Control Infrastructure, Data Analysis and Simulation Feedback at the NDCX-II Accelerator Facility

BERKELEY LAB

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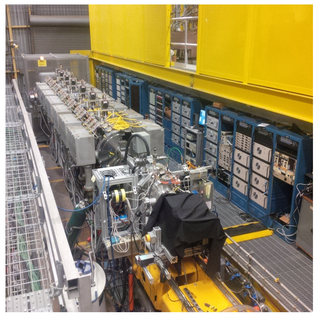
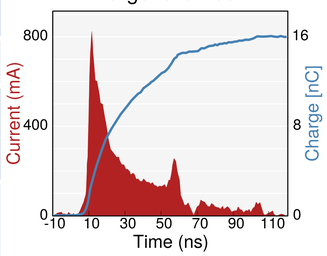
CASIS Workshop, Livermore, May 18th, 2016

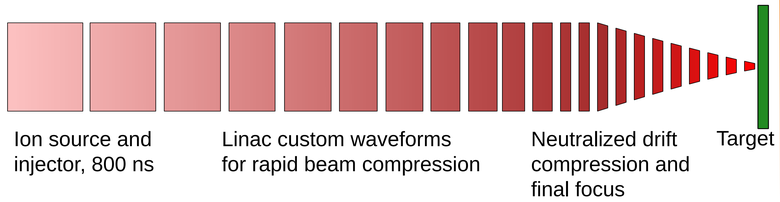
The NDCX-II Facility

	NDCX-II (goals)
Ions/pulse (total)	10^{10} (3×10^{11})
Pulse length	2 ns (~1 ns)
Typical spot size	1 mm^2
Ion species	He, (H, d, …)
E_{kin}	0.12 - 1.2 MeV
Energy spread	~10 %
Repetition rate	2/min
Target temperature	< 0.1 eV (~1 eV)
Radiation environment at the target	Benign, no shielding required
Heated volume	~1 mm^2 × 5 µm = 5×10^6 $µm^3$

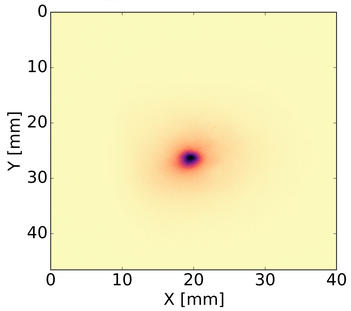


Target chamber

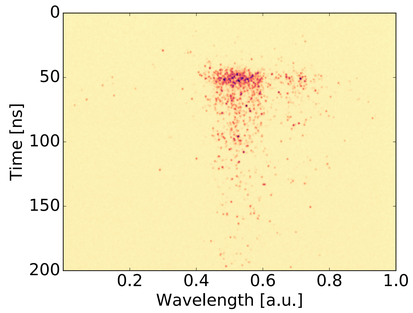




CCD camera



Streak camera



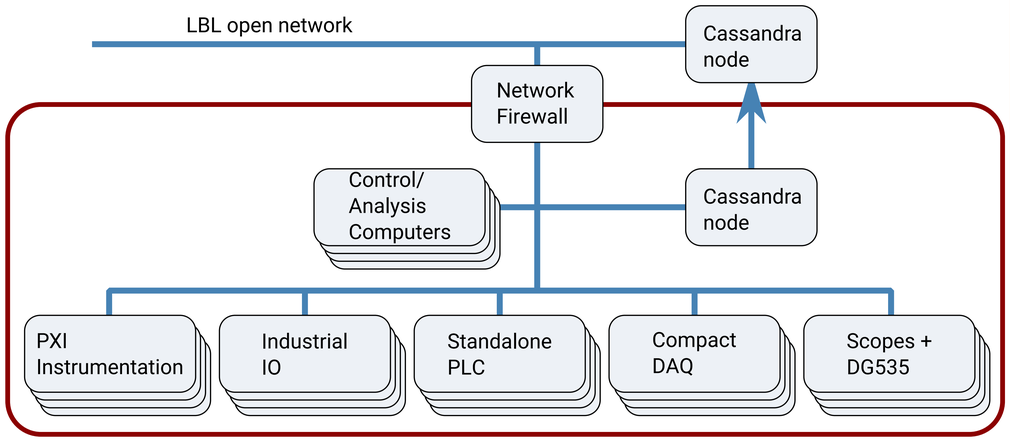
Research Topics:

- Defect dynamics in materials
- Intense beams and beam-plasma physics
- Materials studies for fusion reactors
- Ion heating of matter (Warm-Dense Matter)
- Extreme chemistry

Controls and Database

Pulsed	Non-pulsed
Triggers(NI-PIX 6652/ GFT 9404)	PLC logic (Relays, AI, AO)
Scopes (NI-PXI 5105/5133)	NI-DAQs
Scopes	NI-FieldPoints
DG535	
Cameras	

Approximately 160 scope channels, 80 delay pulse generator channels, 50 power supplies with around 450 analog and digital IO ports.



Cassandra Database:

- Highly scalable; very easy to add nodes to a running system
- Designed to handle large amounts of data
- Optimized for fast writes and sequential reads
- CQL query language similar to SQL-DB
- Python driver available, created a LabVIEW driver

cassandra

Message broker ZMQ:

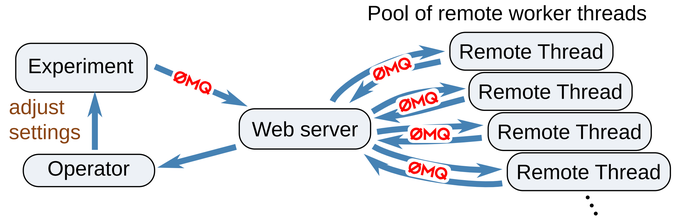
ØMQ

- Available for many languages (including LabVIEW and Python)
- Fast and stable (originated in finance industry)
- Used for remote control of LabVIEW

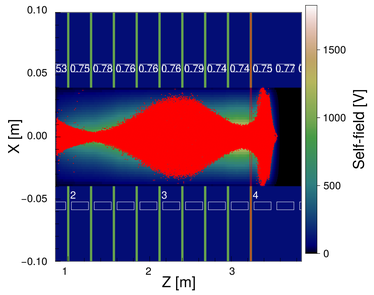
```
class Shot(Model):
    lvtimestamp = columns.BigInt(primary_key=True)
    devicename = columns.Text(primary_key=True)
    data = columns.Text()
    settinghash = columns.Text()
    version = columns.Integer()

class Setting(Model):
    hash = columns.Text(primary_key=True)
    data = columns.Text()
    version = columns.Integer()

class Data(Model):
    devicename = columns.Text(partition_key=True)
    date = columns.Integer(partition_key=True)
    eventtime = columns.DateTime(primary_key=True)
    value = columns.Float(primary_key=True)

class Comments(Model):
    month = columns.Integer(primary_key=True)
    daytime = columns.Integer(primary_key=True)
    species = columns.Text(primary_key=True)
    comment = columns.Text()
    sample = columns.Text()
    shots = columns.Set(colums.BigInt)
```

Simulation Feedback

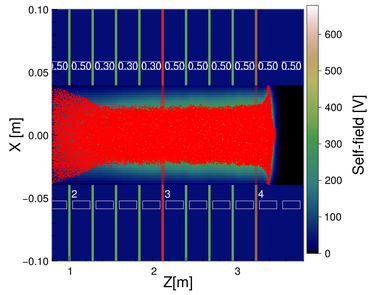
- Simulate complete beamline using Warp
- Use voltage waveforms, timing, etc. from experiment
- Simulate each shot live using 2 desktop computers and a small ZMQ python script, upload results to web page



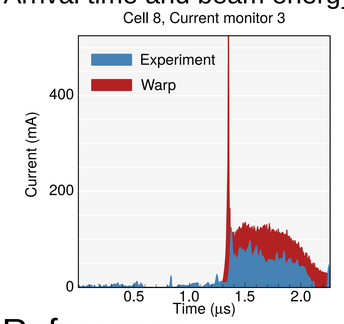
Warp simulation before tuning

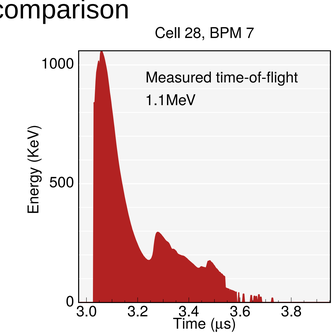


after tuning



Arrival time and beam energy comparison





References:

- P.A. Seidl et al., NIM A 800 98 (2015)
- controls: arxiv.org/abs/1506.04212
- Phys. Proc. 66, 604 (2015)
- warp: http://warp.lbl.gov
- https://bitbucket.org/berkeleylab/atap-labview-cassandra-driver

This work was supported by the Office of Science of the US Department of Energy under contracts DE-AC02–05CH11231 (LBNL), DE-AC52-07NA27344 (LLNL) LLNL-POST-692079