



*А.А. Воробьев, Н.И. Воропаев, В.Л. Головцов, Н.В. Грузинский, П.А.Кравцов,
П. Кравченко, С.М. Микиртычьянц, П.В. Неустроев, Э.М. Спириденков,
Л.Н.Уваров, С.Л.Уваров, В.И.Яцюра*

СИСТЕМА СБОРА ИНФОРМАЦИИ ЭКСПЕРИМЕНТА ПРОТОН

(PRES EXPERIMENT)



Detector system

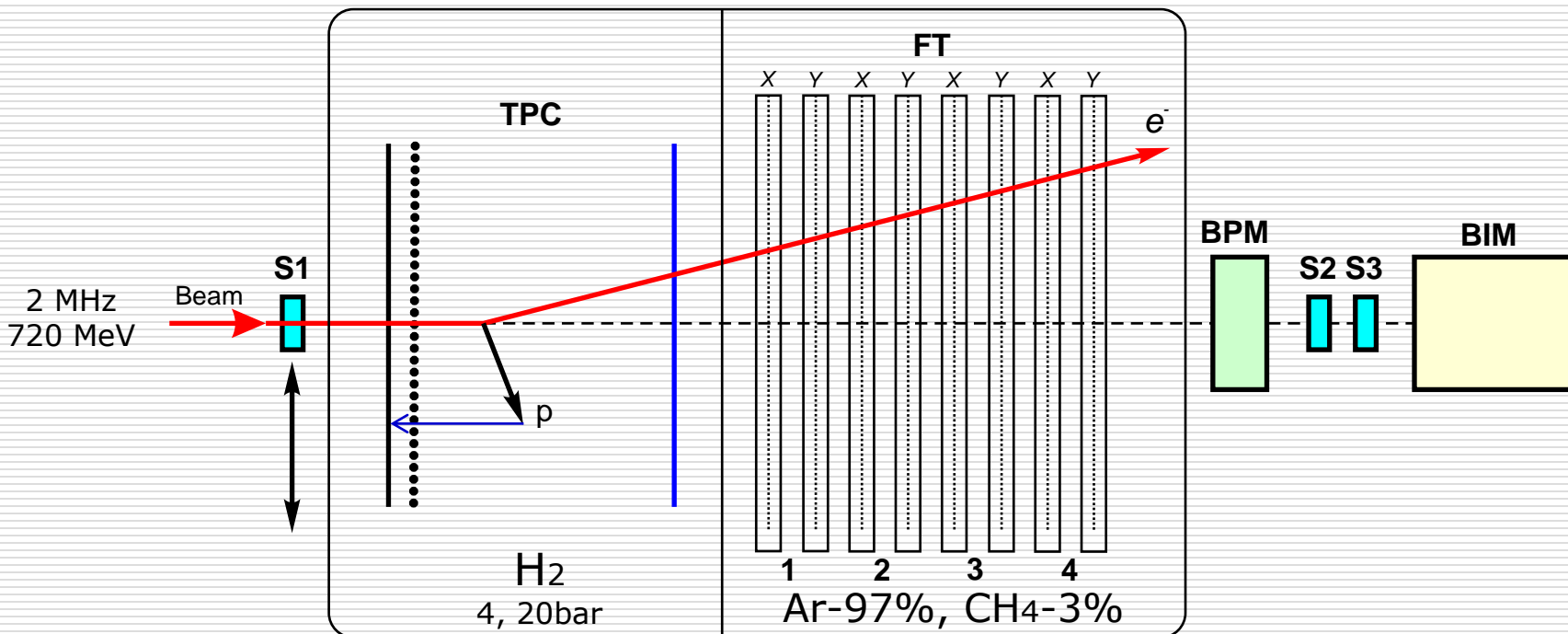
- Time Projection Chamber (TPC)
- Forward Tracker (FT)
- Beam Monitor counters (S1-S3)
- Beam position monitor (BPM)
- Beam intensity monitor (BIM)
- Beam energy 720 MeV

Time parameters

- Beam intensity: 2 MHz
- Trigger rate: ≤ 50 Hz
- Trigger source: TPC

User requirements

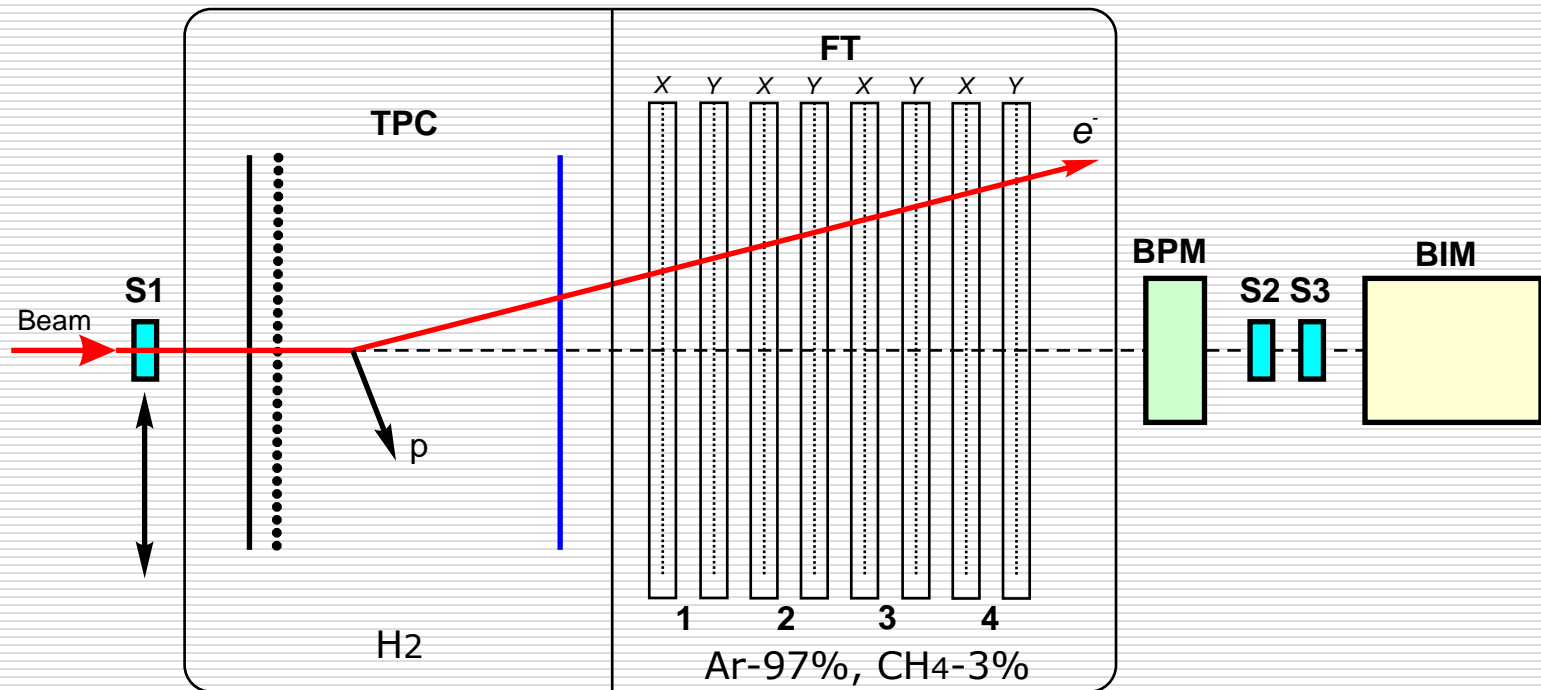
- Data logging
- Online data monitoring





Cathode strip chambers (MWPC) - FT

- 8 chambers (4 XY-layers) + (8 U-layers $\pm 45^\circ$)
- 240x2.5mm strips in each chamber (240x5=1200 wires)
- Back side strips joined into 12 strips (8 U-layers $\pm 45^\circ$)
- 2016 channels in total: $(240 \times 8) + (12 \times 8) = 2016$ channels
- $(40 + 8) = 48$ cards ASF48et (48 channels each)

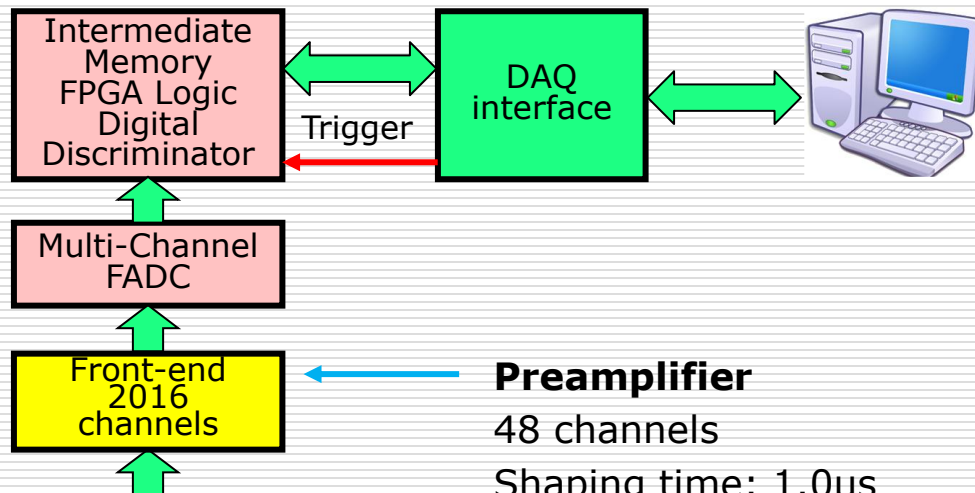




Forward tracker electronics

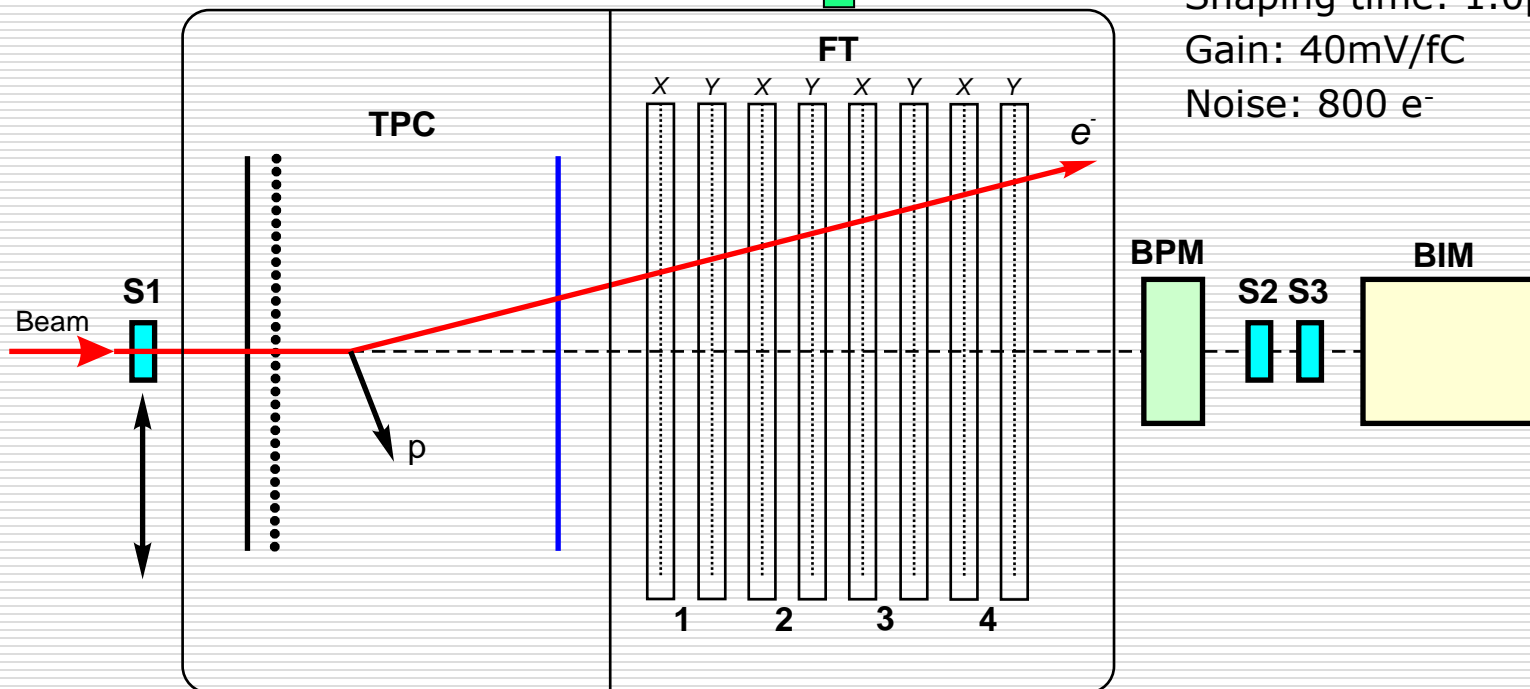
DAQ card (ASF48et) – 48 cards

- 48 independent readout channels/card
- Digital discriminator in each channel
- Option to run adjacent channels
- 12-bit 25MHz pipeline FADC
- Common system clock 100MHz
- Memory:
 - L1 1k words per channel,
 - L2 32k words per card
- Low dead time level



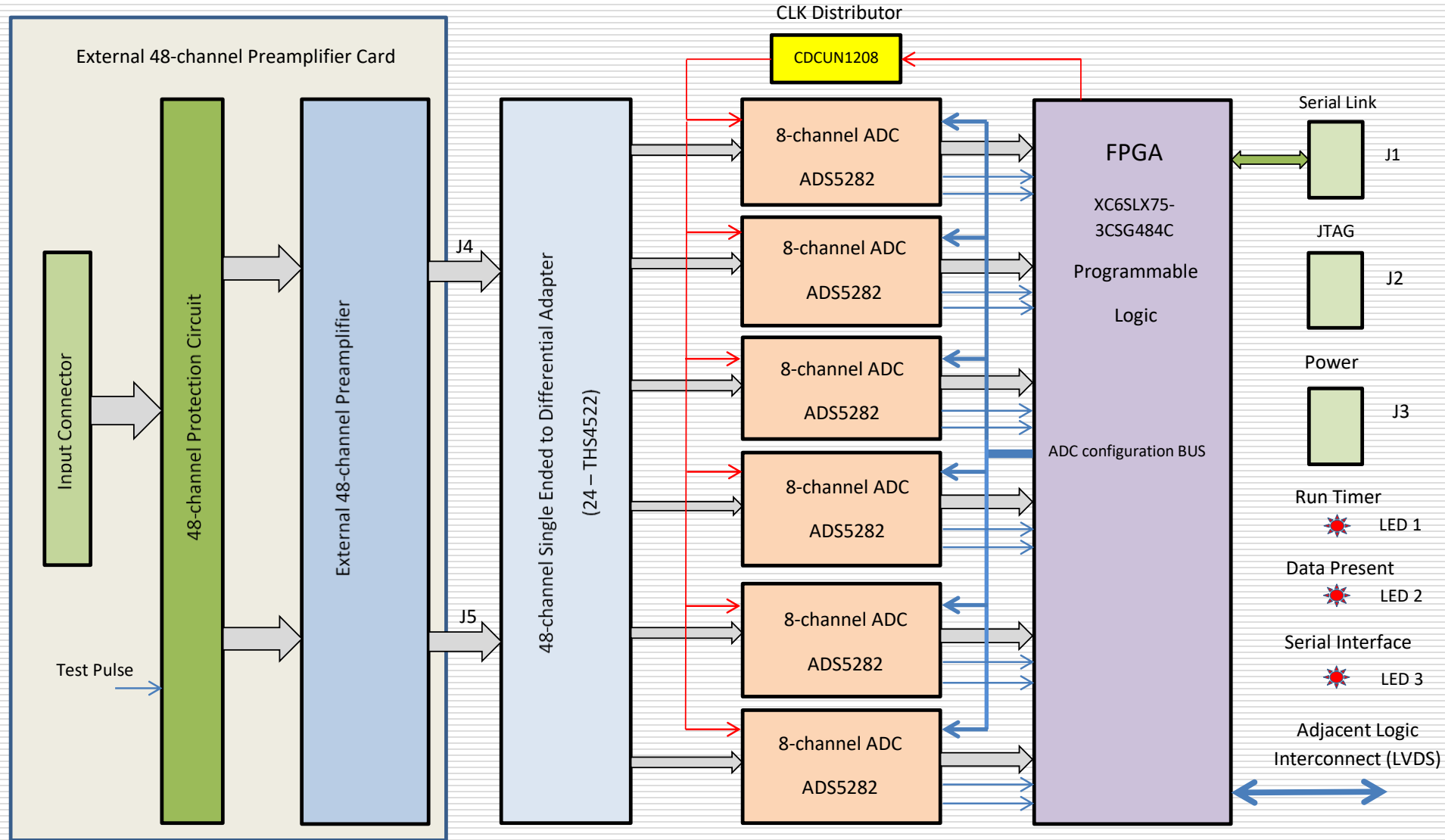
Preamplifier

48 channels
 Shaping time: 1.0 μ s
 Gain: 40mV/fC
 Noise: 800 e⁻

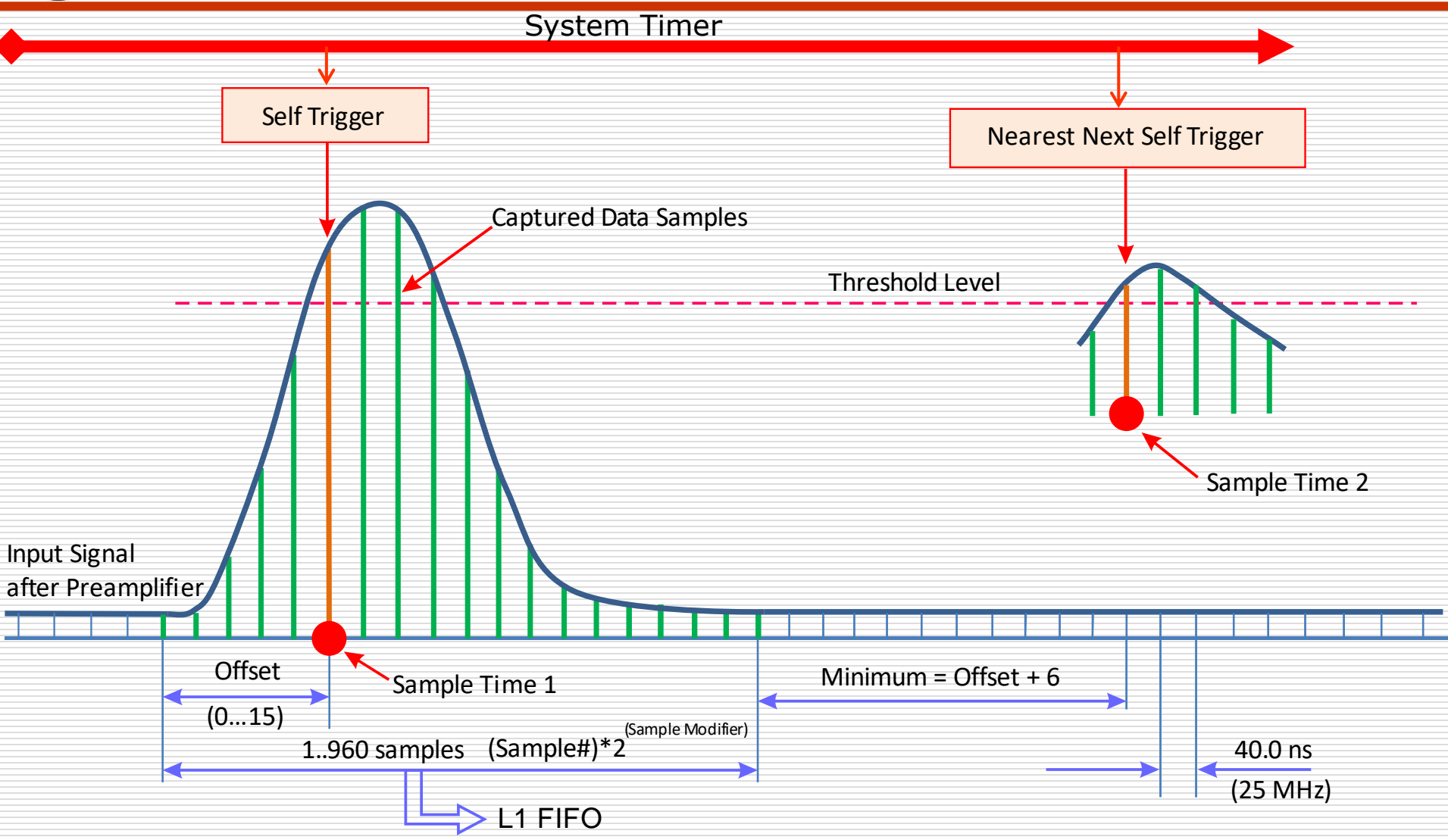


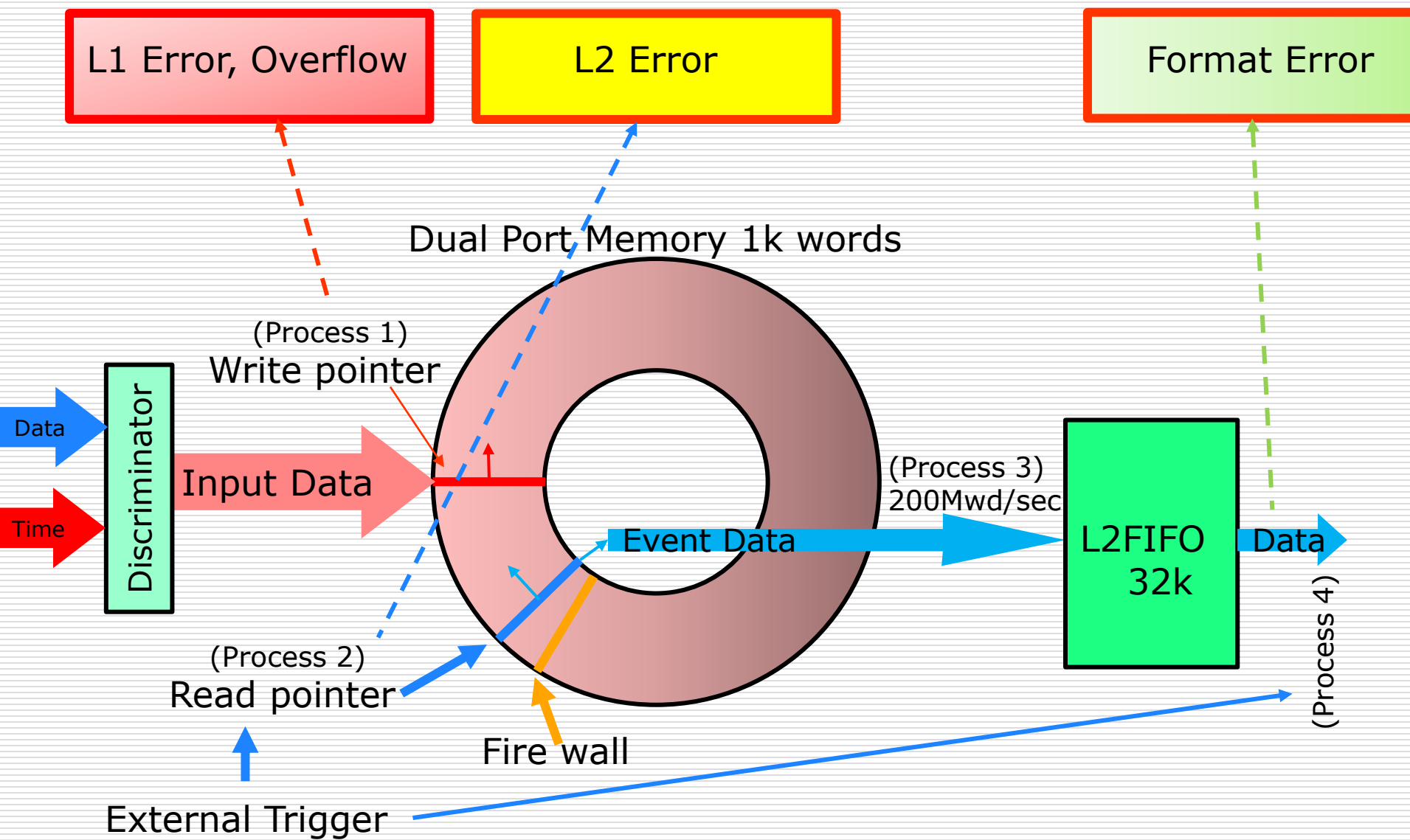


ASF48et diagram



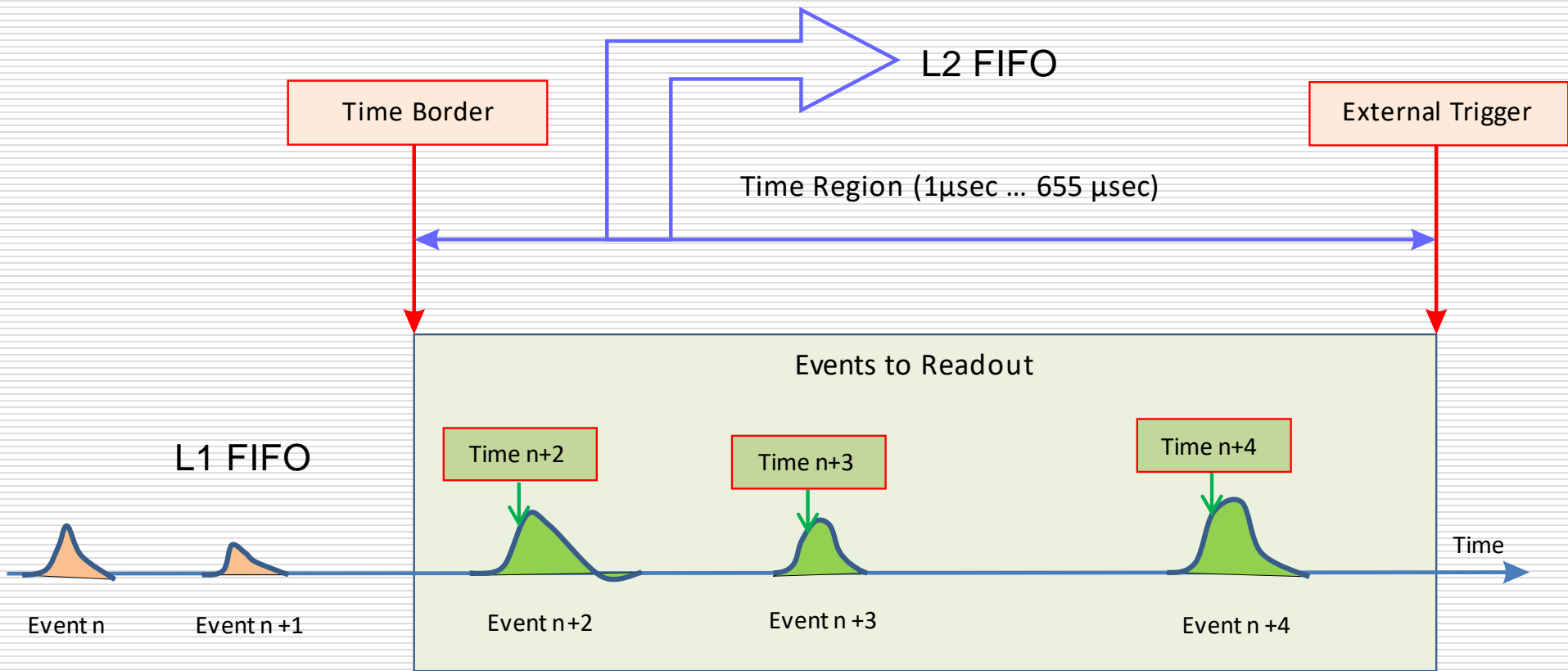
ASF48et signal processing (single channel)





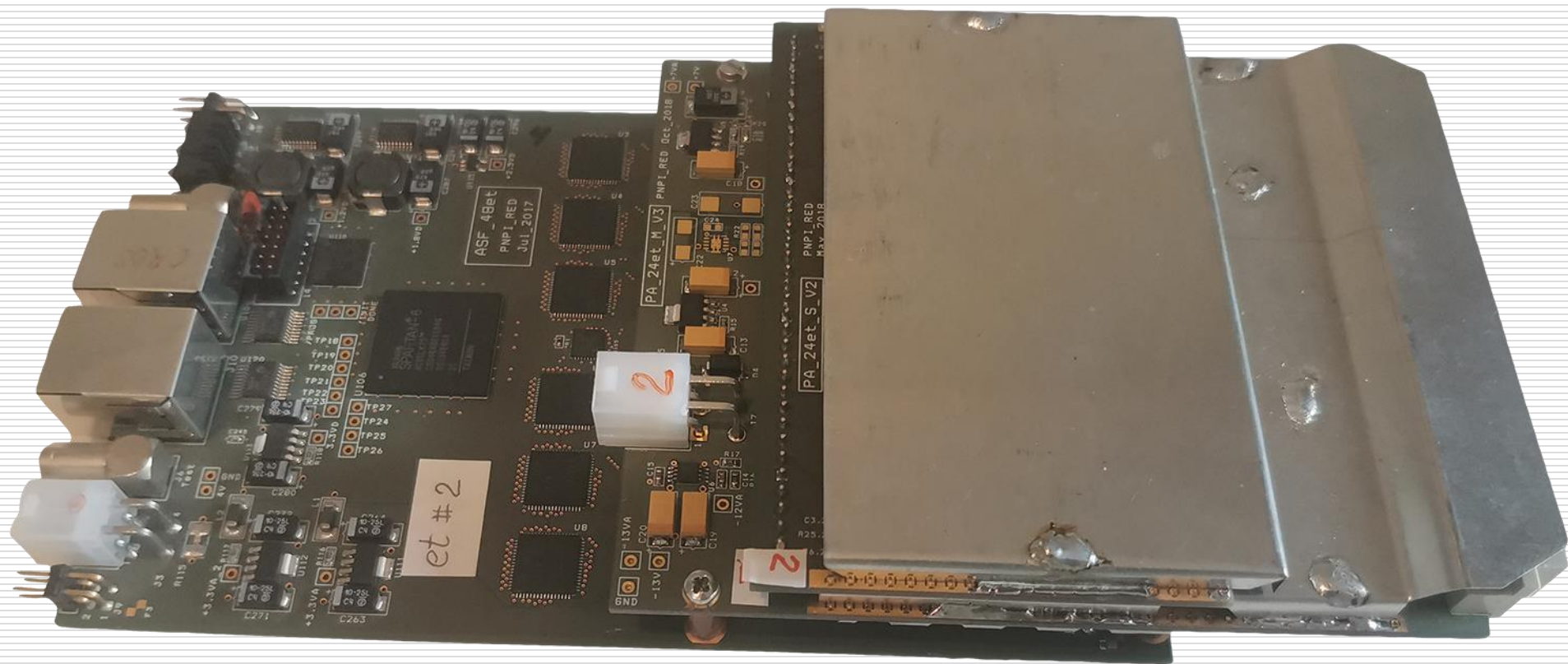


ASF48et signal processing (external trigger)



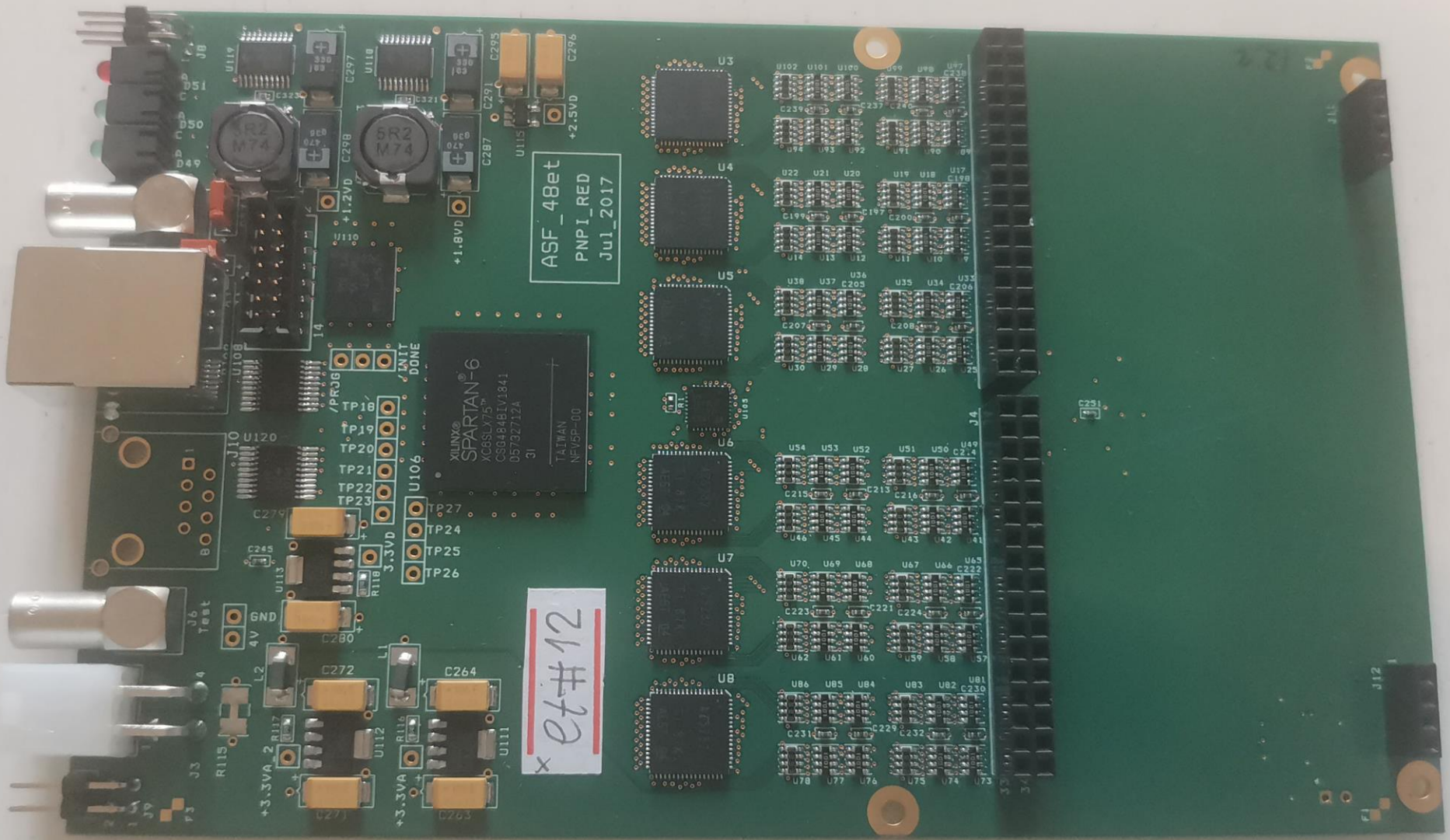


ASF48et with preamplifier



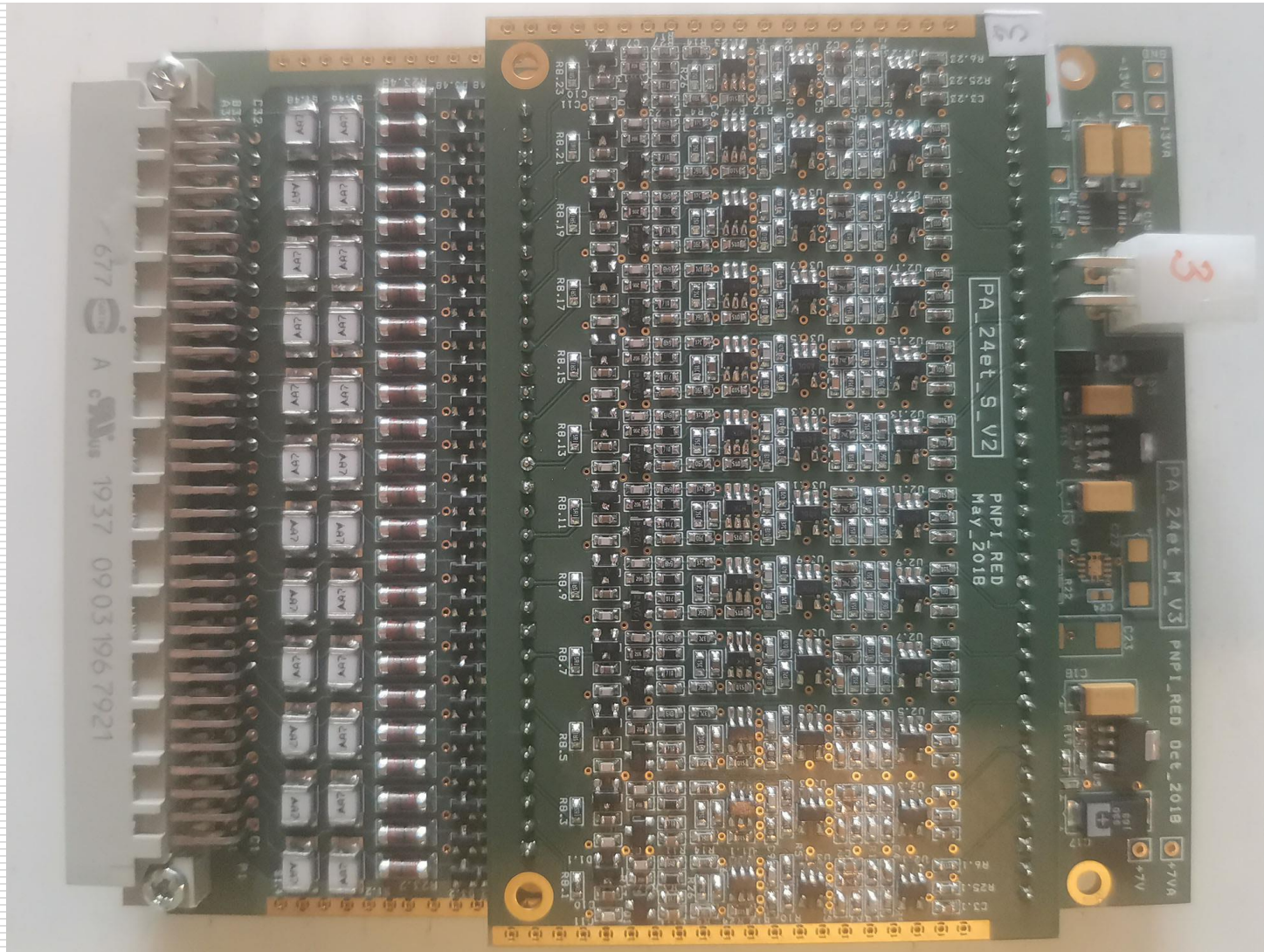


ASF48et no preamplifier (digitizer only)





48-channel preamplifier





Forward tracker event rate simulation

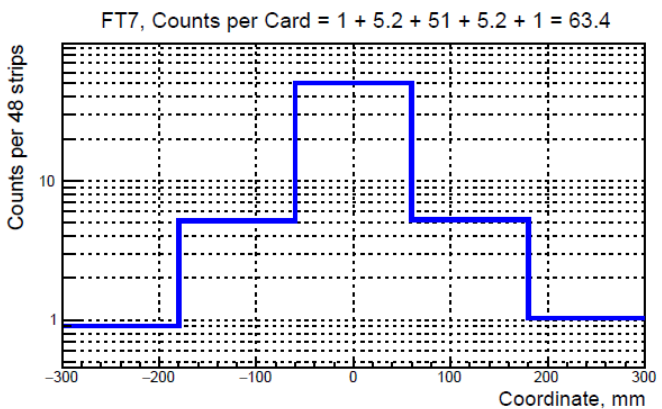
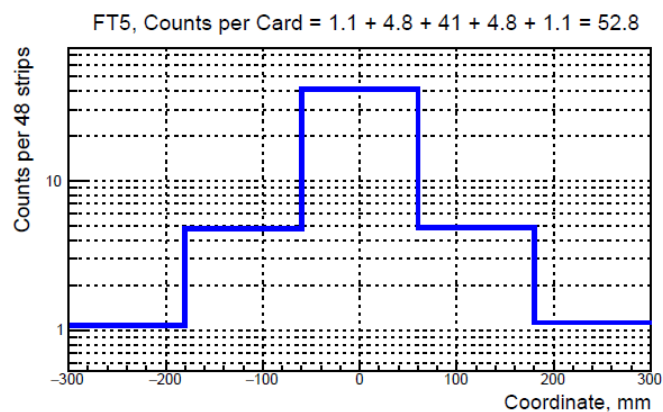
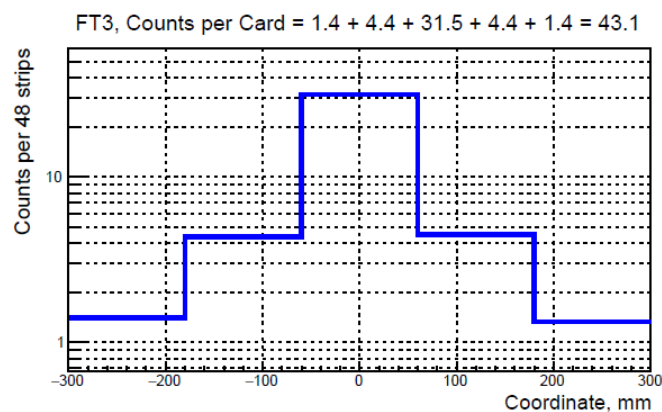
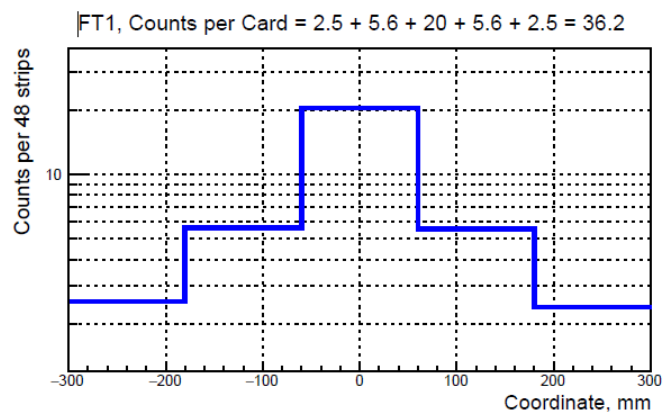
MC simulation FT1, FT3, FT5, FT7

Beam intensity: 2MHz

200 electrons per event (100 μ s)

Recoil energy: 1-10MeV

Average 6 strips (hits) per track





Forward tracker event rate simulation

MC simulation

- ❑ Beam intensity: 2MHz
- ❑ 200 electrons per event (100μs)
- ❑ Recoil energy: 1-10MeV
- ❑ Average 6 strips (hits) per track

Total rate in forward tracker at 50Hz trigger rate:

$$490\text{hit/trigg} \times 50\text{Hz} = 24500 \text{ hit/sec}$$

With 60 ADC samples per signal (hit) data rate:

$$24500 \text{ hit/sec} \times 64\text{words/hit} = 1568000 \text{ words/sec } (**3.14 \text{ Mbyte/sec}**)$$

$$82 \text{ hit/trigg} \times 50\text{Hz} \times 64\text{words/hit} = 262400 \text{ words/sec } (< 5\%)$$

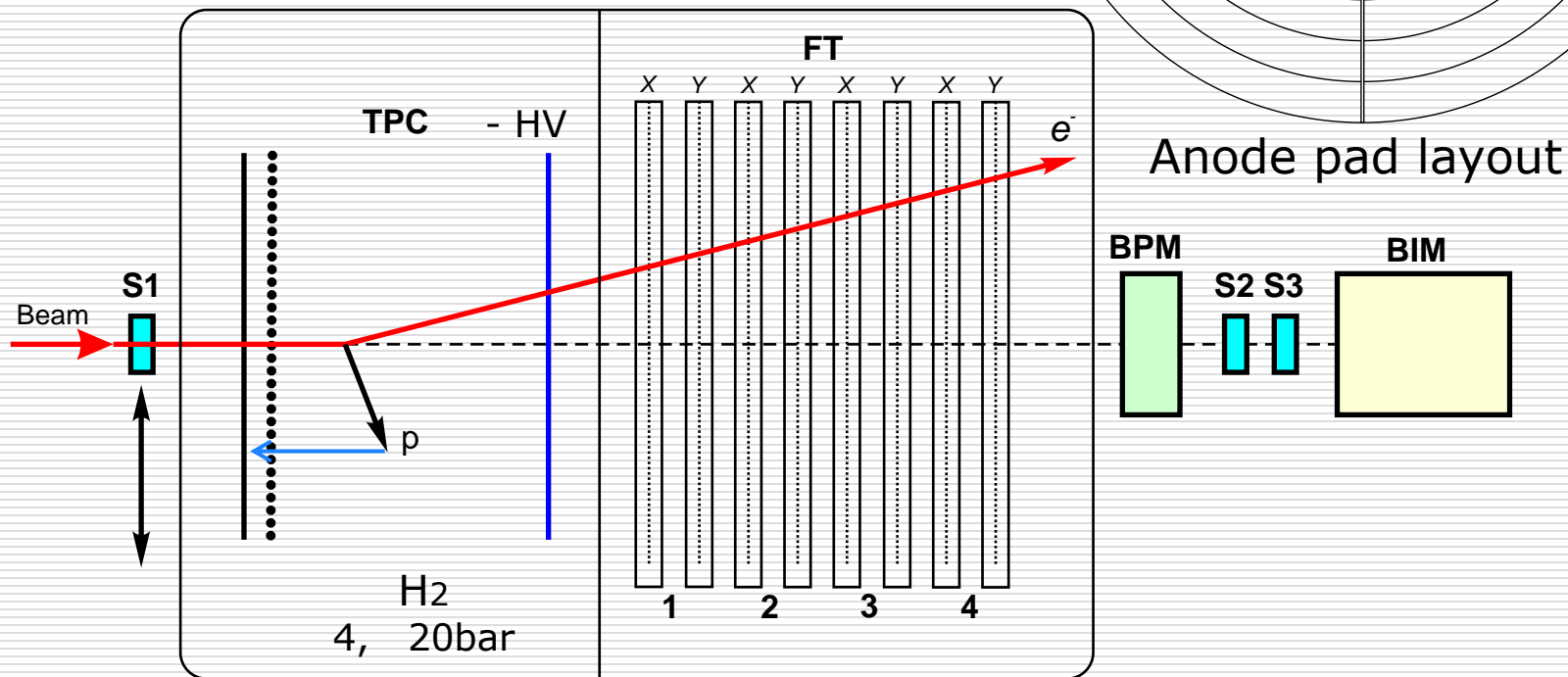
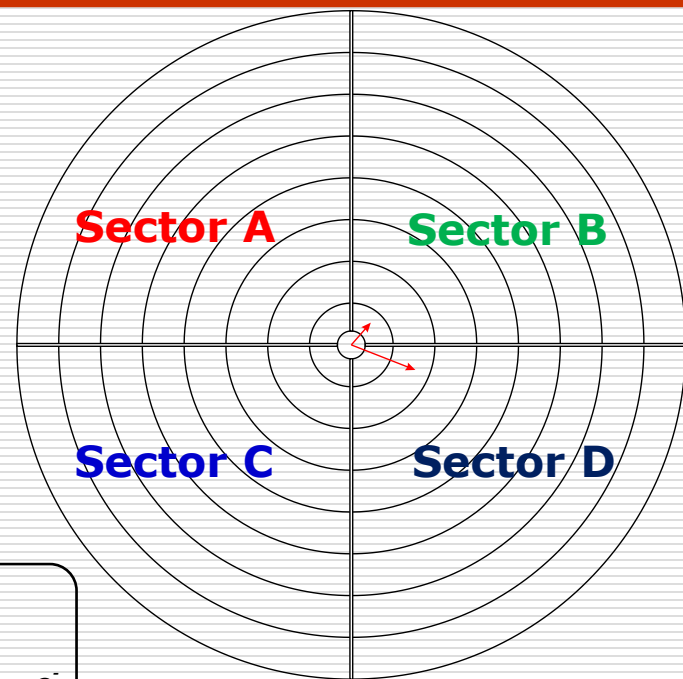
Average hits per trigger (100μs)

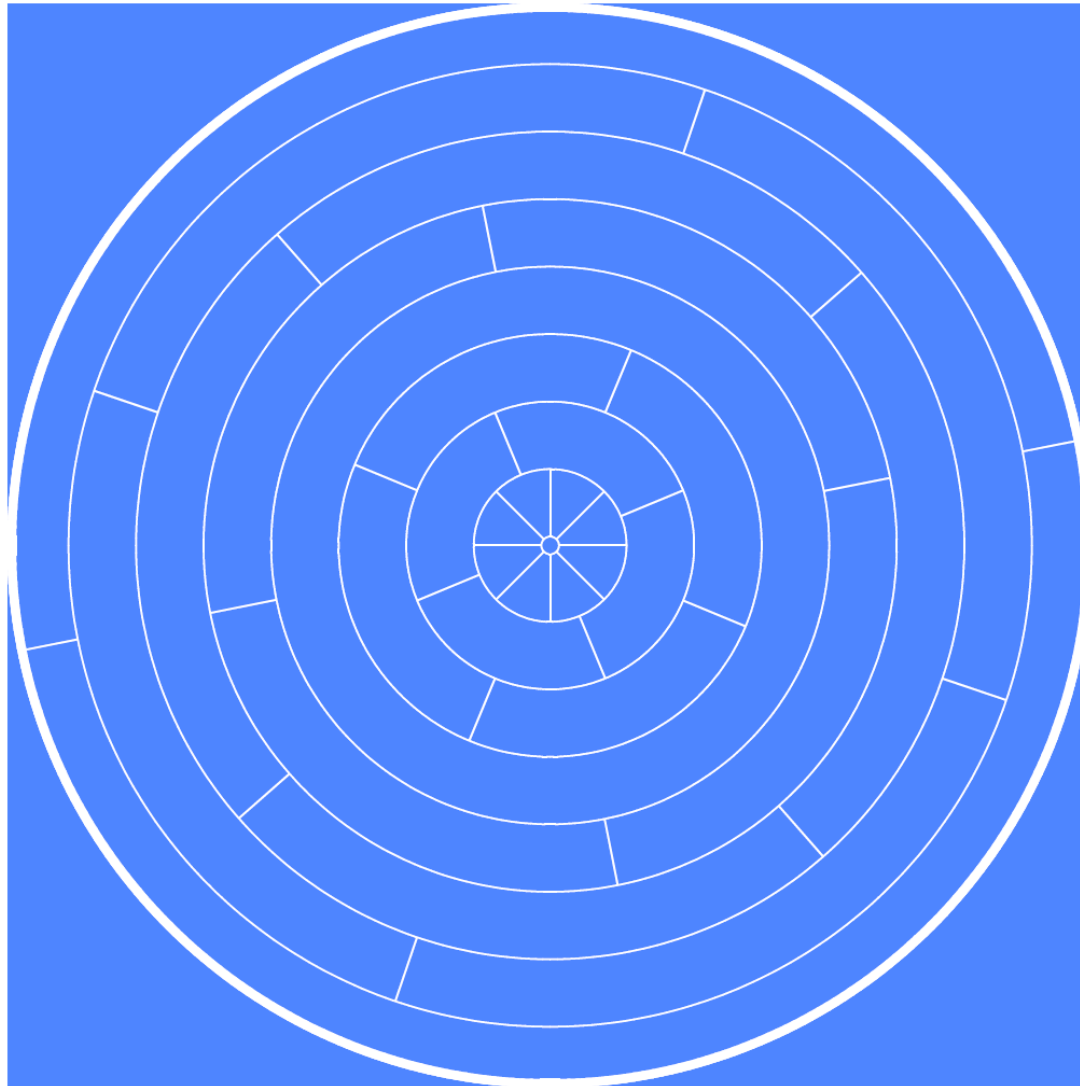
	Card/plane							
Plane	1	2	3	4	5	Z	Sum	R/O
FT1	2,5h/t	5,6h/t	20h/t	5,6h/t	2,5h/t	7,6h/t	43,8h/t	90h/trigg
FT2	1,7h/t	4,6h/t	26h/t	4,6h/t	1,7h/t	7,6h/t	46.2h/t	5760w/trigg
FT3	1,4h/t	4,4h/t	31,5h/t	4,4h/t	1,4h/t	8,6h/t	51,7h/t	108,3h/trigg
FT4	1,2h/t	4,6h/t	36h/t	4,6h/t	1,2h/t	9h/t	56,6h/t	6912w/trigg
FT5	1,1h/t	4,8h/t	41h/t	4,8h/t	1,1h/t	10h/t	62,8h/t	132,1h/trigg
FT6	1h/t	5h/t	46h/t	5h/t	1h/t	11,3h/t	69,3h/t	8448w/trigg
FT7	1h/t	5,2h/t	51h/t	5,2h/t	1h/t	13h/t	76,4h/t	158,2h/trigg
FT8	1h/t	5,4h/t	55h/t	5,4h/t	1h/t	14h/t	81,8h/t	10112w/trigg



Time Projection Chamber

- 32 channels (8 rings)
- 4 Cards ASF12eP (8 chann/card)
- 100 μ s maximum drift time
- Complex trigger logic
- System trigger request generation
- Recoil energy: 1-10MeV
- Beam energy 720 MeV

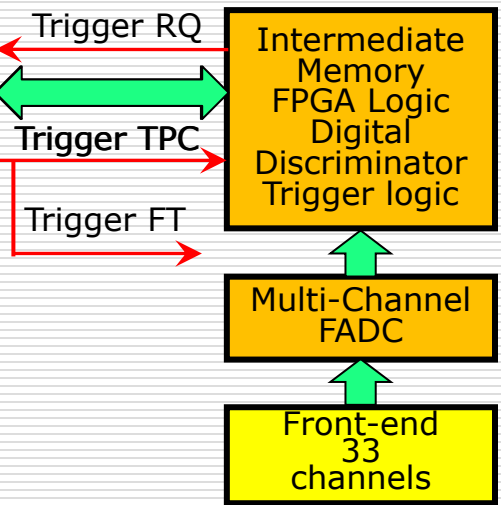
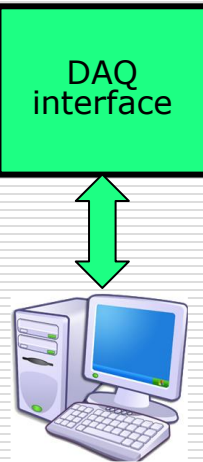




Anode pad layout

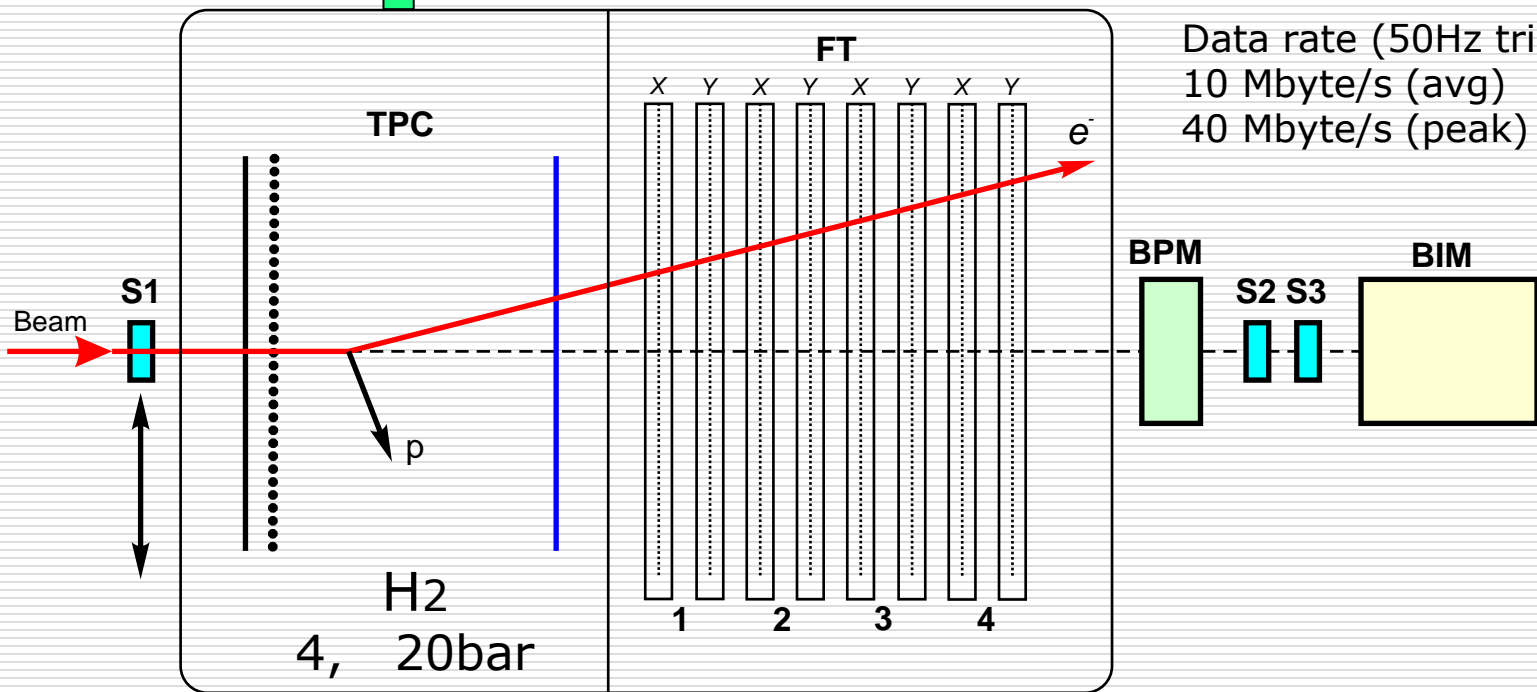


TPC electronics ASF12eP



DAQ card (ASF12eP)

- 8-12 independent readout channels/card
- Dual Digital discriminator in each channel (Single sample or integrated window)
- System trigger request generation logic
- 12-bit 25MHz pipeline FADC
- Common system clock 100MHz
- Memory:
L1 8k words per channel,
L2 32k words per card



Data rate (50Hz trigger):
10 Mbyte/s (avg)
40 Mbyte/s (peak)

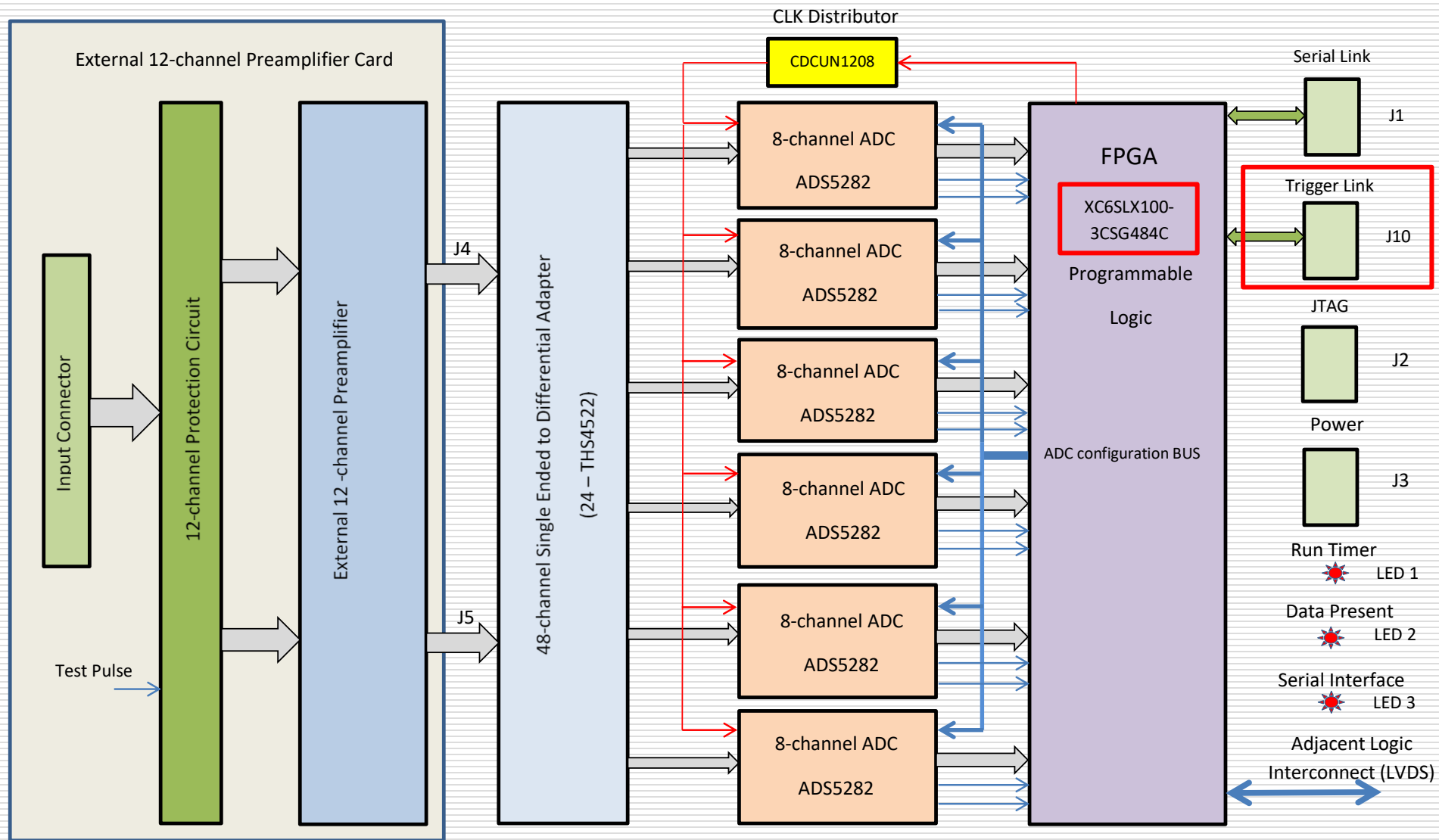


ASF12eP - 12 channel DAQ card

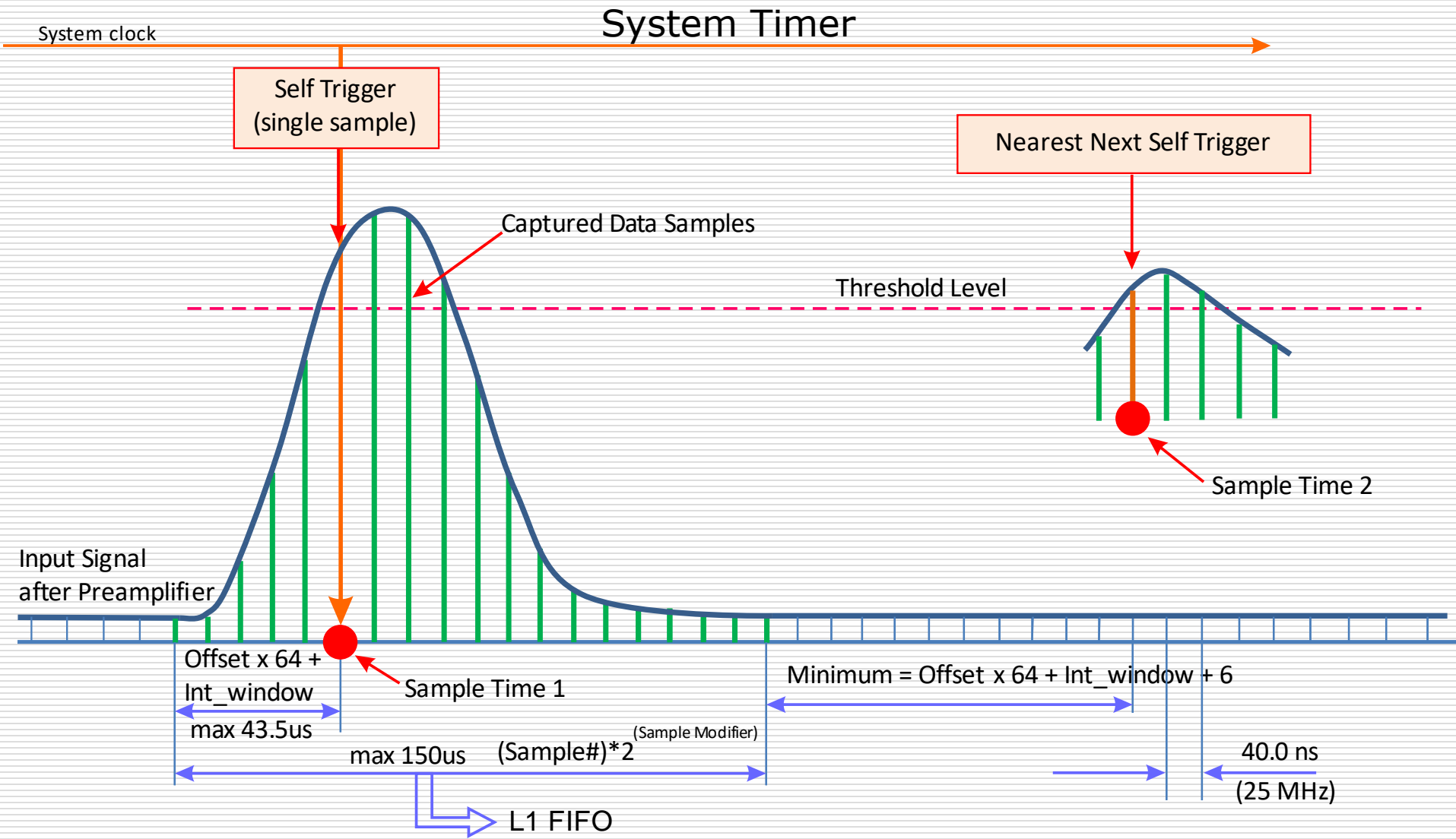




ASF12eP diagram

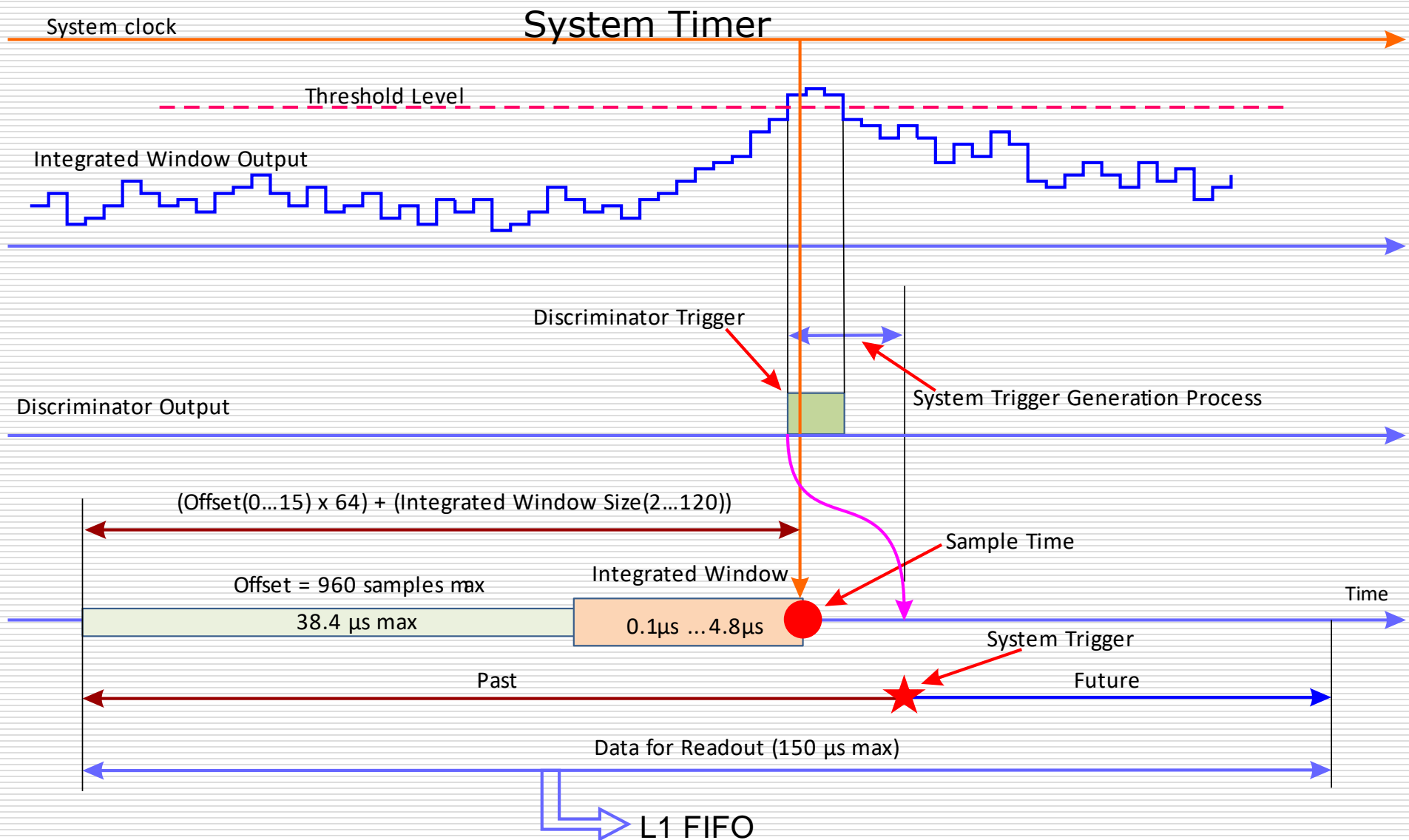


ASF48eP signal processing (single channel)





ASF48eP signal processing (integration window)





Простейший случай:

- Выходы всех дискриминаторов ТРС соединены по **ИЛИ**.
- Каждому электроду ТРС соответствуют два дискриминатора интегрирующий и одиночный
- Каждый из дискриминаторов может быть исключен из «**ИЛИ**»
- При срабатывании одного или нескольких дискриминаторов вырабатывается импульс – **TRIGG REQ** – запрос на системный триггер



Системный триггер, запускает все каналы детектора TPC.

Сигналы со всех электродов TPC считываются и записываются, начиная с заказанного OFFSET-а, (43 μsec max) перед триггером и 40...70 μsec после триггера.

Для увеличения пропускной способности системы рекомендуется выбирать число регистрируемых отсчетов минимально необходимым.

С другой стороны хотелось бы запускать не все каналы, а только «нужные». Однако при этом требуется куда более изощренная логика и всегда существует риск безвозвратной потери данных.

Поэтому плата за прием информации со всех электродов не представляется чрезмерной.



Рассмотрим случай:

- средняя частота триггера – 50 Hz,
- временная апертюра – 100 μ sec (2500 отсчетов на канал),
- 8 используемых каналов на карту.

В этом случае поток данных, порождаемый одной картой, составит:
 $2500 \times 8 \times 50 \text{ Hz} = 1 \text{ Mword/sec}$.

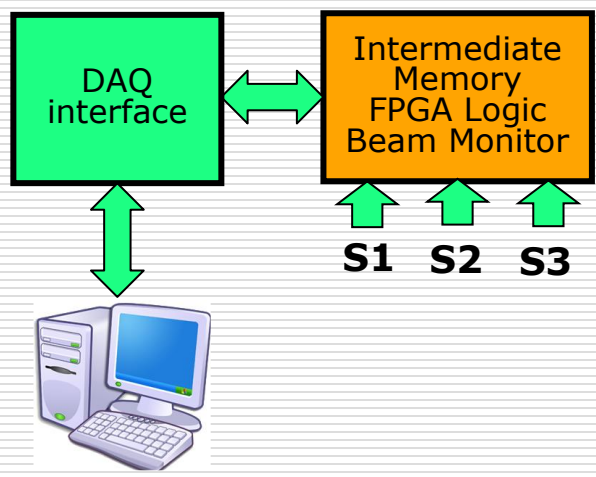
При этом загрузка выходного линка данной карты составляет 20%. Соответственно, поток данных с TPC (4 карты ASF12eP) составит 4 Mword/sec (64 Mbit/sec).

При этом поток данных, порождаемый трекером (48 карт ASF48et – 1920 + 48) не превышает 1.5 – 2 Mword/sec (32 Mbit/sec), т е всего 96 Mbit/sec.

Таким образом ожидается, при средней частоте триггера 50 Hz, поток данных от TPC и Forward tracker-а не должен превышать 100 Mbit/sec.



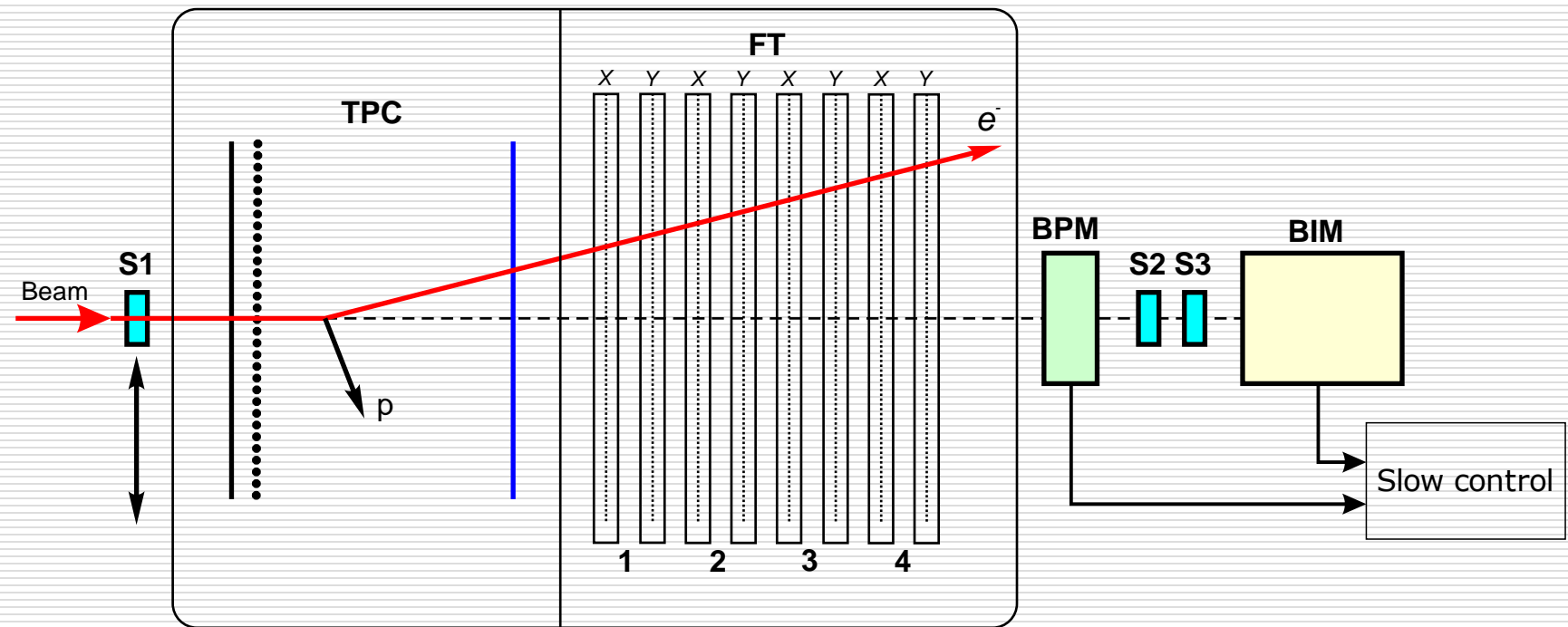
Beam counters electronics



DAQ card (BM-01)

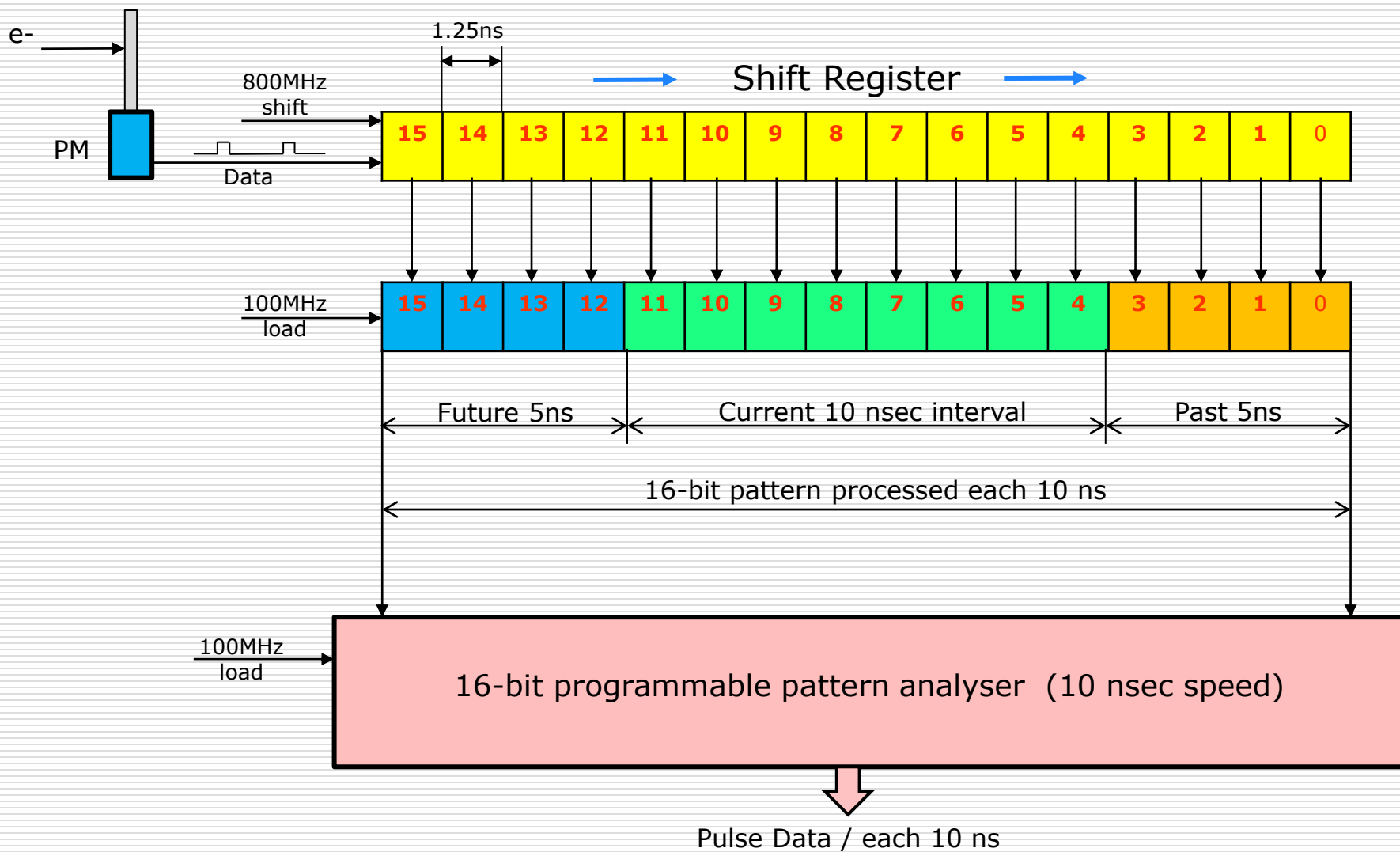
- 800MHz sampling clock (1.25ns resolution)
- 8 Independent Channels
- Common system clock 100MHz
- Generates Set of Test Pulses
- Memory:
 - L1 2048 events per channel (8k words/chann)
 - L2 32k words per card (1000μs at 2MHz beam intensity)

Data rate (2MHz beam): 0.1Mbyte/s per counter





BM-01 Input Data Processing (Single Channel)





Selected Pattern **01**

0000000**01010101**000000000000 – 4 Pulses (1.25ns)

0000000**01001001**000000000000 – 3 Pulses (1.25ns)

0000000**01100111**000000000000 – 2 Pulses (2.5ns, 3.75ns)

0000000**01000000000000000000** – 1 Pulse (1.25ns)

0000000**01100000000000000000** – 1 Pulse (2.5ns)

0000000**01110000000000000000** – 1 Pulse (3.75ns)

0000000**01110001111000000000** – 2 Pulses (3.75ns, 5ns)

0000000**01100000111110000000** – 2 Pulses (2.5ns, 6.25ns)

0000000**01111110000000000000** – 1 Pulse (7.5ns)



Selected Pattern **001**

0000000**001001001**0000000000000000 – 3 Pulses (1.25ns)

0000000**00110011**100000000000000000 – 2 Pulses (2.5ns, 3.75ns)

0000000**001111000111**1000000000000000 – 2 Pulses (5ns, 5ns)

0000000**001**000000000000000000000000 – 1 Pulse (1.25ns)

0000000**001**100000000000000000000000 – 1 Pulse (2.5ns)

0000000**0011**100000000000000000000000 – 1 Pulse (3.75ns)

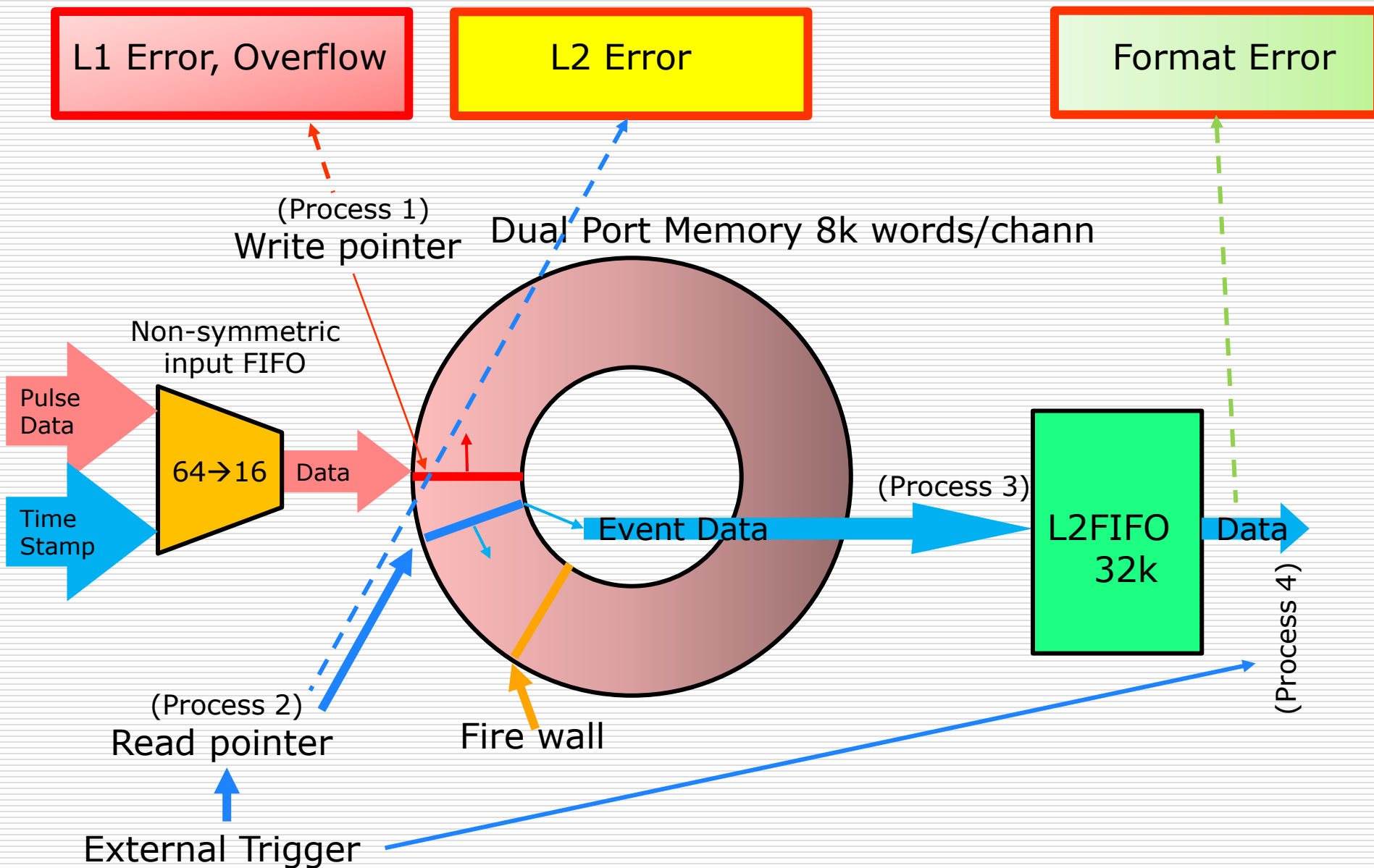
0000000**001111**100000000000000000000000 – 1 Pulse (6.25ns)

0000000**001100000111**1000000000000000 – 2 Pulses (2.5ns, 5ns)

000000**0011111**100000000000000000000000 – 1 Pulse (7.5ns)



BM-01 Input Data Processing (Single Channel)





Time Stamp word format

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Overflow [3:0]				Time Stamp [43:32]											
Time Stamp [31:16]															
Time Stamp [15:0]															

Encoded data word format

[15]----[13]	[12]	[11]----[9]	[8]----[6]	[5]----[3]	[2]----[0]
Pulse count	0	Pulse #4 nonius	Pulse #3 nonius	Pulse #2 nonius	Pulse #1 nonius

RAW data word format

Pulse count	Past[12:11]		Current 10-ns interval (nonius) [10:3]								Future[2:0]		
			0	1	2	3	4	5	6	7			
[15:13]	[12]	[11]	[10]	[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
Encoded count	Input Signal [12:0]												



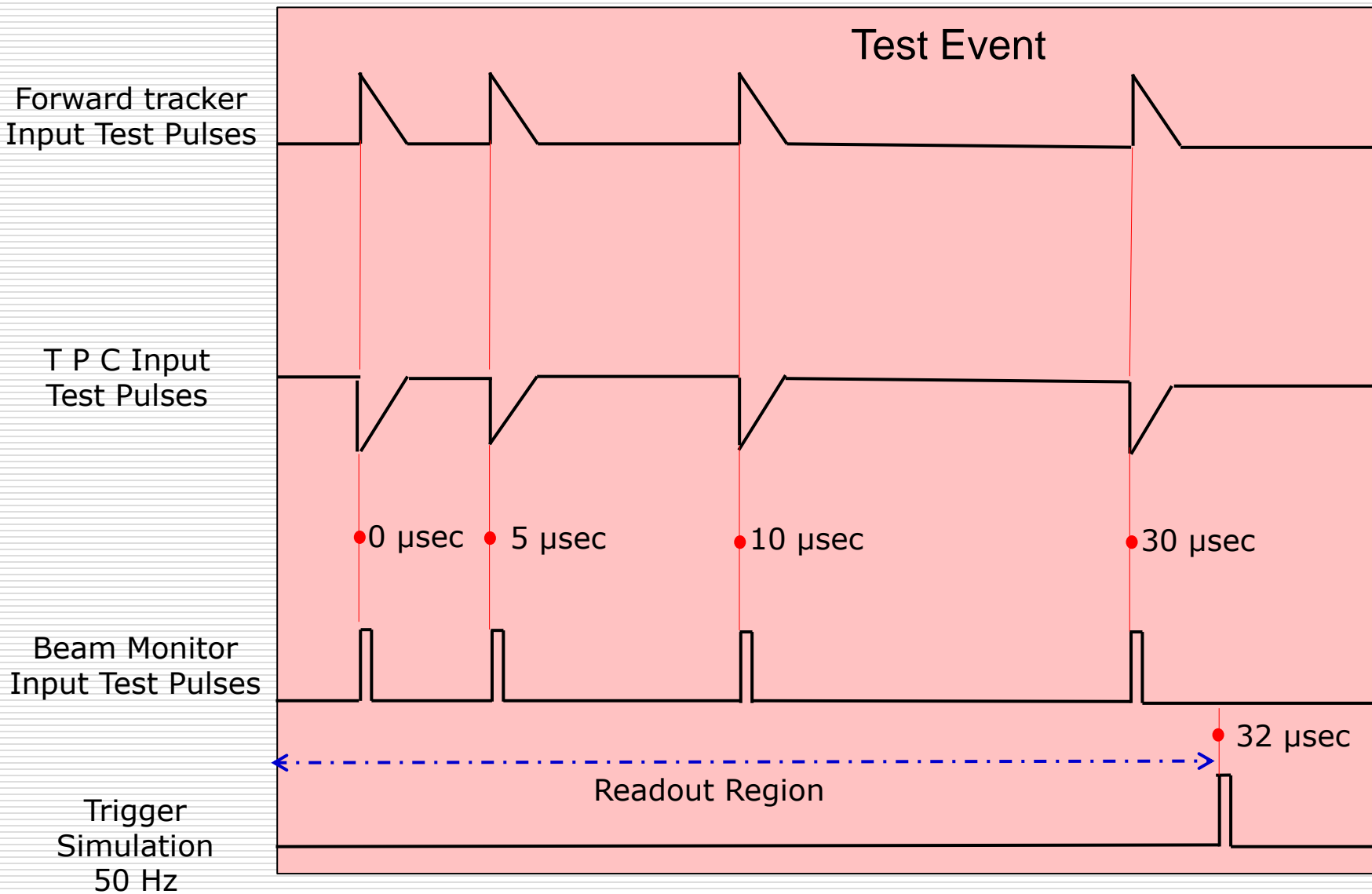
Total Counter Format (Without Dead Time)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0000				Total Counter [43:32]											
Total Counter [31:16]															
Total Counter [15:0]															

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0000				Run Timer [43:32]											
Run Timer [31:16]															
Run Timer [15:0]															



BM-01 Set of Test Pulses Generator





- beam intensity: 2 MHz
- средняя частота триггера – 50 Hz,
- временная апертура – 100 μsec,
- 4 используемых каналов на карту ВМ-01
- размер события, относящегося к 10-nsec интервалу – 5 слов

Среднее количество частиц, относящихся к данному триггеру – 200

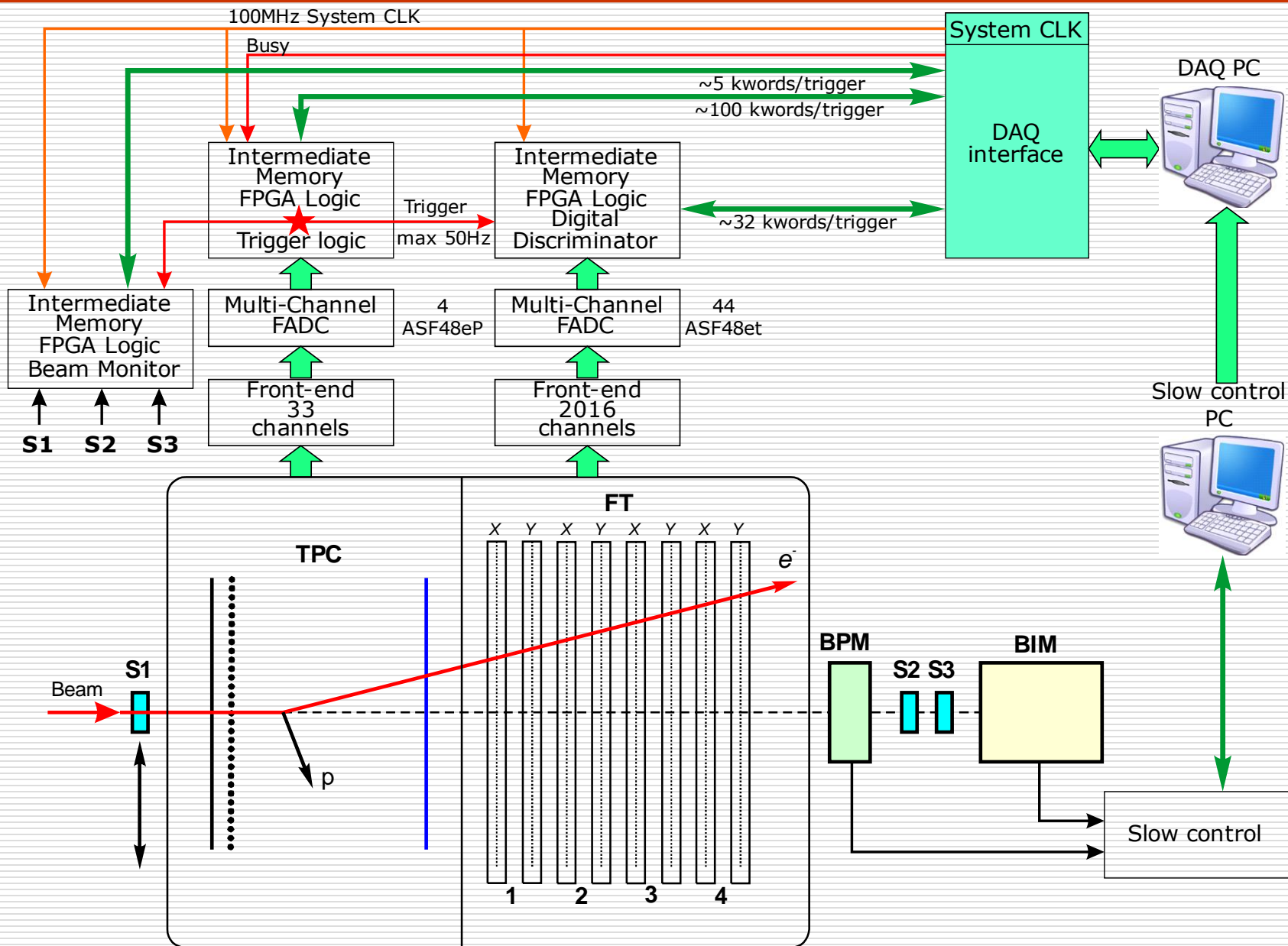
В этом случае поток данных, порождаемый картой ВМ-01, составит:
 $200 \times 5 \times 4 \times 50 \text{ Hz} = 0.2 \text{ Mword/sec. (3.2 Mbit/sec)}$

Это наихудший случай – (10-nsec интервалу -5 слов) соответствует одна частица.

Таким образом ожидается, при средней частоте триггера 50 Hz поток данных от ВМ-01 не будет превышать 3.2 Mbit/sec.

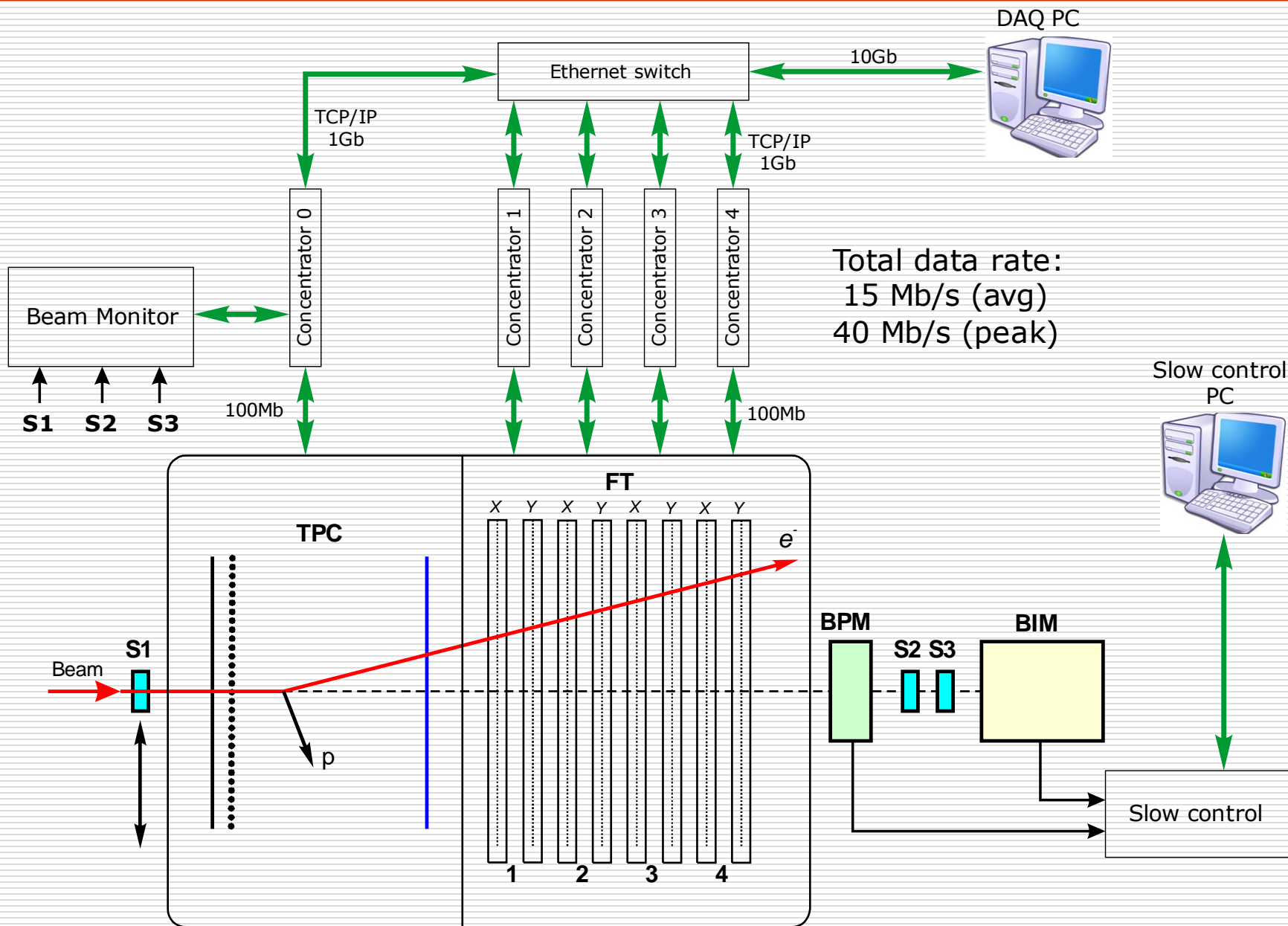


The whole DAQ electronics layout



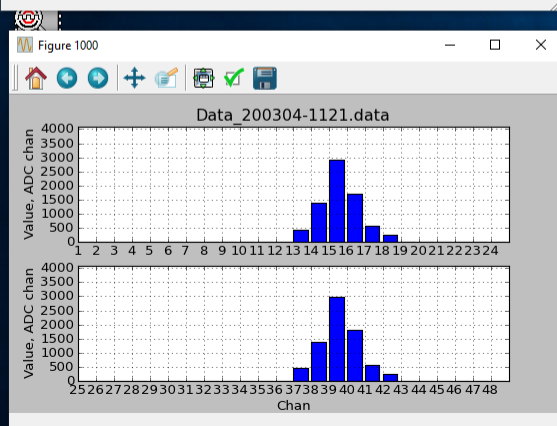
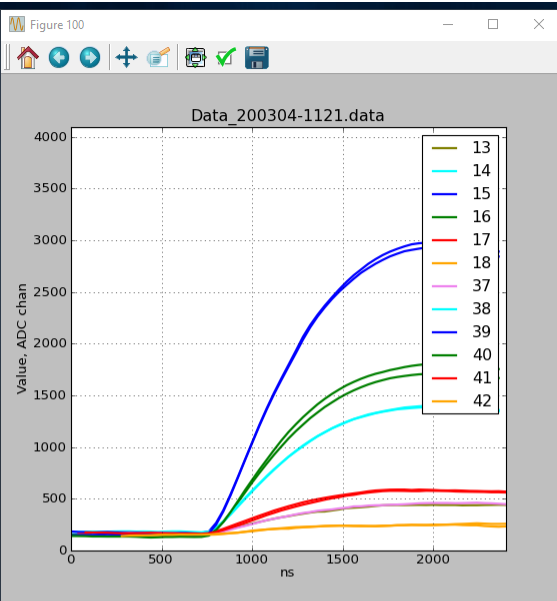


DAQ data flow layout





ASF48et test software



Port: 0 Select Type: ASF48e

ASF48
Fw Base Ver: ASF48et Fw: 09.02.10

Control | Calibr

Chan	Thr	M/S	Adj
1	229		
2	222		
3	208		
4	212		
5	203		
6	207		
7	190		
8	188		
9	219		
10	218		
11	212		
12	224		

Readout
TrigMode: Seft only
Sample: 30
SamMod: 1
Samples: 60
Offset: 9
Buffer: 16384
Push Enable:
Soft -> Ext Trig:
Time Rgn: 10000

Test Pulse
Enable: Ramp:

Readout
Name/IP: 192.168.1.10
ID: 0
Firmware:
CCB16 Reset: CROS Reset:

Data View
Data_200304-1121.data
Last run: Select: Convert: View:

Events | Hist | Thr | Settings

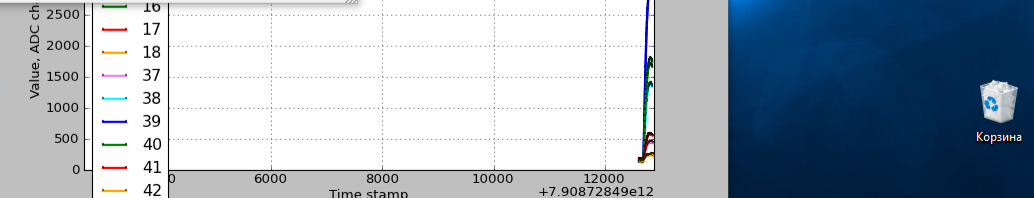
Event head
Card Number: 0
Channel: 13
Trigger time: 7908728502611
Max value: 1402
Base line: 183
Overflow: 0
Pulse file pos: 0x1bd7feel
Data Error: L2 Error: L1 Error:

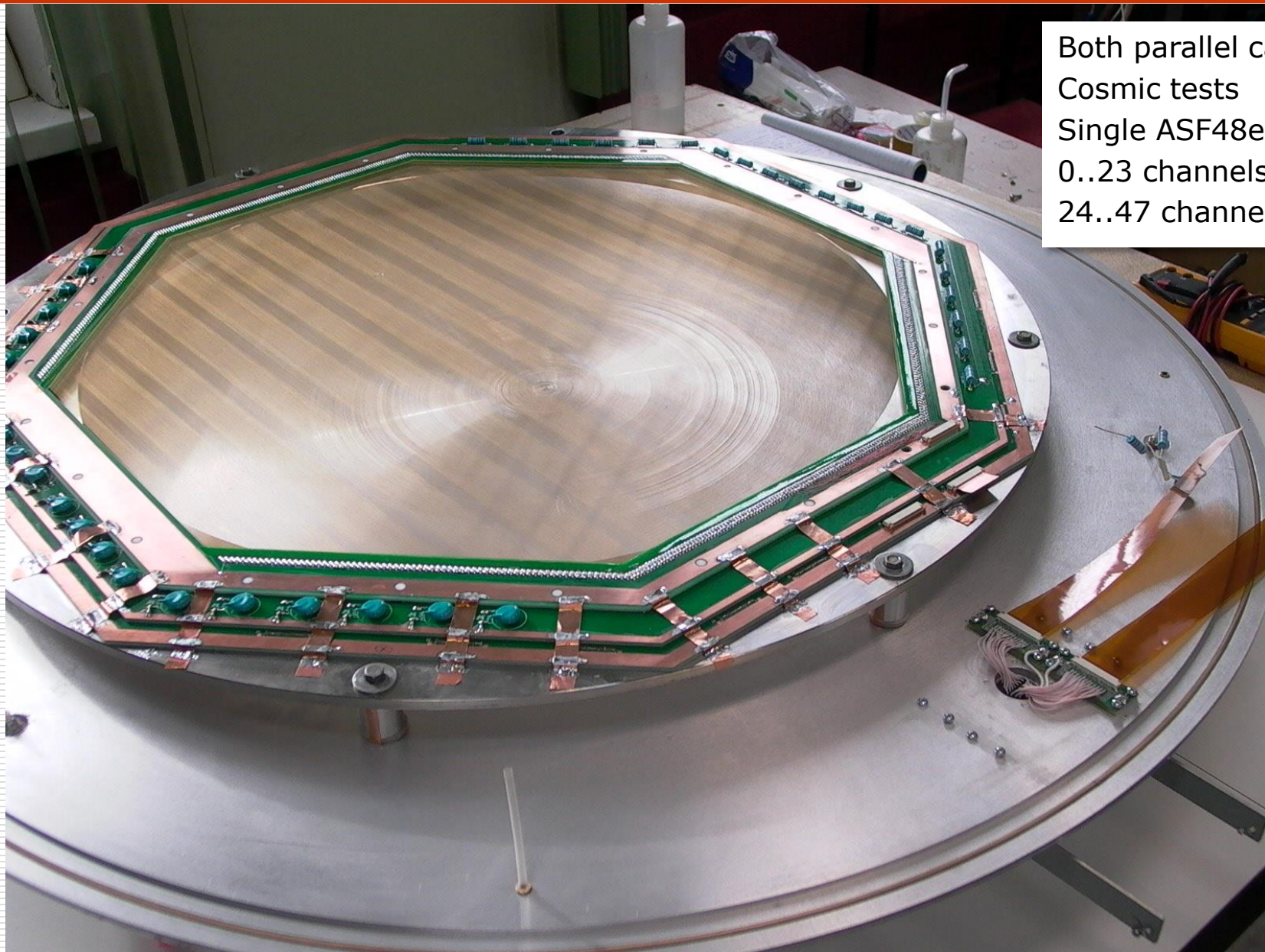
Event filter
Channel: All
Value min: 0 max: 4095
 Multichan events Track
Gap min: 0 Qty min: 0 Trig ch:
max: 100 max: 48

Event select
First: Pred: 227382: Next: Last: clear: trig show: Show:

Trigger select
First: Pred: 22744: Next: Last: clear: event show: Show:

Data_200304-1121.data
Load events: 1000000000 loaded: 227756 events
time: 0
22780 triggers
100% Stop:

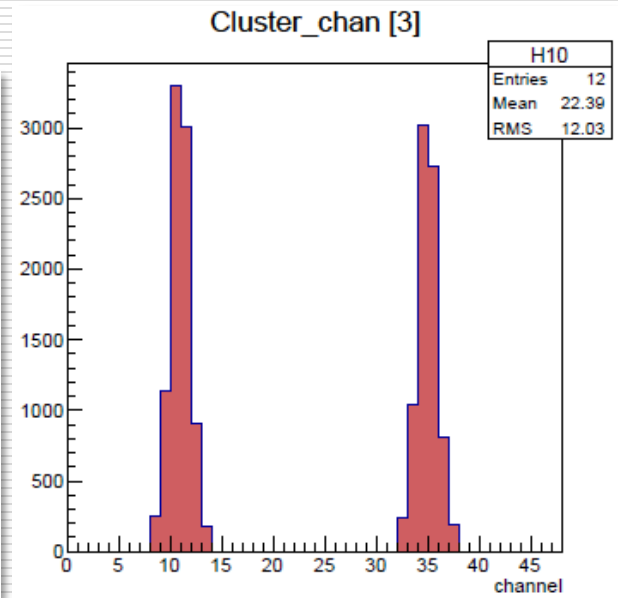
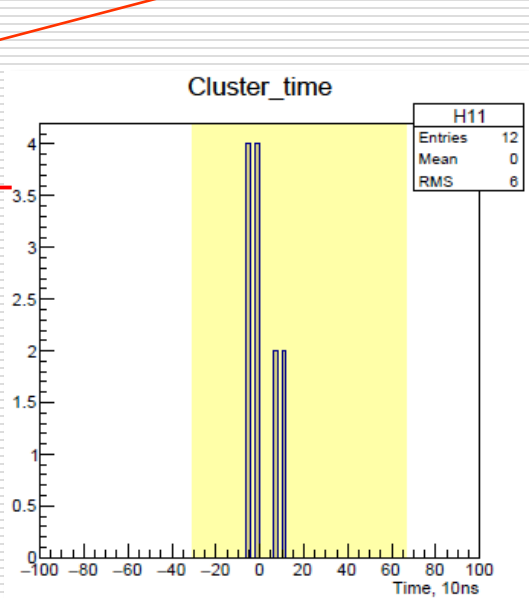
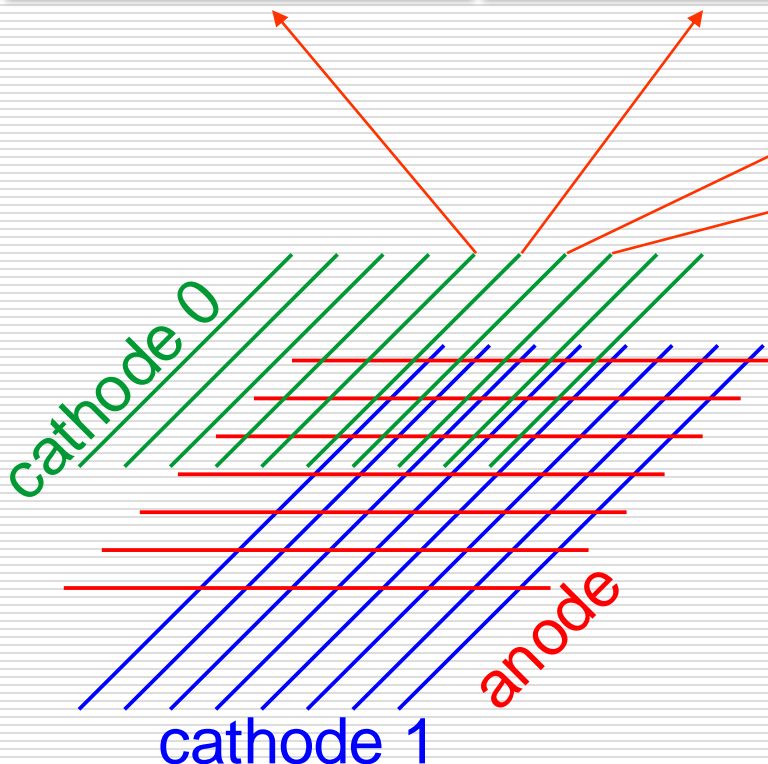
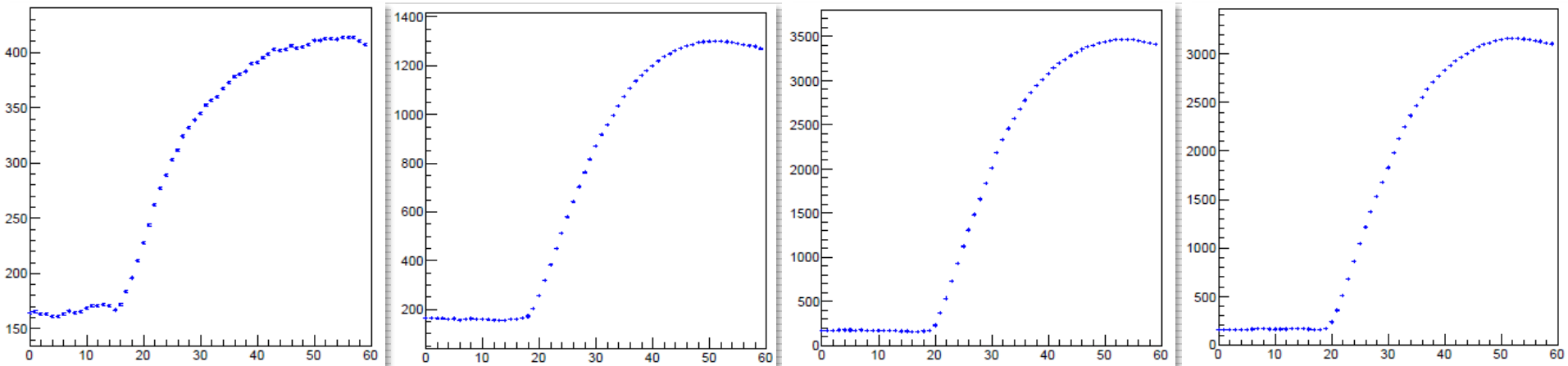




Both parallel cathodes
Cosmic tests
Single ASF48et card:
0..23 channels - top
24..47 channels - bottom



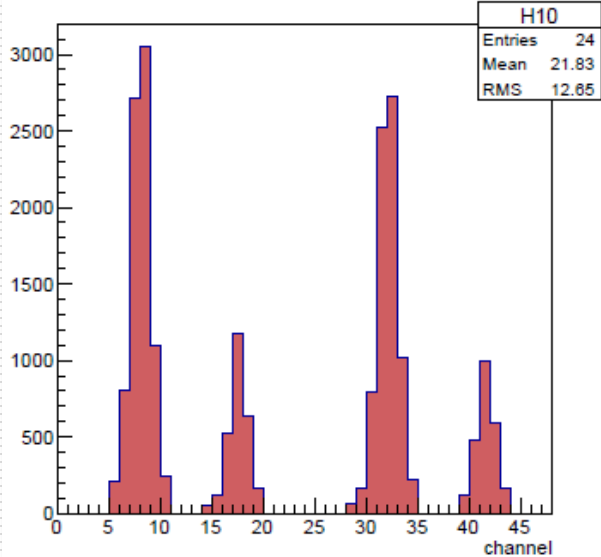
Signal processing





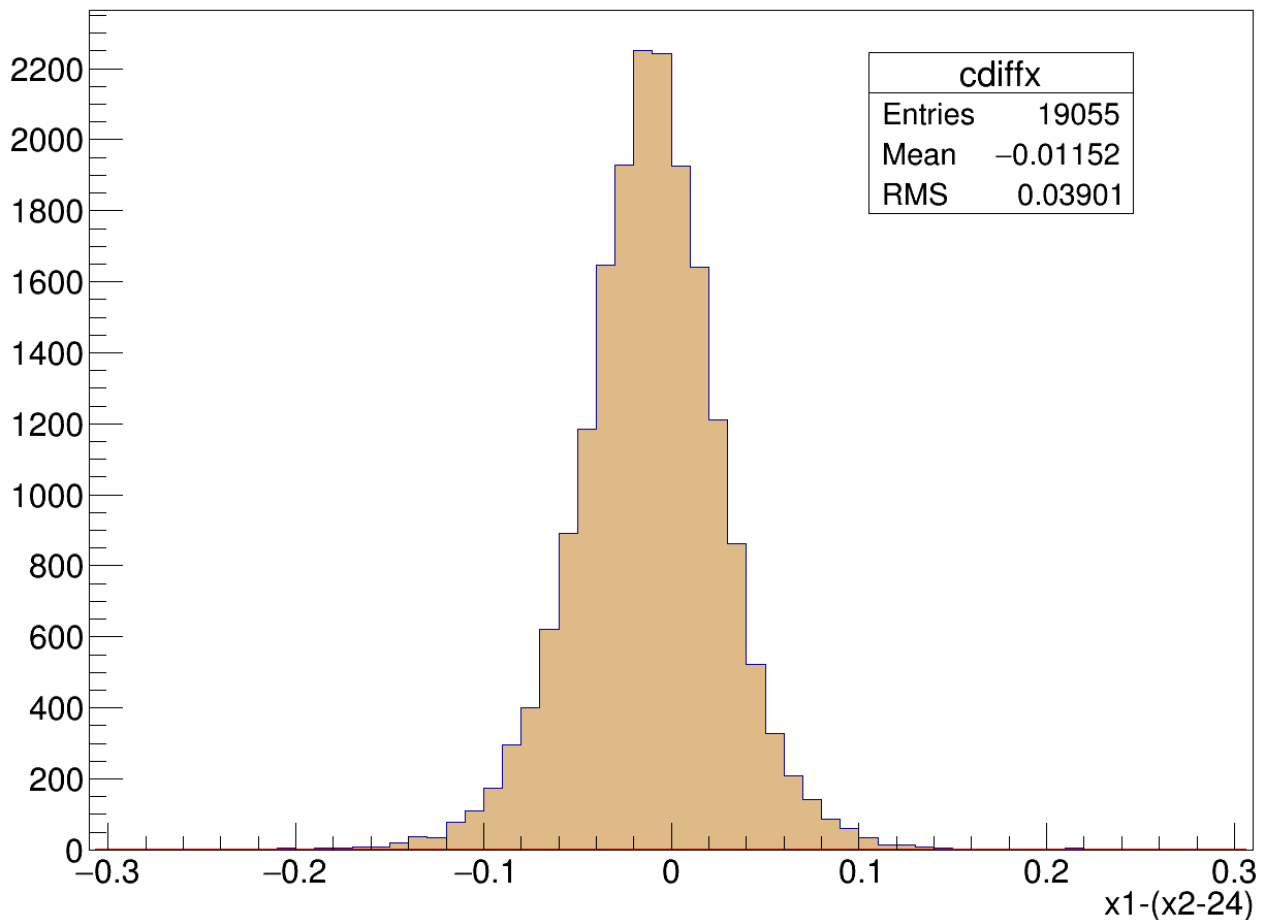
Cosmic data results

Cluster_chan [96]

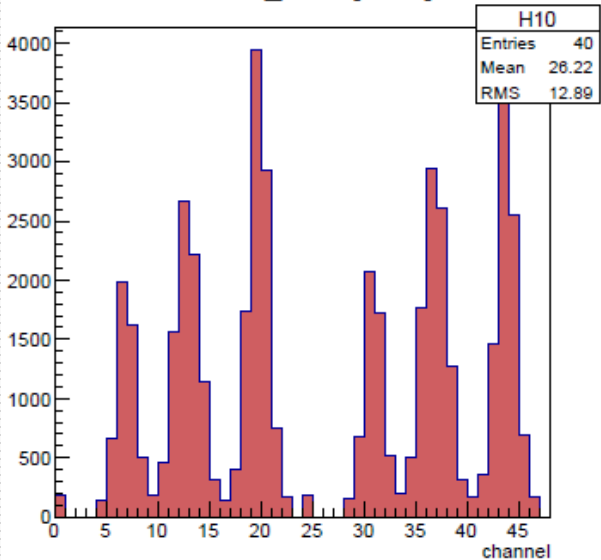


Spatial resolution: 70 μm

Cluster diff

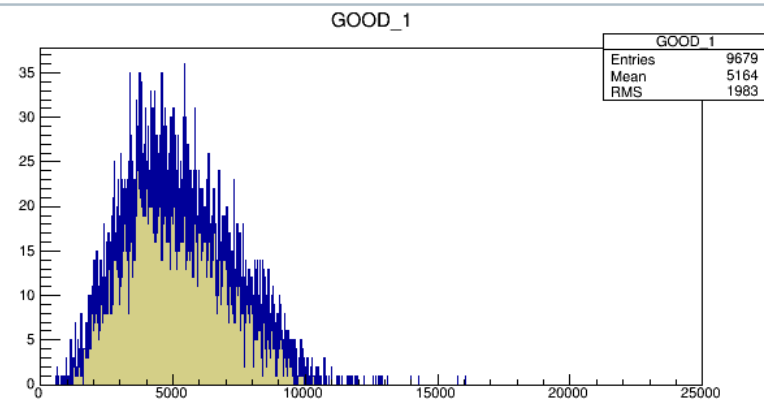
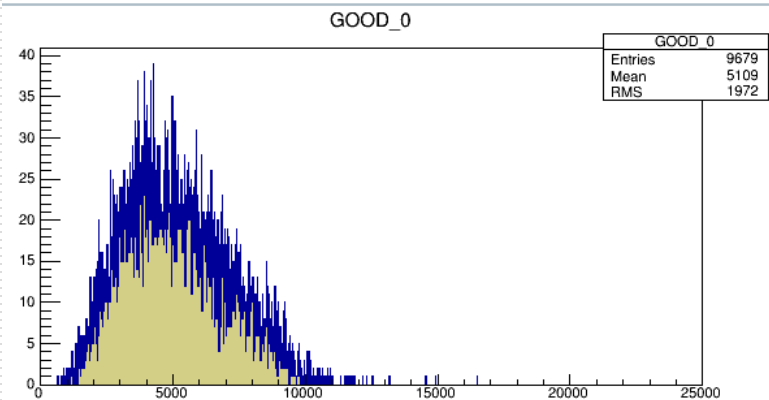
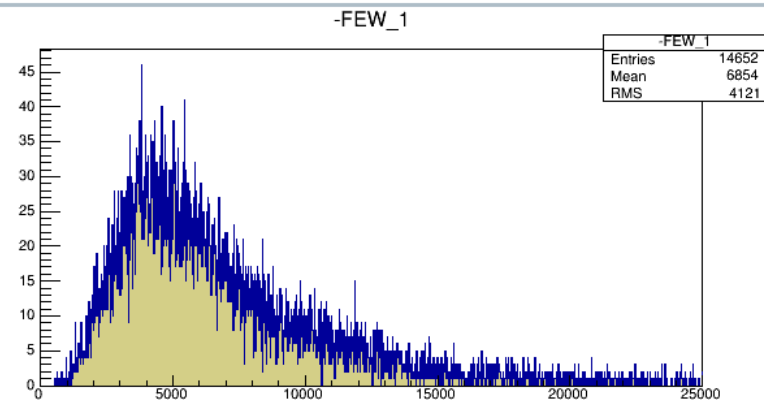
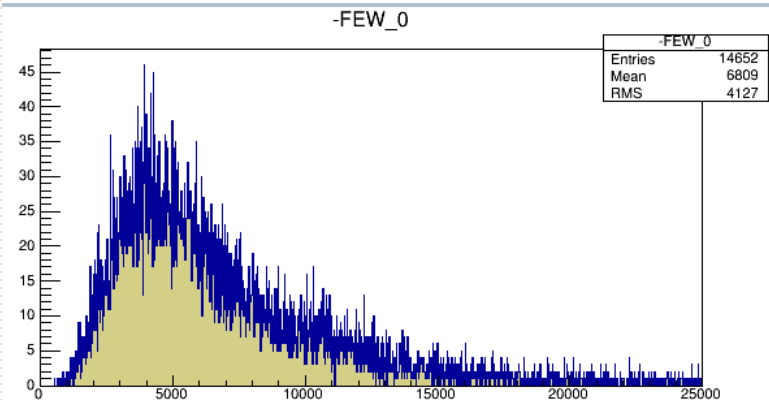
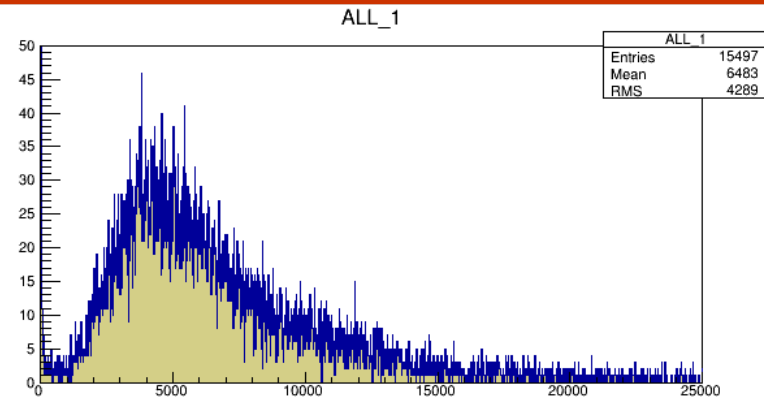
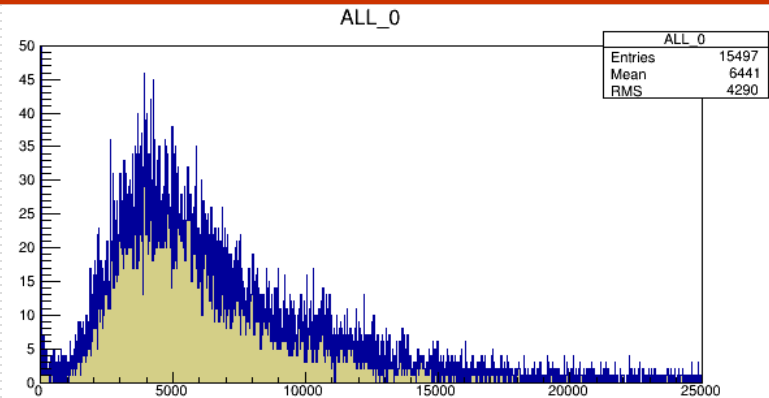


Cluster_chan [8343]



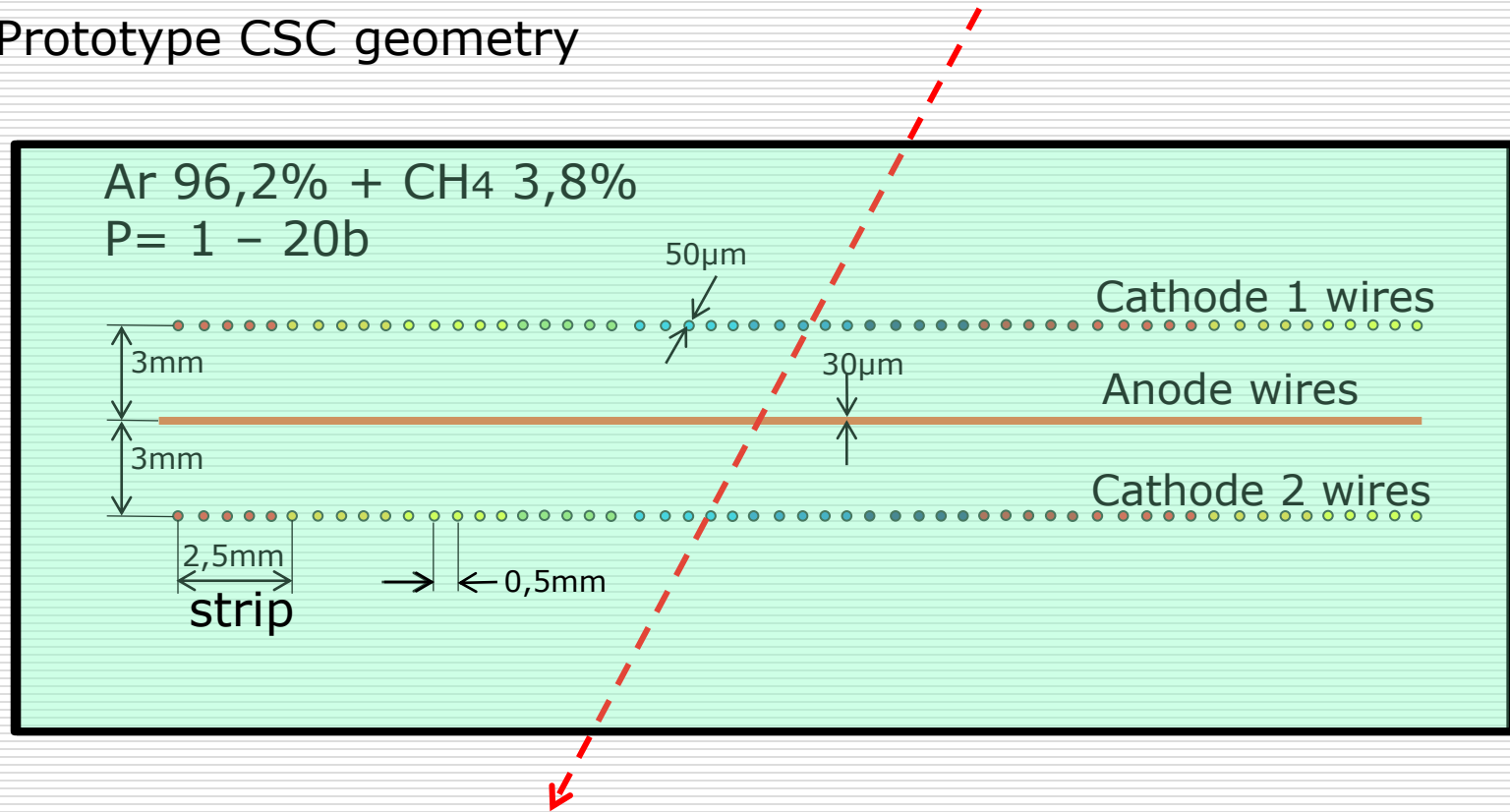


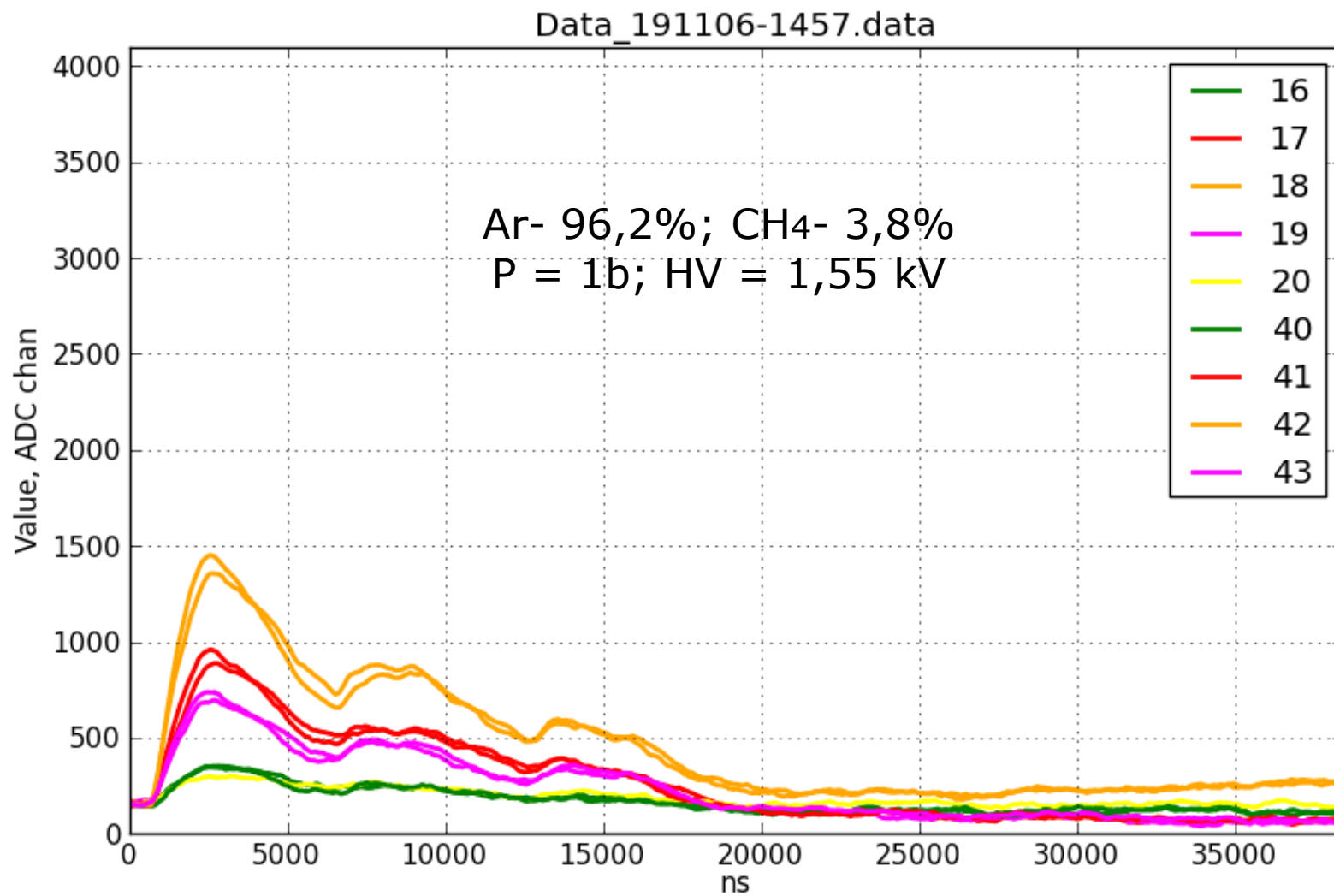
Cosmic data results. Amplitude spectra

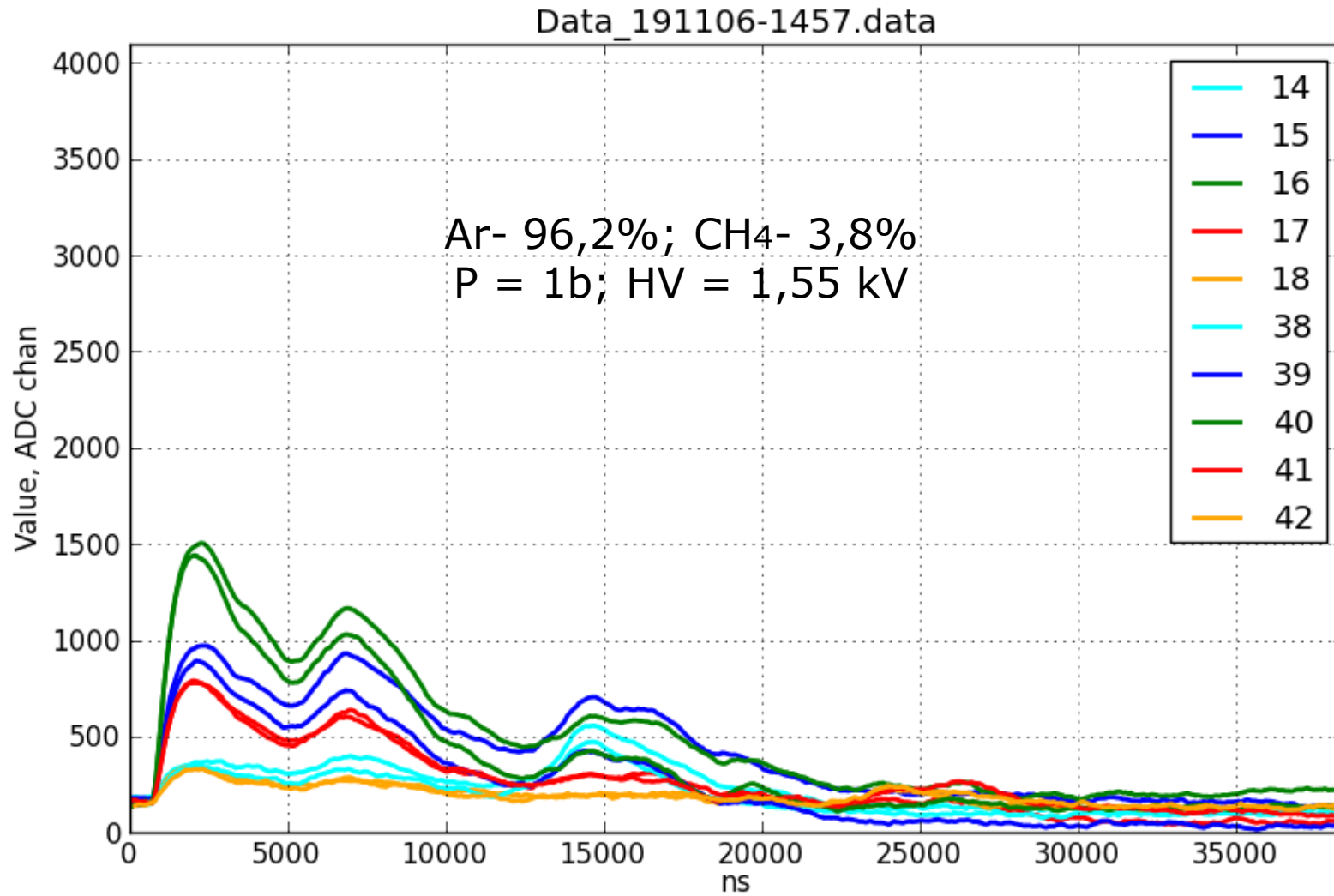


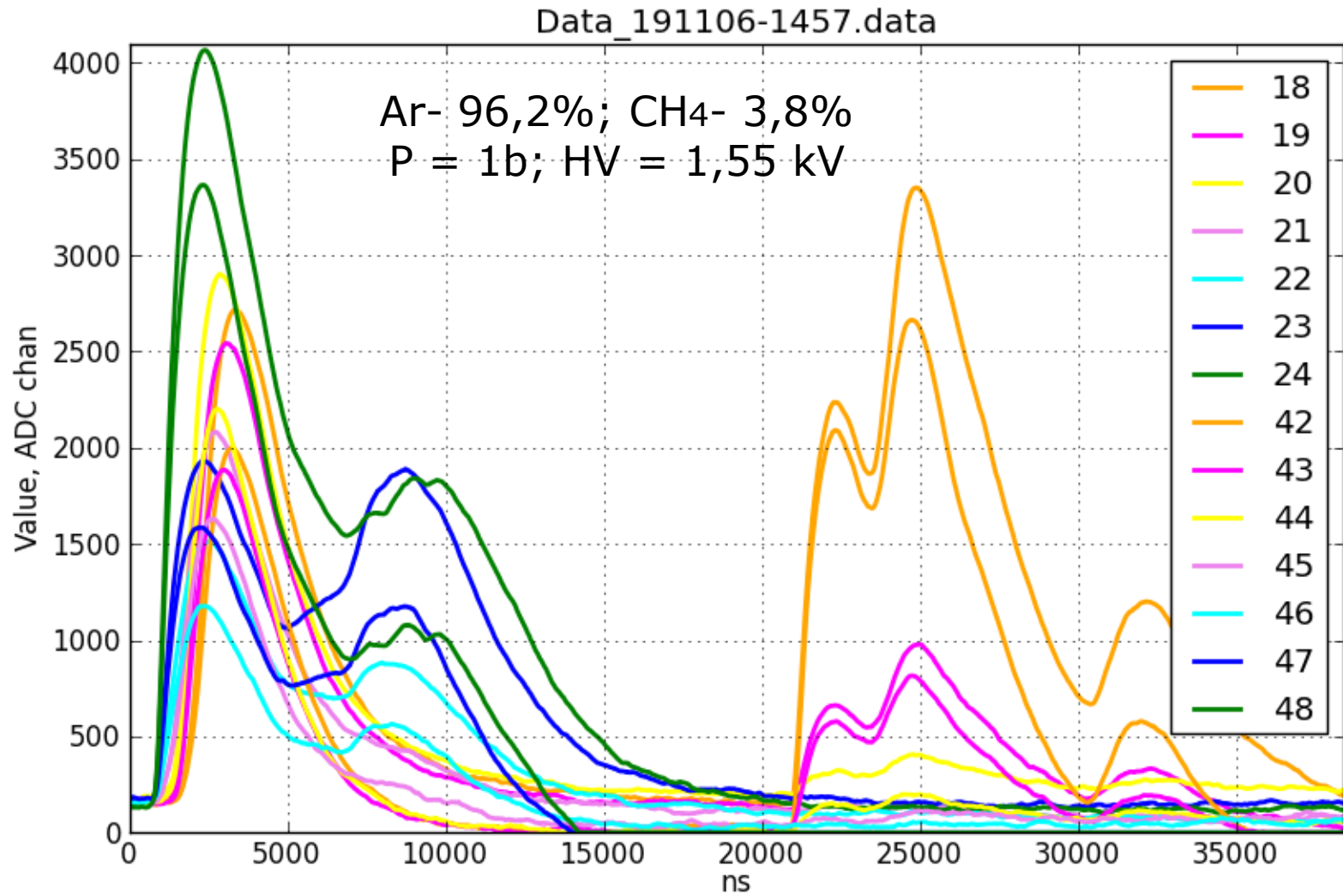


Prototype CSC geometry



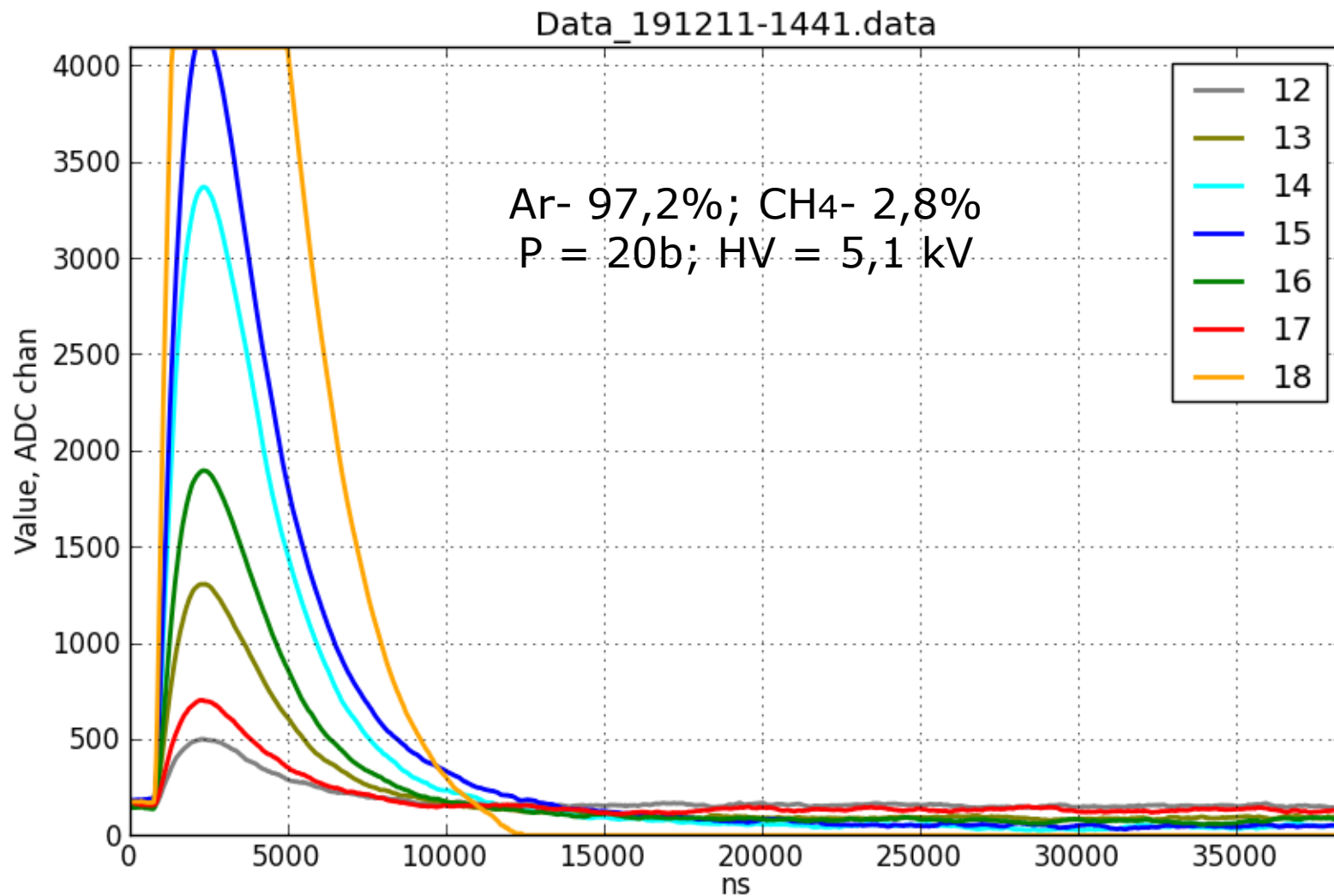






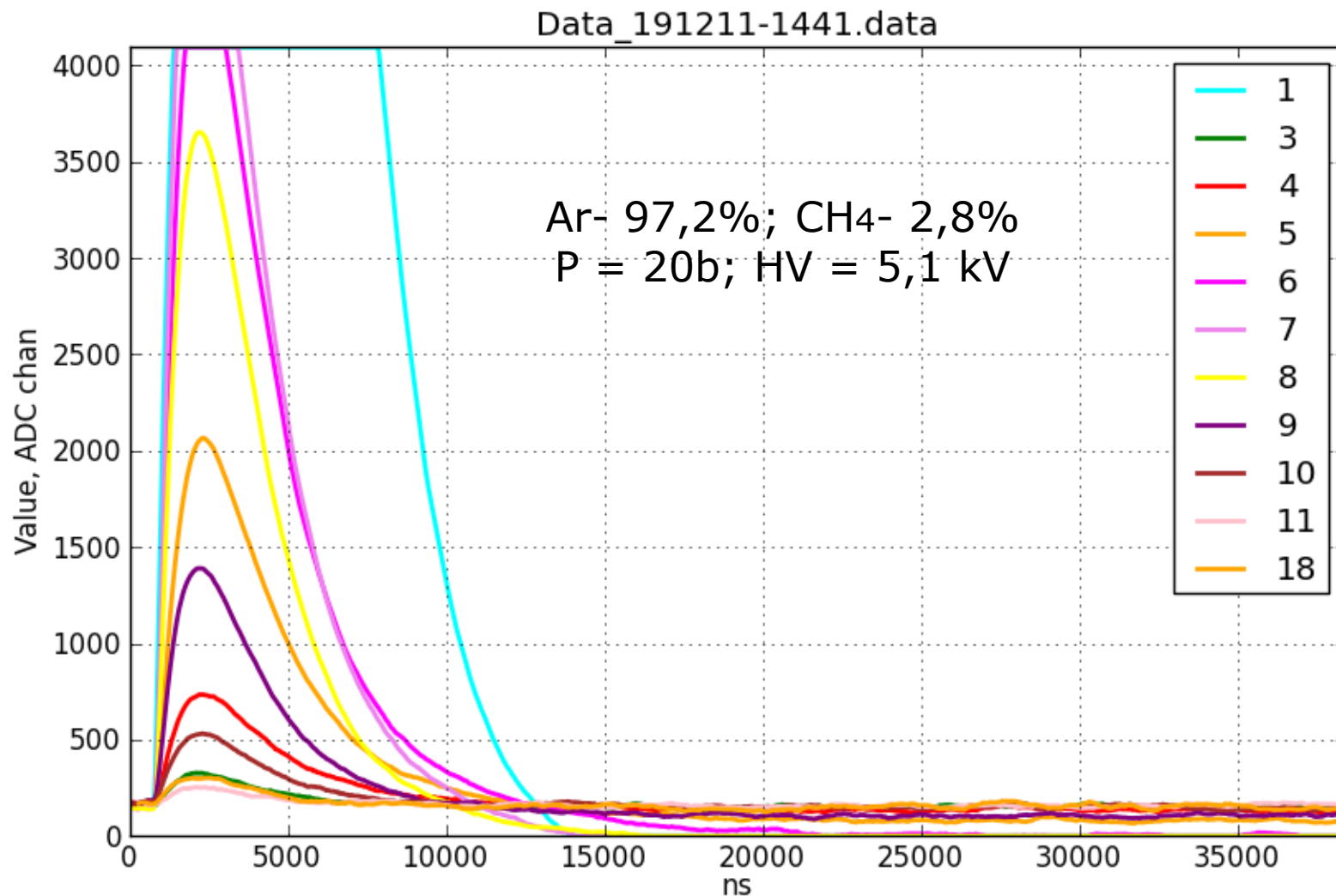


Эффект «дырявой крыши» подавлен высоким давлением



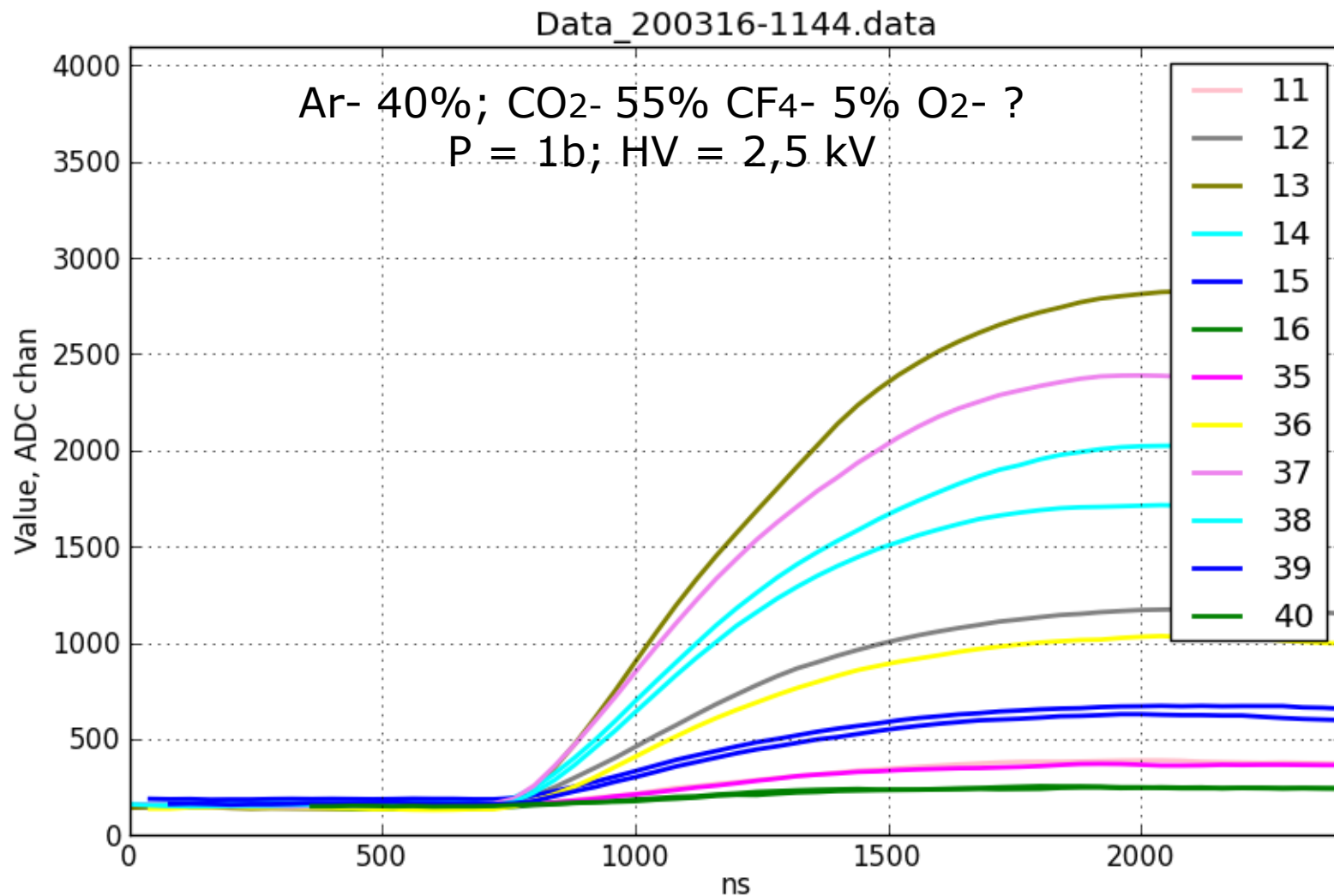


Эффект «дырявой крыши» подавлен высоким давлением





Прототип «большой» камеры (примесь O₂)





Thank you!



DAQ hardware status

Hardware	Design	Production	Firmware
Forward tracker preamplifier	✓	in progress	
Forward tracker digitizer (ASF48et)	✓	✓	✓
TPC preamplifier	?	?	
TPC digitizer (ASF48eP)	✓	✓	in progress
Beam monitor	✓	in progress	in progress
Beam position monitor preamplifier	✓	in progress	
Beam position monitor digitizer	✓	✓	in progress
Beam intensity monitor preamplifier	✓	✓	
Beam intensity monitor digitizer	✓	✓	✓



- ❑ ASF48 test software
- ❑ Full scale DAQ software based on MIDAS
(Maximum Integrated Data Acquisition System)
<http://midas.psi.ch>
 - ❑ Flexible distributed DAQ system
 - ❑ Web interface for run control and monitoring
 - ❑ Data transfer / logging capability
 - ❑ Online data monitoring
 - ❑ Online database
 - ❑ Message logging
 - ❑ Alarms



Data acquisition software

Example Display (offline): run 8 event 3000

events per packet | events per channel | good events | events per diode | amplitude | peak max | peak max diode | peak min | peak min diode | quality | quality bitmask

events good 0
Events: 10591
Mean: 24.1
Peak: 11.79

events good 1
Events: 0
Mean: 0
Peak: 0

events good 2
Events: 0
Mean: 0
Peak: 0

events good 3
Events: 0
Mean: 0
Peak: 0

events good 4
Events: 0
Mean: 0
Peak: 0

Example Display (offline)

events_per_packet | evs_ok | good evs | events per diode | amplitude | peakmax | peakmax par | peakmin | peakmin par

16000
14000
12000
10000
8000
6000
4000
2000
0

-400 -300 -200 -100 0

Event Histograms | Save Active Pad | Save Canvas | Gen. Browser | Free Running | Quit

polfu status - Mozilla Firefox

ELOG - 04.10.16 11:2... x polfu status x

https://localhost:8443

Search

Status ODB Messages Chat ELog Alarms Programs History Sequencer Config Example Help

Run Status

Run
30
Running
Stop

Start: Tue Nov 15 12:55:51 2016 Running time: 0h04m00s

Alarms: On Restart: Yes Data dir: /home/lkst/online/

Experiment Name: polfu

12:59:51 [ASF48,INFO] FIFO is almost full: c40003e2

Equipment

Equipment	Status	Events	Events[s]	Data[MB/s]
ASF48	ASF48@localhost	71771	303.8	1.725

Logging Channels

Channel	Events	MiB written	Compr.	Disk level
#0.run00030.mid	71880	408.750	N/A	11.4 %

Clients

mhttpd [localhost]	ASF48 [localhost]	Logger [localhost]
Analyzer [localhost]		

Experiment polfu
[Help](#)
Tue Nov 15 12:59:51 2016



Software	Status
ASF48 test software	✓
MIDAS frontend (FT)	in progress
MIDAS frontend (TPC)	in progress
FT signal processing	✓
FT clipped signal reconstruction	in progress
MIDAS online analyzer	in progress
MIDAS export analyzer	✓



Software	Status
ASF48 test software	✓
MIDAS frontend (FT)	in progress
MIDAS frontend (TPC)	in progress
FT signal processing	✓
FT clipped signal reconstruction	in progress
MIDAS online analyzer	in progress
MIDAS export analyzer	✓
Hardware	
Digitizers for the TPC, FT, Beam detectors	✓
Beam monitor	in progress
Preamplifiers for the FT, Beam detectors	production
Preamplifiers for the TPC	?