Consuntivi Scientifici 2019
Esperimenti di Gruppo 2

Alessandro Menegolli
Dipartimento di Fisica e INFN, Sezione di Pavia

Grazie a P.W. Cattaneo, G.L. Raselli e V. Re per le slides

CdS INFN Pavia
8 giugno 2020

Attività: 4 settori di ricerca

Le attività di CSN2 sono raggruppate in quattro settori:

Linea 1: Fisica del neutrino.
Oscillazioni di neutrino, decadimento doppio beta.

Linea 2: Radiazione dall'Universo
Raggi cosmici, raggi gamma, neutrini cosmici, antimateria.

Linea 3: L'Universo Oscuro
Materia Oscura, Energia Oscura, Assioni.

Linea 4: Onde gravitazionali, fisica generale e quantistica.
Onde gravitazionali, misure di g, effetti relativistici, proprietà quantistiche del vuoto.

NOTA: dall'11 Febbraio 2020 abbiamo un nuovo Presidente di CSN2: Oliviero Cremonesi (Dir. Ric. INFN-MiB). M. Pallavicini è diventato membro di Giunta per la CSN2.

Bilancio 2019*

Distribuzione delle risorse per linea di ricerca.

	N. esp.	Budget 2019
1-Fisica del neutrino. BOREX, CUORE, CUPID, **CYGNO**, ENUBET_2, GERDA, ICARUS, JUNO, NU_AT_FNAL, **PTOLEMY**, T2K, TRISTAN.	12	27.8%
2-Radiazione dall'Universo AMS2, AUGER, CTA, FERMI, GAMMAMEV, GAPS, HERD_DMP, IXPE_INFN, KM3, LSPE, QUBIC.	11	32.4%
3-L'Universo Oscuro CRESST, DAMA, DARKSIDE, EUCLID, NEWS, QUAX, SABRE, XENON	8	18.1%
4-Onde gravitazionali, fisica generale e quantistica ARCHIMEDES2, **ET_ITALIA**, FISH, G-GRANSASSO-RD, HUMOR, LARASE, LIMADOU_CSN2, LISA, MAGIA-ADV, MOONLIGHT-2, SUPREMO, VIRGO	12	11.8%
Dotazioni di gruppo + esperimenti sotto DTZ (HOLMES_2, LVD, MOSCAB**)**	3	9.9%
Totale FTE Persone	46	*15825 k€* 861 1338

*Bilancio 2019 non ancora approvato, le percentuali fanno riferimento all'assegnato iniziale.

Bilancio: 2013-2019

	2013	2014	2015	2016	2017	2018	2019
Budget (k €)	11367.5	11482.5	12875	12143.5	14641.5	14630.5	15825.0
FTE	550	605	660	717	752	770	861
Persone	856	865	931	1052	1092	1174	1338

CSN2 è la commissione che è cresciuta di più in termini di FTE/persone negli ultimi anni - per lo più da EPR (INAF) e Università:

- FTE cresciuti del 36% dal 2013;
- Numero persone cresciuto del 36% dal 2013;
- Numero sigle circa costante negli ultimi anni (46 nel 2019, ma 50 nel 2020!).
- Budget in crescita del 28% rispetto al 2013.

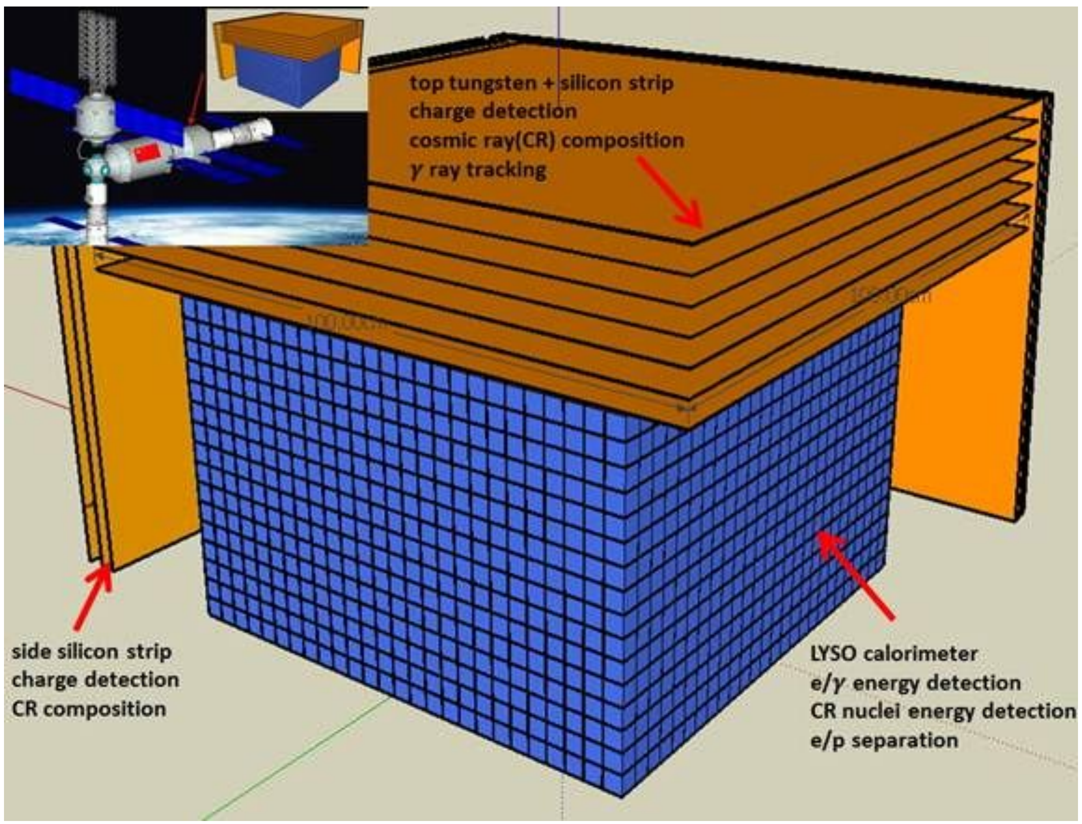
Anagrafica PV 2019

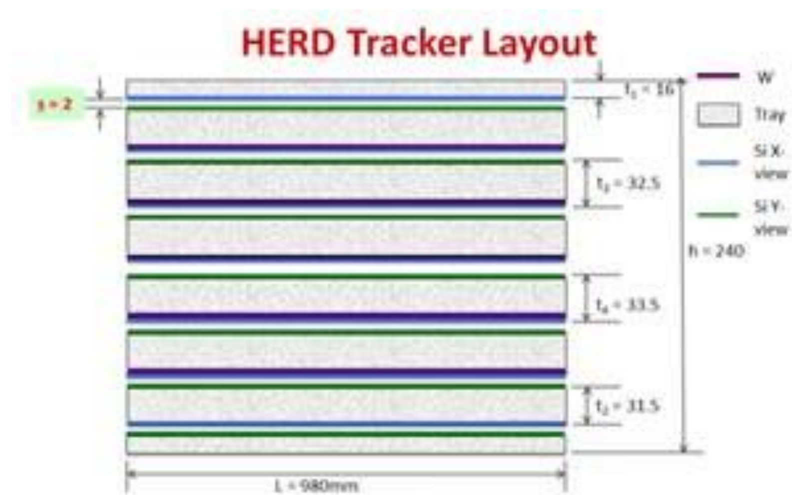
Linea	Esperimento	FTE/persona
1. F, Boffelli, A. Menegolli, C. Montanari, A. Rappoldi, G.L. Raselli, M. Rossella, A. Scaramelli	ICARUS	4.3/7
2. A. Agnesi, P.W. Cattaneo, M. Manghisoni, M. Oddone, F. Pirzio, A. Rappoldi, V. Re, E. Riceputi, M. Sonzogni	GAPS, HERD	4.9/9
3.		
4.		
Totale	**3**	**9.2/15**

1 FTE in meno rispetto al 2018: la diminuzione di ICARUS è compensata in parte da HERD.

HERD

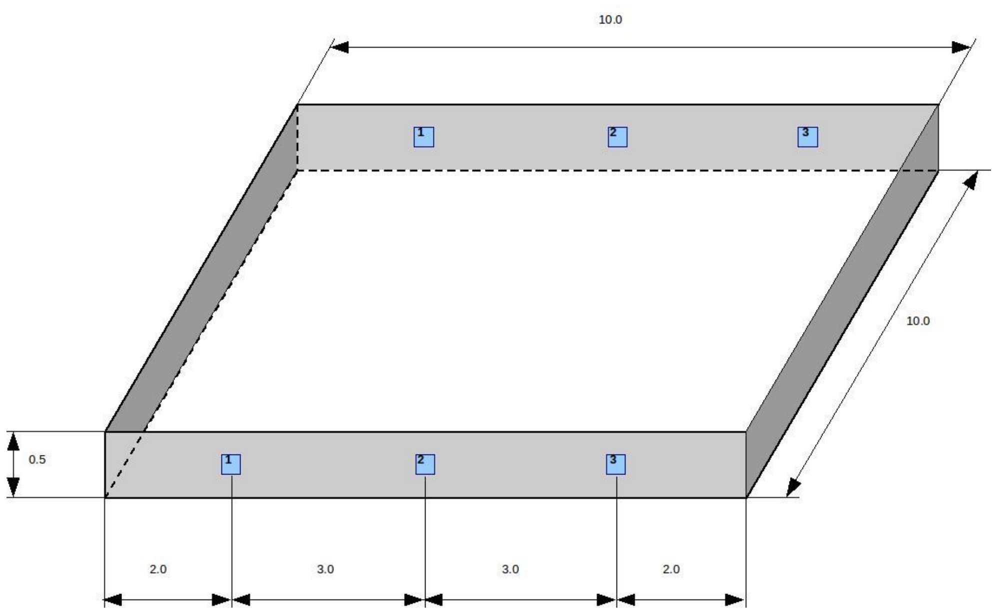
- HERD(High Energy Cosmic Radiation Detection) facility is one of the Cosmic Lighthouse Program onboard China's Space Station, planned to be launched and assembled in 2020.
- The main science objectives of HERD onboard China's space station are detecting dark matter particle, study of cosmic ray composition and high energy gamma-ray observations.
- The main constraints imposed on HERD are: total weight less than around 2 tons and total power consumption less than around 2 kilowatts.





HERD Pavia Consuntivo 2020

We devoted our efforts to develop a prototype of the HERD Plastic Scintillator Detector (PSD) with a scintillator tile (EJ220) read out by 3+3 SiPM from Hamamatsu.



FTE 2019

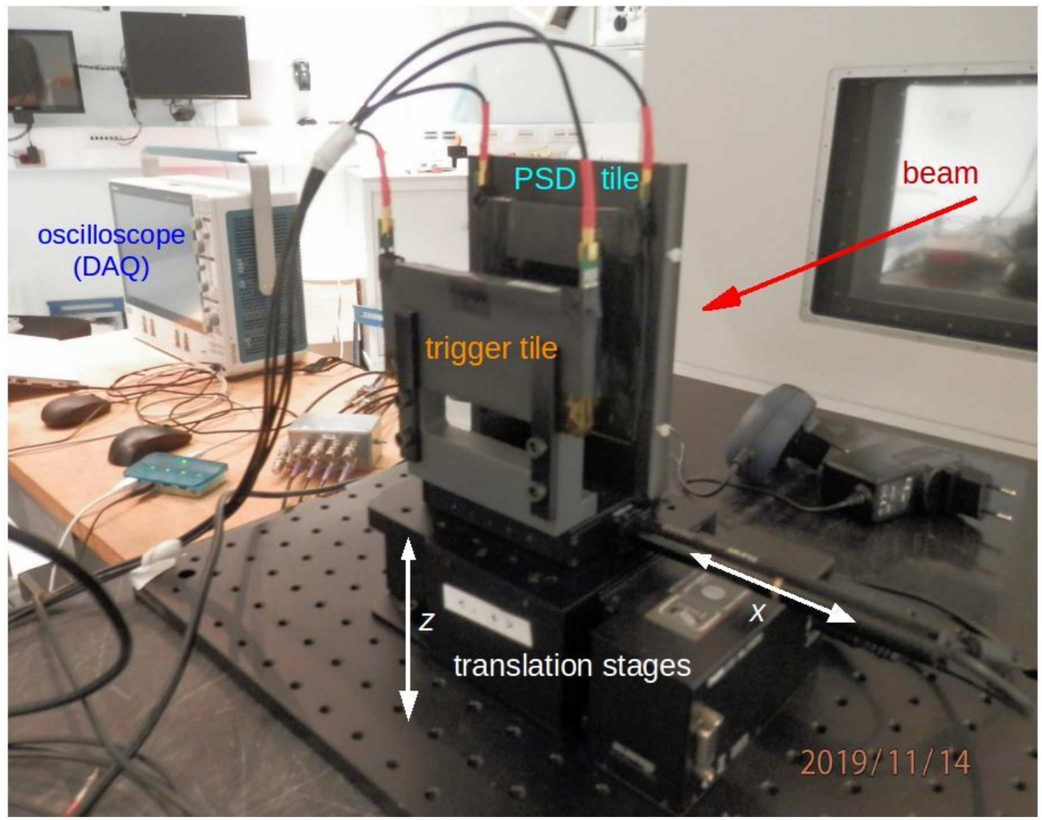
A. Agnesi	0.6
P.W. Cattaneo	0.6
M. Oddone	0.1
F. Pirzio	0.4
A. Rappoldi	0.4
Totale FTE	**2.1**

HERD Pavia Consuntivo 2020

We took data at CNAO twice reading out the tiles with a digital oscilloscope.

Beams of low energy **p** and C simulated relativistic ions energy loss.

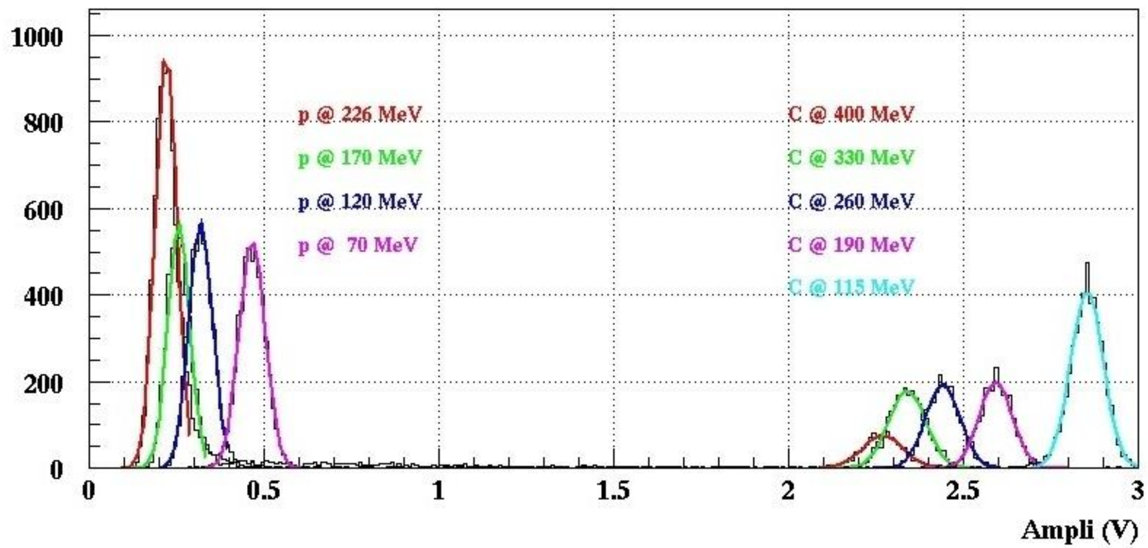
Beam test setup

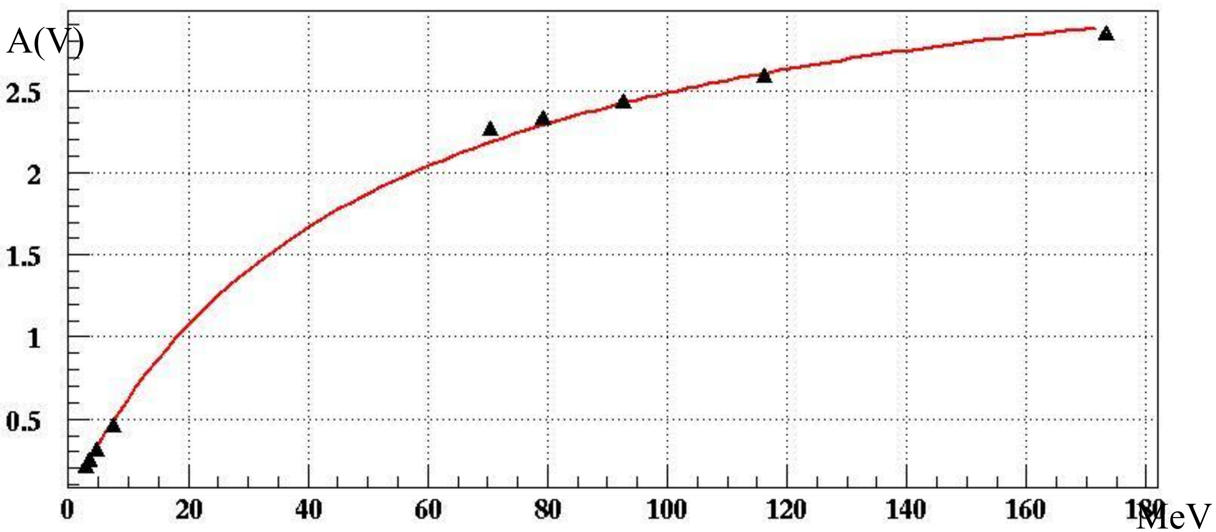


HERD Pavia Consuntivo 2020

Preliminary results presented at INSTR20 (Novosibirsk).

Amplitude with different energies and ions.





Measurement of Birks' effect on scintillator: non-linear dependency of light versus energy loss.

GAPS

- GAPS (General AntiParticle Spectrometer) è stato progettato per studiare la componente di antiparticelle nei raggi cosmici con un focus specifico su antiprotoni ed antideuterio (ed antielio) di bassa energia (< 0.25 GeV/n). L'identificazione per la prima volta di antideuterio nei raggi cosmici sarebbe un segnale quasi certo di nuova fisica esplorando tutta una gamma di modelli teorici di materia oscura.

- GAPS verrà condotto con un volo di lunga durata (>30 giorni) su pallone stratosferico dall'Antartide. Altri voli successivi saranno probabilmente finanziati.

- I gruppi italiani coinvolti sono afferenti a: INFN di Firenze, INFN di Pavia ed Università di Bergamo, INFN di Napoli, INFN ed Università di Torino, INFN ed Università di Roma Tor Vergata, INFN di Trieste.

- La Collaborazione Internazionale oltre alla componente italiana consta di gruppi americani: Columbia University, MIT, UC Berkeley, UCLA, UC San Diego, University of Hawaii at Manoa, Oak Ridge National Laboratory; gruppi giapponesi: ISAS (JAXA).

- Come concordato con la NASA, la finestra di lancio è prevista tra dicembre 2021 e febbraio 2022.

- Le attività nella collaborazione hanno subito un ritardo per il lockdown in Italia, U.S.A e Giappone. Il prototipo dello strumento (GFP = GAPS Functional Prototype) previsto entro la primavera 2020 non è stato quindi ancora realizzato. La collaborazione sta discutendo come rimodulare la schedule. E' possibile che il lancio venga rinviato.

- Il cofinanziamento (circa 900 kEuro) da parte di ASI è attualmente disponibile alla collaborazione GAPS Italia (è stata creata una sigla GAPS_ASI), per coprire spese di personale (assegni di ricerca , cofinanziamento RTD A, et al) e la fabbricazione di parte dell'hardware (elettronica di front-end e back-end del tracciatore, high voltage system)

- Dal 1 giugno, ha preso servizio presso l'Università di Bergamo un RTDA (Elisa Riceputi) cofinanziato da INFN (tramite i fondi ASI GAPS) e UniBG.

The instrument

Time-of-Flight System (TOF)

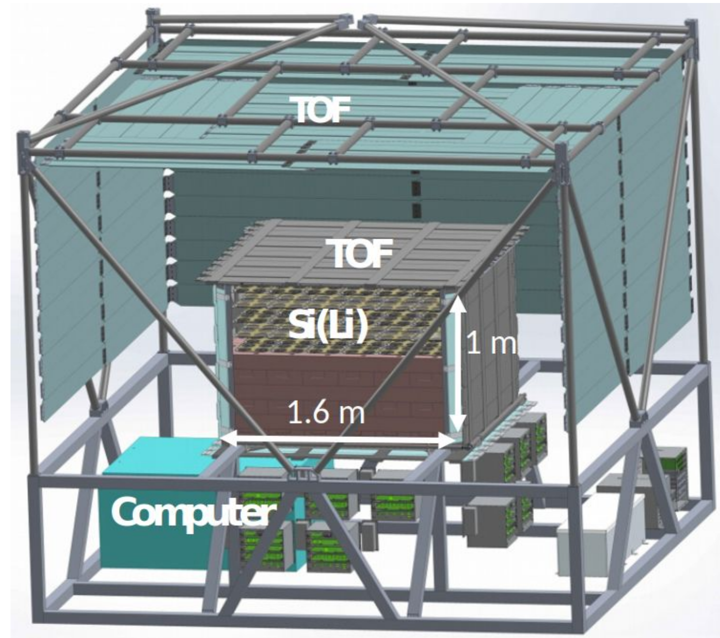
- plastic scintillators with SiPM
- velocity and dE/dx measurements

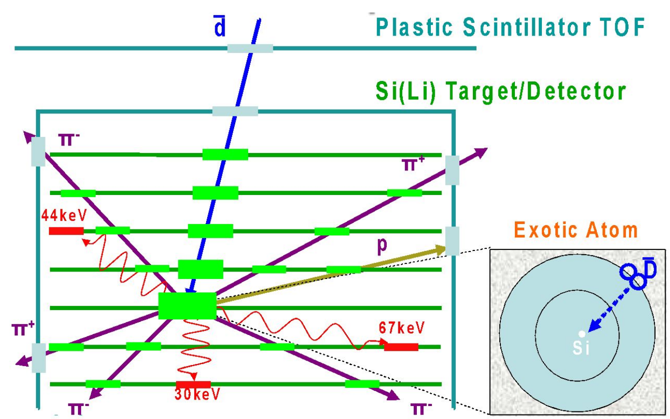
Si(Li) Tracker

- 12×12 **Si(Li)** detectors per layer(*)
  - **4 inch** diameter
  - **2.5mm** thickness
  - segmented into **8 strips**
- **10 layers** with 10 cm spacing

Si(Li) Tracker functions

- **target** to slow an incoming antiparticle and capture it into an exotic atom in an excited state
- **spectrometer** for de-excitation X-rays
- **tracker** to measure antinucleus dE/dx and stopping depth, and annihilation products from nuclear decay

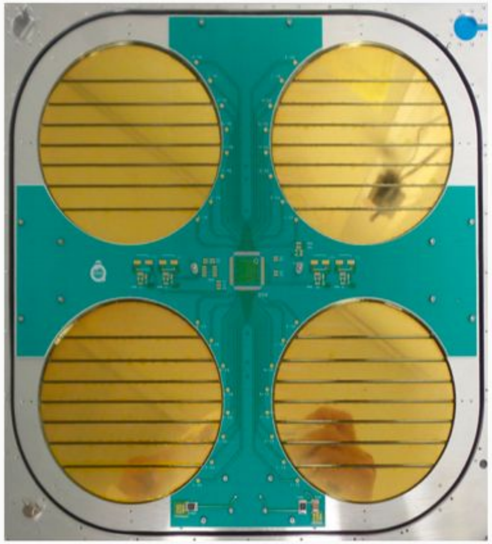




Si(Li) tracker

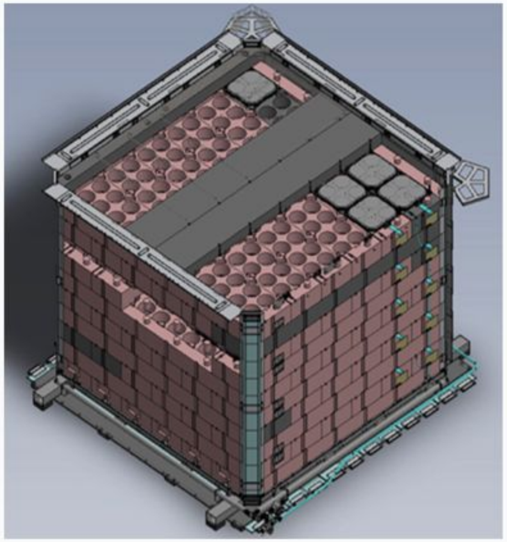
Modular structure

- 4 sensors (8 strips per sensor)
- 1 readout ASIC
- 1 front end board



Si(Li) complete detector

- 360 Modules
- 1440 Detectors
- 11.520 Channels



Front-end electronics requirements

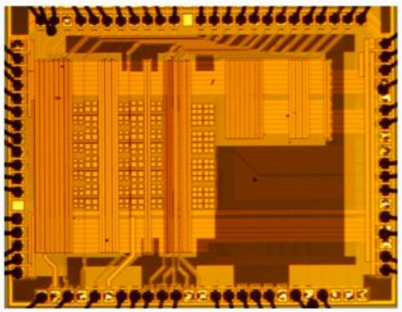
- Channels per ASIC: 32
- Operating temperature: -40 °C
- Power dissipation: <10 mW/ch
- Signal polarity: electrons
- Dynamic range: 10 keV-100 MeV
- Analog Resolution: 4 keV (FWHM) (detector capacitance ≈40 pF)
- Threshold: 10 keV
- Detector leakage current: 5-10 nA

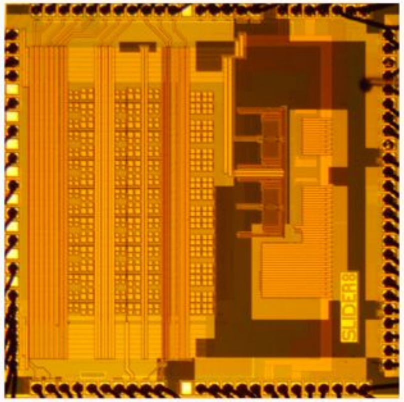
Summary of 2019 activities in Pavia

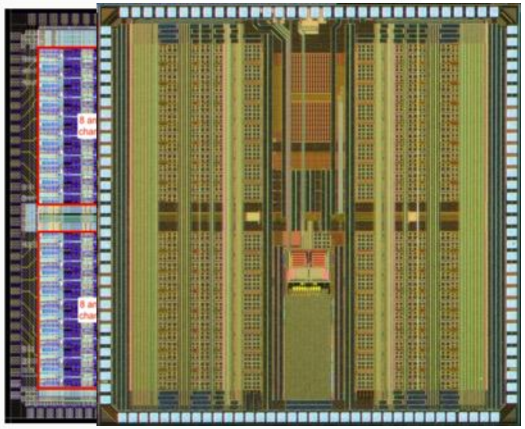
- Characterization of the two ASIC prototypes submitted in 2018
    - **SLIDER4** with 4 analog channels
    - **SLIDER**8 with 8 analog channels, 11-bit ADC and digital backend
- Submission of the first prototype of the flight ASIC
    - **pSLIDER32** with 32 analog channels, 11-bit ADC and digital backend
- Characterization of the pSLIDER32 ASIC
- Test of the SLIDER8 ASIC with detector at MIT
- Design of the Front-end board for the pSLIDER32 ASIC

The SLIDER ASIC family

SLIDER: SiLI DEtector Readout







SLIDER4 (2018)

- 4 analog channels
- No digital back end
- 2 channels with analog output

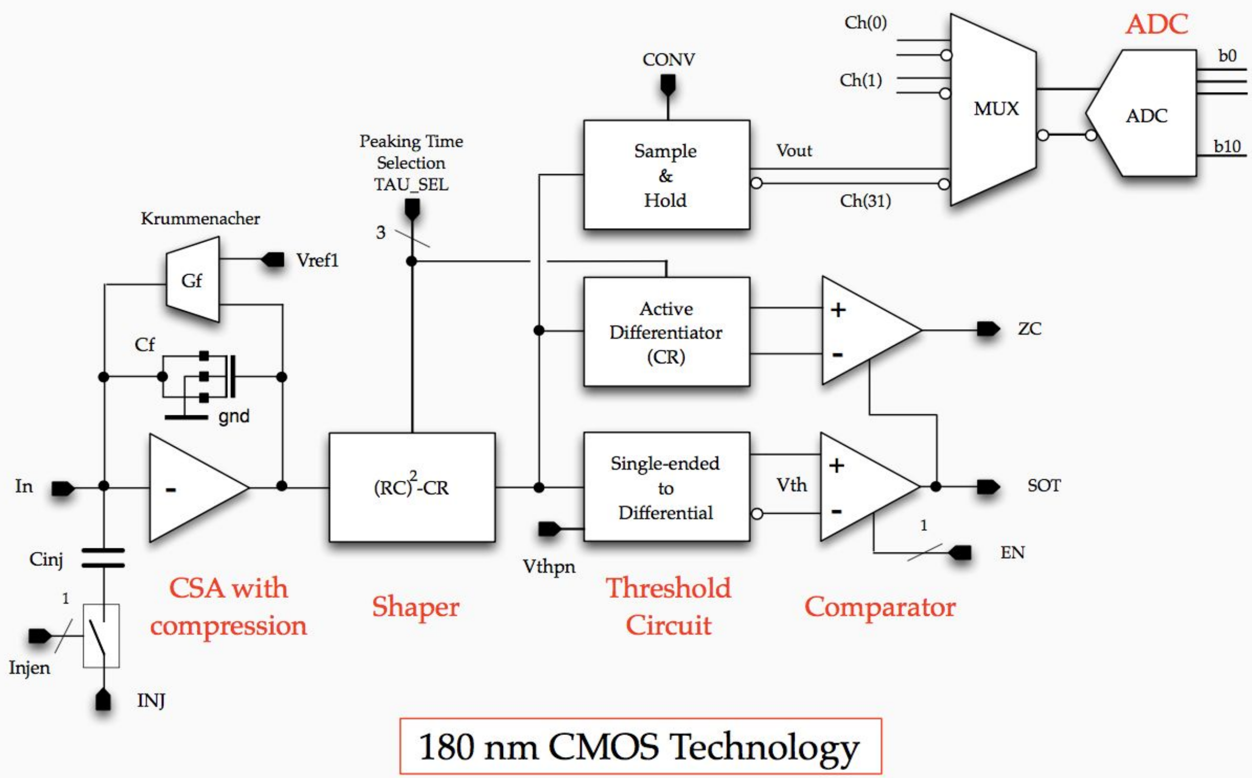
SLIDER8 (2018)

- 8 analog channels
- digital back end
- 11 bit ADC
- No access to analog blocks

pSLIDER32 (2019)

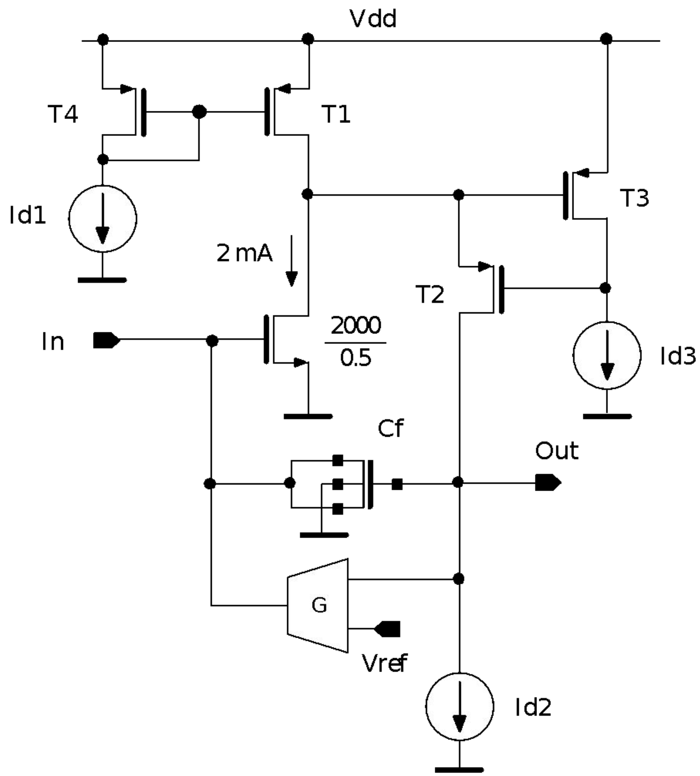
- 32 analog channels
- digital back end
- 11 bit ADC
- 2 channels with access to analog blocks

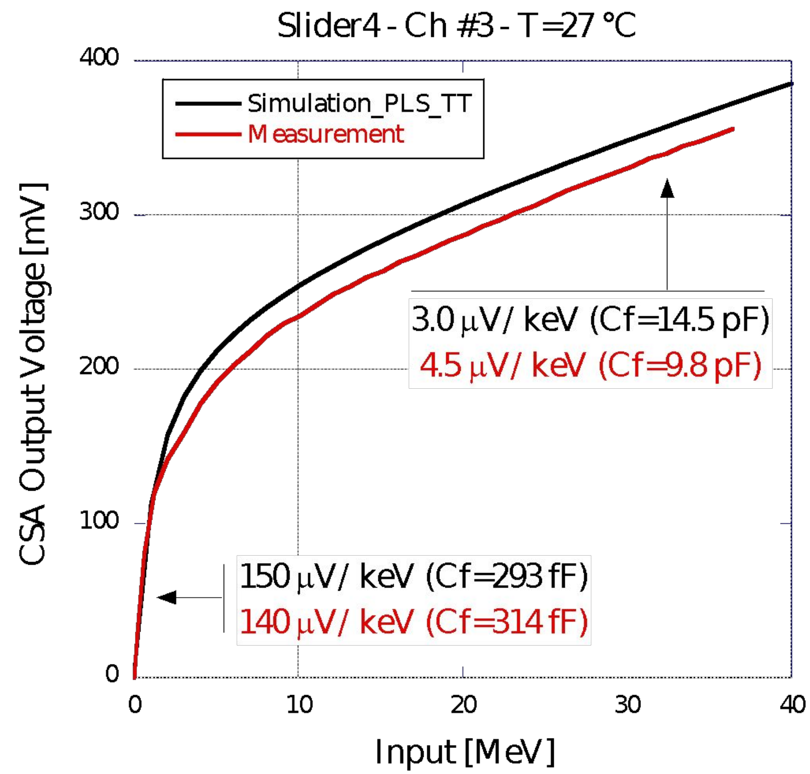
Readout channel block diagram



- **Charge sensitive amplifier**
  with dynamic signal compression
- **CR-$(RC)^2$ filter**
  with 8 selectable peaking times
  (from 250 ns to 1.8 μs)
- **SOT comparator**
  Signal Over Threshold identification
- **Active CR** and **Zero Crossing comparator (ZC)**
  Shaper signal peak detection
- **Single-ended to differential S&H**
  Shaper signal peak storage
- **Injection capacitance C_{inj}**
  Calibration
- **11-bit hybrid SAR ADC**
  One per ASIC

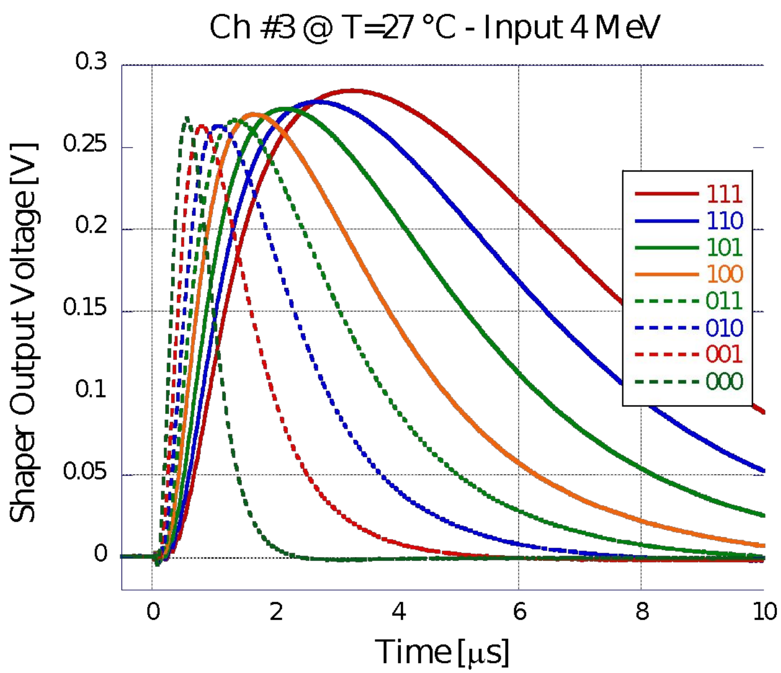
CSA transfer function (Slider4)

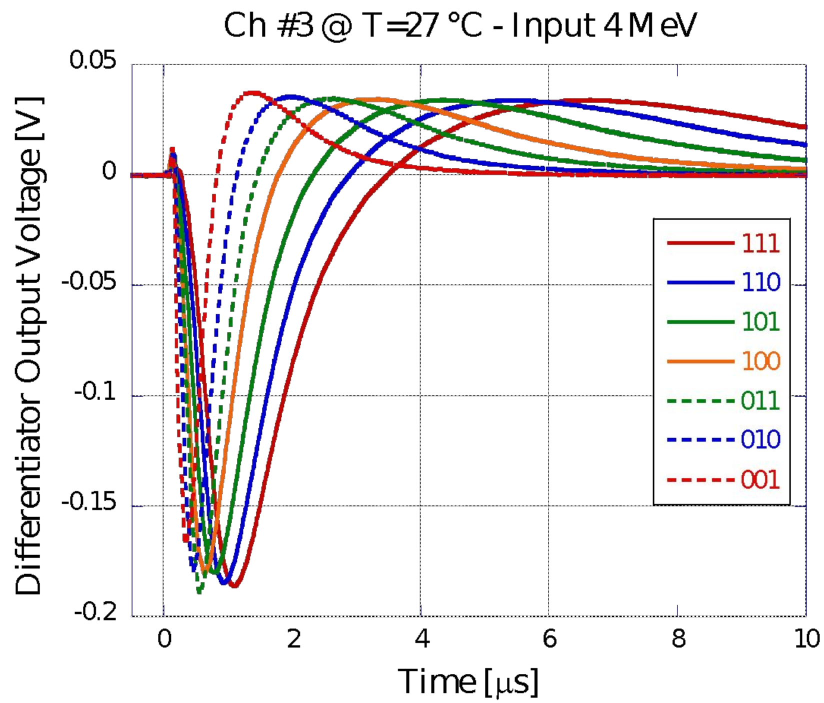




- **Architecture:** active folded cascode loaded by an active cascoded load
- **Sensitivity:** dynamic compression with MOS capacitor (80 µm/20 µm)
- **Reset:** time continuous feedback implemented with a Krummenacher network

Filter and Differentiator (Slider4)





Shaping Stage

- good unipolar semi-Gaussian (CR-RC2) response
- 8 peaking times with measured values higher than simulated ones
  (due to a non-optimum bias of the ASIC)

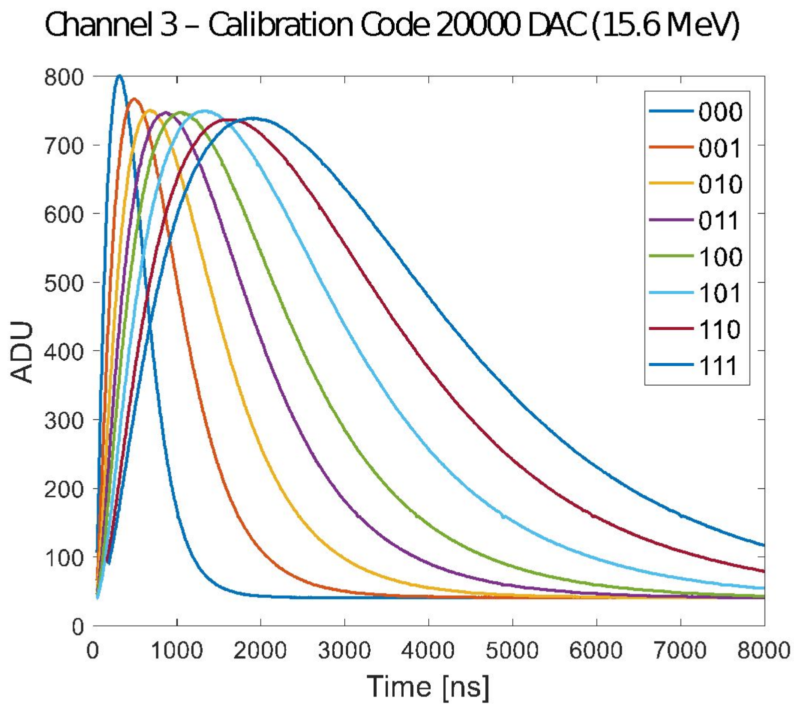
Active differentiator

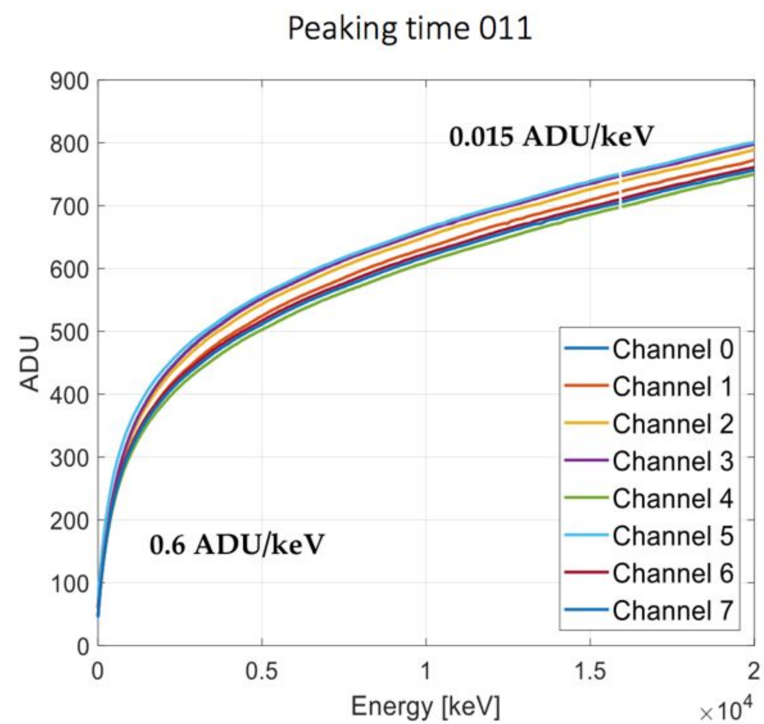
- First derivative of the shaper output voltage
- Zero crossing times close to shaper peaking time
- Gain almost independent of shaper peaking time

Channel digital output (Slider8)

No analog output in Slider8

→ channel time response measured by varying the delay between INJ and CONV signals

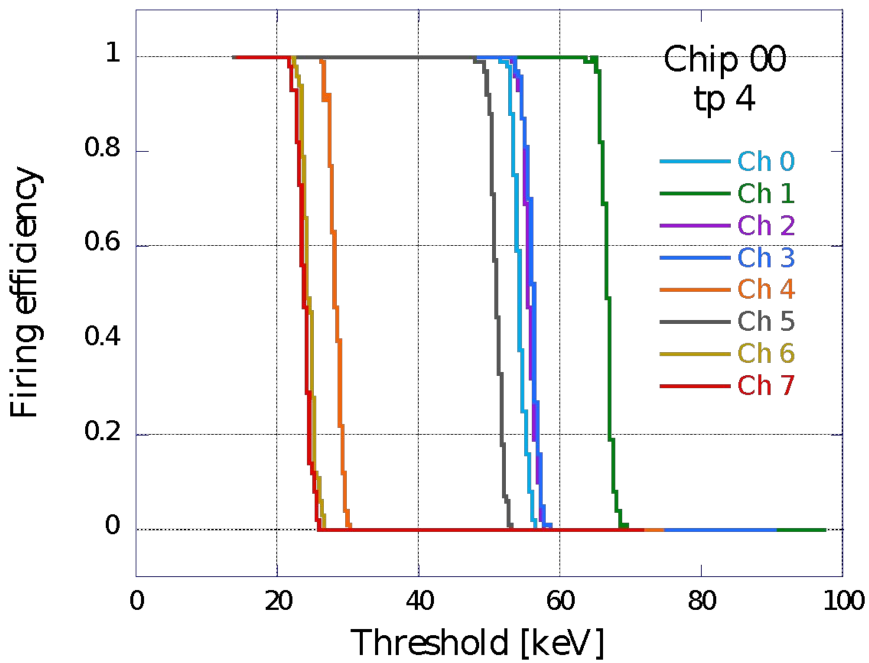


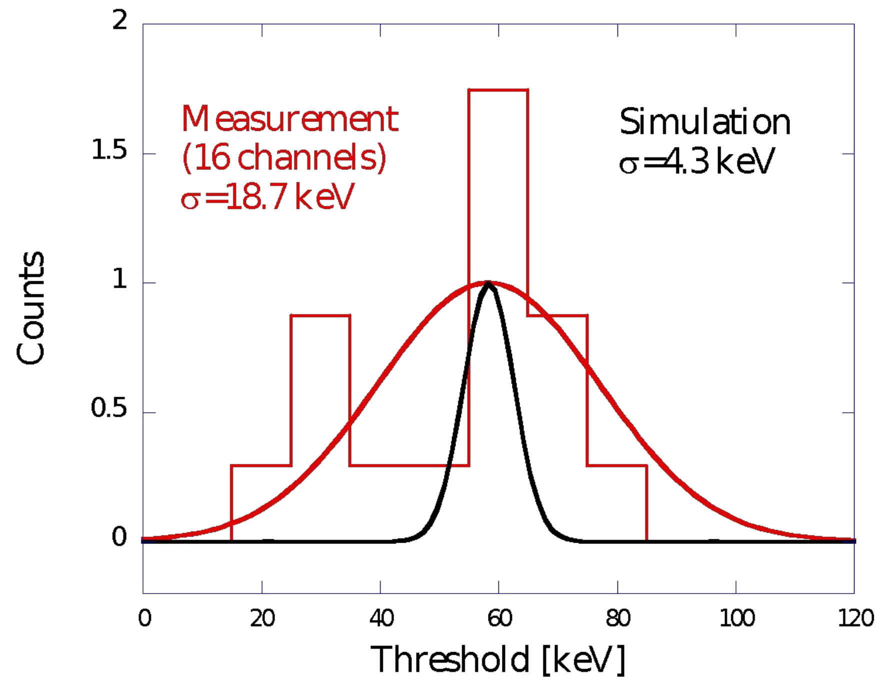


- Good agreement between simulated and measured peaking times
- Amplitude decreases with the peaking time due to the zero in the CSA feedback network

Threshold dispersion(Slider8)

Minimum threshold 10 keV → dispersion σ < 4.6 keV to have hot channels < 2%

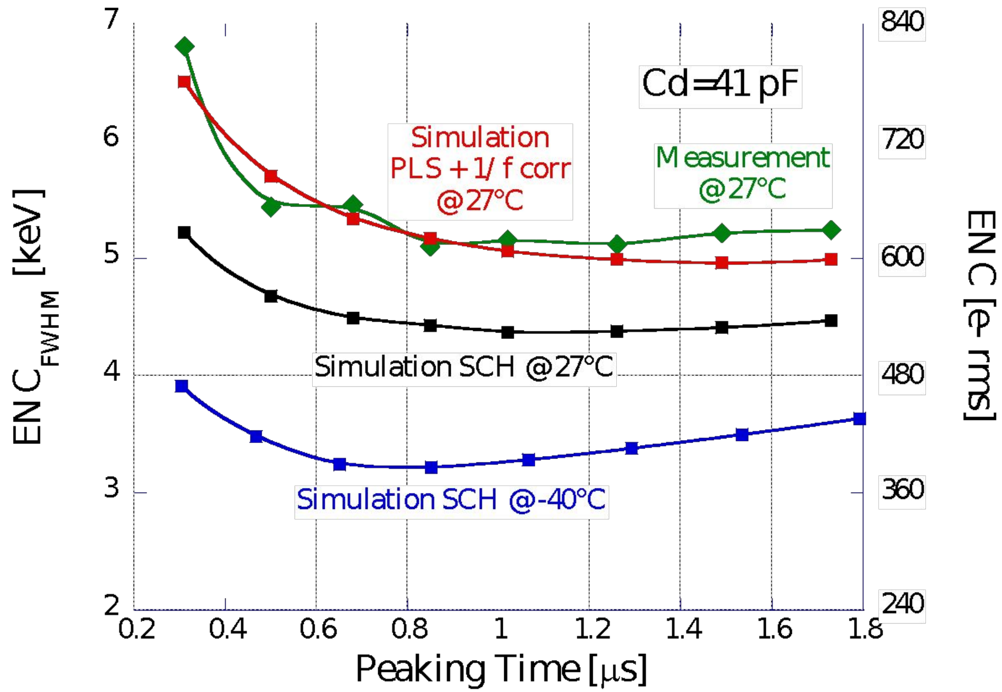


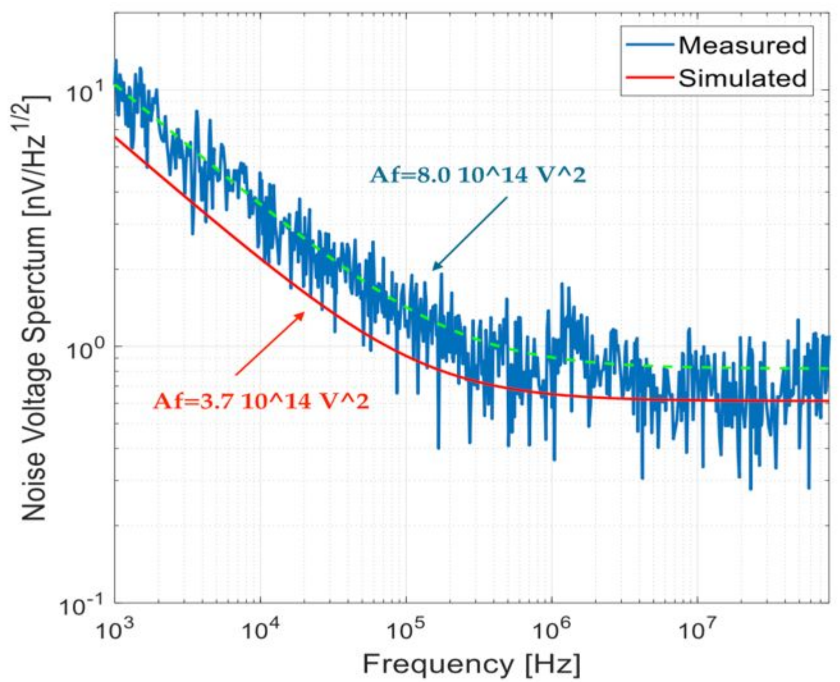


Threshold dispersion larger than expected → two actions has been taken in the new design

- a more careful layout of critical blocks
- a3-bit DAC for threshold fine trimming introduced in each channel

Channel resolution (Slider8)



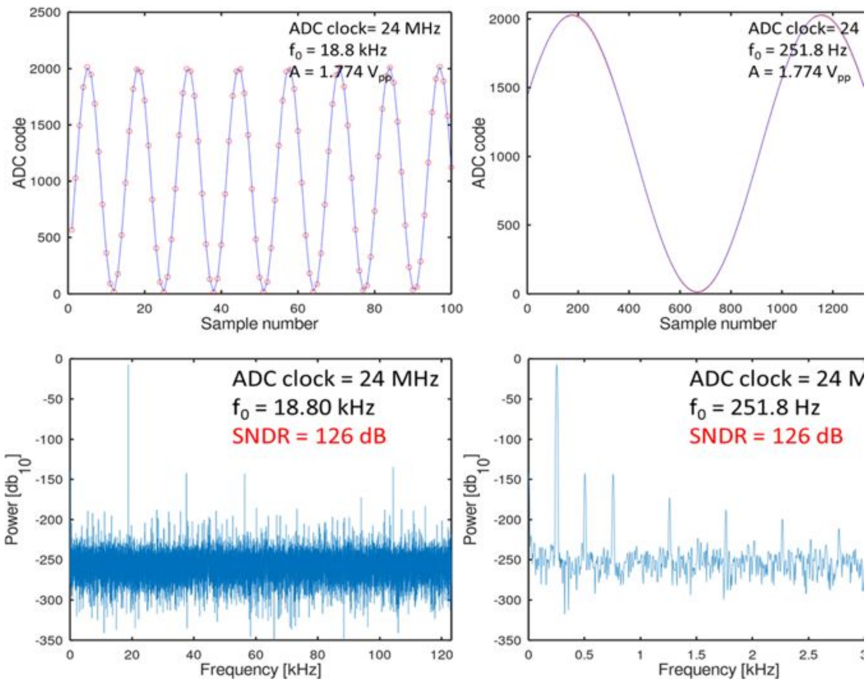


Noise at room temperature higher than expected because of:

- Parasitic resistance in series to the CSA input
- flicker noise coefficient is larger with respect to model (measurement performed on single MOS device)

Slider8: ADC test results

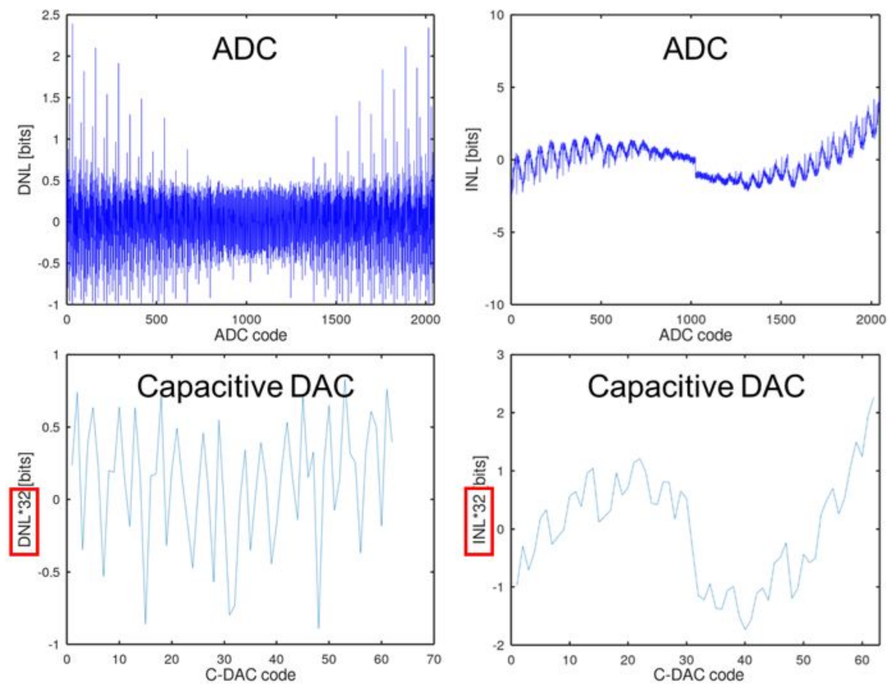
AC characterization



The ADC core has a good dynamic behavior with a very high SNDR ; harmonics are present due to the distortion introduced by the common mode reference circuit, that will be changed in the next version of the chip

Missing codes were found, indicating that a review of the cell is required (parasitics being the most probable contributors to the missing codes)

DC characterization

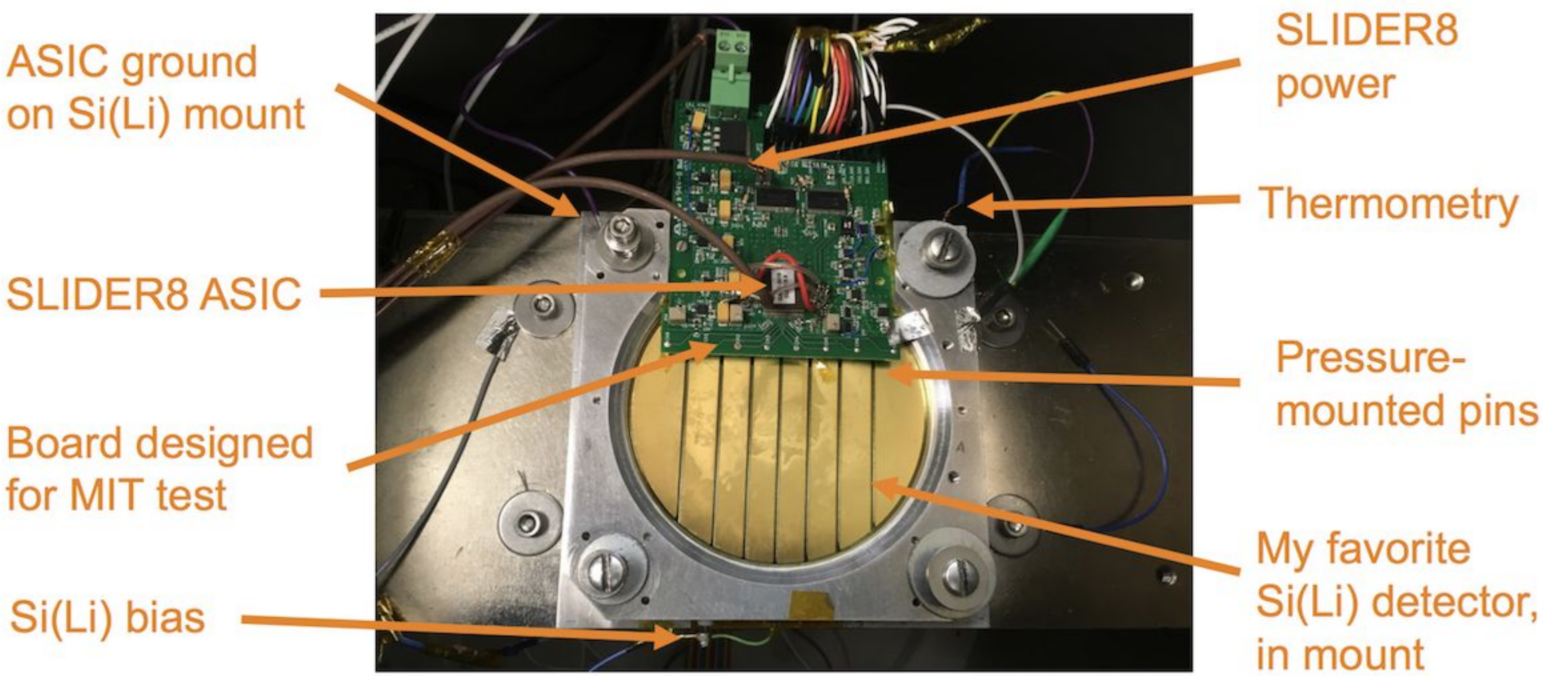


DNL and INL are higher than expected, also considering the good dynamic performance, this can be traced back to an error occurred during ASIC layout assembly:

keepout layers, used to avoid metal filling by the foundry, were not inserted □ worsening of device matching on both C-DAC and R-DAC

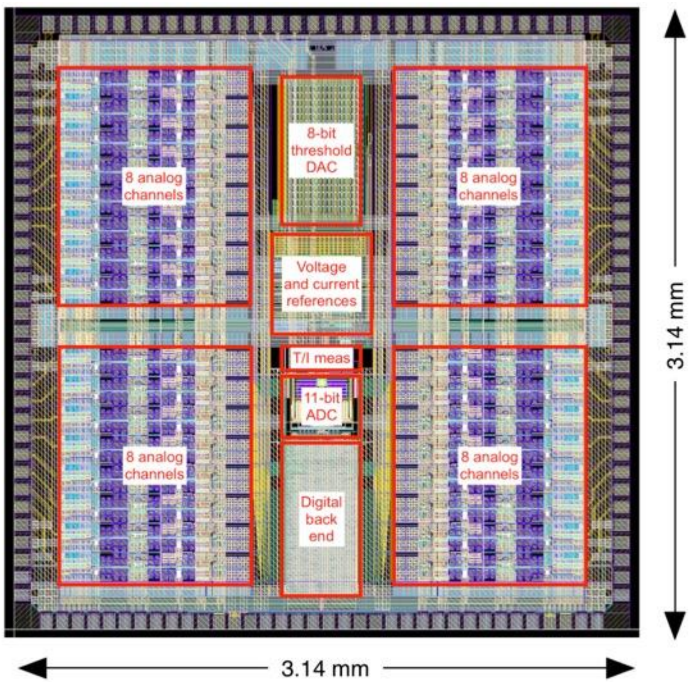
Slider8 with SiLi detector @ MIT

Setup in Vacuum Chamber



- Special board designed to facilitate testing SLIDER8 with the single-detector setup used routinely at MIT
- Setup installed in October
- Testing activity is in progress

pSLIDER32 – first flight ASIC prototype



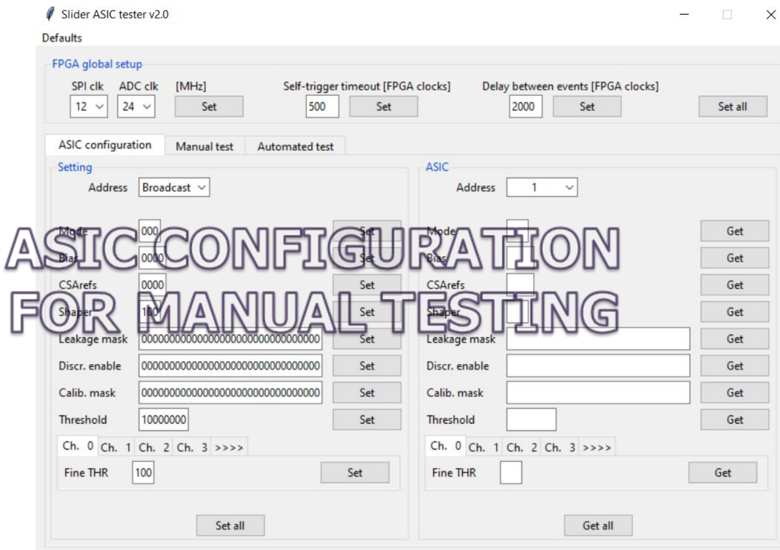
- 32 analog readout channels
- 11-bits ADC
- Digital Back End(registers control, SPI, etc...)
- BGR with 3-bit DAC regulation
- 8-bit DAC for threshold setting
- 3-bit DAC for threshold fine trimming
- Detector leakage current readout
- Temperature sensor readout

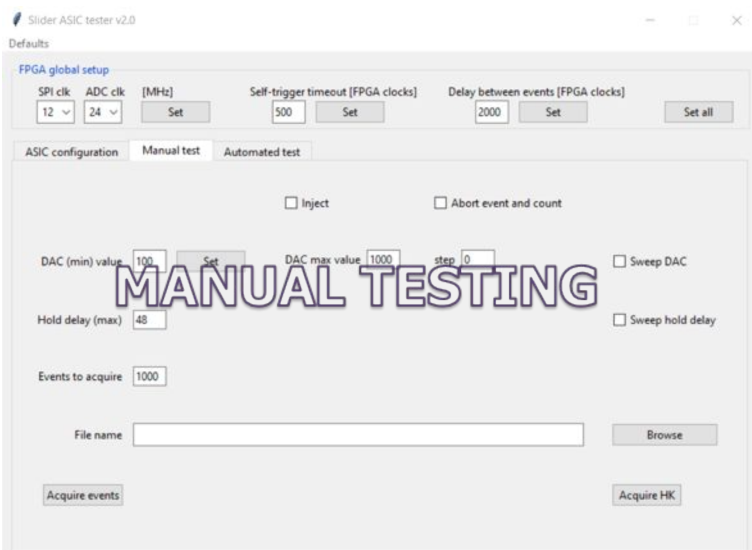
Submitted: June 2019
Delivered: October 2019

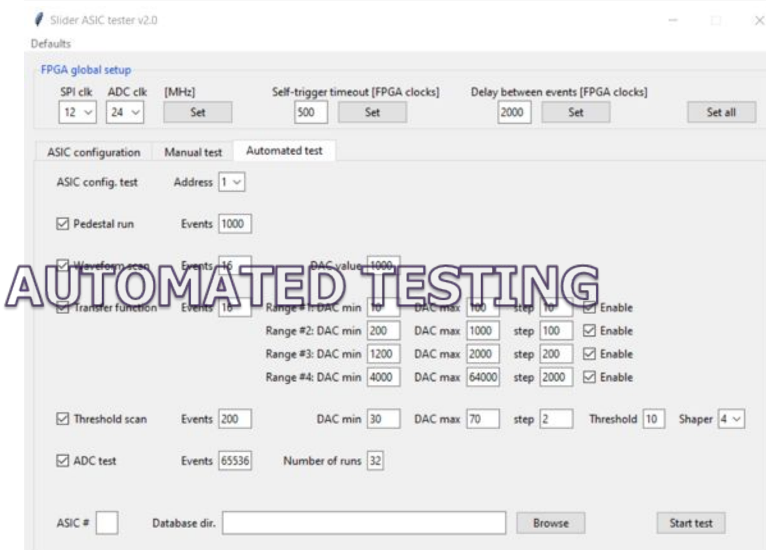
Package
Plastic Thin Quad Flat Pack (TQFP128)

- 14×14 mm^2
- 128 pins
- Pitch of 0.4 mm
- 58 samples

pSLIDER32 test setup

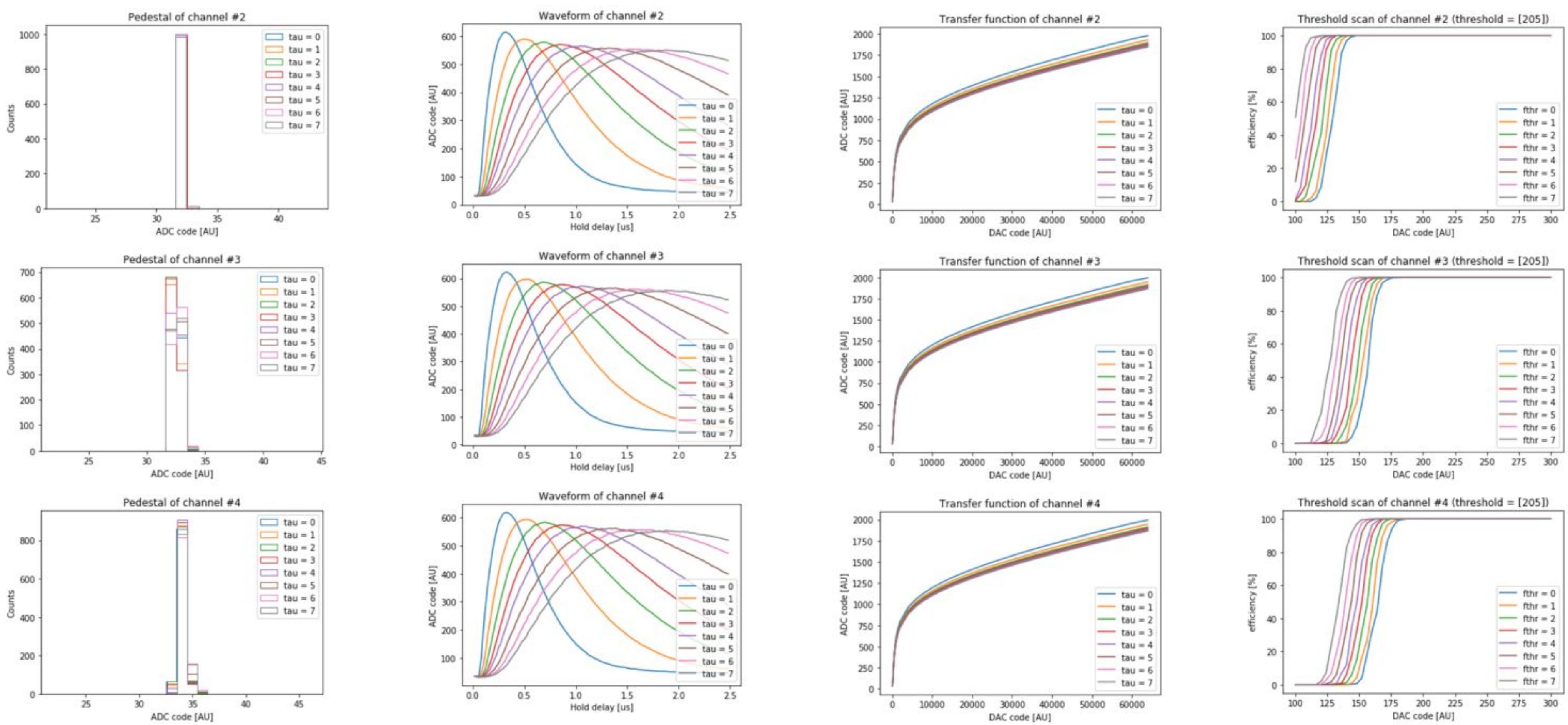






Device selection for GFP assembly

- 36 (out of 58) good ASICs must be selected for GFP assembly
- An automatic test set up procedure has been established (2 h/ASIC)
- Measurement performed: pedestal, time response, transfer function, threshold scan...)



Status and activities

Status in Bergamo

- Lockdown: from March to May
- From May 11 it is possible to access the laboratory with some restrictions

Activities

- Characterization of all the ASICs required for the GFP assembly has been completed

Next plans

- Characterization of the second batch of 6 FE boards
  - 1 FE board to Napoli for test with Power Supply
  - 1 FE board to USA for sensor bonding and module assembly
  - Test of module in Napoli
- Submission of the flight ASIC in September

FTE 2019

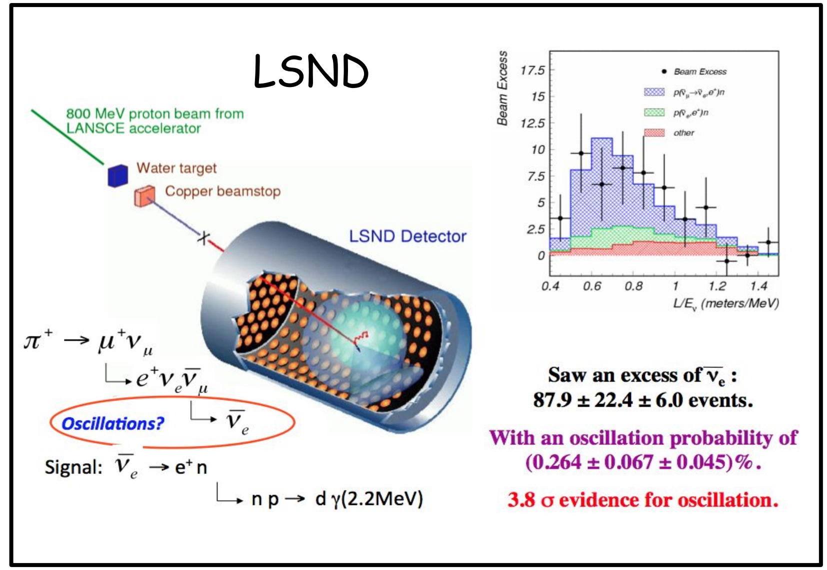
M. Manghisoni	0.7
V. Re	0.3
E. Riceputi	1
M. Sonzogni	0.8
Totale FTE	**2.8**

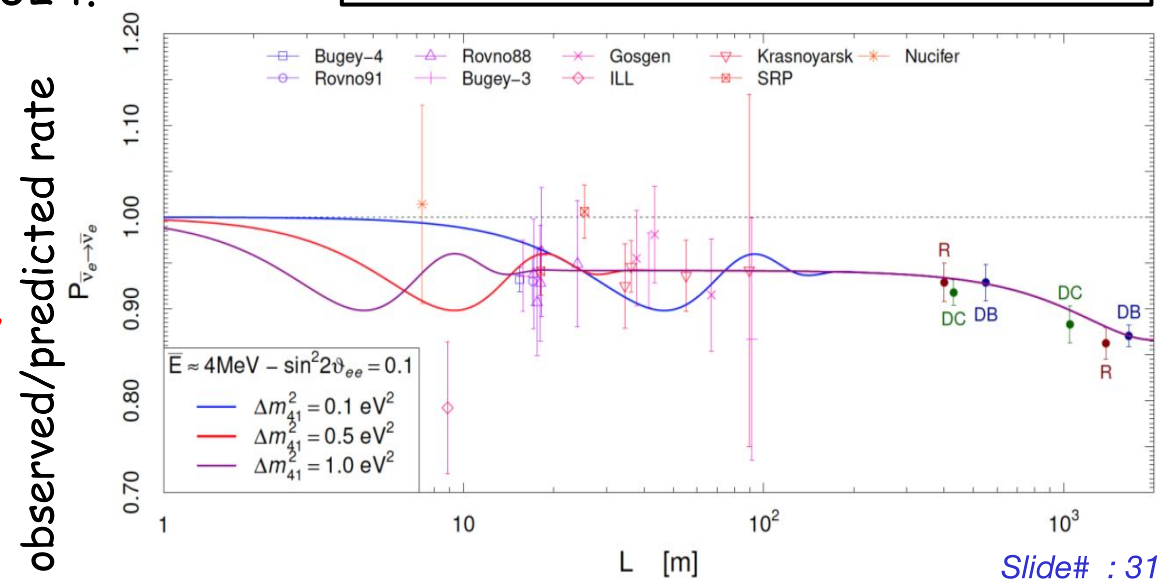
Capitolo	Descrizione	Stanziato	Variato	Subjudice e Cong.	Preimpegno	Impegni	Disponib.	Proposta in corso	Disp. Teorica
U1030102008	Strumenti tecnico-speci	3.000,00	0,00	0,00	0,00	1.796,79	1.203,21	0,00	1.203,21
U1030202001	Rimborso per viaggio e	16.000,00	0,00	0,00	0,00	15.667,71	332,29	0,00	332,29
Totale:		**19.000,00**	**0,00**	**0,00**	**0,00**	**17.464,50**	**1.535,50**	**0,00**	**1.535,50**

ICARUS

The Sterile Neutrino puzzle

- Anomalies have been collected so far in the neutrino sector, despite the well-established 3-flavour mixing picture with $\Delta m^2_{31} \sim 2.4\times10^{-3}\ eV^2$, $\Delta m^2_{21} \sim 8\times10^{-5}\ eV^2$ hinting to the existence of additional ν states:
  - anti−νe appearance from anti-νμ beams in accelerator LSND experiment, 3.8 σ CL;
  - νe disappearance by SAGE, GALLEX exps during their calibration with Mega-Curie sources, observed/predicted rate R =0.84±0.05;
  - anti-νe disappearance by near-by nuclear reactor experiments: R = 0.934±0.024.



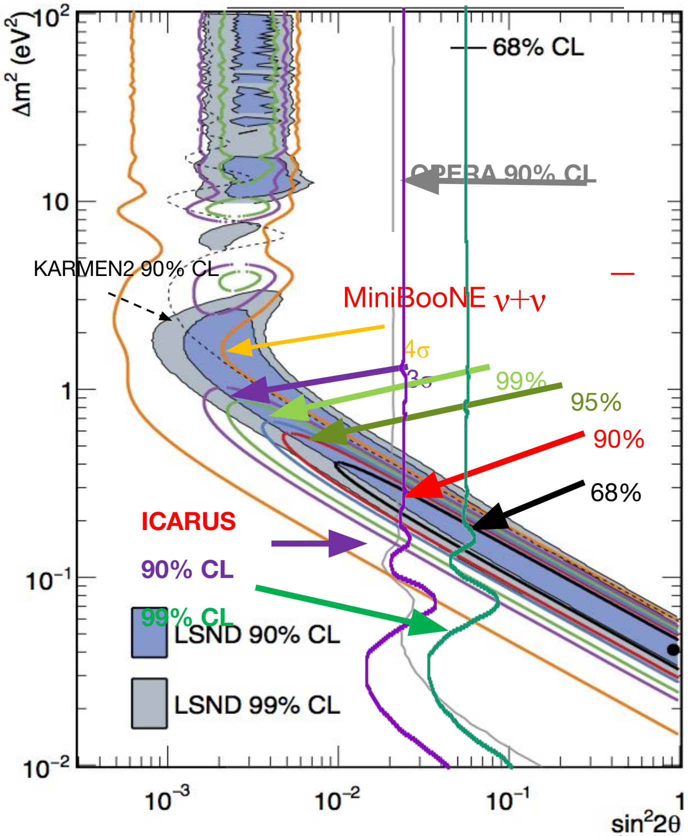


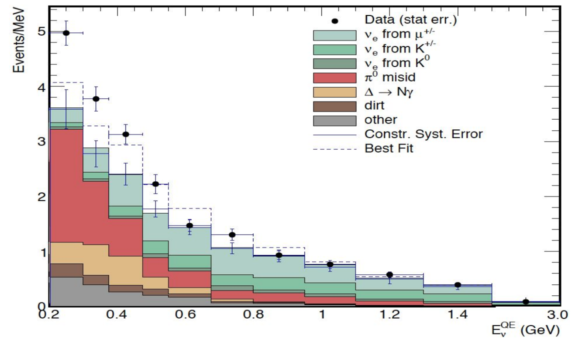
A fourth sterile ν state?

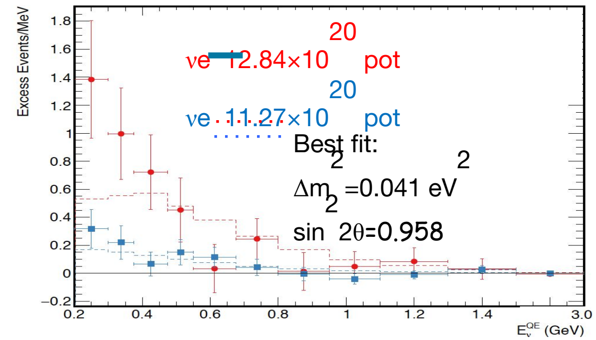
Recent neutrino oscillation results at accelerator beams

- A significant excess of electron-like events in both beam polarities was observed by MiniBooNE (818 tons pure mineral oil) at FNAL Booster beam:

Phys. Rev. Lett. 121, 221801







- The 2ν oscillation region indicated by MiniBooNE overlaps the initial LSND result, with a 6 σ significance for LSND + MB combined analysis.
- However a large part of this region already investigated/excluded by ICARUS LAr-TPC at LNGS exposed to CNGS beam EPJ C(2013) 73: 2599
- … a scenario even more complex because the not observed corresponding νμ disapp. (MINOS, Icecube,…) and cosmology seems to disfavor additional ν states

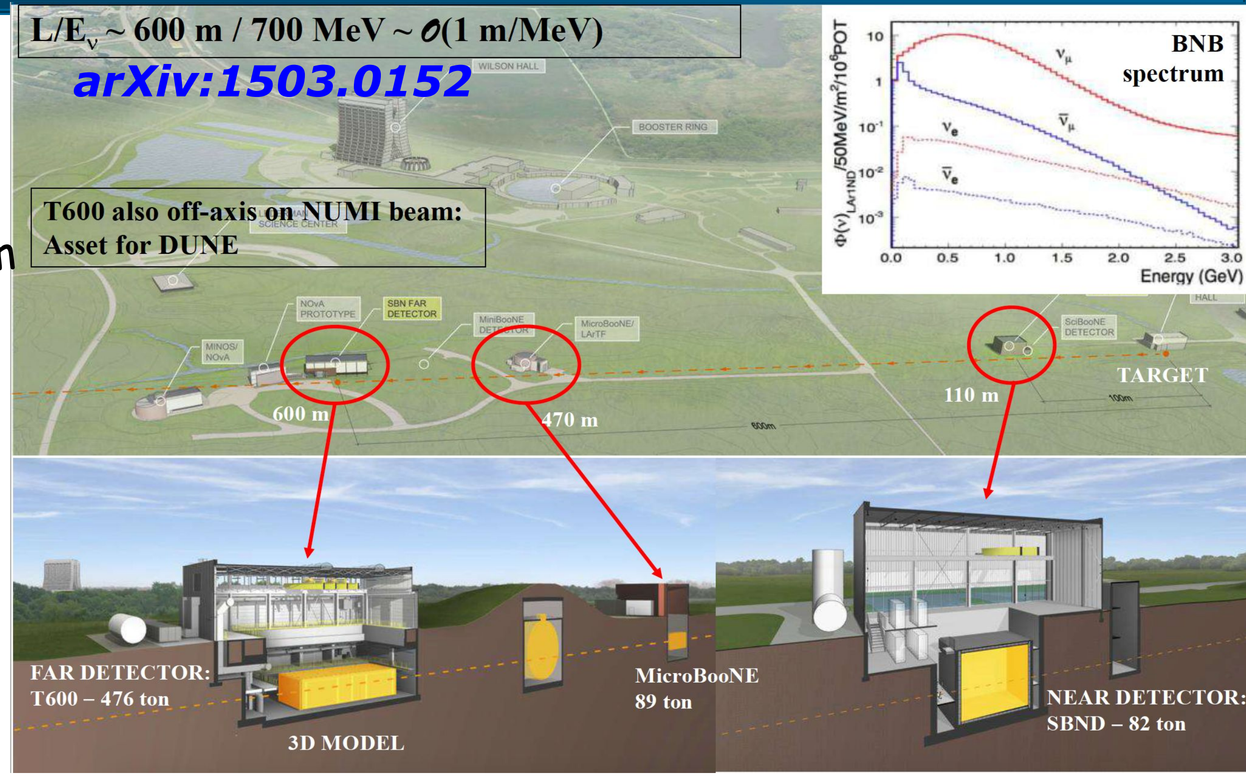
Need of a definitive clarification: measuring both n appearance/disapp.

With the same experiment at accelerator with L/E~ 1 km/GeV by comparing

the ν fluence at two different distances

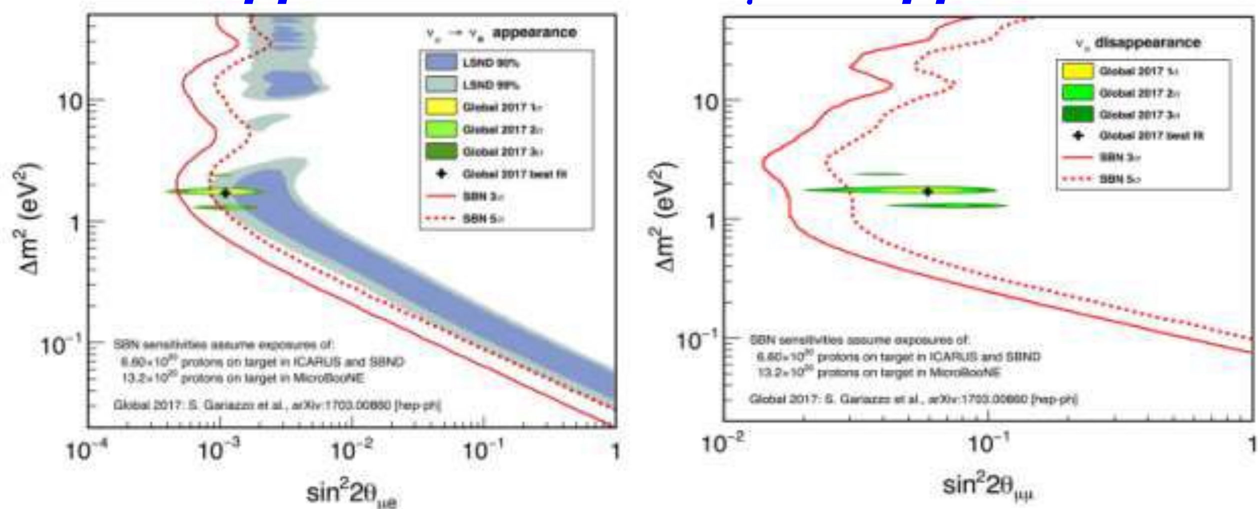
The SBN project at FNAL: 3 LAr-TPCs at Booster beam

- SBN will clarify sterile ν puzzle exploiting similar LAr-TPCs at different distances from target:
  - ICARUS, 476 t LAr at 600 m from target as far detector, shall characterize ν oscillation parameters.
  - MicroBooNE, 89 t LAr, 470 m
  - SBND, 82 t LAr, 110 m will give "initial" BNB flux/composition



- Both νe, νμ channels explored at same time:
  - LSND νe appearance region covered at 5σ in 3 years ($6.6\ 10^{20}$ pot);
  - SBN sensitivity in νμ disapp.: a factor ~10 beyond the current limits.

νe appearance   νμ disappearance



ICARUS Collaboration in SBN

M. Diwan, J. Larkin, W. Gu, D. Mendez, X. Qian, A. Scarpelli, J. Stewart, B. Viren, E. Worcester, M. Worcester, A. Zhang, C. Zhang

Brookhaven National Laboratory, USA

M. Babicz, O. Beltramo, J. Bremer, M. Chalifor, A. De Roeck, S. Dolan, C. Fabre, J. Hrivnak, U. Kose, D. Mladenov, M. Nessi, S. Palestini, F. Pietropaolo[a], F. Resnati, A. Rigamonti, S. Tufnali, A. Zani

CERN, Switzerland

O. G. Miranda, G. Moreno Granados

CINVESTAV, Mexico, USA

B. Behera, T. Boone, C. Hilgenberg, J. Mueller, M. Mooney, D. Warner, R.J. Wilson

Colorado State University, USA

W. F. Badgett, L.F. Bagby, S. Berkman, M. Betancourt, K. Biery, S. Brice, J. Brown, G. Cerati, R. Doubnik, A. Fava, F.G. Garcia, M. Geynisman, S. Hahn, B. Howard, C. James, W. Ketchum, G. Lukhanin, A. Mazzacane, C. Montanari[b], T. Nichols, A. Prosser, R. Rechenmacher, G. Savage, A. Schukraft, A. Soha, D. Torretta, P. Wilson, M. Wospakrik, J. Zennamo, M. Zuckerbrot

Fermi National Accelerator Laboratory, USA

A. Aduszkiewicz, D. Cherdack, A. Wood

University of Houston, USA

V. Bellini, C. Petta, C. Sutera, F. Tortorici

INFN Sez. di Catania and University, Catania, Italy

C. Rubbia

INFN GSSI, L'Aquila, Italy

C. Vignoli

INFN LNGS, Assergi (AQ), Italy

R. Benocci, M. Bonesini, A. Falcone, M.Torti

INFN Sez. di Milano Bicocca, Milano, Italy

A. Cocco

INFN Sez. di Napoli, Napoli, Italy

ICARUS Collaboration in SBN –cont.

A. Braggiotti, S. Centro, C. Farnese, D. Gibin, A. Guglielmi, G. Meng, F. Varanini, S. Ventura
INFN Sez. di Padova and University, Padova, Italy
A. Menegolli, A. Rappoldi, G.L. Raselli, M. Rossella, A. Scaramelli
INFN Sez. di Pavia and University, Pavia, Italy
A. Chatterjee, V. Paolone
University of Pittsburgh, USA
M. Convery, L. Domine, F. Drielsma, D. H. Kao, Q. Lin, G. Petrillo, H. Tanaka, K. Terao, Y.T. Tsai, T. Usher
SLAC National Accelerator Laboratory, Stanford, USA
H. Budd, R. Howell, K.S. McFarland
University of Rochester, USA
T. Coan
Southern Methodist University, USA
J. Asaadi, H. Carranza, Z. Williams, W. Jang, J. Yu
University of Texas (Arlington), USA
P. Abratenko, T. Wongjirad
Tufts University, USA

[a] On Leave of Absence from INFN Padova
[b] On Leave of Absence from INFN Pavia

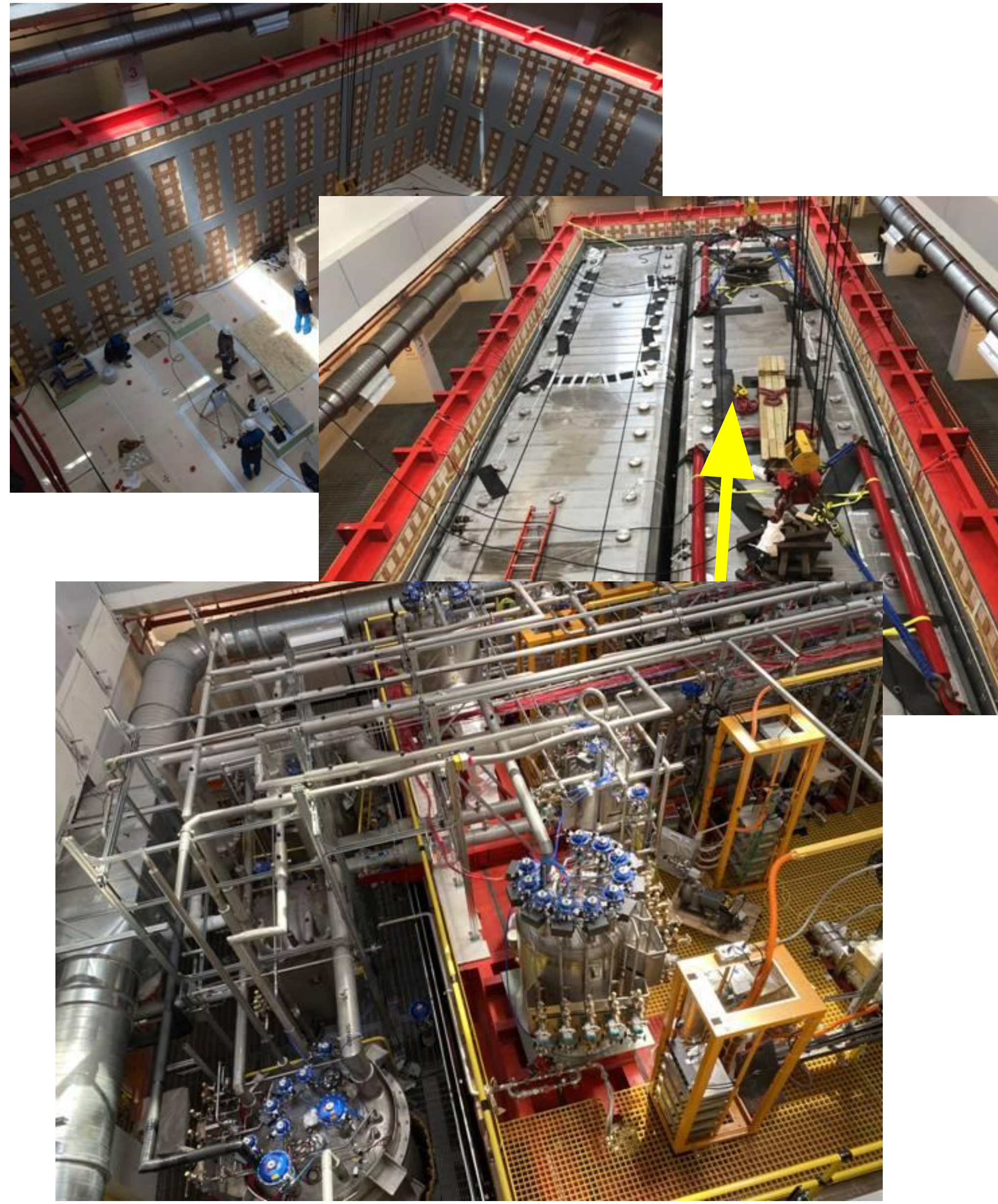
ICARUS Spokesman: C. Rubbia, GSSI

7 INFN groups, 10 USA institutions, 1 Mexican institution, CERN

Additional INFN groups of Bologna, Frascati, Milano, Genova and LNS contributing to cosmic ray tagger are in the process of joining the ICARUS collaboration

The new ICARUS T600 Cryogenics:

- A Passive Thermal Insulation layer and the relative supporting mechanical structure (Warm Vessel) surrounding and mechanically supporting the main argon volumes and the systems located on top and   in close proximity of them;
- An Argon System, providing containment, initial purification during the filling and continuous purification through re-circulation of the main Liquid Argon volumes;
- An Argon System, providing containment, initial purification during the filling and continuous purification through re-circulation of the main Liquid Ar volumes.



Upgrade of the light collection system

- The ICARUS at SBN exploits 90 8" PMTs per TPC with TPB wls coating installed behind wire planes - 5% photocathode coverage of TPC wire area, 15 phe/MeV– to detect ν events down to ~100 MeV:

➢ Precisely identify the time of occurrence (t_0) of any TPC ionizing event with ns resolution:
➢ Generate a trigger signal for read-out
➢ Localize events within 50 cm spatial resolution, give a rough event topology for selection purposes:
➢ PMT timing/gain equalization by laser pulses, λ = 405 nm, FWHM < 100 ps.

JINST 13 (2018) P10030

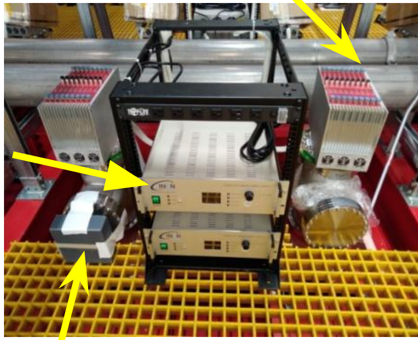
➢ The new "warm" ICARUS TPC electronics hosted in boards inserted in new Mini-crates directly mounted on new signal feed-through flanges includes:

➢ A front-end based on analogue low noise/charge sensitive amplifier - same for Induction/Collection wires;
➢ A serial 12 bit ADC system, with 400 ns sync. sampling;
➢ Optical link read-out for Gigabit/s transmission.

Minicrates are powered by new low noise Power Supplies

Two TPC Mini-crates with 9 read-out CAEN boards each

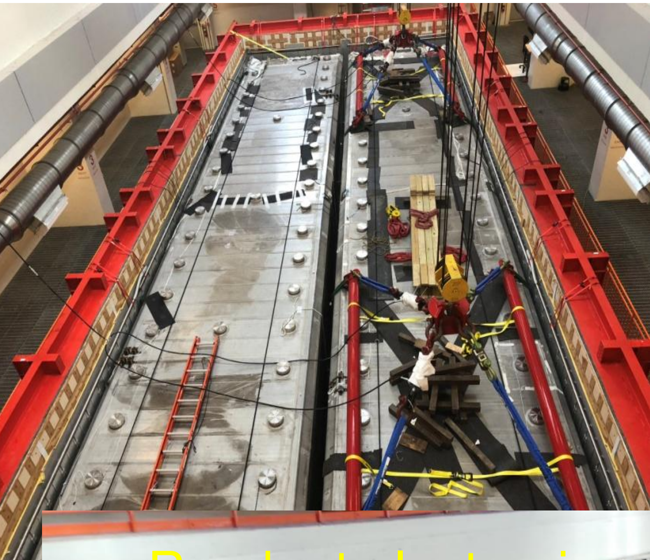
2 Power Supplies



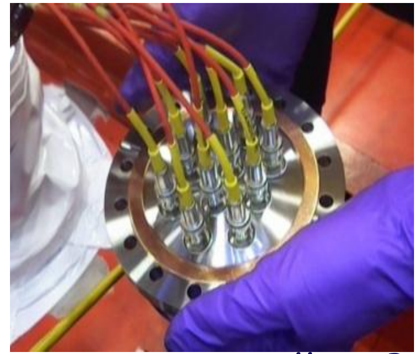
PMT optical fibers feed-through (covered for protection)

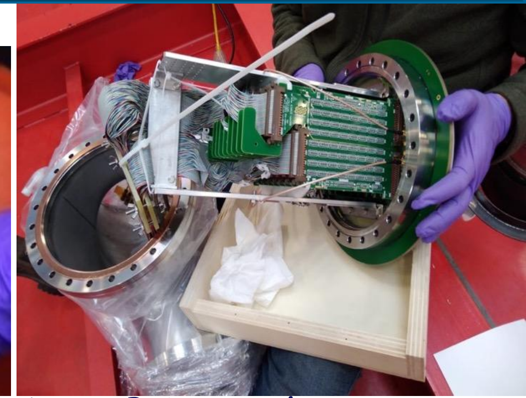
JINST 13 (2018) P12007

ICARUS installation @FNAL



Placement of ICARUS inside the warm vessel after the overhauling at CERN (Aug. 2018)





Installing PMT, TPC signal feed-through flanges (Jan. 2019)

Installing the readout electronics (Summer 2019)

- ✔ *All PMT digitizers, HV electronics and laser system installed*
- ✔ *TPC readout electronics (mini-crates, CAEN boards and Power Supplies) installed and verified;*
- ✔ *Internal/external signal connections verified.*
- ✔ *Signal, TT-link cables deployed and connected*

ICARUS installation @FNAL: PMT electronics & trigger

- PMT electronics installation completed with:
  - 2 HV racks with Bertan power supply modules, CAEN HV distributors, cabling, slow control and service instrumentation.
  - 4 digitizer racks with VME crates, CAEN V1730 digitizers, cabling, slow control and service instrumentation.

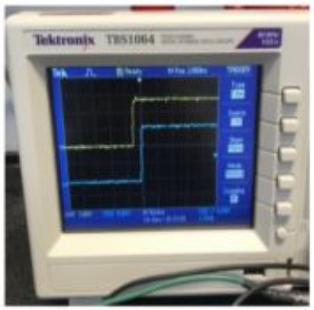
Mezzanine Level
East side

ICARUS installation @FNAL: PMT electronics & trigger

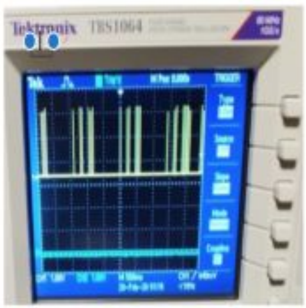
- PMT electronics installation completed with:
  - 2 HV racks with Bertan power supply modules, CAEN HV distributors, cabling, slow control and service instrumentation.
  - 4 digitizer racks with VME crates, CAEN V1730 digitizers, cabling, slow control and service instrumentation.

- Extensive tests in progress at ICARUS with a set-up including SPEXI board connected to WR master switch and a SPEC board at MI-12 for sending beam signals to ICARUS Trigger system.

Mezzanine Level
East side

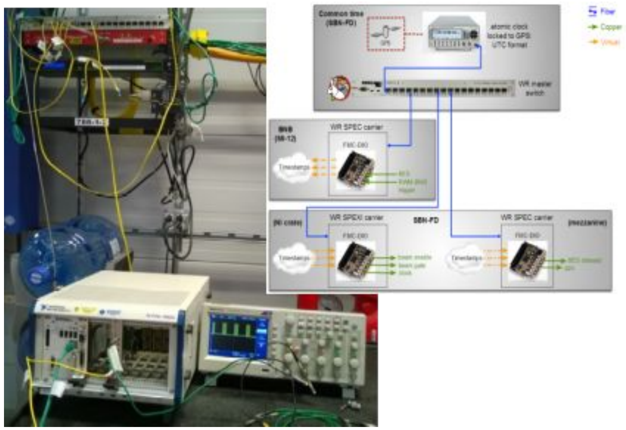


phase locking



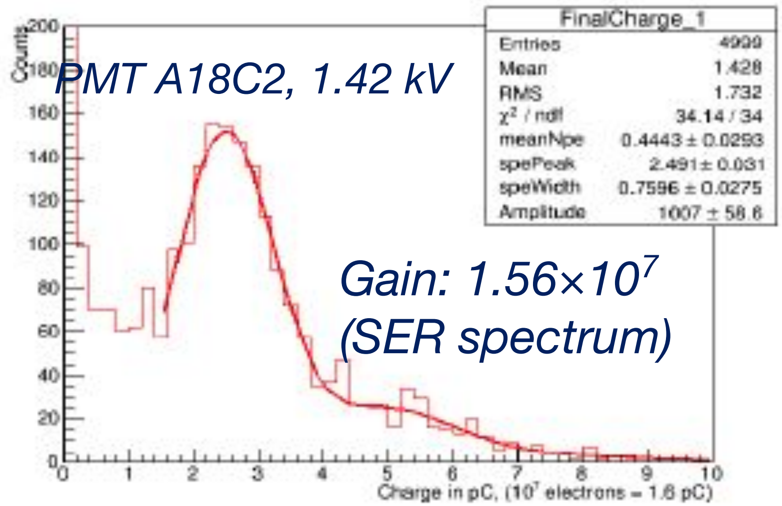
decoding both BNB, NuMI

TTLink by SPEXI



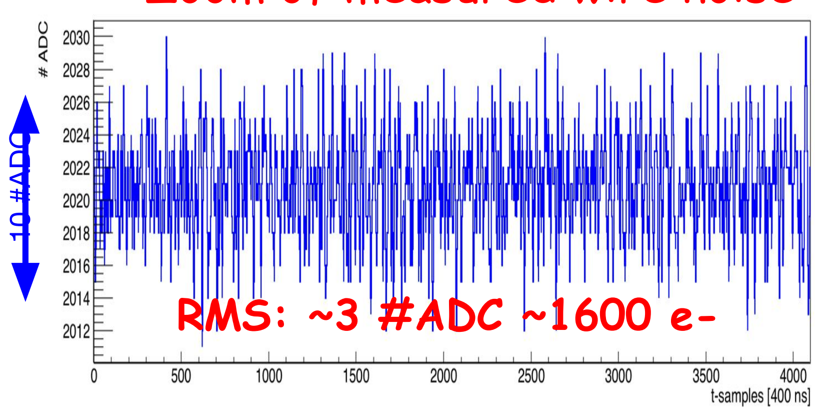
PMT characterization and TPC noise measurement

- All 360 PMTs were characterized after the flanges installation measuring gain, dark rate as a function of applied voltage at warm temperature:
  - A 0.7-2 x 10^7 gain is achieved on average for ~1.4 kV voltage in the whole PMT set;
  - PMT dark count values measured in 1-2 kH range.

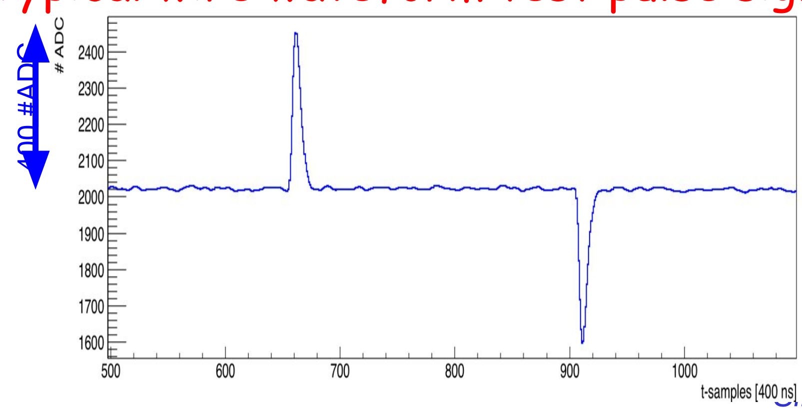


- Successful tests of full TPC readout chain, had been performed for all >54000 chs. to check readout and set baseline for future noise monitoring:
  - Random triggers by injecting test pulse at far end of wires and reading out signals on the other end: RMS ~1600 e-, not too far from ~1300 e- measured in 50-liter LAr-TPC even with a grounding conditions still far from optimal.

Zoom of measured wire noise

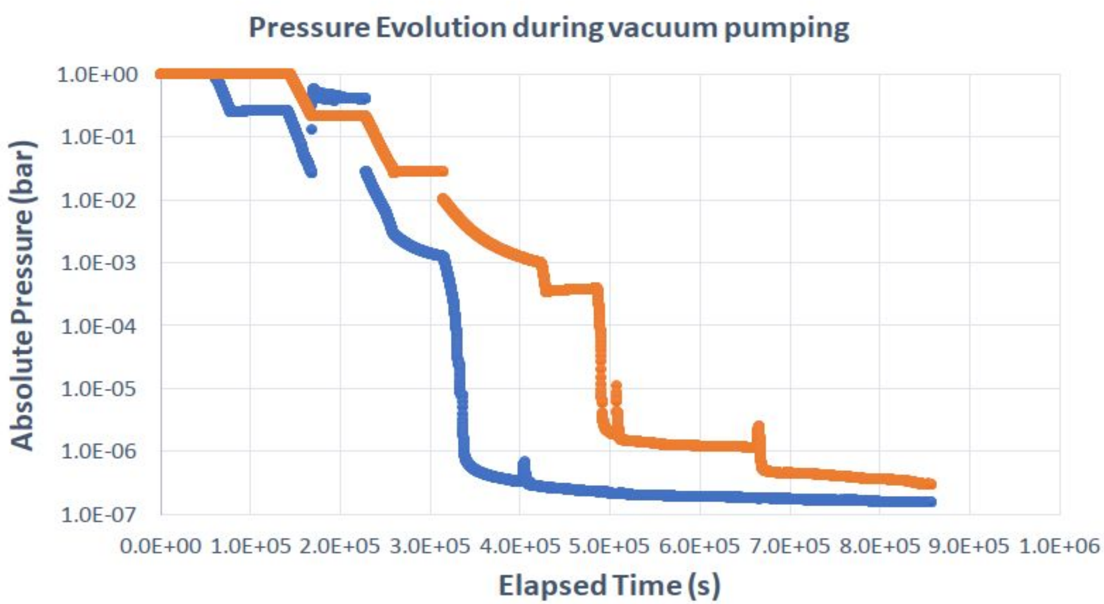


Typical wire waveform test pulse signal



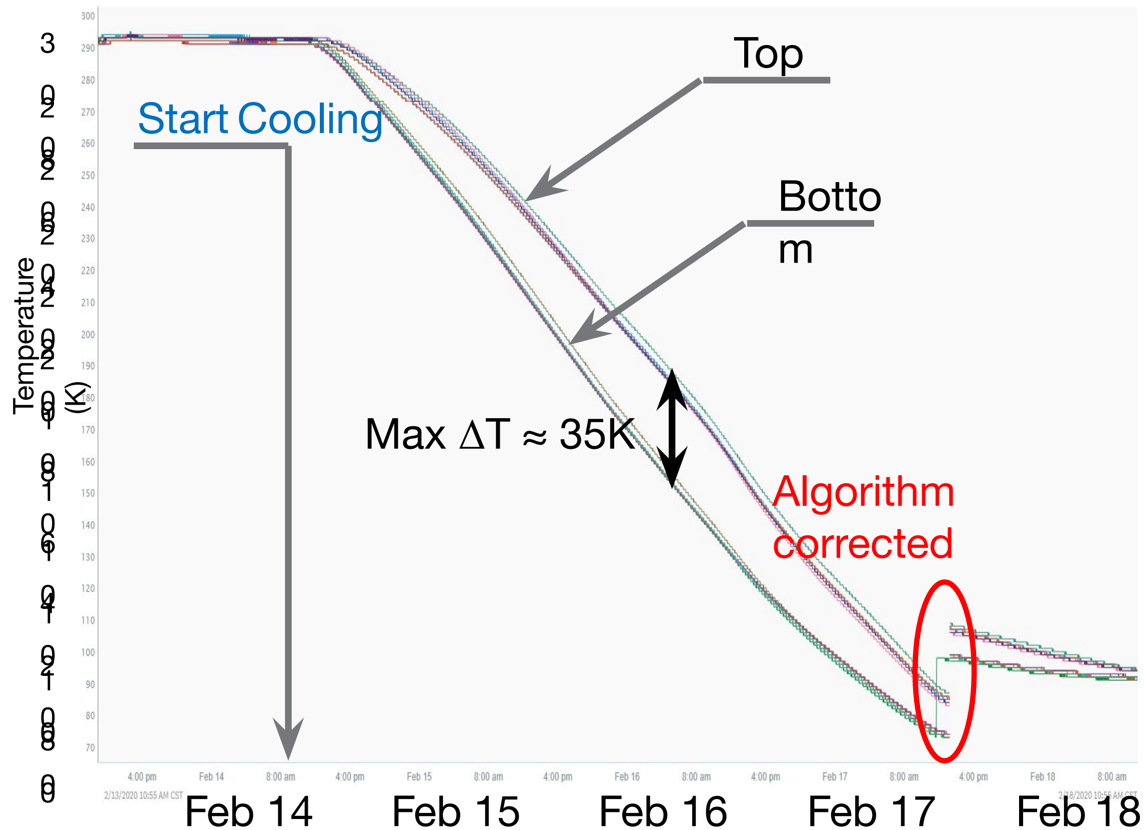
The ICARUS T600 Cryogenic Pre-Commissioning:

- Anomalies Pressure test of argon volumes, storage vessels, cold shields, transfer lines and ancillary cryogenic equipment;
- Removal of air from the argon volumes and leak searches and repair -> high vacuum phase: from Jun '19 to Feb '20;
- Warm test of all cryogenic equipment: sensors, valves, cryogenic pumps;
- Test of safety equipment: Oxygen Deficiency Sensors, alarms, ventilation;
- Test of process controls and programming code;
- Test and qualification of gas analysis systems for argon purity controls.



The ICARUS T600 Cryogenic Commissioning

- Febr. 13th vacuum pumping stopped: the T600 filled with ultra-purified Ar gas. Then cool down for 5 days by circulating LN2 in cold shields. The thermal gradient was kept uniform to within 35 K, to preserve the mechanical alignment of TPC wires;
- At the end of the cooling phase: filling with LAr: ultra-purified by primary + secondary filter in series before being injected in the main volumes. At half of the filling, the primary filter was regenerated. Filling lasted for ~50 days; it was completed on April 21st.
- In the final stage both Ar re-circulation systems (liquid and gas) taken progressively online and the operational parameters adjusted to the steady state conditions.



The ICARUS T600 Current Status

- Due to the COVID-19 outbreak Fermilab has suspended all functions at Batavia Lab. except for essential work to be conducted on site, consistent with the current Illinois "stay at home" announcement:
  - The laboratory is closed to users and all employees telecommute from home;
  - Only specific **essential personnel** is authorized to be on-site;
  - There will be no beam from the accelerators by October 2020;
  - All the experimental plants are set in "safe mode".
- Most of ICARUS operations are mainly being performed from remote since March 23th, including remote survey shifts from the Collaboration. The cryogenic commissioning was supported by a joint effort of Cern/Fermilab cryogenic teams. On site presence is limited to a maximum of 2 people for routine checks.
- Plans to re-start onsite operations after lifting of the present restrictions are being developed in conjunction with the Fermilab management. The completion of TPC/PMT cabling with final tuning and adjustment of grounding would require the presence on site of experts.
- The TPC/PMT noise must be carefully studied during the HV activation. Moreover the direct investigation of the noise source and the possible strategies for its mitigation require TPC/PMT experts facing in person the actual situation.

ICARUS PV: attività 2019

FTE 2019

F. Boffelli	1
A.Menegolli	0.6
C. Montanari	1
A. Rappoldi	0.4
G.L. Raselli	1
M. Rossella	0.3
A. Scaramelli	0
Totale FTE	**4.3**

Attività di installazione/test in corso 2019/2020:

- Cablaggio esterno dei PMT e assemblaggio dei Raks di elettronica.
- Sviluppo del sistema di trigger che utilizza i segnali dei PMT.
- Assemblaggio e test del sistema di calibrazione Laser per i PMT.

Attività software:

- Sviluppo software/Monte Carlo per analisi dati FNAL.
- Sviluppo del sistema di acquisizione dati dei PMT e integrazione nel software di acquisizione del rivelatore.
- Sviluppo software e programmazione FPGA per il trigger.

Attività di R&D:

- R&D nuovi tipi di foto-rivelatori a temperature criogeniche (SiPM arrays).

Responsabilità/Incarichi:

- Coordinamento tecnico di tutte le attività di montaggio a FNAL (C. Montanari).
- Montaggi relativi al sistema di rivelazione della luce di scintillazione: passanti PMT e fibre ottiche laser (M. Rossella, G.L. Raselli).
- Rappresentante del gruppo Icarus-Pavia nell'Istitution Board SBN e ICARUS (G.L. Raselli).
- Chair Editorial and Speakers’ Board (A. Menegolli).

ICARUS PV: pubblicazioni e conferenze 2019

- 11 pubblicazioni tra riviste e proceedings.

- Conferenze:

1. A. Rappoldi, "*ICARUS: a new challenge within the Fermilab Short Baseline Neutrino Program*", New Trends in High-Energy Physics (NTHEP2019, Odessa, Ukraine).
2. G.L. Raselli, "*A comparison between scintillation light Analog and Digital trigger for large volume Liquid Argon Time Projection Chambers*", 15th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD19, Siena, Italy).
3. G.L. Raselli, "*Measurement of Liquid Argon Scintillation Light Properties by means of an Alpha Source placed inside the CERN 10-PMT LAr Detection System*", 15th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD19, Siena, Italy).
4. A. Menegolli, "*Sterile Neutrino searches with the ICARUS detector*", EPS-HEP Conference 2019 (Gand, Belgium).