Next generation of muon experiments (at PSI, JPARC, Fermilab)

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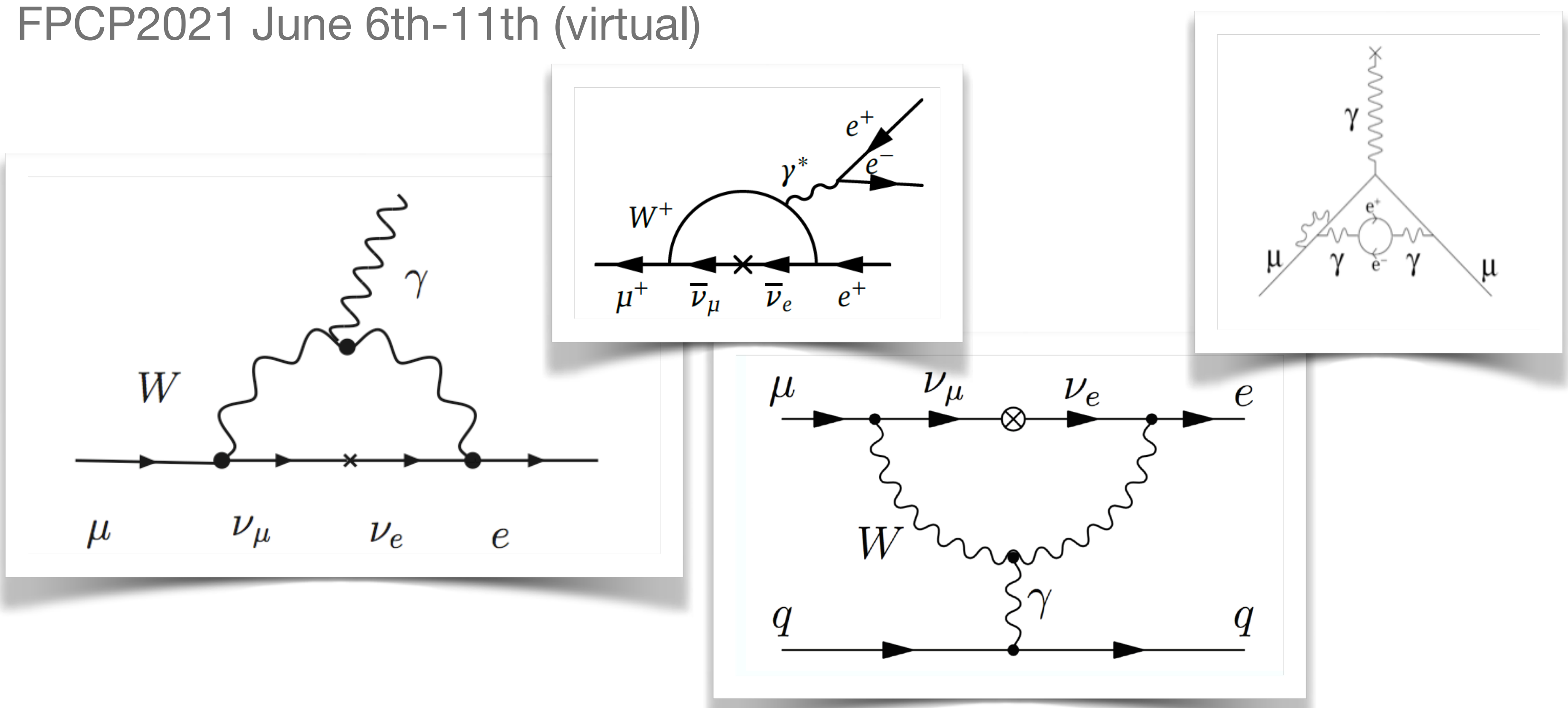
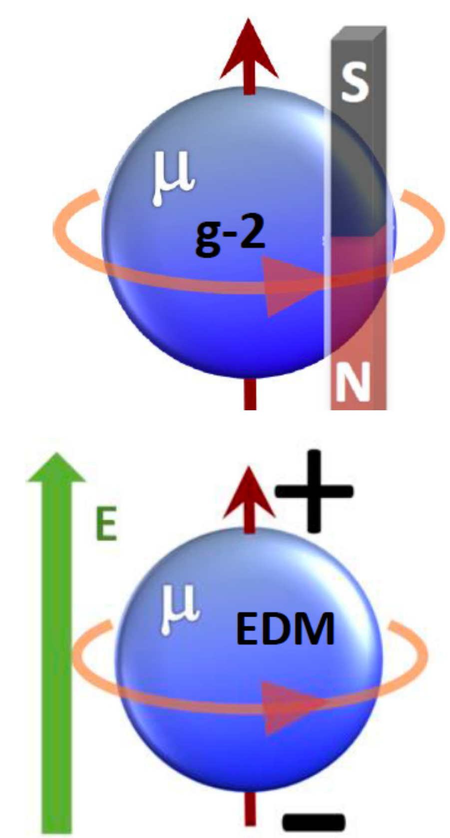
FPCP2021 June 6th-11th (virtual)



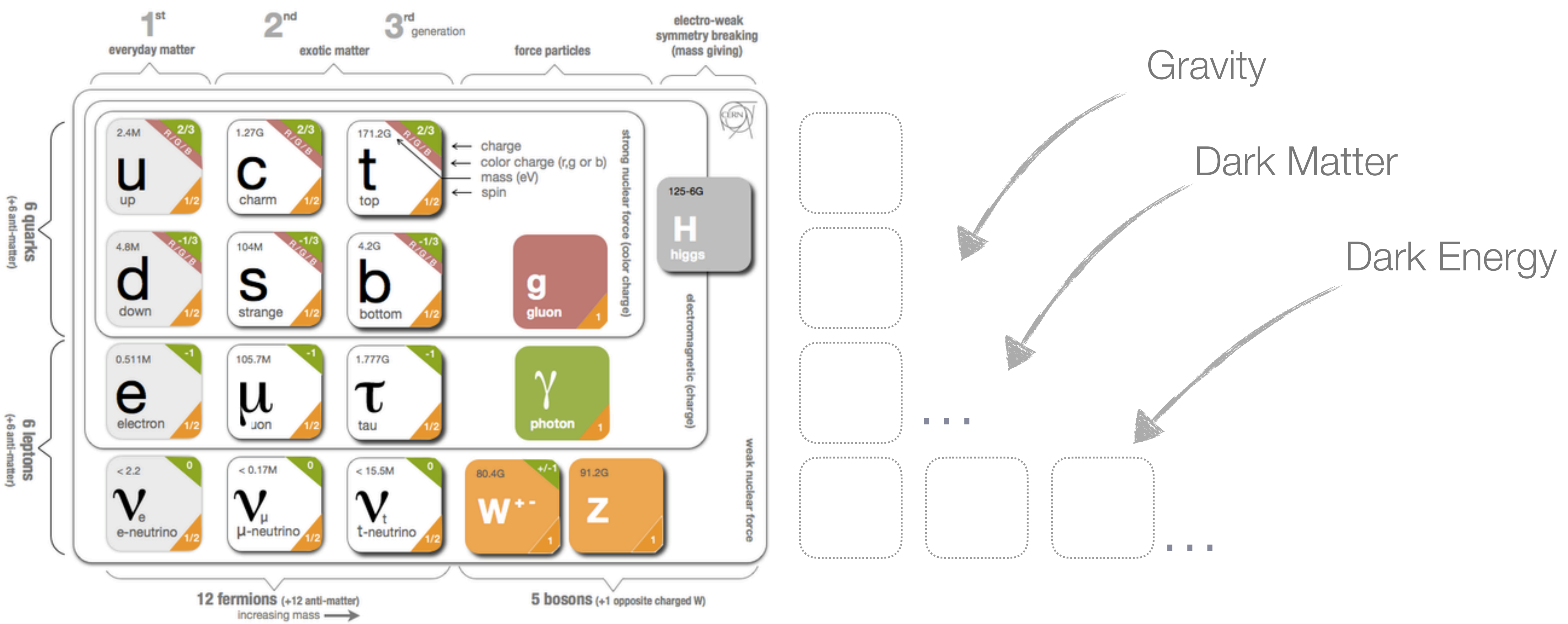


Content

- Introduction: major current muon based experiments (charged lepton flavour violation searches and g-2/EDM with muons):
  - The physics cases
- The Most Intense DC and Pulsed Muon beams in the World:
  - Present and future prospects
- Overview of current experimental activities based on DC and Pulsed muon beams
  - New detector developments

The role of the low energy precision physics

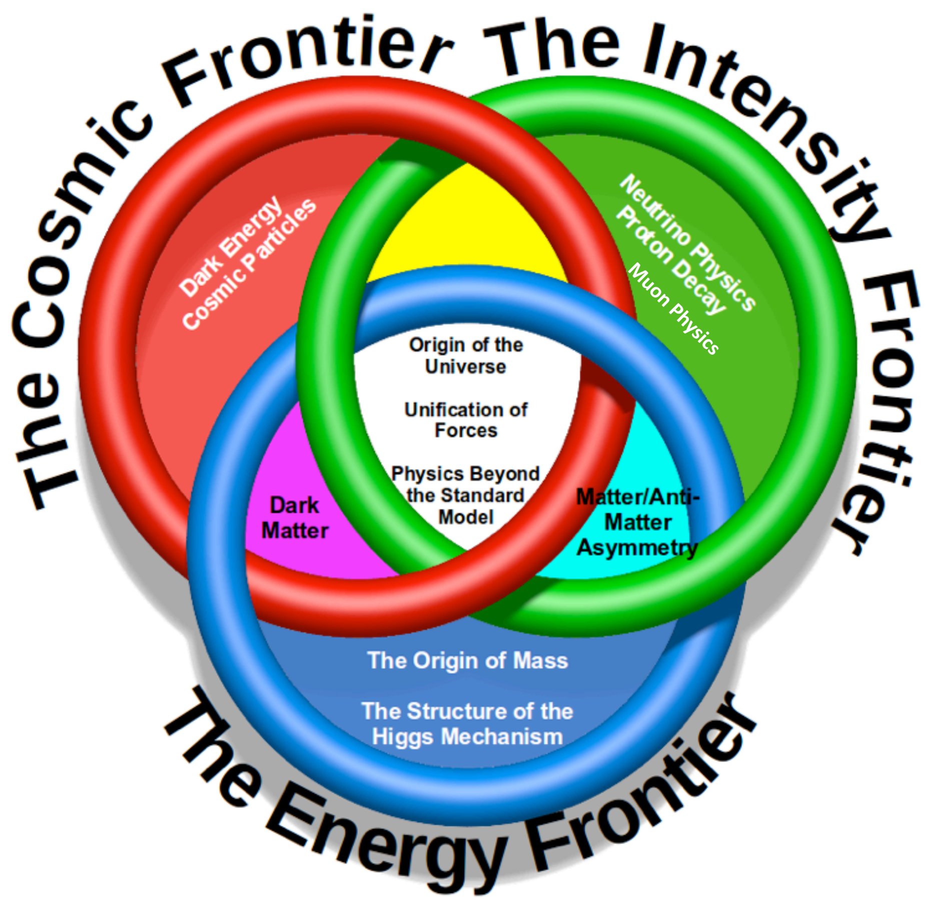
- The Standard Model of particle physics: A great triumph of the modern physics but not the ultimate theory

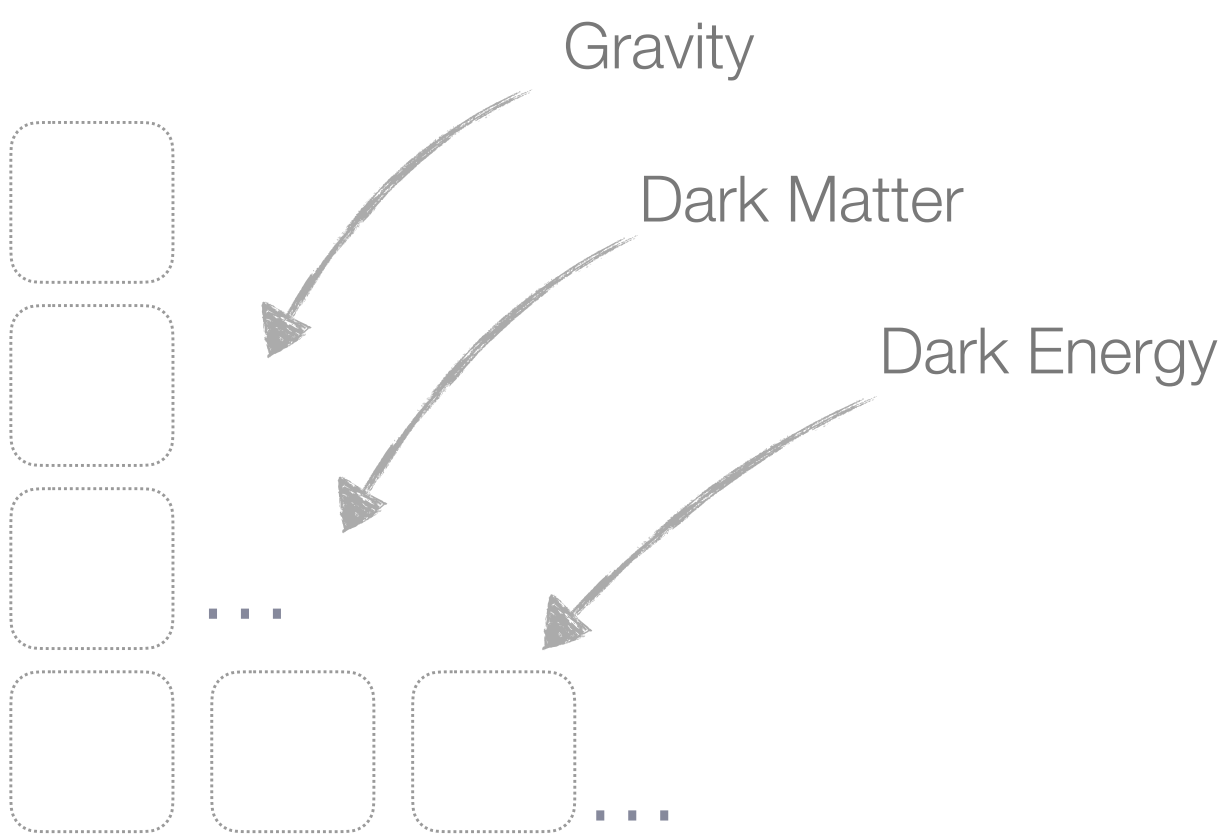


- Low energy precision physics: Rare/forbidden decay searches, symmetry tests, precision measurements very sensitive tool for unveiling new physics and probing very high energy scale

The role of the low energy precision physics

- The Standard Model of particle physics: A great triumph of the modern physics but not the ultimate theory





- Low energy precision physics: Rare/forbidden decay searches, symmetry tests, precision measurements very sensitive tool for unveiling new physics and probing very high energy scale

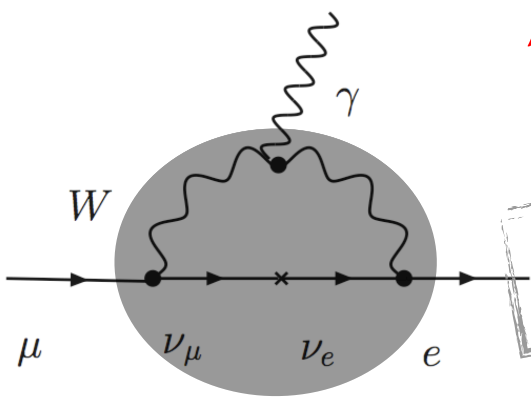
The role of the precision physics at the intensity frontiers

- Two main strategies to unveil new physics
  - Indirect searches
  - Precision tests

Charged lepton flavour violation search: Motivation

SM with massive neutrinos (Dirac)

$\mathcal{B}(\mu^+ \to e^+\gamma) \approx 10^{-54}$

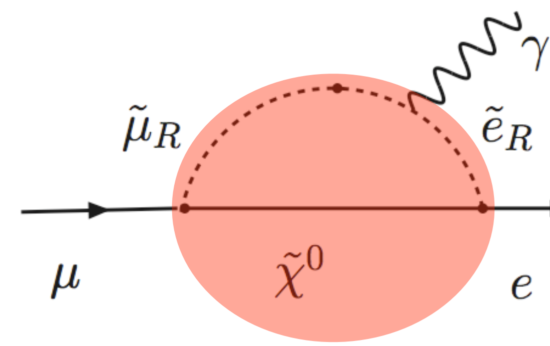


ν oscillations

too small to access experimentally

BSM

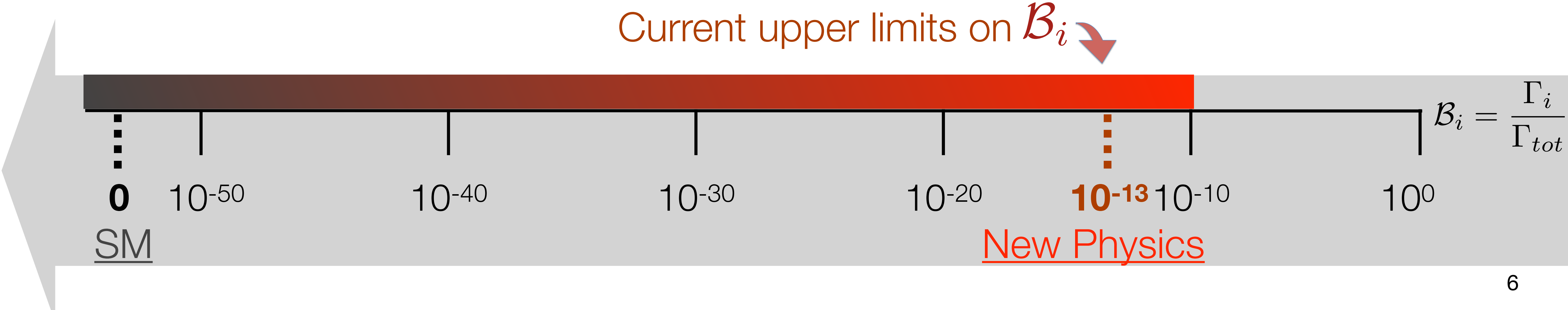
$\mathcal{B}(\mu^+ \to e^+\gamma) \gg 10^{-54}$



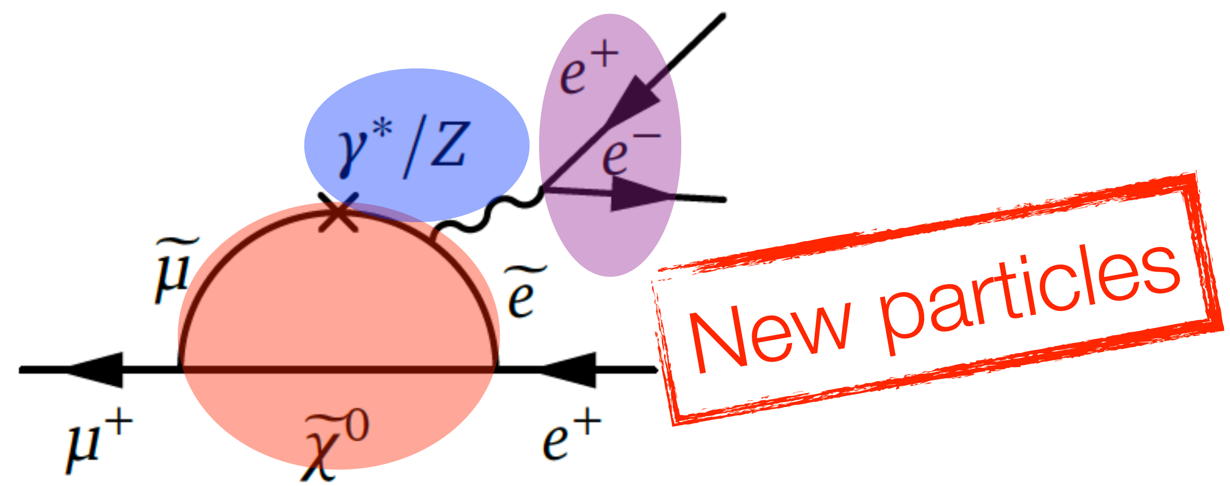
New particles

an experimental evidence:
a clear signature of New Physics NP
(SM background FREE)

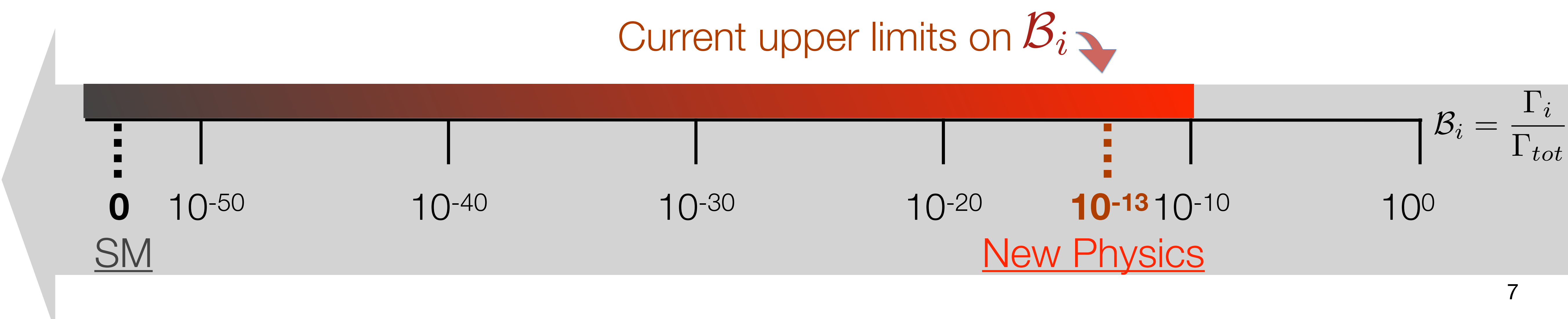
Current upper limits on $\mathcal{B}_i$



Charged lepton flavour violation search: Motivation

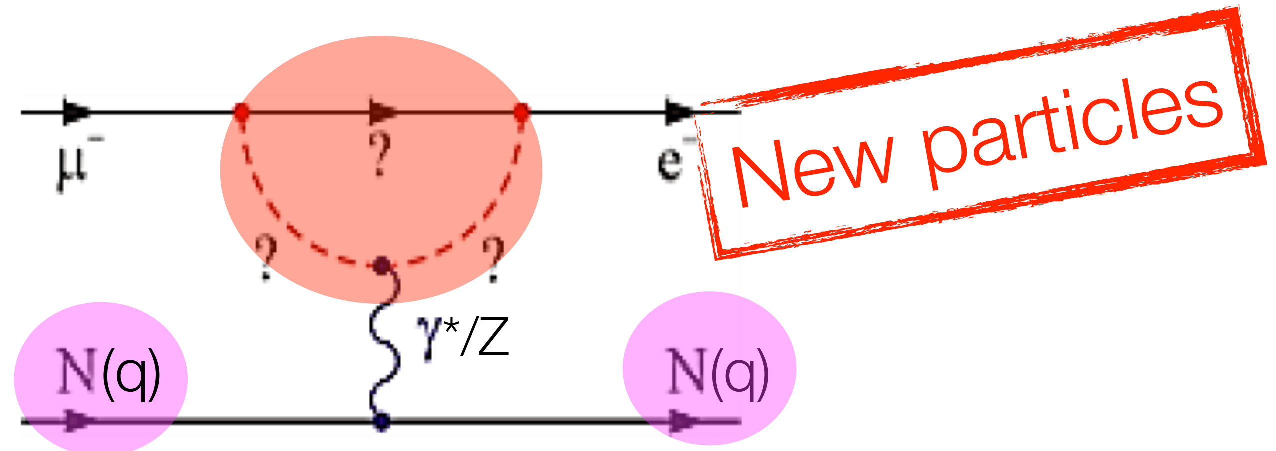


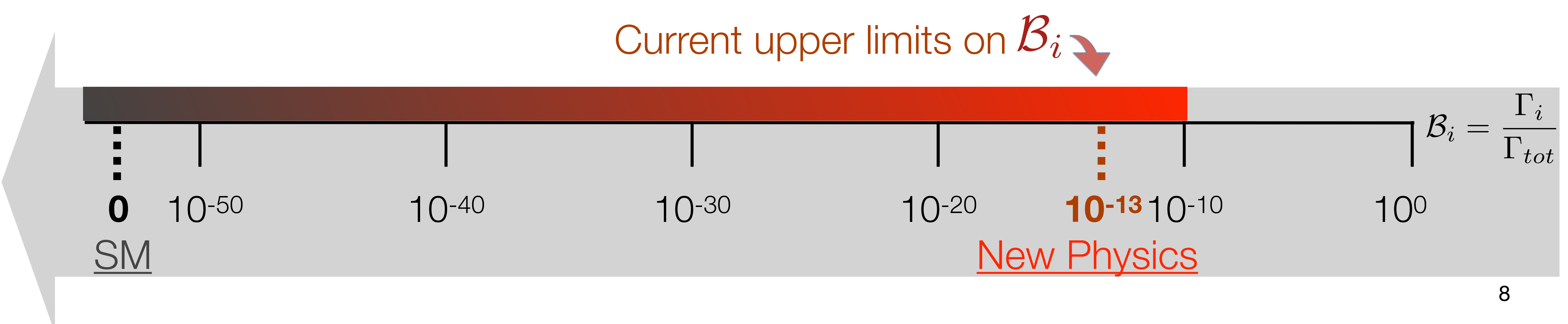
$$\mu^+ \to e^+ e^+ e^-$$



Charged lepton flavour violation search: Motivation

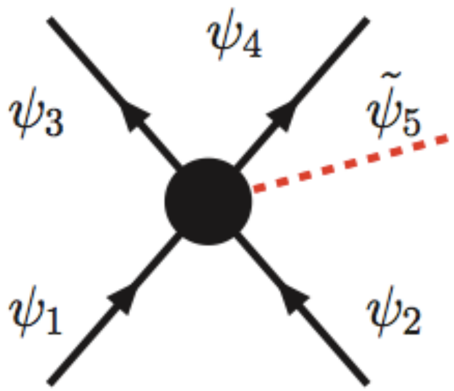
$$\mu^- N \to e^- N$$





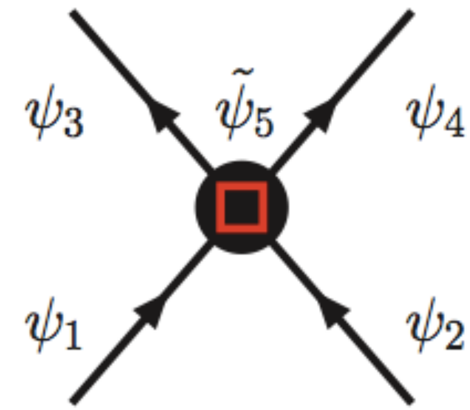
Complementary to "Energy Frontier"

Energy frontier



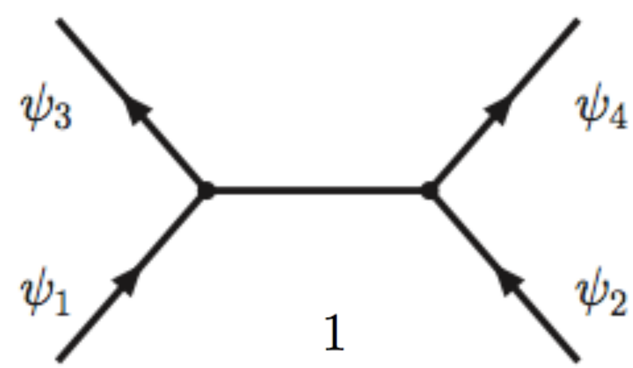
Real BSM particles

Precision and intensity frontier

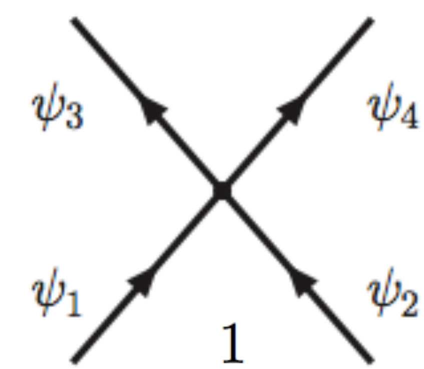


Virtual BSM particles

$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \sum_{d>4} \frac{c_n^{(d)}}{\Lambda^{d-4}} \mathcal{O}^{(d)}$$



$$\frac{1}{p^2 - M^2}$$



$$\frac{1}{\Lambda^2}$$

Unveil new physics

Probe energy scale otherwise unreachable

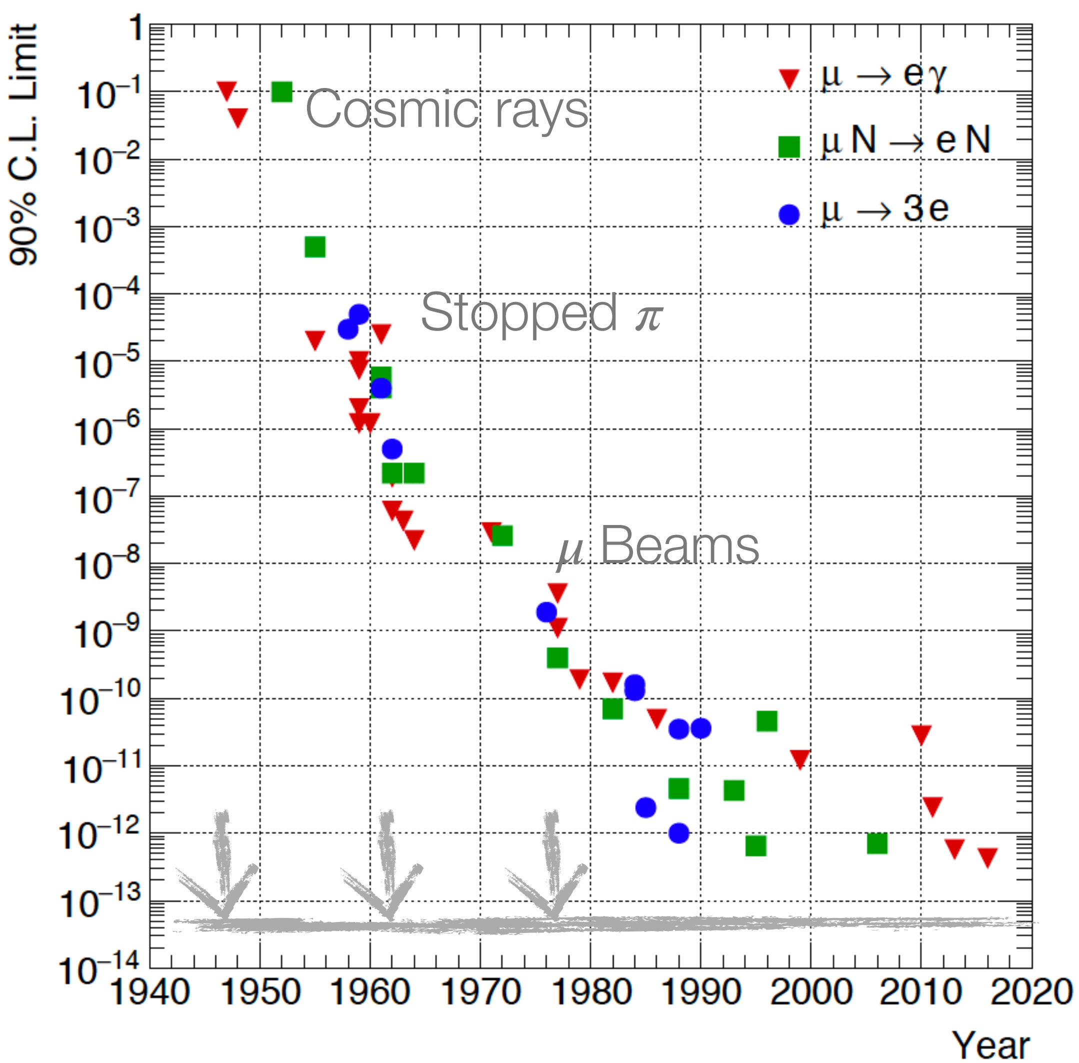
E > 1000 TeV

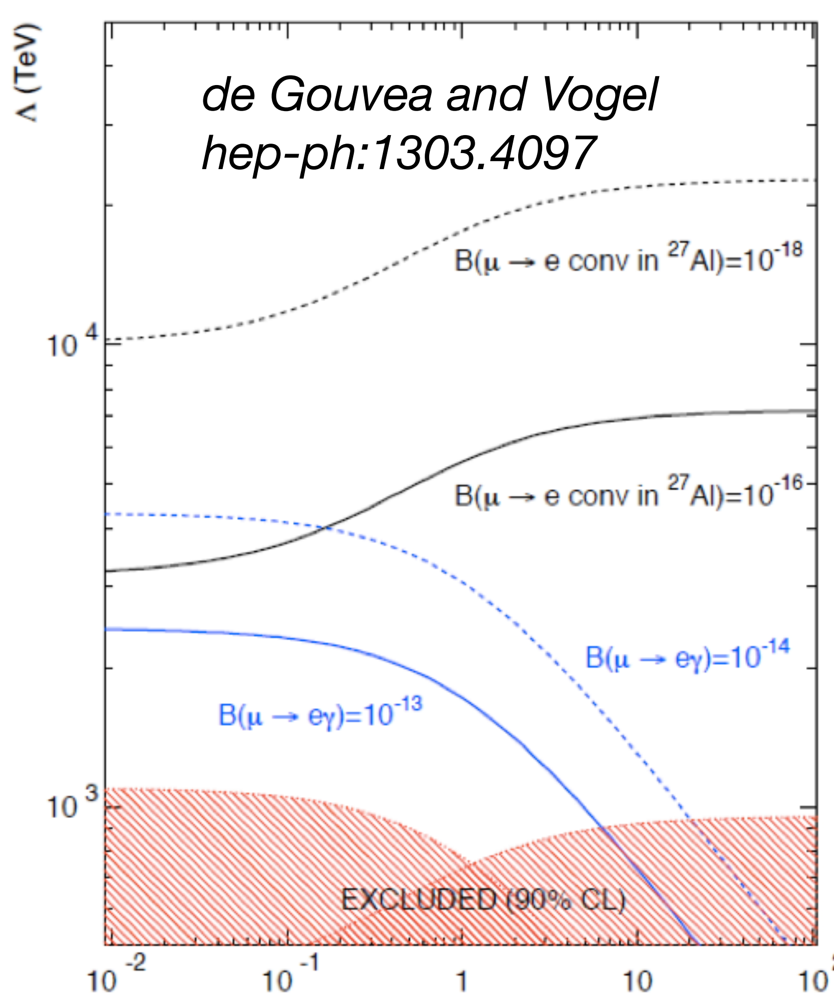
cLFV searches with muons: Status and prospects

- In the near future impressive sensitivities:

	Current upper limit	Future sensitivity
$\mu \to e\gamma$	4.2 x 10^{-13}	~ 6 x 10^{-14}
$\mu \to eee$	1.0 x 10^{-12}	~1.0 x 10^{-16}
$\mu N \to eN'$	7.0 x 10^{-13}	few x 10^{-17}

- Strong complementarities among channels: The only way to reveal the mechanism responsible for cLFV





Beam features vs experiment requirements

- Dedicated beam lines for high precision and high sensitive SM test/BSM probe at the world's highest beam intensities

$I_{beam} \sim 10^8 - 10^{10}$ μ/s

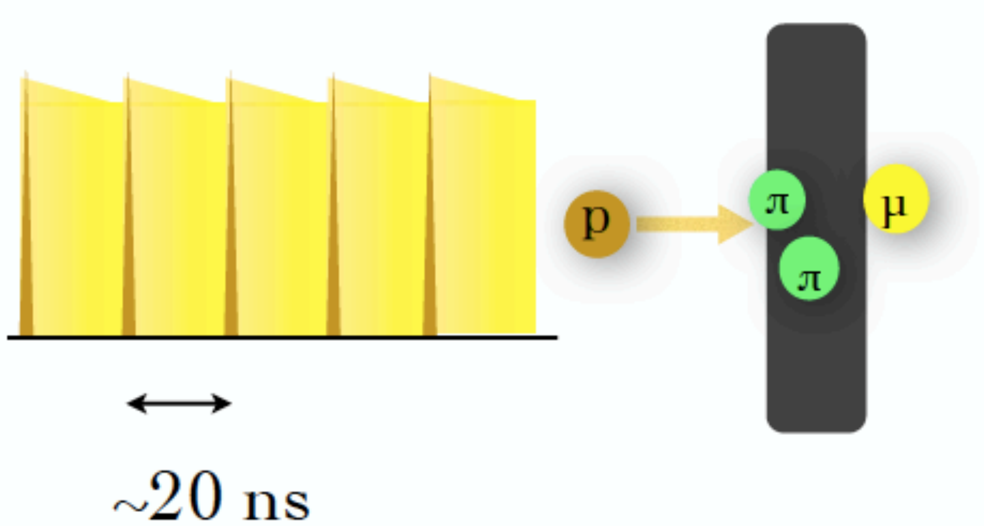
DC or Pulsed?

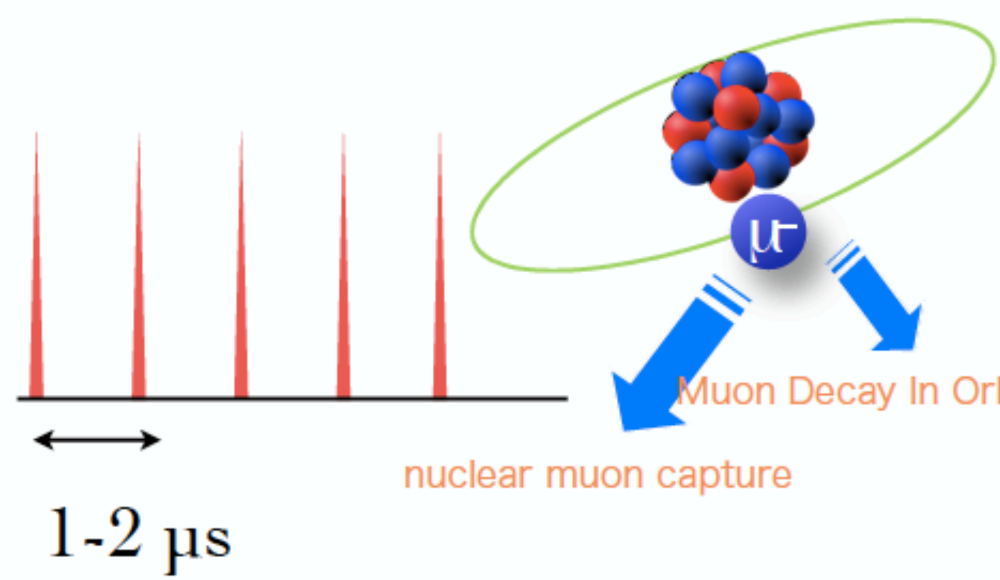
$I_{beam} \sim 10^{11}$ μ/s

- DC beam for coincidence experiments
  - $\mu \rightarrow e \gamma$, $\mu \rightarrow e\ e\ e$

- Pulse beam for non-coincidence experiments
  - μ-e conversion

@ PSI





@ JPARC, FERMILAB

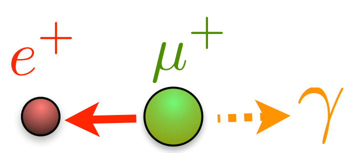
MEG:
Experimental setup and result

A. Baldini et al. (MEG Collaboration), Eur. Phys. J. C73 (2013) 2365

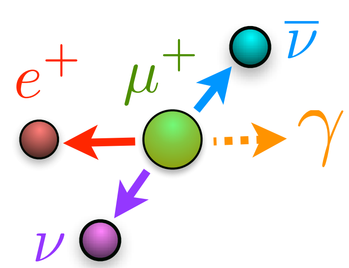
A. Baldini et al. (MEG Collaboration), Eur. Phys. J. C76 (2016) no. 8, 434

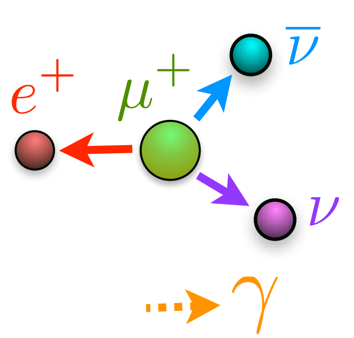
- The MEG experiment aims to search for $\mu^+ \to e^+ \gamma$ with a sensitivity of ~10^{-13} (previous upper limit $BR(\mu^+ \to e^+ \gamma) \leq 1.2 \times 10^{-11}$ @90 C.L. by MEGA experiment)
- Five observables (E_g, E_e, t_{eg}, ϑ_{eg}, ϕ_{eg}) to characterize $\mu \to e\gamma$ events

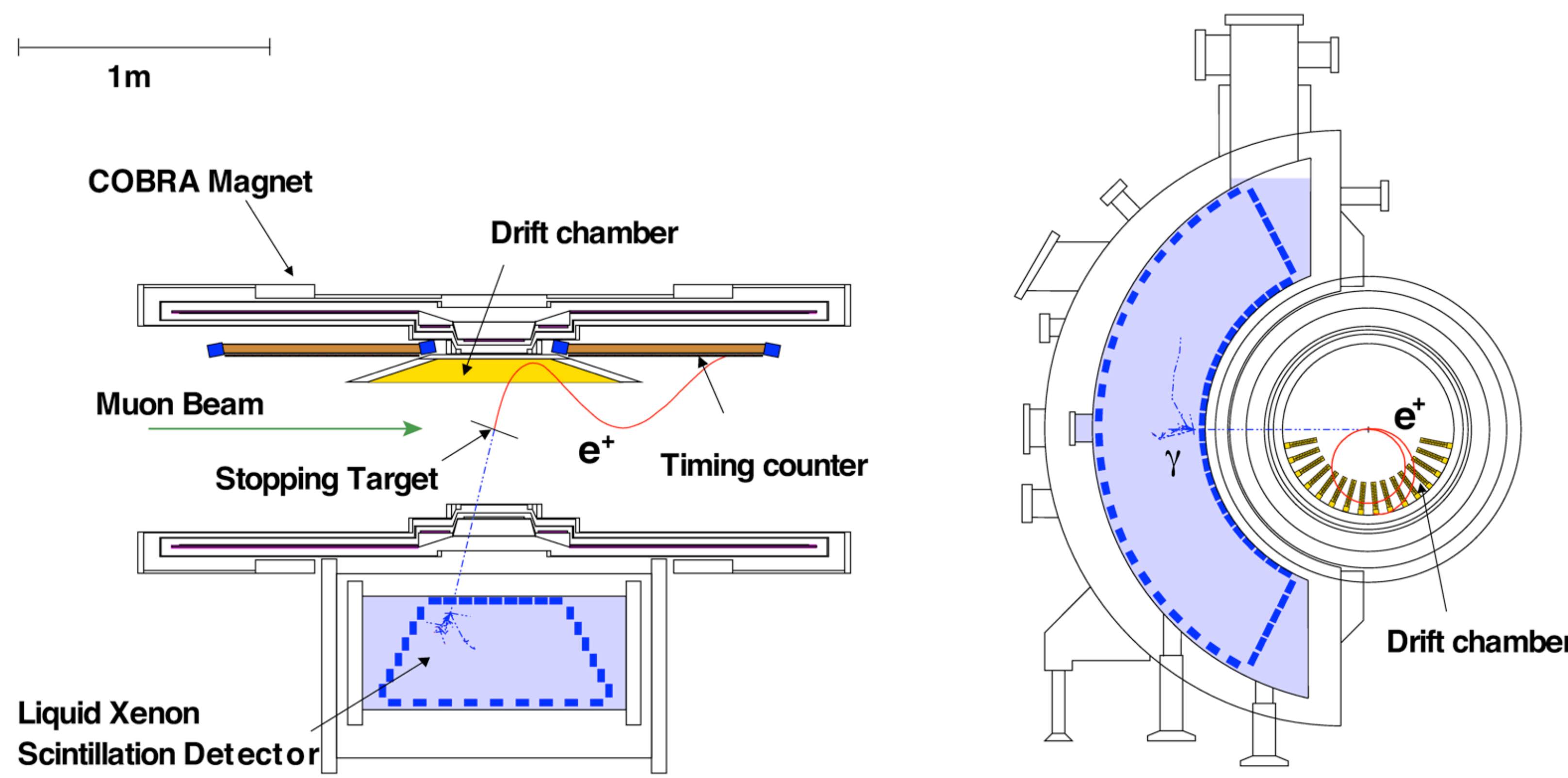
Signature



Backgrounds







Full data sample: 2009-2013

Best fitted branching ratio at 90% C.L.:

$$\mathcal{B}(\mu^+ \to e^+\gamma) < 4.2 \times 10^{-13}$$

How the sensitivity can be pushed down?

- More sensitive to the signal...

high statistics

$$SES = \frac{1}{R \times T \times A_g \times \varepsilon(e^+) \times \varepsilon\,(\text{gamma}) \times \varepsilon(\text{TRG}) \times \varepsilon(\text{sel})}$$

Beam rate
Acquisition time
Geometrical acceptance
Detector efficiency
Selection efficiency

- More effective on rejecting the background...

high resolutions

$$B_{acc} \sim R \times \Delta E_e \times (\Delta E_{gamma})^2 \times \Delta T_{egamma} \times (\Delta \Theta_{egamma})^2$$

Positron Energy resolution
Gamma Energy resolution
Relative timing resolution
Relative angular resolution

The MEGII experiment

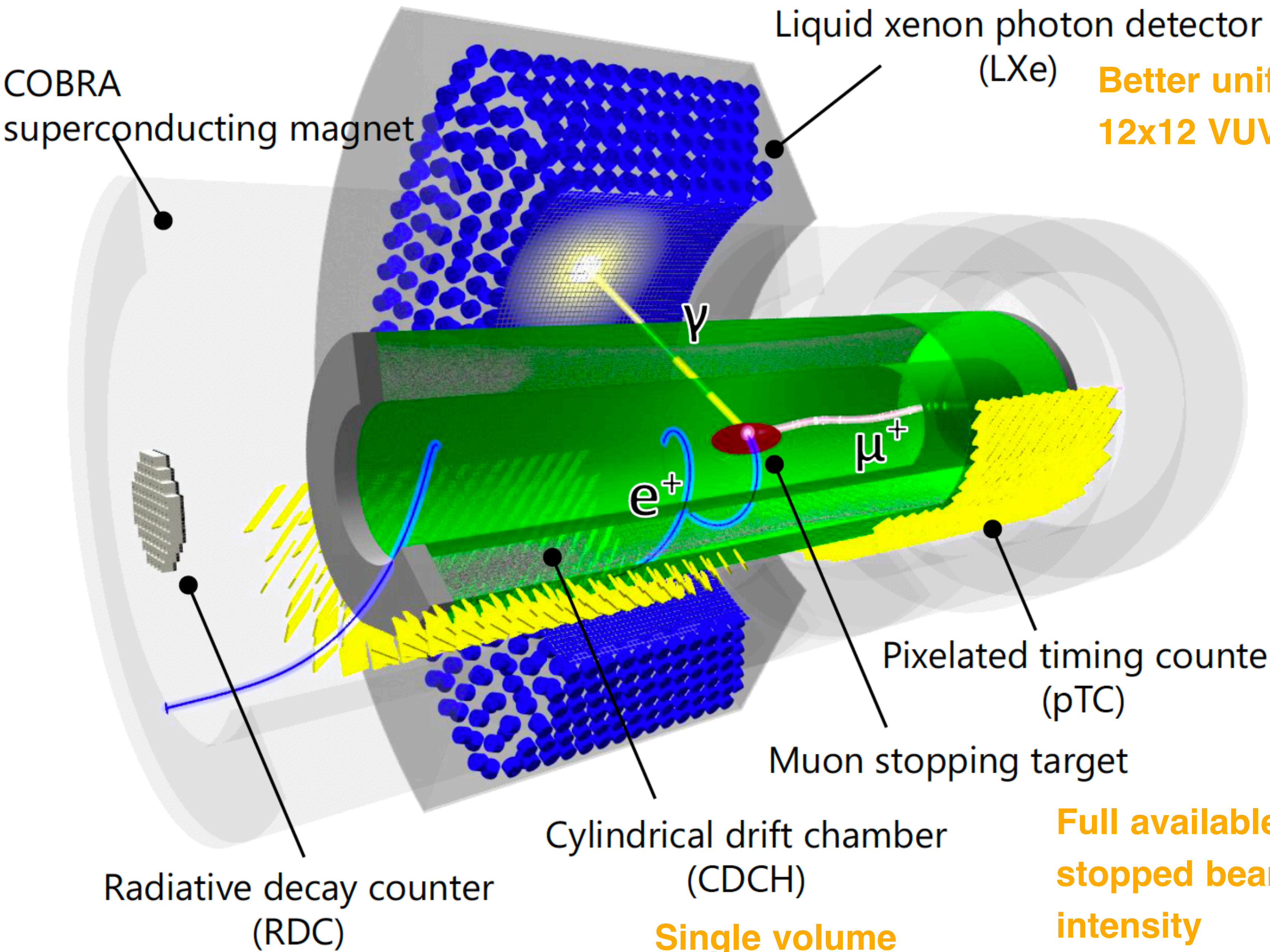
New electronics:
Wavedream

~9000 channels at 5GSPS

x2 Resolution everywhere

Updated and new Calibration methods

Quasi mono-chromatic positron beam



Better uniformity w/ 12x12 VUV SiPM

x2 Beam Intensity

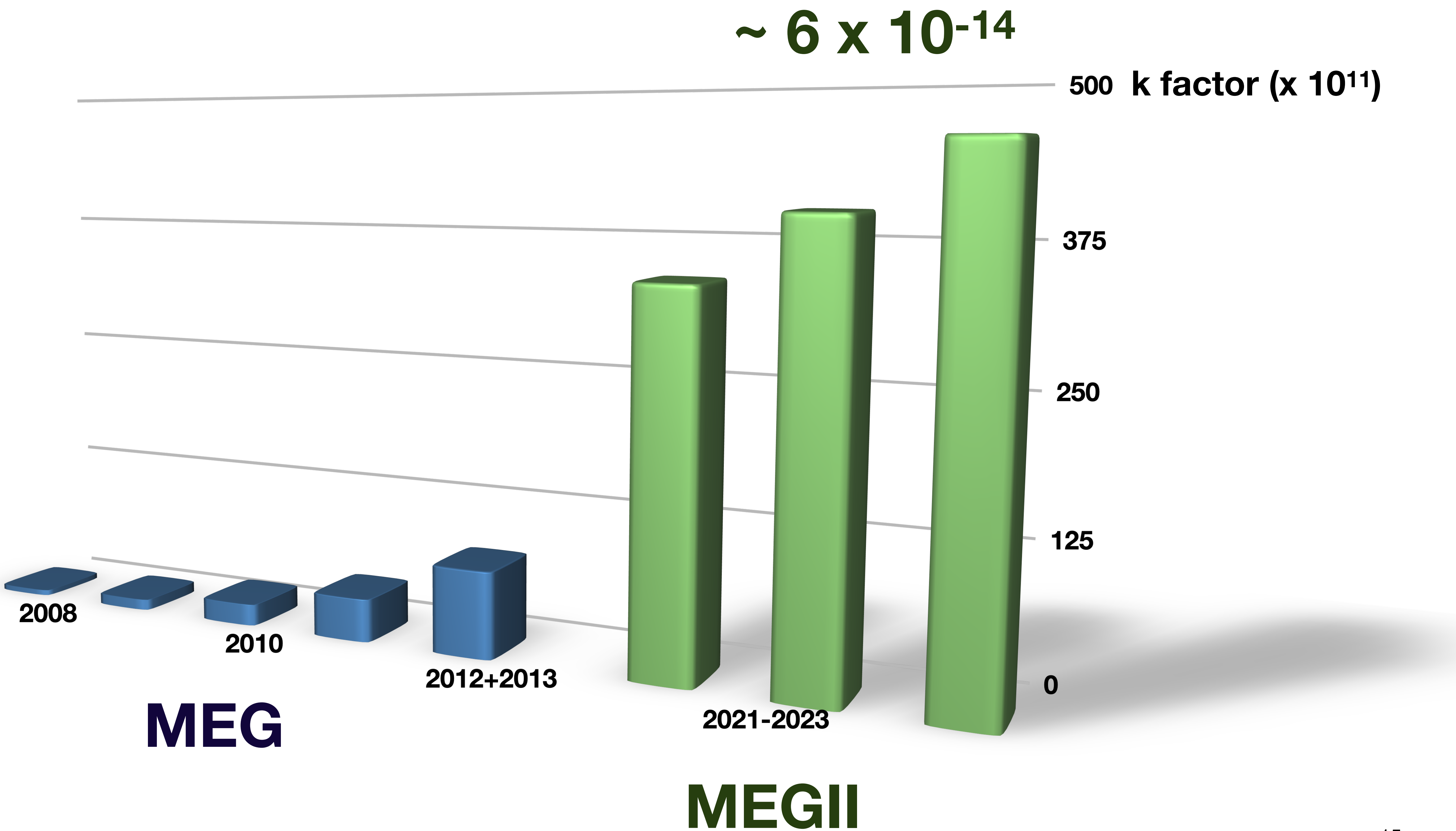
35 ps resolution w/ multiple hits

Background rejection

Single volume $He:iC_4H_{10}$

Full available stopped beam intensity 7×10^7

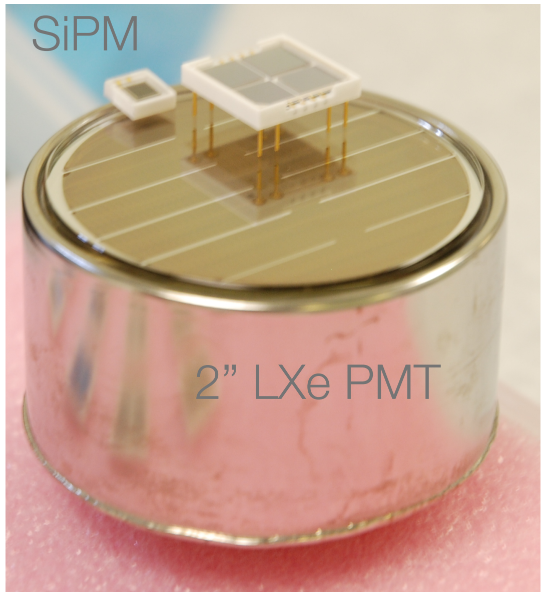
Where we will be



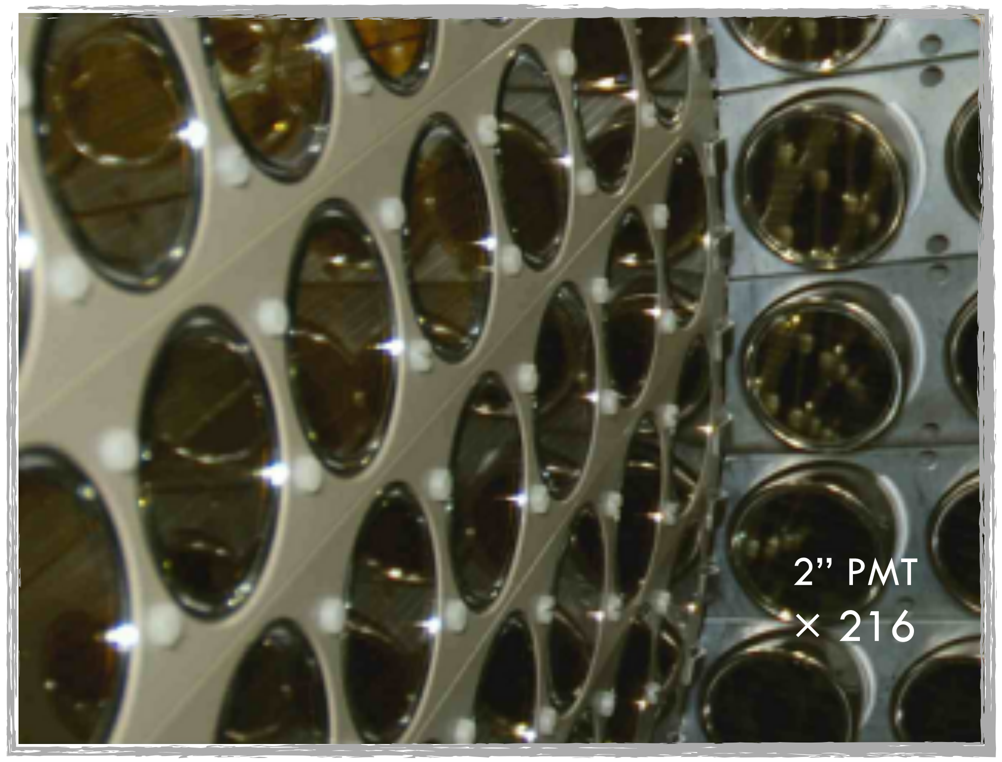
MEGII: The upgraded LXe calorimeter

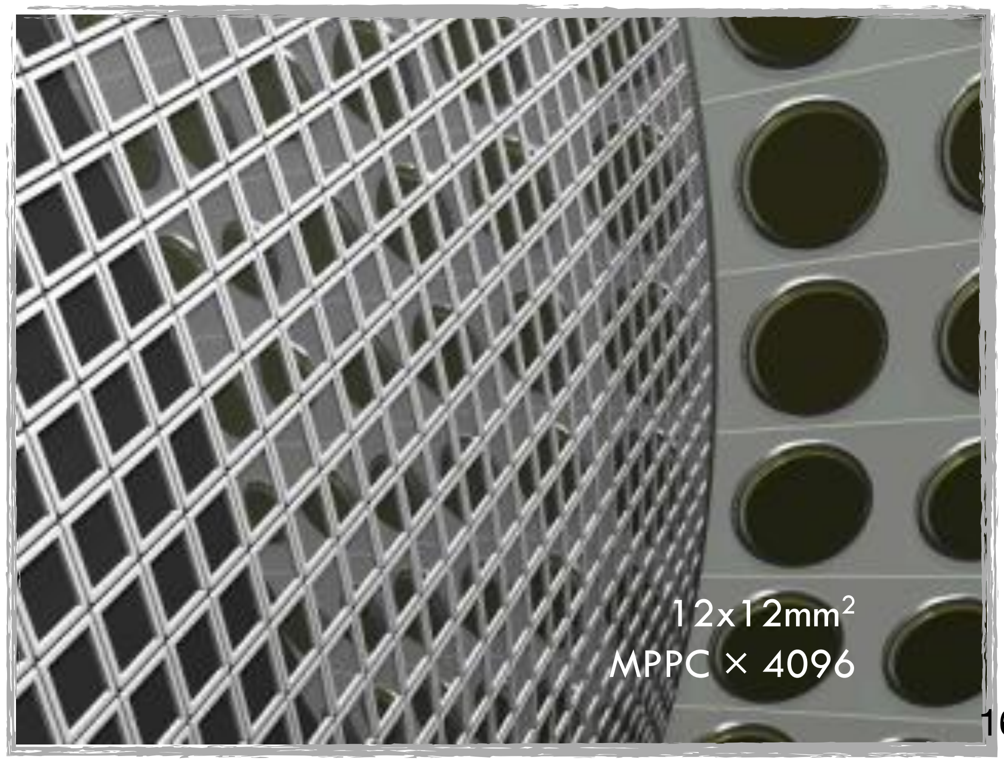
- Increased uniformity/resolutions
- Increased pile-up rejection capability
- Increased acceptance and detection efficiency
- Assembly: Completed
- Detector filled with LXe
- Purification: Ongoing
- Monitoring and calibrations with sources: Ongoing

New



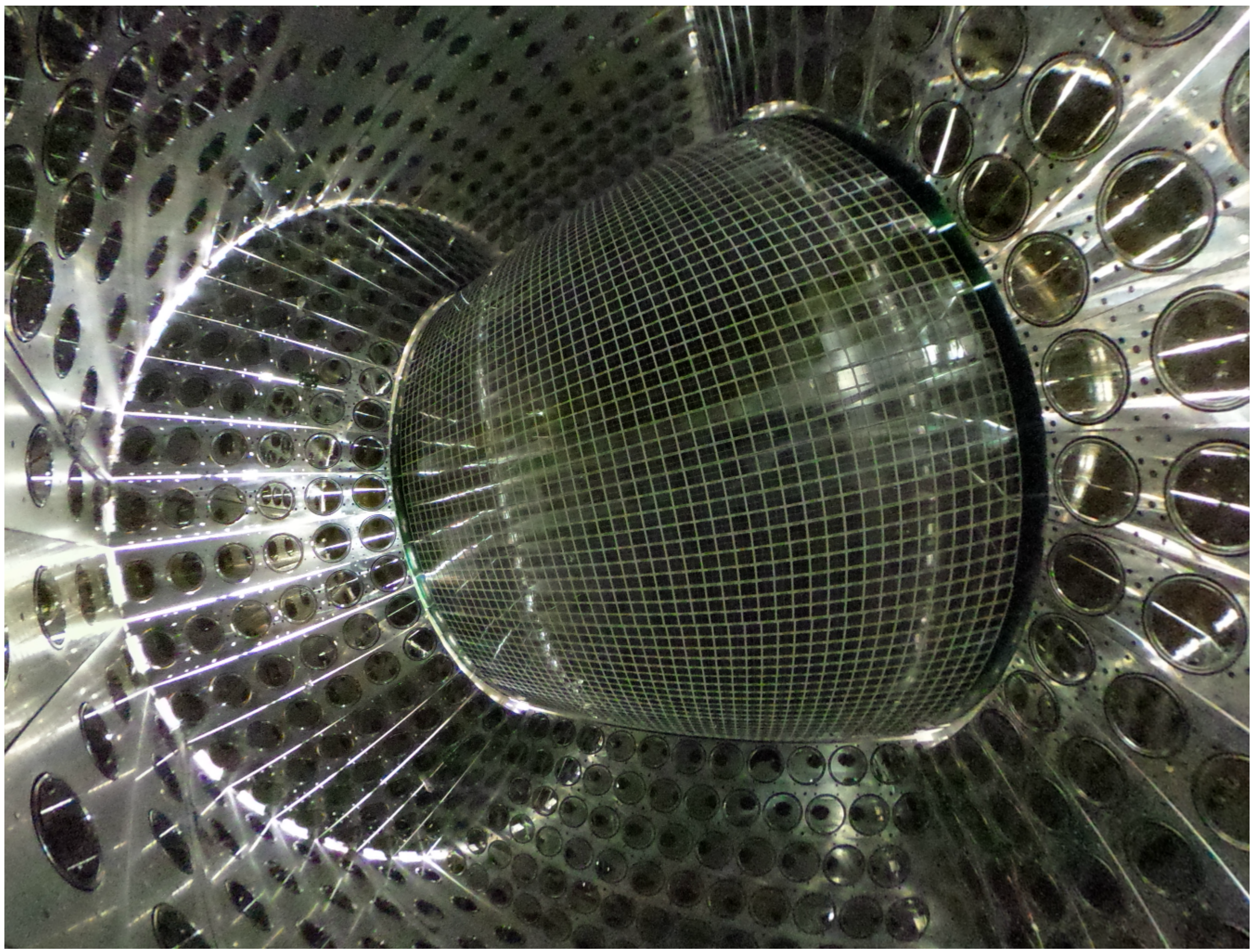
	MEG	MEGII
u [mm]	5	2.4
v [mm]	5	2.2
w [mm]	6	3.1
E [w<2cm]	2.4%	1.1%
E [w>2cm]	1.7%	1.0%
t [ps]	67	60



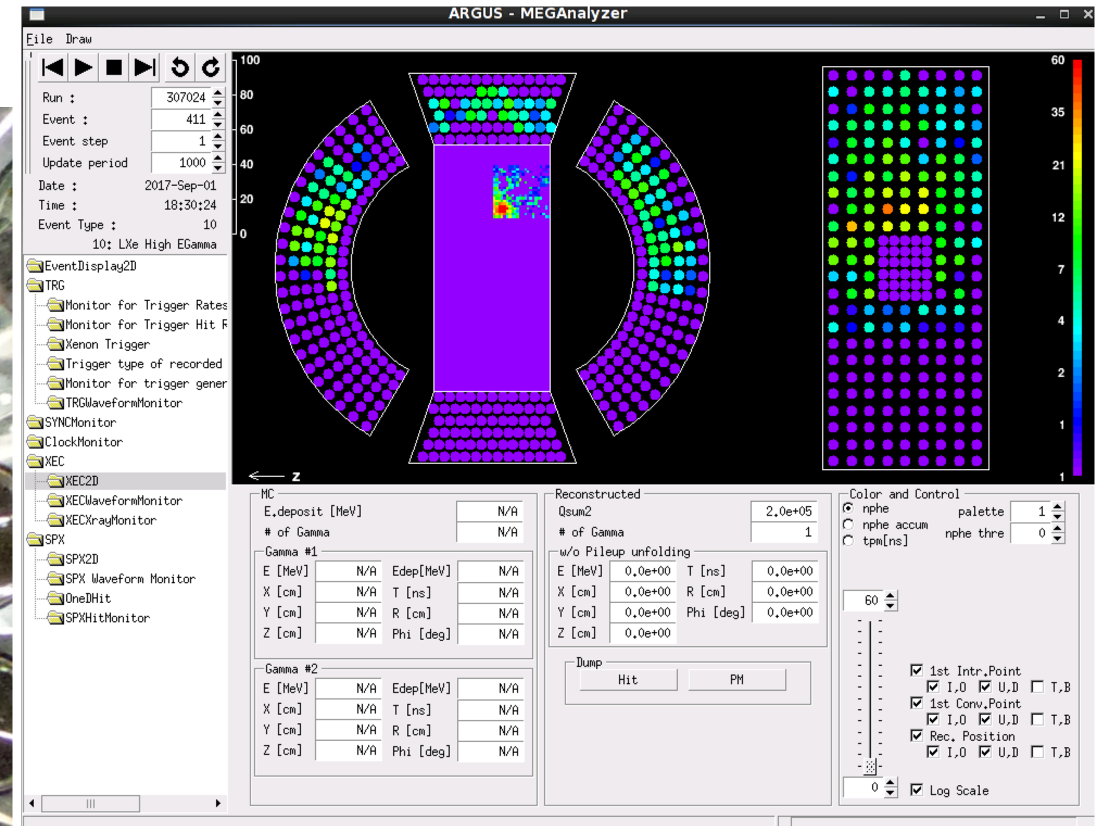


MEGII: The upgraded LXe calorimeter

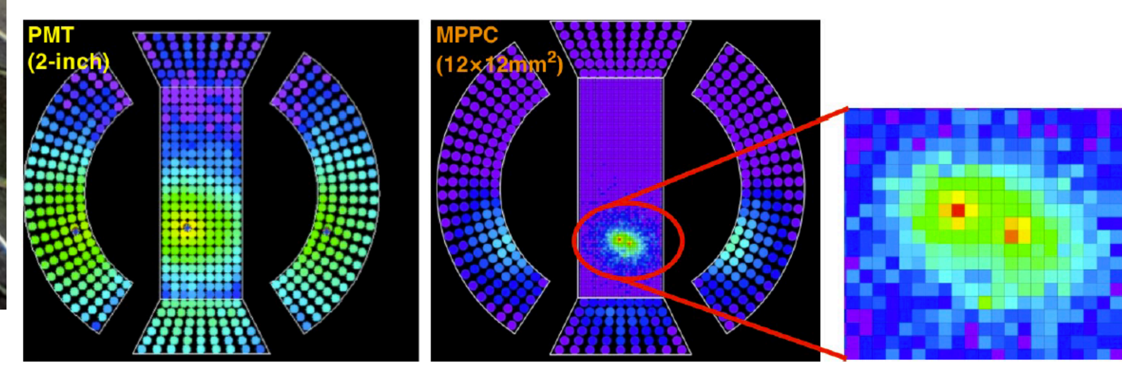
Detector commissioning:



Data



MC simulation

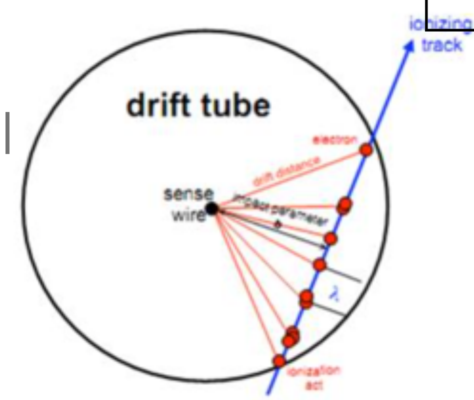


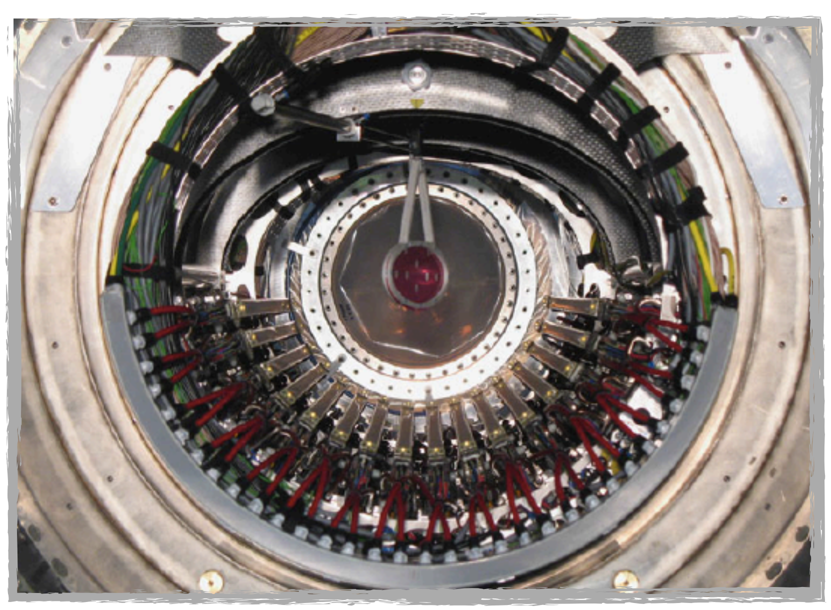
MEGII: The new single volume chamber

- Improved hit resolution: σ_r ~< 120 um (210 um)
- High granularity/Increased number of hits per track/cluster timing technique
- Less material (helium: isobutane = 90:10, 1.6×10^{-3} X_0)
- High transparency towards the TC
- Status: Construction COMPLETED.
  Some tests ongoing before delivering it to PSI (middle of May)

	MEG	MEGII
p [keV]	306	80
θ [mrad]	9.4	6.3
ϕ [mrad]	8.7	5.0
ϵ [%]*	40	70

(*) It includes also the matching with the Timing Counter

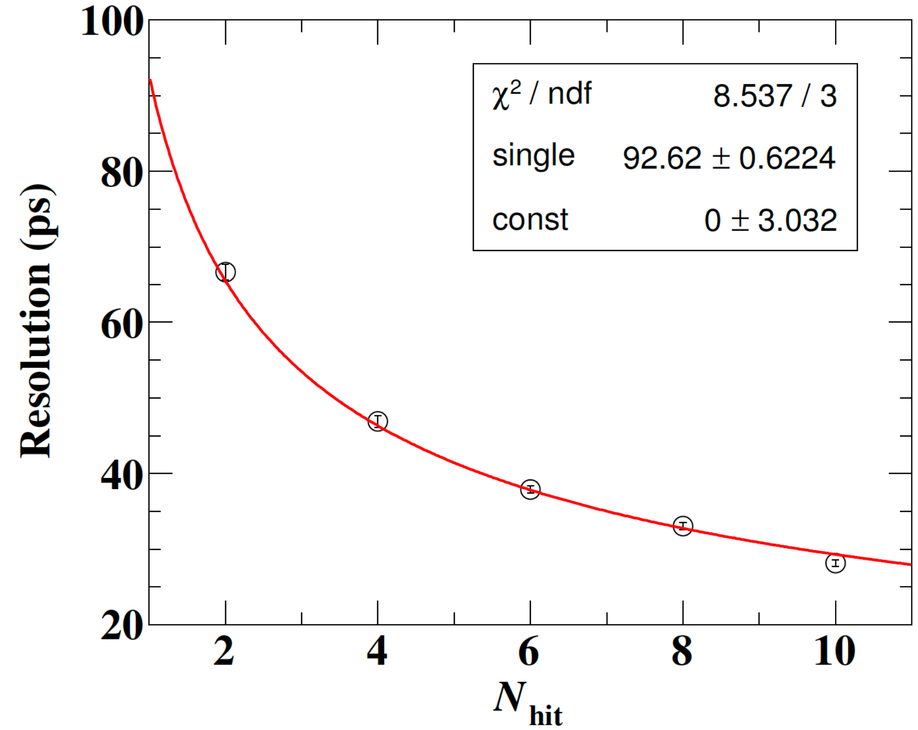


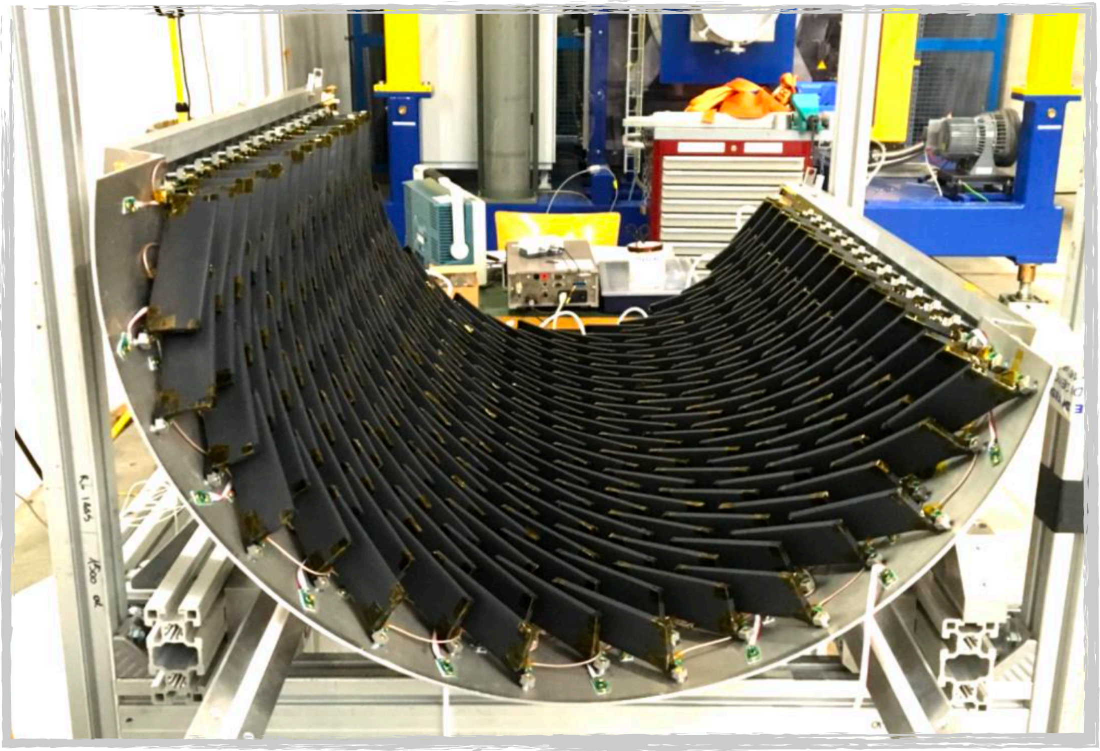


MEGII: the pixelized Timing Counter

- Higher granularity: 2 x 256 of BC422 scintillator plates (120 x 40 (or 50) x 5 mm^3) readout by AdvanSiD SiPM ASD-NUM3S-P-50-High-Gain
- Improved timing resolution: from 70 ps to 35 ps (multi-hits)
- Less multiple scattering and pile-up
- Assembly: Completed
- Expected detector performances confirmed with data during pre-eng. 2016 and 2017

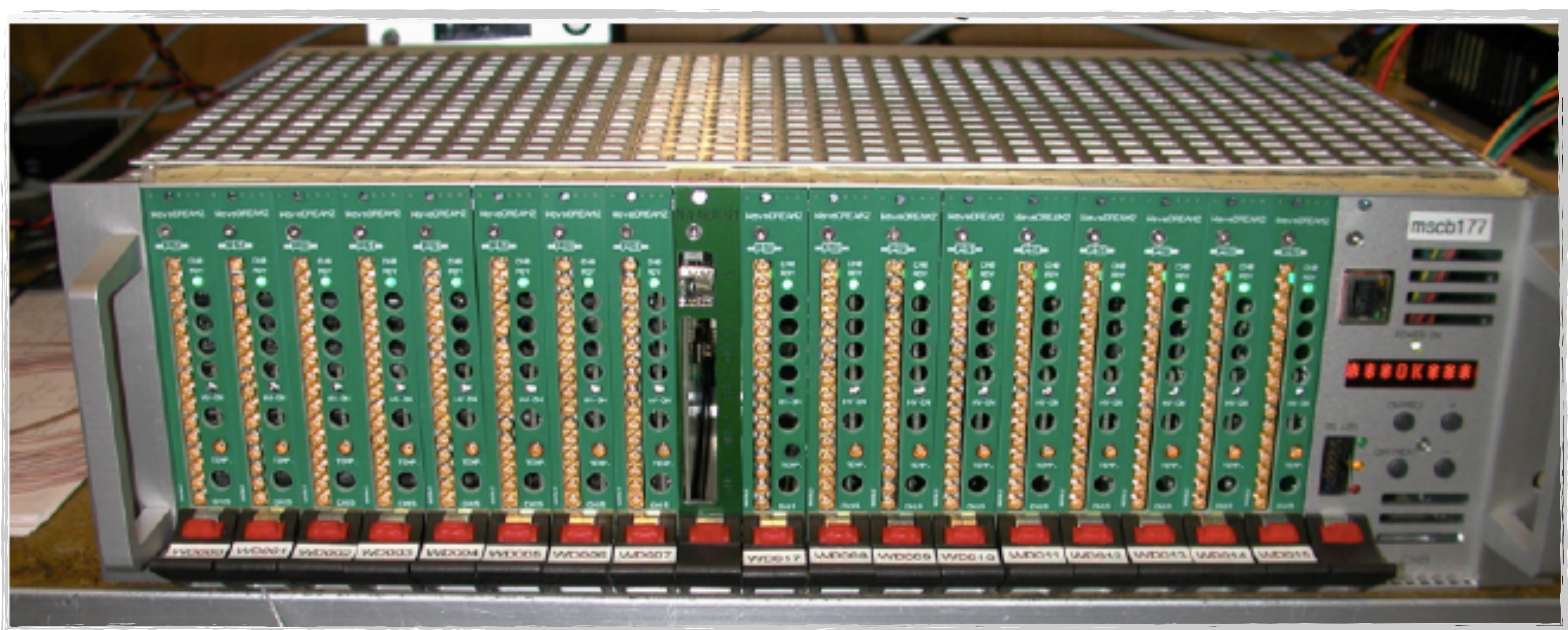
Pilot run 2016





MEGII: The new electronic - DAQ and Trigger

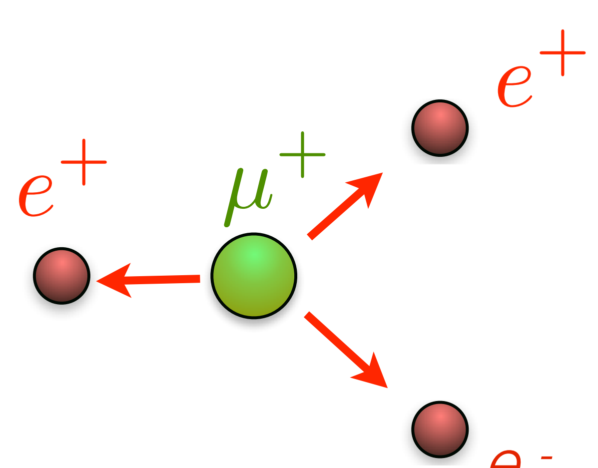
- DAQ and Trigger
  - ~9000 channels (5 GSPS)
  - Bias voltage, preamplifiers and shaping included for SiPMs
- 256 channels (1 crate) abundant tested during the 2016 pre-engineering run; >1000 channels available for the 2017 pre-engineering run; optimised version for 2018 engineering run.
- Trigger electronics and several trigger algorithms included and successfully delivered for the test beams/engineering runs



Mu3e: The $\mu^+ \rightarrow e^+ e^+ e^-$ search

- The Mu3e experiment aims to search for $\mu^+ \rightarrow e^+ e^+ e^-$ with a sensitivity of ~10^{-15} (Phase I) up to down ~10^{-16} (Phase II). Previous upper limit BR($\mu^+ \rightarrow e^+ e^+ e^-$) ≤ 1 x 10^{-12} @90 C.L. by SINDRUM experiment)
- Observables (E_e, t_e, vertex) to characterize $\mu \rightarrow eee$ events

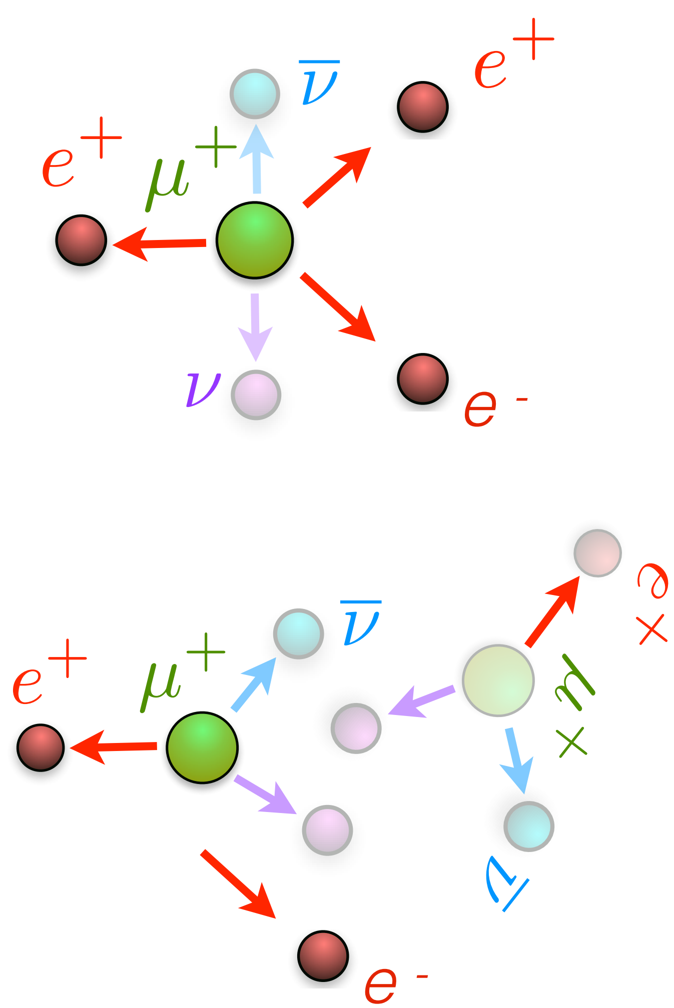
Signature



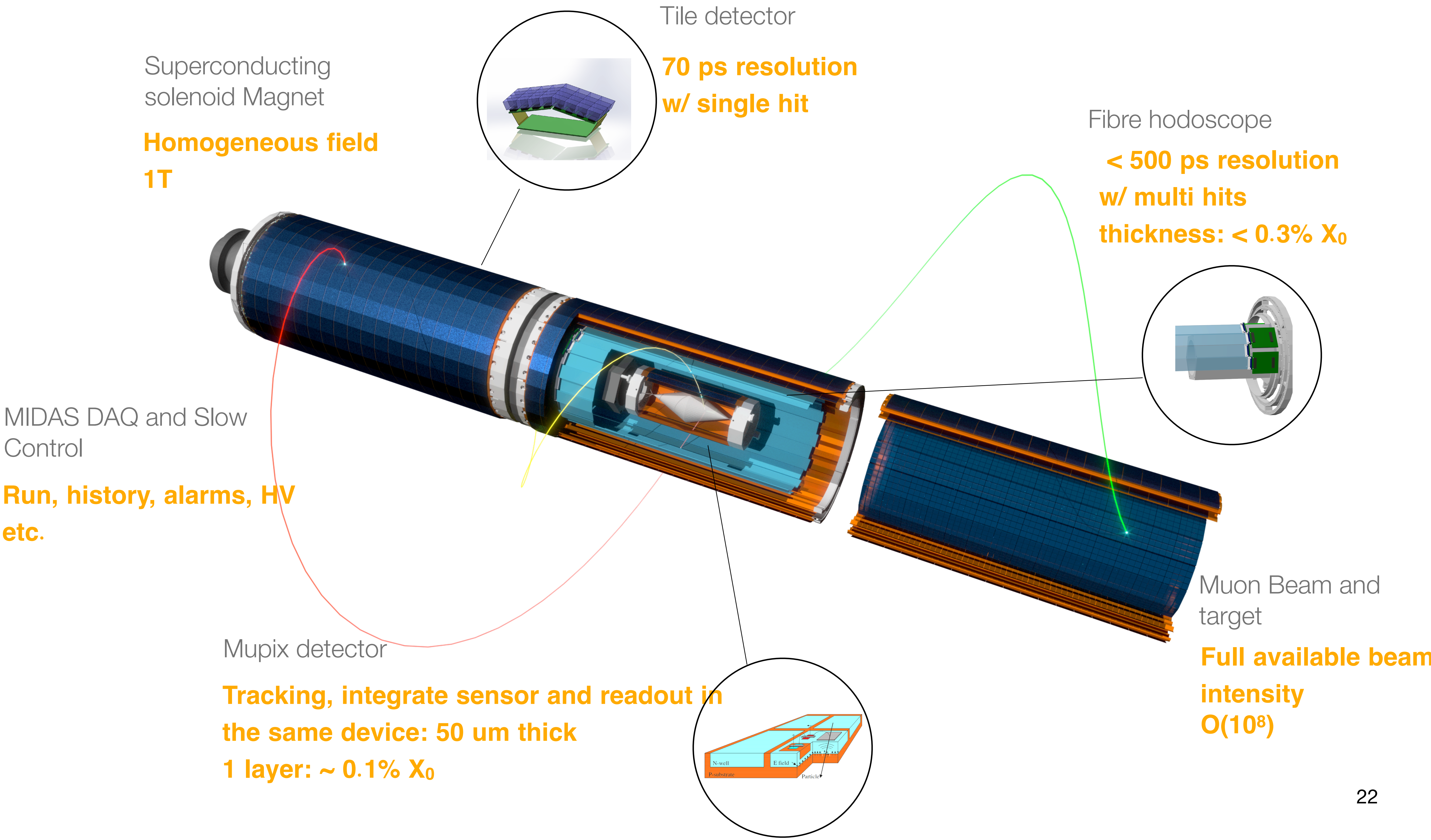
$$\Delta t_{eee} = 0 \qquad \Sigma \overline{p}_e = 0$$

$$\Sigma E_e = m_\mu$$

Background



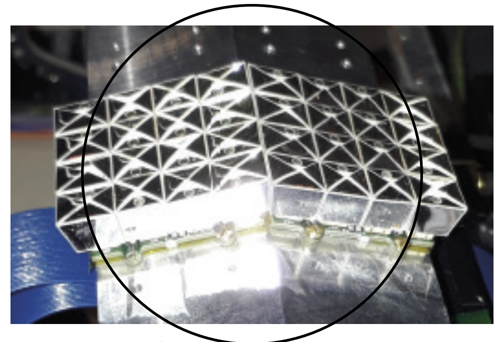
The Mu3e experiment: Schematic 3D



The Mu3e experiment: R&D completed. Prototyping phase

Superconducting solenoid Magnet

Homogeneous field
1T

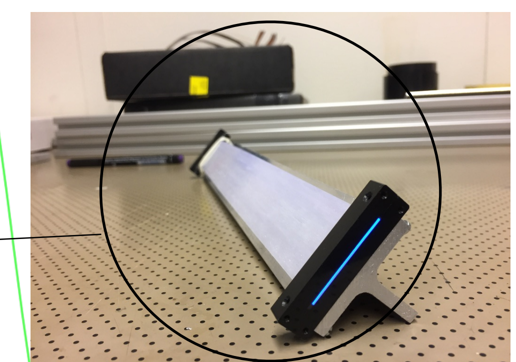


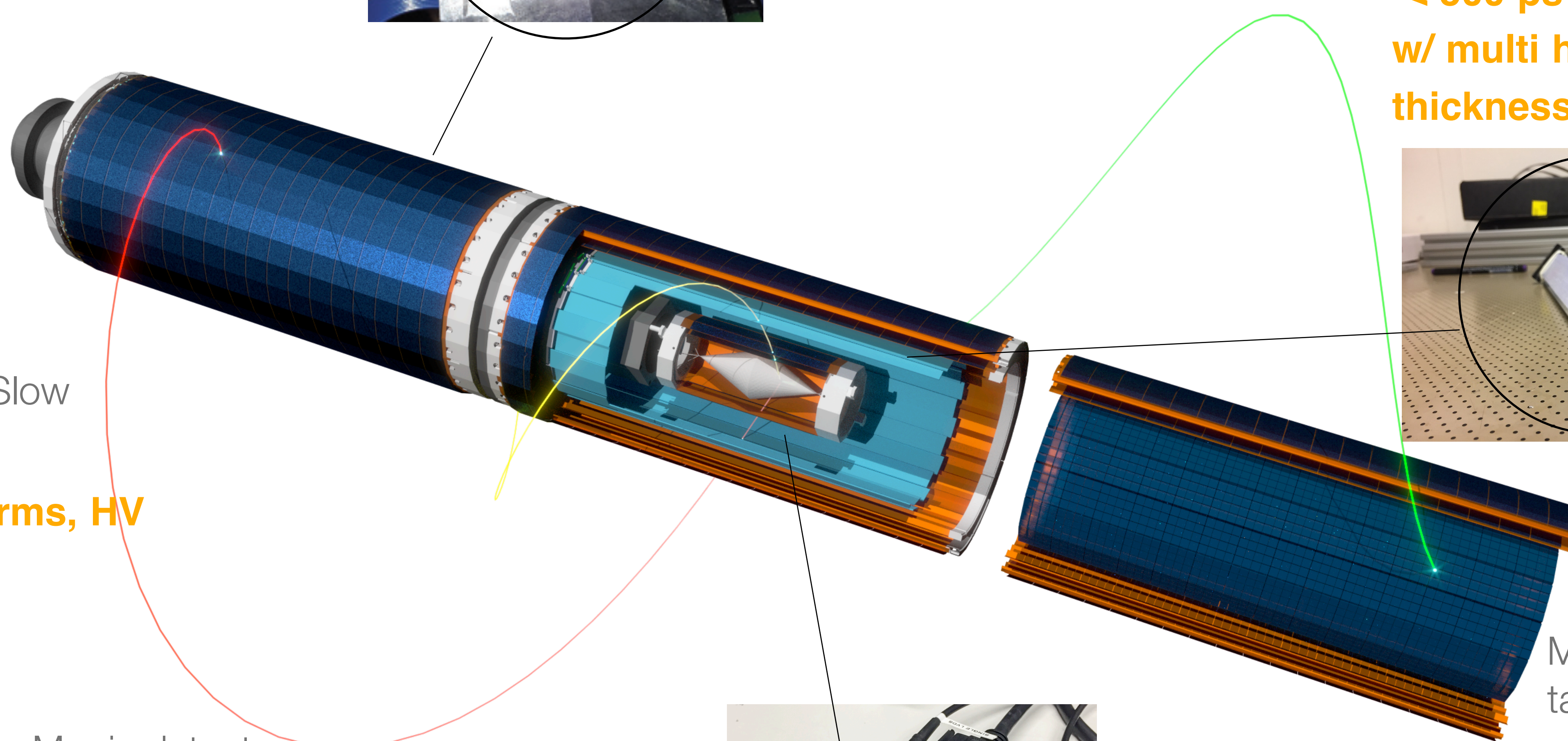
Tile detector

70 ps resolution
w/ single hit

Fibre hodoscope

< 500 ps resolution
w/ multi hits
thickness: < 0.3% X_0





MIDAS DAQ and Slow Control

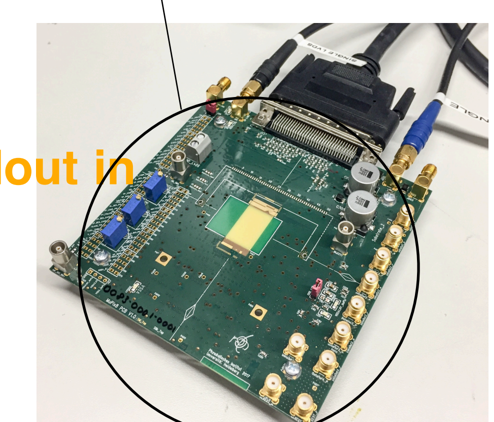
Run, history, alarms, HV etc.

Muon Beam and target

Full available beam intensity
O(10^8)

Mupix detector

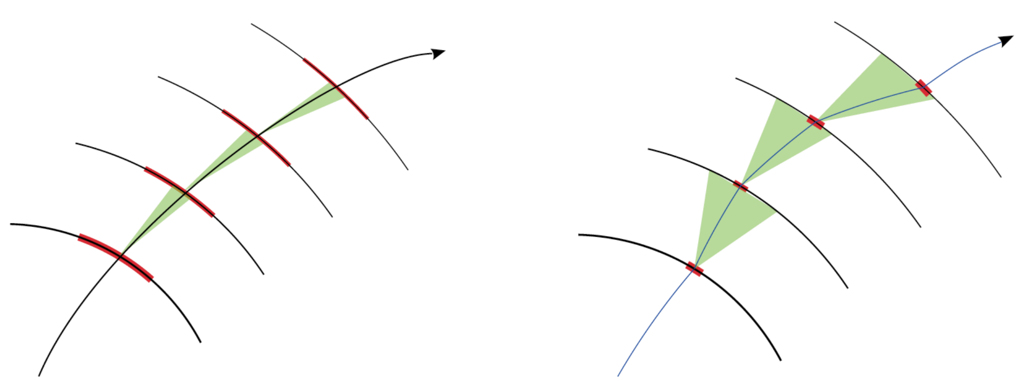
Tracking, integrate sensor and readout in the same device: 50 um thick
1 layer: ~ 0.1% X_0



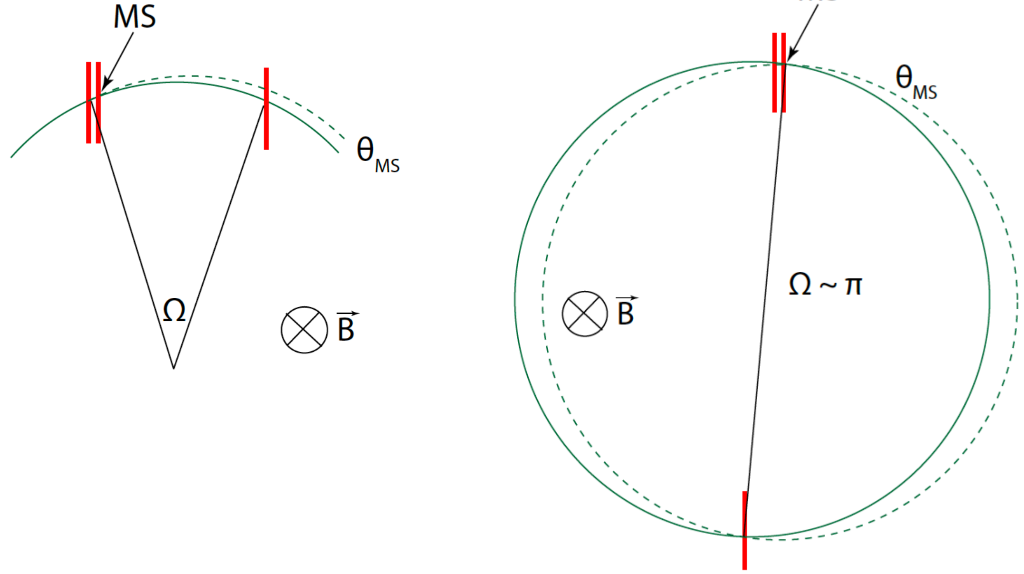
The pixel tracker: The principle

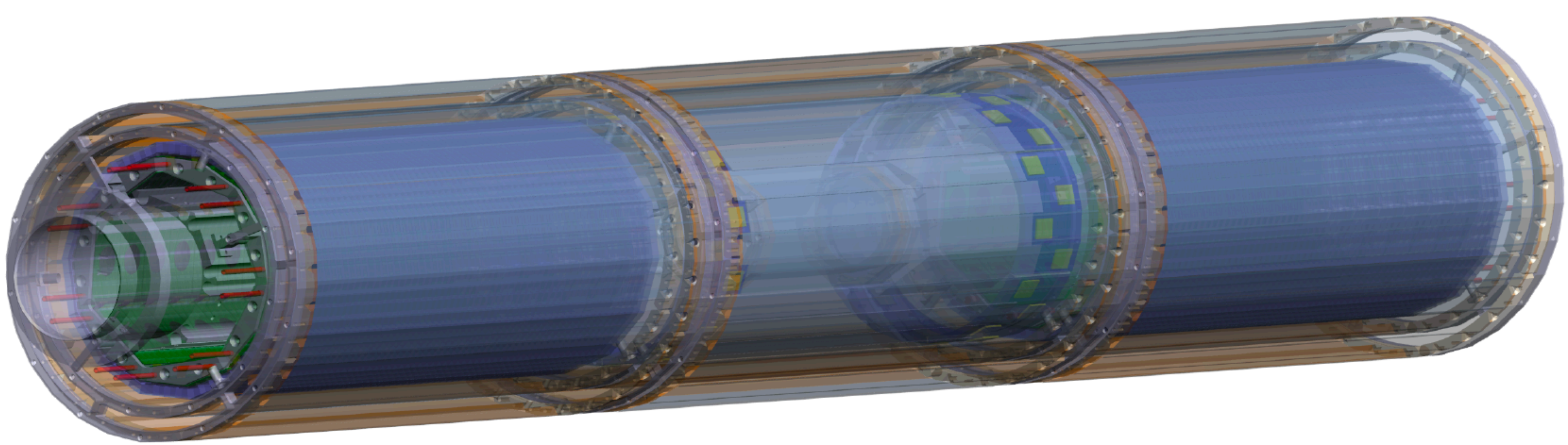
- Central tracker: Four layers; Re-curl tracker: Two layers
- Minimum material budget: Tracking in the scattering dominated regime

Tracking in the spacial and scattering dominated regime



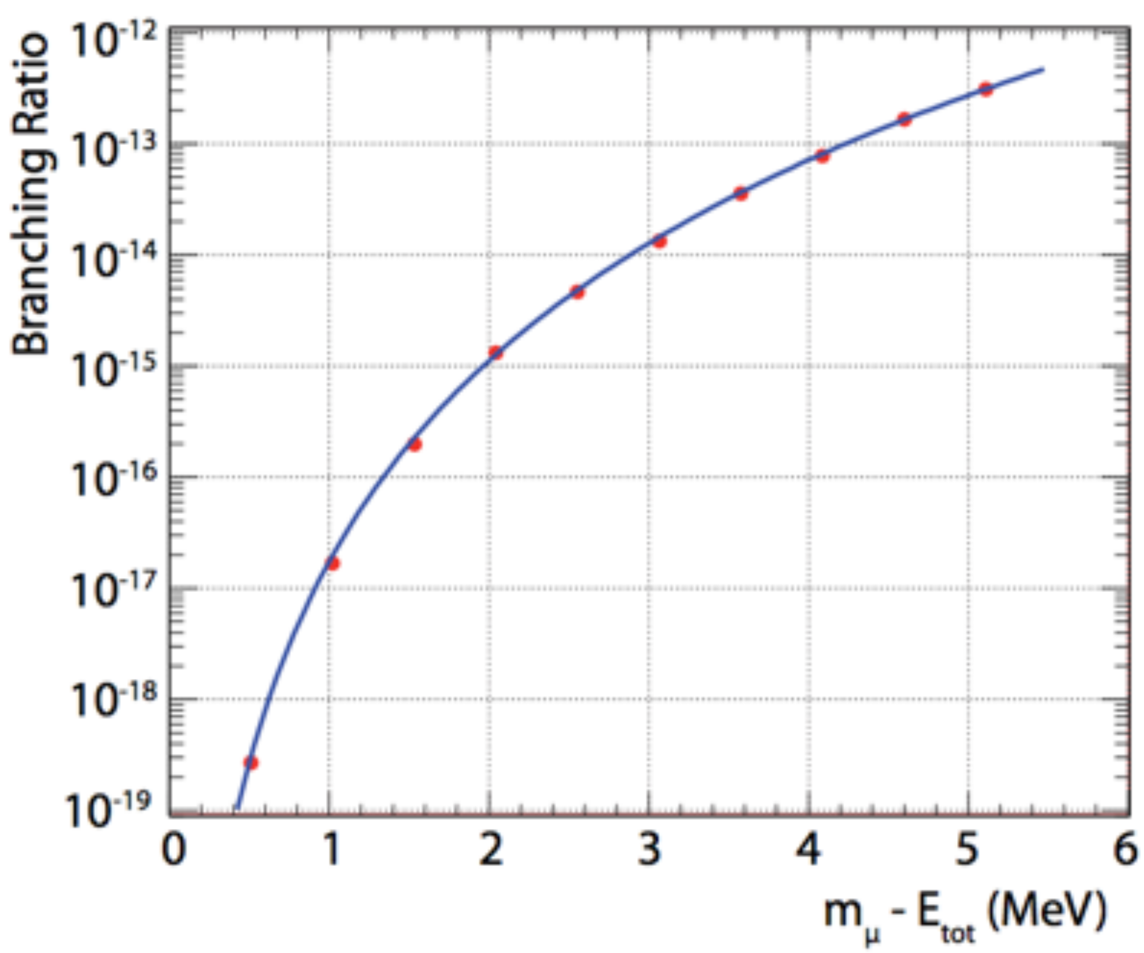
Momentum with re-curlers

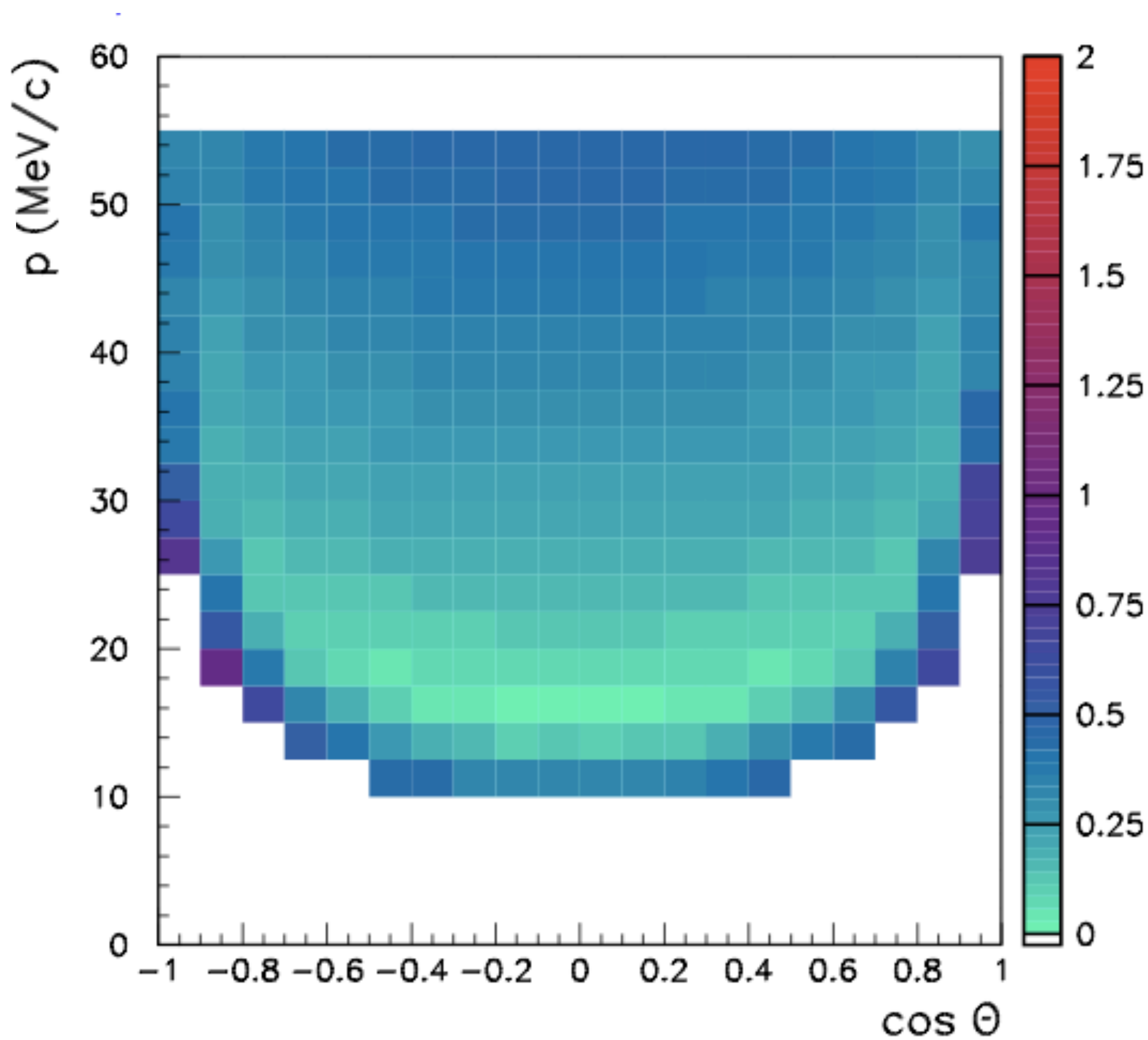




The pixel tracker: The performances

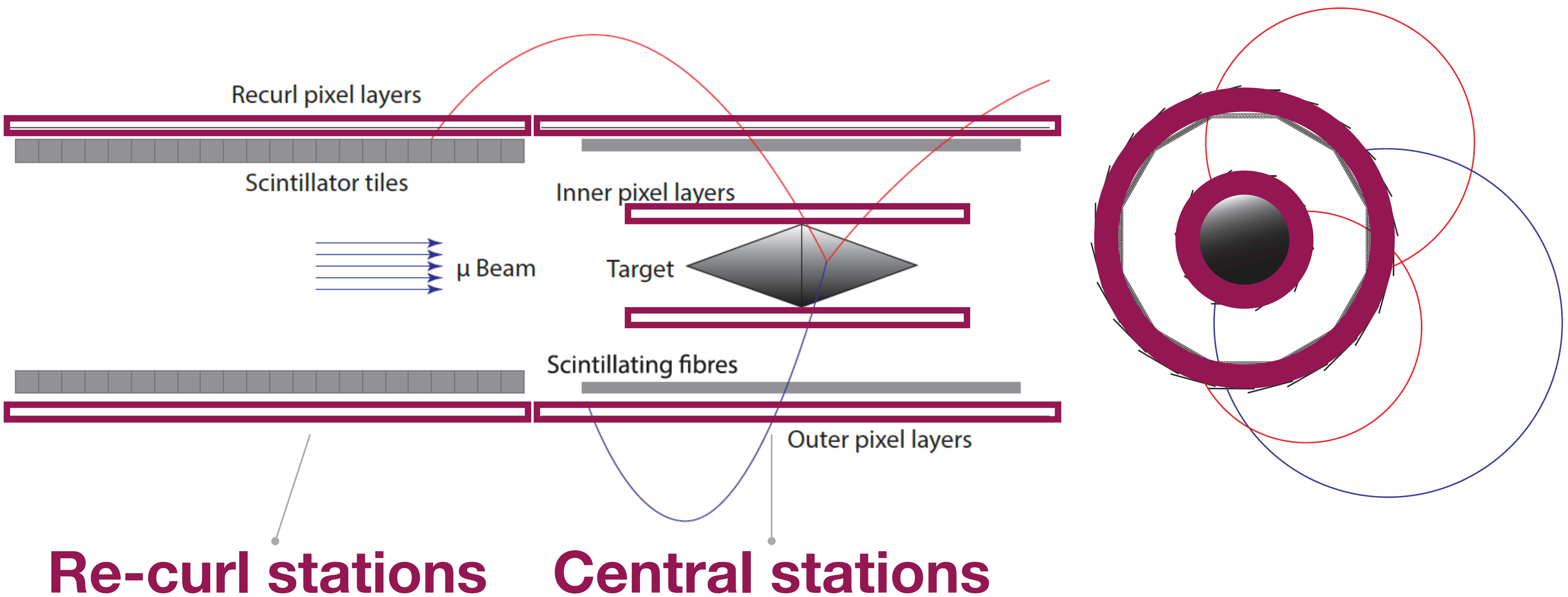
- Momentum resolution: < 0.5 MeV/c over a large phase space
- Geometrical acceptance: ~ 70%
- X/X_0 per layer: ~ 0.011%
- Vertex resolution: < 200 μm





The pixel tracker: Overview

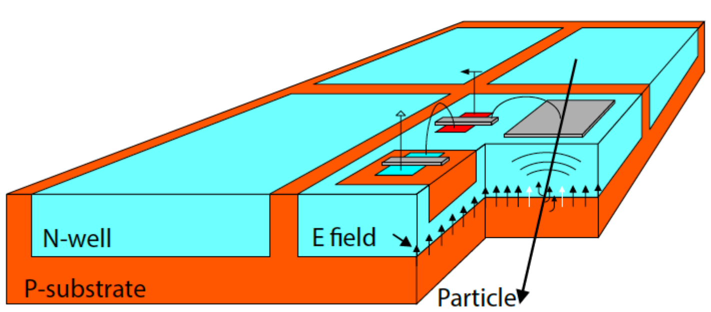
- Central tracker: Four layers; Re-curl tracker: Two layers
- Minimum material budget: Tracking in the scattering dominated regime
- Momentum resolution: < 0.5 MeV/c over a large phase space; Geometrical acceptance: ~ 70%; X/X_0 per layer: ~ 0.011%



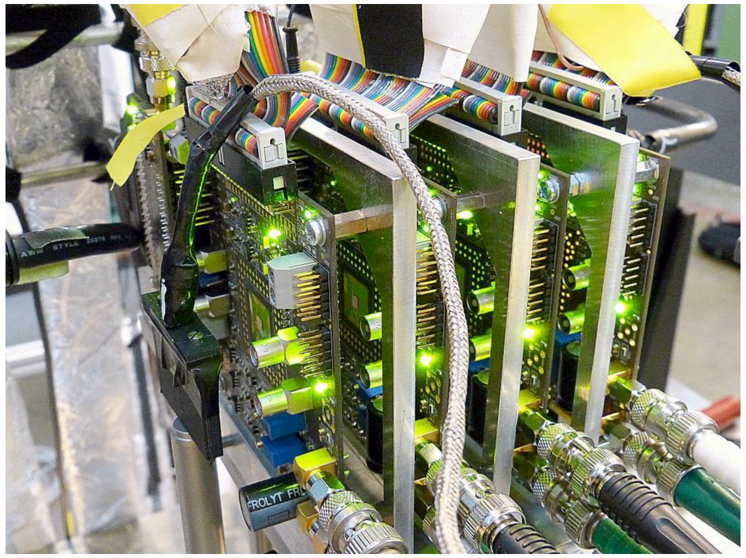
The pixel tracker: The Mupix prototypes

- Based on HV- MAP: Pixel dimension: 80 x 80 μm^2 , Thickness: 50 μm , Time resolution: < 20 ns, Active area chip: 20 x 20 mm^2 , Efficiency: > 99 %, Power consumption : < 350 mW/cm^2
- MuPix 7: The first small-scale prototype which includes all Mu3e functionalities
- MuPix 8, the first large area prototype: from O(10) mm^2 to 160 mm^2 : Ready and extensively tested!
- MuPix 9, small test chip for: Slow Control, voltage regulators and other test circuits. 2019 year test beam campaign
- MuPix 10, towards the final version: O(400) mm^2

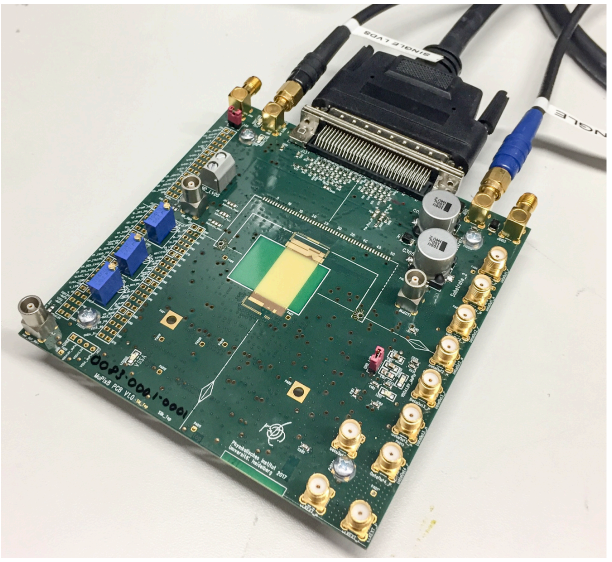
Prototype	Active Area [mm^2]
MuPix1	1.77
MuPix2	1.77
MuPix3	9.42
MuPix4	9.42
MuPix6	10.55
MuPix7	10.55



Mupix 7 telescope

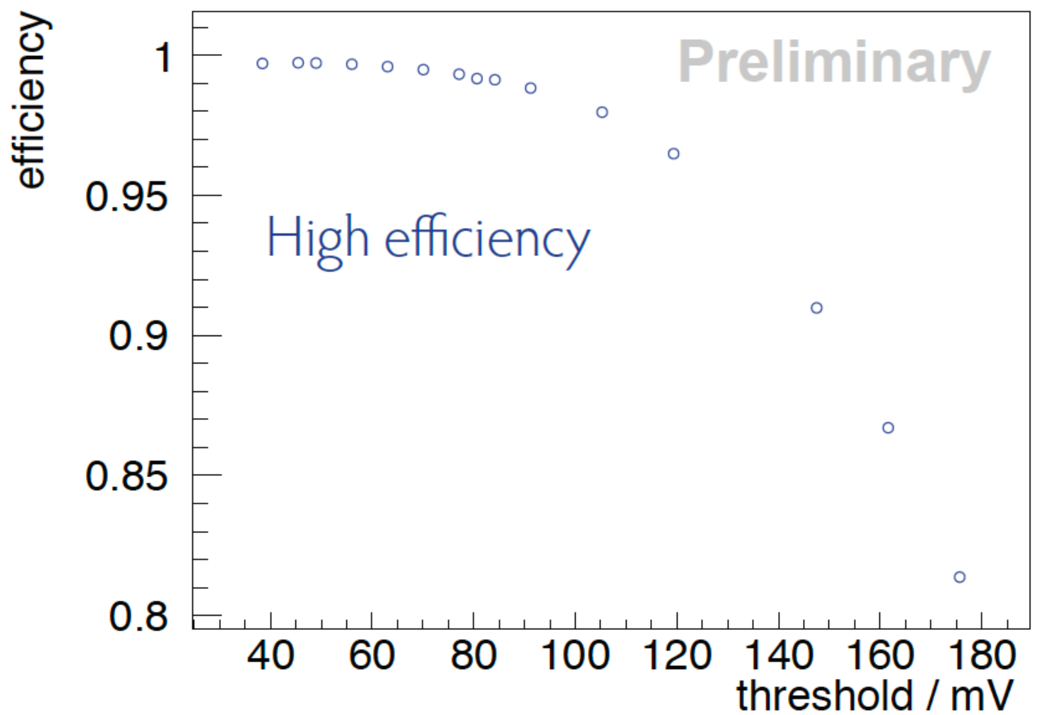


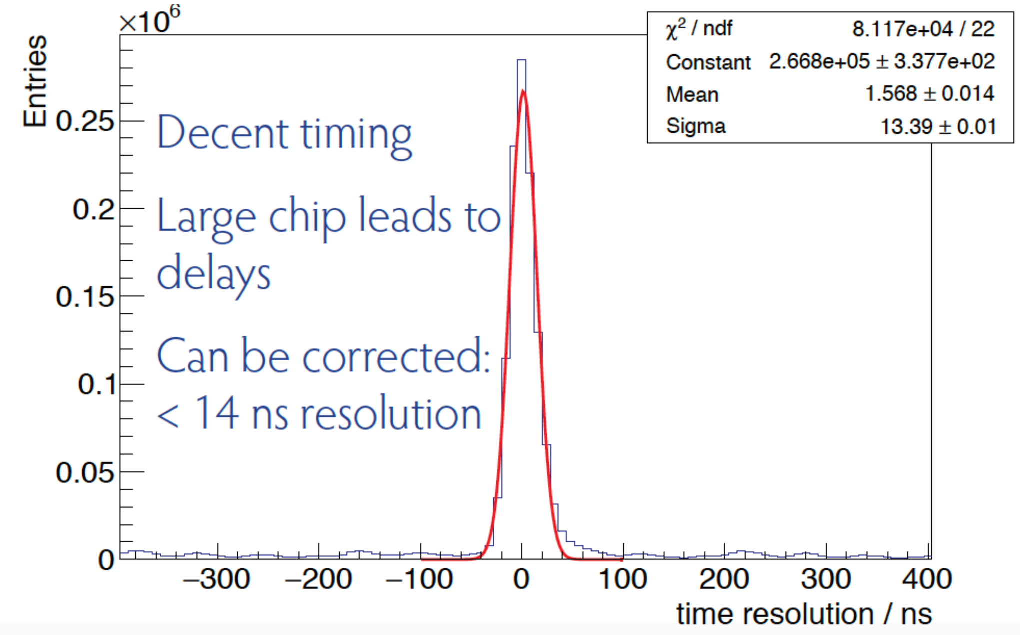
MuPix8



MuPix 8:Results

- Extensive beam test scheduled for the full 2018
- Some preliminary results

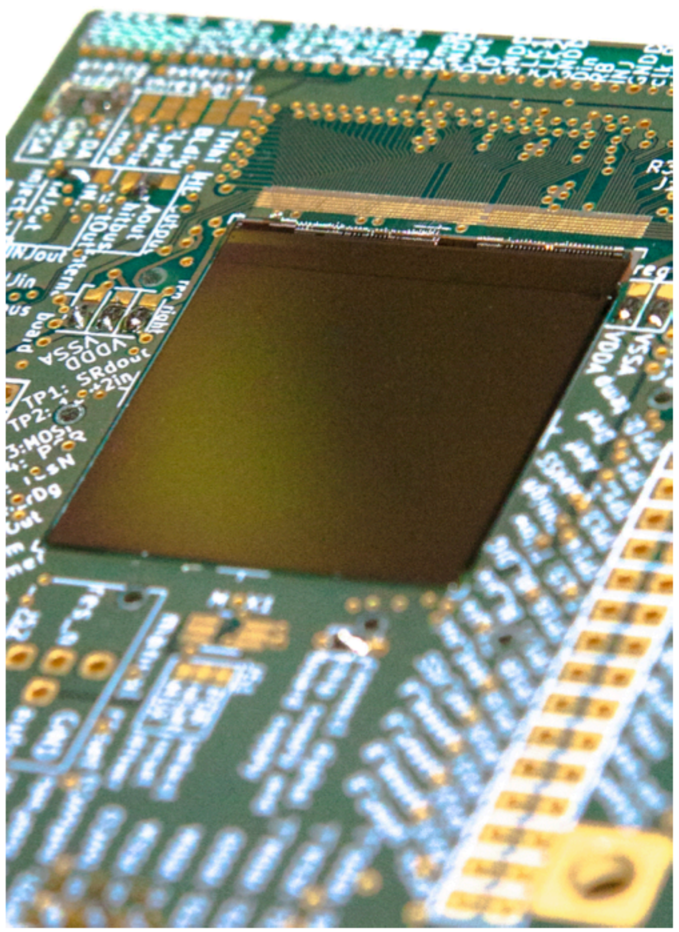




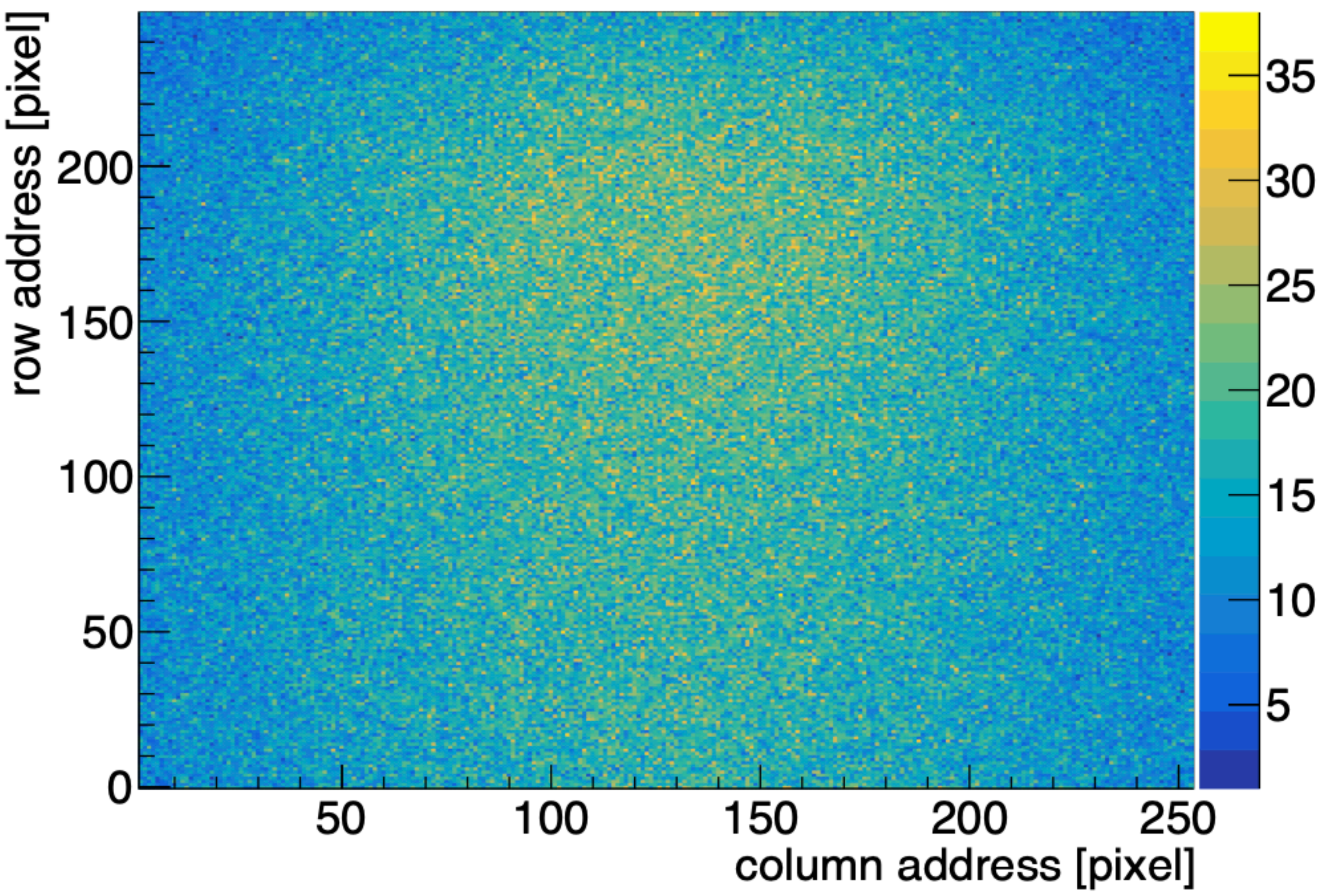
MuPix 10:Results

- Active area: 20.48 x 20.00 mm2. The final prototype
- All Mu3e features included
- Mupix 11: Module production

Mupix 10 chip mounted on a test PCB

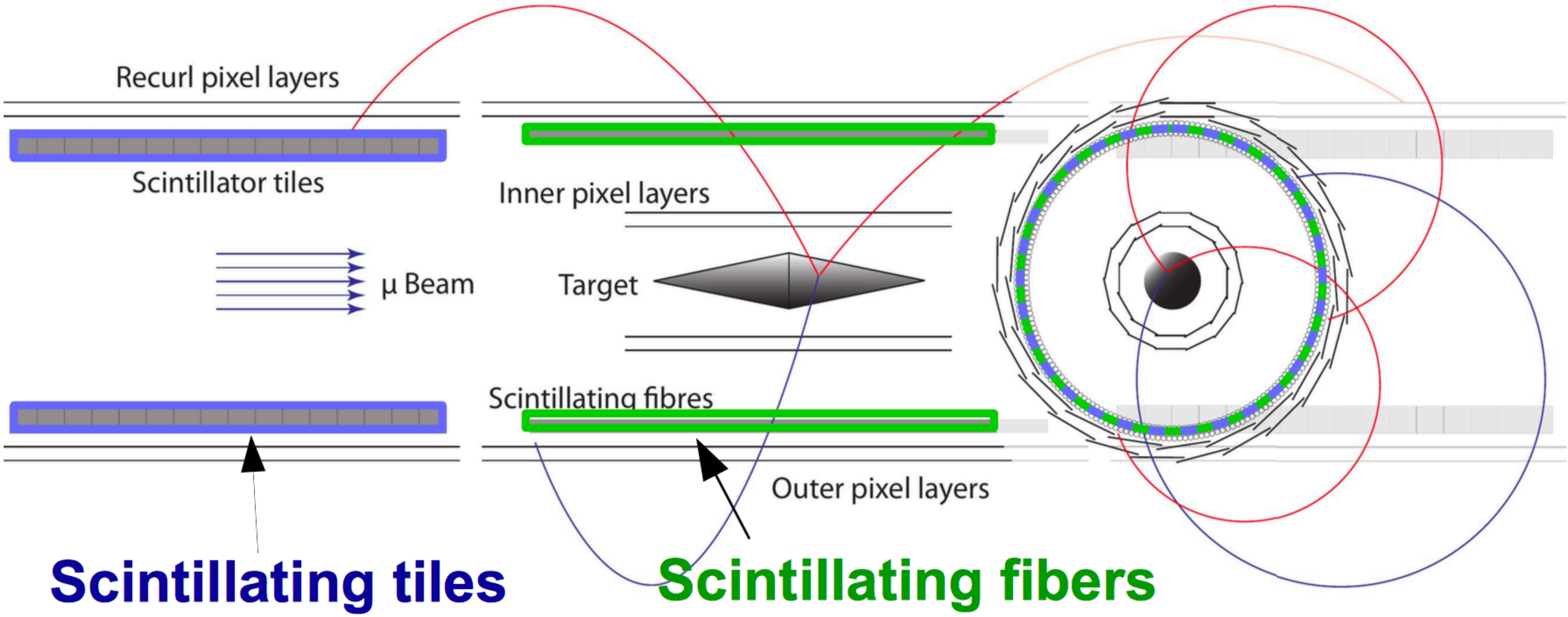


Mupix 10 hit map at a DESY test beam



The timing detectors: Fibers and tiles

- Precise timing measurement: Critical to reduce the accidental BGs
  - Scintillating fibers (SciFi) O(1 ns), full detection efficiency (>99%)
  - Scintillating tiles O(100 ps), full detection efficiency (>99%)



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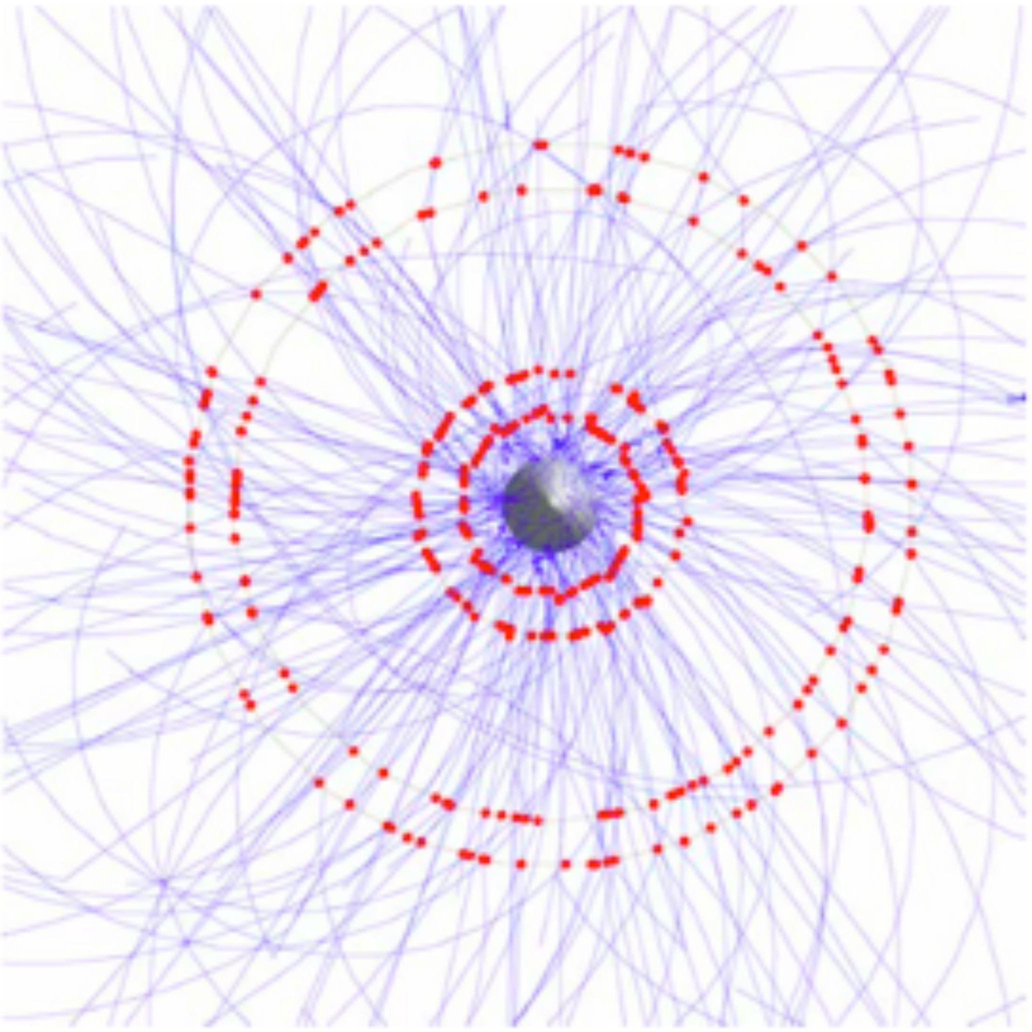
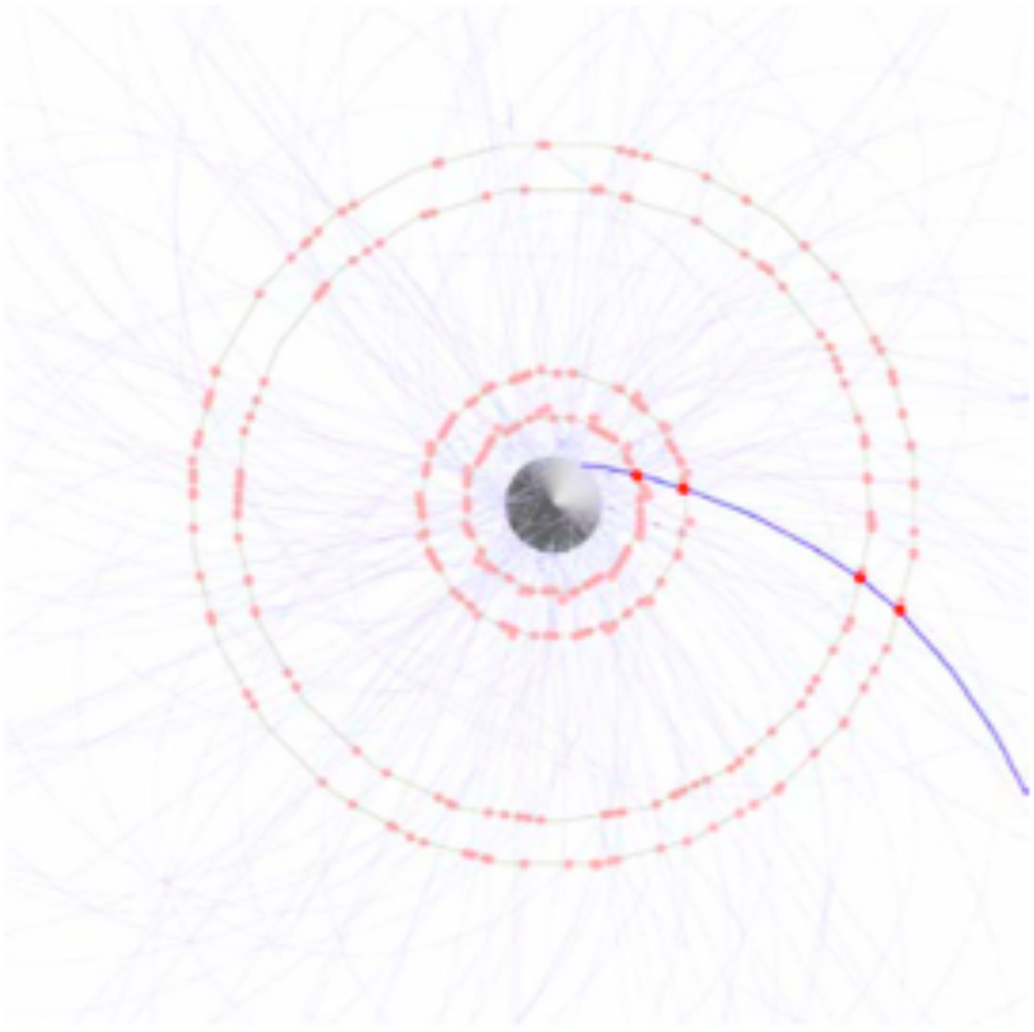


Pixels: O(50 ns)

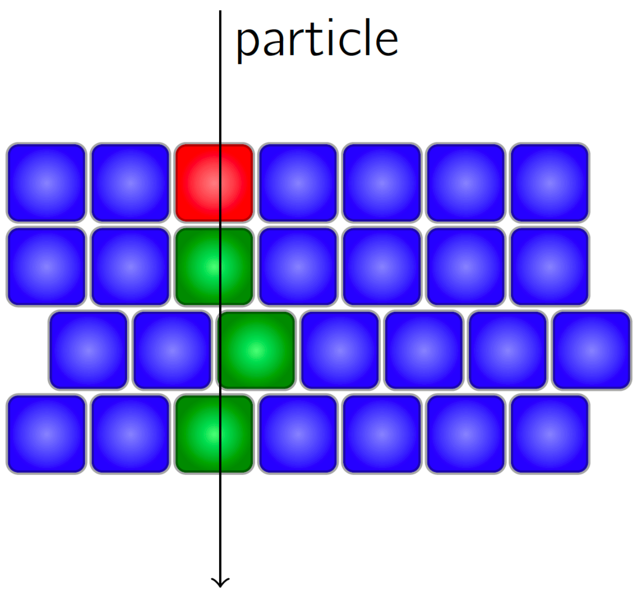


Scintillating fibres O(1 ns);
Scintillating tiles O(100 ps)

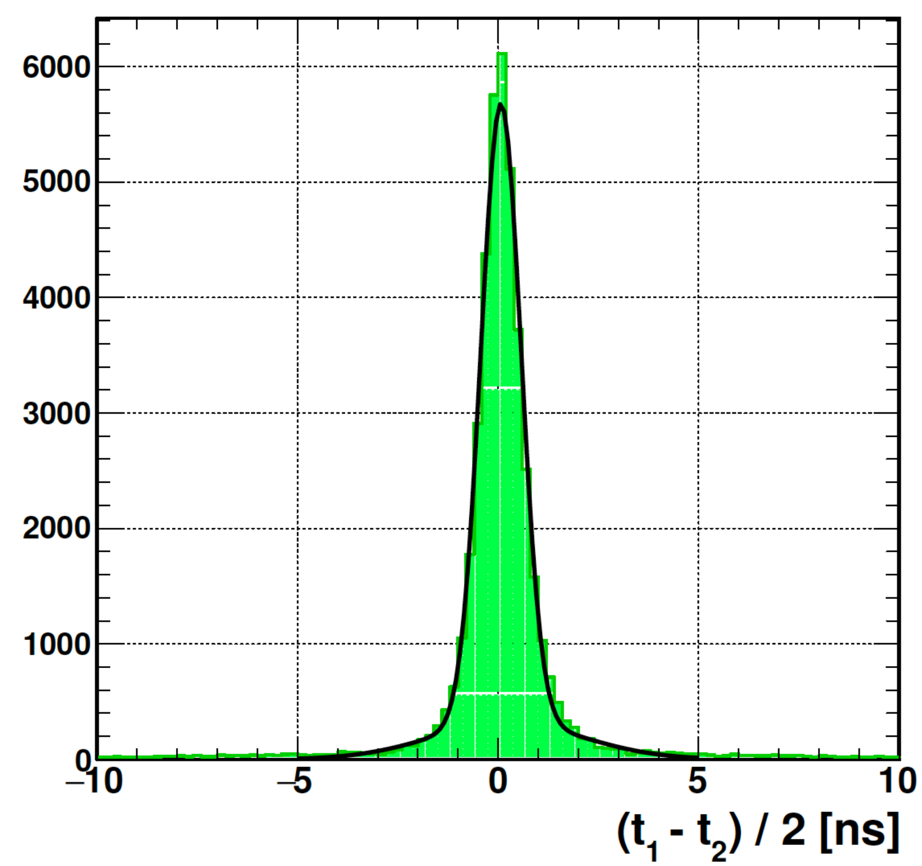
SciFi prototypes: Results

- Confirmed full detection efficiency (**> 97 % @ 0.5 thr in Nphe**) and timing performances for multi-layer configurations (square and round fibres) with several prototypes: individual and array readout with standalone and prototyping (STiC) DAQ

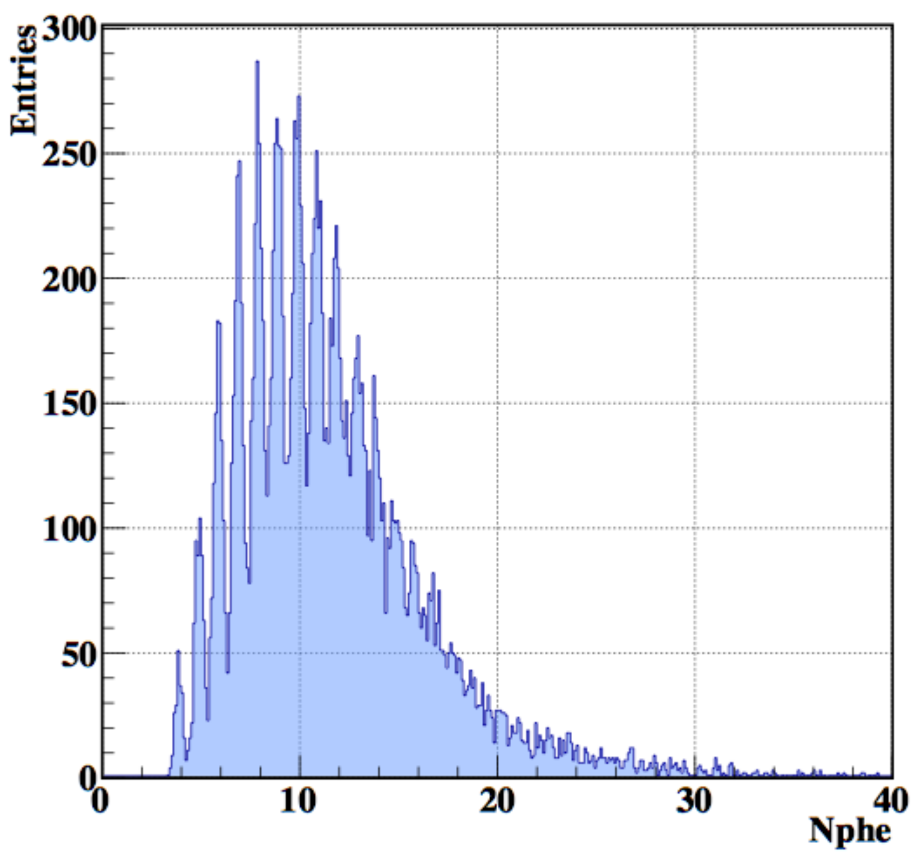
Trigger
offline selection:
hits in 3 layers



3 layer time resolution O(550) ps

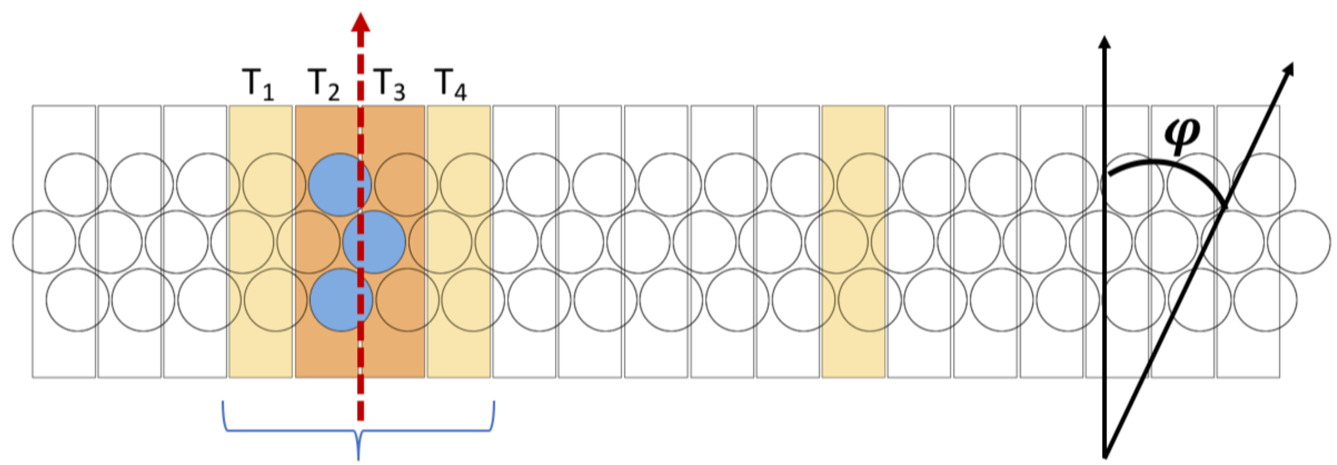


3 layer offline array charge collection (thr > 1.5 Nphe)

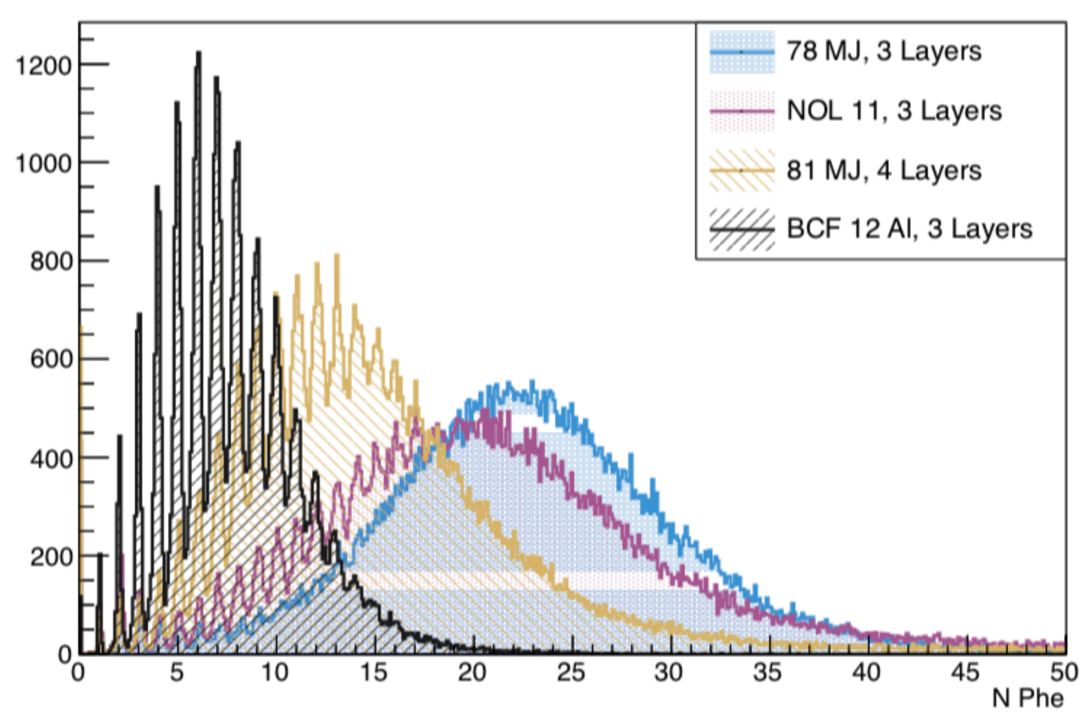


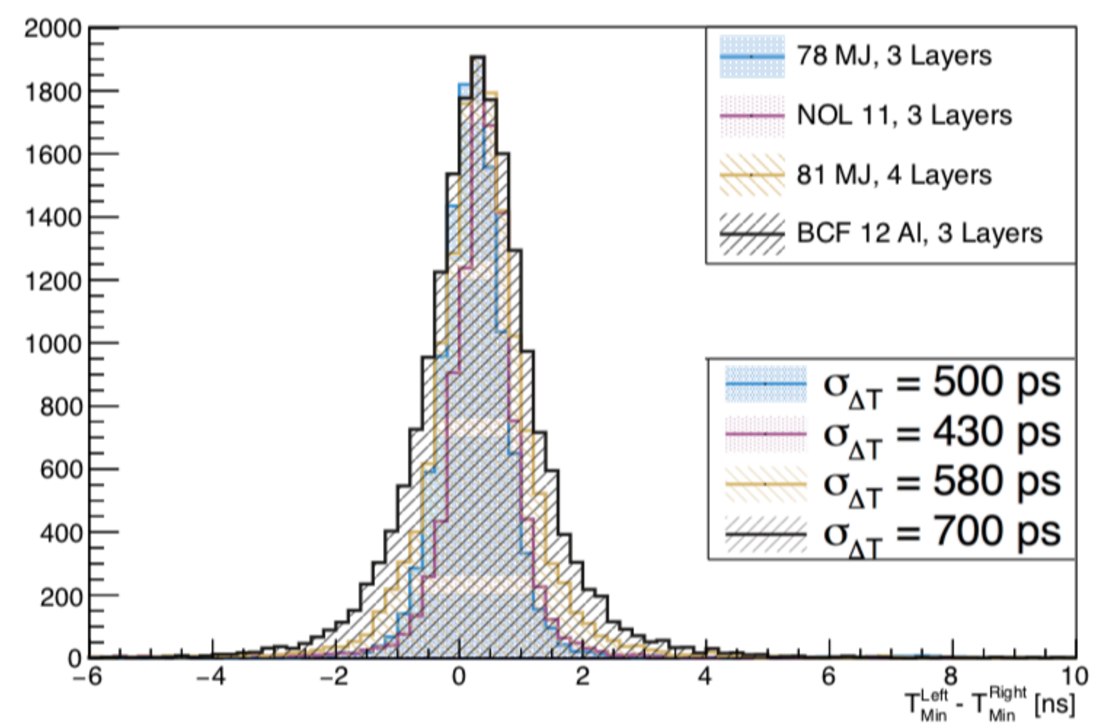
SciFi prototypes: Results

- Studied a variety of fibres (SCSF 78 MJ, clear; SCSF 78 MJ, with 20% TiO2; NOL 11, clear; NOL 11, with 20% TiO2; SCSF 81 MJ, with 20% TiO2; BCF12 clear; BCF12, with 100 nm Al deposit)
- Confirmed full detection efficiency (> 96 % @ 0.5 thr in Nphe) and timing performances for multi-layer configurations (square and round fibres) with several prototypes: individual and array readout with standalone and prototyping (STiC) DAQ



New





SciFi prototypes: Results

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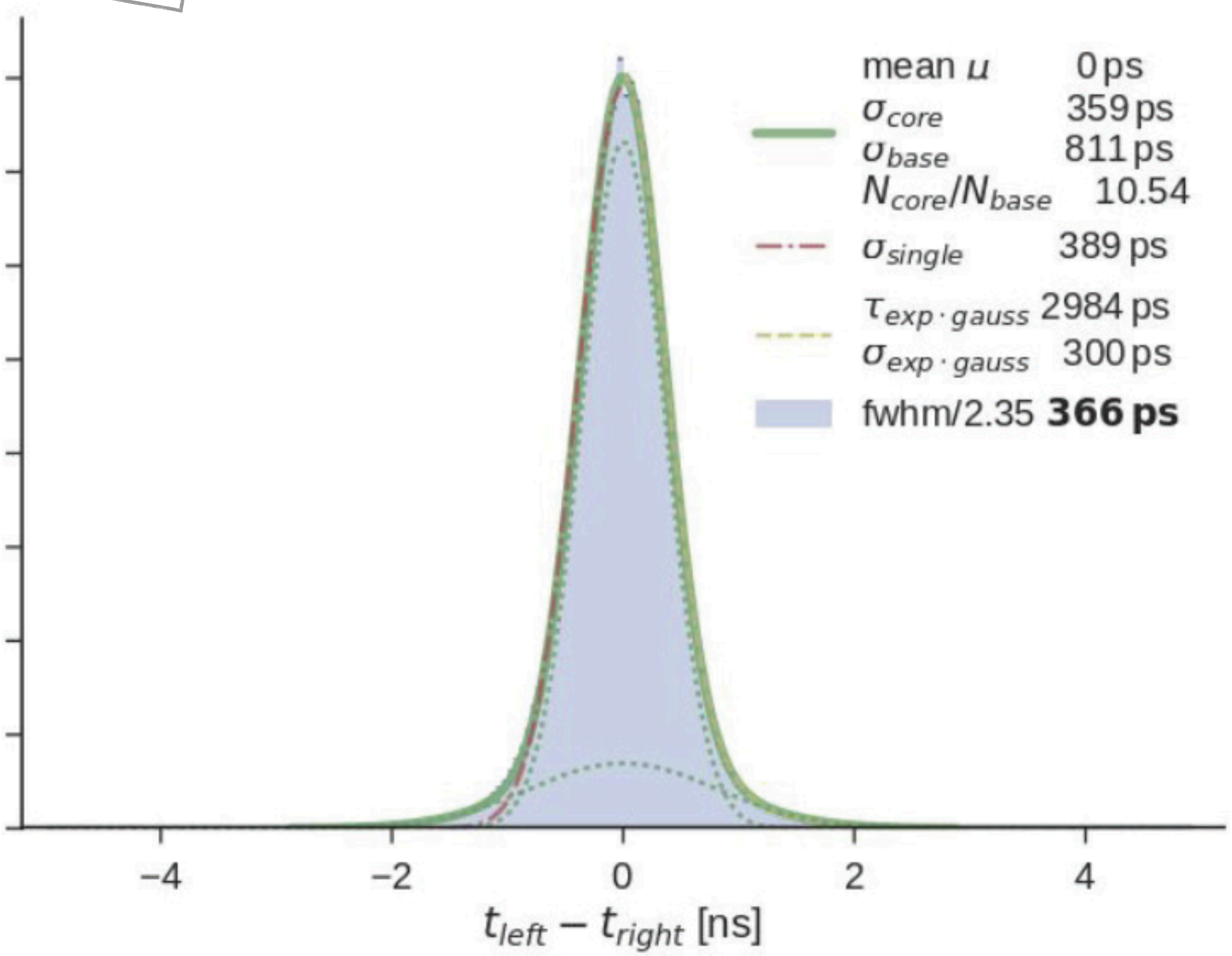
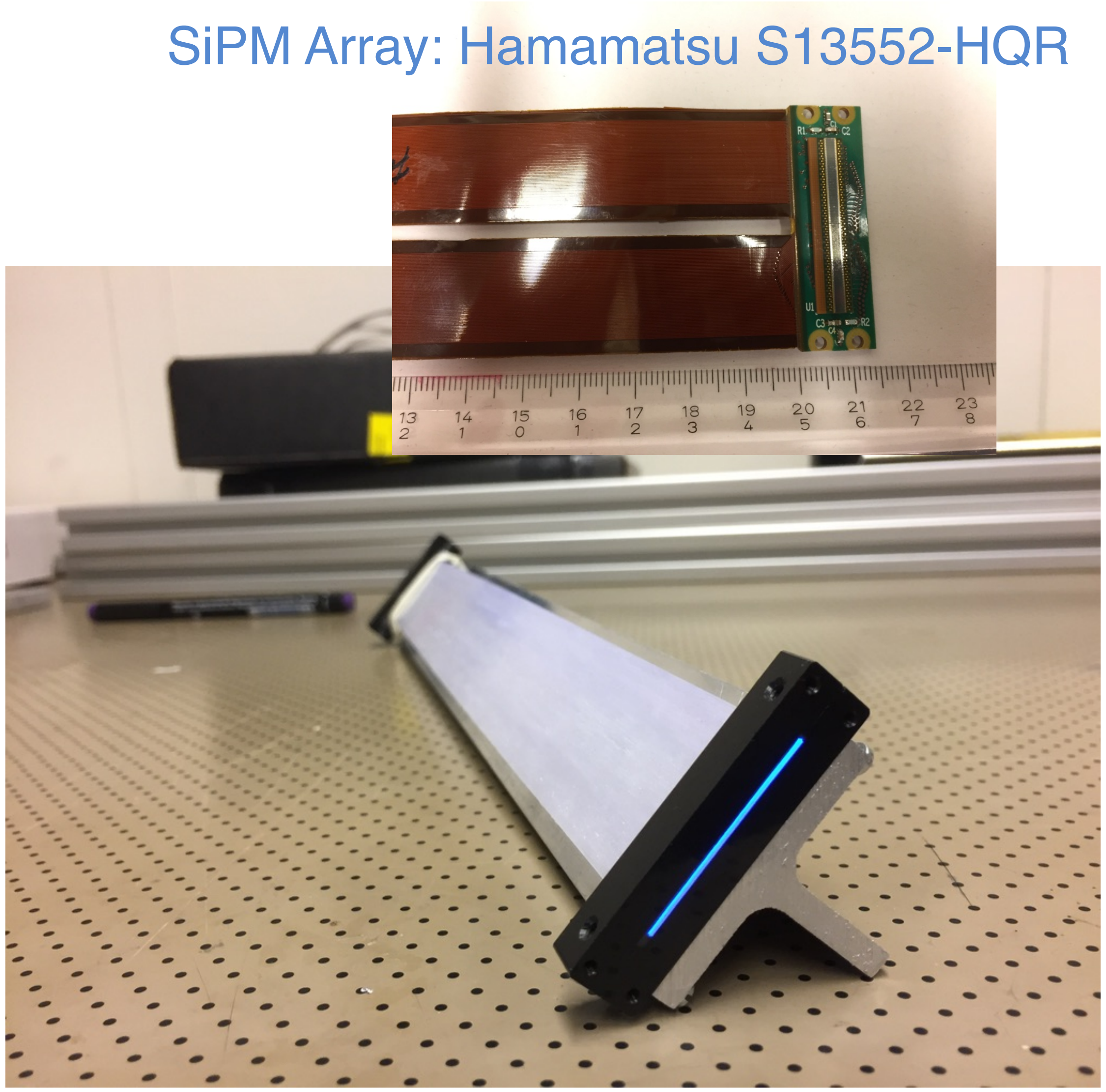
- Confirmed full detection efficiency (> 96 % @ 0.5 thr in Nphe) and timing performances for multi-layer configurations (square and round fibres) with several prototypes: individual and array readout with standalone and prototyping (STiC) DAQ

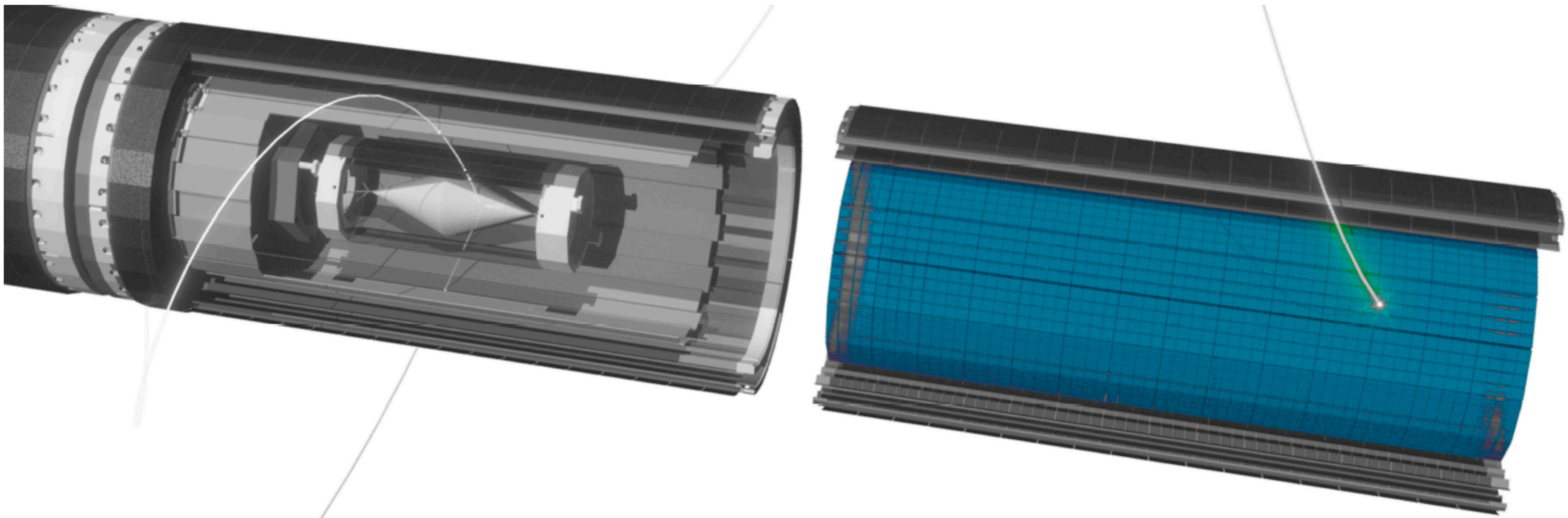
SiPM Array: Hamamatsu S13552-HQR

New





The Tile detector: Overview



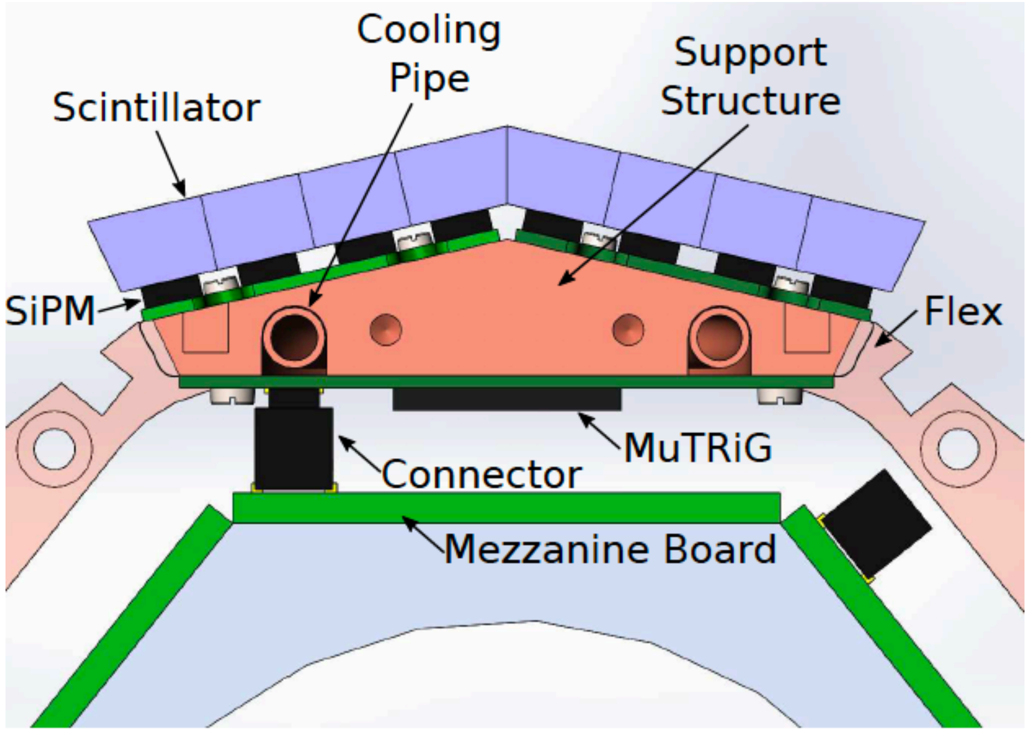
Parts

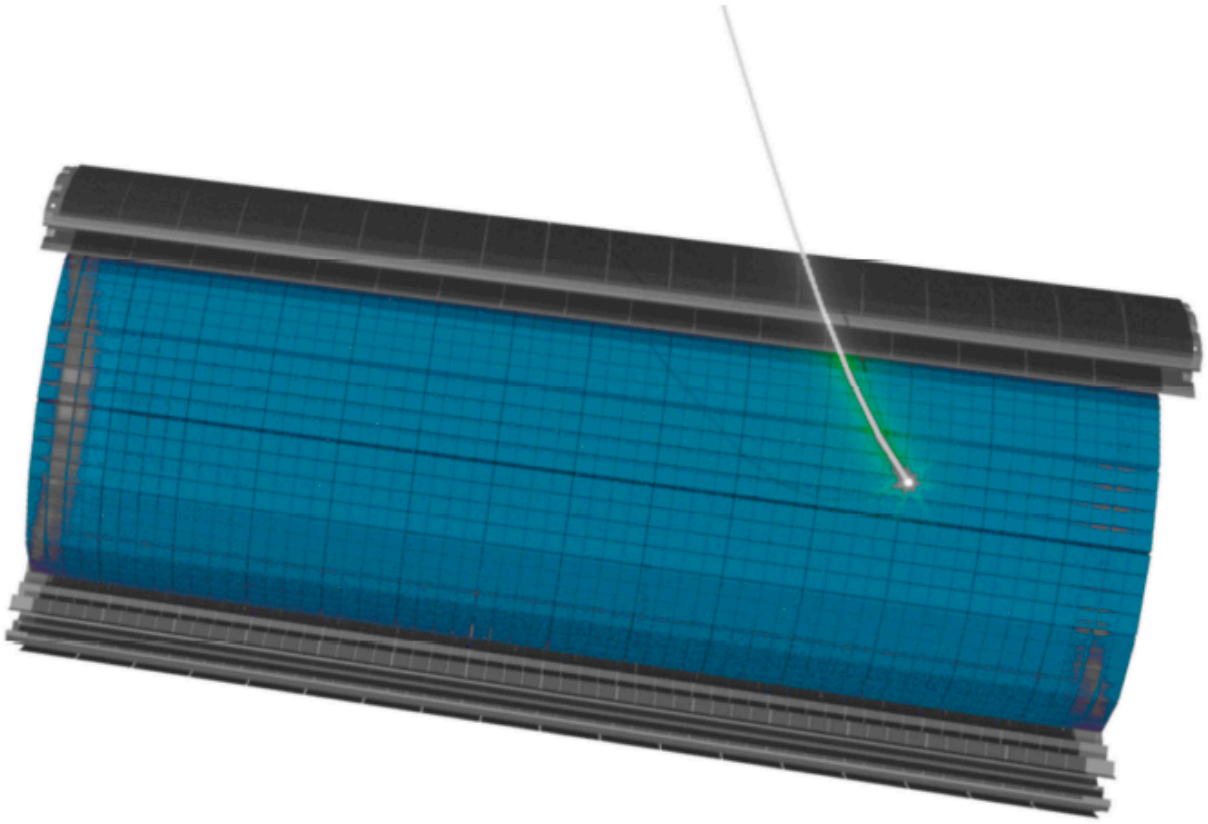
- cylindrical at ~ 6 cm (radius)
- length of 36.4 cm
- 56 x 56 tiles of 6.5 x 6.5 x 5 mm^3
- 3 x 3 mm^2 single SiPM per tile
- Mixed mode ASIC: MuTRiG

Requirements

- high detection efficiency $\varepsilon > 95\%$
- time resolution $\sigma < 100$ ps
- rate up to 50 KHz per tile/channel

The Tile detector: Overview





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Requirements

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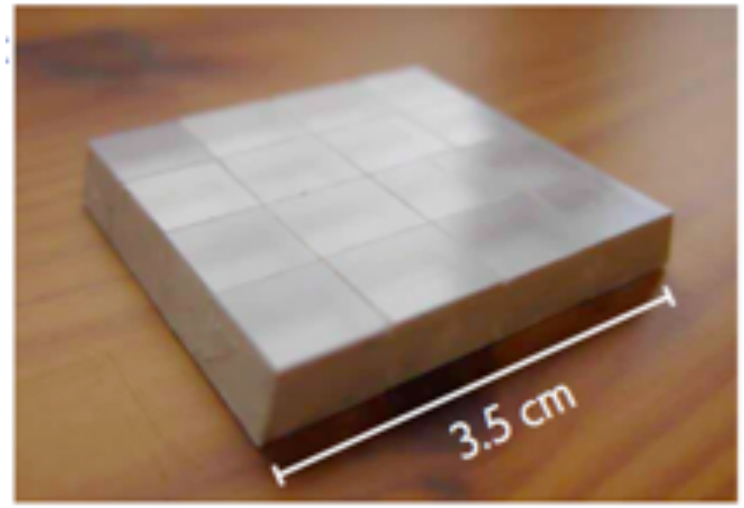
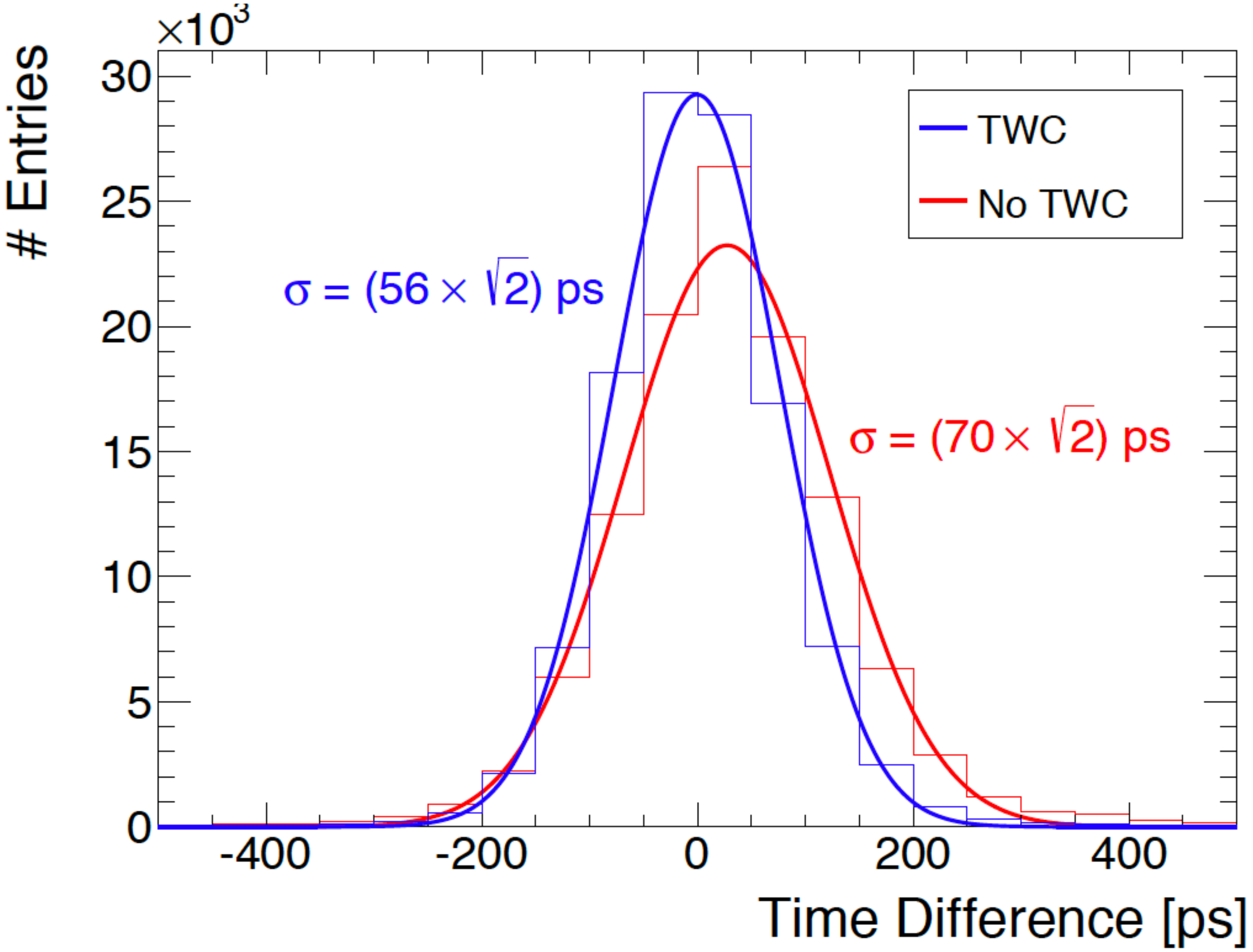
- time resolution $\sigma < 100$ ps
- rate up to 50 KHz per tile/channel

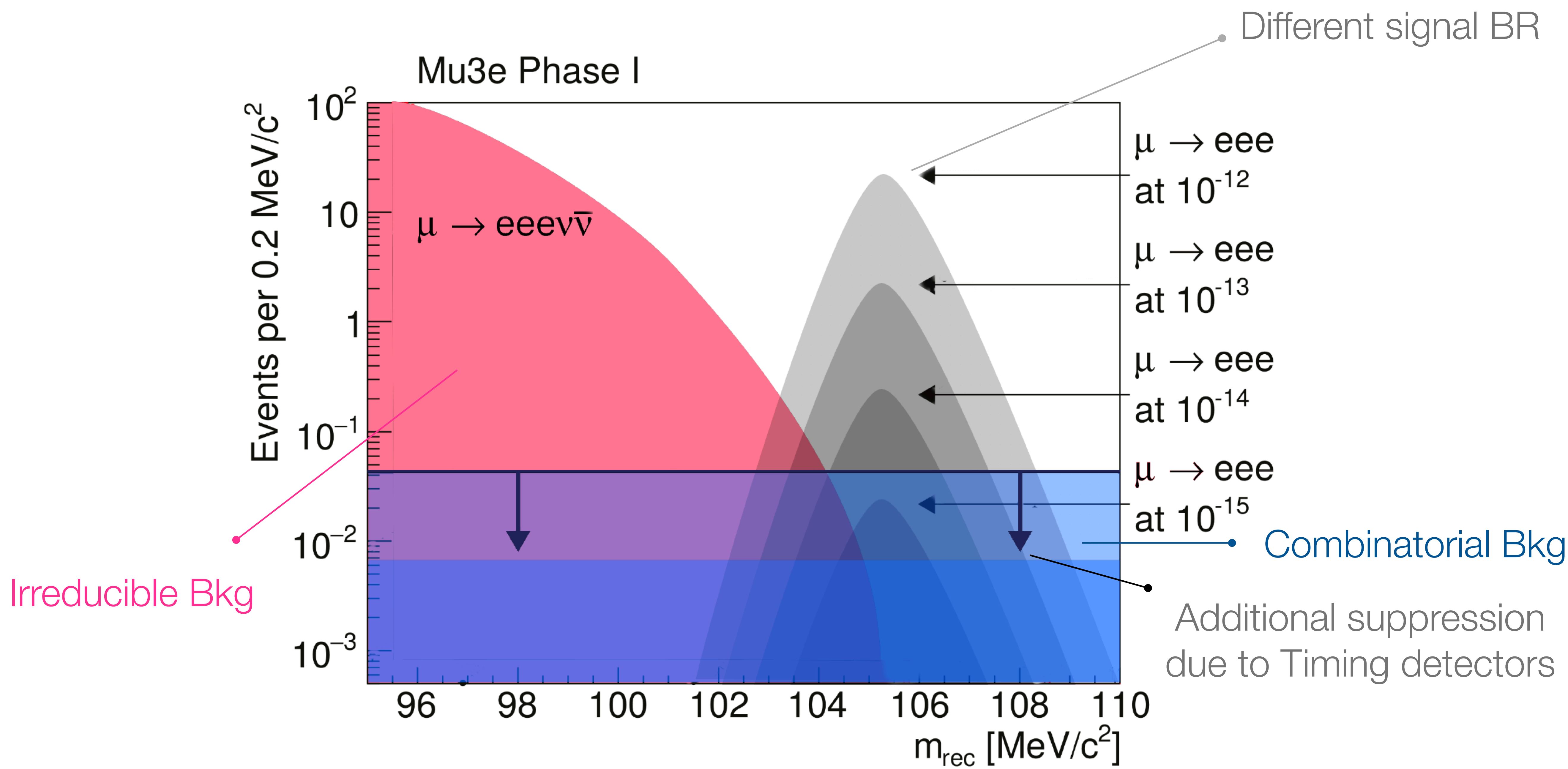
Tile Prototype: Results

- Mu3e requirements fulfilled: Full detection efficiency (> 99 %) and timing resolution O (60) ps
- 4 x 4 channel BC408
- 7. 5 x 8. 5 x 5. 0 mm^3
- Hamamatsu S10362-33-050C (3 x 3 mm^2)
- readout with STiC2



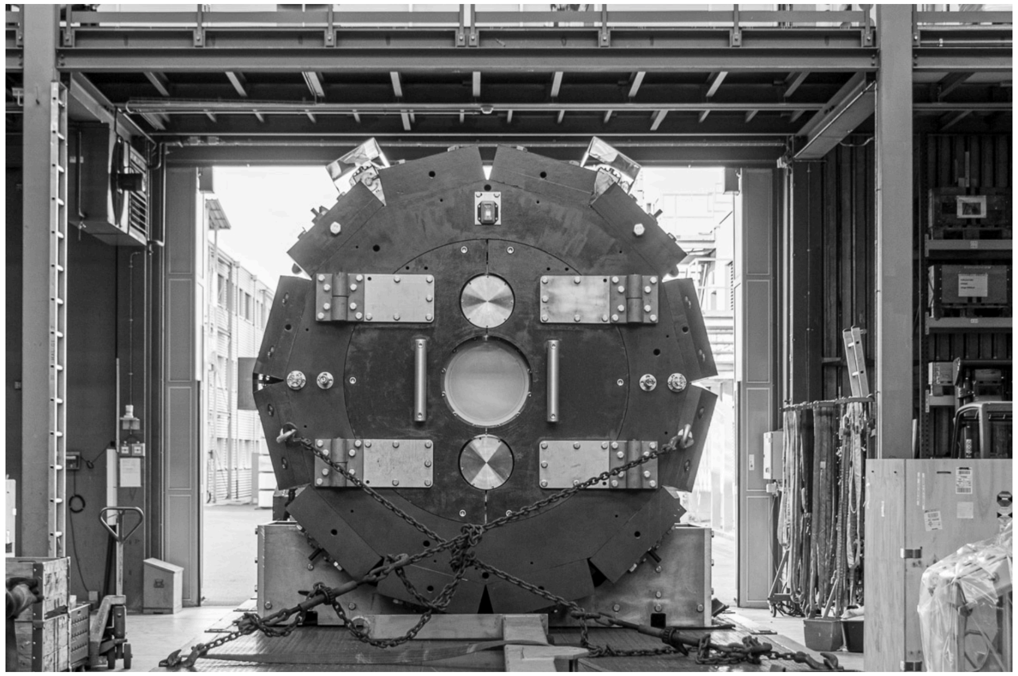


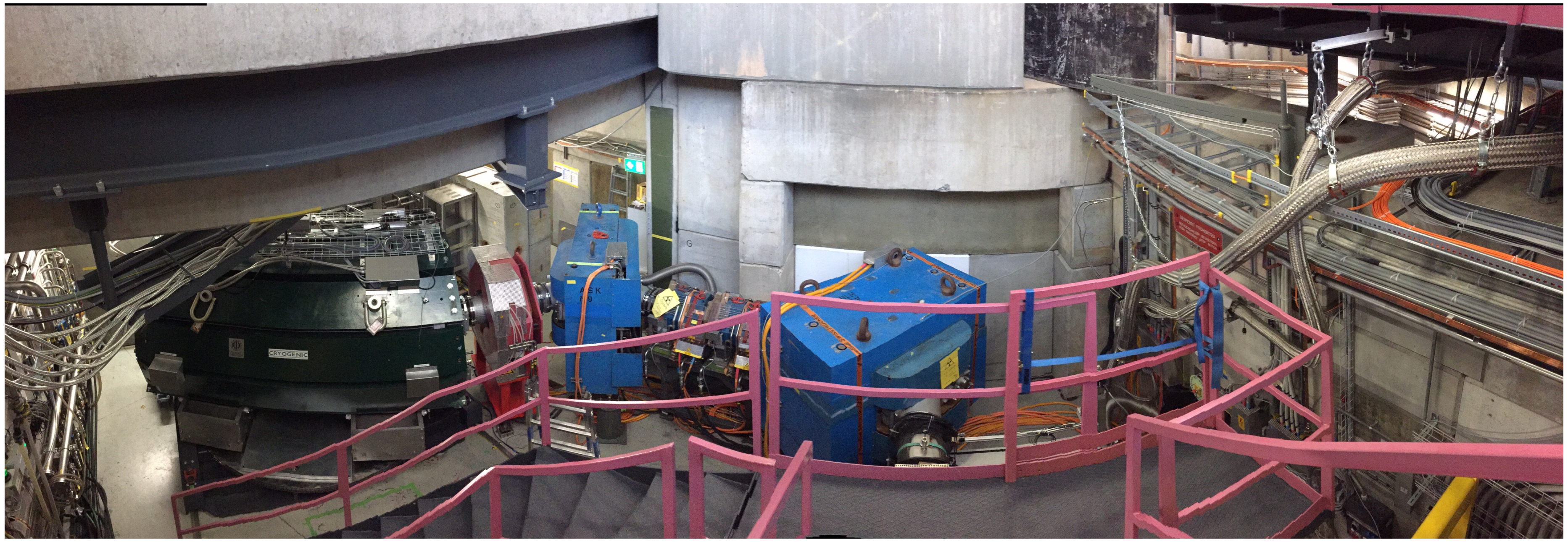
Mu3e Phase I sensitivity



Most recent News

- Mu3e Magnet (Cryogenic) delivered at PSI in summer 2020
- CMBL installed in piE5 area
- Beam Line commissioning with all elements just started (few days ago)
- Slice detector commissioning will follow next weeks



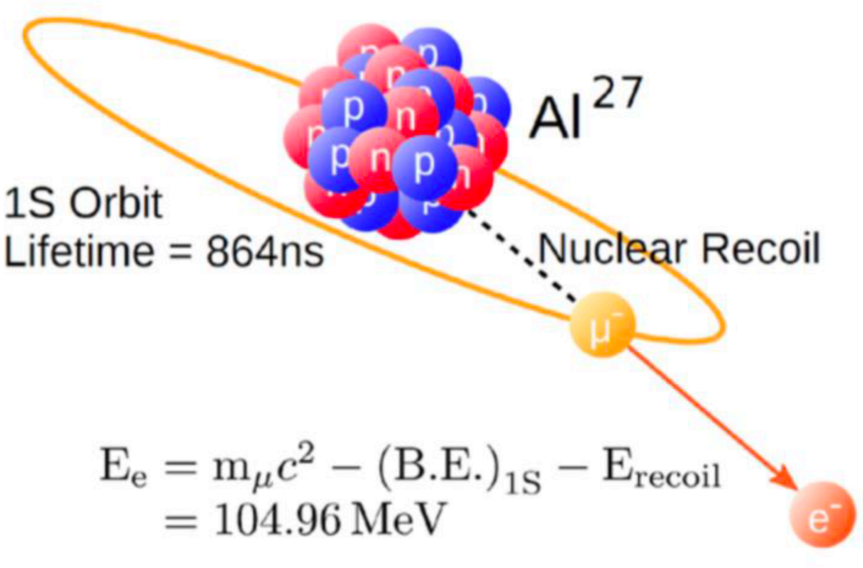


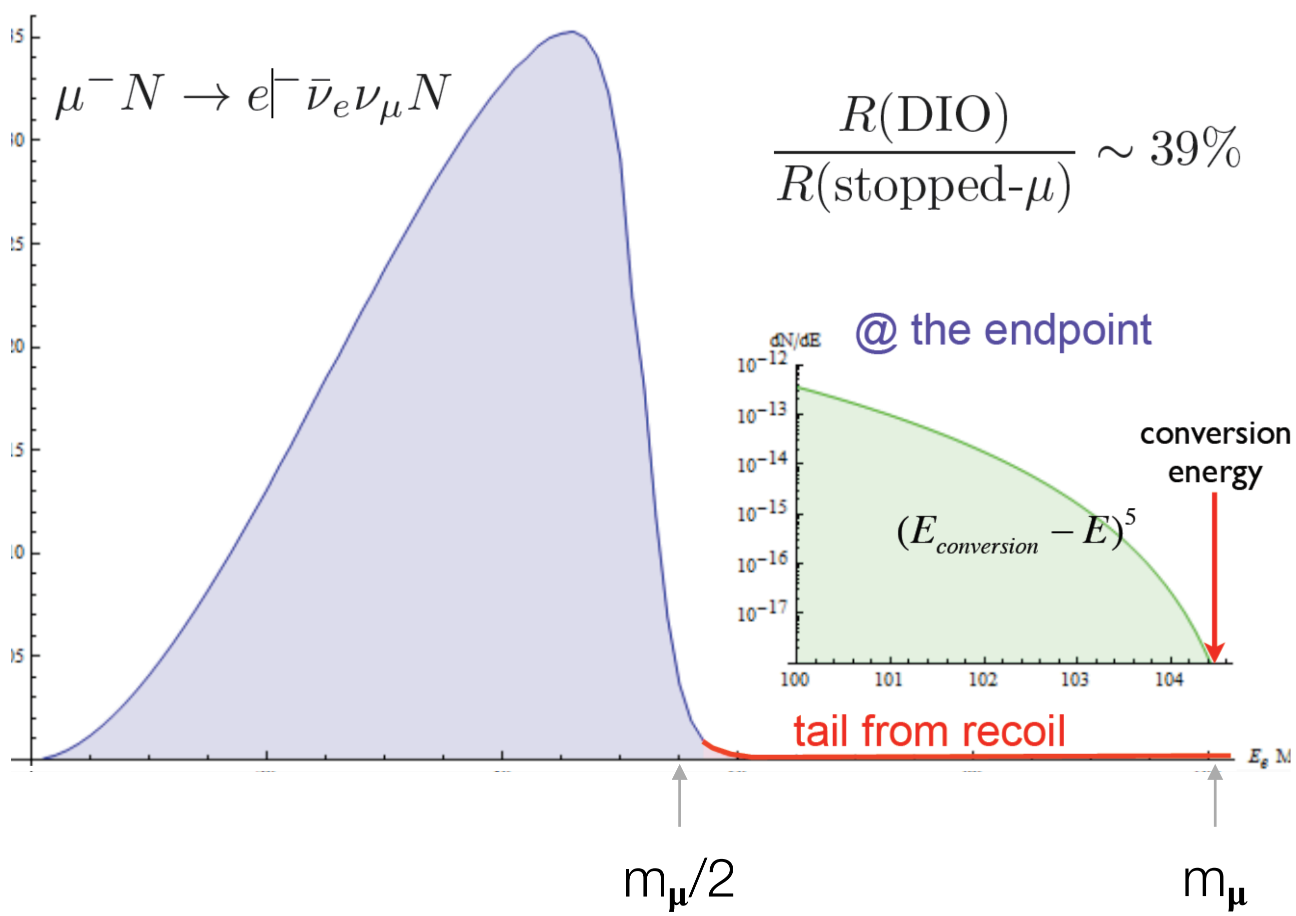
μ⁻ N → e⁻ N experiments

- Signal of mu-e conversion is single mono-energetic electron

$$R_{\mu e} = \frac{\mu^- + A(Z,N) \rightarrow e^- + A(Z,N)}{\mu^- + A(Z,N) \rightarrow \nu_\mu + A(Z-1,N)}$$

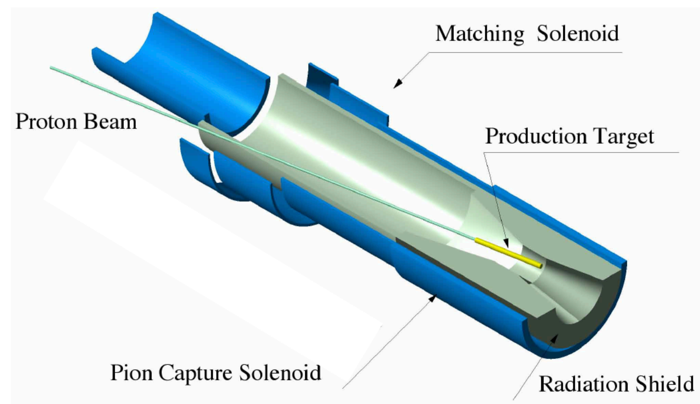
- Background: Any event at the endpoint energy can mimic the signal

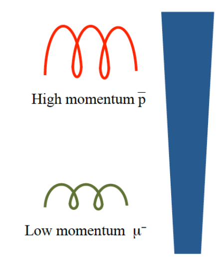




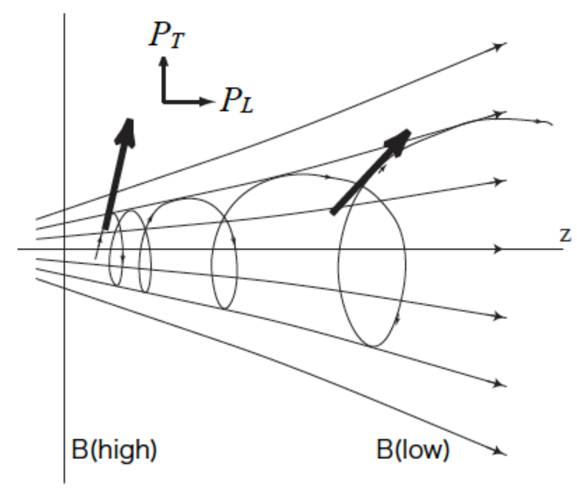
More and selected pulsed muons in three steps

- 1. Pion production in magnetic field

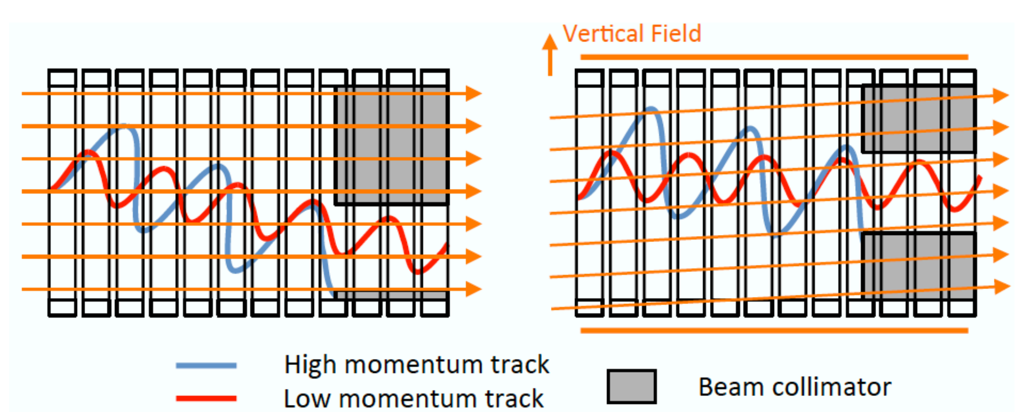


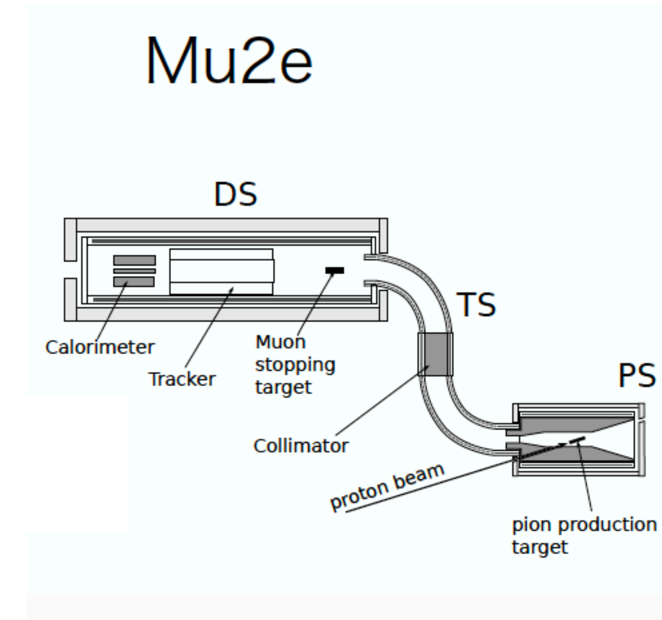


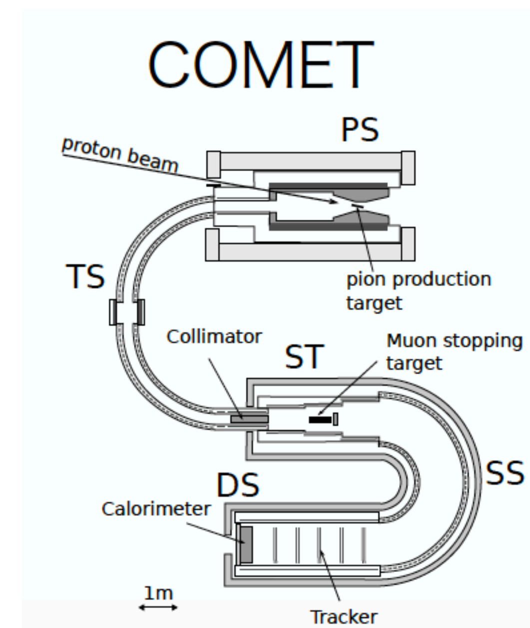
- 2. Pion/muon collection using gradient magnetic filed



- 3. Beam transport with curved solenoid magnets

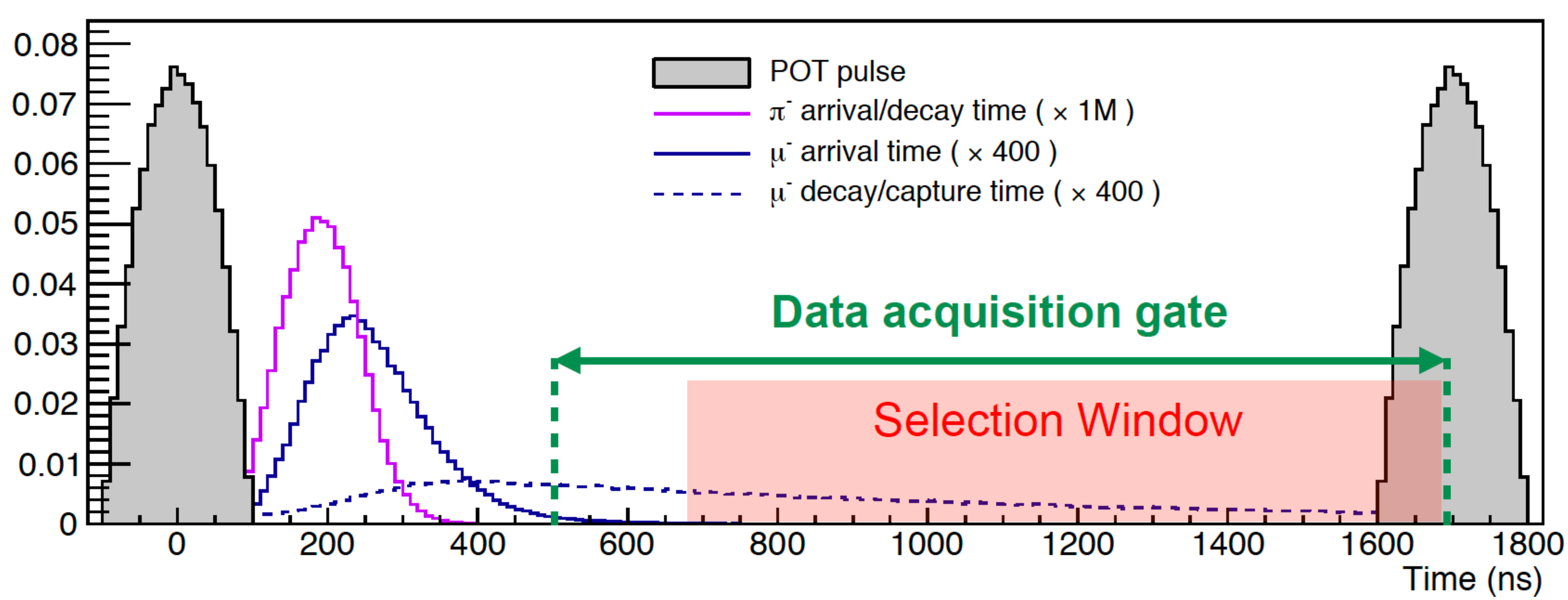






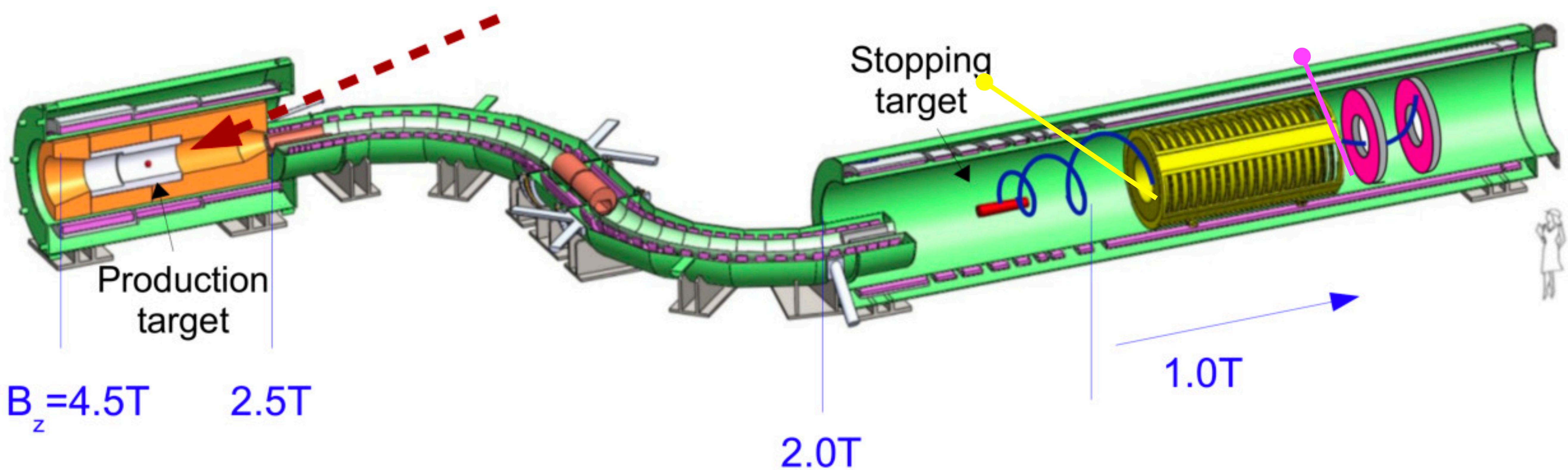
μ⁻ N → e⁻ N experiments

- Signal of mu-e conversion is single mono-energetic electron
- Stop a lot of muons! $O(10^{18})$
- Backgrounds:
    - Beam related, Muon Decay in orbit, Cosmic rays
- Use timing to reject beam backgrounds (extinction factor 10^{-10})
    - Pulsed proton beam 1.7 μs between pulses
    - Pions decay with 26 ns lifetime
    - Muons capture on Aluminum target with 864 ns lifetime
- Good energy resolution and Particle ID to defeat muon decay in orbit
- Veto Counters to tag Cosmic Rays



The Mu2e experiment

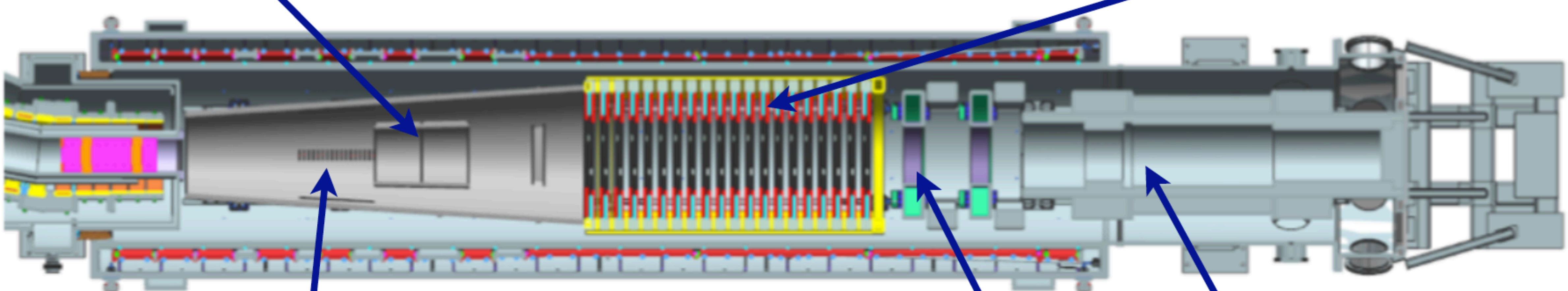
- Three superconducting solenoids: Production, Transport and Detector solenoids
- Muons stop in thin aluminum foils
- High precision straw tracker for momentum measurement
- Electromagnetic calorimeter for PID
- Scintillators for the Veto



The Mu2e experiment

- ***Proton absorber:***
  ❖ made of high-density polyethylene
  ❖ designed in order to reduce proton flux on the tracker and minimize energy loss

- ***Tracker:***
  ❖ ~20k straw tubes arranged in planes on stations, the tracker has 18 stations
  ❖ Expected momentum resolution < 200 keV/c



- ***Targets:***
  ❖ 34 Al foils; Aluminum was selected mainly for the muon lifetime in capture events (**864 ns**) that matches nicely the need of prompt separation in the Mu2e beam structure.

- ***Calorimeter:***
  ❖ 2 disks composed of undoped CsI crystals

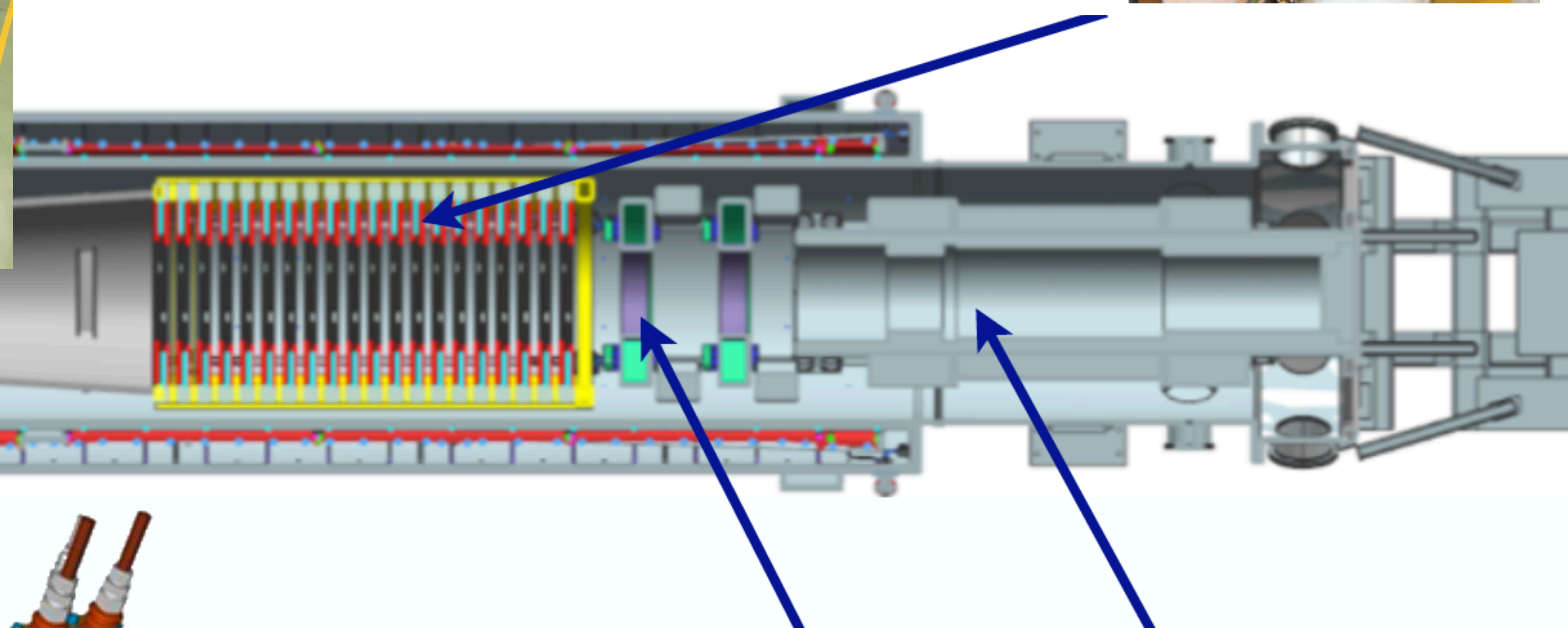
- ***Muon beam stop:***
  ❖ made of several cylinders of different materials: stainless steel and polyethylene

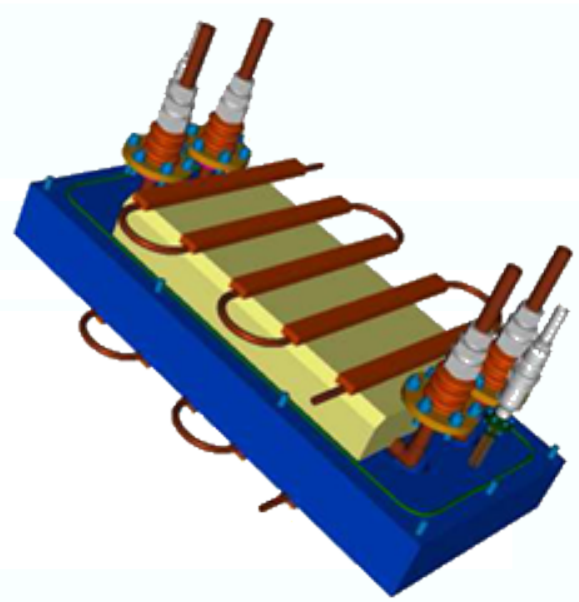
The Mu2e experiment: Status

- 2021: Detector and Beam-line commissioning; 2022-2024: Data taking

- *Tracker:*

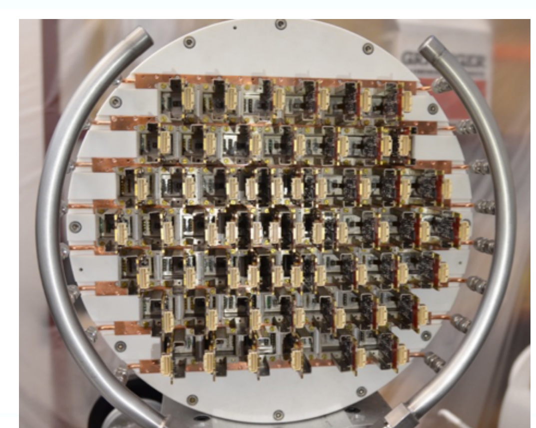
- *Beamline and solenoids*



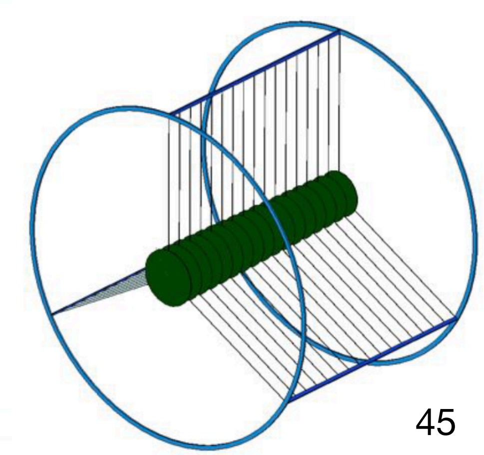


- *Cosmic Ray Veto*

- *Calorimeter:*



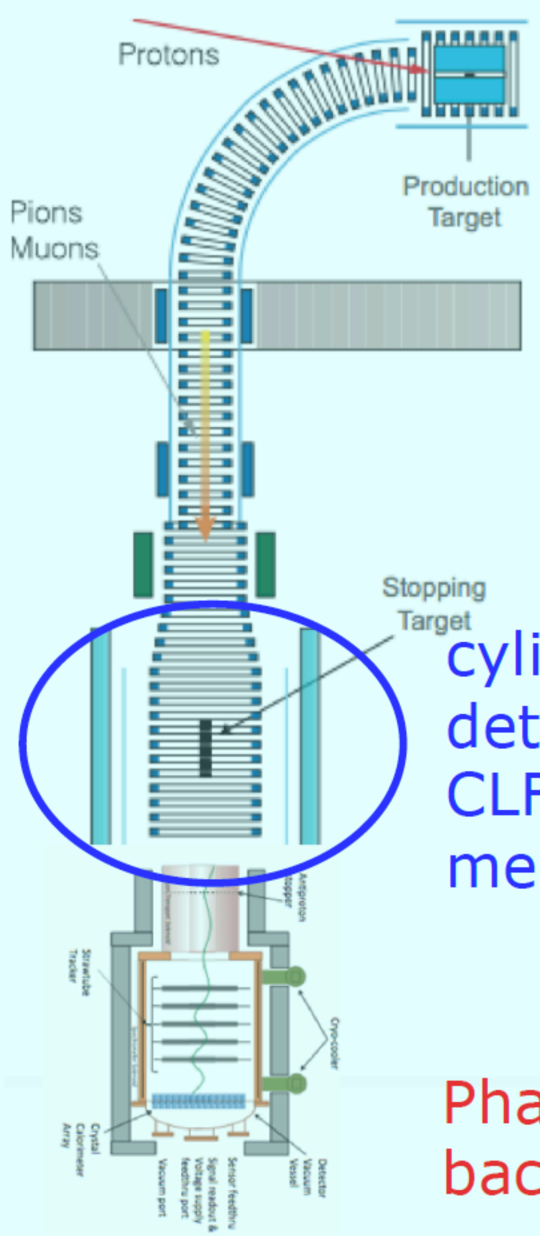
- *Muon beam stop:*



The COMET experiment

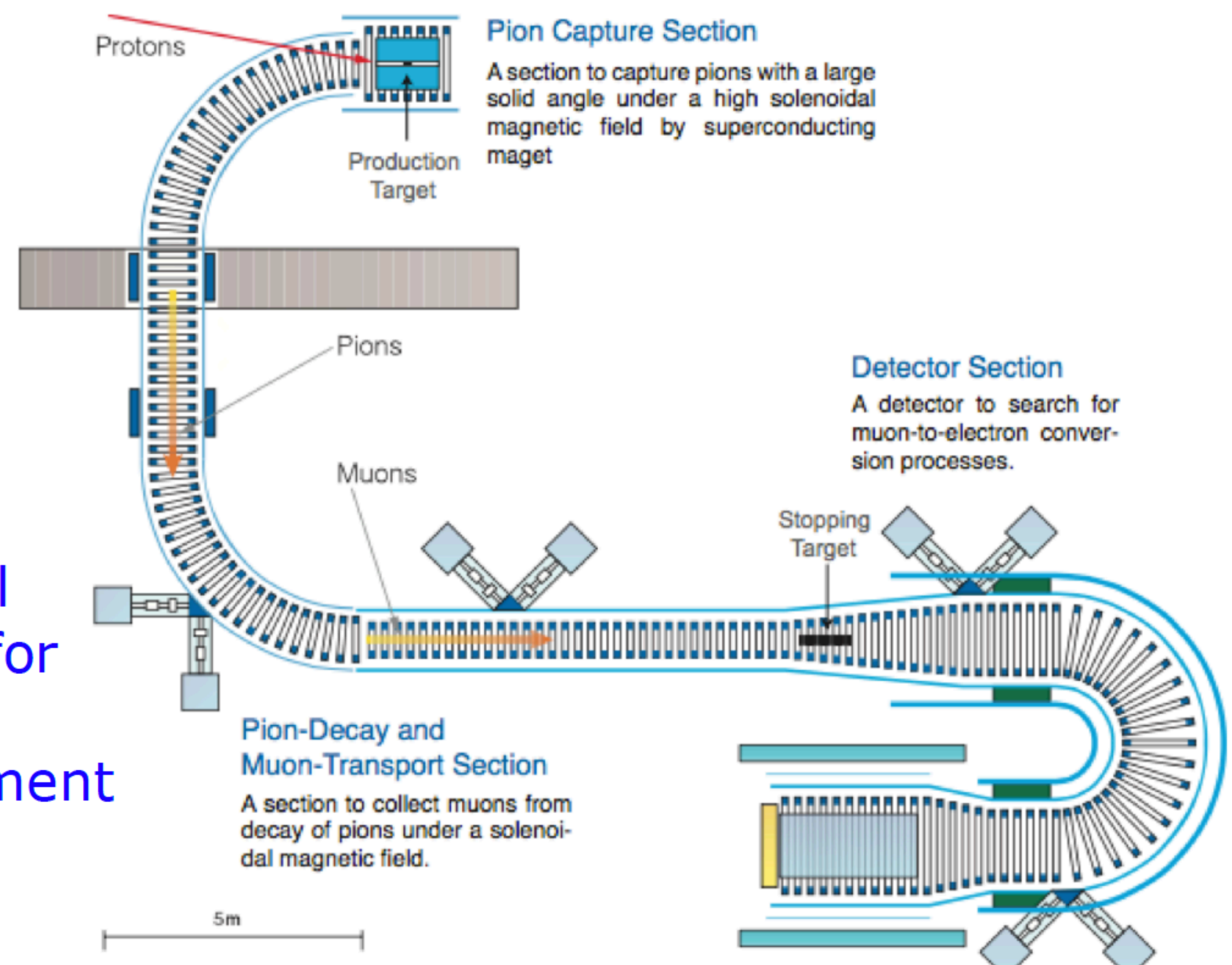
- Stage phase approach: Phase I and Phase II

COMET phase I



cylindrical detector for CLFV measurement

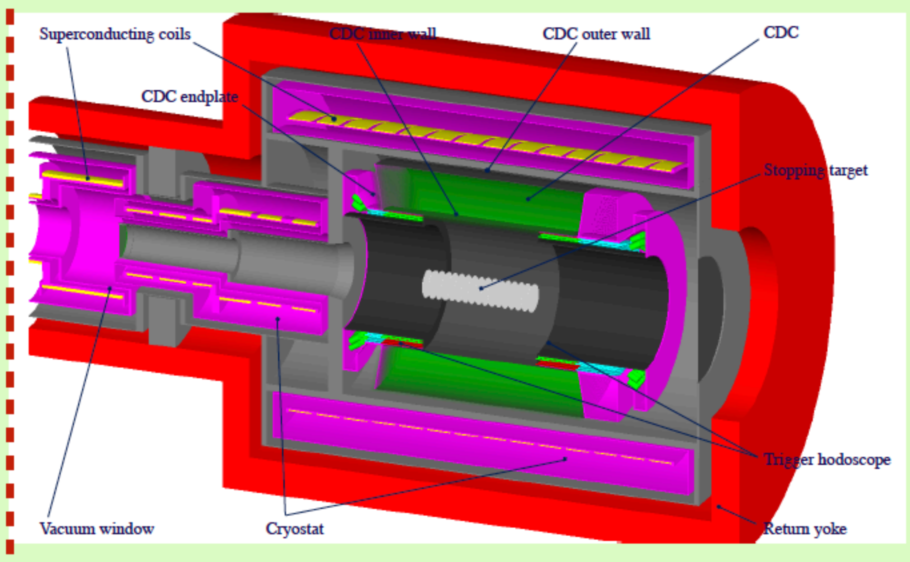
COMET phase II



Phase-II prototype for background characterisation

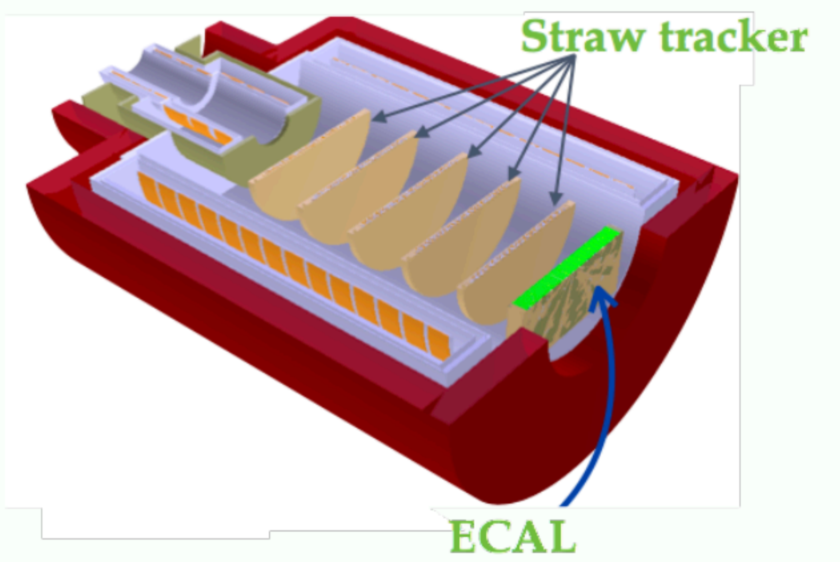
The COMET experiment: The detectors

For μ-e Conversion Search



- "CyDet" = Cylindrical Detector System
- For Phase-I, centre part of beam is dominated by BG, *i.e.* Cylindrical Drift Chamber and Cylindrical Trigger Hodoscope is employed to search for μ-e conversion.
- He-iC_4H_{10} gas-mixture to reduce material budget, Hollow cylinder design to have a BG tolerance

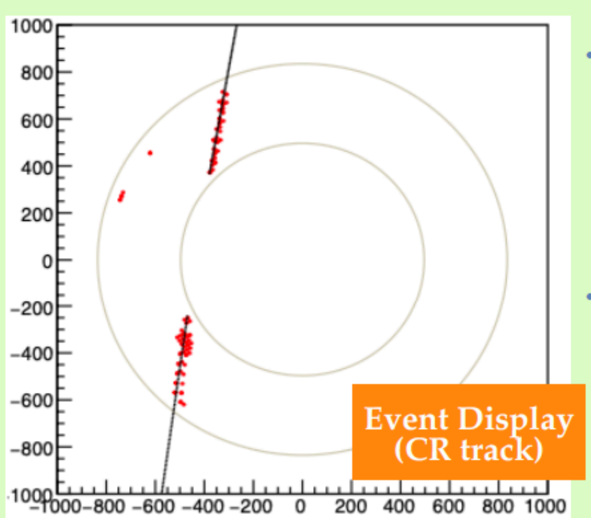
For Beam Measurement



- "StrECAL" = Straw tracker and ECAL
- To measure all delivered beam incl BG, vacuum-compatible tracker and calorimeter is employed
- Straw = Planer/Low-mass, LYSO crystal ECAL = High resolution / High density
- Same concept as Phase-II detector = Prototype of Phase-II Final Detector

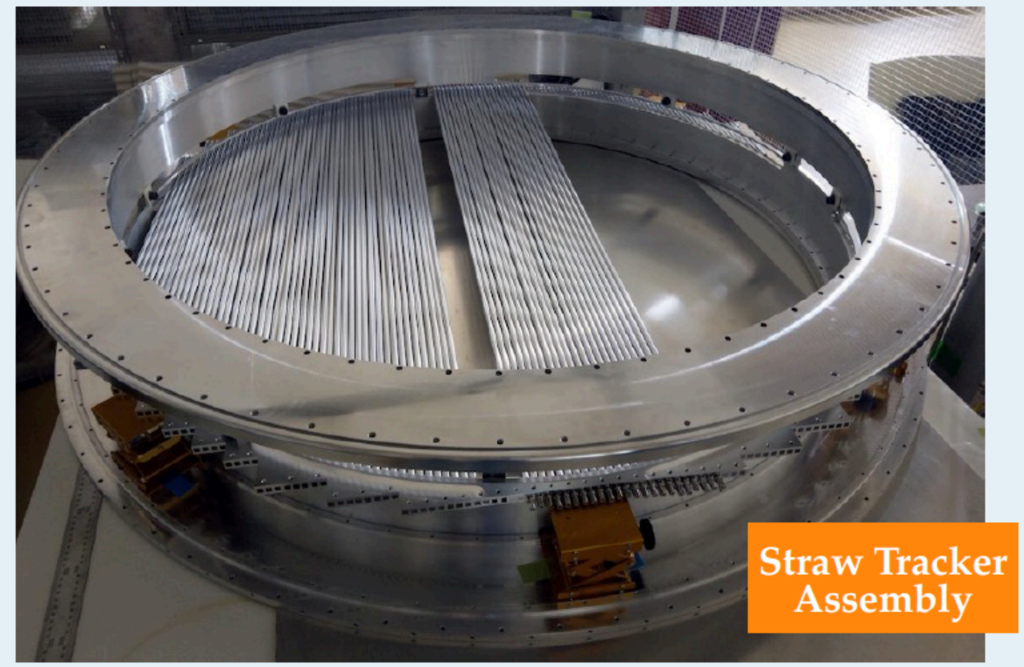
The COMET experiment: The detectors

CyDet (for μ-e conv. search)

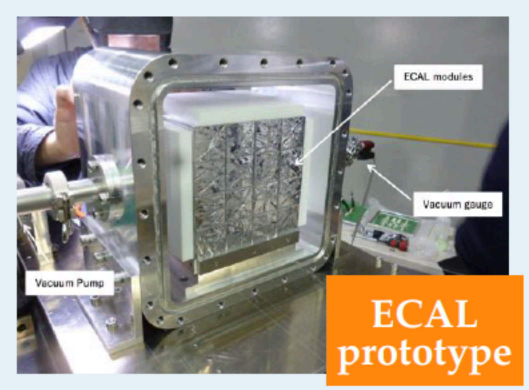


- CDC, completed and under commissioning with cosmic-ray.
- Trigger hodoscope is under development.

StrECAL (for beam measurement)



- Straw 1st station is under construction, will be completed soon.
- Five stations will be constructed in total.

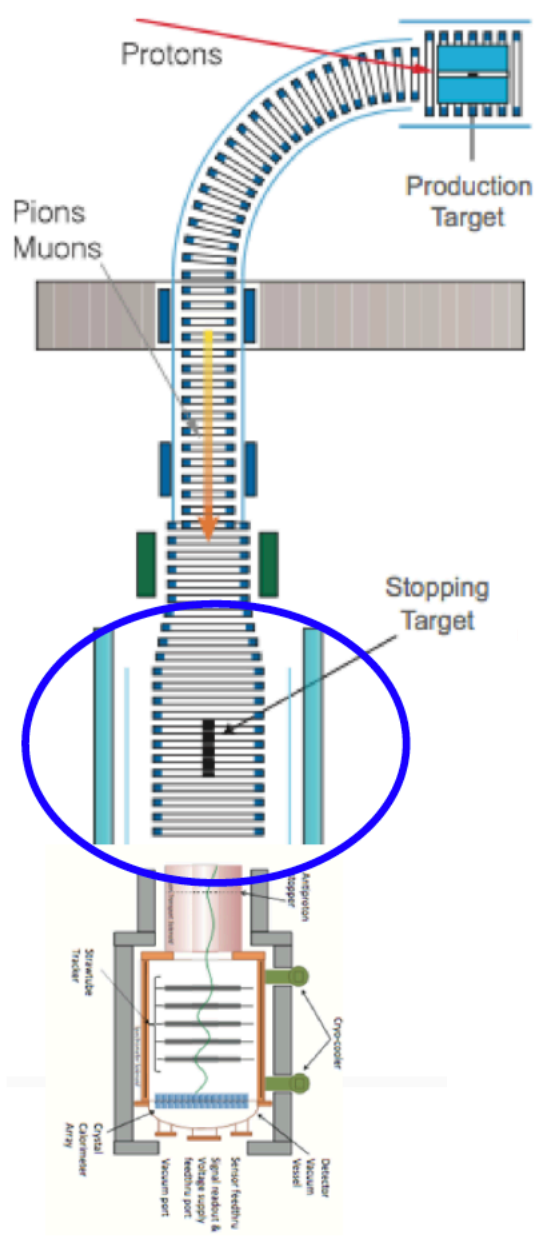


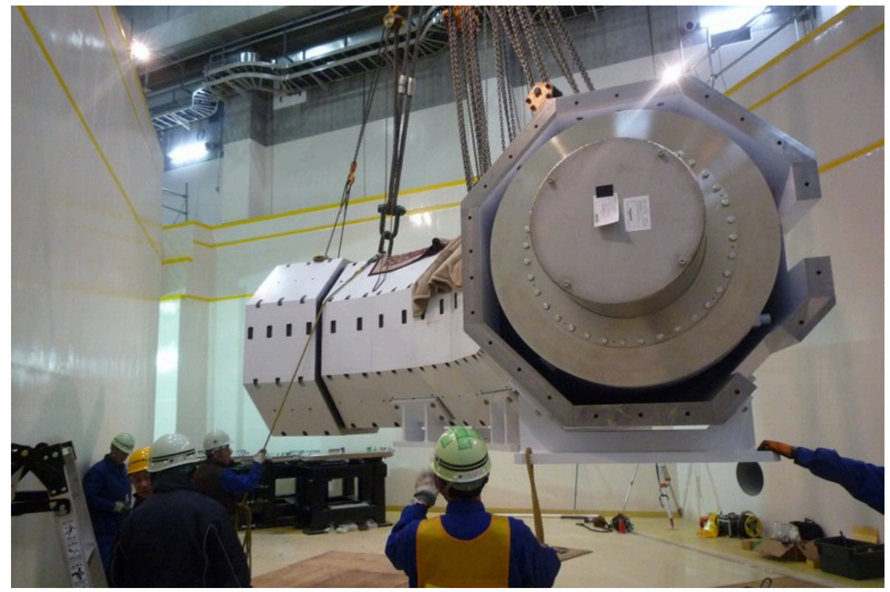
- ECAL prototype successfully completed.
- Detector assembly will start soon.

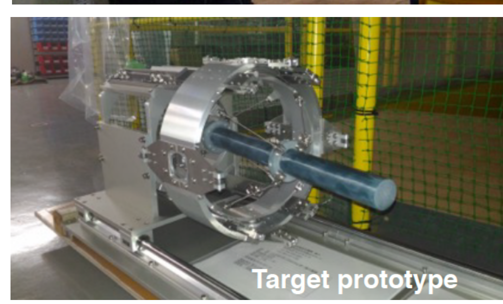
The COMET experiment: Status

- Stage phase approach: ultimate sensitivity with phase II [Data taking in: 2021/2022]

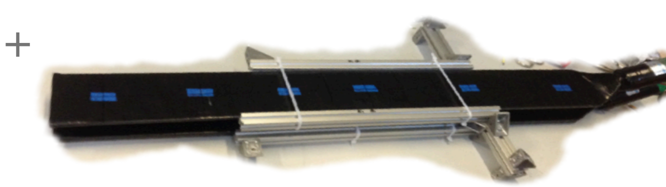
COMET phase I



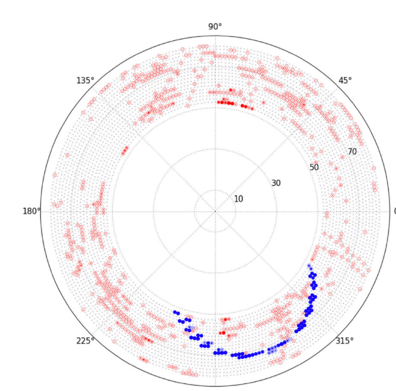


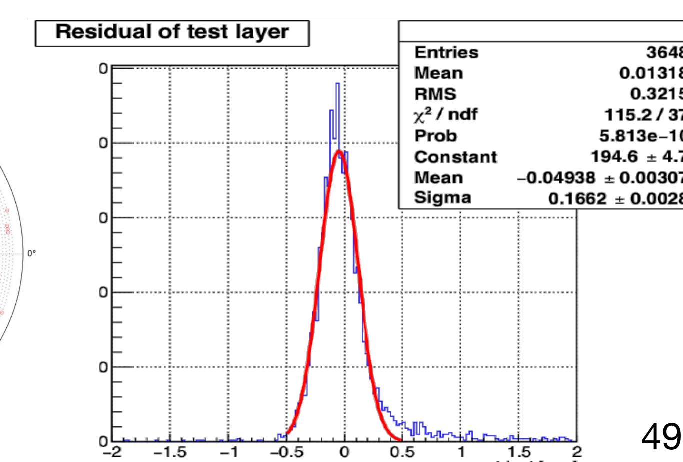


Trigger scintillators + Cerenkov detector



Trigger/DAQ/Analysis: in very good shape

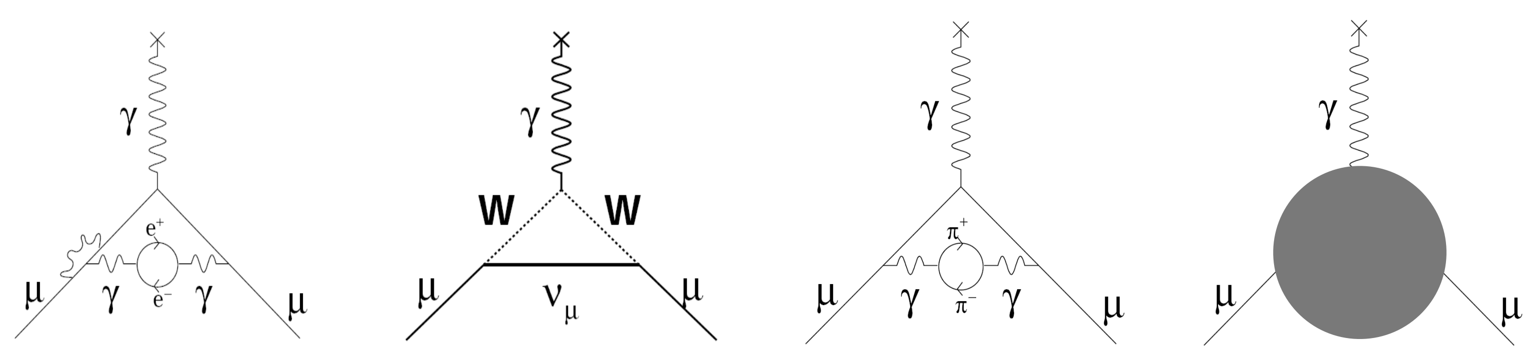




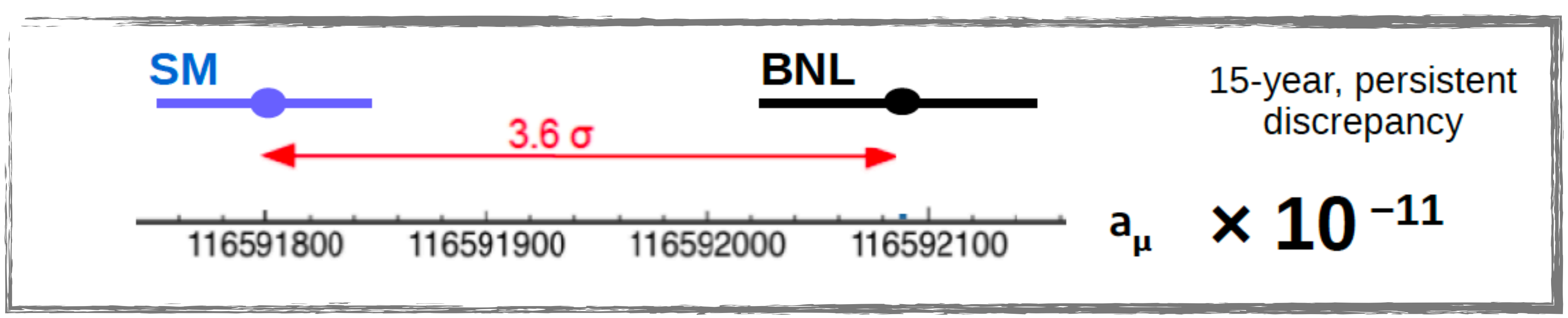
g_μ-2 Motivation

- Dirac's relativistic theory predicted muon magnetic moment “g” = 2
- Experiment suggested that g-factor differs from the expected value of 2
- Standard Model prediction: a(SM) = a(QED) + a(Had) + a (Weak) + **a (NP)**
- BNL E821 result: 3.3σ deviation from SM prediction

$$\mu = (1 + a_\mu)\frac{e\hbar}{2m} \qquad a_\mu = \frac{g_\mu - 2}{2}$$



QED EW QCD UNKNOWN



g_μ-2 in numbers and experimental approaches

Anomalous magnetic moment (g-2)

$a_\mu = (g-2)/2 = 11\,659\,208.9\,(6.3) \times 10^{-10}$ (BNL E821 exp) **0.5 ppm**

$11\,659\,182.8\,(4.9) \times 10^{-10}$ (standard model)

$\Delta a_\mu = \text{Exp} - \text{SM} = 26.1\,(8.0) \times 10^{-10}$ **3σ anomaly**

In uniform magnetic field, muon spin rotates ahead of momentum due to g-2 = 0

$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2 - 1}\right)\frac{\vec{\beta}\times\vec{E}}{c} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$

BNL E821 approach
γ=30 (P=3 GeV/c)

J-PARC approach
E = 0 at any γ

$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$

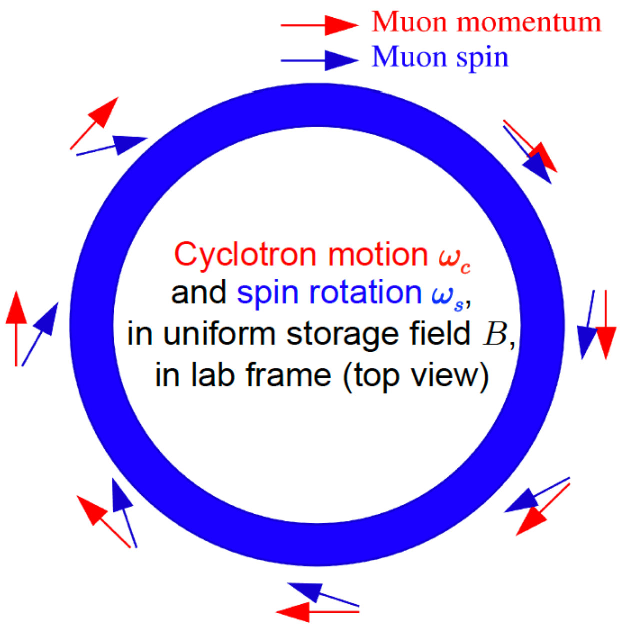
$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B}\right)\right]$$

Continuation at **FNAL** with **0.1ppm** precision

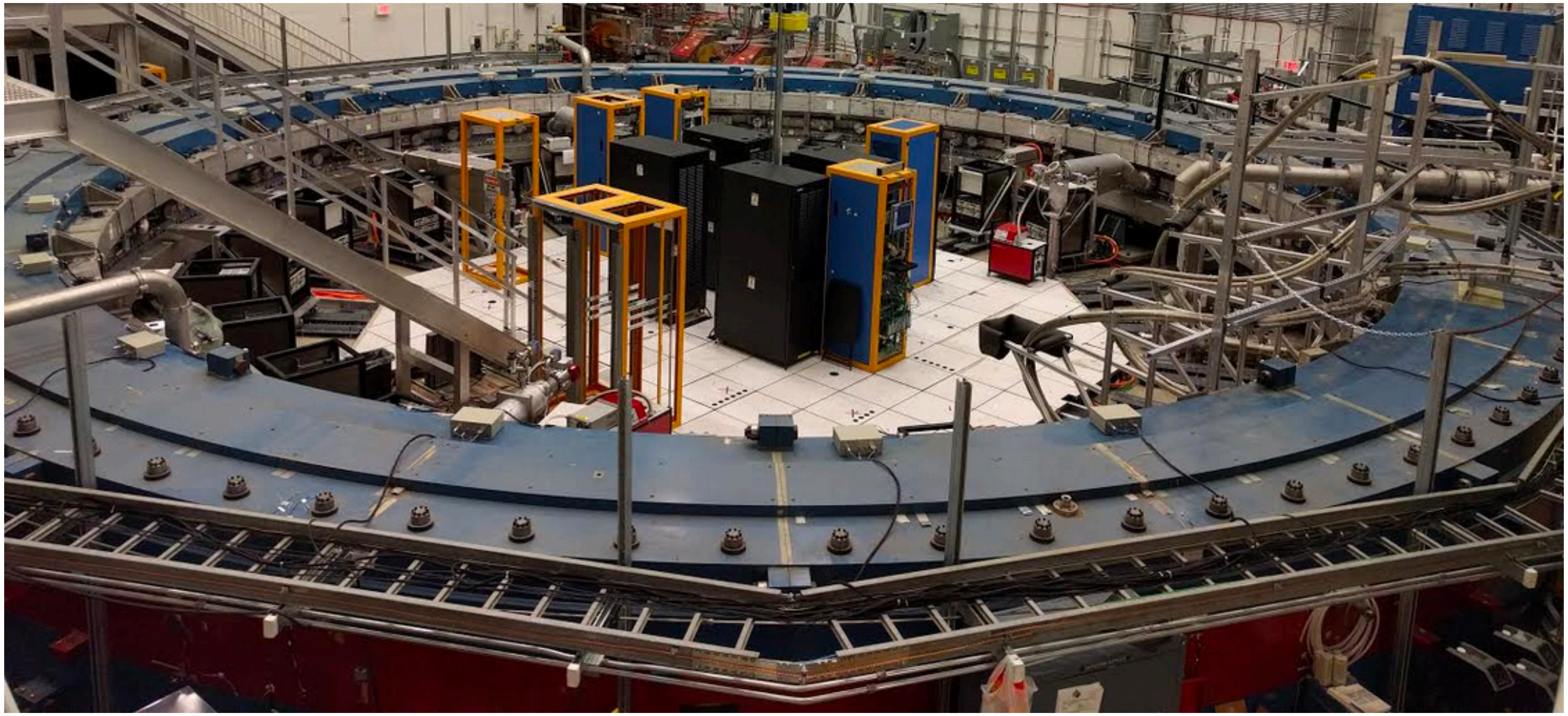
Proposed at **J-PARC** with **0.1ppm** precision

g_μ-2 at FNAL: The Experiment is running

- ω_p is the proton Larmor frequency measured in a field B
- ω_a is the precession frequency measured with decay positrons
- μ_μ/μ_p magnetic moment ratio from muonium hyperfine measurement

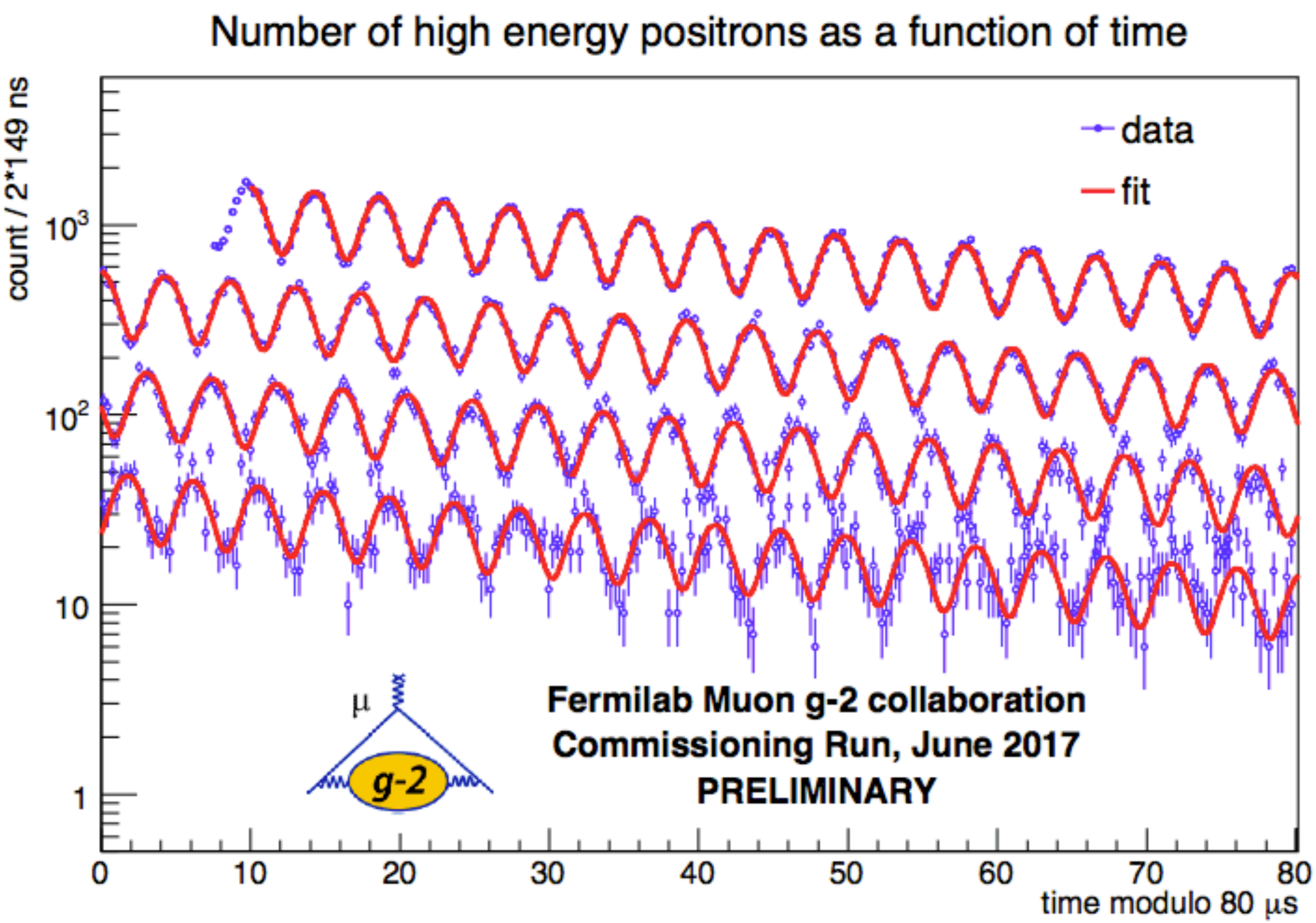


$$a_\mu = \frac{\omega_a/\omega_p}{\mu_\mu/\mu_p - \omega_a/\omega_p}$$



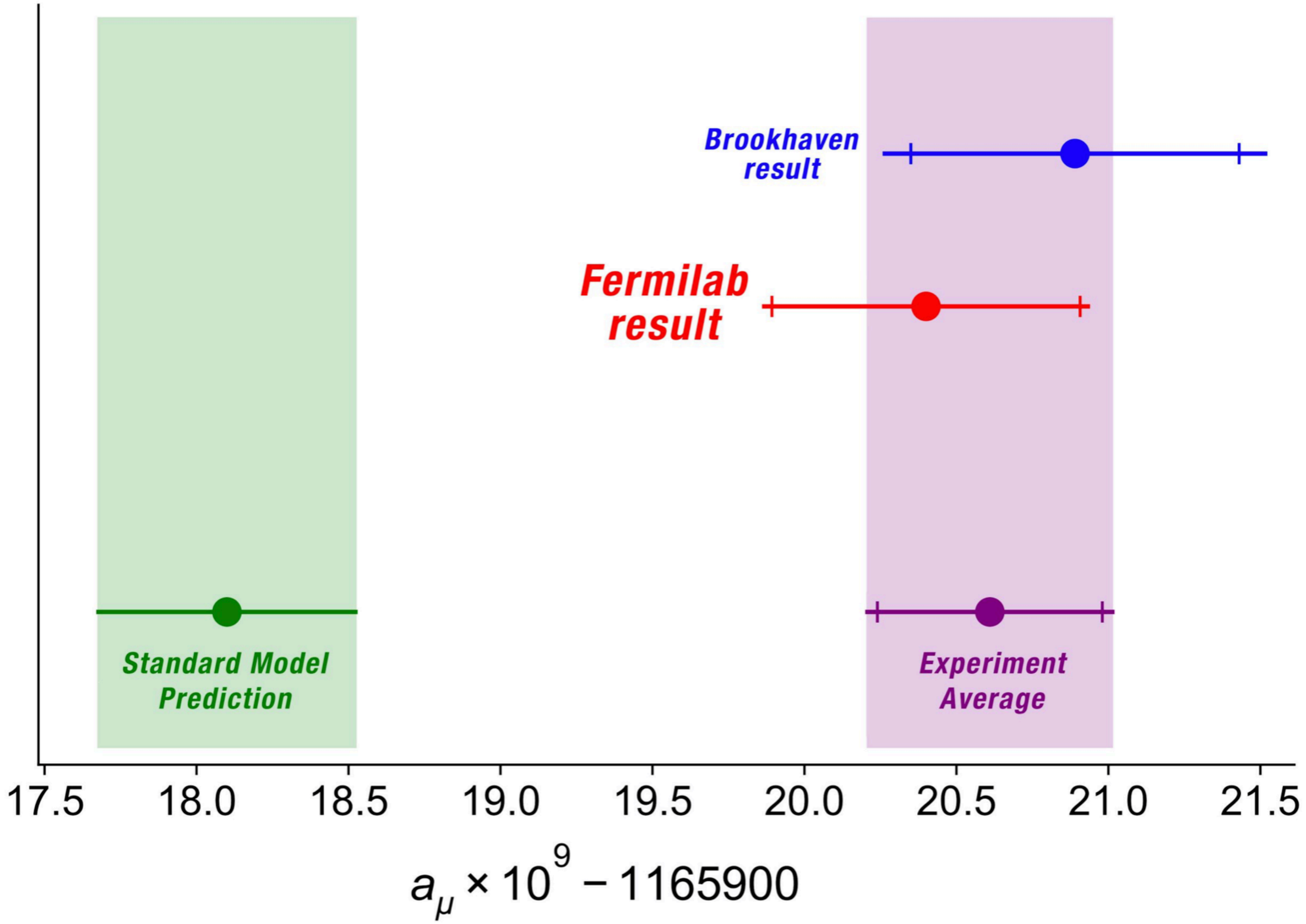
g_μ-2 at FNAL: The journey started in 2017

- First evidence of precessing muons
- Commissioning Run: **2017**

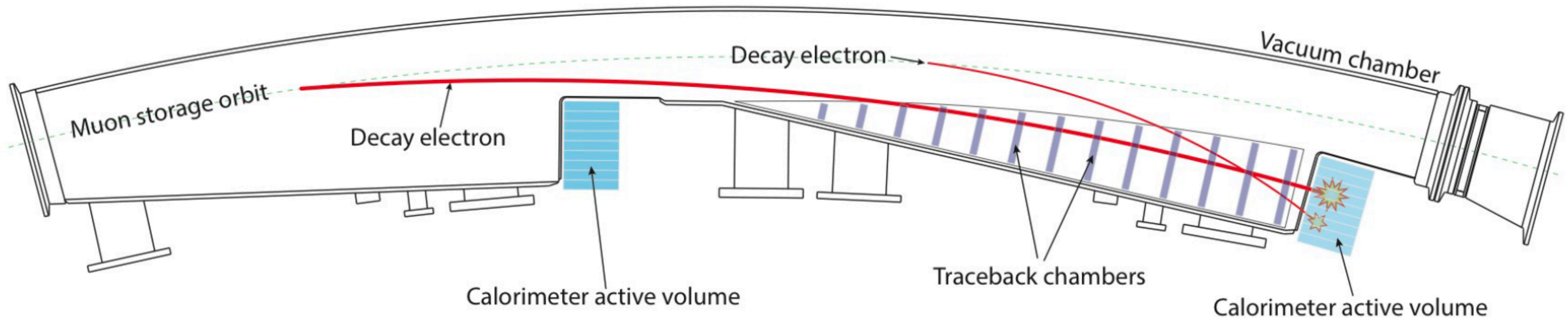


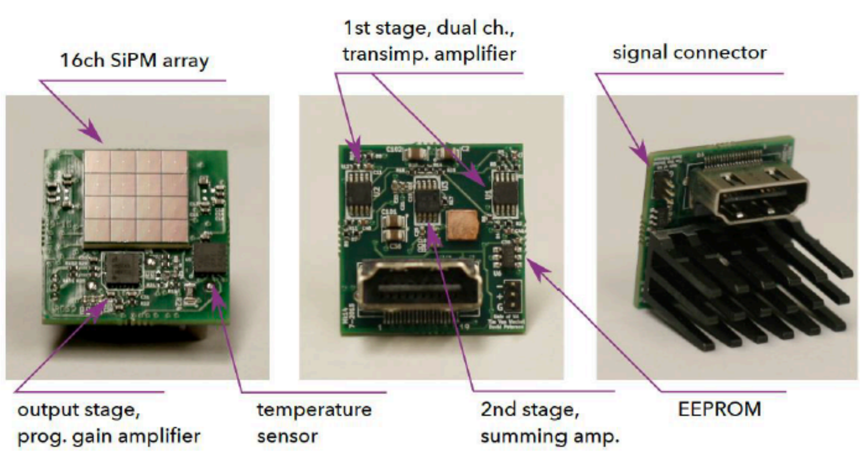
g_μ-2 at FNAL: First Result

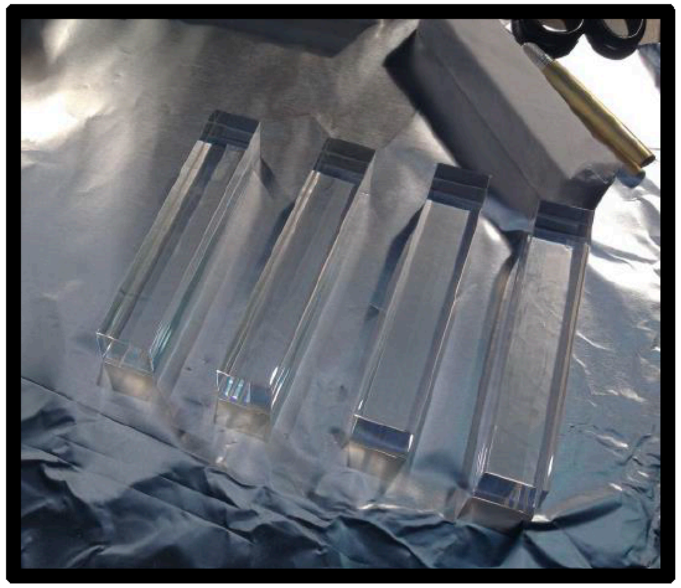
- First Result: **April 2021 [using RUN1 with statistics similar to BNL statistics]**
- **RUN1-3 (already collected): ~ 8x BNL statistics**
- **Aiming at ~ 20x BNL statistics**



g_μ-2 at FNAL: The calorimeters



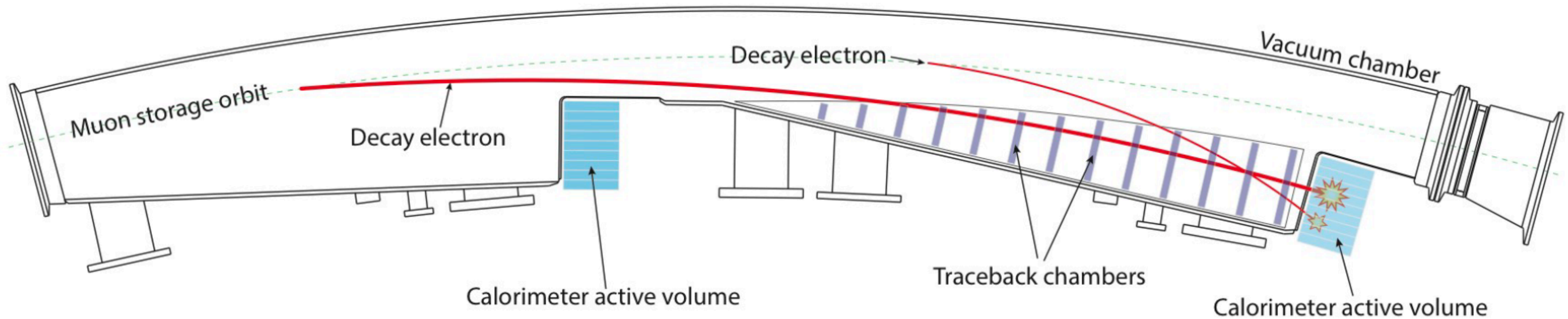




- SiPM readout designed at CENPA
- one per crystal
- 54 per calo, 1296 channels total
- ~10 ns pulses, operate in B field

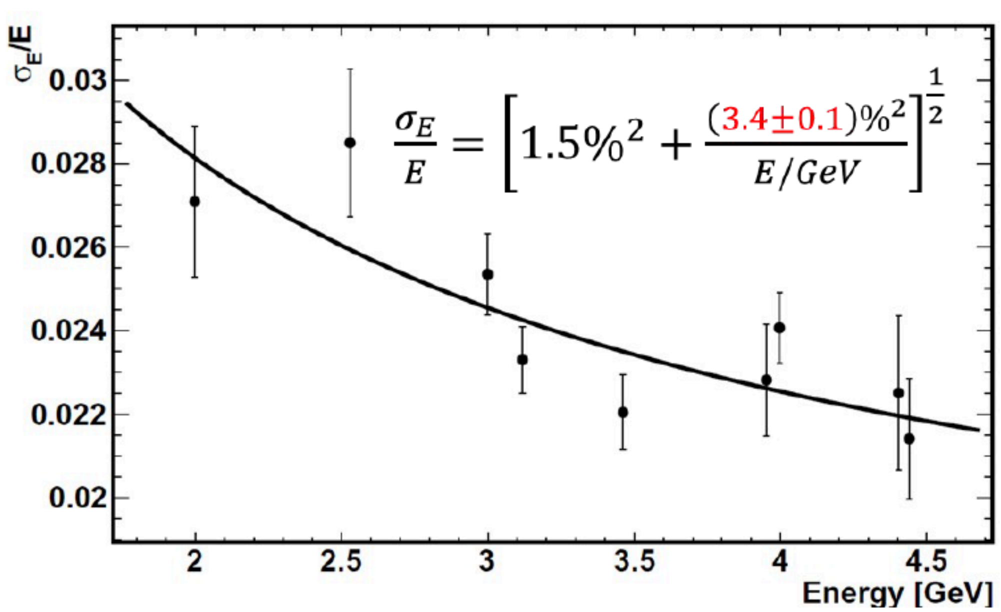
- PbF_2 grown by SICCAS
- dense Cherenkov radiator
- 2.5 cm by 2.5 cm by 14 cm
- 6 x 9 array

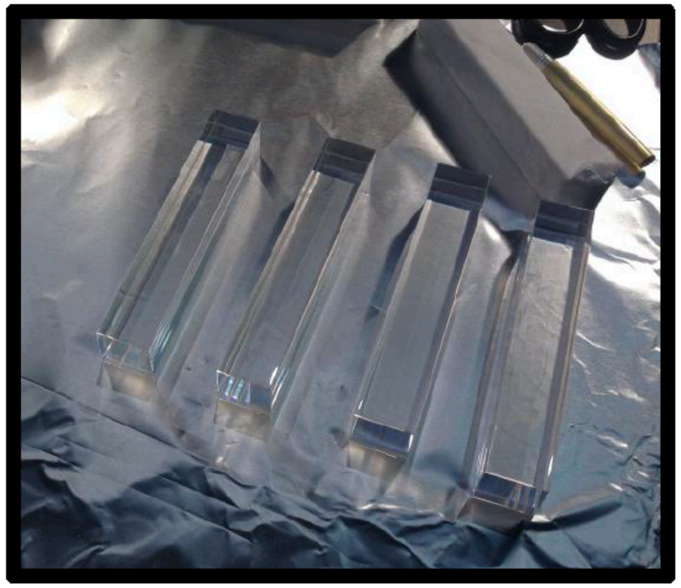
g_μ-2 at FNAL: The calorimeters



Note: SiPM waveform digitised at 12-bit, 800 MS/s

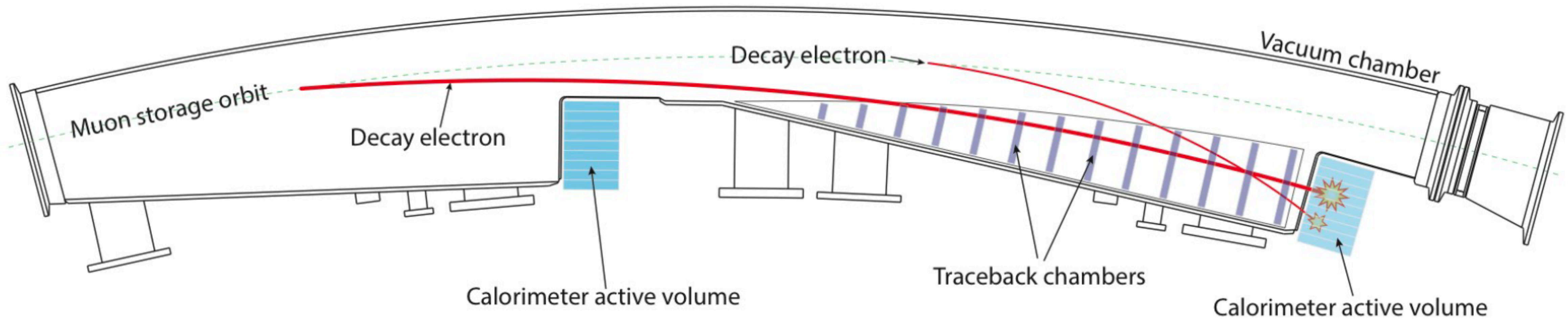
24 segmented PbF_2 with SiPM readout optimized to behave like short pulse duration PMTs to minimize pileup and excellent resolution

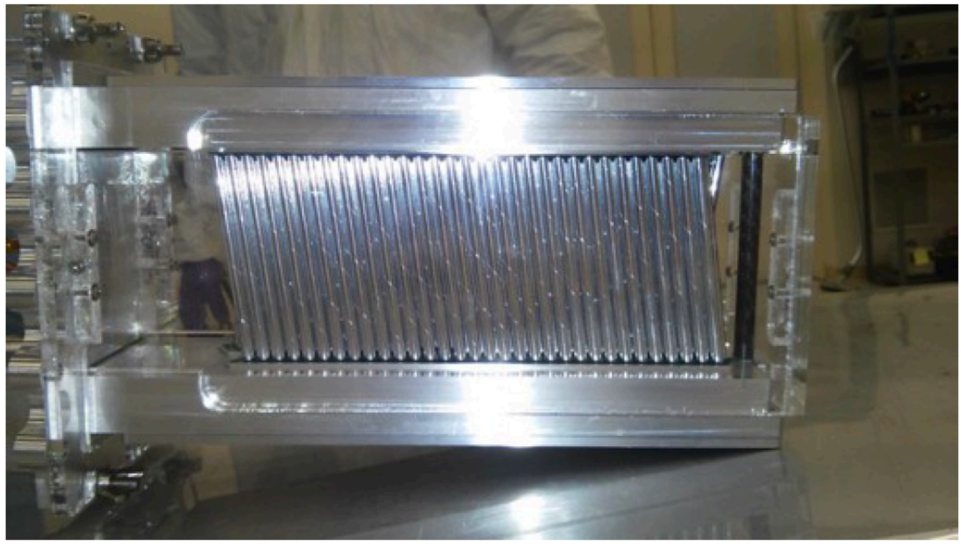


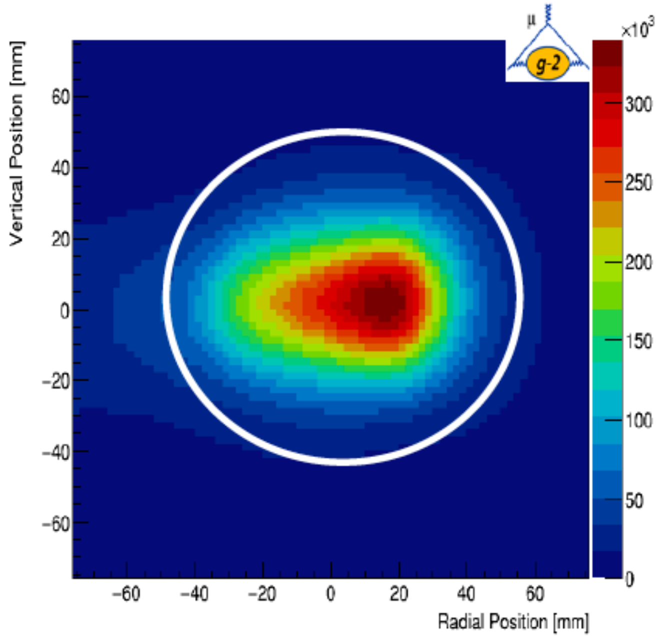


- PbF_2 grown by SICCAS
- dense Cherenkov radiator
- 2.5 cm by 2.5 cm by 14 cm
- 6 x 9 array

g_μ-2 at FNAL: The trackers







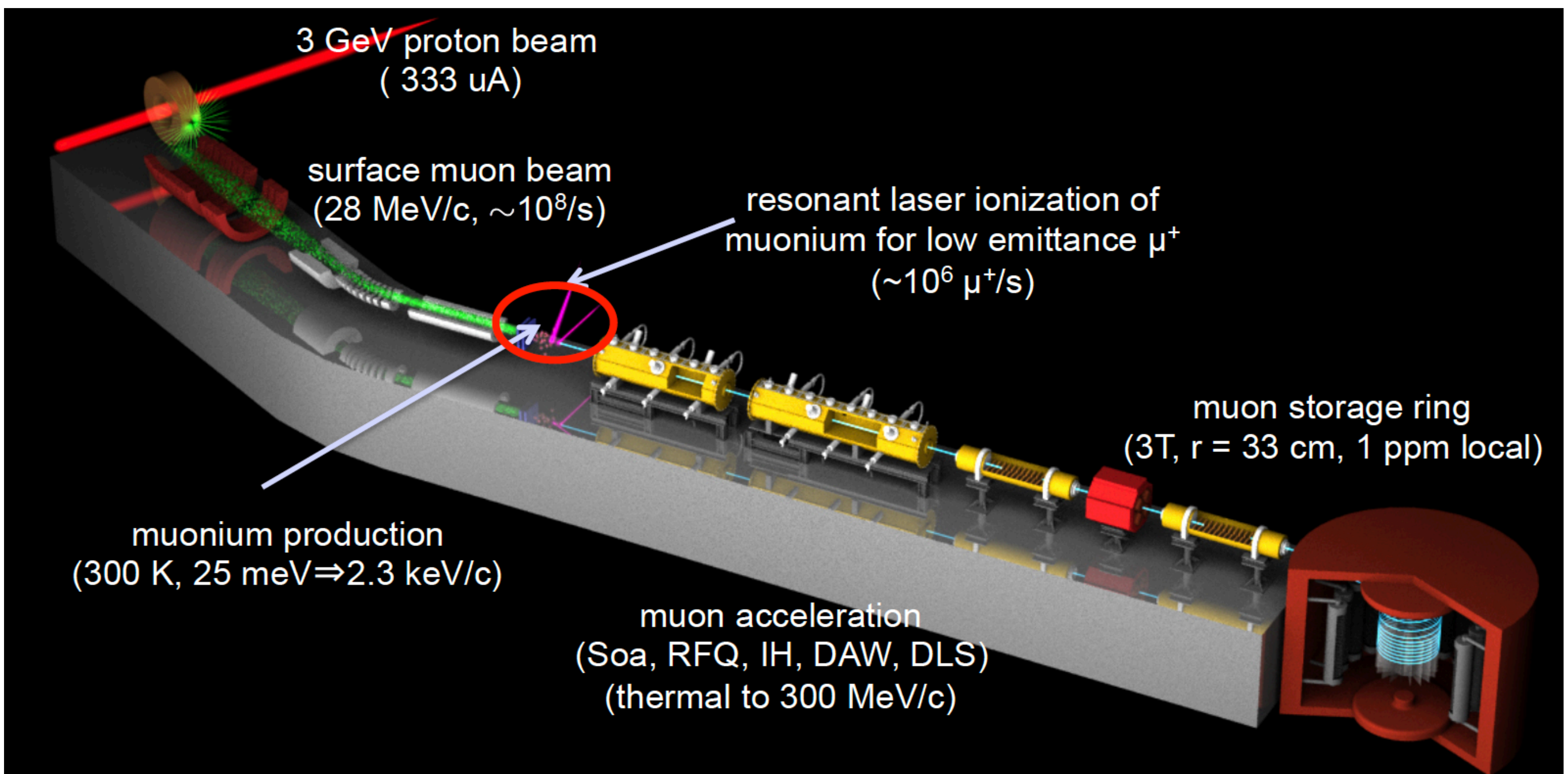
extrapolated decay vertices

Three multiplane straw tracker systems will reconstruct the time-dependent muon decay position within the ring

g_μ-2/EDM at J-PARC

- Put E = 0;
- Weak B field focusing: Need low emittance cold muon
- Uniform tracker detector through out stored orbit

$$-\frac{q}{m_\mu}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2-1}\right)\frac{\vec{\beta}\times\vec{E}}{c}\right]$$

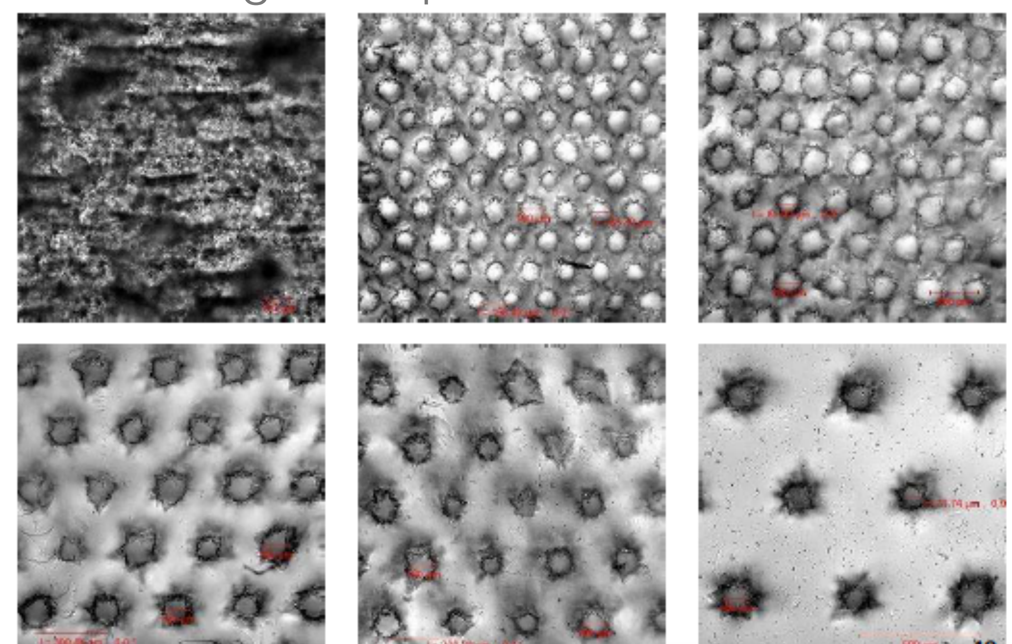


g_μ-2/EDM at J-PARC: Status

- Progress in all aspects. From phase I to phase 2
- New experimental methods and source-limited schedule requires fours years prior data taking

H line > 10^8 surface muon/s

Several silica-aerogel samples test at TRIUMF this summer



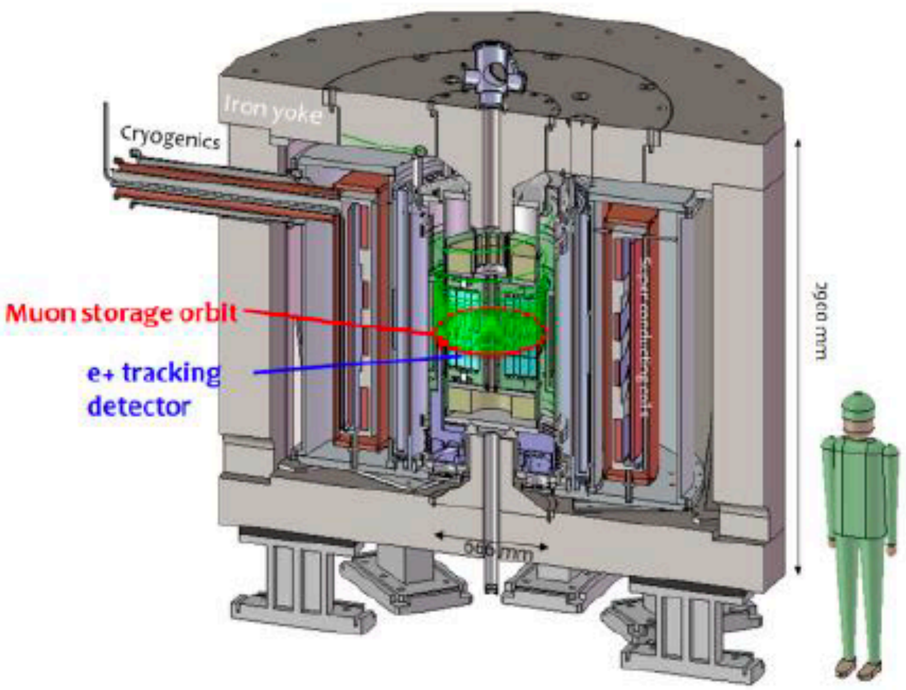
Laser available

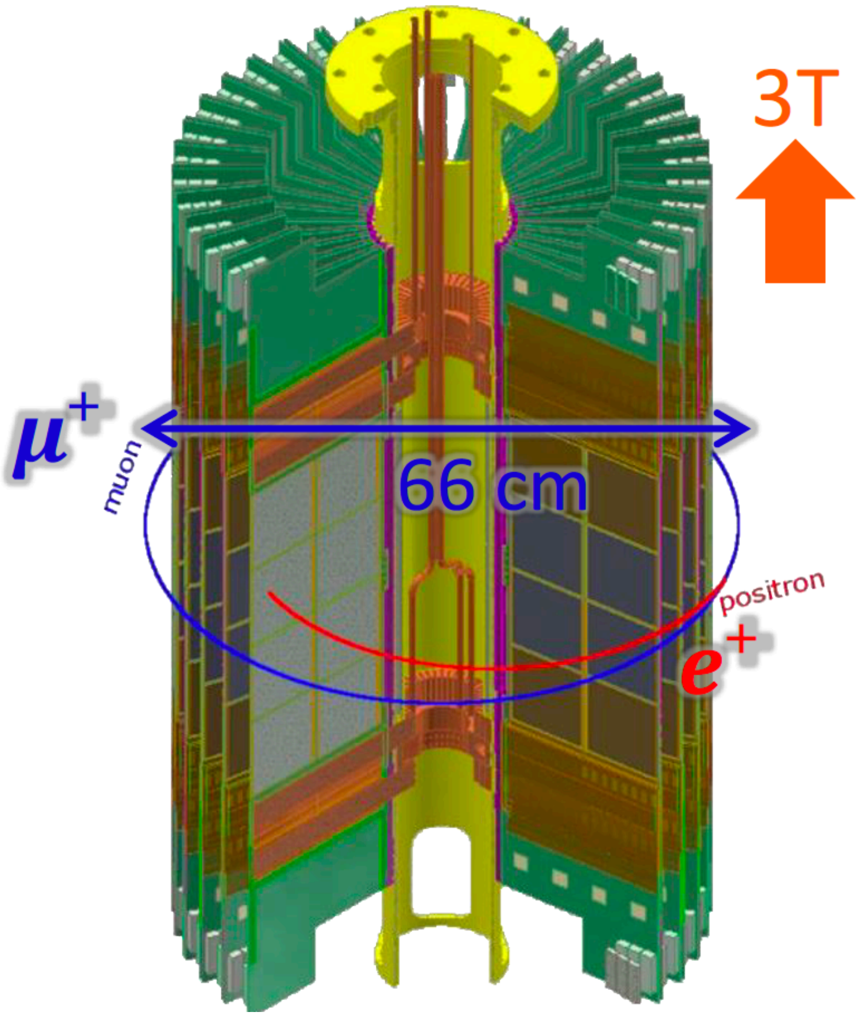
Muon RFQ acceleration test in October

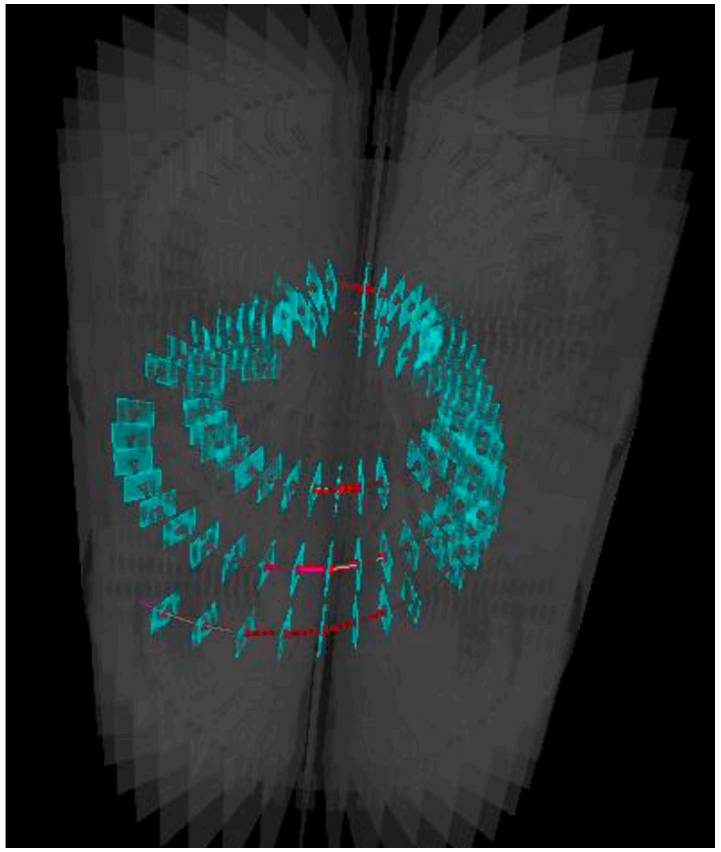
Spiral injection with mini-solenoid progress

Positron Detector

- Based on Silicon strip: mip detection (positron particles with momentum above 200 MeV/c)
- Requirements:
  - Time resolution better than 2 us (Anomalous spin precession period in a 3T field is about 2.1 us)
  - Storage data longer than this period as well as the muon lifetime (~6.6 us with muon p = 300 MeV/c)
  - Pile-up mitigation: readout system with a small time walk (< 1ns over a signal range of 0.5-3 MIP charge)
  - Maximum hit rate: 150 KHz/mm2

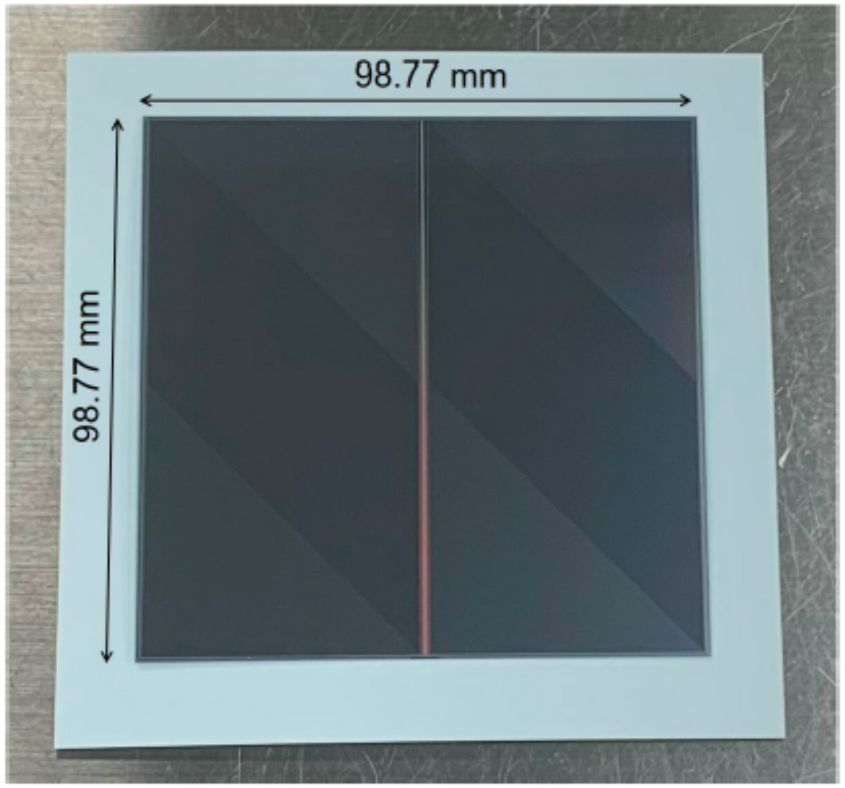


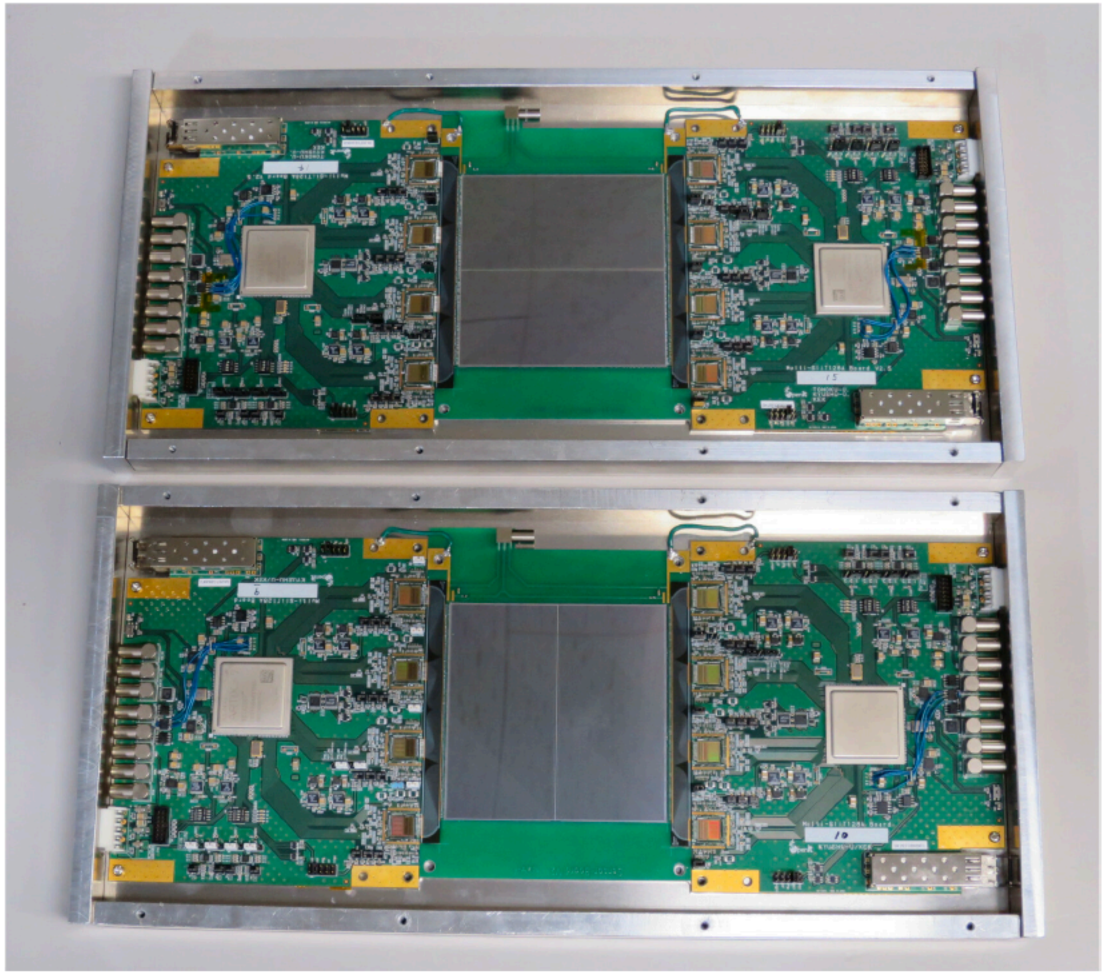




Silicon strip

- Single-side p-on-n silicon strip sensor with a double-metal structure by Hamamatsu (S13804)
- Thickness: 320 um
- Two columns of 512 strips (pitch: 190 um, length: 48.365 mm)
- Strip size to constrain the hit rate less then 2 MHz (estimated maximum rate in experiment : 1.4 MHz)





Outlooks

- Astonishing sensitivities in muon precision physics at intensity frontiers are foreseen for the incoming future
- **Rare/forbidden decay searches and symmetry tests remain among the most exciting places where to search for new physics**
- New detector developments are the keys for addressing this very challenging physics program combined with beam developments

Thanks for your attention!

Back-up