MicroChannel Cooling for NA62

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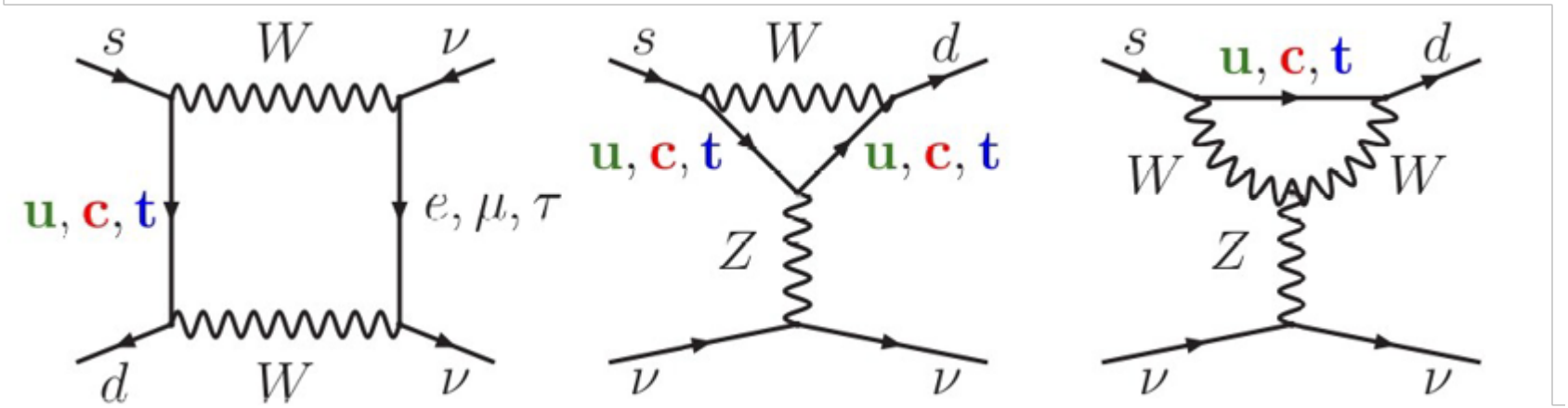
Context and Interest

- NA62 is exploring New Physics at very high energy scales (~100 TeV) with the $K^+ \to \pi^+ \nu\bar{\nu}$

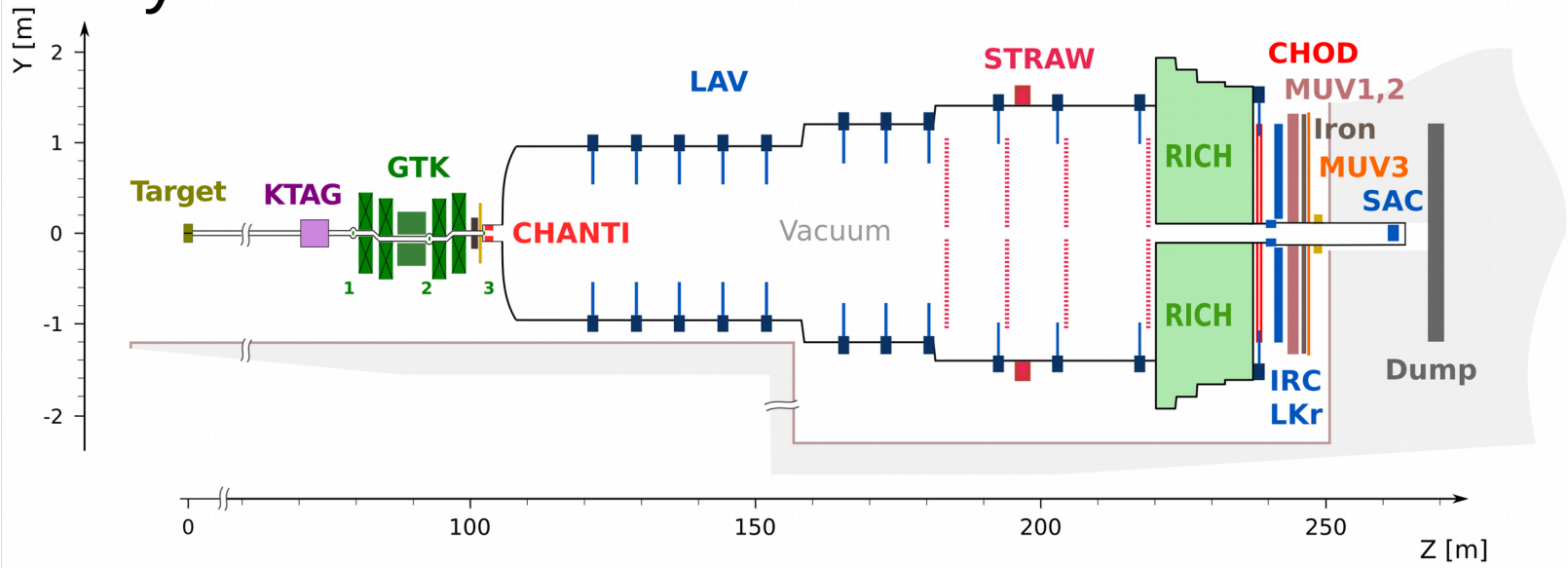


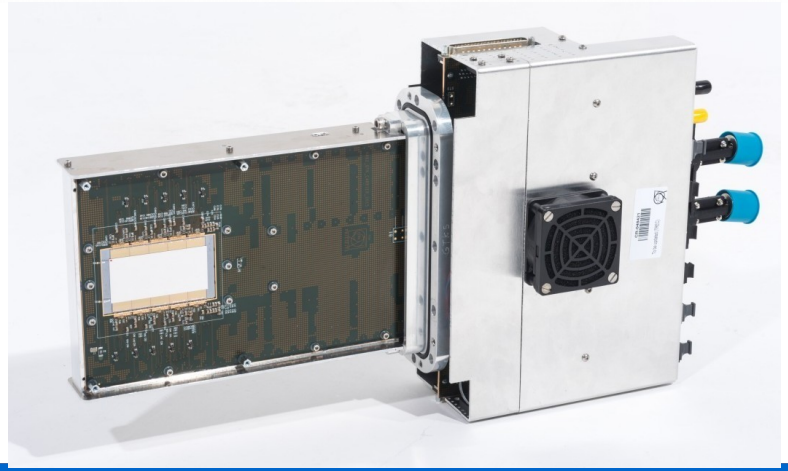
- Experimental challenge is Background Suppression

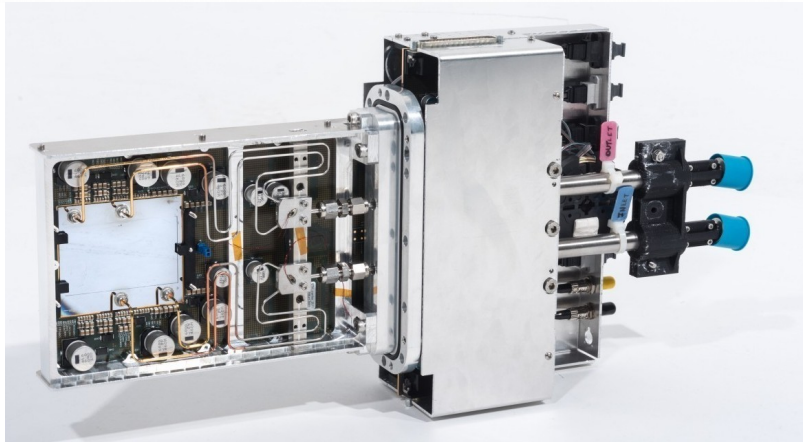
  One example: $B(K^+ \to \pi^+ \pi^0(\gamma\gamma)) \sim 20\ \%$

NA62

- Trackers allows to reject background based on the decays kinematics





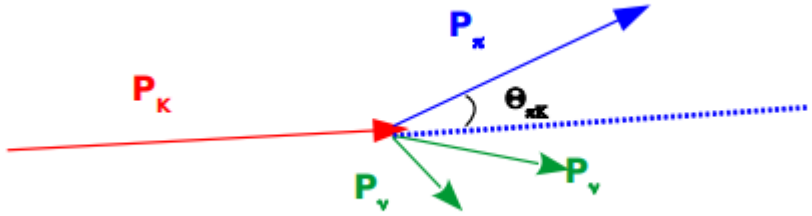


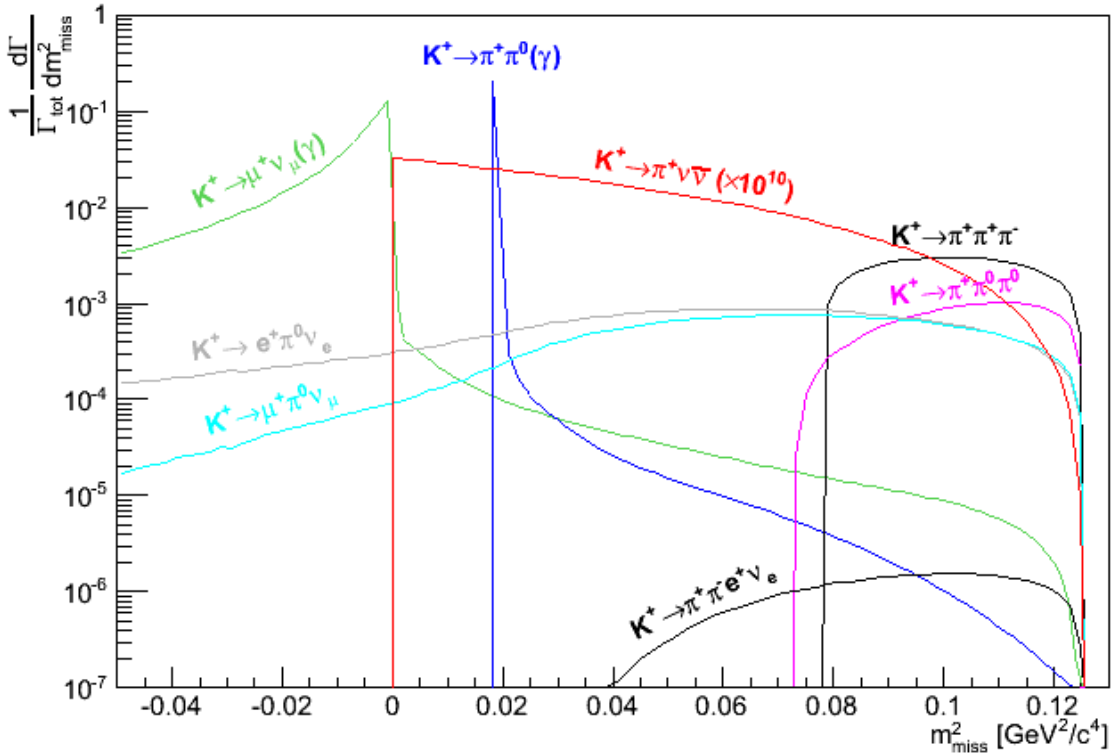
NA62

- Trackers allows to reject bkg based on the decays kinematics

$$m^2_{miss} = (P_K - P_{\pi^+})^2$$

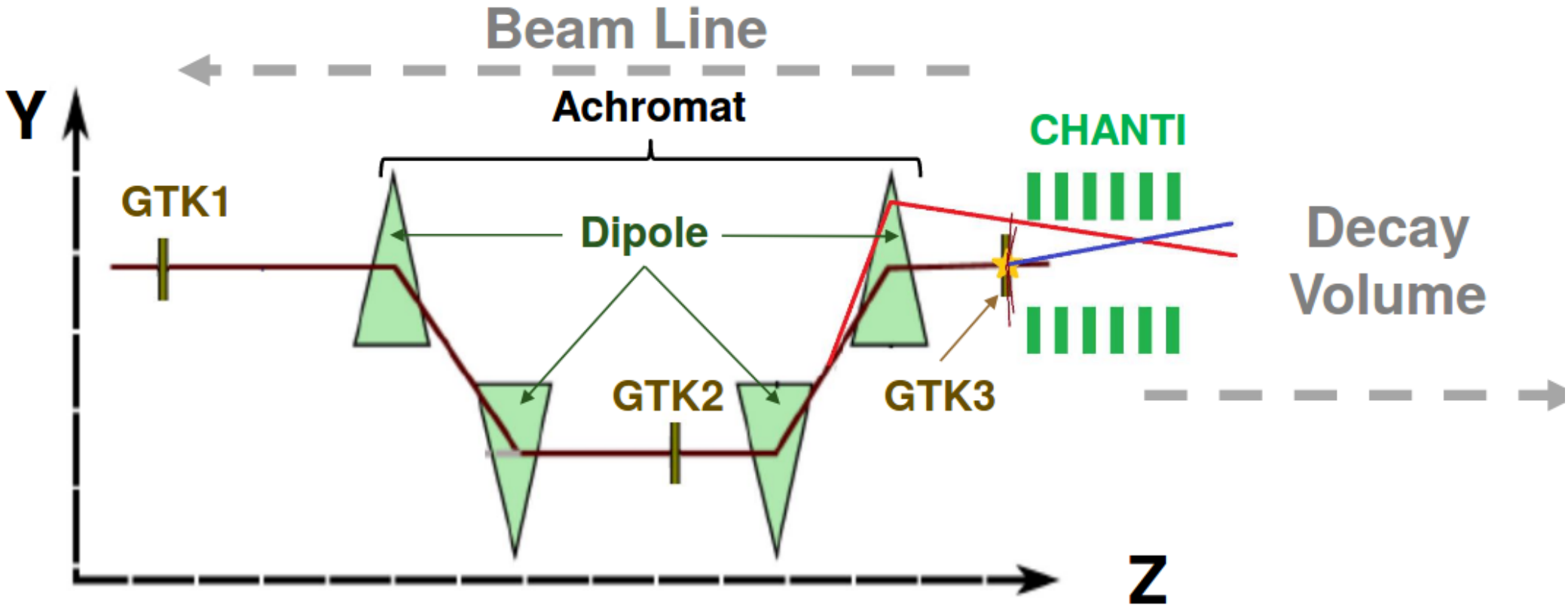
π^+ mass hypothesis





Upstream Background

- Decays along the beam line; beam particle interactions in GTK
- Random track matched in GTK and/or possible additional energy not detected



- Specific cuts against upstream background

1) $K - \pi$ matching 2) Z_{vertex} 3) CHANTI veto

4) Cut on X,Y π^+ at the entrance of the decay volume («Box cut»)

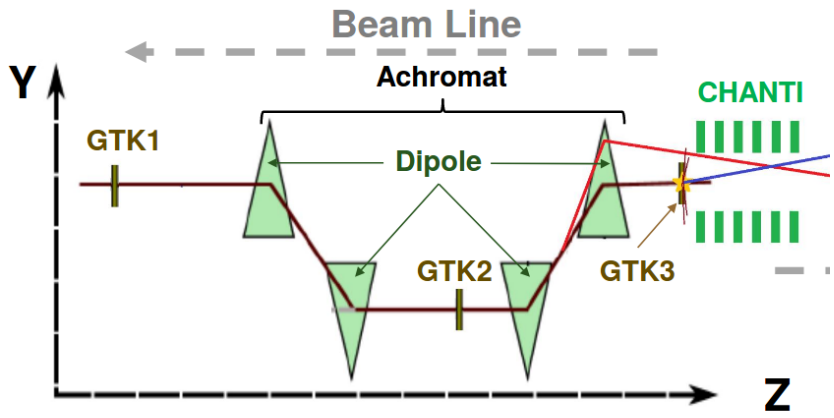
Status

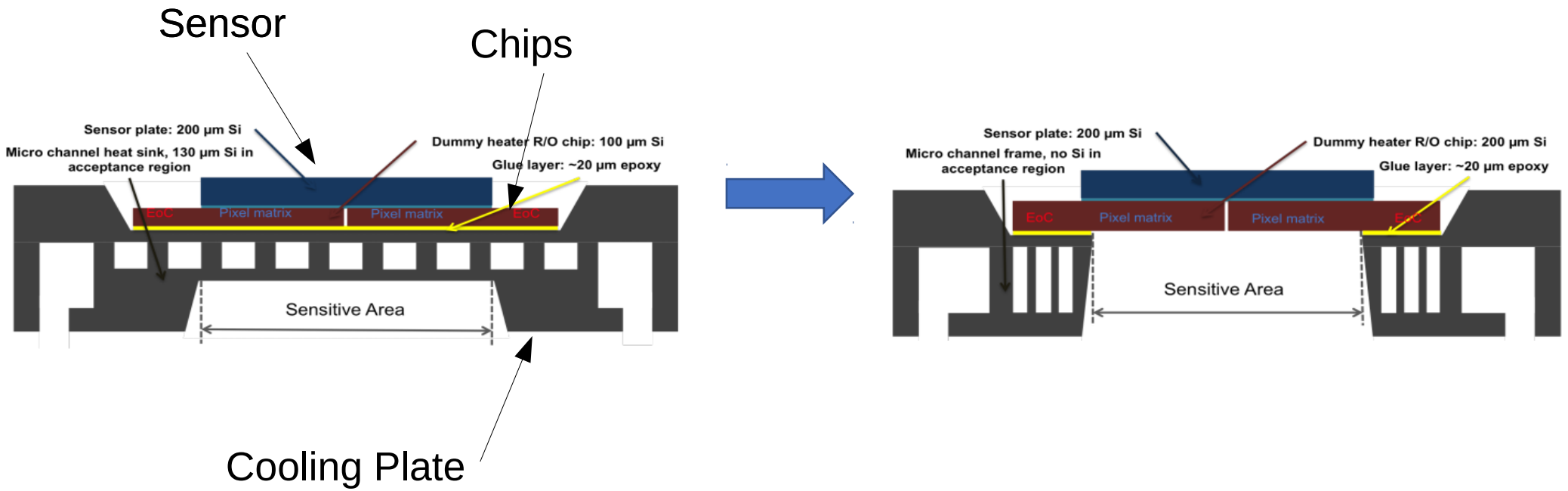
- 2016 data analysis shows a clear need to improve on upstream background

Process	Expected events in R1+R2
$K^+ \to \pi^+ \nu\bar{\nu}$ (SM)	$0.267 \pm 0.001_{stat} \pm 0.020_{syst} \pm 0.032_{ext}$
Total Background	$0.15 \pm 0.09_{\mathrm{stat}} \pm 0.01_{\mathrm{syst}}$
$K^+ \to \pi^+\pi^0(\gamma)$ IB	$0.064 \pm 0.007_{stat} \pm 0.006_{syst}$
$K^+ \to \mu^+\nu(\gamma)$ IB	$0.020 \pm 0.003_{stat} \pm 0.003_{syst}$
$K^+ \to \pi^+\pi^- e^+\nu$	$0.018^{+0.024}_{-0.017}\vert_{stat} \pm 0.009_{syst}$
$K^+ \to \pi^+\pi^+\pi^-$	$0.002 \pm 0.001_{stat} \pm 0.002_{syst}$
Upstream Background	$0.050^{+0.090}_{-0.030}\vert_{stat}$

How to Reduce Upstream Bkg ?

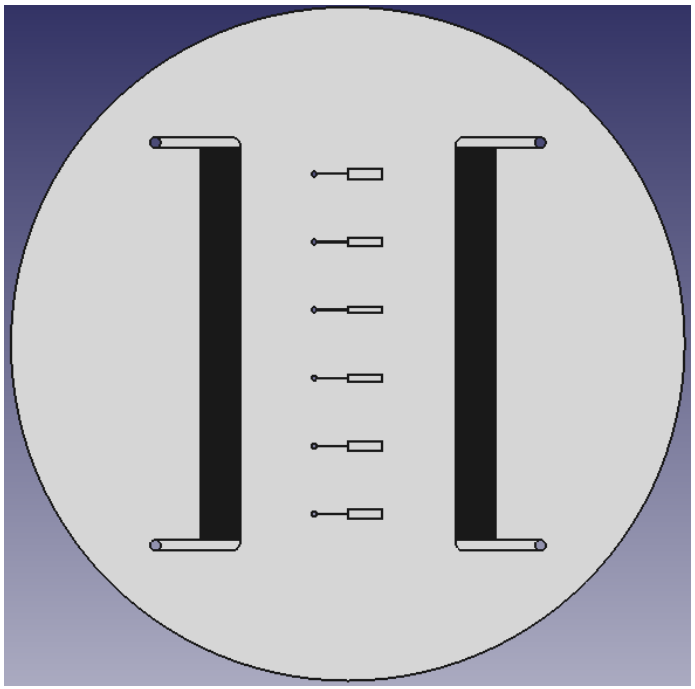
- Reduce material budget of the last tracking plane!
- Most heat is dissipated in chip tips
- Replace **cooling plate** by **cooling frame** : 0.5% X_0 → 0.3% X_0

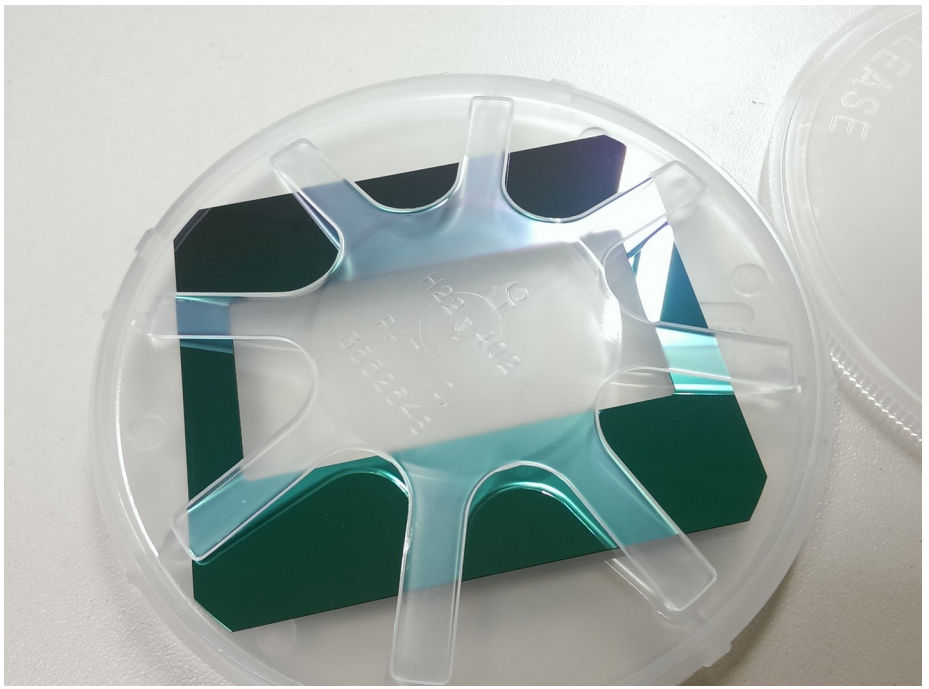




Status

- Simulation of the frame were done at Torino (see next)
- Cooling plate mockup cut by laser produced
- First prototype design being finalized for prod
  - Use CPPM Si-Si anodic bonding (backup : Si-Glass)
  - Use NA62 validated techno for all connection





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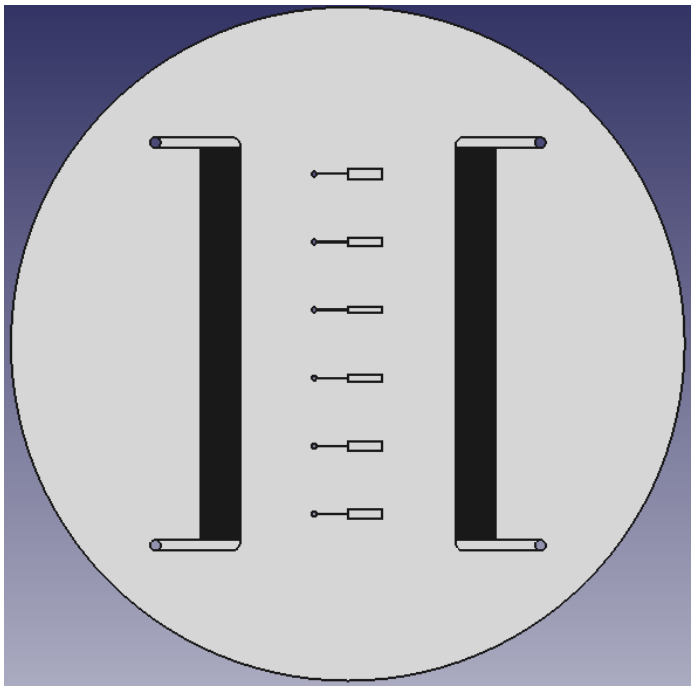
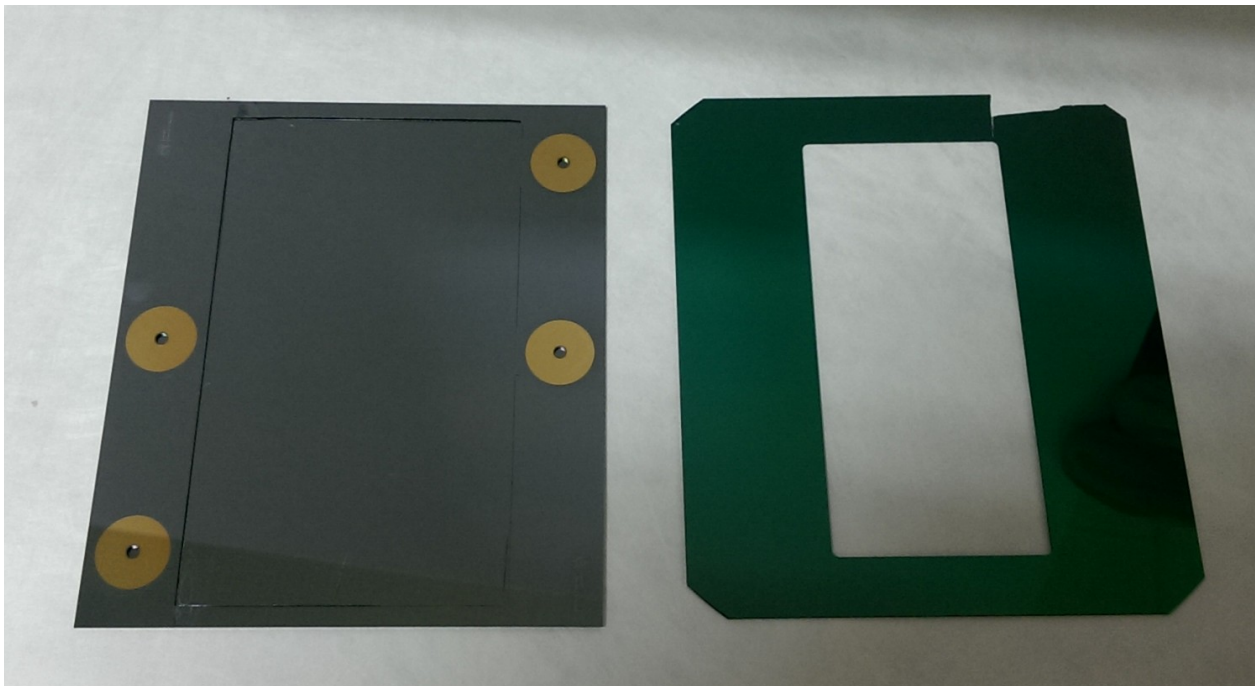




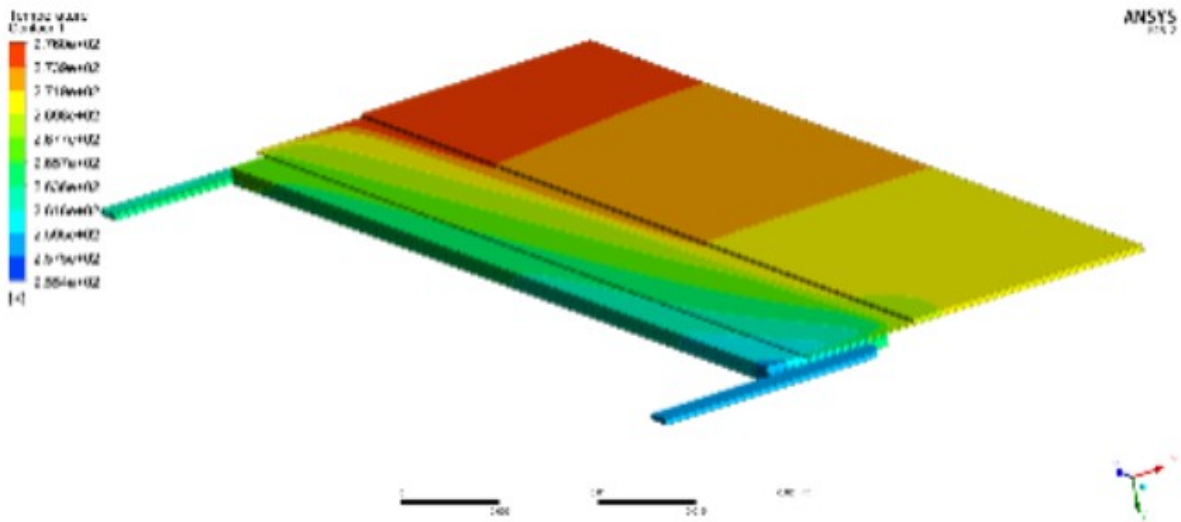
Simulations

Cooling fluid is liquid C6F14

Simulation domain with manifolds	
Mass flow rate	4.5 g/s
N° of channels	30
Channel length	58.2 mm
Manifold length	12.88 mm
Manifold width	1.6 mm
Manifold depth	0.3 mm
Tip radius	1.2 mm
Cover wafer thickness (T1)	0.525 mm

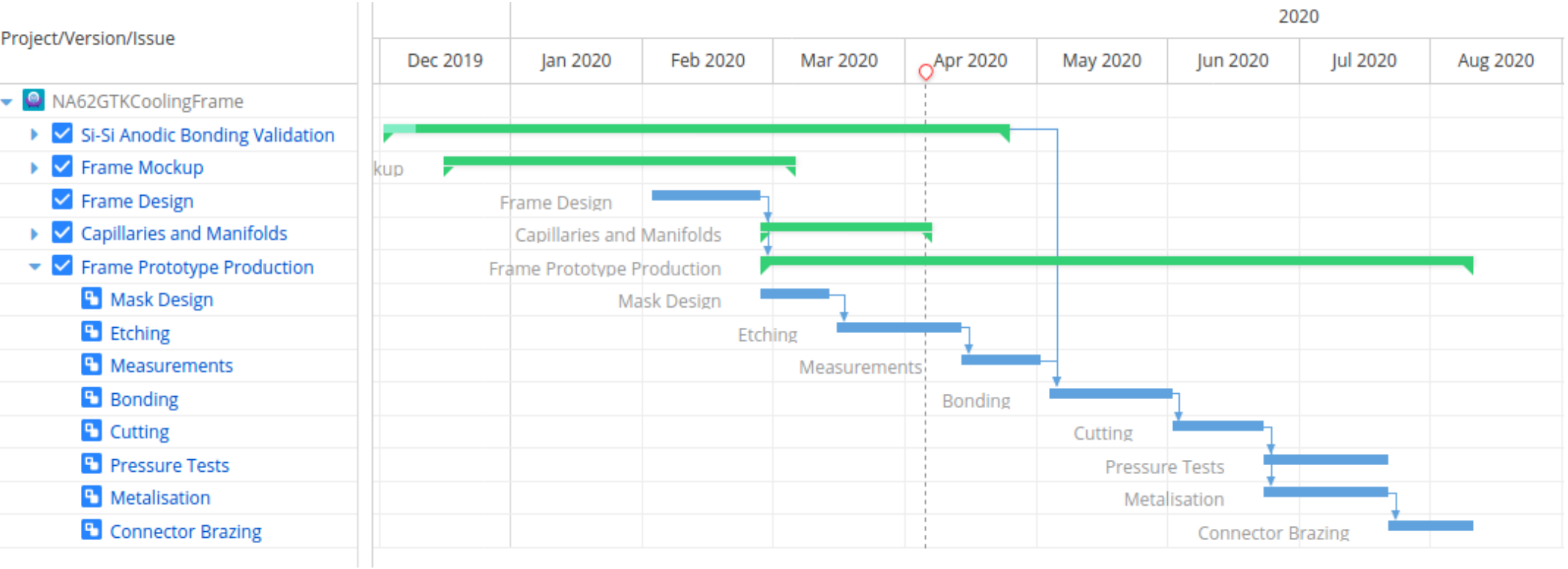
Results	
Pressure drop	4.35 bar
Max sensor temperature	2.6 °C
Min sensor temperature	-3.5 °C
Delta temperature	6.1 °C

- Microchannels are not as long as the sensor because of the introduction of manifolds.
- Silicon thermal capacity is neglected outside the channels area.
- The mass flow rate is not evenly distributed in the channels because there are manifolds.



Project Time Line

- Delays due to Covid-19 not accounted



What about CPPM ?

- **Minimum Investment** but **Maximum Visibility**
  - All costs paid by NA62
  - CPPM (M. P-T) enters only in project management
  - Demonstration in a running experiment of our technology as early as 2021 !
  - Major contribution to a crucial test of the SM
  - Synergy with LHCb and P2O