



Interactive Visual Discovery in Temporal Event Sequences: Electronic Health Records & Other Applications

Ben Shneiderman ben@cs.umd.edu

Founding Director (1983-2000), Human-Computer Interaction Lab
Professor, Department of Computer Science
Member, Institute for Advanced Computer Studies



UNIVERSITY OF
MARYLAND





Interdisciplinary research community

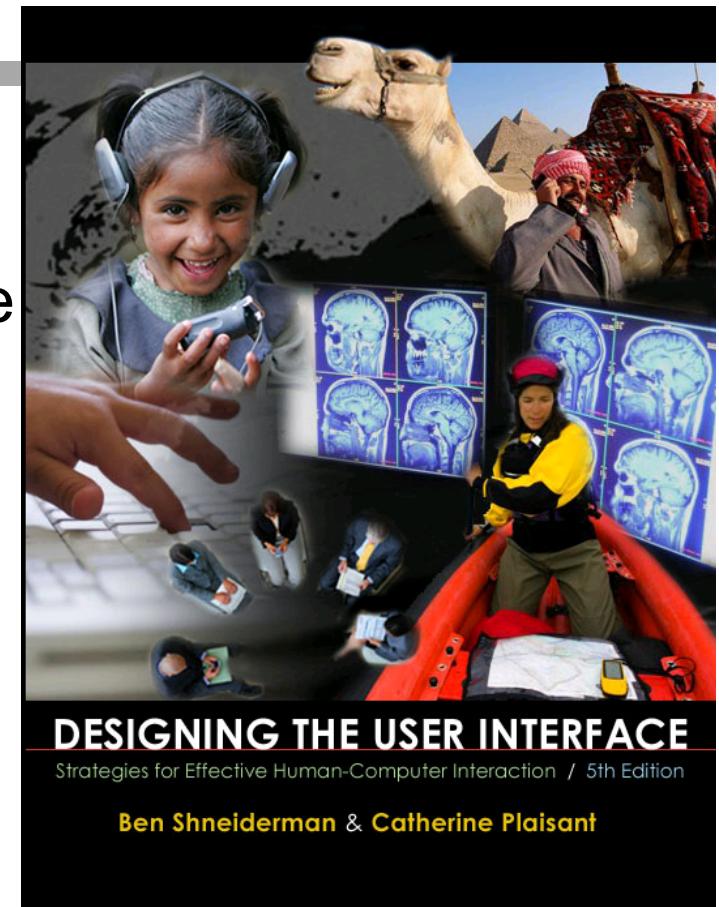
- Computer Science & Info Studies
- Psych, Socio, Educ, Jour & MITH

www.cs.umd.edu/hcil
vimeo.com/72440805



Design Issues

- Input devices & strategies
 - Keyboards, pointing devices, voice
 - Direct manipulation
 - Menus, forms, commands
- Output devices & formats
 - Screens, windows, color, sound
 - Text, tables, graphics
 - Instructions, messages, help
- Collaboration & Social Media
- Help, tutorials, training
- Search • Visualization

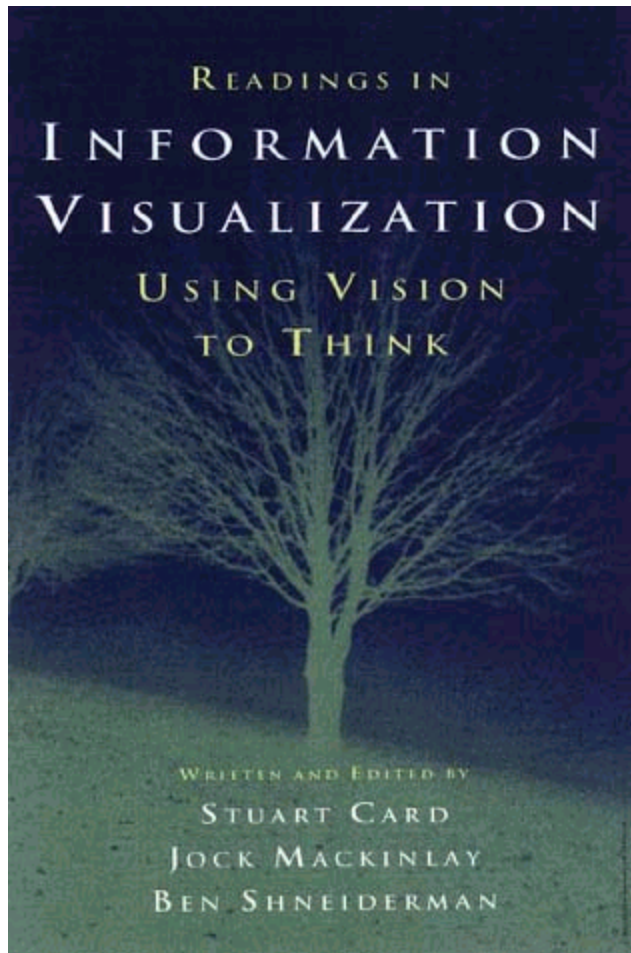


www.awl.com/DTUI

Fifth Edition: 2010



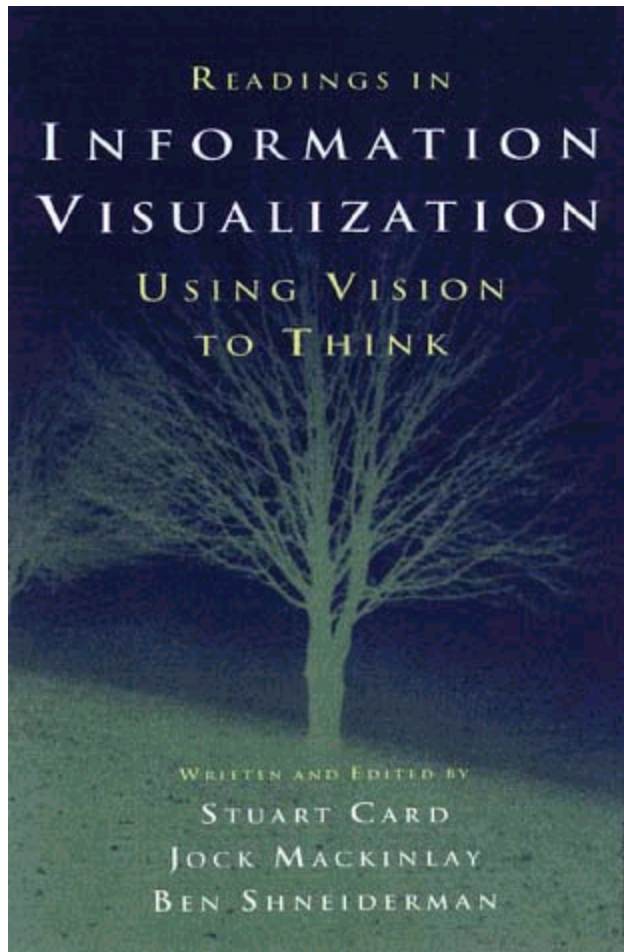
Information Visualization & Visual Analytics



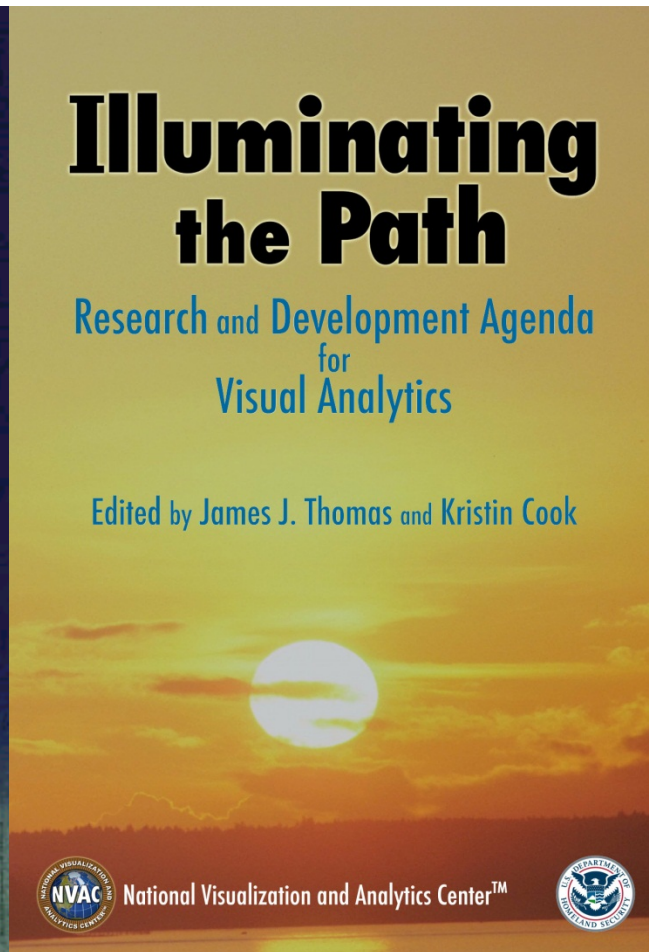
1999



Information Visualization & Visual Analytics



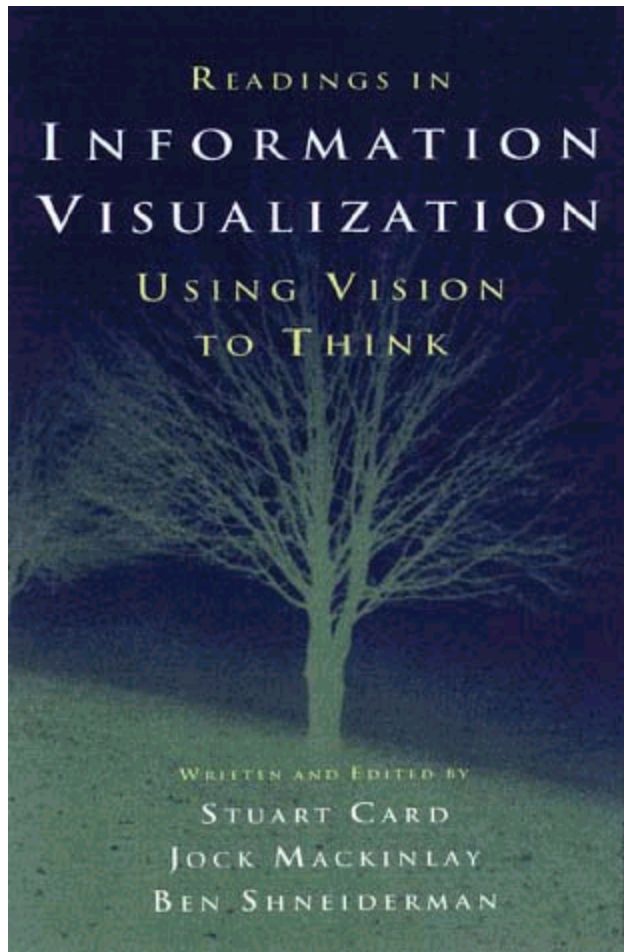
1999



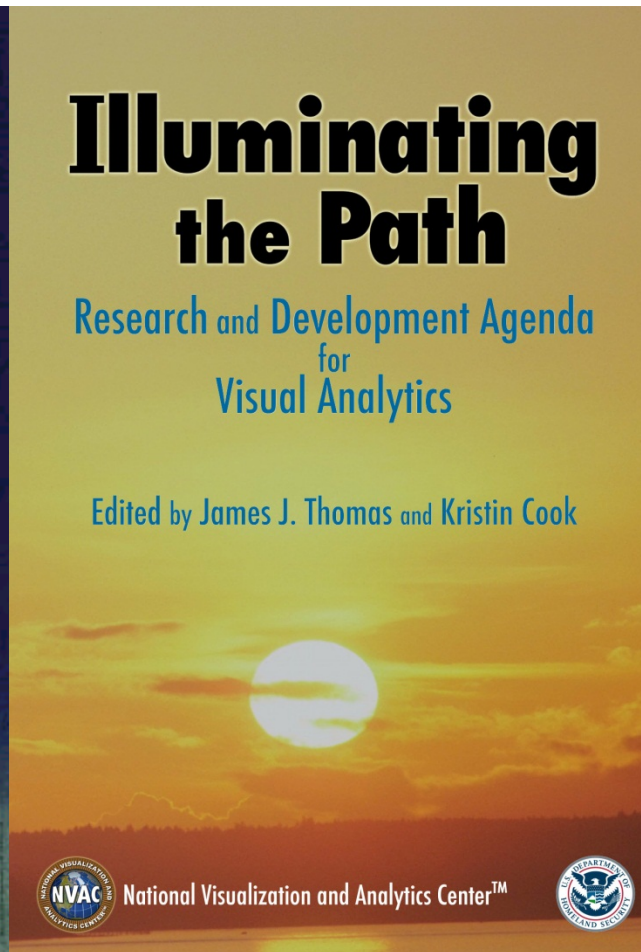
2004



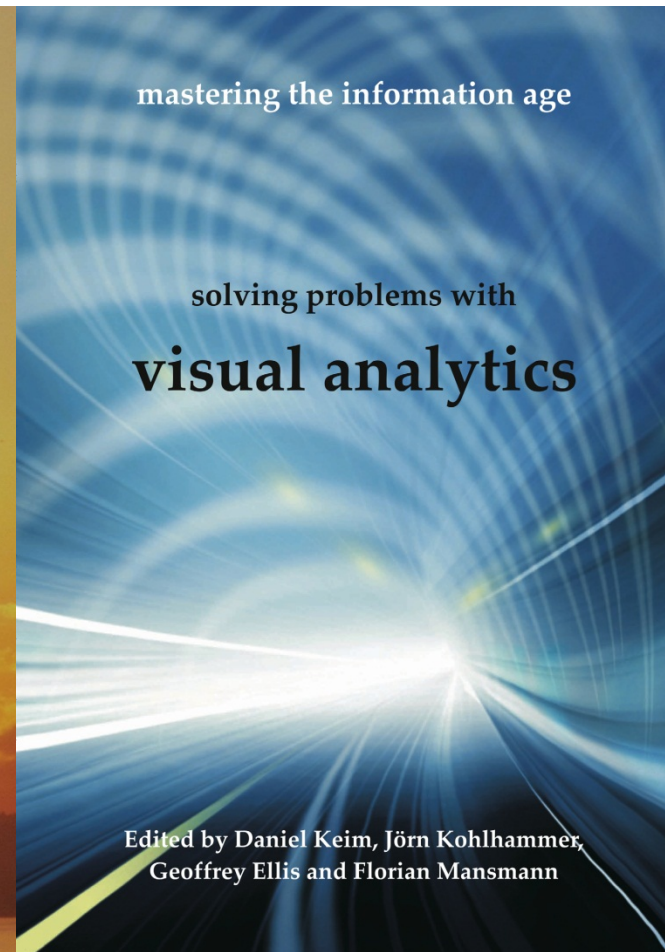
Information Visualization & Visual Analytics



1999



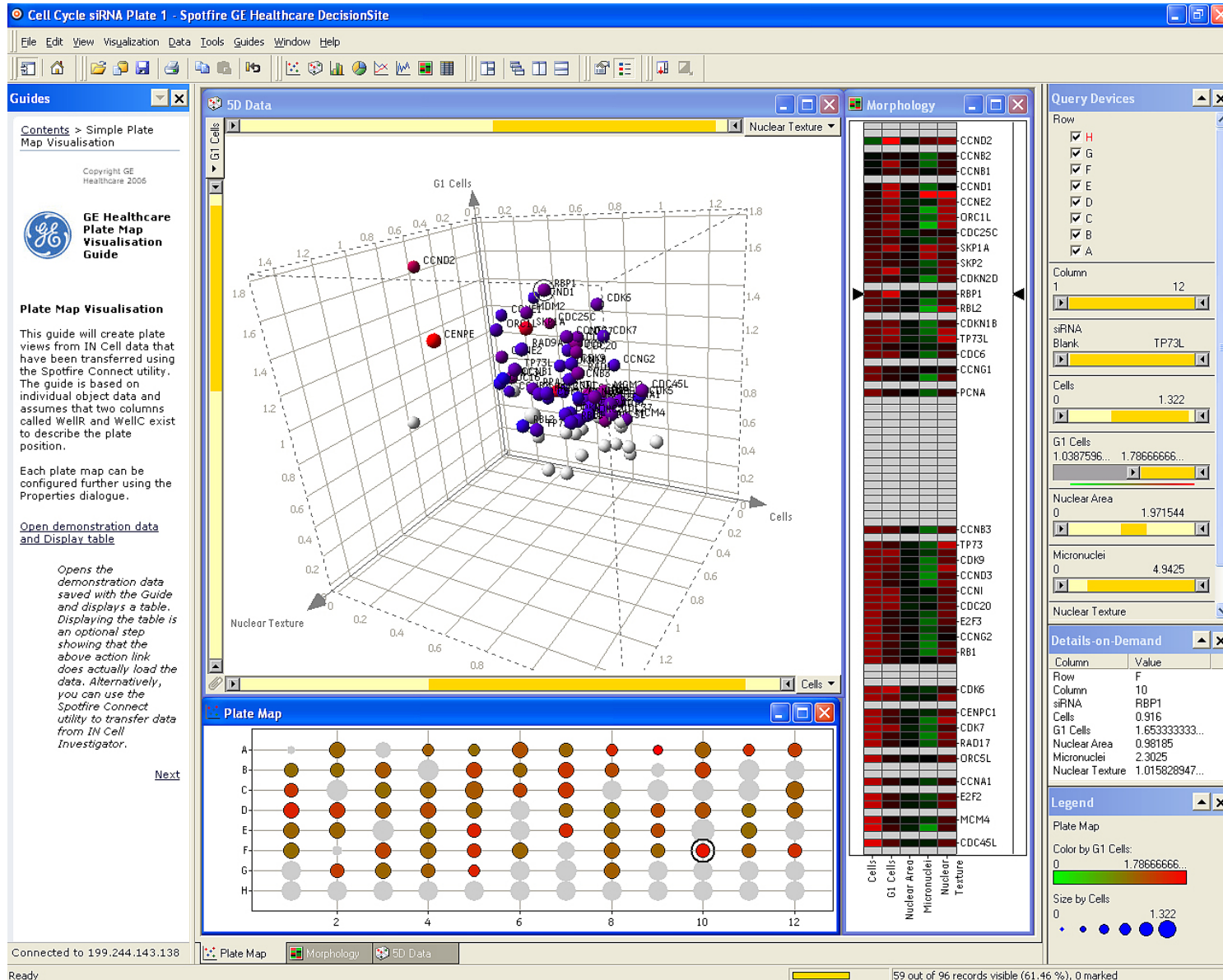
2004



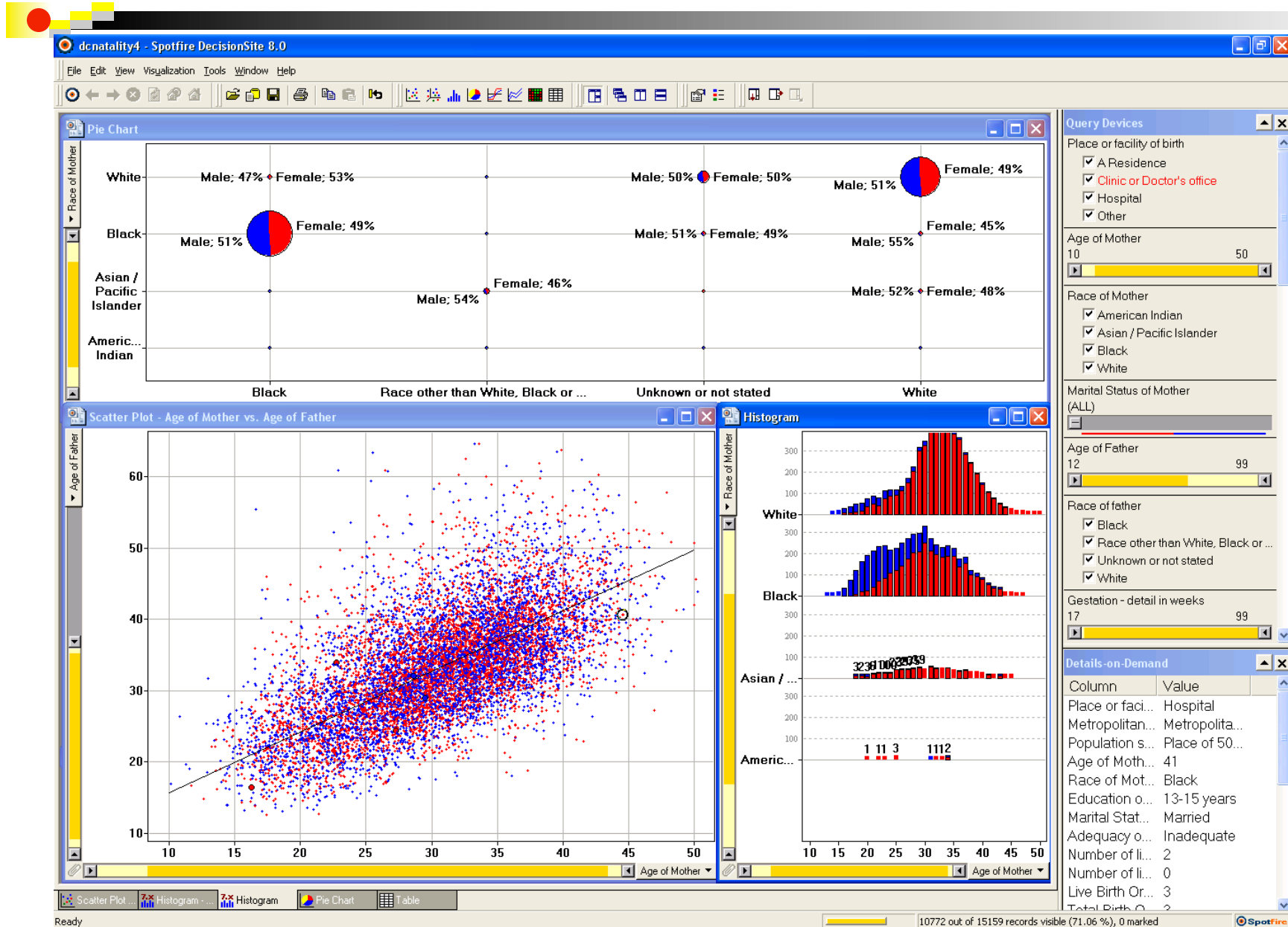
2010

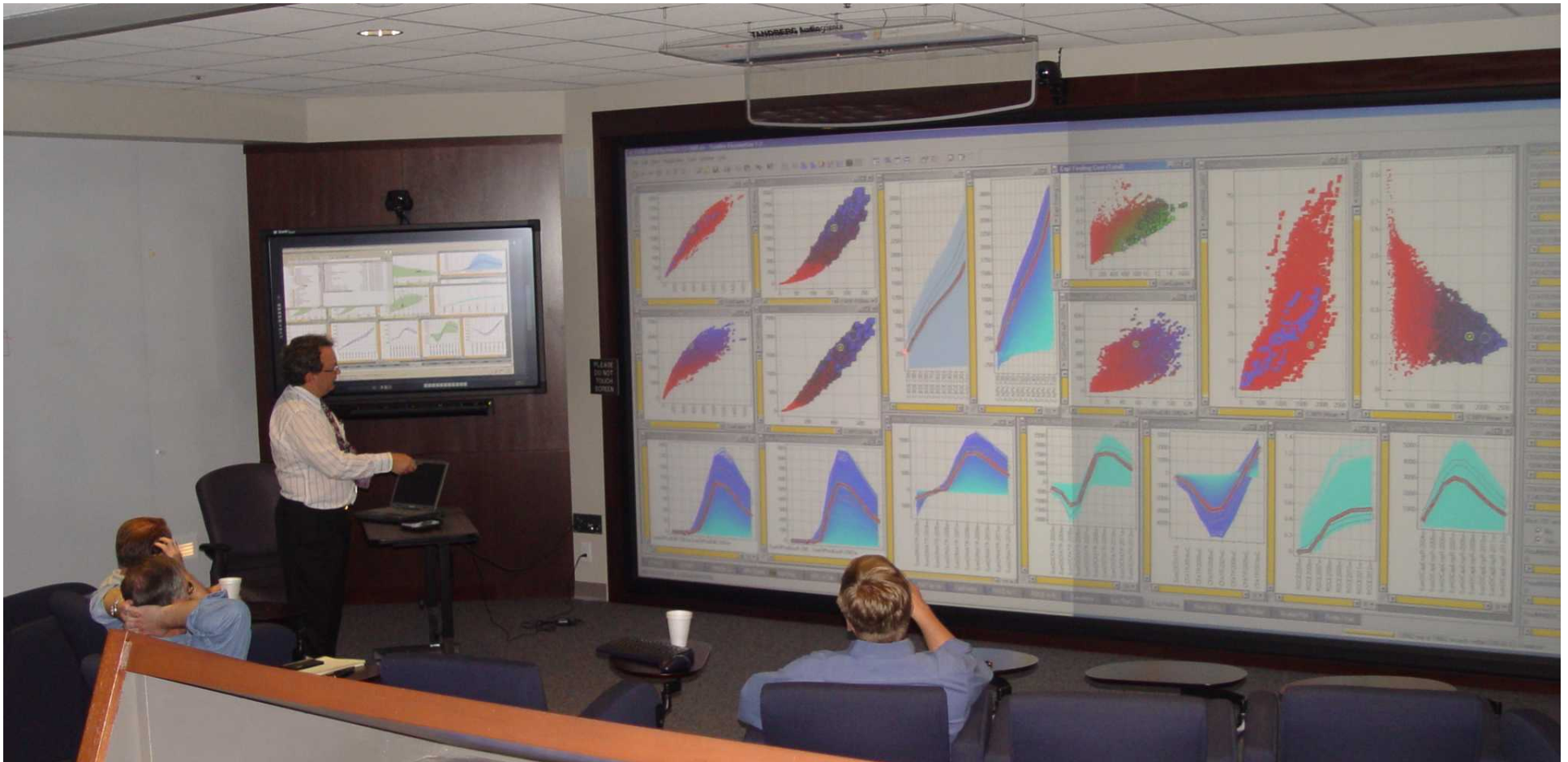


Spotfire: Retinol's role in embryos & vision



Spotfire: DC natality data





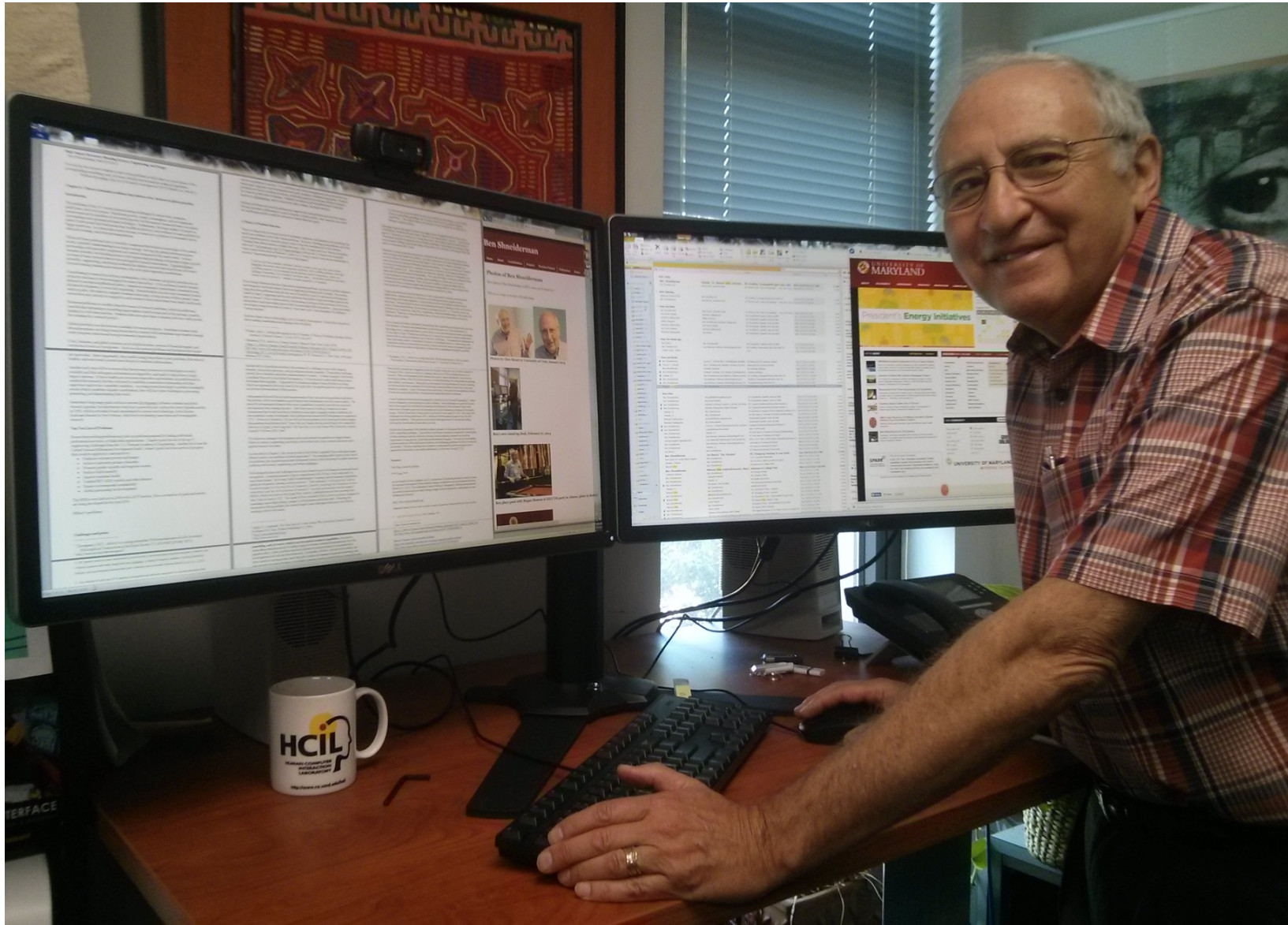
http://registration.spotfire.com/eval/default_edu.asp



10M - 100M pixels: Large displays



16M pixels: My New Workstation

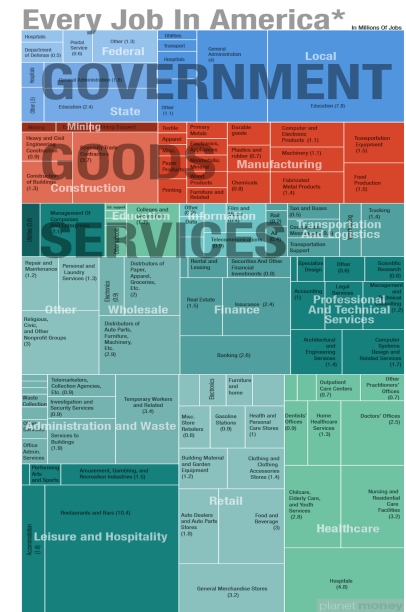
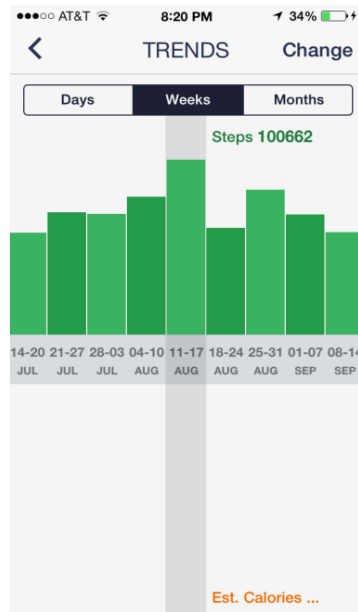
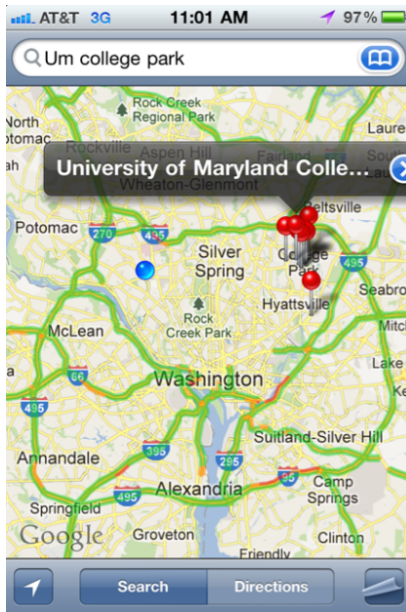


100M-pixels & more



1M-pixels & less

Small mobile devices



Information Visualization: Mantra

- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand

(The Eyes Have It, *IEEE VL*, 1996)



Information Visualization: Data Types

SciViz

- **1-D Linear** Document Lens, SeeSoft, Info Mural
- **2-D Map** GIS, ArcView, PageMaker, Medical imagery
- **3-D World** CAD, Medical, Molecules, Architecture

InfoViz

- **Multi-Var** Spotfire, Tableau, Qliktech, Visual Insight
- **Temporal** EventFlow, TimeSearcher, Palantir, RecordedFuture
- **Tree** Windows Explorer, SpaceTree, Treemap
- **Network** Pajek, UCINet, NodeXL, Gephi, Tom Sawyer

flowingdata.com
infosthetics.com
visual.ly

visualcomplexity.com
perceptualedge.com
visualizing.org

eagereyes.org
datakind.org
infovis.org



EventFlow Team: Oracle support



www.cs.umd.edu/hcil/eventflow



www.umdrightnow.umd.edu/news/umd-research-team-developing-powerful-data-visualization-tool-support-oracle

EHRs: Temporal data



Numerical Events

Stock: Microsoft

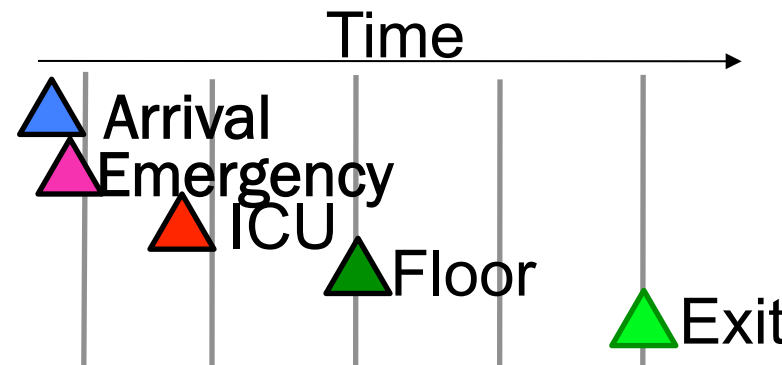
04/26/2010 10:00	31.03
04/26/2010 10:15	31.01
04/26/2010 10:30	31.02
04/26/2010 10:45	31.08
04/26/2010 11:00	31.16



Categorical Events

Patient ID: 45851737

12/02/2008 14:26	Arrival
12/02/2008 14:36	Emergency
12/02/2008 22:44	ICU
12/05/2008 05:07	Floor
12/14/2008 06:19	Exit



Patient Histories: Our Research



Tool	Event Types	Records	Display
LifeLines	Points, Intervals	One	Individual
LifeLines2	Points	Many	Individual, Summary
Similan	Points	Many	Individual
LifeFlow	Points	Many	Individual, Aggregate
EventFlow	Points, Intervals	Many	Individual, Aggregate

www.cs.umd.edu/hcil/toolname



LifeLines: Patient Histories

The screenshot displays the LifeLines software interface, which is divided into two main sections: a patient history timeline on the left and an ultrasound image on the right.

Left Panel: Patient History Timeline

The timeline is organized into horizontal bands representing different categories of medical events:

- Obesity:** A thick black bar spans the top of the timeline.
- Diagnoses:** Includes AtrialFlutter, Flu, Pneumonia, KneePain, Migraine, Fatigue, Diabetes, and Pregnancy.
- Procedures:** Includes Blood, Xray, Pap, Mammo, EKG, and Sonogram.
- Medications:** Includes Cardizem, Ventolyn, Antib., Advil, Insulin, Propanolol, and Lasilix.
- Other:** Includes Dispensed, Batramex stop, PhysicalTherapy, and LowSaltFatDiet.

The timeline is marked with vertical lines and colored bars (red, blue, green) indicating the duration of each event. The bottom of the timeline shows a navigation bar with page numbers 2/92, 93, 94, 95, 96, and 97.

Right Panel: Ultrasound Image

The ultrasound image shows a cross-section of a heart. On the right side of the image, there are technical specifications:

- SCALE MARKS: 1 cm
- DIST: 80mm
- ENH: N
- DEPTH: 13
- NEAR: 13
- FAR: 19
- BAL: 22
- POWER: 67%

Below the image, there is a patient ID field and the text "17mm/3.8 ORIENTED R/L".

LifeLines Control Panel

The control panel is located below the ultrasound image and includes the following settings:

- Layout:** Label, Summary, Search, Zoom
- Location Allowed:** Top Right, Top Right & Left, 4 Corners
- Link from Timeline to Label:** No, Yes
- Font Size:** A slider ranging from 8 to 20.
- Truncation:** No, Yes, with a slider ranging from 0 to 30.

The bottom of the interface shows a taskbar with several open applications: Exploring - sp..., Microsoft Po..., UMD-HCIL Lif..., and LifeLines ...



LifeLines2: Align-Rank-Filter & Summarize

The screenshot displays the LifeLines2 software interface. The main window shows a sequence alignment view with the following settings:

- File:** Lifelines 2 - contrast+create-large.txt.out(deID).txt (deidentified data)
- View:** Record View (selected), Comparison View
- Align by:** Radiology Contrast (3598)
- Rank by:** # of CREAT-H (1190)
- Filter by:** No Filter
- Show Distribution of:** CREAT-H (1190)
- View Record Group:** All Records (3598)
- Legend:** CREAT-H (represented by a red triangle)

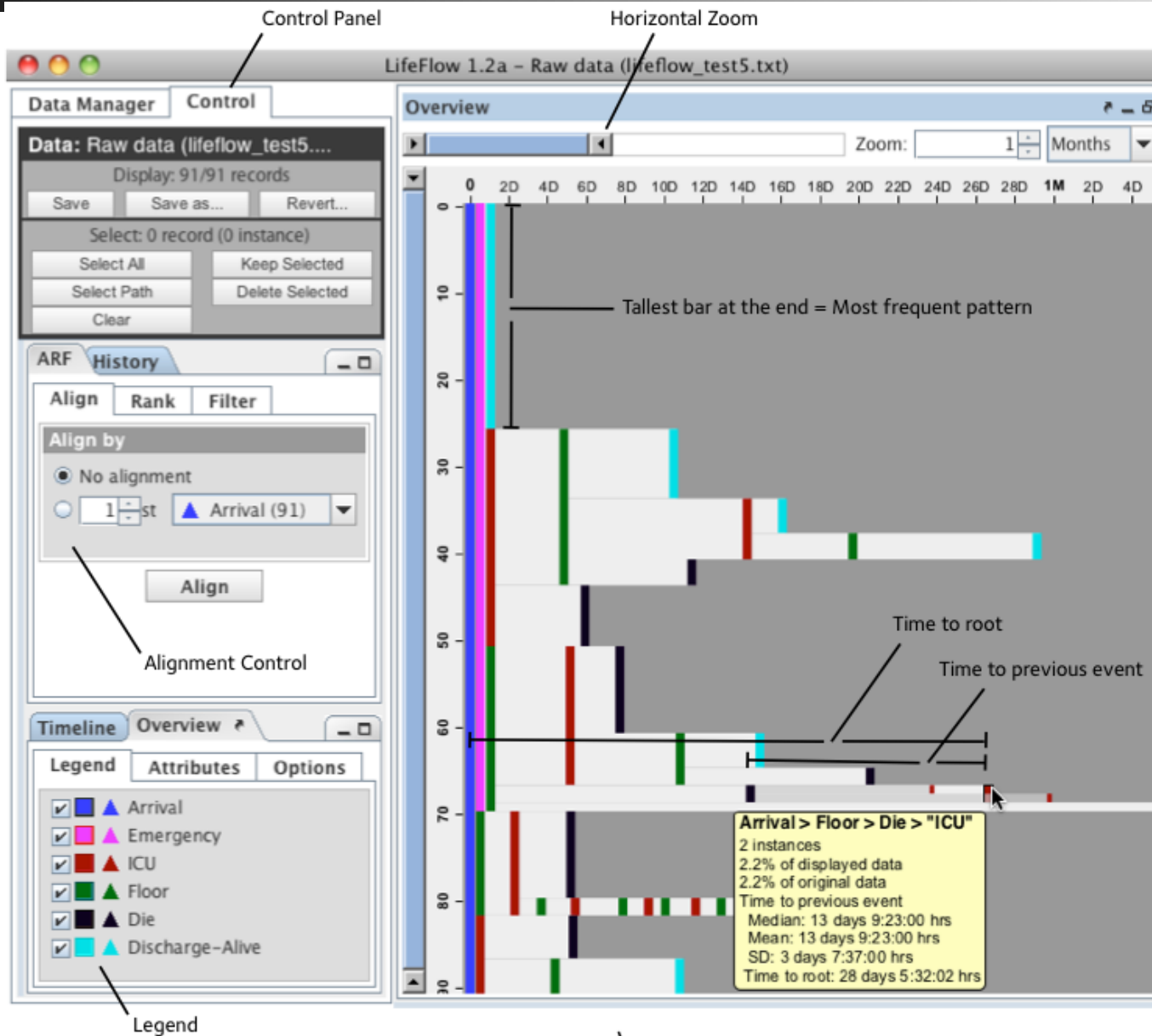
The alignment view shows several records with their corresponding event markers (triangles) over a 13-day period. Below the alignment view is a summary table showing the distribution of events relative to alignment.

Record ID	Rank	-1 D	1 D	2 D	3 D	4 D	5 D	6 D	7 D	8 D	9 D	10 D	11 D	12 D	13 D
0001471	25														
0003108	25														
0003108	25														
000125	25														
0002356	24														
247	149														
458	1		340	239	204	152	124	108	100	80	67	72	51	45	45
645	663		639	465	414	339	308	257	232	210	165	149	139	126	130
2672															

At the bottom of the interface, there are logos for HCIL and the University of Maryland, along with the copyright information: Copyright 2007 - 2008 HCIL UMD.



LifeFlow: Interface with User Controls



Data Manager Control

Raw data (ed_2010_jan.txt)
Showing 7041/7041 records

Selected: 0 record (0 instance)

Align Rank Filter History

Please select how to align:

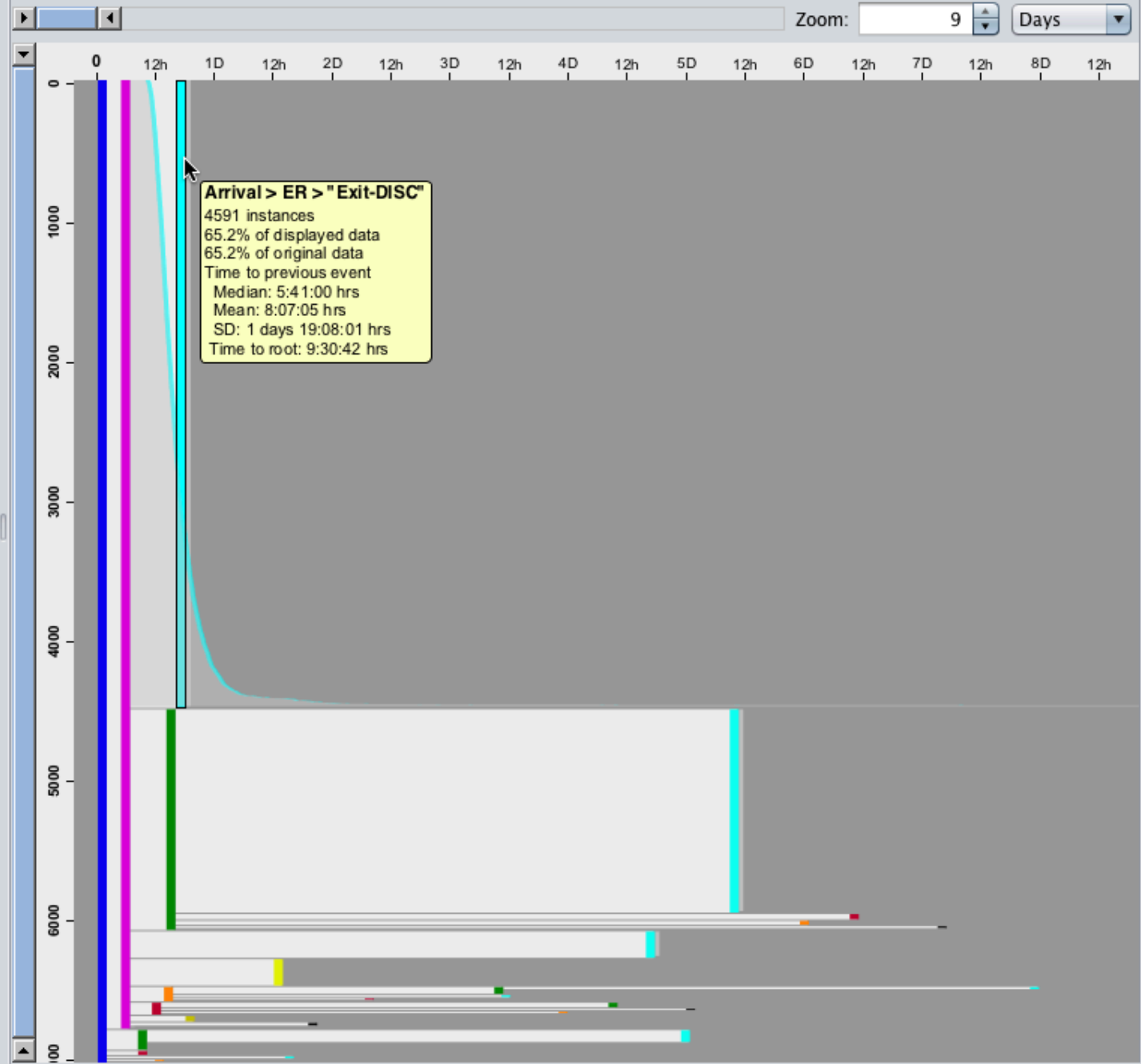
No alignment
 1 st Arrival (7123) from the beginning
 All Arrival (7123)

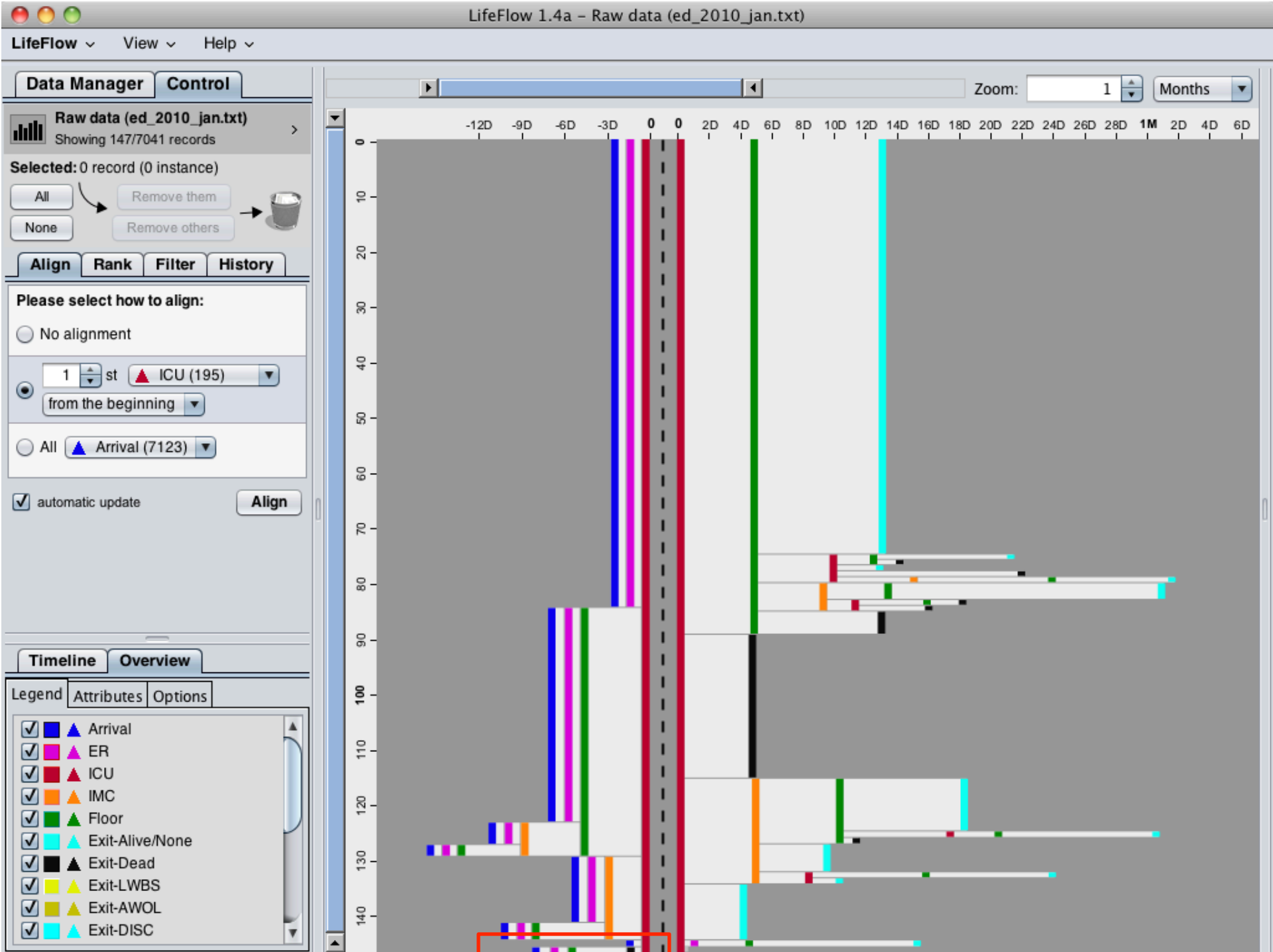
automatic update

Timeline Overview

Legend Attributes Options

- ▲ Arrival
- ▲ ER
- ▲ ICU
- ▲ IMC
- ▲ Floor
- ▲ Exit-Alive/None
- ▲ Exit-Dead
- ▲ Exit-LWBS
- ▲ Exit-AWOL
- ▲ Exit-DISC

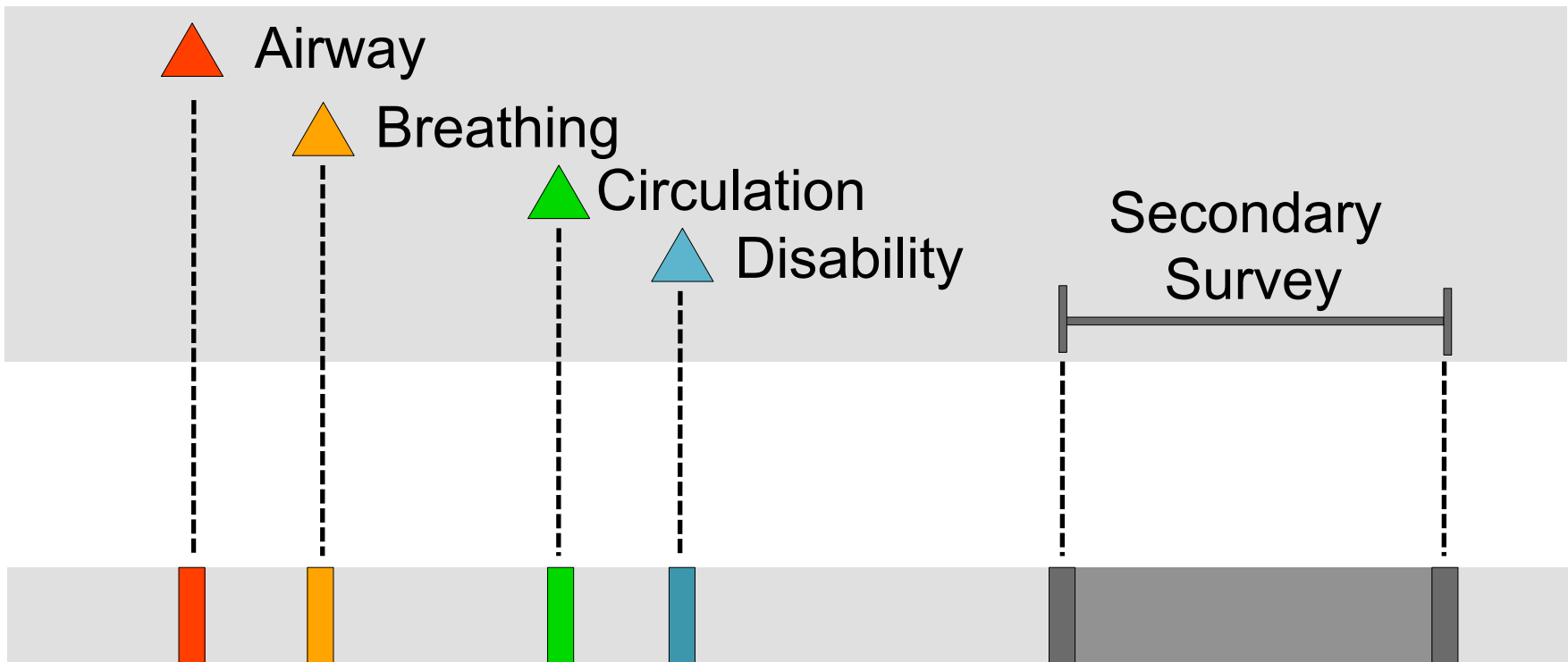




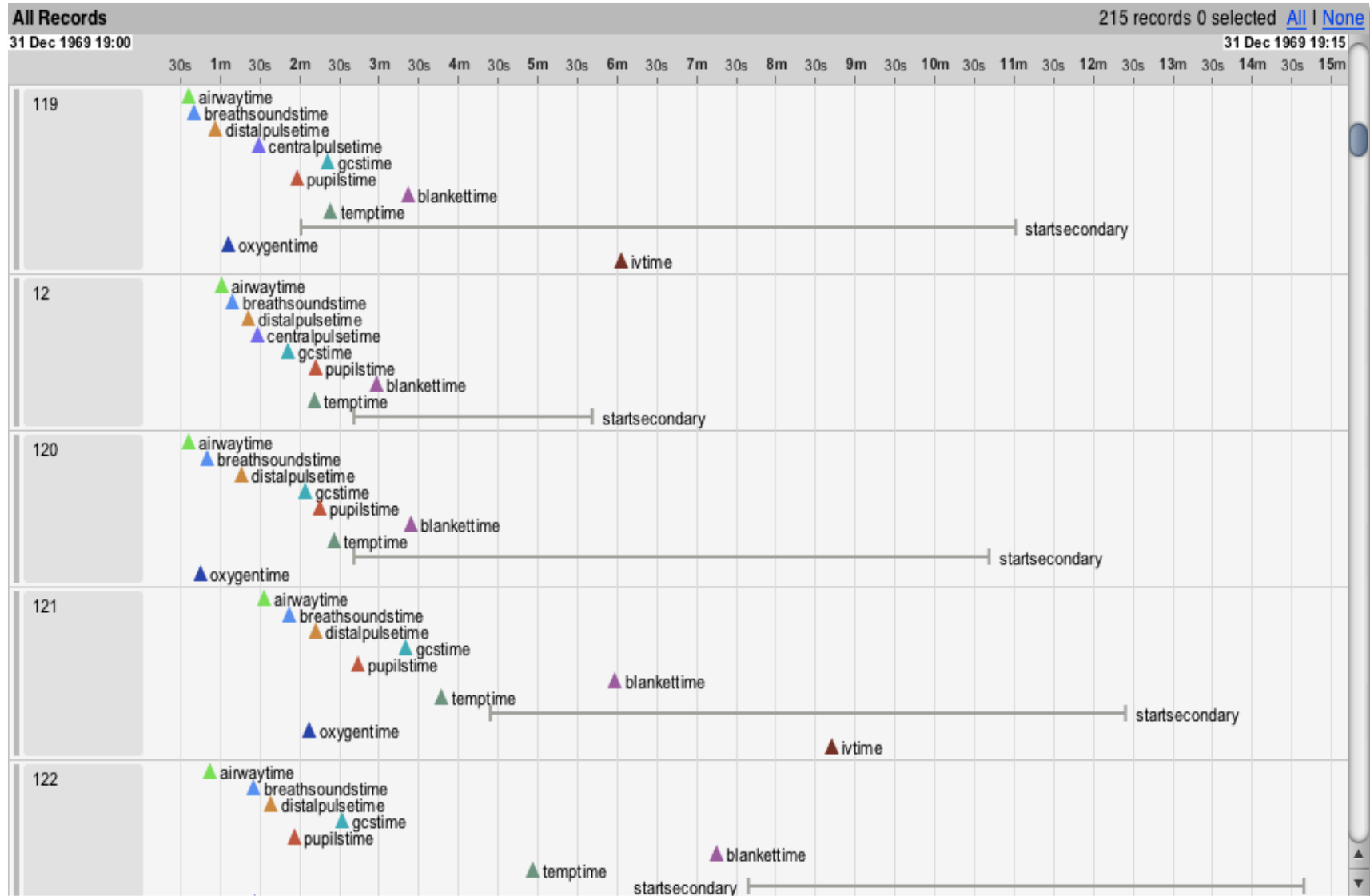
Children's Hospital in DC: Trauma Bay



EventFlow

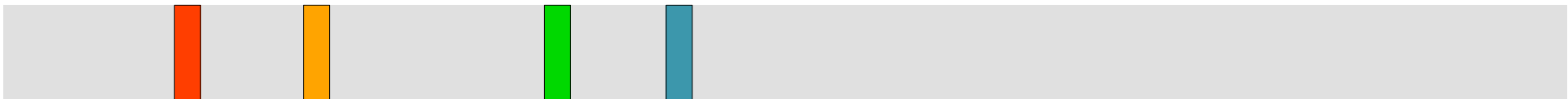
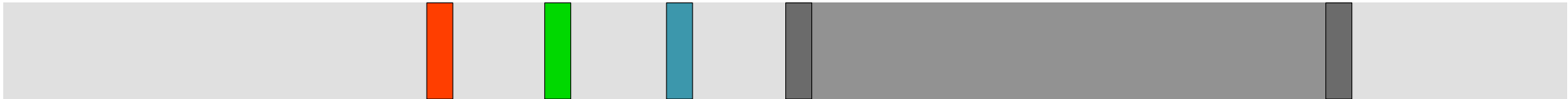
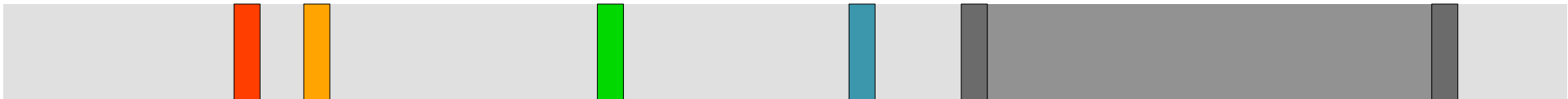
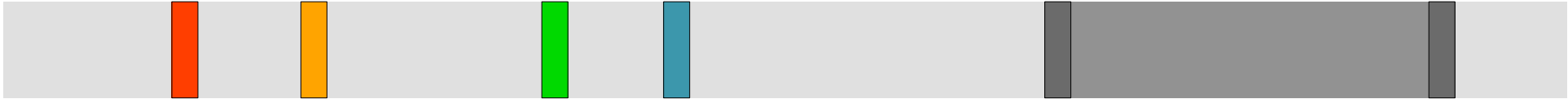


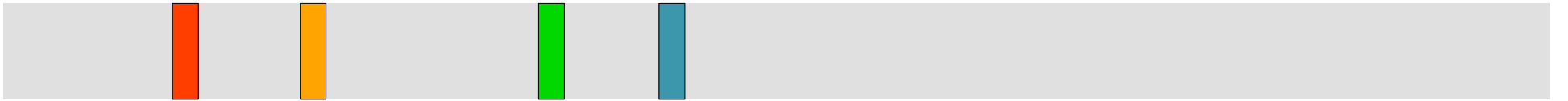
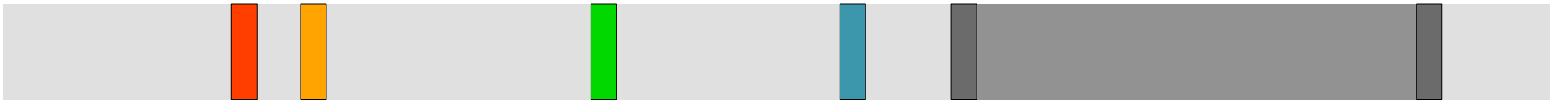
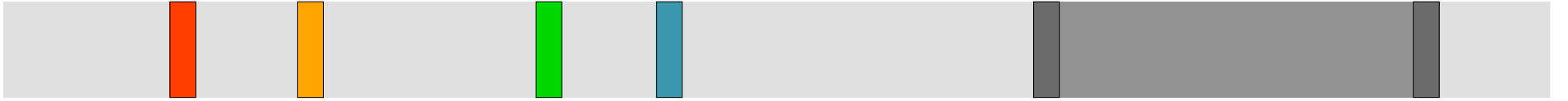
EventFlow: Temporal Events

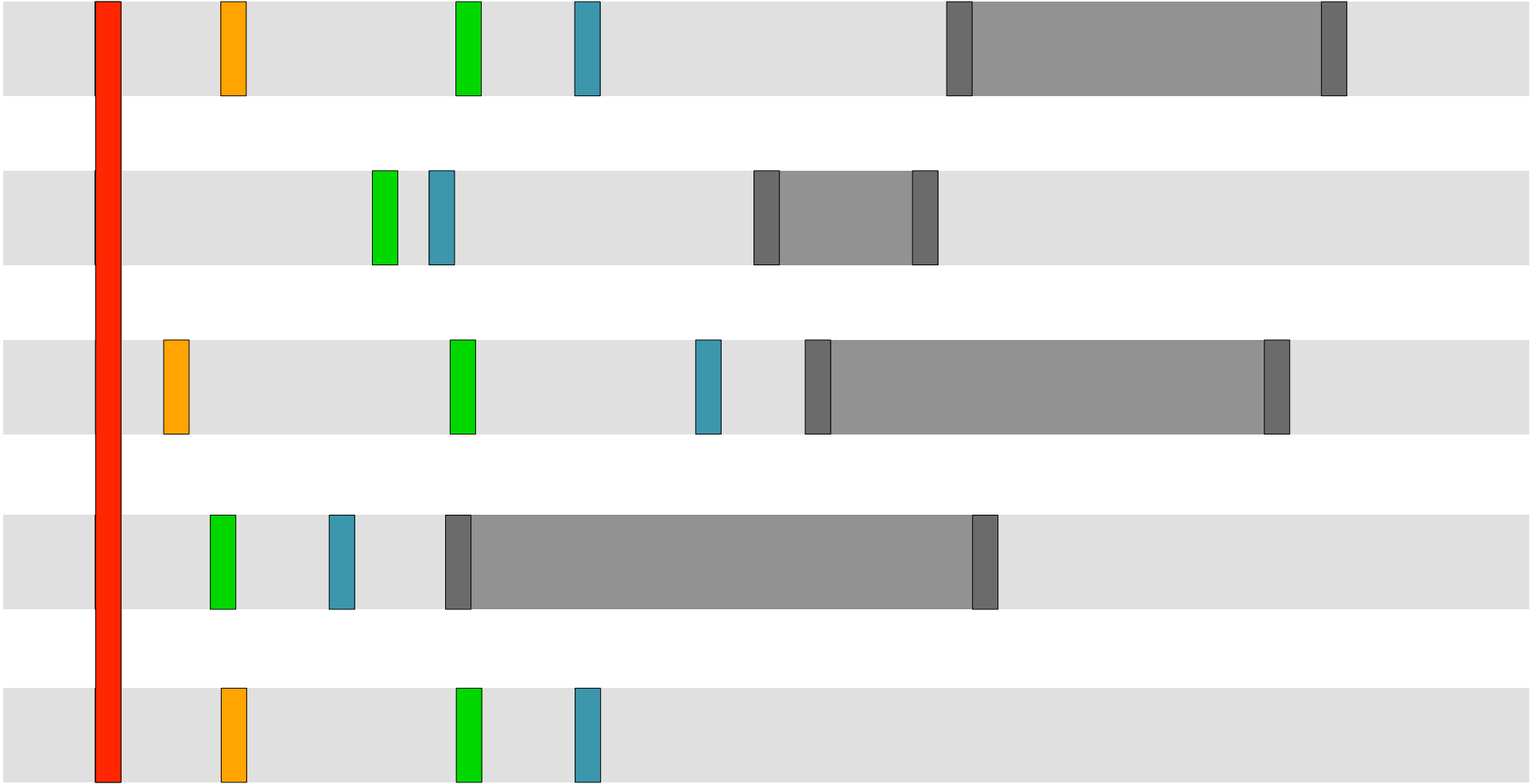


http://youtu.be/dz86_nSxt-M

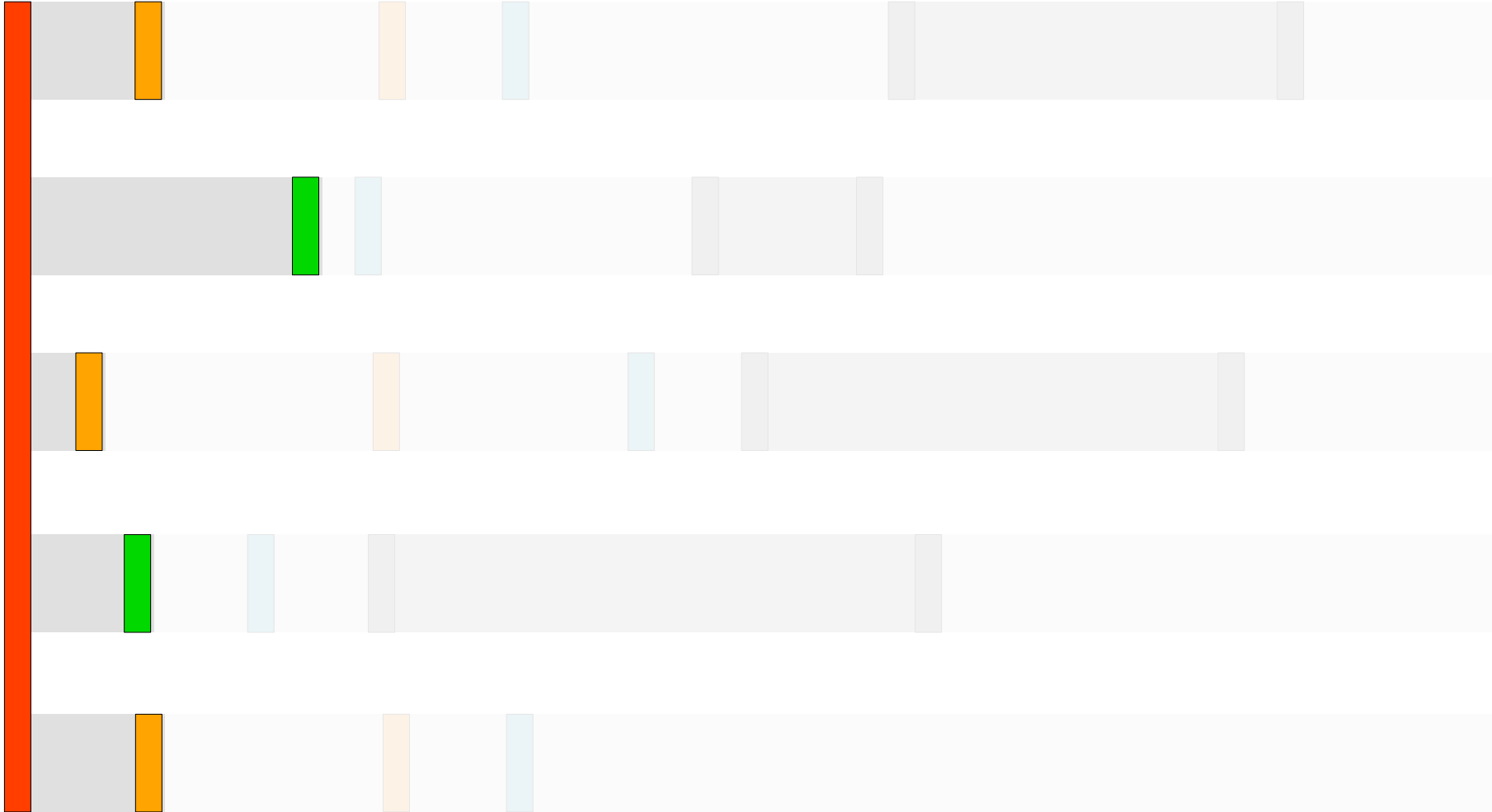




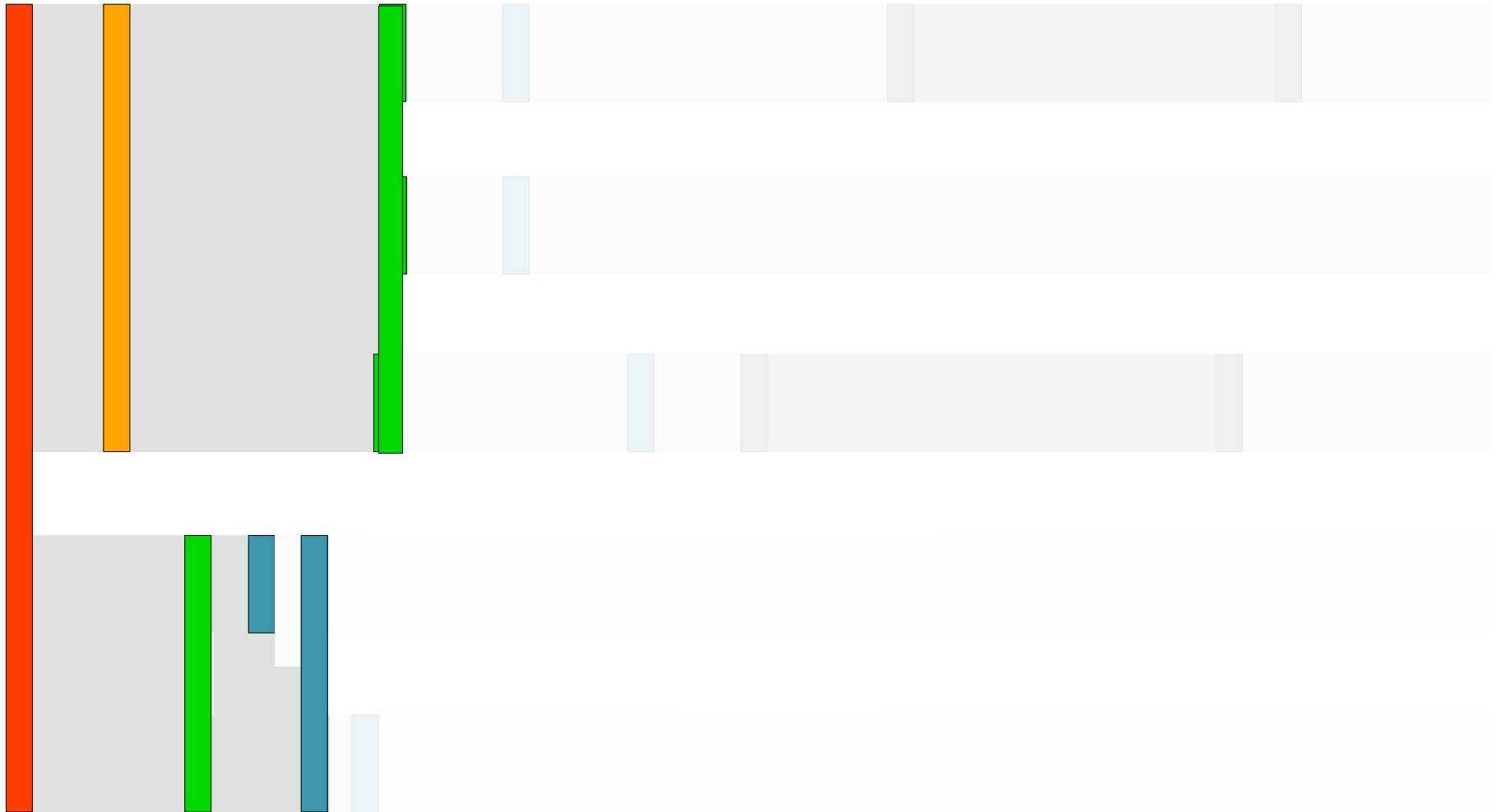


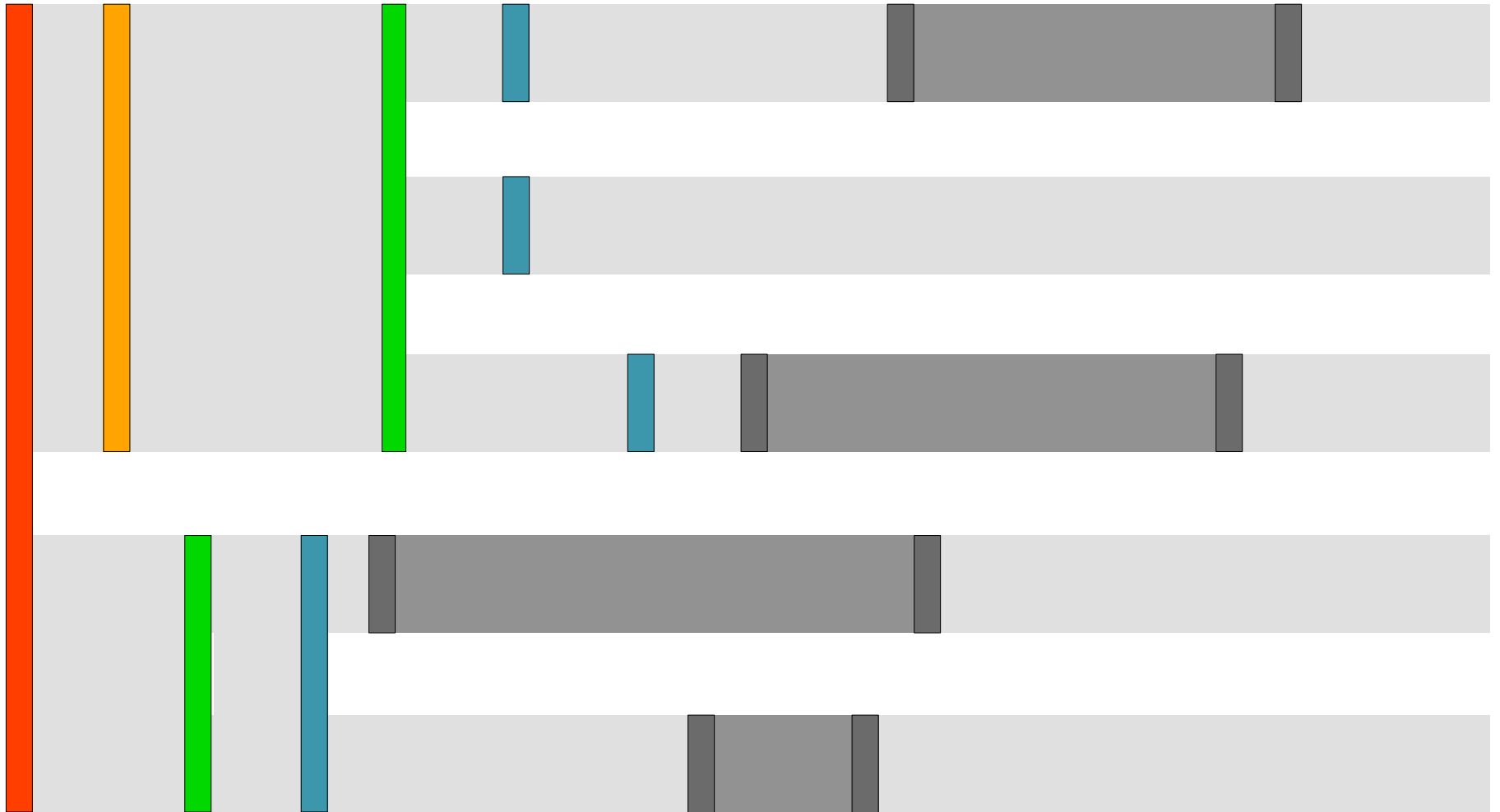


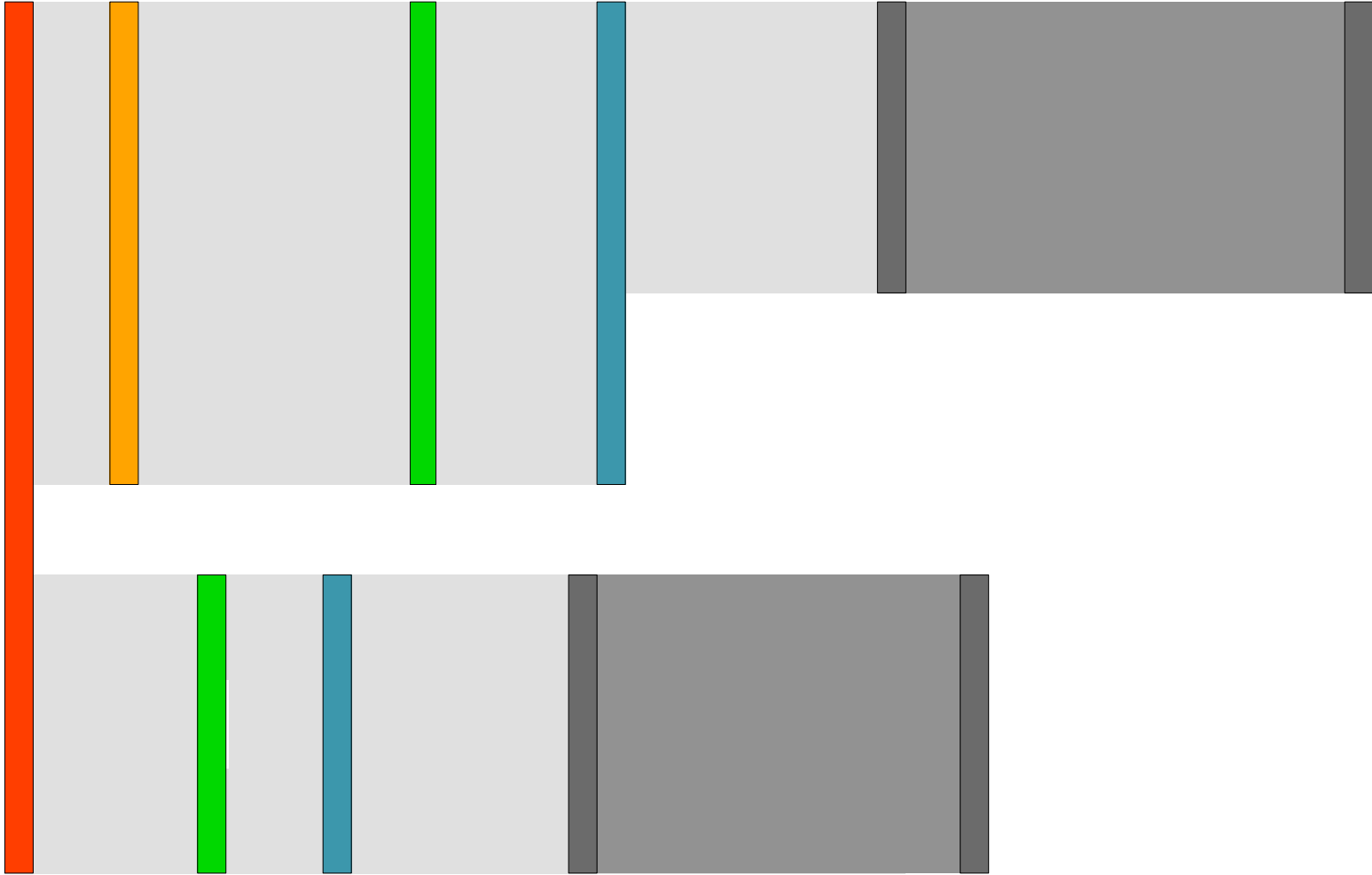


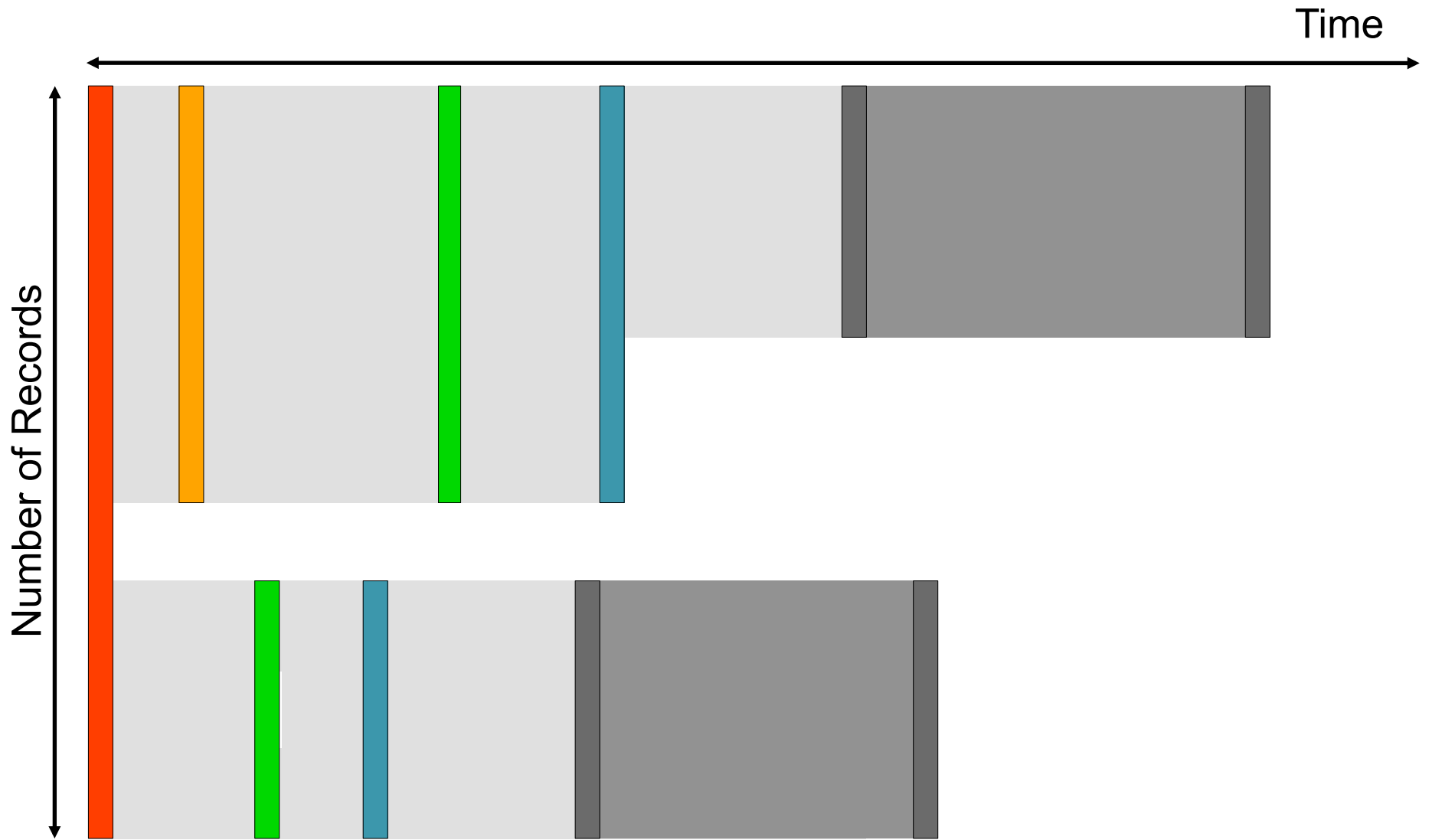




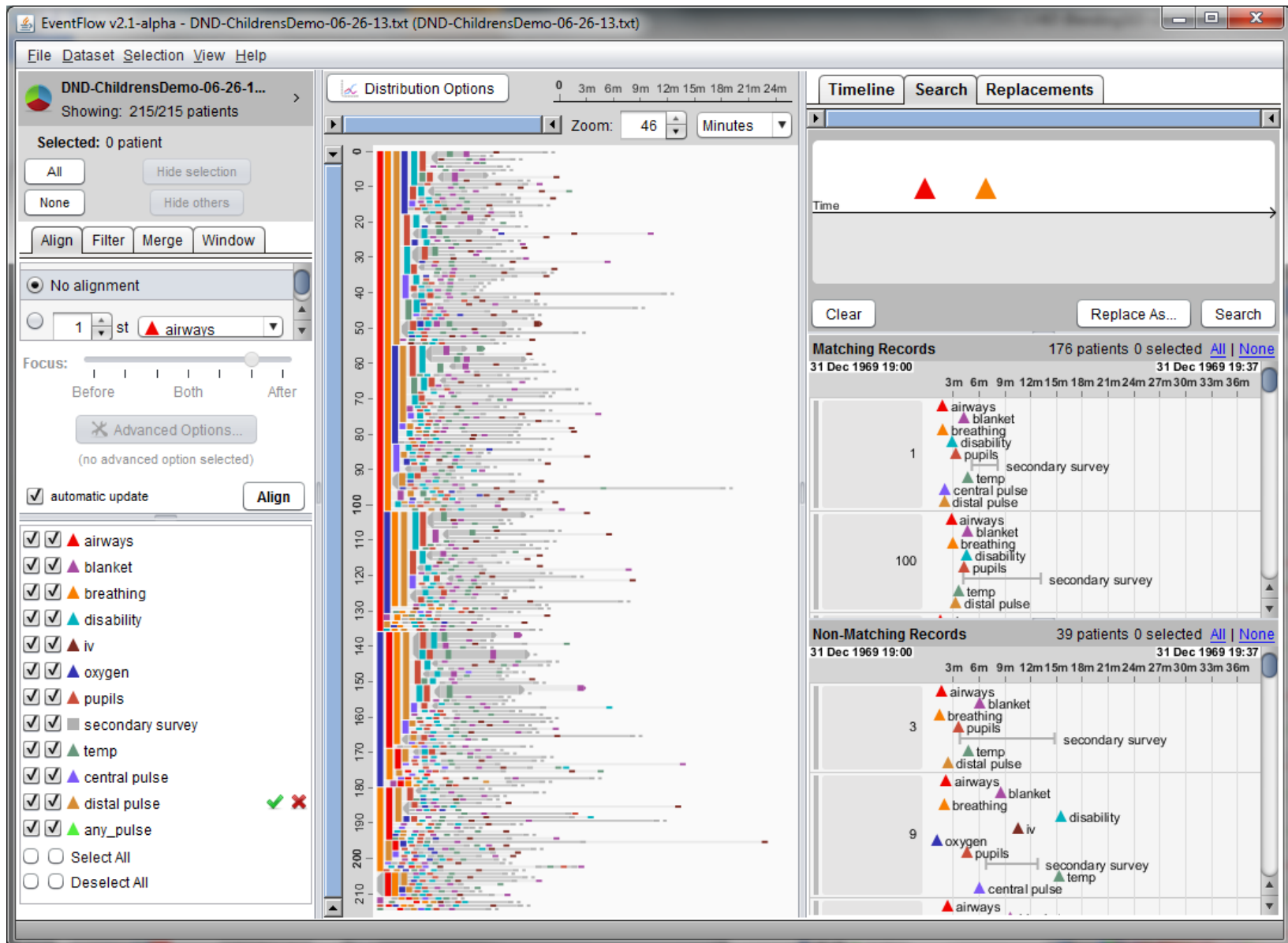




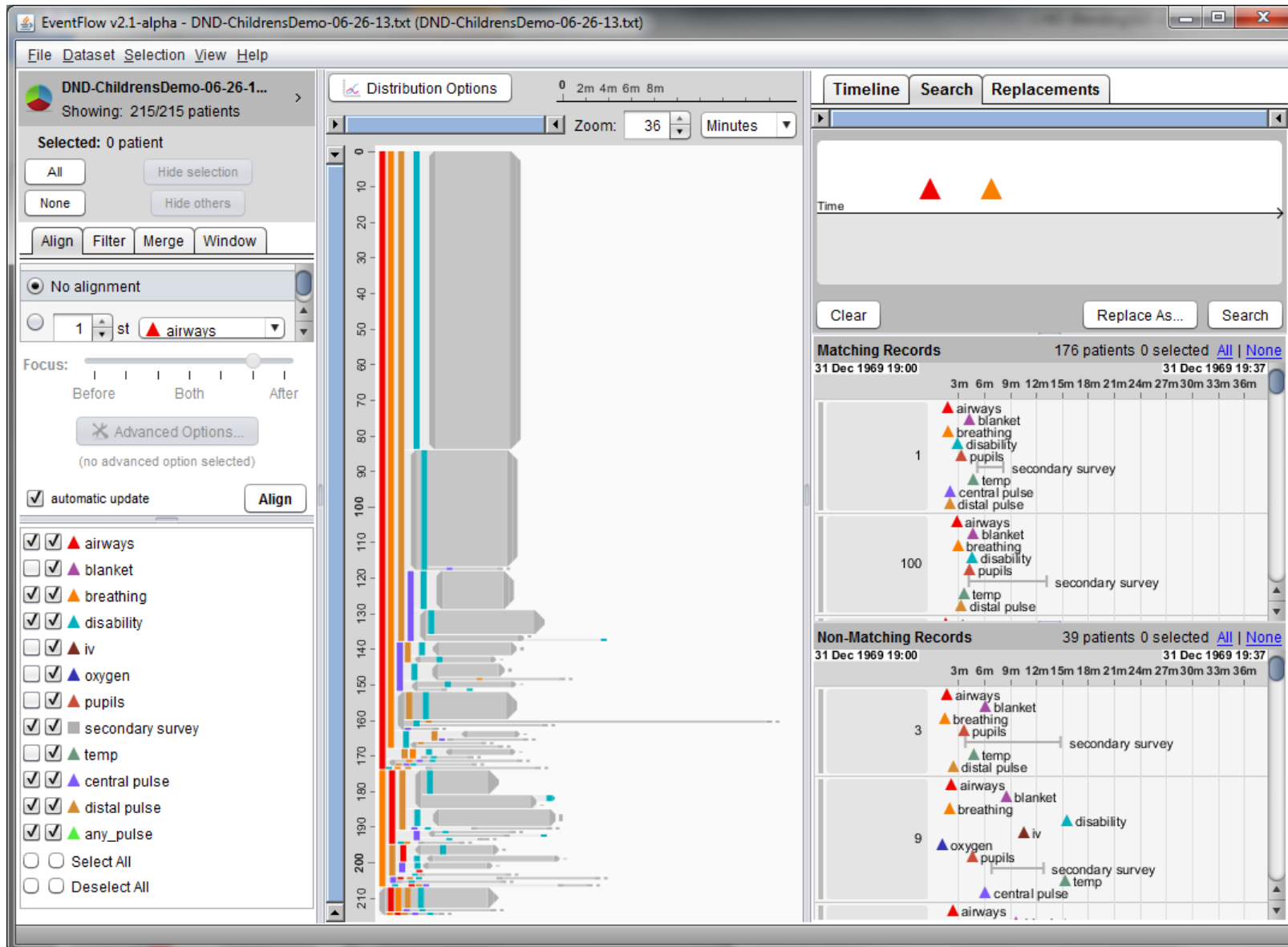




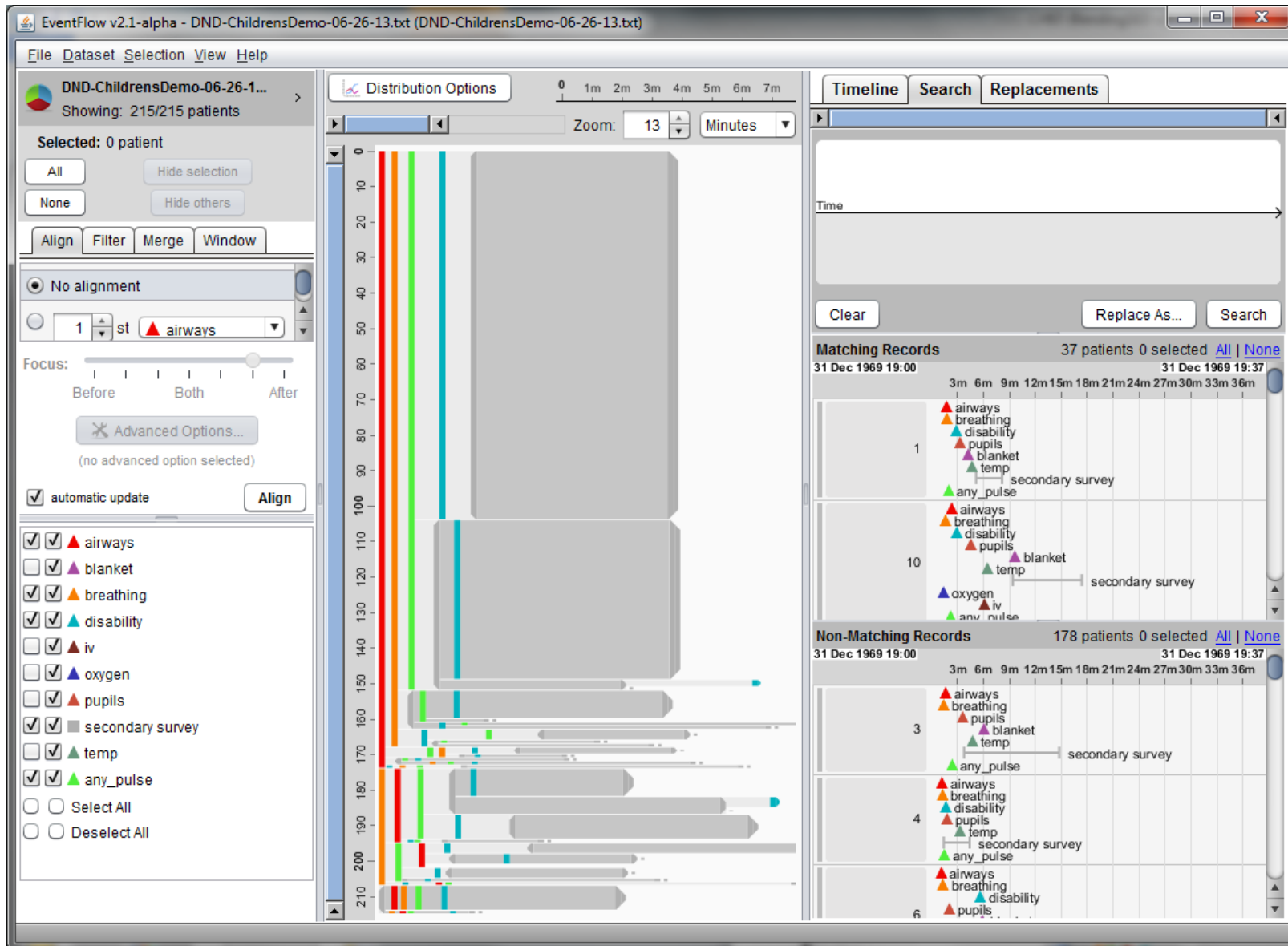
Children's Hospital Trauma Care: EventFlow



Children's Hospital Trauma Care: EventFlow



Children's Hospital Trauma Care: EventFlow



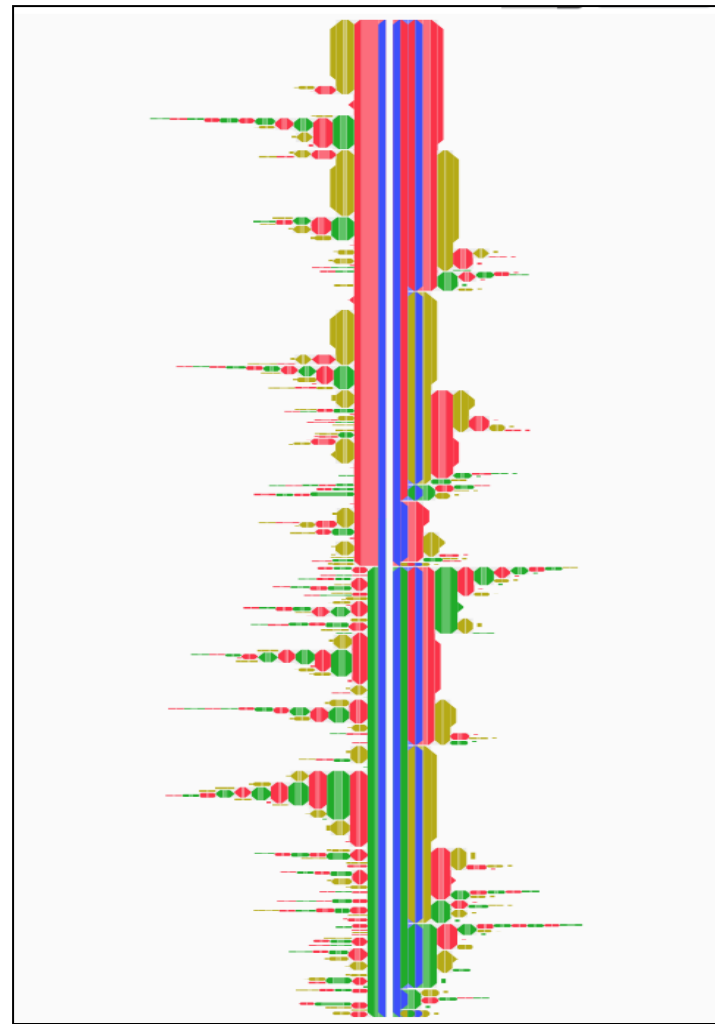
UM-Baltimore: CHIB Projects



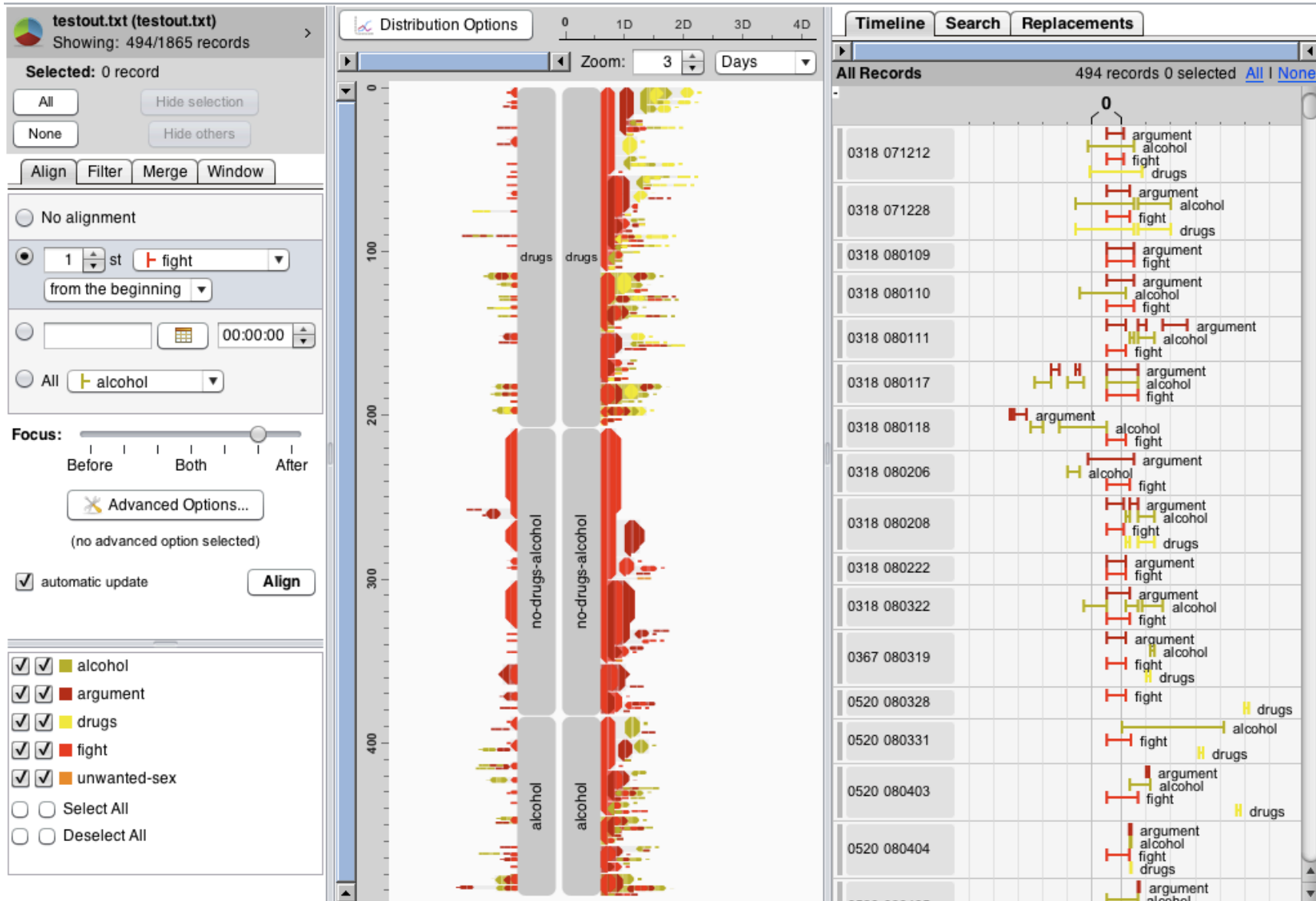
Radiation Therapy: Metastatic Prostate Cancer



Warfarin Usage in Patients with Traumatic Brain Injury



Yale Medical: Seth Powsner & Tami Sullivan

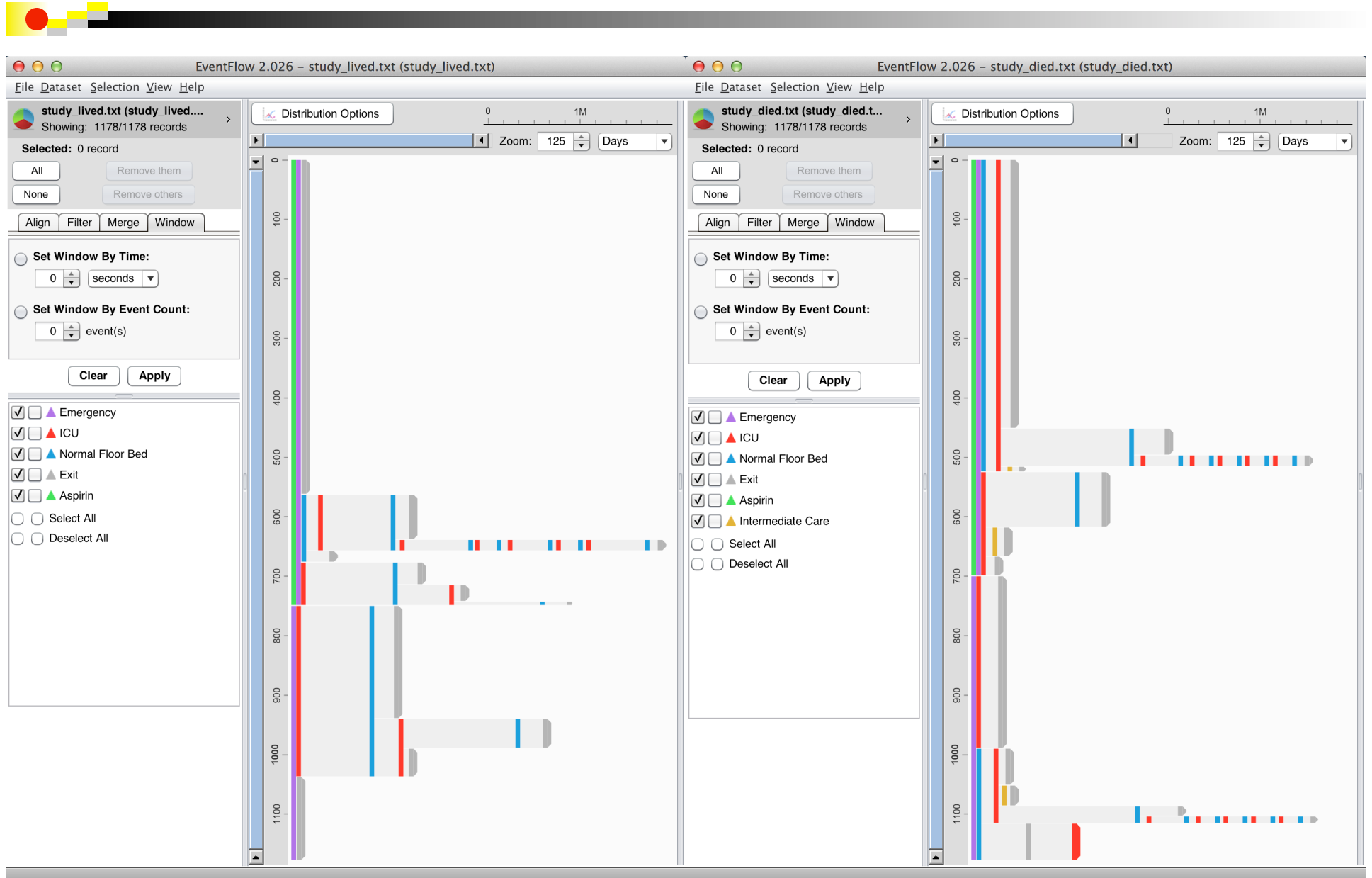


Future Directions: EventFlow

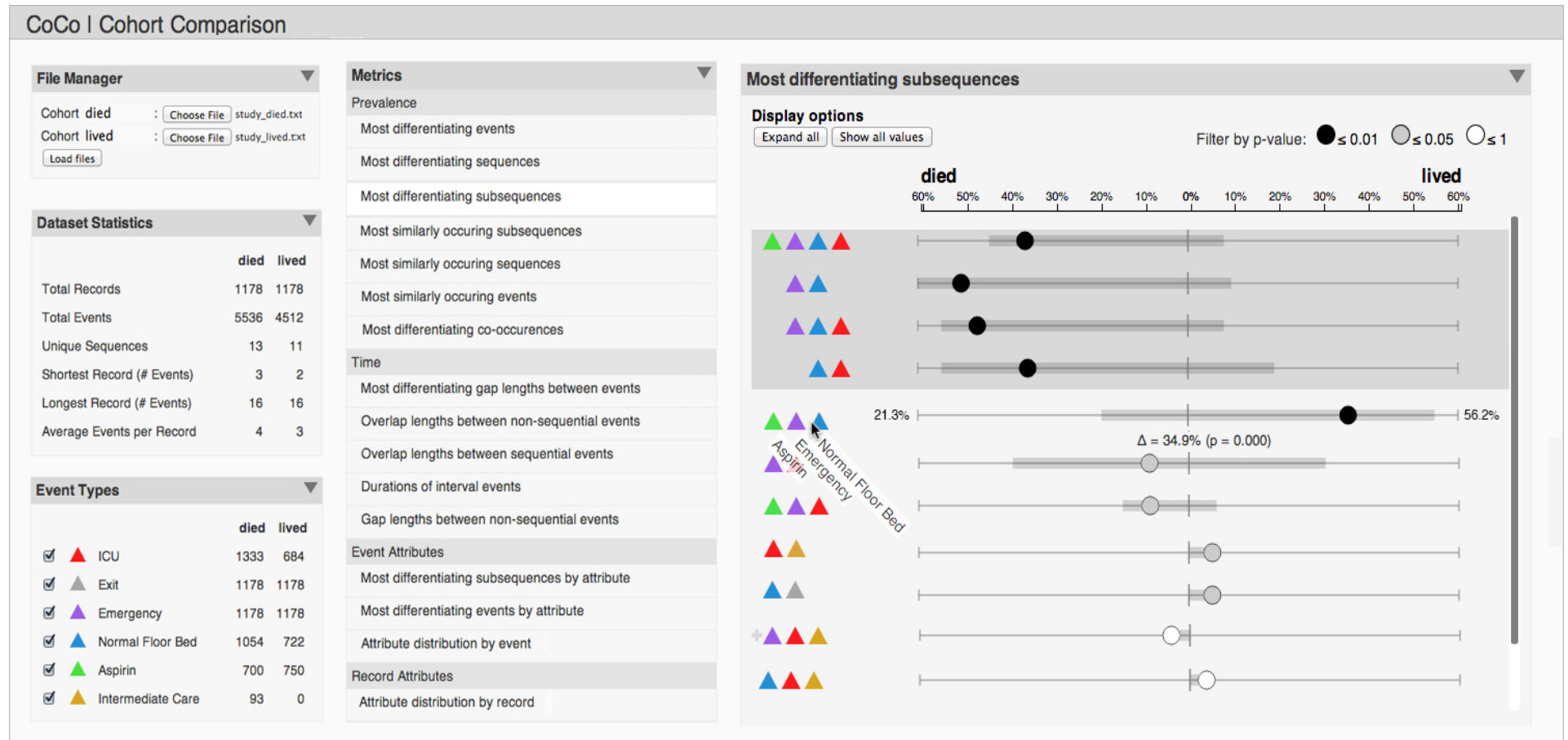
- Refine software to add business features
- Make backend database
- Scalability of many kinds
- Validation across usage domains
- Build community
- Launch startup company?



Cohort Comparison: Dual EventFlow



Cohort Comparison: CoCo



Thanks for getting us to this stage

Catherine Plaisant

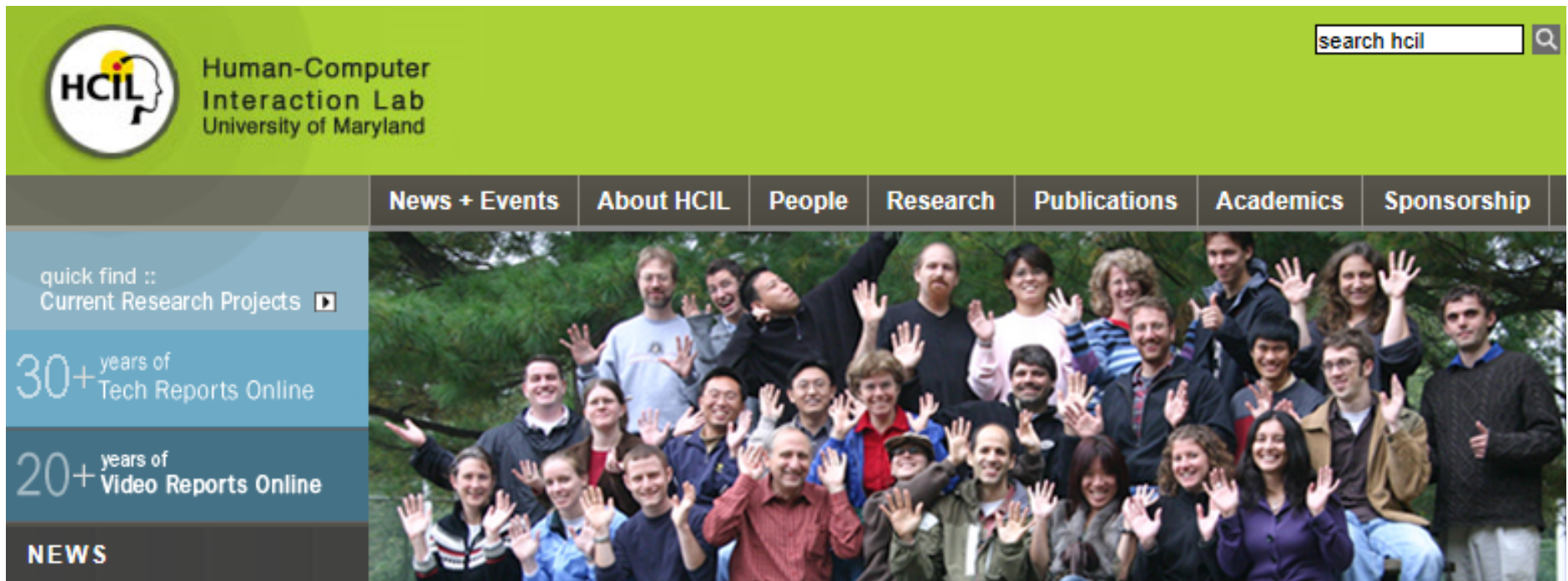
- LifeLines
- LifeLines2 (David Wang)
- LifeFlow (Krist Wongsuphasawat)
- EventFlow team

→ Megan Monroe, Chris Imbriano →

Sana Malik, Fan Du, Chris Musialek, Christi Capati, Duke Chan

THANKS! Sponsors: NIH, Oracle, CHIB





@benbendc

Workshop Website

www.cs.umd.edu/hcil/eventflow/workshop2014/

