Progress of TPC prototype and some considerations for Pixel TPC at Z

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Outline

- Simulation of IBF effect
- Pixel TPC at Z pole run
- TPC prototype R&D

Brief summarize-1

CEPC CDR

Lumi.	Higgs	W	Z	Z(2T)
$\times 10^{34}$	2.93	11.5	16.6	32.1

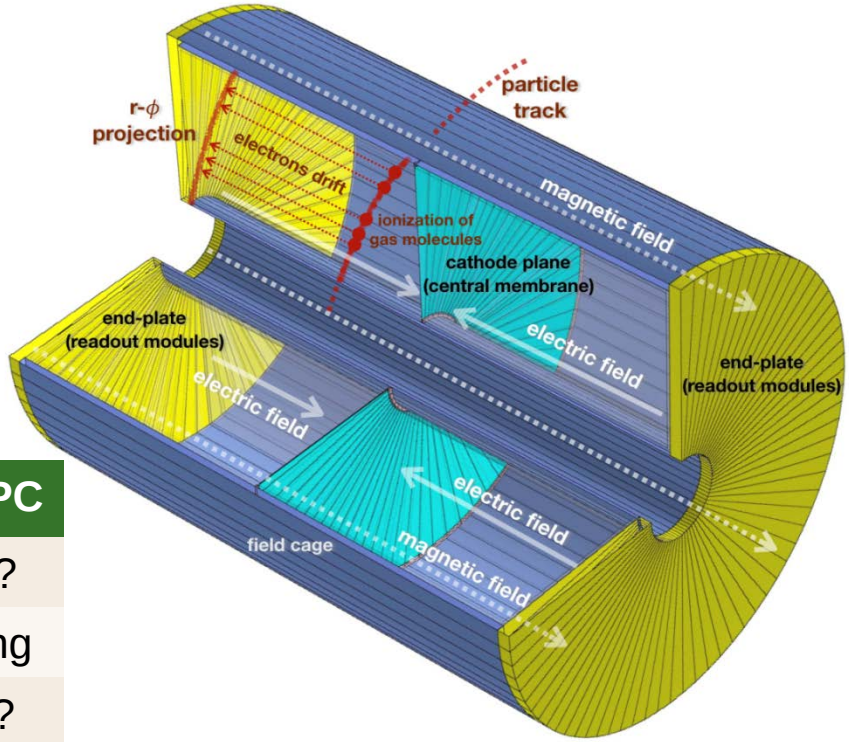
Luminosities exceeded those in the preCDR

- double ring baseline design (30MW/beam)
- switchable between H and Z/W w/o hardware change (magnet switch)
- use half SRF for Z and W
- can be optimized for Z with 2T detector

Brief summarize-2

- TPC limitations for Z
  - Ions back flow in chamber
  - Calibration and alignment
  - Low power consumption FEE ASIC chip

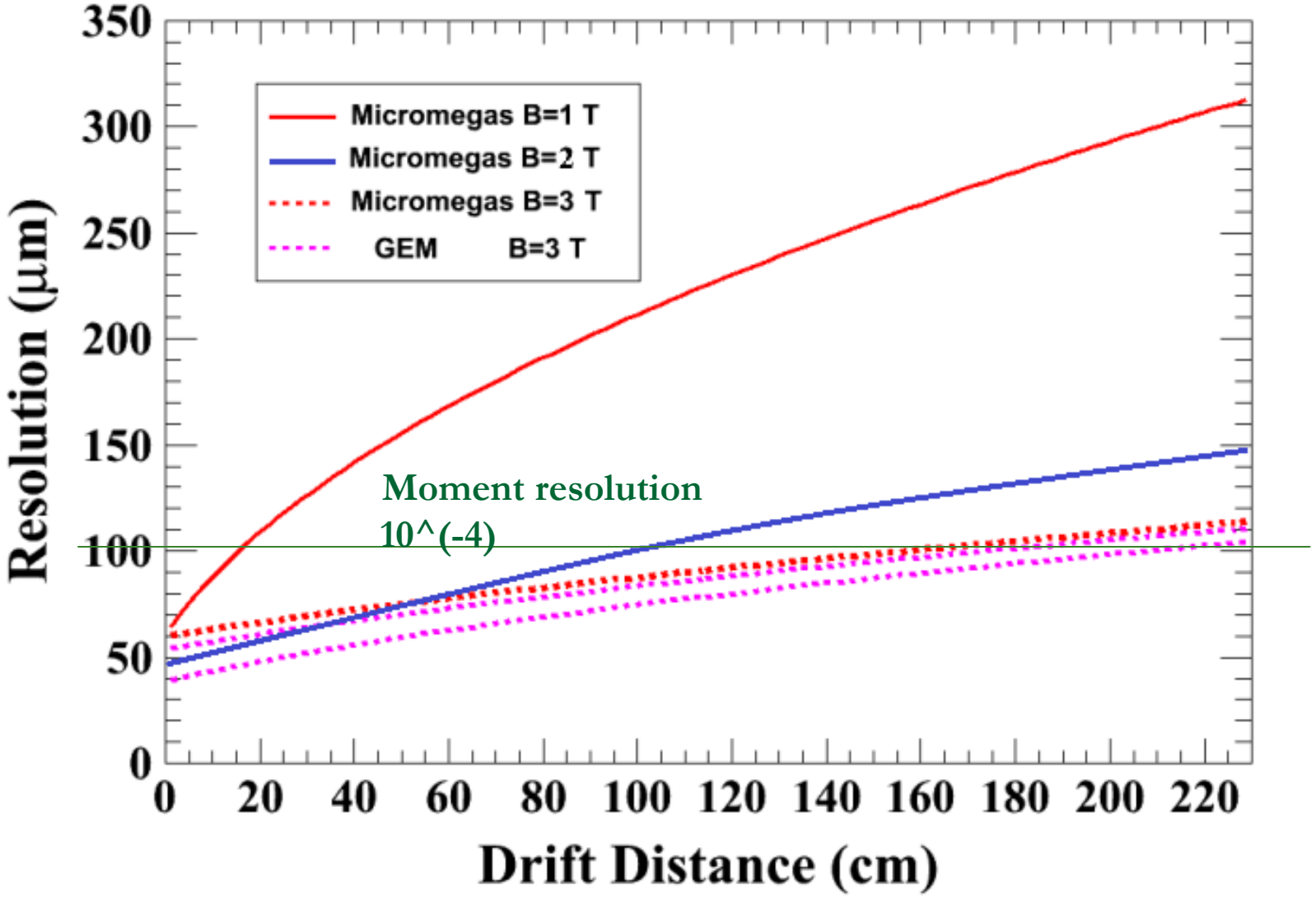
	ALICE TPC	CEPC TPC
Maximum readout rate	>50kHz@pp	w.o BG?
Gating to reduce ions	No Gating	No Gating
Continuous readout	No trigger	Trigger?
IBF control	Build-in	Build-in
IBF*Gain	<10	<5
Calibration system	Laser	NEED



Overview of TPC detector concept

Compare with ALICE TPC and CEPC TPC

Resolution along drift length (simulation)



Simulation of IBF effect

- Simulation
  - Based on the ILC-KEK codes
  - Re-established model
  - Validated with 3 ions disks
  - Still more works with the simulation module till now

MarlinTPC

C 0 0 0 0 Updated 27 days ago

yokaRawMonNeo

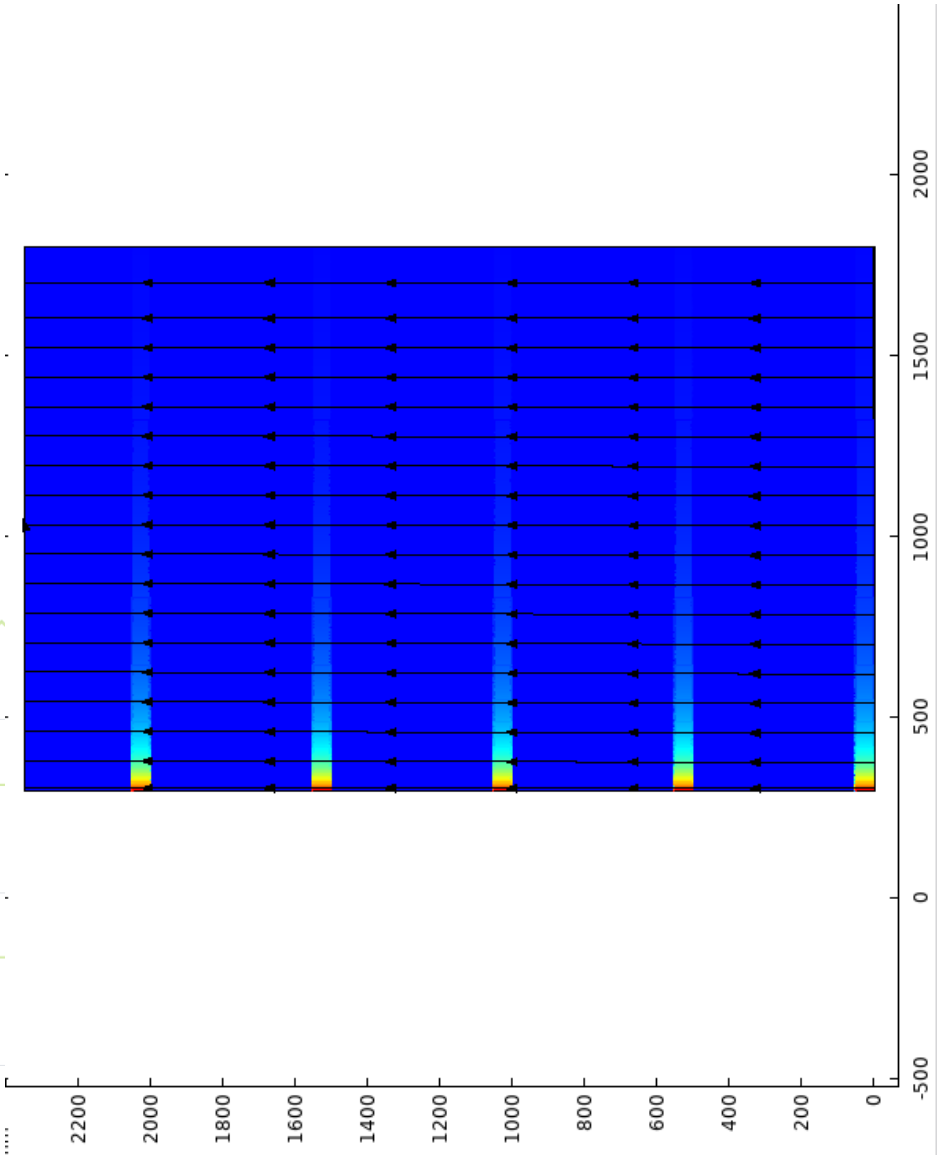
A software for analyzing ALTRO DAQ data for TPC studies.

C++ 0 0 0 0 Updated on Mar 20, 2018

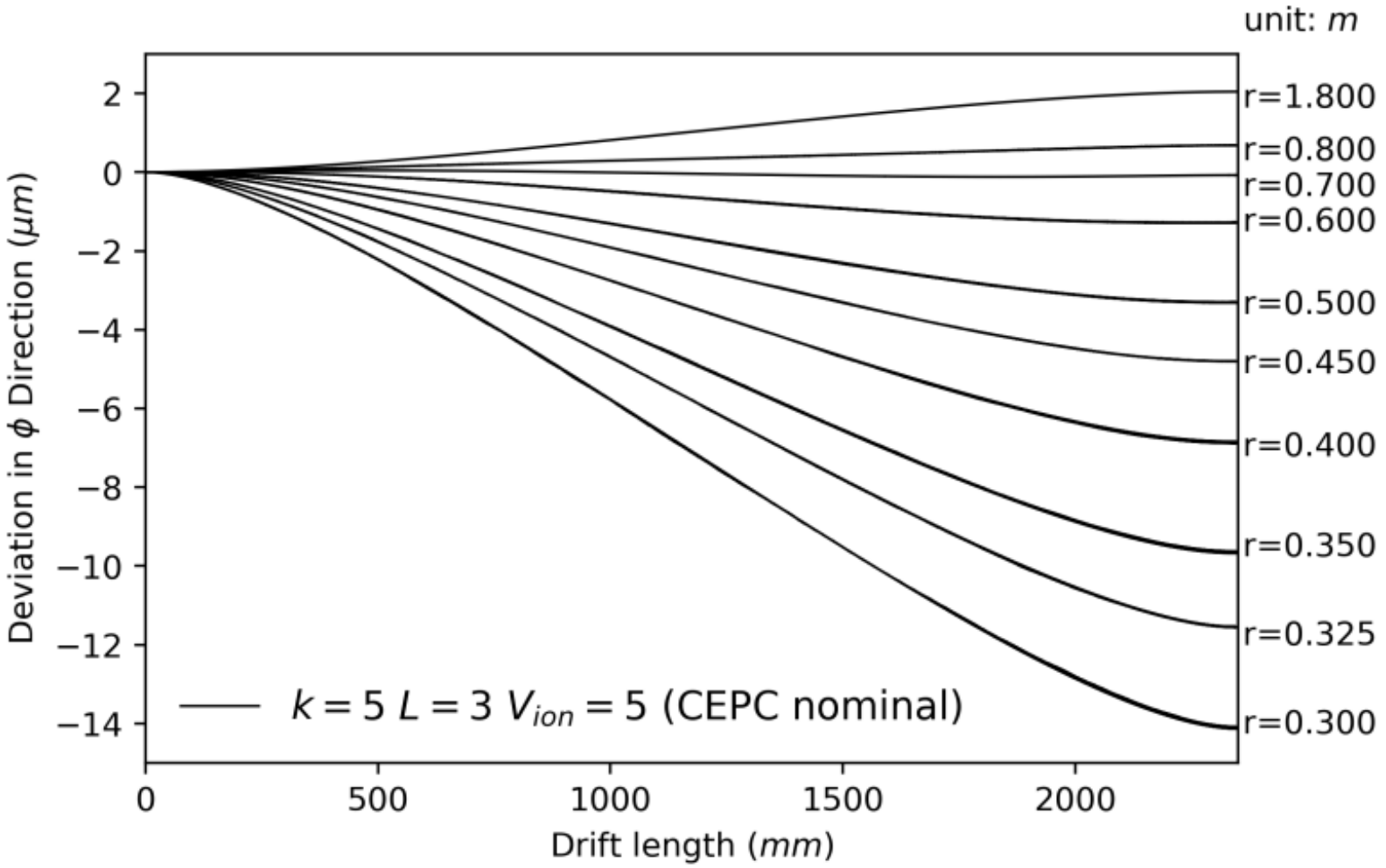
KalTest

Kalman filter implementation based on ROOT

C++ 0 0 0 0 Updated on Oct 31, 2016

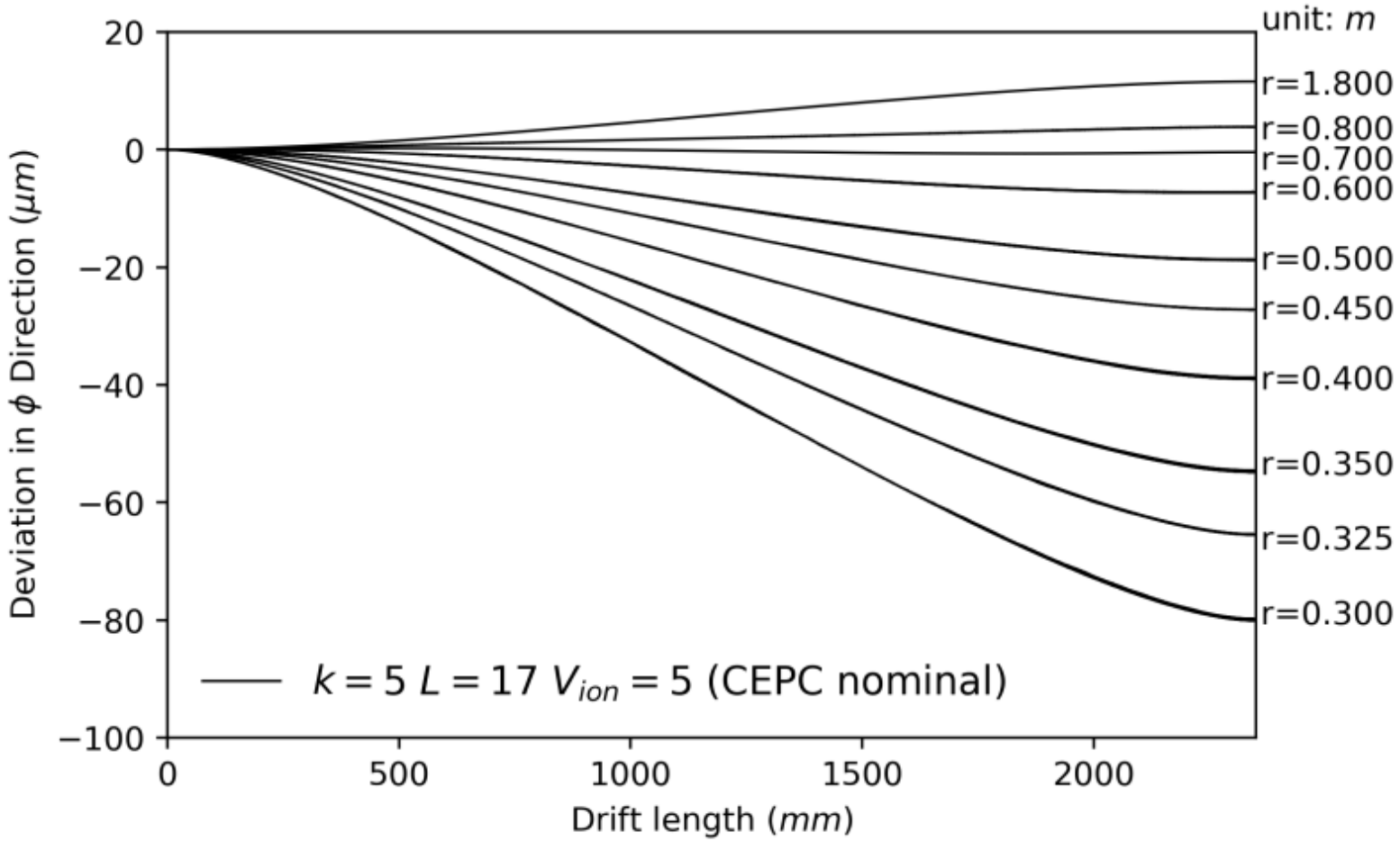


Simulation of deviation with IBF (k=Gain×IBF) @CEPC



Deviation in Φ at CEPC Higgs run with
$3\times10^{34}cm^{-2}s^{-1}$ (Lumi.)

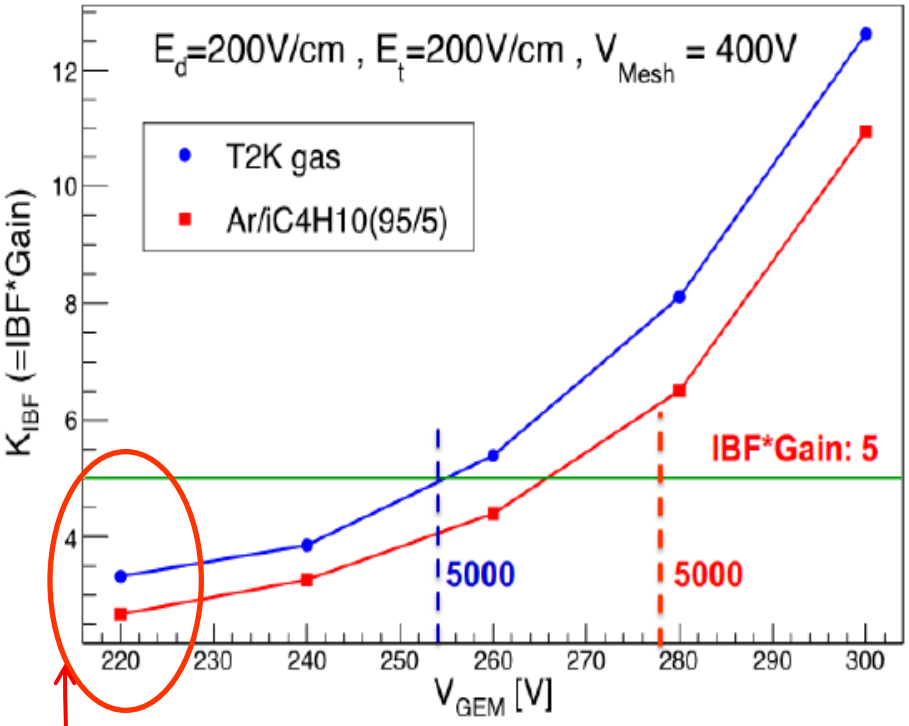
Simulation of deviation with IBF (k=Gain×IBF) @CEPC

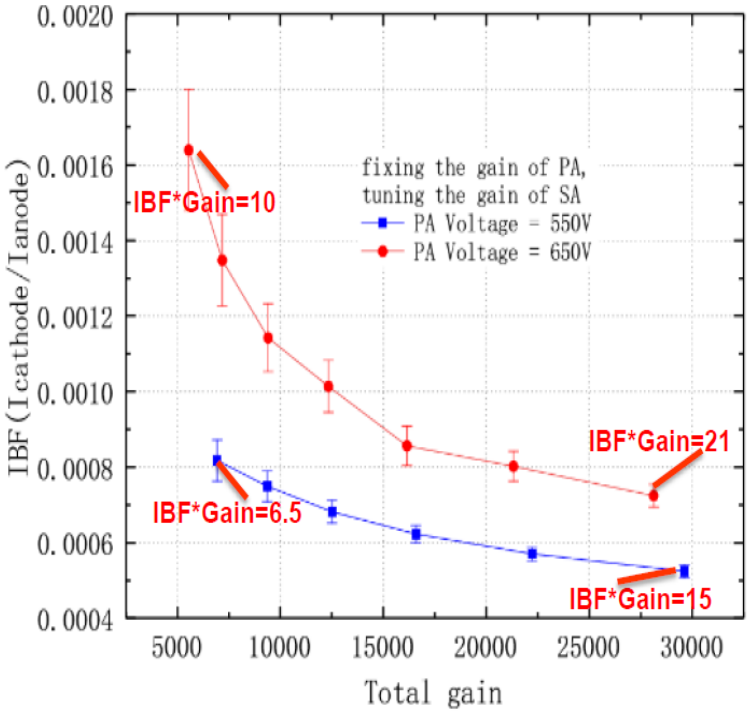


Deviation in Φ at CEPC Z pole run with
$17 \times 10^{34} cm^{-2} s^{-1}$ (Lumi.)

Update results of IBF from detector module

IBF of double mesh MM @USTC/Jianbei Liu



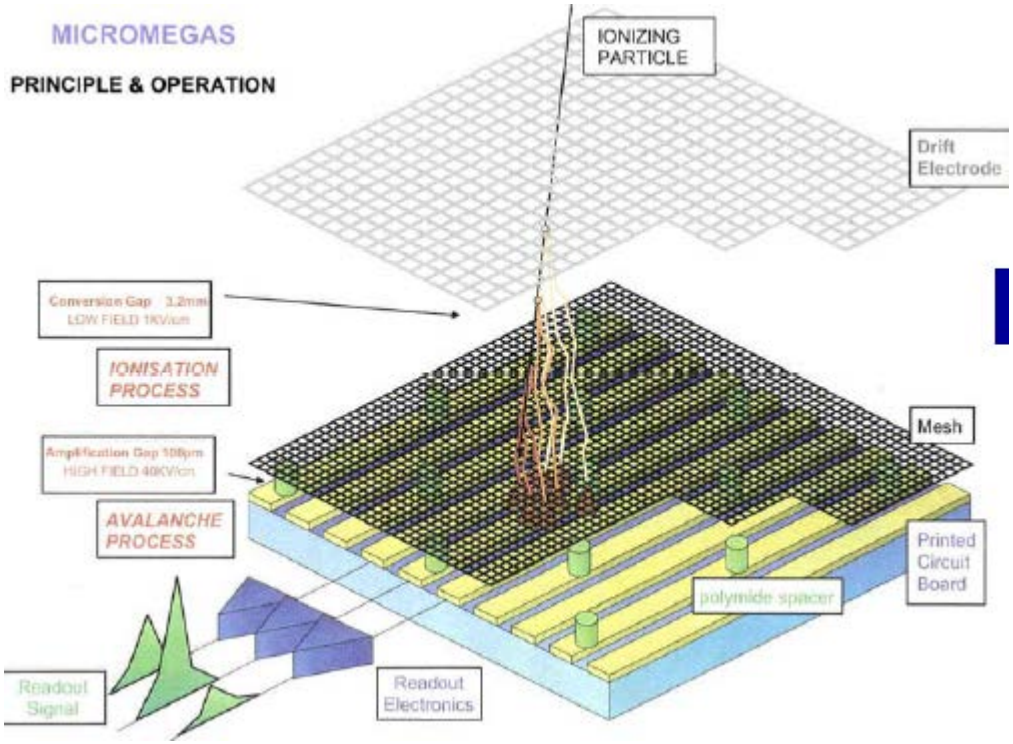


- IBF×Gain has the limitation ratio from the detector R&D at high gain.
- How to do it next ? Any new ideas? (Lower gain and no IBF)

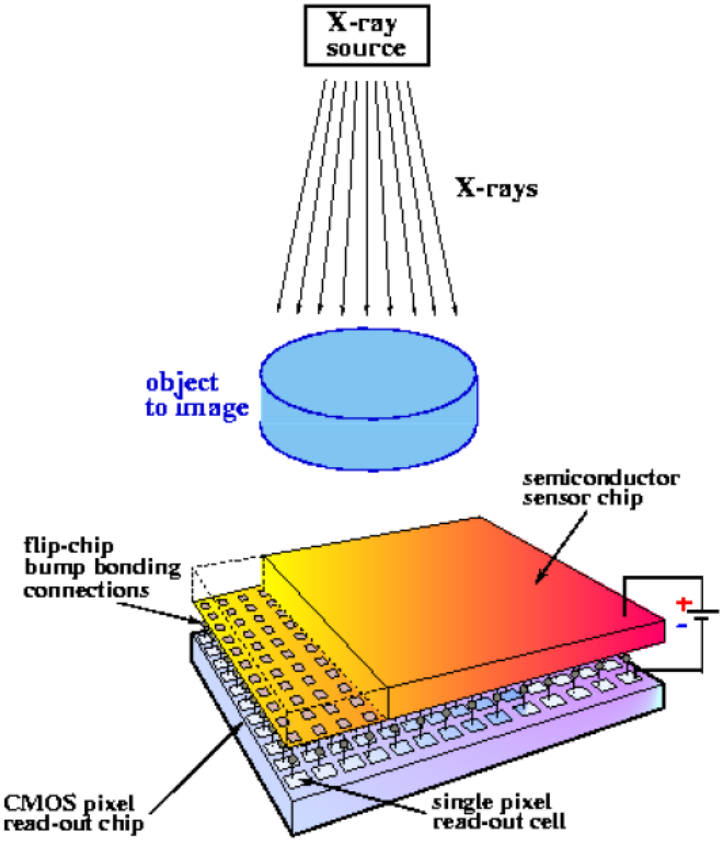
Some considerations for Pixel TPC at Z

1. Pixel TPC
2. Some considerations

Readout of TPC

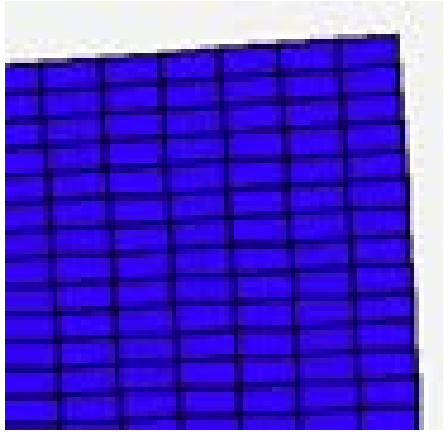


Standard charge collection

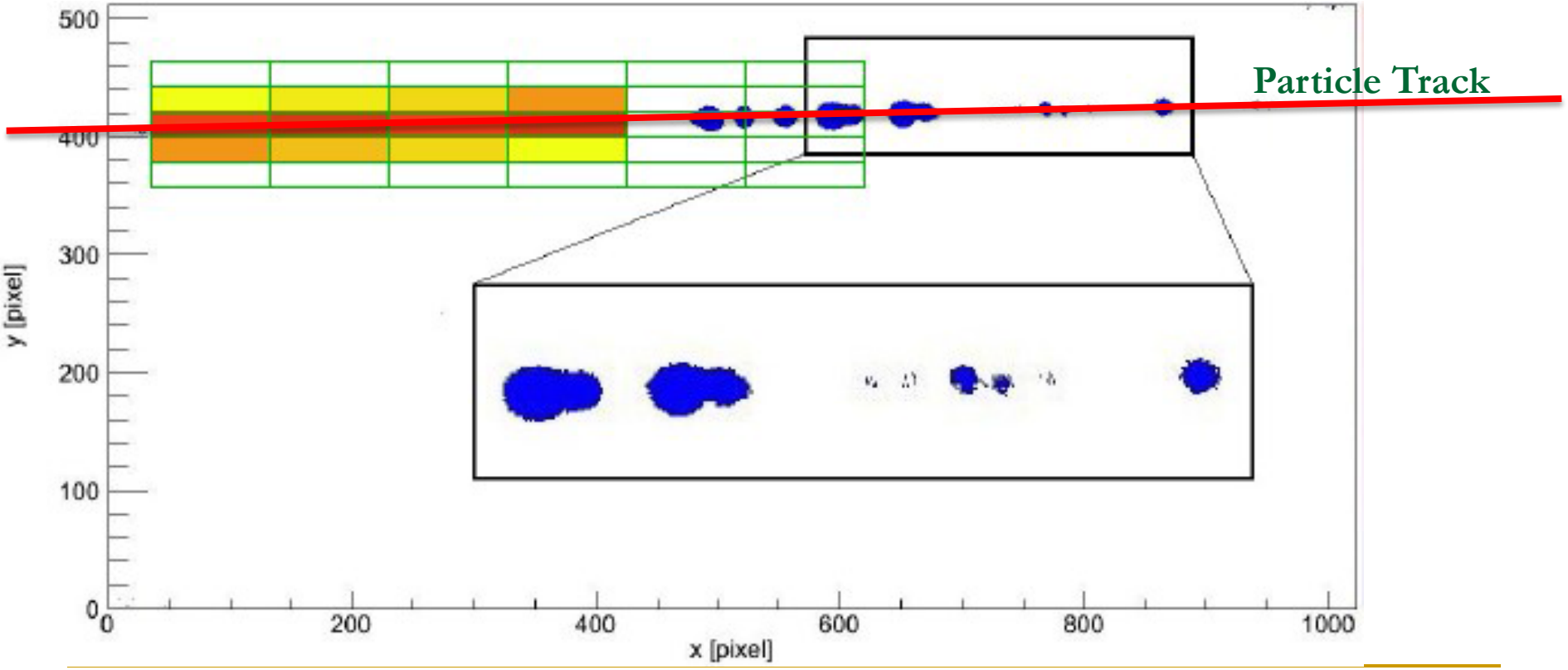


ASIC chip with sensors

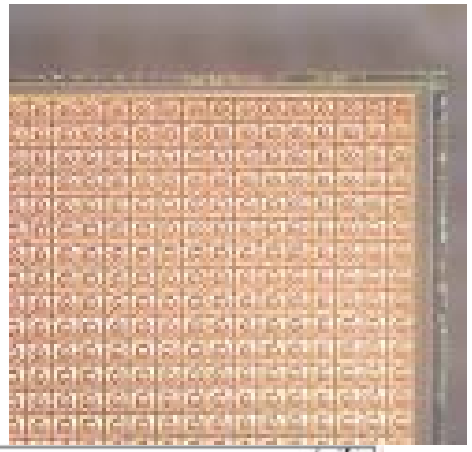
Pad TPC and Pixel TPC



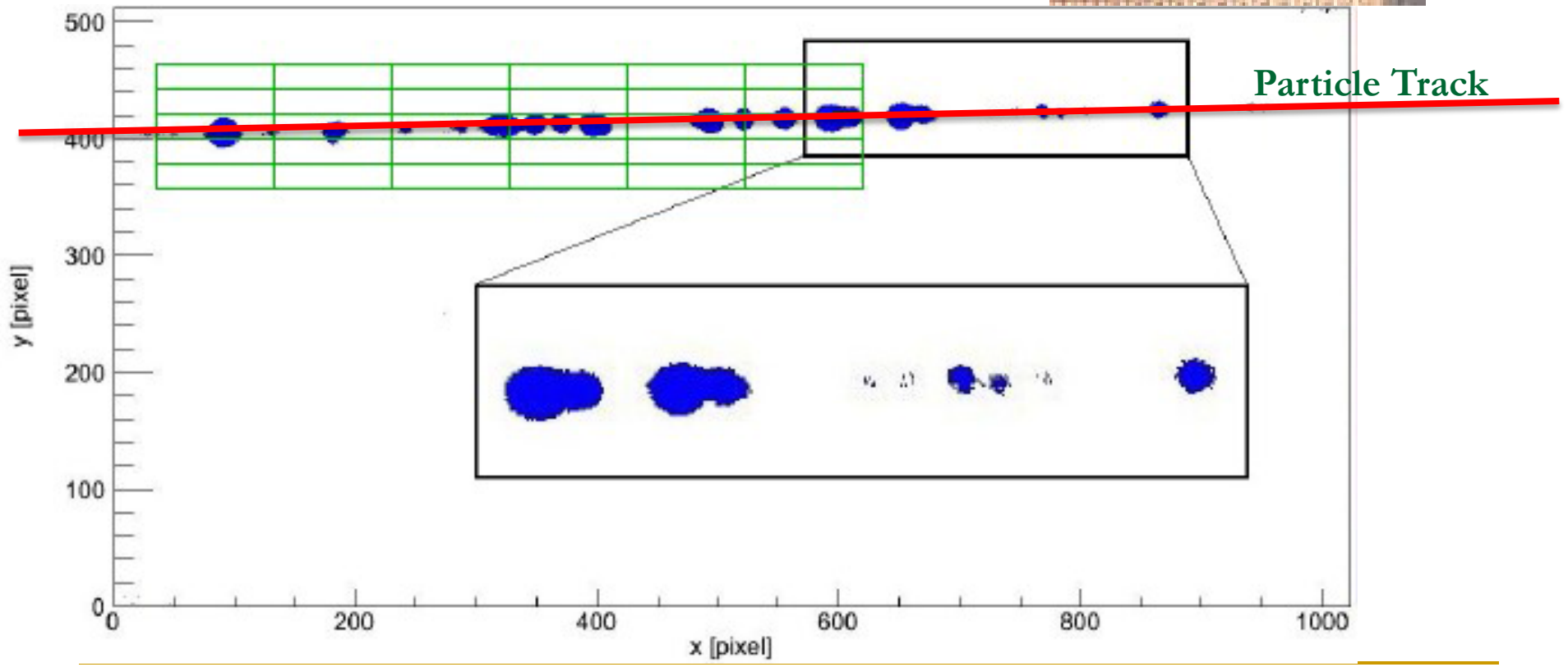
Standard charge collection
Pad: 1.0 x 6.0 mm^2



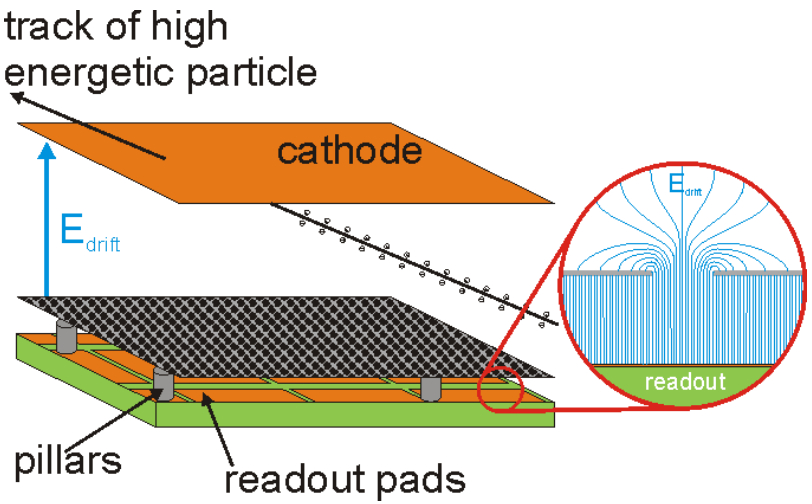
Pad TPC and Pixel TPC



- Pixel: 55x 55 μm^2



InGrid to GridPix readout



- Standard charge collection:
  - Pads of several mm2
  - Long strips (l~10 cm, pitch ~200 μm)
- Instead: Bump bond pads are used as charge collection pads

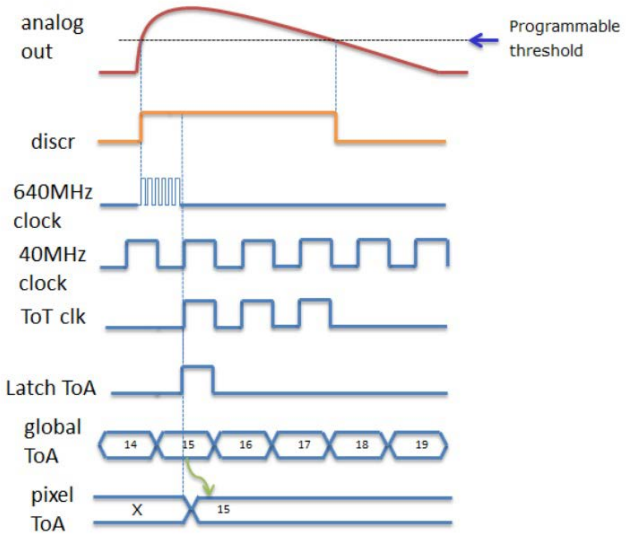
- Smaller pads/pixels could result in better resolution!
- Gain <2000
- At Nikhef the GridPix was invented from 2003.

Benefits of GridPix readout:

- Lower occupancy → better track finding
- Improved dE/dx→ primary e- counting

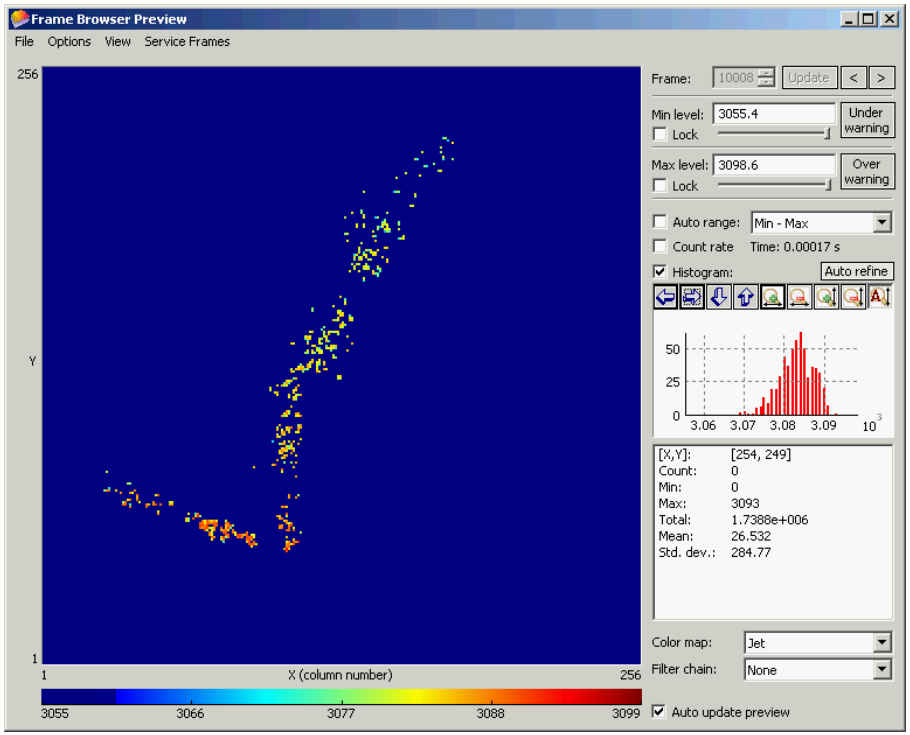
For Collider @cost:
But to readout the TPC with GridPixes:
~100-120 chips/module
240 modules/endcap (10 m^2)
→50k-60k GridPixes

Readout: Timepix ASIC chip



Main characteristics of Timepix3

- Number of pixels: 256 × 256 pixels
- Pixel pitch: 55 × 55 μm2
- Charge (ToT) and time (ToA) available for each hi
- Timing resolution: 1.56 ns for duration of ~410 μs
- Zero suppression on chip (sparse readout)
- Multi-hit capable (pixels sensitive after tToT+475 ns)
- Output rate up to 5.12 Gbps
- For each pixel:
  - preamp/shaper
  - threshold discriminator
  - register for configuration
  - 14-bit counter
- Noise with detector: ~ 650 e-
  - Cin ~ 15 fF



Update parameters till now

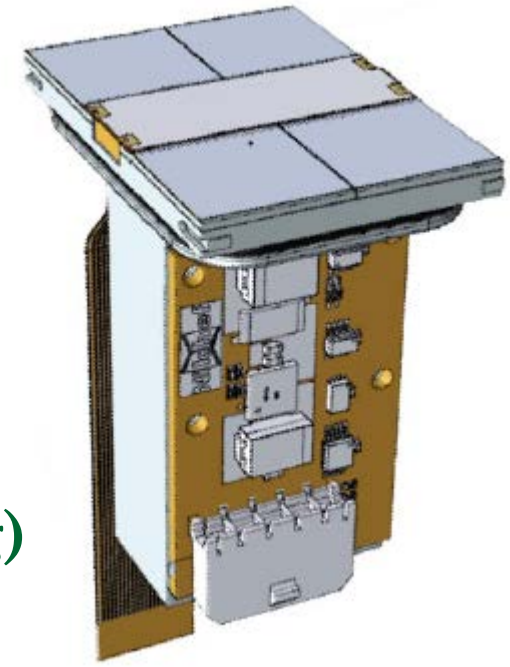
Timepix3 → Timepix4

Timepix4: A 4-side tillable large single threshold particle detector chip with improved energy and time resolution and with high-rate imaging

			Timepix3 (2013)	Timepix4 (2019)	
Technology			130nm – 8 metal	65nm – 10 metal	
Pixel Size			55 x 55 µm	55 x 55 µm	
Pixel arrangement			3-side buttable 256 x 256	4-side buttable 512 x 448	**3.5x**
Sensitive area			1.98 cm^2	6.94 cm^2	
Readout Modes	Data driven (Tracking)	Mode	TOT and TOA		
		Event Packet	48-bit	64-bit	**33%**
		Max rate	0.43x10^6 hits/mm^2/s	**3.58x10^6 hits/mm^2/s**	**8x**
		Max Pix rate	1.3 KHz/pixel	**10.8 KHz/pixel**	
	Frame based (Imaging)	Mode	PC (10-bit) and iTOT (14-bit)	CRW: PC (8 or 16-bit)	
		Frame	Zero-suppressed (with pixel addr)	Full Frame (without pixel addr)	**10x**
		Max count rate	~0.82 x 10^9 hits/mm^2/s	~5 x 10^9 hits/mm^2/s	**5x**
TOT energy resolution			< 2KeV	< **1Kev**	**8x**
Time resolution			1.56ns	**~200ps**	
Readout bandwidth			≤5.12Gb (8x SLVS@640 Mbps)	**≤163.84 Gbps (16x @10.24 Gbps)**	
Target global minimum threshold			<500 e^-	<500 e^-	

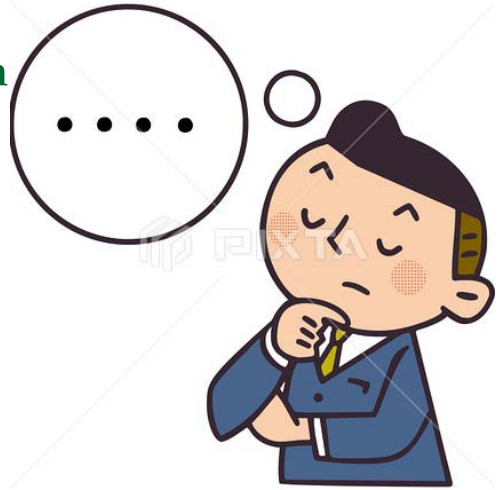
Still many challenges based TPC

- Cost (?)
- Connect with MPGD
  - Capacitance the signal to noise
- Protection layer
- Dead area in boundary
- Track pattern recognition (machine leaning)
- …



Quad assembly

Idea: intermediate solution between pads and pixels for CEPC at Z



- Clusters contain the primary information of the ionisation
- Can we find a solution to resolve clusters?
- Some R&D for pixel TPC:
  - What is the optimal pad size to
    - – improve double hit and double track resolution
    - – do cluster counting for improved dE/dx?
    - → Pixel size:(200μm or large), significant reduce cost
- Almost without IBF (Gain< 2000)
- Micromegas + ASIC Chips (Our option)
- GEMs + ASIC Chips
  - → Some R&D at DESY
- CEPC workshop@ Novermber
- There is a invitation to LCTPC collaboration and one response obtained.
- Kees from NIKEF will attend and discuss some possible collaboration.

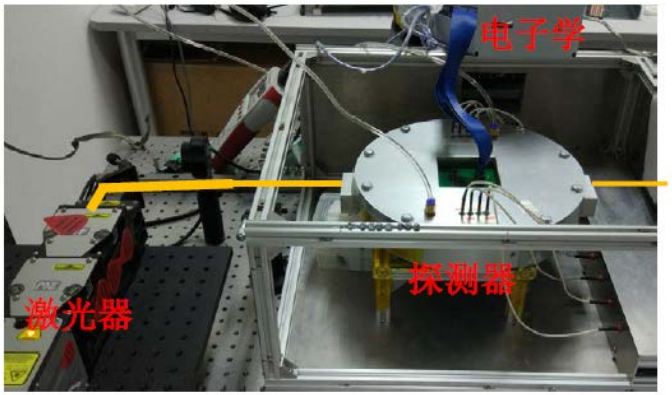
TPC prototype R&D

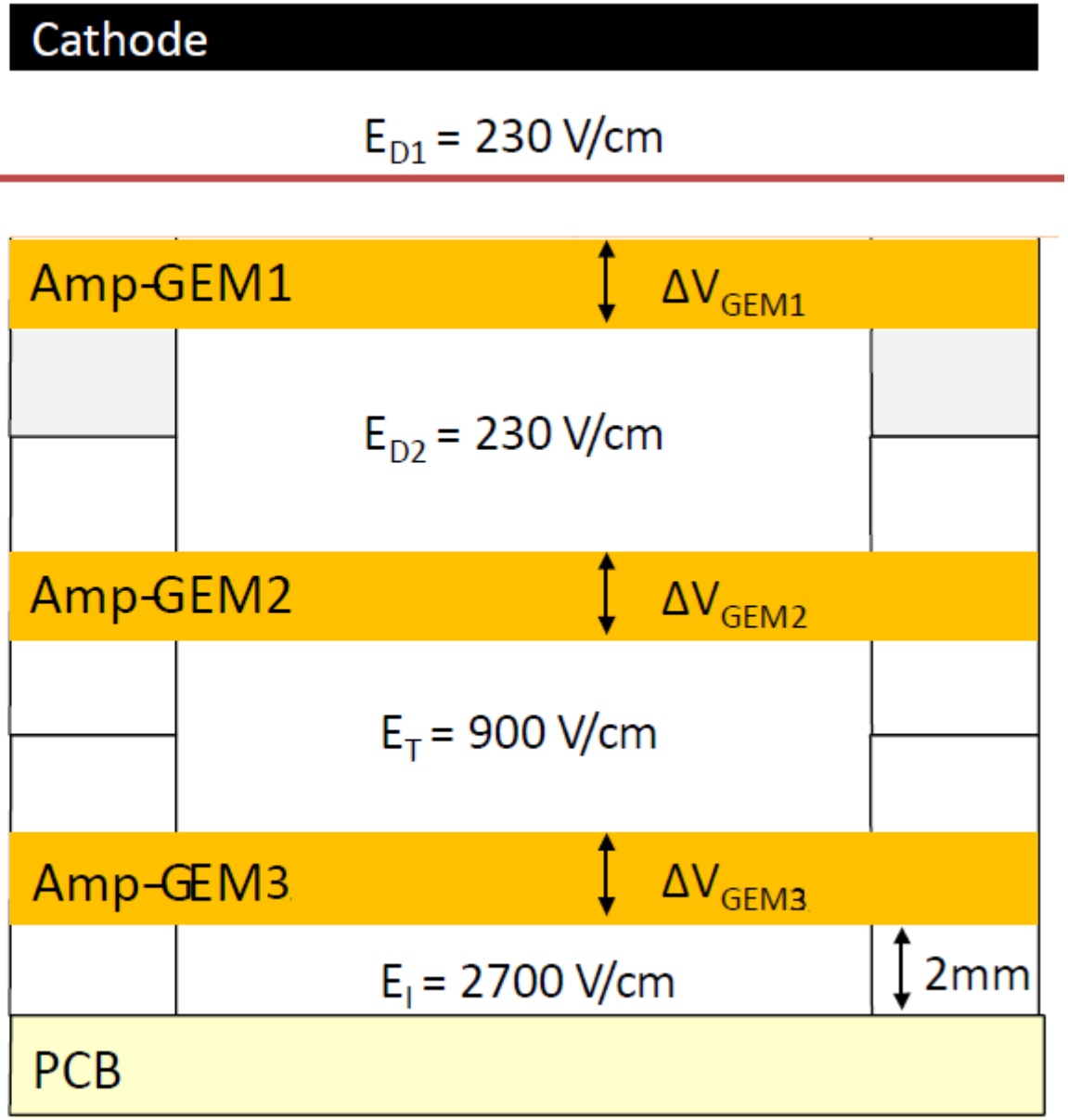
Experimental setup using a laser

Laser

Nd:YAG (λ = 266 nm)

Rep. 20 Hz





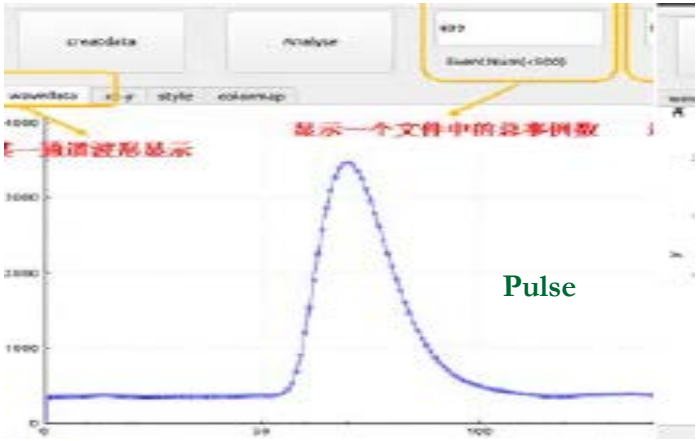
Electronics from Tsinghua

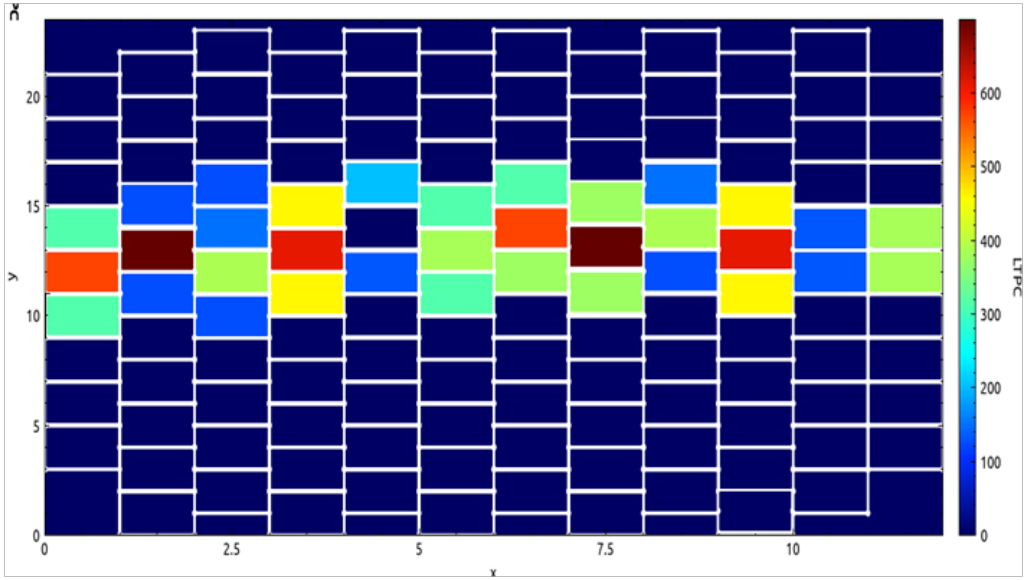
- Amplifier (READY)
  - CASAGEM chip
  - 16Chs/chip
  - 4chips/Board
  - Gain: 20mV/fC
  - Shape time: 20ns
- DAQ (READY)
  - FPGA+ADC
  - 4 module/mother board
  - 64Chs/module
  - Sample: 40MHz
  - 1280chs

Electronics, DAQ and one signal sample

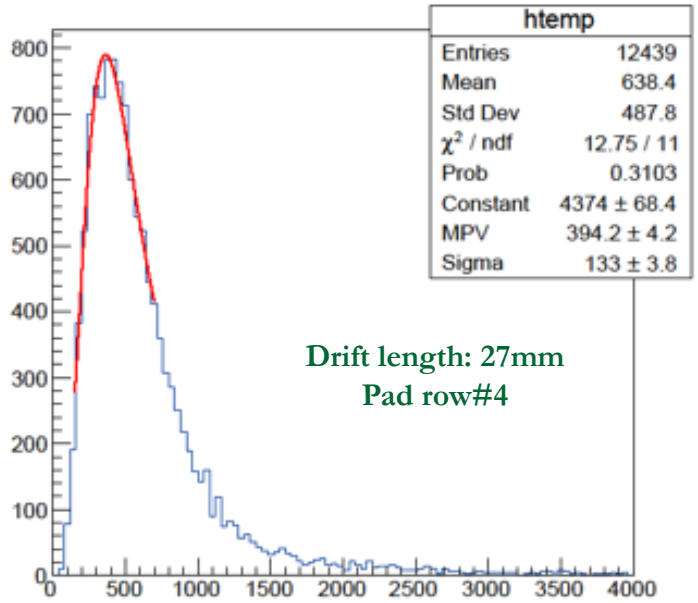
Update photos (For Beam test)

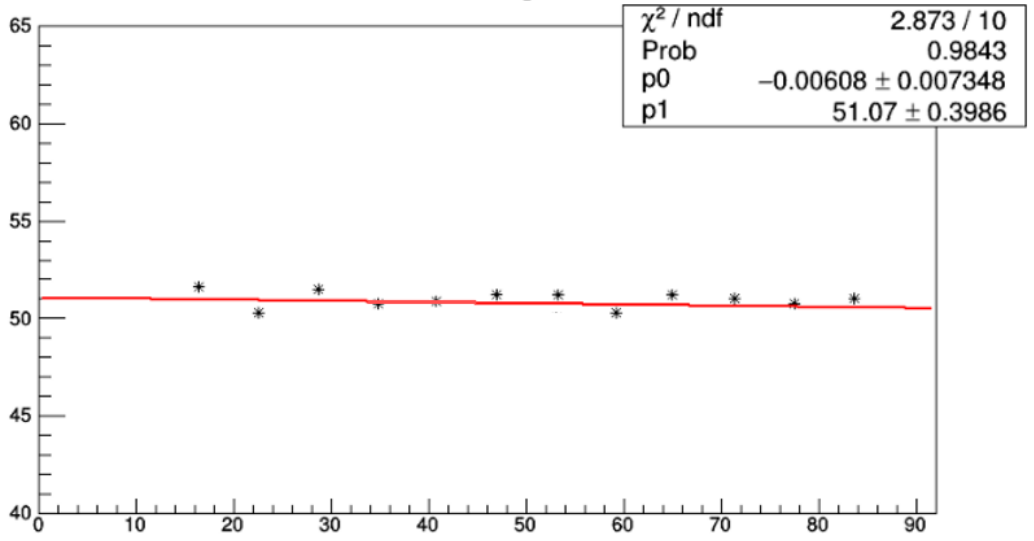
Laser track test@128chs





with weight





Preliminary results of Laser tracker energy spectrum and tracker

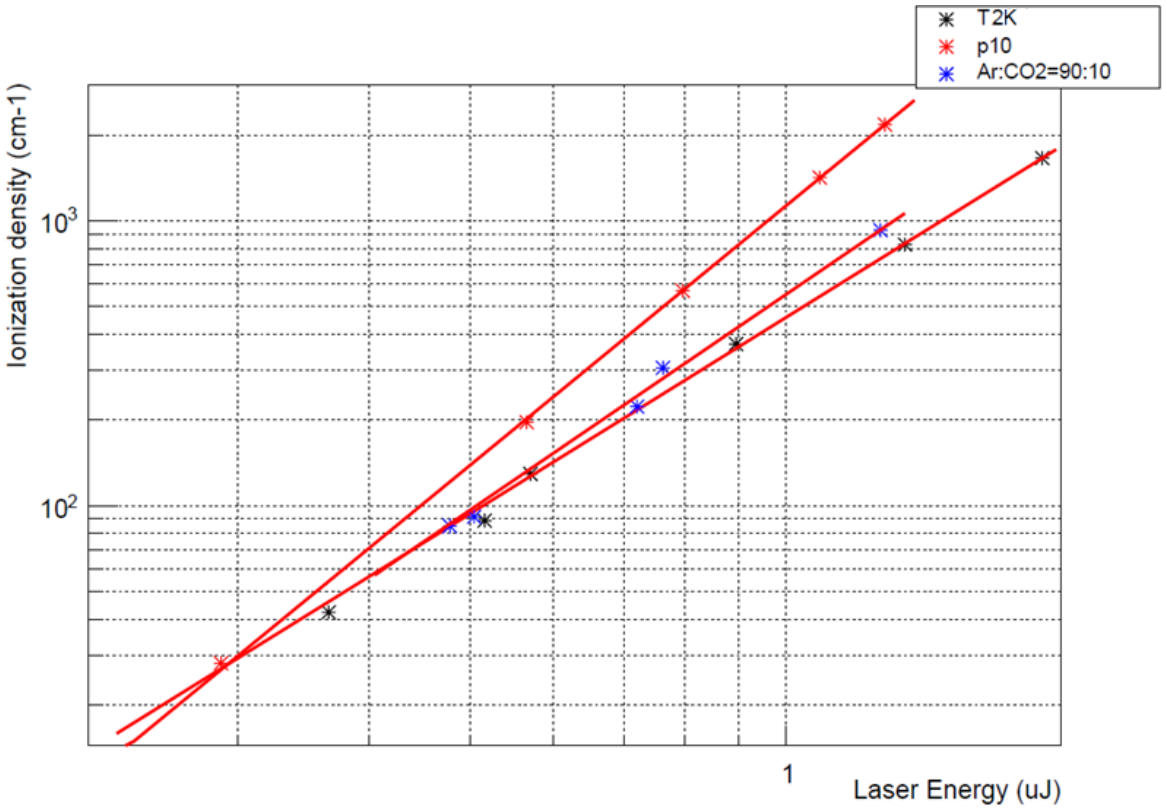
Operation gases and ionization with the laser

The three operation gases for the detector compared with ILC DESY and KEK working gas

- T2K
- P10
- Ar/CO2=90/10

Gas purity

- Ar (99.999%)
- CO2 (99.999%)
- CH4 (99.999%)
- CF4 (99.999%)
- Isobutane (99.9%)



Ionization density unit: [N]/cm
(N is the primary electron number per 0.97mm^2)
Pad size: 0.9mm×6.0mm

Thank you for your attention !