

Consiglio di Sezione – INFN Milano

# GERDA/LEGEND

C. Fiorini  
S. Riboldi

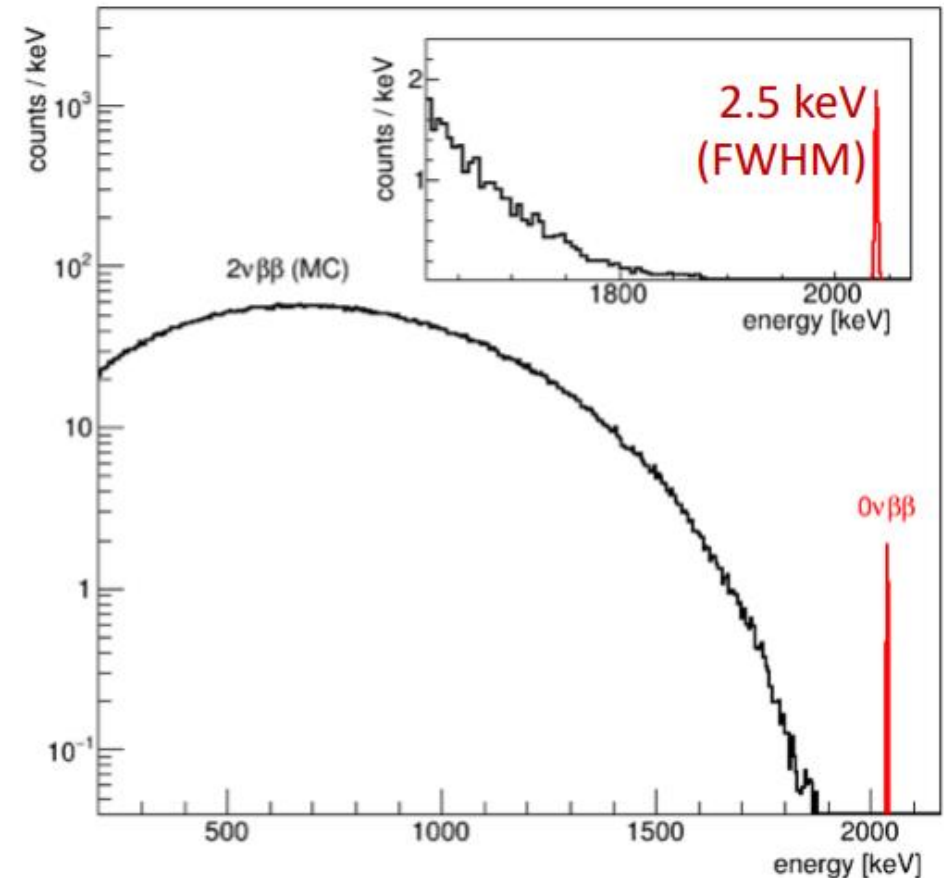
13 Luglio 2022



LEGEND

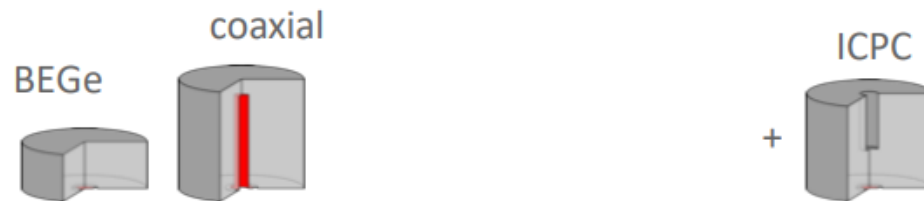
# Key features of $^{76}\text{Ge}$ $0\nu\beta\beta$ searches

- $^{76}\text{Ge} \rightarrow ^{76}\text{Se} + 2e^-$
- Q-value of  $^{76}\text{Ge}$ :  $Q_{\beta\beta} = 2039 \text{ keV}$
- High purity Ge detectors (  $>87\%$   $^{76}\text{Ge}$ )
  - source = detector  $\Rightarrow$  high detection efficiency
  - high purity  $\Rightarrow$  no intrinsic background
  - high density  $\Rightarrow$   $0\nu\beta\beta$  point like events
  - semiconductor  $\Rightarrow$   $\Delta E \sim 0.1\%$  (FWHM) at  $Q_{\beta\beta}$
- **$0\nu\beta\beta$  signature:**
  - Point-like energy deposition in detector bulk volume
  - Sharp energy peak at 2039 keV (FWHM  $\sim 2.5 \text{ keV}$ )

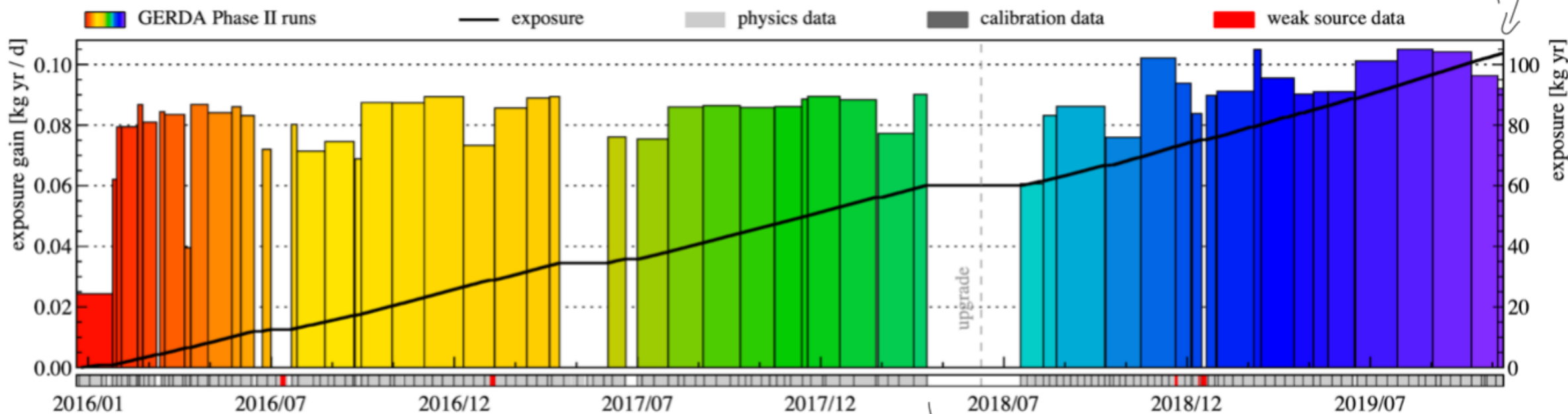




# Phase II data taking: High duty cycle



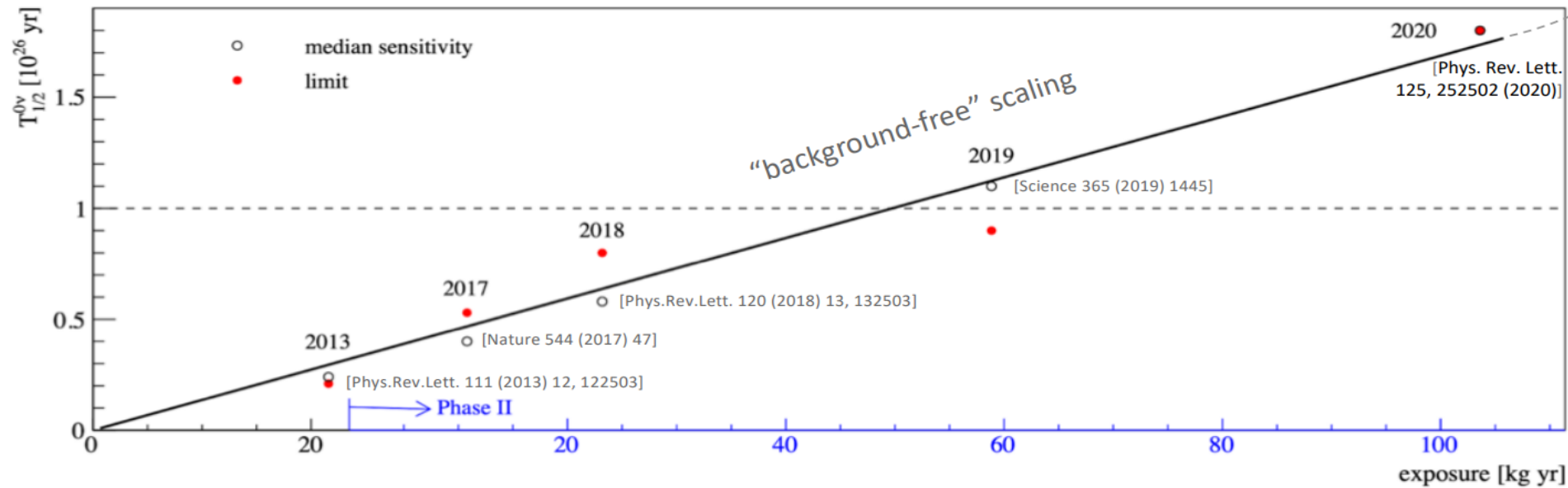
stop in  
Dec. 2019



start in Dec. 2015

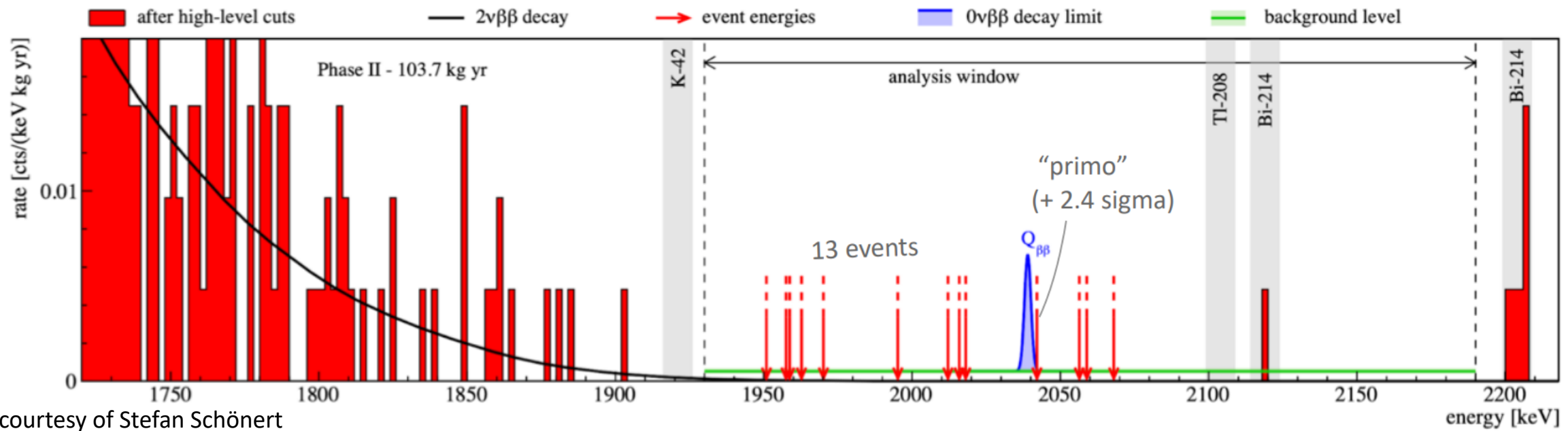
- pre-/post-upgrade data taking with **35.6 / 44.2 kg** of enriched HPGe detectors
- **4 yr** operation, with about **90%** duty cycle (incl. upgrade works), **103.7 kg yr** of data selected for analysis

# The GERDA results in short



$< 10^{-3}$  cts/(keV·kg·yr)  
 $> 100$  kg·yr  
 $> 10^{26}$  yr

all goals surpassed



# From the GERDA to the LEGEND collaboration



LEGEND

A world map showing red location pins across North America, Europe, and Asia. A blue arrow points from the GERDA logo in the top right towards the LEGEND logo and map.

Logos of funding agencies: INFN, DFG, ERC, FNSNF, UKRI, INFN, and others.



# The path from GERDA to LEGEND-200 and LEGEND-1000

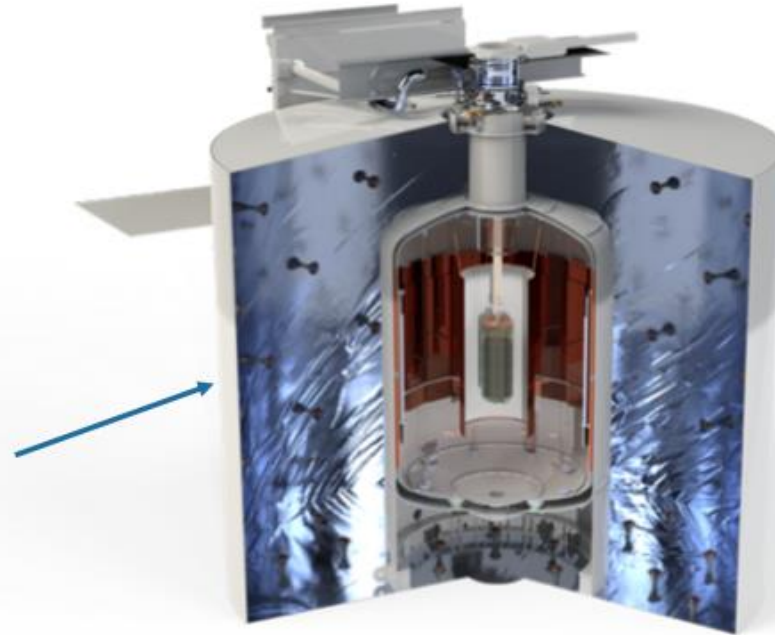
The LEGEND-1000 design builds on a track record of breakthrough developments from GERDA, MJD and LEGEND-200

GERDA @ LNGS:  
40 kg enriched Ge



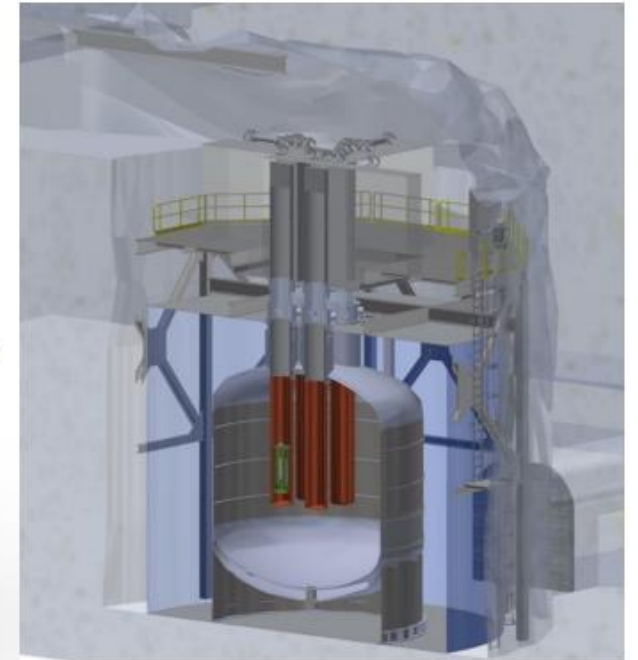
Completed 2019  
World leading sensitivity

LEGEND-200 @  
LNGS: 200 kg <sup>enr</sup>Ge



Commissioning 2021/22

LEGEND-1000 @ LNGS or  
SNOLAB (1000 kg <sup>enr</sup>Ge)

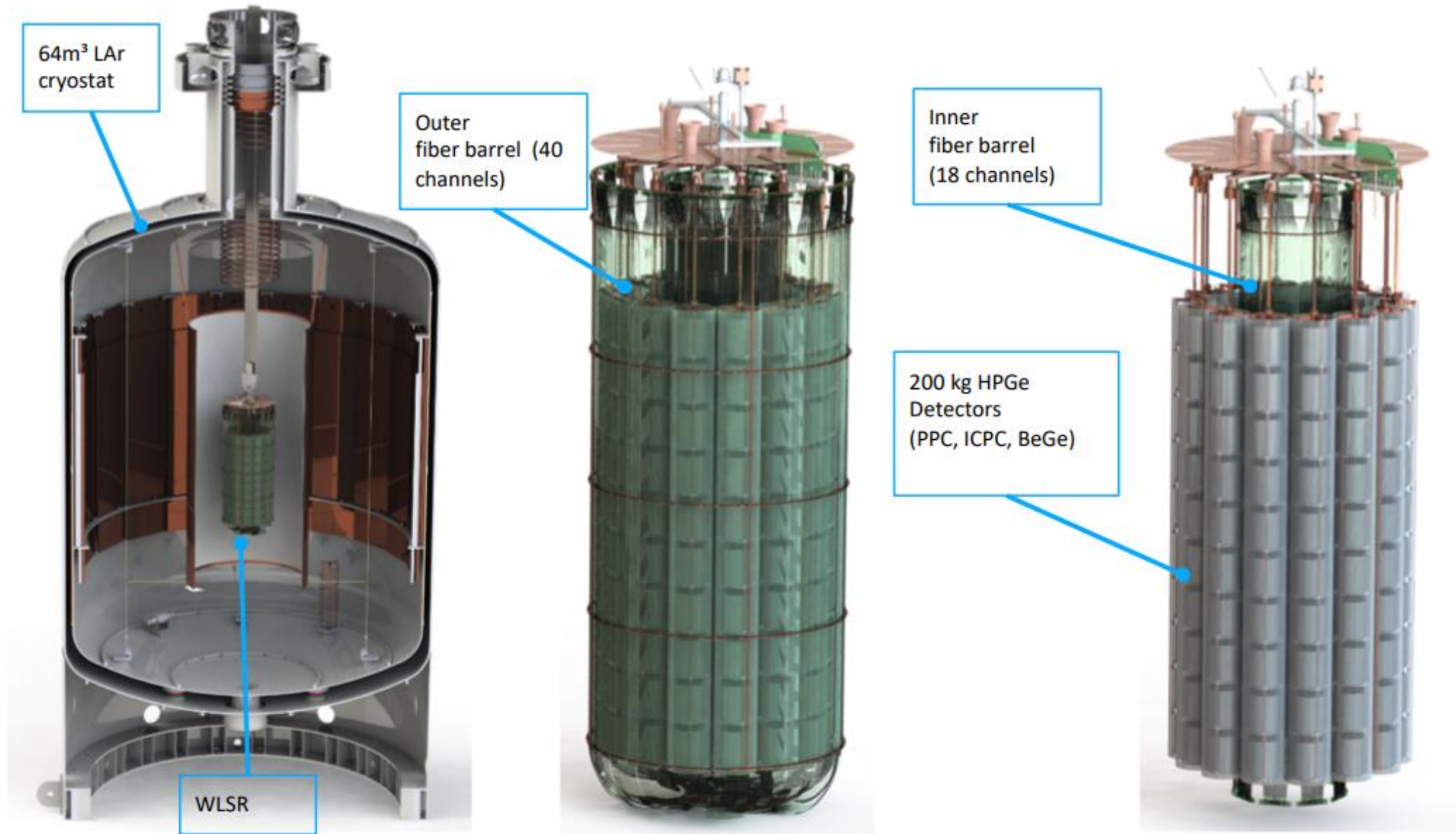


LEGEND-1000 Preconceptual Design  
Report: <https://arxiv.org/pdf/2107.11462.pdf>

US DOE CD1 FY2023

Slide courtesy of Stefan Schönert

# The LEGEND-200 cryostat and detectors



# The LAr inner barrel commissioning

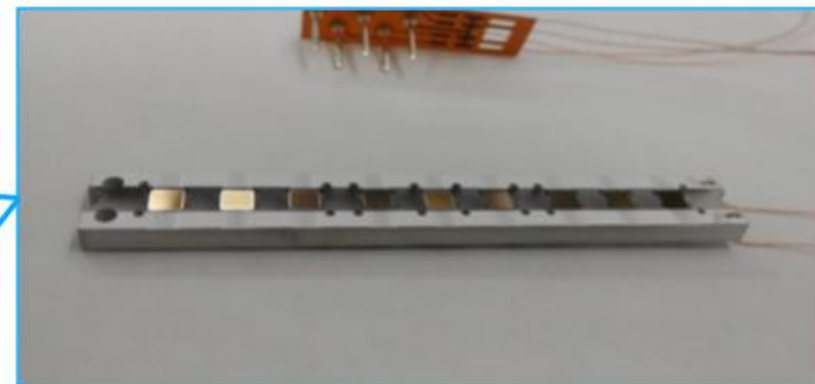
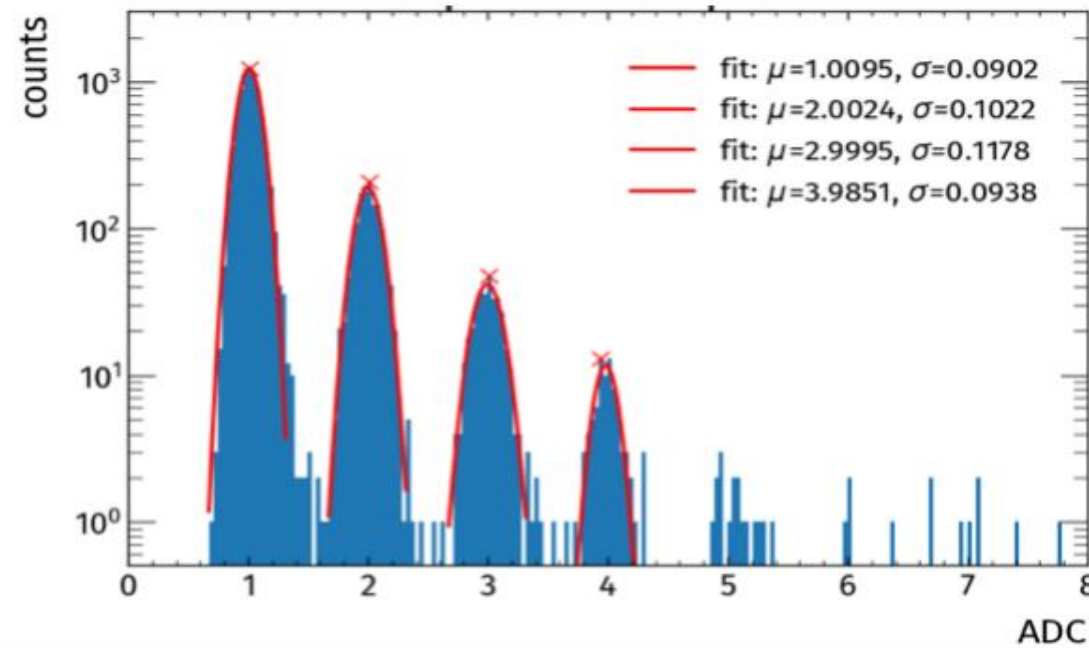


Photo by Enrico Sacchetti





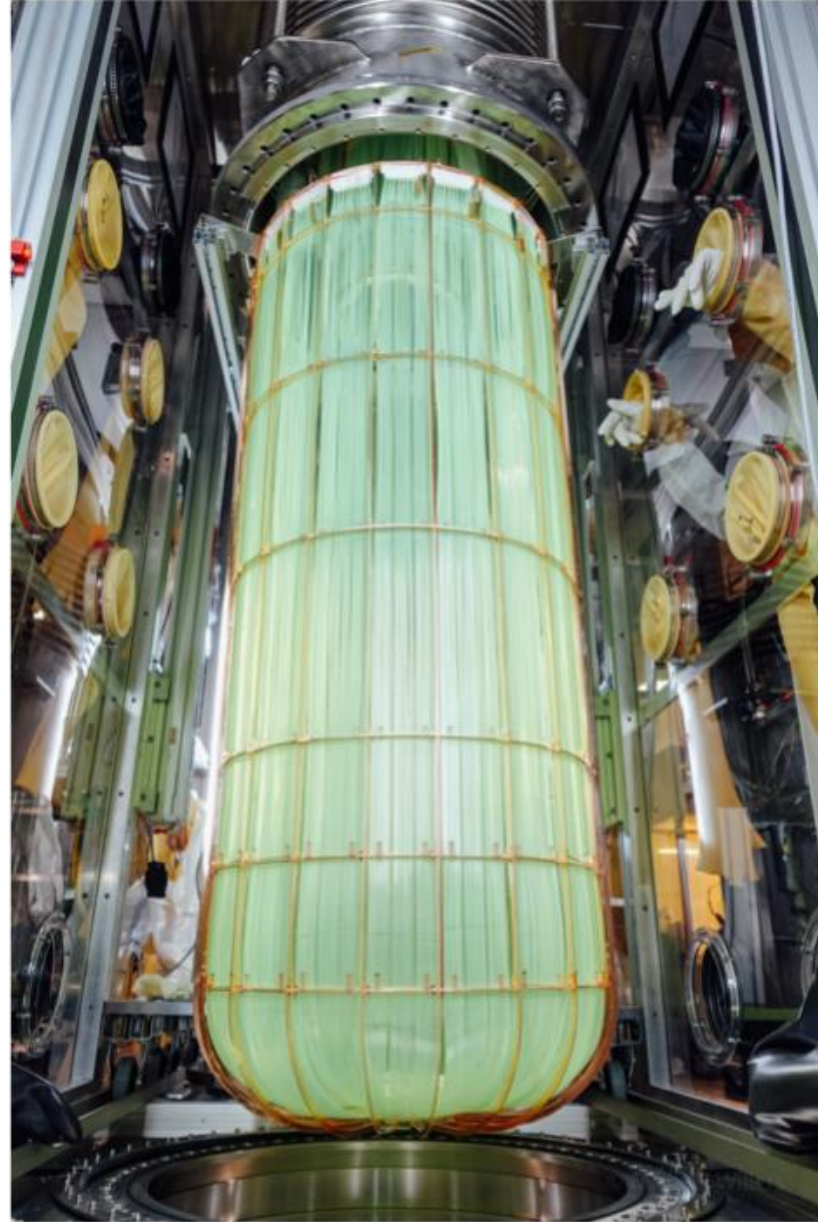
# The Ge detectors ready for installation



# The Ge detectors being installed



# The LAr veto being installed



# The LAr veto is installed

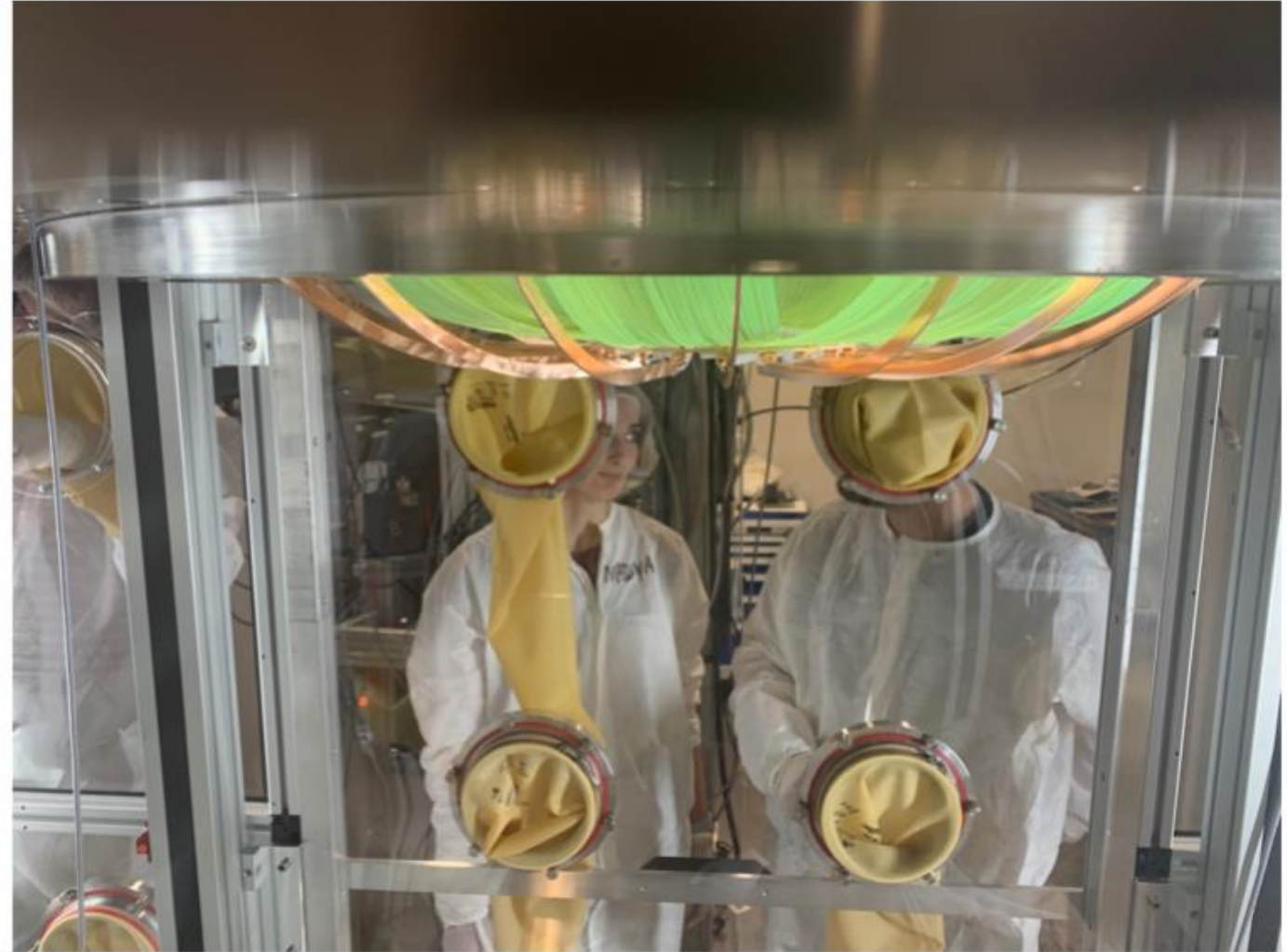
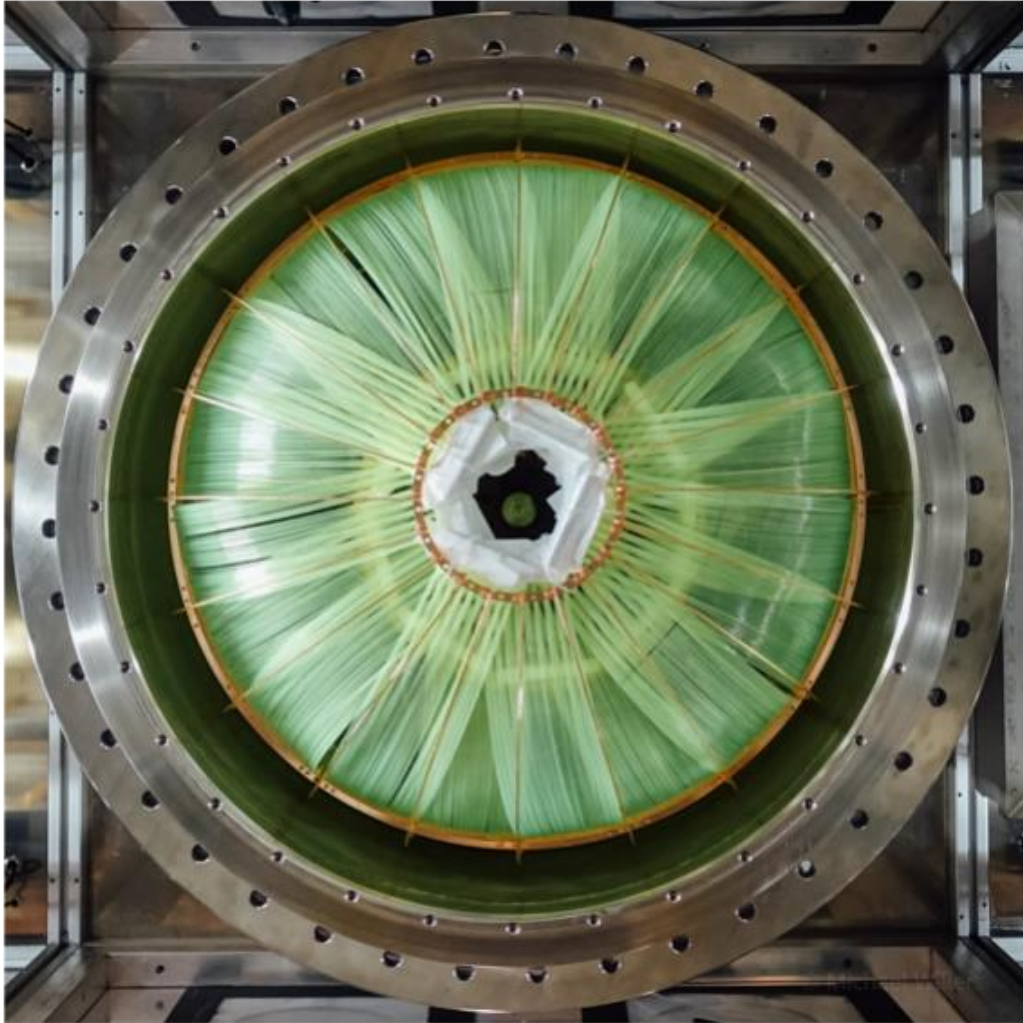


Photo by M. Willers



## Attività 2021-22

- Commissioning L-200 a LNGS (co-responsabilità dell'elettronica di FE dei rivelatori Ge)
- Ottimizzazione set-up sperimentale a LNGS (modifica flangia HV, modifica filtri HV)
- Sviluppo elettronica ancillare per l'esperimento (impulsatore isolato, filtri HV prototipali)
- R&D resistori ultra radio-puri di elevato valore ( $G\Omega$ ) per L-1000
- Filtraggio ottimo dei segnali Ge e SiPM

## Attività 2022-23

- Completamento del commissioning di L-200 a LNGS
- Eventuale sviluppo e produzione di elettronica ancillare per l'esperimento
- R&D resistori ultra radio-puri di elevato valore ( $G\Omega$ ) per L-1000
- Filtraggio ottimo dei segnali Ge e SiPM
- *Disegno di un preamplificatore a basso rumore e basso background per i rivelatori Ge di L-1000 (P.I. Carlo Fiorini- Politecnico di Milano)*

## Anagrafica esperimento

- A. Pullia (PO) 10% - Milano LEGEND P. I.
- S. Riboldi (PA) 40% - Resp. locale
- P. Piseri (PA) 30%
- A. Geraci (PA) 40%
- N. Lusardi (RTDA) 30%

### *ASIC design LEGEND-1000 (C. Fiorini- Politecnico di Milano)*

- C. Fiorini (PO) 10%
- D. Butta (dott.) 100%  
*(finanziato da TUM)*

Totale 2.6 FTE

## Richieste 2023

- Materiale di consumo laboratorio: 3k
- Missioni a LNGS: 3k

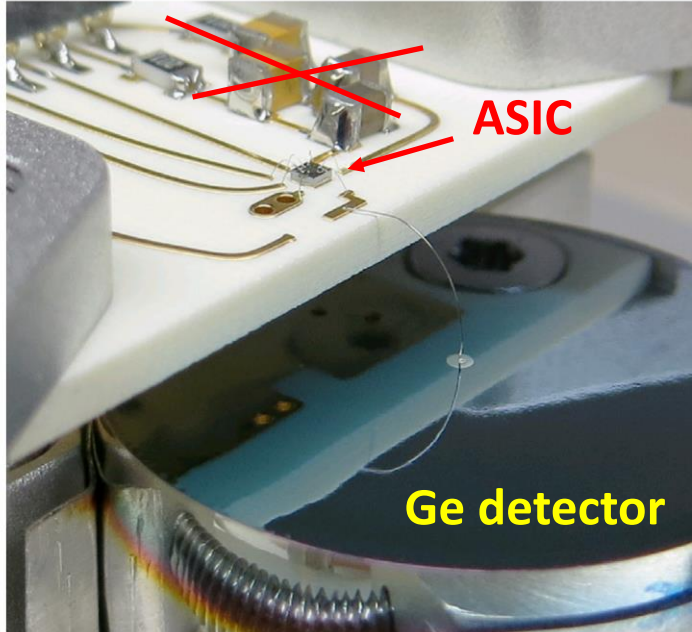
### Sub-judice

- Eventuale produzione filtri HV Ge,  
pico-amperometri isolati,  
Head Electronics: (15k s.j.)

- *Run produzione ASIC: 12k*
- *Schede e componenti per test: 4k*
- *Set-up di laboratorio: 3k*
- *Licenze SW: 2k*
- *Missioni a Monaco per test: 3k*

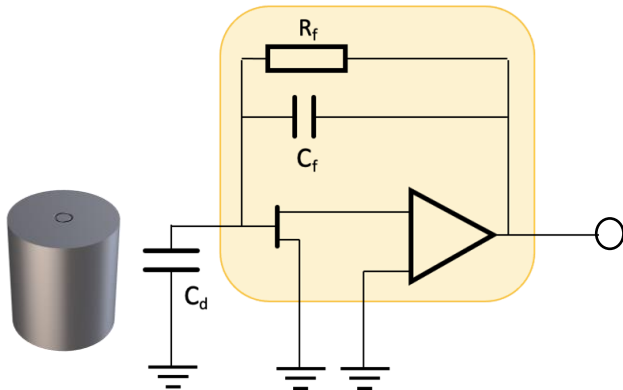
Totale 30k euro (+15k euro s.j.)

# New ASIC for Legend-1000



## ASIC Specifications

- Cryogenic operation in liquid argon
- No external components (e.g. filters, capacitors) → LDO
- 10 MeV dynamic range @  $\sim 2$  V amplitude
- Baseline noise  $< 1$  keV w/ detector, energy resolution in ROI comparable to actual LMFE solution
- Fully differential signal over 10 m /  $50 \Omega$  cables
- Risetime  $\sim 100$  ns / Decay time  $\sim$  few 100 us
- RC-like continuous reset (with linear behaviour)
  - Option 1 (safe): external large-value resistor
  - Option 2 (ambitious): internal continuous reset without external components





# Preliminary architecture

## External Power Supply



$V_{SUPPLY} = 5V$

LDO

$V_{DD} = 4V$

CSA

LINE DRIVER

DIFF OUT

GND

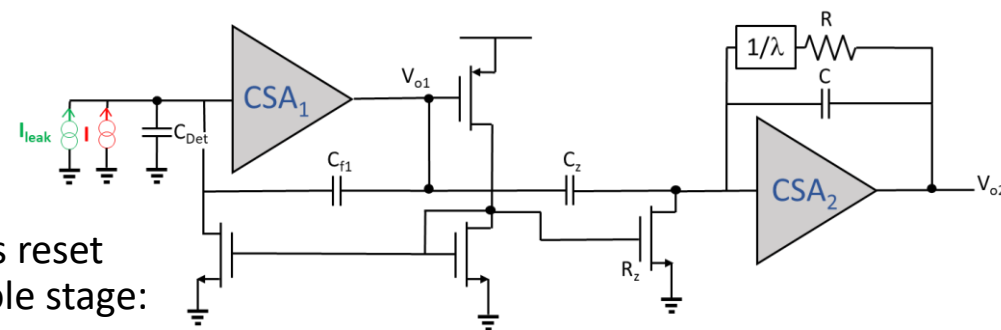
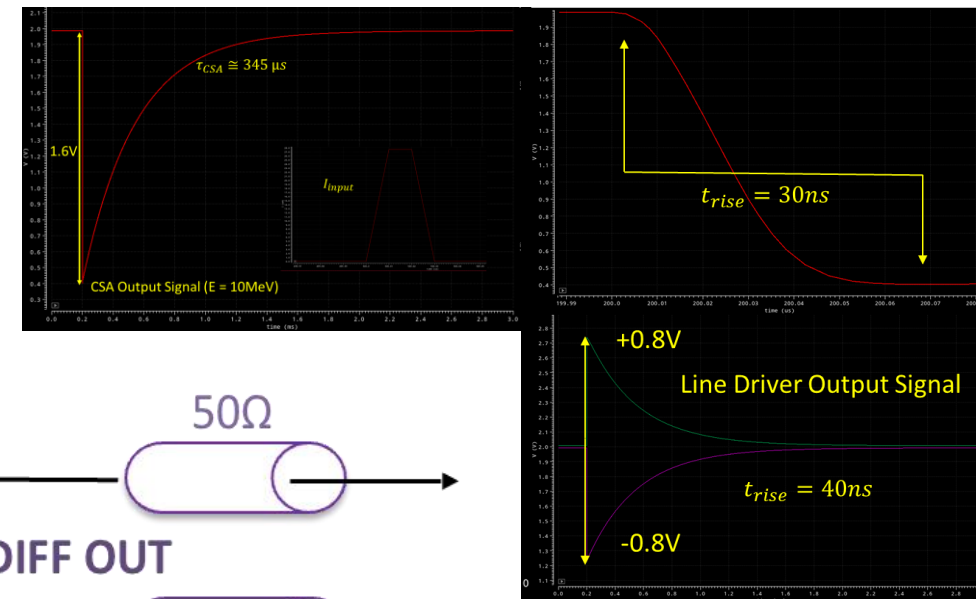
GND

$\tau_{CSA} \cong 100 \mu s$

ASIC

HPGe Detector

$$C_d = \begin{cases} 3pF \\ 5pF \\ 10pF \end{cases}$$



Continuous reset and real pole stage: