TPC Parameters for ILD Integration/Optimization for the DBD

Status 22 April 2010

Optimization: software model

There will be some changes in 2010…

Table 5

Performance/Design

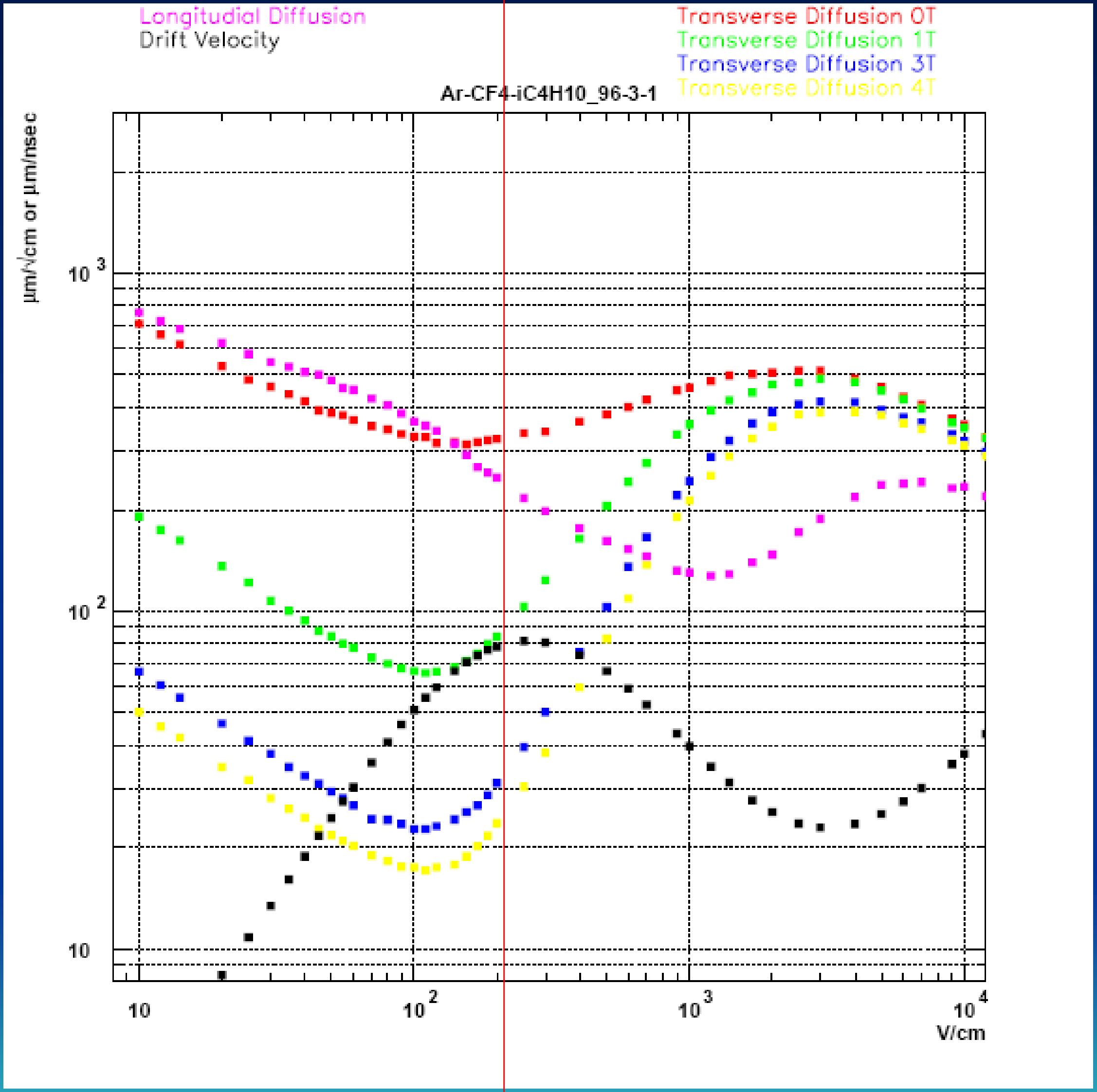
from the Addendum

Size	$\phi = 3.6$m, L = 4.3m outside dimensions
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 9 \times 10^{-5}$/GeV/c TPC only ($\times$ 0.4 if IP incl.)
Momentum resolution (3.5T)	$\delta(1/p_t) \sim 2 \times 10^{-5}$/GeV/c (SET+TPC+SIT+VTX)
Solid angle coverage	Up to $\cos\theta \simeq 0.98$ (10 pad rows)
TPC material budget	$\sim 0.04X_0$ to outer fieldcage in r
	$\sim 0.15X_0$ for readout endcaps in z
Number of pads/timebuckets	$\sim 1{\times}10^6$/1000 per endcap
Pad size/no.padrows	$\sim$ 1mm$\times$4–6mm/$\sim$200 (standard readout)
σ_{point} in $r\phi$	$<$ 100μm (average over $L_{sensitive}$, modulo track ϕ angle)
σ_{point} in rz	$\sim$ 0.5 mm (modulo track θ angle)
2-hit resolution in $r\phi$	$\sim$ 2 mm (modulo track angles)
2-hit resolution in rz	$\sim$ 6 mm (modulo track angles)
dE/dx resolution	$\sim$ 5 %
Performance	$>$ 97% efficiency for TPC only ($p_t >$ 1GeV/c), and
	$>$ 99% all tracking ($p_t >$ 1GeV/c)
Background robustness	Full efficiency with 1% occupancy
Background safety factor	Chamber will be prepared for 10 $\times$ worse backgrounds
	at the linear collider start-up

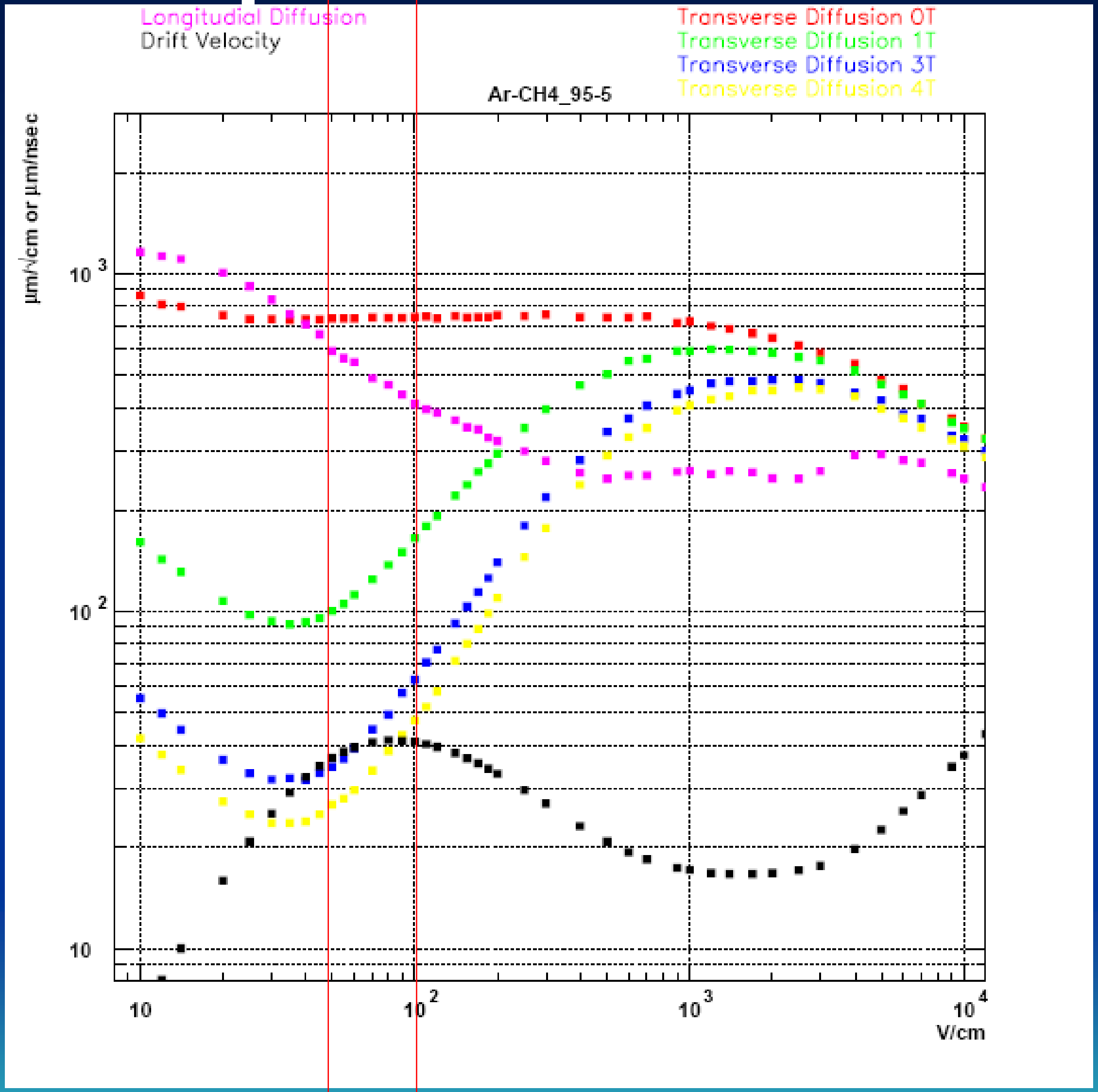
« Gas »

Fundamental decision: we should keep options open for at least two alternative gases, a 'preferred' gas and a 'back-up' gas…

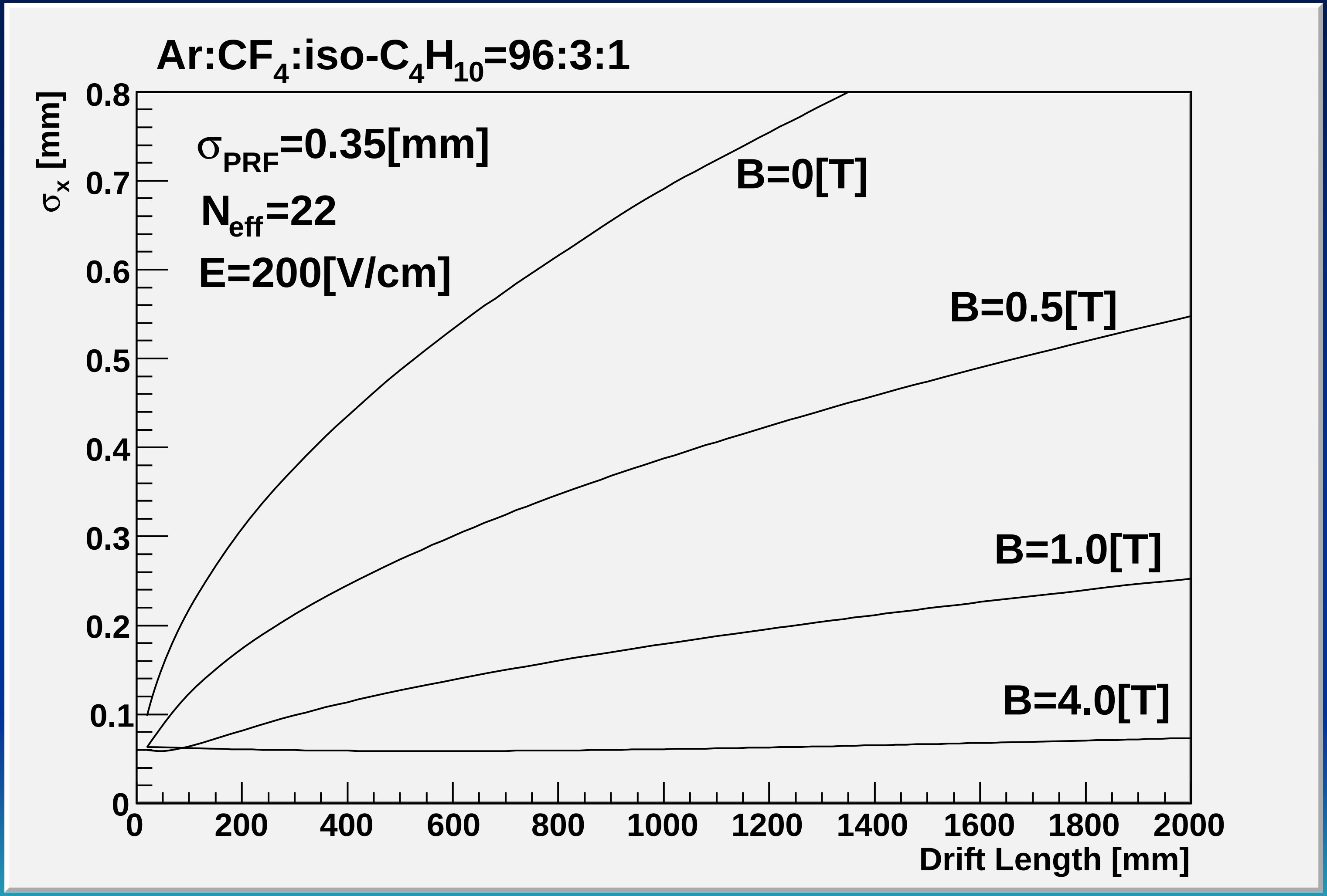
Ar-CF4-iC4H10 (96-3-1%) ‘preferred’



P5 'back up'



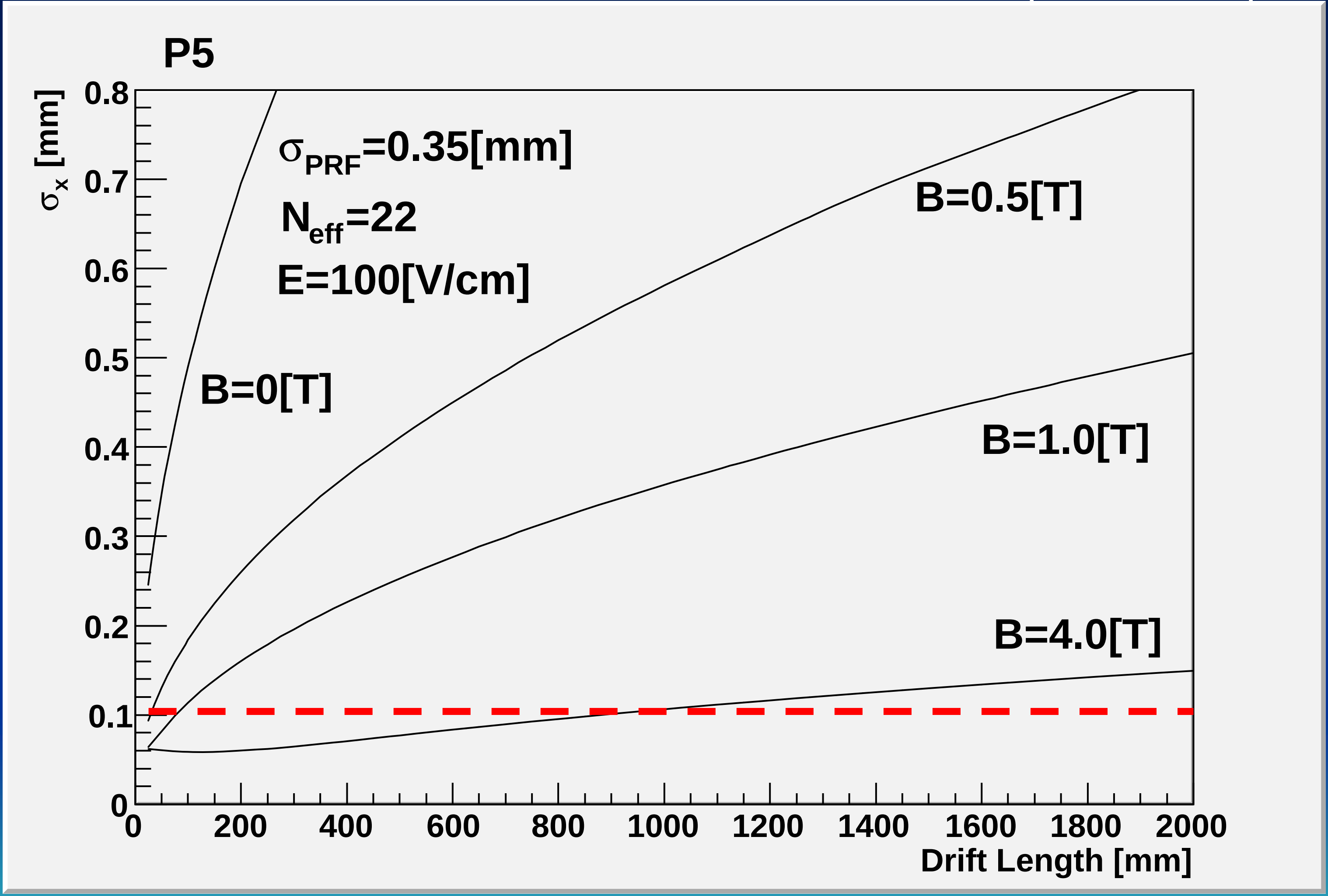
Longitudial Diffusion
Drift Velocity
Transverse Diffusion 0T
Transverse Diffusion 1T
Transverse Diffusion 3T
Transverse Diffusion 4T
Ar-CH4_95-5
µm/√cm or µm/nsec
10 3
10 2
10
10
10 2
10 3
10 4
V/cm



Ar:CF$_4$:iso-C$_4$H$_{10}$=96:3:1
σ$_{PRF}$=0.35[mm]
N$_{eff}$=22
E=200[V/cm]
B=0[T]
B=0.5[T]
B=1.0[T]
B=4.0[T]
σ$_x$ [mm]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Drift Length [mm]

Keisuke Fujii

σ0=23μm, Cd=49 μm/√cm



Performance

- **Momentum precision for the TPC**
  → **What is the best we can do?**

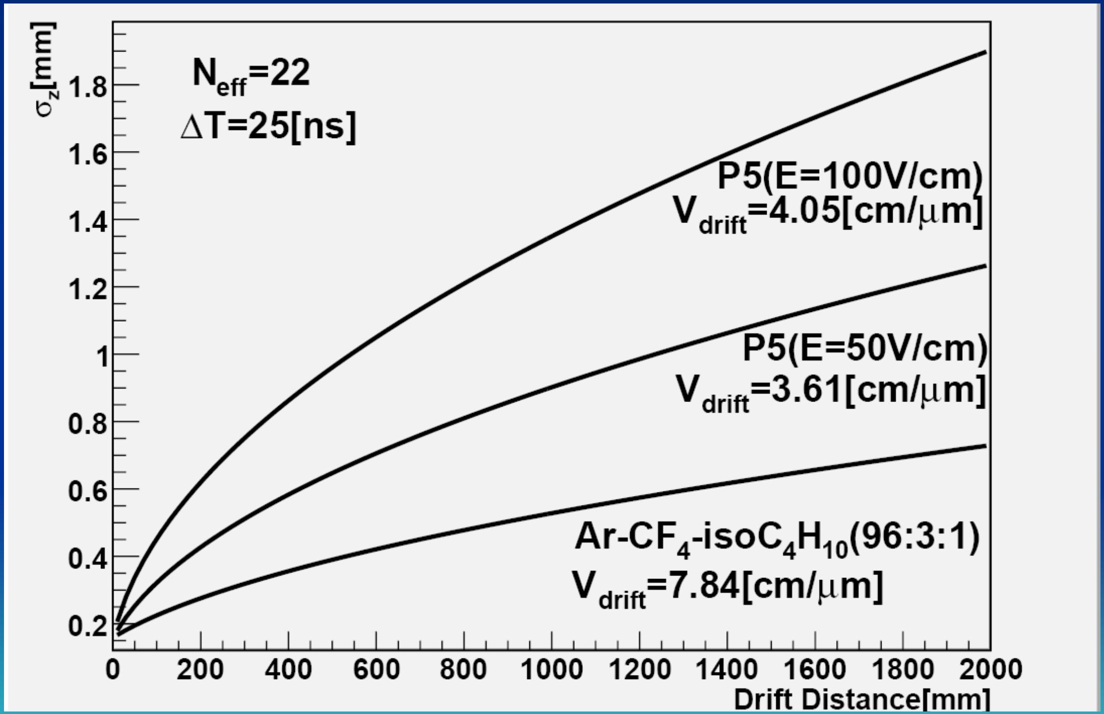
Neff=22
w=1.27 [mm]
sigma_PRF = 350 [microns]

Gas	E [V/cm]	Cd [microns/sqrt(cm)]	sigma_0 [microns]
P5	50	25	25
	100	49	23
Ar-CF4-iso (96:3:1)	200	23	25

Point Resolution σz (z)

R. Yonamine

$$\sigma_z = \sqrt{\frac{1}{N_{eff}}\left(\frac{\left(\Delta T \cdot v_{drift}\right)^2}{12} + \left(C_D^L\right)^2 \cdot z\right)}$$



Part 1 of 2008 eMail to ild-optimization maillist:

There will be some changes in 2010…

1) As a function of drift-distance L_{drift}, the expression for the
r\phi point resolution is, as you know,

sigma_{point}^2 = sigma_0^2 + Cd^2/N_{eff} * L_{drift}

Proposal 1) on point resolution:

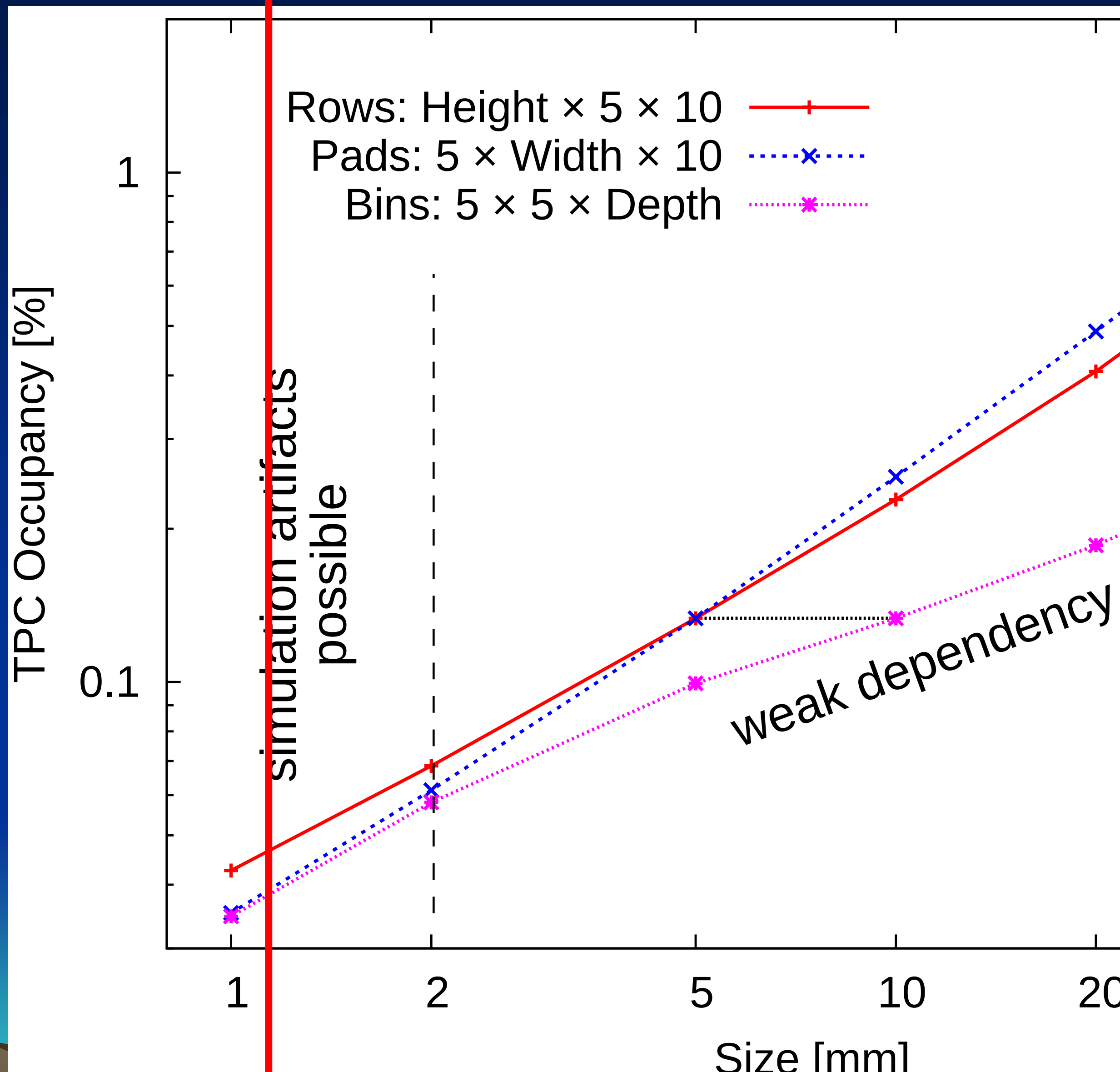
=>sigma_0^2 = (50micron)^2 + (900micron*sin(phi))^2
(where phi is the local azimuthal angle of track wrt the padrow)

=>Cd^2/N_{eff}=25^2/(22/sin(theta)*h/6mm)=(5.3micron/sqrt(cm))^2*(6mm/h)*sin(theta)
(this is for B=4T which we favor, h is the pad height=pad-row pitch in mm,
theta is the polar angle)

=>sigma_z(z)= sqrt{400micron**2 + z(cm) x (80micron/sgrt{cm})**2}

Integration: hardware model iteration #1

Adrian's simulation: bottom line ⇒ want small pads



Width=1.27mm, Height=5mm, Occupancy=0.02% for γ's, e's, n's and 100BX: 0.02%Occ ≈ 0.02fC/cm^3 vol.chg!

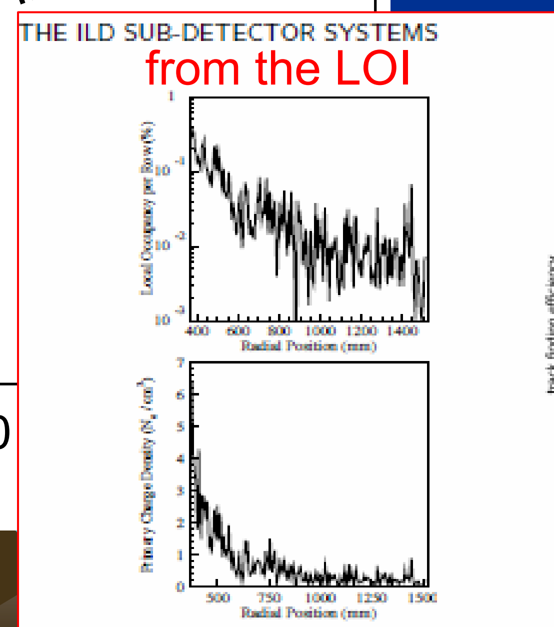


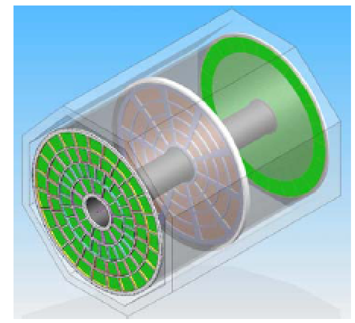
FIGURE 4.3-4. Occupancy for xyz = 1 × 5 × 5

« MDI parameters»

Request from MDI/Integration group (Catherine Clerc) to the TPC contact persons (Takeshi and me).

We propose, not as Catherine started,→ to define one "generic" TPC (not two) for MPGD (neither µgas nor gem specific)…

[ ]	[TPC interface parameters]	Ref	ILD-000-xxxx
		Issue	
		Date	20/01/2010
		Page	2



1. ***Technological description***

Each endplate ≈ 10 m²
Pads :
- ✓ µmégas 7*3mm² i.e. 0.55Mch/endplate
- ✓ Gems : 1*5mm² i.e. 2.3 Mch/endplate

2. ***Overall dimensions***

400 KG/endplate, ≈ 2t full TPC

3. ***Support***

3 tie rods from each endplate face to HCal barrel

4. ***Services***

Cabling (µmégas)
- 80 modules each side.
- For each module (6800 channels) :
- 1 HV cable
- 1 double optical fibre
- 1 low-voltage 32A cable

Each side : 80 HV+80 Double Fibres+80 LV(32A) = 240 cables

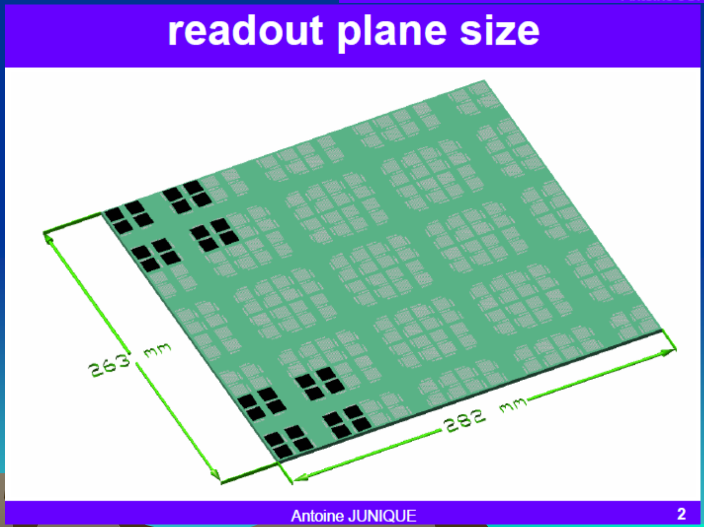
Cooling :

160 W to remove (becomes negligeable is power pulsing can be fully implemented.)
But to be checked
With power pulsing 0.5mW per channel

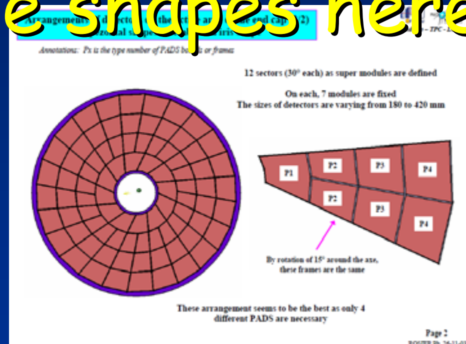
Electronics: since both micromegas and gem have agreed to use S-Altro

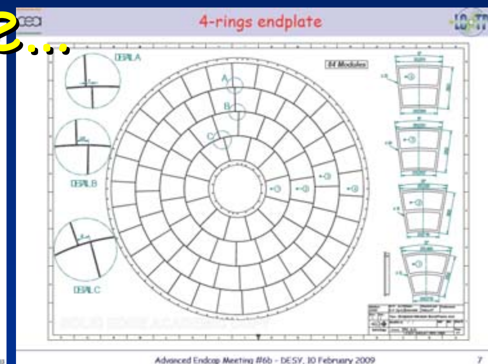
--Basic unit: Antoine Junique's "new readout plane", labeled in what follows here "ROB" (this is the basis for Takahiro's talk on the test set-up at the March 4 WP meeting):

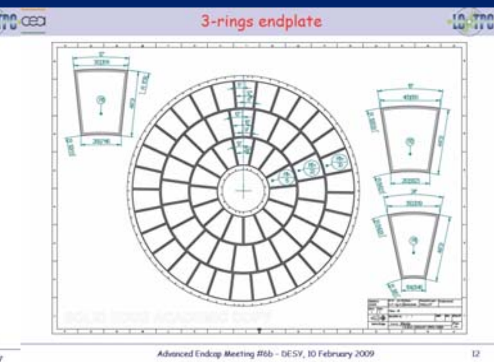
--ROB size:
263 x 282mm^2 ≈
2 x LP1 "ROB"



Exercise: let's see what the endcap thickness with this S-Altro will be (ie, as thin as possible but with as small of pads as possible: 1 mm x 4 mm in this case). "Generic" also means don't worry about sector/module shapes here…







…because these will depend on the outcome of Dan's studies…

Comparison of candidate models

	mass kg	material $\%X_0$	deflection microns	stress Mpa (yield: 241)
LP1	18.87	16.9	33	1.5
Lightened (all aluminum)	8.93	8.0	68	3.2
Lightened (Al-C hybrid)	Al 7.35 C 1.29	7.2	< 168*	< 4.8*
Space-Frame	8.38	7.5	23	4.2

(* values for the aluminum only)

Material: space-frame has slightly more material than the Al-C hybrid.

Deflection: space frame is more rigid than LP1, ~3x more rigid than the lightened (all Aluminum), and > 3x more rigid than the Al-C hybrid.

Sizes

--pad pitch: 4.1 x 1.1mm^2

--1024 pads/smodule

⇒ 4618 mm^2/smodule

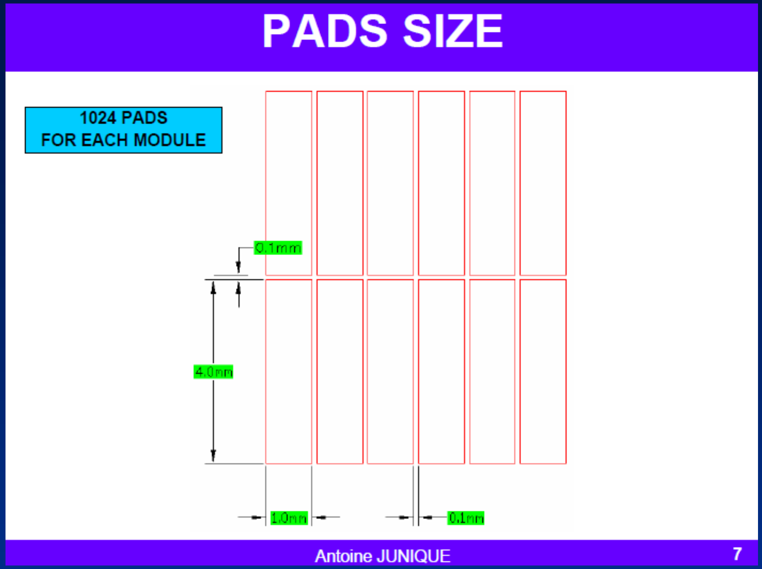
--16384 pads/ROB

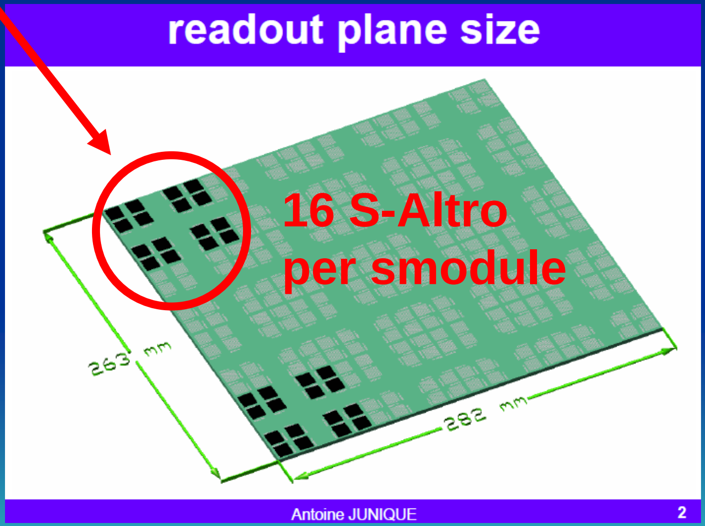
⇒ 73892 mm^2/ROB

--R_endcap ~ 329mm to 1818mm

⇒ 10049290 mm^2/endcap

⇒ 136 ROB/endcap



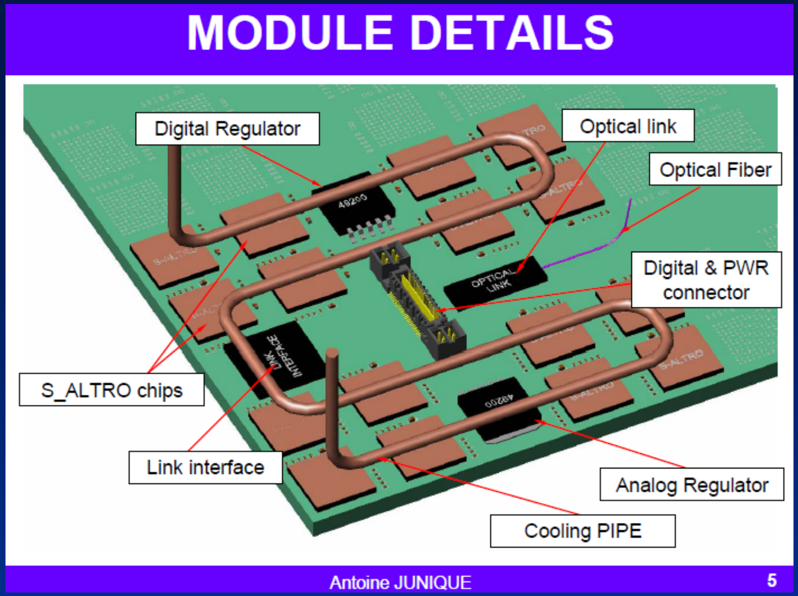


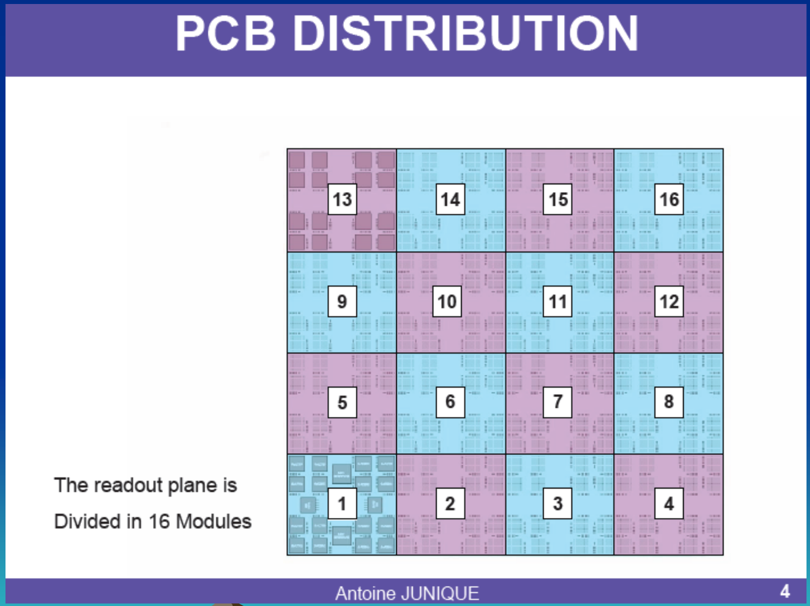
Channels

--64 pads/S-Altro
--16 S-Altro/smodule
--16 smodules/ROB

$\Rightarrow$

--1024 pads/smodule
--16384 pads/ROB
--34816 S-Altro/endcap
--2226897 pads/endcap





sections:"8 ways-out"

Catherine is proposing an "8-fold way" (which agrees with the Ecal segmentation) for extracting cables, cooling pipes etc, it seems logical to subdivide the TPC endcap into 8 sections:

--136 ROB/endcap ⇒ 17 ROB/section

Remember, we don't worry about ROB or section shapes for this exercise (the shapes will vary going from the inside to the outside and are details we can work out later, as soon all the information is available). Here we want to derive the endcap thickness, heatload, etc using Antoine's "new readout plane" for the detector integration...

Cooling

Tests of power delivery, power switching and cooling for S-ALTRO End-Plate

22/Sep/2009
LCTPC Collaboration Meeting
Takahiro Fusayasu
Nagasaki Institute of Applied Science

1

1. Cooling

Considerations on power dissipation

Power consumption

- amplifier 8 mW / channel
- ADC 12mW/channel (10MSPS), 34 mW / channel (40MSPS)
- Digital Proc 2 mW / channel
- data links 2 mW / channel
- power regulation efficiency: 75%
- Total power 32mW/channel (10MSPS), 60mW/channel (40MSPS)

Owing to the bunch-train time structure (beam duty cycle 0.5%), for the ILC and CLIC TPCs electronics a basic ingredient is power pulsing

In principle a factor ~70 (~1.5% electronics duty cycle) can be achieved

What can be achieved in practice is an important R&D issue

- duty cycle 1.5%
- average power / channel 0.5 mW / channel (at 10 MSPS)
- average power / m^2 100 W (at 10MSPS)

Power pulsing cannot be applied to PANDA

15 May 2009 Luciano Musa / CERN 17

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With 2226897 pads/endcap and 0.5mW/pad with power pulsing (1.5% duty cycle)
⇒ 1.1 kW/endcap = 111 W/m^2 at 10 MSPS = 8 W/ROB
or 2 kW/endcap = 200 W/m^2 at 40 MSPS = 15 W/ROB

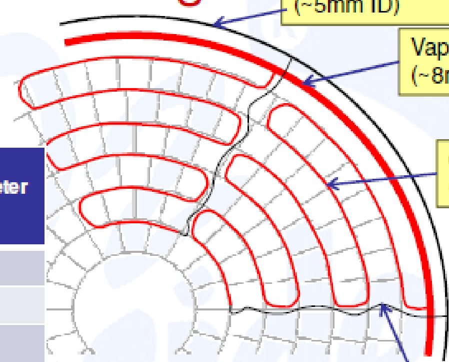
N.B. This is NOT negligible, even "if power pulsing can be fully implemented"!

Cooling

"8 ways-out" means that Bart should look into an "8-loop option" with a pad TPC...

TPC end plate cooling tube routing

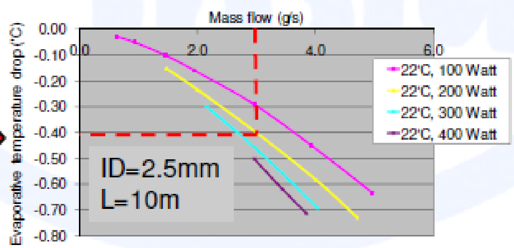
Possible layout of the 6 loops option



	Qty Frames / loop	Heat load per loop (W)	Tube length (m)	Inner diameter (mm)
1 loop	200	1000	48m	6.2
2 loops	100	500	24m	4.3
4 loops	50	250	12m	3
6 loops	34	171	8m	2.2

Similar to AMS-TTCS

AMS test data (2001)
0.4ºC temperature gradient



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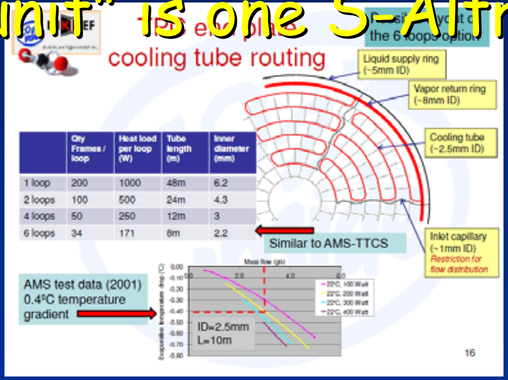
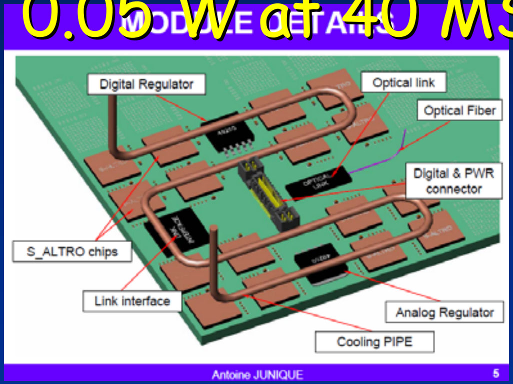
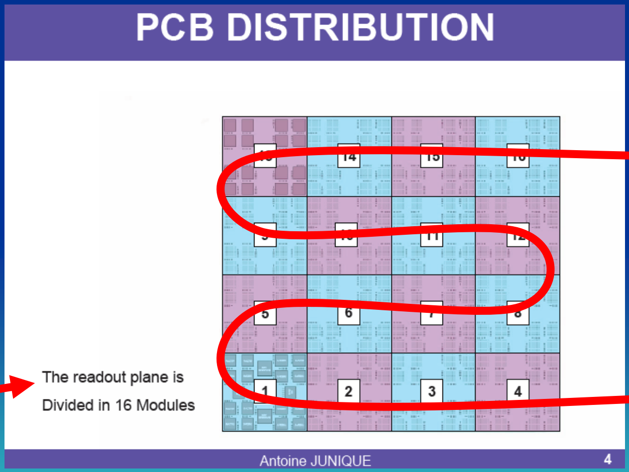
Cooling

Also, these two strategies are different: Bart cools a timepix chip. This corresponds roughly to one ROB in a pad TPC (a “cooling unit”) = 11 W at 40MSPS, where Antoine’s “cooling unit” is one S-Altro = 0.05 W at 40 MSPS.





At Aleph, our “cooling unit” was ~ 1 W, roughly equivalent for this lctpc case 1 smodule = 16 S-Altros = 0.7 W at 40 MSPS or = 0.4 W at 10 MSPS. Should Bart use this?



Cables

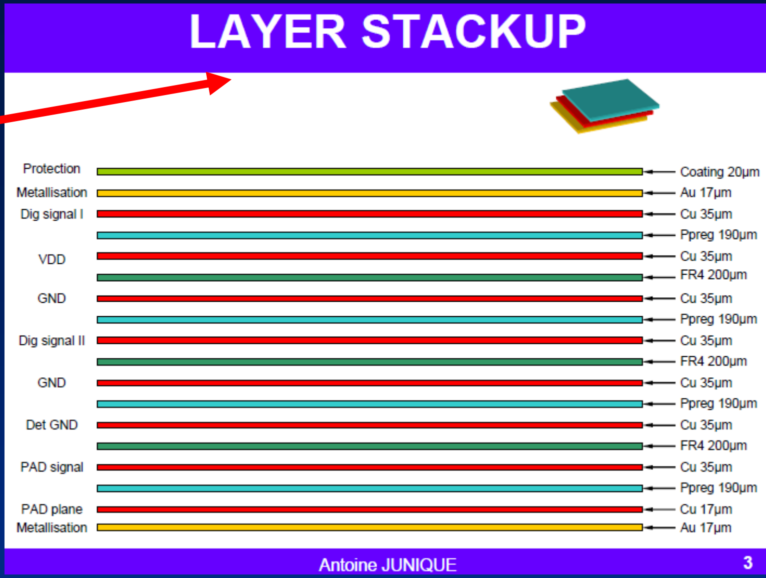
-- Cable for fieldcage: one 70 kV cable, φ ~ 15 mm (Catherine's estimate is o.k.)

-- Cables for MPGD, gating, clock, readout optical fibre, etc : ~ 10/ROB (depends on layout) ⇒ material small.

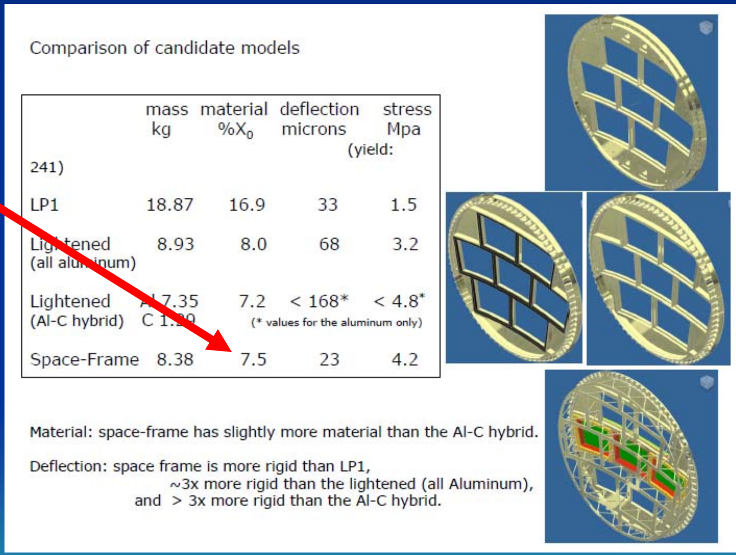
-- Power cables ⇒ material large. This is important because the material is large and is very sensitive to the cable layout scheme, and we have not had enough time to work this out. We must try to do this within the next few weeks.

X_0 Thicknesses

Sum of these plus S-Altros
~ 5 % X_0



Dan estimated at last meeting the space-frame thickness
~ 8 % X_0 for the LP size. We don't know yet how this translates to the LCTPC size.



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~3x more rigid than the lightened (all Aluminum),
and > 3x more rigid than the Al-C hybrid.

Cooling (my guess, needs confirmation)
~ 2% X_0

Cable layout --- work in progress --- but it looks like the above X_0 may be doubled.

LCTPC milestones

2006-2012	Continue LCTPC R&D via small-prototypes and LP tests
2013	Decide on all parameters
2014	Final design of the LCTPC
2018	Four years construction
2019-20	Commission/Install TPC in the ILC Detector