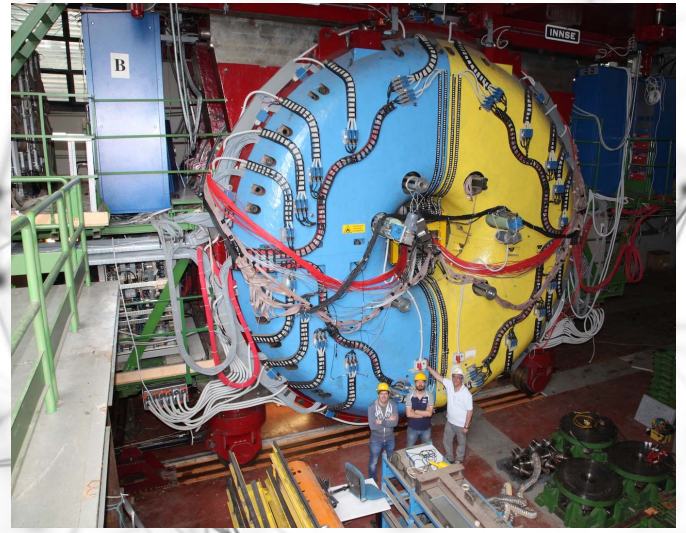
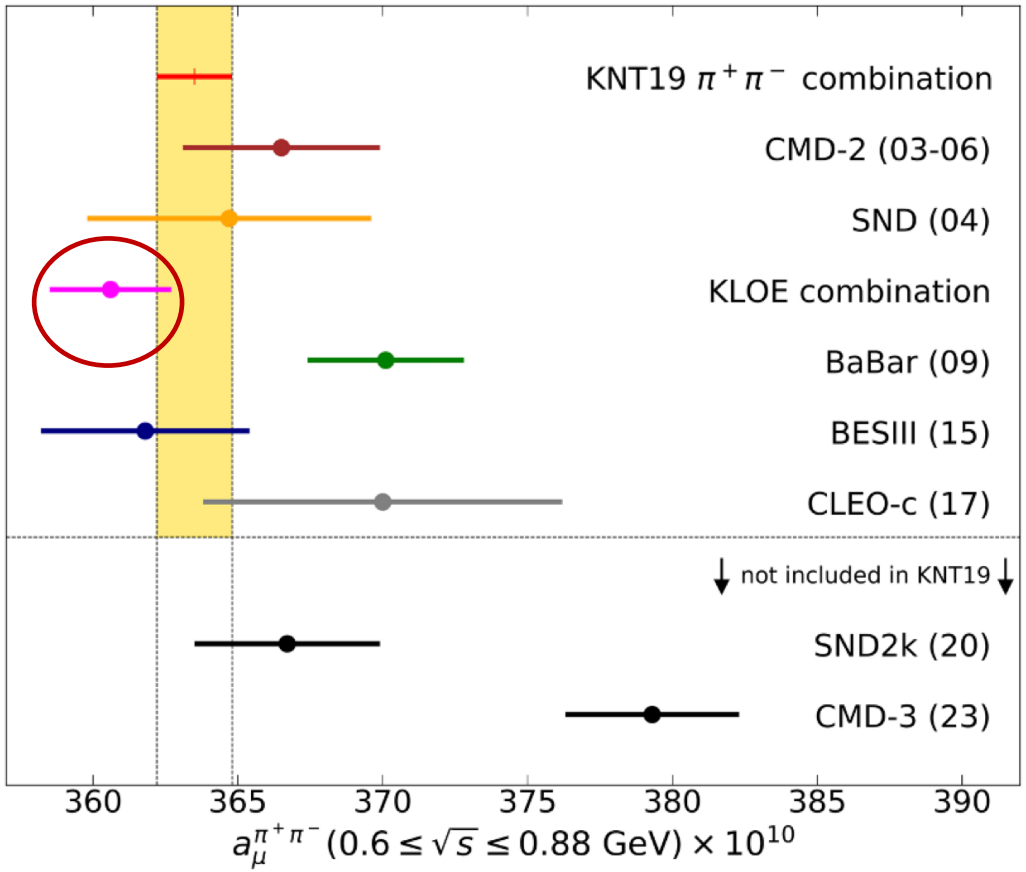
LEVERHULME TRUST

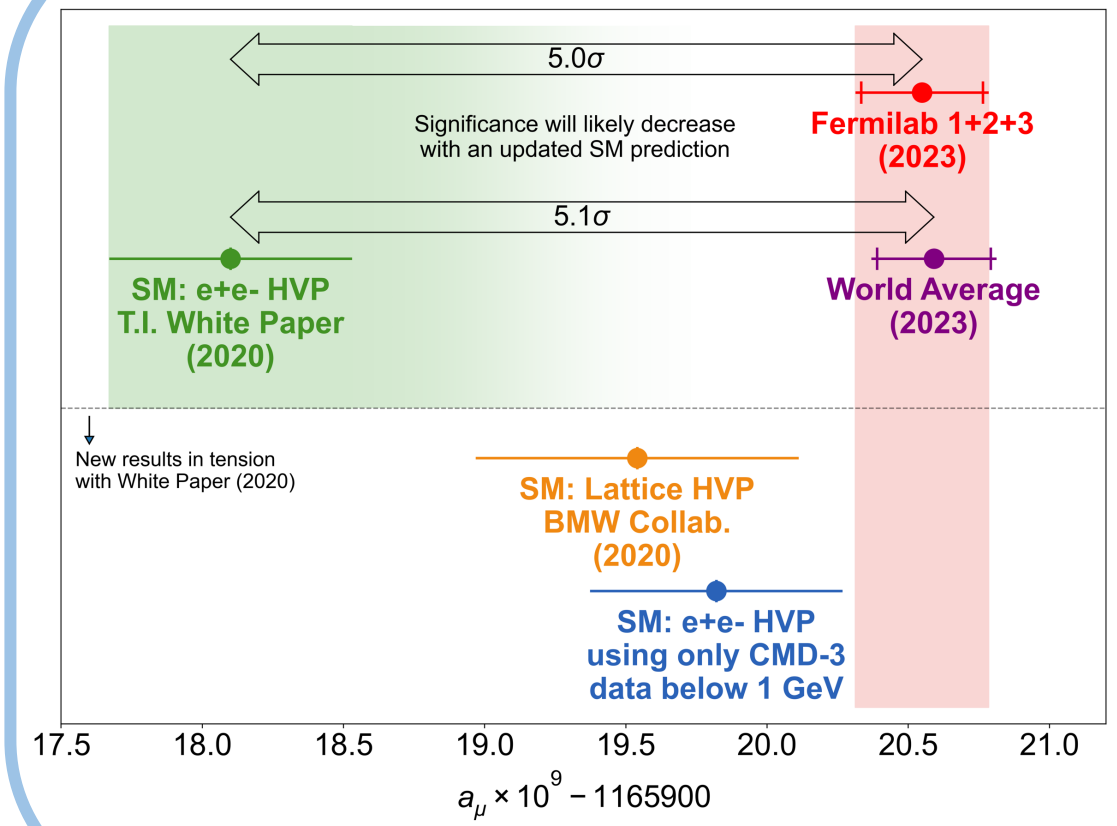


THE KLOE $\pi\pi\gamma/\mu\mu\gamma$ ANALYSIS

ESTIFA'A ZAID ON BEHALF OF THE KLOE-2 COLLABORATION, UNIVERSITY OF LIVERPOOL

THE MUON G-2 LANDSCAPE



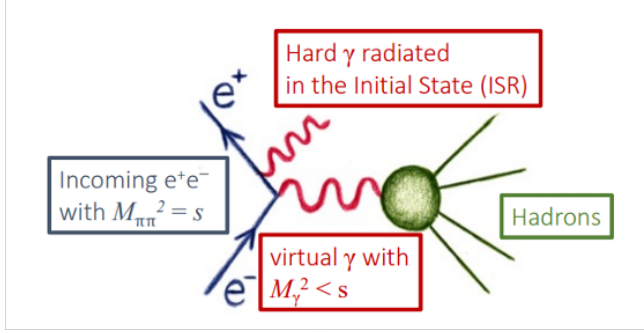


The KLOE measurements have been instrumental in shaping the current landscape of muon g-2.

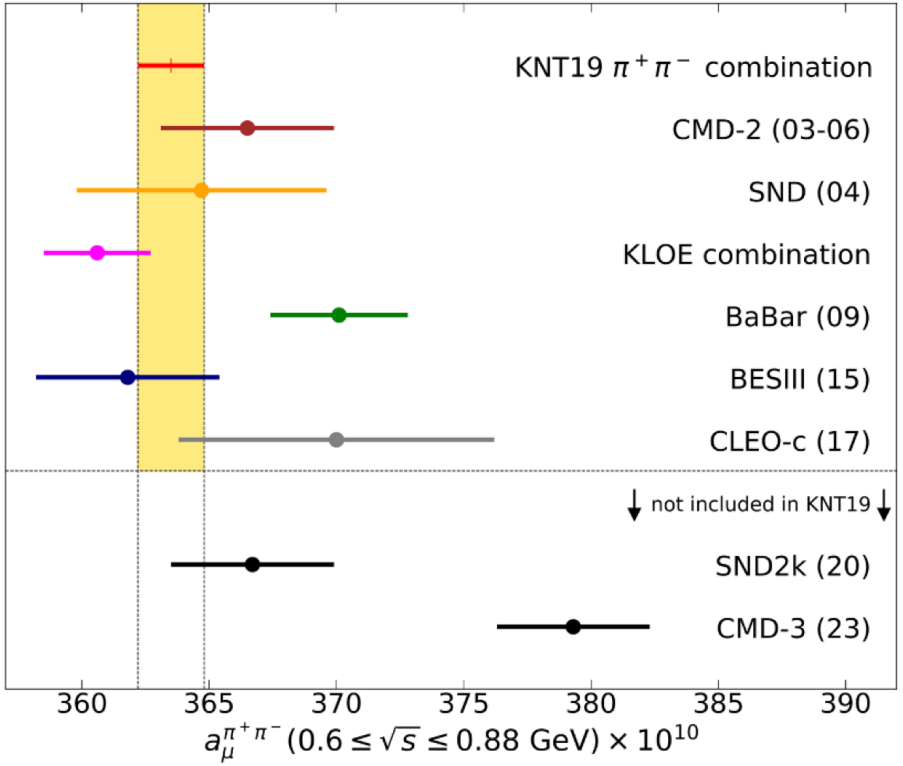
IMPORTANT: THIS PLOT IS VERY ROUGH!
- TI White Paper result has been substituted by CMD-3 only for 0.33 → 1.0 GeV.
- The NLO HVP has not been updated.
- It is purely for demonstration purposes → should not be taken as final!

THE CURRENT EFFORT

- There is a current experimental effort to **discern tensions in the dispersive approach** to determining the muon g-2 SM prediction
- The main contribution to the evaluation of the hadronic contribution to the muon anomaly (a_μ^{HLO}) is taken from the $e^+e^- \rightarrow$ hadron cross section



- A long-standing tension ($\simeq 2.8\sigma$) exists between KLOE cross section measurements and BaBar
- The new CMD-3 $e^+e^- \rightarrow \pi^+\pi^-$ cross section measurement is in tension with both BaBar ($\simeq 2.3\sigma$) and KLOE ($\simeq 5.1\sigma$)
- Combined theoretical prediction for the dispersive approach is limited by tensions between KLOE and BaBar measurements. Even without including CMD-3



THE CURRENT EFFORT

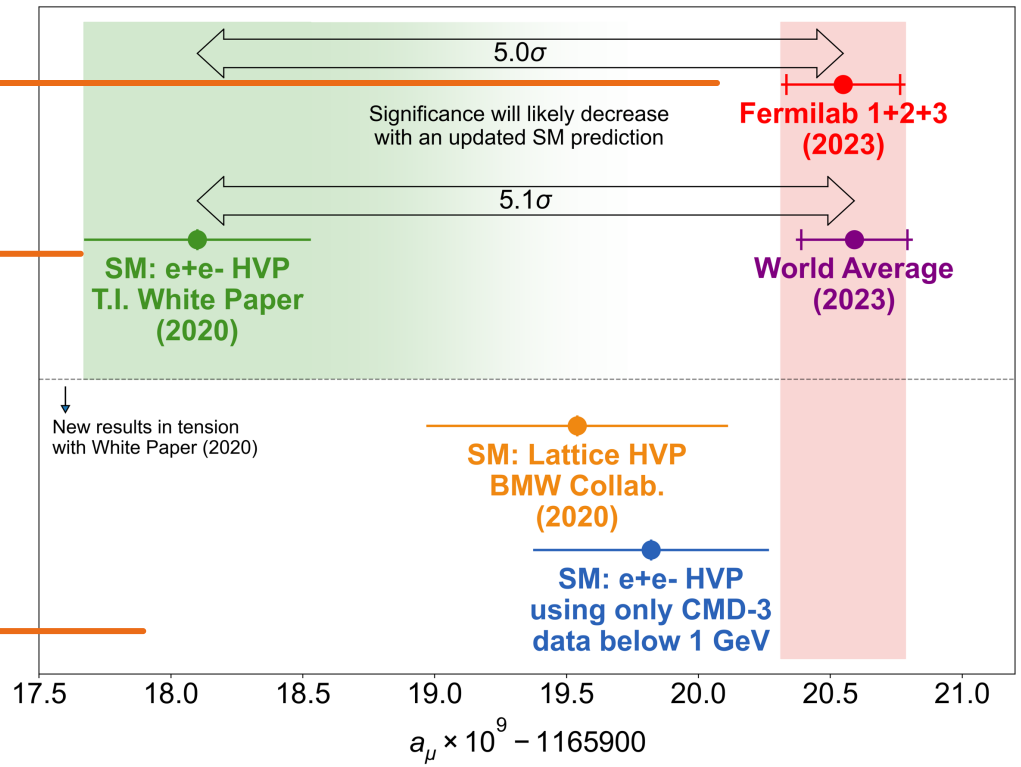
The Leverhulme Trust grant which was awarded to Graziano Venanzoni in 2022 has funded a large group in Liverpool (12 postdocs and 8 PhD students) with the aim of clarifying the muon g-2 puzzle.

LEVERHULME TRUST

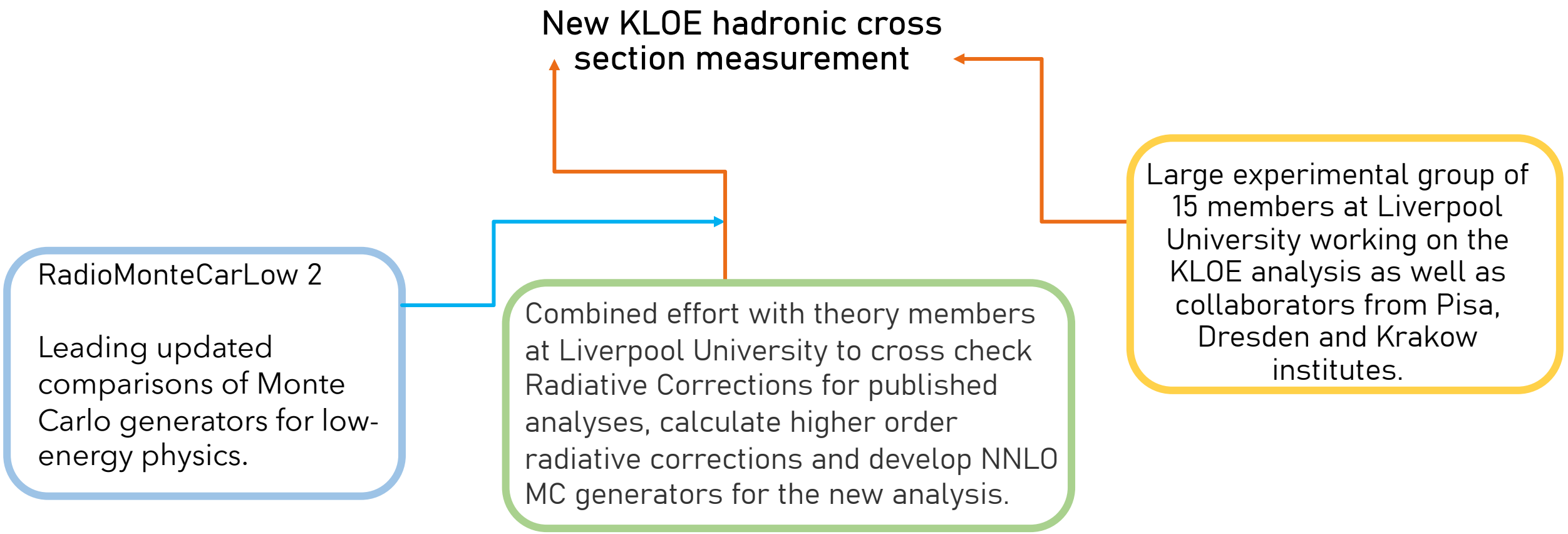
Muon g-2 Experiment at Fermilab Run 4+5+6

New KLOE hadronic cross section measurement

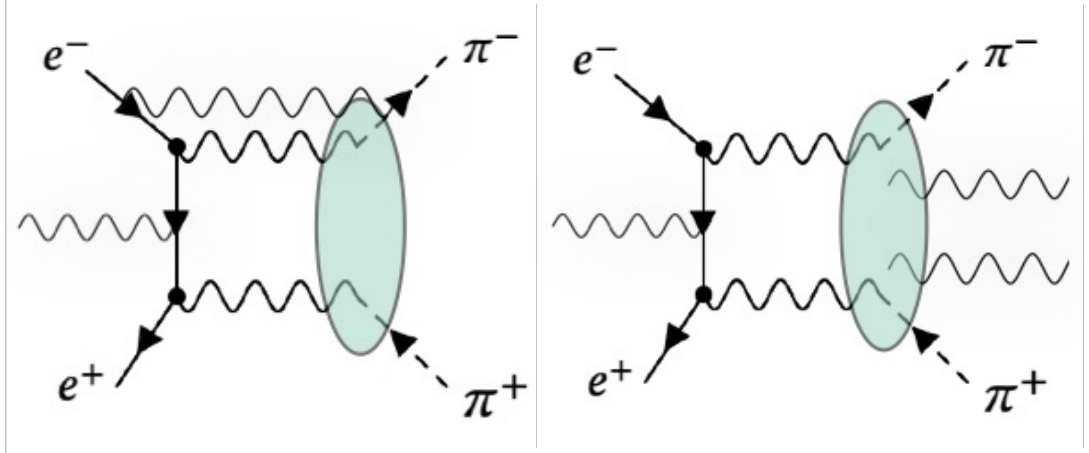
MUonE experiment: a new approach to determining a_μ^{HLO}



THE CURRENT EFFORT



THEORETICAL SUPPORT FOR THE KLOE EXPERIMENT



- Main focus on radiative return processes, $e^+e^- \rightarrow \pi^+\pi^-\gamma$ and $e^+e^- \rightarrow \mu^+\mu^-\gamma$
- Next-to leading (NLO) theoretical predictions currently available
- We are now improving these predictions:
  - Make use of soft-QED approximation
  - Improved theoretical precision to match KLOE-2 data needs

Why Low-Energy Physics, Why Now?

•Renewed interest in low-energy e^+e^- annihilation as a probe of hadronic effects

•Two Physical Review Letters publications highlight recent theoretical advances (including one from our group).

Phys.Rev.Lett. 128 (2022) 2, 022002,
Phys.Rev.Lett. 132 (2024) 23, 231904

Visibility, impact, and the need for support

•Our work is visible: two talks accepted at EPS-HEP 2025

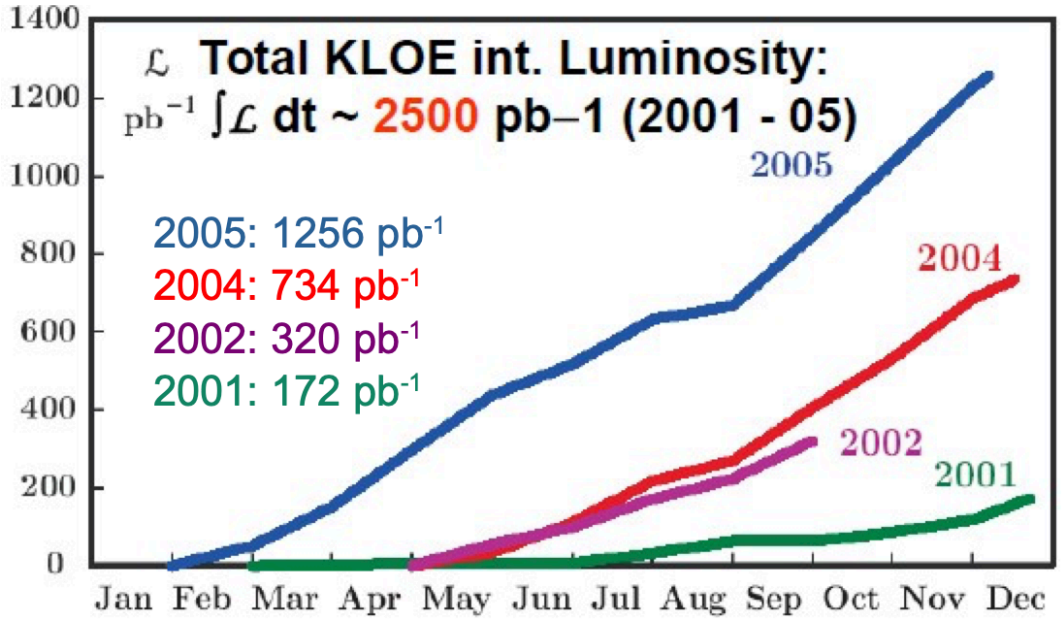
•Precision improvements demand high-performance computing:

- •NNLO theoretical predictions will shed light on analysis of KLOE-next data
- •Tuning of Monte Carlo predictions

•Supporting this request means supporting cutting-edge theoretical input for hadronic physics

CURRENT KLOE HADRONIC CROSS SECTION ANALYSIS

- **Previous KLOE analyses were done on 240 pb^{-1} (~ 3.5 million $\pi\pi\gamma$ events) of data taken in 2002 and 232 pb^{-1} from 2006**



- This ongoing analysis aims to use **2004/2005 KLOE data** to carry out a new measurement. The ~1.7 fb^{-1} includes **~ 25 million $\pi\pi\gamma$ events** which have **never been used** before in such an analysis. 2006 off-peak data will be used for additional cross checks and systematic studies

CURRENT KLOE HADRONIC CROSS SECTION ANALYSIS

Syst Errors (%)	KLOE12 $a_\mu^{\pi\pi}$ ratio	KLOE-next (expected) $a_\mu^{\pi\pi}$ ratio
Background Filter (FILFO)	negligible	negligible
Background Subtraction	0.6	0.2
Trackmass	0.2	0.2
Particle ID	negligible	negligible
Tracking	0.1	0.1
Trigger	0.1	0.1
Unfolding	negligible	negligible
Acceptance ($\theta_{\pi\pi}$)	negligible	negligible
Acceptance (θ_π)	negligible	negligible
Software Trigger (L3)	0.1	0.1
Luminosity	-	-
$\sqrt{s}$ dep. of H	-	-
Total exp. systematics	0.7	0.3
Vacuum Polarisation	-	-
FSR treatment	0.2	0.2
Rad. function H	-	-
Total theory systematics	0.2	0.2
Total systematic error	0.7	0.4

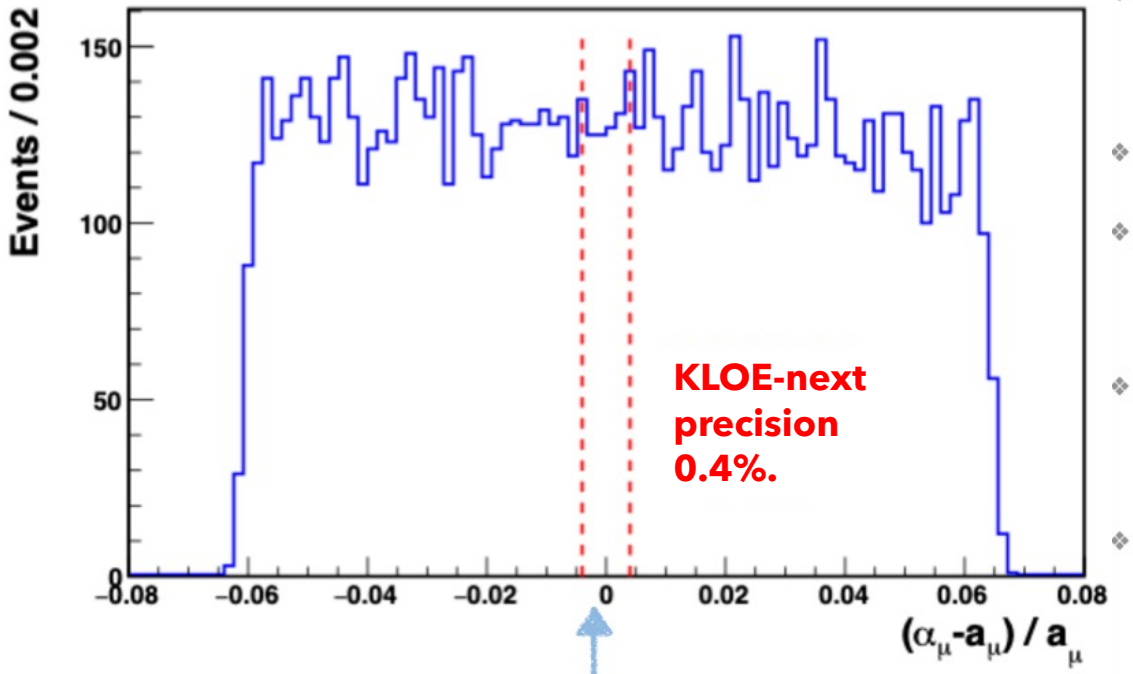
- Analysis group is tackling different aspects using new techniques with the intention of reducing the larger systematic uncertainties.

KLOE12: $0.3\%_{stat} \oplus 0.2\%_{th} \oplus 0.7\%_{syst} \Rightarrow \sim 0.8\%_{tot}$

KLOE-next$_{(goal)}$: $0.1\%_{stat} \oplus 0.2\%_{th} \oplus 0.3\%_{syst} \Rightarrow \sim 0.4\%_{tot}$

- There will be a factor 7 statistical improvement making the statistical uncertainty negligible wrt systematics.
- There will be dedicated work on the background. subtraction procedure to achieve a **x3 reduction of the background subtraction uncertainty**.

A BLINDED ANALYSIS



Blinded value of a_μ is $\pm 6\%$ with respect to true value in simulations. Blinded offset is much larger than KLOE-next precision

Blinding procedure has been documented and undergone an internal review process.

- The new KLOE analysis will be **conducted blindly** to ensure good practice and avoid bias throughout.
- This is not a trivial task and is the **first KLOE a_μ^{HLO} analysis to be blinded.**
- The aim of blinding is to shift the result of the analysis by a small amount without jeopardising the distributions of data and Monte Carlo.
- Two sets of root-tuples will be used in this analysis; **blinded and working (unblinded) root-tuples.**
- For the blinded root-tuples, proposed procedure is as follows:
  - **Removing a small, unknown (to the analysers) fraction of events from each $Q^2_{\pi\pi}$ or $Q^2_{\mu\mu}$ slice in data.**
  - This modifies the measured differential cross section and thus $a_{\pi\pi} \propto \int ds \ldots \sigma_{\pi\pi}(s)$ whilst having no affect on distributions at fixed Q^2 bins.
- Efficiencies are calculated on the working root-tuples ($|F_\pi|^2$ not accessible here).
- **Extraction of $|F_\pi|^2$ is done only on blinded root-tuples.**

KLOE23 timeline

Similar schedule for muons, Bhabha and theory, too

Unblinding by ~end 2025, expected by international theoretical community

	Schedule in November 2024	Month/Ye					
		11/24	12/24	01/25	02/25	03/25	
Binning							
Blinding	Define procedure						
	Produce samples blinding root-tuples						
FILFO + L3	Disable FILFO filter but keep info						
Data Quality							
Linux	Linux development						
GEANT	GEANT3 studies + GEANT4 dev						
Colinear	Measurement of Assymmetry and Form Factor						
Radiative	Measurement of Assymmetry						
Bkg substraction	BDT - instead of Mtrk cut + other bkg						
	add other variables to the bkg fitting						
	use sigma_mtrk cut to clean the sample						
	Kinematic fit ? - Peter Lukin OR other methods						
	Different Mtrk cuts or none (e.g. fit instead)						
	different radiative correction generators						
PID algorithm	Develop PID algorithms						
Data MC tuning	pos - neg tracks (s-t relations)						
	Data MC comparisons						
Tracking	Reproduce old result						
	Develop selection cuts + PID						
Trigger							
Unshifting							
Unfolding							
Documentation	Baseline performance						
	10% unblinding approval						
	Publication						

Main analysis areas are stalled due to the old tape library being down.

It is important for the scientific impact of this result that we keep to the timeline.

To achieve this goal, we have a clear roadmap detailing what we will need to do once we have data and have allocated the person power needed.

But .. we need access to data as a matter of urgency and to ensure that the tape library stays up and running.

THANK YOU VERY MUCH

WE LOOK FORWARD TO SUPPORT
FROM THE LABORATORY