DE LA RECHERCHE À L'INDUSTRIE

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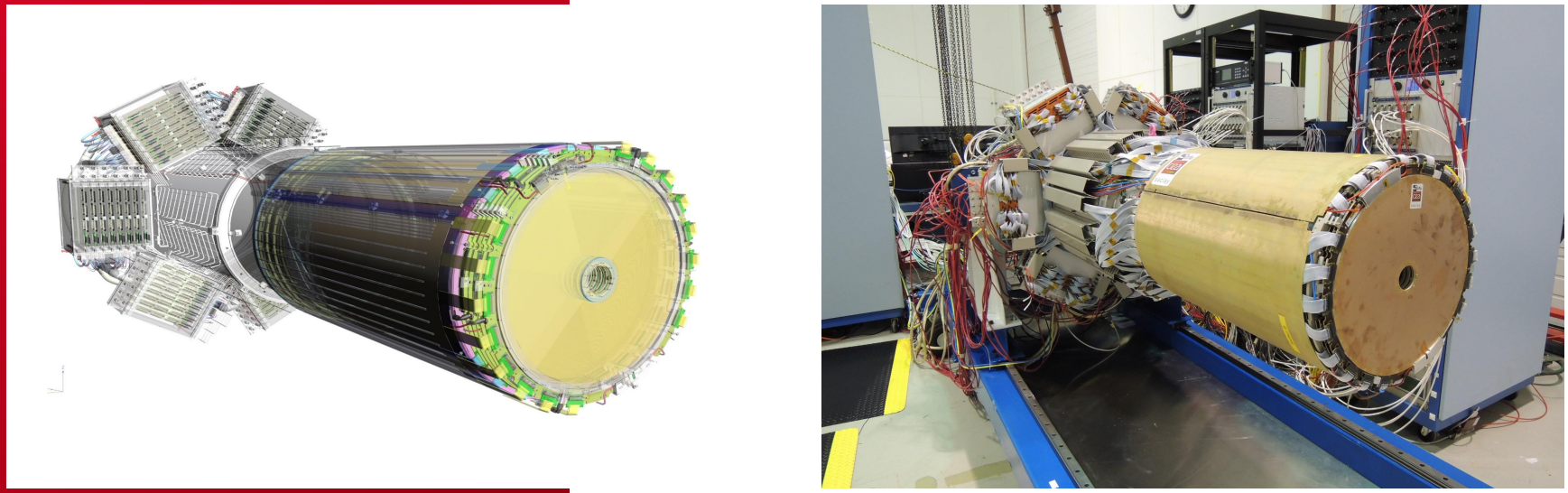
Micromegas Vertex Tracker



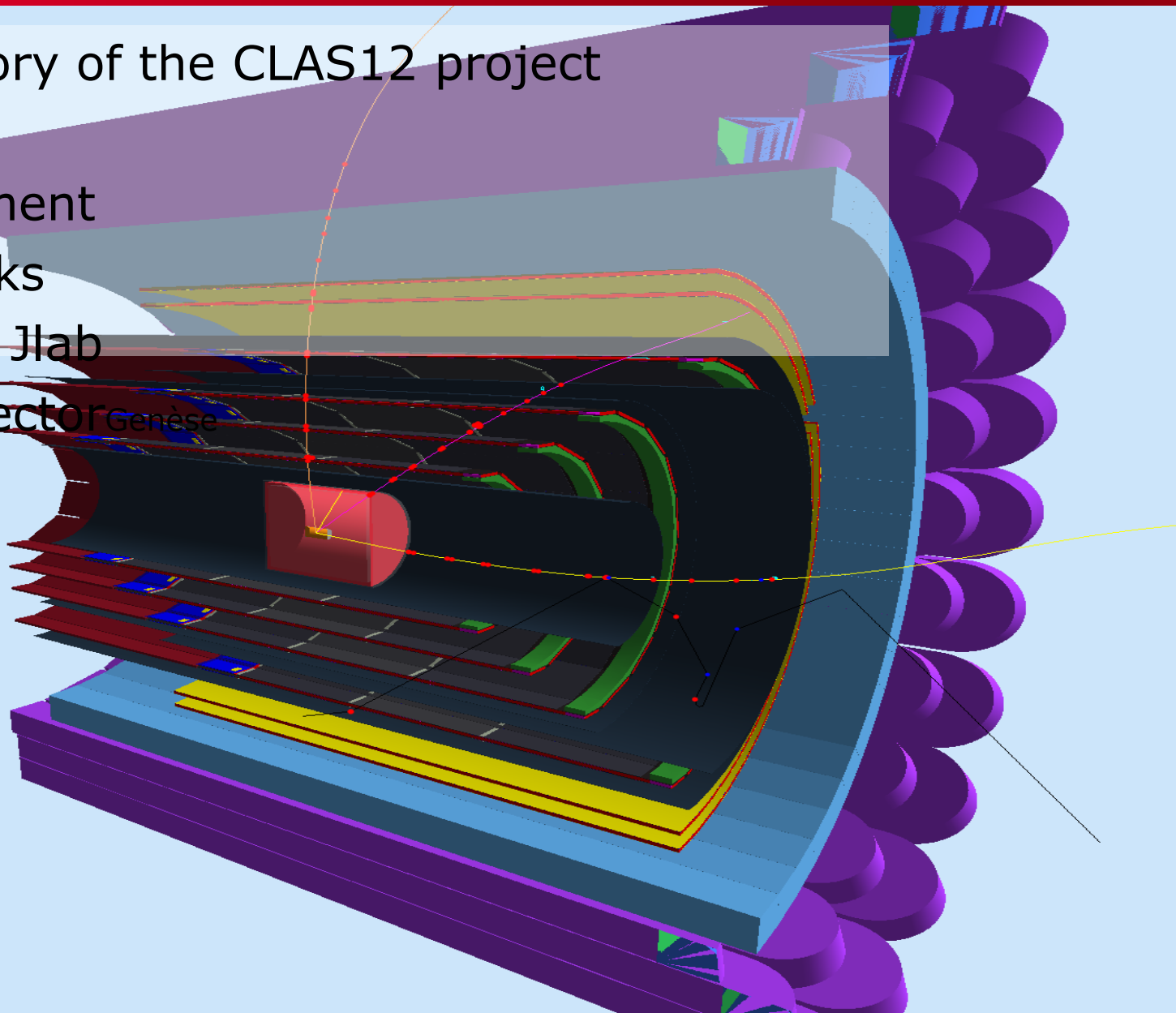
S. AUNE, M.DEFURNE, F. SABATIE

05/10/2023

On the track of MVT

A brief history of the CLAS12 project

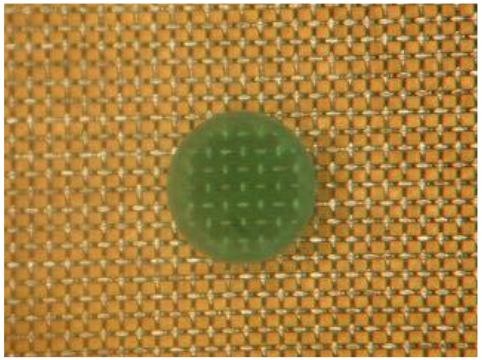
- Genesis
- Development
- First tracks
- Physic @ Jlab
- Next detector



MICROMEGAS AND THE BULK REVOLUTION *2005*

The Bulk, a revolution for Micromegas
The fragile microgrid, the heart of the detector, is anchored to the charge-collection PCB by a forest of pillars: Detector reliability

Schématique de fabrication bulk

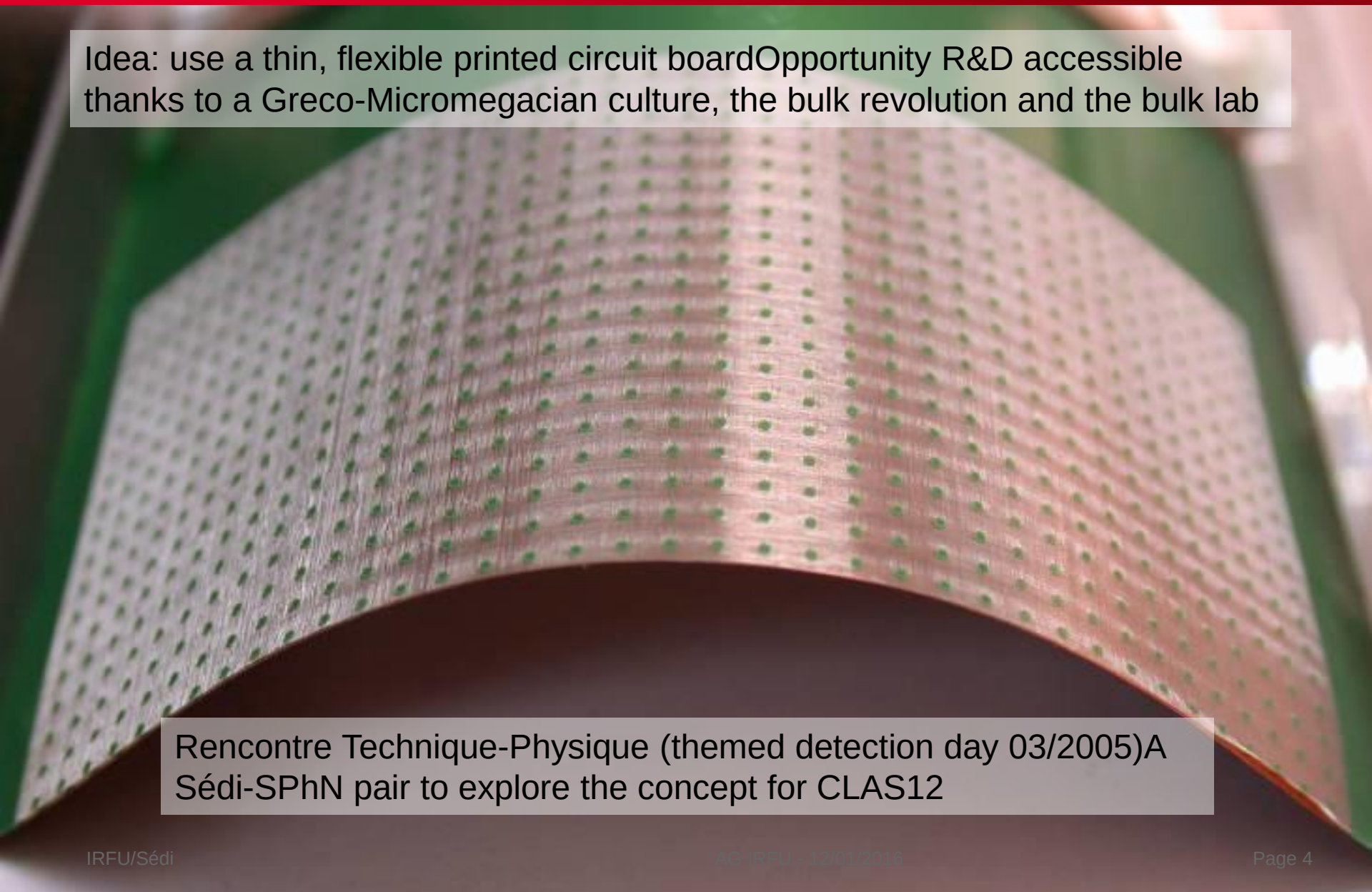


Micro grille prise dans un pilier

In 2005, a mini-bulk lab was set up at SédiR&D and development of processes for prototyping, industrialization of bulk,and ...improvised tests...

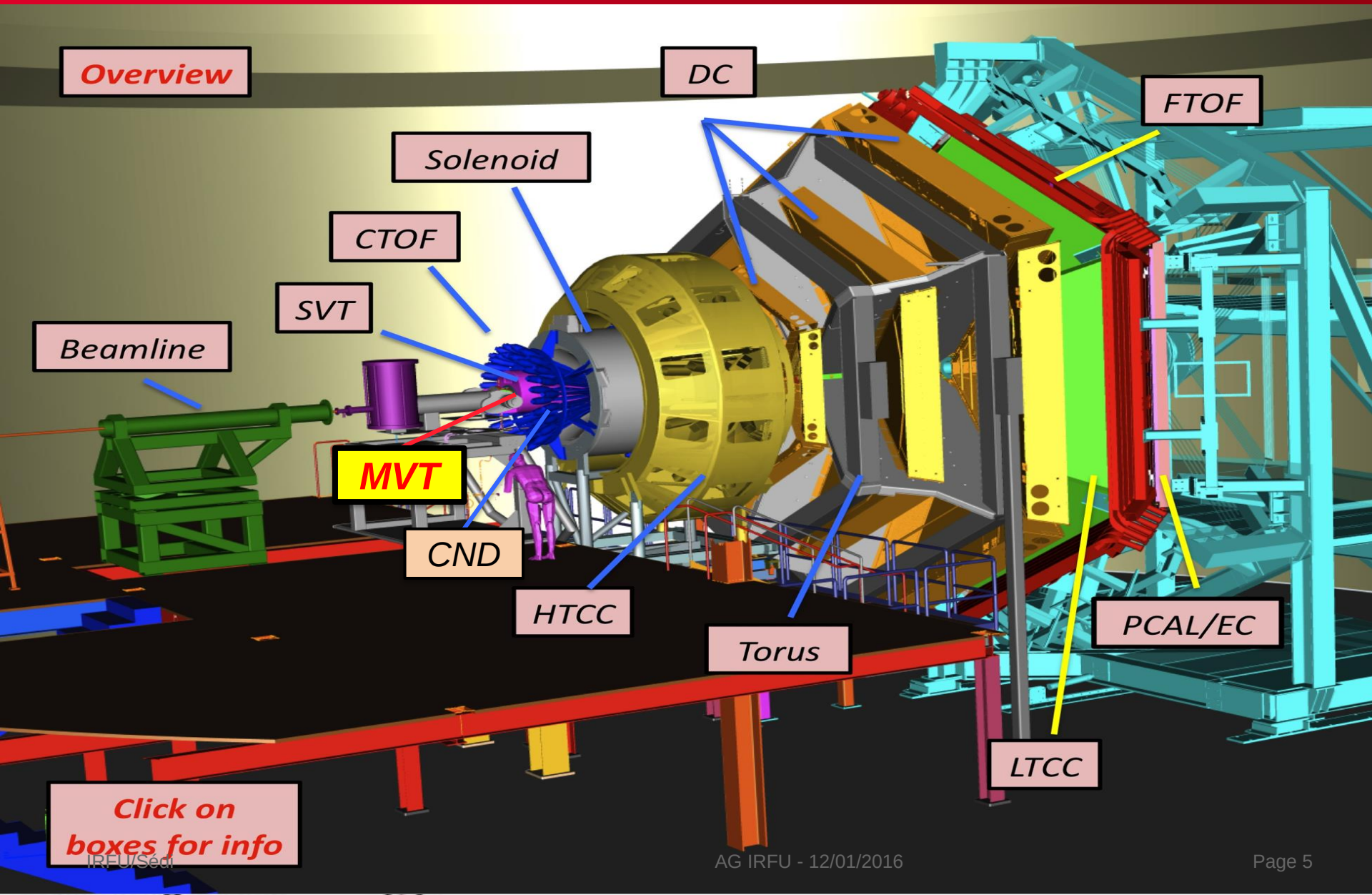
LA GENÈSE DE L'ÉPOPÉE COURBE (2005)

Idea: use a thin, flexible printed circuit boardOpportunity R&D accessible thanks to a Greco-Micromegacian culture, the bulk revolution and the bulk lab



Rencontre Technique-Physique (themed detection day 03/2005)A Sédi-SPhN pair to explore the concept for CLAS12

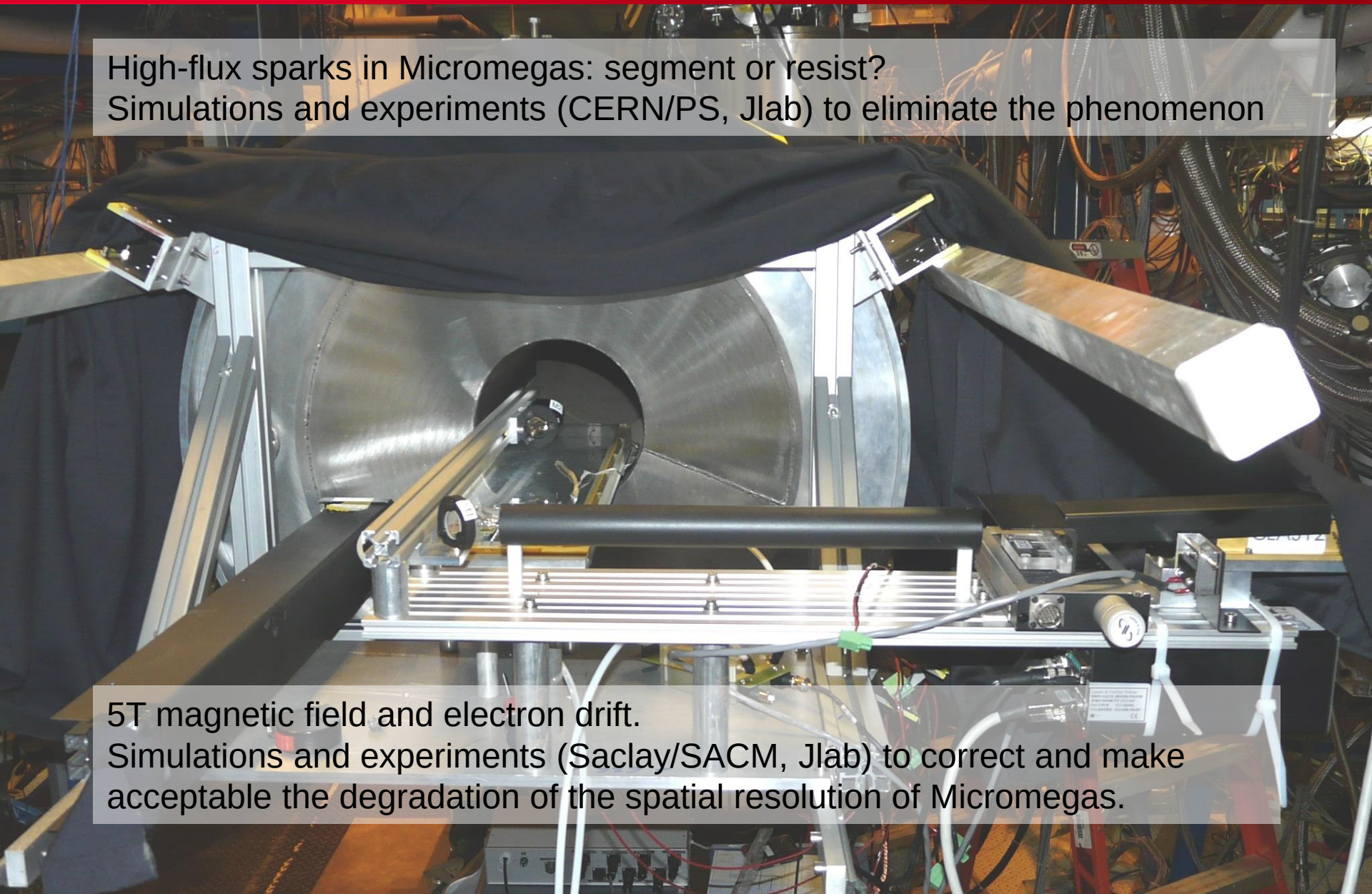
CLAS12 @ JLAB


Overview
DC
FTOF
Solenoid
CTOF
SVT
Beamline
MVT
CND
HTCC
Torus
PCAL/EC
LTCC
Click on boxes for info

CURVED R&D, SEDI-SPHN

2-year R&D on MicromegasRadius of curvature, material, work on detection performanceMechanical support with drift on joint and pillar. Remote electronics with 0.8 m dab.Project green light in 2007

MICROMEGAS IN THE VERTEX TERRA INCOGNITA

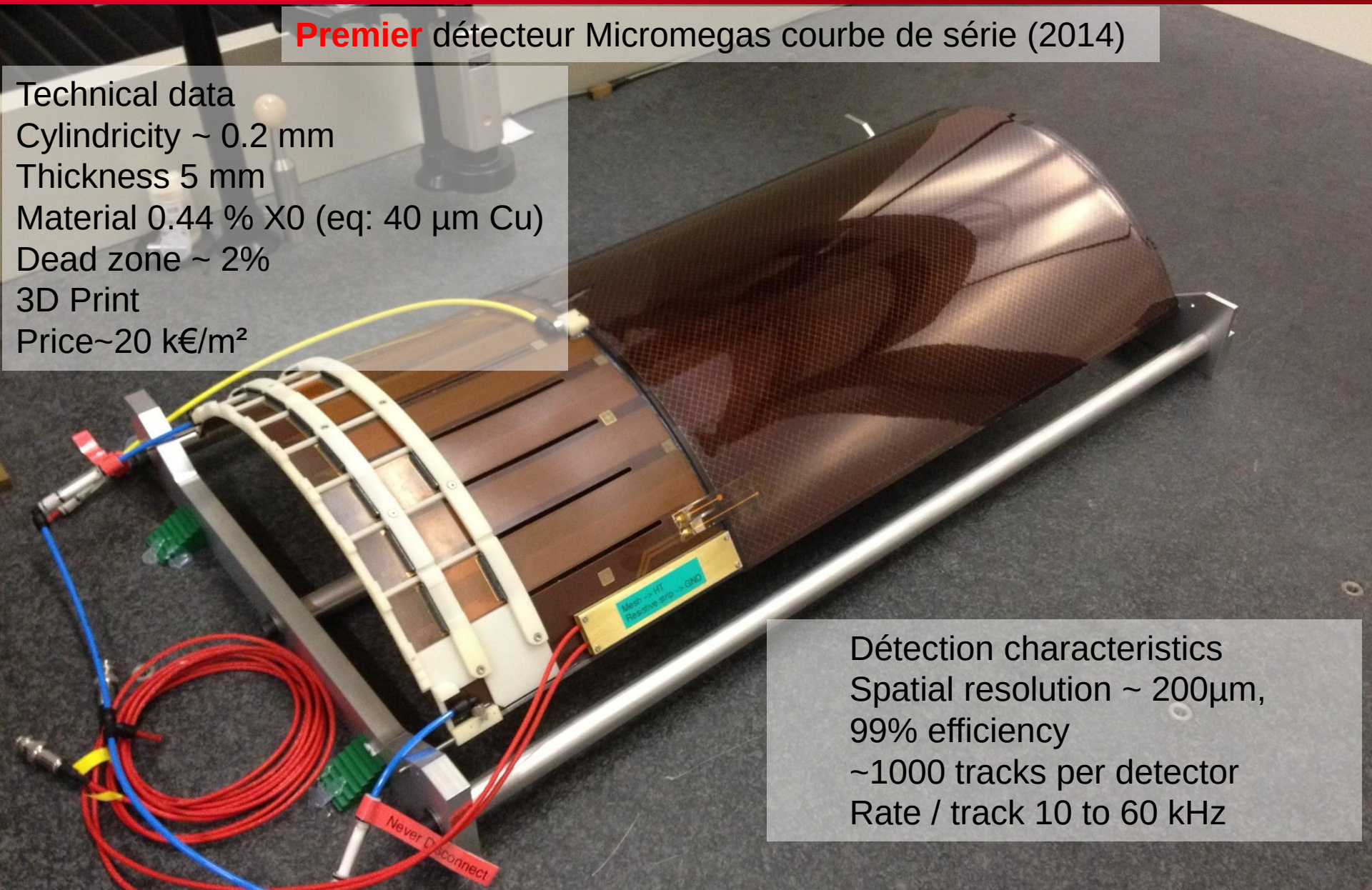


High-flux sparks in Micromegas: segment or resist?
Simulations and experiments (CERN/PS, Jlab) to eliminate the phenomenon

5T magnetic field and electron drift.
Simulations and experiments (Saclay/SACM, Jlab) to correct and make acceptable the degradation of the spatial resolution of Micromegas.

First micromegas tile

Premier détecteur Micromegas courbe de série (2014)

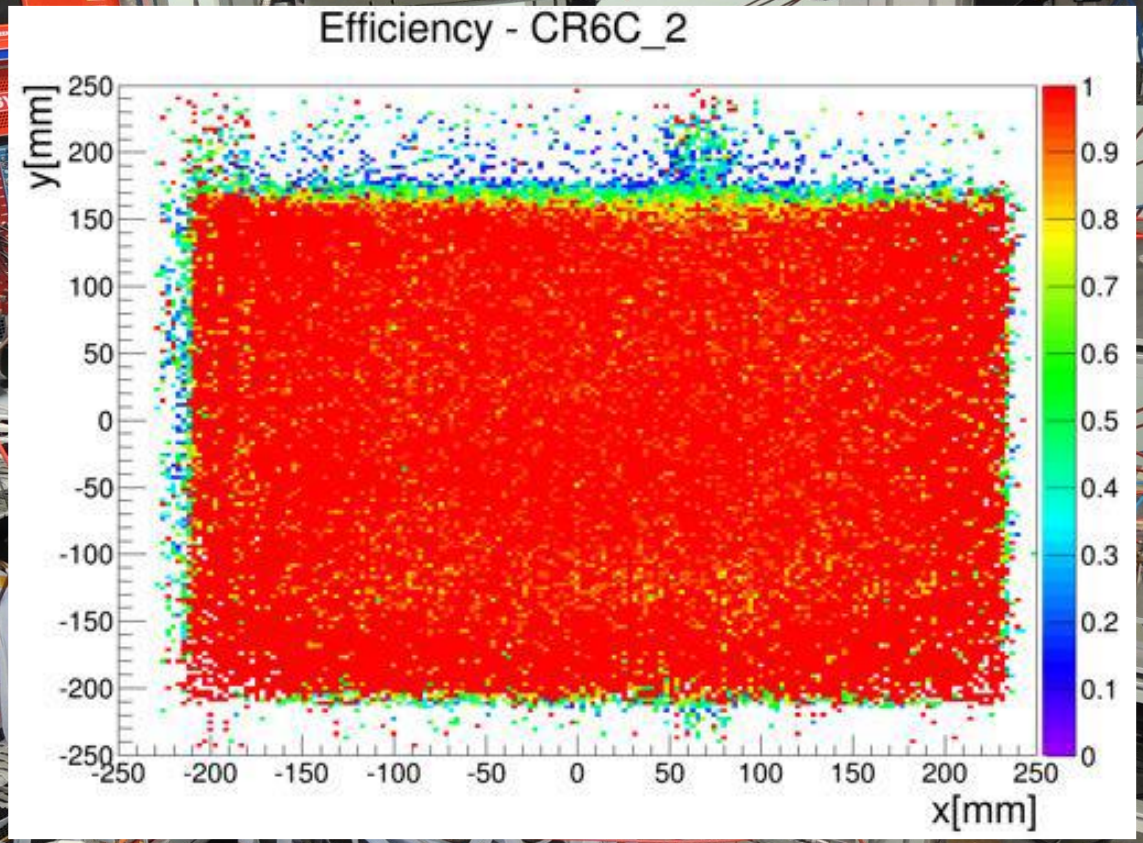


Technical data
Cylindricity ~ 0.2 mm
Thickness 5 mm
Material 0.44 % X0 (eq: 40 µm Cu)
Dead zone ~ 2%
3D Print
Price~20 k€/m²

Détection characteristics
Spatial resolution ~ 200µm,
99% efficiency
~1000 tracks per detector
Rate / track 10 to 60 kHz

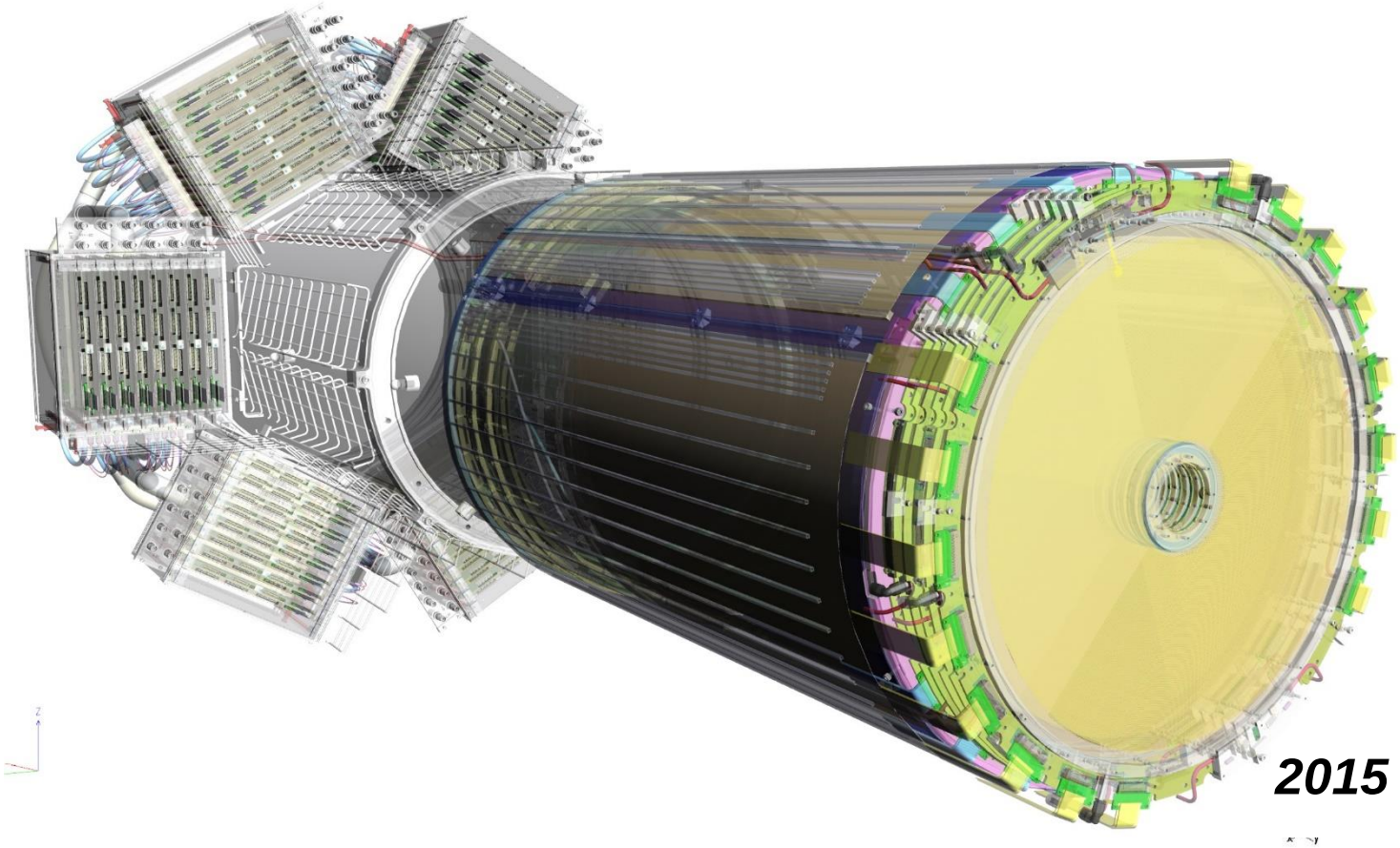
COSMIC DETECTOR

Characterization of detectors with cosmic muons Development of a cosmic bench with multiplexed Micromegas

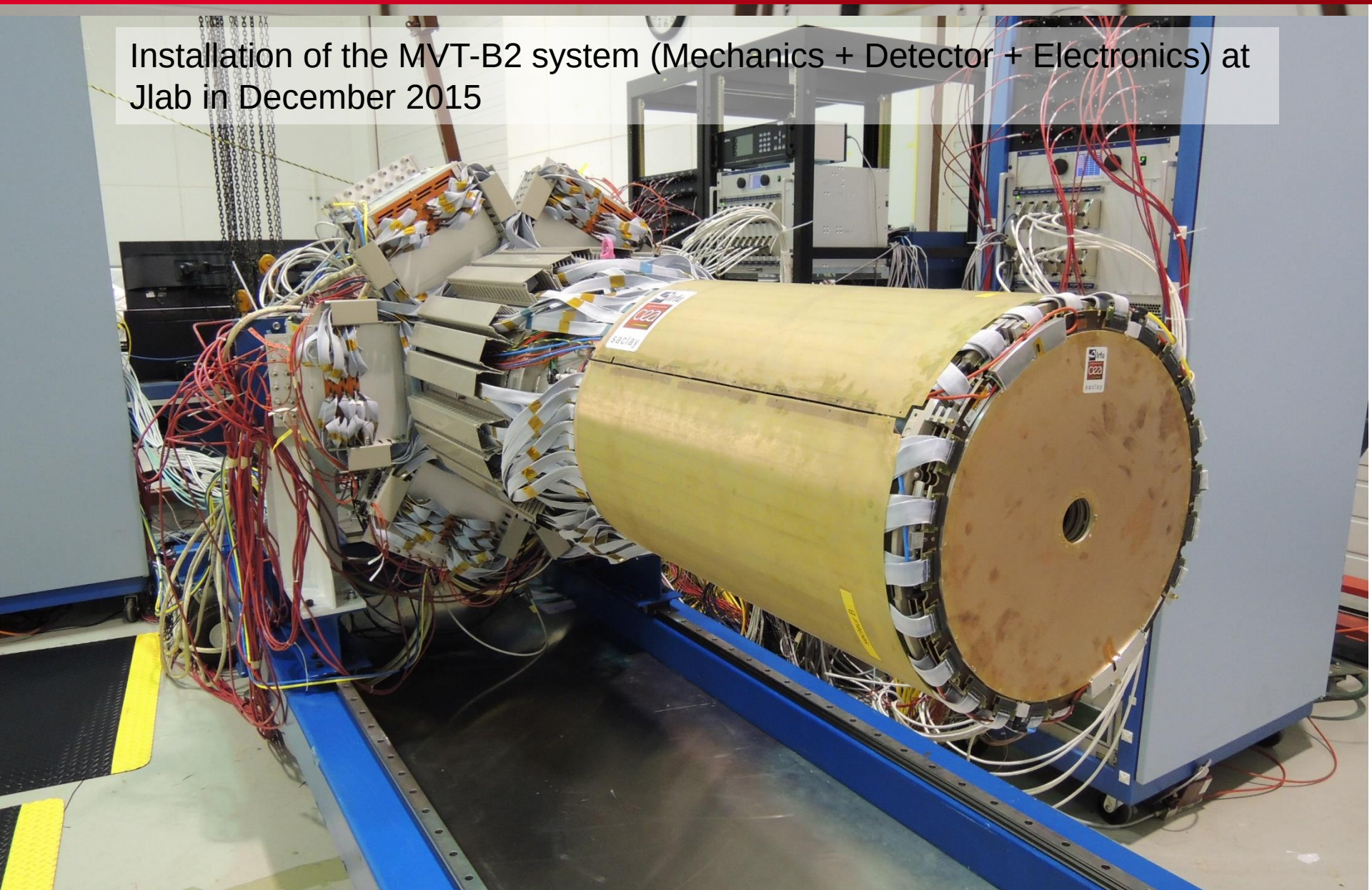


MATTER-FREE MECHANICS

Physicist's need: no material, no space, all curved.
Cylindrical Russian doll crate: evolution and simplification.
Tile detector: towards an integrated carbon frame
The hardest thing is to make it simple.



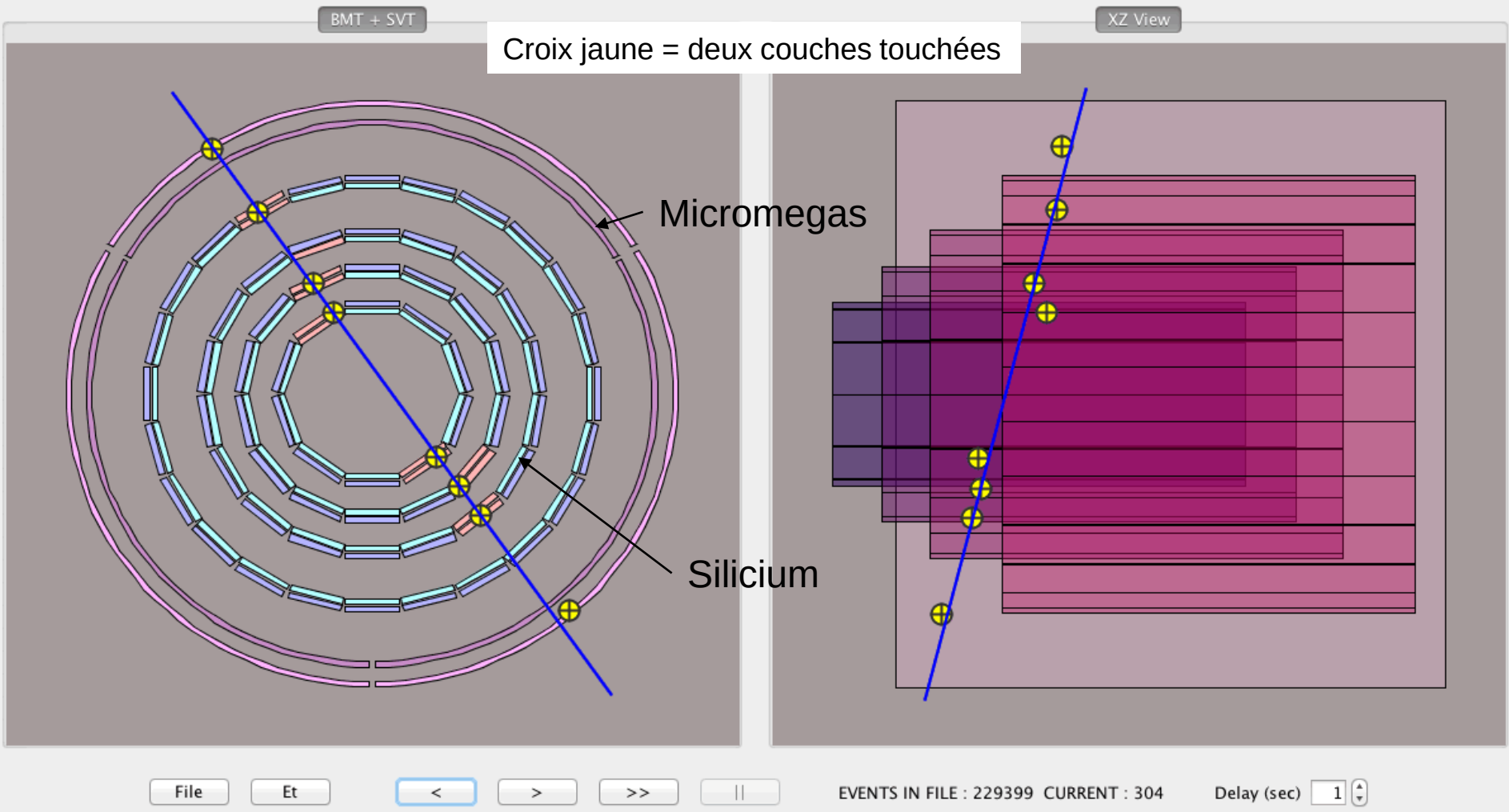
SILICIUM + MICROMEGAS: MARRIAGE FOR ALL



Installation of the MVT-B2 system (Mechanics + Detector + Electronics) at Jlab in December 2015

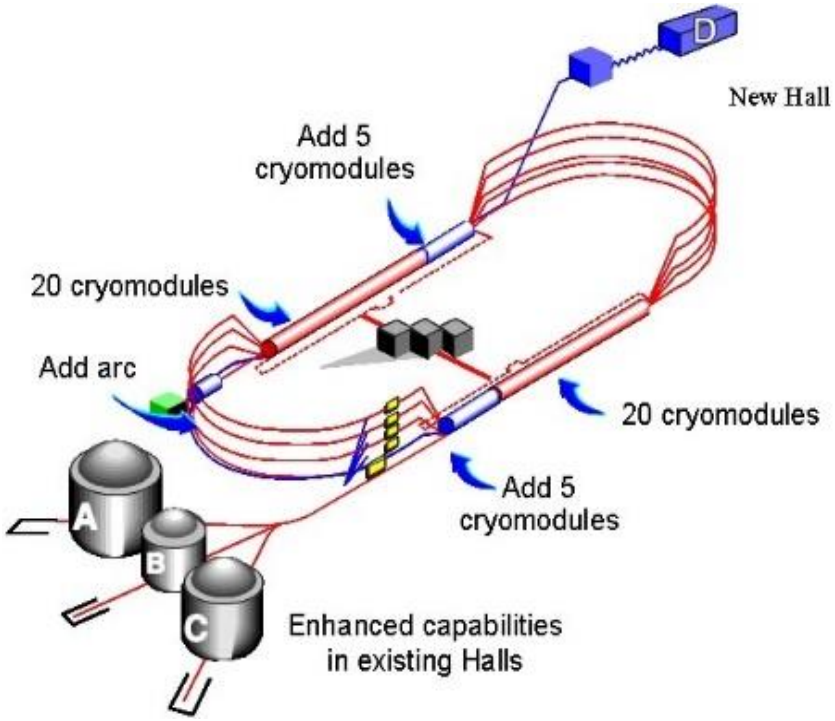
FIRST TRACKS

Reconstruction of the very first tracks in the mixed trajectograph



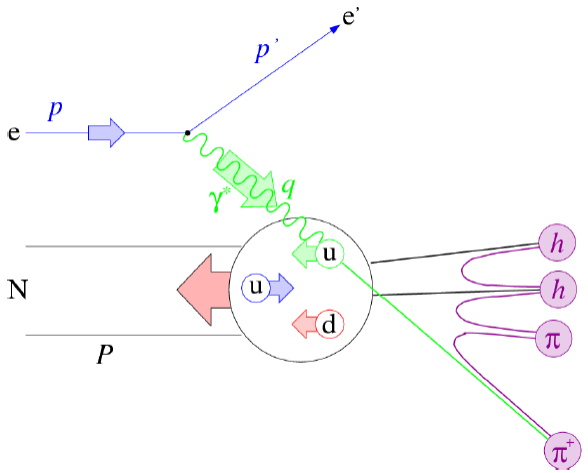
JEFFERSON LABORATORY

A 8-km electronic « femto »-scope to look inside the proton!



Beam energy from 6 to 12 GeV in 2014.

SHINING LIGHT ON QUARKS

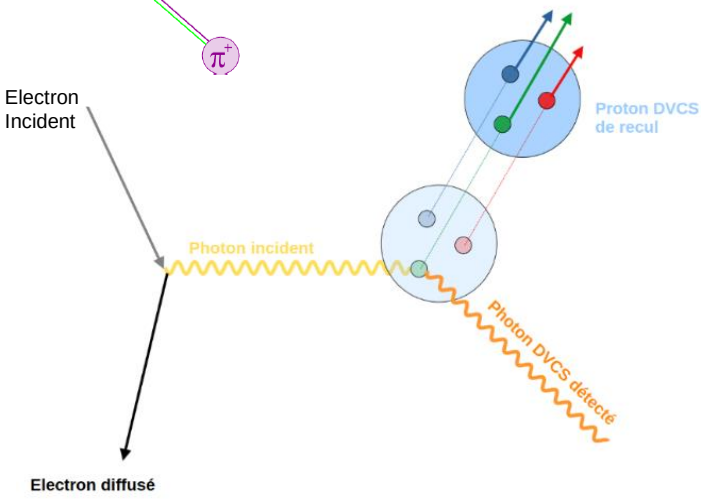


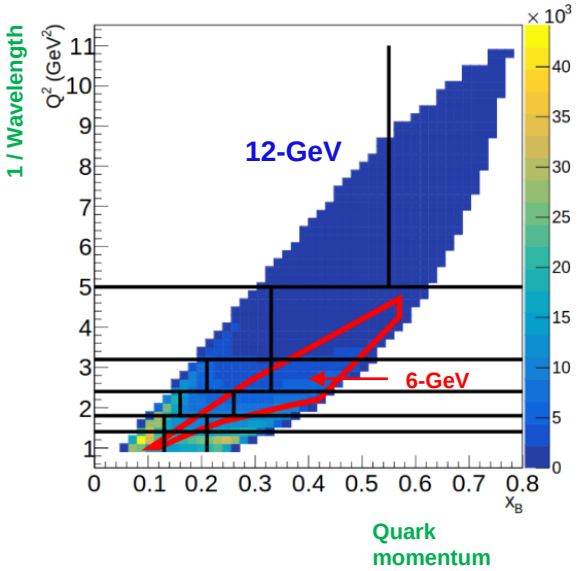
Electrons emits photon interacting with quarks in the proton.

At such a high energy, many processes happen with various information on proton.

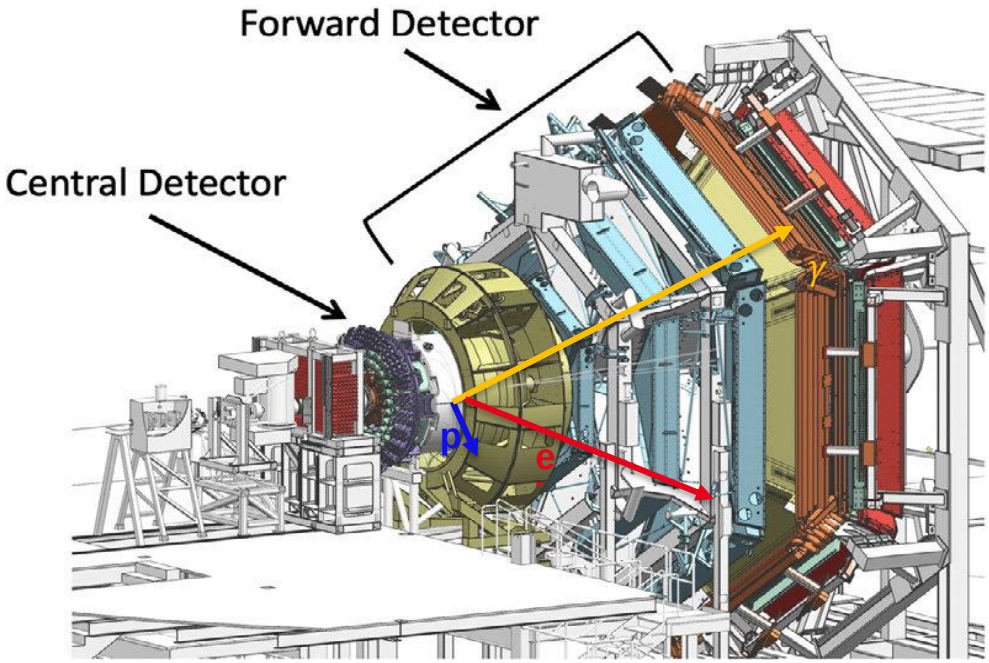
Deeply Virtual Compton Scattering (DVCS)

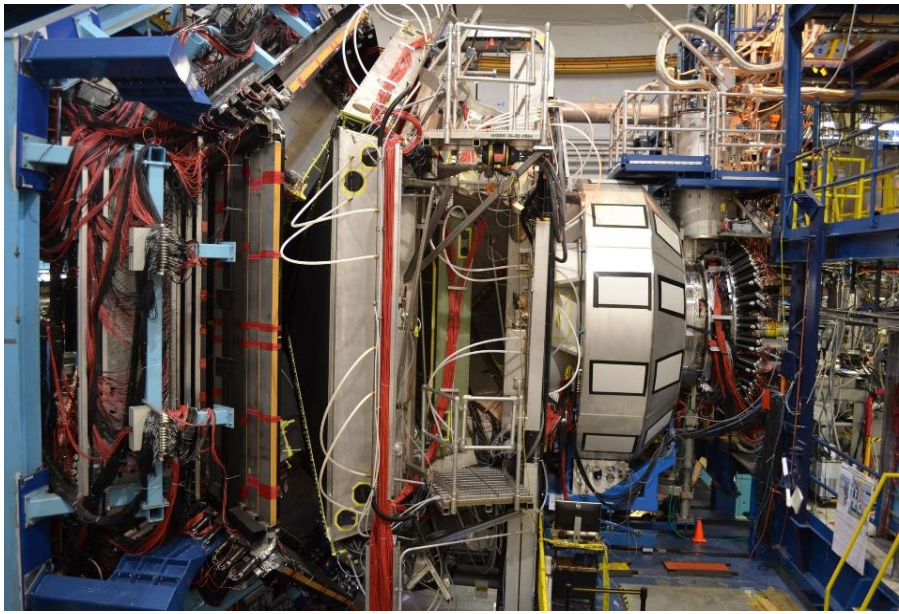
Irfu leading the DVCS program.



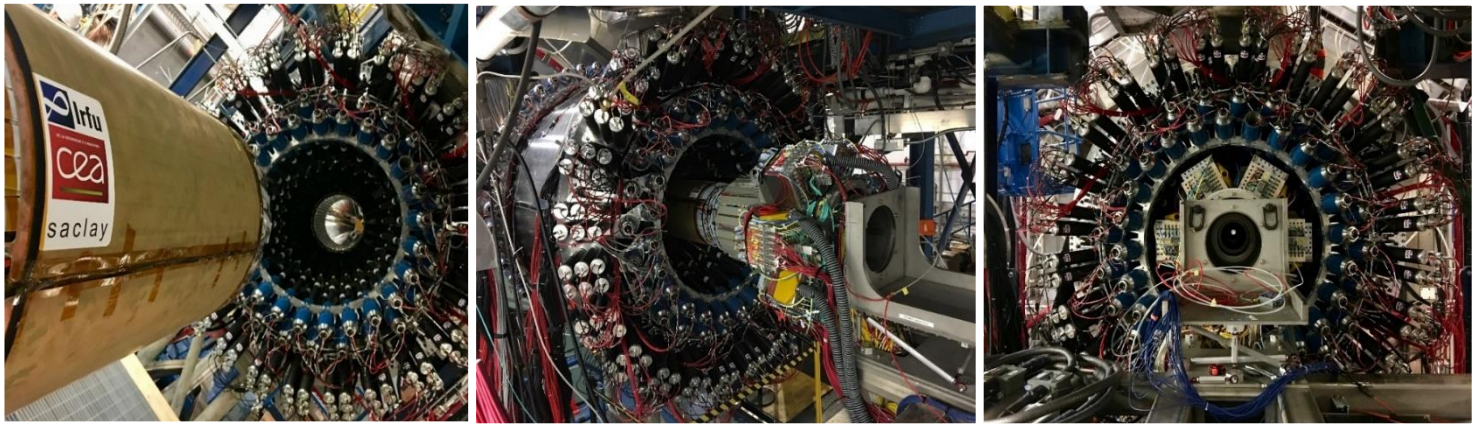


CLAS12 : A BRAND NEW SPECTROMETER





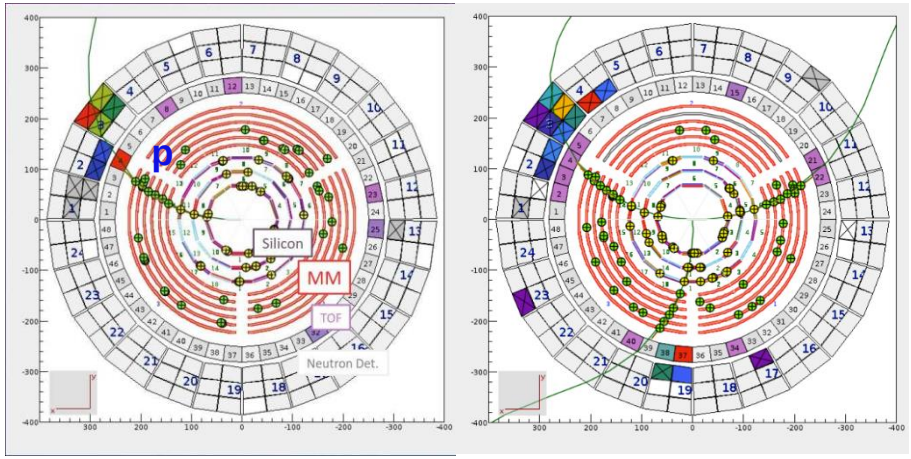
ZOOM IN THE CENTRAL DETECTOR



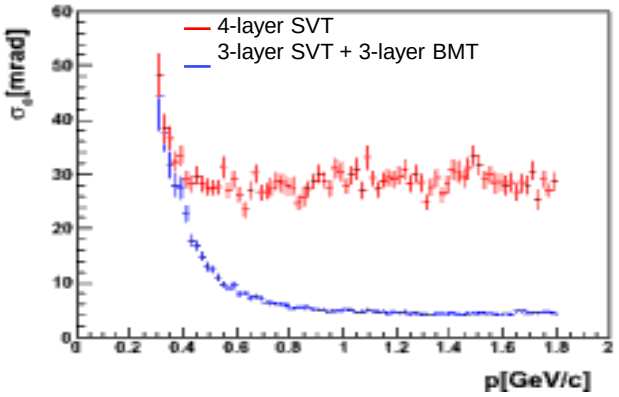
Micromegas and silicon sliding in the solenoid

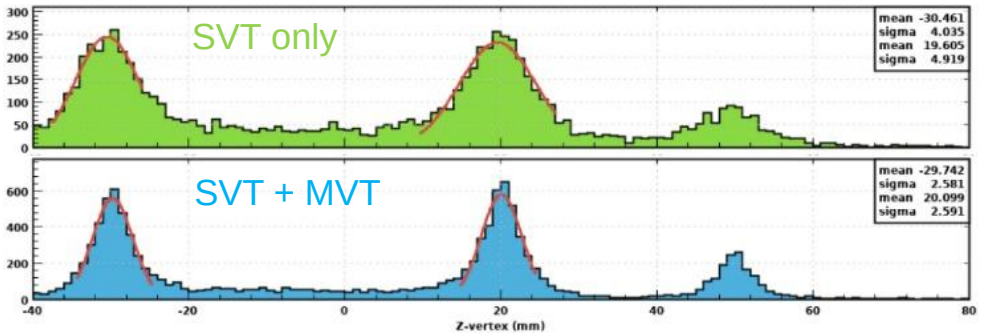
- Working in a 5T-magnetic field.
- With a much higher particle rate × 2.

Micromegas critical for track finding and resolutions!



THE DVCS ANALYSIS OR FINDING A NEEDLE IN A HAYSTACK

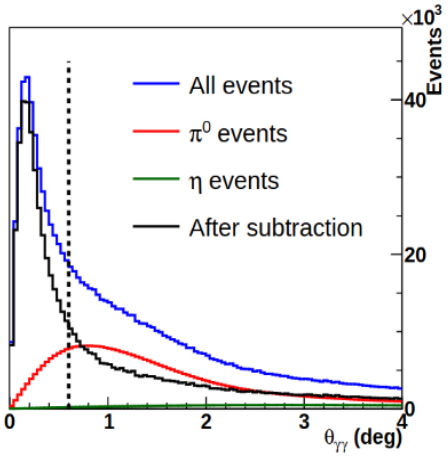




Improving the resolution on the proton helps in sorting DVCS from background.

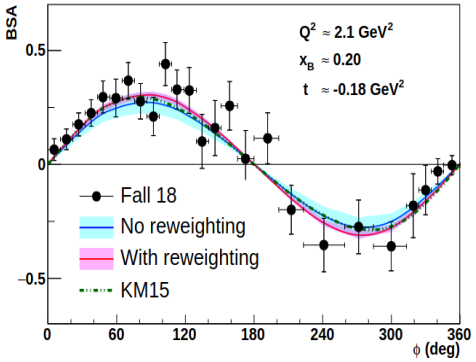
- Improved vertexing.

- Improved momentum reconstruction.

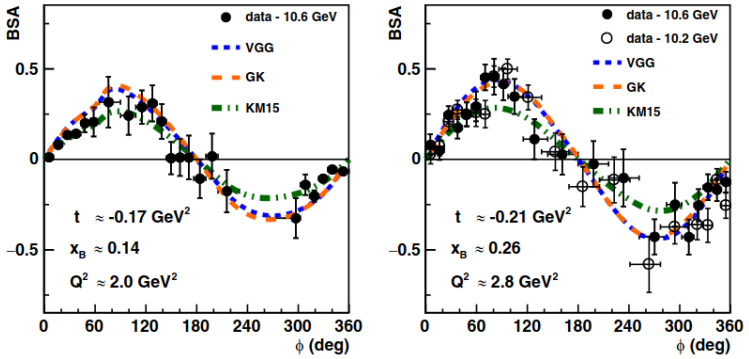


MICROMEGAS KEEPS COLLECTING DATA

DVCS results published in PRL to know more about position/momentum correlations of quarks.



More accurate results compared to 6 GeV



New results thanks to the energy upgrade.

Many more results published by CLAS collaboration thanks to Micromegas…

- many more to come as data collected the past 5 years by MVT is still being analyzed

- And MVT keeps taking data (data taking resuming today at CLAS12).

Not the case at the beginning, Micromegas have become a baseline equipment of CLAS12!

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MICROMEGAS TRACKER FOR EIC

FRANCK SABATIÉ

AND YOU'RE GLUE

Particle physics

And you're glue

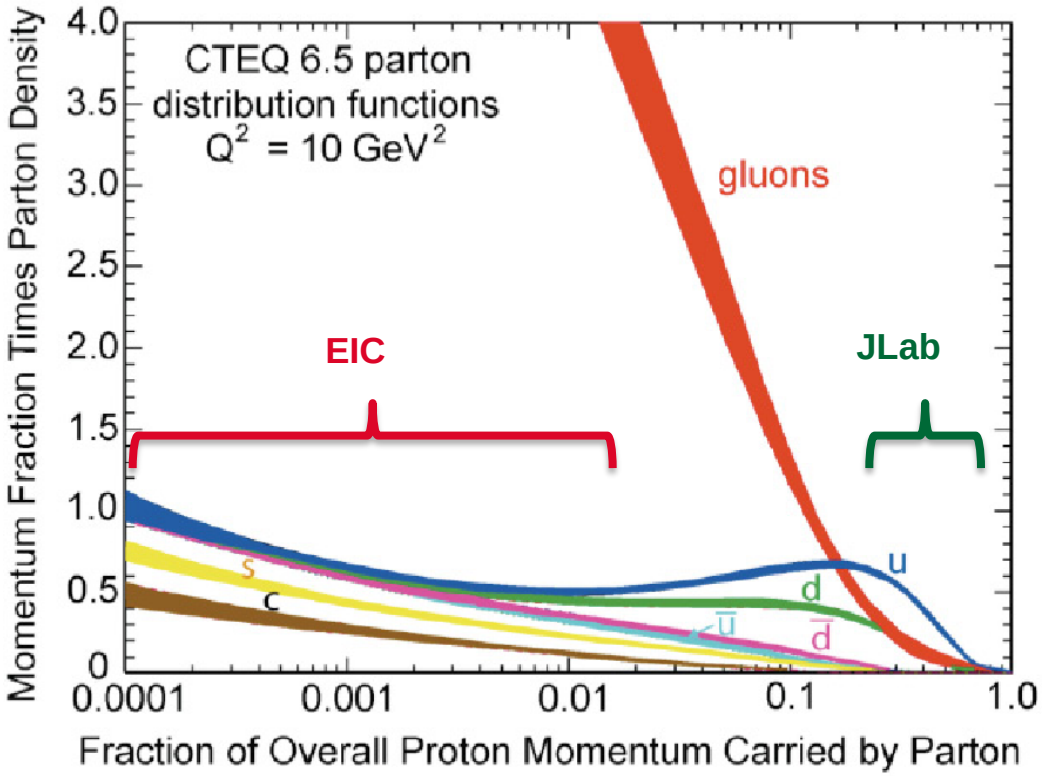
(Nobel 2004)

Frank Wilczek

It's a widely believed half-truth that protons and neutrons are made out of quarks. Actually, physicists are increasingly discovering that it's considerably less than half the truth.

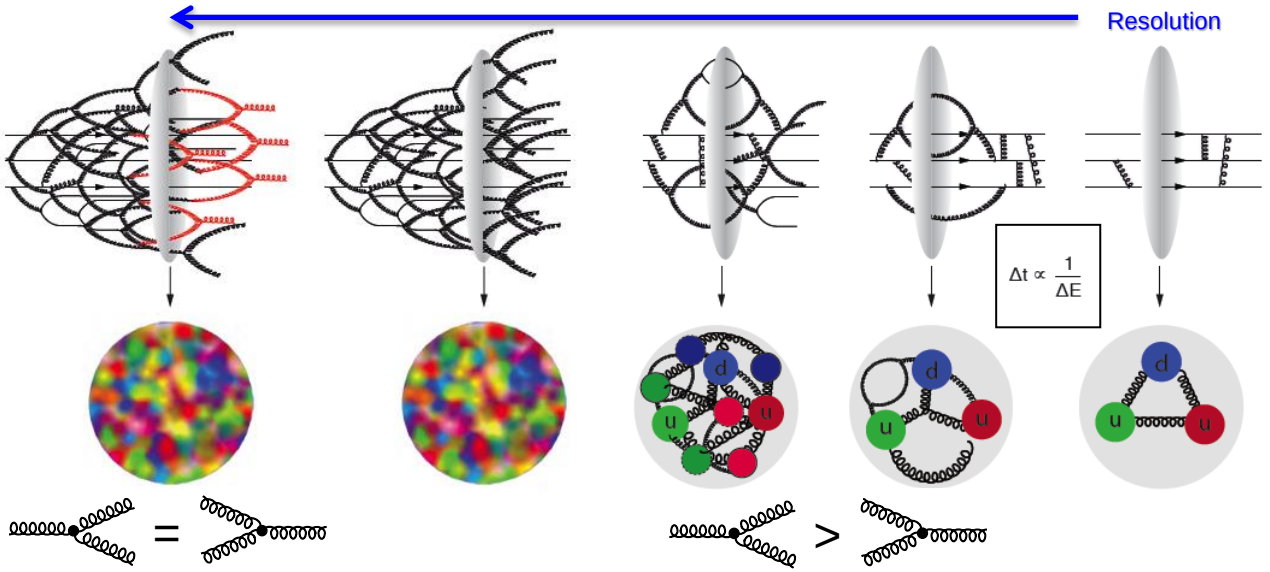
NATURE | VOL 400 |

NO, REALLY …

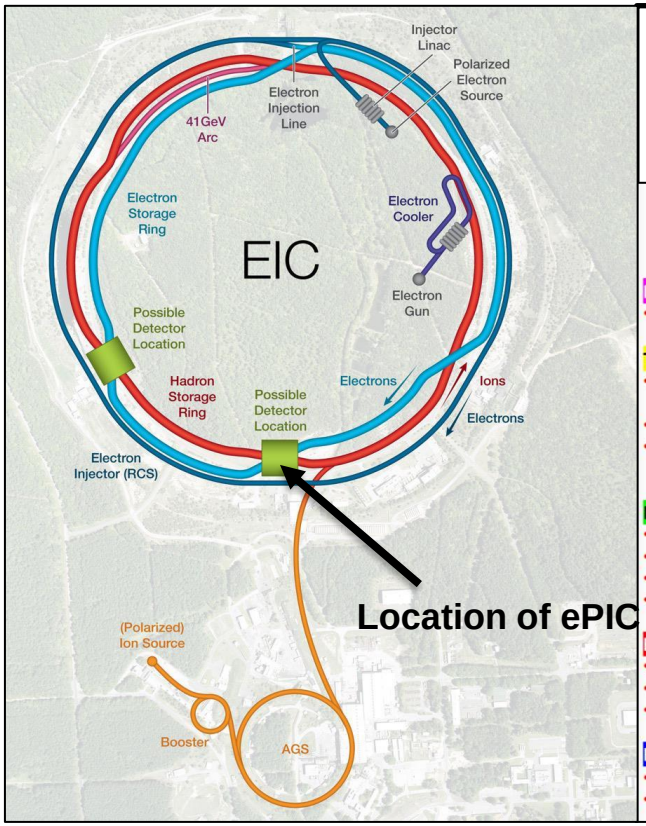


Density of gluons carrying a small fraction of the nucleon's momentum goes nuts
But … until when ?

INVESTIGATING A NEW STATE OF MATTER



THE ULTIMATE MICROSCOPE: EIC AT BROOKHAVEN



The EIC will be the first:

- High-luminosity e-p collider
- Fully polarized collider
- Electron-nucleus collider

Energy range: $29 < s < 141\ GeV$

ePIC detector design

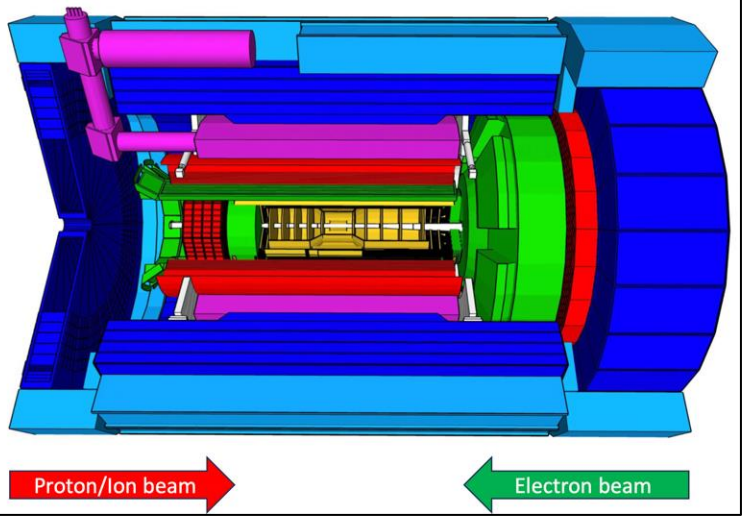
Magnet
- New 1.7 T SC solenoid, 2.8 m bore diameter

Tracking
- Si Vertex Tracker MAPS wafer-level stitched sensors (ALICE ITS3)
- Si Tracker MAPS barrel and disks
- Gaseous tracker: MPGDs (μRWELL, MMG) cylindrical and planar

PID
- high performance DIRC (hpDIRC)
- dual RICH (aerogel + gas) (forward)
- proximity focussing RICH (backward)
- ToF using AC-LGAD (barrel+forward)

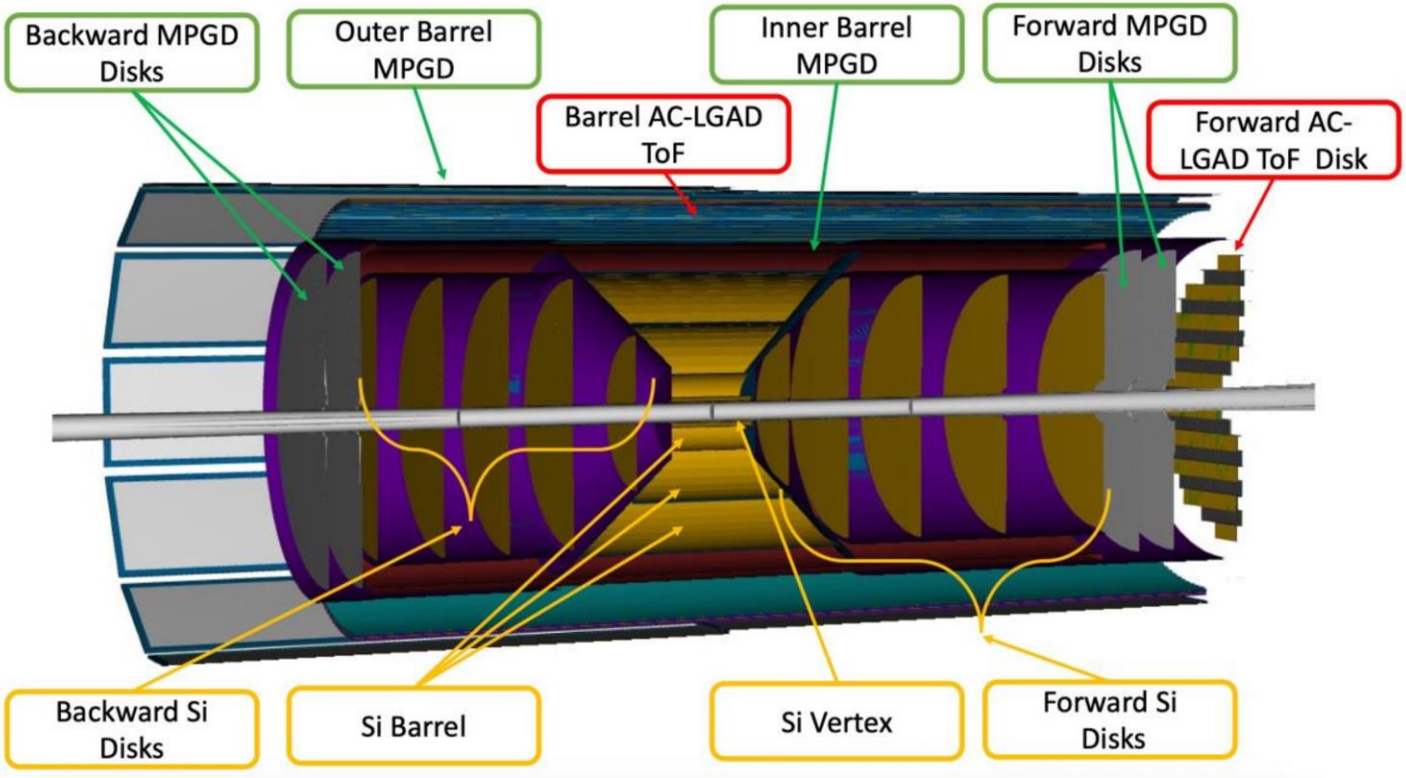
EM Calorimetry
- imaging EMCal (barrel)
- W-powder/SciFi (forward)
- $PbWO_4$ crystals (backward)

Hadron calorimetry
- FeSc (barrel, re-used from sPHENIX)
- Steel/Scint – W/Scint (backward/forward)



$2.4B project, CD-1 in June 2021, first collisions in 2031

EPIC INNER TRACKER



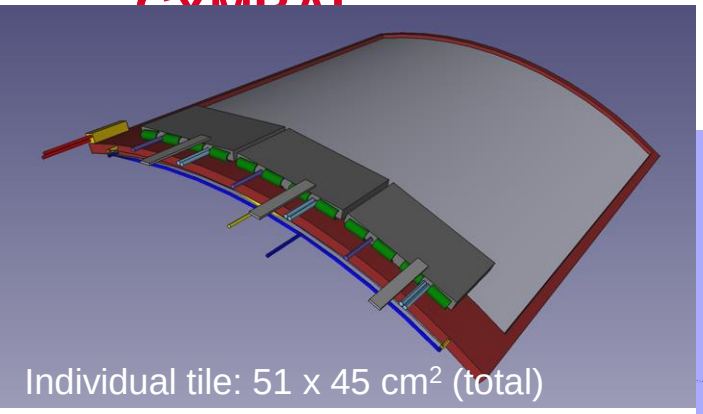
MPGDs and **AC-LGADs** provide:

- additional hit points for track reconstruction
- fast timing hits for background rejection

Courtesy of F. Bossù

MICROMEGAS TRACKER : CYMBAL

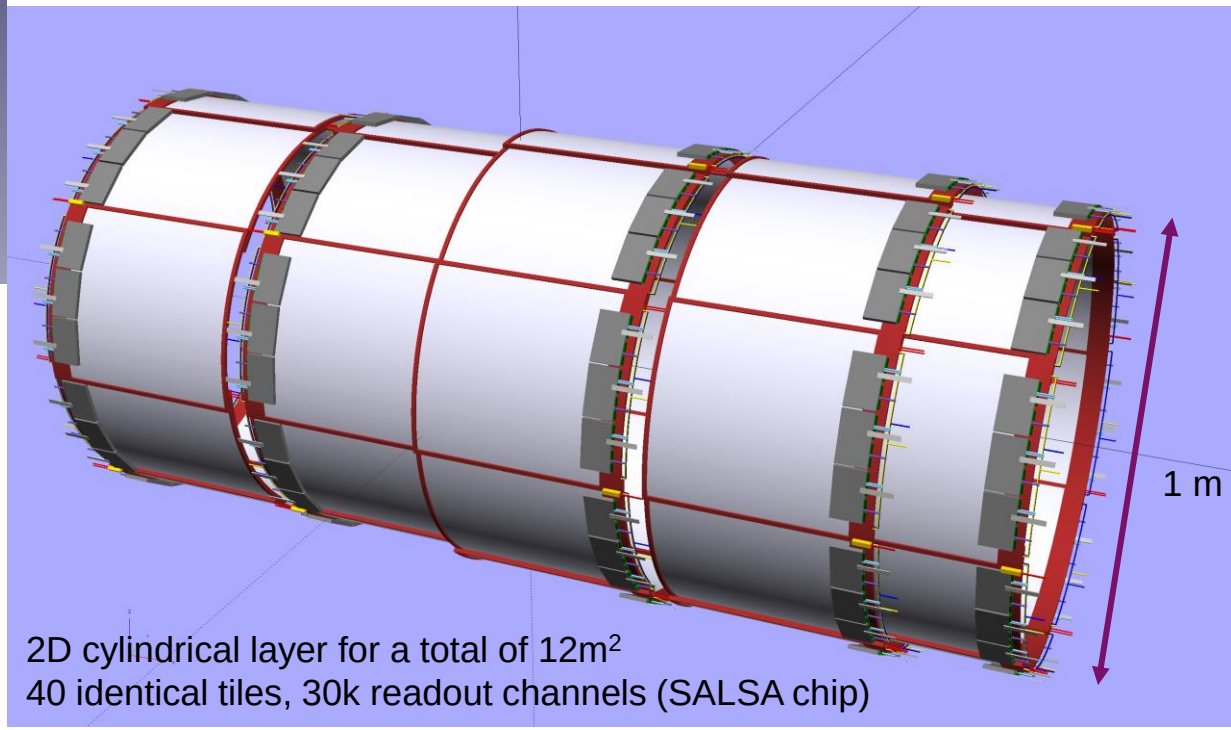
Cylindrical Micromegas Barrel Layer



Individual tile: 51 x 45 cm^2 (total)

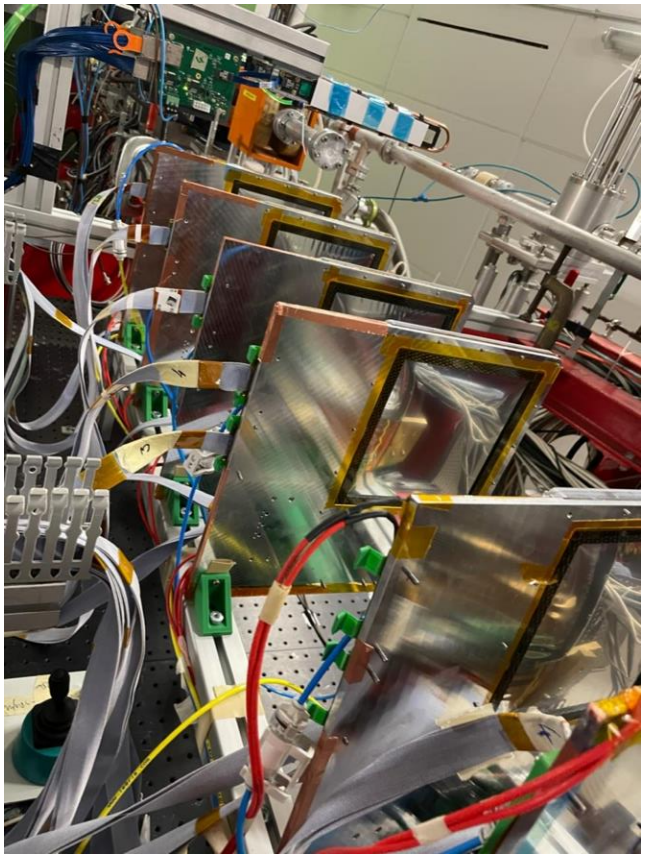
Requirements:

- Tight space (cylindrical shape, 2D)
- Material budget lower than 1% of X_0
- Spatial resolution ~150µm
- Time resolution < 20ns
- Close to CLAS12 performances !



2D cylindrical layer for a total of 12m^2
40 identical tiles, 30k readout channels (SALSA chip)

Courtesy of F. Bossù



- Beam test of about one week in June ‘23 in Mainz at MAMI
- In synergy with the R&D for the P2 experiment
- Tested several small Micromegas and µRWELL prototypes
- Low material budget: ~0.2% of X0 in the active region

+ Francesco et Samy !

The Micromegas adventure goes on !