CepC CDR: potential INFN contributions

F. Bedeschi
CepC CDR meeting,
February 2017

Outline

- Prologue
- Physics
- Detector
- Conclusions

INFN & FCC

- INFN has active collaboration with FCC (ee and hh)
  - Coordination of working groups
    - EW physics, top physics
  - Physics studies
    - ee: Top quark, WW
    - hh: HH, top, BSM
  - Detector studies:
    - Development of FCC-ee detector
      - Experience from LEP
      - Dual Readout calorimeter from RD52 experience
      - Drift chamber from MEG-II experience and 4°
      - Vertex detector from ILD experience for ILC

INFN & CepC

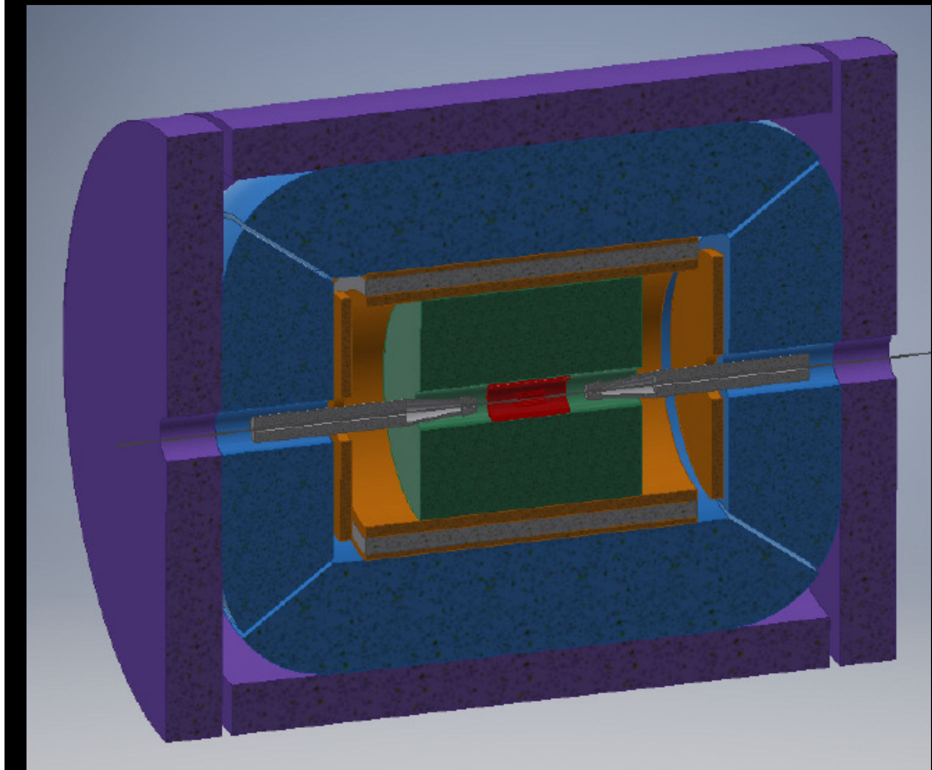
- CepC → FCC-ee: machines almost identical
  - Natural to share work for both
    - Lack of manpower → cooperation much better than competition
    - 2° detector for CepC proposed in HK
      - **IDEA** (International Detector for Electron-positron Accelerator)
      - Same detector currently studied for FCC-ee
- INFN management supports cooperation in many new accelerator projects including CepC
- Good relations with CERN very important → transparency
  - Additional cooperation by China on other big projects at CERN would help EU contributions to CepC

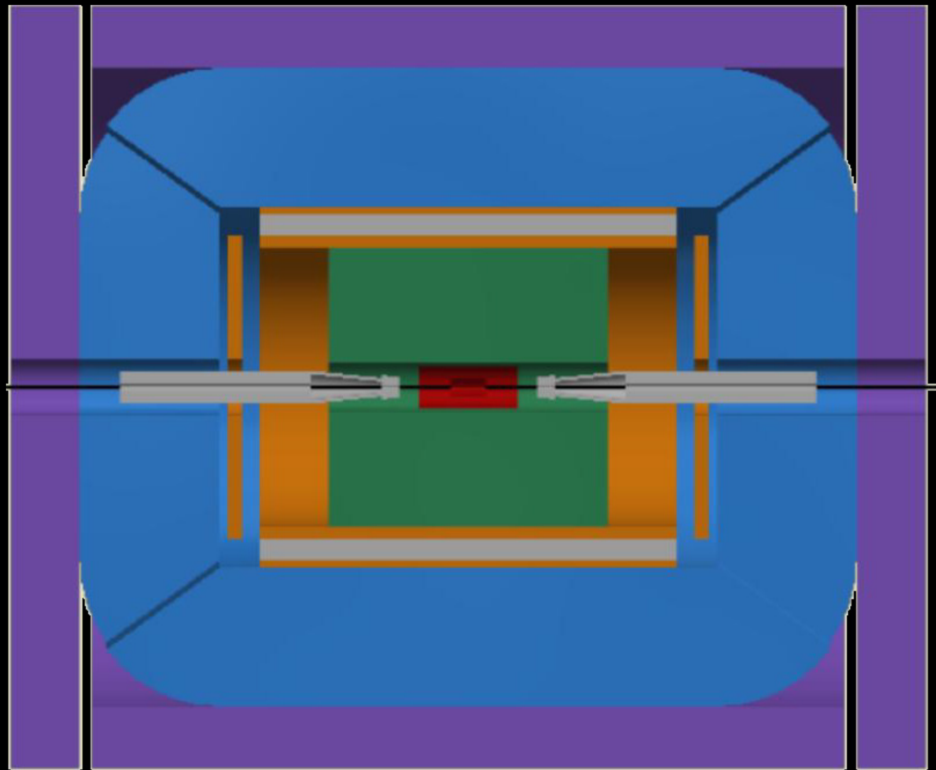
INFN: physics contributions to CDR

- EW physics:
  - Could transfer much work done for FCC on Z and WW
  - Fulvio potential (co)editor of CDR section
- Top physics:
  - Much work already done for FCC could be transfered
  - CepC could now be run at tt threshold
    - What are plans for running CepC at top threshold?
- SppC physics:
  - Many HH production, top and BSM studies made for FCC-hh
  - Potential for significant INFN contributions here
  - What is relevance of SppC in CDR?

INFN: detector contributions to CDR

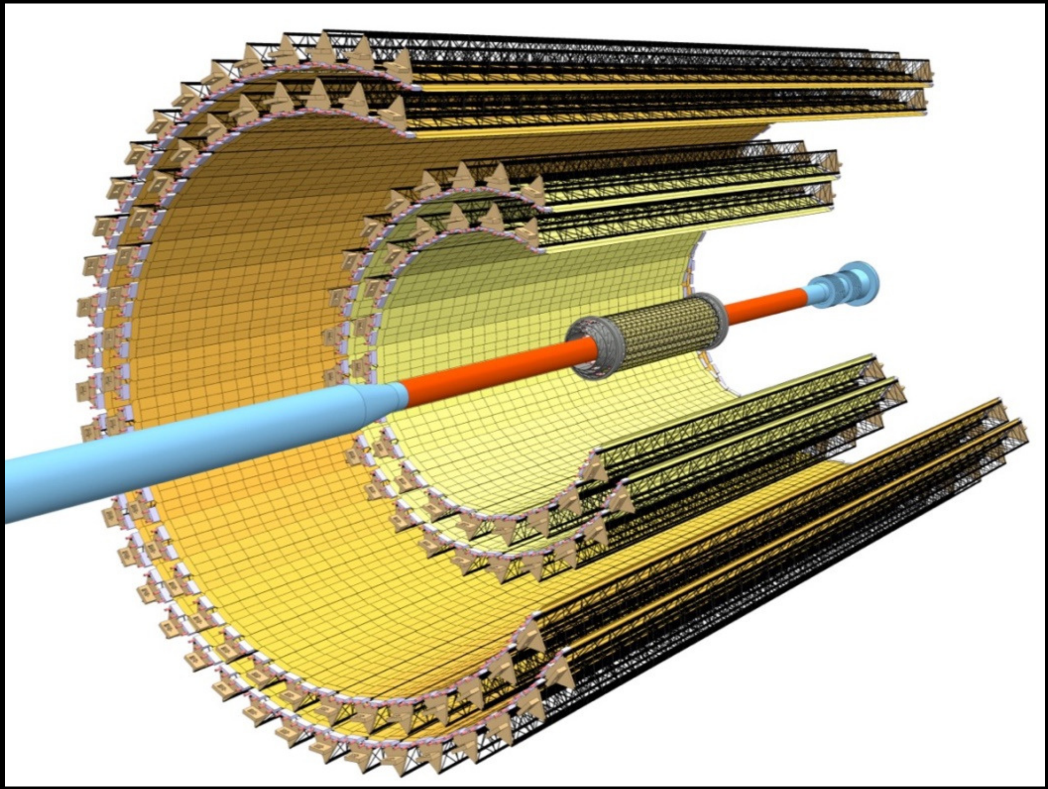
- 2° detector (IDEA)
  - Parallel development with FCC-ee →
  - Compare with CepC baseline/prepare for second interaction p.





Vertex detector

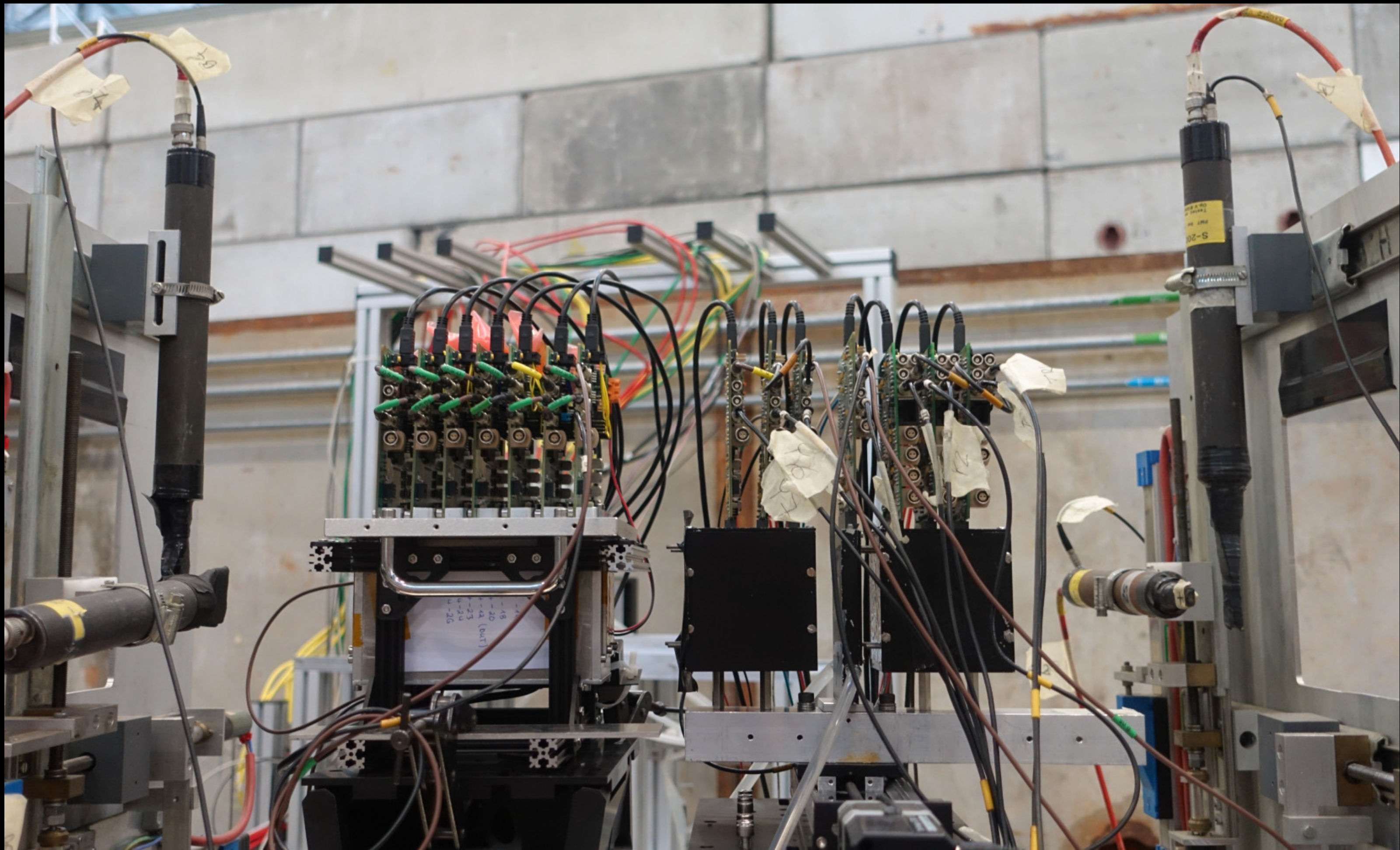
- Build on ALICE ITS technology
  - 30x30 μm MAPS
  - %X0
    - 0.3-1.0% (in-out)
  - Power:
    - 41-27 mW/cm2 (in-out)
  - Radiation hard
  - >100 kHz readout



- Optimize # layers

Vertex detector

- Impressive recent test beam results



Courtesy of ALICE J.W. van Hoorne

Vertex detector

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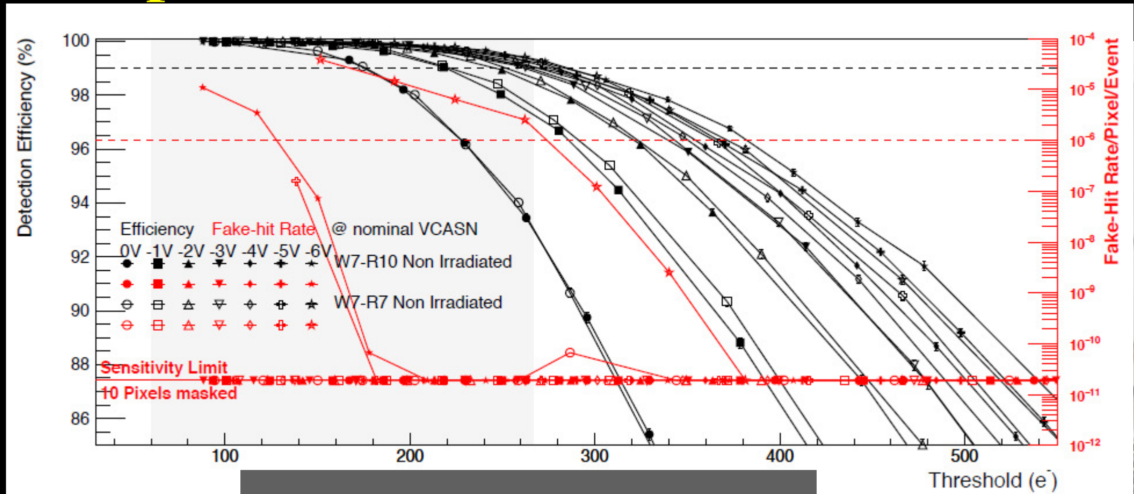
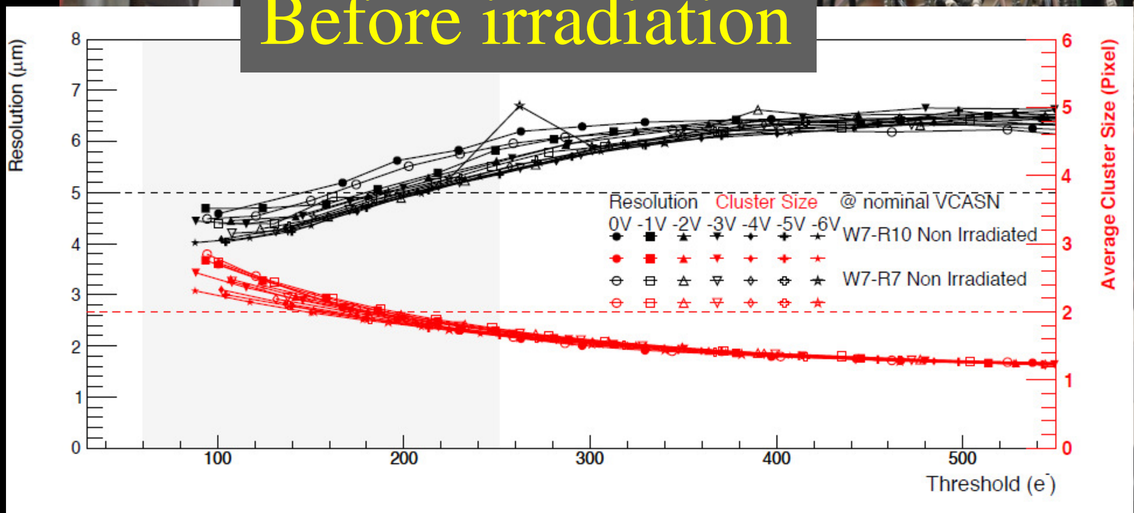


Before irradiation



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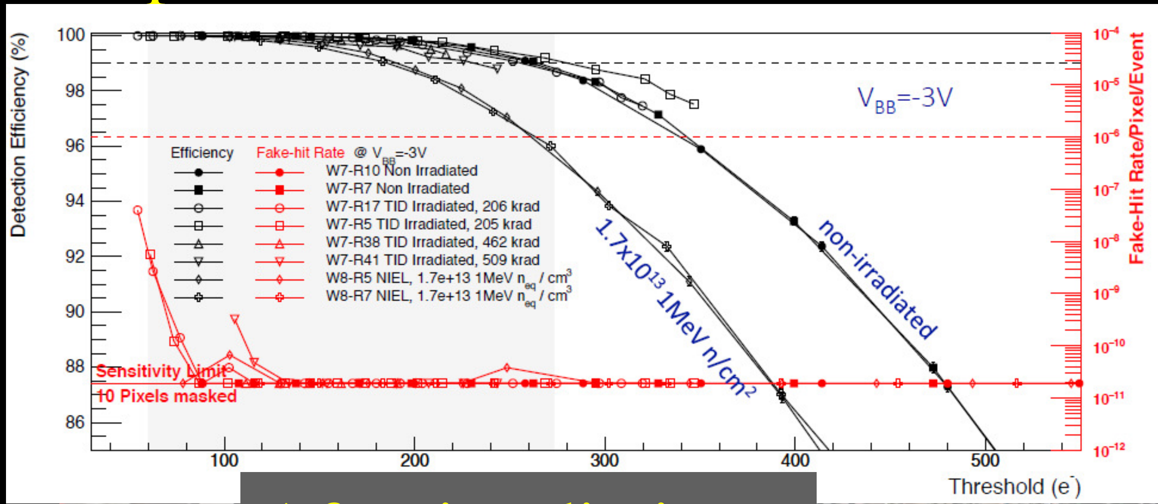

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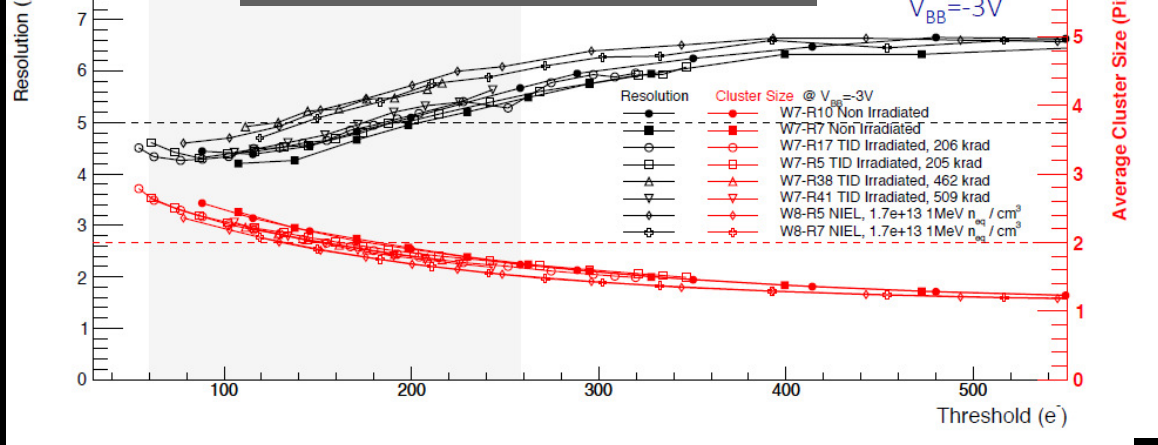

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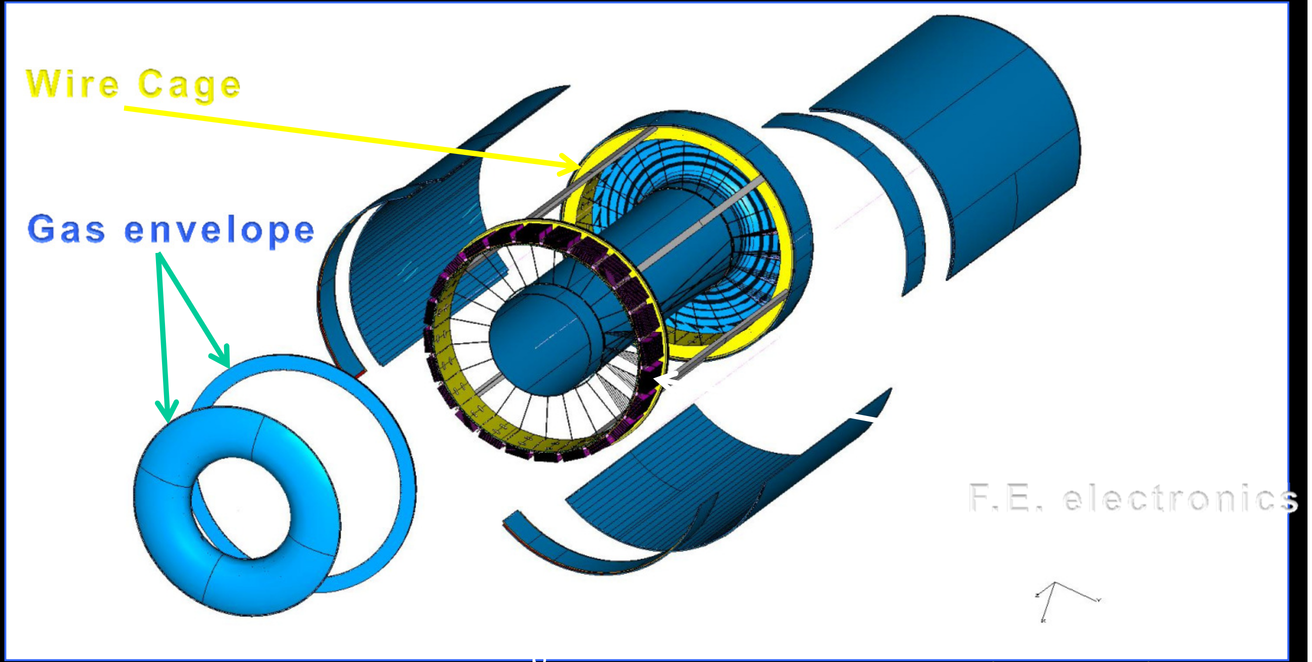
Tracker

- Drift Chamber: fast, small ion buildup, good dE/dx
  - Ultralight chamber (<1% X_0) – gas: He 90% - iC_4H_{10} 10%
  - 4 m long, drift length ~1 cm, drift time ~150ns, σ_{xy} < 100 μm

$$\frac{\Delta p_\perp}{p_\perp} = \frac{8\sqrt{5}\sigma}{.3BL^2\sqrt{n}} p_\perp = 7.1\times 10^{-5} p_\perp [GeV/c]$$

- B = 2 T
- L = 2 m
- N = 112



See talk of F. Grancagnolo

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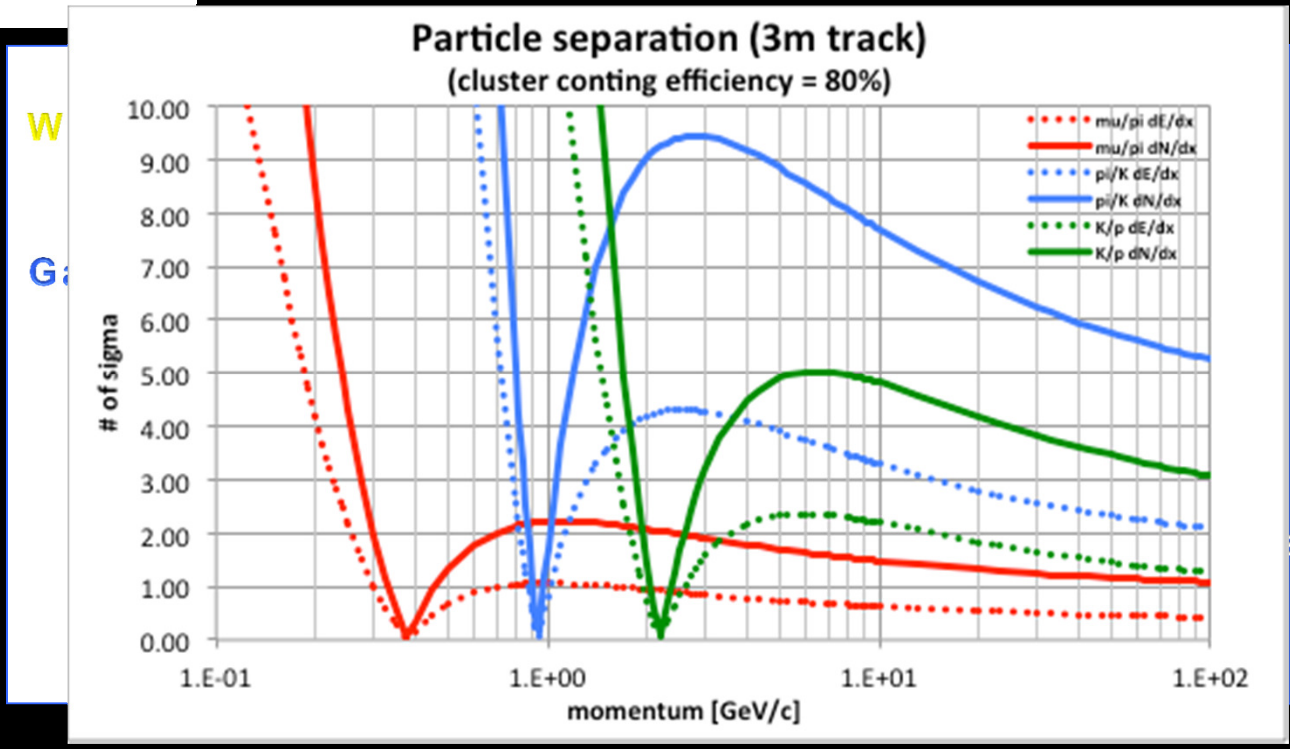
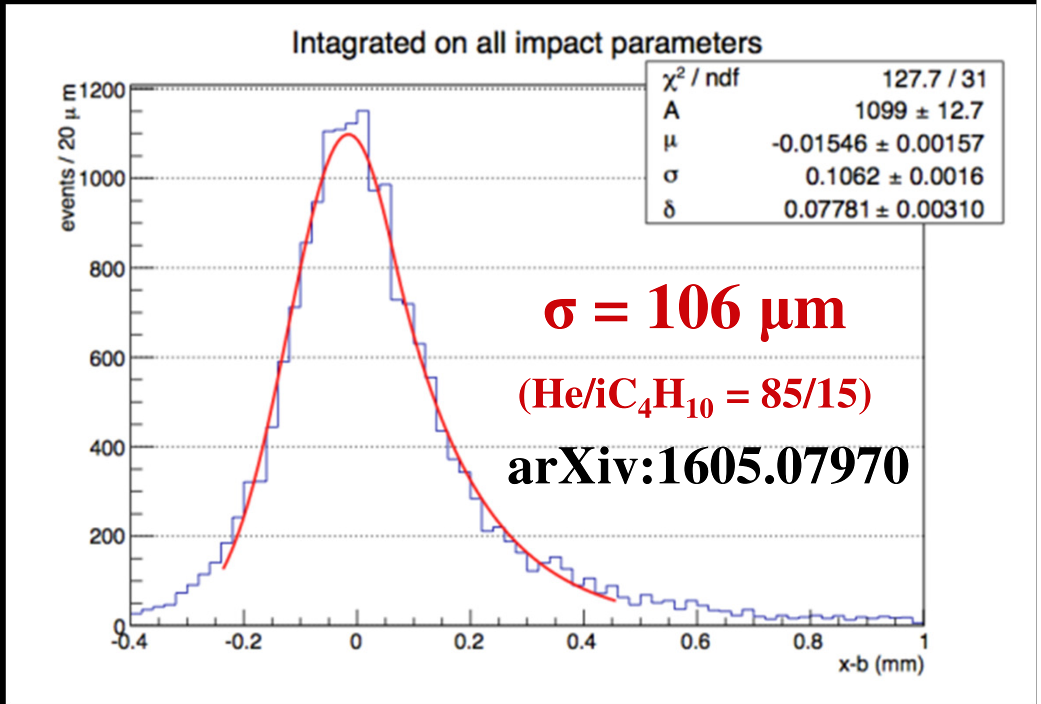
- dE/dx ~ 4%
- dN/dx ~ 2%

See talk of F. Grancagnolo



Tracker

❖ Minimal performance established (MEG-II prototype)



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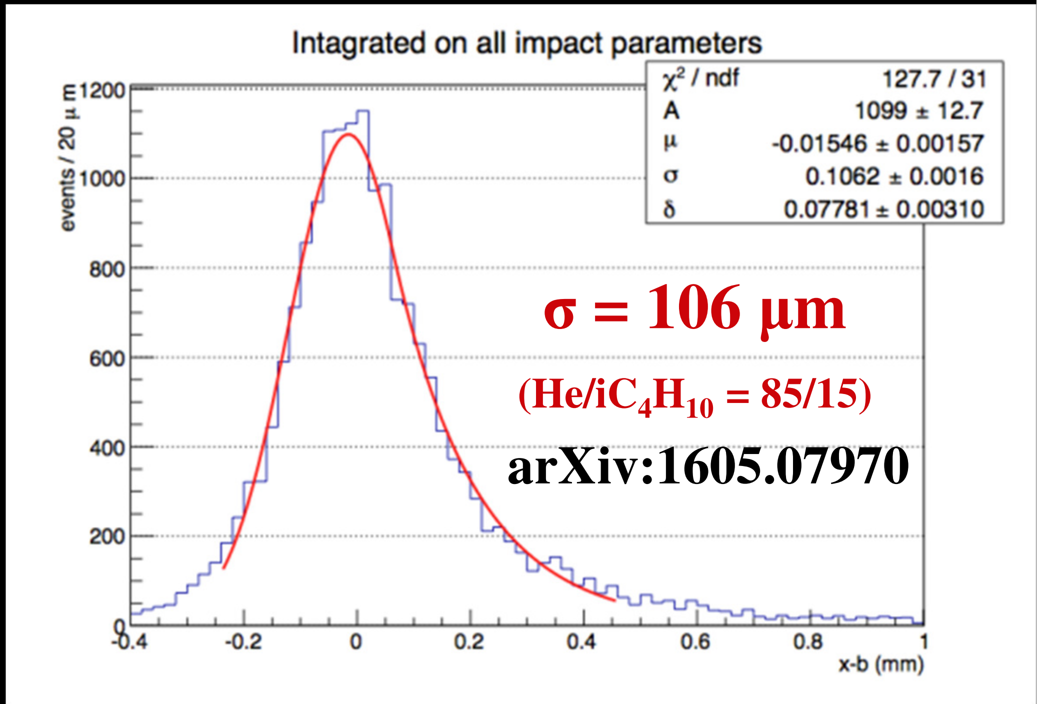
- Technical solutions engineered (MEG-II)



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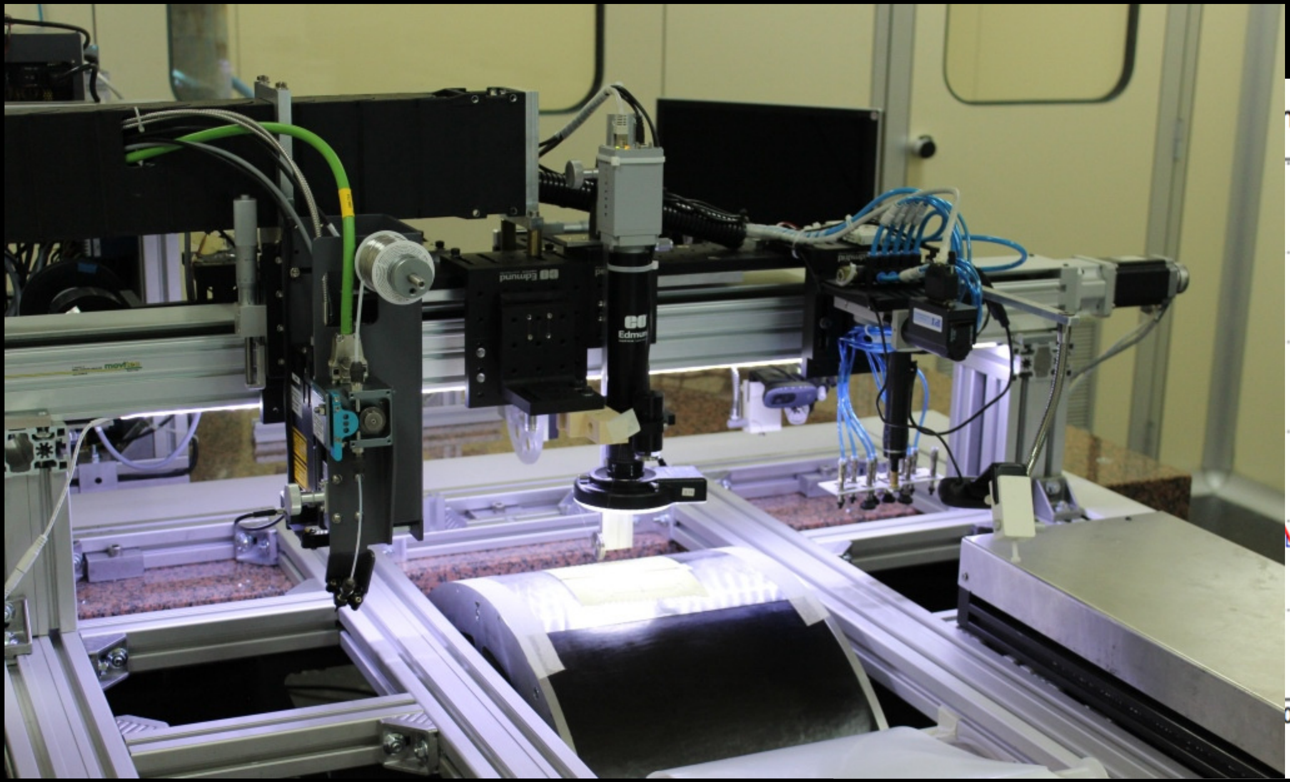
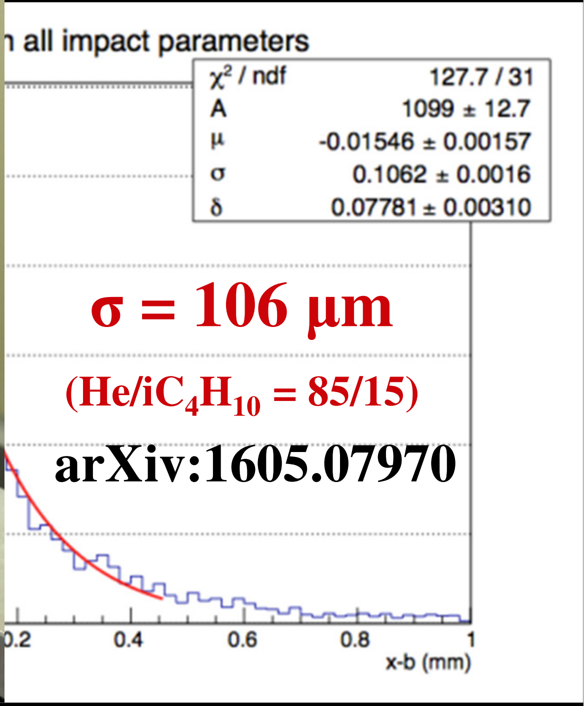
- Technical solutions engineered (MEG-II)
  - E.g. Wire stringing and soldering machine

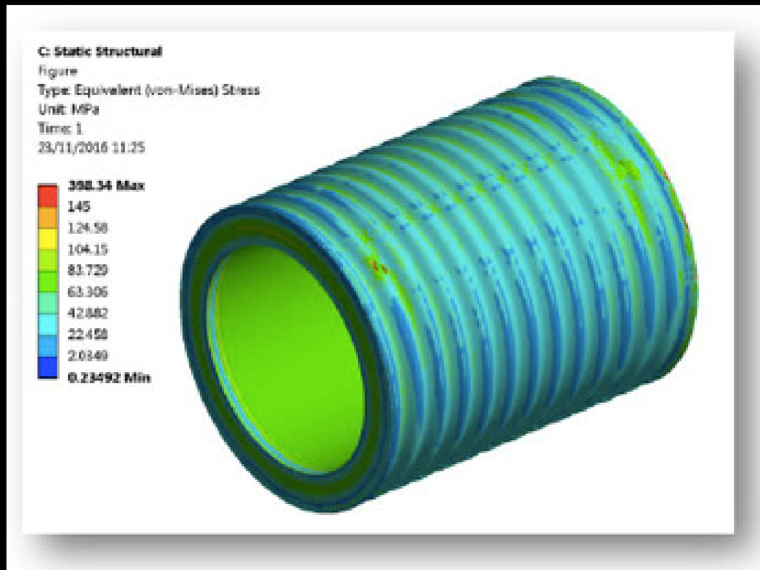




2T solenoid

- Two options:
  - Large bore (R=3.7 m) – calorimeter inside
  - Smaller bore (R=2.2 m) – calorimeter outside
    - Preferred: simpler/ Extreme EM resolution not needed
      - Thick calorimeter
    - Thin (30 cm): total = 0.74 X_0 (0.16 λ) at $\theta = 90°$

Property	Value
Magnetic field in center [T]	2
Free bore diameter [m]	4
Stored energy [MJ]	170
Cold mass [t]	8
Cold mass inner radius [m]	2.2
Cold mass thickness [m]	0.03
Cold mass length [m]	6

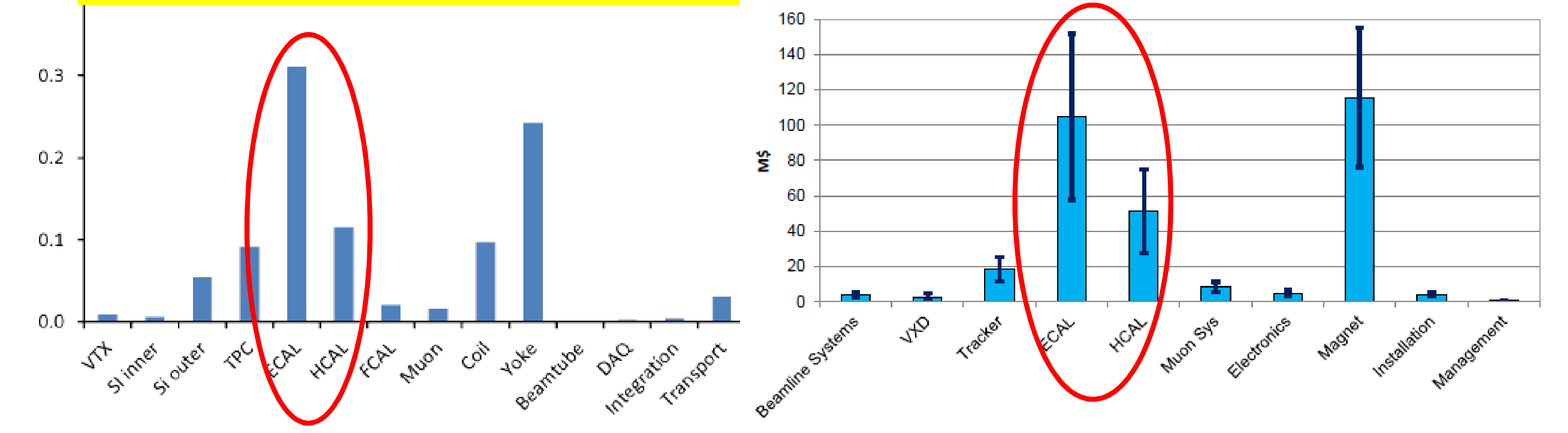


Courtesy of H. ten Kate et al.

Calorimeter

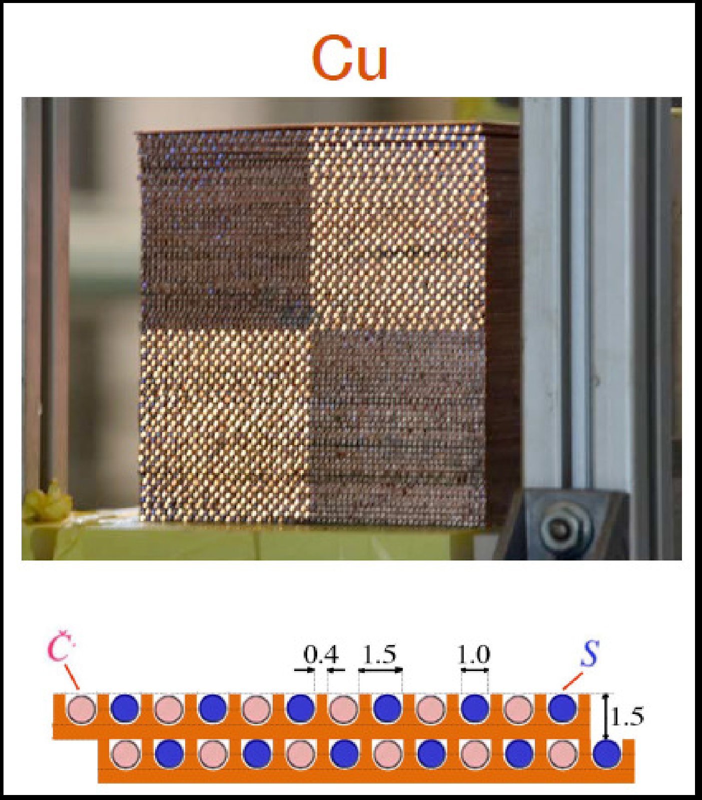
- Particle flow calorimeters are extremely expensive!
- Similar (or better) performances with dual readout
  - EM and HAD in same calorimeter
  - High transverse granularity

ILD: Fractional cost out of 400 M$



Calorimeter

❖ Copper dual readout calorimeter



Courtesy of DREAM/RD52

Calorimeter

- Copper dual readout calorimeter
  - Demonstrated EM resolution

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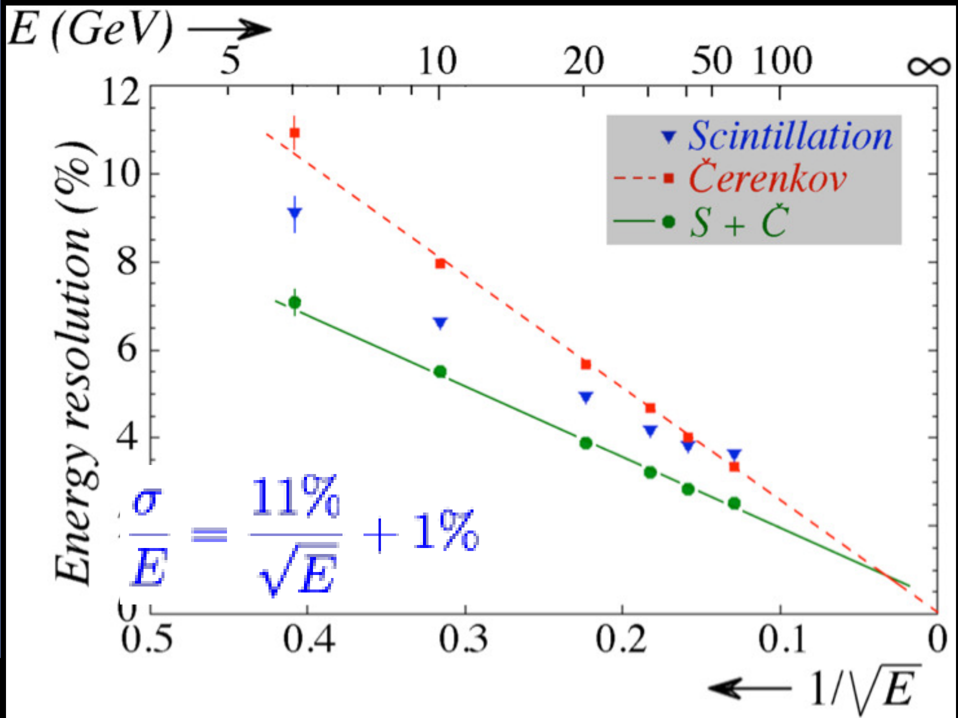

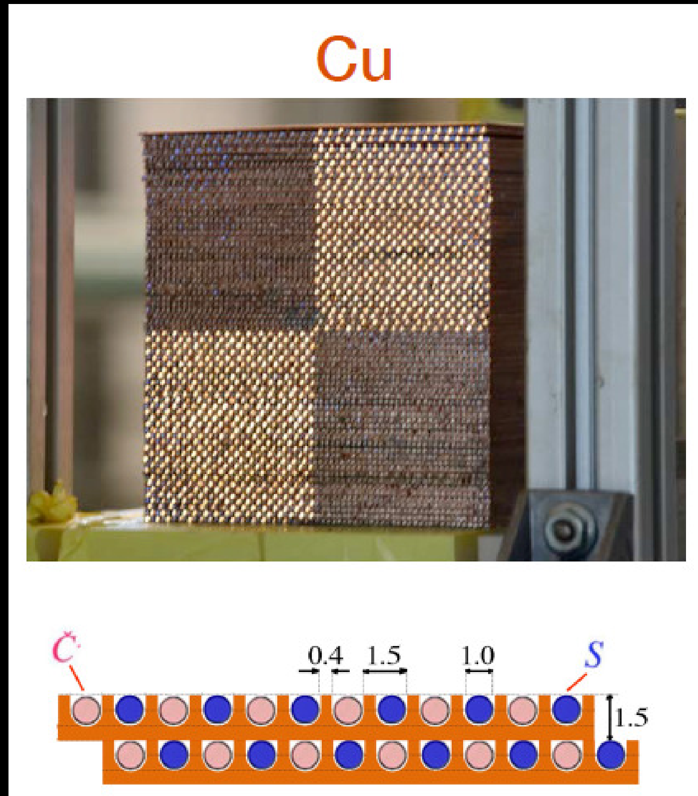

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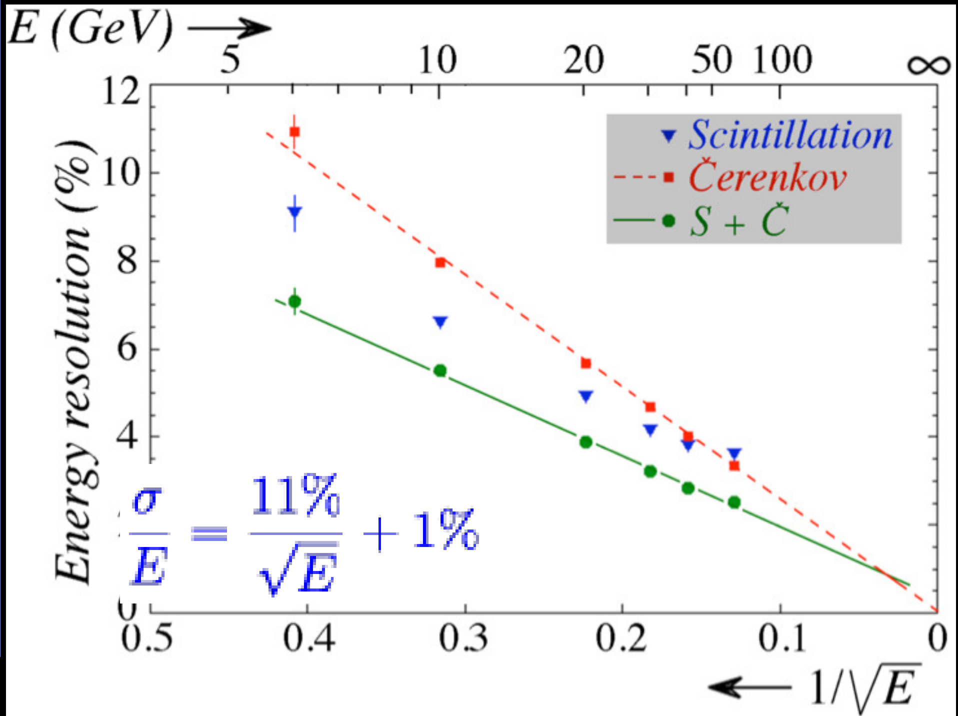
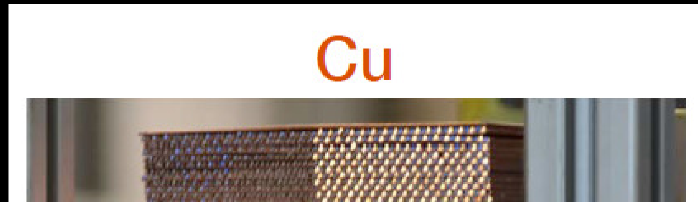
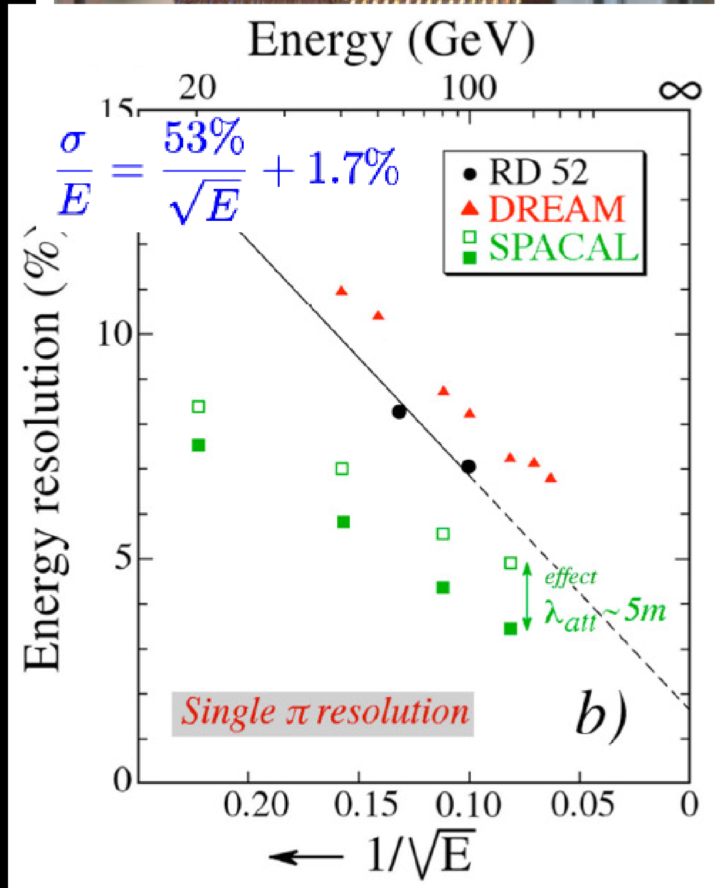
  - Demonstrated EM resolution
  - Observed Had resolution dominated by lateral leakage (~6%)

Courtesy of DREAM/RD52







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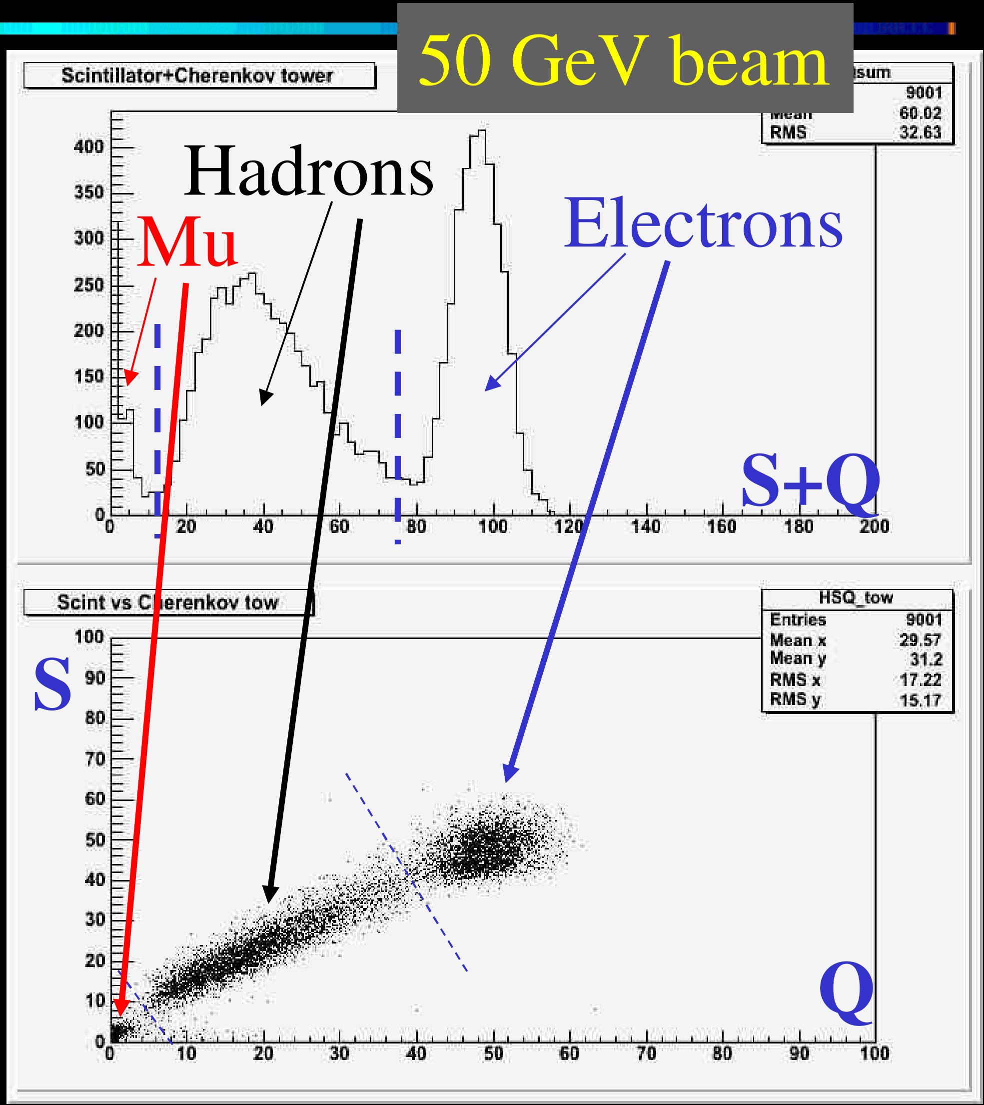

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- Natural μ/π/e separation
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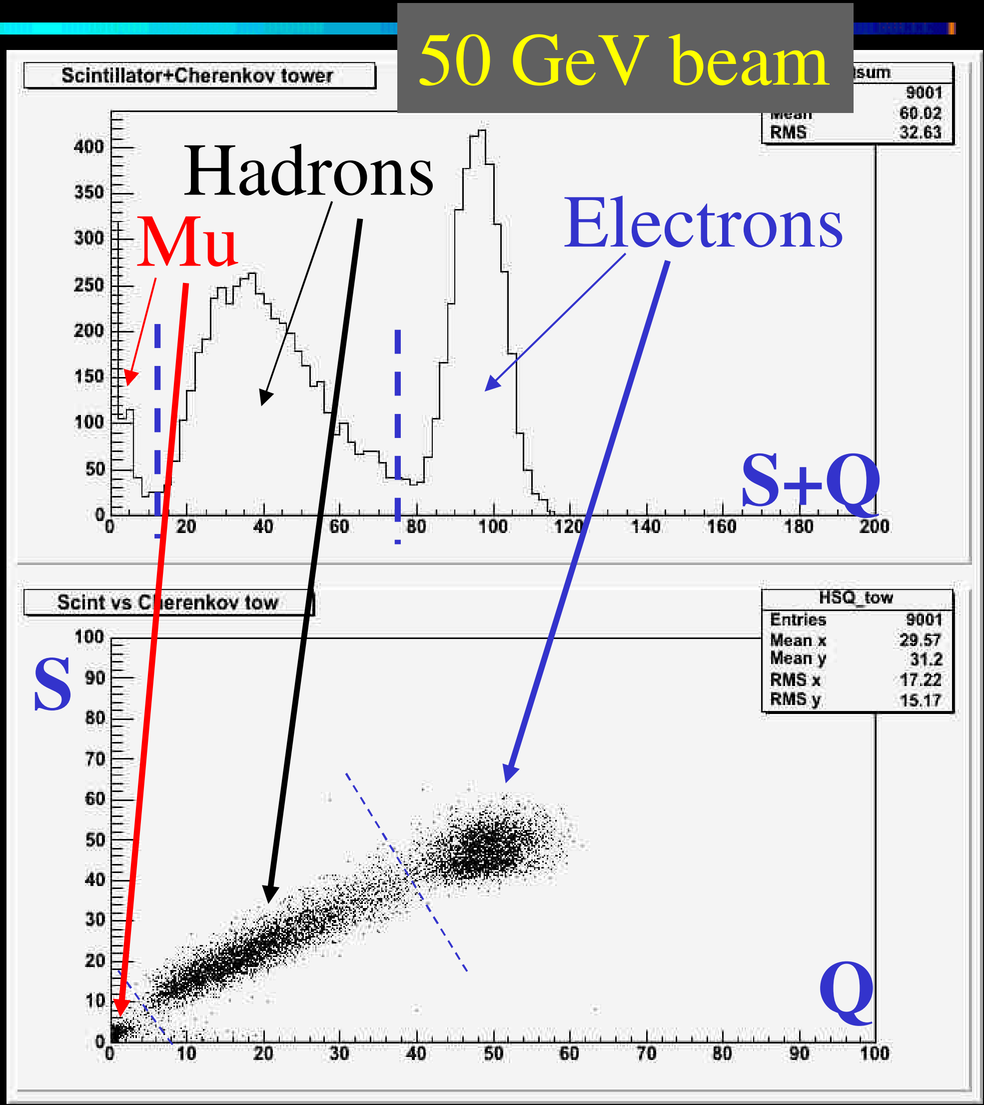
- Preshower (~2 X_0)
  - Acceptance determination
  - e/γ /π^0 separation



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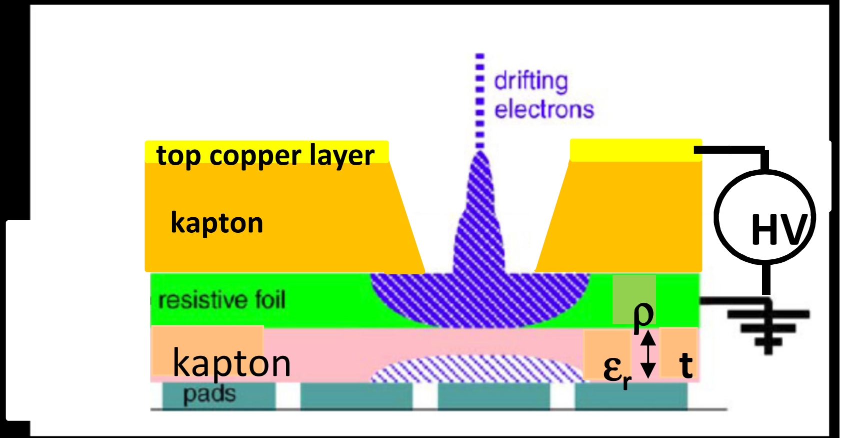

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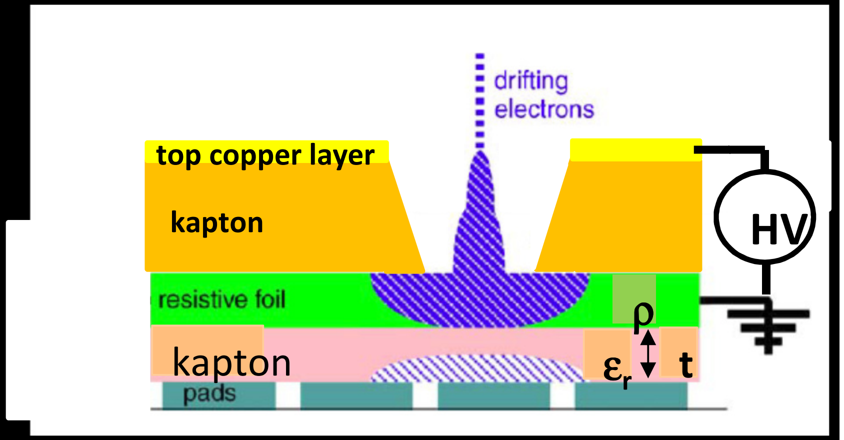
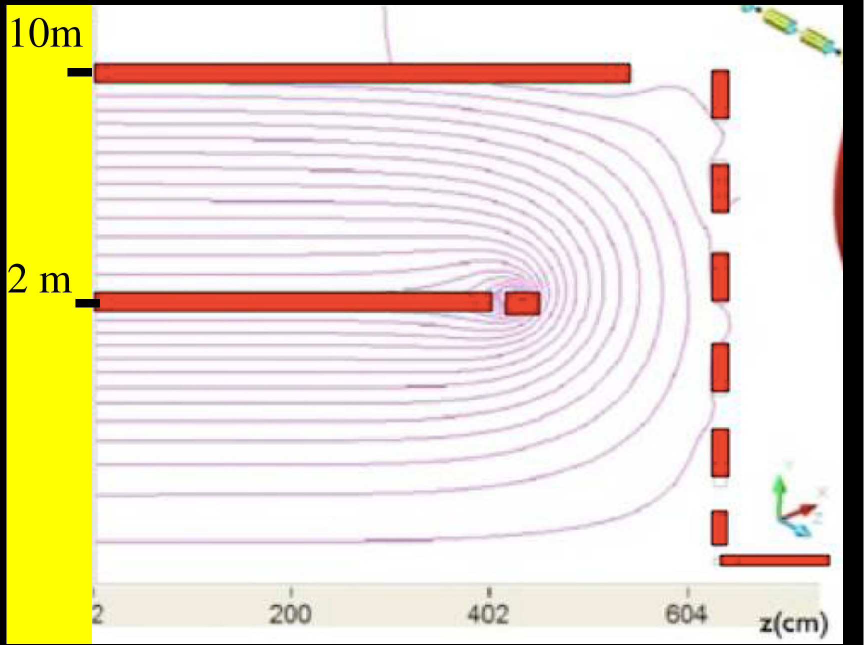
  - ➢ Vertex+DCH: ~ 0.5% @ 100 GeV
- ❖ Better muon ID (?):
  - ➢ More filter behind calorimeter (?)
    - Iron yoke or partial yoke
  - ➢ Followed by additional chambers
    - μ-RWELL low-cost technology already proven for low rate applications (CMS/SHiP)
  - ➢ Potential outer solenoid
    - Flux return → reduced yoke
    - Muon tracking





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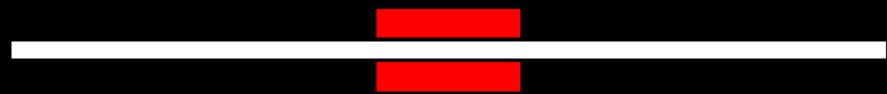

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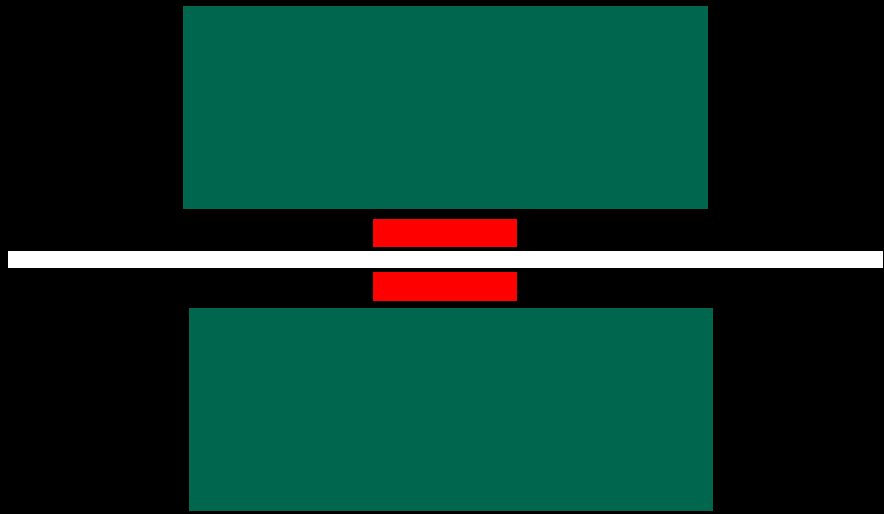

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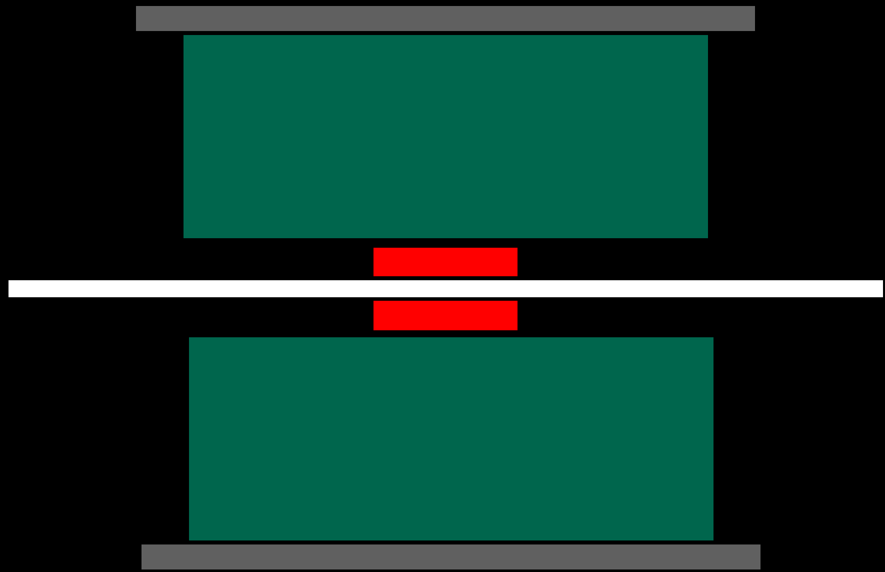

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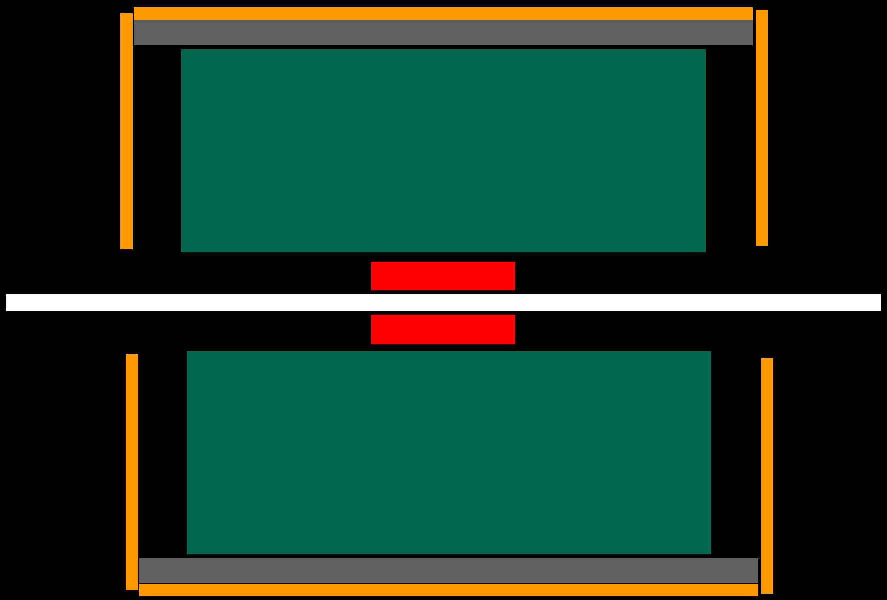

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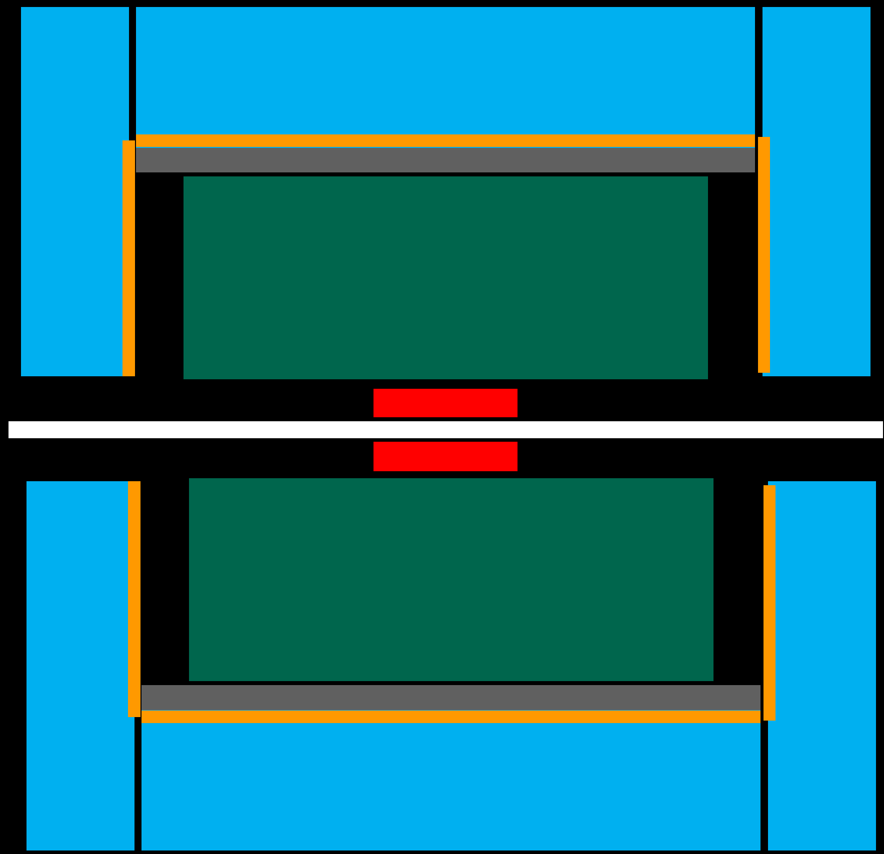

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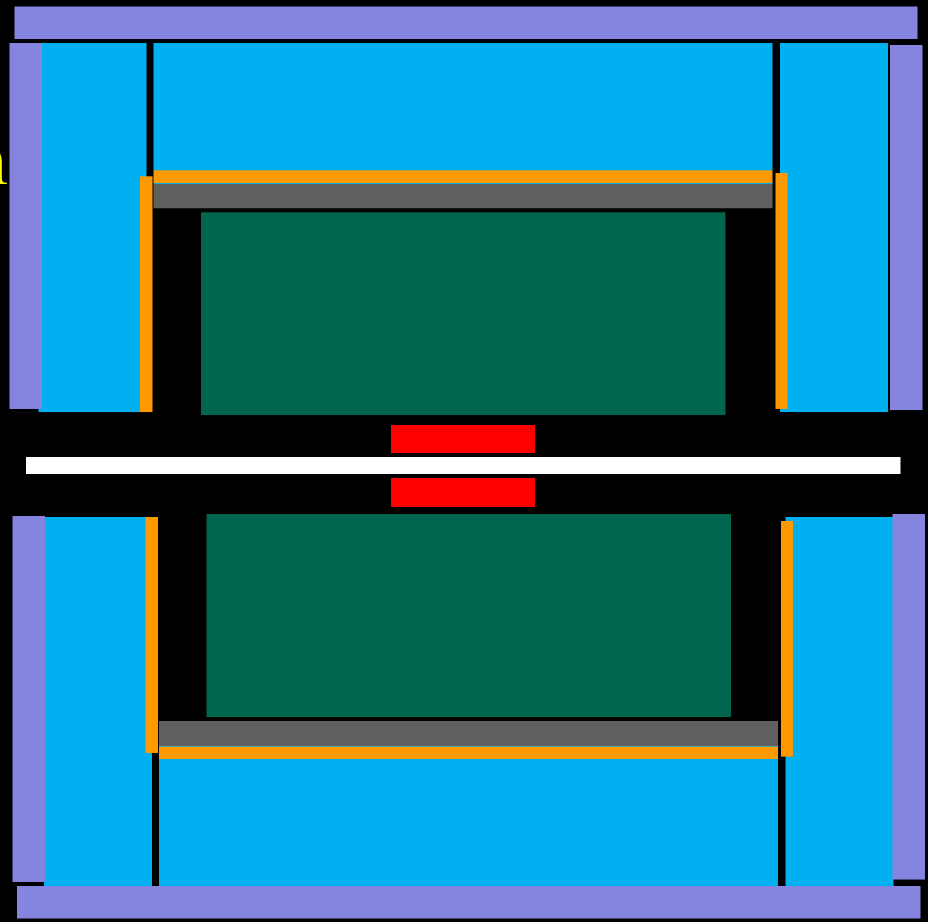

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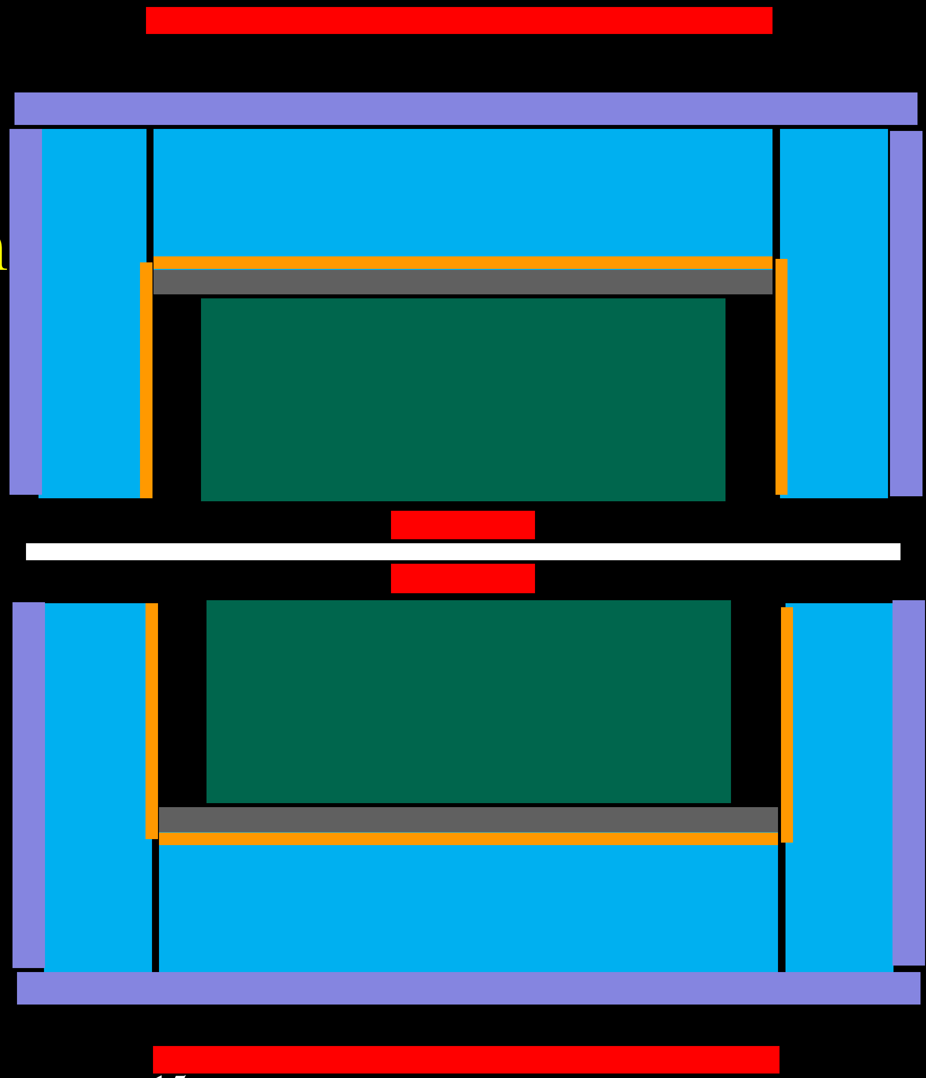
  - (Dual solenoid ?)



Conclusions (HK)

- Proposed detector is:
  - Feasible with existing technology
    - More R&D can only improve
  - Performant in full range of energy and luminosity
    - Fast detector, can resolve beam crossing
  - Very low mass ~3-4% X_0 before solenoid
  - Low cost relative to ILD-like solutions
- Several optimizations needed → future simulation work
  - Pixel layers, preshower, calorimeter and muon system configuration
  - Need for more PID beyond DCH and Calorimeter?
- Major overlap with current FCC-ee baseline detector

INFN: detector contributions to CDR

- Detector performance studies
  - Preliminary work started after HK (thanks Manqi)
    - Simplified detector defined for simulations and optimizations
      - SehWookLee provides modular code for DR full simulation
      - INFN-LE group provides DCH geometry and tracking code from 4°/MEG
      - IHEP group help integrating DR with chamber and VTX detector
        - Patrizia will discuss with Manqi software compatibility issues
        - Other potential studies by CERN connected groups
- Students (.... so far):
  - 1 doctorate and 1 master student will become active starting this March and could do studies with basic configuration (mostly DR)
- Senior physicists:
  - Coordination of work on DR and chamber

INFN: detector contributions to CDR

- Technical descriptions in CDR
  - Vertex detector technical details (Caccia et al.)
  - Drift chamber technical details (Grancagnolo et al.)
  - DR technical details (Ferrari et al.)
  - DR SiPM readout (Caccia et al.)

- Additional potential contributions
  - Pre-shower configuration studies (Giacomelli et al.)
  - Muon system technical details (Giacomelli et al.)
    - Based on CMS upgrade plan
    - R&D on high rate for SppC

Final remarks

- INFN groups already contributing to CDR
  - This involvement could increase in many areas
- INFN theorists involved in physics sections
  - This contribution could grow – needs an organization
- IDEA detector performance studies are being setup
  - Students/seniors will follow CDR work
- Many contributions possible on technical parts
  - Needs to be organized
- Responsibilities in various CDR subgroups should be understood soon