MIPP Trigger System Overview

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Content

- Trigger system in MIPP run 1
  - what worked well and what we need to improve
- Plans for the upgrade
  - Silicon Pixel Detector for interaction triggering
  - Trigger Master board
  - Beam ToF for low momentum
- Implications for detector readout electronics

The trigger in MIPP run 1 - logic

- Trigger logic defines beam triggers and interactions
  - ***beam*** trigger: Coincidence of TBD•T01•$\overline{\text{veto}}$ beam scintillators
  - ***pion beam***, ***kaon beam***, and ***proton beam:*** different combinations of four Beam Čerenkov pmt signals in coincidence with *beam*
  - ***int*** trigger: logic OR of prescaled
    - ***iDC***: multiplicity in drift chamber DC1 ...and...
    - ***SciHi***: interaction scintillator ≥ 2 MIP
  - ***pion int***, ***kaon int***, ***proton int***: *pion beam*, *kaon beam*, and *proton beam* in coincidence with *int*
- *plus various special triggers (pulser, rf, end-of-spill, ...)*

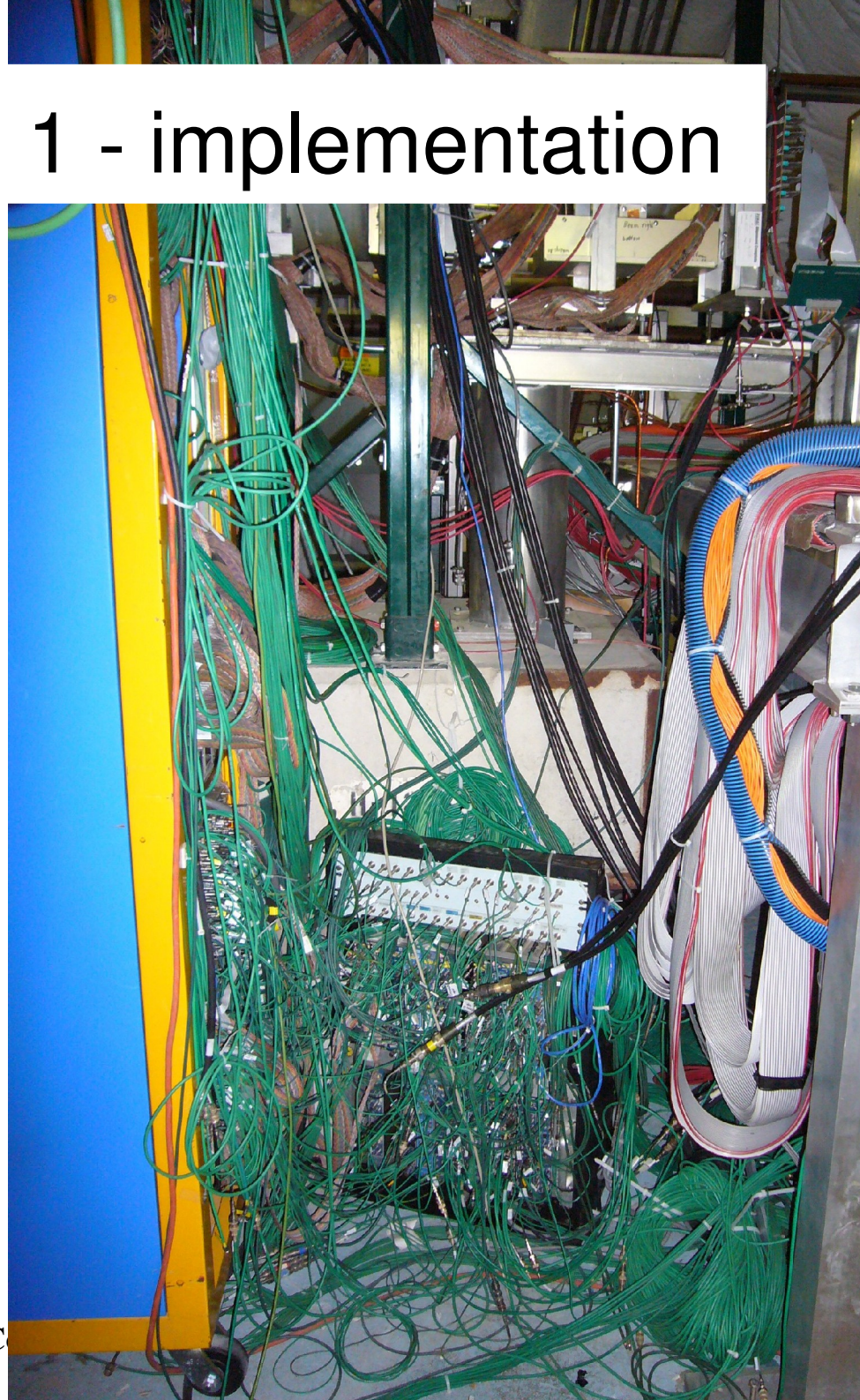
The trigger in MIPP run 1 – logic (cont.)

- The various triggers each had a prescale into the master OR that got fanned out to detectors.
  - prescales programmable from DAQ to
    - take even fractions of π/K/p data
    - enable/disable special triggers

```
runs=> SELECT * from trigconfig where run = 16500;
  run  | bit |              name               |   logic    |  prescale
-------+-----+---------------------------------+------------+-------------
 16500 |   0 | Beam Trigger                    | T01*TBD    |        1834
 16500 |   1 | T01 Trigger                     | T01 3 of 4 | -2147483648
 16500 |   2 | TBD Trigger                     | TBD 3 of 4 | -2147483648
 16500 |   3 | User Trigger 1                  |            | -2147483648
 16500 |   4 | Kaon PID Beam                   |            |          63
 16500 |   5 | Pion PID Beam                   |            |        1184
 16500 |   6 | Proton PID Beam                 |            |         120
 16500 |   7 | BToF                            |            | -2147483648
 16500 |   8 | Kaon w/ Interaction             |            |           0
 16500 |   9 | Pion w/ Interaction             |            |          27
 16500 |  10 | Proton w/ Interaction           |            |           2
 16500 |  11 | ToF w/ Interaction              |            | -2147483648
 16500 |  12 | Raw Pulser                      |            | -2147482648
 16500 |  13 | Inter Spill Calibration Pulser  |            |        1500
 16500 |  14 | SciHi                           |            | -2147483648
 16500 |  15 | IDC                             |            | -2147483648
 16500 |  16 |                                 |            | -2147483648
 16500 |  17 |                                 |            | -2147483648
 16500 |  18 |                                 |            | -2147483648
 16500 |  19 |                                 |            | -2147483648
```

The trigger in MIPP run 1 - implementation

- all logic in NIM modules
  - UVa trigger module was only special module
- all readout (scalers, latches) in Camac
- Lots of lemo cables
- Trigger fan-out at T_0+~200ns
  - longest delay: gate for iDC
- documentation on www



The trigger in MIPP run 1 - comments

- ToF wanted the trigger without latency
  - keep delay cables short
  - addressed differently in the upgrade
- beam trigger and online beam pid worked well
  - no online beamToF pid for low momentum
- Interaction trigger had problems
  - iDC: beam backgrounds (spray) or chamber noise triggered false interactions
  - ScInt: Landau tails caused beam tracks to trigger interactions

Trigger rates

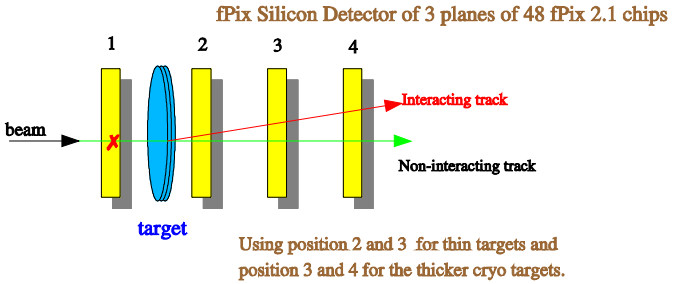
- Trigger rates were and will be limited by TPC readout
  - ~30-60 Hz in first run
  - ~3000 Hz in next run
- Beam rates
  - 1% target $\rightarrow$ need at least 100$\times$ trigger rate, 300 kHz
  - prescale majority particles to take even fractions of all three beam species (π/K/p) $\rightarrow$ want even more
    - 500kHz = 2 μs = 8 beam tracks in TPC drift volume
- MainInjector rf: 53 Mhz = 18.9 ns

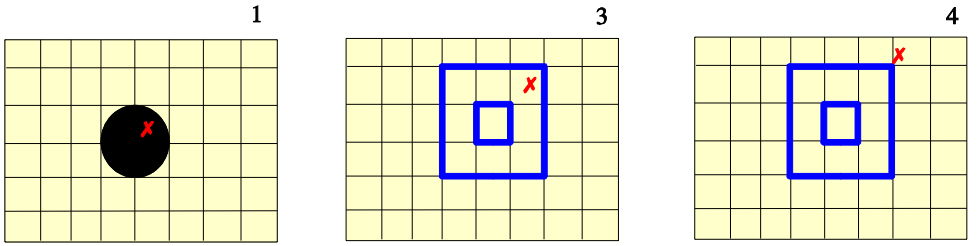
Trigger Upgrade Plans

- Silicon Pixel Detector for interaction triggering
  - Based on fPix Si Pixels
    - see D. Christian's talks 9 Dec'06 (MIPP-doc-177) and today (MIPP-doc-204)
  - Who will work on it?
- Trigger Master board
  - Will be faster, programmable, have more features, ...
  - Who will build it?
- Beam ToF for low momentum
  - want to prescale based on Beam ToF pid at low momentum
  - need particle specific *beam* coincidences at lowest momenta

fPix for Interaction trigger

- Si Pixel Detector with fPix readout:
  - 22×128 (x×y) pixels of 400×50 μm² size = 9.2×6.4 mm² per chip – gives fast *chip hit* signal
  - compare 9.2×6.4 mm² to 50 mm diameter beam spot
- Use Bull's eye trigger and multiplicity
  - prescaled OR gives global Interaction signal
- Hit rate, *chip hit* pulse length, dead time is ok





First layer before target tags where beam is and that there was only 1 hit cell. Brown circle represents where 86% of the beam hits the 4 cells in the center.

A bulls eye target, shown in blue, is made around the one cell hit location of plane1.

Interaction Trigger (cont.)

- This will need to be studied more
  - Determine best placement for all pixel planes
    - Beam divergence: ~1 mrad, first pixel plane to target: ~1 m
    - Vertex resolution
  - Material behind the target
    - Pixels: ~270 μm
    - Mounting and readout for pixels
  - Who is going to do this?

MIPP trigger board

- Collect signals from
  - T00, TBD, T01, beam Veto
  - Beam Čerenkovs
  - fPix hit signals
  - Scale everything (for cross section normalizations)
- Form trigger similar to old logic
  - allow at most 2μs (significantly longer than before)
  - new readout electronics on ~all detectors make this possible

MIPP trigger board (cont.)

- Will we ever want to do anything more fancy?
  - Special charm triggers?
  - High rate special runs (without TPC)?
    - How high?
  - If so, we need to plan for it now.
- “Easy”: All digital logic, need only one (no mass production, cost not a problem)
  - Who will do it?

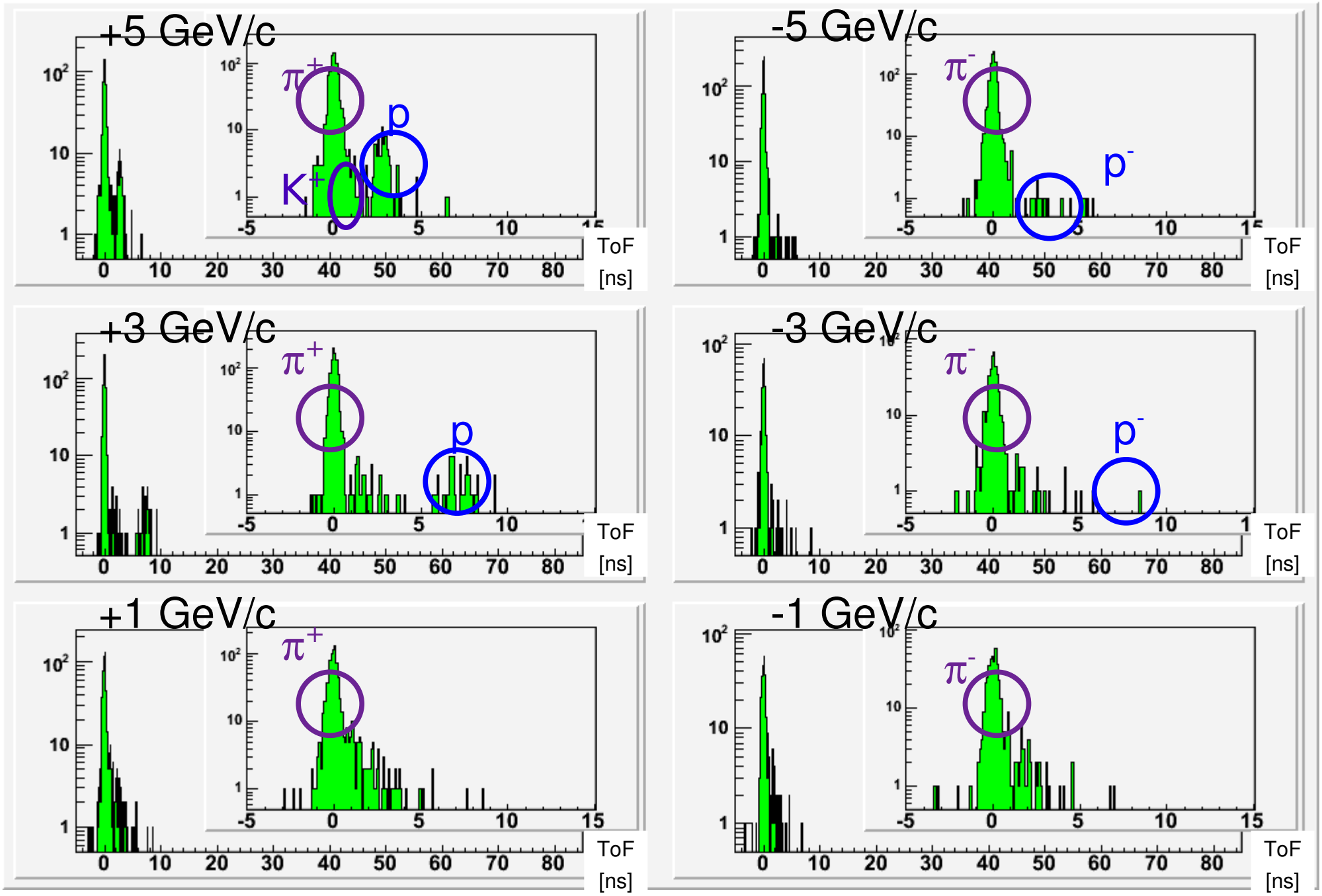
Triggering at low beam momentum

- Beam particles can be significantly below β=1

Beam particle decay and ToF in the MIPP beam line

Particle	Mass M [GeV/c²]	Livetime τ [ns]	Beam Momentum [GeV/c] 1	3	5	10	15	20
Beam-length	95.85 [m]		Survival Probability [%] in MIPP beam:					
Pion	0.14	26.03	18.01	56.48	70.98	84.25	89.20	91.79
Kaon	0.49	12.38	0.00	1.43	7.82	27.96	42.75	52.87
Proton	0.94	1E+39	100.00	100.00	100.00	100.00	100.00	100.00
			Particle Beta:					
Pion	0.14	26.03	0.99	1.00	1.00	1.00	1.00	1.00
Kaon	0.49	12.38	0.90	0.99	1.00	1.00	1.00	1.00
Proton	0.94	1E+39	0.73	0.95	0.98	1.00	1.00	1.00
X(T01-TBD)	37.69 [m]		Time of Flight [ns] between TBD and T01:					
Pion	0.14	26.03	126.94	125.86	125.77	125.73	125.73	125.72
Kaon	0.49	12.38	140.21	127.41	126.33	125.87	125.79	125.76
Proton	0.94	1E+39	172.40	131.73	127.91	126.27	125.97	125.86
			Time of Flight [ns] between TBD and T01 wrt beta=1:					
Pion	0.14	26.03	1.22	0.13	0.05	0.01	0.00	0.00
Kaon	0.49	12.38	14.48	1.69	0.61	0.15	0.07	0.04
Proton	0.94	1E+39	46.67	6.00	2.19	0.55	0.24	0.14

MIPP beam **tests** at low momentum



Implications for detector readouts

- Of course the trigger specifications impact the detector readout systems
- Specifications for detector readouts (subject to change)
  - c.f. MIPP-doc-186

Maximum trigger latency	2 μsec
Minimum time between events	16 μsec
Maximum spill length	6 seconds
Maximum readout time after spill	54 seconds
Maximum number of events per spill	20,000

Trigger summary

- MIPP trigger is conceptually simple (minimum bias)
- Trigger is at the heart of the experiment
  - Without a good trigger we don't have an experiment!
- MIPP needs a Trigger Group
  - Coordinate and lead all aspects of the trigger design
    - with help from Fermilab EED&EPP
  - High profile/visibility/responsibility
  - A small/new group can do this well