ORFP Update: Outline

- Reminder of ORFP objectives
- Current ORFP status and comments
- Schedule and progress
- The future of ORFP
- Summary

ORFP Objectives

- **O**ptics **R**estoration and **F**inalization **P**rocedure
  - Multi-section procedure to correct and finalize steering and optics of CEBAF arcs, linacs, general transport to experiment end stations
- Includes
  - Orbit steering (to rels) and path length (ref to procedure)
  - X/Y coupling correction
  - Dispersion correction
  - M_{56} correction
  - Betatron match correction
- Does not include
  - Injector setup, RF separation, lambertson/extraction steering, linac/LEM gradient/quads

Present Status

- Last update: Rev. 13; April 15, 2014
  - Mostly C-S tuning knobs for 12 GeV $M_{56} \neq 0$ optics
  - Still owned by Spata for 12 GeV commissioning

- Update due by **Aug 31** for **Fall 2015 12 GeV operations**
  - Tool evolution (e.g. CED CMPQ now in eDT)
  - 12 GeV optics impacts (e.g. path length, dispersion impact from $M_{56} \neq 0$ in higher pass arcs)
  - Checking/tuning $M_{56} \neq 0$ arcs (previously all $M_{56} = 0$)
  - Betatron matching philosophy
    - Old: 30 Hz Courant-Snyder / fopt, recombiner tuning knobs
    - New: qsUtility / harp corner matching, spreader matches
      - See qsUtility talk from Dennis Turner
    - E01 qsUtility matching demonstrated Winter 2015

Tool Evolution

- Full document being reviewed
  - Paths in JTabs being corrected where necessary
  - Tool transitions identified, modified
    - e.g. prohibited quad check now in eDT, not CMPQ
    - Injector, corner matching with qsUtility, not MultiHarp
    - M_{56} tool now encompassed within GenericKnobs
    - Pathlength tools (e.g. MOMOD)

Present ORFP

4. Check the Injector-to-North Linac match by inserting viewers ITV0L10, ITV0R05, ITV1L02, ITV1L06, and ITV1L10. Are all of the beam spots round (with an aspect ratio no greater than 2:1)?

YES → Go to Step 5

NO →

A. Open the Emittance Measurement screen (**JTabs⇒Harp⇒Multi-Harp Emittance**) and select the **Injector** tab.

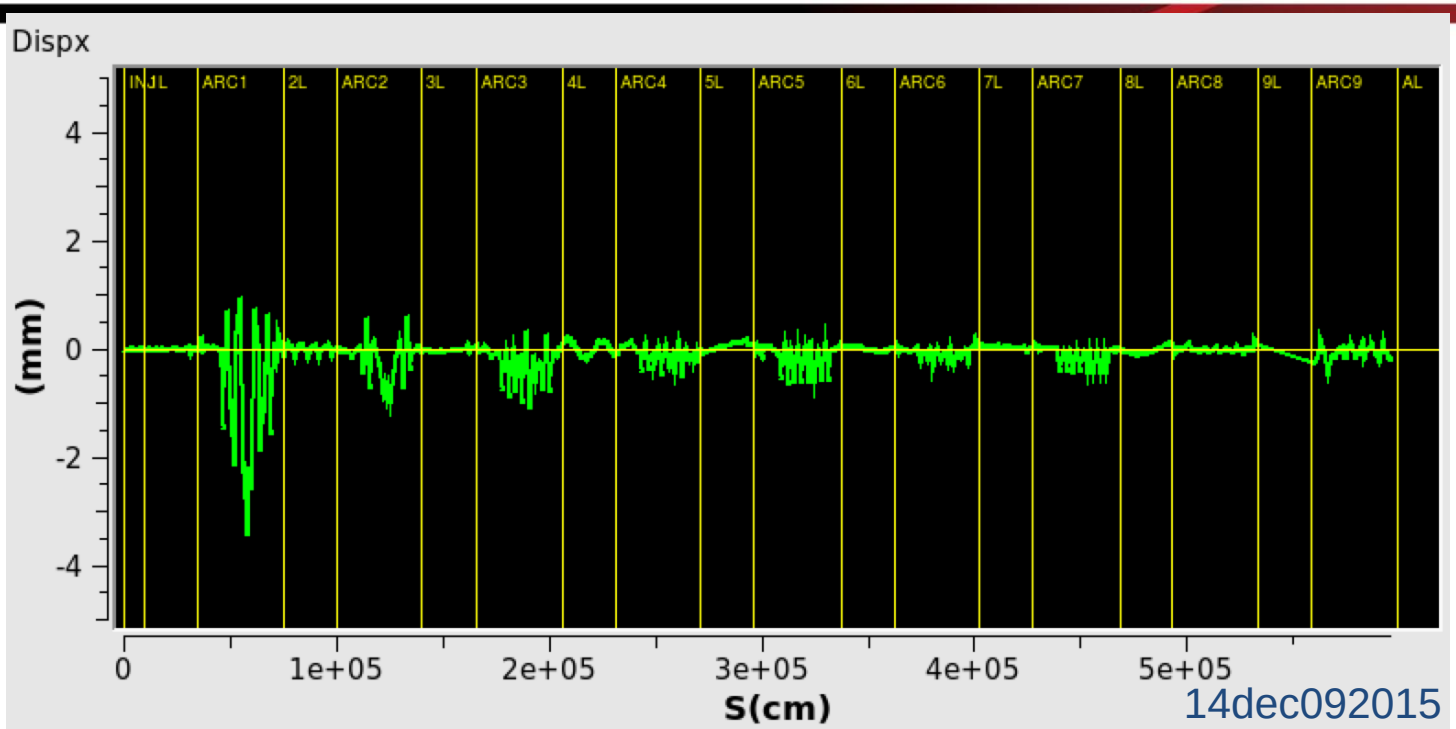
B. Insert the 0R08 insertable beam dump.

C. Restore Tune-Mode beam current of 15 μA (required to produce clean harp traces in the following steps).

D. Turn OFF the injector energy and orbit locks.

E. Click on the **Scan Harps** button and wait for the data collection to be complete (scanning the harps takes several minutes).

M56 Effects on Dispersion



- $M_{56} \neq 0$ could produce ORFP problems by shifting pathlength during dispersion measurements
  - In extremes could even zero or flip “measured” dispersions
  - No obvious strategy but to revert to $M_{56} = 0$ for Fall 2015
  - Model-based design targets (see later slide) may help

M_{56} Correction

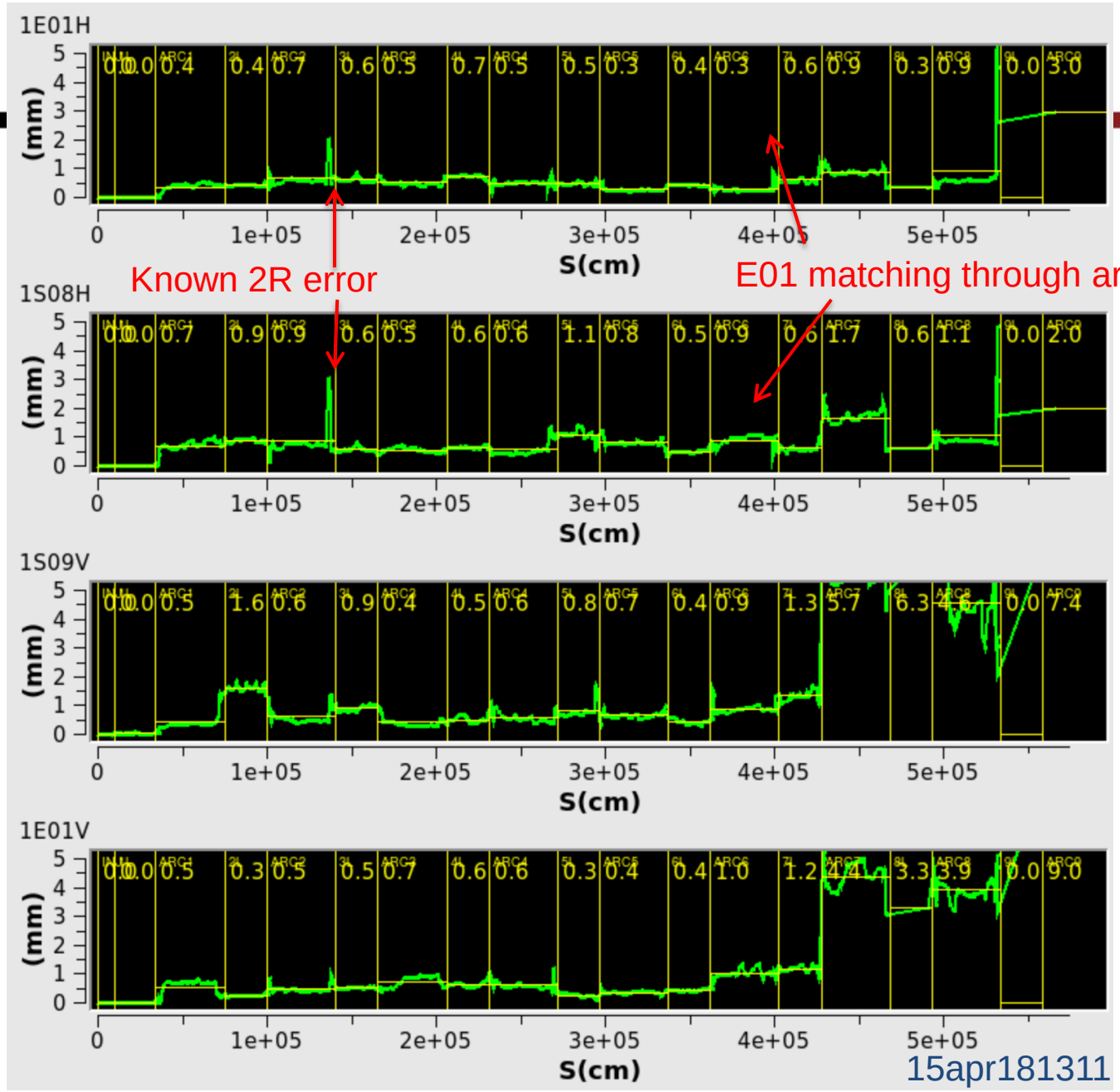
- Previously all arc M_{56} design values were zero
  - ORFP procedure is to null pathlength response to energy offsets
  - Good enough for Fall 2015 run but be prepared for $M_{56} \neq 0$

- Change procedure to adjust M_{56} to (documented) design non-zero value for given lattice
  - Get design arc M_{56} from CED? Model? (Similar to injector chicane M_{56} documentation quandary)
  - Requires calibrated pathlength vs dp/p for M_{56} adjustment

- M_{56} adjustment with isolated dispersive quads in an arc interferes with upstream E01 betatron match
  - Adoption of E01 betatron matching as primary scheme requires adjustment of M_{56} quadrupole knobs

Betatron Match

- Many changes!
  - **Recommendation: put both match methods in ORFP**
  - Add sections for E01 qsUtility zigzag match
    - Model after existing injector match ATLis: a15111, e3332778
    - Have mature qsUtility, all templates in place
    - Preferred approach: quantitatively reproducible (and reliable?)
  - Add conditions for use of C-S instead of qsUtility match
    - Missing or malfunctioning E01 harp, qsUtility match failure
    - Significant C-S mismatch growth in arc/spreader
  - Ensure that all C-S tuning quads are consistent with design optics
    - Must this be a manual process?


1E01H
1S08H
1S09V
1E01V
(mm)
S(cm)
0
1e+05
2e+05
3e+05
4e+05
5e+05
Known 2R error
E01 matching through arc 6
15apr181311

Document Organization: Tuning Quads

- Tables of tuning quads are distributed through document in relevant sections
  - Gather all tables at end of document for convenient reference

- Mike McCaughan has updated (and will continue to update) CED so knobs are properly color coded in eDT and screens
  - Matching quads must be consistent with qsUtility templates

Name	Usage
MQB1S01	V.Dispersion
MQN1S04	Matching
MQL1S05	Matching
MQB1S06	Matching
MQL1S08	Matching
MQL1S09	Matching
MQB1S10	Matching

Name	Usage
MQB1A11	H.Disp/M5,6
MQB1A21	H.Disp/M5,6
MQL1R02	V.Beta
MQL1R03	H.Beta
MQL1R04	V.Beta
MQL1R06	H.Beta
MQB1R10	V.Dispersion

Schedule and Progress

- Have started revision feedback process with Tom Oren in past few weeks
  - Incorporating additional input from Mike McCaughan

- Jul 28: Present detailed revision list to Bteam, circulate
  - Itemize changes and implementations
- Aug 4: Start implementing changes
  - Iteration among core technical group
  - Incorporate existing procedures, e.g. E01 zigzag matching
- Aug 24: Finalized document available to all for comments
- Aug 31: Document finalized, ready for ops training

The Future of ORFP

- The following three slides are longer-term future ideas for ORFP
  - Orthogonal C-S Knobs
  - Model-Based Design Targets
  - RayTrace

- None of them will be implemented for 2015-2016 operations
  - But they are worth discussion about prioritization, and possible development/testing during beam studies
  - They are ordered roughly by my estimate of required effort

Future: Orthogonal C-S Knobs?

- Betatron knobs are pairs of recombiner quads that are “mostly orthogonal”
- Operators iterate between quads, planes to match C-S

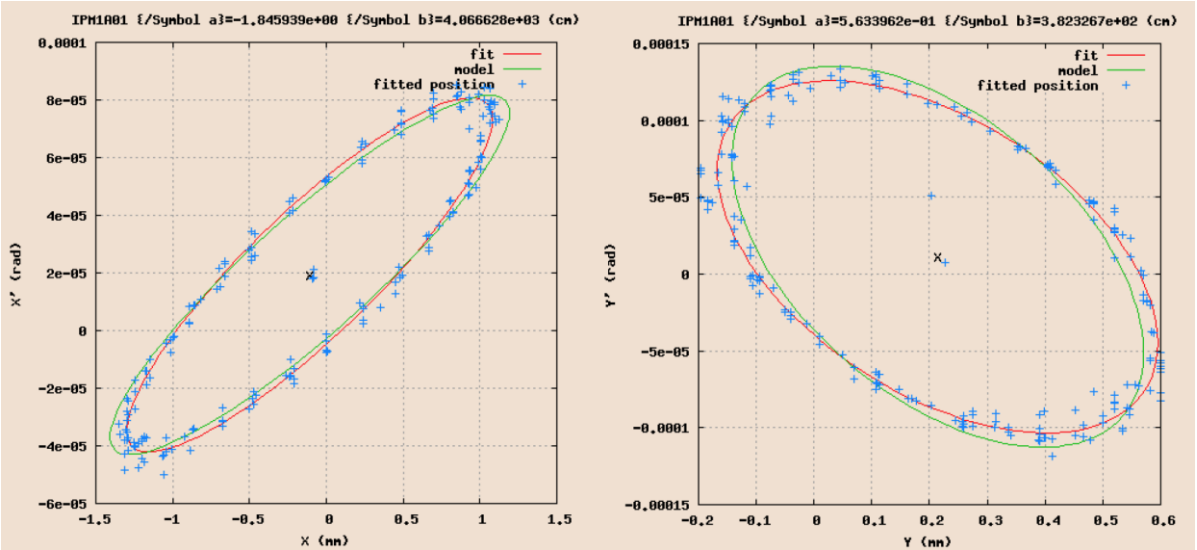
- Data is available in orbits, quad strengths, and model to:
  - Dynamically generate four orthogonal knobs from four C-S quads and difference orbits
  - Orthogonality generation will also fail if C-S orbits are degenerate, producing a procedural C-S orbit degeneracy test
  - Not a high priority, but a nice project for an operator or undergraduate student
  - Would make C-S betatron match fast or even automatable
  - **Recommendation: present computational study at future BTeam**

Future: Model-Based Design Targets?

- There are many places in ORFP that could benefit from availability of model-based design values to operations
- Examples that work well:
  - Steering rels (though not strictly model-based)
  - qsUtility design match parabolas (though not modified to include intermediate quad changes from design)
- Other opportunities for improvement:
  - Harp, SLM, and viewer expected beam aspect ratios
    - Presently calculated by hand from CED, inserted in procedure
  - Dispersion values in arcs, injector chicane (not just positive/negative values)
    - Are BPM differential positions calibrated well enough?

Future: RayTrace?

- In the future RayTrace ideally can…
  - Localize errors more precisely than other ORFP techniques
  - Provide robust, fast, large-scale **transport** matching
  - Note: It does **not** obviate need for beam/transport match
- Would benefit from substantial tool development
  - Similar to evolution of quad scan emittance/matching



R. Bodenstein, Ph.D. Thesis (2012), Fig. 4.3

Summary

- ORFP is being revised for late 2015 12 GeV run
- Revisions address broad range of needed updates
  - Tool and path details
  - Consistency with 12 GeV design lattice (profiles, M_{56})
  - Betatron matches: E01 harp scans, C-S tuning knobs
  - Document organization: tuning knob lists
- Full reviewed revision to be available by Aug 31
- Ideas presented for future developments to support ORFP
  - Orthogonal C-S Knobs
  - Model-based design targets on tuning screens
  - RayTrace transport measurement and correction