ePIC

TOF status and future

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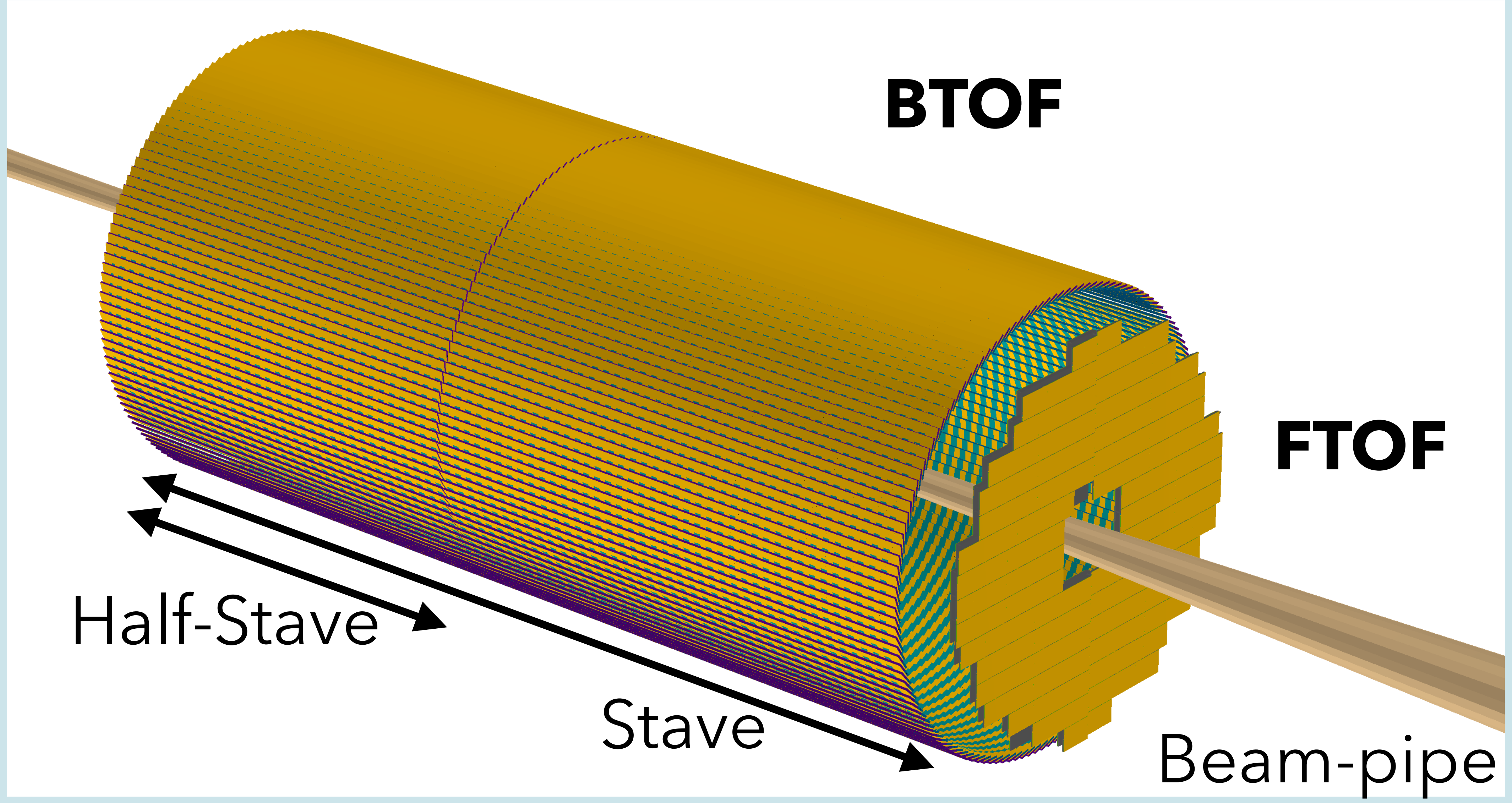
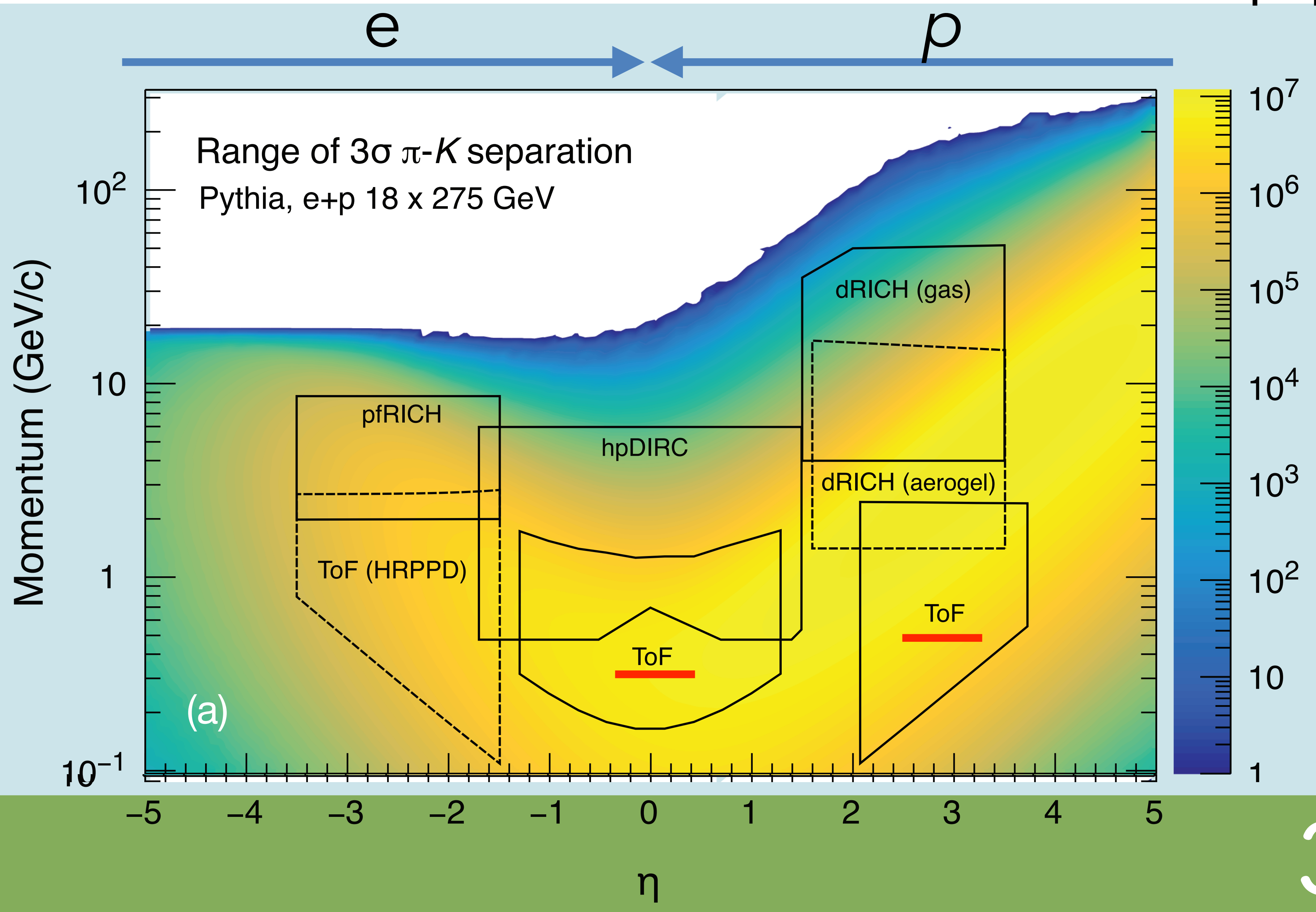
The ePIC Collaboration meeting @ Villa Mondragone

24/01/2025

AC-LGAD TOF

- Two types of AC-LGAD TOF, BTOF and FTOF, are installed for the low-p PID
  - Complementary to the Cherenkov detectors





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  - π/K separation below 1.2 GeV/c is performed
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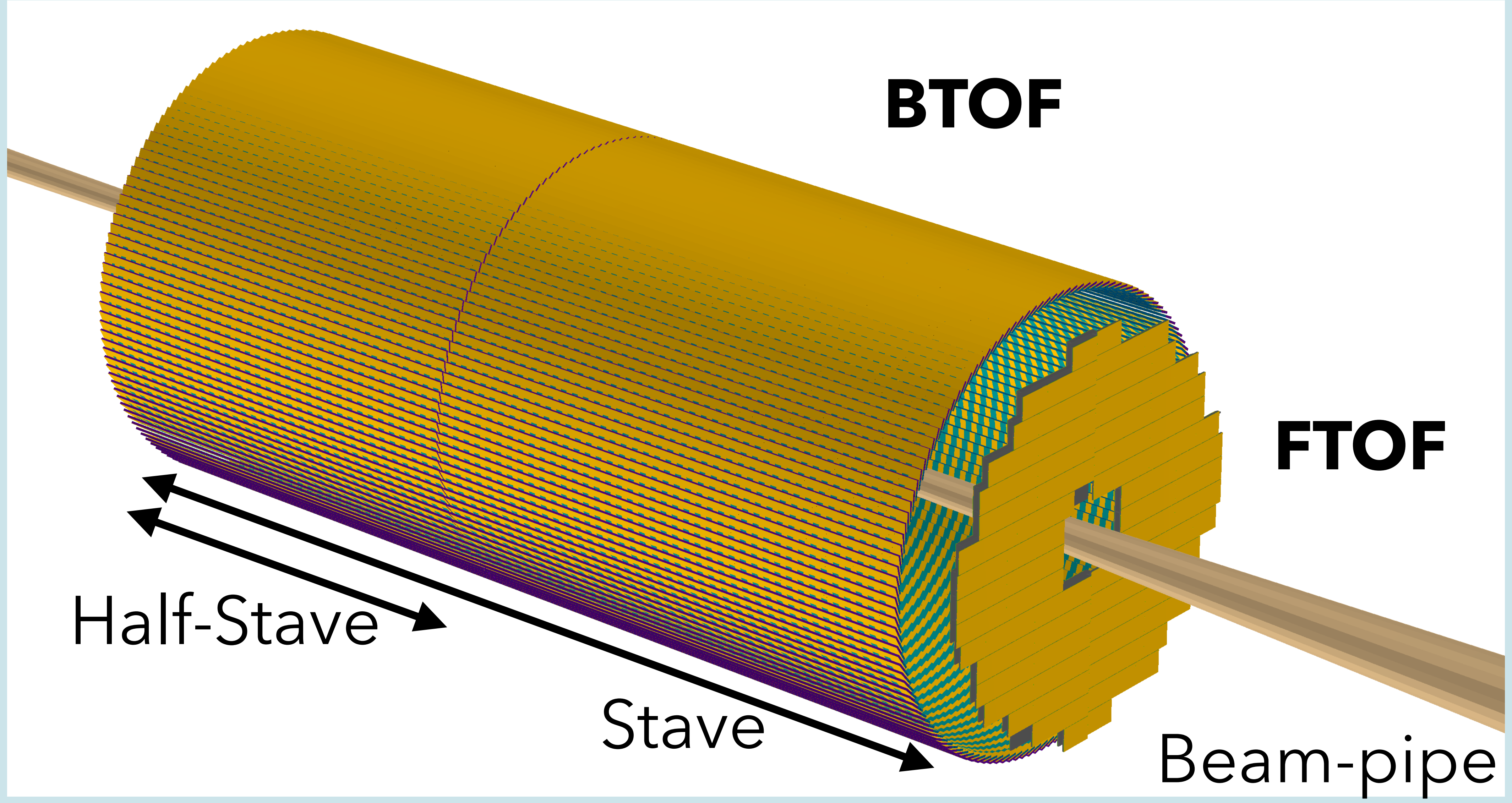

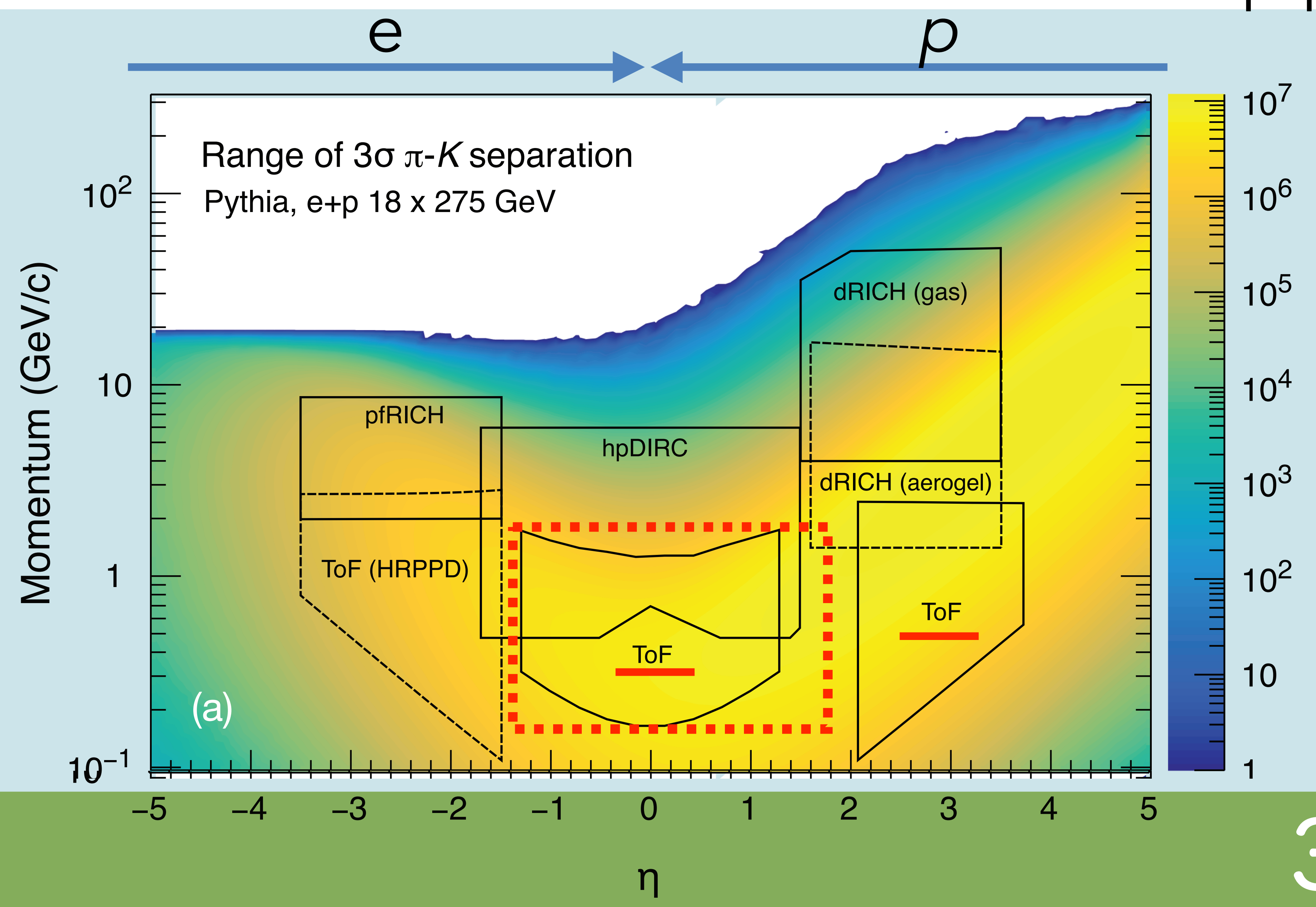

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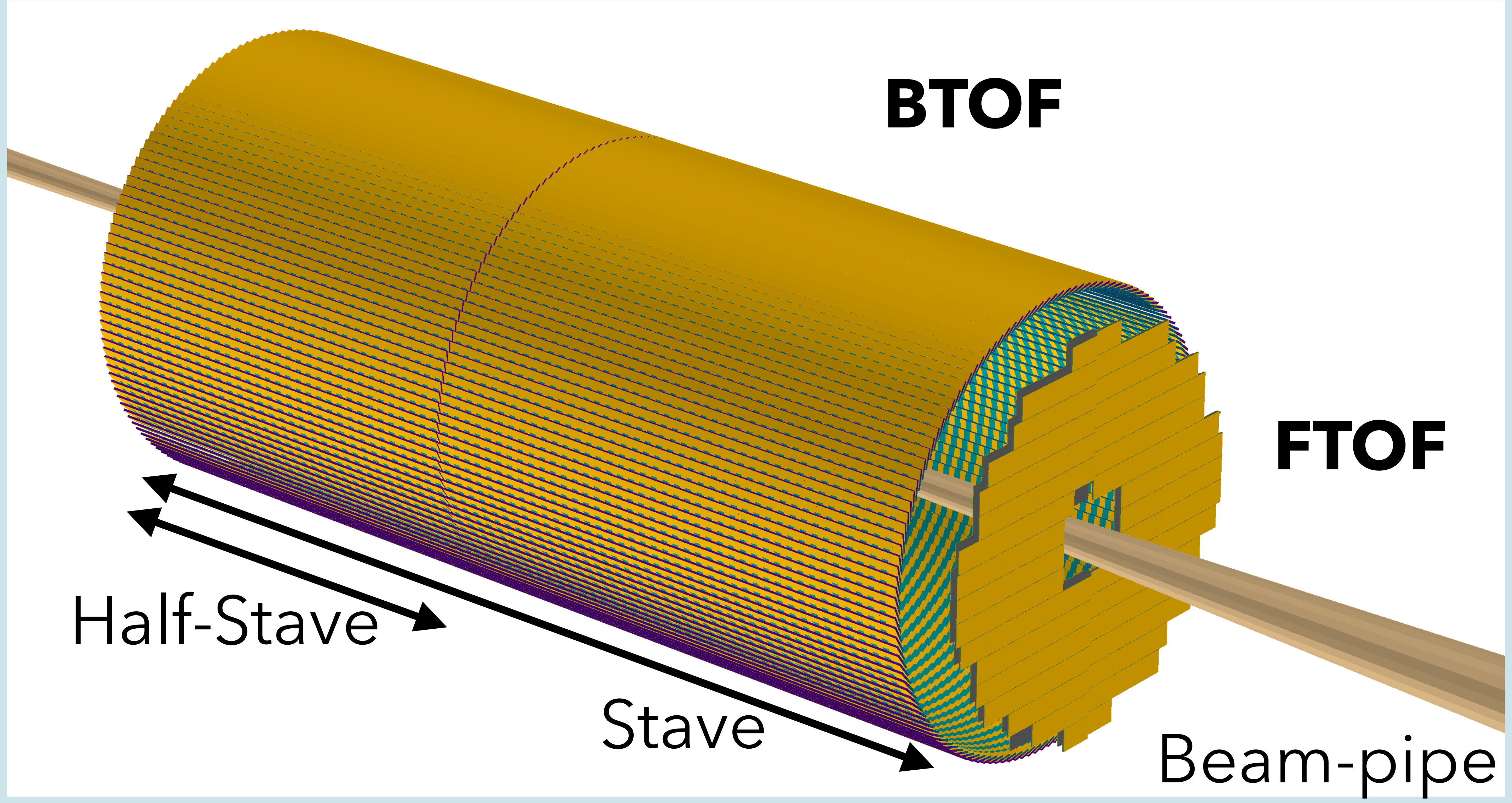
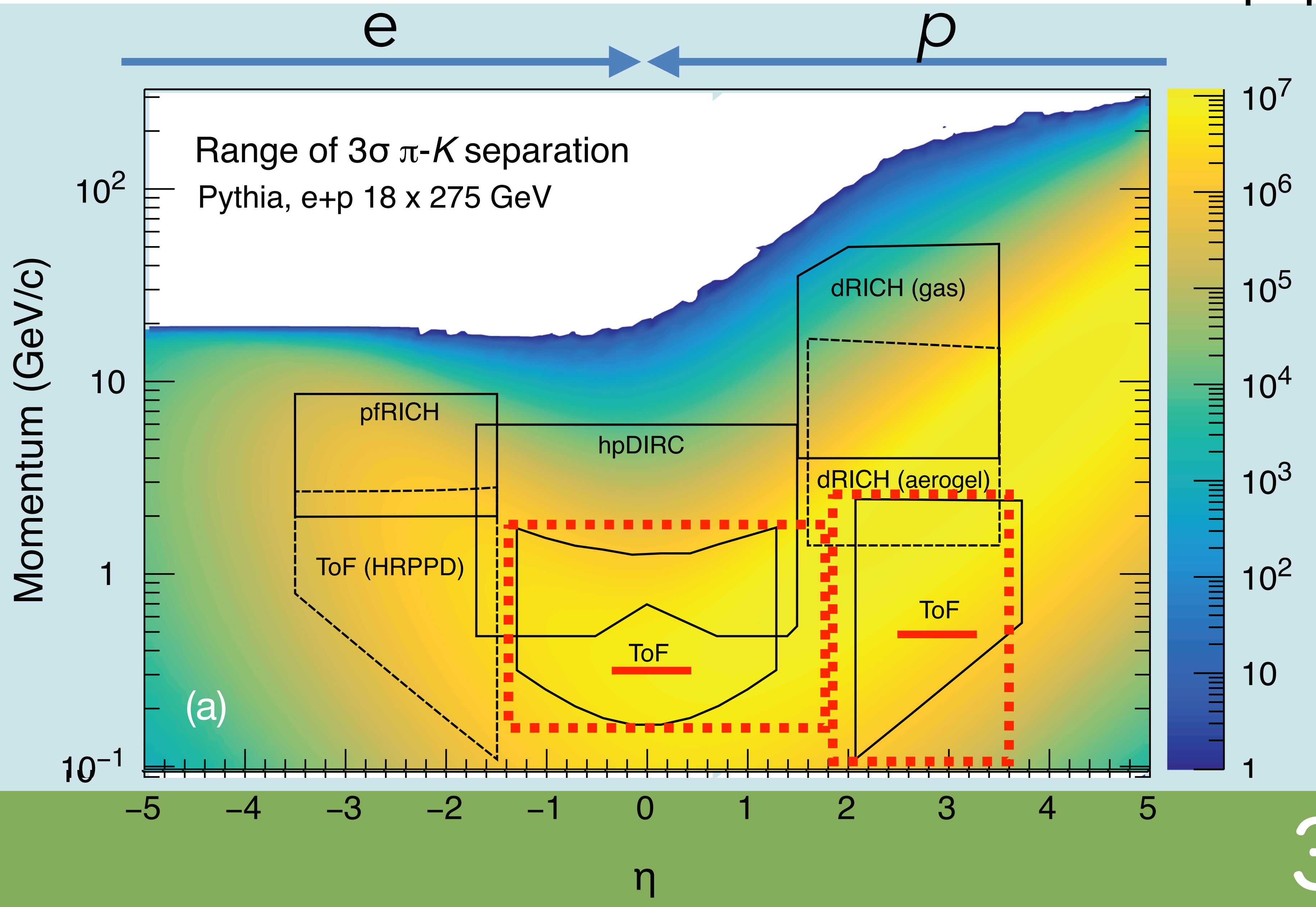
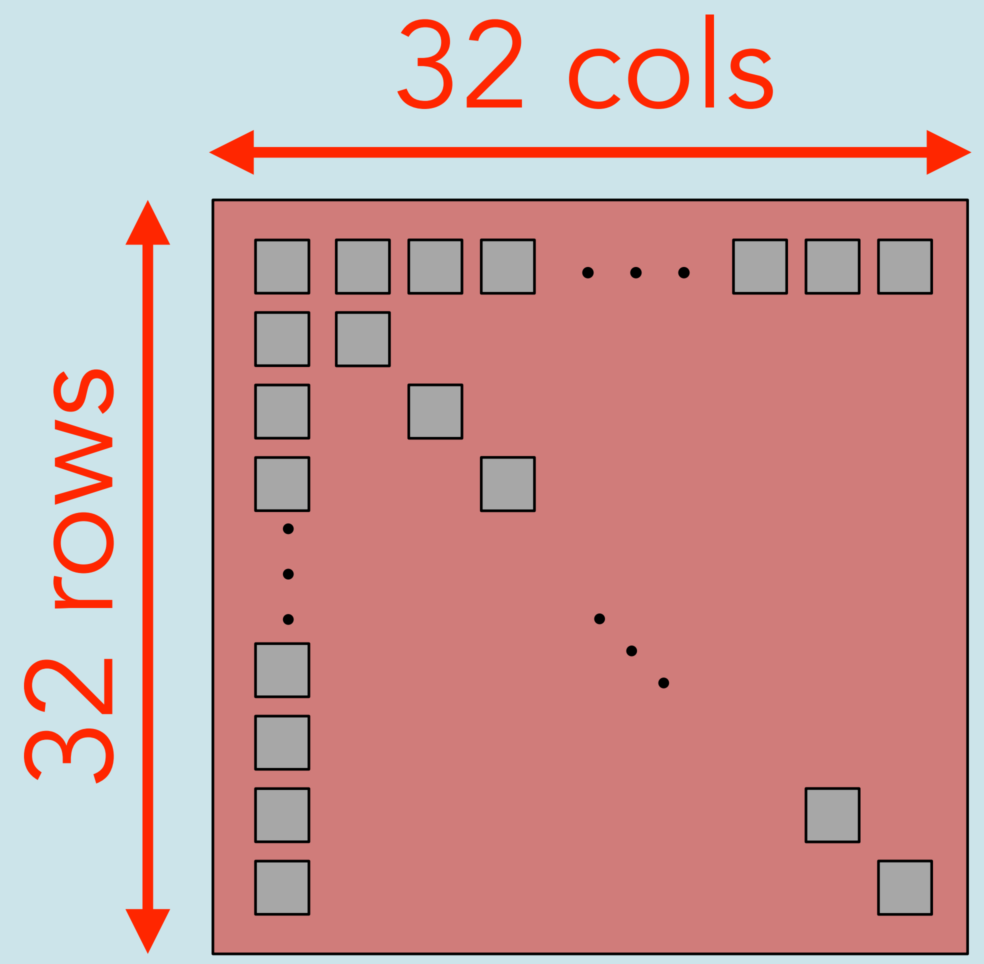
- FTOF covers forward-rapidity ($1.84<\eta<3.61$), hadron going direction
  - π/K separation below 2.5 GeV/c is performed
  - Pixel-type AC-LGAD sensor is used





Baseline of sensor design

- **Pixel-type** AC-LGAD sensor, 1.6 x 1.6 cm^2 sensor size with 0.5 x 0.5 mm^2 metals, is used in **FTOF**
- The readout metal geometry is 32 x 32 and 1024 channels in total each
- 1 ASIC (2D 32x32) is attached to the one sensor



- FTOF pixel sensor
  - **3632 sensors**
  - **1.1 m^2**
  - **3.6 M readout channels**

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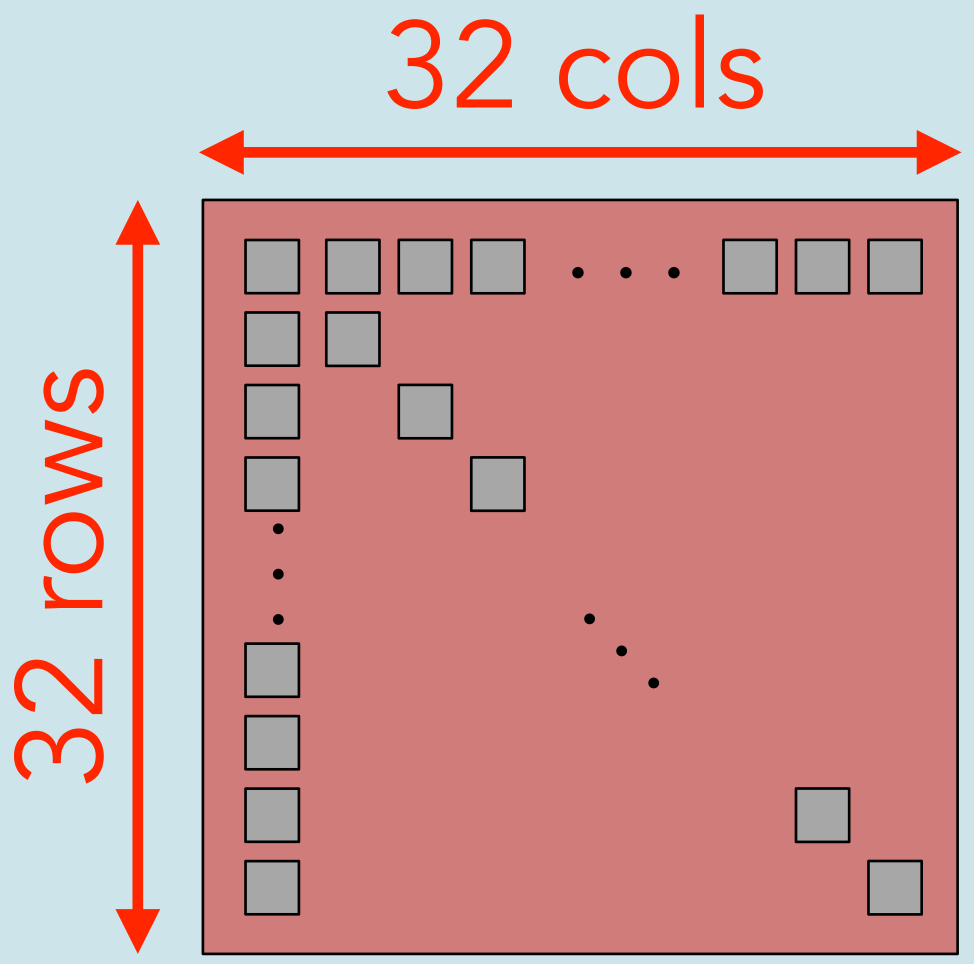
- **Strip-type** sensor, ~~3.2 x 4 cm^2~~ **3.2 x 2 cm^2** sensor size with 0.5 x 10 mm^2 metals with 0.5 mm pitch, is used in **BTOF**
- The readout metal geometry is ~~64x2=256~~ **64x2**=**128** channels in total each
- ~~2~~ **1** ASICs are attached to each sensor with wire bonding



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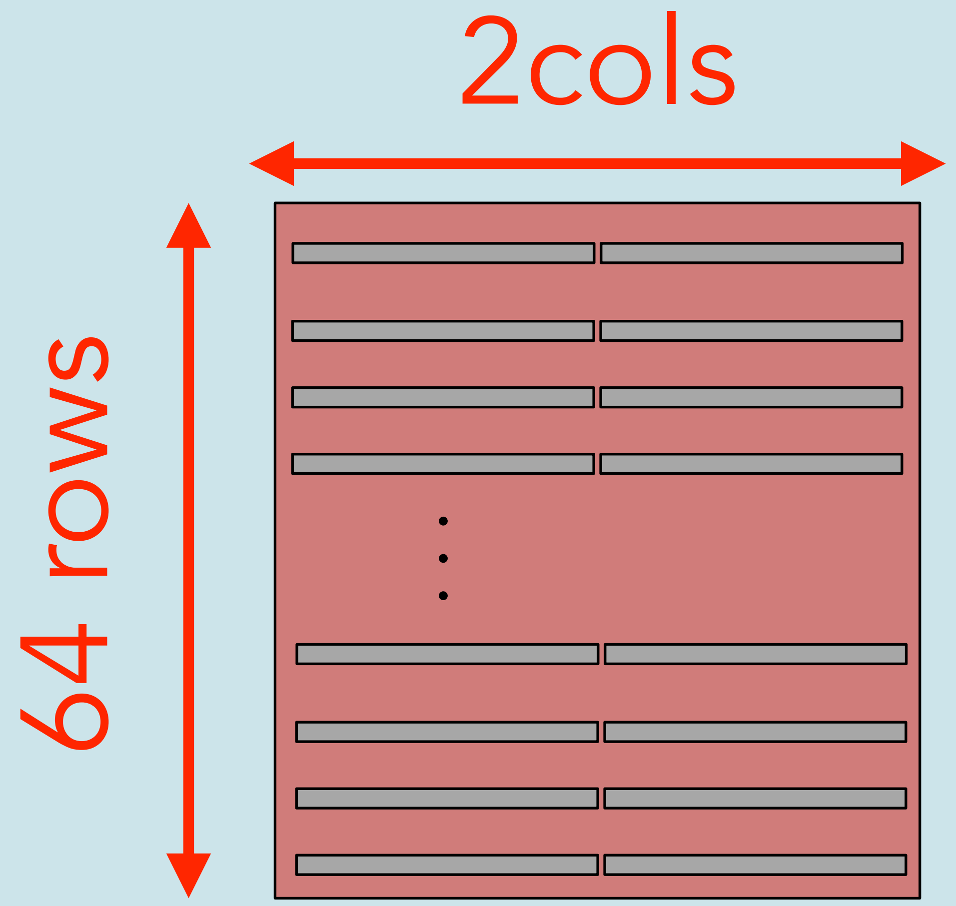

- BTOF strip sensor
  - **18432 sensors**
  - **12 m^2**
  - **2.4 M readout channels**

Baseline of stave structure

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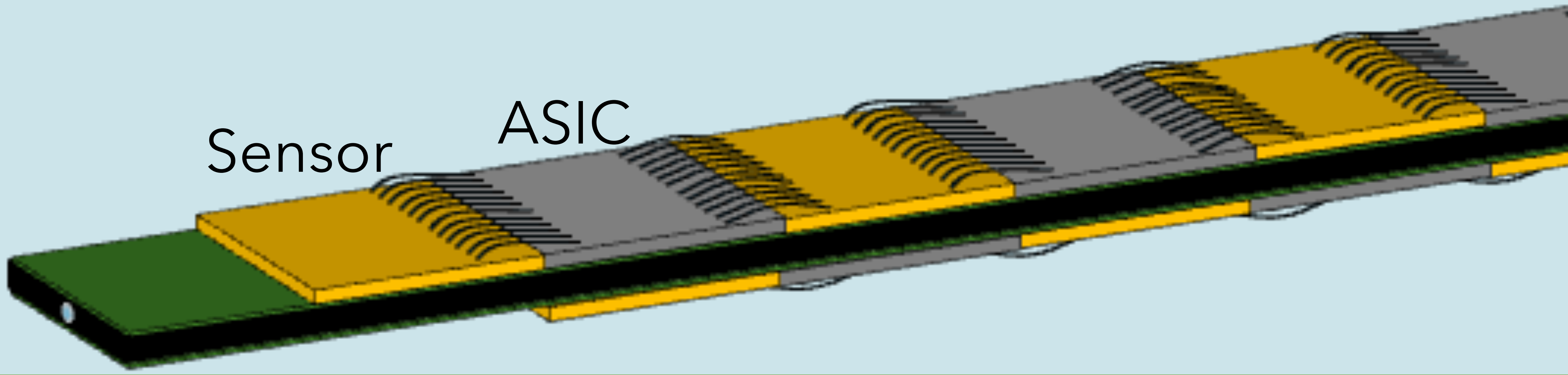
  - Due to readout geometry and efficient cooling ACISs



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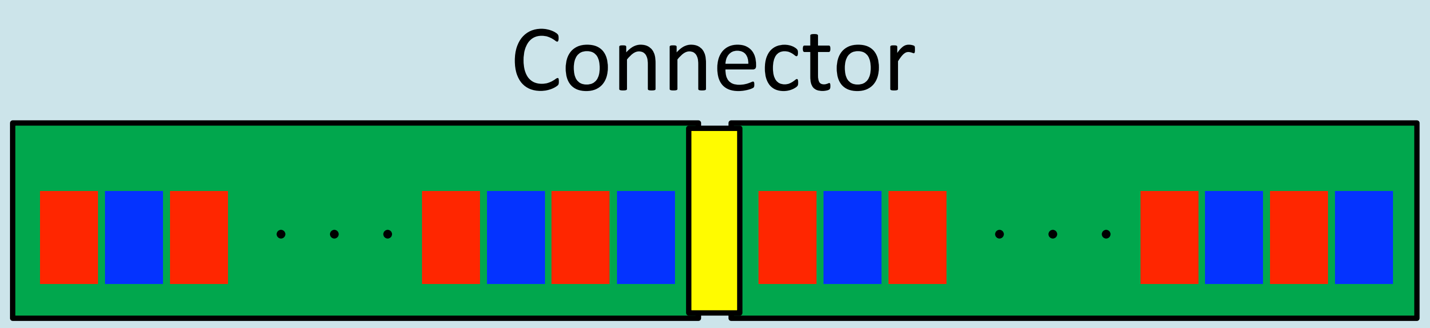
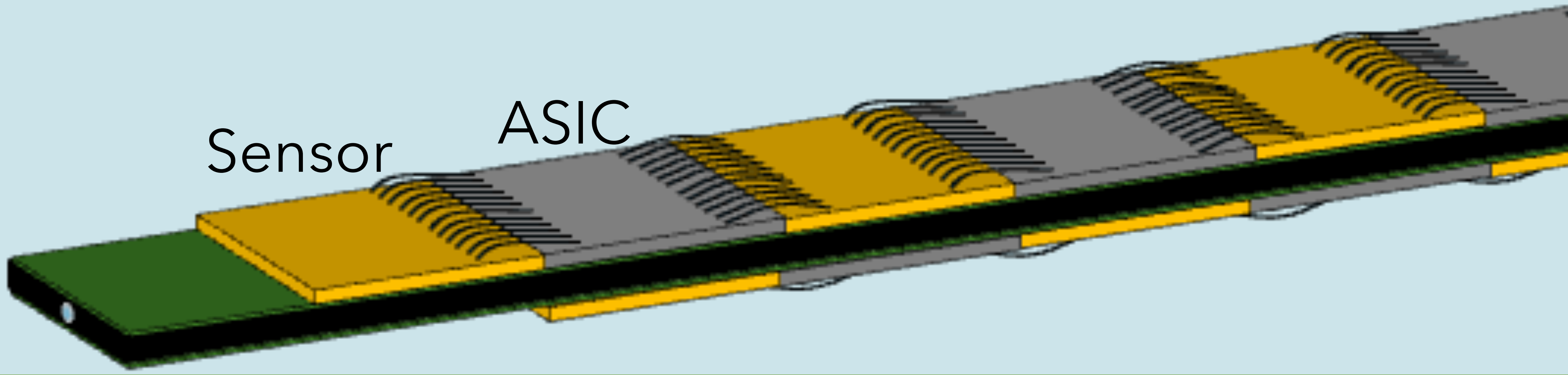
  - A total material budget of ~0.7 % X/X0 is the current target (2~3% X/X0 in total)
  - We start thinking about the feasibility of using shortened pieces connecting with several bonding techniques





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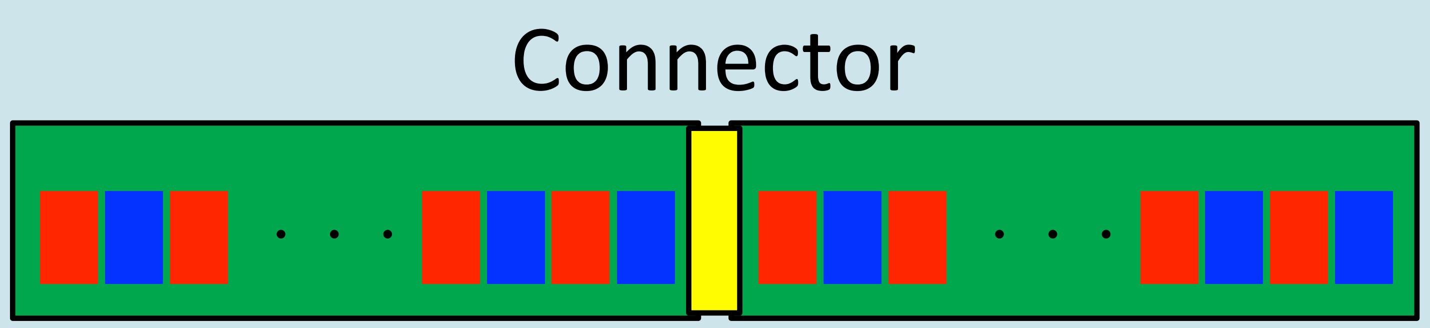
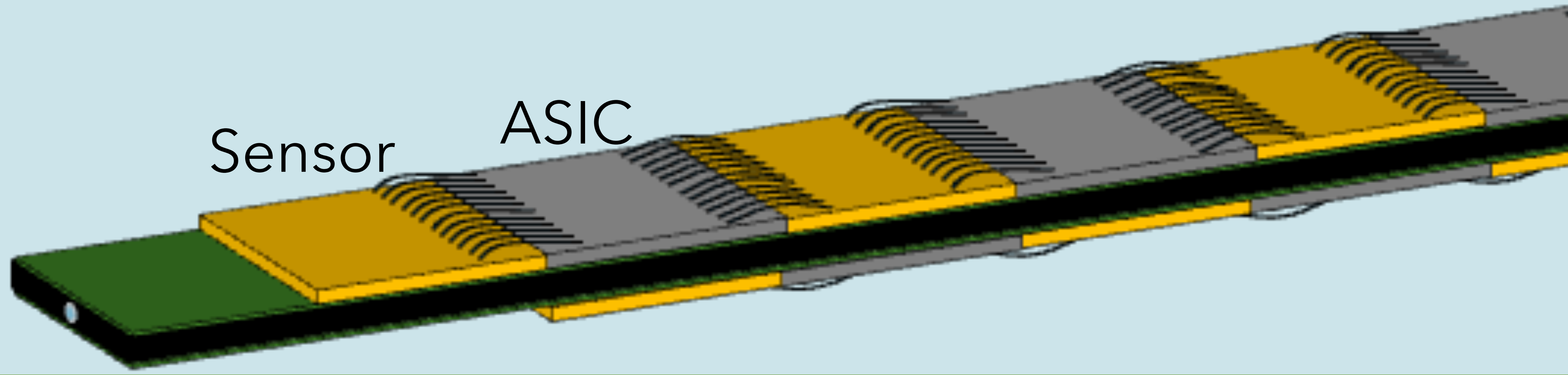
  - We start thinking about the feasibility of using shortened pieces connecting with several bonding techniques
- The material budget effect on the hpDIRC PID performance is under evaluation
  - We discussed how to evaluate the angle resolution on hpDIRC
  - The Tracklet method of BTOF and MPGD hits may be the smallest effects by BTOF material





PID momentum range covered by TOF

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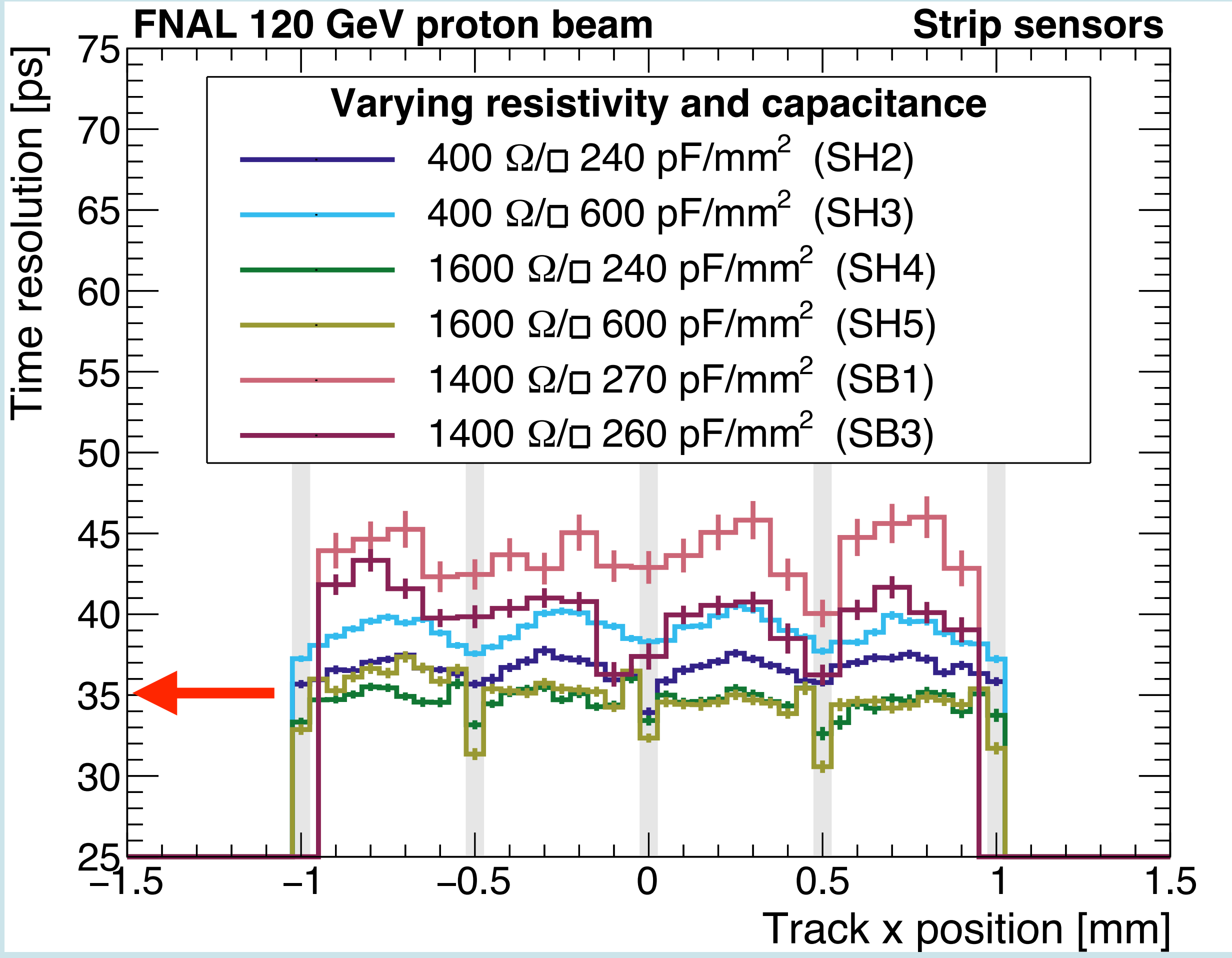

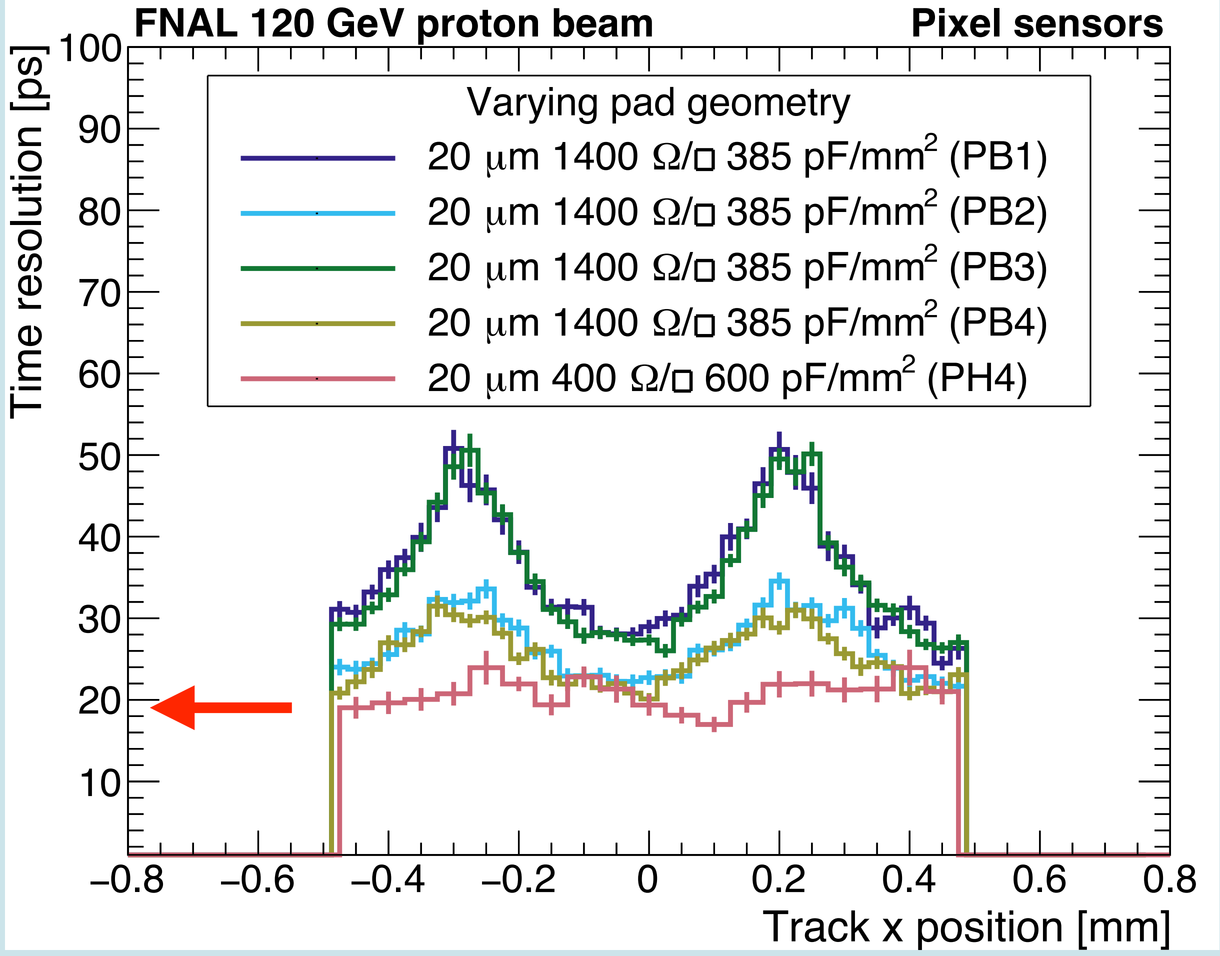

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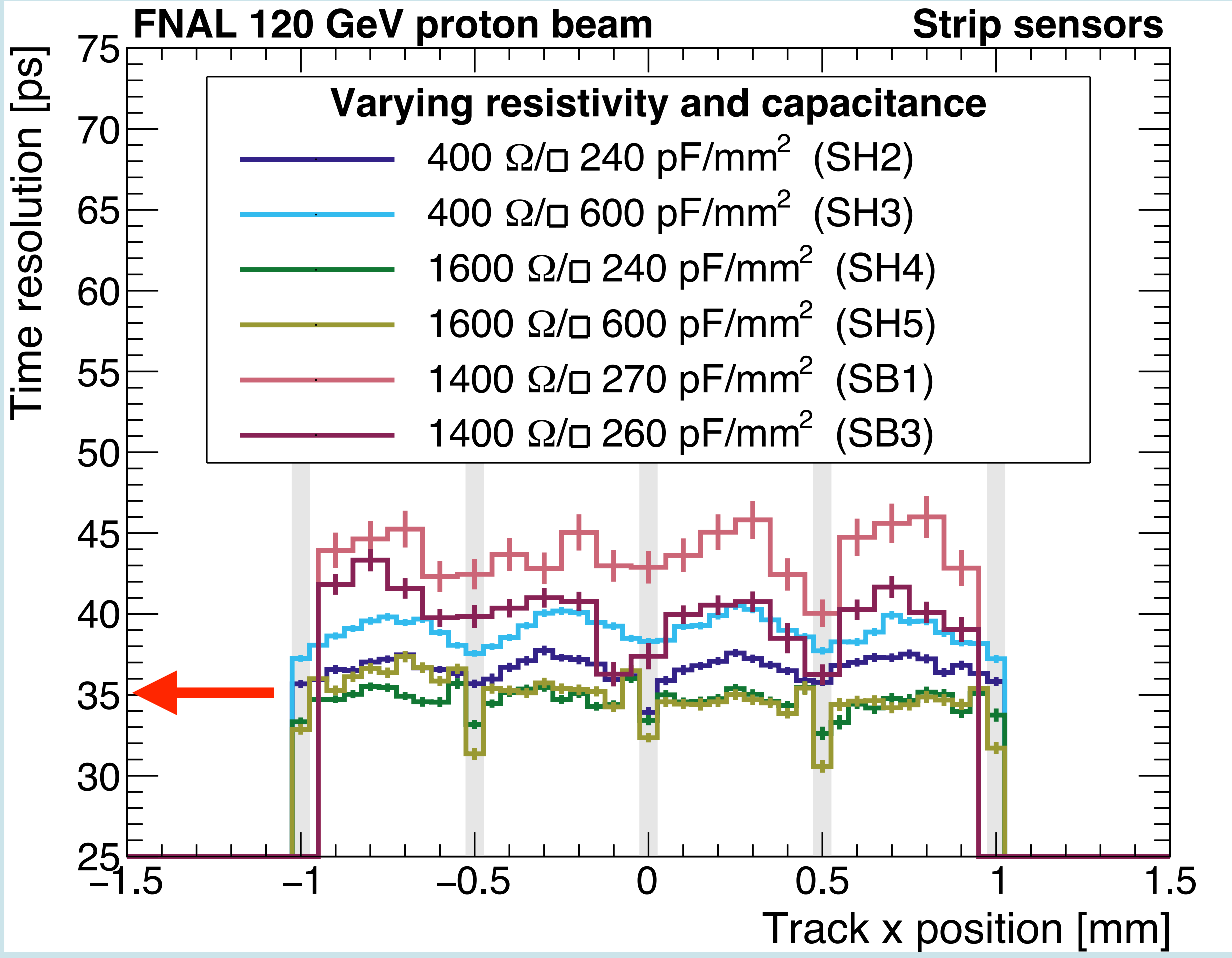

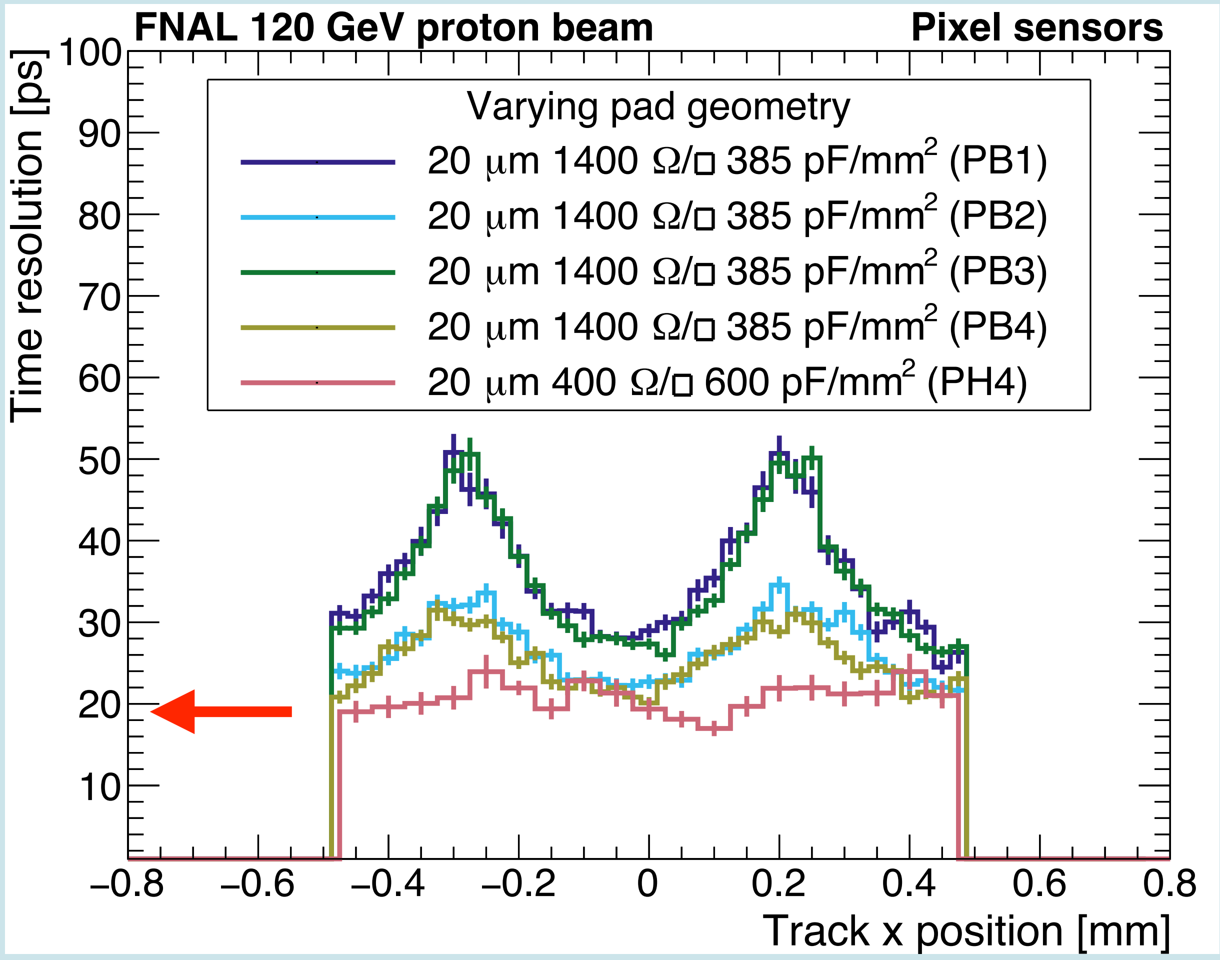

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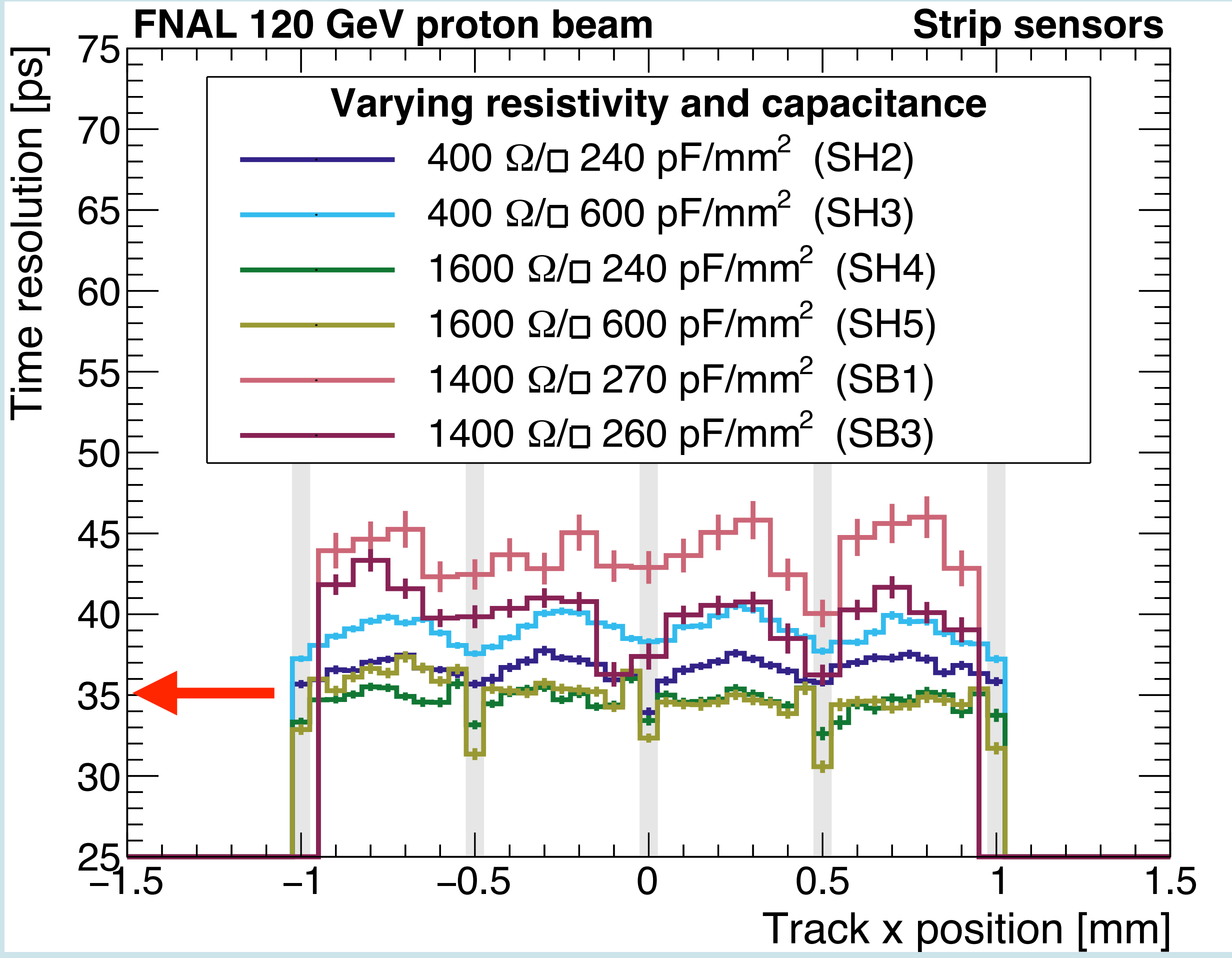

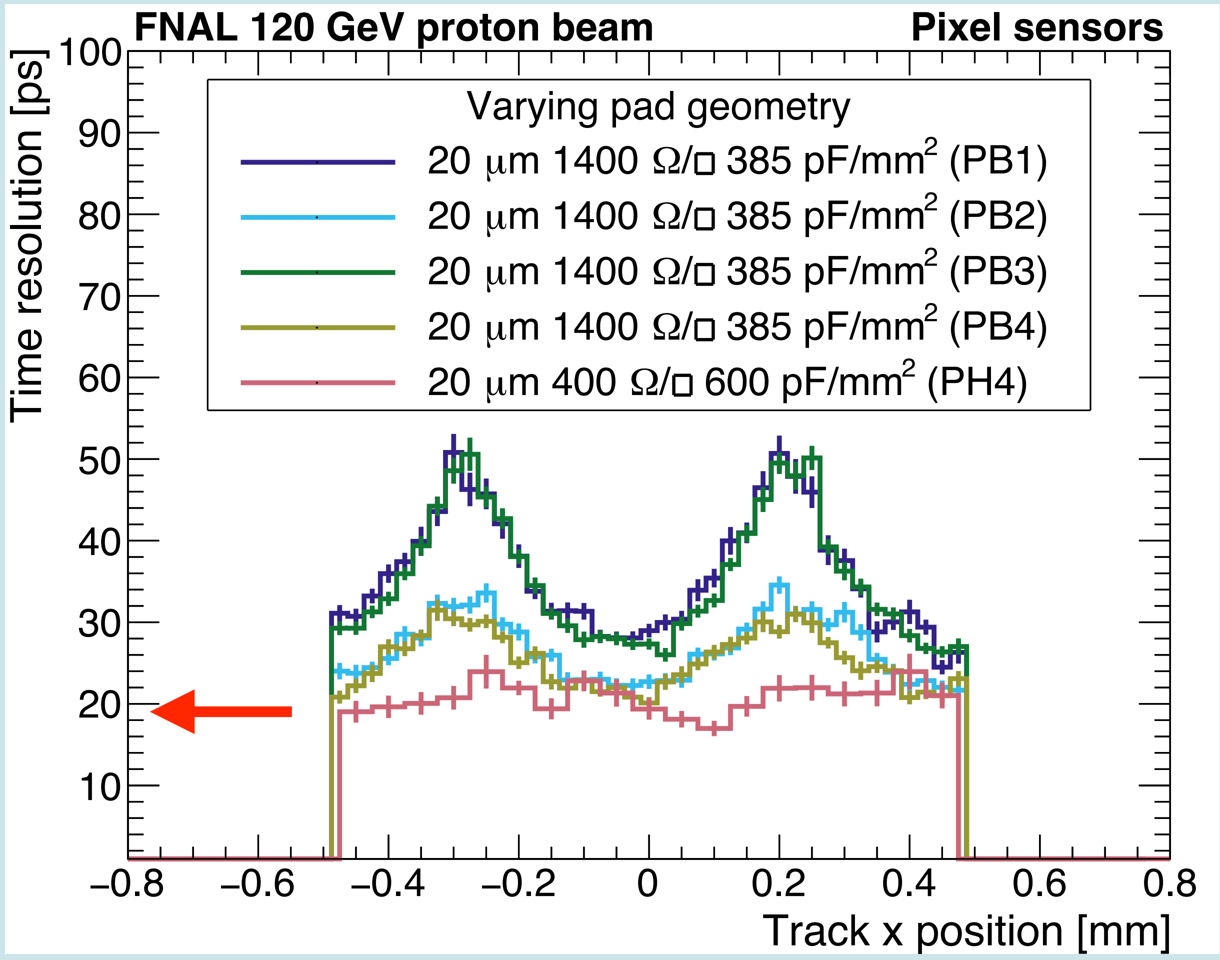

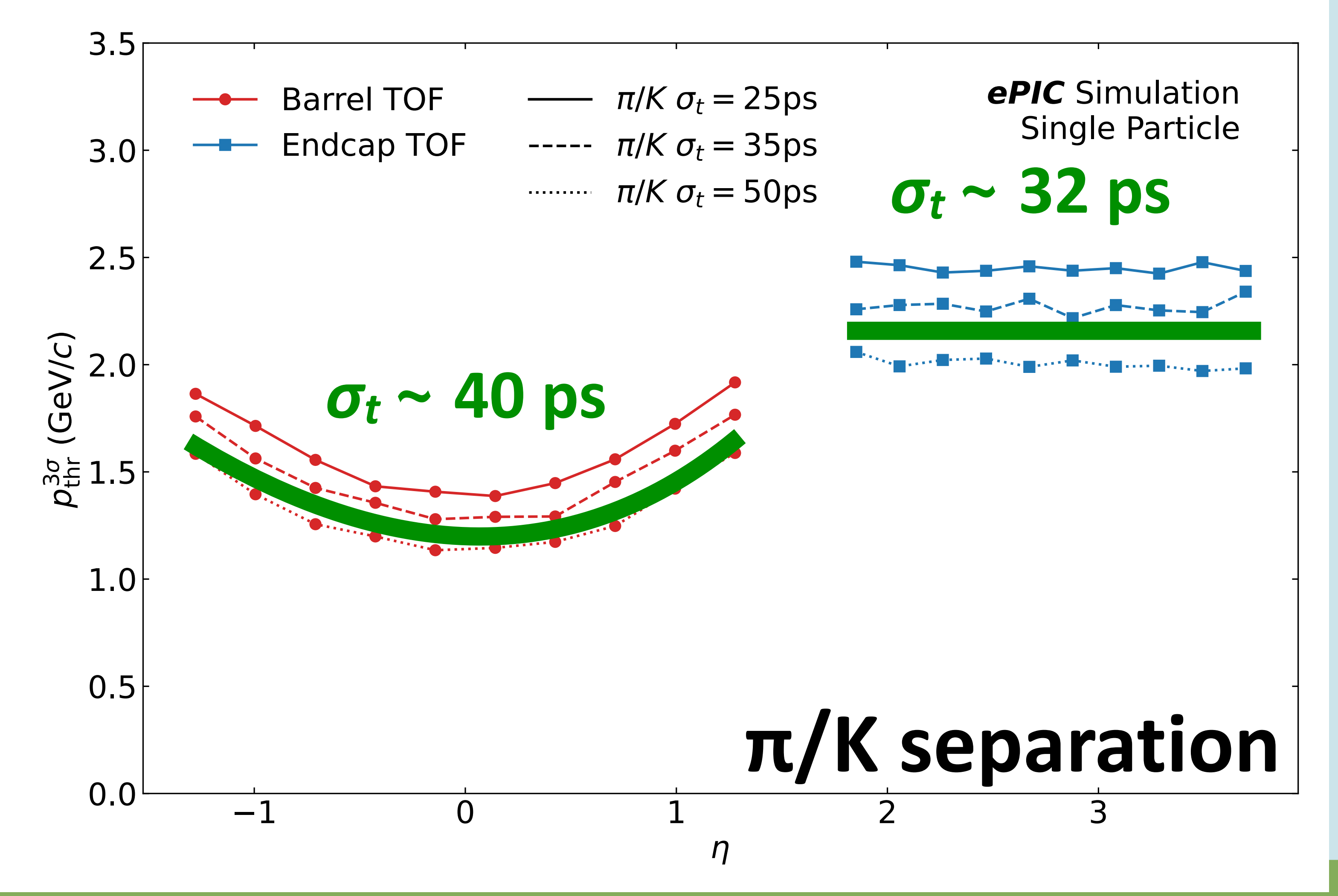

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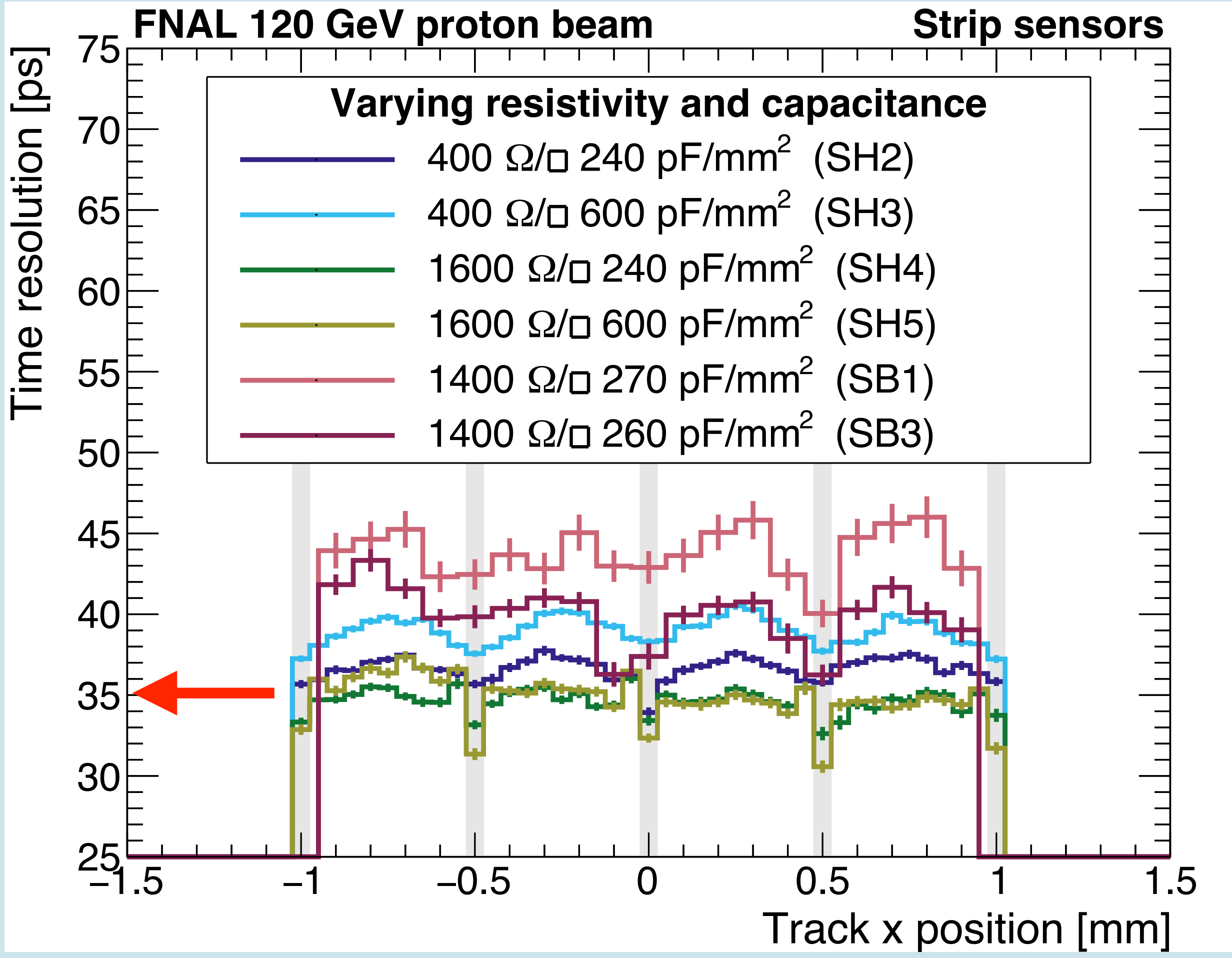

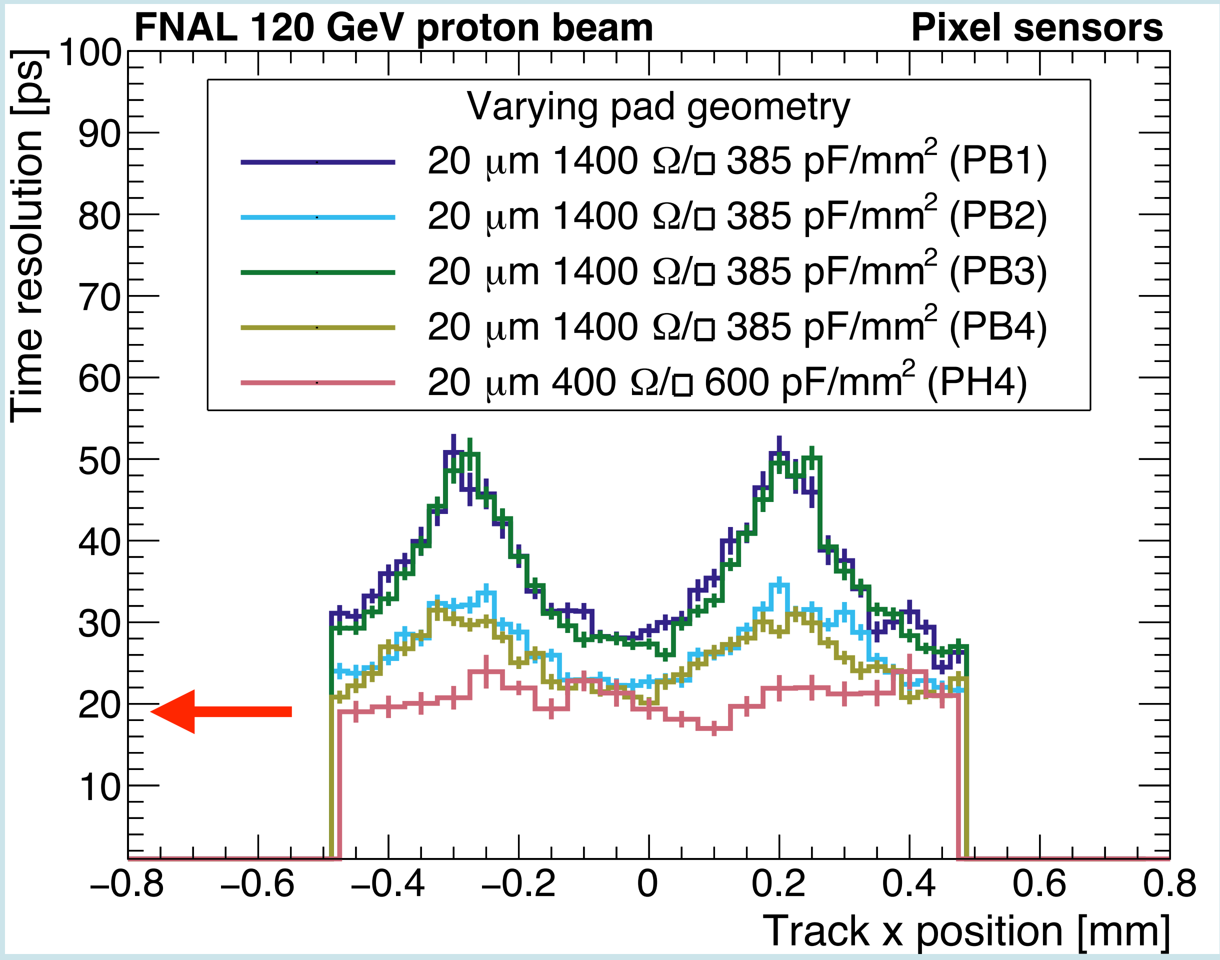

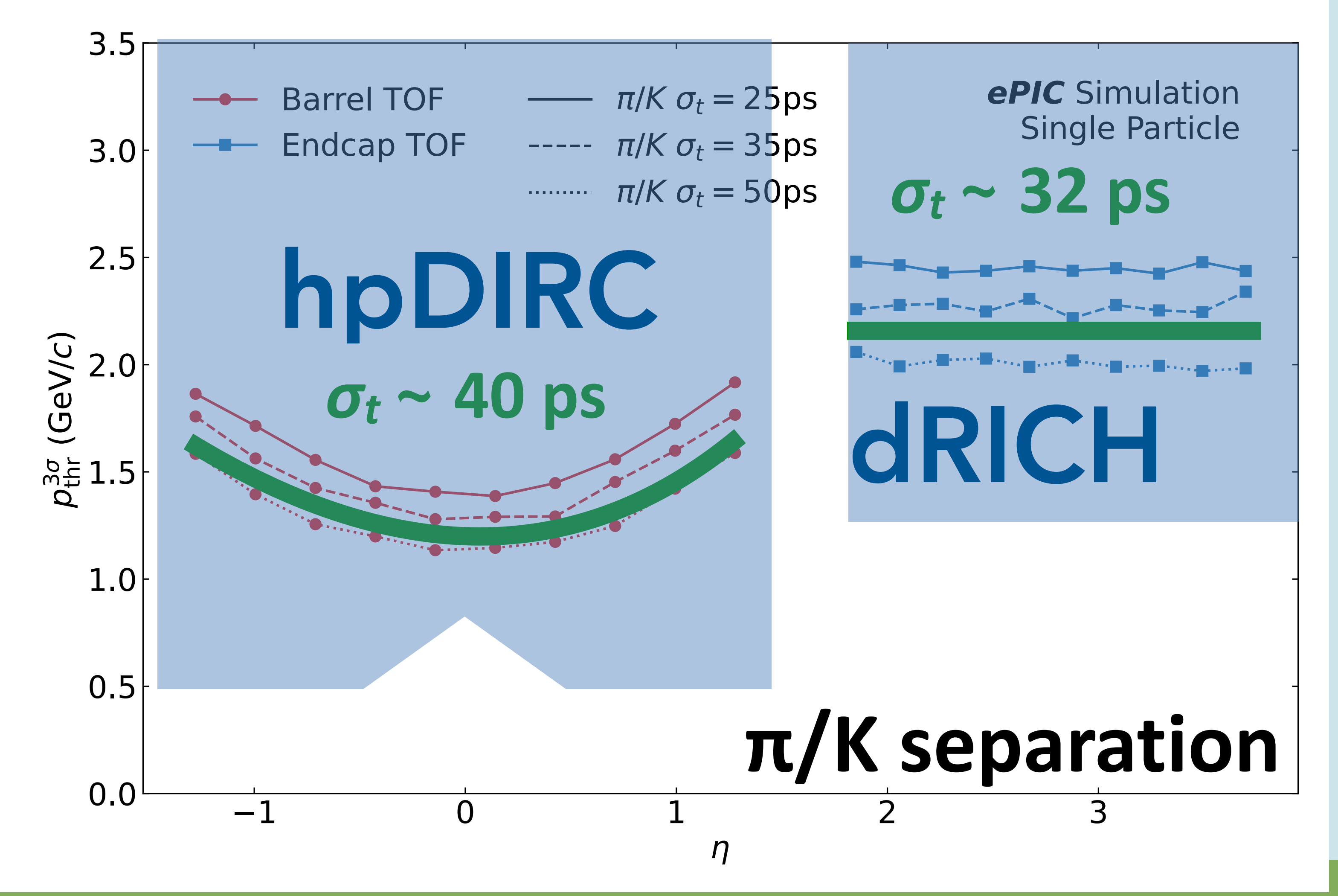

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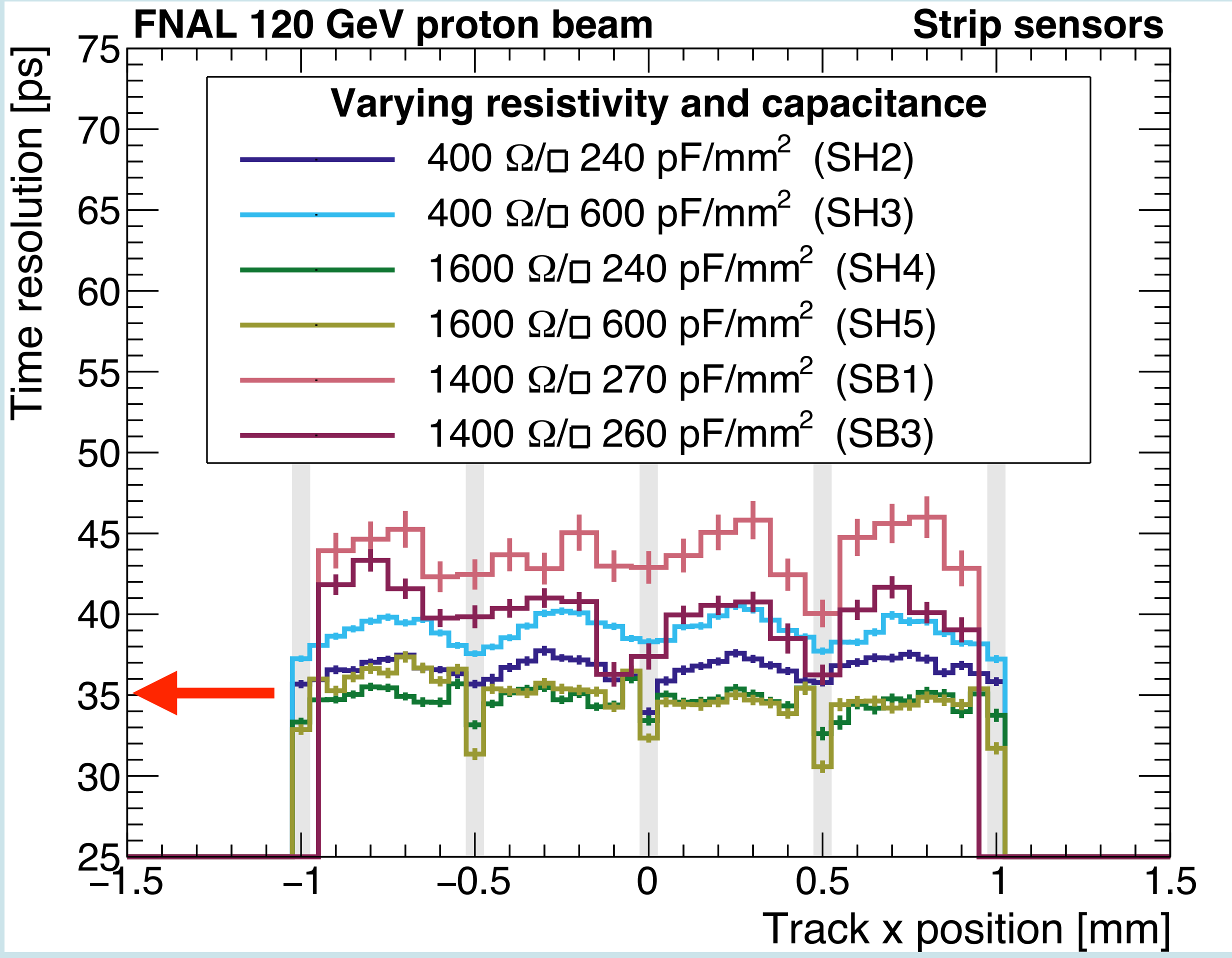
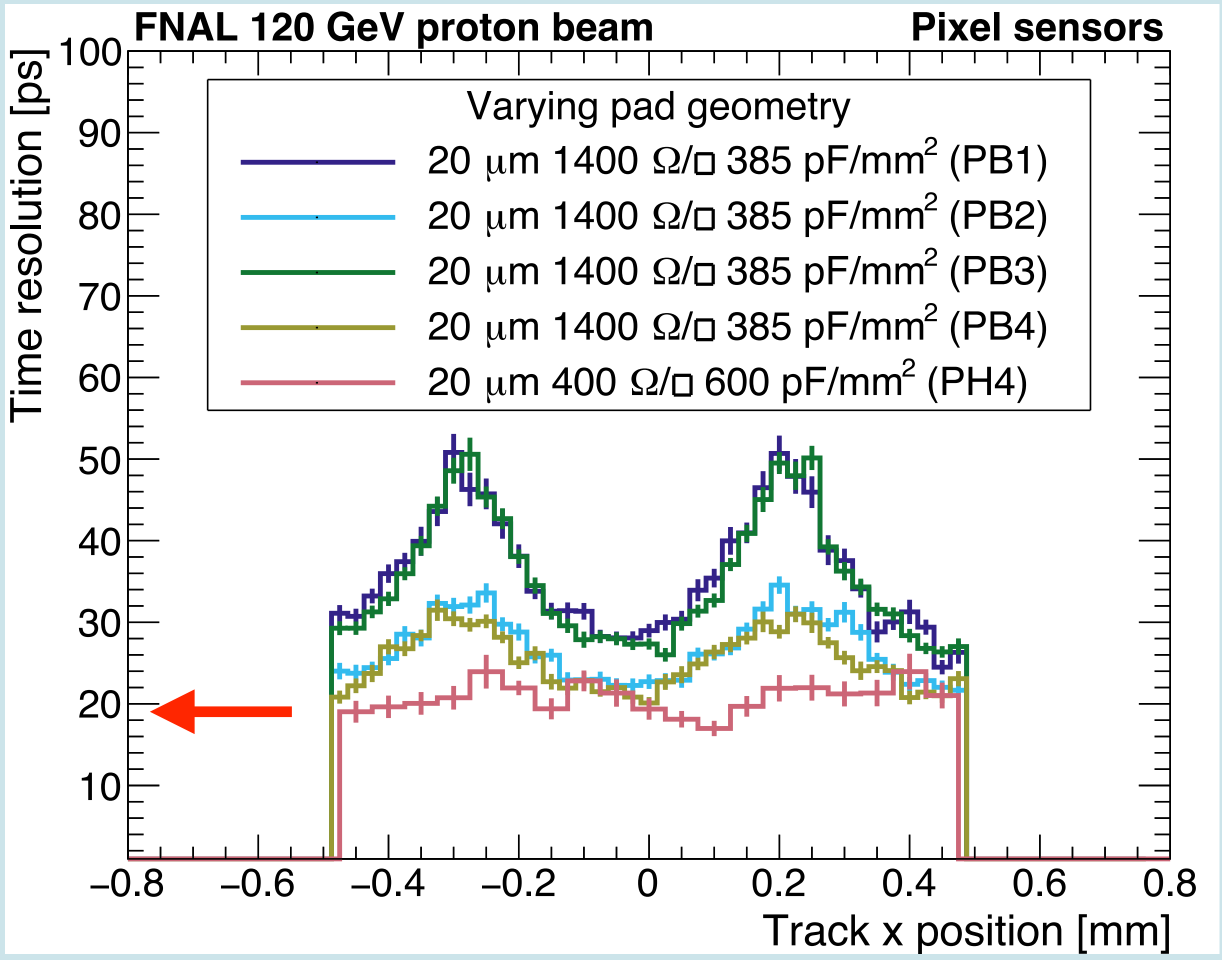
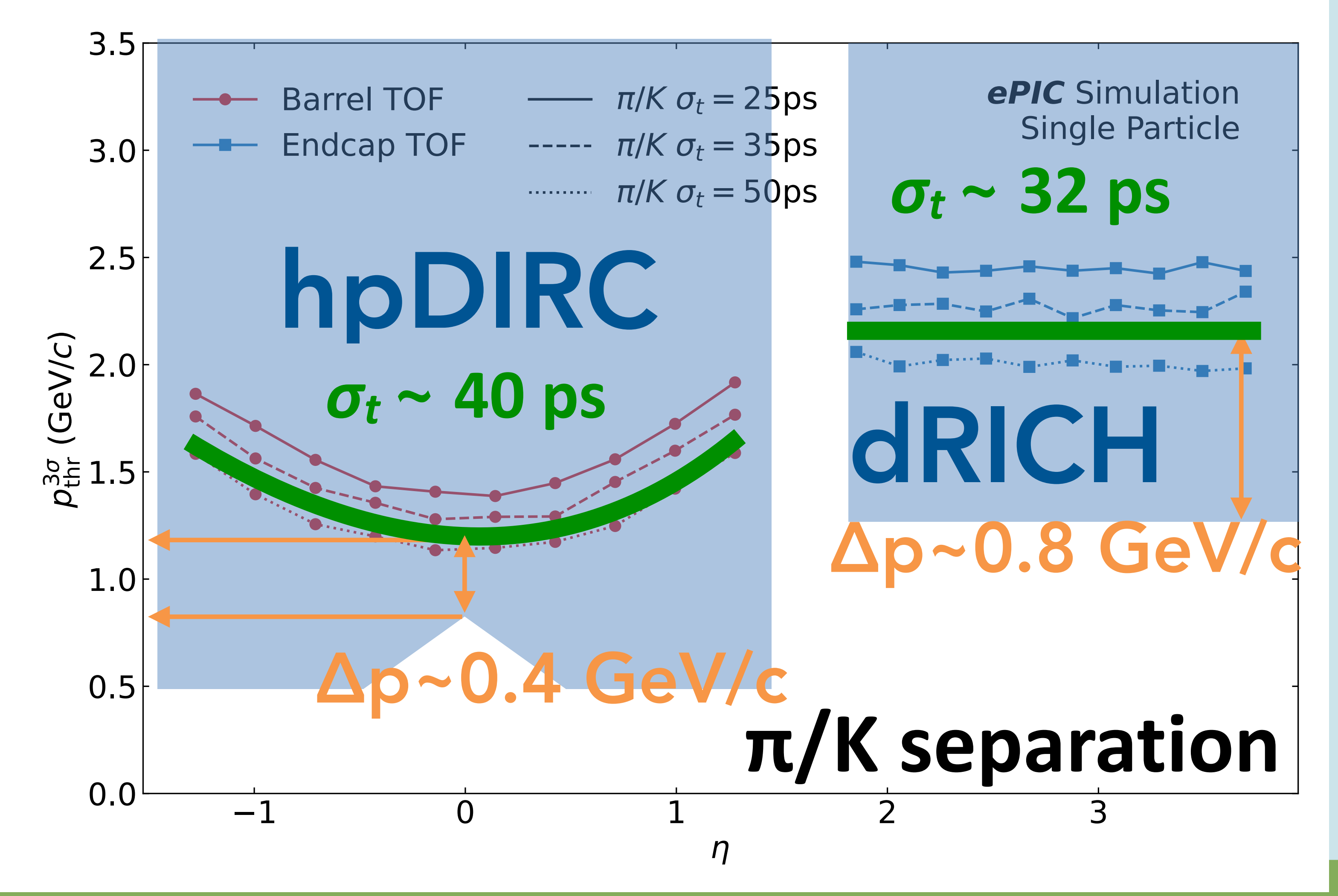
  - **Δp~0.4 GeV/c and Δp~0.8 GeV/c are enough for barrel and forward, respectively?**







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  - -112.5cm < z < 176.5 cm → -112.5cm < z < 155.0 cm
  - -1.33<η<1.74 → **-1.33<η<1.62**

- FTOF shifted toward IP by 17.5 cm
  - z = 185.0 cm → z = 167.5 cm
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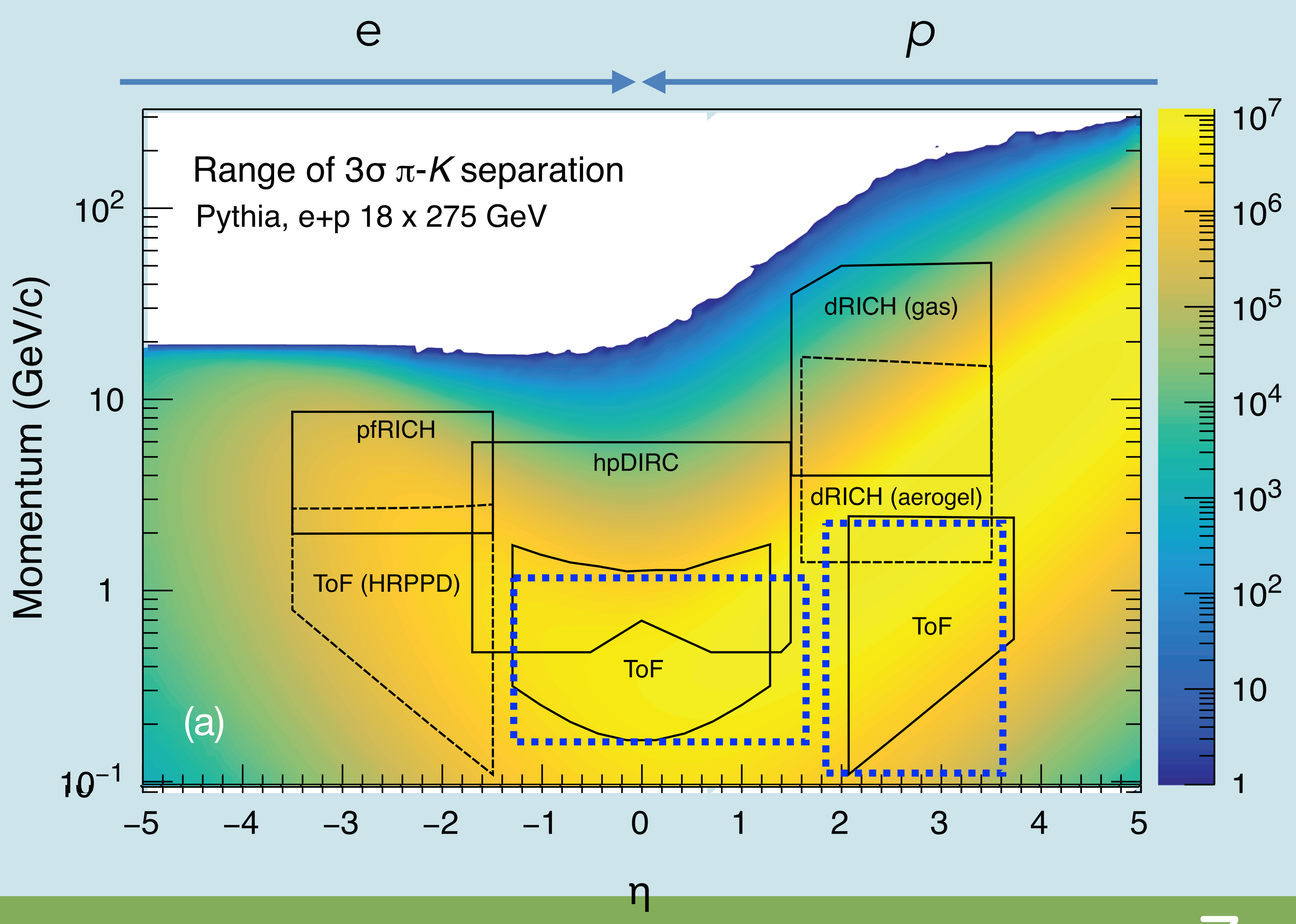

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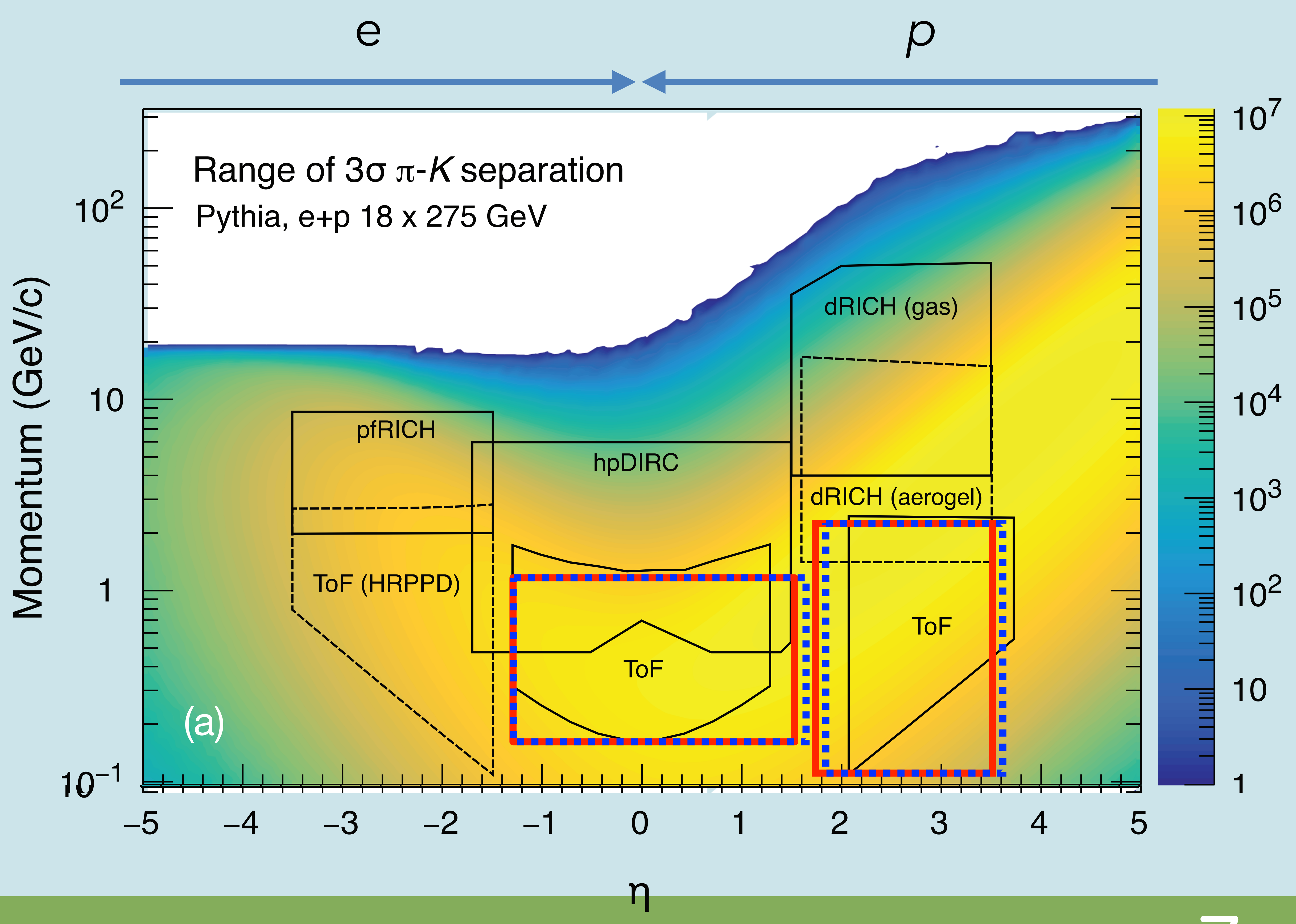

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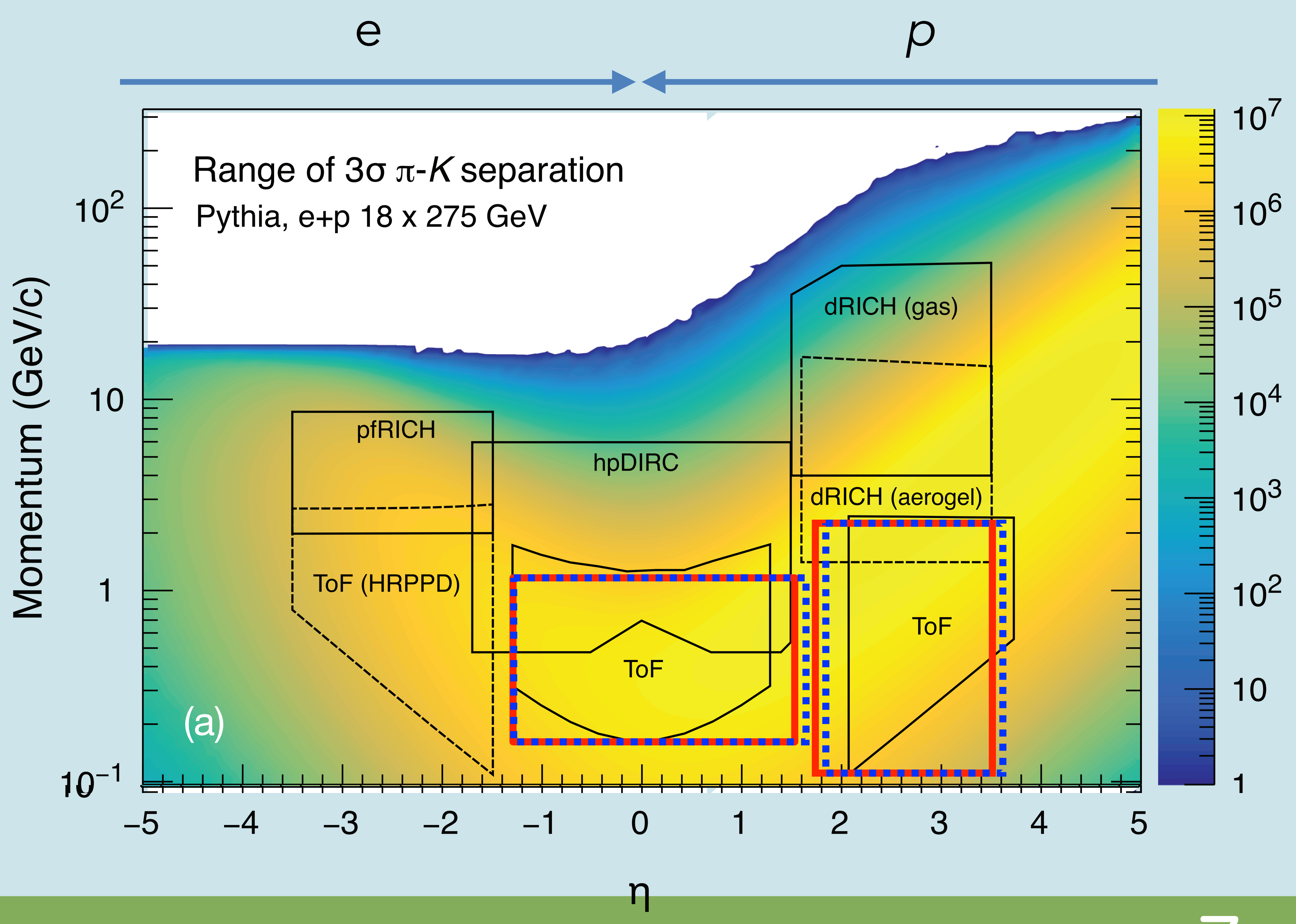
- **FTOF position is closer than before**
  - **PID performance is affected just a bit...**



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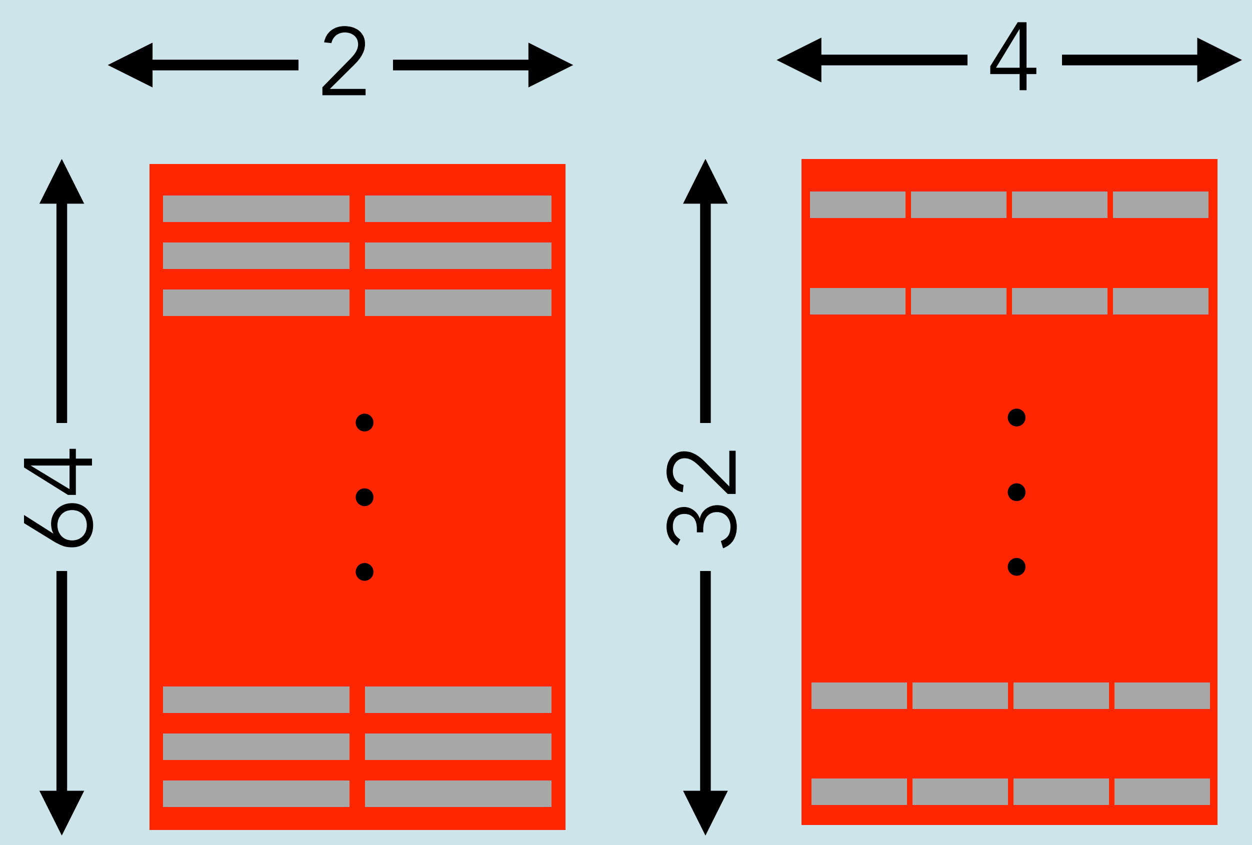

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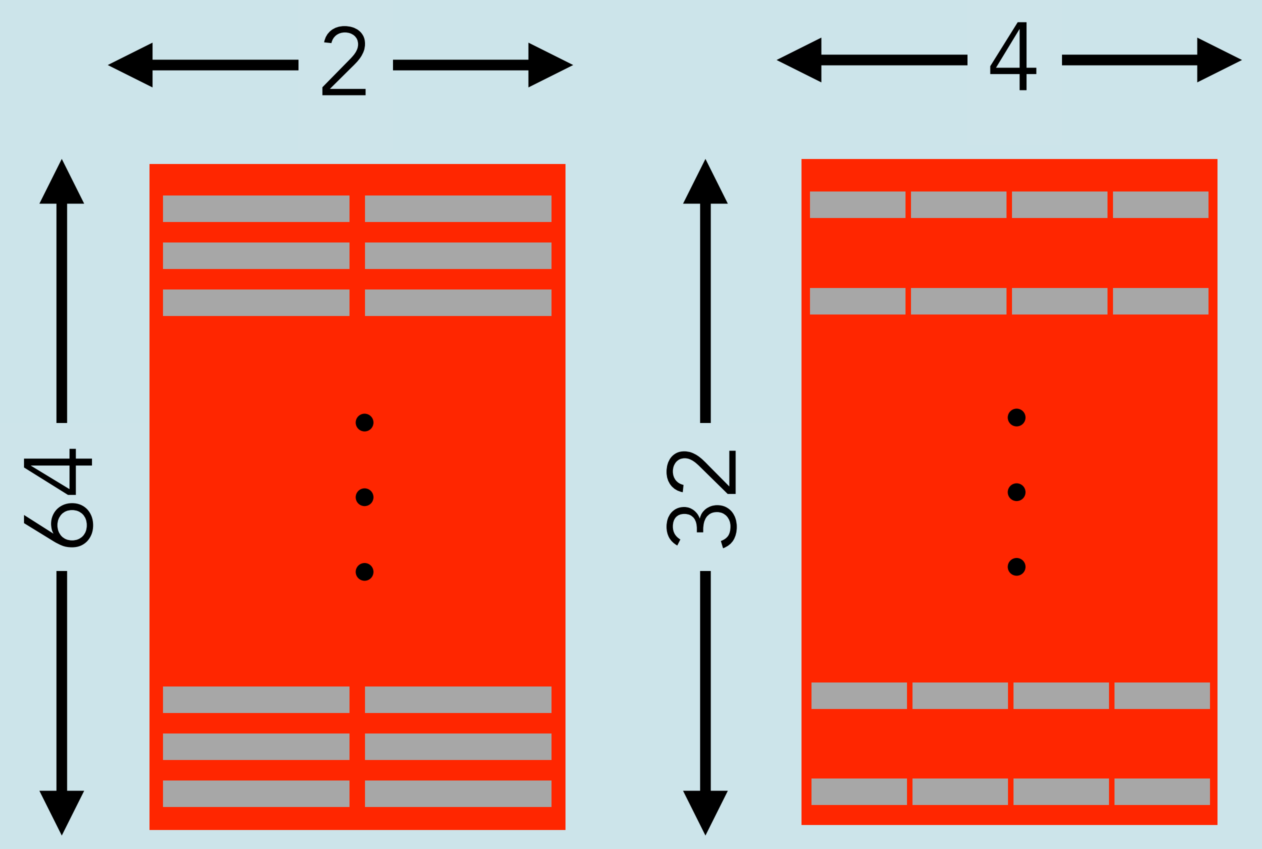
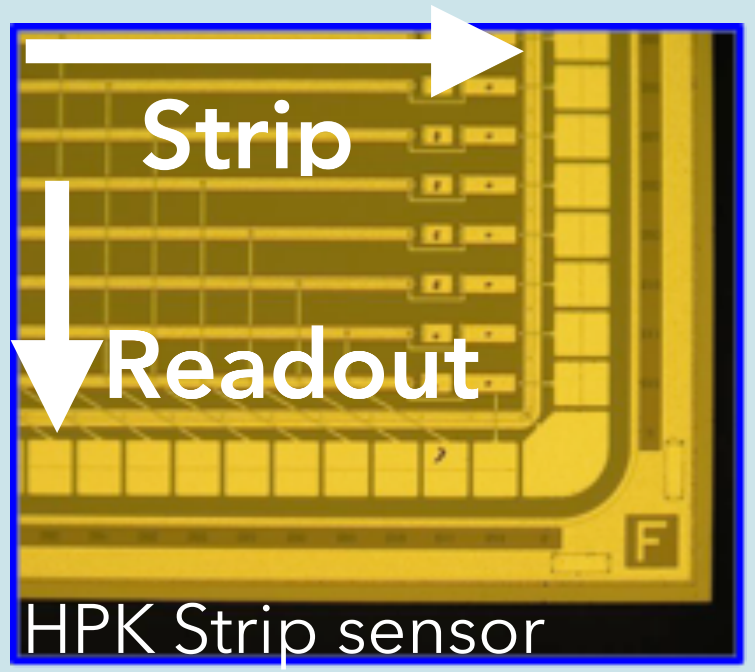
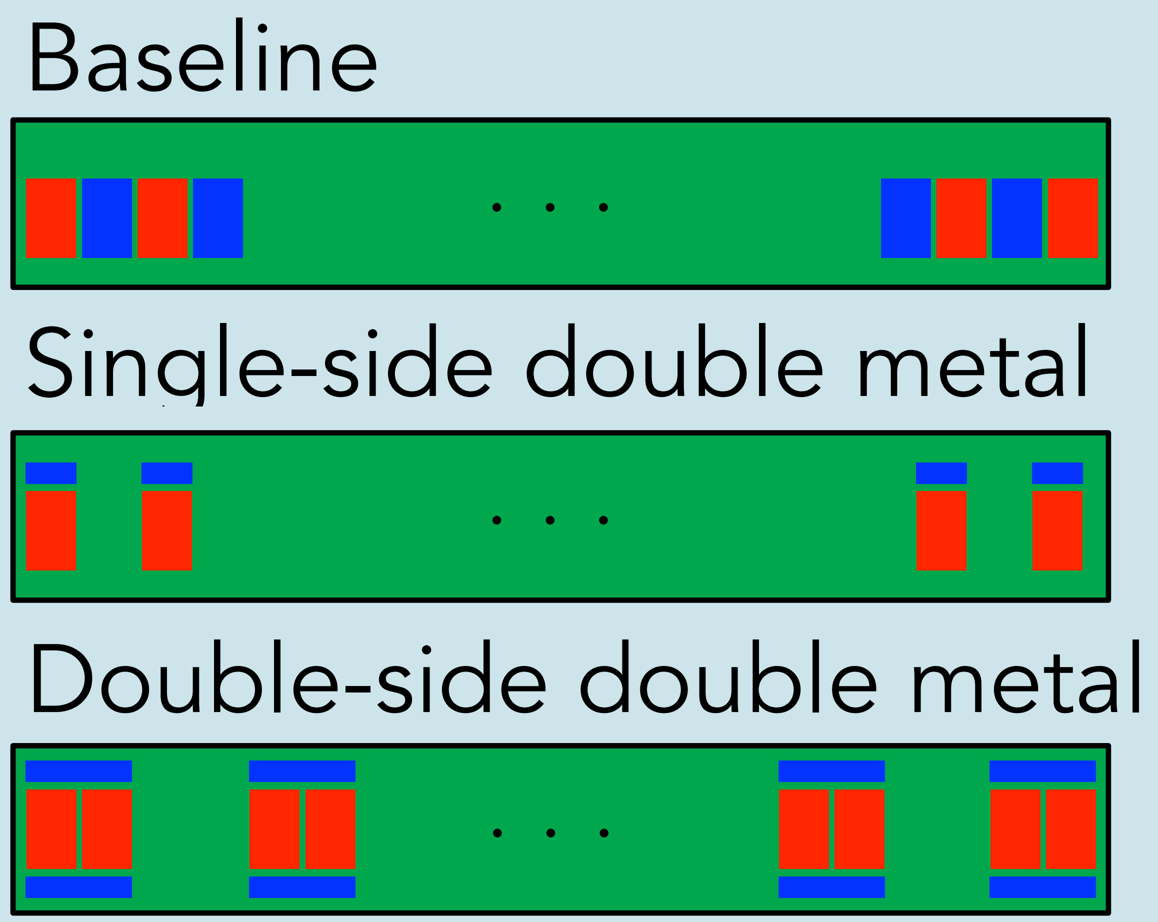


- We will challenge to deploy the double metal layer
  - One side case has 156μm pitch, but the double-side case 312μm
  - ASIC can be put on the side of the sensor → expand design possibility





Summary

- TOF covers at low momentum range PID
- The sensor design baseline for BTOF has been changed
- Technological issues may lead to changes in the kinematic range covered, but not significantly
- We continue developing sensors more suitable for EIC

Extra slides

What we want to clarify today

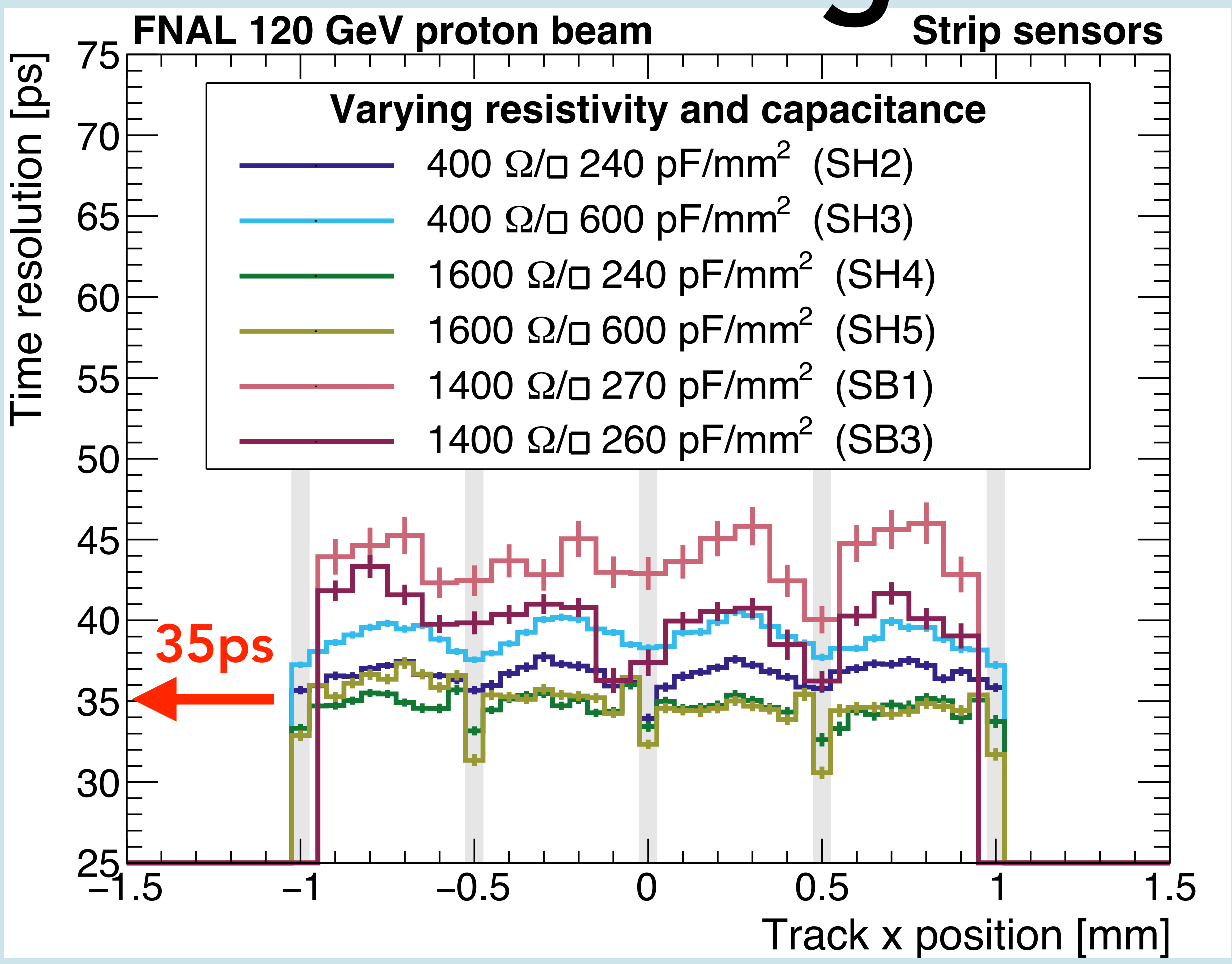
What amount of BTOF material budget is allowed?
What is the kinematic range that TOF should measure?

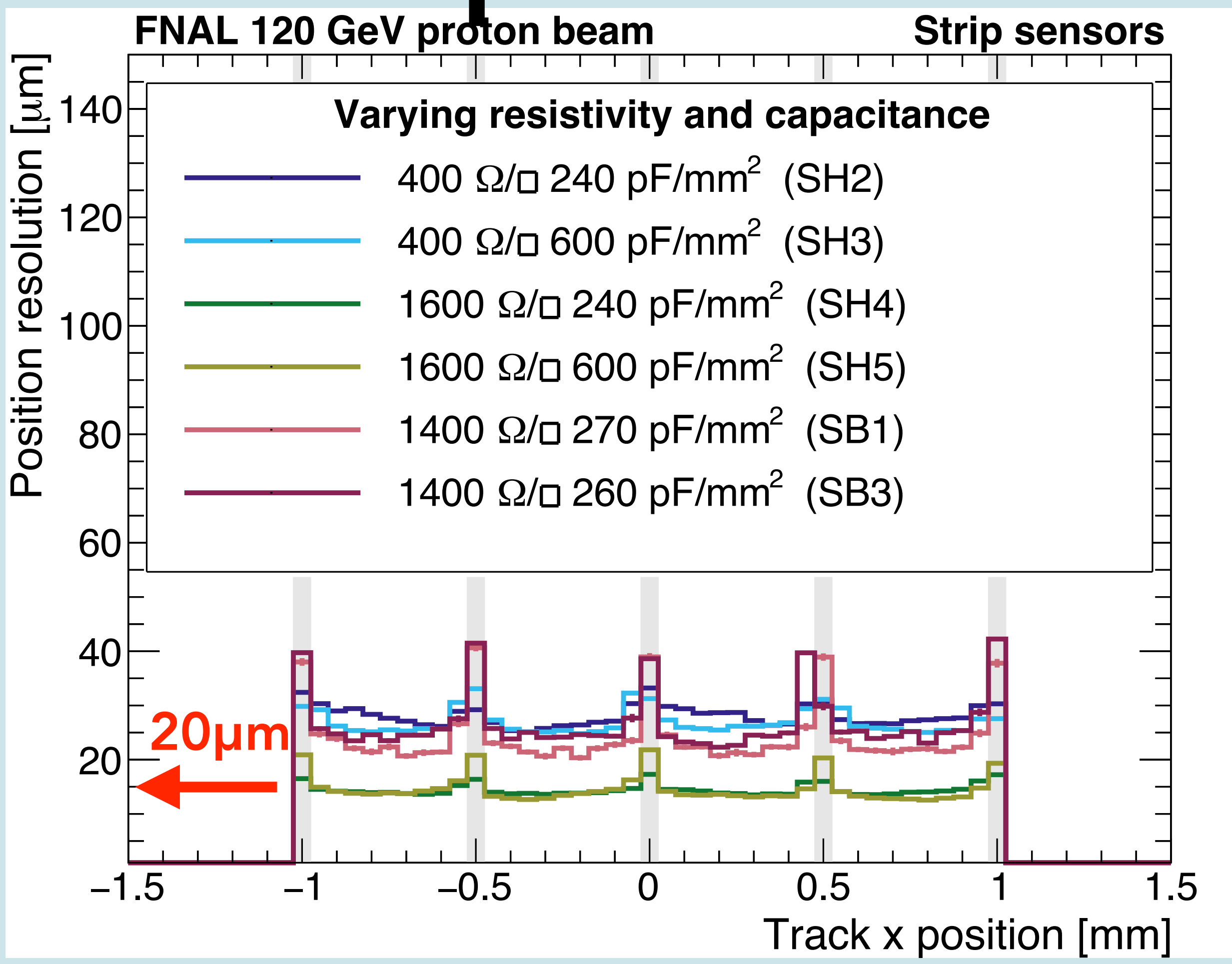
Latest sensor performance

Beam test result at FNAL (from eRD112 FY24 report by FNAL, LBNL)

Strip type results

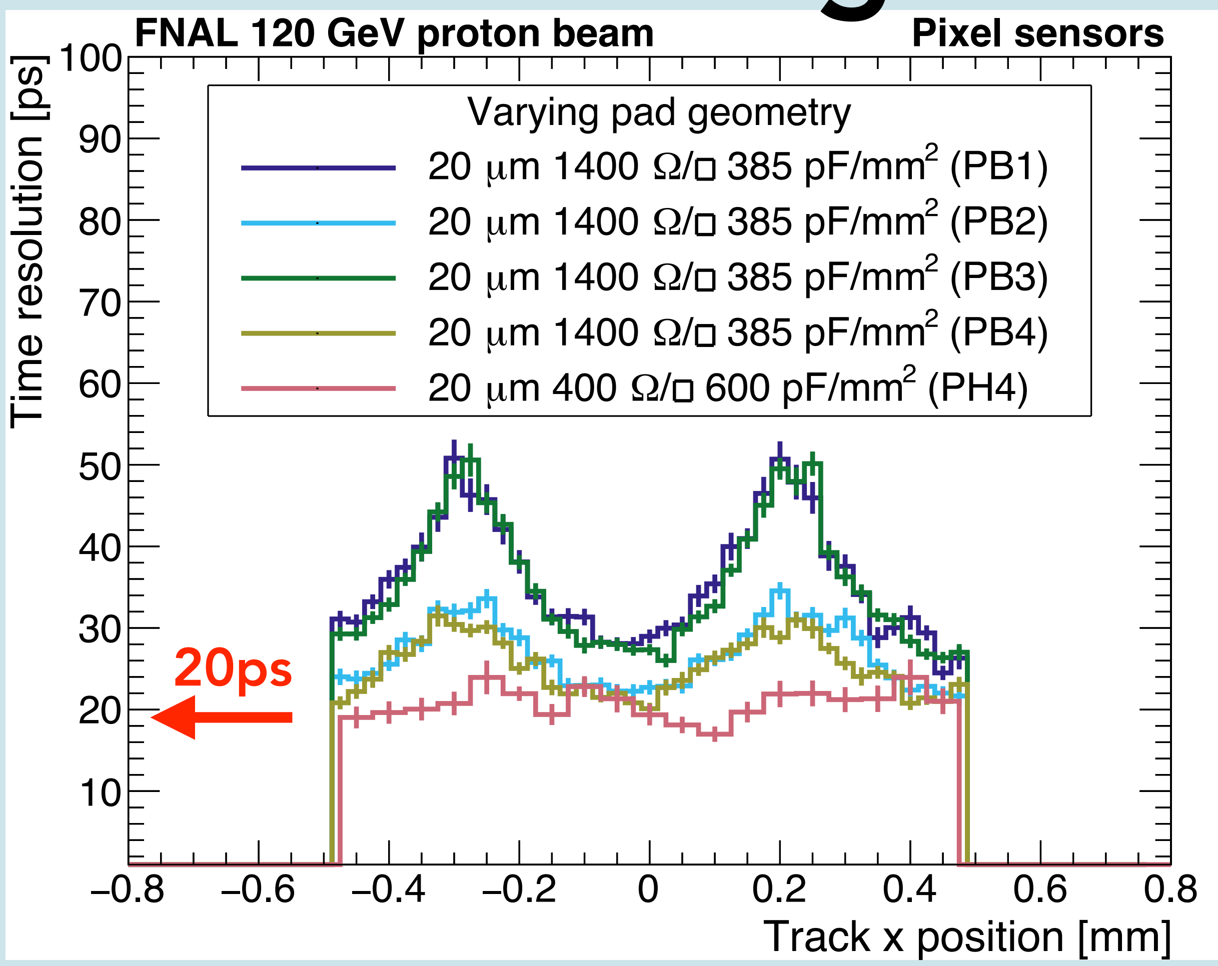
Timing **Spatial**

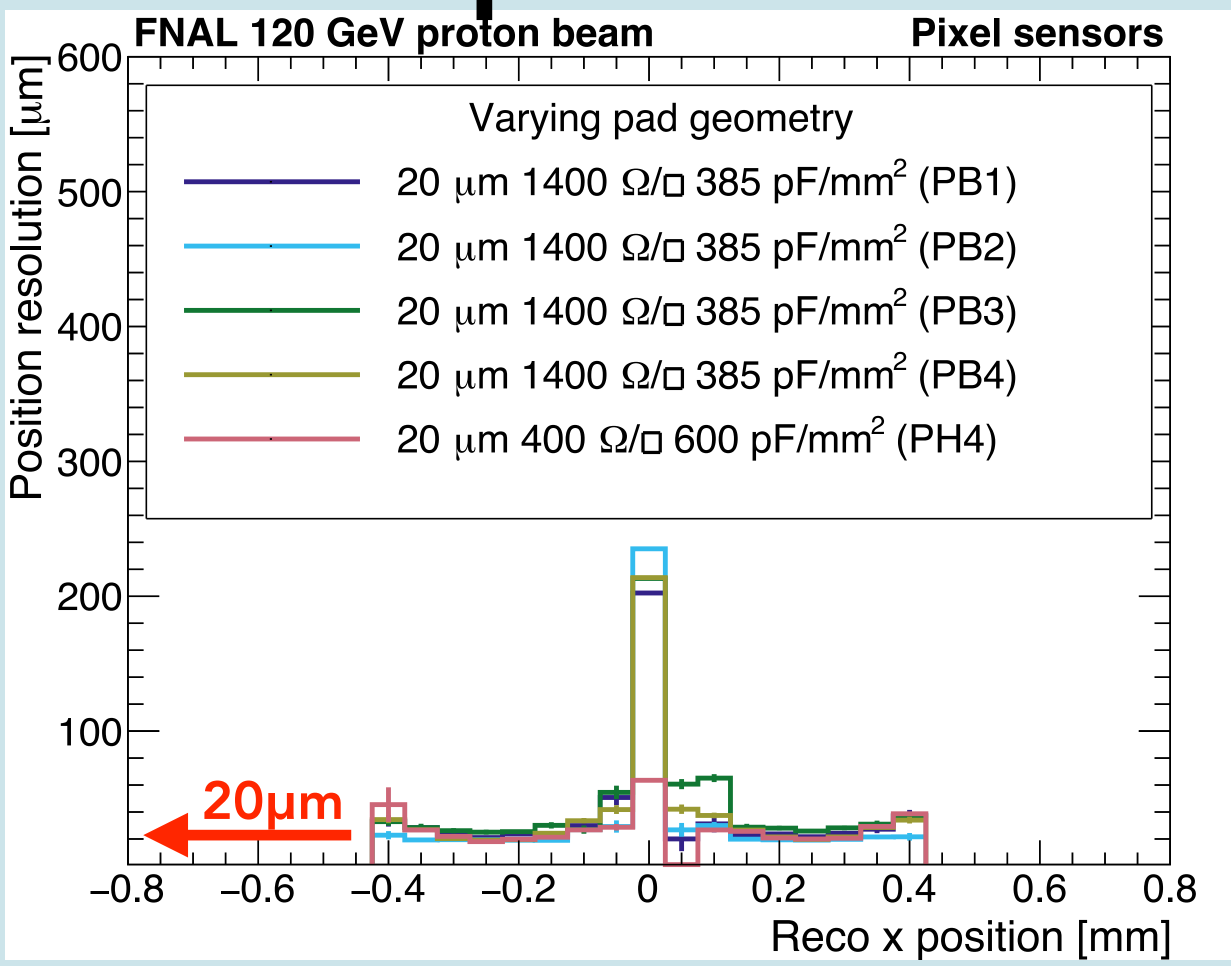




Pixel type results

Timing **Spatial**





- HPK and BNL sensors show reasonable results in both strip and pixel types with the "BEST" bias voltage
  - The higher performance of time resolution should be achieved when considering the electronics jitter and T0 resolution
- The performances are under control and the next prototypes will have higher performance
- The sensors are still smaller than the sensors used in the experiment

Roadmap (ver0)

CURRENT

PROPOSAL

What must be discussed in this meeting

- **What amount of BTOF material budget is allowed?**
  - Effect on the angle resolution on the hpDIRC surface
  - We have a dedicated workfest this afternoon, "Tracking Projections/Resolution @ hpDIRC" (link)
- **What is the lower limit of time resolution performance?**
  - Best timing performance is Δt_{Sensor} = 35 ps → $\mathbf{\Delta t_{BTOF}}$ **= 43 ps** with Δt_{ASIC} = 20 ps, and Δt_{T0} = 15 ps
- **Is it possible to make a long and low-material budget FPC?**
  - What should we know and define? Another solution?
- **What is the best stave design?**
  - We must consider stave production yield and the line layout of the FPC
  - We may have to consider modularization to break it up into smaller pieces
- **What is the impact of the plan to shorten the BTOF by 21cm?**
- **How does the Japanese fund work with eRD109+eRD112?**
  - The Japanese government (MEXT) has decided to support BTOF (in FY25 ~$2M)