

P348: Search for new physics in missing-energy events

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PREPARED FOR SUBMISSION TO SPSC

Proposal for an Experiment to Search for Light Dark Matter at the SPS

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TPU Tomsk (Russia)
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Test Run Report of the P348 Collaboration

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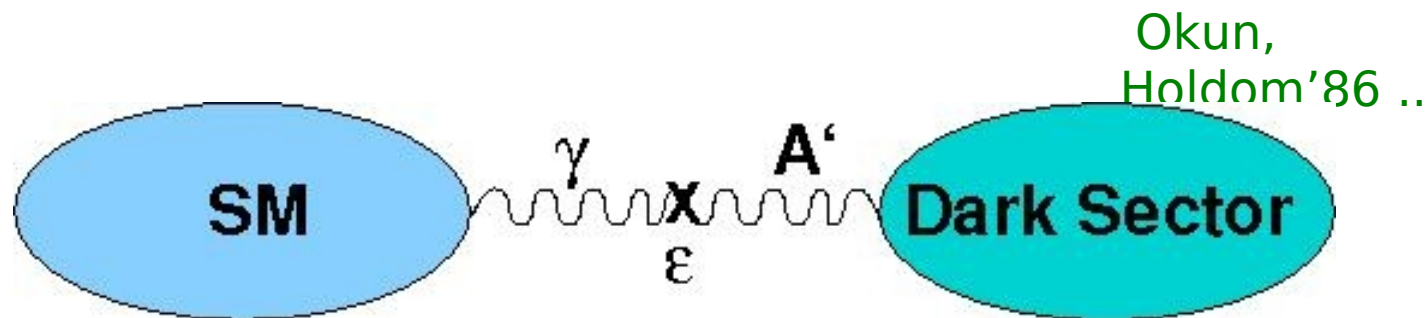
October 14, 2015

¹Contact person, Sergei.Gninenko@cern.ch

- Proposed in Dec. 2013
- Approved for tests April 2014
- Design, production, delivery at CERN, assembly, installation April'14 – May'15
- Test run Sept.-Oct'15



One of main goals: search for $A' \rightarrow \text{invisible}$

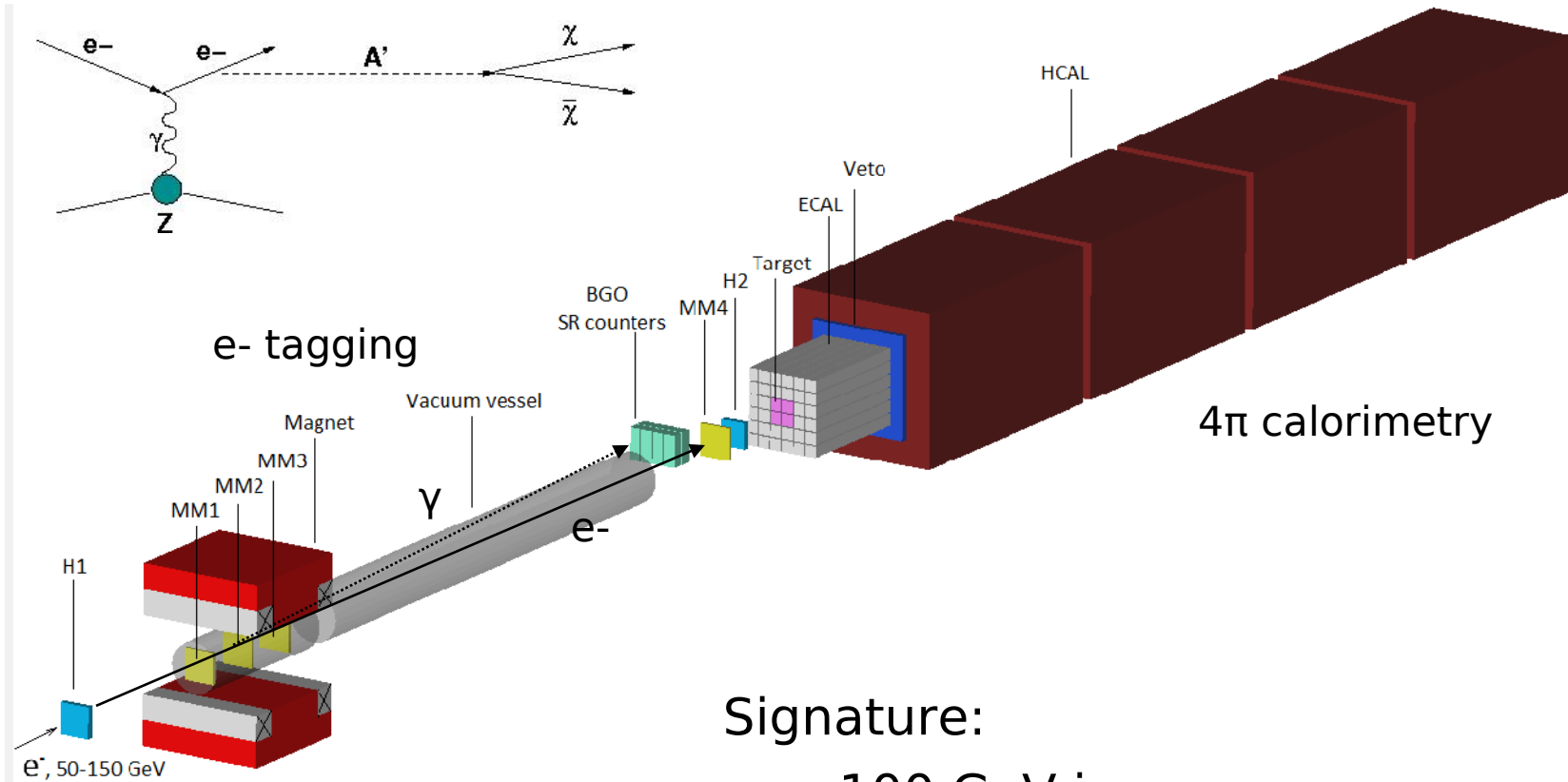


- extra (broken) $U'(1)$, new massive boson A' (dark photon)
- $\Delta\mathcal{L} = \epsilon F^{\mu\nu} A'_{\mu\nu}$ - kinetic γ - A' mixing, ϵ - strength of coupling
- A' could be light: e.g. $M_{A'} \sim \epsilon^{1/2} M_Z$
- new phenomena: γ - A' oscillations, LSW effect, A' decays, possible contributions to $g-2$
- A' decay modes: e^+e^- , $\mu^+\mu^-$, hadrons,.. or $A' \rightarrow \text{invisible}$ if $M_{A'} > M_{\text{DM}}$ and $\alpha_{\text{DM}} \gg \epsilon$

Large literature, many new theoretical and experimental results

Direct Search for $A' \rightarrow \text{invisible}$ decay

Invisible decay of Invisible State!

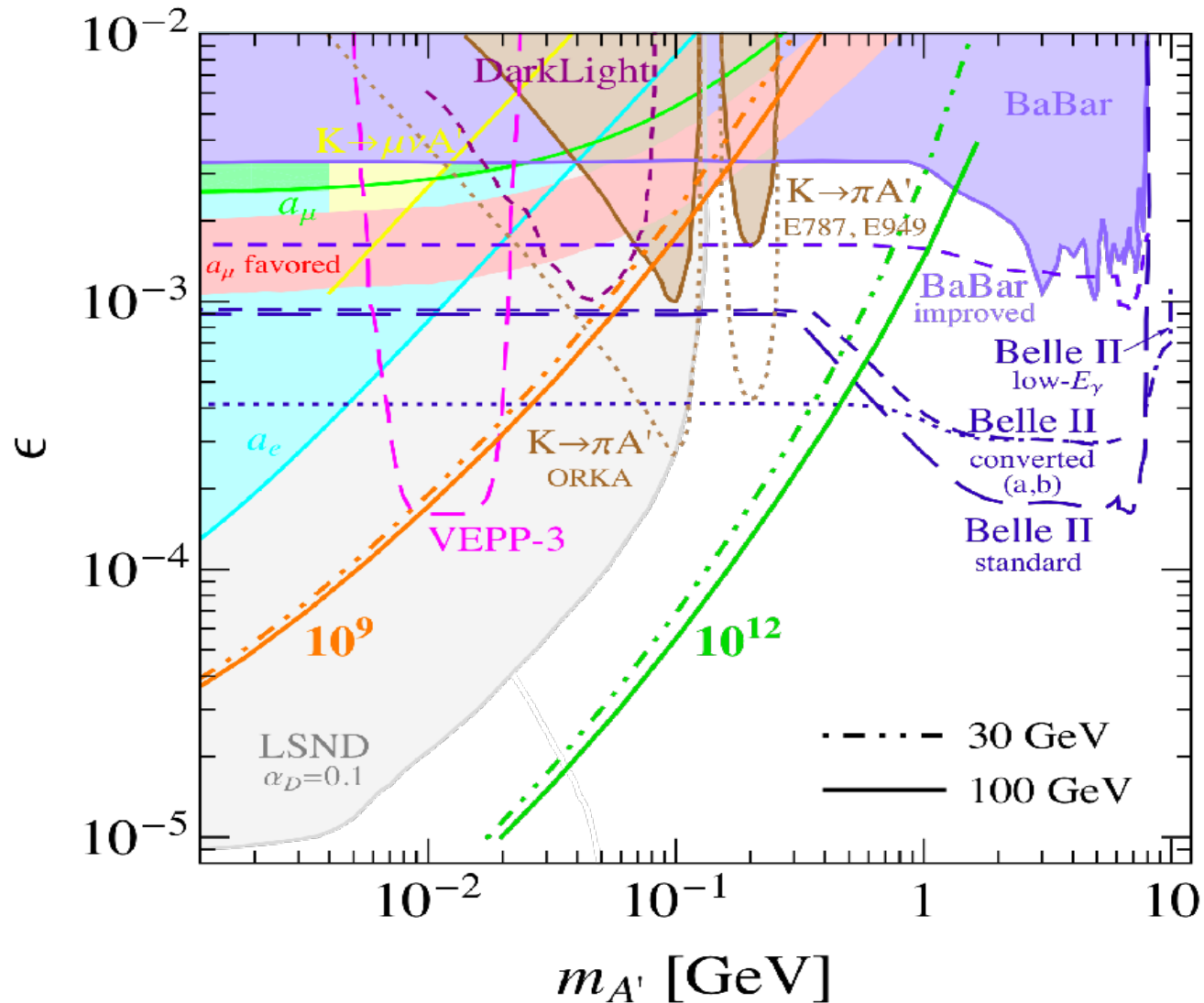


S.G., PRD(2014)

Signature:

- e^- , 100 GeV in,
- e-m shower in ECAL $< \sim 50$ GeV
- no activity in the Veto+ HCAL

Expected limits vs N_{e^-}

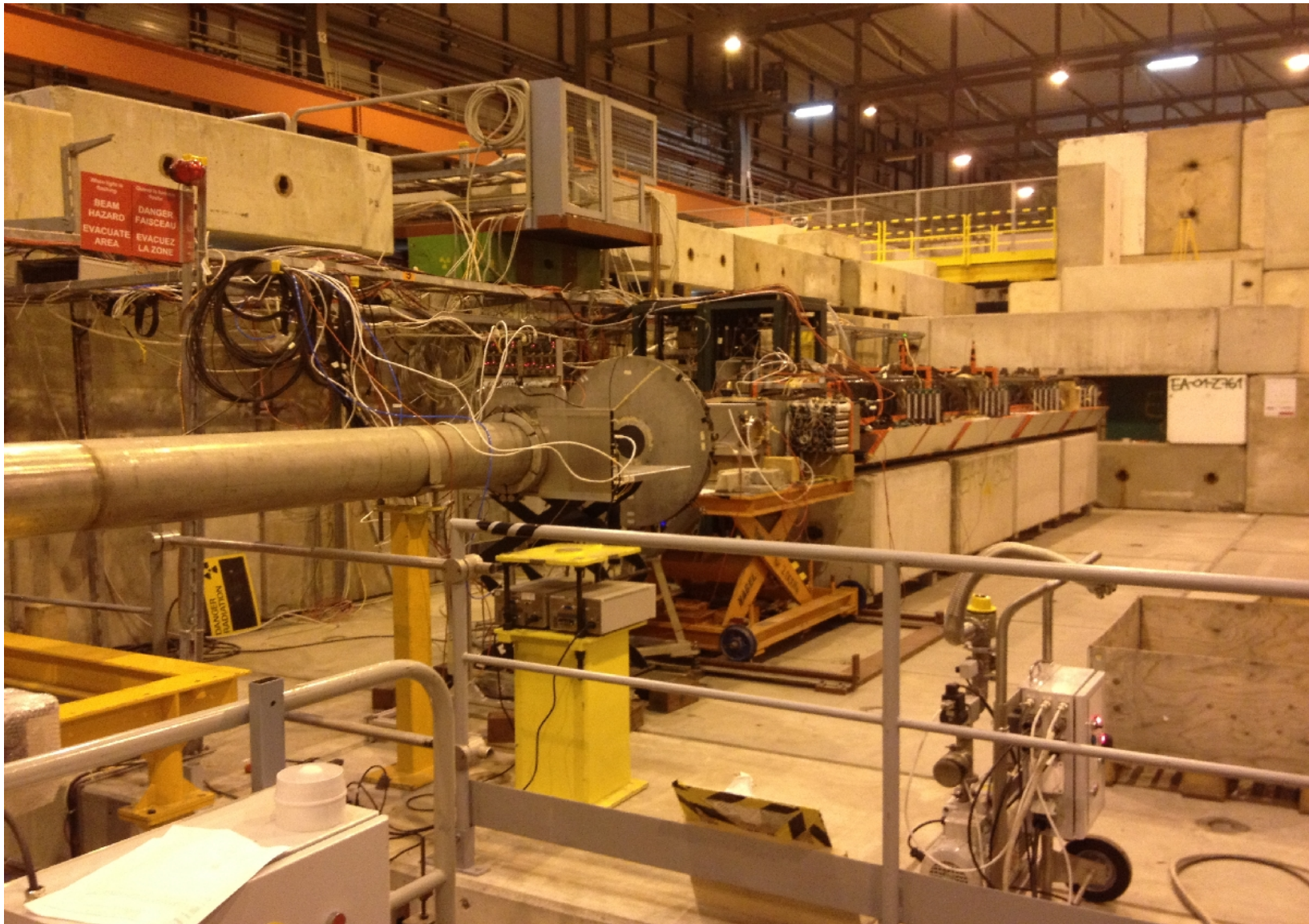




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The P348 downstream part

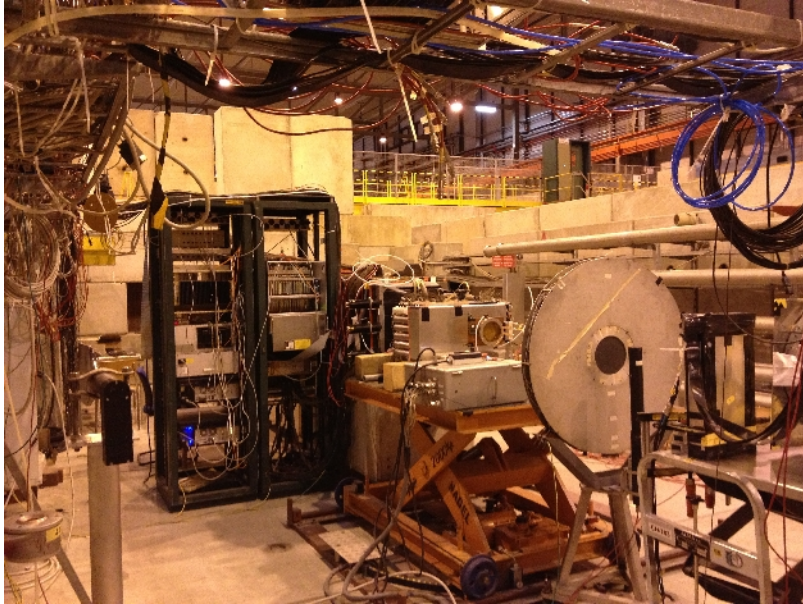
8/14



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BGOs, Micromegas, straws, hodoscopes, ... ^{9/14}

BGO SR array



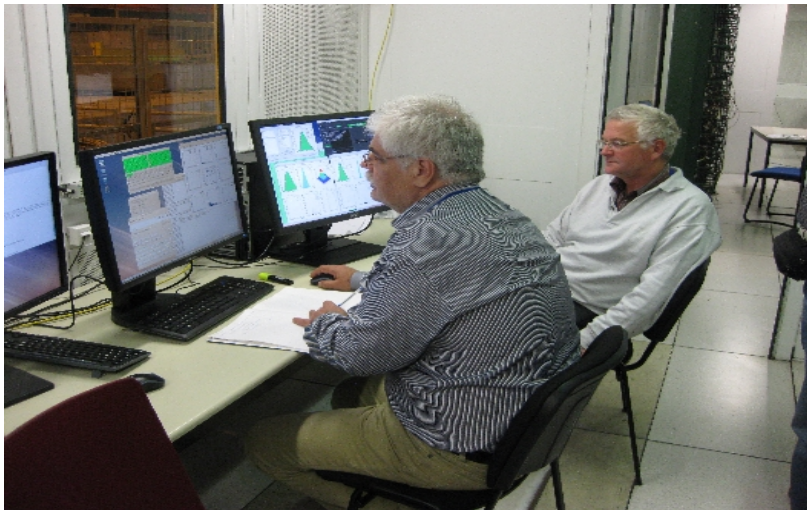
Micromegas



Strow tubes



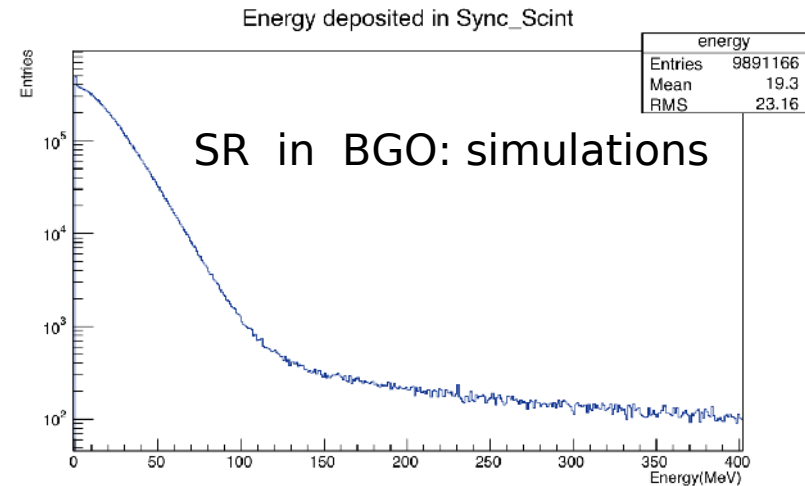
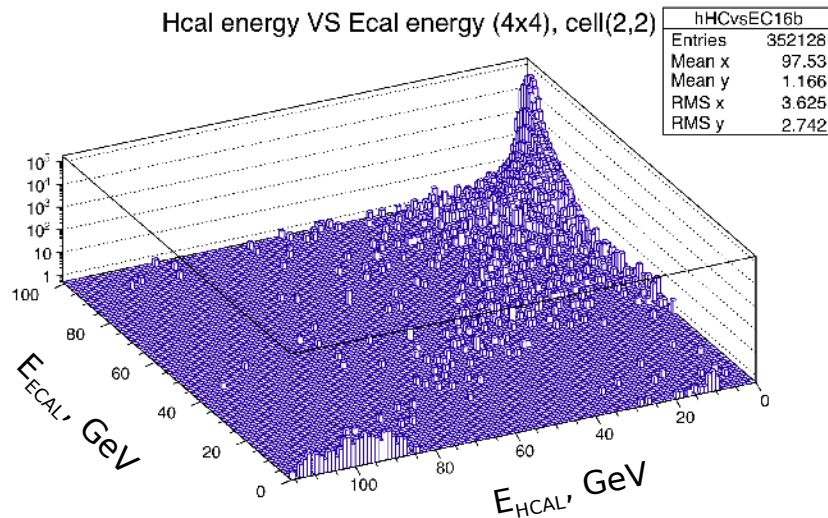
On shift



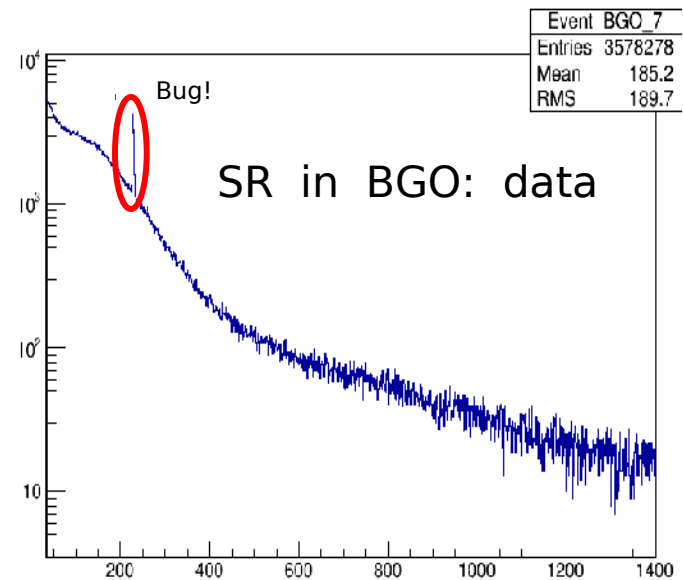
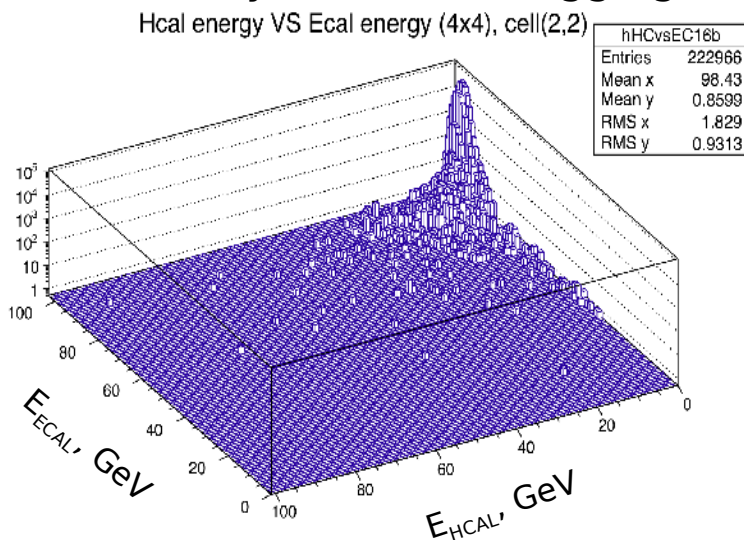
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New Idea: Synchr. Rad. tagging of 100 GeV e^-

No Synchr. Rad. tagging

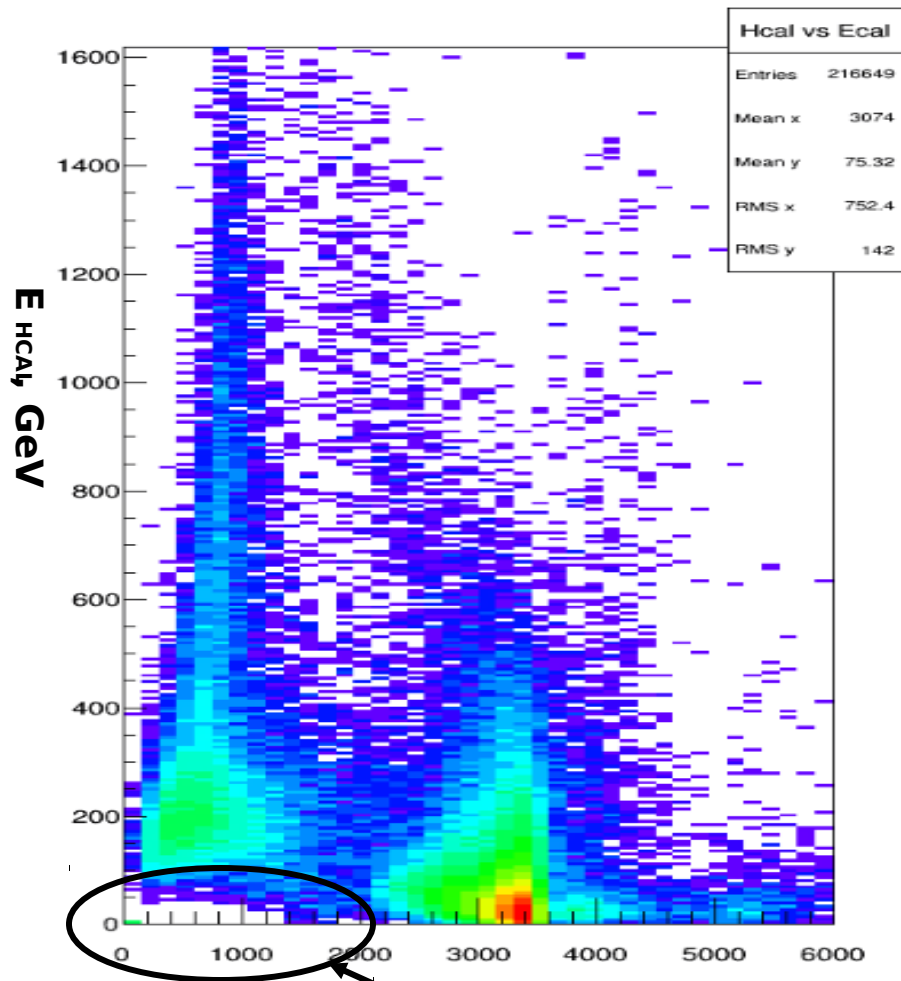


With Synchr. Rad. tagging

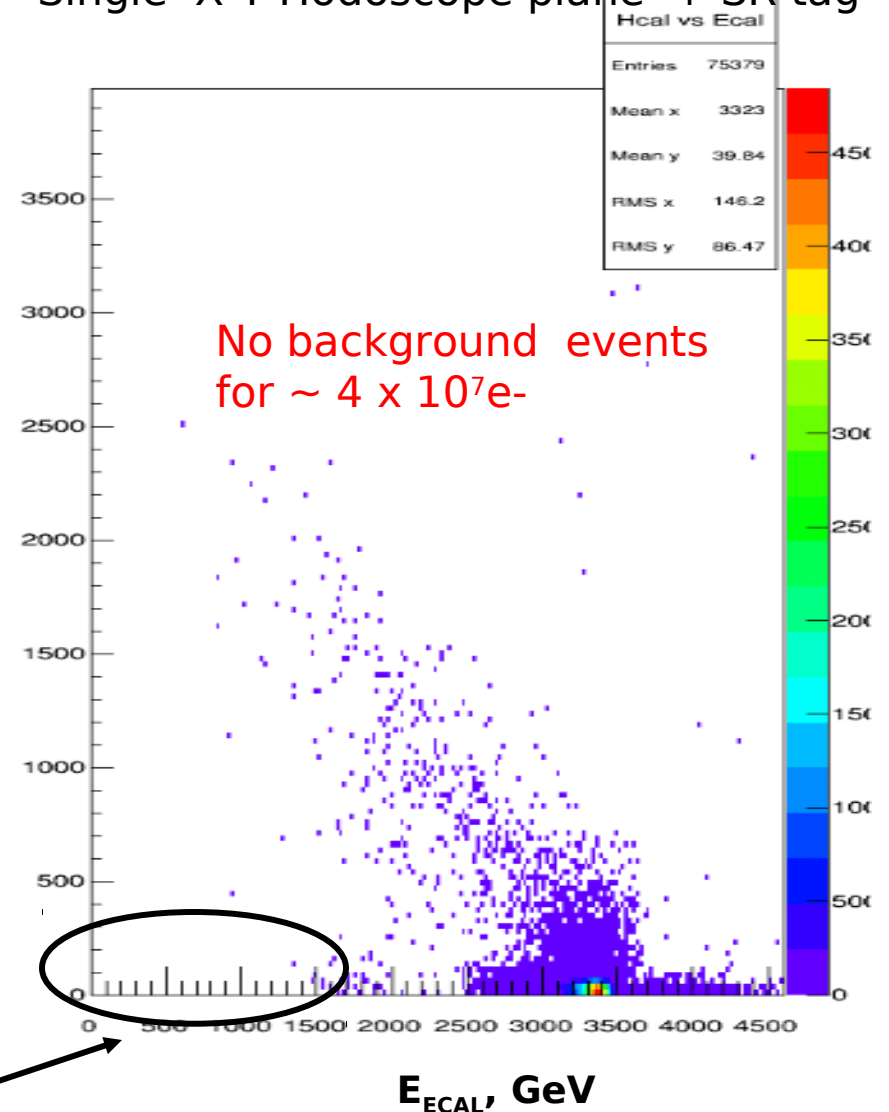


A` signal in the HCal vs ECAL plane

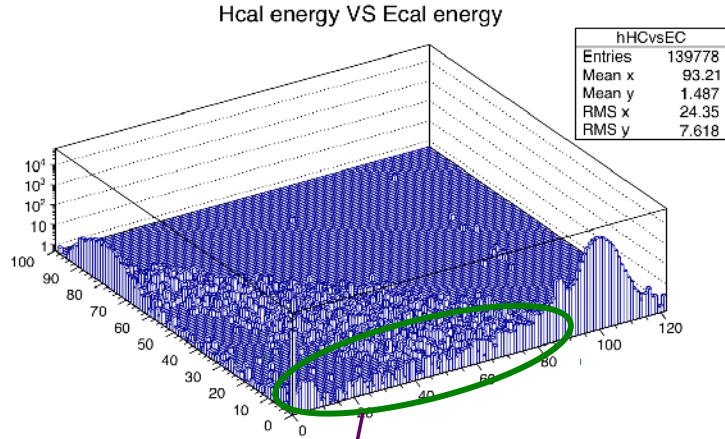
No selections



Single X-Y Hodoscope plane + SR tag

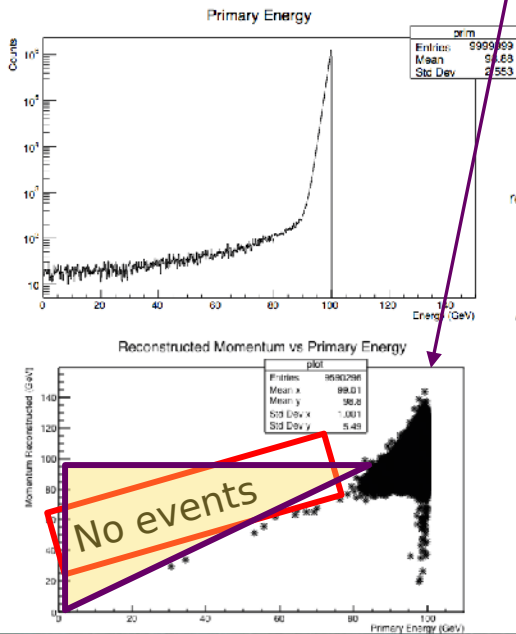


MM performance and background rejection ^{12/14}



No background events are expected with MM tracker for $> 10^{11}$ e-

MM Tracker Simulation Summary

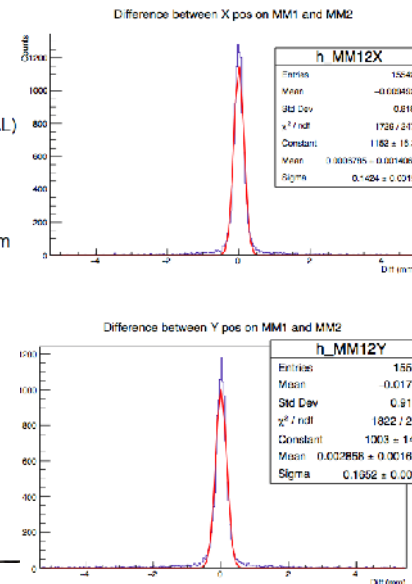


A spread of energy as shown in the plot was given to the primaries and the reconstructed momentum (when there is a hit in the ECAL) compared with the actual primary energy.

As seen in the second plot the reconstructed momentum compares well with the actual primary energy of the particles hitting the ECAL. Most low energy primaries miss the ECAL due to the field.

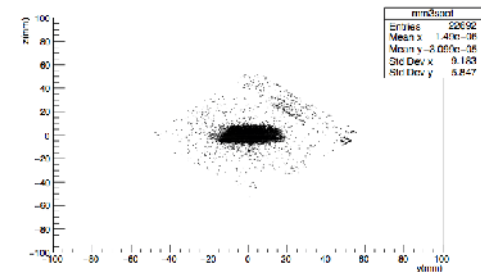
Level of rejection of events when energy deposited in ECAL < 50 GeV and momentum reconstructed with tracker > 50 GeV $\sim 10^{-10}$ for 100 GeV primaries.

MM Tracker Summary from beam run



Resolution of Micromegas confirmed comparing hit points on two modules.

$$\sigma_{MM} \sim \sigma_{ploc} / \sqrt{2} \sim 100 \mu$$



Beam Spot on MM for 100 GeV electrons without field.

Reaction	Physics	Sensitivity
1. $eZ \rightarrow eZ + ..$		
◇ $A' \rightarrow e+e-$ ◇ $A' \rightarrow \text{invisible}$ ◇ $alps$ ◇ mQ	Dark photons, Hidden sectors, $(g-2)_\mu$ new particles, milliQ, charge quantization	$10^{-4} < \varepsilon < 10^{-5}$ $M_{A'} \sim \text{sub-GeV}$ $e' < 10^{-5}-10^{-7}$
2. $\mu Z \rightarrow \mu Z + ...$		
◇ $Z_\mu \rightarrow \nu\nu, \mu+\mu-$ ◇ $\mu \rightarrow \tau$	$(g-2)_\mu$, gauged $L_\mu-L_\tau$, L-phobic boson Z_μ , LFV	$\alpha_\mu < 10^{-11}-10^{-9}$ $< 10^{-9}-10^{-8}/\mu$
3. $\pi(K)p \rightarrow M^0 n$		
◇ $K_L \rightarrow \text{invisible}$ ◇ $K_S \rightarrow \text{invisible}$ ◇ $\pi^0, \eta, \eta' \rightarrow \text{invisible}$	Bell-Steinberger Unitarity, CP, CPT , NHL, 2HDM,	$\sim 10^{-5}$ $\text{Br} < 10^{-8}$ $< 10^{-8}-10^{-7}$
4. pA		
◇ $leptophobic X + h$	$\sim \text{GeV DM}$	$< 10^{-7}-10^{-8} / p$

Summary

- i) P348 – один из немногих Российских экспериментов за всю историю ЦЕРН.
- ii) Основан на новом методе поиска BSM физики в событиях с недостающей энергией с использованием активного beam dump'a. Метод успешно опробован на ускорителе SPS CERN в сеансе Сент.-Окт 2015 г.
- iii) После модификации детектор готов для начала поиска распадов $A' \rightarrow \text{invisible}$ с высокой чувствительностью
- iv) На заседании SPSC Oct'2015, P348 получил высокую оценку и рекомендацию начать поиски в 2016.
- v) Для успешного проведения сеанса в 2016 г, необходимо
 - а) ~ 50 kEuro для закупки FE и DAQ электроники
 - б) ~ 20 kCHF для операционных расходов
- vi) Для дальнейшей поддержки и модернизации P348 необходим Бюджет ~ 15 Млн.руб., в период 2016-2018
Предложение: включить P348 в состав проектов ЦП научных исследований РАН.