

Present and Future Operation Tools and Algorithms at ALS

Thorsten Hellert

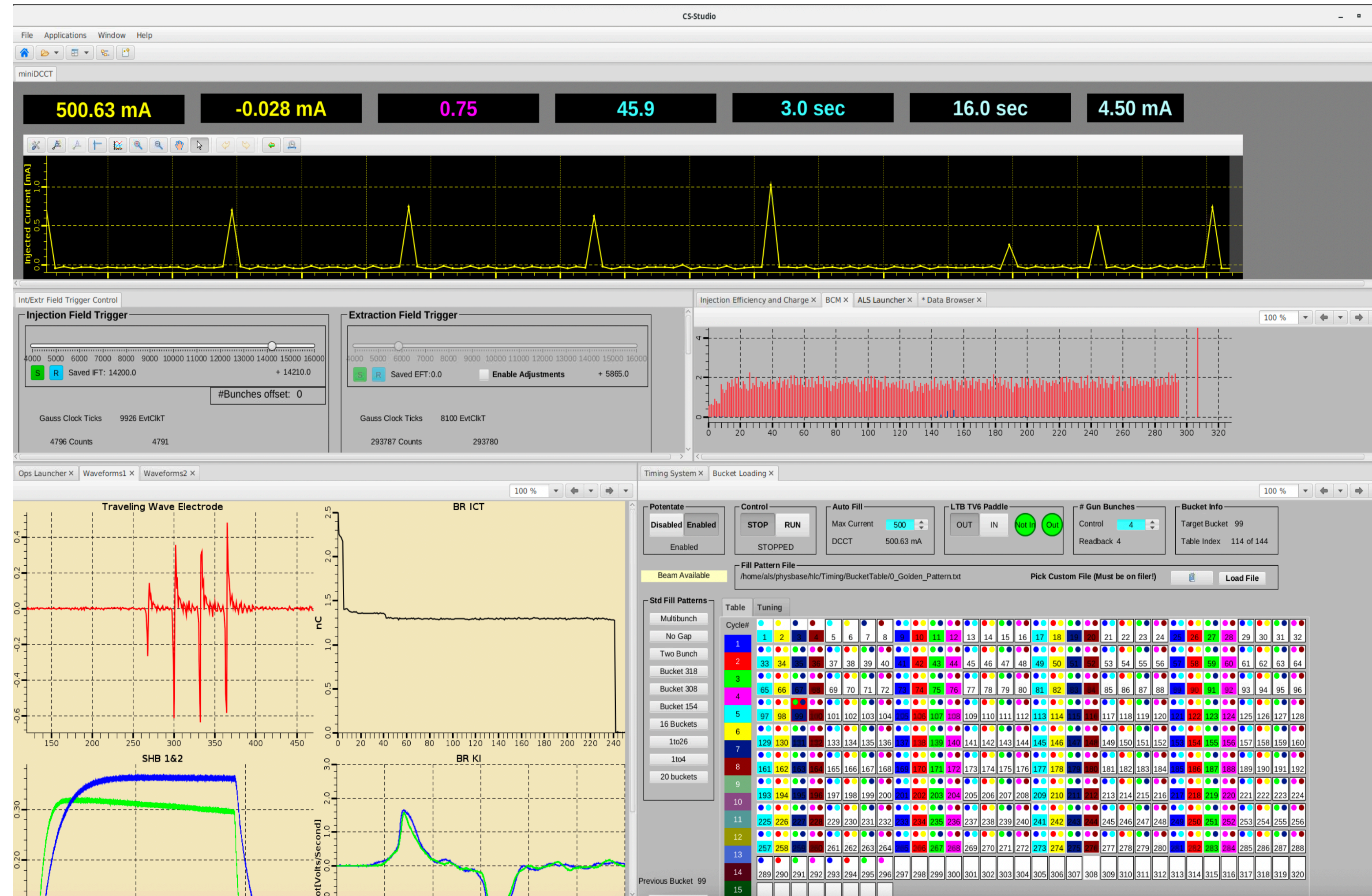
ALS Accelerator Physics Group

20.06.24



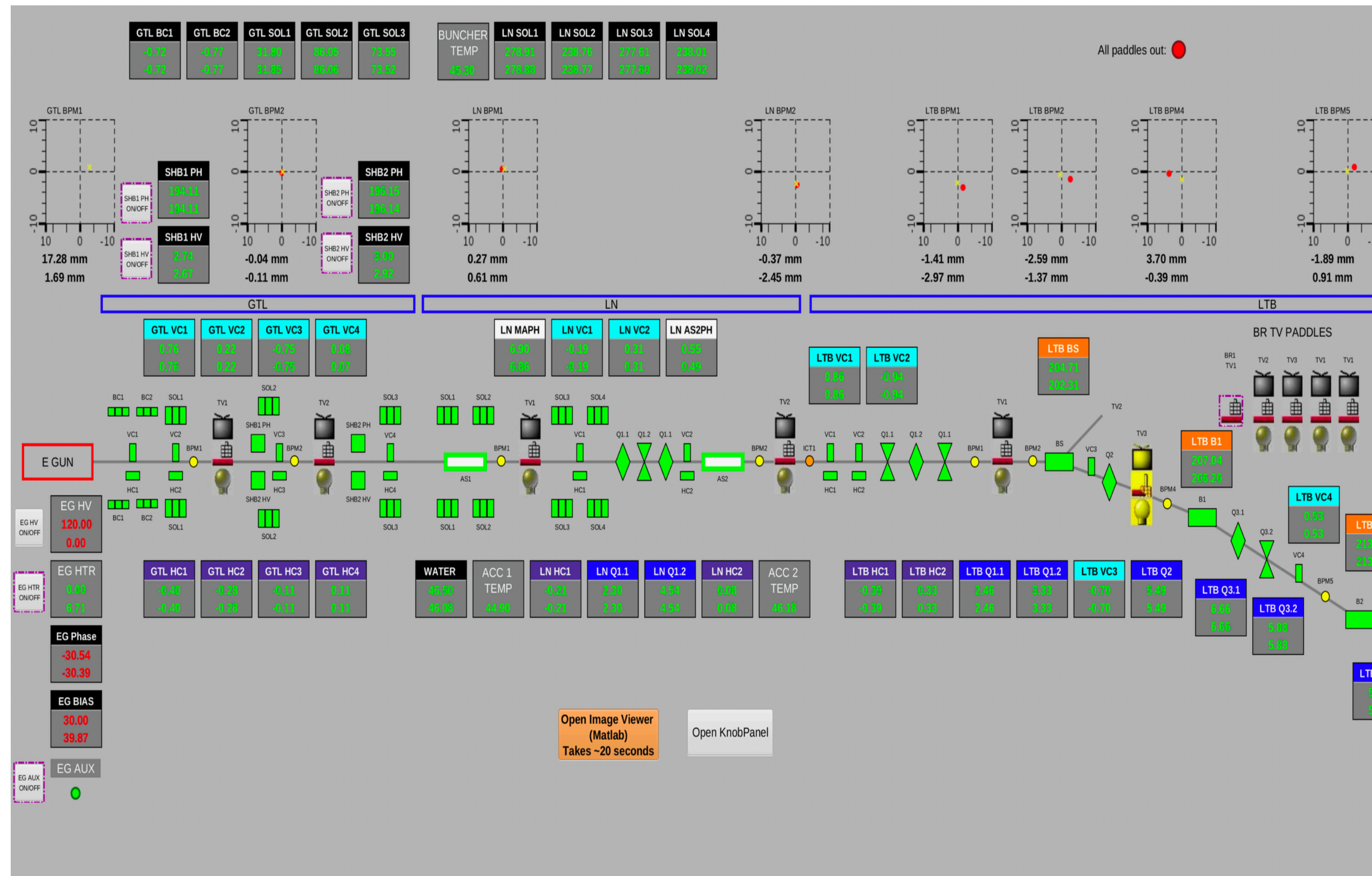
ALS Will Stick with EPICS

- EPICS 7:
 - Flat naming -> adding structures to PV names
- Phoebus Tools:
 - Control Room Displays
 - Alarm handler



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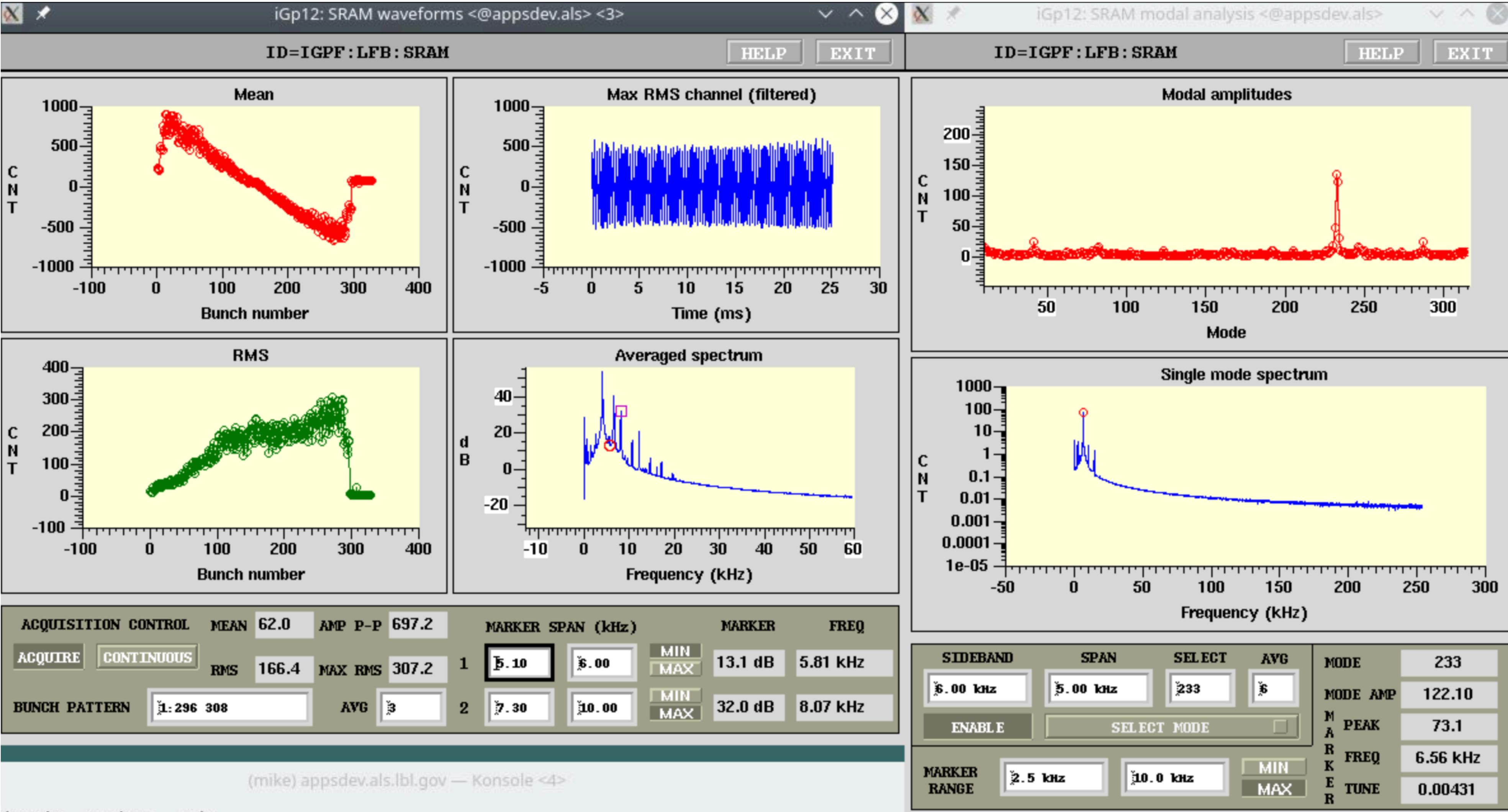
ALS Will Stick with EPICS

- EPICS 7:
 - Flat naming -> adding structures to PV names
- Phoebus Tools:
 - Control Room Displays
 - Alarm handler
- Archiver Appliance:
 - Python / Matlab
 - Grafana (new)



<https://grafana.com/>

LFB & TFB: Dimtel



ALS is Very Matlab Focused

Naming Convention

Family = Group descriptor (text string)

Field = Subgroup descriptor (text string)

DeviceList = [Sector Element-in-Sector]

Basic Functions

```
getpv(Family, Field, DeviceList);
```

```
setpv(Family, Field, Value, DeviceList);
```

```
steppv(Family, Field, Value, DeviceList);
```

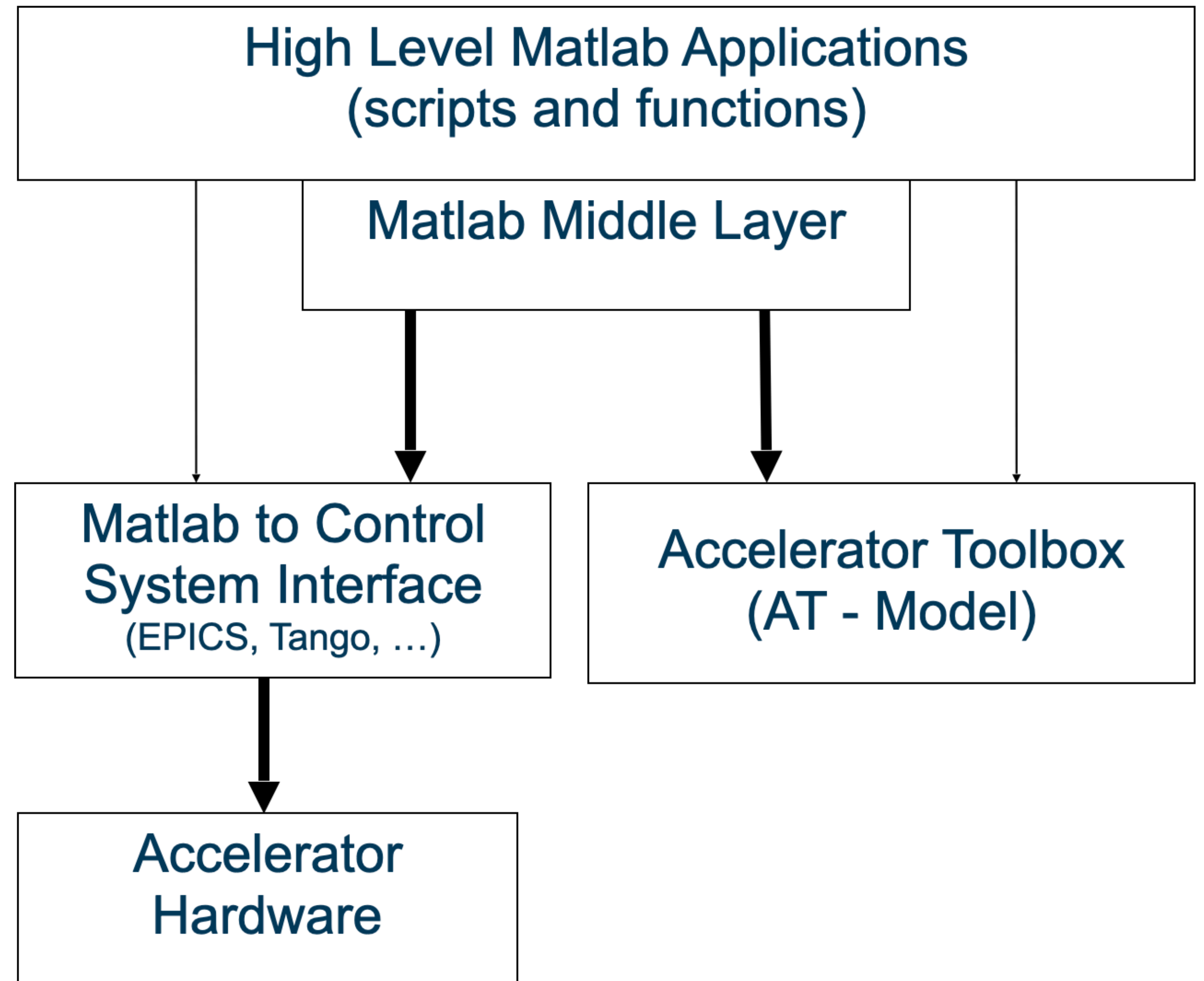
These functions can branch between the model and online.

Examples:

```
x = getpv('BPMx', 'Monitor', [3 4;5 2]);
```

```
h = getpv('HCM', 'Setpoint', [2 1;12 4]);
```

```
setpv('QF', 'Setpoint', 81);
```



Name Server: EPICS Channel Finder

At the ALS, the channel finder service tags channels using the same “Accelerator, Family, Field, Device” scheme as in the MML.

Controls Main × Ops Launcher × ALS Launcher × Linac × MOD1 × MOD2 × miniDCCT × EPBI × Channel Table × Channel Table ×

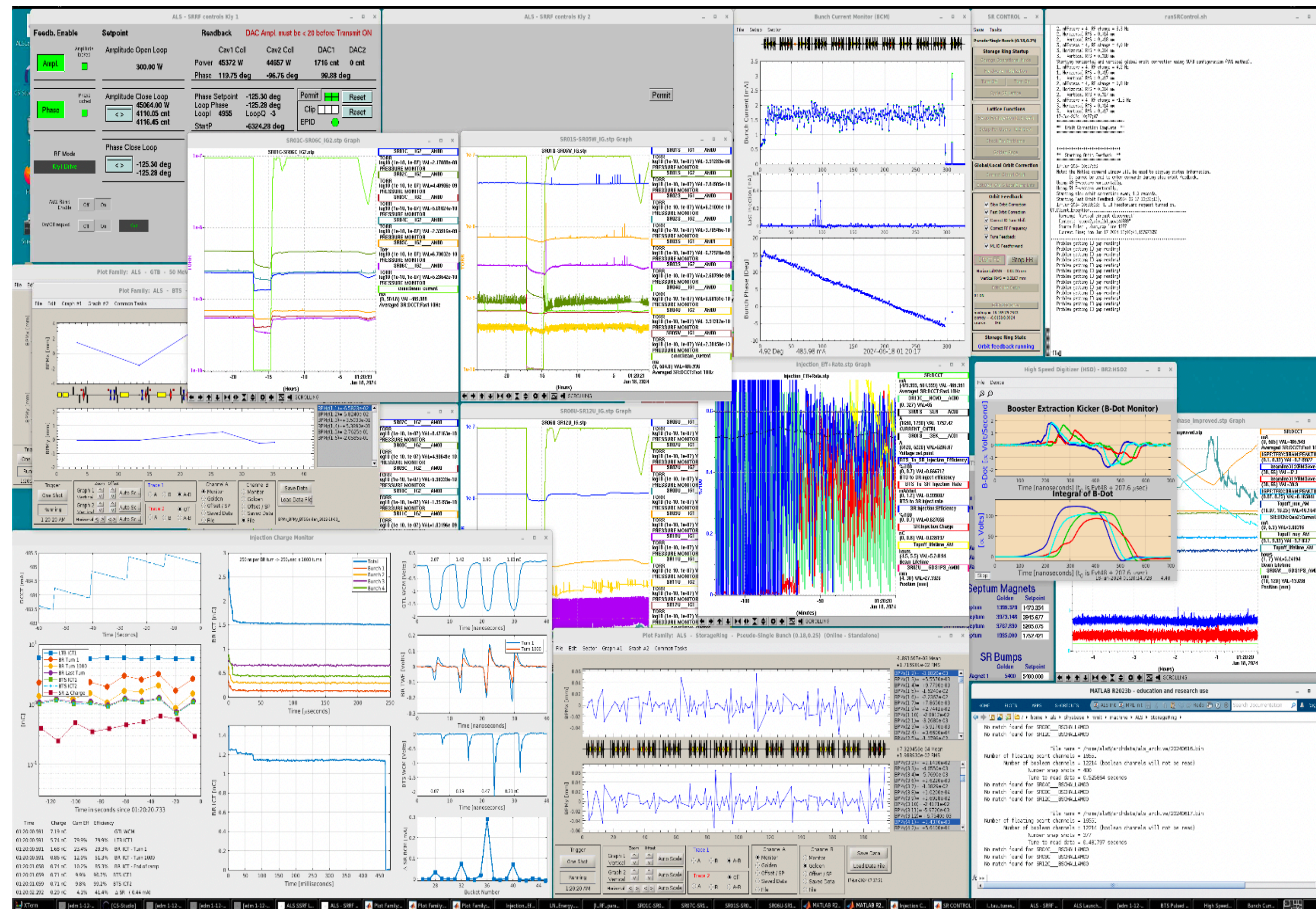
Query: * Acc=SR Family=QF Field=Setpoint Sector=* Device=*

name ▲	Acc	Family	Field	Sector	Device	Position	Golden	archive	recordType	iocName
SR01C__QF1__AC02	SR	QF	Setpoint	1	1	3.378696	96.908063344168553	Fast	ao	ffbsec01
SR01C__QF2__AC03	SR	QF	Setpoint	1	2	12.677306	96.548511743507575	Fast	ao	ffbsec01
SR02C__QF1__AC02	SR	QF	Setpoint	2	1	19.778696	95.675469420609659	Fast	ao	ffbsec02
SR02C__QF2__AC03	SR	QF	Setpoint	2	2	29.077306	96.25629257026965	Fast	ao	ffbsec02
SR03C__QF1__AC02	SR	QF	Setpoint	3	1	36.178696	96.254993755862387	Fast	ao	ffbsec03
SR03C__QF2__AC03	SR	QF	Setpoint	3	2	45.477306	94.968993154771908	Fast	ao	ffbsec03
SR04C__QF1__AC02	SR	QF	Setpoint	4	1	52.578696	97.362668560344588	Fast	ao	ffbsec04
SR04C__QF2__AC03	SR	QF	Setpoint	4	2	61.879111	96.997481310809263	Fast	ao	ffbsec04
SR05C__QF1__AC02	SR	QF	Setpoint	5	1	68.980501	95.703886987555819	Fast	ao	ffbsec05
SR05C__QF2__AC03	SR	QF	Setpoint	5	2	78.279111	95.288593169344963	Fast	ao	ffbsec05
SR06C__QF1__AC02	SR	QF	Setpoint	6	1	85.380501	96.447573180643431	Fast	ao	ffbsec06
SR06C__QF2__AC03	SR	QF	Setpoint	6	2	94.679111	96.5060204101957	Fast	ao	ffbsec06
SR07C__QF1__AC02	SR	QF	Setpoint	7	1	101.780501	95.744347344953354	Fast	ao	ffbsec07
SR07C__QF2__AC03	SR	QF	Setpoint	7	2	111.079111	96.566816850643619	Fast	ao	ffbsec07
SR08C__QF1__AC02	SR	QF	Setpoint	8	1	118.180501	96.1579998863688	Fast	ao	ffbsec08
SR08C__QF2__AC03	SR	QF	Setpoint	8	2	127.480916	97.18719441846909	Fast	ao	ffbsec08
SR09C__QF1__AC02	SR	QF	Setpoint	9	1	134.582305	95.3480583970734	Fast	ao	ffbsec09
SR09C__QF2__AC03	SR	QF	Setpoint	9	2	143.880916	96.182497070246868	Fast	ao	ffbsec09
SR10C__QF1__AC02	SR	QF	Setpoint	10	1	150.982306	96.266783582685619	Fast	ao	ffbsec10
SR10C__QF2__AC03	SR	QF	Setpoint	10	2	160.280916	95.861797805405516	Fast	ao	ffbsec10
SR11C__QF2__AC03	SR	QF	Setpoint	11	2	176.680916	95.543268540128	Fast	ao	ffbsec11
SR11C:QF1:Setpoint	SR	QF	Setpoint	11	1	167.382306	95.775254811217167	Fast	ao	genesys
SR12C__QF1__AC02	SR	QF	Setpoint	12	1	183.782306	96.484200063890142	Fast	ao	ffbsec12
SR12C__QF2__AC03	SR	QF	Setpoint	12	2	193.082721	106.21448885069287	Fast	ao	ffbsec12

Current High Level Applications in Matlab

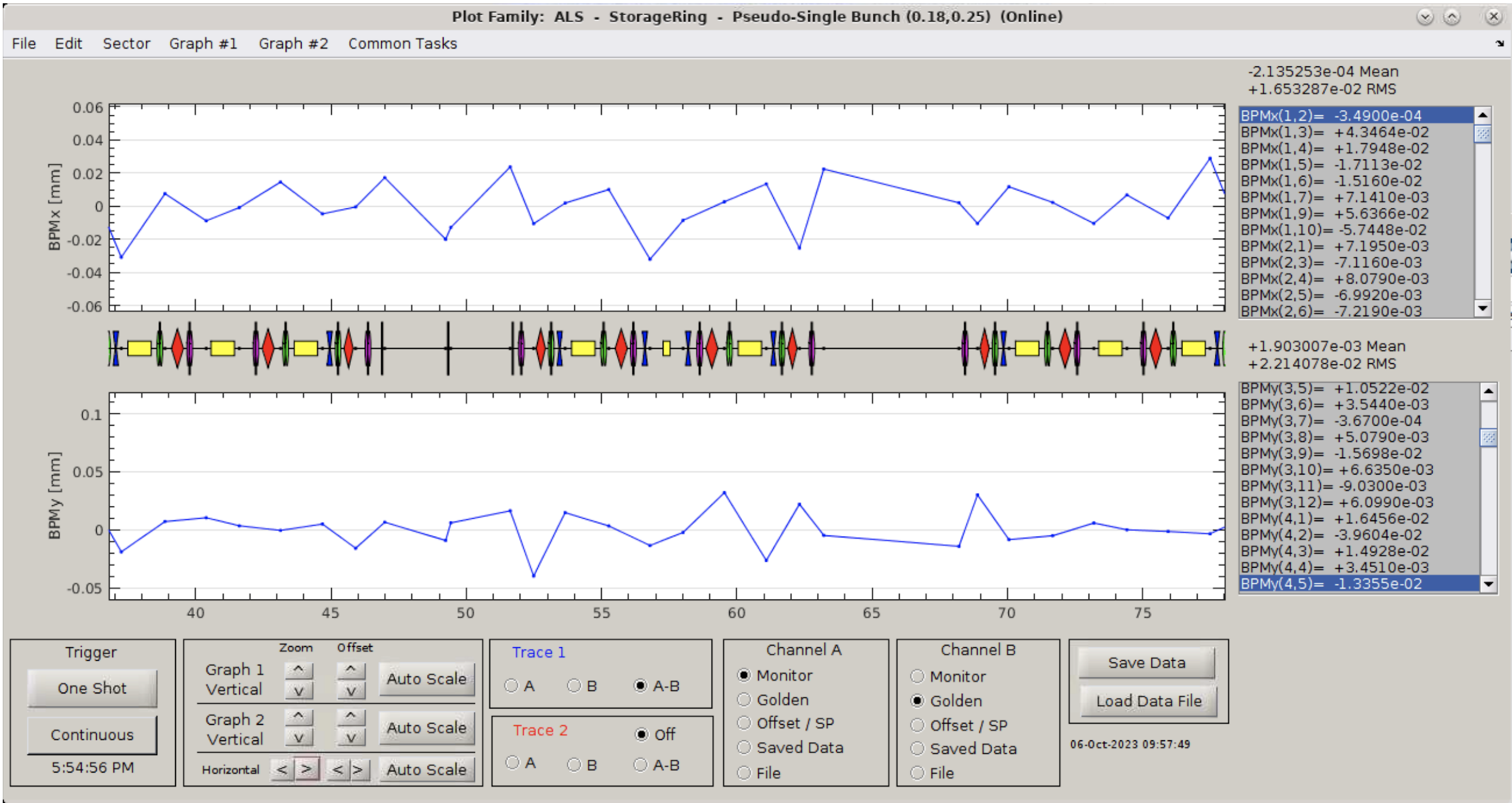


- **Display** (plotfamily, mmlviewer)



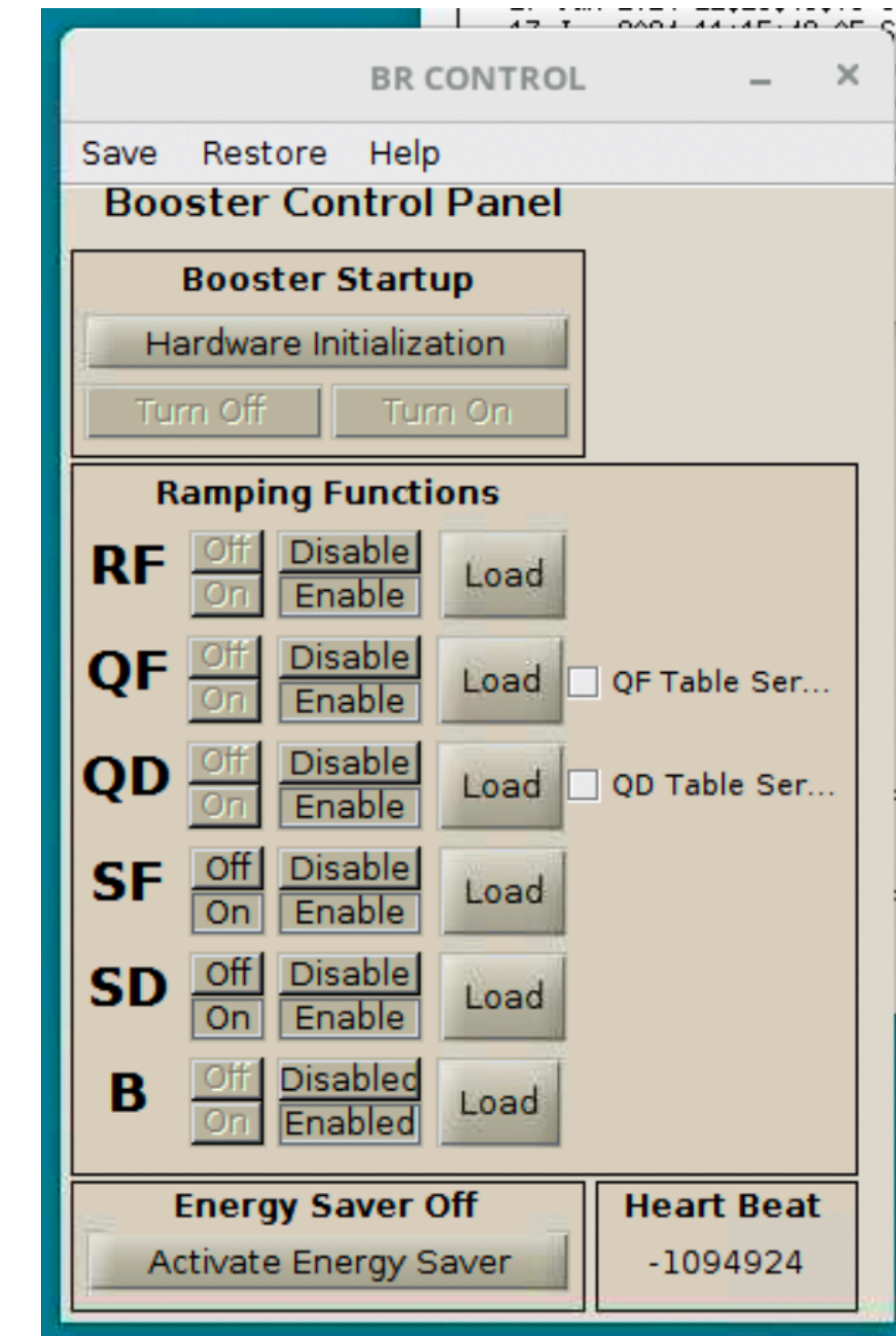
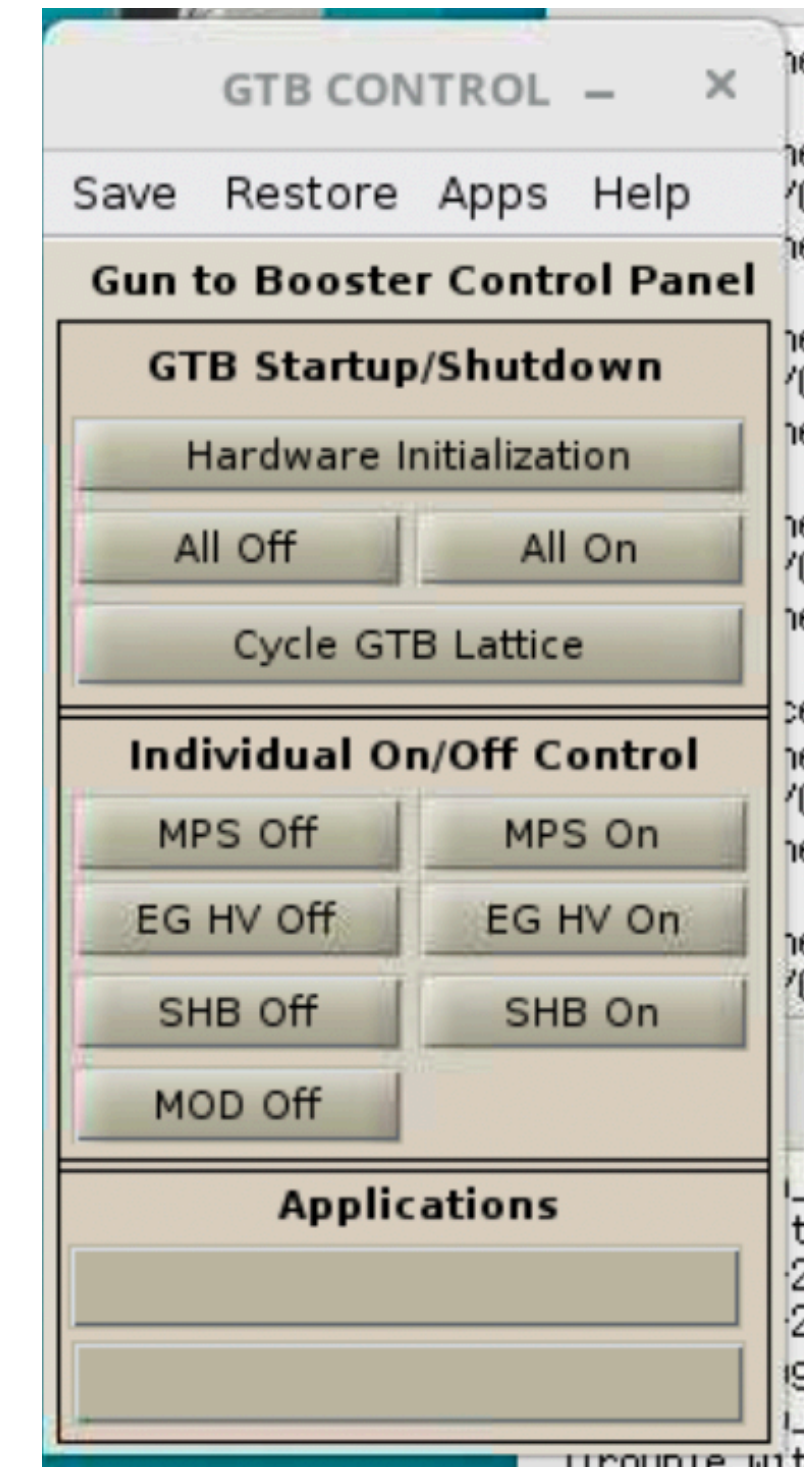
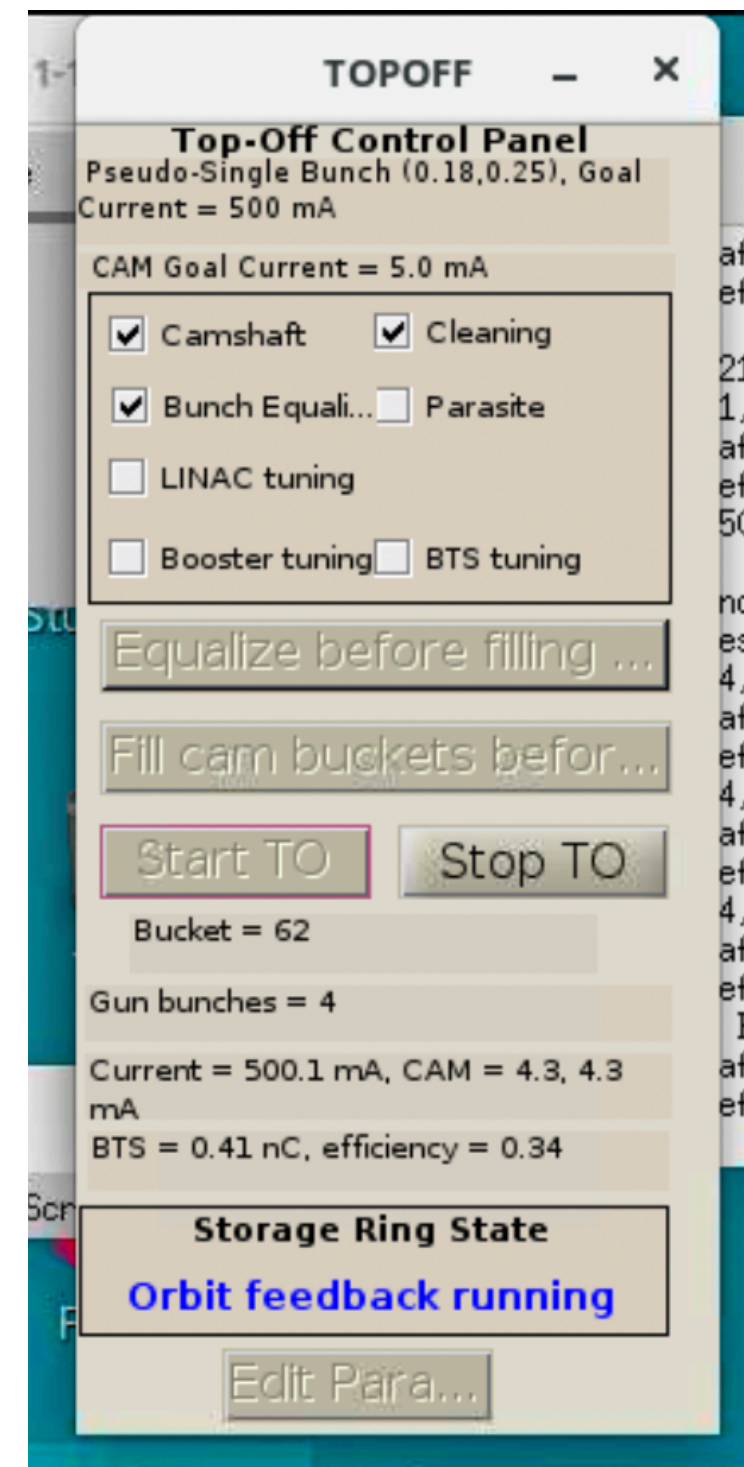
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)



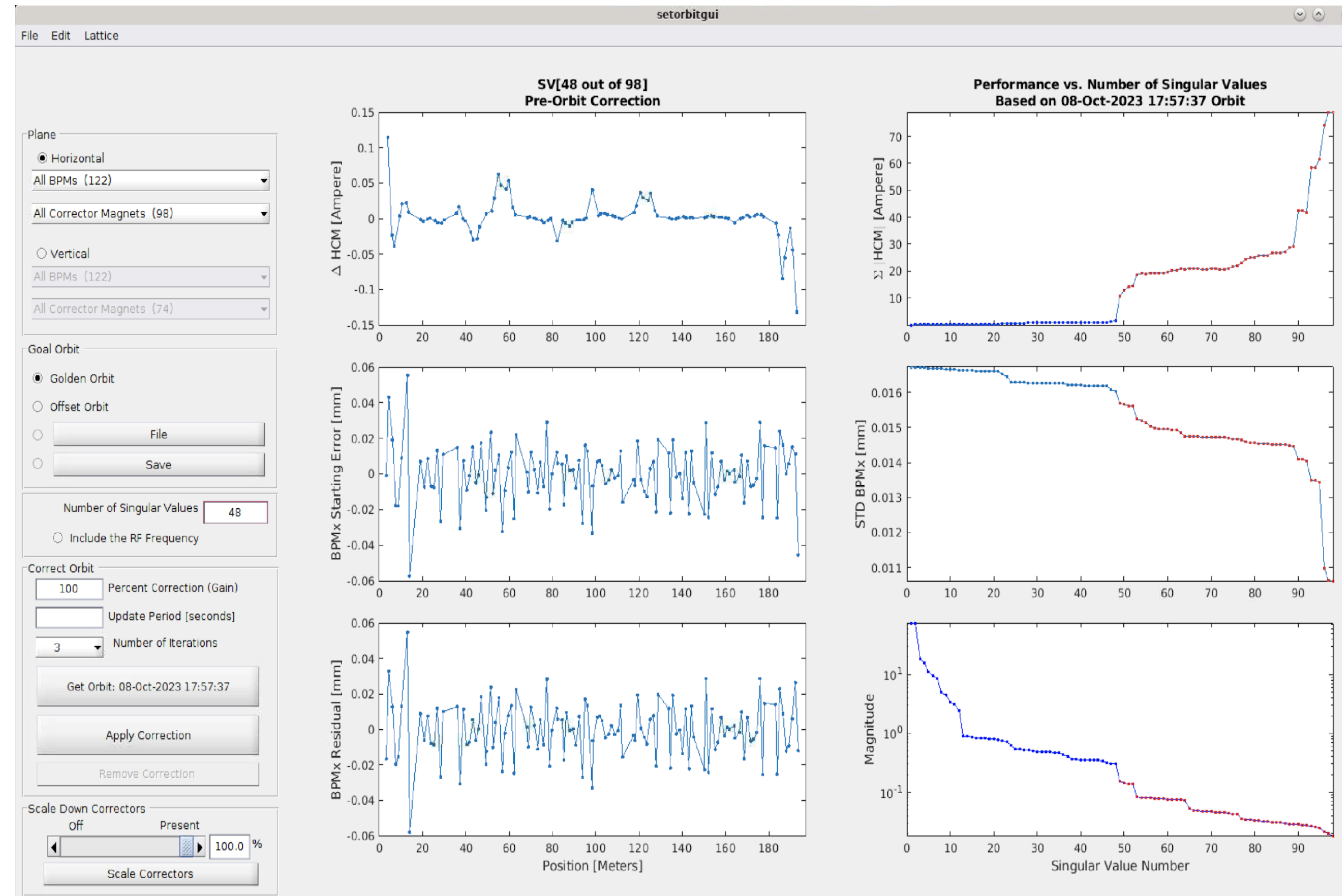
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- **Main Control Panels**



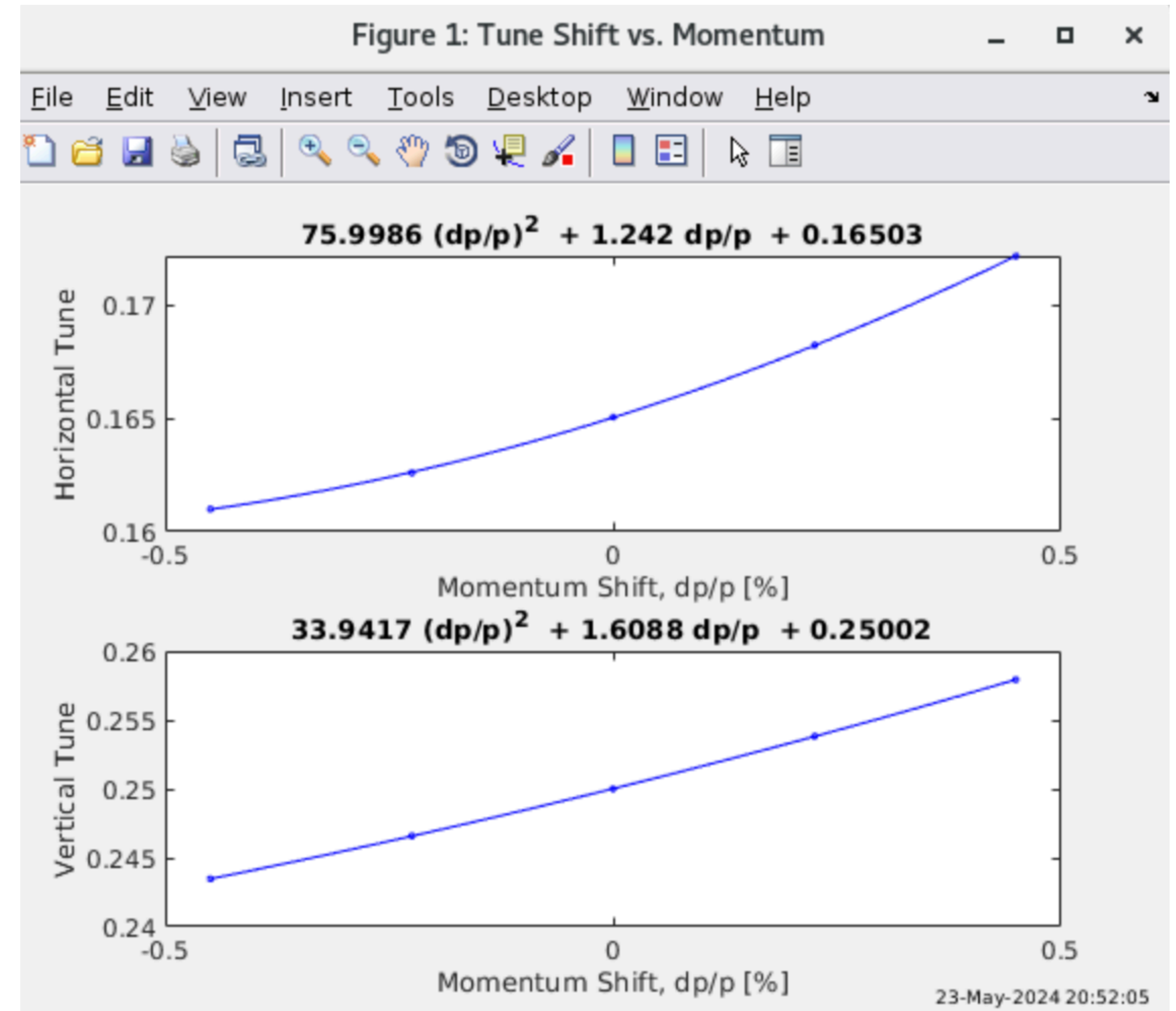
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- **Orbit correction and slow orbit feedback**



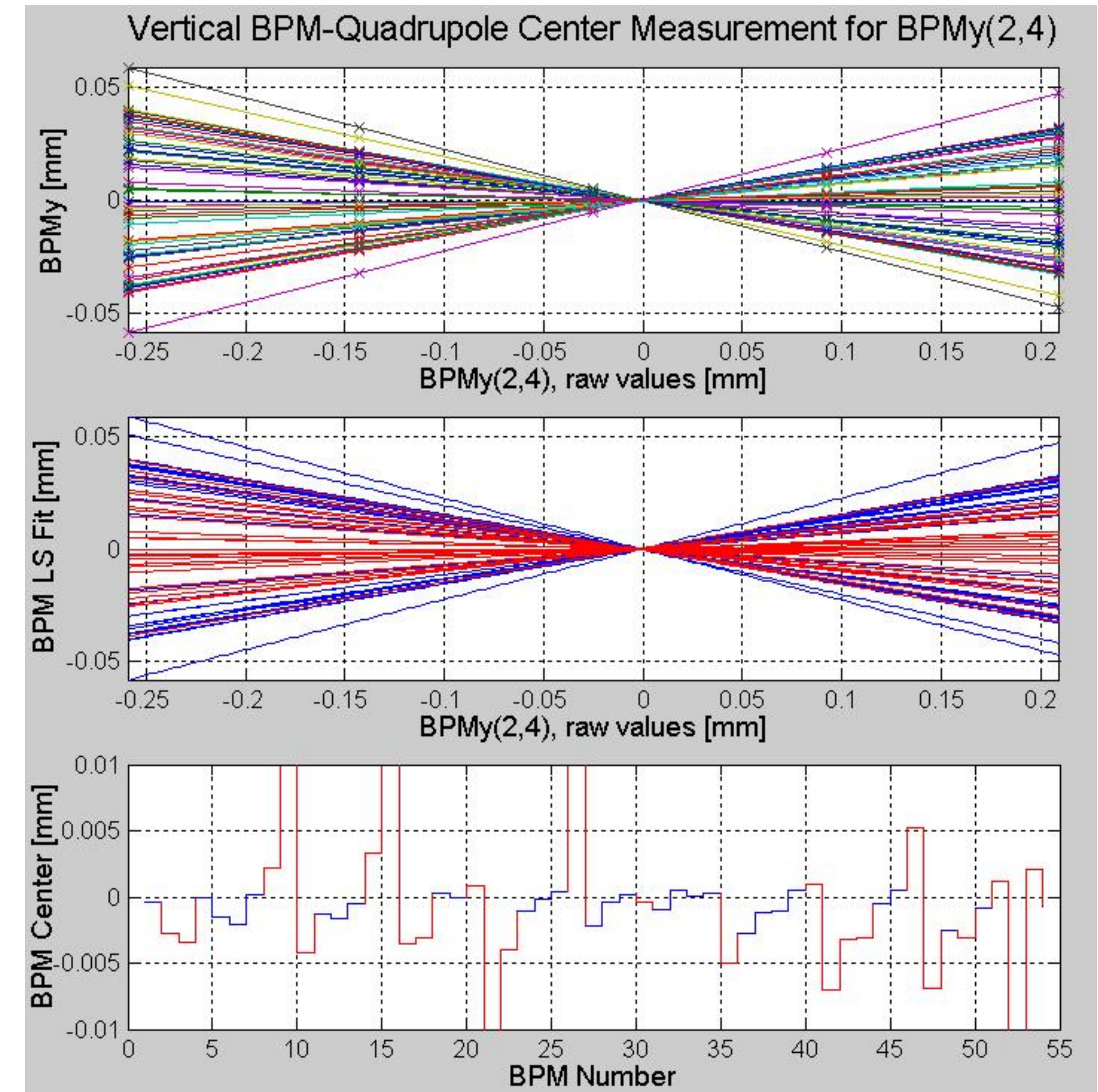
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- **Chromaticity Correction**



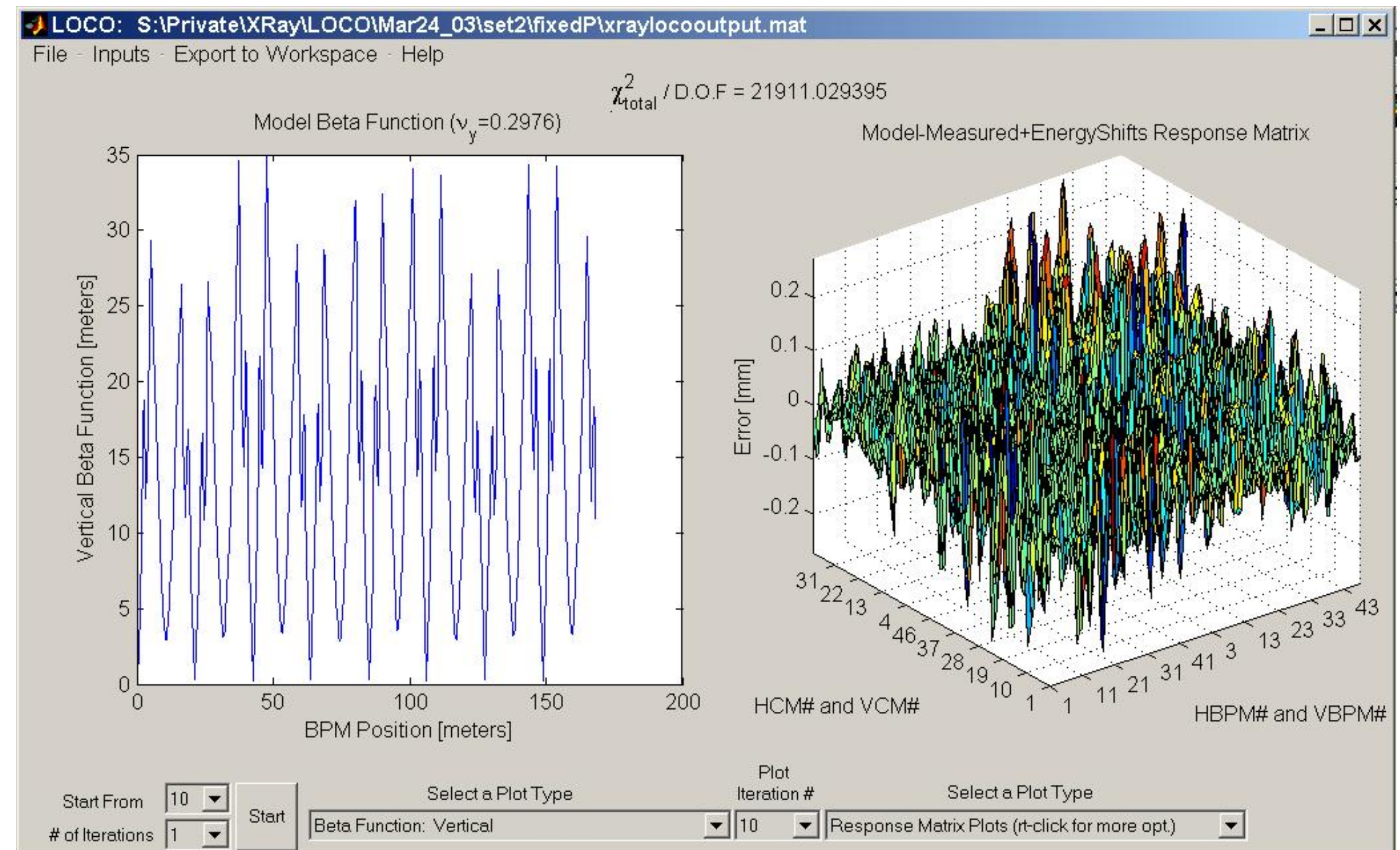
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- **Beam Based Alignment**



High Level Applications in Matlab

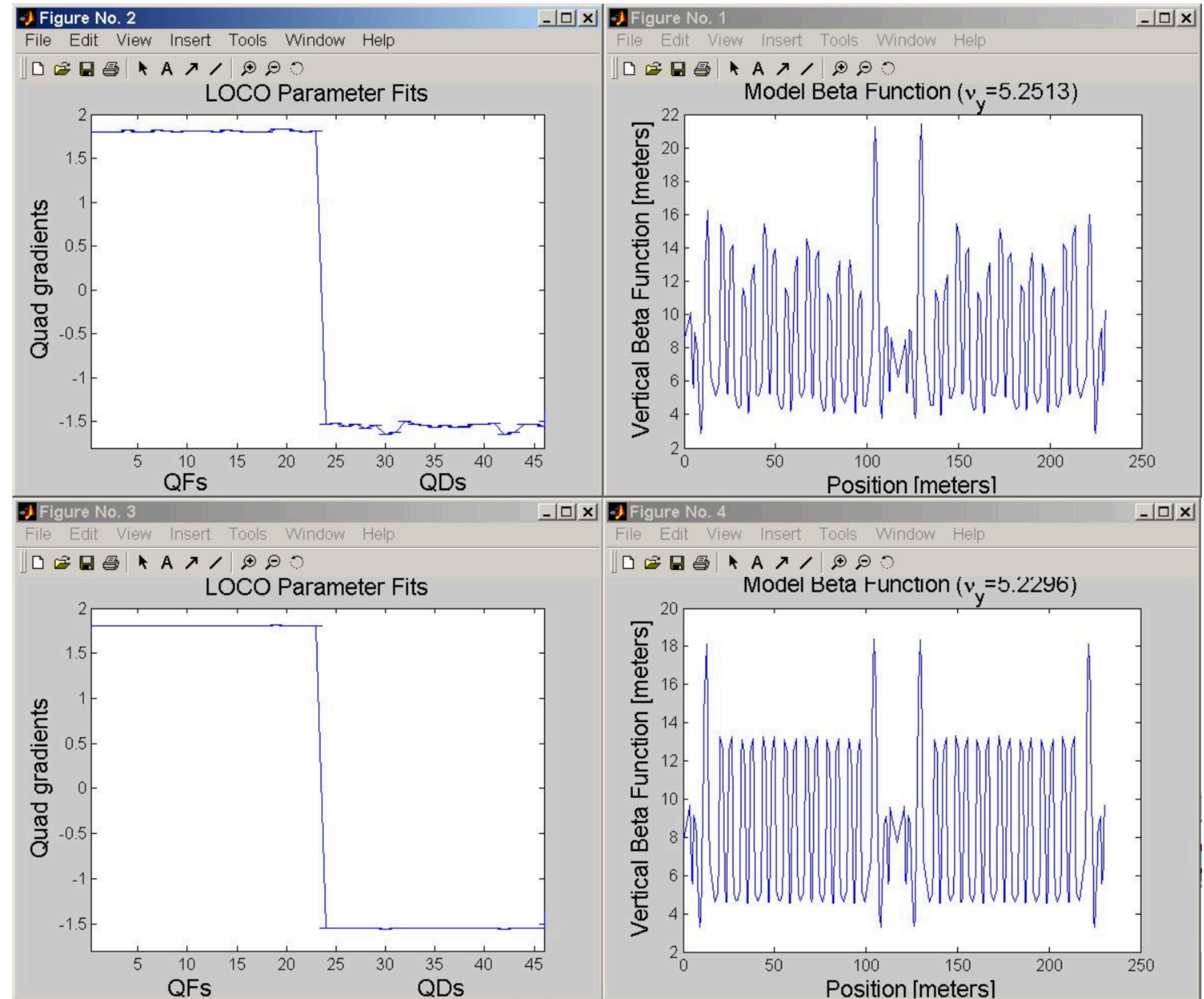
- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- **LOCO (Response matrix analysis, machine calibration)**



High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- LOCO (Response matrix analysis, machine calibration)
- **Insertion device focusing compensation**

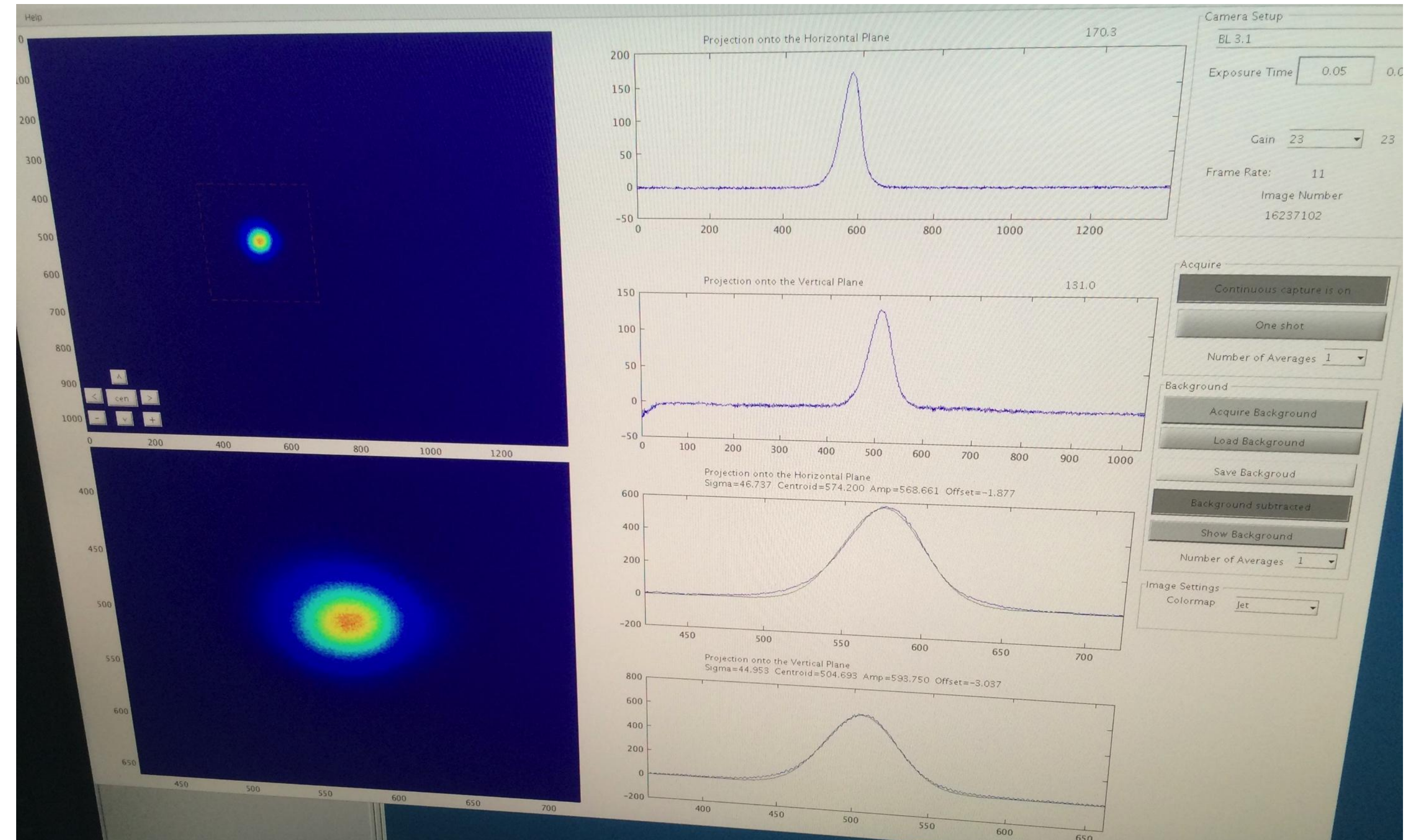
Before



High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- LOCO (Response matrix analysis, machine calibration)
- Insertion device focusing compensation
- **CCD cameras analysis**

Cameras / image displays have all been using Matlab (now slowly moved to Phoebus) for analysis



High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- LOCO (Response matrix analysis, machine calibration)
- Insertion device focusing compensation
- CCD cameras
- **Save/ restore / configuration control**

Saved values come from golden file: /home/als/physbase/mmlt/machine/ALS/StorageRingOpsData/PseudoSingleBunch/GoldenConfig_LowEmittance

Restore Table

Update (3:35:53 PM)

	Family	Field	Select
1	HCM	Setpoint	<input checked="" type="checkbox"/>
2	VCM	Setpoint	<input checked="" type="checkbox"/>
3	QF	Setpoint	<input checked="" type="checkbox"/>
4	QD	Setpoint	<input checked="" type="checkbox"/>
5	QFA	Setpoint	<input checked="" type="checkbox"/>
6	QDA	Setpoint	<input checked="" type="checkbox"/>
7	SF	Setpoint	<input checked="" type="checkbox"/>
8	SD	Setpoint	<input checked="" type="checkbox"/>
9	SHF	Setpoint	<input checked="" type="checkbox"/>
10	SHD	Setpoint	<input checked="" type="checkbox"/>
11	SQSF	Setpoint	<input checked="" type="checkbox"/>
12	SQSF	RampRate	<input checked="" type="checkbox"/>
13	SQSD	Setpoint	<input checked="" type="checkbox"/>
14	SQSD	RampRate	<input checked="" type="checkbox"/>
15	SQSHF	Setpoint	<input checked="" type="checkbox"/>
16	BEND	Setpoint	<input checked="" type="checkbox"/>
17	HCMCHICANE	Setpoint	<input checked="" type="checkbox"/>
18	HCMCHICANEM	Setpoint	<input checked="" type="checkbox"/>
19	TOPSCRAPER	Setpoint	<input checked="" type="checkbox"/>

Restores only the selected items

Restore Setpoints

Allow individual changes to the present column

Edit Mode is Off

All None

Saved Values for Viewing Only (No Restore)

	Family	Field	Select
1	BPMx	Monitor	<input checked="" type="checkbox"/>
2	BPMx	GoldenSetpoint	<input checked="" type="checkbox"/>
3	BPMx	Monitor	<input checked="" type="checkbox"/>
4	BPMx	GoldenSetpoint	<input checked="" type="checkbox"/>
5	HCM	Monitor	<input checked="" type="checkbox"/>
6	HCM	Trim	<input checked="" type="checkbox"/>
7	HCM	FF1	<input checked="" type="checkbox"/>
8	HCM	FF2	<input checked="" type="checkbox"/>
9	HCM	DAC	<input checked="" type="checkbox"/>
10	HCM	RampRate	<input checked="" type="checkbox"/>
11	VCM	Monitor	<input checked="" type="checkbox"/>
12	VCM	Trim	<input checked="" type="checkbox"/>
13	VCM	FF1	<input checked="" type="checkbox"/>
14	VCM	FF2	<input checked="" type="checkbox"/>
15	VCM	DAC	<input checked="" type="checkbox"/>
16	VCM	RampRate	<input checked="" type="checkbox"/>
17	HCMFOFB	Trim	<input checked="" type="checkbox"/>
18	HCMFOFB	FF1	<input checked="" type="checkbox"/>
19	HCMFOFB	FF2	<input checked="" type="checkbox"/>

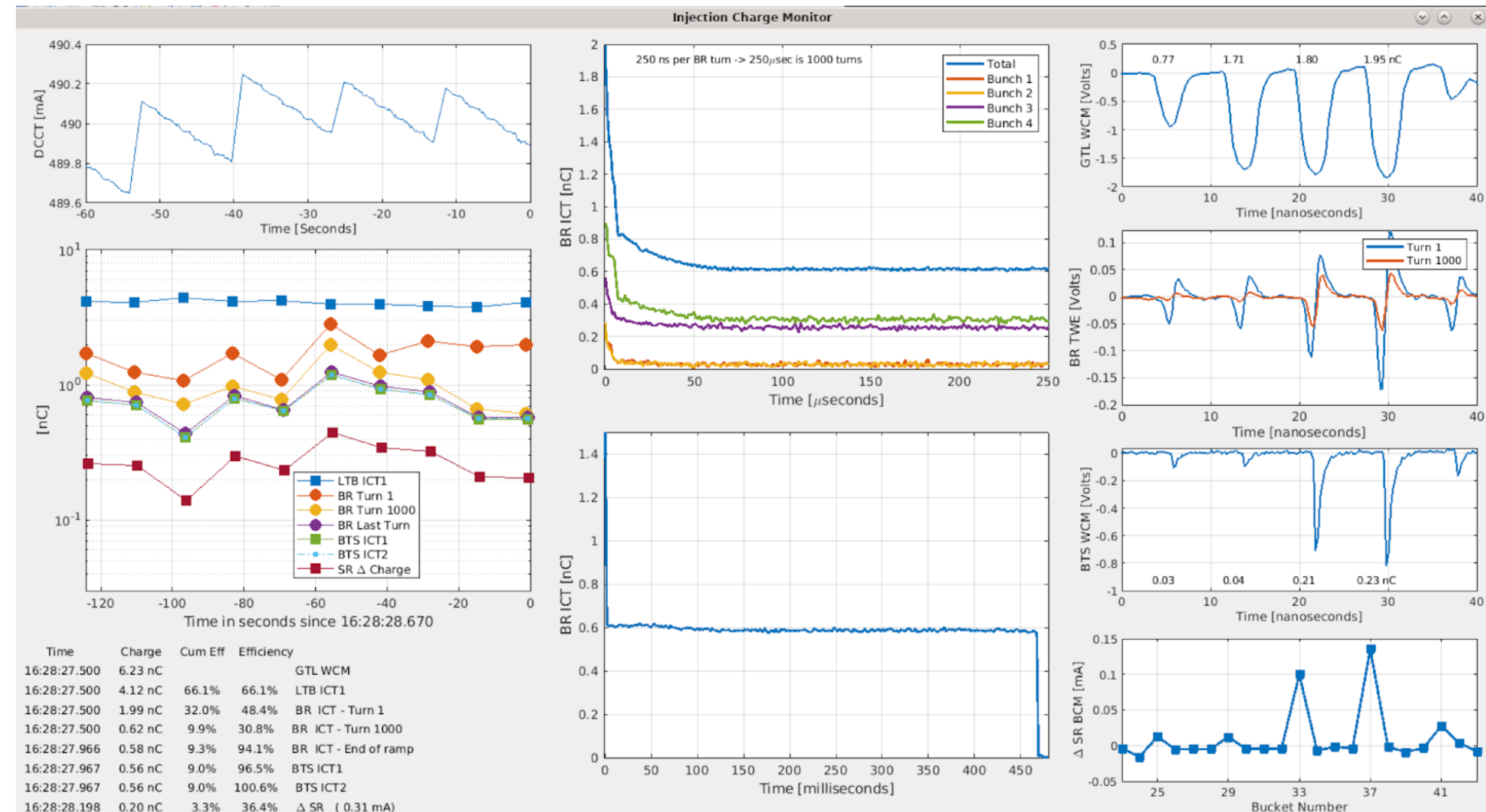
All None

	Common Name	Saved	Present	Difference	Channel Name
1	SR01C HCM2	2.4834	2.1535	0.3299	SR01C_HCM2_AC01
2	SR01C HCM3	-2.8546	-2.9254	0.0708	SR01C_HCM3_AC02
3	SR01C HCM4	2.0643	2.1394	-0.0751	SR01C_HCM4_AC03
4	SR01C HCSD1	-0.1861	-0.2369	0.0508	SR01C_HCSD1_AC00
5	SR01C HCSD2	0.4834	0.4499	0.0336	SR01C_HCSD2_AC01
6	SR01C HCSF1	-0.4171	-0.4024	-0.0146	SR01C_HCSF1_AC02
7	SR01C HCSF2	-1.6436	-1.3695	-0.2740	SR01C_HCSF2_AC03
8	SR02C HCM1	-0.8611	-1.2647	0.4036	SR02C_HCM1_AC00
9	SR02C HCM2	3.2098	3.8261	-0.6163	SR02C_HCM2_AC01
10	SR02C HCM3	4.3154	3.7702	0.5452	SR02C_HCM3_AC02
11	SR02C HCM4	-1.3294	-1.2178	-0.1116	SR02C_HCM4_AC03
12	SR02C HCSD1	1.1803	1.0369	0.1435	SR02C_HCSD1_AC00
13	SR02C HCSD2	-0.7575	-0.5868	-0.1707	SR02C_HCSD2_AC01
14	SR02C HCSF1	0.4060	0.7393	-0.3333	SR02C_HCSF1_AC02
15	SR02C HCSF2	-1.3653	-1.2345	-0.1308	SR02C_HCSF2_AC03
16	SR03C HCM1	-0.9174	-0.7456	-0.1718	SR03C_HCM1_AC00
17	SR03C HCM2	1.6622	1.3624	0.2998	SR03C_HCM2_AC01
18	SR03C HCM3	5.3772	6.2632	-0.8860	SR03C_HCM3_AC02
19	SR03C HCM4	-0.7731	-1.2626	0.4894	SR03C_HCM4_AC03
20	SR03C HCSD1	-1.7643	-1.4993	-0.2650	SR03C_HCSD1_AC00
21	SR03C HCSD2	-0.1011	-0.1552	0.0541	SR03C_HCSD2_AC01
22	SR03C HCSF1	0.0987	0.1154	-0.0167	SR03C_HCSF1_AC02
23	SR03C HCSF2	-0.6371	-0.4230	-0.2141	SR03C_HCSF2_AC03
24	SR04C HCM1	-0.6833	-0.9424	0.2591	SR04C_HCM1_AC00
25	SR04C HCM2	-1.3519	-0.6885	-0.6634	SR04C_HCM2_AC01
26	SR04C HCM3	-1.3273	-2.6350	-1.6923	SR04C_HCM3_AC02
27	SR04C HCM4	2.8719	1.8860	0.9859	SR04C_HCM4_AC03
28	SR04C HCSD1	1.6749	1.5084	0.1665	SR04C_HCSD1_AC00
29	SR04C HCSD2	-0.5050	-0.6395	0.1345	SR04C_HCSD2_AC01
30	SR04C HCSF1	-1.1413	-0.8029	-0.3383	SR04C_HCSF1_AC02
31	SR04C HCSF2	0.0051	0.0204	-0.0153	SR04C_HCSF2_AC03
32	SR04U HCM2	3.8831	3.8465	0.0366	SR04U_HCM2_AC00
33	SR05C HCM1	0.4487	-0.0586	0.5073	SR05C_HCM1_AC00
34	SR05C HCM2	-2.2776	-1.2428	-1.0348	SR05C_HCM2_AC01
35	SR05C HCM3	-3.4285	-2.6524	-0.7761	SR05C_HCM3_AC02
36	SR05C HCM4	2.3152	1.9160	0.3992	SR05C_HCM4_AC03
37	SR05C HCSD1	1.6053	1.5049	0.1005	SR05C_HCSD1_AC00
38	SR05C HCSD2	1.0667	1.1270	-0.0603	SR05C_HCSD2_AC01
39	SR05C HCSF1	-1.4808	-1.2453	-0.2355	SR05C_HCSF1_AC02
40	SR05C HCSF2	-0.8600	-0.7995	-0.0605	SR05C_HCSF2_AC03
41	SR06C HCM1	2.7772	2.1691	0.6082	SR06C_HCM1_AC00
42	SR06C HCM2	-3.5768	-2.4459	-1.1309	SR06C_HCM2_AC01

	Common Name	Saved	Present	Difference	Channel Name
1	BPMx(1,2) (Monitor)	-0.2240	0.0507	-0.2747	SR01C:BPM1:SA:X
2	BPMx(1,3) (Monitor)	-0.3511	-0.3541	0.0030	SR01C:BPM2:SA:X
3	BPMx(1,4) (Monitor)	0.6160	-0.0604	0.6764	SR01C:BPM3:SA:X
4	BPMx(1,5) (Monitor)	0.1075	-0.0731	0.1806	SR01C:BPM4:SA:X
5	BPMx(1,6) (Monitor)	0.8042	-0.1226	0.9269	SR01C:BPM5:SA:X
6	BPMx(1,7) (Monitor)	0.4016	-0.0154	0.4170	SR01C:BPM6:SA:X
7	BPMx(1,9) (Monitor)	-0.1969	-0.0466	-0.1503	SR01C:BPM8:SA:X
8	BPMx(2,3) (Monitor)	0.0504	0	0.0504	SR02C:BPM2:SA:X
9	BPMx(2,4) (Monitor)	0.6727	-0.0356	0.7083	SR02C:BPM3:SA:X
10	BPMx(2,5) (Monitor)	0.9610	0	0.9610	SR02C:BPM4:SA:X
11	BPMx(2,6) (Monitor)	1.4760	0.0429	1.4331	SR02C:BPM5:SA:X
12	BPMx(2,7) (Monitor)	0.5538	-0.0590	0.6129	SR02C:BPM6:SA:X
13	BPMx(2,8) (Monitor)	-0.7323	-0.0942	-0.6381	SR02C:BPM7:SA:X
14	BPMx(2,9) (Monitor)	-0.0963	0.1865	-0.2827	SR02C:BPM8:SA:X
15	BPMx(1,10) (Monitor)	0.9191	0.8278	0.0913	SR02S:IDBPM1:SA:X
16	BPMx(2,1) (Monitor)	0.4214	-0.0093	0.4307	SR02S:IDBPM2:SA:X
17	BPMx(3,2) (Monitor)	-0.0324	-0.2462	0.2137	SR03C:BPM1:SA:X
18	BPMx(3,3) (Monitor)	0.1959	-0.0766	0.2724	SR03C:BPM2:SA:X
19	BPMx(3,4) (Monitor)	0.6309	0.0751	0.5558	SR03C:BPM3:SA:X
20	BPMx(3,5) (Monitor)	0.6270	-1.9772	5.6041	SR03C:BPM4:SA:X
21	BPMx(3,6) (Monitor)	0.8826	-0.2376	1.1202	SR03C:BPM5:SA:X
22	BPMx(3,7) (Monitor)	1.1059	-0.1485	1.2544	SR03C:BPM6:SA:X
23	BPMx(3,8) (Monitor)	-0.0021	0.0370	-0.0392	SR03C:BPM7:SA:X
24	BPMx(3,9) (Monitor)	0.3373	-0.2268	0.5641	SR03C:BPM8:SA:X
25	BPMx(4,2) (Monitor)	0.4792	-0.1445	0.6237	SR04C:BPM1:SA:X
26	BPMx(4,3) (Monitor)	-0.3872	-0.2835	-0.1038	SR04C:BPM2:SA:X
27	BPMx(4,4) (Monitor)	0.6497	0.0524	0.5973	SR04C:BPM3:SA:X
28	BPMx(4,7) (Monitor)	0.6646	0.0536	0.6109	SR04C:BPM6:SA:X
29	BPMx(4,8) (Monitor)	-0.4437	0.1143	-0.5580	SR04C:BPM7:SA:X
30	BPMx(4,9) (Monitor)	-0.0949	-0.0270	-0.0678	SR04C:BPM8:SA:X
31	BPMx(4,5) (Monitor)	0.5018	-0.1283	0.6302	SR04C_BPM4XTFAM00
32	BPMx(4,6) (Monitor)	1.2218	-0.0248	1.2467	SR04C_BPM5XTFAM02
33	BPMx(3,10) (Monitor)	1.5293	0.0152	1.5141	SR04S:IDBPM1:SA:X
34	BPMx(4,1) (Monitor)	1.5479	0.0523	1.4955	SR04S:IDBPM2:SA:X
35	BPMx(3,11) (Monitor)	0.8979	-0.0351	0.9330	SR04S:IDBPM3:SA:X
36	BPMx(3,12) (Monitor)	0.8961	-0.0474	0.9435	SR04S:IDBPM4:SA:X
37	BPMx(5,2) (Monitor)	-0.2213	-0.0868	-0.1345	SR05C:BPM1:SA:X
38	BPMx(5,3) (Monitor)	-0.1088	-0.0101	-0.0987	SR05C:BPM2:SA:X
39	BPMx(5,4) (Monitor)	0.3370	0.1833	0.1536	SR05C:BPM3:SA:X
40	BPMx(5,5) (Monitor)	0.5935	-0.1247	0.7182	SR05C:BPM4:SA:X
41	BPMx(5,6) (Monitor)	0.2702	0	0.2702	SR05C:BPM5:SA:X
42	BPMx(5,7) (Monitor)	0.1819	-0.0247	0.2066	SR05C:BPM6:SA:X

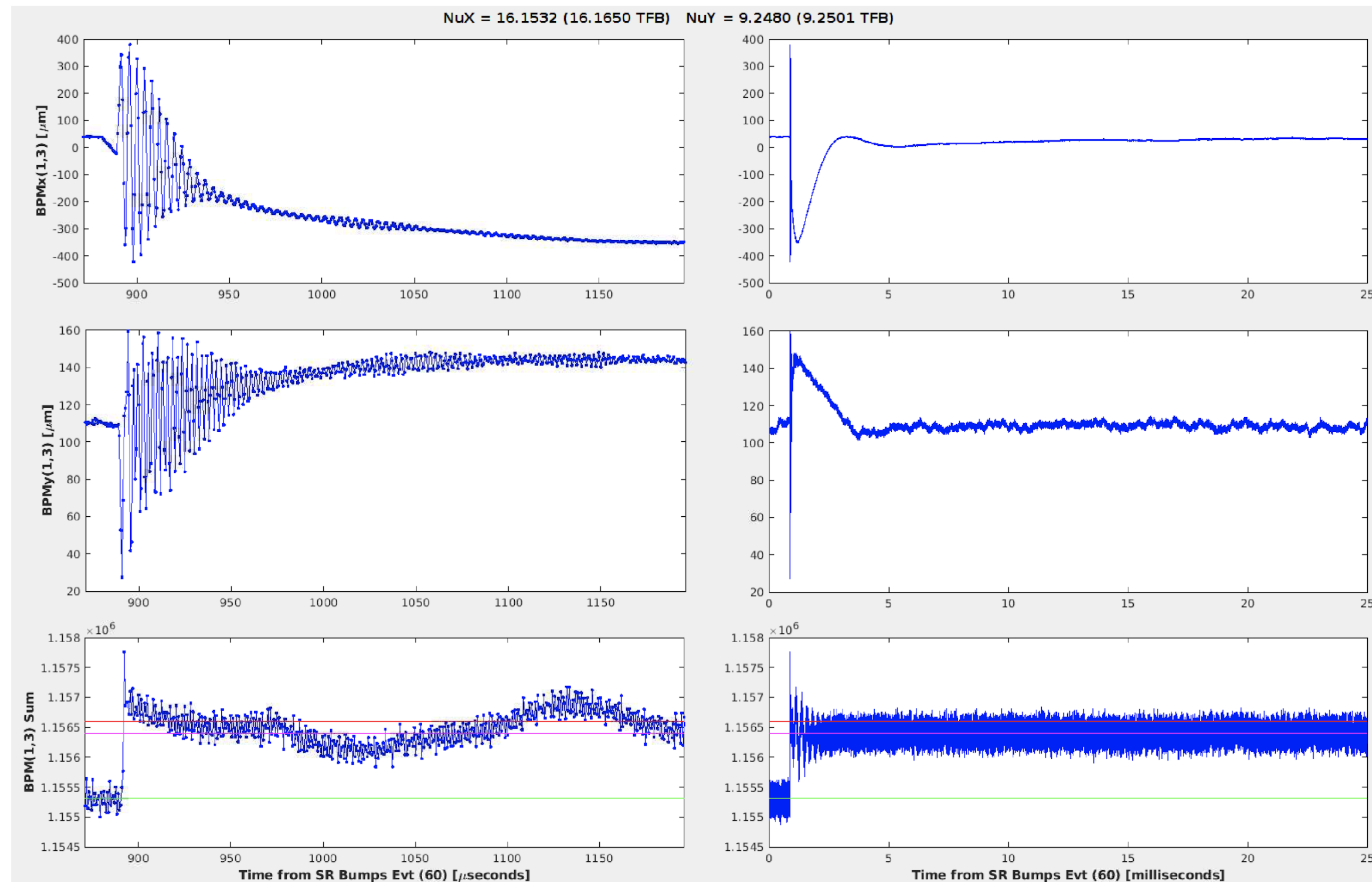
High Level Applications in Matlab

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- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- LOCO (Response matrix analysis, machine calibration)
- Insertion device focusing compensation
- CCD cameras
- Save/ restore / configuration control
- **Injection Monitoring**



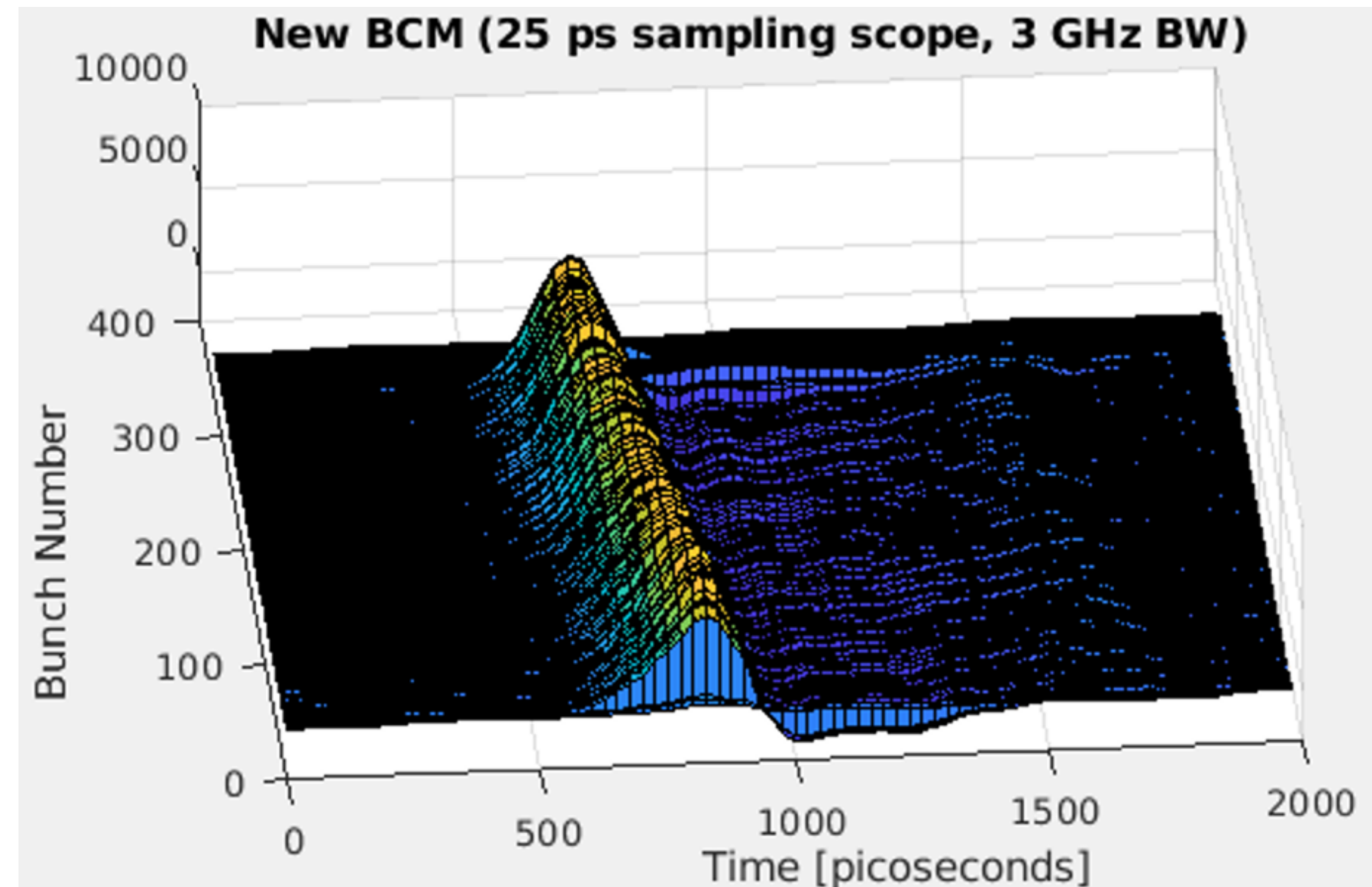
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- Save/ restore / configuration control
- **Injection Monitoring**



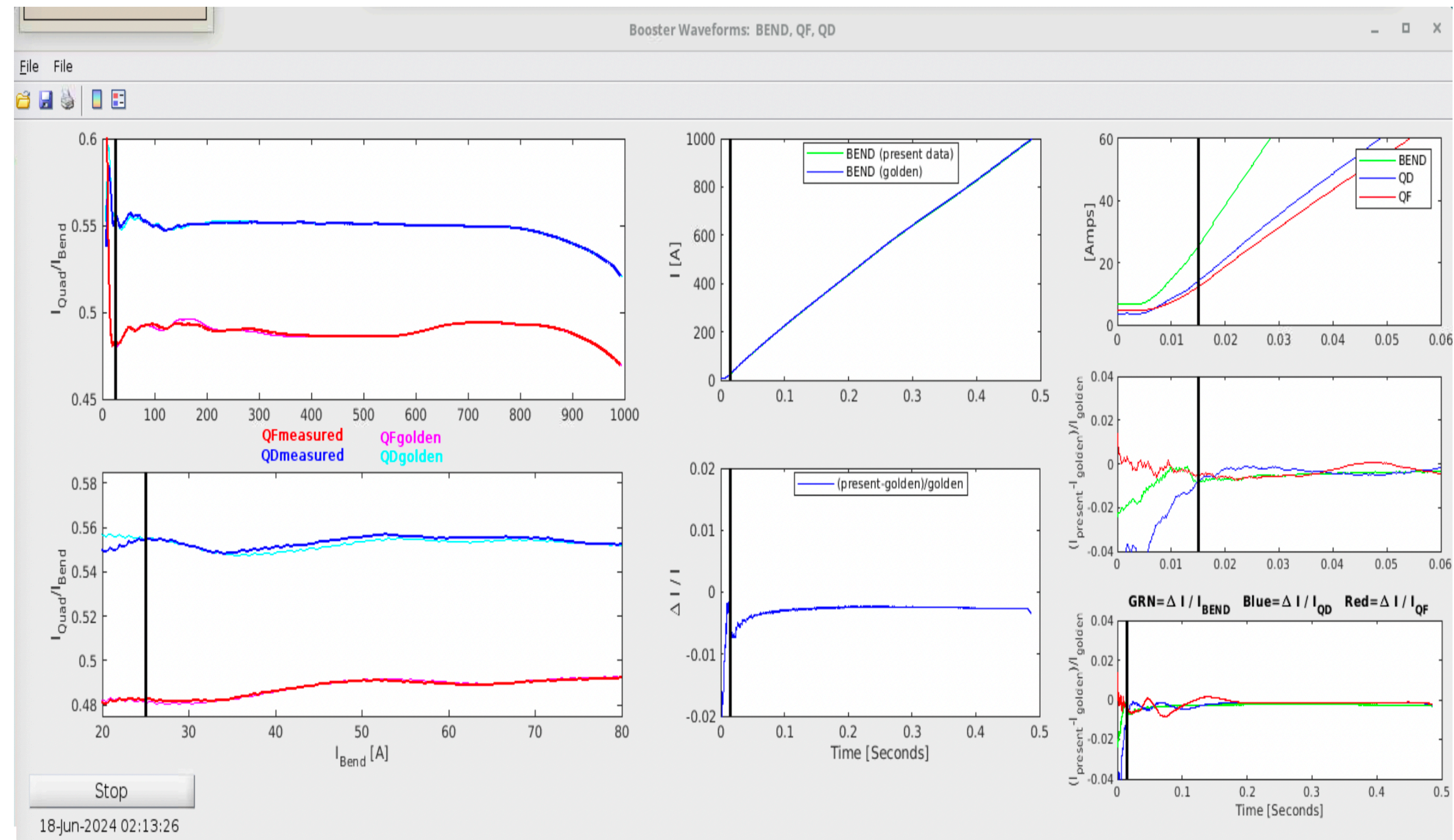
High Level Applications in Matlab

- Display (plotfamily, mmlviewer)
- Main Control Panels
- Orbit correction and slow orbit feedback
- Chromaticity Correction
- Beam Based Alignment
- LOCO (Response matrix analysis, machine calibration)
- Insertion device focusing compensation
- CCD cameras
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- **Energy Ramping**

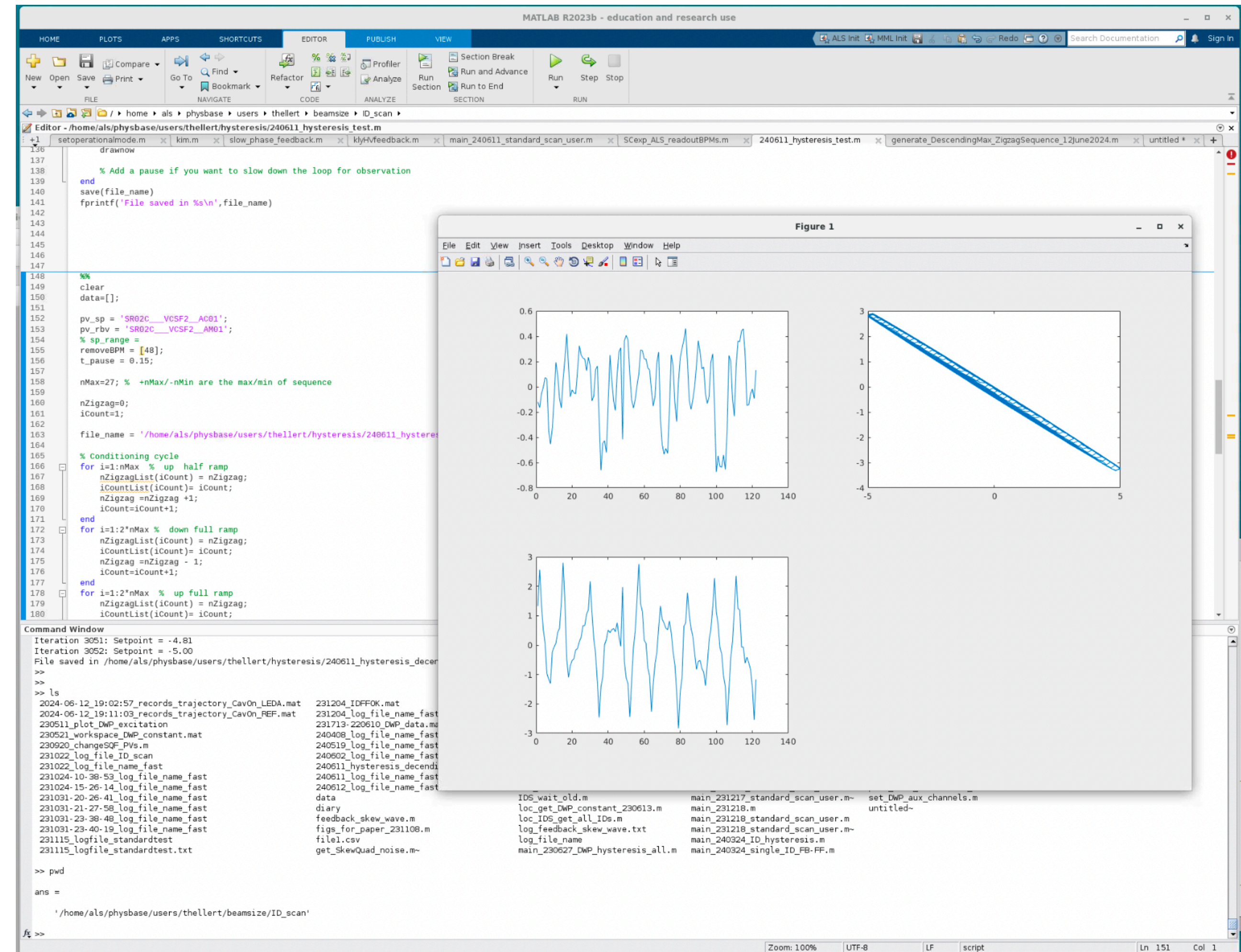


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High Level Applications in Matlab

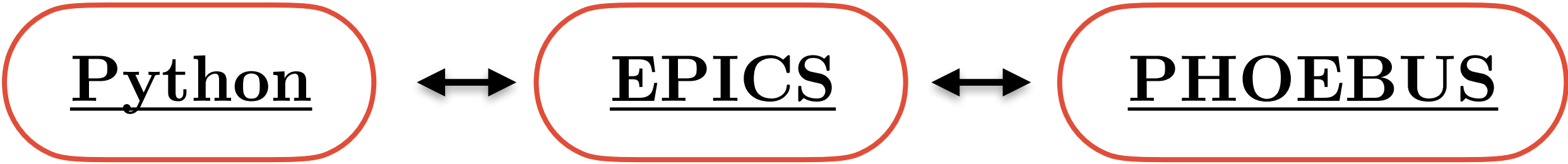
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- **Primary Scripting Language for Physics Shifts**



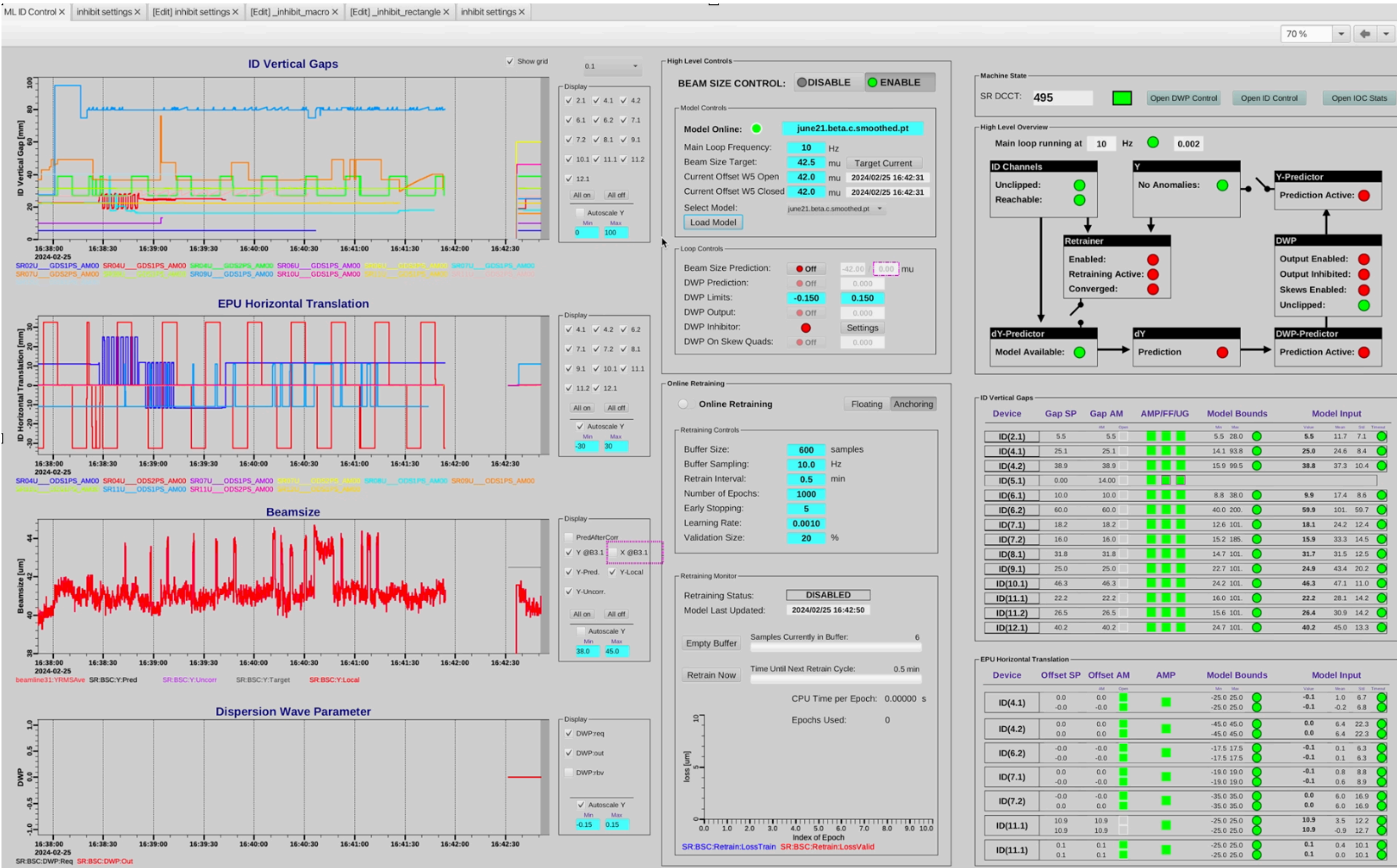
Future Applications



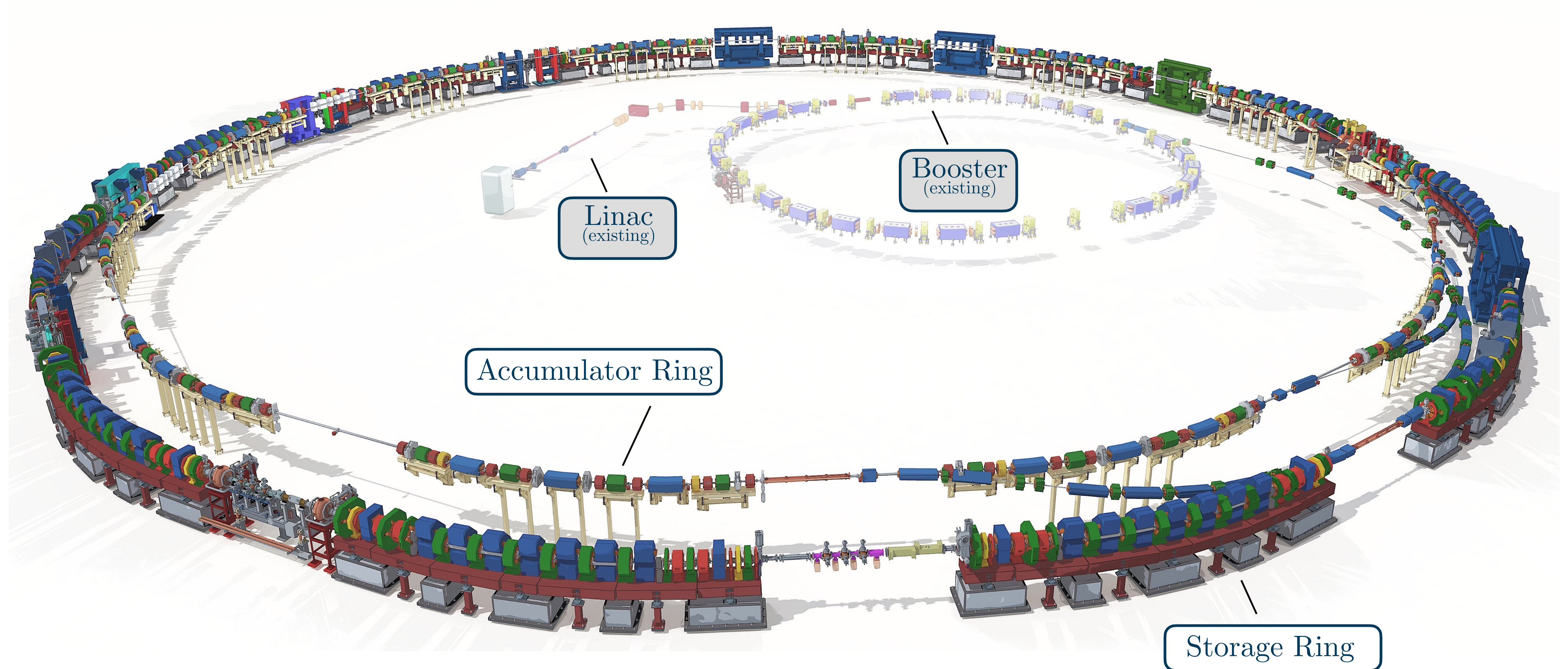
Machine Learning Projects are Implemented in Python



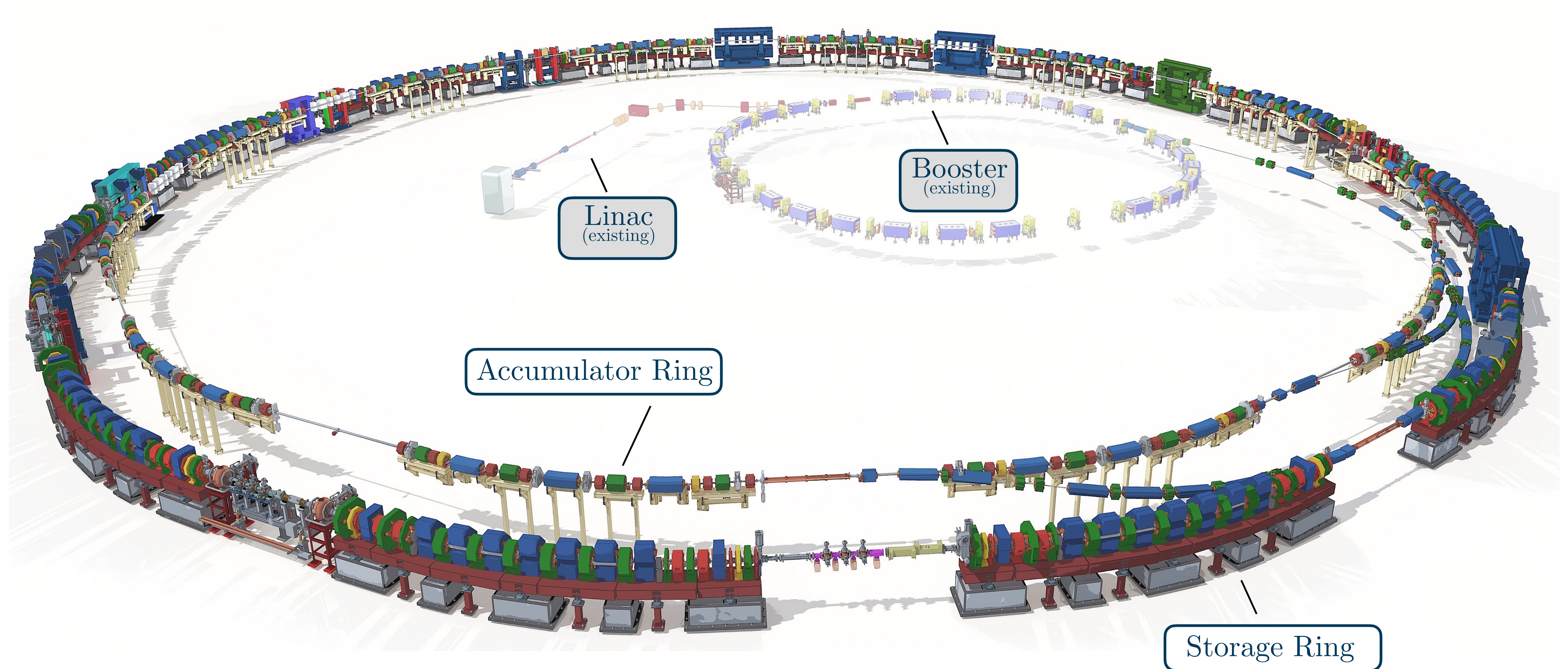
- Machine learning applications will become more important in the future
 - Implemented in python
 - Currently without any middle layer



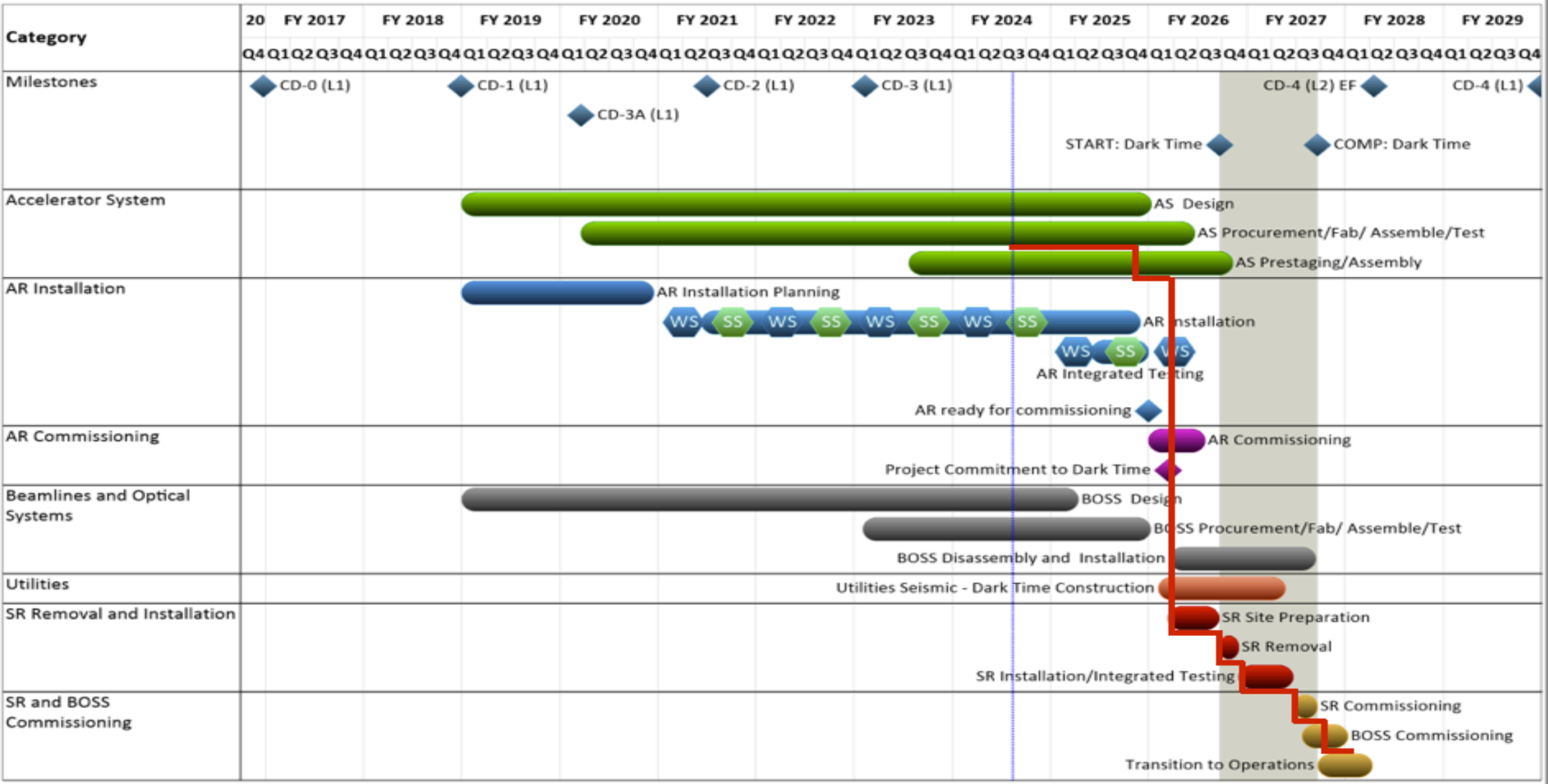
Overview of the ALS-U Accelerator Facility



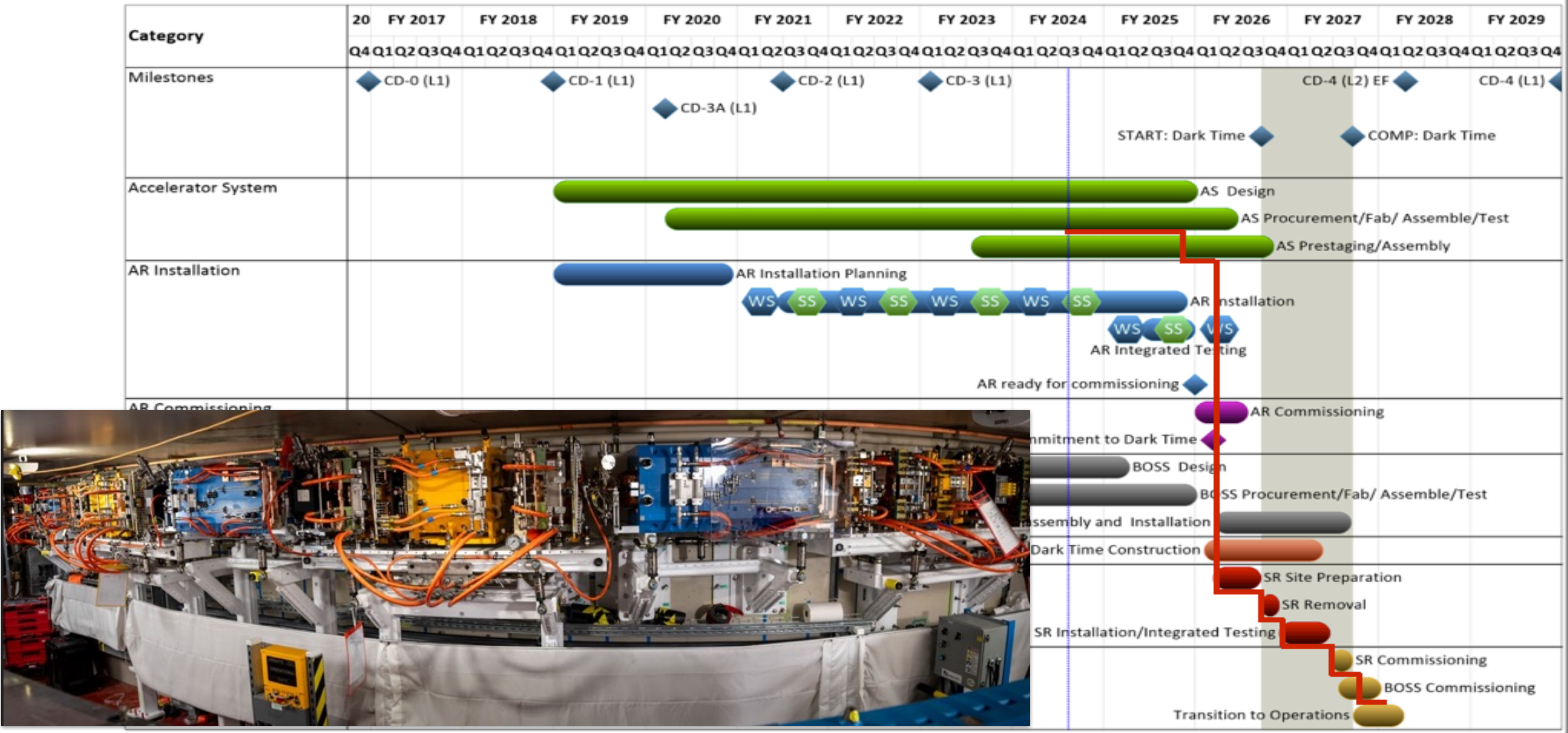
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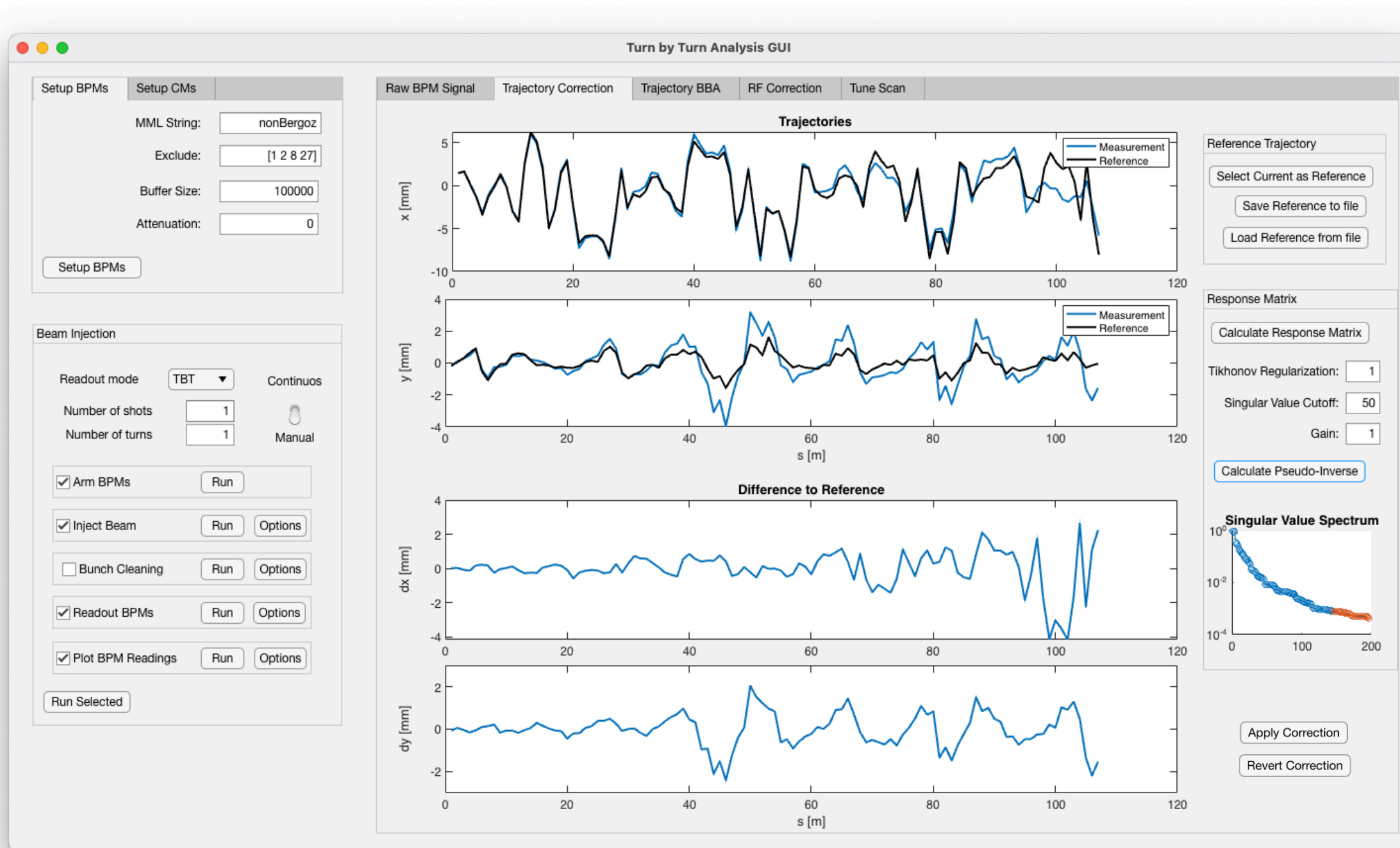
ALS-U Schedule



ALS-U Schedule

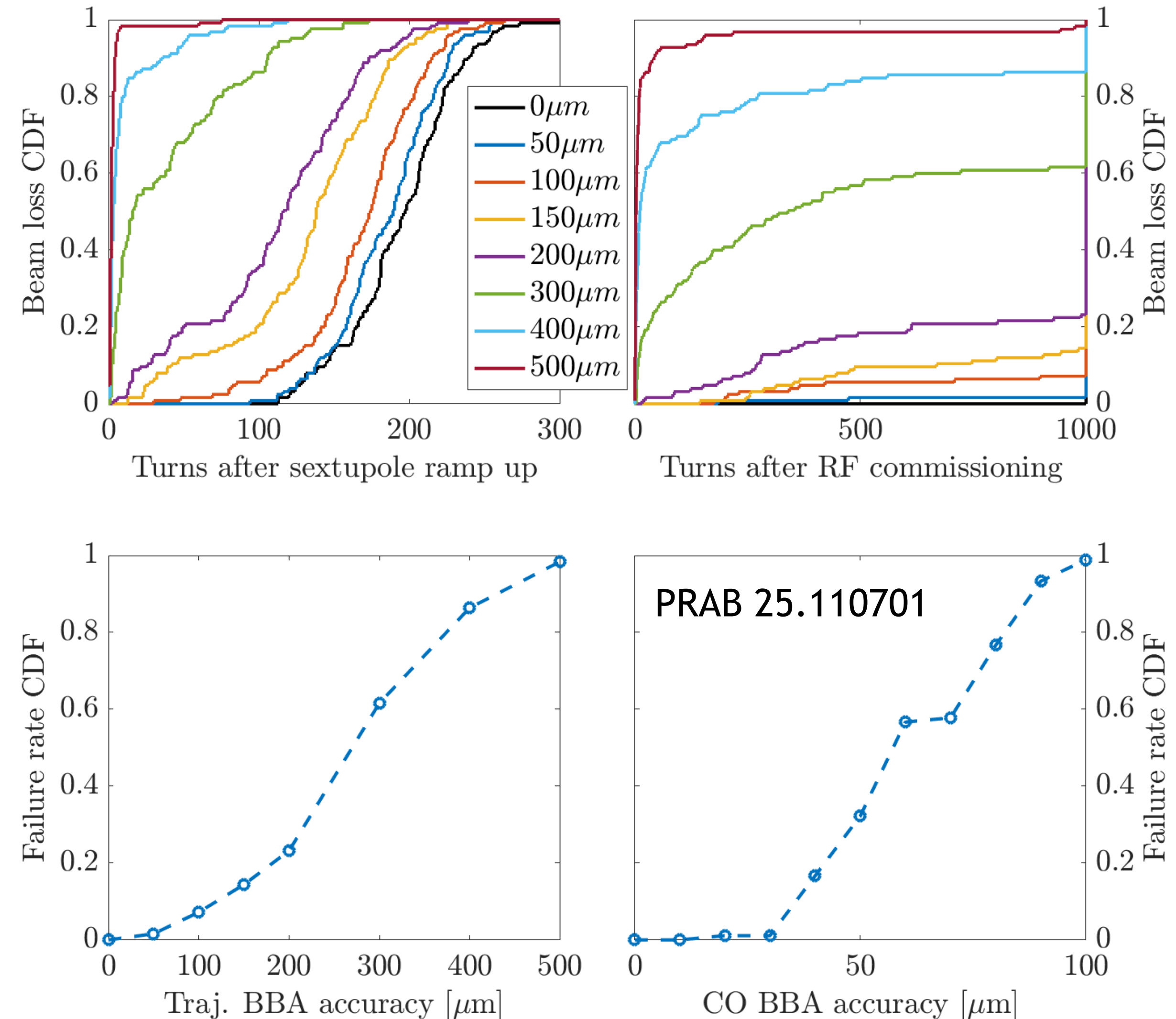


Turn-by-Turn Trajectory Correction / Beam Threading



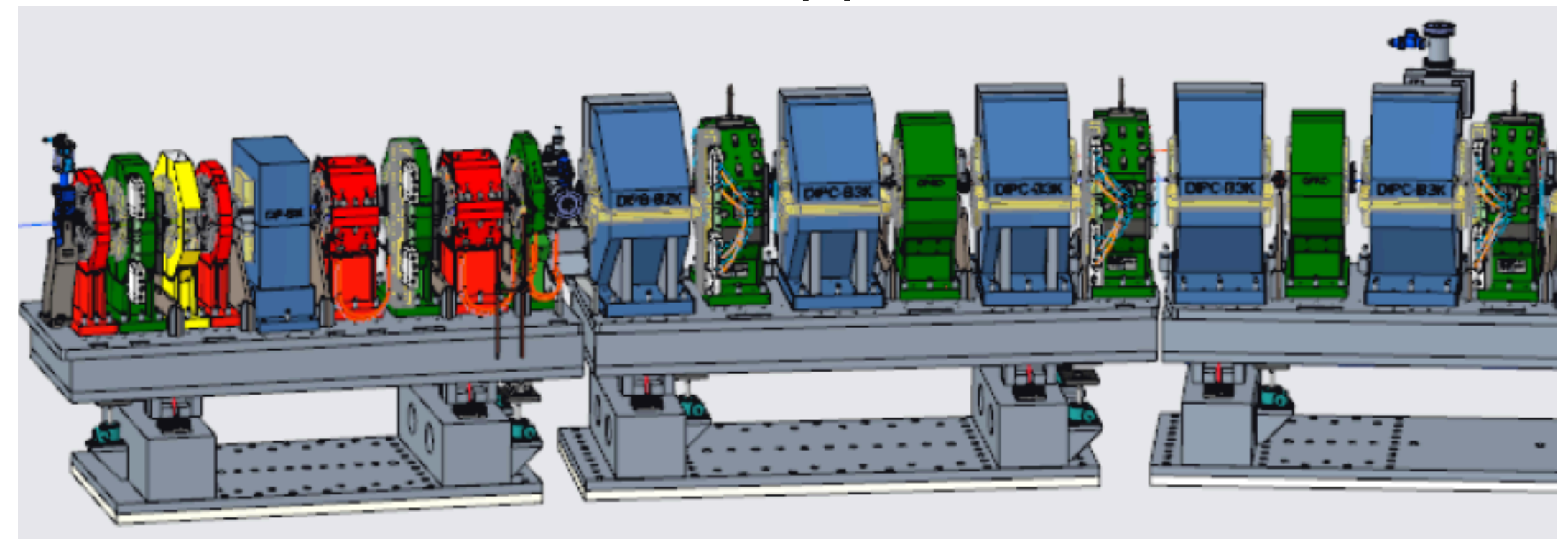
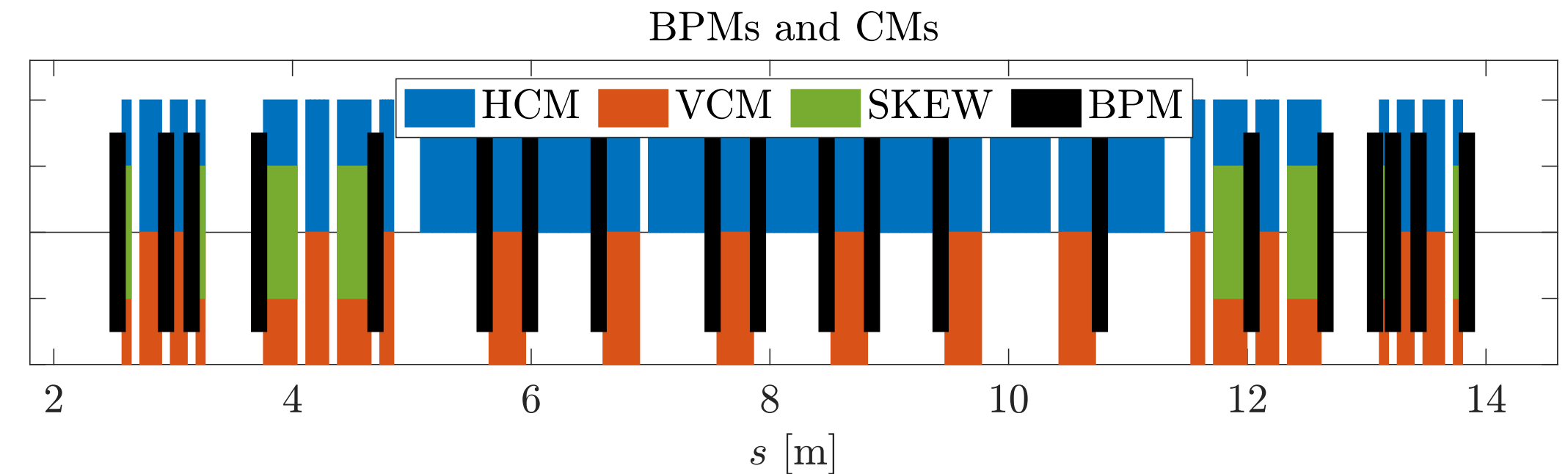
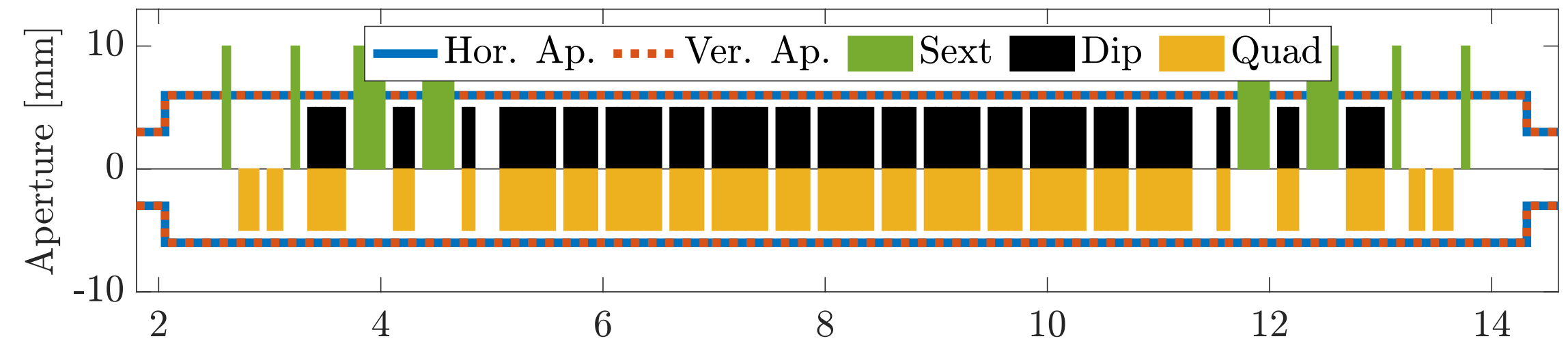
Turn-by-Turn Beam Based Alignment

- Turn-by-Turn BBA Required for ALS-U
 - Commissioning simulations for ALS-U Storage Ring show that without $\sim 100\mu\text{m}$ rms BPM offsets reliable beam capture can not be expected
 - Initial BPM offsets to be expected at $\sim 500\mu\text{m}$ rms
 - Turn by turn BBA routine mandatory for successful beam capture at ALS-U SR



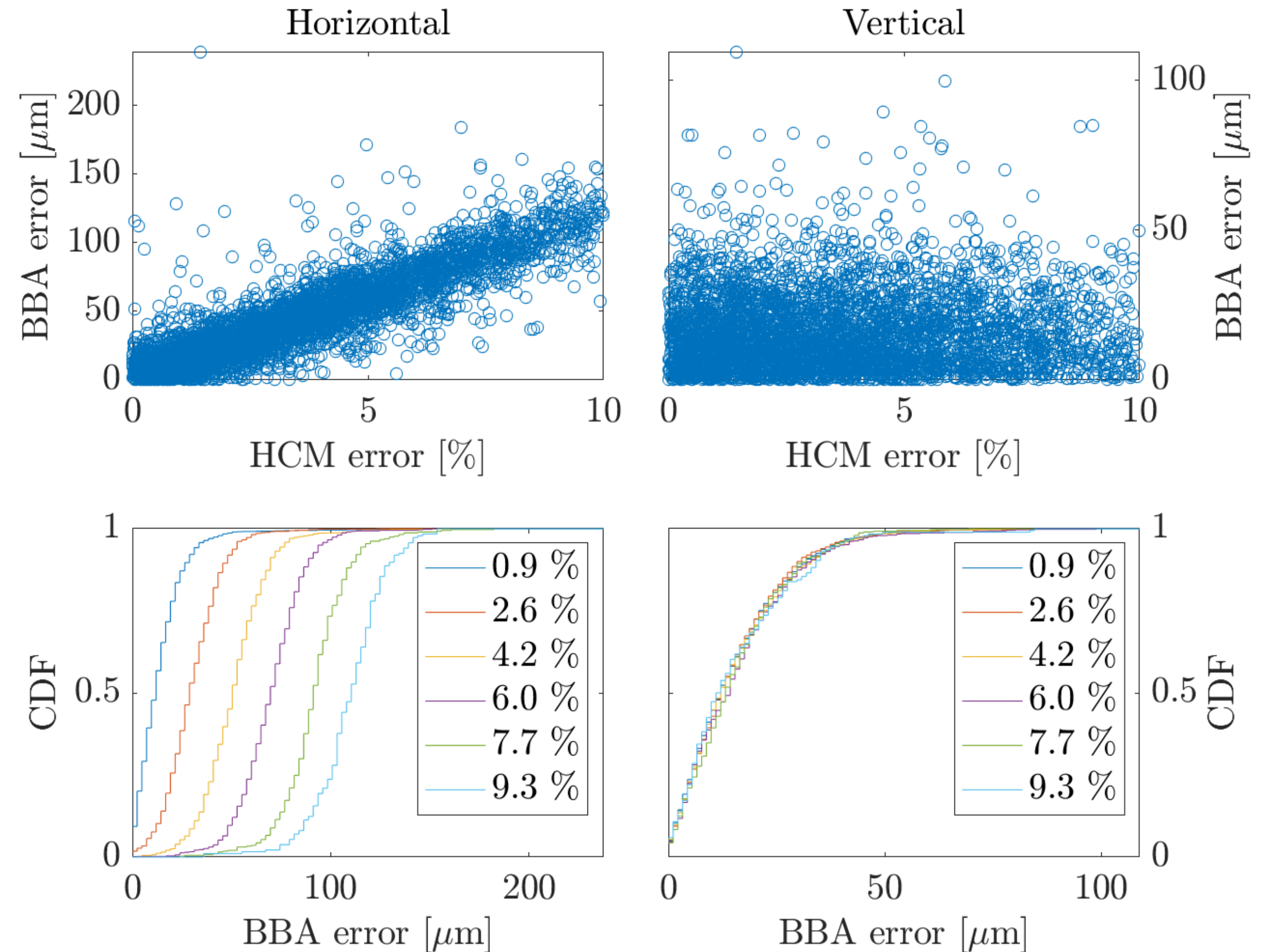
Beam Dynamics Challenges

- **Tight space constraints**
 - Most correctors are embedded in combined function magnets
 - Dipole field compensation critical for BBA
- **Little Margin for Errors**
 - Commissioning simulations show that the lifetime goal of 30min is met with little margin (including IDs)
 - Hysteresis might become critical to compensate



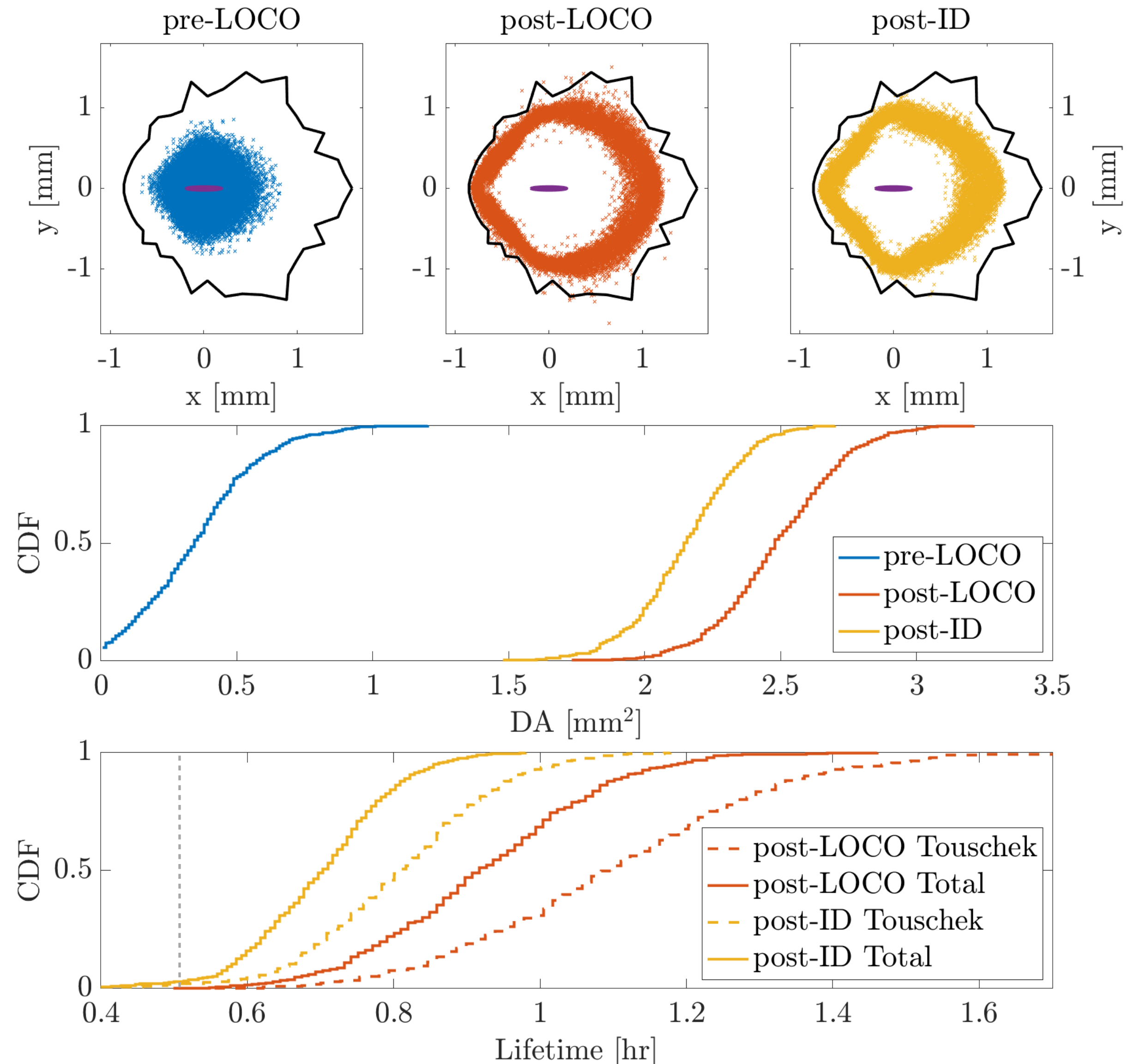
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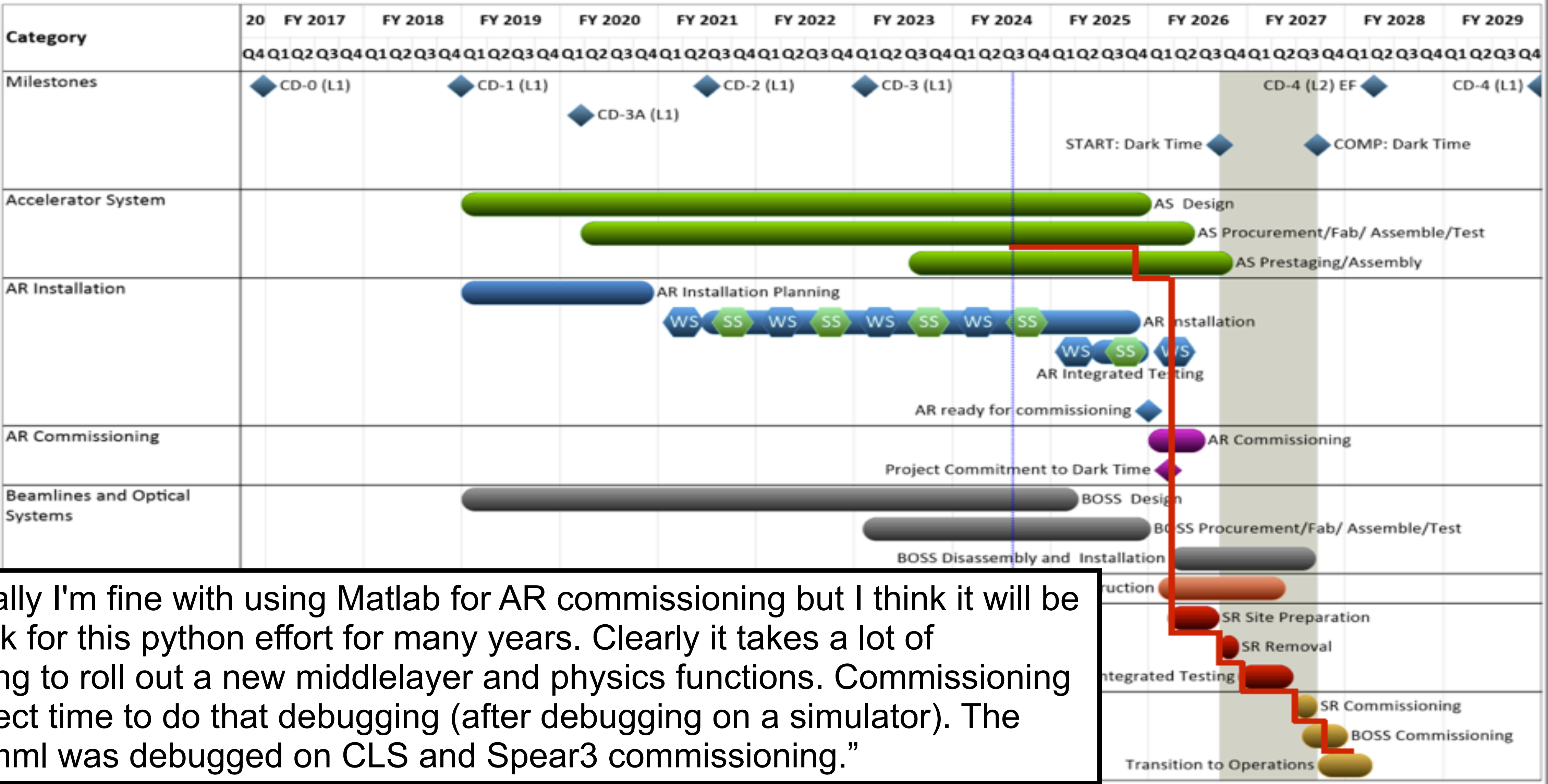


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Outlook



“Personally I'm fine with using Matlab for AR commissioning but I think it will be a setback for this python effort for many years. Clearly it takes a lot of debugging to roll out a new middlelayer and physics functions. Commissioning is a perfect time to do that debugging (after debugging on a simulator). The matlab mml was debugged on CLS and Spear3 commissioning.”