The new TPCs for the T2K near detector upgrade

Marco Zito

IRFU/SPP CEA Saclay

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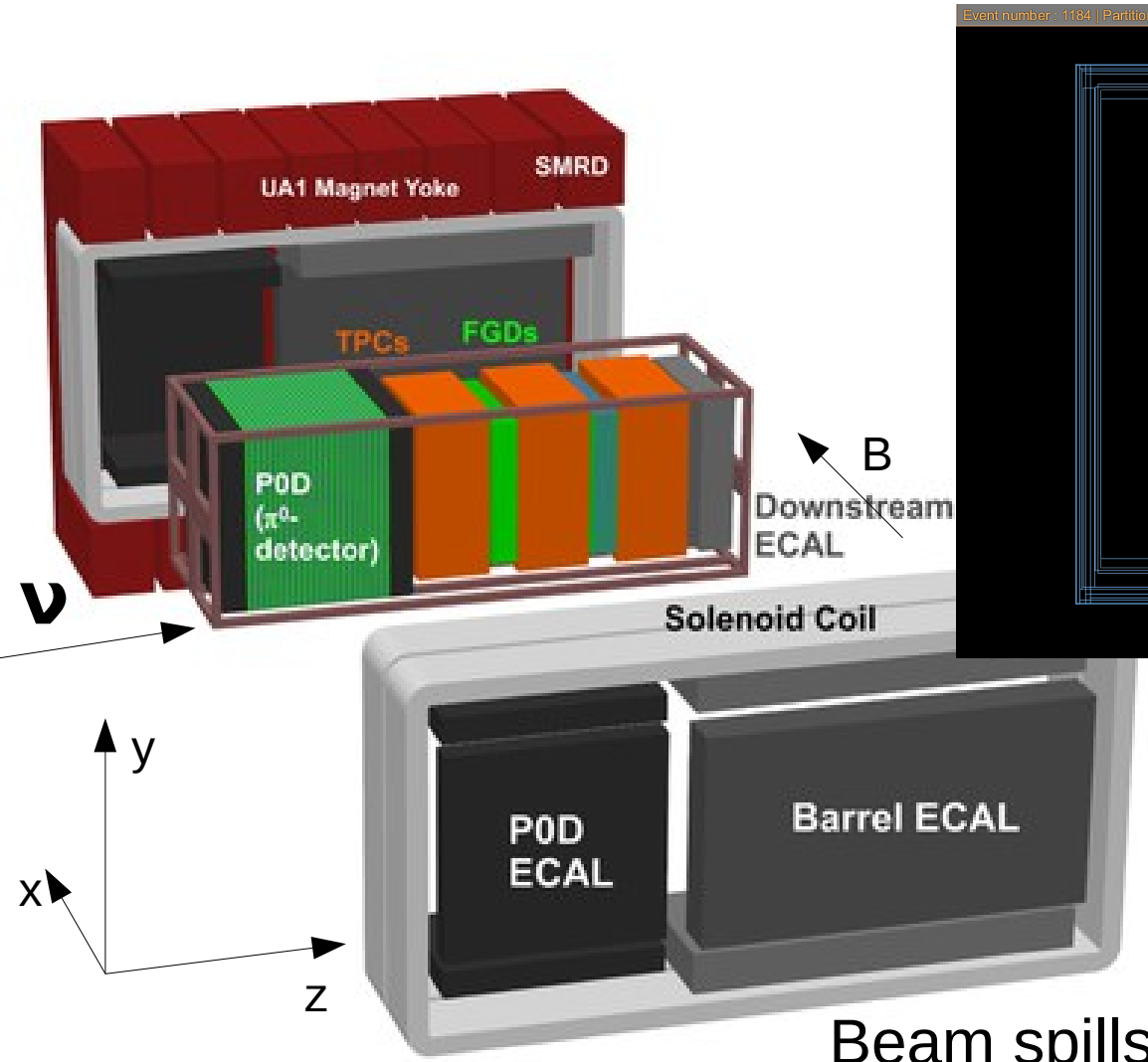
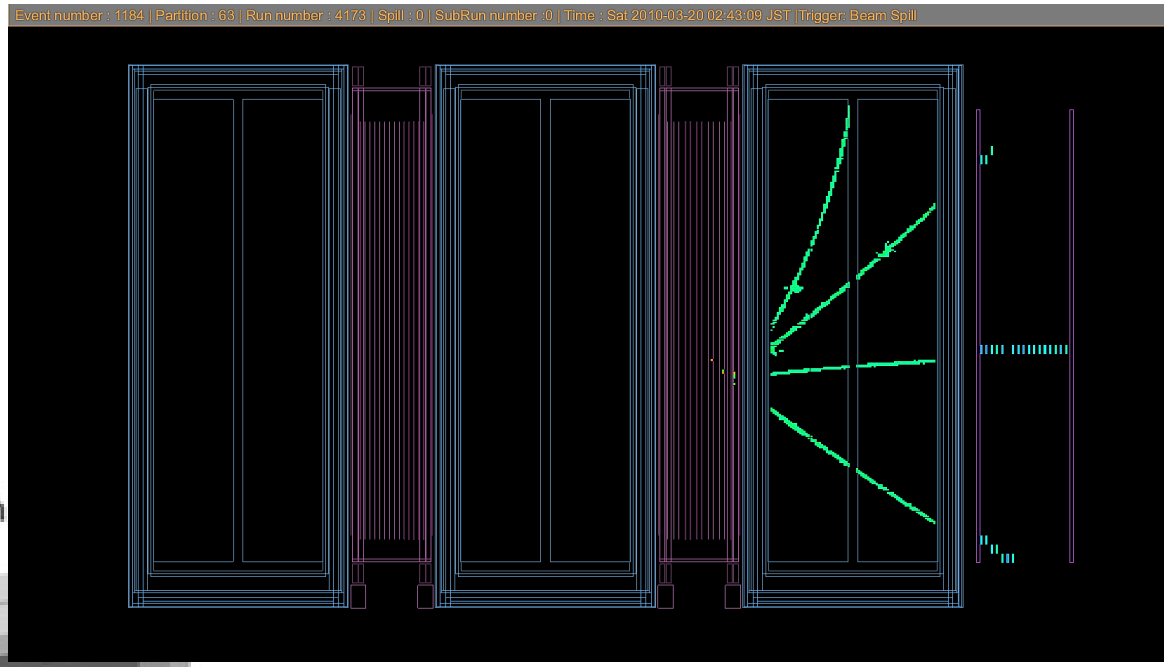
Outline

- Existing T2K ND TPCs
- Required performances for the new TPCs
- Design considerations
- Components
- Next steps

The T2K off axis Near Detector ND280

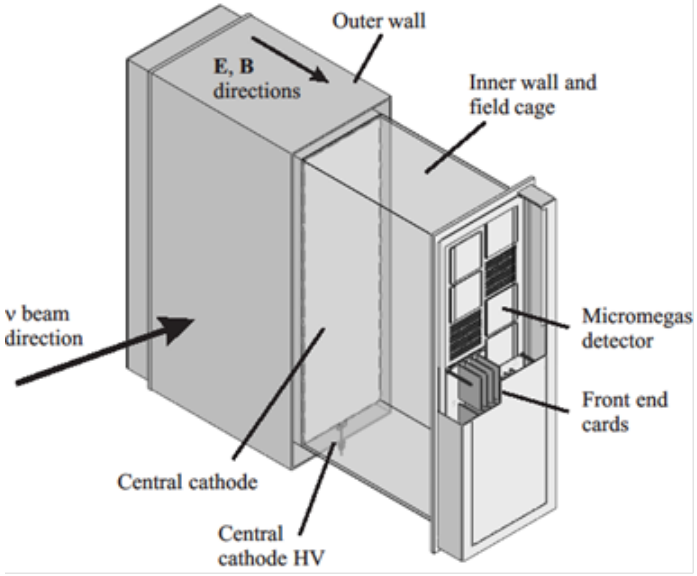


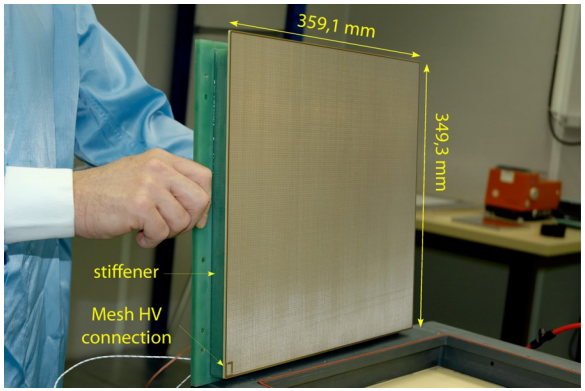


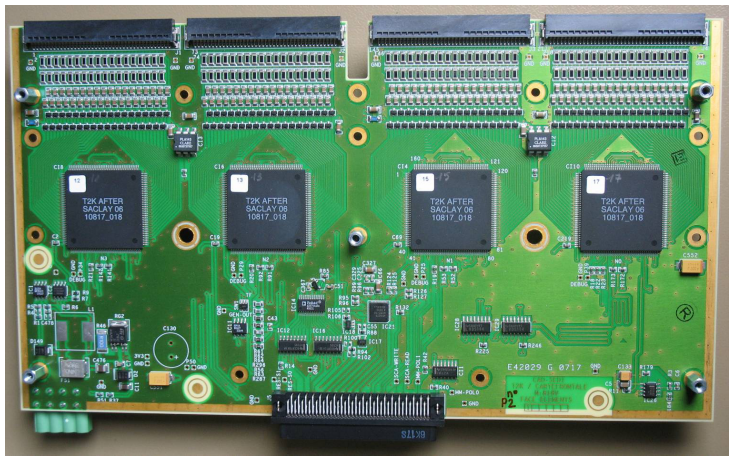
Beam spills every 2.5 s
Low event rate dominated by cosmics
Low multiplicity final states

The T2K TPC

- The existing TPC are operating succesfully since 2010
- They provide a baseline design, invaluable experience and several components or solutions (Micromegas, front and back end electronics) potentially ready to use for the new TPCs







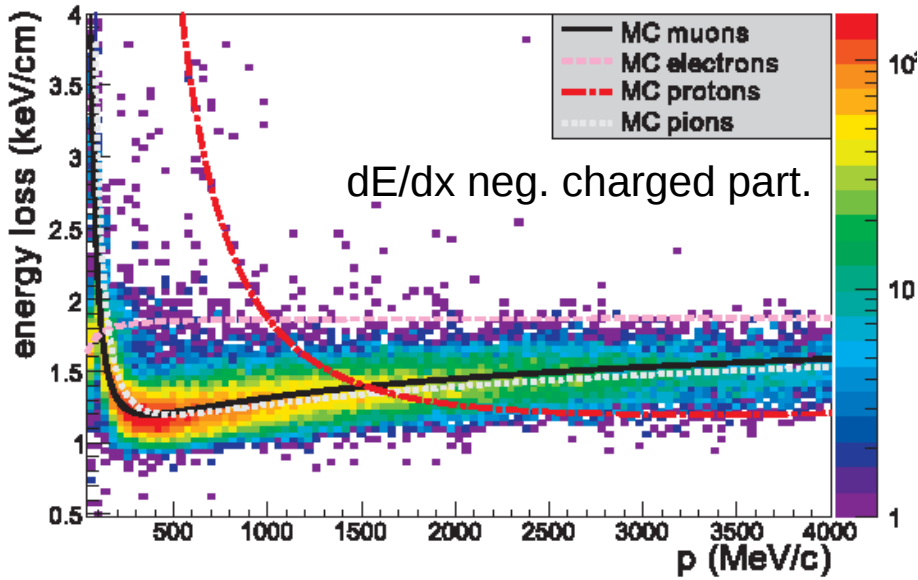
Parameters of the VTPC

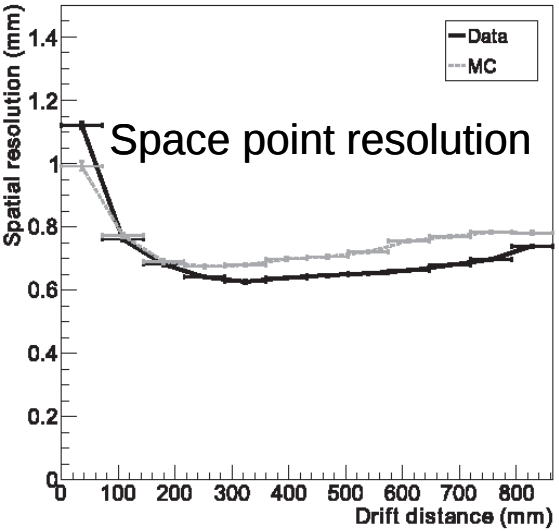
Parameter	Value
Overall x - y - z (m)	2.3 - 2.4 - 1.0
Drift distance (cm)	89.7
Magnetic Field (T)	0.2
Electric field (V/cm)	275
Gas AR-CF_4-iC_4H_{10} (%)	95 - 3 - 2
Drift Velocity $cm/\mu s$	8
Transverse diffusion ($\mu m/\sqrt{cm}$)	240
Micromegas mesh V	350
Micromegas gain	1000
Micromegas dim. z-y (mm)	342 - 359
Pad x - y (mm)	7 - 9.8
N pads	124416
el. noise	800
S/N	100
Sampling frequency (MHz)	25
N time samples	511

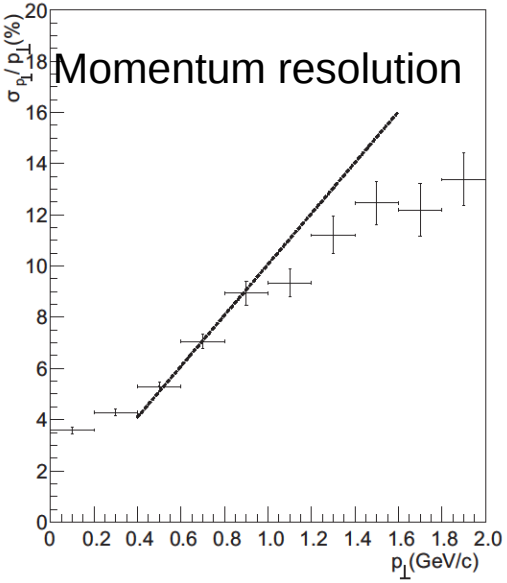
Table 3: Main parameters of the VTPC.

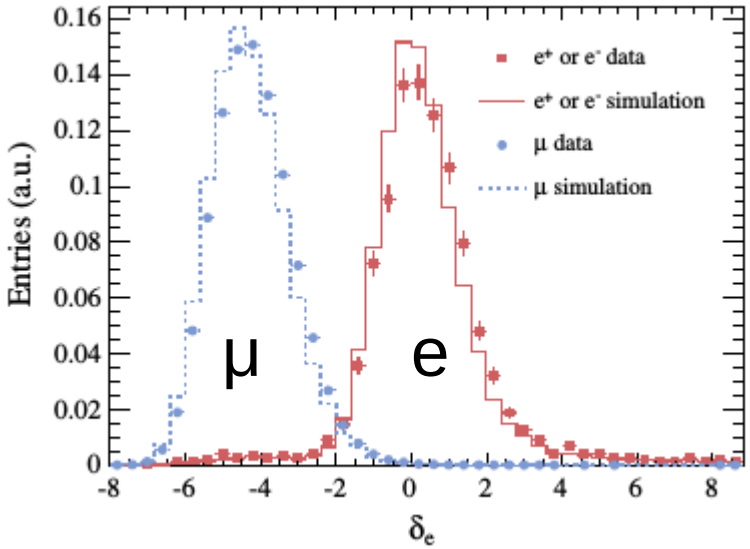
TPC performances

- Playing a key role in the study of the neutrino flux and interactions (charge, momentum and dE/dx PID)
- Space point resolution : 0.6-0.8 mm
- Momentum res. 9% at 1 GeV
- dE/dx: 7.8 % (MIP)



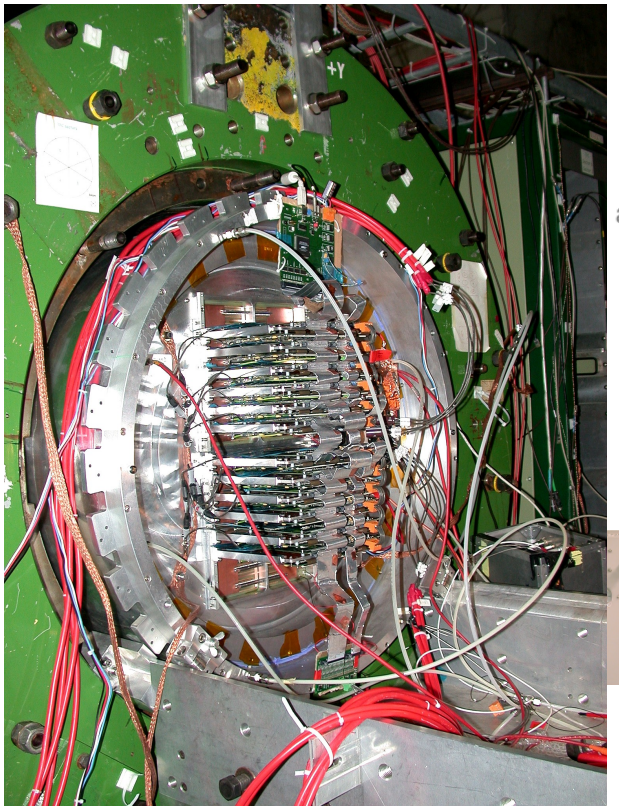






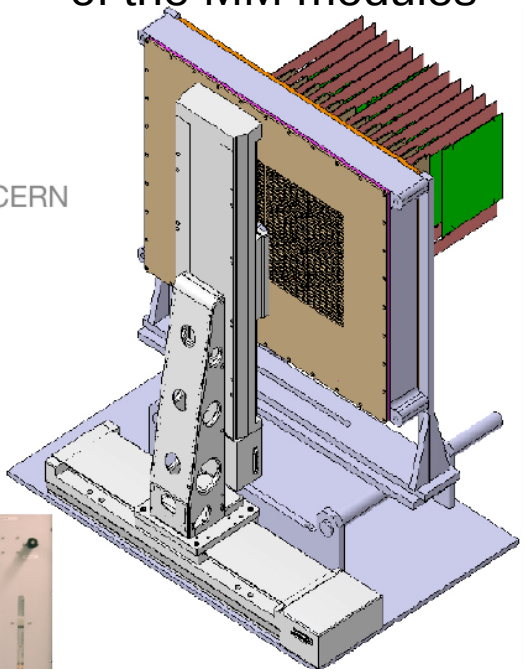
Steps towards building the TPC

2006-2007 Protoype tests.
HARP TPC@CERN

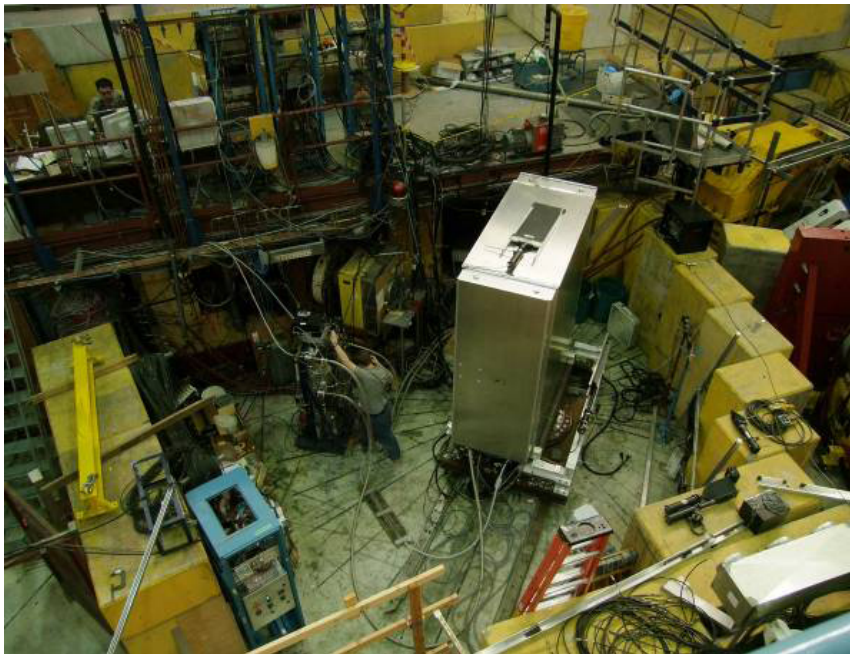


at CERN

2008-2009
Detailed calibration
of the MM modules



2008-2009 Test of the three TPC
with a beam (M11 at TRIUMF)
(charged particles~300 MeV/c)



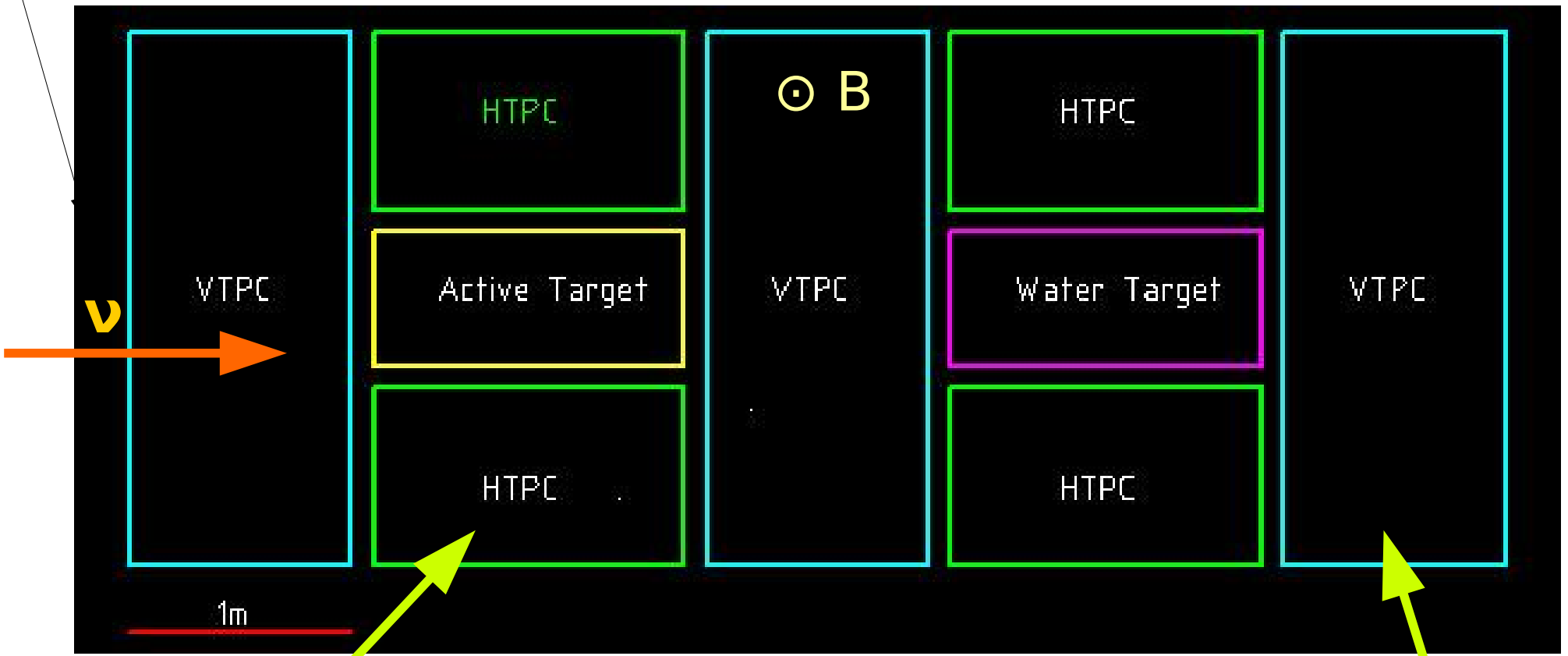
Physics requirements for the TPCs

To improve ND280 performance we have to

1) Extend the angular acceptance
2) Maintaining the current tracking performances
3) Provide PID information for e/muon separation for nue measurement

The baseline design for the upgraded ND280

All this inside the EM calorimeter and the UA1 magnet



New Horizontal TPC

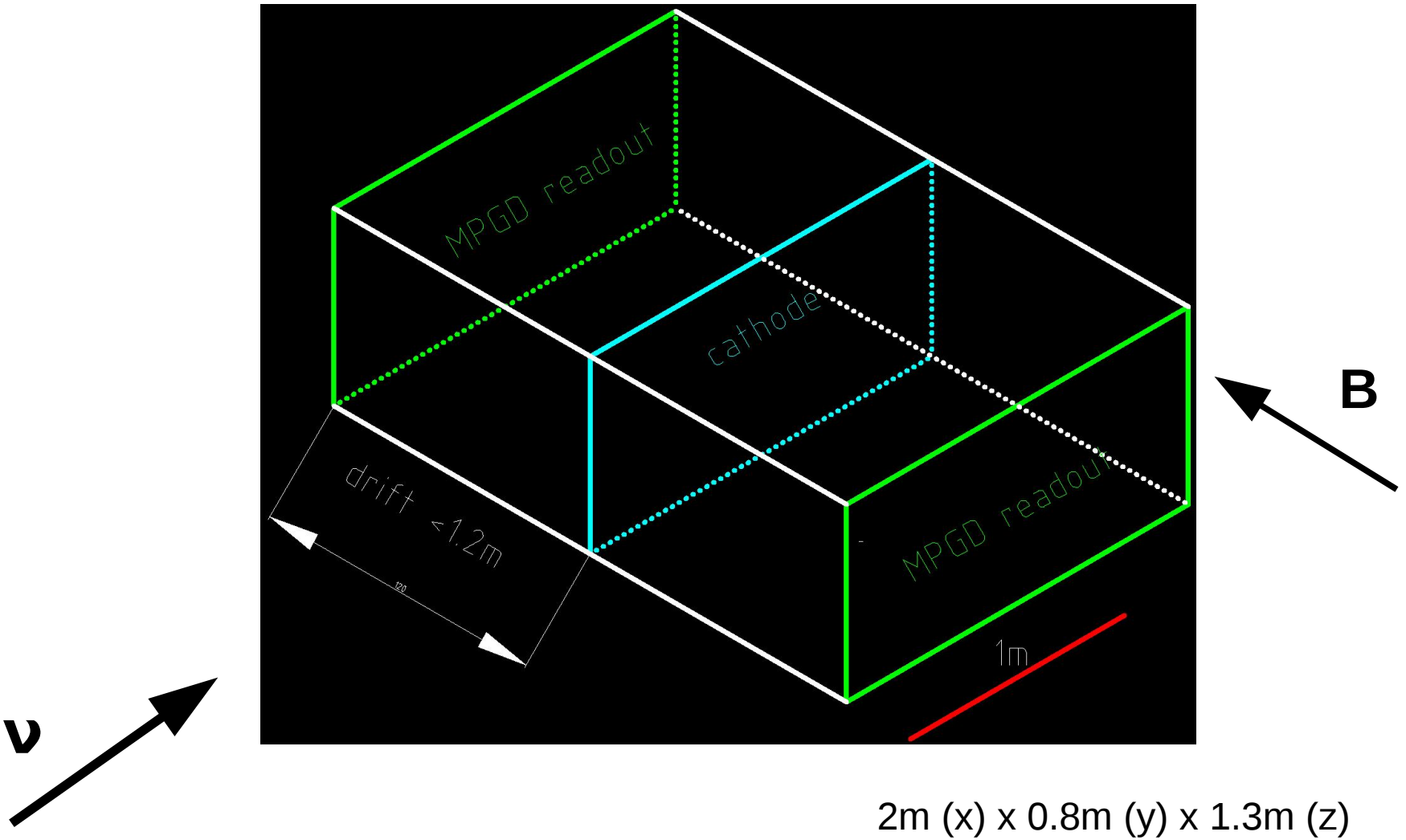
Existing VTPC

We plan to surround the TPC by scintillator planes for T0 and TOF determination.

Requirements for the new TPC

- Momentum resolution: same as for the existing TPC 10% at 1 GeV
- dE/dX resolution: same as for the existing TPC ~8% for a MIP gives ~ 4 σ e – μ separation
- This can be satisfied with a tracking length of ~70 cm for a vertical track
- And a similar pad size (~1 cm**2)

Schematic of the new TPC



2m (x) x 0.8m (y) x 1.3m (z)

HTPC

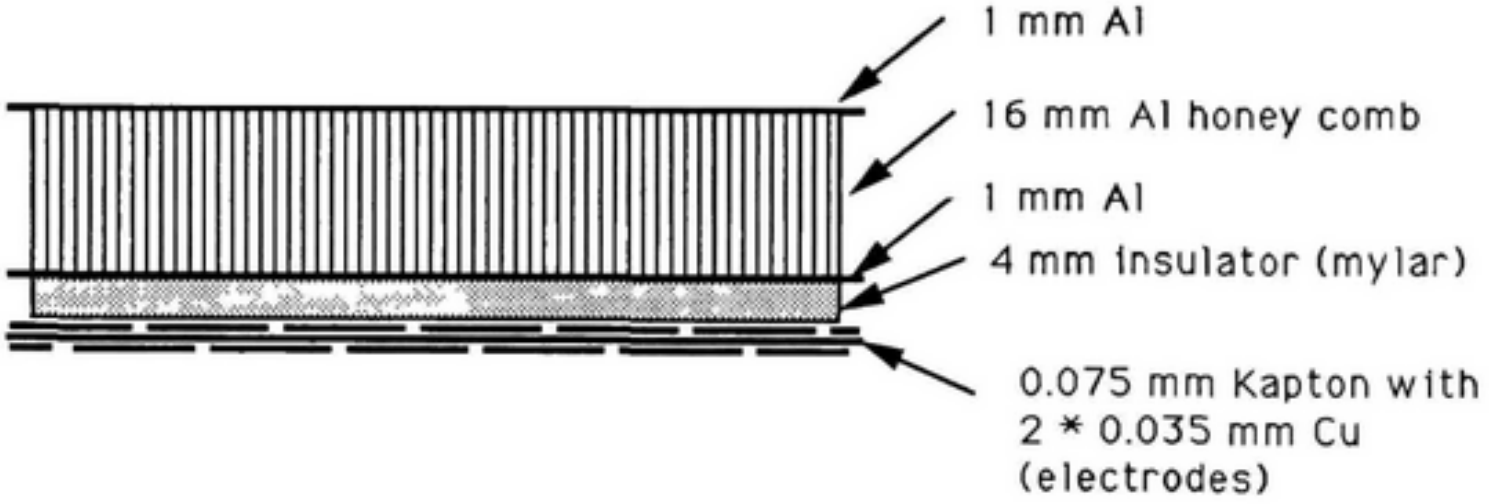
Parameter	Value	Comment
Overall dimensions	2 (x) x 0.8 (y) x 1.3 (z) m**3	4 identical TPC
Volume	2.1 m**3	Each
Drift Length	90 cm	Cathode in the middle
Pad area	~1 cm**2	
Sensitive area tot	7.3 m**2	Tot 4 TPC
N MM	~ 66	Tot 4 TPC with MM ~35x35 cm**2 each
N channels	7.3 10**4	Tot 4 TPC

NB indicative estimates, design still under optimization

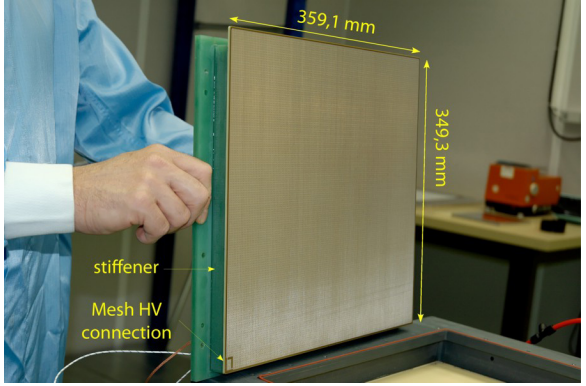
Features

- The additional TPCs are similar in size to the existing VTPC (which will be re-used)
- We plan to use a thin (a few cm) field cage following what was done for the Aleph and Delphi TPCs
- Several technological innovation developed by ILC-TPC and RD51 coll. could also be considered: resistive anode Micromegas, readout electronics on the back of the MM, low mass cooling …
- Will hear more on this in the next session

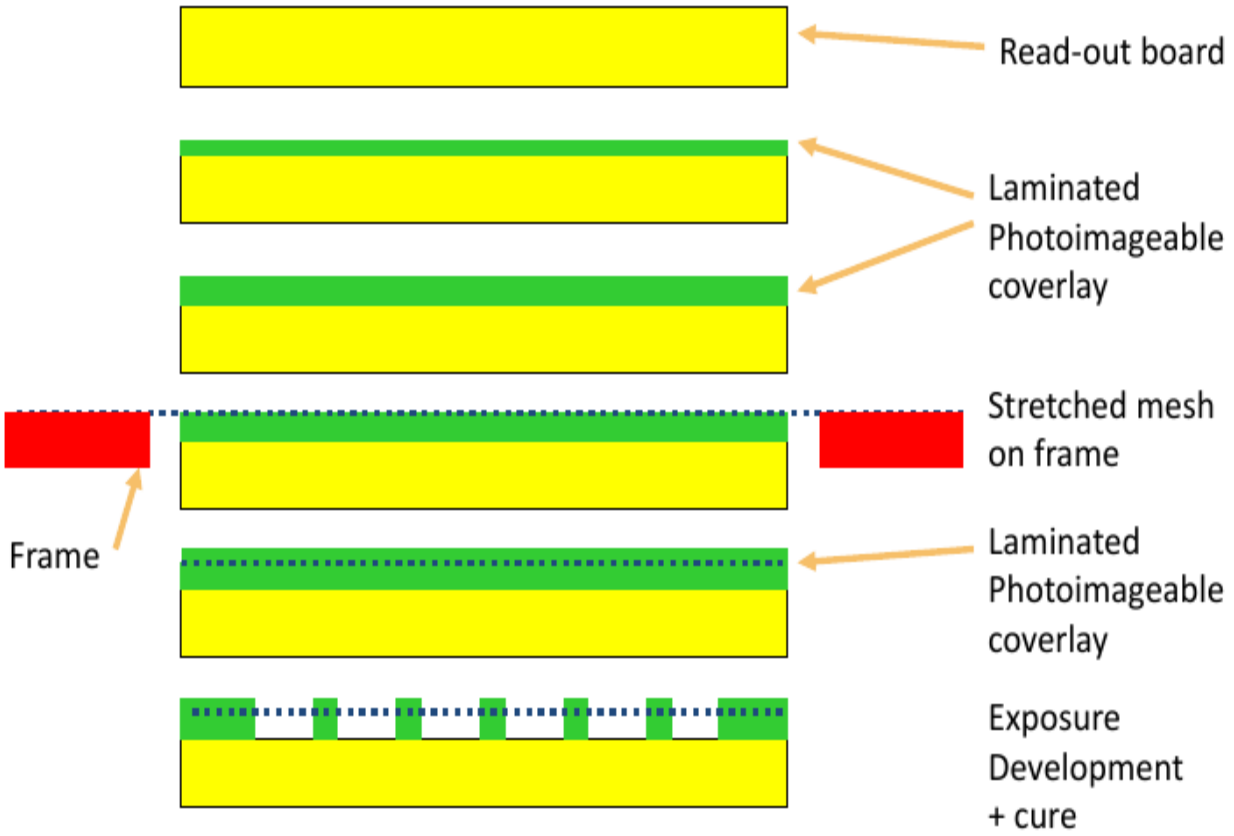
The Aleph TPC field cage



Insulator from a thin Mylar foil winded around many times using a higly resistive glue



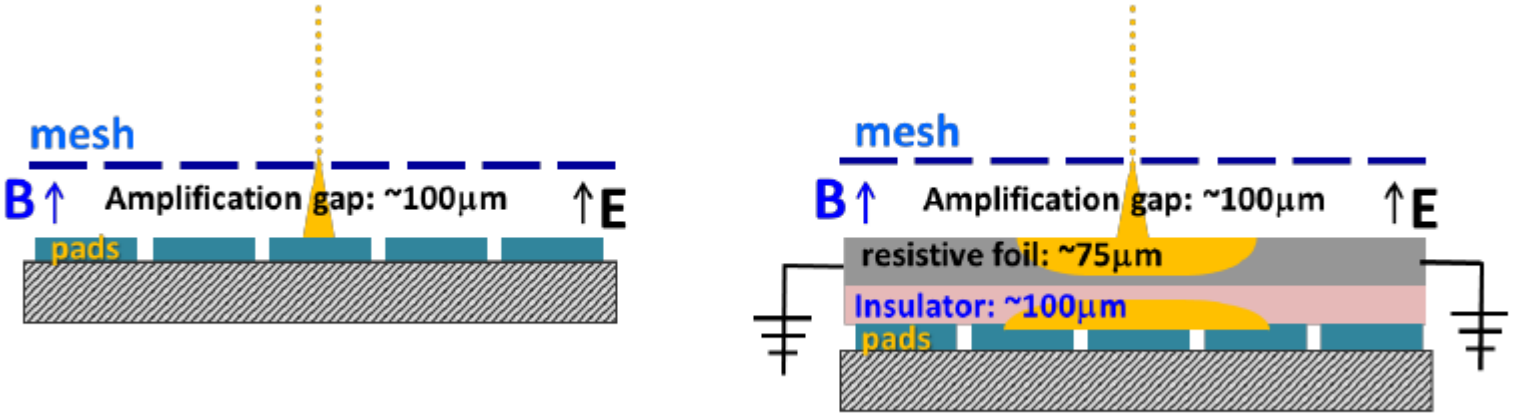
Bulk Micromegas



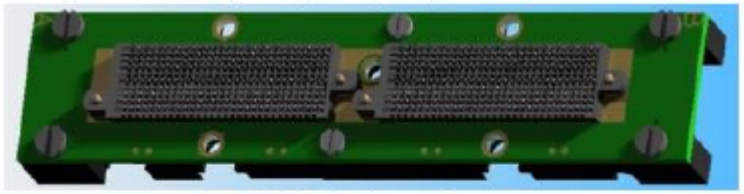
Proven technology. Saclay equipped with a new production line. Micromegas technology succesfully transferred to industry as part of the ATLAS New Small Wheel Phase I upgrade. T2K TPC MM have been produced by the CERN workshop (EP/DT/EF).

Resistive Bulk Micromegas

- Several advantages (charge spread, intrinsic spark protection)
- Pro/con need to be evaluated
- Should be tested on a prototype



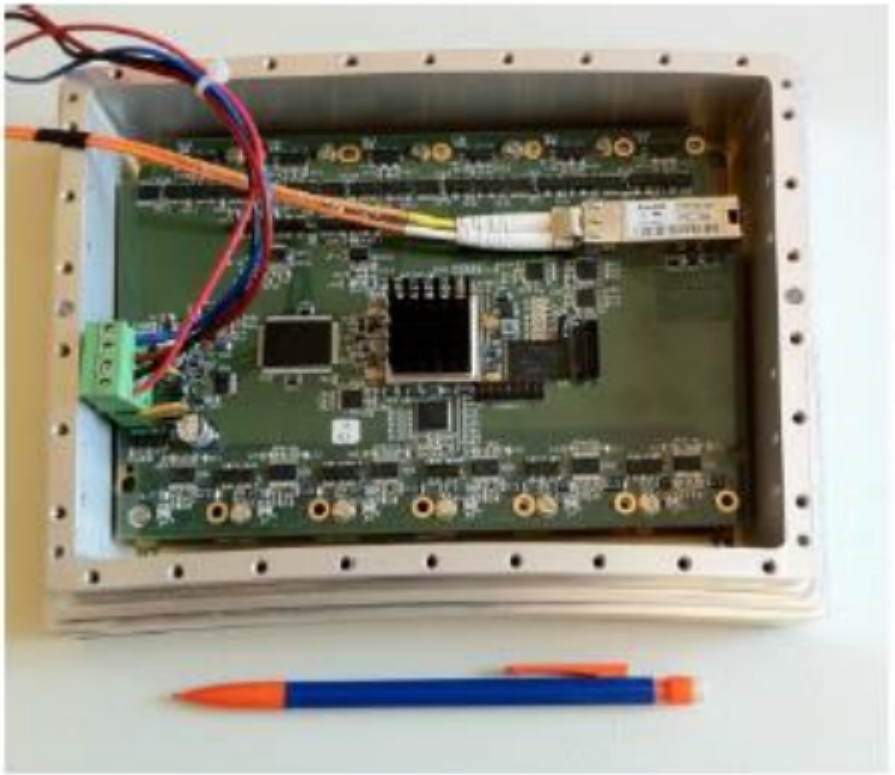
ILC TPC R/O electronics



(a) FECi Detector side connectors

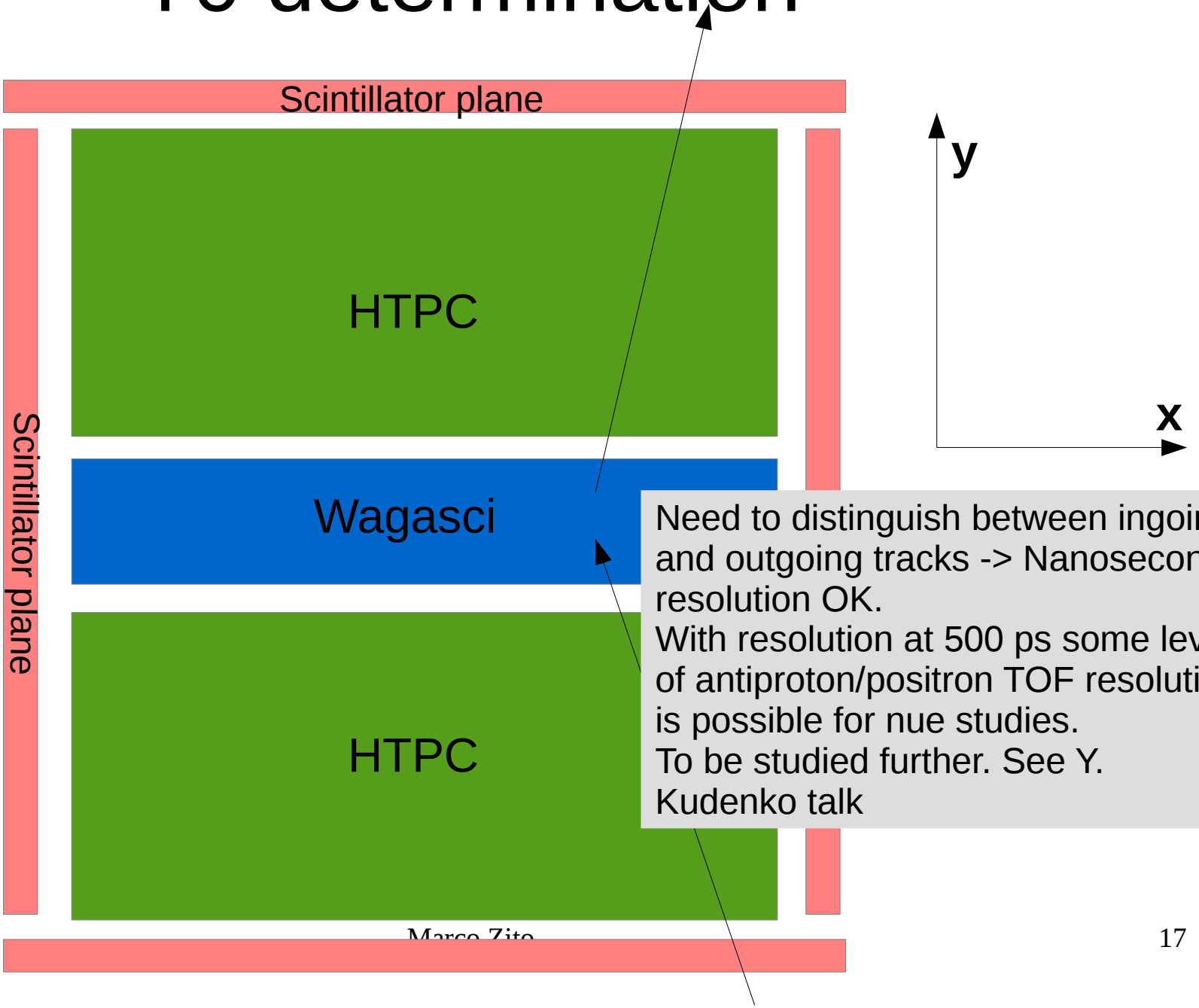
(b) Component side of a FECi

(c) A FECi with its heat sink



Size: 1/10 of a T2K TPC FEC, for the same number of channels. Flat readout achieved for a pad size of 3x7 mm**2. We plan to use a pad size >~70 mm*2. No protection, no packaging for the chip.

T0 determination



Need to distinguish between ingoing and outgoing tracks -> Nanosecond resolution OK.
With resolution at 500 ps some level of antiproton/positron TOF resolution is possible for nue studies.
To be studied further. See Y. Kudenko talk

Next steps

- Finalise the simulation studies to evaluate the performances, towards a finalized overall detector configuration. Then optimize detector parameters (like pad size).
- Design a small prototype to be tested in 2017 (define the gas amplification devices and other parameters)
- Production of the TPCs 2018-2019
- Tests 2019-2020