

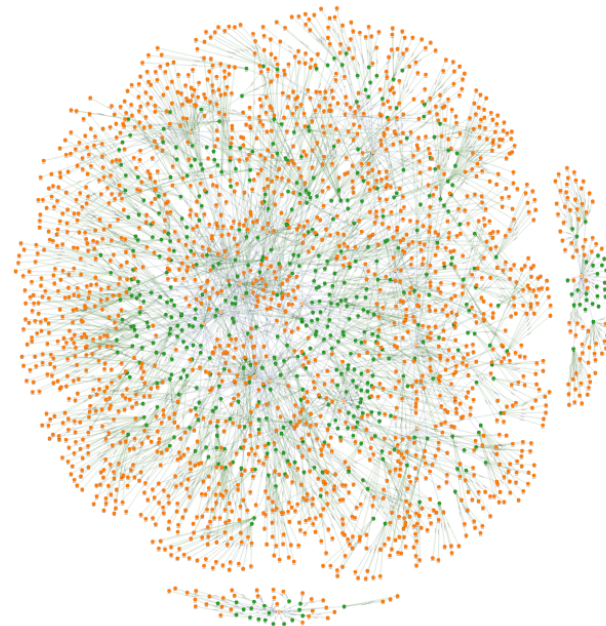
Navigational Data Management

A general approach to representation and exploitation of relationships in scientific data sets.

Joshua Stillerman
Martin Greenwald
Jason Stillerman
John Wright

MIT Plasma Science and Fusion Center

● CModShot
● CModRunDay
● Annotation
— RunOn
— CommentsOn



Alcator C-Mod Runs, Shots and Annotations (**one month**)

“I have a system for storing my data and getting it back, aren’t I done?”

- Collecting data has never been easier, but...
- We’re struggling to keep up with the rapidly growing volume and complexity of scientific data.

Our Thesis

- The challenge is all about giving this mountain of data meaning and putting it into context
- Context is about metadata and relationships among data objects – “**navigational metadata**”
- This is not specific to one science domain
- In general, our approach to capturing and exploiting this class of metadata has been ad hoc and inadequate
- This hampers data discovery and the ability to assemble coherent, complete, useful data sets.



Discovering and Understanding Data Is Largely About Context

- Context is metadata about relationships between data
- Data discovery relies on “adjacency” to find other interesting data
- In the more distant past when things were smaller and simpler, we could keep that context in our heads
 - or in our colleague's heads
- Historically we’ve each build a set of ad-hoc, domain specific tools to store, explore, and retrieve this relationship metadata.
- Similar issues confront all data intensive areas of research.
- Can we solve these problems in our own domain?
- Can we generalize these to provide solutions across a broader set of domains?

Organizing knowledge is an old problem



Complexity: What Sorts Of Data Might Exist From A Typical Experiment?

- Hierarchical data stores with raw and processed data ($\sim 10^5$ named data objects per shot)
- Relational databases with “high level” results
- Electronic logbooks & annotation
- Experimental proposals
- Run Plans & Summaries
- Data provenance systems
- Data catalogs
- Data dictionaries
- Information about experimental campaigns
- & plans
- Publications & presentations
- Information about researchers, authors
- Simulation inputs & outputs
- Source code management systems
- Facility information, with details of experiment, measurement systems
- Document, drawing management systems
- QA, QC information
- WBS for projects

All Of Those Data Are Linked In Multiple and Complex Ways

Alcator C-Mod Mini-Proposal	
MP No. 831	
Subject:	Race to Midnight: 300 kJ or Bust
From:	The Alcator C-Mod Team
Group:	All of Them
Date:	September 19, 2016
Approved by:	Date Approved:
<hr/>	
1. Purpose of Experiments	
<small>Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones.</small>	
<p>This goal of this experiment is to close out operations of Alcator C-Mod by pushing operational space to break the record in stored energy and volume averaged plasmas pressure. This further demonstrates the capabilities of compact, high-field tokamaks.</p>	
2. Background	
<small>Discuss Physics Basis of the proposed research. Prior results at Alcator or elsewhere, and any related work being carried out separately.</small>	
<p>While C-Mod currently holds the records the record volume averaged pressure, it's clear the machine has not fully demonstrated its capabilities. Recently, the stored energy record was broken in EDA H-mode on 1160718013 (5.4 T, 1.3 MA, nI04 ~ 1.1), reaching 253 kJ at only 4 MW of input power. Additionally, MP 826 had identified a transient high, $H_{98} \sim 2.0$, operating regime that could be taken to higher current and power to increase the stored energy. Thus, we have yet to convincingly, in earnest, demonstrate</p>	

All Of Those Data Are Linked In Multiple and Complex Ways

Alcator C-Mod			
Select Calendar Year			
2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007 2006 2005 2004 2003 2002 2001 2000 1999 1998 1997 1996			
Run ID	Date	MP	Description
1160930	Sep 30 2016	813	EDA Access at 8 tesla
		831	Race to Midnight: 300 kJ or Bust
		831	Race to Midnight: 300 kJ or Bust
1160929	Sep 29 2016	750	Investigation of the mode structure of the WCM with a scanning Mirror Langmuir probe
		787	Improving stability of non-inductive LHCD discharges
		832	Fast time resolution LH power deposition to SOL
1160928	Sep 28 2016	627	ρ^* Dependence of Intrinsic Rotation
		823	Measurement of lower hybrid wave power using two toroidally-separated probe arrays
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1160916	Sep 16 2016	759	PDI and MSE measurements with high Te helium target
1160915	Sep 15 2016	727	Localization of the WCM and the QCM in the Er well
		827	Transition dynamics and thresholds in near DN configurations
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MP No. 831

atic relevance. Refer to any relevant

Alcator C-Mod by pushing
1 volume averaged plasmas
ct, high-field tokamaks.

re, and any related work being carried

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ntly, the stored energy
.3 MA, $n_{104} \sim 1.1$), reaching
ad identified a transient
r current and power to
v in earnest demonstrate

All Of Those Data Are Linked In Multiple and Complex Ways

Alcator C-Mod Mini Proposals

ID	Date Filed	First Author	Status	Title
832	9/27/2016	Syunichi Shiraiwa	Submitted	Fast time resolution LH power deposition to SOL

Select Calendar Year

2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007 2006 2005 2004 2003 2002 2001 2000 1999 1998 1997 1996

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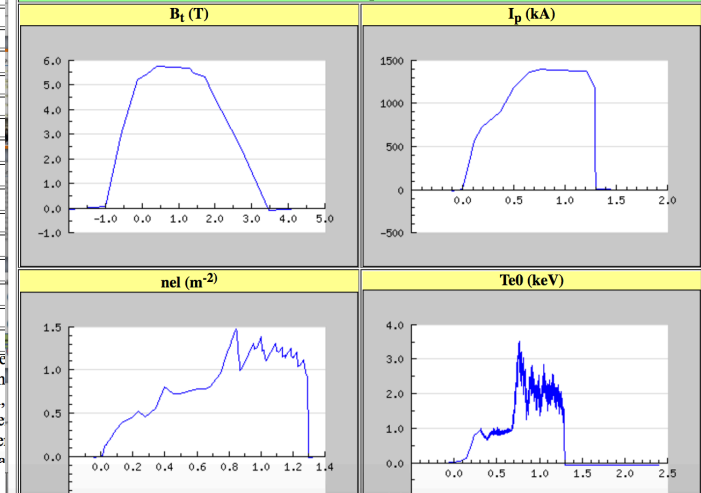
Miniproposals

Miniproposal: 831
Date Filed: 9/19/2016
Title: Race to Midnight: 300 kJ or Bust
First Author: Anne White
Session Leader: Jerry Hughes (shots 35-43)

Operators

Session leader(s): Jerry Hughes
Physics operator(s): Earl Marmor
Engineering operator(s): Gary Dekow

Data Plots (hover mouse over plot to see maximum value)



All Of Those Data Are Linked In Multiple and Complex Ways

Alcator C

ID	Date Filed	First Author	Status	Title
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Select Calen

2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007 2006 2005 2004

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1160930041	jwhughes	SESSION_LEADER	11:29:06:267PM
Shot 41			
We are attempting to shorten up the pre-H period of RF			
Also increased the N2 puff in the beginning			
Data system hang, followed by no power shot			

1160930042	marmar	PHYSICS_OPERATOR	Sep 30 2016 11:37:13:997PM
Ip to 1.4 MA			

1160930042	jwhughes	SESSION_LEADER	Sep 30 2016 11:57:45:183PM
Shot 42			

After a long delay, got a 1.4MA shot! 235kJ
We're going to try for one more!

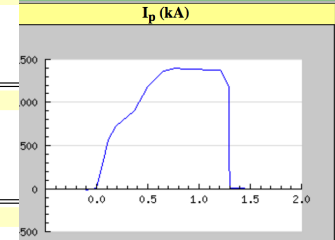
1160930043	marmar	PHYSICS_OPERATOR	Oct 1 2016 12:05:23:313AM
n1_04 to 9e19 nitrogen to 90 msec (from 70)			
plasma, disrupt in rampdown at 1.3 seconds			
that's it folks!			

1160930043	jwhughes	SESSION_LEADER	Oct 1 2016 12:06:46:987AM
Shot 43			
That's all folks			
Matt takes the crown for stored energy.			
Best run . . . ever.			

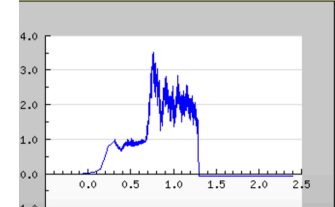
1160930043	jwhughes	SESSION_LEADER	Oct 5 2016 12:19:48:210PM
"Entering Recoil"			



not to see maximum value)



Te0 (keV)



All Of Those Data Are Linked In Multiple and Complex Ways

Alcator C

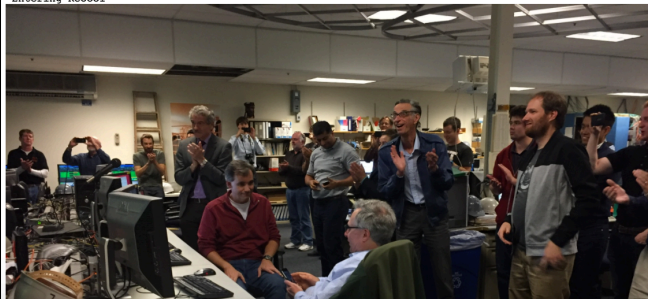
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832	9/27/2016	Syunichi Shiraiwa	Submitted	Fast time resolution LH power dep

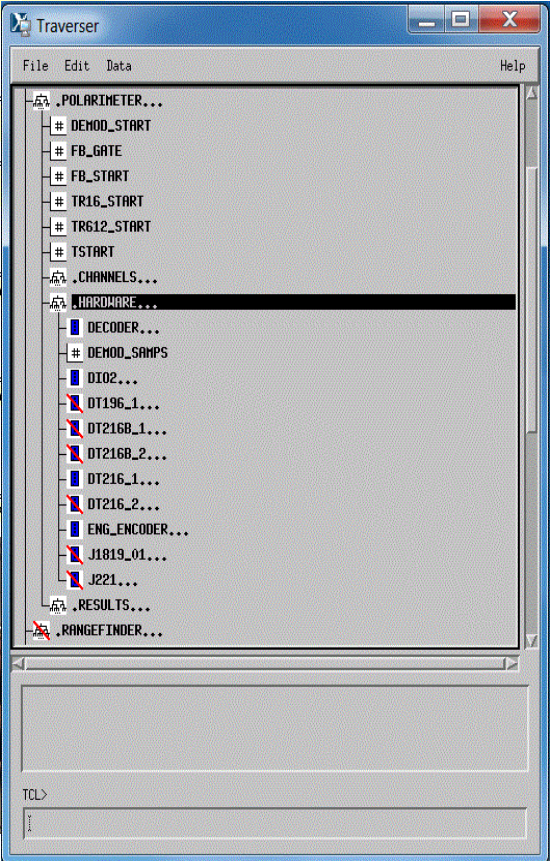
Select Calendar

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ID	Author	Role	Date	Time	Notes
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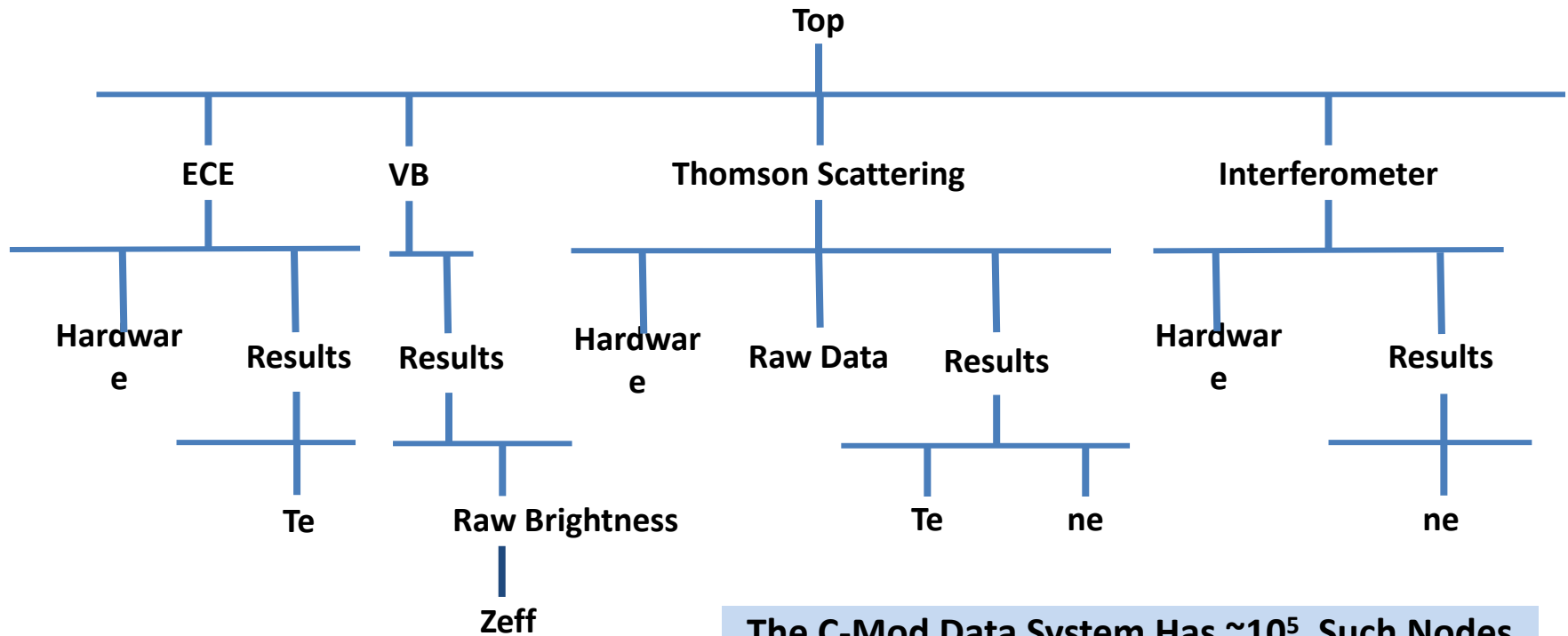




Relationship Web Is Incomplete, Ad Hoc, Asymmetric, Singularly Organized

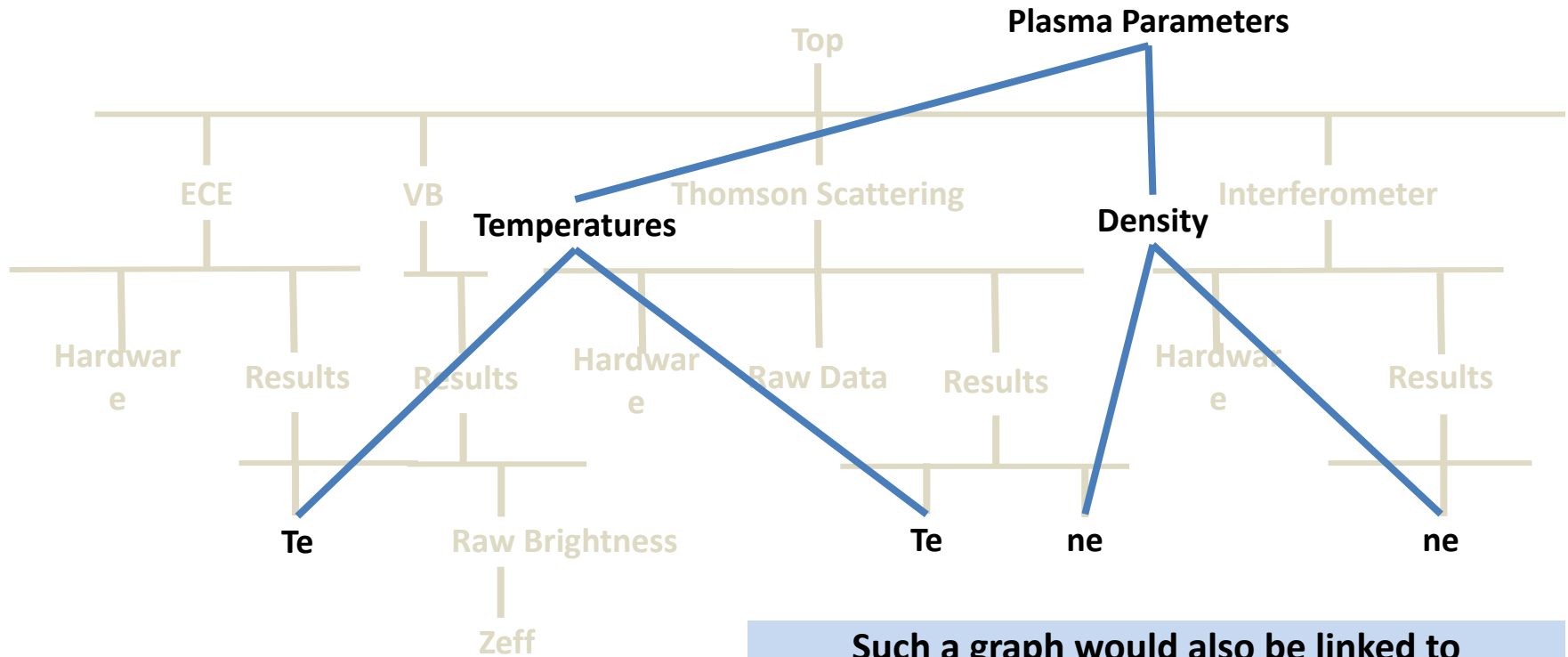
- Incomplete
 - Some relationships are explicitly represented in databases
 - Some are implicit in data or text
 - Some are only known by particular users
 - Some are not recorded and are lost forever
- Ad Hoc
 - We've added this information as needs arise
 - Schemas, vocabulary are not always consistent
 - Level of detail is uneven
- Asymmetric
 - Example: We point to interesting data from the logbook (annotation); but do not point to annotation from data (many, many other examples)
- Singularly organized
 - Trees, Tables (columns, indices), Directory/File Names

Organization of Data – By Diagnostic System



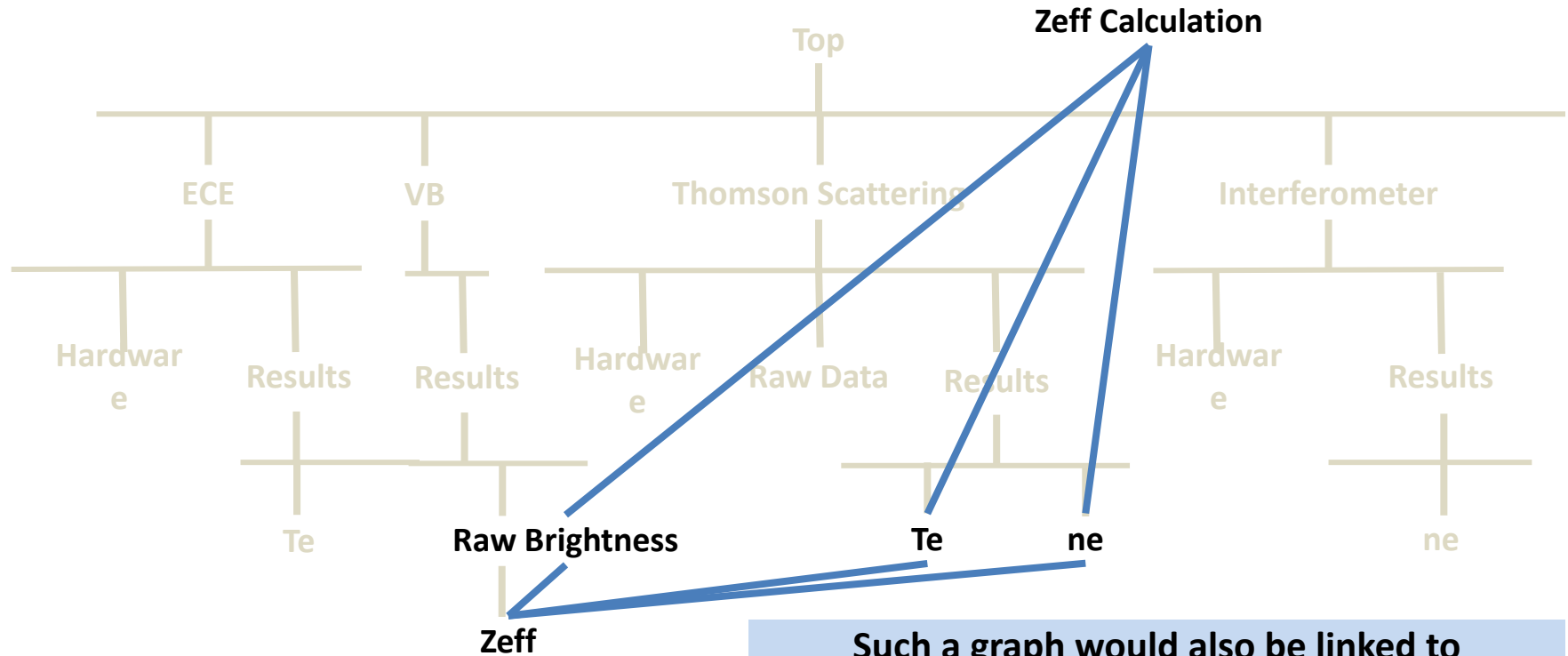
The C-Mod Data System Has $\sim 10^5$ Such Nodes With Significant Metadata For Each Node

Organization of Data – By Physics Parameter



Such a graph would also be linked to descriptions of experiments, annotation, etc.

Organization of Data – By Data Provenance



Such a graph would also be linked to descriptions of analysis codes, annotation, etc.

Approach











- Use graphs to describe relationships between data
- Schema defined using schema.JSON






– Nodes

- Who, what, when, history
- List of properties appropriate to their type
- [URI to have objects stored in other systems]
 - Protocol://location/specifiers
- GUID

– Edges

- Type
- Allowable SRCs, Destinations
- Properties (if needed)

Name ?	Color	SuperClasses ?	Name ?	Color	SuperClasses ?
Annotation		_NDMobject, V	MiniProposal		_ExternalReference
CModRunDay		_RunDay	PDFReference		_ExternalReference
CModShot		_Shot	Person		V
DropboxImage		_ExternalReference	Topic		_NDMobject, V
MDSplus		_ExternalReference	V		

Name ?	Color	SuperClasses ?
CommentsOn		_NDMobject, E
E		
HasImage		_NDMobject, E
HasTopic		_NDMobject, E
RunOn		_NDMobject, E

Approach

- Use graphs to describe relationships between data

- Schema defined using schema.JSON

- Nodes

- Who, what, when, history
- List of properties appropriate to their type
- [URI to have objects stored in other systems]
 - Protocol://location/specifiers

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- Edges

- Type
- Allowable SRCs, Destinations
- Properties (if needed)

```
$ cat PDFReference.json
{
  "id": "http://ndm.mit.edu/ndm/schemas/PDFReference",
  "$schema": "http://json-schema.org/draft-06/schema#",
  "title": "PDFReference",
  "description": "Link to a web accessible PDF",
  "definitions": {},
  "type": "object",
  "allOf": [{ "$ref": "_ExternalReference" } ],
  "properties": {
    "name": { "type": "STRING" },
    "type": {
      "type": "STRING",
      "defaultValue": "PDF"
    }
  },
  "required": ["name"],
  "metadata": {
    "schemaMetadata": {
      "title": "{{@class}} {{$name}}",
      "brief": [],
      "body": ["URI"],
      "links": []
    }
  }
}
```

Approach

- Graph database - OrientDB
- Javascript SPA
- VUEjs
- Auth0
- Docker-compose (microservices)
 - Db server
 - Authenticator Proxy
 - Web Server
 - Notification server
- PM2

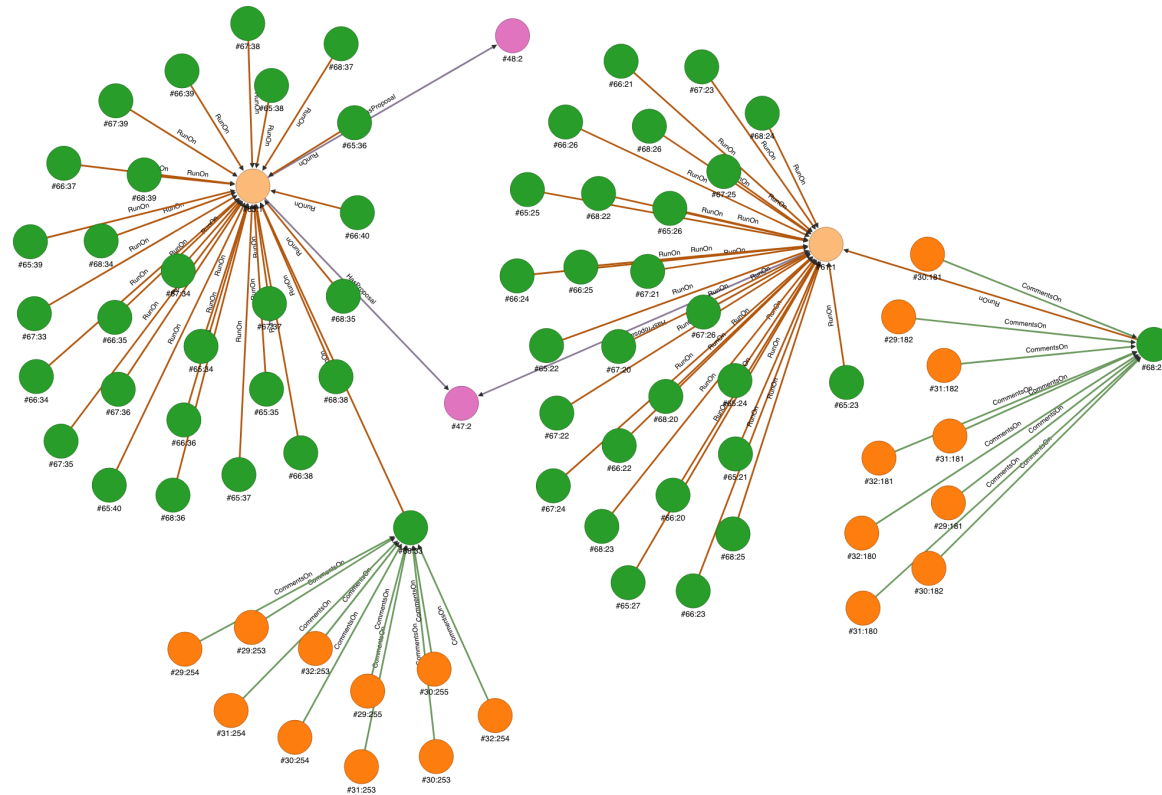
```
$ $ cat docker-compose.yml
version: '3'

services:
  web:
    build:
      context: './Client'
      args:
        - dbname=${ORIENT_DBNAME}
        - dropboxkey=${DROPBOX_KEY}
    ports:
      - 80:80
    depends_on:
      - proxy
  proxy:
    build: './Proxy'
    volumes:
      - ./Proxy/db:/usr/src/app/db
```

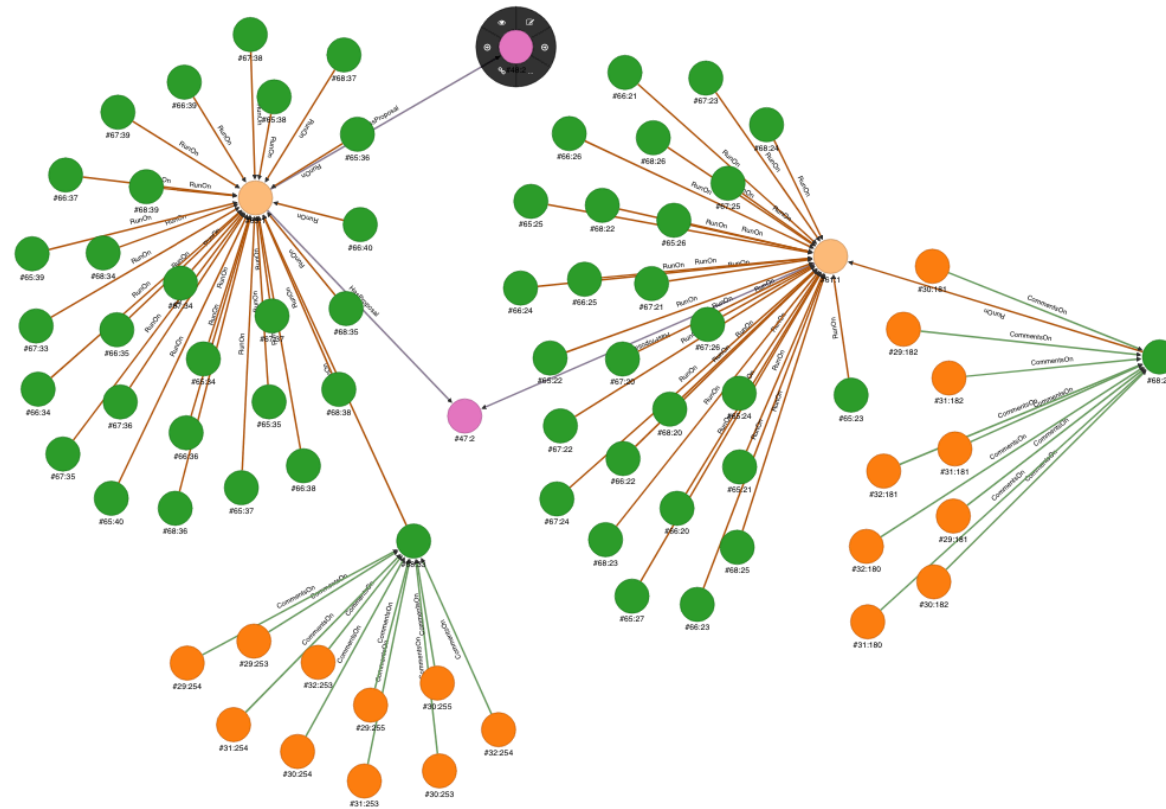
...

Proposals, Run Days, Shots and Annotations

- CModRunDay
- MiniProposal
- CModShot
- Annotation
- HasProposal
- RunOn
- CommentsOn



Proposals, Run Days, Shots and Annotations



Proposals, Run Days, Shots and Annotations



Abstract

This experiment intends to explore the feasibility of operation in partially, pronounced and/or full detachment while maintaining a high-confinement, $H_{98} \sim 1$, I-mode pedestal and core. The goal is provide scoping and demonstration of a possible mixed low-Z seeding approach using Ne/N₂ which can then be followed up with demonstrations over a wider range of I-mode plasmas.

CoAuthors

J.W. Hughes, A. Hubbard, B. Mumgaard, D. Brunner, B. LaBombard, J. Terry, A.Q. Kuang, S. Wolfe, I. Hutchinson, J. Canik (ORNL), C. Thiel (CRPP), B. Lipschultz (U. of York)

submitDate

2019-04-29 16:41:53



Proposals, Run Days, Shots and Annotations

← → ↻ 🏠 ⓘ localhost:8080/miniprops/63:1 🔍 ☆ 📧 📺 🟢 👤 ⋮

NDM

Exploring compatibility of detachment with I-mode plasmas

By **Reinke, Matt**, J.W. Hughes, A. Hubbard, B. Mumgaard, D. Brunner, B. LaBombard, J. Terry, A.Q. Kuang, S. Wolfe, I. Hutchinson, J. Canik (ORNL), C. Thieler (CRPP), B. Lipschultz (U. of York)

This experiment intends to explore the feasibility of operation in partially, pronounced and/or full detachment while maintaining a high-confinement, $H_{98} \sim 1$, I-mode pedestal and core. The goal is provide scoping and demonstration of a possible mixed low-Z seeding approach using Ne/N₂ which can then be followed up with demonstrations over a wider range of I-mode plasmas.

Assessing time-evolving particle transport across I/H transitions

By **Reinke, Matt**, A. Loarte (ITER), M. Cerretti (U. of York), J.W. Hughes, J.E. Rice, A. Hubbard, J. Walk, J. Terry, M. Chilenski, E. Edlund (PPPL), B. Mumgaard, S. Wolfe.

This experiment looks to investigate particle transport across the transition from an I-mode to an ELM-free H-mode, examining the time evolution of both impurity and main ion densities. The primary goal is a search for a solid existence proof, at least transiently, of radially outward high-Z

Proposals, Run Days, Shots and Annotations

The screenshot shows a web browser at `localhost:8080/miniprops/63:1` displaying the NDM (Navigational Data Management) interface. The interface has a dark blue header with the text "NDM". Below the header, there are two proposal cards on a light yellow background.

Proposal 1:

Exploring compatibility of detachment with I-mode plasmas

By **Reinke, Matt**, J.W. Hughes, A. Hubbard, B. Mumgaard, D. Brunner, B. LaBombard, J. Terry, A.Q. Kuang, S. Wolfe, I. Hutchinson, J. Canik (ORNL), C. Thieler (CRPP), B. Lipschultz (U. of York)

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Proposal 2:

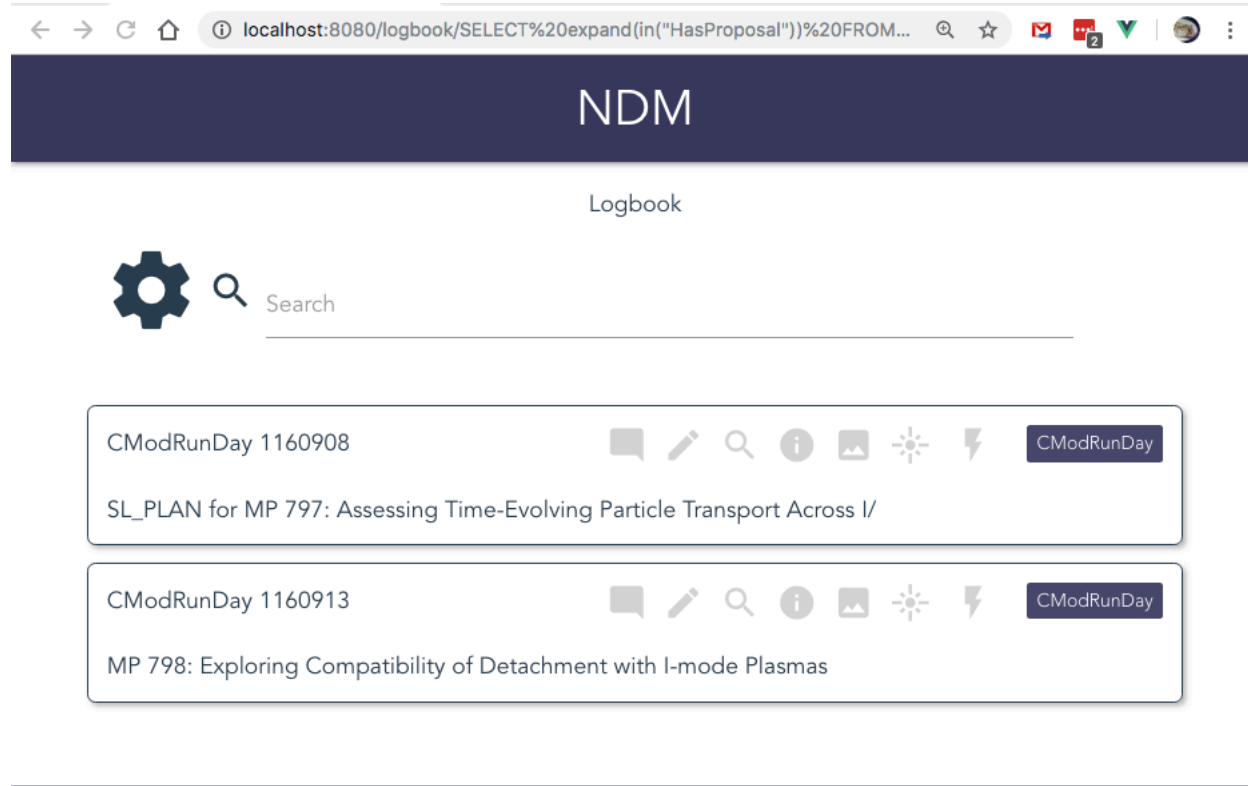
Assessing time-evolving particle transport across I/H transitions

By **Reinke, Matt**, A. Loarte (ITER), J. Walk, J. Terry, M. Chilenski, E. Edl, J.E. Rice, A. Hubbard, J. S. Wolfe.

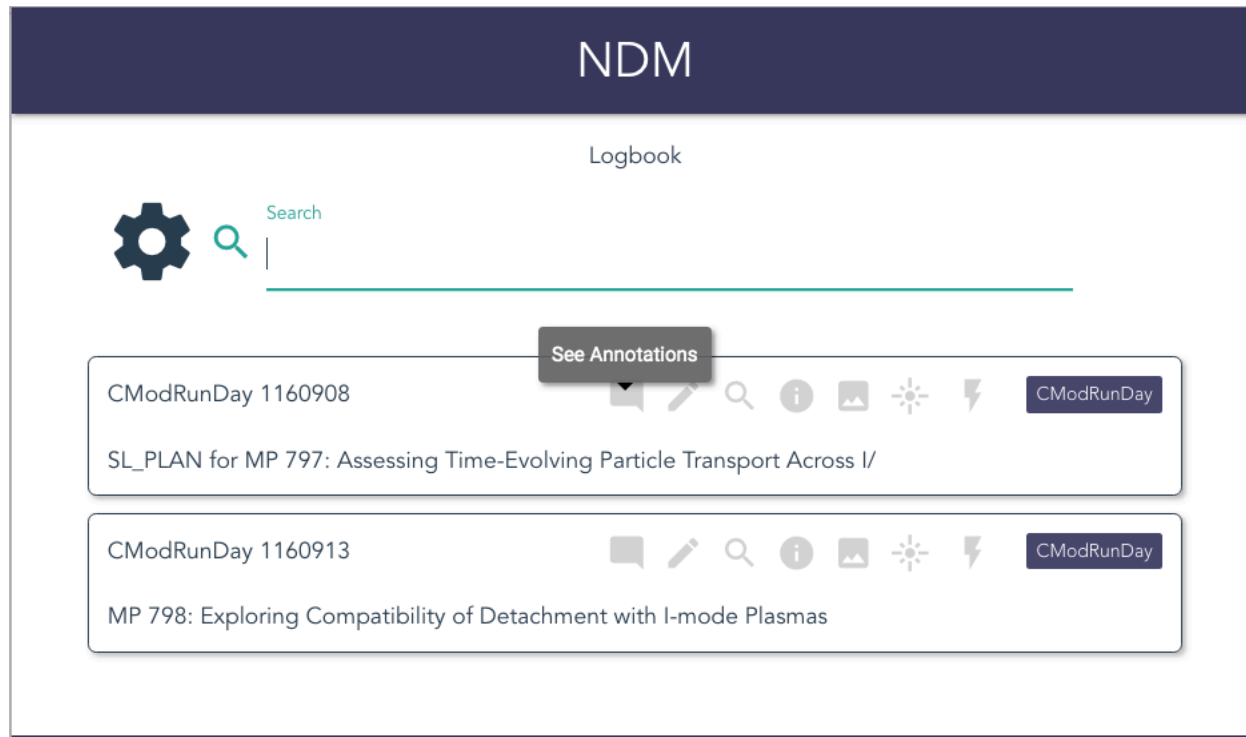
This experiment looks to investigate particle transport across the transition from an I-mode to an ELM-free H-mode, examining the time evolution of both impurity and main ion densities. The primary goal is a search for a solid existence proof, at least transiently, of radially outward high-Z

A context menu is open over the second proposal, showing two options: "Show MiniProposal" and "Show Runs".

Proposals, Run Days, Shots and Annotations



Proposals, Run Days, Shots and Annotations



Proposals, Run Days, Shots and Annotations

The screenshot shows a web browser window with the URL `localhost:8080/logbook/SELECT%20expand(in("HasProposal"))%20FROM...`. The application has a dark blue header with the text "NDM" and "Logbook" below it. A search bar with a gear icon and the word "Search" is visible. The main content area displays a log entry for "CModRunDay 1160908". The entry includes a title "SL_PLAN for MP 797: Assessing Time-Evolving Particle Transport Across I/" and a detailed description of the experiment's purpose and findings.

NDM
Logbook

Search

CModRunDay 1160908

SL_PLAN for MP 797: Assessing Time-Evolving Particle Transport Across I/

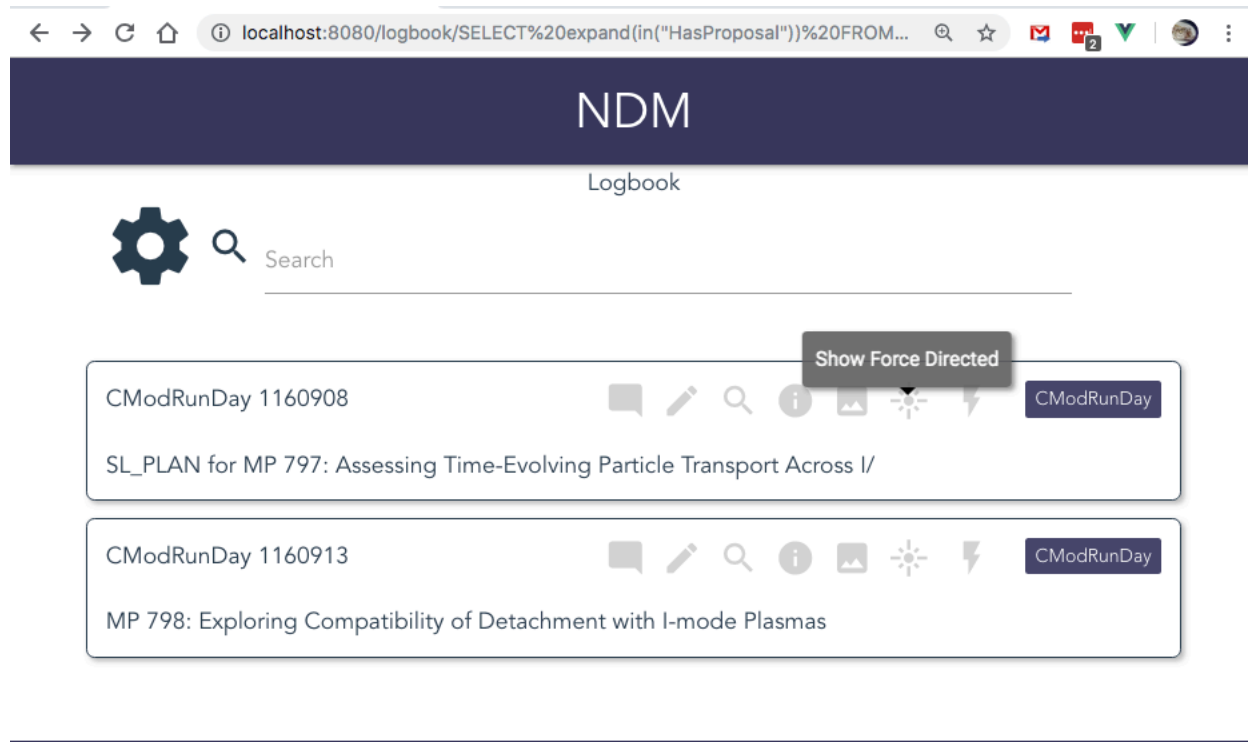
Author: Matt Reinke **Topic:** ' SL_PLAN
Title: SL_PLAN for MP 797: Assessing Time-Evolving Particle Transport Across

SL_PLAN for MP 797: Assessing Time-Evolving Particle Transport Across I/H Tran:

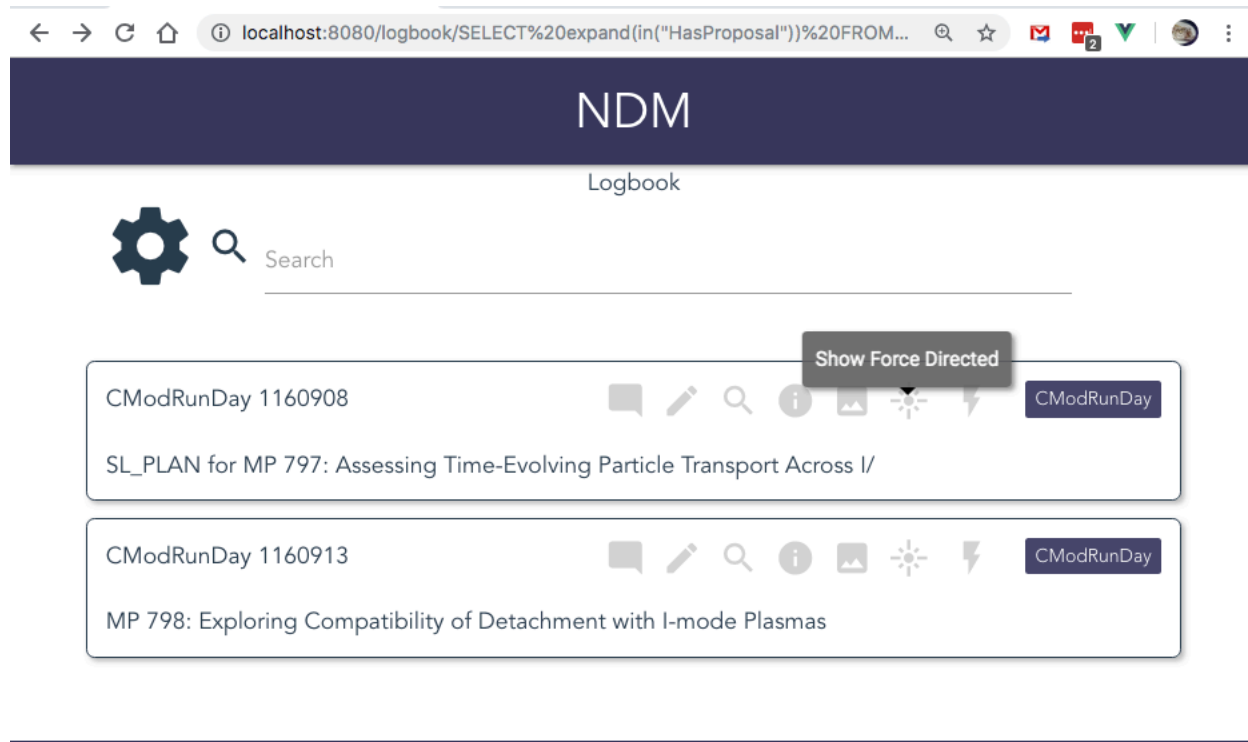
SL: M.L. Reinke
PO: "You sending the Wolfe? That's all you had to say!"

The purpose of this run to test a hypothesis about the possible formation of
of an outward directed impurity flux in the edge transport barrier in cases of
high-temp, opaque pedestal. Indications of this happening at I/H transitions d

Proposals, Run Days, Shots and Annotations

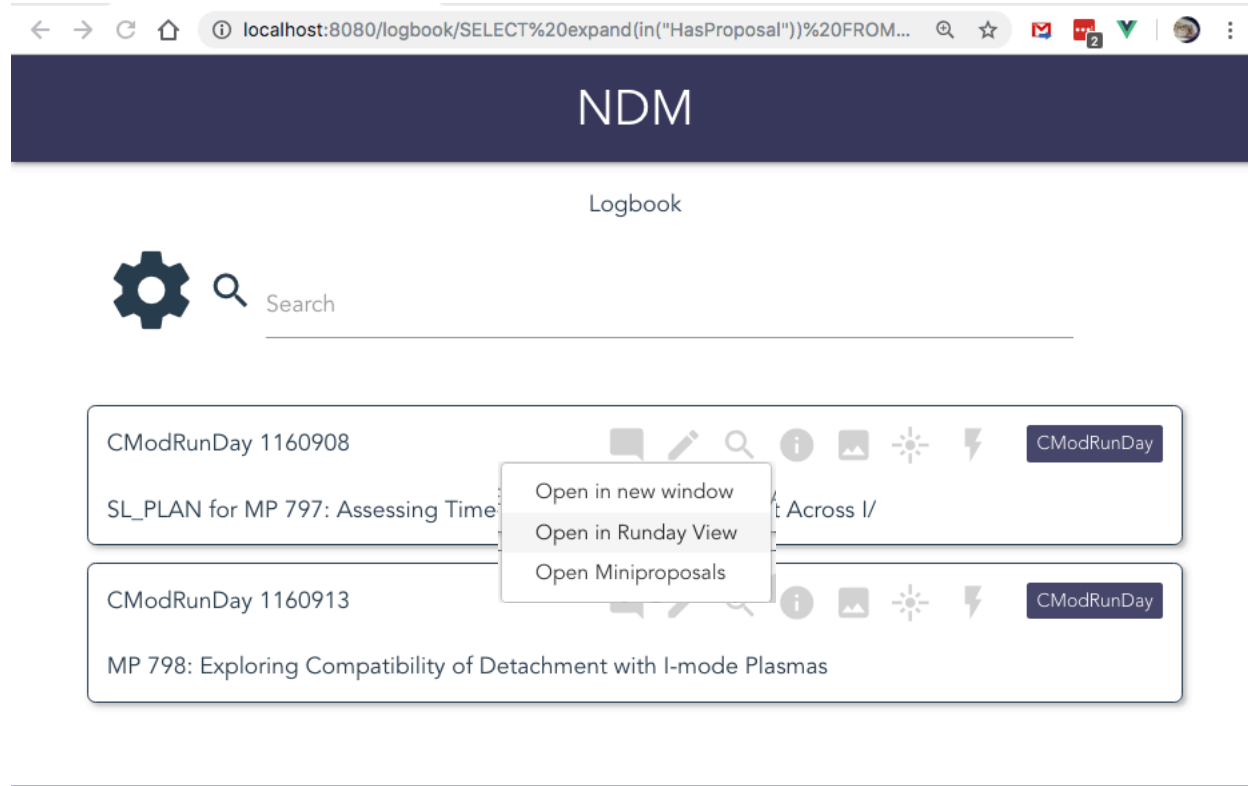


Proposals, Run Days, Shots and Annotations



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Proposals, Run Days, Shots and Annotations



Proposals, Run Days, Shots and Annotations

LogbookMini ProposalsNINT OperationsCable Operations

NDM

Welcome JoshuaLog Out

CModRunDay 1160913

MP 798: Exploring Compatibility of Detachment with I-mode Plasmas

Shot - Monday Apr 29th 04:40 pm

Ramp Up Rate:

Current Set Point Hold Time:

Ramp Down Rate:

Low Volatage Limit in Volts:

Current Set Point:

High Voltage Limit in Volts:

Author: Amanda Hubbard Topic: 'ECE

Title: For Matt's run (~5.4 T) I have changed GPC2 to 1.65 mm, 0 degrees. An

For Matt's run (~5.4 T) I have changed GPC2 to 1.65 mm, 0 degrees. And loaded xcal from 1160908001, which is lik

Leaving GPC set up for 8 T, since we'll be back at that on Wed. So use GPC2 and FRCECE for this run.

Author: Robert Mumgaard Topic: 'SPECTROSCOPY

Title: In preparation for the run I switched H-D from KTOP 4 via R2 4 to KTOP

In preparation for the run I switched H-D from KTOP 4 via R2 4 to KTOP 3 via R2 3 since Matt requested KTOP 4 be

Author: Robert Mumgaard Topic: 'SPECTROSCOPY

Title: Setting up the spectroscopy.

Setting up the spectroscopy.

CHROMEX is setup as 1150923:

A_BOT 09, R1 13, NA, CHROMEX 01

A_BOT 11, R1 06, NA, CHROMEX 02

A_BOT 13, R1 08, NA, CHROMEX 03

A_BOT 15, R1 01, NA, CHROMEX 04

K_BOT 04, R1 17, XOVR 01, PHOTON2 B1

K_BOT 05, R1 09, NA, CHROMEX 05

K_BOT 06, R1 18, XOVR 02, PHOTON2 B2

K_BOT 07, R1 02, NA, CHROMEX 06

K_BOT 08, R1 12, XOVR 03, PHOTON2 B3

MAKE SHOT

UPDATE SHOT

Shot Number

Ramp Up Rate

Ramp Down Rate

Current Set Point

Current Set Point Hold Time

Low Voltage Limit in Volts

High Voltage Limit in Volts

Select a Topic

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Title

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SUBMIT

IAEA-TM Korea 2019

Navigational Data Management - A general approach to
representation and exploitation of relationships in
scientific data sets

30

Conclusions

- Start with simple user interfaces
 - Too much complexity and fanciness inhibits iteration
 - Complexity must be carried along
 - Each user facing function has to implement the shared UI
- Applications need to be customized to their tasks
 - Sharing underlying data structures and APIs
 - facilitates the development of applications
 - Allows for mixing and traversing of information domains
 - Application specific code is needed to achieve needed functionality and usability
- Early users are critical
 - Fancy initial user Interfaces complicates this
- Authentication is difficult
 - Otherization is even harder
- Initial project (and funding) winding down, will continue development.
- We need this to integrate the disparate information about our research.

END
