Commissionning of the bottom HATPC at Tokai

David Henaff on behalf of HA-TPC group

23/12/10
T2K experiment

J-PARC accelerator
- Protons @ 30 GeV
- Produced intense (anti) neutrino beams

ND280
- 280 meters upstream beam target
- Perform measurement before oscillation of beam composition/flux
  → This talk

Super-Kamiokande
- 295 km away from J-Parc
- Measurement after oscillation
- 50kton water Cherenkov detector
- Reconstruction of:
  - Vertex position
  - Momentum
  - Muon vs electron

ND280 & SK off-axis to increase beam intensity at desired L/E
T2K Oscillation constraints

J-PARC
Near Detectors

\( \nu_\mu, \overline{\nu}_\mu \)

Neutrino Beam

T2K physics goals

Long baseline experiments are sensitive to several osc. parameters

- Precise measurements of theta23 and deltam32
- Nu oscillation open questions:
  - CP symmetry
  - Octant of theta23
  - Exotic scenarios (CPT violation, sterile, ...)

Appearance channel

\[
P(n_\mu \to n_e) \approx \sin^2 2\theta_{13} \cdot \sin^2 \theta_{23} \cdot \frac{\Delta m^2_{23} \cdot L}{4E}
\]

\[
P(n_\mu \to n_e) - P(\bar{n}_\mu \to \bar{n}_e) \propto \sin \delta_{CP}
\]

Disappearance channel

\[
P(n_\mu \to n_\mu) \approx 1 - \sin^2 2\theta_{23} \cdot \cos^4 \theta_{13} \cdot \frac{\Delta m^2_{23} \cdot L}{4E}
\]
**Goals of near detector**

- Constrain neutrino flux and neutrino-nucleus interaction models
- Clear improvements of Far detector predictions with ND

**Current design**

- **FGDs**: 2 fine grained detectors composed of plastic scintillator with layers of water
  - *Act as target for nu interaction*
- **vTPCs**: 3 time projected chamber using Micromegas readout plane
  - *Characterisation of outgoing particle: Momentum + PID*
- **POD**: Upstream detector optimised to tag neutral pion detection
- All detectors are surrounded by electromagnetic calorimeter and 0.2T magnet → needed for momentum reconstruction
**ND280 current design & limitation**

**Limitations**

- Mainly a **forward detector** while SK is 4pi (**backward track** not well reconstructed)
- Hadronic part of interaction only partially reconstructed because of proton threshold and missing neutrons
- Loss of information → need to rely on neutrino-nucleus model to reconstruct the neutrino energy from final state lepton
ND280 upgrade

How to overcome this?

*Remove the P0D and install new sub-detectors!*

- **Super-FGD:** Highly segmented target (~2 millions scintillator cubes readout by a 3D network WLS fibers
- Precise location of primary vertex
- Lower threshold for reconstruction of protons and pions + neutron measurement event by event by Time of light

- **HA-TPC:** High Angle TPC on the top and below SFGD
- Improving angular acceptance of charged outgoing particles

- **TOF:** Whole surrounded by plastic scintillator planes to tag external background and measure track direction.
Focus on HA-TPC

Requirements
- Momentum resolution <9% at 1 GeV/c (neutrino energy estimate)
- Energy resolution <10% with 1 module (8% for 2 modules)
- Space resolution ~ 500um
- Low material budget walls ~5%X₀

Encapsulated Resistive Anode Micromegas

See Shivam’s talk!
- Benefits from ILC TPC & RD51 developments
- Classical bulk Micromegas + a resistive layer (DLC) allowing charge spreading on neighbouring pads
  - Gives a better spatial resolution with less pads (1728 to 1152)
  - Reduce spark rate
  - Mesh @ ground → Better E field homogeneity
- Equipped with water cooling to protect electronic and reduce electronic noise.
Design of the Field Cage

Strip foil

- Double Copper strips on Kapton foil (Cu 17um / Kapton 50um / Cu 17um)
  - Allow to reach good electric field uniformity at short distance from walls
  - Produced at CERN
- Coverlay for strip insulation and protection (Glue 20um / Kapton 50um)
Design of the Field Cage

Insulation layer

- **1st Field cage:**
  - Coverlay for strip insulation and protection (Glue 20um / Kapton 50um)
  - Observed current leakage while no issue on mock-up and prototype
  - Took long time and lot of measurement to understand

Causes

- Anti-static spray has deteriorated the insulation
- Kapton resistivity was far from specification!
Design of the Field Cage

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Fixed by increasing the insulation layer and avoid anti-static spray on next FCs
Construction @ CERN

- Deformation under pressure
- Leak test

Inside the cage before closing

Metrology on MF and Cathode alignment

Qualification with cosmics
Upgrade of gas system

**Oct 6:** Started injection of standard T2K mix (95/3/2 Ar/CF4/iC4H10) in H-TPCb

**Oct 9:** reached nominal concentration. Gas quality gradually improving by fresh gas input

**Oct 12:** purification system running

**Oct 31:** T2K mix recirculation opened to the VTPCs, CO2 flow to envelopes

**Nov 3:** gas composition reaches nominal in all connected TPCs (3 V + 1 H)

Gas contamination (O2) stable since then:

- 4.8 ppm from purifier output
- 5.5-6 ppm from chamber return

Gas quality now is OK for normal operation
HA-TPC installation

25th August: Delivery at JPARC

6-7th September: Installation

10th October: Gas ready

11th October: First cosmic track

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14th November: Magnet closure

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Neutrino events!

Coming from SFGD

11th October: First cosmic track

14th November: Magnet closure

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HA-TPC first analysis

Noise:

@ JPARC

Drift velocity:

@ CERN

Analysis ongoing!
Conclusion

➢ The bottom HA-TPC has been built and qualified at CERN successfully

➢ It has been extensively tested with prototype and mock-up during several test beams and cosmic tests
  ➢ The delivery in Japan at J-PARC went well without any damage

➢ It has been installed in September at Tokai and fully cabled

➢ First tracks with TOF and cosmic shows similar behaviour as at CERN
  ➢ Analysis ongoing to fully characterize the TPC at JPARC and finish commissioning

➢ It is now integrated in ND280 DAQ and taking beam events with SFGD and TOF waiting for the top HATPC under production at CERN
  ➢ Expected installation in May 2024
Design of the Field Cage

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
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<tbody>
<tr>
<td>Strips on Kapton foil</td>
<td>Cu 17um / Kapton 50um / Cu 17um</td>
</tr>
<tr>
<td>Coverlay</td>
<td>Glue 150um / Kapton 425um</td>
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<tr>
<td>Aluminium foil</td>
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