Report Scintillator Detector WG

Davide Sgalaberna (CERN) for the SD WG,
ND280 upgrade general meeting
21st February 2018

A. Blondel

Proposed measurement in test beams

Results to be obtained from test beam

-1- general illumination of detector with e.g. few GeV muon beam to get more data on alignment, pulse height uniformity and resolution, effective time resolution, position resolution, calibration procedure etc...
check performance of detector with baby-MIND electronics.

See later

-2- obtain a sample of converted gammas to study the two track separation and the e/gamma PID ability of the device.
Need magnets – Essential for ν_e and $\bar{\nu}_e$ cross-sections

See Stefania's talk

-3- test performance of Baby-MIND electronics in 0.2 T magnetic field could be done separately but may as well do it if we can.

See later and Stefania's talk

-4- exposure to {p π^+ e^+ } and {π^- e^- } in momentum (0.5 to 3 GeV/c) to measure energy loss and time resolution. Try to acquire a sample of stopping pions and muons of both signs to study response to stopping particles and **required dynamic range**
Joint operation with TOF would be very useful

See later for ToF synchro

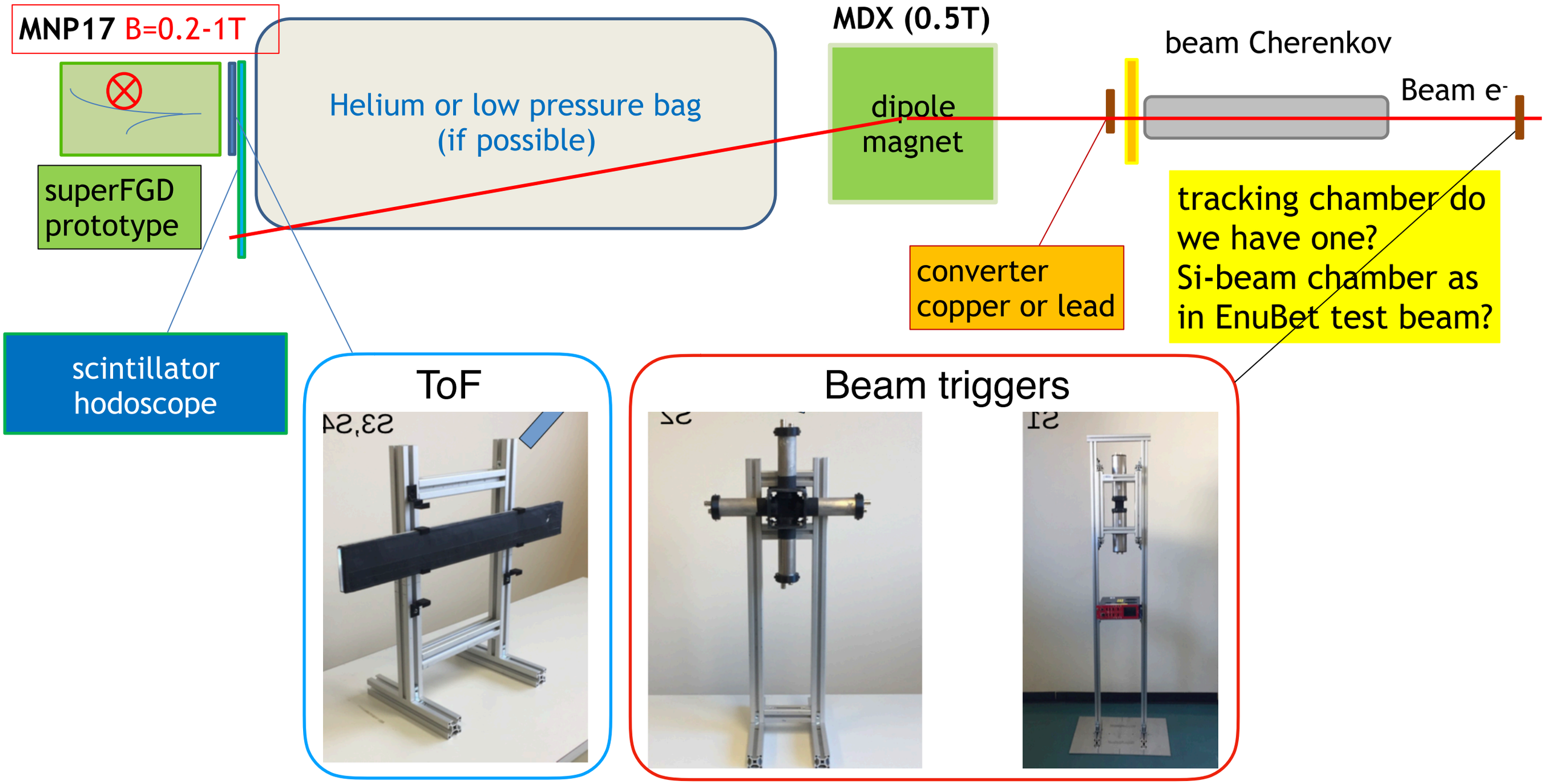
-5- exposure to π^+ and π^- beams to observe a number of elastic scattering events e.g. π^+ **p** $\rightarrow \pi^+$ **p** **(kinematically constrained reaction!)** and higher energy events with many tracks **(multi track separation)**

- Lots of interesting things to do —> please join the efforts!
- Measurements less powerful w/o magnetic field —> June/July enough?
- Priorities would be testing the response, electronics in B-field and tracking

Test beams

A. Blondel
A. Korzenev

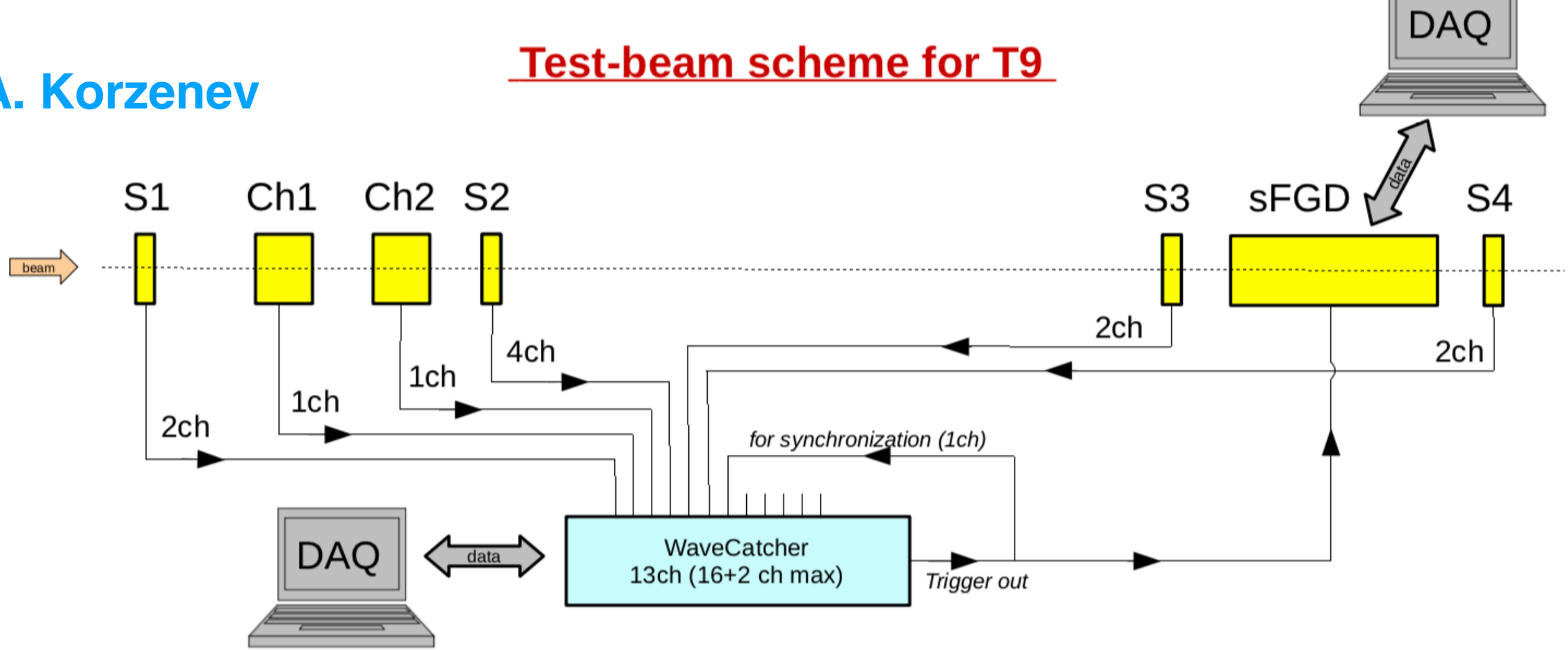
Prototype: 52 x 22 x 8 cm^3 —> plan to instrument all the readout channels
- about 10k cubes and 1736 readout channels



We will be able to instrument all the readout channels with Baby MIND electronics
—> we will have the instruments to perform the measurements (Stefania's talk)

A. Korzenev

Test-beam scheme for T9



- Two independent DAQ systems: WaveCatcher & BabyMIND (sFGD)
  - Synchronized via trigger signal from WaveCatcher
  - Data to be merged offline
- WaveCatcher system:
  - Coincidence between beam scintillator counters
  - PID via ToF + 2 signals from Cherenkov counters
  - Assurance for a single particle within 320 ns time window
- BabyMIND system: detector under study
  - Self-triggering system. WaveCatcher signal goes to one of channels

Trigger: WaveCatcher
S1 and S2 and S3 (8ch)
S1 and S2 and S3 and S4 (10ch)

- The firmware of Baby MIND needs to be upgraded to get input signals from the WaveCatcher —> no more than 2-3 days work
- Discussions with Yannick ongoing to define the needed updates

MPPCs for prototype

T. Matsubara

Required

・20x50x10 cubes … 1700 ch (Full option)

(ref. 20x30x8 cubes (Assembling now) … 1000 ch)

・Operation voltage?
・50 μm is not enough?
25 μm pitch is desirable?
→ Can we mix those?

Available

・S13081-050CS … ~690 units
  ・From WAGASCI for SMRD
  ・50 μm pitch, 667 pixels, 1.3 x 1.3 mm^2, Ceramic package, V_{BR} = ~53 V
・S12571-025C … ~200 units
  ・From Baby-MIND
  ・25 μm pitch, 1600 pixels, 1 x 1 mm^2, Ceramic package, V_{BR} = ~65 V

Buy new*? → Yokoyama-san is asking prices & delivery date to HAMAMATSU

(*) Exactly same types as above are not in catalog. Therefore, similar types below are candidates

・S13360-1325CS
  ・25 μm pitch, 2668 pixels, 1.3 x 1.3 mm^2, Ceramic package, V_{BR} = ~53 V
・12571-015C
  ・15 μm pitch, 4489 pixels, 1 x 1 mm^2, Ceramic package, V_{BR} = ~65 V

- Yokoyama-san waiting for news from Hamamatsu
- May not have all MPPCs in time for June/July. Possibility to use WAGASCI ones
- If we want to test particles stopping power we can disposed the MPPCs in a smart way —> low # of pixels in upstream part of the detectors

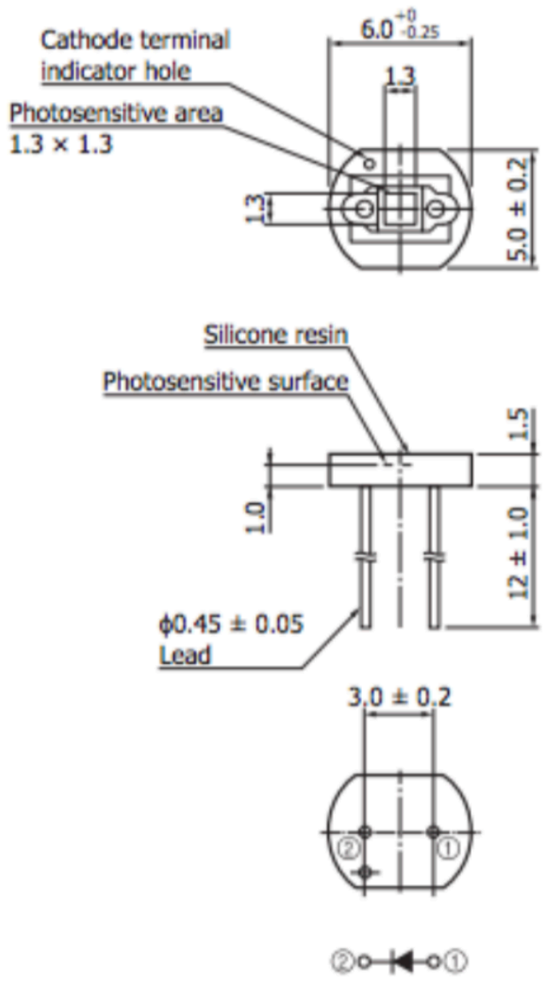
MPPCs for prototype

T. Matsubara

Design of the ceramic package

・Same external dimension between 1.3 x 1.3 mm² & 1 x 1 mm²

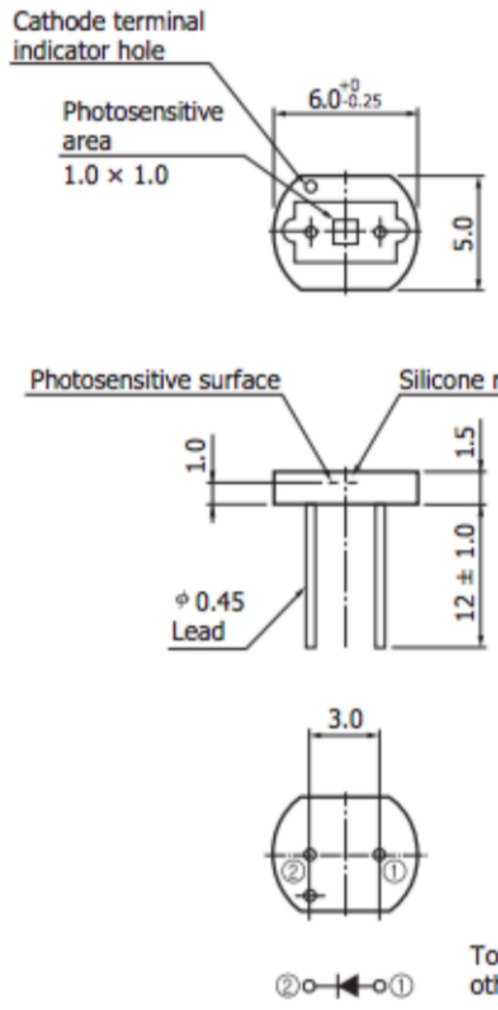
S13360-1325CS/-1350CS/-1375CS



Lead material: Fe-Ni-Co alloy
Lead processing: Au plating
Tolerance unless otherwise noted: ±0.2
Chip position accuracy:
X, Y≤±0.25 with respect to package center
The coating resin may extend a maximum of
0.1 mm above the upper surface of the package.

https://www.hamamatsu.com/resources/pdf/ssd/s13360_series_kapd1052e.pdf

S12571-010/-015C



Tolerance unless otherwise noted: ±0.2

KAPDA0141EA

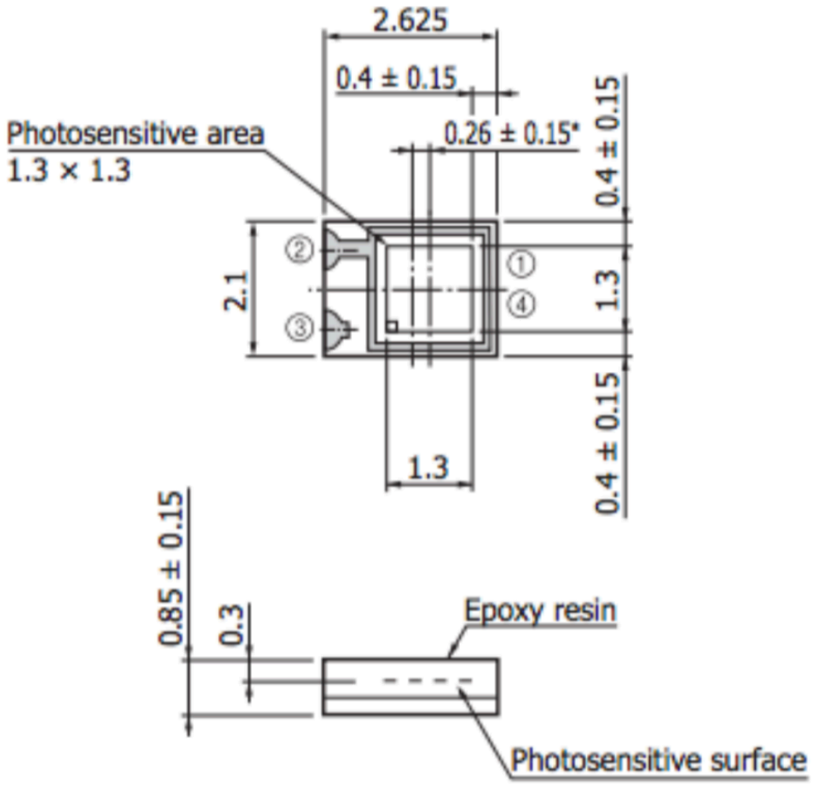
https://www.hamamatsu.com/resources/pdf/ssd/s12571-010_etc_kapd1044e.pdf

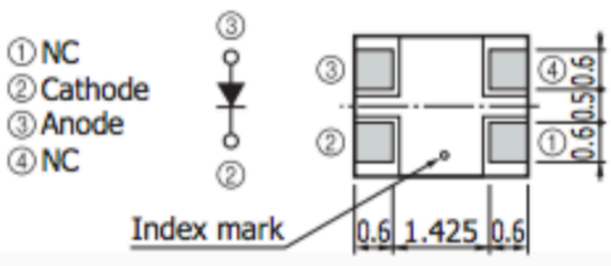
MPPCs for final SuperFGD

T. Matsubara

- Surface mounting MPPCs are the favorite options for the final detector
- ~40% cheaper than other MPPC types
- Less material budget

S13360-1325PE/-1350PE/-1375PE





Tolerance unless otherwise noted: ±0.1
* Distance from chip center to package center

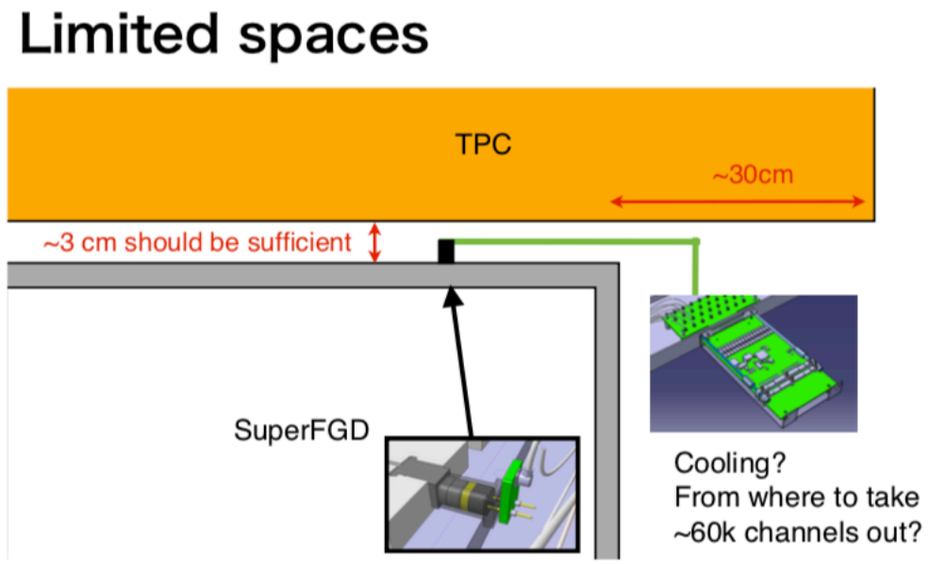
- Latest version of MPPC - S13360-1350CS/PE
  - Area: 1.3 x 1.3 mm^2
  - Number of pixels: 667 pixels (50 μm pitch)
    (*) 25μm pitch with same package size is also available
    Compatible price is expected but need to confirm
- Typical V_{BR} = 53 V
- PDE: 40%
- Dark count rate: 90-270 kHz
- Cross-talk rate: 3%

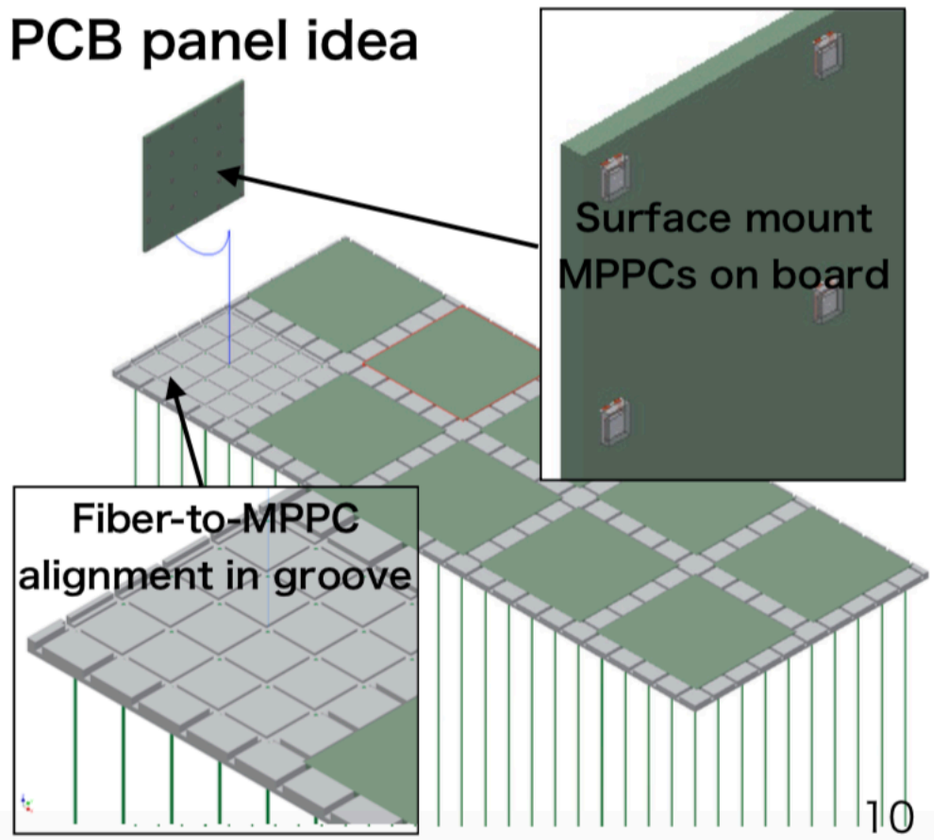
- Cost difference between 25 and 50 mum is not big —> 667 Vs 2668 pixels

MPPCs for final SuperFGD

T. Matsubara

- Choice of MPPC?
  → Surface-mount type is favored
- Design of MPPC-to-fiber interface
  → Good interface w/ small space
  (PCB panel idea by Nakadaira-san)
- PSB design including cabling & FEE
  → Less noise, materials & cooing
- Access for equipments to be replaced
  → Capability to maintain (e.g. ASIC tip only?)
- 2D readout option to avoid top ch's ??
  → Big impact to mechanics
  → Trade-off b/w cost & performance
- Timeline to have decision
  → We have to start buying in 2018 JFY
  after fixing number of channels





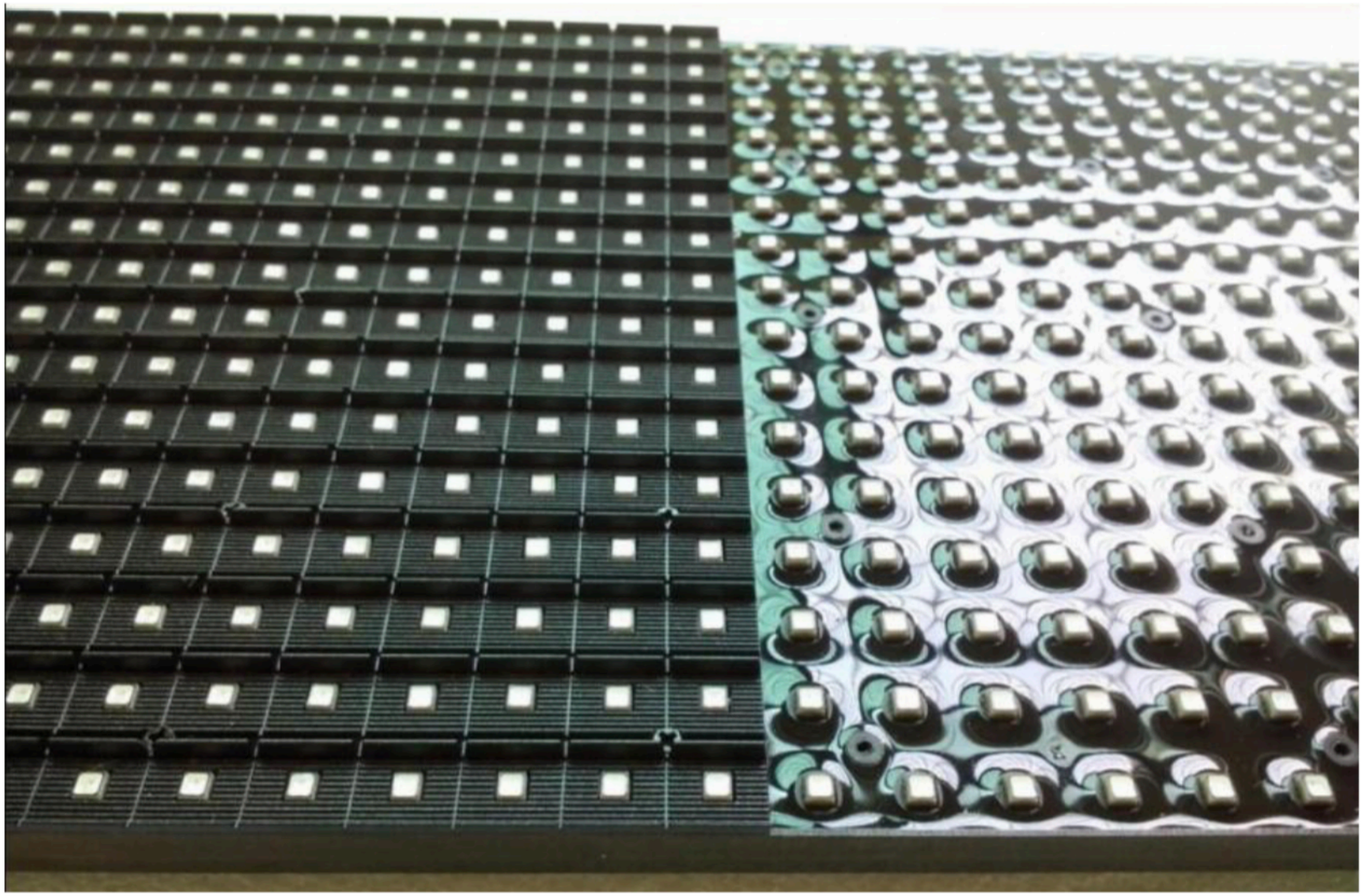
Useful to use the prototype to test interfaces between MPPC / electronics / box

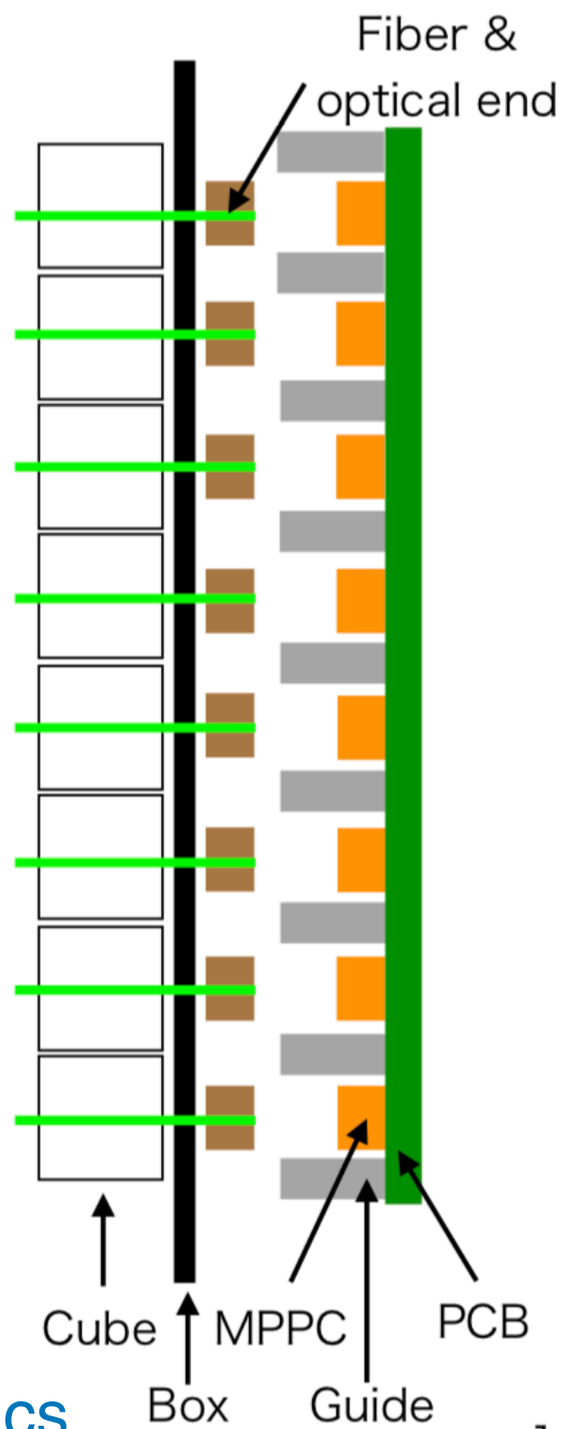
TDR deadline is fall 2018 / beginning 2019 —> important to be ready with final design

MPPCs for final SuperFGD

T. Matsubara

Panel-like structure w/ similar pitch is found in LED screen

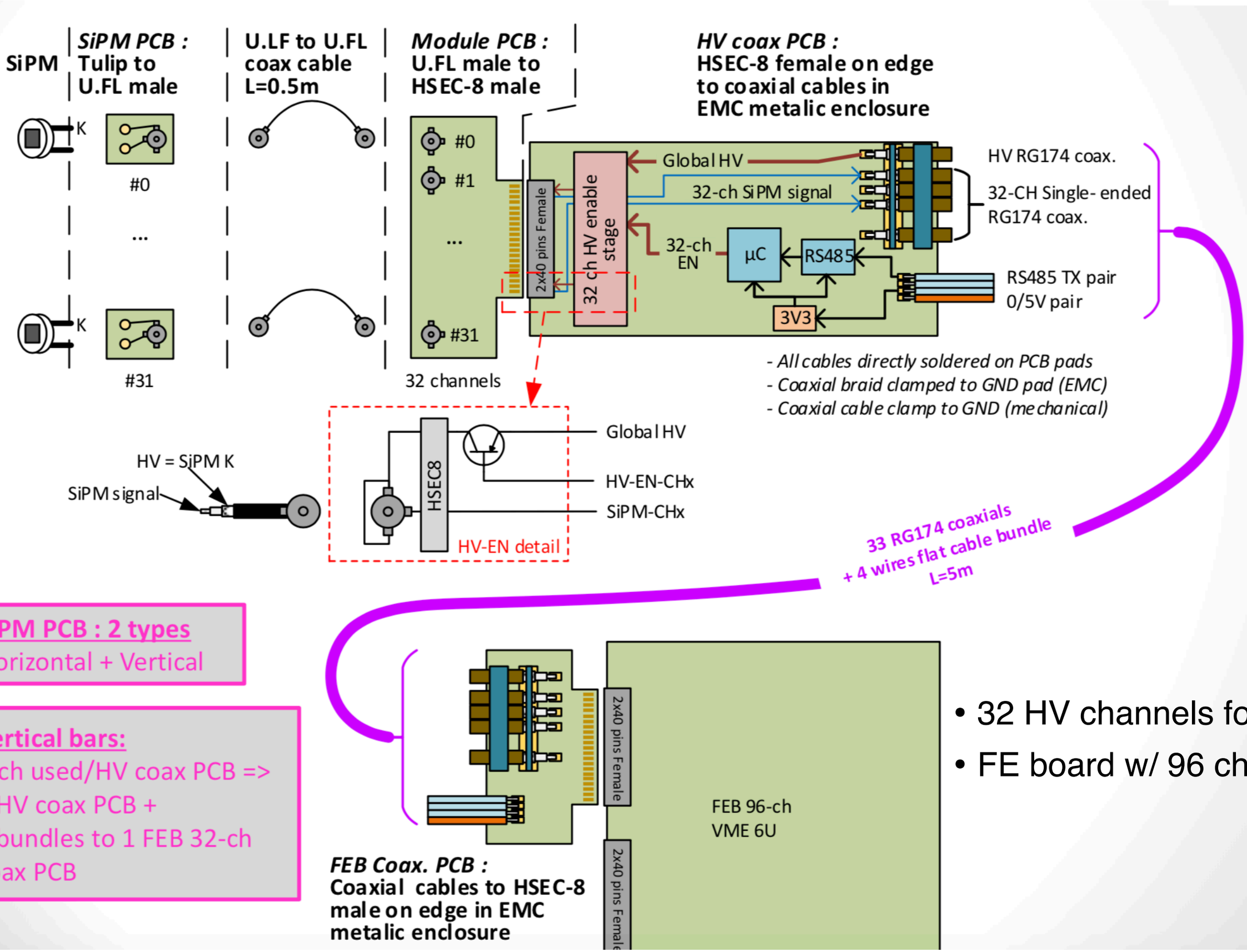




- Very compact design to be integrated with the box and electronics

Baby MIND FE electronics and DAQ

Y. Favre



SiPM PCB : 2 types
Horizontal + Vertical

Vertical bars:
8-ch used/HV coax PCB =>
4 HV coax PCB +
4 bundles to 1 FEB 32-ch coax PCB

- 32 HV channels for MPPCs
- FE board w/ 96 channels

Baby MIND FE electronics and DAQ

Y. Favre

4032 PCB

SiPM

SiPM PCB :
Tulip to
U.FL male

4032 cables

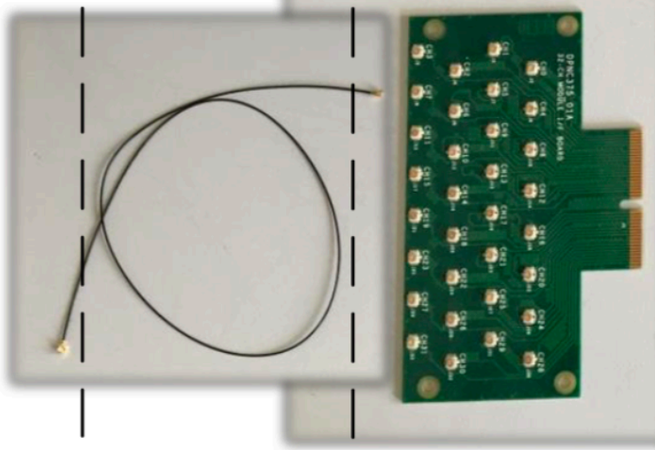
U.LF to U.FL
coax cable
L=0.5m

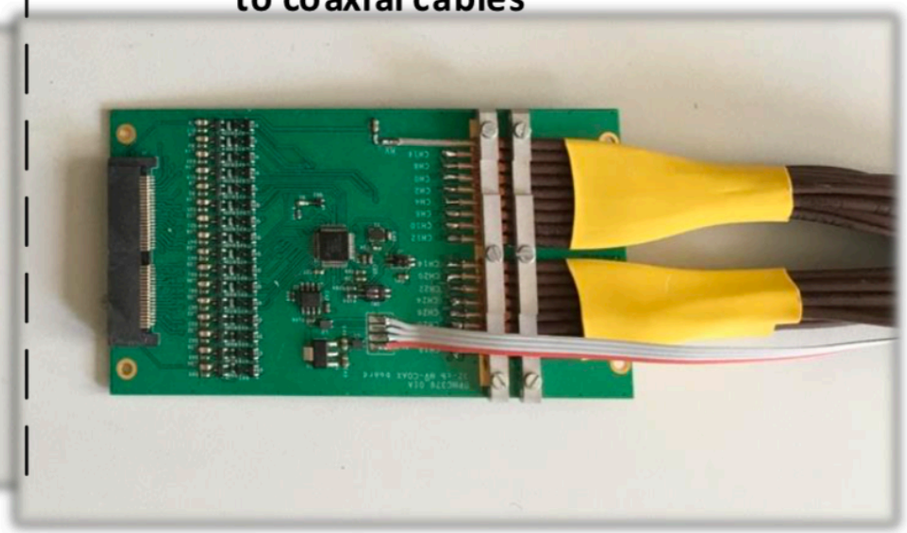
108+72 PCB

Module PCB :
U.FL male to
HSEC-8 male

108+72 PCB

HV coax PCB :
HSEC-8 female on edge
to coaxial cables

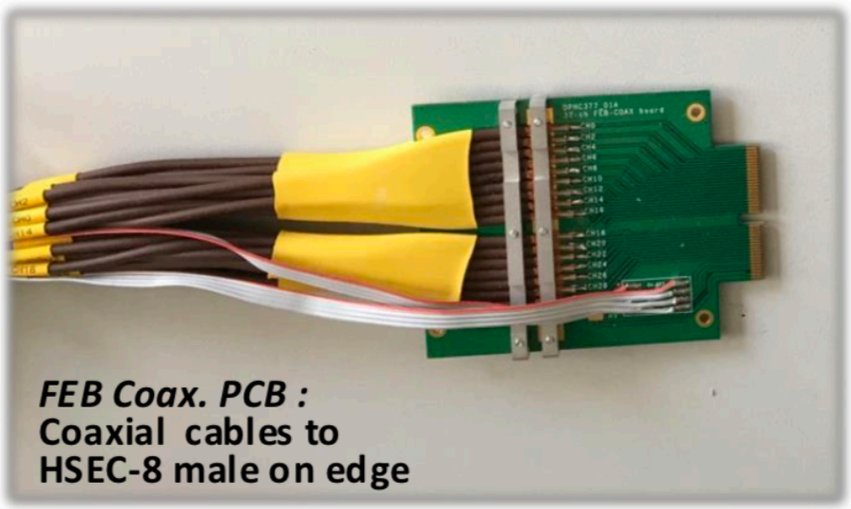




33 RG174 coaxials
+ 4 wires flat cable bundle
L=5m

108 H bundles (33 coax.)
72 V bundles (9 coax.)
180 bundles, 4212 coax. (21km)

126 PCB

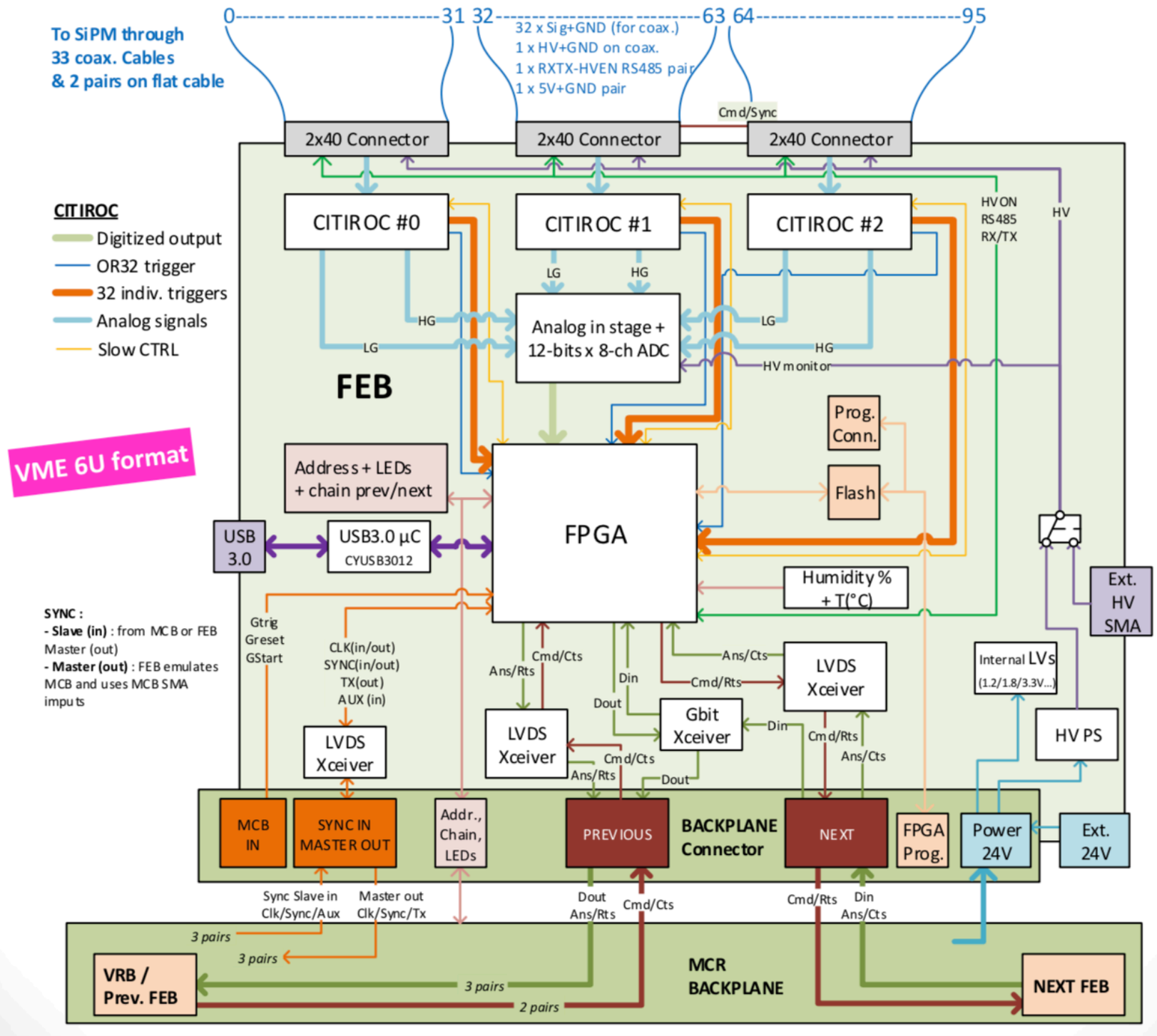


FEB Coax. PCB :
Coaxial cables to
HSEC-8 male on edge

42 PCB

FEB v2 hardware: Bloc diagram

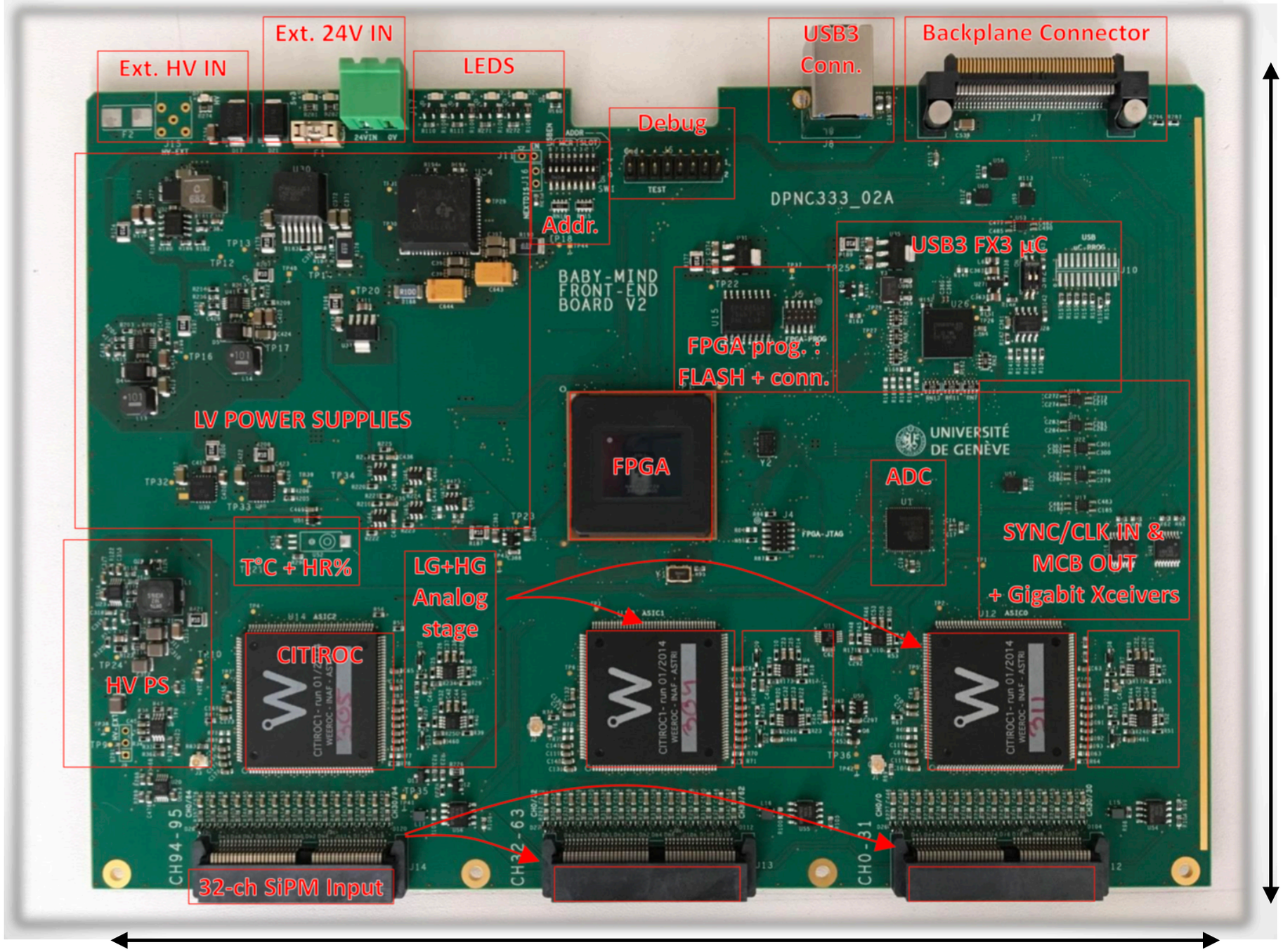
Y. Favre



- 400 MHz rate —> hit time = 2.5 ns (sampling time period)
- With a different FPGA 1.5 ns could be reached
- Below 1 ns may need a dedicated ASIC
- It may be possible to deal with <1ns time resolution on the single hit —> to test

FEB v2 hardware: board view

Y. Favre



- Differently from Baby MIND, in SuperFGD the FE must be on top of the detector
  - layout need a new design, e.g. types of connectors etc.
  - much higher power heating with 60k channels —> cooling system is critical
  - in 0.2 T magnetic field

Test of Baby MIND electronics in B field

Y. Favre

- Baby MIND electronics could be a good starting point for development
- Ferrite coils used in different DC/DC converters need to be tested in B-field
- Can already test it during test beams: can use single FEB
- For the SuperFGD FEB design, we'll have to address that:
  - check if 0.2T is an issue with the current design: this can be checked with formulas & datasheet and tested during the test beam campaign
  - if yes, see if we can orient the coils to be insensitive to the magnetic field
  - if not possible, use LDOs instead (i.e. DC/DC linear converters without coils) providing low voltage (thus high current) to FEB and having more losses (LDO less efficient)

Good B-field

```
Width = 2.27 m (1 m)  [0.22]
Height = 1.59 m (0.3 m) [0.08]
Length = 1.55 m (0.52 m) [0.52]
```

Make sure that all pieces (fibers included) can fit that space without any problem —> shouldn't be an issue

Plans for software

- We need to be prepared for the test beams in June/July
- Need to be ready with data taking and offline analysis

    - data unpacking and ROOT format

    - provide event displays during run time could be useful for tests

- Preliminary simulations with particle guns at different energies

    - look at truth level how many events interaction types we get

- Simulation of SuperFGD with lower # of channels

    - 2-views already shown at the workshop

    - studies with 2 cm^3 cubes can be done in a couple of days

- Prepare software for detector response calibration

Conclusions

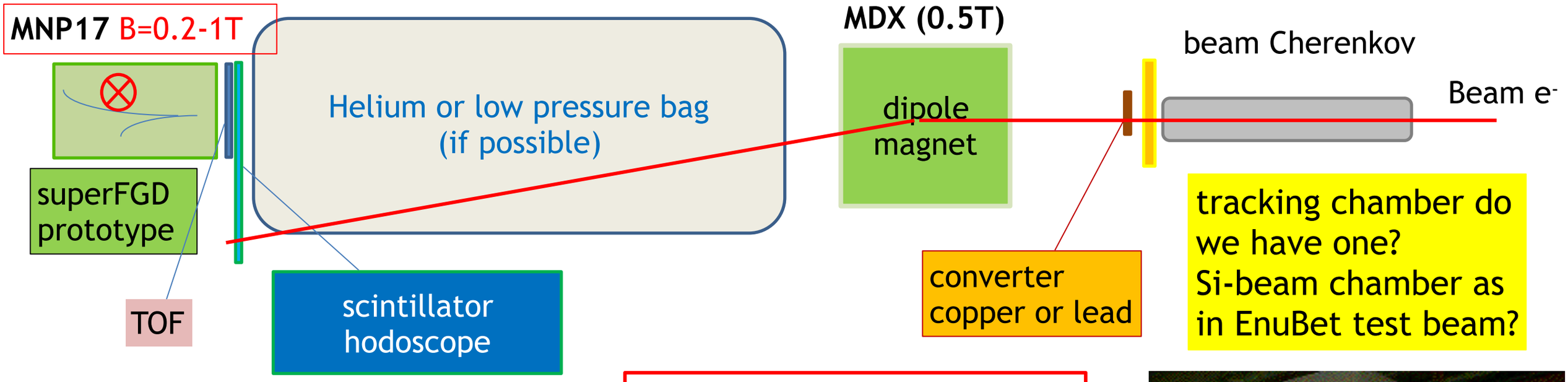
- 8 x 22 x 52 cubes (cm^3) is being prepared @ INR →1736 channels.
- We have started the production to equipe the whole detector
    - Detector in construction at INR'
    - Contribution from CERN&UNIGE for electronics
    - MPPCs will be provided mainly from Japan
- We will be able to test
    - test time resolution, Baby MIND electronics in magnetic field, detector response
    - important answers for the future developments
- Next meeting planned on the 6th of March
- We will focus mainly on the planning for the June/July beam tests

BACKUP

Test beams

A. Blondel

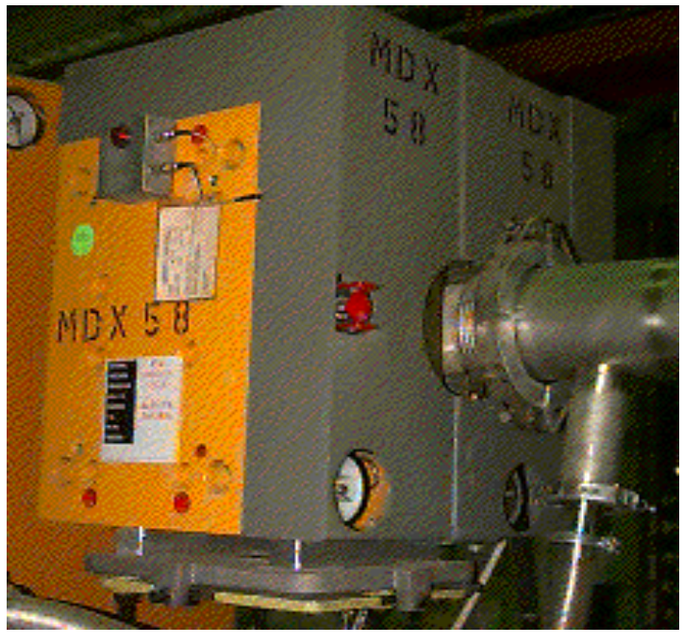
Prototype: 52 x 22 x 8 cm³ —> plan to instrument all the readout channels
- about 10k cubes and 1736 readout channels



Width = 2.27 m (1 m)
Height = 1.59 m (0.3 m)
Length = 1.55 m (0.52 m)

hodoscope
(measures electron momentum
➔ photon energy)

best is probably around 2 GeV/c e- for 200-800 MeV photons
(should be simulated)

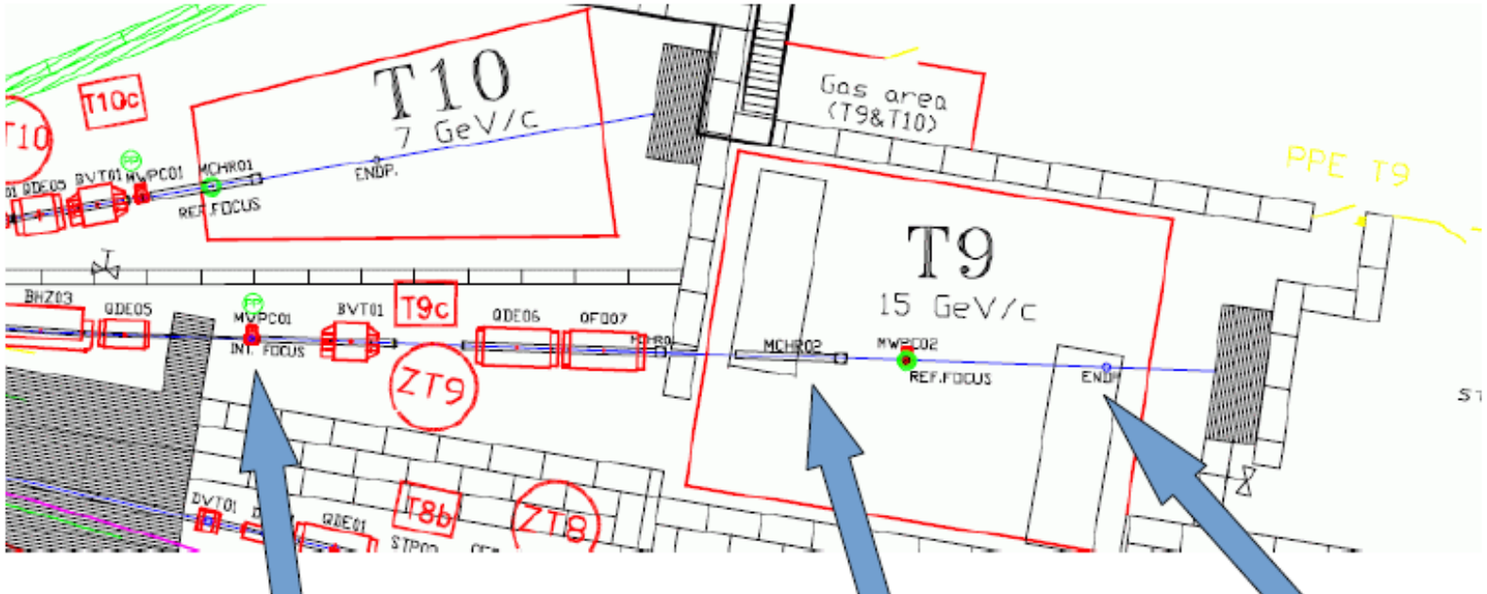


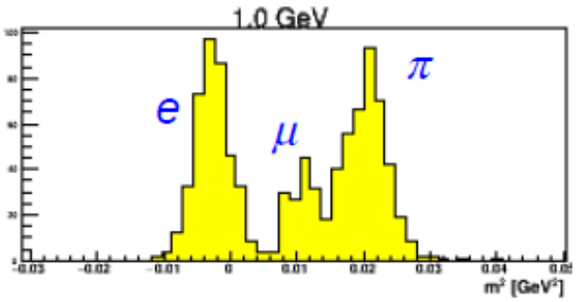
"Photon" magnet (MDX) is available. "Tracking" magnet (MNP17) still pending
Checking availability for June/July test beams
With TPC need to check how much space left by magnet and residual field

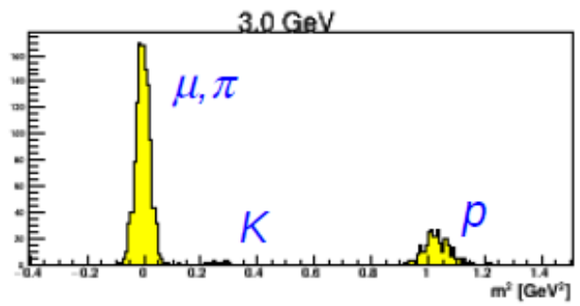
Test beams

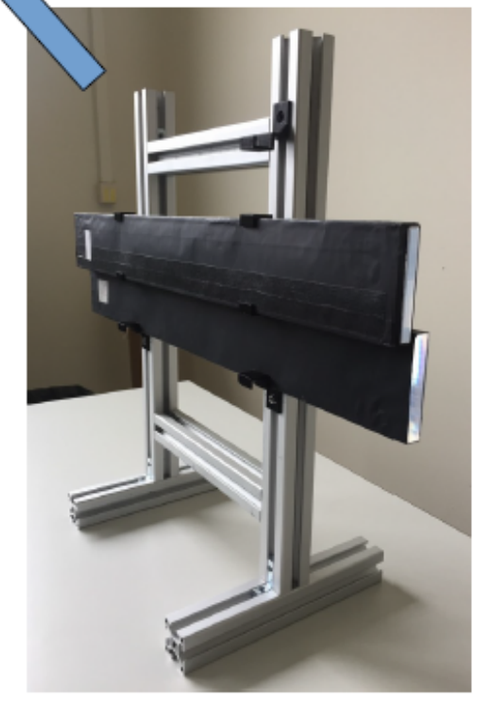
A. Korzenev

ToF and trigger system for the SuperFGD test-beam in June 2017



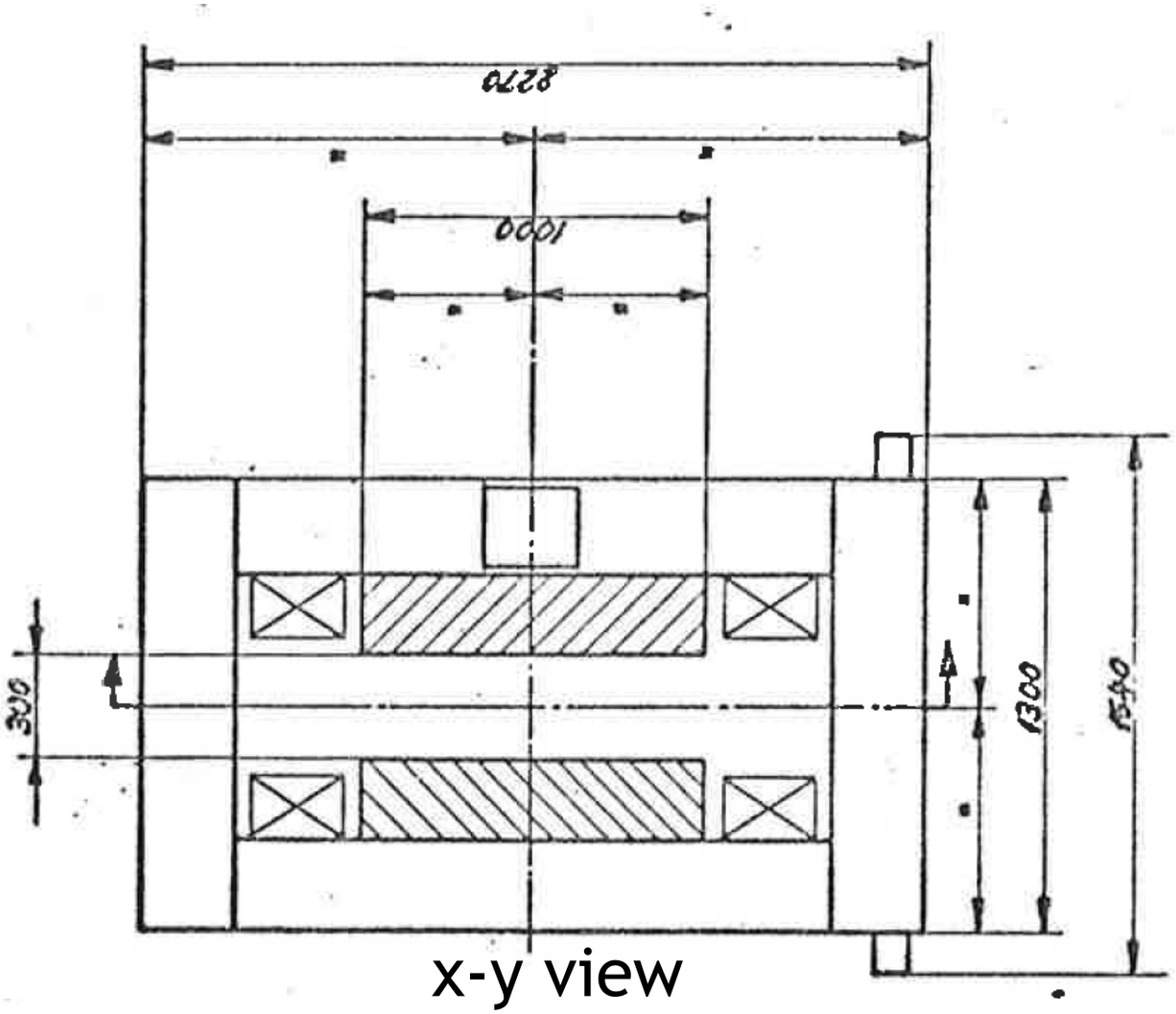




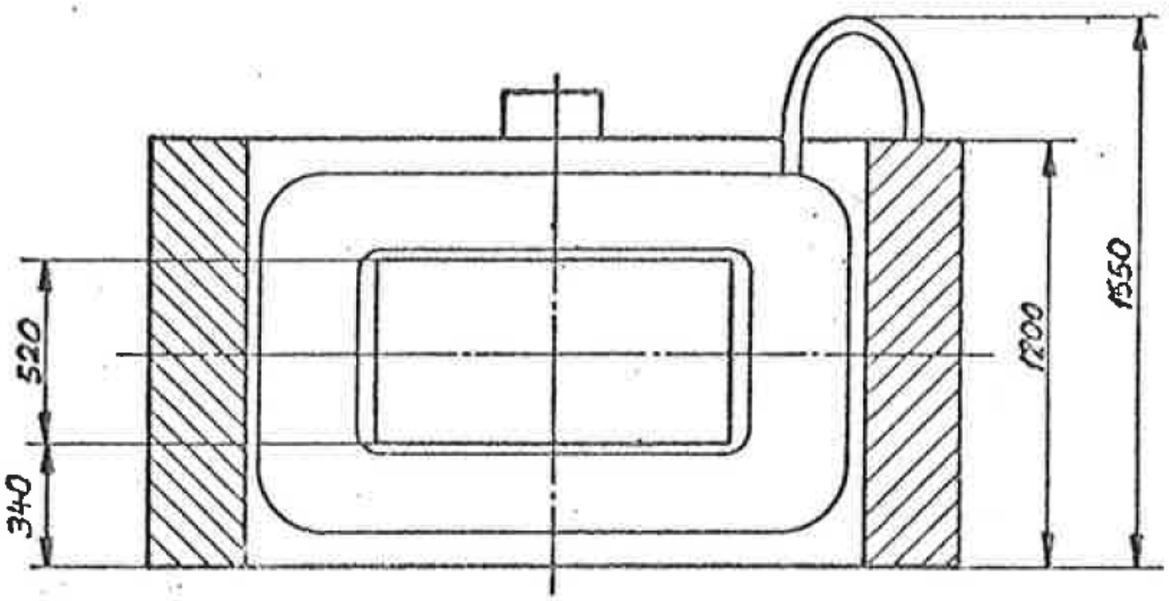


2 bars:
50x6x1 cm^3
δt = 60 ps

To be set upstream of SuprFGD



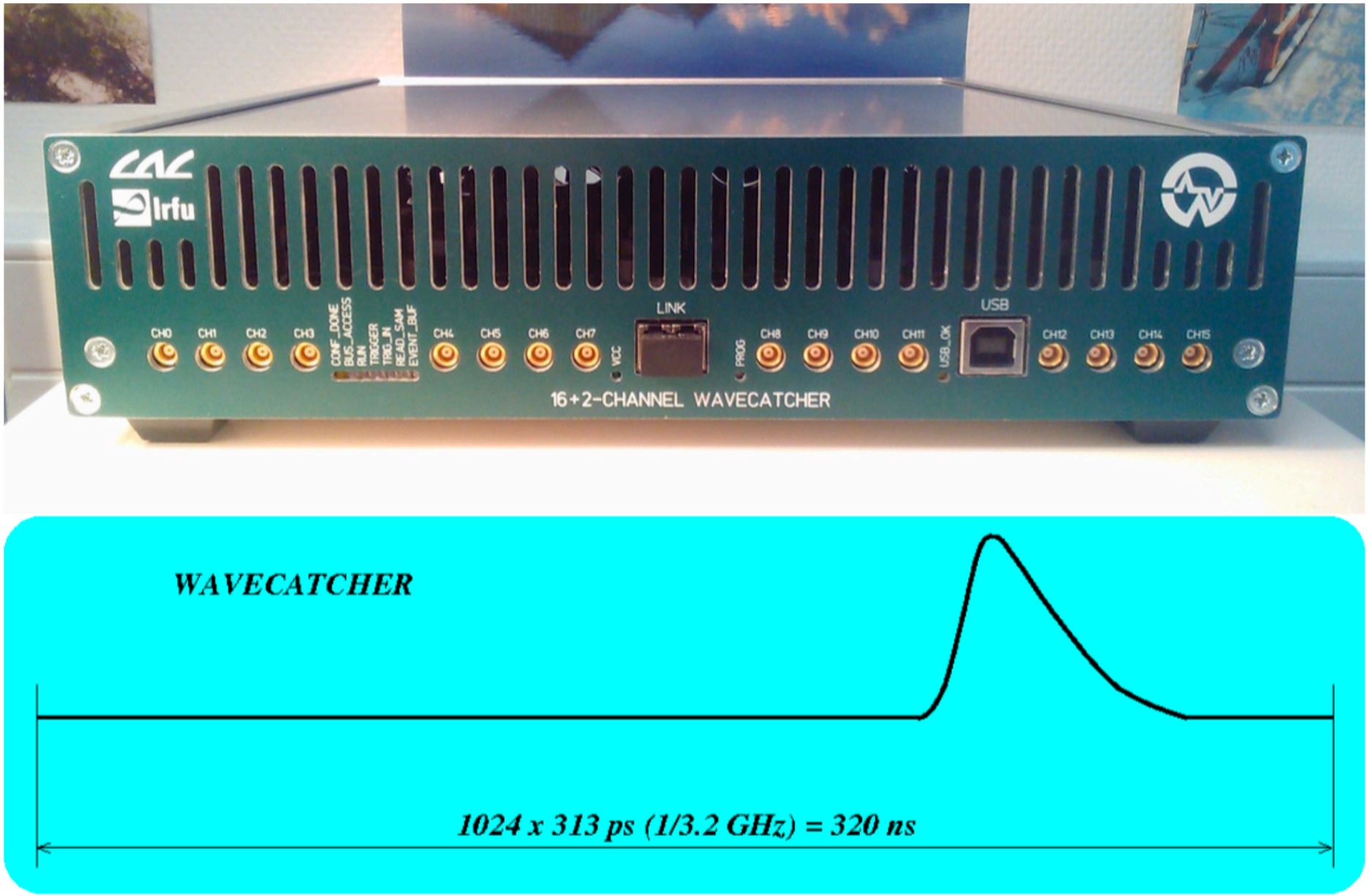
x-y view



x-z view

MNP17 magnet
(laid with B vertical normally
… horizontal possibility?)

DAQ system: WaveCatcher



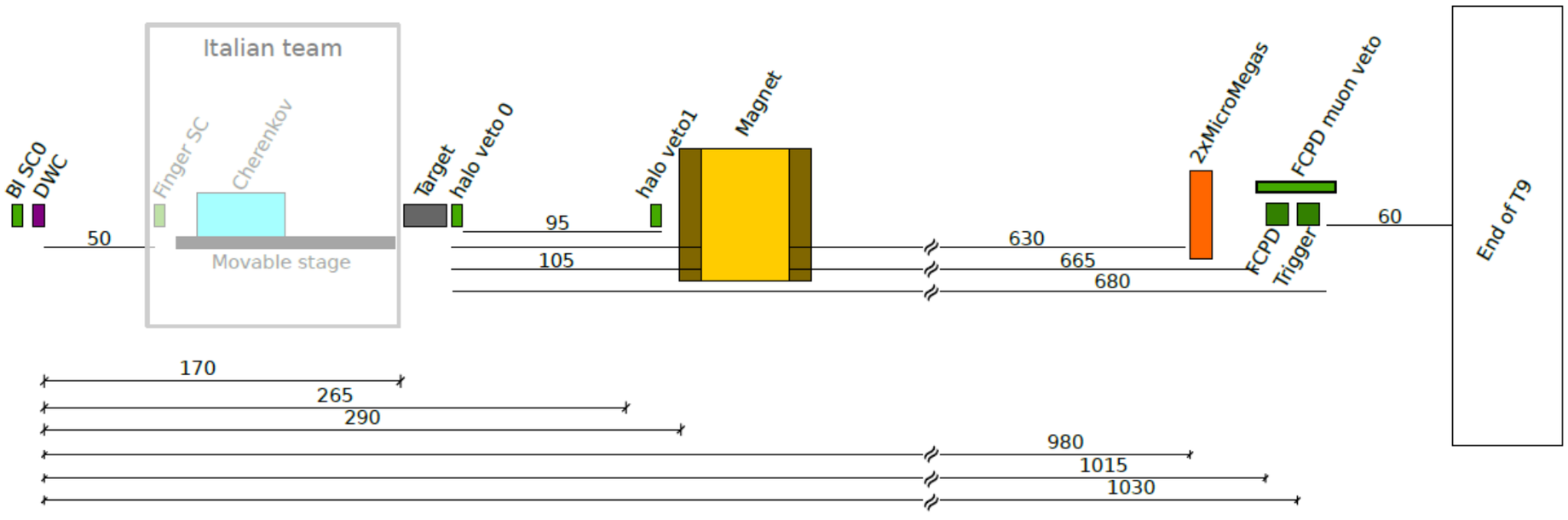
- Technology employs a circular buffer based on arrays of switched capacitors (SCA)
- Sampling rate 0.4 – 3.2 GS/s, buffer 1024 cells, commercial ADC for charge digitization, dead time 120 us, rate below 1 kHz

Conclusions

- Test beams:
  - 25th June - 11th July (SuperFGD)
  - 22nd August - 5th September (TPC)
  - maybe possibility 22nd August - 19th September (parasitic)

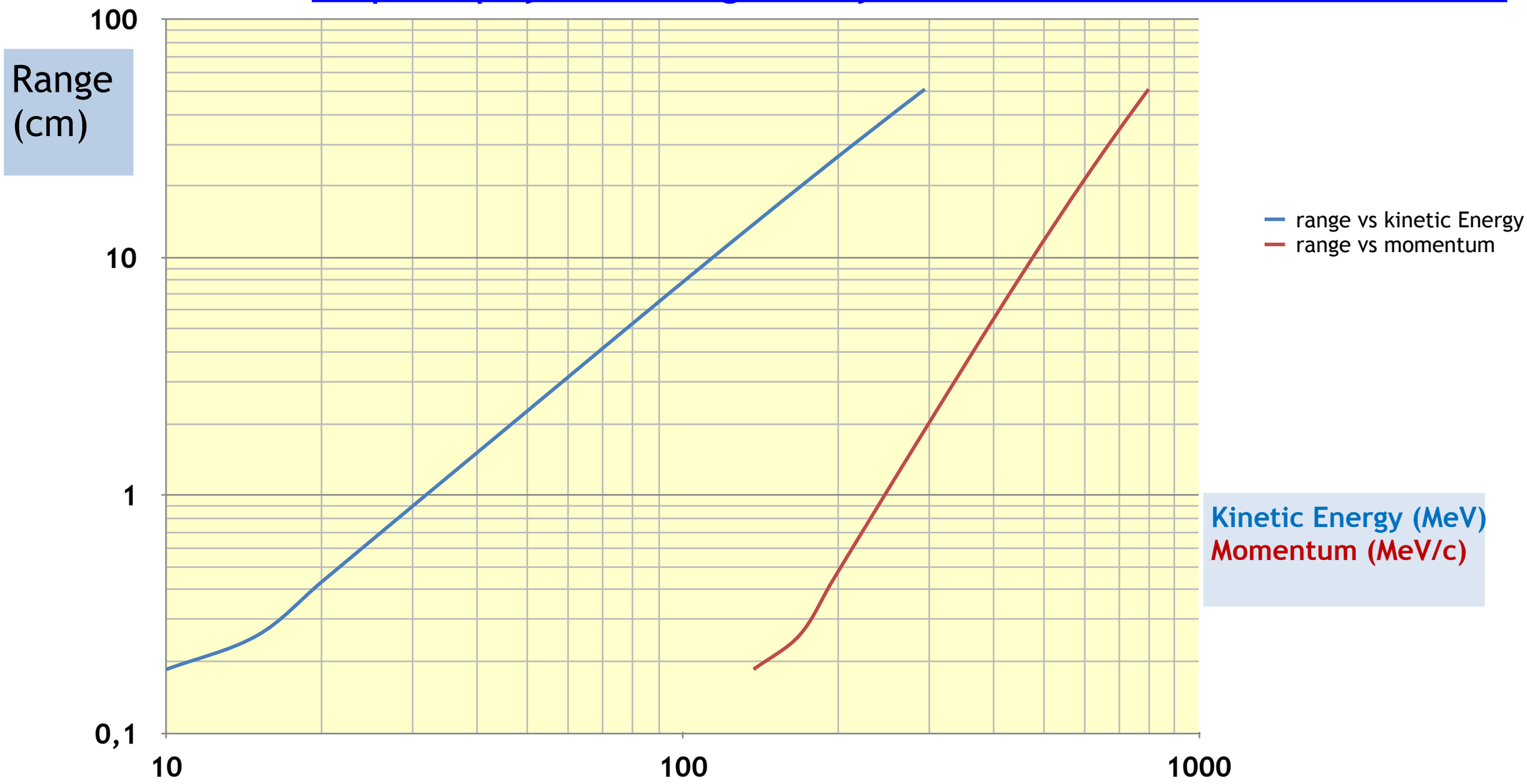
Width = 2.27 m (1 m)
Height = 1.59 m (0.3 m)
Length = 1.55 m (0.52 m)

example of set-up from last year using a magnet,
and with another detector test upstream,
there is 2.9m free space in front of the magnet



Range vs Momentum of protons in Polystyrene

https://physics.nist.gov/PhysRefData/Star/Text/PSTAR.html



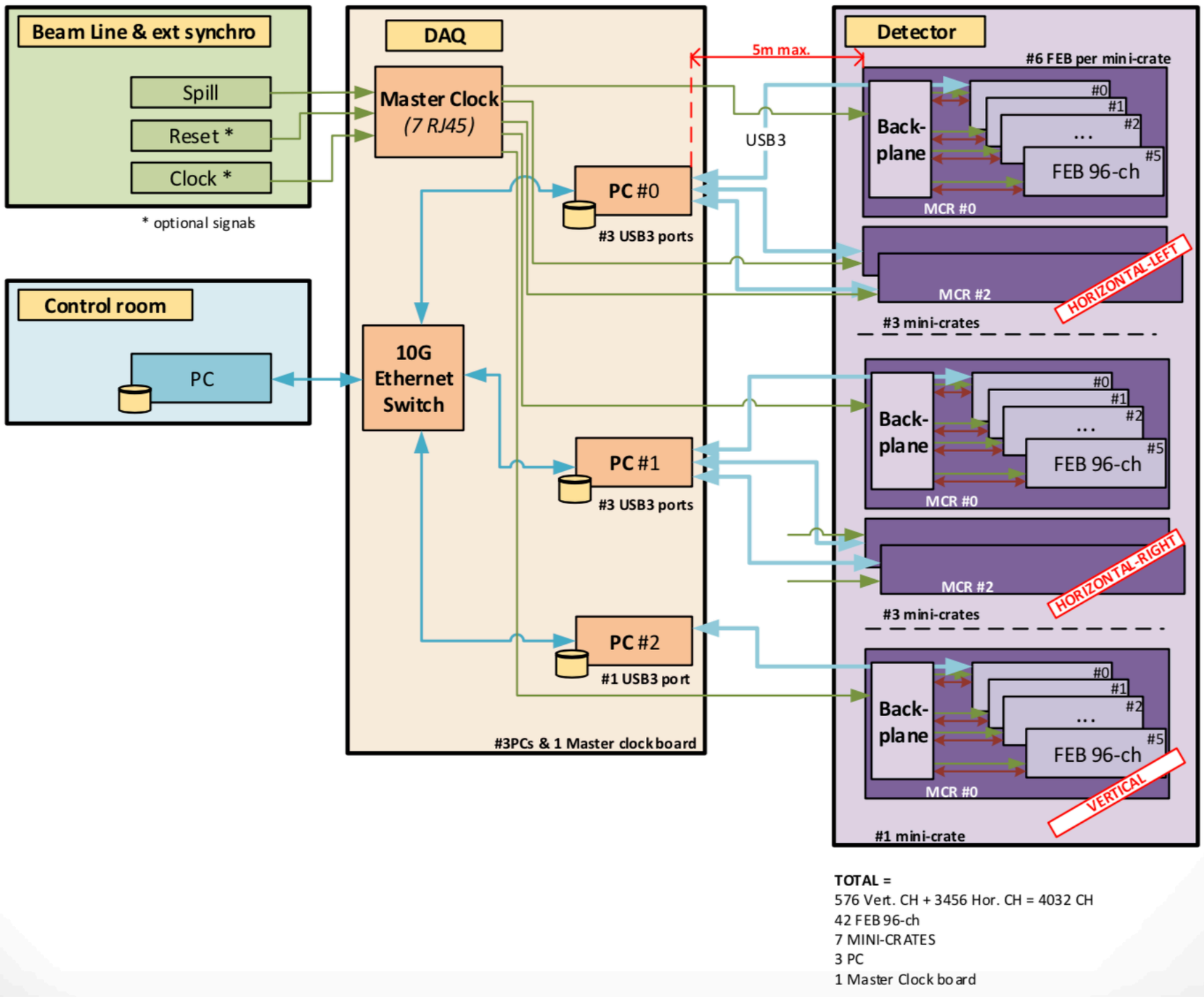
Maximum energy deposition in a single cell: ~30-45 MeV (22 MIPs = 880 pixels)
Range of 500 MeV/c protons : 12cm
Range of 800 MeV/c protons : 50cm

Baby MIND FE electronics and DAQ

Y. Favre

DAQ system overview – overall

Vertical channels :	576-ch,	6 FEBs,	6 FEBs/MCR,	1 MCR/PC,	1 PC	**Total :**
Horizontal channels :	3456-ch,	36 FEBs,	6 FEBs/MCR,	3 MCR/PC ,	2 PCs	7 MCR/42FEBs/3PCs



TOTAL =
576 Vert. CH + 3456 Hor. CH = 4032 CH
42 FEB 96-ch
7 MINI-CRATES
3 PC
1 Master Clock board