RD_FCC

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RD_FCC

- In questa sigla confluiscono una serie di R&D mirati alle esigenze dei futuri collisionatori leptonici circolari (FCC / CepC). Coordinata a livello nazionale da Franco Bedeschi (INFN-PISA)
- Gli studi di R&D che soddisfano i requisiti per intercettare fondi esterni e call di GR5, vengono inseriti in quei canali ma, nonostante questo, chiediamo un supporto a questa commissione per garantire continuità e per portare avanti quella parte di sviluppo che è specifica degli esperimenti a collider
- La sezione di Milano, contribuisce ai seguenti R&D:
  - Beam Studies:
    - Ottimizzazione di una sorgente di positroni per FCC
    - Controllo dell'intensità dei fasci mediante scattering compton (https://indico.cern.ch/event/1178403/)
      - Attività sul nascere condotta da Illya Drebot
  - Rivelatori monolitici a pixel di silicio
    - Sensori sviluppati in ARCADIA
    - Sensori sviluppati in HVR_CCPD (ATLASPIX3)
  - Calorimetro Dual Readout
    - Call Gr5: al suo primo anno

Positrons source optimization by the GIOTTO AI code developed in Milano and Target positron generation

Flow chart of the positron source optimization
(The activity born on knowledges acquired in the frame of the positron source of LEMMA, now fitting on the FCC)

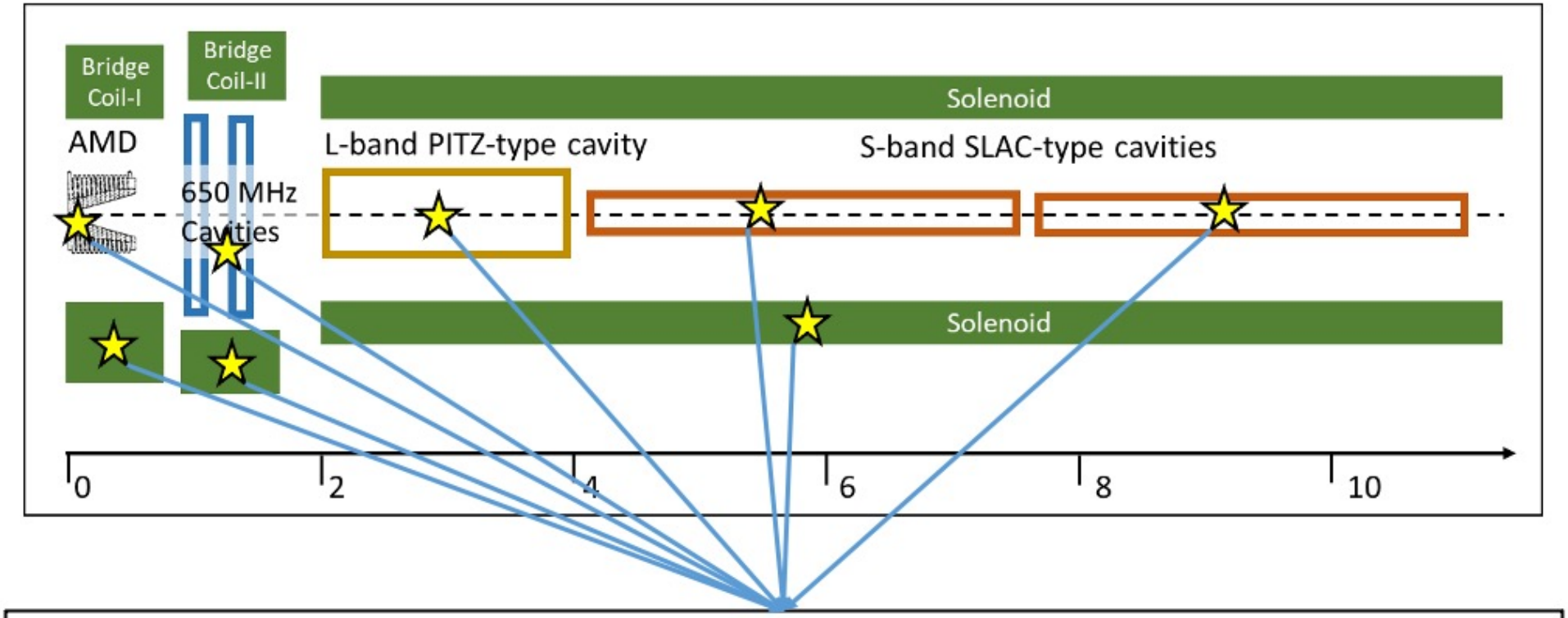
- ❑ Electron acceleration to drive the positron source by using code like Astra and Elegant
- ❑ Simulation of the electron+target interaction (i.e. positron generation) by using codes like Geant4 and/or Fluka
- ❑ Entrapment chain study and optimization **by using the GIOTTO code**. **Main goals: to maximize positrons flux and beam quality**.
- ❑ A collaboration with the PSI group (already on the subject) is under discussion.

Tools: existing or under development in synergy with other activities. GIOTTO can drive external codes that typically cope with strong non-linear correlations.

Computation power: simulations and optimizations can be performed using existing machines.

Travel budget: **1-2 abroad days meeting (1.5 K€)**

Example of the positron trapping chain



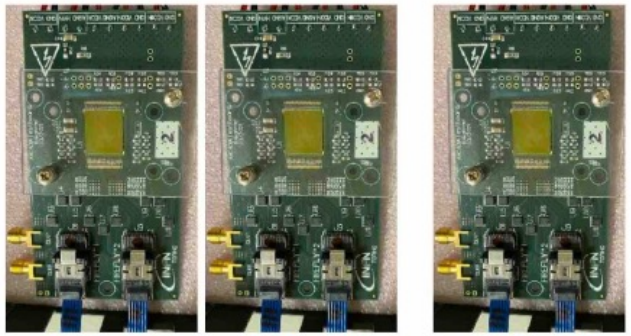
GIOTTO - a Genetic Interface for OpTimising Tracking with Optics

GIOTTO is able to control a huge number of NON-Linear correlated "knobs", e.g. :
the AMD magnetic field, the Bridge coil-I, the Bridge coil-II, the long cavities solenoid,
the cavity positions, gradient and injection phases
the target position inside the AMD, the AMD filed slope, the beam space-charge during target extraction

Rivelatori a pixel di silicio con sensori monolitici

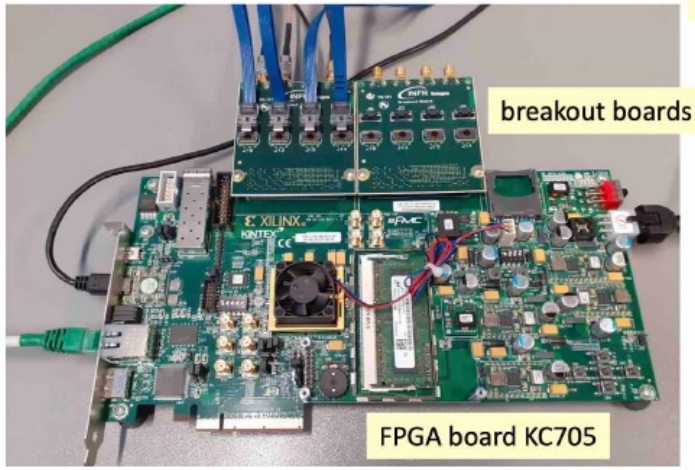
- Una tecnologia è quella sviluppata nel progetto ARCADIA (Call Gr5: 2019-2021) che ha avuto un anno di estensione (2022).
  - PI: Manuel Da Rocha Rolo (INFN - TO)
- Tra i successi di questo R&D
  - Primo dimostratore (MD1): funzionante, non completamente qualificato
  - MD3 sottomesso: il silicio dovrebbe essere disponibile per i test agli inizi del prossimo anno
- Contributo della sezione di Milano
  - Design review
  - Test e caratterizzazione in laboratorio e con fasci di particelle (2022-2023)
- Partecipanti della sezione di Milano
  - Massimo Caccia
  - Attilio Andreazza
  - Romualdo Santoro
  - Agnese Giaz

MD1: DAQ and first results



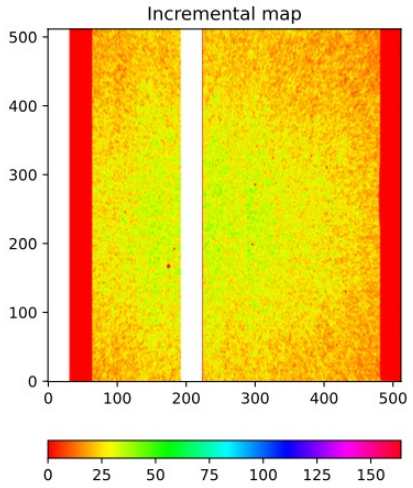
FEB cards

Samtec Firefly cables
(20 cm – 50 cm – 100 cm - 200 cm)

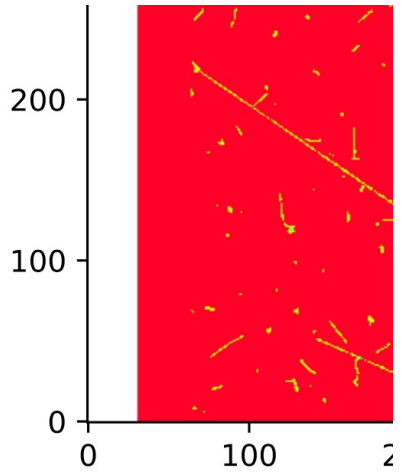


On-line QA-plots

^{90}Sr



Few cosmic tracks
(Tilted sensor)

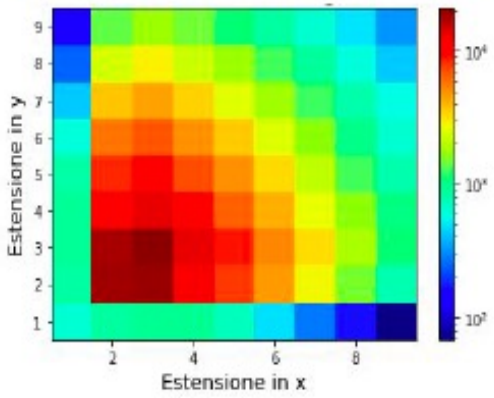


MD1 under test:

Pixel size = 25x25 μm^2
Matrix = 512 x 512
Thickness = 200 μm

Cluster size

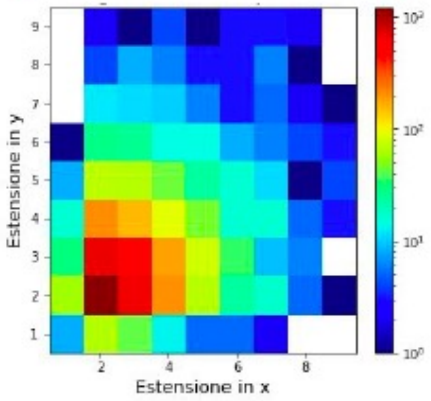
Sorgente non collimata



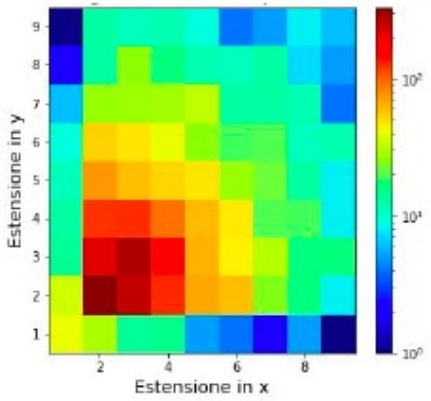
- Cluster size analysis in different condition:
  - ^{90}Sr non-collimated source
  - ^{90}Sr collimated source
  - Cosmic tracks

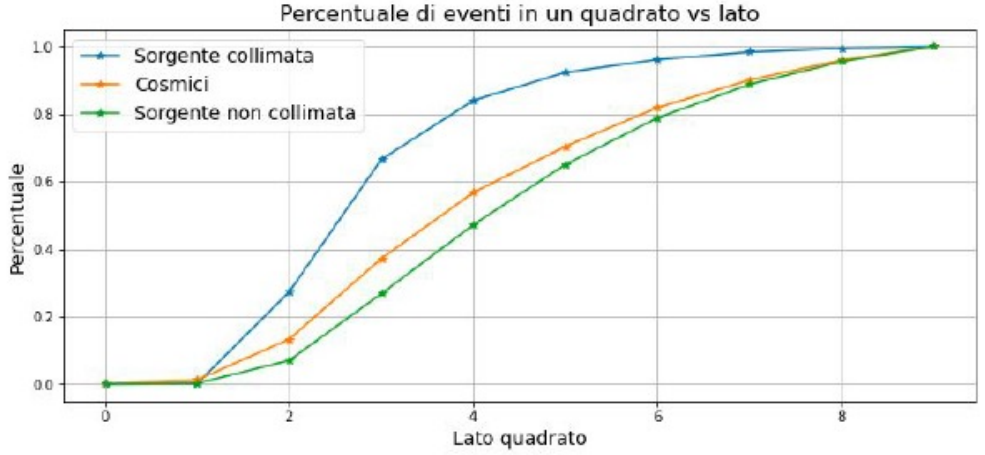
Regione	% in un quadrato 3 × 3	% in un quadrato 5 × 5
Sorgente non collimata	26.8	65.0
Sorgente collimata	66.5	92.3
Cosmici	37.2	70.4

Sorgente collimata



Cosmici



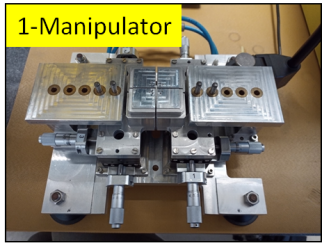


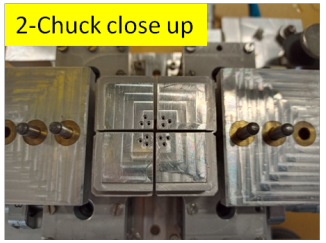
Rivelatori a pixel di silicio con sensori monolitici

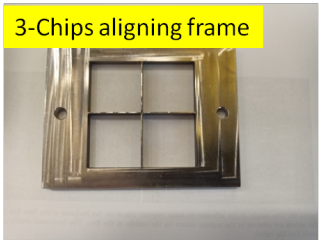
- Le attività previste per il 2023 saranno incentrate sulla qualifica dei nuovi dimostratori (MD3) e confronto con (MD1)
  - Test elettrici
  - Laser
  - Sorgenti radioattive
  - Test con raggi cosmici
  - Test beam
- Richieste su RD_FCC
  - Partecipazione ai test beam necessari alla qualifica dei dimostratori (10k)
    - A seconda della disponibilità e dello stato d'avanzamento delle qualifiche potremmo essere considerare diverse facilities (CERN, DESY, e TIFPA)
  - Supporti meccanici a supporto dei diversi test (5k)

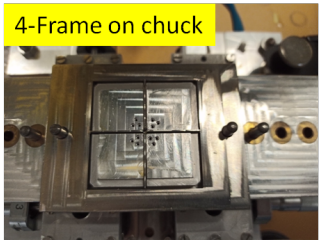
ATLASPIX3 Module Assembly

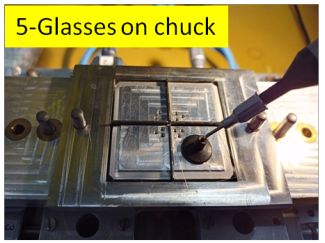
- **ATLASPIX3:** monolithic CMOS sensor, full size system on chip
- Developed multi-chip-modules to integrate service distribution and data readout
- Below is the assembly procedure developed in Milano (shown with **glass squares** for clarity)
- Gap between chip of **100 um ± 50 um** has been achieved

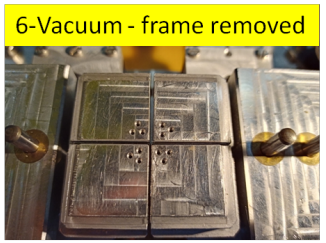


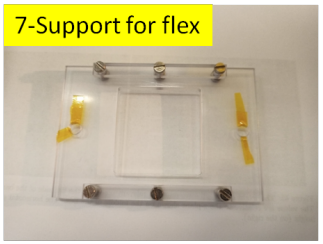


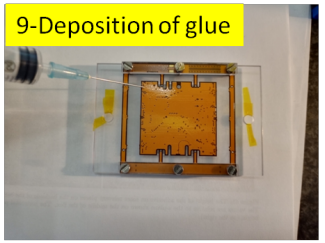


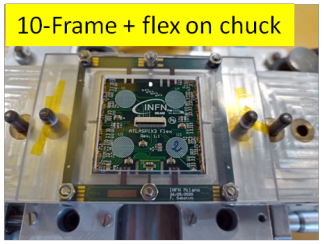


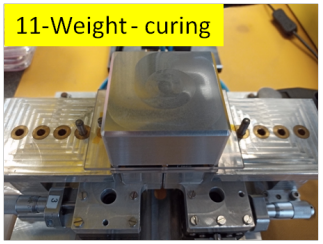


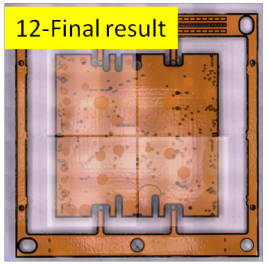






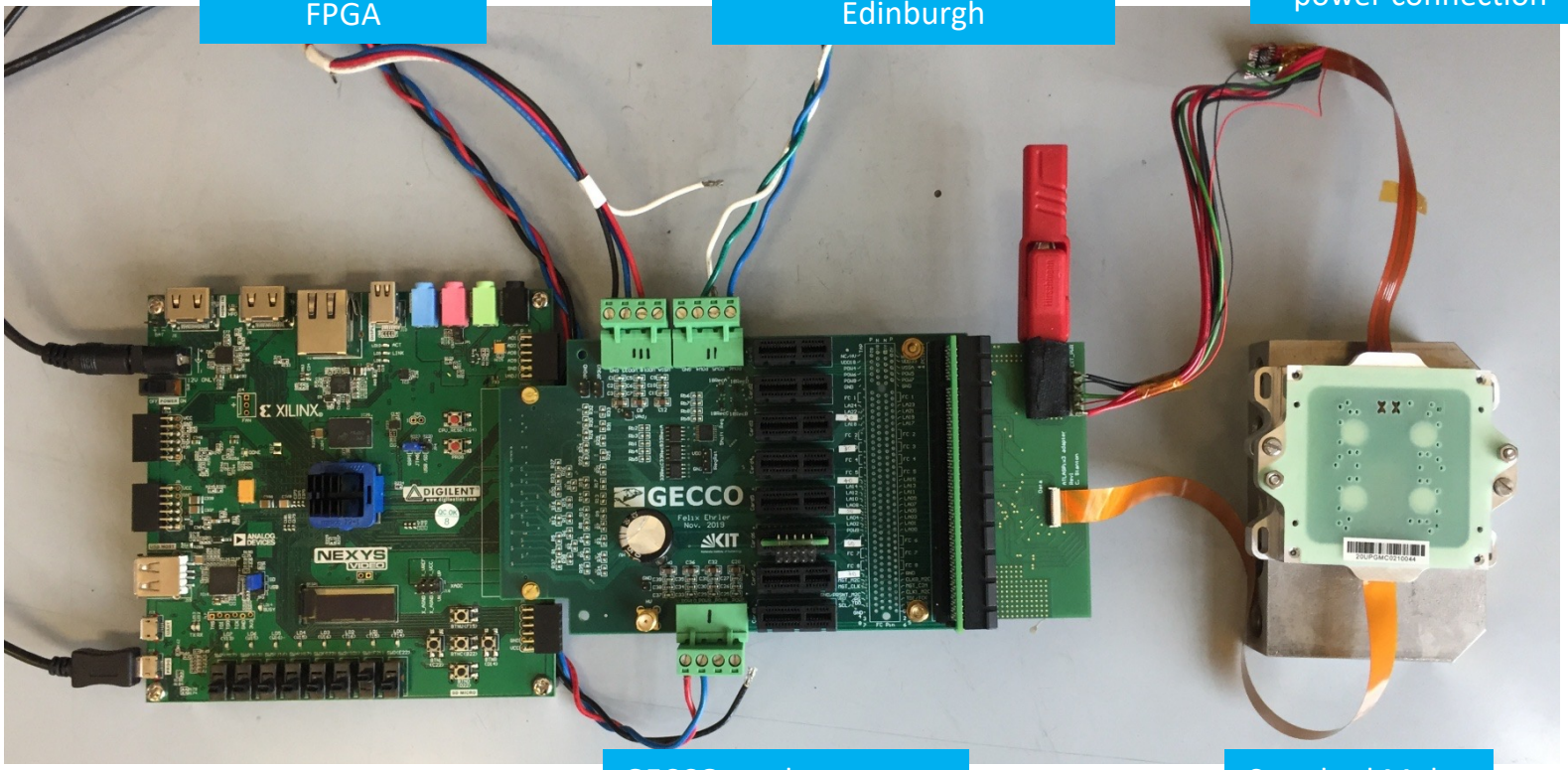






Attilio Andreazza

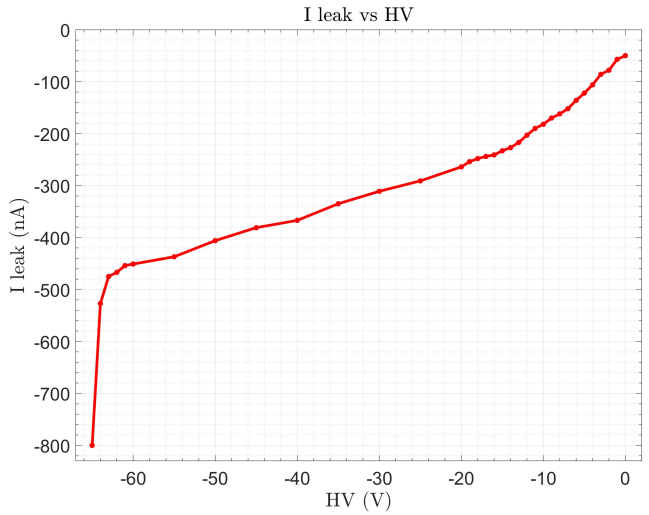
Testing setup

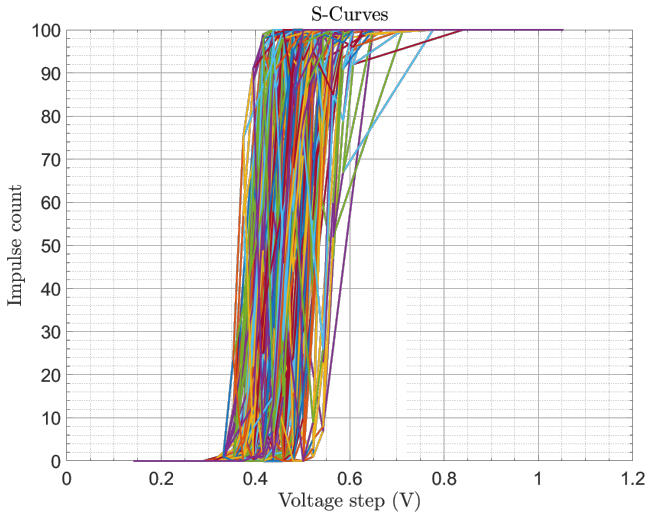


Attilio Andreazza

Module characterization

- **|I leak| < 400 nA** for HV > -60 V. **Breakdown voltage = -65 V**
- Current consumption power-up / configured = 1.65 A / 1.33 A for VDD = 1.9 V
- Successful fitting of pixel thresholds
- **Occasional loss of configuration** during long scans
- Chip 3 can be configured but readout is not working (no wafer probing)

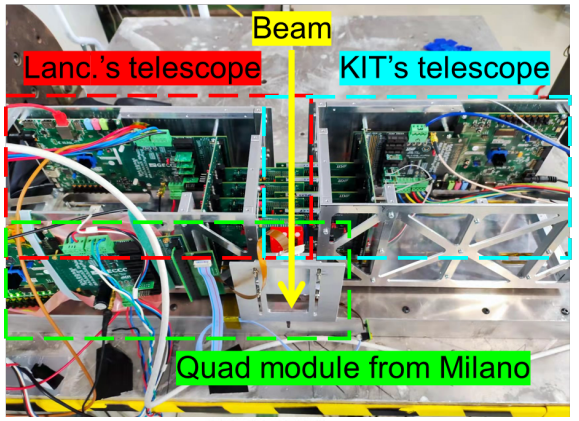


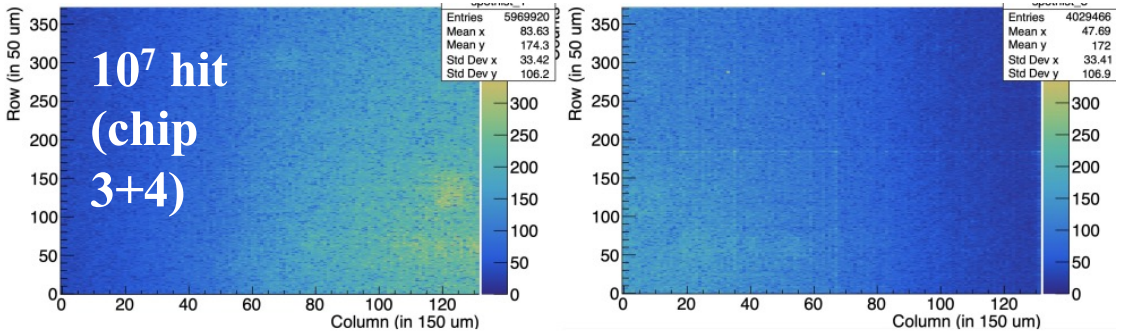


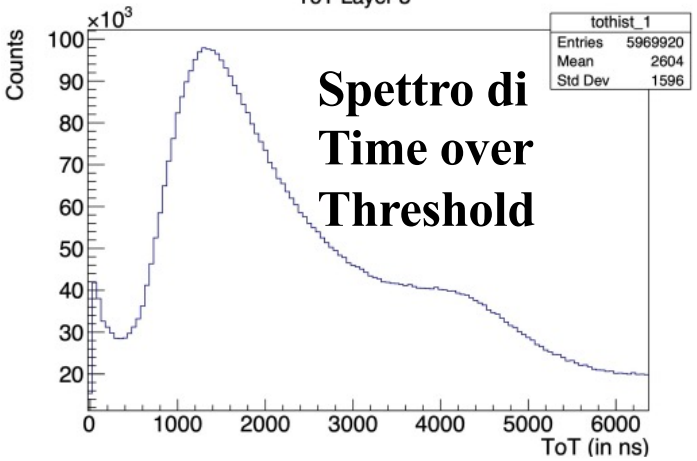
Attilio Andreazza

2022 DESY Test Beam

- Completato l'assemblaggio dei quad modules con ATLASPIX3
  - yield di assemblaggio compatibile con quello osservato a livello di singoli chip
  - Lezione per i future test di ATLASPIX3.1: verificare sotto punte HV e LV dei FE prima di montarli
- Due moduli inseriti nel test beam 4-10 aprile a DESY
  - Raccolti dati anche con i telescopi ATLASPIX3 di KIT e Lancaster
- Causa danneggiamento nel trasporto non tutti i chip operativi (riparati poi al ritorno a Milano)
- Dimostrata comunque l'operatività del modulo:







Attilio Andreazza

ATLASPIX3 Modules: planning

- **9 multi-chip modules with ATLASPix3 has been assembled**
- 2 have been operated in testbeam at DESY

- Set of ATLASPIX3.1 wafers procured:
  - fixes on the main VDDA/VDDD **regulators**
  - on-chip **command-clock-recovery**
  - received 3 × 48 chips after dicing and thinning at OPTIM (F)

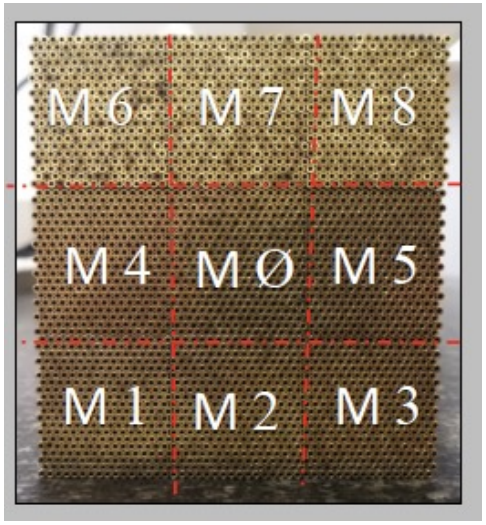
- Designing of a **2nd generation flex hybrid** exploiting ATLASPIX3.1 fixes:
  - Only **one LV supply** (currently 3 are needed), exploiting the internal regulator fixes
  - Input lines for command and clock (dropping trigger and reset signals)
  - Drop of SPI and configuration lines used for debugging module behaviour
  - **A/C coupling on LVDS** lines for compatibility with **serial powering**
  - Use some free space for temperature sensors

- Target is building few **mini-staves** of an outer tracker for FCCee/CepC/ILC

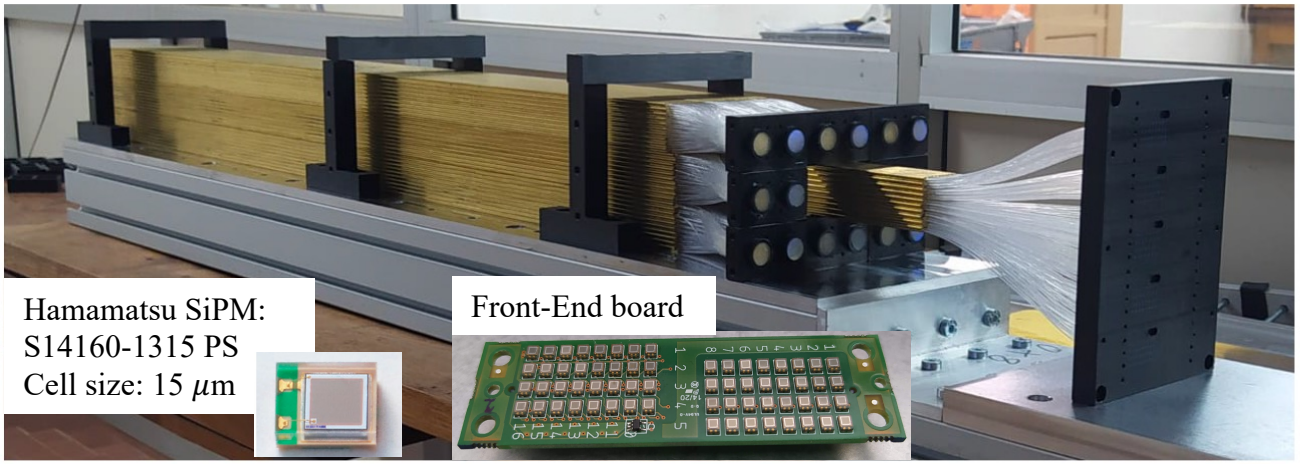
Calorimetria Dual Readout

- Obiettivi di questo R&D:
  - Qualifica su fascio delle performance EM del prototipo ad alta granularità (parzialmente equipaggiato con SiPM)
  - Studio delle problematiche di sistema: costruzione e read-out (design meccanico, assemblaggio, read-out, calibrazione etc.)
  - Qualifica su fascio delle prestazioni adroniche del calorimetro con una piccola parte ad alta granularità
- Attività svolte (2021 - 2022):
  - Costruzione di un prototipo con contenimento EM
  - Qualifica su fascio del prototipo con contenimento EM (DESY e CERN)
- Attività finanziata dalla call di GR5 (Hydra2)
  - Design e costruzione di un prototipo scalabile di dimensioni tali da contenere sciami adronici
  - Qualifica su fascio delle prestazioni adroniche del calorimetro

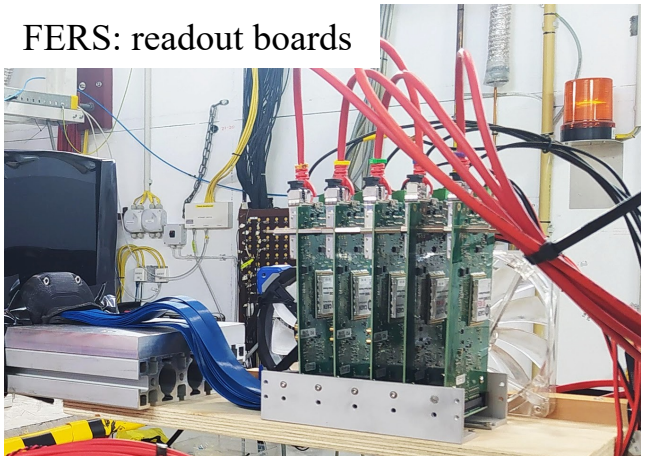
The EM-size prototype



- EM-size prototype (10x10x100 cm^3)
  - 9 modules made of 16 x 20 capillaries (160 C and 160 Sc)
  - Capillaries (brass): 2 mm outer diameter and 1.1 mm inner diameter
- EM-size prototype readout
  - Each capillary of the central module is equipped with its own SiPM: highly granular readout
  - 8 surrounding modules equipped with PMTs (each module will use 1 PMT for C and 1 PMT for Sc fibres)

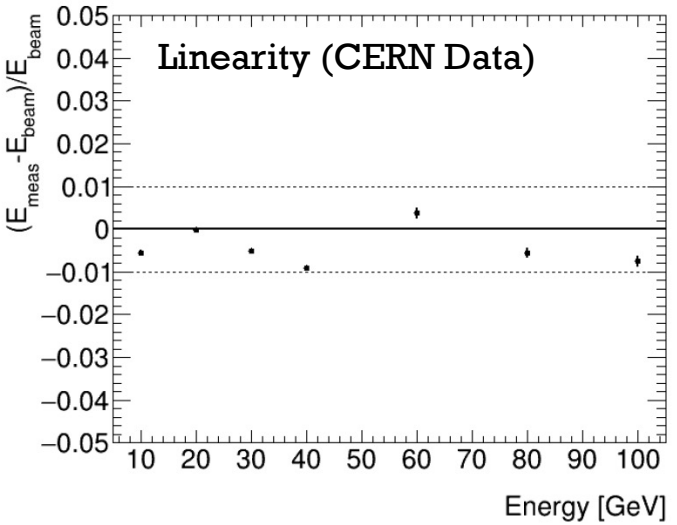


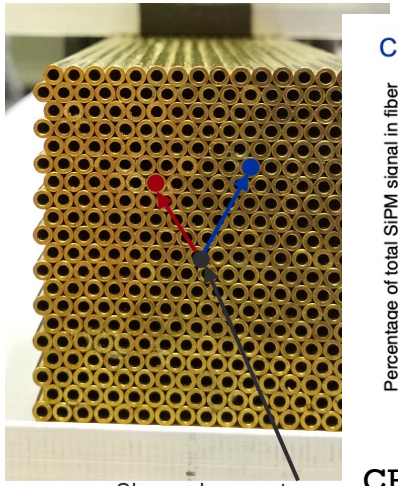
FERS: readout boards

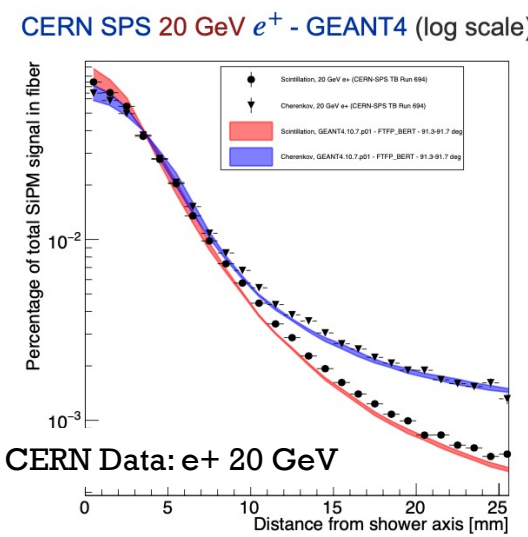


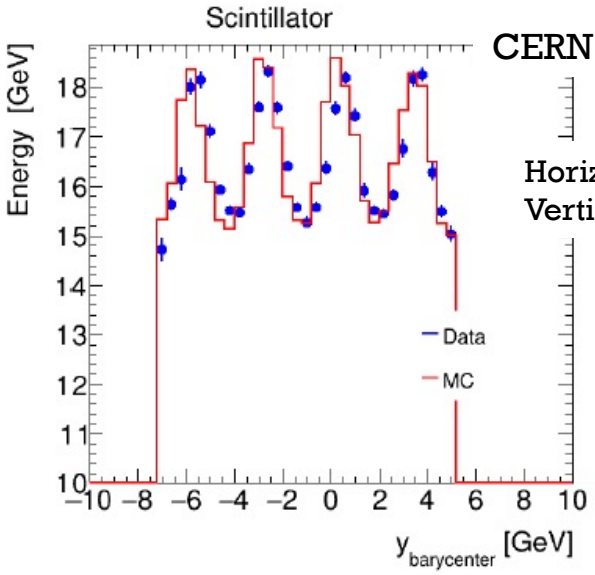
Analisi dati e confronto con il Monte Carlo

- L'analisi dei dati quasi completa:
  - Buona linearità nel range energetico esplorato
  - Si sta utilizzando la simulazione per disaccoppiare l'impatto che alcuni problemi strumentali hanno avuto sulla misura della risoluzione energetica



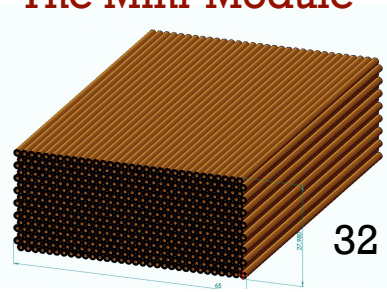

Shower barycenter





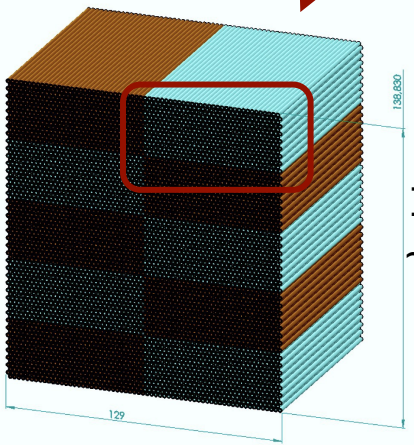
HiDRa: prototipo con contenimento adronico

The Mini-Module



32 x 16 capillaries

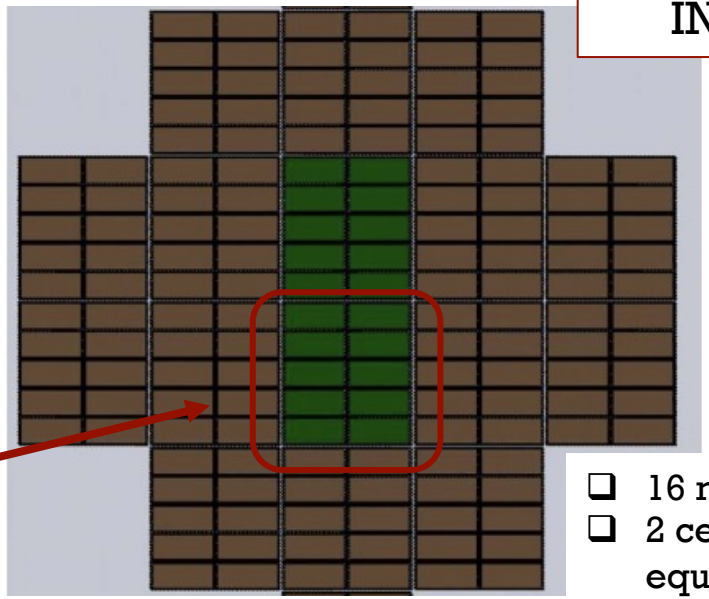
The Module



10 Mini-modules
~ 13 x 13 x 250 cm^3

The hadronic prototype

INFN-GR5

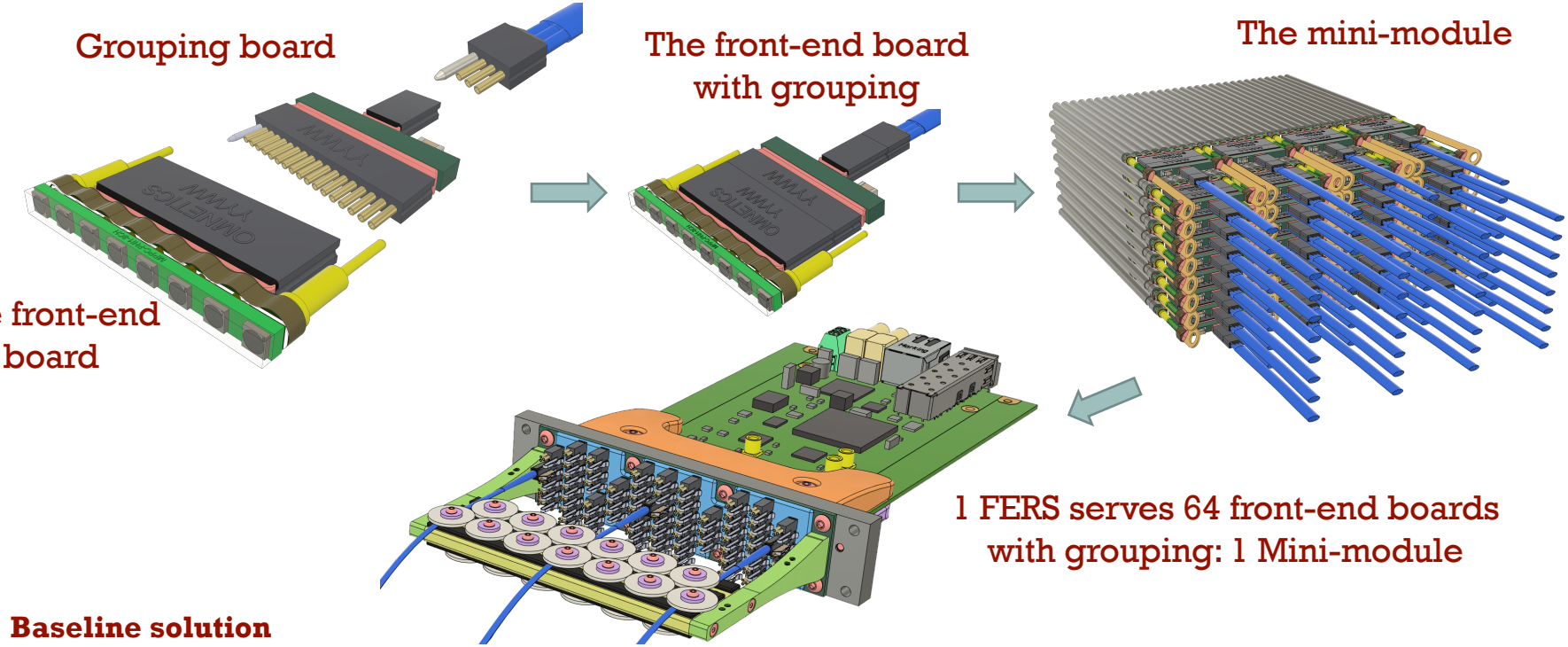


- 16 modules in total
- 2 central modules equipped with SiPMs
- 14 modules equipped with PMTs
- ~ 65 x 65 x 250 cm^3

The challenge:

We have10240 SiPMs, fitting the back side of the detector

FEE-board and cabling



Baseline solution

- Each bar of SiPMs will be operated at the same voltage
- The signals from 8 SiPMs is summed up in the grouping board
- 1 FERS operates the full mini-module
- 20 FERS to operate the central part of the prototype

Calorimetria Dual Readout

- Le attività per il 2023 saranno incentrate sulla qualifica dei nuovi SiPM e sull'integrazione del readout
- Partecipanti della sezione di Milano
  - Massimo Caccia
  - Romualdo Santoro
  - Agnese Giaz
- Hydra2 Gr5
  - PI: Roberto Ferrari (Pavia)
  - Massimo Caccia (Responsabile WP2 – Light Sensors)
  - Romualdo Santoro (Responsabile WP2 – FEE and DaQ development)
    - Responsabile Locale
- Richieste RD_FCC per la calorimetria
  - 4 keuro per Test-Beam

Sintesi richieste RD_FCC

Progetto	
Positron Source	1.5 keuro (missioni)
Pixel	10 keuro (missioni test beam) 5 keuro (consumo ARCADIA setup) 5 keuro (onsumo ATLASPIX3 modules)
Calorimetro	4 keuro (missioni test beam)
Totale Servizio Meccanica	2 MU (Supporto per i test beam)
Totale Servizio Elettronica	4 MU (attività sugli ibridi di ATLASPIX3) 2 MU (Supporto per i test beam)

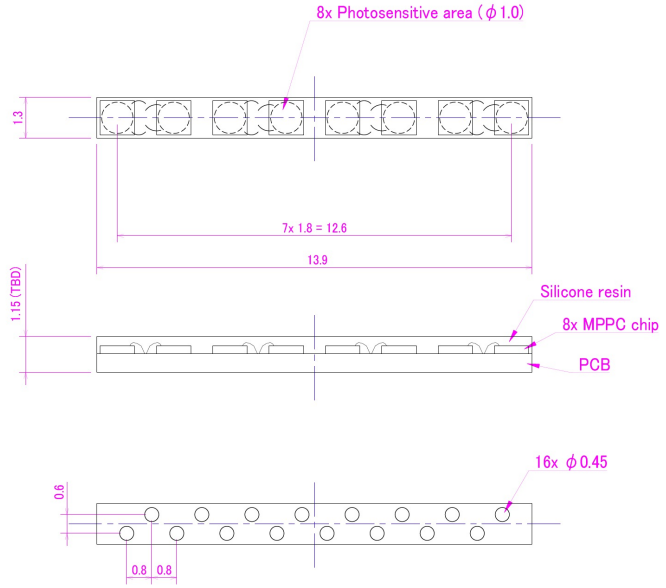
Sintesi anagrafica RD_FCC

Dipendente / Associato	Percentuale totale	Commenti
Attilio Andreazza	30%	
Alberto Bacci	5%	
Francesco Broggi	5%	
Massimo Caccia	50%	Sinergica con Hydra2
Illya Drebot	5%	
Agnese Giaz	50%	Sinergica con Hydra2
Romualdo Santoro	50%	Sinergica con Hydra2

Backup

SiPM readout

Custom SiPM module from Hamamatsu



- Custom designed module with 8 SiPMs (1x1mm^2)
- Distance between SiPMs: 2mm
- Two options under study: 10 and 15 μm pitch
- We are waiting the delivery of a first batch of 20 modules for qualification

FERS readout system

Tested on beam

FERS: A5202

- Two Citiroc1A for reading out up to 64 SiPMs
- One (20 – 85V) HV power supply with temperature compensation
- Two 12-bit ADCs to measure the charge in all channels
- Timing measured with 64 TDCs implemented on FPGA (LSB = 500 ps)
- 2 High resolution TDCs (LSB = 50 ps)
- Optical link interface for readout (6.25 Gbit/s)