Search for the X_{17} particle with PADME detector

William Natale, on behalf of the **PADME Collaboration**
INFN – LNF, Università di Roma Tor Vergata
Flavor Physics and CP Violation (FPCP) conference – 22/05/2026
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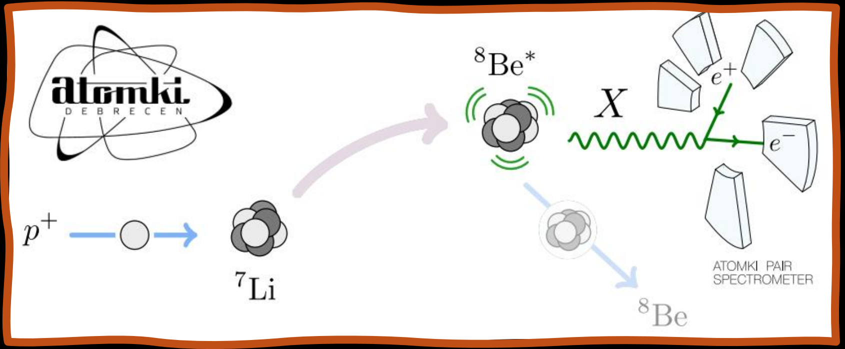
The X_{17} anomaly

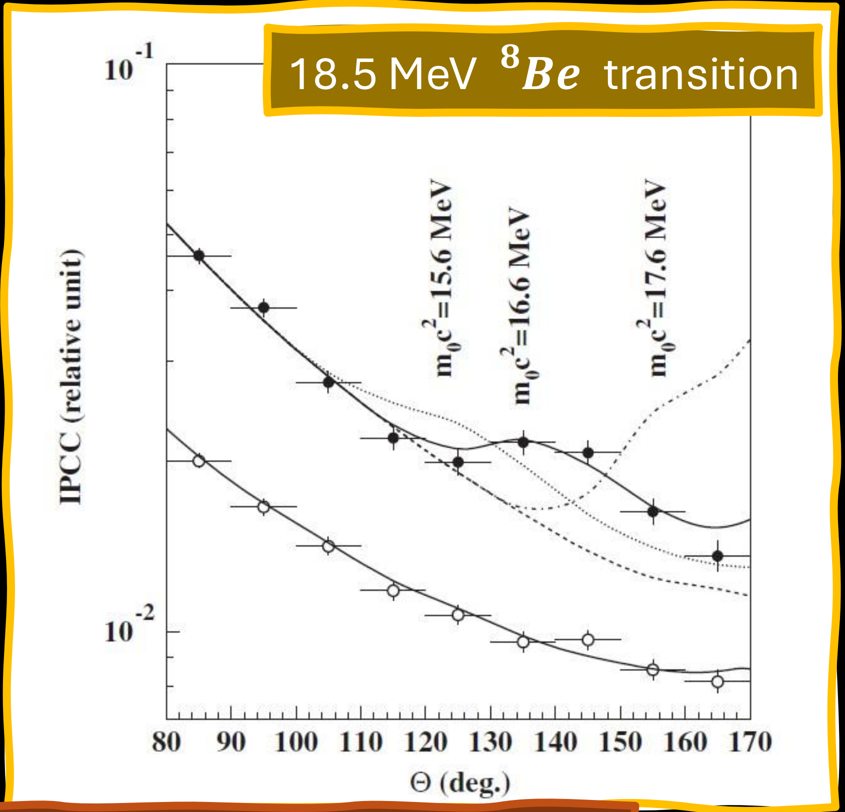


Excesses in angular distribution of e^+e^- pair in nuclear transitions of ^{8}Be, ^{4}He e ^{12}C observed by the **ATOMKI collaboration.**

This anomaly happens at **different angles for different transition energies.**

All of them are compatible with the hypothesis of the production and subsequent decay of a **new particle with mass**

$$m_X = 16.85 \pm 0.04\ \mathrm{MeV/c^2}$$



MEG-II searched for this anomaly in the ^{8}Be **transitions** with a dedicated data taking, setting upper limits at 90% C.L. on the branching fractions:

$$R_{17.6} < 1.8 \times 10^{-6} \quad , \quad R_{18.5} < 1.2 \times 10^{-5}$$

Which do not exclude completely the region suggested by ATOMKI results.

PhysRevLett.116.042501 (2016)

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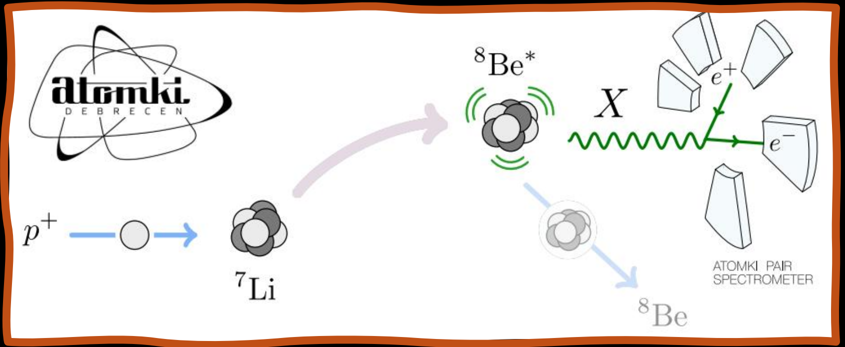

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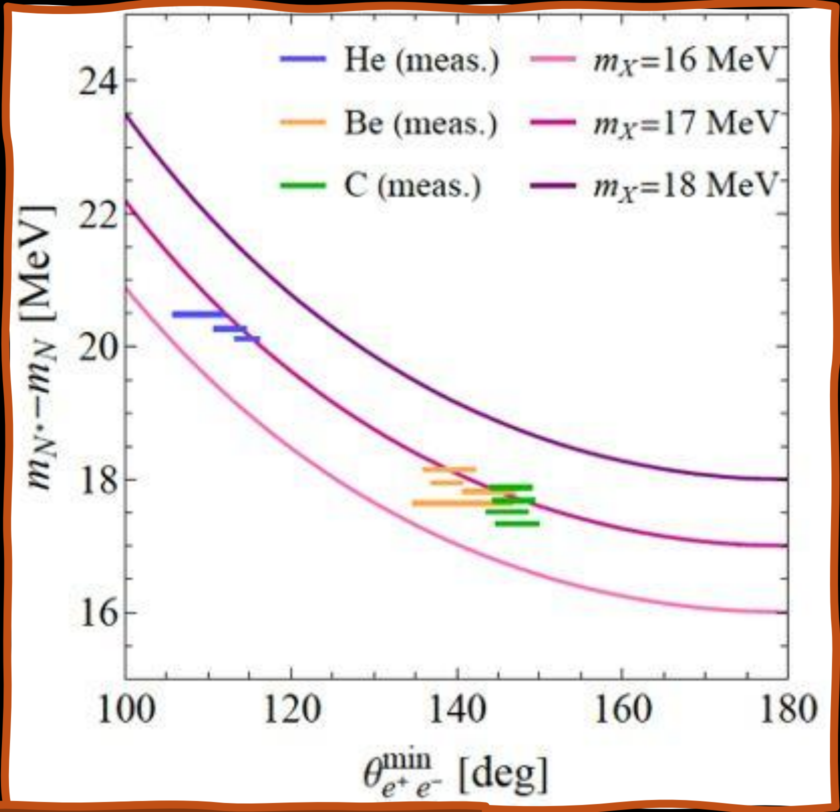

Phys. Rev. D 108, 015009

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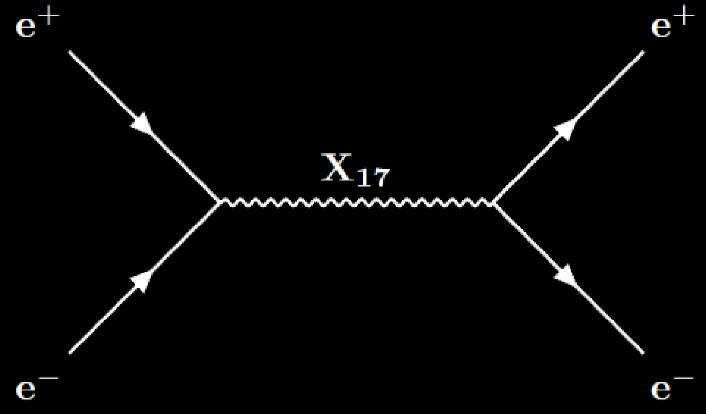
X_{17} search @ PADME Run III

- $\sigma_{res} \propto \frac{g_{Ve}^2}{2m_e} \pi Z\, \delta(E_{res} - E_{beam}) \propto Z$ → dominant with respect to alternative signal production processes
  Phys. Rev. D 97, 095004
  → fine scan of e^+e^- annihilation around $\sqrt{s} \sim 17$ MeV
  → **expected enhancement in $\sqrt{s}$ over the SM background**

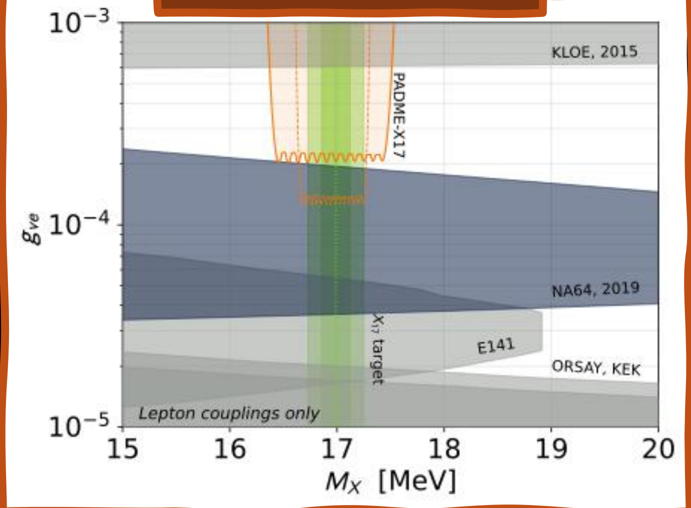


@PADME:

- X_{17} production through **resonant annihilation of e^+ beam on a thin target:** scan around $E_{beam} \sim 282$ MeV aiming to measure 2 body final state yield **N_2(s)**
  → In the approximation with e^- at rest, expected number of X_{17} events is:

$$N_{vector}^{perPoT} \simeq \frac{g_{Ve}^2}{2m_e} \ell_{tar} \frac{N_A \rho Z}{A} f(E_{res}, E_{beam}) \sim 1.8 \times 10^{-7} \times \left(\frac{g_{Ve}}{2 \cdot 10^{-4}}\right)^2 \left(\frac{1\ \text{MeV}}{\sigma_E}\right)$$

Vector scenario



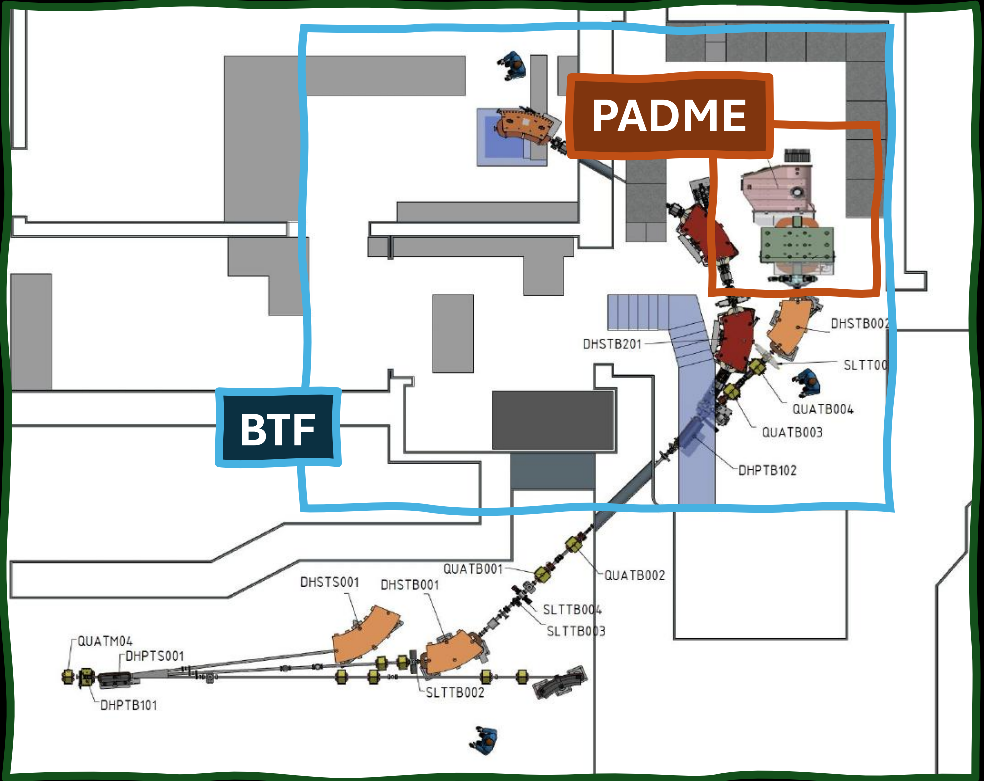
- **Intrinsic width** from ATOMKI **expected to be @eV level**
  → **fine resonant scan** requires **very good beam condition**
  → **peak width dominated by energy resolution**

- **Aiming to measure absolute cross section to be normalized to the Standard Model**

PADME @ Beam Test Facility

The **Beam Test Facility** (BTF) at Laboratori Nazionali di Frascati (LNF) is a facility which can provide e^+/e^- **beam up to 550 MeV** from the DAΦNE LINAC.

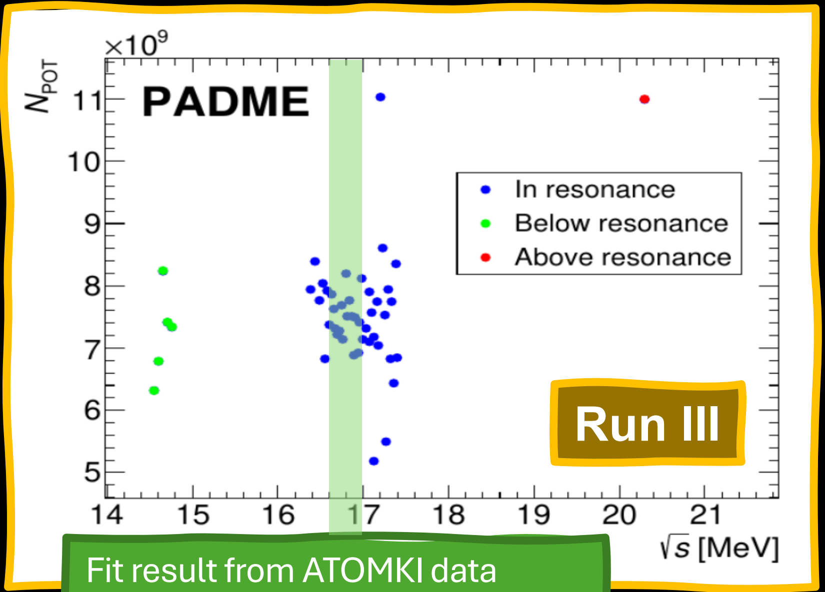
PADME is located at BTF – Hall 1 and it works with e^+**beam** impinging on an **active target**.



Nominal Run III beam conditions:
- 3000 e^+/spill
- 250 ns bunch
- 1 mm^2 at target

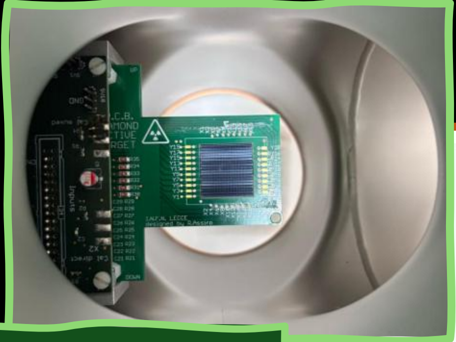
Run III

Run III
42 points around resonance (Scan 1 and 2)
$\sim 10^{10}$ **PoT per on-resonance-point**
$263 < E_{Beam} < 292$ MeV and $\delta E_{Beam} \sim 0.75\ MeV$ corresponding to $16.4 < \sqrt{s} < 17.4$ MeV/c^2
5 points @ $205 < E_{Beam} < 211\ MeV$
1 point @$E_{Beam} = 402\ MeV$

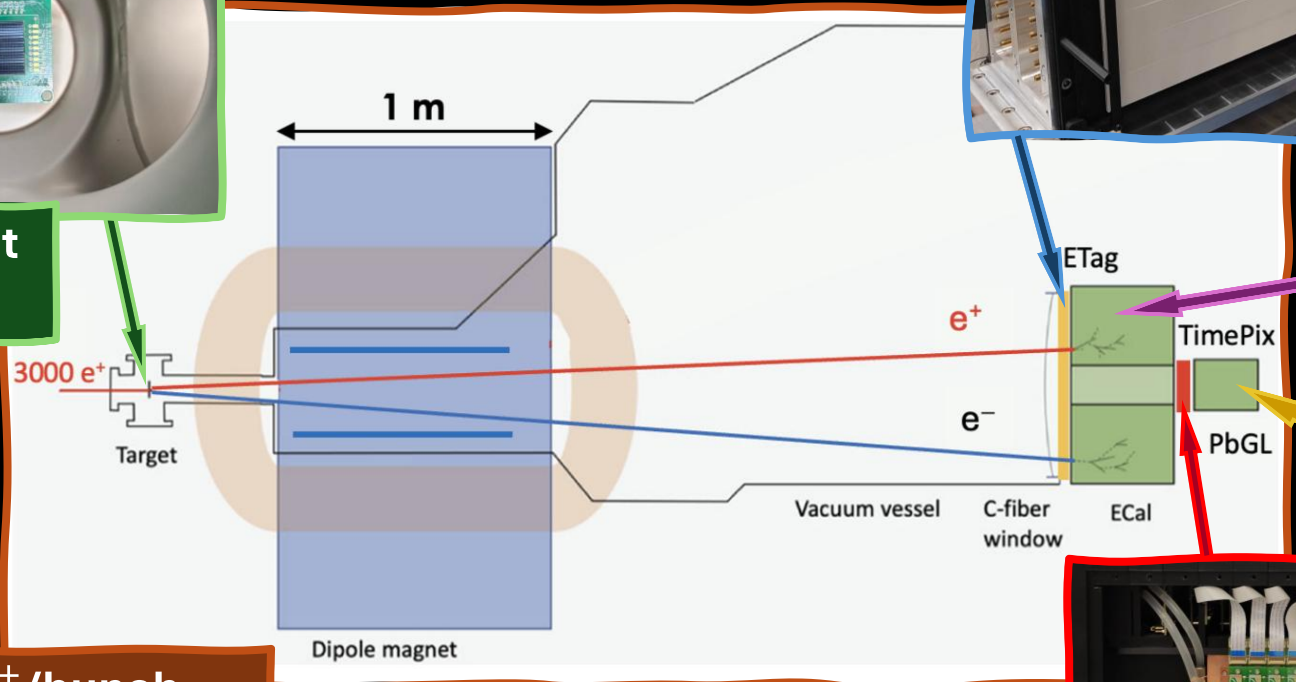


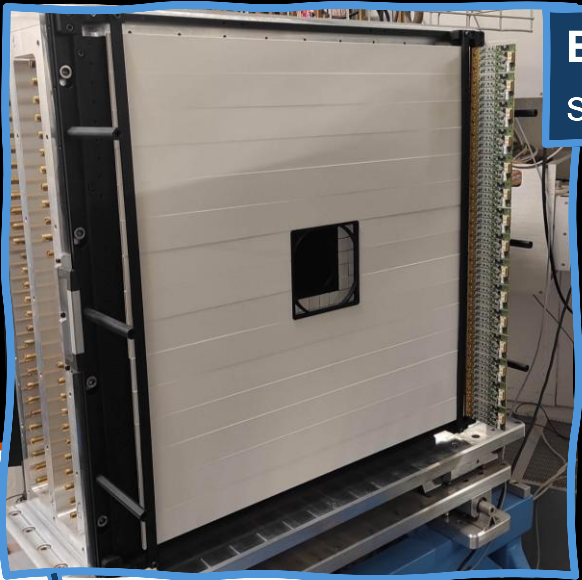
Fit result from ATOMKI data
Phys. Rev. D 108, 015009

Run III: experimental setup

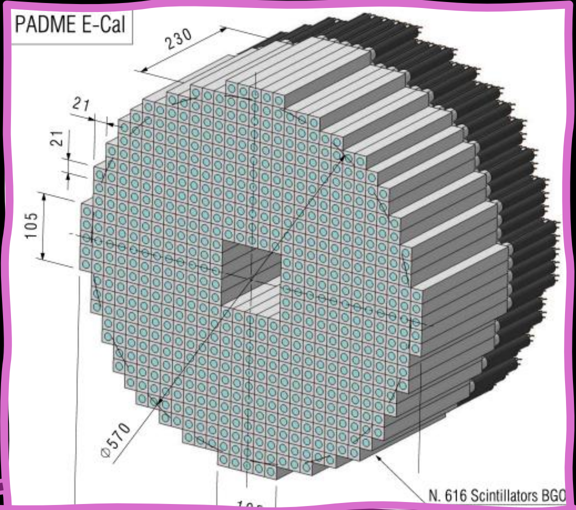


Active Target (diamond)



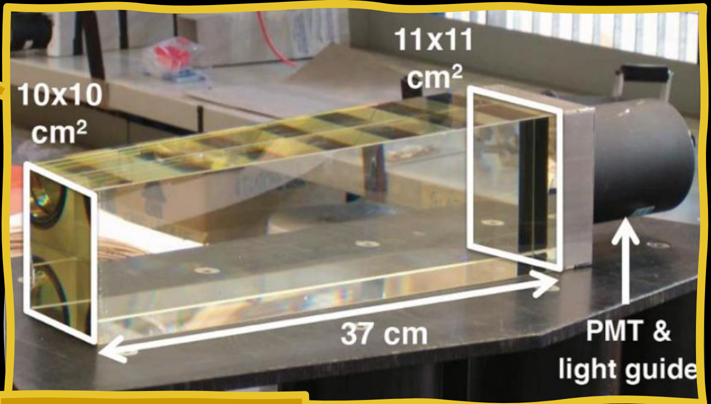


ETag (18 plastic scintillators 4x60x0.5 cm^3)



ECAL (616 BGO crystals $21 \times 21 \times 230\ mm^3$)

TimePix3



LeadGlass

Beam: 3000 e^+/bunch
[262 MeV – 296 MeV]
Bunch length ~200 ns

Run III analysis inputs

Signal + SM hypothesis → $\frac{N_2(s)}{N_{PoT}(s)\, B(s)} = K(s)\left[1 + S(s; M_X, g_{Ve}) \frac{\varepsilon_S(s)}{B(s)}\right]$

VS

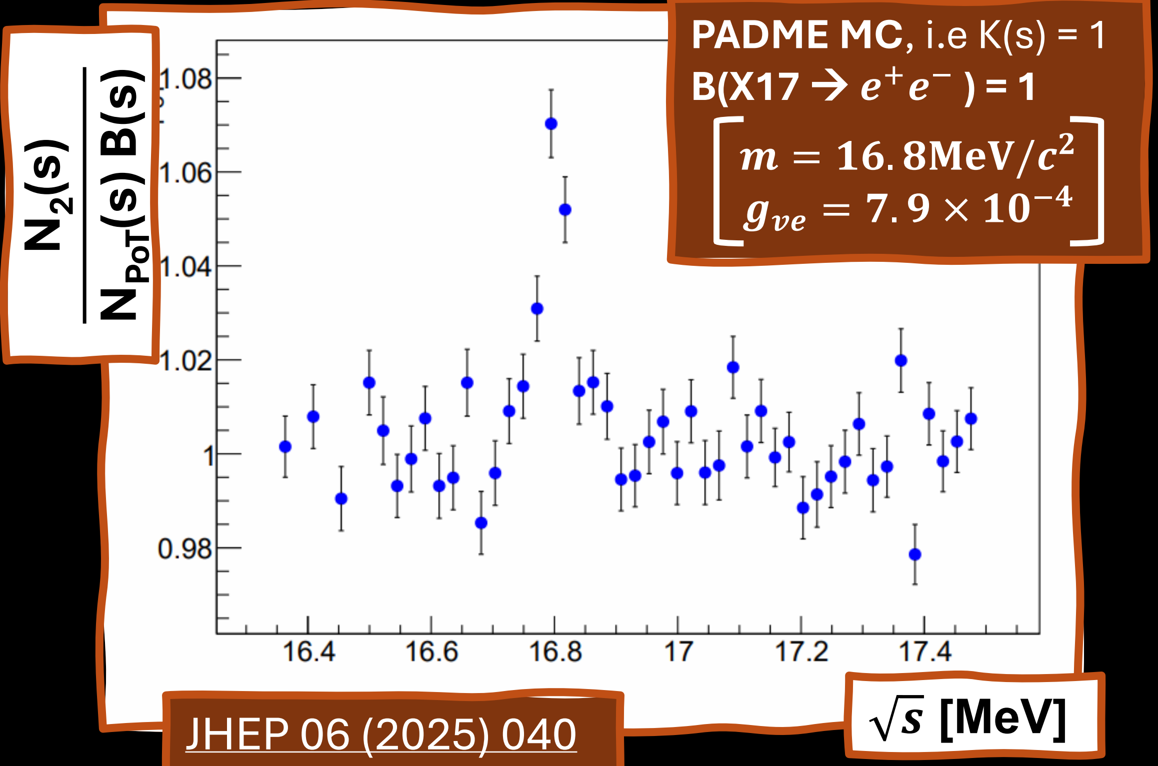
SM only hypothesis → $\frac{N_2(s)}{N_{PoT}(s)\, B(s)} = K(s)$

SM background processes

$e^+e^- \rightarrow e^+e^-$ [s+t]	73%
$e^+e^- \rightarrow \gamma\gamma$	20%
$e^\pm$ N → $e^\pm$ N γ	7%

Analysis inputs:

- K(s) → DATA-MC scale factor expected linear in $\sqrt{s}$
- $N_2(s)$ → number of 2-body final states in ECal
- $N_{PoT}(s)$ → number of e^+ on target from LG beam-catcher
- B(s) → expected SM background yield per PoT
- $S(s; M_X, g_{Ve})$ → expected signal production per PoT for {mass, coupling} = $\{M_X, g_{Ve}\}$
- $\varepsilon_S(s)$ → signal acceptance and selection efficiency



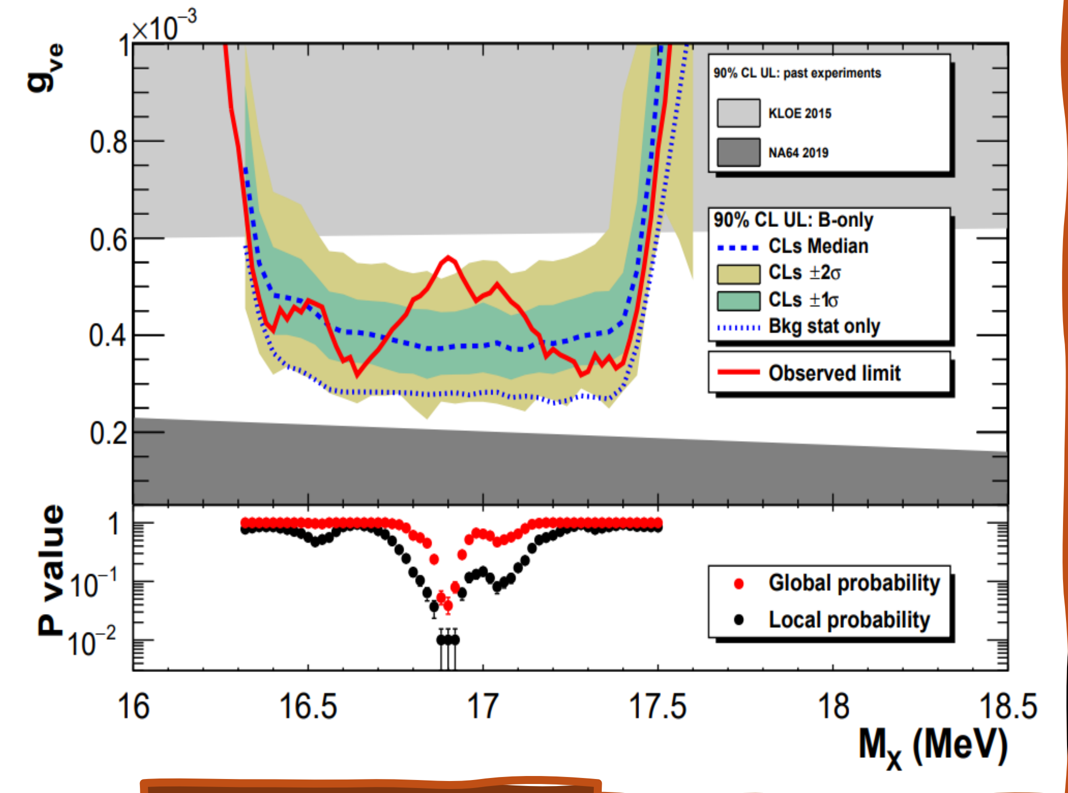
JHEP 06 (2025) 040

Run III results

- Blind analysis performed
  → Error budget validated with dedicated procedure
  see → JHEP06(2025)040

- **No statistically significant signal beyond 3σ was observed**
  → leading to exclusion at 90% CL $g_{Ve} > 5.6 \times 10^{-4}$

- **A local excess was seen at 2.5σ level**
  $$@\, M_X = 16.90(2)\ \text{MeV}, \quad g_{Ve} = 5.6 \times 10^{-4}$$
  the global probability dip reaches $3.9^{+1.5}_{-1.1}\%$, corresponding to
  $(1.77 \pm 0.15)\sigma$ **one-sided**
  (look-elsewhere calculated exactly from the toy pseudo-events)



JHEP 11 (2025), 007

JHEP 11 (2025), 007

Uncorrelated errors

Source	Uncertainty (% per energy point)
$N_2(s)$	0.60
$B(s)$	0.54
$N_{\mathrm{PoT}}(s)$	0.35
Total on $g_R(s)$	0.88

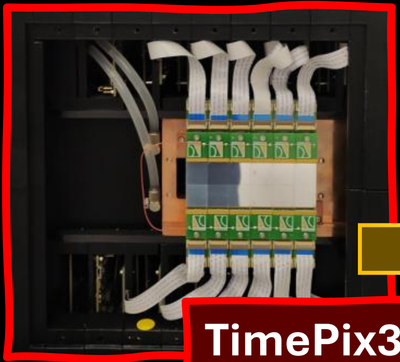
Result not conclusive
Need for more data → Run IV data taking in 2025

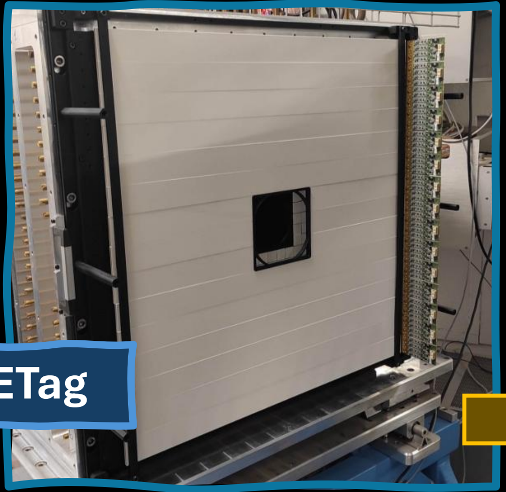
Run III VS Run IV

Run III → UPGRADES → Run IV

Run III

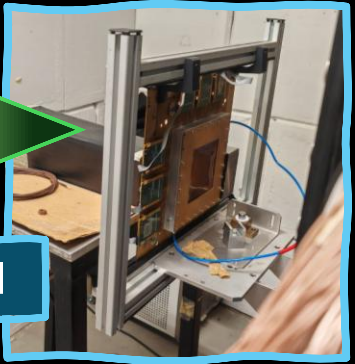
- Total $N_{PoT} \sim 7 \times 10^{11}$
- Acceptance (~10%)
- Flux measurement & Beam related uncertainties
- Insufficient discrimination between charged/neutral particles from ETag
- Passive material of TimePix

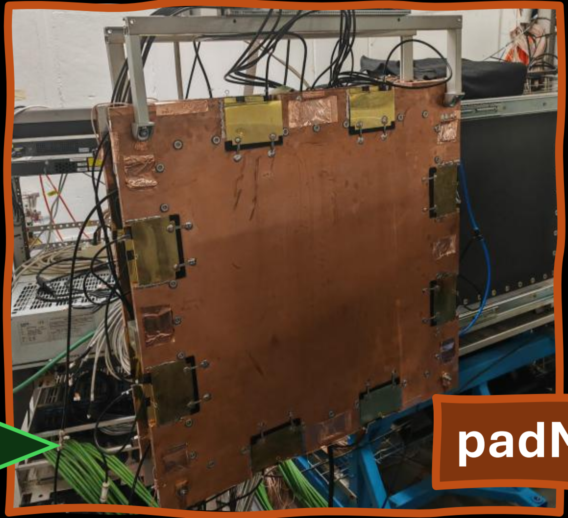




Run IV

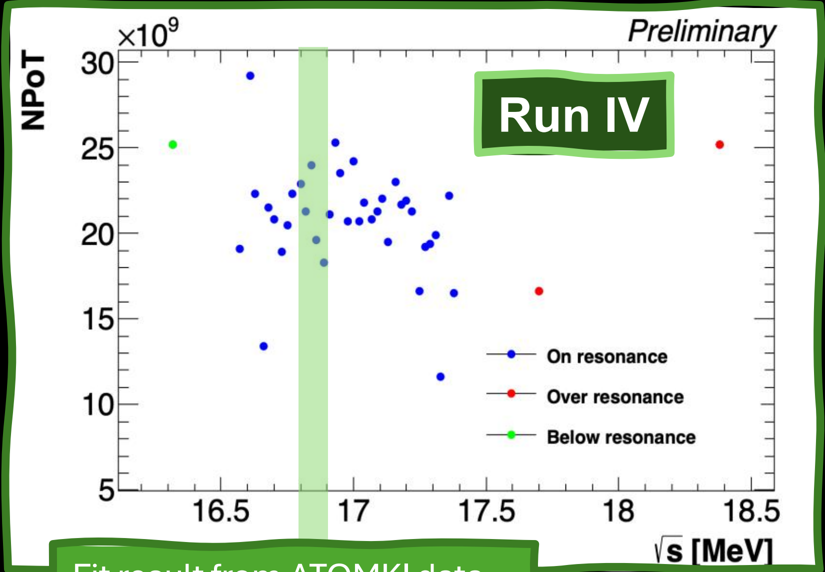
- Total N_{PoT} ~x2 wrt Run III
- New target position (closer to ECAL) → 2x acceptance
- **Gaseous tracking detectors (padMMe and TMM)**
  - → **Discrimination of photons/charged particles**
  - → **Beam monitor capabilities**
- **Improved spatial and angular resolution**
- N_{ee} **normalization to another physical process, like** $N_{\gamma\gamma}$
- Reduced passive material along the beamline





Run IV dataset

- **Run IV dataset is ~x2 larger than Run III**
- Better beam control → **online monitoring during the run**
- Same spacing and strategy of Run III
- More no-target points → **aim to improve background study**



Fit result from ATOMKI data
Phys. Rev. D 108, 015009

Run IV

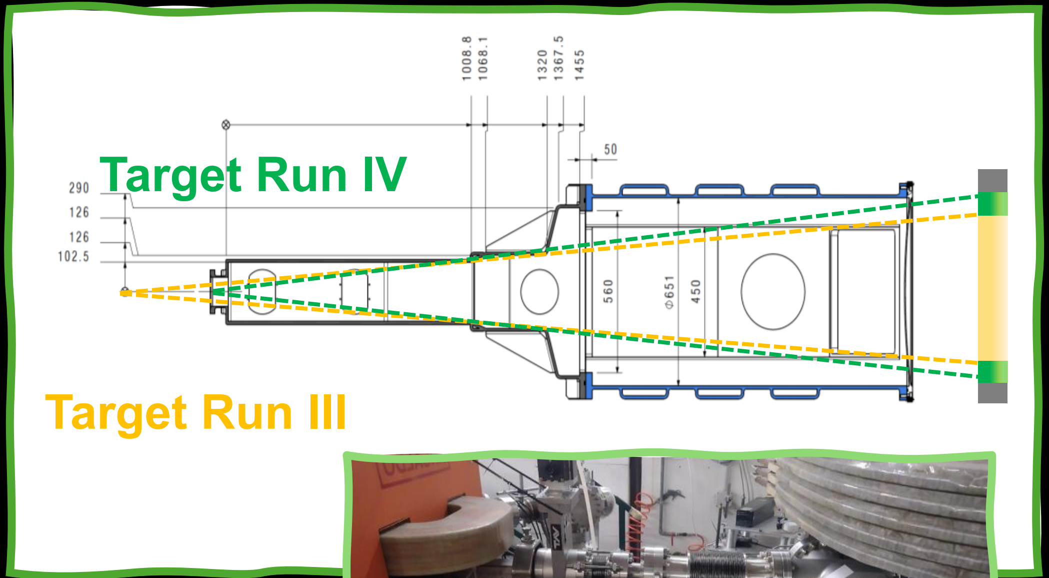
36 around resonance (Scan 1 and 2 – 18 points each)
$\sim 2.2 \times 10^{10}$ **PoT per on-resonance-point**
$268\ \mathrm{MeV} < E_{Beam} < 295\ \mathrm{MeV}$ **and** $\delta E_{Beam} \sim 0.75\ \mathrm{MeV}$
1 point $@260\ \mathrm{MeV}$
2 points $@300 - 330\ \mathrm{MeV}$

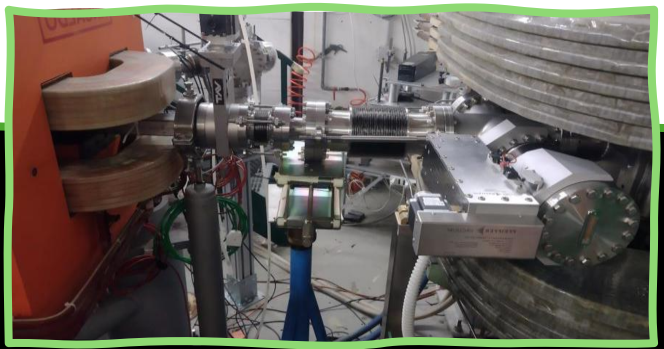
- June – July → Scan 1
- October – November → Scan 2

Nominal Run IV beam conditions:
- 3000 e^+/spill
- 250 ns bunch
- $1\ \mathrm{mm}^2$ at target
- ~1 mm mrad normalized emittance

Measured in the commissioning period!!!

Run IV acceptance





❖ **Target moved** → Acceptance region widened
→ Wider angular coverage

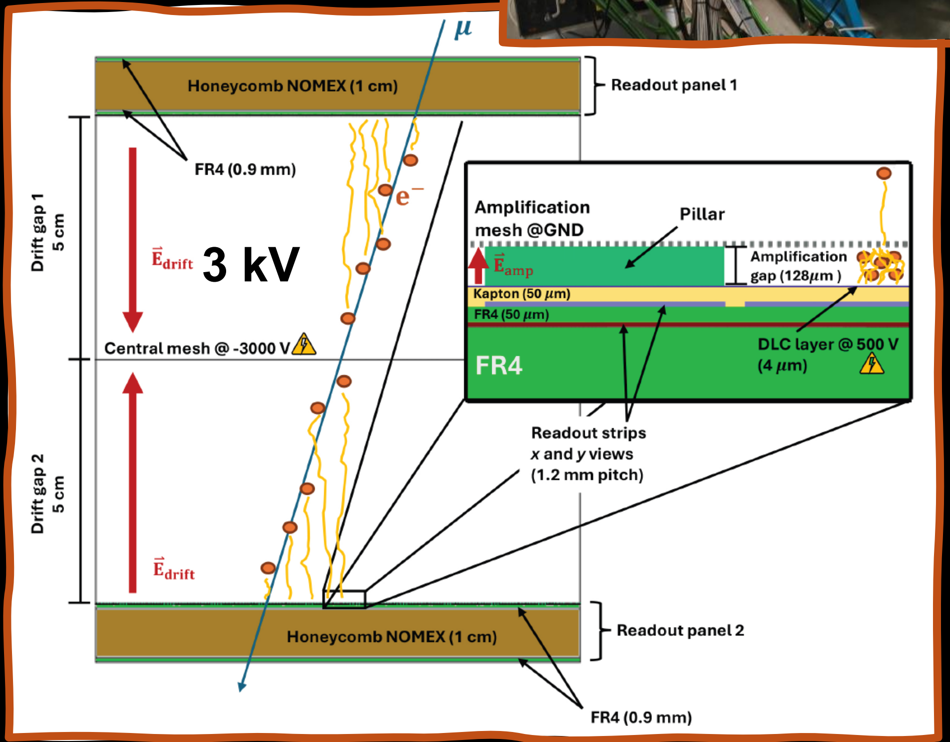
❖ ponit-by-point N_2 **yield increased** → factor of ~ 2.5 wrt Run III
- ❖ Run III data: $N_2 = 3.705 \times 10^{-6}$ (evaluated over 0.78×10^{10} PoT)
- ❖ Run IV data: $N_2 = 9.948 \times 10^{-6}$ (evaluated over 10^{10} PoT)

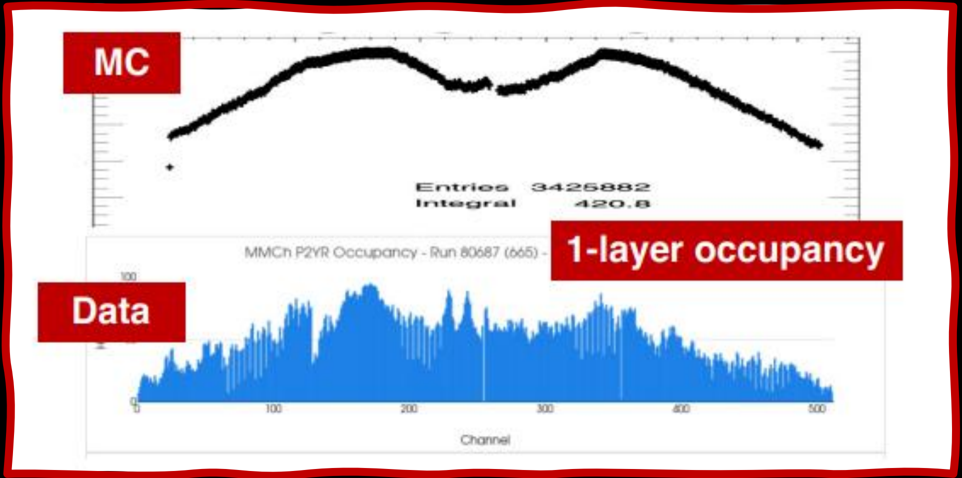
$\frac{Sig}{\sqrt{Bkg}}$ **increases**

Run period	d Target-ECal	θ_{lab} @ 17 MeV	R range @ 17MeV	Magnet "shadow"
Run III	3700 mm	48 – 73 mrad	177 – 270 mm	249 mm
Run IV	3360 mm	43 – 80 mrad	146 – 270 mm	270 mm

padMMe MICROMEGAS tracker

- **e/γ discrimination → charged final states only**
- **Access to different observables N_2/N_{PoT}, ee/N_{PoT}, $ee/\gamma\gamma$**
- gas mixture **Ar:CF4:i-C4H10=88:10:2**
- Main features:
  - → **$65 \times 65 \times 10$ cm^3 - Double drift gap** w/ **same cathode**
  - → **two (x,y)-ReadOut planes**
  - → **3 HV separated regions**
  - → **Hit efficiency > 90%**
- **Beam monitor capability →** central region at low gain (orange+green)
  - Used as online monitor during Run IV data taking
- **Used in Time Projection Chamber mode**
- **Need to face very high occupancy** (with 3000 e^+/spill)

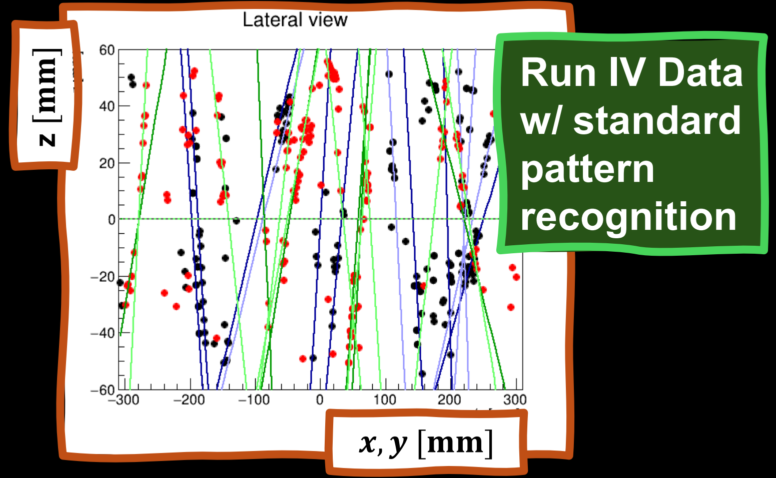




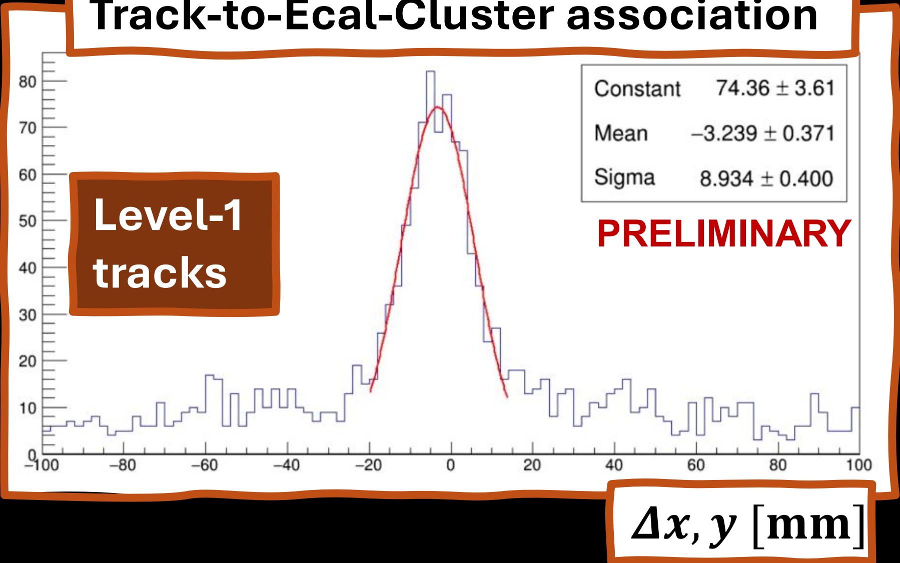
padMMe - Reconstruction

- **Large combinatorial** in standard pattern recognition
  - ~3500/4096 fired strips ~85% occupancy
  - ~200 track candidates found w/o Interaction Point (IP) constraint

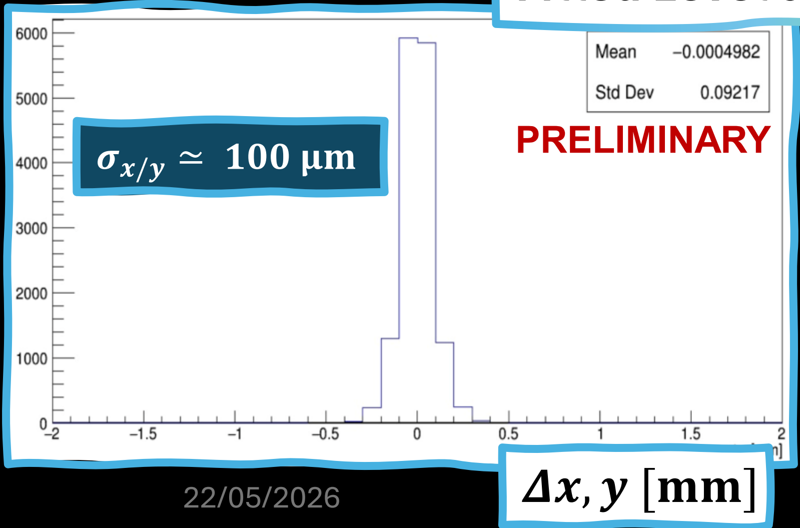
    → **IP-oriented pattern recognition algorithm**
- Each charged particle measured in 2 planes – both X and Y coordinates
  - 4 tracks (2D) expected for charged particle → **Level-0 tracks**
  - High efficiency but a Level-0 track requirement has high bkg component (combinatorial tracks)
  - Need at least 2/3 out of 4 coincidence
  - Two-plane coincidence → **Level-1 tracks**
  - Performances obtained with nominal Run IV beam intensity

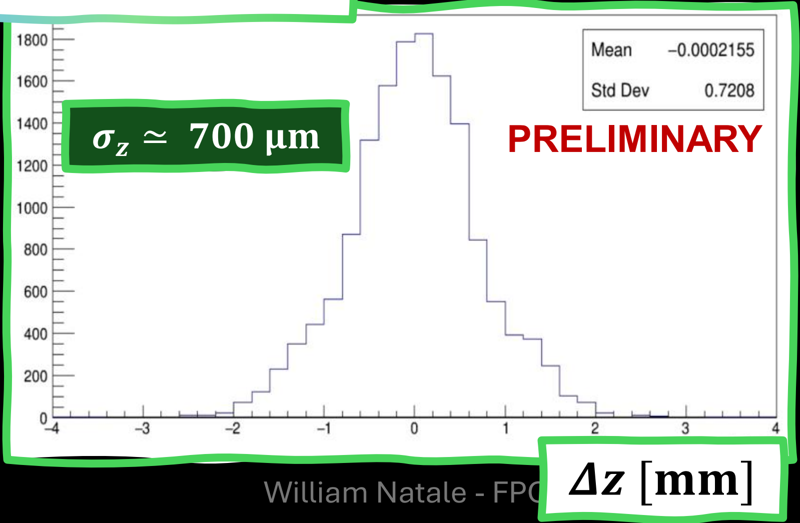


Track-to-Ecal-Cluster association



Fitted Level 0 track residuals

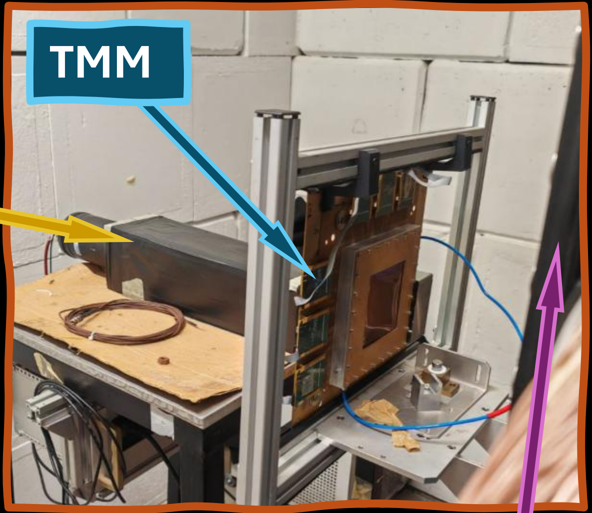


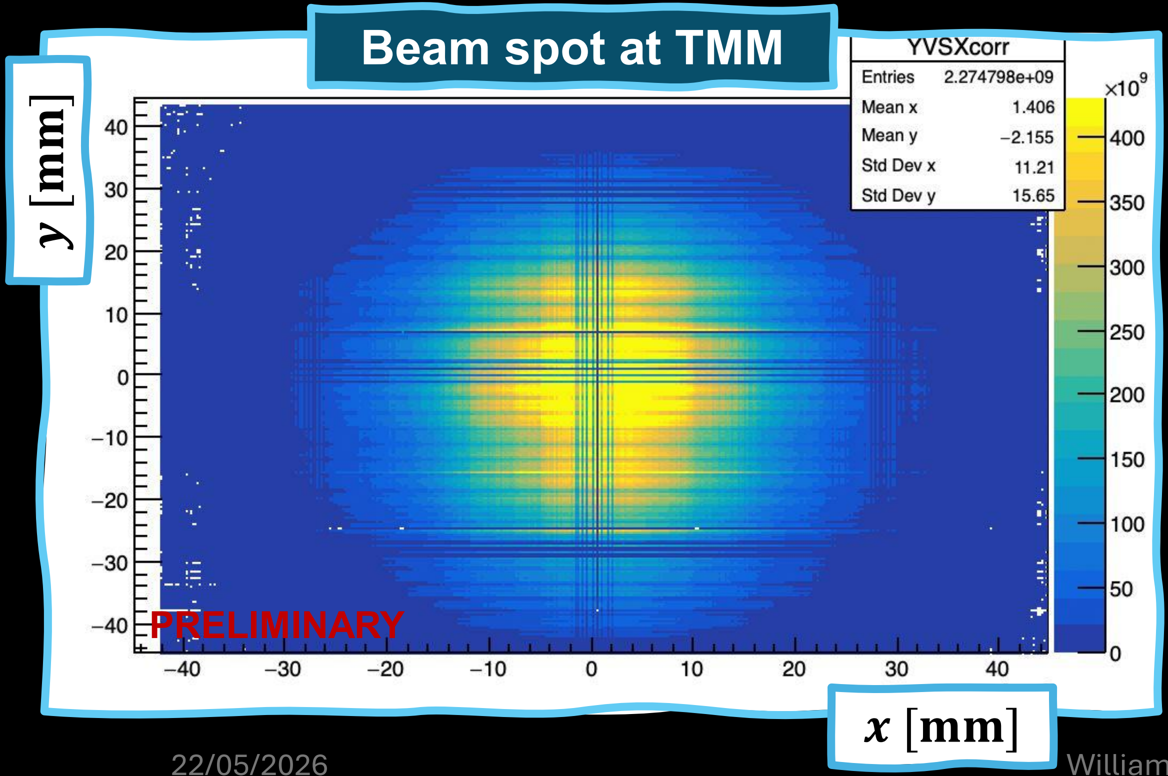


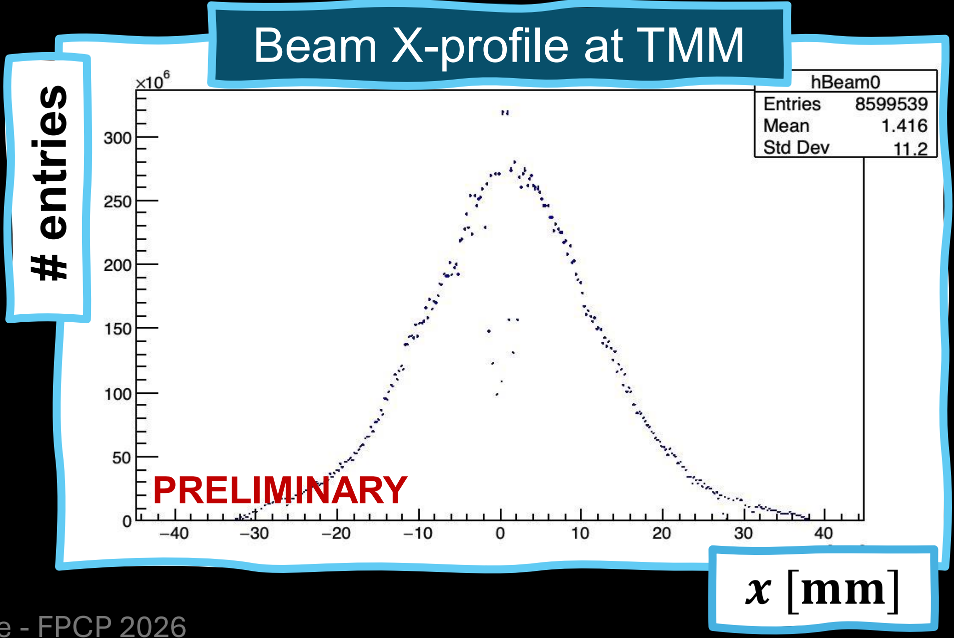
To Be Continued . . .

Run IV beam monitor - TMM

- **A 10x10x5 cm^3 MICROMEGAS** detector:
  - **gas mixture (Ar:CF4:i-C4H10=88:10:2)**
  - **Drift HV 300 V, RO HV 350 V → low gain**
  - Chamber placed **in front of the LG**
- Larger and uniform active area and **less passive material budget wrt TimePix**
- **Beam spot and flux monitor**





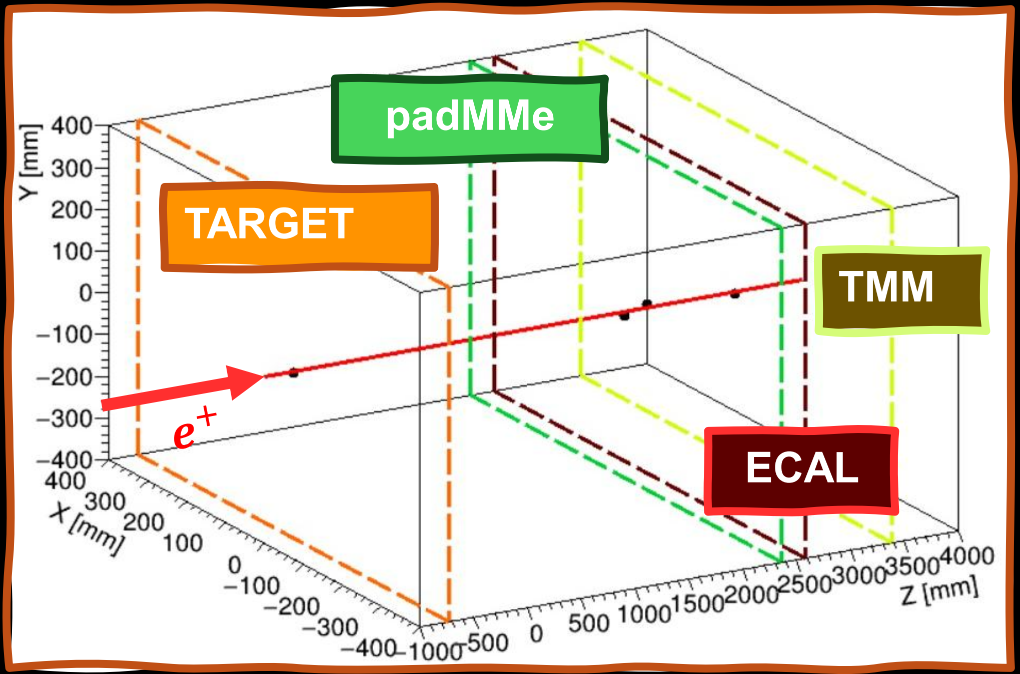


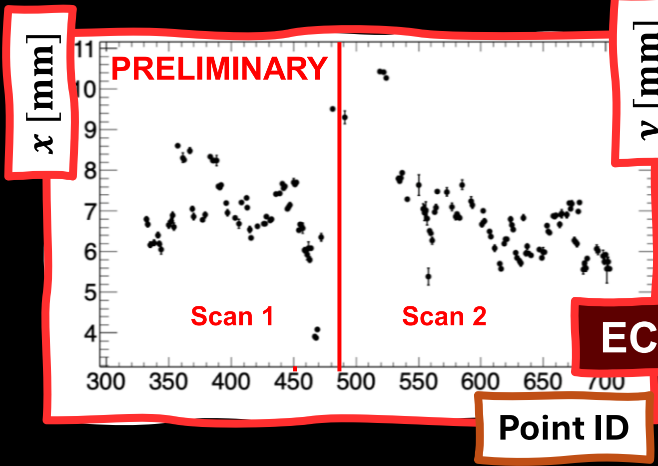
Run IV beam monitor

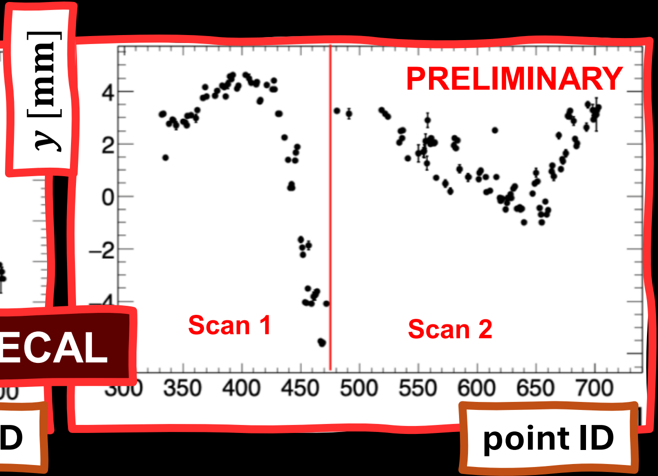
- ❖ **Beam monitor at 4 different transversal planes** using different detectors
  - → Aiming at **measuring: position, angle, beam spread and beam divergence**

- ❖ **Target beam position monitor**
  - → **Beam position stable within 100-150 μm**
  - → consistently hitting the **same strip pair** $(X = 1, Y = -5)$ throughout the data taking

- ❖ **Ecal**: beam position estimated with two-cluster center of gravity



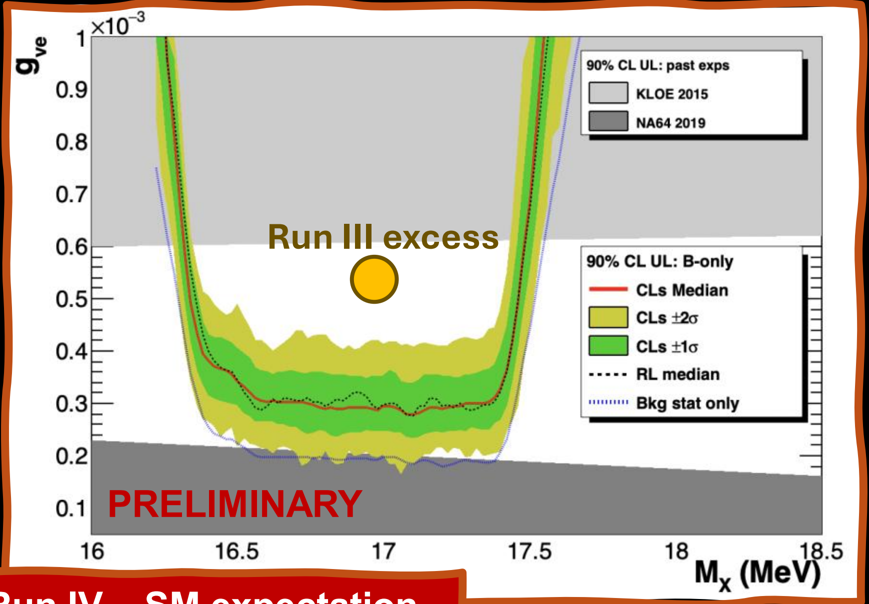




Summary and perspectives

Run III:

- Overall **systematic uncertainty below 0.9%** achieved for the entire Run III dataset
- No statistically significant X_{17} signal observed, largest fluctuation at
  $M_X = 16.90$ MeV (2.5σ local - 1.8σ global)
  - Results interpreted with a **frequentist CLs** procedure to set **upper limits** (vector-boson hypothesis).



Run IV – SM expectation

Run IV:

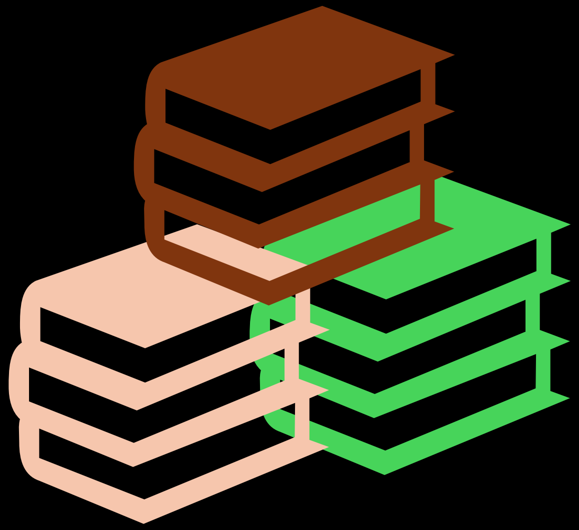
- **36 energy scan points** ($\geq 2 \times 10^{10}$ PoT each) equally separated by 0.75 MeV around the resonance region
- Signal yield increased by a factor of ~ 2.5 wrt Run III (luminosity + acceptance)
- Data analysis on going

Source	Uncertainty [%]	
	Run III	Run IV target
N_2	0.6	0.3
B	0.35	0.3
N_{PoT}	0.55	0.3
TOTAL	0.88	0.5

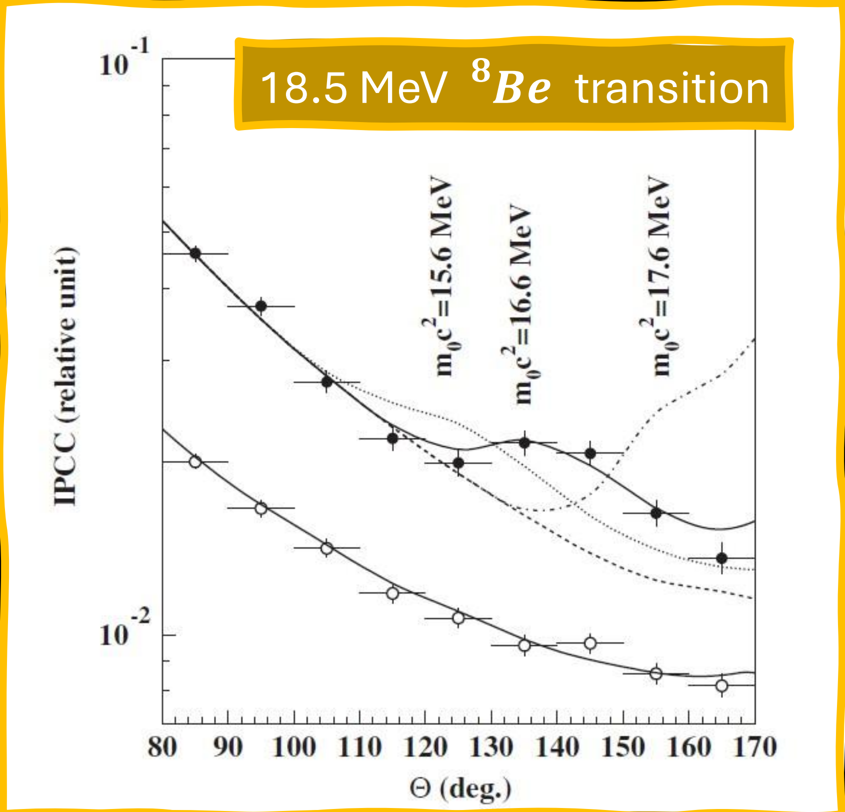
Improve sensitivity → aiming at a factor of 2 error reduction
(higher statistics and better control of systematics)

Thanks for your attention :)

Backup slides

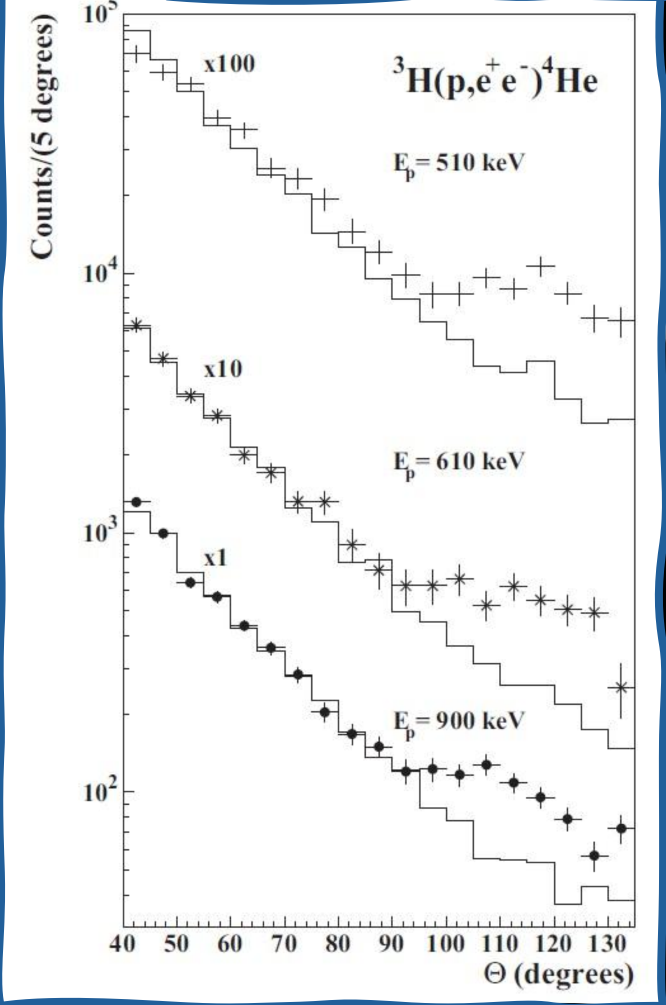


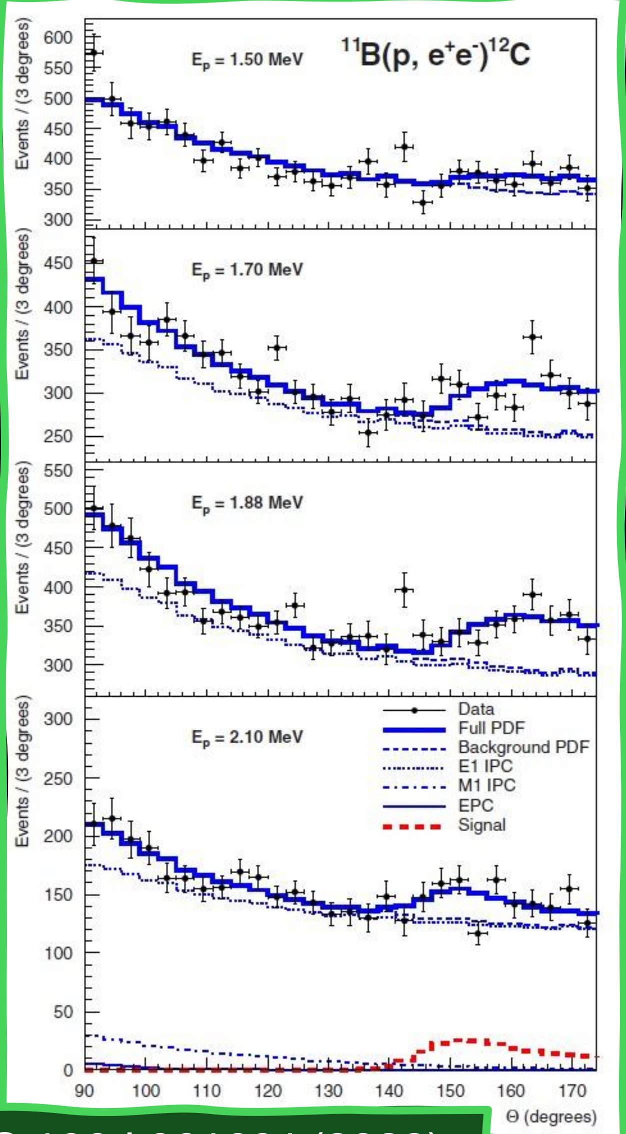
X17 anomaly @ ATOMKI



PhysRevLett.116.042501 (2016)

PhysRevC.104.044003 (2021)





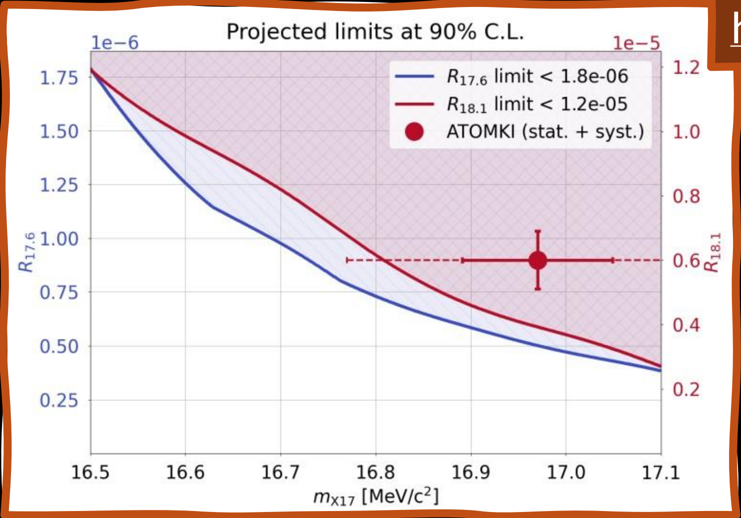
PhysRevC.106.L061601 (2022)

X17 boson nature

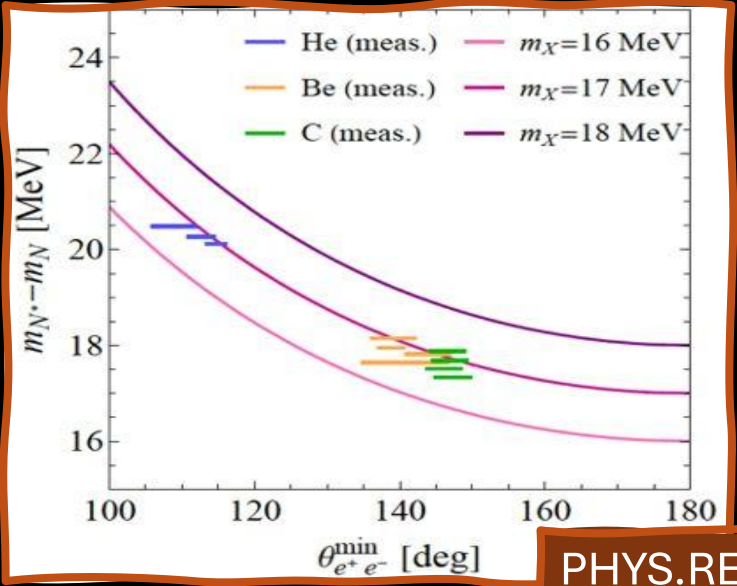
N^*	$J^{P_*}_*$	J^P (f.s.)	scalar X	pseudoscalar X	vector X	axial-vector X
^{8}Be (18.15)	1^+	0^+	...	✓	✓	✓
^{4}He (21.01)	0^-	0^+	...	✓	...	✓
^{4}He (20.21)	0^+	0^+	✓	...	✓	...
^{12}C (17.23)	1^-	0^+	✓	...	✓	✓
^{8}Be (GDR $\rightarrow g.s.$)	1^-	0^+	✓	...	✓	✓
^{8}Be (GDR $\rightarrow 2_1^+$)	1^-	2^+	✓	✓	✓	✓

Parity conservation is assumed !!!

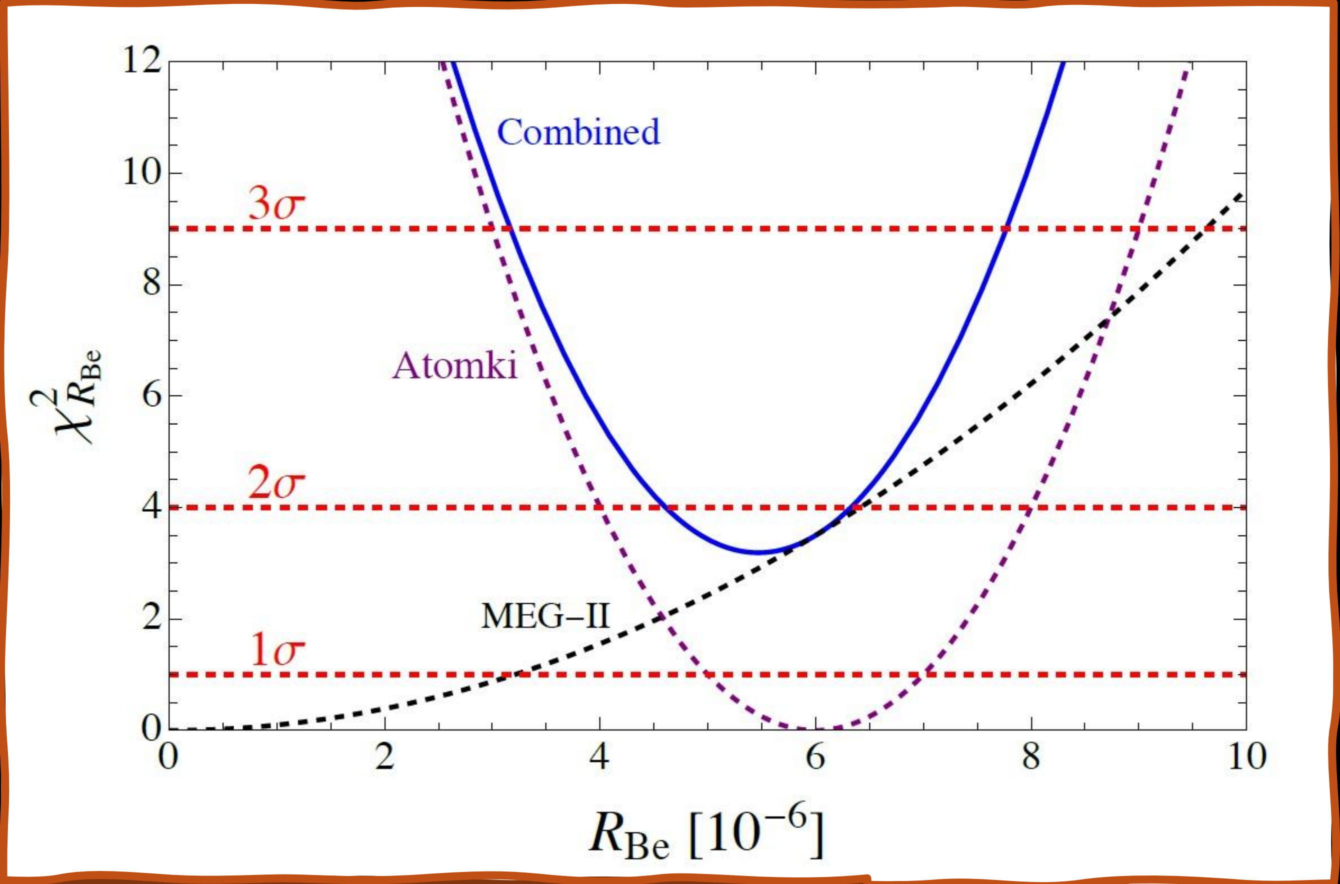
MEG-II VS ATOMKI



https://arxiv.org/abs/2411.07994



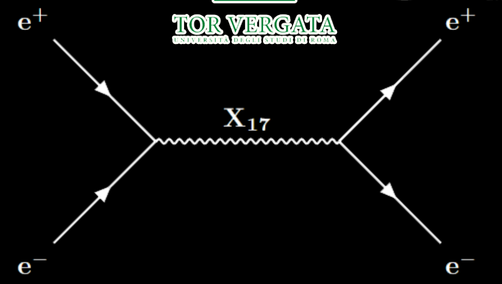
PHYS.REV. D 108, 015009 (2023)



http://dx.doi.org/10.1007/JHEP04(2025)035

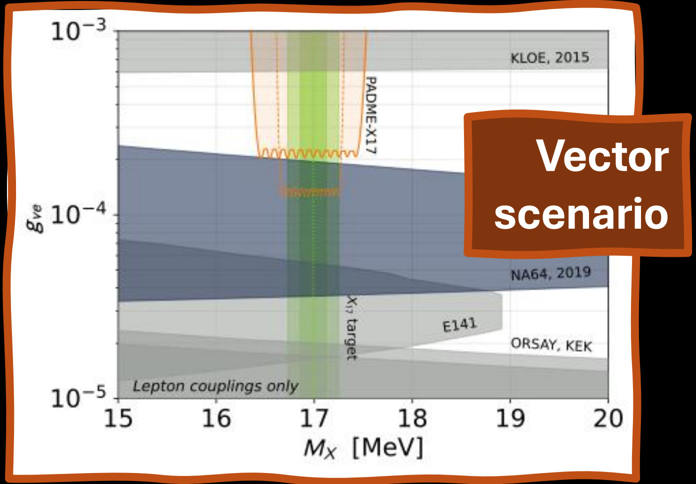
X17 search @ PADME Run III

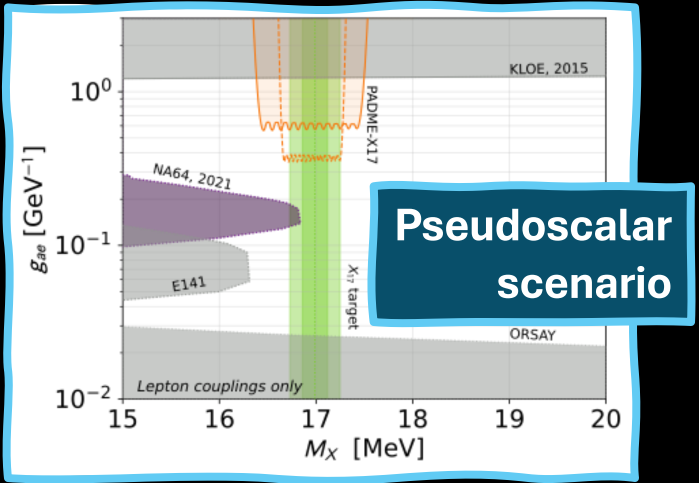
- $\boldsymbol{\sigma_{res} \propto \frac{g_{Ve}^2}{2m_e} \pi Z\, \delta(E_{res} - E_{beam}) \propto Z}$ → dominant with respect to alternative signal production processes
  Phys. Rev. D 97, 095004
- $\sqrt{s}$ has to be as close as possible to the expected mass → fine scan procedure with the positron-beam → **expected enhancement in $\sqrt{s}$ over the SM bkg**

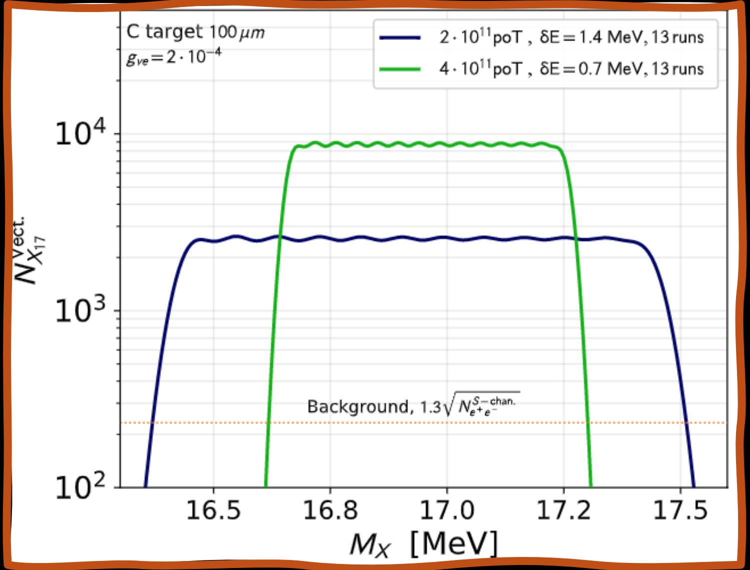


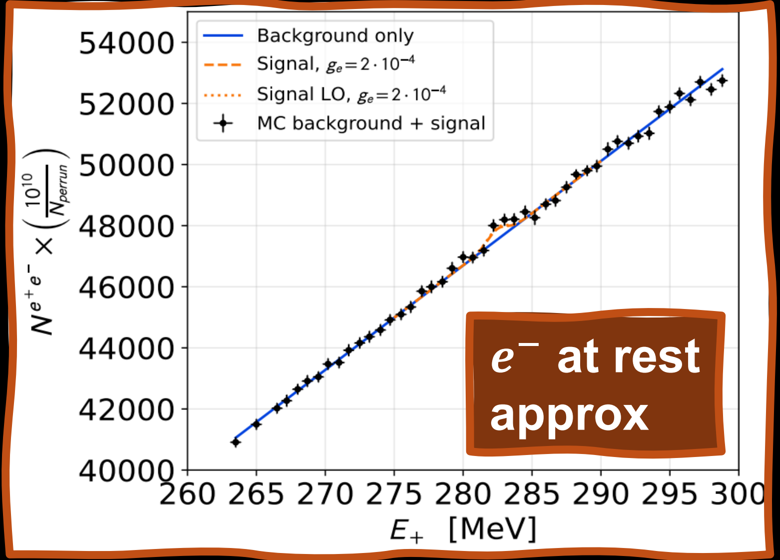
@PADME: X_{17} production through **resonant annihilation** in diamond target electron:
scan around $E_{beam} \sim 282$ MeV aiming to measure 2 body final state yield **N_2(s)**
→ e^- at rest approximation leads to large number of X_{17} **events**

$$N^{perPoT}_{vector} \simeq \frac{g_{Ve}^2}{2m_e} \ell_{tar} \frac{N_A \rho Z}{A} f(E_{res}, E_{beam}) \sim 1.8 \times 10^{-7} \times \left(\frac{g_{Ve}}{2 \cdot 10^{-4}}\right)^2 \left(\frac{1\ \text{MeV}}{\sigma_E}\right)$$





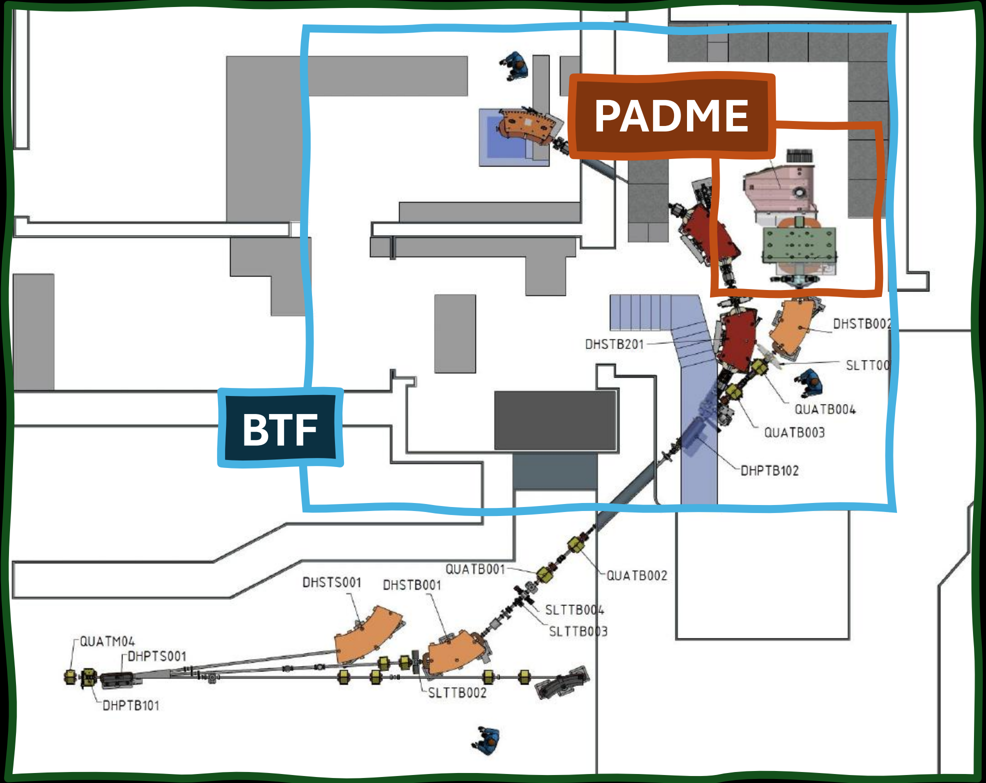




PADME @ Beam Test Facility

The **Beam Test Facility** (BTF) at Laboratori Nazionali di Frascati (LNF) is a facility which can provide **e^+/e^- beam up to 550 MeV** from the DAϕNE LINAC.

PADME is located at BTF – Hall 1 and it works with **e^+beam** impinging on an **active target**.

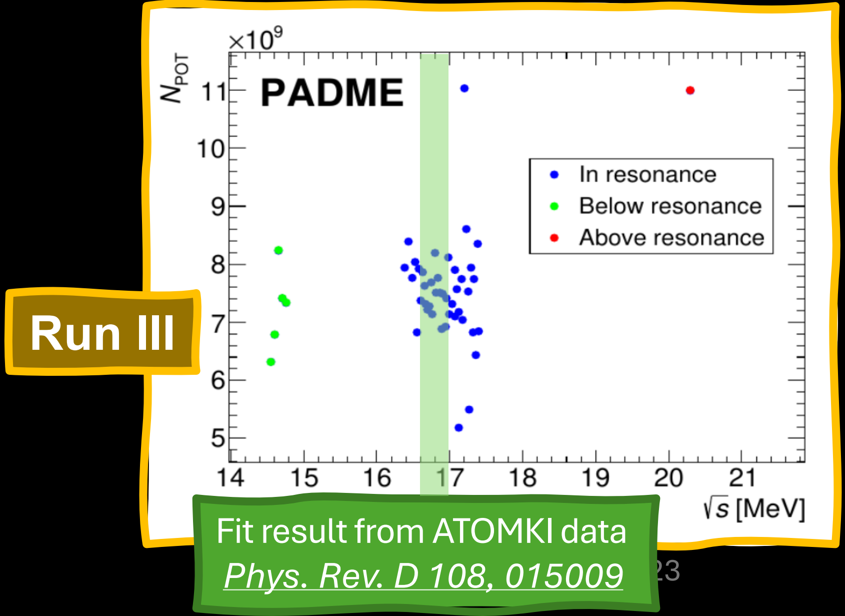


Nominal Run III beam conditions:

- 3000 e^+/spill
- 250 ns bunch
- 1 mm^2 at target

Run III

42 points around resonance (Scan 1 and 2)
$\sim 10^{10}$ **PoT per on-resonance-point**
$263\ MeV < E_{Beam} < 292\ MeV$ **and** $\delta E_{Beam} \sim 0.75\ MeV$
5 points @ 268 **MeV** $< E_{Beam} <$ 295 **MeV**
1 point @$E_{Beam} = 402$ **MeV**



Run III analysis inputs

Signal + SM hypothesis → $\frac{N_2(s)}{N_{PoT}(s)\, B(s)} = K(s)\,[\,1 + S(s; M_X, g_{Ve})\,\frac{\varepsilon_S(s)}{B(s)}\,]$

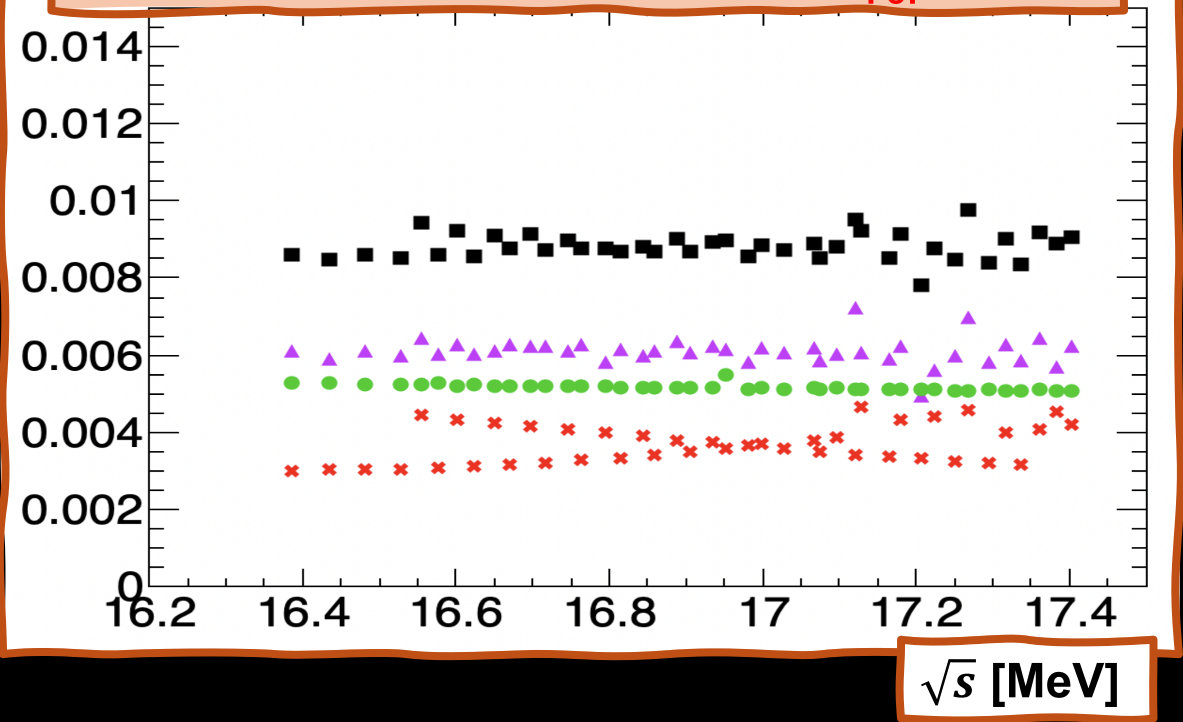
VS

SM only hypothesis → $\frac{N_2(s)}{N_{PoT}(s)\, B(s)} = K(s)$

Analysis inputs:

- **K(s)** → DATA-MC scale factor expected linear in $\sqrt{s}$
- **$N_2(s)$** → number of 2-body final states in ECal
- **$N_{PoT}(s)$** → number of e^+ on target from LG beam-catcher
- **B(s)** → expected background yield per PoT
- **$S(s; M_X, g_{Ve})$** → expected signal production per PoT for {mass, coupling} = $\{M_X, g_{Ve}\}$
- **$\varepsilon_S(s)$** → signal acceptance and selection efficiency

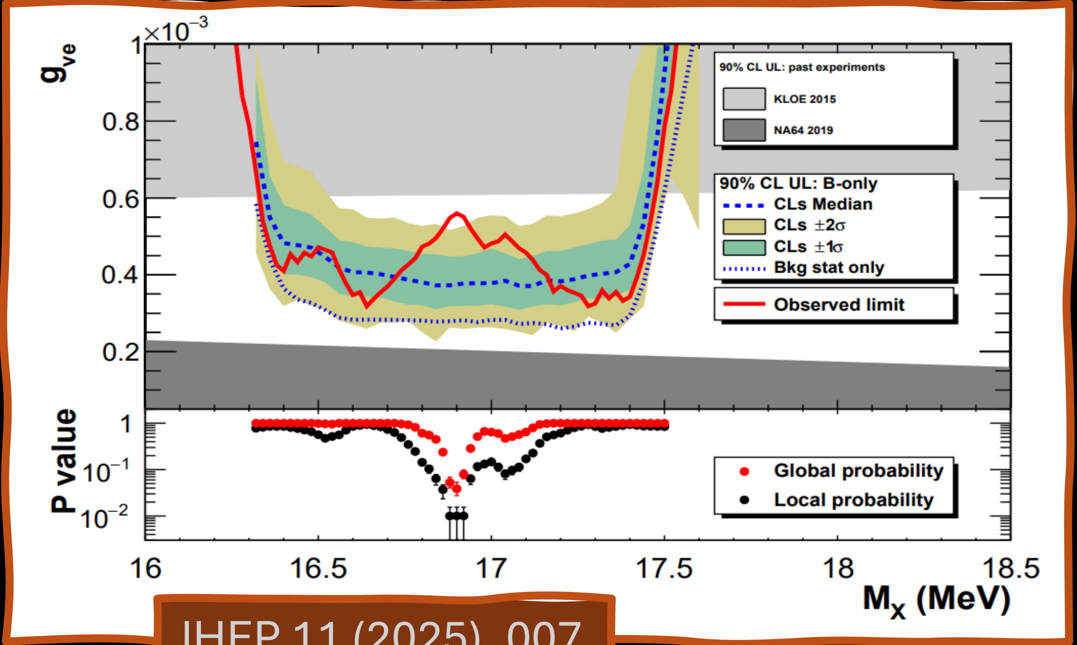
Uncorrelated uncertainty on $g_R(s) = \frac{N_2(s)}{N_{PoT}(s)\, B(s)}$



Run III analysis & uncertainties

❖ Assuming 3σ interval @ATOMKI $m_X = 16.85(4)\mathrm{MeV}/c^2$ (PRD 108, 015009 (2023)), p-value dip deepens to $2.2^{+1.2}_{-0.8}\%$ corresponding to $(2.0 \pm 0.2)\sigma$ **one-sided**

$$g_R(s) = \frac{N_2(s)}{N_{POT}(s)B(s)}$$

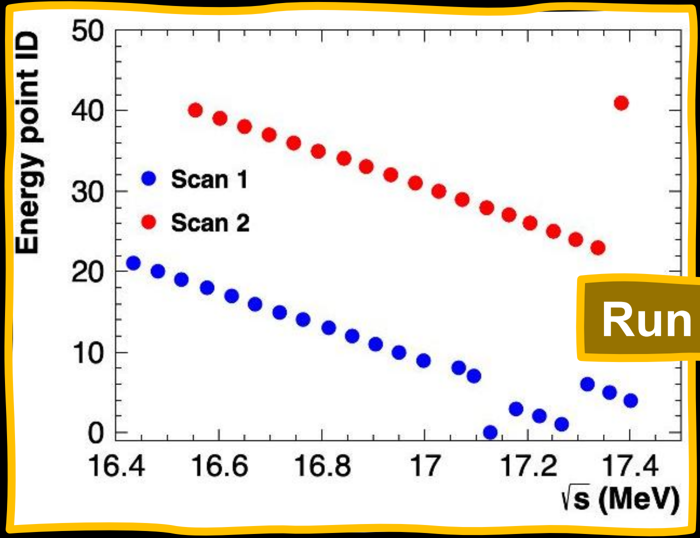


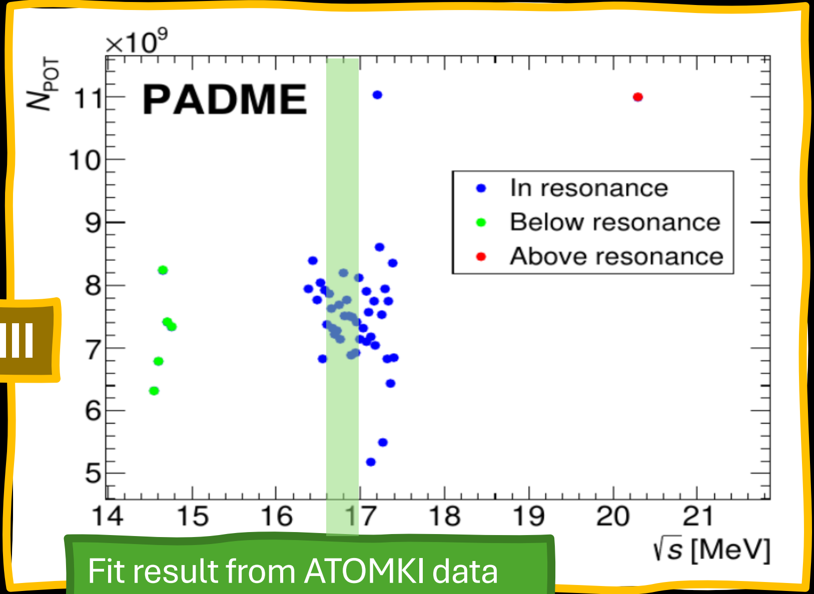
JHEP 11 (2025), 007

Source	Error [%]	
N_2 (Number of $e^+e^-/\gamma\gamma$ candidates)	0.6	Background subtraction (bremsstrahlung) + statistics
N_{POT} (Number of Positrons On Target)	0.35	Beam spread + radiation induced loss
B (Expected SM yeld of $e^+e^-/\gamma\gamma$ per PoT)	0.55	MC statistics + cluster reconstruction efficiency
Total on g_R	**0.89**	

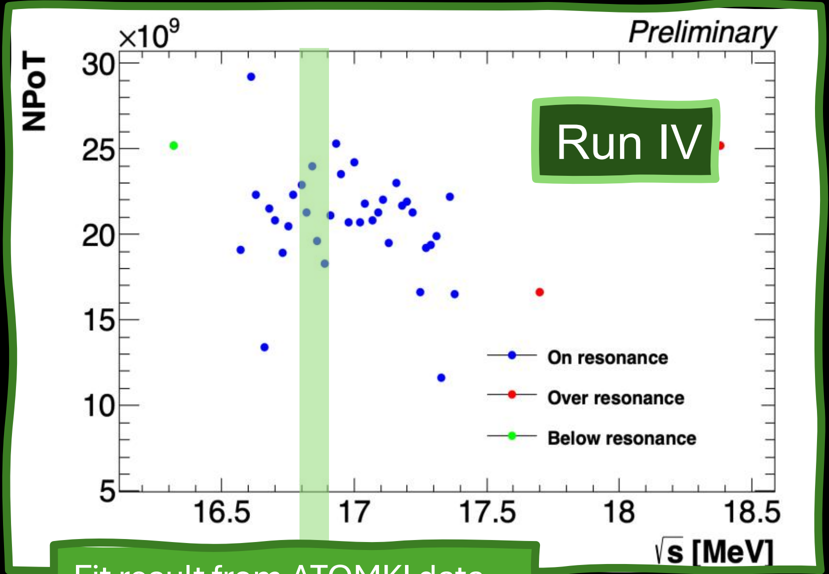
Run III VS Run IV

Run III	Run IV
42 points around resonance (Scan 1 and 2)	36 around resonance (Scan 1 and 2 – 18 points each)
$\sim 10^{10}$ PoT per on-resonance-point	$\sim 2.2 \times 10^{10}$ PoT per on-resonance-point
$263\ MeV < E_{Beam} < 292\ MeV$ and $\delta E_{Beam} \sim 0.75\ MeV$	$268\ \mathrm{MeV} < E_{Beam} < 295\ \mathrm{MeV}$ and $\delta E_{Beam} \sim 0.75\ \mathrm{MeV}$
5 points @ $268\ \mathrm{MeV} < E_{Beam} < 295\ \mathrm{MeV}$	1 point @$260\ \mathrm{MeV}$
1 point @$E_{Beam} = 402\ \mathrm{MeV}$	2 points @$300 - 330\ \mathrm{MeV}$





Fit result from ATOMKI data
Phys. Rev. D 108, 015009

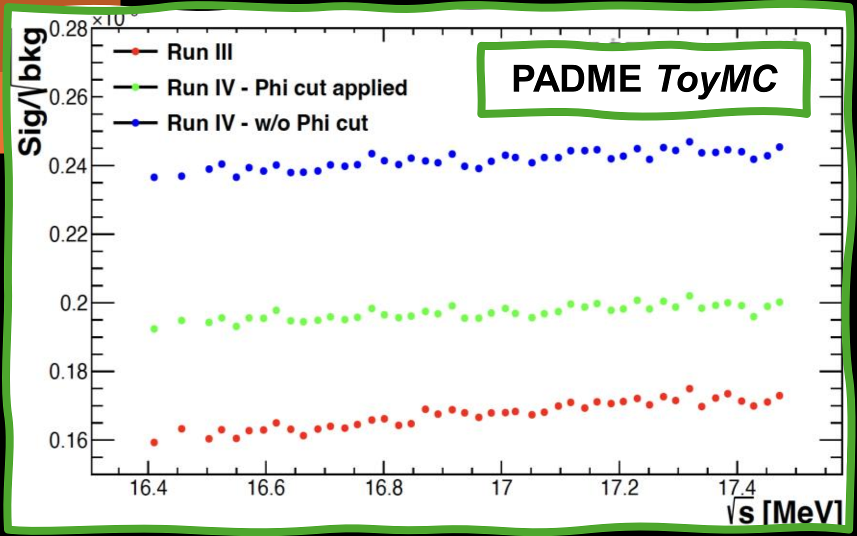


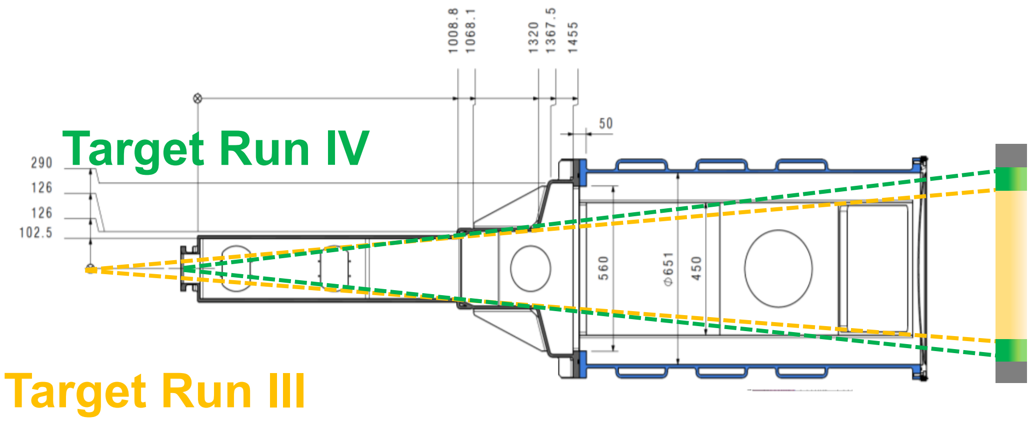
Fit result from ATOMKI data
Phys. Rev. D 108, 015009

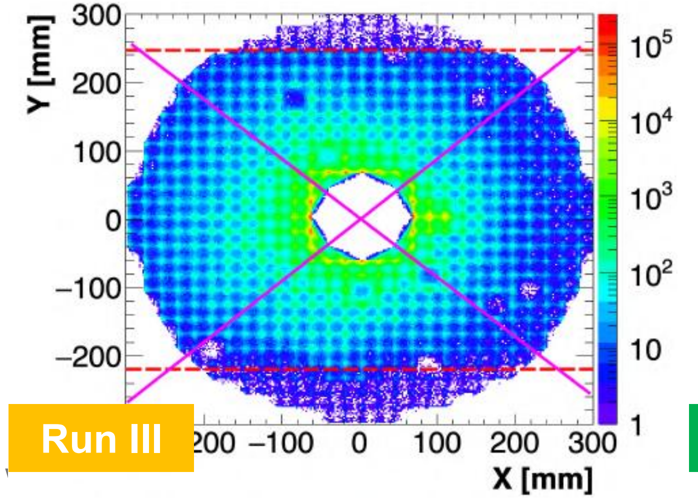
Run IV acceptance

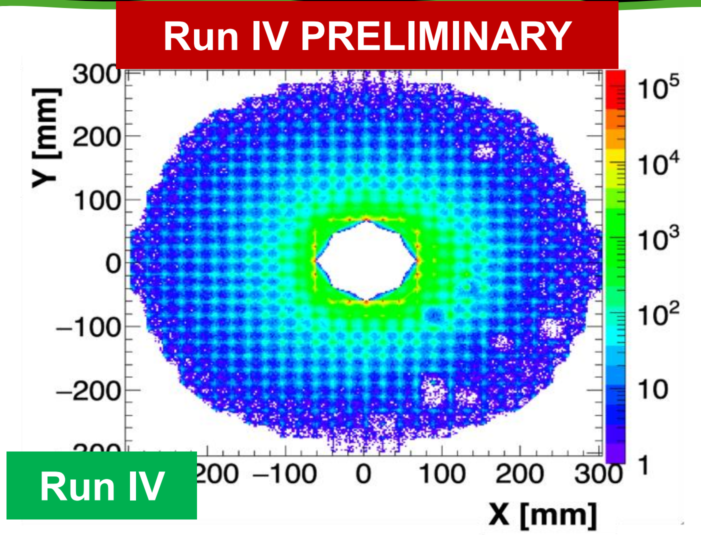
Run period	Target-ECal	θ_{lab} @ 17 MeV	R range @ 17MeV	Magnet "shadow"
Run III	3700 mm	48 – 73 mrad	177 – 270 mm	249 mm
Run IV	3360 mm	43 – 80 mrad	146 – 270 mm	268 mm

- Phi-cut can be totally removed or adapted → **uniformity in the acceptance**
- Acceptance region widened → $\frac{Sig}{\sqrt{Bkg}}$ **increases**
- Run-by-run Run IV N_2 **yield increases** by a factor of $\sim$ 2.5 wrt Run III
  - Run III data: $N_2 = 3.705 \times 10^{-6}$ (evaluated over 0.78×10^{10} PoT)
  - Run IV data: $N_2 = 9.948 \times 10^{-6}$ (evaluated over 10^{10} PoT)

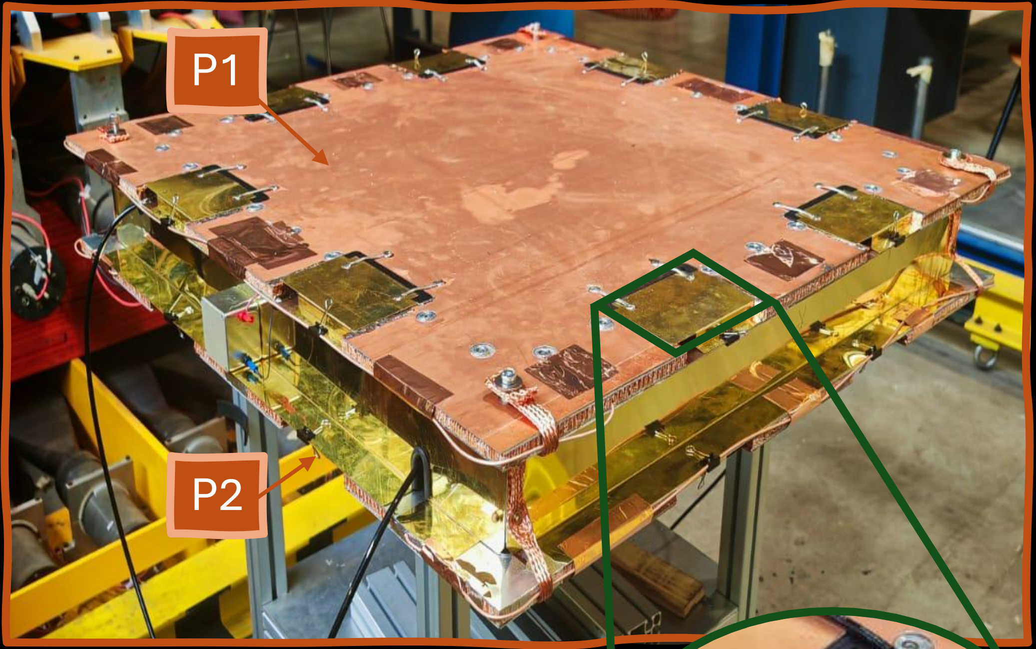




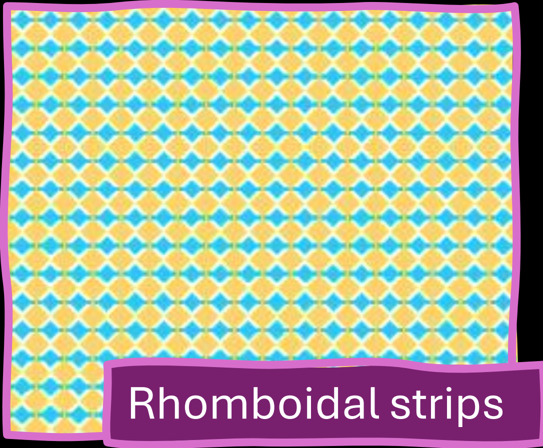




padMMe: readout features



- 512 channels for each side
  → **2048 channels for readout plane.**
- Every 128 channels read out by one **APV25 chip**
- Each APV25 is connected to the Front-End Card for event building.

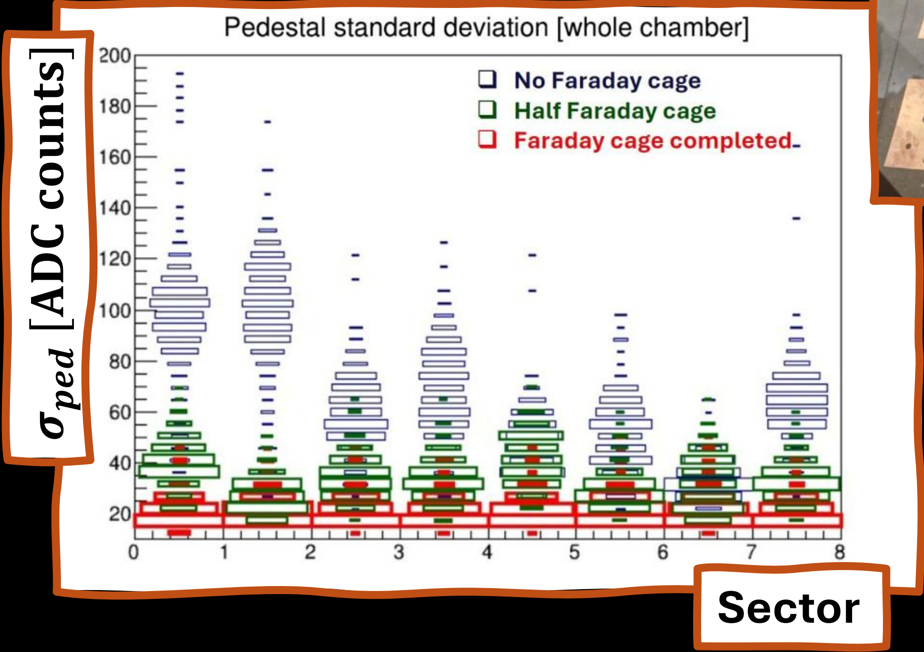


Two different segmentation layout tested:
- **straight strips**
- **rhomboidal strips**

→Same **pitch of 1.2 mm** (X, Y readout) → $\sigma_{X,Y} \sim$ **300 µm**

→Expected Z-resolution **~ 1-2 mm.**

Rhomboidal strips now in PADME



We improved the grounding and shielding of the chamber building a Faraday cage
→ **Electronic noise largely suppressed**

padMMe: HV features

Readout panel is made of **two separate PCB** glued together → hole of 7.2 mm.
Strip segmentation is adapted to have **4 quadrants** for the whole panel.

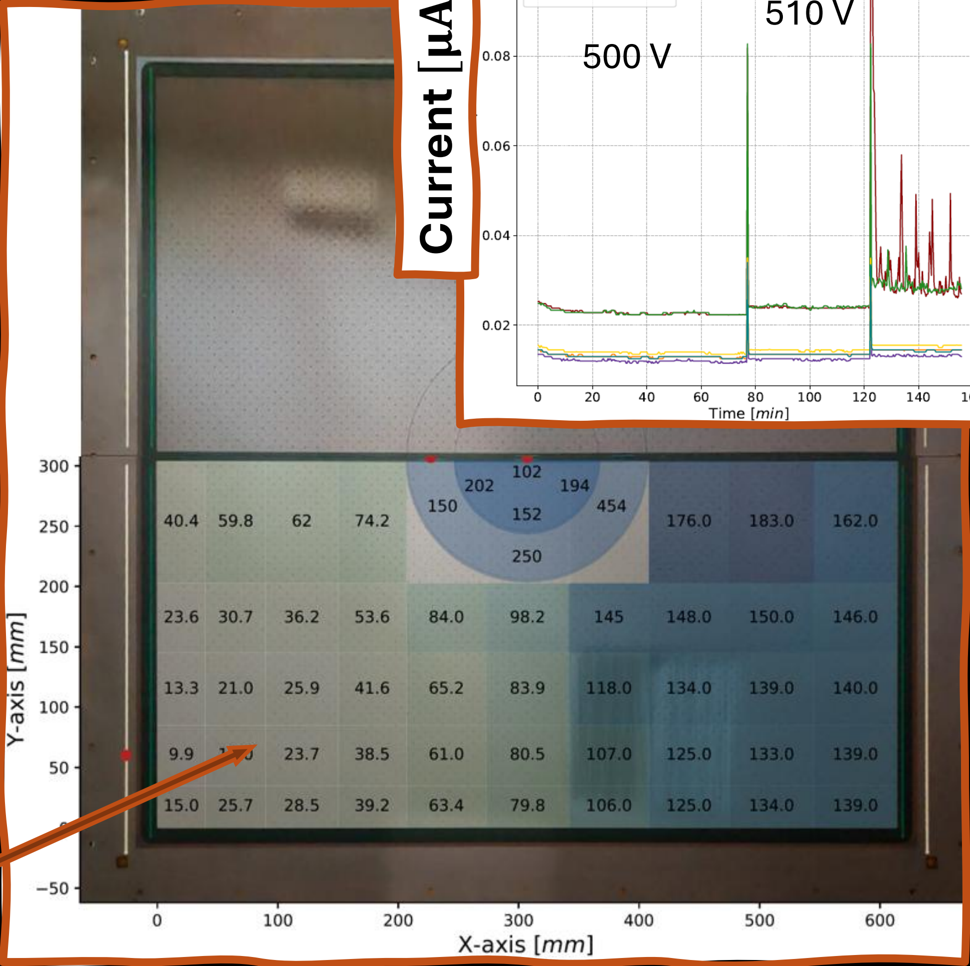
The PCBs have **separate HV regions**, to enable operation in the beam region:

- An **inner circle** (R = 6 cm) → **low gain**
- A **middle ring** (ΔR = 4 cm) → **low gain**
- An **external zone** → **gain** $\sim 10^4$

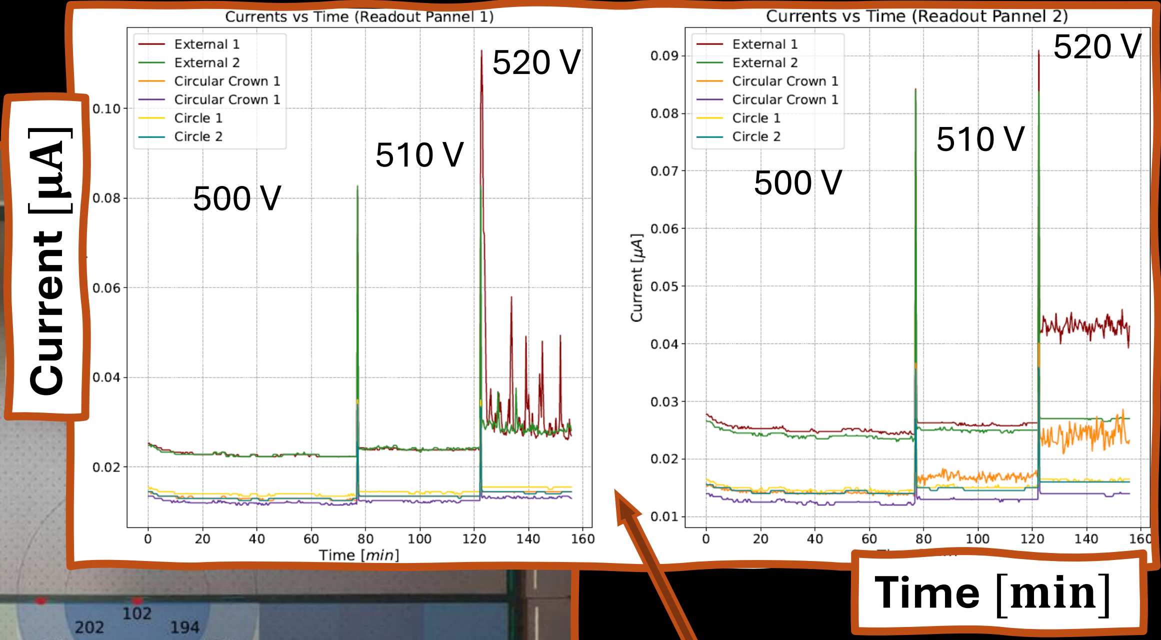
The nominal readout voltage:

- Inner circle → 350 V
- Middle ring → 350 V
- External zone → 490 V

The drift voltage is -3000 V



Resistance map [MΩ]

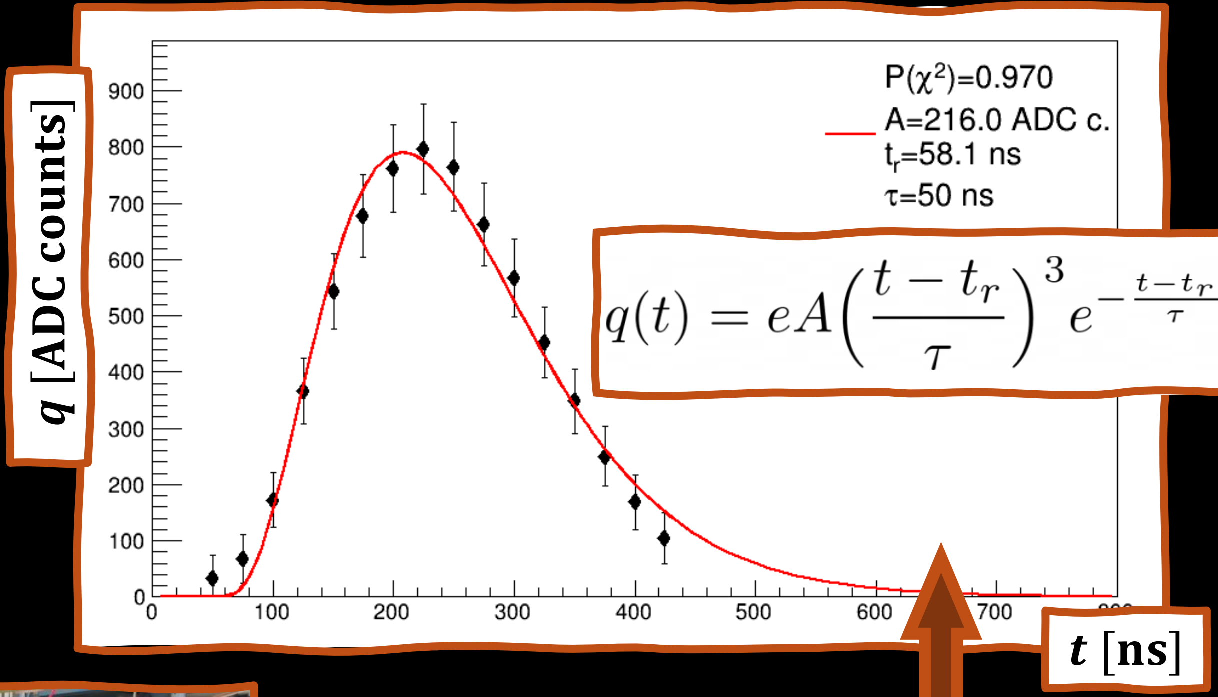


The discharges at high readout HV are reduced thanks to the resistive layer.

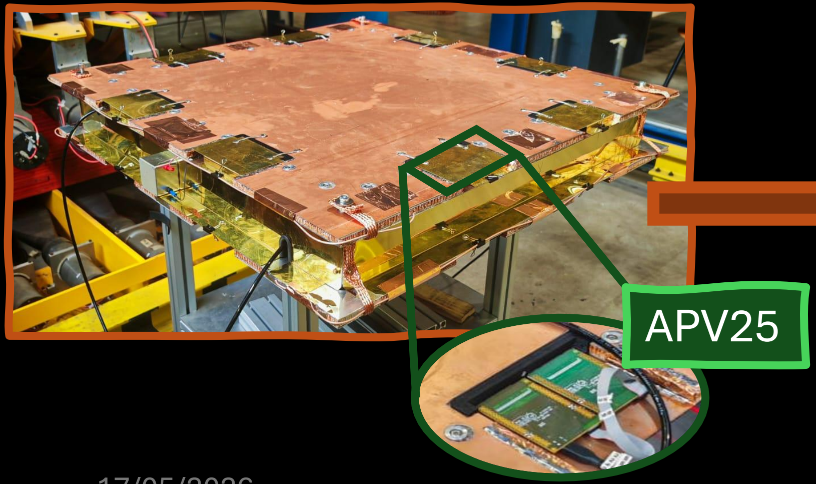
padMMe: Front End & DAQ

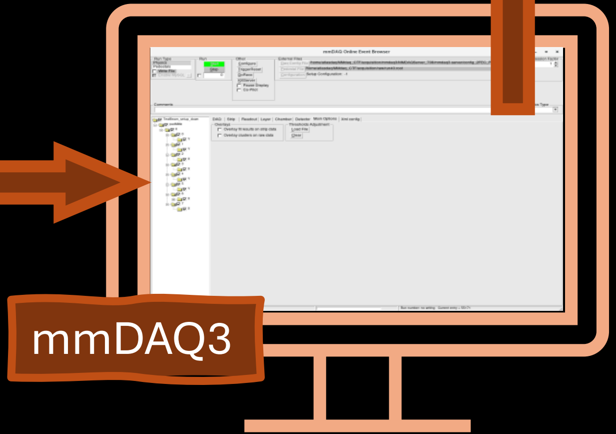
- APV25s are integrated in the Scalable Readout System which includes Front-End Cards.
- APV25 has → **200 ns charge integrator**
  → **50 ns CR-RC shaper.**
  → **Analog signal sampled at 40 MHz (25 ns).**

- **The padMMe DAQ window is 675 ns.**
- The DAQ software is mmDAQ3
  → includes online monitor feature

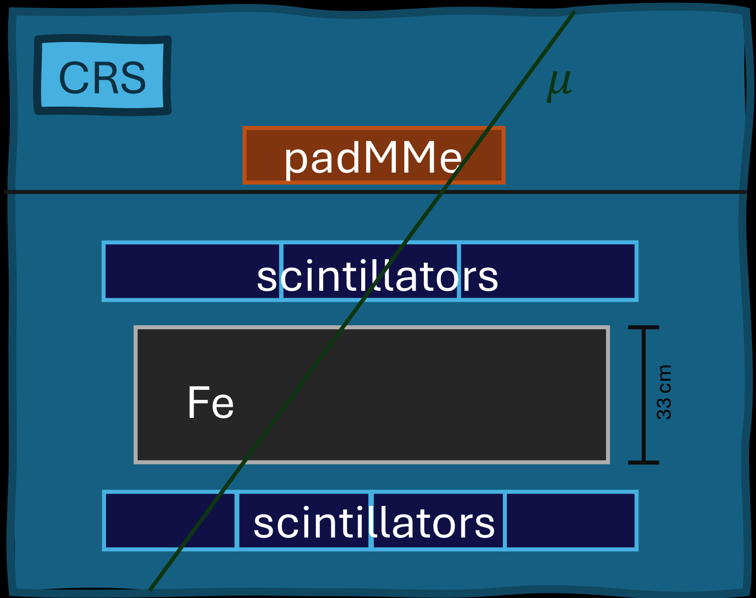


$$q(t) = eA\left(\frac{t-t_r}{\tau}\right)^3 e^{-\frac{t-t_r}{\tau}}$$



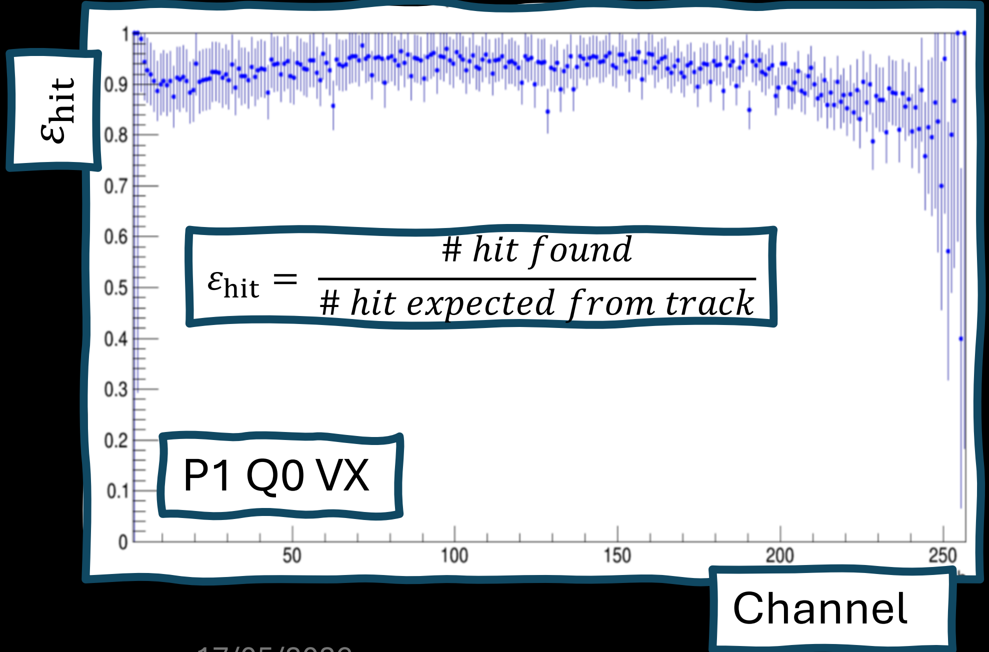


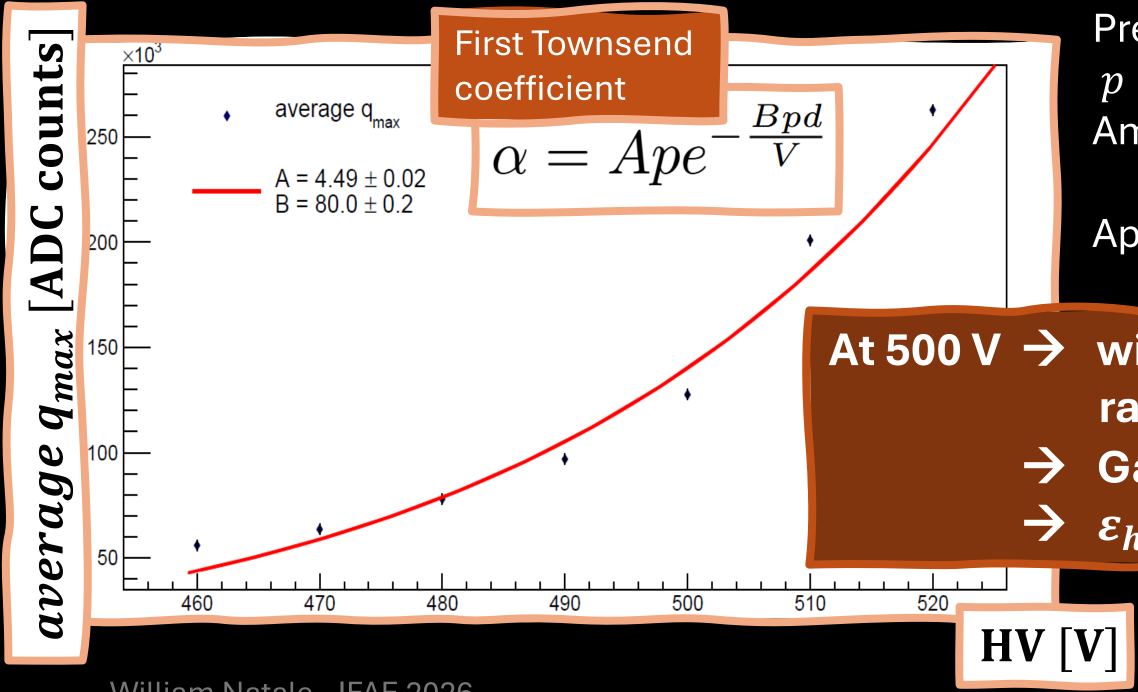
padMMe @ Cosmic Rays Stand



The padMMe was first tested and validated at the **Cosmic Rays Stand at LNF**, using cosmic rays, triggering with two sets of scintillators.

- Study **padMMe response vs readout HV**, to determine the HV work point:
  - measure of the **first Townsend coefficient** α → determination of **gain**
  - **hit efficiencies,** ε_{hit}





Pressure:
$p \sim 1\ bar * \sim 750$ mmHg
Amplification gap:
$d = 128$ μm
Applied voltage: V

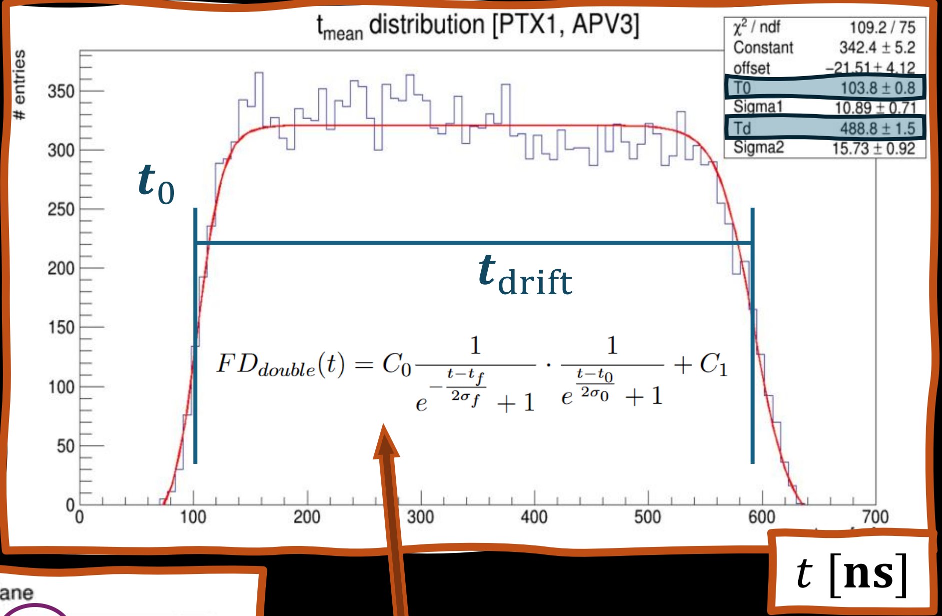
At 500 V → within ADC dinamic range
→ Gain $= e^{\alpha d} \sim 10^4$
→ $\varepsilon_{hit} \sim 90\%$

* 4 mbar overpressure

padMMe @ CRS: reconstruction

We developed a reconstruction algorithm:

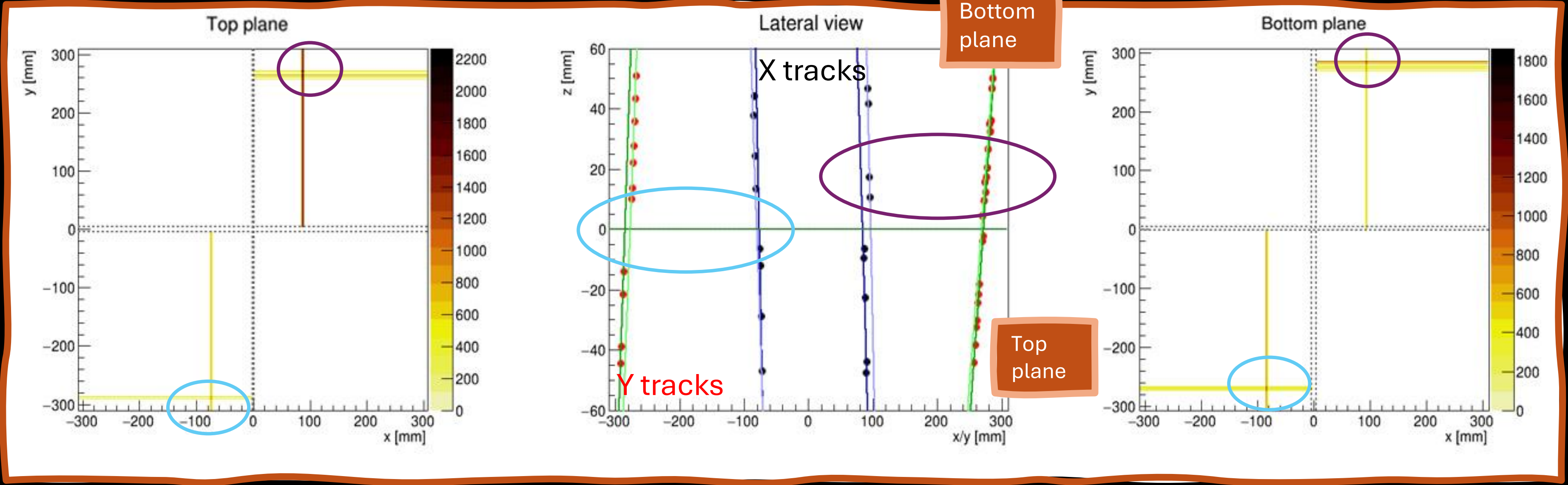
1. **Find the coordinates of the hits →** X and Y from strip position
   Z from drift time: $\boldsymbol{Z = v_{\mathrm{drift}}(t - t_0)}$
2. **Clustering the hits in track candidates** (in average 1-2 candidates with 5-6 hits, per view)
3. **Fitting each candidate to find the track parameters →** $X = \boldsymbol{m}Z + \boldsymbol{c}$
4. **Matching top and bottom planes and x-y views**



From the hit time distribution, we measured the drift velocity:

$$\boldsymbol{v_{\mathrm{drift}} = d/t_{\mathrm{drift}}}$$

$$v_{\mathrm{drift}} = 10.02 \pm 0.02\ \mathrm{cm/\mu s}$$



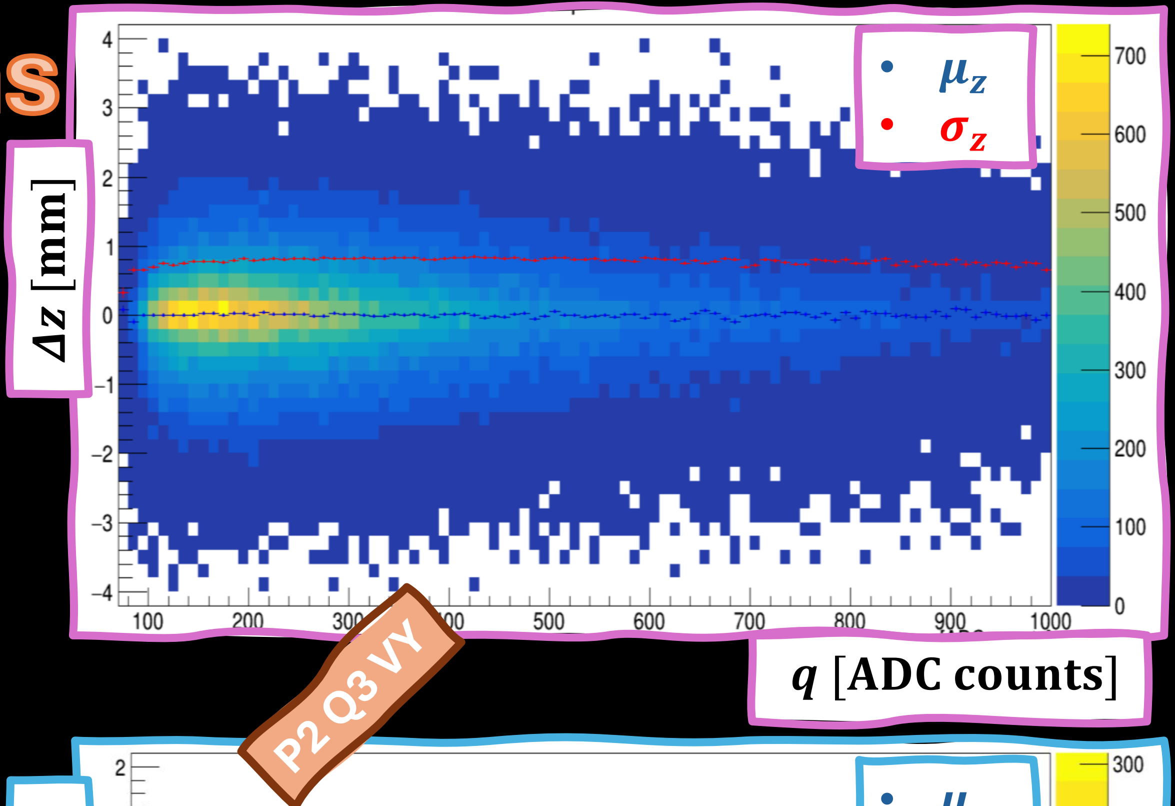
padMMe @ CRS: resolutions

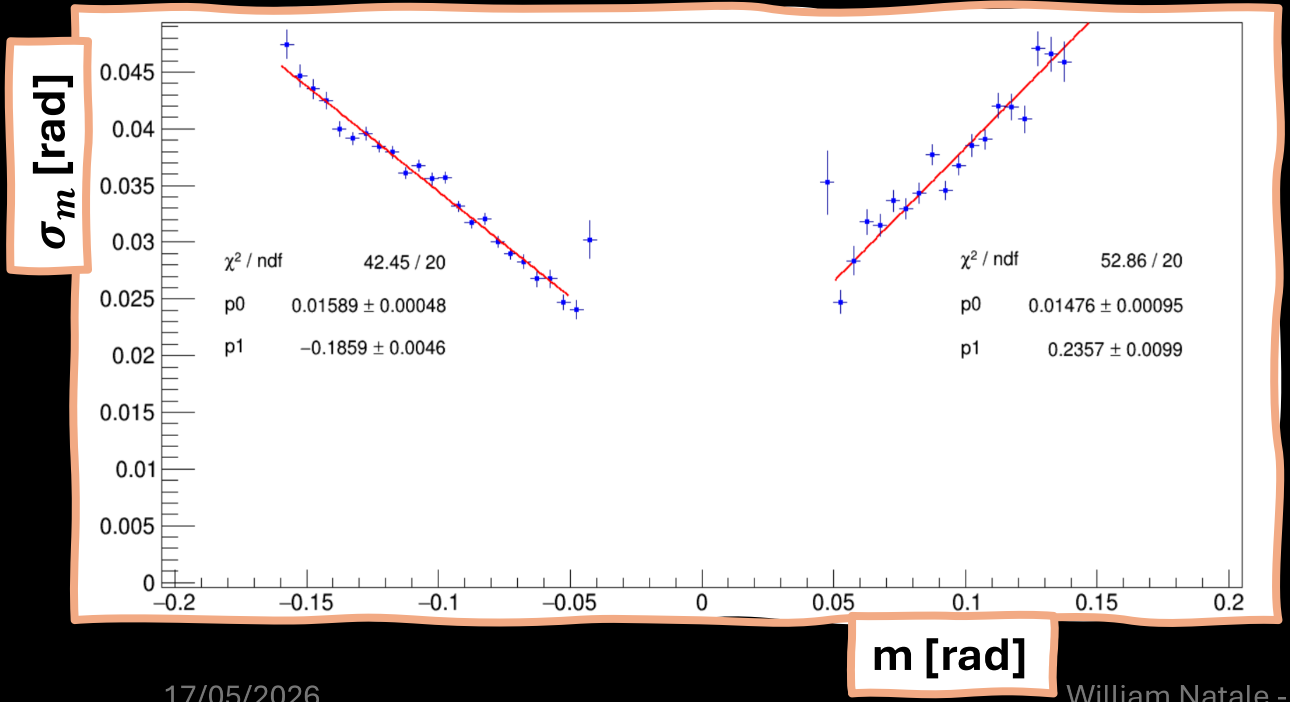
From the residues of the track reconstruction we were able to estimate the resolutions:

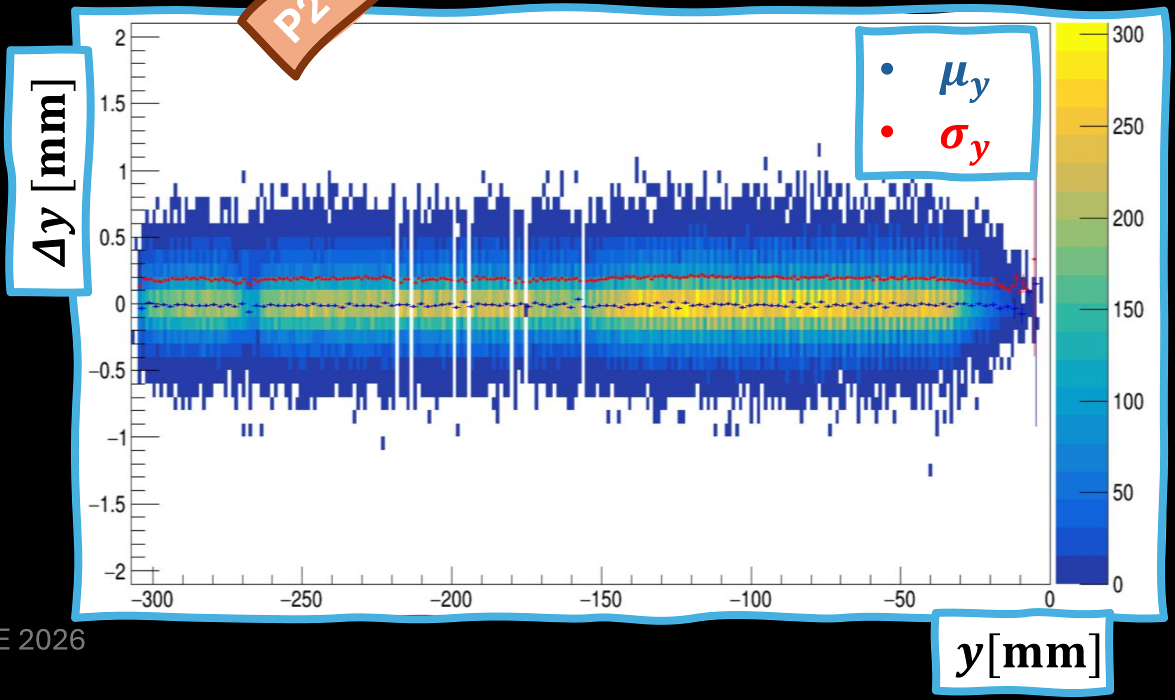
→ $\sigma_{x/y} \simeq$ 100 μm

→ $\sigma_z \simeq$ 700 μm (and constant with charge!)

→ $\sigma_\theta \simeq$ 15 mrad + 0.2 $|\theta|$







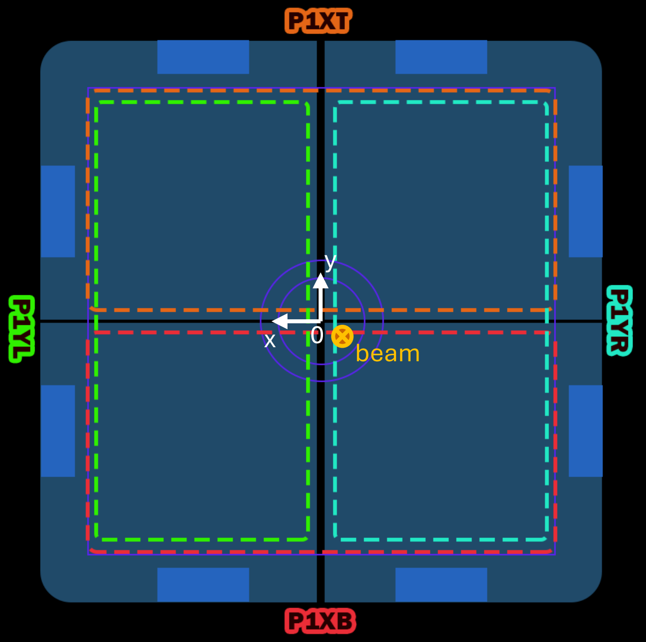
padMMe @ BTF: beam monitoring

Dedicated test runs to check beam monitoring:

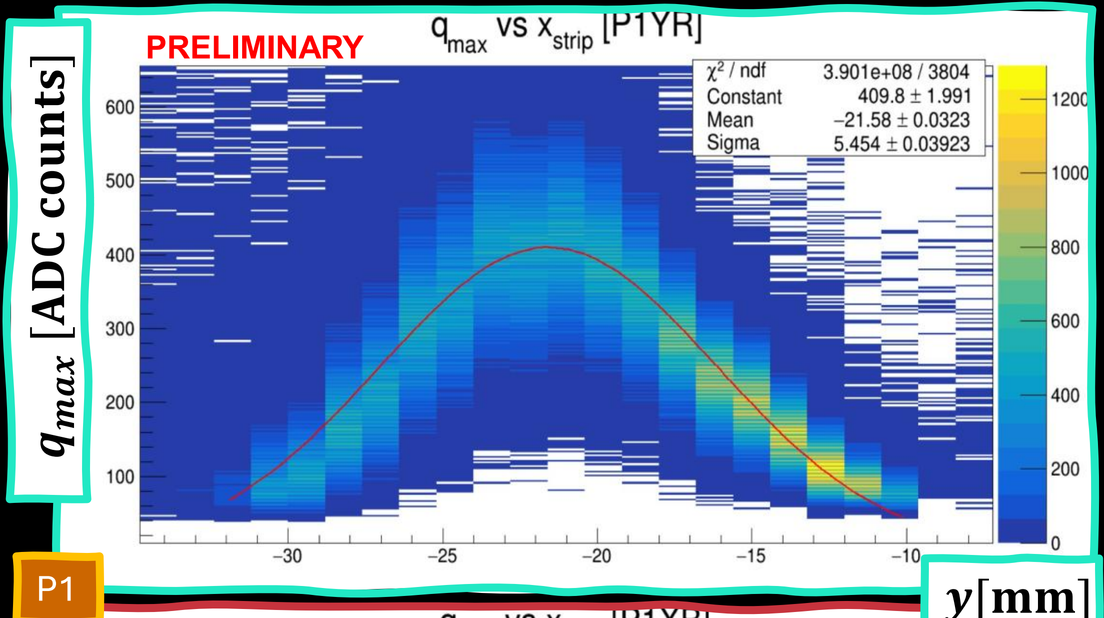
- ❖ Inner circle → ionization chamber regime
- ❖ Middle ring → ionization chamber regime

padMMe slightly off-centred to avoid the dead area of the PCB junction.

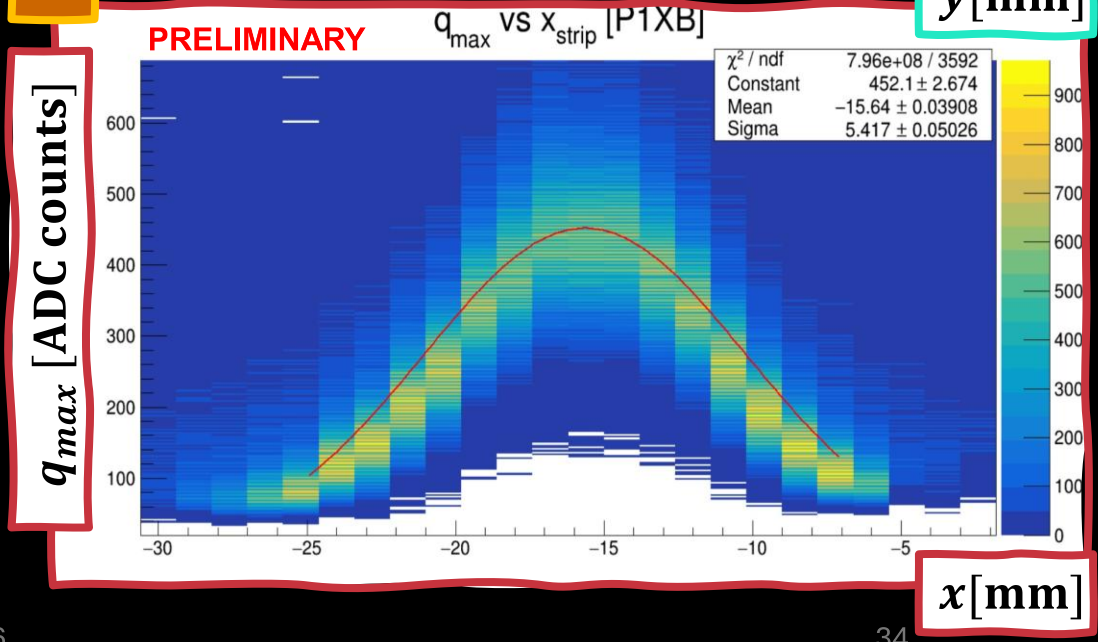
Measured beam spread: $\sim 5.4 \times 5.4\ \mathrm{mm}^2$



It's possible to evaluate beam position and spread with high precision using padMMe



P1



padMMe @ BTF: commissioning measurements

Beam spread @ padMMe with target in/out the beam line

Having the **beam spread measurement at target and at padMMe** we were able to compute:

Target Multiple Coulomb Scattering

$$\theta_{MCS}^{exp} = \frac{\sqrt{\sigma^2_{target-in} - \sigma^2_{target-out}}}{d_{target-padMMe}}$$

$$\theta_{\mathrm{MCS}}^{\mathrm{exp}} = 0.88 \pm 0.01\ \mathrm{mrad}$$

Beam divergence θ_{div} and normalized emittance ε

$$\theta_{div} = \frac{\sqrt{\left(\sigma_x^{padMMe}\right)^2 - \left(\sigma_x^{target}\right)^2}}{d_{target-padMMe}}$$

with target out!

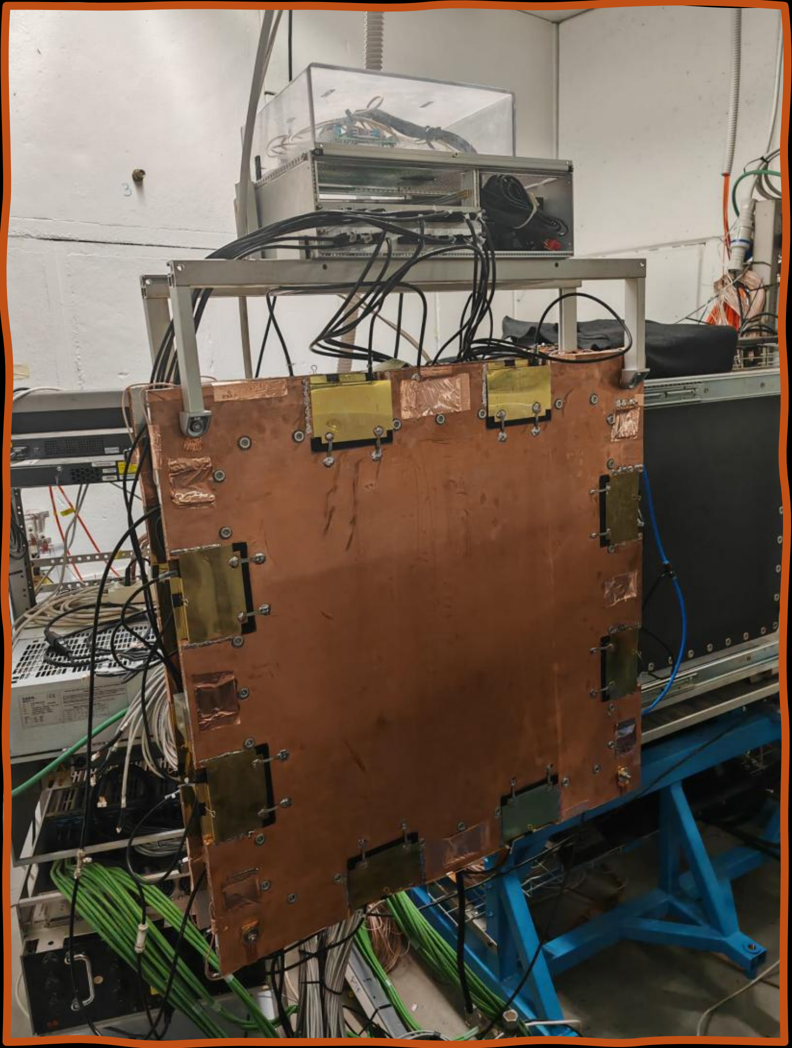
$$\theta_{\mathrm{div}} = 1.08 \pm 0.07\ \mathrm{mrad}$$

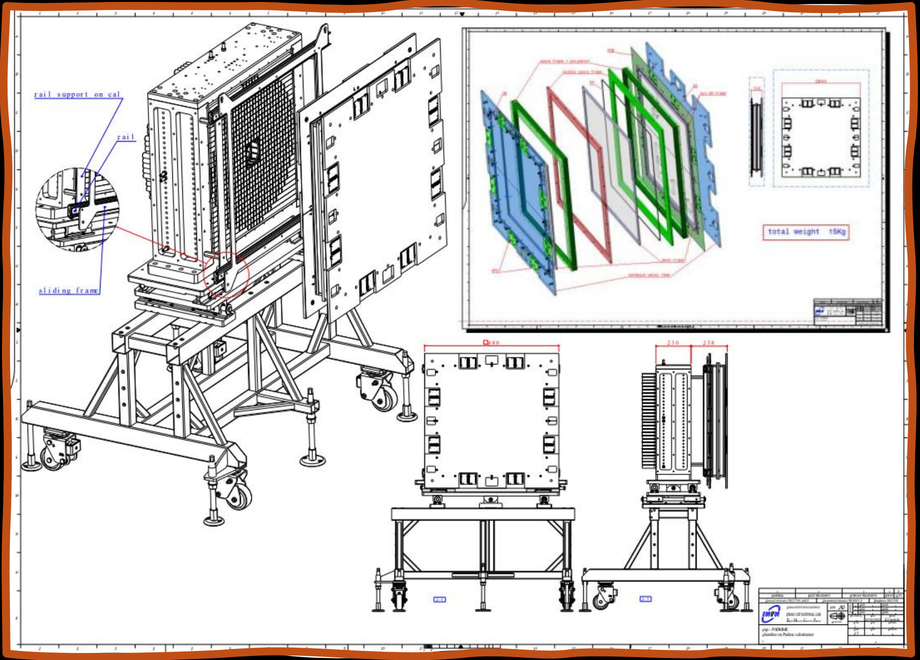
$$\varepsilon_{RMS} = \theta_{div} \cdot \sigma_x^{target}$$

$$\varepsilon = \beta\gamma\varepsilon_{RMS}$$

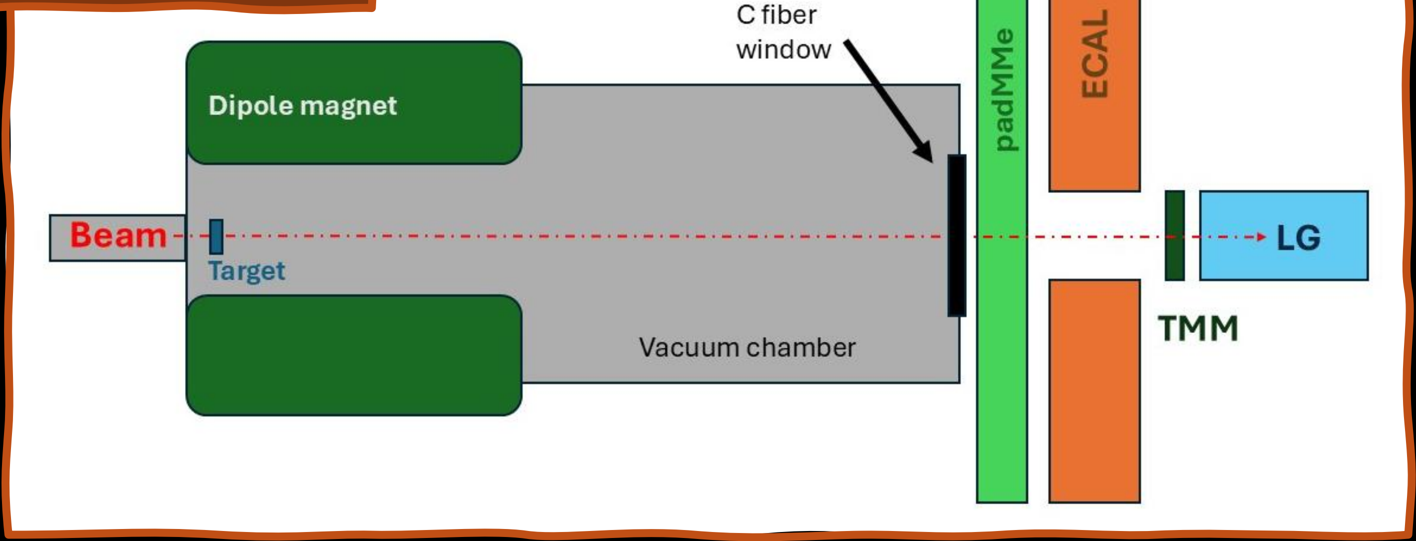
$$\varepsilon = 0.8 \pm 0.2\ \mathrm{mm\ mrad}$$

padMMe @ BTF: installation

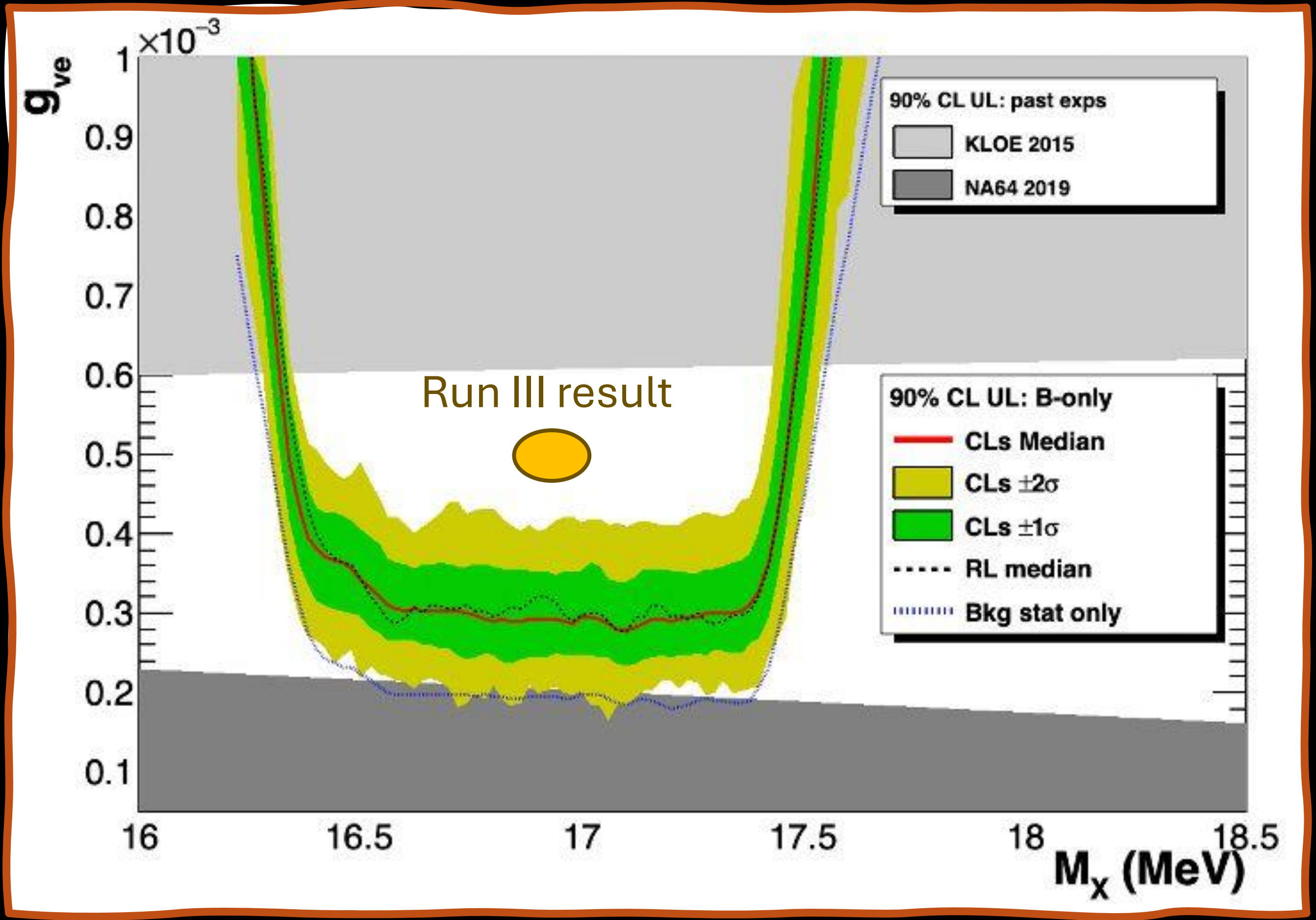




PADME Run IV layout



Run IV: prospects



This plot is obtained considering the Run III dataset but with systematic decreased.

Namely the full systematic uncertainty is lowered to 0.5%

Run IV beam monitor

- **Beam monitor at 4 different transversal planes** using different detectors
  - →Aiming at **measuring: position, angle, beam spread and beam divergence**
- **Target beam position monitor**
  - →**Beam position stable within 100-150 μm**
  - →consistently hitting the **same strip pair** $(X = 1, Y = -5)$ throughout the data taking
- **Ecal**: beam position estimated with two-cluster center of gravity