Overview of the T2K ND280 DAQ
Towards a DAQ system for HyperK

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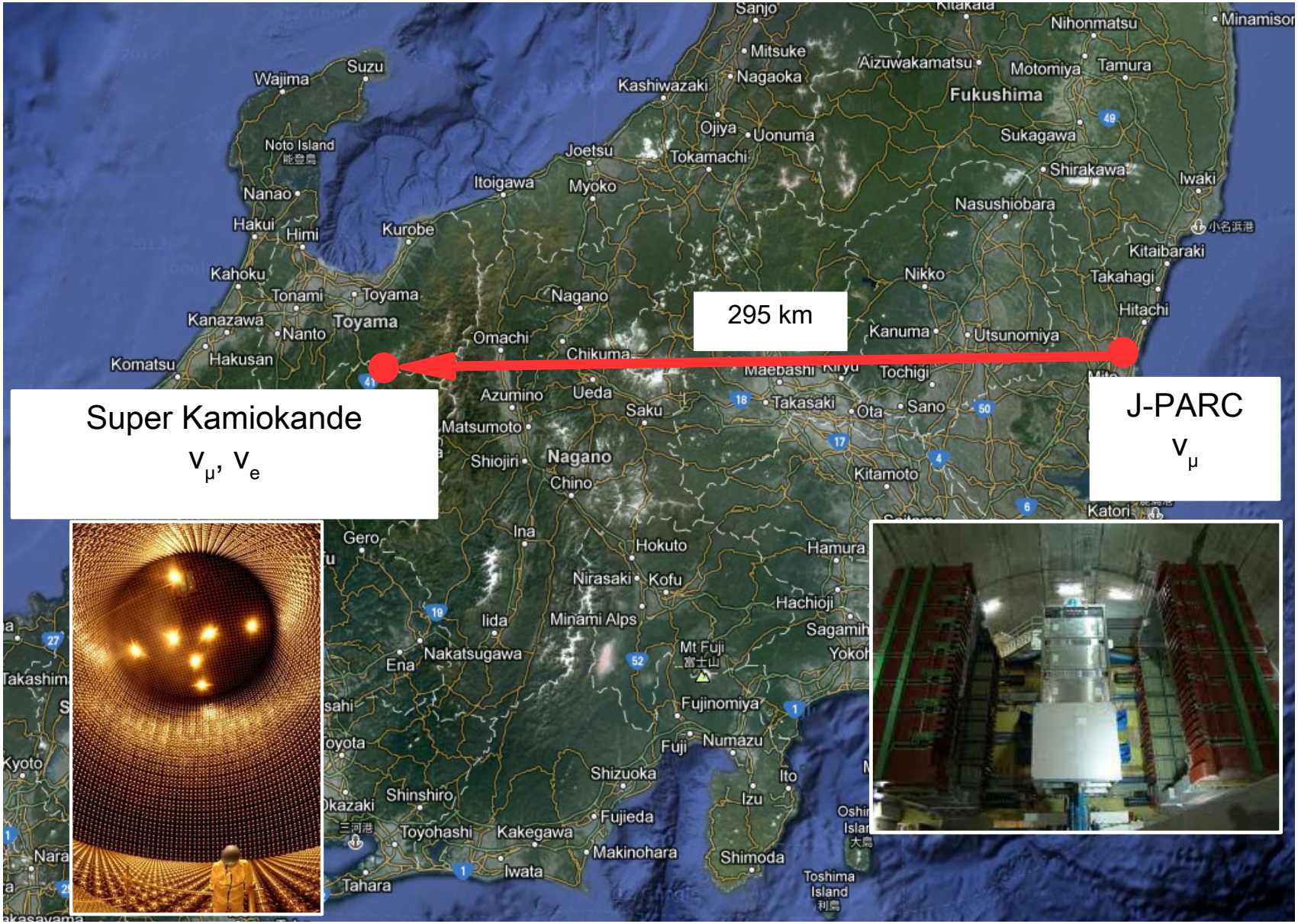
Outline

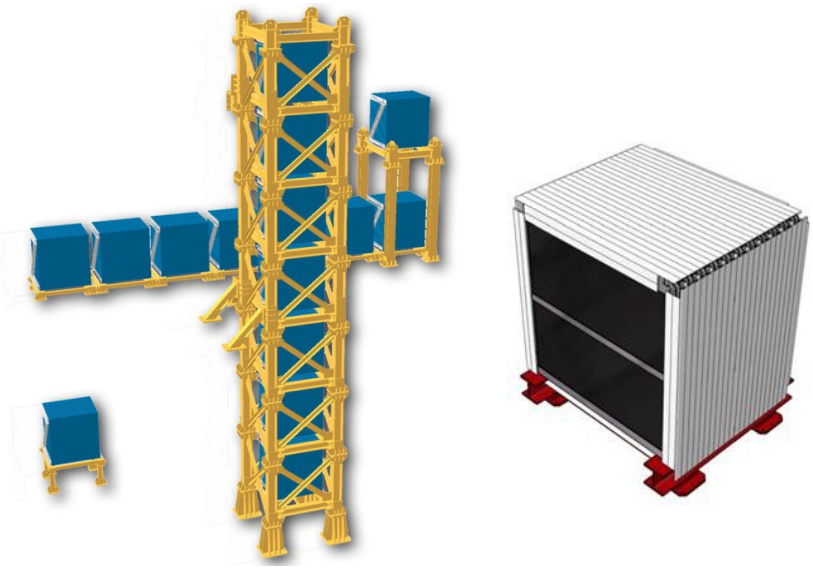
- Brief overview of T2K experiment
- ND280
- T2K DAQ systems
- Data rates for HK
- UK interests

T2K experiment



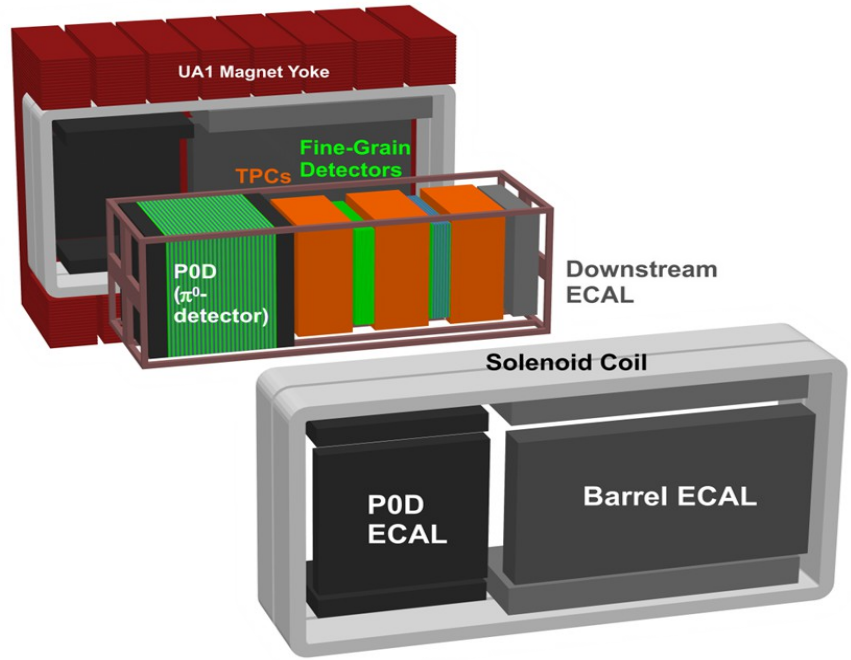
ND 280

INGRID



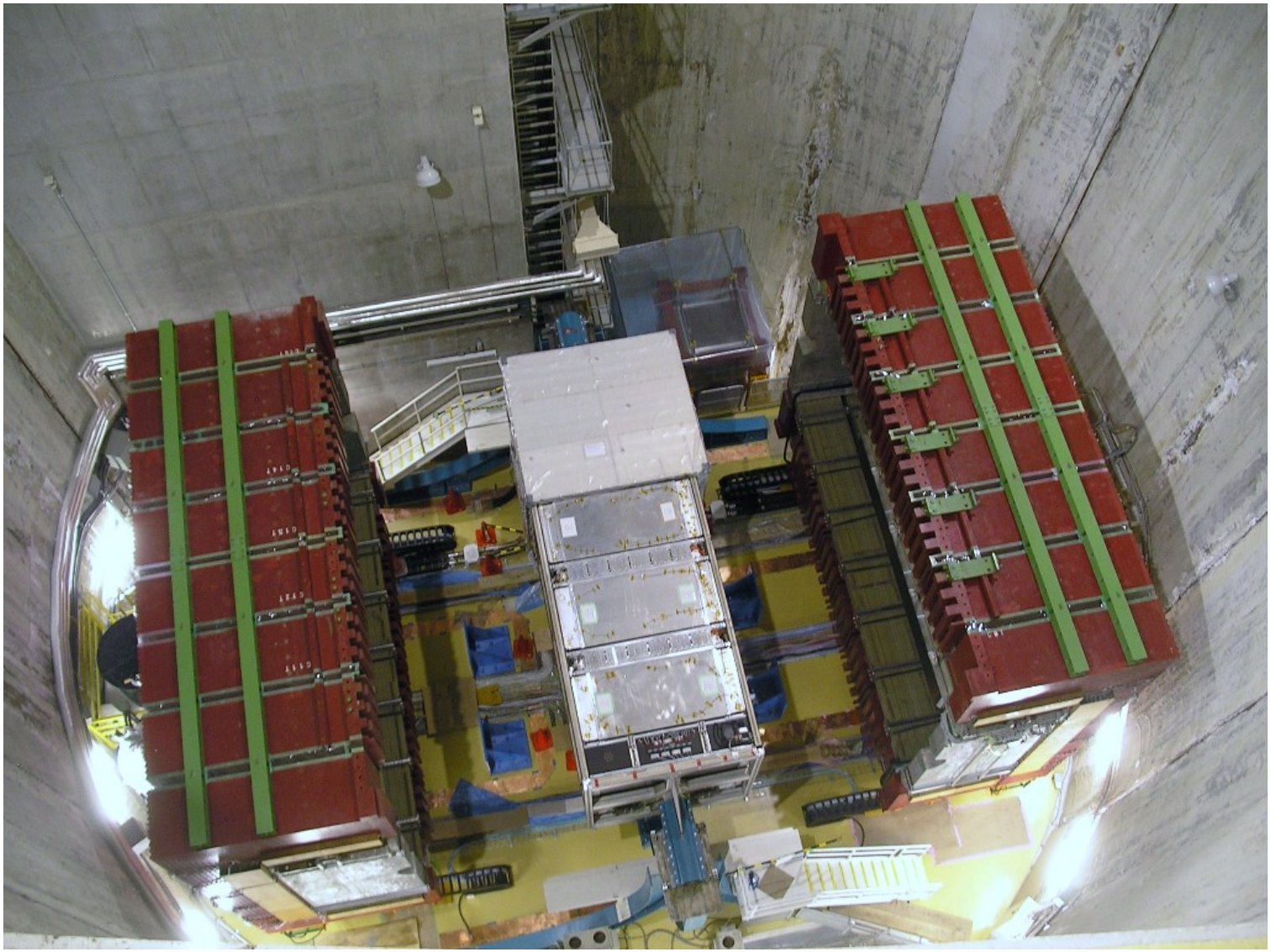
Measurement/monitoring of beam profile

ND280

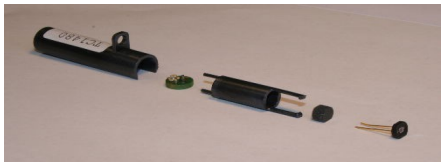


Characterisation of beam interactions *BEFORE* oscillation

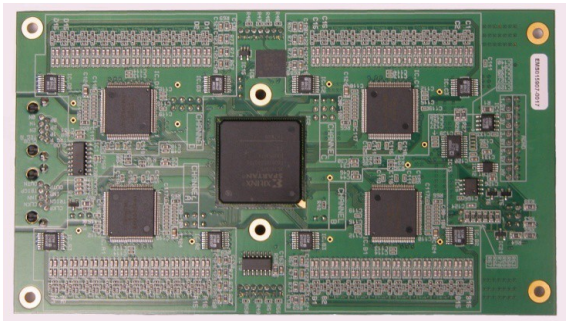
ND 280



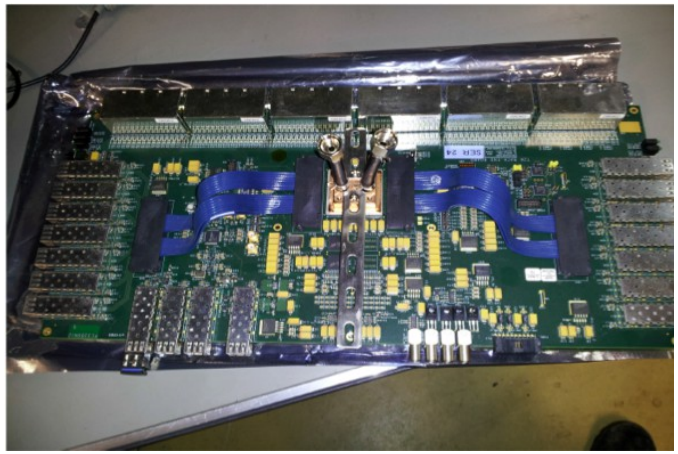
TripT electronics



Multi **P**ixel **P**hoton **C**ounter
(MPPC)

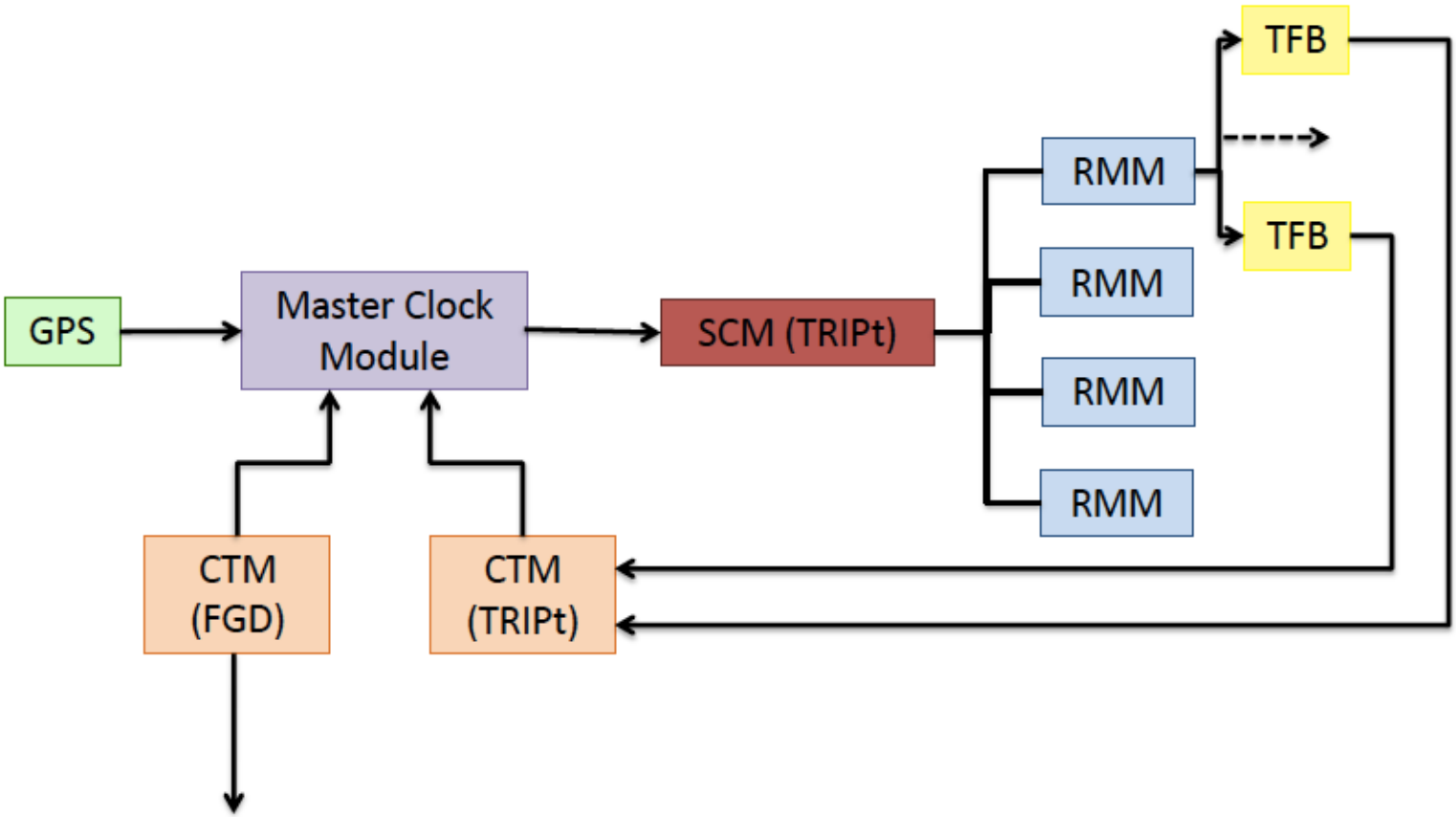


TripT **F**ront end **B**oard
(TFB)

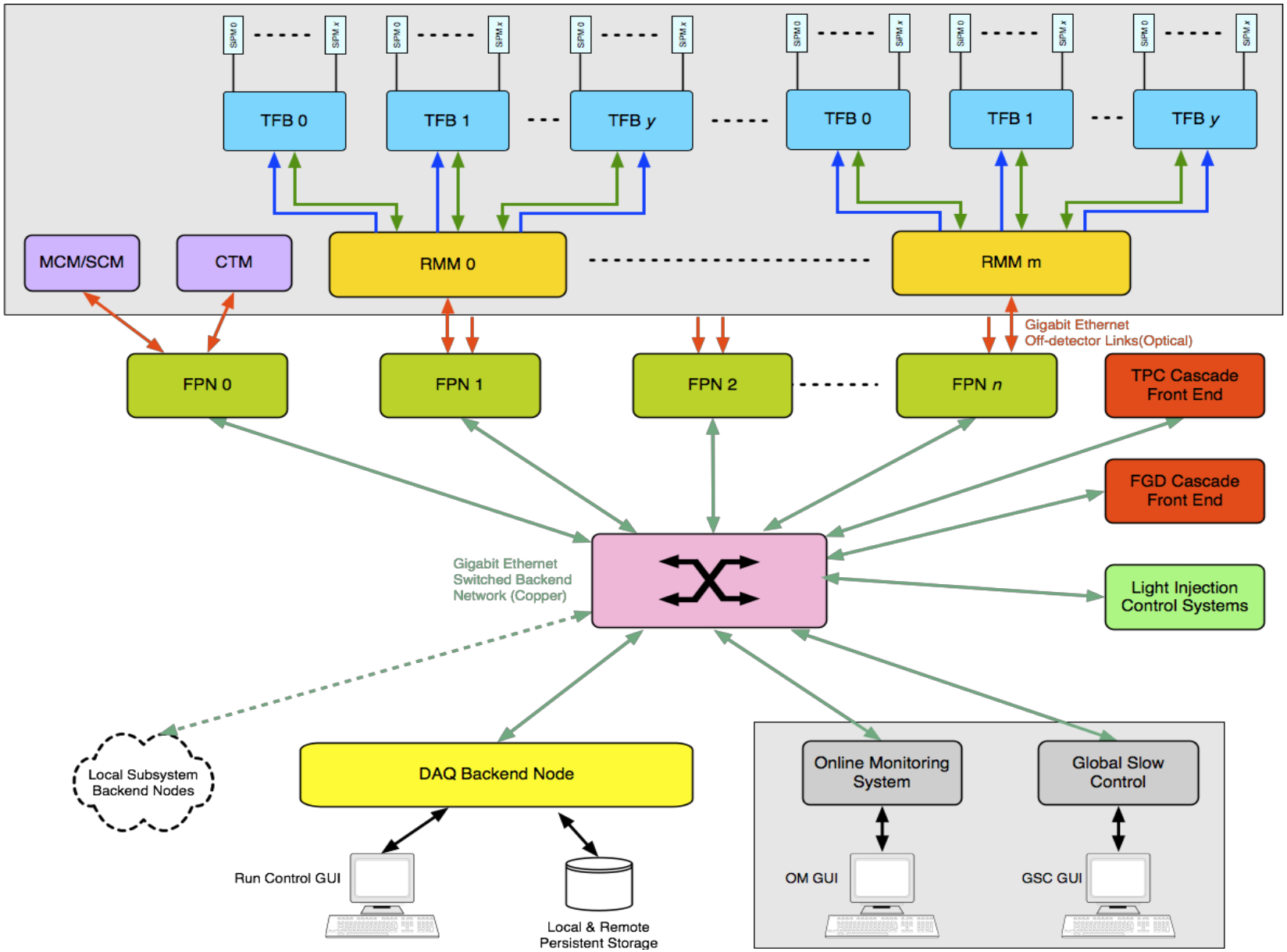


Readout **M**erger **M**odule
(RMM)

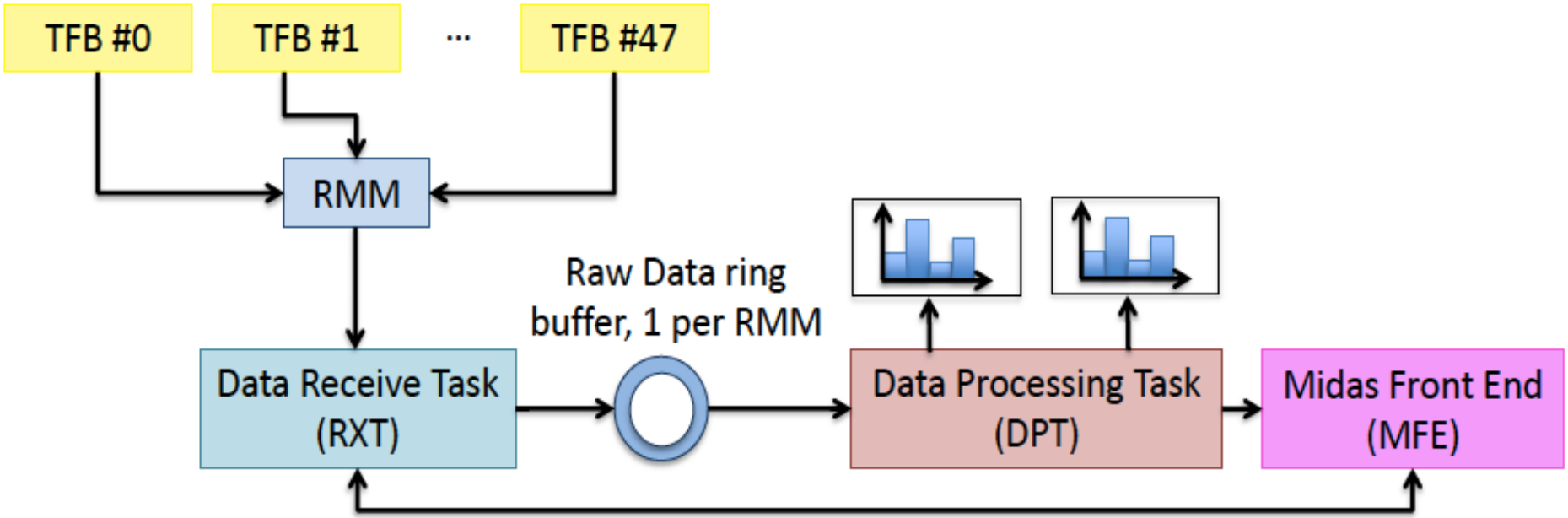
Triggering


GPS
Master Clock Module
SCM (TRIPt)
RMM
RMM
RMM
RMM
TFB
TFB
CTM (FGD)
CTM (TRIPt)

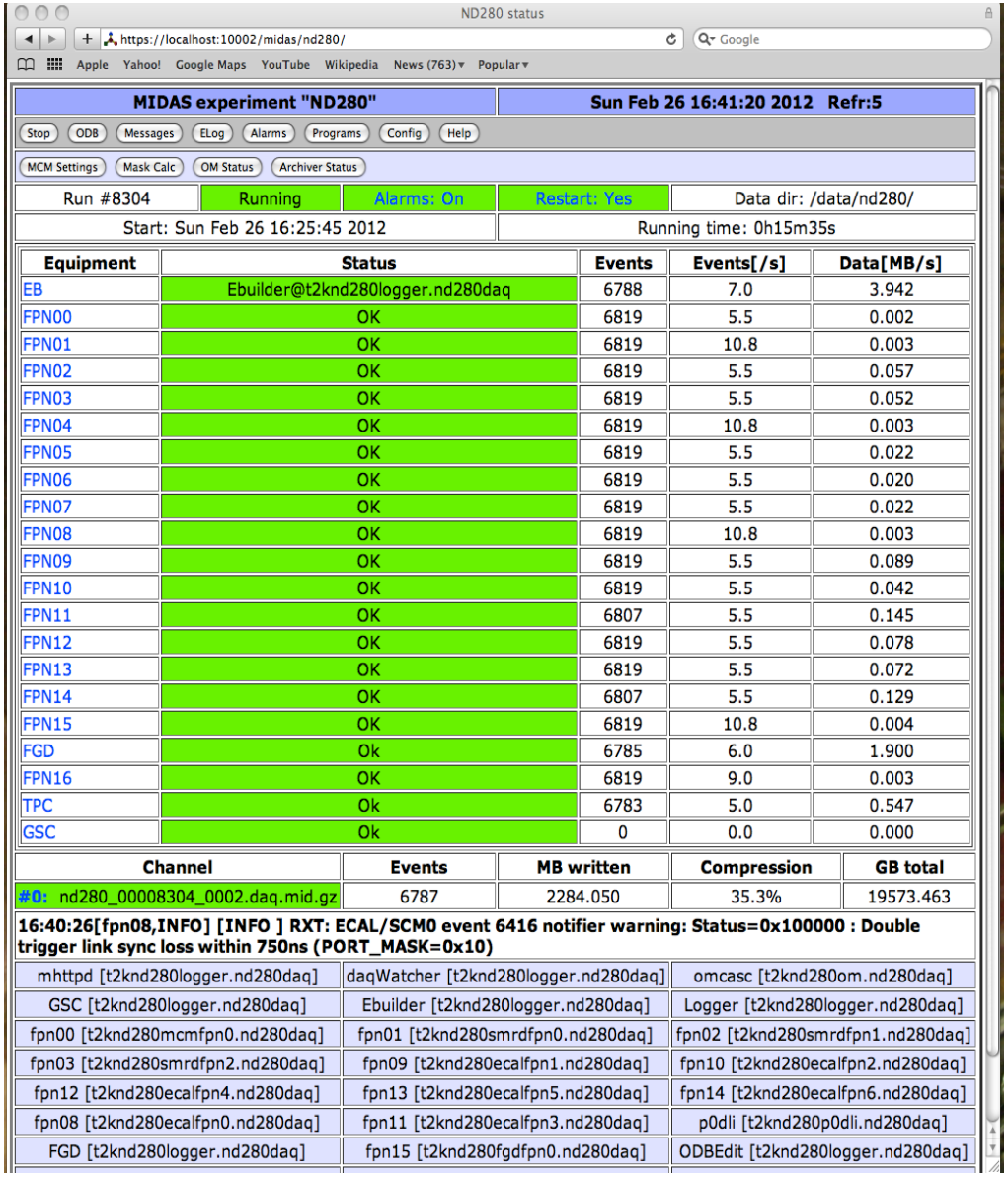
DAQ architecture



FPN processes



MIDAS framework



Equipment	Status	Events	Events[/s]	Data[MB/s]
EB	Ebuilder@t2knd280logger.nd280daq	6788	7.0	3.942
FPN00	OK	6819	5.5	0.002
FPN01	OK	6819	10.8	0.003
FPN02	OK	6819	5.5	0.057
FPN03	OK	6819	5.5	0.052
FPN04	OK	6819	10.8	0.003
FPN05	OK	6819	5.5	0.022
FPN06	OK	6819	5.5	0.020
FPN07	OK	6819	5.5	0.022
FPN08	OK	6819	10.8	0.003
FPN09	OK	6819	5.5	0.089
FPN10	OK	6819	5.5	0.042
FPN11	OK	6807	5.5	0.145
FPN12	OK	6819	5.5	0.078
FPN13	OK	6819	5.5	0.072
FPN14	OK	6807	5.5	0.129
FPN15	OK	6819	10.8	0.004
FGD	Ok	6785	6.0	1.900
FPN16	OK	6819	9.0	0.003
TPC	Ok	6783	5.0	0.547
GSC	Ok	0	0.0	0.000

Channel	Events	MB written	Compression	GB total
#0: nd280_00008304_0002.daq.mid.gz	6787	2284.050	35.3%	19573.463

16:40:26[fpn08,INFO] [INFO] RXT: ECAL/SCM0 event 6416 notifier warning: Status=0x100000 : Double trigger link sync loss within 750ns (PORT_MASK=0x10)

mhttpd [t2knd280logger.nd280daq]	daqWatcher [t2knd280logger.nd280daq]	omcasc [t2knd280om.nd280daq]
GSC [t2knd280logger.nd280daq]	Ebuilder [t2knd280logger.nd280daq]	Logger [t2knd280logger.nd280daq]
fpn00 [t2knd280mcmfpn0.nd280daq]	fpn01 [t2knd280smrdfpn0.nd280daq]	fpn02 [t2knd280smrdfpn1.nd280daq]
fpn03 [t2knd280smrdfpn2.nd280daq]	fpn09 [t2knd280ecalfpn1.nd280daq]	fpn10 [t2knd280ecalfpn2.nd280daq]
fpn12 [t2knd280ecalfpn4.nd280daq]	fpn13 [t2knd280ecalfpn5.nd280daq]	fpn14 [t2knd280ecalfpn6.nd280daq]
fpn08 [t2knd280ecalfpn0.nd280daq]	fpn11 [t2knd280ecalfpn3.nd280daq]	p0dli [t2knd280p0dli.nd280daq]
FGD [t2knd280logger.nd280daq]	fpn15 [t2knd280fgdfpn0.nd280daq]	ODBEdit [t2knd280logger.nd280daq]

T2K ND280 DAQ summary

- DAQ has run stably since start of T2K experiment
- Able to link 5 independent detector systems
- Full training for shifters/sub-detector experts
- 24 hour on call support on-site and remotely

HK DAQ

- UK institutions interested in DAQ
- Small amount of money to spend on technical help
- Main focus is on backend and software trigger
- Interested in working on 1 kT prototype

Data rates

Important to consider data rate in FULL volume

Event class	(estimated) rate (Hz)	Notes
PMT noise	10×10^3	Per PMT
^{238}U chain	158	Assuming SK levels
^{232}Th chain	475	Assuming SK levels
^{222}Rn	2772	Assuming SK levels

Only water radioactivity has been included, external radioactivity from shielding water, construction materials etc has been ignored.

Data rates II

Assume 12 bytes/PMT hit, 100,000 PMTs in detector, 10 hits per background event

Event class	Estimated data rate
PMT noise	12 GB/s
^{238}U chain	20 MB/s
^{232}Th chain	57 MB/s
^{222}Rn	332 MB/s

Accidental rate

Expression from SNO-STR-90-036 (1990)
The accidental rate A is

$$A = \frac{\tau^{-1} k^{n_t} e^{-k}}{(n_t - 1)!}$$

where
n_t = number of tubes firing
N = total number of PMTs $\rightarrow$ 10,000 per compartment
R = Dark noise rate of the tubes = 10 kHz
τ = discriminator time width = 100 ns
$k = NR\tau$

NHit threshold rates

- SK triggers when a hit count exceeds a threshold in a given time window
- Atmospheric and beam events this concept is OK

NHit threshold	Accidental rate
10	12.5 MHz
15	5.2 MHz
20	373 kHz
25	7.3 kHz

- For solar, geo etc this is not OK
- Straightforward NHit cut may reject too much physics
- How can we differentiate between noise and low energy events

Separating noise and low energy events

Angular distributions

- Noise hits should be random across detector
- Hits from low energy events should be less isotropic

Low E event
Less isotropic
Average angle between hits is small

Noise "event"
More isotropic
Average angle between hits is larger

Timing information

- Noise hits randomly dispersed in a trigger window
- Hits from low energy events have a different timing distribution?

The way forward

Generate low energy events (e.g. ^{208}TI, ^{214}Bi etc) using MC
Generate random hits across detector
Look at both of these using the event display
Calculate angular distributions etc

Goal: To develop a "sophisticated" trigger which will remove noise but retain low energy events

Conclusions

- Several UK institutes will contribute to the HK DAQ systems
- Small amount of money to spend on technical support between Jan 2014 and Sept 2014
- Focus on design of backend systems
- Interested in software trigger as part of DAQ
- Participation in 1 kT prototype