Update on the status of the TIC project

Nicola Mori

INFN Florence

6th HERD workshop – Beijing (CN), 27th March 2018

Topics

- The TIC project
  - Brief overview
- The TIC prototype
  - Overview
  - Prototype and beam test
- Optimization studies
  - Alternative design
  - Improvements of the tracking algorithm

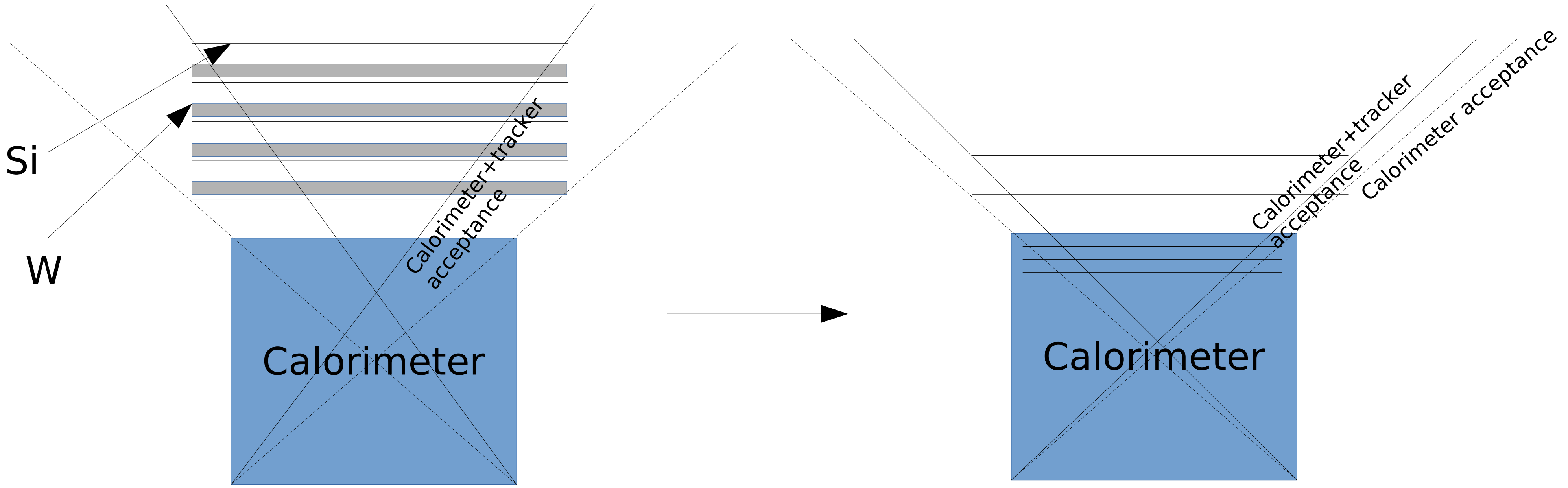
The TIC project

- Optimization of the HERD design
  - Science objectives: charged CRs, gamma rays
  - Charged: large acceptance, thin tracker
    - Statistics at high energy, particle ID
  - Gamma: tall and ~thick tracker
    - Angular resolution, conversion efficiency
  - Need a different approach than the classic one (pair-production telescope + calorimeter) to satisfy the requirements for both species

The TIC project

- The TIC idea:
  1) Use the LYSO as an active converter → remove W
  2) Sample the e.m. shower of the gamma with Si microstrips to reconstruct the track → low-profile
  3) Track charged particles with a Si/fiber tracker → low-profile

The TIC project



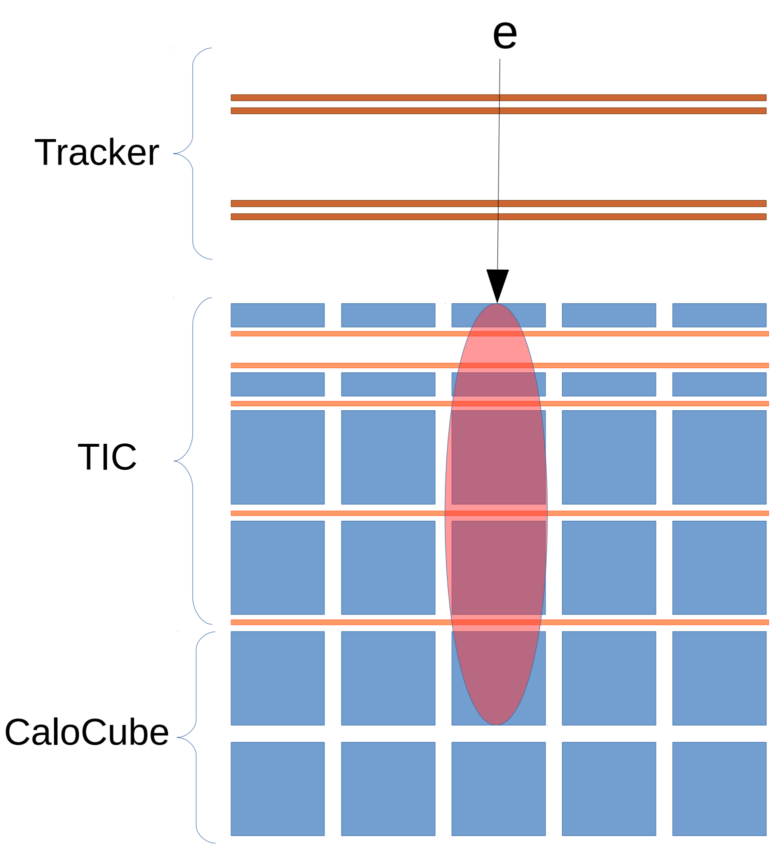
- Less passive material → Better particle ID
- Lower profile → Higher acceptance
- Overall improvement for charged

The TIC project

- Preliminary estimates already presented
  - 4^{th} and 5^{th} HERD workshops
- New results and developments (see later)
- Realization of a prototype demonstrator
  - Financed by INFN
  - Goal: prove the measurement principle and validate MC simulation
- Test beam in May-June 2018 at PS and SPS
  - 0.5 – 100 GeV electrons
  - Shower tracking $\rightarrow$ e = γ
  - Can be tracked upstream to obtain a reference track

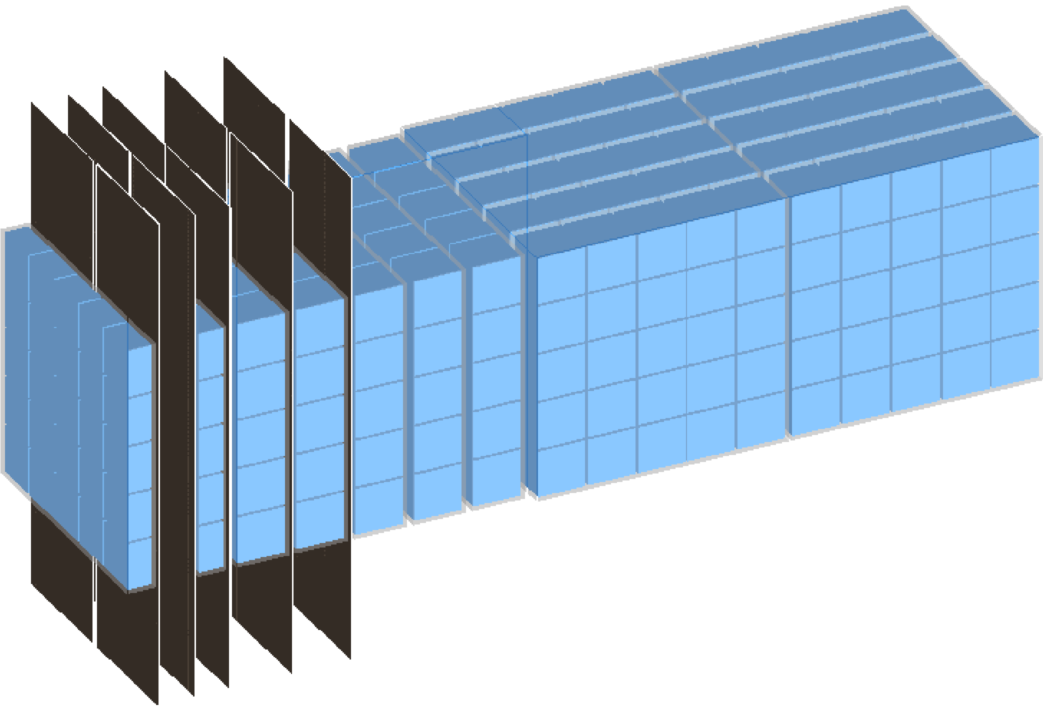
The TIC prototype

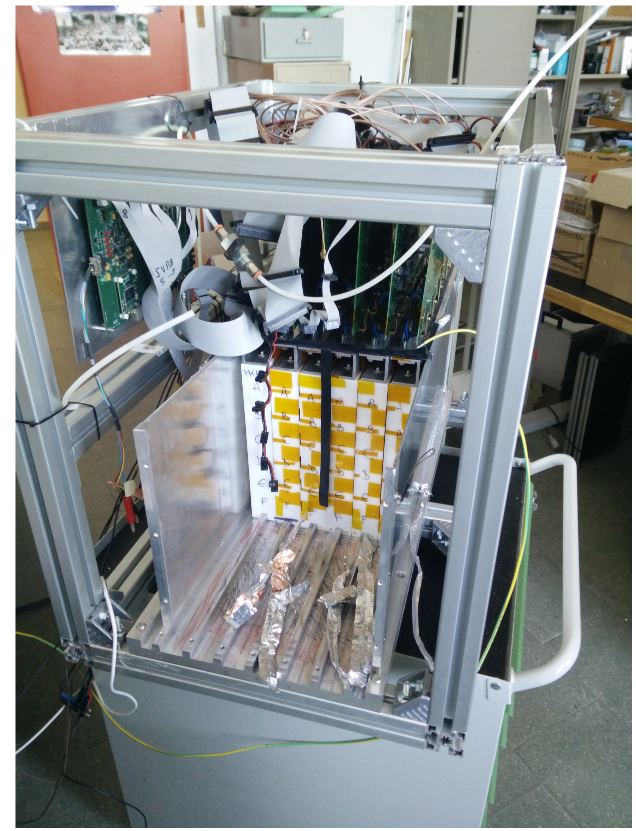
- Built upon the CaloCube prototype by adding spare DAMPE ladders
  - Plus upstream tracker (spare AMS ladders)

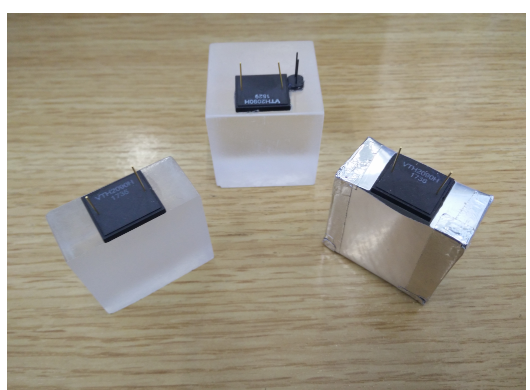


- **CsI crystals**
  - Front: 3.6x3.6x1.8 cm^3
    - Thin layers to reduce MS → low energies
  - Back: 3.6x3.6x3.6 cm^3
  - Layer: 5x5 crystals
  - Photodiodes readout
- **Si microstrip detectors**
  - Pitch: 240 μm
  - Thickness: 320 μm
  - Length: 38 cm
  - Width: 9.5 cm
  - One sided
  - Layer: 2 sensors
    - Segmentation only along X
    - Lack of availability

The TIC prototype





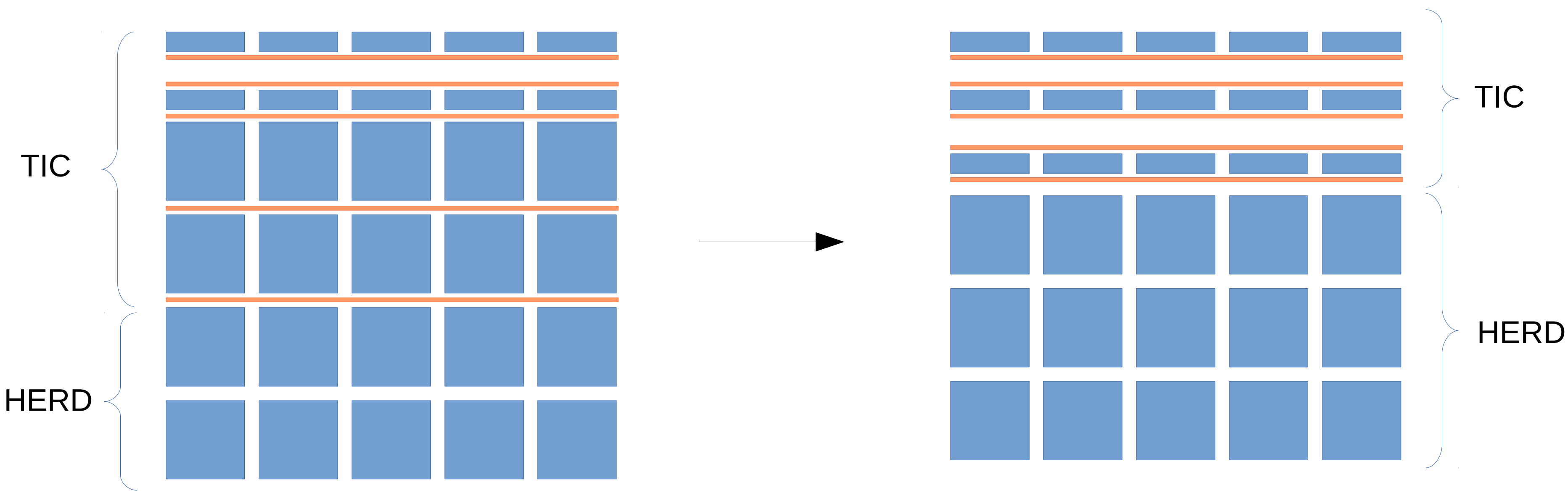


The TIC prototype

- Current status and schedule:
  - Thin crystals: ~ ready
  - Installation of photodiodes and wrapping in vikuiti: next week
  - Adjustment of front trays (longitudinal → transversal): in progress
  - Supports for Si ladders: in progress
  - Integration: ~ mid of April

Optimization studies

- Add more thin crystals to improve performance at low energy
  - more “tracker with active converter”-like



Prototype-like design

- Lighter
- Thinner
- Easier to integrate

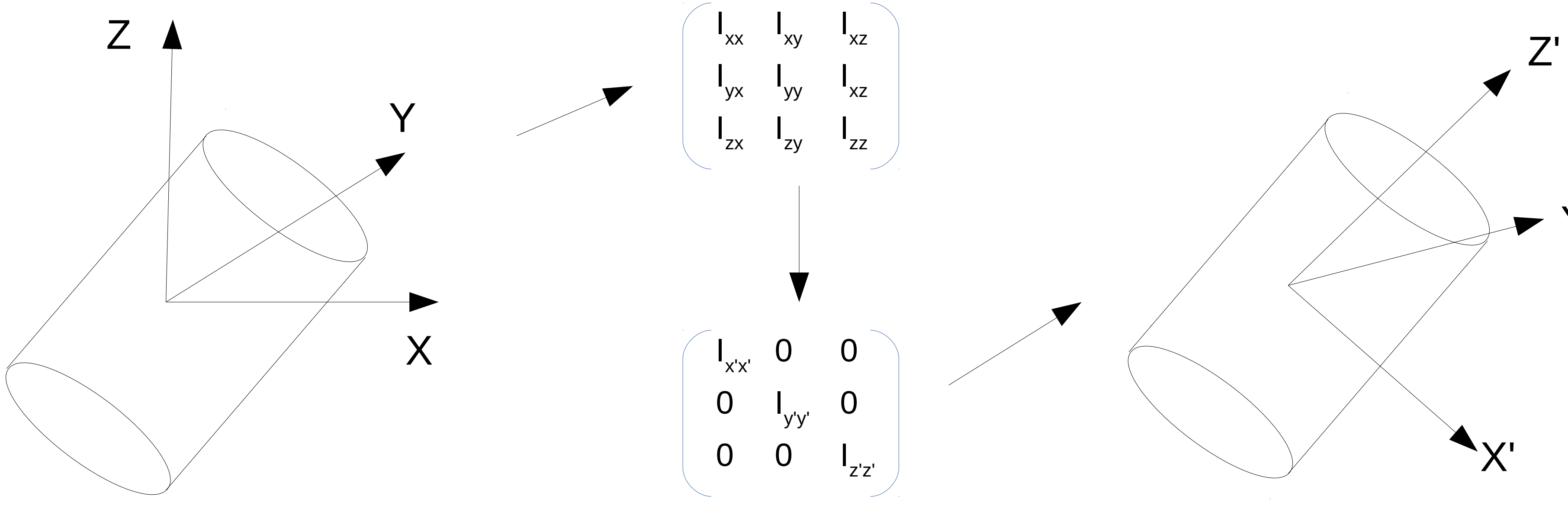
Optimization studies

- Iterative reconstruction algorithm:
  1) Track using only crystals
     1) Find “points” by mean of COG-like algorithm and fit track
     2) Obtain position resolution of crystal track on each Si layer
  2) Track using weighted Si signals
     1) For each event estimate the shower impact point by using scint. track
     2) Weight Si energy deposits with position resolution function for scint. track to suppress outliers
     3) Find points (COG of weighted releases) and fit track
     4) Obtain position resolution of Si track on each Si layer
  3) Iterate tracking with Si

     But using Si tracks and resolution from previous steps instead of scint. ones

Optimization studies

- Alternative tracking algorithm:
  - Still rely on Si hits weighting and iterations
  - Find track by diagonalizing the matrix of the momenta of weighted hits
  - Mechanical analogy: finding the principal axes of inertia of a rigid body



Optimization studies

- For showers, use energy deposits instead of masses to build the “inertia tensor”
- Diagonalize the tensor
- The eigenvector corresponding to the minimum eigenvalue is the direction of the shower axis
  - Like the momentum of inertia of a long cylinder along the main axis is less than those along the other axes
- Stick the axis to the 3D COG of the shower

* Less sensitive to track inclination
* Currently under study

Summary

- TIC might be of valuable help in balancing the HERD performance
  - Detect and track gamma rays without sacrificing geometric factor and PID for charged particles
- A prototype of TIC is currently being built
  - Validate the measurement principle and MC results
  - Test beam in May-June at CERN (PS and SPS)
- Optimization studies are ongoing
  - Simpler, lighter design for integration in HERD
  - New tracking algorithm