TPC and R&D Activities at Saclay

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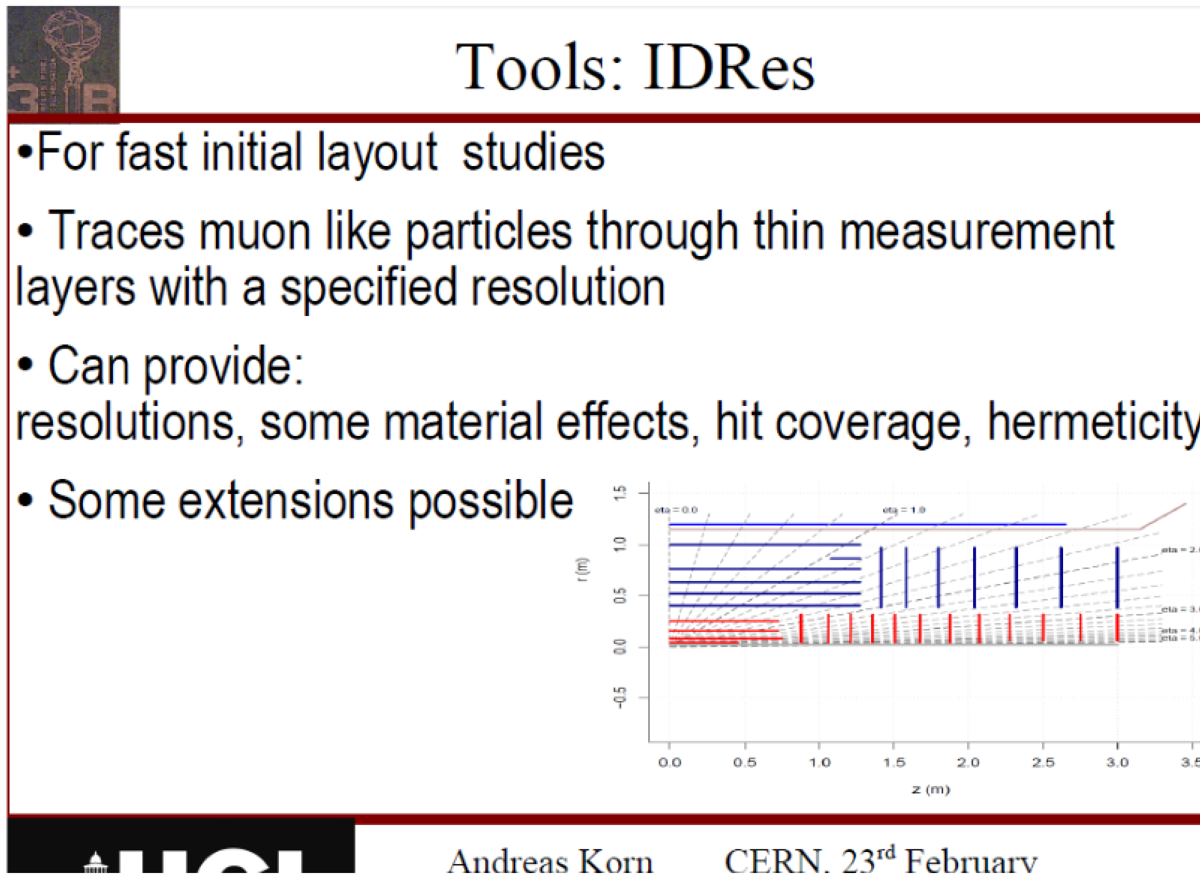
Introduction

- Interest at Saclay for the tracking system of the future detector
  - Tracking design and optimization
  - Study performance of TPC in environment with high luminosity and small bunch spacing $\rightarrow$ Mini TPC project

Tracking studies

- Optimize detector geometry and design
- Up to now: more a learning and thinking phase
  - Use a custom-made (very fast) tool, however limited.
  - Use Atlas IDres tool



ILD (TDR) layout as encoded

The current layout of the proposed vertex detector is summarised in Table III-2.1. It is based

extensive simulation and technical studies. The parameters are considered conservative.

Table III-2.1
Vertex detector parameters. The spatial resolution and read-out times are for the CMOS option described in section 2.1.2.1.

	R (mm)	$\|z\|$ (mm)	$\|\cos\theta\|$	σ (μm)	Readout time (μs)
Layer 1	16	62.5	0.97	2.8	50
Layer 2	18	62.5	0.96	6	10
Layer 3	37	125	0.96	4	100
Layer 4	39	125	0.95	4	100
Layer 5	58	125	0.91	4	100
Layer 6	60	125	0.9	4	100

Table III-2.2
Main parameters of the central silicon systems SIT, SET, and ETD.

SIT (baseline = false double-sided Si microstrips)					
Geometry			Characteristics		Material
R [mm]	Z [mm]	cos θ	Resolution R-ϕ [μm]	Time [ns]	X_0 [%]
153	368	0.910	R: σ=7.0	307.7 (153.8)	0.65
300	644	0.902	z: σ=50.0	σ=80.0	0.65
SET (baseline = false double-sided Si microstrips)					
Geometry			Characteristics		Material
R [mm]	Z [mm]	cos θ	Resolution R-ϕ [μm]	Time [ns]	X_0 [%]
1811	2350	0.789	R: σ=7.0	307.7 (153.8)	0.65
ETD (baseline = single-sided Si micro-strips)					
Geometry			Characteristics		Material
R [mm]	Z [mm]	cos θ	Resolution R-ϕ [μm]		X_0 [%]
419.3-1822.7	2420	0.985-0.799	x: σ=7.0		0.65

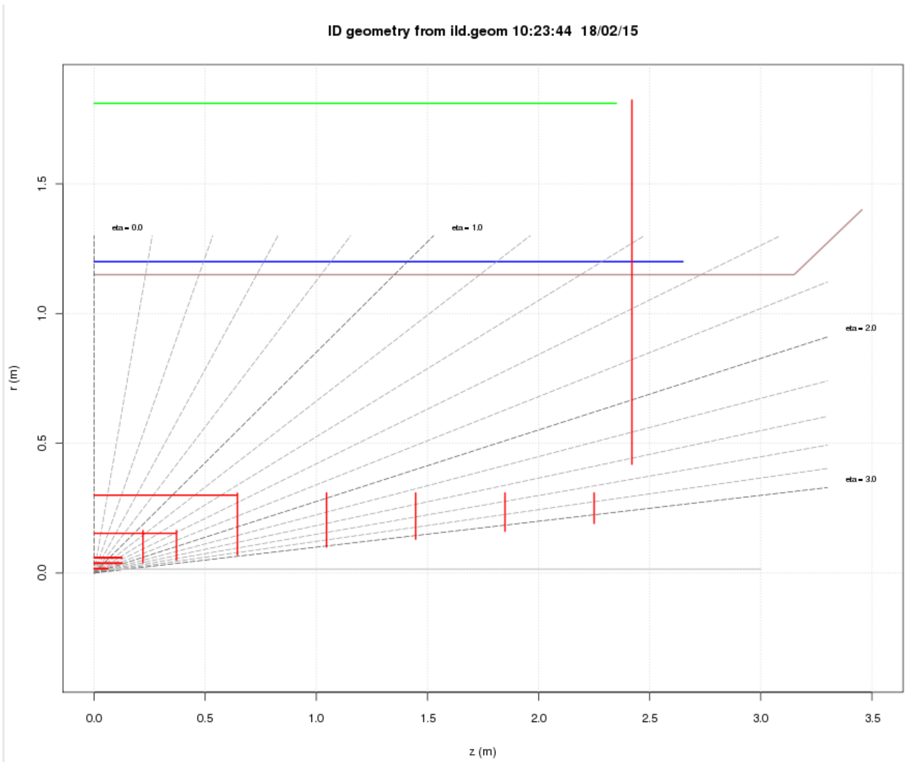
2.2. The ILD silicon tracki

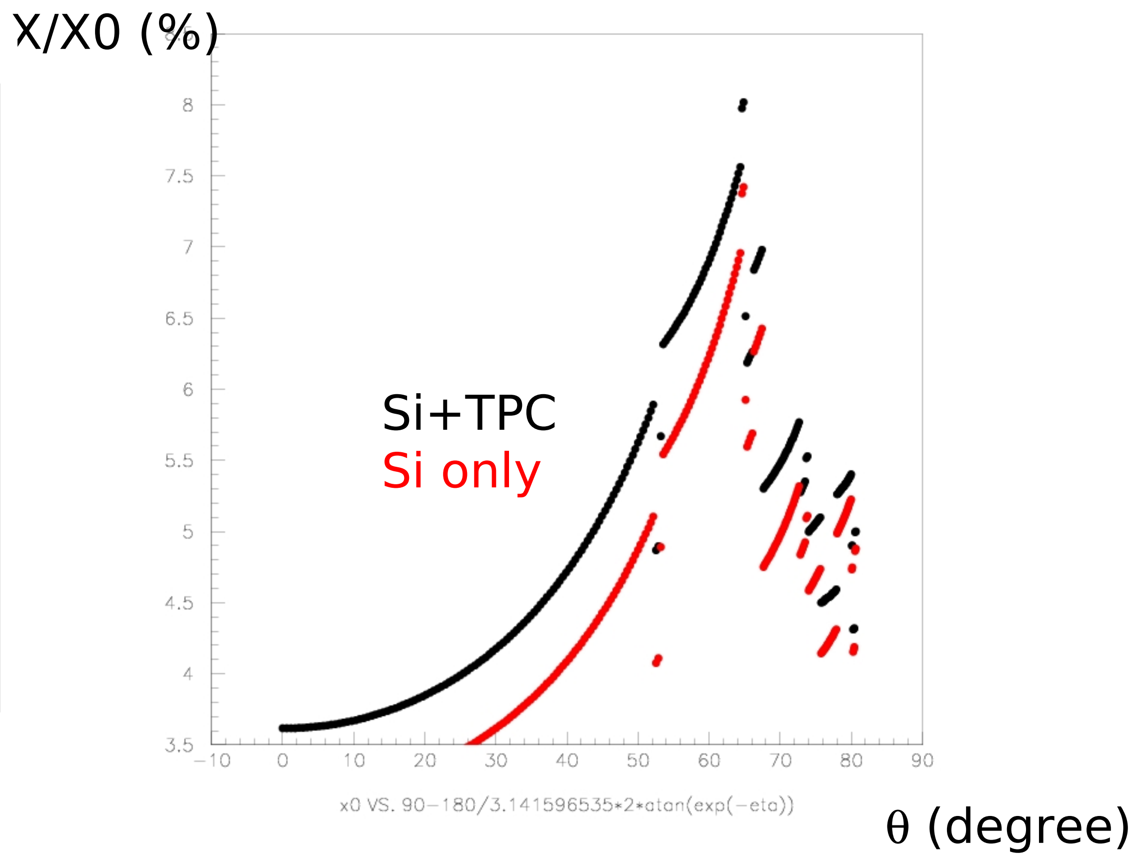
Table III-2.3
Layout of the Forward Tracking Disks. The quoted single hit resolution for the pixel disk depends on its technological implementation which has also an effect on the material budget.

FTD (baseline: pixels for two inner disks, microstrips for the rest)				
Geometry			Characteristics	Material
R [mm]	Z [mm]	cos θ	Resolution R-ϕ [μm]	RL [%]
39-164	220	0.985-0.802		0.25-0.5
49.6-164	371.3	0.991-0.914	σ=3-6	0.25-0.5
70.1-308	644.9	0.994-0.902		0.65
100.3-309	1046.1	0.994-0.959		0.65
130.4-309	1447.3	0.995-0.998	σ=7.0	0.65
160.5-309	1848.5	0.996-0.986		0.65
190.5-309	2250	0.996-0.990		0.65

Comparison of TPC only vs TPC+Silicon

- Encode full ILD geometry easily in Idres
- Material budget as example of output

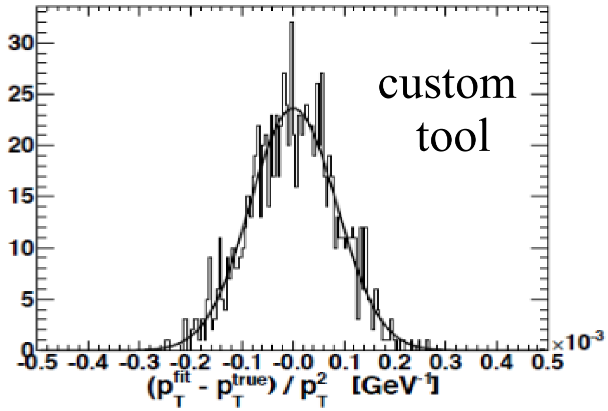




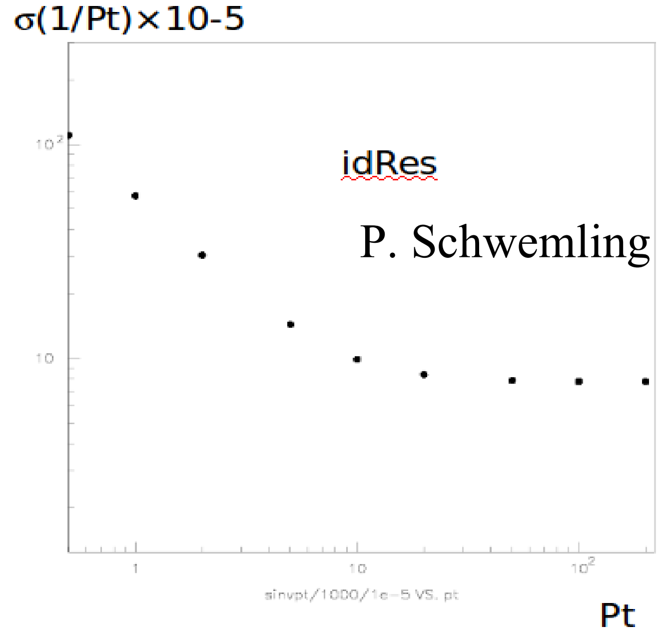
Tracking performance for a given geometry

Plot F. Couderc TPC only

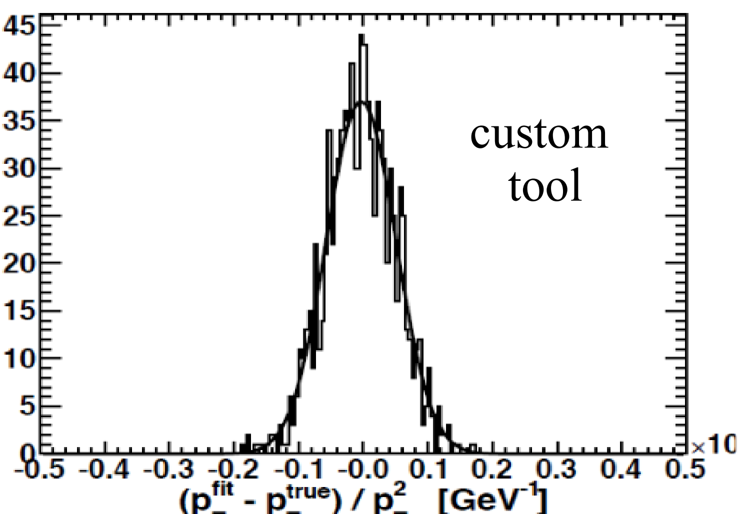
$\sigma_{r\varphi} = 100\mu m$



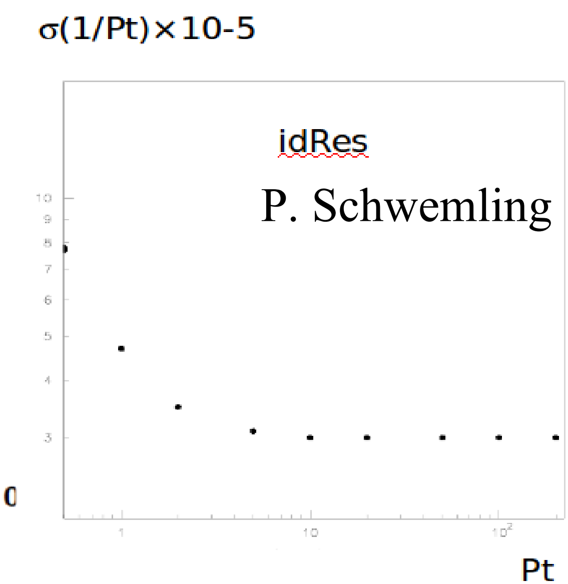
$\Rightarrow \sigma(1/pT) = 8.5 \times 10^{-5}$ / GeV



Plot F. Couderc Only Si tracker



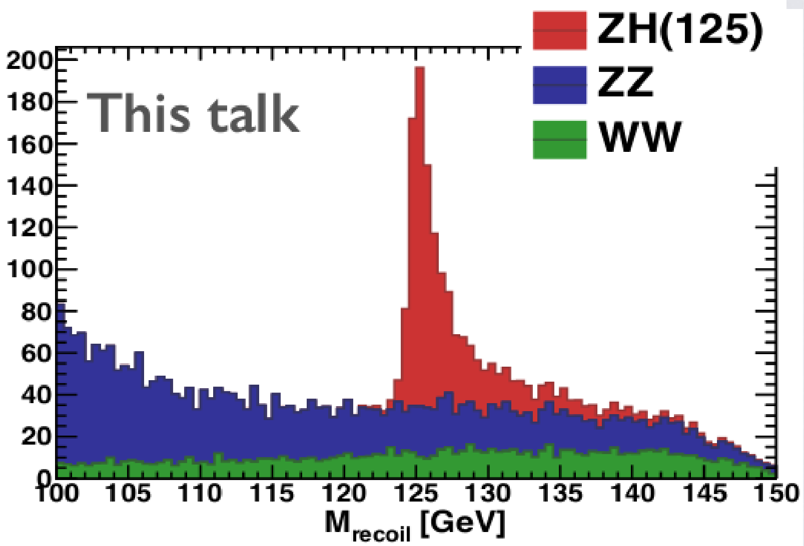
$\Rightarrow \sigma(1/pT) = 5.4 \times 10^{-5}$ / GeV

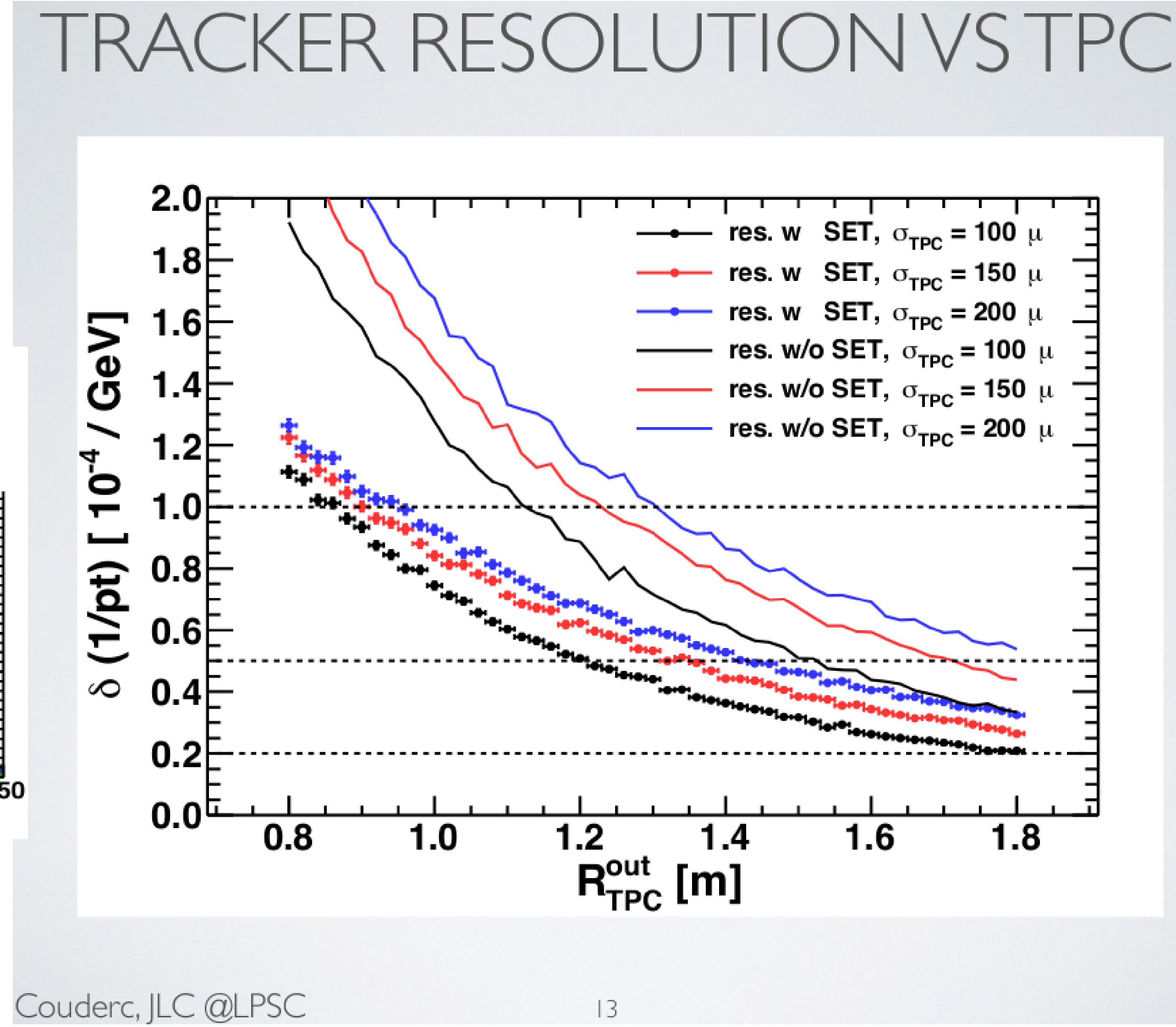


Momentum resolution for different geometry

Used custom fast tool here

Also studied Mrecoil in (Z→ μμ)+X events as benchmark



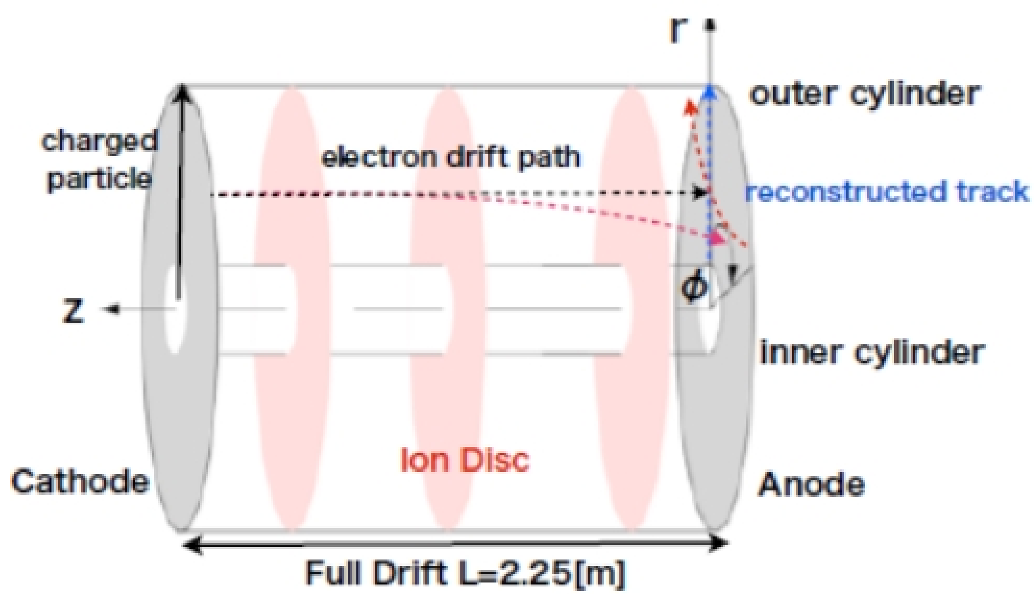


Question whether a state of the art TPC is overkill given the silicon detectors (vertex and outer shell)...preliminary... to be continued..

mini TPC project

Goal

- Test TPC tracking reconstruction performance in the presence of spatial charge.
  - Spatial charge induced by
    - primary ions
    - secondary (amplification) ions back-flow

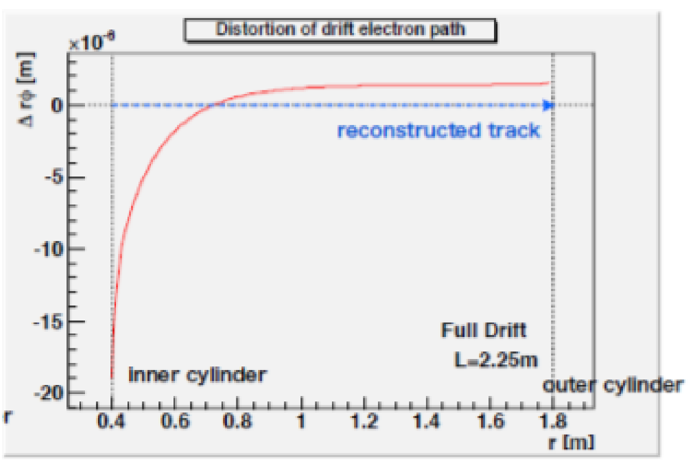


mini TPC project (2)

Goal

- Test TPC tracking reconstruction performance in the presence of spatial charge.
  - Spatial charge induced by
    - primary ions
    - secondary (amplification) ions back-flow
- MC-based estimate of distortions already studied

for ILC



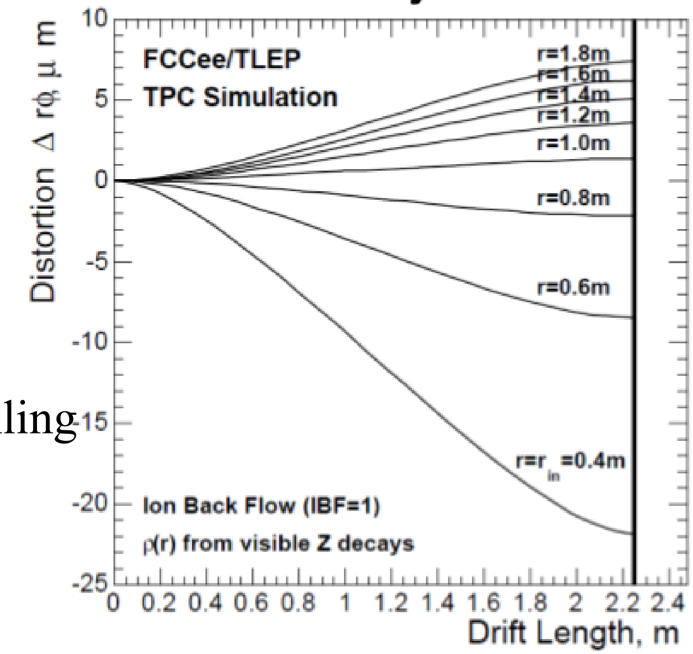
Distortion of drift electron path (Full drift)

Arai Daisuke
2012/February/23 @ WP meeting

for Fcc-ee

Sergei Ganjour
Philippe Schwemling

Electron trajectories

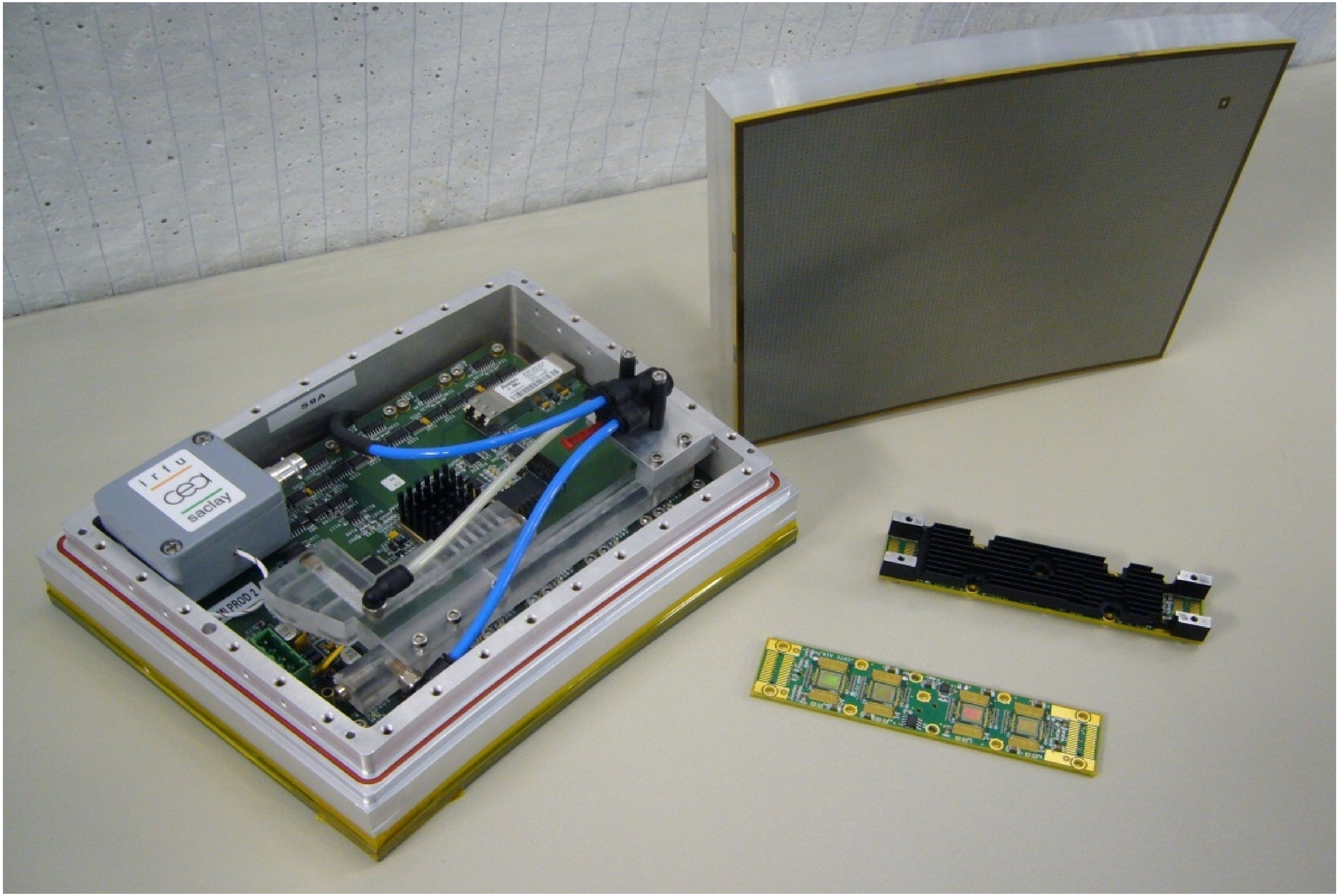


- We want to test performance in real life with a mini-TPC

Mini-TPC project

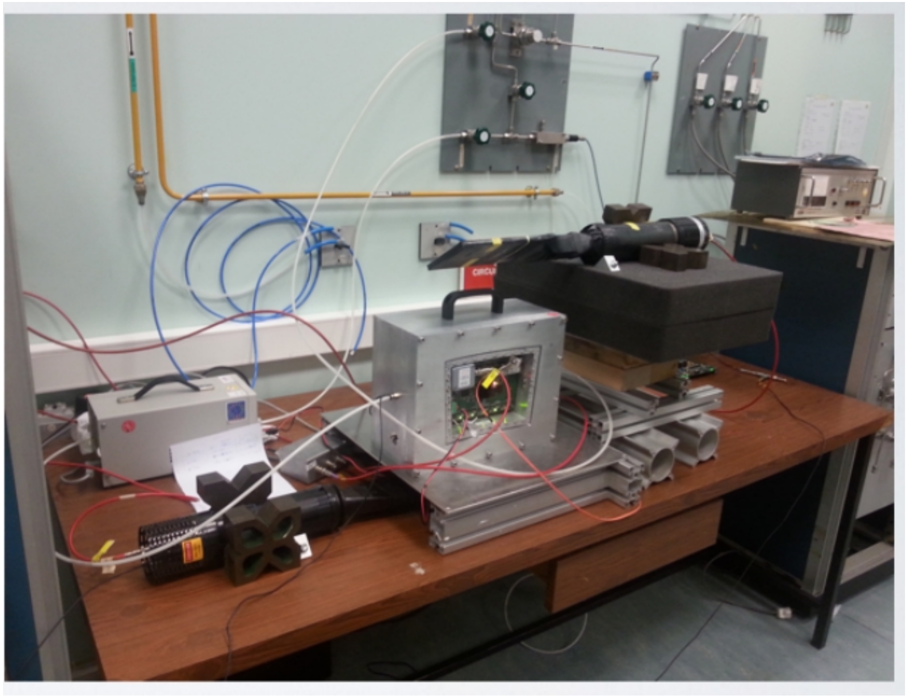
- Recycle existing Chamber present at Saclay
  - need to re-design endplate
- Plug recent micromegas (resistive) detector
  - Relies on existing detector+electronics+DAQ developed for T2K and ILD R&D
- Transparent windows to send UV-rays through the chamber
  - UV rays yield photo-electrons at the cathode level
  - Photo-electrons drift toward micromegas
  - Micromegas amplification yields ion back-flow in drift space
  - Spatial charge is built in ~ 200 ms
- Measure tracking performance with cosmic muons (No Magnetic field)

The typical detecting device

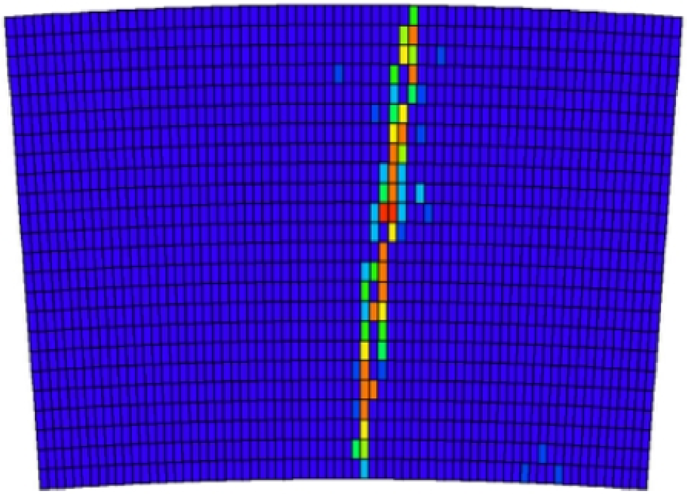


First tests with a micro-TPC

- First tests of detector + electronics+ DAQ + reconstruction software
  - Use of a small chamber ~20 cm x 20cm x o(2 cm drift)
  - Trigger on cosmics with PM+scintillators



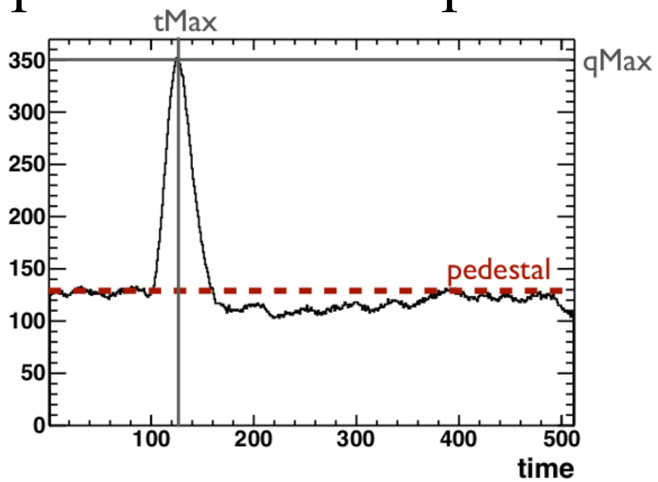
1728 channels



One night of data ~ 3000 events

- No zero suppression
- Sampling frequency : 100 MHz
- Shaper peaking time : 200 ns
- Very long time frames : 511 clock cycles

Typical channel response

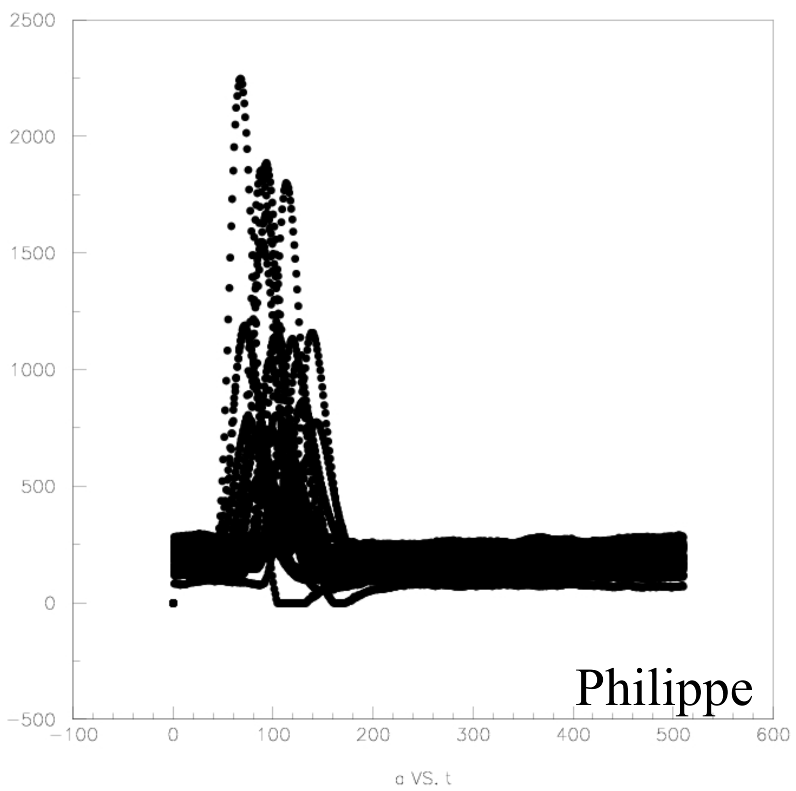


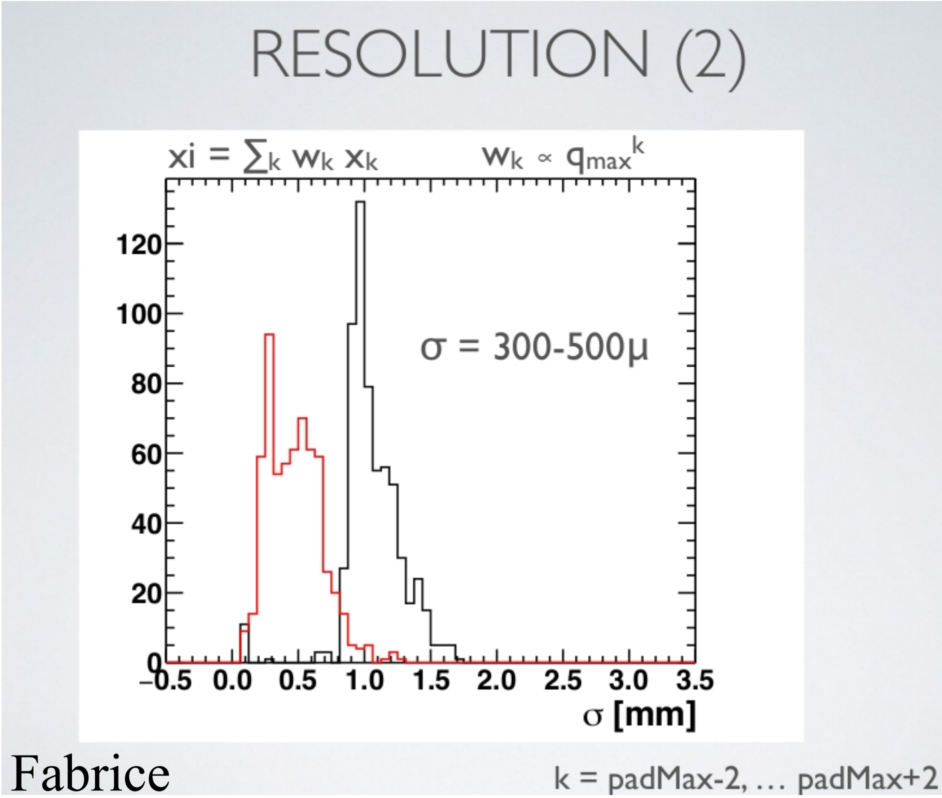
First look at data

Understand detector responses
Test capabilities to reconstruct tracks

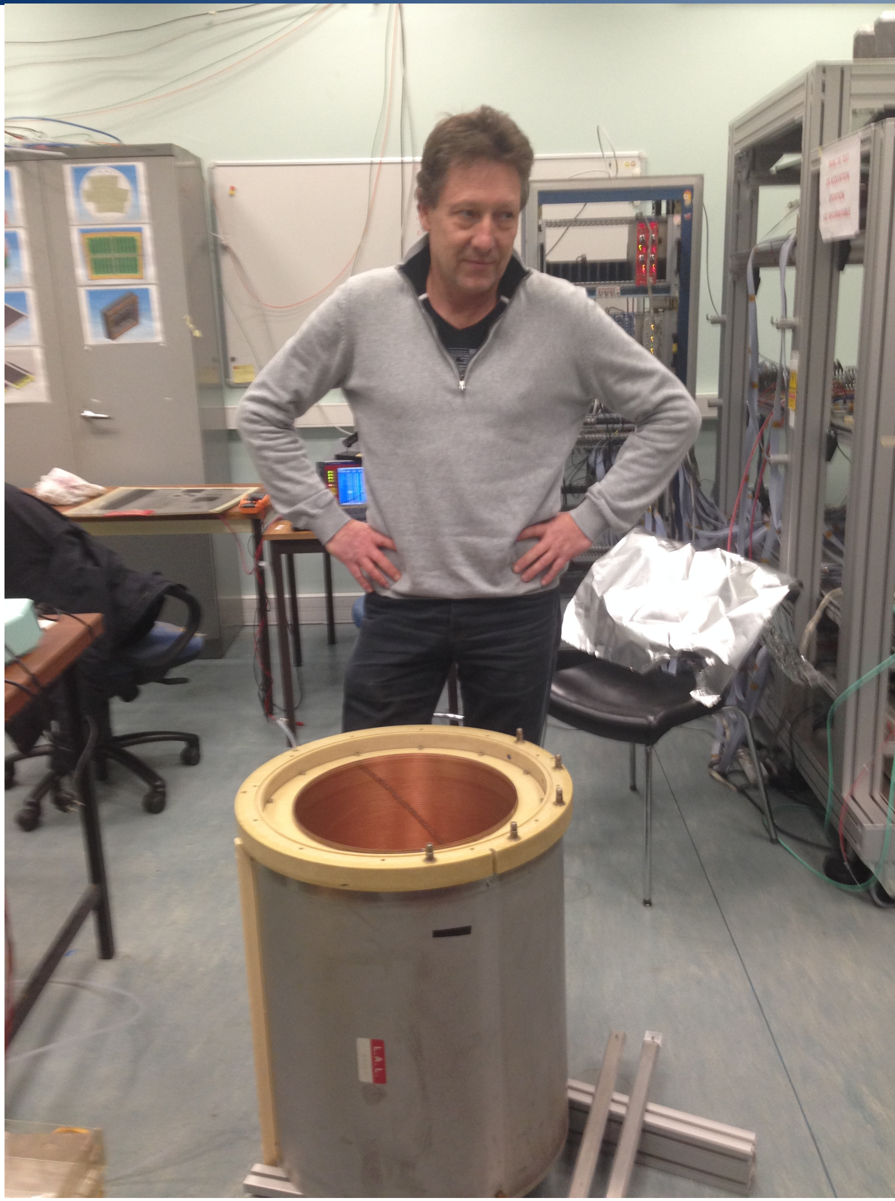
ADC counts
- Timing differences (drift distance)visible
- Pulse shapes differences also visible

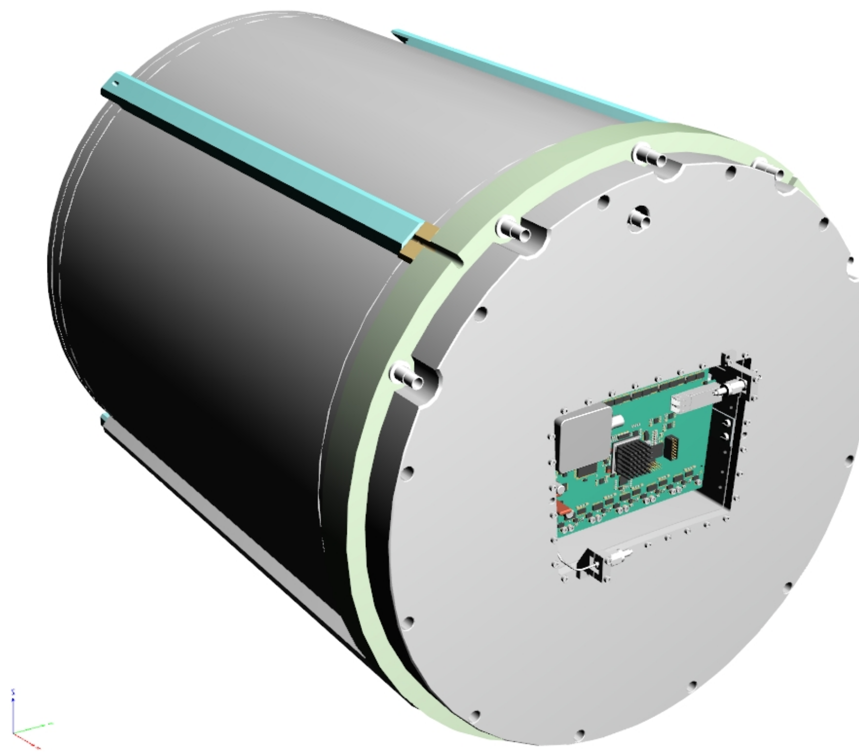
Some track resolution studies,
using a crude tracking algorithm





The chamber



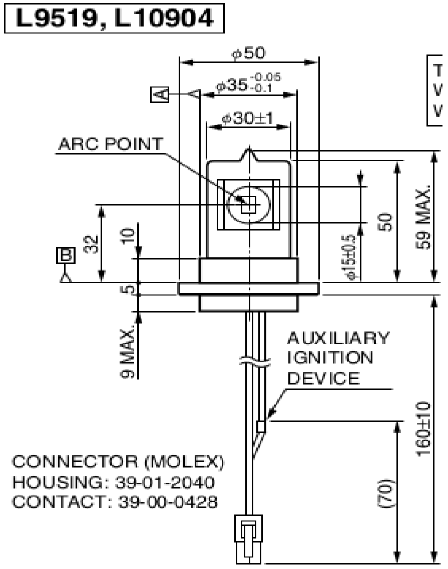


CAD

UV light

Hamamatsu X2D2 Hamamatsu L10904

http://www.hamamatsu.com/jp/en/L10904.html



Between 200 and 240 nm $\phi \sim 0.07 * 20$ µW/cm-2

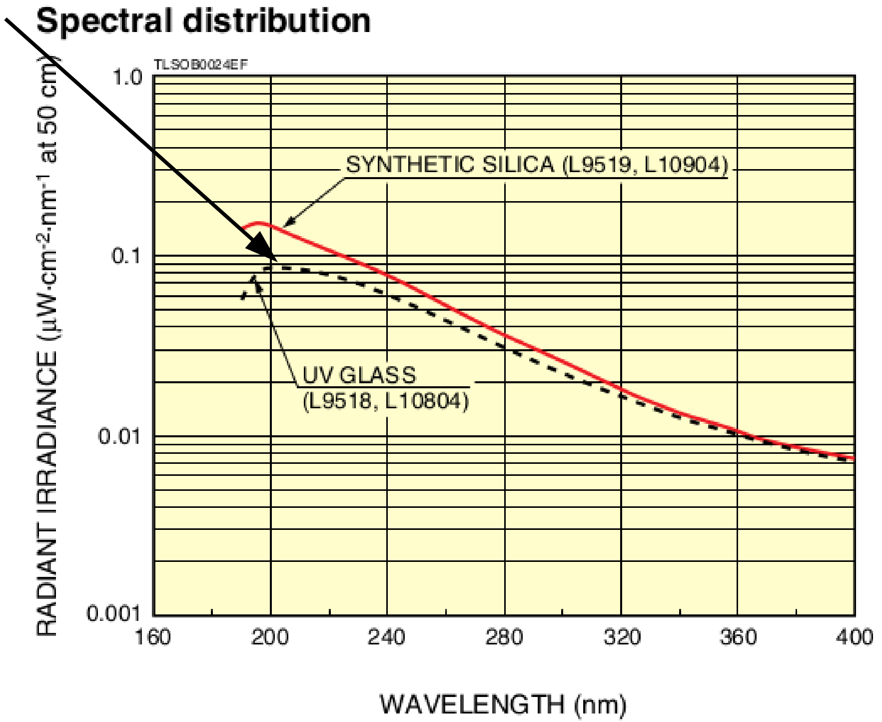
Photon flux: $\phi_\gamma \sim \phi / hc/\lambda$

0.07E-6*20* 200E-9/(6.6E-34*3E8)

$= 1.4\ 10^{12}$ photon/s/cm^2

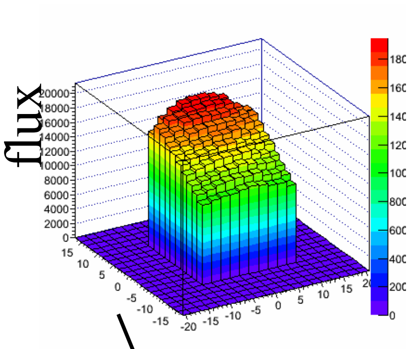
Typical needs to fill charge in TPC :

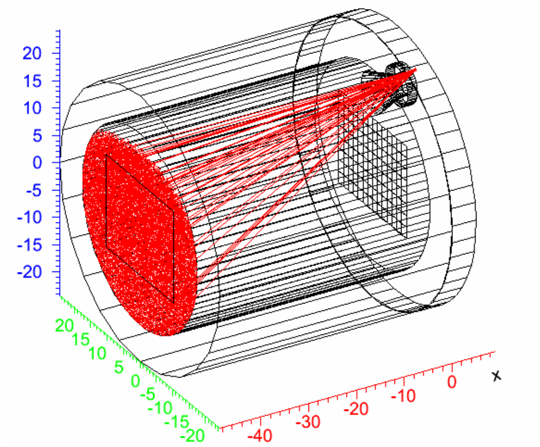
~ 3 10^5 photo-electrons/s

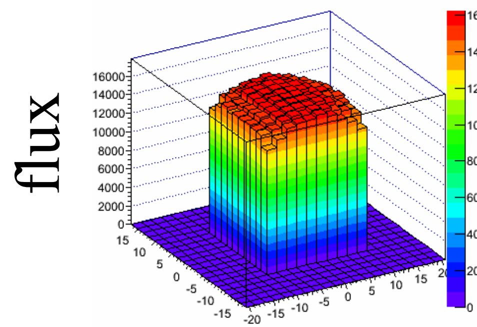


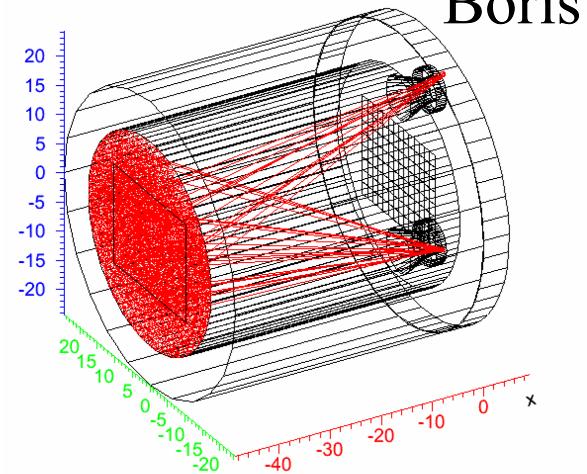
Two Viewports

Boris



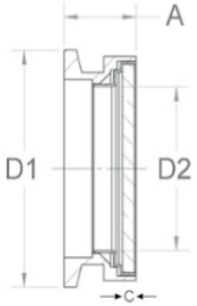




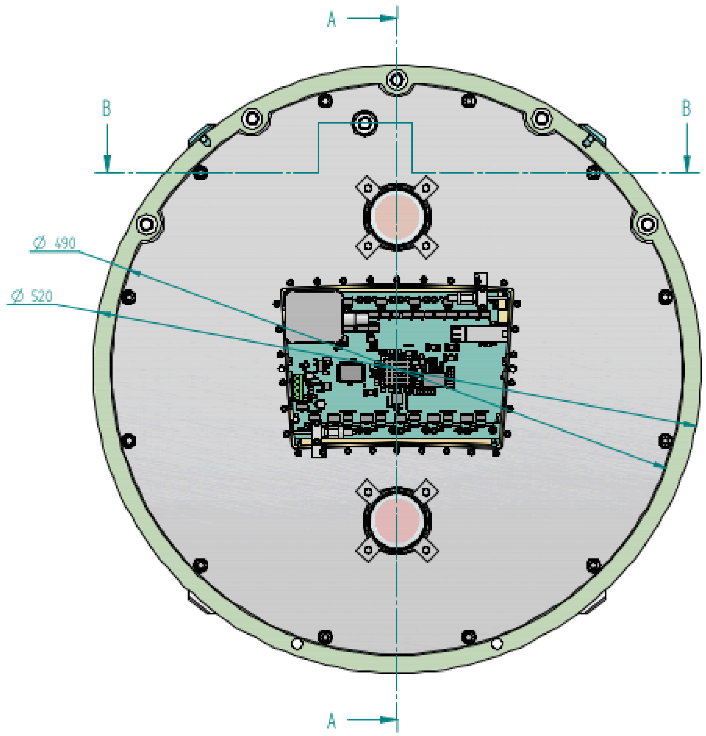


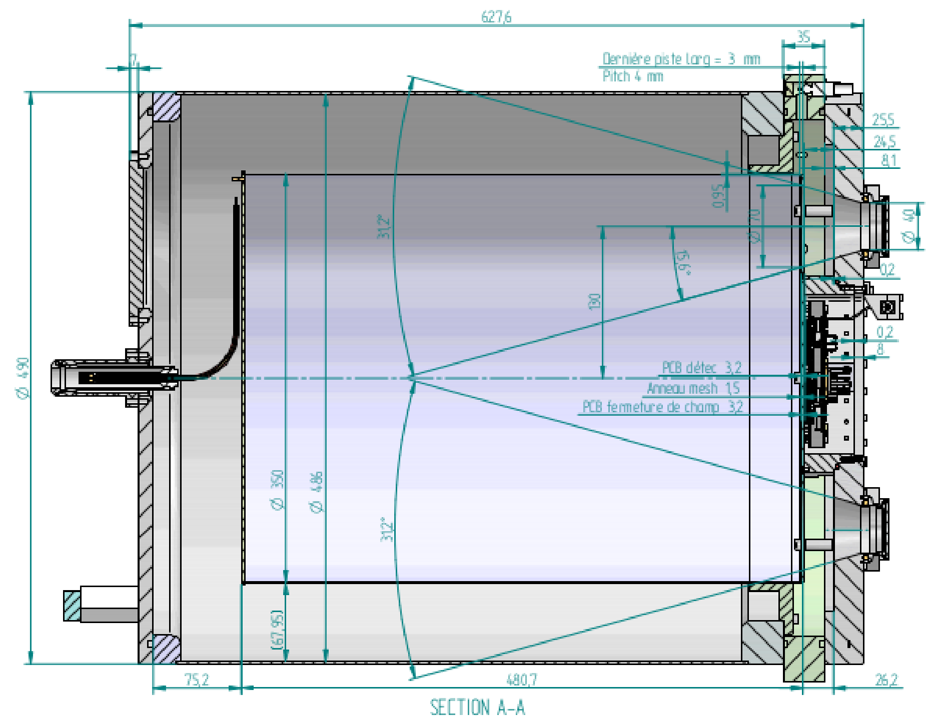
Solid angle effect+UV absorption+ Quantum efficiency= non homogeneous photo-electrons yield

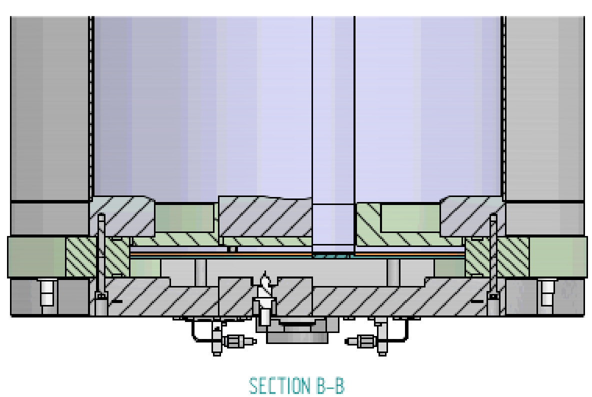
- Two viewports for better control on photon-electron yield homogeneity
- Will use CaF_2 viewport of diameter 3.8cm

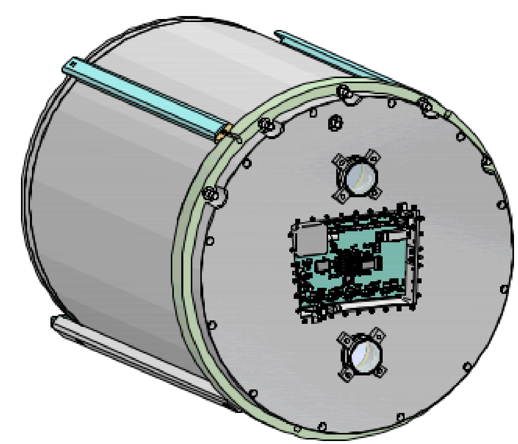


Final design ready

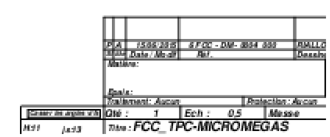








Marc David



Status and plans

- TPC status
  - TPC endplate ordered
  - TPC viewports ordered
  - Should be mounted during summer
- Bench-test
  - Shelves ready
  - Triggering system done (2 scintillators 50x60cm)
  - Need 2 micromegas detector for hodoscope
- UV light
  - Need to design shutter system to control flux

Should be running shortly after Summer

Conclusion

- Activities have been ramping up in the past few months
- Started to look at many things
- Expect fun times ahead very soon with mini-TPC project
  - Commissioning of the detector
  - Data taking
  - Data analysis