Requirements for ALICE ITS3…
and a bit beyond

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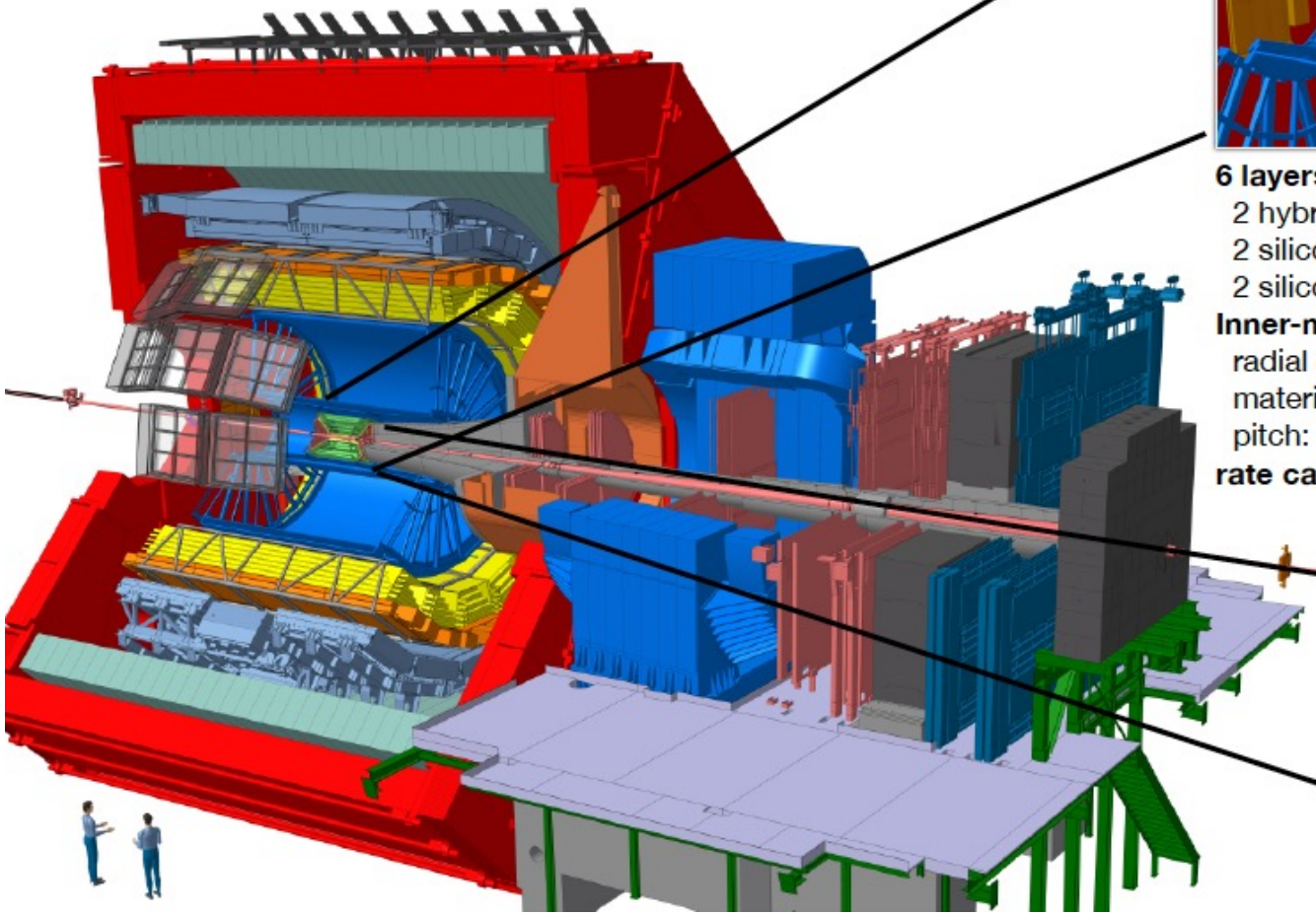
Disclaimer:

no time to contact proper ALICE physicist for this talk

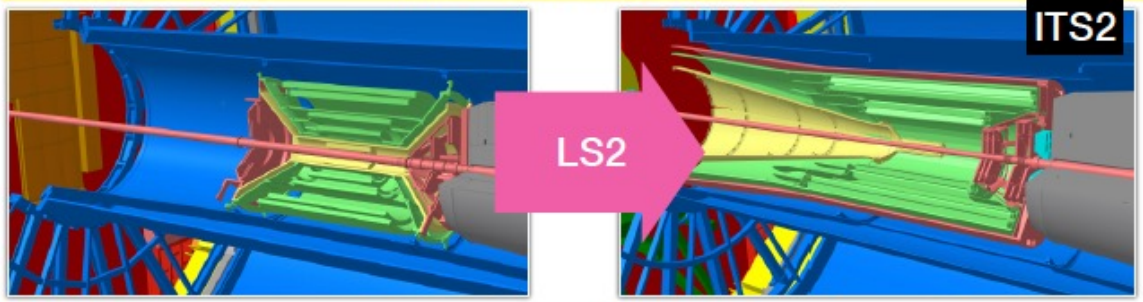
Material mostly stolen from Magnus Mager's talk @ LCWS
https://indico.cern.ch/event/995633/contributions/4259506

ALICE today

Particles with p < 1 GeV/c
critical for physics program



Inner Tracking System



6 layers:
- 2 hybrid silicon pixel
- 2 silicon drift
- 2 silicon strip

Inner-most layer:
- radial distance: 39 mm
- material: $X/X_0 = 1.14\%$
- pitch: 50 × 425 µm²

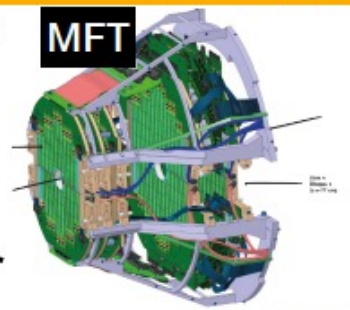
rate capability: 1 kHz

7 layers:
- all MAPS

Inner-most layer:
- radial distance: 23 mm
- material: $X/X_0 = 0.3\%$
- pitch: O(30 × 30 µm²)

rate capability: 100 kHz (Pb-Pb)

Muon Forward Tracker



new detector

5 discs, double sided:
- based on same technology as ITS2

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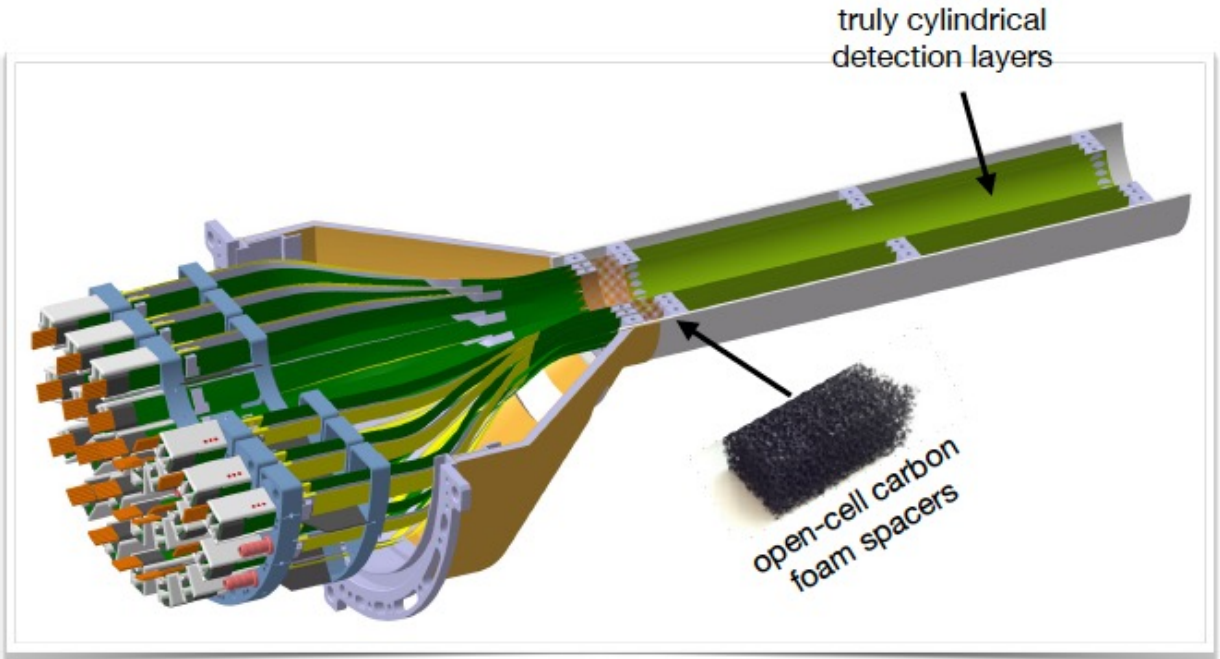
ITS3 concept

ALICE-PUBLIC-2018-013



Beam pipe Inner/Outer Radius (mm)	16.0/16.5		
IB Layer Parameters	Layer 0	Layer 1	Layer 2
Radial position (mm)	18.0	24.0	30.0
Length (sensitive area) (mm)	300		
Pseudo-rapidity coverage	±2.5	±2.3	±2.0
Active area (cm^2)	610	816	1016
Pixel sensor dimensions (mm^2)	280 x 56.5	280 x 75.5	280 x 94
Number of sensors per layer	2		
Pixel size (μm^2)	O (10 x 10)		

Probably 15x15 µm

- Key ingredients:
  - 300 mm wafer-scale chips, fabricated using stitching
  - thinned down to 20-40 µm (0.02-0.04% X0), making them flexible
  - bent to the target radii
  - mechanically held in place by carbon foam ribs
- Key benefits:
  - extremely low material budget: 0.02-0.04% X0 (beampipe: 500 µm Be: 0.14% X0)
  - homogeneous material distribution: negligible systematic error from material distribution

The whole detector will comprise six (!) chips – and barely anything else

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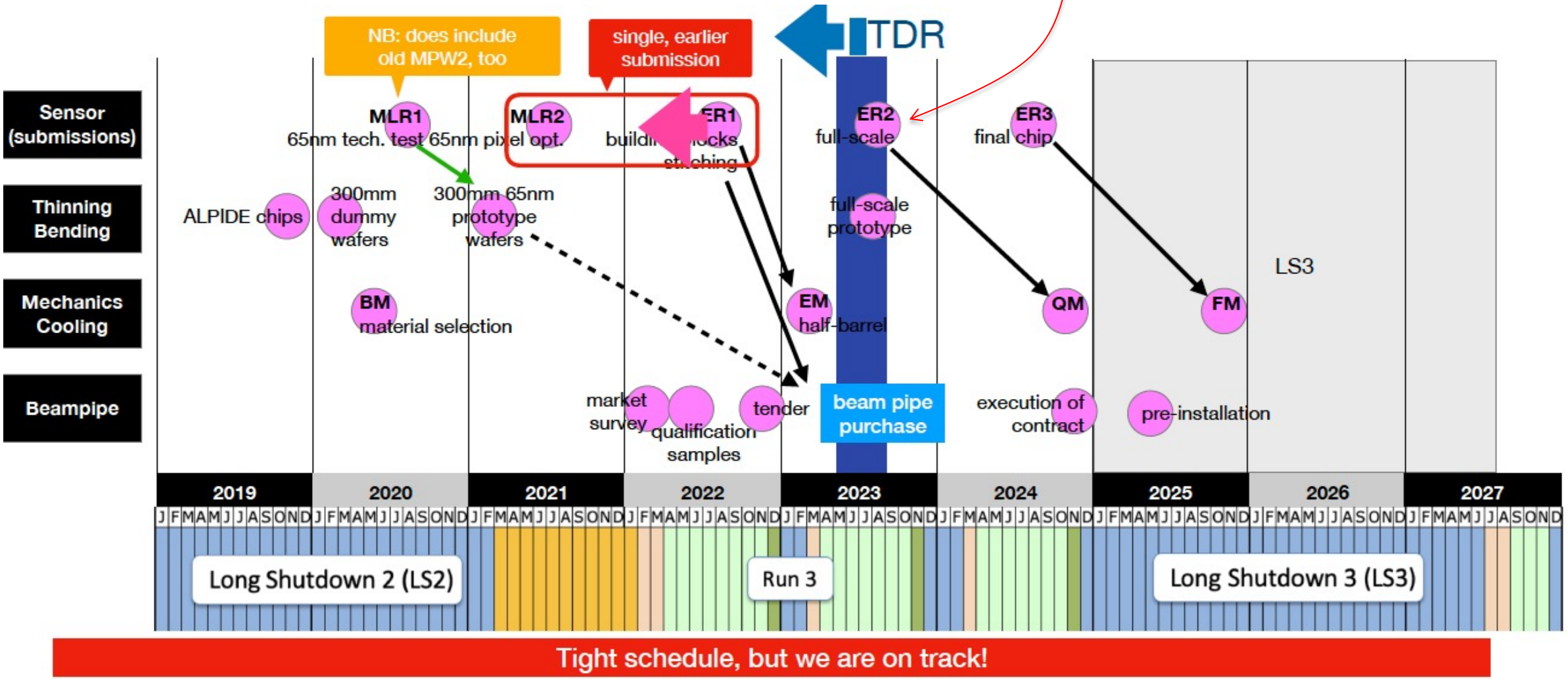
ITS3 timeline

Could be technological demonstrator shared by various scientific project



Tight schedule, but we are on track!

MLR: multiple layer per reticle, **ER:** engineering run,
BM: breadboard module, **EM:** engineering module, **QM:** qualification module, **FM:** final module

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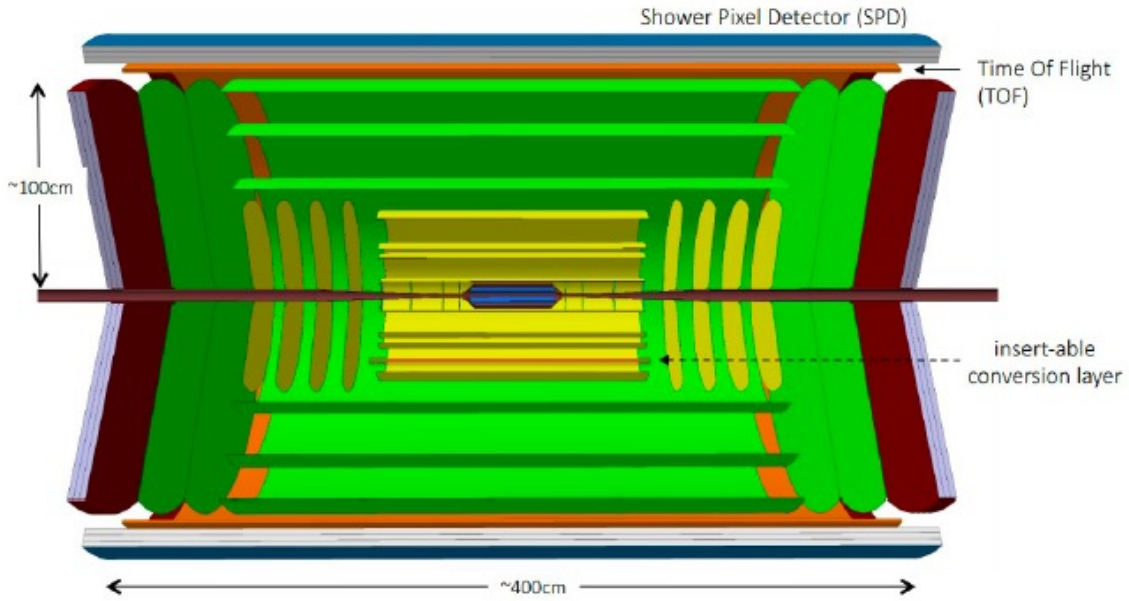
Beyond ITS3 : ALICE-3



"100% CMOS" experiment

Characteristics :

. Hyper-granularity
. $|\eta| < 4$
. B_z = 0.2, 0.5 and/or 1 T ?
. 0.05 % - 0.8% x/X_0 per layer
. $p_T > 50$ MeV/c
. "triggerless"
. $\mathcal{O}$(1 MHz) MB readout

Target PID species :

. $h^{\pm}$, π, K, p + light nuclei
. soft $e^{\pm}$, γ

1st design sub-detectors :

. CMOS tracker, pixel $\mathcal{O}(20\text{x}20\ \mu m^2) \approx$ 10 layers, $|\eta| < 4$
. pixellated TOF CMOS SPAD $\sigma_{TOF} \approx \mathcal{O}$(20 ps), $|\eta| < 1.4$
. electron pre-shower (CMOS sampled), $|\eta| < 4$

LS4 project
budget ~100 MCHF

ALICE ≈ EoI, arXiv:1902.01211

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Some personal comments

- The ITS3 concept is a breakthrough in our domain
  - The breakthrough is the **stitching** part (not the 65 nm technology)
    - Some initial requirements are a compromise
  - Naturally it is risky
    - Yield of stitched sensor
    - Compatibility of power dissipation required over large sensor with air-cooling
  - Budget for sensor fab+thinning/bending
    - R&D phase ~1MCHF
    - Construction ~ 1.3 MCHF

Parameter	ALPIDE (existing)	Wafer-scale sensor (this proposal)
Technology node	180 nm	65 nm
Silicon thickness	50 µm	20-40 µm
Pixel size	27 x 29 µm	O(10 x 10 µm) 5 um resol OK
Chip dimensions	1.5 x 3.0 cm	scalable up to 28 x 10 cm
Front-end pulse duration	~ 5 µs	~ 200 ns
Time resolution	~ 1 µs	< 100 ns (option: <10ns) ?
Max particle fluence	100 MHz/cm^2	100 MHz/cm^2
Max particle readout rate	10 MHz/cm^2	100 MHz/cm^2
Power Consumption	40 mW/cm^2	< 20 mW/cm^2 (pixel matrix) critical
Detection efficiency	> 99%	> 99%
Fake hit rate	< 10^{-7} event/pixel	< 10^{-7} event/pixel
NIEL radiation tolerance	~3 x 10^{13} 1 MeV n_{eq}/cm^2	10^{14} 1 MeV n_{eq}/cm^2
TID radiation tolerance	3 MRad	10 MRad

ITS-3 Kick-off Dec.2019, M.Mager

- The 65nm process offers other benefits (that we cannot ignore)
  - Spatial resolution is first (getting down to 3 um)
  - Due to thin sensitive layer => time resolution might come almost for free