

GlueX DIRC commissioning

EIC PID Consortium meeting

Roman Dzhygadlo

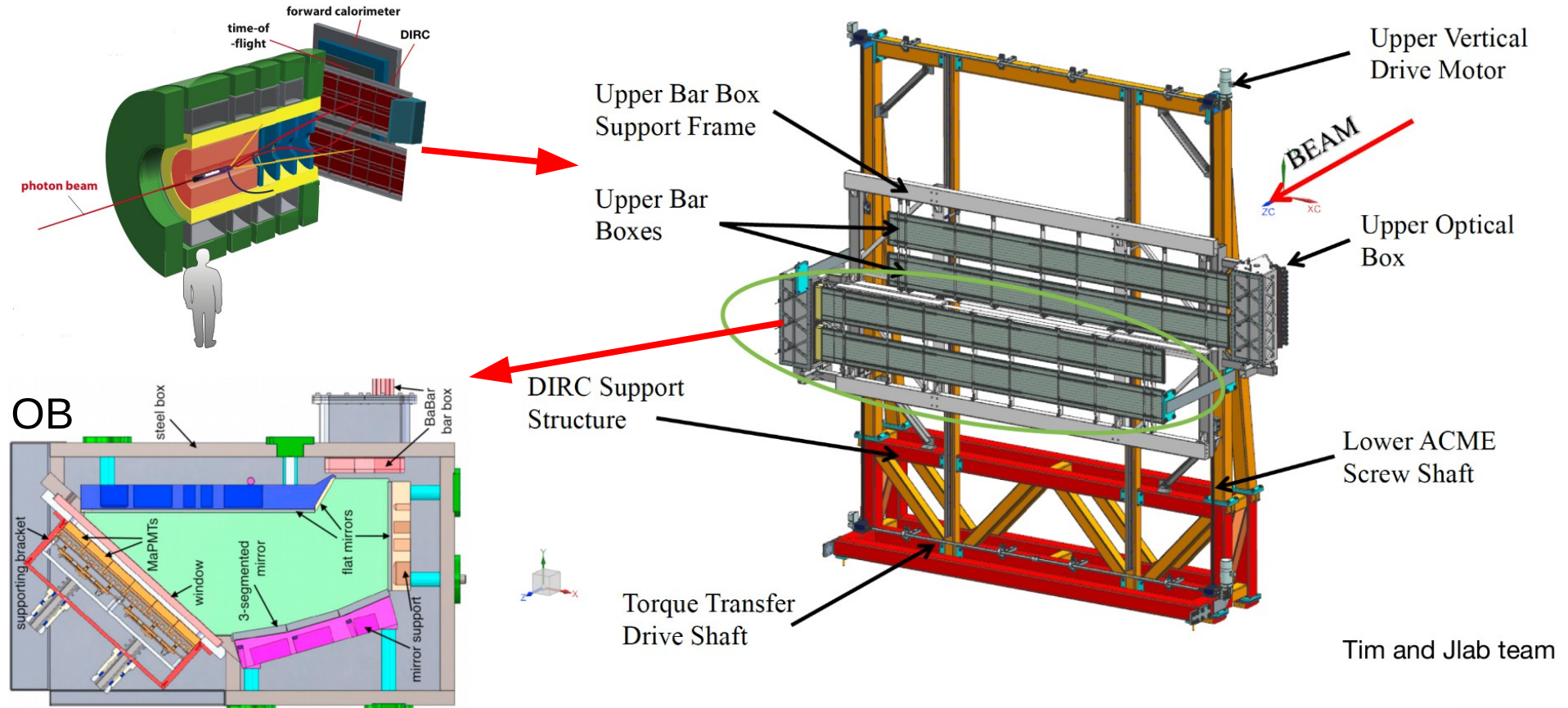
GlueX DIRC team



Commissioning Goals

- Assemble and install lower half of the GlueX DIRC
- Test airflow, water and light leaks
- Integrate DIRC readout with general Hall D DAQ and online/offline monitoring
- Calibrate per-pixel timing offset of MAPMTs using LED system
- Implement reconstruction algorithm and compare data/MC:
 - photon multiplicity
 - Cherenkov angle resolution
- Determine geometric alignment parameters (position and angle offsets) for optical components

The lower half of the DIRC and OB



Window and mirror cleaning

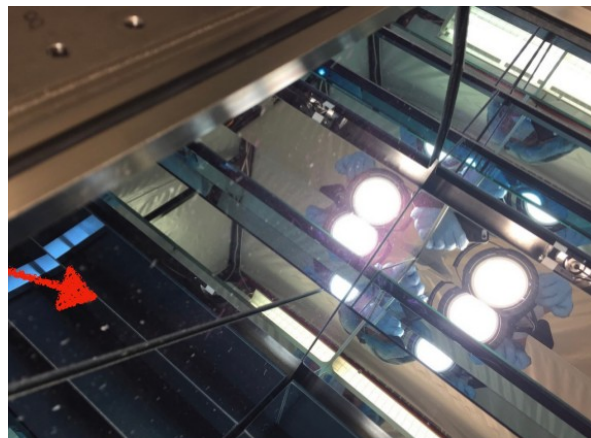


by Greg Kalicy

optical window



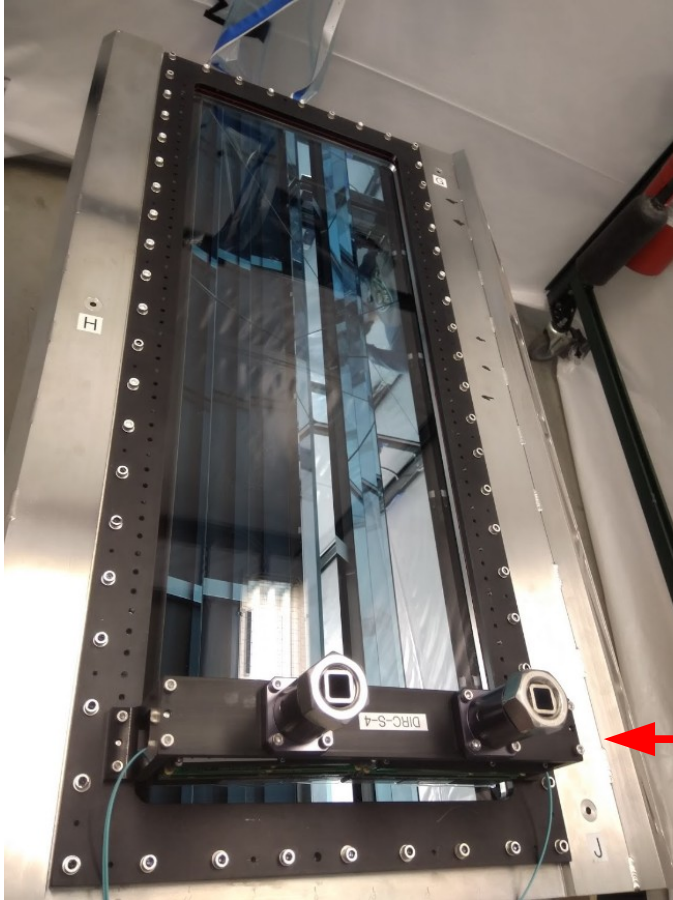
side mirror



before

after

Water leak test



Water leak test with fused silica window after the OB was modified

OK

Test application of one module. New technology for optical coupling

Air flow test and monitoring



DAQ monitoring GUI from Sergey

35.743
- 37.689
35.436
38.512
39.519
39.819
42.672
43.456
39.373
39.396
41.626
- 42.664
45.679
45.41
47.294
48.463
45.11
45.064
47.655
48.286
48.77
- 49.824
51.516
52.677
48.709
50.193
51.662
54.576
52.3
53.084
52.115
- 47.063
54.738
53.646
51.062
47.332

Temperature is
below 60 C!

OK

Optical coupling technique

Inspired by Belle II experience

Custom made 2 mm thick 2 inch x 6 inch cookies (single cookie fo 3 PMTs)

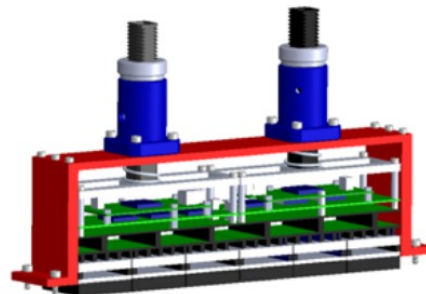
Softest mixture of RTV615 silicone

Flat surfaces

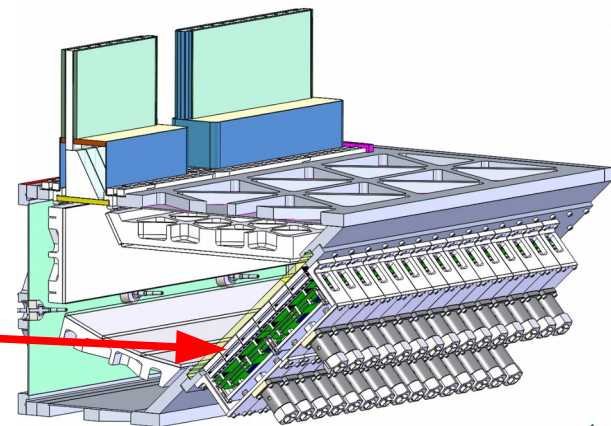
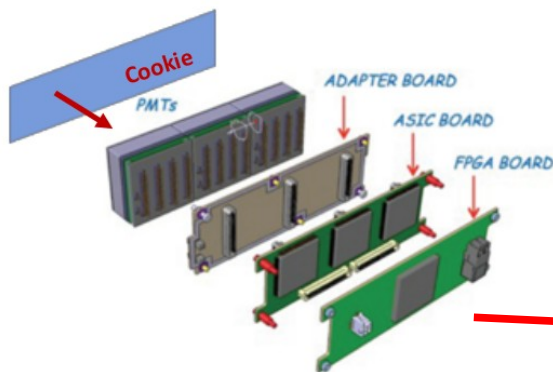
Stored between kitchen foil - handy

One OB needs 36 cookies, we had about 80, but we discarding about 10-15 of them

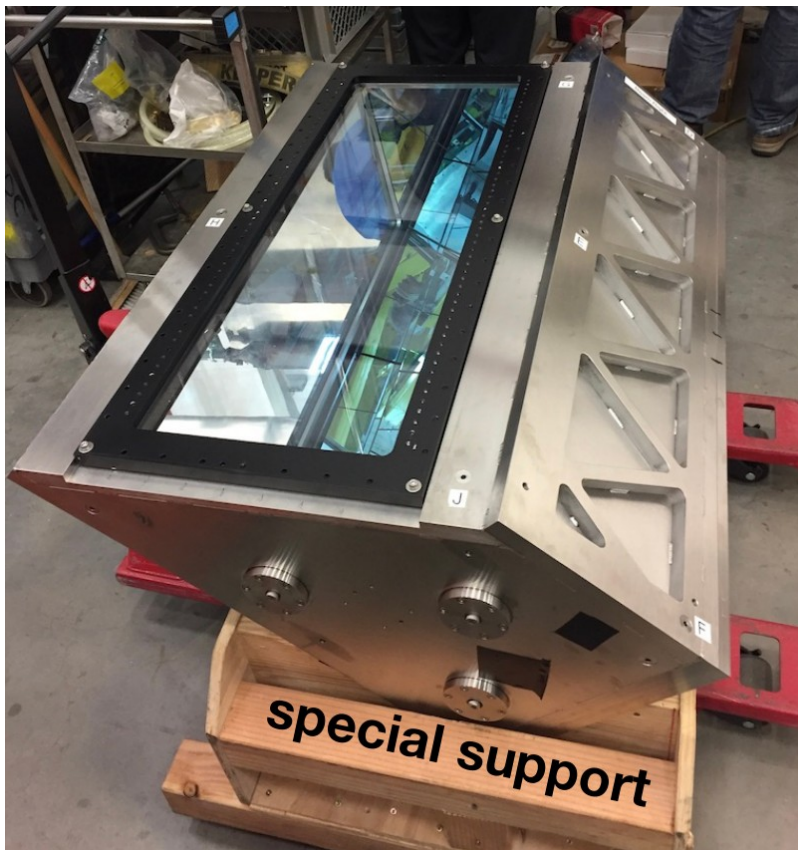
Application requires greasing the cookie on both sides



**PMT/electronics support bracket
developed at MIT-Bates**

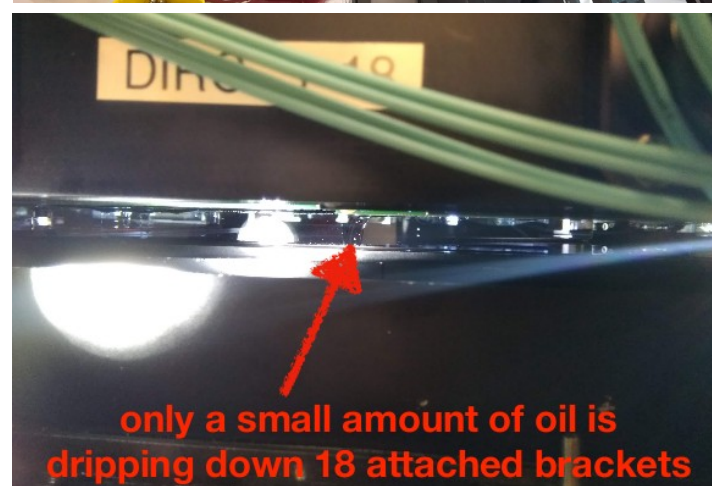
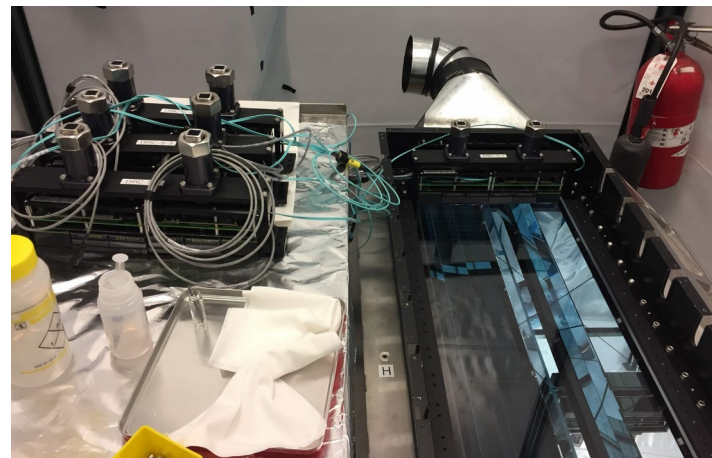


Readout assembling



Readout assembling

- all PMTs were installed in about 2 days
- exchange of an individual module is possible
- greasing oil is quite viscose and does not drip out
- good optical coupling on >99% of the surface (one “control bubble” of the size of about 4 pixels)



Optical coupling check



OB is installed and attached to the bar boxes. All/near all modules installed.

Light leak test



Bar box is not very light tight

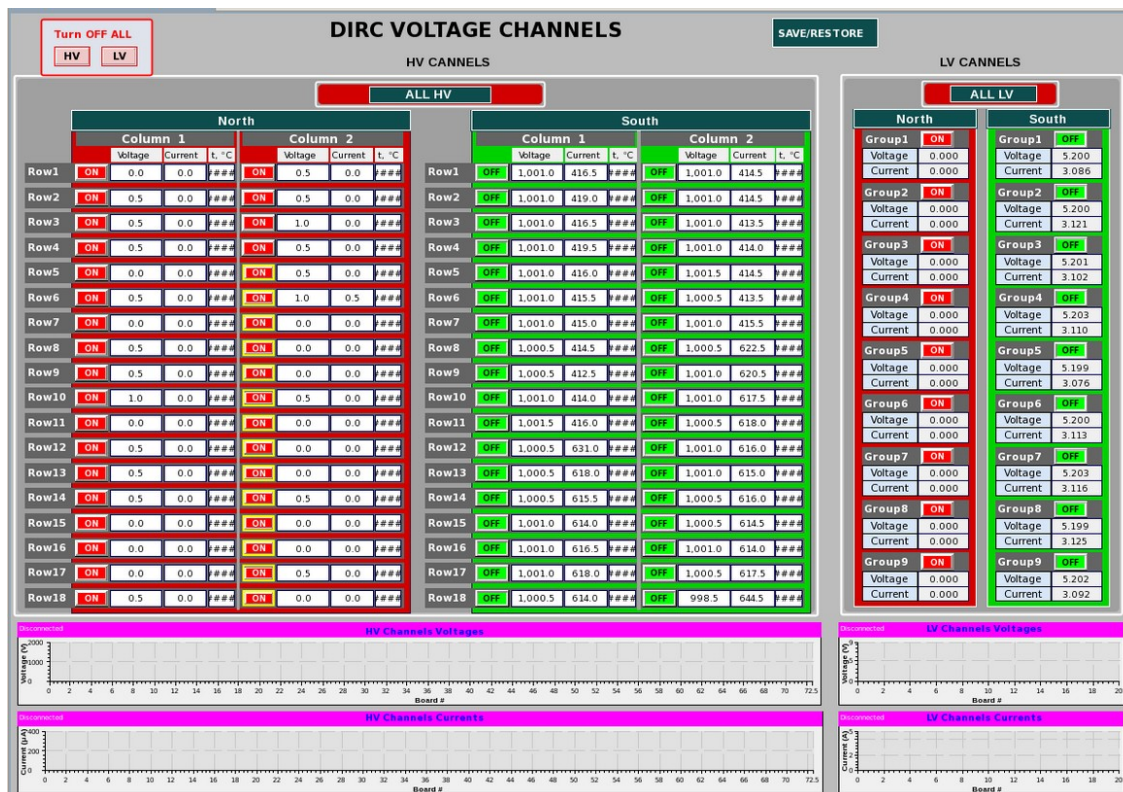
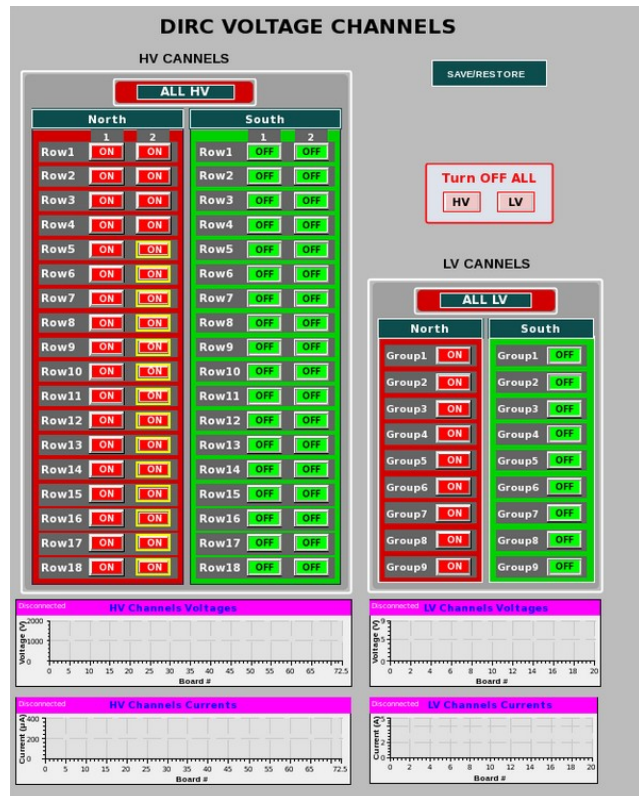
Sealing it with tapes and cloth helped, but still small light leaks remains

=> data taking with hall's lights off during the commissioning

EPICS Integration

Low/high voltage control:

by Hovanes, Vanik, Nick



EPICS Integration

by Hovanes, Vanik, Nick

DIRC environment control:

DIRC ENVIRONMENT

North OpticalBox Interlocks

Environment Variables	Interlock	Limit Setpoint	Limit Readback	Interlock Override
Temp 0.00 °C	<input checked="" type="checkbox"/>	25	25.00	Bypass OFF
Humidity 0.00 %	<input checked="" type="checkbox"/>	0	0.00	Bypass OFF
Light Sensor 0.02 V	<input checked="" type="checkbox"/>	0.1	0.10	Bypass OFF
Hall Light Sensor 0.017 V	<input checked="" type="checkbox"/>	0.1	0.10	Bypass OFF
Airflow Switch	<input checked="" type="checkbox"/>			Bypass ON
Cover Switch	<input checked="" type="checkbox"/>			Bypass ON
Leak Detector	<input checked="" type="checkbox"/>			Bypass ON
N2 Flow 0.00 sl/hr				Bypass ON

HV Interlock ☒
LV Interlock ☒
RESET INTERLOCK

South OpticalBox Interlocks

Environment Variables	Interlock	Limit Setpoint	Limit Readback	Interlock Override
Temp 20.54 °C	<input checked="" type="checkbox"/>	23	23.00	Bypass OFF
Humidity 21.99 %	<input checked="" type="checkbox"/>	60	60.00	Bypass OFF
Light Sensor 0.03 V	<input checked="" type="checkbox"/>	0.1	0.10	Bypass OFF
Hall Light Sensor 0.017 V	<input checked="" type="checkbox"/>	0.1	0.10	Bypass OFF
Airflow Switch	<input checked="" type="checkbox"/>			Bypass ON
Cover Switch	<input checked="" type="checkbox"/>			Bypass ON
Leak Detector	<input checked="" type="checkbox"/>			Bypass ON
N2 Flow 15.12 sl/hr				Bypass ON

HV Interlock ☒
LV Interlock ☒
RESET INTERLOCK

North BarBox

BarBox Top N2 Flow	2.76	sl/hr
BarBox Top N2 Pressure	0.52	H2O in
BarBox Bot N2 Flow	2.76	sl/hr
BarBox Bot N2 Pressure	0.52	H2O in
BarBox Manifold Pressure	1.54	H2O in

Water Skid

Water Flow	2.01	G/m
Water Temp	72.81	°F
Pump Enable	<input checked="" type="checkbox"/>	ON
Alarm Status	<input checked="" type="checkbox"/>	OFF

South BarBox

BarBox Top N2 Flow	1.39	sl/hr
BarBox Top N2 Pressure	0.39	H2O in
BarBox Bot N2 Flow	1.40	sl/hr
BarBox Bot N2 Pressure	0.25	H2O in
BarBox Manifold Pressure	1.54	H2O in

LED pulser control:

RESET **DIRC LED PULSER CONTROL** Pulser Status: WHITE

Color & status	Start/Stop pulsing	Pulse width Readback	Pulse width Setpoint	Frequency Readback	Frequency Setpoint	Number of pulses Readback	Number of pulses Setpoint	Cont. Mode ON/OFF
WHITE <input checked="" type="checkbox"/>	STOP	100 ns	100	5.000 KHz	5,000	CONTINUOUS	-1	OFF
TRIG <input checked="" type="checkbox"/>		100 ns	100	5.000 KHz	5,000	CONTINUOUS	-1	

OUTPUT "MOR" CONTROL

MOR width Readback	MOR width Setpoint	MOR delay Readback	MOR delay Setpoint
100 ns	100	0 ns	0

DIRC LED VOLTAGE CONTROL

Channel Name	Voltage Readback	Voltage Setpoint	Setpoint Readback	ON / OFF	Channel Status	Current Readback	Extra Screens
BIAS	12.410	12.4	12.400	<input checked="" type="checkbox"/>	On	0.097	Advanced Settings
LV 5V	5.002	5	5.000	<input checked="" type="checkbox"/>	On	0.035	Advanced Settings
LV 12V	12.026	12	12.000	<input checked="" type="checkbox"/>	On	0.190	Advanced Settings

FAL Master Or Control

EPICS Integration

by Hovanes, Vanik, Nick

DIRC scalers per pmt/channel:

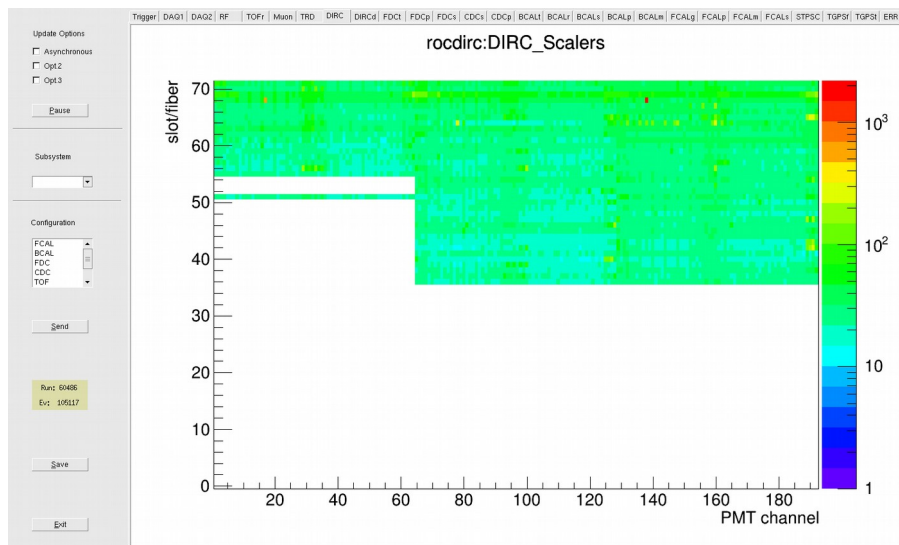
DIRC Scalers (Sums)																	
North									South								
Column 1			Column 2			Column 1			Column 2			Column 1			Column 2		
1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3	1-1	1-2	1-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3	2-1	2-2	2-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3	3-1	3-2	3-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3	4-1	4-2	4-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3	5-1	5-2	5-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3	6-1	6-2	6-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3	7-1	7-2	7-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3	8-1	8-2	8-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3	9-1	9-2	9-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3	10-1	10-2	10-3
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11-1	11-2	11-3	11-1	11-2	11-3	11-1	11-2	11-3	11-1	11-2	11-3	11-1	11-2	11-3	11-1	11-2	11-3
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12-1	12-2	12-3	12-1	12-2	12-3	12-1	12-2	12-3	12-1	12-2	12-3	12-1	12-2	12-3	12-1	12-2	12-3
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13-1	13-2	13-3	13-1	13-2	13-3	13-1	13-2	13-3	13-1	13-2	13-3	13-1	13-2	13-3	13-1	13-2	13-3
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-1	17-2	17-3	17-1	17-2	17-3	17-1	17-2	17-3	17-1	17-2	17-3	17-1	17-2	17-3	17-1	17-2	17-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-1	18-2	18-3	18-1	18-2	18-3	18-1	18-2	18-3	18-1	18-2	18-3	18-1	18-2	18-3	18-1	18-2	18-3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total North Column 1			Total North Column 2			Total South Column 1			Total South Column 2			Total South Column 1			Total South Column 2		
0			0			274,527			341,302			274,527			341,302		

South Column 2 Row 7:1							
1	2	3	4	5	6	7	8
53	50	52	52	58	60	61	66
9	10	11	12	13	14	15	16
46	43	43	44	44	49	55	56
17	18	19	20	21	22	23	24
47	44	41	42	44	46	51	58
25	26	27	28	29	30	31	32
45	40	40	42	44	44	49	57
33	34	35	36	37	38	39	40
47	40	39	49	43	41	46	53
41	42	43	44	45	46	47	48
40	37	38	41	39	44	45	52
49	50	51	52	53	54	55	56
44	39	38	40	62	43	42	49
57	58	59	60	61	62	63	64
39	36	38	40	40	41	46	57

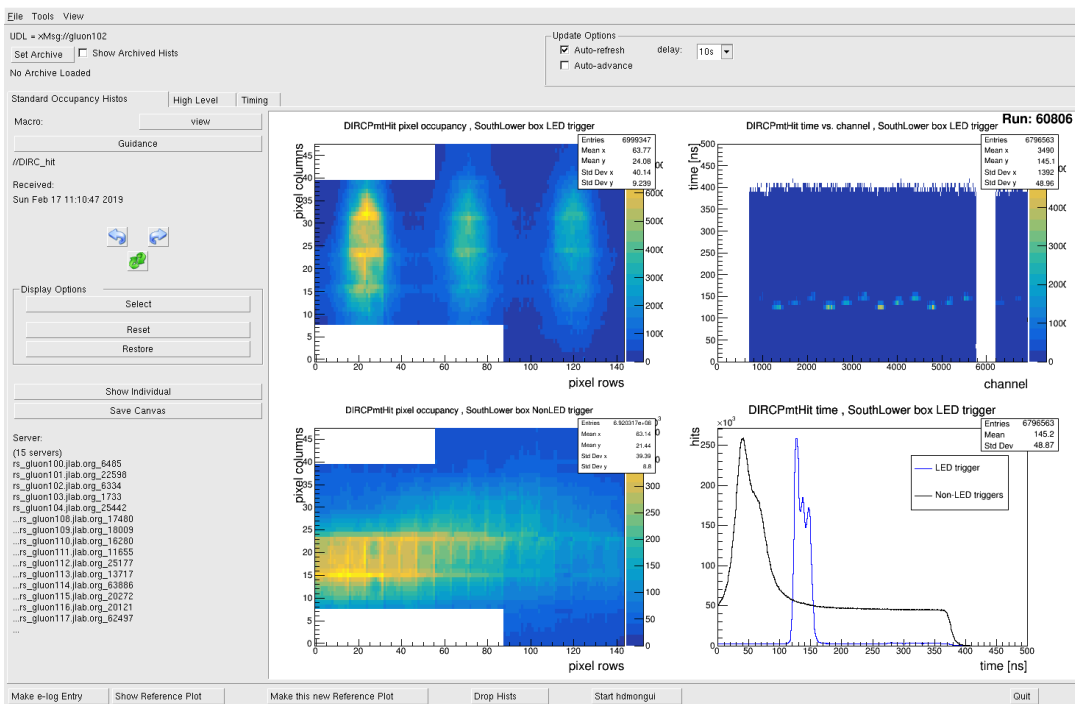
Monitoring Tools

by Sergey

DIRC scaleres:



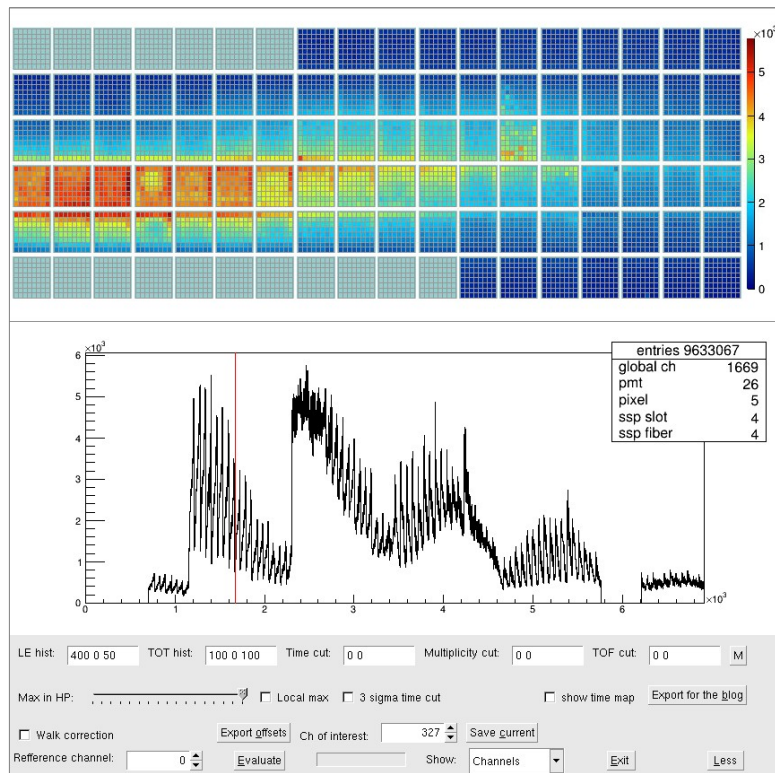
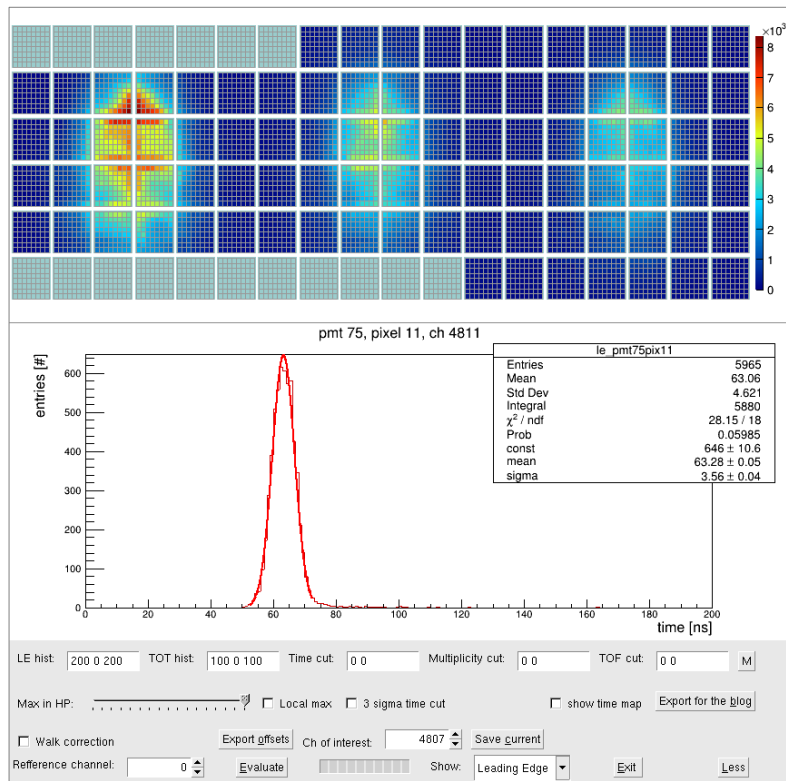
RootSpy:



by David

Monitoring Tools

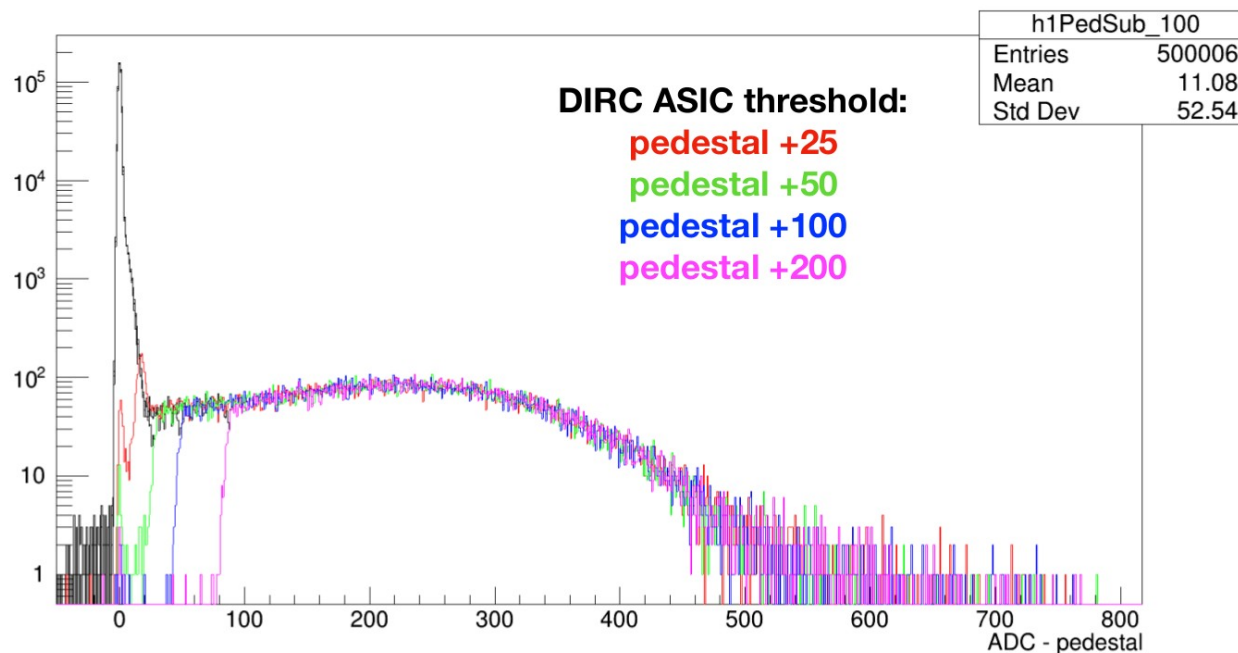
gdisplay:



Laser calibration data

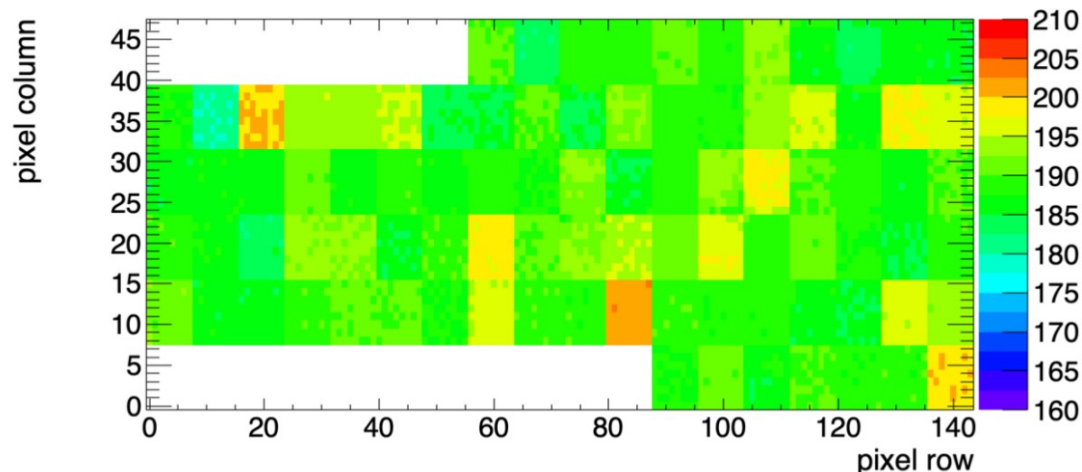
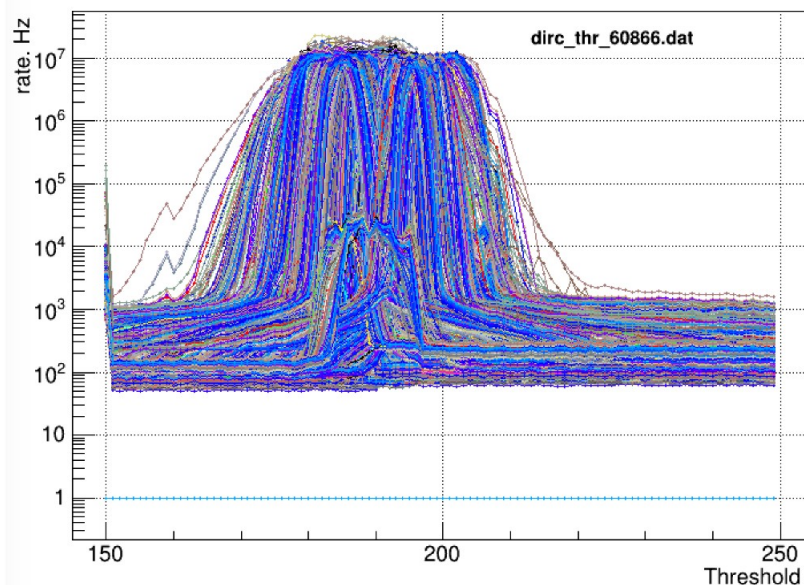
- Per-pixel gains determined from single PE peak fits
- Studying efficiency dependence on threshold in both laser test data and beam data to optimize for production running

Andrew Hurley, W&M

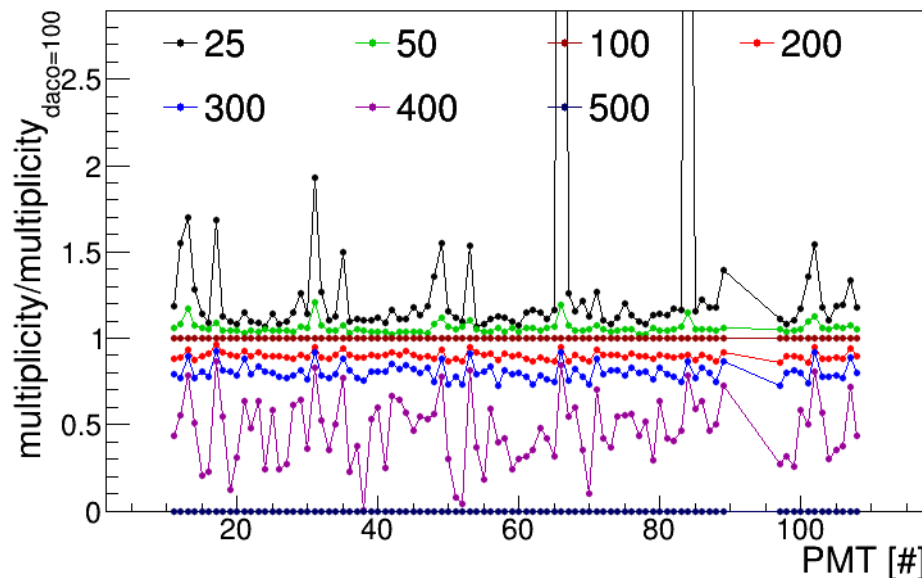
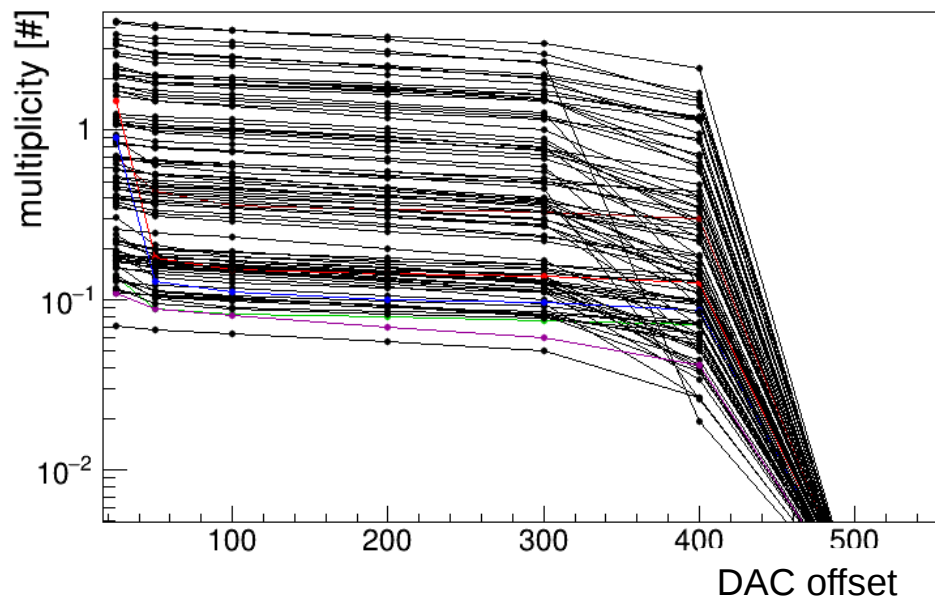


Threshold scans & Pedestal Map

- Sergey wrote program to scan DAC thresholds and save scaler rate for every pixel (part of “daily” DIRC tasks)
- Take centroid of this scan to set pedestal and threshold for each PMT/ASIC
- Pedestals mostly driven by ASIC, so they are common across pixels in a given PMT as seen in threshold scan data
- Single threshold set for each PMT/ASIC is sufficient



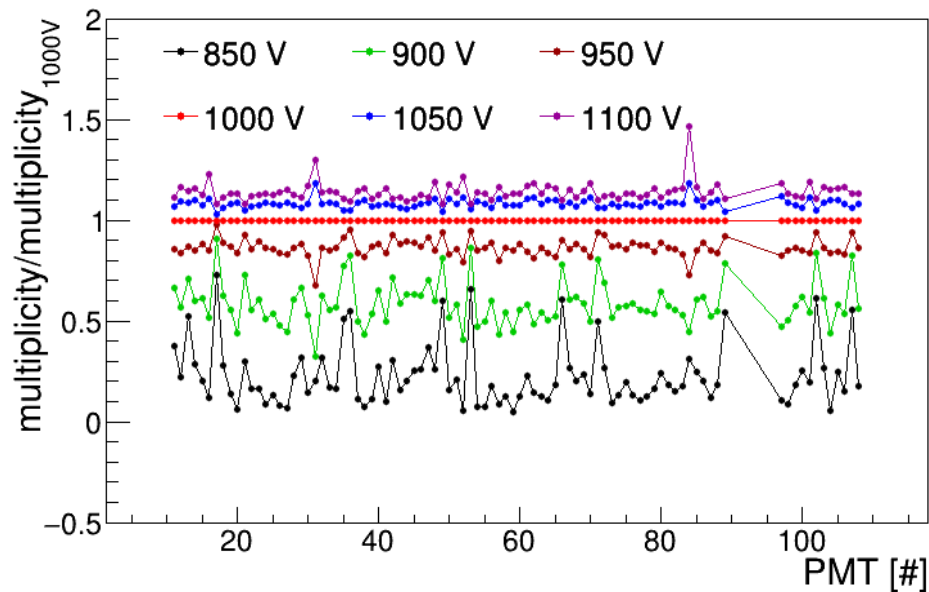
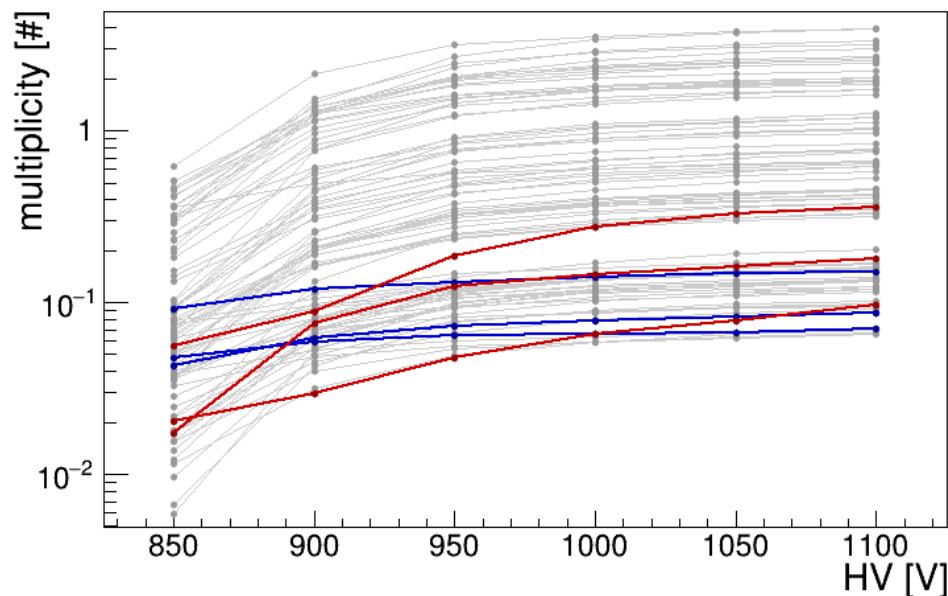
Detected LED multiplicity per PMT



➡ offset 100 was used for most of the data; 1B triggers were collected @ 50, 200

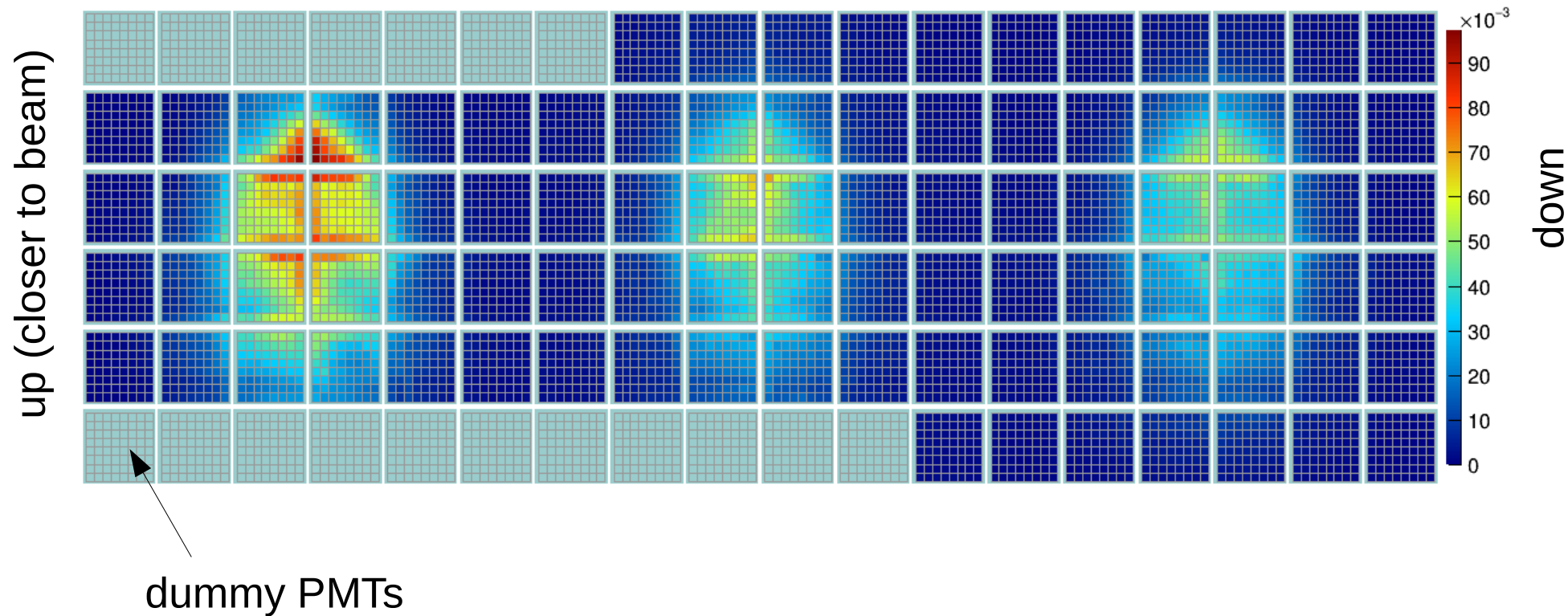
HV scan

Relative multiplicity as a function of the PMT number and HV value:



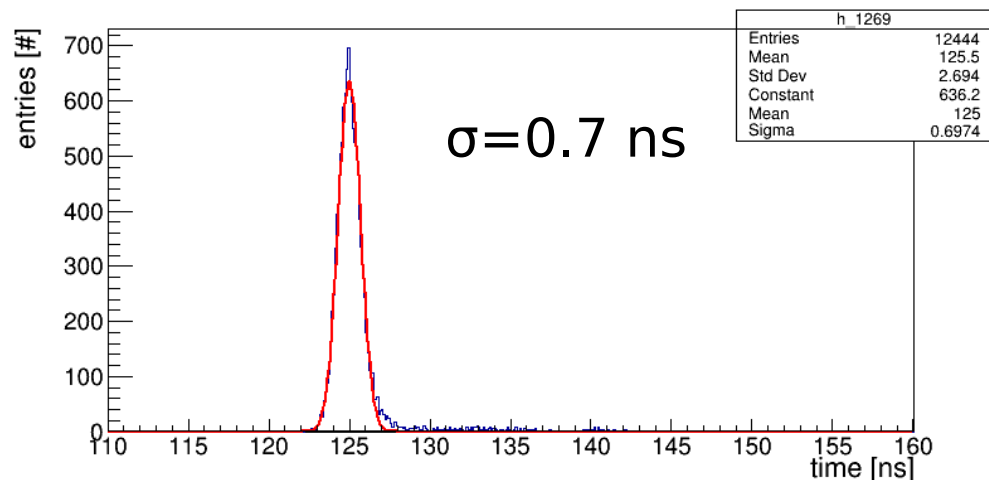
1000 V was used for most of the data

LED Hit Pattern

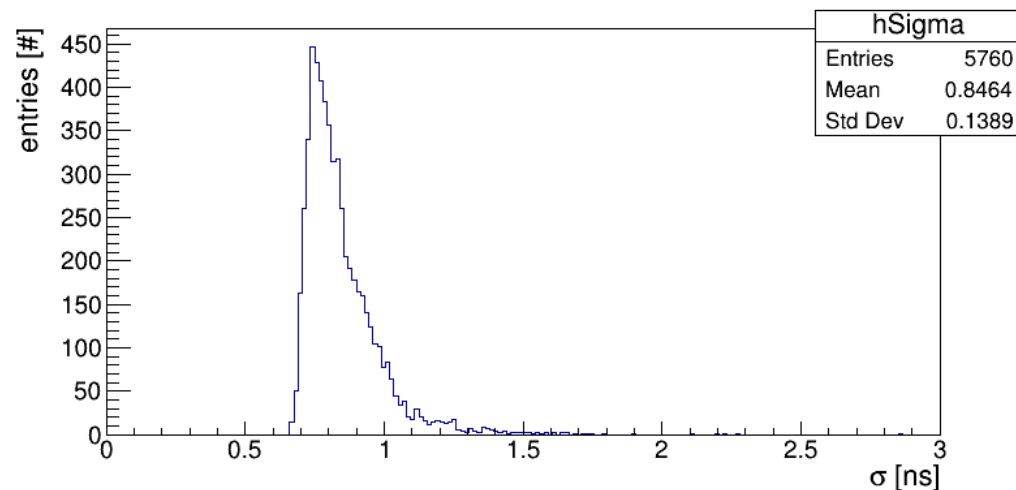


Time resolution from LED data

Example of time distribution for ch 1269:

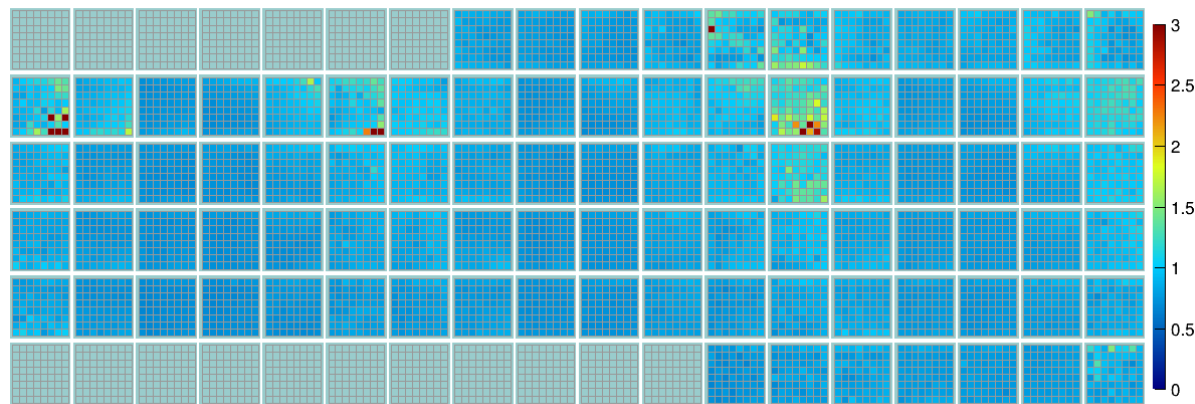


Resolution per channel after walk correction:

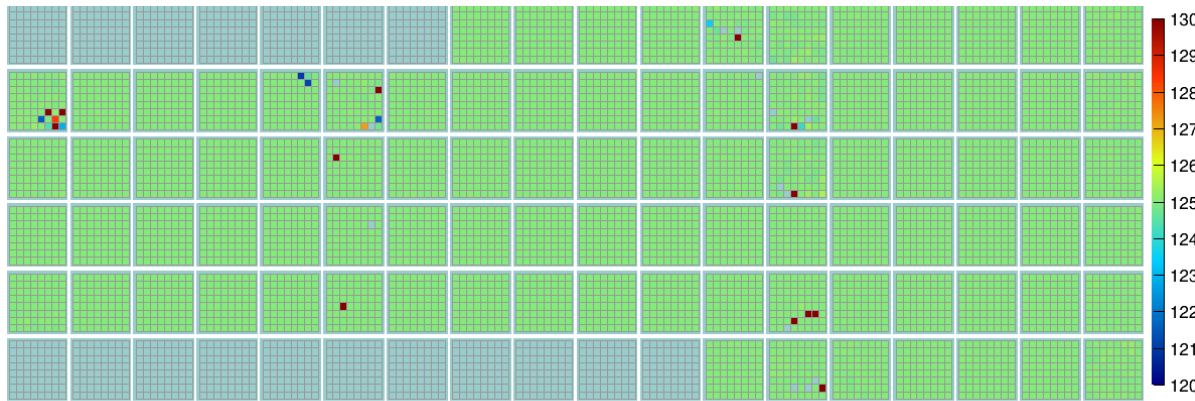


mean resolution 0.8 ns

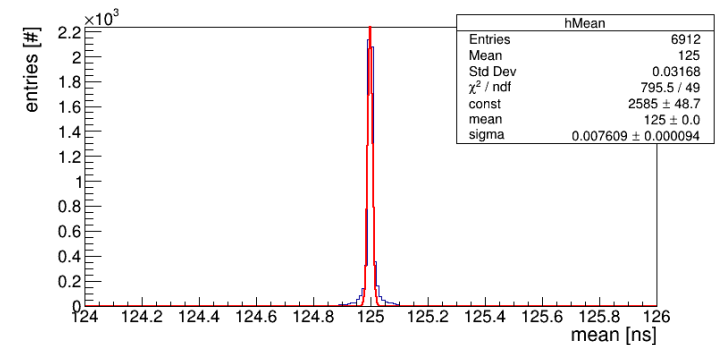
Time resolution from LED data



Time resolution [ns]

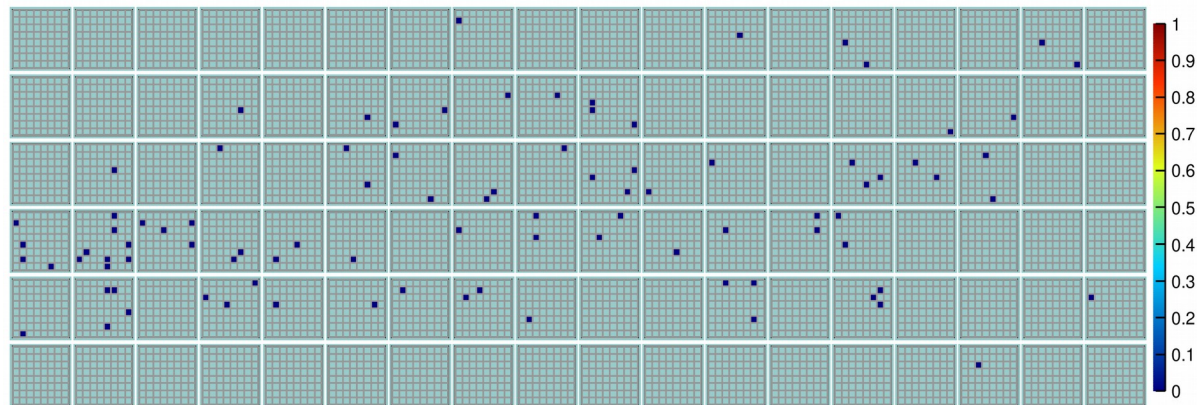


Time offsets [ns]



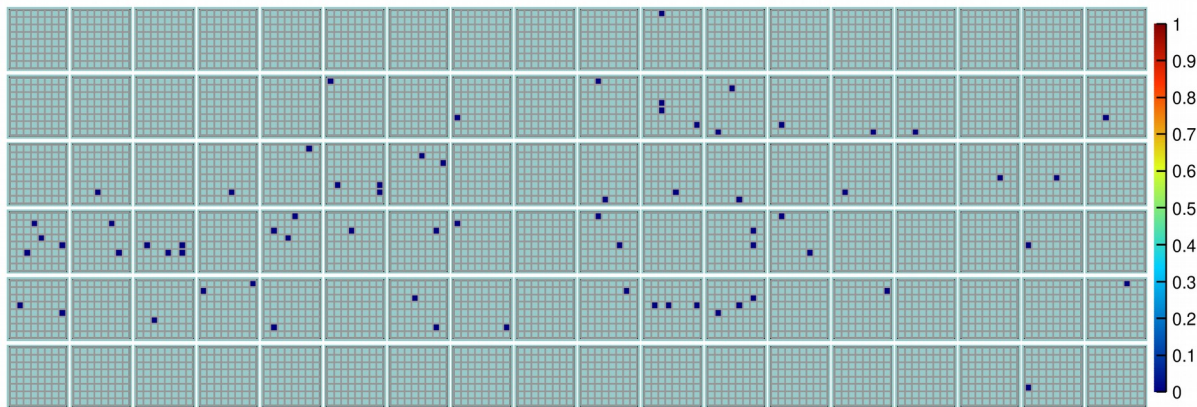
➔ Good start time alignment

Single Event Hit Patterns



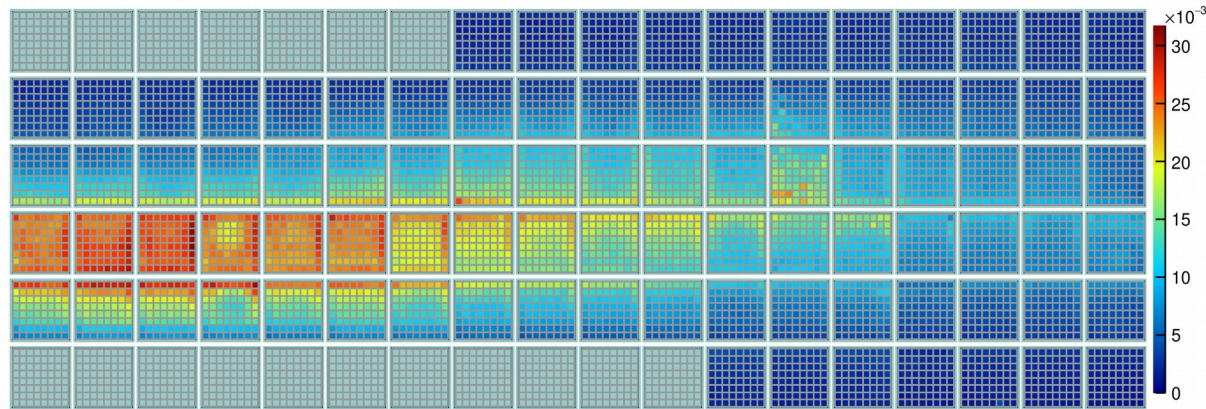
beam data, PID based on
reconstructed ρ, ϕ events

pion

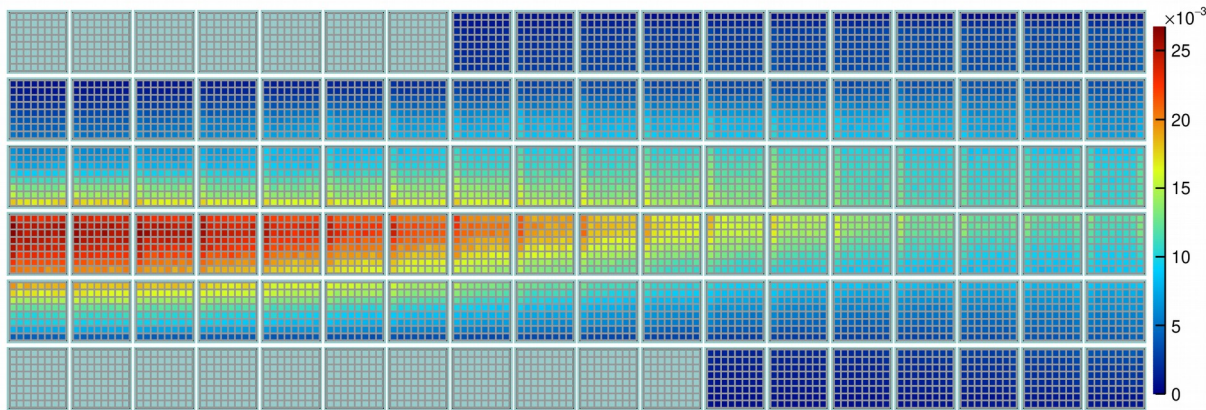


kaon

Hit Pattern Accumulated for All Angles



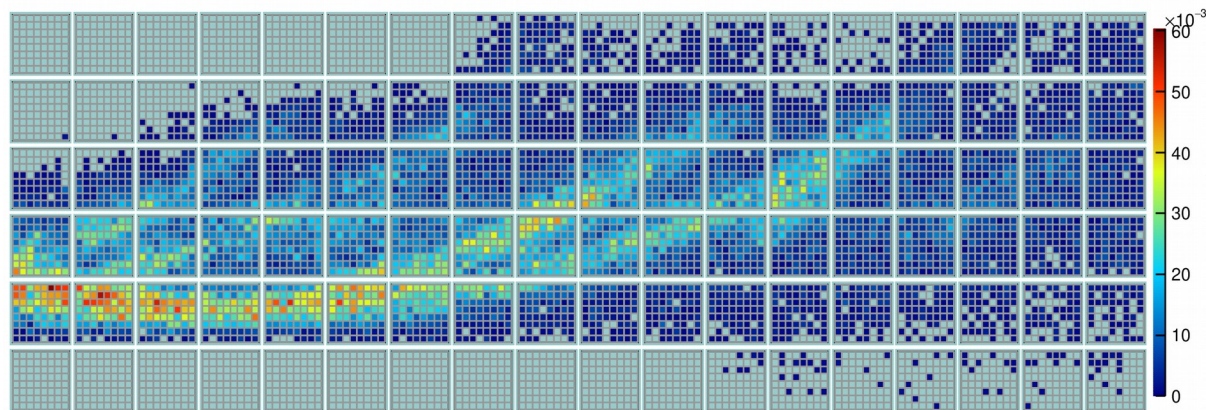
beam data



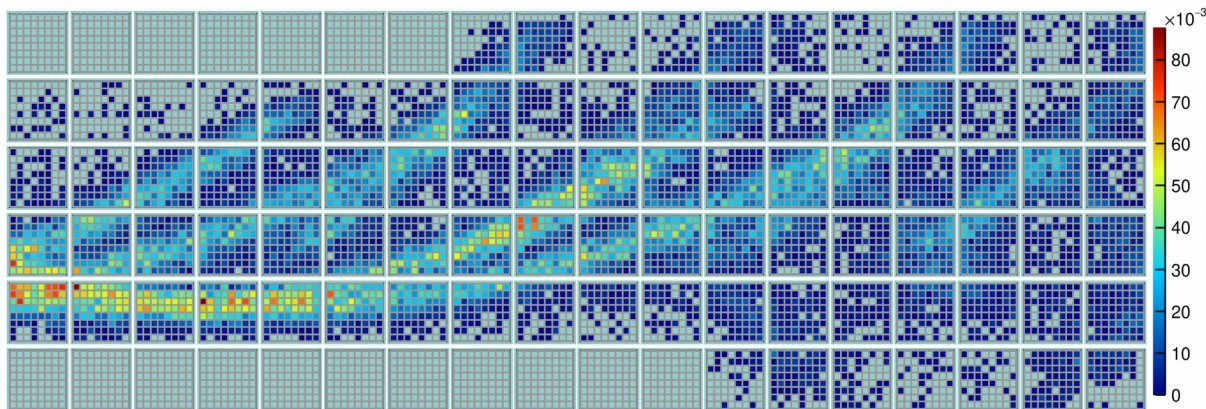
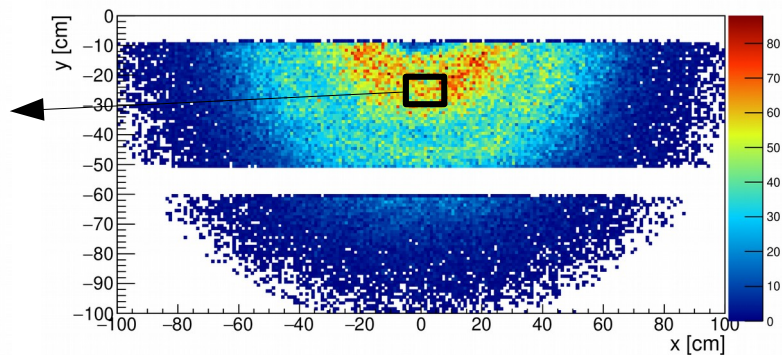
geant4

Hit Pattern

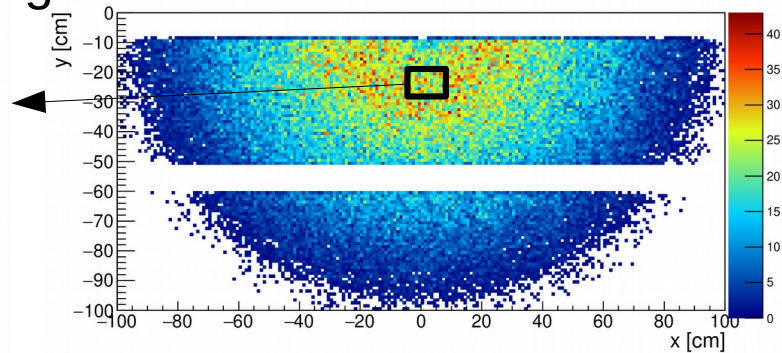
[3.8,4.2] GeV/c pions from beam



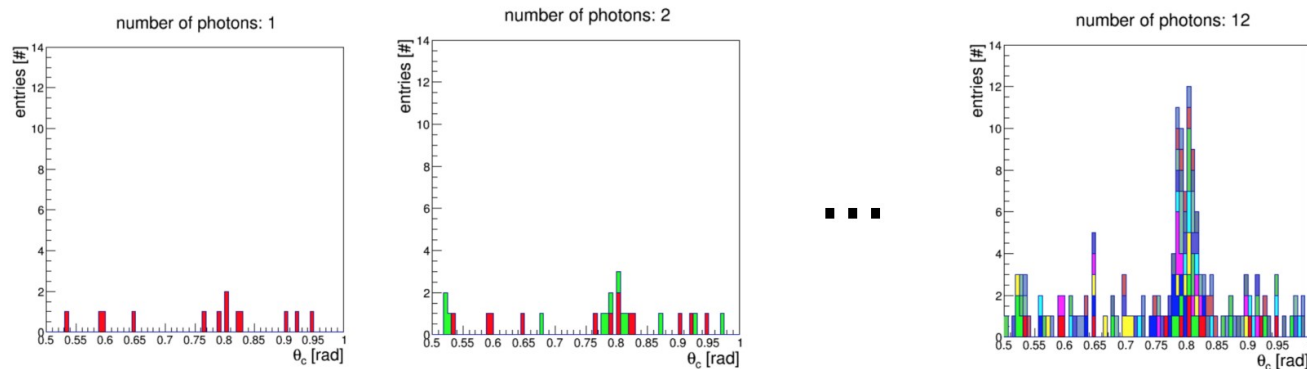
Hit positions on the radiator wall:



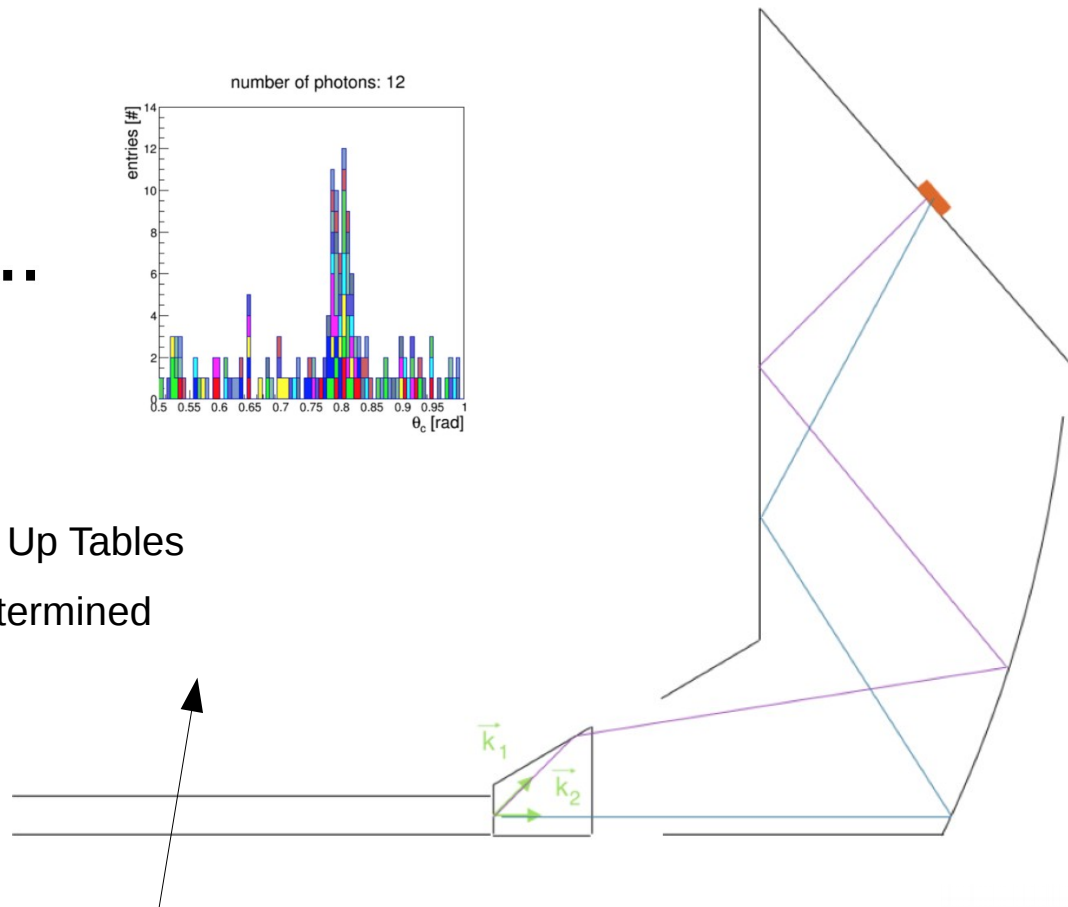
geant4



Geometrical Reconstruction

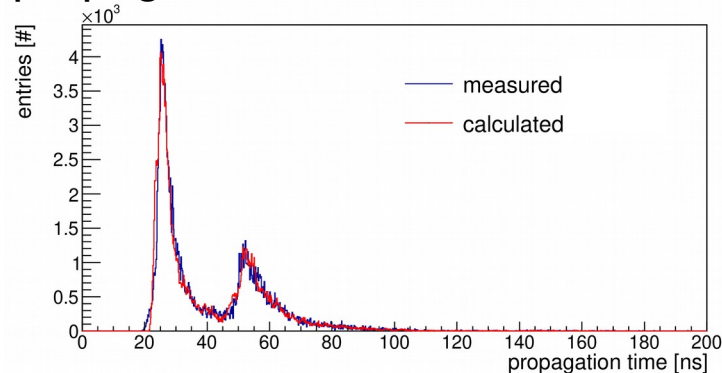


- Geometrical algorithm determine θ_c using Look Up Tables
- PID performed by unbind likelihood fit of the determined θ_c to different mass hypothesis

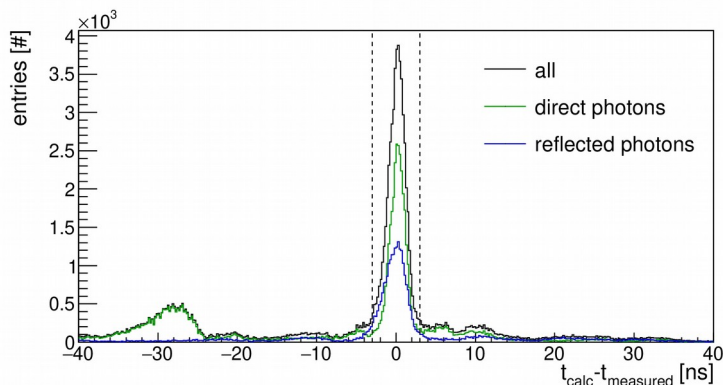
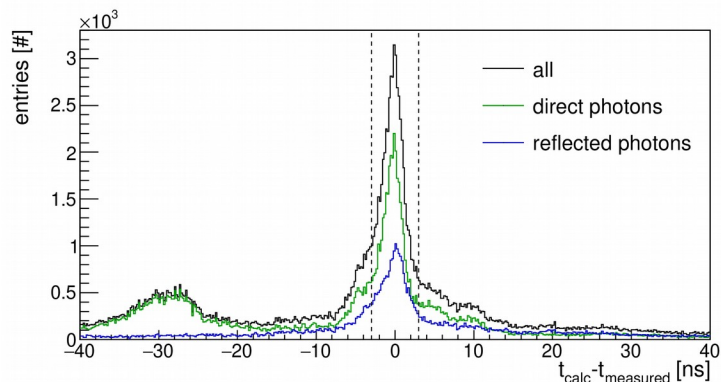
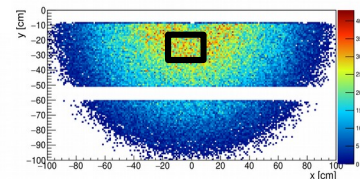
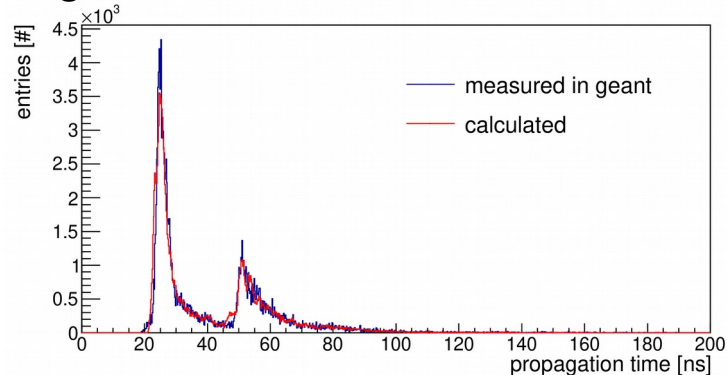


Geometrical Reconstruction

propagation time: beam data



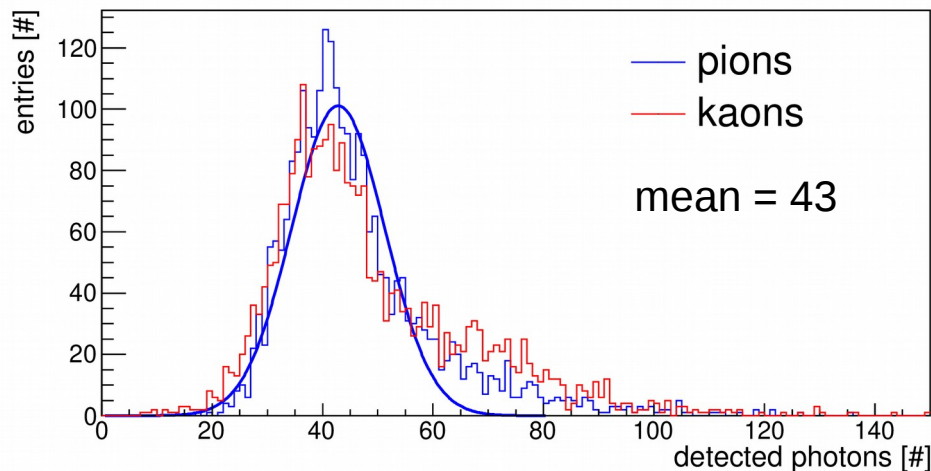
geant4 simulation:



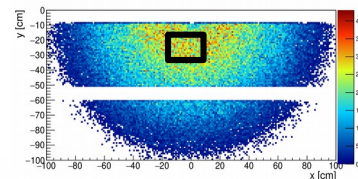
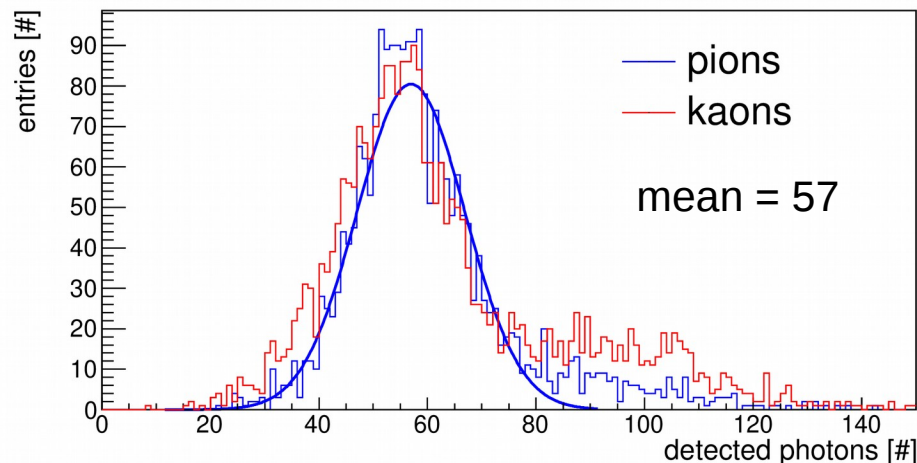
Reconstructed Photon Yield

pions and kaons @ [3.8,4.2] GeV/c:

beam data



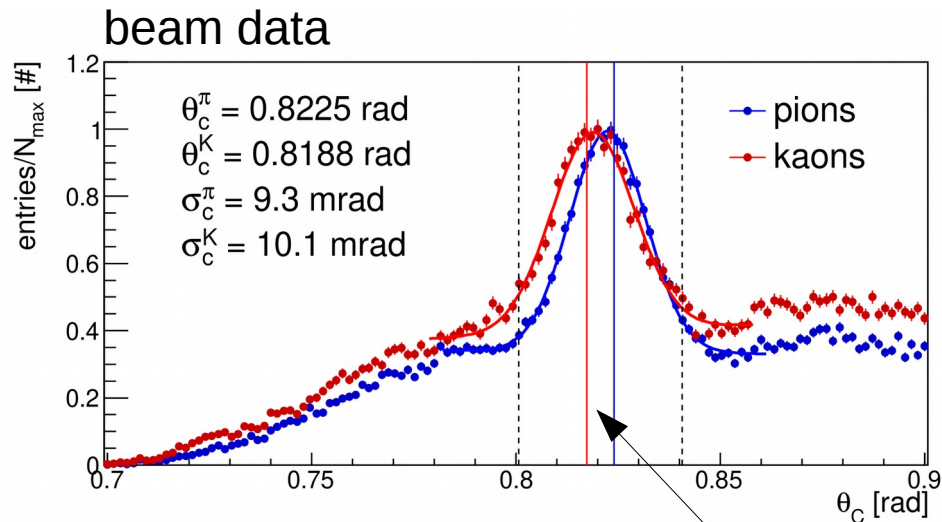
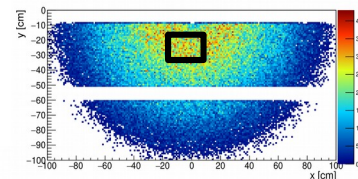
geant4 simulation:



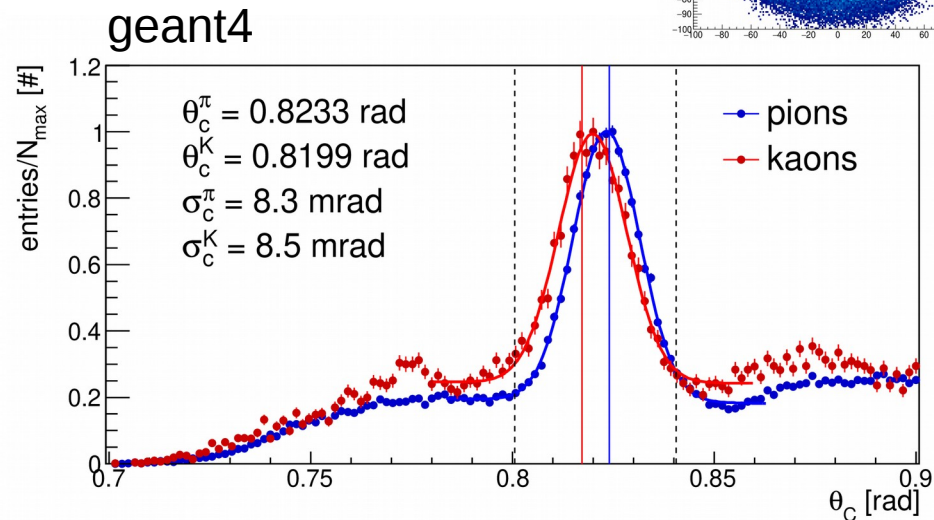
high photon yield but still some discrepancy with simulations

Geometrical Reconstruction

Reconstructed Cherenkov angle for pions and kaons @ [3.8,4.2] GeV/c:



expected θ_c for pions and kaons



obtained SPR 9-10 mrad

Summary

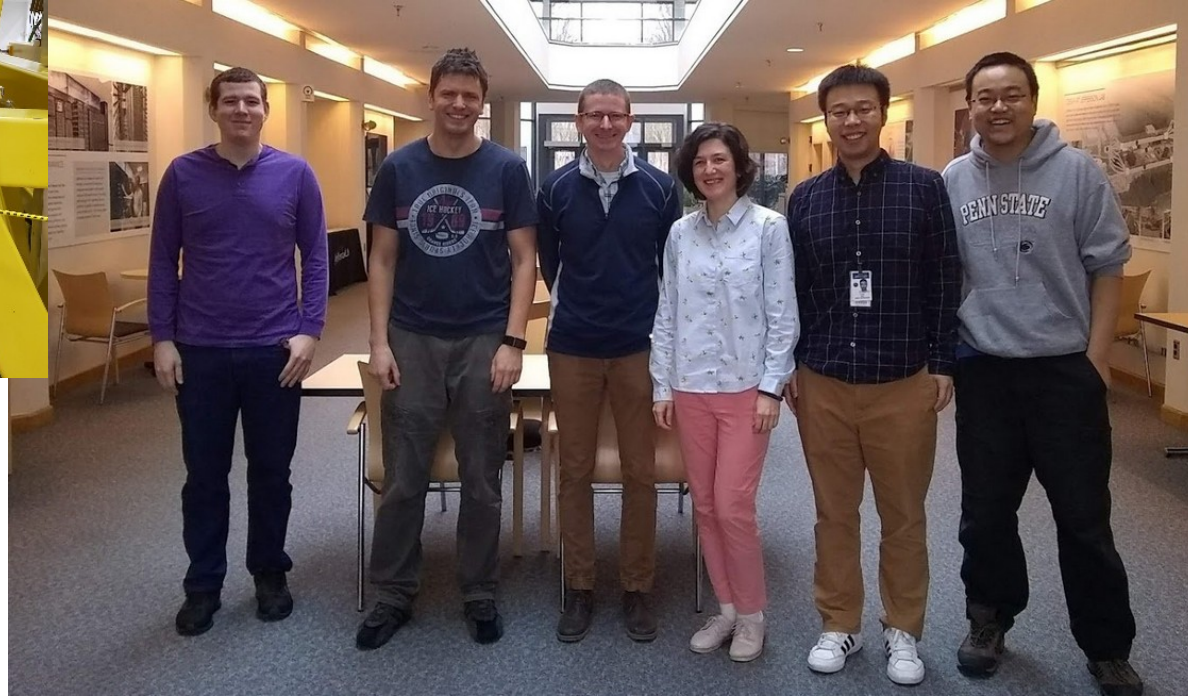
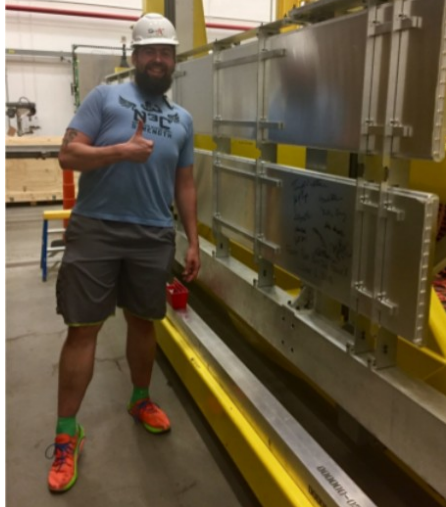
- The lower half of the DIRC was assembled and installed
- Air flow test, water/light leaks tests are OK
- DIRC readout was implemented into Hall D DAQ and online/offline monitoring
- Optimal gain and threshold for PMT's pixels were determined and used to collect ~10B triggers at various beam and detector conditions
- Sub nanosecond timing resolution was obtained
- Geometrical reconstruction algorithm (Look Up Table) was implemented into GlueX software and successfully used to reconstruct first data
- Demonstrated initial performance of the DIRC in terms of the photon yield and SPR
- Good agreement between beam data and geant4 simulations



Successful commissioning of the DIRC

Outlook

- Evaluation of the performance over all available phase space
- Geometric alignment using FastDIRC
- Per PMT/pixel θ_c correction
- Comparisons of beam intensity dependence and threshold dependence of the reconstruction
- Assembling and installation of the second half of the detector



Thank you for the attention