世界范围内的缪子散射、打靶实验

- 缪子作为第二代轻子，对其研究及应用相对较少，其科学和应用潜力巨大。

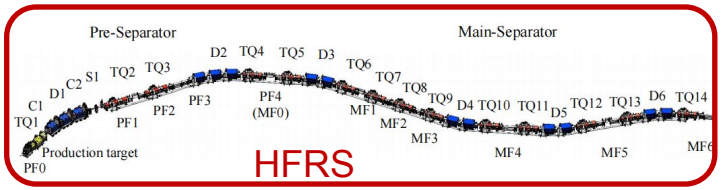
- NA64 和MUonE等实验利用高能缪子(150～160GeV)与靶散射
- 缪子散射蕴含大量的物理课题有待挖掘
  - **不同能量的缪子束流可以对不同的新物理空 间具有敏感性。**

- 中国之前没有开展的缪子物理实验。近年来条件有了很大变化:
  - 中国散裂中子源的100kW，1.6GeV质子加速器已经建成，升级启动中；
  - 国家“十二五”重大科学工程项目“强流加速器装置(HIAF)”正在建设重离子加速器；
    - **2025年验收，第一条中国高能 (GeV)缪子束流？ 机遇！**
  - “十四五”启动建设的“加速器驱动嬗变系统(CiADS)” 拟建设连续流直线质子加速器；
  - 中国原子能科学研究院正在大力推动高功率质子回旋加速器的建设

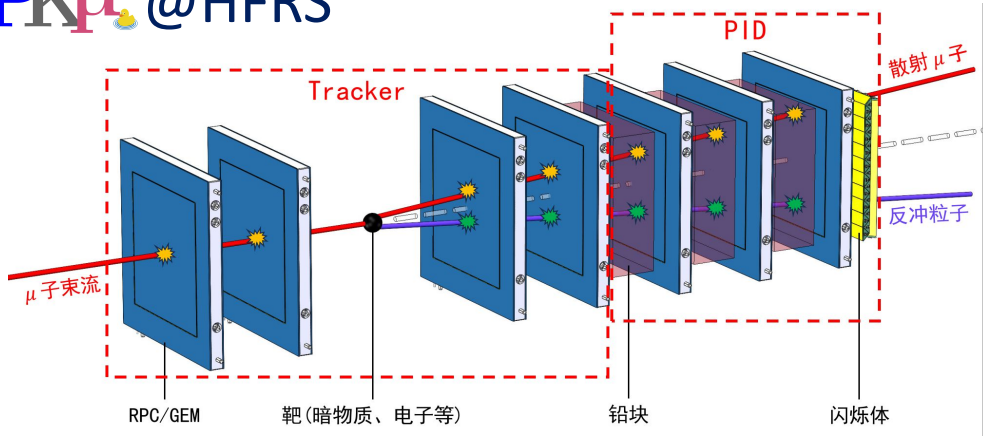
基于HIAF-HFRS装置的缪子散射实验

PKMu(Probing and Knocking with Muons)：由**北京大学**物理学院技术物理系、核物理与核技术全国重点实验室原创提出的的缪子散射实验合作项目，旨在结合缪子散射成像技术与前沿物理研究，通过对缪子散射的测量研究核物理、标准模型和超出标准模型的新物理，如暗物质和暗玻色子探寻、量子纠缠探测、缪子与核散射规律的研究等。

HFRS：**中国科学院近代物理研究所**建设的强流重离子加速器(HIAF)可加速从质子到铀的重离子，可提供高达 10^{11}/s 的高能离子束流。放射性次级束流分离器(HFRS)是 HIAF 上的重要装置，HFRS 束线长 192 米，磁刚度最大 25 Tm，可传输动量高达 7.5 GeV/c 的π/μ粒子。研究表明，基于HIAF-HFRS装置，可获得流强可达 10^6–10^7/s 的GeV能量缪子束流，动量展宽约 4%，束斑直径约 10 cm。



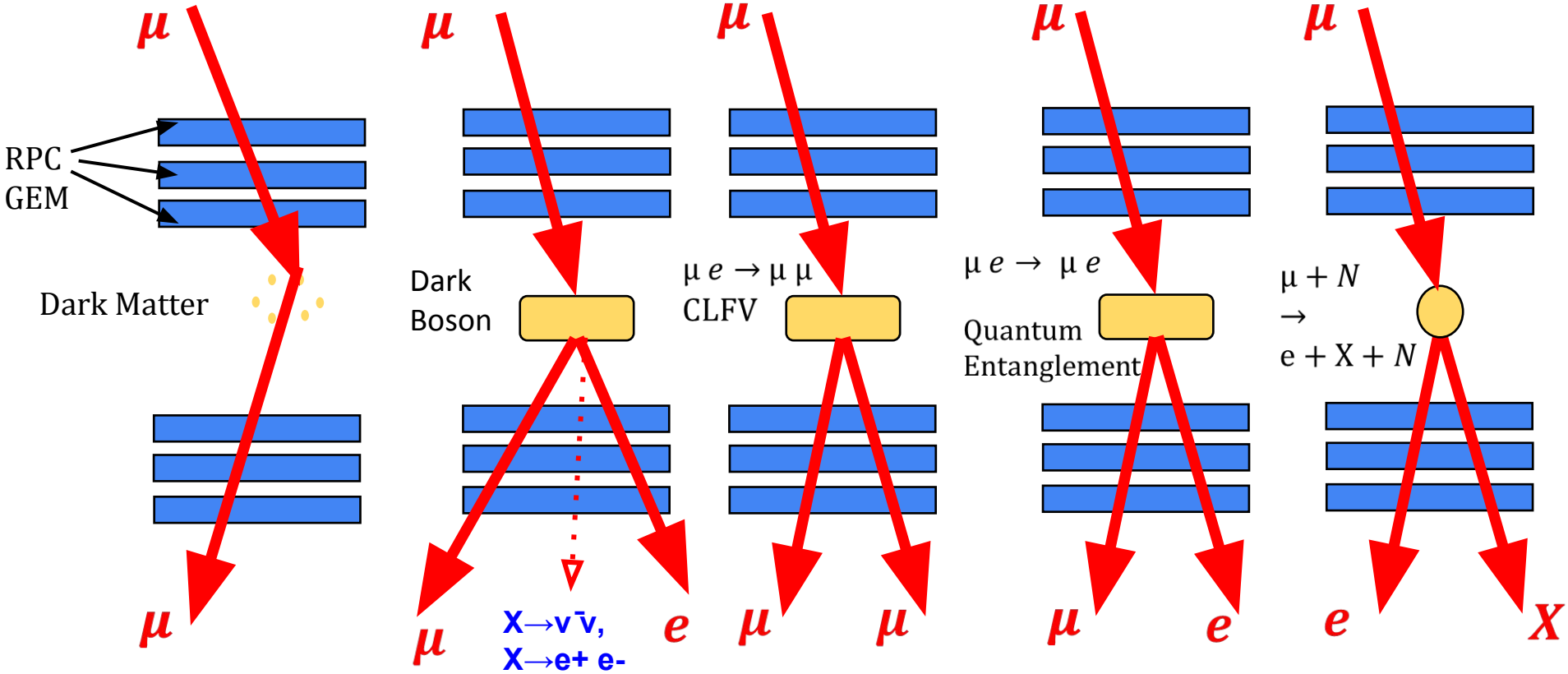
PKμ@HFRS



参考文献：[1] Phys. Rev. D 110, 016017 [2] arxiv:2410.20323 [3] arXiv:2411.12518 [4] Nucl. Instrum. Methods. Phys. Res. A 663 (2012) 22-25

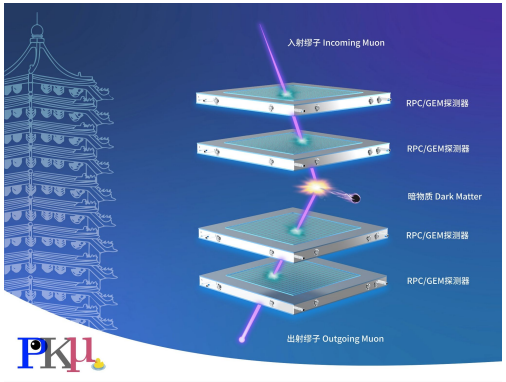
丰富的物理图景

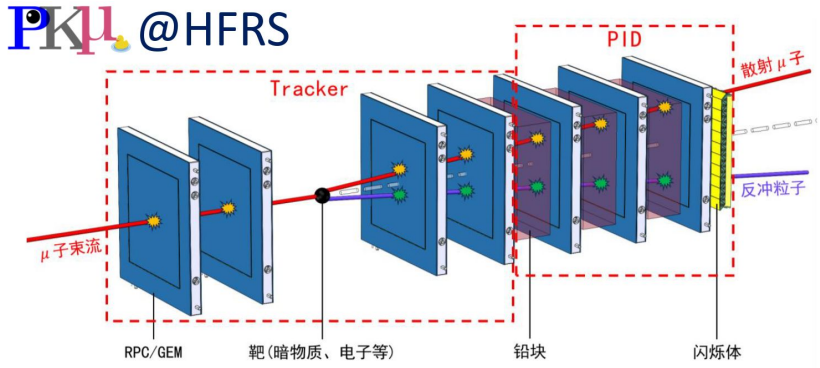
→Cosmic μ or μ beam



亲缪子类型的暗物质/暗世界

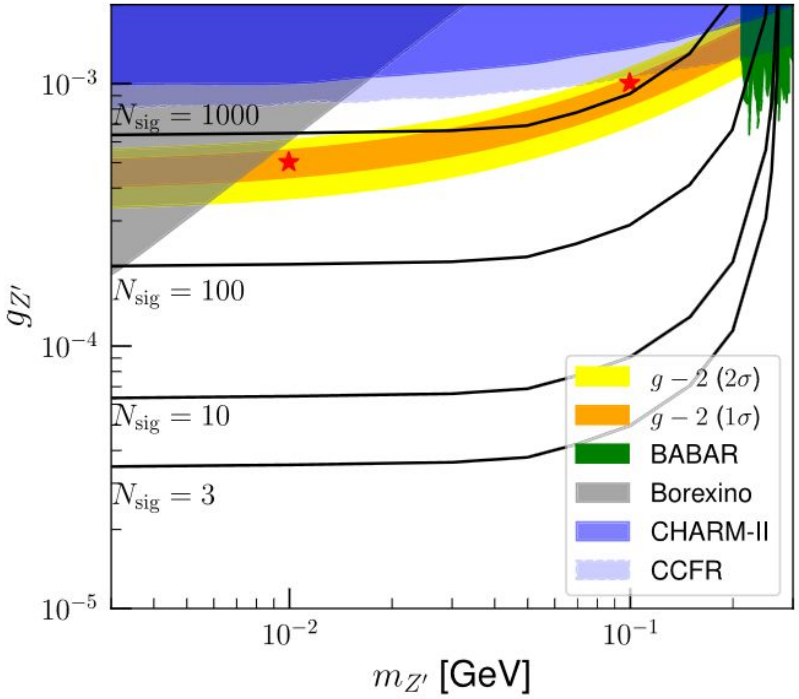
- Muon Philic Dark Matter may be possible or even necessary!
  - $L\mu - L\tau$ gauged model (Z', χ) quite popular recently
  - 1) Direct searches for DM
    - See the PKMu proposal: *Phys.Rev.D* 110 (2024) 1, 016017
  - 2) On target experiments for Dark Boson: (see also cosmology constraints)
    - LDMX,DarkShine; eN → eNZ', Z'→νν̄ or Z'→χχ (dark matter)
    - NA64μ, MMM μN → μNZ', Z'→νν̄ or Z'→χχ (dark matter)
    - MuonE μe → μeZ', Z'→νν̄ or Z'→χχ (dark matter)

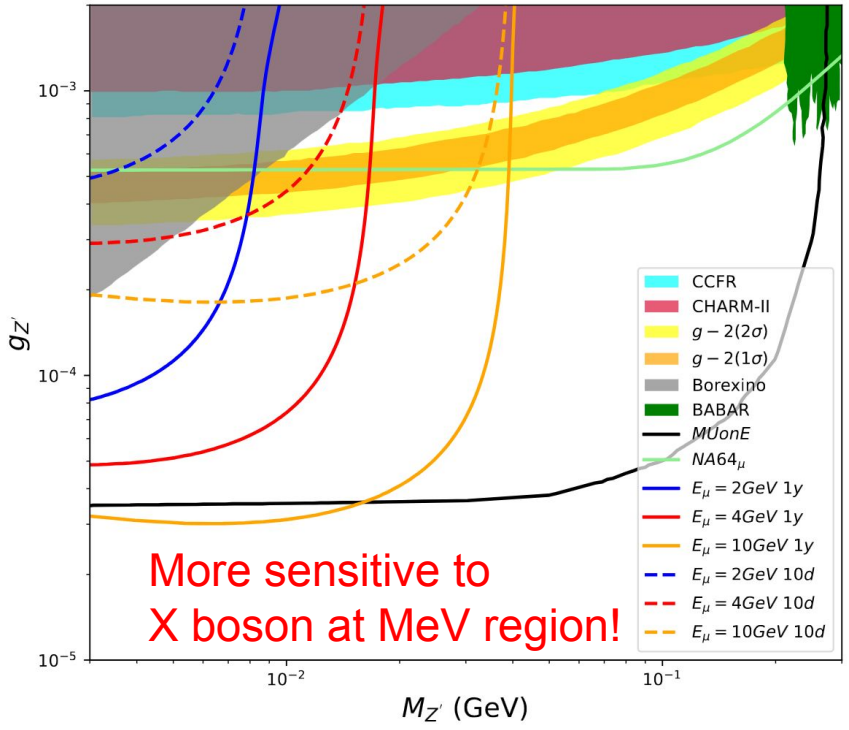




参考文献：[1] Phys. Rev. D 110, 016017 [2] arxiv:2410.20323 [3] arXiv:2411.12518 [4] Nucl. Instrum. Methods. Phys. Res. A 663 (2012) 22-25

10 MeV暗玻色子质量区域可获得世界最好结果

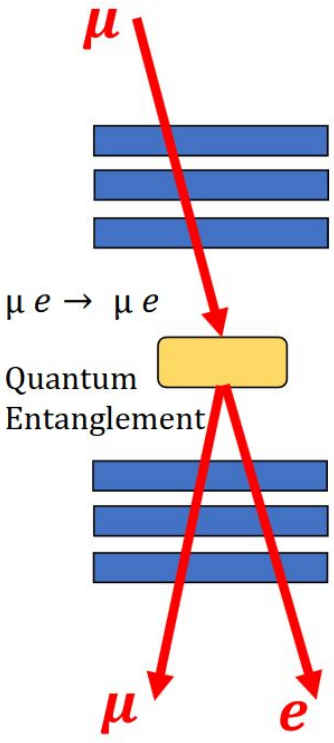




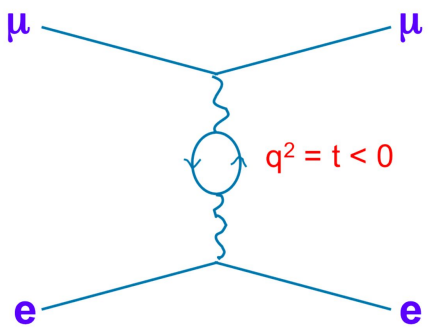
Phys.Rev.D 106 (2022) 5, L051702

Preliminary results

More: 缪子电子散射探测量子纠缠



- MuonE exploits 160 GeV Muon beam to measure muon electron scattering, and a precise determination of the leading hadronic contribution to the muon g-2.
- **Muon electron scattering at lower energy (~GeV)** may be interesting to SM test itself, and Quantum entanglement probe PRD 107, 116007 (2023):



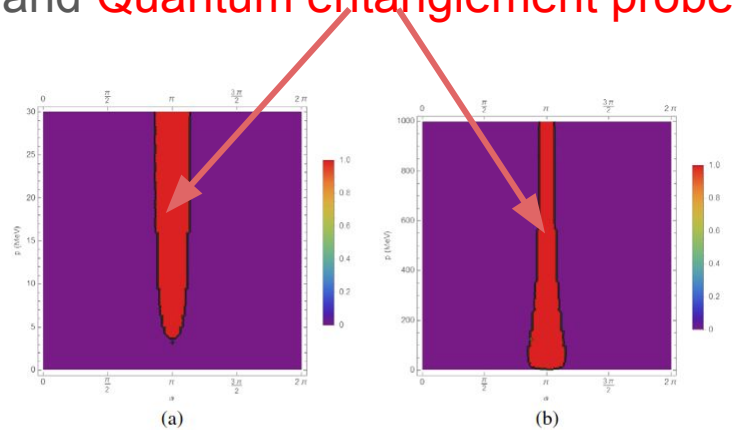
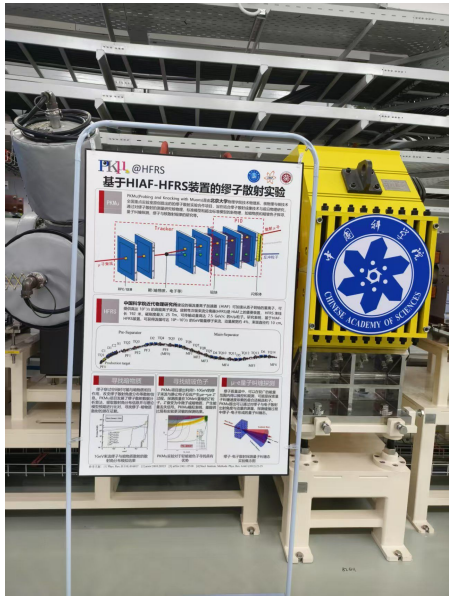


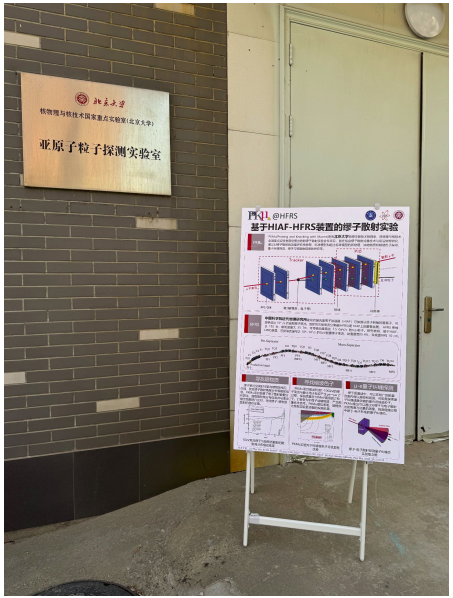
FIG. 15. The red regions correspond to the values of p and θ for which the final state is entangled at low—< 30 MeV—(a) and high—< 1 GeV—(b) energies.

arXiv:2502.07597

arXiv:2411.12518

PKMu@HFRS Lab/Collaboration

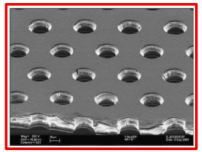


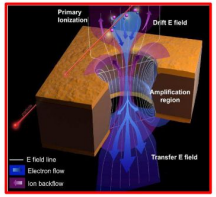


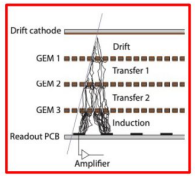
北大缪子探测器研发

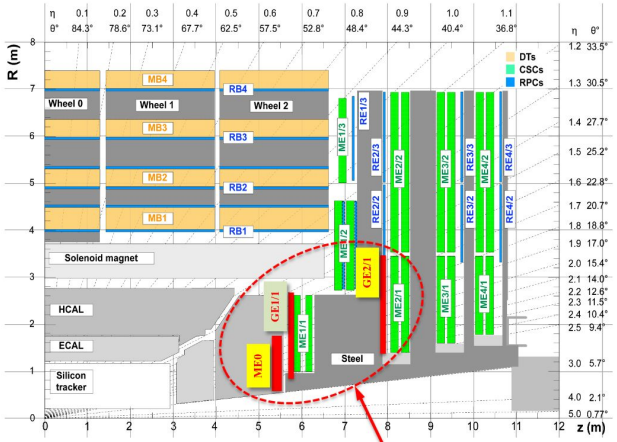
- ➔ CMS Muon Trigger RPC: assembled and tested at PKU at around 2002
- ➔ RPC R&D for nuclear physics
- ➔ CMS GEM upgrade program

北大基地生产的第一个CMS GEM模块









CMS端盖缪子探测器 GEM升级

北京大学、清华大学、中山大学、北京航空航天大学

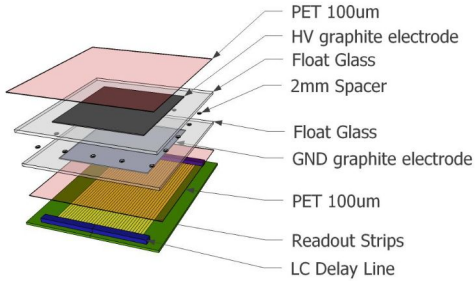
Combination of glass RPC & Delay-line Readout

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Study of spatial resolution properties of a glass RPC

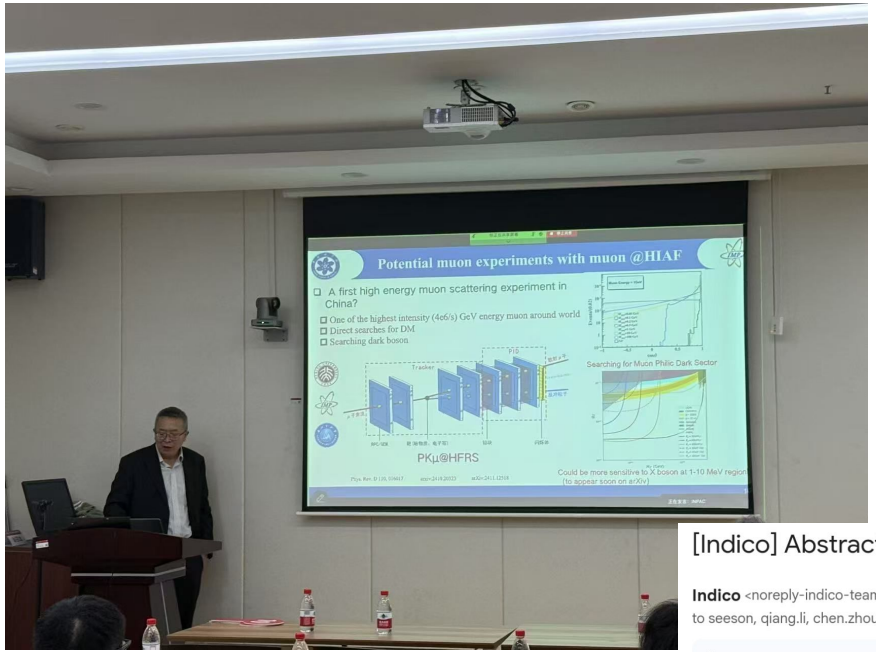
Qite Li, Yanlin Ye*, Chao Wen, Wei Ji, Yushou Song, Rongrong Ma, Chen Zhou, Yucheng Ge, Hongtao Liu



Reference:

- 许金艳,李奇特*, 等, *物理实验*, 41(2021)23
- Qi-Te, Li, et al. *Chinese Physics C* 37 (2013)016002.
- S. Chen, Q. Li*, et al, *JINST*: 10 (2014)10022.

90% R134a+9% i-C_4H_{10}+1% SF_6 50ml/Min



[Indico] Abstract Acceptance notification (#100)

Inbox ×

Indico <noreply-indico-team@cern.ch>
to seeson, qiang.li, chen.zhou, liqt1985, espp2026.input

Fri 4 Apr, 22:22 (20 hours ago)

Translate to Chinese (Traditional)

Dear Qiang Li,

We are pleased to announce that your abstract "Probing and Knocking with Muons" with ID #100 has been accepted as input to the 2026 update process of the European Strategy for Particle Physics.

Your submission will be made public and it will be further discussed by the Physics Preparatory Groups and the European Strategy Group. It also constitutes important input for the preparation of the Open Symposium in Venice at the end of June.

Kind regards,
The Strategy Secretariat

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Indico :: Call for Abstracts
https://indico.cern.ch/event/1439855/