GigaTracKer: status report

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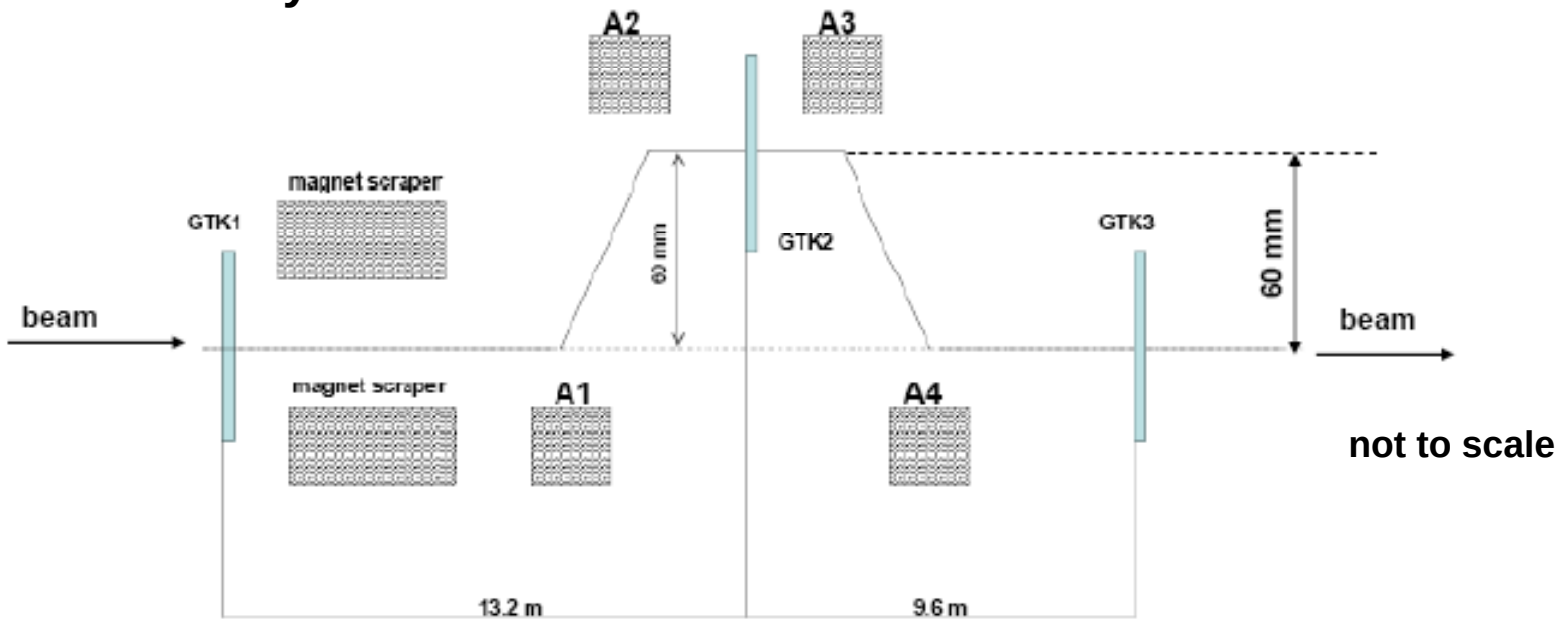
- **Introduction : detector generalities and specifications**
- **Progress report about:**

1. Final and prototype sensors
2. Bump bonding
3. Cooling
4. Chip prototype design
5. DAQ for chip prototype

Introduction : detector generalities and specifications (1)

Detector layout



- **Three same Si-pixel stations: each station (60x27)mm^2**
- **pixel dimensions: (300x300) μm^2 ; thickness: 200 μm**

To measure the following quantities of the beam particles:

- **direction (σ_{RMS} ~14 μrad)**
- **momentum (σ_{RMS} ~ 0.15 GeV/c)**
- **track time (σ_{RMS}~ 200 ps/station -> ~ 150 ps/track)**

Introduction : detector generalities and specifications (2)

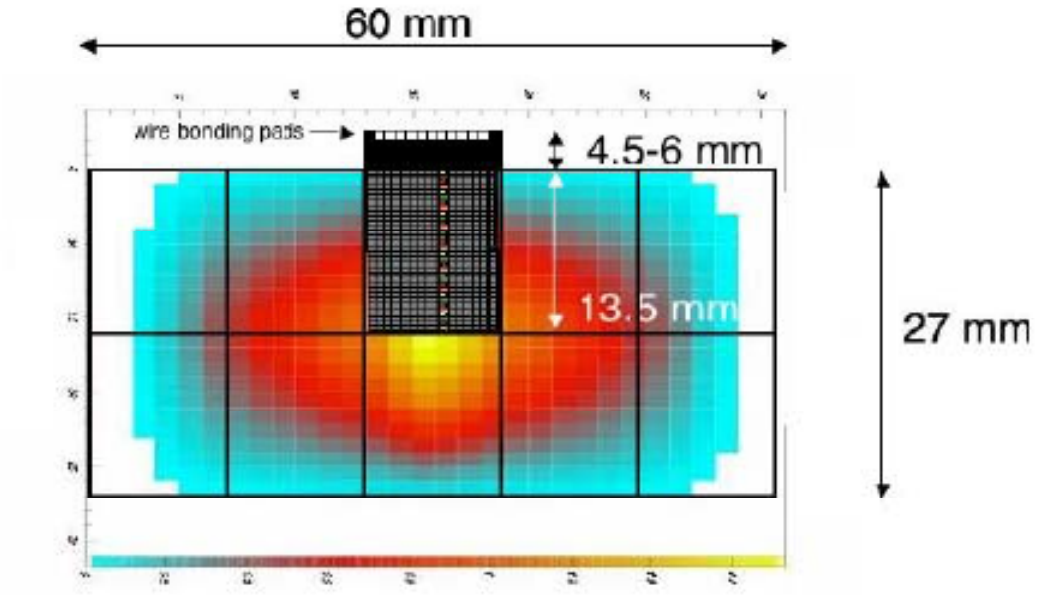
Mounted inside the vacuum tube

Dimensions of the stations to match the beam shape

Sensor technology: **p-in-n**

18000 pixels/ station -> 54000 pixels grand total

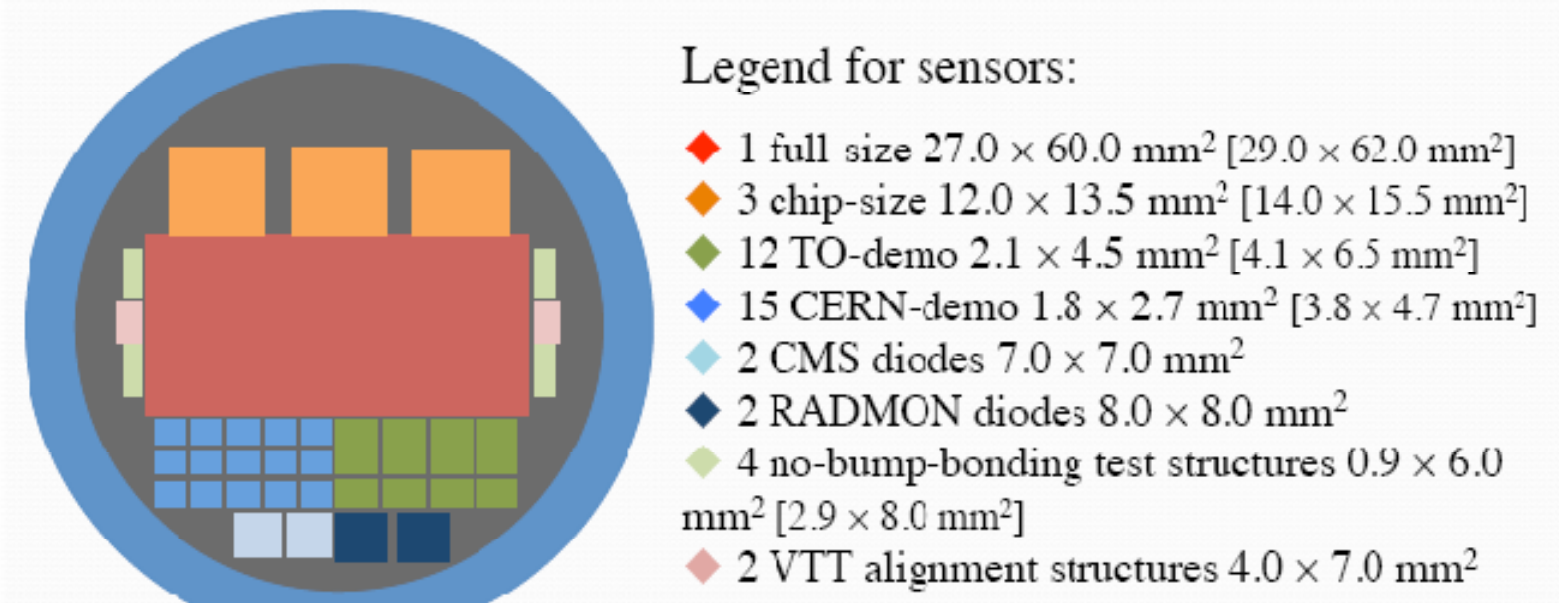
Sensor read-out via 10 chips



Progress report: final and prototype sensors

- **a batch of 20 wafers (-> 20 sensors) has been ordered to FBK-Trento,Italy**
- **wafer layout is ready**
- **bump details (dimensions and position) defined**
- **wafer to be processed before the end of the year**

Wafer layout



Progress report: bump-bonding

- Development of the processes with VTT (Finland)

1. **Bump-bonding of the final chip to the sensor:** standard technique
2. **Bump-bonding of the prototype:** how to bond a diced chip to a sensor ?

This is a technical problem related to the lack of room on diced chips for galvanic contacts for electroplating and thus it is impossible to apply the standard bump-bonding technique.

Two solutions are however available:

1) Reverse rework: most promising and preferred solution

2) Au stud bumps practical only for ~100 pixels: technique off-shelves (backup solution)

Progress report: cooling

Power to be dissipated: 2W/cm^2 -> 32 W | **Target chip temperature < 5 ^{0}C**

Base solution: two half-cylinders of carbon fiber enclosing the sensor+chip

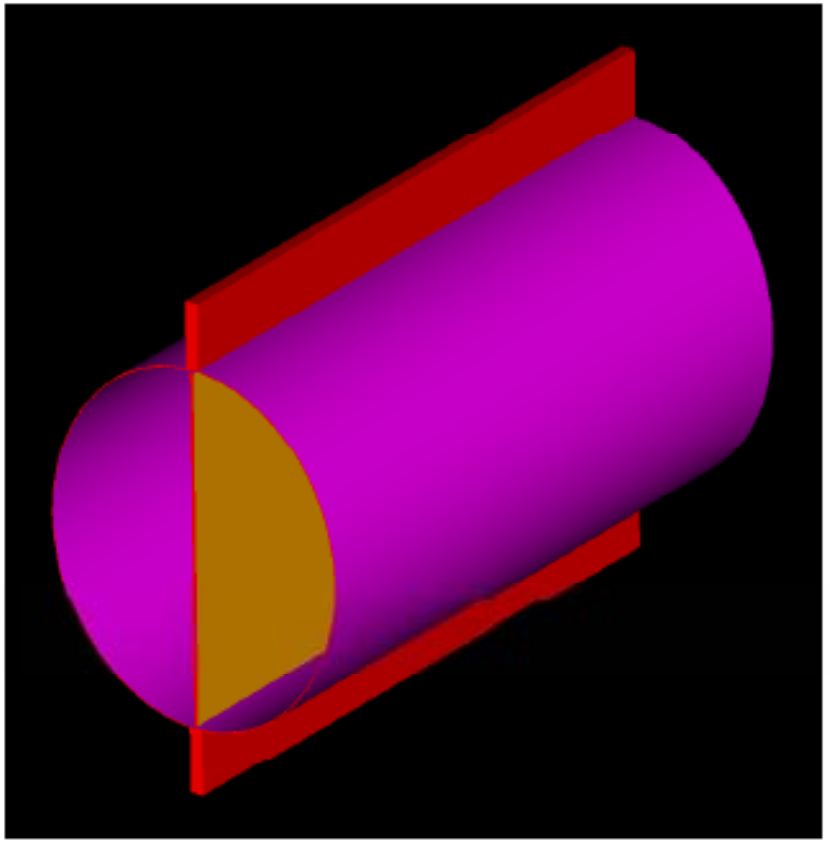
CONFIGURATION 2 – COOLING ANALISYS

COOLING FLUID : NITROGEN		K	°C
Delivery temperature	Ti	100	-173
Wall temperature	Tw	275,6	2,6
dT	T = (Tw – Ti)	175,6	175,6
Tm	Tm = (Tw+Ti)/2	187,8	-85,2

NITROGEN PROPERTIES @ Tm and atmospheric pressure		
Specific weight (Kg/m^3)	ρ	1,79
Specific heat (J/KgK)	Cp	1041
Thermal conductivity (W/mK)	λ	0,024
Kinematic viscosity (m^2/s)	ν	1,34E-05

GENERATED POWER (W)
Q = q x A = (2E+04) x (27E-03 x 60E-03) = 32,4

COOLING SURFACE (m^2)
S = 2 x (27E-03 x 60E-03) + 0,35E-03 x 2 x (27E-03 + 60E-03) = 3,34E-03



Progress report: chip prototype

Introduction:

• The challenging specification of the project is the hit time resolution we are aiming at: ~200 ps (rms) per station

• The sensor, bump-bonding technique, and the DAQ are well within reach with the actual status-of-the-art in this field.

• Also the mechanics and the cooling system, though complex, do not necessitate outstanding effort.

• To summarize: the design of the front-end to beat the jitter and the time walk (which are the main sources of errors) and to get to the specified time resolution is the crucial point.

Front-end: introduction

We are following two design options to cure the time walk:

1. Constant Fraction Discriminator, which recovers hardware-wise the time walk of the signal due to the energy deposit fluctuations
2. Determination of the Time-over-Threshold of the signal and offline correction of the time walk.

Concerning the architecture two configurations are under study:

a) All the electronics dedicated to a pixel (preampli-CFD-TDC) is on the pixel itself. The technology that has been chosen (130 nm) allows to comfortably fit all the components into the (300x300) μm pixel area.

b) Preampli and Time-over-Threshold discriminator is on every pixel and TDC is at the end-of-column and serves 5 pixels.

For each option, in 2007, a prototype has been developed and tested on the bench.

Results have been shown in previous meetings and reports and they resulted to be promising:

$$\sigma < 100 \text{ ps (rms)}$$

More information about the front-end design status

Option a): on-pixel-TDC option: preampli->CFD->TDC within the pixel area (Torino)

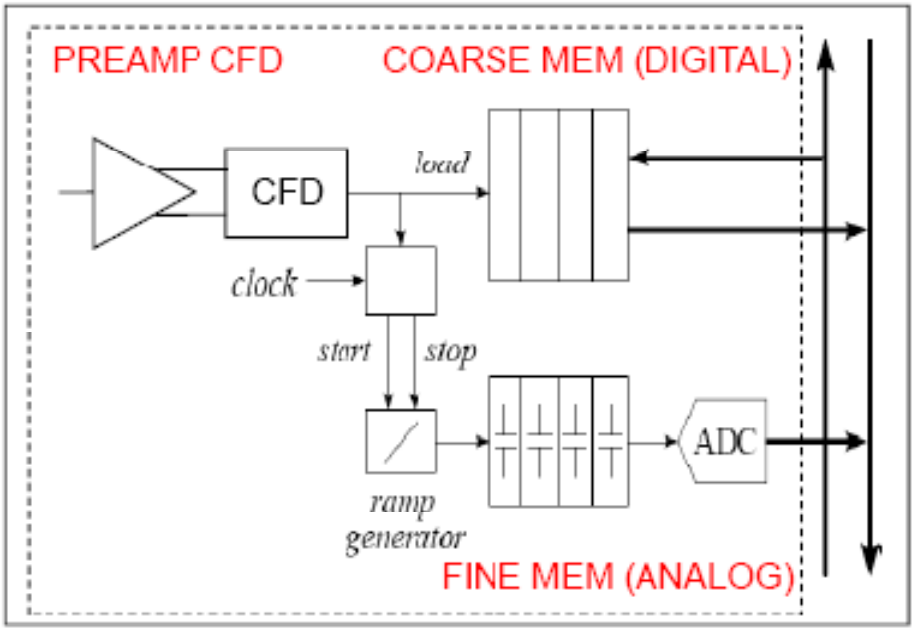
Option b): end-of-column TDC: preampli –> ToT discriminator -> TDC serving 5 pixels placed at the end-of-column.(CERN)

Remark: nothing would prevent to mix the two options, for example CFD with the end-of-column TDC.

- To insist on more than two options seemed not easy to be sustained.
- This possibility, mix of the two options, will be exploited only if the tests will show it is necessary.

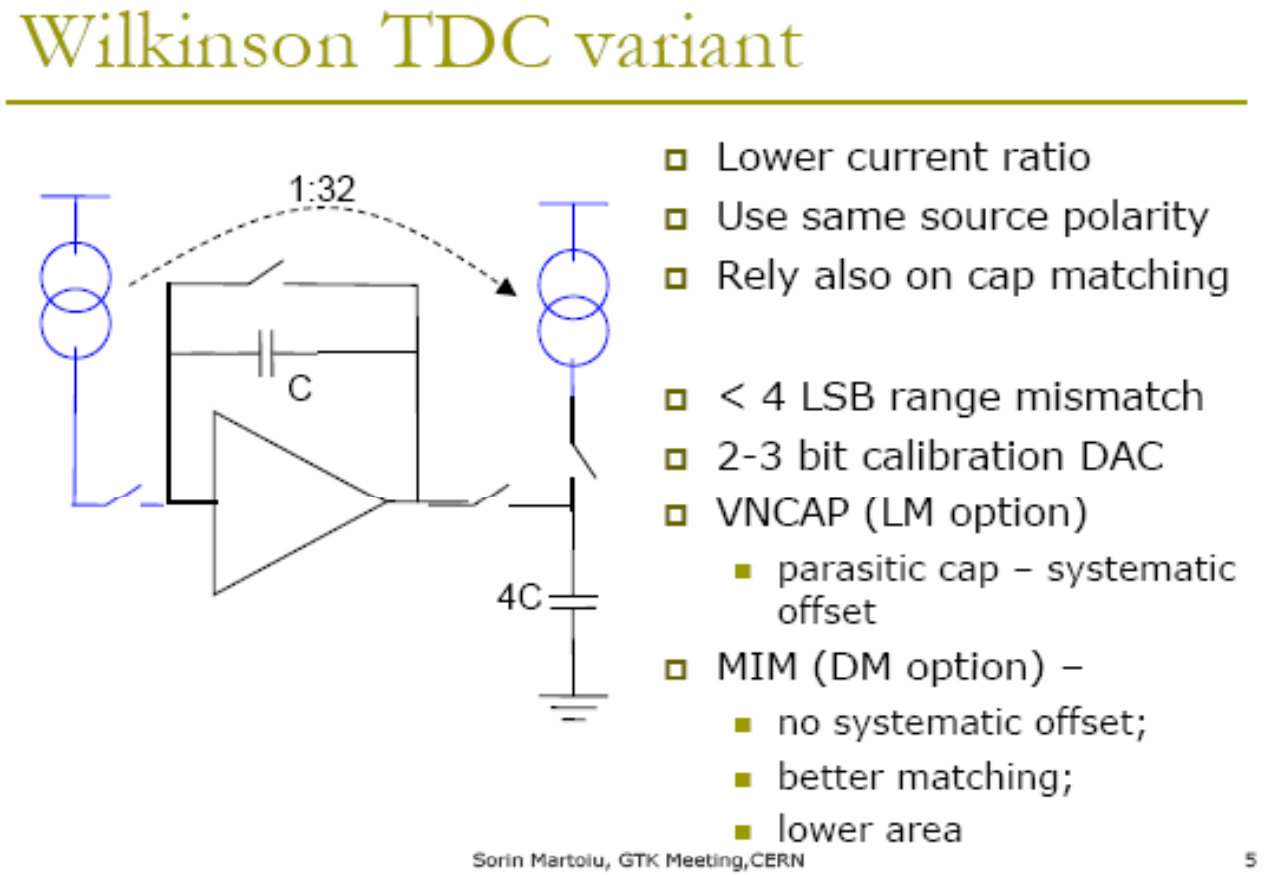
Some more info about the On-pixel-TDC option

CFD-FE Overview



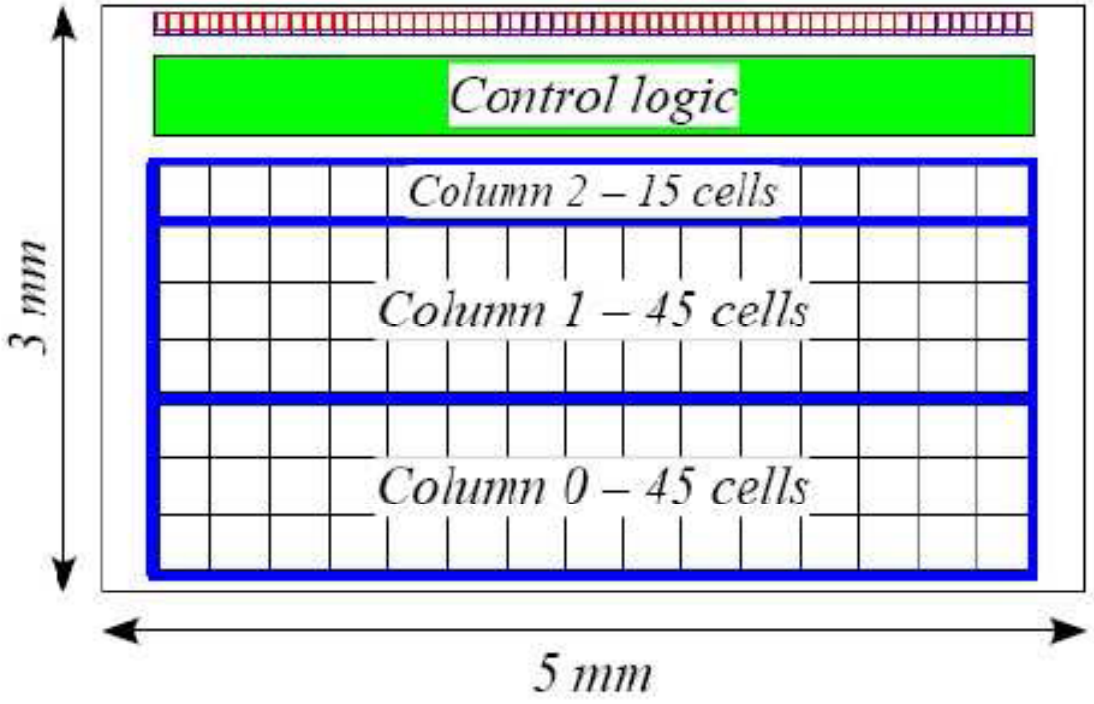
- Efficient de-randomization
- Efficient use of space
- Reduce end-of-column complexity

Some more info about the On-pixel-TDC option (cont'd)

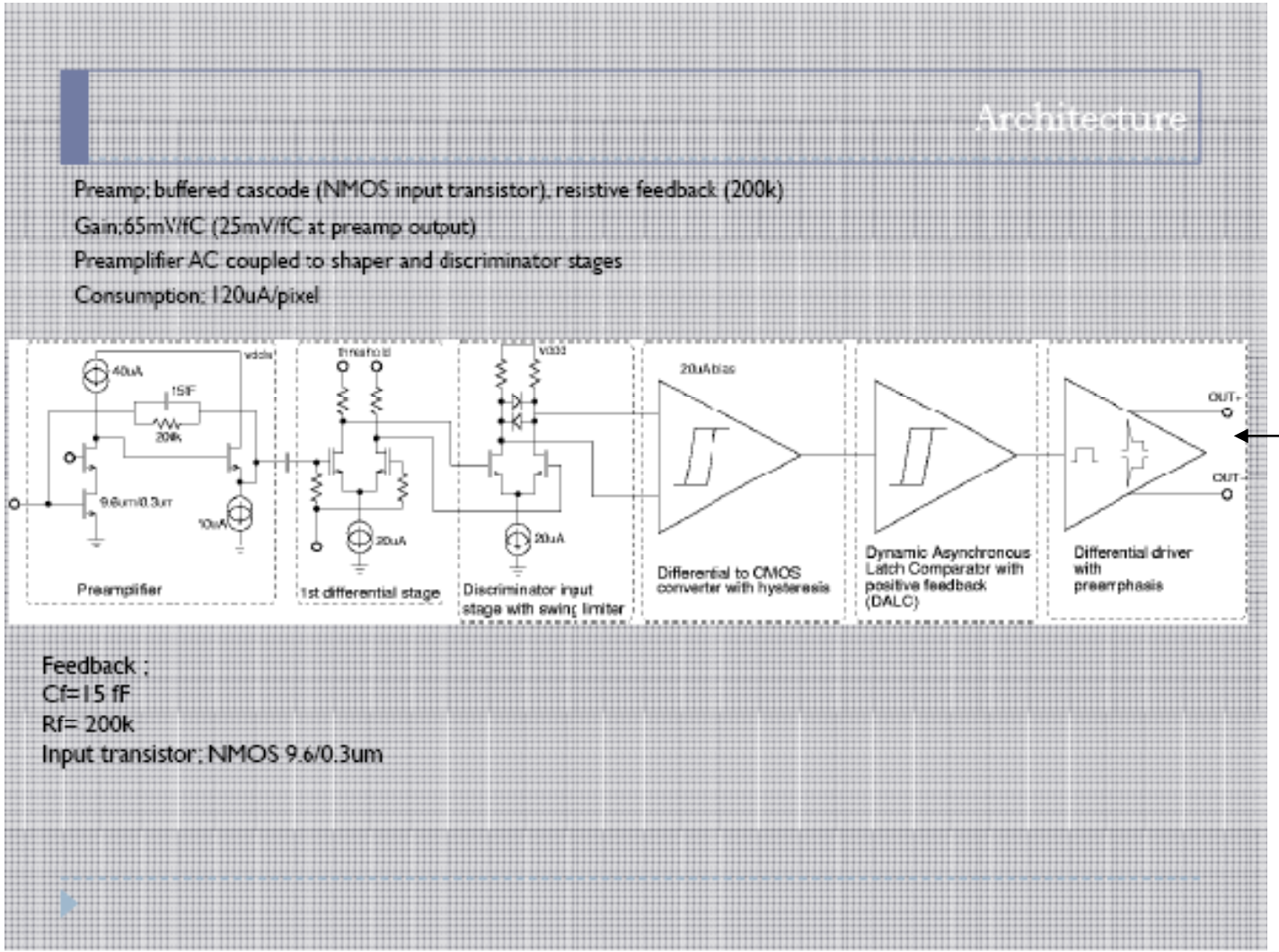


- The baseline design of the full chain is frozen
- Layout is underway

On-pixel-TDC architecture: chip layout

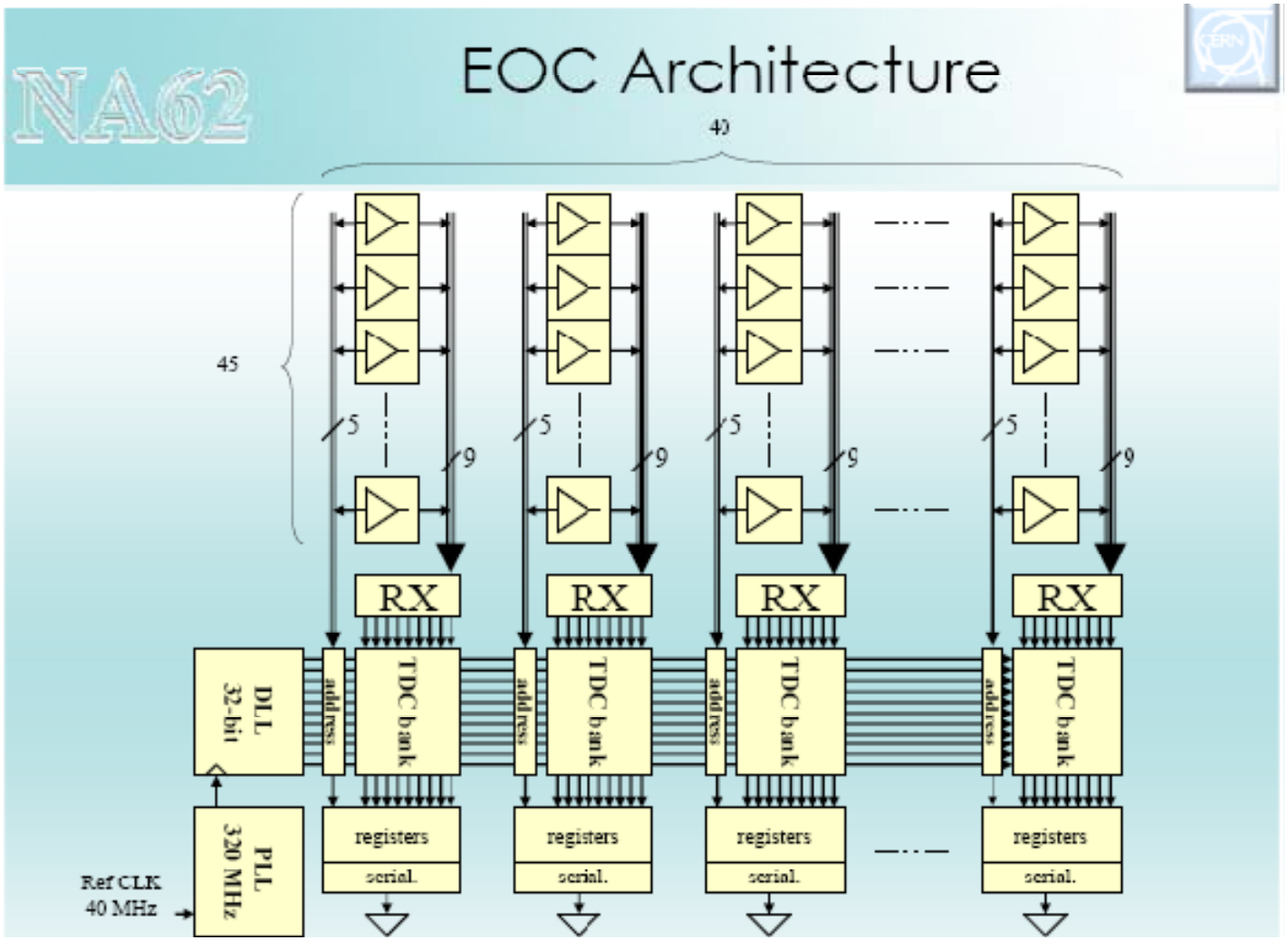


Some more info about the End-of-column-TDC option

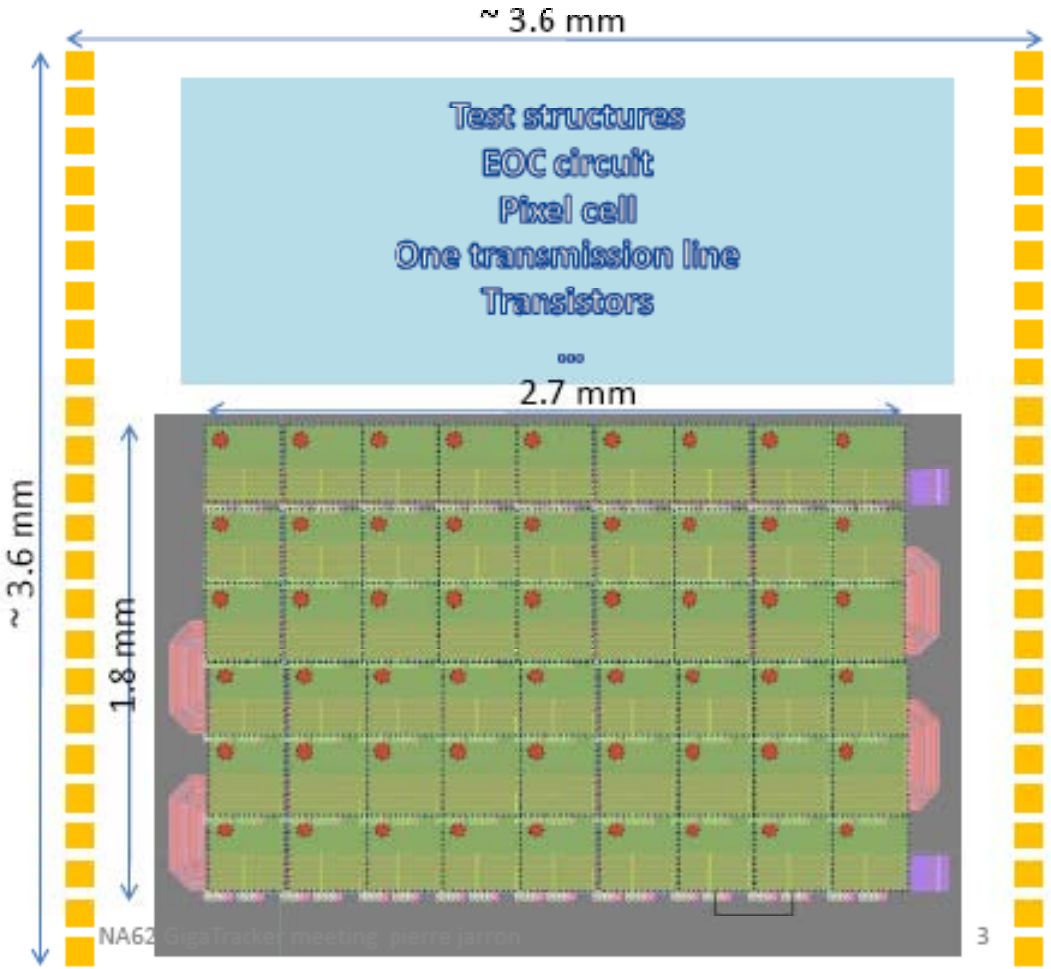


to TDC through a transmission line

Some more info about the End-of-column-TDC option (cont'd)



EOC architecture: chip layout



Status of the chip prototypes

- **Two options:**
  - **on-pixel-TDC**
  - **End-of-Column TDC (EOC)**

Design review on Oct. 7-8th with several CERN-LAL designers

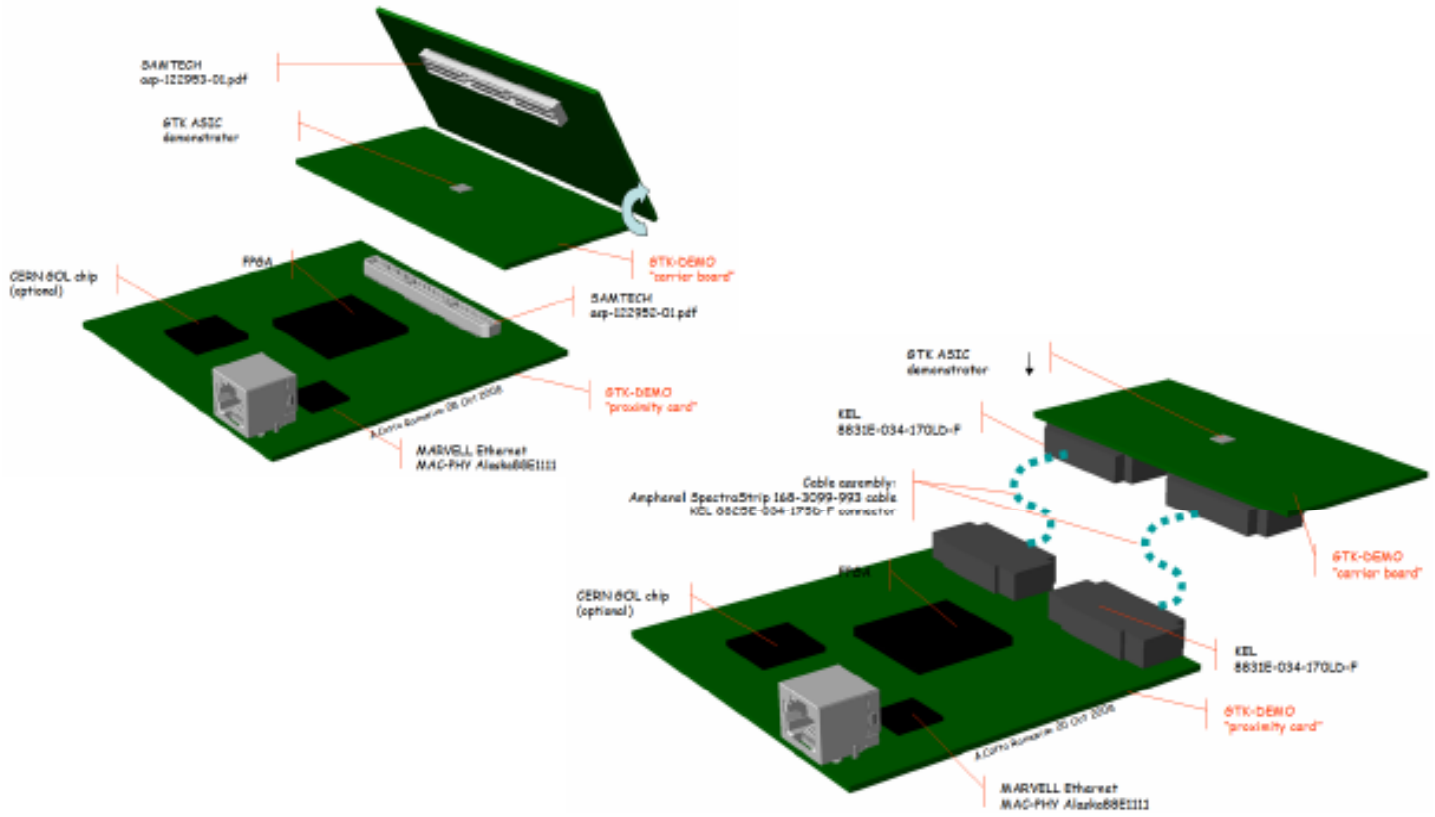
- **all the building blocks are ready**
- **no flaws have been spotted**
- **some further checks to be performed**
- **layout underway for both options**
- **submission moved to Jan. 20th 2009, delivery expected by middle of March 2009.**

Tests on prototypes in Spring-Summer 2009

• before bump-bonding: electrical test and measurements of the jitter+time-walk with charge injection method

• after bump-bonding: test with source/laser and beam.

Progress report: DAQ for chip prototype



Testing of the GTK demonstrators