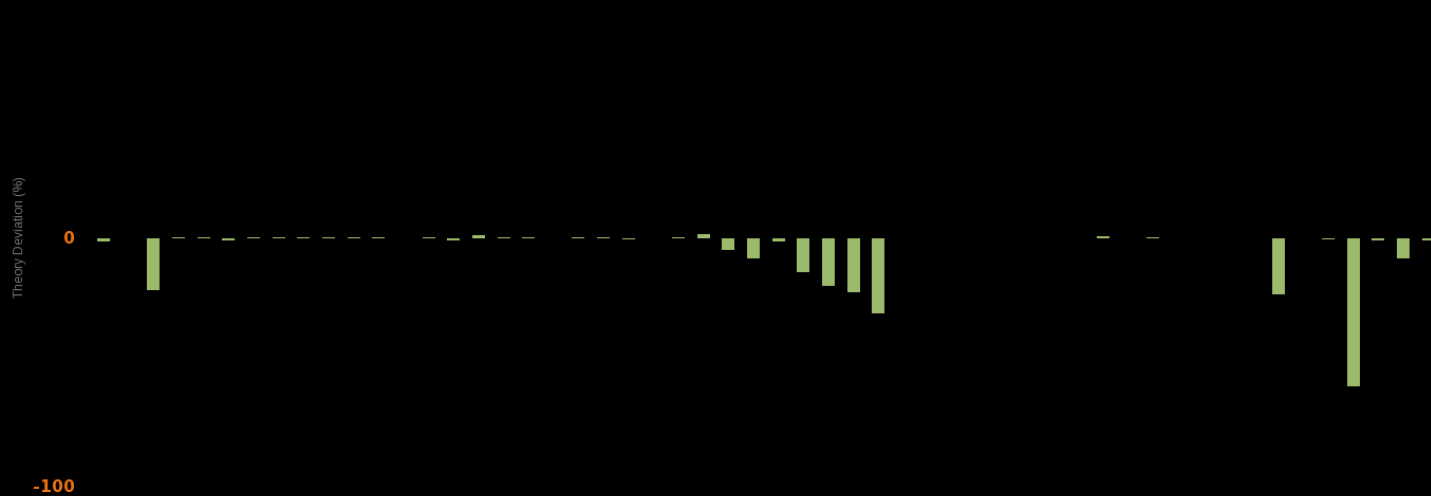
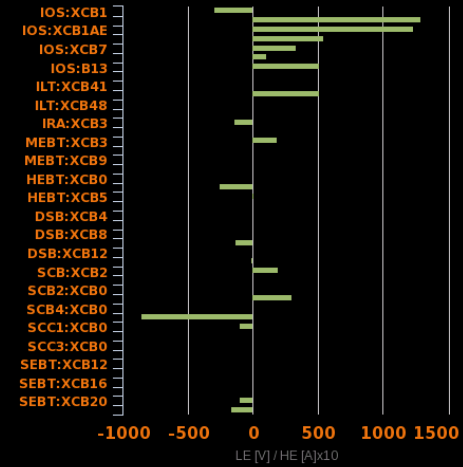
Example: A Good Tune

TuneDisplay Settings

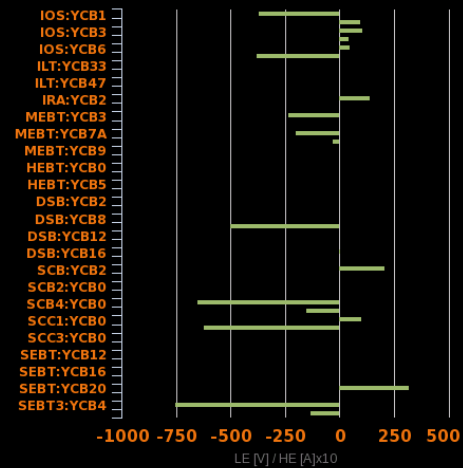
OLIS -> SEBT3A Electrostatic Theory Offset (source)A/Q = 4, E[KeV/u] = 22.4 (final)A/Q = 4, E[MeV/u] = 5



X-Steering Overview



Y-Steering Overview



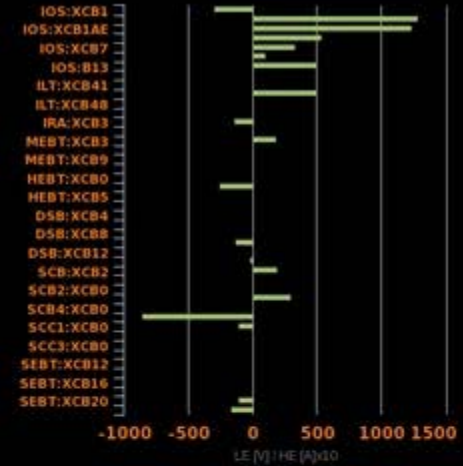
Example: A [very] Bad Tune

TuneDisplay Settings

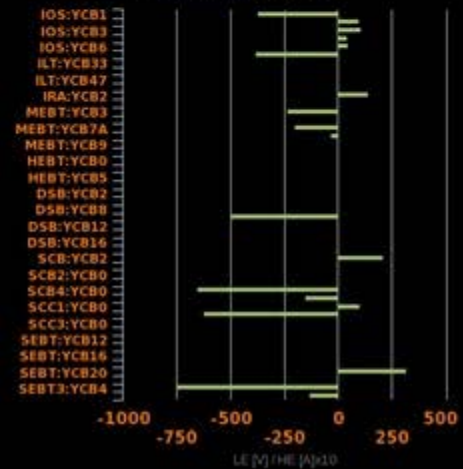
OLIS -> SEBT3A Electrostatic Theory Offset (source)A/Q = 5, E[KeV/u] = 24.46 (final)A/Q = 5, E[MeV/u] = 11.5



X-Steering Overview



Y-Steering Overview



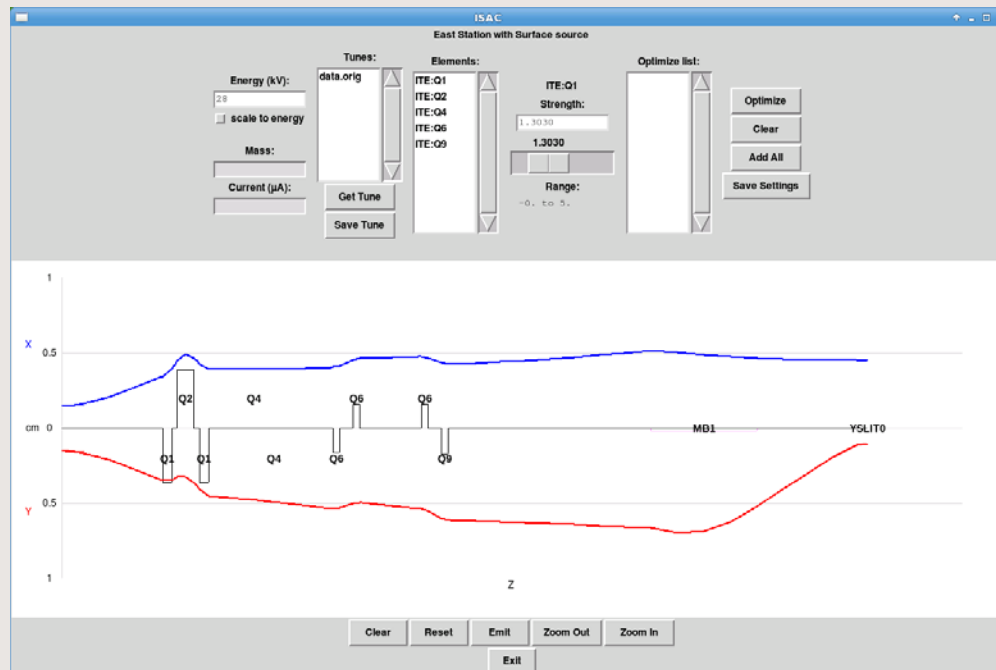
Planned Developments

#0 Fix bugs

#1 Elegant element name display

#2 Superimpose cup readings

#3 Tie-in with ISAC ops beam envelope calculator





Thank you!

Merci

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