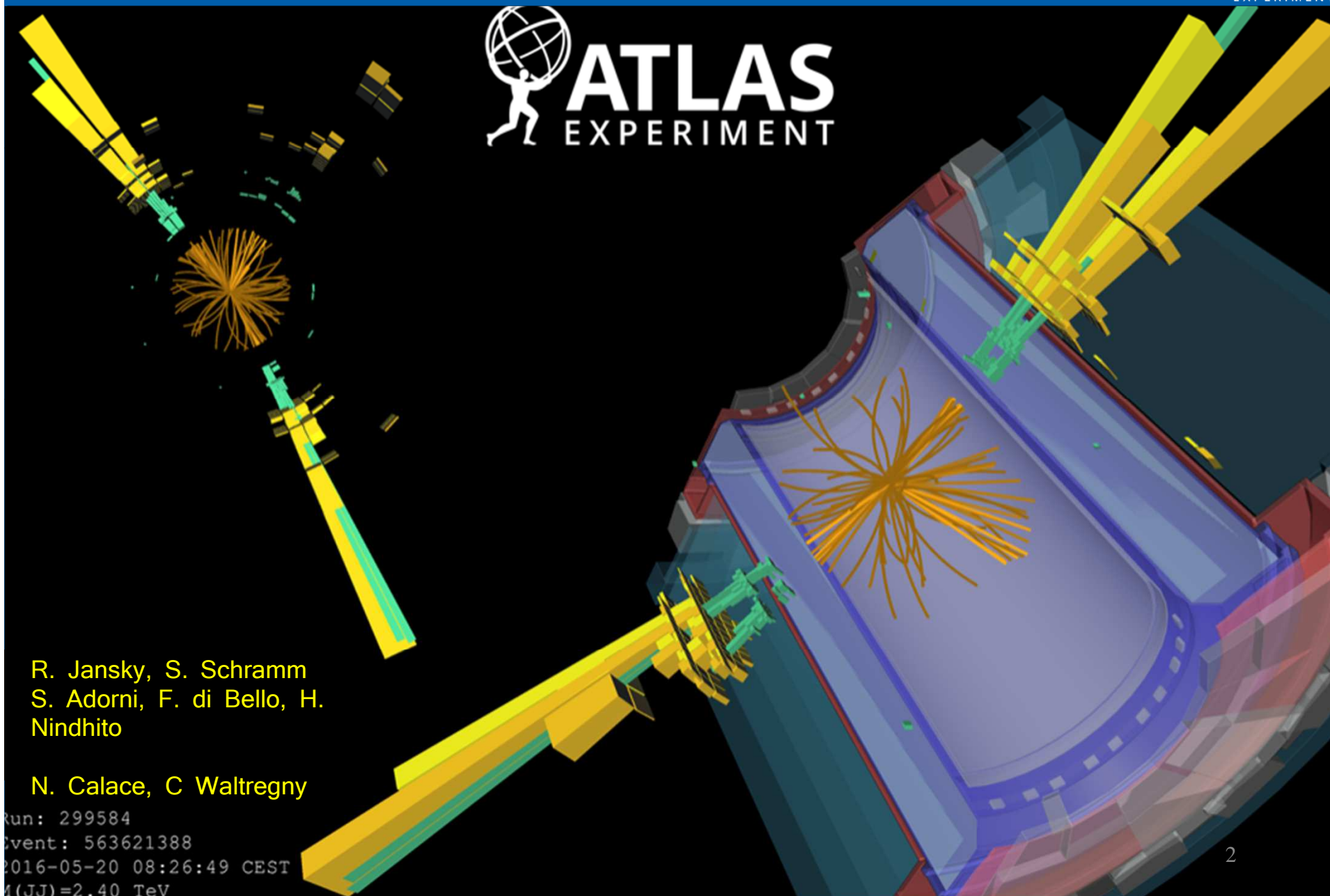


G. Iacobucci group activities - 2018

- ATLAS
 - Data Analysis: boosted di-boson + boosted Higgs \rightarrow bb
 - HL-Luminosity upgrade:
 - Outer Barrel Pixel Mechanics
 - Outer Barrel Patch-Panel 0 (PP0)
 - R&D on Monolithic pixels
- TT-PET project
 - Development of timing monolithic SiGe sensors

Searching for New Physics

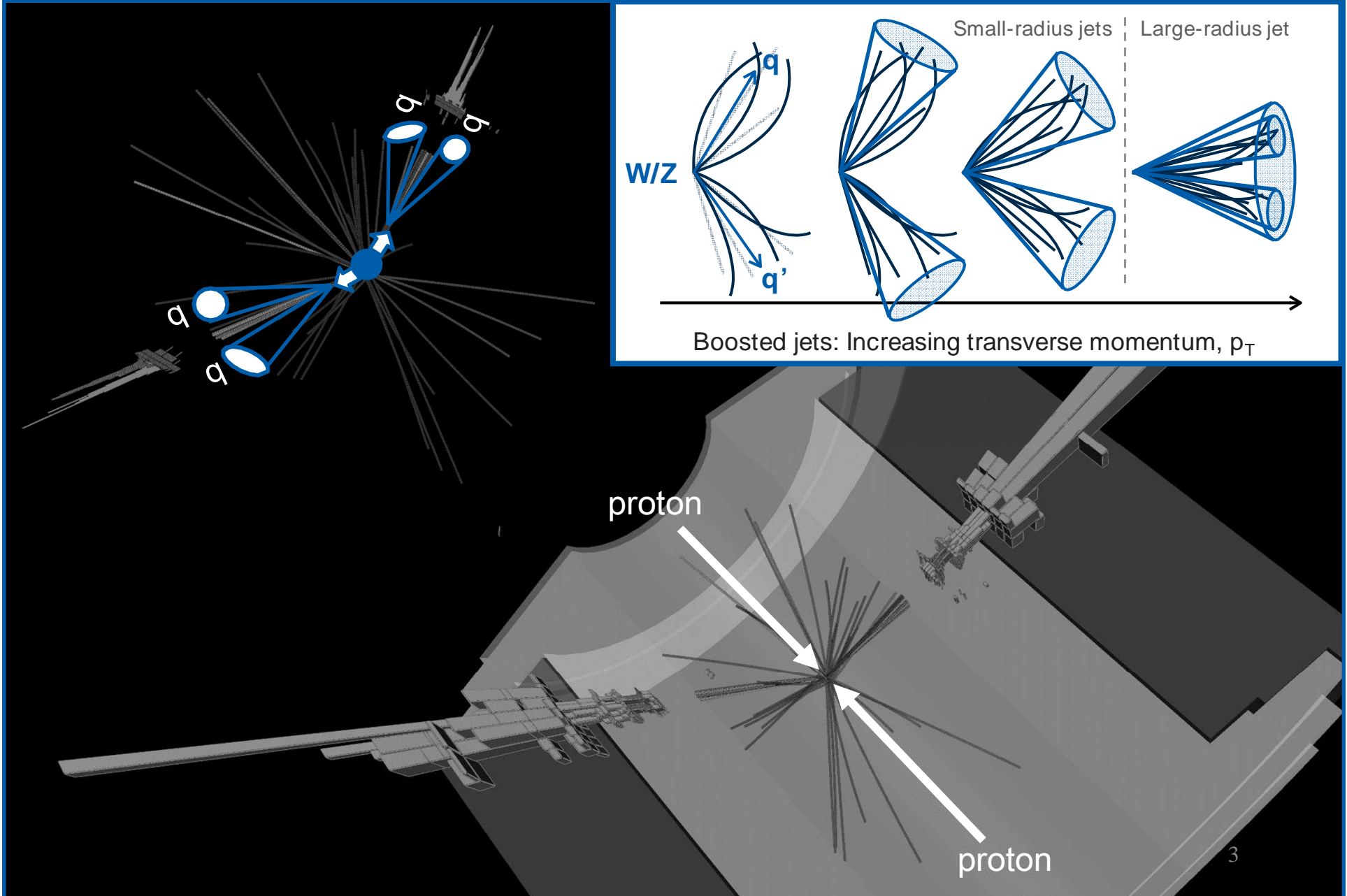


R. Jansky, S. Schramm
S. Adorni, F. di Bello, H.
Nindhito

N. Calace, C Waltregny

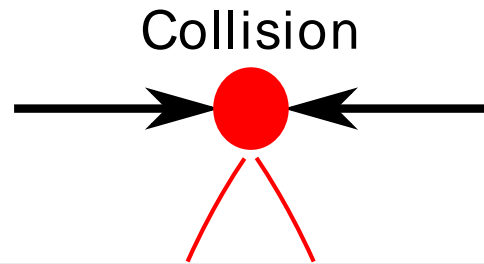
Run: 299584
Event: 563621388
2016-05-20 08:26:49 CEST
sqrt(s)=2.40 TeV

Searching for New Physics: Dibosons



Searching for New Physics: the TCC

Fully utilizing the detector: Track-CaloClusters



Calorimeter

At high p_T :

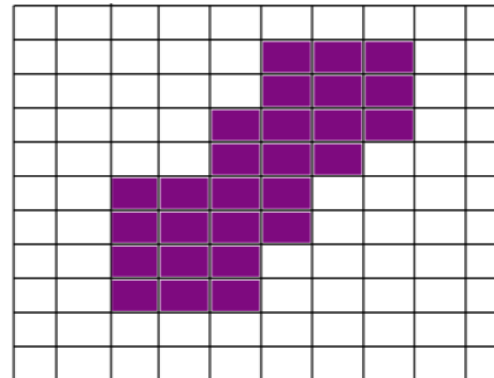
- Poor spatial resolution
- Excellent energy resolution
- Measures charged+neutral

Tracking detector

At high p_T :

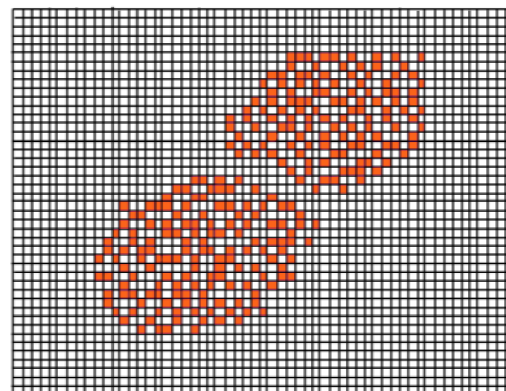
- Excellent spatial resolution
- Poor jet energy resolution
- Only charged particles

Track-CaloClusters (TCCs)



Use calorimeter for energy measurement (p_T, m)

Requires expertise: We are the leading experts in this area

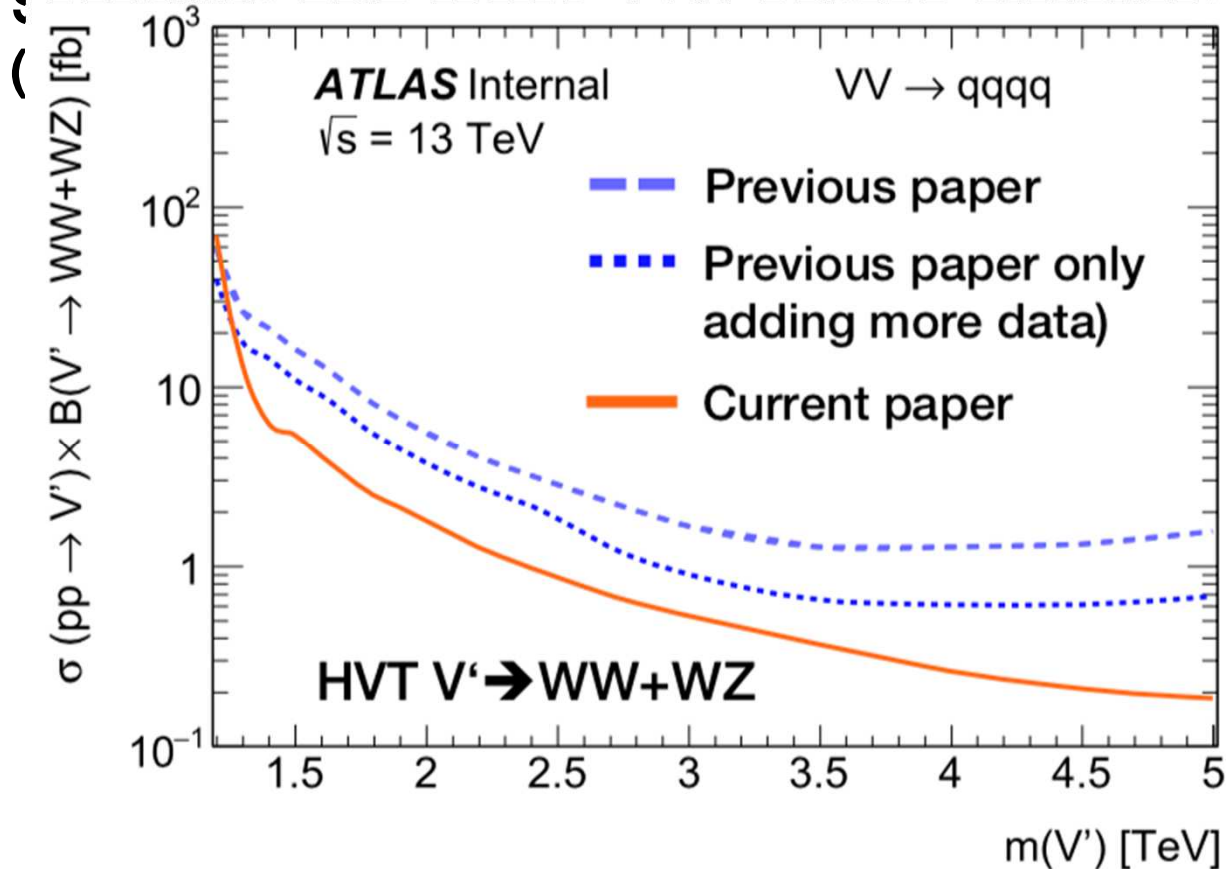


Match tracks to calorimeter cluster(s)

Use tracker for spatial coordinates (η, Φ)

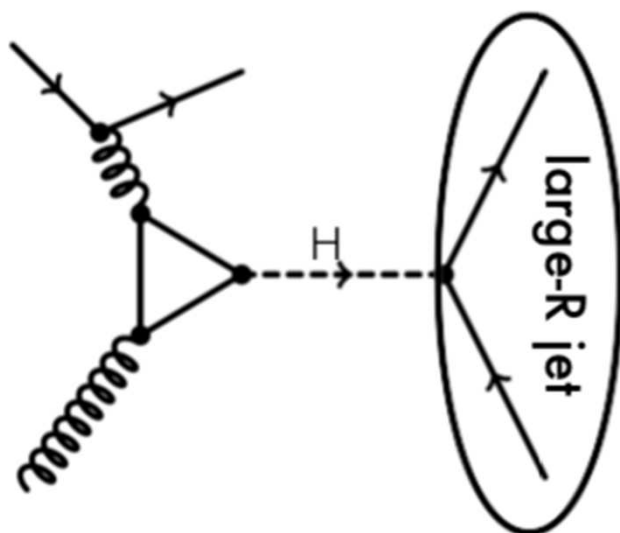
Event Reconstruction Improvements with TCC

- Publication integrates significant improvement on event reconstruction:
Use of TrackCalo-Cluster jets help for advanced high- p_T W/Z identification which was developed by our group.
- **Significant gain factor 2 (4) beyond statistical scaling at 3 TeV**

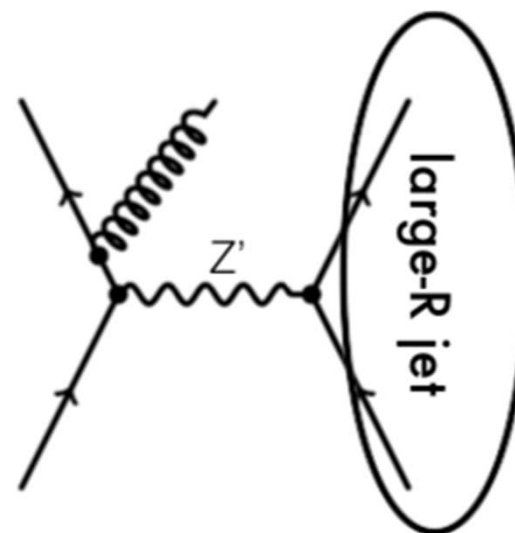


Searching for New Physics with the TCC

Look also for:



Higgs \rightarrow bb

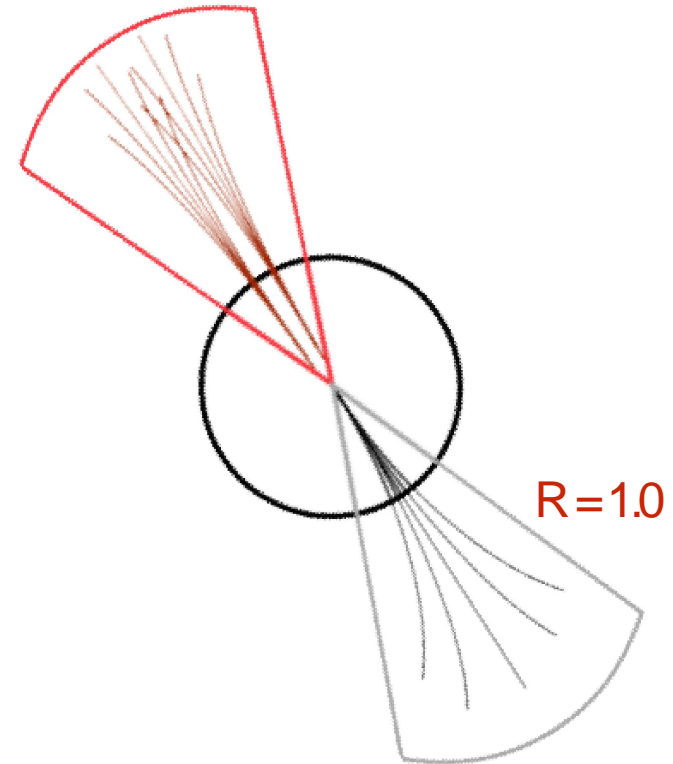
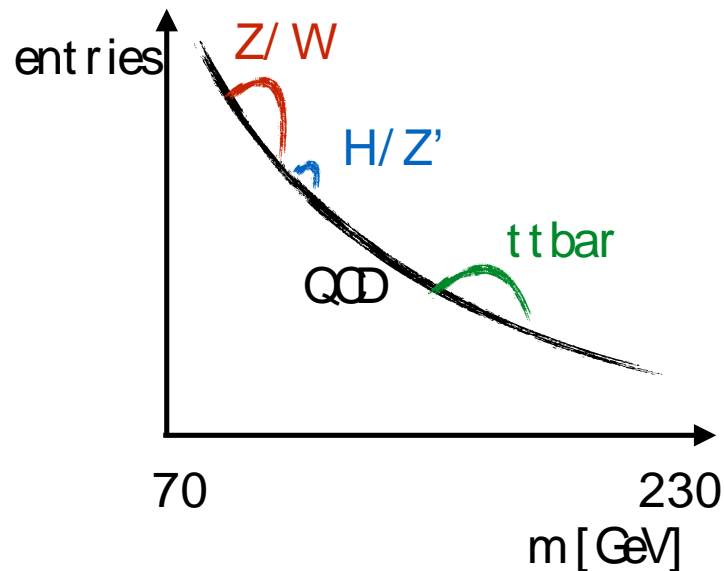


Z' \rightarrow bb production

at very high p_T

Searching for New Physics with the TCC

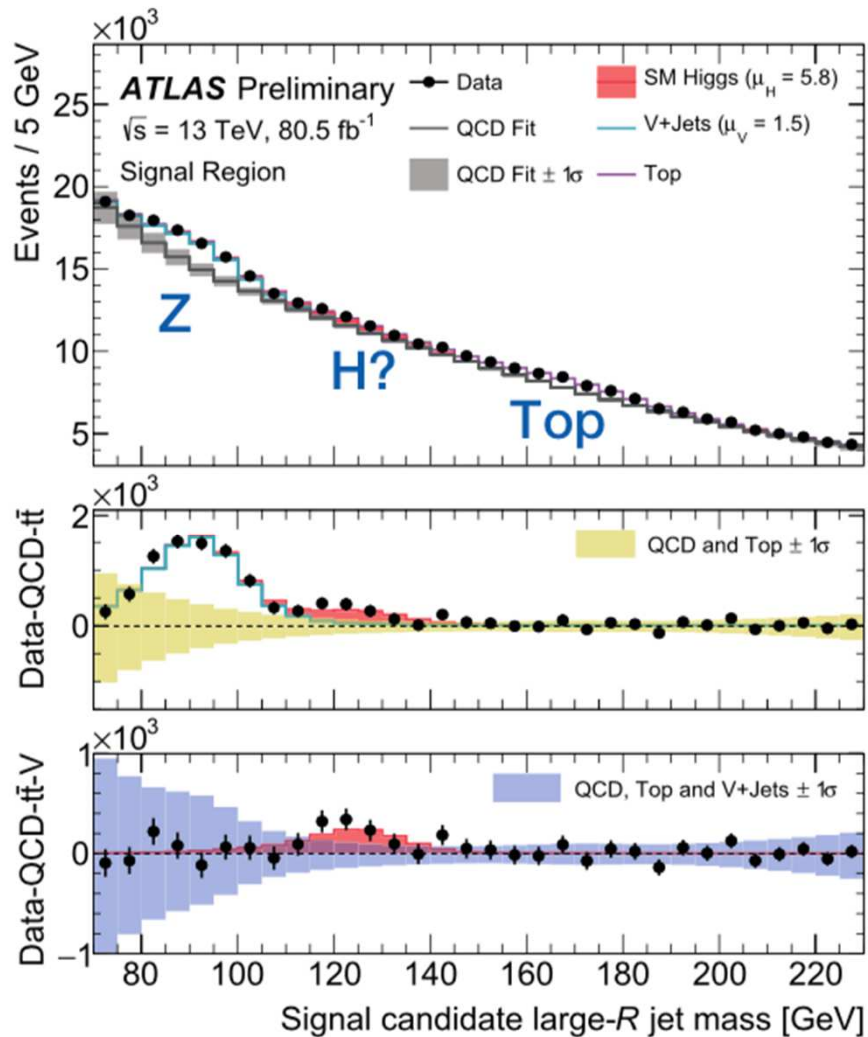
- Two large-R jets, leading > 480 GeV, sub > 250 GeV
- Trigger based on Large-R jet, **other jet also large-R jet asked CDS, simplifies analysis**
- largeR jet with two b-tagged VR track jets
- Search for resonance over QCD BKG (ttbar yield from C)



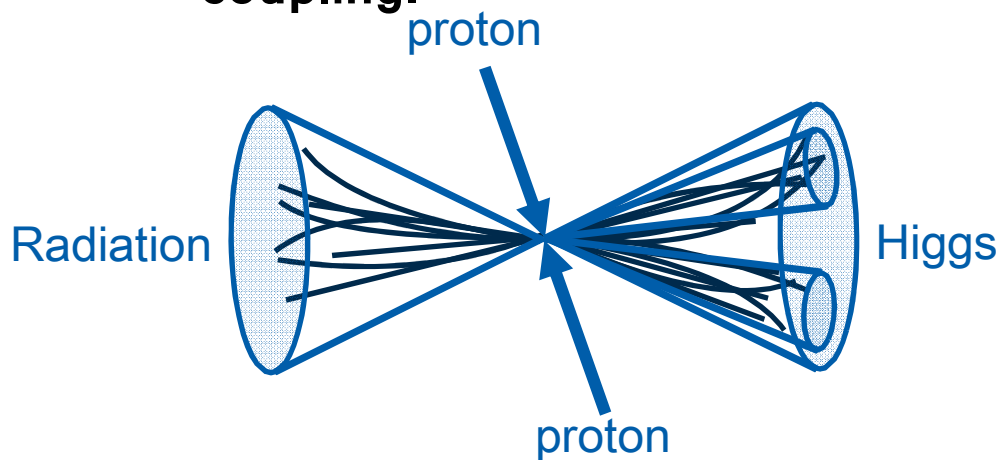
Presentation of the results:

- Z' Limits
- Signal strength measurement of V+jets
- SM H search

Probing Higgs at Highest Energies



- **First time probe Higgs boson in direct (“gluon-fusion”) production.**
- **Opens door to important physics program:**
 - High momentum transfer very sensitive to new physics effects.
 - Only channel to directly probe top and b-quark Yukawa coupling.



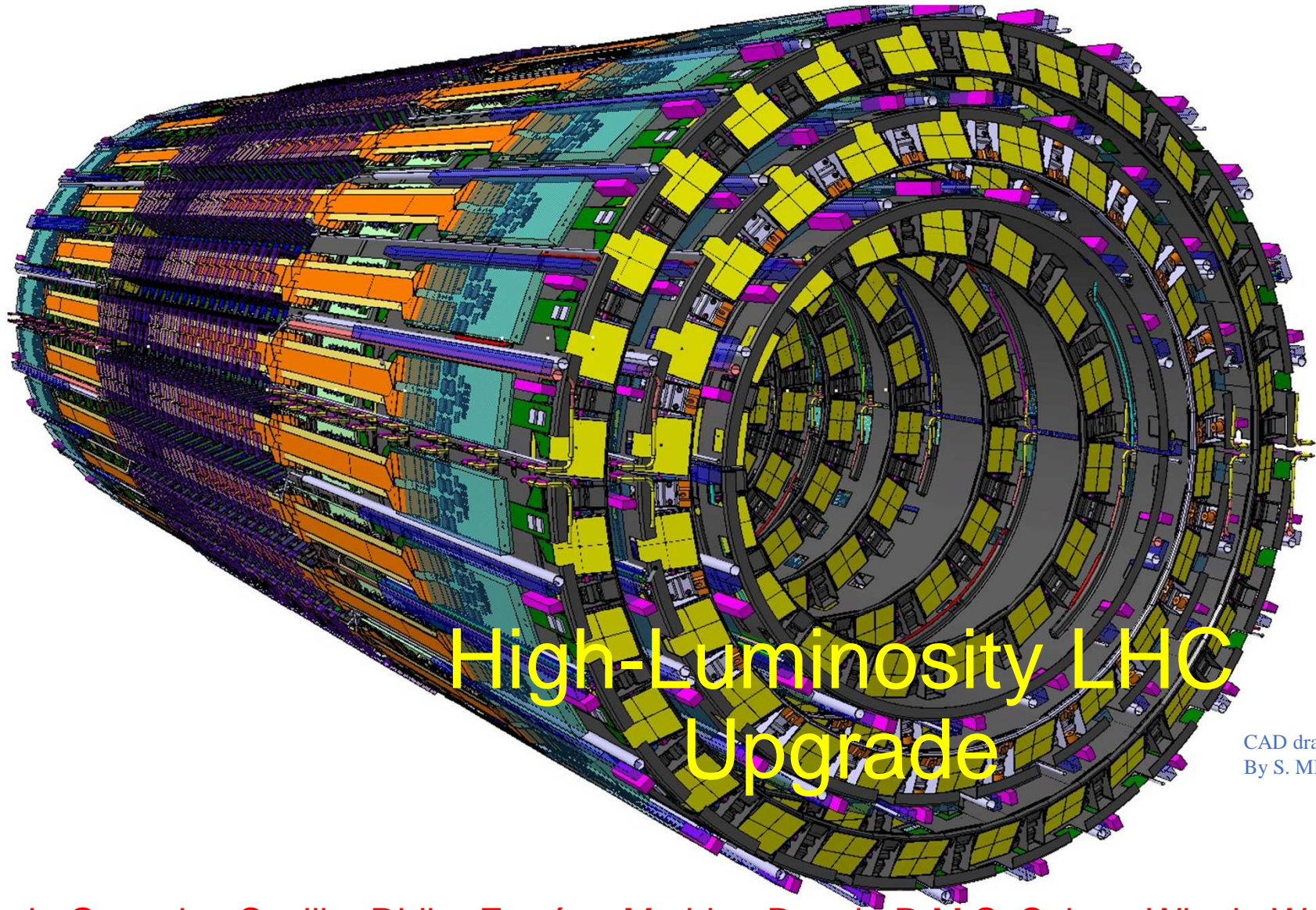
People:

- Roland Jansky, Steven Schrammy
- Sofia Adorni, Francesco di Bello, Herjuno Nindhito

- Charlotte Waltregny (MSc, finished June 2018)
- Noemi Calace (PhD, finished June 2018)

Publications in 2018

1. [Search for low-mass dijet resonances using trigger-level jets with the ATLAS detector in pp collisions at \$\sqrt{s} = 13\$ TeV](#)
2. [Search for resonances in the mass distribution of jet pairs with one or two jets identified as b-jets in proton-proton collisions at \$\sqrt{s} = 13\$ TeV with the ATLAS detector.](#)
3. [In situ calibration of large-R jet energy and mass in 13 TeV proton-proton collisions with the ATLAS detector](#)
4. [Performance of top-quark and W-boson tagging with ATLAS in Run 2 of the LHC](#)
5. [Measurements of b-jet tagging efficiency with the ATLAS detector using tt events at \$\sqrt{s} = 13\$ TeV](#)



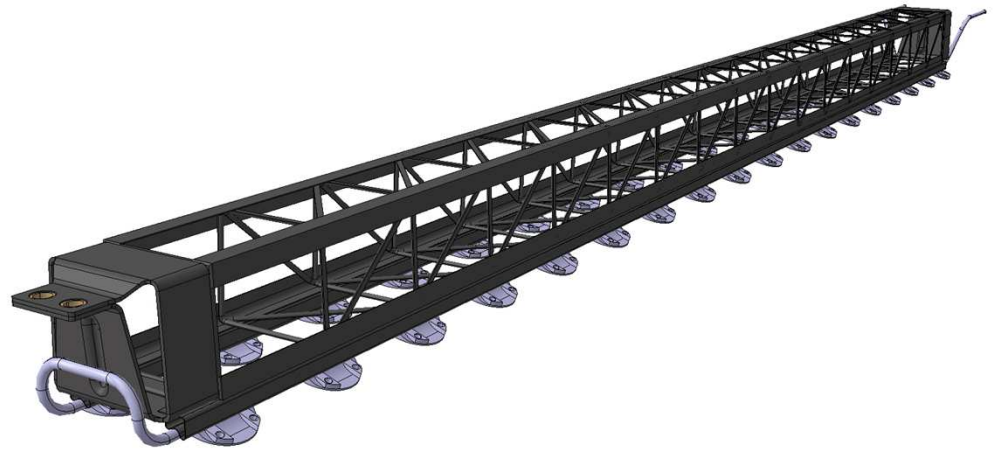
High-Luminosity LHC Upgrade

CAD drawing
By S. MICHAL

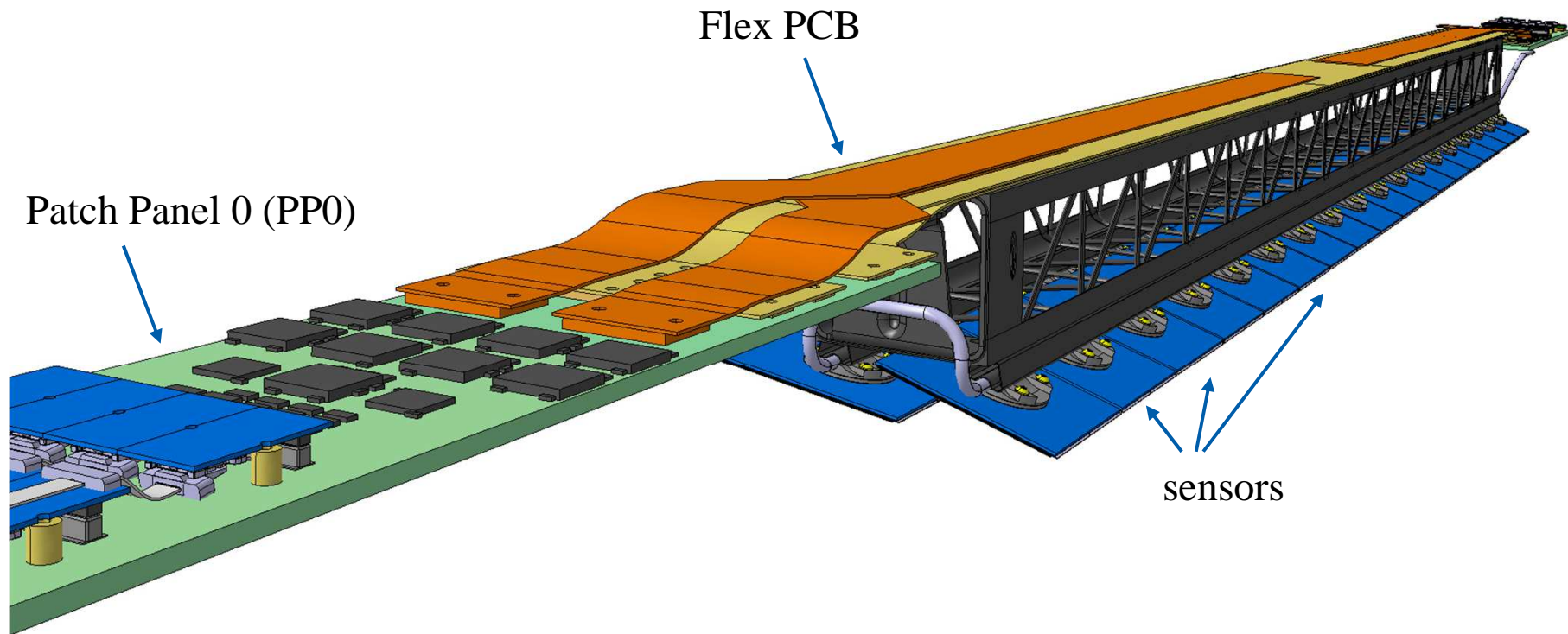
Sergio Gonzalez-Sevilla, Didier Ferrère, Mathieu Benoit, D.M.S. Sultan, Winnie Wong,
Ettore Zaffaroni, Mateus Vicente-Barreto-Pinto, Le Li

Sébastien Michal, Franck Cadoux, Coralie Husi,
Yannick Favre, Stéphane Debieux, Daniel Lamarra, Gabi Pelleriti, Xavier Mesa

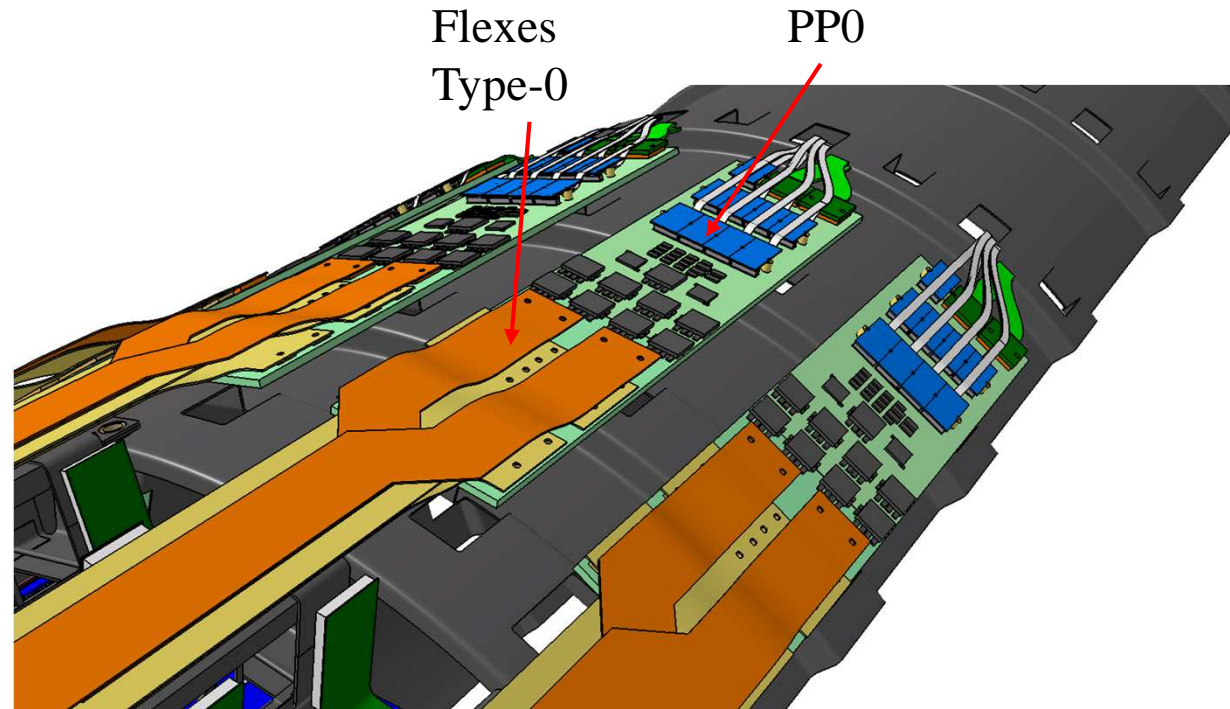
ATLAS ITk Outer Barrel Pixel – “Longeron”



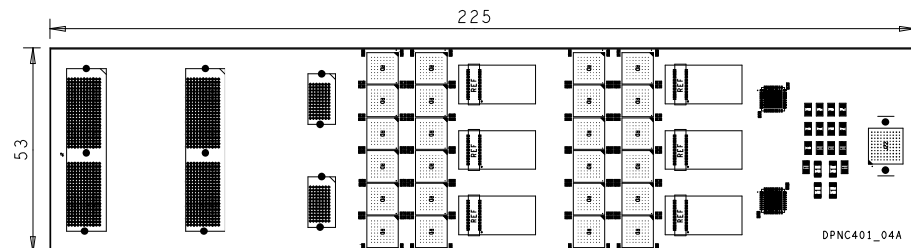
ATLAS ITk Outer Barrel Pixel – “Longeron”



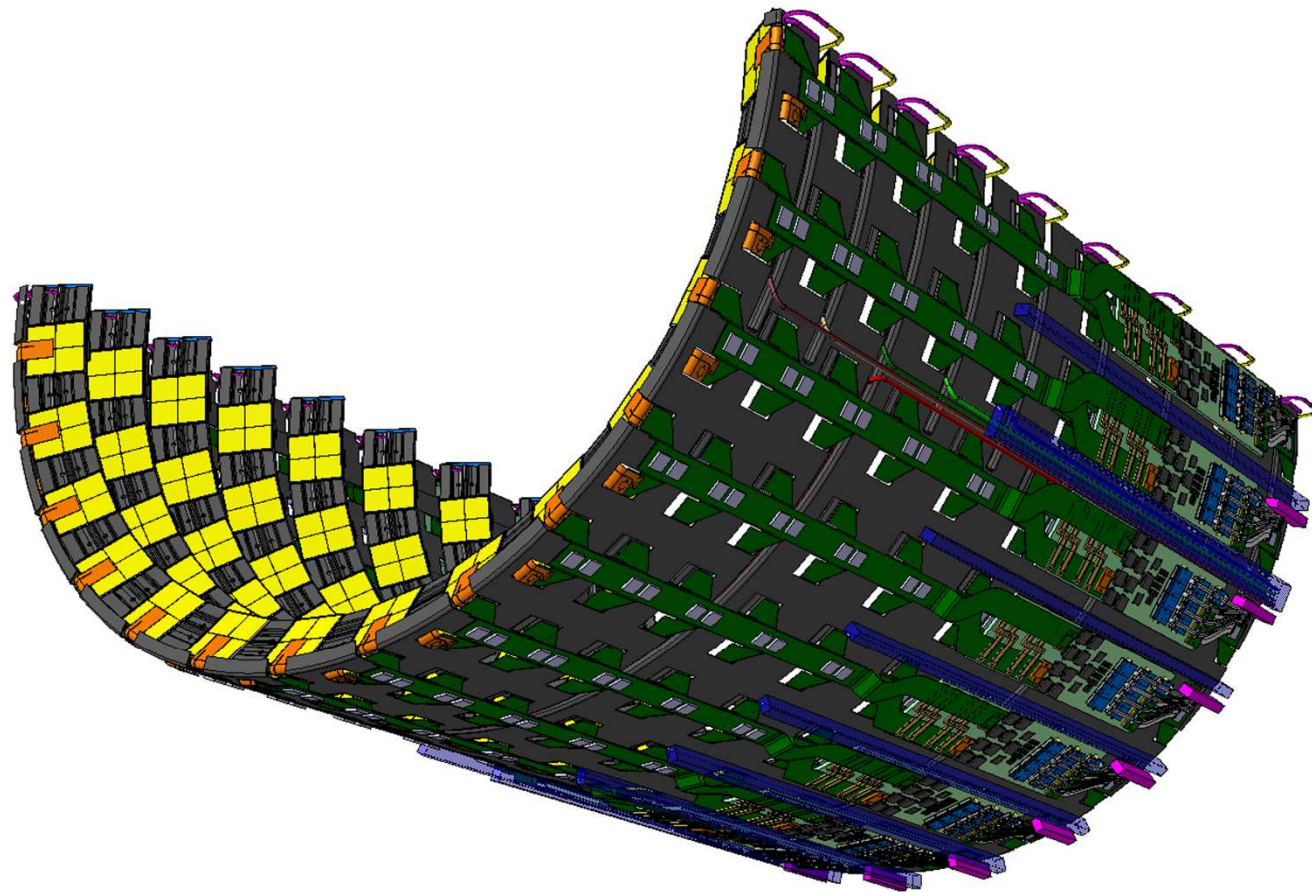
ATLAS ITk Outer Barrel Pixel – Patch Panel 0



- On-detector Patch-Panel-0 (PP0) serving as interface between the Type-0 stave-flexes and the off-detector services
- Very challenging: very tight radial envelope (10 mm to fit PP0, cooling-pipes, cables, etc.), radiation hardness
- Baseline of having lpGBT + VTRx electro-optical converter inside the detector volume



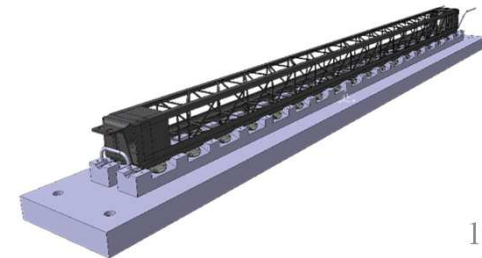
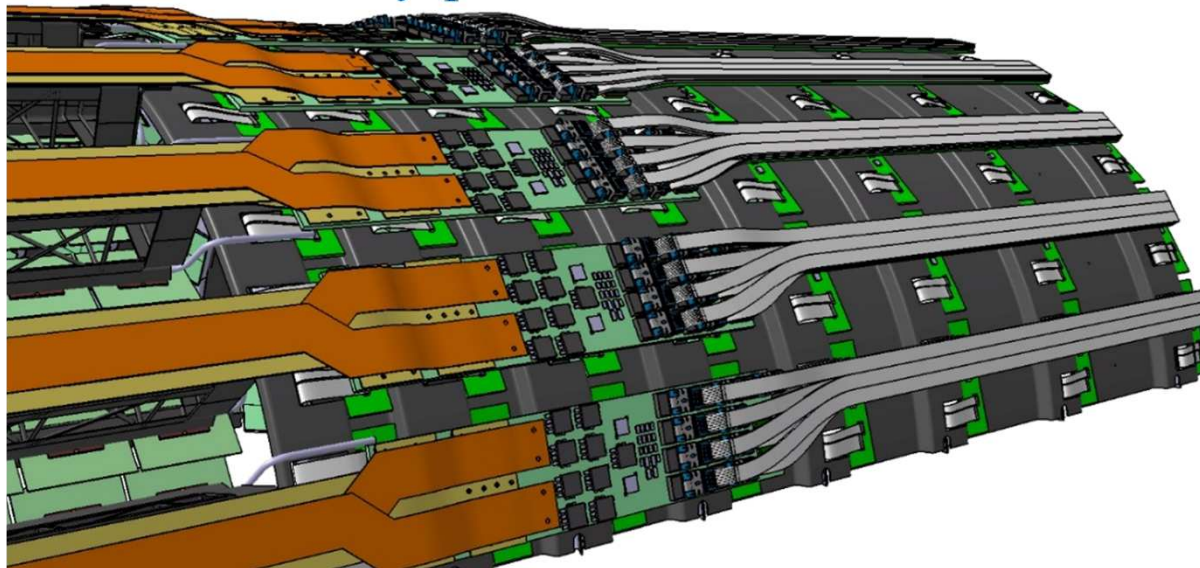
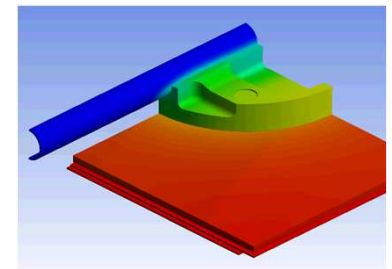
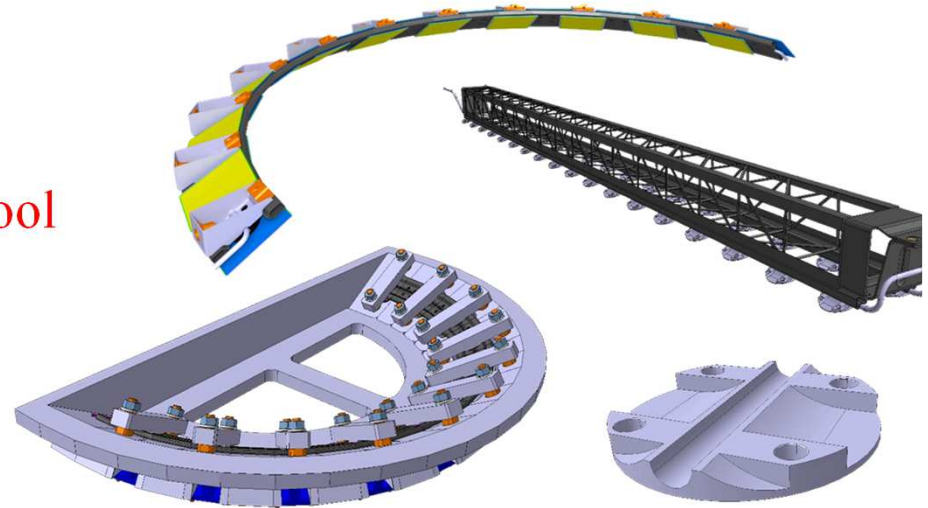
ATLAS ITk Outer Barrel Pixel – “Inclined” section



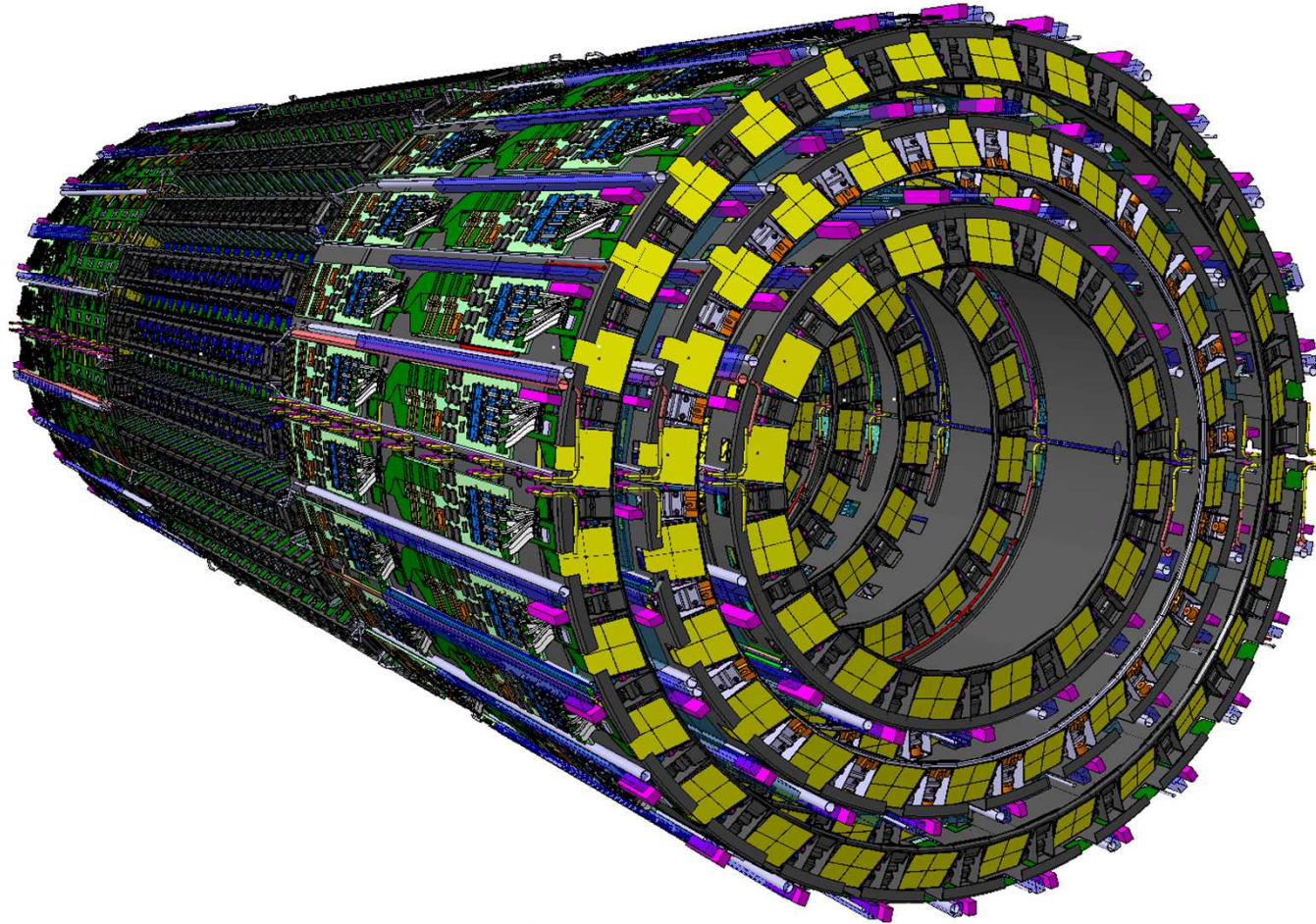
ATLAS ITk Outer Barrel Pixel – Mechanics

- Outer Barrel Engineering
 1. **Local support design** and **assembly tool**
 2. **Services design** and **integration**

→ITK Pixel Local Support
Preliminary Design Review
successfully passed



ATLAS Pixel Outer Barrel





H35demo
(CCPD)

This image shows a microscopic view of a sensor chip assembly. A central chip is mounted on a larger substrate. The chip has a complex pattern of gold and green layers. The assembly is labeled 'H35demo (CCPD)'.

Senseurs HV-CMOS

Deux fronts:

- CCPD (capacitively coupled, glued to frontend chip)
- MAP (Monolithic Active)



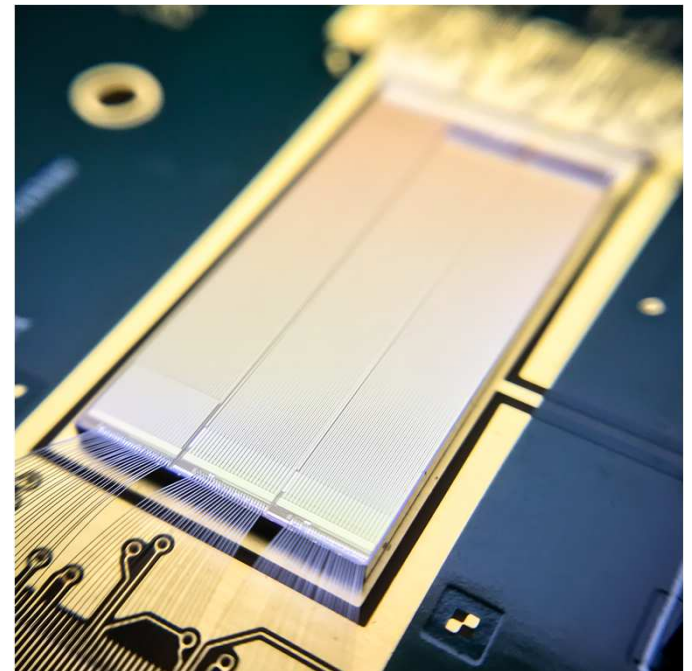
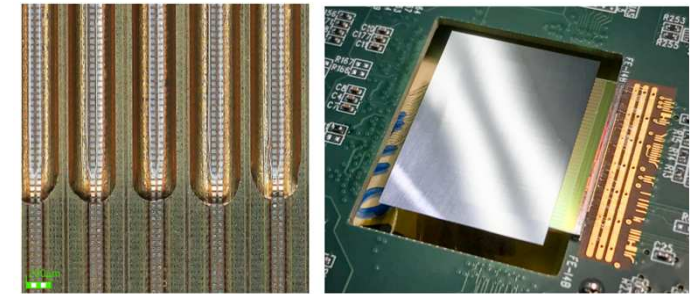
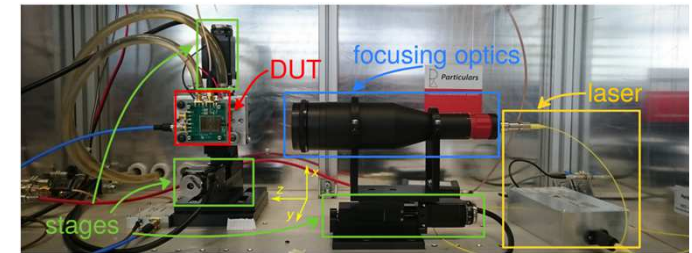
ATLASPix1
(monolithique)

This image shows a microscopic view of the ATLASPix1 sensor chip. The chip is a monolithic active pixel sensor. It features a central area with a grid of pixels, surrounded by a gold-colored frame. The chip is connected to a larger substrate with a complex pattern of gold and black layers. The assembly is labeled 'ATLASPix1 (monolithique)'.

ATLAS CMOS Activities

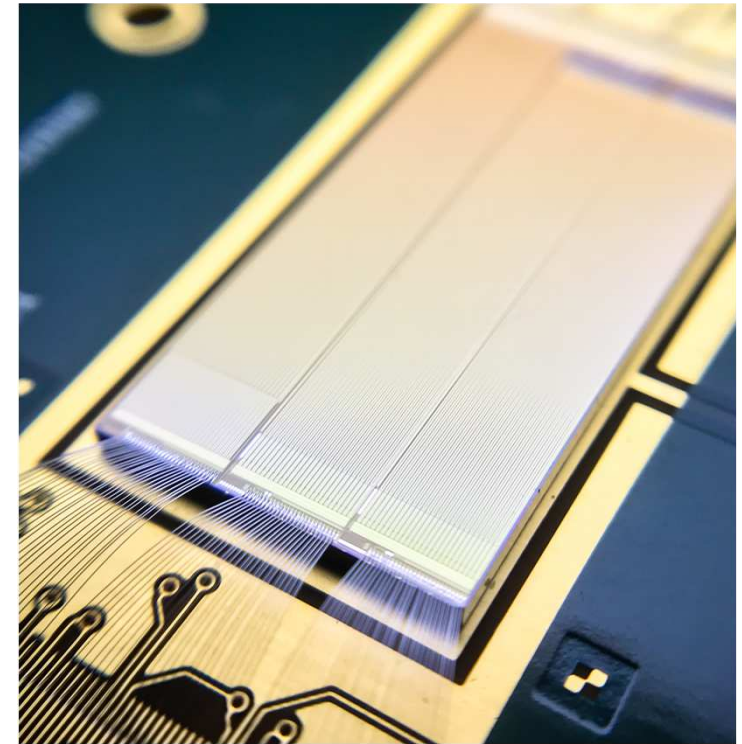
- We completed the study of the **H35DEMO CCPD** in ams h35 350nm HV-CMOS technology
 - First large surface (**2x2 cm²**) HV-CMOS CCPD sensor assembly and **test beam characterization**
 - First complete study of **depletion versus irradiation** (proton and neutron) on substrate with typical resistivities (20-1kΩcm)
- Leading to **3 Publications** :
 1. [TCT Measurement before and after irradiation for protons and neutrons, for different substrate resistivity](#)
 2. [Test beam measurement of capacitively coupled sensors](#)
 3. [Test beam measurement of monolithic sensors](#)

- The **ATLASPix1 Monolithic** Pixel sensor in ams h18 180 nm technology was delivered in 2018
 - **180nm HV-CMOS Engineering run on 20-200 Ω cm substrate**
 - **130x40 μm²** pixels, **25x400 pixels**, **Full-length column sensor** (1.9cm)
 - Thinned down to **60 μm**
 - **Threshold** down to **600e**, **120e dispersion**
 - **6 bit TOT** and **10 bit TOA** (up to 16 ns) , **Trigger-less readout**
 - Serializer, **PLL**, High-Speed data transmission (**1.25Gbps**)
 - **Radiation hardness up to >1x10¹⁵n_{eq}/cm²**, **100MRad**



ATLAS CMOS Activities

- **ATLASPix1** Test beam campaign in Fermilab and CERN to evaluate performance
 - **Efficiency > 98%** after irradiation to ITk out layer fluence ($1 \times 10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$, 100MRad) 7 ns timing resolution after timewalk and row delay correction
- **ATLASPix2** has been produced in **ams** and **TSI** technology and delivered this autumn
 - New design for trigger memory
 - Memory test structure for SEU test design by DPNC
- **ATLASpix3** design ongoing
 - Full matrix targeting ATLAS ITk requirements
 - Submission in February 2019



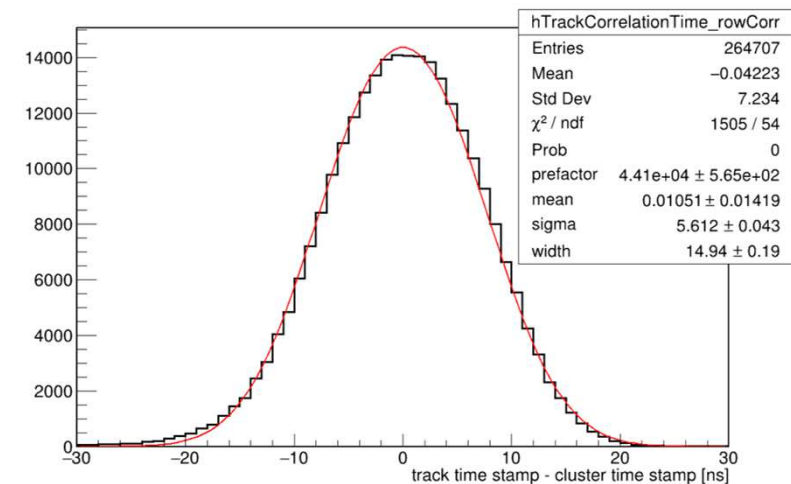
2 Publications:

[Performance of CMOS pixel sensor prototypes in ams H35 and aH18 technology for the ATLAS ITk upgrade,](#)
arXiv:1807.05953

[Characterisation of AMS H35 HV-CMOS monolithic active pixel sensor prototypes for HEP applications,](#)
arXiv:1811.07817

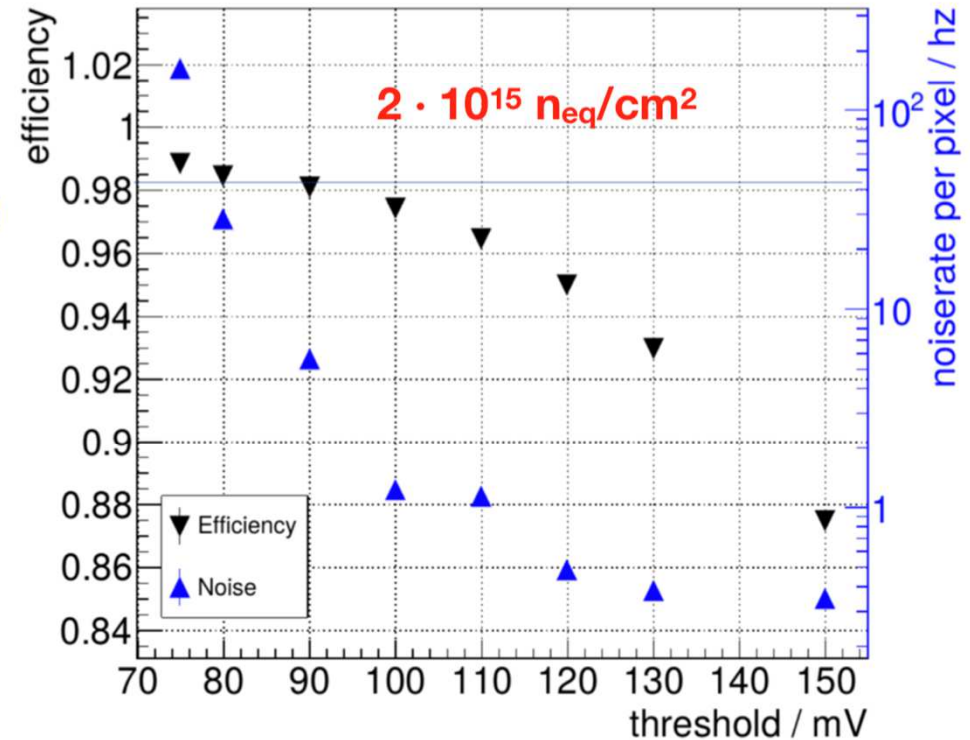
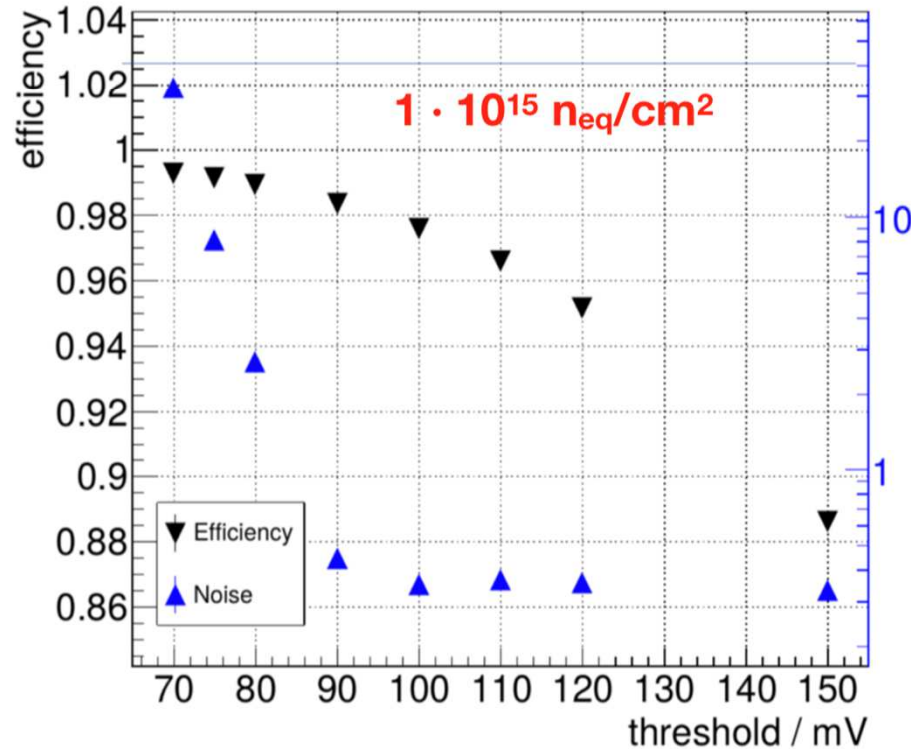
2 PhD thesis : Branislav Ristic and Mateus Vicente

1 Master thesis : Le Li



Time resolution measurement
ATLASPix1, unirradiated

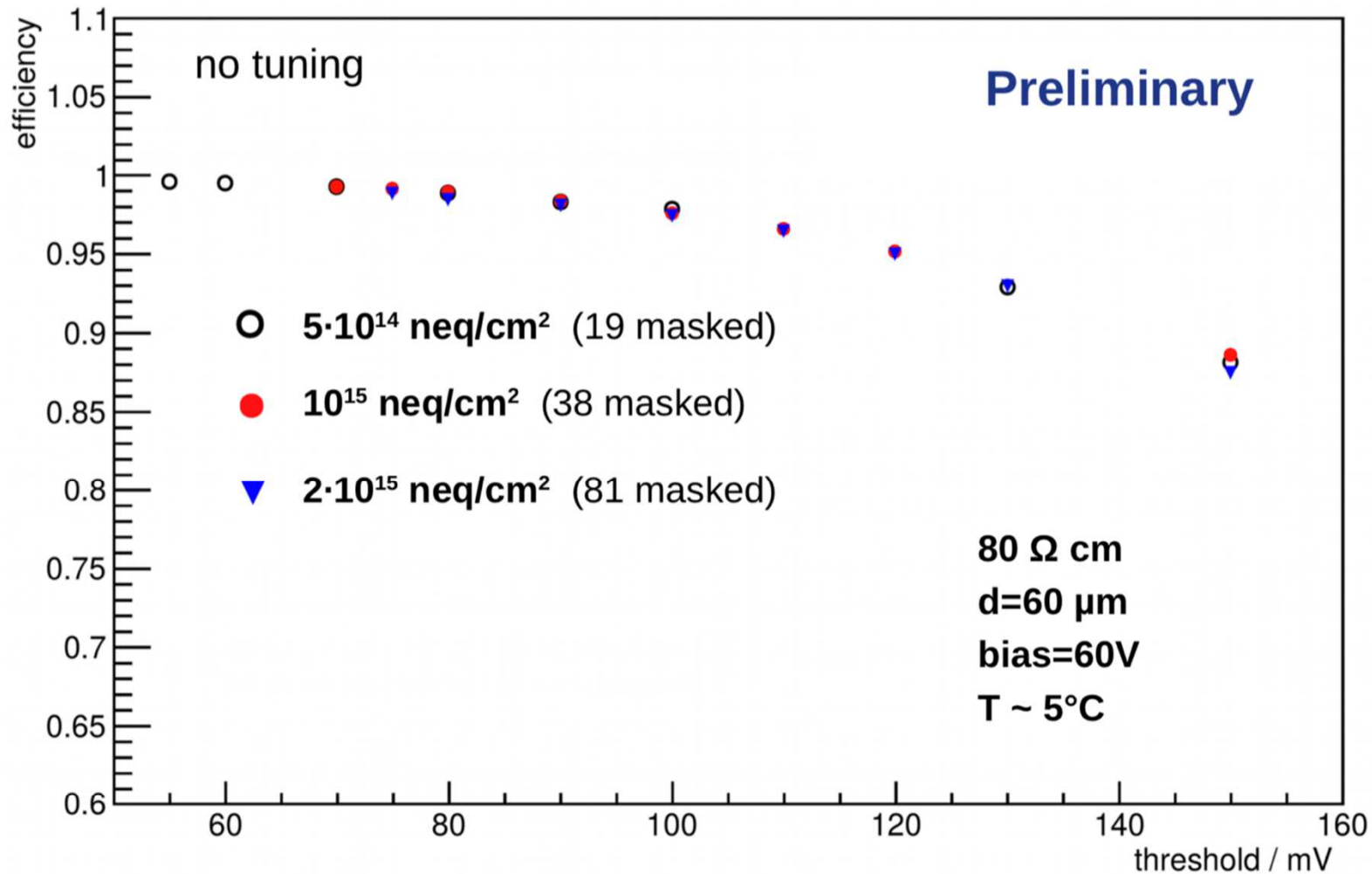
ATLASPix1 neutron irradiated



80 Ωcm samples, 60 μm thick
 Bias = 60 V
 Temperature = 10 $^{\circ}\text{C}$

Very high efficiency after target fluence of 10^{15}
 Noise well below specification

Neutron Irradiated 80 Ω cm Sensors @ 60V



- efficiency (charge collection) does not depend on fluence!

Question:

Will ATLAS decide in favour of this new technology ?

... to be answered in 2019

Monolithic **Timing** Silicon Detectors TT-PET project

Didier Ferrère, Lorenzo Paolozzi, Emanuele Ripiccini, Pierpaolo Valerio,
Daiki Hayakawa, Fulvio Martinelli, Daniele Vitturini

Franck Cadoux, Coralie Husi,
Yannick Favre, Stéphane Debieux, Gabi Pelleriti, Xavier Mesa



The TT-PET Project



a 30 ps Time-of-Flight PET scanner with silicon pixels



In collaboration with:

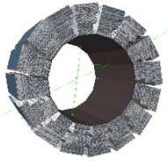
- Roberto Cardarelli - INFN Roma Tor Vergata
- Marzio Nessi - CERN IdeaSquare
- IHP microelectronics
- Edoardo Charbon - EPFL

Funded by:



SWISS NATIONAL SCIENCE FOUNDATION



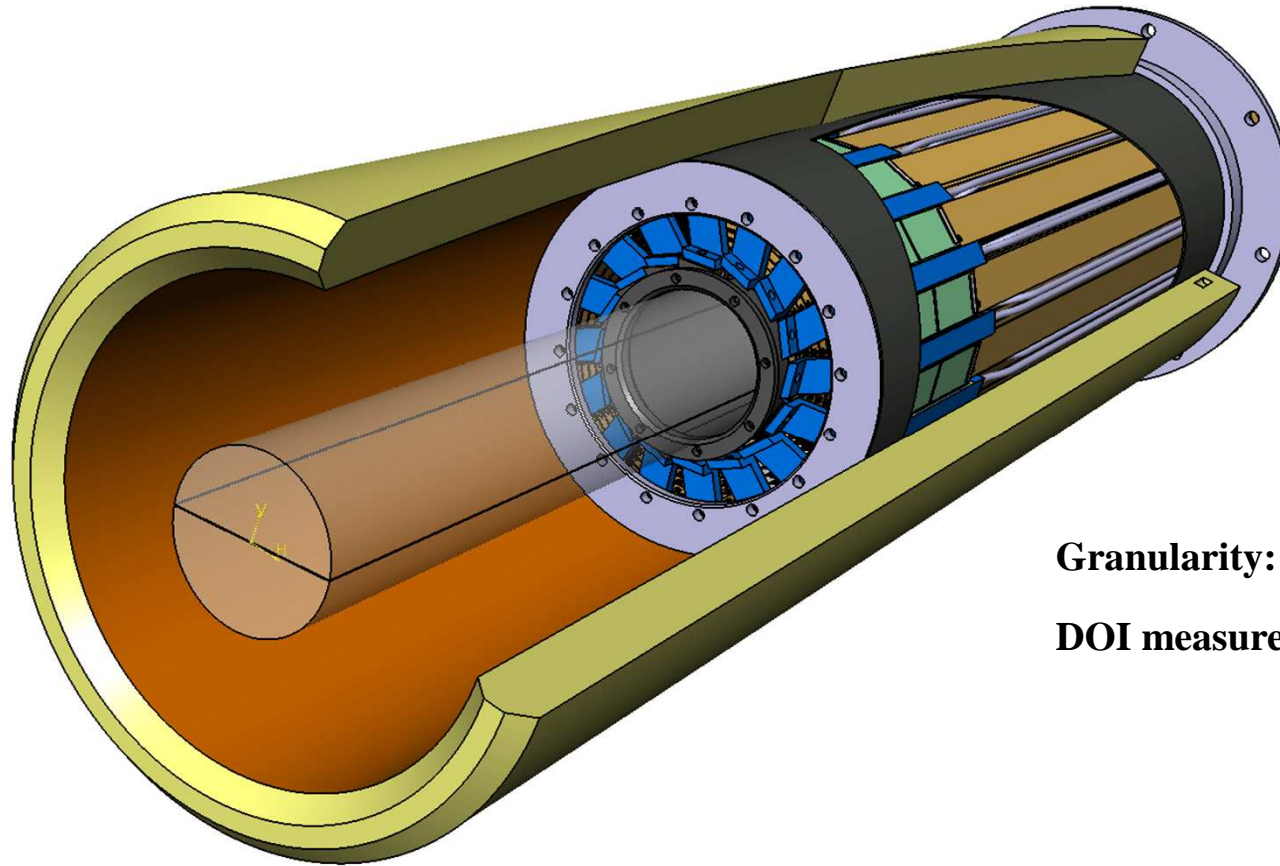


TT-PET

The TT-PET small-animal scanner



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Granularity: $200 \times 500 \times 500 \mu\text{m}^3$

DOI measurement: $200 \mu\text{m}$

Fully engineered at the DPNC:

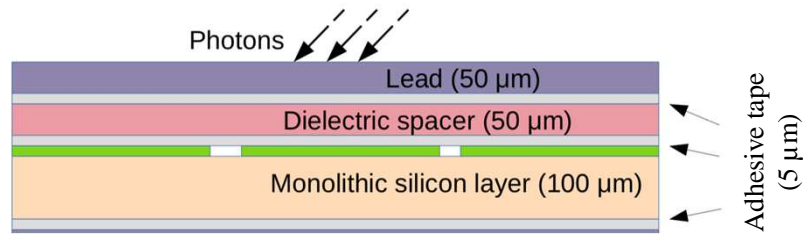


TT-PET

The TT-PET small-animal scanner

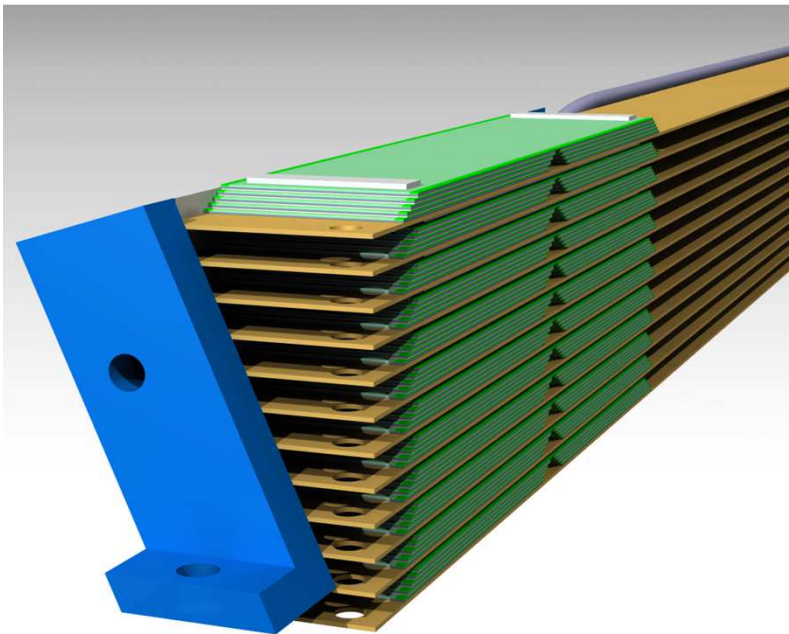
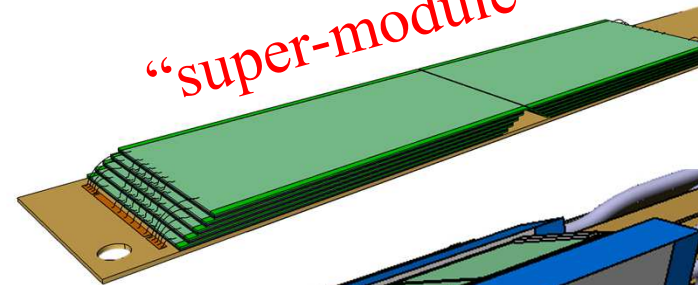


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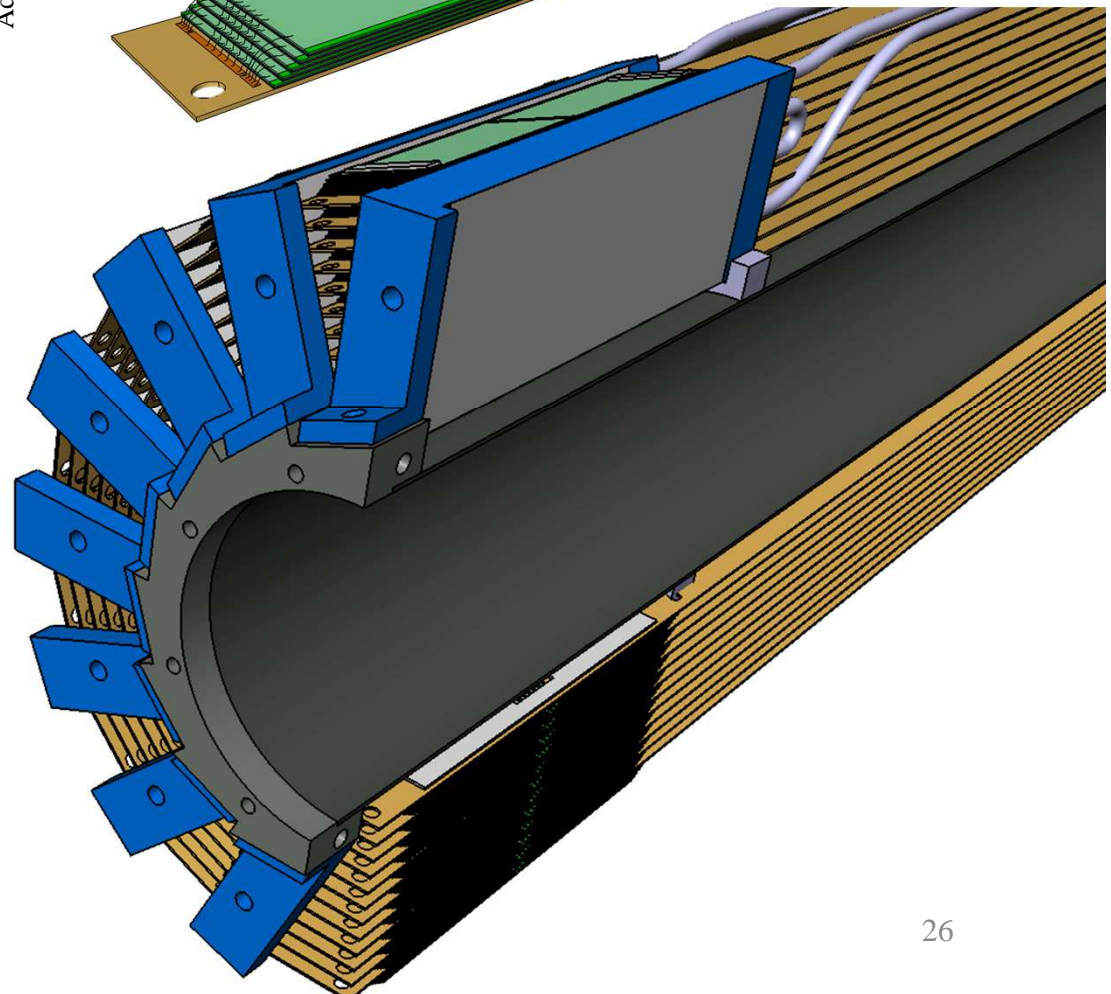


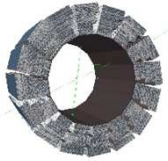
“Detection Unit”

“super-module”



“Tower”



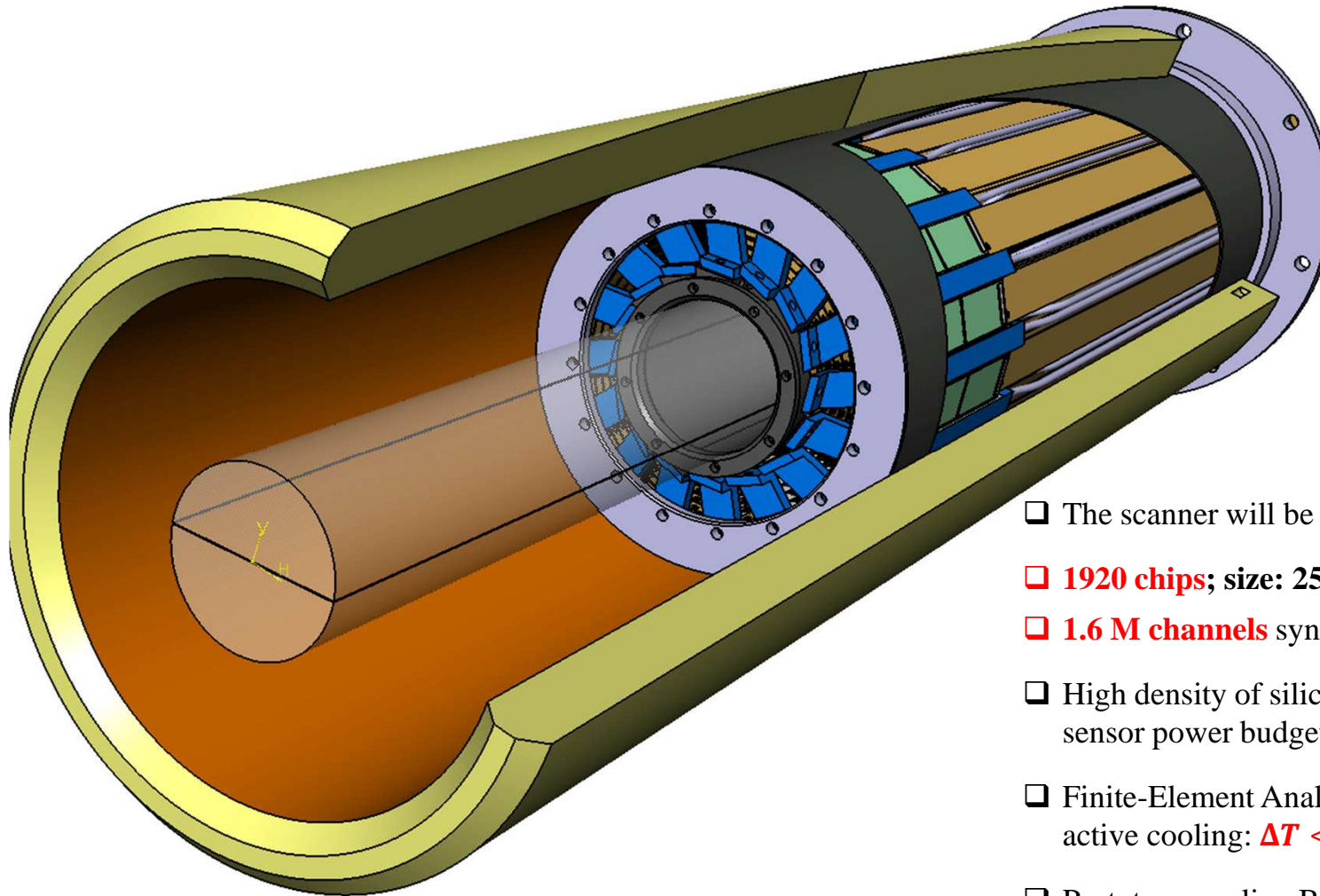


TT-PET

The TT-PET small-animal scanner



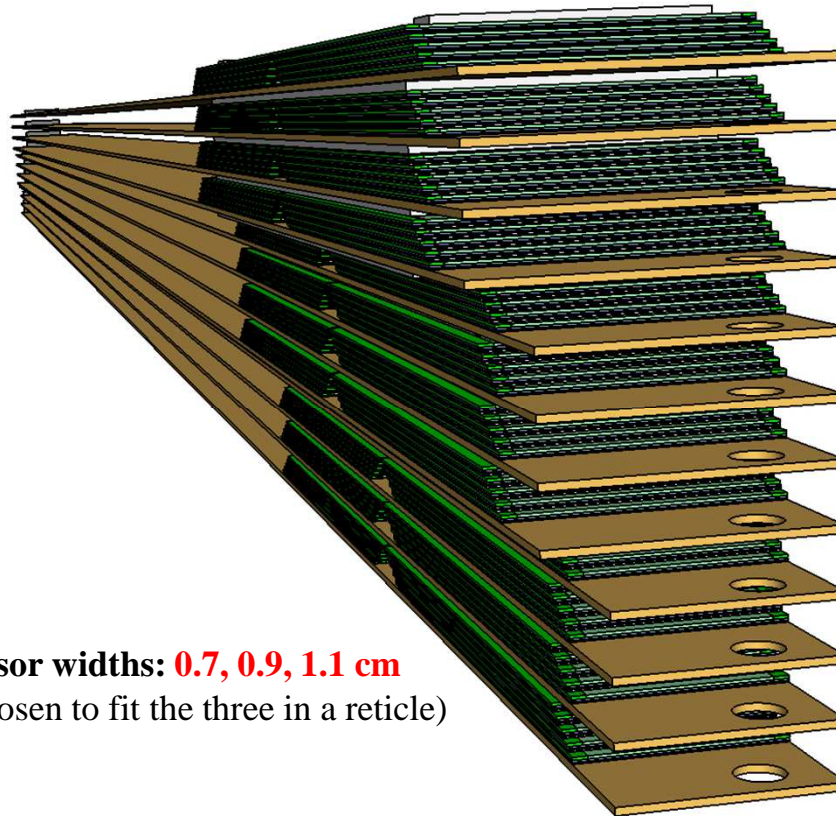
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- ❑ The scanner will be made by **16 towers**
- ❑ **1920 chips**; size: 25mm long, 7,9,11mm wide
- ❑ **1.6 M channels** synchronized at 10ps.
- ❑ High density of silicon pixel sensors:
sensor power budget < **80 mW/cm²**
- ❑ Finite-Element Analysis performed:
active cooling: **$\Delta T < 1^\circ\text{C}$**
- ❑ Prototype cooling Block **produced**
- ❑ Thermomechanical tower prototype
constructed: results within power budget



The TT-PET small-animal scanner



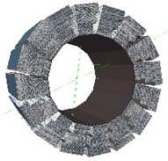
3 sensor widths: 0.7, 0.9, 1.1 cm
(sizes chosen to fit the three in a reticle)

- A scanner tower is a stack of **60 sensors**, tightly coupled.
- Wedge-shaped units: three sensor widths
- Total tower thickness will be **1.5 cm**.
- Two sensors per layer: length = **4.8 cm**

FLUKA and Geant4 simulations performed to predict the scanner efficiency to 511 keV photons, the expected detection rate per chip and the scanner space resolution.

Results of GEANT and FLUKA simulations: Tower efficiency for 511 keV photons: 27%

Scanner sensitivity: 4.1%



TT-PET

Layout of the TT-PET demonstrator



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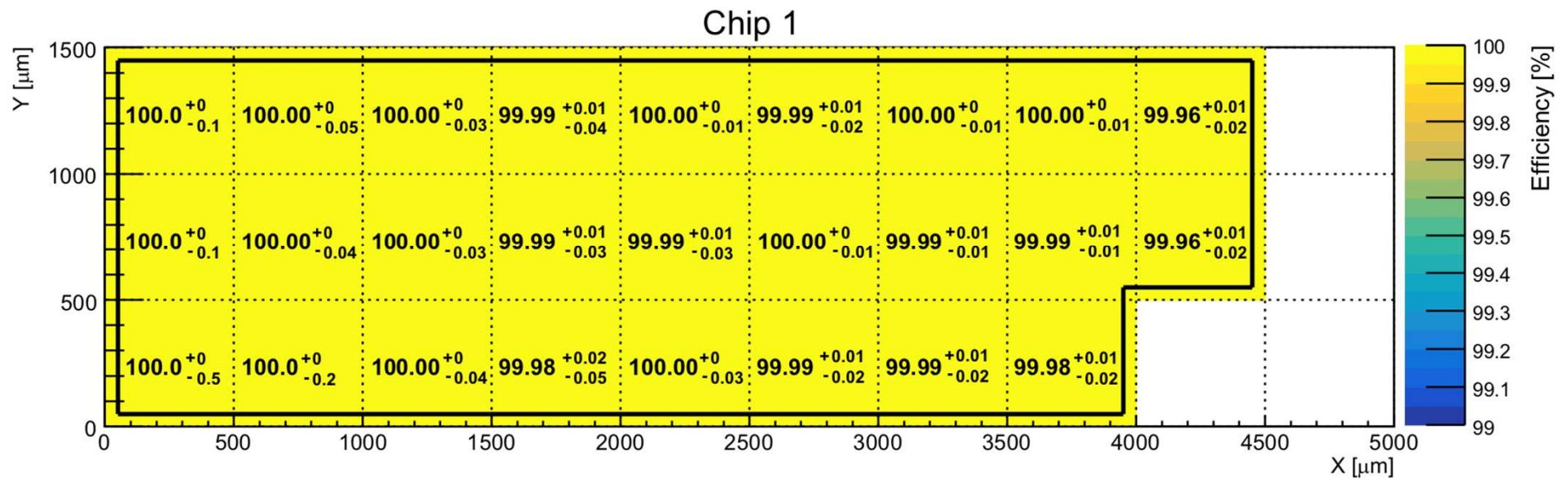
- 3×10 matrix, $500 \times 500 \mu\text{m}^2$ pixels.
- Preamplifier, discriminator, 50 ps binning TDC, logic, serializer integrated in chip.
- Thinned to 100 μm and backside metallized

Three chips tested in the DPNC cleanrooms and at CERN testbeam.

Results →



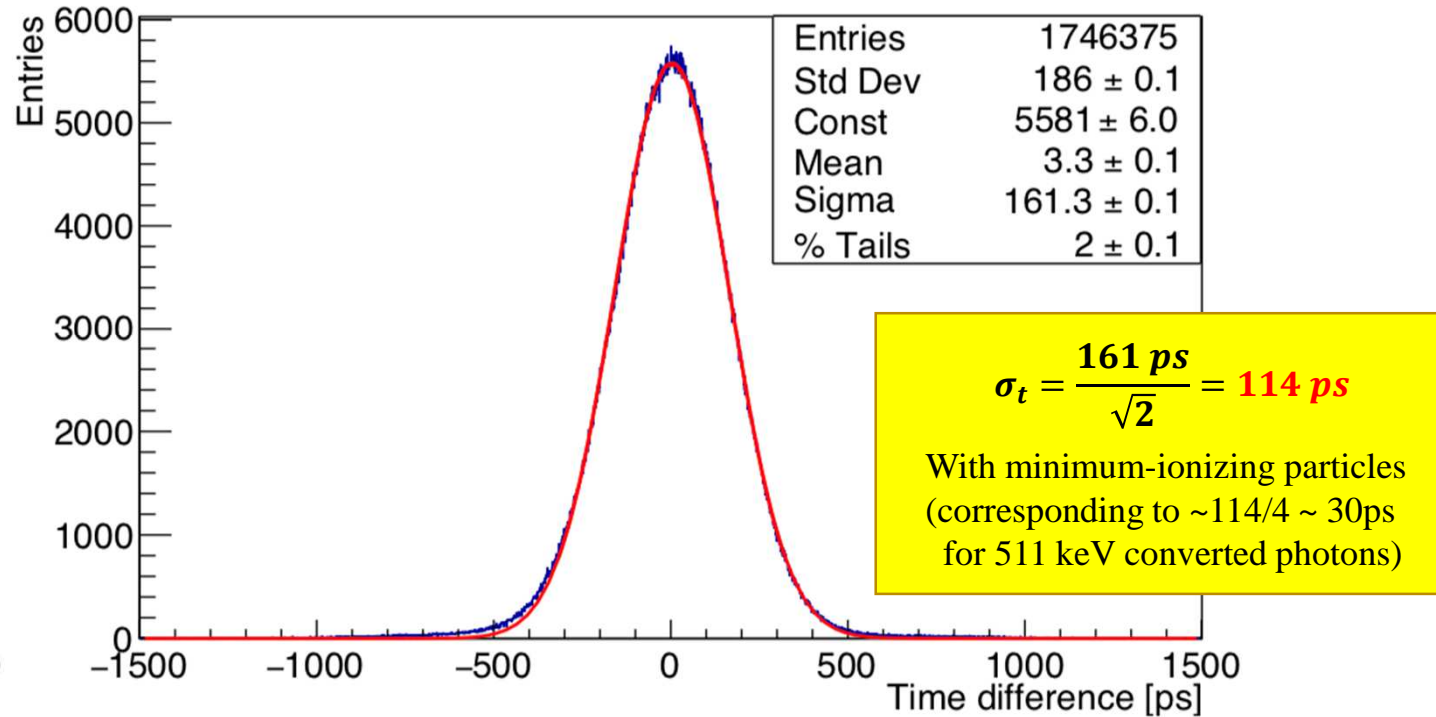
CERN testbeam: Efficiency





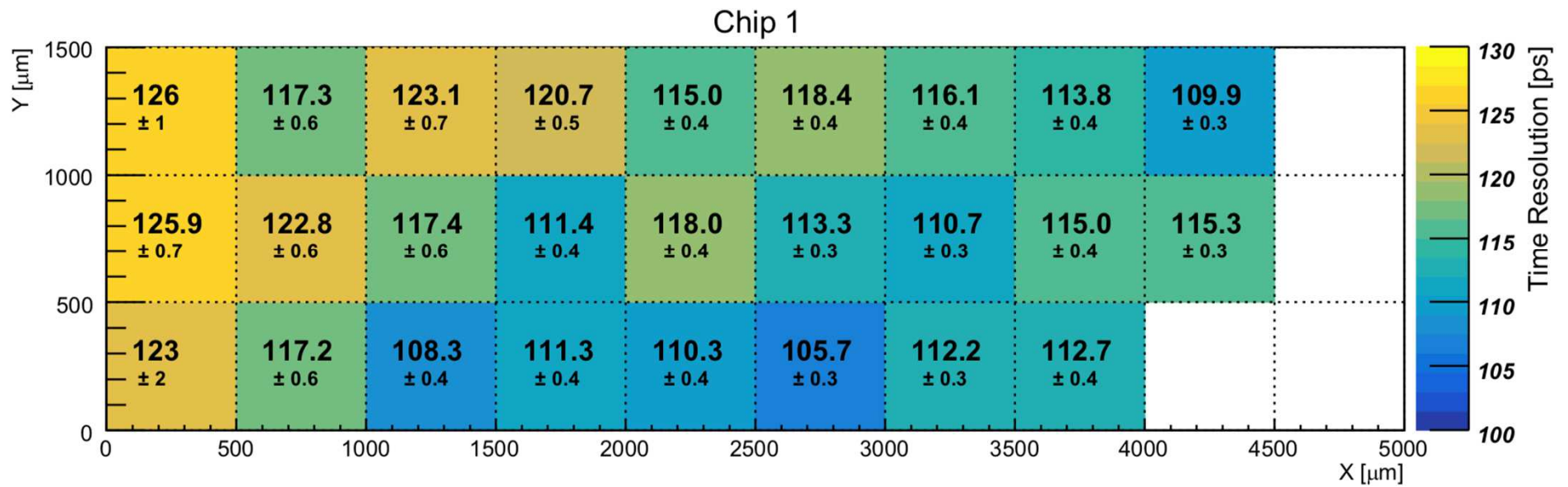
CERN testbeam: Time resolution

Particle hit time difference chip 1 vs chip 0





CERN testbeam: Time resolution





TT-PET Research Output 2018



- 4 articles:

- Demonstrator chip design: [arxiv:1811.10246](https://arxiv.org/abs/1811.10246)
- Demonstrator chip testbeam: [arxiv:1811.11114](https://arxiv.org/abs/1811.11114)
- TT-PET engineering: [arxiv:1812.00788](https://arxiv.org/abs/1812.00788)
- TT-PET simulation & performance: [arxiv:1811.12381](https://arxiv.org/abs/1811.12381)

- 2 patent submissions:

- PLL-less TDC & synchr. System: [EU Patent Application EP18181123.3](https://patent.google.com/patent/EP18181123.3)
- Multi-Junction PicoAD: [EU Patent Application EP18207008.6](https://patent.google.com/patent/EP18207008.6)

In summary:

- Lot of excellent research, including:
 - 14 Articles
 - 2 patents
 - 2PhD + 2 Master theses

Sergio Gonzalez-Sevilla, Mathieu Benoit, D.M.S. Sultan, Winnie Wong, Steven Schramm, Roland Jansky, Lorenzo Paolozzi, Emanuele Ripiccini, Pierpaolo Valerio, Ettore Zaffaroni, Mateus Vicente-Barreto-Pinto, Sofia Adorni, Francesco di Bello, Nerjuno Nindhito, Le Li, Daniele Vitturini

Try to repeat it in 2019 !!