

# The upgrade project of the T2K near detector N280

Marco Zito  
IRFU/DPhP CEA Saclay

Tokai EOI-15 5<sup>th</sup> Workshop  
October 8 2017

DE LA RECHERCHE À L'INDUSTRIE

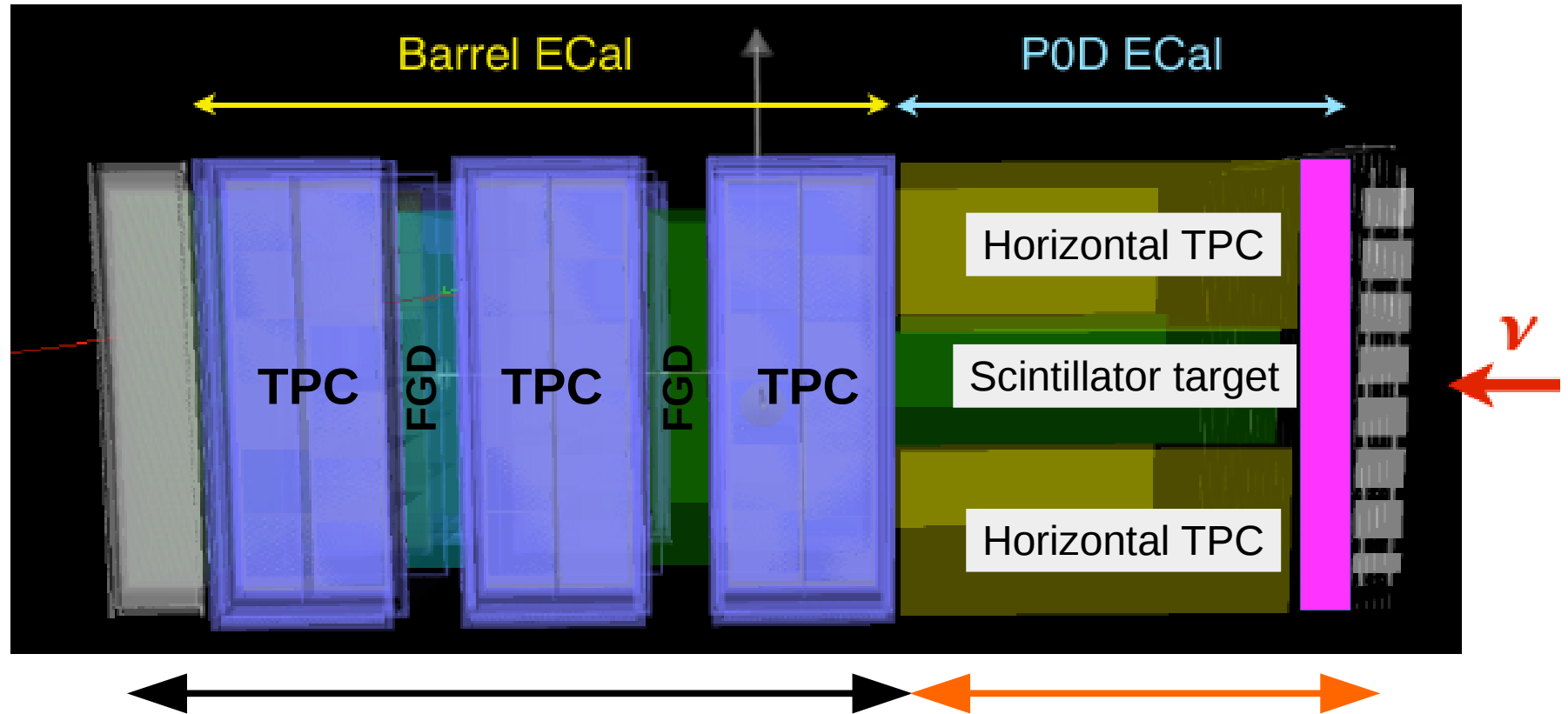
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# Goals of the upgrade

- Recover full theta acceptance (high-angle, backward) for CC events with TPC quality (momentum,  $dE/dx$ , low. det. syst. uncertainties)
- Track low energy protons inside the target (as much as possible with  $\sim 1\text{cm}$  granularity inside scintillator)
- Track ( $4\pi$ ) low momentum pions inside the target with pion/proton separation
- Identify e/ $\mu$  with TPC PID (as in the current TPCs)
- Separate electron/converted gamma inside the target
- Reconstruct track sense with TOF

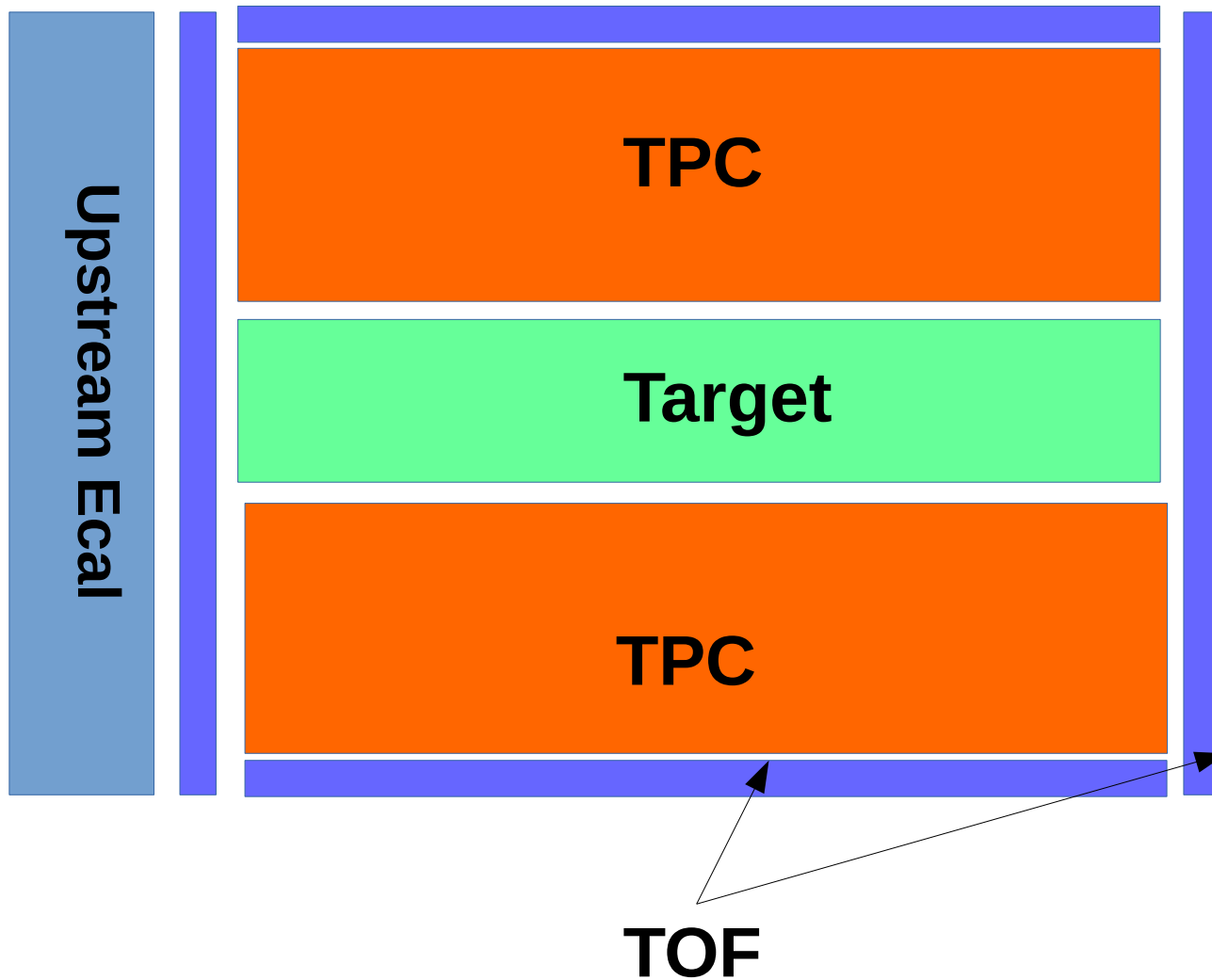
# The ND280 upgraded detector concept



Same as present ND280

New detectors:  
two horizontal TPCs,  
one scintillator target,  
TOF detectors

# Side view



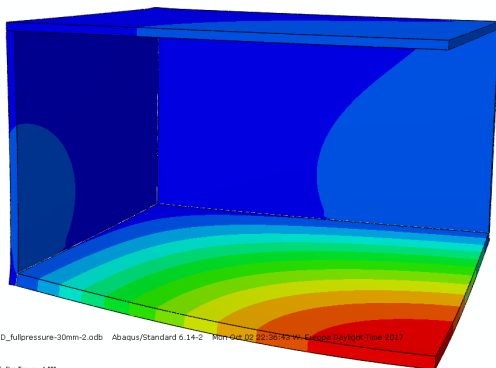
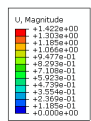
# Work Packages contact persons

ND280 Upgrade Working Group: convener MZ, deputy Masashi Yokoyama

- WP1 Mechanical design and integration (Marcela Batkiewicz, Davide Sgalaberna, Thorsten Lux)
- WP2 TPC field cage and gas vessel (Emilio Radicioni, Gianmaria Collazuol)
- WP3 TPC Readout technology (Alain Delbart, CERN)
- WP4 TPC electronics and DAQ (Denis Calvet, Andrzej Rychter)
- WP5 Gas system and calibration (Blair Jamieson, CERN)
- WP6 Scintillator-based trackers (Masashi Yokoyama)
- WP7 TOF system (Yury Kudenko)
- WP8 Test beam measurements (Federico Sanchez, Stefania Bordoni)
- WP9 High Pressure TPC (Asher Kaboth, Morgan Wascko)
- WP10 Simulation and optimization studies (Davide Sgalaberna)
- WP11 Physics studies (Sara Bolognesi, Claudio Giganti)
- WP12 DAQ (Giles Barr)
- WP13 Software( Yoshi Uchida)

# WP1-face to face meeting

- One-day meeting (03/10) at CERN (<https://indico.cern.ch/event/667668/>)
- More detailed report later by Davide, Marcela
- The meeting was well attended with these groups represented: INFN Padova and Bari, IFAE, Saclay, LPNHE, Geneva, Krakow
- Kick-off for the mechanics/integration work including mailing list (EOI15-WG1-Mechanics) and regular bi-weekly meetings

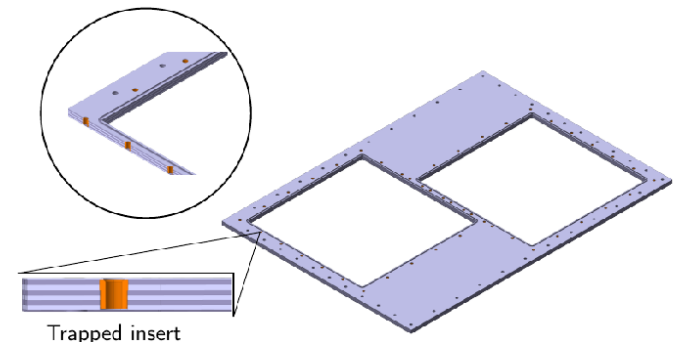


ODB: SFGD\_fullpressure-30mm-2.odb Abaqus/Standard 6.14-2 Mon-06-02 22:36:42 W- Europe Daylight Time 2017

Step: Step1  
Time: 0.000  
Element Type: C3D20R, Scale Factor: \*1.176e+11  
Reference: \*1.000e+00

F. Cadoux

## Prototype – Panel assembly



Trapped insert

H. Przybilski

# R&D related to the ND280 Upgrade

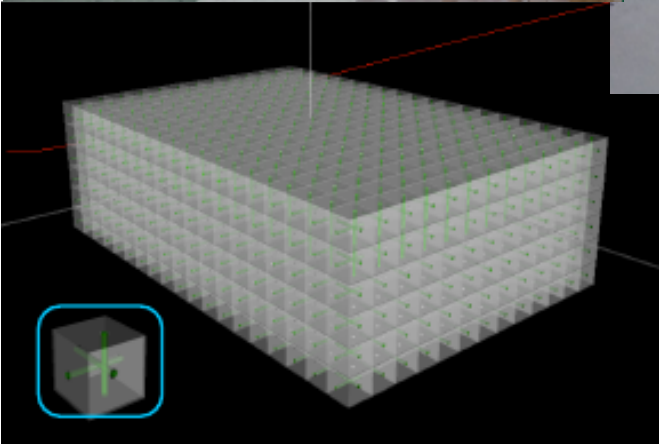
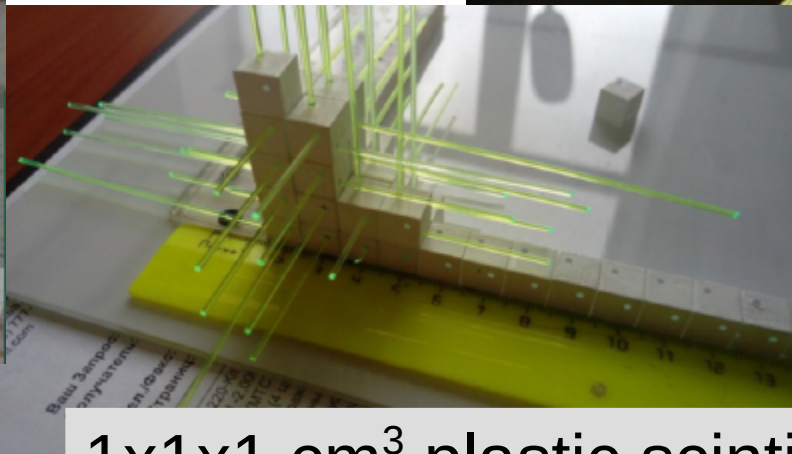
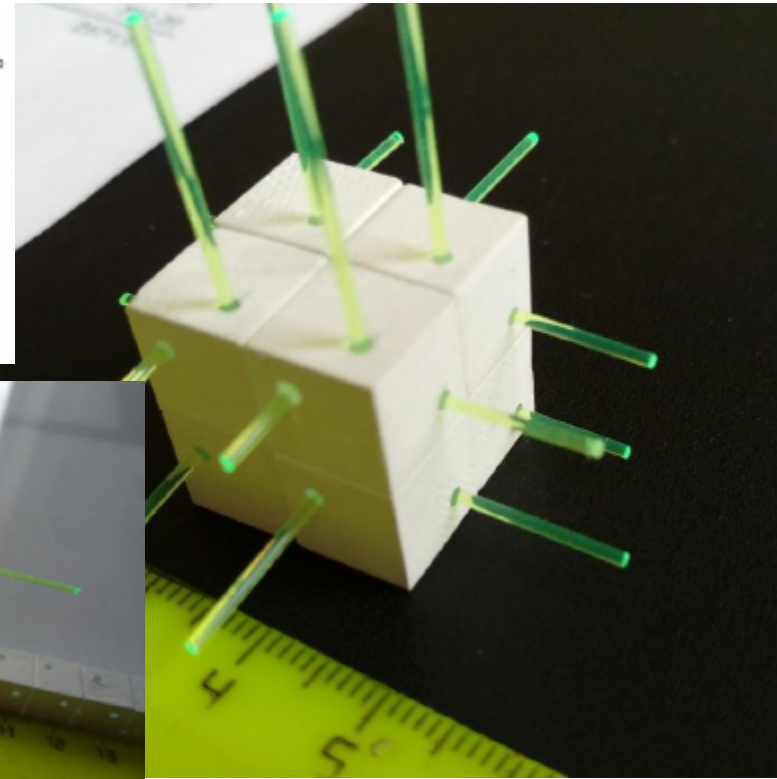
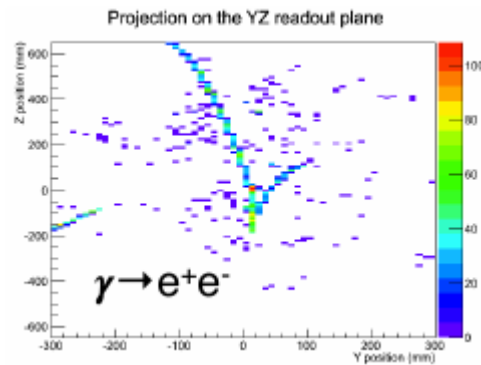
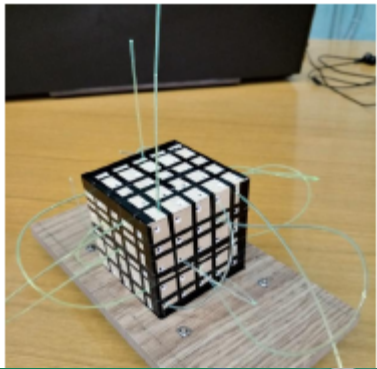
- Super FGD
- Large resistive Micromegas
- Field cage
- High Pressure TPC
- TOF (see recent [arXiv:1709.08972](https://arxiv.org/abs/1709.08972))

This is one of the options for the scintillator detector

Y. Kudenko (INR Moscow)

arXiv:1707.01785

# Super-FGD



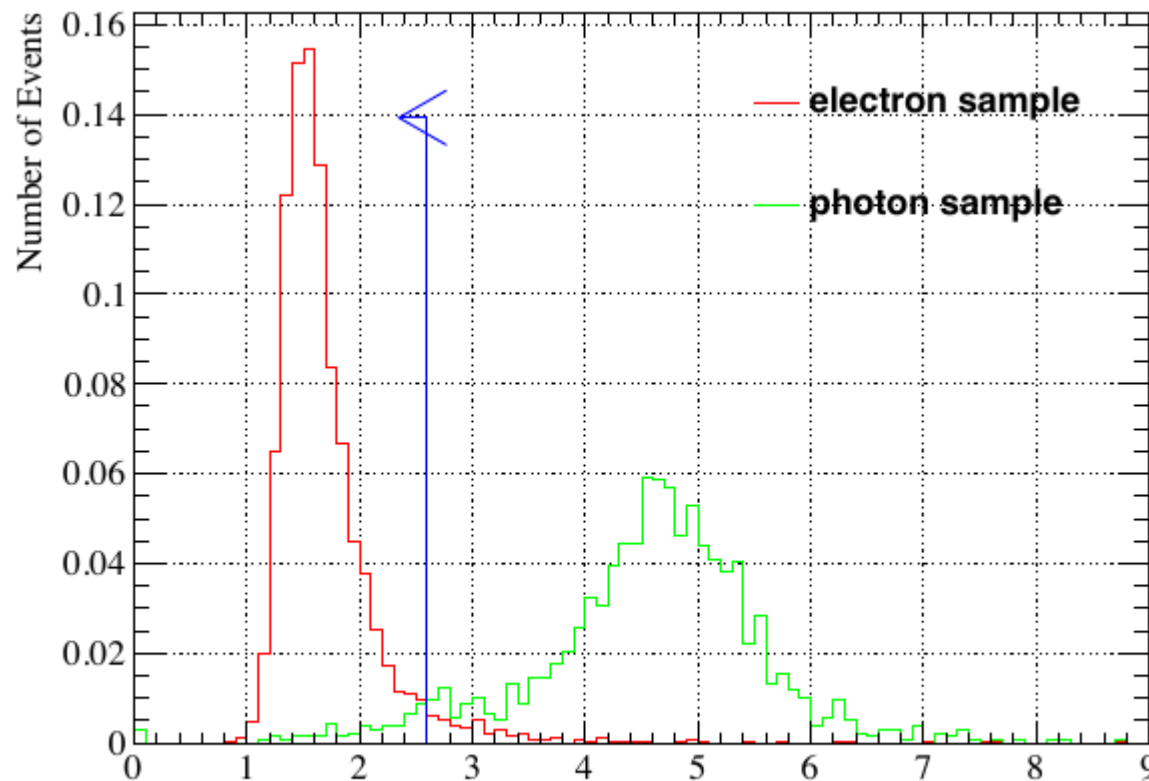
1x1x1 cm<sup>3</sup> plastic scintillator cubes with 3 fibers readout

R&D started, with 5x5x5 cubes & 75 channels (INR/UNIGE/Japan)

10000 cubes in production



# e – gamma separation with Superfgd



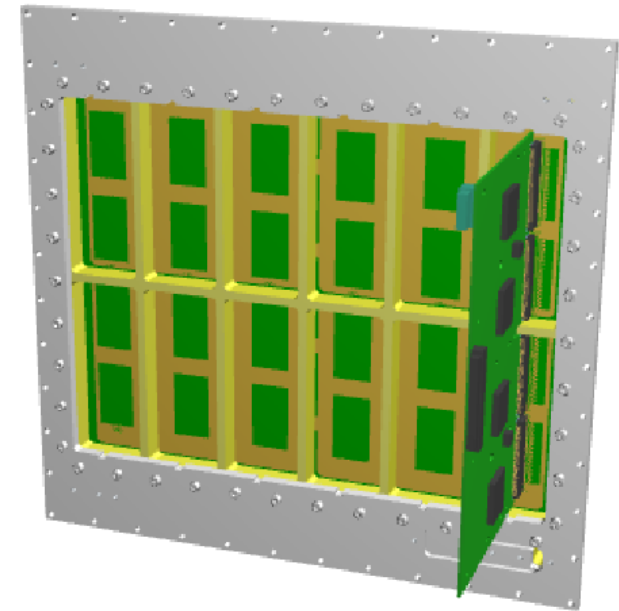
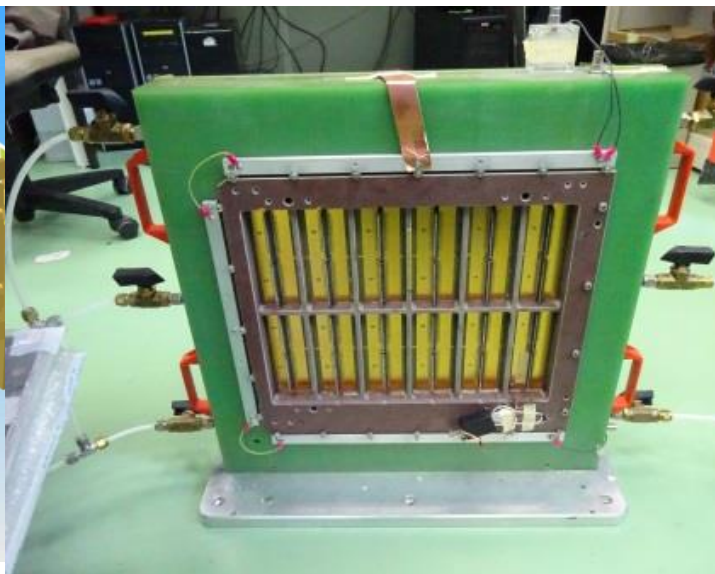
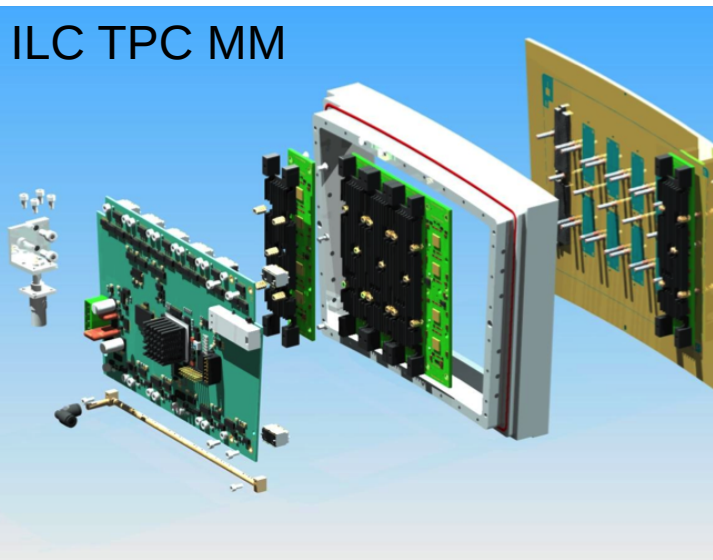
- 97% efficiency to select e-like track events in electron sample
- 94% efficiency to reject  $\gamma$ -like track events in photon sample

CAVEAT: for a particular energy and angle

# Resistive Micromegas R&D

- 4 35x35 cm\*\*2 PCB in construction at CERN
- 2 bulk MM with DLC resistive foil
- To be tested in November in Saclay

ILC TPC MM



# Test beam request

- Call will be open later this month (TBC)
- Competing with many other requests (before LS2), last chance of beam at CERN in time for the Upgrade
- Preliminary request: 2 weeks for the TPC prototype, two weeks for the Super-FGD prototype, + HPTPC

# Summer conferences

- The ND280 Upgrade project has been presented at NUINT, EPS, NUFACT, NNN
- Clear visibility in the community
- Many of us are also among the conveners of the recently launched CERN initiative CENF-ND (<https://twiki.cern.ch/twiki/bin/view/CENF/NearDetector> first face to face meeting around the end of the year)

# Proposal-status

Section	Authors	Status	
Introduction	MZ	Done	
Configuration	MZ		
TPC Field Cage	ER+GMC		
TPC Gas	Blair	Done	
TPC Micromegas	MZ		
TPC electronics	DC	Done	
Target	MY		
TOF	YK	Done	
HPTPC	MW+AK		
Sim studies	DS		
Prototypes + test beams	FS+SB		
Project structure	MZ		

Aim: have a first draft by the end of next week, finalize in November (including requests to CERN)

# Agenda-Sunday morning

09:00	<b>Introduction</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	<i>Marco Zito</i> 09:00 - 09:30
	<b>WP1 Mechanics</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	09:30 - 09:50
10:00	<b>TPC design</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	09:50 - 10:10
	<b>TPC field cage</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	10:10 - 10:30
	<b>Coffee break</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	10:30 - 10:50
11:00	<b>Micromegas detectors</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	10:50 - 11:10
	<b>Gas system</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	11:10 - 11:30
	<b>Discussion</b> <i>Room 116, Tokai Buiding 1, Tokai</i>	11:30 - 11:50
12:00	<b>Lunch</b>	

# Agenda-Sunday afternoon

13:00	<b>High Pressure TPC</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	13:00 - 13:45
14:00	<b>TOF detectors</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	13:45 - 14:45
15:00	<b>Coffee break</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	15:00 - 15:30
	<b>Test beam</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	15:30 - 16:00
16:00	<b>Target overview</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	<i>Masashi Yokoyama</i> 16:00 - 16:10
	<b>Super-FGD scintillator R&amp;D</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	<i>Yury Kudenko</i> 16:10 - 16:35
	<b>R&amp;D in Japan</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	<i>Tsunayuki Matsubara</i> 16:35 - 16:45
	<b>Target structure discussion</b>  <i>Room 116, Tokai Buiding 1, Tokai</i>	<i>Davide Sgalaberna</i> 16:45 - 17:00
17:00	<b>PI Meeting</b>	

Social Dinner at Uoyasu (tuna place, within walking distance) at 19:00

# Agenda-Monday

< Sun 08/10 **Mon 09/10** All days >

Print

PDF

Full screen

Detailed view

Filter

09:00

**Simulation and optimization studies + Physics studies**

10:00

*Room 116, Tokai Buiding 1, Tokai*

09:00 - 11:00

11:00

**CERN Neutrino Activities**

*Albert De Roeck*

*Room 116, Tokai Buiding 1, Tokai*

11:00 - 11:15

**Conclusions**

12:00

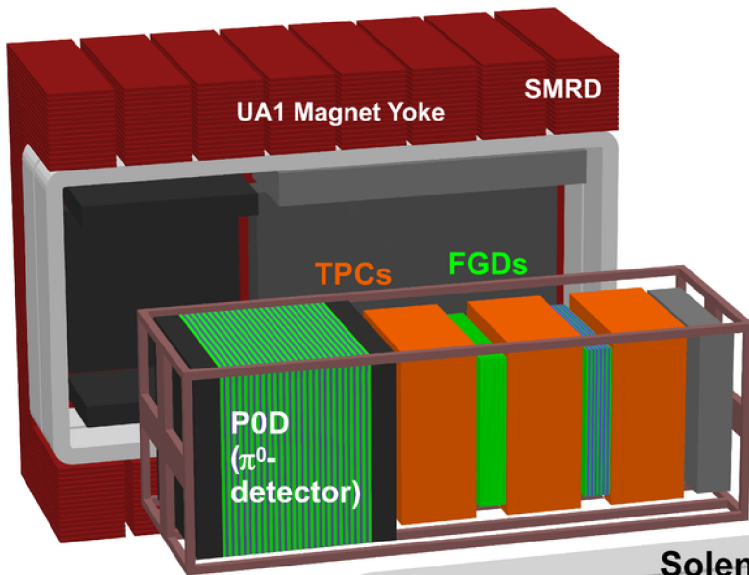
*Room 116, Tokai Buiding 1, Tokai*

11:15 - 12:15

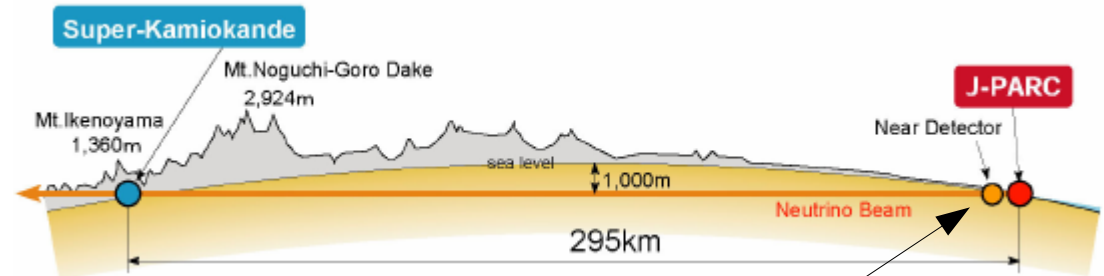
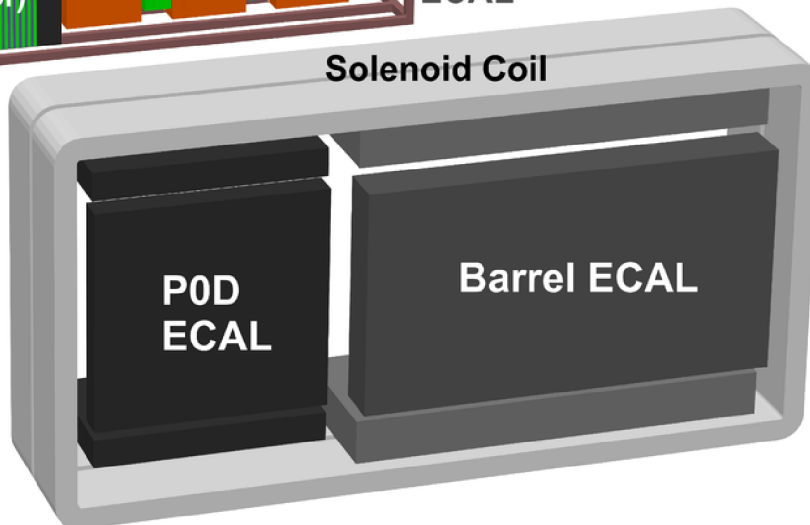




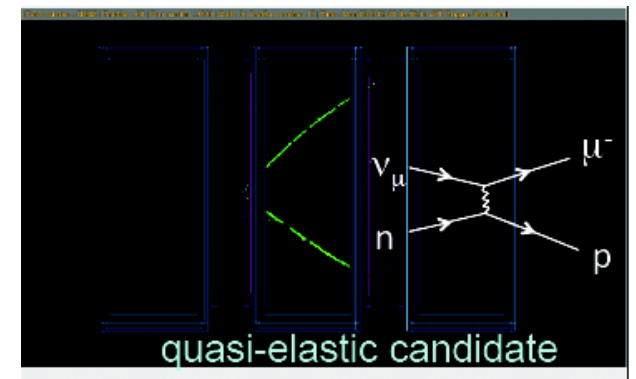
# The T2K ND280 Near Detector



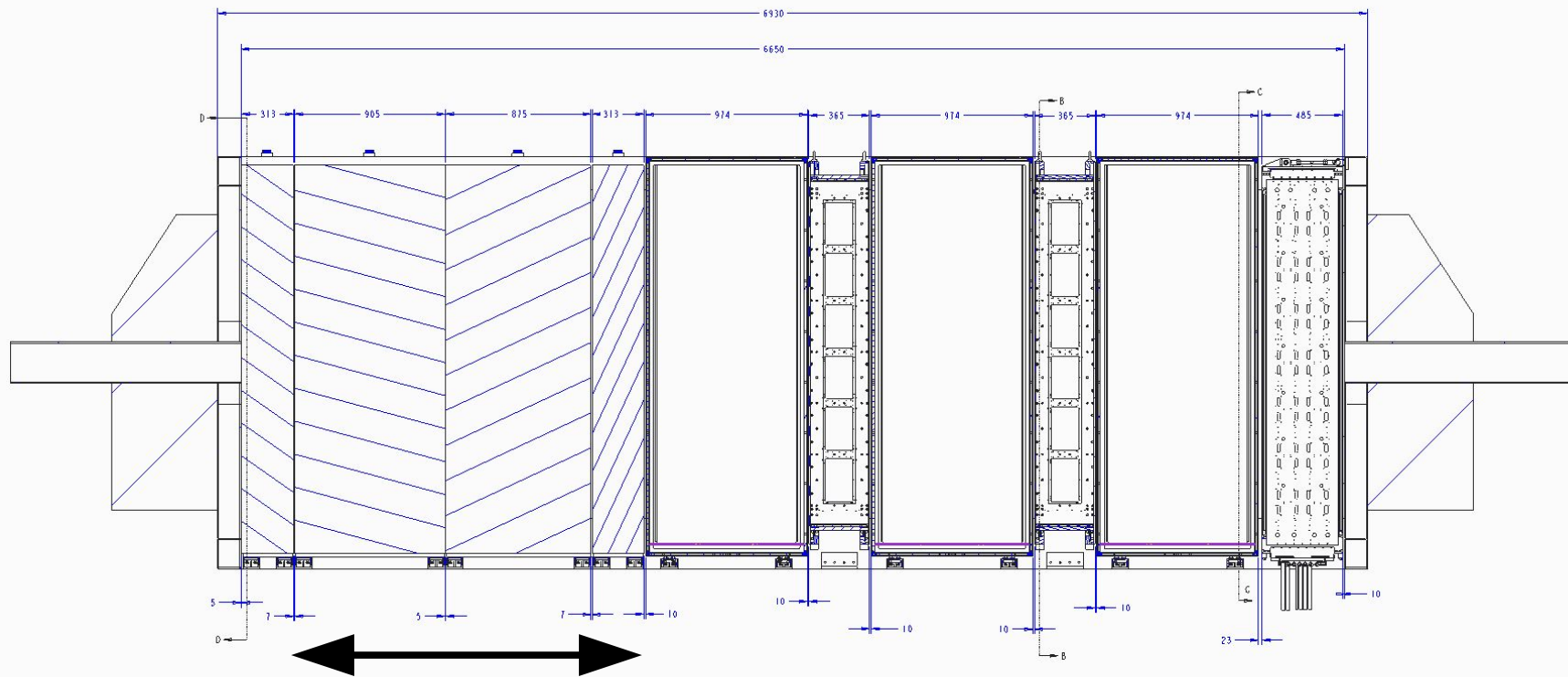
Downstream ECAL



Magnetized near detector at 280m from the neutrino production point (target). Measurement of the interaction rates before oscillation.



# The basket-1

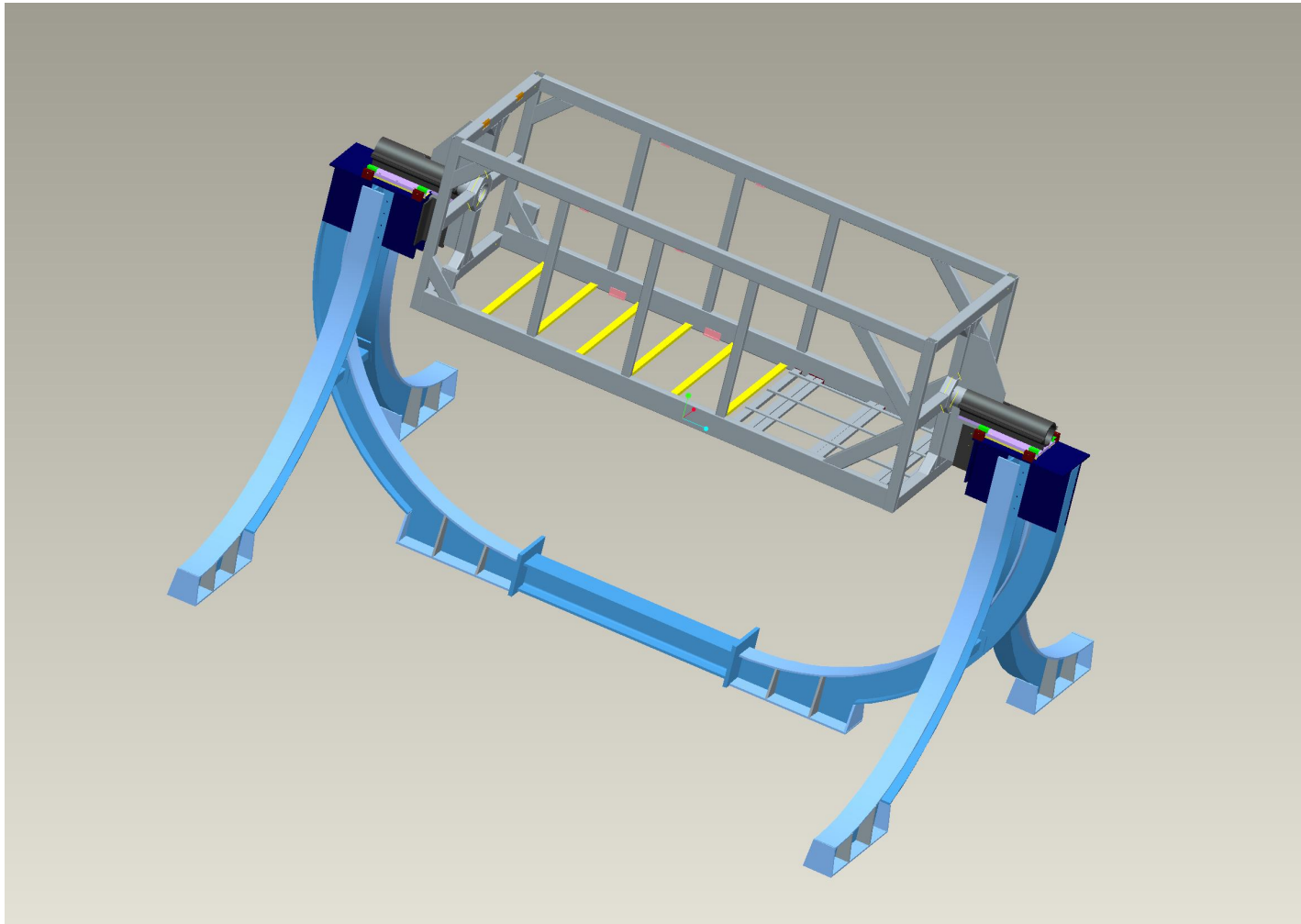


SECTION A-A  
THRU BASKET SHOWING  
DETECTOR POSITIONS

SCALE: 0.100 TYPE: ASSEM NAME: NP48-02-02 SIZE: A0 SHEET 1 OF 4

2103 mm (width-x) x 2239 (height-y) x 2093 (length-z) (from P0D NIM)

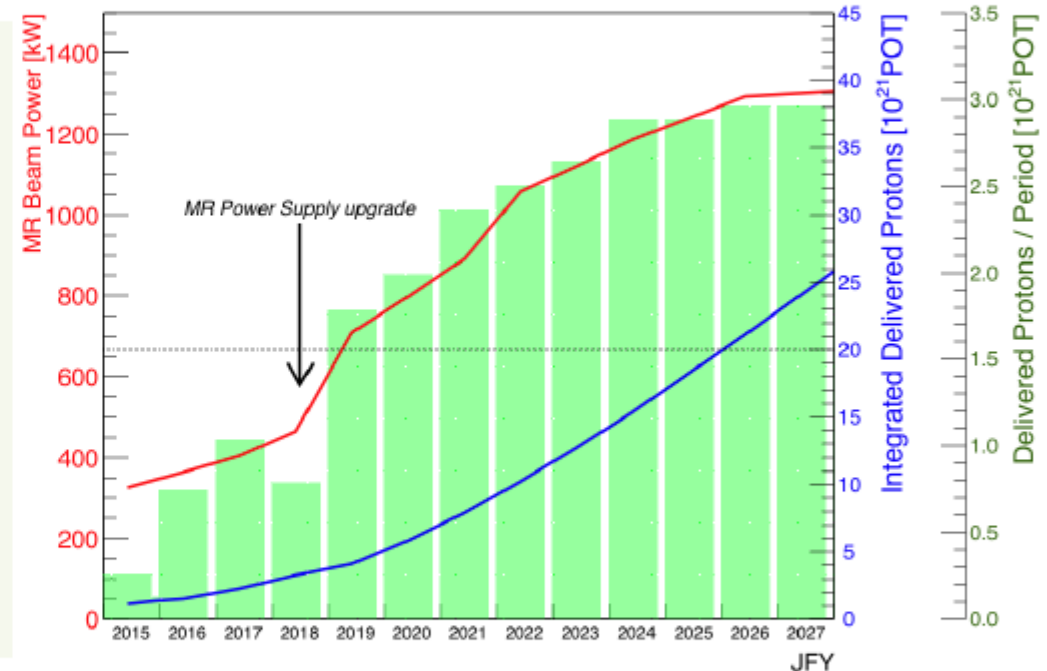
# The basket-2



# T2K phase2 target statistics and systematics

J-PARC MR expected performance  
and T2K-2 POT accumulation scenario

- Target Beam power **1.3 MW**
- **20E21 POT by 2025~2026**
- Increase effective statistics by up to 50%
  - horn current, SK fiducial volume, new event samples
- Reduce systematic error  $\sim 6\%$   
→  $\sim 4\%$



Expected number of events (1:1  $\nu$ :  $\bar{\nu}$  running case)

$\nu_e$  sample : 468 evts  $\pm 20\%$  change depending on  $\delta_{CP}$

$\bar{\nu}_e$  sample : 134 evts  $\pm 13\%$  change depending on  $\delta_{CP}$

# The ND280 Upgrade project

- 2015-2016 ND280 Upgrade Task Force
- November 2016 Open Workshop at CERN
- January 2017 Expression of Interest submitted to CERN SPSC (towards a project in the framework of the CERN Neutrino Platform)
- February 2017: the ND280 project is formally approved by T2K
- March-May 2017 workshops at CERN and Tokai
- <https://indico.cern.ch/event/568177/>  
<https://indico.cern.ch/event/613107/>  
<https://indico.cern.ch/event/633840/>
- <https://indico.cern.ch/event/644360/>

# Expression of Interest SPSC-EOI-015

- Signed by ~190 physicists
- From Bulgaria, Canada, France, Italy, Japan, Germany, Poland, Spain, Sweden, Switzerland, UK, USA
- And CERN
- Aims to be part of the CERN neutrino platform
- Proposal by the end of 2017

## Near Detectors based on gas TPCs for neutrino long baseline experiments<sup>1</sup>

*P. Hamacher-Baumann, L. Koch, T. Radermacher, S. Roth, J. Steinmann*  
RWTH Aachen University, III. Physikalisches Institut, Aachen, Germany

*V. Berardi, M.G. Catanesi, R.A. Intonti, L. Magaletti, E. Radicioni*  
INFN and Dipartimento Interateneo di Fisica, Bari, Italy

*S. Bordonì, A. De Roeck, D. Mladenov, M. Nessi, F. Resnati*  
CERN, Geneva, Switzerland

*Z. Liptak, J. Lopez, A. Marino, Y. Nagai, E. D. Zimmerman*  
University of Colorado at Boulder, Department of Physics, Boulder, Colorado, U.S.A.

*Y. Hayato, M. Ikeda, M. Nakahata, Y. Nakajima, Y. Nishimura*  
University of Tokyo, Institute for Cosmic Ray Research, Kamioka Obs., Kamioka, Japan

*M. Antonova, A. Izmaylov, A. Kostin, M. Khabibullin, A. Khotjantsev, Y. Kudenko, A. Mefodiev, O. Mineev, T. Ovsianikova, S. Suvorov, N. Yershov*  
Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, Russia

*F. Sanchez, M. Cavalli-Sforza, T. Lux, B. Bourguille, M. Leyton*  
Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Campus UAB, Bellaterra (Barcelona) Spain

*J. Arney, P.J. Dunne, P. Jonsson, R.P. Litchfield, W. Ma, L. Pickering, M. A. Uchida, Y. Uchida, M.O. Wascko, C.V.C. Wret*  
Imperial College, London, United Kingdom

*C. Bronner, M. Hartz, M. Vagins*  
Kavli Institute for the Physics and Mathematics of the Universe (WPI), University of Tokyo, Kashiwa, Chiba, Japan

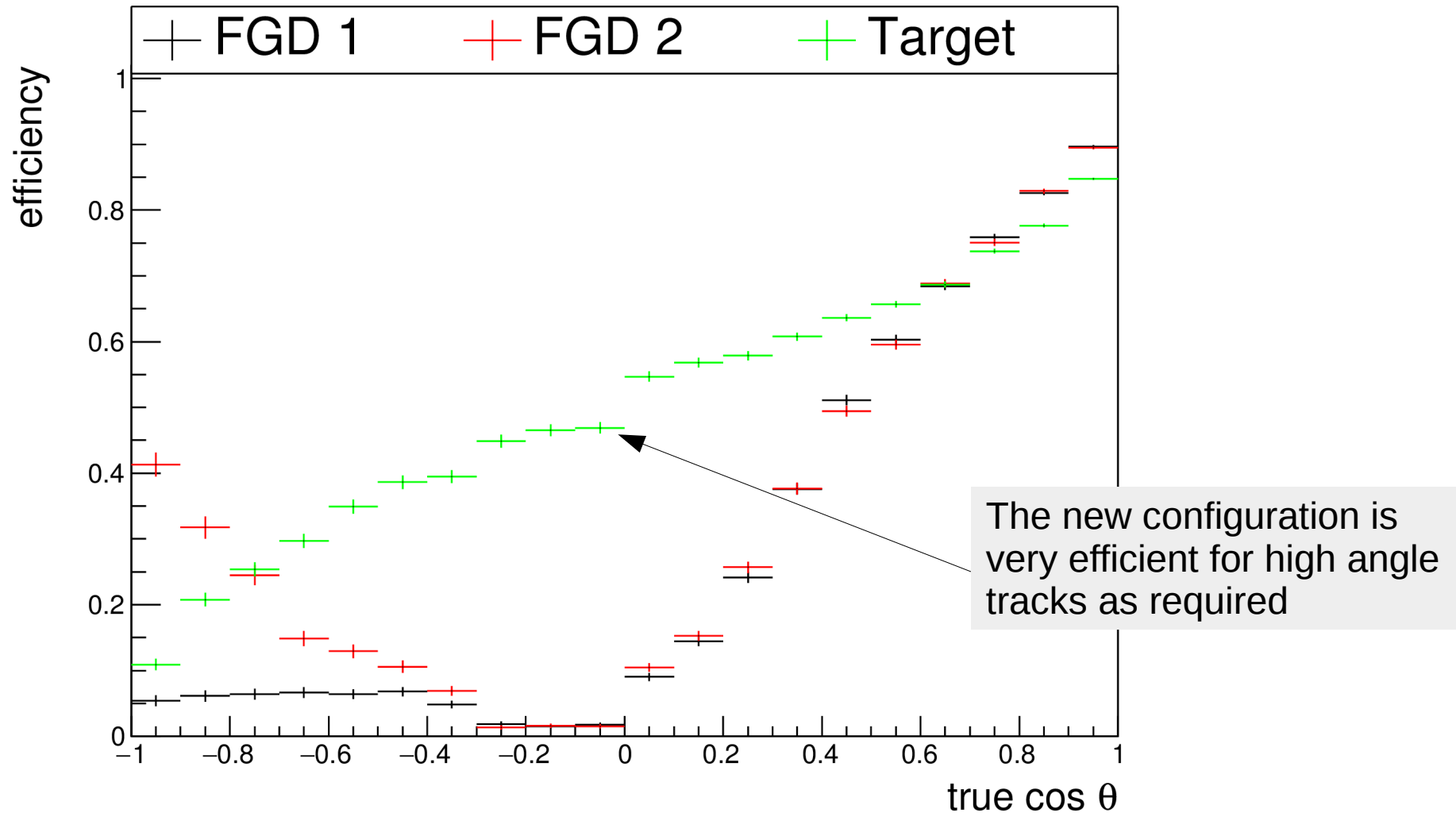
*S. Bolognesi, D. Calvet, P. Colas, A. Delbart, S. Emery, F. Gizzarelli, M. Lamoureux, M. Martini, E. Mazzucato, G. Vasseur, M. Zito*  
IRFU, CEA Saclay, Gif-sur-Yvette, France

CERN-SPSC-2017-002 / SPSC-EOI-015  
05/01/2017



<sup>1</sup> Corresponding authors: Alain Blondel (alain.blondel@cern.ch), Marco Zito (marco.zito@cea.fr)

# Muon tracking efficiency



Studies with full GEANT4 simulation



# ND280 Upgrade: sub-detectors

- Atmospheric pressure TPCs (Horizontal TPC)  
2 detectors ( $\sim 2\text{m} \times 2\text{m} \times 0.8\text{ m}$ )
- Active targets (one,  $\sim 2\text{tons}$ )
- TOF detectors
- other ND280 detectors and systems (ECAL, DAQ, ...)
- R&D for a High Pressure TPC

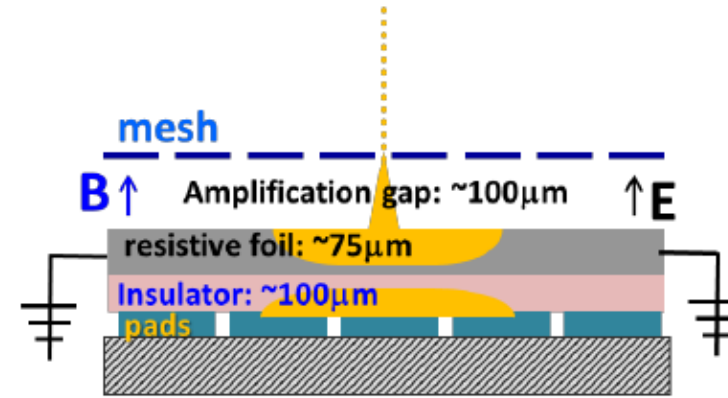
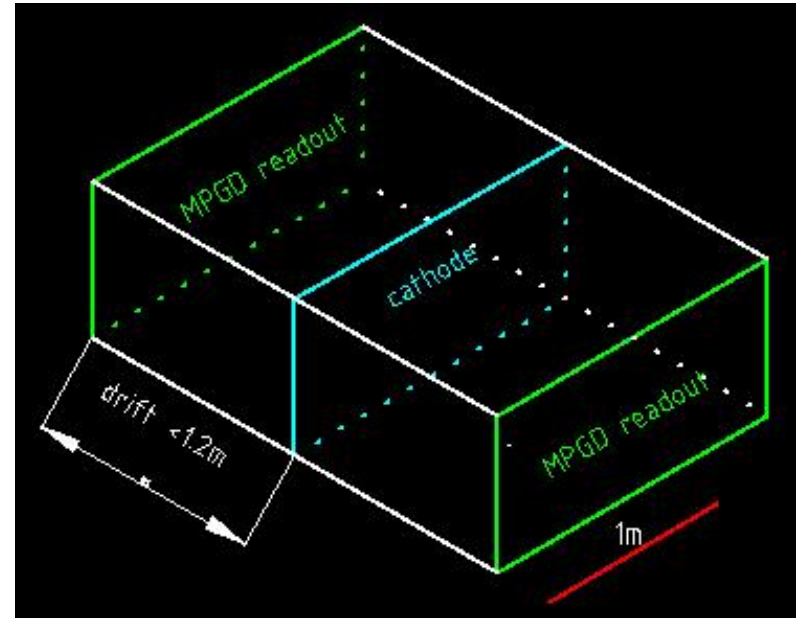
# Horizontal TPCs

Similar in size and technology to the existing TPC.

Resistive Micromegas for spreading the charge and spark protection (ILC TPC R&D).

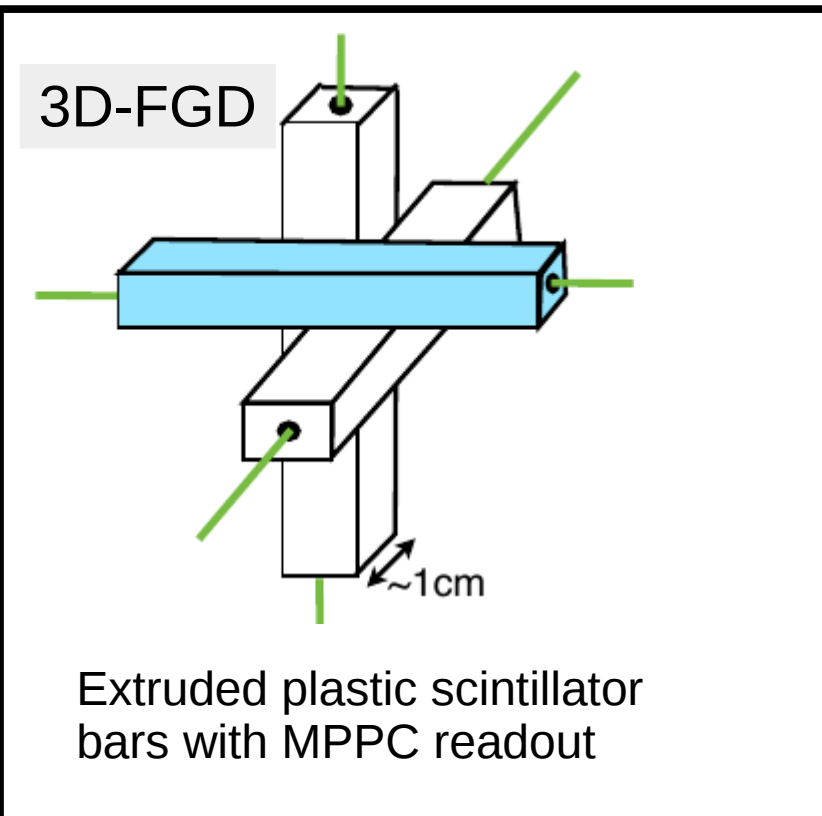
Thin field cage along the lines of the Aleph TPC.

~1cm pad size, ~30-50k channels



# The scintillator-based target detector

- Various design options are being studied



Last workshop: decision to concentrate on totally active scintillator target

Existing FGD, 2D configuration  
NIM A 696 (2012) 1–31

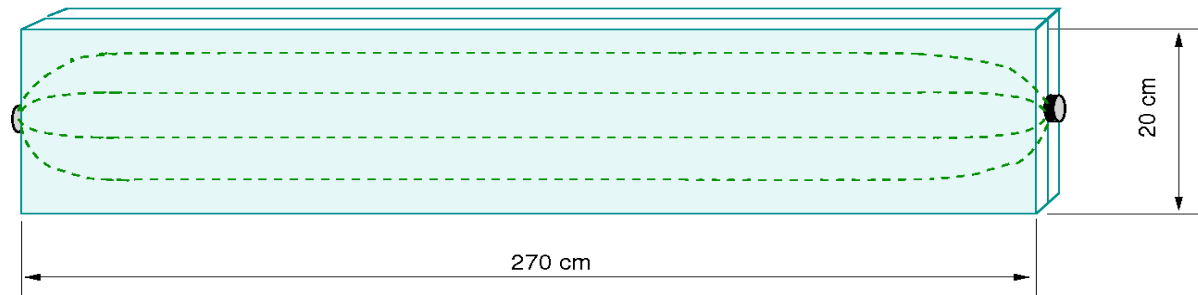
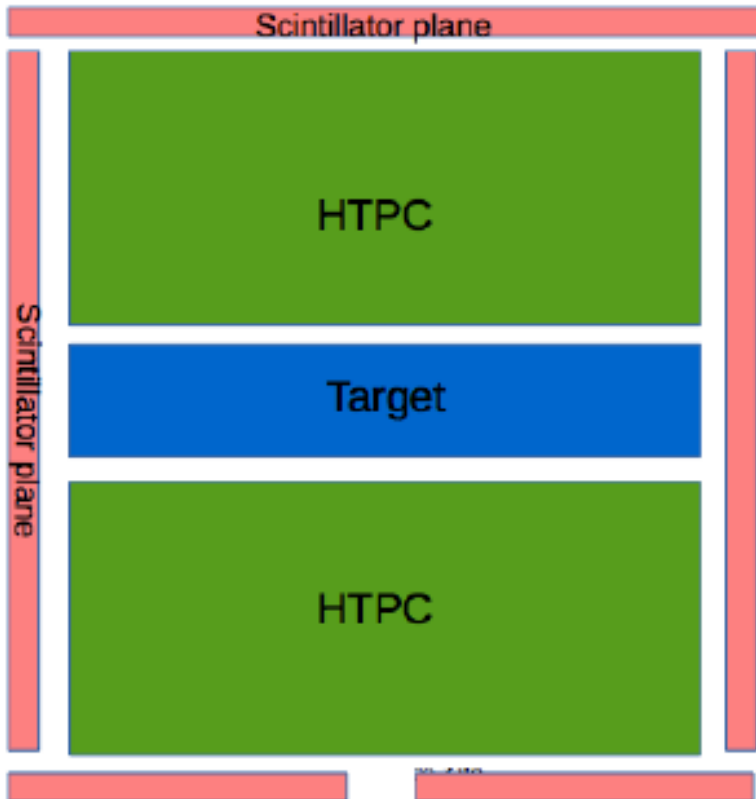
# Time of Flight detector

Purpose:

- determine the sense of the tracks
- improve particle Identification

Extruded plastic scintillator

- WLS Kuraray 1mm fibers (glued), single connector, 3x3mm<sup>2</sup> MPPC, double-end
- Time resolution 630-650 ps
- R&D studies at INR (Moscow)



Cast plastic scintillator

- about 4m attenuation length
- 8 sensors of 6x6 mm<sup>2</sup>
- Time resolution is 120-140 ps
- R&D at University of Geneva (SHiP)

