Event matching for LHCf and ATLAS data

LHCf Collaboration Meeting, Nagoya, 2023

Kosuke Kinoshita 16,Oct,2023

Table of contents

1. **Introduction**
   - motivation event matching for LHCf and ATLAS
2. **Trigger system**
   - explanation of ECR and L1ID used for event match
3. **Event match**
   - Detailed step event match
4. **Confirmation**
   - Offset bcid and time
5. **Conclusion**

Introduction

- **Motivation of joint analysis LHCf-ATLAS**

1. Process by process analysis events can be performed

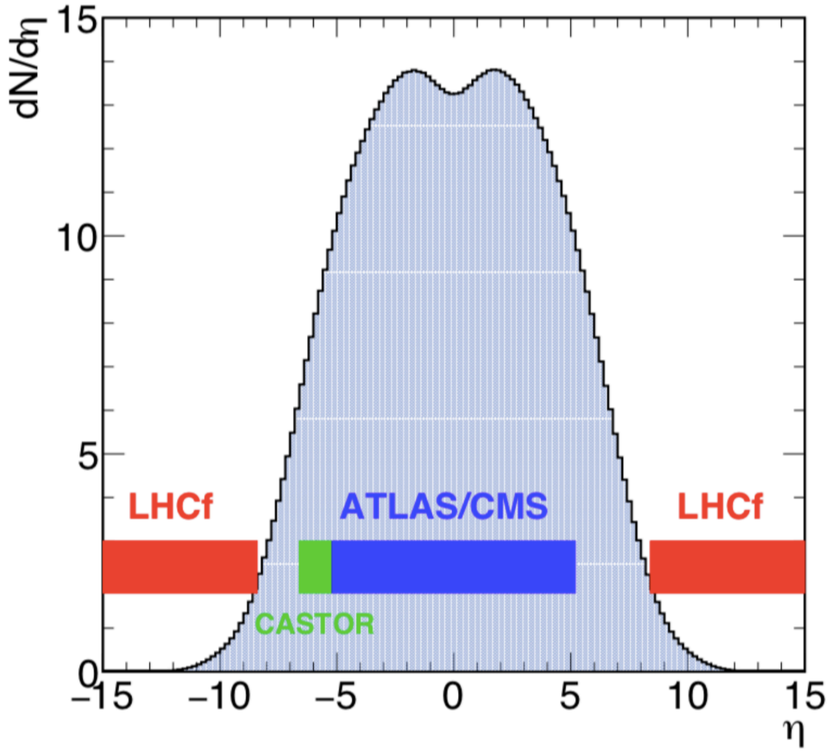
   ATLAS : wide particle detection range ($|\eta| < 5$)

   LHCf : forward area ($|\eta| > 8.4$)

   η : pseudrapidity

   ➡It is possible to determine from which process the particles detected by LHCf are from.

2. Contribute to the development of hadronic interaction model



Trigger system

○ Flow of recording event data

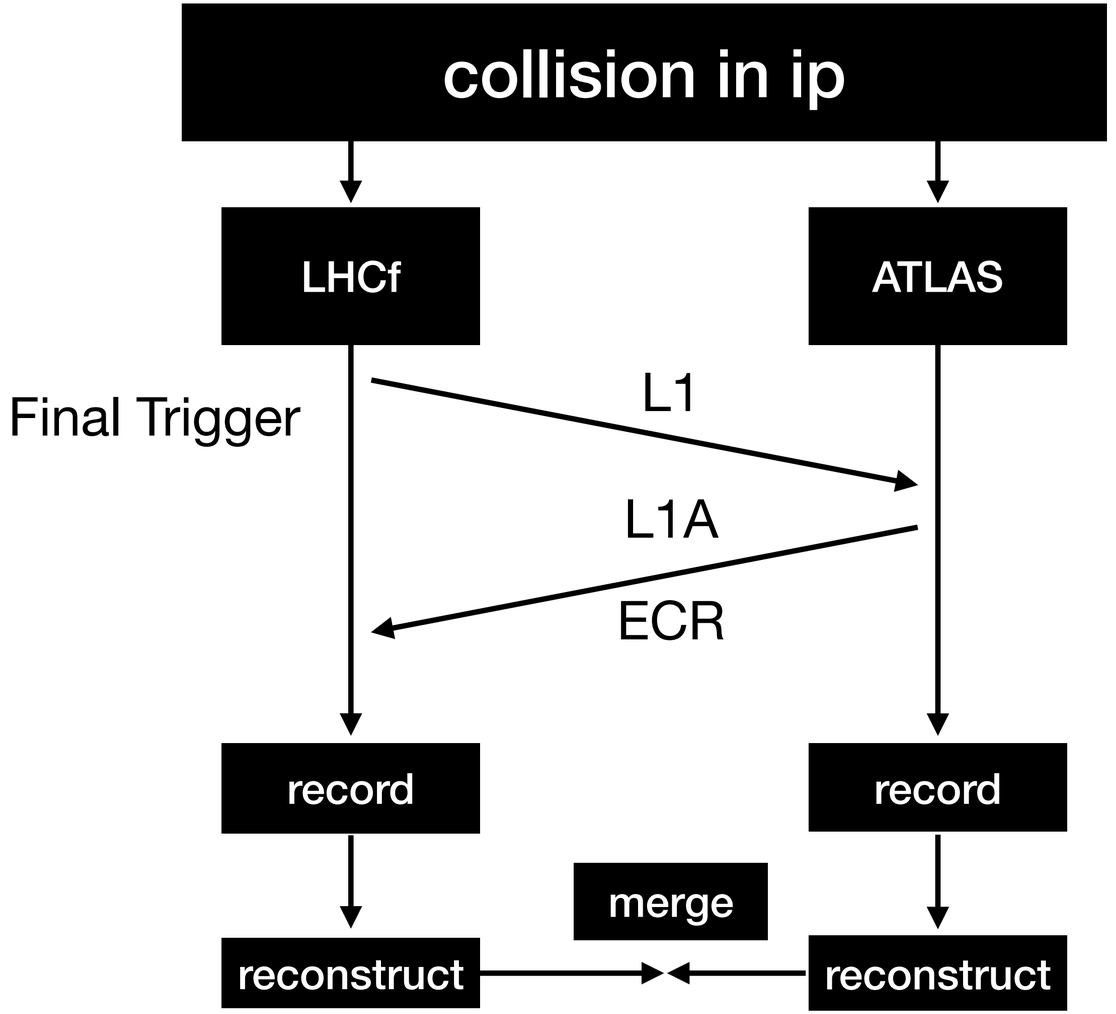
1. Send L1 to ATLAS → Record event ATLAS
2. send L1A (0 or 1) to LHCf side

ATLAS data is **not** lined up in time order

L1ID : Recording number of L1A
ECR : Reset L1ID by every 4 sec
LumiBlock(LB): data block of ATLAS

➡Using for event matching

ECR is recorded separately in LHCf and ATLAS, so there is offset.



Event matching

- **Data : Op2022, reduction data**
  - Handling data easier than rec.
  - Save as root file.

LHCf

```
Output file: /mnt/lhcfs5/data/menjo/Op2022/Arm1Rec_v0/data_red/run80300_red_arm1.root
Filter: ffff
Modification: enabled

  KEY: TTree    lhcfarm1;1      LHCf data
root [2] lhcfarm1->Show(0)
======> EVENT:0
 arm             = 1
 run             = 80300
 gnumber         = 892
 number          = 0
 time            = 1663995619
 time_usec       = 233827
 trigger         = 4
 beam            = 1
 bcid            = 3118
 quality_flag    = 1
 atlas_trigger_accept = 1
 atlas_ecr       = 4764
 atlas_l1id      = 55654
 photon_nhit     = (vector<unsigned int>*)0x3b686c0
 photon_flag     = (vector<vector<unsigned int> >*)0x46c25a0
 photon_energy   = (vector<vector<double> >*)0x2eeda00
 photon_pid      = (vector<vector<bool> >*)0x46d5e70
 photon_poscal   = (vector<vector<vector<double> > >*)0x46d4f90
 photon_pos      = (vector<vector<vector<double> > >*)0x470c5e0
 photon_l20      = (vector<double>*)0x2cc3290
 photon_l90      = (vector<double>*)0x46d6490
 neutron_flag    = (vector<unsigned int>*)0x46d4b50
 neutron_energy  = (vector<double>*)0x469c2b0
 neutron_pid     = (vector<bool>*)0x3828fb0
 neutron_poscal  = (vector<vector<double> >*)0x3ad7a60
 neutron_pos     = (vector<vector<double> >*)0x303e2e0
 neutron_l20     = (vector<double>*)0x46d3850
 neutron_l90     = (vector<double>*)0x46d3da0
 pi0_flag        = (vector<unsigned int>*)0x46d40c0
 pi0_type        = (vector<int>*)0x46c1c60
 pi0_energy      = (vector<double>*)0x3b5ad30
 pi0_mass        = (vector<double>*)0x38c4350
 pi0_momentum    = (vector<vector<double> >*)0x46c9c40
 pi0_photon_tower = (vector<vector<int> >*)0x3b243b0
 pi0_photon_energy = (vector<vector<double> >*)0x287db40
 pi0_photon_pos  = (vector<vector<vector<double> > >*)0x3b32680
 pi0_photon_r    = (vector<double>*)0x2f96540
 dE              = (vector<vector<double> >*)0x92b8350
 fc              = (vector<double>*)0x9b549d0
 zdc             = (vector<double>*)0x2dd5280
```

ATLAS

```
======> EVENT:0
runNumber         = 435229
eventNumber       = 1357290666
lumiBlock         = 1473
bcid              = 3176
avgIntPerCrossing = 0.0185244
actIntPerCrossing = 0.0213777
trigger           = 1
trigger_TBP       = 1
tbp               = 0,
                    0, 0, 0, 0, 2752551360, 2147485696, 0, 0, 79756288, 1041,
                    0, 0, 0, 0, 0
tav               = 0,
                    0, 0, 0, 0, 0, 2147483648, 0, 0, 0, 0,
                    0, 0, 0, 0, 0
passBits          = 0
extendedLevel1ID  = 3321979085
timeStamp         = 1663995061
timeStampNSOffset = 517908805
zdc_ZdcAmp        = 0,
                    0
zdc_ZdcAmpErr     = 0,
                    0
zdc_ZdcEnergy     = 0,
                    0
zdc_ZdcEnergyErr  = 0,
                    0
zdc_ZdcTime       = 0,
                    0
zdc_ZdcStatus     = 1,
                    1
zdc_ZdcTrigEff    = 0,
                    0
zdc_ZdcModuleMask = 0
zdc_ZdcLucrodTriggerSideAmp = 0,
                    0
zdc_ZdcModuleAmp = 0,
                    0, 0, 0, 0, 0,
                    0, 0
zdc_ZdcModuleTime = -100,
                    -100, -100, -100, -100, -100,
                    -100, -100
zdc_ZdcModuleFitAmp = 0,
                    0, 0, 0, 0, 0,
                    0, 0
zdc_ZdcModuleFitT0 = -100,
                    -100, -100, -100, -100, -100,
                    -100, -100
zdc_ZdcModuleStatus = 0,
                    2, 2, 2, 0, 2, 2, 2
zdc_ZdcModuleChisq = 0,
                    0, 0, 0, 0, 0,
                    0, 0
zdc_ZdcModuleCalibAmp = -1000,
                    -1000, -1000, -1000, -1000, -1000,
                    -1000, -1000
zdc_ZdcModuleCalibTime = -1000,
                    -1000, -1000, -1000, -1000, -1000,
                    -1000, -1000
zdc_ZdcModuleBkgdMaxFraction = 0,
                    0, 0, 0, 0, 0,
                    0, 0
```

Event matching

○ Detailed step event match

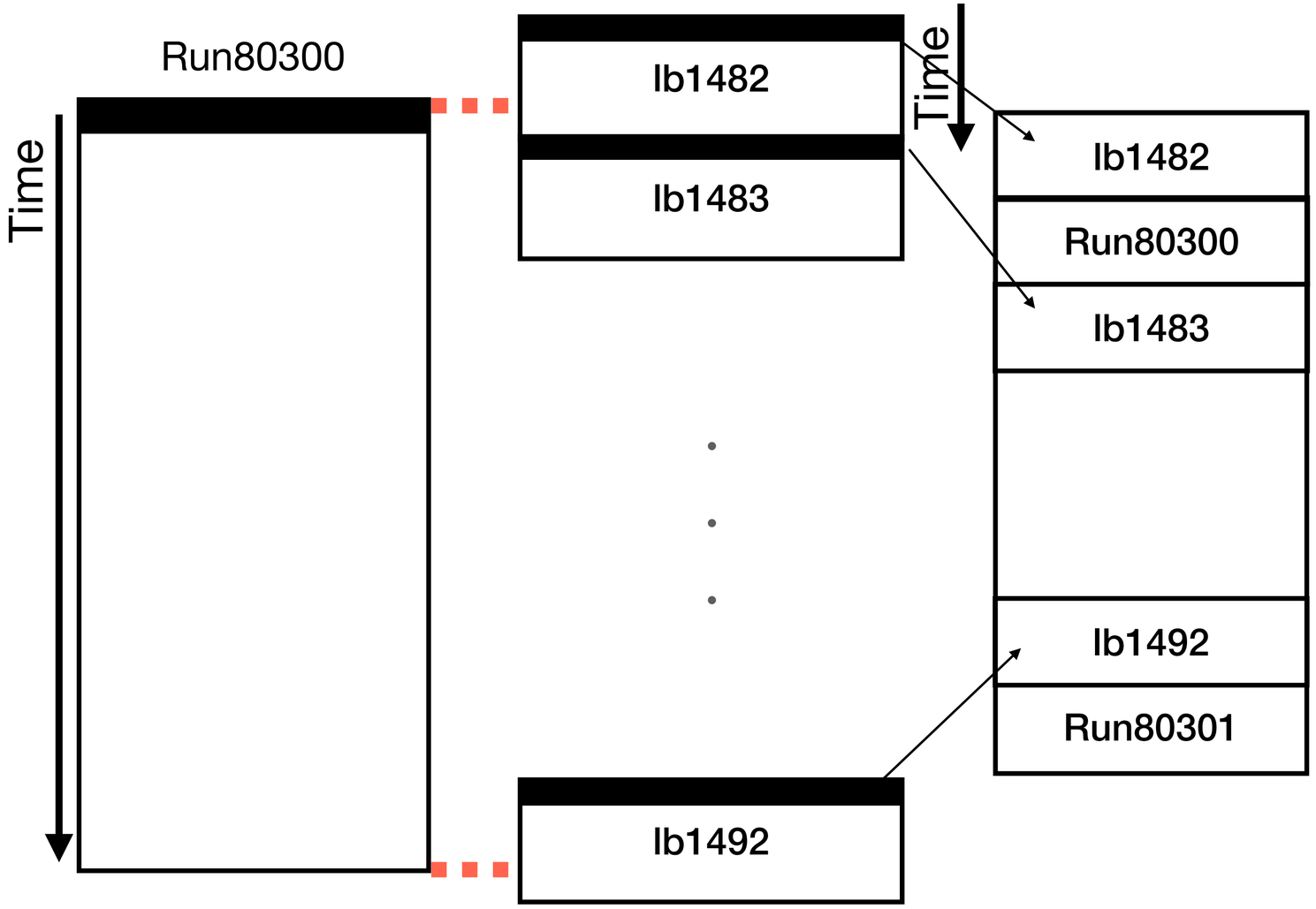
1. Make correspondence table between Run and LB (Run-LB table)
   - Previous table shows LHCf time with minute precision
   - Create a new seconds precision table
2. Calculate ECR offset and event match
   - Match using TimeStamp, L1ID for the run and corresponding LB
   - Check if the ECR offsets of the first and last matching event is equal in the time-sorted lb match.
   - ECR offset is equal in lb → L1ID, ECR
   - ECR offset is not equal in lb → L1ID, TimeStamp
3. Check the offset of bcid,time

Event matching

- **Run-LB table**

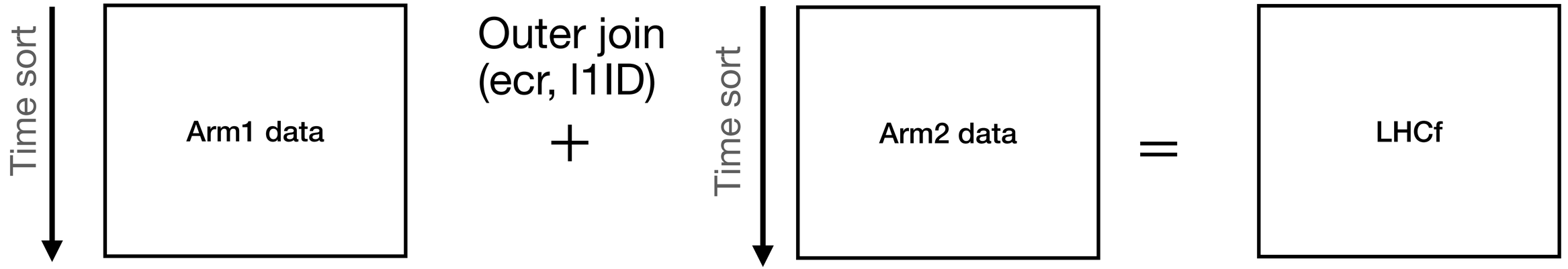
1. Get the event with the smallest value of Time in the data
2. Do this for each LB even for ATLAS data
3. Arrange 1 and 2 in order of Time

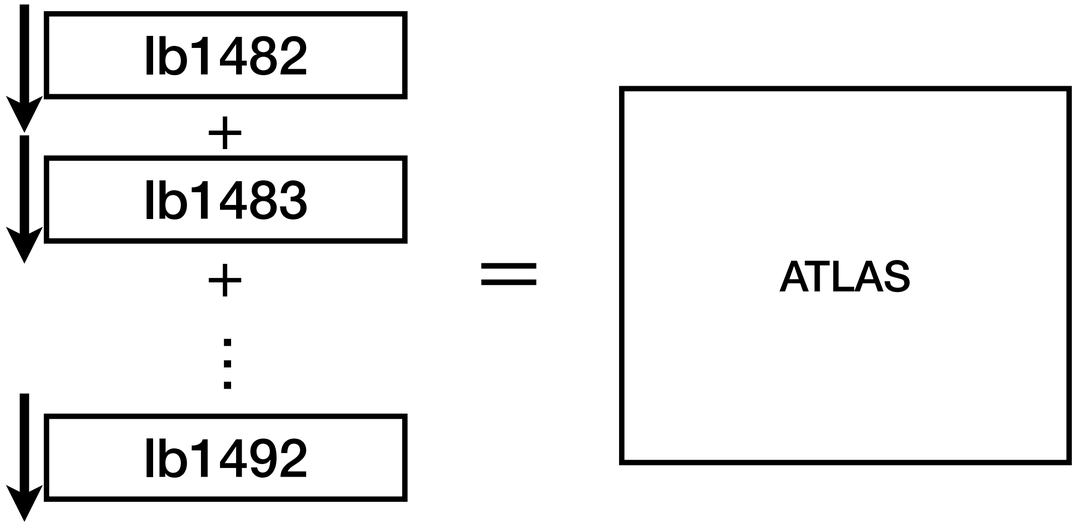
ex)Run80300 corresponds to LB1482~LB1492



Event matching

- **Merge Arm1 and Arm2**





Sort by time per lb.
All data is not combined to create ATLAS data.
➡Data size are too large
➡created for each LB corresponding to Run.

Event matching

- **ATLAS data**

```
[kinoshita.kosuke@lhcfx4 ~]$ cd /mnt/lhcfnas3/data/JointAnalysis/Op2022/
[kinoshita.kosuke@lhcfx4 Op2022]$ ls
Run3LBFiles_1
Run3LBFiles_2
user.steinber.data22_13p6TeV.00435229.physics_MinBias.merge.AOD.r14470_p5587.1_ANALYSIS
user.steinber.data22_13p6TeV.00435229.physics_MinBias.merge.AOD.r14470_p5587.2_ANALYSIS
```

```
user.steinber.33458234.ANALYSIS._000001.root
user.steinber.33458234.ANALYSIS._000002.root
user.steinber.33458234.ANALYSIS._000003.root
user.steinber.33458234.ANALYSIS._000004.root
user.steinber.33458234.ANALYSIS._000005.root
user.steinber.33458234.ANALYSIS._000006.root
user.steinber.33458234.ANALYSIS._000007.root
```

lb(lb number)_(root file number).txt

```
[kinoshita.kosuke@lhcfx4 Run3LBFiles_1]$ ls lb1482_0
lb1482_014.txt  lb1482_026.txt  lb1482_030.txt
lb1482_024.txt  lb1482_027.txt  lb1482_032.txt
```

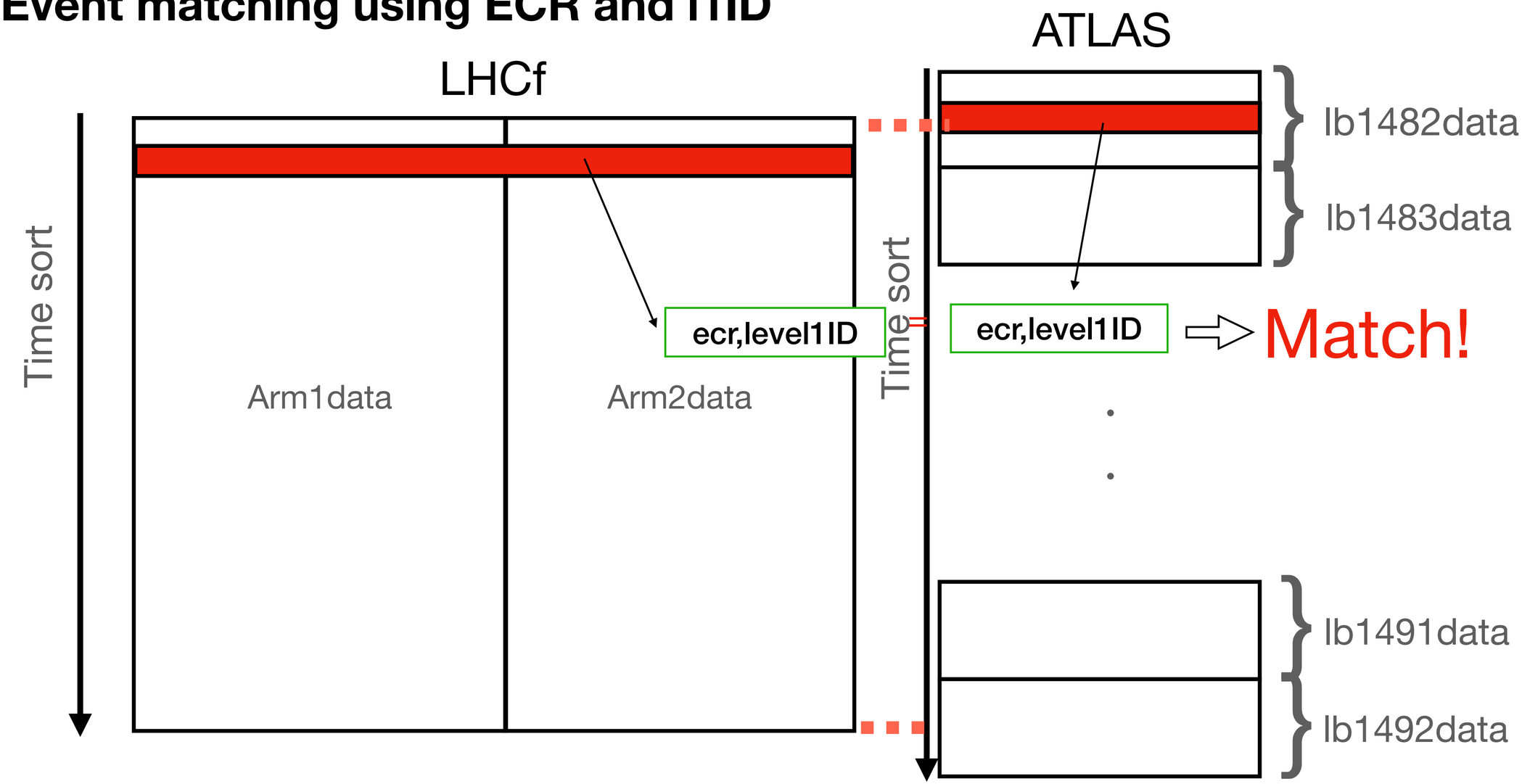
```
14 348220
14 348221
14 348222
14 348223
14 348224
14 348225
14 348226
14 348227
14 348228
14 348229
14 348230
14 348231
14 348232
14 348233
```

← (root file number) (entry number)

ex) get lb1482data
1.Record entry number written in lb1482_014
2.Get data for entry number 1 from user.steinber.33458234.ANALYSIS._000014.root
3.Repeat for other root number 24,26,27,30,32

Event matching

Event matching using ECR and l1ID



Data set

- data : Op2022
  LHCf : Run 80266~80364
  ATLAS : RunLBFiles_1

```
[kinoshita.kosuke@lhcfx4 data_red]$ pwd
/mnt/lhcfs5/data/menjo/Op2022/Arm2Rec_v0/data_red
[kinoshita.kosuke@lhcfx4 data_red]$ ls -1U | wc -l
85
```

```
[[kinoshita.kosuke@lhcfx4 data_red]$ pwd
/mnt/lhcfs5/data/menjo/Op2022/Arm1Rec_v0/data_red
[[kinoshita.kosuke@lhcfx4 data_red]$ ls -1U | wc -l
367
```

Events with no data in ATLAS and data in LHCf : 10,439,204
→Problem with the event reconstruction process.
Events with no data in LHCf and data in ATLAS : 0 (a few)
→Possible LHCf event missing at the time of Run switched

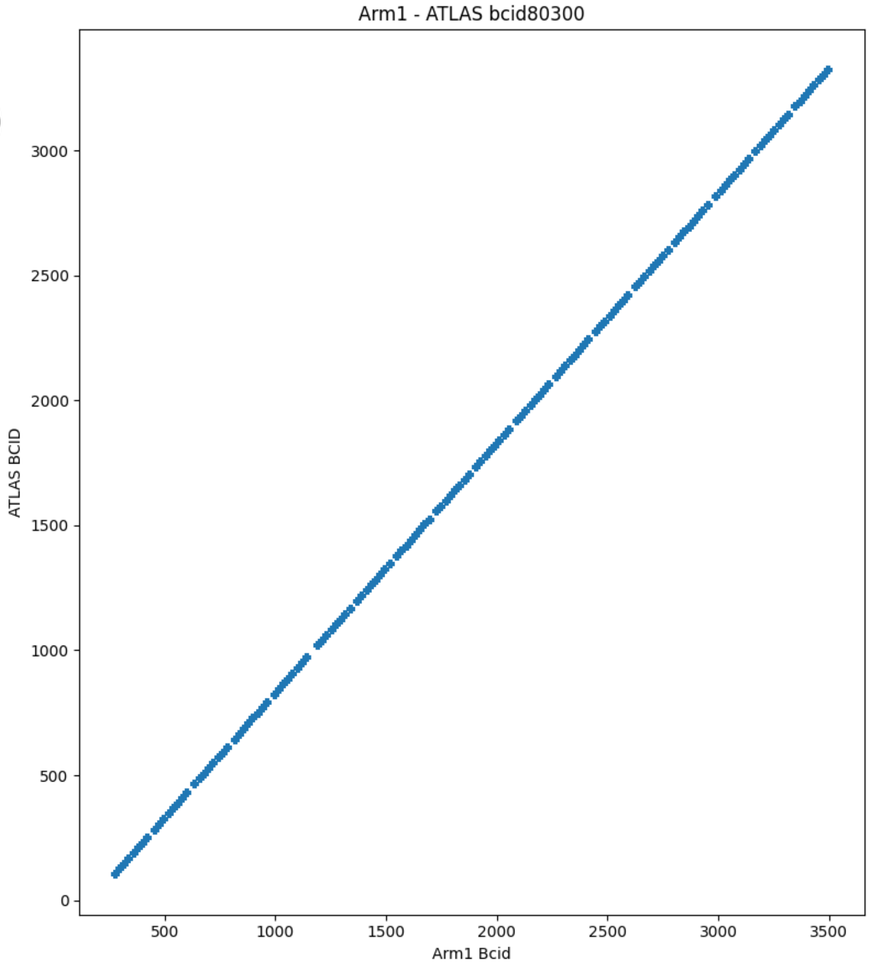
Check event match for LHCf-ATLAS bcid offset and Time offset.

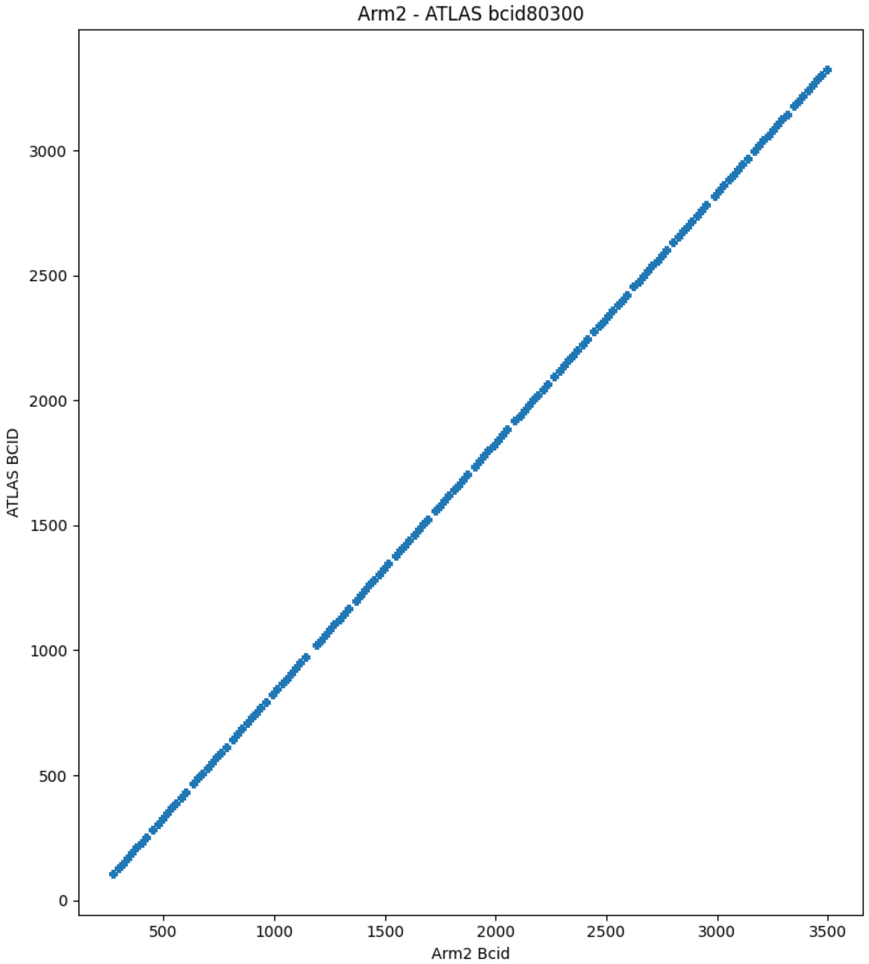
Confirmation

- **bcid scatter plot**

  offset : 174(all events)

  vertical : ATLAS
  horizontal : LHCf
  left : Arm1
  right : Arm2

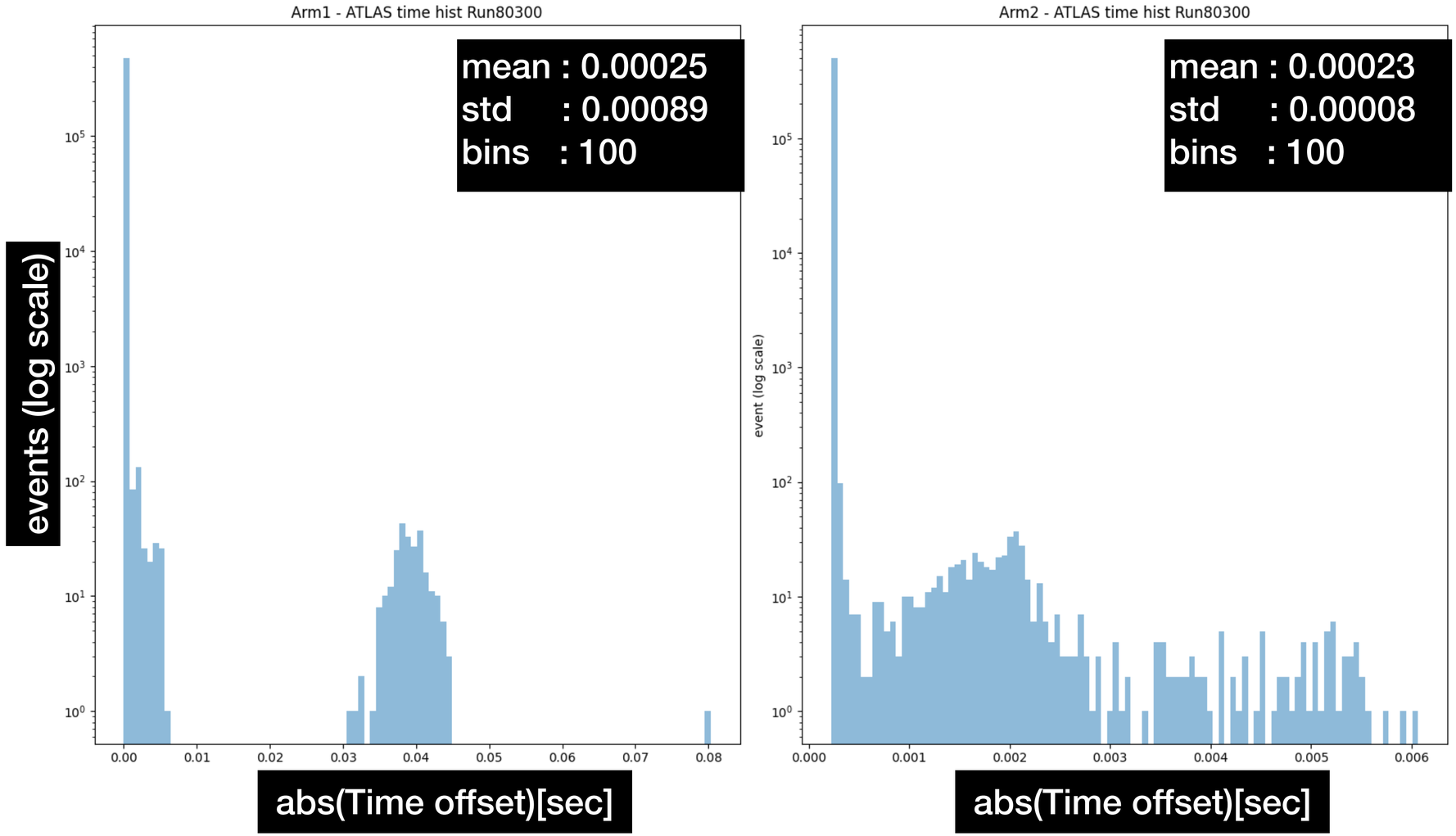




Confirmation

- **time offset hist**

  vertical : event(log)
  horizontal : Time
  left : Arm1
  right : Arm2



Conclusion

- **Summary of event matching.**
  missing events(LHCf = 0events ,ATLAS = 10,439,204 events)
  Bcid offset is constant.
  The distribution of TimeStamps for Arm1 is 10 times wider than for Arm2.

- **Policy**
  Check for bugs in the code.
  Match and check with ver2 as soon as ver2 is ready.
  Check to see if the events coincide in terms of physical phenomena
  Perform physical analysis of events

Back Up

Back Up

- The number of events in ATLAS varies greatly from one file version to another.

```
[kinoshita.kosuke@lhcfx4 ~]$ cd /mnt/lhcfnas3/data/JointAnalysis/Op2022/
[kinoshita.kosuke@lhcfx4 Op2022]$ ls
Run3LBFiles_1
Run3LBFiles_2
user.steinber.data22_13p6TeV.00435229.physics_MinBias.merge.AOD.r14470_p5587.1_ANALYSIS
user.steinber.data22_13p6TeV.00435229.physics_MinBias.merge.AOD.r14470_p5587.2_ANALYSIS
```

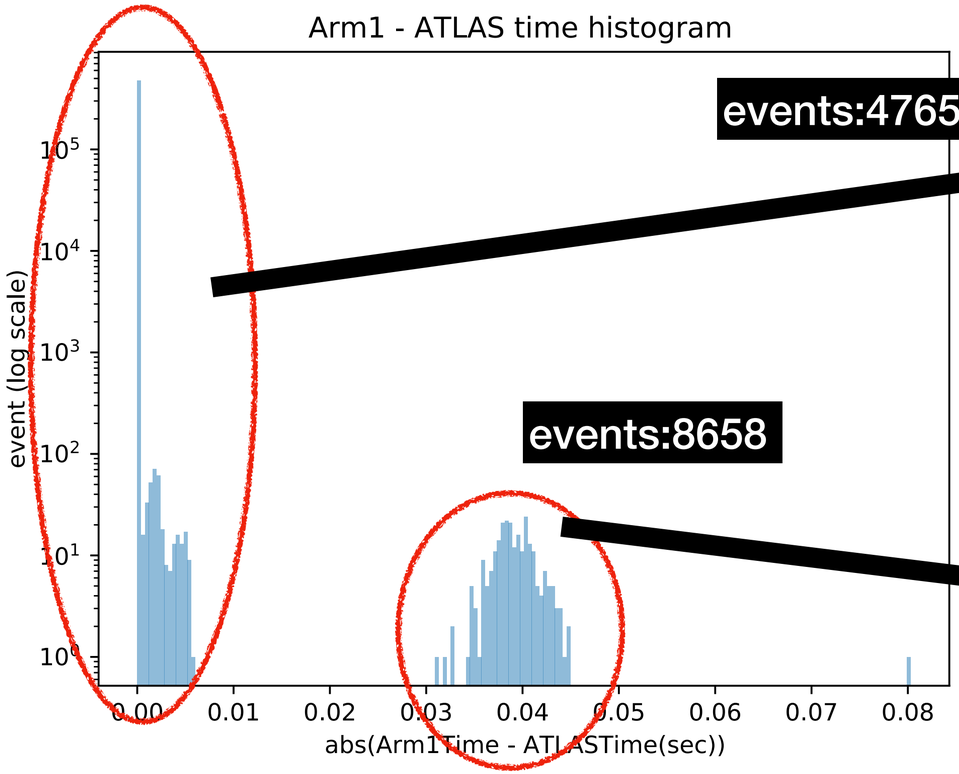
```
[menjo@lhcfx1 Run3LBFiles]$ wc  lb1486*
 26614  53228 266140 lb1486_014.txt
 11555  23110 127105 lb1486_023.txt
 22794  45588 227940 lb1486_026.txt
  4355   8710  47905 lb1486_027.txt
 11317  22634 113170 lb1486_029.txt
  4522   9044  45220 lb1486_030.txt
  5630  11260  61930 lb1486_032.txt
  8546  17092  85460 lb1486_034.txt
 95333 190666 974870 total
[menjo@lhcfx1 Run3LBFiles]$
```

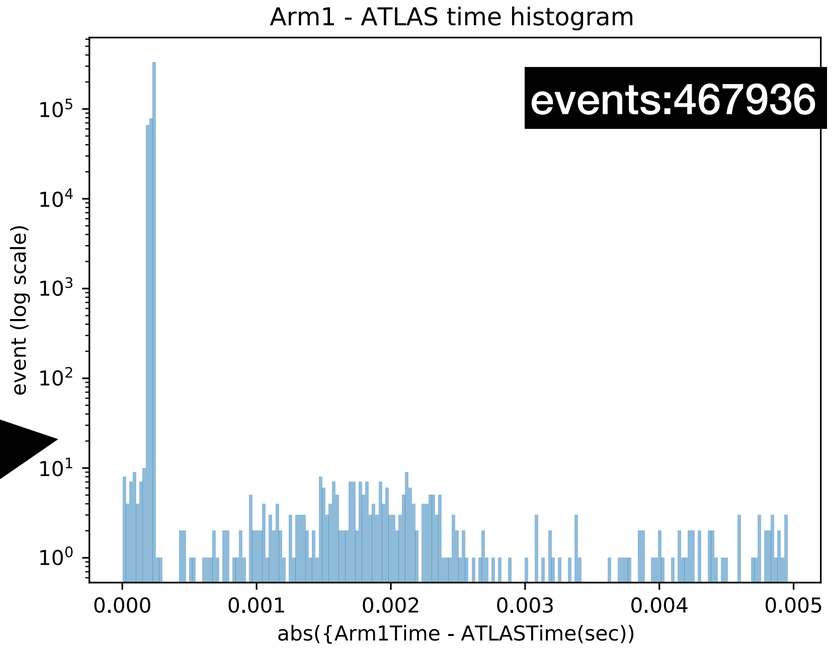
version1
events:95333

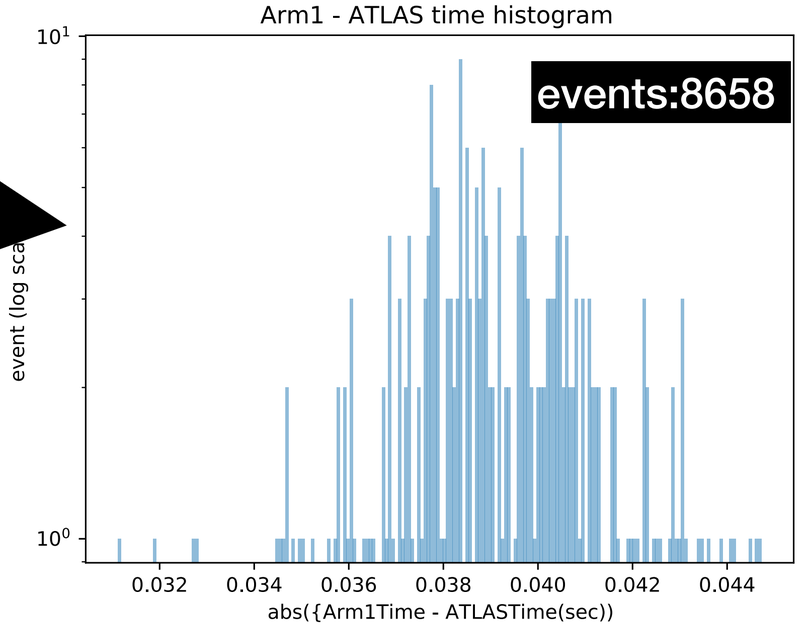
```
-bash-4.2$ wc  lb1486*
 48411   96822  580932 lb1486_121.txt
 21017   42034  252204 lb1486_130.txt
 41367   82734  496404 lb1486_133.txt
  8012   16024   96144 lb1486_134.txt
 20613   41226  237050 lb1486_136.txt
  8199   16398   90189 lb1486_137.txt
 20556   41112  236333 lb1486_139.txt
 15568   31136  186816 lb1486_141.txt
183743  367486 2176072 total
-bash-4.2$
```

version2
events:95333

Confirmation

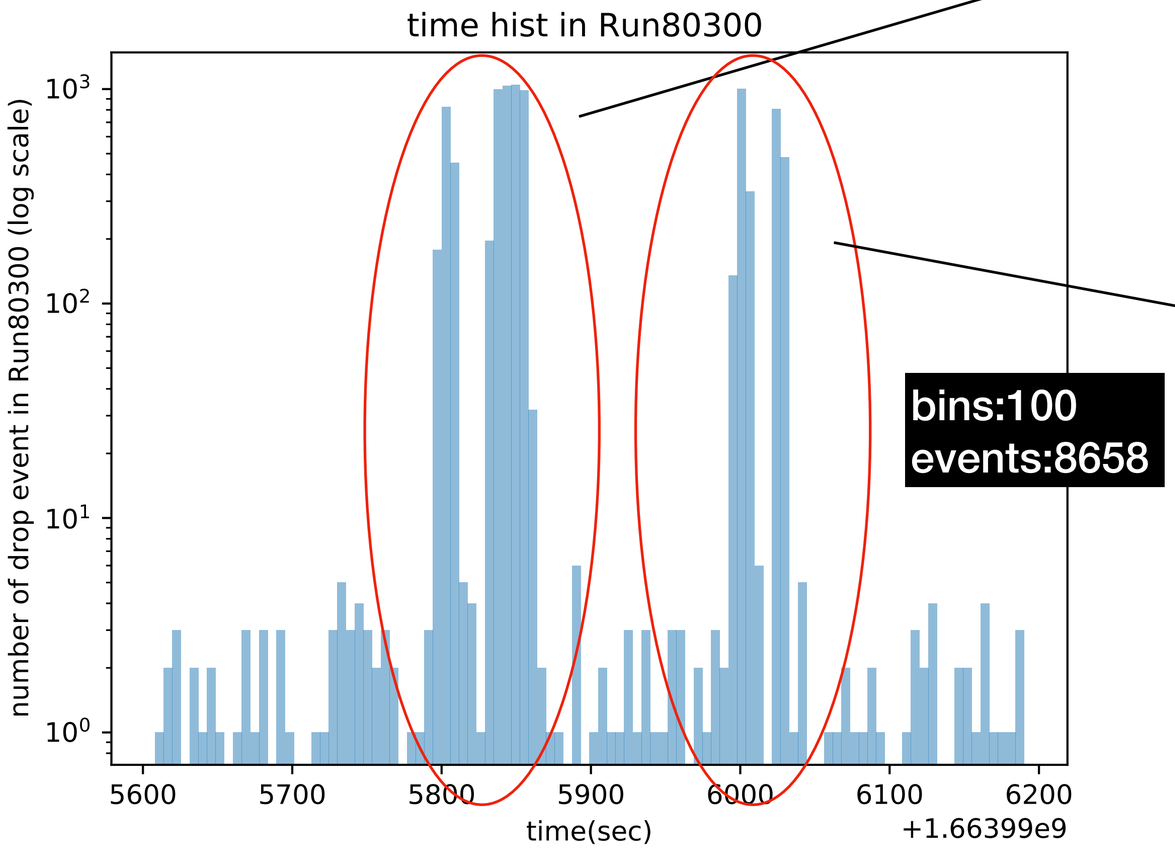


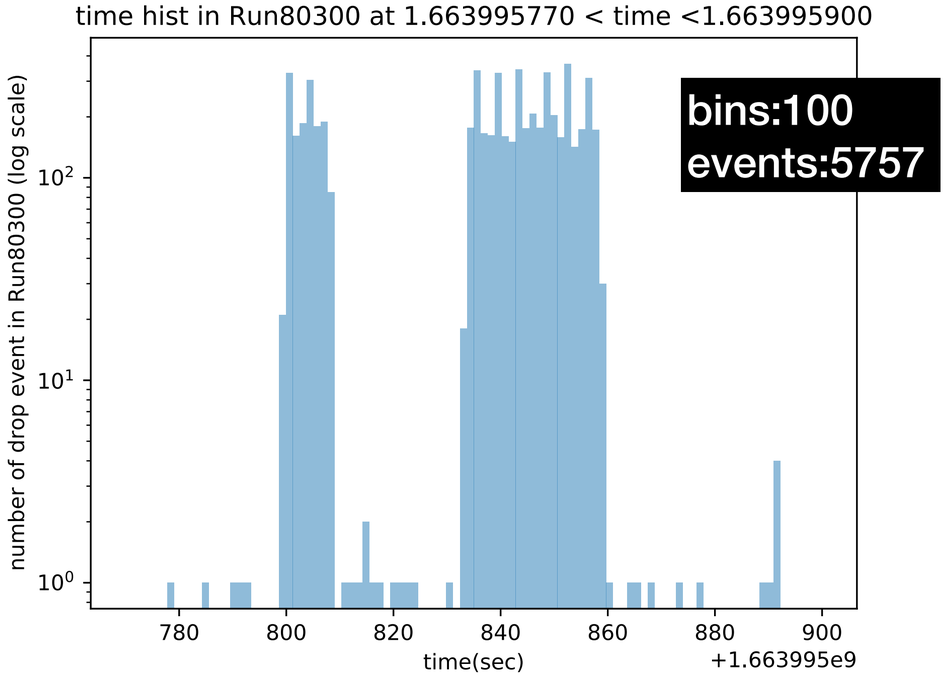


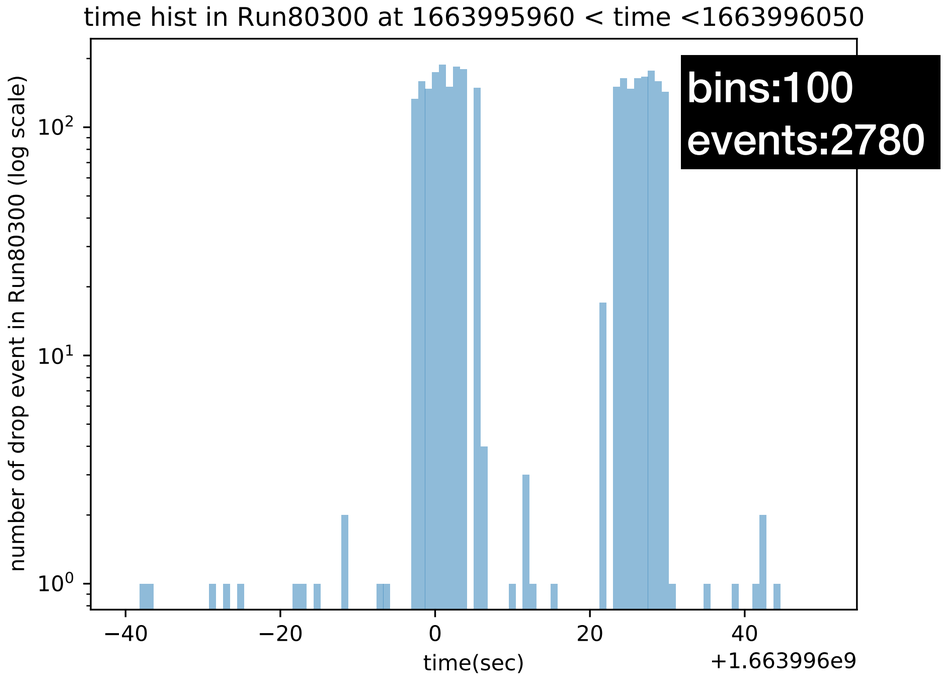


Back Up

number of all event :975285
number of los event:8658



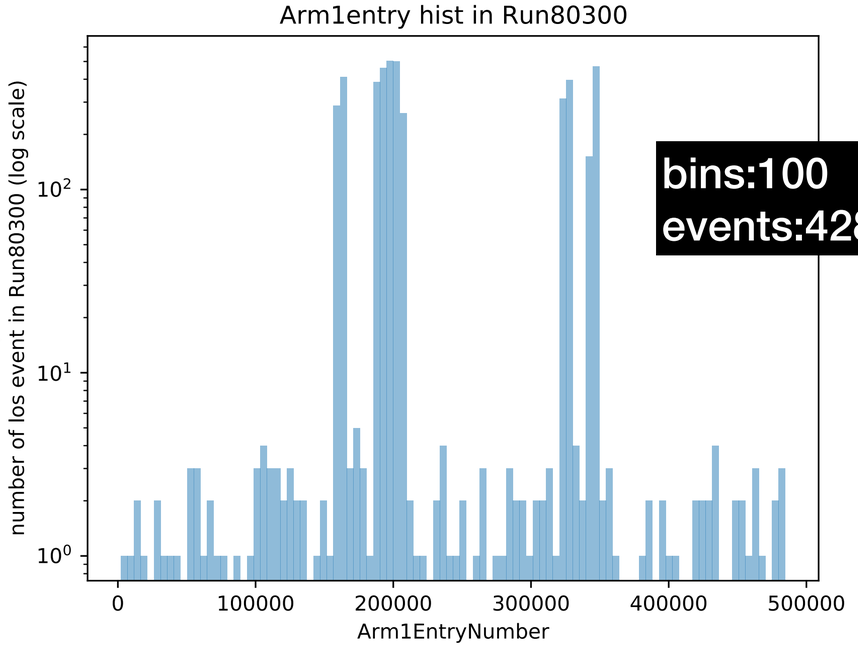




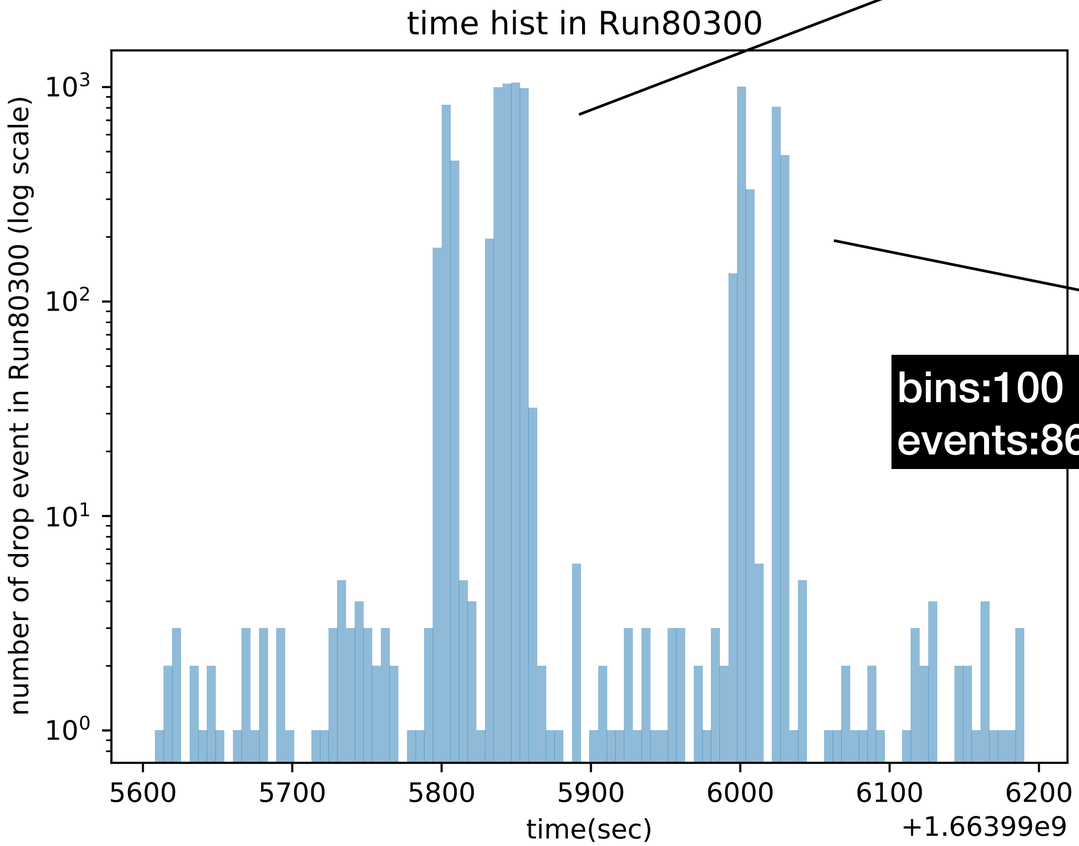
Back Up

number of all event :975285
number of los event:8658

Arm1

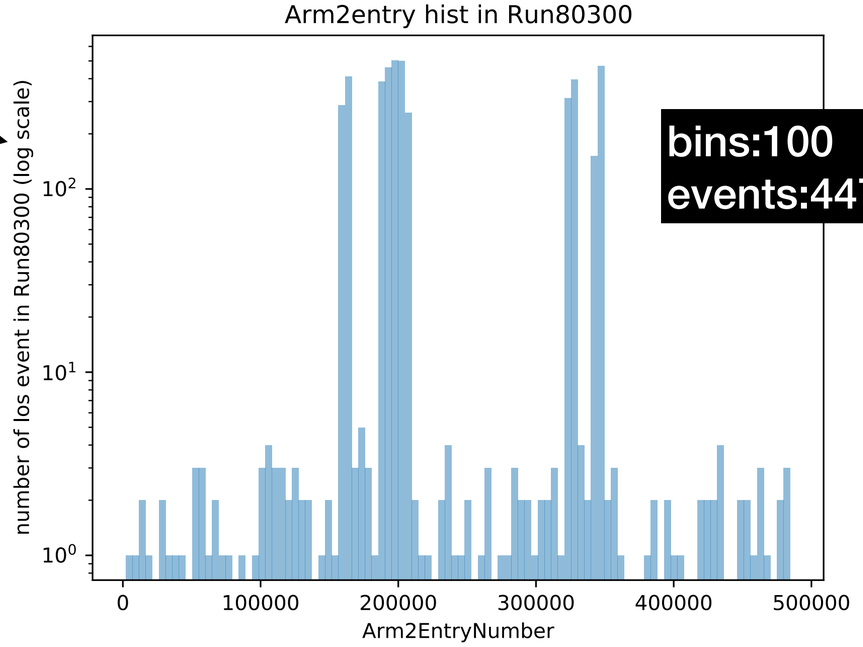


bins:100
events:4286



bins:100
events:8658

Arm2



bins:100
events:4470

Back Up

$$p + p \rightarrow e^{-} + X$$

previous : Unknown

joint analysis : confirming