# LPNHE-neutrino group: Items to be discussed

- Thanks for the strong support of our ND280-upgrade activities (our contributions are well on-track!). Shipment (donnation) to Japan?
- Contributions to the computing for T2K/HK?
- Thanks for the resources allocated for the HK R&D: good progress in the design of the timing system (also fruitful collaboration with SYRTE colleagues). A collaboration review will take place during Summer 2022. Need an explicit statement from the IN2P3 directorate about a possible level of financial support (which is a requirement for the review)

# LPNHE-neutrino group: Items to be discussed

- Contribution to the NA61/SHINE Common Fund. Planned new data-taking for T2K during the 2022 run with a replica of the T2K target to reduce even further the neutrino flux uncertainties
- Discussions started about a future upgrade of the near detector ND280++ after the start of the HK data-taking. Could potentially make a contribution to the upgrade of the timing system (profiting from the HK R&D).
- Ecole de GIF2022 “Neutrino”@LPNHE

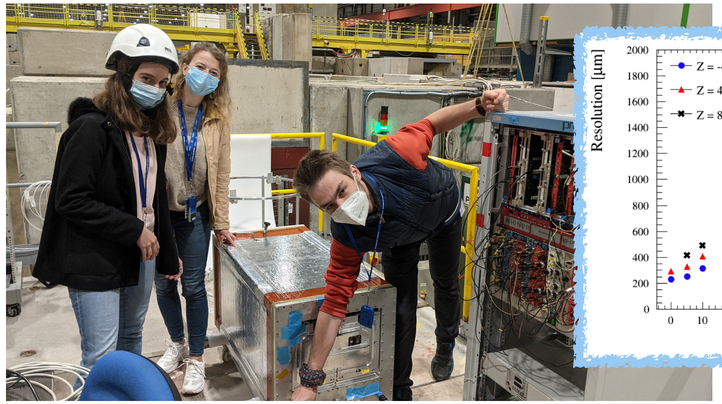
# T2K-II and ND280 Upgrade

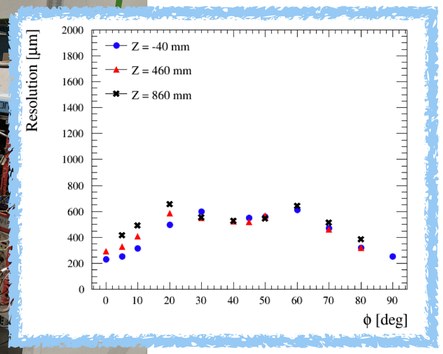
# LPNHE group activities

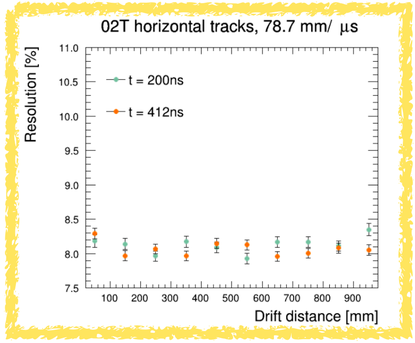
- Strong contribution of LPNHE group on T2K-II and the Near Detector upgrade
  - CG → coordinator of ND upgrade and member of the T2K Executive Committee
  - MG → convener of the reconstruction group
  - BP → coordinator of NA61 analyses for T2K
- Our goal is to install the ND280 upgrade at J-PARC in 2022 and prepare the tools to exploit the first ND upgrade data
- These activities are only possible thanks to the invaluable help of 2 ANR postdocs (Adrien Blanchet, Sergey Suvorov) and 3 PhD students (Viet and Vlada mostly on ND upgrade, Lucile on T2K Oscillation Analysis and HK)
  - Postdocs of Adrien and Sergey will finish at the end of 2022
  - Viet will also finish his thesis in 2022, Lucile and Vlada in 2023
  - Need to reinforce the LPNHE neutrino group to fully exploit T2K-II (and HK!)

# HA-TPC performances and reconstruction

- Results from 2018 CERN test beam and 2019 DESY test beam both published on PRD → Sergey corresponding author for both papers
- Another test beam with the Field Cage prototype was done at DESY in 2021
  - Allow to test ERAM performances for long drift distances
- Preliminary analysis show performances better than our requirements:
  - Spatial resolution between 200 and 600 μm (depending on angle and drift distance)
  - dE/dx resolution ~8% for tracks crossing one ERAM module
  - Paper in preparation → Vlada and Sergey

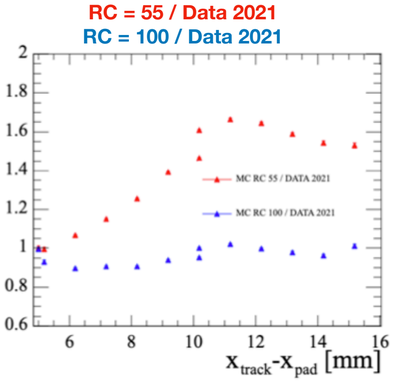


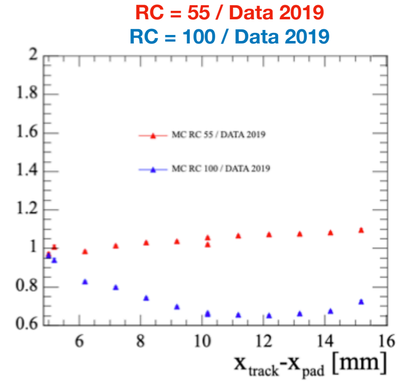


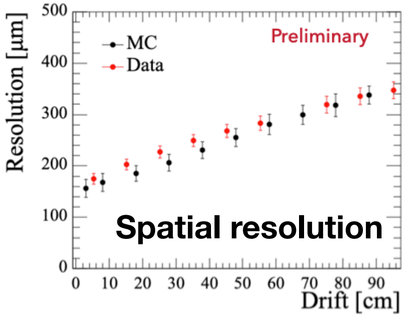



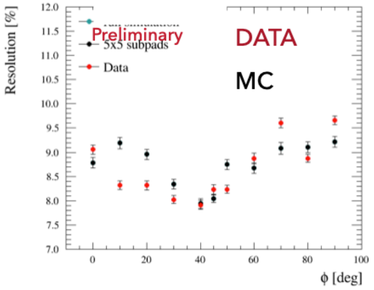

DAQ: Adrien
Test beam analysis: Vlada and Sergey
TPC simu and reco: Sergey

**Sergey developed the ERAM simulation and implemented it in the ND280 Software**
**Currently finalizing the HA-TPC reconstruction**



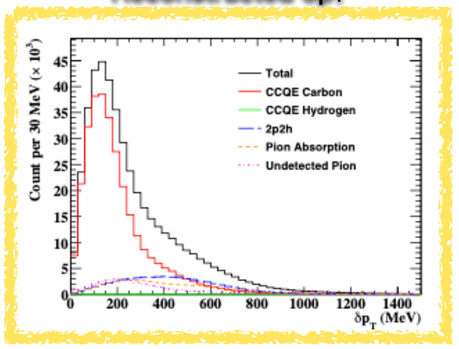




**σ(dE/dx)/dE/dx < 9%**

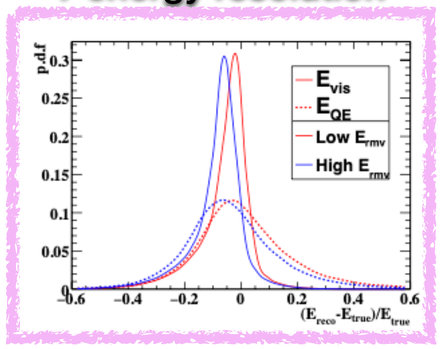
# ND280 upgrade performances

## Exploiting hadronic informations

Reconstructed $\delta p_T$

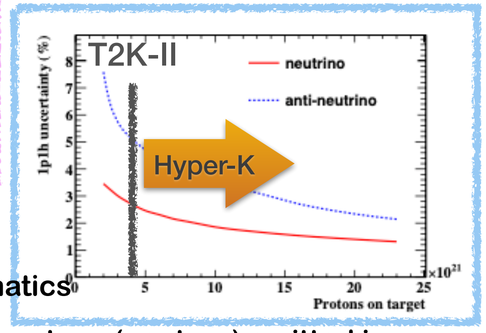



$\nu$ energy resolution




arXiv:2108.11779
Accepted for publication on PRD
Viet corresponding author!

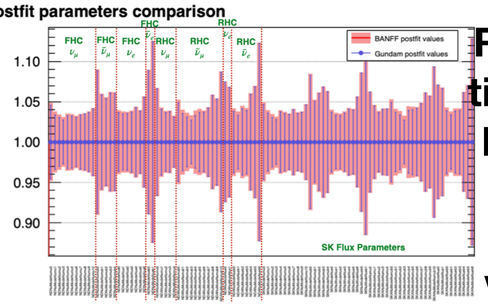
Uncertainty on 1p1h vs POT




- Analyses done so far by ND280 mostly exploited the μ kinematics
- With the upgrade we will be able to reconstruct muons and protons (neutron) emitted in $\nu$ ($\bar{\nu}$) QE interactions
  - Reconstruct variables in the transverse plane → more sensitive to nuclear effects → $\delta p_T = |p_T^{\mu} - p_T^{p(n)}|$
  - $E_{vis} = E_{\mu} + T_{p(n)}$ → where T is the kinetic energy
    - Evis better estimator of the neutrino energy than QE formula
- ND280 Upgrade will exploit these variables to better constraint cross-section systematics
  - Benefit of the upgrade for T2K-II but also for Hyper-K


Adrien developed a new fitter for ND280
Designed to be easily extendable to ND Upgrade samples and to fit different variables (currently we only use lepton kinematics in ND fits)

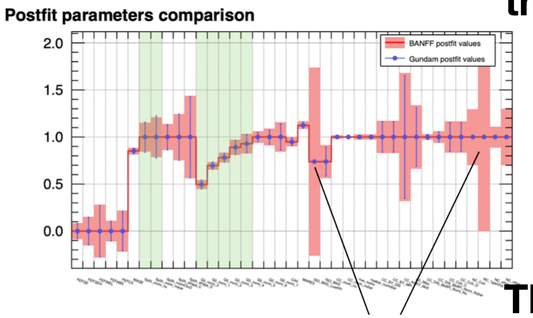
Postfit parameters comparison




Reproduce current results but 3 times faster → 6h to do the 2020 ND280 fit (~20 hours for official ND fitter)

Vlada is using this fitter for the the new T2K Oscillation Analysis

Postfit parameters comparison




LLR group (Jafaar and Margherita) have added the expected super-FGD samples

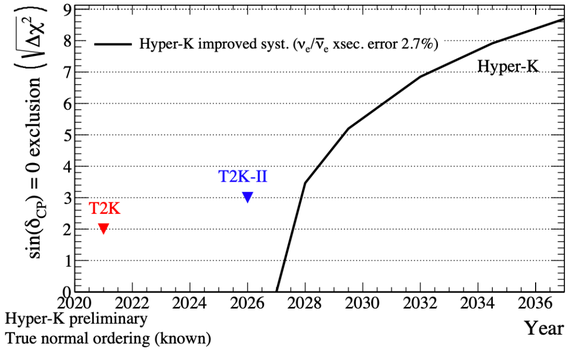
The tool is ready to contribute to T2K OA

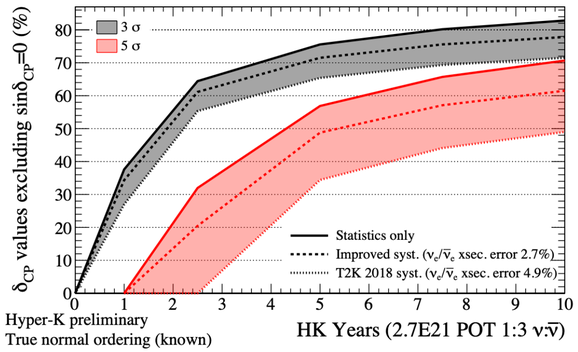
# Installation of ND280 Upgrade

- LPNHE contributions to TPC FEC finalized → see Jean-Marc slides
- Some delays in the fabrication of the first HA-TPC field cage at Nexus → received it at CERN only this week (TBC!!)
- Commissioning of ERAM detectors and of field cage at CERN on-going
  - Test Beam at CERN PS in April
- Shipment and installation of first HA-TPC at J-PARC in Fall 2022
- Second TPC will be ready at CERN by the end of 2022 → installation at J-PARC by March 2023
- We hope to have ~4 months of data with ND upgrade by Summer 2023

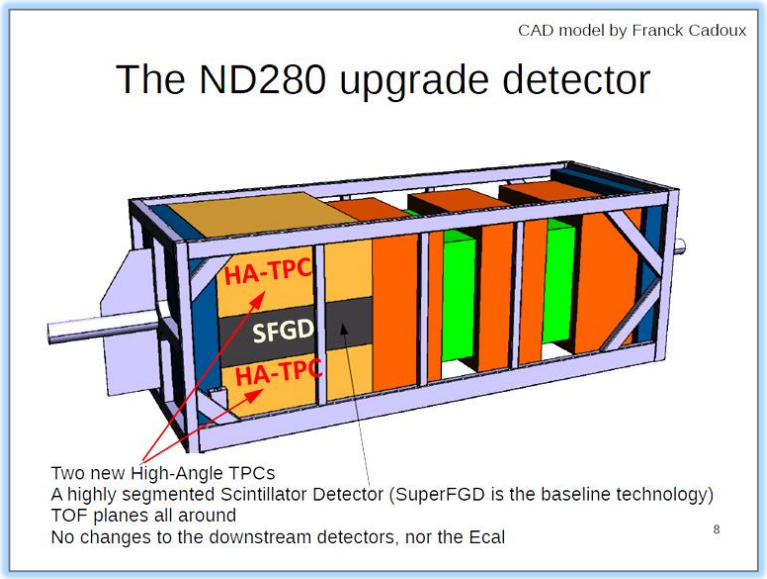
# Longer term

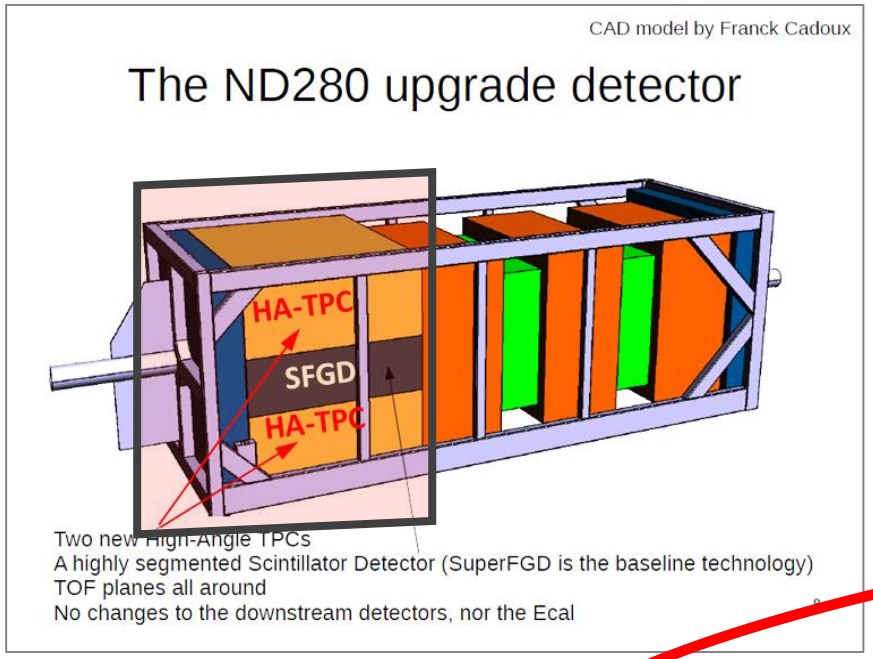
- Once the ND280 upgrade will be installed we will exploit its data to:
  - Reduce systematic uncertainties in T2K-II
    - CPV at ~3σ by 2027 for maximal CP violation
  - Prepare the early discovery of CP violation with Hyper-K
    - CPV at >5σ by 2029 for large values of CPV
    - Discovery of CPV requires an excellent control of systematics uncertainties and ND280 will have a central role for this
- With the lessons learned from the first few years of data taking with ND280 Upgrade we might want to consider further upgrade of ND280 for Hyper-K
  - Add water target?
  - Larger sFGD for $\nu_e$ measurements?
  - Excellent opportunity for additional contributions to HK bringing our expertise from T2K → several European groups are participating to the brain-storming for ND280 Upgrades for HK
- Request to IN2P3: one CR position to contribute to T2K-II and prepare Hyper-Kamiokande



# *Engagement du LPNHE dans l'Upgrade du détecteur ND280 / T2K-II*

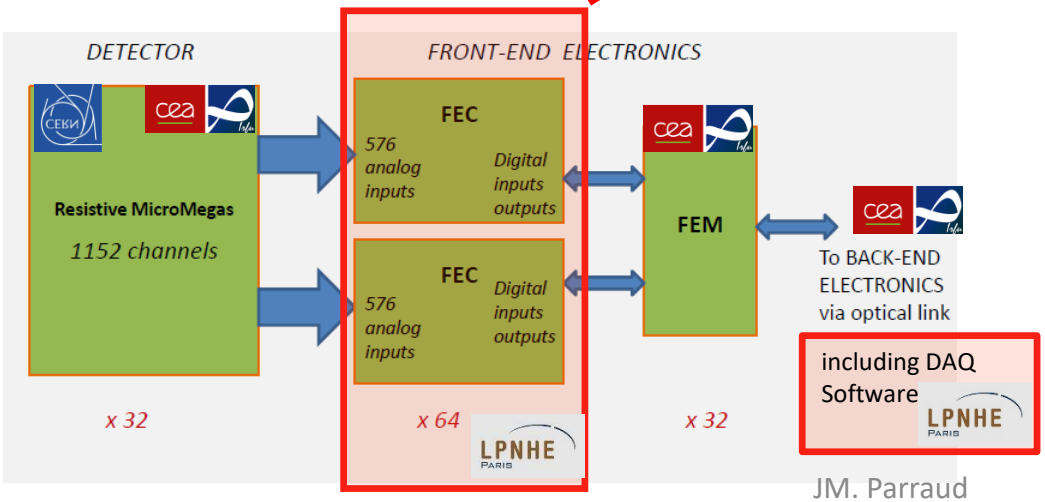


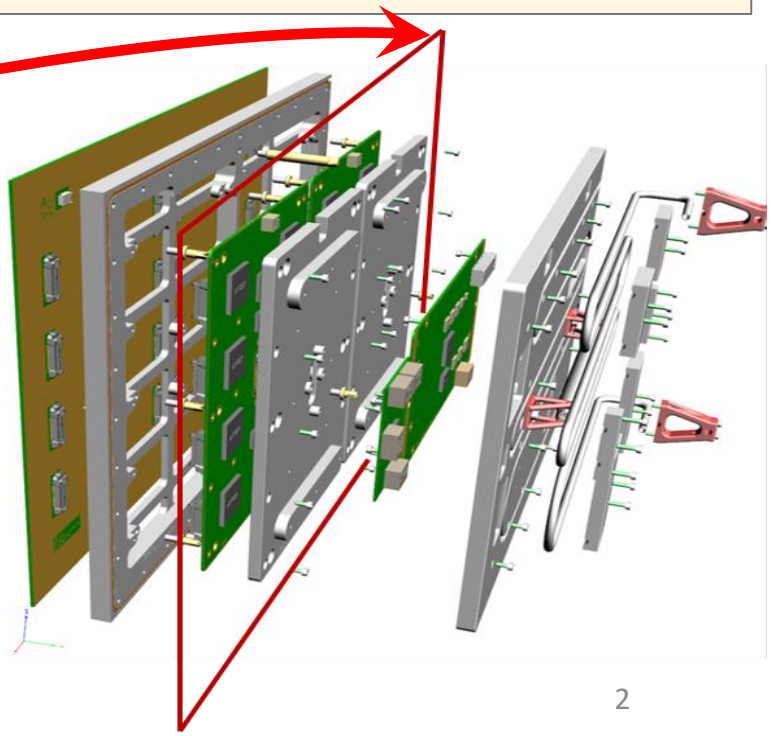



L'ancien calorimètre est remplacé par une *cible à scintillateurs* (SFGD) et 2 *chambres à dérive* (HA-TPC) équipées d'électronique de lecture.

En collaboration avec des équipes de l'**Irfu/CEA**, du **CERN** et de labos **italiens**, **polonais**, **espagnols** et **allemands**, l'équipe du **LPNHE** participe à la construction des **nouvelles HA-TPC**, à plusieurs niveaux de compétences techniques :

- ✓ *électronique*
- ✓ *mécanique*
- ✓ *informatique*

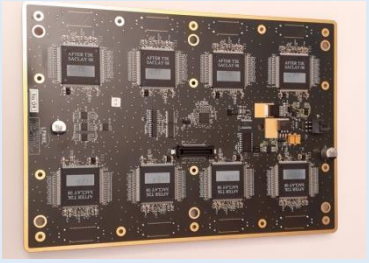


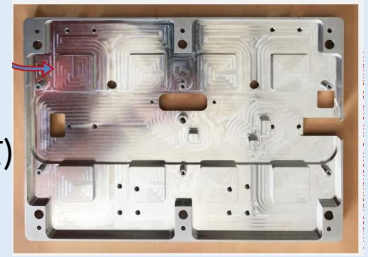
## Contribution du LPNHE pour l'upgrade-T2K

3 livrables :

► Conception + fabrication
**Cartes électroniques** FEC (*front-end card*) - *Quantité* = ***84***
(*64* sur le détecteur + *8* spares + *12* pour bancs-tests collab)
→ Production : **marché PUMA** / **Ouestronic** : pré-série de **12** + série de **72**



► Conception conjointe avec l'Irfu + fabrication
**Capots de refroidissement** des cartes FEC - *Quantité* = ***80***
(*64* sur le détecteur + *8* spares + *8* pour tests *fabriqués au LPNHE*)
→ Production : **Chanteloup-Associés** : pré-série de **8** + série de **64**



► Développement des **softwares** DAQ - acquisition des données des HA-TPC
- software embarqué sur les cartes back-end *TDCM* de l'Irfu
- software sur PC d'acquisition de l'expérience

# Equipe *Upgrade-T2K* du LPNHE

## *Equipe scientifique (physiciens)*

- Boris POPOV — Responsable scientifique local
- Claudio GIGANTI — Co-responsable du projet Upgrade-ND280
- Marco ZITO

→ Chercheurs

- Mathieu GUIGUE → Enseignant-chercheur
- Marco MARTINI → Chercheur associé
- Jacques DUMARCHEZ
- Pierre BILLOIR
- Alain BLONDEL

→ Chercheurs émérites

- Jean-Michel LÉVY → Chercheur bénévole
- Adrien BLANCHET
- Sergey SUVOROV

→ Post-docs

- Quoc Viet NGUYEN
- Lucile MELLET
- Vlada YEVAROUSKAYA

→ Doctorants

## *Equipe technique (ITA)*

- Jean-Marc PARRAUD — Responsable technique local
- François TOUSSENEL

→ Électroniciens concepteurs

- Stefano RUSSO → Électronicien Tests CERN/Commissioning
- Éric PIERRE → Électronicien CAO
- Julien CORIDIAN → Électronicien câbleur
- Yann ORAIN → Mécanicien B.E.
- Patrick GHISLAIN
- Sébastien LEFÈVRE

→ Mécaniciens atelier

- Diego TERRONT
- Vincent VOISIN

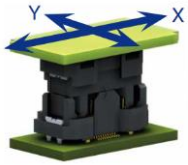
→ Informaticiens

- Bernard CARACO → Gestionnaire administratif

## Carte FEC

→ *Jean-Marc Parraud, François Toussenel, Eric Pierre, Julien Coridian*

Cette carte est une évolution de la carte FEC existante sur les TPCs de la phase I, avec *2x plus de voies*. Carte de *traitement de signaux analogiques* et *conversion numérique*, elle réutilise le chip Asic *AFTER* (design Irfu/CEA) déjà implanté et éprouvé sur les cartes de la phase I.




***Challenges*** **:** → **576 voies de mesures** par carte, circuit imprimé à *10 couches de cuivre*
→ choix de **connectique « flottante »** - - - - - - *NOUVEAU pour la collab*

***Contraintes*** **:** **RoHS** (sans plomb) - fabrication PCB **halogen free**

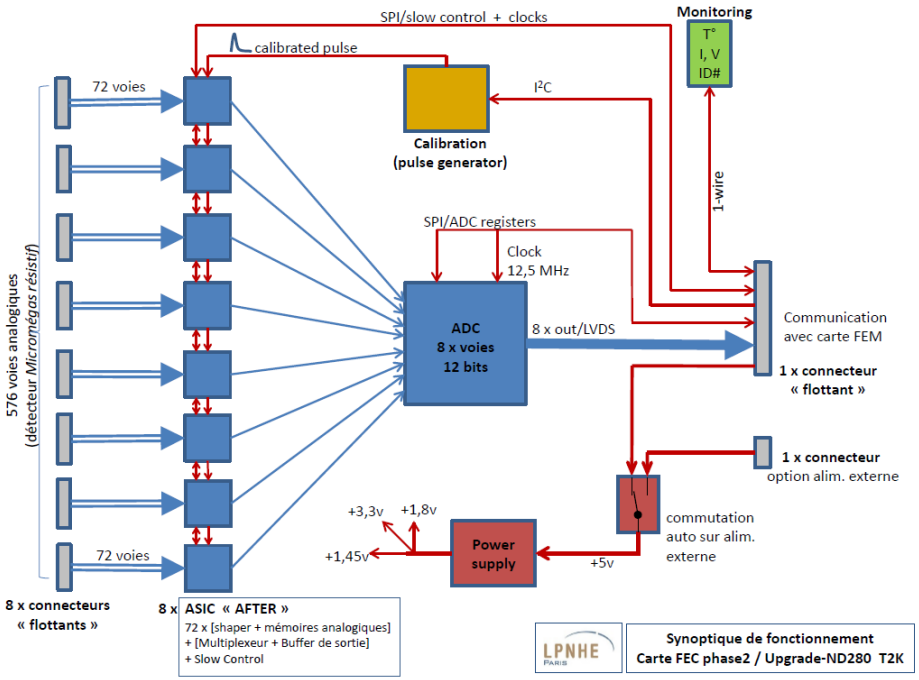
***FEC / Phase2*** :

**Based on FEC/Phase1** that works fine for more than 10 years at T2K-Tokai site.

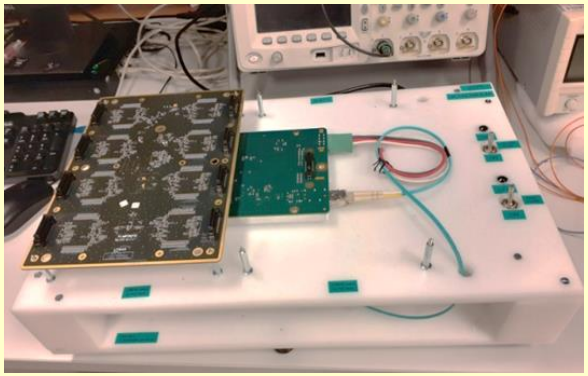
Use of the **same ASIC** (→ « **After** » / IRFU) for the read out and processing of analog signals coming from the detector. **Qty=8** (qty=4 in Phase1)

Use of an **8 channel ADC** (**AD9637-40**), instead of a 4 channel ADC.

The **global architecture remains the same** as it was in Phase1.




**Banc de test** des cartes FEC réalisé par l'équipe de l'*Université de Technologie de Varsovie*



→ destiné aux tests de la production des cartes chez Ouestronic
→ A testé les 84 cartes avec succès

## Calendrier

| | | | |
|---|---|---|---|
| - | 11 avril | 2019 | Revue synthétique IN2P3 « **RSP** » |
| - | Février | 2020 | 2 x cartes FEC prototypes + essais à l'Irfu-CEA |
| - | Mai | 2020 | Lancement appel d'offres PUMA pour cartes FEC → *choix OUESTRONIC* |
| - | Juillet | 2020 | **12 x cartes FEC / pré-série** OUESTRONIC |
| - | Août | 2020 | 2 x capots prototypes (réalisés à l'Irfu) |
| - | 29 oct. | 2020 | Revue Irfu-CEA « **PRR** » des cartes FEC → *lancement prod en novembre* |
| - | Février | 2021 | **8 x capots** réalisés au LPNHE |
| - | Mars | 2021 | **8 x capots / pré-série** Chanteloup-Associés |
| - | Juin/Juil | 2021 | **Tests en faisceau** à DESY → *1ère fois / électronique FE en champ magnétique* |
| - | Oct. | 2021 | **Software DAQ-MIDAS** fonctionnel pour testbeam au CERN en novembre |
| - | Nov. | 2021 | **Tests en faisceau** au CERN |
| - | Nov. | 2021 | **72 x cartes FEC / série** OUESTRONIC *FIN de la production* |
| - | Février | 2022 | **64 x capots / série** Chanteloup-Associés *FIN de la production* |

| | | | |
|---|---|---|---|
| - | Avril~juin | 2022 | **Tests + Envoi pour intégration au CERN** des 64 cartes <FEC/capots> |
| - | Juin | 2022 | Développement final **software DAQ + software embarqué** |
| - | Automne | 2022 | **Intégration** des HA-TPC au CERN |

## Développement softwares DAQ

**1-** Software sur PC d'acquisition : → Adrien Blanchet, Mathieu Guigue

Upgrade du précédent *soft de contrôle-commandes* de la *phase I*, *construit autour de MIDAS.*

→ Collaboration active avec l'équipe de l'Irfu-CEA

« *MIDAS est un système d'acquisition de données moderne* »

**2-** Software embarqué sur les cartes back-end *TDCM (phase II)* de l'Irfu : → Diego Terront

Transposition du précédent système (*Irfu-CEA*) tournant sur les cartes de la *phase I*
(1 x CPU, sans système d'exploitation)
en un système plus flexible utilisant **2 x CPU**, dont 1 tournant sur **Linux embarqué**.

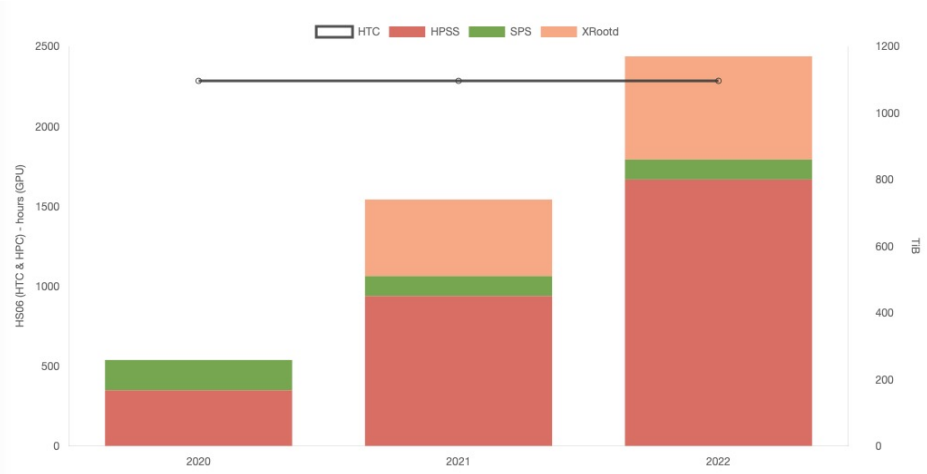
→ Collaboration avec Denis Calvet / Irfu-CEA
→ Expérience accumulée qui pourra être partagée avec d'autres projets

# Status of computing for T2K and HK

DIRAC GridPP instance in the UK

Resources and data management in UK and IN2P3

JENNIFER 2
EU grant n.822070




**LPNHE & IN2P3 contributions to T2K/HK:**

- Hosting ND280 data to CC as T1
  - Transfer to disk and tape in progress 

- T2K offline database hosted at CC
  - Setting machines and parameters in progress 

- Software containerization for ND280 (LPNHE)
  - Deployment of Docker & Singularity images ✓
  - Ready for production 7 this year! ✓
  - Getting ready for Supernovae production for HK this year ✓
- R&D database for HK hosted at CC-IN2P3 (with INFN) 


Log on https://hkdbweb.in2p3.fr

# Near and long-term plans for computing

~Linear increase of resources allocated started in 2020

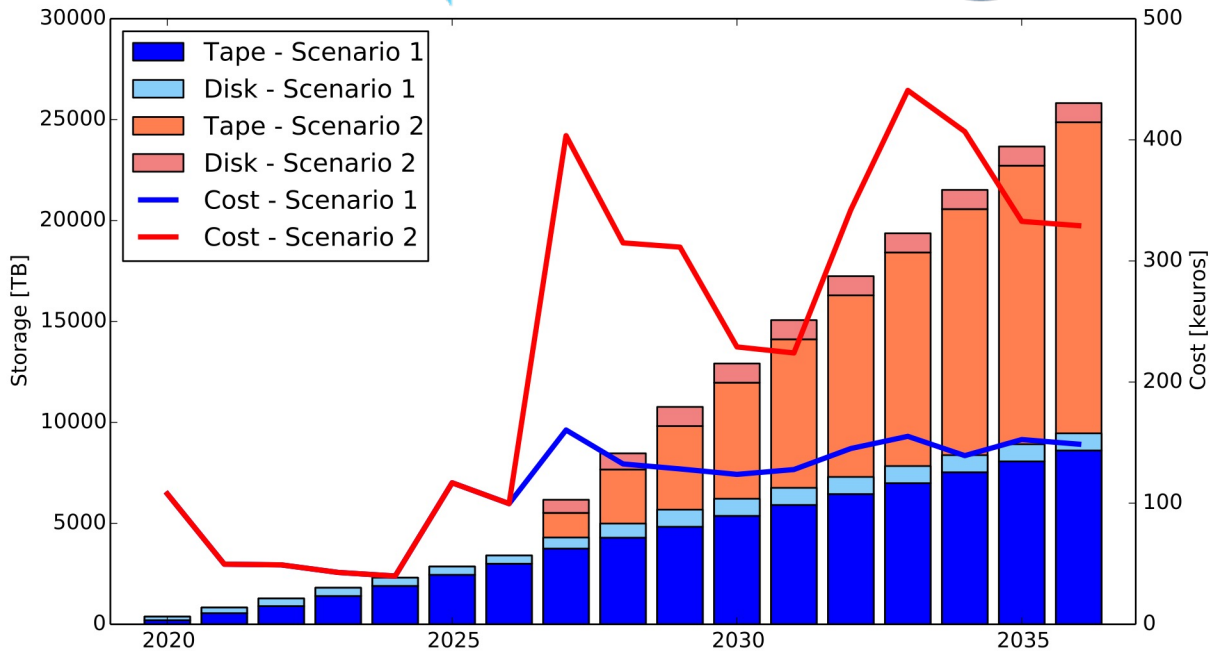
Finish replication of raw data and old productions to tape and disk over 2022

**ND280/HK databases at CC-IN2P3:**

- Move to HK production DB at CC-IN2P3 in April
- Storage of official information afterwards
- Need to confirm long-term support soon

**CC-IN2P3 as Tier1 for ND280/HK:**

- Production for T2K this year
- **Replication of first ND280 Upgrade data to CC-IN2P3**
- New production for HK this Spring (4MCPU.h)
- Store results on disk and tape at CC-IN2P3



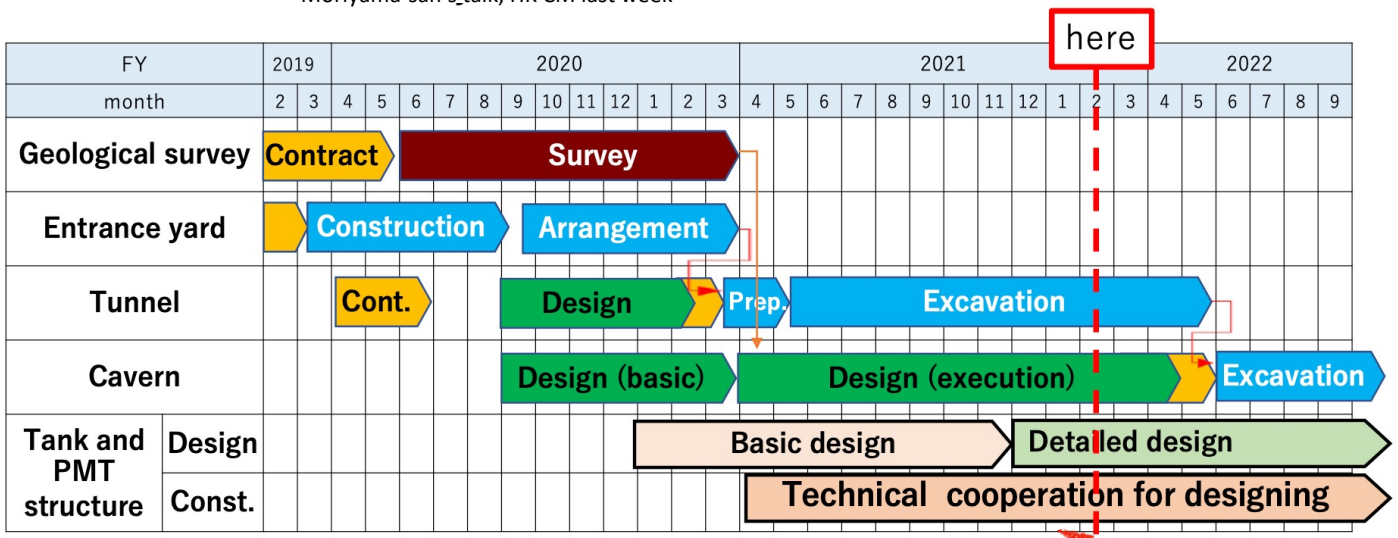

Lot of efforts and time being invested!

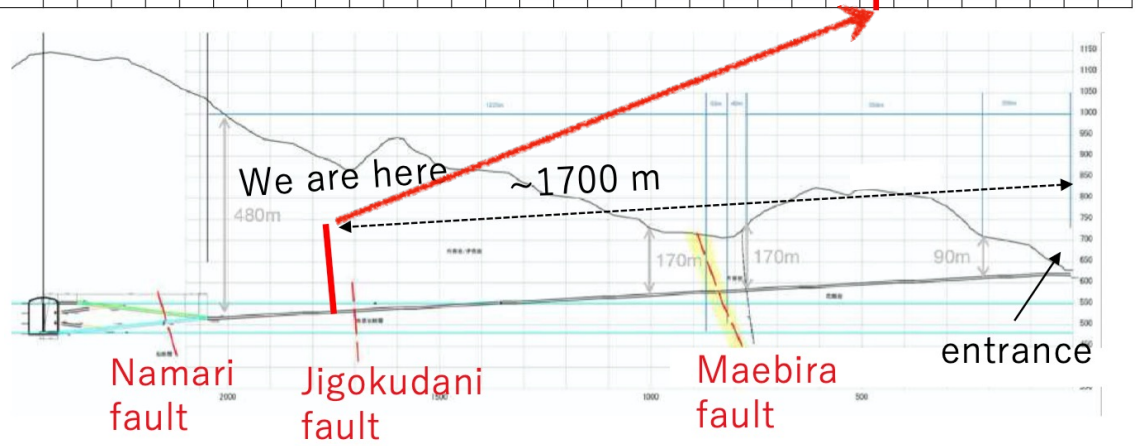
# Progresses on the HK far detector construction


~300 PMTs are delivered per month
~3000 PMTs were already delivered

50.4 oku-yen newly allocated budget for next FY

Moriyama-san's talk, HK CM last week




- **The excavation of the access tunnel is going well and will complete on time!!**

  Subsequent excavation (cavern) will start in March

# Time and clock for HK: context

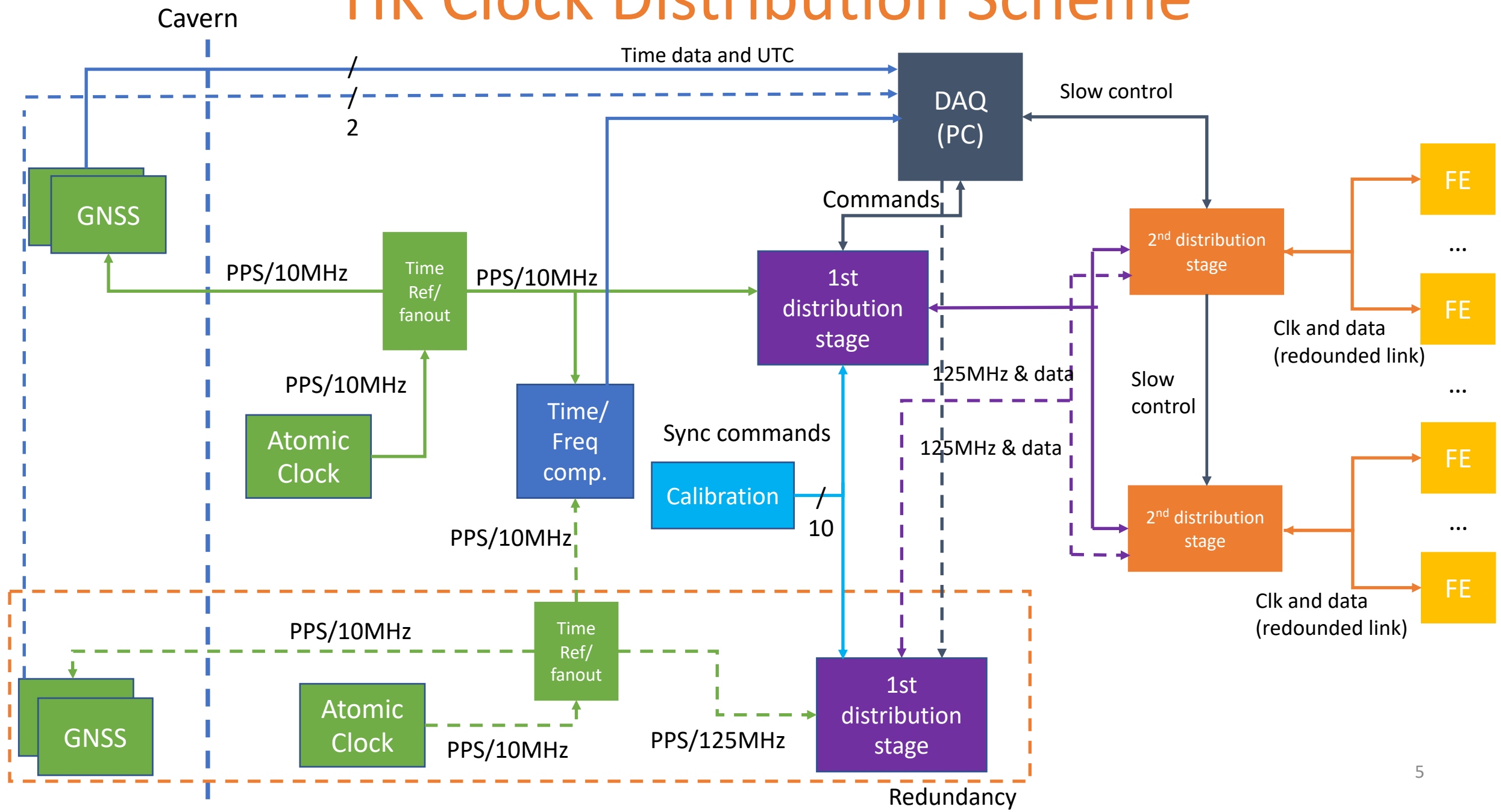
LPNHE, CEA and INFN have joint forces to design a complete time distribution scheme that will be submitted to the international collaboration this spring. If approved the group will be in charge of the construction and commissioning. Together with the LLR digitizer it will give IN2P3 a central role in HK!

The proposal envisions to provide a system that fulfil the needs of both HK far and intermediate detector. Possible synergies can be found with the future T2K upgrades (when integrated in HK).

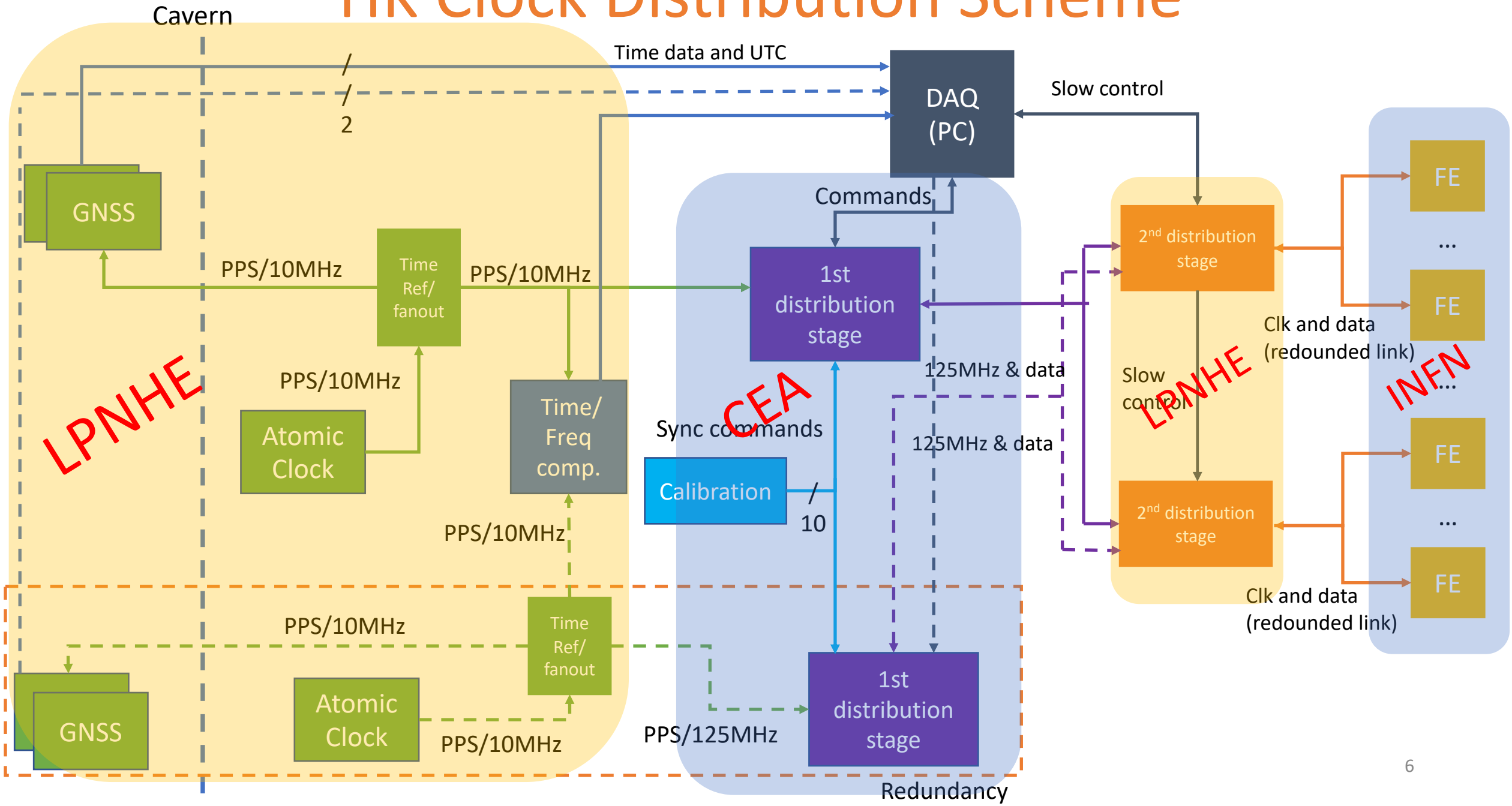
To conceive this proposal, an intense and fruitful R&D campaign is being carried out. Its results will be available for other IN2P3 experiments. This group believes that the time distribution system will be a strategic assets for future experiments due to the constant size increase of particle detectors.

This program has already created synergies across CNRS institutes thanks to a very fruitful collaboration with the SYRTE lab (Observatoire de Paris).

# HK Clock Distribution Scheme

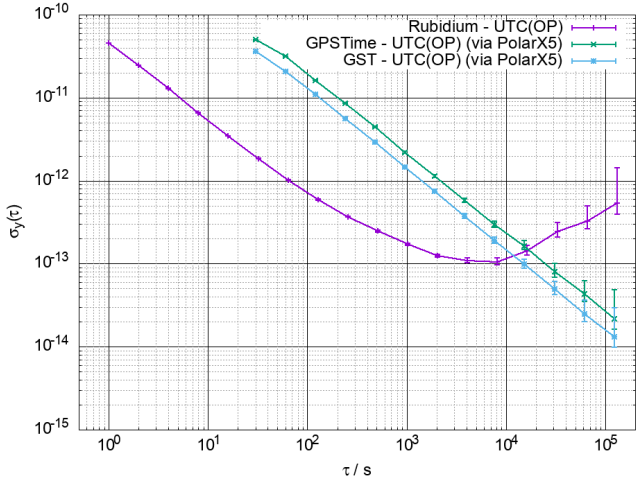


# HK Clock Distribution Scheme

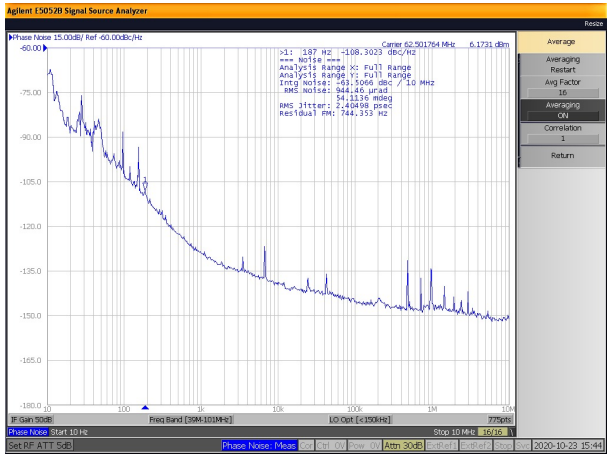


# Status

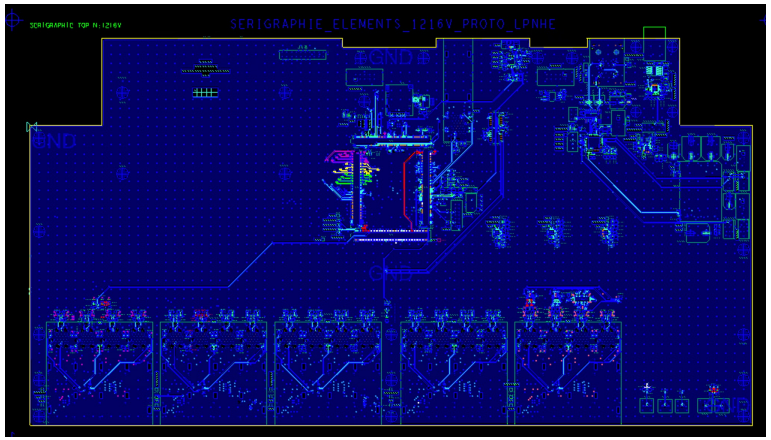
- Lucile is contributing to the clock and GNSS antenna characterization.
- The final conceptual scheme has been conceived.
- Test and characterization campaigns have been carried out.
- First prototypes have been designed (great synergy with CEA)
- The technical note (include precise cost estimation) for the final review is being prepared




GNSS and atomic clock characterization




Clock Jitter at endpoint (FE) characterization

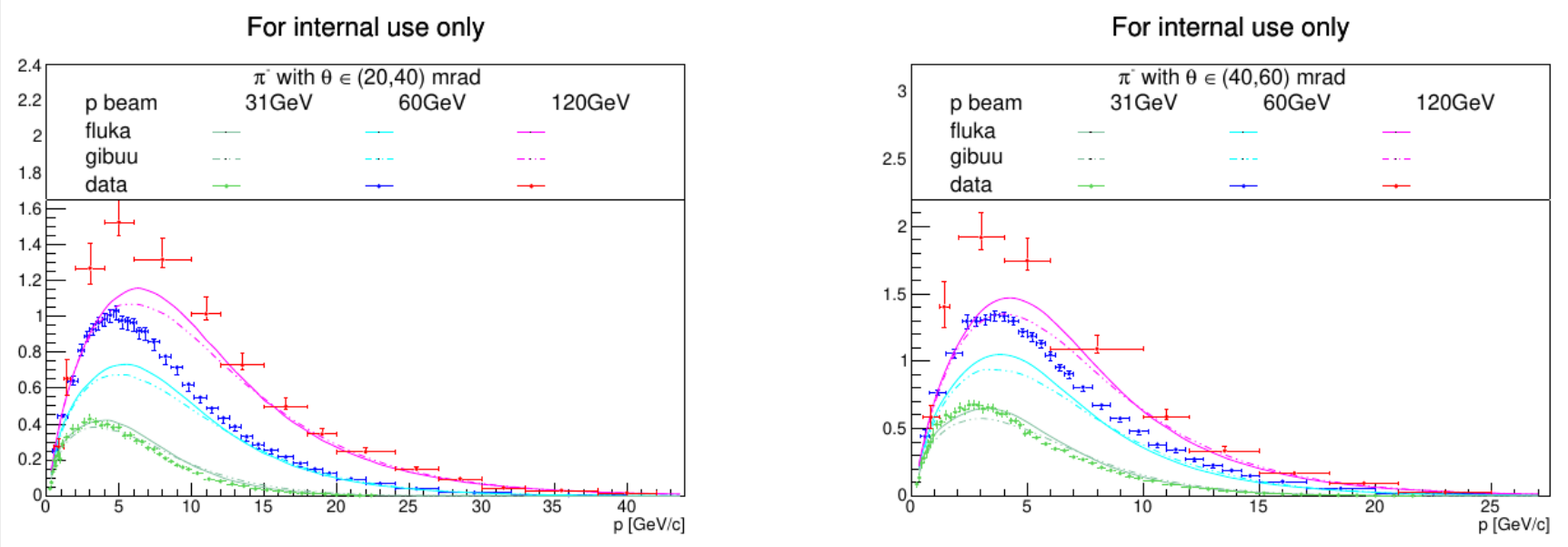


Second distribution stage prototype board

We look forward to share our material with the IN2P3 management to prepare the financial proposal for the final commitment

# Contributions to NA61/SHINE

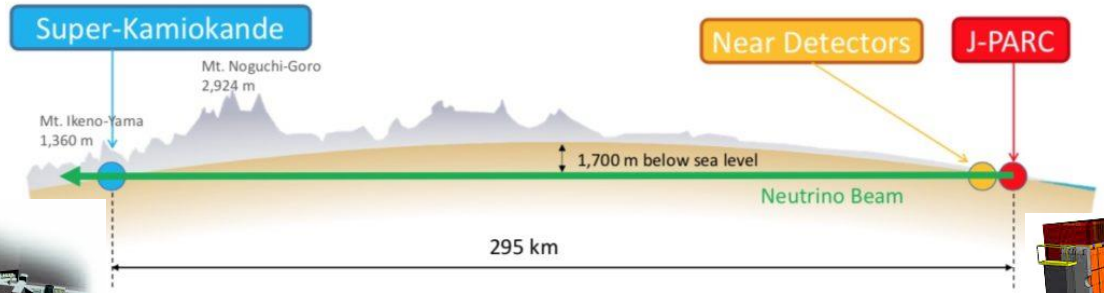
- Coordination of the analysis efforts for neutrino experiments
- Participation in the spectrometer upgrade @ CERN
- New data-taking for T2K-II during the 2022 run
- Successful internship by Claire Dalmazzone (Ecole Polytechnique/EPFL). Now applying for a PhD grant @ STEP'UP ED



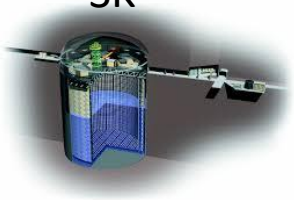

Example of "evolution" plots for pC@31GeV/c (T2K), preliminary results for pC@60GeV/c and pC@120GeV/c (DUNE) hadron yields compared to FLUKA and GiBUU model predictions

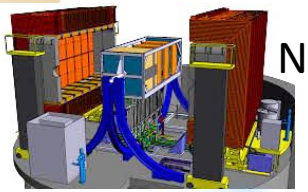
# Backup slides

**T2K** : expérience implantée au Japon, en service depuis 2009
→ étude des ***neutrinos***
- *oscillation des neutrinos*
- *violation de CP/matière-antimatière*

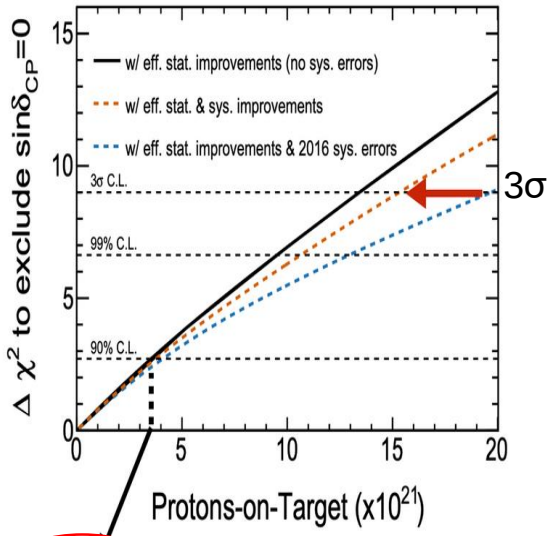



SK



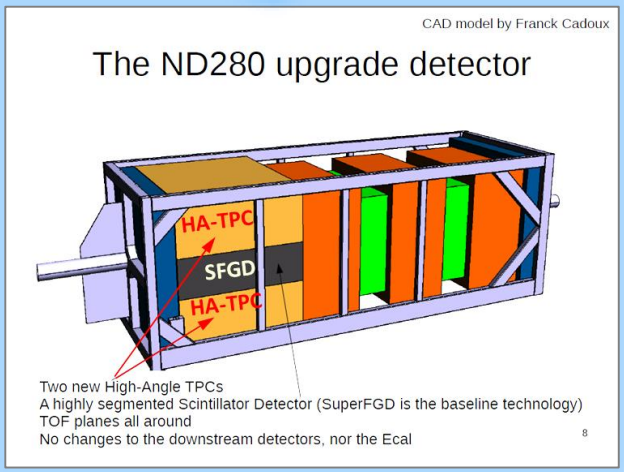


ND280

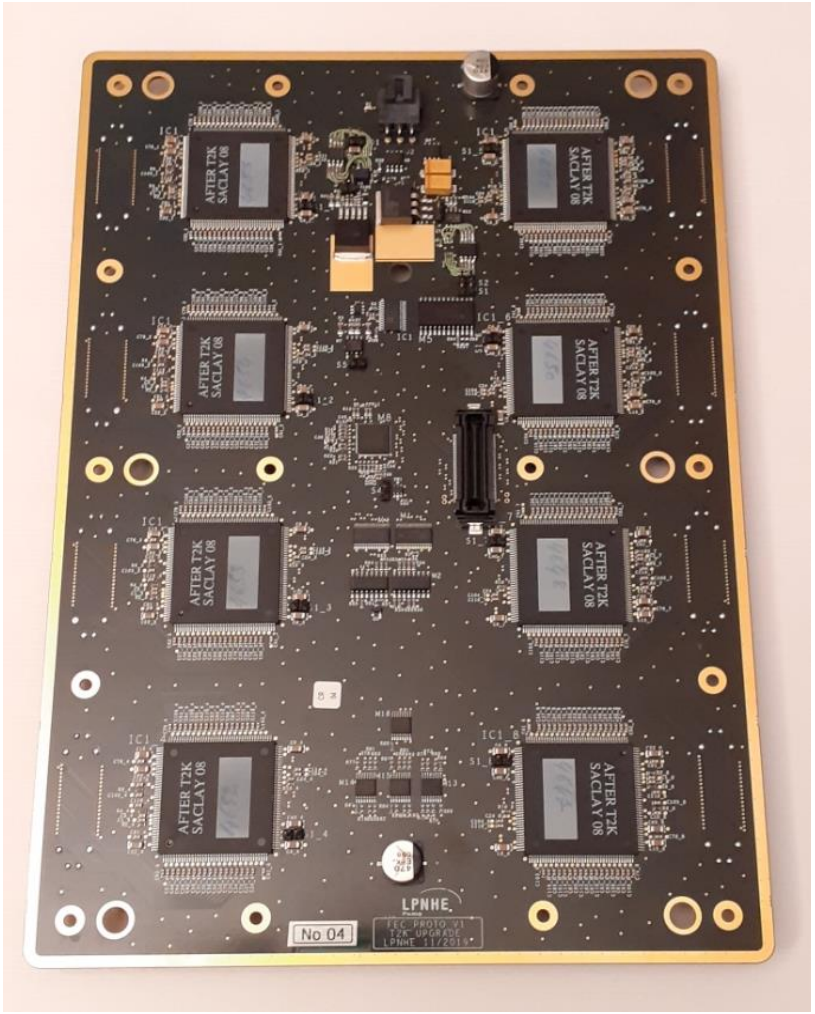


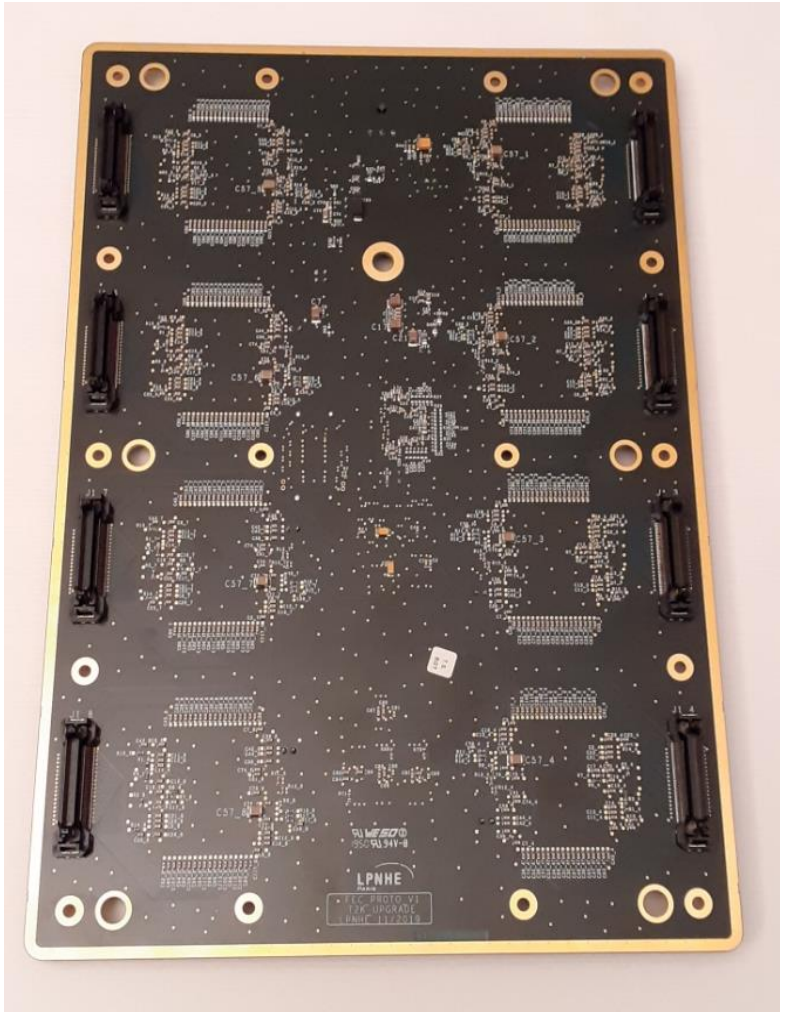

**T2K** : ~10 ans de prise de données à ce jour.
Pour obtenir des résultats statistiques probants pour la physique, il faudrait cumuler les données pendant de (trop) nombreuses années.

**T2K-II** → **Upgrade** du **faisceau** et du **détecteur proche** (ND280) : ***diminution des incertitudes systématiques***.
Le cumul de données pourrait être suffisant au bout ***de 4 à 5 ans.***



## Carte FEC



## Capot de refroidissement carte FEC

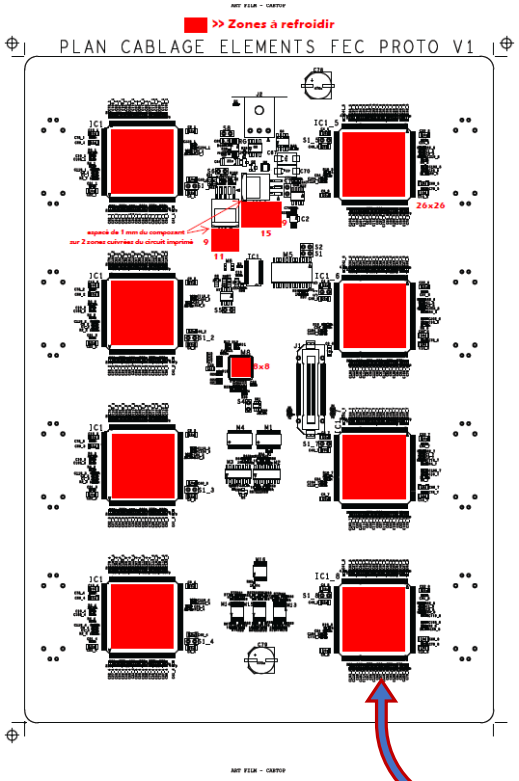
→ Yann Orain, Patrick Ghislain, Sébastien Lefèvre

↳ Design réalisé en collaboration avec l'équipe du ***BE/mécanique de l'IRFU***

Capot réalisé en aluminium *Fortal*.
Usinage standard à la *commande nu*

Le refroidissement de la carte est réalisé par transfert thermique entre les composants dissipateurs de chaleur et le capot.

Le capot est lui-même refroidi par un serpentin dans lequel circule de l'eau refroidie.




*Silicone pads*