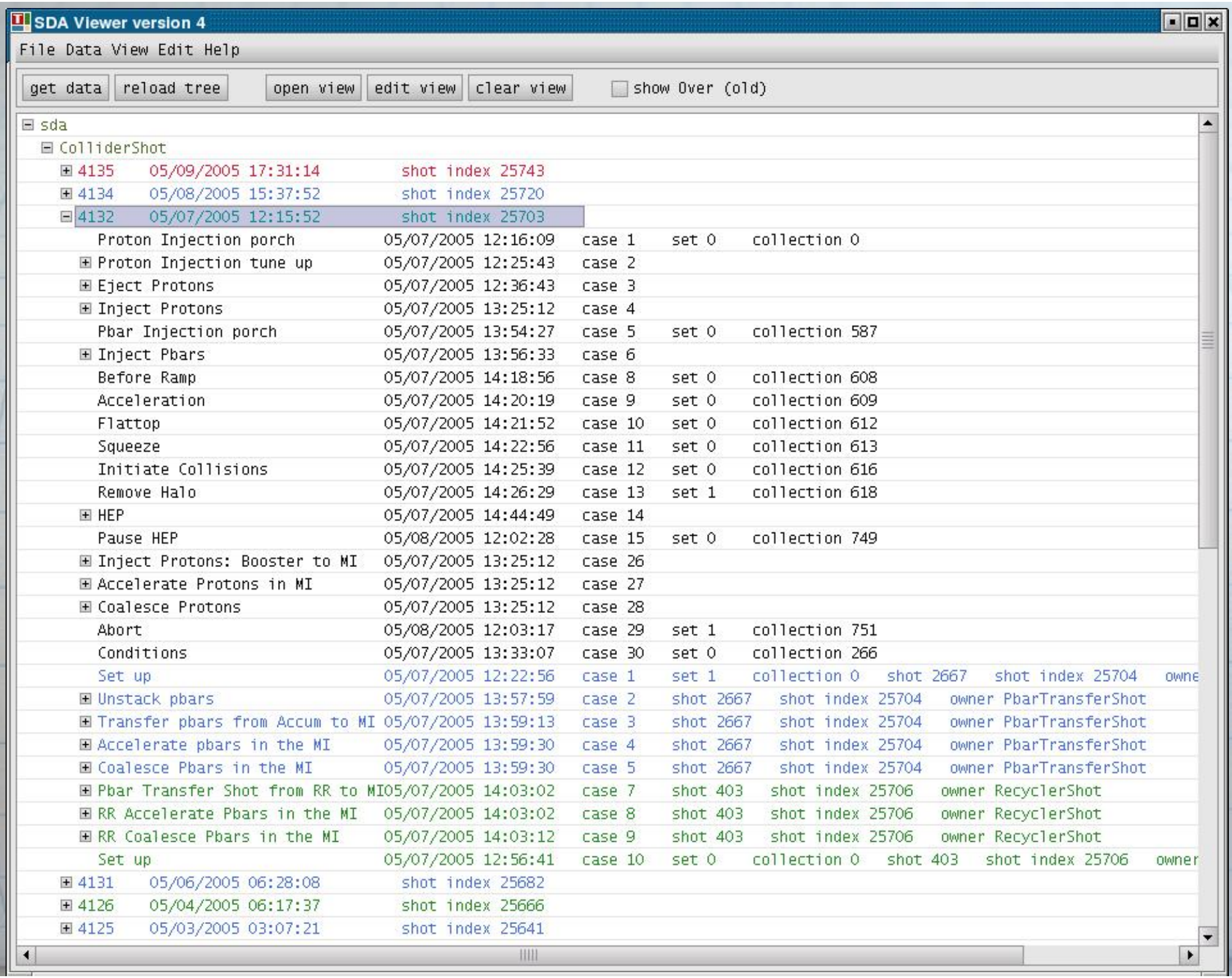
SDA Time Intervals

Timofei B. Bolshakov,
Jerry Cai, Elliott McCrory, Dennis Nicklaus,

FermiLab,
LAFS workroup

What is SDA?

- **Sequenced Data Acquisition**
- Backed up with **Hierarchical** Data Logging System.


SDA Viewer version 4
File Data View Edit Help
get data
reload tree
open view
edit view
clear view
show Over (old)
sda
ColliderShot
4135 05/09/2005 17:31:14 shot index 25743
4134 05/08/2005 15:37:52 shot index 25720
4132 05/07/2005 12:15:52 shot index 25703
Proton Injection porch 05/07/2005 12:16:09 case 1 set 0 collection 0
Proton Injection tune up 05/07/2005 12:25:43 case 2
Eject Protons 05/07/2005 12:36:43 case 3
Inject Protons 05/07/2005 13:25:12 case 4
Pbar Injection porch 05/07/2005 13:54:27 case 5 set 0 collection 587
Inject Pbars 05/07/2005 13:56:33 case 6
Before Ramp 05/07/2005 14:18:56 case 8 set 0 collection 608
Acceleration 05/07/2005 14:20:19 case 9 set 0 collection 609
Flattop 05/07/2005 14:21:52 case 10 set 0 collection 612
Squeeze 05/07/2005 14:22:56 case 11 set 0 collection 613
Initiate Collisions 05/07/2005 14:25:39 case 12 set 0 collection 616
Remove Halo 05/07/2005 14:26:29 case 13 set 1 collection 618
HEP 05/07/2005 14:44:49 case 14
Pause HEP 05/08/2005 12:02:28 case 15 set 0 collection 749
Inject Protons: Booster to MI 05/07/2005 13:25:12 case 26
Accelerate Protons in MI 05/07/2005 13:25:12 case 27
Coalesce Protons 05/07/2005 13:25:12 case 28
Abort 05/08/2005 12:03:17 case 29 set 1 collection 751
Conditions 05/07/2005 13:33:07 case 30 set 0 collection 266
Set up 05/07/2005 12:22:56 case 1 set 1 collection 0 shot 2667 shot index 25704 owne
Unstack pbars 05/07/2005 13:57:59 case 2 shot 2667 shot index 25704 owner PbarTransferShot
Transfer pbars from Accum to MI 05/07/2005 13:59:13 case 3 shot 2667 shot index 25704 owner PbarTransferShot
Accelerate pbars in the MI 05/07/2005 13:59:30 case 4 shot 2667 shot index 25704 owner PbarTransferShot
Coalesce Pbars in the MI 05/07/2005 13:59:30 case 5 shot 2667 shot index 25704 owner PbarTransferShot
Pbar Transfer Shot from RR to MI 05/07/2005 14:03:02 case 7 shot 403 shot index 25706 owner RecyclerShot
RR Accelerate Pbars in the MI 05/07/2005 14:03:02 case 8 shot 403 shot index 25706 owner RecyclerShot
RR Coalesce Pbars in the MI 05/07/2005 14:03:12 case 9 shot 403 shot index 25706 owner RecyclerShot
Set up 05/07/2005 12:56:41 case 10 set 0 collection 0 shot 403 shot index 25706 owner
4131 05/06/2005 06:28:08 shot index 25682
4126 05/04/2005 06:17:37 shot index 25666
4125 05/03/2005 03:07:21 shot index 25641

What is SDA?

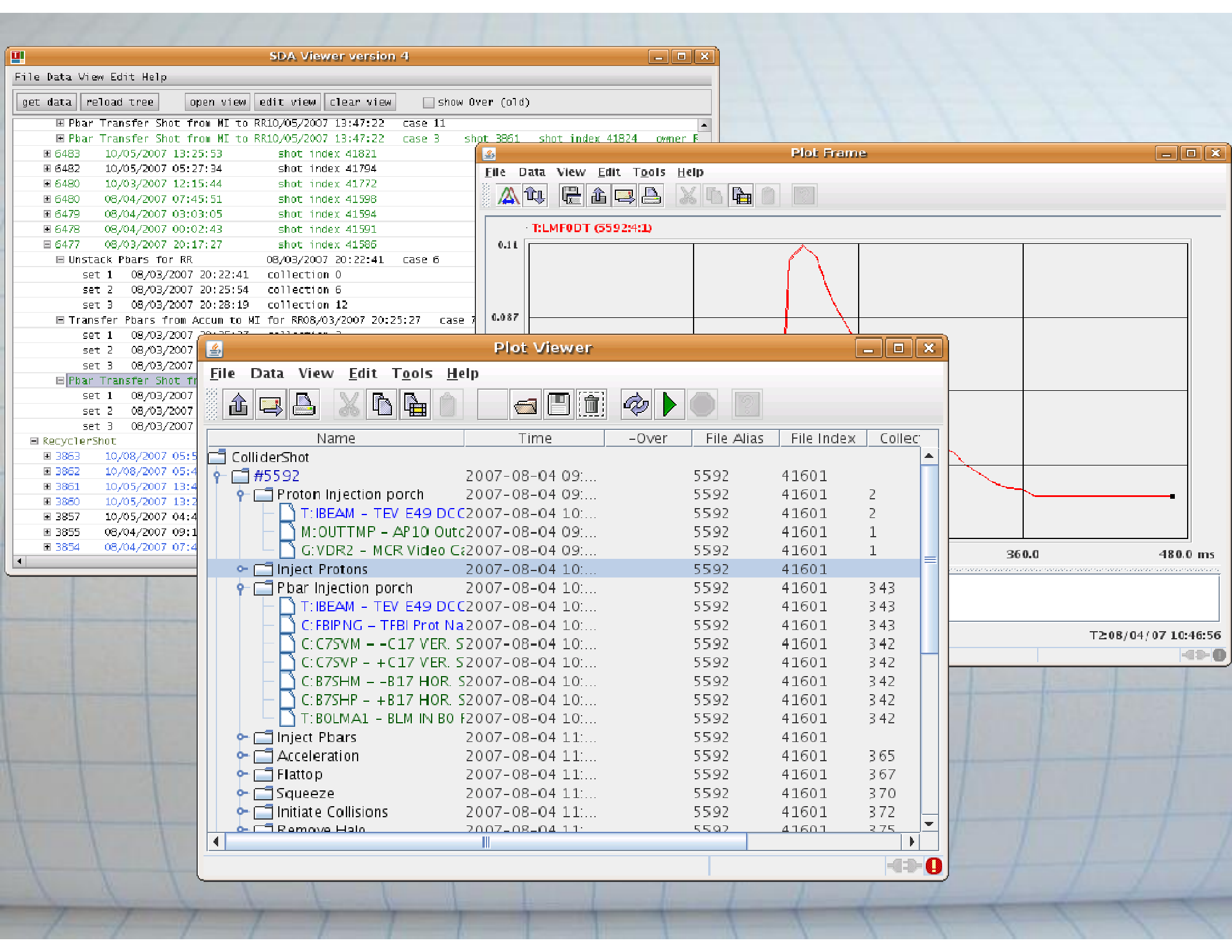
- **Sequenced Data Acquisition**
- Backed up with **Hierarchical** Data Logging System.
- Based on rules and driven by events
- Terms: **Event, Device, Collection, Shot, Case, Set.**

ACNET Events

- 256 **Tclk** events + delay
- Absolute and Relative Time events, delays.
- State variable changes.
- **Changes of ACNET special device readings (category of devices).**

What is SDA?

- **Sequenced Data Acquisition**
- Backed up with **Hierarchical** Data Logging System.
- Based on rules and driven by events
- Terms: **Event, Device, Collection, Shot, Case, Set.**
- Numerous tools, tables, applications..


SDA Viewer version 4
File Data View Edit Help
get data
reload tree
open view
edit view
clear view
show Over (old)
Pbar Transfer Shot from MI to RR10/05/2007 13:47:22 case 11
Pbar Transfer Shot from MI to RR10/05/2007 13:47:22 case 3 shot 3861 shot index 41824
6483 10/05/2007 13:25:53 shot index 41821
6482 10/05/2007 05:27:34 shot index 41794
6480 10/03/2007 12:15:44 shot index 41772
6480 08/04/2007 07:45:51 shot index 41598
6479 08/04/2007 03:03:05 shot index 41594
6478 08/04/2007 00:02:43 shot index 41591
6477 08/03/2007 20:17:27 shot index 41586
Unstack Pbars for RR 08/03/2007 20:22:41 case 6
set 1 08/03/2007 20:22:41 collection 0
set 2 08/03/2007 20:25:54 collection 6
set 3 08/03/2007 20:28:19 collection 12
Transfer Pbars from Accum to MI for RR08/03/2007 20:25:27 case 7
RecyclerShot
3863 10/08/2007 05:5
3862 10/08/2007 05:4
3861 10/05/2007 13:4
3860 10/05/2007 13:2
3857 10/05/2007 04:4
3855 08/04/2007 09:1
3854 08/04/2007 07:4
Plot Frame
File Data View Edit Tools Help
T:LMF0DT (5592:4:1)
0.11
0.087
360.0
480.0 ms
T≥08/04/07 10:46:56
Plot Viewer
File Data View Edit Tools Help
Name
Time
-Over
File Alias
File Index
Collec
ColliderShot
#5592 2007-08-04 09:... 5592 41601
Proton Injection porch 2007-08-04 09:... 5592 41601 2
T:IBEAM - TEV E49 DCC 2007-08-04 10:... 5592 41601 2
M:OUTTMP - AP10 Outc 2007-08-04 09:... 5592 41601 1
G:VDR2 - MCR Video Ca 2007-08-04 09:... 5592 41601 1
Inject Protons 2007-08-04 10:... 5592 41601
Pbar Injection porch 2007-08-04 10:... 5592 41601 343
T:IBEAM - TEV E49 DCC 2007-08-04 10:... 5592 41601 343
C:FBIPNG - TFBI Prot Na 2007-08-04 10:... 5592 41601 343
C:C7SVM - -C17 VER. S 2007-08-04 10:... 5592 41601 342
C:C7SVP - +C17 VER. S 2007-08-04 10:... 5592 41601 342
C:B7SHM - -B17 HOR. S 2007-08-04 10:... 5592 41601 342
C:B7SHP - +B17 HOR. S 2007-08-04 10:... 5592 41601 342
T:BOLMA1 - BLM IN B0 F 2007-08-04 10:... 5592 41601 342
Inject Pbars 2007-08-04 11:... 5592 41601
Acceleration 2007-08-04 11:... 5592 41601 365
Flattop 2007-08-04 11:... 5592 41601 367
Squeeze 2007-08-04 11:... 5592 41601 370
Initiate Collisions 2007-08-04 11:... 5592 41601 372
Remove Halo 2007-08-04 11:... 5592 41601 375

Summary tables

- **Intensities and Emittances**, averages and bunch by bunch for both Collider Shot and Pbar Transfers from Accumulator to Recycler.
- ñ**Supertables**ò for both Collider Shot and Pbar Transfers from Accumulator to Recycler.
- Performance plots.
- Luminosity plots.
- OSDA ï API for reading SDA data.
- Physicists named SDA Shot Data Analisys.

Mozilla Firefox <2>

File Edit View Go Bookmarks Tools Help

http://www-bd.fnal.gov/javaapplications/html_write/ShotSummary

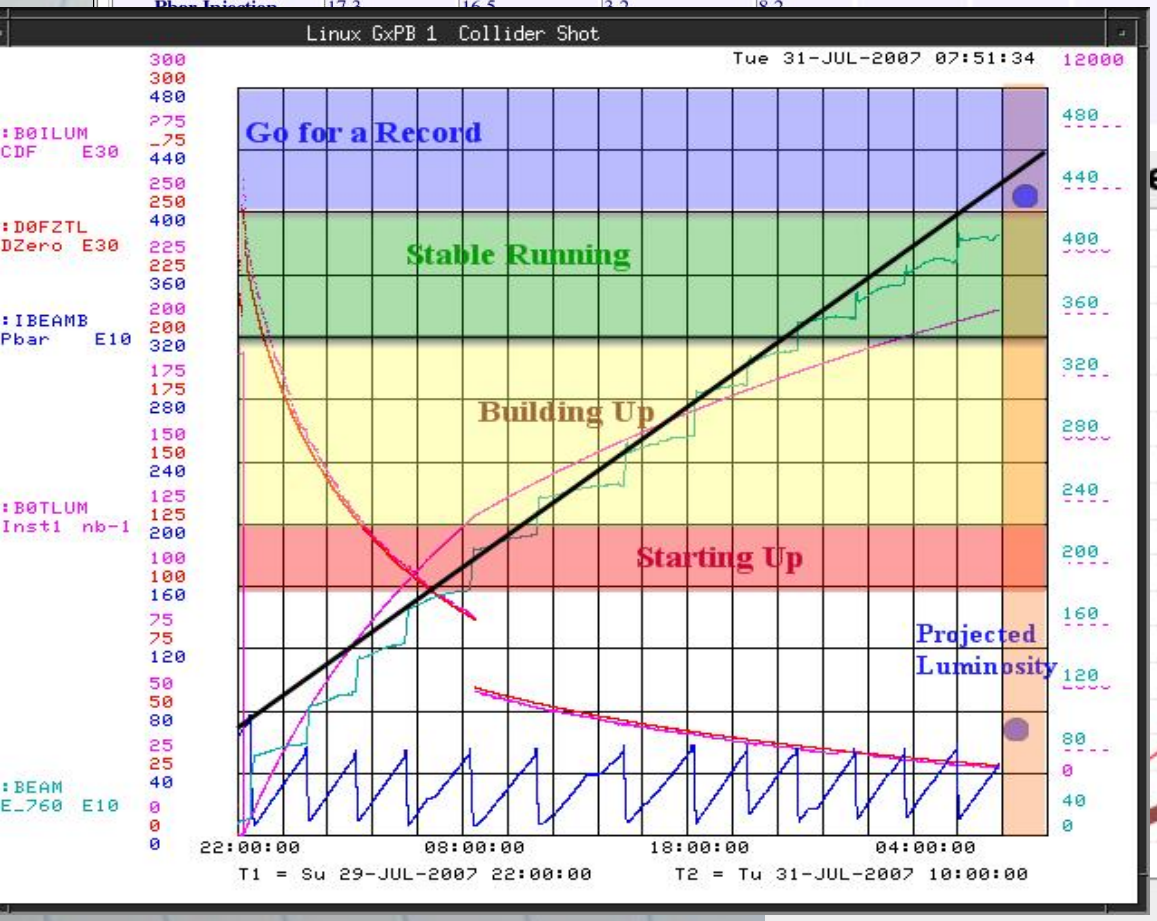
Getting Started Latest Headlines

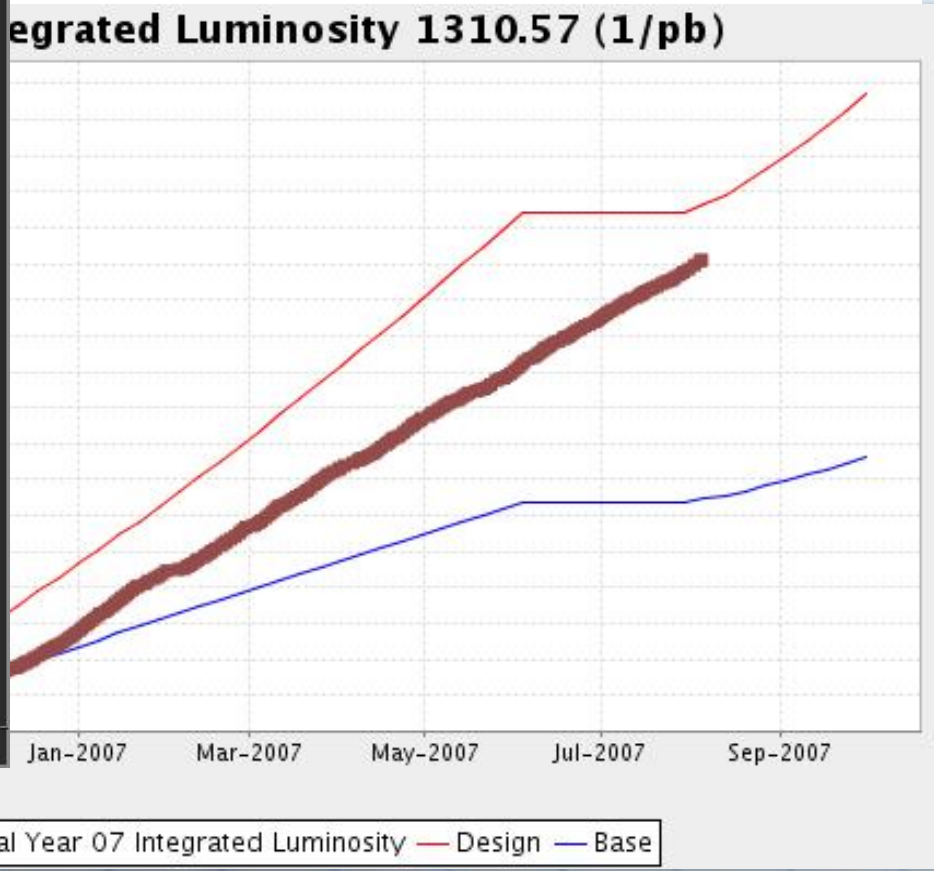
Recomputed Emittances Table

Shot Summary 4100 04/17/2005 01:50:29 Initial Stack size: 138.9 E10 Initial Stash size: No

Store # 4100	Proton Vertical pi-mm-mr	Proton Horizontal pi-mm-mr	Proton Longitudinal eV-sec	Pbar Vert pi-mm-n
Accumulator	.	.	.	2.0
Recycler	.	.	.	ï¿½
MI 8 GeV	12.7	13.9	.	5.3
MI 150 GeV	12.2	13.3	.	4.9
Proton Injection	16.7	14.2	3.3	.
Pbar Injection Porch	16.8	15.3	3.2	.

# 138 Tev p bunch length at 150, before helix opened (ns)	# 139 Tev p bunch length before ramp (ns)	# 140 Tev p bunch length at Remove Halo (ns)	# 141 p bunch growth (hours)	# 142 pbar bunch growth (hours)	# 143 time on helix (minutes)	# 144 p lifetime on helix (hours)	# 145 pbar lifetime at 150 (hours)	# 146 p lifetime, 1st 2 hours into store (hours)	# 147 pbar lifetime, 1st 2 hours into store (hours)
2.58	2.72	1.65	-22.39	-66.46	45.12	36.95	21.67	151.46	21.49
			-24.01	-54.68	24.48	32.43	11.95	73.99	22.51

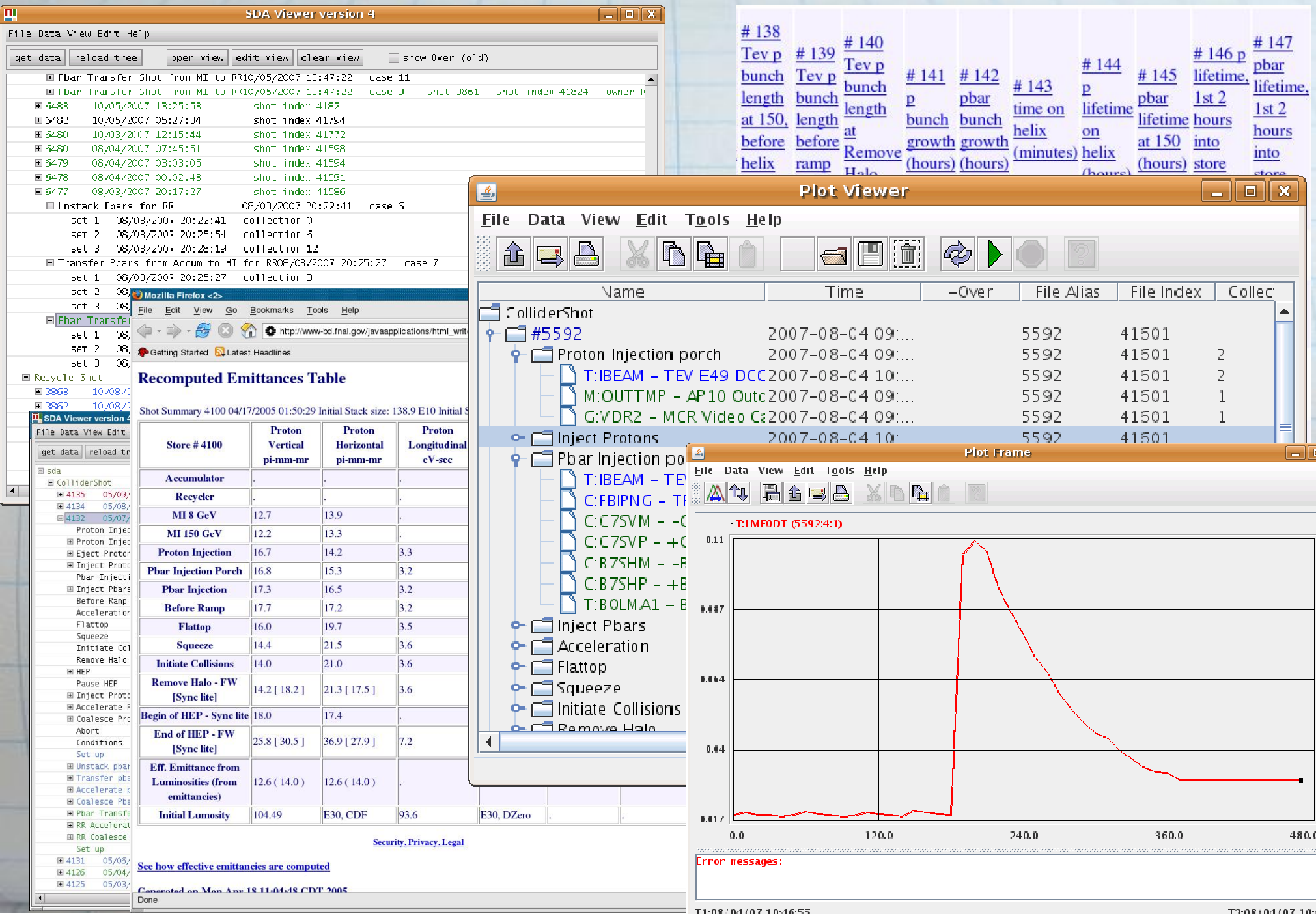




What is SDA?

- **Sequenced Data Acquisition**
- Backed up with **Hierarchical** Data Logging System.
- Based on rules and driven by events
- Terms: **Event, Device, Collection, Shot, Case, Set.**
- Numerous tools, tables, applications.
- Defines common language for different workgroups.
- Used during Fermilab Collider Run II for **fine tuning** of accelerator complex.

SDA tools and tables screenshots.



# 138 Tev p bunch length at 150, before helix	# 139 Tev p bunch length before ramp	# 140 Tev p bunch length at Remove	# 141 p bunch growth (hours)	# 142 pbar bunch growth (hours)	# 143 time on helix (minutes)	# 144 p lifetime on helix	# 145 pbar lifetime at 150 (hours)	# 146 p lifetime, 1st 2 hours into store	# 147 pbar lifetime, 1st 2 hours into

What is SDA?

SDA was vital for fine tuning
of Fermilab Accelerator complex
during Collider Run II.

How Fermilab SDA is organized?

There are several types of Shots. Each has a rule for starting a shot (an event) and a rule for stopping a shot (another event).

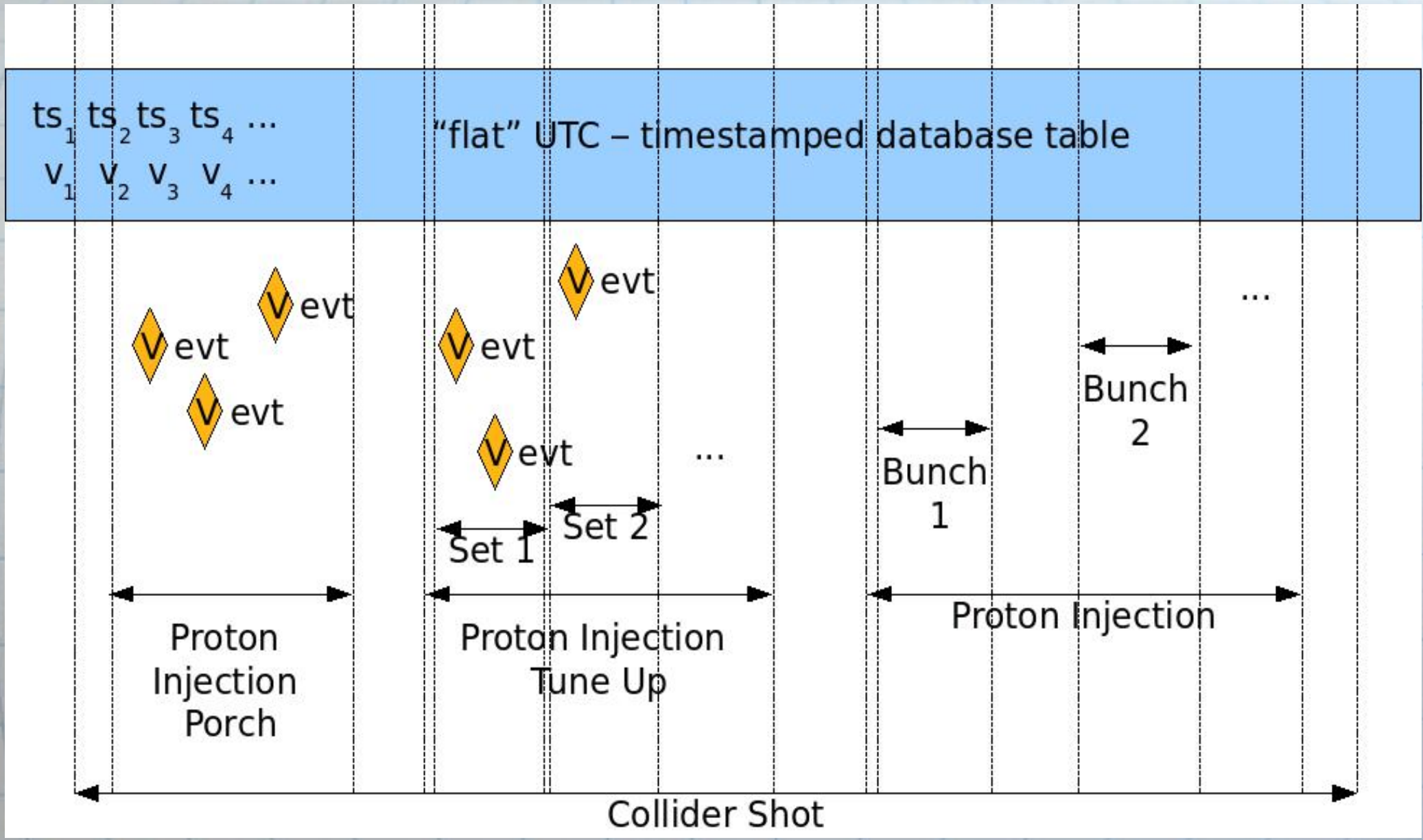
Shot has collections. Each type of collection has rules with starting and stopping events too.

Inside collection there are event-based rules for devices.

Type of collection defines a Case. Different devices are collected during "Inject Pbars" and "Remove Halo" cases.

Flat Datalogger is considered as database table with fields: device_name, timestamp, device_value.

Example of Time Intervals / Collections.



SDA on Collections.

ColliderShot # 5592

- Proton Injection Porch
  - Collection #1
- Proton Injection Tune Up
  - Collection #2 - Set 1
- ...
- ...
- Inject Pbars
  - Collection # 120 - Set 1
  - Collection # 121 - Set 2
  - Collection # 122 - Set 3
  - ...
- Before Ramp

Recycler Shot # 3855

- Setup
- Pbar Transfer Shot From RR to MI
  - Collection # 1 - Set 1
  - Collection # 4 - Set 2
  - ...
- Accelerate Pbars In MI
  - Collection # 2 - Set 1
  - ...
- Coalesce Pbars in the MI
  - Collection # 3 - Set 1
  - ...

Why redesign ?

LAFS (LHC At Fermilab Software) group was formed in Fermilab in Autumn 2006.

LAFS Goal - share experience & software with CERN and learn from new CERN control system.

SDA was one of the initial project.

"Proof of design" SDA version based on **XML DB** was implemented.

Our collaborators did not like it :

- XML DB is not common (boosts support cost).

- Huge initial time investment (device rules).

- No integration with time - based datalogger.

Initial time investment.

To define Fermilab-like SDA one needs to define shot start/stop rules, collection rules and device reading rules.

Some collections have up to 350 devices reading rules.

It may be unclear which devices to include.

The set of collection types is rather clear from the beginning.

Collections → Time Intervals.

SDA Time Intervals (TI) provides a solution of these problems and enriches Fermilab SDA with Temporal Logic.

The idea is to get rid of individual device-related rules, but leave all the Collection-related rules. Collections become "empty", so they are renamed to Time Intervals.

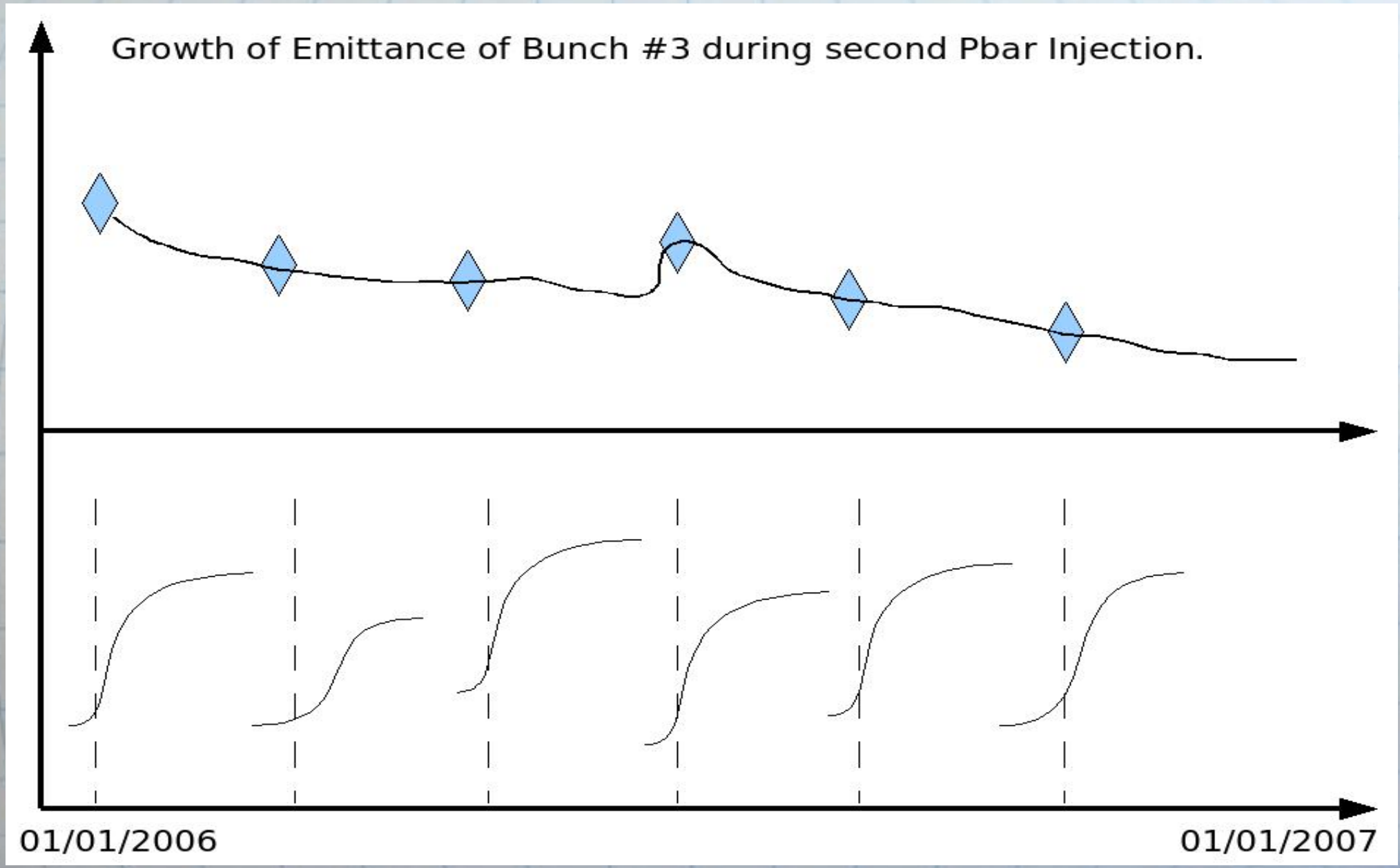
Time Intervals are stored in a relational database. The TI table can be used in SQL queries to "flat" time-based datalogger table, providing "filtering" and "tagging".

Implementation - SQL Tables.

```
CREATE TABLE ti(
    owner           INT not null,
    shot            INT not null,
    theCase         INT not null,
    theSet          INT not null,
    file_idx        INT not null,
    coll_idx        INT not null,
    success         TINYINT DEFAULT 1,
    tStart          Timestamp not null,
    tStop           Timestamp not null
)
create unique index ti1 on ti(  owner, file_idx, coll_idx )
create index ti2      on ti( owner, shot, theCase, theSet )
create index ti_tstart on ti(  tStart )
create index ti_tstop  on ti(  tStop )
```

Implementation - Filtering

Read values of Device during Pbar Injection #2

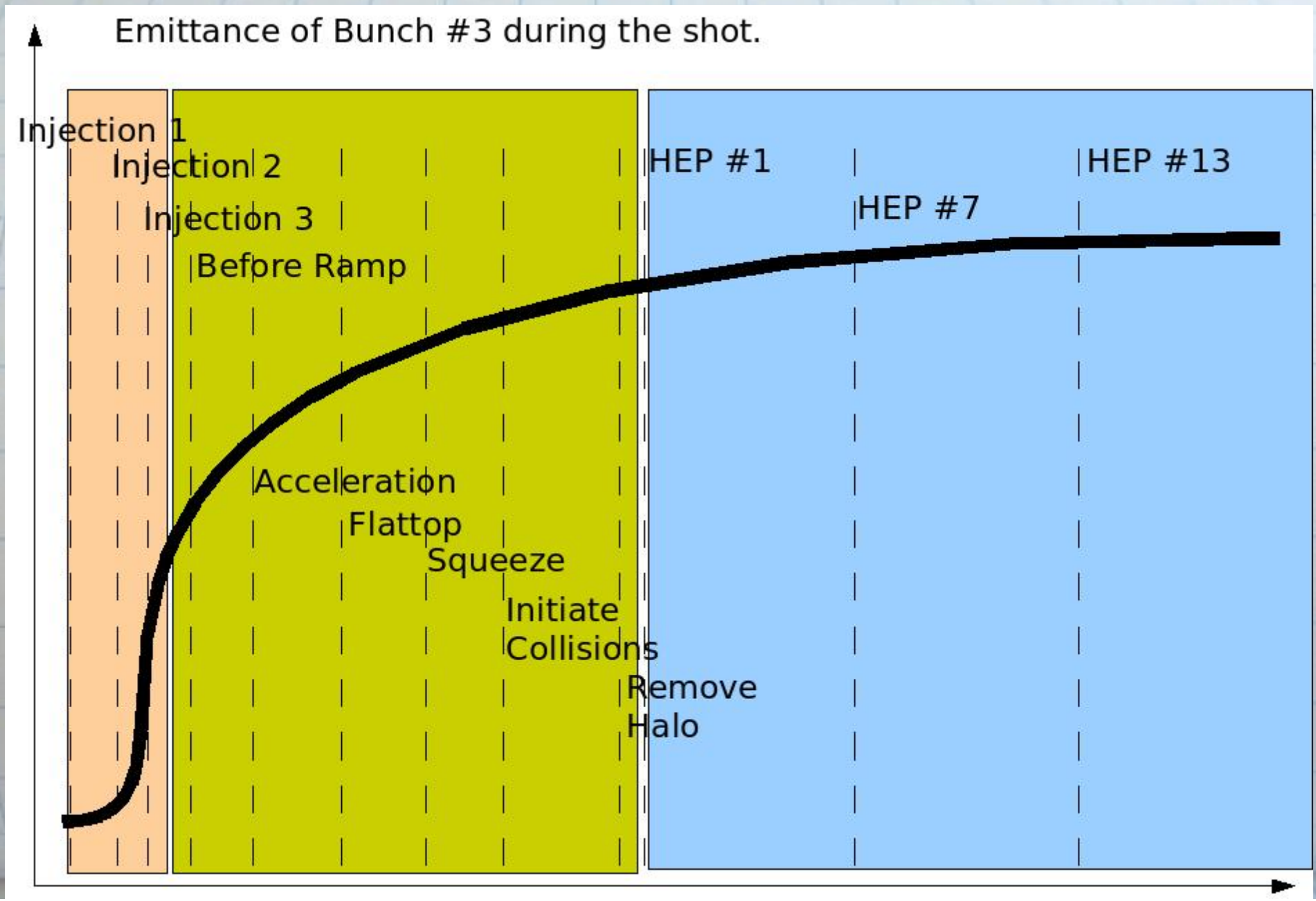


Implementation - Filtering

```
SELECT A.ts, A.value
   FROM flat_dl A,  ti B
   WHERE
      A.ts >= '01/01/2006' AND A.ts <= '01/01/2007'
AND
      A.device    = "Device"        AND
      B.owner     = ColliderShot    AND
      B.theCase   = InjectPbars     AND
      B.theSet    = 2               AND
      B.success   = 1               AND
      A.ts >= B.tStart AND A.ts <= B.tStop
   ORDER BY
      A.ts
```

Implementation - Data Tagging

How reading of Device changed throughout shot?



Implementation ï Data Tagging

```
SELECT A.ts, A.value, B.theCase, B.theSet
    FROM flat_dl A,  ti B
    WHERE
        A.device     = "Device"          AND
        B.owner      = ColliderShot      AND
        B.shot       = 5592
        B.success    = 1                      AND
        A.ts >= B.tStart AND A.ts <= B.tStop
    ORDER BY
        A.ts
```

Implementation - Temporal Logic

How much time was spent between shots throughout the year (average)? And between HEP (Collisions mode)?

How many transfers from Accumulator to Recycler was done during ColliderShot #5592?

How much time was spent in shot setup is comparing to total HEP time?

List all the time intervals of Pbar Injection? And Proton Injection? And throughout last 3 year? Does it grow?

Implementation - Temporal Logic

```
public class SdaTimeInterval{
    private long start, stop;
    private List <SdaTimeInterval> children;
    private SdaTimeInterval parent;

    private int[]  logicCoords;     // owner/shot/case/set
    private int[] uniqueCoords;   //  unique keys
    private String[]     names;     // owner and case names
    private boolean valid = true;

    public boolean includes( SdaTimeInterval interval );
    public boolean overlaps( SdaTimeInterval interval );
    public boolean before( SdaTimeInterval interval );
    public boolean after (SdaTimeInterval interval );
    public boolean insideOf( SdaTimeInterval interval );
```

Implementation

SDA TI was implemented in Fermilab in Spring 2007.

It is actively used since.

What is not covered by TI?

Fermilab SDA allows for saving bunch of high frequency data collected at necessary time, TI cannot provide it.

Fermilab SDA collections provides all the information about a given stage - physicist can look at all the relevant devices.

Data, collected on event are always more precise then data read on time.

Thank you
for attention.