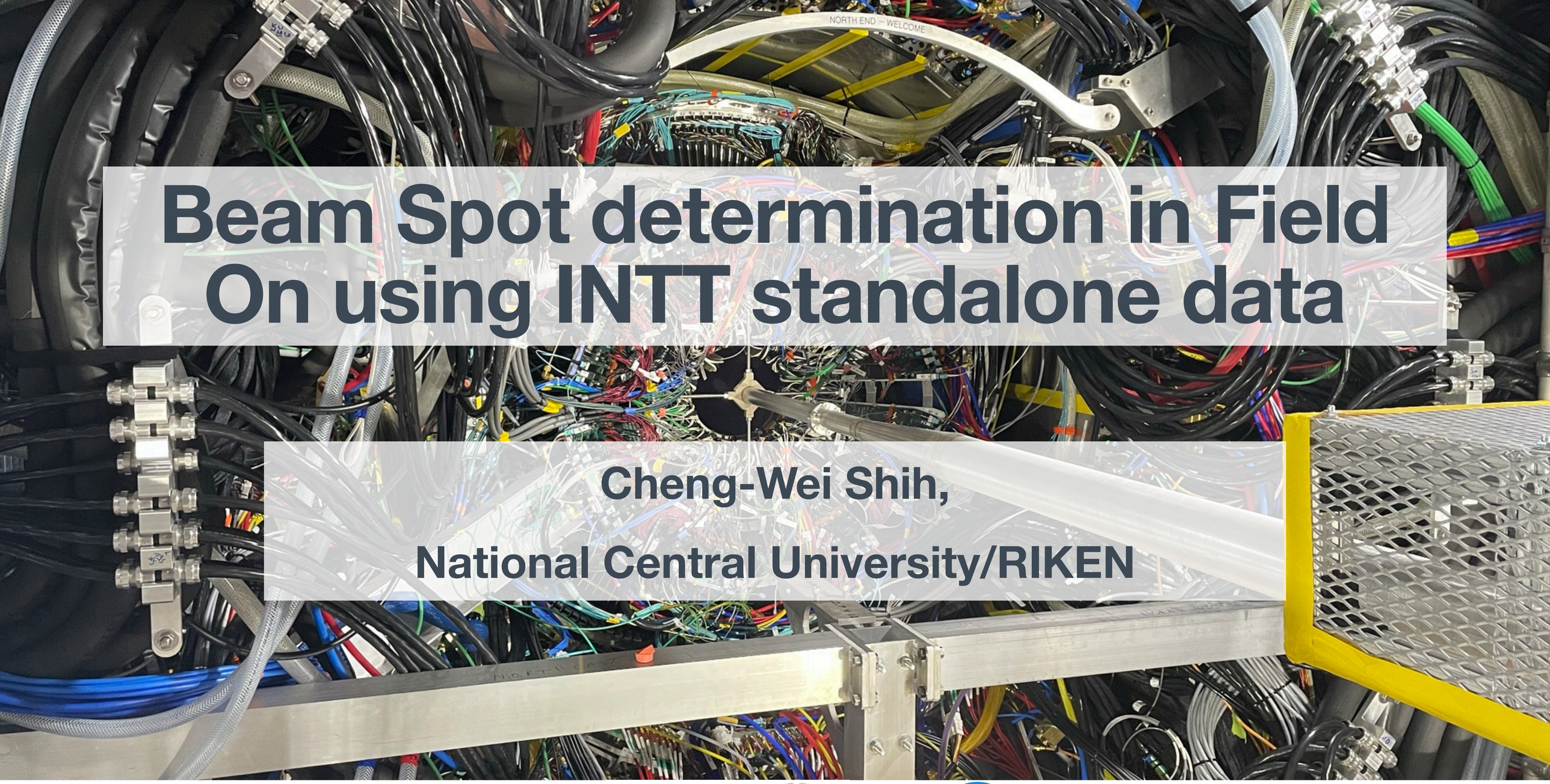


Beam Spot determination in Field On using INTT standalone data

Cheng-Wei Shih,

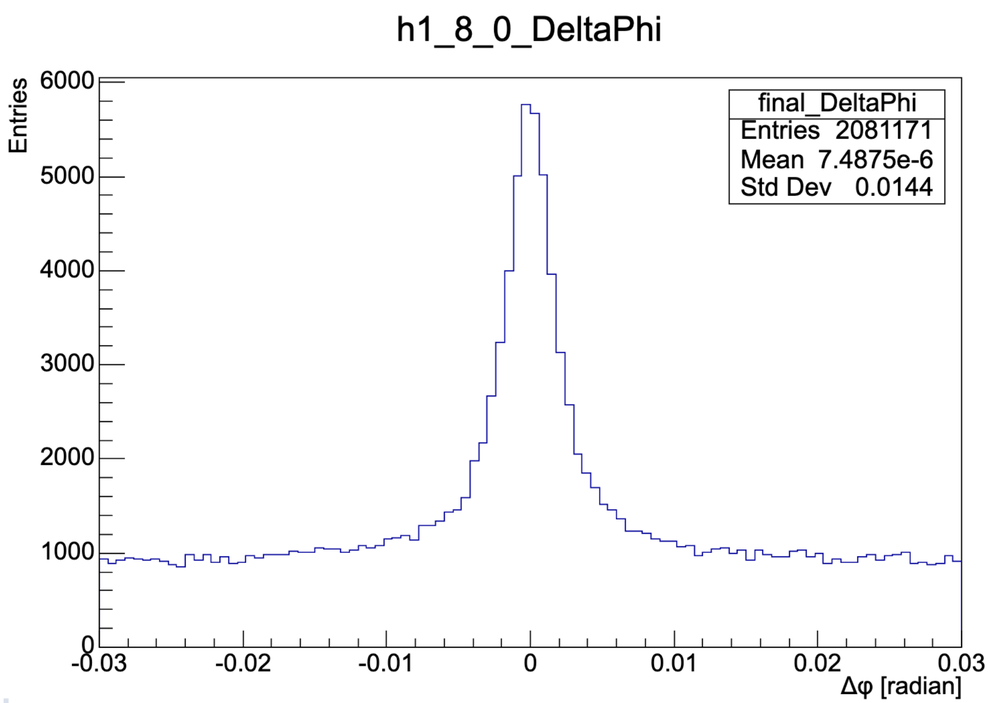
National Central University/RIKEN

Jan 26th, 2026
INTT meeting

sPHENIX INTT sPHENIX 國立中央大學 National Central University RIKEN

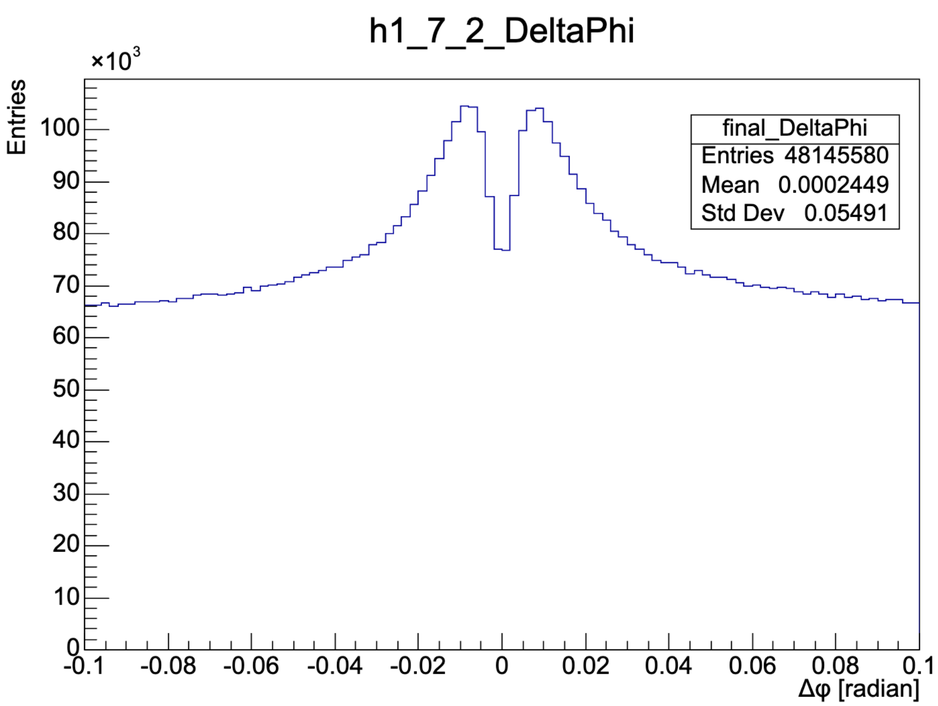
Difference between field off and on

Field Off



All particles go straightly, single prominent peak

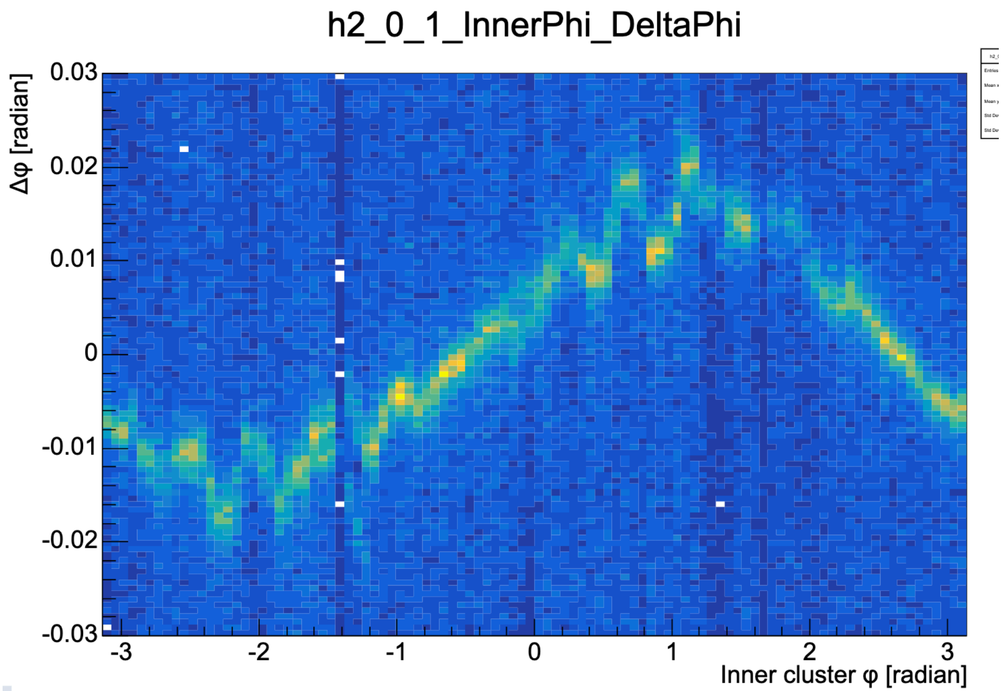
Field ON



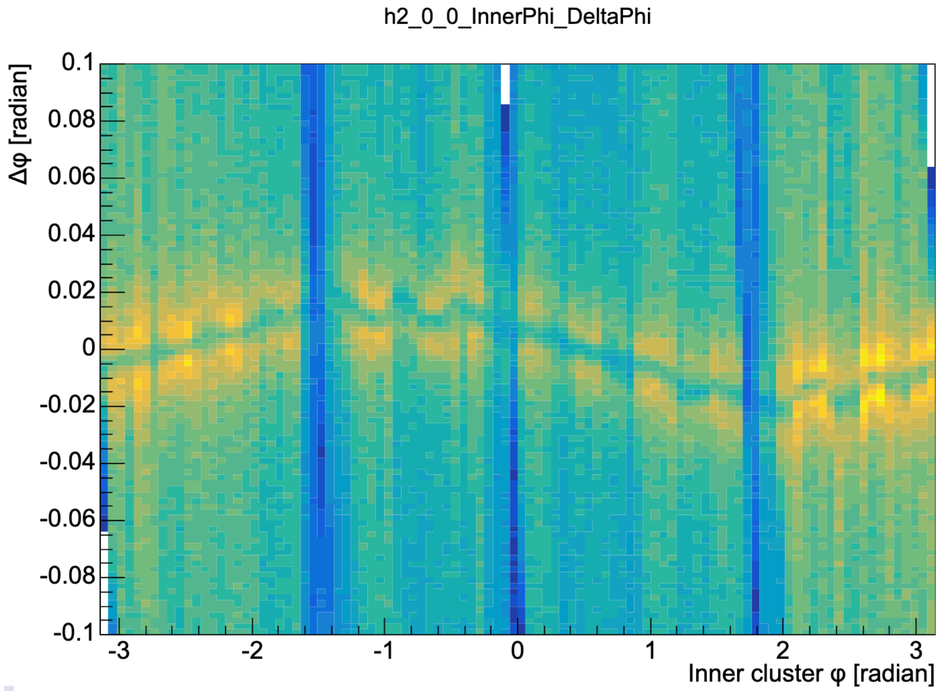
Two structures due to particles with differnet charges bent by the magnetic field

Difference between field off and on

Field Off



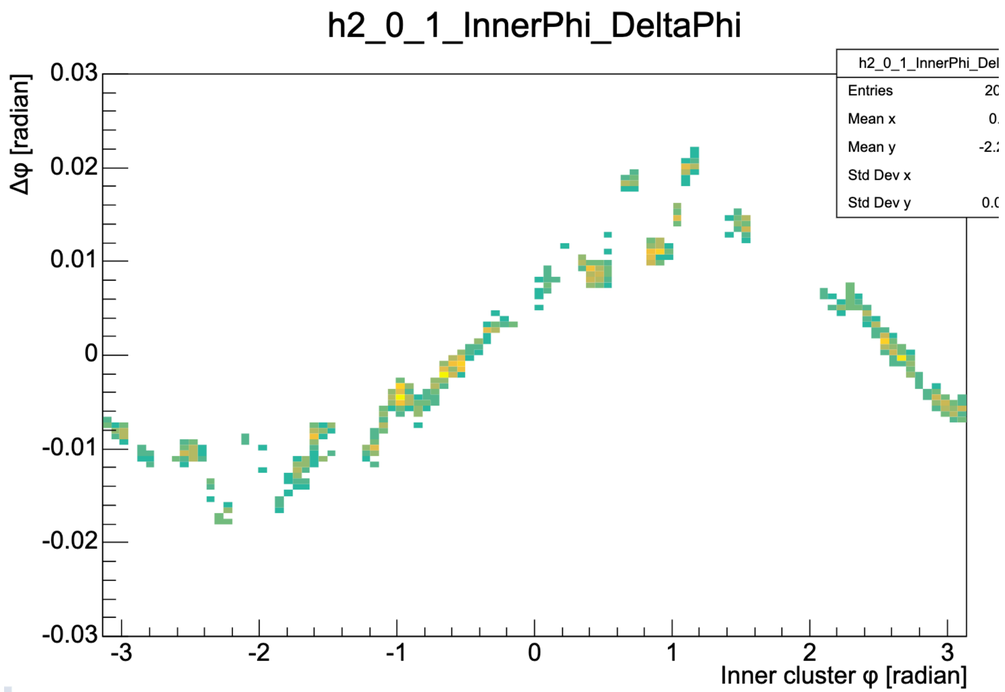
Field ON



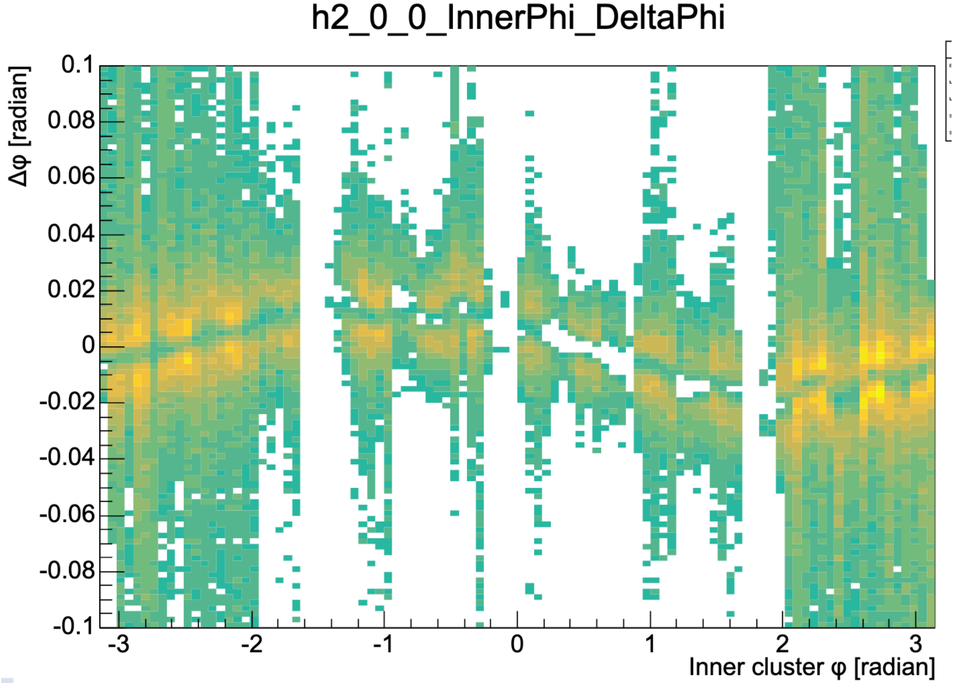
The 2D correlation is necessary as it is the input to the quadrant-method beam spot search
We just need the correlation part → have to remove the background

The original approach to remove the background

Field Off



Field ON

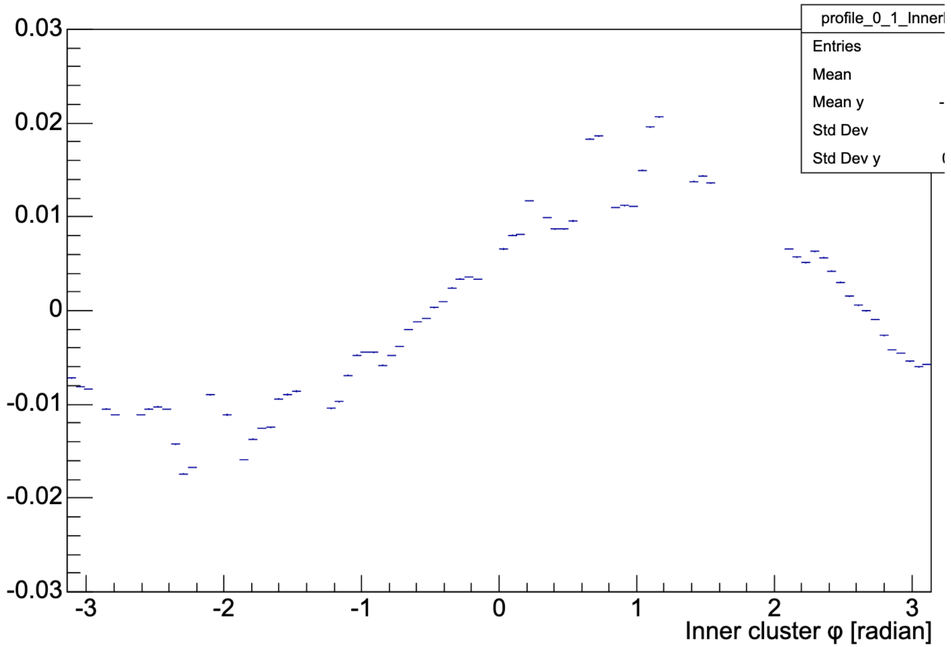


Original approach (work well in field off):

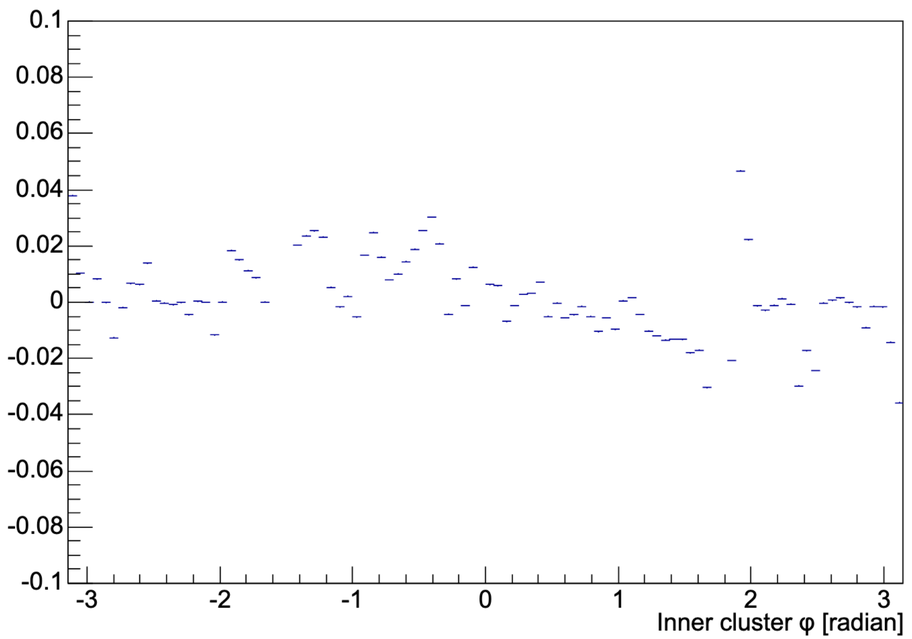
1. Systematically subtract the entries of all cells by 70% of the average of the entries of the top 7 cells
2. In each x slice, determine the average point using TProfileX
3. Fit the correlation with a horizontal line

The original approach to remove the background

Field Off



Field ON



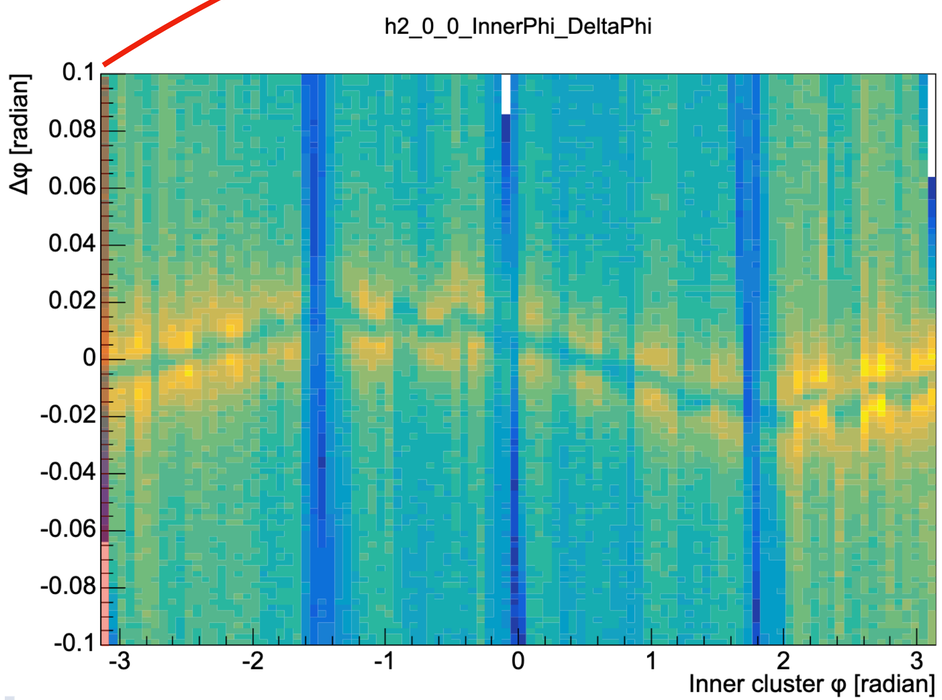
Original approach (work well in field off):

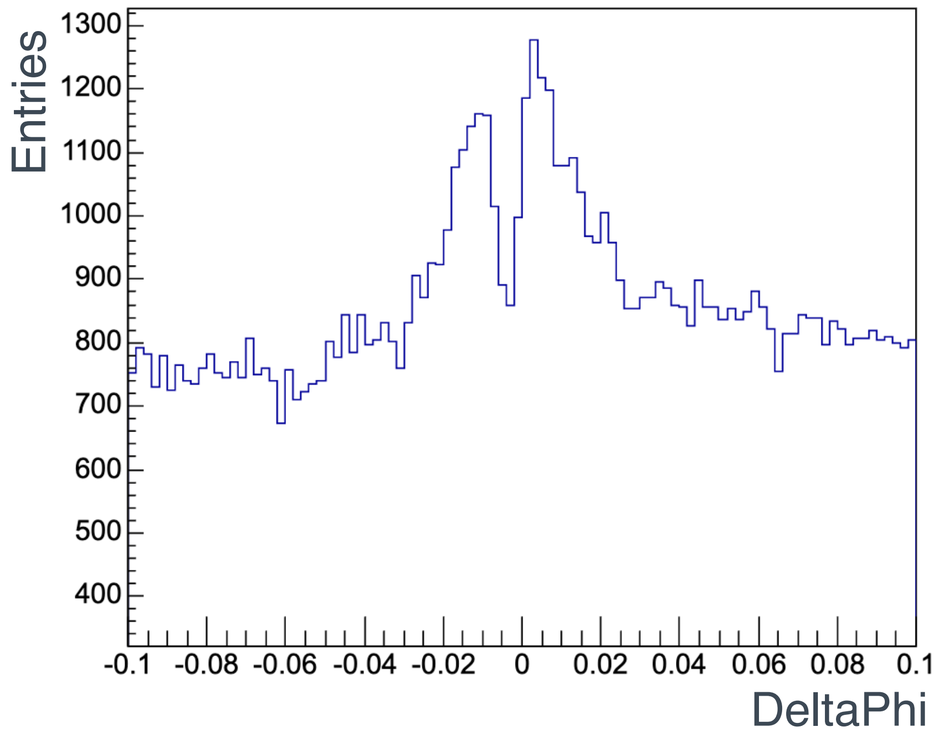
1. Systematically subtract the entries of all cells by 70% of the average of the entries of the top 7 cells
2. In each x slice, determine the average point using TProfileX
3. Fit the correlation with a horizontal line

It doesn't work in field ON case, the signal is smeared

New approach for field-on data

- Take the 1D distirbution for each x slice (100 slices in total)

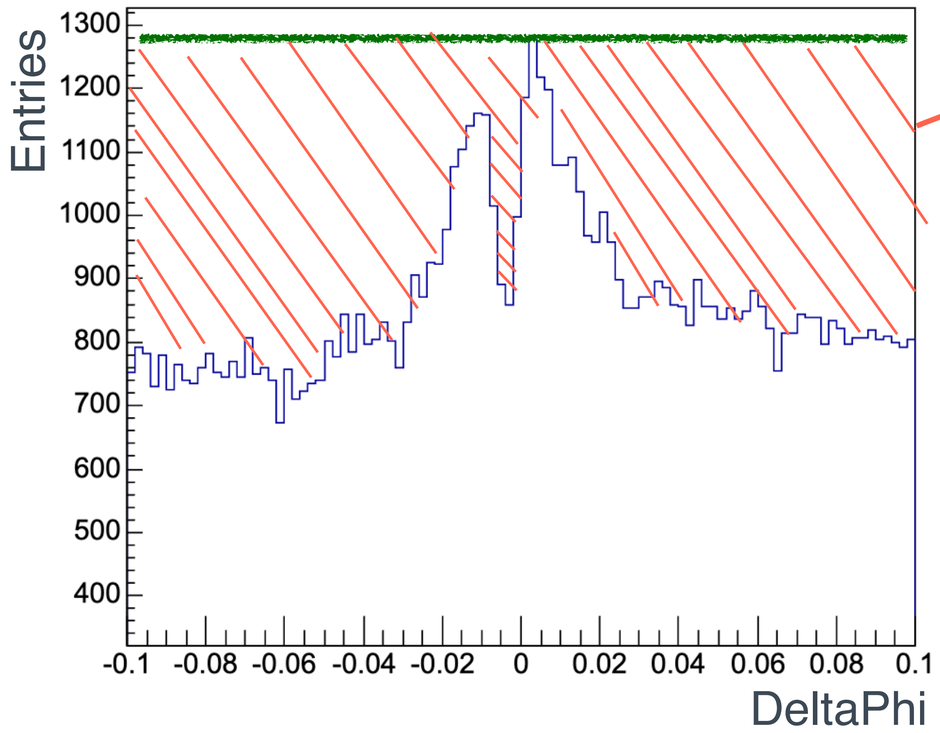


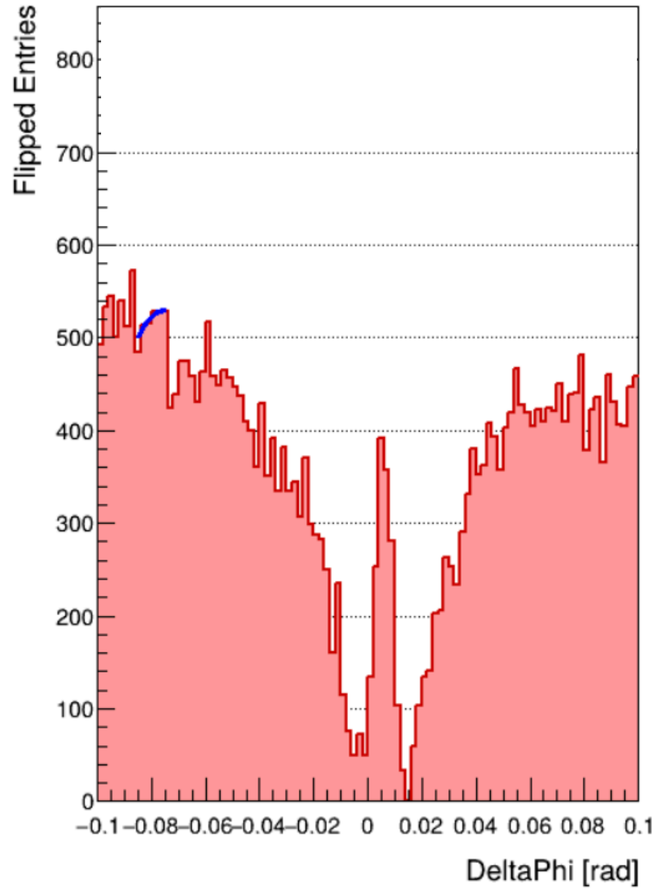


Two structures observed

New approach for field-on data

- Flip the historgram (make it upside down)



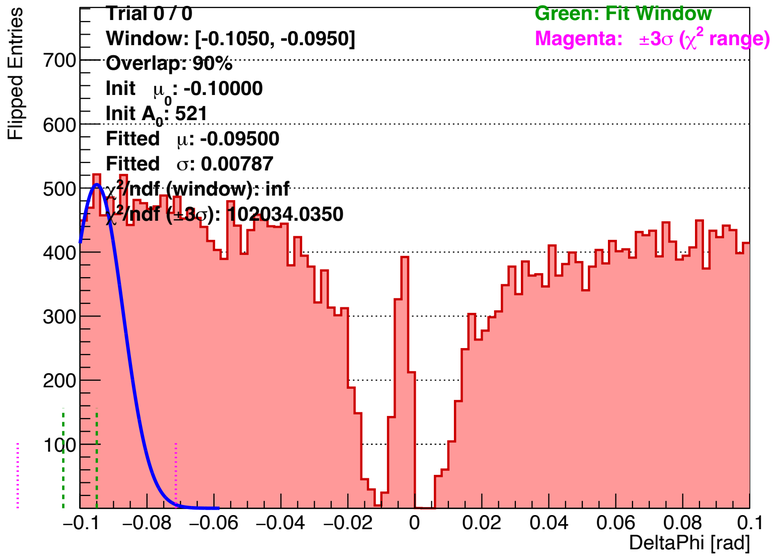


Now we see single Gaussian distribution somewhere in the middle

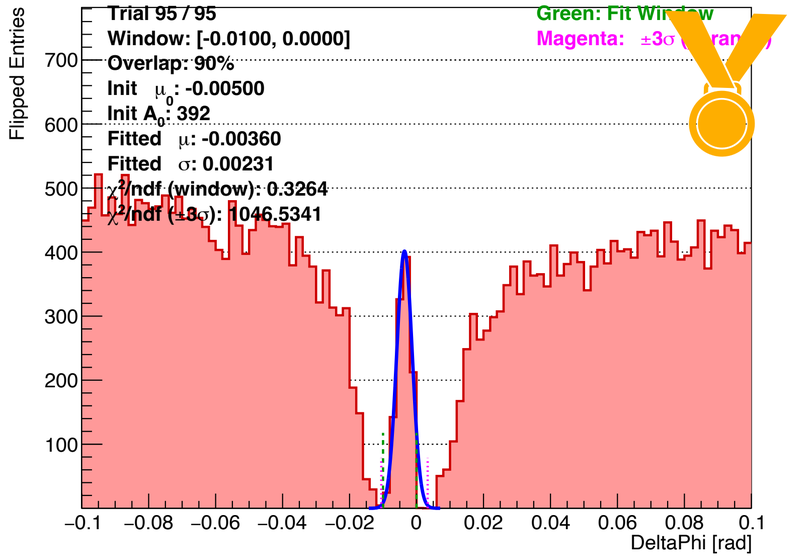
New approach for field-on data

- Scan the distribution by sequentially fitting a Gaussian function to a certain range of distribtuion*
- The mean value of the Gaussian function with the smallest reduced chi2 is taken as the final value of this x slice**
- Repeat the procedures for all x slices

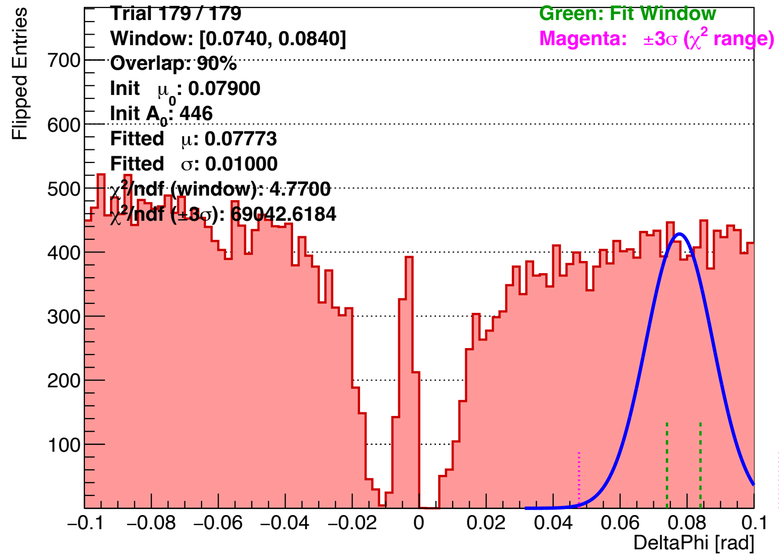
Trial 0/0: Window Center = -0.1000 rad



Trial 95/95: Window Center = -0.0050 rad



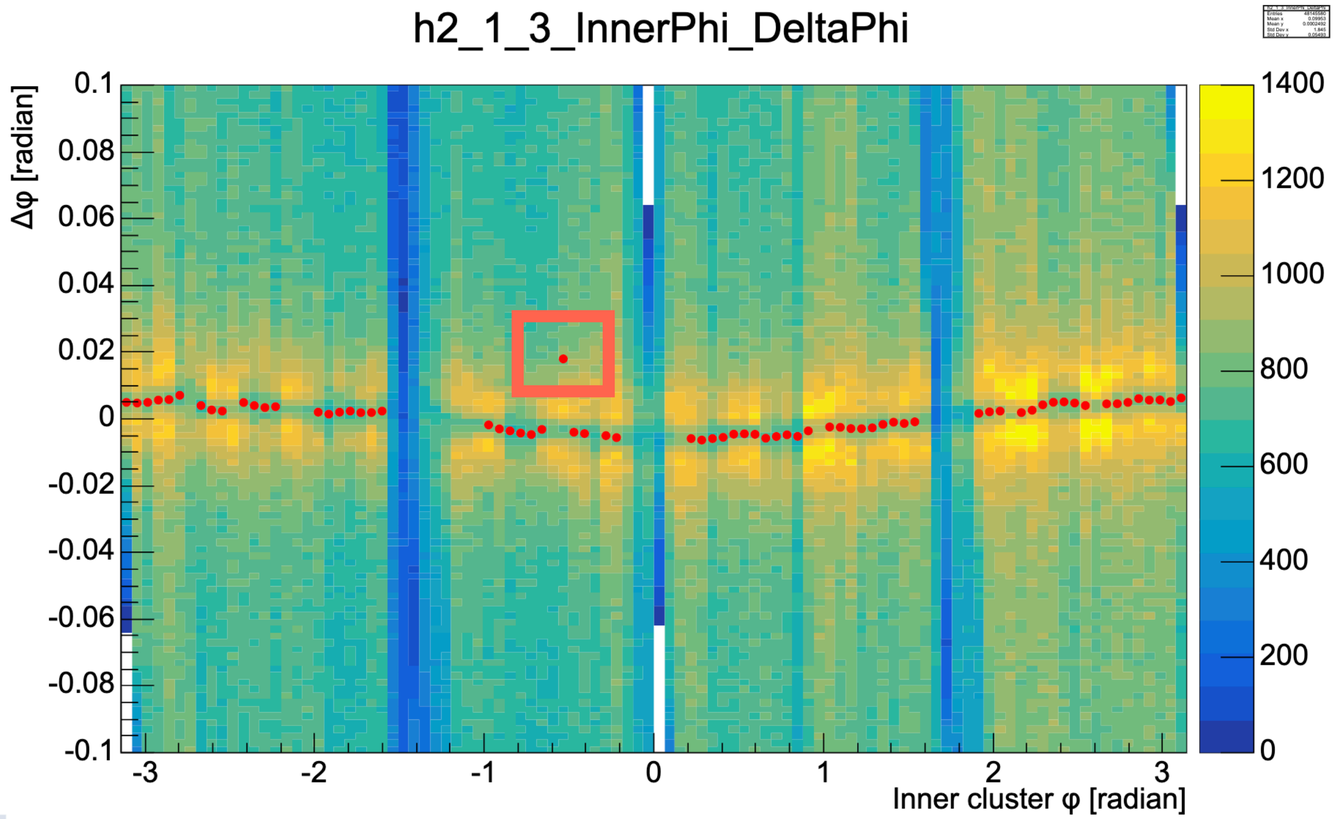
Trial 179/179: Window Center = 0.0790 rad



* Gaussian fit width is forced to be smaller than 0.01

** The reduced chi2 is calculated within 3σ of the fit Gaussian width

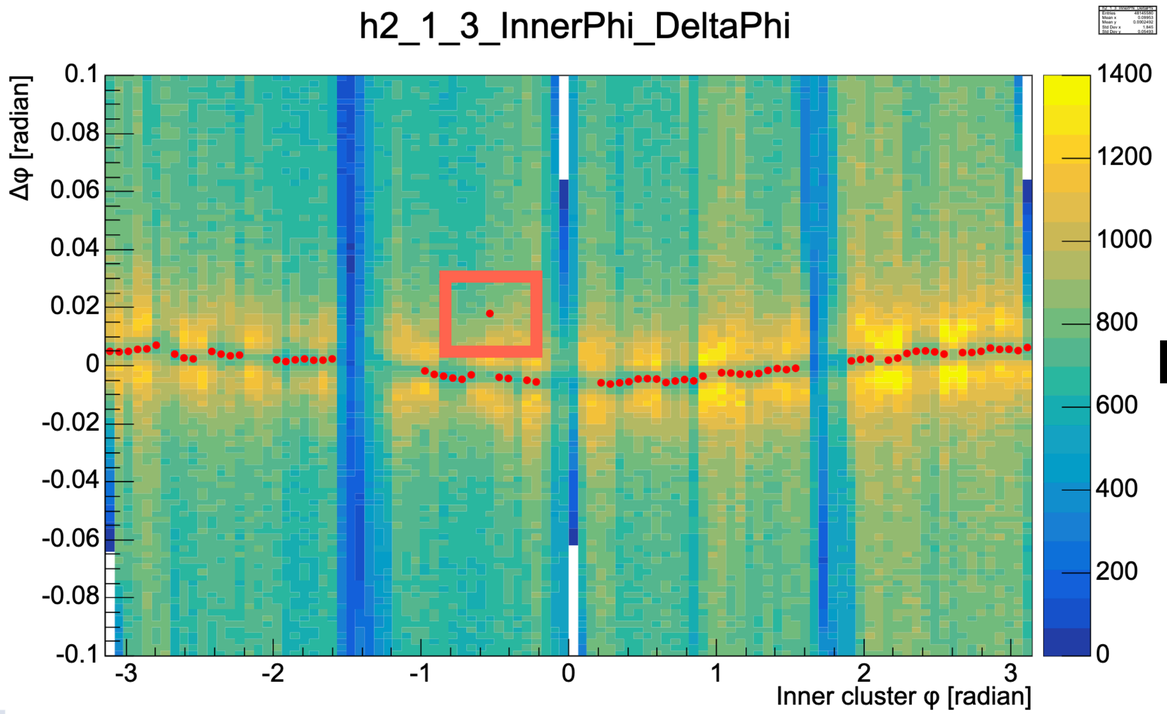
New approach for field-on data

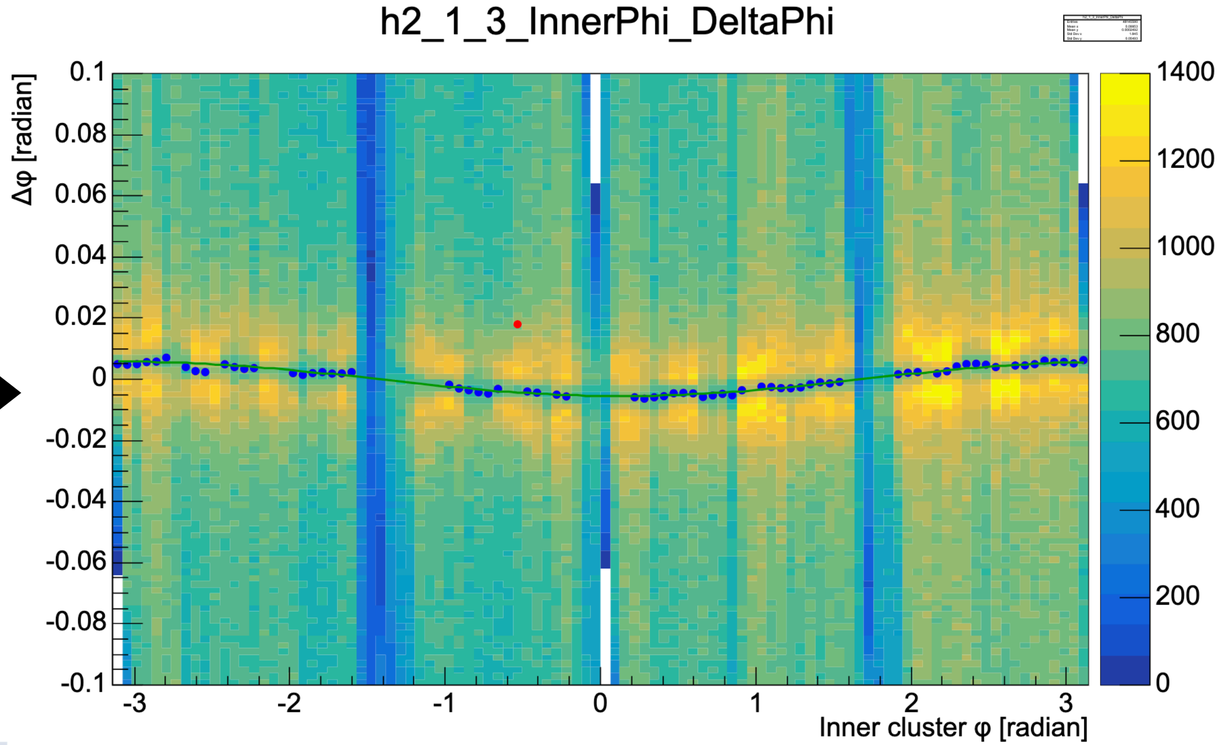


In general, this method works pretty well already. But still few outliers could appear even with some strict cuts on fit width and amplitude

New approach for field-on data

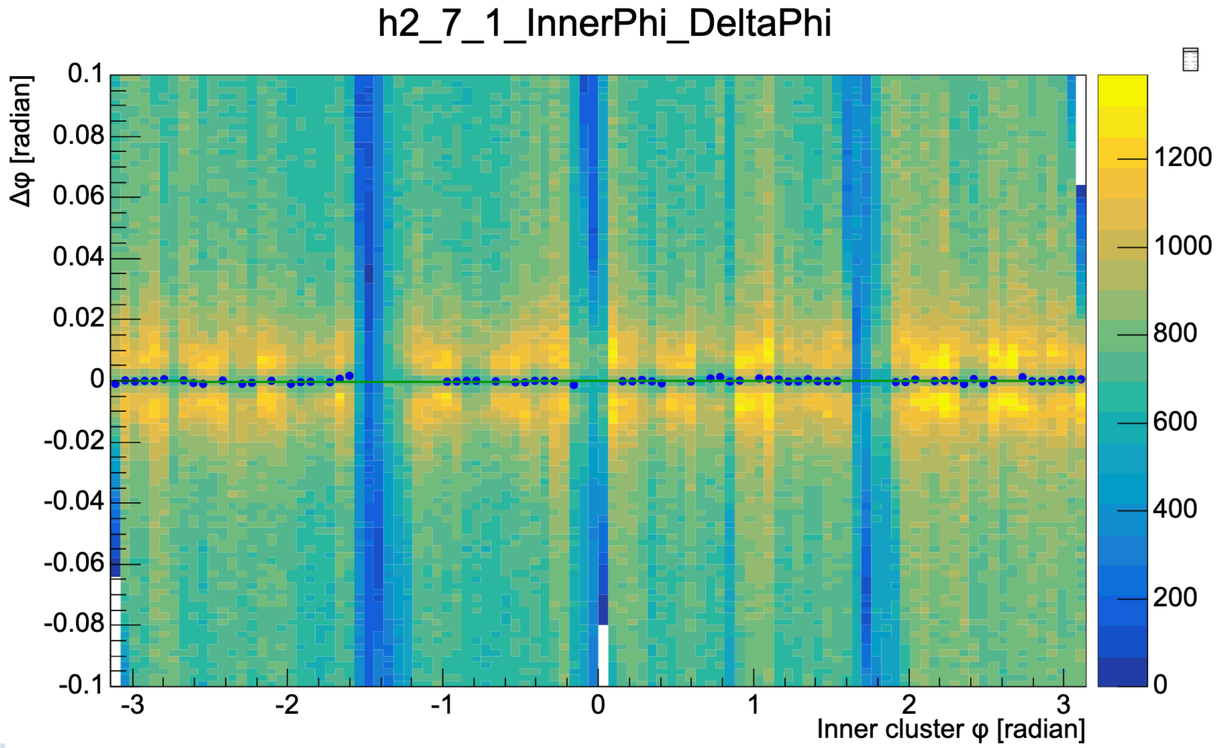
- Therefore, the RANSAC (random sample consensus) approach is introduced as the final outlier removal
  - Sample a certain fraction (90% in this case) of the total data points
  - Make a fit to this subset (sine wave in this case)
  - Iterate the procedures several times (1000 times in this case)
  - Pick up the one with the smallest reduced chi2 (or the one with the highest number of inliers)
  - Identify the outliers based on the best fit





It works well! The correlation can be clearly determined, the rest of the beam spot determine procedures remain unchanged

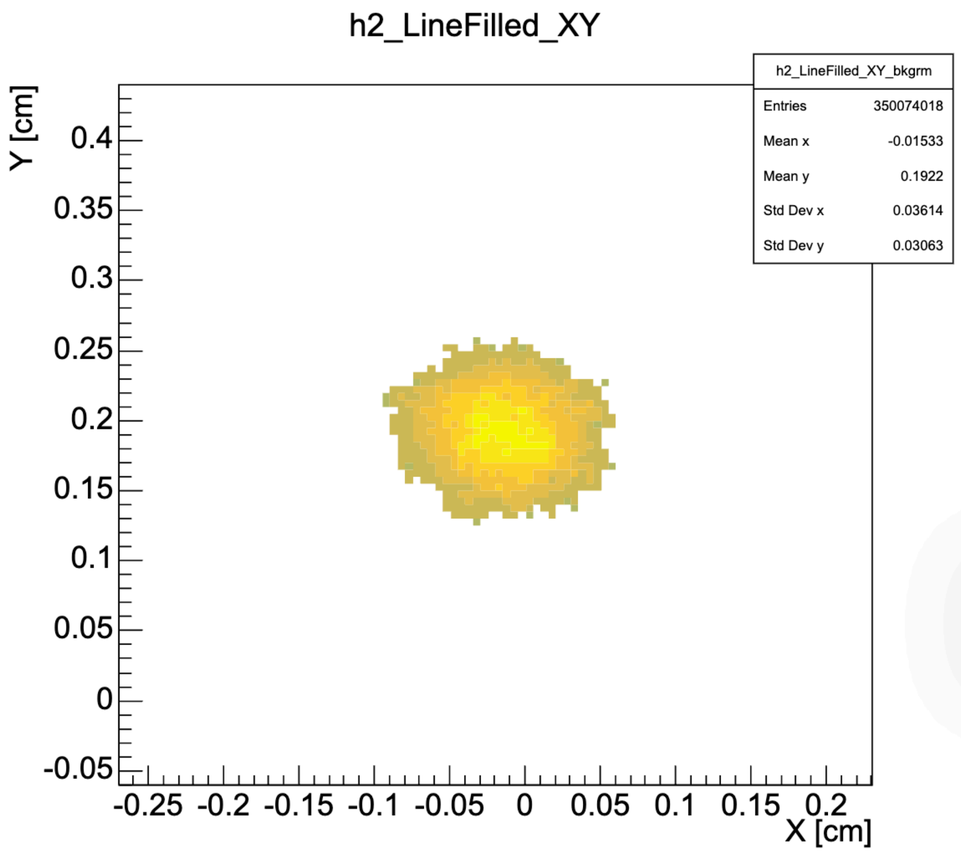
New approach for field-on data



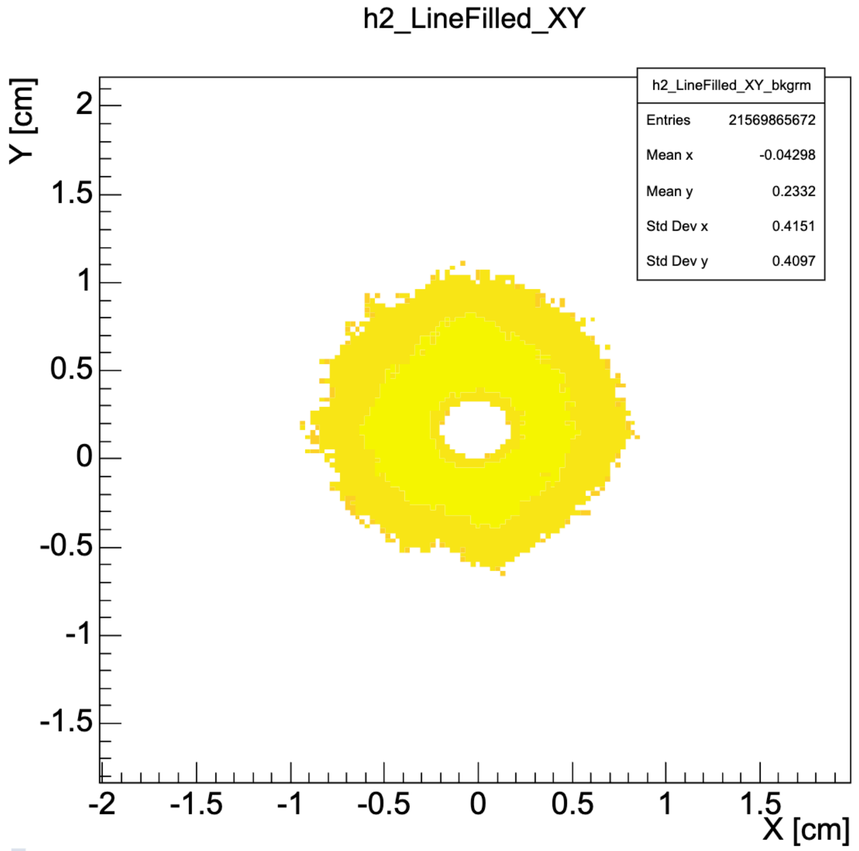
Flat correlation is the indication that you have found the beam spot location

Beam spot by line-fill method

Field Off



Field ON



This method still works though the structure is quite different

Issue spot in intt_setting table

Spotted by Hao-Ren

Somehow the physics run 80125, is not listed in the INTT database

Message ID: **1656**	Entry time: **Tue Dec 23 20:54:50 2025**
Author:	Hanpu Jiang
Subject:	12/23 evening shift
Run:	

Run Number	Run Type	Reason for Stop	Duration [min]	Notes
80118	Cosmic	Reach 1 hour	60 min	
80119	Cosmic	Reach 1 hour	59 min	
80120	Cosmic	Beam injection	45 min	
80123	Physics	To include TPC	11 min	
80125	Physics	SEB05 busy	31 min	
80126	Physics	Reach 1 hour	60 min	
80127	Physics	Handle to owl shift		

```
daq=> select * from intt_setting where runnumber > 80000;
 runnumber | n_collisions | open_time | readout_mode | dac0 | dac1 | dac2 | dac3 | dac4 | dac5 | dac6 | dac7
-----------+--------------+-----------+--------------+------+------+------+------+------+------+------+------
     80001 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80002 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80003 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80004 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80005 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80006 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80007 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80008 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80009 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80010 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80011 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80012 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80013 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80014 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80015 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80016 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80017 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80119 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80120 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80122 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80123 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80124 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80126 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
     80127 |          127 |        59 | streaming    |   35 |   45 |   60 |   90 |  120 |  150 |  180 |  210
```

InttDacMap.cpp

- This is the module for assigning the INTT hit DAC values
  - From adc0 - adc7 to thresholds we set to the comparators
- We kept all adc settings in the sPHENIX PSQL DB (intt_setting)
- Currently, the InttDacMap.cpp module reads the table from CDB file, which is outdated
  - There are only three DAC maps in the sPHENIX CDB file system
- We need to come up with a way to have the correct DAC values assigned to the INTT hits
  - We either update the CDB files or
  - We load the values from PSQL database

In the sPHENIX CDB file system

```
[ecie9969@sphnxuser08 cdb]$ ls INTT_DACMAP/*/*/*
INTT_DACMAP/05/2b/052bc59ac86636e7ee2310c636a0218e_CDBTTree_INTT_DACMAP_2024.root
INTT_DACMAP/fb/c5/fbc57b510a51212c46c98b6cef0219f8_CDBTTree_INTT_DACMAP.root
INTT_DACMAP/fd/55/fd551e8101598bcecdb3b305c19379f1_cdb_intt_dac_35_45_60_90_120_150_180_210_streaming.root
```

The dinamic of the threshold settings in INTT lifetime

			adc0
Run24	pp	triggered	30
		streaming	35
	AuAu	triggered	35
Run25	AuAu	triggered	30/25 (35?)
	pp	triggered	30?
		streaming	35
	OO	triggered	30
		streaming	35

```
class InttDacMap
{
 public:
  InttDacMap();
  virtual ~InttDacMap() {}

  virtual int LoadFromCDB(std::string const& calibname);
  virtual int LoadFromFile(std::string const& filename);
  virtual int WriteToFile(std::string const& filename);
```

Summary

- The algorithm for determining the correlation between Δϕ and inner cluster ϕ has been developed for the field ON data. Now the INTT-standalone beam spot search algorithm is back in operation
  - But the new method requires 10 times more statistics, but that is ok

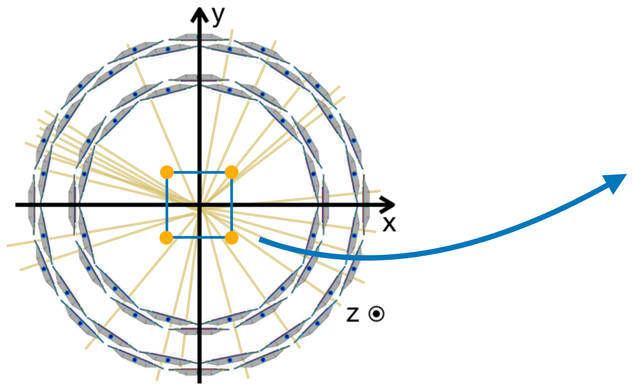
- We would have to update the codes for the INTT hit DAC assignment

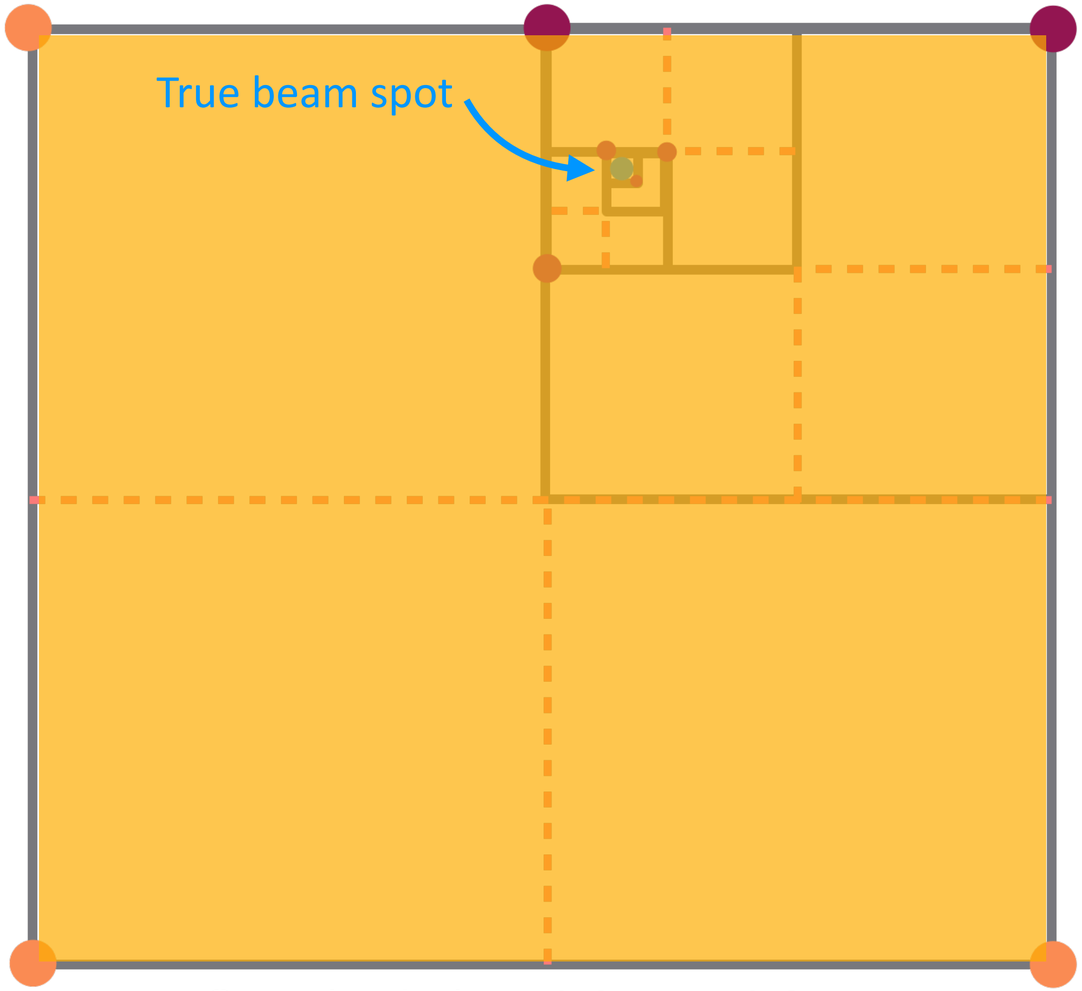
Backup

Beam spot identification - Quadrant method

Limited by INTT geometry, per-event vertex XY reconstruction is challenging
The stable beam spot O(0.1 mm) enables the average vertex XY reconstruction

- **Approach 1:** Quadrant method
- **Procedures:**
  1. Define search window (true vertex covered)
  2. In each iteration, test 4 corners
  3. Move search window to the quadrant whose corner is closer to true beam spot
  4. Repeat the procedures 2 and 3
  5. True beam spot is confined in a tiny window after iterations



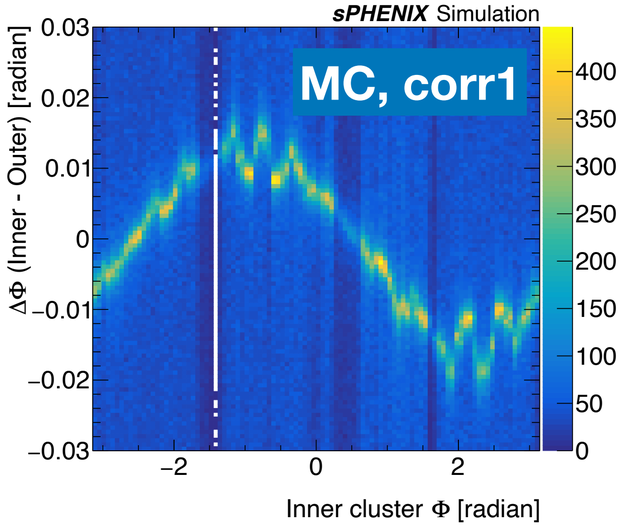


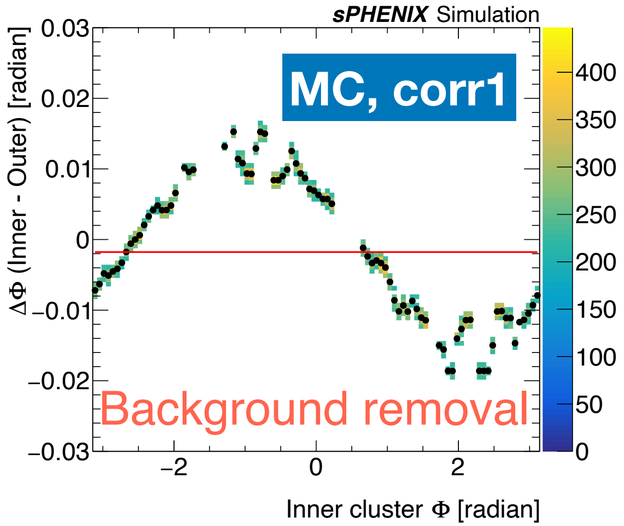
Search window: 0.8 cm x 0.8 cm

Beam spot identification - Quadrant method

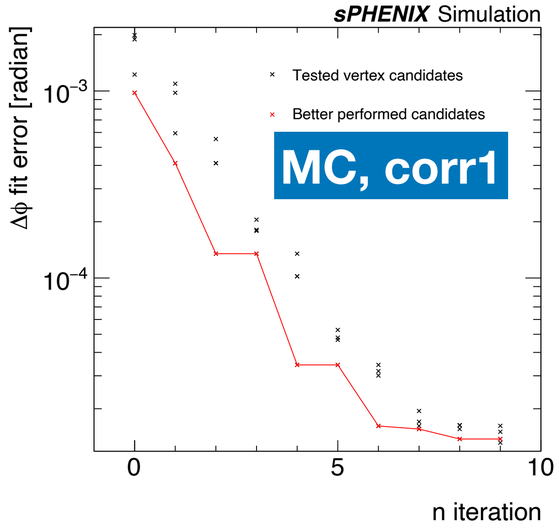
Two correlation plots for **each corner**

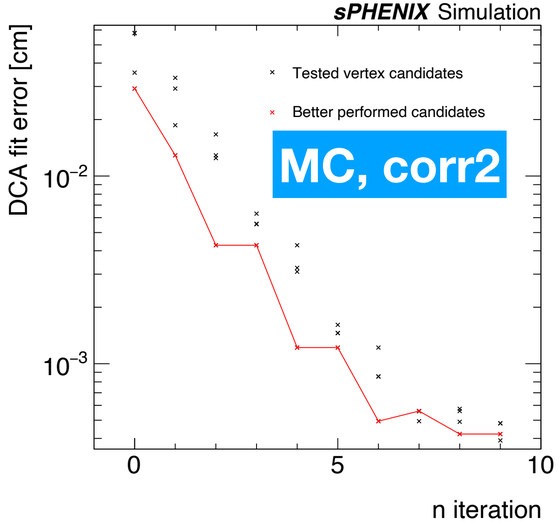
1. Δϕ as a function of inner cluster ϕ
2. DCA as a function of inner cluster ϕ



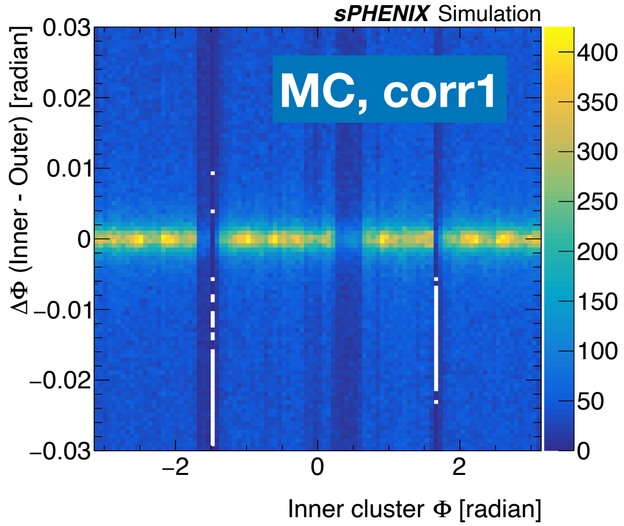


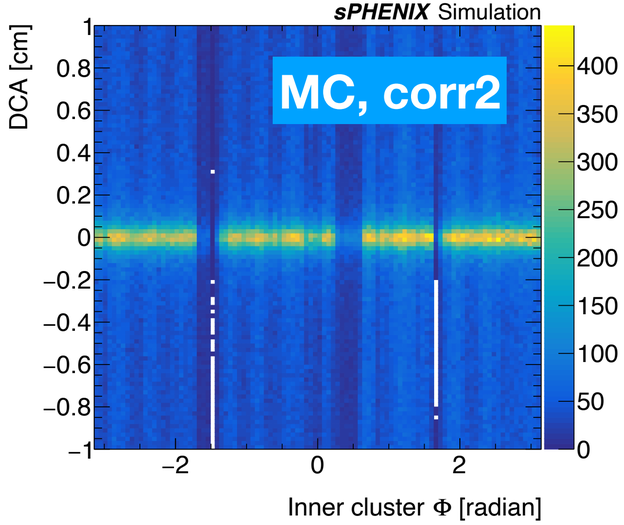
In iteration





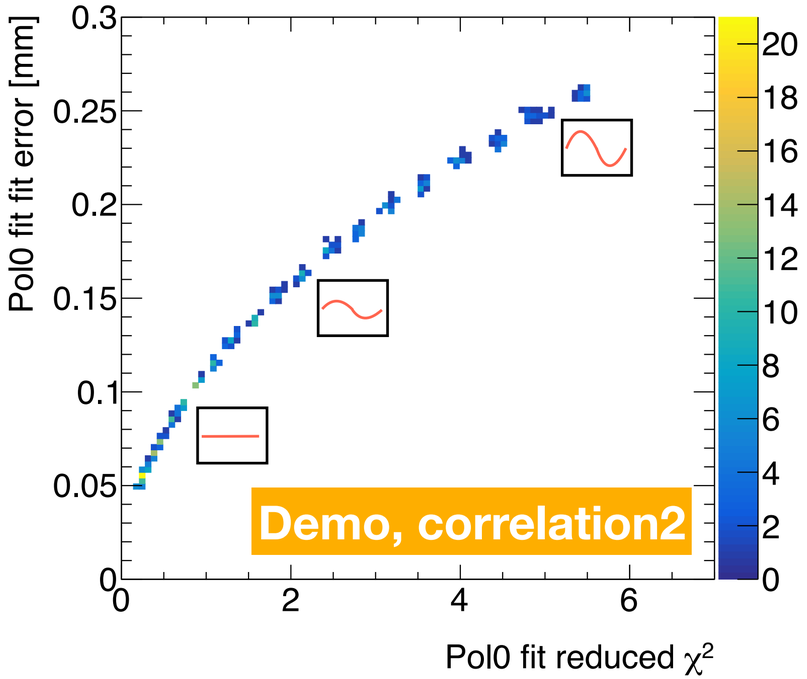
The correlations post having the best estimation of the beam spot





Beam spot identification - Quadrant method

- If the given vertex XY is getting closer to the true beam spot, correlations of Δϕ - inner ϕ(1) and DCA - inner ϕ(2) become flat
  - Correlation shape quantified by Polynomial-0 fit
  - Two quantity candidates: reduced χ^2 and fit error



Pol0 fit error is more sensitive in the region that the correlation shape is closer to the horizontal line