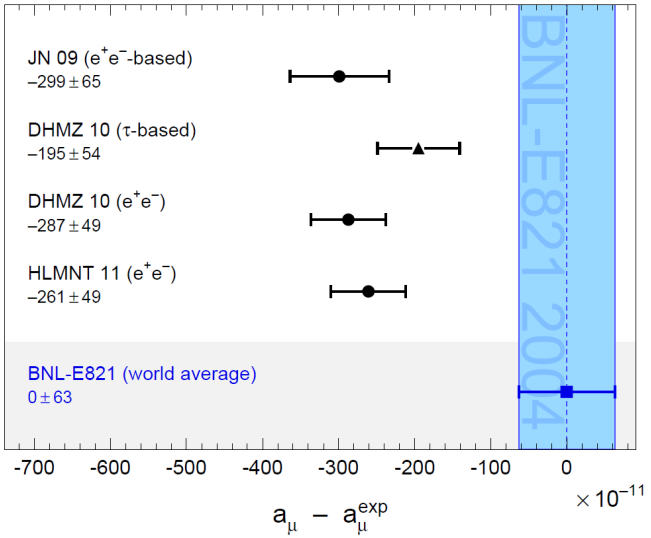

G.Simi

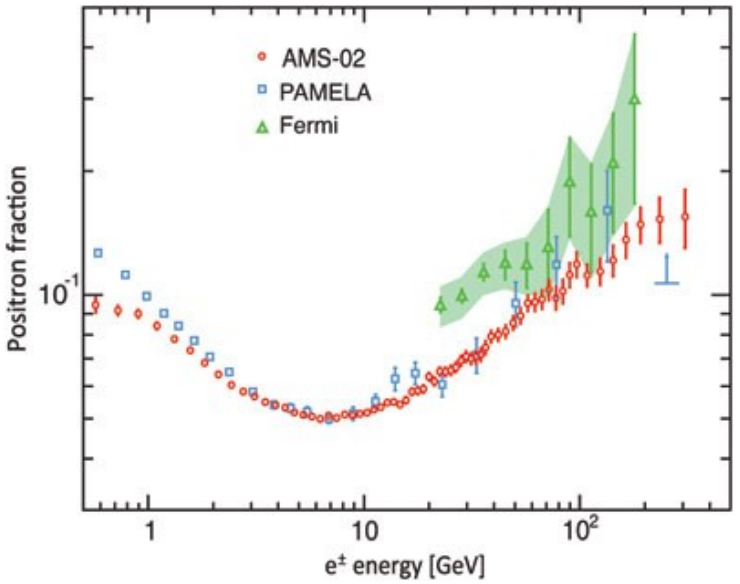
Consiglio di sezione INFN Padova

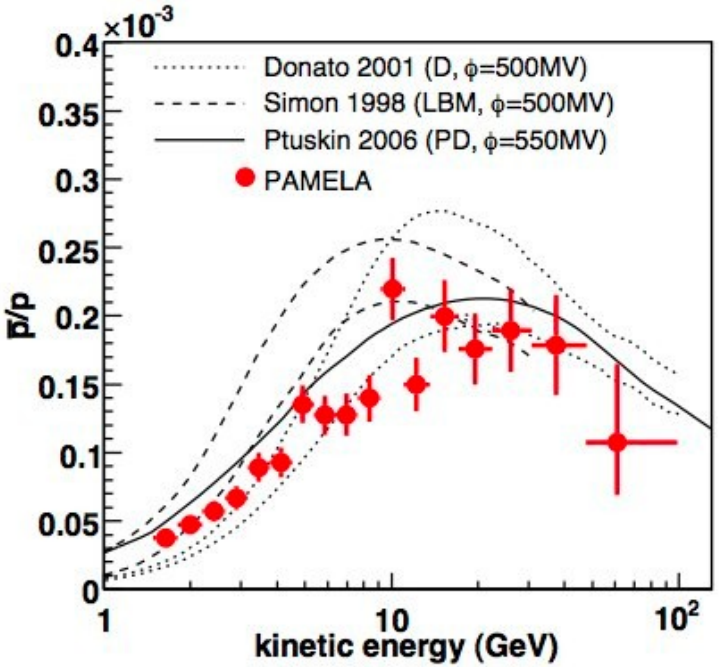
1/7/2013

# Motivation

- Positron excess in PAMELA/AMS data
  - Difficult to explain by thermal DM annihilation
- $g_\mu$-2 anomaly
- DAMA/LIBRA modulation
- 511KeV line from galactic center
- Muonic hydrogen lamb shift



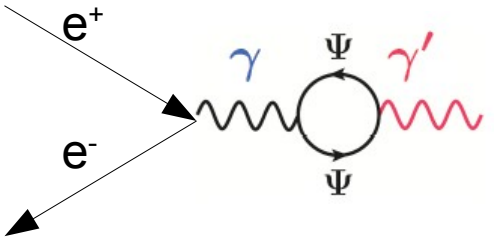



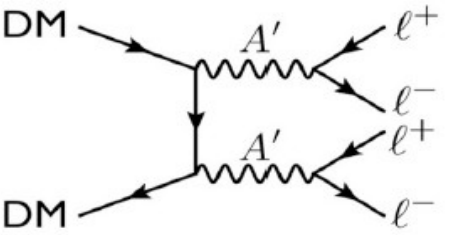
# Hidden sector

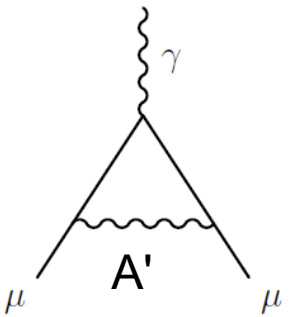
- New U(1)' gauge symmetry ⇒ A' gauge boson
- Absence of anomaly in anti-protons
  - $M_{A'}$<1GeV
- Beam dump searches
  - $M_{A'}$>20MeV
- Decay into leptons
  - Coupling to SM trough kinetic mixing $\varepsilon \sim 10^{-2}-10^{-6}$

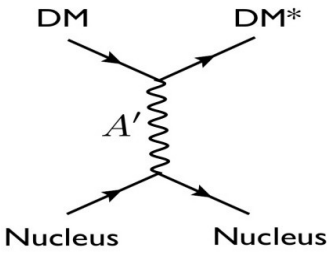
    [Holdom, Phys. Lett B166, 1986]
- Positron excess could be explained by DM annihilation into hidden sector photons, $g_\mu$-2 anomaly by a modification of the vertex diagram (PRD79,015014 PLB671,391 )
- DM signal in DAMA/LIBRA from inelastic scattering via A' exchange



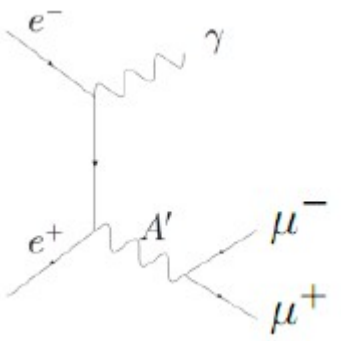

$$\Delta \mathscr{L} = \epsilon\, e\, A'_{\mu}\, J^{\mu}_{em}$$



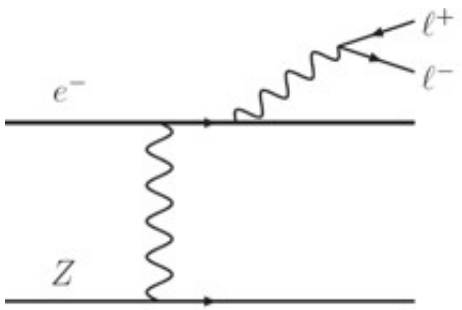
# How to search for heavy photons

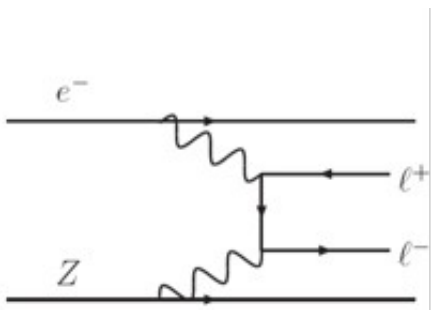


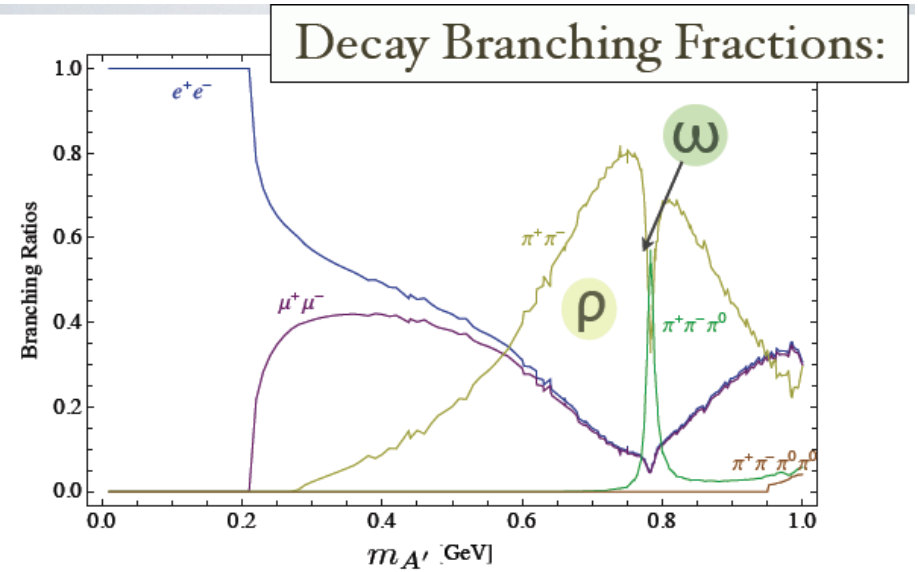

- in $e^+e^-$ annihilations: Babar, Belle,

  KLOE

- Electro-production in fixed target experiments
  - Proposed by D.Bjorken et. al. Phys. Rev. D80, 2009,075018



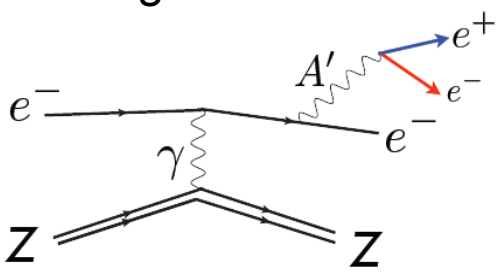



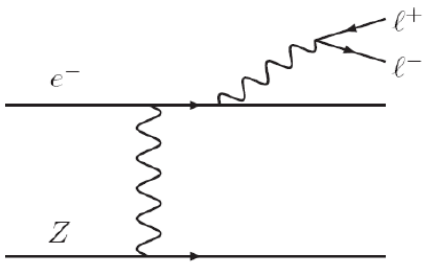
# Signatures

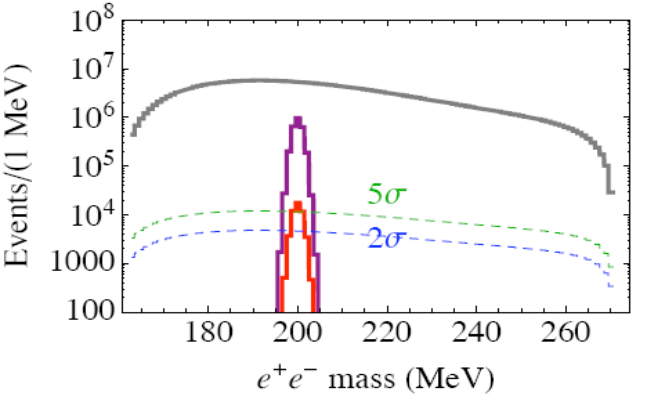
- Invariant mass peak over a copious QED background

signal

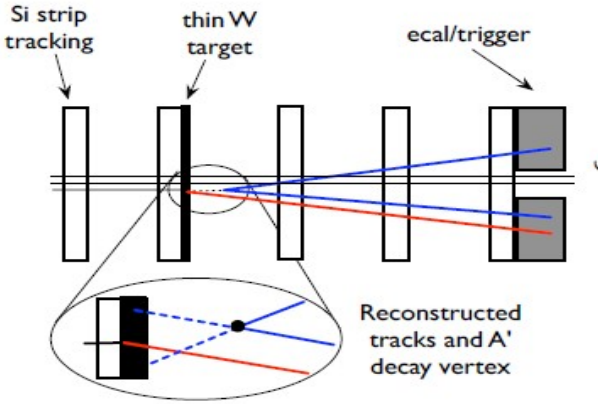


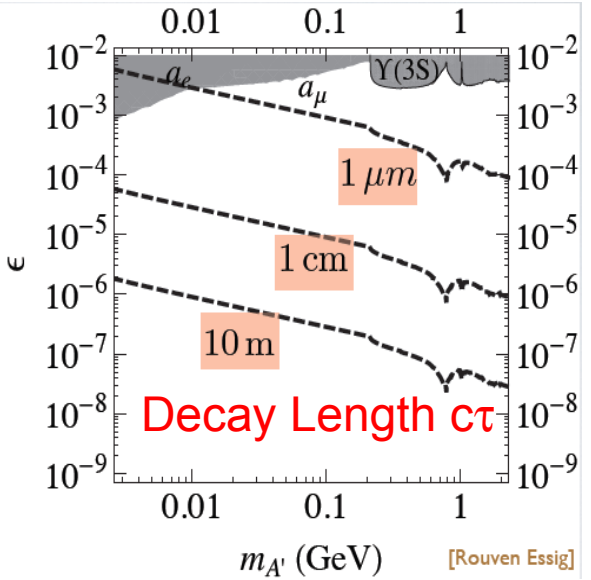

QED background




- Detached decay vertex

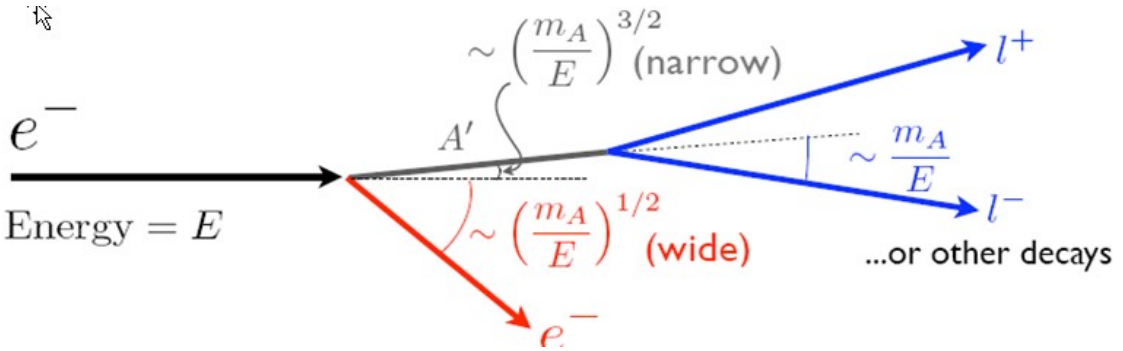



[Rouven Essig]

# HPS Design

- A' kinematics ⇒ need good forward coverage down to ~ $\theta_{decay}/2$. This puts detectors close to the beam.




$E_{A'} \approx E_{beam}$
$\theta_{A'} \approx 0$
$\theta_{decay} = m_{A'}/E_{A'}$

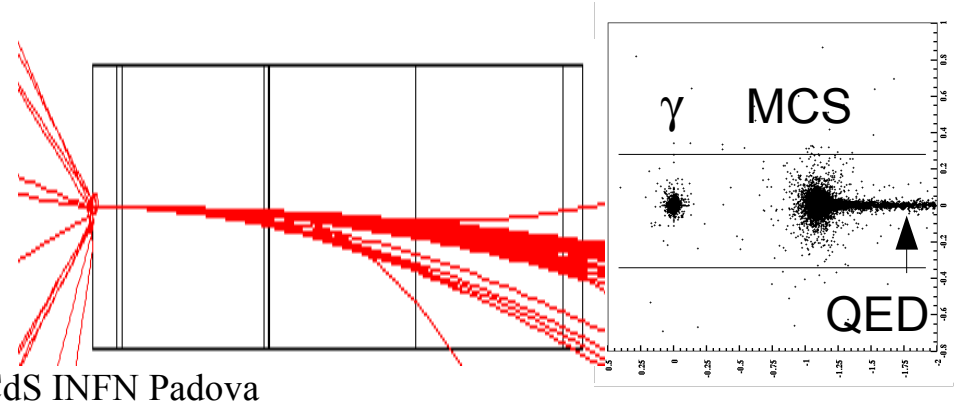
- Vertexing A' decays requires detectors close to the target. Bump hunting needs good momentum/mass resolution. Both need tracking and a magnet.

Want $\Delta m/m \sim 1\%$ for bump hunt
Want $\Delta z \sim 1$mm

Beam's Eye View
$e^+$ and $e^-$

entering ECal

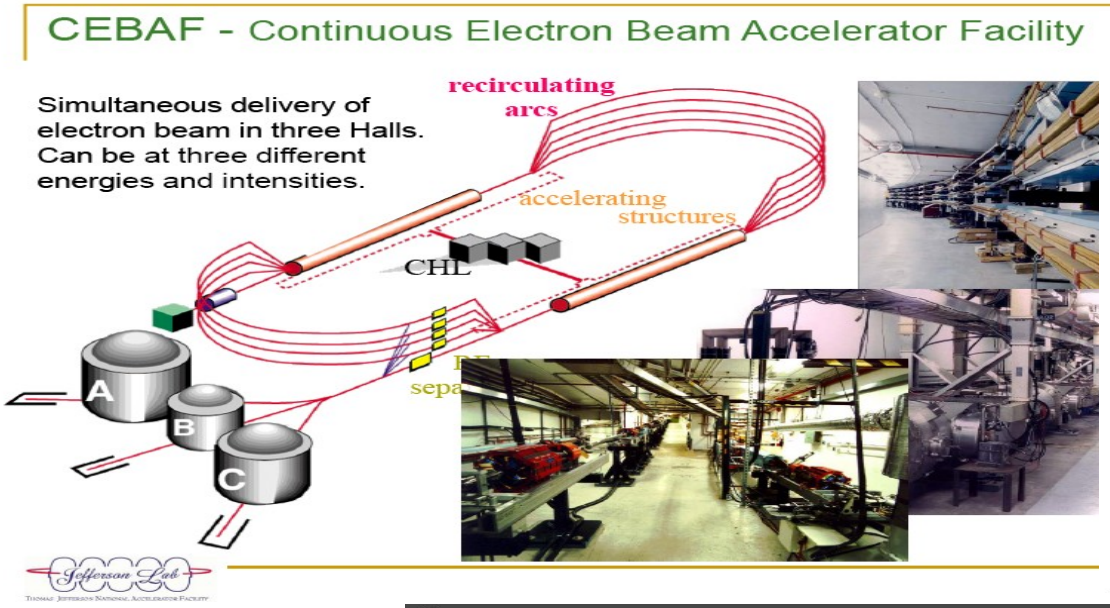
- Trigger with a high rate Electromagnetic Calorimeter downstream of the magnet to select $e^+$ and $e^-$.

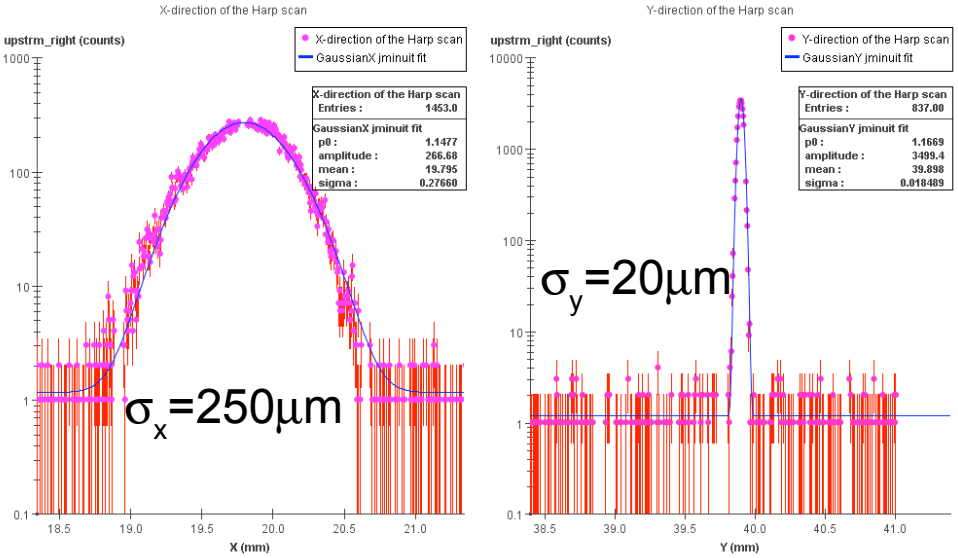



Dead zone

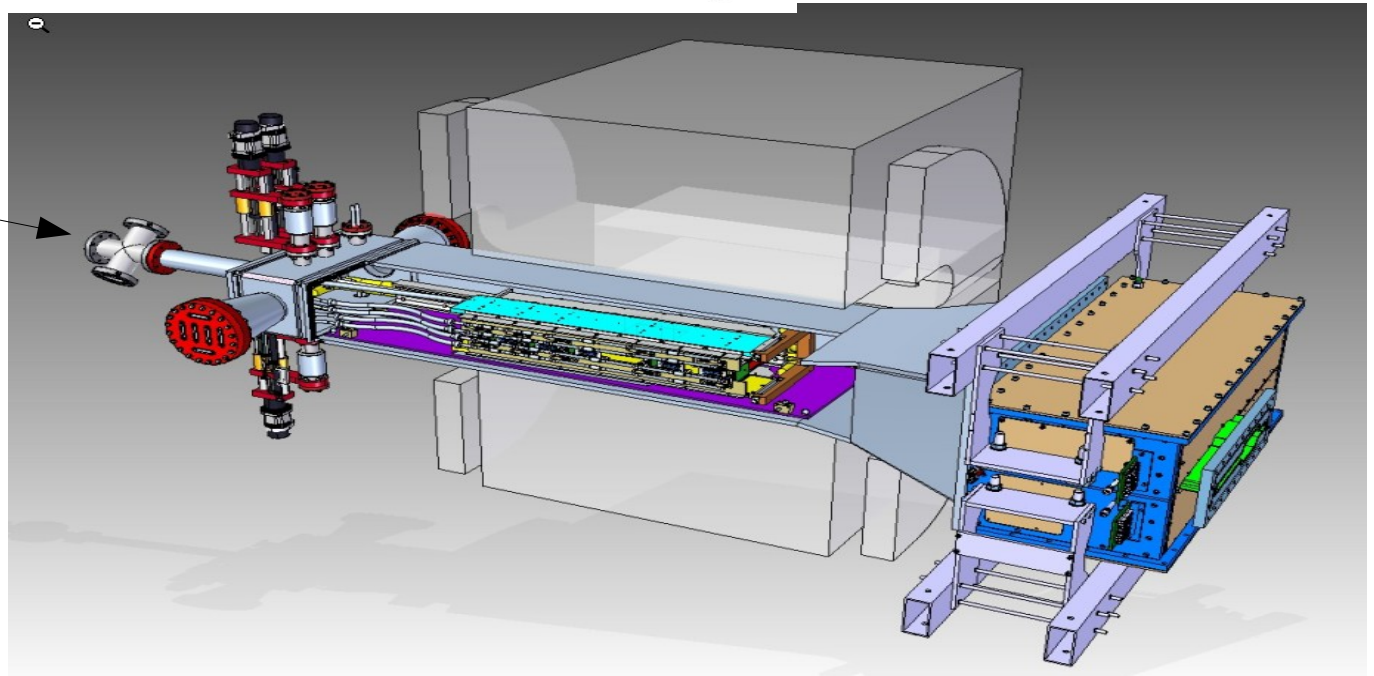
- Beam, QEDand Multiple Couplomb Scattering background in the bending plane => split detectectors

# Installed detector



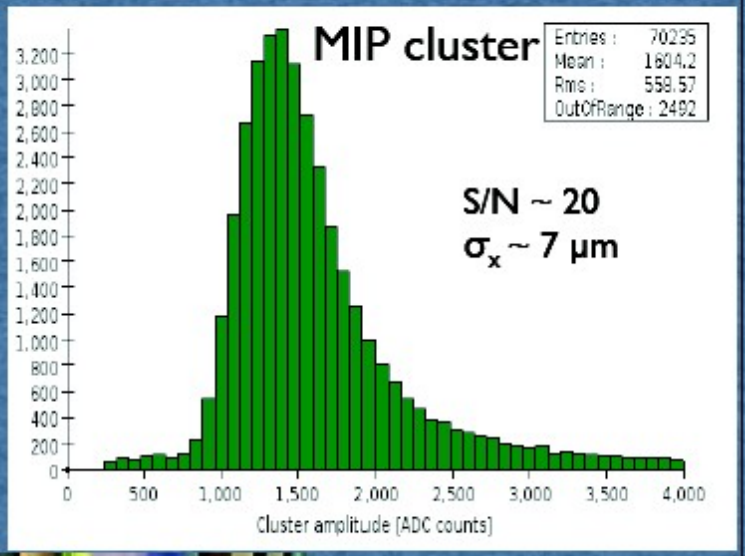



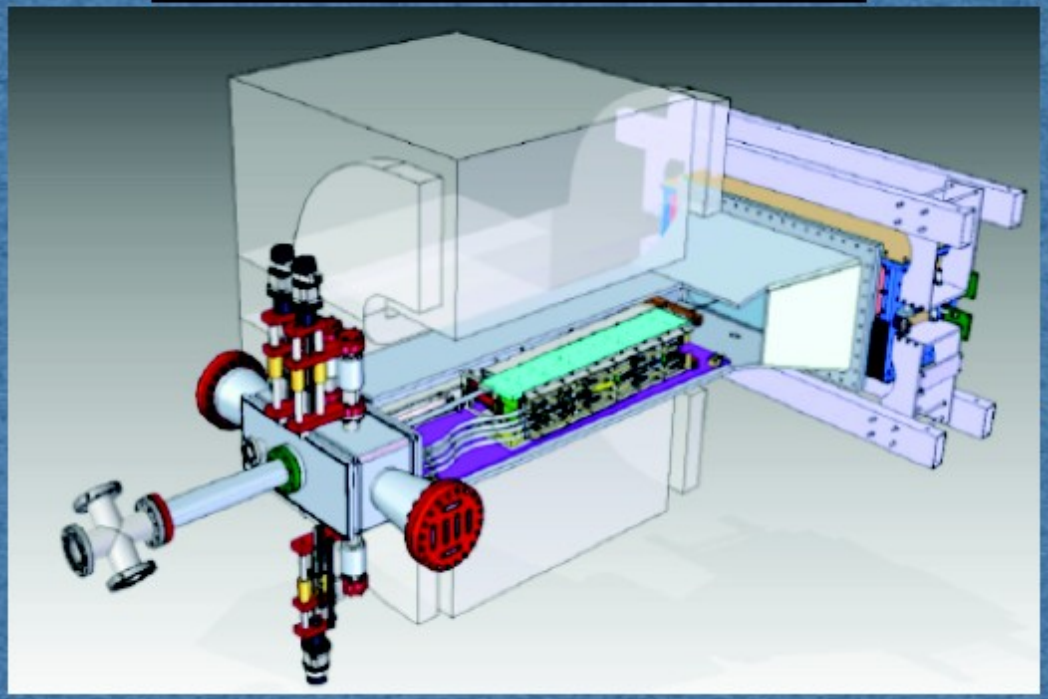

Beam

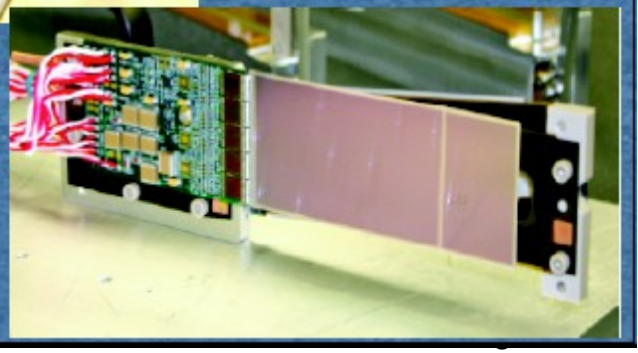


# Silicon Vertex Tracker (SVT)

- 5 layers (axial+stereo), microstrip in vacuum
- Split top/bottom to avoid beam and wall of flame
- 0.5Tm pair spectrometer magnet
- Spatial Res: ~6 um
- Time resolution ~2-3 ns
- CMS APV25 readout (40MHz readout)

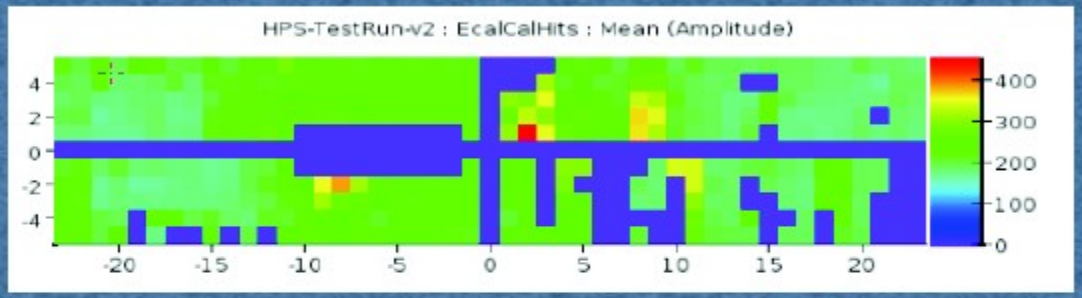



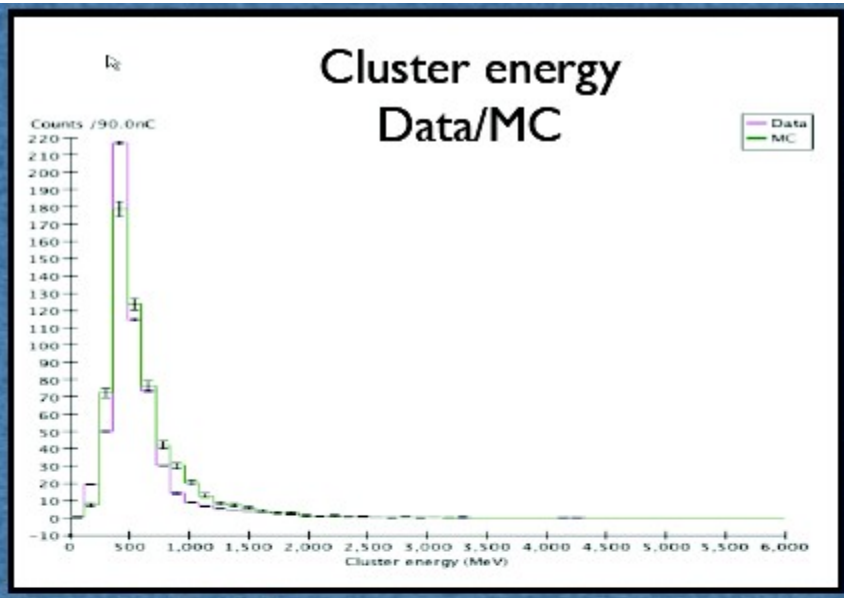



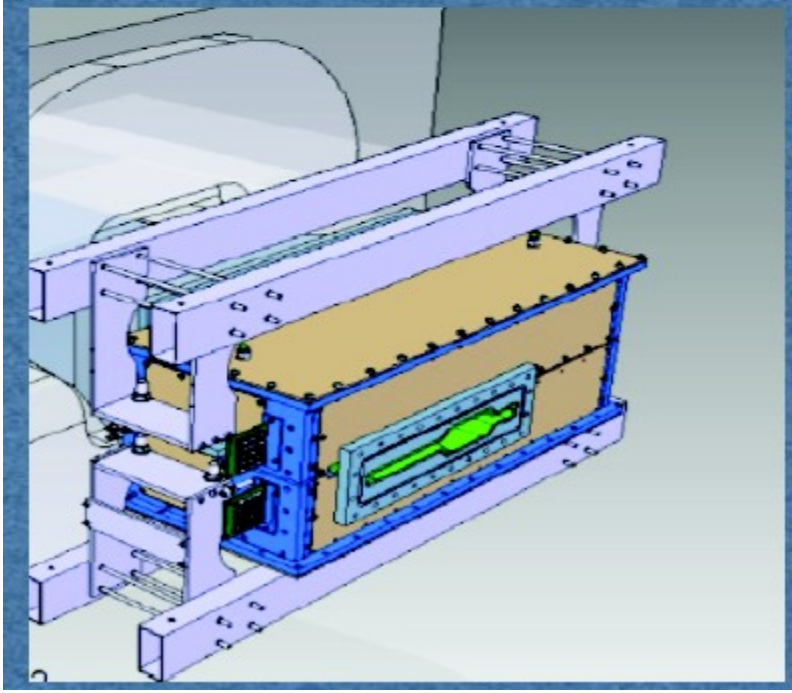


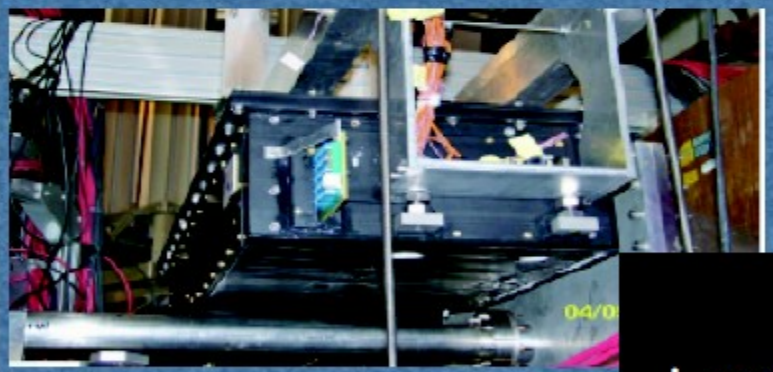
# Electromagnetic Calorimeter

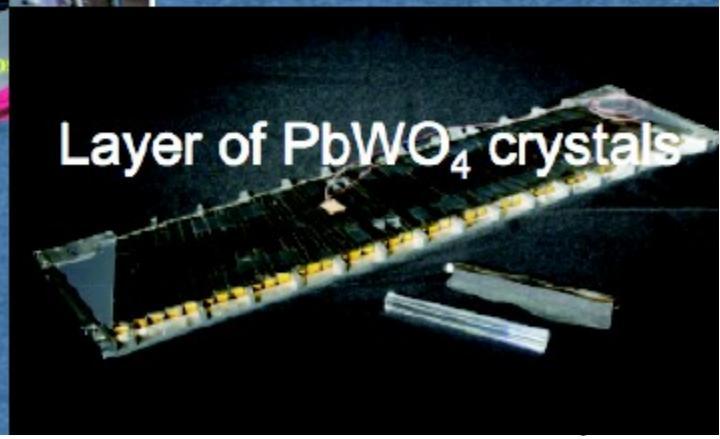
- 442 PbWO crystals
- APD readout (0.5x0.5 cm2)
- Thermal enclosure stabilized at 0.5 °C
- 15 mrad off beam axis



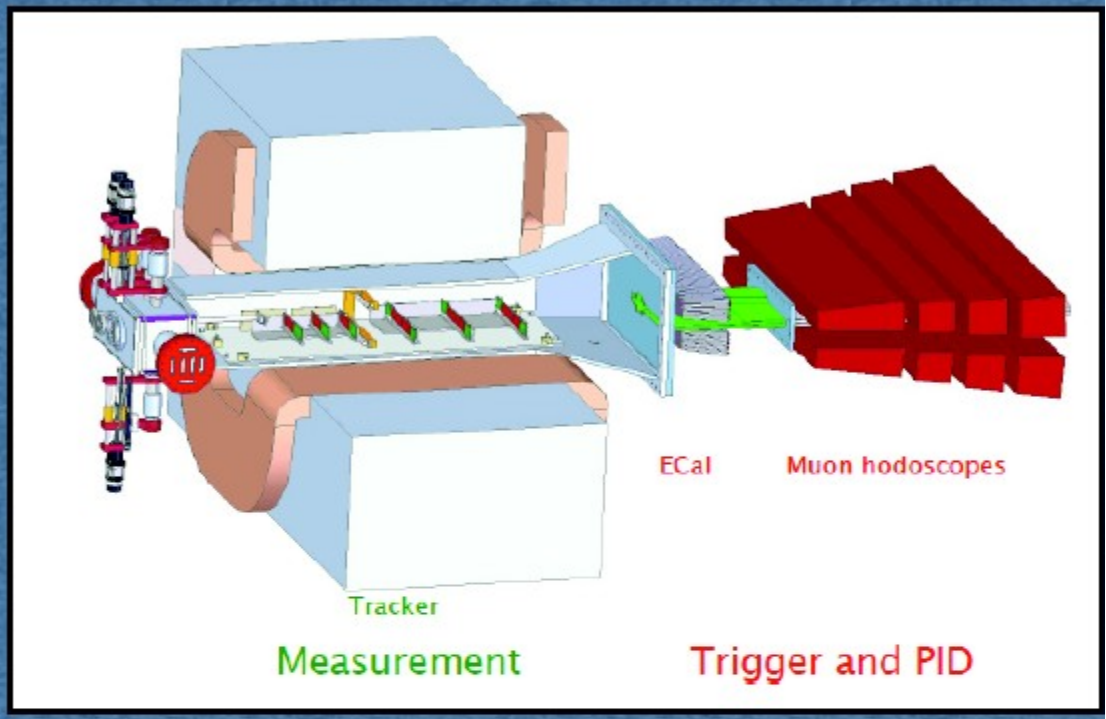




# The INFN commitment in HPS


- Due to our large commitment in the Hall-B Forward Tagger (FT-Cal) we are mainly interested in contributing to the ECal
- Some solutions have already been tested on FT-Cal design, making our action efficient and effective (hopefully!)

(see A.Celentano talk, later)




## HPS ECal

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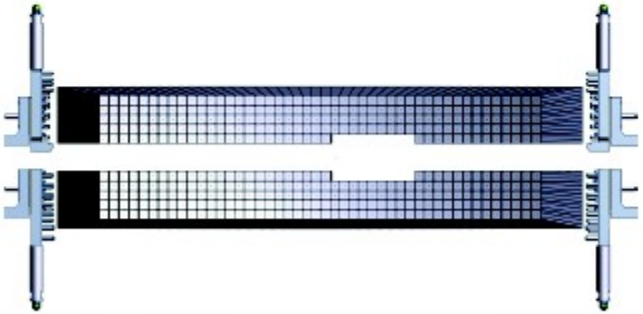
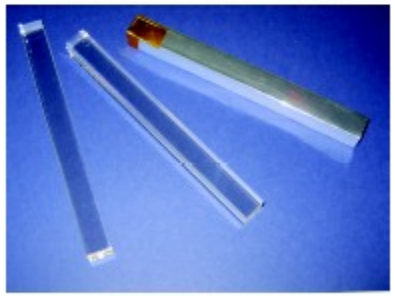
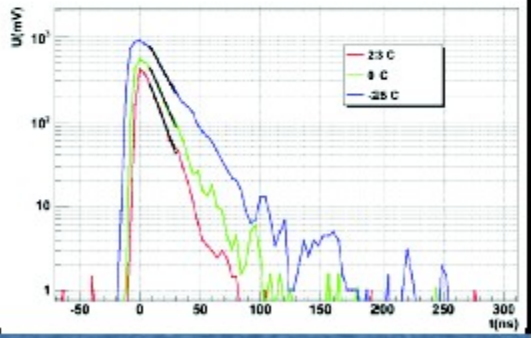
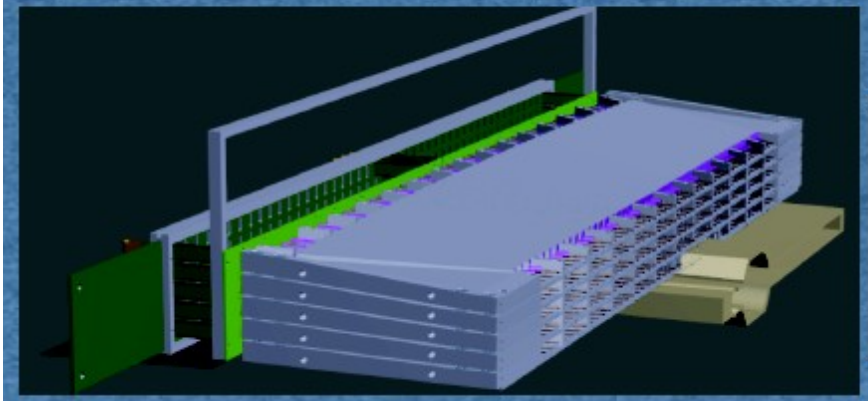







- Recoil electron detection (see M.Osipenko talks tomorrow)
- Data analysis (GEMC simulations and ECal reconstruction)

# New motherboard (design and construction)



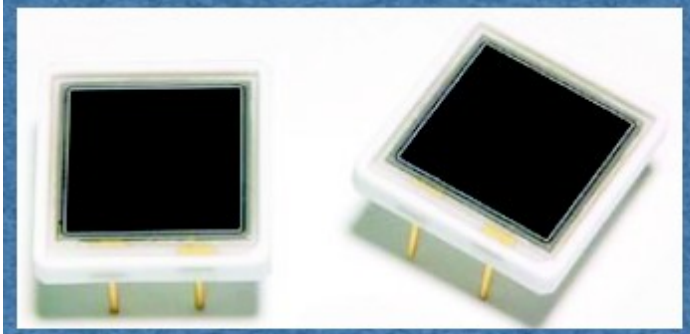
## ECal Light Monitoring System (design)

- Channel matching
- Check crystal/sensor optical coupling
- Crystal transparency
- Gain and stability
- Front-end electronic linearity

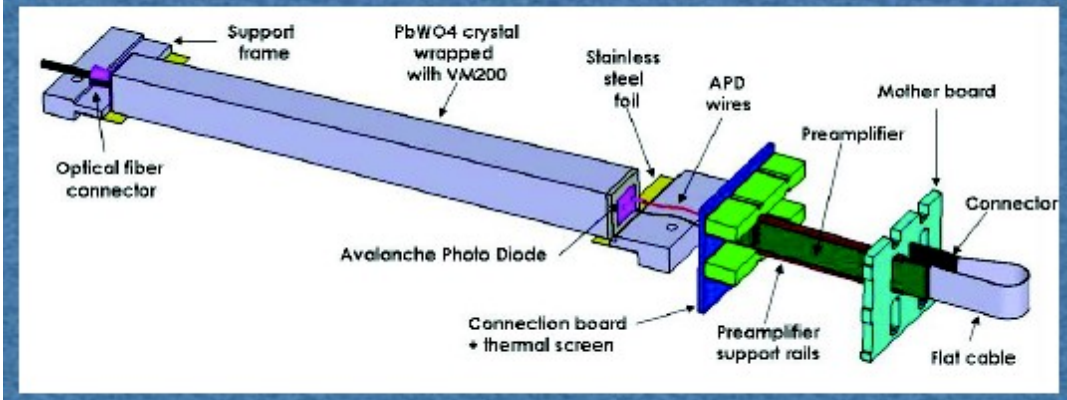
→

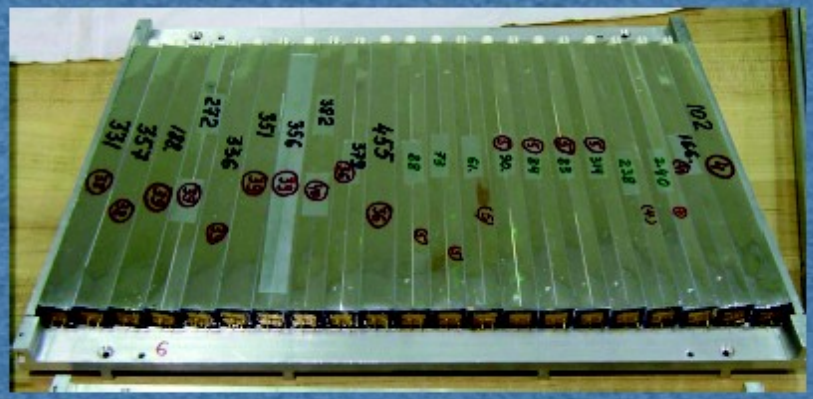
- Custom circuit from INFN-GE EW
- Individual blue LED (470nm)
- All specs fulfilled

## Photo sensors (APD)



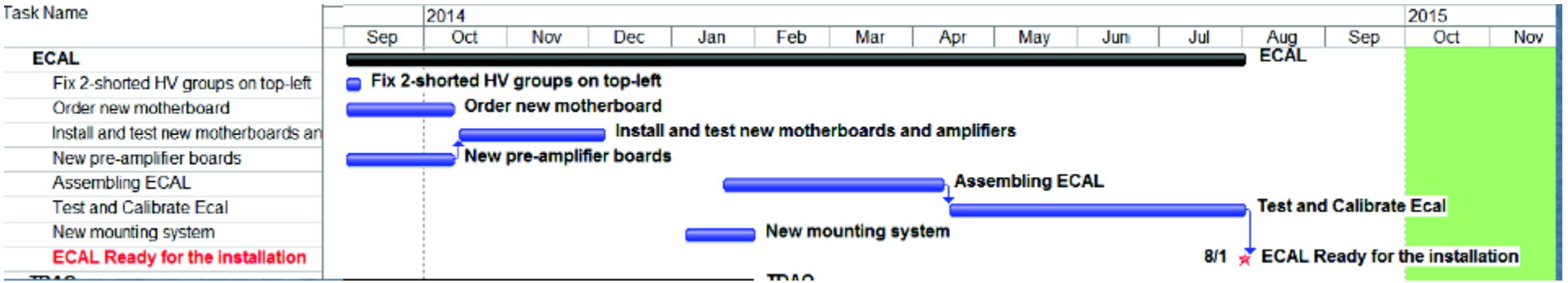
- New Motherboard design and manifacture
- ECal LMS design
- Plan to replace the existing APD (CMS-like) with the new LAAPD
- Qualify the new sensors
- Replacing old APDs with new



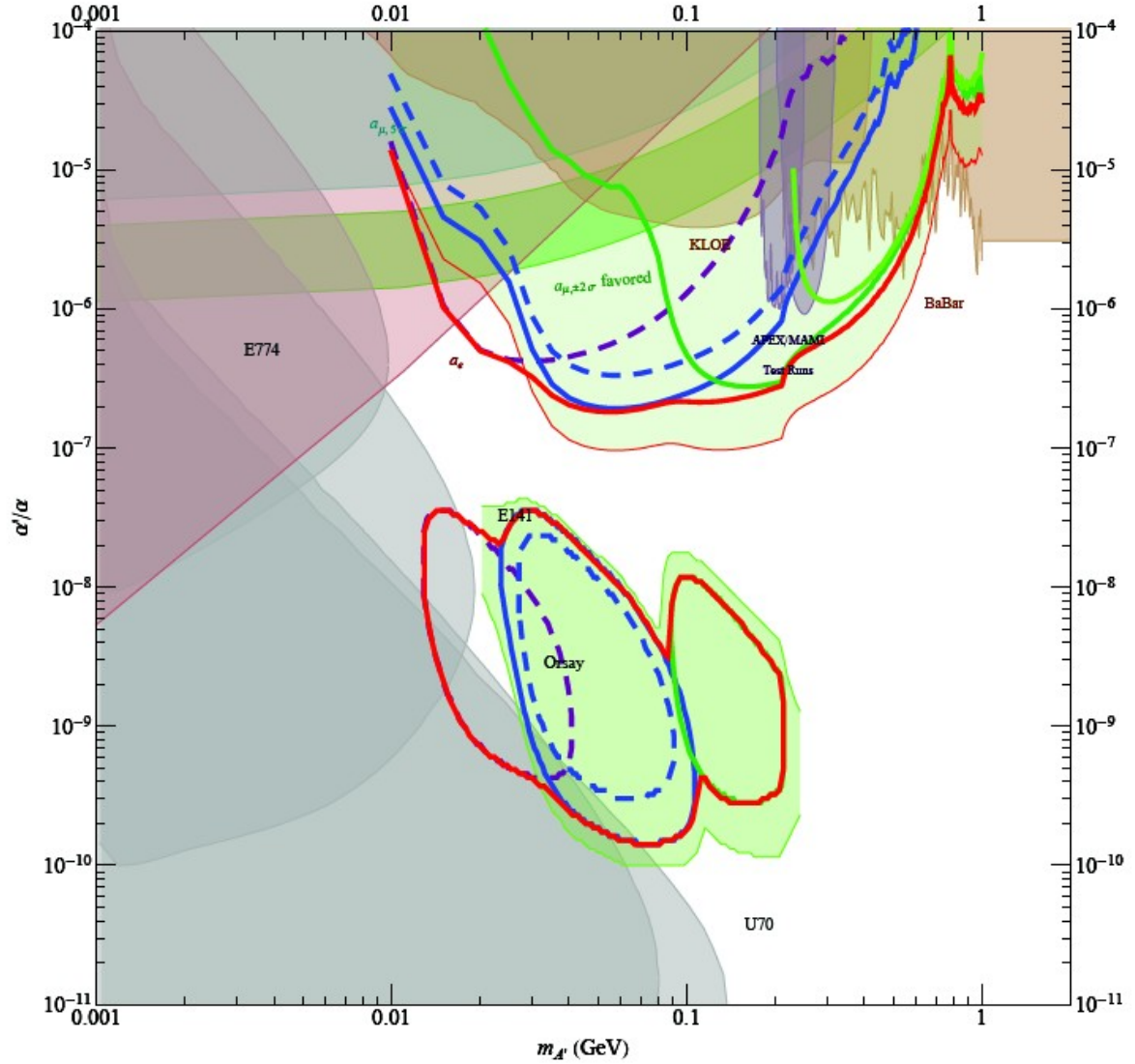



# HPS Schedule

- JLab PAC39 approved 6 weeks of running with maximum A-rate
- Installation expected by September 2014
- Data taking expected in Fall 2014 / Spring 2015 (2w commissioning + 4w prod + 18+w prod (?))
- New proposal being submitted to next JLab PAC to obtain a beam time extension



# HPS Reach




1w+1w @2.2 GeV

2w+2w @6.6 GeV

@2.2+@6.6GeV Combined

3m+3m each Combined

# INFN Contribution

## Budget

### INFN contribution

| | |
|---|---|
| Motherboards (design, production, test) | €10k |
| LED Light Monitoring System (design) | €5k |
| Consumables | €3k |
| TOT | €18k |
| TOT (VAT+Cont) | €25k |

**Secured**

| | |
|---|---|
| LAAPD (500pcs) Hamamatsu | €215k |
| Tooling for crystal assembly | €10k |
| Tooling for APD test | €10k |
| Shipping | €5k |
| Consumables | €3k |
| TOT | €240k |
| TOT (Cont) | €270k |

**Funding request to INFN CSNIII in July13, decision in September 2013**

**Needs a clear schedule for HPS run time**

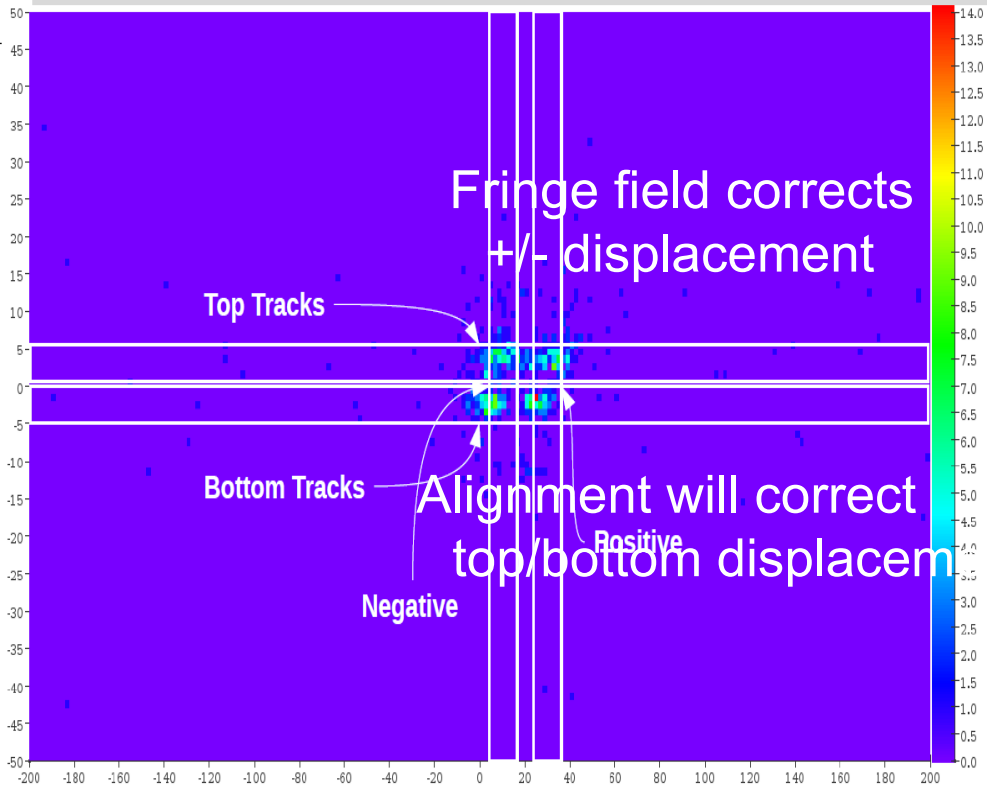
*Needs other 30-40k euro for preamps

**Funds only includes equipment

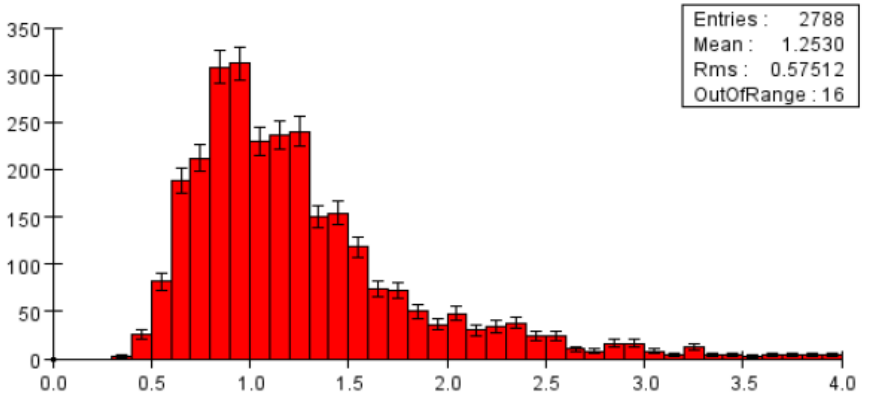
# Padova+Cagliari: Tracking Refinements

- Adding magnet fringe fields and improving alignment
- Improving track reconstruction efficiency and purity ( > 90%)
- Studies of e+e- pairs shown below:

Extrapolated Track Positions at Target
Accurate to few mm

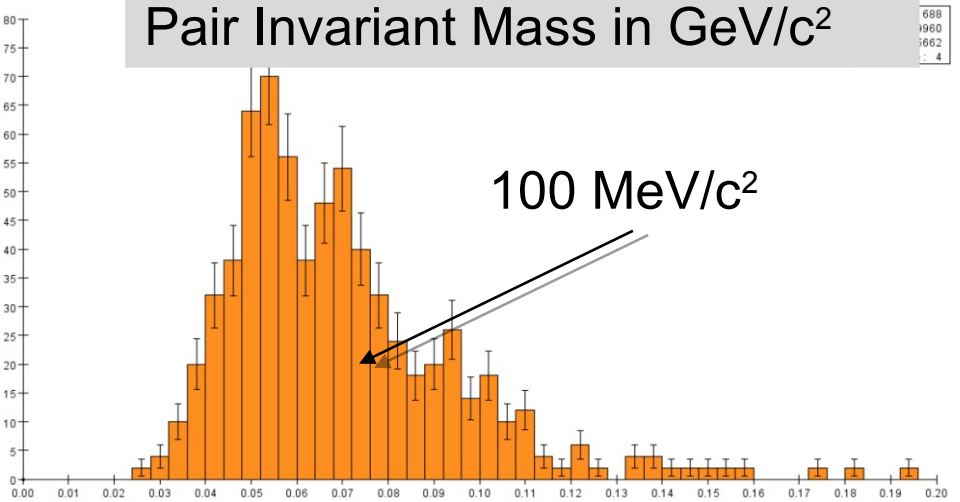



Track Momentum in GeV/c




Invariant Mass

Pair Invariant Mass in GeV/c²



# Servizi

- Nessuna richiesta per il momento

Table 3: INFN-JLAB12 manpower commitment.

| Activity | INFN-JLAB12 manpower (FTE) | Site |
|---|---|---|
| New motherboards design | 30 days | Genova |
| Individual motherboards tests | 15 days | Genova |
| Full motherboard assembly tests | | JLAB |
| LAAPD characterization | 40 days | TorVergata |
| Crystal preparation: tooling | 5 days | Genova |
| Crystal preparation (50 pcs): procedure optimization | 5 days | Genova |
| Crystal preparation (200 pcs): un-gluing and cleaning | 15 days | Catania |
| Crystal preparation (200 pcs): un-gluing and cleaning | 15 days | Cagliari |
| LAAPD glueing: tooling | 5 days | Genova |
| LAAPD glueing (50 pcs): procedure optimization | 5 days | Genova |
| LAAPD glueing (200 pcs) | 15 days | Catania |
| LAAPD glueing (200 pcs) | 15 days | Cagliari |
| Assembly test: tooling | 10 days | Genova |
| Assembly test (50 pcs): procedure optimization | 5 days | Genova |
| Assembly test (200 pcs) | 15 days | Catania |
| Assembly test (200 pcs) | 15 days | |
| Assembly failure | 5 days | |
| Assembly failure | 5 days | |
| Light Monitoring System | 30 days | |
| Total | 110 days | |
| Total | 50 days | |
| Total | 50 days | |
| Total | 40 days | |