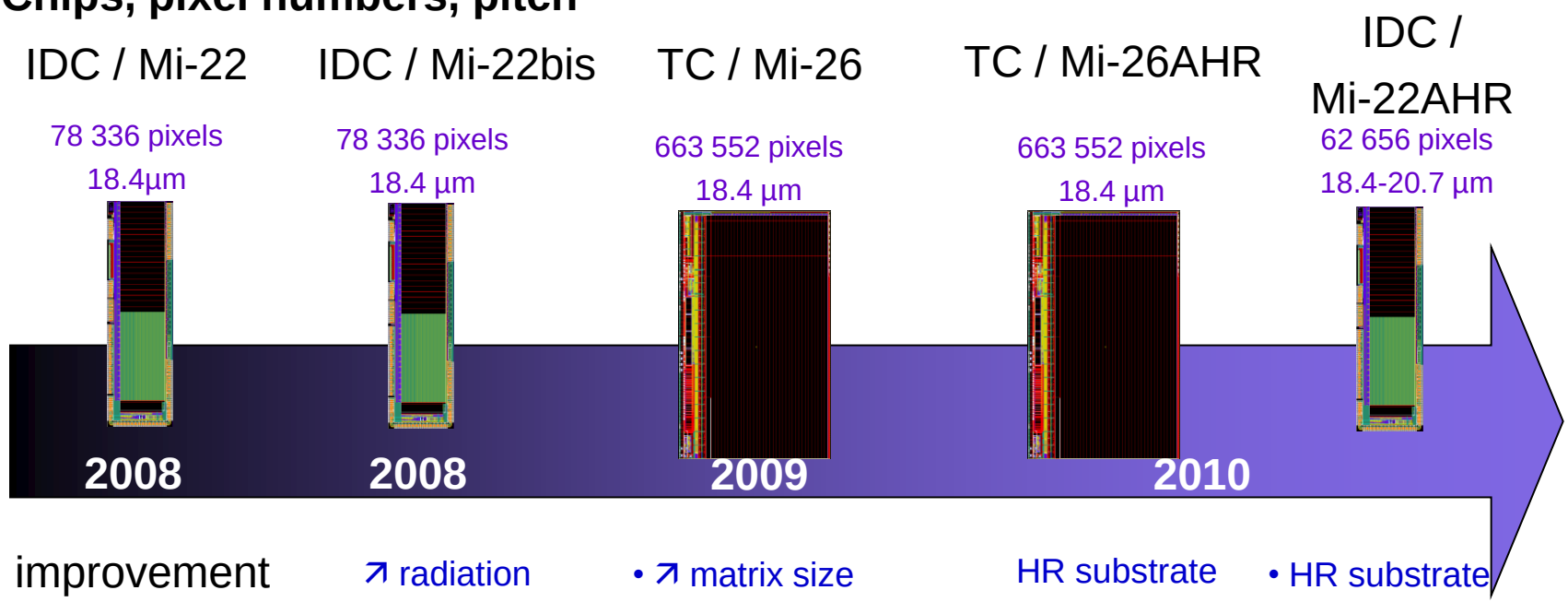
Further improvement of the TC performances

Marie GELIN** on behalf of **IPHC - Strasbourg** and **IRFU – Saclay

- Investigation of a new substrate (High Resistivity)
- Beam test preliminary results on TC (Telescope Chip) HR and IDC (Intermediate Digital Chip) HR
- Extra-uses of those chips in different projects

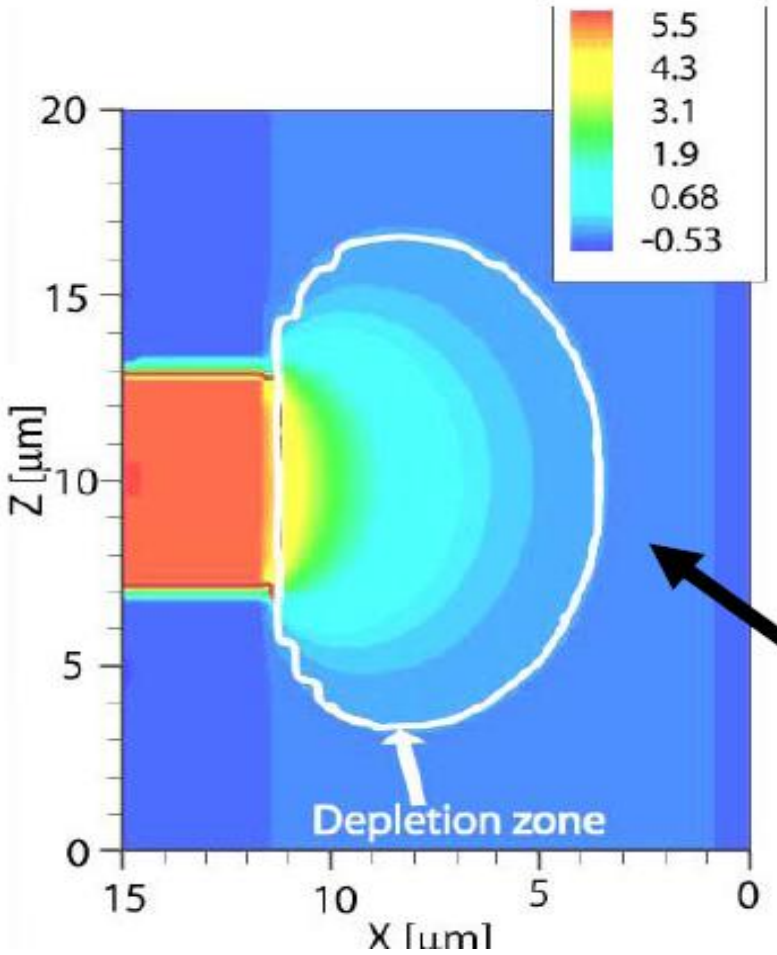
Chips development shared IPHC-IRFU through EUDET

Chips, pixel numbers, pitch

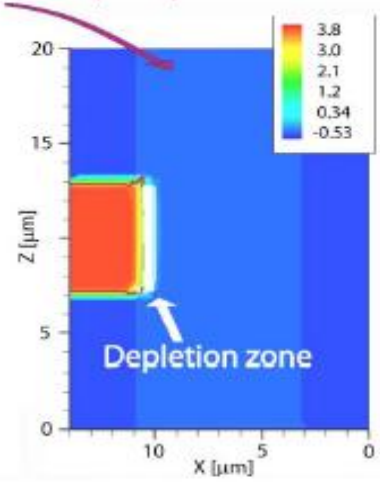


improvement	↗ radiation hardness	• ↗ matrix size • ↗ Functionalities (zero suppression)	HR substrate	• HR substrate • pixel improvement • study another pitch • elongated pixels • ↗ depletion voltage
σ_{dig}~3.5 µm ε_{det} > 99.8 %	σ_{dig}~3.5 µm ε_{det} > 99.8%	σ_{dig}~3.5 µm ε_{det} > 99.8 %	σ_{dig}~3.5 µm ε_{det} > 99.8 %	σ_{dig}~3.5 µm ε_{det} > 99.8 %

What change H R substrate ?



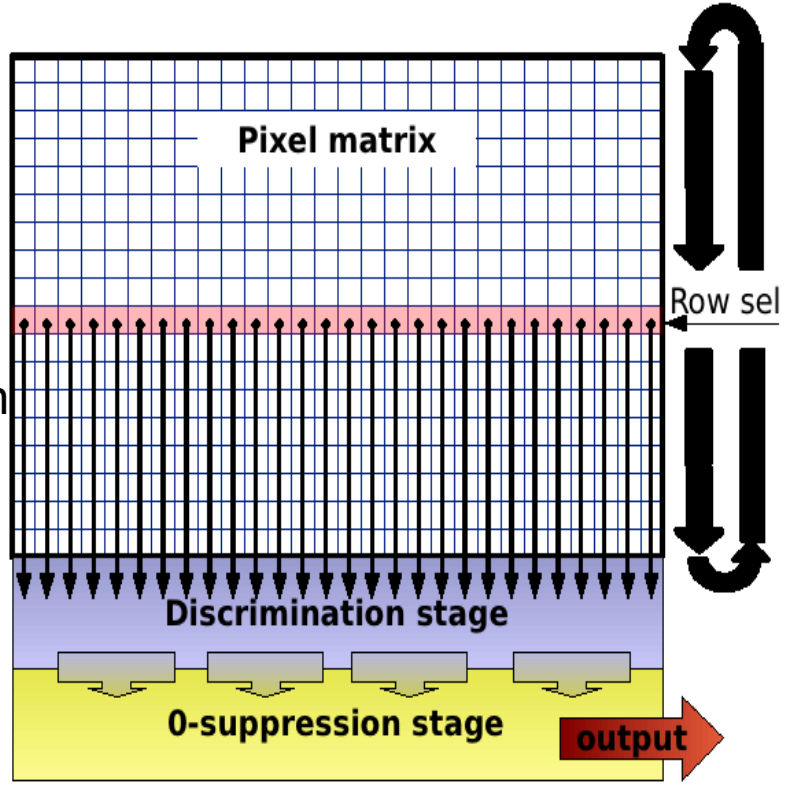
For comparison: standard CMOS technology, low resistivity P-epi



high resistivity (1kOhm*cm) P-epi: size of depletion zone size is comparable to the P-epi thickness!

TC / MIMOSA-26 : description

- ✗ CMOS 0.35 µm OPTO process
- ✗ Pixel Size : 18.4 x 18.4 µm²
- ✗ Active Area :
  1152 x 576 pixels (21.2 x 10.6 mm²)
- ✗ Rolling-shutter mode
  - ➔ 80 MHz clock → 112 µs integration
- ✗ One pixel contains:
  - ➔ Amplification
  - ➔ Double Sampling
- ✗ 1 discriminator per column with
  - ➔ Offset compensation
  - ➔ Correlated Double Sampling



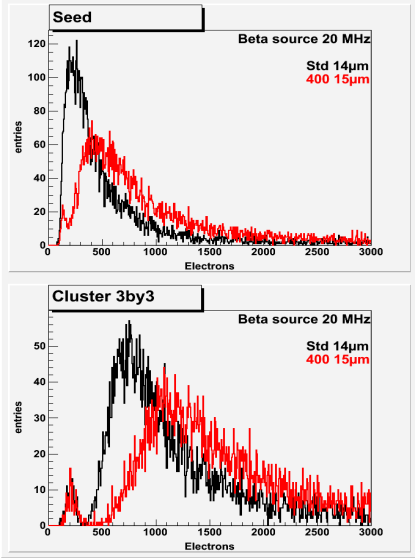
- ✗ Parallel sparse data scan → Two memories
- ✗ Data compression factor x10 to 1000 depending on occupancy

Test Results on 2010 wafers

- 2010 : Standard EPI layer v.s. high resistivity EPI layer

⇒ *Charge collection & S/N (Analogue output, Freq. 20 MHz)*

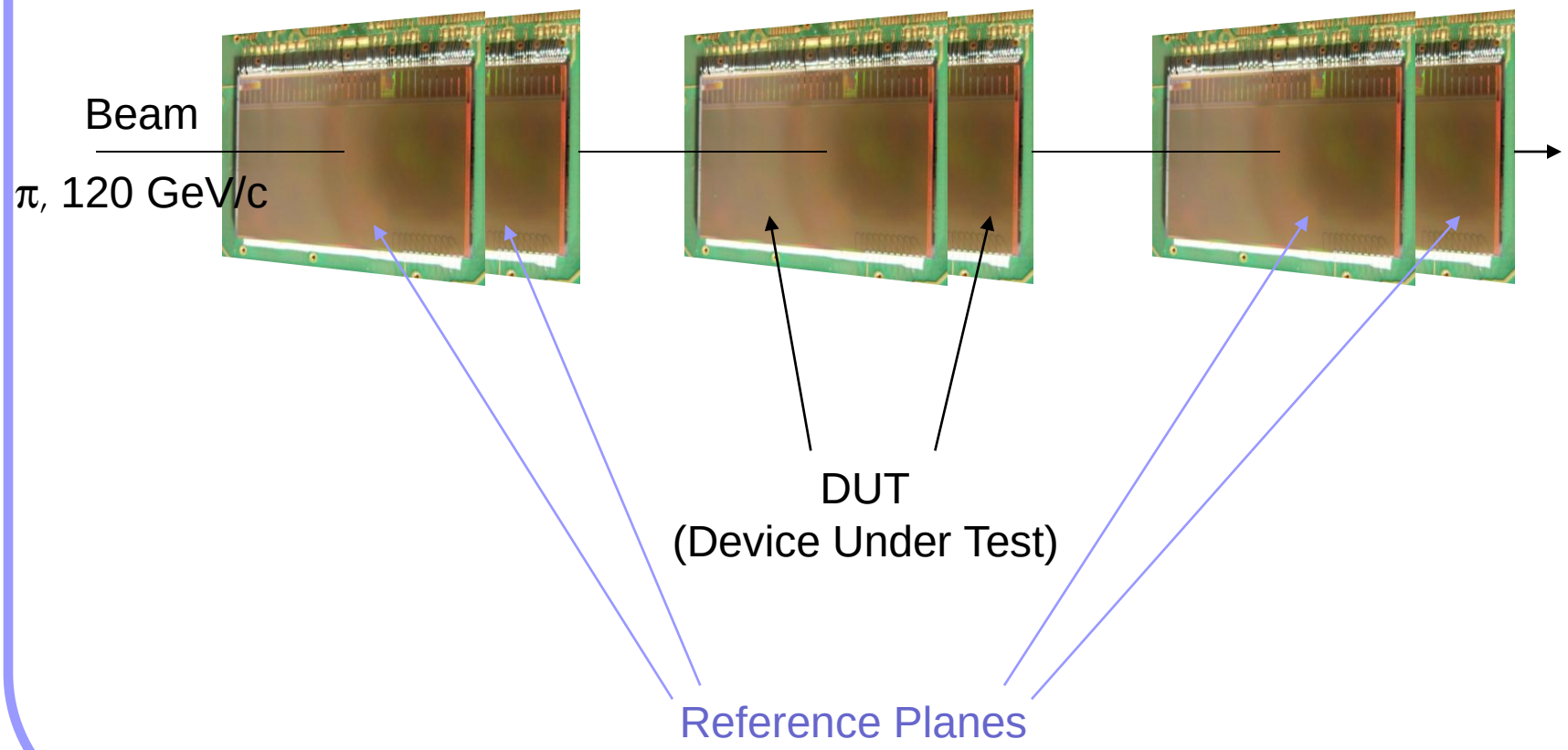
EPI layer	Standard (~10 Ω.cm) 14 µm			High resistivity (~400 Ω.cm)			
	Seed	**2x2**	**3x3**	EPI	**seed**	**2x2**	**3x3**
Charge Collection (^{55}Fe source)	~21%	~ 54 %	~ 71 %	10 µm	~ 36 %	~ 85 %	~ 95 %
				15 µm	~ 31 %	~ 78 %	~ 91 %
				20 µm	~ 22 %	~ 57 %	~ 76 %
S/N at seed pixel (^{106}Ru source)	~ 20 (230 e^-/11.6 e^-)			10 µm	~ 35		
				15 µm	~ 41		
				20 µm	~ 36		



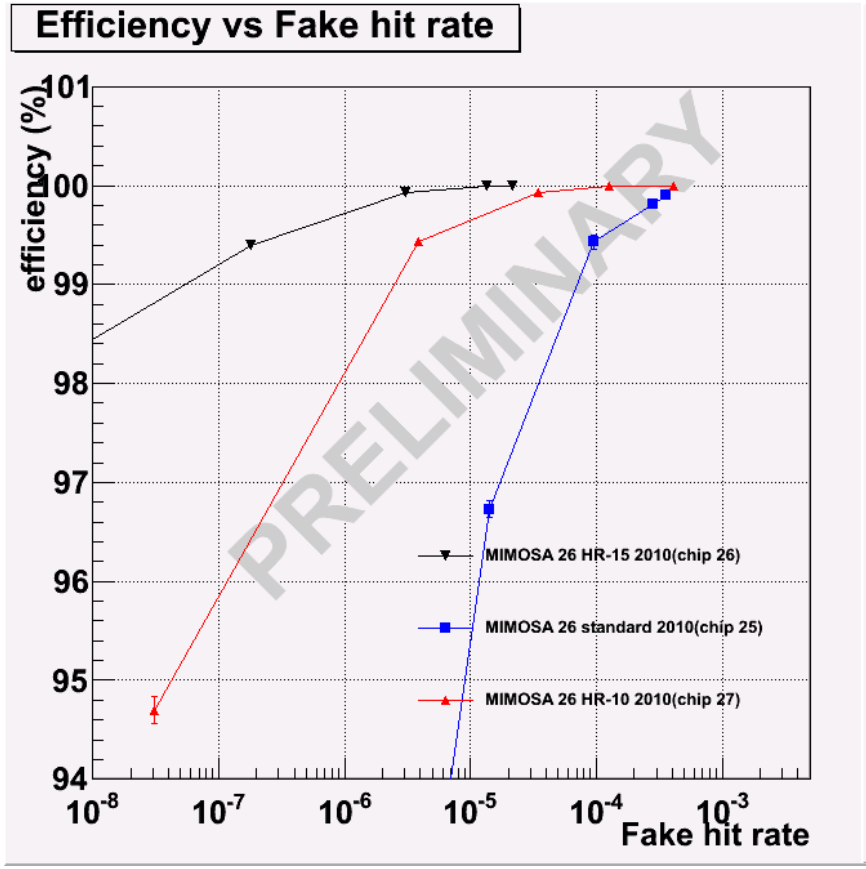
⇒ Discriminated Output characterization

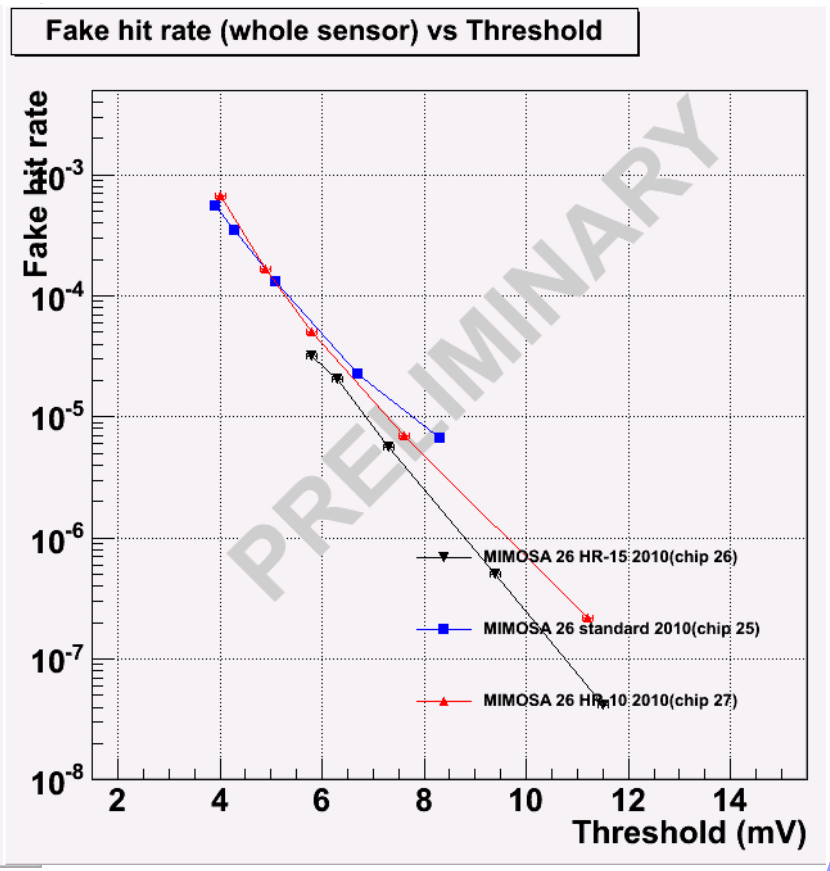
For standard epitaxial layer, the results on analogue outputs and discriminated ones are similar for the 2009 and 2010 wafers

TC / Mi-26 AHR Beam Test Set-up



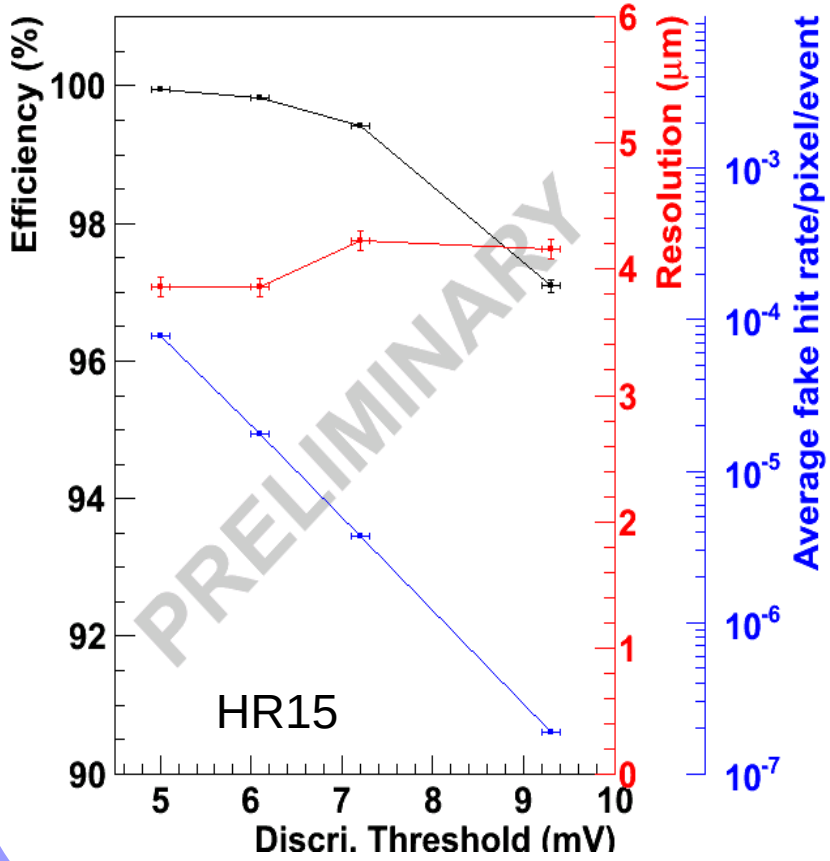
TC / Mi-26AHR TB Results (no irradiation)

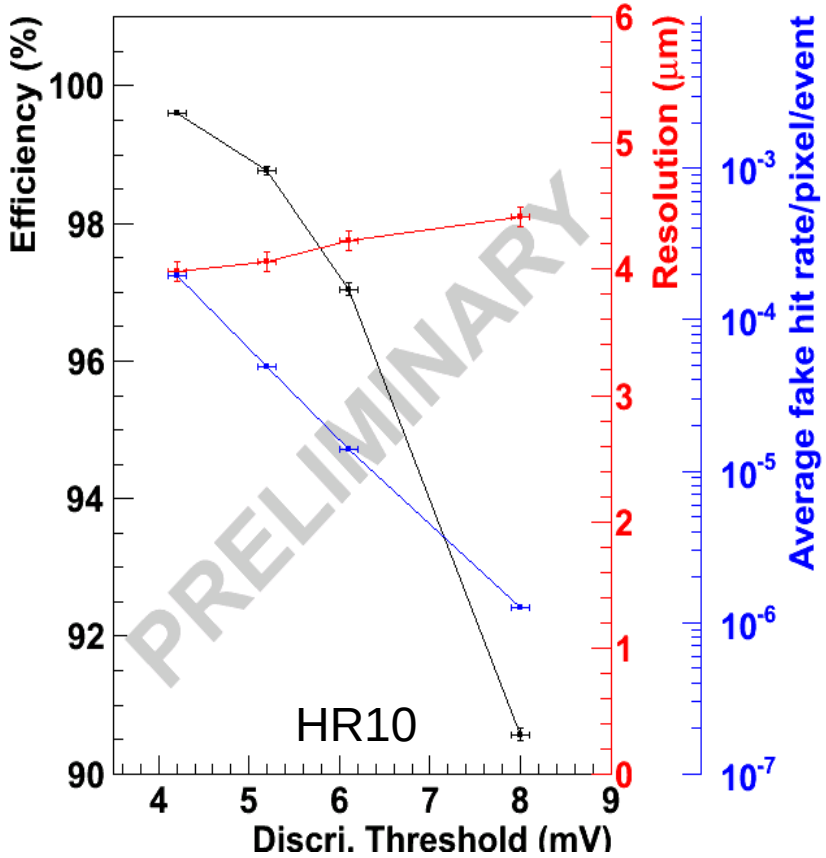




TC / Mi-26AHR TB Results : after 1.10^{13} N_{eq}

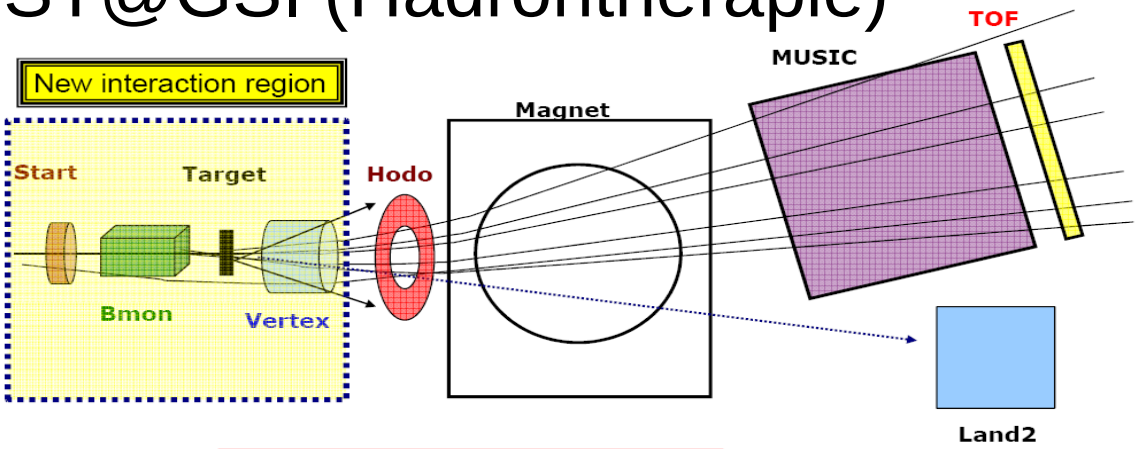
T ~ 0°C





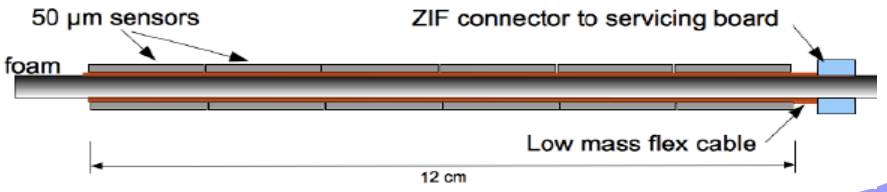
Extra-Use of TC

- FIRST@GSI (Hadrontherapie)



Goal: measure Z, A, emission angle and p of all fragments from the target

- Duplication of Eudet-telescope
- PLUME (**P**ixelated **L**adder using **U**ltra-light **M**aterial **E**mbedding)



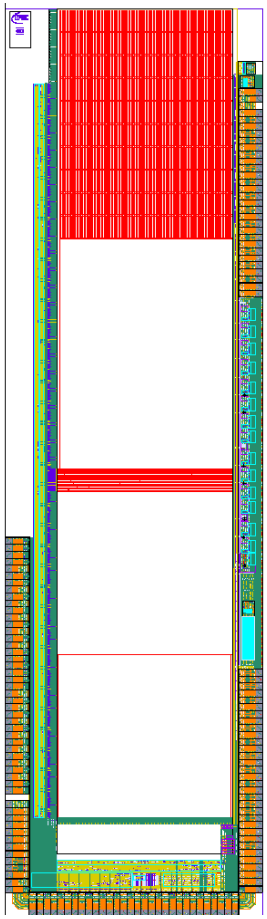
IDC / MIMOSA-22 AHR

Main parameters :

- **AMS-OPTO 0.35*µm***
- **Pixel Pitch : 18.4 / 20.7 µm**
- **8 Analog test Outputs (4608 pixels)**
- **128 end-column discriminators (73728 pixels)**

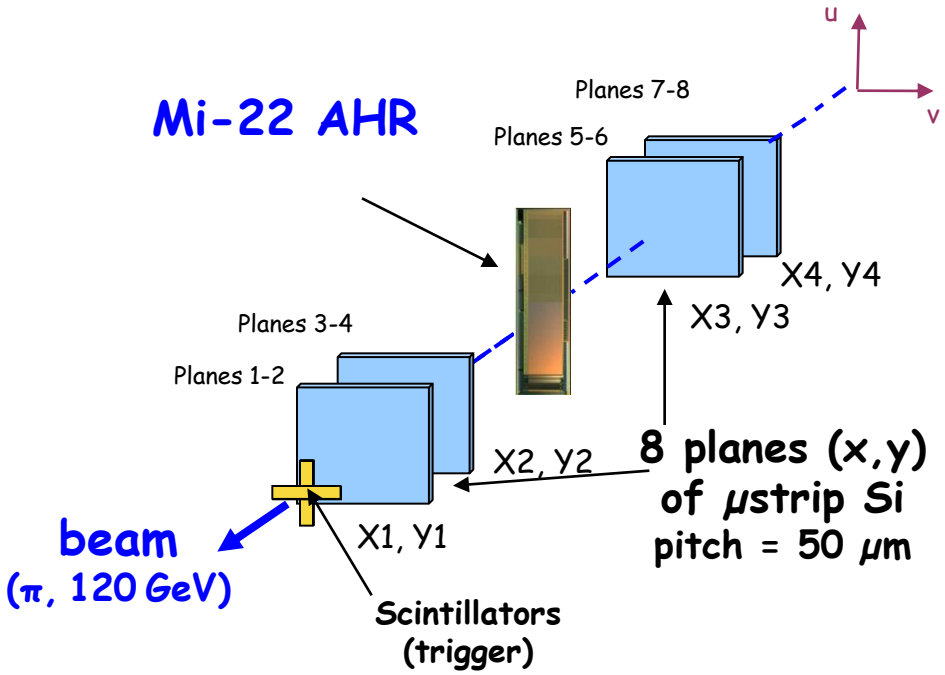
Matrix : Sub-arrays with different diode surfaces

Pixel amelioration	Common Source	18.4 / 20.7 µm
	CASCODE	18.4 / 20.7 µm
New structure	Elongated pixels	N x 18.4 µm
	Depletion volt. pixels	20.7 µm

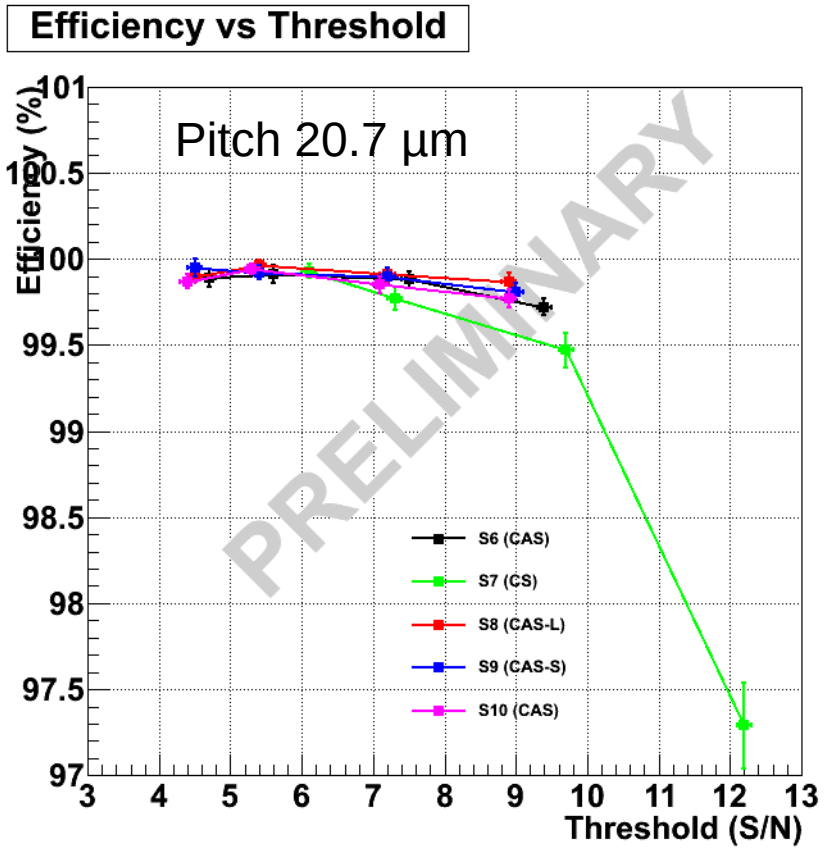


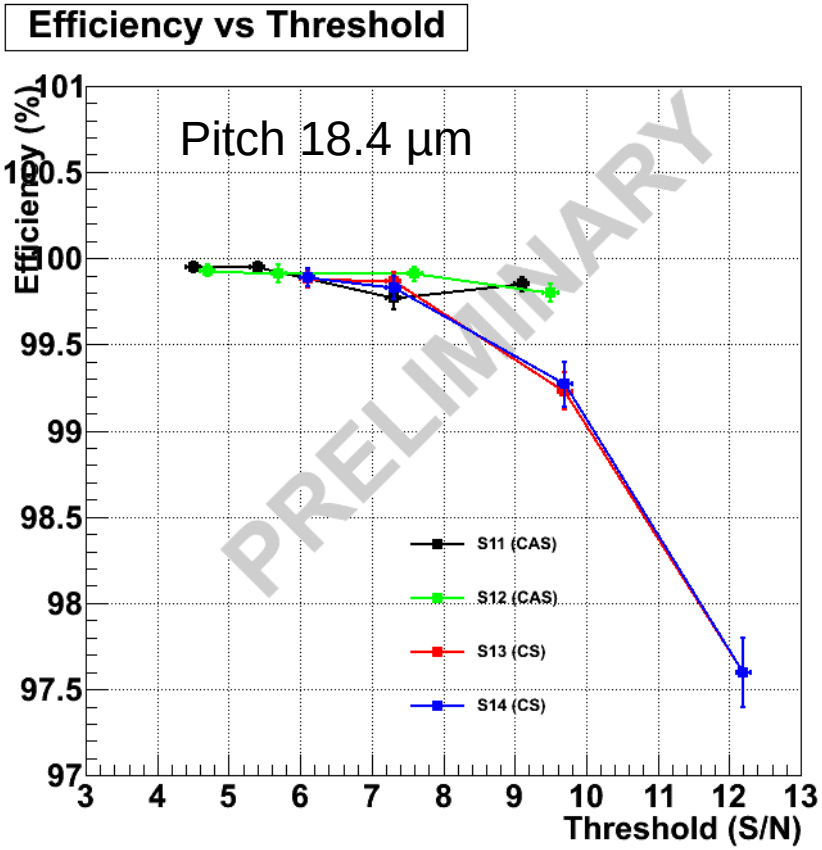
M22-AHR Layout

IDC / Mi-22 AHR beam test set-up

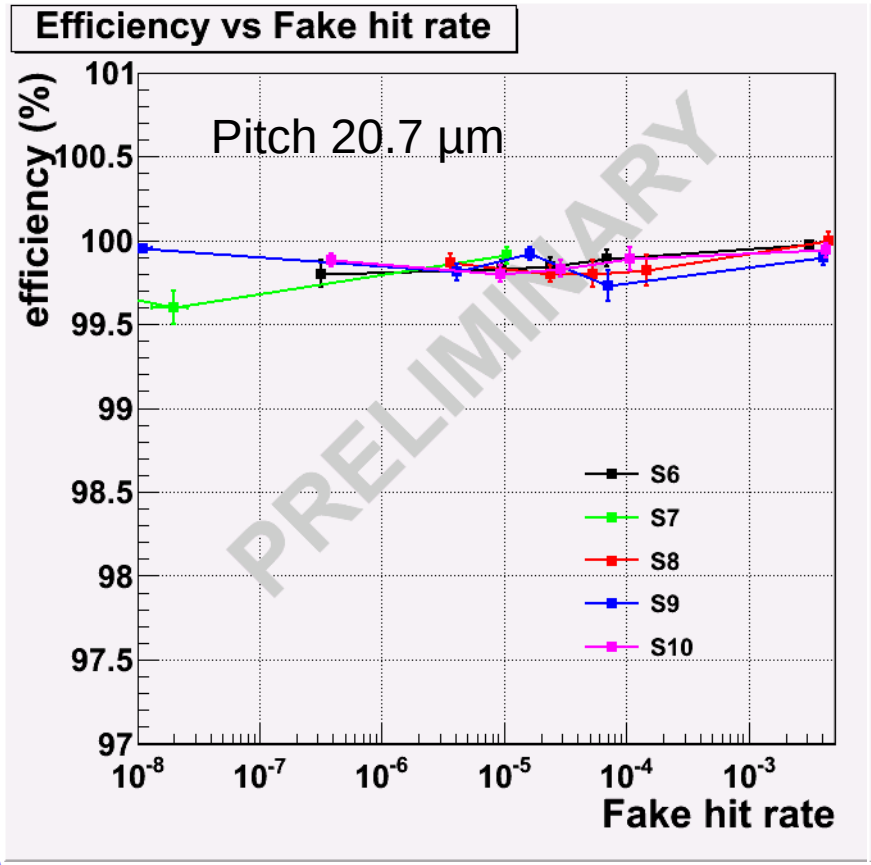


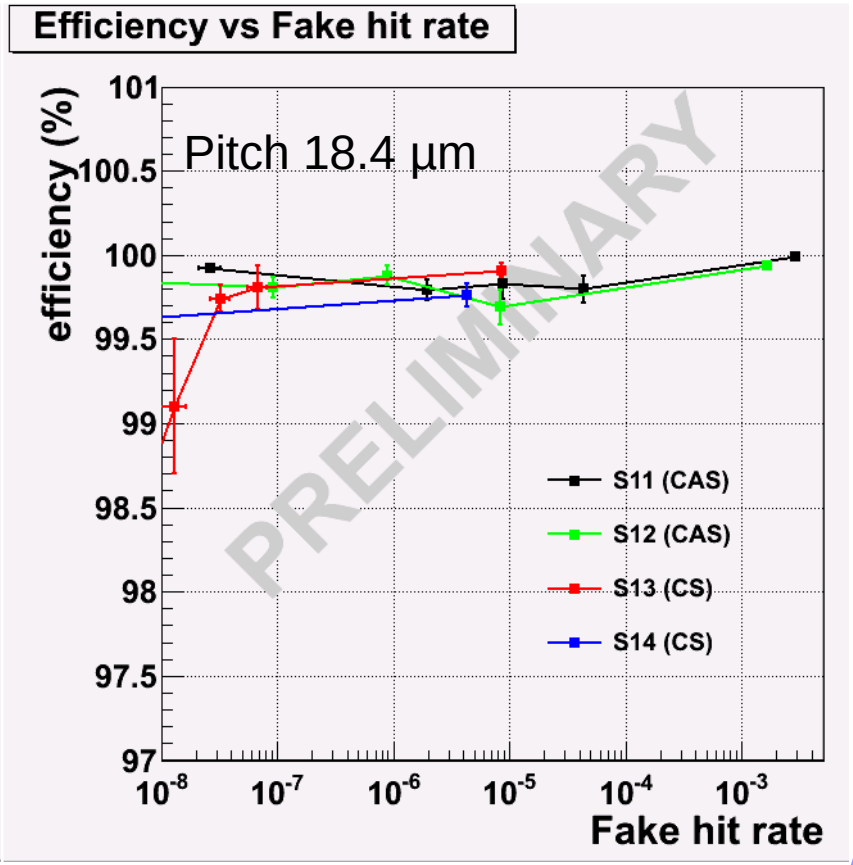
IDC August Test beam results



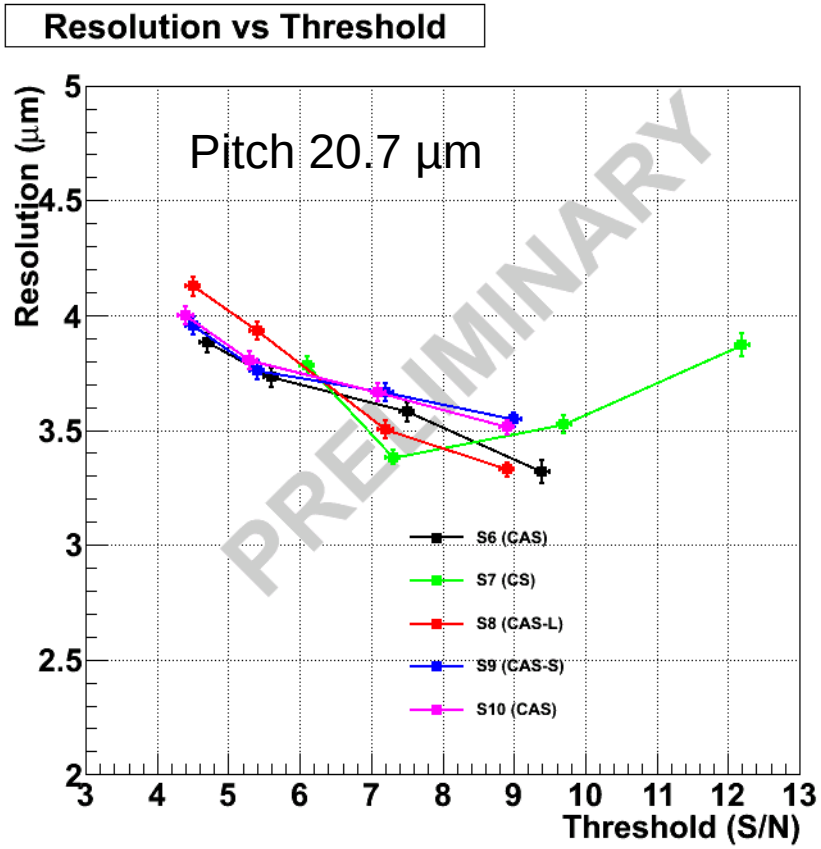


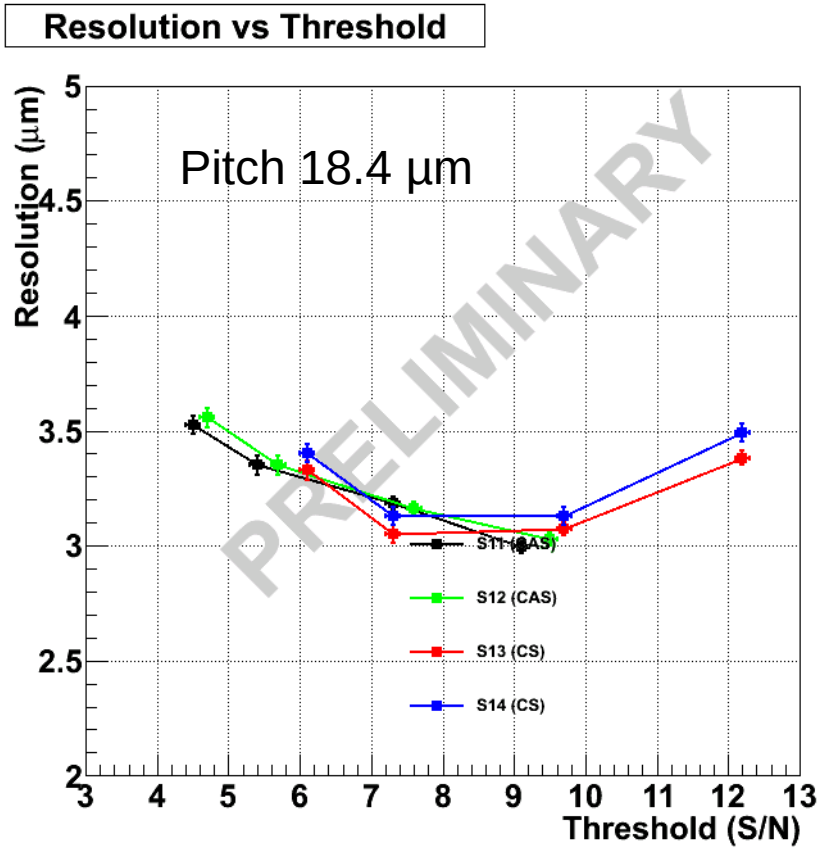
IDC August Test beam results (2)





IDC August Test beam results (3)





Mi-22 AHR beam test summary

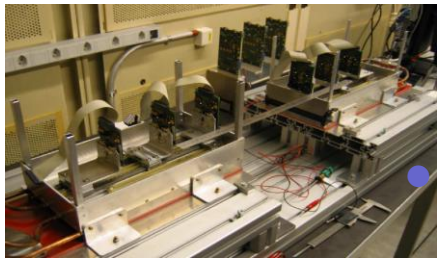
- Pixel amelioration characterization :
  - No-irradiated
  - After a 3.10^{12} N_{eq} dose
  - After a 150 kRad dose
  - After a 3.10^{12} N_{eq} + 150KRad dose

  } at 15 and 30 °
- New structures characterization :
  - Elongated pixels without irradiation
  - Depletion voltage pixels before / after $1.10^{13}N_{eq}$

Uses of TC / IDC architecture

EUDET 2007/2010

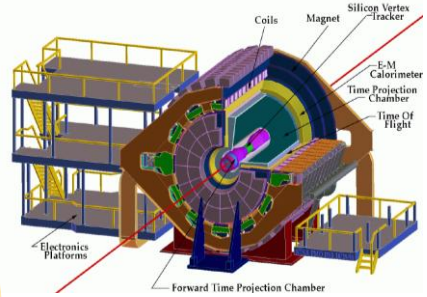
Beam Telescope



- **FP6 EUDET Project (DESY-Hamburg, Germany)**
  - Surface: 6 x 2 cm²
  - Read-out speed: A. 20 MHz → D. at 100 MHz
  - Temp. & Power: No constraints

STAR 2010

Solenoidal Tracker at RHIC

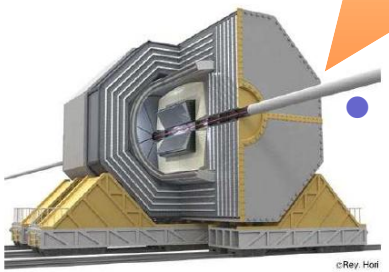


- **STAR Experiment (RHIC – Brookhaven, USA)**
  - Surface: ~1600 cm²
  - Temp. & Power: 30°C, ~100mW/cm²
  - Read-out speed: A. 50 MHz → D. up to 250 MHz

- **CBM Experiment (GSI – Darmstadt, Germany)**
  - Surface: ~500 cm²
  - Read-out speed: D. 15 x 10^9 pixels/sensor/s
  - Rad Tol: 1 MRad, > 10^{13} N_{eq} /cm²

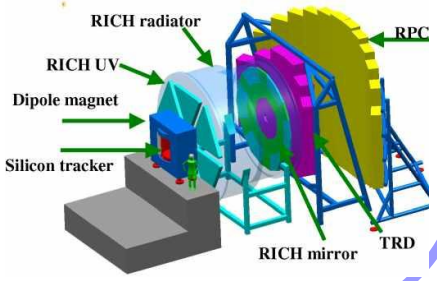
ILC >2012

International Linear Collider



CBM 2012

Compressed Baryonic Matter



- **ILC Experiment**
  - 5-6 layers of det.: ~3000 cm²
  - Read-out speed: D. 15 x 10^9 pixels/sensor/s
  - Temp. & Power: 30°C, ~100 mW/cm²
  - Rad Tol: ~300 kRad, ~10^{12} N_{eq} /cm²

Uses of TC / IDC architecture (2)

- Eudet (FP6) → FP7
  - AIDA
  - HP2
- FOCAL (FOrward electromagnetic CALorimeter) for ALICE upgrade

Summary

- Investigation on new substrate (HR)
  - Study on 2 promising chips
  - Thanks to this new substrate, we expect to improve the radio-tolerance (TC / Mi-26 AHR after $1.10^{13} N_{eq}$)
- Use of the TC beyond Eudet project
  - First (hadrontherapie)
  - Telescope copies
  - STAR
  - AIDA telescope chips

- Back-up

Mi-22 AHR different sub-arrays