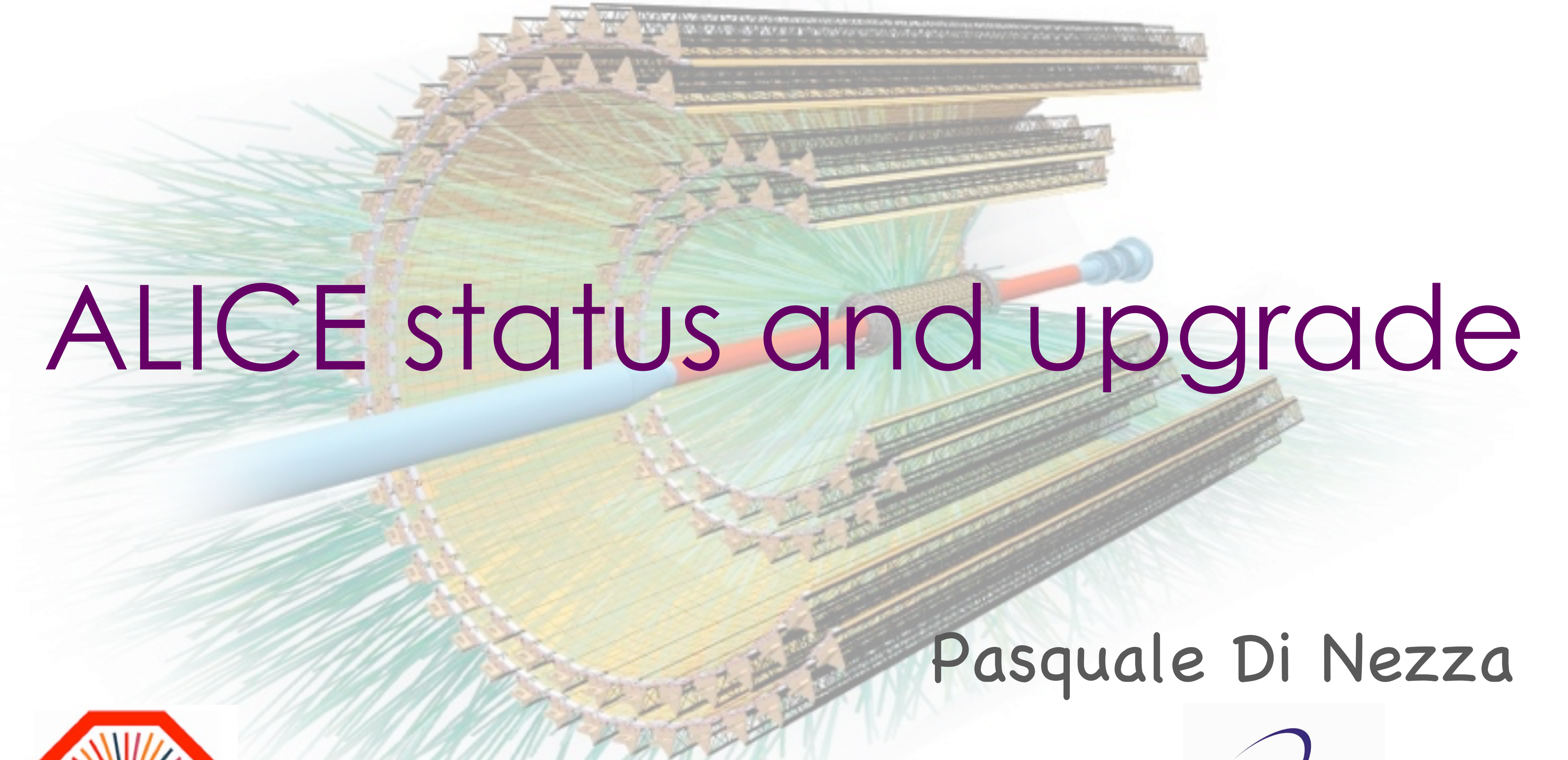
ALICE status and upgrade



Pasquale Di Nezza

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

ALICE

50th LNF Scientific Committee meeting, Nov 2015

LNF group and activities

13 researchers for 11.7 FTE
Average participation of 90%

1. N. Bianchi
2. L. Calero Diaz
3. E. Danè
4. P. Di Nezza
5. A. Fantoni
6. P. Gianotti
7. S. Liuti
8. A. Moregula
9. V. Muccifora
10. A.R. Reolon
11. F. Ronchetti
12. S. Sakai
13. E. Spiriti

Responsibilities:
- 1 Period Run Coordinator
- 1 deputy spokesperson in calo MB
- 1 member of the calo MB
- 1 Heavy Flavour Physics convenor

F. Ronchetti:
- Run Coordinator for the 2015 data taking

Technicians:
M.Matteo, A.Orlandi, L.Passamonti, D.Pierluigi, A.Russo, A.Viticchiè

ALICE

LNF activities: analysis

→ LNF group is an important contributor to the physics@LHC

LNF paper contribution in 2014-2015

- Measurement of jet quenching with semi-inclusive hadron-jet distributions in central Pb-Pb collisions [LNF co-primary author] (JHEP 09 (2015) 170)
- QGP review paper (300 pages, Eur. Phys. J. C (2014) 74:2981) [LNF co-primary author]
- Quenching by electron decay from Heavy Flavor quark, upcoming publication [LNF co-primary author]

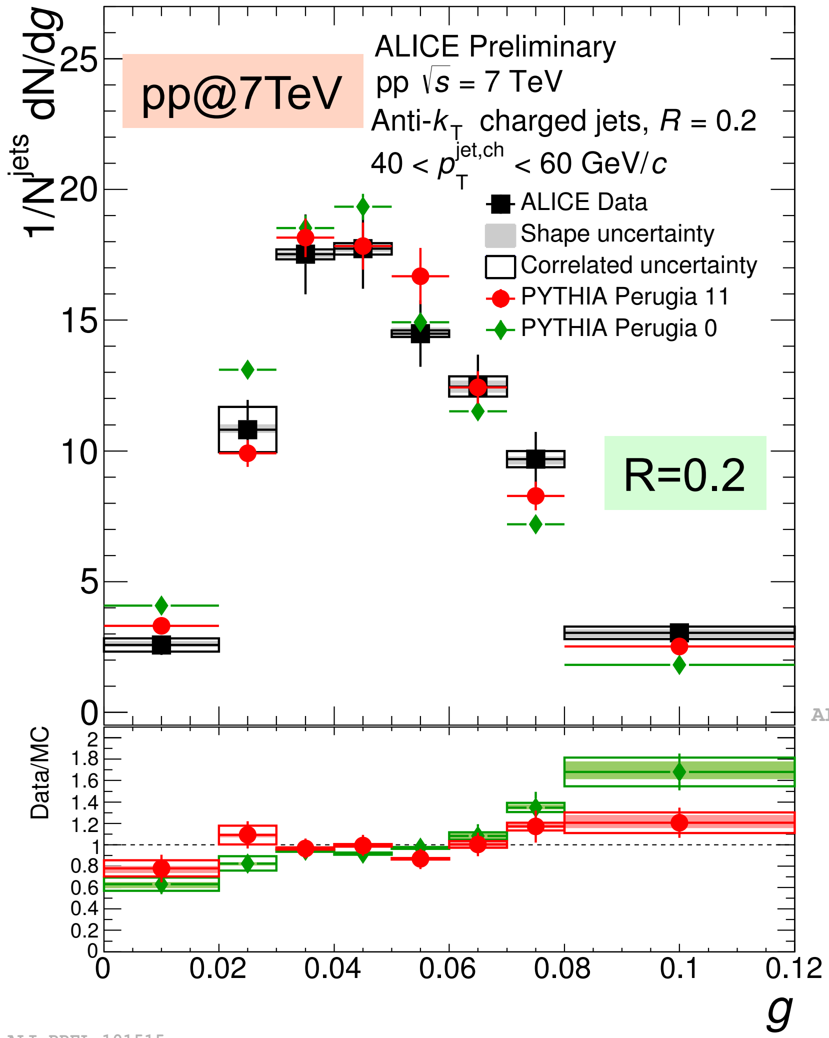
Phenomenological studies of jet quenching

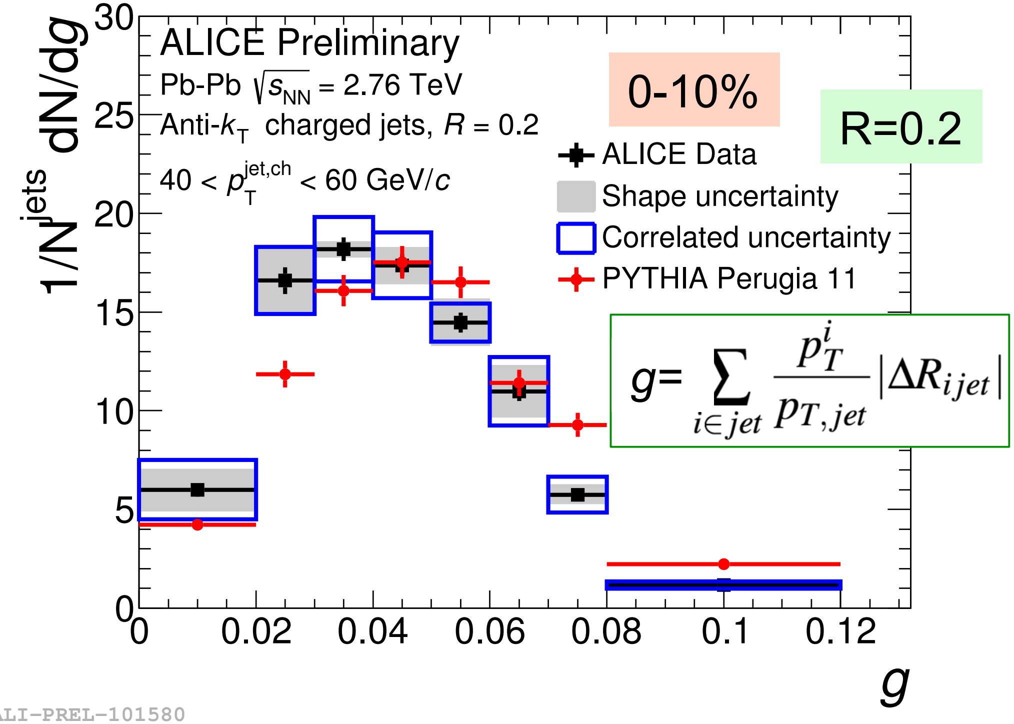
Collaboration with the University of Santiago de Compostela & LNF theory group

Bridge between polarised physics and LHC

Λ reconstruction globally and in jets => First link of GPDs and TMDs at TeV scale
Collaboration with Tufts University and University of Virginia

A new observable: Jet shapes





- New variables to characterize Jet-core shapes (constituents in R=0.2)
  - ✓ Radial moment (g), Dispersion in p_T, leading-sub leading p_T
- Consistent with PYTHIA in pp
- Core of Pb-Pb jets more collimated than pp jets

Presented @QuarkMatter 2015

ALICE upgrade strategy

This requires statistics (luminosity) and precision measurements

Target for **upgrade programme** (Run3 + Run4)

- Pb-Pb recorded luminosity $\geq 10\ nb^{-1}$ ➡ 8×10^{10} events

I. Upgrade detectors, readout systems and online systems to

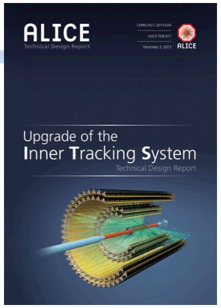
- read out all Pb-Pb interactions at a maximum rate of 50kHz (i.e. $L = 6 \times 10^{27}\ cm^{-2}s^{-1}$), with a minimum bias trigger (at present 500Hz)

➡ Gain a factor **100** in statistics over originally approved programme (Run1 + Run2)

II. Significant improvement of vertexing and tracking capabilities at low p_T

- **New Inner tracking System**

It targets LHC 2nd Long Shutdown



CERN-LHCC-2013-24

J. Phys. G (41) 087002

ALICE upgrade strategy

LNF main involvement in the next years

This requires statistics (luminosity) and precision measurements

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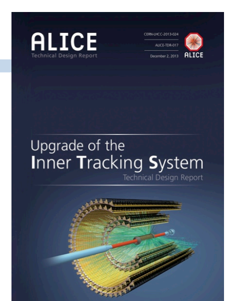
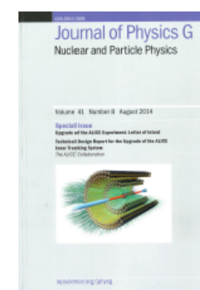
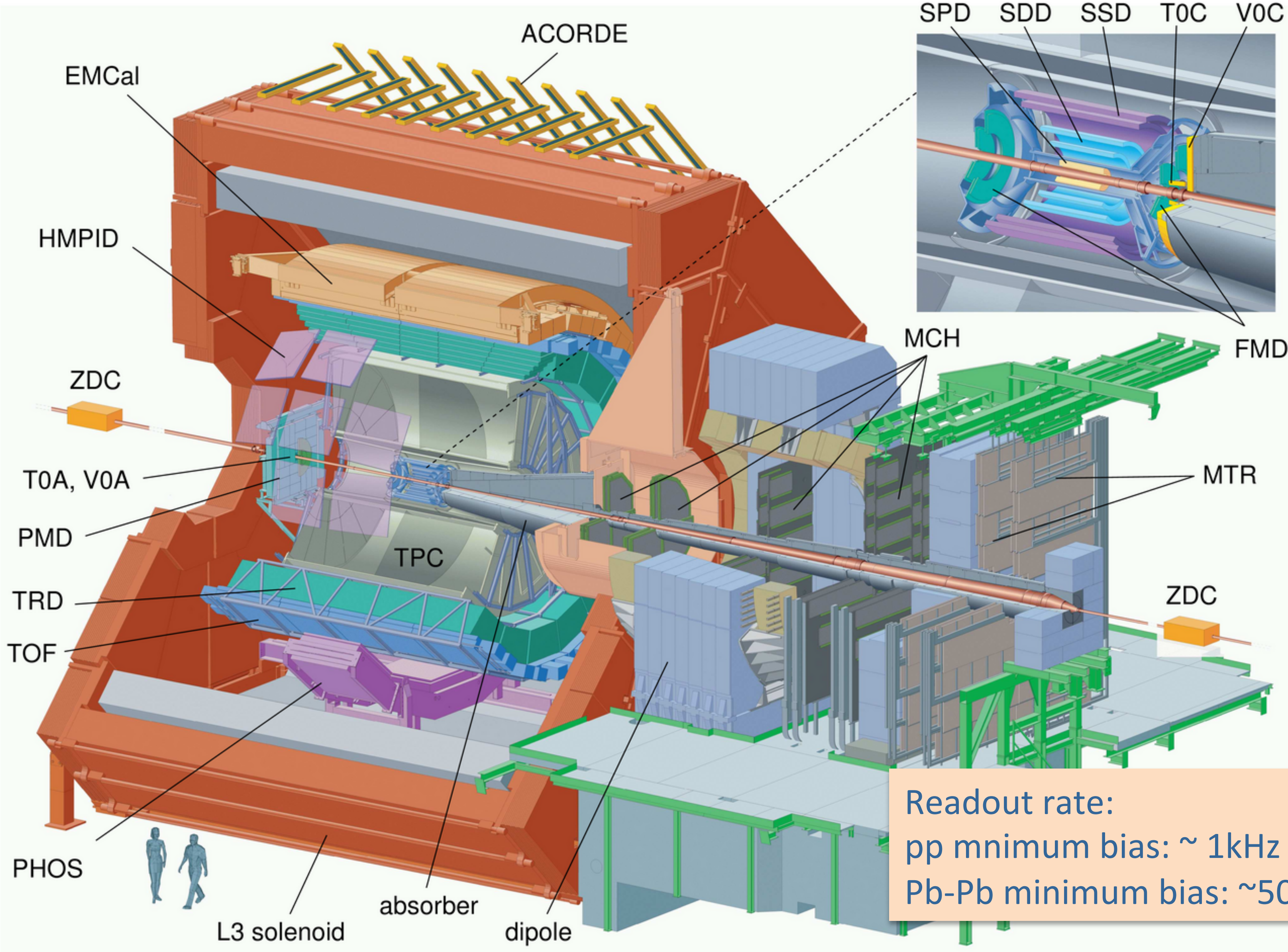


CERN-LHCC-2013-24



J. Phys. G (41) 087002

ALICE: the actual setup



Readout rate:
pp mnimum bias: ~ 1kHz
Pb-Pb minimum bias: ~500 Hz

ITS upgrade design objectives

1. Improve impact parameter resolution by a factor of ~3

- Get closer to IP (position of first layer): 39mm ➡ 23mm
- Reduce x/X_0 /layer: ~1.14% ➡ ~ 0.3% (for inner layers)
- Reduce pixel size: currently 50μm x 425μm ➡ O(30μm x 30μm)

2. Improve tracking efficiency and p_T resolution at low p_T

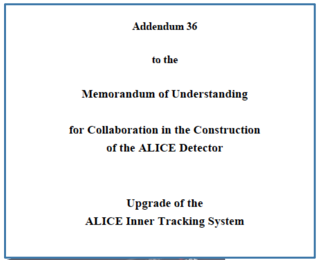
- Increase granularity:
  - 6 layers ➡ 7 layers
  - silicon drift and strips ➡ pixels

3. Fast readout

- readout Pb-Pb interactions at > 100 kHz and pp interactions at ~ several 10^5 Hz (currently limited at 1kHz with full ITS)

4. Fast insertion/removal for yearly maintenance

- possibility to replace non functioning detector modules during yearly shutdown

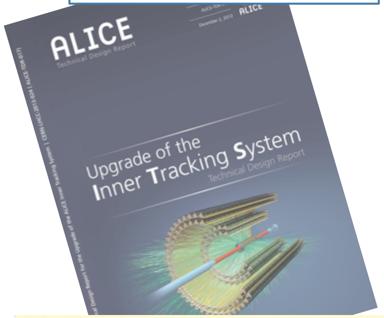

Addendum 36

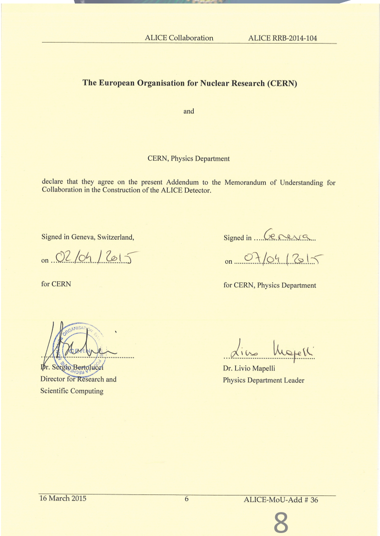
to the

Memorandum of Understanding

for Collaboration in the Construction
of the ALICE Detector

Upgrade of the
ALICE Inner Tracking System




ALICE Collaboration ALICE RRB-2014-104

The European Organisation for Nuclear Research (CERN)

and

CERN, Physics Department

declare that they agree on the present Addendum to the Memorandum of Understanding for Collaboration in the Construction of the ALICE Detector.

Signed in Geneva, Switzerland, Signed in Genève

on 02/04/2015 on 07/04/2015

for CERN for CERN, Physics Department

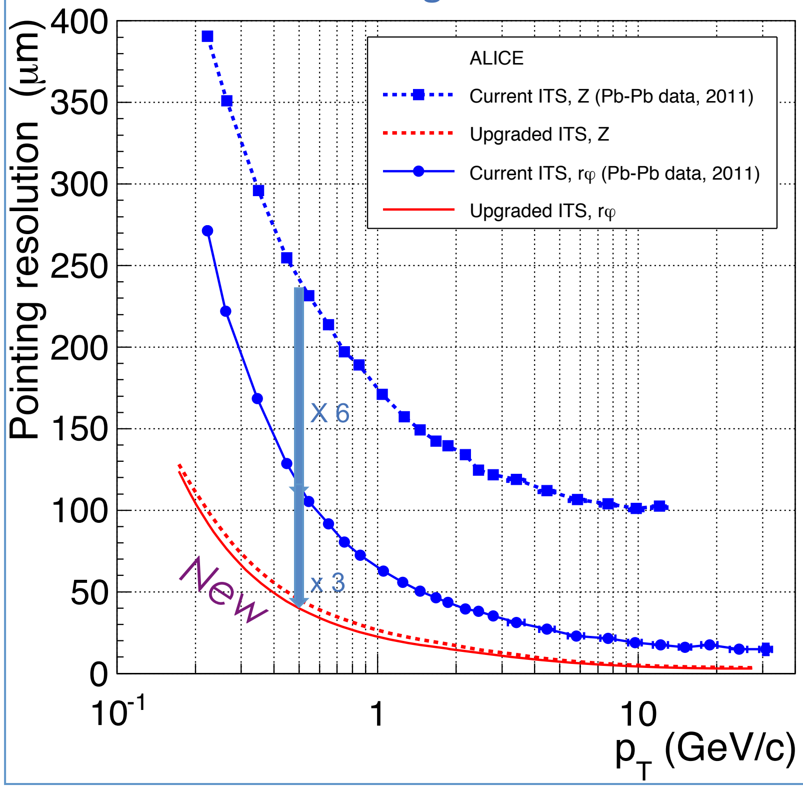
Dr. Sergio Bertolucci
Director for Research and
Scientific Computing

Dr. Livio Mapelli
Physics Department Leader

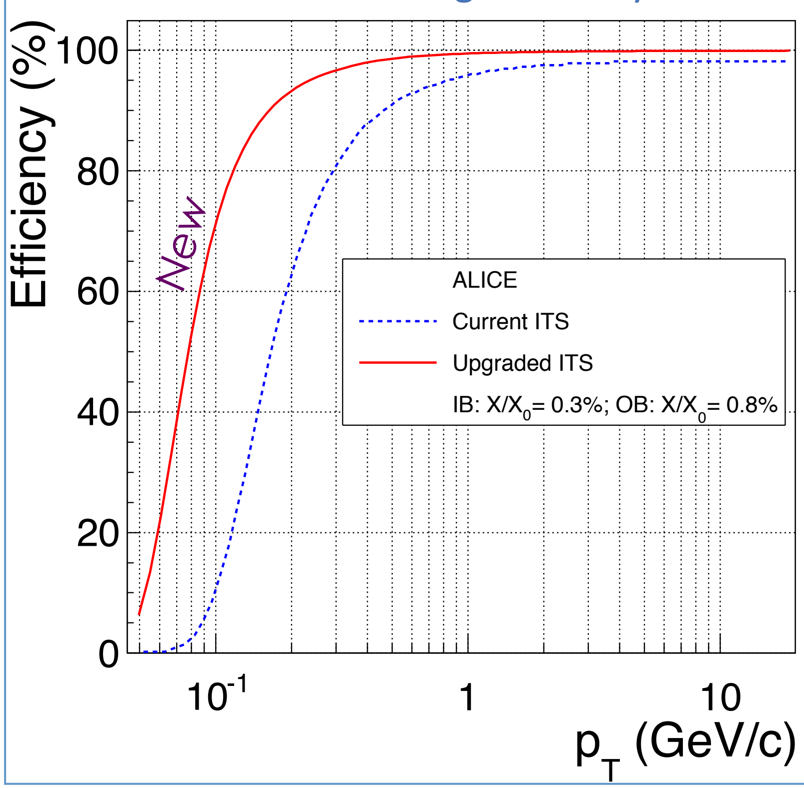
16 March 2015 6 ALICE-MoU-Add # 36

ITS – Performance del detector

Pointing Resolution



Tracking efficiency

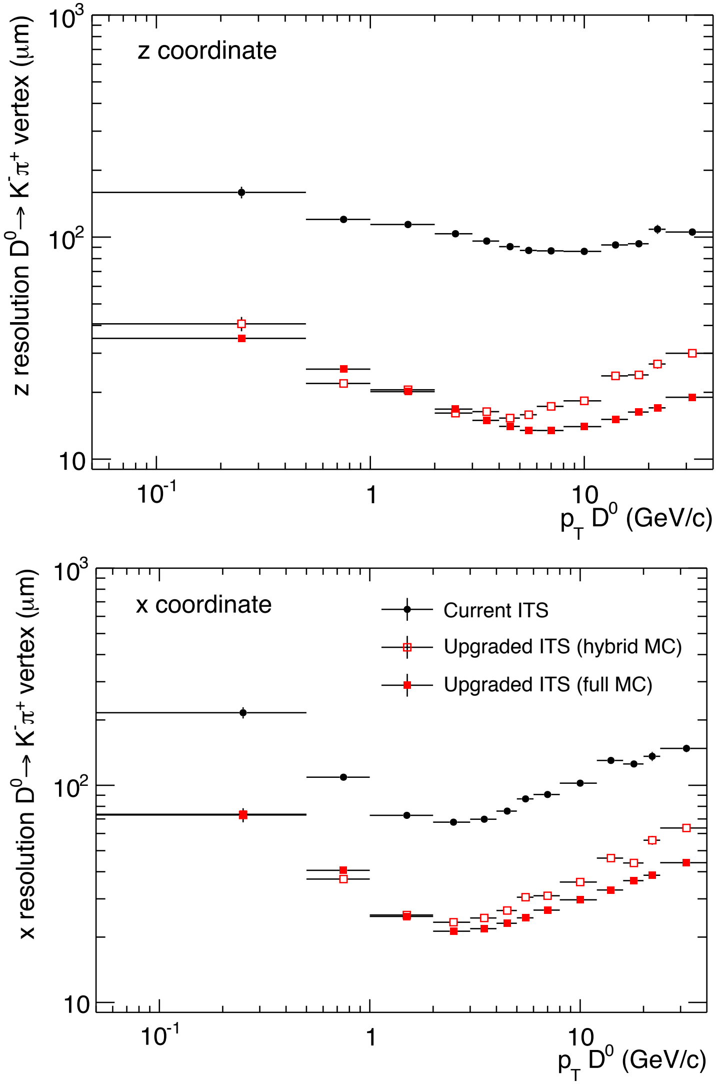


~40 μm a p_T=500 MeV

Fundamental improvement of the resolution (left) and tracking efficiency (right) from the old to the new ITS

ITS – Physics Performance

Example: $D^0 \rightarrow K^- p^+$



Observable	Current, 0.1 nb^{-1}		Upgrade, 10 nb^{-1}	
	p_T^{min} (GeV/c)	statistical uncertainty	p_T^{min} (GeV/c)	statistical uncertainty
Heavy Flavour				
D meson R_{AA}	1	10 %	0	0.3 %
D_s meson R_{AA}	4	15 %	< 2	3 %
D meson from B R_{AA}	3	30 %	2	1 %
J/ψ from B R_{AA}	1.5	15 % (p_T-int.)	1	5 %
B^+ yield	not accessible		3	10 %
Λ_c R_{AA}	not accessible		2	15 %
Λ_c/D^0 ratio	not accessible		2	15 %
Λ_b yield	not accessible		7	20 %
D meson v_2 ($v_2 = 0.2$)	1	10 %	0	0.2 %
D_s meson v_2 ($v_2 = 0.2$)	not accessible		< 2	8 %
D from B v_2 ($v_2 = 0.05$)	not accessible		2	8 %
J/ψ from B v_2 ($v_2 = 0.05$)	not accessible		1	60 %
Λ_c v_2 ($v_2 = 0.15$)	not accessible		3	20 %
Dielectrons				
Temperature (intermediate mass)	not accessible			10 %
Elliptic flow ($v_2 = 0.1$)	not accessible			10 %
Low-mass spectral function	not accessible		0.3	20 %
Hypernuclei				
$^3_\Lambda$H yield	2	18 %	2	1.7 %

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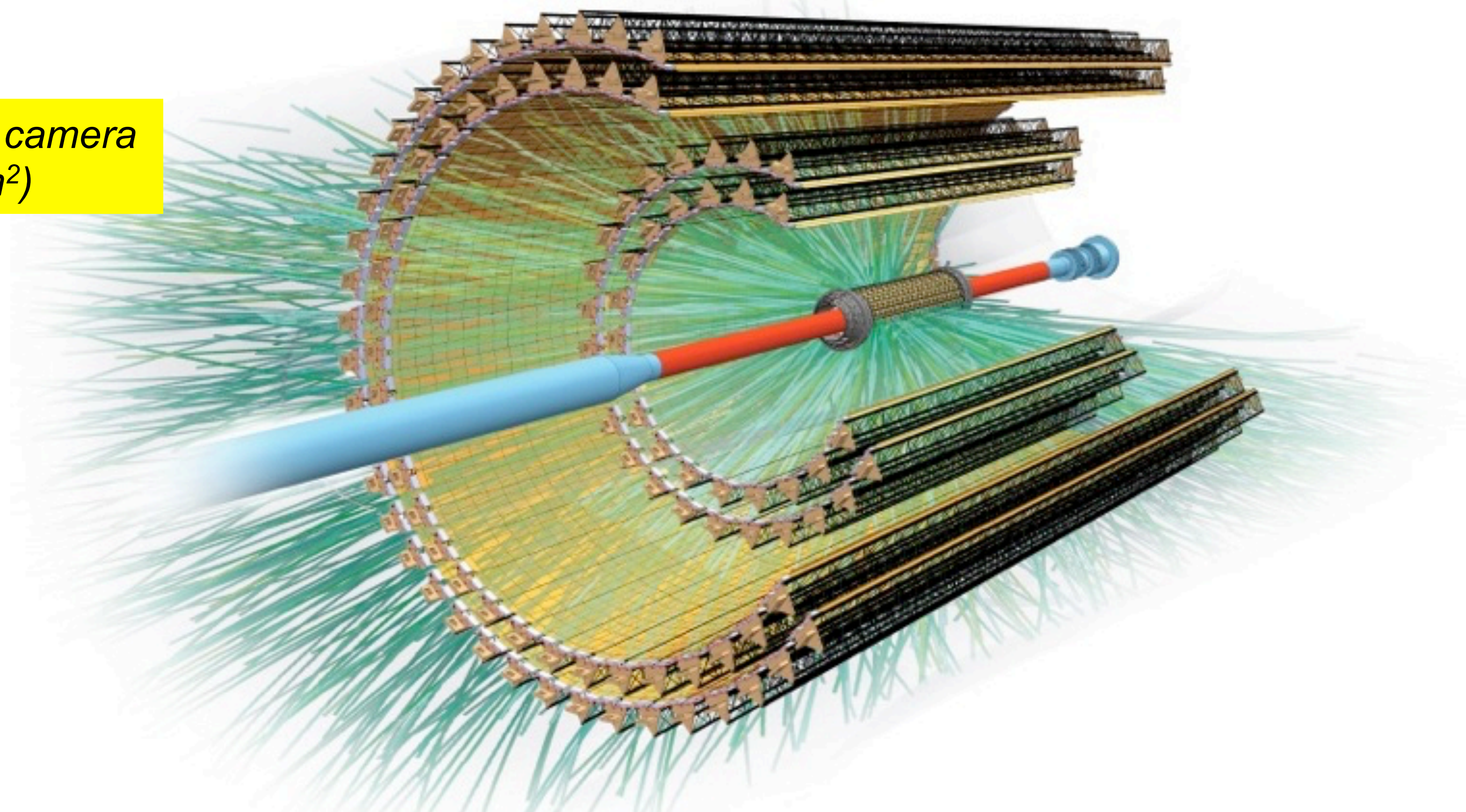
ITS new layout

12.5 G-pixel camera
(~10 m^2)



7-layer barrel geometry based on MAPS

r coverage: 23 – 400 mm

η coverage: $|\eta| \leq 1.22$
for tracks from 90% most luminous region

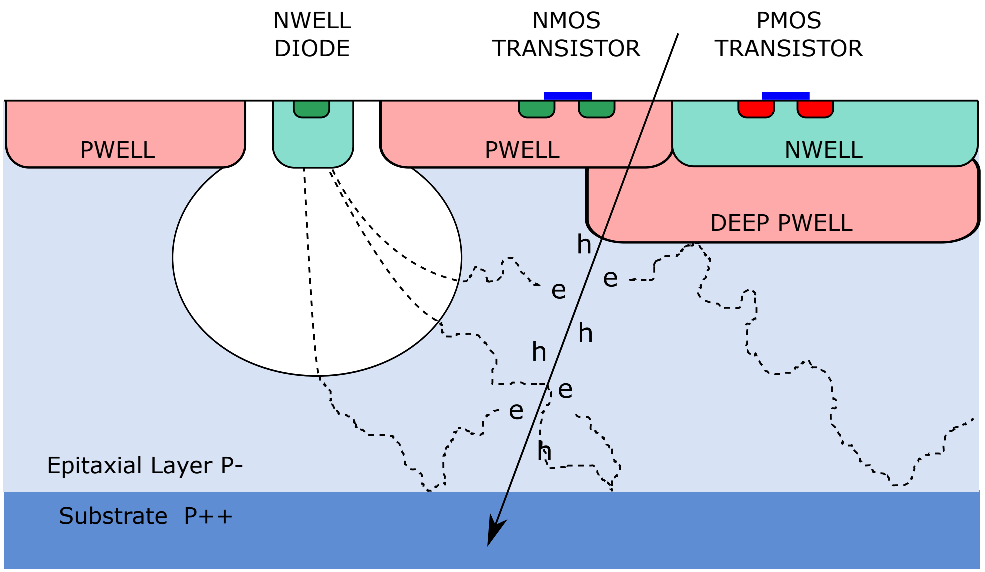
3 Inner Barrel layers (**IB**)

4 Outer Barrel layers (**OB**)

Material /layer : 0.3% X_0 (IB), 1% X_0 (OB)

ITS Pixel Chip – technology choice

CMOS Pixel Sensor using TowerJazz 0.18μm CMOS Imaging Process



Tower Jazz 0.18 μm CMOS

- feature size 180 nm
- metal layers 6

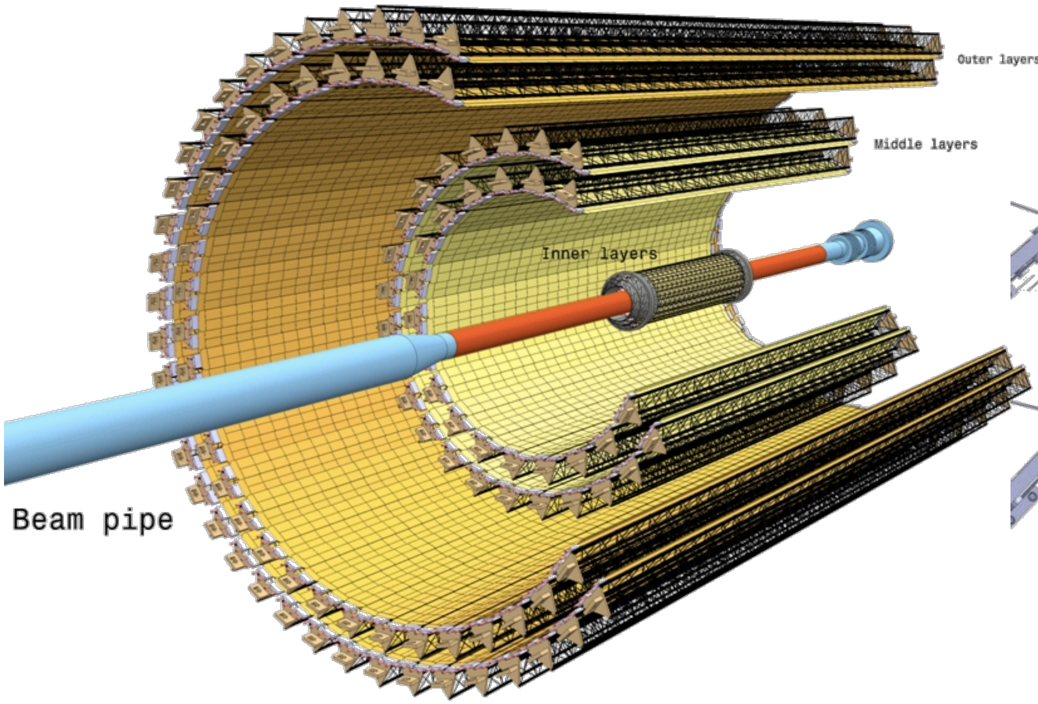
➔ Suited for high-density, low-power

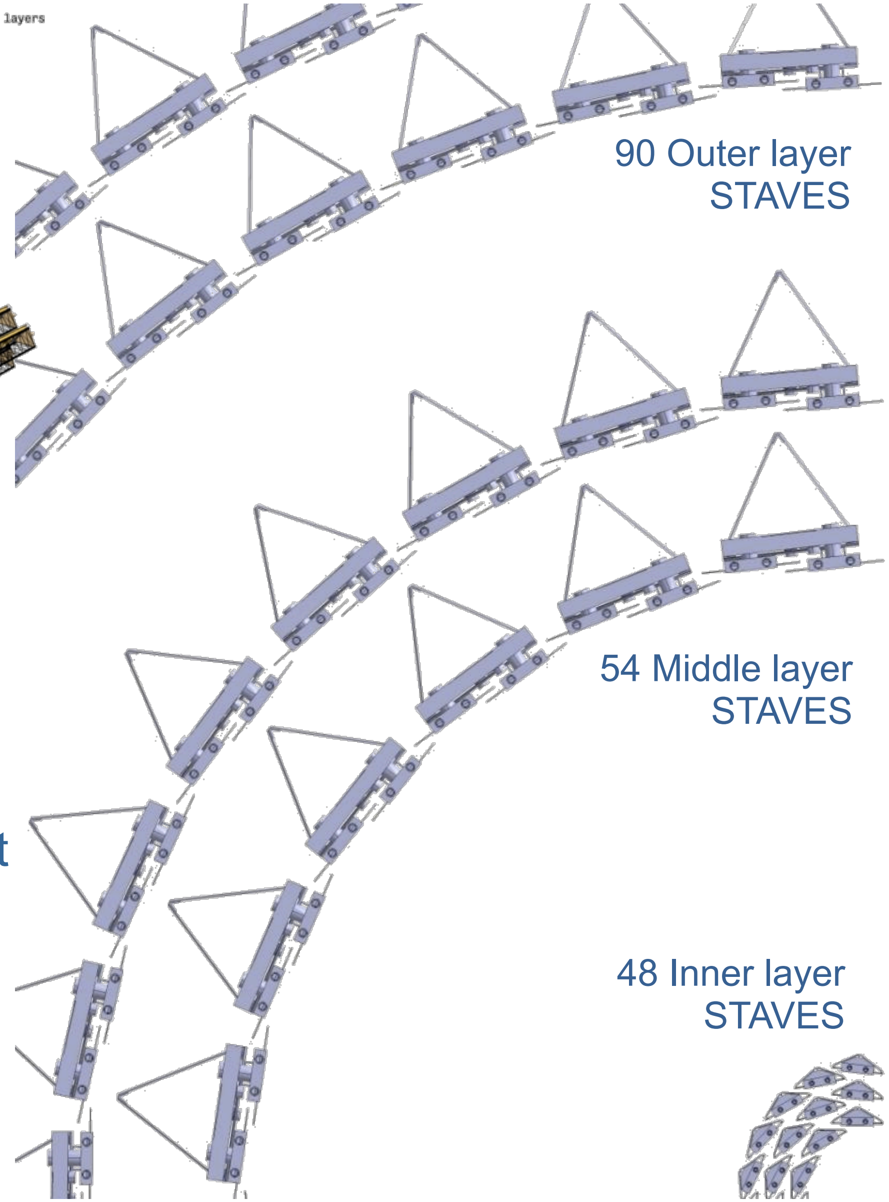
- Gate oxide 3nm

➔ Circuit rad-tolerant

- High-resistivity (> 1kΩ cm) p-type epitaxial layer (20μm - 40μm thick) on p-type substrate
- Small n-well diode (2-3 μm diameter), ~100 times smaller than pixel => low capacitance
- Application of (moderate) reverse bias voltage to substrate can be used to increase depletion zone around NWELL collection diode
- Quadruple well process: deep PWELL shields NWELL of PMOS transistors, allowing for full CMOS circuitry within active area

ITS new layout

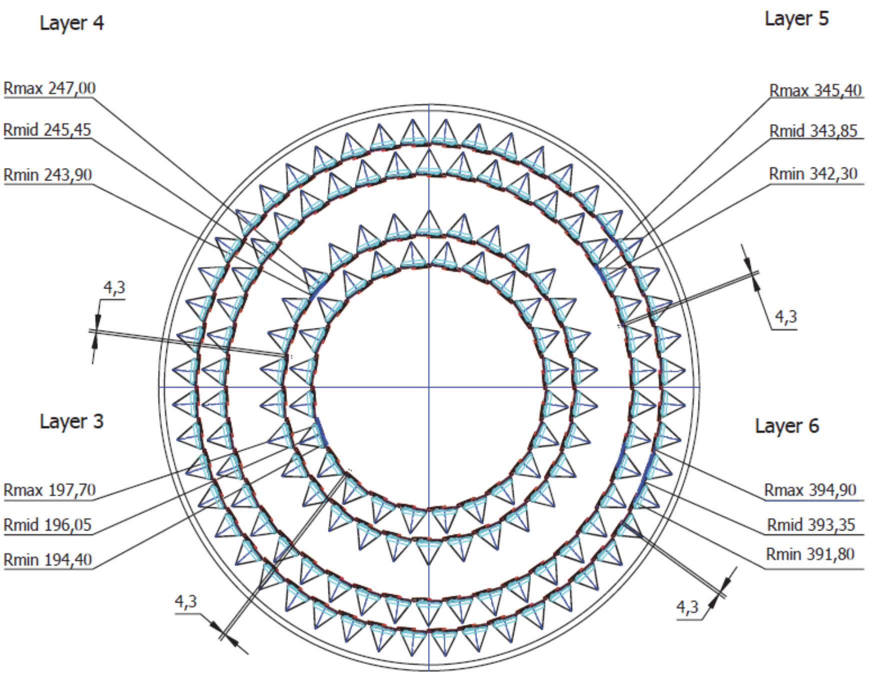


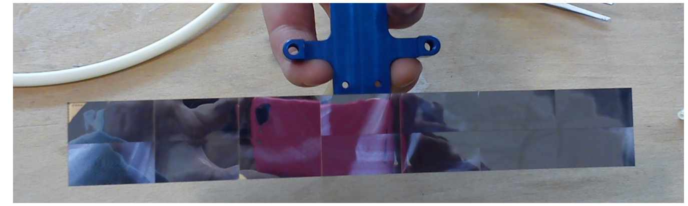


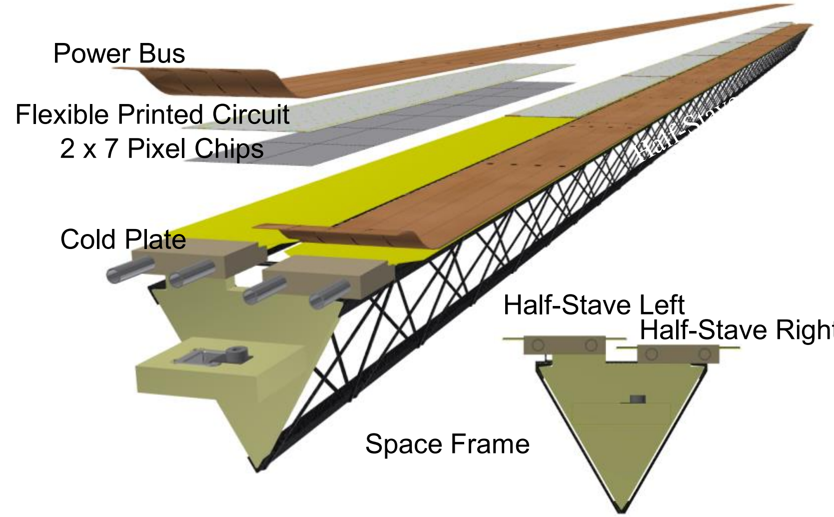
ITS layers are (azimuthally) segmented in staves, which are mechanically independent

Radial coverage 23mm÷405mm

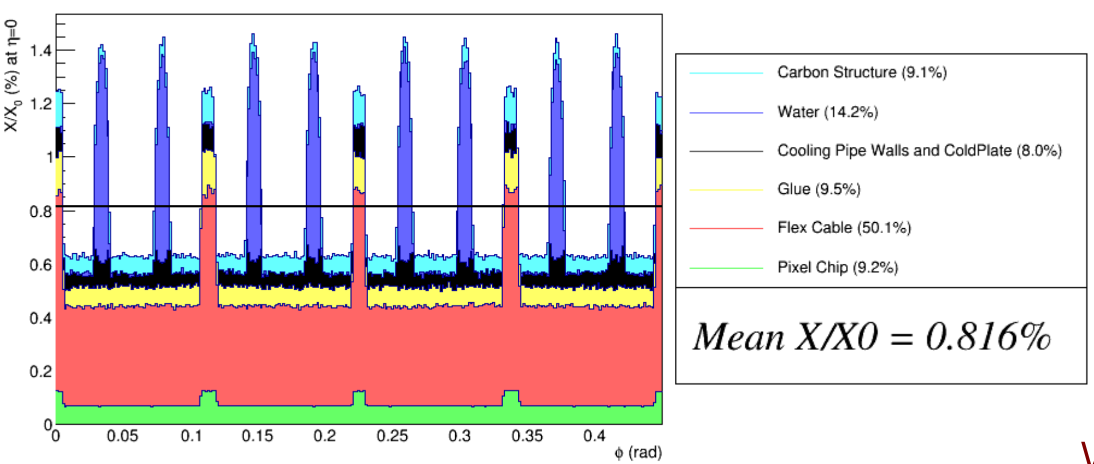
Outer Barrel

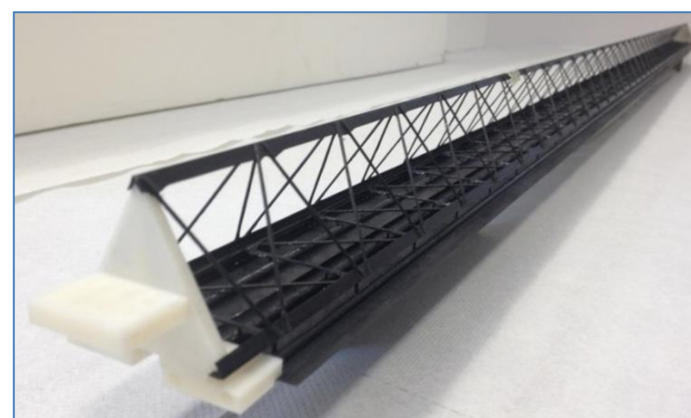






Outer Barrel Stave

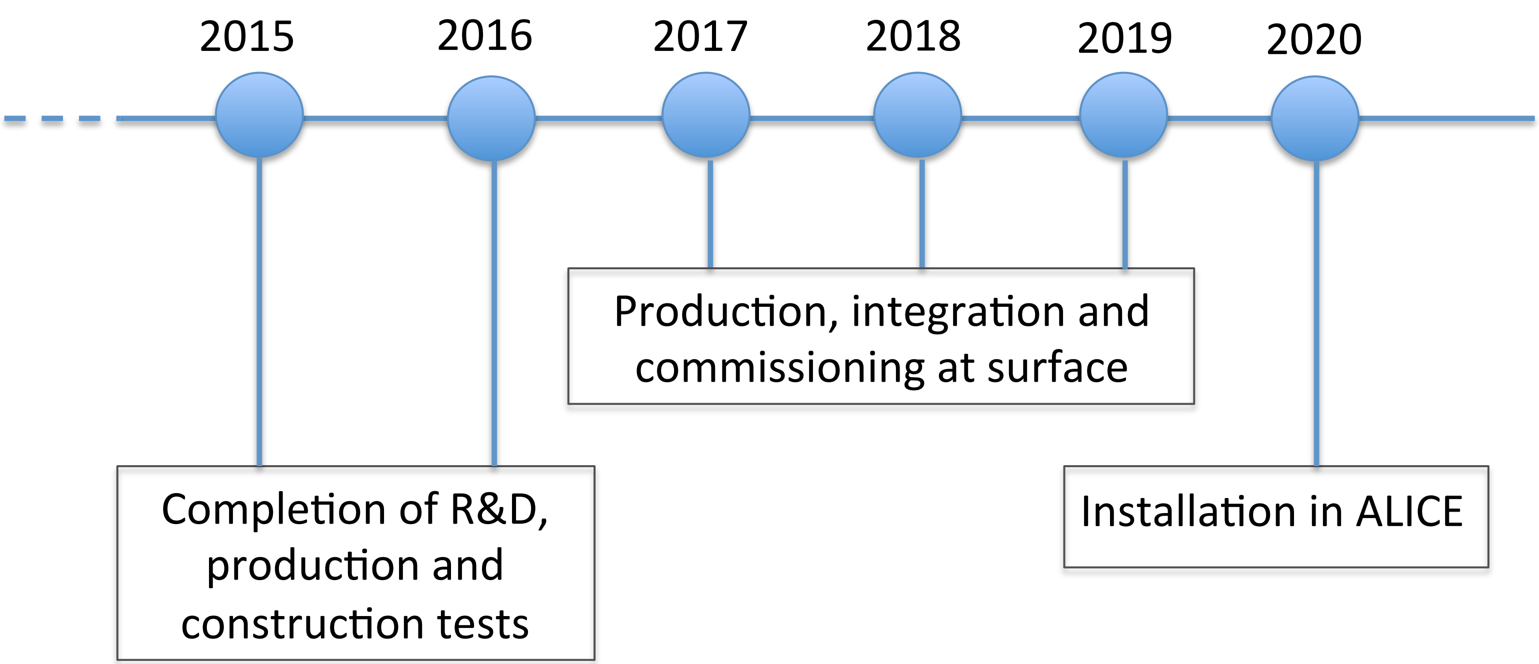




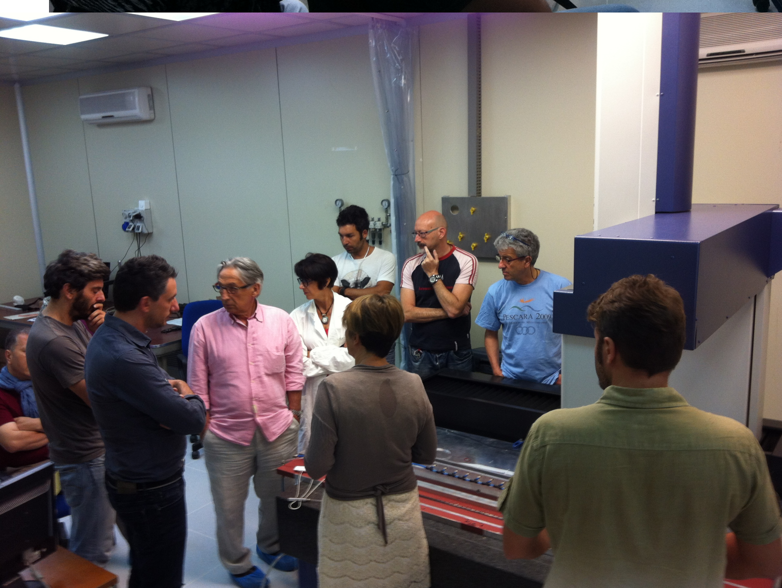
Max Length 1500 mm
Weight of the structure ~30 gr

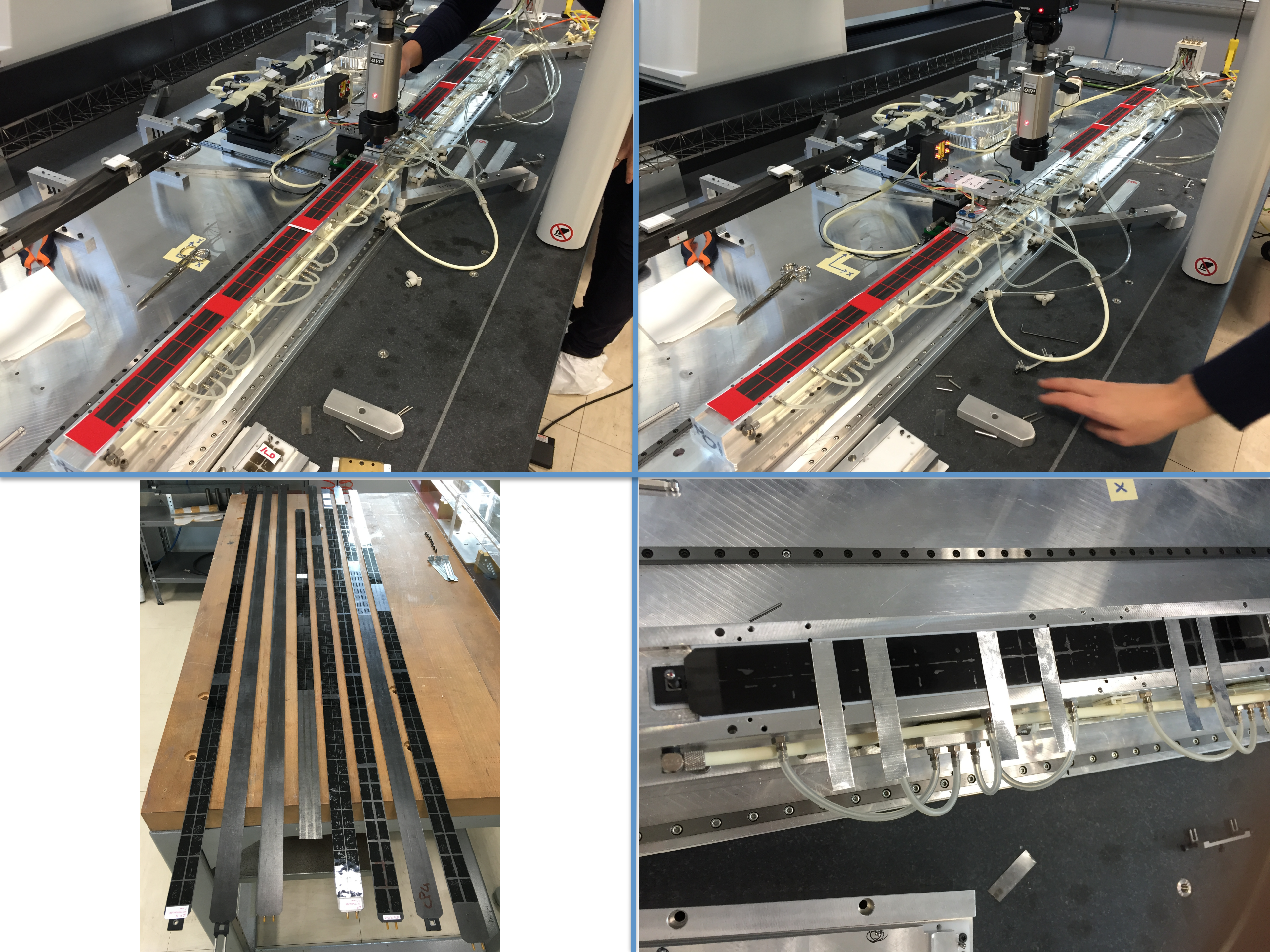
The full stave must be assembled with an accuracy of <20 μm

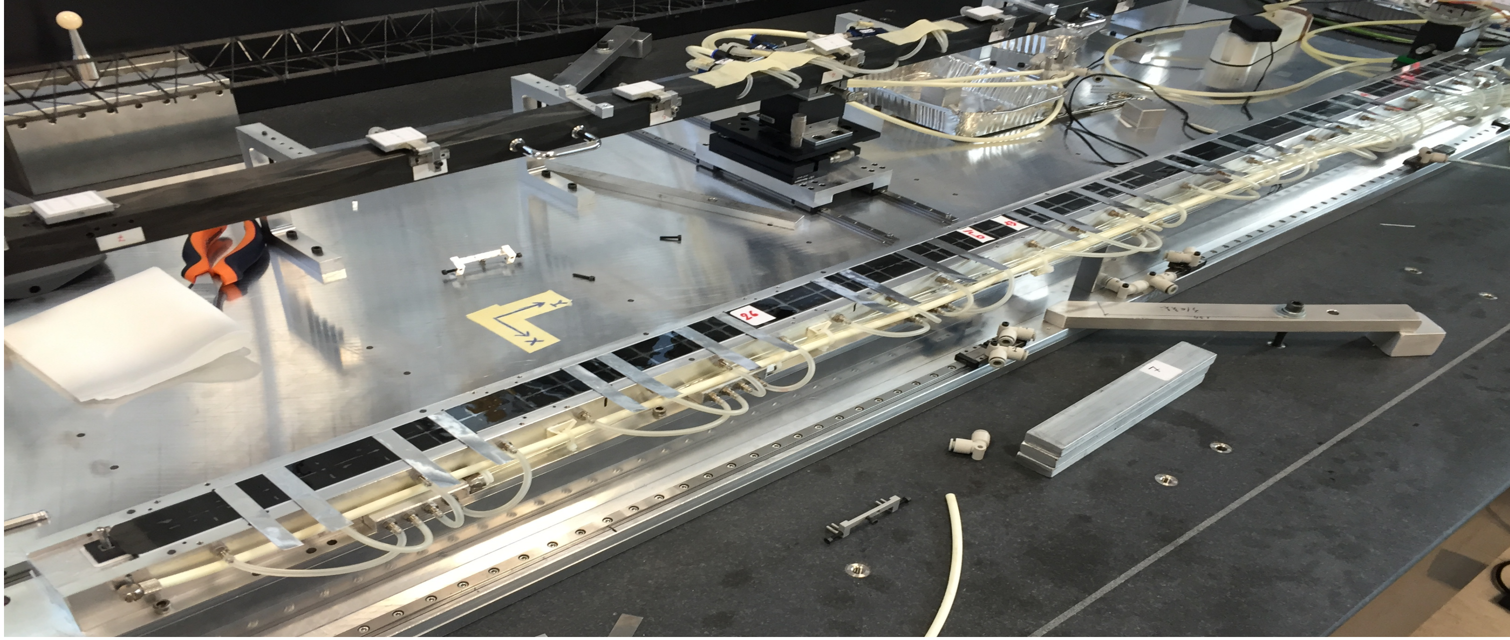
Big effort in the development of jigs, tools, procedures

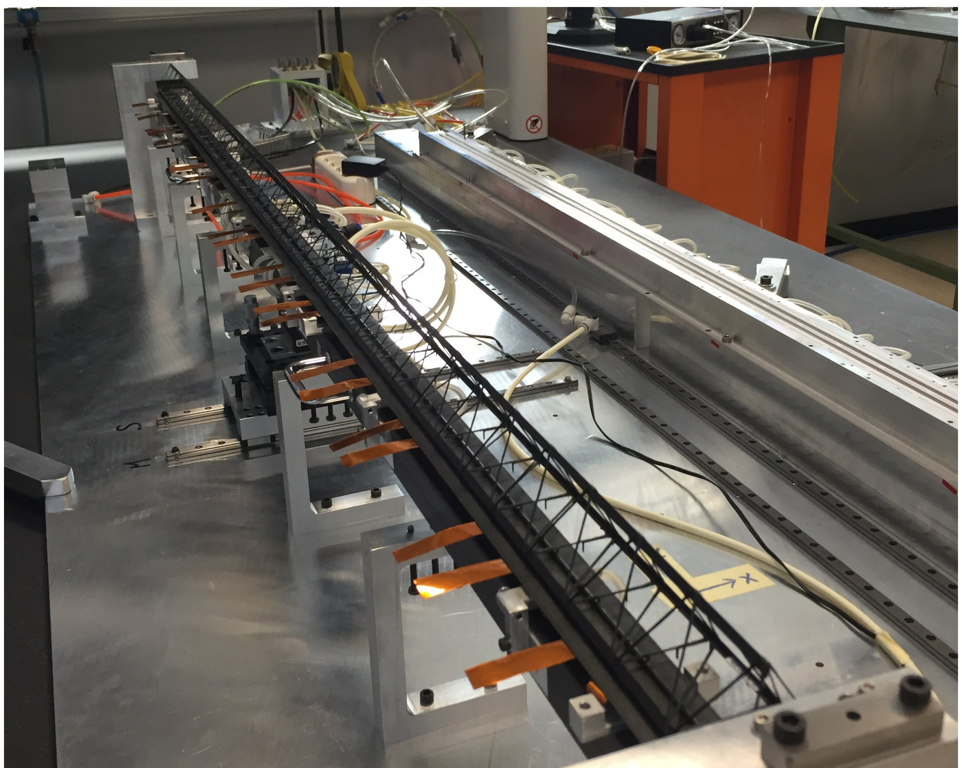


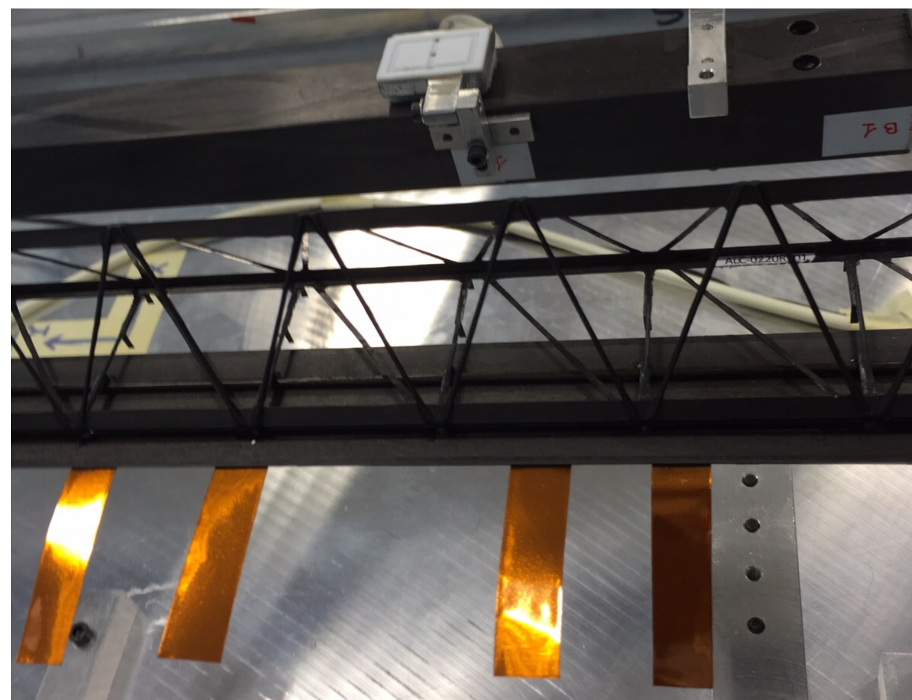
Training sessions in Clean Room

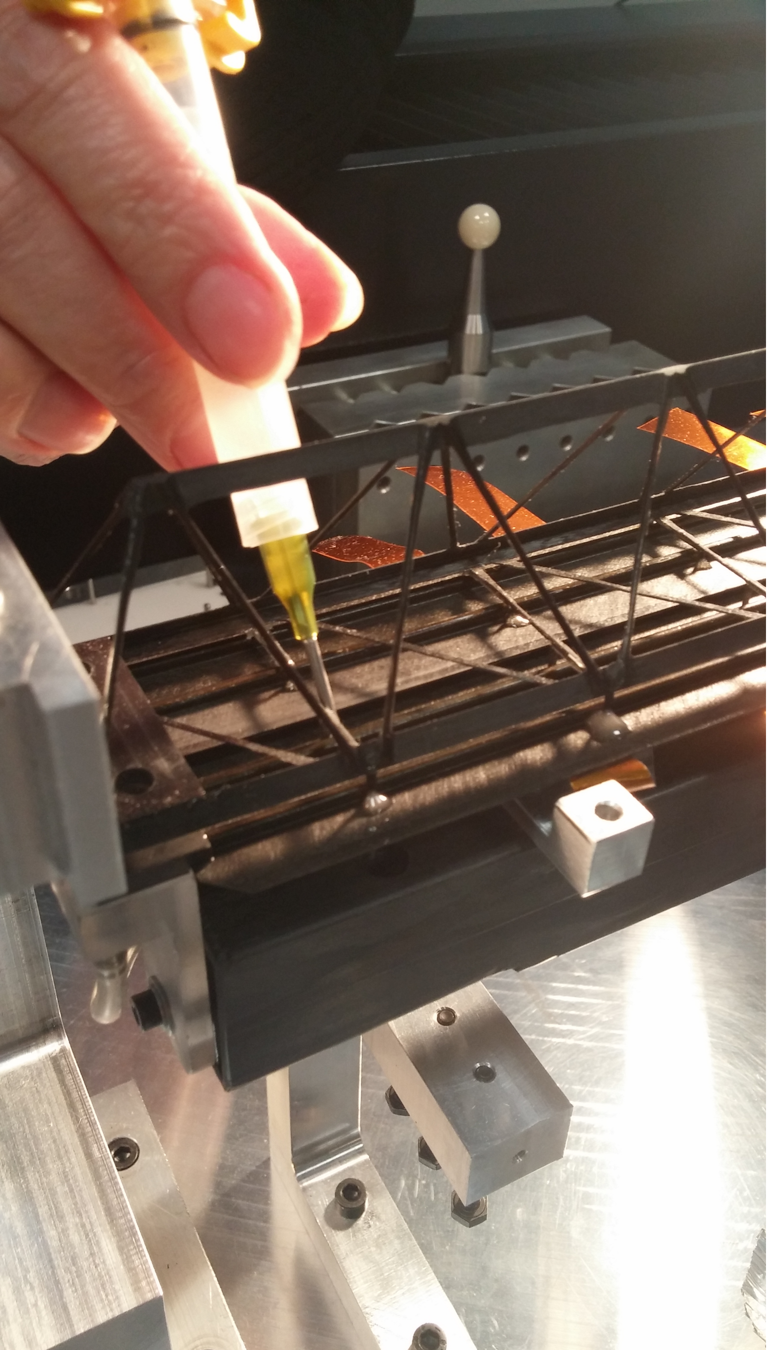


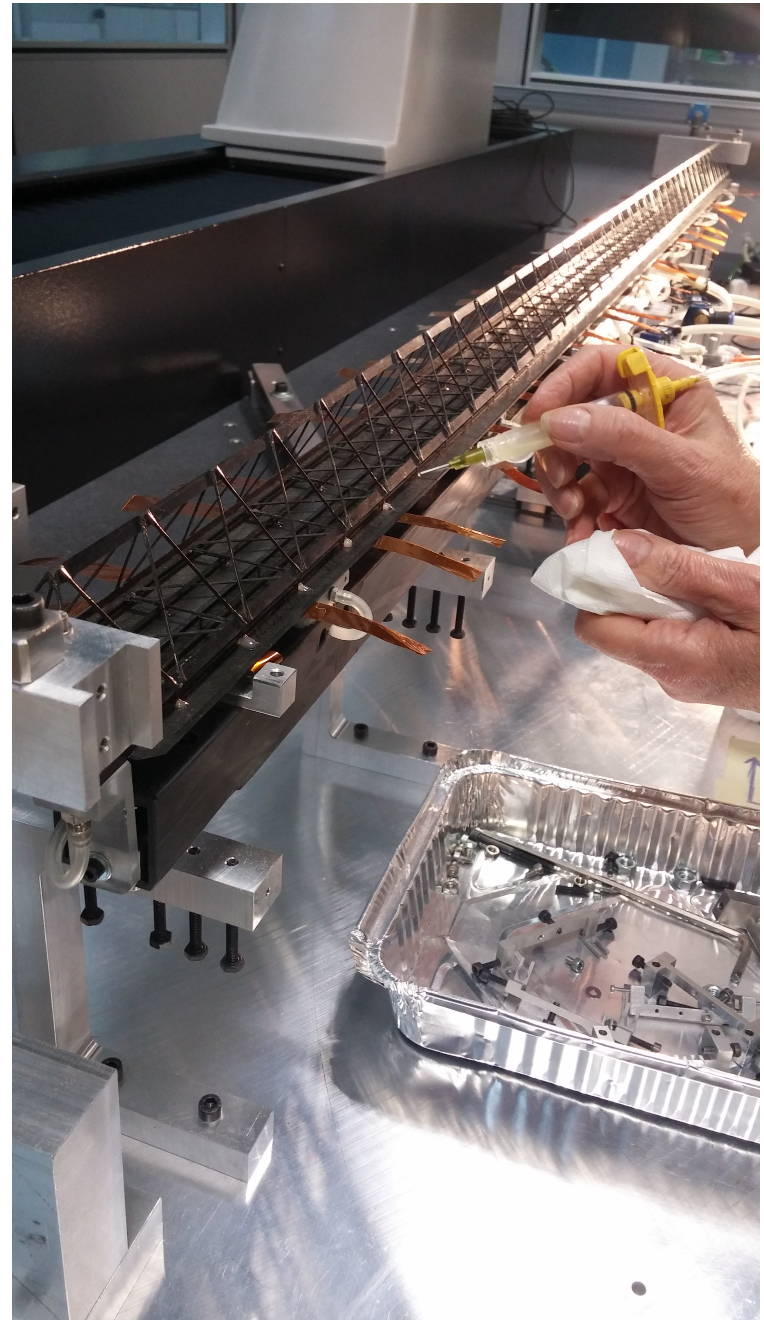

QVP

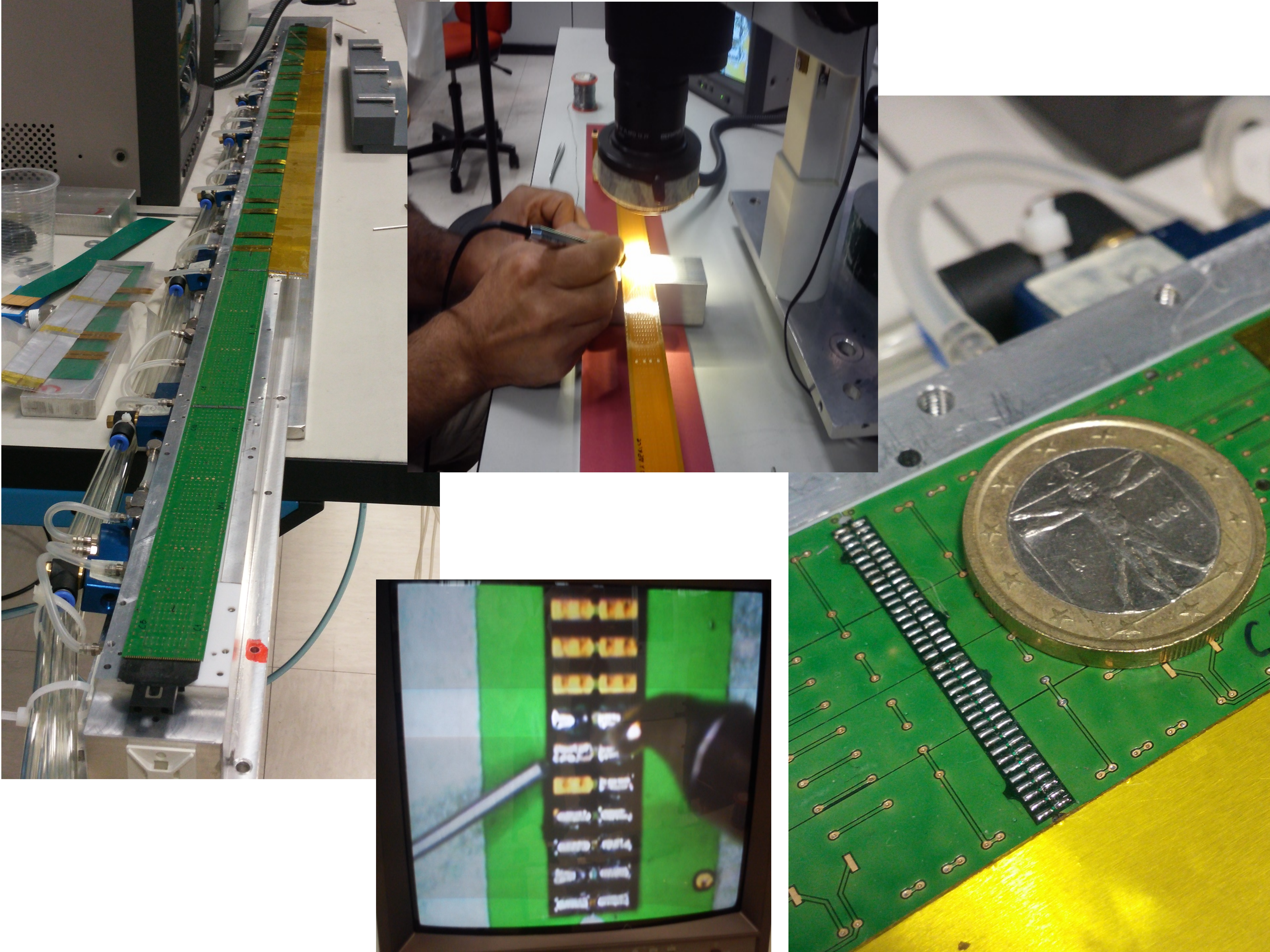












Working Scheme

- Optics and electrical module (2x7 chips) acceptance

- Half-Stave assembling (x2):
    - Cold plate
    - 7x module gluing (minimize glue, maximise surface for thermal contact)
    - 7x module soldering (~250 connections per HS)
    - Power bus soldering (~100 connections per HS)
    - Electronic test

- Stave assembling (carbon fiber space frame)
    - Gluing of 2 half-staves

- Survey → DB
- Electronic test, validation
- Shipping to CERN for insertion into the final barrel

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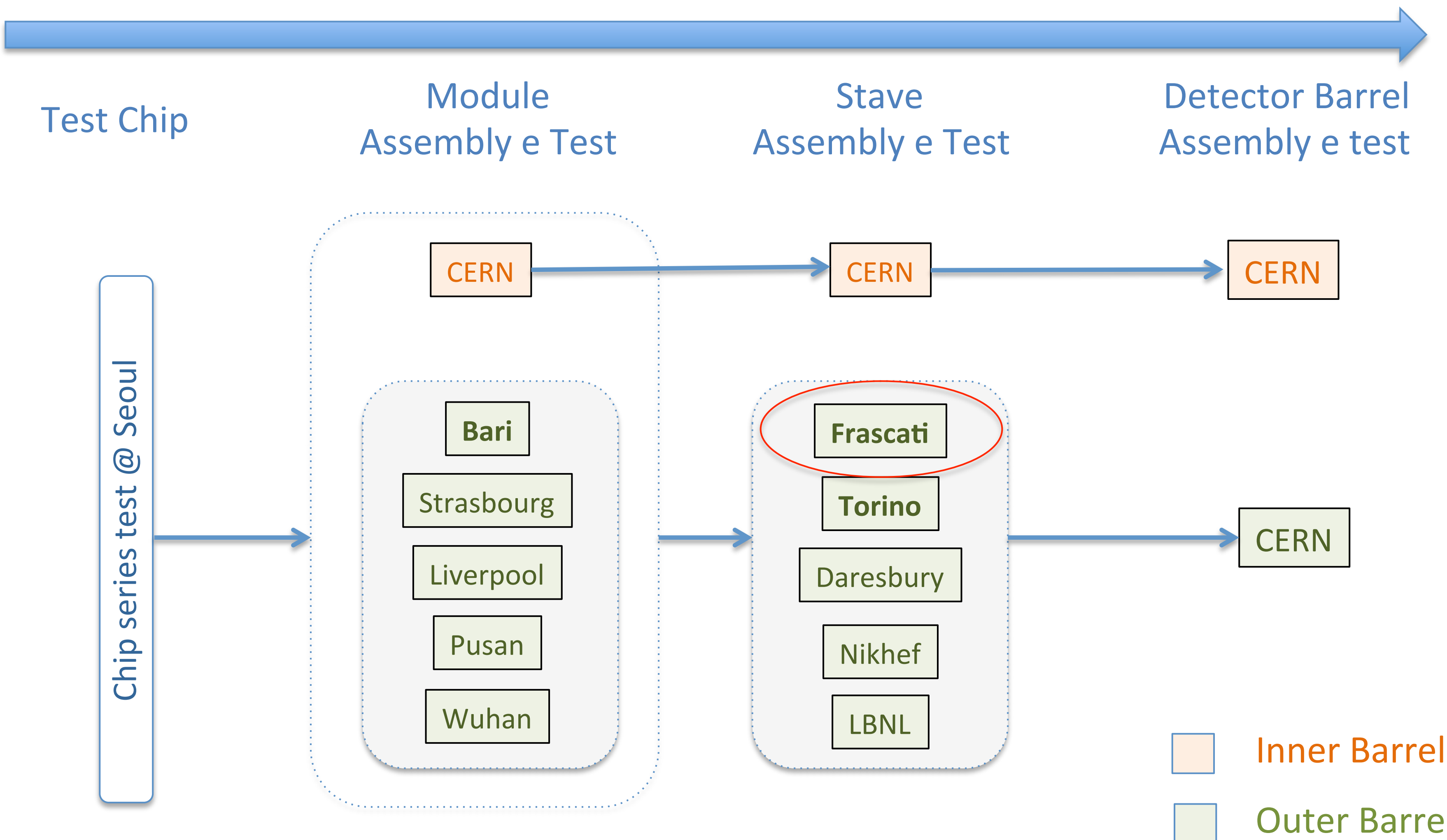
<u>Manpower</u>

- Until beginning of 2017: 3 people for 4 days/week

- Construction (from 2017): 5 people for 5 days/week for 80 weeks

Responsibilities



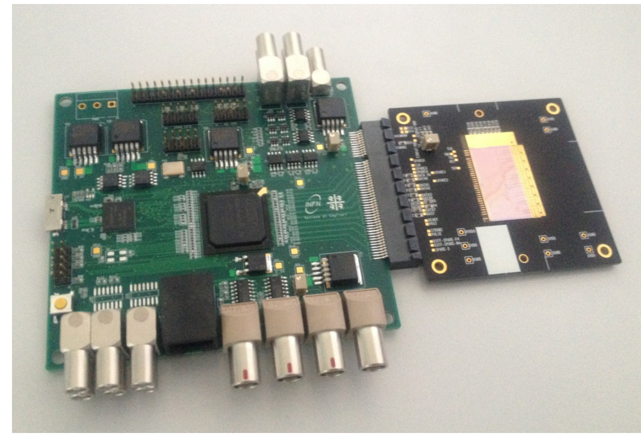
pALPIDE Characterization

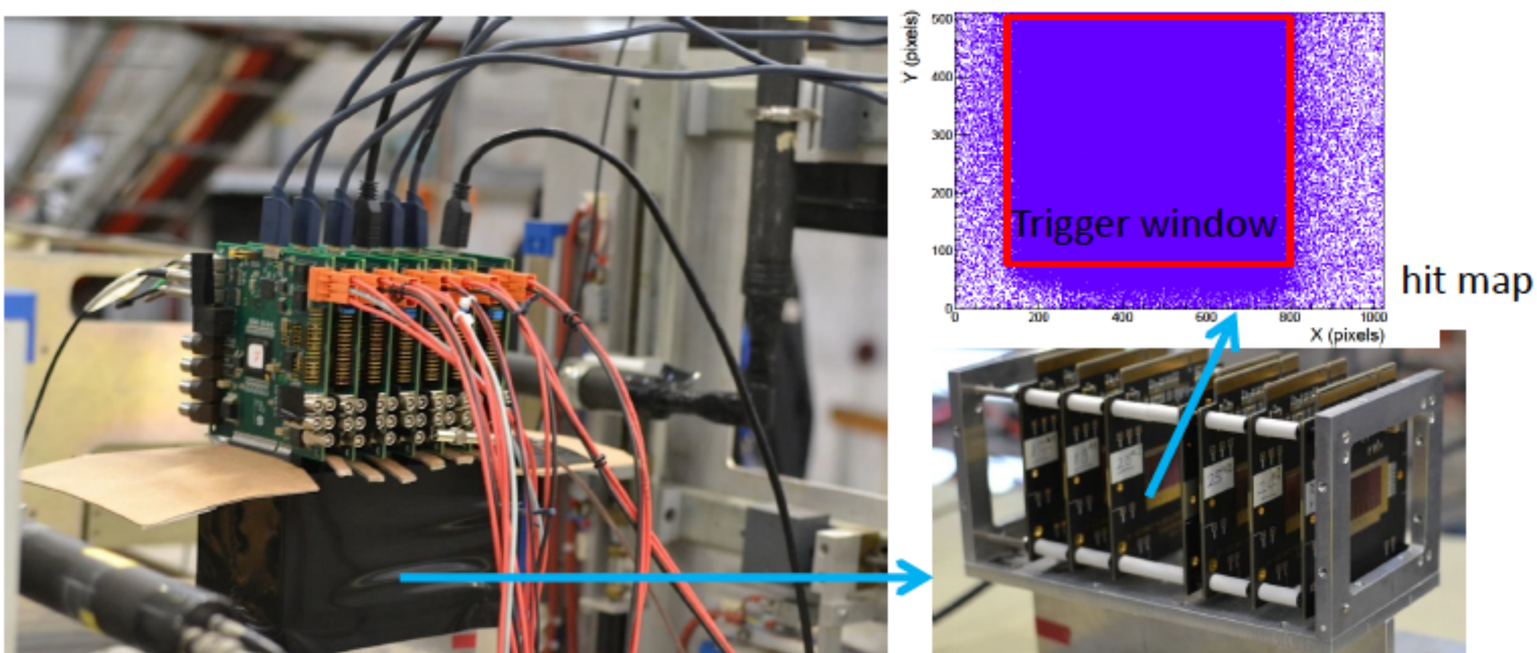
Intensive test beam campaign

- PS: 5-7 Gev π^-
- SPS: 120 Gev π^-
- PAL (Korea): 60 MeV e^-
- BTF (Frascati): 450 MeV e^-
- DESY: 5.8 Gev e^+

Scan of main parameters ➔ ~ 200 settings

7-plane telescope based on pALPIDE chip





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ALICE

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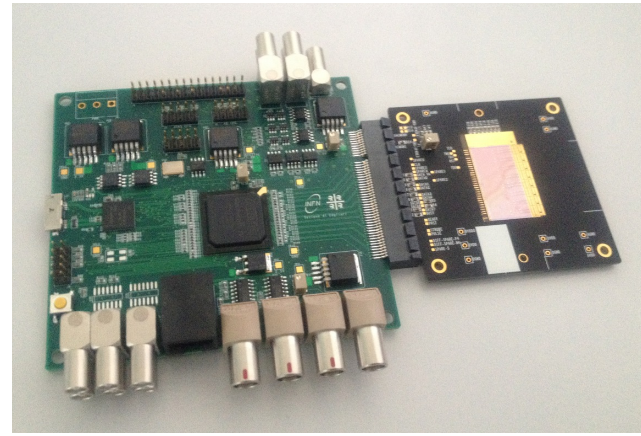


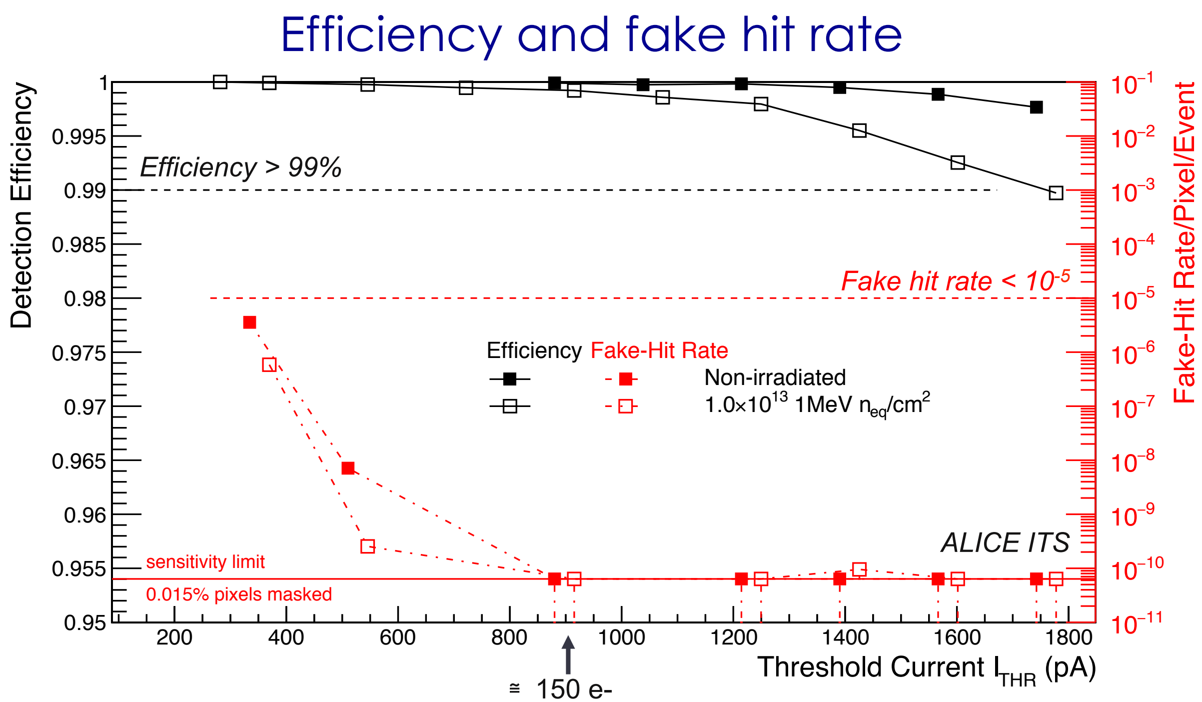
Test beam @LNF

2014: May, Jun, Sep, Nov
2015: Mar, May, Dec(7-14)

→ efficiency and characterization of irradiated chips

In 2015 the DAQ has been entirely developed at LNF

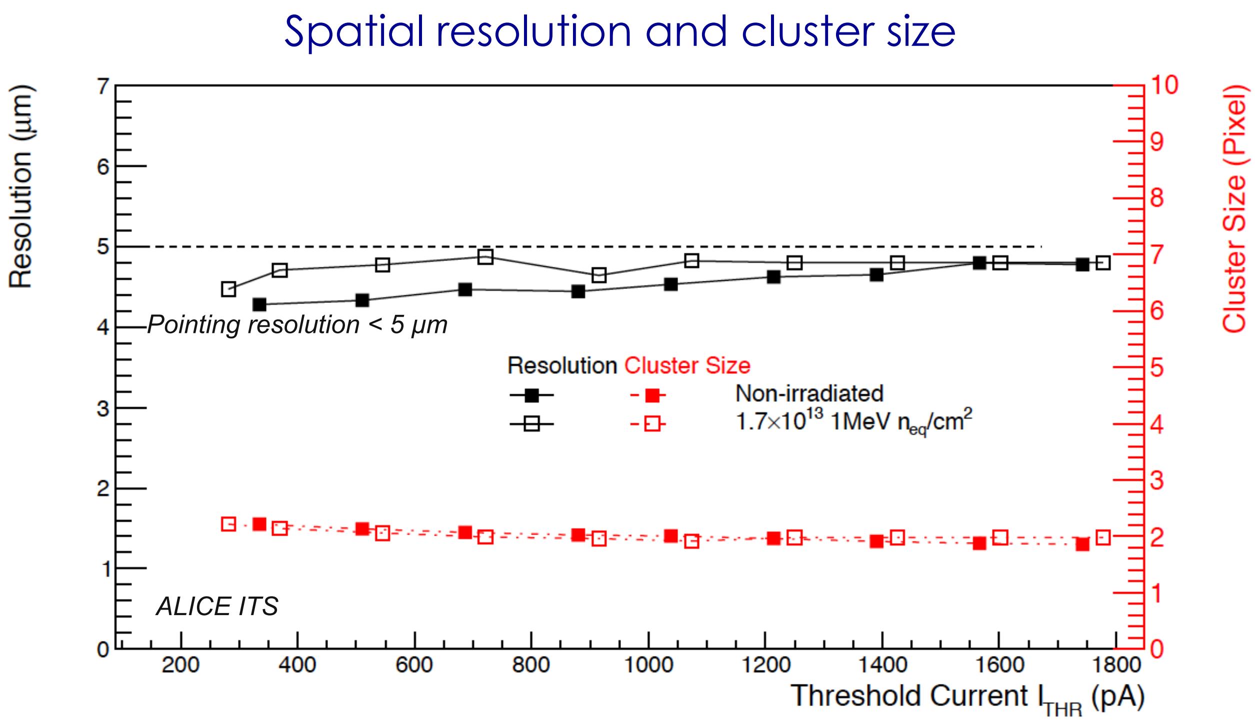
Test Beam: ALPIDE-2



λ_{fake} << 10^{-5} / event/pixel and ε_{det}>99.5% over a wide threshold range

Chip of 50 μm thick: 3 non irradiated and 3 irradiate with neutrons to 10^{13} (1MeV $n_{eq)}$/cm^2 → excellent performance also after the irradiation

Test Beam: ALPIDE-2

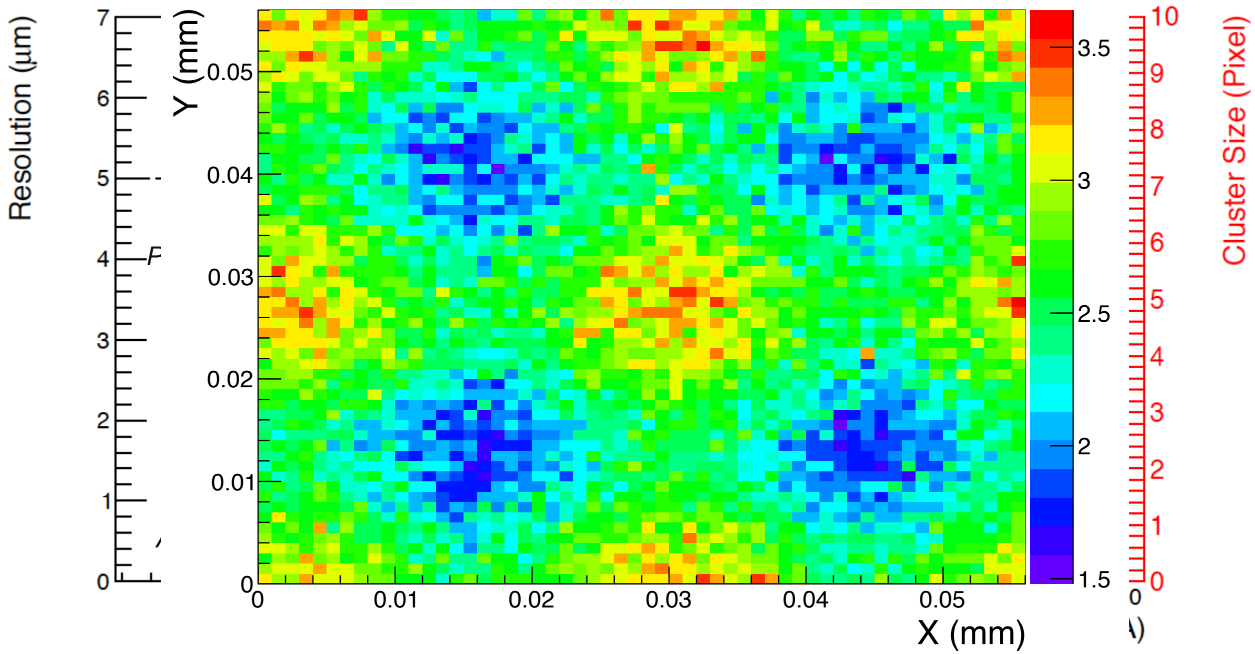


Space point resolution (including tracking error ~3 μm) < 5 μm

Chip of 50 μm thick: 3 non irradiated and 3 irradiate with neutrons to 10^{13} (1MeV $n_{eq)}$/cm^2 → excellent performance also after the irradiation

Test Beam: ALPIDE-2

Spatial resolution and cluster size



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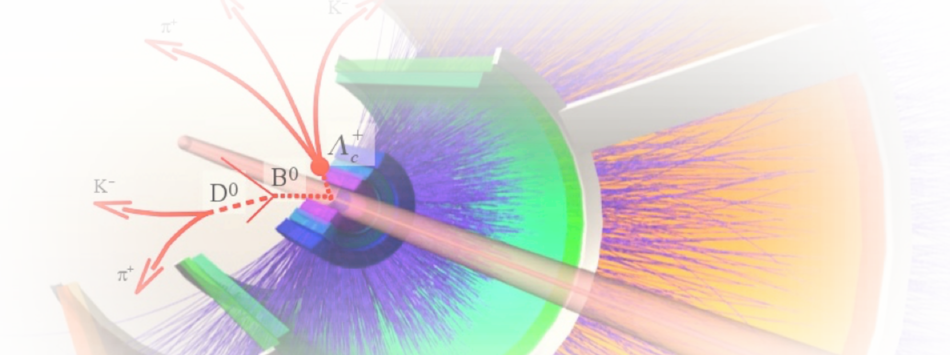
Conclusions



- ✓ The ALICE-LNF group consists of highly committed personnel (<FTE>=90%)

- ✓ Within the international collaboration, presence in the management and in coordination positions

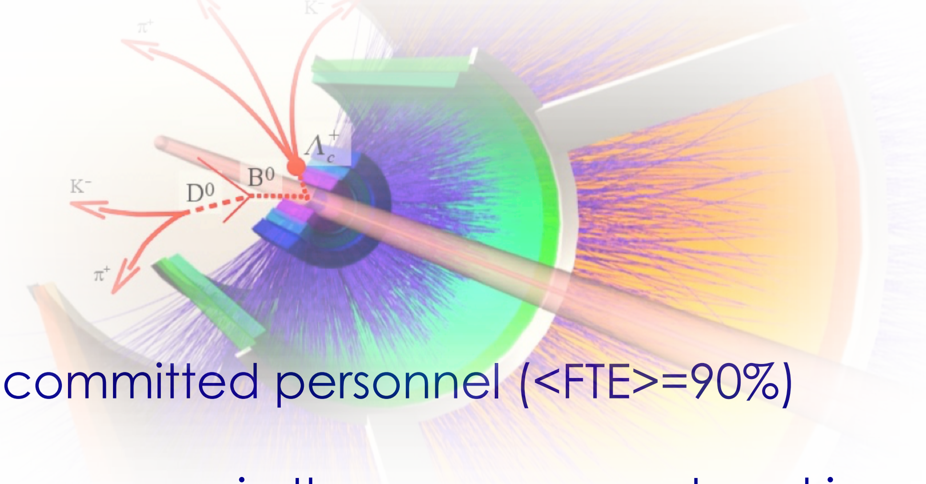
- ✓ Advanced analysis carried on (jets, HF, GPD/TMD) and papers co-authors

Key role in the construction of one of the most advanced solid state detectors

- ✓ *R&D for assembling, jig design and construction, procedures and protocols*
- ✓ *Test beams intense campaigns @BTF in the last 2 years*

Very good support from the LNF services (workshop, electronics, vacuum)
First silicon detector ever built at LNF → huge additional know-how for the lab

Conclusions



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We have no lack of enthusiasm!